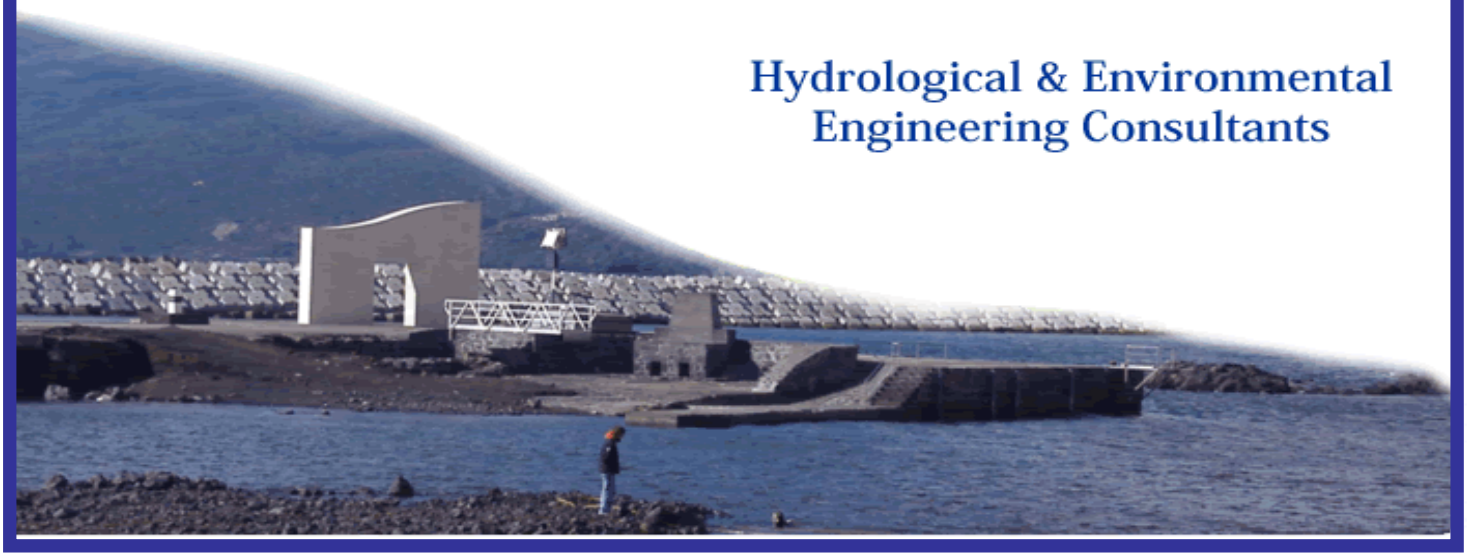
Hydro Environmental Ltd

Hydrology and Drainage Assessment for the N59 Kentfield Road improvement

On behalf of

Road Design Office
Galway Co. Council

September 2023



Hydrological & Environmental Engineering Consultants

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1 Introduction

1.1 Background

Hydro Environmental Ltd were requested by the Road Design Office, Galway Co. Council to carry out a hydrology and drainage assessment of proposed road improvement works to the N59 National Secondary Road at Kentfield, Galway. The section of proposed road improvement is only 120m in length and is located 2km from Galway City out of the Moycullen Road near Glenlo Abbey Hotel. The general location of the proposed road improvement works area is presented below in Figure 1-1 which shows the indicative site area for the works. The existing road elevations range from 26 to 29m OD Malin datum over the 120m road length. The works at this section are primarily online with slight widening required to accommodate the road design type.

Figure 1-1 General location of the N59 road improvement project area

1.2 Description of Works

The proposed works will involve realigning a 359m section of the existing N59 road in the townland of Kentfield, the road section is located just to the north of Glenlo Abbey. The proposed design is to provide a Type 2 single carriageway as per DN-GEO-03036 and CC-SCD-00002. This consists of two by 3.5m wide carriageways and 0.5m hard strips and 3m verges on both sides (14m wide footprint). The realignment is online through realignment widening. The realignment will maintain access to existing domestic and agricultural properties, some properties will be reset back to achieve the required

setback distance from carriageway. Facilities for vulnerable road users will not be provided within the scope of works for this realignment, however a 3m verge will be provided on both side of the carriageway to accommodate a future footpath/cycle track if a retrofit scheme is being progressed along the N59 in the future.

The vertical alignment will have curves that are in accordance with table 1.3 of DN-GEO-03031 Rural Road Link Design. It is anticipated soil cut of 3,329m3 and soil fill of 3,542m3 is required to achieve the proposed vertical alignment. Vertical alignment involves tie in at two locations, the northern end at Ch. 0+421m and the southern end at Ch. 0+770m. The vertical alignment was selected to eliminate the hidden dip within the vertical alignment, resulting in considerable fill at Ch.575m and cut at Ch.650m.

The proposed drainage system is in the form of kerb and gully system connected to an attenuation tank (arched type system) to control the quantity and quality of runoff. A petrol interceptor located upstream from the outfall which is a small stream providing connectivity into the local watercourse at the River Corrib.
The principal objectives for the proposed road drainage system include:

- To ensure the speedy removal of surface water from the road pavement, to provide safe driving conditions,
- To mimic, in as far as is practical, the existing road drainage regime, particularly in relation to runoff rates and watercourse outfalls,
- To ensure that the impact of the drainage outfalls on the receiving waters is negligible,
- To minimise the impact of runoff on the receiving environment, and
- To provide effective sub-surface drainage to maximise longevity of the road pavement and associated earthworks.

