APPENDIX 4
Hydrology & Hydrogeology Chapters of the EIAR

Chapter 9 Hydrogeology

9.1 Introduction

9.1.1 Aims of Study

This section of the Environmental Impact Assessment Report seeks to assess and evaluate the proposed road development in relation to hydrogeology. It has been prepared by expanding the desk study work carried out for the Constraints Study and Route Corridor Selection Report. This report section was prepared in accordance with the Transport Infrastructure Ireland (TII) / National Roads Authority (NRA) publication '*Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes (2008)*'.

The road alignment has been separated out into four different sections as detailed below:

- Section A: Ch.1+000 – Ch.5+697 – N5 between the tie-in to the N5 Ballaghaderreen By-Pass (East) and Frenchpark Roundabout on the R361
- Section B: Ch.10+000 – Ch.24+200 – N5 between the Frenchpark Roundabout and the N61 Roundabout at Gortnacrannagh
- Section C: Ch.30+000 – Ch.40+452 – N5 between the N61 Roundabout and the Strokestown Roundabout at Lavally
- Section D: Ch.50+000 – Ch.53+970 – N5 between the Strokestown Roundabout (Junction 19) and the tie-in to the existing N5 in the townland of Scramoge.

The study entails an assessment of published literature available from various sources including a web based search for relevant material. Available geological and geotechnical intrusive and geophysical investigation work carried out for the early EIAR stage have been used to identify areas of subsurface karstification and to ascertain the depth and type of subsoil underlying the proposed road alignment, thus enabling an assessment of groundwater vulnerability. In addition geological and geotechnical intrusive investigation work was carried out previously for the preliminary N5 Strategic Corridor Investigations in 2008-2009 and this information was also available for review. Site specific aerial photography and LiDAR data has been reviewed to locate any potential features of hydrogeological interest, and these have been investigated on the ground by walkover surveys in order to assess their significance and the likelihood of environmental impacts on them associated with this project.

This assessment includes liaison with the agricultural and ecological specialists to obtain relevant information on the private wells and sites of ecological importance along the proposed route.

The scope of the study entails:

- Description of the hydrogeological setting underlying the proposed road alignment;
- Description and evaluation of the likely impacts of the development in terms of construction and operational phases including the character, magnitude and duration of such impacts;
- Description and development of proposed mitigation measures to minimise any potential impacts;

- Description of the residual impacts after mitigation.
- Description of impact interactions and cumulative impacts.

9.2 Methodology

9.2.1 Data Sources

The following list of data sources were the main information sources reviewed as part of this Environmental Impact Assessment Report section:

Ordnance Survey

- Discovery Series Mapping (1:50,000)
- Six Inch Raster Maps (1:10,560)
- Ortho maps (1995, 2000, 2005)

Geological Survey of Ireland (GSI)

- Bedrock Geology Mapping
- Aquifer Mapping
- Groundwater Vulnerability Mapping
- Groundwater Source Protection Mapping
- Teagasc Subsoil Classification Mapping
- Well Database
- Karst Features and Tracer Test Database
- Unpublished Turlough Database
- Groundwater Protection Schemes (1999). Department of the Environment, Heritage and Local Government (DoEHLG), Environment Protection Agency (EPA) and Geological Survey of Ireland (GSI)
- County Roscommon Groundwater Protection Scheme 2003
- Geology of Geology of Longford and Roscommon: A geological description to accompany the bedrock geology 1:100,000 scale map series, Sheet 12 2003 GSI 1992.
- The GSI Groundwater Newsletter

Environmental Protection Agency (EPA)

- Teagasc Sub Cover Classification Mapping
- Teagasc Subsoil Classification Mapping
- Water Quality Monitoring Database and Reports
- Water Framework Directive Classification
- Towards Setting Guideline Values for The Protection of Groundwater in Ireland

Roscommon County Council

- Roscommon County Development Plan 2014 – 2020
- Planning Register
- Water Services – Abstractions, Discharges & Supply Schemes
- Karst, Turloughs and Eskers; The Geological Heritage of County Roscommon 2014

National Parks and Wildlife Service (NPWS)

- Designated Areas Mapping
- Site Synopsis Reports

Other sources

- Aerial survey photography (flown 2006, 2007, 2010, 2012 & 2015)
- LIDAR data (Flown Feb 2015)
- Priority Drilling Limited Ground Investigation Preliminary Ground Report 2009
- Geophysical Surveys along alignment (IGSL Site Investigations Ltd. 2015)
- IGSL Site Investigations Ltd. Ground Investigation Report 2016
- Review of Office of Public Works (OPW) online mapping
- Met Eireann metrological data
- Water Framework Directive River Basin Management Plans
- GSI Establishment of Groundwater Zones of Contribution for the Peak Mantua Group Water Scheme (GWS)
- GSI Establishment of Groundwater Zones of Contribution for the Corracreigh (Cloonyquin) GWS
- GSI Establishment of Groundwater Zones of Contribution for the Polecat (GWS)

9.2.2 Legislation and Guidelines

The following legislation was taken into account during this assessment

- The S.I. No. 349 of 1989, European Communities (Environmental Impact Assessment) Regulations, and subsequent amendments (S.I. No. 84 of 1994, S.I. No. 352 of 1998, S.I. No. 93 of 1999, S.I. No. 450 of 2000 and S.I. No. 538 of 2001).
- S.I. No. 473 of 2011, European Union (Environmental Impact Assessment and Habitats) Regulations 2011.
- 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
- Directive 2011/92/EU (as amended by Directive 2014/52/EU)

This assessment was carried out in accordance with the following guidelines:

- DoEHLG, 2010. Appropriate Assessment of Plans and Projects in Ireland - Guidance for Planning Authorities;
- Environmental Protection Agency, 2002. Guidelines on the information to be contained in Environmental Impact Statements;
- Environmental Protection Agency, 2003. Advice Notes on current practice (in the preparation of Environmental Impact Statements);
- Institute of Geologists of Ireland, 2002. Geology in Environmental Impact Statements, A Guide;

- Institute of Geologists of Ireland, 2013. Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements
- National Roads Authority, 2008. Environmental Impact Assessment of National Road Schemes – A Practical Guide;
- National Roads Authority, 2008. Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes.

The following Draft Guidance documents have also been consulted:

- Guidelines on the Information to be contained in Environmental Impact Assessment Reports, Draft May 2017; and
- Advice Notes for Preparing Environmental Impact Statements, Draft September 2015.

9.2.3 Consultation with Regulatory and Other Bodies

Consultation was made with all relevant regulatory bodies including various departments of Roscommon County Council and the GSI.

9.2.4 Field Surveys

Field surveys were carried out to assess the hydrogeological aspects of the proposed road development. Detailed site walkovers were made at any key areas of concern. At sensitive locations, water supply springs, wells and / or boreholes were visited and assessed in respect to use, well characteristics, yield and recharge area. In addition to field study work, a dye tracer study was also carried out in conjunction with the GSI in order to better inform the understanding of the movement of groundwater in areas of karst near Mantua and Lugboy.

Ground investigations have been undertaken for the proposed development during three separate periods in 2007, 2008 and 2015/2016. These investigations consisted of: 123 cable percussion boreholes to determine the characteristics of the overburden material, 93 rotary cores to determine the bedrock conditions and rock strength, 96 trial pits and 130 dynamic / hand probes. In addition geophysical surveys were carried out at 13 different locations along the length of the proposed development including at areas of known or suspected karstic activity (the results of this also informed the locations of some of the Boreholes/ other testing).

9.2.5 Impact Assessment

An impact assessment has been made of any key hydrogeological feature identified along the proposed road alignment. The methodology follows guidelines established by the EPA for the preparation of EIAR as well as TII/NRA guidelines.

9.3 Existing Environment

9.3.1 Regional Overview of Geology and Hydrogeology

9.3.1.1 Bedrock Geology

Geological maps from the GSI were reviewed to obtain an overview of the bedrock geology traversed by the proposed road alignment. The alignment predominantly transverses over Carboniferous rocks with three rock formations identified which are summarised in Table 9.1 below (**Refer Figure 9.1, EIAR Volume 3**).

Table 9.1: Bedrock Geology Encountered Along Proposed Road Section (West To East)

Chainage	Bedrock type	Formation	
1+000-12+000 14+250 – 35+000 38+000 - 53+200	Undifferentiated Visean Limestone Dark grey to black thinly bedded cherty limestone	VIS VISoo	Visean Limestone
12+000-14+500	Sandstone, siltstone, mudstone	BO	Boyle Sandstone
35+000 – 38+000	Dark fine grained limestone and shale	BM	Ballymore Limestone
53+200 – 54+350	Conglomerate & red Sandstone	FT	Fearnaght

Undifferentiated Visean Limestone

The majority of the route alignment (almost 90%) is underlain by undifferentiated Visean Limestones. Undifferentiated Visean Limestone is the most common division of bedrock in county Roscommon accounting for approximately 60% of the total area. These are shelf limestones and are described as pale to medium grey, fossiliferous, clean, medium to coarse-grained limestones. Due to the lack of drilling and exposure data, these Visean rocks have not been extensively subdivided. One division within the Visean rock has been made, where Oolitic limestones have been mapped in the south of the county. Oolitic rocks are a very clean form of limestone, and may exhibit enhanced permeability, although no specific data are available. The route alignment passes in close proximity to an area of oolitic limestone at Ch.19+000 – 22+000. Karstification is abundant and widespread in the Visean rocks with karst mapping in the area highlighting a high density of features. Additional karst features are likely to exist in these rocks that have not yet been recorded, a number of which have been identified in this assessment. These rocks can transmit significant quantities of localised groundwater particularly through solutionally enlarged underground conduits and fissures, however permeability is likely to vary widely.

Boyle Sandstone Formation

Boyle Sandstone crops out along a north-east to south-west plane from Castlerea to Ballinameen and the route alignment passes over this outcrop near Bellanagare for approximately 2.7km. The Boyle Sandstone Formation consists of a sequence of poorly-bedded, red purple pebbly grit and coarse sandstone conglomerates with mudstones. The basal and upper beds of this formation are reported to comprise reasonably competent sandstones, which suggest that faults and fractures in this formation will remain relatively open and able to transmit significant quantities of groundwater.

Fearnaght Formation

The Fearnaght Formation consists of pale, quartz rich conglomerate with a sandy matrix, red and purple mica-rich flaggy sandstones and purple-brown clean sandstones and therefore constitutes a clean sandstone aquifer. The route alignment passes over this rock unit for a short distance (<1 km) near Scramoge (Ch.53+200 – 54+000). The clean sandstone lithology of this formation suggests a potentially highly permeable aquifer.

Structural Features

The regional structure of the area is influenced by three major structural events, namely the Taconic, Caledonian and Variscan Orogeies. The most recent of these geological events was the Variscan Orogeny and consisted of a north-south compression event and resulted in the folding, uplifting and block faulting with minimal metamorphism. Major faults are mapped along the Strokestown and Castlerea Inliers with the route alignment crossing these structural features at chainages 11+750, 14+250 and 53+200. Such Features can potentially represent preferential pathways for groundwater flow.

9.3.1.2 Subsoil Geology

Desk Based Subsoil Mapping

Geological maps from the GSI and Teagasc were reviewed to obtain details on subsoil classifications within the region. The subsoil type underlying the proposed road alignment is predominantly glacial tills (Sandstone and limestone) and cutover peats (Table 9.2) with minor areas of alluvium, lake sediments and exposed bedrock (**Refer Figure 9.2, EIAR Volume 3**). Further details are available in **Chapter 8 Soils & Geology.**

Table 9.2: Main Subsoil Geology Encountered Along Proposed Road Section (West To East)

Subsoil name	Description
Devonian Sandstone Till (TDSs)	Tills (boulder clay or drift) consisting of accumulations of unsorted, unstratified mixtures of clay, silt, sand, gravel, and boulders. These tills derive their characteristics from their sandstone parent material giving them generally a reddish brown colour with sandy deposits and frequent cobbles.
Sandstone Till (Devonian & Carboniferous) (TDCSs)	
Limestone Till(TLs)	Tills derived chiefly from limestone bedrock containing a high content of fine grained particles. These tills have formed into large deposits creating significant surface features known as moraines.
Cut Peat (Cut)	Peat deposits comprise unconsolidated brown to black organic material with extremely high water content. Peat occurs in both raised and blanket bog across the region. These bogs have been worked for peat both on a commercial and local scale leaving cutover peat exposed in many areas.
Rock outcrop and rock close to surface (Rck)	Limestone rock dominates the region and in many areas karstified bedrock is exposed at the surface.

Till

Till, often referred to as boulder clay or drift, is a diverse material that is largely deposited sub-glacially and has a wide range of characteristics due to the variety of parent materials and different processes of deposition. Tills are often tightly packed, unsorted, unbedded, and have many different particle and stone sizes and types, which are often angular or sub-angular. The eastern section of the alignment from 30+000 to the eastern tie in with the existing road, is located within the Mid Roscommon Ribbed Moraine Geological site (RO022) (**Refer to Chapter 8**). These ribbed moraines have been deposited at the base of the ice sheet and indicate the ice moving in a northwest to southeast direction.

The type of parent material plays a critical role in providing the particles that create different subsoil permeability, with sandstones giving rise to a high proportion of sand sized grains in the till matrix, clean limestones providing a relatively high proportion of silt, while shales, shaly limestones and mudstones break down to the finer clay sized particles.

Sandstone Till (Devonian and Devonian/Carboniferous), Limestone Till (Carboniferous) and Sandstones and Shales Till (Lower Palaeozoic) are present in distinct units along the proposed road and relate to the nature of the underlying bedrock material.

Coarse grained tills have a good strength with low compressibility and are therefore good for use as earthworks during the road development construction. Finer grained material has a variable strength with low to medium compressibility and can be variable regarding use as earthworks.

Peat

Deposition of peat occurred in post-glacial periods associated with the start of warmer and wetter climatic conditions. Peat is an unconsolidated brown to black organic material comprising a mixture of decomposed and undecomposed plant matter that accumulated in a waterlogged environment. Peat has an extremely high water content averaging over 90% by volume.

Numerous pockets of cutover peat are located along the entire length of the proposed road alignment with limited areas of raised bog in close proximity to the route. Peat soils are considered to be problematic for construction work owing to their high organic content, high compressibility and low shear strength and therefore excavation and replacement with suitable material is likely.

Alluvium

There are limited alluvial sediments identified within the study area. It is expected that some alluvial sediments will be present along the main rivers traversing the alignment, namely the Carricknabraher, Owennaforeesha and Owenur, Strokestown and Scramoge. These sediments consist of unconsolidated materials of all grain sizes, from coarse gravel down to finer silts and clays, and may contain organic detritus. The deposits are usually bedded, consisting of many complex strata of waterlain material.

Alluvium deposits have a poor strength and high compressibility, and are therefore considered poor material for use as earthworks during the road development construction.

Lake Sediments

Lake or lacustrine deposits were formed in the quiet waters of lakes formed by the melting glacier waters. They typically consist of silty and clayey material, similar to the finer type of alluvium. Limited lake deposits have been mapped and these are located to the south and east of Strokestown.

Lake deposits have a poor strength and high compressibility, and are therefore considered poor material for use as earthworks during road development construction.

Made Ground

Made ground is located in localised areas along the alignment but is not likely to be extensive. Generally where made ground is present it is associated with urban developments within the vicinity of the alignment including Frenchpark, Bellanagare and Strokestown and at the locations of existing roads which are crossed by the route.

9.3.1.3 Aquifer Classification

The GSI has classified geological strata for hydrogeological purposes based on the value of the groundwater resource and the hydrogeological characteristics. There are 3 principal types of aquifer, corresponding to whether they are major, minor or unproductive groundwater resources. These are further subdivided into 10 aquifer categories (DELG/EPA/GSI, 1999) (Table 9.3).

Table 9.3: Aquifer Types

Aquifer Type	Description	Code
Regionally Important (R)	Karstified bedrock dominated by diffuse flow	(Rkd)
	Karstified bedrock dominated by conduit flow	(Rkc)
	Fissured bedrock	(Rf)
	Extensive sand & gravel	(Rg)
Locally Important (L)	Sand and gravel	(Lg)
	Bedrock which is Generally Moderately Productive	(Lm)
	Bedrock which is Moderately Productive only in Local Zones	(Ll)
	Locally important karstified bedrock	(Lk)
Poor (P)	Bedrock which is Generally Unproductive except for Local Zones	(Pl)
	Bedrock which is Generally Unproductive	(Pu)

There are 3 aquifer classes traversed by the proposed road alignment with the majority (89% of the road length) lying within a Regionally Important Karstified Aquifer, dominated by conduit flow (Rkc) (Table 9.4) (**Refer Figure 9.3, EIAR Volume 3**). The aquifer types that are encountered from west to east along the proposed road are summarised in Table 9.5 below.

Table 9.4: Aquifer Types Underlain By Proposed Road Alignment

Aquifer Type	Description	Code
Regionally Important	Karstified bedrock dominated by conduit flow	Rkc
Locally Important	Bedrock which is generally moderately productive Bedrock which is moderately productive only in local zones	Lm Ll

Table 9.5: Location Of Aquifer Types Along Proposed Road Alignment

Section	Approximate Chainage	Length	Aquifer Type
A	1+000 – 5+697	4.7 km	RKc
B	10+000 – 11+950 14+500 – 24+200	11.65 km	RKc

Section	Approximate Chainage	Length	Aquifer Type
B	11+950 – 14+200	2.25 km	Ll
C	30+000 – 40+542	10.54 km	RKc
D	50+000 – 53+200	3.2 km	RKc
D	53+200 – 53+970	0.8 Km	Lm

A summary of the main characteristics is provided by the GSI in its aquifer classification process and this is detailed below in Table 9.6.

Table 9.6: Typical Characteristics For Aquifers In Study Area

Aquifer property	Aquifer Type		
	Rkc	**Lm**	**Ll**
Transmissivity	Variable; can range from 15 - 1000m^2/d with higher values possible	No information available.	Variable: reported as 2-76m^2/d in sandstones and 5-10 m^2/d in limestones; enhanced zones occurring locally
Productivity	Highly productive with high yielding springs	High productivity likely.	Moderate to low.
Borehole yields	High & Intermediate yielding springs 1100 - 7000 m^3/d	No information available.	No information available.
Potential extent of flow systems	Regional – long flow paths >1km	Regional/local – flow paths can be >1km	Local – Flow paths short (30-300m)
Large springs	Yes	Potential	Unlikely
Lithology	Dinantian Pure Bedded Limestones and abundant karst features	Dinantian Sandstones	Dinantian mixed sandstones, Shales, & limestones
Structural geology	Major fault along NW boundary; dips generally <10° - steeper near faults	Faulted bounded inlier; NW/SE cross cutting trending faults	Faulted bounded inlier; NE/SW with parallel faulting
Surface water groundwater interaction	High degree of interconnection with numerous karst features	Moderate interconnection. Groundwater discharging to rivers/streams	Likely to be low given low permeability characteristics
Groundwater Flow/aquifer thickness	Most GW flow in upper epikarst and zone of interconnected solutionally enlarged fissures/conduits; generally not extending > 30m	GW within the weathered zone and upper interconnected zone extending to < 30m	Most GW flow within upper weathered zone of interconnected fissures not likely to extend more than 15m
Annual fluctuation in water levels	Highly variable	1 – 2m reported at the Castlerea springs	No criteria

Note: Productivity class I implies that significant quantities of water can be abstracted with little consequent drawdown in the groundwater table, and class V indicates that the drawdown can be significant for a given abstraction rate

9.3.2 Groundwater Bodies

The Water Framework Directive (WFD) provides for the protection, improvement and sustainable use of waters, including rivers, lakes, coastal waters, estuaries and groundwater within the EU Member States. It aims to prevent deterioration of these water bodies and enhance the status of aquatic ecosystems; promote sustainable water use; reduce pollution; and contribute to the mitigation of floods and droughts. Under the Water Framework Directive large geographical areas of aquifer have been subdivided into smaller groundwater bodies (GWB) in order for them to be effectively managed. There are 5 separate hydrogeologically defined GWB traversed by the proposed road alignment as shown in Table 9.7 below. (**Refer Figure 9.4, EIAR Volume 3**).

Table 9.7: GWB Traversed By Proposed Road Alignment

WFD GWD	Code	Chainage	Status
Carrick on Shannon	IE_SH_G_048	1+000 – 3+400 14+250 – 53+150	Poor (at Risk)
Carrick on Shannon 4	IE_SH_G_067	3+400 – 11+600	Poor (at Risk)
Castlerea Bellanagare 1	IE_SH_G_068	11+600 – 14+250	Good
Scramoge North	IE_SH-G_201	53+150 – 54+000	Good
Scramoge South	IS_SH_G_202	54+000 – 54+350	Good

According to interim classification work carried out as part of the Water Framework Directive, the Castlerea Bellanagare 1 and Scramoge North & South GWB's are classified as having good status in terms of quality and quantity. The overall risk result of 2*a Probably Not At Risk* is applied to Castlerea Bellanagare GWB while a risk status of *2b Not at Risk* is applied to Scramoge. The objective for these GWB's is to *Maintain* their good status. The Carrick on Shannon GWB is classified as having poor status and is assigned an overall risk result of 1*a At Risk.* The objective for this GWB is to *Restore* to good status by 2021. Given that the proposed road realignment predominantly passes through the Carrick on Shannon GWB, there is the potential to impact water quality and groundwater flows and particular care is therefore required.

For the purpose of this assessment, aquifer characteristics have been considered for each GWB traversed by the proposed road alignment. The descriptions have been taken from the GSI 'Summary of Initial Characterisation' draft reports for each hydrogeologically defined groundwater body. Site specific data including depth to bedrock and subsoil type, collated during the work for this road development has been used to supplement and validate the general information.

9.3.2.1 Carrick on Shannon GWB

The Carrick on Shannon GWB is characterised with widespread Karstification. This karstification results in groundwater flow through a network of solution enlarged conduits which result in a highly permeable aquifer with rapid groundwater flow. As a result of the karstification there is a wide range of permeabilities and transmissivities reported within the GWB. Tracer tests carried out in the area reported rapid velocities and flow paths potentially several kilometres in length. Most of the groundwater flow is expected to take place within the upper epikarstic layers (weathered bedrock) and a zone of interconnected solutionally enlarged fissures (conduits) beneath this to a depth of c. 30m below ground level (bgl). The groundwater body supports high to intermediate springs in the area including the

Peak/Mantua spring supply source. There is a high degree of surface water/groundwater interconnection with numerous karst features such as Turloughs, swallow holes, springs, dolines and caves. Groundwater flow is variable depending on the topography and karst nature of the GWB.

9.3.2.2 Castlerea GWB

The Castlerea GWB is characterised by unconfined aquifer composed in mainly low permeability rocks which have local zones of enhanced permeability. The GWB is made up of locally important aquifers (LI) with transmissivities ranging from 2-76m^2/d within the sandstones and 5-10m^2/d within the impure limestones. Groundwater flow is predominantly within the upper 15m consisting of the upper weathered horizon and a connected fracture zone below this. Deeper flow is reported in areas of deformation and faulting. Groundwater flow paths are generally short and less than 300m with flow directions influenced by local topography.

9.3.2.3 Scramoge North GWB

The Scramoge GWB is made up of the Fearnaght sandstones with flow concentrated in the fractured and weathered zones. Given the lithology of the GWB, permeability / transmissitivies are expected to be high. As with the other GWB, the groundwater flow is mainly within the upper 30m of the bedrock within the weathered horizon and zone of interconnected fissures. Regionally groundwater flow is expected to be a northwesterly direction with flow paths ranging from 500-2000m in length.

9.3.2.4 Scramoge South GWB

This GWB is similar to the Scramoge North GWB being made up of Fearnaght Sandstones. The dominant sandstone lithology gives rise to higher permeabilities and degree of interconnection. Groundwater flow is expected mainly within the upper 30m of the bedrock. Regional groundwater flow reflects topography, flowing in a southeast direction. Given the permeability characteristics groundwater is expected to discharge to surface waters so locally flowing towards rivers and streams. Flow paths are expected to range from local to regional scale (up to 500-2000m).

9.3.3 Groundwater Vulnerability

The risk to groundwater is defined through assessments of groundwater vulnerability, aquifer potential and source protection areas. Groundwater vulnerability represents the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities. It depends on the travel time of infiltrating water (and contaminants), the amount of contaminants that can reach groundwater and the contaminant attenuating capacity of the geological materials through which the water and contaminants infiltrate. The final groundwater vulnerability rating is determined by both the thickness of the unsaturated subsoil which the contaminants move through and the attributes of the overlying subsoil and more specifically the subsoil permeability (DELG/EPA/GSI, 1999). The nature of groundwater recharge (point or diffuse) and how readily water is received also influences the final vulnerably rating of an area. Areas where water (and contaminants) can quickly move from the land surface to groundwater are deemed to be more vulnerable and in that regard groundwater vulnerability is primarily dependant on the permeability and depth of the overburden.

The GSI guidelines given in their Groundwater Protection Schemes (DELG/EPA/GSI, 1999) can be combined with site investigation data (geological and hydrogeological characteristics) to obtain appropriate vulnerability ratings for the ground along the proposed road alignment. Four groundwater vulnerability categories are defined: extreme (E), high (H), moderate (M) and low (L). A subset of the 'extreme' category is termed the 'X – extreme' category, and relates to areas of bedrock outcrop or subcrop (<1m), or within 30m of a location of point recharge (i.e. karst feature). Table 9.8 outlines the geological and hydrogeological characteristics which determine the vulnerability of an area.

Table 9.8: Groundwater Vulnerability Mapping Guidelines

Vulnerability Rating	Hydrogeological Conditions				
	Subsoil Permeability (Type) and Thickness			Unsaturated Zone	Karst Features
	High permeability (sand/gravel)	Moderate permeability (e.g. Sandy subsoil)	Low permeability (e.g. Clayey subsoil, clay, peat)	(Sand/gravel aquifers only)	(< 30m radius)
Extreme (E)	0 – 3.0m	0 – 3.0m	0 – 3.0m	0 – 3.0m	n/a
High (H)	> 3.0m	3.0 – 10.0m	3.0 – 5.0m	> 3.0m	n/a
Moderate (M)	n/a	> 10.0m	5.0 – 10.0m	n/a	n/a
Low (L)	n/a	n/a	> 10.0m	n/a	n/a

n/a = not applicable.
Precise permeability values cannot be given at present.
Release point of contaminants is assumed to be 1-2m below ground surface.

The GSI mapping indicates the vulnerability of the groundwater closest to the ground surface from contaminants assumed to be released 1m to 2m below the ground surface. Vulnerability mapping is used for guidance only and should be supported by site investigation data and contaminant specific assessments where appropriate. In this regard a detailed programme of ground investigations has been undertaken along the proposed road development allowing the site specific vulnerability to be determined. In unsaturated bedrock aquifers the target for protection is the groundwater table within the bedrock unit, and for saturated aquifers it is the top of the bedrock.

In karst areas groundwater is particularly vulnerable to contamination with an extreme rating as:

- water ingress can be rapid through solution enlarged fissures
- sinking streams enable direct entry of water with little or no attenuation of contaminants
- karst features such as dolines can provide direct water entry routes through vertical shafts
- soil cover over karst limestone tends to be minimal or absent and so provides little or no protection (GSI, 2002).

9.3.3.1 Vulnerability Mapping Along the Proposed Road Development

The vulnerability mapping for County Roscommon is available from the GSI website and GIS datasets. The road alignment traverses all of the vulnerability ratings outlined in Table 9.8 above (**Refer Figure 9.4, EIAR Volume 3**). The ground investigations completed to date allow a site specific assessment of groundwater vulnerability to be undertaken along the proposed road development in accordance with Table 9.8 above. The resulting vulnerabilities are given in Table 9.9 along each of the sections of the road alignment. For the purposes of developing Table 9.9, changes in vulnerability occurring for lengths of less than 50m were ignored.

Table 9.9: Vulnerability Mapping Along the Proposed Road Development

Section	Vulnerability	Approximate Chainage	Length (m)	Vulnerability Assessment Criteria*
A	Extreme	1+000 - 1+400	3,800	TP301
		1+650 - 4+250		TP302, TP303, BH401A.1, BH 403, BH 401B, TP305, TP315, BH 402, BH 403, TP306
		4+600 - 5+400		TP309
A	High	1+400 - 1+650	600	TP301A
		4+250 - 4600		BH405
A	Moderate	5+400 - 5+698	298	BH 407
B	Extreme	10+700 - 10+900	4,100	BH479B
		12+450 - 14+250		TP311A, BH 483A, BH 418, TP313, BH 419, BH 420, TP314, BH 420A
		19+200 - 21+300		BH431A, BH432, BH433, BH434, BH434A
B	High	10+100 - 10+700	6,250	BH409, BH479A
		11+950 - 12+450		BH482, BH 483
		14+500 - 14+950		BH422, BH423
		15+650 - 16+150		BH425, BH425B
		17+200 - 19+200		TP318, TP364, BH428, BH428A, BH430, BH430B
		21+300 - 21+850		BH434B
		22+150 - 23+800		BH435A, BH436
B	Moderate	10+000 - 10+100	3,800	BH408
		10+900 - 11+950		BH479C, BH480E, BH480A, BH 481B, BH 480D, BH 481, BH 481A
		14+250 - 14+500		BH421
		14+950 - 15+650		BH423A, BH424
		16+150 - 17+200		BH425A, BH426
		21+850 - 22+150		BH435
		23+800 - 24+150		Bh437
C	Extreme	33+450 - 34+950	8,050	BH451, BH491, BH486, BH504
		31+100 - 37+250		BH485, BH44, BH459, BH459A, BH460
		39+450 - 39+850		BH471
C	High	30+000 - 30+500	10,043	BH437C
		31+550 - 33+450		BH442. BH445, BH447, BH448, BH449, BH450
		34+950 - 36+100		BH 489, BH 445, BH458
		37+250 - 37+700		BH461, BH462, BH464, BH464A, BH464B
		39+100 - 39+450		BH469,
		39+850 - 45+543		BH472, BH473
C	Moderate	30+500 - 31+550	2,450	BH438, BH440
		37+700 - 39+100		BH466

Section	Vulnerability	Approximate Chainage	Length (m)	Vulnerability Assessment Criteria*
D	Extreme	50+950 - 51+100	1,175	BH475
		51+225 - 52+250		BH502, BH477
D	High	50+000 - 50+950	2,350	BH473, BH474
		52+250 - 52+500		BH478
		53+200 - 54+350		BH500, TP351
D	Moderate	51+100 - 51+225	825	BH501, BH476
		52+500 - 53+200		BH479, BH480, BH481

**Assessment of vulnerability was based on the completed ground investigations and the relevant borehole and trial pit logs. See Chapter 8 Soils & Geology for further details of ground investigations undertaken and mapping of same.*

The proposed road development crosses mapped vulnerability ratings of extreme (E) and (X) for long sections and therefore groundwater is potentially at risk in these areas from the proposed development.

9.3.4 Hydraulic Conditions

As groundwater percolates downwards through the substrata the underlying aquifer becomes saturated. At the level of saturation the groundwater table or phreatic surface is formed. This may slope steeply and often mirrors the overlying topography, generally falling towards the nearest free water surface such as a lake, river or sea. Its stability is dependent on the supply of water from above, falling under dry summer conditions and rising through the wetter winter months.

Where there is an impermeable layer underlying the aquifer and this layer outcrops at the ground surface, then the groundwater will flow at the surface in a seepage zone or spring. When the aquifer is overlain by an impermeable layer it is subject to pressure. When this occurs with the groundwater being fed from a distance it becomes a confined aquifer, with the surface level to which the groundwater table would rise to if allowed, termed as the piezometric surface.

When boreholes are drilled into confined aquifers, they become artesian wells. If the piezometric surface within the 'artesian aquifer' is above the ground surface elevation then the artesian well is termed a 'flowing well', and a fracture or flaw in the impermeable overlaying material will in such conditions result in an artesian spring.

Occasionally a small area of impermeable material exists in a large aquifer, which may have resulted through geological faulting, or perhaps from the formation of a lens of clay occurring in an otherwise sandy glacial drift. A localised groundwater table, known as a perched groundwater table may result, which may often be considerably above the actual true phreatic surface level.

9.3.4.1 Recharge and Discharge

Aquifer recharge refers to the amount of water replenishing the groundwater flow system. The recharge rate is generally estimated on an annual basis, and is assumed to consist of input (i.e. annual rainfall) less water losses prior to entry into the groundwater system (i.e. annual evapotranspiration and runoff). The estimation of a realistic recharge rate is important in source protection delineation as it is used to estimate the size of the zone of contribution (i.e. the outer source protection area) (GSI, 2003b). Point recharge occurs within the study area via swallow holes and collapse features associated with the karstified limestone. Diffuse recharge occurs over the entire area via rainfall percolating through the subsoil.

There are two Met Éireann synoptic weather stations in the vicinity of the study area located at Claremorris to the west and Mount Dillion, Lanesborough to the east. Climate averages are computed over a 30 year period of consecutive records with this time period considered long enough to smooth out year to year variations. Met Éireann currently reference 1981 to 2010 as the baseline period for day-to-day weather and climate comparisons. However due to gaps in data availability at Claremorris synoptic station during that period complete data is available for the period 1971-2000. Data was only available from 2007 onwards at Mount Dillion in Lanesborough and is therefore insufficient for averaging purposes. The mean annual rainfall at Claremorris for the 1971 to 2000 period was 1173.6mm per annum. The mean annual potential evapotranspiration (PE) rate for the period 1971 – 1995 (1971-2000 data not available) is given as 461.6mm per annum, with the actual evapotranspiration estimated at about 95% of the PE.

The GSI has produced detailed recharge mapping for the country based largely on the thickness and permeability of subsoil cover and effective rainfall for an area. This mapping gives an estimate of the likely proportion of effective rainfall that will reach groundwater as recharge. Due to the limited permeability and available storage within certain bedrock units, some of the infiltrating water may be rejected due to the rock not being capable of receiving it and in these areas recharge caps have been assigned. It must be noted that actual annual recharge to groundwater depends on the site specific subsoil infiltration rates and the proportion of surface runoff. **Figure 9.6 (EIAR Volume 3)** illustrates groundwater recharge conditions across the study area. Areas of peat have been assigned an extremely low recharge coefficient of 4% due to their poor permeability. The majority of the route alignment is estimated to have a recharge coefficient of 22.5% which is relatively low due to the poorly draining limestone tills (high clay/ silt content) present. Actual recharge to the karstified aquifer is likely to be far higher due to the presence of numerous karst features which will provide point recharge to groundwater, particularly through enclosed depressions or dolines which tend to funnel surface runoff into areas where bedrock is connected hydraulically to the surface. There are many recorded groundwater springs and seepages that maintain base flows in the streams and rivers through point sources at the head and within the watercourse. Due to the high karstification in the area there is significant interaction between groundwater and surface water flows. The Scramoge River is a noted losing river during dry flow conditions with water seeping through the Limestone river bed to the aquifer.

9.3.5 Karst Landscape and Features

9.3.5.1 Karst Landscape

Karst is a term used to describe the distinctive landforms that develop on rock types that are readily dissolved by water. In Ireland, limestone (composed of calcium carbonate) and to a lesser extent dolomite (calcium and magnesium carbonate) are by far the most widespread rocks that show karst features. Rain water is slightly acidic and can readily dissolve limestone rock. In addition when rainwater passes through soil material before reaching the limestone rock, it becomes more acidic and can dissolve the rock more readily. As the acidic water passes down through cracks in the limestone it enlarges them by dissolving the rock and thus allows a greater quantity of water to enter and eventually fissures are formed. Over time these fissures are further enlarged to form conduits or large cave systems. These underground passages can become large enough to allow all rainwater from an area to be engulfed into the rock extremely quickly. The terrain of a karst landscape may be pitted with deep conical or saucer shaped hollows some of which can be very large. These small to medium sized enclosed depressions or dolines correspond to collapsed underground features. Dolines often collect rainwater and channel it very quickly underground. Once underground, water flowing in small fissures and cracks can combine to form small streams, which can expand further into large underground rivers. These underground waters will, at some point, return to the surface as springs and seepages or in some areas may discharge directly to the coast. Rivers can also originate in non-limestone bedrock areas, flow into a limestone region and then immediately sink underground through swallow holes.

Areas of karst can be identified by a general absence of permanent surface water features. In addition the presence of characteristic surface terrain features will dominate a karst landscape. In that regard the presence of swallow holes and enclosed depressions, springs, caves, dry valleys and Turloughs will identify a region as karst.

9.3.5.2 Implications for Road Developments

Karst regions may provide particular problems for engineering works associated with major road and bridge construction. These problems mainly arise from the unpredictable occurrence, extent and depth of underground cavities which may lead to subsequent road subsidence and inadequate foundation support for bridge structures.

An important feature of karst areas is the absence of surface water which often leads to groundwater being the main source of supply (GSI, 2002). The presence of private well supplies in the vicinity of the road development have an increased risk to contamination from road runoff and from constructional activities due to the potential preferential flows within the Karst that may currently exist or develop over time.

9.3.5.3 Karst Features Along the Route

County Roscommon has a high level of Karstification with numerous karst features identified along the proposed road development (**Refer Figure 9.4, EIAR Volume 3**). The area is low-lying and overlain by glacial till deposits. These deposits generally cover the karstic nature of the underlying bedrock, however bedrock is exposed in many areas. Specific karst mapping has been carried out for the entire route (**Refer Figure 9.5 – 9.10, EIAR Volume 3**). This mapping was compiled following a review of: aerial photography, the GSI karst database, walkover surveys of identified sites, local anecdotal information and preliminary site investigation results. It is important to note that there are likely to be further unmapped features present on the ground, as well as unseen underground features. There are six areas along the route alignment where clusters of karst features are encountered either along the alignment or in close proximity – see Figure 9.3 in EIAR Volume 3. In these areas the road construction may interact with complex hydrogeological flow regimes.

1. *<u>Churchstreet/ Portaghard (Ch. 3+450 – Ch. 4+100)</u>*

A number of depressional features, related to the underlying karst bedrock, are located in the vicinity of Churchstreet/Portaghard between chainages 3+450 – 4+100. These features act as drainage for surrounding lands discharging directly to the bedrock. During extreme rainfall events, localised ponding at these features occurs (winter pluvial flooding), which then drains slowly through these features to bedrock. The proposed road alignment does not pass in close proximity to these depressional (karst) features.

2. *Leggatinty (Ch. 10+000 – Ch. 14+000)*

There is a large concentration of karst features in the vicinity of Leggatinty and the proposed road development passes in close proximity to these between Ch. 10+000 and Ch. 14+000. Groundwater and surface water interact due to the presence of a highly developed karst system consisting of an underground cave/conduit system and a number of disappearing streams (swallow holes); there are also a number of enclosed depression features present in this area. The acidic runoff from the upstream peat and forestry areas is likely to have increased the weathering and solutionisation of the limestone bedrock in this area. These highly weathered conduit systems (including Pollnagran cave) have been shown to connect through a trace with a spring adjacent to the Carricknabraher River north-east of the route (flow path length of less than 1km). Pollnagran cave, listed as a Geological Heritage Site (Ref. RO026) and is an active cave system of some 750m in length with an entrance in a shallow blind valley where a surface stream disappears underground – see Plate 9.1 below. A site walkover survey also identified a number of other depressions which may be collapsed karst features – see Plate 9.3 below.

Plate 9.1 View of the Entrance to Pollnagran Cave Showing the Local Stream Disappearing Underground into the Large Karst Cave System

This highly karstified system of underground caves and voids may pose a structural challenge for constructing the road with potential for further weathering of the bedrock and eventual collapse. It also represents a potential point source pathway for road runoff contaminants to rapidly enter a regionally important bedrock aquifer and also to reach the Carricknabraher River.

3. *Kilvoy, Corry East & Cloonyeffer (Ch .18+000 – Ch. 22+500)*

The route alignment transects a concentration of karst features in the vicinity of Kilvoy & Corry East between Ch. 18+000 and Ch. 22+500. The road alignment passes close to the location of a number of active and inactive swallow holes and enclosed depressions between Ch. 18+400 and Ch. 19+000, with Pollaweneen swallow hole and spring system being of most significance. The presence of these underground caves and voids may pose a structural challenge for constructing the road with potential for further weathering of the bedrock and collapse. The swallow holes adjacent to the route alignment may not all be active but may however provide potential point source pathway for road runoff contaminants to rapidly enter the underlying regionally important bedrock aquifer.

