N17 Milltown to Gortnagunned Road Improvement Project

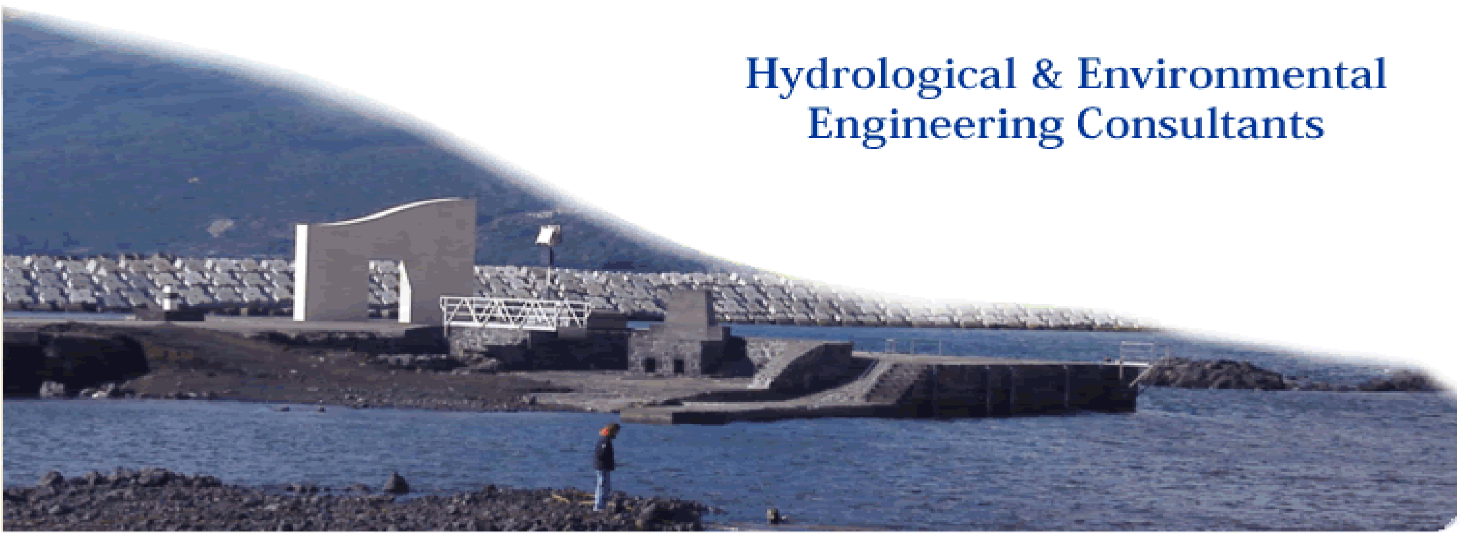
Hydrological Impact Assessment

On behalf of

Road Design Office

Galway Co. Council.

September 2021



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1. Introduction

Galway County Council is planning a 3km upgrade of the N17 National Primary Route, between the townlands of Milltown and Gortnagunned and occurring predominately within the townland of Drum. The road development involves realignment of the existing N17 road to remove a number of substantially deficient bends on this 3km section which will improve aspects such as safety, sight distance, cross sectional width and drainage.

The proposed scheme will tie-in on the Northern end with an existing section of the N17 that that's has already been upgraded and on the Southern end will tie in with the town of Milltown.

The road type proposed for the project corresponds to a Type 1 Single Carriageway arrangement with north and southbound carriageway widths of 3.65m each, 2.5m wide hard shoulders and 3m verge widths giving an overall plan width of just over 18m.

This report examines the impact of the proposed road development on hydrology and hydrogeology.

2. Existing Baseline Environment

2.1 Hydrology

2.1.1 Regional Hydrology

The 3km road is located entirely within the River Clare Catchment. This river is a primary tributary of the Corrib, discharging to Lough Corrib west of the N84 Headford Road and the Carrowbrowne in the townlands of Coarsefield and Angilham. The total Catchment area of the Clare to the Corrib is 1100km^2 which is just over one third of the total Corrib catchment. The Mainline of the River Clare passes through Milltown Village to the Southwest of the project area having a catchment area to Milltown of 392km^2. Almost the entire project area drains southwest to Carrownageeha Stream (EPA code 30C59). This tributary stream outfalls to the River Clare in the townland of Cartron 400m downstream of Miltown GAA Grounds, refer to Figure 1. The River Clare catchment area to the Carrownageeha confluence is 405km^2 and the total catchment area of the Carrownageeha Stream is 12.4km^2.

Both the River Clare and its tributaries including the Carrownageeha Stream underwent Arterial drainage works in the 1960's by the OPW and are maintained channels with maintenance works on the Carrownageeha perform typically every 5 to 7 years (These maintenance works involve sediment and vegetation removal and vegetation cutback using an excavator. These watercourses are modified watercourses and maintained to convey flood water typically within channel bank up to the 3year return period flood.

2.1.2 Catchment Flows

The river Clare to its confluence with the Carrownageeha is 405km^2 and has a mean annual rainfall of 1120mm per annum and an annual catchment Evapotranspiration rate of 461mm ration giving an effective rainfall depth of 659mm. This gives an annual discharge rate of the Clare Catchment to Miltown of 8.46cumec. Given the karstic nature of the Clare catchment the annual average River Flow is likely to be less than 8.46cumec to Miltown as underground outflows via preferential karst conduits are likely to bypass the river joining it further downstream or directly to Lough Corrib itself. Based on the downstream hydrometric gauge at Ballygaddy Tuam the annual recorded flow rate is 7.71cumec (16.8 l/s per km^2) and therefore to Miltown the annual flow rate in the Clare River is likely to be 6.82cumec suggesting that almost 20% of the effective rainfall bypasses the river as deeper groundwater flow to downstream springs and seepages.

The Low Flow Statistics for the Clare River based on the Ballygaddy hydrometric gauge (30007) gives a 95-percentile low flow of 3.5l/s per km2 and a 99-percentile low flow of 1.8l/s per km^2. Therefore, the estimated low flow rates in the Clare River to Miltown are a 95-percentile flow rate of 1.41cumec and 99% flow rate of 0.72cumec. For the much smaller Carrownageeha stream the low flow rate is likely to be much lower given the relatively impervious nature of the catchment soils with low annual groundwater recharge rates typically less than 100mm per annum. A representative 95-percentile low flow rate of 1l/s per km^2 will be used for this stream catchment and a rate of 0.5l/s per km^2 for 99-percentile low flow. These rates are 3.5 times lower than the River Clare rate to its Ballygaddy gauge near Tuam.

A low flow measurement after a period of prolonged dry weather was carried out on the 18 June 2020 on the Drum stream (tributary of the Carrownageeha Stream) at L2227 bridge, Gortnagunned (ITM 538300, 764836, see Plate 1). This gave flow measurement of 3.5l/s at 5.1km^2 catchment area. This measured value represents a low flow rate of 0.7l/s per km^2 and is likely to be representative of dry weather flow (98-percentile) conditions.

The EPA hydrotool which is an ungauged catchment estimator primarily developed using measured flow data from Larger catchments (>30km2) gives an estimated flow duration curve for both the Clare River at the confluence with the Carrownageeha Stream (E139020, N261720) and on the Drum Stream adjacent to the Miltown Business Park at Gortnaloura (E139220, N263640). The estimates for the Clare river reasonably agree with the measured low flow rates from Ballygaddy gauge. However, the Hydro-tool low flow estimates for the Drum stream overestimates the low flow rate by a least a factor of two based on the measured low flow rate

Table 1 EPA Hydro-tool flow duration curve estimates

Stn Ref	River/Stream	Area Km2	1%	5%	10%	50%	90%	95%	99%
30-2794	Clare	392.8	40.18	26.65	20.60	6.84	1.71	1.25	0.73
30-3549	Drum	7.65	0.817	0.559	0.455	0.103	0.032	0.021	0.013

Plate 1 Drum Stream at the L2227 bridge Gortnagunned (18th June 2020)