The preliminary drainage proposals have been developed in accordance with the TII Design Manual for Roads and Bridges and in particular in accordance with the TII Drainage systems for National Roads DN-DNG-03022.

The proposed storm drainage discharge will be to a single outfall point that discharges to the Surface stream at Glenlo Abbey. As part of the Sustainable Urban Drainage Systems (SUDs) requirements attenuation and flow control will be provided upstream of the outfall to limit the discharge to estimated greenfield flood runoff rates. To this aim the attenuation storage volume will be designed with a minimum storm return period of in 1:100 years. A climate change allowance of 20% will be added to all attenuation volumes. The proposed attenuation tank is shown in the drainage drawings for the scheme (DR-01-GC/19/18753).

2 Hydrology Baseline

2.1 Topography

The general topography is one of a moderate sloping hillslope falling northeast towards the River Corrib. Upgradient of the road the hillslope falls to the road at typically 1 in 8 and downgradient of the road the slope gentles slightly to a fall of 1 in 16. Further to the northeast towards the former Clifden Rail line the land flattens to a gentle slope. The River Corrib typically only floods to the former Clifden Rail line embankment which is over 460m away and typical winter flood levels are less than 7m O.D. T existing and proposed he road elevation is typically above 25m OD.

2.2 Surface Drainage

2.2.1 Drainage Features

The upgradient hillslope catchment draining towards the road is c. 34Ha. There is evidence of only one small watercourse draining northeast across the existing N59 road at the southern (Galway City) end of the proposed alignment at Glenlo Abbey. This stream flows along the northwest boundary of the Glenlo abbey property and disappears underground via karst swallow hole area near the golf driving range within the Glenlo Abbey estate, refer to Figure 2-1. A former spring feature is also identified on historical mapping to the east of the driving range (E526750, N728440), however there is on evidence of this spring today. For the purposes of this assessment the stream reference above will named as the Glenlo Stream. The catchment are of this stream is based on mapping and lidar estimated to be c. 31ha to its culvert at the existing N59. A large section of the existing N59 and upgradient lands to the southeast of the scheme drain through a number of small rectangular openings in the Glenlo Estate front masonry boundary wall with the N59 and eventually discharge to the Glenlo stream a short distance upstream of its swallow hole at the Driving range. It is understood that this swallow hole discharges underground to a large land drain to the northeast that flows to the Corrib, passing under the Clifden Rail Line. Such links have not been proved, but in any case, this disappearing stream eventually discharges to the old River channel of the Corrib and Corrib SAC c. 500m from the swallow hole feature. The Corrib floodplain lands in this overbank area are drained by a series of northeast orientated wide drains (2 to 4m top width).

The drainage catchment areas of the Glenlo stream and the N59 to the southeast and northwest are presented in Figure 2-2 .