A geophysical survey consisting of 2D-Resistivity and seismic refraction (p-wave) was carried out by Minerex Geophysics Limited. This identified a potential zone of karstification (Area 303) underlying the road footprint between Ch. 18+400 -19+450. A graphical interpretation of the output from the 2D-Resistivity survey is given in Plate 9.2 below. The strata interpreted from the geophysical survey were: topsoil approximately 0.5m thickness, overlying 3 – 4m of very stiff / very dense overburden or weathered rock, overlying up to 4m of extremely weathered / karstified limestone rock with competent limestone bedrock beneath. A number of cross sections were also completed perpendicular to the road profile at this location and lower resistivities (likely karstified rock) were also present across these sections and therefore a confirmed zone of three dimensional karstified rock exits.

During site walkover visits a number of further potential karst features were identified in the area usually consisting of surface depressions. The proposed road development crosses a depression which likely corresponds to a collapsed karst feature at Ch. 19+050 which is shown in Plate 9.3 below.

Plate 9.3 View of Potential Karst Feature Identified During Site Walkover Survey

The Peak-Mantua Groundwater Supply is located 150m north of Ch. 15+850, 2km east of Bellanagare Village. Given the proximity of this supply and the presence of underground conduits, there was a potential for an underground connection between this area of karst and the supply. This water supply consists of a spring source supplying 84 households. Given the proximity of the road development to the spring there is potential for water quality and well yield impacts should the road alignment be located within the recharge zone of the spring. The potential impacts of the road development on this group water scheme (GWS) are discussed in detail in Section 9.3.6.

During preliminary site investigations a borehole was drilled close to Ch. 20+450 (BH434). Voids and discontinuities were encountered at this location with a local solutionally weathered zone reported. Core recovery is a measure of how much rock has been lost during drilling. Core loss can be attributed to the presence of an open cavity or the washout of weak zones by the drilling flush. The presence of cavities or weak zones can also be identified in the drilling process when sudden increases in the advance rate occur. Core loss was recorded at BH434 at three depths below ground level; 9.09-9.83m, 10.0-10.88m, 11.50-11.81m. Given the karst nature of the bedrock at this location, it is likely that these core losses correspond to cavities or fractures in the rock.

A known karst feature is located adjacent (c.65m) to the proposed road development at Ch. 20+450 in the townland of Cloonyeffer. This karst feature consists of a sinking stream which drains into a pond with no apparent outlet.

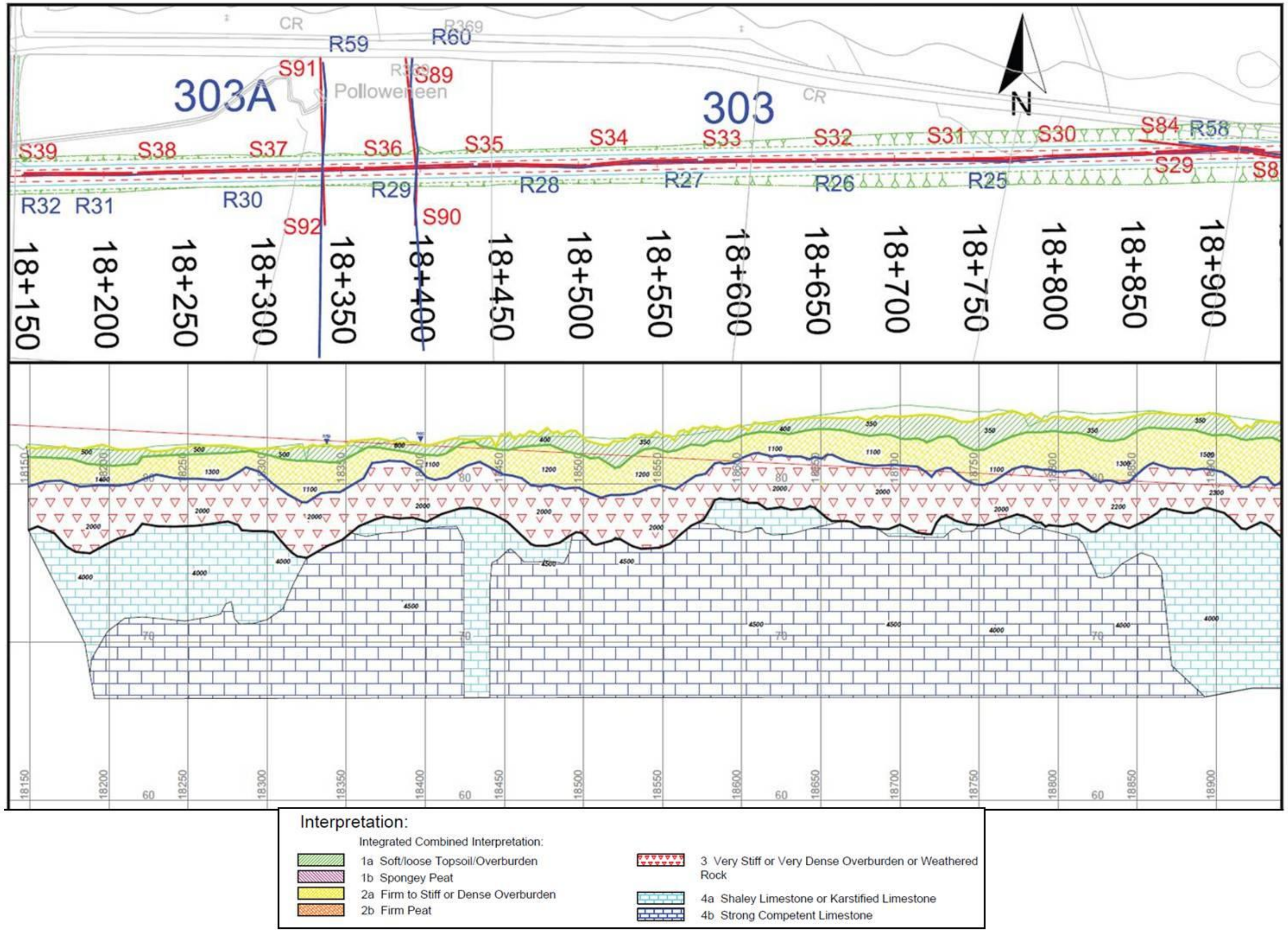

Plate 9.2 Geophysical Survey Location & Interpretation at Area 303 (Ch.18+150 – 18+900) (Minerex Geophysics Limited)

4. *Tullyloyd (Ch. 34+350)*

The proposed road development passes close to the Ovaun Stream near Tullyloyd. At this location a swallow hole feature is present which is active and is located on a spur off the Ovaun Stream channel some 450m upstream of Clooncullaan Lough. Flow monitoring and dye tracing were carried out at this location in order to access the groundwater/surface water interactions. It was found that two scenarios occur for groundwater/surface water flow at this location depending on the flow in the Ovaun Stream. During high flow conditions in the Ovaun Stream (Winter) the swallow hole was found to be receiving a small portion of the Ovaun Stream flow (10%). The majority of Ovaun Stream flow continues west-south-west to Lough Clooncullaan based on evidence from tracer releases which was carried out as part of this assessment in February 2016– see Plate 9.4a and 9.4b below.

Plate 9.4a View of Swallow Hole Feature on a Spur Channel Connected to the Ovaun Stream

Plate 9.4b Dye Plume Released 11 Feb 2016 Remaining in the Ovaun Stream Continuing Towards Lough Clooncullaan and Bypassing the Spur Channel to the Swallow-Hole

The area was revisited in late April 2016 and a reversal in flow conditions was observed. Low flow conditions were present in the Ovaun Stream (Summer) and the majority (90%) of the stream flow was discharging into the swallow hole with the remainder of the flow continuing on to Lough Clooncullan. In order to fully access the impacts of the proposed development, a tracer test was carried out at this location in May 2016. The tracer study was carried out following consultations with the GSI groundwater division and with their support. Fluorescein dye was released at this swallow hole feature on the 12th of May 2016 with 9 separate monitoring locations put in place at the likely downstream outflow locations. Downstream monitoring locations included: the Polecat spring GWS, Annaghmore Lough inflow stream/drain (spring-fed) and downstream locations on the Owenure River. The fluorescein dye was found in the Owenur River at Drummullin Bridge on the 26th of May 2016. The dye was not found at any other monitoring locations. The resulting trace line is shown in Plate 9.5 below as recorded by the GSI. The dye was not found at Ballyslish Bridge on the Owenur upstream of Drummullin. It was therefore concluded that the swallow hole is discharging water underground to a spring (or springs/seepages) located on or adjacent to the Owenur River between Ballyslish and Drummullin Bridges. A number of springs are indicated adjacent to the Owenur River at Creeve and it is likely that this is the location to which the Tullyloyd swallow hole is discharging.

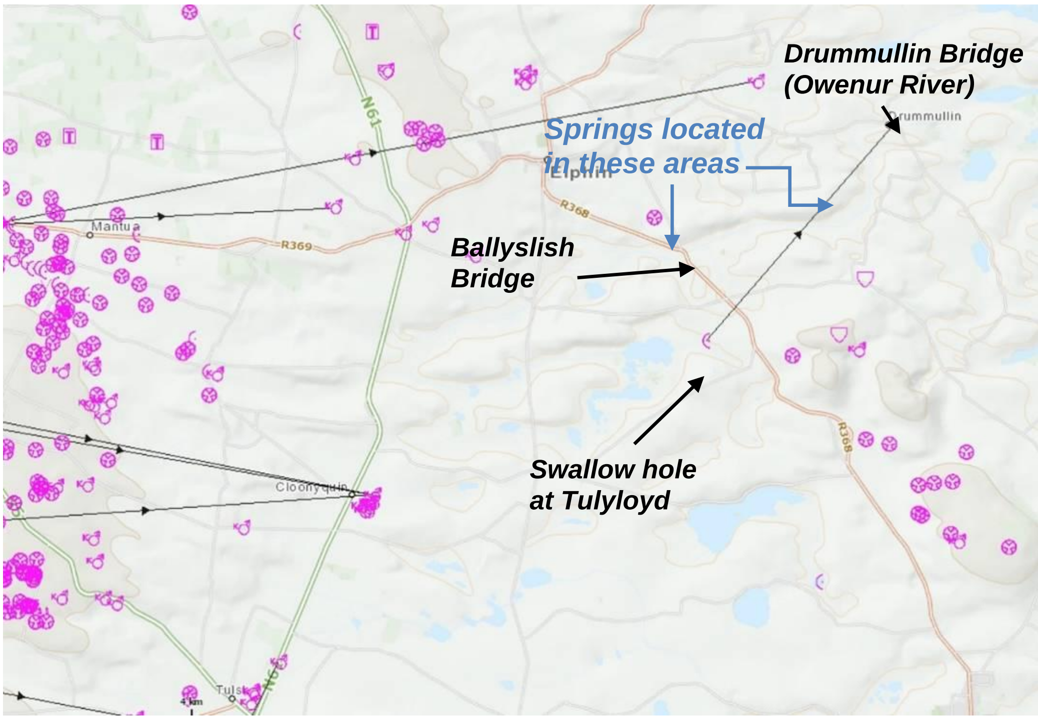

Plate 9.5 Latest Karst Traced Underground Connection Map Published by the GSI (GSI, August 2016). The Roughan & O'Donovan Trace Line is Shown from the Tulyloyd Swallow Hole to Drummullin (Not to Scale).

5. *Cregga (Ch. 35+500 – Ch. 37+500)*

A Turlough is located at Cregga (see Plate 9.6 & Plate 9.7a/b) and a number of karst features are also recorded in the area. A Turlough or Karst lake is a wetland at the interface between groundwater and surface water and is a characteristic feature of the Irish karst landscape. Turloughs are transient lakes that occur in topographic depressions of karstified limestone areas due to high groundwater levels as a result of high rainfall levels. Turloughs give rise to Groundwater Dependent Terrestrial Ecosystem (GWDTE) and provide a habitat for many floral and faunal species. The Turlough at Cregga appears to have two visible direct bedrock/groundwater outlets which are enlarged (see Plate 9.7a), however during a site walkover it was noted that almost the entire base area of the Turlough is directly on the limestone bedrock itself and therefore the discharge to groundwater is diffuse over a large area. The Turlough fills during the Autumn/Winter months and remains inundated with water for a significant portion of the year. The primary outlet from the Turlough is direct to bedrock groundwater at its base however there is also one high level surface water outlet. During particularly high water levels in the Turlough, water can overflow through a pipe under the R368 to a surface drain that eventually discharges to Annaghmore Lough which is a European Designated Site – see Plate 9.7b. A detailed assessment of the Turlough has been carried out by Roger Goodwillie & Associates and this is given in Appendix 7.3.

Plate 9.6 **View of the Turlough at Cregga Looking South-west Showing Seasonal Flooding**

Plate 9.7a **View of the Two Visible Turlough Outlets at Cregga During a Dry Period. (It Must be Noted that Bedrock is at, or Close to, the Ground Surface Over the Base of the Entire Turlough Area and Therefore Groundwater Can Enter Bedrock Diffusely Over a Large Area).**

Plate 9.7b **Overflow from Cregga Turlough Under the R368 to the Surface Drain that Eventually Discharges to Annaghmore Lough**

6. *Vesnoy (Ch. 51+000 – Ch. 51+225)*

The geophysical survey identified a potential karst feature (Area 305) underlying the road footprint between Ch. 51+000 – Ch. 51+225. Lowest resistivities were recorded near the surface indicating peat material. Higher velocity overburden layers were found either side of a dip in the peat with thin weathered / karstifed rock also present. This has been interpreted as a historic karst feature with subsidence and peat infill or more specifically a doline – see Plate 9.8 below for details.

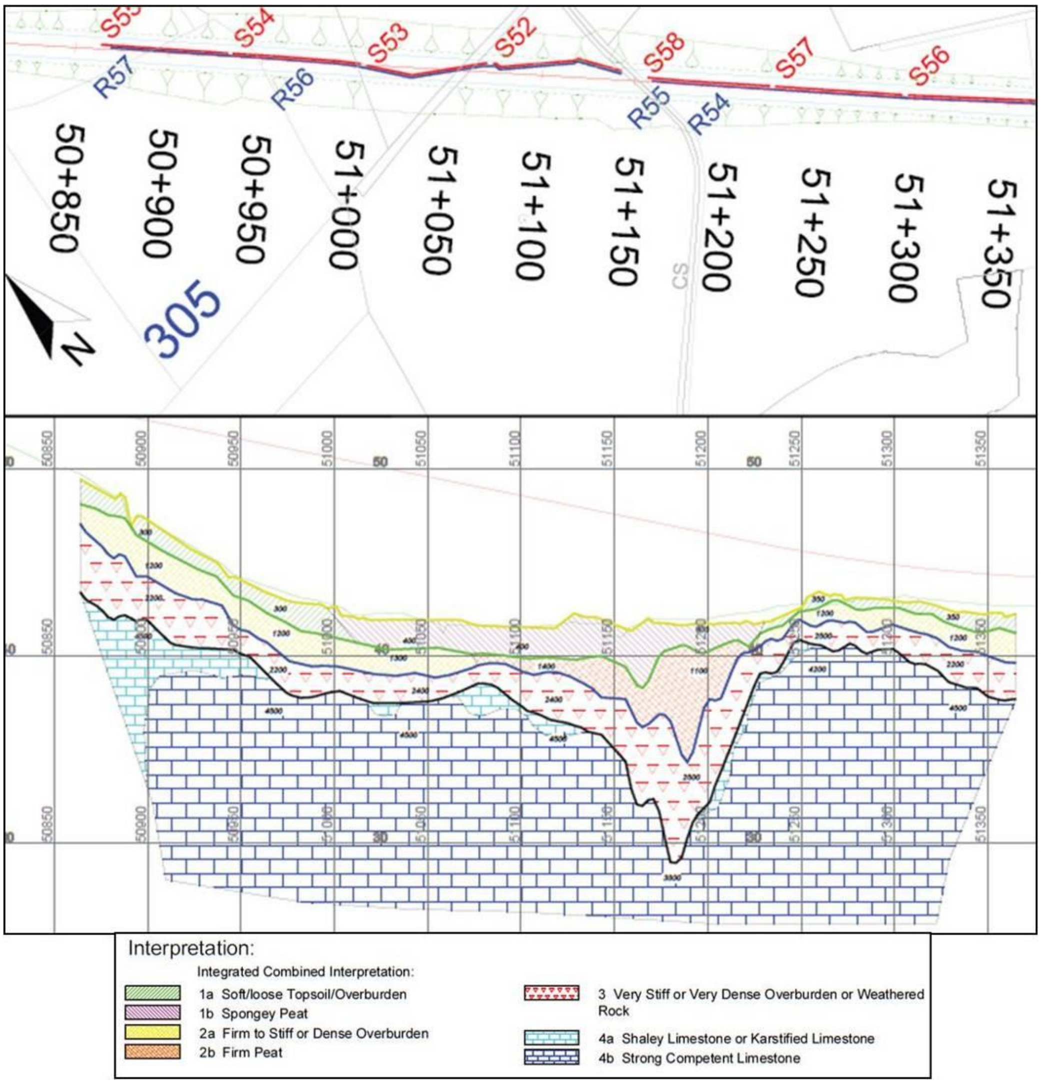

Plate 9.8 Geophysical Survey Location & Interpretation at Area 305 (Ch. 50+850 – Ch. 51+350) (Minerex Geophysics Limited)

9.3.6 Groundwater Supply Sources

There is a very high dependency on groundwater in County Roscommon with 80-85% of the water supplies met from groundwater sources. These include public supply sources, group water schemes and private groundwater wells. Details of public and group water schemes along the road alignment have been obtained from the Local Authority. Details of private supply wells have been obtained from a number of sources including the GSI database, information obtained during the public consultation, agricultural land surveys and a well survey carried out in sensitive areas along the proposed development.

9.3.6.1 Source Protection Schemes

The GSI carries out source protection mapping whereby source protection areas are delineated around significant groundwater supply sources. The areas are subdivided into inner (SI) and outer (SO) protection areas, based on the 100 day Time of Travel (TOT) and the catchment area respectively. The associated groundwater vulnerability is superimposed on these sub-divisions, to give source protection zones as listed below in Table 9.11 (DoELG, EPA & GSI, 1999).

Table 9.11: Groundwater Vulnerability Rating Relevant To Source Protection Zones

Vulnerability Rating	Source Protection Zone	
	Inner (SI)	Outer (SO)
Extreme (E)	SI/E	SO/E
High (H)	SI/H	SO/H
Moderate (M)	SI/M	SO/M
Low (L)	SI/L	SO/L

Source protection areas are delineated using several hydrogeological methods, varying in complexity, cost and the level of data and hydrogeological analysis required. Four methods, in order of increasing technical sophistication, that are used by the GSI are: calculated fixed radius; analytical methods; hydrogeological mapping; and numerical modelling.

As each method has limitations the boundaries must be seen as a guide for decision-making which can be reappraised in the light of new knowledge or changed circumstances.

Inner Source Protection (SI) zones are designed to protect against the effects of human activities that might have an immediate effect on the source and, in particular, against microbial pollution. The area is defined by a 100-day TOT from any point below the water table to the source. In karst areas, it will not usually be feasible to delineate 100-day TOT boundaries, as there are large variations in permeability, high flow velocities and a low level of predictability. In these areas, the total catchment area of the source will frequently be classed as SI. If it is necessary to use the arbitrary fixed radius method, a distance of 300m is normally used. A semi-circular area is used for springs. The distance may be increased for sources in karst aquifers and reduced in granular aquifers and around low yielding sources (DoELG, EPA & GSI, 1999). In karst areas, for spring sources, dye tracing surveys are carried out to identify the extent of the source protection area.

The Outer Source Protection (SO) zone area covers the remainder of the zone of contribution (ZOC) (or complete catchment area) of the groundwater source. It is defined as the area needed to support an abstraction from long-term groundwater recharge i.e. the proportion of effective rainfall that infiltrates to the water table. The abstraction rate used in delineating the zone will depend on the views and recommendations of the source owner. A factor of safety can be taken into account whereby the maximum daily abstraction rate is increased (typically by 50%) to allow for possible future increases in abstraction and for expansion of the ZOC in dry periods. In order to take account of the heterogeneity of many Irish aquifers and possible errors in estimating the groundwater flow direction, a variation in the flow direction (typically ±10-20°) is frequently included as a safety margin in delineating the ZOC. If the arbitrary fixed radius method is used, a distance of 1000m is recommended with, in some instances, variations in karst aquifers and around springs and low-yielding wells (DoELG, EPA & GSI, 1999).

The boundaries of the source protection areas are based on the horizontal flow of water to the source and, in the case particularly of the Inner Protection Area, on the time of travel in the aquifer. Consequently, the vertical movement of a water particle or contaminant from the land surface to the water table is not taken into account. This vertical movement is a critical factor in contaminant attenuation, contaminant flow velocities and in dictating the likelihood of contamination, and can be taken into account by mapping the groundwater vulnerability to contamination (DoELG, EPA & GSI, 1999).

Source protection mapping has not been carried out by the GSI for the three groundwater supplies (Peak-Mantua, Curracreigh and Polecat GWS's) that are located in the vicinity of the road alignment. However, Zone of Contribution (ZOC) mapping has been carried out by the GSI and ZOC reports are available and have been consulted. It must be noted that one of these reports is at draft stage (Peak-Mantua) and the ZOC is currently in the process of being revised.

9.3.6.2 Regional Water Supply Schemes

There is one regional supply scheme within the vicinity of the proposed alignment. The North Roscommon Regional Water Supply Scheme serves approximately 6,500 people in the vicinity of Ballaghaderreen and is sourced by surface water from Lower Lough Gara approximately 2.7km north of the road alignment. An abstraction rate of 7,000m^3/day from the lough was reported by the EPA in 2014. The lough is fed primarily by the Breedoge and Lung Rivers however it is likely that groundwater springs are also contributing to water levels in the lough.

9.3.6.3 Group Water Supply Schemes

There are three Group Water Supply (GWS) schemes within the vicinity of the proposed road development as detailed below:

(i) Peak Mantua GWS; this supply source is fed through a spring supply. There is a groundwater source protection plan being developed by the GSI for this scheme – a draft version of this report was available for review.

(ii) Curracreigh GWS; this supply source is fed through a spring. There is a groundwater source protection plan developed by the GSI for the scheme.

(iii) Polecat GWS; this supply source is fed through a spring. There is a groundwater source protection plan developed by the GSI for the scheme.

Each of these groundwater supply schemes are described in detail below:

Peak Mantua GWS

The Peak Mantua GWS consists of a spring water supply with an abstraction rate of 80m^3/day. The supply source is named Tober Knockageely spring and is marked as a Holy Well on the historic ordnance survey mapping of the area. The spring is located to the east of Bellanagare in the townland of Peak – refer Plate 9.9 below. This scheme supplies approximately 40 domestic connections and serves up to 90 people. The spring supplies water to a holding tank by gravity with an overflow into an adjacent drainage ditch which flows into a tributary of the Owennaforeesha River. The water supply is disinfected prior to entering domestic supply with filtration, ultra violet irradiation and chlorination all taking place.

The topography of the surrounding area is generally flat with a slight gradient to the west/north west. There is higher ground c. 3km to the south (maximum elevation of 161mOD) and lower ground to the north. The surface water catchment generally drains in a north-westerly direction. Land use in the area is predominantly low intensity agricultural usage for grazing purposes. There is a plot of forestry located to the west of the supply and a larger area under forestry to the east. The supply is located in a rural setting with few houses in the vicinity.

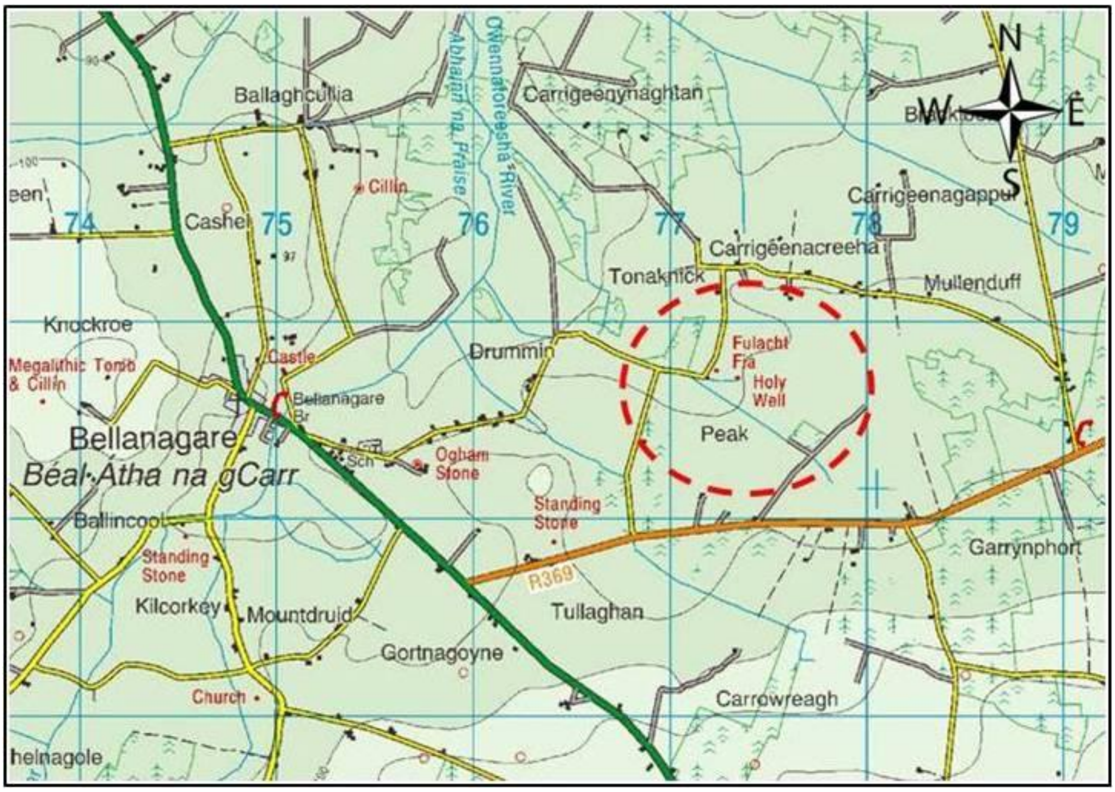

Plate 9.9 Location of the Peak Mantua GWS Spring (Not to Scale)

The area is underlain by limestone which is classified as a Regionally Important Karst Aquifer dominated by conduit flow (R_{kc}). The area immediately surrounding the spring is mapped as having peaty soils present with low permeability glacial till present across most of the surrounding area. Subsoil cover is highly variable and bedrock is exposed in many areas particularly to the south and west. Groundwater vulnerability in the vicinity of the spring is classified as being low with high and extreme vulnerability area located to the south and west. The location of the spring and the reported regional drainage pattern suggests that groundwater flow arises from the Rathcroghan Uplands to the south and flows northwards generally reflecting local topography. Recharge occurs in a diffuse manner across the area from rock outcrops and through the overlying subsoils. Recharge may also occur directly through specific karst points of entry such as swallow holes and dolines but no such point sources have been identified from the recent tracer surveys. Groundwater flows occur in the limestone bedrock from the upland area to the south through interconnected joints, fissures and fractures many of which may be solutionally enlarged. Groundwater then discharges to springs and streams to the north including Tober Knockageely spring. The GSI draft Zone of Contribution report document for this supply reports that the groundwater table is assumed to be a subdued reflection of topography with the locations of water courses and springs around the perimeter of higher ground reflecting where the water table intersects with the low-lying ground at the base of the hill. The GSI have therefore developed a draft ZOC map for the Peak Mantua GWS as shown in Plate 9.10 below.

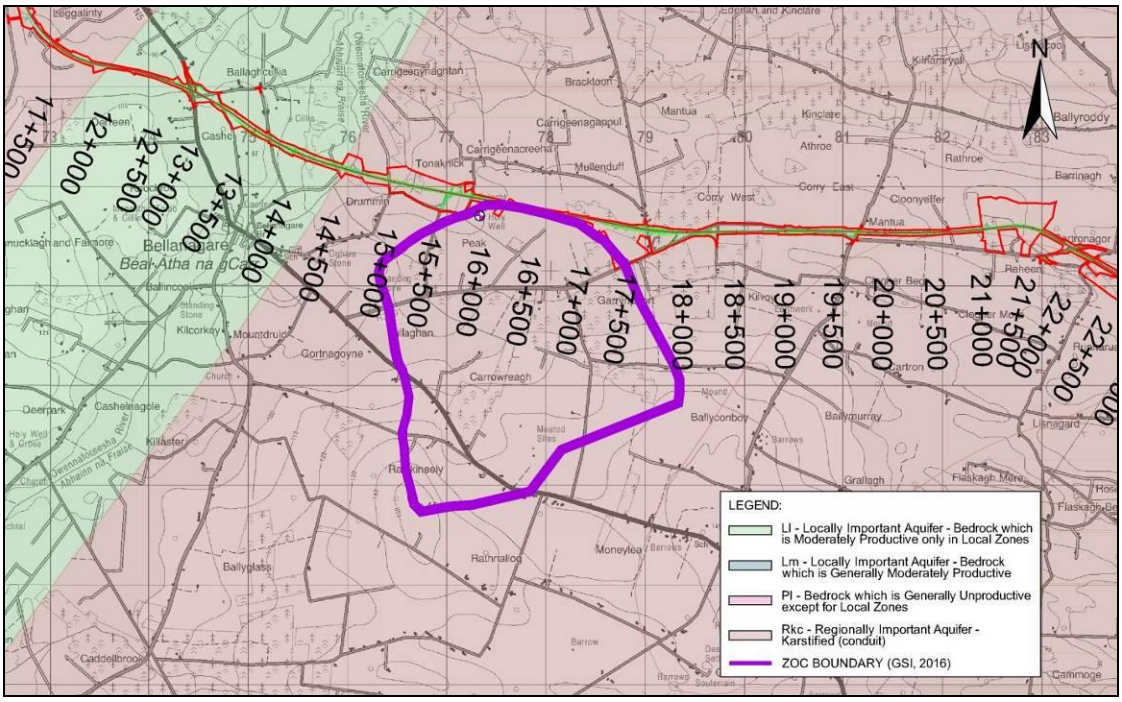

Plate 9.10 Zone of Contribution (ZOC) for the Peak Mantua GWS Scheme (Source: GSI, 2016) (Not to Scale)

The road alignment passes to the north of Tober Knockageely spring and is therefore outside the current draft zone of contribution which has been developed by the GSI. The GSI is currently in the process of revising the ZOC for this scheme and are undertaking a number of trace tests in the area to better understand groundwater flow. A number of swallow holes and karst features have however been identified in the vicinity of the Peak/Mantua area – see Plate 9.10 above for details. Given that the ZOC is still at draft development stage, there was a possibility that karst features to the east and particularly a swallow hole located adjacent to the R369 at Corry West could be connected to the karst system with the ZOC in that scenario extending further to the east. In order to confirm if the Polloweween swallow hole feature at Kilvoy Corry West is connected to the Peak-Mantua hydrogeological system, a tracing study was carried out in June 2015 as part of this assessment. Further tracing studies were also carried out as part of this assessment and by the GSI in May/June 2016. The 2015 tracer study involved a discrete slug of Rhodamine WT dye being injected into the swallow hole with 13 No. potential downstream locations being monitored for the appearance of the dye over a number of weeks. No evidence of the dye inserted into the swallow hole at Mantua was found at the Peak-Mantua GWS supply springs or in any of the surrounding monitored locations. Out of the thirteen monitoring locations a dye trace was only observed at a single location at Carrownahorheeny/Shankill. This tracer test was carried out in conjunction with the GSI who were also carrying out tracing studies in the wider area to identify sources for both the Peak-Mantua Group scheme spring supply and the Curracreigh GWS source (see description below). The GSI tracing which released various dyes at five Swallow hole features in the wider area to the south of the road alignment and confirmed positive links for the Curracreigh GWS source (described below). Further tracer tests were carried out by GSI in the area north of the Peak-Mantua supply in June/July 2016 to more accurately delineate the Zone of Contribution (ZOC) boundary for both supplies and no connections were confirmed southwards to these spring supplies. Two positive connections between the Rathcroghan upland plateau to the south were confirmed to the Peak-Mantua supply spring. In addition three positive connections were confirmed between this upland area (south of the proposed alignment) and the Curracreigh GWS supply spring. These trace lines are shown in Plate 9.14 below. Each of these traced connections confirm the assumptions made by the GSI in delineating the draft ZOC boundary of the Peak-Mantua and Curracreigh supplies with the upland area to the south providing the recharge zone for both supplies. In this regard the proposed road development is located outside the ZOC of both the Peak-Mantua GWS and the Curracreigh GWS. A further tracer study, undertaken by Roughan & O'Donovan in May 2016, confirmed that the karst swallow hole features located adjacent to the proposed alignment at Corry West are connected to springs located outside Elphin and not the Peak-Mantua or Curracreigh supplies. Further details of this trace are given in the Polecat GWS description below – see Plate 9.14.

Curracreigh GWS

Curracreigh GWS is an amalgamation of a number of GWS including; Annaghmore/Corraslira GWS, Clooncullana/Clooncunny GWS, Cloonyquinn GWS and Rathcroaghan/Tulsk GWS. The scheme is supplied by a large spring at Cloonyquinn which is approximately 6km south southwest of Elphin and 2.5km south of the proposed road development. The spring is located adjacent to the N61 in Cloonyquinn as shown in Plate 9.11 below. Land use in the area is dominated by grassland mainly in use for livestock grazing. The area is scattered with houses and farmyards which receive their water supply from the source spring. The reported abstraction rate from Curracreigh spring is $300m^3$/day and serves over 800 people with filtration, ultraviolet irradiation and chlorination being provided prior to distribution. Overflows from the spring flow to a drain and then to a stream located north-east of Cloonyquinn. This stream discharges to a small lake named Lough Ean approximately 1.5km to the east. There are a number of other springs located in close proximity to the supply spring including Pollavrumary spring.

Plate 9.11 **Location of the Curracreigh GWS Spring (Not to Scale)**

The area is underlain by limestone which is classified as a Regionally Important Karst Aquifer dominated by conduit flow (R_{kc}). Subsoils in the area are dominated by glacial limestone tills. Sandstone tills are located to the west and north-west. Pockets of cutover peat are present in the low-lying flat areas. The source spring is located in an area of high groundwater vulnerability with pockets of moderate vulnerability present in the vicinity. A large area of extreme groundwater vulnerably with rock outcrops is mapped to the west of the spring in the upland area. Given the presence of numerous springs at this location, it is clear that the area is a very large discharge zone for groundwater. Flows in these springs are reported to be consistently high throughout the year. Similar to the Peak Mantua GWS, recharge to these springs is likely from the Rathcroghan Uplands to the west/north-west where rock is at the ground surface and karst features are present. Rainfall infiltrates to groundwater very quickly both diffusely and also directly through karst features. Groundwater discharges to the springs and streams to the north and east of the plateau, including the source spring. Groundwater flows in the limestone bedrock aquifer through interconnected joints, fissures and fractures some of which are likely to have been solutionally enlarged. The GSI have carried out tracer studies in the area and have also produced a ZOC report for this particular scheme. The latest ZOC boundary map which reflects tracer studies carried out in 2016 is shown in Plate 9.12 below. The results of tracer studies carried out by the GSI in 2015 and 2016 confirm that underground karst connections from the southwest are feeding this spring source and that the assumptions made in delineating the ZOC boundary were generally correct – see Plate 9.14 below for the latest ZOC boundary as mapped by the GSI. It can be seen that the ZOC area predominantly extends to the west of

Cloonyquinn towards the (Rathcroghan) upland area and that the proposed road development is located well outside the ZOC boundary.

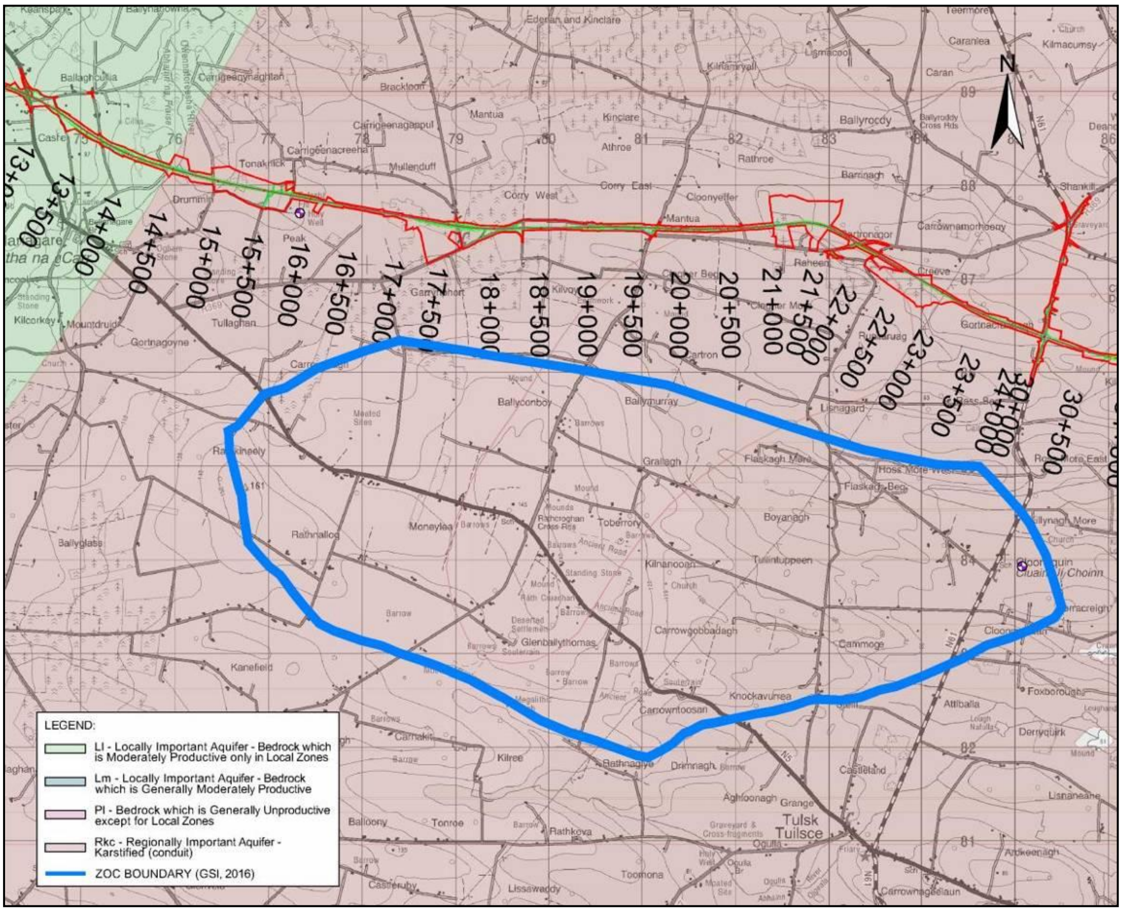

Plate 9.12 Zone of Contribution (ZOC) for the Curracreigh GWS Scheme (Source: GSI, 2016) (Not to Scale)

Polecat Spring GWS

The Polecat Springs GWS consists of a spring fed water supply with an estimated abstraction rate of 550m^3/day. The supply source consists of a surface abstraction from a large groundwater spring supply. There are also two other groundwater springs located in the immediate vicinity (but not abstracted from) and all three are connected to the same underlying aquifer. The average yield of the main Polecat spring has been estimated by the GSI at 4,500m^3/day. The springs are located to the north-east of Elphin in the townland of Lissavilla – refer to Plate 9.13 below. This scheme supplies approximately 1000 domestic and agricultural connections and serves up to 400 people.