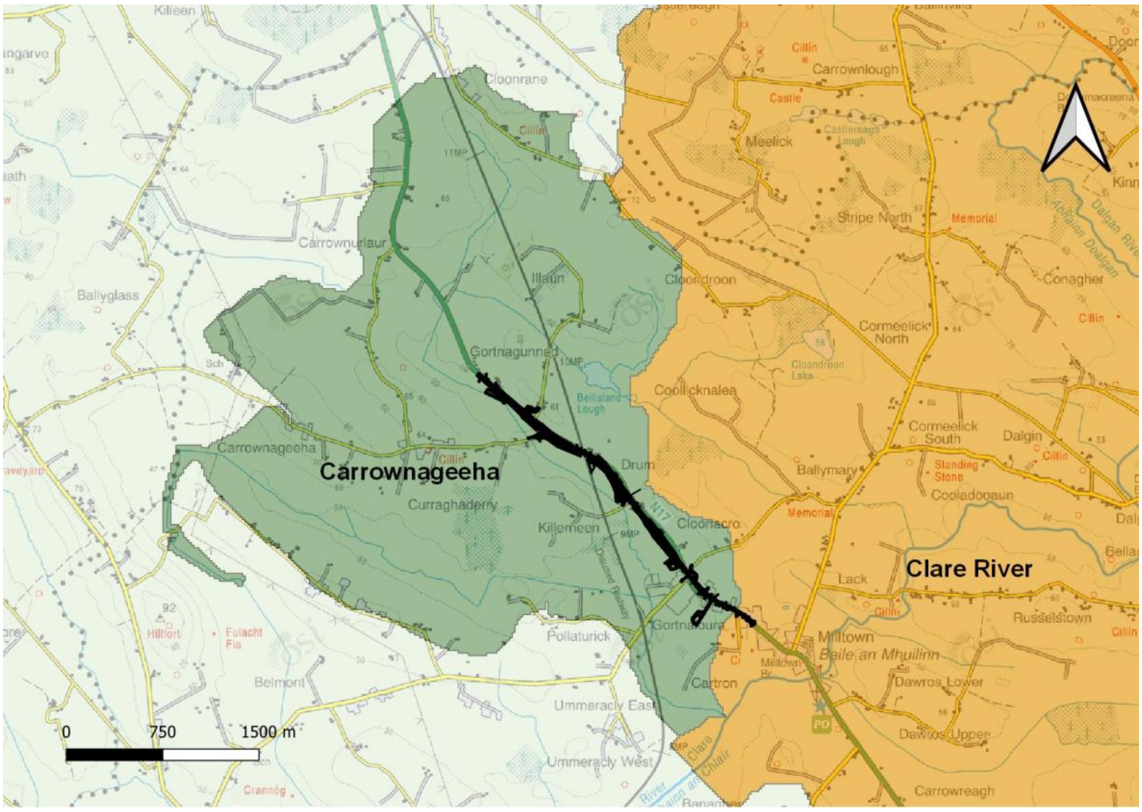

Figure 1 Carrownageeha Stream and River Clare Catchments to Milltown

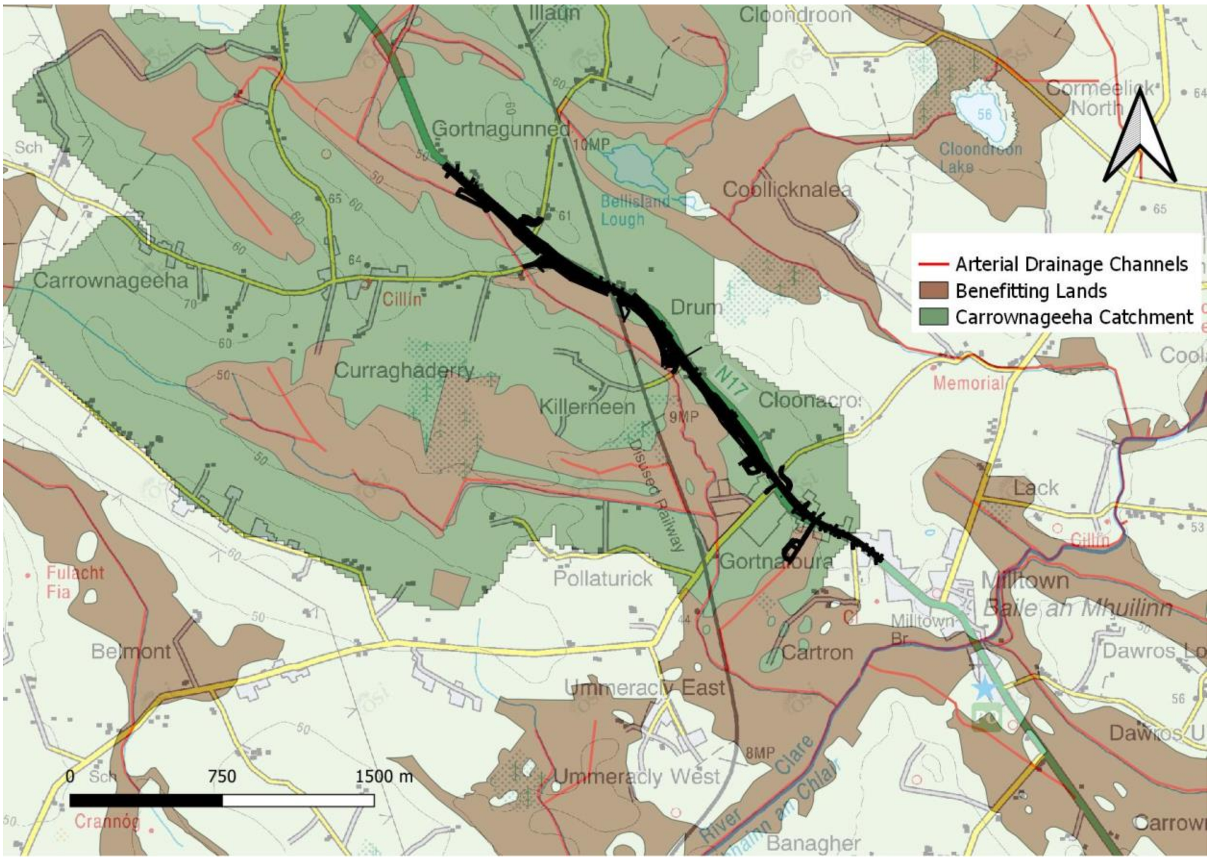

Figure 2 Arterial Drainage channels and benefiting lands map

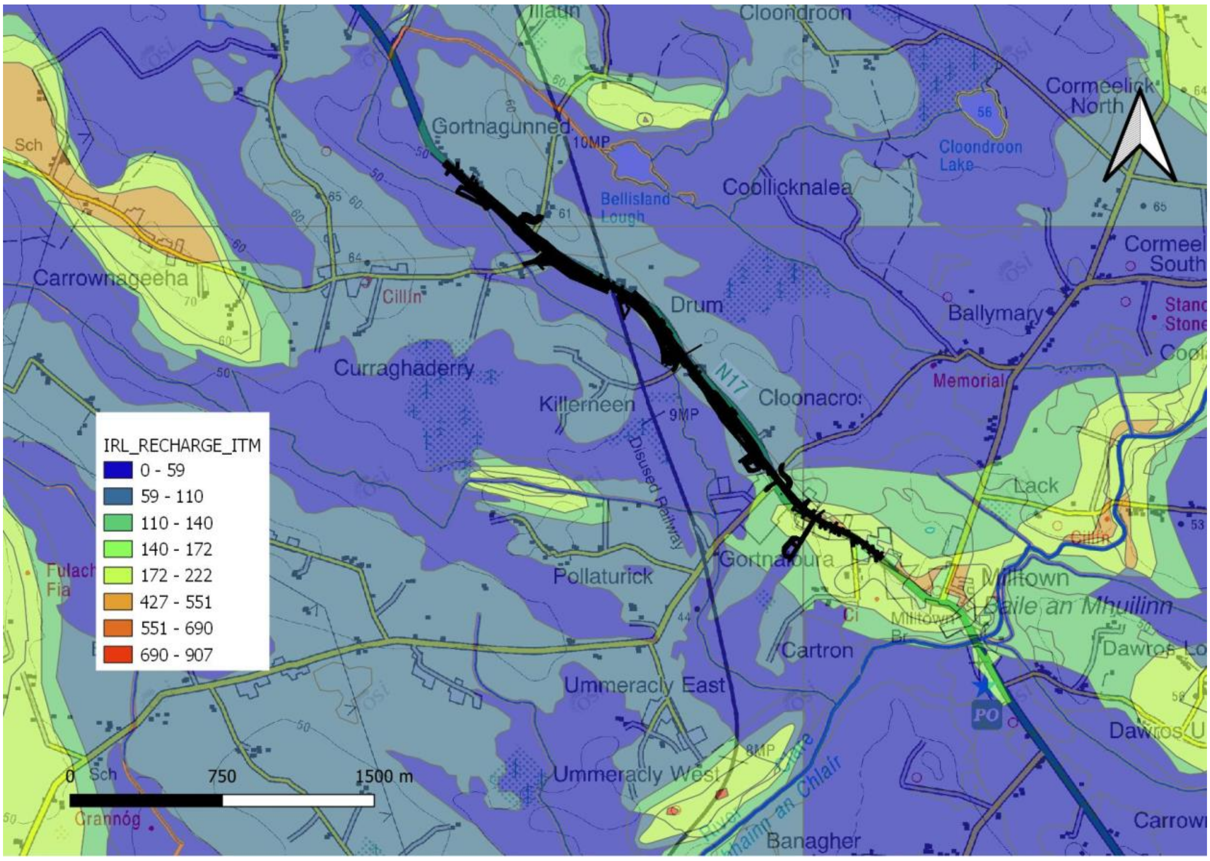

Figure 3 GSI Groundwater Recharge Rates based on soils and sub-soils

Plate 2 Underpinned road culverts along the Drum tributary Stream

Plate 3 Maintained Drum Stream Channel

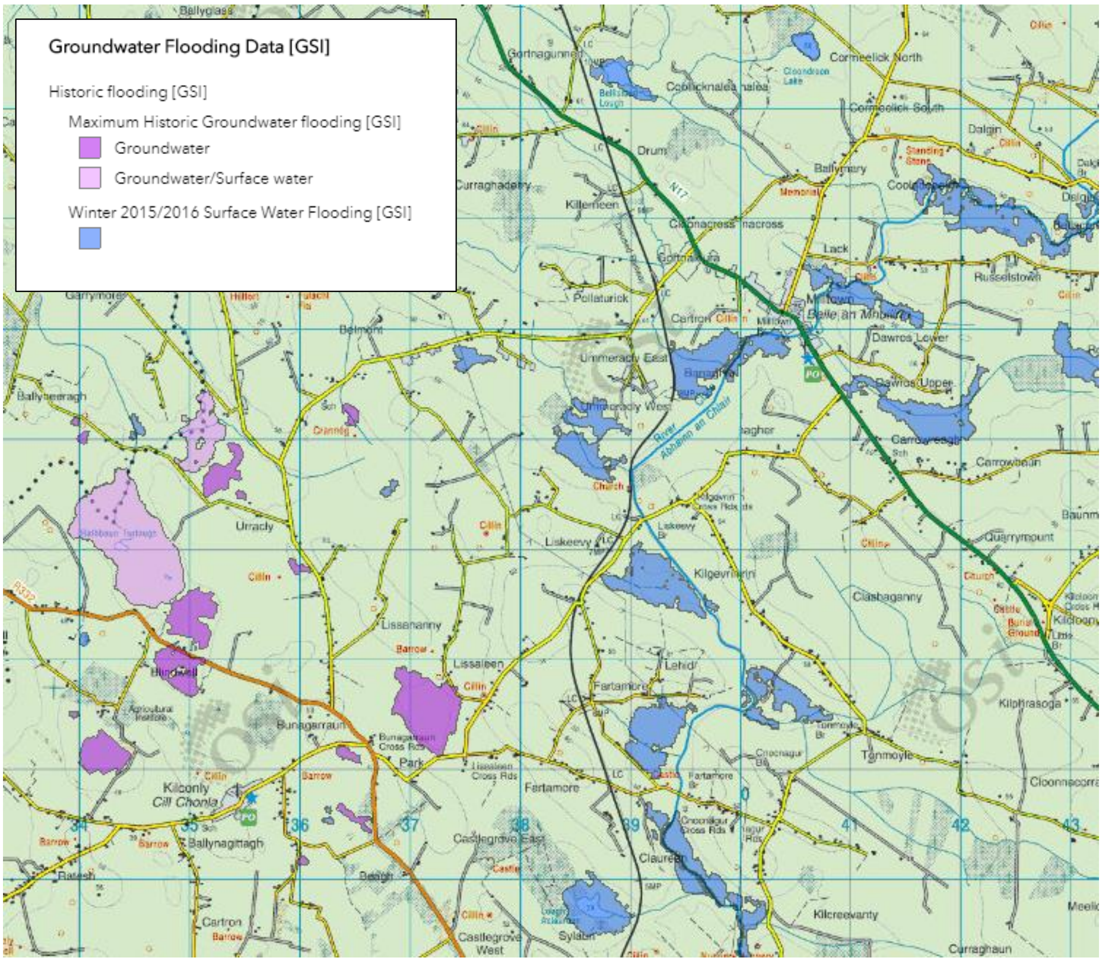

Figure 4 GSI Flood mapping

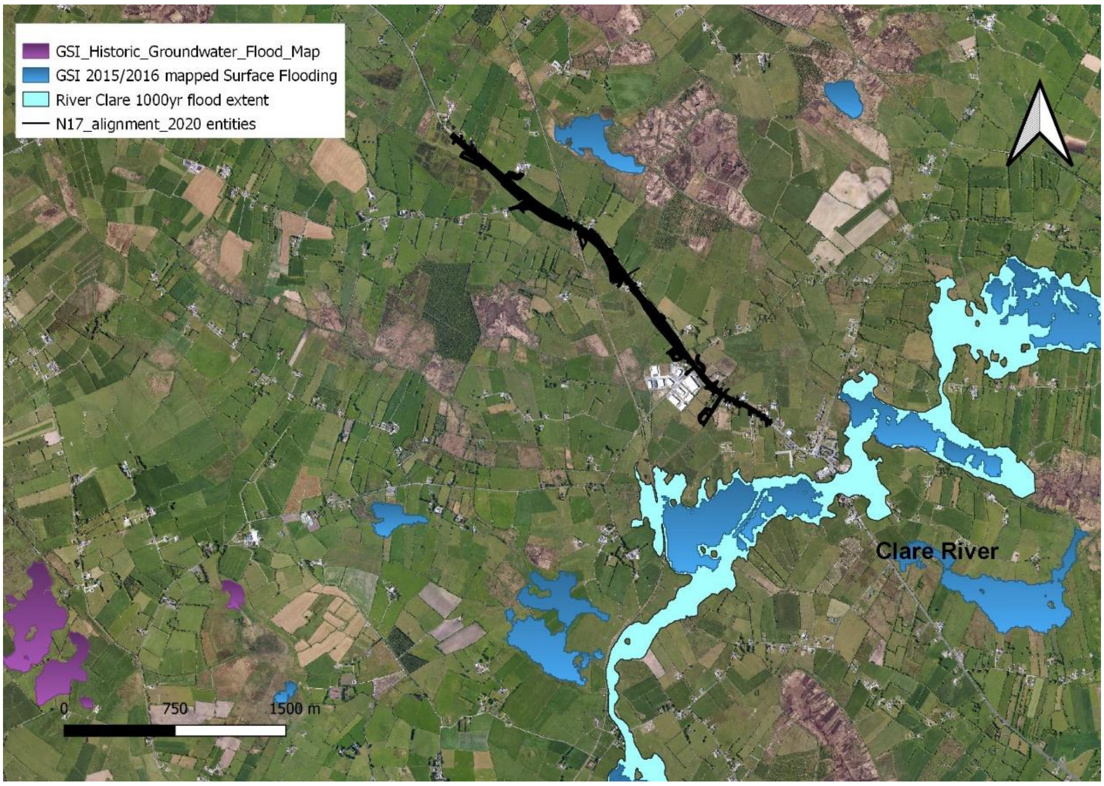

Figure 5 Flood Extents mapping using OPW Cfram and GSI groundwater flooding database