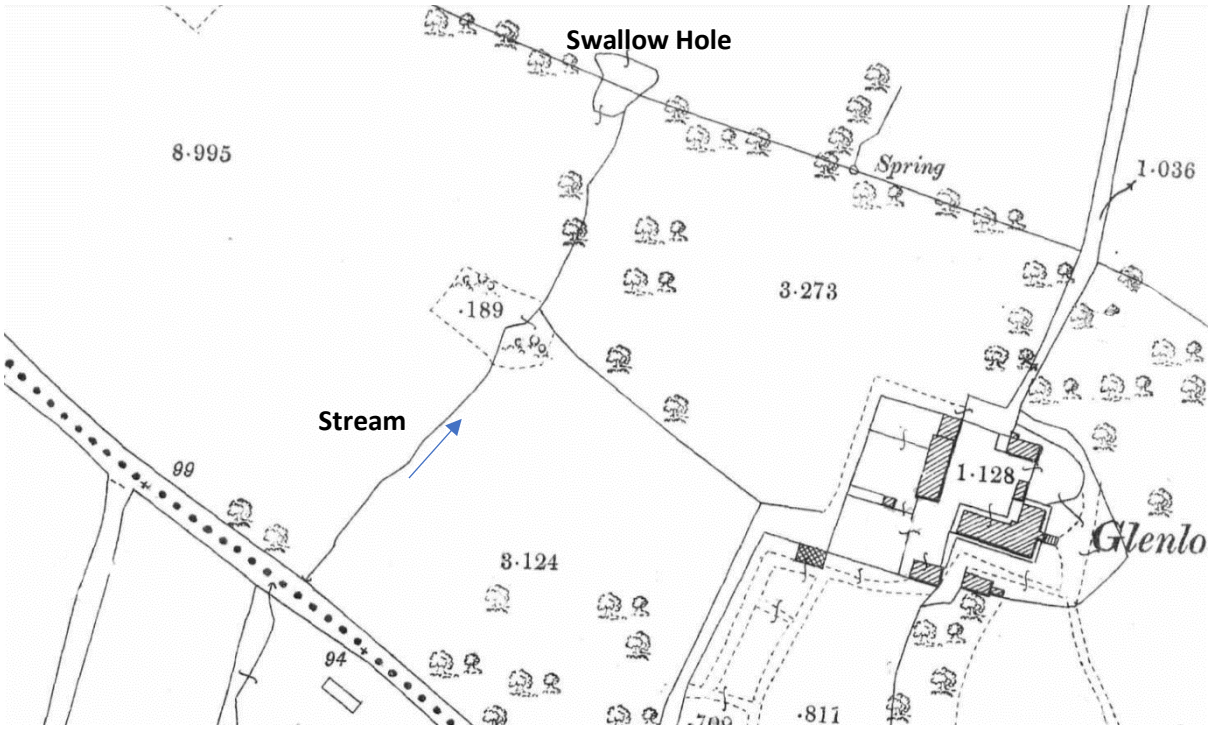


Figure 2-1 25inch OSI Historical Map showing Swallow hole area of spring.

The current drainage from the road is over the edge drainage into existing fields and wooded areas downgradient of the road. There is no major flooding identified along this section of road, however sheet flow along and across the road is likely to occur during short high intensity downpours given the hill slope nature upgradient of the road. Some flooding was identified downstream at the swallow-hole feature near the driving range in the past but it is understood this has been alleviated through cleaning out the swallow hole which had become blocked by sediments.

The Glenlo Stream at the N59 is not a fishery stream and can dry out completely during drought periods. The existing n59 road culvert is a pipe culvert and represents a barrier to fish passage in any case with a steep between the culvert outlet and the downstream channel. The downstream channel is a gravel bed and is prone to scouring and undercutting from the stream flow.

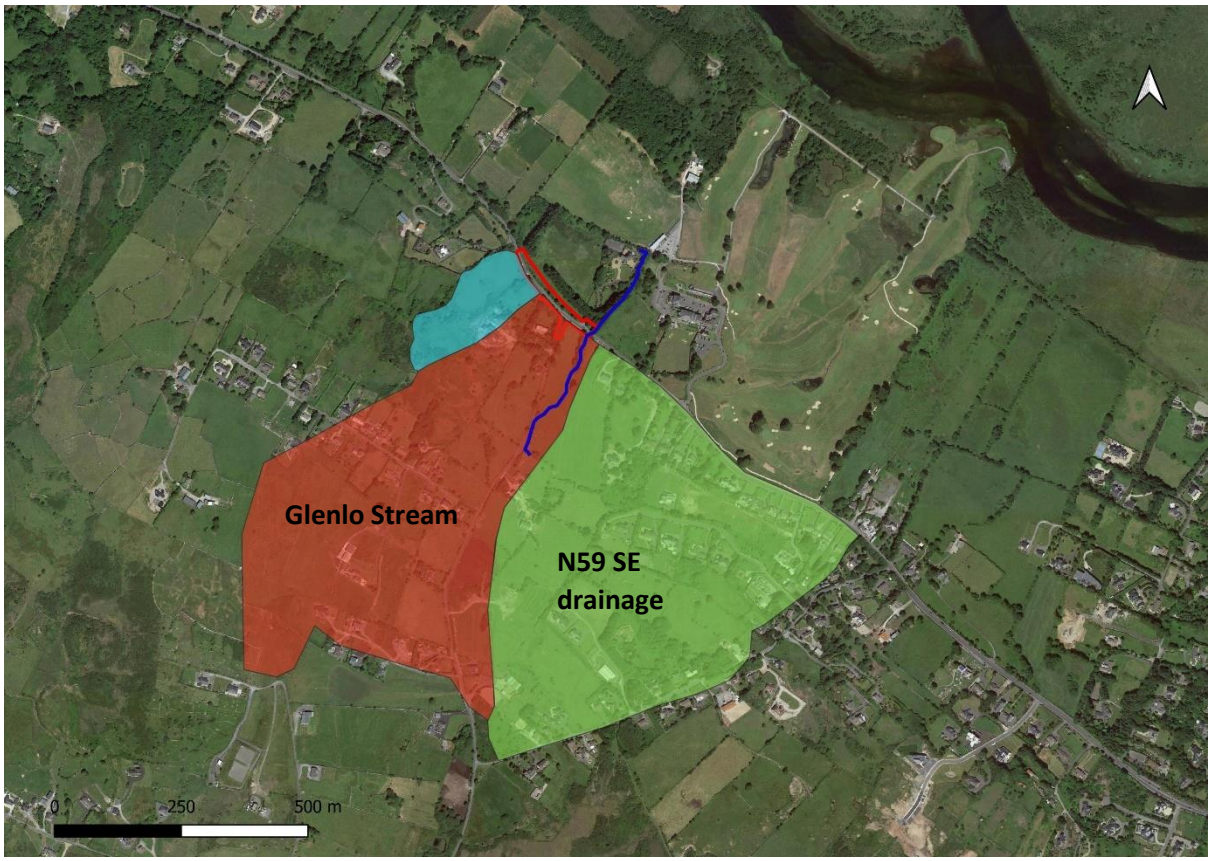


Figure 2-2 Surface drainage Catchment areas

2.2.2 Glenlo Stream Flows

The sol factor for this sloping catchment can be described as moderate runoff soils with a SOIL index type 3 based on the UK and Ireland Flood Studies classification (NERC, 1975). Applying the IH124 equation for small ungauged catchments the mean annual maximum flood flow (cumec):

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

Where, AREA is Catchment area =0.31km^2, SAAR is mean annual rainfall = 1283 mm and SOIL = 0.4 for Soil index type 3. This gives a QBAR estimate of 0.226cumec which is a greenfield flood runoff rate of 7.29l/sec per ha.

