i. Preface

THIS ENVIRONMENTAL IMPACT ASSESSMENT REPORT CONSISTS OF THE FOLLOWING DOCUMENTS:

Volume 1

- Non-Technical Summary

Volume 2

- Main Report

Volume 3

- Figures

Volume 4

- **APPENDICES**

Document Control

Status	Issued For	Signed	Date	Approved
Final	*Publication*	*Fergus Meehan*[1]	*February 2019*	*Emer Concannon*[2]

[1] *B.Eng., PgDip. Env., C.Eng MIEI*

[2] *B.Eng., MBA, C.Eng MIEI*

ii. Acknowledgments

This Environmental Impact Assessment Report (hereafter referred to as **EIAR**), has been prepared and coordinated by the TII National Roads Project Office of Sligo County Council, under the auspices of Transport Infrastructure Ireland. The following are the key bodies responsible for the project delivery. The qualifications and experience of the key team members is outlined in Chapter 1 of this EIAR (Volume 2 – Main Report).

The following constitutes the appendices, which are associated with certain Chapters of the EIAR. In this regard; they should be read in conjunction with Volume 2 (Main Report) of the EIAR.

Table 1-1: N16 Lugatober, Project Team – Engineering & Project Management

Study/Element	Body Responsible
Engineering & Project Management	TII National Roads Project Office (Sligo County Council)
Ground Investigation (& Factual Report)	Priority Geotechnical
Stage 1 Road Safety Audit	Atkins
Geotechnical Interpretive Report	Roughan & O'Donovan

Table 1-2: N16 Lugatober, Project Team – Environment

Study/Element	Body Responsible
Population & Human Health	Optimize Consulting and Dr. Martin Hogan
Noise & Vibration	Envest Environmental
Air Quality & Climate Change	
Biodiversity	McCarthy Keville O' Sullivan (with input from Denyer Ecology and Dr. Maria Long)
Soils and Geology	Barry Transportation
Hydrology & Hydrogeology	Hydro Environmental (Galway)
Landscape & Visual	RPS Ireland Ltd.
Material Assets and Land – Agriculture	John Bligh & Associates
Material Assets and Land – Non-Agriculture	
Archaeology, Architecture & Cultural Heritage	CRDS

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1 Appendix 1.1; Chapter 1 (Main Report Reference);

Responses to Informal Scoping

Figure 1-1: Submission received from Health Services Executive

Seirbhís Sláinte Comhshaoil - Sligeach / Liatroma / Iarthar an Chabháin
Ard Eoghain, Sligeach F91T25N
Tel: 071 91 45132
Environmental Health Service – Sligo / Leitrim / West Cavan,
Ardaghowen, Sligo F91T25N
Finan.Gallagher@HSE.ie

Mr. Fergus Meehan
N16 – Project Engineer
Sligo County Hall
Riverside
Sligo

June 22nd 2018.

Re: Scope of EIA (Informal) for the proposed development of road N16 Lugatober (Drumkilsellagh to Lugnagall)

Dear Mr. Meehan,

Thank you for your recent correspondence regarding the above and for the "Scope of EIA (Informal)" document.

Having read the document it is considered that the final EIAR would benefit from consideration of the following: -

a) A review of any private drinking water wells which might be in use in the area of the development (if any exist) and any protective or mitigation measures which may be required to protect same.
b) A noise survey relating to the construction and completed phases of the proposed development focussing on the closest noise receptors.
c) An assessment of dust generation from the proposal along with mitigation.

We look forward to receiving the final EIAR.

Mise le meas,

Finán Ó Gallchobhair
Principal Environmental Health Officer

ROAD DESIGN OFFICE
26 JUN 2018
SLIGO

Seirbhís Sláinte Nios Fearr a Forbairt | Building a Better Health Service

Figure 1-2: Submission received from Inland Fisheries Ireland

IASCACH INTÍRE ÉIREANN
INLAND FISHERIES IRELAND

Mr. Fergus Meehan
Project Engineer (N16 Lugatober Road Project)
SligoTII National Roads Project Office
Sligo County Council
Business Centre
Market Yard
Sligo

11 July 2018

RE: N16 Lugatober (Drumkilsellagh to Lugnagall) Scope for EIA

Dear Mr. Meehan,

The above road development has the potential to impact on three separate catchments, the Drumcliff River, the Tully Stream and the Doonally River. Having reviewed the Scope for the EIA, IFI has the following comments to make:

1 Section 3.4.1 states that the project will not cross any significant riparian areas, however there is potential for the development to impact on three fish bearing catchments, the Drumcliff River which is a salmon and sea trout fishery, the Doonally River which provides habitat for sea trout and brown trout as well as the smaller Tully Stream which is likely to support a population of brown trout. Pollution and silt control mitigation measures must be included to protect these catchments during the construction and operational phases of the road development.

2 The impacts of the diversion and modifications to the tributaries of the Drumcliff River should be assessed. There should be no net loss of habitat as a result of realignment of the tributaries. There should be no change in the hydrological regime downstream of the works as a result of removing meanders etc., to facilitate culvert installations.

3 The crossing of the Tully Stream is by a clear span structure which will have a minimum impact on the watercourse, provided pollution mitigation measures are in place.

4 The potential for the introduction or spread of invasive species should be assessed. Measures should be put in place to prevent the spread of invasive species as a result of this development. IFI provide a number of guidance documents on invasive species including a Bio-security Protocol which are available at: http://www.fisheriesireland.ie/Research/invasive-species.html

5 IFI guidance document *"Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Waters, 2016"* should be followed, and is available at: http://www.fisheriesireland.ie/fisheries-and-construction-works

IFI looks forward to continued consultation in relation to this road project.

Yours sincerely

Aisling Donegan
Senior Fisheries Environmental Officer

scc-N16-0718

IIE Béal an Átha, Teach Árd na Rí, Sráid na Mainistreach, Béal an Átha, Co. Mhaigh Eo, F26 KO29
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2 Appendix 3.1: Chapter 3 (Main Report) Reference;

Application of Design Alternatives – Junction Siting, Side Road Arrangements & Vulnerable Road Users

2.1 Introduction

The following report represents an extension of the 'Consideration of Alternatives' examined in the 'N16 Sligo to County Boundary, Route Selection Report', focusing more closely on discreet options established during the design process.

The Design Alternatives considered within this report include:

- Junction Siting and Side Road Arrangement (Section 2.2); and
- Vulnerable Road Users (Section 2.3)

2.1.1 Appraisal of Options

Where more than one viable option was established for a particular location, the TII Project Appraisal Criteria (PAG) criteria as outlined below were used to compare the options:

- Economy[3];
- Safety;
- Environment;

The three remaining criteria, namely, Accessibility, Integration and Physical Activity, were not considered to influence the decision making at a local level (i.e. Junction Arrangements).

The Multi Criteria Analysis performance matrix for appraisal is outlined in *Table 2-1*. This is a similar integer system to that recommended in *PE-PAG-0203, Project Appraisal Guidelines for National Roads Unit 7.0 - Multi Criteria Analysis.*

Table 2-1: TII PAG – MCA Criteria

Score Index	Impact Level
7	Major, or Highly Positive
6	Moderately Positive
5	Minor, or Slightly Positive
4	Not significant, or neutral
3	Minor, or slightly negative
2	Moderately negative
1	Major or highly negative.

[3] This Economic Assessment, for the purposes of options comparisons, was undertaken only on the items which differentiate the various options and in this regard should not be considered to represent a final outturn (e.g. if the paved surface is similar for options, then this is not factored into the assessment).

The assessment, initially provides an overview of the various arrangements and then, where appropriate, presents the MCA assessment.

2.2 Junction Siting and Side Road Arrangements

Representing a supplementary appraisal to the initial Sligo to County Boundary Route Selection Report, the Emerging Preferred Route Corridor (within the project extents) was initially assessed for various options which could be considered as reasonable design alternatives in terms of Junction Siting and Side Road Arrangements. Although numerous scenarios have already been considered for reducing conflict points (merging side roads) within the aforementioned Route Selection Report, the assessment also continued to consider same within the design process.

Arising from the options assessment, the following junction and side road alternatives were established (see *Table 1-2*). The appraisal and selection in each case of the preferred option is set out in the subsequent sections.

Table 2-2: Overview of Junction Arrangements considered

Junction Arrangement	Description	Option	Description
JA 01	Southern Tie In	Option A	Online Tie-In to the existing network
		Option B	N16 Roundabout with the L-3406-0 (Drum Road)
JA 02	N16/L74515-0	Option A	Simple T Junction (L74515-0
		Option B	Underbridge Arrangement (L-74515-0)
JA 03	Existing N16 at Castlegal	Option A	Link Road to the L-3406-0
		Option B	Simple T Junction at Castlegal
		Option C	Simple T Junction at Lugatober
JA 04	N16/L7413-0 at Lugatober	Option A	Simple T Junction at Lugatober
JA 05	Existing N16 at Lugatober	Option A	Simple T Junction at Ch. 1,315m
		Option B	Simple T Junction at Ch. 1,150m
JA 06	N16/L3404-0/L34041-0	Option A	Simple T Junction, L3404-0 (North/West Offline)
		Option B	Simple T Junction, L3404-0 (Online)
		Option C	Simple T Junction, L3404-0 (Online) & L34041-0 (Offline)
		Option D	Simple T Junction, L-3404-0 (Online, collecting L34041-0)
		Option E	Simple T Junction, L3404-0 (Online) & L34041-0 (Offline)

2.2.1 Junction Arrangement 01 (JA 01) - Southern Tie In

The nature of the southern Tie-In to the existing network provided two potential configurations. This included the following options; both of which are considered in the proceeding section:

- Option A: Online Tie-In to the existing Network;
- Option B: N16 Roundabout with the L-3406-0 (Drum Road).

2.2.1.1 Option A: Online Tie-In to the existing network

An online Tie-In as outlined in Figure 2-1, was the first arrangement considered for the Southern Tie-In. This arrangement was not considered appropriate for the following reasons:

(1) The vertical topography at the interception point of the new alignment and the existing N16, means that an immediate connection is not possible as outlined in *Figure 2-2*. This effectively dictates that the tie in, would have to occur almost proximate to the existing bend which has a grossly substandard radius of c. 120m. This would result in an undesirable tie-in point, in terms of both Geometry and Stopping Sight Distance.

Considering the foregoing; this option was not considered appropriate to progress for assessment.

Figure 2-1: Option A; Online Tie into Network

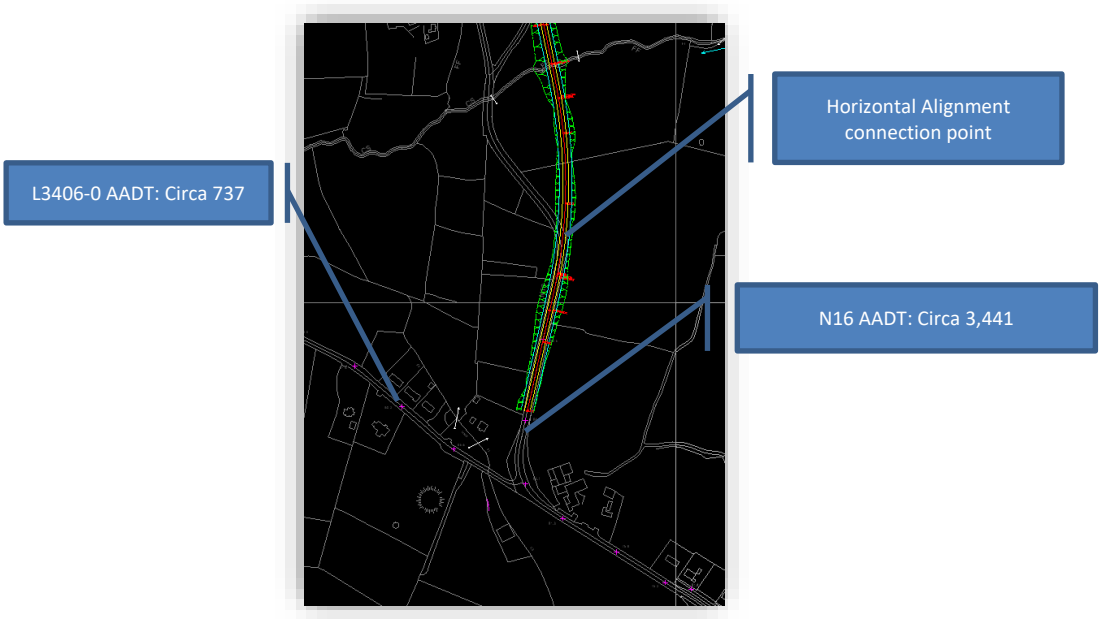
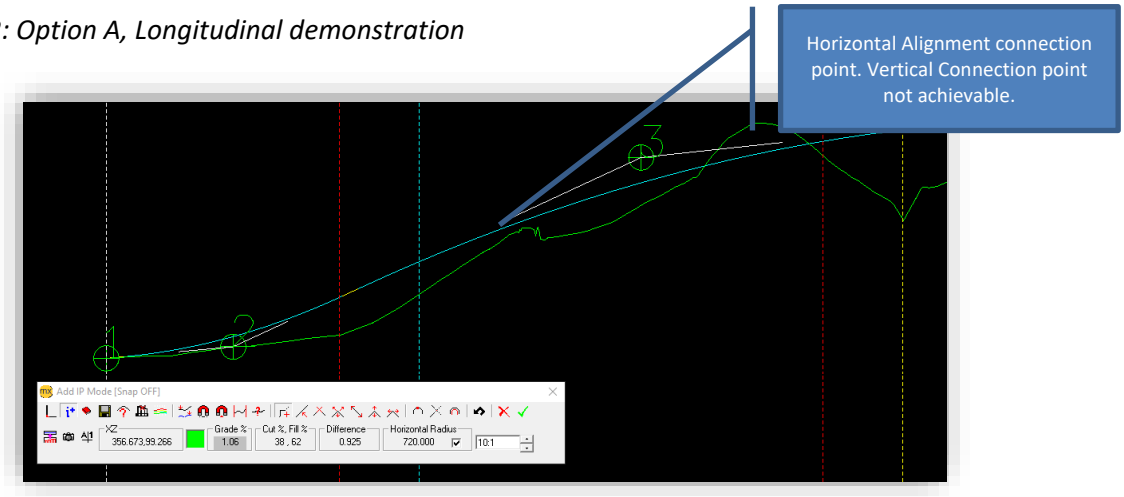


Figure 2-2: Option A, Longitudinal demonstration



2.2.1.2 Option B: N16 Roundabout with the L-3406-0 (Drum Road)

The grossly deficient horizontal nature of the existing alignment at the N16's connection point with the L-3406-0 (See *Figure 2-3*), by its nature, presents an opportune Tie-In point for a roundabout. The

general advantages and disadvantages of providing a roundabout as extracted from DN-GEO-03060 are set out in *Table 2-3* below.

Table 2-3: Extract from Table 2.1 of DN-GEO-03060

Junction Type	Advantages	Disadvantages
Roundabout	Simplifies conflicts and provides a clear indication of priority. Facilitates right turning flows and U-turns. Can facilitate a change in road standard/cross section.	Major road traffic must yield to traffic from the right, which may cause delays. Dominant flows on one approach may lead to excessive delays or may lead to excessive delays on other approaches.

Further specific benefits of such an arrangement include:

- The roundabout can be placed in a manner which will allow for the provision of full Stopping Sight Distance on the approach of the proposed N16, existing N16 and the L-3406-0;
- Approach gradients can be designed to be relatively flat (less than 2%) on each of the incoming roads;
- The roundabout will provide a distinctive break in the national network between 2 different categories of road; i.e. a legacy network and a new section which will be in compliance with the TII Design Standards. It will also permit an ease of extension, for the intended future completion of the N16 Sligo to County Boundary Emerging Preferred Route occurring to the south;
- The scheme termination point will remove the existing substandard junction and deficient horizontal curvature radii (120m radius bend) at the Drum Road (See *Figure 2-3*).

As this option represents the only viable arrangement for this junction, no further MCA was required.

Figure 2-3: Junction with Drum Road (L-3406-0)

2.2.2 Junction Arrangement 02 (JA 02): Proposed N16 connection with the L-74515-0

2.2.2.1 Design Solutions

The proposed N16 intercepts the L-74515-0 in the townland of *Castlegal* at circa Ch. 690m. This local road, which has an AADT of circa 109, is a cul-de-sac, which serves over 17 properties sited on the foothills of Copes Mountain. As the road ascends/descends the mountain, quite steep gradients of greater than c. 10% are encountered in a number of places.

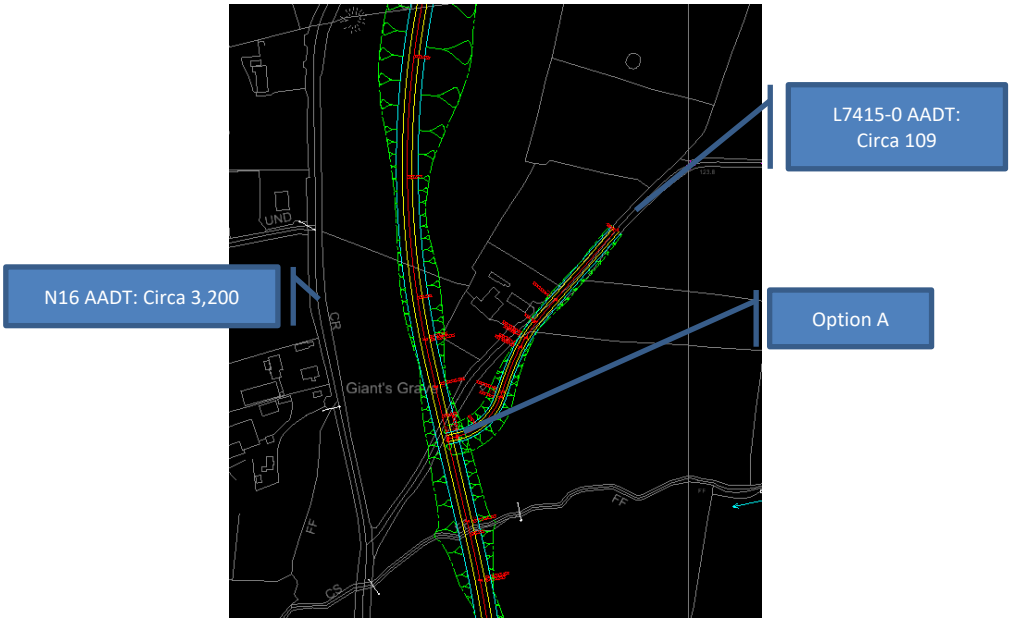
There are two possible options for connecting the local road as outlined below:

- Option A: Simple T Junction (L-74515-0);
- Option B: Underbridge Arrangement (L-74515-0).

2.2.2.1.1 *Option A: Simple T Junction (L-74515-0)*

Option A comprises a Simple T Junction between the L-74515-0 and the proposed N16 (See *Figure 2-4*). Provision for East-West local connectivity is assessed separately in section 2.2.3.

Figure 2-4: Option A, Simple T Junction (L-7415-0)

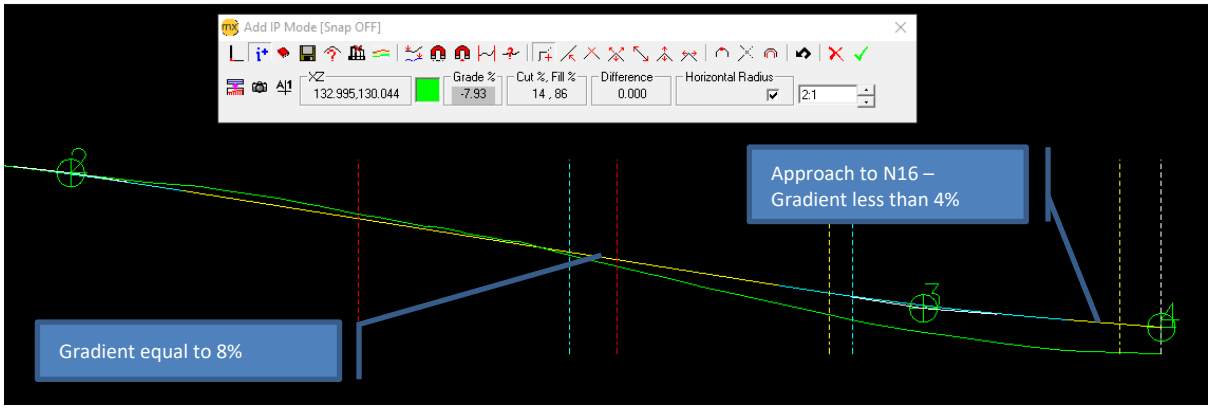


The vertical geometry of the side road can be designed so that it is equal to 8%, this is a permitted relaxation[4] for situations in hilly terrain where the Desirable Minimum Gradient of 7% cannot be achieved

It is also possible to provide a dwell area of 15m with a gradient of less than 4%. This is a permitted relaxation, from the desired 2.5%, for areas which are considered to be difficult situations (in accordance with section 5.6.4 of DN-GEO-03060).

[4] Section 4.1.2 of DN-GEO-03031 (formerly TD09)

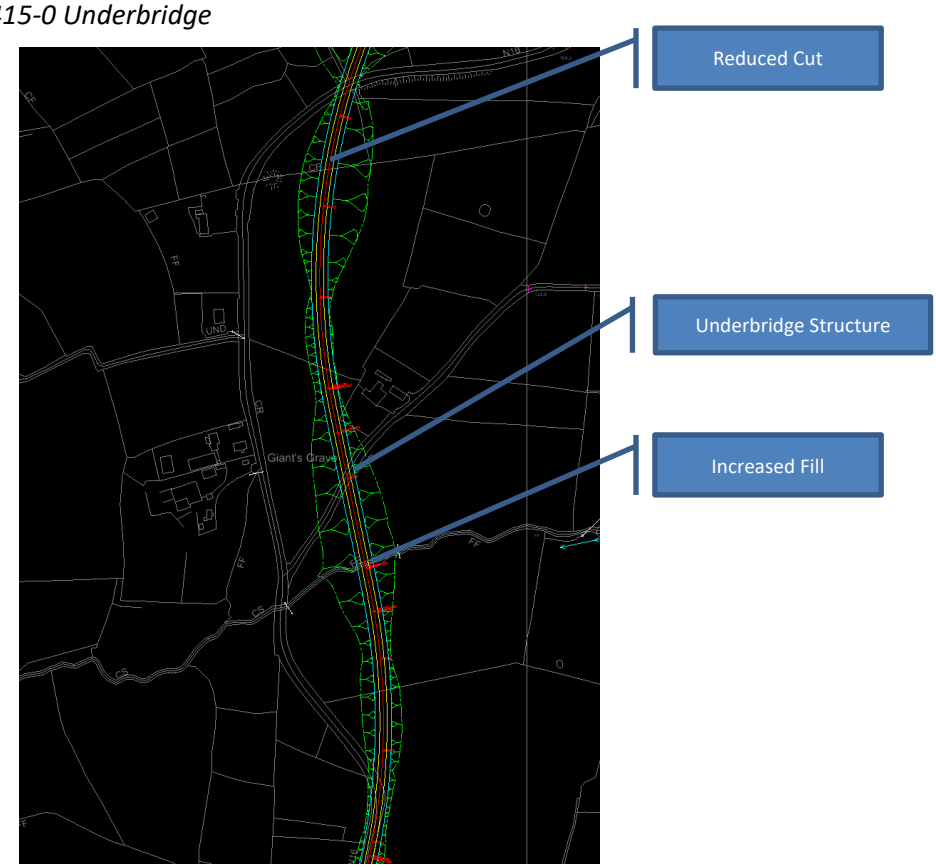
Figure 2-5 Option A, Simple T Junction (L-7415-0) – Vertical Geometry



2.2.2.1.2 *Option B: Underbridge Arrangement (L-74515-0)*

An underbridge arrangement as outlined in *Figure 2-6* is also a viable design solution. This arrangement permits a potential opportunity to reduce mainline conflict points and also permits the local road to retain its current geometric characteristics; however, it also requires a modification of the N16's vertical geometry in order to achieve vertical clearance for the structure. The reconnection of the L-74515-0 to the national network would be the arrangement outlined in the 2.2.3.1.1.[5]

Figure 2-6: Option B: L7415-0 Underbridge



[5] This is due to the fact that a One Step Relaxation in Vertical Curvature is required in order to provide adequate clearance across the L-74515-0. This prohibits the siting of direct accesses within the proximity of same; thus eliminating the options described in 2.2.3.1.2 and 2.2.3.1.3 as potential solutions.

2.2.2.2 Assessment of Options

The following section sets out the assessment process in relation to JA 02. The assessment was undertaken under the headings of Economics and Safety[6] as outlined below.

Economics

A construction and land valuation option comparison estimate was undertaken on the two options. The results of the subsequent MCA are outlined in *Table 2-4*.

Table 2-4: 'Economics' MCA Score

Option	Score Index	Impact Level	Reason
JA 02 Opt A	4	Not Significant, or Neutral	The cost of this option represents approximately 1% to 2% of a potential total Construction Contract Value. This it is expected would have a 'Not Significant, or Neutral Impact' on the Projects Economic Benefits (e.g. BCR NPV)
JA 02 Opt B	1	Major, or Highly Negative	The cost of this option represents approximately 18% to 20% of a potential total Construction Contract Value. This it is expected would have a 'Major, or Highly Negative' impact on the Projects Economic Benefits (e.g. BCR NPV)

Safety

Option A is the best option from a Safety perspective, as it reduces the number of access points to the new route. However, Option B is also positive insofar as it improves the existing junction arrangement.

Table 2-5: 'Safety' MCA Score

Option	Score Index	Impact Level	Reason
JA 02 Opt A	6	Moderately Positive	This is a 'Moderately Positive' option from a 'Safety' perspective as it improves the existing junction geometry, particularly in relation to southbound Stopping Sight Distance, which is increased from circa 90m/65m to the Desirable Minimum Standards (215m).
JA 02 Opt B	7	Major, or Highly Positive	This is a 'Highly Positive' option from a 'Safety' perspective as it reduces the number of access points to the proposed route.

2.2.2.2.1 *Results of Multi Criteria Analysis*

The results of the MCA are outlined in *Table 2-7*. This indicates that Option A with 10 points is the most desirable solution. This is mainly due to the economic difference between the two options and the fact that Option A, in addition to its economic benefits, provides a solution which is also considered positive in terms of Safety.

Table 2-6: Results of MCA

Criteria	Junction Assessment 02 (JA 02)	
	Opt A	Opt B
Economy	4	1

[6] Given the separation between the options, in terms of 'Economy' in particular, it was considered that 'Environmental' differences were not of a level in this instance, which would influence the final decision making.

Criteria	Junction Assessment 02 (JA 02)	
	Opt A	Opt B
Safety	6	7
TOTAL	**10**	**8**

2.2.3 Junction Arrangement 03 (JA 03) Severed existing N16 at Castlegal

2.2.3.1 Design Solutions

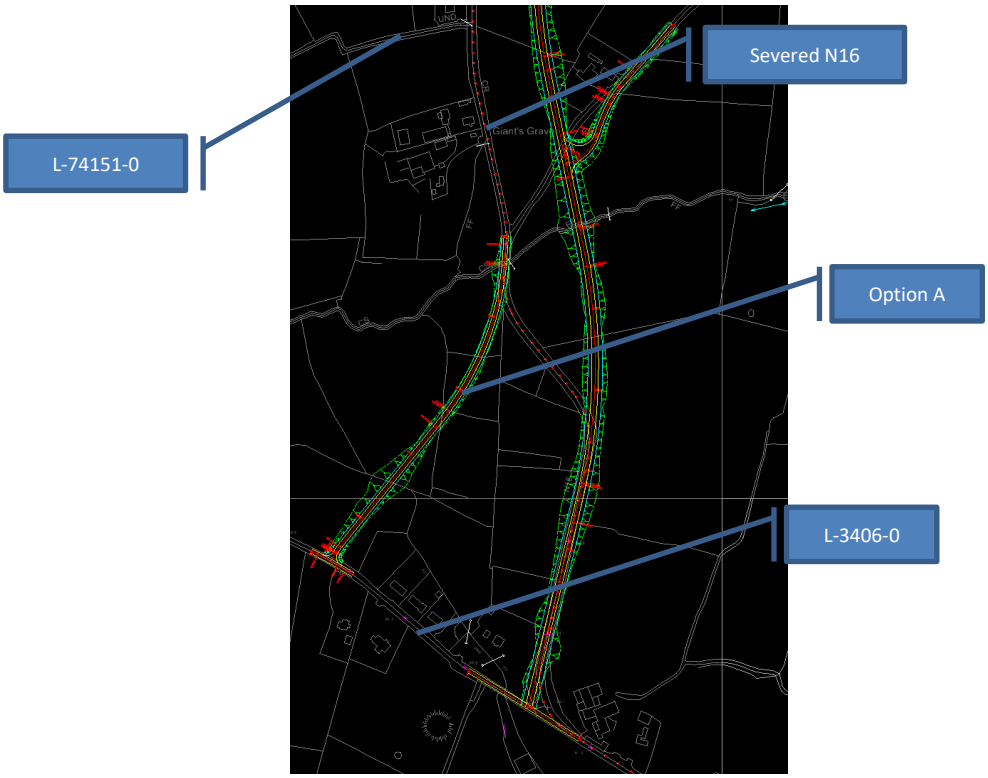
A section of the exiting N16 is severed at *Castlegal* townland as a result of the proposed N16's location. Three viable design options have been established which connect this section of road back into the proposed new network. These include:

- Option A: Link Road to the L-3406-0;
- Option B: Simple T Junction direct connection at *Castlegal*;
- Option C: Simple T Junction direct connection at *Lugatober*;

2.2.3.1.1 *Option A: Link Road to the L-3406-0*

The first arrangement considered for this severed section of the existing N16 was a circa 460m link road, which would connect the L74151-0 and a number of properties (agricultural, domestic and a shot blasting business premises) to the L-3406-0, thereby, removing a direct connection to the proposed N16 and potentially reducing the number of conflict points. The design solution is indicated in *Figure 2-7*.

Figure 2-7: Option A; Link Road to the L-3406-0



2.2.3.1.2 *Option B: Simple T Junction direct connection at Castlegal*

The second arrangement, is one which collects each of the aforementioned properties together and connects this severed section of the N16 directly to the proposed new route in the townland of *Castlegal*; this in effect would result in a Simple Right/Left Staggered Junction with the nearby L-74515-0 which has already been discussed in section 2.2.2.

This connection measures approximately 170m (including the relinking section to the north) in length and is outlined in Figure 2-8.

A simple low speed quadrant link was preferred over a straight direct connection between the existing N16 and the proposed N16, in order to reduce speeds and demarcate the cul-de-sac arrangement.

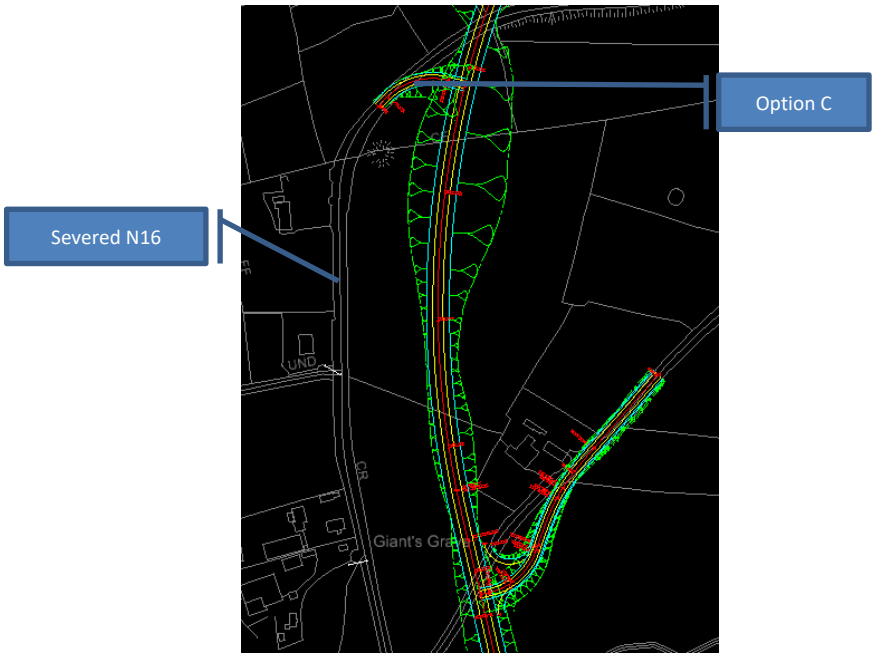
Figure 2-8: Option B: Simple T Junction direct connection at Castlegal

2.2.3.1.3 *Option C: Simple T Junction direct connection at Lugatober*

The third arrangement, is one which collects each of the aforementioned properties together and connects this severed section of the N16 directly to the proposed new route in the townland of Lugatober. The selection of this arrangement could influence how the L-7413-0 (which occurs further north is treated).

This connection measures approximately 70m in length and is outlined in *Figure 2-9* .

Figure 2-9: Option C: Simple T Junction direct connection at Lugatober



2.2.3.2 Assessment of Options

The following section set out the assessment process in terms of the selection of the optimal junction layout for the severed section of the existing N16 at *Castlegal*. The assessment was undertaken under the headings of Economics, Safety and Environment as outlined below.

2.2.3.2.1 *Multi Criteria Analysis*

Economics

A construction and land valuation option comparison estimate was undertaken on the three options. The results of the subsequent MCA are outlined in *Table 2-7*.

Table 2-7: 'Economics' MCA Score

Option	Score Index	Impact Level	Reason
JA 03 Opt A	3	Minor, or Slightly Negative	The cost of this option represents approximately 3% of a total potential Construction Contract Value. This it is expected would have a 'Minor or Slightly Negative Impact' on the Projects Economic Benefits (e.g. BCR NPV)
JA 03 Opt B	4	Not Significant, or Neutral	The cost of this option is considered modest (<2%) and not of the degree which would have an impact on the schemes economic value. Therefore the impact is considered to be 'Not Significant, or Neutral'
JA 03 Opt C	4	Not Significant, or Neutral	The cost of this option is considered modest (<2%) and not of the degree which would have an impact on the schemes economic value. Therefore the impact is considered to be 'Not Significant, or Neutral'

Safety

Option A is the best option from a Safety perspective, as it completely removes the severed properties to the L-3406-0. However, both other options do group all effected properties to one defined access

point and would be good design solution from the perspective of DN-GEO-03030[7]; moreover, a Simple T Junction, or a Right/Left Staggered (as it would be in the same location as the L-72415-0 Simple T Junction) is in accordance with the recommended junction types in DN-GEO-03060[8].

Table 2-8: 'Safety' MCA Score

Option	Score Index	Impact Level	Reason
JA 03 Opt A	7	Major, or Highly Positive	This is a 'Highly' positive option from a 'Safety' perspective as it groups together 2 local roads and removes direct accesses in this location off the national network.
JA 03 Opt B	6	Moderately Positive	This is a 'Moderately Positive' option from a 'Safety' perspective as it groups all existing direct accesses to 1 common defined assess point. This is an improvement on the existing situation in accordance with DN-GEO-03030.
JA 03 Opt C	6	Moderately Positive	This is a 'Moderately Positive' option from a 'Safety' perspective as it groups all existing direct accesses to 1 common defined assess point. This is an improvement on the existing situation in accordance with DN-GEO-03030.

Environment

There is not considered to be any notable difference between the options in terms of a number of Environmental disciplines, such as Noise & Vibration, Air Quality, Biodiversity, Hydrology & Hydrogeology, Landscape and Visual, Archaeology, Cultural Heritage & Architectural Heritage. Impacts on property in terms of loss of land is factored into the Economy criteria described in the foregoing section; therefore the main impact from an environmental effect is considered to be community severance, or a change in journey times for those properties which are effected by each of the different options. *Table 2-9* outlines the difference between the options and the attributed MCA index scores.

Table 2-9: 'Environment' MCA Score

Option	Score Index	Impact Level	Reason
JA 03 Opt A	3	Minor, or Slightly Negative	This option would require a considerable divert for any properties currently located on the severed section to travel to the north, or vice versa. This divert has been measured as being in the order of 1.5m to 2.2km depending where properties are located on the severed section. This divert is considered 'Minor, or Slightly Negative'.
JA 03 Opt B	5	Minor, or Slightly Positive	In terms of reducing community severance, this option is most centrally located and reduces the impact as far as is possible. This option is considered to be the best from an Environmental perspective and is thus scored 'Minor, or Slightly Positive'.
JA 03 Opt C	3.5	'Minor, or Slightly Negative' to 'Not Significant, or Neutral'	This option would require a minor divert for the most southerly of properties, located on the severed section to travel to the south (Sligo), or vice versa. This divert has been measured as being c. 800m for the most southerly of properties travelling to Sligo. This divert is considered to be 'Minor or Slightly Negative to Not Significant, or Neutral'

[7] Guidance on Minor Improvements to National Roads (including Erratum No. 1, dated April 2013 and Erratum No. 2, dated June 2013)

[8] Geometric Design of Junctions (priority junctions, direct accesses, roundabouts, grade separated and compact grade separated junctions)

2.2.3.2.2 *Results of Multi Criteria Analysis*

The results of the MCA are outlined in *Table 2-10*. This indicates that Option B with 15 points is the most desirable solution. This is considered a suitable option selection for the following reasons:

- The volume of traffic on the proposed N16 is in the order of circa 3,441 and is not considered high for a National Primary route, therefore the benefits of relocating the direct access to the L-3406-0 (Option A) are lessened;
- A direct connection to the N16 is a notable improvement from the existing arrangement which has 8 different direct access points;
- From a geometric perspective and considering the geographical constraints, it is not possible to provide FOSD at this location, therefore a direct access will not impact on same;

Table 2-10: Results of MCA

Criteria	Junction Arrangement 03 (JA 03)		
	Opt A	Opt B	Opt C
Economy	3	4	4
Safety	7	6	6
Environment	3	5	3.5
TOTAL	13	15	13.5

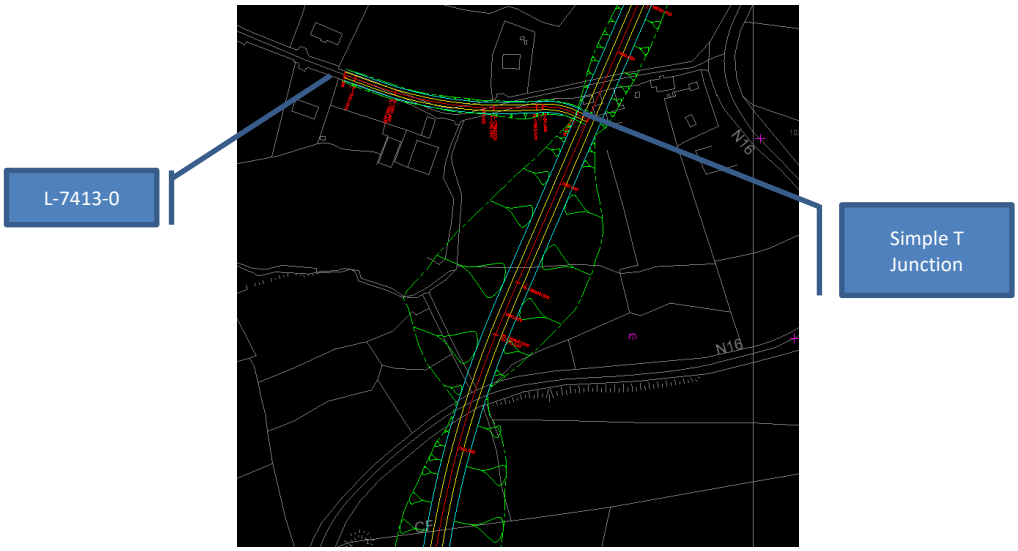
2.2.4 **Junction Arrangement 04 (JA 04) L-7413-0 at Lugatober**

2.2.4.1 Design Solutions

In the case of the L-7413-0's interaction with the proposed N16 at *Lugatober*, the topographical arrangement permits only one viable solution as outlined in *Figure 2-10*. This represents a Simple T junction with the proposed new route.[9]

[9] The provision of a road underbridge is not feasible due to the nature of the topography. To provide such an arrangement would increase the height of an already significant fill section by circa 7m, it would also require the demolition of a residential property. Such an arrangement was considered in the N16 Sligo to County Boundary Route Selection Report.

Figure 2-10: Option A: Simple T Junction at Lugatober (L-7413-0)



2.2.5 Junction Arrangement 05 (JA 05) Severed existing N16 (EAST) at Lugatober

2.2.5.1 Design Solutions

A section of the exiting N16 is severed at *Lugatober* townland as a result of the proposed N16's location. Two viable design options, have been established in order to connect this section of road back into the proposed new network. These include:

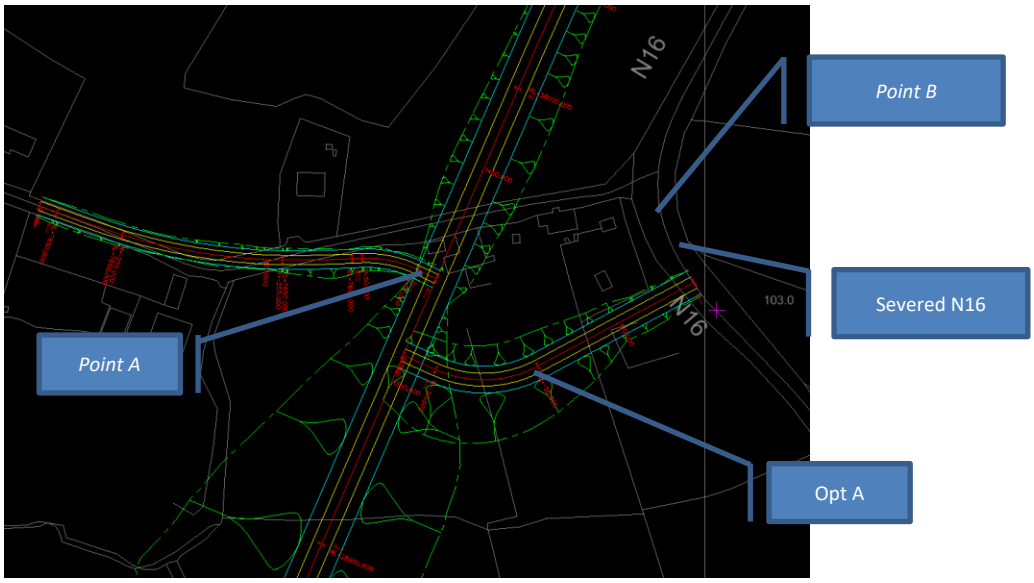
- Option A: Simple T Junction at Ch. 1,315m;
- Option B: Simple T Junction at Ch. 1,150m;

2.2.5.1.1 *Option A: Simple T Junction at Ch. 1,315m*

The first arrangement was a circa 130m link road which would connect the existing N16 and a number of properties (agricultural and domestic premises) to the proposed route at circa Ch. 1,315m; this in effect would result in a Simple Right/Left Staggered T Junction (50m separation) with the nearby L-7413-0 which has already been discussed in section 2.2.4.

The design solution which is outlined in *Figure 2-11* passes through a low lying topographical depression requiring a fill section of circa 4m to 5m in height.

Figure 2-11: Option A: Simple T Junction at Lugatober (EAST) – Ch. 1,315m

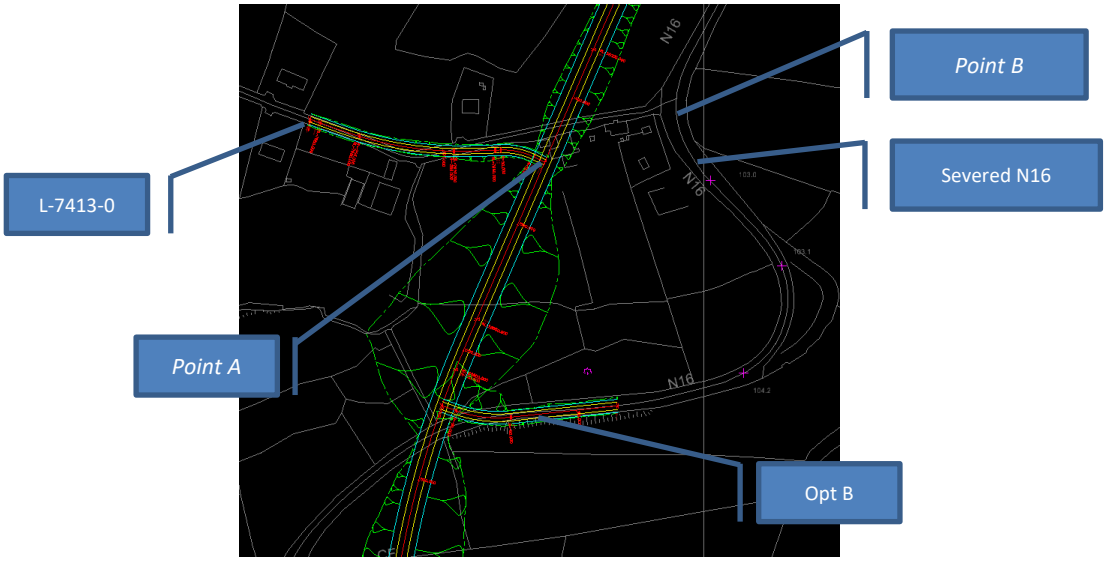


2.2.5.1.2 *Option B: Simple T Junction at Ch. 1,150m*

The second arrangement utilises the existing N16[10], to collect each of the aforementioned properties and connect the existing N16 directly into the proposed new route in the townland of *Castlegal* – Similar to Option A, this in effect would result in a Simple Right/Left Staggered Junction (200m separation) with the nearby L-7413-0 (which has already been discussed in section 2.2.4).

The option is located on the inside of a bend; however the bend, comprises a Desirable Minimum Radius curve (720m), which is not considered 'Sharp' as defined in DN-GEO-03060; therefore, this design is in compliance with the DMRB.

Figure 2-12: Option B: Simple T Junction at Lugatober (EAST) – Ch. 1,150m



[10] The provision of a road underbridge at the intersection of the existing N16 is not feasible due to the nature of the topography. To provide such an arrangement would increase the height of an already significant fill section by circa 7m.

2.2.5.2 Assessment of Options

The following section set out the MCA assessment process for JA 05. The assessment was undertaken under the headings of Economics, Safety and Environment as outlined below.

2.2.5.2.1 *Multi Criteria Analysis*

Economics

A construction and land valuation option comparison estimate was undertaken on the two options. The results of the subsequent MCA are outlined in *Table 2-11*.

Table 2-11: 'Economics' MCA Score

Option	Score Index	Impact Level	Reason
JA 05 Opt A	3	'Minor or Slightly Negative'	The cost of this option represents approximately 3% a potential total Construction Contract Value. This it is expected would have a 'Minor or Slightly Negative Impact' on the Projects Economic Benefits (e.g. BCR NPV)
JA 05 Opt B	4	'Not Significant, or Neutral'	The cost of this option represents approximately 1% of a potential total Construction Contract Value. This, it is expected would have a 'Not Significant, or Neutral' Impact on the Projects Economic Benefits (e.g. BCR NPV)

Safety

Table 2-12 presents the MCA pertaining to Safety, which is improved by both options.

Table 2-12: 'Safety' MCA Score

Option	Score Index	Impact Level	Reason
JA 05 Opt A[11]	6	Moderately Positive	This is a 'Moderately Positive' option from a 'Safety' perspective as it groups all existing direct accesses to 1 common defined assess point. This is an improvement on the existing situation in accordance with DN-GEO-03030.
JA 05 Opt B	6	Moderately Positive	This is a 'Moderately Positive' option from a 'Safety' perspective as it groups all existing direct accesses to 1 common defined assess point. This is an improvement on the existing situation in accordance with DN-GEO-03030.

Environment

In a similar situation to JA 03, there is not considered to be any notable difference between any of the options in terms of a number of Environmental disciplines, such as Noise & Vibration, Air Quality, Biodiversity, Hydrology & Hydrogeology, Landscape and Visual, Archaeology, Cultural Heritage & Architectural Heritage. This is in consideration of the fact that groundwater levels will not be

[11] In relation to Option A, it is considered that the following factors are corrected prior to assessment:

- The Vertical Alignment of the Mainline will require an elevation which will ensure the vertical alignment of Option A is kept below 8%, while also ensuring dwell areas of less than 4% can be achieved;
- Minor verge improvement works will be required on the retained severed section of the existing N16 in order to ensure a Stopping Sight Distance of 90m for a 60kph design speed can be achieved;

interfered with and that the Petrifying Springs described below in Figure 2-13 will not be directly impacted upon.

Figure 2-13: Location of petrifying springs at West of Castlegal (Lugatober)

The main environmental effect is thus considered to be community severance aspects which is expanded upon in *Table 2-13*.

Table 2-13: 'Environment' MCA Score

Option	Score Index	Impact Level	Reason
JA 05 Opt A	3.5	'Minor, or Slightly Negative' to 'Not Significant, or Neutral'	Design Option A results in a 280m additional trip for people wishing to travel from the west side of the alignment to the east side (the severed section of the N16). Usage however is considered to be low considering the low density of housing in the area (on the severed section of the existing N16) and is likely to be confined to neighbouring houses and agricultural land.
JA 05 Opt B	3	'Minor, or Slightly Negative'	Design Option B results in a 660m additional trip for people wishing to travel from the west side of the alignment to the east side (the severed section of the N16). Usage however is considered to be low considering the low density of housing in the area (on the severed section of the existing N16) and is likely to be confined to neighbouring houses and agricultural land.