2.1.3 Flooding and Flood Risk

The GSI have recently produced flood maps for groundwater flooding and surface flooding associated with the Dec/Jan 2016 extensive flood event included on this mapping is estimated low to high probability groundwater flooding, refer to Figure 5 above for the Road project area. This shows extensive surface flooding from the River Clare downstream of Milltown at the confluence with the Carrownageeha Stream. No Surface flooding in 2015/2016 was identified along the Drum Tributary Stream. The nearest groundwater Turlough Flooding is southwest at the Rathbaun turlough (pNHA) 5km from the Road Development. The preliminary Flood Risk Assessment mapping shows the proposed road development to be out of the high and medium flood risk zones and shows extensive flooding of the Clare River both upstream and downstream of Milltown Village, refer to Figure 5 and 6. The OPW arterial drainage land benefitting mapping can also be used as a flood risk screening tool for potential flood risk areas that have been protected through the arterial drainage. The various culverts along the Drum tributary have been underpinned by c. 0.8m and drainage channel regraded, refer to plates 2 and 3.

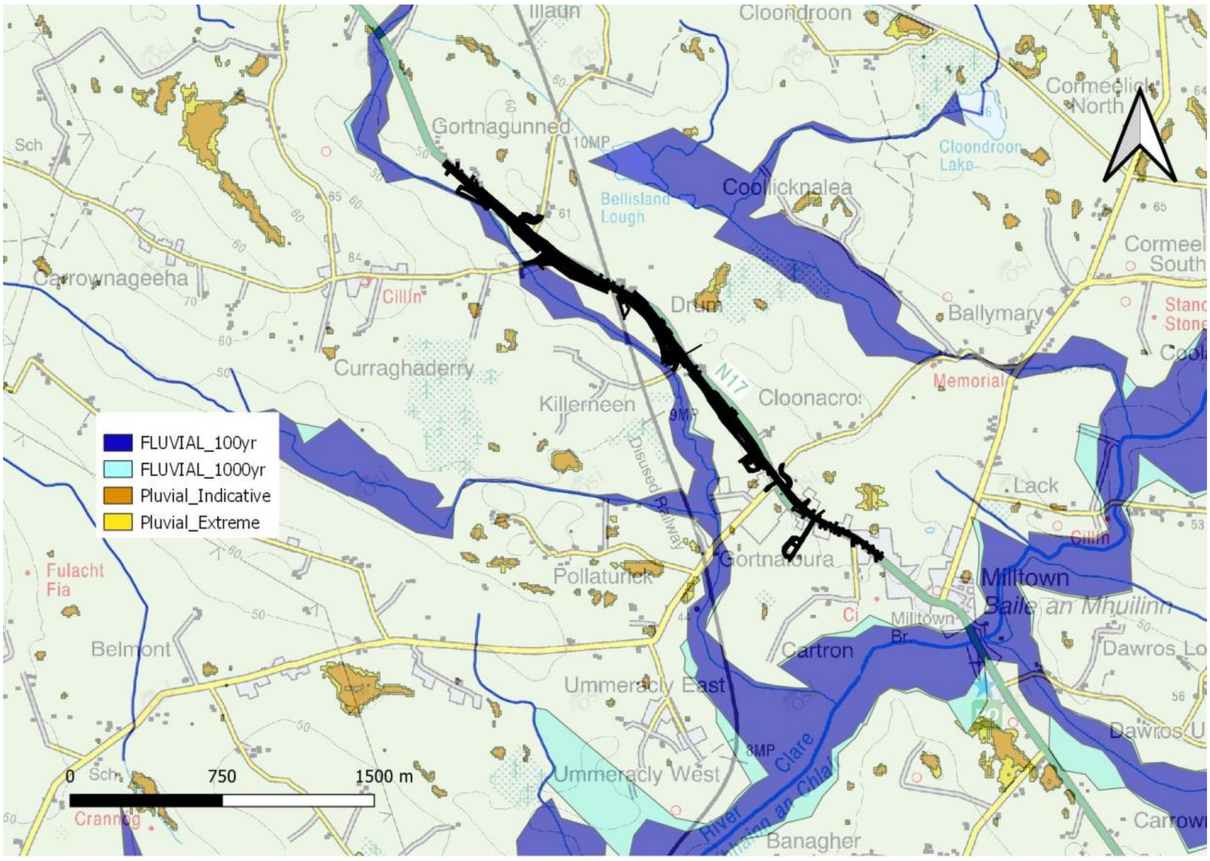

Figure 6 Preliminary Flood Risk mapping based on OPW PFRA(2011)

2.1.4 Ecological Receptors

Sensitive aquatic ecological receptors within the study area are peatlands south of the scheme towards the Clare River confluence. Along the proposed road scheme, the Land is generally classified as improved grassland. There are two areas of wet grassland, a small area adjacent to the N17 at the northwest end of the scheme and a second larger area adjacent to the disused rail line both east and west and immediately to the south of the N17at Drum, refer to Figure 4.3 of the Ecological Impact Assessment report by MKO (December 2020).

The Drum Stream is classified as a depositing /Lowland River is heavily modified by arterial drainage works and is identified as a potential pathway for pollution to enter the Corrib SAC which extends up along the Clare and lower reach of the Drum stream close to the site.

The Lough Corrib SAC (000297) extends up along the River Clare river channel past Milltown to just north of Clonfad village and 10km east of Dunmore. The SAC also extends up along the Carrownageeha stream and Drum Stream terminating at a local road at Killerneen, 600m to the north of the Milltown business park at Gortnaloura, refer to Figure 7. The proposed road alignment does not encroach any NHA, pNHA, SPA or SAC sites. The closest site to the road development is the Lough Corrib SAC at Gortnaloura which is extends along the Drum stream channel to the local road near chainage 1550. The local road is to be realigned from immediately north of the road bridge and SAC.

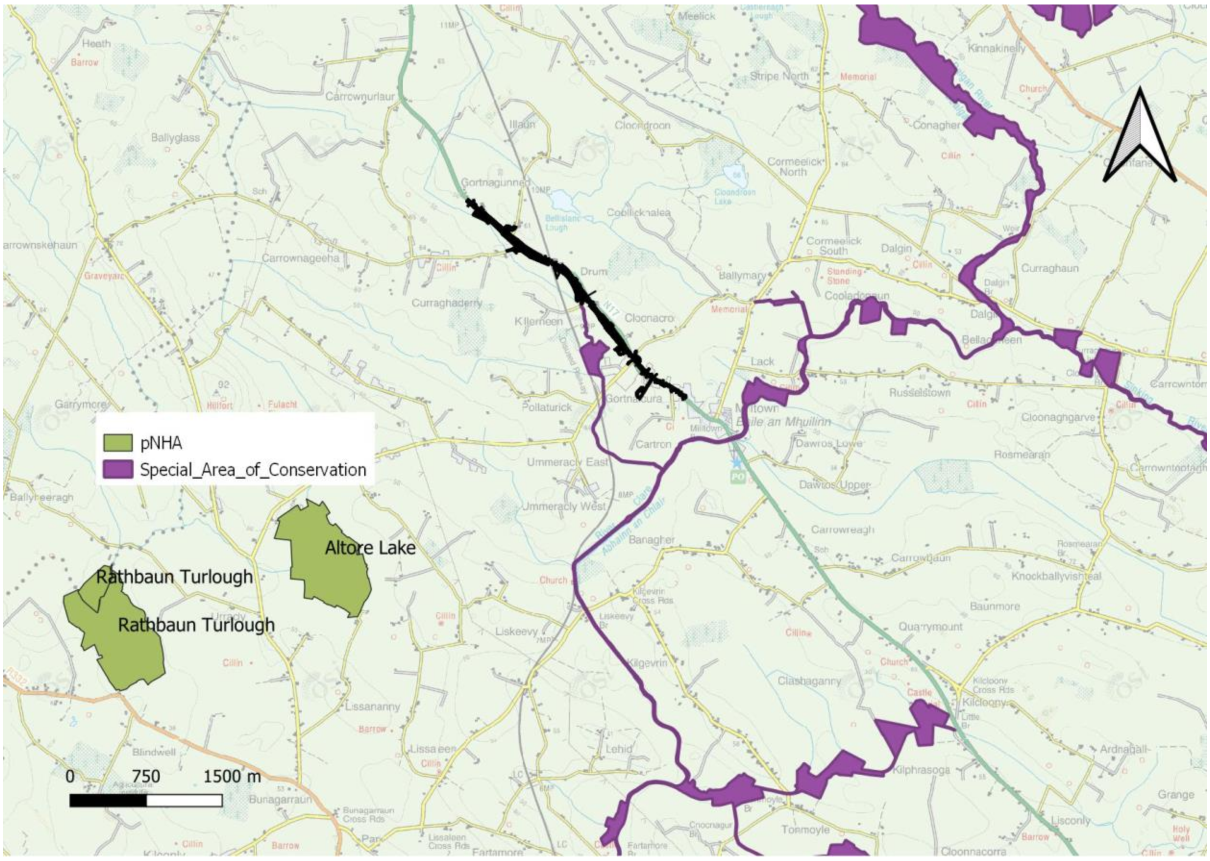

Figure 7 SAC and NHA's in proximity to proposed road development

2.1.5 Water Quality Status and Pressures

The ecological quality of River channels is reflected in their measured Q-rating. Q-ratings for the River Clare are available at different monitoring locations/stations along the river reach. The relevant up to date station for the Clare River near Milltown is located at a road bridge 1.5km upstream of Milltown (RS30C010100) (E141270, N263647). The latest published Q-rating for 2018 gives a Q-rating of 3-4 representing moderate ecological status. The portion of Clare River through Milltown and its downstream tributaries including the subject streams of the Drum and Carrownageeha are currently unassigned in respect to Q-status. However further downstream the Clare near Tuam the latest published Q-Rating is good at a value of 4.

There are no Q-ratings for the Drum Stream and its fishery potential is limited by the fact that it can virtually dry out during low flow periods. The lower reach section of this stream is prone to vegetation and weed growth given the low water depths and narrow channel. The typical channel dimension is trapezoidal shape with 1m base width, 3 to 4m top-width and typical channel depth of 1.2m.

During low-flow periods there is limited dilution available from the Drum Stream to assimilate pollutant discharges.

The Milltown Sewerage scheme discharges waste effluent to the Clare River downstream of Milltown at an outfall located adjacent to the Milltown GAA grounds which is upstream of the confluence with the Carrownageeha Stream. Irish Water and Galway Co. council have recently completed construction of a Municipal Waste Water treatment facilities at Milltown which reduces significantly the municipal waste load on the Clare River.