The main spring is located in a low-lying valley adjacent to the L-1031 approximately 3km north-east of Elphin. A broad plateau orientated north-south occurs west of the spring, extending from Elphin to Croghan (8km to the northwest). The surrounding area to the north of the main spring is scattered with drumlins which are oriented southwest-northeast. Land use in the surrounding area is mainly agricultural and is used for grazing.

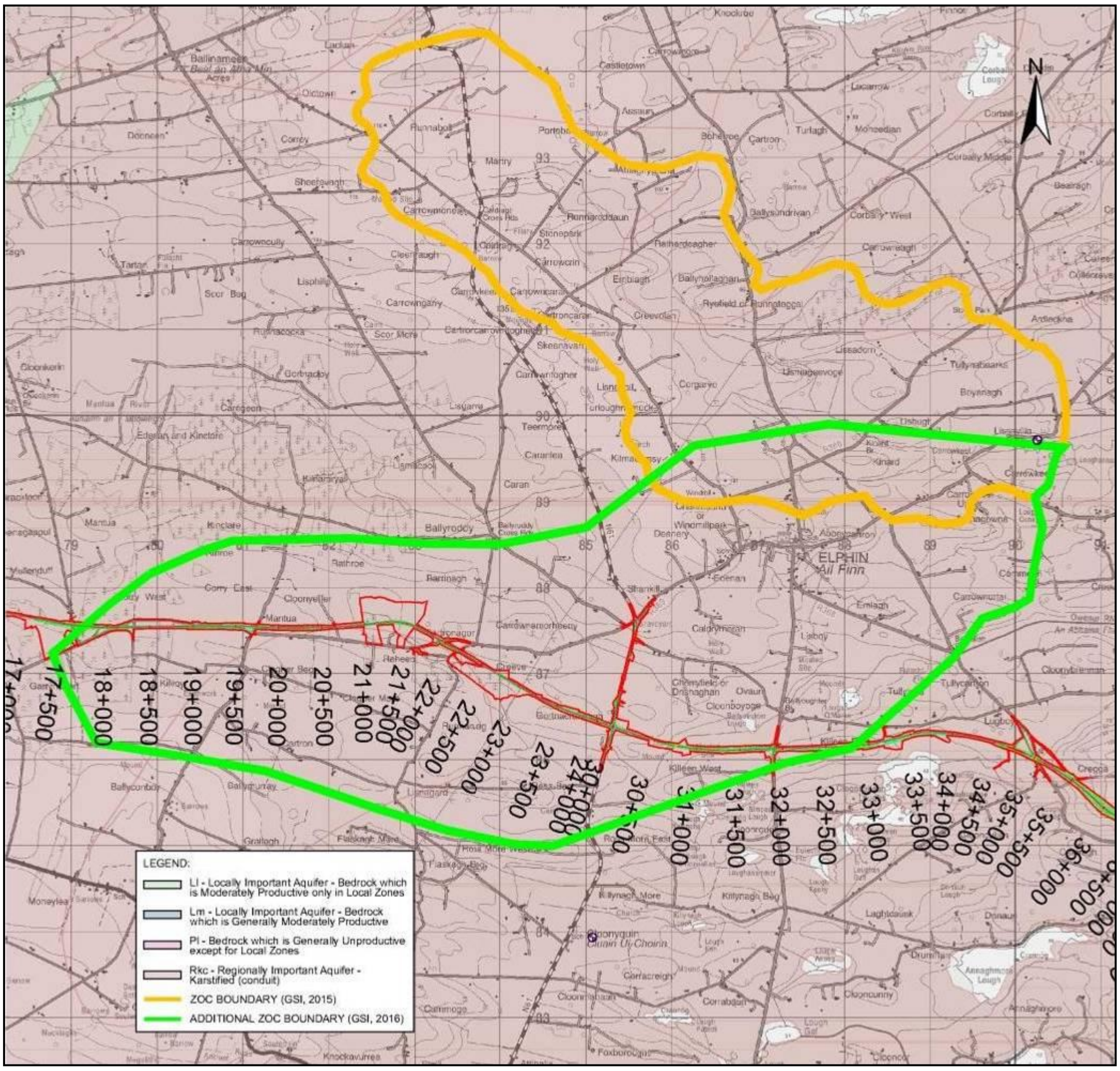

Plate 9.13 Zone of Contribution (ZOC) for the Polecat GWS Scheme (Source: GSI, 2016) (Note: This ZOC Boundary was Recently Reviewed by the GSI Following the Results of the 2016 Tracer Test with the Additional Area Added Shown in Green) (Not to Scale)

In February 2015, the GSI produced a Groundwater ZOC report and map for the Polecat GWS. The corresponding ZOC boundary for the supply is shown in orange in Plate 9.13. During a tracer study carried out as part of this current environmental assessment, Rhodamine WT dye was released at a swallow hole (Polloweneen) located at Corry West near Mantua in May 2016. This dye subsequently appeared at all three Polecat springs with an estimated time of travel of 10 days. The swallow hole (Polloweneen) at Corry West is located approximately 10km south-west of the Polecat supply. An underground karst connection in the limestone bedrock therefore exists which allows groundwater to travel relatively quickly between the area surrounding Corry West and Polecat Springs at Lissavilla – see Plate 9.14 below. Given the results of this tracer test, the previous ZOC map for the Polecat supply was updated by the GSI in October 2016. This resulted in the ZOC boundary being expanded and the corresponding additional ZOC boundary for the supply is shown in green in Plate 9.13. Having regard to these results, it will be necessary to provide protection to groundwater in the area surrounding Corry West given that road surface water runoff has a direct underground pathway to the Polecat Spring Supply through the Polloweneen Swallow Hole.

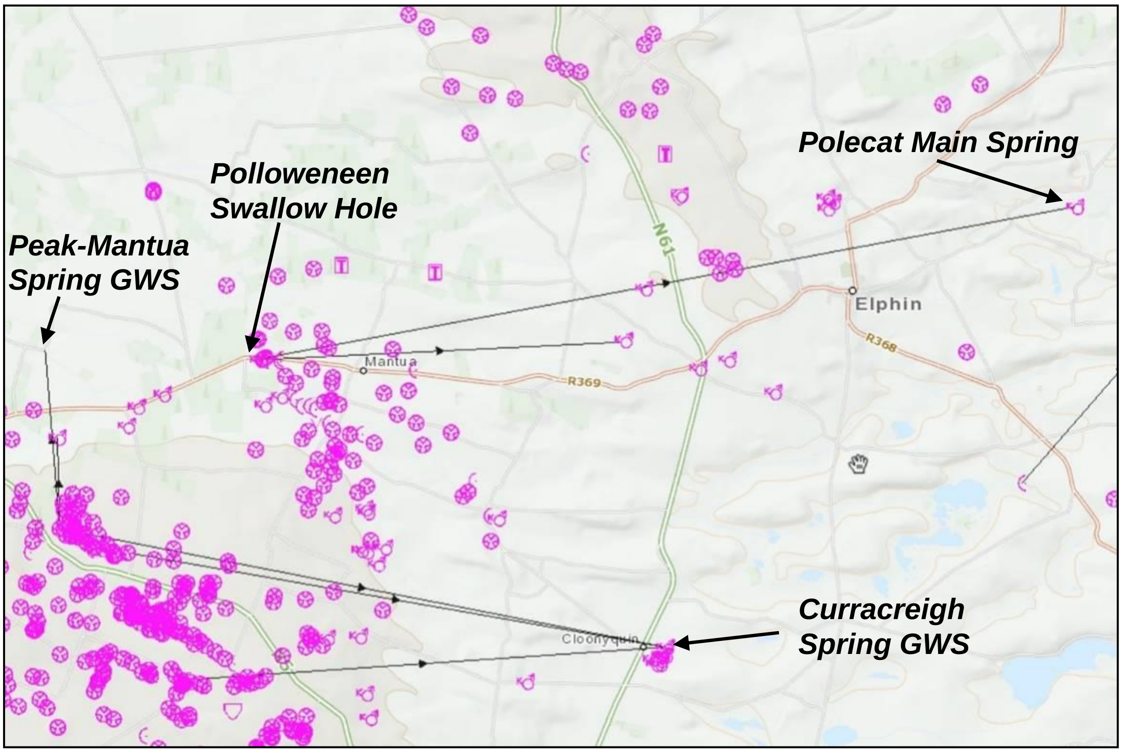

Plate 9.14 Latest Karst Traced Underground Connection Map Published by the GSI (GSI, August 2016). The 2 No. Roughan & O'Donovan Trace Lines are Shown from the Polloweneen Swallow Hole (Not to Scale).

Northeast Roscommon Regional Water Supply Scheme

The North East Roscommon Regional Water Supply extends from Roosky in the east to Tulsk in the west and from Drumsna in the north to Ballyleague in the south. The water supply scheme serves over 5,000 people including residents of Strokestown, Elphin, Tulsk and Scramoge. The supply for this source is taken from Lisheen Lake located approximately 6km north of Strokestown. Roscommon County Council also maintain a number of groundwater supply boreholes located in the vicinity of Strokestown. Drinking water supply for residents in areas surrounding Strokestown is augmented from these boreholes. Groundwater protection zones have not been drawn up for these supplies by either the GSI or the EPA. The closest of these boreholes is located at Kiltrustan located to the north of Strokestown. This supply is from deep abstraction boreholes which are drilled to a depth of c.62.5m with a reported maximum abstraction rate of $59m^3$/day.

Commercial and Industrial Water Supplies

There are no large commercial or industrial premises along the proposed alignment route. A large limestone quarry (Laragan Quarry) is located on the northeastern slopes of Greywood Hill. The quarry is supplied by the public supply and has its own abstraction well bored deep into the limestone Bedrock.

Domestic and Agricultural Water Supplies

The majority of residential houses along the proposed road alignment are connected to either the North Roscommon Regional water supply scheme or the Peak Mantua GWS. A total of 20 groundwater supply boreholes or spring wells for domestic and agricultural use were identified during the assessment of the study area. Many of these locations are also connected to mains supplied water. A number of springs and seepages were identified that are used primarily for livestock.

9.3.7 Natural Heritage

The NPWS and GSI websites were queried regarding the presence of any listed wetland habitats or geological heritage sites traversed by the proposed road alignment, or within the immediate area. A comprehensive review of Biodiversity and Soils & Geology are given separately in **Chapters 7 & 8** and therefore a summarised overview of designated sites is given below.

9.3.7.1 Designated Sites

Special Areas of Conservation (SPA) 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.

No SAC or SPA is traversed by the proposed road, however there are six designated sites which were screened-in during Appropriate Assessment; Bellenagare Bog (cSAC and SPA), Annaghmore Lough (cSAC), Cloonshanville Bog (cSAC & SPA), Lough Gara (SPA) and Lough Forbes Complex (SPA).

Bellanagare Bog cSAC and SPA

Bellanagare Bog is listed as a SPA (Ref. 004105), a candidate Special Area of Conservation (000592) and is also listed as a proposed National Heritage Area (pNHA) (Ref. 000592). The bog is located some 1.5km south of Frenchpark in the townland of Leggatinty. The road alignment passes approximately 200m to the north of Bog. The bog shows the characteristics of a blanket bog habitat and is classified as an intermediate raised bog. The site is selected as a SAC for the following habitats and/or species listed on Annex I&II of the E.U. Habitats Directive: Active Raised Bog [7110], Degraded Raised Bog [7120], Rhynchosporion Vegetation [7150], Marsh Fritillary (Euphydryas aurinia) [1065].

Annaghmore Lough cSAC

Annaghmore Lough is designated as a candidate Special Area of Conservation (Ref. 001626) and is located approximately 3km south of Elphin. The Lough lies at the centre of a network of small lakes in a rolling, drift-covered landscape. The site was selected as a cSAC for the following habitats and/or species listed on Annex I&II of the E.U. Habitats Directive: Alkaline fens [7230] and Vetigo geyeri (Geyer's Whorl Snail) [1013]). In addition the site is important for wintering birds and is listed as a wildfowl sanctuary (WFS-44). This site is relatively intact with minor damage; cattle grazing, burning on the fen and drainage pose the main potential threats to the site. This is a site of considerable conservation importance given the habitats and rare species present. The proposed road development passes approximately 0.9km to the north of this SAC.

Cloonshanville Bog cSAC

Cloonshanville Bog is designated as a candidate Special Area of Conservation (Ref. 000614) and is located approximately 1km north of Frenchpark in the townland of Cloonshanville. The site was selected as a cSAC for the following habitats and/or species listed on Annex I&II of the E.U. Habitats Directive: Active raised bogs [7110], Degraded raised bogs still capable of natural regeneration [7120], Depressions on peat substrates of the Rhynchosporion [7150] and Bog woodland [91D0]. A large flush area occurs in the centre of the bog. This body of flush bogland is reported as supporting an extensive area of bog woodland. It is likely that these wetland conditions are maintained by groundwater springs or seepages. The road alignment passes within 1.7km to the south of this designated site

Lough Gara SPA

Lough Gara is a shallow medium-sized lake, situated some 6km north-east of Ballaghaderreen. There are two main sections to the lake, a larger northern basin and a smaller southern basin which are joined by a narrow channel. The main inflowing river to the lake system is the River Lung while the main outflow from the lake is the River Boyle. The lake is classified as a mesotrophic system, with reduced planktonic algal growth. Callow Bog cSAC is situated on the southern shore of the lake. The site was selected as a Special Protection Area due to the presence of the following species: Whooper Swan (Cygnus cygnus) [A038] and Greenland White-fronted Goose (Anser albifrons flavirostris) [A395].

Lough Forbes Complex cSAC (001818)

This cSAC consists of a natural lake system, active raised bogs degraded raised bogs, depressions on peat substrates and alluvial forests. The site is a Special Area of Conservation (SAC) selected for the following habitats and/or species listed on Annex I& II of the E.U. Habitats Directive Natural Eutrophic Lakes [3150], Raised Bog (Active) [7110], Degraded Raised Bog [7120], Rhynchosporion Vegetation [7150], Alluvial Forests [91E0]. This site is located downstream of the road project and is fed by the River Shannon.

9.3.7.2 National Heritage Areas (NHA's)

There are no National Heritage Areas (NHA's) in the immediate vicinity of the road alignment, however Bellangare Bog is designated as a pNHA (Ref. 000592) and is described above due to it being afforded additional protection as a SPA and cSAC. There are also 3 NHA's just north of Frenchpark; Bella Bridge Bog, Cornaveagh Bog and Tullaghan Bog.

9.3.7.3 Geological Heritage Sites

There is a statutory requirement placed on Local Authorities to have due regard for conservation of geological heritage features under the Planning and Development Act 2000, as amended, the Planning and Development Regulations 2001, the Heritage Act 1995 and the Wildlife (Amendment) Act 2000.

The Irish Geological Heritage Programme is a partnership between the GSI and the NPWS. It aims to identify, document, and protect the wealth of geological heritage in the Republic of Ireland and conserve it against ever increasing threats, and also to promote its value with the landowners and the public. The GSI provides scientific appraisal and interpretative advice on geological and geomorphological sites, and is responsible for the identification of important sites that are capable of being conserved as NHAs. Of the majority of geological sites not eventually selected for NHA designation, some have been promoted as County Geological Sites (CGS), which have no statutory protection, but may be included within County Development Plans. Many counties have now adopted CGS's into their development plans, and are promoting their interest through Heritage Plans (GSI website).

CGS's have been incorporated into the Roscommon County Development Plan 2014-2020, listed as 'Sites of Geological Interest'. The following are located along the proposed road development:

Mid Roscommon Ribbed Moraines (RO022)

The Mid Roscommon Ribbed Moraines (Ref. RO022) are listed in the Roscommon County Development plan as a 'County Geological Site'. The area consists of a ribbed moraine field with superimposed drumlins. The road development passes through this site along the eastern section of the alignment from Ch. 30+000 to the eastern tie in with the existing road. The features are too large to conserve however the landscape itself is unique and is recommended for promotion by the GSI. Few restrictions are imposed for development within this area however consultation with the GSI is advised. The GSI was consulted regarding the road development and has requested access and information during construction works in order to gain information on the geology of the area to supplement data currently held on record.

Pollnagran Cave (RO026)

Pollnagran is a 750m long, active stream cave located in the townland of Leggatinty near Frenchpark. It is the only known active stream cave in County Roscommon. The cave has an entrance on private lands in a shallow valley where a surface stream disappears underground. The cave therefore forms part of a wider active karst limestone bedrock system in the area with the stream emerging as a spring to the north. Noted as a rare active stream cave, the GSI have designated it as a County Geological Site given its unusual and rare nature in County Roscommon.

Laragan Quarry (RO016)

Laragan Quarry is a large working quarry located north of Strokestown. The road alignment passes to the south of the quarry and within 150m distance. The quarry is excavated into Carboniferous limestone which is reported as potentially belonging to the Ballymore Limestone Formation. The quarry provides a view of near perfect horizontal limestone beds and provides a window into the bedrock which is normally rarely exposed in County Roscommon. The GSI reports the quarry as a good representative site displaying Carboniferous limestone bedrock in County Roscommon. It is anticipated that the representative rock faces exposed in the quarry will be preserved for geological purposes after the final closure stage of the quarry.

9.3.7.4 Sites of Key Ecological Interest (KER's)

The ecological assessments for the project were reviewed to locate any sites along the proposed road alignment that could be potentially impacted relative to hydrogeological aspects. Key ecological receptors were identified by the Ecological Specialist as described in Chapter 7 Biodiversity of this EIAR.

Ecological receptors were reviewed and those found to be sensitive to changes to hydrological and hydrogeological regimes are summarised in Table 9.12 below.

Table 9.12: Ecological Receptors Of Interest (Refer To Chapter 7 - Biodiversity For Further Details)

No.	Location/Name	Chainage	Main Habitat(s)	Conservation Rating
KERs 1a(N) & 1b(C)	Turlaghnamaddy	4+000 – 4+500	Wet Grasslands with encroaching scrub (Molina Meadows)	National
			Potential Marsh Fritillary Habitat	County

No.	Location/Name	Chainage	Main Habitat(s)	Conservation Rating
KERs 2a(LH) & 2b(N)	Frenchpark	5+000 – 5+500	Cutover bog Raised Bog	Local Higher National
KER 4(C)	Leggatinty	10+750 – 10+850	Wet Grasslands with encroaching scrub (Molina Meadows)	County
KER 5(N)	Leggatinty	11+750 – 11+850	Wet Grasslands with encroaching scrub (Molina Meadows)	National
KERs 6a(N), 6bN), 6b(C), 6b(LH), 6c(N), 6c(LH), 6c(LL)	Leggatinty/ Derreen	10+900 – 12+350	Raised & Cutover bog Cutover bog recolonised with wet grassland and scrub	National & County Local
KERs 15a(LH), 15b(LL), 15c(N), 15d(C), 15e(C)	Tullyloyd	33+350 – 35+750	Alkaline Fen Wet Grassland Annex I Alkaline Fen Transition mire and rich fen habitat	Local Higher Local Lower National County
KER 16(N)	Cregga	36+650 – 37+950	Turlough and associated groundwater dependent habitats (Annex I Habitat)	National
KER17 (LH)	Cloonradoon	50+850 – 51+800	Raised & Cutover bog	Local Higher

9.3.8 Hydrochemical and Groundwater Table Data

In order to quantify the existing environment and establish existing baseline groundwater quality, an assessment of existing groundwater quality has been made utilising all available information.

9.3.8.1 Preliminary Water Quality Testing

A water sampling programme has been undertaken as part of the EIAR preparation in order to establish baseline quality in the underling aquifers. A number of piezometers and standpipes were installed in boreholes which were drilled as part of preliminary ground investigations – **refer to Chapter 8 for details**. Six of these locations were sampled on a bi-monthly basis for a suite of water quality parameters. In addition water quality sampling has also taken place at Cregga Turlough (GW5) which is an area of groundwater/surface-water interaction. Results of the water quality testing are given in Table 9.13 below. The locations of these water quality sampling points are given in **Figures 10.2 – 10.6 in EIAR Volume 3**.

Table 9.13: Summary* of Hydrochemistry and Water Quality at Groundwater Sampling Locations

Location	pH	Total N mg/l	No2-N mg/l	No3-N mg/l	Total P µg/l	MRP µg/l	Total Coliforms (cfu/100ml)	Faecal Coliforms (cfu/100ml)	Mg (mg/l)
GW1	6.6	11.9	<0.005	<0.1	1.61	0.016	22.5	23	36.5

Location	pH	Total N mg/l	No2-N mg/l	No3-N mg/l	Total P µg/l	MRP µg/l	Total Coliforms (cfu/100ml)	Faecal Coliforms (cfu/100ml)	Mg (mg/l)
GW2	6.85	1.13	<0.005	0.923	0.06	0.032	165	80	<5
GW3	7.1	<0.5	<0.005	0.288	0.07	0.014	10000	1000	<5
GW4	7	<0.5	<0.005	0.186	0.68	0.013	1250	<100	6
GW5 (Cregga Turlough)	7.5	0.90	<0.005	0.515	<0.05	0.028	160	36	36
GW6	7.4	1.11	<0.005	<0.1	0.39	0.093	2000	200	12

*Mean values quoted

9.3.8.2 Regional Water Supply Schemes

No water chemistry data were available for raw water quality at the abstraction point for the North Roscommon Water Supply. A high level of treatment occurs prior to distribution with water quality monitored on a daily basis.

9.3.8.3 Groundwater Supply Schemes (GWS's)

Peak Mantua GWS

The water supply at Peak Mantua is reported as being 'flashy' and highly responsive to rainfall. This is due to the karst nature of the underlying bedrock with rapid entry of rainfall to groundwater through karst features such as dolines and swallow holes and the subsequent fast time of travel through fractures and fissures in the bedrock possible. Quality data of both treated and untreated water have been collected over an extended period and a summary of hydrochemistry and water quality data is given in Table 9.14 below. Generally values are within both the Drinking Water Limit (DWL) and Threshold Values (TV). The water is 'hard' with a reported calcium carbonate concentration of 354 mg/l. The 'hard' nature of the water is caused by the dissolution of calcium carbonate when the water passes through the limestone bedrock. Microbial contamination was found to be present in both the untreated and the treated water historically. In addition Clostridium perfringens and Cryptosporidium have been present historically (prior to UV treatment being incorporated) in the treated water suggesting agricultural pollution sources. Individual elevated levels of ammonium, aluminium and iron may be associated with the peat which is present in the vicinity of the spring. The presence of microbial contamination and the high variation in other water quality parameters highlights the vulnerability of this water supply to contamination. The karst nature of the surrounding bedrock aquifer which allows rapid recharge through karst features is the most likely pathway for contaminants entering this water supply.

Table 9.14: Summary of Hydrochemistry and Water Quality from the Treated Water at the Peak Mantua GWS (Source: GSI)

Parameter	Average Value	Drinking water limit DWL) / Threshold Value (TV)
Conductivity (µS/cm)	585	1500
pH	7.5	-
Calcium Carbonate ($CaCO_3$) (mg/l)	354	-
Nitrate (NO_3-N) (mg/l)	4.5	50; 37.5
Ammonium (NH_4.N) (mg/l)	0.042	0.233, 0.175
Chloride (Cl) (mg/l)	15.8	250; 24

Parameter	Average Value	Drinking water limit DWL) / Threshold Value (TV)
Total Coliforms (MPN/100ml)	35 exceedances	0
Faecal Coliforms (MPN/100ml)	32 exceedances 17 exceedances (>100 counts)	0
Manganese (µg/l)	14	50 (DWL – indicator parameter)
Iron (µg/l)	51	200

Curracreigh GWS

Water quality at the Curragreigh GWS is highly variable. A rapid response to rainfall is reported which is likely related to karst features which allow direct and rapid entry of rainfall to groundwater and therefore heavy rainfall events strongly impact water quality. Water quality data were collected over an extended period and a summary of hydrochemistry and water quality data is given in Table 9.15 below. Generally values are within both the DWL and TV. The water is 'hard' with an average calcium carbonate concentration of 338 mg/l and this is due to the underlying limestone bedrock through which the water flows. A historic presence of total and faecal coliforms is reported in untreated (raw) water results, however no coliforms were found in the most recent raw water sampling undertaken in 2014. Between 2002 and 2012, total/faecal coliforms were present in treated water samples in 3 of 43 samples. Clostridium perfringens were reported in the treated water on five occasions most recently in 2010. Elevated phosphate concentrations were also reported historically. The presence of microbial contamination and elevated levels of other water quality parameters highlights the vulnerability of this supply. Direct recharge through karst features is the most likely pathway for contaminants entering this water supply.

Table 9.15: Summary of Hydrochemistry and Water Quality from the Treated Water at the Curracreigh GWS (Source: GSI)

Parameter	Average Value	Drinking Water Limit DWL) / Threshold Value (TV)
Conductivity (µS/cm)	572	1500
pH	7	-
Calcium Carbonate ($CaCO_3$) (mg/l)	338	-
Nitrate (NO_3-N) (mg/l)	7.5	50; 37.5
Ammonium (NH_4-N) (mg/l)	0.026	0.233, 0.175
Chloride (Cl) (mg/l)	13.1	250; 24
Total Coliforms (MPN/100ml)	17 exceedances (<100 counts) 12 exceedances (>100 counts)	0
Faecal Coliforms (MPN/100ml)	19 exceedances (<100 counts) 10 exceedances (>100 counts)	0
Manganese (µg/l)	14	50 (DWL – indicator parameter)
Iron (µg/l)	72	200

Polecat GWS

Water quality at the Polecat GWS shows a frequent presence of microbial contamination and exhibits water quality deterioration after heavy rainfall events. This indicates an impact from human and/or animal waste as well as being a reflection of rapid subsurface karst groundwater flow pathways. Direct recharge through karst features is the most likely pathway for contaminants entering this water supply. The water supply is reported as being moderately "hard" with recorded values for electrical conductivity and turbidity values indicating a flashy catchment which responds quickly to rainfall events. A summary of historical Hydrochemistry and water quality results at the Polecat GWS are shown given in Table 9.16 below.

Table 9.16: Summary of Hydrochemistry and Water Quality from the Treated Water at the Curracreigh GWS (Source: GSI)

Parameter	Average Value	Drinking Water Limit DWL) / Threshold Value (TV)
Conductivity (µS/cm)	520	1500
Manganese (µg/l)	26	50 (DWL – indicator parameter)
Iron (µg/l)	145	200
Nitrate (NO_3-N) (mg/l)	4.1	50; 37.5
Ammonium (NH_{4-}N) (mg/l)	0.016	0.233, 0.175
Chloride (Cl) (mg/l)	15.8	250; 24
Total Coliforms (MPN/100ml)	53 exceedances	0
Faecal Coliforms (MPN/100ml)	48 exceedances 12 exceedances (>100 counts)	0
Clostridium perfringens (MPN/100ml)	5 exceedances	0

9.3.9 Site Investigations and Groundwater Levels

A preliminary geotechnical drilling programme was carried out by IGSL along the proposed road alignment. This included the drilling of cable percussion and rotary core boreholes. Cable percussion boreholes which encountered groundwater during drilling were left for a period of time up to 20 minutes after the water strike, to obtain an approximate representative groundwater table measurement. The level of groundwater was recorded in rotary core boreholes 5 minutes after completion. (Tables 9.17 & 9.18).

Table 9.17: Groundwater Strikes Encountered During Cable Percussion Drilling by IGSL Ltd.

Borehole Location	Water Strike (mBGL)	Water Level After 20 Min (mBGL)
BH401A	1.7	-
BH405	2.8	1.9
BH421	6.4	1.4
BH422	3.6	2.4
BH423	2.6	1.9
BH424	1.2	1.2
BH425B	2.5	1.9

Borehole Location	Water Strike (mBGL)	Water Level After 20 Min (mBGL)
BH434A	2.1	1.1
BH434B	2.1	1.0
BH437	4.9	4.2
BH439	3.6	0.7
BH441	2.9	1.1
BH450	3.6	3.0
BH451	2.0	0.8
BH466	5.6	2.2
BH475	2.1	1.7
BH476	5.1	2.7
BH477	1.2	0.7
BH477.1	1.2	0.7
BH478	3.6	2.1
BH479	2.2	1.3
BH481	2.2	-

Table 9.18: Groundwater Strikes Encountered During Rotary Core Drilling by IGSL Ltd.

Borehole Location	Water Strike (mBGL)	Water Level After 5 Min (mBGL)
RC409	-	1.1
RC410	7.5	2.0
RC412	5.5 10.5	- -
RC414	10.5	-
RC417	3.0	-
RC418	-	1.4
RC419	-	1.2
RC420	-	3.9
RC420A	4.5	-
RC421	-	1.2
RC422	4.5	6.0
RC423	8.5	-
RC425	8.5	-
RC425B	9.0	-
RC428	11.9	-
RC429	3.0 7.0	- -
RC430B	-	7.2
RC431A	-	6.7

Borehole Location	Water Strike (mBGL)	Water Level After 5 Min (mBGL)
RC432	-	7.6
RC434	-	4.7
RC437	-	9.6
RC438	-	17.3
RC439	4.0	1.0
RC440	4.0	0.8
RC441A	3.2	1.0
RC442	-	4.6
RC444	-	10.0
RC450	4.0	-
RC452	-	5.0
RC476	0.0	-
RC480	9.2	-

In addition a ground investigation programme was undertaken by Priority Geotechnical in 2008 within the preferred route corridor. Details of these ground investigations are given in Table 9.19 below. Monitoring of water levels in these boreholes took place for some time initially (between 2009 and 2010), then recommenced in 2015 as part of this design effort; a summary of water levels is also given.

Table 9.19: Groundwater Strikes Encountered During Cable Percussion / Rotary Core Drilling by Priority Geotechnical (PGL) in 2008

Borehole Location	Water Strike (mBGL)	Water Level After 20 Min (mBGL)
BH09A	6.0	5.9
BH30	9.3	9.2
BH35	0.5	0.4
BH35A	0.5 2.8	0.4 2.65
BH45	6.0	5.8
BH48A	2.9 5.2	2.8 5.0
BH58	5.0	Artesian flow
BH60	4.0	0

It is noted that the groundwater levels given in the tables above are not necessarily representative of the final groundwater table depth, and that seasonal variations are likely.

A summary of water levels in the boreholes drilled as part of the current ground investigation programme are given in Table 9.20 below. Please refer to Figures 8.1 – 8.25 for details of the locations of all boreholes which are part of this current ground investigation programme.

Table 9.20: Monitored Groundwater Levels (mBGL) (*Refer to Figures 8.1 – 8.24 of EIAR Volume 3 for Borehole Locations*)

BH No.	06/01/15	20/01/15	27/08/15	10/09/15	23/09/15	07/10/15	15/10/15	23/10/15	04/11/15	17/11/15	20/11/15	11/12/15	21/12/16	18/02/16	14/03/16	19/04/16	13/05/16
402A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.25	3.25
409	0.25 A.G/L	0.15 A.G/L	0.175 A.G/L	GL	0.13 A.G/L	0.08 A.G/L	GL	0.02 A.G/L	0.10 A.G/L	GL	0.175 A.G/L	GL	-	GL	-	0.00	0.00
410	0.24 A.G/L	0.25 A.G/L	0.15 A.G/L	0.07 A.G/L	0.07 A.G/L	0.05 A.G/L	GL	G/L	0.20 A.G/L	GL	0.30 A.G/L	GL	-	0.00	-	0.10	0.10
412	2.70	2.74	2.93	3.03	2.98	3.05	3.13m	3.05	3.00	3.2m	2.96	3.2m	-	2.78m	-	3.0m	3.0m
413	5.48	5.56	5.90	6.02	5.94	5.97	6.10	5.99	5.94	8.85	5.79	5.10	4.55	4.35	5.20	6.08	6.10
419	1.40	1.74	3.50	3.92	3.69	4.56	4.80	4.96	2.53	0.20	1.31	0.00	2.10	3.45	3.50	4.70	4.80
420	-	-	-	-	-	-	-	-	-	-	-	2.60	2.50	2.90	3.00	Dry	0.00
421	-	-	-	-	-	-	0.70	-	-	0.30	-	0.00	0.00	0.30	0.56	0.70	0.70
421B	0.39	0.52	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
422	0.67	0.66	0.86	1.03	0.97	1.05	1.2m	1.15	0.91	0.4m	0.57	0.2m	0.20	0.20	0.70	1.1m	1.20
422B	0.23	0.28	0.43	0.45	0.42	0.46	-	0.52	0.40	-	0.29	-	-	-	-	-	-
423	-	-	-	-	-	-	0.60	-	-	0.30	-	0.00	0.00	0.00	0.20	0.65	0.60
425	Damaged	Damaged	0.55	0.77	0.74	1.02	1.10	1.20	Damaged	0.38	Damaged	0.00				0.90	1.10
425B	-	-	-	-	-	-	0.70	-	-	GL	-	0.00	0.00	0.10	0.45	0.65	0.70
428	0.90	1.08	0.55	0.74	0.59	0.78	0.90	1.13	0.87	0.66	0.62	0.23	0.30	0.10	0.95	2.17	0.90
428A	7.60	7.50	6.50	6.57	6.57	6.57	6.65	6.58	6.45	5.80	7.52	4.70	4.10	3.90	4.80	7.70	6.65
429	6.61	6.60	5.90	5.97	6.03	6.20	6.35	6.38	6.05	5.27	5.74	4.00	3.90	3.75	6.35	Dry	6.35
430	4.54	4.54	Dry	Dry	4.52	4.53	Dry	Dry	4.54	Dry	4.54	Dry	Dry	Dry	Dry	Dry	Dry
431	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry	Dry
432	5.53	5.55	5.57	5.62	5.63	5.81	6.00	5.80	5.67	5.30	5.50	4.80	4.30	4.80	4.95	5.60	6.00
435A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Dry	0.00
436	-	-	-	-	-	-	1.00	-	-	1.00	-	-	-	-	-	-	1.00
438	0.50	0.70	1.19	1.30	1.47	1.55	1.78	1.74	1.49	0.80	0.90	0.20	0.20	0.35	1.10	1.58	1.78
439	0.07	0.34	0.33	0.47	0.62	0.68	0.76	0.74	0.40	GL	0.05	GL	0.00	0.00	0.55	0.75	0.76
440	0.25 A.G/L	0.01	0.07	0.33	0.38	0.42	0.55	0.45	0.28	GL	0.15 A.G/L	GL	0.00	0.00	0.45	0.50	0.55

BH No.	06/01/15	20/01/15	27/08/15	10/09/15	23/09/15	07/10/15	15/10/15	23/10/15	04/11/15	17/11/15	20/11/15	11/12/15	21/12/16	18/02/16	14/03/16	19/04/16	13/05/16
441	0.30	0.33	0.39	0.41	0.44	0.49	0.63	0.65	0.40	0.10	0.34	0.00	0.00	0.25	0.33	0.75	0.63
442	0.20 A.G/L	0.14 A.G/L	0.05	0.09	0.16	0.12	0.90	0.09	0.05	0.30	0.13 A.G/L	0.00	0.10	0.15	0.26	0.40	0.90
444	0.95	2.73	4.72	5.12	5.50	5.71	6.00	6.00	4.20	0.90	2.45	0.70	0.54	0.90	3.68	5.70	6.00
449	0.30	0.40	2.64	4.55	4.99	6.13	6.60	6.20	4.20	0.40	2.30	0.23	0.18	2.11	3.67	7.00	6.60
450	0.29	0.46	2.56	3.83	3.83	3.83	Dry	3.83	1.75	0.40	0.85	0.19	0.30	0.76	2.78	3.67	Dry
451	-	-	-	-	-	-	1.20	-	-	0.20	-	0.00	0.22	1.10	0.95	1.00	1.20
452	-	-	4.27	5.40	5.52	5.66	5.85	5.86	4.75	3.25	3.80	2.80	2.25	2.10	3.67	4.80	5.85
453	15.65	15.65	12.05	12.07	15.67	15.67	Dry	15.67	15.67	Dry	15.65	Dry	Dry	Dry	Dry	Dry	Dry
459	19.58	19.58	19.55	19.60	19.60	19.63	Dry	19.55	19.55	Dry	19.60	Dry	Dry	Dry	Dry	Dry	Dry
459A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.50	0.00
460	14.90	14.90	14.91	14.92	14.87	14.93	Dry	14.90	14.90	Dry	14.90	Dry	Dry	Dry	Dry	Dry	Dry
461	-	-	-	-	-	-	Dry	-	-	Dry	-	Dry	Dry	Dry	Dry	Dry	-
471	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
476	-	-	-	-	-	-	0.30	-	-	GL	-	0.00	-	-	-	0.76	-
478	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.52	-
479A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.62	2.62	2.62
479B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.70	4.65	4.70
479C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.00	3.00	3.00
480	-	-	-	-	-	-	1.10	-	-	GL	-	-	-	-	-	-	-
480A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.38	-	3.54
480B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.60	-	3.80
80D	-	-	-	-	-	-	-	-	-	4.30	-	-	-	-	-	-	-
481	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.23
481A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.30
482	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.90
483	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.95
483A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.65
486A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.54

BH No.	06/01/15	20/01/15	27/08/15	10/09/15	23/09/15	07/10/15	15/10/15	23/10/15	04/11/15	17/11/15	20/11/15	11/12/15	21/12/16	18/02/16	14/03/16	19/04/16	13/05/16
489	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.20	4.50	5.30
490	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Dry
491	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.71
492	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.53
493	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Dry
494	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Dry
495	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Dry
496	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.76
497	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.70
498	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.14
499	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Dry	Dry	Dry
500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.72
501	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.10
502	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		1.10
503	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.45
504	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.20

Note: A.G/L = Meters Above Ground level. G/L = At Ground level. All other figures are meters below ground level.

9.4 Potential Impact Assessment

9.4.1 Methodology

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

This assessment of hydrogeological impacts for the proposed road development has been based on the analysis and interpretation of the data acquired during the Constraints Study and Route Corridor Selection phases, as well as site specific investigations undertaken as part of the Design, EIAR and NIS, including the ecological study, intrusive site investigation, agricultural survey and hydrogeological investigations. The procedure follows guidelines established by the TII/NRA in its 'Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes and the TII/NRA DN-DNG-03065 Road Drainage and the Water Environment'.

Key hydrogeological attributes that have been considered along the proposed road alignment include:

- High yielding springs and wells used for groundwater supply and their surrounding Source Protection Zones (SPZs);
- Low-yielding wells used mainly for domestic and farm water supply; and
- Any significant natural hydrogeological features (including large springs or groundwater dependent habitats);
- The dominant hydrogeological characteristics (aquifer classification) of the underlying strata;
- Sensitive karst features and groundwater systems.

The individual importance of these attributes has been then assessed with respect to their quality, extent / scale and rarity (Table 9.21).

Table 9.21: 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

For the purposes of this assessment and particularly with reference to the identified KERs and how their importance was rated from the ecological perspective (see Chapter 7), the following rating criteria were used in respect to the attribute values :

- Local Importance Lower value - Low
- Local Importance Higher value – Medium
- County/ Regionally Important – High
- National Importance – Very high

- European Importance – Extremely High

Impacts are categorised as one of 3 types:

- Direct Impact – where the existing hydrogeological environment along or in close proximity to the proposed road alignment is altered, in whole or in part, as a consequence of road construction and / or operation.
- Indirect Impact – where the hydrogeological environment beyond the proposed road corridor is altered by activities related to road construction and / or operation.
- No Predicted Impact – where the proposed road alignment has neither a negative nor a positive impact on the hydrogeological environment.

The EPA document 'Advice Notes on Current Practice (in the Preparation of Environmental Impact Statements)' further expands the type of the impact with respect to the following criteria:

- Cumulative Impact – where the combination of many minor impacts creates one, larger, more significant impact.
- Potential Impact – the impact of the proposed development before mitigation measures are fully established.
- Worst-case Impact – the impact of the proposed development should mitigation measures substantially fail to fulfil their intended function.
- Residual Impact – the final or designed impact which results after the proposed mitigation measures have fully established.

An appraisal on the duration of the impact can be made over the construction and operation phases of the road development:

- Temporary – construction-related and lasting less than one year
- Short-term – lasting 1 to 7 years
- Medium-term – lasting between 7 to 15 years
- Long-term – lasting 15 to 60 years
- Permanent – lasting over 60 years

The TII/NRA guidelines also define the impact significance level relative to the attribute importance (Table 9.22).