The 100year growth factor is 1.96, the factorial standard error of the equation is 1.65 and climate change allowance of 20% gives a design flow for the culvert of 0.89cumec. This design flow of 0.89cumec exceeds the existing 600mm diameter pipe culvert capacity and a minimum culvert size of 1200mm diameter is likely to be required for a successful OPW Section 50 application should the existing culvert require to be extended or replaced by the proposed road scheme. For the present configuration the design flow will surcharge the existing pipe culvert generating barrel velocities in excess of 3m/s.

Plate 2-1 View of 600mm N59 road culvert for the Glenlo stream (this section is likely to be an extension and possibly an older stone culvert is present in the middle / upstream section of the road

The mean annual flow in this stream is estimated to be 7l/s and the 95 and 99-percentile low stream flows are estimated to be 0.62 and 0.31l/s based on typical catchment runoff rates of 2l/s per km2 at 95-percentile and 1l/s per km2 at 99-percentile. These low flows will provide limited dilution during drought periods for drainage discharges and a HAWRAT analysis should be carried out to assess the potential impact of road drainage (refer to 3.1.5).

2.2.3 River Corrib

The scheme area is approximately 300m upgradient of the River Corrib Floodplain and is 630m upgradient of the Old Corrib River channel. The scheme area is 525m from the Corrib SAC which extends out from the River to the Clifden Rail line embankment. The local drains in the area including the proposed receiving stream drain northeast to the R. Corrib and SAC and therefore a hydraulic connection between the road and the SAC exists. Flood levels in the River Corrib based on the CFRAM study and statistical analysis of gauged Lake and River levels reach 7.4m OD at 100year flood event and 7.8m at the 1000year flood events. These flood levels are over 18m lower than the road elevation and therefore the road development will not be impacted on by Corrib Flooding.

Figure 2-3 Corrib 100 and 1000year return period flood extents – from CFRAM study.

2.2.4 Water Supply

Water Supply in this section of the N59 is from public piped supply with no local surface or groundwater sources identified within 300m of the road. The abstraction is from the River Corrib at Terryland. The reach from Terryland abstraction upstream to Menlough is a designated water source under EU regulations (IEPA1_WE_30C020600). This designated drinking water river reach is located downstream of the Old River and Friars Cut and downstream of road development.

2.3 Hydrogeology

The bedrock geology underlying the road is igneous rock formation of the Errisbeg Townland Granite batholith which is from the Devonian Series and described as a moderately hard megacrystic pink/grey monzogranite. Limestone formation is present to the northeast (downgradient of the route) coming to within 100 to 300m of the road. This Limestone bedrock is referred to Burren Limestone formation which extends over a considerable area east and northeast of the Corrib. This is a clean pale grey skeletal limestone and is readily weather and karstic.

The bedrock aquifer associated with the granite bedrock is classified as a poor aquifer (Pl) generally unproductive except for local zones. The recharge rate to groundwater within this granite groundwater body is poor at c. 100mm per annum with rainfall contributing to surface runoff either

as overland sheet flow, stream flows and interflow in the soil / subsoils. The limestone formation a short distance to the northeast is categorised as Regionally Important karst conduit flow bedrock aquifer. Aquifer vulnerability along the route which is determined from depth of overburden cover is typically extreme with small sections of extreme with outcropping and extreme vulnerability. The watercourses and groundwater flow are northeast to the River Corrib and the Lough Corrib SAC and SPA (000297). The lough Corrib SAC extends to the Clifden Rail line embankment some 460 to 500m northeast of the route.

There are no groundwater source protection zones within this area and water supply is via the public city mains which is extracted from the Corrib downstream at Terryland.