2.2 Hydrogeology

2.2.1 Aquifers

The proposed road development and surrounding area is underlain by Visean undifferentiated Limestones which are clean, pale grey, fossiliferous limestone which are subject to kartification. The aquifer Classification associated with this limestone formation is a Regionally Important Karstic conduit flow aquifer, refer to Figure 8. To the southeast of Milltown Village SW-NE faulting occurs and the bedrock formation is the Oakport and Kilbryan Limestone formation. These are impure muddy limestones and their lithology is described as dark nodular calcarenites and shales and is subject to less karstification. The aquifer type associated with this bedrock is classified as LI Locally Important Aquifer - Bedrock which is Moderately Productive only in Local Zones.

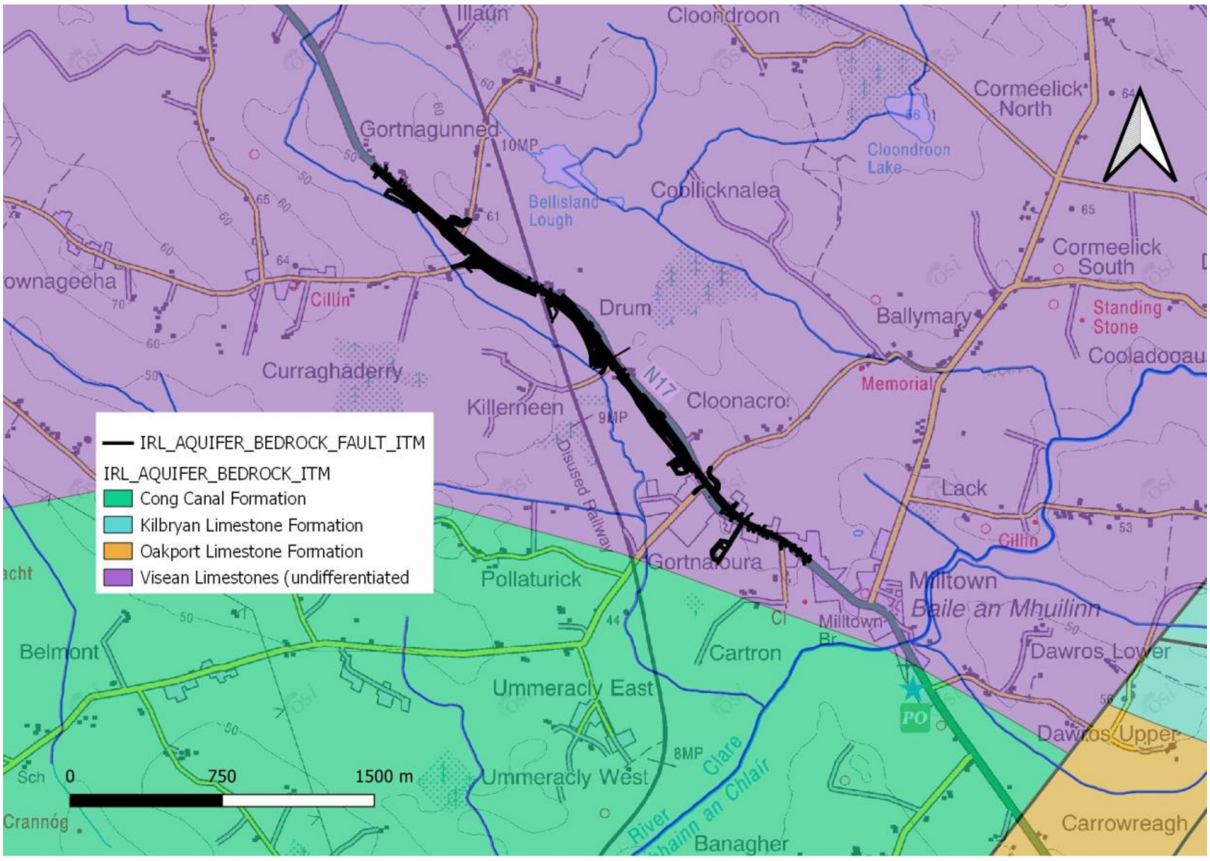

Figure 7 GSI Bedrock Formations

2.2.2 Karst Features

There are no mapped karst features in proximity to the proposed road development. This may be associated with the large depth of overburden in the Drum area which is generally of low permeability. There are no significant groundwater supplies within or proximate to the study area. The section of road that may have potential for karstification is in the shallow overburden area towards the southern tie-end of the scheme close to Milltown.

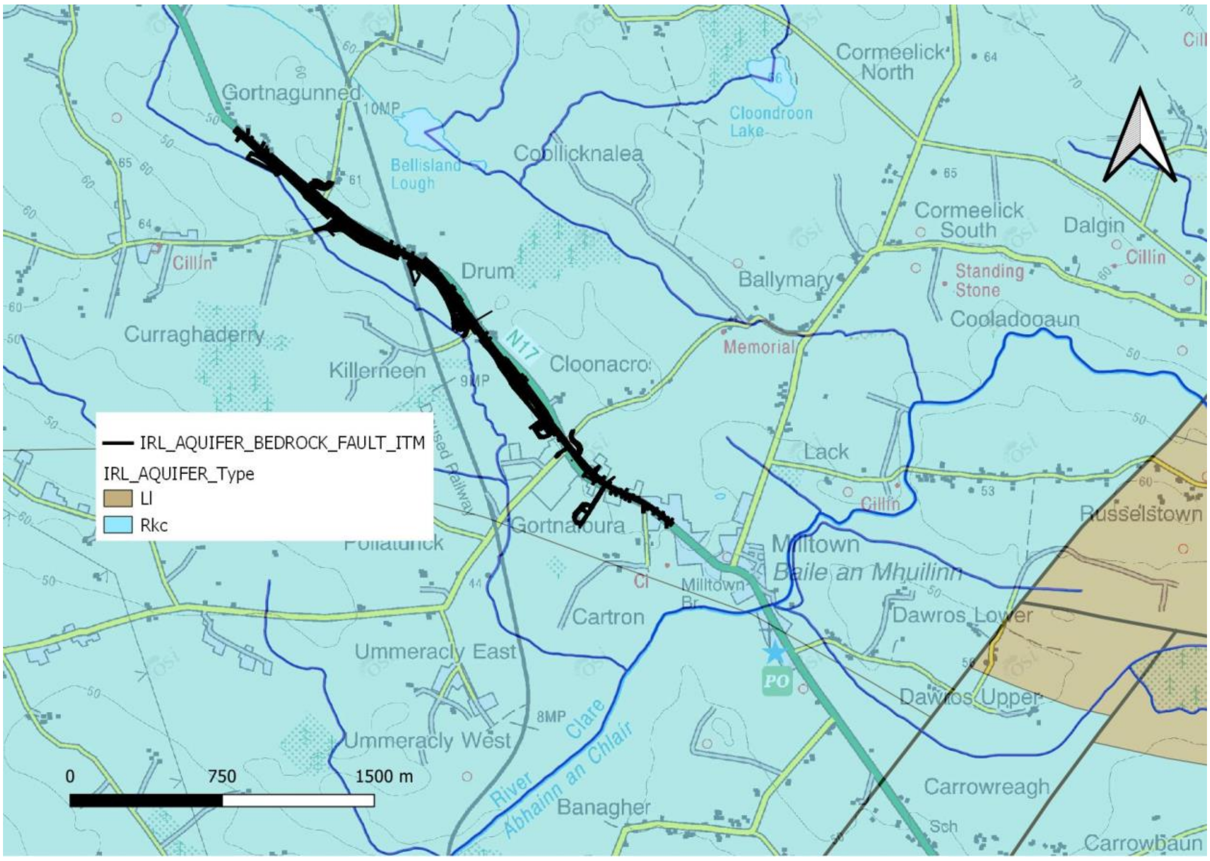

Figure 8 Bedrock Aquifer Classification

2.2.3 Groundwater Vulnerability

The GSI aquifer vulnerability mapping is presented in Figure 9. This shows that a large section of the road development to the northwest of the L22208 Gortnaloura junction is classified as low vulnerability suggesting overburden depths exceeding 10m throughout. The section of road development to the southeast the L22208 Gortnaloura junction increases in vulnerability from medium to extreme vulnerability with bedrock and sub rock close to and at ground level.

Table2 Groundwater vulnerability Rating versus road chainage

Road Chainage	Aquifer Type	Groundwater Vulnerability
0 - 2240	Rkc	Low
2240 - 2450	Rkc	moderate
2450 - 2490	Rkc	high

2490 - 2730	Rkc	Extreme and extreme with outcropping
24730 - 2910	Rkc	high
2910 - 2930	Rkc	Extreme

Given the Aquifer classification the Road drainage design will require a sealed drainage system for pavement runoff waters in the section of high to extreme groundwater vulnerability (i.e. Ch 2450 to 2930) to meet TII Road drainage guidelines. Surface road drains in the low and medium vulnerability section (chainage 0 to 2450) can be an unsealed, open drainage system given the depth of overburden.

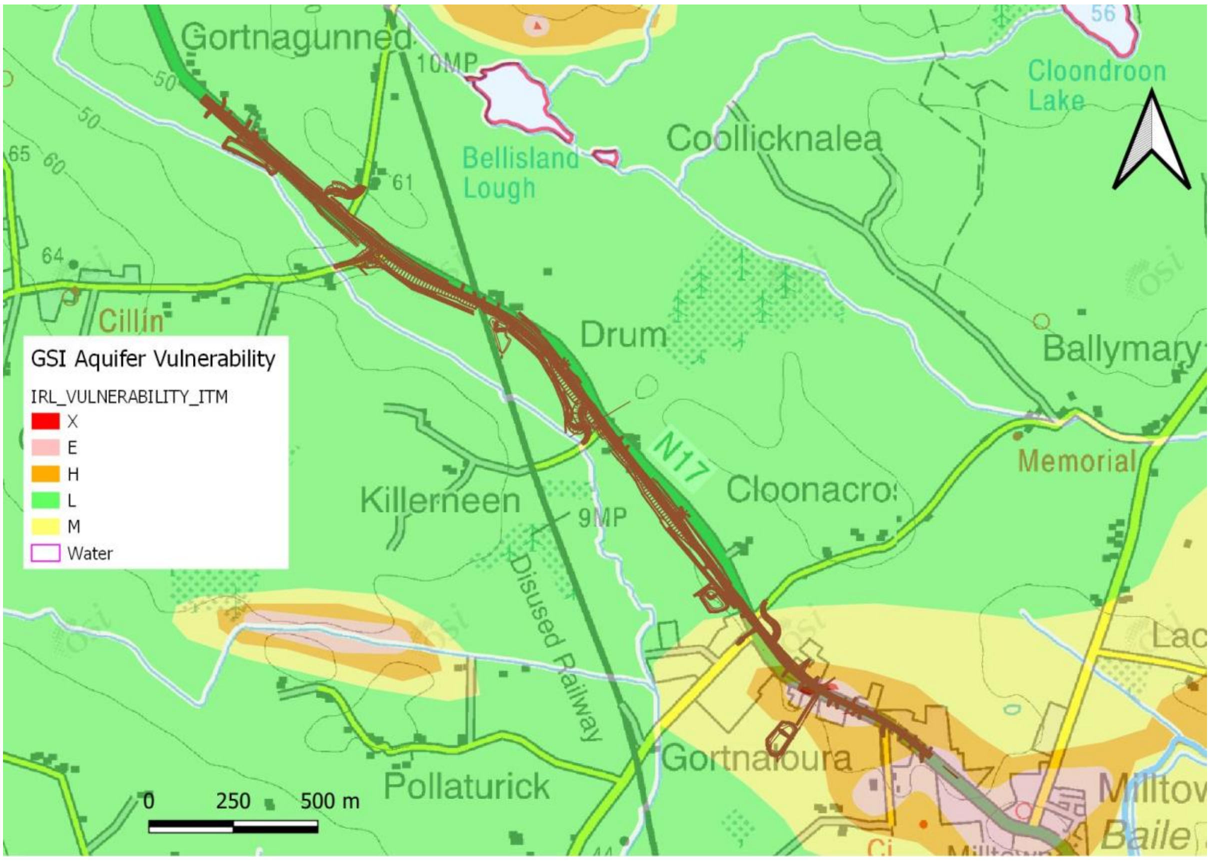

Figure 9 Groundwater Vulnerability to Pollution – GSI vulnerability mapping

2.2.4 Water Resources and wells

The area is serviced by Milltown group water Scheme with the supply source a treated surface water abstraction from the Clare River approximately 1.5km upstream of the Town. This abstraction is for a P.E. of 1400 households within the group scheme area. The proposed road development is downstream of the is abstraction and therefore will not have the potential to impact the supply source either via groundwater or surface water.