Table 9.22: Criteria for Rating Impact Significance

Impact Level	Attribute Importance				
	Extremely High	Very High	High	Medium	Low
Profound	Any permanent impact on attribute	Permanent impact on significant proportion of attribute			
Significant	Temporary impact on significant proportion of attribute	Permanent impact on small proportion of attribute	Permanent impact on significant proportion of attribute		

Impact Level	Attribute Importance				
	Extremely High	**Very High**	**High**	**Medium**	**Low**
Moderate	Temporary impact on small proportion of attribute	Temporary impact on significant proportion of attribute	Permanent impact on small proportion of attribute	Permanent impact on significant proportion of attribute	
Slight		Temporary impact on small proportion of attribute	Temporary impact on significant proportion of attribute	Permanent impact on small proportion of attribute	Permanent impact on significant proportion of attribute
Imperceptible			Temporary impact on small proportion of attribute	Temporary impact on significant proportion of attribute	Permanent impact on small proportion of attribute

The magnitude of impacts is defined in accordance with the criteria provided in the EPA publication 'Guidelines on the information to be contained in Environmental Impact Statements' (Table 9.23).

Table 9.23: Rating of Significant Environmental Impacts

Importance of Attribute	Magnitude of Impact			
	Negligible	**Small**	**Moderate**	**Large**
Extremely High	Imperceptible	Significant	Profound	Profound
Very High	Imperceptible	Significant / Moderate	Profound / Significant	Profound
High	Imperceptible	Moderate / Slight	Significant / Moderate	Severe /Significant
Medium	Imperceptible	Slight	Moderate	Significant
Low	Imperceptible	Imperceptible	Slight	Slight / Moderate

The TII/NRA criteria for rating impact significance have been used to assess actual and potential changes to hydrogeological criteria (Table 9.24).

Table 9.24: Estimation of Magnitude of Impact on Hydrogeology Attributes

Magnitude of Impact	Criteria	Typical Examples
Large Adverse	Results in loss of attribute and / or quality and integrity of attribute	• Removal of large proportion of aquifer • Changes to aquifer or unsaturated zone resulting in extensive change to existing water supply springs and wells, river baseflow or ecosystems • Potential high risk of pollution to groundwater from routine run-off • Calculated risk of serious pollution incident >2% annually

Magnitude of Impact	Criteria	Typical Examples
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	• Removal of moderate proportion of aquifer • Changes to aquifer or unsaturated zone resulting in moderate change to existing water supply springs and wells, river baseflow or ecosystems • Potential medium risk of pollution to groundwater from routine run-off • Calculated risk of serious pollution incident >1% annually
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	• Removal of small proportion of aquifer • Changes to aquifer or unsaturated zone resulting in minor change to water supply springs and wells, river baseflow or ecosystems • Potential low risk of pollution to groundwater from routine run-off • Calculated risk of serious pollution incident >0.5% annually
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	• Calculated risk of serious pollution incident <0.5% annually

As all proposed outfalls from the road drainage will discharge to surface water and sealed drainage is to be used in all sections of regionally important karst bedrock aquifer of high and extreme vulnerability, an assessment for the risk of serious spillage for individual outfall road sections and the entire road length has been included as part of the hydrological report chapter. This minimises the risk as this reduces the opportunity for road pollution to enter groundwater.

9.4.1.1 Cut Sections

Cut sections along a road section have the potential to impact the level of the groundwater table in the surrounding area as well as to cause a deterioration in aquifer water quality. The main impact targets will be water supply springs, wells and boreholes as well as any nearby groundwater dependent habitats and karst related features. Typically the impact increases:

- With increased depth of road cutting below groundwater table ;
- With increased permeability of the soil and / or bedrock strata between the road cutting and groundwater feature;
- With increased lateral continuity and uniformity in soil and / or bedrock strata between the road cutting and groundwater feature, and
- In the absence of any hydrogeological boundaries such as watercourses, between the road cutting and water supply well or groundwater feature.

Road cuttings will increase the vulnerability of the underlying aquifer to pollution through either a complete loss of overburden where cuttings are into the bedrock or by reducing the protective overburden depth and thus increasing the vulnerability for contaminated road drainage if not transmitted in a sealed drainage system to infiltrate to and potentially contaminate the groundwater. Deep cuttings can locally change the GSI risk classification for groundwater resources/aquifers.

A summary of the main cut sections along the proposed development together with the aquifer vulnerability is given in see Table 9.25.

Extensive road cuttings can if not mitigated significantly increase the runoff volume to be conveyed within the road drainage system and the volume to be ultimately discharged to receiving waters at road drainage outfalls. This can have an adverse effect on the receiving waters in terms of chemistry and water balance. Groundwater quality can be indirectly impacted if drainage systems are not adequately designed and maintained, to ensure conveyance of potentially contaminated surface run-off through these areas in sealed drains / channels where fissured/weathered bedrock is exposed and the aquifer is a regionally important karst bedrock aquifer.

Cut sections can impact potential groundwater recharge and cause dewatering of the intercepted aquifer. There is also the potential to intercept and truncate high yielding groundwater flows within the karst aquifer.

It is assumed that where deep cut sections are located along the proposed road alignment, there will always be a direct potential temporary impact to the quality of the underlying aquifer during the construction phase and until appropriate measures are in place to prevent infiltration of contaminated run-off and drainage waters. However in terms of the flow regime, there is the potential for a permanent impact on the underlying aquifer which will remain during the operational phase.

Cut sections will reduce the depth of subsoil from particular areas along the proposed road alignment. This will have a localised effect on the groundwater vulnerability rating, as the pathway for potential contaminants to migrate into the underlying aquifer is shortened. Areas where bedrock is at or close to surface will be particularly sensitive.

An assessment in relation to hydrogeological aspects at all significant proposed cut sections as outlined in 9.25 is given in Table 9.26.

Table 9.25: Significant Cut Sections Along Proposed Road Alignment

Chainage	Maximum Cut depth (m)	Depth to bedrock (mbgl)	Hydrogeological Comments
13+000 - 13+800	10.9	0 - 2.9	Extreme groundwater vulnerability; Locally Important Aquifer. Groundwater table likely to be intercepted.
18+800 – 20+600	6.6	1 – 5.9	High/Extreme groundwater vulnerability; Regionally Important Karstified Aquifer. Possible interception of groundwater at this location.
22+000 – 22+600	4.2	3.7 – 6.2	High to moderate groundwater vulnerability Regionally Important Aquifer. Unlikely to encounter groundwater at this location.
23+250 – 30+450	8.6	3.7 - 5.7	High to moderate groundwater vulnerability. Regionally Important Karstified aquifer. Groundwater not likely to be encountered at this location.
30+000 – 30+500	7.8	3 – 6	High groundwater vulnerability. Regionally Important Karstified aquifer. This cut may intercept groundwater.

Chainage	Maximum Cut depth (m)	Depth to bedrock (mbgl)	Hydrogeological Comments
32+100 – 33+100	13	0 – 5	Extreme groundwater vulnerability. Regionally Important Karstified aquifer. Groundwater not likely to be encountered at this location.
35+600 – 36+450	27	1 – 4.4	High to Extreme groundwater vulnerability with exposed rock in places. Regionally Important Karstified aquifer. This cut may intercept groundwater.
36+850 – 37+600	14.5	0 – 3	High to Extreme groundwater vulnerability with exposed rock in places. Regionally Important Karstified aquifer. This cut may intercept groundwater.
39+650 – 40+050	4.7	1 – 3.5	Extreme groundwater vulnerability with exposed rock in places. Regionally Important Karstified aquifer. This cut may intercept groundwater.
50+000 – 50+650	7	3.7	High groundwater vulnerability. Regionally Important karstified aquifer. Groundwater unlikely to be intercepted at this location.
52+450 – 52+700	5	3.8 – 7	High to Moderate groundwater vulnerability. Regionally Important Karstified aquifer. Groundwater unlikely to be intercepted at this location.

Table 9.26: Rating of Significant Environmental Impacts Caused by Cut Sections

Attribute		Impact		
Site Name	**Importance**	**Description**	**Magnitude of Impact**	**Impact Rating**
Locally Important Aquifer: Cut section 13+000 - 13+800	Medium	Potential interception of local groundwater table with maximum cut depths of up to 10.9m with Sandstone bedrock encountered at depths of approximately 4m. Potential contaminated road drainage entering the underlying aquifer.	Small Adverse	Slight
Regionally Important Karstified Aquifer: Cut section 18+800 – 20+600	High	Potential interception of local groundwater table and limestone bedrock with cut depths of up to 6.6m and known karst Swallow hole features in the area and in close proximity to the road. Potential contaminated road drainage entering the underlying karst conduit flow aquifer.	Small Adverse	Slight / Moderate
Regionally Important Karstified Aquifer: Cut section 22+000 – 22+600	High	Cutting primarily located within the overburden with maximum cut depth of 4.2m and unlikely to intercept the groundwater table.	Small Adverse	Slight

Attribute		Impact		
Site Name	**Importance**	**Description**	**Magnitude of Impact**	**Impact Rating**
Regionally Important Karstified Aquifer: Cut section 23+250 – 30+450	High	Potential interception of local groundwater table and limestone bedrock with cut depths of up to 8.6m and discharges to Mantua Stream and local unnamed streams to the north and south. (cutting into bedrock)	Small Adverse	Slight / Moderate
Regionally Important Karstified Aquifer: Cut section 30+000 – 30+500	High	Potential interception of local groundwater table with maximum cut depths of up to 7.8m with bedrock encountered at depths of approximately 6m. Potential contaminated road drainage entering the underlying aquifer.	Small Adverse	Slight
Regionally Important Karstified Aquifer: Cut section 32+100 – 33+100	High	Potential interception of local groundwater table with cut depths of up to 13m with overburden a maximum of 6m over limestone bedrock. Potential contaminated road drainage entering the underlying karst conduit flow limestone aquifer.	Small Adverse	Slight / Moderate
Regionally Important Karstified Aquifer: Cut section 35+600 – 36+450	High	An extensive deep cutting with maximum cut depth of 27m into hill slope at Cregga with cutting into bedrock. No groundwater encountered but cutting will intercept interflow, deeper percolation flow and overland runoff from the steep hillslope.	Moderate Adverse	Moderate
Regionally Important Karstified Aquifer: Cut section 36+850 – 37+600	High	A major cutting that runs north around Cregga Turlough and south of the Laragan Quarry with a maximum cut depth of 14.5m. The permanent groundwater table is unlikely to be encountered but cutting will intercept interflow, deeper percolation flow and overland runoff from the steep hillslope that would otherwise enter the nearby Cregga Turlough. Potential for contaminated runoff from road and drainage system entering Cregga Turlough.	Moderate Adverse	Moderate
Regionally Important Karstified Aquifer: Cut section 39+650 – 40+050	High	This cutting has a maximum cut depth of 4.7m and bedrock or the permanent groundwater table unlikely to be encountered.	Small Adverse	Slight
Regionally Important Karstified Aquifer: Cut section 50+000 – 50+650	High	This cutting has a maximum cut depth of 7m but is unlikely to encounter the limestone bedrock which is at depth. It is unlikely that the water table will be encountered. Dewatering from the cutting unlikely to be significant.	Small Adverse	Slight

Attribute		Impact		
Site Name	**Importance**	**Description**	**Magnitude of Impact**	**Impact Rating**
Regionally Important Karstified Aquifer: Cut section 52+450 – 52+700	High	This cutting has a maximum cut depth of 5m and is unlikely to encounter the limestone bedrock which is at depth but unlikely to encounter the water table. Dewatering from the cutting unlikely to be significant.	Small Adverse	Slight

9.4.1.2 Embankment Sections

Road embankment sections are required along the route and range from 1m up to 12.3m in height – refer to Table 9.27 for details. In areas of soft ground the soft material must be excavated to depth and replaced by suitable bearing material before the embankment is constructed. Such construction can produce a drainage effect whereby the road formation acts as a wide and potentially deep longitudinal linear drain capable of intercepting, dewatering and conveying flow along the alignment.

Table 9.27: Rating Of Significant Environmental Impacts Caused By Embankment Sections

Chainage (m)	Location	Maximum Height (m)	Underlying Soil
10+000 – 10+700	Corskeagh, Mullen & Leggatinty	3.1	Peat, Silt & Glacial Till
12+150 – 12+900	Leggatinty, Derreen & Cashel	3.7	Glacial Till, Sandstone bedrock
13+800 – 15+700	Ballaghcullia to Peak	6.4	Peat, Glacial Till, overlying limestone bedrock
21+200 – 21+850	Cartronagor	3.6	Glacial Till
22+750 – 23+150	Creeve	4.0	Glacial Till
30+600 – 32+000	Killeen West & Lurgan	6.5	Peat, silt, glacial till, limestone bedrock
34+500 – 35+075	Tullyloyd & Tullycarton	6.7	Peat, glacial till
34+500 – 35+075	Lugboy	9.2	Glacial till, limestone bedrock
36+475 – 36+875	Cregga & Cuilrevagh	12.3	Glacial till, limestone bedrock
37+675 – 38+150	Cuilrevagh & Tullen	11.8	Glacial till, limestone bedrock
40+150 – 40+500	Lavally	7.3	Glacial till, limestone bedrock
50+800 – 51+250	Vesnoy, Cloonradoon & Bumlin	7.8	Peat, Glacial till, limestone bedrock
52+800 – 53+400	Scramoge	9.0	Peat, Glacial till, limestone bedrock

Road embankments by their raised nature can obstruct and divert overland flows which may alter the recharge characteristics of an area.

The weight of road embankments may result in the compaction of the native subsoil material under the embankment which would result in the loss of porosity and permeability in the underlying subsoil which could restrict shallow subsurface groundwater flow. In karstified areas the weight of the embankment could potentially cause a collapse in the weathered limestone bedrock resulting in potential settlement and drainage issues and conduit flow systems associated with shallow weathered and / or karstified bedrock. Such impacts may have adverse effects on the functioning of nearby aquatic habitat wetland and fen systems through potential drainage effects of the road construction and the potential interception and interference of subsurface flows.

Whether the road is at grade or on embankment, areas of soft, compressible organic soils that are generally not suitable as road formation material will have to be removed and replaced by suitable road bearing fill material, that by its nature will be significantly more permeable. This has the potential for the road formation, depending on the vertical alignment and the local topography, to act as a large linear drain which could potentially dewater the surrounding overburden and intercept and divert the natural interflow, and groundwater flows. This drainage effect by the road formation on the surrounding overburden can have a significant adverse impact through potentially drying of nearby wetland habitats such as Blanket bog, wet heath and wet grassland including Molina Meadows. There are a number of locations, predominantly towards the west end of the road development where sensitive wetland habitats adjacent to the road are at risk of such impact from potential drainage effects by the permeable road formation layer. Further areas towards the east at Tullyloyd Fen and Cregga Turlough are also identified as vulnerable to such impacts in terms of the recharge to these features/habitats.

The hydrogeological impact of road embankments and at-grade sections as a result of excavation of soft material and replacement by more permeable bearing material or where local drainage channels are modified as a result of the road development (culverting, diversions and truncation of drains, provision of new drains and deepening/widening of existing drains) are generally imperceptible at the catchment and sub-catchment scale but at the local site drainage scale can represent moderate to significant changes in the drainage pattern. Such changes could have an impact on nearby sensitive terrestrial wetland habitats including raised Bog Peatlands (cutover, eroding and intact Blanket Bog) wet heath and wet grassland including Annex I Molina Meadows habitat and groundwater fed fen habitats.

9.4.1.3 Impact on Natural Heritage

<u>*European Designated Sites (SAC/SPA)*</u>

An assessment of the potential impact for European Designated Sites which were "screened in" during the Screening for Appropriate Assessment was carried out and is summarised in Table 9.28 below. None of the designated sites are assessed to be close enough to produce any perceptible groundwater regime changes from the proposed development and have therefore been assessed as having an impact rating of imperceptible.

Table 9.28: Rating of Significant Environmental Impacts Caused to European Designated Sites

Impact				
Site Name	**Importance**	**Description**	**Magnitude of Impact**	**Impact Rating**
Bellanagare Bog SAC (000592) SPA (004105)	Extremely Important	Sealed drainage systems and lined attenuation ponds are proposed in all areas adjacent to sensitive receptors which will prevent potential pollution or contamination of groundwater. Spill risk assessments have been carried out for each of the outfalls for road drainage and are detailed in Chapter 10.	Slight	Imperceptible
Annaghmore Lough (Roscommon) SAC (001626)	Extremely Important		Slight	Imperceptible
Cloonshanville Bog SAC (000614)	Extremely Important		Slight	Imperceptible
Lough Forbes Complex SAC (001818)	Extremely Important		Slight	Imperceptible
Lough Gara SPA (004048)	Extremely Important		Slight	Imperceptible
Callow Bog Callow SAC (000595)	Extremely Important		Slight	Imperceptible

The impacts rating to NHA's and Geological Heritage sites is considered to be slight to imperceptible with the exception of Pollnagran Cave located in the townland of Leggatinty. This Geological Heritage Site is discussed in more detail in Table 9.31 together with Hydrogeological Features.

9.4.1.4 Impact on Key Ecological Receptors

An assessment has been made of the potential impacts by the proposed road development on identified hydrologically sensitive ecological receptors. Given the interrelationship between hydrology and hydrogeology processes, this assessment is presented for combined hydrological and hydrogeological impacts, mitigation and residual impacts in the Hydrology Chapter 10 for each of the relevant KERs. This assessment includes the drainage impacts of the permeable formation layer on subsurface flows and the effect of road cuttings and outfalls on such receptors.

9.4.1.5 Road Drainage and Attenuation Ponds

Depending on the type of bedrock aquifer and its vulnerability to pollution (overburden cover and water table) there exists a potential for contamination of the underlying aquifer from contaminants in the routine drainage waters or as a result of spillage and road maintenance. Where the aquifer is classified as regionally important karst bedrock aquifer and of extreme vulnerability then this impact is classified as a potential moderate permanent impact. In order to protect a regionally important karst conduit flow aquifer system from pollution the proposed storm drainage system will collect and convey the road pavement runoff waters to road drainage outfalls that will ultimately discharge to surface waters.

There are no proposed road drainage outfalls that will discharge directly to groundwater. However in this predominantly karstic catchment the surface streams and groundwater systems are interlinked through losing and gaining reaches, swallow-hole and spring features located along channel banks and within the bed itself. There is evidence that many of the receiving streams in dry weather periods are potentially losing streams when the groundwater table retreats below the bed level of the stream channel and thus providing a gradient for streamflow to infiltrate through the channel bed and through swallow hole/spring features located along and within the river channel. One instance of a known indirect discharge to groundwater is proposed as part of the development. Outfall No. OUT34.01 discharges to a surface drain which then flows into the Ovaun Stream a short distance downstream. The Ovaun Stream is an OPW maintained channel and discharges to Clooncullaan Lough some 750m downstream of this surface drain. Approximately 260m downstream from where the surface drain joins the Ovaun Stream, there is a swallow hole feature located off the main channel on a spur in the townland of Tullyloyd – this area has been described previously in **Section 9.3.5**. A tracer study undertaken as part of this assessment, proved that this swallow hole feature discharges back into the Owenur River some 3km to the north-east at Creeve. Although the proposed road drainage outfall is to a surface water drain discharging to a surface water body, this swallow hole, some 770m downstream of the outfall, provides a pathway for road drainage to discharge to and potentially contaminate the groundwater aquifer. In this regard a groundwater risk assessment has been carried out in line with the EPA document "Guidance on the Authorisation of Discharges to Groundwater" (2011). The outcome of this risk assessment indicated that the discharge will have an imperceptible impact on groundwater quality.

9.4.1.6 Groundwater Protection Response (GPR)

A groundwater risk assessment has been carried out in line with the TII/NRA Document DN-DNG-03065 in relation to potential impacts on groundwater from the proposed road drainage system and specifically in relation to the use of permeable drainage systems. DN-DNG-03065 outlines the required methodology for carrying out such an assessment and the specific criteria involved.

Table A.4 of DN-DNG-03065 – Groundwater Protection Response Matrix for the use of permeable drains in road schemes is reproduced as Plate 9.15 below. A significant portion of the proposed development has a response of ***R4*** indicating that the use of permeable road drainage systems is ***Not Acceptable***. In this regard, where the proposed road development crosses areas of extreme (and high) aquifer vulnerability and where rock is at or close to the ground surface (i.e. all areas in which the overburden cover is less than 5m) a sealed drainage system will be provided so that infiltration to groundwater via the linear drainage system does not occur. This sealed system will also be used adjacent to sensitive ecological wetland areas – refer to Chapter 10 for further details. In less vulnerable areas where the overburden depth is greater than 5m (aquifer vulnerabilities of moderate and low) unlined drainage systems will be used which will allow some infiltration to groundwater depending on the permeability of the overburden. These areas will correspond to the groundwater protection response **R2(1), R2(2) and R2(3)**. The response **R2(1)** states that the use of permeable drainage systems is:

- ***Acceptable,*** provided that there is a consistent minimum thickness of 2m of unsaturated subsoil (due to the presence of karstified rock) beneath the invert level of the drainage system. It is also noted that particular attention must be paid to the presence of karst features and receptors (such as; public wells, group schemes, industrial water supply sources and springs).

In addition to response **R2(1)**, the response **R2(2)** states that the use of permeable drainage systems is:

- ***Acceptable***, provided that there is a consistent minimum thickness of 2m unsaturated subsoil beneath the invert level of the drainage system (where the subsoil is classed using BS5930 as; Sand, Gravel or Silt); or,

- ***Acceptable***, provided that there is a minimum consistent unsaturated thickness 1m of "appropriate material" beneath the invert level of the point of discharge.

In areas of Extreme vulnerability and karst bedrock aquifer setting, which is present along almost the entire development, response **R2(3)** states that the use of permeable drainage systems is:

- ***Acceptable,*** provided that the drainage system is located at least 15m away from karst features that indicate enhanced zones of high bedrock permeability (e.g. swallow holes and dolines).

It must be noted that whilst efforts have been made to avoid karst features where possible, this was not possible due to the difficult bedrock setting and route constraints. In particular a known karst feature (doline/collapsed feature) is located within the proposed road footprint at Ch.19+050. In order to construct the proposed road, it will be required to excavate this feature to bedrock and backfill it with free draining material. In this area the groundwater response is either **R2(3)** or **R4**, however a sealed drainage system is proposed at this location and therefore the requirements for a 15m offset given by response **R2(3)** do not occur.

Vulnerability rating	Source protection area	Resource protection area (aquifer category)							
		Regionally Important Aquifer			Locally Important Aquifer			Poor aquifer	
		Rk*	Rf	Rg	Lg	Lm	Ll	Pl	Pu
Extreme: Rock near Surface or karst (X)	R4	R4	R4	R3(2)	R3(2)	R3(1)	R3(1)	R3(1)	R3(1)
Extreme (E)	R4	R2 (3)	R2 (2)	R3(2)	R3(2)	R2 (2)	R2 (2)	R2 (1)	R2 (1)
High (H)	R3(2)	R2 (2)	R2 (2)	R2(2)	R2(2)	R2 (2)	R2 (2)	R2 (1)	R2 (1)
Moderate (M)	R3(1)	R2 (1)	R2 (1)			R2 (1)	R2 (1)	R1	R1
Low (L)	R3(1)	R1	R1			R1	R1	R1	R1

Plate 9.15: Groundwater Protection Response Matrix for the Use of Permeable Drains in Road Schemes (TII/NRA DN-DNG-03065)

A summary of the type of drainage systems proposed along the length of the proposed development and the associated Groundwater Protection Response is given in Table 9.29 below. It must be noted that at each outfall there is typically either one or two attenuation ponds, which will be lined to prevent infiltration, prior to outfall to the watercourse. In order to simplify this assessment, it is considered that for each network and outfall listed below, the pond will receive the same level of treatment as the road drainage system. In this regard if a sealed drainage system is proposed then the associated ponds will be lined with both an impermeable geomembrane and cohesive material to prevent infiltration. In areas where permeable drains are permitted, the attenuation ponds will be lined with cohesive material only.

Table 9.29: Summary of Proposed Locations of Sealed Drainage Systems Along The Proposed Development And Associated Groundwater Protection Response (Refer to Chapter 10 for Details of Drainage Outfall Sections)

Section	Outfall Network	Groundwater Protection Response	Combined Filter Drain	Drainage System Proposed
A	OUT1.01	R2(2)	Yes	Permeable
	OUT4.01	R2(2)	Yes	Sealed between Ch.4+000 to 4+250, otherwise permeable
	OUT5.01	R2(1)	Yes	Sealed between Ch.5+000 to 5+500 otherwise permeable
B	OUT10.01	R4 & R2(3)	No	Sealed drainage
	OUT12.01	R4 & R2(3)	No	Sealed drainage
	OUT14.01	R2(2)	Yes	Permeable*
	OUT14.02	R4	No	Sealed drainage
	OUT21.01	R4	No	Sealed drainage
	OUT21.02	R4	No	Sealed drainage
	OUT22.01	R2(2)	Yes	Permeable*
C	OUT30.01	R2(2)	Yes	Permeable
	OUT30.02	R2(2)	Yes	Sealed between Ch.30+750 to 31+850
	OUT24.01	R2(1)	Yes	Permeable
	OUT33.01	R2(2)	Yes	Permeable
	OUT33.02	R4	No	Sealed drainage
	OUT34.01	R2(2)	Yes	Permeable
D	OUT51.01	R2(2)	Yes	Permeable*
	OUT51.02	R2(3)	No	Sealed drainage
	OUT40.01	R4	No	Sealed drainage
	OUT40.02	R4	No	Sealed drainage
	OUT52.01	R2(2)	Yes	Permeable*
	OUT52.02	R2(3)	No	Sealed drainage
	OUT53.01	R2(2)	Yes	Permeable

** With the exception of where the road is on embankment > 1.5 as per the requirements of TII Standard DN-DNG-03022 Drainage Systems for National Roads*

The proposed drainage system will incorporate a range of appropriate pollution control features to limit the water quality impact to receiving waters. These include the use of filter drains, sealed drainage systems (as per Table 9.28) and the use of a vegetated sediment bay with a plan area of at least 10% of the total basin area for all attenuation ponds upstream of the drainage outfall – refer to TII/NRA DN-DNG-03022 standard for details. Further detention storage is provided within the storm attenuation pond system for settlement of suspended pollutants. The vegetated system will allow for the take up of nutrients in the drainage water. These treatment systems will be provided upstream of all proposed outfalls.

Attenuation ponds / wetland treatment areas that are located in hydrogeologically sensitive locations such as groundwater fed ecological receptors or where the groundwater vulnerability rating is Extreme have been assessed regarding their potential impact on the hydrogeological environment. The principal impact arises from poorly constructed ponds where contaminated water would be able to percolate / infiltrate downwards through the pond lining into the underlying aquifer, overspills during sustained heavy rainfall events, or where discharge outfalls into ecologically sensitive surface water features.

The proposed drainage system is designed based on the aquifer properties and its vulnerability reduces the impact level from Moderate Permanent Impact to a Slight Permanent Impact as potential for leakage in such sealed drainage system remains as does the potential for losing channel sections of streams and river receiving the road drainage discharge to discharge to groundwater. A number of the attenuation ponds are sited in areas considered to be of a sensitive hydrogeological nature (Table 9.30). The impacts presented below in Table 9.30 relate to potential impacts should the feature fail to achieve its designed purpose. These impacts are assessed for each of the proposed outfalls which are described further in Chapter 10 Hydrology.

Table 9.30: Rating of Significant Environmental Impacts Caused by Road Drainage and Attenuation Ponds

Attribute			Impact		
Outfall Ref.	**Importance**	**Vulnerability**	**Description**	**Magnitude of Impact**	**Impact Rating**
OUT1.01	High	Extreme/High	Long-term Infiltration of contaminants to the groundwater aquifer via unlined sections of the linear road drainage system and point sources via the unlined base of attenuation ponds, and potential impact from losing* sections of receiving streams and rivers.	Small adverse	Slight / Moderate
OUT4.01	High	Extreme/High		Small adverse	Slight / Moderate
OUT5.01	High	Extreme		Small adverse	Slight / Moderate
OUT10.01	High	Extreme		Small adverse	Slight / Moderate
OUT12.01	High	Extreme/High		Small adverse	Slight / Moderate
OUT14.01	High	Low		Negligible	Imperceptible
OUT14.02	High	Moderate/High		Small adverse	Slight / Moderate
OUT21.01	High	Moderate		Negligible	Imperceptible
OUT21.02	High	Moderate		Negligible	Imperceptible
OUT22.01	High	Moderate		Negligible	Imperceptible
OUT30.01	High	Extreme/High		Small adverse	Slight / Moderate
OUT30.02	High	Extreme		Small adverse	Slight / Moderate
OUT24.01	High	Extreme		Small adverse	Slight / Moderate
OUT33.01	High	High		Small adverse	Slight / Moderate
OUT33.02	High	High		Small adverse	Slight / Moderate
OUT34.01	High	Extreme		Small adverse	Slight / Moderate
OUT51.01	High	Extreme		Small adverse	Slight / Moderate
OUT51.02	High	Extreme		Small adverse	Slight / Moderate
OUT40.02	High	Extreme		Small adverse	Slight / Moderate
OUT40.01	High	Extreme		Small adverse	Slight / Moderate
OUT52.01	High	Extreme		Small adverse	Slight / Moderate
OUT52.02	High	Extreme		Small adverse	Slight / Moderate
OUT53.01	High	Moderate/High		Small adverse	Slight / Moderate

**A losing section of a river or stream is where a watercourse loses flow to groundwater through infiltration through its bed/banks as a linear sink or as a point sink such as a swallow hole features.*

9.4.1.7 Impact on Aquifer Characteristics

There will be a very limited impact on the nature of the underlying aquifers as the road will normally only cover a very small fraction of a groundwater body. The majority of the proposed road development is underlain by a Regionally Important Aquifer (89%) which has an attribute rating of High importance (County importance). The remainder is underlain by Locally Important Aquifers of medium importance (local high).

A generalised assessment has been made for each aquifer type along the proposed road alignment, based on potential characteristic changes caused by cut and fill sections (Table 9.31).

Table 9.31: Rating of Significant Environmental Impacts on Aquifer Characteristics

Attribute		Impact		
Site Name	**Importance**	**Description**	**Magnitude of Impact**	**Impact Rating**
Regionally Important Aquifer	High	Localised changes to groundwater levels in aquifer and / or overlying subsoil caused by dewatering at cut sections	Small Adverse	Slight
		Localised changes to down-gradient hydrochemistry in aquifer or overlying subsoil caused by routine surface runoff and spillages	Small Adverse	Slight / Moderate
		Localised changes to up-gradient groundwater levels and hydrochemistry caused by flow restriction	Small Adverse	Slight
Locally Important Aquifer	Medium	Localised changes to up-gradient groundwater levels and hydrochemistry caused by flow restriction	Small Adverse	Imperceptible
		Localised changes to groundwater levels in aquifer and / or overlying subsoil caused by dewatering at cut sections	Small Adverse	Imperceptible
		Localised changes to down-gradient hydrochemistry in aquifer or overlying subsoil caused by routine surface runoff and spillages	Small Adverse	Imperceptible

9.4.1.8 Impact on Hydrogeological Features

Karst swallow hole features located at Churchstreet/Portaghard, Leggatinty, Mantua and Lugboy provide direct connection of surface runoff to the underlying aquifer with no attenuating subsoil protection. In addition there is a Turlough located at Cregga which provides surface water/groundwater interaction as this Turlough feature seasonally fills and empties to the groundwater table. There are a number of other smaller karst collapse / swallow features along and adjacent to the route that potentially could provide a pathway for contaminated surface waters to enter virtually unattenuated and untreated into the groundwater system. Ratings of these hydrogeological receptors are given in Table 9.32. Ecological receptors of importance (KERs) are addressed comprehensively in Chapter 10 – Hydrology.

Table 9.32 Rating of Significant Environmental Impacts on Hydrogeological Features

Attribute		Impact		
Site Name	**Importance**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
Leggatinty swallow holes, Caves and karst features Ch 10+000 to 14+000	Locally High	**Construction**		
		Restriction and interception of subsurface flow resulting in reduction in groundwater flow and yield	The proposed road development is upstream of the Leggatinity cave and swallow-hole features and will intercept surface streams that discharge to these features. The stream flow will be maintained in these streams through culverting temporary works and diversions.	Negligible / Slight
		Damage to Feature by Construction Works.	The main potential damage of the road construction on these features is the potential blockage of these features by uncontrolled construction runoff sediments.	Negligible / Slight
		Potential for contaminated infiltration / discharge entering aquifer via karst feature from construction runoff and spillages.	Site runoff waters from the construction could potentially enter these features via overland flow and therefore there is a potential direct connection to the groundwater aquifer.	Moderate
		Operational		
		Direct encroachment of feature by road footprint	The proposed road alignment is located well upstream of these features in peatland areas outside the Leggatinty Karstified zone.	Negligible
		Contamination of feature by road drainage outfalls and by the drainage system – Routine runoff Accidental road spillage	There are no proposed road drainage outfalls discharging to this feature and the aquifer vulnerability along the road alignment in the contribution zone is typically moderate to low vulnerability.	Slight
		Impact of road alignment on recharge to or discharge from hydro feature	The proposed road development is upstream of the Leggatinty cave and swallow-hole features and will intercept surface streams that discharge to these features. In this area all contributing streams to the swallow holes will be maintained through culverting and sensitive drainage design and the road formation will be prevented from acting as a longitudinal drain	Slight

Attribute		Impact		
Site Name	**Importance**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
Peak-Mantua GWS Ch 15+850	High	**Construction**		
		Restriction and interception of subsurface flow resulting in reduction in groundwater flow and yield. Damage to Feature by Construction Works (collapse, infill etc.).	The proposed road and its construction site area is located to the north and outside of the mapped recharge zone for the spring which the GSI have shown to extend southwards of the spring and away from the road development. This is currently only draft mapping and has not been confirmed through dye tracing surveys and therefore extension of the recharge zone to the north where the road alignment traverses cannot be ruled out. The road is underlain by a Regionally Important bedrock aquifer with conduit flow and has been deemed low vulnerability at this location.	Slight to Moderate
		Potential contaminated infiltration / discharge entering aquifer via karst feature construction site works construction runoff and potential spillages.	In terms of construction impacts a reasonable buffer of some 150m is available between the potential site works and the source which is sufficient to minimise any potential construction impacts involving contaminated runoff water impacting the source and any potential well yield impacts arising from temporary dewatering of excavations and potential interference with groundwater flows.	Negligible / Slight
		Operational		
		Direct encroachment of feature by proposed road development	The road alignment passes within 150m to the North of the spring source at Ch 15+850. At this location the road alignment is at grade, to the west it is in embankment and to the east it is slightly in cut. The local road near the spring is to be realigned forming an underpass under the mainline which will involve locally deep excavation into the subsoils. There is no direct encroachment of the spring source.	Negligible
		Contamination of feature by road drainage outfalls and by the drainage system – Routine runoff Accidental road spillage	There are no proposed road drainage outfalls discharging to this feature and the aquifer vulnerability along the road alignment in the contribution zone is typically moderate to low vulnerability.	Slight
		Impact of road alignment on recharge to or discharge from hydro feature	The zone of contribution of the spring source is believed to extend southwards from the spring source based on a draft mapping by the GSI. The road alignment is located to the north of the spring placing it outside if the recharge zone. This zone of contribution has not been confirmed by the GSI with recent dye tracing of springs and swallow-holes inconclusive and therefore the potential for the road alignment to be located within the zone of contribution cannot be completely ruled out. However given the impermeable nature and generally deep depth of overburden (Low aquifer vulnerability) it is highly unlikely that a preferential flow path would be encountered that would significantly impact the yield and water quality of the spring source as a result of the road development.	Slight to Moderate

Attribute		Impact		
Site Name	**Importance**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
Polecat GWS Ch 17+750 – 32+750	High	**Construction**		
		Restriction and interception of subsurface flow resulting in reduction in groundwater flow and yield. Damage to Feature by Construction Works (collapse, infill etc.).	The proposed road and its construction site area is located inside the revised mapped recharge zone for the spring which the GSI have shown to extend some 10km west of Elphin. This area was not originally within the Polecat ZOC but was revised following tracer tests carried out as part of this assessment. The mapping revision which resulted in the extension of the recharge zone to include this area was solely due to a single known connection between Polloweneen Swallow Hole and therefore diffuse contributions across the entire revised ZOC are unlikely. The road is underlain by a Regionally Important bedrock aquifer with conduit flow at this location and is deemed of low vulnerability due to peat subsoil deposits.	Slight to Moderate
		Potential contaminated infiltration / discharge entering aquifer via karst feature construction site works construction runoff and potential spillages.	In terms of construction impacts a reasonable buffer of some 150m is available between the potential site works and the source which is sufficient to minimise any potential construction impacts involving contaminated runoff water impacting the source and any potential well yield impacts arising from temporary dewatering of excavations and potential interference with groundwater flows.	Negligible / Slight
		Operational		
		Direct encroachment of feature by proposed road development	The road alignment passes within 150m to the North of the spring source at Ch 15+850. At this location the road alignment is at grade, to the west it is in embankment and to the east it is slightly in cut. The local road near the spring is to be realigned forming an underpass under the mainline which will involve locally deep excavation into the subsoils. There is no direct encroachment of the spring source.	Negligible
		Contamination of feature by road drainage outfalls and by the drainage system – Routine runoff Accidental road spillage	There are no proposed road drainage outfalls discharging to this feature and the aquifer vulnerability along the road alignment in the contribution zone is typically moderate to low vulnerability.	Slight
		Impact of road alignment on recharge to or discharge from hydro feature	The road alignment is located within the mapped recharge zone due to a single known karst connection between Polloweneen Swallow Hole and the supply spring. It is proposed to redirect cut-off drains to the swallow hole which will maintain the recharge regime of the feature. Given the impermeable nature and depth of overburden (Low aquifer vulnerability) it is highly unlikely that a preferential flow path would be encountered that would significantly impact the yield and water quality of the spring source as a result of the road development.	Slight to Moderate

Attribute		Impact		
Site Name	**Importance**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
Kilvoy and Corry East swallow hole and karst features Ch 18+400 to 19+300	Locally High	**Construction**		
		Restriction and interception of subsurface flow resulting in reduction in groundwater flow and yield.	This section of the road alignment has a number of karst swallow-hole features running near and in close proximity to the road alignment. The bedrock in this area appears given the density of such features to be soluble and highly karstified. The largest feature, Polloweneen swallow-hole, is a sink to a small local stream. The proposed road passes to the south 25m upstream of this feature. Other swallow hole features are located in proximity to the proposed road footprint which drain local overland flow one of which is lost completely at Ch.19+050.	Moderate
		Damage to Feature by Construction Works (collapse, infill etc.).	The geotechnical investigations show considerable weathered bedrock zones along the proposed road development at this location. There is a potential for damage and collapse of these features that could give rise to potential flooding issues and to sink holes.	Slight/ Moderate
		Potential contaminated infiltration / discharge entering aquifer via karst feature construction site works construction runoff and potential spillages.	The construction activity will be reasonably proximate to these features which increases the risk for damage through infill, collapse and groundwater pollution from uncontrolled construction site runoff during construction activities. These swallow-holes represent point sources of pollution to the regionally important karst bedrock aquifer. Potential damage to the Polloweneen swallow hole could give rise to flooding as the feature drains a moderate size stream.	Moderate
		Operational		
		Direct encroachment of feature by road alignment	Local cut off drains from the north side of the road alignment will discharge to the Polloweneen swallow-hole feature. This swallow-hole feature shows evidence of surcharging at the feature during flood conditions. This represents a flood risk to the Road further to the east with a potential for flood waters to infiltrate and migrate in the formation layer eastwards to lower road levels. A drainage solution to mitigate this flood risk is required.	Moderate/ Significant
		Contamination of feature by road drainage outfalls and by the drainage system – Routine Runoff Accidental Spillage	There are no proposed road drainage outfalls discharging to these swallow hole features with the road pavement drainage being collected and conveyed in a sealed system eastward to outfall to a surface stream at Ch 21+150.	Slight
		Impact of road alignment on recharge to or discharge from hydro feature	The karstification at this location poses a threat to the road stability as it represents a risk of potential collapse from the development of sink-holes. As part of the design for identified karst zones beneath or close to the road development basal reinforcement will be required combined with a drainage layer to maintain existing drainage patterns.	Moderate

Attribute		Impact		
Site Name	**Importance**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
Tullyloyd (Ovaun Stream) Swallow hole feature Ch 34+400	Locally High	**Construction**		
		Restriction and interception of subsurface flow resulting in reduction in groundwater flow and yield.	This feature is located adjacent to a maintained arterial drainage channel that outfalls into the Clooncullaan Lough. The swallow hole feature has a spur channel that is connected to the Ovaun Stream. Site visits throughout the year have shown that flow in the Ovaun Stream outfalls both to Clooncullaan Lough and the swallow-hole feature with the proportionality varying significantly over the summer/winter season with water levels in the lake dictating flow conditions.	Negligible / Slight
		Damage to Feature by Construction Works (collapse, infill etc.).	This feature is located 150m down gradient of the road alignment which is at grade and in embankment to the east of this feature.	Slight
		Potential contaminated infiltration / discharge entering aquifer via karst feature construction site works construction runoff and potential spillages.	The construction activity will be reasonably proximate to this feature which increases the risk for damage from potential uncontrolled site runoff resulting in potential deposition of sediment in the bed of this feature and potential contamination (sediment laden runoff, water quality and construction spillages) of the connected groundwater aquifer. This swallow-holes represent a point sources of pollution to the Regionally important karst bedrock aquifer and may potentially be connected to springs further to the east, however dye tracer studies undertaken as part of this assessment showed this features is not connected to the Polecat Springs GWS.	Moderate
		Operational		
		Direct encroachment of feature by road alignment.	The proposed road alignment is located at grade and on embankment over 150m upgradient of the feature and therefore no direct encroachment of the feature will occur. This distance and proposed road vertical alignment provide ample buffer distance to minimise any potential for direct impact in respect to flow capacity.	Negligible / Slight
		Contamination of feature by road drainage outfalls and by the drainage system – Routine Runoff Accidental Spillage	There are no proposed road drainage outfalls discharging directly to this swallow-hole feature however the proposed road drainage will discharge to a small tributary drain that connects to the Ovaun Stream approximately 400m upstream of this feature. Dye tracing results show that a proportion of the Ovaun Stream Flow discharges to this feature with the remainder of flow discharging westwards to the Clooncullaan Lough. The proportional split varies considerably depending on seasonality. There is a potential for point source contamination of the regionally important karst aquifer system from the road drainage discharge via this feature both routine road drainage and potential road accident spillages.	Moderate
		Impact of road alignment on recharge to or discharge from hydro feature	The impact of the road drainage discharge on this feature in respect to flooding is shown to be negligible in respect to increased flood levels at this feature as result of the road drainage discharge to the Ovaun Stream.	Slight

Attribute		Impact		
Site Name	**Importance**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
Cregga Turlough Ch 36+650 to Ch 37+950	Locally High	**Construction**		
		Silts and sediments arising from construction works from the large road cutting (excavation, blasting etc.)	The proposed construction works involve significant deep bedrock cutting into the steep hill slopes above the Cregga Turlough Area. Given the terrain and the large excavation works involved, there is a high potential for sediment runoff or spillages from the works to enter the Turlough area which in the short term could impact the water chemistry of the Turlough and result in silt deposition within the Turlough area.	Slight to Moderate
		Spillages (hydrocarbons, cement etc.)	Spillages occurring during the works could potentially flow or percolate into the subsurface water flow and potentially enter Cregga Turlough polluting surface and groundwater.	Moderate
		Disturbance due to construction machinery and carrying out of temporary Works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).	The proposed road development does not encroach the Turlough extents (as defined by Roger Goodwillie & Associates – see Appendix 7.3) but will intercept its natural recharge waters via overland flow, interflow and deeper percolating flow which temporarily could impact the water balance of the Turlough	Moderate to Significant
		Operational		
		Road drainage and outfalls impacting on water Quality - Routine road runoff Accidental fuel spills	The road drainage will be a sealed system and will not discharge to the Cregga Turlough. This avoids potential water quality impacts from the routine road runoff waters and accidental road spillages.	Negligible
		Road drainage system – Outfalls, Culverts, interceptor drains, diversions and truncations affecting the water flow regime.	A loss of recharge water arising from direct rainfall on the road pavement area which will be piped to an outfall that discharges to the Ovaun Stream.	Moderate to Significant
		Interception of drainage paths by the permeable Road formation resulting in diversion of waters and in a dewatering effect on adjacent soils and wetland areas.	The deep cutting will intercept hill slope runoff, interflow and groundwater recharge and flow which will impact potentially on the flow regime, the water balance and the water chemistry of the Turlough. Such an impact is considered to represent a potential significant impact to the hydrological function of the Turlough Habitat.	Significant

9.4.1.9 Impact on Groundwater Resources

Three large group water schemes are located within the study area. The Curracreigh GWS scheme is located some 2.5km south of the proposed development. Following consultation with the GSI in relation to the proposed development and its potential impact on this supply, it has been determined that this supply will not be impacted as the ZOC is primarily to the west of the spring source.