2.2.5.2.2 *Results of Multi Criteria Analysis*

The results of the MCA are outlined in *Table 2-14*. This indicates that Option B is marginally the better option with 12 points. This is considered a suitable option[12] selection for the following reasons:

- There is a notable difference between the two options in terms of economic construction cost;
- There are no notable differences between the options in terms of Safety;
- Differences in terms of Environment are marginal and confined to mainly being local community trips;

[12] Prior to incorporation into the design and in accordance with the DMRB and as already outlined a departure from standards will be required for this option in relation to Stopping Sight Distance across the paved area.

Table 2-14: Results of MCA

Criteria	Junction Arrangement 03 (JA 03)	
	Opt A	Opt B
Economy	3	4
Safety	6	6
Environment	3.5	3
TOTAL	12.5	13

2.2.6 Junction Arrangement 06 (JA 06) – L-34041-0 and L-3404-0 (The Glencar Road)

2.2.6.1 Design Solutions

The potential design arrangements for the L-34041-0 and the L-3404-0 are largely dictated by the vertical geometry of the mainline carriageway, the nature of the existing topography and the constraints in the area. These arrangements are described below, together with various junction arrangements for each mainline design.

Mainline Design (MDO) Option 001 – Vertical Arrangement No. 01

This design arrangement is outlined in *Figure 2-14* (Horizontal Plan) and *Figure 2-15* (Vertical Profile). A Vertical Hog curve placed within a straight section to the south of a 720m radius Horizontal Curve, results in a Cut of circa 2.2m (excluding road construction) through a hill area located at circa Ch. 2,100m. This design arrangement is largely controlled by the vertical requirement to tie into the existing network to the north.

Figure 2-14: N16 Mainline Option 001 – Collinsford/Lugnagall – Horizontal Geometry

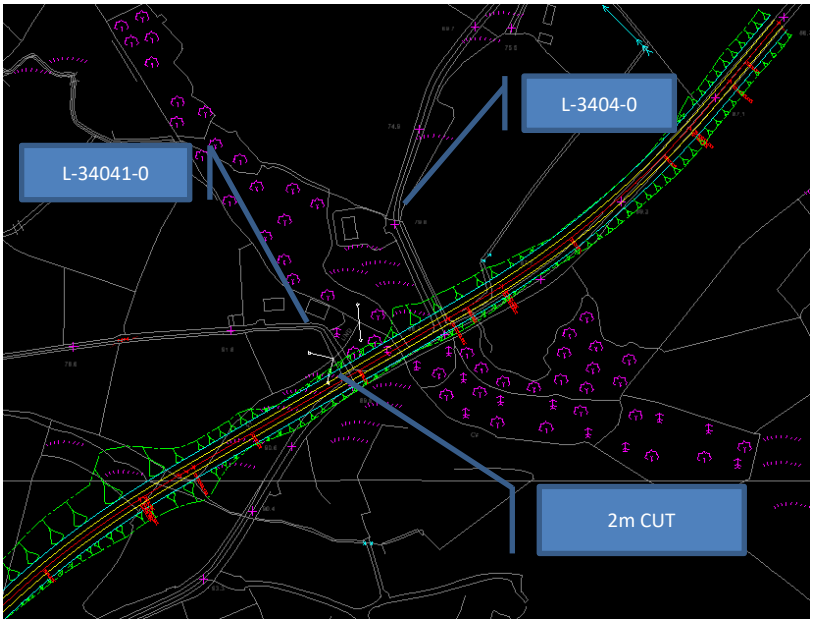
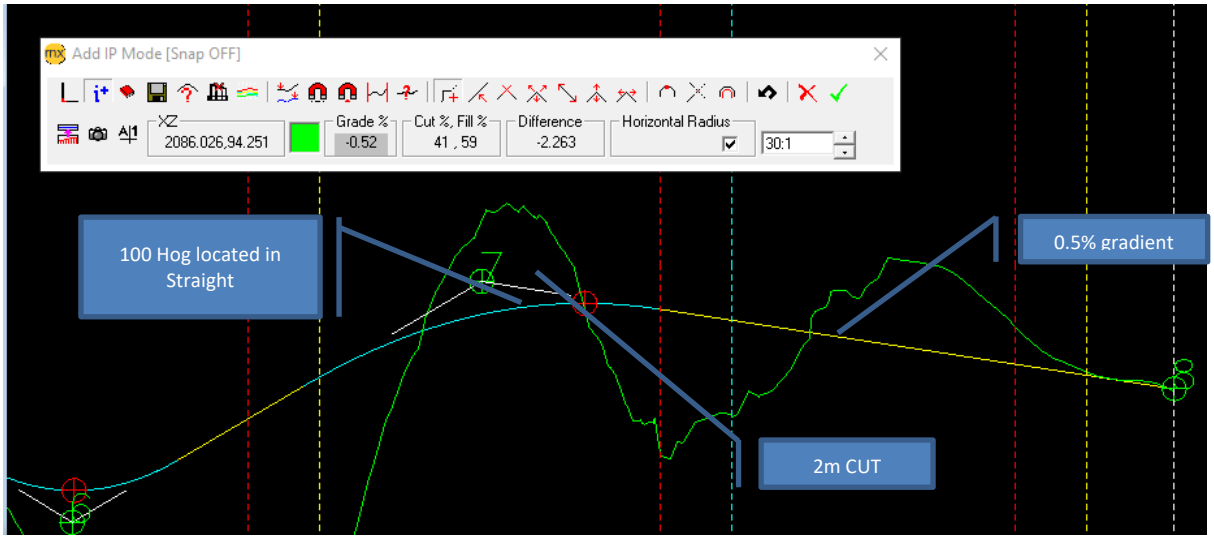


Figure 2-15: N16 Mainline Option 001 – Collinsford/Lugnagall – Vertical Geometry



Mainline Design (MDO) Option 002 – Vertical Arrangement No. 02

This design arrangement is outlined in *Figure 2-16* and *Figure 2-17*. A Vertical Hog curve to Desirable Minimum standards placed within the 720m radius Horizontal Curve to the north, results in a Cut of circa 5.5m (excluding road construction) through a hill area located at circa Ch. 2,100m. This design arrangement is largely controlled by the vertical requirement to tie into the existing network to the north.

Figure 2-16: N16 Mainline Option 002 – Collinsford/Lugnagall – Horizontal Geometry

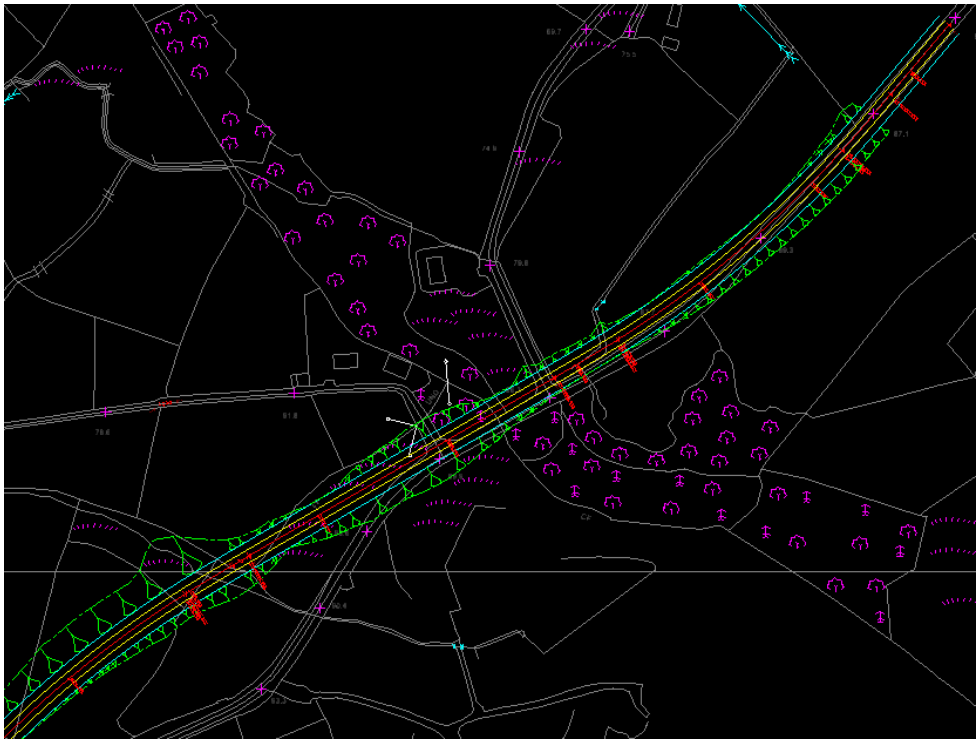
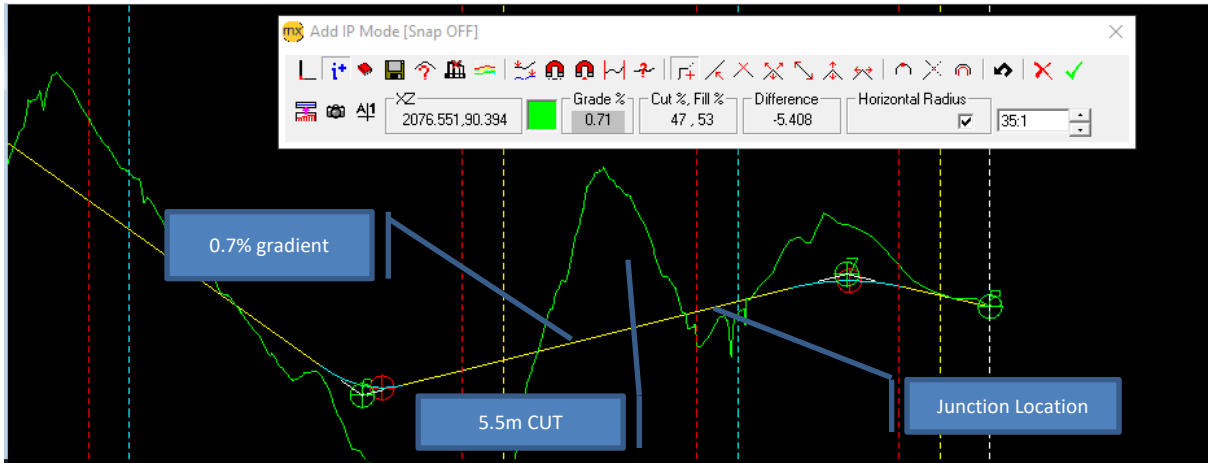


Figure 2-17: N16 Mainline Option 002 – Collinsford/Lugnagall – Vertical Arrangement



Mainline Design (MDO) Option 003 – Vertical Arrangement No. 03

This design arrangement is outlined in *Figure 2-18* and *Figure 2-19*. A Vertical Hog curve to Desirable Minimum standards placed within the 720m radius Horizontal Curve to the north, results in a Cut of circa 4m (excluding road construction) through a hill area located at circa Ch. 2,100m. This design arrangement is largely controlled by the vertical requirement to tie into the existing network to the north.

Figure 2-18: N16 Mainline Option 003 – Collinsford/Lugnagall – Horizontal Geometry

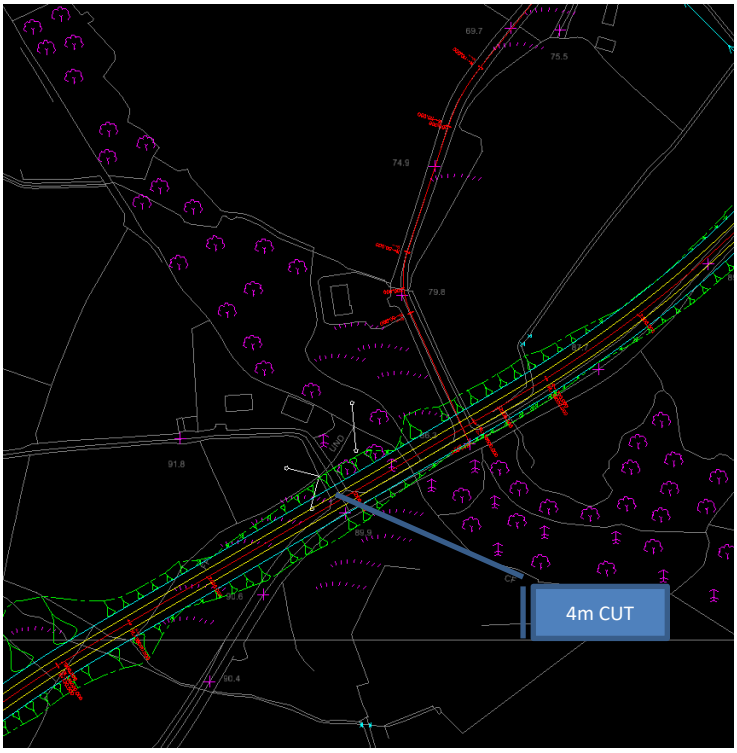
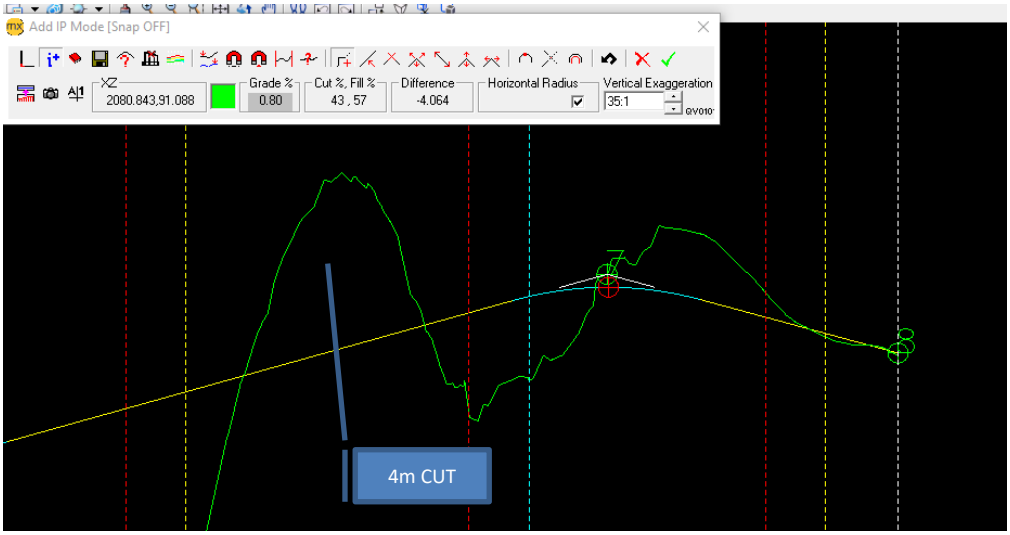


Figure 2-19: N16 Mainline Option 003 – Collinsford/Lugnagall – Vertical Arrangement

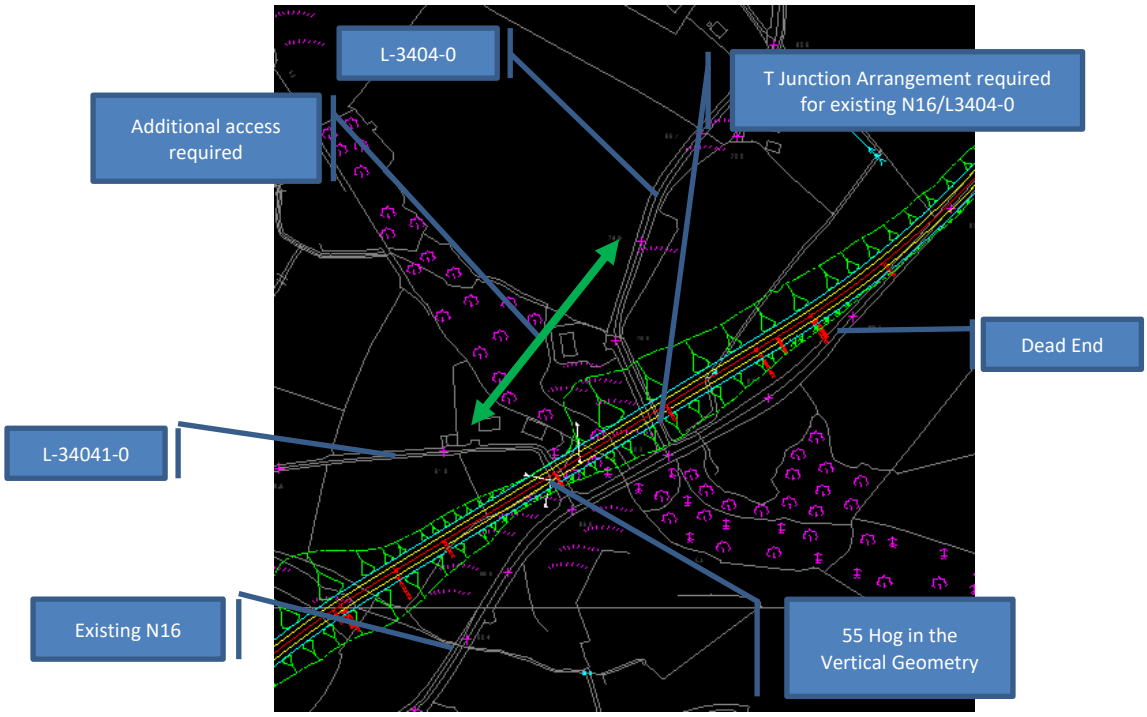


Consideration of an Underbridge

Consideration was had to the potential provision of an underbridge for the L-3404-0 as outlined in *Figure 2-20*. This was not considered a feasible solution for the following reasons:

- In a vertical sense, to provide an appropriate clearance over the L-3404-0, a 55 HOG is required. This is one step below the Desirable Minimum, which consequently means an additional direct access cannot be added to the mainline in its vicinity;
- Considering the first point, access for the L-34041-0 would have to be via the L-3404-0, meaning the construction of an additional link to that shown in *Figure 2-20* and further impacts on both adjoining properties;
- The connection of the existing N16 and the L-3404-0 would have to utilise the existing T Junction arrangement as a skew structure cannot achieve the vertical clearance required. This has the resulting effect of leaving a cul-de-sac/dead end arrangement where the existing N16 intercepts the proposed N16. Given the level of traffic likely to use the L-3404-0 link, this arrangement is considered unsafe;
- There are significant economic costs to such an arrangement, considering the additional embankment and structure required;
- Such an arrangement creates significant engineering features in proximity to 2 no. adjacent dwelling houses.

Figure 2-20: Consideration of an Underbridge[13]



2.2.6.1.1 *Overview of Junction Arrangements*

The foregoing Mainline Design arrangements allow for the various Junction Arrangements outlined in *Table 2-15*, which are described in the subsequent sections.

[13] See also Option 08-v2 in the N16 Sligo to County Boundary Route Selection Report which presents a similar arrangement.

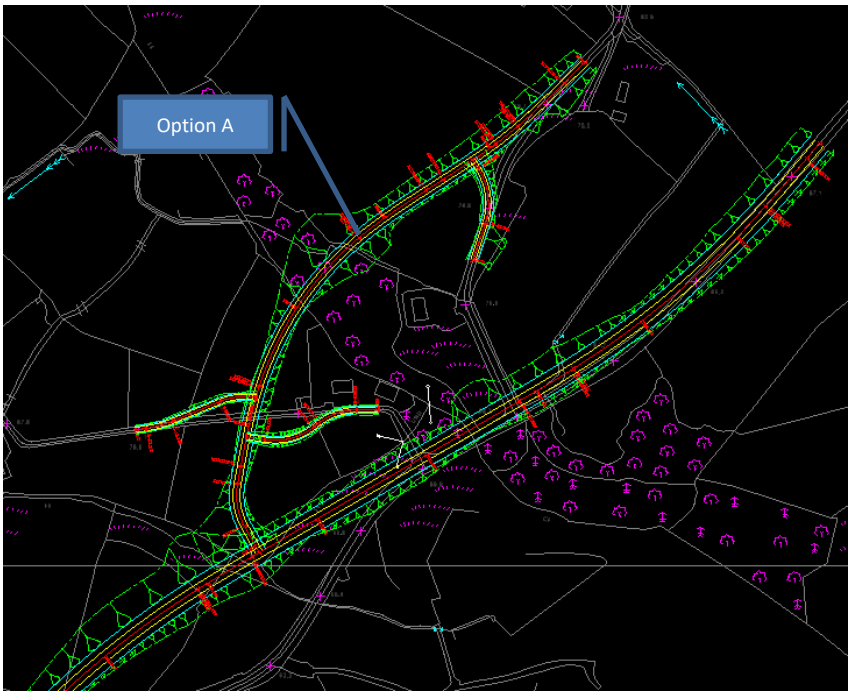
Table 2-15: Junction Options Overview

Option Reference	Description	Mainline Option Ref
JA 06, Option A	Simple T Junction, L3404-0 (North/West Offline)	Vertical Arrangement No. 01 & 03
JA 06, Option B	Simple T Junction, L3404-0 (Online)	Vertical Arrangement No. 01 & 03
JA 06, Option C	Simple T Junction, L3404-0 (Online) & L34041-0 (Offline)	Vertical Arrangement No. 01 & 03
JA 06, Option D	Simple T Junction, L-3404-0 (Online, collecting L34041-0)	Vertical Arrangement No. 02
JA 06, Option E	Simple T Junction, L3404-0 (Online) & L34041-0 (Offline)	Vertical Arrangement No. 02

JA 06, Option A (MDO 001 & 003)

Option A, as outlined in *Figure 2-21* is a circa 500m realignment of the L-3404-0 which collects severed sections of the existing L-3404-0 and the L-34041-0, including accesses to domestic and agricultural properties. These reconnections of severed links cumulatively measure circa 280m, which amounts to circa 780m in total of new roads.

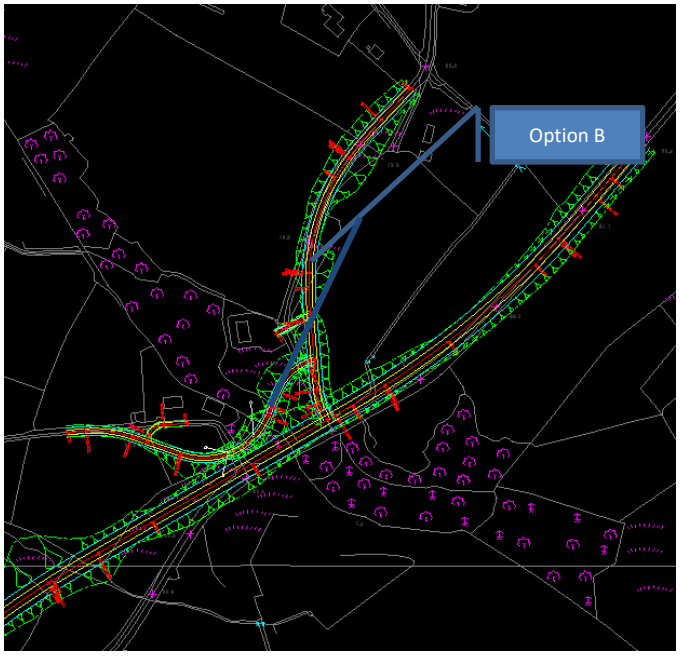
Figure 2-21: JA 06 Option A



JA 06, Option B (MDO 001 & 003)[14]

Option B, as outlined in *Figure 2-22* is a circa 310m realignment of the L-3404-0 which collects the severed section of the L-34041-0, including accesses to domestic and agricultural properties, these reconnections of severed links cumulatively measure circa 250m which amounts to 560m overall. This arrangement will result in a direct access being within the Junction Stopping Sight Distance envelope of the L34041-0's T Junction with the L3404-0.

Figure 2-22: JA 06 Option B



JA 06, Option C (MDO 001 & 003);

Option C, as outlined in *Figure 2-23* is a circa 310m realignment of the L-3404-0. It also includes a separate access arrangement for the L34041-0, which collects the severed section of the L-34041-0, including accesses to domestic and agricultural properties. These reconnections of severed links cumulatively measure circa 210m which amounts to circa 520m of new roads overall.

A radius of 60m, applied to the L34041-0, was considered appropriate given the existing private nature of the lands being served, its cul-de-sac nature, it's low design speed, it's low usage, and the fact that, the existing radius to the east is 20m as outlined in *Figure 2-23*.[15]

An alternative discreet option for the L34041-0 is provided in *Figure 2-24*. This is also considered a viable option[16], considering the fact that the landholding being accessed is in the one holding.

[14] Due to the difficult nature of the topography and the constraints in the area; Relaxations and Departures will be applied to the upgrades of local roads under this Junction Arrangement. In each case this will be an improvement over the existing situation.

[15] This arrangement was modified later in the design process to a direct double 'T' connection between both roads. This was established b

[16] There is a 10% vertical gradient on the connecting private road; however, this is not a change from the existing scenario.

Figure 2-23: JA 06 Option C

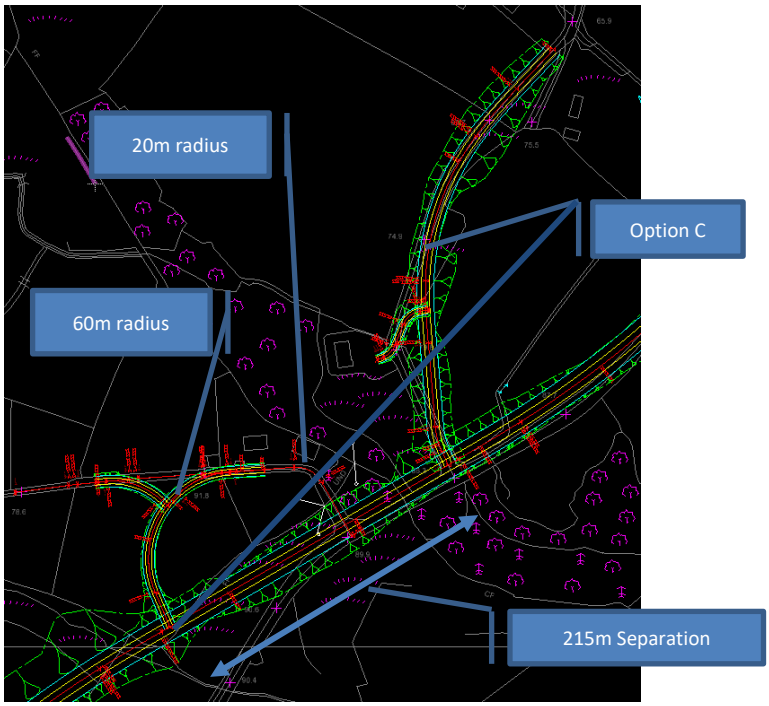
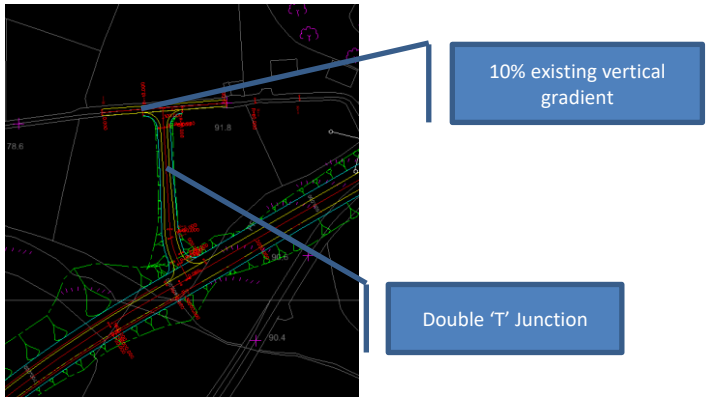


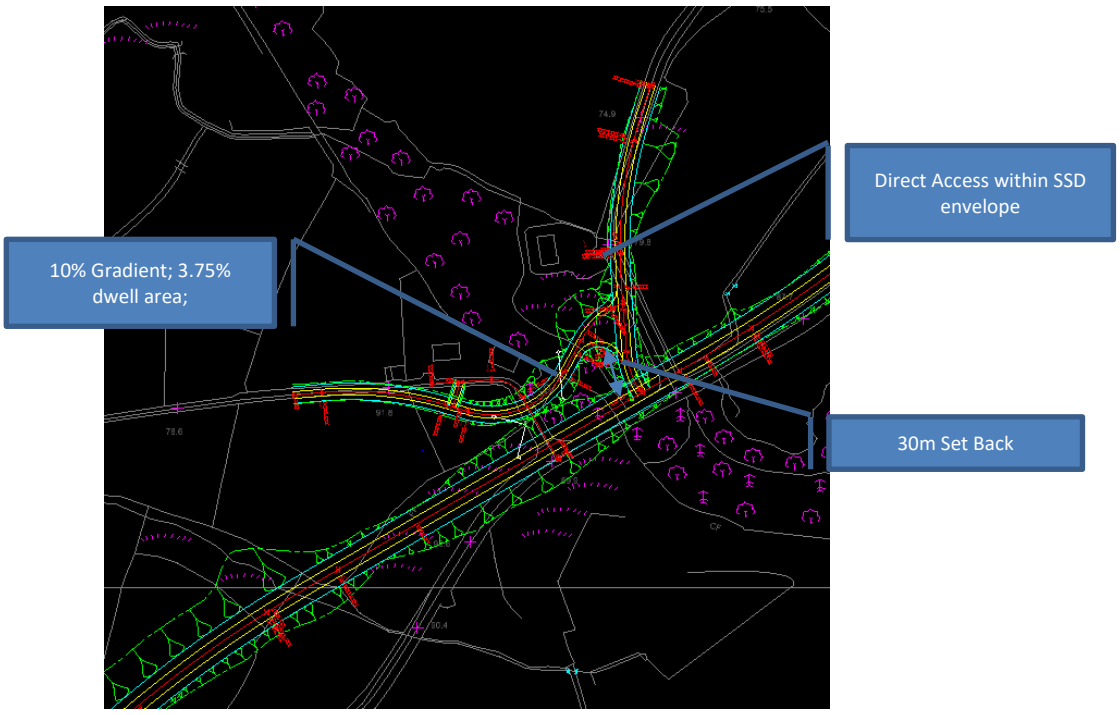
Figure 2-24: Alternative L34041-0 arrangement



JA 06, Option D (MDO 002);

Option D, as outlined in *Figure 2-25* is a circa 190m realignment of the L-3404-0 which collects the severed section of the L-34041-0, including accesses to domestic and agricultural properties, these reconnections of severed links measure circa 215m, which in total measures circa 405m of new roads. This arrangement will result in a direct access being within the Junction Stopping Sight Distance envelope of the L34041-0's T Junction with the L3404-0.

Figure 2-25: JA 06, Option D

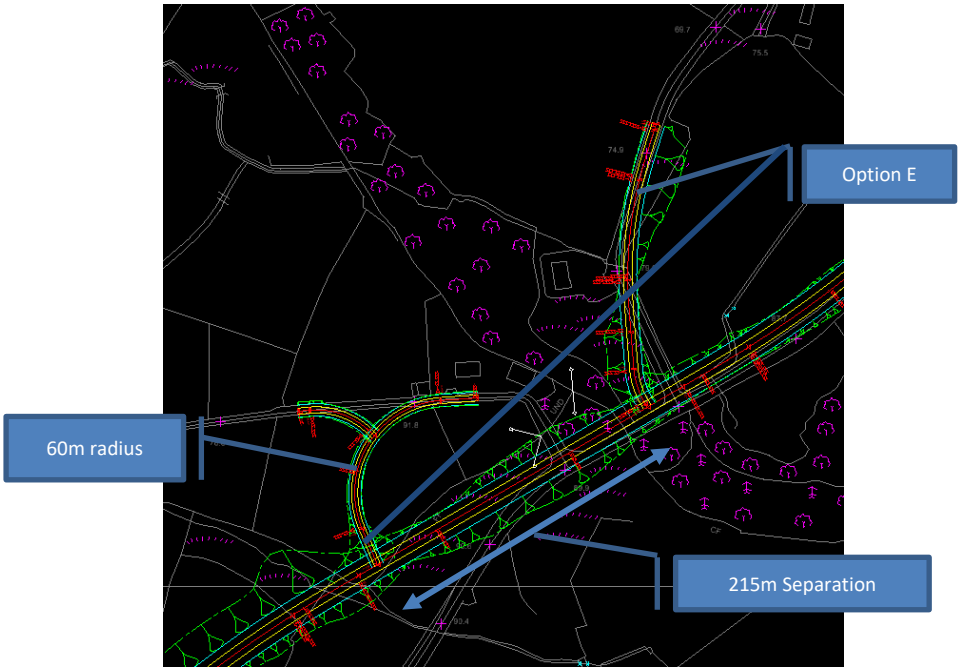


JA 06, Option E (MDO 002);

Option E, as outlined in Figure 2-26 is a circa 190m realignment of the L-3404-0 which collects the severed section of the L-34041-0, including accesses to domestic and agricultural properties, these reconnections of severed links measure circa 210m which amounts in total to circa 390m of new roads.

The shorter realigned section of the L3404-0 is achievable due to the lower elevation of the tie in point with the proposed N16, meaning appropriate vertical gradients can be achieved.

Figure 2-26: JA 06 Option E



Summary of Road Lengths

In summary, *Table 2-16*, outlines the total new road lengths associated with each alternative junction arrangement. Section 2.2.6.2 sets out the assessment of these options.

Table 2-16: Junction Options Overview

Option Reference	Total New Road length (m)
JA 06, Option A	780m
JA 06, Option B	560m
JA 06, Option C	520m
JA 06, Option D	405m
JA 06, Option E	390m

2.2.6.2 Assessment of Options

The following section set out the assessment process for Junction Arrangement No. 06 (L3404-0 and the L34041-0) in the townlands of *Collinsford* and *Lugnagall*. The assessment was undertaken under the headings of Economics, Safety and Environment as outlined below.

2.2.6.2.1 *Multi Criteria Analysis*

Economics

A construction and land valuation Option Comparison Estimate was undertaken on the various different options. The results of the subsequent MCA are outlined in Table 2-17.

Table 2-17: Economic MCA Score[17]

Option	Score Index	Impact Level	Reason
JA 06 Opt A	1	Major Negative	The cost of this option represents circa 25% of a potential total construction contract and is circa €0.51m greater than the lowest costing option. Considering the nature of the junction (which requires an extensive re-arrangement), this it is expected would have a 'Major Negative' effect on the Projects Economic Benefits (e.g. BCR NPV).
JA 06 Opt B	2	Moderately Negative	The cost of this option represents circa 22% of a potential total construction contract and is circa €0.29m greater than the lowest costing option. Considering the nature of the junction (which requires an extensive re-arrangement), this it is expected would have a 'Moderately Negative' effect on the Projects Economic Benefits (e.g. BCR NPV).
JA 06 Opt C	2	Moderately Negative	The cost of this option represents circa 21% of a potential total construction contract and is circa €0.21m greater than the lowest costing option. Considering the nature of the junction (which requires an extensive re-arrangement), this it is expected would have a 'Moderately Negative' effect on the Projects Economic Benefits (e.g. BCR NPV).
JA 06 Opt D	3	Minor, or Slightly Negative	The cost of this option represents circa 18% of a potential total construction contract and is circa €0.03m greater than the lowest costing option. Considering the nature of the junction (which requires an extensive re-arrangement), this it is expected would have a 'Minor, or Slightly Negative' effect on the Projects Economic Benefits (e.g. BCR NPV).
JA 06 Opt E	3	Minor, or Slightly Negative	The cost of this option represents circa 17% of a potential total construction contract and is the lowest costing option. Considering the nature of the junction (which requires an extensive re-arrangement), this it is expected would have a 'Minor, or Slightly Negative' effect on the Projects Economic Benefits (e.g. BCR NPV).

Safety

Strategically, from a safety perspective; option A is the best option, options B and D are also considered good options with similar benefits, as are C and E. All options represent significant improvements from the existing arrangement insofar as:

- The separation of junctions at this location and between the L3404-0 and the L34041-0 is either eliminated (options A, B and D), or improved (options C and E) to full Desirable Minimum Stopping Sight Distance;
- The existing geometry of the L3404-0 is improved in all options;

[17] In order to correlate the Economic Cost to the MCA Index; the range between the highest and lowest value was established, with the highest value achieving an Index of '1' (Major Negative) and the lowest value achieving an Index of '3' (Minor or Slightly Negative). Each of the remaining options were determined on a pro-rata basis.

Table 2-18 sets out the associated Safety Assessment pertaining to each option.

Table 2-18: 'Safety' MCA Score

Option	Score Index	Impact Level	Reason
JA 06 Opt A	7	Highly Positive	This is the best option from a safety perspective, insofar as a realignment of the L3404-0 to the north permits a simple collection of the L34041-0 as it intercepts it, via a Right/Left stagger. This option eliminates the existing L34041-0 direct access to the N16. This is a 'Highly' positive option from a 'Safety' perspective.
JA 06 Opt B	6	Moderately Positive	Option B also eliminates the existing double access arrangement; however in doing so, a situation arises, whereby a direct domestic and agricultural access is located in the north bound Stopping Sight Distance envelope of the L34041-0, as it connects with the L3404-0 (although both accesses have low usage). The direct connection of the L34041-0 to the L3404-0 occurs at a distance of 50m from the L3404-0's connection with the proposed N16. This is the minimum separation distance, permitted in accordance with section 5.2.2 of DN-GEO-03060 and therefore is considered an appropriate arrangement. Considering the foregoing this option is considered to be 'Moderately' Positive.
JA 06 Opt C	6	Moderately Positive	Option C retains the existing double access arrangement of the L34041-0 and the L3404-0 to the N16, however it increases the separation of the Stopping Sight Distance envelope for both junctions to the Desirable Minimum (215m). This is a significant improvement on the existing situation which is 85m. Although the design objective is to remove accesses where it is achievable to do so, the topography and constraints in this area make it difficult to achieve this without notable impacts. In this regard, as the L34041-0 is a low usage link comprising 2 domestic properties and agricultural lands, a second direct connection is considered appropriate. Considering the foregoing this option is considered to be 'Moderately' Positive.
JA 06 Opt D	6	Moderately Positive	As per Option B
JA 06 Opt E	6	Moderately Positive	As per Option C

Environment

In terms of Environment there is not considered to be a significant difference between the various options in terms of Noise & Vibration, Air Quality, Archaeology, Cultural Heritage & Architectural Heritage. In terms of Landscape & Visual the lesser the quantity of new roads proposed, will generally result in lesser impacts, however these are not considered to be significant.

The main impacts in terms of environment are associated with:

- Agricultural Property Impacts;
- Non Agricultural Property Impacts (Domestic);
- Amenity Disturbance; and
- Biodiversity Impacts.

Property – Agricultural

Land use is grassland with a hilly topography and elevations between 80-90m OD. Land quality is average to good with farming activity based on grassland for beef and sheep production. *Table 2-19* sets out the MCA assessment in relation to Agricultural Property.

Table 2-19: 'Environment – Agricultural Property' MCA Score

Option	Score Index	Impact Level	Reason
JA 06 Opt A	2	Moderately Negative	Main agricultural impacts are: ➢ *Collinsford*: Landtake and Severance of agricultural lands (Medium Impact predicted); ➢ *Lugnagall*: Landtake and Severance of agricultural lands (Low/Medium Impact predicted);
JA 06 Opt B	3	Minor, or Slightly Negative	Main agricultural impacts are: ➢ *Collinsford*: Landtake and Severance of agricultural lands (Low Impact predicted). Workshop and yards not directly impacted; ➢ *Lugnagall*: No notable change (Low Impact predicted);
JA 06 Opt C	3	Minor, or Slightly Negative	Main agricultural impacts are: ➢ *Collinsford*: Landtake and Severance of agricultural lands (Low Impact predicted). Workshop and yards not directly impacted; ➢ *Lugnagall*: No notable change (Low Impact predicted);
JA 06 Opt D	3	Minor, or Slightly Negative	Main agricultural impacts are: ➢ *Collinsford*: Landtake and Severance of agricultural lands (Low Impact predicted). Workshop and yards not directly impacted; ➢ *Lugnagall*: No notable change (Low Impact predicted);
JA 06 Opt E	3	Minor, or Slightly Negative	Main agricultural impacts are: ➢ *Collinsford*: Landtake and Severance of agricultural lands (Low Impact predicted). Workshop and yards not directly impacted; ➢ *Lugnagall*: No notable change (Low Impact predicted);

Property – Non-Agricultural (Domestic)

In terms of Non-Agricultural Property, it is not expected that any property will require to be demolished as a result of the proposal; therefore there are no Moderate, or Significantly Negative Effects. In all options, there are modifications required to existing accesses; however, these will not, it is expected require significant modification of existing drives, or garden areas. In this regard, all options are considered to be Minor, or Slightly Negative.

Local Amenity Disturbance

Amenity Disturbance is a separate discipline which has been assessed in order to reflect the general impacts on property owners whose lands/properties are affected by the various proposals. Two broad headings were used for this particular assessment which are outlined below and expanded upon in *Table 2-20*.

- Severance/Increase in local journeys;
- Disturbance/Reduced Space (or Island Effect)/Reduced Amenity;

Table 2-20: 'Environment – Local Amenity Disturbance' MCA Score

Option	Score Index	Impact Level	Reason
JA 06 Opt A	3	Minor, or Slightly Negative	Relocation of existing junctions result in a minor change in journey patterns. The addition of a new road to the north/east of existing properties results in a minor change.
JA 06 Opt B	3	Minor, or Slightly Negative	The connection of the L34041-0 to the L3404-0 results in the creation of an additional road proximate to both residential properties. This is likely to add to the current intrusion levels and reduce the amenity value surrounding the properties.
JA 06 Opt C	3.5	Not Significant, or Neutral to Minor, or Slightly Negative	Although this option retains insofar as is possible the existing arrangement, it increases road level heights for the most easterly of the properties. This is likely to add to the current intrusion levels and reduce the amenity value surrounding the property.
JA 06 Opt D	3	Minor, or Slightly Negative	As per Option B
JA 06 Opt E	4	Not Significant, or Neutral	This option retains insofar as is possible the existing arrangement.

Biodiversity

Impacts on Biodiversity are related to the proximity of Lugnagall Flush (See Table 2-21 and Figure 2-27) and Crockauns/Keelogyboy Bogs NHA (See Figure 2-28). Table 2-22 outlines the results of the MCA assessment.

Table 2-21: Summary of ecological evaluation

Site no.	Site name	Annex I habitats	Ecological evaluation
10	Lugnagall Flush – south of road (See Figure 2-27)	Small remnants of alkaline fen and petrifying springs	County Ecological Importance as supports two Annex I habitats and overlaps with Crockauns/ Keelogyboy Bogs NHA

Figure 2-27: Lugnagall Flush Annex I wetland habitats

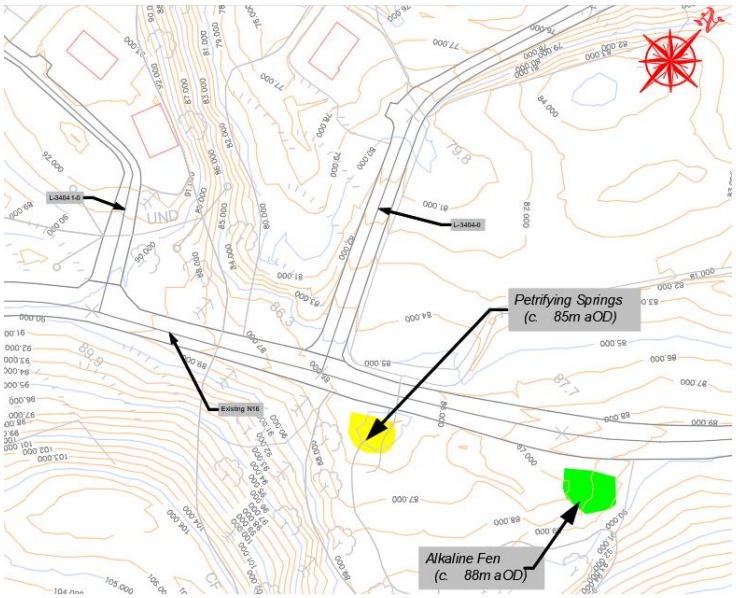


Figure 2-28: Crockauns/Keelogyboy Bogs NHA

Table 2-22: 'Environment – Biodiversity' MCA Score

Option	Score Index	Impact Level	Reason
JA 06 Opt A (VA 01 or 03)	4	Not Significant, or Neutral	No direct impact on Lugnagall Flush, or Crockauns/Kellyogyboy Bogs Biodiversity Sites. VA is circa 2.2m – 4m at the Cut Section. Based on observed ground water levels this is unlikely to impact on the ground water table.
JA 06 Opt B (VA 01 or 03)	4	Not Significant, or Neutral	No direct impact on Lugnagall Flush, or Crockauns/Kellyogyboy Bogs Biodiversity Sites. VA is circa 2.2m – 4m deep at the Cut Section. Based on observed ground water levels this is unlikely to impact on the ground water table.
JA 06 Opt C (VA 01 or 03)	4	Not Significant, or Neutral	No direct impact on Lugnagall Flush, or Crockauns/Kellyogyboy Bogs Biodiversity Sites. VA is circa 2.2m – 4m deep at the Cut Section. Based on observed ground water levels this is unlikely to impact on the ground water table.
JA 06 Opt D (VA 02)	2	Moderately Negative	No direct impact on Lugnagall Flush, or Crockauns/Kellyogyboy Bogs Biodiversity Sites. VA 02 is circa 5.5m deep at the Cut Section. Based on observed ground water levels, there is some potential for this option to impact upon the hydrogeological regime table.
JA 06 Opt E (VA 02)	2	Moderately Negative	No direct impact on Lugnagall Flush, or Crockauns/Kellyogyboy Bogs Biodiversity Sites. VA 02 is circa 5.5m deep at the Cut Section. Based on observed ground water levels, there is some potential for this option to impact upon the hydrogeological regime table.

2.2.6.2.2 *Results of Multi Criteria Analysis*

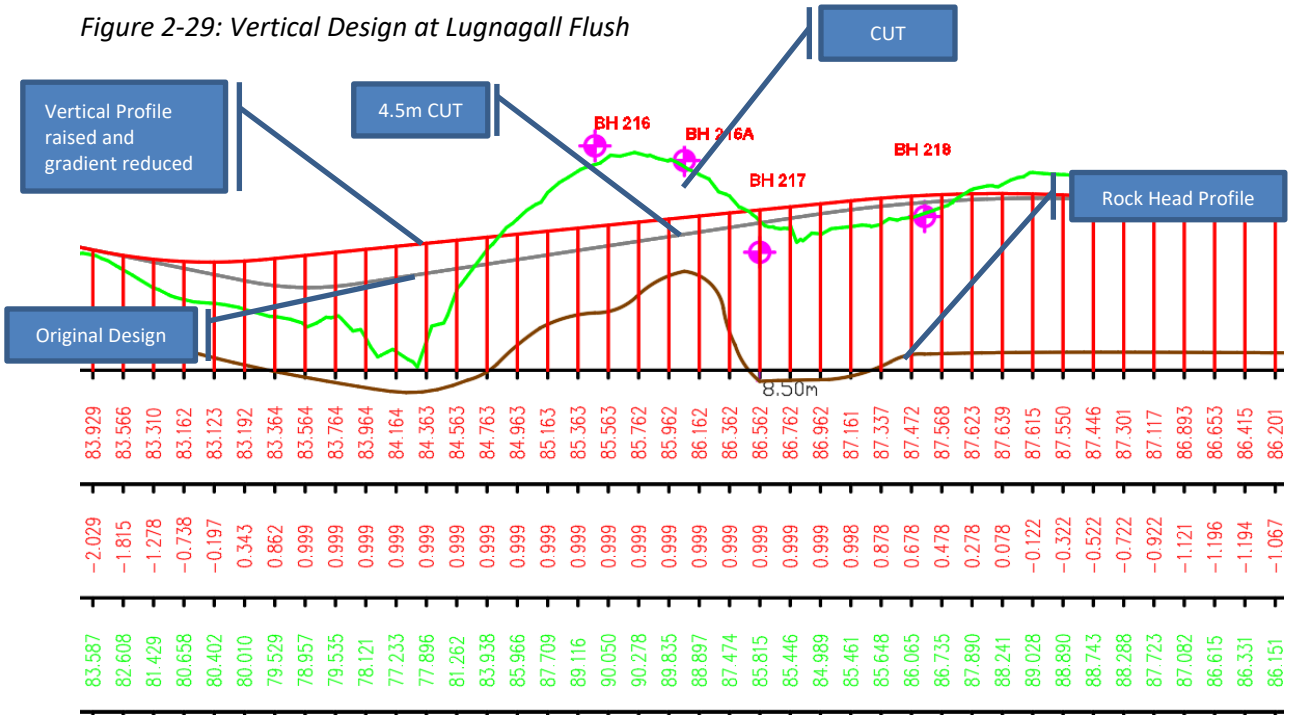
The results of the MCA are outlined in *Table 2-23*. This indicated a highest index score (12) for Option E. This option provides good Economic and Safety benefits, while also reducing Amenity Disturbance as far as is practically possible. However, following multi-disciplinary assessments, it was considered that it did pose a risk, in terms of the Hydro-geological regime to Lugnagall Flush. In this regard, following group workshops and design iterations, the Vertical Profile was raised at c. Ch. 2,080m in order to reduce the risk in terms of impacting upon the aforementioned regime.

This raising of the Vertical Profile has consequential effects in terms of the vertical gradients associated with the L3404-0[18]. In addition, the alternative arrangement for the L34041-0 as described in *Figure 2-24* will be incorporated into the design.