Figure 2-4 Bedrock Aquifer Map

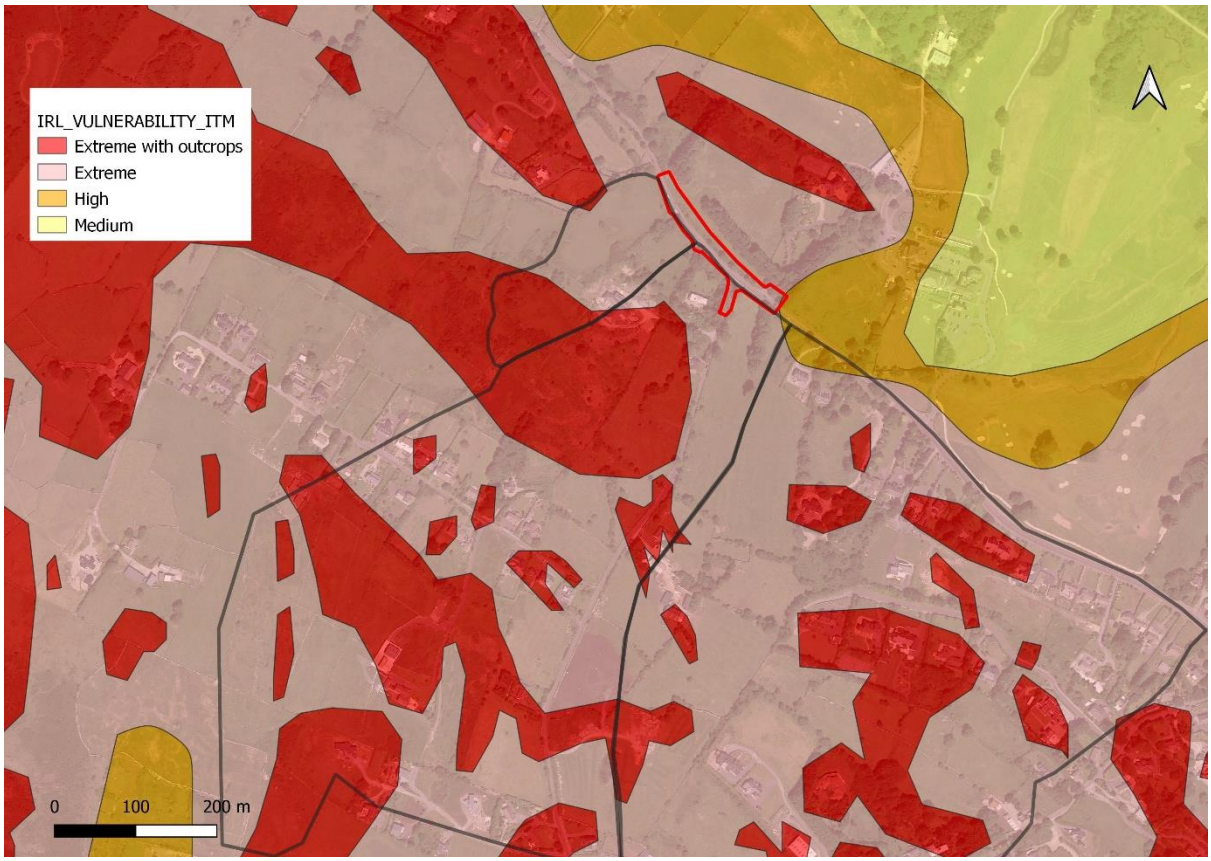


Figure 2-5 Aquifer Vulnerability Mapping

3 Potential Impacts

3.1.1 Groundwater Impacts

The proposed road improvement / realignment is unlikely to directly impact groundwater flows or groundwater resources with the proposed road cutting shallow and the underlying aquifer being a poor productivity granite bedrock aquifer (PI). The proposed cutting will not intercept the groundwater table. The Aquifer vulnerability is extreme and extreme with outcrop/sub crop.

The option for using permeable drainage systems to collect and dispose of the road drainage waters is assessed using the TII Groundwater Protection Response Matrix set out in Table A.4 of TII DN-DNG-03065 (2015). This assessment is present below in Table 3-1.

Table 3-1 Groundwater Protection Response to use of permeable drainage systems

Road Chainage	Aquifer Type	Groundwater Vulnerability	Groundwater Protection Response
Entire length	PI	Extreme and extreme with outcropping	R3(1) – Not generally acceptable unless the following requirements are met: 1. Consistent minimum thickness of 1m unsaturated subsoil, natural or man-made 2. If Karst Features are present drainage system must be at least 15m away and cognisance of potential instability in this area. 3. Particular attention must be paid to receptors such as supply wells and springs 4. If discharge to surface water is not possible

Discharge to Surface water is possible via out falling to the Glenlo Stream which is the natural drainage receptor for the existing N59 road at Kentfield.

This assessment identifies that the road drainage will need to be sealed and discharged to the nearby Glenlo Stream. Disposal of road drainage via French drains, soakaways and engineered infiltration field is not recommended in this case given the vulnerability class and the existence of a receiving surface watercourse.

There is a pathway for pollutants both during construction and operation to enter the downstream regionally important karst limestone bedrock aquifer (Rkc) via the surface flow pathway of the Glenlo Stream which disappears underground at a karst Swallow-holes feature adjacent to the Glenlo Driving Range. This pathway also connects to the Corrib SAC and SPA via groundwater and surface flows. Uncontrolled release of drainage water during the operational phase or site runoff during the

constructional phase construction site has a potential pathway via surface and groundwater flows to enter the Corrib SAC and SPA. This is considered given the scale of the Corrib flows and catchment area relative to the proposed road development footprint to represent at worst case a potential minor to moderate negative short term constructional impact and a minor to imperceptible long term negative impact.

3.1.2 Surface hydrology impacts

The proposed road development through its drainage will collect all pavement runoff and discharge it to the Glenlo stream with the proposed outfall to be located downstream of the N59 Culvert. This has the potential to increase runoff rates in the receiving stream and to introduce routine road pollutants and the potential also for pollution from accidental road traffic accident to enter the watercourse. A Sustainable Urban drainage solution is required by the TII road drainage design manual to prevent impact on flows and water quality. The TII drainage guidelines in respect to surface drainage and treatment is proposed as set out in DN-DNG-03063, DN-DNG-03065 and DN-DNG-03066.

The proposed road drainage design is to collect all road pavement surface water runoff in a piped sealed drainage system and pass it through an attenuation pond and petrol interceptor before discharging to the Glenlo stream. The attenuation pond will be lined and fitted with a flow control valve that will throttle the flow back to greenfield runoff rates. The attenuation pond will be fitted with a penstock that can be closed-off in the event of a serious accidental spillage from a road accident, allowing pollution to be contained and disposed of off site appropriately.