There are many historical wells shown on the historical OSI maps near the existing road which supplied individual dwellings along the N17. Many historical wells are mapped but no springs or risings near the proposed road development have been identified, historical or otherwise.

2.2.5 Quaternary

The sub-soils within the study area are presented in Figure 10, obtained from GSI mapping. The road alignment is primarily located on the glacial till defined as till derived from carboniferous sandstones and cherts. The alignment runs close to boundary between the till on the higher ground to the northeast and the cut-over raised peat to the southwest with the alignment partially cutting through sections of this peat. An Alluvium deposit is present to the north of chainage 2300 which is associated with lands draining eastward to the Clare river. The soil along the route within the carboniferous tills is described as surface gleys, a mineral soil poorly drained.

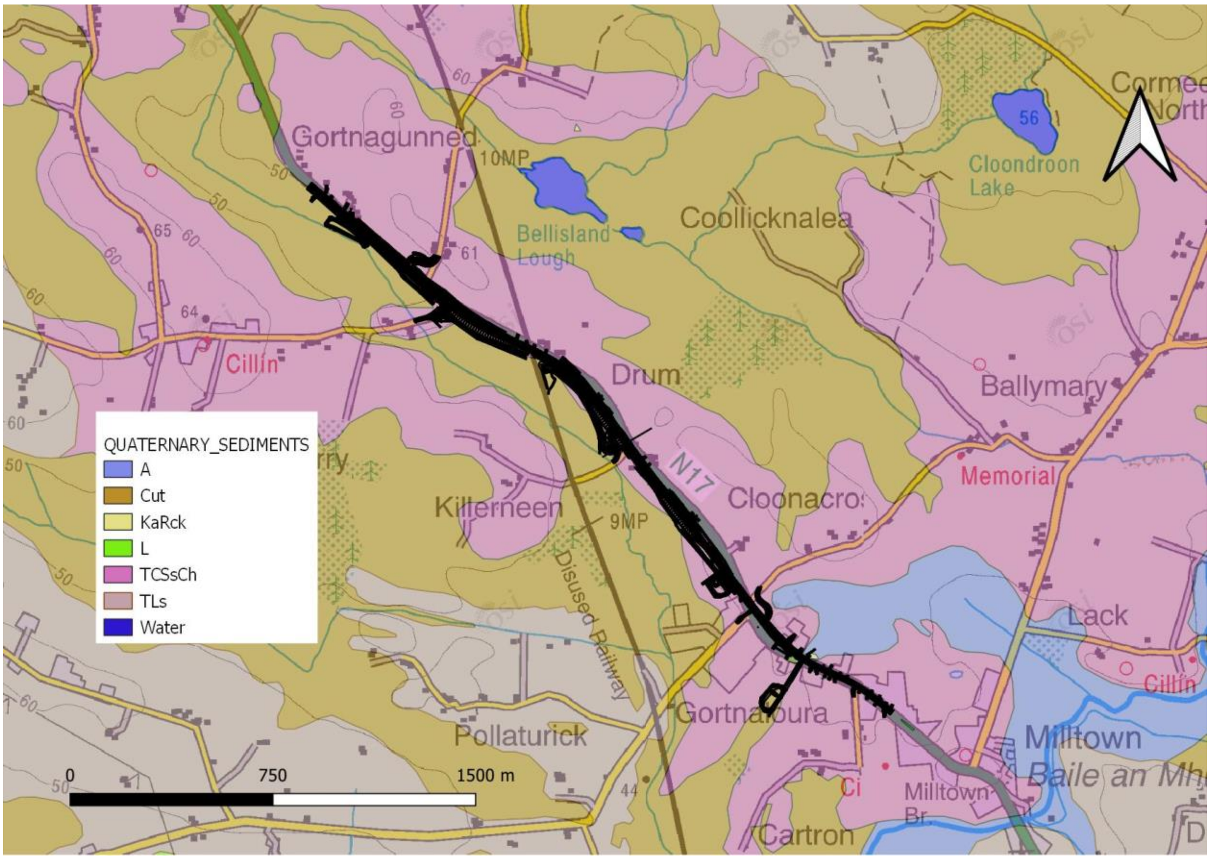

Figure 9 Quaternary Sediment classifications within the Study Area.

2.2.6 Groundwater Levels

Within deep quaternary deposits from Ch. 0 to 2300 described as poorly drained mineral soils overlaying Carboniferous till the soil and subsoil permeability is very low and the depth to the water table is likely to be perched and strongly influenced by the surface drainage levels. In the Shallower tills towards the end of the scheme the groundwater table is likely to be within the upper weathered section of the bedrock. The topography and permeability limits any significant groundwater flows that would generally be in southerly direction. Within the cutover peat located on the lower lying lands to the south and southwest of the proposed road the water table is likely to be close to the surface with potential for winter ponding of rainwater.

3. Potential Hydrological Impacts

3.1 Introduction

The proposed Development is a relatively short section of national road to be upgraded being slightly less than 3km. The alignment follows relatively closely the existing road alignment and provides improved local road junctions. The design ADDT for the N17 is 10,650 vehicles with HGVs representing 6.9%.

The road alignment is primarily in fill or at grade. There are two reasonably shallow road cut sections of c. 2.3m deep between Ch 1030 to 1290 and c. 2.2m deep between Ch 2330 and 2550. The first cutting is completely within the overlying glacial till and the second cutting is likely to encounter the limestone bedrock.

There are no river or stream crossing structures required by the proposed road development. With the Drum Stream remaining to the southwest of the road alignment over its length.

Given the scale and nature of the proposed road development it can have a potential for causing a significant impact to the hydrological regime both during the construction and on-going operation. Consequently, such projects require careful planning and detailed assessment to ensure the best solution is achieved.

The principal potential hydrological impacts to the character of the receiving waters are associated with the potential for sediment loading and associated road drainage pollutants entering such watercourses during both construction and operational phases.

3.2 Proposed Road Drainage features

The existing N17 Road has generally uncollected and untreated, over the edge, drainage of the road pavement. It is also likely that many small clapper culverts and or stone drains cross under the current alignment to facilitate the natural drainage from north to south.

The proposed road development provides an opportunity of installing a designed road drainage system for the 3km of road pavement which if suitably designed provides an opportunity of eliminating uncontrolled surface flow discharges towards the Drum Stream which ultimately via Carrownageeha enters the Clare River. The Clare river channel and the lower reaches of the Drum stream channel are within the Lough Corrib SAC and therefore represent highly sensitive receiving waters.

The proposed road drainage has been designed in accordance with guidance from the TII guidelines (DN-DNG-03022, DN-DNG-03063 and DN-DNG-03065). There are four proposed road drainage outfalls as summarised below in Table 3 draining the 2,950m length of Road. All the Outfalls directly or indirectly discharge into the Drum Stream which eventually becomes the Carrownageeha Stream and which outfalls to the Clare River 700m southwest of Milltown.

Table 3 Drainage outfall details

outfall reference	outfall Chainage	pavement Chainage	pavement width	paved area	Receiving watercourse
1	180	0 to 770	12.3	9471	Drum stream Channel
2	1150	770 to 1540	12.3	9471	toe drain at rail line
3	2100	1540 to 2120	12.3	7134	Field Drain
4	2300	2120 to 2950	14.6	12118	Field Drain adjacent to L2227

3.3 Operational impacts

3.3.1 Surface Waters Spillage Risk Assessment

A pollution risk assessment using the TII DN-DNG-03065 Method D to assess the potential pollution impacts from a serious road traffic incident on the receiving environment was performed. This considers the road length involved, the ADDT two- way traffic flow, the percentage of Heavy Good Vehicles using the road and the spillage rate which is a function of the road type, and the side roads and junctions encountered.

$$P_{SPL} = RL * SS *(ADTT*365*10^{-9}) * (\%HGV/100)$$

Where P_{SPL} annual probability of a serious spillage

RL is road length in km

SS is the spillage factor

AADT is the annual average daily traffic (for design year)

%HGV is the percentage of heavy goods vehicles

Given the number of side roads and entrances off the proposed road development an SS factor from Table A.5 of 1.81 will be used for the entire road length.

The annual probability of a serious pollution incident is as follows

$$P_{INC} = P_{SPL} * P_{POL}$$

Where

P_{INC} The probability of a spillage with an associated risk of a serious pollution incident occurring

P_{POL} the probability, given a spillage, that a serious pollution incident will result which includes emergency response time (a P_{POL} = 0.75 is selected representing remote location with response time > 1hour)

The overall annual risk of serious pollution incident to Surface waters for the 2.95km road development having a design ADDT of 10,650 and %HGV = 6.9% is very low. The individual outfalls have even a much lower risk of causing serious pollution incident to receiving surface waters as shown in Table 4:

Table 4 Individual Outfall annual spillage risk of serious pollution incident to receiving water

outfall reference	Annual Spillage Risk of serious pollution to surface waters %
1	0.022
2	0.022
3	0.017
4	0.024

Given the sensitivity of the receiving waters and the proximity of an SAC within 1km of the proposed road outfalls the following road drainage water treatment and protection measures have been incorporated in the design.

- Attenuation Ponds have been designed both for storm water attenuation and first flush water quality detention
- Upstream of all outfalls and downstream of the drainage ponds an oil/petrol interceptor is to be provided suitably sized for the drainage pavement area

- A shut off penstock at the Pond outlet is to be provided which in the event of a serious pollution incident the pond can be closed off from the outfall and used to contain the spillage for appropriate removal and treatment.

3.3.2 Groundwater Risk Assessment

A pollution risk assessment from road drainage on groundwater in accordance with the TII DN-DNG-03065 Method C was carried out. This assessment determines the groundwater protection response for the use of permeable drain systems on road schemes. Permeable drainage systems permit surface runoff to infiltrate into the ground. The groundwater pollution risk is a function of

- hydraulic and contaminant load which is a function of rainfall and traffic numbers
- the infiltration capacity of the subsoil
- thickness, permeability and porosity of the saturated and unsaturated zones
- the presence or lack of weathered bedrock
- groundwater flow mechanisms – diffuse / intergranular or preferential fracture flow

For the proposed development realignment, the underlying Aquifer is a Regionally Important Karst Aquifer, but is outside any source protection area. The sub-soil is a limestone till of moderately low permeability. The winter water table level is typically within 2m of the ground level in the glacial till, groundwater flooding has not been identified as a risk along the entire alignment. The resulting groundwater protection response for use of permeable drainage in the various vulnerability sections of the road alignment is presented below in Table 5.