Table 2-23: Results of MCA

Element		Junction Assessment 06 (JA 06)				
		Opt A	Opt B	Opt C	Opt D	Opt E
Economy	Economy	**1**	**2**	**2**	**3**	**3**
Safety	Safety	**7**	**6**	**6**	**6**	**6**
Environment	Agri Property Impacts	2	3	3	3	3
	Non Agri Property Impacts	3	3	3	3	3
	Amenity Disturbance	3	3	3.5	3	4
	Biodiversity Impacts	4	4	4	2	2
	Sub Total Env.	**3**	**3.25**	**3.375**	**2.75**	**3**
Avergae MCA		**3.67**	**3.75**	**3.79**	**3.92**	**4.00**
Total MCA		**11.00**	**11.25**	**11.38**	**11.75**	**12.00**

Figure 2-29: Vertical Design at Lugnagall Flush



2.3 Vulnerable Road Users

The following outlines alternatives considered in relation to catering for Vulnerable Road Users, including by extension the Cycleway and Pedestrian Strategy.

2.3.1 General Principles and Arrangements

Section 3.17 of DN-GEO-03036 outlines the general principles in relation to the design of facilities for Cyclists and Pedestrians. As there is no existing infrastructure in proximity to the proposed road

[18] Vertical Gradient of 8.55% and dwell area gradient of 4.8% - Requiring a departure from Standards.

development which permits the consideration of a cycleway remote from the mainline, the application of design alternatives considered the latter two options described in Table 2-24.

Table 2-24: DN-GEO-03036, Section 3.17, Rural Areas Cycle and Pedestrian Facility Layouts

3.17 General Principles *Cycle/Pedestrian Facilities shall be provided as part of all Type 2 and Type 3 Single Carriageway and Type 2 and Type 3 Dual Carriageway national road schemes and shall be provided as follows:* ➢ *As a Cycleway remote from the road designed in accordance with DN-GEO-03047. This may include the use of suitable disused railways, canal tow paths or forest trails where appropriate.* ➢ *Within the maintenance strip or verge of the national road in accordance with the design details outlined in this document.* ➢ *Using a suitable existing alternative route incorporating appropriate signage. This option shall require a Departure from Standards which shall outline the justification for the use of this option.* *…*

The availability of feasible existing alternative routes was first considered, with the severed sections of the exiting N16 (due to the low volume of AADT) firstly being considered.

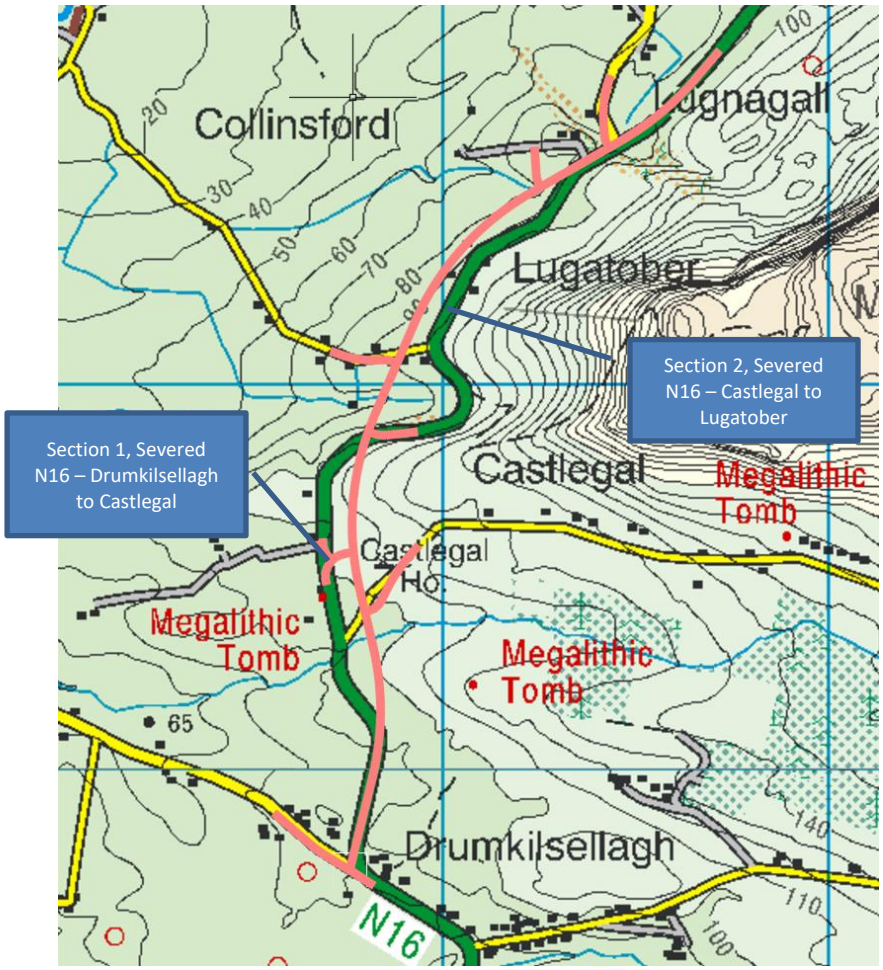
Figure 2-30 provides an overview of the two respective severed sections which include:

(1) Severed N16 – *Drumkilsellagh* to *Castlegal;* and

(2) Severed N16 – *Castlegal* to *Lugatober*.

In order to achieve continuity, the connecting use of both options would require a crossing point of the mainline carriageway at the townland boundary of *Castlegal/Lugatober*.

Figure 2-30: Examination of Suitable Existing Alternative Routes (Severed N16)

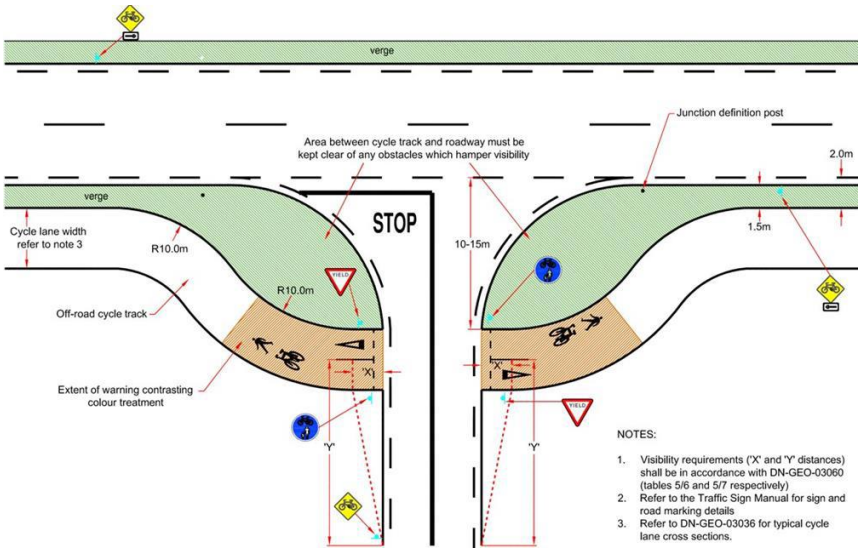


The assessment which examined Horizontal and Vertical Geometry concluded that Section (1) was appropriate for use as an alternative route. Section (2) was not considered appropriate due to the difficulties in achieving a desirable gradient on the northern most tie in point to the proposed new N16 (the Tie-In gradient would be in the order of 14%).

In this regard, it was proposed that a dedicated online two way cycle facility be integrated with an offline facility between Drumkilsellagh and Castlegal, which will incorporate appropriate lining and signage. The connection point between the offline and online sections will be separated via a Staggered Approach Barrier in accordance with Figure 7.5 of TII DN-GEO-03047.

Conflict points with the local network and direct accesses are considered, due to the low volume of traffic concerned, to be low risk, and as such are designed as uncontrolled crossings in accordance with the requirements of DN-GEO-03060 and are in this regard designed as bend out crossings in accordance with section 5.4.1 of the aforementioned standard and as outlined in Figure 2-31.

Figure 2-31: Extract from DN-GEO-03060, Figure 5.7, Bend out Crossing

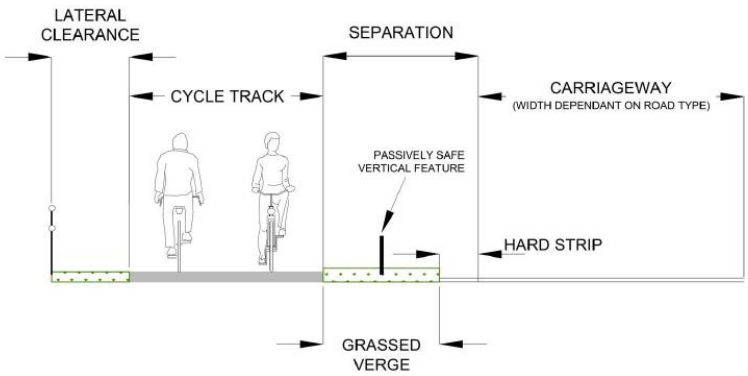


The mainline Cycleway will terminate at the proposed N16's junction with the L3404-0, until such time as the remainder of the N16 Sligo to county Boundary Emerging Preferred Route is upgraded.

Table 2-25: Cycle Track Geometry

Element	Width (m)	Notes
Separation	2m (including 0.5m Hard Strip)	N/A
Cycle Track	2m	Shared use Two Way cycle facility with pedestrians Low Volume Route[19], One Step below Des Min. Record as a Relaxation.
	3m	Mainline Chainage 100m to 370m – Extra 'wobble room' is provided considering the vertical gradient is c. 4.5%
Lateral Clearance	1m	N/A
Total Verge Width Required	4.5m	N/A

Figure 2-32: DN-GEO-03036: Ref. Figure 3.3: Off-Road Two-Way Cycle Track



[19] Low Volume is defined in Section 3.17.2 of DN-GEO-03060 as below 1500 users per day. This cycle way will likely cater for less than 10% of this value.

Safety Barriers where required (in accordance with DN-REQ-03034) will be positioned between the carriageway and the cycle track. The minimum distance between the cycle track and the safety barrier shall be equal to the working width of the safety barrier and comply with the minimum lateral clearance requirements outlined earlier. In addition, any exposed safety barrier posts facing the cycle track will be of a type that would not snag cyclists.

In accordance with Section 3.4 of DN-GEO-03060 road markings and signs will be adequately provided at the entry and at suitable distances along the cycle route. Yield signs and road markings will be provided to indicate vehicle priority at junctions.

2.3.2 Grade Separation (Vulnerable Road Users)

In accordance with the National Cycle Manual which was published by the National Transport Authority in June 2011, the five needs of a cyclist (and by extension other Vulnerable Road Users) are:

1. Road Safety;
2. Coherence;
3. Directness;
4. Attractiveness;
5. Comfort

In order to help achieve these needs, the design was appraised with a focus on reducing the number of conflicts which arise, in relation to cycleway design, where:

> *… different modes of transport share the same space. Junctions by their nature are particularly susceptible to conflict. The relative speed, direction and mass of cyclists, pedestrians or vehicles will determine the severity of the outcome of an actual conflict. Awareness of potential conflict and addressing it through a legible design is fundamental in providing cycling facilities. Through legible design, all conflicts will then be obvious to all road users in advance, and the resolution of each conflict will be mutually understood by all road users.*

The optimal manner to achieve this was considered to be one which as far as is reasonably practicable separated vulnerable road users from conflicts with road traffic. In this regard, an appraisal of potential options for grade separation took place in order to achieve a 2.7m high subway for vulnerable road users in accordance with DN-GEO-03040, Subways for Pedestrians and Pedal Cyclists Layout and Dimensions**.** This is considered below in terms of 'North to South' strategic connectivity and 'Local' connectivity.

2.3.2.1 North to South strategic connectivity

Vulnerable Road Users who which to travel from the south of the project to the north (e.g. Glencar), or vice versa, will not, other than at the southern Tie-In point, be required to conflict with national traffic. Conflict points with the local network and direct accesses are considered, due to the low volume of traffic concerned to be low risk and as such are designed as uncontrolled crossings in accordance with the requirements of DN-GEO-03047, Rural Cycleway Design (Offline).

2.3.2.2 Local connectivity

Local connectivity for Vulnerable Road Users presents conflict points with national traffic where the local road network interacts with the proposed new alignment. Two Locations as outlined in Figure 2-33 were examined (Table 2-26) in order to establish if the vertical design could facilitate (or be designed to facilitate) the provision of a subway. As outlined in Table 2-26, this resulted in the provision of an subway underpass where the proposed route intercepts the L7413-0.

Figure 2-33: Vulnerable Road Users – Potential Crossing Points

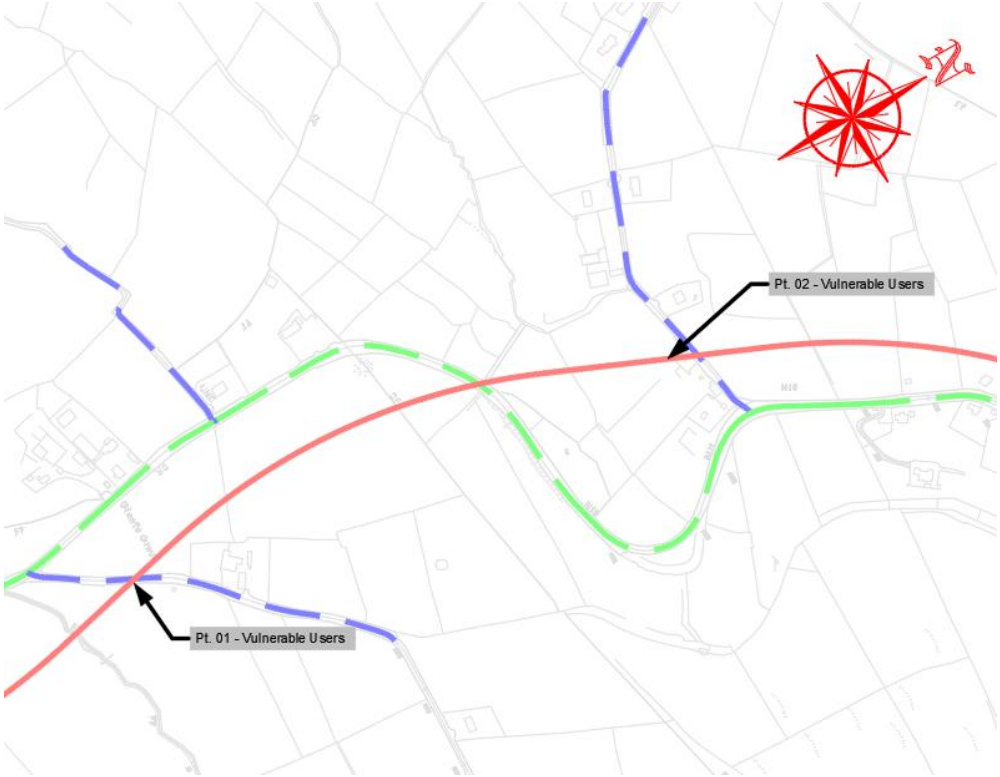
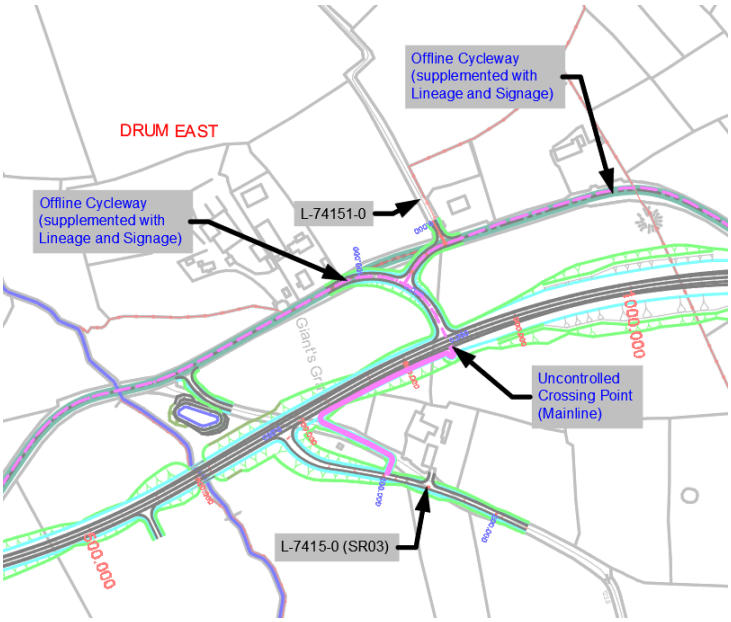


Table 2-26: Grade Separation (Vulnerable Road Users)

Location	Assessment
Point 01	The vertical clearance in the alignment is not sufficient to allow the provision of a vulnerable road users underpass. Considering vertical gradient requirements of the mainline and the phasing requirements of the vertical/horizontal curves, it is not viable to increase the embankment height (using Desirable Minimum vertical curves) sufficiently enough to achieve adequate clearance.
Point 02	The vertical clearance in the alignment is sufficient to allow the provision of a vulnerable road users underpass.

As a consequence of the foregoing, the only conflict point remaining with National Traffic, was that for users on the L7415-0 who which to travel to the south or north. In order to reduce complexity and simplify the crossing requirements, it is proposed as outlined in Figure 2-34 to relocate those users to the north, where they can gain access, via an uncontrolled pedestrian crossing, to the severed N16 as described in section 2.3.1 between Drumkilsellagh and Castlegal.

Figure 2-34: Vulnerable Road Users – Uncontrolled Pedestrian Crossing for the L-7415-0



3 Appendix 4.1: Chapter 4 (Main Report) Drainage – Technical Details

3.1 Design Methodology, Capacity Checks and Analytical Factors

The following section of this report presents the design methodology, capacity checks and analytical factors associated with the drainage design as presented in section 4.4 of the EIAR (Volume 1 – Main Report).

3.1.1 Design methodology & checks (associated with section 4.4.1 of the EIAR)

The Design Methodology & Checks are described in the following sections under the two Criteria Described above.

3.1.1.1 Criterion 1 (See section 4.4.1 of the EIAR Main Report) - The interception and diversion of existing land drainage

The following section of this report considers the following factors relevant to Criterion 1:

- Analytical factors;
- Watercourse capacity checks.

3.1.1.1.1 *Analytical Factors*

The following is a brief outline of the main analytical factors associated with the drainage design which have been applied in establishing Greenfield runoff flood flows. Site specific complexities arise as outlined below in using recommended TII calculations for catchment areas less than 0.4km^2. In this regard, two alternative approaches have been used in these instances for:

(1) Capacity checks of existing and new watercourses; and

(2) Sizing of proposed culverts.

Greenfield Runoff Flood Flows

Empirical Calculations

The TII standard, DN-DNG-03064[20] (*Drainage of Runoff from Natural Catchments*) provides guidance in relation to limiting the frequency and severity of flooding caused by runoff from beyond the road boundary. It outlines the following empirical methods for the estimation of the mean annual flood flows:

- ADAS (the Agricultural Development and Advisory Service) method for catchments areas <0.4km^2. It assumes a 75-year return period, which is then converted to a 100-year return period;
- IH 124 (Centre for Ecology and Hydrology) method for catchments areas >0.4km^2 but <25km^2.

The design of the *Proposed Road Development* considered these foregoing approaches, but also considered guidance provided by the specialist conducting the Hydrological & Hydrogeological impact assessment aspect of the EIAR.

[20] http://www.tiipublications.ie/

Following an appraisal of the TII recommended approaches, the IH124 formulae was considered appropriate for catchments equal to, or greater than 0.4km^2. However, it was established for the following reason, that the ADAS method proposed in DN-DNG-03064[20] was not appropriate for the specific site characteristics of the *Proposed Road Development:*

- The formulae is based upon the Bilham (1962) rainfall intensity, which relates the time of concentration to the selected return period. The factors used in this formulae present what is considered to be a very conservative approach (presenting unexpectedly quite high runoff volumes) for current climatic and specific site conditions, which includes a topography which is of a mountainous nature. This was confirmed by comparing results of this equation against results of the IH124 formulae for a 0.4km^2 catchment.

The following section describes the site specific modified approach for catchments less than 0.4km^2. The IH124 method is then presented in the subsequent section dealing with catchments greater than 0.4km^2.

Catchments less than 0.4km^2

(1) The ADAS formulae described above for catchment areas less than 0.4km^2 was corrected for site specific requirements through the use of a modified formulae which is described below and which substitutes the Bilham prediction for rainfall intensity with site specific rainfall intensities derived from Met Éireann DDF data published on the FSU Portal (http://opw.hydronet.com)[21].
The ADAS equation described above has been derived from '*Report No. 05, 1980, Pipe Size Design for Field Drainage'*.

The design flow (m^3/ s) is determined from the following equation:

Equation 3-1: ADAS Method

$$Q_C = 2.78\ F_A\ A\ (RB/T)$$

Table 3-1: Variables associated with Equation 3-1

Q_C is flow in l/sec
F_A is the annual rainfall factor (dimensionless):
$F_A = 0.00127\ R_A - 0.321$
R_A is the average annual rainfall (SAAR) (mm)
R_B is the design storm rainfall (mm)
T is the time of concentration (hr.)
$T = 6.09\ (L_C)^{0.39}$
$L_C = 0.0001\ (L^2/Z)$
L = Catchment Length (m)
Z = Height of watershed above outfall (m).
The constant 2.78 takes account of the differing dimensions of the variables.

This approach was considered appropriate in determining the requirements for soft infrastructure, i.e. the sizing of new watercourse/land drainage requirements and the checking of capacities on existing watercourses.

[21] In accordance with the findings of FSU (1975), a 1 in 140 year return period is used to generate a 1 in 100 year fluvial flood event.

(2) There are two streams (Lugatober and Collinsford streams) and one open drain (Lugatober 2) crossed by the *Proposed Road Development*. Similar to the above, the sizing requirements for the culverts (hard infrastructure) examined the existing site conditions including runoff potential and topography, and the existing culverts already in place to accommodate these watercourses. It was considered following a number of iterations that the most appropriate design flows for these catchments would be the mean value of the modified ADAS formulae described above and the IH124 method which is described below.

Catchments greater than 0.4km^2

The IH 124 method was developed by The Centre for Ecology and Hydrology formerly the UK Institute of Hydrology. It is especially for use in small catchments <25 km2 from the 'Modified Catchment Characteristics Equation' (MCCE) used in the Flood Studies Report (FSR). The MCCE gives an estimate of the mean annual flood for a rural catchment QBAR, where:

Equation 3-2: IH124 Method

$$Q_a = 0.00108\ AREA^{0.89}\ SAAR^{1.17}\ SOIL^{2.17}$$

Table 3-2: Variables associated with Equation 3-2

AREA = Catchment Area (km^2)
SAAR = Average Annual Rainfall (mm), adopted as 1182mm
SOIL = FSR Standard percentage runoff parameter, dependent on five soils parameters

Mean annual flood (m^3/ s) calculated as described above can be converted to mean annual flood flows for other return periods by applying a factor (Qt) in accordance with the FSR. A growth factor of 0.87 is applied for a 1 in 100, 1.64 is applied for a 1 in 30 year return period, 1.77 for a 1 in 50 year return period and 1.96 is applied for a 1 in 100 year return period.

Standard Average Annual Rainfall

The rainfall increases with altitude west, to east, with typical annual average rainfall amounts of 1,200mm to 1,300mm along the coastline area, increasing to 1,300mm to 1500mm in the vicinity of the existing N16, and reaching levels of 1,800mm to 1,900mm towards the summit of Copes Mountain and the townland of *Crockaun's*.

The various catchment (See Figure 4.7 contained within Volume 3 for catchment areas) average annual rainfalls are outlined below in Table 3-3.

Table 3-3: Catchment Average Annual Rainfalls

WC Ref	Chainage (m)	Area (km^2)	Annual Rainfall SAAR (mm)
SC02	605m	1.53	1465
SC03	1,295m	0.214	1560
SC04	1,500m	0.071	1560
SC05	1,935m	0.166	1570
SC06	2,105m	0.229	1570

Winter Rainfall Acceptance Potential

The Winter Rainfall Acceptance Potential (WRAP) for the catchments described in Table 3-3, as recommended by the Hydrological & Hydrogeological assessment undertaken in the Environmental Impact Assessment Report, is SOIL Index 5 representing the classifications of 'Very Low' WRAP, or, conversely very high runoff classifications (See Table 3-4). The WRAP Soil Index score is based on the depth to an impermeable horizon, permeability class of the soil, and the topographical slope and has five index classes 1 to 5 representing very high, high, moderate, low and very low WRAPS.

Table 3-4: Runoff potential and soil classes

General soil description	General soil description	General soil description
Well drained sandy, loamy or earthy peat soils Less permeable loamy soils over clayey soils on plateaux adjacent to very permeable soils in valleys	Very low	S1
Very permeable soils (e.g. gravel, sand) with shallow groundwater Permeable soils over rocks Moderately permeable soils some with slowly permeable subsoils	Low	S2
Very fine sands, silts and sedimentary clays Permeable soils (e.g. gravel, sand) with shallow groundwater in low lying areas Mixed areas of permeable and impermeable soils in similar proportions	Moderate	S3
Clayey or loamy soils	High	S4
Soils of the wet uplands: Bare rocks or cliffs Shallow, permeable rocky soils on steep slopes Peats with impermeable layers at shallow depth	Very High	S5

Climate Change

The most common effect associated with climate change is that it will adversely impact both the frequency and severity of flooding. Generally, climate change theory suggests the occurrence of milder and wetter winters (with more intense rainfall events) while summers may become hotter and drier. Consequently, it will also lead to increased evaporation, decreased recharge and lower groundwater tables; all resulting in a decline of the reliable yield from water resource zones.

The design makes allowance for an increase of rainfall intensities of circa 20% for the network drainage.

Flood Flows

Based on the empirical methods described above, the mean annual flood has been calculated and factored up to the 50 year and 100 year return periods as outlined in the proceeding tables.

Table 3-5: Surface Water Catchment – Greenfield Runoff Calculations, IH124 Calculations

Surface Water Catchment (SC)	Outfall	Description	Total (Ha)	Area (Km^2)	Q (m^3/sec) (75 year Return) +20% CC ADAS	Q (m^3/sec) (1 year Return)	Factorial Safety Error & 20% CC IH124	Q (m^3/sec) (100 year Return)	Q (m^3/sec) (50 year Return)
						Q (m3/sec)	Q (m3/sec) FSR		
SC01	N/A	Willowbrook	1020	10.20	35.41	9.589	18.987	37.214	33.606
SC02	Culvert 01	Tully Stream	153	1.53	6.55	1.773	3.510	6.879	6.212
SC06 & 07	Culvert 05	Lugnagall	40	0.40	2.136	0.579	1.145	2.245	2.027

Table 3-6: Surface Water Catchment – Greenfield Runoff Calculations, ADAS Calculations

Surface Water Catchment (SC)	Outfall	Description	Total (km2)	Lc (m)	T (Hrs)	Area (Ha)	Storm Met Eireann (FSU)		Flood Flow (m3/sec)		Design Flow (m3/sec)	Design Rate (m3/ha)
							140yr	2yr	Q2	Q100	Q100+CC	
SC03	Culvert 02	Lugatober 1	0.214	0.233	3.449	21.4	53.2	20.3	0.718	1.881	2.257	0.105
SC04	Culvert 03	Lugatober 2	0.071	0.367	4.120	7.1	56.1	21.6	0.212	0.551	0.661	0.093
SC05	Culvert 04	Collinsford	0.166	0.111	2.587	16.6	48.2	18	0.658	1.763	2.115	0.127

Watercourse Capacity Checks

Manning's Equation

Manning's equation as outlined below, was used to calculate the existing capacity of streams intercepted by the *Proposed Road Development*. Using the equations provided in the foregoing section, the characteristics of each stream were then compared against the calculated 1 in 75 years Return Period Flow (a flood storm) and are presented accordingly in *Table 3-8*.

Equation 3-3: Flowrate in a trapezoidal channel using the Manning's Equation

$$Q = \frac{A\, S^{\frac{1}{2}} R^{\frac{2}{3}}}{n}$$

Table 3-7: Variables associated with Equation 3-3

Q is the flow rate (m^3/s)
S is the longitudinal gradient of the ditch (m/m)
A is the cross-sectional area of the flow (m^2);
R is the Hydraulic Radius; and
n is the Manning roughness coefficient - values of Manning's n are given in Appendix C;

Table 3-8: Existing and required outfall capacities

Watercourse	Chainage Location (m)	Existing estimated Capacity Q (m3/sec)	1 in 75 year Return Period Flow Q (m3/sec)	Capacity breach in the 1 in 75 year return period	Notes
Willowborough Stream	N/A	25.99	35.41	Yes	The *Proposed Road Development*, by its nature will not change the flow regime to this watercourse.
Tully Stream	600m	38.92	6.55	No	N/A
Lugatober Stream	1230m	4.36	2.758	No	N/A
Lugatober (2)	1,500m	4.44	0.807	No	N/A
Collinsford Stream	1925m	7.81	2.643	No	N/A
Lugnagall Stream	2210m	3.45	2.136	No	N/A

In a similar manner to the foregoing, all design interception ditches and all minor drainage ditches intercepted by the *Proposed Road Development* have been subjected to a similar design check. All these new open drains as depicted in Figures 4.7.1 and 4.7.2 contained within volume 3 achieve adequate capacity to accommodate the predicted flood flows.

3.1.1.2 Criterion 2 (See Section 4.4.1) – Road surface drainage – Surface water conveyance & site control

The following section of this report describes the analytical factors associated with Criterion 2 (Road Surface Drainage).

3.1.1.2.1 *Analytical Factors*

Extreme Rainfall Return Periods

For the purposes of design, 'Extreme Rainfall Return Periods', were provided by Met Éireann for the study area encompassing the limits of the *Proposed Road Development*.

Table 3-9: Met Éireann – Return Period Rainfall Depths for Sliding Durations

Met Eireann
Return Period Rainfall Depths for sliding Durations
Irish Grid: Easting: 172197, Northing: 341382,

	Interval		Years											
DURATION	6months,	1year,	2,	3,	4,	5,	10,	20,	30,	50,	75,	100,	150,	200,	250,	500,
5 mins	2.7,	3.7,	4.3,	5.1,	5.6,	6.0,	7.3,	8.8,	9.7,	11.0,	12.2,	13.1,	14.5,	15.5,	16.4,	N/A ,
10 mins	3.8,	5.2,	5.9,	7.0,	7.8,	8.3,	10.2,	12.2,	13.5,	15.4,	17.0,	18.3,	20.2,	21.7,	22.9,	N/A ,
15 mins	4.5,	6.1,	7.0,	8.3,	9.2,	9.8,	12.0,	14.4,	15.9,	18.1,	20.0,	21.5,	23.7,	25.5,	26.9,	N/A ,
30 mins	5.9,	8.0,	9.1,	10.7,	11.7,	12.6,	15.2,	18.1,	19.9,	22.5,	24.8,	26.6,	29.2,	31.3,	33.0,	N/A ,
1 hours	7.8,	10.4,	11.8,	13.7,	15.0,	16.0,	19.2,	22.7,	25.0,	28.1,	30.8,	32.9,	36.0,	38.4,	40.4,	N/A ,
2 hours	10.3,	13.6,	15.3,	17.7,	19.3,	20.5,	24.4,	28.6,	31.3,	35.0,	38.2,	40.6,	44.3,	47.1,	49.4,	N/A ,
3 hours	12.2,	15.9,	17.8,	20.5,	22.3,	23.7,	28.0,	32.7,	35.7,	39.8,	43.3,	46.0,	50.0,	53.1,	55.6,	N/A ,
4 hours	13.7,	17.7,	19.8,	22.8,	24.7,	26.2,	30.9,	35.9,	39.2,	43.5,	47.3,	50.2,	54.5,	57.8,	60.5,	N/A ,
6 hours	16.1,	20.7,	23.0,	26.4,	28.6,	30.3,	35.5,	41.1,	44.7,	49.5,	53.7,	56.8,	61.6,	65.2,	68.1,	N/A ,
9 hours	18.9,	24.2,	26.8,	30.6,	33.1,	34.9,	40.8,	47.0,	50.9,	56.3,	60.9,	64.4,	69.6,	73.5,	76.7,	N/A ,
12 hours	21.3,	27.0,	29.9,	34.0,	36.7,	38.7,	45.0,	51.7,	55.9,	61.7,	66.6,	70.3,	75.8,	80.0,	83.4,	N/A ,
18 hours	25.0,	31.5,	34.8,	39.4,	42.4,	44.7,	51.7,	59.1,	63.8,	70.1,	75.5,	79.6,	85.6,	90.2,	93.9,	N/A ,
24 hours	28.1,	35.2,	38.8,	43.8,	47.0,	49.5,	57.0,	65.0,	70.0,	76.8,	82.6,	86.9,	93.4,	98.2,	102.2,	115.5,
2 days	36.7,	44.9,	49.0,	54.6,	58.2,	60.9,	69.2,	77.9,	83.3,	90.4,	96.5,	101.1,	107.8,	112.8,	116.9,	130.4,
3 days	44.0,	53.2,	57.7,	63.9,	67.8,	70.7,	79.7,	88.9,	94.7,	102.3,	108.7,	113.4,	120.4,	125.7,	129.9,	143.9,
4 days	50.8,	60.8,	65.6,	72.2,	76.4,	79.6,	89.1,	98.9,	104.9,	112.9,	119.6,	124.6,	131.9,	137.3,	141.7,	156.2,
6 days	63.1,	74.5,	79.9,	87.4,	92.1,	95.6,	106.1,	116.9,	123.5,	132.1,	139.3,	144.7,	152.5,	158.3,	163.0,	178.3,
8 days	74.5,	87.1,	93.1,	101.3,	106.4,	110.2,	121.6,	133.2,	140.2,	149.5,	157.2,	162.8,	171.1,	177.3,	182.2,	198.3,
10 days	85.3,	99.0,	105.5,	114.3,	119.8,	123.9,	136.1,	148.4,	155.9,	165.6,	173.7,	179.7,	188.4,	194.9,	200.0,	216.8,
12 days	95.7,	110.5,	117.4,	126.8,	132.6,	136.9,	149.9,	162.8,	170.7,	180.9,	189.4,	195.7,	204.8,	211.5,	216.8,	234.2,
16 days	115.8,	132.4,	140.1,	150.5,	157.0,	161.7,	175.9,	190.1,	198.6,	209.7,	218.9,	225.6,	235.4,	242.6,	248.3,	266.8,
20 days	135.2,	153.4,	161.8,	173.1,	180.1,	185.3,	200.6,	215.8,	225.0,	236.8,	246.6,	253.7,	264.1,	271.7,	277.7,	297.3,
25 days	158.7,	178.8,	188.0,	200.4,	208.0,	213.6,	230.2,	246.6,	256.4,	269.1,	279.5,	287.1,	298.1,	306.2,	312.5,	333.2,

NOTES:
N/A Data not available
These values are derived from a Depth Duration Frequency (DDF) Model
For details refer to:
'Fitzgerald D. L. (2007), Estimates of Point Rainfall Frequencies, Technical Note No. 61, Met Eireann, Dublin',
Available for download at www.met.ie/climate/dataproducts/Estimation-of-Point-Rainfall-Frequencies_TN61.pdf

Climate Change

In a similar manner to that already outlined; a climate change factor of 20% has been incorporated into the hydrological calculations.

Road Runoff

Road runoff has been calculated, using the Rational Method and extreme rainfall data tables for various storm return periods.

Equation 3-4: Rational Method

$$Q = C \times I \times A$$

Table 3-10: Variables associated with Equation 3-4

Q = the peak discharge;
C= Coefficient of permeability taken as 0.95 for an asphaltic surface;
i = rainfall intensity;
A = catchment area, calculated from contour mapping of the preliminary design road surface.

Where groundwater is encountered in cut sections, road runoff will be kept separate from sub-surface flows being carried in narrow filter drains.

Flood Storage

Flood Storage is provided in accordance with TII –DNG-03022 (for the reasons outlined in Table 3-11), in order to provide controls for the 1 in 100 year storm, providing a peak discharge rate equivalent to the existing Greenfield Runoff Rate (based on QBAR - denoting the Mean Annual Flood flow rate).

Table 3-11: Extract from DN-DNG-03066, Design of Earthworks, Drainage, Network Drainage, Attenuation and Pollution Control

5.8 Runoff from paved areas is effectively instantaneous when compared to greenfield runoff. If allowed to flow unrestricted, it will discharge into receiving waters at orders of magnitude greater than the undeveloped site. This can lead to flooding and flashy runoff from the catchment that could cause scour and erosion. It can also lower groundwater recharge.
5.9 The development or alteration of greenfield and brownfield sites may lead to flooding and channel erosion downstream of the development. The reduction in infiltration to soil can lead to low base flows in watercourses and reduce aquifer recharge and also damage habitats.
5.10 In general for small rainfall events, there is no measurable runoff taking place from greenfield areas into receiving watercourses. In contrast, runoff from road schemes takes place for the majority of rainfall events. Runoff from larger rainfall events can cause a large increase in the total volume of runoff.
5.11 In order to try to replicate the natural response of an undeveloped catchment, runoff rates from the site are restricted to closely match those of the pre-developed site. In doing so, attenuation storage is required to store the volumes of water occurring during storm events. The principle is that runoff for events of equivalent frequency of occurrence to the same peak rate of runoff that would have occurred pre - development. This is generally the greenfield rate (or other agreed rate in the case of brownfield sites). This slows down the response time to storm events and reduces the peak runoff rate. It does not greatly reduce the increase in runoff volume caused by developments. Infiltration systems can work well in achieving runoff volume reduction.
5.12 The objective of storm water management is to mimic the natural greenfield runoff characteristics of the site. In the case of brownfield site, this may be estimated pre-development rate and agreed with the relevant statutory body.
5.13 Determining the required attenuation storage volume involves estimating the greenfield runoff rate or brownfield runoff rate for various return periods and the post development runoff at different return periods to determine the volume required to reduce the post development peak flow rate to peak greenfield runoff rate for the critical storm duration up to a 1 in 100 year return period.
5.14 NRA HD 33 outlines the design return period requirements for runoff rates and associated attenuation facilities. There should be no increased risk of flooding in the receiving watercourse due to construction of the road up to the 100 year return period.

Greenfield Runoff Rate and Storage Requirements

The permitted discharge rate is calculated using the IH 124 method, which has already been referred to in terms of detail within section 3.1.1.1.1. As each particular site is less than 50ha, CIRIA C697 recommends that the analysis should calculate the flow for 50ha but linearly scale the flow rate based on the ratio of the size of the development to 50ha. In accordance with the guidance set out in DN-DNG-03066, a standard factorial error has not been applied as a conservative approach is considered appropriate for discharge limits. This is because the consequences of estimating a higher discharge could lead to flooding.

The critical storm (based on the rainfall intensities which have been provided by Met Éireann), runoff rates and permitted discharge rates for each particular pond are outlined in the proceeding table.

Table 3-12: Critical Storm, Runoff Rates and Permitted Discharge Rates

Duration	Rainfall (100 Yr)	Pond 1: Doonally			Pond 2: Castlegal			Pond 3: Collinsford			Pond 4: Lugnagall		
		Discharge	6.9	l/s	Discharge	4.5	l/s	Discharge	20.4	l/s	Discharge	2.6	l/s
hrs	mm	V in	V out	Storage	V in	V out	Storage	V in	V out	Storage	V in	V out	Storage
		m3	m3	m3	m3	m3	m3	m3	m3	m3	m3	m3	m3
0.5	26.6	141	12	128	90	8	82	386	37	349	48	5	43
1	32.9	174	25	149	112	16	96	477	74	403	59	9	50
2	40.6	215	50	165	138	32	106	589	147	441	73	18	55
3	46	244	75	169	156	48	108	667	221	446	83	28	55
4	50.2	266	100	166	171	64	107	728	294	433	90	37	54
6	56.8	301	150	151	193	96	97	824	442	382	102	55	47
9	64.4	341	225	116	219	144	75	934	662	271	116	83	33
Qbar and Q100		SAAR	1465	mm	SAAR	1465	mm	SAAR	1560	mm	SAAR	1570	mm
		AREA	0.5	Ha	AREA	0.5	Ha	AREA	0.5	Ha	AREA	0.5	Ha
		SOIL	0.5	WRAP	SOIL	0.5	WRAP	SOIL	0.5	WRAP	SOIL	0.5	WRAP
		Qbar	13.10183	l/s per ha	Qbar	13.10183	l/s per ha	Qbar	14.10125	l/s per ha	Qbar	14.20707	l/s per ha
		Q100	25.67959	l/s per ha	Q100	25.67959	l/s per ha	Q100	27.63846	l/s per ha	Q100	27.84586	l/s per ha

Table 3-13: Storage Calculations (with 20% for Climate Change)

Ref	Location	Storage (m3)
Pond 1	Doonally	203
Pond 2	Castlegal	130
Pond 3	Collinsford	535
Pond 4	Lugnagall	66

Water Quality Treatment

Provision will be made in the attenuation pond design to minimise the risk for pollution from surface water emanating from the road surface. This shall be in the form a permanent pool located in each of the attenuation ponds. The design of these features is based on the guidance set out in TII DNG-DN03066 which recommends the CIRIA C697 empirical approach to calculate treatment volumes as outlined in *Equation 3-5* and *Table 3-14*.

Equation 3-5: CIRIA C697, Empirical Method to calculate treatment volumes.

$$V_t = 9D[\frac{SOIL}{2} + \left(1 - \frac{SOIL}{2}\right)I]$$

Table 3-14: Variables associated with Equation 3-4

where:

Vt = Water quality treatment volume (as a function of the total development area)

SOIL = Soil classification (from Flood Studies Report or Wallingford Procedure WRAP map)

I= Fraction of the area which is impervious

D = M5-60 minute rainfall depth

The site specific variables are presented in *Table 3-15* while *Table 3-16* outlines the results equated with each particular pond.

Table 3-15: Site specific variables

Criteria	Factor	Notes
D	16	Based on M5-60 minute rainfall depth
Soil	0.5	Soil Classification
I	1	Fraction of Area which is impervious
Vt (m3)	144	Water Quality Treatment Volume

Table 3-16: Calculation of Treatment Volumes and Discharge Rates

Criteria	Pond 1	Pond 2	Pond 3	Pond 4
	Doonally	Castlegal	Collinsford	Lugnagall
Catchment Area (Ha) (Impervious Road Area)	0.53	0.34	1.45	0.18
Factor of Safety	2	2	2	2

Criteria	Pond 1	Pond 2	Pond 3	Pond 4
	Doonally	Castlegal	Collinsford	Lugnagall
Treatment Volume (m3)	153	98	418	52
Discharge Rate (l/s)	6.94	4.45	20.45	2.56

4 Appendix 4.2: Chapter 4 (Main Report Reference):

Outline Construction & Demolition Waste Management Plan

4.1 Introduction

4.1.1 General

Sligo County Council is currently planning a 2.54km upgrade of the N16 National Primary Route, between the townlands of *Drumkilsellagh* and *Lugnagall* and occurring predominately within the townland of *Lugatober*. The project location is depicted in *Figure 5-1*.

The project will remove a number of substantially deficient bends on this section of the route and in so doing, will improve aspects such as safety, sight distance, cross sectional width and drainage.

The road type proposed for the project corresponds to a Type 2 Single Carriageway arrangement as outlined in *Figure 5-1*. The design arrangement is described in detail within Chapter 4 of the EIAR.

Figure 4-1: Project Location

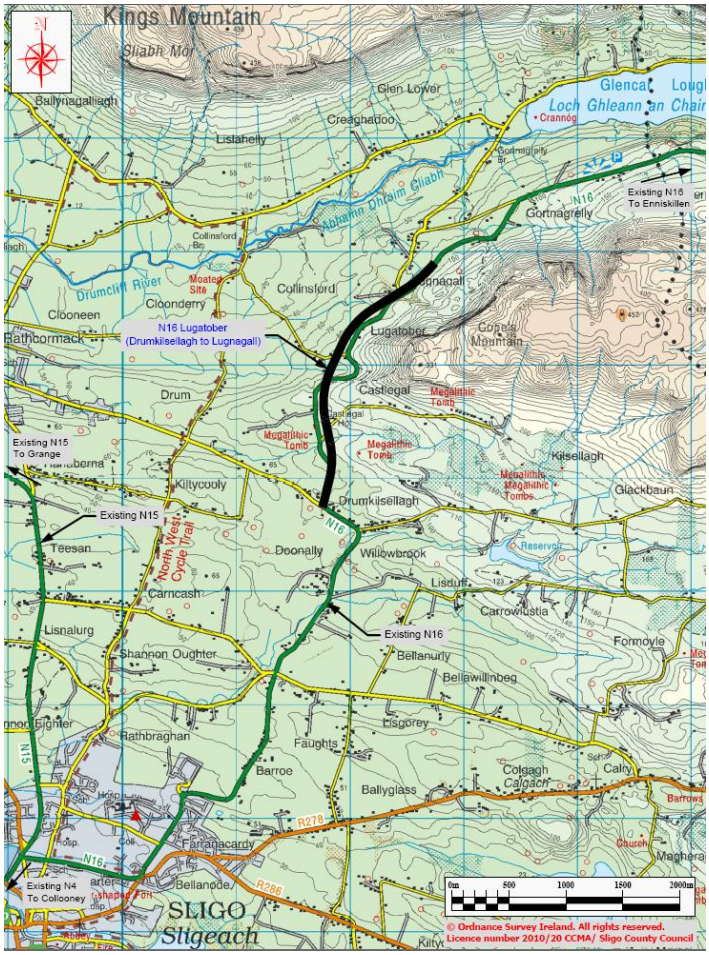
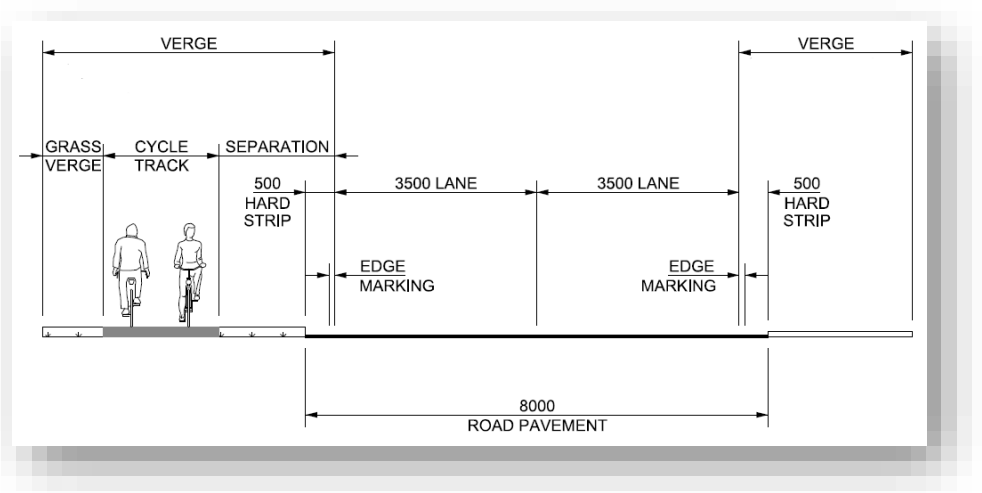


Figure 4-2: Type 2 Single Carriageway



This document has been drafted in order to initiate the Construction & Demolition Waste Management Plan for the N16 Lugatober Road Project. It is preliminary in nature as it has been prepared at a stage when exact quantities and volumes of waste material cannot be determined. In the event of waste being produced, it will ultimately be the responsibility of the appointed contractor in accordance with the contract documents to:

- Identify methods for dealing with the Waste;
- Comply with all necessary planning, environmental and waste legislation;
- Apply for and obtain all necessary approvals, consents and licences in accordance with *inter-alia* the provisions of the Waste Management Acts (as amended) and Regulations (as amended) and also with regard to the *TII Guidelines for the Management of Waste from National Road Construction Projects (2014)*.

Having regard to the above; the Outline Construction and Demolition Plan will be a **Live** document and will be developed to form the Project Construction and Demolition (C&D) Waste Management Plan which will be incorporated into the Environmental Operating Plan. The obligation to develop, maintain and operate a more detailed Construction and Demolition Waste Management Plan will form part of the contract documents for the project.

This document has been prepared with reference to the following guidance documents:

- *Best Practice Guidelines on the Preparation of Waste Management Plans for Construction and Demolition projects,* (DoEHLG);
- *Guidelines for the Management of Waste from National Road Construction Projects,* (TII);

Due to the stage of the design, quantities and volumes of materials are generally not presented in this report. The report will be updated to reflect such quantities once they have been established (Version No. 2 of this **Live** Document).

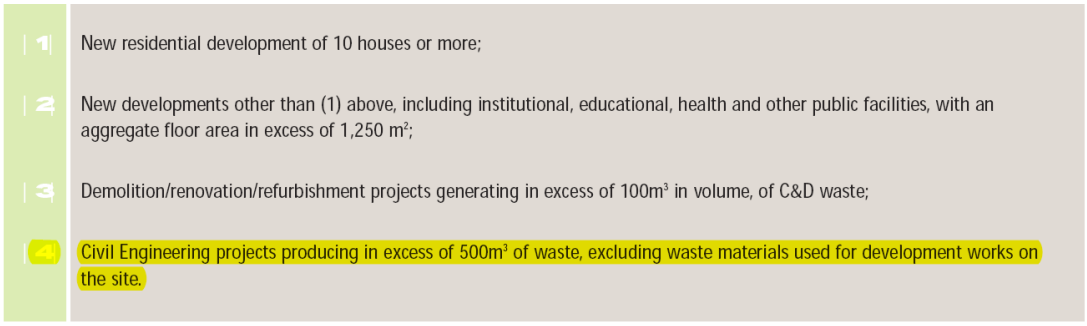
At contract award stage, a Waste Management Co-ordinator (WMC) will be appointed by the contractor who will be responsible for the management of wastes during the course of the project.