3.1.3 Attenuation Calculations

For Water Quality it is recommended that the first flush of 20mm rainfall be capture and contained within a pond for an average residence time of 24hours as permanent storage within the pond. The total Impervious are to be drained is 0.29ha. Therefore the first flush volume is 54m^3. The greenfield runoff rate QBAR (mean annual maximum flow rate) is determined from the IH124 equation giving a QBAR rate of 6.91l/s per ha for Soil type 3, mean annual rainfall of 1283mm. This reduces to 1.87 l/s for the 0.27ha impervious area being drained. This greenfield rate is much too low to be achieved using a flow control device and a permissible outflow rate of 5l/s is used as the safe limit for sustainable operation of a flow control device. Based on 5l/s permissible outflow rate the storage volume for attenuation required at the 100year rainstorm event and with 20% climate change allowance is 98.2m^3. The total storage required including the first flush volume and attenuation is 152m^3. To meet the total storage requirement an underground tank, with a volume of 153m^3 is proposed. An arched system (Stormtech or similar) is proposed. This system will be sealed and contains an “isolator row” which acts as a sediment trap and improves water quality. A high-level overflow will be provided at the outlet of the tank. A hydrocarbon interceptor will also be provided, and a penstock valve will be provided downstream of the tank in the event of a spillage.

The natural hill slope runoff upgradient of the road will have to be drained under the road either in existing drains, upgraded drains or new carrier drains to avoid sheet flow crossing the road pavement and the flooding of lands adjacent to the road alignment. An interceptor French drain could be place in the grass verge on the western side of the road to collect and drain the upslope land drainage

disposing this land runoff to ground and minimise any sheet flow onto the pavement. This drain could also be connected to the Glenlo Stream which is its natural pathway.

3.1.4 Serious Pollution from Spillage Risk Assessment

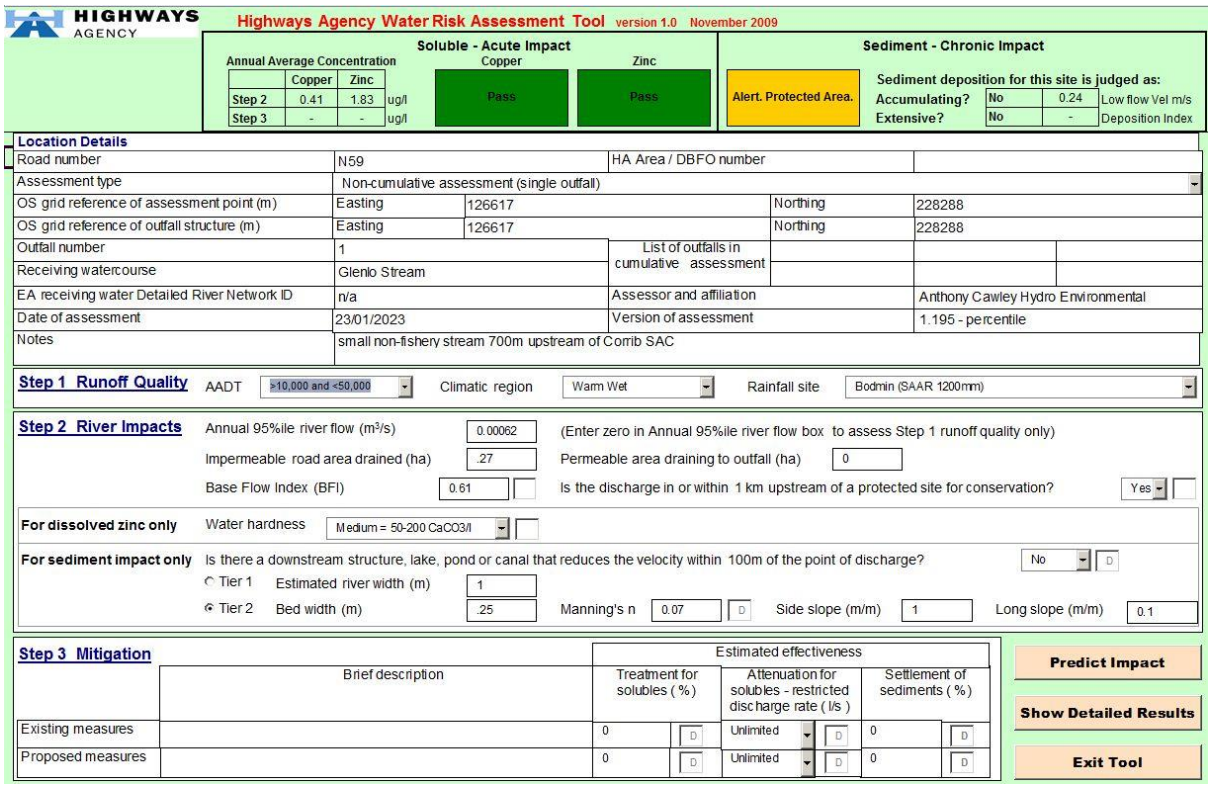
A spillage risk assessment of serious accidental spillage impacting the Glenlo stream was caried out. This assessment is based on an urban National Road risk factor of 0.85 based on billion HGV per km/year. The design ADDT for this road is 17298 and 9.86% HGV's. The probability of a serious pollution incident occurring because of a serious spillage is selected as 0.6 based on a response time of <1 hour. The road length involved is 0.25km. The annual probability of a spillage from the proposed road length is miniscule at 0.000092. The annual probability of a serious pollution incident is 0.0055% and therefore extremely unlikely.