Table 5 Groundwater Protection Response to use of permeable drainage systems

Road Chainage	**Aquifer Type**	**Groundwater Vulnerability**	**Groundwater Protection Response**
0 - 2240	Rkc	Low	R1
2240 - 2450	Rkc	moderate	R2(1)
2450 - 2490	Rkc	high	R2(2)
2490 - 2730	Rkc	Extreme and extreme with outcropping	R2(3) and R4
24730 - 2910	Rkc	high	R2(2)
2910 - 2930	Rkc	Extreme	R2(3)

Refer to Table A.4 in the Dn-DNG-03065 for the response definitions and requirements.

Based on the Groundwater risk assessment and the groundwater protection response Matrix a sealed kerb and gully drainage system will be used in the high and extreme Vulnerability sections of the Road (i.e. Ch 2450 to 2950) which avoids any potential for infiltration from road drainage carrier drains to the underlying karstified regionally important bedrock aquifer. In the low and moderate vulnerability sections unsealed open drainage system comprising grass channels and French drains is permitted and proposed. All the Ponds will be unlined as they are in low and moderate groundwater vulnerability zones. Due to low sub-soil permeability, all road drainage runs will have a surface water outfall.

Two areas of wet grassland are encountered along the road scheme, a small area immediately adjacent to the N17 at the northwest end of the scheme and a larger area at Drum on the south side of the N17 adjacent to the Railway Line. Drainage effects from development can cause a drying of wet grassland areas with an eventual loss of such habitat close to the drains. The road is back online at the Northwest end of the scheme but a proposed water attenuation pond for road drainage treatment is proposed within this wet grassland area resulting in direct loss of wet grassland area. Existing embankment toe drains will be retained to collect natural drainage from the embankment slopes and therefore existing drainage will not change significantly. The second and more extensive area of wet grassland at Drum will have its most northerly section of wet grassland encroached by the scheme to facilitate the local road connection to the N17. Embankment toe drains are proposed that will encroach slightly into the northerly section of this wet grassland and may cause some local drying of the lands immediately adjacent to the Drains. The overall hydrological impact is classified as a local moderate impact on such a receptor. Mitigation is not proposed as the primary impact comes from the direct encroachment of the road development as opposed to the road drainage.

3.3.3 HAWRAT Analysis of Routine Road Drainage discharges 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 the potential impact to receiving watercourses research has found the first flush runoff (10 to 15mm rainfall runoff) can produce elevated concentrations locally in the receiving waters. The impact of contaminants within routine road runoff depends on the loading (associated with traffic numbers) and the available dilution in the receiving watercourse.

TII DMRB publications document DN-DNG-03065 (HD45) 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 Water Framework Directive (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) numbers.

A HAWRAT assessment has been carried out for all proposed drainage outfalls directly discharging to surface watercourses along the proposed road development, see Table 6 below. The HAWRAT assessment tool uses the AADT category of 10,000 to 40,000 in the assessment process which is appropriate for the Design Year AADT number of 10,650. This ADDT category is likely to be precautionary in terms of its water quality predictions as the ADDT numbers are much closer to 10,000 than 40,000. It is also important to note that the HAWRAT assessment is based on direct discharges to watercourses in the absence of proposed drainage design measures, that include petrol interceptors, water quality treatment ponds and wetlands and attenuation ponds, and therefore, the predictions are worst case, not including any treatment performance which will achieve more than 60% reduction in suspended sediments and associated heavy metals. The HAWRAT analysis was carried out on all the proposed outfalls in the absence of proposed water quality and attenuation measures and the required level of treatment quantified, refer to Table 6 below.

In general, HAWRAT is considered to provide a very precautionary means to assess those road outfall discharges on the receiving water quality with respect to soluble and sediment-bound pollutants. The screening parameters are sediment and the dissolved heavy metals of zinc and copper concentrations. These represent the primary waste constituents in the road drainage discharges and used as screening parameters for other pollutant substances such as de-icing agents of salt and grit, hydrocarbons, Cadmium, Pyrene, PAHs, nutrients and organics.

Table 6 Results of the HAWRAT Road Outfall Water Quality Assessment of Receiving Surface Waters – Drum Stream

Outfall No.	Water Hardness (mg/l $CaCO_3$)	Dissolved Copper (ug/l)	Dissolved Zinc (ug/l)	Sediment Deposition Index	Comment
1	High > 200	0.20	0.62	162	**Pass** Soluble, **Fail** Sediment Accumulates (Settlement required 38%)
2	High > 200	0.14	0.44	123	**Pass** Soluble, **Fail** Sediment accumulates (Settlement required 19%)
3	High > 200	0.10	0.32	87	**Pass** Soluble, **Pass** Sediment accumulates but not extensive
4	High > 200	0.11	0.34	87	**Pass** Soluble, **Pass** Sediment Sediment accumulates but not extensive
4 Combined analysis	High > 200	0.31	0.96	n/a	**Pass Soluble,** **Sediment not applicable refer to individual sites**

Refer to appendix 1 for full detailed HAWRAT results output

These analyses show that sufficient dilution is available at 95 percentile low flow in the Drum Stream as meet the threshold limits for associated road drainage heavy metal pollutants. It is generally fond that if the soluble zinc and copper limits are met then the limits for the other associated road drainage pollutants will be satisfied. Water detention is to be provided which will contain the first flush event of 20mm from the road pavement within the Pond before releasing it slowly. Such treatment facilities should achieve up to 60% settlement. In case of outfalls 2, 3 and 4 the discharge will be to a field drain before reaching the Drum stream which will provide additional primary settlement.

A cumulative assessment on the water quality of the Drum Stream from the combined effect of the 4 outfalls passes the HAWRAT Analysis in respect to the soluble pollutants with no additional treatment required.

The conclusion of this assessment is that the proposed Road drainage routine discharges will not result in any significant impact on the water quality of the receiving Waters of the Drum Stream and the Lough Corrib SAC and an imperceptible impact on the downstream receiving Clare River. The proposed water quality treatment will further safe guard the receiving water quality and will avoid any significant accumulation of sediment at the respective outfalls.

3.3.4 Stormwater and drainage water flow and Flood Impacts

The proposed road development through its increased paved area and drainage system can result in increased storm flows to receiving streams and can represent in a potential barrier to overland flow from the northeast to southwest if not appropriately designed. The drainage design for the proposed road has been designed not to increase flooding. This is achieved through the provision of storm water attenuation ponds and flow controls upstream of each outfall to limit outflow to greenfield flood runoff rates and the provision of interceptor drains to facilitate land drainage from the northeast discharging under the road to the existing land drains on the southeast side of the road. The separation of land drainage flows from road pavement flows is important from storm attenuation and water treatment design of the pavement runoff and rationalising the storage required.

The natural greenfield runoff rate for the Milltown area is determined using the IH124 ungauged flood estimation equation for small catchments. This equation is presented below as follows:

$$QBAR = 0.00108*AREA^{0.89} * SAAR^{1.17} * SOIL^{2.17}$$

Where QBAR is the mean annual flood rate (m3/s)

AREA is drainage area (km2)

SAAR is mean annual rainfall (mm)

SOIL is the Winter Rainfall acceptance potential (conversely runoff coefficient) for type 2 soils represents Milltown area SOIL = 0.3.

The design flood $Q_{100} = X_{100} * QBAR$

Where from the national flood growth curve $X_{100} = 1.96$

This gives a greenfield flood runoff rate Q_{100} = of 6.5l/s per ha and an annual flood runoff rate (2.44year return period) of 3.32 l/s per ha.

The attenuation storage is sized based on the 100year rain storm event + 20% climate change discharging at greenfield flood rate of 6.5l/s per ha.

Table7 Attenuation Storage Required

Pond	Permissible maximum Greenfield outflow (l/s)	Storm Attenuation Storage m3	Permanent First Flush Storage for water treatment m3	Total storage required m3
1	6.2	640	189	829
2	6.2	640	189	829
3	4.6	482	143	625
4	7.9	819	242	1061

Storage includes 20% increase in 100year rain storm depth for medium range climate allowance
Detention storge for water quality treatment sized for 20mm first flush rainfall depth
Minimum freeboard between maximum flood level and attenuation pond bund is 300mm.

The critical storm event for sizing the attenuations storage comes out as 9 – 12hour storm duration.

The natural drainage from the higher ground northeast of the road is collected in separate interceptor drains that run parallel to the road alignment and cross under the road in culvert sections at various appropriate locations to discharge to the existing drainage network southwest of the road which eventually discharge to the Drum stream. This ensures that the potentially polluted road runoff waters are isolated for treatment in the water quality and attenuation ponds before returning it the natural drainage network. The proposed interceptor drains and culverts prevent the upgradient land runoff from ponding upstream of the road that could potentially cause flooding and drainage problems or increased flows to the road pavement drainage.

3.3.5 Rock Cuts

There are two sections of road cut both of which are reasonably shallow and will not result in any significant radius of water table drawdown or aquifer dewatering rates. Based on the shallow cutting of c. 2 to 2.5m depth the operational dewatering effect on the local water table will be small to imperceptible due to either the cutting not intercepting the water table and / or the low sub soil permeabilities. Any zone of influence is unlikely to extend beyond the CPO line for the development.

3.4 Construction Phase Impacts

3.4.1 Construction activities

The construction phase of the proposed road development involves temporary and permanent works near and within watercourses, generally associated with the construction of culverts and outfalls, realignment of drainage channels. The aspects of the construction phase that are relevant to hydrology are summarise below.

- Construction of 4 No road drainage outfalls discharging to surface watercourses/drains
- Construction of wetland treatment systems, attenuation ponds and infiltration basins upstream of the proposed road drainage outfall
- Construction of permanent interceptor drains
- Construction of the proposed road drainage network including carrier drains, filter drains, grassed surface water channels, etc.
- Construction of 1 site compound near Ch 2250
- Construction of a material deposition area near Ch 1100- for surplus topsoil, U1 material (material that does not comply with the requirements outlined in TII Series 600 Cl. 601.1) and peat encountered during construction. Such material is not suitable as construction material and is excess material.

- Construction of temporary drainage works such as sedimentation ponds and silt traps as required to treat soiled construction water. Temporary diversions and interceptor drains will be constructed to reduce the potential for soiled water runoff from the construction site. For further details of control of sediment and erosion refer to the Construction Environmental Management Plan (CEMP).

Construction activities pose a significant risk to watercourses and groundwater particularly from contaminated surface water runoff from construction activities entering nearby watercourses and accidental spillages of hydrocarbons, chemicals and concrete.

Construction activities within and alongside surface waters associated road construction and its road drainage facilities and outfalls 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 in-stream works can potentially represent a severe disruption to aquatic ecology.

The main contaminants arising from construction runoff include:

- Elevated silt/sediment loading in 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 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 cements 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

Given the sensitivity of the receiving water environment being an SAC and Fishery potential watercourse the uncontrolled discharge of soiled construction waters from the site works would represent a short-term moderate to significant negative impact on the Drum Stream and a minor to moderate short-term impact on the Clare River in the vicinity of its confluence with the Drum / Carrownageeha Streams.

3.4.2 Deposition of Excess Construction material

The construction of the proposed road development will result in excess material (Peat material and material with high silt content) which is not suitable as construction material and is more than the landscaping requirement. The estimated reuse of excavated material will be approximately 70% at 25,000m3 and it is estimated volume of unsuitable material is 11,000 m3. This material is to be deposited on site within an engineered material deposit area. The transport and deposition of this material if not suitably controlled could, given the proximity to watercourses and field drains enter the Drum Stream and the downstream SAC waters including the River Clare. Depending on the severity such an impact could result in moderate to significant impact on the stream and river water quality and result in significant sediment accumulation on the watercourse bed which overtime could migrate downstream resulting in potential smothering of potential and existing spawning gravel beds.