The waste material considered within this Outline (or Preliminary) C&D Plan covers the waste generated by the project, this can be defined as the material generated which does not satisfy the exclusions set out in the Directive on Waste (elaborated upon in section 4.2.1 of this report).

4.1.2 Requirement for plan

A Construction & Demolition Waste Management Plan is required as there may be potential for the project to exceed the thresholds set out in the DoEHLG publication *'Best Practice Guidelines on the Preparation of Waste Management Plans for Construction and Demolition Projects'*, which are set out below.

Figure 4-3: Thresholds for the preparation of a Construction and Demolition Waste Management Plan



The TII *Guidelines for the Management of Waste from National Road Construction Projects* recommends that the drafting and implementation of the C&D waste management begin early in the design process, thus the preparation of this document at the earliest stage of the route design process.

4.2 Waste Arising

4.2.1 Exclusion from the Legislation for Excavated Material Re-used at a Construction Site[22]

The Directive on Waste contains a number of exclusions which make clear that certain materials are not subject to its requirements. A key one affecting construction projects such as this one is set down in Article 2(1)(c). This states that the requirements of the EU legislation do not apply to:

> *uncontaminated soil and other naturally occurring material excavated in the course of construction activities where it is certain that the material will be used for the purposes of construction in its natural state on the site from which it was excavated*

This provision is repeated in the Waste Management Act, as Section 3(1)(c)[23]. Should materials generated by construction activities fall within this provision, they are not then subject to the other requirements of the EU or national waste legislation. This means that, for example, such materials are not defined as *'waste'*, do not need to be handled by duly authorised waste collectors and do not need to pass to disposal or recovery facilities that are subject to waste licences or other equivalent form of statutory authorisation. In addition, the requirements of the Waste Hierarchy (explained in the next section) do not generally apply, that is with the exception of prevention which is described below.

4.2.2 The Waste Hierarchy

Besides the requirements that the off-site handling of waste generated by this project are subject to the required statutory authorisations under the Waste Management Act, there is also a necessity that it conforms to the Waste Hierarchy. This is a requirement of Article 4 of the Directive on Waste, being transposed as Section 21A of the Waste Management Act[24]. As explained above, the Hierarchy only

[22] Based on an interpretation by Duncan Laurence Environmental.

[23] As amended by the European Communities (Waste Directive) Regulations 2011 (SI 126 of 2011)

[24] As amended by the European Communities (Waste Directive) Regulations 2011 (SI 126 of 2011)

applies to material that is defined as "waste". This means that it does not apply to the proportion of the soil that is handled on-site in conformity with the statutory exclusion discussed above.

The Waste Management Hierarchy will become activated for any material which does not satisfy the aforementioned exclusion; in this regard the construction contract documents for the project will clearly set out the staged approach which the contractor will be required to adhere to, through the use of the Hierarchy.

In order of priority, the hierarchy sets out the most desirable approaches to Waste Management as comprising:

(a) Prevention;
(b) Preparing for re-use;
(c) Recycling;
(d) Other recovery (including energy recovery); and
(e) Disposal;

The Waste Hierarchy is examined in more detail in section 4.4 of this report.

4.3 Waste Handling

4.3.1 **Outline**

Wastes should they be generated by the project will be managed in accordance with the Waste Management Legislation and the principles of the Waste Hierarchy.

4.3.2 **Waste Handling Procedures**

During the construction phase of the project, the appointed contractor will have responsibility for the development and management of appropriate waste handling procedures in accordance with the relevant legislation. In effect, this will mean identifying and segregating wastes encountered into their appropriate categories and designating Waste Storage Areas (WSA's) within the Projects land take for the storage of waste prior to transport for recovery/disposal at suitably licensed/permitted facilities.

Notwithstanding the foregoing, an overview of the expected methods to handle the expected waste elements is described in the following sections.

4.3.2.1 Excavated Geological Material

The excavation of waste geological material (material which does not satisfy the exclusion outlined in section 4.2.1), has been reduced to imperceptible quantities as a result of the design approach including the balancing of cut:fill materials and the provision of a Soil Repository/Borrow Pit in the townland of Castlegal. No organic geological materials are expected to be encountered during the construction of the Road Project.

Any marginal quantities of such material arising, will typically be loaded directly onto vehicles for reuse/recovery or disposal. Temporary stockpiling of this material is therefore not anticipated onsite.

4.3.2.2 Hazardous Wastes

There are no hazardous wastes expected to be encountered during the construction phase of the Project.

4.3.2.3 Waste Removal

Any removal of waste material shall be carried out in accordance with the legislation already quoted in the foregoing sections of this report. It shall undergo a comprehensive waste assessment and classification by a suitably qualified person, in accordance with the Waste Management Catalogue and shall be disposed of/treated in a suitably licensed facility.

4.4 The Hierarchy

4.4.1 Outline

The following sets out how the Waste Hierarchy will be applied during Phases 3, 4, 5 and 6 of the TII PMG.

4.4.2 Waste Prevention

Waste prevention is the first tier of the Waste Management Hierarchy and the most effective as it ensures that the waste is not created in the first instance.

As outlined in Chapter 10 (Soils and Geology) of this EIAR, the provision of the Soil Repository/Borrow Pit in the townland of *Castlegal* is an application of Waste Prevention:

> *By excavating the Soil repository/borrow pit, there will be a reduction in the need to import additional material, this will maintain the sustainability of existing quarries in the area, it also provides resource efficiency within the site. The material that cannot be used due to its moisture content will be used to restore ground at the soil repository to its original levels. The balance of the need for the project with the need to protect the environment is upheld. The use of the repository for material that is unsuitable as road construction material due to its moisture content is waste prevention as it does not need to go to a landfill which maintains the sustainability of the landfill.*

In addition, the nature of the design which has avoided any residential property has reduced demolition requirements, thereby also applying the principles of prevention.

During the subsequent construction stage of the development, waste prevention shall be the appointed contractor's responsibility. Options may include but are not limited to include the following:

- A careful balancing of the materials being ordered against what is required to carry out the works;
- Avoidance of poor quality material specification which leads to unnecessary and potentially un-useable materials arriving on site;
- Careful management of materials after they have arrived on site, i.e. storage and handling procedures;
- Use of pre-formed or pre-manufactured elements which would reduce the onsite generation of scrap metals.

4.4.3 Waste Reuse, Recycling and Recovery

Potential options the appointed contractor may consider for the reuse, recycling and recovery of waste arising from the project include the following:

4.4.3.1 Geological Materials

In relation to the soft subsoil material generated, there is potential that this material may lend itself to processing into acceptable Class 2C fill by air drying or lime stabilisation, this will be confirmed/examined during the design/construction phase of the project.

Such a process could be considered as *'Reuse' or 'Recovery'* in accordance with the Directive on Waste and the Waste Management Acts. Obligations will thus be placed on the Contractor within the Contract Documents to deal with this material in compliance with the provisions of the relevant legislation.

4.4.3.2 Concrete

Waste concrete is expected to arise principally during culvert, structures and retaining wall construction works. It is likely that where possible this waste concrete shall be returned to the supplier for reuse, otherwise it may be incorporated into the permanent works where it considered suitable to do so.

4.4.3.3 Metals and Timber

Metals and timber waste as with the concrete outlined above will typically arise during structures/culvert/retaining wall construction works and will principally be rebar reinforcement and structural shuttering. Best practice for dealing with this excess waste metal and timber includes segregating into appropriate skips/containers and transferring to metals and wood recycling facilities.

4.4.3.4 Packaging and Plastics

A concerted effort should be made on site to reduce the amount of packaging and plastics generated by site deliveries, this could include; requesting suppliers to collect their own packaging for recycling. The remaining waste packaging remaining onsite should be segregated into separate containers for collection and distribution to waste packaging and recycling facilities.

4.4.3.5 Canteen Waste

Receptacles shall be provided at staff canteens to allow for the segregation and storage of individual waste streams. These shall include receptacles for food waste, dry recyclables, and residual bin.

4.4.4 **Waste Disposal**

Waste Disposal shall only be considered by the appointed contractor once all options have been exhausted within the principles of waste *Prevention*, *Reuse* and *Recycling*.

4.5 Demolition Plan

In general the project has successfully sought to avoid existing dwellings and properties, this significantly reduces the requirement for demolition. However, a number of farm sheds and out houses will require demolition.

A coherent Demolition Plan shall be prepared by the appointed contractor and included as an integral part of the Project C&D Waste Management Plan.

A principal objective of the Demolition Plan will be to ensure that where a building or structure requires demolition, the sequence of operations to be followed is predetermined and documented, thereby ensuring that an appropriately selective dismantling/demolition methodology is employed.

Special attention should be paid to the sorting/segregation arrangements employed to separate the demolished structure into individual material fractions. In addition, the transportation and reception arrangements associated with the movement of materials to other construction sites for reuse or reprocessing should also be considered.

Health and Safety procedures should be adhered to in accordance with the requirements of the relevant authorities in the removal of hazardous waste material during the demolition process. The procedures and processes for removal of hazardous waste material will be identified in the Project C&D Waste Management Plan by the appointed contractor.

Special or hazardous wastes should be retained in isolation from other wastes to avoid further contamination. Certain C&D materials are hazardous e.g. lead, tars, adhesives, sealants. Asbestos containing construction materials are classified as hazardous (see European Waste Catalogue Codes

in Appendix 2 of the '*Best Practice Guidelines on the Preparation of Waste Management Plans for Construction and Demolition Projects'* for a schedule of hazardous construction materials).

If such materials are mixed with non-hazardous materials e.g. lead-based paint tins discarded onto a stockpile of brick and concrete, the entire quantity of material becomes hazardous and must be managed as hazardous waste.

4.6 Roles including training and responsibilities for C&D waste

A Construction and Demolition Waste Manager shall be appointed as part of the Construction Contract Tender Award process. This Manager will have overall responsibility for waste management onsite. The role will include the important activities of conducting waste checks/audits and adopting construction and demolition methodology that is designed to facilitate maximum reuse and/or recycling of waste.

The Plan shall make provision to ensure that the C&D Waste Manager is appropriately trained and is assigned the authority to require measures to be taken to fulfil the Plan's objectives and targets.

The role of the C&D Waste Manager should ensure that the opportunity is taken to educate all colleagues, site staff, including sub contractors and suppliers, about alternatives to conventional construction waste disposal. The Plan should make provision for the C&D Waste Manager and site crew to be trained in materials management thereby being in a position to:

- Distinguish reusable materials from materials suitable for recycling;
- Ensure maximum segregation at source;
- Co-operate with site manager on the best location's for stockpiling reusable materials;
- Separate materials for recovery; and
- Identify and liaise with operators of recovery outlets.

4.7 Record Keeping Procedures

The contractor shall develop a record keeping system that will ensure that details of all arising's, movement and treatment of C&D waste are recorded. All materials being transferred from the site, whether for recycling or disposal, shall be subject to a documented tracking system which can be verified and validated.

4.8 Waste Auditing Protocols

Waste auditing protocols shall be the responsibility of the Waste Manager who shall carry out auditing in accordance with an Audit Plan for the project to be included in the developed Construction and Demolition Waste Management Plan.

The self audit should cover the following elements:

- A systematic study of all waste management practices which have been adopted on-site;
- Special attention should be dedicated to obvious opportunities for waste reduction, but all areas and stages within the project should be reviewed;
- Details of raw material inputs and the quantity, type and composition of all waste from the site should be identified;
- The audit findings should highlight corrective actions that may be taken in relation to management policies or site practices in order to bring about further waste reductions;
- A tracking system shall be stipulated to determine the success or failure of corrective actions.

Summary audit reports outlining types, quantities of waste arising's and their final treatment method shall be sent to the Clients Representative. These summary reports shall be prepared and issued on the last Friday of each calendar month for the duration of the Construction Project.

5 Appendix 4.3: Chapter 4 (Main Report Reference);

Outline Erosion & Sediment Control Plan

5.1 Introduction

5.1.1 General

Sligo County Council is currently planning a 2.54km upgrade of the N16 National Primary Route, between the townlands of *Drumkilsellagh* and *Lugnagall* and occurring predominately within the townland of *Lugatober*. The project location is depicted in *Figure 5-1*.

The project will remove a number of substantially deficient bends on this section of the route and in so doing, will improve aspects such as safety, sight distance, cross sectional width and drainage.

The road type proposed for the project corresponds to a Type 2 Single Carriageway arrangement as outlined in Figure 5-2. The design arrangement is described in detail within Chapter 4 of the EIAR.

Figure 5-1: Project Location

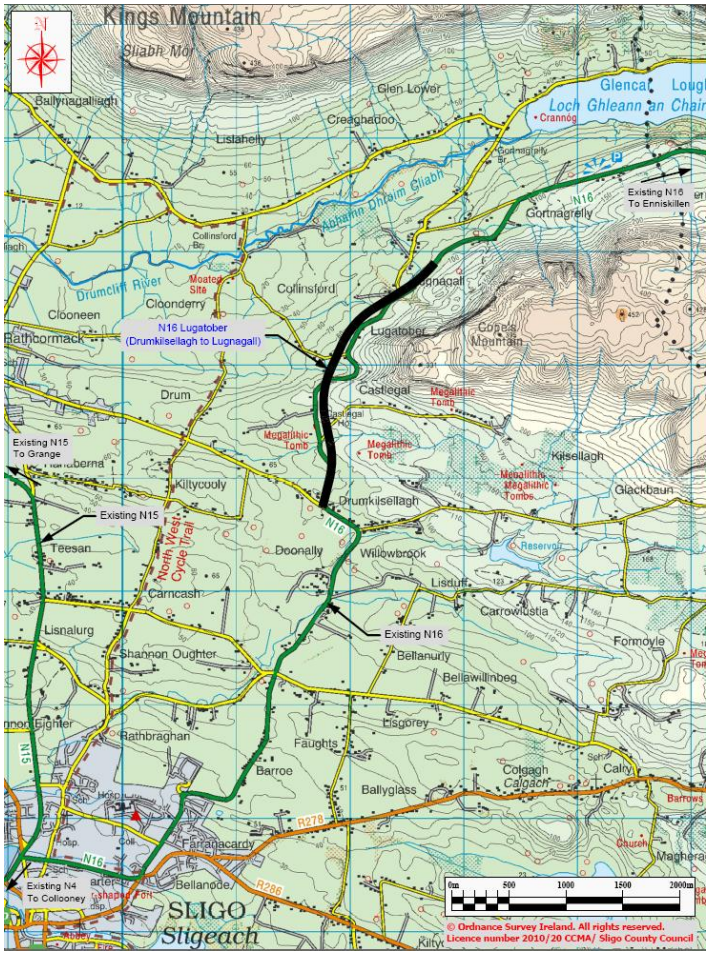
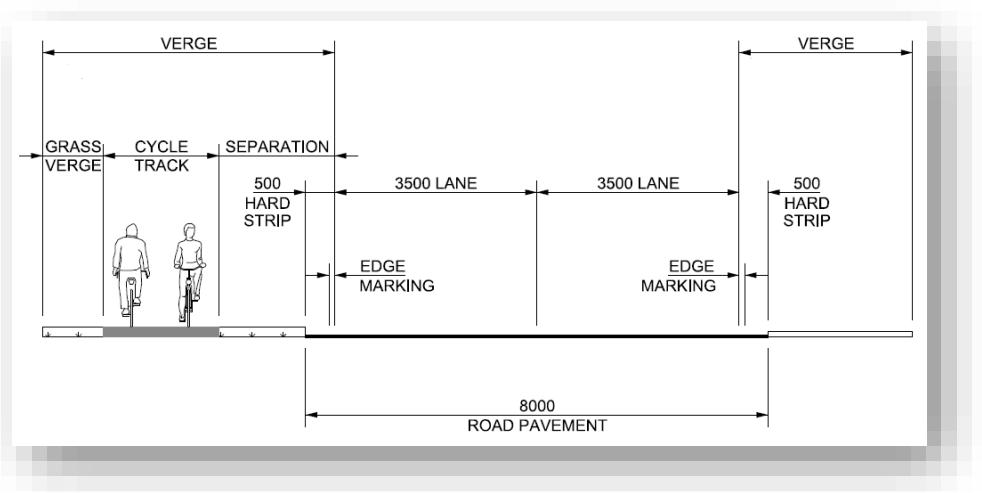


Figure 5-2: Type 2 Single Carriageway



This Outline Erosion and Sediment Control (OESC) Plan has been prepared as a method of water quality mitigation to offset potential Construction Stage pollution impacts from the N16 Lugatober Road Project to adjacent watercourses including the Willsborough Stream, the Tully Stream and various tributaries of the Drumcliff River.

The Plan is intended to be a **working** document and has been prepared to inform the Construction Stage Erosion and Sediment Control Plan, which, in turn, will form an integral part of the Environmental Operating Plan for the Project. In particular, the **mitigation, control, monitoring and emergency measures** for the Project in relation to Erosion and Sediment Control are described in this document. The Plan is also used to:

- Inform the Hydrological & Hydrogeological and in turn the Biodiversity Impact Assessments; and
- Ensure sufficient lands have been included on a permanent and temporary basis within the CPO to treat sediment runoff during the Construction Stage for the project;

Numerous references are contained herein. However, the main body of this report is guided by the technical guidance documents: *Control of water pollution from linear road projects*, and *Environmental Good Practice on Site Design (Fourth Edition),* published by CIRIA (C648 and C741 respectively).

The main activities likely to give rise to sediment pollution include the construction of Earthworks and Stream/Drain crossings.

5.1.2 Principles of Erosion and Sediment Control

The principles of erosion and sediment control during the construction stage of a Roads Project as outlined in CIRIA C648 include.

(1) Erosion control (preventing runoff) is much more effective than sediment control in preventing water pollution. Erosion control is less subject to failure from high rainfall, requires less maintenance and is also less costly;
(2) Plan erosion and sediment control at the design stage, as far as practicable, so that requirements can be built into the design and land requirement for the project and to inform the details of the Construction Stage Erosion and Sediment Control Plan;
(3) Minimise erosion and potential for soiled water to be generated by minimising runoff from the construction site;
(4) Install drainage and runoff controls **before** starting site clearance and earthworks;
(5) Minimise the area of exposed ground;

(6) Prevent natural runoff entering the site from adjacent ground, as this creates additional polluted water;
(7) Provide appropriate control and containment measures on site;
(8) Monitor and maintain erosion and sediment controls throughout the project;
(9) Minimise the site area disturbed and trafficked by construction vehicles
(10) Establish vegetation as soon as practical on all areas where soil has been exposed.

This Outline ESC plan will initiate these principles for eventual incorporation and expansion in the Construction Stage ESC Plan.

5.1.3 Contents of Outline Plan

This plan contains the following information:

(1) An identification of existing land use and the nature of the receiving environment;
(2) An outline of the main construction activities likely to be relevant in relation to erosion and sediment generation;
(3) An outline of the relevant S-P-R linkage which may cause potential for sediment pollution. A typical outline of S-P-R is outlined in *Table 5-1*;

Table 5-1: Source – Pathway – Receptor

SPC	Description
(S) Source	The construction activities which are likely to generate sediment runoff
(P) Pathway	The potential pathways for the above mentioned pollution to reach sensitive areas
(R) Receptor	Areas which are considered sensitive in terms of sediment laden runoff

(4) An outline of available site information which allows for an appreciable understanding for the sediment runoff which is likely to be generated and particular risks which may be encountered in specific areas;
(5) An outline of the controls determined at the current plan stage for incorporation and expansion within the detailed ESCP;
(6) An overview of Monitoring and Audit Requirements; and
(7) Emergency Procedures.

5.2 Site Characteristics

5.2.1 General

The following gives a general overview of the Site Characteristics which are considered to be relevant in terms of Erosion and Sediment Control.

5.2.2 Landscape Character

The topography within the study area is dominated by the tall massive mountains that lie to the north and south of Glencar Lake, which itself is located in a lower valley, occurring circa 1.6km to the north east of the road project. This lake discharges to the Drumcliff River which flows west to the Atlantic.

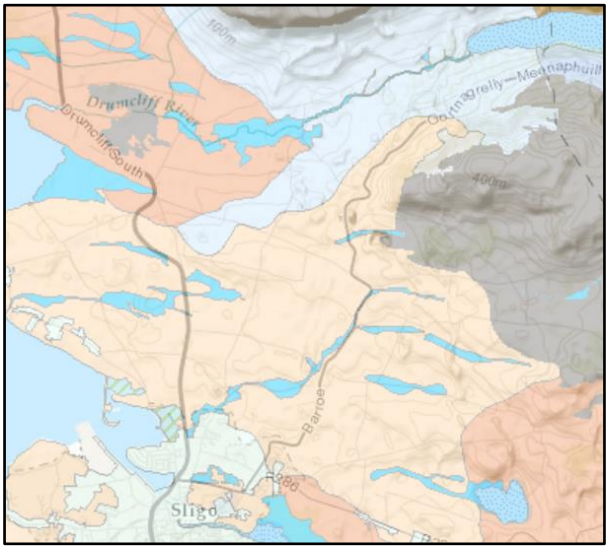
The existing N16 road extends to the south of the Lake and as its sits at a higher level in the topography, it is afforded views to the north across the Lake and the escarpments and summits of Kings Mountain beyond. Copes Mountain is less visible from the existing N16, due to the fact, that the existing road sits on the lower slopes of Copes Mountain and this close proximity restricts views.

5.2.3 Agriculture in the study area

In terms of land use, the area is used primarily for agriculture. Farming enterprises in the study area are predominantly involved in sheep and beef production with some dairy farming practices occurring to the south of the study area.

Agriculture land cover in the study area is defined by the drumlin topography and the suitability of the soils to agricultural use. The main soil association within the Project Area is the Mullanbane association (*Figure 5-3* - Light orange) which is a Typical Brown Earth soils described as having a coarse loamy texture and derived from limestone drift. The soils are limited to grassland and forestry use due to poor drainage, soil structure and prevalence of steep slopes.

Figure 5-3: Study area soils map (Teagasc)



5.2.4 Solid Geology

A summary of the geological sequence and main rock types likely to be encountered along the route from north to south are shown in Table 5-2. These are based on the available information on the 1:100,000 scale Geological Survey of Ireland map of the area.

Table 5-2: Geological Formations occurring in the Study Area

PERIOD	FORMATION	ROCK TYPES
Carboniferous (Dinantian)	Glencar Limestone Formation	Dark fine limestone and calcareous shale
Carboniferous (Dinantian)	Ballyshannon Limestone	Pale grey calcite limestone
Carboniferous (Dinantian)	Mullaghmore Sandstone	Sandstone, siltstone and shale
	Benbulben Shale Formation	Calcareous shale with minor calcarenite

5.2.5 Drainage Features

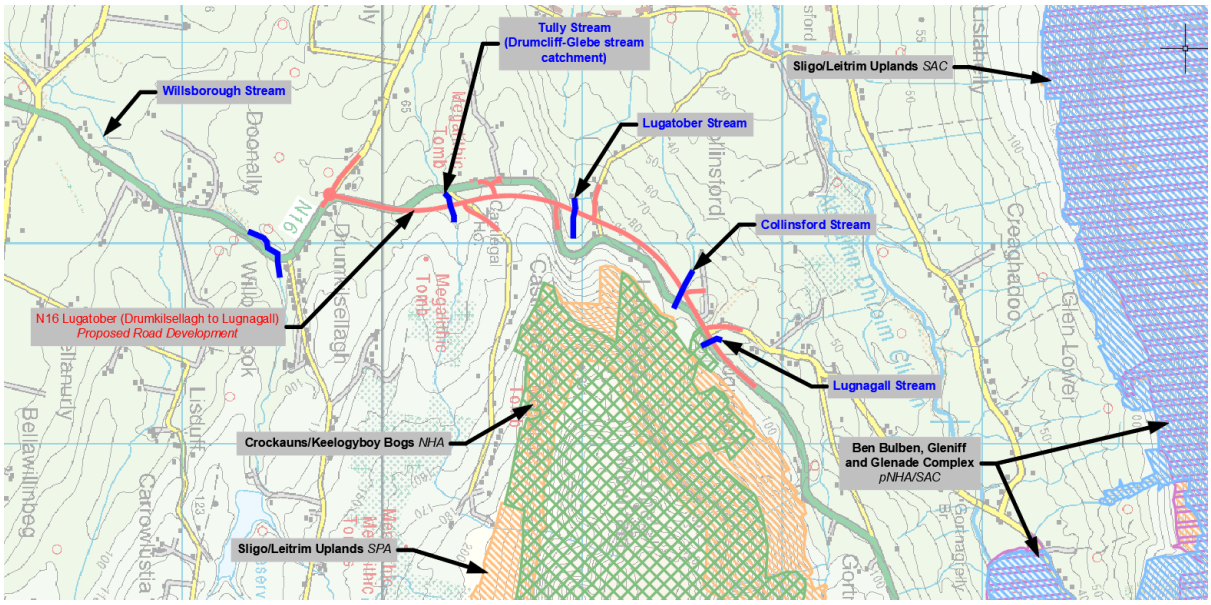
Glencar Lough, as already outlined occurs to the north east of the project. In terms of drainage features, it occurs upstream, therefore there no potential for runoff potentially emanating from the site reaching the lake.

The largest river basin is the Drumcliff River catchment which discharges into Drumcliff Bay and which occurs to the north of the Project. This river has a total catchment area of approximately 61.3km^2. The Road Project crosses tributaries of the Drumcliff River as outlined in *Figure 5-4* and Table 5-5.

The main streams crossed by the project include:

- The Tully Stream;
- The Lugatober Stream;
- The Collinsford Stream;
- The Lugnagall Stream;

Figure 5-4: Streams Intercepted by the Proposed Road Development



Road crossings of watercourses represent a potential impact on the flow regime and morphology of the watercourse as a result of these features requiring bridging or culverting.

The existing N16 road within the study area is generally over the edge drainage with no drainage water treatment or attenuation provided. Some local gullies have been provided in sections prone to ponding which discharge over the edge.

5.2.6 Hydrogeological Features

5.2.6.1 Karst features

The bedrock formation for this area particularly the more pure limestones to the east and south, have a potential for karstification and the development of conduit flow preferential groundwater pathways to develop. Outcrop and sub-crop areas have been identified in the *Carncash* townland (to the south of the project extents) area and the hillslopes near *Lugatober* and *Lugnagall*. The OSI historical mapping shows the location of a number of small springs/risings and supply wells throughout the Study area which have been mapped and defined as hydrogeological Features. A walkover visit and the OSI historical mapping reveal little evidence of significant surface karst features present within the Study area except for a local zone of karstification near *Carncash* (occurring to the south of the project). There are no major springs, turloughs, swallow-holes or cave features present. There are a number of small doline features evident from the aerial photography of the area which may represent possible collapse features in the *Doonally* to *Carncash* townlands (occurring to the south of the project extents).

5.2.6.2 Water abstractions / groundwater supplies

There are no major group water sources, within the study area, or any designated source protection areas, located within or in proximity to the study area. Small local household borehole supplies and wells are used to supply a number of individual, or locally grouped households and agricultural supplies within the study area. The majority of these supply sources are located on the hill slopes up gradient to the East of the Existing N16 road Generally, boreholes and sunk wells were found supplying households and small springs and dug wells supplying agriculture supply connections. The more elevated northern section of the route from *Lugatober* north is supplied by individual and grouped private wells and boreholes. South of *Lugatober* mains supply is available from Glackbaun public water supply.

5.2.7 **Biodiversity**

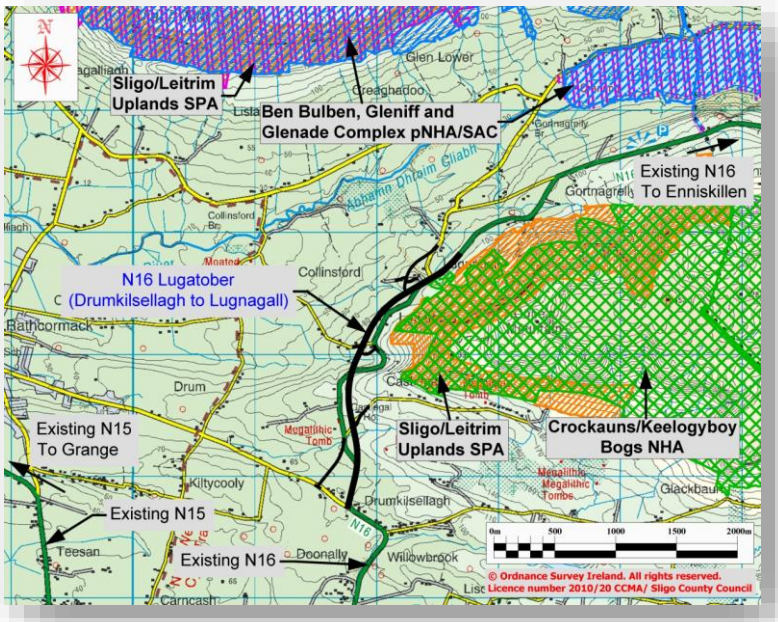
5.2.7.1 Relevant Designated Sites

The various designated sites in proximity to the Study area are:

- Crochauns/Keelogyboy Bogs NHA (002435);
- Sligo Leitrim Uplands SPA (004187);
- Ben Bulben, Gleniff and Glenade Complex SAC and pNHA (000623);
- Cummeen Strand / Drumcliff Bay SAC and pNHA (000627) in the coastal and estuarine waters and shoreline area to the west of the Route options;
- Cummeen Strand SPA (004035);
- Drumcliff Bay SPA (004013);

The potential impact to these designated sites is limited to potential indirect impacts via watercourse discharges and groundwater flow.

Figure 5-5: Project Location with reference to designated sites



5.2.7.2 Groundwater Dependent Habitats

A number of groundwater dependant wetland habitat sites have been identified within the study area which have the potential of being impacted by the Project. A summary of these key groundwater dependant wetland habitat sites is presented in Table 5-3 below.

Table 5-3: Summary Description Groundwater Dependent Wetland Sites

Site name	Grid Reference	Annex I habitats	Ecological evaluation	Relevance to Road Project
Lugnagall Flush – South of Existing N16	G725416	Small remnants of alkaline fen and petrifying springs	**County** Ecological Importance as supports two Annex I habitats and overlaps with Crockauns/ Keelogboy Bogs NHA	The Road Project is adjacent to, but downslope of this site.
Lugatober North, Flush			**National ecological importance.** Annex I priority habitat and are relatively extensive at the site. **National ecological importance.**	The Road Project is adjacent to, but downslope of this site.
South of Collinsford	G718413	Small areas of tufa formation and vegetation with affinity to petrifying springs	**County** Ecological Importance as has some affinity to the Annex I priority habitat and is associated with a small area of mature wet woodland.	The Road Project occurs approximately 250m upslope of this Site.
East of Drum	G713409	Rich fen and flush vegetation with some affinity to alkaline fen	**Local** (higher value) ecological importance as vegetation has a slight affinity to the Annex I habitat alkaline fen but is not considered to be a good example.	The Road Project occurs approximately 250m upslope of this Site.
West of Castlegal	G718409	Three petrifying springs with small amount of tufa formation within semi-natural woodland	**County** Ecological Importance as springs are small but are examples of an Annex I priority habitat.	The Road Project is proximate to but downslope of this site.

5.2.7.3 EPA Water Quality

The EPA Envision map viewer was consulted on 26th of July 2018 regarding the water quality status of the watercourses in the study area. There are no monitoring points of the Tully Stream or the two tributaries of the Drumcliff River in Lugatober. The Drumcliff River which is located downstream of the proposed works includes two sampling points downstream of the development site on watercourses: Station ID RS35D040400 and Station ID. RS35D040300.

Water quality sampling carried on two occasions as part of EIAR study found water quality in the Tully Stream to be unpolluted.

The Biotic Index of Water Quality (BIWQ) was developed in Ireland by the Environmental Protection Agency (EPA). Q-values are assigned using a combination of habitat characteristics and structure of the macro-invertebrate community within the waterbody. Individual macro-invertebrate families are, according to their sensitivity to organic pollution and the Q-value is assessed based primarily on their relative abundance within a sample. The current status of the Drumcliff River at the two sampling points downstream of the proposed road development is Q4 *Good Status*.

River Basin Management Plans (RBMPs) have been published for all River Basin Districts in Ireland in accordance with the requirements of the Water Framework Directive. The online EPA Envision map viewer provides access to water quality information at individual waterbody level and at Water Management Unit level for all the River Basin Districts in Ireland. Waterbodies can relate to surface

waters (these include rivers, lakes, estuaries [transitional waters] and coastal waters) or to groundwater.

5.2.7.4 Fisheries

The Project study area lies within the Western River Basin District and the WFD catchment delineated as Sligo Bay & Drowes.

The WFD waterbodies within or connected to the study area are listed in Table 5-4.

Table 5-4: WFD waterbodies within or connected to the Study Area indicating relevant WFD River Sub-basin and WFD Sub-catchment along with WFD Status and assessed fisheries status.

WFD River Sub-catchment	WFD River Sub-basin	WFD Status 2010-12	WFD Waterbody River / Lake	Fisheries status	Relevance to the Project
Drumcliff_SC_010	Drumcliff_010	Moderate	Glencar Lough	Important recreational fishery for salmon, sea trout & brown trout. Eels also likely to be present.	The Road Project is removed from this lake and any likely discharges will be to its outflow rather than inflow, or the lake itself.
			Upper Drumcliff River	Important recreational fishery for salmon, sea trout & brown trout. Eels & lamprey also likely to be present.	The Road Project is proximate to tributaries of this river. However its separation is 800m to 1,000m upslope.
	Drumcliff_020	Good	Lower Drumcliff River		
	Cregg_35_010	Unassigned	Tully Stream	Small coastal stream; trout and eels likely to be present; no angling interest.	The Road Project crosses this watercourse in the townland of *Drumkilsellagh/Castlegal.*

A description and evaluation of each waterbody within the study area in terms of aquatic ecology and fisheries is shown presented in *Table 5-5*.

Table 5-5: Waterbody Description and Evaluation (Fisheries and aquatic ecology).

Waterbody	Townland	Crossing location etc.	Aquatic Ecology & Fisheries Assessment	Relationship to Road Project
Tully Stream	Drum East	571743E 840296N	Good quality small stream with extensive trout spawning/ nursery habitat.	The Road Project crosses this watercourse in the townland of Drumkilsellagh/Castlegal.
Lugatober Stream	Lugatober	570763E 840937N	Moderate quality stream (possibly spring-fed); sand/ gravel/ cobble substrate	Occurs circa 400m downslope of the Road Project.
Collinsford Stream	Lugnagall	572250E 841483N	Small good quality stream; v steep gradient	The Road Project crosses this watercourse in the townland of Lugatober.
Lugnagall Stream	Lugnagall	572539E 841930N	Small good quality stream; steep gradient	Occurs circa 50m downslope of the Road Project.

5.3 Source – Pathway - Receptor

5.3.1 General

In order to establish the main effects which runoff from the Construction Stage of the project will have on the receiving environment, it is important to establish the:

- Source of such pollution;
- Potential pathway for this pollution to migrate; and
- Key receptors which this pollution could cause effects to;

Where there is a link between these three criteria it is important that appropriate mitigation in the form of erosion and sediment control is provided.

5.3.2 Potential Sources of Pollution

Pollution can damage the water environment in a number of various ways as indicated in *Table 5-6*.

Table 5-6: Common water pollutants and their effects on the aquatic environment.

Common Causes of Pollution	Adverse effect on the aquatic environment
Silt	Reduces water quality, clogs fish gills, covers aquatic plants.
Bentonite (very fine silt)	Reduces water quality, clogs fish gills, covers aquatic plants.
Cement or concrete wash water (highly alkaline)	Changes the chemical balance, is toxic to fish and other wildlife.
Hydrocarbons	Suffocates aquatic life, damaging other wildlife (e.g. Birds), and to water supplies including industrial abstractions.

The following paragraph's outlines what are considered to be the main sources of pollution arising from the Construction Stage of the Road Project.

5.3.2.1 Earthworks

The most significant area of concern regarding erosion and sediment control on any road construction project is those soil, subsoil and peat surfaces which are exposed during the earthworks operations.

Typically these surfaces are exposed during:

- The initial site clearance works;
- Excavation of cut slopes;
- Construction of fill slopes with acceptable glacial till material;
- Construction of haul roads for earthworks operations;
- The transport of soil materials and disposal
- Stockpiling of acceptable and unacceptable earthworks material for reuse or removal offsite;

5.3.2.2 Structures & Concrete

Concrete, grout and other cement-based products which would typically be used in the construction of structures are highly alkaline and corrosive and can have a devastating effect upon water quality. Cement-based products generate very fine, highly alkaline silt (11.5 pH) that can physically damage fish by burning their skin and blocking their gills. This alkaline silt can also smother vegetation and the bed of watercourses and can mobilise pollutants such as heavy metals by changing the water's pH. Concrete and grout pollution is often highly visible.

Particular risks are posed to water quality when construction is taking place over or near surface waters (eg bridges or headwalls).

5.3.2.3 Watercourse Crossings

Watercourses crossed by the project have already been outlined in section 5.2.5. The most sensitive watercourse is considered to be the Tully Stream which contains Brown Trout locally. The other watercourses which are considerably smaller are only fishery sensitive in their downstream reaches.

There will be no diversion permitted of the Tully Stream. As part of the drainage network design and culverting process, smaller streams and land drains will be severed as they pass underneath the alignment; these severed sections will be straightened and/or, made perpendicular to the alignment through the provision of precast culverts.

Modification of these channels has the potential to generate sediment laden pollution.

5.3.2.4 Construction Compounds & Machinery Re-fuelling/lubrication

The location of site specific construction compounds are set out in section 5.5.3.5 of this Plan. Particular considerations in relation to the location of such facilities and their generation of pollution during the construction stage include:

- Sanitary wastewater treatment;
- Hard-standing runoff;
- Potential for hydrocarbon pollution to groundwater and surface water;

5.3.3 Potential Pathways

The potential pathway link is the flow path from an area of exposed ground to an adjacent watercourse or sensitive habitat. This might include for example sheet flow over the edge of an exposed embankment which subsequently has a route via the ground topography to enter into adjacent land drains discharging to watercourses. Additionally, there is potential for pathways to be exacerbated, by the potential for sheet flow, surface water runoff coming from Copes Mountain. In general, potential pathways have been examined based on:

- An examination of watercourses mapped on the EPA Envision website and confirmed during site visits;
- Reference to watercourses mapped on the OSi mapping;
- An examination of the topography of the area in the vicinity of the project using detailed Digital Terrain Model (DTM) information;
- An examination of karst features in the area;

A Flow path may also be through the overburden cover or exposed bedrock to the groundwater table and travelling westward with the groundwater gradient providing baseflow to the streams and river reaches further downgradient.

5.4 Investigation and Survey Information

5.4.1 Soils and Geotechnical

A detailed ground investigation contract was completed between the period of February and September, 2018. The investigation was designed to gather geotechnical and groundwater information along the proposed alignment.

The programme of field works consisted of the following:

- 20 Cable Percussion boreholes;

- 11 Rotary boreholes;
- 23 Trial Pits;
- 12 Dynamic Probes;
- 2 Pavement Cores;
- 5 Standpipe Well Installations;
- In-situ Testing;
- Geophysical survey.

The results of these field investigations indicate that:

- Soils encountered along the route are all capable of being excavated employing conventional hydraulic plant;
- The only anticipated area of rock excavation is located in the cutting between c. Ch. 740 to c. Ch. 1,160m (and in the adjacent Soil Repository/Borrow Pit) which will encounter moderately strong to strong limestone;
- All topsoil is considered as suitable for landscaping purposes and can be stripped and stored for reuse;
- Made ground is predominantly reworked glacial till and is expected to have a reuse of 50%, provided that it is free of organic soils and domestic refuse, waste materials etc.;
- Circa 55% of cohesive glacial tills are expected to be directly re-useable within the embankment construction. The reuse of further cohesive fill materials can be improved by either natural drying or lime stabilisation to reduce the moisture content and MCV to within an acceptable range.;
- Areas of soft cohesive glacial till and made ground are unlikely to be suitable as foundations. Soft ground is defined as having an undrained shear strength below 40kPa for earthworks construction. A summary of anticipated soft ground beneath at grade sections and embankments along the project is provided in *Table 5-7* (See Figure 13.4.1 and 13.4.2 contained within Volume 3 of the EIAR). The maximum depth of soft ground does not exceed 4m thickness and the average depths are less than 2m, therefore excavation and replacement is considered to be the most appropriate solution in all cases.

Table 5-7: Soft Ground Areas

Location	Chainage (m)		Average Depth (m)	Max Thickness (m)
	From	To		
Drumkilsellagh	240	500	1.3	1.6
Tully Stream Valley	550	650	1.1	1.4
Lugatober Stream valley	1,160	1,330	1.8	4
L-34041-) Local Road junction	1,870	1,980	1.4	1.9
Lugnagall	2,170	2,300	1.3	1.6

5.4.2 Water Quality

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

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

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

The collated information relating the water quality and macro-invertebrate community composition is condensed to a numerical scale of Q-values or Biotic Index. The indices are grouped into four classes based on a river's suitability for beneficial uses such as water abstraction, fishery potential, amenity value, etc. (refer to Table 10.14 below).

Table 5-8: Biological River Water Quality Classification System

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

The monitored rivers that traverse the P*roposed Road Development* vary in quality from being slightly polluted (Q3-4) to moderately unpolluted (Q2-3).

The EPA river water quality status for the Drumcliff River catchment (Drumcliff_SC_010) is "Good" based on the 2010 to 2015 monitoring period. The Q-rating is measured by the EPA at reference station RS35D040250 at Collinsford Bridge and at station RS35D040400 in the lower reach 500m upstream of Drumcliff Bridge. For the 2015 sampling result both sites achieved a Q-rating of 4 (unpolluted) and for the previous 2012 sampling 3-4 (slightly polluted) for the upper station and 4 (unpolluted) for the lower station. Both sites assessed are now in satisfactory condition for the first time since 2000. The water quality risk status for Drumcliff catchment is classed as "not at Risk".

The Tully Stream[25] system is not monitored and is classed as "unassigned" and the risk status is also unassigned. No Q-Rating assessment has been carried out for this small catchment.

The EPA river water quality status for the Willsborough Stream[26] catchment (Willsborough_35_010) is "Good" based on the 2010 to 2015 monitoring period. The Q-rating is measured by the EPA at three reference stations within the catchment located station RS35W010060 in the upper Reaches at bridge south of Glackbaun, and at RS35W010150 (in the middle reach at road bridge west of Willsborough and at RS35W010300 in the lower reach at Sligo-Bundoran road bridge. All three sites have good status (a Q-rating of 4) for 2015 assessment with slight decline in the upper station near Glackbaun from high to good quality. The water quality risk status for Willsborough catchment is classed as "not at Risk".

The water quality status of the downstream transitional waters of the Drumcliff Estuary and the Garavoge Estuary are classified as unassigned and good respectively. The risk status for these transitional waterbodies is "not at Risk" and "Review" respectively.

[25] Described as labelled as 'Drumcliff_Glebe' on EPA Maps (https://gis.epa.ie/EPAMaps/);

[26] Described as 'Willsborough (Stream)' on EPA Maps (https://gis.epa.ie/EPAMaps/). Also known locally as the 'Doonally Rover'.

5.5 Erosion and Sediment Controls

5.5.1 General

The principal objectives in relation to erosion and sediment control during the earthworks operation as will be:

- To keep the area exposed to the elements to an absolute minimum;
- To minimise the amount of runoff from the site;
- To have an efficient earthworks operation to ensure that fill is placed as material is removed;
- To ensure that the unacceptable material is removed and placed in controlled repository areas in an efficient manner;

5.5.2 Principal Avoidance Measures

The protection of watercourses from pollution arising from construction works is achieved by avoidance in the first instance. In this regard, the following measures will be implemented during the construction phase:

(1) Site clearance involving topsoil stripping will progress with the earthworks and will not be carried out over large areas in advance resulting in these areas being exposed for long periods of time;

(2) It is estimated, following onsite treatment measures that that there will be approximately 59,000 m^3 of soft subsoil material excavated during the course of the earthworks operation. The majority of this material will remain onsite for the following purposes:
   a. Landscaping Measures;
   b. Construction of bunding surrounding Attenuation Ponds; and
   c. Backfilling of the Soil Repository/Borrow Pit at *Castlegal*.

   The Soil Repository/Borrow Pit is located centrally within the overall site configuration (c. Ch. 1,000m) and proximate to the largest section of embankment requiring Fill material (c. 1,150m to c. 1,325m). This will facilitate:

   a. An earthworks construction period that is as short as possible, thus minimising the period during which open ground is exposed
   b. Minimisation of the transportation/journey lengths involved, thus minimising the opportunity for material to be spilled on haulage rotes and enter the water system via road runoff;
   c. Efficient earthworks operations ensuring that material can be removed and replaced with fill in the minimum amount of time thus reducing the ingress of water into the construction works and limiting the amount of dewatering of the works;

(3) Internal haul roads will be limited to the confines of the Land Made Available (LMA). Haul roads outside the limits of the site or permanent earthworks are not anticipated;

5.5.3 Principal Control Measures

5.5.3.1 General

The control measures for specific construction tasks and in relation to particular features are outlined in the following sections.

(1) Before works commence on site, the contractor will be required to prepare an Environmental Operating Plan (EOP) in accordance with the NRA guidance document for EOP's. The key elements of this plan will be as follows:
   a. Appointment of an Environmental Manager by the main contractor;
   b. Incorporation of environmental commitments and requirements;

c. Outlining methods by which construction work will be managed to meet these environmental commitments and requirements;
d. Identification of roles and responsibilities of the main contractor's staff having regard to the main contractor's organisational structure;
e. Incorporation of procedures for communicating with the public and communicating within the main contractor's organisation;
f. Incorporation of procedures for environmental awareness training;
g. Incorporation of monitoring procedures and responses to the results of monitoring, where contractually required; and
h. Provision of a system of audit and review with regard to the effectiveness of the plan.

In addition to the foregoing, the contractor will be required to incorporate a fully developed construction stage Erosion and Sediment Plan for the proposed works based on this Outline Plan. The contractor will be required to incorporate all of the avoidance and mitigation measures outlined in this Plan in the Construction Stage Plan. In addition, the Contractor will be required to consult with the NPWS and IFI in relation to the final detail of the Plan and shall include their requirements in this regard.

(2) In order to prevent the potential for disturbance of ground outside the construction footprint, the site will be fenced off, prior to works commencing;
(3) Before earthworks commence on site (at each particular construction section) and before they are needed - drainage, erosion control and sediment control measures must be in place and functioning;
(4) Silt Fences[27] will be erected along or just in front of the permanent land acquisition boundary in the following cases (sited inside any separate land drainage systems conveying land runoff from the lands outside the CPO (pt. 5 below):
    a. At all sections of road construction where the works are at or above existing ground level and to extend linearly (along the earthworks perimeter) 50m along the adjacent cut section;
    b. Along any other identified surface pathways for sediment laden runoff;
(5) Where land drains intersect the site boundary or where the adjacent land falls towards the construction site – temporary cut-off drains will be provided to intercept this clean runoff water and divert to the nearest watercourse. Small check dams at 50m centres, will be constructed in these cut-off drains to trap any sediment and prevent erosion. Silt fences will be provided immediately before the outfall to existing watercourses as a precaution and to allow a response time in the event of an emergency. These check dams will be subject to periodical checks and maintenance.
(6) All watercourses will be will be fenced off with double silt fences located at least 10m back from the watercourse bank until such time as the road crossing is constructed.
(7) All silt fences at watercourse crossings will be inspected on a daily basis and repairs or replacements carried out as required. A record of such inspections/ repairs/ replacements will be included as part of the Environmental Operating Plan.
(8) Dewatering and surface water runoff discharges from the construction site, including any advance works, during and for the duration of the construction works will be controlled, collected and routed via appropriate Construction treatment measures. These measures will be in accordance with the CIRIA publication's *Control of Water from Linear Construction Projects* and *Environmental Good practice on site guide (fourth edition)*. These measures shall include settlement lagoons, provided prior to each outfall discharge. Each pond will be provided with a double silt fence located before the discharge point. These facilities will be

[27] Installed in accordance with the manufacturer's recommendations and in compliance with the Design Criteria outlined in CIRIA C648 Control of Water Pollution from Linear Construction Projects

inspected/ maintained at least on a daily basis and the maintenance record will be available for inspection by the Client and other statutory organisations as part of the EOP;

(9) Construction settlement ponds should be sized to provide a 6hour residence time for a 6hr duration 10year rain storm event (35mm).

(10) Direct connections between the settlement pond outfalls and the watercourse will not be allowed. Instead, the outfall will be allowed to disperse across at least 3m of undisturbed vegetated ground, covered with a coir mesh or similar matting prior to reaching the watercourse;

(11) Haul roads shall be constructed so that the natural contour is followed as clearly as possible and so that runoff is diverted to a treatment area;

(12) Silt fencing shall remain in place until ground vegetation has recovered. Any accumulated silt will then be removed and disposed of to a licensed facility.

5.5.3.2 Earthworks[28]

5.5.3.2.1 *Cuts and Embankment Excavation*

The following principal controls will be put in place:

(1) The area of the earthworks operation will be kept to an absolute minimum at any one time. Earthworks operations will be as self-contained as is practicable having regard to environmental constraints. The importation and placement of road foundation fill will be carried out in an integrated operation such that fill will be placed as soon as practicable after excavation.

(2) The excavation of soft materials will be carried out in a manner that minimises the amount of water entering the face of the works. This will be achieved by placing fill in the excavated area as soon as is practicable (generally the same day).