3.1.5 Hawrat analysis

A road drainage water quality assessment using Hawrat software as per requirement by TII Guidelines was carried out on the Glenlo Stream in respect to the proposed road drainage outfall.

A 95percentile low flow estimate of 0.62l/s, an impervious pavement area of 0.27ha, an annual Rainfall category of 1200mm, and ADDT range category of >10,000 to < 50,000 was used in this analysis. The characteristics of the stream channel was specified having a longitudinal gradient of 1 in 10, a manning's roughness of 0.07 and channel base width 0.25 and 45degree side slopes.

The analysis passes both the soluble acute impact and the sediment deposition without requirement for treatment, refer to ? and ?. The proposed attenuation pond and first flush retention volume and the petrol/oil interceptor will provide treatment through physical settlement which is likely to achieve up to 50% reduction in sediment concentrations reaching the outfall.



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

Soluble - Acute Impact

Annual Average Concentration

	Copper	Zinc	
Step 2	0.41	1.83	ug/l
Step 3	-	-	ug/l

Copper: Pass — Zinc: Pass

Sediment - Chronic Impact

Alert. Protected Area.

Sediment deposition for this site is judged as:

Accumulating?	No	0.24	Low flow Vel m/s
Extensive?	No	-	Deposition Index

Location Details

Road number	N59	HA Area / DBFO number	
Assessment type	Non-cumulative assessment (single outfall)		
OS grid reference of assessment point (m)	Easting 126617	Northing	228288
OS grid reference of outfall structure (m)	Easting 126617	Northing	228288
Outfall number	1	List of outfalls in cumulative assessment	
Receiving watercourse	Glenlo Stream		
EA receiving water Detailed River Network ID	n/a	Assessor and affiliation	Anthony Cawley Hydro Environmental
Date of assessment	23/01/2023	Version of assessment	1.195 - percentile
Notes	small non-fishery stream 700m upstream of Corrib SAC		

Step 1 Runoff Quality — AADT: >10,000 and <50,000 — Climatic region: Warm Wet — Rainfall site: Bodmin (SAAR 1200mm)

Step 2 River Impacts

Annual 95%ile river flow (m³/s): 0.00062 (Enter zero in Annual 95%ile river flow box to assess Step 1 runoff quality only)

Impermeable road area drained (ha): .27 — Permeable area draining to outfall (ha): 0

Base Flow Index (BFI): 0.61 — Is the discharge in or within 1 km upstream of a protected site for conservation? Yes

For dissolved zinc only — Water hardness: Medium = 50-200 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

Tier 1 — Estimated river width (m): 1

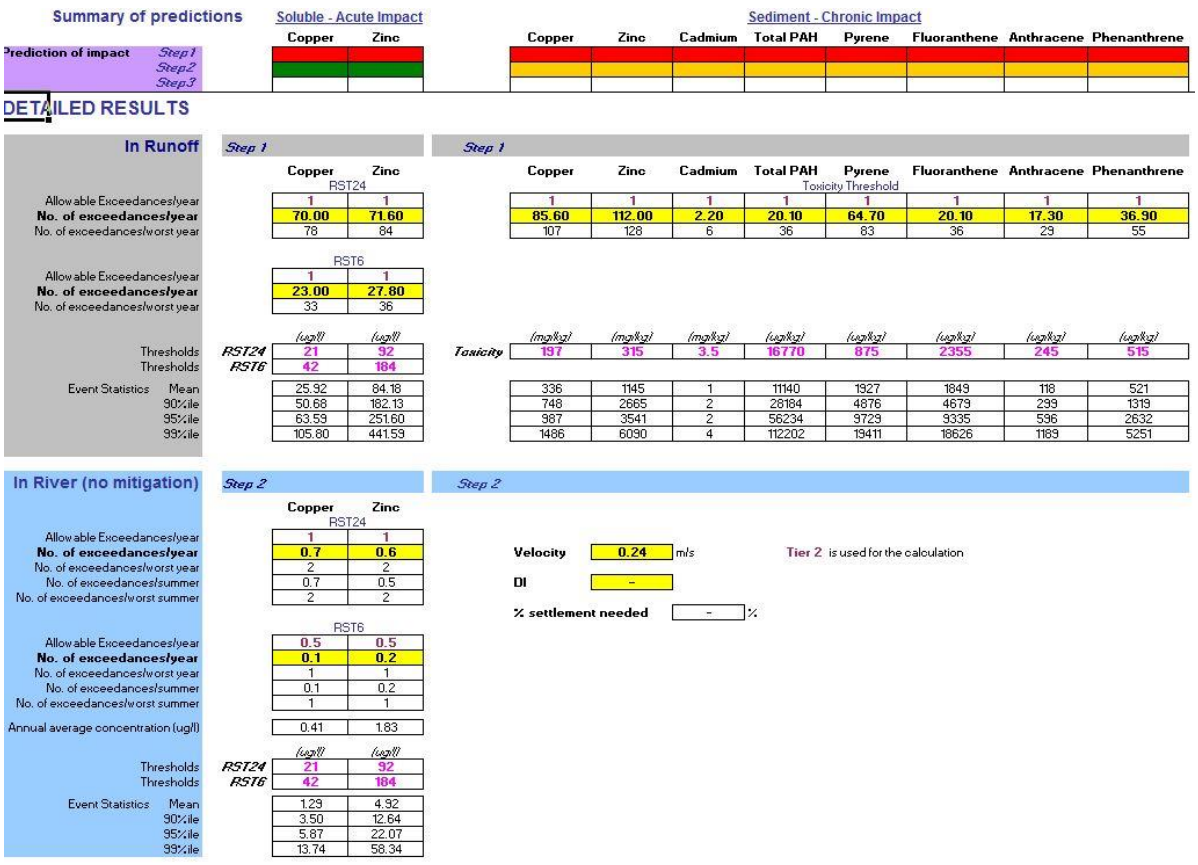
Tier 2 — Bed width (m): .25 — Manning's n: 0.07 — Side slope (m/m): 1 — Long slope (m/m): 0.1