The Peak-Mantua GWS scheme ZOC boundary is located close to the proposed development at Chainage 15+850 and is spring fed. There is a potential for an impact on the yield of this supply due to the construction of the road particularly in cut sections. Impacts on supply are unlikely however as the spring receives a consistent supply year round whilst other localised seepages and disappearing streams reduce significantly during summer months. This indicates a deeper groundwater supply is feeding the Peak-Mantua spring which would likely not be affected by the road construction which is proposed largely at grade in the area. The main area of concern would be an impact on water quality which could occur from silt and sediment runoff or from construction spillages entering the aquifer via karst features.

The proposed development is located within the revised Polecat GWS ZOC between Chainage 17+750 and 32+750 – refer to Figure 9.5 EIAR Volume 3. The Polecat GWS is spring fed and the ZOC boundary was revised in 2016 to include an area to the west of Elphin primarily due to this assessment proving a karst connection between a swallow hole at Polloween and the Polecat spring supply. There is potential for an impact on the yield of this supply due to the construction of the road due to intercepted overland flow. Impacts on supply are likely to be low as the swallow hole is fed primarily by local spring which will not be impacted by the proposed development and therefore the Polecat supply spring receives a consistent supply year round. Any intercepted and diverted overland flow would reduce significantly during summer months and therefore the potential impact is reduced. A survey of flow rates in the local stream discharging to the Polloween swallow hole indicates that when compared to the yield of the Polecat supply, it forms only a small proportion of the supply. In addition, cut-off drains in the areas will be redirected to this swallow hole to reduce the potential impact. Overall only a slight impact is expected on the supply to Polecat springs. The main area of concern would be an impact on water quality which could occur from silt and sediment runoff or from construction spillages entering the aquifer via karst features.

Small private groundwater sources impacted by the proposed road alignment are also of concern and those within 200m of the proposed development have also been summarised in Table 9.30 below. Beyond this distance the impacts of the proposed road development are unlikely to cause drawdown to a domestic supply. Properties with confirmed and reported private supplies that would either be potentially impacted by the proposed road development, would be of interest for ongoing water level and hydrochemistry monitoring during the proposed development, or are of interest regarding the nature of the underlying aquifer have been identified (Table 9.32). The proposed road development will result in the loss of two spring supplies which are used for agricultural purposes. Mitigation measures will also be required in a number of other locations where existing supplies are located close to the proposed development. The ratings of significant impacts on groundwater resources are given below in Table 9.33. The locations of these supplies are shown in **Figures 9.5 – 9.10; EIAR Volume 3**.

Table 9.33: Rating of Significant Environmental Impacts on Groundwater Resources (Refer to Figures 9.5 – 9.10, EIAR Volume 3 for Locations)

Attribute		Impact		
Site Name	**Importance**	**Nature of impact**	**Description of Impact**	**Impact Rating**
Peak-Mantua GWS Ch.15+800	High	Reduction in yield of water supply for GWS domestic usage.	The proposed road development is at grade in the vicinity of this supply however changes in the hydrogeological regime in the area may impact the yield in the spring supply. This is mainly related to deep cutting which have the potential to draw down groundwater levels locally. In addition overland flow which enters the aquifer through karst features may be redirected as part of the works impacting on the supply.	Moderate
		Contamination of water supply from road drainage entering aquifer via karst features.	The proposed road development is at grade in the vicinity of this supply however the development is located close to the ZOC and a number of karst features are located within a 3-4km radius. If these karst features are connected to the supply there is a potential for silt laden or contaminated road drainage to enter and contaminate the supply.	Significant
Polecat GWS Ch.17+750 - 32+750	High	Reduction in yield of water supply for GWS domestic usage.	The proposed road development is within the GWS ZOC, however this is mainly due to the karst connection between Polloween swallow hole and the supply springs. A potential impact would therefore relate to changes in the hydrogeological regime in the area which may impact the yield in the spring supply. This is related locally to a potential reduction in overland flow entering the Polloween swallow hole.	Moderate
		Contamination of water supply from road drainage entering aquifer via karst features.	The proposed road development is at grade in the vicinity of the Polloween swallow hole, however the development is located close to the karst feature with a number of other karst features located within a 3-4km radius. If these karst features are connected to the supply there is a potential for silt laden or contaminated road drainage to enter and contaminate the supply.	Significant
Curracreigh GWS	High	Reduction in yield of water supply for GWS domestic usage.	The proposed road development is located outside the ZOC for this supply. Tracer studies undertaken have shown the supply receives recharge from the south and the road is located to the north. There are no significant cuttings or otherwise which could potentially impact this supply.	Imperceptible

Attribute		Impact		
Site Name	**Importance**	**Nature of impact**	**Description of Impact**	**Impact Rating**
		Contamination of water supply from road drainage entering aquifer via karst features.	No karst features noted in the area which could be connected to this supply.	Imperceptible
Domestic well supply used for private supply to commercial premises	Medium	Loss of water supply for domestic usage	Located at Ch. 1+850 and c.85m from the mainline. Drawdown unlikely.	Slight/ Moderate
		Contamination of water supply from road drainage entering aquifer via karst features	No karst features noted in the area.	Negligible
Spring used for agricultural supply	Medium	Loss of water supply for domestic usage	Located at Ch. 1+850. Road development will result in the loss of this supply	Significant
		Contamination of water supply from road drainage entering aquifer via karst features	N/A	N/A
Domestic Well supply	Medium	Loss of water supply for domestic usage	Located at 13+550 and some 155m away from the mainline. This well is reported to be to a depth of 61m. The road is in cut of c.10.9m in the area. Drawdown unlikely at this distance.	Slight
		Contamination of water supply from road drainage entering aquifer via karst features	Well is located c.155m away from mainline.	Negligible
Domestic Well supply	Medium	Loss of water supply for domestic usage	Located at 13+550 and some 188m away from the mainline. This well is reported to be to a depth of 61m. The road is in cut of c.10.9m in the area. Drawdown unlikely at this distance.	Slight
		Contamination of water supply from road drainage entering aquifer via karst features	Well is located c.188m away from mainline.	Negligible
Domestic Well supply	Medium	Loss of water supply for domestic usage	Located at Ch.13+650 and c.50m away from the mainline. Supply depth reported to be 31m. The road is in cut of c.6.3m. Slight drawdown may occur.	Moderate
		Contamination of water supply from road drainage entering aquifer via karst features	No karst features noted in the area.	Slight.
Agricultural Well supply	Medium	Loss of water supply for domestic usage	Located at Ch. 30+350 and c.80m away from the mainline. Road is in cut of 4.6m. Drawdown unlikely.	Slight/ Moderate
		Contamination of water supply from road drainage entering aquifer via karst features	Supply unlikely to be connected to karst features located at Tullyloyd.	Negligible

Attribute		Impact		
Site Name	**Importance**	**Nature of impact**	**Description of Impact**	**Impact Rating**
Agricultural Well supply	Medium	Loss of water supply for domestic usage	Located at 32+900 and c.83m away from the mainline. The supply is reported to be up to a depth of 42m. The road is in cut of 16.3m at this location. Slight drawdown may occur.	Slight/ Moderate
		Contamination of water supply from road drainage entering aquifer via karst features	Supply unlikely to be connected to karst features located at Tullyloyd.	Negligible
Domestic Well supply to two residential homes and farmyard	Medium	Loss of water supply for domestic usage	Located at Ch. 33+800 and c.132m away from the mainline. Supply reported to be at a depth of 36m. The road is in fill at this location. Drawdown is unlikely.	Slight.
		Contamination of water supply from road drainage entering aquifer via karst features	Supply unlikely to be connected to karst features located at Tullyloyd.	Negligible
Domestic Well supply to two residential homes and farmyard	Medium	Loss of water supply for domestic usage	Located at 35+400 and c.125m away from the mainline. The supply is reported to be up to a depth of 35m. The road is in cut of 19m at this location. Drawdown or loss of supply may occur.	Slight/ Moderate
		Contamination of water supply from road drainage entering aquifer via karst features	Supply unlikely to be connected to karst features located at Tullyloyd.	Negligible
Reported spring agricultural supply	Medium	Loss of water supply for domestic usage	Located at Ch.38+050 this is a spring supply servicing agricultural lands. Road development would result in the loss of this supply.	Significant.
		Contamination of water supply from road drainage entering aquifer via karst features	N/A	N/A
Domestic Well supply	Medium	Loss of water supply for domestic usage	Located at Ch.52+700 and c.136m away from the mainline. Road is in slight cut of c1.5m. Drawdown unlikely.	Slight
		Contamination of water supply from road drainage entering aquifer via karst features	No karst features reported in this area.	Negligible
Domestic Well supply	Medium	Loss of water supply for domestic usage	Located at Ch.53+950 and c.125m away from the mainline. Road is at grade in the location. Drawdown unlikely.	Slight
		Contamination of water supply from road drainage entering aquifer via karst features	No karst features reported in this area.	Negligible

Attribute		Impact		
Site Name	**Importance**	**Nature of impact**	**Description of Impact**	**Impact Rating**
Polecat GWS located north-east of Elphin	High	Reduction in yield of water supply for GWS domestic usage.	Any change to the supply of water to Polloween swallow hole has the potential to reduce the yield marginally at this spring.	Moderate
		Contamination of water supply from road drainage entering aquifer via karst features.	Polloween swallow provides a direct connection between the cut-off drains associated with the road and this spring supply. Contamination from suspended solids could occur if sediment is washed into the swallow hole feature.	Moderate
Kiltrustan Public Water Supply	High	Loss of water supply for public usage	Borehole located in Kiltrustan uplands some 40m above the elevation of the road footprint but supply borehole extends to a depth of c.63m BGL. Road is at grade in this area and will have no impact on this supply.	Negligible
		Contamination of water supply from road drainage entering aquifer via karst features	A number of karst enclosed depressions located in the area but due to elevation difference between the road and the supply borehole are unlikely to be linked in the aquifer. Road drainage collected and routed away from karst features.	Negligible

9.5 Mitigation Measures

9.5.1 Overview of Mitigation Measures

Mitigation measures follow the principles of avoidance, reduction and remedy. Where avoidance has not been possible, then consideration has been given to trying to locally modify the proposed road alignment both vertically and horizontally to reduce / minimise the extent of the impact.

9.5.2 General Mitigation Measures

9.5.2.1 Operational Mitigation

The impact of road construction on aquifers and groundwater resources can be minimised by applying sound design principles and by following good work practices as outlined by the TII/NRA in its 'Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes (2008)'.

For groundwater the following were the main responses and guidelines considered during the development of the hydrogeological mitigation measures for the proposed road development:

- Where possible, re-align the road down-gradient or an appropriate distance up-gradient of the source protection area for high yielding water supply springs and wells and natural hydrogeological features;
- Where possible, minimise the depth of road cutting within a source protection area or zone of contribution to minimise the impact on groundwater flows to down gradient springs, wells, wetlands and other hydrogeological features;

- Where possible, minimise the depth of road cutting in order to ensure that its zone of contribution does not extend up gradient to a hydrogeological feature or wetland;
- Provide sealed drains along sections of road overlying the vulnerable parts of locally important or regionally important aquifers;
- Provide site-specific measures to protect relatively small natural hydrogeological features such as springs, seeps or wetlands;
- Assess the potential impact of re-grading small streams on nearby wells or springs;
- Ensure all surface water run-off discharged to groundwater via soakaways is passed through systems for settlement or filtration of suspended solids with the parallel effect of removing contaminants (certain heavy metals and hydrocarbons) associated with the suspended solids;
- Groundwater monitoring may be appropriate in certain instances, instead of automatically providing specific mitigation measures. In these circumstances however, thresholds should be set that will trigger the introduction of pre-defined mitigation measures;
- Specifying regular monitoring of groundwater during the construction period and for a defined period thereafter, following opening of the proposed development;
- All wells abandoned as part of the road development should be sealed and abandoned in accordance with "*Well Drilling Guidelines (2007)"* produced by the Institute of Geologists of Ireland (IGI). Ground investigation boreholes should be backfilled using bentonite or cement bentonite grout in accordance with the *Specification and Related Documentation for Ground Investigation (2006)* published by the Institution of Engineers of Ireland; and
- Abandon obsolete ground investigation boreholes / water supply wells and springs in accordance with the appropriate well drilling guidelines.

The above guidelines have been considered during the development of the design such that impacts have been minimised. Site specific mitigation measures for the unavoidable impacts are detailed in Section 9.5.3.

In formulating hydrogeological mitigation measures, regard was made to the requirements of the Water Framework Directive (Directive 2000/60/EC of the European Parliament, 2000) and Groundwater Directive (Directive 2006/118/EC of the European Parliament, 2006) and the enabling national legislation. In developing mitigation measures, there was co-ordinated and ongoing consultation with the River Basin Management Projects, the National Parks and Wildlife Service (NPWS), Local Authorities, Group Water Schemes and Environmental Protection Agency (EPA) as required.

The following mitigation will be incorporated in respect of groundwater supplies:

- All groundwater supplies currently in use that are within the footprint of the proposed road development will be replaced either through the provision of a private supply or by providing a connection to an existing public or group water scheme;
- All groundwater supplies currently in use that are up to 150m from the development boundary or 50m beyond the zone of influence of cuttings will be monitored (for water level and quality) immediately prior to the commencement of construction activities, during on a regular basis and for a time (typically

monthly for 12 months) after construction. Monitoring of any private supplies is subject to agreement by the relevant land/ property owner. Should it be concluded that any of these monitored private supplies be lost or contaminated as a result of the development, these shall be replaced either through the provision of a private supply or by providing a connection to an existing public or group water scheme.

9.5.2.2 Constructional Mitigation

During the construction phase any compound areas / service yards are to be located away from key hydrogeologically sensitive areas and features (Swallow holes, springs, turloughs, etc.) and these have been set out in the Construction Erosion and Sediment Control Plan (CESCP). Further details are also set out in Section 9.5.3 below. In terms of avoiding regionally important aquifers, this was not possible as it is the dominant aquifer type along the route and therefore best environmental practises have been set out in the CESCP to protect against potential pollution. To minimise the risk of pollution to the groundwater, any fuel storage, refuelling and maintenance of construction vehicles will be carried out in accordance with the procedure set out in the CESCP in order to manage any spillages.

Procedures are set out in Chapter 10 Hydrology and the CESCP which will require that any hydrocarbon leakages or spillages during construction will be dealt with immediately. These measures will absorb the bulk of the contaminant immediately with absorbent material, storing it and the contaminated soil in a stockpile underlain and covered by plastic to prevent leachate generation, until such times as it can be removed off-site by an appropriately licensed waste management company.

Where significant groundwater flows are encountered in deep bedrock cut sections, mitigation will be provided to ensure the continued flow of same where possible. The mitigation may involve either piping, construction of gravel filled pathways or short diversions such as the potential case at Cregga Turlough which is outlined in Chapter 10. The Contractor shall be made aware of any areas of potential karst features located at shallow depths, and site traffic in these areas kept to a minimum to reduce the potential compression and collapse of subsurface flow features.

Imported fill shall be in accordance with the requirements of the NRA/TII Specification for Road Works. Where water supply wells and springs are located underneath the proposed road development footprint, these will be sealed to prevent contaminants entering the aquifer (*Well Drilling Guidelines (IGI, 2007)*).

9.5.3 Site Specific Mitigation Required

9.5.3.1 Extreme Vulnerability Areas

<u>Construction</u>

Prior to the commencement of construction works, clean runoff water from lands adjacent to and up gradient of the works area will be diverted to local watercourses through the installation of cut-off ditches. Soiled construction runoff water will undergo treatment before discharge by being passed through a settlement pond (either temporary or permanent pond system). The treated water may be discharged to a surface water body, but depending on drainage features may also discharge to ground (i.e. Mantua, Cregga Turlough) so as to maintain the existing recharge conditions. Further details on the protection of groundwater from pollution during construction are given in the CESCP.

Operational

Throughout the proposed road development in areas of extreme and high vulnerability and near sensitive ecological receptors, a sealed drainage system will be used – see Table 9.28 for details. This avoids potential for infiltration to groundwater as a linear source and this approach is in accordance with best practise. However, some watercourses in this karst bedrock area have naturally losing sections of channel which can discharge to groundwater. This has the potential to provide a pathway for road runoff to enter the groundwater system. Wetland systems will be provided at all outfalls to protect both surface and groundwater from any adverse quality and/or quantity impacts of the road drainage discharge.

9.5.3.2 Hydrogeological Features

Each of the hydrogeological features identified that are potentially at risk due to the proposed development were assessed based on the potential magnitude of the impact in Table 9.35. Where an impact rating was deemed to be slight or negligible it is considered that the adherence to good construction practices can adequately mitigate the level of risk involved and no additionally specific mitigation is required. Each of the features which were found to have an impact rating greater than slight have been considered to require some form of mitigation to reduce the magnitude of the risk posed. Table 9.35 gives details of the specific mitigation measures proposed at each hydrogeological feature. These mitigation measures are further detailed below.

Wetland and Ecologically Sensitive Areas – General Mitigation Measures

Construction

The adherence to best practise construction methods shall ensure that dewatering does not occur to these sensitive areas. In addition the practices set out in the CESCP will ensure that soiled constructional runoff waters do not enter these areas.

Operational

All wetland and ecologically sensitive features (i.e. Tullyloyd Fen) that are traversed or are in close proximity to the proposed road development will incorporate sealed drainage systems to minimise or reduce the potential for contamination – see Table 9.28 for details. The use of over the edge embankment drainage and toe drains shall not be permitted in these sensitive areas as they have the potential to either drain or introduce additional surface and groundwater flows to these features. The use of french drains to convey road runoff is not to be permitted in these areas as they provide a potential pathway for road runoff contaminants to enter the bedrock aquifer. Refer to Chapter 10 – Hydrology for further details of the drainage systems proposed along the proposed development.

Deep Cut Sections

Construction

At deep cut sections such as Killeen East (32+100 to 33+100) and Cregga Hill (35+600 to 37+600) the adherence to best practise construction methods shall ensure that the correct management of surface water runoff occurs. Detailed construction mitigation measures are proposed to ensure overland and interflow are kept separate and no pollution occurs in the Turlough and associated groundwater body – refer to the CESCP for details.

Operational

A separate filter drain / cut-off channel will be provided to collect and drain intercepted groundwater and interflow to nearby watercourses (Ovaun River and/or Cregga Turlough) separate from road drainage.

Karst Features at Leggatinty

The swallow-hole, enclosed depressions and associated karstified bedrock located at Leggatinty are required to be protected from contamination by surface water runoff. To achieve this, the alignment has been routed away from these karst features and the road drainage will not be discharged to such features.

Construction

A double silt fence will be constructed along the site boundary so as to intercept and minimise the potential direct runoff from the works area to the adjacent swallow holes and watercourses. No untreated temporary discharge from the construction runoff will be permitted to the swallow holes at this location. However suitably treated discharge can be permitted provided it is passed through a temporary sedimentation pond for removal of sediment. Further details are presented in the CESCP.

Operational

Stormwater drainage from the proposed road will be collected and conveyed away from the area through a sealed drainage system. No road drainage will therefore be discharged to a karst feature.

Blanket Bogs, Wet Grassland Areas (Molina Meadows) (KERs 1a/b, 2a/b, 4, 5, 6a-c & 7a/b)

Detailed mitigation measures proposed for each of the KER' is given in Chapter 10 Hydrology and therefore only a summary is provided here.

Construction

A double silt fence will be constructed along the site boundary so as to intercept and minimise the potential direct runoff from the works area to the adjacent wetland areas. No untreated temporary discharge from the construction runoff will be permitted to discharge to watercourses. Further details are provided in the CESCP.

Operational

In respect to these wetlands systems (blanket bog and areas of Molina meadows) the road drainage has been designed to achieve a drainage neutral effect on these sensitive habitats. This is achieved by where possible, preserving existing drainage paths, the inclusion of shallow drains with check dams to retain high water levels, culverting watercourses appropriately and, to prevent drainage effects of the road formation, the provision of impervious subsurface liners either in a transverse or longitudinal configuration – see **Figure 4.39 and Figures 9.5 – 9.10 EIAR Volume 3** for details. In areas of bog, a longitudinal impermeable geotextile barrier will be installed along the edge of the road formation face to prevent /block the draining of the peat. In addition, stormwater drainage from the proposed road will be collected and conveyed away from the bog through a sealed drainage system. In wetland areas (such as the Molina meadows), a transverse impermeable barrier is provided at intervals to prevent the road formation draining adjacent wetland areas. The use of over the edge embankment drainage shall not be permitted as they have the potential to introduce additional surface and groundwater flows to these areas. Where toe-drains are proposed in these areas, the will be shallow in depth and will incorporate check-dams at regular intervals so as to maintain and contain surface water in these wetland areas. Refer to Figures 9.5 – 9.10 for locations of longitudinal and transverse barriers proposed along the alignment.

Fen Wetland at Tullyloyd

Construction

The fen at Tullyloyd is required to be protected from contamination by surface water runoff and dewatering. The fen is at risk during construction phase when site traffic, and spillages could cause a significant degradation in the Annex I habitat. A double silt fence will be constructed along the site boundary so as to intercept and minimise the potential direct runoff from the works area to the adjacent wetland areas. No untreated temporary discharge from the construction runoff will be permitted to discharge to watercourses. Further details are provided in the CESCP.

Given that a portion of road runoff will ultimately be discharging (770m downstream of the outfall) to groundwater, a groundwater risk assessment has been carried out in line with the EPA document "Guidance on the Authorisation of Discharges to Groundwater" (2011). The outcome of this risk assessment indicated that the discharge will have an imperceptible impact on groundwater quality.

Operational

Between Ch. 33+400 and Ch. 34+000 a drainage blanket will be provided to allow flow to pass beneath the road formation so as not to affect the existing seepages present within the Fen. Transverse barriers will also be provided within the road formation every 100m to block drainage away from the area in the permeable road formation layer. Refer to Figures 9.5 – 9.10 for locations of longitudinal and transverse barriers proposed along the alignment. Existing transverse flow paths/ditches will be maintained so as not to interfere with the existing water balance of this area. In addition shallow toe drains with check dams will be provided in this area to maintain wet conditions. A sealed road drainage system is proposed in this area which will be attenuated and treated in ponds which will reduce the risk of contamination and pollution of the fen wetland. A two stage treatment pond for road runoff is proposed at Ch. 34+850 to ensure a high quality discharge to the receiving watercourse.

Swallow Hole and Karst Features at Kilvoy and Corry East

The swallow hole and karst features at Mantua are required to be protected from contamination by surface water runoff particularly during construction. This area is highly karstified and vulnerable to pollution and future potential collapse making geological conditions difficult for road construction.

Construction

A double silt fence will be constructed along the site boundary so as to intercept and minimise the potential direct runoff from the works area to the adjacent swallow holes and watercourses. No untreated temporary discharge from the construction runoff will be permitted to the swallow holes at this location. However suitably treated discharge can be permitted provided it is passed through a temporary sedimentation pond for removal of sediment. Further details are presented in the CESCP.

Operational

Existing and intercepted overland and interflow from the cut-off ditches will be directed to the swallow hole to maintain existing recharge. Cut-off drains on the southern side of the alignment between Ch.18+500 and Ch.19+100 discharge via a drainage pipe at Ch. 18+500 beneath the carriageway to the swallow hole. Stormwater drainage from the proposed road will be collected and conveyed away from the area through a sealed drainage system. Transverse barriers will also be provided within the road formation every 100m between Ch. 18+800 and 19+300 to block drainage away from the area in the permeable road formation layer. This will mitigate the risk of flooding in the cutting to the east during an extreme rainfall event. Refer to Figures 9.5 – 9.10 for locations of longitudinal and transverse barriers proposed along the alignment.

Cregga Turlough

Construction

The Turlough located at Cregga will be protected, in particular during the construction phase when it will be most at risk from site traffic, and spillages of hydrocarbons. Detailed construction mitigation is proposed at this location both to maintain the existing flow paths and water balance of the Turlough and also to prevent pollution of both surface and groundwater. Please refer to the CESCP for details.

Operational

Interceptor drains will be incorporated to capture hill slope runoff (overland and shallow interflow) as well as deeper percolating groundwater flow. These drains will be connected to Cregga Turlough through the use of suitable drainage channels and a permeable distribution area provided underneath the alignment in this location and therefore the hydrological regime will be maintained. Given the strong interaction between surface and ground water at the Turlough, this area has also been addressed the Hydrology Section of this EIAR; further details of the treatment of overland and shallow groundwater flow to the Turlough are given in Chapter 10 – Hydrology. Stormwater drainage from the proposed road will be collected and conveyed away from the area through a sealed drainage system and suitably treated prior to discharge.

Table 9.35: Proposed Mitigation Measures For Hydrogeological Features With The Corresponding Residual Impact Rating

Attribute		Impact		
Site Name	**Importance**	**Description of Impact**	**Mitigation Measure**	**Residual Impact**
Leggatinty swallow holes, Caves and karst features Ch 10+000 to 14+000	Locally High	Construction		
		Potential contaminated infiltration / discharge entering aquifer via karst feature construction site works construction runoff and potential spillages.	A CESCP has been developed which the contractor must adhere to. This plan will ensure flows to the stream will be maintained through culverting (refer to Chapter 10) temporary works and diversions and that there is no appreciable deterioration in water quality	Slight
Peak-Mantua Spring Supply Ch 15+900	High	Construction		
		Restriction and interception of subsurface flow resulting in reduction in groundwater flow and yield.	The implementation of the CESCP will ensure no construction related impacts to the Peak-Mantua spring supply. This will include silt fences erected on or inside the development boundary which together with the fenceline will restrict construction activity in the vicinity of the zone of contribution and inhibit silt or sediment material from moving southwards into the ZOC and entering the recharge zone. No works will take place outside the land acquisition boundary and therefore works within the ZOC will not be permitted.	Negligible
		Damage to Feature by Construction Works (collapse, infill etc.).		
		Operational		
		Impact of road alignment on recharge to or discharge from hydro feature	The implementation of the CESCP will be required by the contractor. The design will ensure surface and groundwater flows in the area are maintained largely intact. Streams will be maintained through culverting (Refer to Chapter 10) and diversions. The road is not in cut at this point and will stay outside the ZOC for the spring supply. This will ensure that there is no appreciable change in recharge/discharge to the spring supply.	Negligible
Polecat Spring Supply ZOC – (Polloween swallow hole) Ch 17+750 – 32+750		Construction		
		Restriction and interception of subsurface flow resulting in reduction in groundwater flow and yield.	The implementation of the CESCP will ensure no construction related impacts to the Polloween swallow hole (which is connected to the Polecat spring supply). This will include silt fences which will restrict construction activity in the vicinity of the zone of contribution. In addition, interception ditches (cut-off ditches) will be constructed in advance of the main ground works which will redirect overland flow into the swallow hole and maintain its current recharge regime.	Slight
		Damage to Feature by Construction Works (collapse, infill etc.).		

Attribute		**Impact**		
Site Name	**Importance**	**Description of Impact**	**Mitigation Measure**	**Residual Impact**
Polecat Spring Supply ZOC – (Polloween swallow hole) Ch 17+750 – 32+750		Operational		
		Impact of road alignment on recharge to or discharge from hydro feature	The implementation of the CESCP and EOP will be required by the contractor. The design will ensure surface and groundwater flows in the area are maintained largely intact. Interception ditches will be constructed in advance of the main ground works which will redirect overland flow into the swallow hole and maintain its current recharge regime. This will ensure that there is no appreciable change in recharge/discharge to the spring supply.	Slight
Kilvoy and Corry East swallow hole and karst features Ch 18+400 to 19+300	Locally High	Construction		
		Restriction and interception of subsurface flow resulting in reduction in groundwater flow and yield.	The proposed road development has been routed away from these karst features, however stormwater drainage, which would have previously entered the area as overland flow, will be collected and conveyed away from karst areas. The CESCP and the measures outlined in Chapter 10 for overland and stream flow diversions will ensure that any reductions in flow to the feature are not appreciable.	Slight
		Damage to Feature by Construction Works (collapse, infill etc.).	A CESCP has been developed and will be implemented by the contractor. These features will be fenced off with a double silt fence. This will ensure that damage and collapse of these features does not occur as heavy machinery will not be allowed to work in close proximity.	Slight
		Potential contaminated infiltration / discharge entering aquifer via karst feature construction site works construction runoff and potential spillages.		
		Operational		
		Flood risk to the road from surcharging of the swallow hole feature.	Cut-off drains from the north and south of the alignment will be directed to a drainage pipe at Ch.18+500 which will discharge to the swallow hole. In addition two transverse barriers will be incorporated beneath the road to the east to mitigate the flood risk to the road at the base of the cutting.	Slight
		Failure of the road due to the collapse of karst features beneath the road footprint.	Basal reinforcement (Ch. 18+450 – Ch. 19+300 & Ch. 20+350 – Ch. 20+550 combined with a drainage layer (Ch 18+400 – Ch. 19+300m) to maintain existing drainage patterns has been incorporated into the road construction design at this location.	Slight

Attribute		Impact		
Site Name	**Importance**	**Description of Impact**	**Mitigation Measure**	**Residual Impact**
Ovaun Stream Swallow hole feature Ch 34+400	Locally High	Construction		
		Damage to Feature by Construction Works (collapse, infill etc.).	The construction works will not take place within 100m of this feature. The CESCP will ensure that construction works do not impact on this feature.	Slight
		Potential contaminated infiltration / discharge entering aquifer via karst feature construction site works construction runoff and potential spillages.	All site drainage is being routed through an attenuation pond which is to be constructed in advance of any works and will provide treatment prior to discharge. In addition the CESCP will ensure that construction works do not impact on this feature.	Slight
		Operational		
		Contamination of feature by road drainage outfalls and by the drainage system – Routine Runoff Accidental Spillage	An assessment of flows in the Ovaun has shown that only a small proportion enters groundwater through the swallow hole feature. This occurs some 150m downstream of where the road drainage outfall is located. The road drainage is treated to a high standard in an attenuation pond with a treatment forebay and penstock provided prior to this outfall point. Given the low level of contaminants anticipated and the treatment measures involved the risk to groundwater is very low.	Slight
Cregga Turlough Ch 36+650 to Ch 37+90	Locally High	Construction		
		Silts and sediments arising from construction related activity (excavation, breaking, blasting etc.)	A CESCP has been developed and will be implemented by the contractor. Construction sequencing has been developed to avoid sediment laden waters entering the Turlough. Refer to the CESCP for full details.	Slight
		Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	The measures outlined in the CESCP will ensure contaminated waters do not enter the Turlough.	Slight
		Disturbance due to construction machinery and carrying out of temporary Works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.)		
		Operational		
		Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effect on adjacent soils and wetland areas	All overland flow and flows arising from the rock cut face will be directed into infiltration galleries located between Ch.36+500 to Ch.36+700, Ch.37+670 to Ch.37+870 and Ch.38+030 to 38+130. This will ensure that all natural overland flow to the Turlough will be largely maintained with no appreciable change.	Slight

9.5.3.3 Ground Collapse

The presence of karst features has been noted along a number of sections of the alignment at Churchstreet/Portaghard, Leggatinity, Kilvoy Kilvoy, Corry East & Cloonyeffer, Gortnacrannagh/Killeen West, Tullyloyd, Cregga and Vesnoy. There is a risk that unmapped karst features may exist beneath the road footprint at other locations. Should the presence of karst features be encountered during the earthworks, the road construction may require basal reinforcement or similar mitigation measures.

9.5.3.4 Groundwater Supply Sources

Mitigation measures are summarised in Table 9.36 below. A routine groundwater monitoring programme will be established to collect water levels of all public and private groundwater supplies that are up to 150m from the development boundary or 50m beyond the zone of influence of cuttings. This will involve these supplies being monitored (for water level and quality) immediately prior to the commencement of construction activities, during on a regular basis and for a time (typically monthly for 12 months) after construction, so that any impacts during the construction phase can be identified. In the event of contamination being recorded, the source of same will be identified and rectified. In such cases until the presence of contamination is removed and proven no longer to be a risk an alternate water supply will be provided. Where low yielding wells have to be replaced, where the source of the contamination cannot be identified or mitigation of same is either not possible or not financial viable, an alternate water supply will be provided either by a replacement well or provide alternative water supplies (i.e. connection to a regional/group water supply scheme).

Table 9.36: Rating of Significant Environmental Impacts on Groundwater Resources

Attribute		Impact		
Site Name	**Importance**	**Description of Impact**	**Mitigation Measure**	**Residual Impact**
Peak-Mantua GWS Ch.15+800	High	Reduction in yield of water supply for GWS domestic usage.	See Table 9.34 above	Slight
		Contamination of water supply from road drainage entering aquifer via karst features.	See Table 9.34 above	Slight
Spring used for agricultural supply. Ch. 1+850	Medium	Loss of water supply for agricultural usage	New supply source to be provided either through provision of a borehole or connection to a group water scheme.	Slight
Domestic Well supply. Ch. 13+650	Medium	Loss of water supply for domestic usage	Monitoring of water level and quality will take place and appropriate action taken if impacts recorded.	Slight
Agricultural Well supply. Ch. 30+350	Medium	Loss of water supply for domestic usage	Monitoring of water level and quality will take place and appropriate action taken if impacts recorded.	Slight
Domestic supply. Ch. 35+400	Medium	Loss of water supply for domestic usage	Monitoring of water level and quality will take place and appropriate action taken if impacts recorded.	Slight

Attribute		Impact		
Site Name	**Importance**	**Description of Impact**	**Mitigation Measure**	**Residual Impact**
Agricultural Well supply. Ch. 32+900	Medium	Loss of water supply for domestic usage	Monitoring of water level and quality will take place and appropriate action taken if impacts recorded.	Slight
Polecat GWS located north-east of Elphin	High	Reduction in yield of water supply for GWS domestic usage.	Monitoring of water level and quality will take place and appropriate action taken if impacts recorded – see Table 9.34 for further mitigation measures.	Slight
		Contamination of water supply from road drainage entering aquifer via karst features.	The CESCP will be implemented in full which will limit construction sediment entering the swallow hole. In addition monitoring of water level and quality will take place and appropriate action taken if impacts recorded – see Table 9.34 for further mitigation measures.	Slight
Spring agricultural supply. Ch.38+050	Medium	Loss of water supply for domestic usage	New supply source to be provided either through provision of a borehole or connection to a group water scheme.	Slight

9.5.3.5 Attenuation Ponds

In order to prevent seepage through the base and sidewalls of attenuation ponds, the main body of the pond will be lined with cohesive material, and additionally with an engineered liner where sealed drainage systems are used, subject to Section 9.4.1.6 and outlet by infiltration will not be permitted. The treatment forebay and main attenuation area will be lined as above and suitably planted to promote the removal of contaminants. A penstock is also provided at the outlet so that in the event of an accidental spillage entering the pond, the outlet can be closed and the contaminant removed by pumping.

9.6 Residual Impacts

Residual impacts, remaining after the specific mitigation, have been assessed and are summarised in Table 9.34 and Table 9.35. All other residual impacts have been assessed as slight residual impact.