(3) Where pumping out of the excavation is necessary, this will be carried out using appropriately sized pumps. A clean stone filled perforated pipe (or similar) will be used as a sump for the pump intake. The pumped out water will be directed to the earthworks drainage system and to the settlement lagoon (or other) treatment system. The outlet from the pump shall be designed so as not to mobilise additional sediment – e.g. shall discharge onto plastic sheeting, rock pile, etc.

5.5.3.2.2 *Subsoil Stabilisation*

Subsoil Stabilisation is an activity which involves spreading powdered lime evenly over the surface of thin loose lifts (150-350 mm) of the Class U1 material, mixing it with the clay by rotavating, and then allowing the mix to dry or cure over a short period of time prior to compaction. Should this activity be proposed to be used by the contractor, the following controls will be applied:

(1) The activity shall only be carried out under calm and dry metrological conditions. Lime application shall not be exposed to wind and where any risk occurs will be misted/sprayed down immediately;

(2) The activity will not take place within 50m of any watercourse;

(3) Following mixing (which should take place generally within 15 minutes of spreading the lime on the surface) the material shall be compacted within 1 hour and appropriately sealed[29]. In no case will this material be allowed to be left unsealed overnight;

[28] The following is in addition to those points outlined under 5.5.3.1

[29] 'Sealed' for the purposes of this report shall mean covered with a minimum 300mm lift of suitable construction material.

5.5.3.2.3 *Transportation*

The transportation of materials, will be carried out, in an efficient manner, so as, to minimise the number of trips, minimise the length of individual trips, and minimise the escape of material from the trucks. The following principal controls will be put in place:

(1) The construction operation will be managed so as to minimise journey lengths;
(2) Where any excavated material is "sloppy" and presents a risk of splashing over the top of the trucks the capacity of the trucks will be limited to 75% of the height of the lowest side of the truck;
(3) Trucks leaving and entering the site will do so via a defined/controlled construction entrance;
(4) Road cleaning will be carried out at least daily to ensure that there is no build-up of sediment on the public roads;
(5) In the event of a substantial quantity of spoil material being required to be exported offsite, then a proprietary mobile truck wheel wash system shall be installed at the relevant locations. All trucks leaving such sites will be required to pass through this facility. The water from the sediment tanks shall be discharged via the site runoff treatment system (i.e. settlement ponds, etc.) and the sediment portion shall be removed offsite to a licenced facility.

5.5.3.2.4 *Stockpiles*

It is envisaged that topsoil and soft subsoils will be the main material which will require to be stockpiled during the course of the construction period. The following controls will be in place for the stockpiling of this material:

(1) Topsoil stripping over large areas in advance of main excavation works will not be permitted. It will be restricted to the minimum required for efficient earthworks operations and in any case will only be carried out in construction area units where earthworks is on-going.
(2) Each construction area unit will be topsoiled as the works proceeds thus limiting both the amount and the length of time for which materials have to be stockpiled.
(3) Stockpiles will not be located within 10m of a watercourse, or land drain, or within 25m of the Tully Stream, the Lugatober Stream, the Collinsford Stream, or the Lugnagall Stream.
(4) Runoff from a stockpile will be collected via a shallow toe drain, located outside the silt fence, which will have check dams at regular intervals and will be designed to have a retention time of at least 5 hours. Prior to outfall, straw wrapped in geotextile bags and inset into the base of the drain by at least 100mm shall be provided followed by a silt fence upstream of the outlet.
(5) Stockpiles of non-granular materials shall be limited in height to not more than 2.5m.

5.5.3.3 Waterbodies and Sensitive Habitats[30]

5.5.3.3.1 *Introduction*

The following outlines the control measures that will be put in place to protect waterbodies and sensitive habitats from sediment ingress during the construction stage – these are in parallel to the measures outlined elsewhere in this document.

(1) All works in proximity to watercourses shall follow the best practice guidance outlined in the following documents:
    a. TII/NRA '*Guidelines for the crossing of Watercourses During Construction of National Road Schemes (2008)'*;
    b. Inland Fisheries Ireland, *Guidelines on Protection of Fisheries During Construction Works in and Adjacent to Waters, 2016*;

[30] The following is in addition to those points outlined under 5.5.3.1

(2) Preserve natural vegetation near watercourses and along the perimeter of the site as much as practically possible;
(3) Leave a 5m grassed strip next to river banks when stripping topsoil or place grassed soil bunds along river banks to prevent site runoff directly entering watercourses;
(4) Place straw bales or sand bags along the sides of temporary or existing bridges to prevent runoff entering the watercourse.

5.5.3.3.2 *Watercourses*

The following measures relate to crossings of existing watercourses traversed by the Road Project.

The Tully Stream

No diversion of the Tully Stream is permitted. The method of crossing this stream, in accordance with IFI requirements ,shall be via a clear span structure as outlined in Chapter 4 of the EIAR.

Tributaries of the Drumcliff River

Other than the Tully Stream, permanent diversions are proposed on all streams crossed by the *Proposed Road Development*. The following control measures shall be applied in each instance:

(1) General diversion works shall be undertaken in the dry. In-stream works will be required to connect the realigned section to the existing channel. The channels shall be free of any erosion potential prior to their opening, this may include fully established vegetation or the use of sediment control mats which are biodegradable. The opening shall be carried out in a carefully controlled manner and under the supervision of the EAO and an IFI representative.
(2) All of these watercourse crossings will be maintained by precast box and pipe culverts as described in Chapter 4 of the EIAR;
(3) Crossings will be provided with a silt trap and a sedimat immediately downstream of the crossing point;
(4) The silt trap shall be left in place for at least 6 weeks following completion of the work and shall be inspected and maintained at least 3 times per week;
(5) The area of disturbance of the watercourse bed and bank shall be the absolute minimum required for the installation of the crossing;

The principal avoidance and control measures to be adopted at these crossings include:

(6) No in-stream works will be carried out between 1st October and 1st May. In accordance with IFI recommendations, in-stream works shall be carried out in the period July to September (unless expressly agreed with the IFI in advance);
(7) All works will be carried out under the supervision of the Clients Representative;
(8) In-stream working will be kept to an absolute minimum, will be carried out in the close season only, NPWS and IFI will be informed at least 2 weeks prior to commencement, in-stream works will be allowed on a Permit-to-Work basis that must be signed by the Clients Representative at the commencement of the works and on a weekly basis thereafter;
(9) Where in-stream or bank side works is for the purpose of constructing a structural element that requires the placing of concrete then a cofferdam shall be constructed and made as water tight as possible. Pumping out from the cofferdam shall be to a settlement tank of sufficient capacity to allow solids to settle prior to discharge;
(10) Sand bags shall be double bagged and use washed sand only. Each bag shall be marked with a reference number and a record of placing and removal shall be maintained in the EOP;
(11) There will be no machinery working in-stream. Where excavation, breaking, etc. is required at the bank, it will be carried out with machinery operating from the bank;
(12) Machinery operating from the bank will work on “bog mats” to minimise damage to the vegetated banks;

5.5.3.4 Concrete Works[31]

The use and management of concrete in or close to watercourses must be carefully controlled to avoid spillage which has a deleterious effect on water chemistry and aquatic habitats and species. Where the use of concrete near and in watercourses cannot be avoided the following control measures will be employed:

(1) Hydrophilic grout and quick-setting mixes or rapid hardener additives shall be used to promote the early set of concrete surfaces exposed to water;
(2) When working in or near the surface water and the application of in-situ materials cannot be avoided, the use of alternative materials such as biodegradable shutter oils shall be used;
(3) Any plant operating close to the water will require special consideration on the transport of concrete from the point of discharge from the mixer to final discharge into the delivery pipe (tremie). Care will be exercised when slewing concrete skips or mobile concrete pumps over or near surface waters;
(4) Placing of concrete near watercourses will be carried out only under the supervision of the Clients Representative;
(5) There will be no hosing into surface water drains of spills of concrete, cement, grout or similar materials. Such spills shall be contained immediately and runoff prevented from entering the watercourse;
(6) Washout from concrete lorries shall not be permitted to enter any surfacewater or groundwater bodies. The preferred option is to wash out the container and chute back at the batching plant, or, alternatively in a designated onsite concrete wash down area, which is set back at least 100m from any watercourse and is of an impermeable nature. Concrete waste shall be disposed of in accordance with the site specific Construction & Demolition Waste Management Plan;

Chute washout locations will be provided with appropriate designated, contained impermeable area and treatment facilities including adequately sized settlement tanks. The clear water from the settlement tanks shall be pH corrected prior to discharge (which shall be by means of one of the construction stage settlement facilities) or alternatively disposed of as waste in accordance with the contractor's Waste Management Plan included in the EOP.

5.5.3.5 Construction Compounds[32]

5.5.3.5.1 *Introduction*

A Construction Compound will be required for the duration of the works. Provision has been made for this compound to the west of the proposed alignment at circa Ch. 500m as described in Chapter 4 of the EIAR.

The activities at the compounds may include stores, offices, materials storage areas, materials processing areas, plant storage, parking of site and staff vehicles, and other ancillary facilities and activities.

5.5.3.5.2 *Controls*

The Compound will have appropriate levels of security to deter vandalism, theft and unauthorised access.

[31] The following is in addition to those points outlined under 5.5.3.1

[32] The following is in addition to those points outlined under 5.5.3.1

Surface runoff from compounds will be minimised by ensuring that the paved/ impervious area is minimised. All surface water runoff will be intercepted and directed to appropriate treatment systems for the removal of pollutants prior to discharge.

The compounds will be fenced off and a silt fence erected and maintained on the site boundary.

Wastewater drainage from all site offices and construction facilities will be contained and disposed of in an appropriate manner to prevent water pollution and in accordance with the relevant statutory requirements.

The storage of fuels, other hydrocarbons and other chemicals within the construction compounds shall be in accordance with relevant legislation and with best practice. In particular:

- All fuel/ Hydrocarbon/ Chemical (fluid) storage areas shall be bunded to 110% of storage capacity;
- Storage of these materials within a compound shall be organised so as to be as far away from all water bodies as is practicable;
- The Emergency Response Plan shall include arrangements for dealing with accidental spillage and relevant staff shall be trained in these procedures;

5.5.4 Runoff Estimation

In order to appropriately size sediment control facilities for runoff, the following approach will be adopted. Runoff from the exposed surfaces is calculated using the Modified Rational (MR) Method and applying extreme rainfall information obtained from Met Éireann and specific to the area.

MR Formula:	Q	=	C **x** i **x** A
Where	Q	=	the peak discharge (m^3/hour);
	C	=	Coefficient of permeability taken conservatively at 0.6[33]
	i	=	rainfall intensity (m/hour)[34];
	A	=	the contributing area (10,000m^2);
Resulting in:			
	Q	=	0.6 **x** 0.041[35] (m/hour) **x** 10,000m^2
	Q	=	246 m^3/hour for a 1Ha site
	Q	=	4100 litres /minute

5.5.5 Land Availability

Areas required for sediment control treatment locations, will be included in the Compulsory Purchase Order of the Project.

5.6 Monitoring and Audit

5.6.1 Introduction

This Outline Erosion and Sediment Control Plan will be developed by the contractor into the Construction Erosion and Sediment Control Plan (CESCP) and will form part of the Environmental Operating Plan (EOP). While the final details of the CESCP will require agreement with the NPWS and

[33] For a stripped Construction Site.

[34] Depth of rainfall constituting a 1 in 100 year (1 hour) flood event.

[35] Based on Return Period Rainfall depths received from Met Eireann.

IFI, the minimum requirements of same shall include all of the controls, measures, mitigations and monitoring described in this document. The monitoring of all aspects of the EOP, including the CESCP, will be carried out by the contractor as the responsible party. The responsibilities of the Employer will be discharged by the Employer's Site Representative staff.

5.6.2 Monitoring and Audit

5.6.2.1 General

The avoidance, control and mitigation measures outlined in this document will ensure that erosion and sediment arising from the works is controlled. They have been developed in accordance with best practice, and have been shown to work on other projects. As with all systems, there is a requirement to have monitoring, audit and feedback loops to demonstrate the operation of the system. The following describes the framework Pre-construction Monitoring and Construction Monitoring regime and the detailed construction stage monitoring by the Contractor and the Employers Representative are described in the subsequent paragraphs.

5.6.2.2 Pre-Construction and Construction Stage

Where activities close to the watercourse are being carried out that could potentially lead to pollution, a portable turbidity reading will be carried out daily to ensure that sediments from the construction site are being controlled.

This monitoring will be reviewed on an ongoing basis during construction. Should investigatory levels (a breach of the limits set out in the second schedule to the European Communities (Quality of Salmonid Waters) Regulations, 1988, measured at the point of discharge to the nearest watercourse) be reached (as a result of the construction works) then corrective action shall be taken.

5.6.2.2.1 *Contractor*

The procedures and monitoring and audit regime outlined in this section shall be used by the contractor to ensure and demonstrate the effective operation of the avoidance, control and mitigation measures for Erosion and Sediment control. It will facilitate use as a feedback loop to target any issues that may arise.

The following are the main procedures that will be followed:

(1) The contractor shall appoint an Environmental Officer, whom shall be responsible for implementing/overseeing all aspects of this plan;
(2) The contractor will be obliged to hold a full day training course for all site staff immediately before works commence on site on the EOP and in particular the CESCP. The subject of this course shall be the measures that have been put in place to protect the environment and the procedures and monitoring and recording that is to be undertaken in accordance with the EOP.
(3) Environmental Checklists shall be prepared for each operation. Responsibility for completion of these checklists will be assigned to individual members of the contractor's staff. The following operations will also require a Permit-to-Work before operations can commence each of which must be counter signed by the Employers Representative:
    (a) Any in-stream works;
    (b) Placing of concrete in, or within 50m of watercourses;
    (c) Completion of sediment removal facilities prior to initial discharge to watercourse;
    (d) Restart of works following any pollution incident
(4) All environmental monitoring and checklists shall be recorded and added to the EOP on a daily basis;

(5) The EOP shall assign particular responsibility and monitoring duties to particular named staff and the Site Agent/ Manager shall ensure that this is implemented in full. Training for each member of staff on their specific area of responsibility shall be carried out before the commencement of that operation. A record of all training carried out shall be maintained in the EOP and a further copy issued to the Employers Representative;
(6) Monitoring for turbidity shall be undertaken as described at section 5.6.2.2. The results shall be relayed to the Employers Representative;
(7) All other watercourses in the vicinity of the works shall be monitored on a daily basis and turbidity readings taken. The results shall be issued to the Employers Representative on a daily basis;
(8) All mitigation/control measures shall be inspected daily by designated contractor staff and maintenance and repairs carried out immediately;
(9) Any direct release of sediment to a watercourse causing plumes or exceedance's of the turbidity investigatory level shall trigger an investigation commencing with notification to the Employers Representative who shall determine the appropriate course of action which may involve the cessation of works, the initiation of emergency procedures and the notification to the NPWS and the IFI. In such a case of cessation, works shall not recommence until appropriate corrective measures to avoid any repetition are put in place. Such measures shall be agreed with the Employers Representative following consultation with the NPWS and IFI.

5.6.2.2.2 *Employers Representative*

Separate from the on-going and detailed monitoring carried out by the contractor as part of the EOP, the Employers Representative shall carry out the inspection/ monitoring regime described below on behalf of the employer. The results will be stored in the Employers Representative's Monitoring file and will be available for inspection/ audit by the Client, NPWS or IFI staff. All inspections/ monitoring/ results will be recorded on standard forms.

(a) Inspect the principal control measures outlined in this plan on a monthly basis. Report findings to the Contractor;
(b) Inspect surface water treatment measures (ponds, tanks, mini-dams, sandbags, etc.) and obtain turbidity readings;
(c) Inspect all outfalls to watercourses and obtain turbidity/suspended solids as outlined in section 5.6.2.2 readings;
(d) Visually inspect watercourses to which there is a discharge from the works and those where there is construction works in the vicinity;
(e) Wheel wash facilities shall be inspected on a weekly basis;
(f) Stockpiles shall be monitored while being filled or emptied;
(g) Control measures for works at or near water bodies shall be inspected;
(h) Concrete operations at or near watercourses shall be supervised and designated chute washing out facilities shall be inspected;
(i) Site compounds shall be inspected;
(j) The Contractor's EOP monitoring results shall be audited on a frequent basis (Once per month at a minimum);
(k) Any and all exceedance of the investigatory level for turbidity/suspended solids shall be reported where deemed necessary to the NPWS and IFI and shall be investigated thoroughly by the Employers Representative and the Contractor. Where the works are identified as the source causing the exceedance, the procedure outlined in Item "I(i) to I(iv)" below shall be followed;
(l) Any direct release of sediment to a watercourse causing plumes or exceedance of the turbidity/suspended solids investigatory levels shall result in:
    (i) the relevant NPWS and IFI staff being notified immediately;

(ii) the contractor will be required to take immediate action and to implement measures to ensure that such discharges do not re-occur;

(iii) Works if stopped shall not recommence until appropriate corrective measures to avoid any repetition are put in place. Such measures shall be agreed with the Employers Representative following consultation with the NPWS and IFI;

(iv) Works and/ or discharges from the works shall not recommence until written consent is received from the Employers Representative

(m) Where the Employers Representative considers that the risk of a sediment release is high, he/she shall inform the contractor and request protective action to be taken. Where the contractor does not take immediate action the Employers Representative shall instruct the contractor to take action and same shall be reported to the Contract Manager and the Client.

5.7 Emergency Procedures

5.7.1 Introduction

Prior to commencing works, the Contractor shall prepare an Emergency Response Plan based on a thorough risk assessment. The plan shall detail the procedures to be undertaken in the event of the release of any sediment into a watercourse, serious spillage of chemical, fuel or other hazardous wastes (e.g. concrete), non-compliance incident with any permit or license, or other such risks that could lead to a pollution incident, including flood risks.

5.7.2 Resources

Relevant staff, including cover staff, shall be trained in the implementation of the Emergency Response Plan and the use of any spill kit/ control equipment as necessary. The contractor shall provide a list of all such staff to the Employer's Site Representative detailing the name, contact number, and training received, and the date of that training.

The Contractor shall provide a full list, including the exact locations, of all pollution control plant and equipment to the Employer's Site Representative. All such plant and equipment shall be maintained in place and in working order for the duration of the works.

5.7.3 Spill Response

The Emergency Response Plan shall include a simplified Spill Response with the following as a minimum:

(1) Instruction to stop work;
(2) Instruction to contain the spill;
(3) Details of spill clean-up material location;
(4) Name and contact details of responsible staff;
(5) Measures particular to the location and the activity;
(6) Instruction to contact the Employers Representative (including Name and Contact Details).

This Spill Response shall be displayed at several locations throughout the site and at all sensitive locations.

The Employers Representative shall be responsible for notifying the IFI/NPWS and shall also determine if and when works may proceed once corrective actions have been completed.

6 Appendix 7.1: Chapter 7 (Main Report Reference);

Noise Methodology & Calculations

6.1 Appendix

6.1.1 Noise Monitoring Methodology

The following sound level meters were used during the noise monitoring surveys;

Table 6-1: Sound level meters were used during the noise monitoring surveys.

Sound Level Meters
Norsonic Nor140 (Serial No. 1402988 – Calibration Date – 09/02/2017)
Cirrus Optimus Green CR:171B (Serial No. G068599 - Calibration Date – 09/01/2018)
Bruel and Kjaer 2250L Sound Level Analyser (Serial No. 3002367- Calibration Date – 13/02/2017)

The sound level meter was placed at a height of approximately 1.5m and away from reflecting surfaces at each monitoring location. A wind shield was used on the microphone throughout the survey and the sound level meter was calibrated before and after the survey period.

The weather conditions recorded during the noise monitoring surveys were as follows;

Table 6-2: Weather conditions recorded during the noise monitoring surveys.

Monitoring Period	Description of Weather Conditions
Daytime – Wednesday 4th April	Breezy. Sunny. Clear skies. Cool. Temperature ~7°C.
Night-time – Wednesday 4th April / Thursday 5th April	Light Breeze. Clear skies. Cool. Temperature ~5°C.
Daytime – Thursday 5th April	Calm in morning, Getting breezier through the day. Sunny with cloudy periods. Clear skies. Cool. Temperature ~8°C.

6.1.2 Noise Monitoring L_{den} Calculations

N16 Baseline Noise Monitoring - 24 Hour Survey - Lden Calculations				
NSR Location Reference				
NML 1 (24 Hour Location 1)	**Survey Date - 4th / 5th April 2018**		**NML 1**	
Survey Time Period	**Survey Time**	**$L_{Aeq\ 1h}$(dB)**	**$L_{Aeq\ 1h}$(dB) Average**	**L_{den} (dB) Note 1**
L_{day}	7:00:00	53.2	**55.4**	**60.3**
	8:00:00	53.1		
	9:00:00	56.9		
	10:00:00	48		
	11:00:00	58.7		
	12:00:00	55.1		
	13:00:00	49.4		
	14:00:00	55.1		
	15:00:00	51.1		
	16:00:00	57.9		
	17:00:00	58.7		
	18:00:00	54.1		
$L_{evening}$	19:00:00	54.4	**55.1**	
	20:00:00	51.7		
	21:00:00	54.9		
	22:00:00	57.4		
L_{night}	23:00:00	57.4	**53.4**	
	0:00:00	57.5		
	1:00:00	51.1		
	2:00:00	48.3		
	3:00:00	48.6		
	4:00:00	50.1		
	5:00:00	50.4		
	6:00:00	52.4		
Note 1: $L_{den} = 10 \times \log_{10}(1/24)(12 \times 10^{Lday/10} + 4 \times 10^{(5 + Levening)/10} + 8 \times 10^{(10 + Lnight)/10})$ dB(A)				
Lday = 07:00 to 19:00 hours				
Levening = 19:00 to 23:00 hours				
Lnight - 23:00 to 07:00 hours				

N16 Baseline Noise Monitoring - 24 Hour Survey - Lden Calculations

NSR Location Reference			
NML 2 (24 Hour Location 2)	Survey Date - 4th / 5th April 2018	NML 2	

Survey Time Period	Survey Time	$L_{Aeq\ 1h}$(dB)	$L_{Aeq\ 1h}$(dB) Average	L_{den} (dB) Note 1
L_{day}	7:00:00	51.2	52.0	53.9
	8:00:00	52.5		
	9:00:00	49.9		
	10:00:00	52.5		
	11:00:00	50.8		
	12:00:00	52.8		
	13:00:00	53.6		
	14:00:00	52.2		
	15:00:00	54.0		
	16:00:00	52.4		
	17:00:00	49.9		
	18:00:00	48.8		
$L_{evening}$	19:00:00	48.5	46.2	
	20:00:00	46.7		
	21:00:00	44.8		
	22:00:00	42.6		
L_{night}	23:00:00	43.2	46.4	
	0:00:00	41.5		
	1:00:00	36.0		
	2:00:00	38.3		
	3:00:00	34.3		
	4:00:00	36.7		
	5:00:00	40.5		
	6:00:00	54.5		

Note 1: $L_{den} = 10 \times \log_{10}(1/24)(12 \times 10^{Lday/10} + 4 \times 10^{(5+Levening)/10} + 8 \times 10^{(10+Lnight)/10})$ dB(A)

Lday = 07:00 to 19:00 hours

Levening = 19:00 to 23:00 hours

Lnight - 23:00 to 07:00 hours

N16 Baseline Noise Monitoring - CRTN 15 Minute Surveys - Lden Calculations

NSR Reference	$L_{Aeq\ 15min}$ (dB)	$L_{A10\ 15min}$ (dB)	$L_{A90\ 15min}$ (dB)	$L_{A10\ (18hour)}$ (dB) Note 1	L_{den} (dB) Note 2	Monitoring Start Time	Description of Noise Sources
NML 3	61.9	59.0	44.6	57	**59**	11.20	Traffic noise dominant. Sheep bleating in field, dog barking, birdsong and leaf rustle. Approx. 75 - 80 vehicles with 10% HGV passing on N16 every 15 minutes
	58.1	57.8	44.2			12.52	
	57.6	58.2	45.0			14.32	
NML 4	54.8	53.9	44.4	53	**55**	11.48	Traffic noise dominant. Birdsong and leaf rustle. Approx. 75 - 80 vehicles with 10% HGV passing on N16 every 15 minutes
	51.7	52.2	44.7			13.20	
	55.0	55.0	45.0			14.53	
NML 5	60.9	65.1	49.6	64	**65**	12.12	Traffic noise dominant. Dog barking. Leaf rustle. Ocassional shot-blasting in nearby shed. Approx. 75 - 80 vehicles with 10% HGV passing on N16 every 15 minutes
	68.8	73.7	41.7			13.40	
	55.0	55.0	45.0			15.13	
NML 6	54.0	54.1	42.8	53	**55**	12.32	Traffic noise dominant. Birdsong and leaf rustle. Banging from nearby shed. Approx. 75 - 80 vehicles with 10% HGV passing on N16 every 15 minutes
	50.1	52.0	40.4			13.58	
	55.0	55.0	45.0			15.35	

Note 1: $L_{A10\ (18hour)}$ = (average of three L10 measurments) - 1

Note 2: $L_{den} = 0.86 \times L_{A10(18hr)} + 9.86$dB

NSR = Noise Sensitive Receptor

Noise measurements were taken in accordance with the *National Roads Authority:* Guidelines for the Treatment of Noise and Vibration in National Road Schemes

N16 Baseline Noise Monitoring - 24 Hour Surveys

		NML 1 (24 Hour Location 1)					NML 2 (24 Hour Location 2)						
Date	**Time**	**LAeq**	**LAmax**	**LAmin**	**LA10**	**LA90**	**LAeq**	**LAmax**	**LAmin**	**LA10**	**LA90**	**Wind Speed m/s**	**Rainfall (mm)**
04/04/2018	16:00:00	57.9	82.4	34.3	62.1	43.8	52.4	75.6	40.5	55.4	46.4	4.016	0
04/04/2018	17:00:00	58.7	74.8	37.3	63.9	45.3	49.9	75.1	39.4	52.7	43.5	3.254	0
04/04/2018	18:00:01	54.1	75.7	33.3	59.1	41.8	48.8	63.7	36.7	52.2	41.4	3.239	0
04/04/2018	19:00:01	54.4	81.8	36.5	57.5	43.9	48.5	65.2	35.2	51.8	40.8	3.88	0
04/04/2018	20:00:01	51.7	66	37.3	56	45.2	46.7	61.8	33.0	50.5	39.2	3.261	0
04/04/2018	21:00:01	54.9	67.1	36	59.4	44.7	44.8	59.3	29.9	48.5	36.8	2.949	0
04/04/2018	22:00:01	57.4	69.7	37.3	62.1	43.2	42.6	63.7	28.5	46.1	30.6	2.674	0
04/04/2018	23:00:01	57.4	68.7	36.3	61.5	42.5	43.2	62.4	28.3	45.5	29.5	3.147	0
05/04/2018	00:00:01	57.5	84.5	37.3	61	41.2	41.5	60.8	28.5	41.9	29.6	2.308	0
05/04/2018	01:00:01	51.1	71	38.6	54.5	43.8	36.0	60.6	28.5	38.2	29.6	1.804	0
05/04/2018	02:00:01	48.3	63.5	36.3	51.9	43.7	38.3	61.2	28.3	39.9	29.3	1.827	0
05/04/2018	03:00:01	48.6	59.1	38.4	52.1	44.4	34.3	56.7	28.3	34.8	29.3	2.064	0
05/04/2018	04:00:01	50.1	72.7	39.5	53.2	46.3	36.7	58.5	28.5	37.2	29.5	1.751	0
05/04/2018	05:00:01	50.4	70.7	37.8	54.3	45	40.5	63.6	28.7	40.7	33.7	2.529	0
05/04/2018	06:00:01	52.4	80.4	38.4	56.4	46.9	54.5	83.9	30.0	55.9	39.3	2.811	0
05/04/2018	07:00:01	53.2	74.6	38.1	57.8	45	51.2	65.2	30.7	55.6	38.7	3.117	0
05/04/2018	08:00:01	53.1	69.6	33.1	57.2	42.3	52.5	71.2	33.1	55.9	41.3	2.949	0
05/04/2018	09:00:01	56.9	72.8	34.1	62.9	41.3	49.9	62.9	30.7	54.0	38.5	3.277	0
05/04/2018	10:00:01	48	82.9	34.6	51.8	42.8	52.5	77.6	32.9	55.5	42.2	3.145	0
05/04/2018	11:00:01	58.7	81.8	34.5	64.1	41.8	50.8	65.1	35.6	54.3	41.4	3.086	0
05/04/2018	12:00:01	55.1	76.8	37.9	58.9	43.6	52.8	82.4	34.2	54.5	41.9	3.467	0
05/04/2018	13:00:01	49.4	85.5	38.3	52.7	45.1	53.6	75.5	34.9	56.1	42.4	3.605	0
05/04/2018	14:00:01	55.1	82.1	37.5	57.9	44	52.2	69.3	36.7	57.3	41.9	2.499	0
05/04/2018	15:00:01	51.1	73.3	37	54	43.6	54.0	79.7	36.4	57.1	41.4	3.812	0

7 Appendix 9.1: Chapter 9 (Main Report Reference);

Annex I Wetland Survey

N16 LUGATOBER:
ANNEX I WETLAND SURVEY 2018

November 2018

Report produced by Denyer Ecology for:
Sligo TII National Roads Project Office

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CONTENTS

1 INTRODUCTION

Denyer Ecology was commissioned to undertake a targeted assessment of Annex I wetland habitats (including Priority Habitats) on the N16 Lugatober Proposed Road Development (EIA). This work follows previous work which undertaken by Denyer Ecology in 2016 as part of the wider N16 Sligo to County Boundary Route Selection Report. The Lugatober Project comprises a 2.5km stretch, selected out of the Emerging Preferred Route.

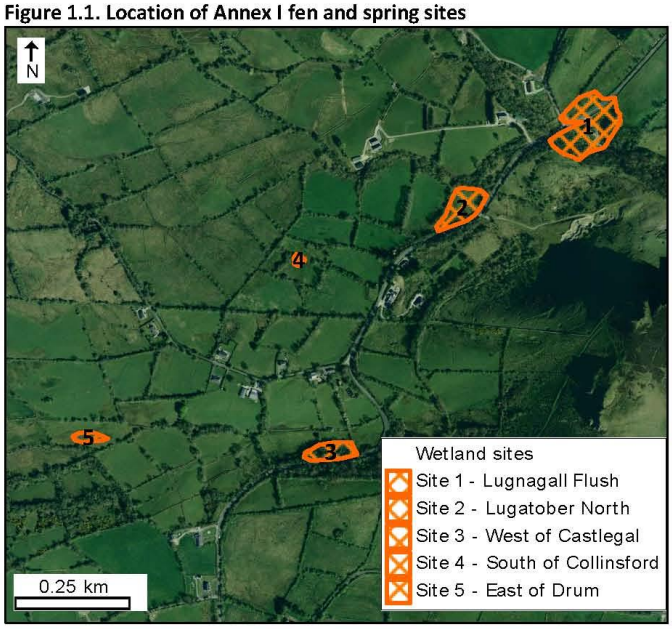
There are five wetland sites located within the potential zone of influence of the Proposed Road Development (shown on Figure 1.1). These support the priority Annex I habitats '*Petrifying springs with tufa formation*' [7220] and '*Alkaline fens*' [7230]:

- Wetland Site No. 1: Lugnagall Flush - Annex I alkaline fen and petrifying spring habitats.
- Wetland Site No. 2: Lugatober North – Annex I petrifying springs within wet grassland and woodland.
- Wetland Site No. 3: West of Castlegal (Lugatober) – Annex I petrifying springs within woodland.
- Wetland Site No. 4: South of Collinsford – wetland valley vegetation with affinity to Annex I petrifying springs and Annex I alkaline fen.
- Wetland Site No. 5. East of Drum – wetland vegetation in depression in wet grassland with affinity to Annex I alkaline fen.

Annex I wetland habitats at sites 1, 2, 4 and 5 were surveyed and mapped by Denyer Ecology in 2016. Sites which are in close proximity to the Proposed Road Development were re-surveyed in 2018, including site 3 which was not surveyed in 2016. The aims of the 2018 survey were to:

- Update the 2016 botanical and bryological surveys of the wetland vegetation at sites 1 and 2.
- Undertake detailed relevé sampling of representative Annex I wetland habitats at each site.
- Assess the current condition and potential sensitivities of the springs.
- Provide a baseline for future monitoring if necessary.

Figure 1.1. Location of Annex I fen and spring sites



2 METHODOLOGY

2.1 Habitat survey

At each site, wetland (fen and spring) habitats of potential conservation interest were walked over by an ecologist. The main vascular plant and bryophyte species present were recorded. The focus was on the most abundant species, indicator species and rare/ protected species and therefore the species lists do not necessarily list all flora species present. All wetland sites of interest were classified using *A Guide to Habitats in Ireland* (Fossitt, 2000) and additional habitat specific classification systems as relevant e.g. *Irish Petrifying Spring Communities* (Lyons, 2015; Lyons & Kelly 2017). Since the 2016 surveys, guidelines for the assessment of petrifying springs have been published (Lyons & Kelly, 2016) and these monitoring methods were followed for the 2018 detailed spring surveys.

2.2 Detailed relevé

Detailed botanical survey (relevé sampling) was undertaken at each site. At Lugnagall Flush, one relevé was undertaken in the petrifying spring area and one relevé in the alkaline fen area. At W of Castlegal, one relevé was undertaken in the westernmost (and most developed) petrifying spring in the woodland. At Lugatober North, one relevé was undertaken in the main spring in the north-east of the site. The relevés were positioned to contain representative spring vegetation in each habitat. The following were recorded from within the relevé and adjacent vegetation (as relevant):

- Grid reference
- Relevé aspect and slope
- Spring water pH and Electrical Conductivity (measured, where possible, from flowing water in field using handheld device)
- Tufa type and cover in relevé
- Water type and cover in relevé
- Surface cover of vegetation, bare tufa, leaf litter, bare soil and stone etc.
- Vascular plant, bryophyte and *Chara* species presence and percentage cover
- Presence and cover of other algae (not *Chara*) (not identified)
- Woody species and canopy cover
- Vegetation height

2.3 Condition assessment

2.3.1 Petrifying springs [7220]

The condition of the springs and their 'Conservation Score' was assessed using the '*Monitoring Guidelines for the Assessment of Petrifying Springs in Ireland*' (Lyons & Kelly, 2016).

2.3.2 Alkaline fen [7230]

There are currently no standard published guidelines for the assessment of alkaline fen in Ireland. The currently accepted method is to use the '*Guidelines for a national survey and conservation assessment of upland vegetation and habitats in Ireland* (Perrin et al., 2014). These were developed for upland survey but have been found to be relevant for lowland fen examples.

2.4 Ecological evaluation criteria

The ecological importance of the survey area was assessed using the criteria listed in the *Guidelines for Assessment of Ecological Impacts of National Roads Schemes* (NRA, 2009) and the *Guidelines for Ecological Impact Assessment in the UK and Ireland* (CIEEM, 2016). The assessment was based on the presence and quality of the Annex I fen and spring habitats and associated species and does not taken into account fauna species.

Ecological evaluation scheme:

- International ecological importance
- National ecological importance
- County ecological importance

- Local (higher value) ecological importance
- Local (lower value) ecological importance

2.5 Plant species nomenclature

Vascular plant nomenclature will follow that of the *New Flora of the British Isles*. 3rd Edition (Stace, 2010). The bryophyte nomenclature adopted by Blockeel et al. (2014a & b) is used; this is based on the *Checklist of British and Irish bryophytes* (Hill et al., 2008) with minor modifications to reflect recent taxonomic changes.

2.6 Constraints

The optimal time to survey fen and spring habitats is between May to September. Surveys of sites 1 and 2 were undertaken in mid-May. However, due to poor spring weather, the flowering plant season was late in 2018. Survey of site 3 was undertaken in late September. It is therefore possible that some species will have been missed. It is not considered that this will affect the results of the evaluation and condition assessment.

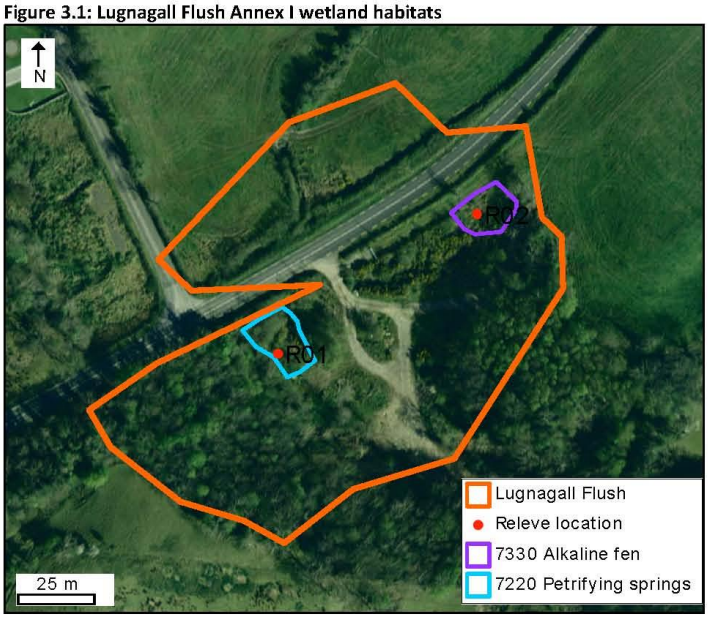
3 2018 SURVEY RESULTS

3.1 Wetland Site 1: Lugnagall Flush

3.1.1 Mapping and relevé location

The petrifying spring (7220) and alkaline fen (7230) habitats at Lugnagall Flush were mapped in 2016. There was no change in the area of each habitat in 2018 (Figure 3.1). Relevé locations are shown on Figure 3.1. The results from the 2018 detailed relevé survey are included in Appendix B; and the data from the 2016 survey is included in Appendix C. These results can be also used as a baseline for any future monitoring. It should be noted that, as in the 2016 survey, no Annex I spring or fen habitats were recorded to the north of the road due to agricultural improvement and drainage (Appendix C).

Figure 3.1: Lugnagall Flush Annex I wetland habitats



Aerial Photography licence No. 2010/20 CCMA/ Sligo County Council

3.1.2 Condition assessment of Annex I spring habitat

The spring area in the west of the site (Figure 3.1) is considered to support the Annex I habitat 'Petrifying springs' due to the presence of some typical petrifying spring vegetation and occasional tufa. The spring vegetation has most affinity to **Group 4 *Palustriella commutata-Agrostis stolonifera* springheads vegetation community** (Lyons & Kelly, 2017). The relevé was located in the best example of spring vegetation remaining in this area (R01; Figure 3.1). The species richness for the relevé was 23, including 8 positive indicator species. For comparison, a mean species richness of 20, was recorded by Lyons (Lyons, 2015) for that vegetation community in a survey of tufa springs across Ireland. The relevé at Lugnagall has typical species composition and diversity for this vegetation community and the cover of the main indicator species *Palustriella commutata* (15%) is within the recorded range (10-95%). However, this relevé was positioned in the best example of spring vegetation at the site and cover of typical tufa species was lower across the general spring area. The relevé failed on two criteria: presence of regenerating woody species (Ash *Fraxinus excelsior*) and water flow. Water flow from the spring is being abstracted by a pipe from the spring at the source (Photograph 1.4; Appendix B). The presence of regenerating woody species suggests that the spring area is drying out. The Conservation Score for the spring (Lyons & Kelly, 2016) is 3, which ranks it as 'Moderate Conservation Value' (52.3% of springs surveyed nationally were ranked as moderate; Lyons & Kelly, 2016).

3.1.3 Condition assessment of Annex I fen habitat

The remnant wetland area in the east of the site (Figure 3.1) is considered to support the Annex I habitat 'Alkaline fen' due to the presence of some typical alkaline fen vegetation. However, the areas of typical fen vegetation are localised and occur in a mosaic with wet grassland and scrub. The fen/ flush vegetation has most affinity to **RFLU4 *Schoenus nigricans–Scorpidium scorpioides* flush** (Perrin et al., 2014). *Schoenus nigricans* and *Schoenus nigricans* are absent, but the vegetation has a tall structure (with Molinia caerulea) typical of this community. The relevé was located in the best example of fen vegetation remaining in this area (R02; Figure 3.1). The species richness for the relevé was 31, including 1 'brown' moss and 3 positive indicator species. The relevé at Lugnagall supports some typical species for this vegetation community, but grades into less species rich wet grassland and brown mosses are rare. The relevé was positioned in the best example of spring vegetation at the site and cover of typical fen species was lower across the general fen area. The wetland is becoming overgrown with scrub and trees. The relevé failed on three criteria: cover of positive indicator species and brown mosses; cover of scattered tress and scrub; and, drainage impacts in the local vicinity. There is a well and water abstraction from a spring to the south of the fen area which may be impacting on the vegetation (Photo 2.5; Appendix B).

3.1.4 Change in Annex I fen and spring habitat

Historic mapping from 1888-1913 (25" OSI mapping accessed online) shows three springs in the area to the south of the road. One is in the position of the current remnant spring area, one in the fen area and one in a central area. The central area has now been destroyed by infilling, but surface water presence in the 2018 survey suggested that there may be a spring in this area. In addition there is some vegetation with affinity to Annex I petrifying springs habitat in the small area of wet woodland to the south (east of the remnant spring area). There was a waterpipe in a watercourse adjacent to this area that had abundant *Palustriella commutata* on the joins in the pipe, suggesting that the water leaking from it is alkaline spring water.

Aerial photography from 1995 and 2000 (OSI mapping accessed online) shows a large area of wetland vegetation to the south of the road, from the spring area in the west to the remnant fen area in the east. By 2005, roads had been created into this area, separating the fen and spring areas.

The site was surveyed in 2011 (Wilson, 2011; Appendix D). At this time it was stated that the fen had been damaged by infilling and drainage works. There was a small remnant of fen to the north of the road which had reverted to wet grassland by 2016 (Denyer, 2016; Appendix C). The spring area to the south of the road was described as having an area of 2m x 8m that was intact and species rich. The photograph of the spring in this area (Appendix D) shows that the spring vegetation was very open, with abundant *Palustriella commutata* and extensive tufa formation. In additional site photographs

from 2011 (provided by Faith Wilson and Peter Foss), the blue water pipe, which abstracts water from the spring source, is visible and appears to be relatively newly installed. There was a small tree below the springhead which has now been removed.

In 2016 the vegetation in the spring area had become taller and less species rich with a higher proportion of grassland species. Tufa formation was present, but less abundant than in 2011. By 2018 however, there was very little tufa formation recorded from the spring area (one small area recorded) and typical spring bryophytes (such as *Palustriella falcata*) were much less frequent overall in the site. Interestingly, the number of positive Annex I spring indicators species has remained consistent in this area since 2011 (Table 3.1), with 10-12 species recorded in each survey. The slight increase in the 2018 survey is probably due to higher survey effort as a detailed relevé was recorded. Therefore, whilst the overall frequency and local abundance of the spring vegetation has declined, the spring area still has high affinity to the Annex I priority habitat 'petrifying springs'.

The fen area was not recorded in the 2011 survey. The vegetation has not changed significantly since 2011, with 4 positive Annex I spring indicators species recorded in each year (Table 3.2). No brown mosses were recorded in 2011. It is likely that the small amount of *Palustriella commutata* present at the site in 2018 was overlooked in 2016 (as there was no detailed relevé survey), rather than being a new arrival.

Table 3.1. Number of Annex I petrifying spring positive indicator species recorded 2011-2018

Survey year	2011	2016	2018
Positive indicator sp. (bryophytes)	3 species recorded: *Campylium stellatum* *Palustriella commutata*	4 species recorded: *Bryum pseudotriquetrum* *Palustriella commutata* *Palustriella falcata* *Pellia endiviifolia*	7 species recorded: *Aneura pinguis* *Bryum pseudotriquetrum* *Campylium stellatum* *Fissidens adianthoides* *Palustriella commutata* *Palustriella falcata* *Pellia endiviifolia*
Positive indicator sp. (vascular plants & Chara)	8 species recorded: *Anagallis tenella* *Carex panicea* *Carex lepidocarpa* *Chara* sp.[1] *Equisetum telmateia* *Eriophorum latifolium* *Festuca rubra*[2] *Parnassia palustris*	6 species recorded: *Anagallis tenella* *Carex lepidocarpa* *Carex panicea* *Chara vulgaris* *Equisetum telmateia* *Festuca rubra*	5 species recorded: *Anagallis tenella* *Carex lepidocarpa* *Chara vulgaris* *Equisetum telmateia* *Festuca rubra*
Total positive indicators	**10 species**	**10 species**	**12 species**

[1]Likely to be *Chara vulgaris*; [2]Not included in the site species list, but present in survey photographs
NB the species list refers to the whole habitat area as there was no relevé survey in 2011 or 2016.

Table 3.2. Number of Annex I alkaline fen positive indicator species recorded 2016-2018

Survey year	2016	2018
Brown moss species	0 species recorded	1 species recorded: *Palustriella commutata*
Positive indicator sp. (vascular plants & Chara)	4 species recorded: *Anagallis tenella* *Carex dioica* *Carex lepidocarpa* *Molinia caerulea*[2]	3 species recorded: *Carex panicea* *Carex lepidocarpa*[1] *Molinia caerulea*
Total positive indicators	**4 species**	**4 species**

[1]Previously known as *Carex viridula* sp. *brachyrrhyncha*
[2]Not included in the site species list, but present in survey photographs
NB the species list refers to the whole habitat area as there was no relevé survey in 2016.

3.1.5 Future prospects of Annex I fen and spring habitat

The main factors affecting the condition of alkaline fen and petrifying spring habitats are water quality (e.g. pH, mineral composition and nutrient levels), water quantity (e.g. flow rate), disturbance and grazing. At Lugnagall Flush the main historic factors negatively impacting the wetland habitats have been infilling and water abstraction. In the absence of any development or activity, such as those related to the N16 Lugatober Proposed Road Development, the main future impact is likely to be the loss of fen and spring species and invasion of tall grasses and woody vegetation as a result of the continued drying of the habitat from water abstraction, compounded by a lack of grazing. There were frequent signs of dumping in the area of the springs. This can directly impact springs through habitat loss but may also impact on water chemistry by increasing nutrients and introducing pollutants. The spring area has shown a significant change in the quality and quantity of spring vegetation since 2011 and even 2016 and is likely to continue to deteriorate in the next few years. To maintain the Annex I fen and spring habitats the water supply needs to be enhanced (removal or reduction of abstraction) and infilling around the wetland areas to be halted.

3.1.6 Ecological evaluation

Lugnagall Flush was ranked as 'Site rating B' Nationally Important in the Sligo Wetland Survey (2011), despite recent degradation. The spring area corresponds with the Annex I priority habitat 'Petrifying springs' and the fen area corresponds to the Annex I habitat 'Alkaline fen'. The site also overlaps with Crockaun/ Keelogbuy Bogs NHA. However, the site has clearly degraded further since 2011 (and 2016), with the loss of any calcareous springs/ rich fen on the northern side of the road and a reduction in size and tufa formation in the spring area on the southern side of the road. There was little tufa and low cover of the tufa bryophyte *Palustriella commutata* present in 2018, despite tufa being relatively abundant in the 2011 survey. Water abstraction is ongoing, and the wetland areas are likely to degrade further. It is therefore now considered to be of **County ecological importance**.

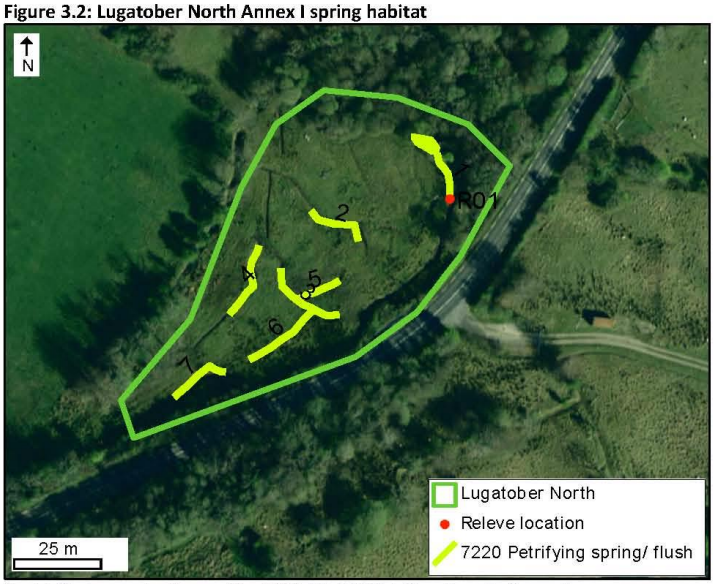
3.2 Wetland Site 2: Lugatober North

3.2.1 Description, mapping and relevé location

The petrifying spring (7210) habitats within wet grassland and woodland at Lugatober North were mapped in 2018 (Figure 3.3). There is one main spring (1), with obviously flowing water, in the north-east of the site and the relevé (R01) was undertaken in this spring (Figure 3.2). In addition, there are a number of smaller springs (2-7) within a network of apparently man-made channels throughout the site (Figure 3.2). The results from the 2018 detailed relevé survey, spring descriptions and photographs are included in Appendix E. These results can be also used as a baseline for any future monitoring.

Historic mapping from 1888-1913 and aerial photography (OSI mapping accessed online) suggest that the area where spring 2 is located has supported some scattered trees/ scrub since the late 19th century. Aerial photography from 1995 to at least 2005 shows scrub in the area of springs 2-7. It is highly likely that the field supported fen/ spring vegetation with scattered scrub, which was cleared and drained at some point in the last 10 years. The drainage channels have subsequently formed the springs 2-7. Spring 1 (main spring) may be older as it appears more natural and had the highest flow and species diversity of all the springs on site. Tufa formation and positive indicator species for the Annex I habitat 'Petrifying springs' were frequent in all springs.