Step 3 Mitigation

	Brief description	Estimated effectiveness: Treatment for solubles (%)	Attenuation for solubles - restricted discharge rate (l/s)	Settlement of sediments (%)
Existing measures		0	Unlimited	0
Proposed measures		0	Unlimited	0

Predict Impact | Show Detailed Results | Exit Tool

Figure 3-1 Hawrat Summary Results for N59 Glenlo Stream outfall soluble and sediment impact without treatment



Summary of predictions

Prediction of impact	Soluble - Acute Impact: Copper	Soluble - Acute Impact: Zinc
Step1		
Step2		
Step3		

Sediment - Chronic Impact	Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene

DETAILED RESULTS

In Runoff

	Step 1 Copper	Step 1 Zinc	Step 1 Cadmium	Step 1 Total PAH	Step 1 Pyrene	Step 1 Fluoranthene	Step 1 Anthracene	Step 1 Phenanthrene
	RST24			Toxicity Threshold				
Allowable Exceedances/year	1	1	1	1	1	1	1	1
No. of exceedances/year	**70.00**	**71.60**	**2.20**	**20.10**	**64.70**	**20.10**	**17.30**	**36.90**
No. of exceedances/worst year	78	84	6	36	83	36	29	55
	RST6							
Allowable Exceedances/year	1	1						
No. of exceedances/year	**23.00**	**27.80**						
No. of exceedances/worst year	33	36						
	(ug/l)	(ug/l)	(mg/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Thresholds RST24	21	92	197	315	3.5	16770	875	2355	245	515
Thresholds RST6	42	184						
Event Statistics Mean	25.92	84.18	336	1145	1	11140	1927	1849	118	521
90%ile	50.68	182.13	748	2665	2	28184	4876	4679	299	1319
95%ile	63.59	251.60	987	3541	2	56234	9729	9335	596	2632
99%ile	105.80	441.59	1486	6090	4	112202	19411	18626	1189	5251

In River (no mitigation)

	Step 2 Copper	Step 2 Zinc
	RST24	
Allowable Exceedances/year	1	1
No. of exceedances/year	**0.7**	**0.6**
No. of exceedances/worst year	2	2
No. of exceedances/summer	0.7	0.5
No. of exceedances/worst summer	2	2
	RST6	
Allowable Exceedances/year	0.5	0.5
No. of exceedances/year	**0.1**	**0.2**
No. of exceedances/worst year	1	1
No. of exceedances/summer	0.1	0.2
No. of exceedances/worst summer	1	1
Annual average concentration (ug/l)	0.41	1.83
	(ug/l)	(ug/l)
Thresholds RST24	21	92
Thresholds RST6	42	184
Event Statistics Mean	1.29	4.92
90%ile	3.50	12.64
95%ile	5.87	22.07
99%ile	13.74	58.34

Velocity 0.24 m/s — Tier 2 is used for the calculation

DI -

% settlement needed - %

Figure 3-2 Hawrat Detailed Results for proposed N59 Glenlo Stream outfall soluble and sediment impact without treatment

4 Mitigation Measures

4.1.1 Operational Mitigation

No additional mitigation is required for the operational phase of the project with the standard TII Road drainage requirements sufficient to protect and prevent impact both the surface and groundwaters.

4.1.2 Constructional Mitigation

The Glenlo Stream represents a pathway to a regionally important karst bedrock aquifer via the downstream swallow hole and to the Corrib SAC and SPA waters via surface and groundwater routes.

Careful management of construction runoff is required so as not to cause pollution of this stream and to prevent sediment clogging the downstream swallow hole system. All site runoff waters should be collected and passed through settlement facilities that includes settlement pond and silt fence system upstream of its outfall to the Glenlo Stream. Careful management of construction plant and refueling is required as is the careful control of chemicals and concrete products.

It is recommended that the proposed attenuation site be used initially as a construction settlement pond during earthworks with all site construction waters draining towards the stream collected and discharged through settlement pond prior to reaching the Glenlo Stream. The Glenlo Stream should be protected by silt fence erected along its northwestern bank within the project work area.