9.6.1 Road Drainage

There is a potential residual impact on groundwater quality from losing streams which has been assessed as a slight impact. There is also a potential residual impact for sealed drains which are not sealed, however this is considered to be so small that it will have a slight to imperceptible residual impact.

9.6.2 Cut Sections

Any significant cut sections exceeding 3m in depth and associated drainage system along the proposed road alignment would be expected to locally lower the groundwater table where intercepted. This represents a localised slight residual impact.

9.6.3 Hydrogeological features

Features such as the Leggatinty and Mantua swallow holes, Leggatinty and Drummin Bogs, Tullyloyd Fen and Cregga Turlough will always be potentially at risk from contaminated surface water runoff entering their hydrogeological regime. The proposed mitigation of sealed drainage systems in these areas mitigate this potential impact reducing it to a slight residual.

9.6.4 Groundwater Resources

Groundwater resources have the potential to be impacted by the proposed development. The quality of groundwater is at risk in high and extreme vulnerability areas and in areas of karst bedrock. A comprehensive suite of mitigation measures are proposed both during the construction and operational phase of the road development which will mitigate these impacts. Any potential impact on quality will be at a very localised scale. Given the mitigation proposed there is a slight residual impact from the proposed development with respect to groundwater quality as a resource. In terms of the quantity of groundwater available within the aquifer (the yield of the resource) there will be an imperceptible effect at the regional scale. There is the potential for residual impacts at the local level where well yields may be impacted or reduced. With the mitigation proposed as part of the development this is assessed as a slight residual impact.

Chapter 10 Hydrology

10.1 Introduction

This chapter of the EIAR presents the hydrological assessment of the proposed N5 Ballaghaderreen to Scramoge Road Project. The chapter sets out the methodology used in the assessment (Section 10.2), describes the existing hydrological environment (Section 10.3), details the likely significant hydrological impacts associated with the construction and operational phase of the proposed road development, (Section 10.4), describes measures to mitigate identified significant impacts (Section 10.5) and details residual impacts post mitigation (Section 10.6).

The principal potential hydrological impacts to the character of the receiving waters are associated with the proposed road 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 the complex karst drainage system which has been identified across the area of the project. The assessed potential impacts include:

- Surface watercourses crossed by the proposed road involving culvert and bridge structures and 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 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 (namely a Turlough at Cregga, Annaghmore Lough (Special Area of Conservation; Site Code: 001626), an Alkaline Fen at Tullyloyd, Clooncullaan Loughs, and Bellanagare Bog;
- Potential impacts on surface water abstraction in proximity to surface water crossings and downstream of storm outfalls (e.g. Lough Gara Abstraction Source).

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 Statements, March 2002;
- EPA Advice Notes on Current Practice in the preparation of Environmental Impact Statements, September 2003;
- Surface Water and Drainage Guidance in the National Roads Authority Design Manual for Roads and Bridges;
- TII/NRA Guidelines on Procedures for the Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes;

- TII/NRA Environmental Impact Assessment of National Roads Schemes – A Practical Guide, November 2008;
- DoEHLG (Nov 2009) Flood Risk Management and the Planning System Guidance document.

The following Draft Guidance documents have also been consulted:

- Guidelines on the Information to be contained in Environmental Impact Assessment Reports, Draft May 2017; and
- Advice Notes for Preparing Environmental Impact Statements, Draft September 2015.

The Hydrological Impact Assessment Methodology is in general agreement with the guidance outlined in Section 5.6 of the TII/NRA 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/NRA guidelines.

The hydrological assessment has been prepared by expanding and updating the desk study work carried out for the Constraints Study and Route Corridor Selection Reports. 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
- EPA Hydrometric Data System

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 WEB Site
- Floodmaps Site
- OPW FSU (Flood Studies Update) Web Portal Site for Flood flow Estimation
- OPW Preliminary Flood Risk Assessment Mapping (pFRA).

Roscommon County Council

- Roscommon County Development Plan 2014 – 2020
- Planning Register
- Water Services – Abstractions, Discharges & Supply Schemes

National Parks and Wildlife Service (NPWS)

- Designated Areas Mapping
- Site Synopsis Reports

Other sources

- Shannon River Basin Management Plan (2009 – 2015)
- Aerial survey photography
- Geological Survey of Ireland (GSI) Web Mapping

10.2.2 Consultation with Regulatory and Other Bodies

Consultation took place with all relevant regulatory bodies including various departments of Roscommon County Council, the OPW, GSI and Inland Fisheries Ireland and the Peak Mantua Group Water Supply Group Scheme.

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, including site visits during the December 2015 flood event. Flow estimation in selected outfall streams was also conducted.

10.3 Existing Environment

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 between Ballaghaderreen and Cloonyquin, and Poor to Good between Cloonyquin and Strokestown. The groundwater status for this region is classified as Poor.

The N5 Ballaghaderreen to Scramoge Road proposed road development crosses several watercourses which are part of the Upper Shannon Catchment. The rivers in the Western section of the Study Area which are traversed by the proposed road development flow to the Shannon via the Breedoge River catchment and Lough Gara. Those in the middle section flow via Lough Nablahy and the remaining eastern section flows via the Mountain River Catchment and Kilglass Lough. The proposed road development is in Hydrometric Area No.26 (Upper Shannon Catchment).

The locations of each of the major watercourses along the proposed road development are given in Figure 10.1 in Volume 3 of the 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 5 No. major watercourse crossings together with a number of other crossings of minor watercourses and 22 No. 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 (see Table 10.24).

The proposed road development is divided into four sections heading west to east – see Figure 10.1 in Volume 3 of the EIAR. There are no significant watercourses in section A. In general, watercourses in section B flow in a south-westerly to north-easterly direction. These watercourses ultimately feed the Upper Shannon Catchment first via the Breedoge River and then via Lough Gara which is designated as a Special Protection Area (Site Code: 004048) and is used as a large public water supply source with abstraction from its lower lake. The Carricknabraher is a tributary of the Breedoge, as is the Owennaforeesha River.

Lough Gara lies south west of the Curlew Mountains situated almost 6 kilometres to the North of Frenchpark. Lough Gara is supplied by the Lung River, which enters at the Southwest side, and the Breedoge River, which enters the lake at the Southeast side. From the main upper lake the outflow is through the northeastern corner at Cuppanagh. From that point the river becomes the Boyle River which flows past the town of Boyle into Lough Key and on to the River Shannon.

The Owenur River in section C, flows from West to East crossing the proposed road development at Killeen West and flows to the upper Shannon via Lough Nablahy. Lough Clooncullaan feeds the Owenur River.

The Strokestown and Scramoge Rivers in section D, flow from South to North and join to become the Mountain River and then flow to the Upper River Shannon via Kilglass Lough. The Scramoge River is the largest watercourse crossed by the proposed road development.

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.

Table 10.1 Road Section and Associated Catchments

Section No.	Chainage:		Section Length, km	No. of Watercourse Crossings	No. of Outfalls
	From	To			
A	N5 tie in Ch.1+000	5+700	4.7	0	3
B	10+000	24+200	14.2	5	7
C	30+000	40+550	10.5	1	7
D	50+000	54+000	4.0	2	5
Total			**33.4**	**8**	**22**

10.3.2 River Catchments

10.3.2.1 Carricknabrahar River

For the greater part of its length, the Carricknabraher flows eastward crossing the existing N5 east of Frenchpark before continuing east, where it enters the Breedoge River. The Carricknabraher is fed by local streams and has a catchment area of some 20.25km^2 upstream of where it traverses the proposed road development. There are no sources of gauged flood flow information for the River.

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 DTM contours. The FSU only considers the DTM model and has been shown for various catchments to be inconsistent with respect to the watershed.

Table 10.2 FSR Catchment Characteristics of the Carricknabraher River

Catchment Characteristic	
AREA (km^2)	20.25
Annual Rainfall SAAR (mm)	1120
Winter Rainfall Acceptance potential SOIL Index	0.45
Channel Flood Slope S1085 (m/km)	6.4
URBAN – fraction of catchment	0%

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

Catchment Characteristic	
AREA (km^2) (OPW DTM model)	17
Annual Rainfall SAAR (mm)	1110
FARL	1.0
BFISOIL Baseflow Index of Soils	0.454
Drainage Density DRAIND km per km^2	0.815
Channel Flood Slope S1085 (m/km)	7.86
Arterial Drainage Factor ARTDRAIN2	0.3576
URBAN – fraction of catchment	0%

10.3.2.2 Owennaforeesha River

The Owennaforeesha River is also a tributary of the Breedoge River and rises in Brackloon 4.7km south of Bellanagare and flows northwards through Bellanagare village and connects with the Breedoge River in Ballynahowna, 2.8km north of Bellanagare. The river has a catchment area of 26.146km^2 upstream of where it traverses the proposed road development. There are no sources of gauged flood flow information for the River.

Table 10.4 FSR Catchment Characteristics of the Owennaforeesha River

Catchment Characteristic	
AREA (km^2)	26.15
Annual Rainfall SAAR (mm)	1120
Winter Rainfall Acceptance potential SOIL Index	0.36
Channel Flood Slope S1085 (m/km)	3.1
URBAN – fraction of catchment	0%

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

Catchment Characteristic	
AREA (km^2) (OPW DTM model)	26.1
Annual Rainfall SAAR (mm)	1087
FARL	1.0
BFISOIL Baseflow Index of Soils	0.5047
Drainage Density DRAIND km per km^2	0.691
Channel Flood Slope S1085 (m/km)	4.25
Arterial Drainage Factor ARTDRAIN2	0.6896
URBAN – fraction of catchment	0%

10.3.2.3 Owenur River

The Owenur River is fed from Lough Clooncullaan and takes outflow from Lough Nahincha, Lough O'Moran and several smaller streams before ultimately discharging to the Upper Shannon via Cloonahee Lough.

The Owenur has a catchment area of 31.6km^2 upstream of where the proposed road development traverses the river. This is a gauged river having a hydrometric gauging station (ref 26018) located at Bellavahan Bridge (the river having a catchment at that point of 118km^2). The Bellavahan Bridge gauging station has a good A2 Rating Classification for its flood flow-stage relationship. The record period available for the station is from 1956 to 2013 having a mean annual flood flow of 9.5cumec (Qbar) and a maximum discharge over the 57 year record of 19.6 cumec.

Based on the www.OPW.ie/hydro database the Owenur River has a mean annual flow rate of 2.465m^3/sec and a 95-percentile low flow of 0.13m^3/sec (data derived for the period 1972 to 2002 at Bellavahan Bridge.

Table 10.6 FSR Catchment Characteristics of the Owenur River

Catchment Characteristic	
AREA (km^2)	31.6
Annual Rainfall SAAR (mm)	1120
Winter Rainfall Acceptance potential SOIL Index	0.45
Channel Flood Slope S1085 (m/km)	2.1
URBAN – fraction of catchment	0%

Table 10.7 FSU Catchment Descriptors of the Owenur River (Source OPW FSU Web Portal Site)

Catchment Characteristic	
AREA (km^2) (OPW DTM model)	32.4
Annual Rainfall SAAR (mm)	1062
FARL	0.922
BFISOIL Baseflow Index of Soils	0.5811
Drainage Density DRAIND km per km^2	0.764
Channel Flood Slope S1085 (m/km)	0.1
Arterial Drainage Factor ARTDRAIN2	0.0
URBAN – fraction of catchment	0%

10.3.2.4 Strokestown River

The Strokestown River is a tributary of the Upper Shannon Catchment and rises in Carrowclogher 2.1km south of Strokestown and flows northwards through Strokestown before combining with the Scramoge river to become the Mountain River at Ballymartin, 4.8km north of Strokestown. The river has a catchment area of 5.3km^2 at the location where the proposed road development crosses it. There are no sources of active gauged flood flow information for the River.

Table 10.8 FSR Catchment Characteristics of the Strokestown River

Catchment Characteristic	
AREA (km^2)	5.3
Annual Rainfall SAAR (mm)	1120
Winter Rainfall Acceptance potential SOIL Index	0.3
Channel Flood Slope S1085 (m/km)	2.2
URBAN – fraction of catchment	10%

Table 10.9 FSU Catchment Descriptors of the Strokestown River (Source OPW FSU Web Portal Site)

Catchment Characteristic	
AREA (km^2) (OPW DTM model)	4.13
Annual Rainfall SAAR (mm)	1016
FARL	1.0
BFISOIL Baseflow Index of Soils	0.527
Drainage Density DRAIND km per km^2	0.757
Channel Flood Slope S1085 (m/km)	1.8015

Catchment Characteristic	
Arterial Drainage Factor ARTDRAIN2	0.0
URBAN – fraction of catchment	0.1008

10.3.2.5 Scramoge River (Mountain River)

The Scramoge River combines with the Strokestown River to become becomes the Mountain River at Ballymartin. The Sramoge River has a catchment area of some 188km^2 upstream of where the proposed road development crosses it. The Mountain River has a catchment area of some 216km^2 at the location of the proposed crossing of same by the road development. This is a gauged river having a hydrometric gauging station (ref 26017) located at Gillstown.

Table 10.10 FSR Catchment Characteristics of the Scramoge River

Catchment Characteristic	
AREA (km^2)	188
Annual Rainfall SAAR (mm)	1120
Winter Rainfall Acceptance potential SOIL Index	0.27
Channel Flood Slope S1085 (m/km)	0.9
URBAN – fraction of catchment	0%

Table 10.11 FSU Catchment Descriptors of the Scramoge River (Source OPW FSU Web Portal Site)

Catchment Characteristic	
AREA (km^2) (OPW DTM model)	195.1
Annual Rainfall SAAR (mm)	1041
FARL	0.913
BFISOIL Baseflow Index of Soils	0.5833
Drainage Density DRAIND km per km^2	0.629
Channel Flood Slope S1085 (m/km)	0.9182
Arterial Drainage Factor ARTDRAIN2	0.0
URBAN – fraction of catchment	0.0

10.3.3 Flood Risk Assessment (FRA)

A flood risk assessment has been undertaken for the proposed road development. The vertical alignment assessment is subdivided in four sections relative to the primary receiving watercourse as set out earlier and listed below:

- Section A: Local Stream outfalling to the Lung River (Lough Gara)
- Section B: Carricknabrahar & Owennaforeesha
- Section C: Owenur River
- Section D: Strokestown River and Scramoge River

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. 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 floodmaps.ie and the pFRA and CFRAM flood mapping were consulted as initial screening. For all of the river crossings, hydraulic flood modelling was carried out to estimate the design flood level and potential impact of the proposed road development, details of which are summarised in Table 10.12.

Table 10.12 Predicted Design Flood Levels and Flood Flows at Each of the Major River Crossings (0.01% Annual Exceedance Probability)

River Name	Chainage (m)	0.01% AEP Flood Level (mOD)	0.01% AEP Flood Flow (m^3/s)
Carricknabrahar River	10+130	79.46	40.3
Owenaforeesha River	14+540	67.46	30.7
Owenur River	30+800	48.30	49.2
Strokestown River	51+250	40.65	5.0
Scramoge River	52+875	40.67	87.8

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 are summarised in Table 10.13 below. Refer to Section 10.4 for further details.

Table 10.13 Flood Risk Assessment Summary: Road Vertical Alignment

Section	Chainage	Comment on Flood Risk Areas	Overall Flood Risk	Mitigation
A: Local Stream	1+1000 – 5+697	Minimal Flood Risks	Low	None
B: Carricknabrahar River	10+000 – 24+198	Minimal Flood Risks	Low	None
B:Owenaforeesha River		Minimal Flood Risks	Low	None
C: Owenur River	30+000 – 40+511	Minimal Flood Risks	Low	None
D: Strokestown River	50+000 – 54+357	Minimal Flood Risks	Low	None
D: Scramoge River		Minimal Flood Risks	Low	None

This assessment indicates minimal flood risk to the Proposed Road Development.

10.3.4 Surface Water Quality

10.3.4.1 Rivers

<u>EPA Monitoring River Programme</u>

The 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 t 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 10.14 below).

Table 10.14 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

The monitored rivers that traverse the proposed road development vary in quality from being slightly polluted (Q3-4) to moderately unpolluted (Q2-3). There are 19 No. monitoring stations that are of relevance to the proposed road development (refer to Table 10.15 for monitoring results).

Table 10.15: EPA Monitored River Water Quality Within or Near Study Area

Biological Quality Ratings (Q Values)													
River Name	**Station No.**	**Year**											
Carricknabraher	**Station Nos.**	**1980**	**1983**	**1987**	**1992**	**1996**	**1999**	**2002**	**2005**	**2008**	**2011**	**2014**	
Cloonshanville Bridge	100	4	4	4-5	4	3-4	4	3-4	3-4	4	4	4	
U/s Owennaforeesha River	200	3	4	-	3	3-4	3-4	3	3	4	3	-	
Owennaforeesha	**Station Nos.**	**1981**	**1984**	**1987**	**1992**	**1996**	**1999**	**2002**	**2005**	**2008**	**2011**	**2014**	
Bellanagare Bridge	100	4	4	3-4	4	4	3-4	3-4	3-4	3-4	4	3-4	
100 m u/s Breedoge confl	200	-	-	-	4-5	4	4	4-5	4	4	3	-	
Owenur	**Station Nos.**	**1980**	**1984**	**1987**	**1992**	**1996**	**1999**	**2002**	**2005**	**2008**	**2011**	**2014**	
Ballyoughter Br	100	4	4	4	4	4	3-4	3	4	4	4	4	
Ballyslish Bridge	300	4	4	4	4	4	4	3-4	4	4	4	4	
Bellanagrange Br	500	4	3-4	4	3-4	3	3	4	4	4	4	4	
Scramoge	**Station Nos.**	**1981**	**1984**	**1986**	**1987**	**1992**	**1996**	**1999**	**2002**	**2005**	**2008**	**2011**	**2014**
Bridge d/s Lough Conny More	50	-	-	-	4	4	4	4	4	4	4	3	3-4
Cloonfree Bridge	200	4-5	4	4	4	4	4	4	4-5	4	4	4	3-4
Clooncony Bridge	300	3-4	4	4-5	4	3	4	4	4	4	4	4	4
Scramoge Bridge	600	4	4	4-5	4	4	4	4	4-5	4	4	4	4
Strokestown	**Station Nos.**	**1984**	**1987**	**1992**	**1996**	**1999**	**2002**	**2006**	**2008**	**2011**	**2014**		
Br at S. end of Strokestown	50	-	3	2-3	2-3	2-3	3	3-4	2-3	2-3	3		
Br 1.5 km d/s Strokestown	100	3-4	3	2-3	4	2-3	3	3	3	3	3-4		
Br SW Toberpatrick	200	4	4	4	3-4	4	4	3-4	4	4	4		
Breedoge	**Station Nos.**	**1981**	**1983**	**1987**	**1992**	**1996**	**1999**	**2002**	**2005**	**2008**	**2011**	**2014**	
Loughbally Br	100	3-4	4	-	4	3-4	4-5	4	3	-	-	-	
Bella Bridge	200	5	4-5	4-5	4-5	-	-	-	-	-	-	-	
Breedoge Bridge	300	5	4	4	4	4-5	4	4	4	4	4	3-4	
Mountain	**Station Nos.**	**1981**	**1984**	**1987**	**1992**	**1996**	**1999**	**2005**	**2008**	**2011**	**2014**		
1 km u/s Kilglass Lough	100	4	4	4	4	3-4	3-4	4	3-4	3-4	3-4		

The WFD 'Water Matters' website mapping section provides details on the assessments of the 5 water bodies / sub catchments being traversed by the proposed road development at downstream receptors (Table 10.16).

Table 10.16 WFD Classification of River Waters Near the Ballaghaderreen to Scramoge Road Development

Waterbody Name		Code	Status	Objective	Risk
Carricknabrahar River	Tributary of Breedoge	IE_SH_26_3912	Moderate	Restore	1a - At Risk
Owennaforeesha	Tributary of Breedoge	IE_WE_32_3732	Moderate	Restore	1a - At Risk
Owenur	Cloonahee Lough	IE_WE_26_2513	Good	Restore	1a - At Risk
Strokestown	Tributary of Mountain River	IE_WE_34_1421	Poor	Protect	1a - At Risk
Scramoge	Tributary of Mountain River	IE_WE_34_1762	Poor	Restore	1a - At Risk
Breedoge	**Not Traversed by PRD***	IE_SH_26_2898	Poor	Restore	1a - At Risk
Mountain River	**Not Traversed by PRD**	IE_SH_26_3801	Poor	Restore	1a - At Risk

* PRD – Proposed Road Development

The highest quality river is the Strokestown River having a Good status and a Water Framework Objective of 'Protect' as opposed to the 'Restore' which is required for all the other above listed watercourses.

10.3.4.2 Lakes

As part of a national water quality monitoring programme a number of lakes throughout the country are sampled and the trophic status assessed. Lake water quality is most commonly assessed by reference to a scheme proposed by the Organisation for Economic Cooperation and Development (OECD, 1982). This scheme defines the traditional trophic categories by setting boundaries for the annual average values for total phosphorus, chlorophyll A and water transparency, and for the maximum and minimum vales of the latter two parameters.

A modified version of these criteria is used in which annual maximum chlorophyll-a concentration is the only parameter used. This has been further subdivided into six water quality categories by reference to the maximum levels of planktonic algae measured during the period (refer to Table 10.17). Indicators relating to water quality and the probability of pollution are also shown.

Table 10.17 Trophic Classification Scheme for Lake Waters

Classification Scheme		Category Description				
Lake Trophic Category		Annual Maximum Chlorophyll-a (mg/m^3)	Algal Growth	Degree of Deoxygenation in Hypolimnion	Level of Pollution	Impairment of Use of Lake
Oligotrophic	(O)	<8	Low	Low	Very low	Probably none
Mesotrophic	(M)	8 – 25	Moderate	Moderate	Low	Very little
	Moderately (m-E)	25 – 35	Substantial	May be high	Significant	May be appreciable
Eutrophic	Strongly (s-E)	35 – 55	High	High	Strong	Appreciable
	Highly (h-E)	55 – 75	High	Probably total	High	High
Hypertrophic	(H)	>75	Very high	Probably total	Very high	Very high

The trophic status provides an indication as to what degree the lake is enriched by the presence of nutrients such as phosphorus and to a lesser extent nitrogen in the form of nitrate.

Along the proposed road alignment there are three lake stations currently monitored as part of the EPA water quality reporting. Lough Gara, Annaghmore Lough and Grange Lough are all classified as Oligotrophic/Mesotrophic in terms of water quality indicating that nutrient enrichment is low and eutrophication is not a major concern.

Under the WFD classification for surface water bodies, there are 5 lakes that are listed close to the proposed road development (refer to Table 10.18).

Table 10.18 WFD Classification of Lake Waters Within Study Area

Waterbody Name	Code	Status	Objective	Risk
Lough Gara	IE_SH_26_728	Good	Protect	1b - Probably at Risk
Nablahy Lough	IE_SH_26_682	Good	Protect	2a - Probably Not At Risk
Kilglass Lough	IE_SH_26_748	Moderate	Restore	2a - Probably Not At Risk
Annaghmore Lough	IE_SH_26_669	Moderate	Restore	2a - Probably Not At Risk
Grange Lough	IE_SH_26_706	Good	Protect	2a - Probably Not At Risk

10.3.5 Ecological Receptors

A number of key ecological receptors (KER's) adjacent to the proposed road development have been identified and discussed in detail in Chapter 7. These receptors are summarised in Table 10.19 below.

Table 10.19 Ecological Receptors: Summary

KER No.	Chainage Range	Description	Receptor Importance
KERs 1a(N) & 1b(C)	4+000 – 4+500	Wet Grassland (Molina Meadows) Potential Marsh Fritillary Habitat	National / County Importance

KER No.	Chainage Range	Description	Receptor Importance
KERs 2a(LH) and 2b(N)	5+000-5+500	Raised Bog Cutover Bog Bog Woodland	Local Importance (higher value) National Importance
KER 3(LH)	10+125-10+150	Carricknabraher River – the OPW have indicated this is a Salmonid watercourse	Local Importance (higher value)
KER 4(C)	10+750-10+850	Wet Grassland (Molina Meadows) Potential Marsh Fritillary Habitat	County Importance
KER 5(N)	11+800 – 12+150	Wet Grassland (Molina Meadows) Potential Marsh Fritillary Habitat	National Importance
KERs 6a(N), 6b(N), 6b(C), 6b(LH), 6c(N), 6c(LH), 6c(LL)	10+900 – 12+350	Raised Bog Cutover Bog Wet Heath Bog Woodland	National Importance County Importance Local Importance (lower value)
KERs 7a(N) and 7b(LH)	13+950 – 14+450	Raised Bog Cutover Bog Bog Woodland	National Importance Local Importance (higher value)
KER 8(LH)	14+450 – 14+800	Owennaforeesha River – the OPW have indicated this is a Salmonid watercourse	Local Importance (higher value)
KER 9(LH)	14+500 – 14+650	Bog Woodland	Local Importance (higher value)
KER 10(LH)	15+150 – 15+300	Bog Woodland	Local Importance (higher value)
KER 11(LH)	16+700 – 17+200	Bog Woodland Cutover Bog	Local Importance (higher value)
KER 12(LH)	18+250 – 20+250	Mixed Broadleaved Woodland	Local Importance (higher value)
KER 13(LH)	30+550 – 31+950	Owenur River Marsh and Wet Grassland Wet Grassland Reedswamp & Poor Fen	Local Importance (higher value)
KER 14(LH)	32+900 – 34+450	Mature Tree Lines Wet Grassland	Local Importance (higher value)
KERs 15a(LH) 15b(LL), 15c(N), 15d(C), 15e(C)	33+350 – 35+750	Lough Clooncullaan, Wetland complex Rich Alkaline Fen Reed Swamp Reed Swamp	National Importance Local Importance (higher & lower value) County Importance
KER 16(N)	36+650 – 37+950	Turlough (Cregga)	National Importance
KER 17(LH)	50+850-51+800	Cutover Bog Bog Woodland, Scrub and Grassland	Local Importance (higher value)
KER 18(LH)	52+150 – 52+650	Mixed Woodland & Scrub	Local Importance (higher value)

KER No.	Chainage Range	Description	Receptor Importance
KER 19(LH)	52+850 – 53+250	Scramoge River - the OPW have indicated this is a Salmonid watercourse	Local Importance (higher value)
KER 20(LH)	53+300 – 53+950	Mixed Broadleaved /Conifer Woodland	Local Importance (higher value)

10.3.5.1 SAC's and SPA

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.

No SAC or SPA is traversed by the proposed road development, however there are six designated sites which were screened-in during the Appropriate Assessment screening comprising Bellanagare Bog (SAC and SPA), Annaghmore Lough (SAC), Cloonshanville Bog (SAC), Lough Gara (SPA) and Lough Forbes Complex (SPA).

Bellanagare Bog SAC and SPA

Bellanagare Bog is listed as a SPA (Ref. 004105), a candidate Special Area of Conservation (000592) and also as a proposed National Heritage Area (pNHA) (Ref. 000592). The bog is located some 1.5km south of Frenchpark in the townland of Leggatinty. The proposed road development passes approximately 200m to the north of Bog. The bog shows the characteristics of a blanket bog habitat and is classified as an intermediate raised bog. The site is selected as a SAC for the following habitats and/or species listed on Annex I&II of the E.U. Habitats Directive: Active Raised Bog [7110], Degraded Raised Bog [7120], Rhynchosporion Vegetation [7150], Marsh Fritillary (Euphydryas aurinia) [1065].

Annaghmore Lough SAC

Annaghmore Lough is designated as a candidate Special Area of Conservation (Ref. 001626) and is located approximately 3km south of Elphin. The Lough lies at the centre of a network of small lakes in a rolling, drift-covered landscape. The site was selected as a SAC for the following habitats and/or species listed on Annex I&II of the E.U. Habitats Directive: Alkaline fens [7230] and Vetigo geyeri (Geyer's Whorl Snail) [1013]). In addition the site is important for wintering birds and is listed as a wildfowl sanctuary (WFS-44). This site is relatively intact with minor damage; cattle grazing, burning on the fen and drainage pose the main potential threats to the site. This is a site of considerable conservation importance given the habitats and rare species present. The proposed road development passes approximately 1.8km to the north of this SAC.

Cloonshanville Bog SAC

Cloonshanville Bog is designated as a candidate Special Area of Conservation (Ref. 000614) and is located approximately 1km north of Frenchpark in the townland of Cloonshanville. The site was selected as a SAC for the following habitats and/or species listed on Annex I&II of the E.U. Habitats Directive: Active Raised Bog [7110], Degraded Raised Bog still capable of natural regeneration [7120], Depressions on peat substrates of the Rhynchosporion [7150] and Bog woodland [91D0]. The proposed road development passes within 1.7km to the south of this designated site.

Lough Gara SPA

Lough Gara is a shallow medium-sized lake, situated some 6km north-east of Ballaghaderreen. There are two main sections to the lake, a larger northern basin and a smaller southern basin which are joined by a narrow channel. The main inflowing rivers to the lake system are the River Lung and the Breedoge River while the main outflow from the lake is the River Boyle. The lake is classified as a mesotrophic system, with reduced planktonic algal growth. Callow Bog SAC is situated on the southern shore of the lake. The site was selected as a Special Protection Area due to the presence of the following species: Whooper Swan (Cygnus cygnus) [A038] and Greenland White-fronted Goose (Anser albifrons flavirostris) [A395]. The proposed developed is located c.2.6km south of Lough Gara SPA at its closest point.

Lough Forbes Complex SAC (001818)

This SAC consists of a natural lake system, active raised bogs degraded raised bogs, depressions on peat substrates and alluvial forests. The site is a candidate Special Area of Conservation (SAC) selected for the following habitats and/or species listed on Annex I& II of the E.U. Habitats Directive Natural Eutrophic Lakes [3150], Raised Bog (Active) [7110], Degraded Raised Bog [7120], Rhynchosporion Vegetation [7150], Alluvial Forests [91E0]. This site is located downstream of the proposed road development and is fed by the River Shannon. Based on precautionary principle, the site has been considered to lie within the Zone of Impact of the proposed development in respect of a potential surface water spillage. The proposed developed is located c.10.5 km west of the Lough Forbes Complex SAC at its closest point.

NHA's and pNHA's

This is the national designation for wildlife, and is an area considered important for the habitats present or which holds species of plants and animals whose habitat needs protection. Listed sites that were published on a non-statutory basis in 1995, but have not since been statutorily proposed or designated, are regarded as proposed NHA i.e. pNHA. All NHA's are afforded legal protection from damage from the date they are formally proposed for designation. No NHAs or pNHAs are traversed by the proposed road development (**see Figure 7.1 in EIAR Volume 3**).

Designated Sites in the Zone of Impact of the Proposed Road Development

All European sites located greater than 15km from the Proposed Road Development, with no identifiable connectivity or located in a separate hydrological catchment (Water Framework Directive Catchment Mapping) were deemed to be outside the Zone of Impact of the proposed alignment as no pathways for significant effects were identified.

Additional European sites with hydrological connectivity, located downstream in the Shannon Catchment are considered to be sufficiently remote from the proposed development as results in their exclusion beyond reasonable scientific doubt from being likely to be impacted either by construction activities or operation of the proposed road development. The worst case scenario would be a major pollution incident towards the eastern end of the proposed road development which would have to travel a distance in excess of 70km discharging through a sequence of waterbodies before affecting at any such sites. The buffering and dilution effect of these waterbodies will ensure imperceptible impact on European sites with identifiably hydrological connectivity but located outside the 15km buffer zone.

Table 10.20 summarises the numbers of protected sites occurring within a number of buffer zones from the proposed road development.

Table 10.20 Summary of SAC, SPA, NHA and pNHA Sites Adjacent to the Proposed Road Development

Site	1km Buffer	5km Buffer	10km Buffer	15km Buffer
SAC	2	5	8	17
SPA	1	2	3	4
NHA	0	2	4	9
pNHA	2	7	16	34

10.3.5.2 Water Supply Sources

Regional Water Supply

There are two regional water supply schemes and two Group Water Supply (GWS) schemes in proximity to the proposed road development.

North Roscommon Regional Water Supply

The principal source of the North Roscommon water supply is Lower Lough Gara, located approximately 5km North of Frenchpark. The scheme serves 6,500 people including those in Ballaghaderreen and the surrounding areas. Water is treated by flocculation, clarification, filtration and chlorination. The treatment plant was commissioned in 1982 and upgraded in 1991. The plant produces 7,000m^3 a day.

Water quality is monitored by Roscommon County Council to ensure that the parametric values from the European Communities (Drinking Water) No. 2 Regulations, 2007 are complied with. Both check and audit monitoring is carried out.

Northeast Roscommon & Ballyleague Regional Water Supply Scheme

The North East Roscommon Regional Water Supply extends from Roosky in the east to Tulsk in the west and from Drumsna in the north to Ballyleague in the south. The water supply scheme serves over 5,400 people including residents of Strokestown, Elphin, Tulsk and Scramoge. The supply for this source is taken from Lisheen Lake located approximately 6km north of Strokestown. Roscommon County Council also maintain a number of groundwater supply boreholes located in the vicinity of Strokestown which augment the supply. Boil water notices have frequently been issued for this supply scheme due to continued microbiological contamination from human and agricultural sources. In January 2016 Irish Water, awarded a contract for the design, construction and commissioning of a new water treatment plant for the North East Roscommon & Ballyleague Regional Water Supply Scheme. Construction of the plant commenced in 2016 and is expected to be completed in 2017.

There are three Group Water Scheme supplies within the Study area both of which are spring supplies from the Bedrock Aquifer. The springs are located at Peak, Curracreigh and Lissavilla. A brief description of each scheme is given below. Further more detailed descriptions may be found in **Section 9.3.1**.

Peak Mantua Group Water Supply Scheme

The Peak Mantua Group Water Scheme (GWS) consists of a spring water supply with an abstraction rate of 80m^3/day. The supply source is named Tober Knockageely spring which is located to the east of Bellanagare in the townland of

Peak. This scheme supplies approximately 40 domestic connections and serves up to 90 people.

Curracreigh Group Water Scheme

Curracreigh GWS is an amalgamation of a number of GWS's including; Annaghmore/Corraslira GWS, Clooncullana/Clooncunny GWS, Cloonyquinn GWS and Rathcroaghan/Tulsk GWS. The scheme is supplied by a large spring at Cloonyquinn which is approximately 6km south of Elphin. The spring is located adjacent to the N61 national secondary road in Cloonyquinn. The reported abstraction rate from Curracreigh spring is 300m^3/day and serves over 800 people.

Polecat Group Water Scheme

Polecat Group Water Scheme (GWS) is supplied from a spring (Pollacat spring) located 3km northeast of Elphin. The scheme abstracts approximately 550m^3/d (395 domestic and 588 non domestic/land connections). Polecat GWS is a co-operative and an amalgamation of three GWSs (Aughrim, Creeve and Corbally/Boheroe GWSs). The scheme recently received a significant capital upgrade now providing full treatment (filtration and disinfection) prior to distribution.

10.4 Impact Assessment

10.4.1 Introduction

Road projects given their scale and nature have significant potential for causing impact to 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 Corridor Selection phases, as well as site specific investigations undertaken as part of the EIA, including the ecological study, intrusive site investigation, agricultural survey, topographical survey and hydrological walkover and 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/NRA.

Key hydrological attributes identified along the proposed road development include:

- European Designated Sites including: Bellanagare Bog SAC (000592) SPA (004105), Annaghmore Lough (Roscommon) SAC (001626), Cloonshanville Bog SAC (000614), Lough Forbes Complex SAC (001818), Lough Gara SPA (004048) and Callow Bog SAC.
- Nationally Important Annex 1 habitats such as a Turlough at Cregga, raised bog at Bellanagare and Leggatinty, Alkaline Fen at Tullyloyd, wet grassland at Leggatinty and raised bog at Corskeagh.
- Surface drinking water supply abstraction source at Lough Gara
- 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.

The individual importance of these attributes has been then assessed with respect to their quality, extent / scale and rarity as set out in Table 10.21 below.

Table 10.21 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

For the purposes of this assessment and particularly with reference to the identified KERs and how their importance was rated from the hydrological perspective (this is in agreement with the approach used for rating ecological sites – see Chapter 7), 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

Details of the importance rating assigned to each of the key hydrological attributes, and in particular the KERs, is indicated in Table 10.34.

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 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 road development design the adequacy of culvert sizes for local drainage areas and small river catchments is based on providing conveyance for the 100 year 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 error 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 error 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, concrete surface water channels and filter drains where permitted, which convey storm runoff to one of the various surface outfall locations located along the 33.4km length of mainline road.

10.4.3.2 Qualitative 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

<u>Operational General Impacts:</u>

- Permanent interference with river, streams and floodplains at road bridge / 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 dimension 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 road alignment and associated drainage network and outfalls. At some locations, the creation of the proposed road perpendicular to the natural drainage path 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 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 (Cb), Lead (Pb), copper (Cu) and Zinc(ZU). 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 HGV's (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 receiving aquatic system. Increased salinity of watercourses can alter the ecological balance of the aquatic system and increase the bioavailability of chemical contaminants.

Construction General Impacts

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 impact to watercourses altering the pH, smothering the stream bed and physically damaging fish through burning and clogging by the fine silt of gills.
- Accidental Spillage of hydrocarbons from construction plant and at Storage depots / construction compounds.
- Faecal contamination arising from inadequate treatment of on-site toilets and washing facilities.

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 Culvert Crossings

Table 10.22 below presents a summary of the primary culvert crossings including upstream contributing catchment area and Table 10.23 presents the proposed culvert sizes.

Table 10.22: Proposed Road Culvert Crossings

Culvert No.	Location	Ch.	Drainage District Channel	Watercourse Name	WFD River Basin Catchment	Ecological Evaluation	Catchment	
							Area, km^2	Ref. No.
WB10.01	N5	10,130	OPW Boyle Scheme	Carricknabraher	Upper Shannon	4	20.26	1
WB14.01	N5	14,540	OPW Boyle Scheme	Owennaforeesha	Upper Shannon	3-4	26.15	3
WB30.01	N5	30,750	Elphin DD	Owenur River	Upper Shannon	4	31.60	11
WB52.01	N5	52,830	Strokes-town DD	Scramoge River	Upper Shannon	3-4	188.12	15
WC12.01	N5	12,700	OPW Boyle Scheme	Trib. Of Carricknabraher	Upper Shannon	4	3.74	2
WC12.02	LT-56403 North	255	No	-	Upper Shannon	-	3.74	2

Culvert No.	Location	Ch.	Drainage District Channel	Watercourse Name	WFD River Basin Catchment	Ecological Evaluation	Catchment	
							Area, km^2	Ref. No.
WC14.01	N5	14,600	OPW Boyle Scheme	Trib.of Owennaforeesha	Upper Shannon	3-4	5.93	4
WC15.01	N5	15,210	OPW Boyle Scheme	-	Upper Shannon	-	0.09	5
WC21.01	N5	21,325	No	Mantua River	Upper Shannon	-	1.16	6
WC21.02	LS-6023	70	No	Mantua River	Upper Shannon	-	1.53	7
WC23.01	N5	23,200	No	-	Upper Shannon	-	0.17	9
WC24.01	N61 South	235	No	-	Upper Shannon	-	10.24	10
WC24.02	N61 North	800	No	-	Upper Shannon	-	2.16	8
WC33.01	N5	33,200	No	-	Upper Shannon	-	0.16	12
WC33.02	Access	33,200	No	-	Upper Shannon	-	0.16	12
WC33.03	Access	33,345	No	-	Upper Shannon	-	0.16	12
WC51.01	N5	51,110	Strokes-town DD	Strokestown River	Upper Shannon	3-4	5.30	14
WC52.01	LS-6121 East	50	No	-	Upper Shannon	-	0.25	16

As can be seen from above Table 10.22, the majority of the streams intercepted are relatively small in respect to catchment area and the recommended dimensions provided below support the existing stream channel dimensions and will not result in any significant contraction of the streamflow 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.