Figure 3.2: Lugatober North Annex I spring habitat



Aerial Photography licence No. 2010/20 CCMA/ Sligo County Council

3.2.2 *Condition assessment of Annex I spring habitat*

All of the springs at Lugatober North (Figure 3.2) are considered to be examples of the Annex I habitat 'Petrifying springs' due to the presence of typical petrifying spring vegetation and locally frequent tufa. The spring vegetation has most affinity to Group 4 *Palustriella commutata-Agrostis stolonifera* Springheads vegetation community (Lyons & Kelly, 2017). The relevé was located in the best spring example (R01, spring 1, Figure 3.2). This spring had the highest water flow, cover of tufa, cover of the typical tufa bryophyte *Palustriella commutata,* frequency of additional positive indicator species and diversity. The species richness for the relevé was 30, including 12 positive indicator species. For comparison, a mean species richness of 20, was recorded by Lyons (Lyons, 2015) for that vegetation community in a survey of tufa springs across Ireland. The relevé at Lugatober North has typical species composition for this vegetation community but has high diversity. The cover of the main indicator species *Palustriella commutata* (35%) is within the recorded range (10-95%) and was present throughout most of the unwooded section of channel. The relevé passed on all condition assessment criteria (Appendix E) and is considered to be in good condition. The Conservation Score for the main spring (01) (Lyons & Kelly, 2016) was 6, which ranks it as 'High Conservation Value' (33.0% of springs surveyed nationally were ranked as moderate; Lyons & Kelly, 2016). Species diversity and tufa formation in the drainage channels (02-07) were lower and these would rank as 'Moderate Conservation Value'.

3.2.3 *Future prospects of Annex I fen and spring habitat*

The main factors affecting the condition of petrifying spring habitats are water quality (e.g. pH, mineral composition and nutrient levels), water quantity (e.g. flow rate), disturbance and grazing. There were no obvious current threats or pressure to spring vegetation at this site (although there has probably been historic drainage at the site). In the absence of any development or activity, such as those related to the N16 Lugatober Proposed Road Development, there is no predicted future change to the springs.

3.2.4 Ecological evaluation

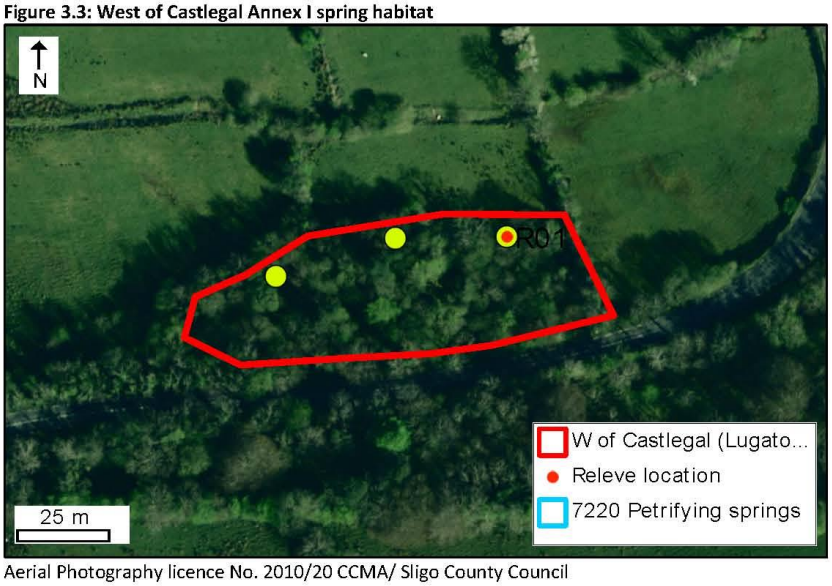
The springs Lugatober North are good examples of an Annex I priority habitat and are relatively extensive at the site. The main spring (01) has high species diversity for this spring vegetation community. The site is therefore considered to be of **National ecological importance.**

3.3 Wetland Site 3: Springs west of Castlegal (Lugatober)

3.3.1 Mapping and relevé location

The petrifying spring (7220) habitats within woodland at West of Castlegal were mapped in 2016. There was no change in the area/ location of each spring in 2018 (Figure 3.3). Relevé location is shown on Figure 3.3. The results from the 2018 detailed relevé survey are included in Appendix F; and the data from the 2016 survey is included in Appendix G. These results can be also used as a baseline for any future monitoring.

Figure 3.3: West of Castlegal Annex I spring habitat



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3.3.2 Condition assessment of Annex I spring habitat

The springs within the woodland (Figure 3.3) are considered to be examples of the Annex I habitat 'Petrifying springs' due to the presence of typical petrifying spring vegetation and locally abundant tufa. The spring vegetation has most affinity to Group 2 *Palustriella commutata-Geranium robertianum* Springheads vegetation community (Lyons & Kelly, 2017). The relevé was located in the best spring example (R01; Figure 3.3). This spring had the most well-developed tufa formation and cover of the typical tufa bryophyte *Palustriella commutata*. The species richness for the relevé was 15, including 3 positive indicator species. For comparison, a mean species richness of 14, was recorded by Lyons (Lyons, 2015) for that vegetation community in a survey of tufa springs across Ireland. The relevé at W of Castlegal has typical species composition and diversity for this vegetation community, with typical species *Palustriella commutata, Carex remota* and *Equisetum telmateia* locally abundant. The cover of the main indicator species *Palustriella commutata* (25%) is within the recorded range (25-95%) for this community. The relevé did not fail any criteria in the condition assessment (Appendix F) and is considered to be in good condition with no current negative threats or pressures. The

Conservation Score for the spring (Lyons & Kelly, 2016) is 4, which ranks it as 'Moderate Conservation Value' (52.3% of springs surveyed nationally were ranked as moderate; Lyons & Kelly, 2016).

3.3.3 Change in Annex I spring habitat

There were no obvious changes to the vegetation in comparison with the 2016 survey results. The number of positive Annex I spring indicators species has remained consistent in this area since 2016 (Table 3.3), with 4 species recorded in each survey. The typical tufa bryophyte *Fissidens adianthoides* was not recorded in 2016 and similarly *Pellia endiviifolia* was not recorded in 2018. These are small bryophytes that are easily overlooked when they have low cover and are highly likely to have been present in the spring(s) in both years. The slight increase in the 2018 survey is probably due to higher survey effort as a detailed relevé was recorded. Therefore, the woodland springs at this site still have high affinity to the Annex I priority habitat 'petrifying springs'.

Table 3.3. Number of Annex I petrifying spring positive indicator species recorded 2011-2018

Survey year	2016	2018
Positive indicator sp. (bryophytes)	2 species recorded: *Fissidens adianthoides* *Palustriella commutata*	2 species recorded: *Palustriella commutata* *Pellia endiviifolia*
Positive indicator sp. (vascular plants & Chara)	2 species recorded: *Crepis paludosa* *Equisetum telmateia*	2 species recorded: *Crepis paludosa* *Equisetum telmateia*
Total positive indicators	**4 species**	**4 species**

NB the species list refers to the whole habitat area (three springs) as there was no relevé survey in 2016.

3.3.4 Future prospects of Annex I fen and spring habitat

The main factors affecting the condition of petrifying spring habitats are water quality (e.g. pH, mineral composition and nutrient levels), water quantity (e.g. flow rate), disturbance and grazing. There were no obvious threats or pressure to spring vegetation at this site and no changes were recorded since the 2016 survey. In the absence of any development or activity, such as those related to the N16 Lugatober Proposed Road Development, there is no predicted future change to the springs.

3.3.5 Ecological evaluation

The springs at W of Castlegal were ranked in 2016 as being of **County ecological importance** as they are an example of an Annex I priority habitat but are relatively small and localised. There has been no change in the condition of the springs since 216 and therefore there is no change to this evaluation.

4 POTENTIAL IMPACTS FROM N16 LUGATOBER PROPOSED ROAD DEVELOPMENT

A summary of the potential impacts on Annex I wetland habitats resulting from the construction and operation of the N16 Lugatober Proposed Road Development is given in Table 3.4. This is a summary only and the full impact assessment and mitigation measures are included in Chapters 9 Biodiversity and 11 Hydrology and hydrogeology of the EIAR.

Three of the wetland sites (Sites 1, 2 & 3) are in close proximity (within 30m) of the proposed N16 Lugatober Proposed Road Development. There is the potential for both construction and operational impacts on these sites as a result of the Proposed Road Development. Sites 3 and 4 are located further from the Proposed Road Development and there will be no construction impacts. However, there is the potential for operational impacts, from hydrological regime change for instance. The Proposed Road Development has been designed to reduce potential impacts on Annex I wetland habitats. Where these cannot be avoided through design (e.g. disturbance and dust from construction), suitable mitigation measures have been specified to avoid all significant construction and operational impacts to Annex I wetland habitats (Table 3.4).

Table 3.4. Summary of potential impacts to Annex I wetland sites

Site	Ecological Value	Proximity to Proposed Road Development	Potential construction impacts	Potential operation impacts	*Residual impacts
1. Lugnagall Flush	County	Within c10m of the spring area (to the north) and c20m north from the nearest spring source	• Direct loss of habitat • Direct disturbance • Dust impacts • Surface water run-off	• Change to recharge area • Change to drainage • Surface water run-off • Accidental spillage	No significant impacts
2. Lugatober North	(National)	Within c15m of the spring area (to the south/ south-east)	• Direct loss of habitat • Direct disturbance • Dust impacts • Surface water run-off	• Change to recharge area • Change to drainage • Surface water run-off Accidental spillage	No significant impacts
3. West of Castlegal	(County)	Within c30m of the spring area (to the north)	• Direct loss of habitat • Direct disturbance • Dust impacts Surface water run-off	• Change to recharge area • Change to drainage • Surface water run-off • Accidental spillage	No significant impacts
4. South of Collinsford	(County)	Within 75m of the fen/ spring area (to the north-west)	None	• Change to recharge area	No significant impacts
5. East of Drum	Local (higher)	Within 320m of the fen/ spring area (to the west)	None	• Change to recharge area	No significant impacts

*Full impact assessment details in Chapters 9 Biodiversity and 11 Hydrology and hydrogeology.

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APPENDIX A:
ANNEX I FEN AND SPRING INDICATOR SPECIES

Appendix A – Annex I fen and spring indicator species

The lists of indicator species used to assess the condition of Annex I fen and spring habitats (Table 1) were taken from the *Monitoring guidelines for the assessment of petrifying springs in Ireland* (Lyons and Kelly, 2016) and *Guidelines for a national survey and conservation assessment of upland vegetation and habitats in Ireland.* Version 2.0. (Perrin et al., 2014) for alkaline fen.

Table 1. Indicator species for Annex I fen and spring habitats

Indicator species type	Indicator species
***Petrifying springs with tufa formation *(Cratoneurion)* (7220)**	
High quality indicator species	*Catoscopium nigritum* *Hymenostylium recurvirostrum* var. *insigne* *Leiocolea bantriensis* *Orthothecium rufescens* *Saxifraga aizoides* *Seligeria oelandica* *Seligeria patula* *Tomentypnum nitens*
Positive indicator species - bryophytes	*Aneura pinguis* *Bryum pseudotriquetrum* *Campylium stellatum* *Didymodon tophaceus* *Eucladium verticillatum* *Fissidens adianthoides* *Jungermannia atrovirens* *Palustriella commutata* *Palustriella falcata* *Pellia endiviifolia* *Philonotis calcarea* *Scorpidium cossonii* *Scorpidium scorpioides*
Positive indicator species – vascular plants & charophytes	*Anagallis tenella* *Carex lepidocarpa* *Carex panicea* *Chara vulgaris* *Chrysosplenium oppositifolium* *Crepis paludosa* *Equisetum telmateia* *Equisetum variegatum* *Eriophorum latifolium* *Festuca rubra* *Parnassia palustris* *Pinguicula vulgaris* *Selaginella selaginoides*
Typical accompanying species – bryophytes	*Breutelia chrysocoma* *Calliergonella cuspidata* *Ctenidium molluscum* *Leiocolea turbinata* *Plagiomnium elatum* *Pohlia wahlenbergii* *Riccardia chamedryfolia* *Trichostomum crispulum*

Appendix A – Annex I fen and spring indicator species

Indicator species type	Indicator species
Typical accompanying species – vascular plants	*Agrostis stolonifera* *Bellis perennis* *Cardamine pratensis* *Carex flacca* *Cirsium palustre* *Epilobium parviflorum* *Eriophorum angustifolium* *Filipendula ulmaria* *Geranium robertianum* *Hypericum tetrapterum* *Juncus articulatus* *Juncus inflexus* *Leontodon autumnalis* *Mentha aquatica* *Nasturtium officinale* agg. *Poa trivialis* *Primula vulgaris* *Prunella vulgaris* *Ranunculus flammula* *Ranunculus repens* *Sesleria caerulea* *Succisa pratensis* *Tussilago farfara* *Veronica beccabunga*
Negative indicator species - bryophytes	*Brachythecium rivulare* *Cratoneuron filicinum* *Platyhypnidium riparioides*
Negative indicator species - vascular plants	*Apium nodiflorum* *Dactylis glomerata* *Epilobium brunnescens* *Epilobium hirsutum* *Eupatorium cannabinum* *Heracleum sphondylium* *Juncus effusus* *Petasites hybridus* *Phragmites australis* *Rumex obtusifolius* *Urtica dioica*
Alkaline fens (7230)	
Brown mosses	*Bryum pseudotriquetrum* *Calliergon sarmentosum* *Campylium stellatum* *Ctenidium molluscum* *Drepanocladus revolvens* *Fissidens adianthoides* *Palustriella commutata* *Palustriella falcata* *Scorpidium cossonii* *Scorpidium scorpioides*
Small-sedge flushes	*Carex panicea* *Carex viridula* *Eleocharis quinqueflora* *Juncus bulbosus* *Pinguicula vulgaris*

Appendix A – Annex I fen and spring indicator species

Indicator species type	Indicator species
***Schoenus flush* and *Carex rostrata* fen**	*Anagallis tenella* *Carex dioica* *Carex lasiocarpa* *Carex panicea* *Carex viridula (Carex lepidocarpa)* *Carex rostrata* *Cirsium dissectum* *Molinia caerulea* *Pinguicula vulgaris* *Schoenus nigricans* *Selaginella selaginoides*

Lyons, M.D. & Kelly, D.L. (2016) Monitoring guidelines for the assessment of petrifying springs in Ireland. Irish Wildlife Manuals, No. 94. National Parks and Wildlife Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs, Ireland.

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APPENDIX B - LUGNAGALL SPRING AND FEN SURVEY AND CONDITION ASSESSMENT RESULTS 2018

SITE AND SPRING DETAILS

Site name: Lugnagall Flush (spring)	**Spring name:** Spring 01	**Relevé No.:** R01
Survey date: 17/05/18	**Relevé dimensions:** 2m x 2m	**Relevé area:** 4m^2
Grid reference: G 72484 41609	**Spring type:** Flush	
Slope: c 5°	**Altitude (m):** c100m	**Aspect:** NE
pH: 7.64	**EC:** 1490 µS/cm	**Temp.:** 10.9°C

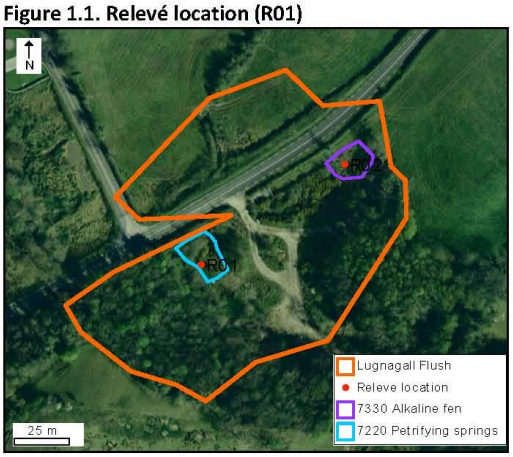
Spring description:

This site supports a small spring and flush area that is a remnant of a larger area of spring, fen and flush, but which has been disturbed by dumping, woodland removal, road creation, soil movement and water abstraction. The site is bordered by the N16 to the north, small areas of wet woodland to the east and west and disturbed ground to the south. The spring emerges on the southern border of the remnant wetland area but is not visible as concrete has been placed over the top of the spring. A water pipe (blue) flows downhill from the spring origin (Photograph 1.4). Spring water leaks from the pipe at various locations and therefore there is a small channel through which water flows down the hill, adjacent to the pipe. This is the main remnant wetland area within the site. To the east of the pipe, there are a few areas with typical spring vegetation within vegetation that is otherwise best described as wet grassland. These occur in localised wet areas, some of which are flushed and quaking. There is very little tufa within the remnant spring vegetation at the site, one small area in the NW of the site (close to the woodland to the west) was the only tufa observed (Photograph 1.5). The spring vegetation extends into the woodland to the west of the wetland area. There is no spring vegetation at the springhead as it has been capped with concrete and the water abstracted. In the localised wet areas, spring vegetation is characterised by species such as the bryophytes *Palustriella commutata*, *P. falcata, Bryum pseudotriquetrum, Aneura pinguis* and *Campylium stellatum*; the charophyte *Chara vulgaris*; and vascular plants *Equisetum telmateia, Mentha aquatica, Anagallis tenella, Carex lepidocarpa* and *Festuca rubra*. Additional species in the adjacent wet grassland/ fen include the vascular plants: *Agrostis stolonifera, Angelica sylvestris, Apium nodiflorum, Cardamine pratensis, C. flacca, C. panicea, Cirsium palustre, Deschampsia cespitosa, Epilobium hirsutum, Eriophorum angustifolium, Juncus articulatus, Potentilla erecta, R. repens, Molinia caerulea* and *Succisa pratensis* and the mosses *Breutelia chrysocoma, Calliergonella cuspidata, Hylocomium splendens, Philonotis fontana* and *Plagiomnium elatum.* The spring vegetation has most affinity to **Group 4 *Palustriella commutata-Agrostis stolonifera* Springheads** vegetation community (Lyons & Kelly, 2017).

Relevé location:

The relevé (red circle, Photograph 1.1) is located in the western part of the spring complex (Figure 1.1). This is a very wet area with flowing water at the time of survey. It located to the north (and downslope) of the spring origin, which is on the southern border of the spring complex area. The red line shows the approximate direction of flow from the spring to the relevé location. This location had some of the best spring vegetation within the complex, although tufa formation was not present within the relevé (Photographs 1.2-1.3)

Figure 1.1. Relevé location (R01)



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APPENDIX B - LUGNAGALL SPRING AND FEN SURVEY AND CONDITION ASSESSMENT RESULTS 2018

Photograph 1.1. Relevé location in spring area (view to SW)

DETAILED RELEVÉ

Physical characteristics

Tufa	% Cover	Water	% Cover	Surface	% Cover
Cascade	0	Flowing/ trickling	30	Living field/ ground flora	75
Paludal (1)	-	Pool/ standing water	-	Bare tufa (active/ recent)	-
Stream crust	-	Dripping	-	Ancient/ inactive tufa	-
Oncoids/ ooids	-	Damp	70	Leaf litter/ standing dead	20
Dam	-	Dry, not impacted by spring	-	Bare soil	5
Cemented rudites	-	Other:	-	Bare stone	-
Non-tufa	100			Other:	-
TOTAL	**100**	**TOTAL**	**100**	**TOTAL**	**100**

Paludal tufa: 1 = weak/ thin/ discontinuous, 3 = strongly forming/ continuous/ conspicuous
Cover values: record to nearest 5%. If <5% then use 3%, 1% 0.5%, 0.1%

Shrub/ canopy layer

Species	Routed outside Canopy (%)	Routed inside Canopy (%)	Routed inside Height (m)
Alnus glutinosa	1	-	-
Ulex europaeus	<1%		
Fraxinus excelsior (seedling)	1%		
TOTAL CANOPY (ROOTED INSIDE + ROOTED OUTSIDE) %	**TOTAL %: <2%**	**TOTAL %**	**TOTAL %**
MAX HEIGHT (m) ABOVE QUADRAT (ROOTED INSIDE + ROOTED OUTSIDE):			**5**

Field/ ground flora

FORBS	%	GRAMINOIDS	%	BRYOPHYTES	%	WOODY	%
Apium nodiflorum	8	*Agrostis stolonifera*	5	*Brachythecium rutabulum*	1	*Fraxinus excelsior*	<1
Mentha aquatica	15	*Deschampsia cespitosa*	<1	*Calliergonella cuspidata*	1		
Ranunculus repens	1	*Festuca rubra*	4	*Cratoneuron filicinum*	1		
Succisa pratensis	<1	*Carex lepidocarpa*	1	*Breutelia chrysocoma*	5	**TOTAL WOODY <50cm**	**<1**
Angelica sylvestris	<1	*Holcus lanatus*	5	*Palustriella commutata*	15		
Ficaria verna	<1			*Pellia endiviifolia*	1	**PTERIDOPHYTES**	
				Kindbergia praelonga	<1	*Equisetum telmateia*	8
				Bryum pseudotriquetrum	1	**TOTAL PTERIDOPHYTES**	**8**
				Aneura pinguis	<1		
				Fissidens adianthoides	<1	**ALGAE**	
						TOTAL ALGAE	**0**
TOTAL FORBS	**25**	**TOTAL GRAMINOIDS**	**16**	**TOTAL BRYOPHYTES**	**25**	**TOTAL CANOPY**	**75**

APPENDIX B - LUGNAGALL SPRING AND FEN SURVEY AND CONDITION ASSESSMENT RESULTS 2018

Photos

Photo 1.2. Relevé, view to SW

Photo 1.3. Close-up of relevé vegetation

Photo 1.4. Water pipe abstracting flow from springhead

Photo 1.5. Tufa formation to north of relevé

Condition assessment

Criteria	Result	Target value	Result and pass/ Fail
Species assessment criteria			
High quality indicator species	None recorded	n/a (included below)	n/a (included with positive indicator species)
Positive indicator species	8 species recorded: *Aneura pinguis, Bryum pseudotriquetrum, Carex lepidocarpa, Equisetum telmateia, Festuca rubra, Fissidens adianthoides, Palustriella commutata, Pellia endiviifolia*	3 species AND no loss from baseline number of species	Result = 8 positive indicator species **PASS**
Typical accompanying species (neutral indicators)	6 species recorded: *Agrostis stolonifera, Breutelia chrysocoma, Calliergonella cuspidata, Mentha aquatica, Ranunculus repens, Succisa pratensis*	n/a	For information only
Invasive species	None recorded	Absent	Result = absent **PASS**
Negative herbaceous indicator species	1 species recorded: *Apium nodiflorum*	Total cover should not be dominant or abundant	Result = *Apium nodiflorum* frequent **PASS**

APPENDIX B - LUGNAGALL SPRING AND FEN SURVEY AND CONDITION ASSESSMENT RESULTS 2018

Criteria	Result	Target value	Result and pass/ Fail
Negative bryophyte indicator species	1 species recorded: *Cratoneuron filicinum*	No one species dominant or abundant; if ≥2 species present) then fails if ≥2 are frequent or 1 is abundant	**Result** = *Cratoneuron filicinum* occasional, 1 species recorded **PASS**
Negative woody indicator species	1 species recorded: *Fraxinus excelsior*	Absent (except in wooded springs)	1 x Fraxinus excelsior seedling **FAIL**
Spring water composition and flow			
Nitrate level	Not determined	No increase from baseline and not above 10 mg/l	n/a
Phosphate level	Not determined	No increase from baseline and not above 15 µg/l	n/a
Water flow	Not determined	No alteration of natural flow	Water abstraction **FAIL**
Impacts of grazing			
Field layer height	20cm	Height between 10 and 50cm	**Result** = 20cm **PASS**
Trampling/dung	None recorded	Impact should not be abundant/dominant	**Result** = none recorded **PASS**
Overall Structure & Functions Assessment			
All pass or one minor/borderline fail AND, if some indicators are Not Determined, the number of passes is at least five AND there is a pass for Positive Indicator Species		Green - Favourable	**Result** = 2 fail **UNFAVOURABLE - INADEQUATE**
1 - 2 Fail		Amber - Unfavourable Inadequate	
>2 Fail		Red – Unfavourable Bad	
Future prospects: Negative activities			
A04.03 Abandonment of pastoral systems, lack of grazing		Moderate negative impact, originating outside of site	**Result** = ≥2 High intensity negative activities **UNFAVOURABLE - BAD**
J02.01 Landfill, land reclamation and drying out, general		High negative impact, originating inside of site	
J02.05 Modification of hydrographic functioning, general		High negative impact, originating inside of site	
J02.07 Water abstractions from groundwater		High negative impact, originating inside of site	

Conservation Score

Criteria	Result	Score
Species diversity score	8 positive indicator species (=moderate diversity)	2
HQ Indicator Species	0	0
Tufa-forming capacity	Sparse tufa formation (=low tufa formation)	1
Other positive characteristics	0	0
Conservation Score		3
Rank		Moderate

APPENDIX B - LUGNAGALL SPRING AND FEN SURVEY AND CONDITION ASSESSMENT RESULTS 2018

SITE AND FEN DETAILS

Site name: Lugnagall Flush (fen)	**Fen name:** Fen 01	**Relevé No.:** R02
Survey date: 17/05/18	**Relevé dimensions:** 2m x 2m	**Relevé area:** 4m^2
Grid reference: G 72549 41657	**Fen type:** Lowland flush	
Slope: c 10°	**Altitude (m):** c100m	**Aspect:** SW
pH: n/a no running/ standing water	**EC:** n/a	**Temp.:** n/a

Fen description:

This is a small remnant area of fen to the east of the spring area. The fen is bordered by a fence to the south, trees and scrub to the east and west and infilling to the south. The vegetation is transitional to wet grassland but has some affinity to Annex I alkaline fen. The relevé was undertaken in the best example of fen vegetation, where some fen bryophytes were present (Photographs 2.1-2.3). There were small areas of standing water (e.g. Photograph 2.4), but no tufa was found, and no springs were observed. There is a well and water abstraction from a spring to the south of the fen area which may be impacting on the vegetation (Photo 2.5). There is also considerable soil disturbance and infilling go the south (uphill) which could influence groundwater movement to the fen area. The wetland is becoming overgrown with scrub and trees such as *Ulex europaeus, Salix cinerea, Betula pubescens* and *Rubus fruticosus* agg. (Photograph 2.1) There is no recent classification system for lowland fen vegetation communities in Ireland and so the classification system for the National Survey of Upland Habitats is used. The fen/ flush area at Lugnagall has most affinity to **RFLU4 *Schoenus nigricans–Scorpidium scorpioides* flush** (Perrin et al., 2014). Schoenus nigricans and *Schoenus nigricans* are absent but the vegetation has a tall structure (with *Molinia caerulea*) typical of this community, rather than the shorter, sedge dominated vegetation with open ground typical of RFLU1a.

Relevé location:

The relevé (red circle) is located in the centre of the fen complex in a narrow area bordered by scrub. This supported the best example of fen in the fen area (Photograph 2.1, Figure 1.1).

Photograph 2.1. Relevé location in fen area (view to E)

APPENDIX B - LUGNAGALL SPRING AND FEN SURVEY AND CONDITION ASSESSMENT RESULTS 2018

DETAILED RELEVÉ

Physical characteristics

Cover scores	DOMIN	Median vegetation height	cm	Topography	
Bare soil	-	Field layer	30	Flat	
Bare rock	-	Dwarf shrub layer	-	Summit	
Surface water	-	Ground layer	5	Upper-slope	
Litter	4			Mid-slope	
Bryophyte layer	5			Lower-slope	Y
Field layer	8				
Dwarf shrub layer	-				

Cover values: DOMIN values used

Field/ ground flora

FORBS		GRAMINOIDS		BRYOPHYTES		WOODY	
Succisa pratensis	4	*Luzula campestris*	1	*Palustriella commutata*	2		
Angelica sylvestris	4	*Carex flacca*	4	*Calliergonella cuspidata*	5		
Mentha aquatica	3	*Anthoxanthum odoratum*	3	*Breutelia chrysocoma*	4		
Filipendula ulmaria	3	*Juncus articulatus*	5	*Hylocomium splendens*	4		
Cirsium palustre	2	*Agrostis stolonifera*	3	*Thuidium tamariscinum*	1		
Lysimachia nummularia	3	*Festuca rubra*	3	*Plagiomnium undulatum*	3		
Potentilla sterilis	1	*Holcus lanatus*	3	*Lophocolea bidentata*	2		
		Juncus inflexus	4	*Plagiomnium elatum*	3		
		Eriophorum latifolium	1	*Philonotis calcarea*	2		
		Carex lepidocarpa	2	*Brachythecium rivulare*	1		
		Molinia caerulea	4	*Pseudoscleropodium purum*	1		
		Carex panicea	3			**PTERIDOPHYTES**	
						Equisetum telmateia	5
						LICHENS	
						ALGAE	

Cover values: DOMIN values used

APPENDIX B - LUGNAGALL SPRING AND FEN SURVEY AND CONDITION ASSESSMENT RESULTS 2018

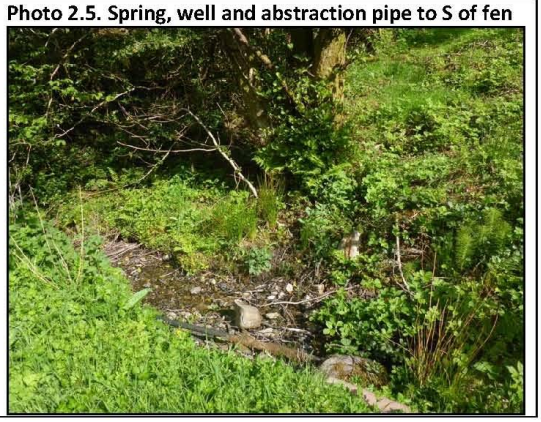
Photos

Photo 2.2. Relevé, view to NW

Photo 2.3. Close-up of relevé vegetation

Photo 2.4.Fen vegetation to SE of relevé location

Photo 2.5. Spring, well and abstraction pipe to S of fen



APPENDIX B - LUGNAGALL SPRING AND FEN SURVEY AND CONDITION ASSESSMENT RESULTS 2018

Condition assessment

Criteria	Result	Target value	Result and Pass/ Fail
Vegetation composition criteria			
Brown moss species	1 species recorded: *Palustriella commutata*	At least 1 species present	Result = 1 brown moss species **PASS**
RFLU1a/RFLU2: positive indicator species	n/a	At least 2 species present	n/a
RFLU4/RFEN1a: positive indicator species	3 species recorded: *Carex panicea, Carex lepidocarpa* (prev. *C. viridula), Molinia caerulea*	At least 3 species present	Result = 3 positive indicator species **PASS**
RFLU1a/RFLU2: brown mosses and vascular indicator species	n/a	At least 20% cover	n/a
RFLU4/RFEN1a: brown mosses and vascular indicator species	Total cover of positive indicator species <15%	At least 75% cover	Result = <15 % cover **FAIL**
Negative indicator species (relevé)	*Anthoxanthum odoratum*: <1% *Epilobium hirsutum*: absent *Holcus lanatus*: <1% *Ranunculus repens*: <1%	Cover of each species should be <1% in relevé	Result = 3 species recorded, all <1% cover each **PASS**
Negative indicator species (local vicinity)	*Juncus effusus*: 5% *Phragmites australis*: absent	Total cover <10% in local vicinity	Result = 1 species recorded, <10% cover **PASS**
Non-native species	Absent	Cover of each species <1% in relevé	Result = absent **PASS**
Scattered native trees and scrub	50% cover of scattered tress and scrub in fen area	Total cover <10% in local vicinity	Result = 50% **FAIL**
Vegetation structure			
Live leaves/flowering shoots	100% above 5cm	At least 50% are more than 5cm above ground level	Result = All above 5cm **PASS**
Physical structure			
Disturbance (relevé)	None	Cover of disturbed, bare ground < 10%	Result = absent **PASS**
Disturbance (local vicinity)	Soil infilling of former fen area to south, but no disturbance within remnant fen area	Cover of disturbed, bare ground < 10%	Result = absent **PASS**
Drainage (local vicinity)	Infilling, drain and water abstraction to south of fen area leading to drying out, loss of fen species and scrub invasion >10%	Area showing signs of drainage resulting from ditches or heavy trampling or tracking < 10%	Result = >10% **FAIL**
Disturbance where tufa is present (local vicinity)	n/a	Disturbed proportion of vegetation cover < 1%	n/a
Overall monitoring stop assessment			
All criteria passed			**FAIL**
1 or more criteria pass but expert judgement used (where marginal) to pass criteria			
1 or more criteria fail		3 criteria fail	
Overall Structure & Functions Assessment (habitat level)			
No stop failures			**Result = UNFAVOURABLE – BAD**
1-25% of stops failed			
> 25% of stops failed		Only 1 stop recorded as the habitat area is small, but this was in the best example of the fen so the whole fen would fail	
Future prospects: Negative activities			

APPENDIX B - LUGNAGALL SPRING AND FEN SURVEY AND CONDITION ASSESSMENT RESULTS 2018

Criteria	Result	Target value	Result and Pass/ Fail
A04.03 Abandonment of pastoral systems, lack of grazing		Moderate negative impact, originating outside of site	**Result = UNFAVOURABLE – BAD (**
J02.01 Landfill, land reclamation and drying out, general		High negative impact, originating inside of site	
J02.05 Modification of hydrographic functioning, general		High negative impact, originating inside of site	

Assess only the criteria relevant to the provisional community being assessed

APPENDIX C:

LUGNAGALL FLUSH 2016 SURVEY RESULTS

1.1 Site 10 - Lugnagall Flush

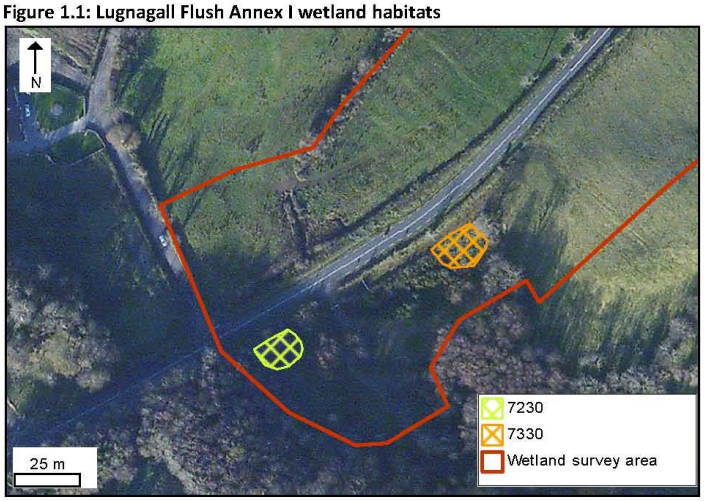
1.1.1 Sligo Wetland Survey (SWS) 2011

This site was surveyed as part of the Sligo Wetland Survey (SWS). The site is located to the north and south of the N16. In 2011 it was noted that the site has been damaged by infilling and disturbance: '*This formerly extensive area of petrifying springs have been damaged in recent years as a result of infilling and drainage works. Only a few remnants remain on both side of the road and these are mostly damaged. Areas of former fen on the southern side of the road have reverted to wet grassland/improved grassland as a result of the drainage works. An area of approximately 2m by 8m of springs remain on the southern side of the road which are still intact and species rich.*'

1.1.2 Lugnagall Flush 2016 survey

The wetland area mapped in 2011 was re-surveyed for this project. This includes the areas to the south and north of the road (Figure 1.1) and, in addition, the survey area was extended to the east. The site appears to have been further damaged (since 2011) by infilling to the south of the road and improvement to the north of the road.

Figure 1.1: Lugnagall Flush Annex I wetland habitats



NB: 7230 yellow hatching = Alkaline fen. 7230 orange hatching = 7220 'Petrifying springs'

1.1.2.1 Lugnagall – North of N16

No signs of fen or springs were recorded to the north of the road. There was a small area of marsh, with *Equisetum telmateia,* just north of the hedgerow in the western corner of the NW field (**Error! Reference source not found.** and **Photo *1.2***) and also the NE field (**Photo *1.3***). Presumably this is where the areas of former springs/ fen were located. However, apart from *Equisetum telmateia*, there were no typical spring or fen indicator species remaining. The main species present were *E. telmateia, Iris pseudacorus, Ranunculus repens* and *Calliergonella cuspidata* (e.g. **Photo *1.2***). The NW area showed signs of poaching by grazing animals and the NE area was overgrown with long vegetation. It is concluded that calcareous springs and fen have been lost from the northern part of the site.

1.1.2.2 Lugnagall – South of N16

The survey area south of the road had been subject to historic (and recent) infilling (**Photo *1.4***). A small area of probably former spring/ fen was found in the south-east of the site (Figure 1.1; **Photo *1.5***). This was not shown on the 2011 survey map. This area appears to be a remnant of the much

larger former fen at this site (shown on older aerial photographs and maps) and was probably overlooked in the previous survey. It is bordered by a fence to the south, trees and scrub to the east and west and infilling to the south (**Photo *1.6***). The vegetation has some affinity to rich fen and flush (PF1). Vascular plant species recorded include: *Anagallis tenella*, Angelica sylvestris, Cardamine pratensis, Carex dioica*, C. flacca, C. lepidocarpa*, C. nigra, Cerastium fontanum, Cirsium palustre, Equisetum telmateia, Filipendula ulmaria, Glyceria fluitans, Juncus articulatus, J. inflexus, Mentha aquatica, Ranunculus acris, R. flammula, R. repens, Rumex obtusifolius* and *Succisa pratensis* and the mosses *Breutelia chrysocoma, Calliergonella cuspidata, Hylocomium splendens* and *Plagiomnium undulatum.* The wetland is being overgrown by scrub and trees such as *Ulex europaeus, Salix cinerea, Betula pubescens* and *Rubus fruticosus.* No tufa formation was seen, or species indicative of calcareous springs.

No 'brown' fen mosses were recorded. However three indicator* species of *Schoenus flush* and *Carex rostrata* fen were recorded and it is likely that the former fen area comprised one of these communities. The vegetation therefore has some affinity to the **Annex I habitat Alkaline fen**, although it is a degraded remnant of the former fen area and is likely to continue to degrade due to lack of management/ grazing.

In the south-west of the site there is a small remnant area of calcareous springs/ rich fen and flush (Figure 1.1). This was recorded in the 2011 survey although it may have been further reduced in area since then, due to infilling and growth of coarse vegetation. The 2011 survey shows a photo with open calcareous springs and tufa formation, the vegetation was found to be much more overgrown in the 2016 survey (**Photo *1.7***). Some tufa formation was found to be still present with bryophytes typical of petrifying springs such as abundant *Palustriella commutata** (**Photo *1.8***) with *Bryum pseudotriquetrum*, P. falcata** and *Pellia endiviifolia**. The stonewort, *Chara vulgaris*, which is also indicative of calcareous springs, was present in a few locations. Additional species include the vascular plants: *Agrostis stolonifera, Anagallis tenella, Angelica sylvestris, Apium nodiflorum, Carex lepidocarpa, Cardamine pratensis, Carex dioica, C. flacca, C. panicea*, Cirsium palustre, Deschampsia cespitosa, Epilobium hirsutum, Equisetum telmateia** (locally abundant), *Eriophorum angustifolium, Festuca rubra*, Juncus articulatus, Mentha aquatica, Potentilla erecta, R. repens, Molinia caerulea, Nasturtium officinale, Scrophularia auriculata* and *Succisa pratensis* and the mosses *Breutelia chrysocoma, Calliergonella cuspidata, Hylocomium splendens, Philonotis fontana* and *Plagiomnium undulatum.* The spring vegetation extends into the wet woodland to the north (**Photo 1.9**) and is bordered by woodland to the east and west and recent infilling to the south (**Photo *1.10***).

A number of species recorded in the 2011 survey were not refound in 2016. Some of these species may have been missed due to survey timing, but it is likely that some species have been lost due to ongoing infilling activity and lack of management/ grazing leading to vegetation succession and decline in species richness. However, seven species indicative of the **Annex I priority habitat Petrifying springs** were recorded and the vegetation has affinity with the Irish petrifying springs plant community: Group 4 *Palustriella commutata-Agrostis stolonifera* Springheads (Lyons, 2015). Therefore, this area is still considered to be an example of this Annex I priority habitat, despite recent degradation.

There are historic bryophyte records from 'Lugnagall' for a number of rare and protected bryophyte species. However, the site does not contain habitat suitable to support these species and the records are likely to be form the adjacent limestone cliffs and slopes.

The Sligo Wetland Survey ranked this site as 'Site rating B' Nationally important but the site has clearly degraded further since 2011. There has been the loss of any calcareous springs/ rich fen on the northern side of the road and a reduction in size and species richness on the southern side of the road. However, as the site overlaps with Crockauns/ Keelogboy Bogs NHA, it is still considered to be of **National ecological importance**.

Photographs 1.1 – 1.10 Lugnagall Flush 2016

Photo 1.1: Field in NW of survey area (view to south). Red arrows marks probable location of former spring

Photo 1.2: Former fen/ spring vegetation in NW of site

Photo 1.3: Field in NW of survey area (view to west). Red arrows marks probable location of former spring

Photo 1.4: Infilling of site, to the south of the N16 (view to west)

Photo 1.5: Alkaline fen in SE of site (view to north)

Photo 1.6: Infilling (road) to south of Alkaline fen (view to west). Red arrow marks the Alkaline fen.

Photo 1.7: Calcareous spring vegetation with tall vegetation becoming dominant

Photo 1.8: Petrifying spring vegetation with *Palustriella commutata* and *Equisetum telmateia*

Photo 1.9: Petrifying spring in woodland

Photo 1.10: Recent infilling to the south of the petrifying springs

APPENDIX E - LUGATOBER NORTH SPRING SURVEY AND CONDITION ASSESSMENT RESULTS 2018

SITE AND SPRING DETAILS

Site name: Lugatober North	**Spring name:** Spring 01	**Relevé No.:** R01
Survey date: 27/09/18	**Relevé dimensions:** 1m x 4m	**Relevé area:** 4m^2
Grid reference (start): G 72265 41450	**Grid reference (end):** G 72264 41447	**Spring type:** Springhead and spring
Slope: c 5°	**Altitude (m):** c75m	**Aspect:** N
pH: 7.3	**EC:** 1233 µS/cm	**Temp.:** 11.6°C

Spring description:

This small site supports a number of tufa forming springs within wet grassland and a wooded stream. The wet grassland has typical species such as *Agrostis stolonifera, Holcus lanatus, Juncus inflexus, J. articulatus, J. effusus, Iris pseudacorus, Cirsium palustre, Ranunculus repens, Festuca rubra, Juncus articulatus, Filipendula ulmaria, Taraxacum officinale* agg., *Trifolium repens, Cynosurus cristatus, Calliergonella cuspidata.* The field appeared to be managed by grazing, but there had been no recent grazing. Within the wet grassland there is a main spring (1) and a series of smaller channels/ springs (2-7) (Figure 1.1).

The main spring has the highest diversity and water flow. It arises in the NE of the site within a small channel and had a good flow at the time of survey. It then forms a small stream flowing down the hill, through wet grassland. Tufa formation is present throughout the channel in small amounts, mostly as paludal tufa around the bases of bryophytes and vascular plants. The main species recorded within the spring include the vascular plants *Anagallis tenella, Briza media, Carex echinata, C. flacca, C. lepidocarpa, Cirsium palustre, Equisetum telmateia, Festuca rubra, Filipendula ulmaria, Hypericum tetrapterum, Juncus articulatus, J. effusus, J. inflexus, Parnassia palustris,* and *Succisa pratensis*, charophyte *Chara vulgaris* and bryophytes *Calliergonella cuspidata, Cratoneuron filicinum, Palustriella commutata, Pellia endiviifolia* and *Philonotis calcarea* (see relevé list for additional species). The spring flows into a small area of woodland to the north, which lines a stream. Here the spring widens out into a flush and cascade, discharging into the stream. Additional species recorded within the wooded flush include *Asplenium scolopendrium, Brachypodium sylvaticum, Carex remota, Geum urbanum* and *Hedera hibernica.* Bryophytes were present but had lower cover in this area.

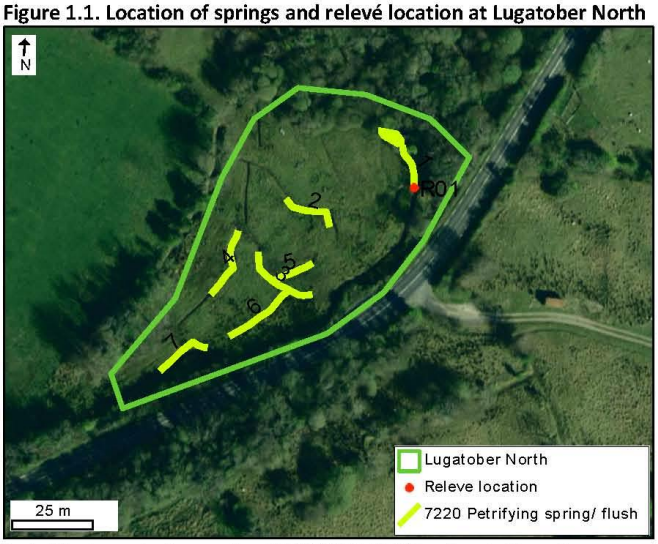
The additional springs (2-7) have formed in narrow man-made channels across the site. These have lower diversity than the main spring but do have frequent tufa formation and support locally abundant spring and fen species. Species recorded from these channels include *Anagallis tenella*, Briza media, Carex echinata, C. flacca, Carex lepidocarpa*, C. panicea*, Equisetum palustre, E. telmateia*, Eriophorum latifolium*, Festuca rubra*, Juncus articulatus, J. bulbosus, J. effusus, J. inflexus, Mentha aquatica, Parnassia palustris*,* and *Succisa pratensis*, charophyte *Chara vulgaris** and bryophytes *Aneura pinguis*, Bryum pseudotriquetrum*, Calliergonella cuspidata, Campylium stellatum*, Cratoneuron filicinum, Didymodon fallax, D. tophaceus*, Fissidens adianthoides*, Leiocolea turbinata, Palustriella commutata*, Pellia endiviifolia** and *Philonotis calcarea*.* [*Positive indicator species for Annex I priority habitat 7220 Petrifying springs]. It is not clear whether there was any tufa forming vegetation in this area prior to the formation of the channels. The tufa formation and presence of tufa species may be due to seepage of ground water through the exposed banks of the small channels. The spring vegetation has most affinity to **Group 4 *Palustriella commutata-Agrostis stolonifera* Springheads** vegetation community (Lyons & Kelly, 2017).

Relevé location:

The relevé is located in spring 1, in the NE of the site (Figure 1.1). The relevé is positioned at the springhead/ origin of the spring. As the channel is very narrow, with a steep bank to the north, the relevé dimensions were 1m x 4m along the channel. This location had high cover of typical spring species and moderate cover of paludal tufa. (Photographs 1.6-1.8)

APPENDIX E - LUGATOBER NORTH SPRING SURVEY AND CONDITION ASSESSMENT RESULTS 2018

Figure 1.1. Location of springs and relevé location at Lugatober North



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DETAILED RELEVÉ

Physical characteristics

Tufa	% Cover	Water	% Cover	Surface	% Cover
Cascade	-	Flowing/ trickling	50	Living field/ ground flora	80
Paludal (1)	35	Pool/ standing water	10	Bare tufa (active/ recent)	10
Stream crust	-	Dripping	-	Ancient/ inactive tufa	-
Oncoids/ ooids	-	Damp	40	Leaf litter/ standing dead	10
Dam	-	Dry, not impacted by spring	-	Bare soil	-
Cemented rudites	-	Other:	-	Bare stone	-
Non-tufa	65			Other:	-
TOTAL	**100**	**TOTAL**	**100**	**TOTAL**	**100**

Paludal tufa: 1 = weak/ thin/ discontinuous, 3 = strongly forming/ continuous/ conspicuous
Cover values: record to nearest 5%. If <5% then use 3%, 1% 0.5%, 0.1%

Shrub/ canopy layer

Species	Routed outside Canopy (%)	Routed inside Canopy (%)	Routed inside Height (m)
Alnus glutinosa	30	-	-
TOTAL CANOPY (ROOTED INSIDE + ROOTED OUTSIDE) %	**TOTAL %: 30%**	**TOTAL %**	**TOTAL %**
MAX HEIGHT (m) ABOVE QUADRAT (ROOTED INSIDE + ROOTED OUTSIDE):			**10-15m**

Field/ ground flora

FORBS	%	GRAMINOIDS	%	BRYOPHYTES	%	WOODY	%
Cirsium palustre	1	*Agrostis stolonifera*	<1	*Aneura pinguis*	<1		
Parnassia palustris	<1	*Carex flacca*	5	*Calliergonella cuspidata*	3		
Prunella vulgaris	1	*Carex lepidocarpa*	1	*Cratoneuron filicinum*	<1		
Ranunculus repens	<1	*Festuca rubra*	5	*Didymodon tophaceus*	<1	**TOTAL WOODY <50cm**	-
Succisa pratensis	<1	*Holcus lanatus*	<1	*Didymodon ferrugineus*	<1		
Taraxacum officinalis agg.	<1	*Juncus effusus*	3	*Didymodon insulanus*	<1	**PTERIDOPHYTES**	

APPENDIX E - LUGATOBER NORTH SPRING SURVEY AND CONDITION ASSESSMENT RESULTS 2018

FORBS	%	GRAMINOIDS	%	BRYOPHYTES	%	WOODY	%
				Fissidens adianthoides	<1	*Equisetum telmateia*	5
				Leiocolea turbinata	<1	**TOTAL PTERIDOPHYTES**	**5**
				Lophocolea bidentata	<1		
				Palustriella commutata	35	**ALGAE**	
				Pellia endiviifolia	8	*Chara vulgaris*	20
				Philonotis calcarea	6	**TOTAL ALGAE**	**0**
				Plagiomnium elatum	<1		
				Rhytidiadelphus triquetrus	<1		
				Riccardia chamedryfolia	<1		
				Scorpidium cossonii	<1		
TOTAL FORBS	**3**	**TOTAL GRAMINOIDS**	**15**	**TOTAL BRYOPHYTES**	**57**	**TOTAL CANOPY**	**80**

Photos

Photo 1.1. Lugatober North wet grassland (view to NE)

Photo 1.2. Tufa stream/ spring 1, north (downstream) of the relevé, within wet grassland (view to S)

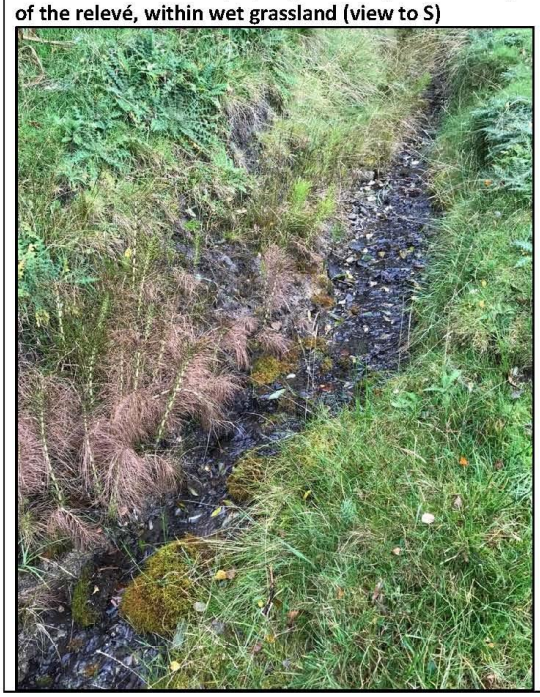


Photo 1.3. Tufa spring 4 (view to W)

APPENDIX E - LUGATOBER NORTH SPRING SURVEY AND CONDITION ASSESSMENT RESULTS 2018

Photo 1.4. Tufa stream/ flush downstream of the relevé, within woodland (view to S).