The proposed material deposition site is to be located near Chainage 1100 adjacent to the railway track and embankment on its southwest side. The material deposit area will initially generate sediment laden runoff waters which if uncontrolled and untreated will enter the Drum Stream resulting in local and downstream significant impacts. Eventually the surface of the deposition will vegetate and sediment laden runoff will reduce.

3.4.3 Construction compound

A construction compound is to be near Ch 2400 to Ch 2500, the north-eastern side, where there are two houses proposed for demolition as part of the CPO. Construction compounds are often used for storing of material, chemical and hydrocarbons for parking, site offices and services including toilets and washing facilities. Site Compounds if not properly controlled represent a source of pollution both to groundwater and surface water.

4 Mitigation Measures

4.1 Operational Phase

The drainage design has incorporated best practice in respect to drainage collection system which is sealed and avoids infiltration to a regionally important karst aquifer within the high, extreme and extreme with outcrop/sub-crop vulnerability section of the Road alignment from 2450m to 2945m which protects the groundwater aquifer from pollution.

Road pavement drainage is to be collected and isolated from the natural land drainage passing it through water attenuation and water quality detention ponds before out falling to the existing drainage channels downstream of the road (southwest). These facilitates are part of the road design and meet the TII guidance in respect to road drainage, the environment and drainage systems for National Roads. The drainage design protects the receiving watercourses and the downstream sensitive receptors including the Lough Corrib SAC. As part of the drainage design the outflow from the ponds will be passed through an oil/petrol interceptor to prevent contamination of the surface waters from hydrocarbon contamination.

No additional mitigation measures are proposed as the potential impact on the receiving hydrogeological and hydrological environments at the operational phase of the road will be insignificant. The proposed modern road drainage system is an improvement over the existing situation on the N17 which is non-existent, being uncontrolled over the edge discharges. The proposed road represents a safer road and therefore, reduces the potential for serious accidental spillage

4.2 Construction Phase

As is normal practice for road construction projects an outline Sediment Erosion and Pollution Control Plan has been developed and this plan will be finalised by the Contractor in advance of the commencement of construction and the following will be implemented as part this plan:

- An Incident Response Plan detailing the procedures to be undertaken in the event of spillage of chemical, fuel or other hazardous wastes, logging of non-compliance incidents and any such risks.
- A Sediment Erosion Control Plan.
- Continue to Inform and consult with Inland Fisheries Ireland (IFI)
- Continue to Inform and consult with National Parks and Wildlife Service (NPWS)

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

- Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters (Inland Fisheries Ireland, 2016)

- Shannon Regional Fisheries Board – Protection and Conservation of Fisheries Habitat with 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 C793 The SUDS Manual
- CIRIA C624 Development and Flood Risk – guidance for the construction industry
- CIRIA C532 Control of Water Pollution from Construction Sites Guidance for Consultants and Contractors
- CIRIA C648 Control of Water Pollution from Linear Construction Projects, technical guidance
- CIRIA C649 Control of Water Pollution from Linear Construction Projects, site guide
- Guidelines for the Crossing of Watercourses during the Construction of National Road schemes (NRA, 2006)
- Road Drainage and the Water Environment DN-DNG-03065 (TII, June 2015)
- Vegetated Drainage Systems for Road Runoff DN-DNG-03063 (TII, June 2015)

The principal mitigation measures that will be prescribed for the construction phase to protect the aquatic environment are:

4.2.1 General Measures

- Management of excess material stockpiles to prevent siltation of watercourses 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 and avoiding stockpiling of material in vicinity of sensitive watercourses
- Where construction works are carried out adjacent to bogs, fens, stream and river channels, protection of such waterbodies from silt load shall be carried out through use of reserved grassed buffer areas, timber fencing with silt fences or earthen berms. These measures will provide adequate treatment of constructional site runoff waters before reaching the watercourses
- Use of settlement ponds, silt traps and bunds and minimising construction activities near and 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 or sedi-mat.
- The construction site runoff will be treated through primary settlement such that it will not reduce the environmental quality standard of the receiving watercourse.
- Riparian vegetation along the identified sensitive watercourses (i.e. the Drum Stream) will be fenced off to provide a buffer zone for its protection to a minimum distance of 5m except for proposed crossing points

- The use and management of concrete (which has a deleterious effect on water chemistry and aquatic habitats and species) in or close to watercourses will be carefully controlled to avoid spillage.

4.2.2 Construction Compounds

- The constructional compound area will be required to be located on dry land and set back from river and stream channels and out of floodplain areas.
- The storage of oils, fuel, chemicals, hydraulic fluids, etc. will only occur within a prescribed bunded area within the constructional compound.
- Protection measures will be put in place to ensure that all hydrocarbons used during the construction phase are appropriately handled, stored and disposed of in accordance with the TII document "Guidelines for the crossing of watercourses during the construction of National Road Schemes". All chemical and fuel filling locations will be contained within bunded area within the Construction Compound site.
- Surface water flowing onto the construction area will be minimised through the provision of temporary berms, diversion channels and cut-off ditches, where appropriate
- Foul drainage from all site offices and construction facilities will be contained and disposed of in an appropriate manner to prevent pollution.

4.2.3 Material Deposit Site

The material deposit areas if not correctly constructed, could represent a serious source of pollution to an adjacent watercourse should untreated runoff waters containing high concentration of sediment enter the watercourse.

- To prevent slippage and uncontrolled sediment runoff the material deposition site will be bunded and fitted with double erosion control fencing (double silt fences) and a sediment settlement pond at the outlet. This facility will be constructed in advance of its use as deposition areas.
- Runoff from the material deposition areas will be treated in temporary settlement ponds which will be provided upstream of the outfall to the receiving watercourse or drain. 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 the material deposition site 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. Within the deposit area any external drains should be diverted around the material deposit area to minimise site runoff waters.

- The construction sequencing and design of the material deposition areas will ensure that there will be negligible impact on adjacent watercourses.

The potential for constructional phase impacts on water quality in receiving streams and the underlying Regionally Important Karst Aquifer has been reduced to slight and imperceptible through the implementation of the Outline Erosion and Sediment Control Plan.

5 Conclusions

The impact on hydrogeology and underlying regionally important karst conduit flow aquifer will be imperceptible both during construction and operation phases. A sealed drainage system has been included in the high and extreme groundwater vulnerability sections of the proposed road (Ch 2450 to 2945) and no road drainage outfalls discharge directly to groundwater. Downstream in the Clare River there are losing section of river reach which in dry weather periods can infiltrate to groundwater. Given the minimal impact of the Drum stream and the much larger Clare River the potential impact from the proposed road development will be imperceptible.

Direct encroachment and minor drainage effects of two small areas of wet Grassland have been identified and the impact rating has been assessed as a local moderate adverse impact on a wet grassland habitat. Mitigation is not proposed as the impact is associated with direct encroachment by the road development associated by the provision of an attenuation pond and local road connection to the Mainline road. These areas of wet grassland were not identified as a Key Ecological Receptor (KER) and therefore not of Local high value or higher.

The potential for constructional phase impacts on water quality in receiving streams and drains has been reduced to slight and imperceptible through the implementation of the Outline Erosion and Sediment Control Plan & CEMP.

During the operational phase, water quality in the receiving streams will be protected from road drainage discharges. Oil and petrol interceptors along with surface pond treatment systems will be placed upstream of all surface water outfalls and groundwater infiltration basins. These are designed to capture first flush rainfall events and provide protection against both minor or large road spillages. An operational spillage assessment for the proposed road development was carried out for all outfalls, and the results show low risk of impact from serious accidental spillage involving a HGVs. In conclusion, residual water quality impacts on these watercourses will be slight to imperceptible during the operational phase.

There will be no significant constructional or operational water quality pollution impacts or hydrological regime change to the Drum Stream or the Lough Corrib SAC.

In conclusion, there will be no significant constructional or operational hydrological impacts to the surface or groundwater environment from the proposed Road Development.

Appendix 1 Road Drainage Outfall - HAWRAT Results

HIGHWAYS AGENCY

Highways Agency Water Risk Assessment version 1.0 November 2009

Soluble - Acute Impact

Annual Average Concentration	Copper	Zinc	
Step 2	0.20	0.62	ug/l
Step 3	-	-	ug/l

Copper	Zinc
Pass	Pass

Sediment - Chronic Impact

Fail. 39 % settlement needed.

Sediment deposition for this site is judged as:			
Accumulating?	Yes	0.06	Low flow Vel m/s
Extensive?	Yes	162	Deposition Index

Location Details

Road number	N17	HA Area / DBFO number	Outfall 1
Assessment type	Non-cumulative assessment (single outfall)		
OS grid reference of assessment point (m)	Easting 538008	Northing	765163
OS grid reference of outfall structure (m)	Easting 538008	Northing	765163
Outfall number		List of outfalls in cumulative assessment	
Receiving watercourse	Drum		
EA receiving water Detailed River Network ID		Assessor and affiliation	
Date of assessment	23/09/2020	Version of assessment	
Notes			

Step 1 Runoff Quality AADT: >10,000 and <50,000 Climatic region: Colder Wet Rainfall site: Paisley (SAAR 1205.3mm)

Step 2 River Impacts

Annual 95%ile river flow (m^3/s): .00485 (Enter zero in Annual 95%ile river flow box to assess Step 1 runoff quality only)

Impermeable road area drained (ha): .937 Permeable area draining to outfall (ha): .937

Base Flow Index (BFI): 0.62 Is the discharge in or within 1 km upstream of a protected site for conservation? No D

For dissolved zinc only Water hardness: High = >200mg CaCO3/l

For sediment impact only Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge? No D

Tier 1 Estimated river width (m): 2

Tier 2 (selected) Bed width (m): 1 Manning's n: 0.1 Side slope (m/m): 0.5 Long slope (m/m): 0.001

In Runoff

	Step 1			Step 1							
	Copper	Zinc		Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
	RST24			Toxicity Threshold							
Allowable Exceedances/year	1	1		1	1	1	1	1	1	1	1
No. of exceedances/year	69.50	57.20		88.20	116.00	2.20	49.20	113.20	49.20	23.40	92.80
No. of exceedances/worst year	78	67		101	138	4	64	127	64	36	106
	RST6										
Allowable Exceedances/year	1	1									
No. of exceedances/year	19.30	22.50									
No. of exceedances/worst year	32	31									
	(ug/l)	(ug/l)		(mg/kg)	(mg/kg)	(mg/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Thresholds RST24	21	385	Toxicity	197	315	3.5	16770	875	2355	245	515
Thresholds RST6	42	770									
Event Statistics Mean	24.00	67.53		345	1189	1	16007	2769	2657	170	749
90%ile	45.95	144.85		760	2738	2	35481	6138	5890	376	1661
95%ile	57.54	191.09		999	3684	2	70795	12247	11752	750	3313
99%ile	90.93	346.16		1442	6003	4	89125	15419	14795	945	4171

In River (no mitigation)

	Step 2	
	Copper	Zinc
	RST24	
Allowable Exceedances/year	2	2
No. of exceedances/year	0	0
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
	RST6	
Allowable Exceedances/year	1	1
No. of exceedances/year	0	0
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.20	0.62
	(ug/l)	(ug/l)
Thresholds RST24	21	385
Thresholds RST6	42	770
Event Statistics Mean	0.56	1.65
90%ile	1.36	3.63
95%ile	2.68	7.37
99%ile	7.58	22.54

Step 2

Velocity	0.06	m/s
DI	162.19	
% settlement needed	39	%

Tier 2 is used for the calculation

Outfall 1 HAWRAT analysis

HIGHWAYS AGENCY

Highways Agency Water Risk Assessment version 1.0 November 2009

Soluble - Acute Impact

Annual Average Concentration

	Copper	Zinc	
Step 2	0.14	0.44	ug/l
Step 3	-	-	ug/l

Copper	Zinc
Pass	Pass

Sediment - Chronic Impact

Fail. Protected Area. 19 % settlement needed.