Table 10.23: Minimum Sizing of Water-Crossing Culverts

Culvert No.	Location	Ch.	Length (m)	Size (Pipe Dia) (m)	Size		Mammal Pass Requirement	Fisheries Requirement
					W (m)	H (m)		
WB10.01	N5	10,130	32	N/A	8.00	3.30	Bridge will over span bank to maintain mammal pass	Bridge to be constructed online
WC12.01	N5	12,700	37	N/A	2.70	2.70	Separate 600mm dia pipe for mammal pass next to crossing	Culvert to be constructed offline
WC12.02	LT-56403 North	312	33	N/A	2.70	2.70	Separate 600mm dia pipe for mammal pass next to crossing	Culvert to be constructed online

Culvert No.	Location	Ch.	Length (m)	Size (Pipe Dia) (m)	Size		Mammal Pass Requirement	Fisheries Requirement
					W (m)	H (m)		
WB14.01	N5	14,525	40	N/A	7.00	3.30	Bridge will over span bank to maintain mammal pass	Bridge to be constructed online, with stream diversions not to exceed 60 degrees angle or meandering.
WC14.01	N5	14,600	42	N/A	3.30	2.40		Culvert to be constructed offline, with stream diversions not to exceed 60 degrees angle or meandering.
WC15.01	N5	15,210	44	1.20	N/A	N/A		Culvert to be constructed online
WC21.01	N5	21,325	30	N/A	2.70	1.80		Culvert to be constructed online, with stream diversions not to exceed 60 degrees angle or meandering.
WC21.02	LS-6023	70	25	N/A	3.00	1.80		Culvert to be constructed offline, with stream diversions not to exceed 60 degrees angle or meandering.
WC23.01	N5	23,200	37	1.20	N/A	N/A		Drainage pipe changed to a culvert
WC24.01	N61 South	235	26	N/A	4.20	2.40		Culvert to be constructed offline, with stream diversions not to exceed 60 degrees angle or meandering.
Culvert WC24.02	N61 North	800	20	1.80	N/A	N/A		-
WB30.01	N5	30,750	27	N/A	9.00	3.60	Bridge will over span bank to maintain mammal pass	Bridge to be constructed online
WC33.01	N5	33,200	37	1.20	N/A	N/A		Culvert to be constructed online
WC33.02	Access	33,200	10	1.20	N/A	N/A		Culvert to be constructed online
WC33.03	Access	33,345	10	1.20	N/A	N/A		Culvert to be constructed online
WC51.01	N5	51,110	47	N/A	4.20	2.10	Single mammal ledge.	Culvert to be constructed offline, with stream diversions not to exceed 60 degrees angle or meandering.

Culvert No.	Location	Ch.	Length (m)	Size (Pipe Dia) (m)	Size		Mammal Pass Requirement	Fisheries Requirement
					W (m)	H (m)		
WC52.01	LS-6121 East	50	30	1.50	N/A	N/A		Culvert to be constructed online
WB52.01	N5	52,830	21	N/A	20.00	3.60	Bridge will over span bank to maintain mammal pass	Bridge to be constructed online

Notes:

1) *All box culverts are to be constructed to an invert level 500mm below that of the existing channel.*
2) *All piped culverts are to be constructed to an invert level minimum 300mm below that of the existing channel.*
3) *The sizes indicated above are full sizes inclusive of any increases required to accommodate depressed inverts or mammal ledges.*

The above crossing sizes (Table 10.23) 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 1200mm diameter concrete pipe or equivalent.

Under the 1945 Arterial Drainage Act 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. 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.

Section 50 applications for all culvert and diversion arrangements have been submitted and approved by the OPW as part of the design process. The proposed culverting at each of the watercourse crossings 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

Stream diversions/realignments are not proposed on the major Salmonid Rivers; the Carricknabraher, Owenoforeesha and Scramoge Rivers. 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.).

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 10.24 summarises the proposed watercourse diversion locations and mitigation – mitigation measures are discussed in more detail in Section 10.5.

Table 10.24: Impact Assessment of Diversions/Realignments of Non-sensitive Watercourses

Chainage From	Chainage To	Ref.	Impact on Flood Flow Magnitude	Impact on Watercourse Morphology	Designed Protection Measures
10130	10330	WD10.01	Minor	Slight	Bank Erosion control at bends
12700	12740	WD12.01	Minor	Slight	Bank Erosion control at bends
14600	14680	WD14.01	Minor	Slight	Bank Erosion control at bends
14590	14600	WD14.02	Minor	Slight	Bank Erosion control at bends
17300	17570	WD17.01	Minor	Slight	Bank Erosion control at bends
21300	21330	WD21.01	Minor	Slight	Bank Erosion control at bends
21740	21760	WD21.02	Minor	Slight	Bank Erosion control at bends
21770	21830	WD21.03	Minor	Slight	Bank Erosion control at bends
30000	30030	WD24.01	Minor	Slight	Bank Erosion control at bends
30600	30720	WD30.01	Minor	Slight	Bank Erosion control at bends
30720	30850	WD30.02	Minor	Slight	Bank Erosion control at bends
33190	33195	WD33.01	Minor	Slight	Bank Erosion control at bends
33200	33350	WD33.02	Minor	Slight	Bank Erosion control at bends
51100	51105	WD51.01	Minor	Slight	Bank Erosion control at bends
51100	51190	WD51.02	Minor	Slight	Bank Erosion control at bends
52850	52900	WD52.01	Minor	Slight	Bank Erosion control at bends
52800	53000	WD52.02	Minor	Slight	Bank Erosion control at bends

10.4.7 Bridge Crossings

Clear span bridges are proposed to avoid constructing piers in-stream at the Carricknabraher, Owennaforeesha, Owenur and Scramoge River crossings. The Strokestown River is also crossed by the proposed road development using a box culvert structure which provides a complete span of the channel given the relatively smaller river channel size.

In order to avoid any potential scour risk associated with the construction of these bridge structures, abutments for bridges will be sufficiently set back from the channel edge with foundations located at depth. This will protect the river channel from changes in morphology, whereby, the channel over time could naturally migrate towards one of the abutments. Each of the proposed major watercourse crossings are discussed in more detail below.

10.4.7.1 Carricknabraher River Bridge Crossing

The span of the proposed bridge is 8m. The estimated design flood level at this crossing point is 79.46m O.D. and therefore the minimum soffit level for the bridge is 79.76m O.D. which provides the required 300mm clearance above the design flood level (100year Flood level with a 20% allowance for the potential effects of Climate Change as per OPW Section 50 requirements).

10.4.7.2 Owennaforeesha River Bridge Crossing

The span of the proposed bridge is 7.0m. The estimated design flood level at this crossing point is 67.46m O.D. and therefore the minimum soffit level for the bridge is 67.76m O.D. which provides the required 300mm clearance above the design flood level (100 year Flood level with a 20% allowance for the potential effects of Climate Change as per OPW Section 50 requirements).

10.4.7.3 Owenur River Bridge Crossing

The span of the proposed bridge is 9.0m. The estimated design flood level at this crossing point is 48.30m O.D. and therefore the minimum soffit level for the bridge is 48.6m O.D. which provides the required 300mm clearance above the design flood level (100 year Flood level with a 20% allowance for the potential effects of Climate Change as per OPW Section 50 requirements).

10.4.7.4 Scramoge River Bridge Crossing

The span of the proposed bridge is 20m. The estimated design flood level at this crossing point is 40.67m O.D. and therefore the minimum soffit level for the bridge is 40.97m O.D. which provides the required 300mm clearance above the design flood level (100 year Flood level with a 20% allowance for the potential effects of Climate Change as per OPW Section 50 requirements).

10.4.7.5 Strokestown River Box Culvert Crossing

The span of the proposed box culvert is 4.2m. The estimated design flood level at this crossing point is 40.74m O.D. and the soffit level for the bridge is 41.04m O.D. which provides the required 300mm clearance above the design flood level (100 year Flood level with a 20% allowance for the potential effects of Climate Change as per OPW Section 50 requirements).

The hydrological impact of each of these crossings will have a negligible impact on flooding in terms of flood levels and flow velocities either locally, upstream or downstream of the site as it does not represent a contraction of the river and floodplain flow and retains the natural river channel.

10.4.8 Storm Outfalls

The proposed road development has 22 separate storm outfall discharges along its 33.4km mainline length, which represents on average of one outfall for every 1.5km of road length – see Table 10.25. All of these outfalls discharge to surface watercourses. These outfalls have a 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 development. These impacts are assessed by using the guidelines provided in the appropriate TII/NRA DMRB document DN-DNG-03065 – "*Road Drainage and the Water Environment*". These storm outfalls also have the potential to impact the flood and morphological regime of a receiving water by increasing the volume and rate of runoff during storm events. The morphology of the stream is significantly influence by ambient flow and flooding conditions in the stream. The potential increase in flow arises from increased impervious area by 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 increase the rate of runoff over the natural Greenfield condition. It is anticipated that the proposed road drainage outfalls will give rise to an overall improvement in water quality of the receiving watercourses as it will generally improve the existing situation of untreated storm drainage from the existing N5 road being discharged. 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.

10.4.9 Predicted impact of Storm Discharge on Flooding / Morphology

The 22 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 is presented in Table 10.32 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 catchment area <10km^2 and Slight to Negligible Impact where catchment area exceeds 10km^2. The reason for this reduced potential stormwater flood impact in larger catchment sizes is due to the smaller stormwater volume relative to the natural stream and river flood volume. The potential increase in the ambient flood levels arising in larger catchment sizes therefore is reduced.

10.4.10 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 proposed 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 (HGV's). A Spillage risk Assessment for the proposed development has been carried out in accordance with the TII//NRA standard DN-DNG-03065 – see Table 10.25. The spillage assessment shows the proposed road development to have very low magnitude of risk for individual or grouped catchment outfalls and shows the overall spillage risk for the entire development to be < 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 N5, 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.

Table 10.25 Spillage Risk Assessment at Proposed Outfalls and for Catchments

Outfall	Outfall Chainage	Mainline Length (m)	Outfall Risk (%)	Catchment Combined Risk (%)	River System	Comment
OUT1.01	1+150	1477	0.019	0.019	-	Low Risk
OUT4.01	4+195	2027	0.027	0.027	-	Low Risk
OUT5.01	5+600	1300	0.018	0.046	Carricknabrahar	Low Risk
OUT10.01	10+350	2041	0.028			Low Risk
OUT12.01	12+700	509	0.006	0.006	Trib. Of Carricknabrahar	Low Risk
OUT14.01	14+500	1800	0.016	0.046	Owennaforeesha	Low Risk
OUT14.02	14+500	3300	0.030			Low Risk
OUT21.01	21+050	3525	0.031	0.036	Mantua River	Low Risk
OUT21.02	21+350	527	0.005			Low Risk
OUT22.01	22+900	1073	0.010	0.010	-	Low Risk
OUT30.01	30+500	2000	0.018	0.018	Trib. Of Owenur	Low Risk
OUT30.02	30+900	1763	0.018	0.023	Owenur River	Low Risk
OUT24.01	N61 0+800	-	0.005			Low Risk
OUT33.01	33+250	737	0.008	0.008		Low Risk
OUT33.02	33+750	1750	0.018	0.060	Unnamed	Low Risk
OUT34.01	34+750	3975	0.042			Low Risk
OUT51.01	51+000	3800	0.042	0.042	Ovaun River	Low Risk
OUT51.02	51+422	1019	0.011	0.012	Strokestown	Low Risk
OUT40.01	L1405 0+300	-	0.001			Low Risk
OUT52.01	52+850	661	0.007	0.020	Scramoge	Low Risk
OUT52.02	52+830	420	0.005			Low Risk
OUT53.01	53+250	708	0.008			Low Risk
Total			**0.374**			**Low risk = <1%**

Note: The total is given for indicative purposes only.

10.4.11 Dilution Flow Estimates in receiving Rivers and Streams

The 95-percentile low flow rates in the receiving watercourses (road drainage outfalls) was estimated using the EPA Hydrotool empirical Low Flow formulae for Ireland based on the hydrometric gauge network for Ireland and Catchment Descriptors (see Table 10.29). The EPA Hydrotool was also used for a number of larger tributaries (Carricknabraher River, Owennaforeesha River, Mantua Stream, Owenur River, Strokestown River and the Scramoge River); see Table 10.26 below.

Table 10.26 Summary of 95th-Percentile Low Flow Rates in the Receiving Watercourses

River/Stream	Area (km^2)	Upper 95% CI (m^3/s)	Lower 95% CI (m^3/s)	95th Percentile Flow (m^3/s)	Median Flow (m^3/s)
Carricknabraher River	19.9	0.042	0.019	0.028	0.298
Owennaforresha River	26.3	0.029	0.013	0.019	0.375
Mantua Stream	5.0	0.005	0.002	0.004	0.071
Owenur River	33.1	0.087	0.038	0.058	0.497
Strokestown Stream	11.9	0.013	0.006	0.009	0.169
Scramoge River	197.1	0.600	0.267	0.4	3.261

It must be noted that the catchment areas shown above are those based on point estimates by the EPA Hydrometric Data System and will therefore slightly differ (<5%) from those which are based on the outfall locations given in Section 10.3.

Based on the above estimates a general equation for the study area based on an area flow relationship can be developed to estimate the 95-percentile and median flows for other streams as follows:

$$q_{95} = 0.0005x^{1.293}$$
$$q_{50} = 0.015x - 0.006$$

where x is the area of the catchment.

The fitted formula (using the EPA data) given is for a catchment area of 1km^2, a 95th-percentile flow rate of 0.5l/s and a median flow of 9l/s. This is applicable to the study area and is not a nationally derived equation. These low flow estimates were used to determine the available dilution characteristics at each of the outfalls as given in Table 10.29. In addition the median flows were also used in the HAWRAT calculations described above (Table 10.27).

10.4.12 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.

There are a total of 22 outfall locations over a 33.4km road length. This 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 available dilutions and the evaluated individual outfall water quality impacts are presented in Tables 10.29 and 10.30 respectively. 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/NRA DMRB 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 22 proposed drainage outfalls along the proposed development see Table 10.27 below. The HAWRAT assessment tool uses a minimum AADT of 10,000 in the assessment process which is well above the projected traffic figures for the N5 Ballaghaderreen to Scramoge road project (almost twice the AADT for some sections), and thus actual pollutant concentrations are expected to be considerably lower than the estimates from the HAWRAT assessment.

Table 10.27 Results of the HAWRAT Assessment

Outfall No.	Water Hardness (mg/l $CaCO_3$)	Average Annual Concentration					
		Without Mitigations (ug/)l			With Mitigations (ug/l)		
		Copper	Zinc	Sediment	Copper	Zinc	Sediment
1.01	High >200	1.82	5.65	Pass	1.09	3.39	Pass
4.01	High >200	0.65	2.03	**FAIL**	0.39	1.22	Pass
5.01 & 10.01	Medium 50 - 200	0.26	0.8	Pass	0.16	0.48	Pass
12.01	Medium 50 - 200	0.19	0.58	Pass	0.11	0.35	Pass
14.01 & 14.02	Medium 50 - 200	0.31	0.97	Pass	0.19	0.58	Pass
21.01 & 21.02	High >200	0.91	3.2	Pass	0.55	1.92	Pass
22.01	High >200	0.98	3.05	Pass	0.59	1.83	Pass
30.01 & 30.02	High >200	0.21	0.76	Pass	0.13	0.46	Pass
30.03	Low < 50	0.45	1.41	Pass	0.27	0.84	Pass
33.01 & 33.02	High >200	0.76	2.35	Pass	0.45	1.41	Pass
34.01	High >200	1.58	4.93	**FAIL**	0.95	2.96	**Pass***
51.01 & 51.02	High >200	0.48	1.73	**FAIL**	0.29	1.04	Pass
40.01	Low < 50	1.26	3.94	**FAIL**	0.76	2.36	Pass
52.01, 52.02 & 53.01	High >200	0.01	0.03	Pass	0	0.02	Pass

**Outfall 34.01 failed the initial assessment with the mitigation of one pond. An additional pond was added downstream of the first pond the HAWRAT assessment was then passed.*

It can be seen that all of the outfalls passed the HAWRAT assessment with the exception of outfall OUT34.01. The failure was based on the sediment load from the associated road drainage. An additional secondary treatment pond was added to the design at this outfall in response to the initial failure of the HAWRAT and the proposed outfall subsequently passed the HAWRAT assessment. This two stage treatment approach will serve to further reduce the sediment load and will ensure no degradation in water quality occurs at this location.

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.**

10.4.13 Impact on Natural Heritage

10.4.13.1 European Designated Sites (SAC/SPA)

An assessment of the potential impact for European designated sites was carried out and is summarised in Table 10.28 below.

Table 10.28: Rating of Significant Environmental Impacts Caused to European Designated Sites

Impact				
Site Name	**Importance**	**Description**	**Magnitude of Impact**	**Impact Rating**
Bellanagare Bog SAC (000592) SPA (004105)	Extremely Important	Changes to surface hydrology or water balance in the sensitive habitat due to the construction of the proposed road development.	Slight	Imperceptible
Annaghmore Lough (Roscommon) SAC (001626)	Extremely Important		Slight	Imperceptible
Cloonshanville Bog SAC (000614)	Extremely Important		Slight	Imperceptible
Lough Forbes Complex SAC (001818)	Extremely Important		Slight	Imperceptible
Lough Gara SPA (004048)	Extremely Important		Slight	Imperceptible
Callow Bog SAC	Extremely Important		Slight	Imperceptible

The nature of the proposed road development will result in only small localised changes in surface water flow. Each of the hydrologically sensitive areas listed above are located outside the zone of influence and 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 N5; the proposed 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.

10.4.14 Impact on Water Supply Sources

There will be no impact on either the North Roscommon Regional Water supply or the Northeast Roscommon & Ballyleague Regional Water supply as they are both located a significant distance downstream (>2km) from the proposed road development with only one road drainage outfall discharging to each catchment. Impacts on the three local group groundwater supply schemes have been addressed in detail in **Chapter 9 Hydrogeology**.

10.4.15 Impact to Ecological Receptors

A number of ecological receptors adjacent to the proposed road development have been identified and discussed in detail in the **Chapter 7**. A water quality impact assessment was carried out at each outfall location along the proposed road development and the results are given in Table 10.33. Each of the outfalls have been assessed in terms of the predicted impact on the receiving waters in respect to flooding and morphological changes and the outcome of this assessment is given in Table 10.33.

The results of the impacts presented in Tables 10.33 and 10.34 were used to assess potential hydrological impacts to identified ecological receptors. This assessment summary is given in Table 10.35.

Table 10.29 Dilution Characteristics of Receiving Surface Watercourses

Outfall	Outfall Chainage	Road Section	Total Impervious Road Area (ha)	Catchment Area (km^2)	95% DWF l/s	Dilution Characteristics	Receiving Water Details	Comment
OUT1.01	1+150	Ch. 1,000 to Ch. 2,477	3.4	0.135	<0.5	Low summer dilution available	-	Minor stream
OUT4.01	4+195	Ch. 2,477 to Ch. 4,504	2.52	1.41	0.8	Low summer dilution available	-	Outfall downstream of KER1
OUT5.01	5+600	Ch. 4,504 to Ch. 10,150	4.77	20.9	29.4	Good summer dilution	Carricknabraher River	Outfall downstream of KER2 & upstream of KER3
OUT10.01	10+350	Ch. 10,150 to Ch. 12,191				Good summer dilution	Carricknabraher River	Outfall upstream of KER3
OUT12.01	12+700	Ch. 12,191 to Ch. 12,700	0.553	3.74	5.3	Moderate to low dilution available	Trib. of Carricknabraher River	Outfall downstream of KER6
OUT14.01	14+500	Ch. 12,700 to Ch. 14,500	6.3	32.1	23.2	Good summer dilution	Owennaforeesha River	Outfall downstream of KER7 & 8
OUT14.02	14+500	Ch. 14,500 to Ch. 17,800				Good summer dilution	Owennaforeesha River	Outfall downstream of KER7 & 8
OUT21.01	21+050	Ch. 17,800 to Ch. 21,350	5.25	1.16	0.9	Low summer dilution available	Mantua Stream	Outfall upstream of KER12
OUT21.02	21+350	Ch. 21,350 to Ch. 21,877				Low summer dilution available	Mantua Stream	Outfall upstream of KER12
OUT22.01	22+900	Ch. 21,877 to Ch. 22,950	1.44	0.36	1	Low summer dilution available	Trib. of Owenur River	-
OUT30.01	30+500	Ch. 22,950 (section B) to Ch. 30,750 (section C)	5.428	31.6	55.3	Good summer dilution	Owenur River	Outfall upstream of KER15
OUT30.02	30+900	Ch. 30,750 to Ch. 32,513				Good summer dilution	Owenur River	Outfall upstream of KER13

Outfall	Outfall Chainage	Road Section	Total Impervious Road Area (ha)	Catchment Area (km^2)	95% DWF l/s	Dilution Characteristics	Receiving Water Details	Comment
OUT24.01	N61 0+800	Shankhill Roundabout	1.01	2.34	1.5	Low summer dilution available	Trib. of Owenur River	Outfall upstream of KER13
OUT33.01	33+250	Ch. 32,513 to Ch. 33,250	3.1	0.16	<0.5	Low summer dilution available	Ovaun River	Outfall within KER14
OUT33.02	33+750	Ch. 33,250 to Ch. 35,000				Low summer dilution	Ovaun River	Outfall within KER14
OUT34.01	34+750	Ch. 35,000 to Ch. 38,975	5.26	3.33	2.4	Moderate summer dilution	Ovaun River	Outfall within KER14
OUT51.01	51+000	Ch. 38,875 to Ch. 51,150	4.984	5.3	0.4	Low summer dilution	Strokestown River	Outfall downstream of KER17
OUT51.02	51+400	Ch. 51,150 and Ch. 52,169				Low summer dilution	Strokestown River	Outfall located within KER17
OUT40.01	L1405 0+300	Kildalloge Roundabout	1.01	0.236	<0.5	Low summer dilution	-	
OUT52.01	52+850	Ch. 52,169 and Ch. 52,830	2.51	188.12	381.8	Good summer dilution	Scramoge	Outfall upstream of KER19
OUT52.02	52+830	Ch. 52,830 and Ch. 53,250				Good summer dilution	Scramoge	Outfall upstream of KER19
OUT53.01	53+250	Ch. 53,250 and Ch. 53,958				Good summer dilution	Trib. of Scramoge	Outfall upstream of KER19 & downstream of KER20

Table 10.30 Water Quality Impact Assessment

Outfall	Outfall Chainage	Dilution Characteristics	Receiving Water Details	Water Quality Impact	Comment
OUT1.01	1+150	Low summer dilution available	-	Slight Permanent Local	Minor stream
OUT4.01	4+195	Moderate summer dilution	-	Slight Permanent Local	Outfall 1.3km upstream of converge with Carricknabraher River
OUT5.01	5+600	Good summer dilution	Carricknabraher	Slight Permanent Local	Outfall 0.2km upstream of converge with Carricknabraher River
OUT10.01	10+350	Good summer dilution	Carricknabraher	Slight Permanent Local	Outfall direct to Carricknabraher River
OUT12.01	12+700	Moderate to low dilution available	Trib. of Carricknabraher	Slight Permanent Local	Outfall to minor stream
OUT14.01	14+500	Good summer dilution	Owennaforeesha	Slight Permanent Local	Outfall direct to Owennaforeesha River
OUT14.02	14+500	Good summer dilution	Owennaforeesha	Slight Permanent Local	Outfall direct to Owennaforeesha River
OUT21.01	21+050	Low summer dilution available	Mantua River	Slight Permanent Local	Outfall direct to Mantua River
OUT21.02	21+350	Low summer dilution available	Mantua River	Slight Permanent Local	Outfall direct to Mantua River
OUT22.01	22+900	Low summer dilution available	Trib. of Owenur	Slight Permanent Local	Outfall to minor stream
OUT30.01	30+500	Good summer dilution	Owenur River	Slight Permanent Local	Outfall direct to Owenur River
OUT30.02	30+900	Good summer dilution	Owenur River	Slight Permanent Local	Outfall direct to Owenur River
OUT24.01	N61 0+800	Low summer dilution available	Trib. of Owenur	Slight Permanent Local	Outfall 1.5km upstream of converge with Owenur River
OUT33.01	33+250	Low summer dilution available	Unnamed	Slight Permanent Local	Outfall 0.3km upstream of Clooncullaan Lough
OUT33.02	33+750	Low summer dilution	-	Slight Permanent Local	Outfall 0.3km upstream of Clooncullaan Lough
OUT34.01	34+750	Moderate summer dilution	Ovaun River	Slight Permanent Local	Outfall 1.3km upstream of Clooncullaan Lough Swallow hole located 750m downstream.
OUT51.01	51+000	Good summer dilution	Strokestown River	Slight Permanent Local	Outfall direct to Strokestown River

Outfall	Outfall Chainage	Dilution Characteristics	Receiving Water Details	Water Quality Impact	Comment
OUT51.02	51+400	Low summer dilution available	-	Slight Permanent Local	Outfall to minor stream
OUT40.01	L1405 0+300	Low summer dilution available	-	Slight Permanent Local	Outfall to minor stream
OUT52.01	52+850	Good summer dilution	Scramoge River	Slight Permanent Local	Outfall direct to Scramoge River
OUT52.02	52+830	Good summer dilution	Scramoge River	Slight Permanent Local	Outfall direct to Scramoge River
OUT53.01	53+250	Good summer dilution	Trib. of Scramoge River	Slight Permanent Local	Outfall 0.4km from Scramoge River

Table 10.31 Impact Assessment of Storm Drainage on Receiving Waters in Respect to Flooding and Morphological Changes

Outfall	Outfall Chainage	Mainline Road Length (m)	Total Impervious Road Area ha	Receiving Water Catchment Area ha	Channel / lake Capacity	100yr Greenfield Flood Runoff Rate in Receiving Stream (l/s)	Potential Impact
OUT1.01	1+150	1477	3.4	0.135	Narrow vegetated channel moderate capacity	895	Slight Local
OUT4.01	4+195	2027	2.52	1.41	Good capacity channel	2252	Slight Local
OUT5.01	5+600	1300	4.77	20.9	Good capacity wide flat gravelly base	24140	Slight Local
OUT10.01	10+350	2041					Slight Local
OUT12.01	12+700	509	0.553	3.74	Narrow vegetated channel moderate capacity	5367	Slight Local
OUT14.01	14+500	1800	6.3	32.1	Good capacity wide flat gravelly base	18671	Slight Local
OUT14.02	14+500	3200					Slight Local
OUT21.01	21+050	3325	5.25	1.16	Good capacity channel	1893	Slight Local
OUT21.02	21+350	527					Slight Local
OUT22.01	22+900	1073	1.44	0.36	Narrow vegetated channel moderate capacity	895	Slight Local
OUT30.01	30+500	2000	5.428	31.6	Good capacity wide flat base.	35862	Slight Local
OUT30.02	30+900	1763					Slight Local
OUT24.01	N61 0+800	-	1.01	2.34	Moderate Capacity Channel	1058	Slight Local
OUT33.01	33+250	737	3.1	0.16	Sluggish overgrown channel of moderate capacity	895	Slight Local
OUT33.02	33+750	1750					Slight Local
OUT34.01	34+750	3975	5.26	3.33	Sluggish overgrown channel of moderate capacity	4840	Slight Local
OUT51.01	51+000	3800	4.984	5.3	River channel with good capacity wide flat base.	3036	Slight Local
OUT51.02	51+400	1019					Slight Local

Outfall	Outfall Chainage	Mainline Road Length (m)	Total Impervious Road Area ha	Receiving Water Catchment Area ha	Channel / lake Capacity	100yr Greenfield Flood Runoff Rate in Receiving Stream (l/s)	Potential Impact
OUT40.01	L1405 0+300	-	1.01	23.6	Moderate capacity channel	295	Slight Local
OUT52.01	52+850	661	2.51	188.12	River channel with good capacity wide flat base	57909	Slight Local
OUT52.02	52+830	420					Slight Local
OUT53.01	53+250	708					Slight Local

Table 10.32 Rating of Potential Hydrological Impacts to Identified Key Ecological Receptors

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 1a(N) & 1B(C) Ch. 4+000 to Ch. 4+500	Wet Grassland (Molina Meadows) National Importance & County Importance	Construction	Silts and sediments arising from works adjacent to watercourses and construction site runoff.	The wet Grassland type systems are not very sensitive in terms of water quality and soil chemistry to associated construction pollution.	Negligible
			Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	Construction spillages do not represent a significant threat to these wet lands.	Negligible
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands. Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.)	There is no proposed direct encroachment into the KER nor are there any temporary works proposed within the KER.	Negligible
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	There are no proposed drainage outfalls discharging to this KER. The water quality impact from the road drainage system will be negligible.	Negligible
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Interceptor toe drains and a culvert are proposed in the vicinity of the KER which could potentially slightly alter the drainage in the vicinity of the Wet grassland and Molina Meadows both north and south of the road.	Slight to moderate
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands.	At this location the road formation itself is at grade and excavation of unsuitable material beneath the road alignment will be minimal.	Negligible

Attribute		Impact			
KER Receptor No.	Receptor Name and importance	Stage	Nature of Impact	Description of Impact	Impact Rating
KER 2a(LH) & 2b(N) Ch. 5+000 to Ch. 5+500	Degraded and intact Raised Bog and Cutover bog National Importance & Local Importance (Higher Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	This raised bog habitat system is not very sensitive in terms of water quality and soil chemistry impact associated from construction activities.	Negligible
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages do not represent a significant threat to this peatland system.	Negligible
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams, culverts channel diversions, sediment ponds, silt fences etc.).	There is no direct encroachment into the KER but the alignment comes close to the cutover bog section of this KER.	Slight
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges - Accidental fuel spills from road	There are no proposed drainage outfalls discharging to this KER. The water quality impact from the road drainage system will be negligible	Negligible
			Road Drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Interceptor toe drains and a culvert are proposed in the vicinity of the KER which could potentially alter the drainage in the KER.	Slight to moderate
			Changes to watercourse channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on watercourse channel morphology at this section will be negligible with no culverting proposed.	Negligible
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas.	At this location the road formation itself is in embankment and excavation of unacceptable material beneath the road alignment at 2 to 3m excavation depths could give rise to drainage impacts on the adjacent cutover bog and potentially on the Raised Bog Habitat further to the south. In addition a bog access road is proposed adjacent to the proposed alignment which could also change the drainage regime of the bog locally.	Moderate

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 3(LH) Ch. 10+125 to Ch. 10+150	Carrickna-braher River Local Importance (Higher Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	This River System which hosts aquatic habitats and species is sensitive to water quality impacts associated from construction activities.	Moderate / Significant
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands	Construction spillages if uncontrolled represent a significant threat to aquatic life both locally and downstream.	Moderate
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).	There is a proposed water course crossing of this KER which may involve direct encroachment through in-stream works, floodplain and river bank works.	Moderate
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	There are two proposed road drainage outfalls discharging to this KER. The water quality impact from the road drainage system based on traffic numbers represents a locally moderate adverse impact.	Slight
			Road Drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Road drainage outfalls will undergo attenuation and effect of road drainage and interceptor drains will have a negligible to small adverse impact on the flow regime and water balance.	Slight
			Changes to watercourse channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on watercourse channel morphology at this section will be minor as the proposed culvert/bridge with be full spanning and river regrading works are not proposed.	Slight
			Changes to watercourse channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition	Impact on watercourse morphology at this section will be negligible with no culverting proposed.	Negligible
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas	Given the scale of the river catchment, such interception by the road and it formation layer will be negligible in terms of the water balance.	Negligible

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 4(C) Ch. 10+750 to Ch. 10+850	Wet Grassland (Molinia Meadows) County Importance	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	This raised bog habitat system is not very sensitive in terms of water quality and soil chemistry impact associated from construction activities.	Negligible
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages do not represent a significant threat to this peatland system.	Negligible
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams, culverts channel diversions, sediment ponds, silt fences etc.)	There is no proposed direct encroachment into the KER but alignment comes very close to the cutover bog section of this KER.	Slight
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	There are no proposed drainage outfalls discharging to this KER. The water quality impact from the road drainage system will be negligible.	Negligible
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Interceptor toe drains are proposed in the vicinity of the KER which could potentially alter the drainage in the KER.	Slight
			Changes to watercourse channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on watercourse channel morphology at this section will be negligible with no culverting proposed.	Negligible
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas.	At this location the road formation itself is on embankment and excavation of unacceptable material beneath the road alignment will be required to depths of 2 to 2.5m which could give rise to slight drainage impacts on the adjacent Grasssland.	Slight

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 5(N) Ch. 11+480 to Ch. 12+150	Wet Grassland (Molinia Meadows) National Importance	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition)	This raised bog habitat system is not very sensitive in terms of water quality and soil chemistry impact associated from construction activities.	Negligible
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages do not represent a significant threat to this peatland system.	Negligible
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).	There is no proposed direct encroachment into the KER but alignment comes very close to the cutover bog section of this KER.	Slight
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	There are no proposed drainage outfalls discharging to this KER. The water quality impact from the road drainage system will be negligible.	Negligible
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Interceptor toe drains and a culvert are proposed in the vicinity of the KER which could potentially alter the drainage flow towards the KER.	Slight / moderate
			Changes to watercourse channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on watercourse channel morphology at this section will be minor to negligible with only a small low gradient drain being crossed and culverted.	Negligible
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas.	At this location the road formation itself is on embankment and excavation of unacceptable material beneath the road alignment will be required to depths of up to 4m which could give rise to drainage impacts on the adjacent Grasssland by the permeable road formation layer.	Moderate

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 6(a)(N), 6b(N), 6b(C), 6b(LH), 6c(N), 6c(LH), 6c(LL) Ch. 10+900 to Ch. 12+450	Peatland complex of Raised Bog and Cutover Bog with Wet Heath & Bog woodland National Importance, County Importance & Local Importance (Higher & Lower Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition)	This raised bog habitat system is not very sensitive in terms of water quality and soil chemistry impacts associated from road construction activities.	Negligible
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages do not represent a significant threat to this peatland system.	Negligible
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).	There is no proposed direct encroachment into National Important Raised Bog area of the KER but alignment encroaches the cutover bog section of this KER.	Slight / moderate
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	There are no proposed drainage outfalls discharging to this KER. The water quality impact from the road drainage system will be negligible.	Negligible
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Interceptor toe drains and a culvert are proposed in the vicinity of the KER which could potentially alter the drainage in the KER.	Slight to moderate
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on stream channel morphology at this section will be negligible with only one pipe culvert crossing proposed and no major diversions proposed	Negligible
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas.	At this location the road formation is in at grade and embankment and excavation of unacceptable material beneath the road alignment will be significant particularly between 10+900 to 11+700 at up to 4m excavation depth which could give rise to drainage impacts on the adjacent cutover bog and on the Raised Bog Habitat to the south (a portion of which forms part of the Bellanagare Bog SAC/SPA).	Moderate

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 7a(N) & 7b(LH) Ch. 13+950 to Ch. 14+450	Peatland complex of Raised Bog and Cutover Bog with Bog woodland National Importance and Local importance (Higher Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	This raised bog habitat system is not very sensitive in terms of water quality and soil chemistry impact associated from construction activities.	Negligible
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages do not represent a significant threat to this peatland system.	Negligible
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.)	There is no proposed direct encroachment into National Important Raised Bog area of this KER but alignment encroaches the cutover bog section.	Slight / moderate
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	There are no proposed drainage outfalls discharging to this KER. The water quality impact from the road drainage system will be negligible.	Negligible
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	A number of local drains in the cutover bog will be intercepted and diverted to longitudinal drains Interceptor toe drains and a culvert are proposed in the vicinity of the KER which could potentially alter the drainage in the KER.	Slight to moderate
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on stream channel morphology at this section will be negligible with only one pipe culvert crossing proposed and no major diversions proposed.	Negligible
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas	At this location the road formation is in sizeable embankment and excavation of unacceptable material beneath the road alignment will be significant at depths potentially up to 6m excavation which could give rise to drainage impacts on the adjacent cutover bog and on the Raised Bog Habitat to the north.	Moderate

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER (LH) Ch. 14+450 to Ch. 14+800	Owennaforeesha River Local Importance (Higher Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	This River System which hosts aquatic habitats and species is sensitive to water quality impacts associated from construction activities.	Moderate / Significant
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages if uncontrolled represent a significant threat to aquatic life both locally and downstream.	Moderate
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).	There is a proposed water course crossing of this KER which may involve direct encroachment floodplain and river bank works.	Moderate
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	There are two road drainage outfalls to this river and it adjoining tributary proposed which represents a direct potentially contaminated discharge to the KER. The water quality impact from the road drainage system based on traffic numbers represents a locally small to moderate adverse impact.	Slight / Moderate
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Road drainage outfalls will undergo attenuation and effect of road drainage and interceptor drains will have a negligible to small adverse impact on the flow regime and water balance of the river.	Slight
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on stream channel morphology at this section is possible with a new culvert and channel diversion to be constructed. The proposed dimensions will be full spanning at 7m.	Moderate
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effect on adjacent soils and wetland areas.	Given the scale of the river catchment such interception by the road and it formation layer will be negligible in terms of the water balance.	Negligible

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 9(LH) Ch. 14+500 to Ch. 14+650	Bog Woodland Local Importance (Higher Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	This Bog Woodland is not very sensitive in terms of water quality and soil chemistry impact associated from construction activities of a road project.	Negligible
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages do not represent a significant threat to this peatland system.	Negligible
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).	Direct encroachment into the KER and loss of woodland is proposed which is dealt with in the biodiversity impact assessment.	See Chapter 7 for details.
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	There are no proposed drainage outfalls discharging to this KER. The water quality impact from the road drainage system will be negligible.	Negligible
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Interceptor toe drains are proposed in the vicinity of the KER which could potentially alter the drainage in the KER and may potentially give rise to drier conditions.	Slight
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on stream channel morphology at this section is not applicable.	Negligible
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas.	At this location the road formation is on embankment and excavation of unsuitable material beneath the road alignment will be required to depths of up to 5m which could give rise to slight drainage impacts on the adjacent bog woodland.	Slight

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 10(LH) Ch 15+150 to Ch 15+300	Bog Woodland Local Importance (Higher Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	This Bog Woodland is not very sensitive in terms of water quality and soil chemistry impact associated from construction activities of a road project.	Negligible
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages do not represent a significant threat to this peatland system.	Negligible
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).	Direct encroachment into the KER and loss of woodland is proposed which is dealt with in the biodiversity impact assessment.	See Chapter 7 for details.
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	There are no proposed drainage outfalls discharging to this KER. The water quality impact from the road drainage system will be negligible.	Negligible
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Interceptor toe drains are proposed in the vicinity of the KER which could potentially alter the drainage in the KER and may potentially give rise to drier conditions.	Slight
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on stream channel morphology at this section is not applicable as there is no watercourse present.	N/A
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas.	At this location the road formation itself is at embankment and excavation of unsuitable material beneath the road alignment will be required to depths of up to 4m which could give rise to slight drainage impacts on the adjacent bog woodland.	Slight

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 11(LH) Ch 16+700 to Ch 17+200	Cut-over Bog and Bog Woodland Local Importance (Higher Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	This Ker comprising forestry on cutover bog is not very sensitive in terms of water quality and soil chemistry impact associated from construction activities of a road project.	Negligible
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages do not represent a significant threat to this peatland system.	Negligible
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).	Direct encroachment into the KER and loss of the KER is proposed which is dealt with in the biodiversity impact assessment.	See Chapter 7 for details.
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	There are no proposed drainage outfalls discharging to this KER. The water quality impact from the road drainage system will be negligible.	Negligible
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Interceptor toe drains are proposed in the vicinity of the KER which could potentially alter the drainage in the KER and may potentially give rise to drier conditions.	Slight
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on stream channel morphology at this section is not applicable.	Negligible
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas.	At this location the road formation is at grade but excavation and removal of unsuitable material beneath the road alignment will be required to depths of up to 2m which could give rise to slight drainage impacts on the adjacent peat. The KER is not very sensitive to drainage and such drying effects and therefore the impact will be negligible	Negligible