Photo 1.5. Tufa cascade in lower part of stream within woodland (view to W)

Photo 1.6. Relevé (springhead, view to S)

Photo 1.7. Close-up of relevé vegetation with abundant *Chara vulgaris*

APPENDIX E - LUGATOBER NORTH SPRING SURVEY AND CONDITION ASSESSMENT RESULTS 2018

Photo 1.8. Close-up of relevé vegetation with tufa formation (left) and *Palustriella commutata* (right)

Photo 1.9. Tufa formation in spring 2

Photo 1.10. *Chara vulgaris* and tufa formation in spring 3

Photo 1.11. *Chara vulgaris*, tufa formation and *Philonotis calcarea* in spring 5

Photo 1.12. Tufa formation with *Pellia endiviifolia* in spring 7

Photo 1.13. Fen vegetation dominated by *Eriophorum latifolium* in spring 4

Condition assessment

Criteria	Result	Target value	Result and pass/ Fail
Species assessment criteria			

APPENDIX E - LUGATOBER NORTH SPRING SURVEY AND CONDITION ASSESSMENT RESULTS 2018

Criteria	Result	Target value	Result and pass/ Fail
High quality indicator species	None recorded	n/a (included below)	n/a (included with positive indicator species)
Positive indicator species	12 species recorded: *Aneura pinguis, Carex lepidocarpa, Chara vulgaris, Didymodon tophaceus, Equisetum telmateia, Festuca rubra, Fissidens adianthoides, Palustriella commutata, Parnassia palustris, Pellia endiviifolia, Philonotis calcarea, Scorpidium cossonii*	3 species AND no loss from baseline number of species	Result = 12 positive indicator species **PASS**
Typical accompanying species (neutral indicators)	8 species recorded: *Agrostis stolonifera, Calliergonella cuspidata, Carex flacca, Leiocolea turbinata, Plagiomnium elatum, Ranunculus repens, Riccardia chamedryfolia, Succisa pratensis*	n/a	For information only
Invasive species	None recorded	Absent	Result = absent **PASS**
Negative herbaceous indicator species	1 species recorded: *Juncus effusus*	Total cover should not be dominant or abundant	Result = *Juncus effusus* occasional to frequent **PASS**
Negative bryophyte indicator species	1 species recorded: *Cratoneuron filicinum*	No one species dominant or abundant; if ≥2 species present) then fails if ≥2 are frequent or 1 is abundant	**Result** = *Cratoneuron filicinum* occasional, 1 species recorded **PASS**
Negative woody indicator species	None recorded	Absent (except in wooded springs)	Result = absent **PASS**
Spring water composition and flow			
Nitrate level	Not determined	No increase from baseline and not above 10 mg/l SEP	n/a
Phosphate level	Not determined	No increase from baseline and not above 15 µg/l SEP	n/a
Water flow	Not determined	No alteration of natural flow	No obvious impacts **PASS**
Impacts of grazing			
Field layer height	20cm	Height between 10 and 50cm	**Result** = 20cm **PASS**
Trampling/dung	None recorded	Impact should not be abundant/dominant	**Result** = none recorded **PASS**
Overall Structure & Functions Assessment			
All pass or one minor/borderline fail AND, if some indicators are Not Determined, the number of passes is at least five AND there is a pass for Positive Indicator Species		Green - Favourable	**Result** = all pass **GREEN - FAVOURABLE**
1 - 2 Fail		Amber - Unfavourable Inadequate	
>2 Fail		Red – Unfavourable Bad	
Future prospects: Negative activities			
None observed			**Result** = none recorded **GREEN - FAVOURABLE**

Conservation Score

Criteria	Result	Score
Species diversity score	12 positive indicator species (=high diversity)	3
HQ Indicator Species	0	0

APPENDIX E - LUGATOBER NORTH SPRING SURVEY AND CONDITION ASSESSMENT RESULTS 2018

Criteria	Result	Score
Tufa-forming capacity	Smaller consolidated deposits or strongly formed paludal tufa (=high tufa formation)	3*
Other positive characteristics	0	0
Conservation Score		6
Rank		High

*The lower part of the main spring (spring 01) is strongly tufa forming = 'Massive, strongly consolidated deposits' (score 4). However, species diversity in this area was lower and would have scored 1-2, so the overall score would have been the same.

APPENDIX F - W OF CASTLEGAL SPRING SURVEY AND CONDITION ASSESSMENT RESULTS 2018

SITE AND SPRING DETAILS

Site name: West of Castlegal	**Spring name:** Spring 01	**Relevé No.:** R01
Survey date: 17/05/18	**Relevé dimensions:** 2m x 2m	**Relevé area:** 4m^2
Grid reference: G 71972 40913	**Spring type:** Flush in woodland	
Slope: c 15°	**Altitude (m):** c100m	**Aspect:** NNE
pH: n/a no standing or flowing water	**EC:** n/a	**Temp.:** n/a

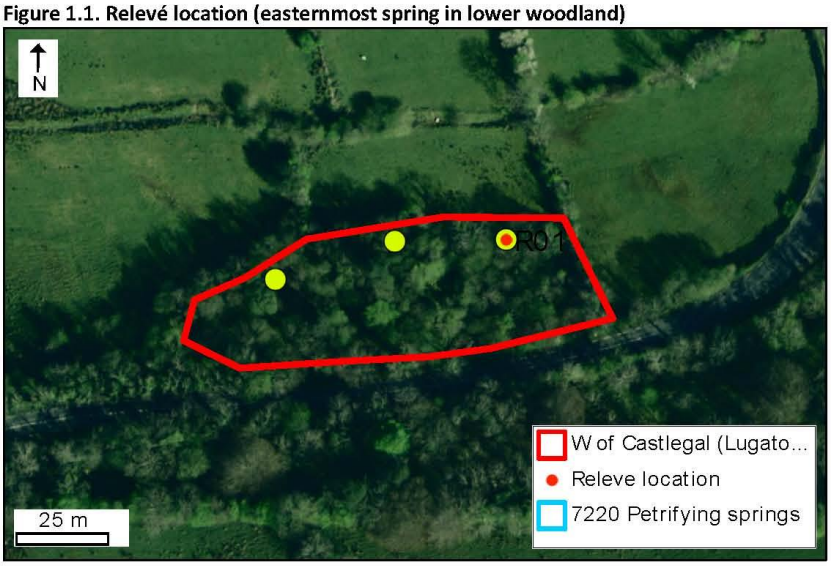
Spring description:

This site supports a series of petrifying springs within a woodland on a south facing slope. The lower slopes of the woodland are flushed and peaty with frequent *Alnus glutinosa*. There are three springs within the woodland. The easternmost spring (Spring 01) (Photographs 1.1-1.3) has the most developed tufa formation and the relevé was located in this spring. The central spring (Spring 02) has lower cover of tufa and the tufa bryophyte *Palustriella commutata* (Photograph 1.4). The westernmost spring (Spring 03) is on flatter ground with more diffuse tufa formation and wetland species such as *Iris pseudacorus* (Photograph 1.5-1.6). The woodland appears to be grazed as the shrub and field layer are sparse, however there are no signs of grazing damage on the springs. The springs support the typical tufa bryophyte *Palustriella commutata* with a range of woodland species (e.g. *Ajuga reptans, Carex remota, Carex sylvatica, Ficaria verna, Geranium robertianum, Primula vulgaris, Viola riviniana, Thamnobryum alopecurum* and *Thuidium tamariscinum*,) and wetland species (e.g. *Agrostis stolonifera, Angelica sylvestris, Carex flacca, Crepis paludosa, Equisetum telmateia, Filipendula ulmaria, Juncus articulatus, Lysimachia nummularia, Mentha aquatica, Ranunculus flammula R. repens Calliergonella cuspidata, Cratoneuron filicinum, Pellia endiviifolia* and *Plagiomnium undulatum*). The spring vegetation has most affinity to **Group 2 *Palustriella commutata-Geranium robertianum* Springheads** vegetation community (Lyons & Kelly, 2017).

Relevé location:

The relevé (R01, Figure 1.1) is located in the easternmost spring (Spring 01), located on the lower slope of the woodland. This spring has the most well-developed tufa formation of the three springs in the woodland (Photographs 1.1-1.3).

Figure 1.1. Relevé location (easternmost spring in lower woodland)



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APPENDIX F - W OF CASTLEGAL SPRING SURVEY AND CONDITION ASSESSMENT RESULTS 2018

DETAILED RELEVÉ

Physical characteristics

Tufa	% Cover	Water	% Cover	Surface	% Cover
Cascade		Flowing/ trickling	-	Living field/ ground flora	80
Paludal (3)	92	Pool/ standing water	3	Bare tufa (active/ recent)	15
Stream crust	-	Dripping	-	Ancient/ inactive tufa	-
Oncoids/ ooids	3	Damp	97	Leaf litter/ standing dead	5
Dam	-	Dry, not impacted by spring	-	Bare soil	-
Cemented rudites	-	Other:	-	Bare stone	-
Non-tufa	100			Other:	-
TOTAL	**100**	**TOTAL**	**100**	**TOTAL**	**100**

Paludal tufa: 1 = weak/ thin/ discontinuous, 3 = strongly forming/ continuous/ conspicuous
Cover values: record to nearest 5%. If <5% then use 3%, 1% 0.5%, 0.1%

Shrub/ canopy layer

Species	Routed outside Canopy (%)	Routed inside Canopy (%)	Routed inside Height (m)
Alnus glutinosa	70	-	-
Fraxinus excelsior (seedling)	1		
TOTAL CANOPY (ROOTED INSIDE + ROOTED OUTSIDE) %	**TOTAL %: 71**	**TOTAL %**	**TOTAL %**
MAX HEIGHT (m) ABOVE QUADRAT (ROOTED INSIDE + ROOTED OUTSIDE):			**15**

Field/ ground flora

FORBS	%	GRAMINOIDS	%	BRYOPHYTES	%	WOODY	%
Filipendula ulmaria	5	*Carex remota*	15	*Palustriella commutata*	25	*Hederal hibernica*	<1
Mentha aquatica	2	*Carex flacca*	15				
Ranunculus repens	1	*Agrostis stolonifera*	2				
Lysimachia nummularia	2	*Juncus articulatus*	1			**TOTAL WOODY <50cm**	**<1**
Ajuga reptans	1						
Ficaria verna	2					**PTERIDOPHYTES**	
Crepis paludosa	5					*Equisetum telmateia*	1
Ranunculus flammula	2					**TOTAL PTERIDOPHYTES**	**1**
						ALGAE	
						TOTAL ALGAE	**0**
TOTAL FORBS	**20**	**TOTAL GRAMINOIDS**	**33**	**TOTAL BRYOPHYTES**	**25**	**TOTAL CANOPY**	**80**

APPENDIX F - W OF CASTLEGAL SPRING SURVEY AND CONDITION ASSESSMENT RESULTS 2018

Photos

Photo 1.1. Relevé, view to S

Photo 1.2. Close-up of relevé vegetation

Photo 1.3. Tufa formation in spring 01 to S of relevé

Photo 1.4. Central spring (Spring 02)

Photo 1.5. Western spring (Spring 03)

Photo 1.6. Tufa formation in Spring 03

APPENDIX F - W OF CASTLEGAL SPRING SURVEY AND CONDITION ASSESSMENT RESULTS 2018

Condition assessment

Criteria	Result	Target value	Result and pass/ Fail
Species assessment criteria			
High quality indicator species	None recorded	n/a (included below)	n/a (included with positive indicator species)
Positive indicator species	3 species recorded: *Palustriella commutata, Crepis paludosa, Equisetum telmateia*	3 species AND no loss from baseline number of species	Result = 3 positive indicator species **PASS**
Typical accompanying species (neutral indicators)	8 species recorded: *Agrostis stolonifera, Carex flacca, Filipendula ulmaria, Juncus articulatus, Mentha aquatica, Ranunculus repens, Ranunculus flammula, Ranunculus repens*	n/a	For information only
Invasive species	None recorded	Absent	Result = absent **PASS**
Negative herbaceous indicator species	None recorded	Total cover should not be dominant or abundant	Result = absent **PASS**
Negative bryophyte indicator species	None recorded	No one species dominant or abundant; if ≥2 species present) then fails if ≥2 are frequent or 1 is abundant	Result = absent **PASS**
Negative woody indicator species	n/a as wooded spring	Absent (except in wooded springs)	n/a
Spring water composition and flow			
Nitrate level	Not determined	No increase from baseline and not above 10 mg/l	n/a
Phosphate level	Not determined	No increase from baseline and not above 15 µg/l	n/a
Water flow	Not determined	No alteration of natural flow	No obvious impacts **PASS**
Impacts of grazing			
Field layer height	15cm	Height between 10 and 50cm	**Result** = 15cm **PASS**
Trampling/dung	None recorded	Impact should not be abundant/dominant	**Result** = none recorded **PASS**
Overall Structure & Functions Assessment			
All pass or one minor/borderline fail AND, if some indicators are Not Determined, the number of passes is at least five AND there is a pass for Positive Indicator Species		Green - Favourable	**Result** = all pass **GREEN - FAVOURABLE**
1 - 2 Fail		Amber - Unfavourable Inadequate	
>2 Fail		Red – Unfavourable Bad	
Future prospects: Negative activities			
None observed			**Result** = none recorded **GREEN - FAVOURABLE**

Conservation Score

Criteria	Result	Score
Species diversity score	8 positive indicator species (=moderate diversity)	2
HQ Indicator Species	0	0
Tufa-forming capacity	Patchy paludal tufa (=moderate tufa formation)	2
Other positive characteristics	0	0
Conservation Score		4
Rank		Moderate

APPENDIX G:

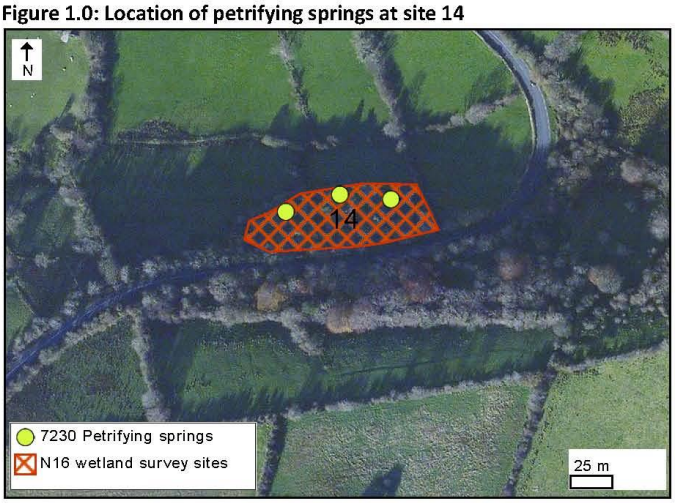
WEST OF CASTLEGAL 2016 SURVEY RESULTS

1.1 Site 14 - W of Castlegal

Site 14 is a woodland on a southern facing slope, adjacent to the N16 (**Error! Reference source not found.**). The lower slopes of the woodland are flushed and peaty and *Alnus glutinosa* is frequent (Photo 1.1). Three petrifying springs were recorded on the lower slopes of the woodland. The easternmost spring (spring 1) had very visible tufa formation, both on the woodland floor (Photo 1.2) and on the moss *Palustriella commutata* (Photo 1.3). The central spring, spring 2 (Photo 1.4) was more vegetated, with typical wet woodland species and was also located on the lower slopes of the woodland. Spring 3, in the west, was on flatter ground (Photo 1.5) and was more diffuse, but tufa formation on *Palustriella commutata* was still obvious (Photo 1.6).

Typical species within the springs include *Palustriella commutata** with *Agrostis stolonifera, Ajuga reptans, Calliergonella cuspidata, Carex flacca, Cirsium palustre, Crepis paludosa, Equisetum palustre, E. telmateia*, Filipendula ulmaria, Fissidens adianthoides, Geum urbanum iris pseudacorus, Juncus effusus, Lophocolea bidentata, Mentha aquatica, Palustriella falcata*, Plagiomnium undulatum* and *Ranunculus repens.* Three indicator species for **Annex I priority habitat Petrifying springs** were recorded and the spring vegetation has affinity to the Irish petrifying springs plant community: *Group 2 Palustriella commutata-Geranium robertianum* Springheads (Lyons, 2015). They are therefore considered to be small examples of the **Annex I priority habitat Petrifying springs** and the site is ranked as being of **County Ecological Importance**.

Figure 1.0: Location of petrifying springs at site 14



[NB – code should be 7220 for Petrifying springs]

Photographs 1.1-1.6 West of Castlegal 2016

Photo 1.1: Woodland at site 14

Photo 1.2: Tufa formation at petrifying spring 1

Photo 1.3: *Palustriella commutata* and tufa formation in petrifying spring 1

Photo 1.4: Petrifying spring 2

Photo 1.1: Petrifying spring 3

Photo 1.6: *Palustriella commutata* and tufa formation in petrifying spring 3

APPENDIX H:

SOUTH OF COLLINSFORD 2016 SURVEY RESULTS

1.1 Site 12 - S of Collinsford

This is a small wetland area in a wet grassland field (Figure 1). It appears to be a springhead at the start of a small stream which flows downhill to the west. The peat is locally deep and unstable. The main wetland area comprises species-rich rich fen and flush vegetation (Photo 1.1). This does not have many species indicative of highly calcareous water and it may be that either the spring is not highly calcareous, or there is an influence of nutrient rich surface water from the surrounding grazed grassland. Typical species include abundant *Calliergonella cuspidata, Carex nigra* and *Equisetum palustre* with *Agrostis stolonifera, Brachythecium rivulare, Bryum pseudotriquetrum, Cardamine pratensis, Cerastium fontanum, Cirsium palustre, Cratoneuron filicinum, Dactylorhiza fuchsii, Epilobium palustre, Festuca rubra, Ficaria verna, Iris pseudacorus, Juncus articulatus, Mentha aquatica, Plagiomnium rostratum, P. elatum, P. undulatum, Ranunculus flammula, R. repens, Silene flos-cuculi, Taraxacum officinale* and *Trifolium repens.* There is only one species indicative of alkaline fen. However, in the west of the flush, adjacent to the small area of wet woodland, there was a small area with tufa deposits on the bryophyte *Calliergonella cuspidata* (Photo 1.2). This is not a species typically associated with tufa formation. This vegetation has some affinity to Irish petrifying springs plant community: Group 6 *Carex lepidocarpa* Small Sedge Springs (Lyons, 2015), but no *Palustriella commutata* or *Carex lepidocarpa* were recorded.

The stream flows downhill through a small area of wet willow-alder-ash woodland (WN6) with some mature *Salix cinerea* trees (Photo 1.3). There are more species typical of petrifying springs here (Photo 1.4) with frequent *Palustriella commutata** and *Aneura pinguis, Chrysosplenium oppositifolium, Conocephalum conicum, Dichodontium pellucidum* agg., *Equisetum telmateia*, Eurhynchium striatum, Juncus articulatus, Jungermannia atrovirens, Mentha aquatica, Pohlia melanodon* and *Ranunculus acris.* Tufa formation is low with occasional patches. This has a slight affinity with the Irish petrifying springs plant community: *Group 2 Palustriella commutata-Geranium robertianum* Springheads (Lyons, 2015).

As the flush vegetation has some affinity to the **Annex I priority habitat Petrifying springs** and is associated with a small area of mature wet woodland, the site is considered to be of **County Ecological Importance.**

Figure 1: Wetland site 12 showing location of small springs

Photo 1.1: Rich fen and flush vegetation showing flushed peat (looking west)

Photo 1.2: Tufa formation on the bryophyte Calliergonella cuspidata

Photo 1.3: Wet willow woodland with petrifying spring/ stream

Photo 1.4: Small area of petrifying spring/ stream in the wet woodland

APPENDIX I:

EAST OF DRUM 2016 SURVEY RESULTS

1.1 Site 13 - E of Drum

Site 13 comprises an area of rich fen and flush within a field of wet grassland (Figure 1, Photo 1.1). The vegetation is dominated by *Carex nigra* and *Calliergonella cuspidata* (Photo 1.2) with *Agrostis stolonifera, Anthoxanthum odoratum, Cardamine pratensis, Carex flacca, Carex viridula* agg.*, *C. panicea**, *Cerastium fontanum, Cirsium palustre, Deschampsia cespitosa, Epilobium hirsutum, Equisetum palustre, Eriophorum angustifolium, Filipendula ulmaria, Galium palustre, Holcus lanatus, Iris pseudacorus, Juncus effusus, J. articulatus, Lotus pedunculatus, Mentha aquatica, Plagiomnium elatum, Ranunculus flammula, R. repens, Rhytidiadelphus squarrosus, Silene flos-cuculi* and *Trifolium repens.* Only two indicator species of **alkaline fen** were recorded and no 'brown mosses'. However the calcareous spring bryophyte *Philonotis calcarea* was locally abundant in depressions (Photo 1.3). The vegetation therefore has a slight affinity to the **Annex I habitat alkaline fen** but is not considered to be a good example. Given this, the site is considered to be of **Local (higher value) ecological importance**.

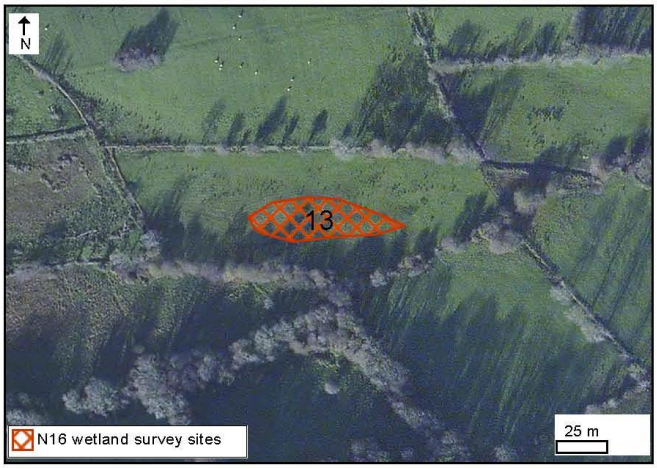


Figure 1: Location of wetland area at site 13

Photo 1.1: Rich fen and flush vegetation at site 13

Photo 1.2: Calliergonella cuspidata *locally dominant in marsh/ rich fen and flush vegetation*

Photo 1.3: Locally abundant Philonotis calcarea

8 Appendix 9.2: Chapter 9 (Main Report Reference);

Whorl Snails Survey

Survey for Geyer's whorl snail, *Vertigo geyeri,* at multiple sites along the N16 at Lugatober, north of Sligo town.

Dr Maria P. Long MCIEEM

November 2018

(Above) Spring in woodland, west of Castlegal
(Below) Flush in grassland west of Lugatober

Introduction

Associated with a proposed road development, the project biodiversity specialists (McCarthy Keville O'Sullivan) requested a review of the N16 Lugatober Route Corridor for the presence of whorl snails, particularly *Vertigo geyeri*. In September 2018, molluscan specialist Dr Maria Long was commissioned by Fergus Meehan, Project Engineer, TII Project Office, Sligo County Council to carry out this work.

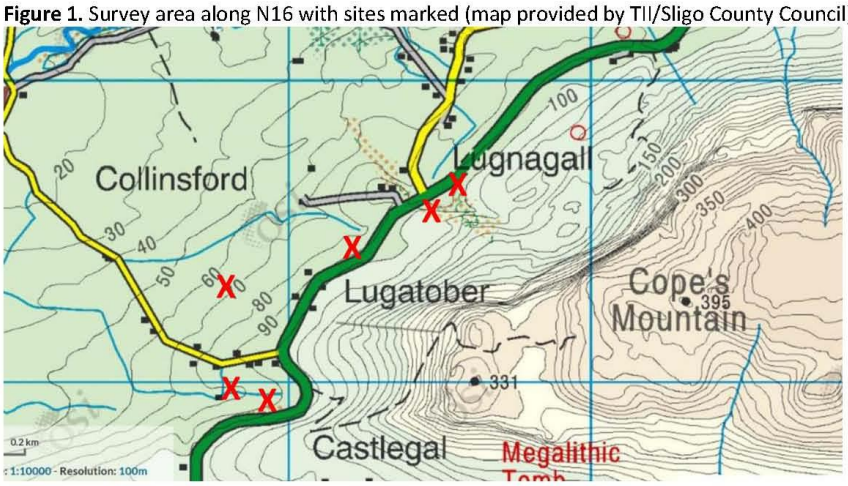
Potentially suitable habitat in the form of petrifying springs and patches of alkaline fen had already been identified at a number of locations by Denyer Ecology (detailed in reports to TII in 2016 and 2018). Thus six areas required a visit, an assessment of suitability, and finally, sampling should it be deemed possible that they might support *Vertigo geyeri* (or any of the protected *Vertigo* species).

This report presents the findings of the field survey to identify and assess areas of potentially suitable habitat, as well as the results of subsequent sampling and lab work.

Survey area

The survey area runs from near a bad bend in the road west of Castlegal townland, north along the N16 corridor to Lugnagall townland. Survey locations are marked approximately on Figure 1. Castlegal townland is approximately 7km NNE of Sligo town. The entire stretch sits with the 10 km square: G74.

Figure 1. Survey area along N16 with sites marked (map provided by TII/Sligo County Council).



Introduction to the protected *Vertigo* species

Three species of these tiny snail species are protected under the European Habitats Directive (listed on Annex II) and are usually indicators of high-quality habitat, with good continuity of habitat conditions over time. A number of recent studies have provided and collated detailed information on their status and distribution in Ireland (e.g. Moorkens and Killeen, 2011; Long and Brophy, 2017), and the recent Red List for non-marine molluscs gives information on their rarity in Ireland (Byrne, 2009).

Vertigo angustior

The narrow-mouthed whorl snail, *Vertigo angustior*, grows to less than 2mm in height and has a narrow, yellowish-brown shell. Unlike most other *Vertigo* species, its mouth opens to the left (Figure 2). In Ireland, this species is often found in sand dune habitats, but it is also found inland in wetlands. In these situations, the snail is associated with decaying vegetation in the litter layer or damp moss at the base of plant such as *Iris pseudacorus* and tall sedges, in open unshaded habitats. It is not tolerant of shading. Generally it occurs in open-structured, humid litter, but in very wet conditions can climb 10-15 cm up the stems of plants or onto damp decaying timber. In dry conditions it may be found in the soil, just below the litter layer. At many of its inland sites it is restricted to a narrow band, sometimes only a few metres wide (but of variable length), where there is an appropriate transition zone between wetland and terrestrial habitats. It normally occurs in association with permanently moist but free-draining soil, not subject to inundation. This lack of tolerance to flooding makes many potential habitat areas unsuitable.

Vertigo geyeri

Vertigo geyeri, Geyer's whorl snail, is small (<2mm high), with a glossy shell with fine, regular growth-lines (Figure 2). It has four simple, peg-like teeth in the mouth. *Vertigo geyeri* has very specific habitat requirements, being found at the bases of small sedges and mosses (often in the decaying leaf matter) in calcareous flushes and fens. This species requires stable hydrological conditions, needing the ground to be constantly saturated, yet it is not tolerant of flooding. It also requires quite open conditions, so light to moderate grazing levels are generally beneficial, though open conditions may also be maintained due to wetness. Tufa formation is a good indicator for the presence of this species, as is the presence of the so-called 'brown mosses' (e.g. *Campyllium stellatum, Drepanocladus* spp., *Scorpidium* spp.). A degree of small-scale habitat heterogeneity greatly benefits the long-term survival prospects of *Vertigo geyeri* (e.g. small tussocks of *Schoenus nigricans*, small moss hummocks or uneven terrain), as it allows them to shelter or escape in conditions caused by very wet or very dry weather.

Vertigo moulinsiana

Vertigo moulinsiana, Desmoulin's whorl snail, is the largest of the *Vertigo* species found in Ireland and reaches sizes of up to 2.7mm high. It is broadly egg-shaped and has a red-brown relatively glossy shell (Figure 2). It shows a preference for calcareous wetlands and needs tall-growing vegetation. As such it is often associated with reed-beds and swamps, and some types of fens (e.g. *Cladium* fens) and marshes. Suitable vegetation types are additionally often found bordering waterbodies such as canals, ditches, lakes and rivers. Examples include areas with *Glyceria maxima*, *Phragmites australis* and some tall or tussock-forming *Carex* species. This species, in contrast with other *Vertigo* species, can migrate considerable distances vertically during the year, climbing high in the vegetation in autumn, and remaining low during winter. It can withstand certain amounts of flooding, but appears to be relatively intolerant of drying out.

Figure 2. *Vertigo angustior* (left), *Vertigo geyeri* (middle), *Vertigo moulinsiana* (right). Photographs copyright Maria P. Long.

Existing records for *Vertigo* species

The website of the National Biodiversity Data Centre (biodiversityireland.ie) was checked for existing records of all three *Vertigo* species in the vicinity.

Vertigo moulinsiana is not known from the vicinity, and suitable habitat is unlikely to be found in the study area.

Vertigo angustior is known from nearby 10km squares, but all are coastal records from sand dune habitats. Suitable wetland/marsh habitat may be found in study area, but is unlikely.

Vertigo geyeri is known from within the 10km square of the study area (G74). There are records from seven separate one-kilometre squares in G74, but only two of these are on the south side of the Ben Bulben range. These are both in the Glencar valley, are in Co. Leitrim, and are from within the past 20 years. The one-kilometre references of these records are G7644 and G7542. The closest is about 5km from the study area. The presence of petrifying springs and alkaline fens in the study area, coupled with the knowledge of multiple *Vertigo geyeri* sites in the vicinity, make it quite possible that locations within the study area could support this protected species.

Survey methodology

Two field visits were undertaken on 22nd and 24th October 2018. Each study area was visited and walked, and a decision was made on whether to sample (based on habitat suitability) and how many samples to take. Notes were taken on habitat and vegetation type, and grid references were taken at regular intervals.

The potential of each habitat area for supporting *Vertigo geyeri* was rated as follows:

N – not suitable for supporting *Vertigo geyeri*.
L – low suitability, low chance of the target species occurring.
M – moderate suitability, moderate chance of occurrence of species.
H – high suitability, species may occur.

Vertigo geyeri is the most difficult of the three species to survey for because the species cannot be easily found in the field. It is usually found in the saturated moss/litter layer in fens, flushes and springs, and cannot be easily spotted due to the muddy and wet conditions. Thus samples are bagged (see below, and refer to Long and Brophy, 2017, for fuller sampling protocol) and returned to the lab for the laborious process of drying, sieving and sorting.

The equipment needed for *Vertigo geyeri* surveys includes:
- muslin bags (approx. 3L; these are used to store vegetation and litter samples collected on site, for later lab analysis)
- jars (for storing molluscs collected in field which may need either further ID work, or to be kept as voucher specimens)
- hand lens (x10), and/or head-band magnifier
- GPS (handheld Garmin)
- mobile phone – for communication and photos
- weather writer and recording sheet for recording site notes, grid refs, etc.

Mollusc species found were identified with reference to Cameron (2003), Kerney & Cameron (1979) and other relevant works (e.g. Cameron *et al.*, 2003).

Results

Vertigo angustior and *Vertigo moulinsiana*

Based on the habitat walkover survey, the occurrence of *Vertigo moulinsiana* and *Vertigo angustior* anywhere within the study area was ruled out because of lack of suitable habitat to support them. These species are not considered further here.

Vertigo geyeri

In advance of the survey both the known presence of alkaline fen and petrifying springs, as well as the occurrence of previous records of *Vertigo geyeri* in the area, meant that the likelihood of encountering habitat worth sampling was high.

Following walkover, a number of areas were deemed to be of 'low' or 'low to moderate' suitability for *Vertigo geyeri*, and so samples were taken at some of these, including also at some areas with 'no to low' potential. A total of six samples were taken from across the site, and notes on these and on all areas visited are presented here.

Area 1 – 'west of Castlegal'

This is an area of native woodland on a slope. There are a number of petrifying springs within the woodland. Please refer to the reports by Denyer (2016, 2018) for TII for fuller details. The springs were mostly deemed to have 'no' or 'no to low' potential for supporting *Vertigo geyeri* based on the fact that the habitat was too shaded, leaf fall from the trees influenced the nature of the vegetation in the springs (making it largely unsuitable for *Vertigo geyeri*), and the absence of the 'brown mosses' and low sedges which typically dominate *Vertigo geyeri* habitat. However, there was an extensive area of the moss *Palustriella commutata* at one spring head, and it was decided to take one sample there (S1) (see top photo on cover page).

S1 GRID: G 71907 40897

Area 2 – Lugatober stream and tributaries

The Lugatober stream and its tributaries in the vicinity of the 'west of Castlegal' woodland were walked as directed. Tufa deposition (including small tufa steps and terraces in the stream bed) and very small patches of brown mosses were noted at the eastern end where the stream flows through open grassland in a shallow bed, but all were too small/unsuitable for sampling for *Vertigo geyeri.* Further west, all areas were unsuitable having either tall vegetation on the banks, deep/steep banks, or open muddy sides due to stock access. Overall, all areas along the stream were classed as being either 'not suitable' or of 'no to low' suitability, and no samples were taken.

Area 3 – Lugnagall 'spring'; Area 4 – Lugnagall 'fen'

Areas 3 and 4 sit at either side of a very damaged and altered area, where dumping and land reprofiling have taken place. Both areas are very small in area, and have undoubtedly suffered from the effects of the neighbouring land use.

Area 3 consists of a spring which is used as a water supply for nearby houses. There are concrete slabs over part of the springhead, and a hose pipe leads away from this area. There are small quaking areas near the slabs, and downslope. The area surrounding the spring supports brambles and trees, and so the spring is quite shaded. Overall, this area is of 'no to low' suitability only. One sample (S2) was taken in a quaking patch near the springhead.

S2 GRID: G 72487 41612

Area 4 is a very small area with fen vegetation, bounded by a grassy track, scrub and areas with dumping. While the vegetation is similar to that of alkaline fen, a number of the plants typical of this habitat are missing (e.g. many of the brown mosses), and it is more grassy than a good quality fen would be. However, there are small areas with good cover of bryophyte species such as *Calliergonella cuspidata* and *Breutelia chrysocoma*. The potential of this habitat patch to support *Vertigo geyeri* was deemed to be 'low'. A sample was taken here (S3).

S3 GRID: G 72553 41659

Area 5 – field with runnels (Lugatober north)

This field is located just north of the existing road and contains a number of runnels, some of which appear to have been modified by the landowner in the past. Most show tufa deposition on their bases and sites, and some contain well-developed clumps of brown mosses. In this field, some areas were deemed to be of 'low to moderate' potential for supporting *Vertigo geyeri*. Two samples were taken here, S4 and S5. S4 was taken in an almost pure mound of *Palustriella commutata* at a small springhead on the edge of a small stream that runs near the road on the southern side of the field. S5 was taken along a runnel/drain where tufa was evident and well-developed clumps of mosses were found. There were also charophytes in this runnel/drain, as well as small patches of low-growing sedges.

S4 GRID: G 72263 41446

S5 GRID: G 72225 41433

Area 6 – field with flush (south of Collinsford)

An unusual area of flushed vegetation exists in this field, running downslope to a small wooded area where its character changes to be more spring-like. Iron seepage was evident in some puddles in the flush. The vegetation consists of species such as *Iris pseudacorus, Juncus articulatus, Mentha aquatica, Calliergonella cuspidata, Carex disticha, Ranunculus flammula, Carex nigra, Equisetum palustre* and a range of species more typical of the adjoining agricultural grassland. Based on the vegetation present, and the lack of brown mosses, the area was deemed to be of 'no to low' suitability for *Vertigo geyeri.* One sample (S6) was taken.

S6 GRID: G 71866 41340

Lab results

All samples taken were found to be negative for *Vertigo geyeri*.

Summary and Discussion

Given the abundance and quality of the petrifying spring habitats in this area, it was important to check for the presence of *Vertigo geyeri*. On visiting the sites, however, it became clear that the optimal conditions for the species were not present – e.g. carpets of brown mosses, areas of low-growing sedges, small to moderate tussocks of *Schoenus nigricans,* etc. However, the species can sometimes be found in areas which are at the extremes of its tolerance in terms of environmental and habitat conditions, and so based also on the fact that there are nearby records for the species, it's occurrence at these locations could not be completely ruled out.

Upon processing of samples, all were found to be negative for *Vertigo geyeri*.

This is a tiny and cryptic species, and not finding the snail, even following rigourous sampling, does not mean it is not present. However, based on a detailed habitat walkover of all study areas, and assessment of the vegetation and habitat conditions present, it is possible to state that it is highly unlikely that *Vertigo geyeri* is present in any of these areas.

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Report submitted by email to Fergus Meehan, Project Engineer, TII, Sligo County Council, by email, mid November 2018.

9 Appendix 9.3: Chapter 9 (Main Report Reference);

Invasive Alien Species Management Plan

McCarthy Keville O'Sullivan

Planning & Environmental Consultants

DOCUMENT DETAILS

Client:	Sligo County Council
Project title:	N16 Lugatober (Drumkilsellagh to Lugnagall) Road Project
Project Number:	170904
Document Title:	Invasive Species Management Plan
Doc. File Name:	ISMP F – 2019.02.11 - 170904
Prepared By:	McCarthy Keville O'Sullivan Ltd. Planning & Environmental Consultants Block 1, G.F.S.C. Moneenageisha Road, Galway

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1 INTRODUCTION

1.1 General Introduction

Sligo County Council is currently planning a 2.54km upgrade of the N16 National Primary Route, between the townlands of Drumkilsellagh and Lugnagall and occurring predominately within the townland of Lugatober. The project location is depicted on Figure 1.1. The project will remove a number of substantially deficient bends on this section of the route and in so doing, will improve aspects such as safety, sight distance, cross sectional width and drainage.

A site-specific invasive species survey was carried out as part of the EIAR surveys in September and October 2017 and May 2018. The survey focused on those species listed on the Third Schedule of Regulations 49 and 50 of the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. 477 of 2011). The only Third Schedule invasive species recorded in relation to the proposed works was Japanese Knotweed. This report provides management to prevent the spread of Third Schedule invasive species. The survey also noted any species listed on the 'the Union List' of invasive alien species ([EU) 1143/2014)]. Union list species are noted as being a risk to Irish biodiversity, however their management has not yet come under Irish legislation. No union list species were recorded during the surveys.

This document constitutes an Invasive Species Management Plan the management of Knotweed and measures to avoid the spread of this Third Schedule species. Maps showing the locations of the invasive species recorded in relation to the site boundary of the proposed works are provided in Section 2 of this report.

This document has been prepared with reference to current legislation and best practice guidelines in the identification, treatment and management of invasive alien species listed on the 'Third Schedule' of Regulations 49 and 50 of the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. 477 of 2011).

The objectives of this report are summarised below:

- Provide site specific best practice guideline measures for the control and management of invasive species.
- Provide detailed recommendations for the management of invasive species listed on the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. 477 of 2011).

The contractor employed to carry out the proposed construction work will be responsible for preparing a site-specific Method Statement in accordance with the site-specific management measures described in this report.

1.2 Statement of Authority

Field surveys were undertaken by John Hynes in September and October 2017 and May 2018. John has over 5 years consultancy experience and is a member of the Chartered Institute of Ecology and Environmental Management.

This report was prepared by Laoise Kelly, Ecologist with McCarthy Keville O'Sullivan. Laoise has undertaken a range of habitat surveys and mapping for various development led projects nationwide. She has also undertaken targeted invasive species surveys for sites located in Sligo, Roscommon, Wicklow, Cork and Donegal. This invasive species management plan was prepared by Laoise Kelly and reviewed by John Hynes (B. Sc. Env., M. Sc., CIEEM).

1.3 Legislative Framework

Regulations 49 and 50 of the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. 477 of 2011) include legislative measures to deal with the dispersal and introduction of invasive alien species:

Regulation 49
'*a person shall be guilty of an offence if they: plant; disperse; allow or cause to disperse; spread or cause to grow the plant in the Republic of Ireland'. The list of species in the Third Schedule includes Japanese Knotweed, Giant Knotweed and their hybrid Bohemian Knotweed*'.

Regulation 50
'*an offence to or intend to; import; buy; sell; breed; reproduce or propagate; offer or expose for sale; advertise; publish a price list; transport; and distribute any plant species or vector material listed in the Third Schedule*'.

Non-native species subject to restrictions under Regulations 49 and 50 are included in the 'Third Schedule' of the European Communities (Birds and Natural Habitats) Regulations 2011 (S.I. 477 of 2011). Invasive species included in this list include Japanese Knotweed, Giant Hogweed, Giant Knotweed, Giant Rhubarb, Himalayan Balsam, Himalayan Knotweed, Bohemian Knotweed and Rhododendron. Vector materials which aid in the spread of these species include soil or spoil taken from places infested with Japanese Knotweed (*Fallopia japonica*), Giant Knotweed (*Fallopia sachalinensis)* or their hybrid Bohemian Knotweed (*Fallopia x bohemia*). Two vector materials are referred to in the regulations (Third Schedule Part 3), one is blue mussel seed and the second is:

> *''Soil or spoil taken from places infested with Japanese Knotweed, Giant Knotweed or their hybrid Bohemian Knotweed''.*

1.3.1 Guidance Documents

The following guidance documents and literature sources were consulted during the preparation of this report:

- Regulation (EU) 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species (IAS Regulation)
- NRA (2010). *Guidelines on management of noxious weeds and non-native invasive plant species on national roads*. National Roads Authority.

- Crushell, P., Foss, P., Hurley, C. & O'Loughlin, B. (2011). *County Kerry Invasive Species Survey 2011 - Pilot Mapping Study of the River Lee Catchment, Tralee.* Report prepared for Kerry County Council and The Heritage Council.
- O'Flynn, C. (2010) *Report on the Dirty Dozen Non-Native Invasive Species, Co. Donegal.* National Biodiversity Data Centre (NBDC).
- Stokes et al. (2004). Stokes, K., O'Neill, K. & McDonald, R.A. (2004) *Invasive species in Ireland.* Unpublished report.
- Actions for Biodiversity 2011-2016, Ireland's 2nd National Biodiversity Plan.
- Department of Environment (2013). *An Invasive Alien Species Strategy for Northern Ireland.* www.doeni.gov.uk
- Irish Water (2016) *Information and Guidance Document on Japanese Knotweed Asset Strategy and Sustainability.* Irish Water.
- Invasive Species Ireland (2016) *Best Practice Management Guidelines Japanese Knotweed Fallopia japonica*

2 DESCRIPTION OF THE PROPOSED WORKS

The Physical Characteristics of the Proposed Road Development are contained within the townlands of Drumkilsellagh, Doonally (ED Drumcliff East), Castlegal (ED Glencar), Drum East, Lugatober (occurring predominately within), Collinsford and Lugnagall. The detailed description of the proposed road development is provided in Chapter 4 of the EIAR. The outline description of the proposed road development is as follows:

- Circa 2.54km of Realignment to the existing N16 National Primary Route (c. 790m online and c. 1,750m offline);
- Junction Improvements including:
  - One At Grade Roundabout;
  - Six Simple T Junctions, including two Right/Left Staggered T Junctions;
- Circa 1,500km of realignment to the existing local road network (tie-in works);
- Three Direct Access connections to the National Primary network (including two agricultural and one Local Authority maintenance connections);
- Circa 1,500m of Vulnerable Road Users (Unsegregated cycle and pedestrian) tracks located predominately with the mainline verge space, interlinking as necessary with alternative offline routes;
- One Vulnerable Road Users Subway underpass;
- One River/Stream Clear Span Structure;
- Culverts and associated diversions of existing minor watercourses and drainage ditches;
- All the necessary drainage works associated with the Proposed Road Development;
- The diversion of services and utilities;
- Earthworks operations;
- 1 no. Steepened Cut Slope (Reinforced Earth) in the townland of Lugatober;
- One no. Soil Repository/Borrow Pit;
- Environmental mitigation works;
- The other consequential construction works necessary in order to complete the project.

3 JAPANESE KNOTWEED (*FALLOPIA JAPONICA*)

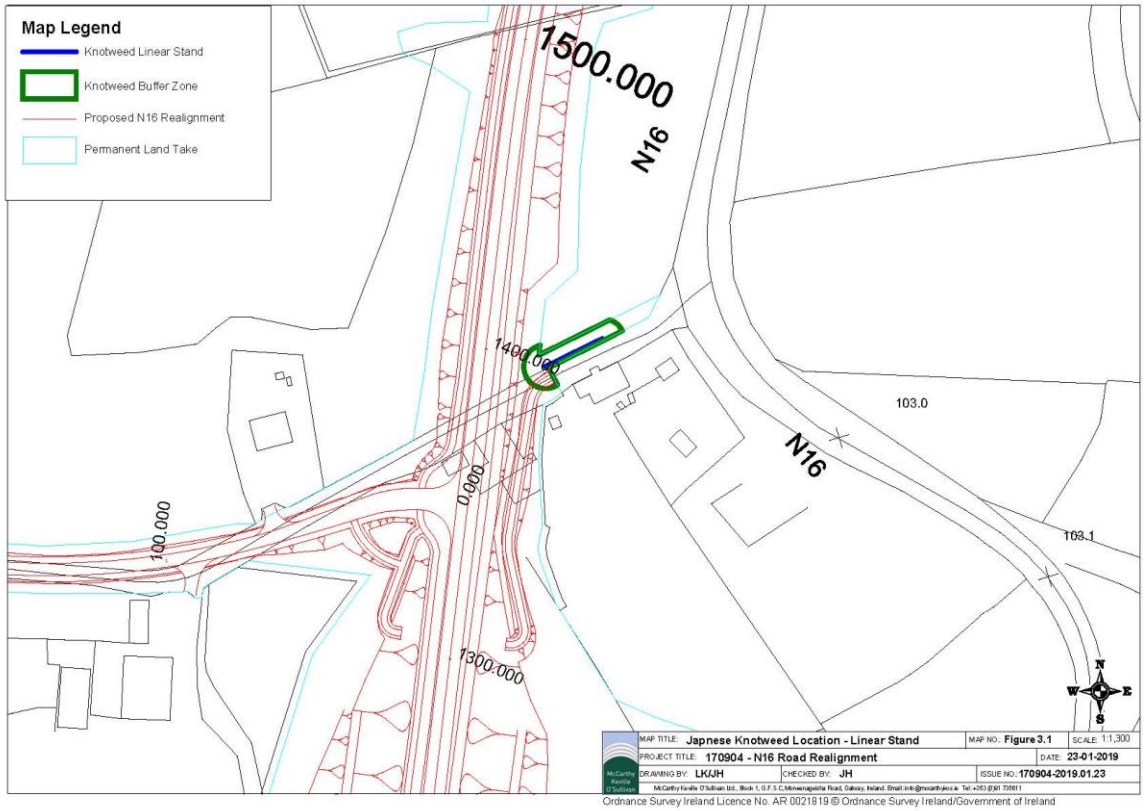
Japanese Knotweed *(Fallopia japonica)* is a tall, vigorous, ornamental plant that escaped cultivation in the late nineteenth century and has since become an aggressive invader in both rural and urban environments. The plant can grow up to 2-3m high and its root system can extend up to 3m into the ground and 7m laterally from the parent plant. As a result, a 7m buffer from the above-ground growth of the plant is applied to allow for potential root growth of the Knotweed. No works should take place within 7m of a stand of Knotweed prior to the preparation of a site-specific management plan. The reason this plant is such a threat is due to the nature of its regeneration. Cut fresh stems can produce fresh shoots and roots from nodes when immersed in soil or water. Very small fragments (0.7g) of fresh Knotweed shoot and root material have the potential to start a whole new plant.