Sediment deposition for this site is judged as:

Accumulating?	Yes	0.07	Low flow Vel m/s
Extensive?	Yes	123	Deposition Index

Location Details

Road number	N17	HA Area / DBFO number	Outfall 2
Assessment type	Non-cumulative assessment (single outfall)		
OS grid reference of assessment point (m)	Easting 538832	Northing	764450
OS grid reference of outfall structure (m)	Easting 538801	Northing	764558
Outfall number		List of outfalls in cumulative assessment	
Receiving watercourse	Drum		
EA receiving water Detailed River Network ID		Assessor and affiliation	
Date of assessment	23/09/2020	Version of assessment	
Notes			

Step 1 Runoff Quality AADT >10,000 and <50,000 Climatic region Colder Wet Rainfall site Paisley (SAAR 1205.3mm)

Step 2 River Impacts

Annual 95%ile river flow (m^3/s) .007 (Enter zero in Annual 95%ile river flow box to assess Step 1 runoff quality only)

Impermeable road area drained (ha) .937 Permeable area draining to outfall (ha) .937

Base Flow Index (BFI) 0.62 Is the discharge in or within 1 km upstream of a protected site for conservation? Yes

For dissolved zinc only Water hardness High = >200mg CaCO3/l

For sediment impact only Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge? No D

Tier 1 Estimated river width (m) 2

Tier 2 (selected) Bed width (m) 1 Manning's n 0.1 Side slope (m/m) 0.5 Long slope (m/m) 0.001

In Runoff

Step 1 – RST24 (Copper, Zinc) and Toxicity Threshold (sediment-bound pollutants)

	Copper	Zinc	Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Allowable Exceedances/year	1	1	1	1	1	1	1	1	1	1
No. of exceedances/year	69.50	57.20	88.20	116.00	2.20	49.20	113.20	49.20	23.40	92.80
No. of exceedances/worst year	78	67	101	138	4	64	127	64	36	106

RST6

	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	19.30	22.50
No. of exceedances/worst year	32	31

	Copper (ug/l)	Zinc (ug/l)		Copper (mg/kg)	Zinc (mg/kg)	Cadmium (mg/kg)	Total PAH (ug/kg)	Pyrene (ug/kg)	Fluoranthene (ug/kg)	Anthracene (ug/kg)	Phenanthrene (ug/kg)
Thresholds RST24	21	385	Toxicity	197	315	3.5	16770	875	2355	245	515
Thresholds RST6	42	770									
Event Statistics Mean	24.00	67.53		345	1189	1	16007	2769	2657	170	749
90%ile	45.95	144.85		760	2738	2	35481	6138	5890	376	1661
95%ile	57.54	191.09		999	3684	2	70795	12247	11752	750	3313
99%ile	90.93	346.16		1442	6003	4	89125	15419	14795	945	4171

In River (no mitigation)

Step 2

RST24	Copper	Zinc
Allowable Exceedances/year	1	1
No. of exceedances/year	0	0
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0

RST6	Copper	Zinc
Allowable Exceedances/year	0.5	0.5
No. of exceedances/year	0	0
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.14	0.44

	Copper (ug/l)	Zinc (ug/l)
Thresholds RST24	21	385
Thresholds RST6	42	770
Event Statistics Mean	0.41	1.21
90%ile	0.97	2.60
95%ile	1.93	5.33
99%ile	5.71	16.36

Step 2

Velocity	0.07	m/s
DI	122.78	
% settlement needed	19	%

Tier 2 is used for the calculation

Outfall 2 HAWRAT analysis

HIGHWAYS AGENCY

Highways Agency Water Risk Assessment

version 1.0 November 2009

Soluble - Acute Impact

Annual Average Concentration

	Copper	Zinc	
Step 2	0.10	0.32	ug/l
Step 3	-	-	ug/l

Copper	Zinc
Pass	Pass

Sediment - Chronic Impact

Alert. Protected Area.

Sediment deposition for this site is judged as:

Accumulating?	Yes	0.07	Low flow Vel m/s
Extensive?	No	87	Deposition Index

Location Details

Road number	N17	HA Area / DBFO number	Outfall 2
Assessment type	Non-cumulative assessment (single outfall)		
OS grid reference of assessment point (m)	Easting 539248	Northing	763785
OS grid reference of outfall structure (m)	Easting 539366	Northing	763864
Outfall number		List of outfalls in cumulative assessment	
Receiving watercourse	Drum Stream		
EA receiving water Detailed River Network ID		Assessor and affiliation	
Date of assessment	23/09/2020	Version of assessment	
Notes			

Step 1 Runoff Quality AADT: >10,000 and <50,000 Climatic region: Colder Wet Rainfall site: Paisley (SAAR 1205.3mm)

Step 2 River Impacts

Annual 95%ile river flow (m^3/s): .0076 (Enter zero in Annual 95%ile river flow box to assess Step 1 runoff quality only)

Impermeable road area drained (ha): .713 Permeable area draining to outfall (ha): .713

Base Flow Index (BFI): 0.62 Is the discharge in or within 1 km upstream of a protected site for conservation? Yes

For dissolved zinc only Water hardness: High = >200mg CaCO3/l

For sediment impact only Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge? No D

Tier 1 Estimated river width (m): 2

Tier 2 Bed width (m): 1 Manning's n: 0.1 Side slope (m/m): 0.5 Long slope (m/m): 0.001

In Runoff

Step 1

	Copper	Zinc
	RST24	
Allowable Exceedances/year	1	1
No. of exceedances/year	**69.50**	**57.20**
No. of exceedances/worst year	78	67
	RST6	
Allowable Exceedances/year	1	1
No. of exceedances/year	**19.30**	**22.50**
No. of exceedances/worst year	32	31
	(ug/l)	(ug/l)
Thresholds RST24	21	385
Thresholds RST6	42	770
Event Statistics Mean	24.00	67.53
90%ile	45.95	144.85
95%ile	57.54	191.09
99%ile	90.93	346.16

Step 1

	Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
	Toxicity Threshold							
Allowable Exceedances/year	1	1	1	1	1	1	1	1
No. of exceedances/year	**88.20**	**116.00**	**2.20**	**49.20**	**113.20**	**49.20**	**23.40**	**92.80**
No. of exceedances/worst year	101	138	4	64	127	64	36	106
	(mg/kg)	(mg/kg)	(mg/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Toxicity	197	315	3.5	16770	875	2355	245	515
Event Statistics Mean	345	1189	1	16007	2769	2657	170	749
90%ile	760	2738	2	35481	6138	5890	376	1661
95%ile	999	3684	2	70795	12247	11752	750	3313
99%ile	1442	6003	4	89125	15419	14795	945	4171

In River (no mitigation)

Step 2

	Copper	Zinc
	RST24	
Allowable Exceedances/year	1	1
No. of exceedances/year	**0**	**0**
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
	RST6	
Allowable Exceedances/year	0.5	0.5
No. of exceedances/year	**0**	**0**
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.10	0.32
	(ug/l)	(ug/l)
Thresholds RST24	21	385
Thresholds RST6	42	770
Event Statistics Mean	0.30	0.88
90%ile	0.69	1.86
95%ile	1.38	3.85
99%ile	4.50	11.94

Step 2

Velocity	0.07	m/s
DI	87.42	
% settlement needed	0	%

Tier 2 is used for the calculation

Outfall 3 HAWRAT analysis

HIGHWAYS AGENCY — Highways Agency Water Risk Assessment version 1.0 November 2009

Soluble - Acute Impact

Annual Average Concentration	Copper	Zinc	
Step 2	0.11	0.34	ug/l
Step 3	-	-	ug/l

Copper	Zinc
Pass	Pass

Sediment - Chronic Impact

Alert. Protected Area.

Sediment deposition for this site is judged as:

Accumulating?	Yes	0.07	Low flow Vel m/s
Extensive?	No	87	Deposition Index

Location Details

Road number	N17	HA Area / DBFO number	Outfall 4
Assessment type	Non-cumulative assessment (single outfall)		
OS grid reference of assessment point (m)	Easting 539310	Northing	762836
OS grid reference of outfall structure (m)	Easting 539618	Northing	763366
Outfall number		List of outfalls in cumulative assessment	
Receiving watercourse	Drum Stream		
EA receiving water Detailed River Network ID		Assessor and affiliation	
Date of assessment	23/09/2020	Version of assessment	
Notes			

Step 1 Runoff Quality AADT >10,000 and <50,000 Climatic region Colder Wet Rainfall site Paisley (SAAR 1205.3mm)

Step 2 River Impacts

Annual 95%ile river flow (m^3/s) .012 (Enter zero in Annual 95%ile river flow box to assess Step 1 runoff quality only)

Impermeable road area drained (ha) 1.21 Permeable area draining to outfall (ha) 1.21

Base Flow Index (BFI) 0.62 Is the discharge in or within 1 km upstream of a protected site for conservation? Yes

For dissolved zinc only Water hardness High = >200mg CaCO3/l

For sediment impact only Is there a downstream structure, lake, pond or canal that reduces the velocity within 100m of the point of discharge? No D

Tier 1 Estimated river width (m) 2

Tier 2 Bed width (m) 1.5 Manning's n 0.1 Side slope (m/m) 0.5 Long slope (m/m) 0.001

In Runoff

Step 1	Copper	Zinc
RST24		
Allowable Exceedances/year	1	1
No. of exceedances/year	69.50	57.20
No. of exceedances/worst year	78	67
RST6		
Allowable Exceedances/year	1	1
No. of exceedances/year	19.30	22.50
No. of exceedances/worst year	32	31
	(ug/l)	(ug/l)
Thresholds RST24	21	385
Thresholds RST6	42	770
Event Statistics Mean	24.00	67.53
90%ile	45.95	144.85
95%ile	57.54	191.09
99%ile	90.93	346.16

Step 1	Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
Toxicity Threshold								
Allowable Exceedances/year	1	1	1	1	1	1	1	1
No. of exceedances/year	88.20	116.00	2.20	49.20	113.20	49.20	23.40	92.80
No. of exceedances/worst year	101	138	4	64	127	64	36	106
	(mg/kg)	(mg/kg)	(mg/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Toxicity	197	315	3.5	16770	875	2355	245	515
Event Statistics Mean	345	1189	1	16007	2769	2657	170	749
90%ile	760	2738	2	35481	6138	5890	376	1661
95%ile	999	3684	2	70795	12247	11752	750	3313
99%ile	1442	6003	4	89125	15419	14795	945	4171

In River (no mitigation)

Step 2	Copper	Zinc
RST24		
Allowable Exceedances/year	1	1
No. of exceedances/year	0	0
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
RST6		
Allowable Exceedances/year	0.5	0.5
No. of exceedances/year	0	0
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.11	0.34
	(ug/l)	(ug/l)
Thresholds RST24	21	385
Thresholds RST6	42	770
Event Statistics Mean	0.32	0.94
90%ile	0.74	2.00
95%ile	1.48	4.11
99%ile	4.74	12.74

Step 2

Velocity	0.07	m/s
DI	87.07	
% settlement needed	0	%

Tier 2 is used for the calculation

Outfall 4 HAWRAT analysis