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 12(LH) 18+250 – 20+250	Mixed Broadleaved Woodland Local Importance (higher value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	This KER comprising forestry is not very sensitive in terms of water quality and soil chemistry impact associated from construction activities of a road project.	Negligible
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages do not represent a significant threat to this forestry system.	Negligible
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).	Direct encroachment into the KER and loss of the KER is proposed which is dealt with in the biodiversity impact assessment.	See Chapter 7 for details.
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	There are no proposed drainage outfalls discharging to this KER. The water quality impact from the road drainage system will be negligible.	Negligible
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Interceptor toe drains are proposed in the vicinity of the KER which could potentially alter the drainage in the KER and may potentially give rise to drier conditions.	Slight
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on stream channel morphology at this section is not applicable.	N/A
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas.	The KER is not very sensitive to drainage and such drying effects and therefore the impact will be negligible	Negligible

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 13(LH) Ch 30+550 to Ch 31+950	Upper Owenur River Marsh and Wet Grassland, Wet Grassland Reedswamp & Poor Fen Local Importance (Higher Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	This River System which is a highly modified river channel with no natural pattern of riffles, glides and pools. For the purposes of this assessment it is treated as a potential Salmonid river and thus sensitive to pollution from road projects.	Slight to Moderate
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages if uncontrolled represent a threat to aquatic life both locally and downstream.	Slight to Moderate
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).	There is a proposed water course crossing of this KER with the bridge crossing to be designed on line which will involve direct encroachment through limited in stream works, floodplain and river bank works.	Moderate
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	There is one proposed road drainage outfalls to this river which represents a direct potentially contaminated discharge to the KER. The water quality impact from the road drainage system based on traffic numbers represents a slight adverse impact.	Sligh
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Road drainage outfalls will undergo attenuation and the effect of road drainage and interceptor drains will have a negligible to slight adverse impact on the flow regime and water balance of the river.	Slight
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on stream channel morphology at this section is possible with the online bridge construction, however it is not envisaged that instream works are required for this crossing and therefore the impact on channel morphology will be slight to imperceptible. .	Slight
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effect on adjacent soils and wetland areas.	Given the scale of the river catchment interception and discharge by the road and it formation layer to this river will be negligible in terms of the water balance and flow regime of the receiving waters.	Negligible

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 14(LH) 32+900 – 34+450	Mature Tree Lines/ Wet Grassland Local Importance (higher value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	This KER comprising mainly tree lines is not very sensitive in terms of water quality and soil chemistry impact associated from construction activities of a road project.	Negligible
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages do not represent a significant threat to this tree line and grassland system.	Negligible
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).	Impacts relating to this KER are dealt with in the biodiversity impact assessment.	See Chapter 7 for details.
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	There are no proposed drainage outfalls discharging to this KER. The water quality impact from the road drainage system will be negligible.	Negligible
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Interceptor toe drains are proposed in the vicinity of the KER which could potentially alter the drainage in the KER and may potentially give rise to drier conditions.	Slight
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on stream channel morphology at this section is not applicable.	N/A
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas.	The KER is not very sensitive to drainage and such drying effects and therefore the impact will be negligible	Negligible

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 15a(LH), 15b(LL), Ch. 33+350 to Ch. 34+350	Lough Cloonculla an, and Surrounding Wetland Complex, Local Importance (Higher & lower Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	This alkaline Fen System to the north of the Lough is buffered by drainage channels that connect to the Lough and such fen systems would not be very sensitive to water quality impacts arising for road construction works both routine construction runoff or potential spillages during construction.	Slight to moderate
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages if uncontrolled represent a threat to aquatic life both locally and downstream.	Slight to Moderate
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.)	The road alignment passes close to the Annex I Alkaline fen and construction works will involve considerable excavation of unacceptable material and embanking of the road which may temporarily impact on drainage to and from the Fen and Lough system.	Slight to Moderate
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	Road drainage will discharge to a local drain that borders alkaline Fen to the north and also to the Ovaun Stream that enters the Lough immediately to the South of the KER. The potential water quality impact of these drains on the KER is likely to be slight given that these drains direct water into the Lough. Given the volume of water available in the Lough and the low volume of road runoff, there will be an imperceptible impact on water quality. The potential for spillage represents a slight to moderate impact.	Slight To Moderate
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Road drainage outfalls will undergo attenuation and the effect of road drainage and interceptor drains will be designed to have a negligible impact.	Slight
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on stream channel morphology at this section will be negligible.	Negligible

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effect on adjacent soils and wetland areas.	At this location the road alignment is in significant embankment and removal of unsuitable material beneath the road alignment will be required to depths of anything up to 8m. The proposed road construction could potentially intercept and divert the recharging north to south subsurface flows eastwards with the permeable road formation and thus potentially impact the water balance and hydrochemistry of the KER.	Moderate to Significant

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
15c(N), 15d(C) & 15e(C) Ch. 33+350 to Ch. 34+350	Annex I Transition Mire and Rich Fen Habitat National & County Importance	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition)	These KERs are reasonably buffered from the road construction site and unlikely assuming reasonable construction practices to be impacted by road construction works through direct encroachment of such habitats or by impacts from sediment runoff or potential spillages during construction.	Slight
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.		
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.)		
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	Road drainage will discharge to the Ovaun Stream downstream of these KERs and therefore road drainage discharges and potential spillages from the Road are unlikely to impact the water quality status of the Transition Mire and Fen and Wetland Habitat.	Negligible
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Road drainage outfalls will undergo attenuation and the road drainage and interceptor drains are designed to have a negligible impact.	Negligible
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on stream channel morphology at this section will be negligible as no encroachment outfall or culvert is proposed.	Negligible
			Interception of drainage paths by the permeable Road formation resulting in diversion of waters and in a dewatering effect on adjacent soils and wetland areas.	Up gradient of these KERs the alignment is in deep cutting into bedrock which is likely to intercept surface and sub-surface flows off the hillslopes to the northeast. The impact of the cutting and cut-off drains on hydrological regime of the KERs is likely to represent a small adverse impact.	Slight to Moderate

Attribute		**Impact**			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 16(N) Ch. 36+650 to Ch. 37+950	Turlough (Cregga) National Importance Annex I Priority Habitat	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	The proposed construction works involve significant deep bedrock cutting into the steep hill slopes above the Cregga Turlough Area. Given the terrain and the large excavation works involved, there is a high potential for sediment runoff from the works entering the Turlough area which, in the short term, could impact the water chemistry of the Turlough and result in silt deposition within the Turlough area.	Moderate to Significant
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	The road alignment does not encroach the Turlough area but will intercept its natural recharge waters via overland flow, interflow and deeper percolating flow which temporarily could impact the water balance of the Turlough and its habitat.	Moderate to Significant
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.)		
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	The road drainage will be a sealed system and will not discharge to the Cregga Turlough. This avoids potential water quality impacts from the routine road runoff waters and accidental road spillages.	Negligible
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	A loss of recharge water arising from direct rainfall on the road pavement area which will be piped to an outfall that discharges to the Ovaun Stream.	Slight
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition. Interception of drainage paths by the permeable Road formation resulting in diversion of waters and in a dewatering effect on adjacent soils and wetland areas.	The deep cutting will intercept hill slope runoff, interflow and groundwater recharge and flow which will potentially impact on the flow regime, the water balance and the water chemistry of the Turlough. Such an impact is considered to represent a potential significant impact to the hydrological function of the Turlough Habitat.	Significant

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 17(LH) Ch. 50+850 to Ch. 51+800	Cut-over Bog Bog Woodland Scrub and Grasslands Local Importance (Higher Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	This KER is not very sensitive in terms of water quality and soil chemistry impact associated from construction activities of a road project	Negligible
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages do not represent a significant threat to this semi-natural habitat system.	Negligible
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).	Direct encroachment into the KER and loss of cut-over bog and woodland is proposed which is dealt with in the biodiversity impact assessment.	See Chapter 7 for details.
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	The proposed road will outfall to the Strokestown River. The water quality impact from the road drainage system on this receptor will be negligible.	Negligible
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Interceptor toe drains are proposed in the vicinity of the KER which could potentially alter the drainage in the KER and may potentially give rise to drier conditions.	Slight
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on stream channel morphology at this section may be associated with the culverting of the Strokestown River. In the context of the overall KER such a local impact is considered small to negligible.	Negligible
			Interception of drainage paths by the permeable Road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas.	At this location the road formation is embankment and excavation of unacceptable material beneath the road alignment will be required at relatively shallow depths of 1 to 2m which is unlikely to give rise to significant drainage effects on the KER.	Negligible

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 18(LH) Ch. 52+150 – Ch. 52+650	Mixed Woodland & Scrub Local Importance (Higher Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	This KER comprising mainly woodland is not very sensitive in terms of water quality and soil chemistry impact associated from construction activities of a road project.	Negligible
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages do not represent a significant threat to this woodland system.	Negligible
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).	Direct encroachment into the KER and loss of the KER is proposed which is dealt with in the biodiversity impact assessment.	See Chapter 7 for details.
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	There are no proposed drainage outfalls discharging to this KER. The water quality impact from the road drainage system will be negligible.	Negligible
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Interceptor toe drains are proposed in the vicinity of the KER which could potentially alter the drainage in the KER and may potentially give rise to drier conditions.	Slight
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on stream channel morphology at this section is not applicable.	N/A
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas.	The KER is not very sensitive to drainage and such drying effects and therefore the impact will be negligible	Negligible

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 19(LH) Ch. 52+850 to Ch. 53+250	Scramoge River Local Importance (Higher Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	This River System which hosts aquatic habitats and species is sensitive to water quality impacts associated from construction activities.	Moderate / Significant
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages if uncontrolled represent a significant threat to aquatic life both locally and downstream.	Moderate
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).	There is a proposed bridge construction over the Scramoge River which may involve limited in-stream works, floodplain and river bank works during construction.	Moderate
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	The proposed road development outfalls to this river which represents a direct potentially contaminated discharge. The water quality impact from the road drainage system based on traffic numbers represents a locally slight adverse impact.	Slight
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Road drainage outfalls will undergo attenuation and effect of road drainage and interceptor drains will have a negligible to small adverse impact on the flow regime and water balance of the river.	Slight
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on stream channel morphology at this section is possible with existing proposed river bridge to be constructed. The proposed dimensions will be full clear spanning at 20m.	Moderate
			Interception of drainage paths by the permeable Road formation resulting in diversion of waters and in a dewatering effect on adjacent soils and wetland areas.	Giver the scale of the Scramoge river catchment such interception by the road and it formation layer will be negligible in terms of the overall water balance.	Negligible

Attribute		Impact			
KER Receptor No.	**Receptor Name and importance**	**Stage**	**Nature of Impact**	**Description of Impact**	**Impact Rating**
KER 20(LH) Ch. 53+300 – Ch. 53+950	Mixed Broadleaved /Conifer Woodland Local Importance (Higher Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	This KER comprising mainly woodland is not very sensitive in terms of water quality and soil chemistry impact associated from construction activities of a road project.	Negligible
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.	Construction spillages do not represent a significant threat to this woodland system.	Negligible
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).	Direct encroachment into the KER and loss of the KER is proposed which is dealt with in the biodiversity impact assessment.	See Chapter 7 for details.
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	There are no proposed drainage outfalls discharging to this KER. The water quality impact from the road drainage system will be negligible.	Negligible
			Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Interceptor toe drains are proposed in the vicinity of the KER which could potentially alter the drainage in the KER and may potentially give rise to drier conditions.	Slight
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Impact on stream channel morphology at this section is not applicable.	N/A
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas.	The KER is not very sensitive to drainage and such drying effects and therefore the impact will be negligible	Negligible

10.4.16 Impacts of Material Deposition Areas

A total of 17 areas have been identified as deposition areas for the excess soft and unacceptable material along the route. These sites are all within easy haulage distances from the location of large soft ground deposits and are detailed in the Table 10.35 below: These sites provide a storage capacity of 0.978 million m^3 which can accommodate the anticipated 0.96 million $m^3$of potentially excess unacceptable material which may be encountered of along the proposed road development.

Table 10.33 Location of Material Deposition Areas

Area No.	Chainage and Location	Area (Hectares)	Approx. Capacity (m^3)
1	Ch.4+640 – Ch. 4+750, South of proposed N5	0.4	8,000
2	Ch. 4+750 – Ch. 4+80, North of proposed N5	1.1	22,000
3	Ch. 5+400 – Ch. 5+680, South of proposed N5	1.4	28,000
4	Ch.14+700 – Ch. 15+520, South of proposed N5	4.5	90,000
5	Ch.14+950 – Ch. 15+200, North of proposed N5	2.6	52,000
6	Ch.15+320 – Ch. 15+600, North of proposed N5	1.8	36,000
7	Ch.15+550 – Ch. 15+780, South of proposed N5	2.9	58,000
8	Ch.16+075 – Ch. 16+130, South of proposed N5	0.4	8,000
9	Ch.17+000 – Ch. 17+600, South of proposed N5	1.8	36,000
10	Ch. 17+050 – Ch. 17+150, South of proposed N5	0.4	8,000
11	Ch. 17+150 – Ch. 17+600, South of proposed N5	7.3	146,000
12	Ch. 17+640 – Ch. 17+875, South of proposed N5	2.0	40,000
13	Ch. 21+000 – Ch. 21+175, South of proposed N5	2.7	54,000
14	Ch. 20+950 – Ch. 21+450, North of proposed N5	5.4	108,000
15	Ch. 21+350 – Ch. 21+750, North of proposed N5	5.4	108,000
16	Ch. 22+150 – Ch. 22+850, South of proposed N5	8.4	168,000
17	Ch. 22+680 – Ch. 22+840, North of proposed N5	0.4	8,000
Total Storage Volume		**48.9**	**978,000**

These material deposition sites 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. In addition wheel wash facilities will be provided at the entrance/exit as outlined in the Construction Erosion and Sediment Control Plan (CESCP).

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 sequence of each of the material deposition areas is such that the area allocated for material deposition is compartmentalised to allow a deposition area to be first established in one compartment, while the runoff water from this compartment flows into and is contained within an adjacent compartment. This will allow settlement of sediment to take place. Once settlement of the sediments has occurred, this settlement area is then itself filled with peat and the adjacent compartment acts as the settlement area for the runoff from this section. This process is repeated as the works advance.

A 2.5m wide permanent maintenance access track will extend around the external perimeter of the peat restoration areas and combined with the foundation to the perimeter berm for access. Materials will initially be delivered to the working area for access road and perimeter berm construction by low ground pressure vehicles such as tracked dumpers and light weight, wide track excavators.

Any local drains within these areas will be either diverted around the site or truncated so as to minimise the volume of water entering such areas to that of direct rainfall and the soil moisture of the material itself.

The construction sequencing and design of the material deposition areas will ensure that there will be negligible impact on adjacent watercourses. In addition a Construction Erosion and Sediment Control Plan has been developed which deals specifically with environmental protection/ mitigation measures for the material deposition areas.

10.5 Mitigation Measures

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 Corridor Selection stage and the Design stage, by moving the proposed alignments either laterally or vertically within the route corridor, 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 locally modify the proposed road alignment 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 impacts it is necessary to also consider any associated impacts to the hydrological and ecological regimes.

10.5.2 Constructional Mitigation

A Construction Erosion and Sediment Control Plan has been prepared for the proposed road development. Reference should be made in the first instance to this Plan for specific construction mitigation proposals – a summary of the key mitigation are also given below. As is normal practice with large road infrastructure projects an Environmental Operating Plan (EOP) will be prepared for the proposed road development and the following will be implemented as part this plan:

- EOP will incorporate an Emergency Response Plan detailing the procedures to be undertaken in the event of spillage of chemical, fuel or other hazardous wastes, non-compliance incident with any permit of license or other such risks that could lead to a pollution incident, including flood risks.
- All necessary permits and licenses for in stream construction work for 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 consent has been received for all culverts and bridges proposed for this road development.
- Inform and consult with Inland Fisheries Ireland (IFI).

- Refine and finalise Construction Erosion and Sediment Control Plan.

Construction operation 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/NRA, 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 constructional 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 constructional works are carried out adjacent to turloughs, fens, stream and river channels and lakes protection of such waterbodies from silt load shall be carried out through use of grassed buffer areas, timber fencing with silt fences or earthen berms to provide adequate treatments of runoff and constructional site runoff waters to the watercourses.
- 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 that occur in areas of land that will be used for site compound/storage facilities will be fenced off at a minimum distance of 5m. 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 shall not be constructed on lands designated as Flood Zone A or B in accordance with the OPW Flood Risk Management Guidelines (November 2009). Compounds will not be permitted in or within 100 metres of a European Site.
- 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 shall 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 shall 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, 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 plant will be carried out only in a designated contained impermeable area.

10.5.3 General Operational Mitigation

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, sealed 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 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 treatment systems will be provided upstream of all proposed outfalls.

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 and where the road cuttings intercepts bedrock or where the cutting reduces the vulnerability to extreme (Overburden Cover < 3m) 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 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 outline Construction Erosion and Sediment Control Plan. 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 transitions 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/NRA 2008.

10.5.3.4 Watercourse Diversions

The proposed stream and drain diversions have been assessed in Table 10.26. Localised mitigation measures have been identified to prevent bank erosion at sites of bends which were found often to coincide with the proposed road 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.

10.5.4 Specific Mitigation Measures

Each of the hydrological features identified that are potentially at risk due to the proposed road development were assessed based on the potential magnitude of the impact in Table 10.34. Where an impact rating was deemed to be slight or negligible it is considered that the adherence to good construction practices can adequately mitigate the level of risk involved and no additional specific mitigation is required. Each of the features which were found to have an impact rating greater than slight have been considered to require mitigation to reduce the magnitude of risk posed.

Table 10.36 gives details of the specific mitigation measures proposed at each hydrological feature. Further details of mitigation measures at the following ecologically important sites are described below.

10.5.4.1 Cregga Turlough

Cregga Turlough is located approximately 3.2km to the north-west of Strokestown in the townlands of Cregga and Cuilrevagh. Cregga Turlough is situated in a depression with a rounded ridge of hills along the eastern side and relatively high land to the west except at the central point where the contours lead to Annaghmore Lough, less than 1km away. The proposed road development runs north and north-east of Cregga Turlough between Ch. 36+600 and Ch. 37+950. Setback distances from the proposed road adjacent to the Turlough are between 100 – 250m with agricultural grassland providing the buffer.

Due to the undulating nature of the landscape at this location, sections of the proposed road development require significant earthworks as it passes the Turlough including large cuttings between Ch. 35+150 to Ch. 36+450 and Ch. 36+900 to Ch. 37+650.

The Turlough receives surface runoff from surrounding areas and discharges directly to groundwater through its base. It is therefore imperative that any silt and sediment laden waters running off the construction works are controlled through interception and settlement in sedimentation ponds prior to discharge.

The water balance in the Turlough during construction must be maintained and therefore cut-off drains shall be provided to direct waters away from the construction site and to the Turlough.

The following specific construction requirements to reduce potential contamination impacts upon the Turlough will be put in place – refer to CESCP for further details:

- Pre-construction water quality monitoring shall take place in the Turlough to establish baseline conditions – see Figures 10.2 – 10.6 in EIAR Volume 3 for location of same.
- A water quality monitoring programme will be undertaken at suitable locations in the receiving watercourse during the construction phase.
- The storage of oils, fuel, chemicals, hydraulic fluids, shall only take place within site compounds. Storage shall be undertaken in accordance with current best practice for oil storage.
- All machinery operating in the works area adjacent to the Turlough will be cleaned in advance of works and routinely checked to ensure no leakage of oils or lubricants occurs.

Detailed and specific construction sequencing together with specific drainage designs are proposed in this area – refer to the CESCP for details. The construction sequence for cuttings adjacent to Cregga Turlough shall ensure that they are completed in sections so that the base gradient allows conveyance to temporary settlement ponds located within the cutting. A temporary settlement pond may be relocated as the dig advances with the preceding settlement area only filled in once the new settlement area is operational and the road and cutting drainage is constructed. Settlement ponds, temporary or otherwise, will be constructed prior to the excavation works commencing and will be constructed as detailed in the Construction Erosion and Sediment Control Plan. During construction, impermeable barriers will be placed at 50m intervals in the permeable infiltration galleries shown in Figure 10.5.

Operational

The road construction and cutting into the hillslopes surrounding Cregga Turlough have the potential to intercept and divert necessary and significant recharge waters from the Turlough. Without mitigation a significant volume of recharge water could be intercepted and diverted northwest in the road drainage system to the Ovaun stream that outfalls to Clooncullaan Lough.

The design of this section of the proposed road (Ch. 36+000 to Ch. 38+600) will include suitable drainage design to separate the natural hill slope runoff, interflow and ground waters from the potentially contaminated road pavement waters. Recharge flow from the cuttings will be collected in a separate filter drain and discharged to the Turlough at two separate outfall locations via an infiltration basin so as to maintain the recharge regime of Cregga Turlough.

To capture and separate natural water runoff from up-gradient lands, cut-off ditches will be provided along the up-gradient boundary of the cut section (which is in the natural catchment of the Turlough). The intercepted water will be allowed to discharge to the Turlough through infiltration galleries constructed between Ch. 36+500 to Ch. 36+700, Ch. 37+670 to Ch. 37+870 and Ch. 38+030 to Ch. 38+130 to facilitate the natural recharge of the Turlough. These infiltration galleries are to be utilised during the operational phase of the proposed road development to allow natural recharge water to drain to the Turlough. The inclusion of impermeable barriers at 50m intervals in the permeable infiltration galleries will restrict water flowing laterally along the road formation and will direct water towards the Turlough.

No direct discharge of road pavement runoff waters to the Turlough will be permitted. This will avoid any potential pollution of the Turlough and its groundwater system. This also avoids any potential downstream impacts to Annaghmore Lough SAC as the Cregga Turlough in flood conditions overflows via a surface drain to the Lough. The road pavement waters will be collected in a sealed drainage system and discharged to the Ovaun Stream Outfall at Ch. 34+650.

10.5.4.2 Ovaun Stream

The Ovaun Stream discharges to Clooncullaan Lough some c.2km downstream of the proposed road drainage and cut-off ditch outfall discharges. During the construction phase, this watercourse could, in the absence of mitigation, be at risk as a downstream receptor from potential soiled water runoff and spillages of hydrocarbons from construction vehicles.

A swallow-hole feature connected via a spur channel off the Ovaun Stream drainage district channel that outfalls to the lake has been identified 770m downstream of the Road Outfall. Dye tracer releases carried out of the environmental assessments, show that a proportion of the channel flow discharges to the swallow hole. A larger catchment scale dye tracing study was also carried which identified that this swallow hole discharges to the Owenur River between Ballyslish Bridge and Drummullin northeast of Elphin.

In order to protect both Clooncullaan Lough and the groundwater body from potential contamination from soiled site runoff in the form of suspended sediment, the two wetland treatment ponds located at Ch. 34+850 will be constructed in advance of the main earthworks to treat this construction runoff. Where necessary additional temporary treatment ponds will be provided within the cutting to ensure the highest level of sediment removal is achieved. These treatment ponds will ensure that all waters entering the watercourse will be afforded treatment prior to discharge and therefore no deterioration in water quality will occur.

Specific construction mitigation measures relating to the overland outfall to the Ovaun River are detailed in the CESCP.

Operational

Surface water runoff from the cutting between Ch. 35+150 and Ch. 36+150, which includes intercepted hill slope runoff and interflow, and the road pavement runoff will be discharged to the Ovaun Stream through a maintained channel and will outfall through a regraded existing minor drain. Hydraulic modelling of the new channel has been undertaken to access the flood risk impacts, particularly at the culverted crossing under the proposed road development. No increased risk of flooding is posed to the surrounding lands. The intercepted hill-slope drainage/runoff water will be kept separate from the road pavement runoff so as to avoid / minimise the potential volume of potentially contaminated road drainage runoff waters and the treatment of such waters by the downstream attenuation pond system

In order to protect both the Lough and the groundwater body from potential contamination, road drainage runoff will be isolated and discharged through a series of two wetland treatment systems comprising of forebay, reed beds and pond systems located at Ch. 34+850 prior to its outfall to the Ovaun Stream (via a local drain). The level of treatment will ensure that the road runoff discharge will not impact on the receiving water quality of the Stream, Lough or groundwater system.

Given that a portion of road runoff will essentially be discharging (770m downstream of the outfall) to groundwater, a groundwater risk assessment has been carried out in line with the EPA document "Guidance on the Authorisation of Discharges to Groundwater (2011)" – refer to Chapter 9 Hydrogeology for details. The outcome of this risk assessment indicated that the discharge will have an imperceptible impact on groundwater quality.

10.5.4.3 Alkaline Fen at Tullyloyd

Constructional

The fen feature will be protected, in particular during the construction phase when it will be most at risk from site traffic, soiled water runoff and spillages of hydrocarbons.

During the construction phase it will be necessary to ensure that the fen area is avoided by all groundworks and is protected from construction runoff. A small berm feature and silt fence along the boundary with the fen area will be constructed so as to intercept and divert any surface water runoff from the working area into the small stream to the north (west of OUT34.01), via suitable measures to remove suspended solids and potential contaminants (i.e. large settlement pond area). Refer to Figures 10.2 – 10.7 for details.

In order to prevent longitudinal drainage in the road formation towards the natural low point of its profile at Ch. 33+850, transverse barriers will be installed in its foundation at 200m intervals between Ch. 33+200 and Ch. 34+500. See Figure 4.39 in EIAR Volume 3 for typical cross-sectional detail at lined sections.

Operational

The road has the potential to intercept recharge to the Fen. Mitigation in the form of permeable construction in the road formation layers will be provided to allow the interflow to transmit southwards under the road to the fen system.

The design of this section of road will include suitable drainage systems to prevent any operational phase surface runoff from the road pavement entering the fen area via overland flow. No direct surface outfall to the fen shall be permitted. Discharge shall be to the existing drainage channel downstream of the fen. A sealed drainage system will be provided along this ecologically sensitive section and the road drainage will pass through a lined wetland treatment system prior to outfall.

The road embankment adjacent to the fen will be constructed on a granular layer so as to maintain existing pathways for overland and interflow from the west and southwest to continue discharging to the fen. It may be necessary to strip back overburden layer to shallow bedrock so as to ensure that the drainage layer functions appropriately. This granular layer will be wrapped in a geotextile to avoid infiltrating fines reducing its porosity over time. Importantly this granular layer shall be isolated from any existing or constructed surface drains so that it does not have the potential to drain the wetland as opposed to supply it.

Leggatinty Bog

In order to prevent drainage of adjacent blanket bog by the road formation, a longitudinal impermeable sub-surface barrier will be installed running parallel to the road alignment between Ch. 10+500 and Ch. 10+650 on the west side of the alignment, between Ch.11+600 and Ch. 12+000 on the north side of the alignment and between Ch. 11+750 and Ch. 12+250 on the south side of the alignment. Refer to Figure 4.39 in EIAR Volume 3 for typical cross-sectional detail at lined sections.

10.5.4.4 Additional Mitigation Measures

A number of precautionary measures are also proposed in some locations even when the level of impact was categorised as slight or negligible. Shallow toe drains with check dams will be incorporated to maintain water levels in the wetlands adjacent to KER's 1, 4, 5, 6, 9, 10,11,13,17 & 18. At KER 13 transverse barriers at every 200 – 300m in the road formation will also be incorporated as a precaution to prevent any draining of the wetland area – refer to Figures 9.5 – 9.10 for locations.

At KER 1, transverse barriers to prevent longitudinal drainage in the road formation will be provided at 100m intervals between: Ch.4+050 and Ch. 4+500 to prevent dewatering. At KER 4, a longitudinal impermeable barrier will be provided along the eastern boundary of the alignment to prevent potential dewatering. To prevent longitudinal drainage from the road formation layer impacting KER 5, transverse impermeable barriers will be provided between Ch. 10+900 and Ch. 11+600 at 100m intervals – refer to Figures 9.5 – 9.10 for locations.

The extent of longitudinal barriers or transverse barriers proposed is dictated by the natural contours of the surrounding lands and whether it is blanket bog or wet grassland habitat (Refer to Figure 4.39 in EIAR Volume 3 for typical cross-sectional detail at lined sections).

All other mitigation measures proposed at each hydrological feature are summarised in Table 10.36. General mitigation measures described above will apply at all KER locations including maintaining existing watercourses in place.

Table 10.34 Proposed Mitigation Measures for Hydrological Features with the Corresponding Residual Impact Rating

<table>
<tr><th colspan="2">Attribute</th><th colspan="4">Impact</th></tr>
<tr><th>KER Receptor No.</th><th>Receptor Name and Importance</th><th>Stage</th><th>Description of Impact</th><th>Mitigation Measures Proposed</th><th>Residual Impact</th></tr>
<tr><td>KER 1a(N) & 1B(C)
Ch. 4+000 to Ch. 4+500</td><td>Wet Grassland (Molina Meadows) National Importance & County Importance</td><td>Operational</td><td>Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.</td><td>No Improvements to drains in the area surrounding the wetland area.
Transverse barrier at 100m intervals.
Additional culvert beneath the road to ensure overland flow connectivity to wetlands.
Check dams to be incorporated in toe drains to maintain water levels in the wetlands.</td><td>Negligible</td></tr>
<tr><td rowspan="2">KER 2a(LH) & 2b(N)
Ch. 5+000 to Ch. 5+500</td><td rowspan="2">Degraded and intact Raised Bog and Cutover Bog National Importance & Local Importance (Higher Value)</td><td rowspan="2">Operational</td><td>Road Drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.</td><td rowspan="2">Longitudinal barrier in the road formation returned to competent bedrock/overburden to prevent the migration of water into road formation.
The proposed bog access road shall be of floating road construction with existing drainage channels maintained and thus drainage of the bog will be negligible.</td><td>Negligible</td></tr>
<tr><td>Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas.</td><td>Slight</td></tr>
</table>

Attribute		Impact			
KER Receptor No.	**Receptor Name and Importance**	**Stage**	**Description of Impact**	**Mitigation Measures Proposed**	**Residual Impact**
KER 3(LH) Ch. 10+125 to Ch. 10+150	Carricknabraher River Local Importance (Higher Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	A Construction Erosion and Sediment Control Plan (CSECP) has been developed. The measures outlined in the CSECP will ensure no adverse impacts on water quality occur.	Slight
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands		
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).		
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	Road drainage will be treated in an attenuation pond with a treatment forebay provided prior to outfalling to receiving watercourse. The attenuation pond will be fitted with a penstock or similar restriction at the outfall to the receiving channel.	Slight
KER 4(C) Ch. 10+750 to Ch. 10+850	Wet Grassland (Molinia Meadows) County Importance	Operational	Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	All existing watercourses and local drainage channels will be maintained to ensure increased drainage of lands does not occur. Transverse barriers at 100m intervals. Check dams to be incorporated on toe drains to maintain wet conditions.	Slight
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas		
KER 5(N) Ch. 11+480 to Ch. 12+150	Wet Grassland (Molinia Meadows) National Importance	Operational	Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	All existing watercourses and local drainage channels will be maintained to ensure increased drainage of lands does not occur. Transverse barriers at 100m intervals. Check dams to be incorporated on toe drains to maintain wet conditions.	Slight
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas.		

Attribute		Impact			
KER Receptor No.	**Receptor Name and Importance**	**Stage**	**Description of Impact**	**Mitigation Measures Proposed**	**Residual Impact**
KER 6(a)(N), 6b(N), 6b(C), 6b(LH), 6c(N), 6c(LH), 6c(LL) Ch. 10+900 to Ch. 12+450	Peatland complex of Raised Bog and Cutover Bog with Wet Heath & Bog Woodland National Importance, County Importance & Local Importance (Higher & Lower Value)	Construction	Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).	A Construction Sediment Erosion and Control Plan (CSECP) has been developed. The measures outlined in the CSECP will ensure no adverse impacts on water quality occur.	Slight
		Operational	Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Longitudinal barrier running along the edge of the road formation. Maintain transverse flow paths/ditches through culverting/piping. Use of shallow toe drains with check dams as appropriate.	Slight
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas.		Slight
KER 7a(N) & 7b(LH) Ch. 13+950 to Ch. 14+450	Peatland complex of Raised Bog and Cutover Bog with Bog Woodland National Importance and Local importance (Higher Value)	Construction	Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.)	A Construction Sediment Erosion and Control Plan (CSECP) has been developed. The measures outlined in the CSECP will ensure no adverse impacts on water quality occur.	Slight
		Operational	Road drainage system – outfalls, culverts, interceptor drains, diversions and truncations affecting the water flow regime.	Longitudinal & transverse drains. Check dams on toe drains to maintain wet conditions.	Slight
			Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effects on adjacent soils and wetlands areas.		

Attribute		Impact			
KER Receptor No.	**Receptor Name and Importance**	**Stage**	**Description of Impact**	**Mitigation Measures Proposed**	**Residual Impact**
KER 8 (LH) Ch. 14+450 to Ch. 14+800	Owennaforeesha River Local Importance (Higher Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	A Construction Sediment Erosion and Control Plan (CSECP) has been developed. The measures outlined in the CSECP will ensure no adverse impacts on water quality occur.	Slight
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.		
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).		
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	Road drainage will be treated in an attenuation pond with a treatment forebay provided prior to outfalling to receiving watercourse. The attenuation pond will be fitted with a penstock or similar restriction at the outfall to the receiving channel.	Slight
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	All existing watercourses and local drainage channels will be maintained to ensure drainage of lands does not occur.	Slight

Attribute		Impact			
KER Receptor No.	**Receptor Name and Importance**	**Stage**	**Description of Impact**	**Mitigation Measures Proposed**	**Residual Impact**
KER 13(LH) Ch 30+550 to Ch 31+950	Upper Owenur River Marsh and Wet Grassland, Wet Grassland Reedswamp & Poor Fen Local Importance (Higher Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	A Construction Sediment Erosion and Control Plan (CSECP) has been developed. The measures outlined in the CSECP will ensure no adverse impacts on water quality occur.	Slight
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.		
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).		
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	Road drainage will be treated in an attenuation pond with a treatment forebay provided prior to outfalling to receiving watercourse. The attenuation pond will be fitted with a penstock or similar restriction at the outfall to the receiving channel.	Slight

<table>
<tr><th colspan="2">Attribute</th><th colspan="4">Impact</th></tr>
<tr><th>KER Receptor No.</th><th>Receptor Name and Importance</th><th>Stage</th><th>Description of Impact</th><th>Mitigation Measures Proposed</th><th>Residual Impact</th></tr>
<tr><td rowspan="5">KER 15a(LH), 15b(LL),
Ch. 33+350 to Ch. 34+350</td><td rowspan="5">Lough Clooncullaan, and Surrounding Wetland Complex Local Importance (Higher & lower Value)</td><td rowspan="3">Construction</td><td>Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).</td><td rowspan="3">A Construction Sediment Erosion and Control Plan (CSECP) has been developed. The measures outlined in the CSECP will ensure no adverse impacts on water quality occur.</td><td rowspan="3">Slight</td></tr>
<tr><td>Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.</td></tr>
<tr><td>Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.)</td></tr>
<tr><td rowspan="2">Operational</td><td>Road drainage and outfalls impacting on water quality:
- Routine road runoff discharges.
- Accidental fuel spills from road.</td><td>Road drainage will be treated in an attenuation pond with a treatment forebay provided prior to outfalling to receiving watercourse. The attenuation pond will be fitted with a penstock or similar restriction at the outfall to the receiving channel.</td><td>Slight</td></tr>
<tr><td>Interception of drainage paths by the permeable road formation resulting in diversion of waters and in a dewatering effect on adjacent soils and wetland areas.</td><td>Transverse barriers every 100m in the road formation.
Maintain transverse flow paths/ditches.
Shallow toe drain with check dams if required.</td><td>Slight</td></tr>
<tr><td>15c(N), 15d(C) & 15e(C)
Ch. 33+350 to Ch. 34+350</td><td>Annex I Transition Mire and Rich Fen Habitat National & County Importance</td><td>Operational</td><td>Interception of drainage paths by the permeable Road formation resulting in diversion of waters and in a dewatering effect on adjacent soils and wetland areas.</td><td>Transverse barriers every 100m in the road formation.
Maintain transverse flow paths/ditches.
Shallow toe drain with check dams if required.</td><td>Slight</td></tr>
</table>

Attribute		Impact			
KER Receptor No.	**Receptor Name and Importance**	**Stage**	**Description of Impact**	**Mitigation Measures Proposed**	**Residual Impact**
KER 16(N) Ch. 36+650 to Ch. 37+950	Turlough (Cregga) National Importance Annex I priority Habitat	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	A Construction Sediment Erosion and Control Plan (CSECP) has been developed. The measures outlined in the CSECP will ensure no adverse impacts on water quality occur.	Slight
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.		
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.)		
		Operational	Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	Interceptor ditches and filter drains will collect existing overland and interflow which discharge to the Turlough in three distribution galleries between Ch.36+500 to Ch.36+700, between Ch.37+670 to Ch. 37+870 and between Ch.38+030 to Ch.38+130,. The existing ground will be excavated to bedrock and filled with free draining material to existing ground level to facilitate the dispersal/infiltration of overland drainage intercepted by the proposed road development. The provision of transverse impermeable bunds at 50m intervals to prevent longitudinal flow of sub-surface water will be incorporated within the free draining material. This will ensure that the existing water balance of the Turlough is maintained.	Slight
			Interception of drainage paths by the permeable Road formation resulting in diversion of waters and in a dewatering effect on adjacent soils and wetland areas.		

Attribute		Impact			
KER Receptor No.	**Receptor Name and Importance**	**Stage**	**Description of Impact**	**Mitigation Measures Proposed**	**Residual Impact**
KER 19(LH) Ch. 52+850 to Ch. 53+250	Scramoge River Local Importance (Higher Value)	Construction	Silts and sediments arising from in stream works and works adjacent to watercourses and construction site runoff. Silts and sediments and nutrient pollution arising from handling of peat (excavation, removal, deposition).	A Construction Sediment Erosion and Control Plan (CSECP) has been developed. The measures outlined in the CSECP will ensure no adverse impacts on water quality occur.	Slight
			Spillages (hydrocarbons, cement etc.) into watercourses and onto wetlands.		
			Disturbance due to construction machinery and carrying out of temporary works (cofferdams culverts channel diversions, sediment ponds, silt fences etc.).		
		Operational	Road drainage and outfalls impacting on water quality: - Routine road runoff discharges. - Accidental fuel spills from road.	Road drainage will be treated in an attenuation pond with a grease trap provided prior to outfalling to receiving watercourse. The attenuation pond will be fitted with a penstock or similar restriction at the outfall to the receiving channel.	Slight
			Changes to stream channel morphology as a result of culverting, diversions, channel regrading works and outfall discharges giving rise to short term erosion and deposition.	All existing watercourses and local drainage channels will be maintained to ensure drainage of lands does not occur.	Slight

10.6 Residual Impacts

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

- Flood Risk;
- Water Quality;
- Channel Morphology; and
- Impacts on Key Ecologically sensitive areas (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 which represents a higher design standard to 50 year recommended in the TII/NRA Guidelines. 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.

There is a deep cutting at Cregga and there will be a substantial diversion of hillslope runoff, interflow and groundwater flow which currently enters the Ovaun Stream and Clooncullaan Lough system. This has been mitigated through the provision of interceptor drains that will convey this intercepted runoff back into the system maintaining existing conditions.

At the deep cutting section in the Cregga area, the substantial diversion of hillslope runoff, interflow and groundwater flow which currently enters the Turlough system has been mitigated through the provision of interceptor drains that will convey intercepted runoff water beneath the road through an infiltration gallery to its original location discharging to Cregga Turlough.

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 an 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 provided for 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 all 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

This 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, sealed 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 N5 road. 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

No negative impacts to Regional Supplies surface water abstraction sources area are anticipated (Lough Gara lake abstraction source) during the construction and operation phases. There will be no residual impact from the proposed road development.

10.6.3 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

The residual impact of the proposed road development on key ecologically sensitive areas (also known as Key Ecological Receptors or KERs) has been assessed and the results are shown in Table 10.35. Only a slight residual impact from the proposed road development is anticipated at key ecologically sensitive areas.

In addition, and as outlined above, the proposed development will result in a positive impact on water quality of the receiving watercourses as it will generally improve the existing situation of untreated storm drainage from the existing N5 road. The risk of serious pollution to these watercourse will also be reduced with the inclusion of pollution control measures which can be closed off in the event of a serious pollution incident arising.