The non-native invasive species Japanese Knotweed (*Fallopia japonica*) was recorded on the *Proposed Road Development* in the townland of Lugatober (Grid Ref 571878 841098). This infestation consisted of a linear strip (approximately 20m) recorded in the road side hedgerow (Plate 3.1 and Figure 3.1).

A second infestation was recorded in the townland of Lugnagall (Grid Ref 572380, 841629). The infestation consisted of two small stands which measures approximately 2m x 2m (Plate 3.2 and Figure 3.2).

There was also signage present at the Southern tie-in (Grid Ref 571723, 839775) which indicated that Japanese knotweed had been recorded and treated in the past. No evidence of Knotweed was recorded at this location during the 2017 and 2018 surveys. The location of this historic stand of Knotweed is shown in Figure 3.3.

Plate 3.1. Linear stand of Knotweed growing in association with residential hedge as shown on Figure 3.1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Knotweed Buffer Zone
Proposed N16 Realignment
Permanent Land Take
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N16
1400.000
103.0
N16
0.000
100.000
103.1
1300.000
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MAP NO.: Figure 3.1
SCALE: 1:1,300
PROJECT TITLE: 170904 - N16 Road Realignment
DATE: 23-01-2019
DRAWING BY: LK/JH
CHECKED BY: JH
ISSUE NO.: 170904-2019.01.23
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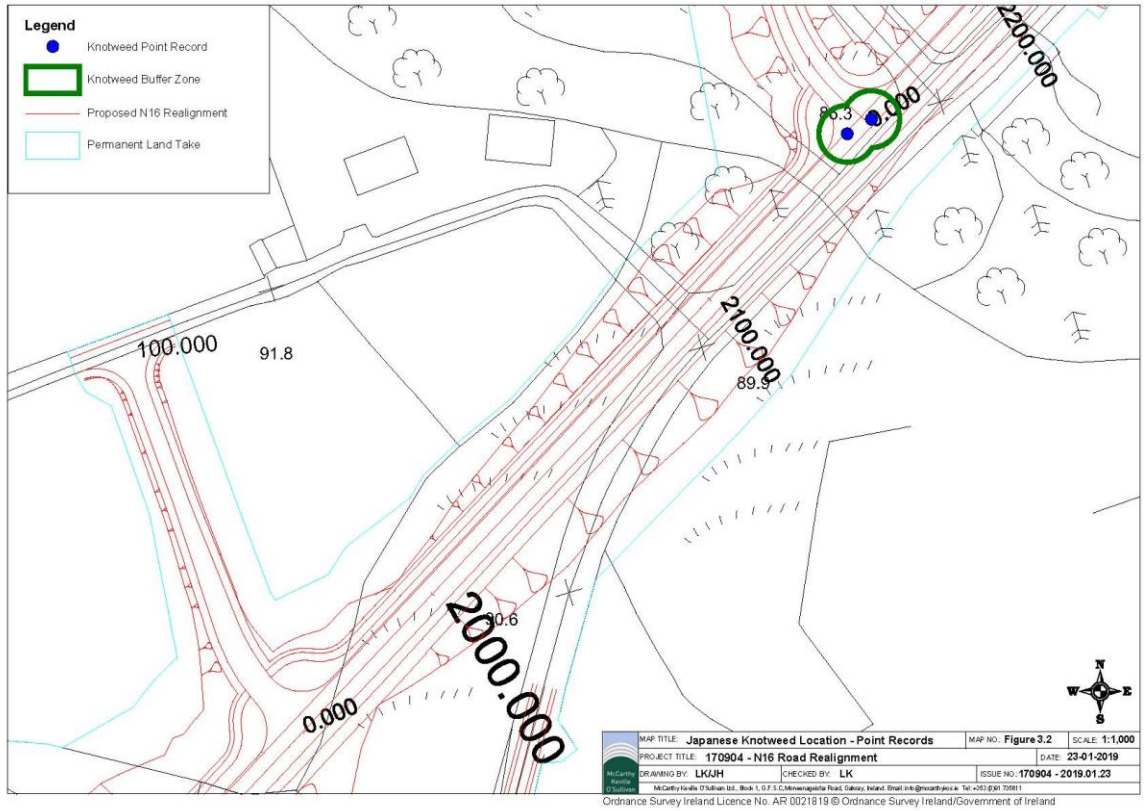
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Knotweed Point Record
Knotweed Buffer Zone
Proposed N16 Realignment
Permanent Land Take
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100.000
91.8
2100.000
89.9
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0.000
MAP TITLE: Japanese Knotweed Location - Point Records
MAP NO.: Figure 3.2
SCALE: 1:1,000
PROJECT TITLE: 170904 - N16 Road Realignment
DATE: 23-01-2019
DRAWING BY: LK/JH
CHECKED BY: LK
ISSUE NO.: 170904 - 2019.01.23
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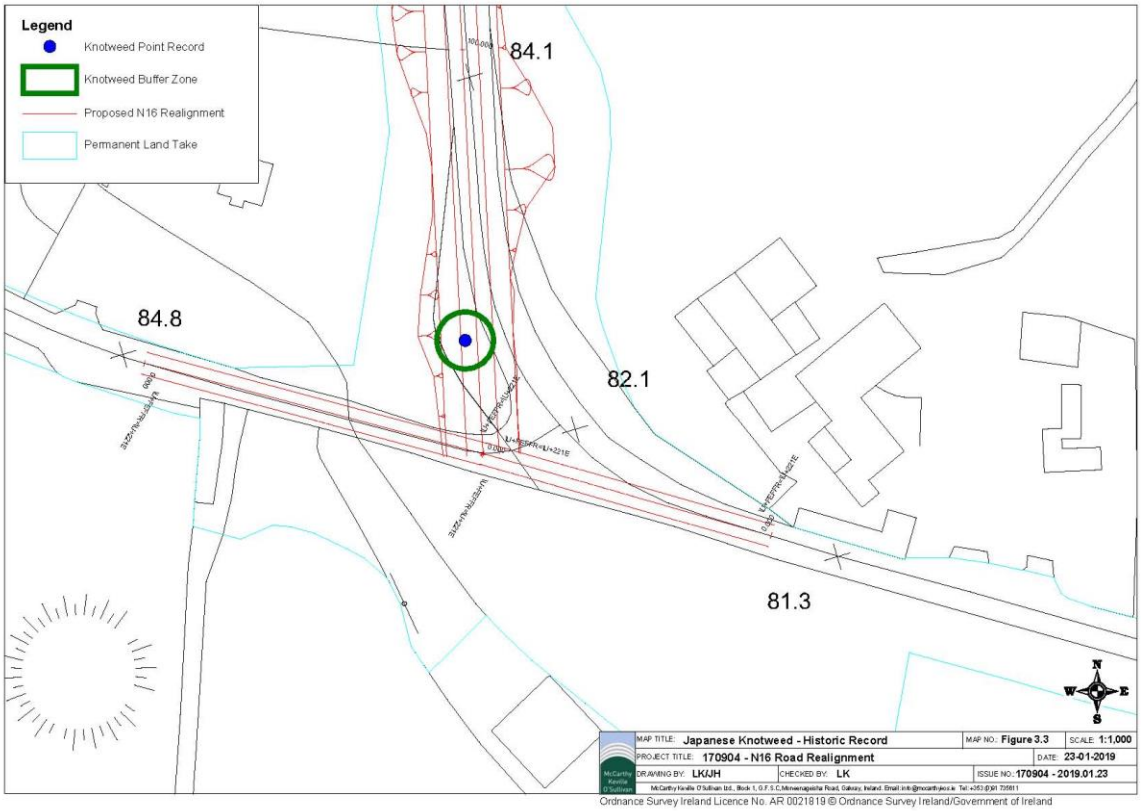
Legend
Knotweed Point Record
Knotweed Buffer Zone
Proposed N16 Realignment
Permanent Land Take
84.1
84.8
82.1
81.3
N
W
E
S
MAP TITLE: Japanese Knotweed - Historic Record
MAP NO.: Figure 3.3
SCALE: 1:1,000
PROJECT TITLE: 170904 - N16 Road Realignment
DATE: 23-01-2019
DRAWING BY: LK/JH
CHECKED BY: LK
ISSUE NO.: 170904 - 2019.01.23
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Plate 3.2. Individual stands of Knotweed growing within field as shown in Figure 3.1 (seen as yellow leaved plants as per October 2017).

4 MANAGEMENT PLAN

The following paragraphs detail the proposed management of Japanese Knotweed within and adjacent to the proposed development site. All works will adhere to Invasive Species Ireland (2016) *Best Practice Management Guidelines Japanese Knotweed Fallopia japonica*. All excavation activities within 7m of a stand of Knotweed will be supervised by a suitably qualified ecologist.

4.1 Burial

The proposed road development will entail the use of a soil repository/borrow pit for the provision of material for the works, e.g. to create backfill for embankments. The location of this borrow pit is shown in Figure 4.1. According to Invasive Species Ireland Guidelines one option for the treatment of Knotweed is deep burial. This method includes the use of root barrier membrane to cover the Knotweed material before infilling with clean material at a minimum depth of 5m.

The proposed borrow pit will also act as a soil repository for the proposed works. The pit will measure approximately 30m wide and on average circa 11m-12m deep. It is proposed to bury Knotweed material that is impacting on the proposed works within this soil repository/borrow pit (this will include the remnants of the Knotweed stands that have undergone herbicide treatment described in section 4.1.1.2 of this report). A clearly defined area will be created within the soil repository pit for the deposition of contaminated Knotweed material. This will comprise plywood or other solid material in order to create a clearly defined, solid boundary. Based on trial pit excavations, expected volumes of Knotweed material will be estimated in order to inform the size of the deposition area/exclusion zone within the soil repository pit. Detailed measures on how this will be carried out are provided below.

4.1.1 Site Preparation

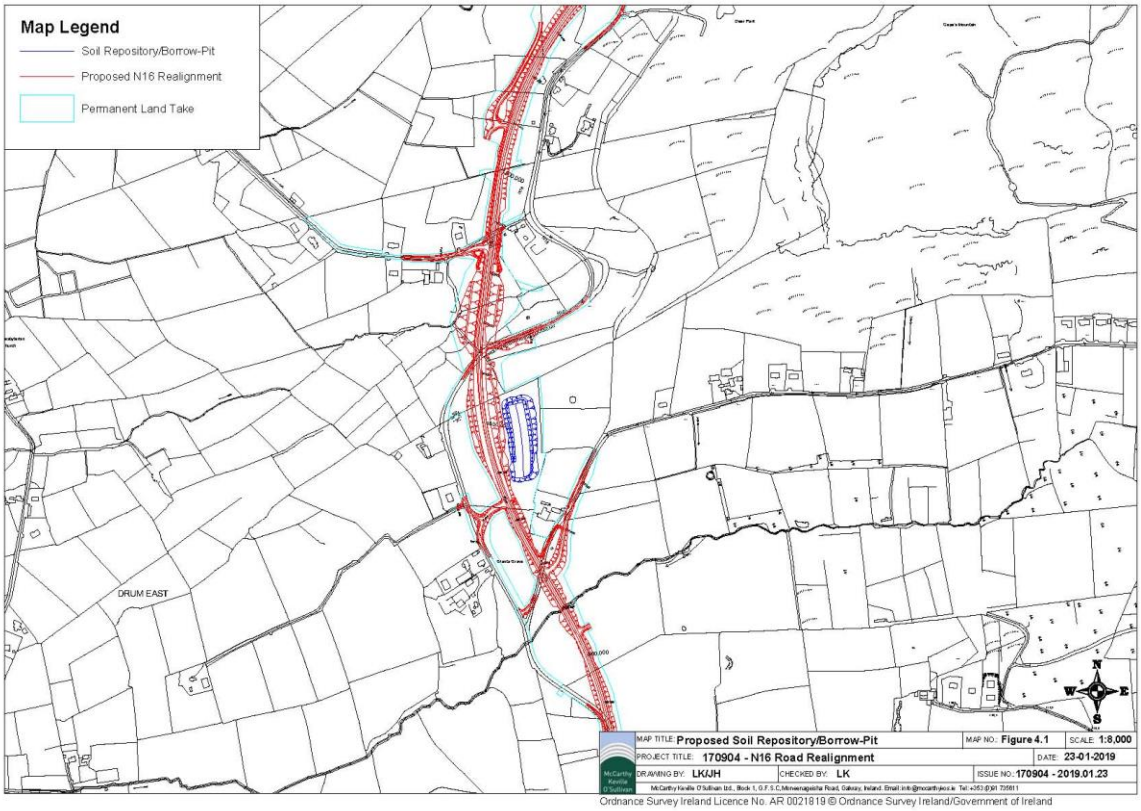
A pre-commencement survey will be carried out by the ecologist and the extents of Knotweed including a 7m buffer from the plant will be physically marked out. This will be done using wooden posts and tape and/or spray paint where the buffer extends into hard surface areas.

4.1.1.1 Trial Holes

- As the true extent of Knotweed cannot be determined until such a time as excavations commence, trial holes will be dug in proximity to a stand to ascertain the extent of Knotweed within the potentially contaminated area.
- Trial holes will be dug at the outer extent (within the CPO) of the 7m Knotweed buffer and work towards the centre of the Knotweed stand. This will determine the actual extent of the lateral and vertical root growth of the plant.
- Once the true extent of the plant is determined this will again be marked out using posts and tape and/or marker spray.
- All excavation activities within 7m of a stand of Knotweed will be supervised by a suitably qualified ecologist.

4.1.1.2 Herbicide Treatment

- The existing stands within the proposed works footprint (see Figure 3.2 and 3.3.) have been sprayed with two consecutive treatments herbicide in 2018, they will be sprayed again, twice annually in 2019 and again in 2020 in advance of construction.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Soil Repository/Borrow-Pit
Proposed N16 Realignment
Permanent Land Take
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N
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MAP NO.: Figure 4.1
SCALE: 1:8,000
PROJECT TITLE: 170904 - N16 Road Realignment
DATE: 23-01-2019
DRAWING BY: LK/JH
CHECKED BY: LK
ISSUE NO.: 170904 - 2019.01.23
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4.1.1.3 Site Set-up

- Prior to commencement all staff will be given a toolbox talk on the characteristics of Japanese Knotweed and adherence to site hygiene during the proposed works.
- A pre-commencement survey will be carried out by the ecologist and the extents of Knotweed including a 7m buffer from the plant will be physically marked out. This will be done using wooden posts and tape and/or spray paint where the buffer extends into hard surface areas.
- Prior to works within the 7m Knotweed buffer zone of any stand, a designated bio-secure area will be set-up to facilitate brushing down of boots and machinery prior to leaving the contaminated area to prevent material being spread off site.
- A clearly defined area will be created within the soil repository pit for the deposition of contaminated Knotweed material. This will comprise plywood or other solid material in order to create a clearly defined, solid boundary. Based on trial pit excavations, expected volumes of Knotweed material will be estimated in order to inform the size of the deposition area/exclusion zone within the soil repository pit.
- The exclusion zone will be signed with warning signs in order to prevent access of machinery or personnel prior to and during the proposed works other than those designated for Knotweed works.

4.1.2 Knotweed Excavation and Burial

- Excavation within the CPO line will be carried out by a designated suitably sized excavator (preferably a rubber duck/non-tracked machine) under the supervision of a suitably qualified ecologist.
- The excavator will work from the centre of the Knotweed stand out towards its lateral extent. Contaminated material will be placed in a waiting dumper that is positioned on an impermeable membrane (radon barrier or equivalent).
- The dumper will only be three quarters filled. Before moving away from the membrane, the dumper wheels and machine body will be brushed down to remove any potentially contaminated material that was lost during filling and this material placed in the dumper bucket along with the other contaminated spoil.
- The dumper will drive slowly to the soil repository (see Figure 4.1.) and deposit the material within the already defined exclusion zone within the repository pit.
- The dumper will again be cleaned down prior to moving away from the exclusion zone and any loose material collected on a membrane and disposed of with the other contaminated material within the exclusion zone.
- The excavator will be cleaned down on location using brushes and shovels and all material disposed of by the methods previously described.
- The excavator will only move away from the Knotweed excavation area once completely cleaned down and signed off by the ecologist.
- This will be carried out at each of the locations where Knotweed is impacting on the development footprint.

4.1.3 Site Hygiene

The following measures will be adhered to during the construction works;

- The contractor will assign a member of their team as Environmental Officer.
- Prior to the commencement of works the Environmental Officer will ensure a 7m buffer will be temporarily fenced off/or marked out with marker-spray around identified stands of Japanese Knotweed to avoid accidental disturbance (The 7m buffer is provided in Figure 3.1 – 3.3).
- All works within the 7m Knotweed buffer will be carried out under the supervision of a suitably qualified ecologist.
- Ensure all site users are given a toolbox talk and are aware of the locations of the invasive species recorded and adhere to avoiding these locations.
- Only people familiar with identifying Japanese Knotweed will be allowed to work in close proximity to the plant.
- Clean down will be carried out using brushes and shovels and power washing avoided. This is to prevent potentially contaminated run-off spreading outside the site.
- Machinery used in the excavation works will be cleaned down in a clearly designated area as assigned by the contractor. All material removed from the machinery will be collected within the designated area and disposed of by means of one of the desired management options described above.

To avoid the introduction of invasive species to the site the following best practice measures are recommended.

- Any material imported to the site will be screened for invasive species by a suitably qualified ecologist before transportation to the site.
- All machinery will be thoroughly cleaned down prior to arriving on the site to avoid the potential spread of invasive species from elsewhere.

5 CONCLUSIONS

The bespoke management plan for the treatment of invasive species outlined in this document has been designed to follow the guidance outlined in Section 1.3. Careful implementation of the prescribed management measures will ensure that the works are conducted within the confines of legislation as outlined in Section 1.2.

It should be noted that this management plan provides options for the management of Third Schedule invasive species only within the footprint of the current proposal.

10 Appendix 10.1: Chapter 10 (Main Report Reference)

HAWRAT Analysis of Proposed Road drainage outfalls

10.1 Introduction

This assessment investigates the impact on the receiving water environment from routine road drainage runoff of the proposed N16 road realignment using the Highways Agency Water Risk Assessment Tool (HAWRAT). HAWRAT was developed using UK datasets and research showed that pollution impacts from routine road runoff is broadly correlated with Annual Daily Traffic numbers. The lowest AADT Road used in the research was 11,000 and the tool provides three AADT bands of 10,000 to 50,000, 50,000 to 100,000 and > 100,000.

It should be noted for the subject road the projected design AADT is only 4,400 which represents a lightly trafficked road and well below the thresholds AADTs provided for in HAWRAT. Furthermore, UK meteorological conditions are only included for in HAWRAT with west / northwest of Ireland meteorological conditions persistently wetter (note for N16 Lugotober road section the SAAR is >1500mm). The wettest UK site available in HAWRAT is Ardtalnaig with SAAR of 1344mm and climate classification of cold-wet with the majority of the sites have SAAR less than 1000mm. Increased annual rainfall was found to reduce the pollutant build up and thus the chronic impact of first flush events on the receiving waters.

10.2 Methodology

It is reported in the TII documentation (DN-DNG-03065) that HAWRAT inherently adopts is a precautionary approach producing a conservative estimate of potential impact of water quality in a receiving stream downstream of a discharge. HAWRAT was developed primarily for use on non-urban trunk roads and motorways in England adopted to reflect conditions within Wales, Scotland and Northern Ireland . TII consider it to be appropriate for use on National Roads in Ireland as climatic conditions are considered to be similar.

The HAWRAT program includes for the following pollutants

- Soluble pollutants of copper and zinc which are associated with acute pollution impacts and expressed as event mean concentrations and
- Sediment bound pollutants associated with chronic pollution impacts that include total copper, total zinc, cadmium, pyrene, fluoranthene, anthracene, phenanthrene and total polycyclic aromatic hydrocarbons (PAH).

A tiered consequential approach to the assessment is adopted in HAWRAT which includes the following steps:

Step 1 the drainage runoff quality (prior to any pre-treatment and discharge into a water body)

Step 2 in-stream impacts (after initial dilution and dispersion)

Step 3 in-Stream impacts post-mitigation (drainage treatment measures)

HAWRAT predicts the statistical distribution of key pollutant concentrations (described above) in untreated and undiluted road runoff over a long release period. The pollutant distribution uses a statistical model based on a ten year rainfall series relevant for the chosen UK site and its climatic region. The results are assessed on a pass/fail basis against toxicity thresholds for dissolved copper and zinc in the absence in the first instance of any pre-treatment within the road drainage system or in-stream dilution. At Step the available dilution of the receiving stream using the 95-percentile low

flow is used to calculate the dilution of soluble pollutants and the potential dispersion of sediments and compared to the pollutant thresholds. For the sediment bound pollutant the ability for the sediment to disperse or accumulate and the extent of sediment accumulation in the form of a deposition index is considered in the receiving stream.

The final step s includes for pollution control measures within the road drainage system upstream of the outfall such as the performance of a SUDS in reducing the pollutant sediment soluble loadings.

HAWRAT is designed to assess the short-term impact risks to receiving watercourses which relate to the intermittent nature of road runoff. Long-term impacts in terms of in-stream annual average concentrations for soluble pollutants of copper and zinc is also assessed in HAWRAT. To pass the HAWRAT assessment both soluble and sediment depositions are required to Pass.

10.3 N16 Lugatober HAWRAT Analysis Results of Routine Road Drainage Impacts

10.3.1 Road Drainage Outfalls and Receiving Watercourses

There are 4 proposed road pavement drainage outfalls discharging to watercourses, refer to Table 10-1 below. The drainage characteristics in terms of low, mean and flood flow are presented in Table 10-2

Table 10-1: Proposed Road Drainage Receiving Watercourses

Outfall	Outfall Chainage (m)	Outfall Grid Location ITM	Stream name	Mainline Road Chainage	Total Impervious area (ha)
1	0	E571991 N839427	SC01 Willowborough	0 – 600 M.L. 0 – 70 (SR 02)	0.533
2	600	E571720 N840320	SC03 Tully	600 – 850	0.337
3	1925	E572070 N841560	SC05 Collinsford	845 – 2290 (ML) 0 – 168 (SR 08)	1.451
4	2250	E572523 N841791	SC07 Lugnagall Stream	2290 – 2525 (ML)	0.183

Table 10-2: Flow characteristics of Receiving Watercourses

Outfall	WC Ref	Area (Km2)	Annual Rainfall (mm)	Mean Flow (l/s)	95-percentile low flow (l/s)	Mean annual flood flow (cumec)	Catchment Greenfield Runoff Rate (l/s per ha)
1	SC01	11.75	1500	372.6	11.8	10.88	9.5
2	SC02	1.53	1465	46.8	1.5	1.77	11.6
3	SC03	0.27	1545	8.9	0.3	0.41	13.9
4	SC06/SC07	0.40	1570	13.6	0.4	0.58	14.2

The Willsborough Stream and Drumcliff-Glebe (Tully Stream) are considered to be fishery sensitive both locally at the proposed outfall points and in their upstream and particularly downstream reaches. The smaller drainage channels of the Collinsford and Lugnagall Streams are considered to be fishery sensitive in their downstream reach (refer to Biodiversity Chapter of the EIAR) but less sensitive locally at the proposed outfall sites.

The Willsborough Stream Discharges into the Garvogue Estuary which is a designated SAC (Cummeen Strand/Drumcliff SAC) and SPA (Cummeen Strand SPA). The Garvogue Estuary is also a Shellfish Waterbody (EPA Geohieve, 2018).

The two more northerly catchments of the Drumcliff-Glebe (Tully Stream) and the Drumcliff River with its associated tributaries that include the Lugatober, Collinsford and Lugnagall streams discharge into Drumcliff Estuary c. 5km to the west of the *Proposed Road Development*. The Drumcliff Estuary is a designated European site being part of the Cummeen Strand/Drumcliff SAC and the Drumcliff Bay SPA. It is also a designated Shellfish Waterbody (EPA Geohieve, 2018).

There are no European sites within 1km of the proposed outfalls and therefore the acute threshold limits for dissolved copper and zinc with allowable exceedances of 2 per annum are outlined in Table 10-3 .

Table 10-3: Acute Threshold limits for Cooper and Zinc

	Copper (ug/l)	*Zinc (ug/l)*
RST24	21	92
RST6	42	184

RST24 is runoff specific threshold for 24hours

RST6 is runoff specific threshold for 24hours

The only potential for combined effects of a number of Road outfalls on a downstream watercourse is from Outfalls 3 and 4 which discharge to tributaries of the Drumcliff River. These tributaries join the Drumcliff River 2km apart. The catchment are of the Drumcliff River is 50km2 and 95-percentile low flow is estimated to be conservatively greater than 0.05cumec which provides ample dilution for these discharges either individually or combined.

The proposed discharges are to pass through petrol interceptors and undergo treatment in the form of retention and settlement in wet Ponds designed to capture and treat first flush events as set out in the TII DNG-DN03066 which recommends the CIRIA C697 approach to calculate treatment volumes. The Storage provided in the treatment ponds are presented in Table 10-4.

The Indictive treatment efficiencies of wet /Retention Ponds presented in Table 7-1 of the TII DN-DNG-03022 is 60% removal of Suspended Solids and 40% removal of Dissolved Copper and 30% removal of Dissolved Zinc.

Table 10-4: Proposed Storm water attenuation storage volume, permissible flood discharge rate and for attenuation ponds

Outfall	Location	Required Water Quality Retention Volume (m3)	Discharge Rate (l/s)
1	Willsborough Stream Pond 1	153	6.94
2	Tully Stream Pond 2	98	4.5

Outfall	Location	Required Water Quality Retention Volume (m3)	Discharge Rate (l/s)
3	Collinsford Stream Pond 3	418	20.45
4	Lugnagall Stream Pond 4	52	2.56

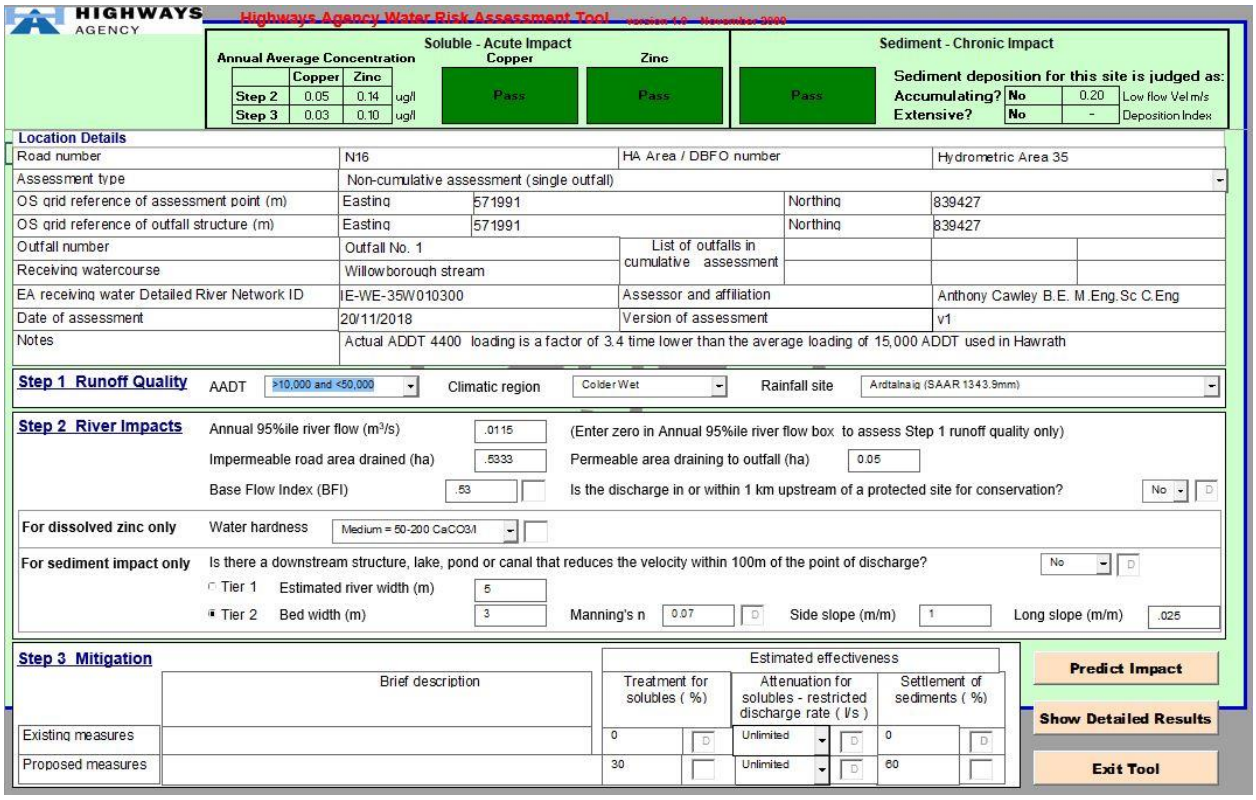
10.3.2 HAWRAT RESULTS

10.3.2.1 Outfall 1

The road drainage from Ch0 to 600 and includes 70m of the realigned SR 02 (N16) representing a total impervious pavement area of 0.533ha and the mainline AADT is 4345 to 4426 discharges via a 400m open drain to the Willsborough Stream. The HAWRAT results output are presented below in Figure 10-1 and show that the in-stream predictions of soluble copper and zinc and sediment deposition index pass the acute and chronic threshold limits without requiring any pre-treatment of the road runoff. Pre-treatment is also included for with the treatment performance of 60% reduction in sediments and 30% reduction in soluble pollutants of copper and zinc achieved by the retention pond.

The predicted increase in annual average concentration of soluble copper and zinc in receiving watercourse is 0.03 and 0.10 µg/l which are significantly lower than the Water quality Standards of 4 and 30 µg/l (Salmonid Waters for Hardness > 100mg/l CaCO3).

Figure 10-1: HAWRAT Results Outfall 1



DETAILED RESULTS

In Runoff

Step 1

	Copper	Zinc
	RST24	
Allowable Exceedances/year	1	1
No. of exceedances/year	63.00	56.70
No. of exceedances/worst year	81	64
	RST6	
Allowable Exceedances/year	1	1
No. of exceedances/year	18.00	20.60
No. of exceedances/worst year	24	27
	(ug/l)	(ug/l)
Thresholds	*RST24* 21	92
Thresholds	*RST6* 42	184
Event Statistics Mean	23.36	67.70
90%ile	45.65	147.58
95%ile	54.99	194.62
99%ile	96.36	372.28

Step 1

	Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
				Toxicity Threshold				
	1	1	1	1	1	1	1	1
No. of exceedances/year	83.80	112.10	2.20	48.30	111.00	48.30	23.00	91.00
No. of exceedances/worst year	97	128	7	59	127	59	32	101
	(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
	331	1165	1	16068	2780	2667	170	752
	733	2672	2	35481	6138	5890	376	1661
	962	3572	3	70795	12247	11752	750	3313
	1383	5637	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)	0.05	0.14
	(ug/l)	(ug/l)
Thresholds	*RST24* 21	92
Thresholds	*RST6* 42	184
Event Statistics Mean	0.15	0.51
90%ile	0.36	0.89
95%ile	0.75	1.93
99%ile	2.34	10.58

Step 2

Velocity 0.20 m/s Tier 2 is used for the calculation

DI -

% settlement needed - %

In River (with mitigation)

Step 3

	Copper	Zinc
	RST24	
Allowable Exceedances/year	2	2
No. of exceedances/year	0.00	0.00
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	0.00	0.00
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)	0.03	0.10
	(ug/l)	(ug/l)
Thresholds ıresholds	*RST24* 21	92
Thresholds	*RST6* 42	184
Event Statistics Mean	0.11	0.36
90%ile	0.25	0.62
95%ile	0.53	1.35
99%ile	1.63	7.41

DI -

10.3.2.2 Outfall 2

The road drainage from Ch600 to 850 representing a total impervious pavement area of 0.337ha and the mainline AADT of 4345 discharges to the Tully stream Chanel upstream of the existing N16 Road culvert. The HAWRAT results output are presented below in Figure 10-2and show that the in-stream predictions of soluble copper and zinc and sediment deposition index pass the acute and chronic threshold limits without requiring any pre-treatment of the road runoff. Pre-treatment is also included for with the treatment performance of 60% reduction in sediments and 30% reduction in soluble pollutants of copper and zinc achieved by the retention pond.

The predicted increase in annual average concentration of soluble copper and zinc in receiving watercourse is 0.11 and 0.33 µg/l which are significantly lower than the Water quality Standards of 4 and 30 µg/l (Salmonid Waters for Hardness > 100mg/l CaCO3).

Figure 10-2: HAWRAT Results Outfall 2

HIGHWAYS AGENCY

Highways Agency Water Risk Assessment Tool version 1.0 November 2009

Soluble - Acute Impact

Annual Average Concentration

	Copper	Zinc		Copper	Zinc
Step 2	0.15	0.48	ug/l	Pass	Pass
Step 3	0.11	0.33	ug/l		

Sediment - Chronic Impact: Pass

Sediment deposition for this site is judged as:

Accumulating?	No	0.14	Low flow Vel m/s
Extensive?	No	-	Deposition Index

Receiving watercourse	Tully stream	cumulative assessment	
EA receiving water Detailed River Network ID	IE-WE-35C980970	Assessor and affiliation	Anthony Cawley B.E. M.Eng.Sc C.Eng
Date of assessment	20/11/2018	Version of assessment	v1
Notes	Actual ADDT 4400 loading is a factor of 3.4 time lower than the average loading of 15,000 ADDT used in Hawrath		

Step 1 Runoff Quality AADT: >10,000 and <50,000 | Climatic region: Colder Wet | Rainfall site: Ardtalnaig (SAAR 1343.9mm)

Step 2 River Impacts

Annual 95%ile river flow (m³/s): .0015 (Enter zero in Annual 95%ile river flow box to assess Step 1 runoff quality only)

Impermeable road area drained (ha): .2436 | Permeable area draining to outfall (ha): .02

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

For dissolved zinc only Water hardness: Medium = 50-200 CaCO3

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): 5

Tier 2 Bed width (m): 1.5 | Manning's n: 0.07 | Side slope (m/m): 1 | Long slope (m/m): .042

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		30	Unlimited	60

Predict Impact | Show Detailed Results | Exit Tool

DETAILED RESULTS

In Runoff

Step 1

	Copper	Zinc
	RST24	
Allowable Exceedances/year	1	1
No. of exceedances/year	63.00	56.70
No. of exceedances/worst year	81	64
	RST6	
Allowable Exceedances/year	1	1
No. of exceedances/year	18.00	20.60
No. of exceedances/worst year	24	27
	(ug/l)	(ug/l)
Thresholds *RST24*	21	92
Thresholds *RST6*	42	184
Event Statistics Mean	23.36	67.70
90%ile	45.65	147.58
95%ile	54.99	194.62
99%ile	96.36	372.28

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	83.80	112.10	2.20	48.30	111.00	48.30	23.00	91.00
No. of exceedances/worst year	97	128	7	59	127	59	32	101
	(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
Mean	331	1165	1	16068	2780	2667	170	752
90%ile	733	2672	2	35481	6138	5890	376	1661
95%ile	962	3572	3	70795	12247	11752	750	3313
99%ile	1383	5637	4	89125	15419	14795	945	4171

In River (no mitigation)

Step 2

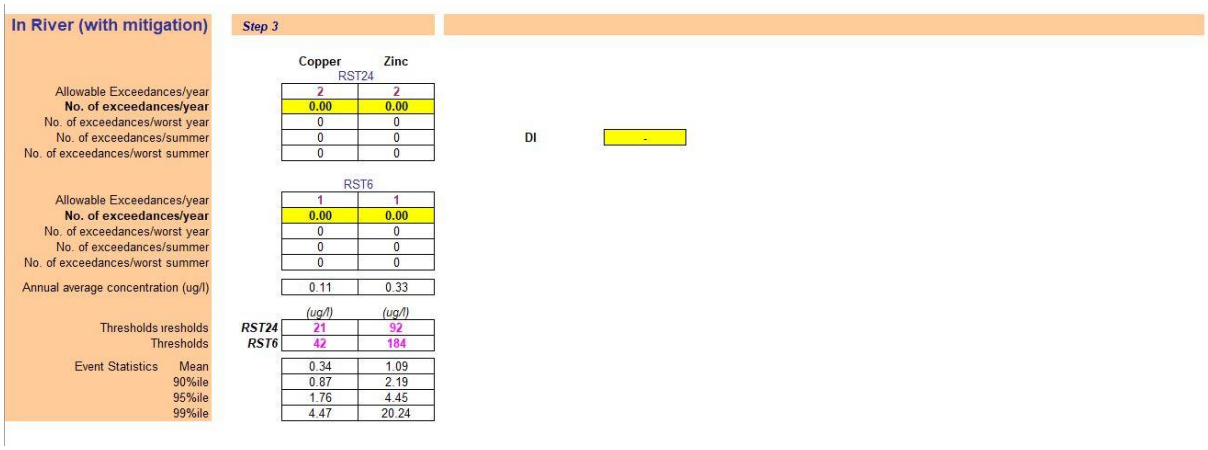
	Copper	Zinc
	RST24	
Allowable Exceedances/year	2	2
No. of exceedances/year	0	0
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
	RST6	
Allowable Exceedances/year	1	1
No. of exceedances/year	0	0
No. of exceedances/worst year	0	0
No. of exceedances/summer	0	0
No. of exceedances/worst summer	0	0
Annual average concentration (ug/l)	0.15	0.48
	(ug/l)	(ug/l)
Thresholds *RST24*	21	92
Thresholds *RST6*	42	184
Event Statistics Mean	0.48	1.55
90%ile	1.25	3.12
95%ile	2.52	6.36
99%ile	6.39	28.91

Step 2

Velocity 0.14 m/s — Tier 2 is used for the calculation

DI -

% settlement needed - %



In River (with mitigation)	Step 3		
	Copper	Zinc	
	RST24		
Allowable Exceedances/year	2	2	
No. of exceedances/year	0.00	0.00	
No. of exceedances/worst year	0	0	
No. of exceedances/summer	0	0	DI -
No. of exceedances/worst summer	0	0	
	RST6		
Allowable Exceedances/year	1	1	
No. of exceedances/year	0.00	0.00	
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	0.33	
	(ug/l)	(ug/l)	
Thresholds ıresholds RST24	21	92	
Thresholds RST6	42	184	
Event Statistics Mean	0.34	1.09	
90%ile	0.87	2.19	
95%ile	1.76	4.45	
99%ile	4.47	20.24	

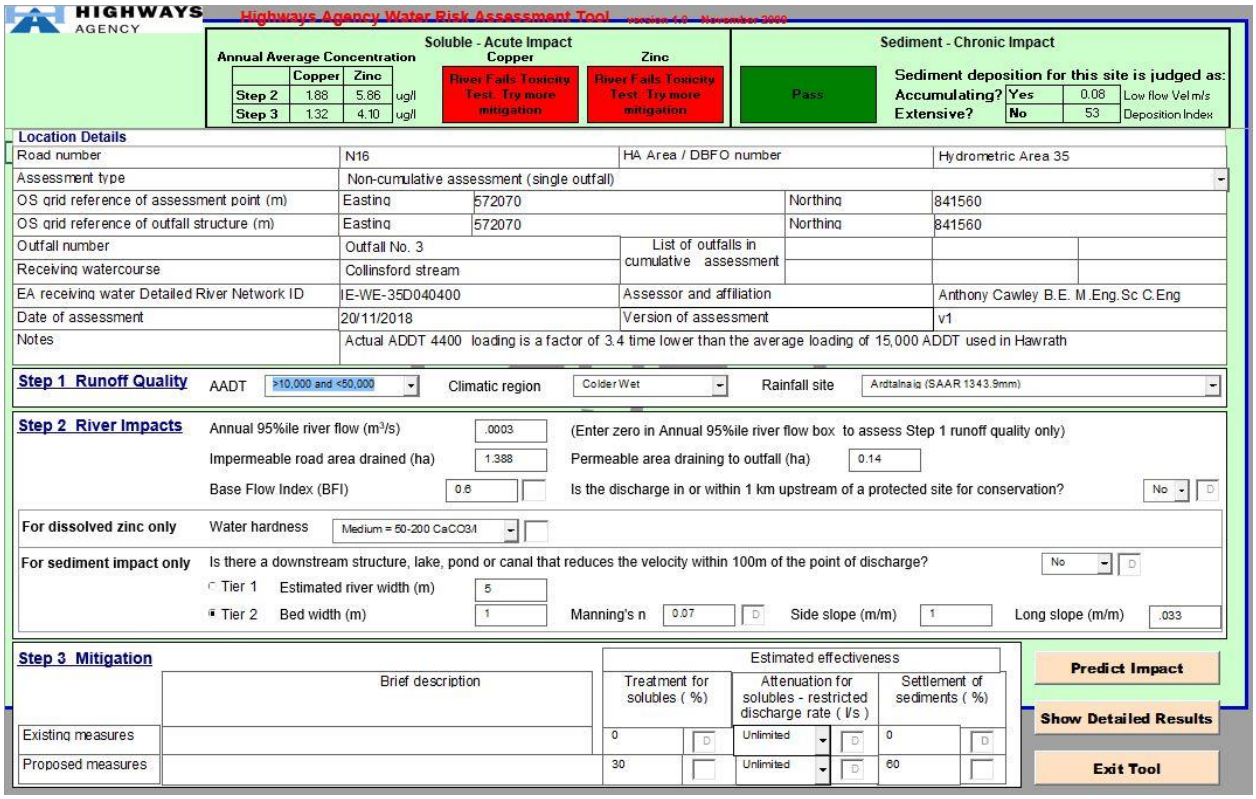
10.3.2.3 Outfall 3

Outfall 3 to the Collinsford Stream system has the largest road area of the four proposed road drainage outfalls draining Ch 850 to 2290 and a 168m section of local road (SR 08), representing a total impervious pavement area of 1.45ha. The mainline AADT is 4345 to 3504 discharges to the Tully stream Chanel upstream of the existing N16 Road culvert. The HAWRAT results output are presented below in Figure 10-3and show that the in-stream predictions of soluble copper and zinc fail the acute threshold limits and pass the sediment deposition index with the pre-treatment of the road runoff included for at 60% reduction in sediments and 30% reduction in dissolved copper and zinc pollutants.

The predicted increase in annual average concentration of soluble copper and zinc in receiving watercourse is 1.32 and 4.10 µg/l are well inside the WFD annual average limits of 4 µg/l copper and 30 µg/l zinc respectively for Hardness exceeding 100mg/l CaCO3.

It should be noted that the design AADT numbers are over 7 times lower than the mid-point of the lowest AADT's range available in the HAWRAT analysis (10,000 to 50,000AADT) and even accounting for load factor of only 50% reduction for this outfall (achieved in HAWRAT by artificially increasing the available dilution by a factor of 2) this outfall passes the HAWRAT soluble pollutant analysis. In the lower reaches adjacent to the Drumcliff River confluence the Catchment area is 1.1km^2 and the 95-percentile low flow is approximately 1l/s and consequently in lower reach it passes the HAWRAT analysis for the AADT range of 10,000 to 50,000.

Figure 10-3: HAWRAT Results Outfall 3



HIGHWAYS AGENCY — Highways Agency Water Risk Assessment Tool

Soluble - Acute Impact

Annual Average Concentration	Copper	Zinc	
Step 2	1.88	5.86	ug/l
Step 3	1.32	4.10	ug/l

Copper: River Fails Toxicity Test. Try more mitigation

Zinc: River Fails Toxicity Test. Try more mitigation

Sediment - Chronic Impact

Pass

Sediment deposition for this site is judged as:

Accumulating? Yes 0.08 Low flow Vel m/s

Extensive? No 53 Deposition Index

Location Details

Road number	N16		HA Area / DBFO number		Hydrometric Area 35
Assessment type	Non-cumulative assessment (single outfall)				
OS grid reference of assessment point (m)	Easting	572070		Northing	841560
OS grid reference of outfall structure (m)	Easting	572070		Northing	841560
Outfall number	Outfall No. 3		List of outfalls in cumulative assessment		
Receiving watercourse	Collinsford stream				
EA receiving water Detailed River Network ID	IE-WE-35D040400		Assessor and affiliation		Anthony Cawley B.E. M.Eng.Sc C.Eng
Date of assessment	20/11/2018		Version of assessment		v1
Notes	Actual ADDT 4400 loading is a factor of 3.4 time lower than the average loading of 15,000 ADDT used in Hawrath				

Step 1 Runoff Quality AADT >10,000 and <50,000 Climatic region Colder Wet Rainfall site Ardtalnaig (SAAR 1343.9mm)

Step 2 River Impacts

Annual 95%ile river flow (m^3/s) .0003 (Enter zero in Annual 95%ile river flow box to assess Step 1 runoff quality only)

Impermeable road area drained (ha) 1.388 Permeable area draining to outfall (ha) 0.14

Base Flow Index (BFI) 0.6 Is the discharge in or within 1 km upstream of a protected site for conservation? No

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) 5

Tier 2 Bed width (m) 1 Manning's n 0.07 Side slope (m/m) 1 Long slope (m/m) .033

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		30	Unlimited	60

Predict Impact | Show Detailed Results | Exit Tool

DETAILED RESULTS

In Runoff

Step 1

	Copper	Zinc
RST24		
Allowable Exceedances/year	1	1
No. of exceedances/year	63.00	56.70
No. of exceedances/worst year	81	64
RST6		
Allowable Exceedances/year	1	1
No. of exceedances/year	18.00	20.60
No. of exceedances/worst year	24	27
	(ug/l)	(ug/l)
Thresholds RST24	21	92
Thresholds RST6	42	184
Event Statistics Mean	23.36	67.70
90%ile	45.65	147.58
95%ile	54.99	194.62
99%ile	96.36	372.28

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	83.80	112.10	2.20	48.30	111.00	48.30	23.00	91.00
No. of exceedances/worst year	97	128	7	59	127	59	32	101
	(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
Mean	331	1165	1	16068	2780	2667	170	752
90%ile	733	2672	2	35481	6138	5890	376	1661
95%ile	962	3572	3	70795	12247	11752	750	3313
99%ile	1383	5637	4	89125	15419	14795	945	4171

In River (no mitigation)

Step 2

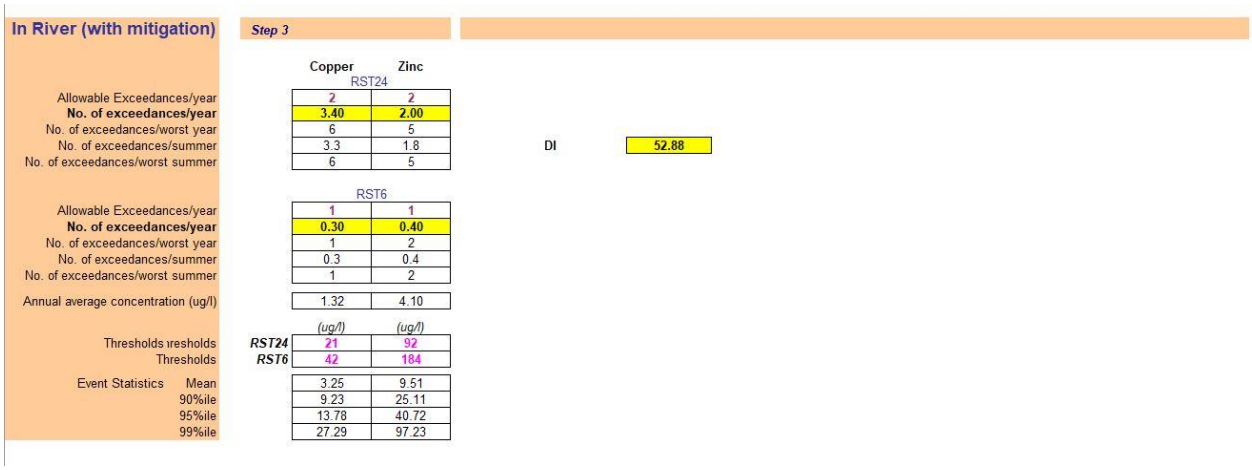
	Copper	Zinc
RST24		
Allowable Exceedances/year	2	2
No. of exceedances/year	6.7	3.7
No. of exceedances/worst year	10	8
No. of exceedances/summer	6.4	3.4
No. of exceedances/worst summer	10	7
RST6		
Allowable Exceedances/year	1	1
No. of exceedances/year	1.1	0.7
No. of exceedances/worst year	3	3
No. of exceedances/summer	1	0.7
No. of exceedances/worst summer	3	3
Annual average concentration (ug/l)	1.88	5.86
	(ug/l)	(ug/l)
Thresholds RST24	21	92
Thresholds RST6	42	184
Event Statistics Mean	4.65	13.58
90%ile	13.19	35.88
95%ile	19.69	58.18
99%ile	38.99	138.90

Step 2

Velocity 0.08 m/s Tier 2 is used for the calculation

DI 132.21

% settlement needed 25 %



In River (with mitigation)	Step 3	Copper	Zinc
		RST24	
Allowable Exceedances/year		2	2
No. of exceedances/year		3.40	2.00
No. of exceedances/worst year		6	5
No. of exceedances/summer		3.3	1.8
No. of exceedances/worst summer		6	5
		RST6	
Allowable Exceedances/year		1	1
No. of exceedances/year		0.30	0.40
No. of exceedances/worst year		1	2
No. of exceedances/summer		0.3	0.4
No. of exceedances/worst summer		1	2
Annual average concentration (ug/l)		1.32	4.10
		(ug/l)	(ug/l)
Thresholds hresholds	RST24	21	92
Thresholds	RST6	42	184
Event Statistics Mean		3.25	9.51
90%ile		9.23	25.11
95%ile		13.78	40.72
99%ile		27.29	97.23

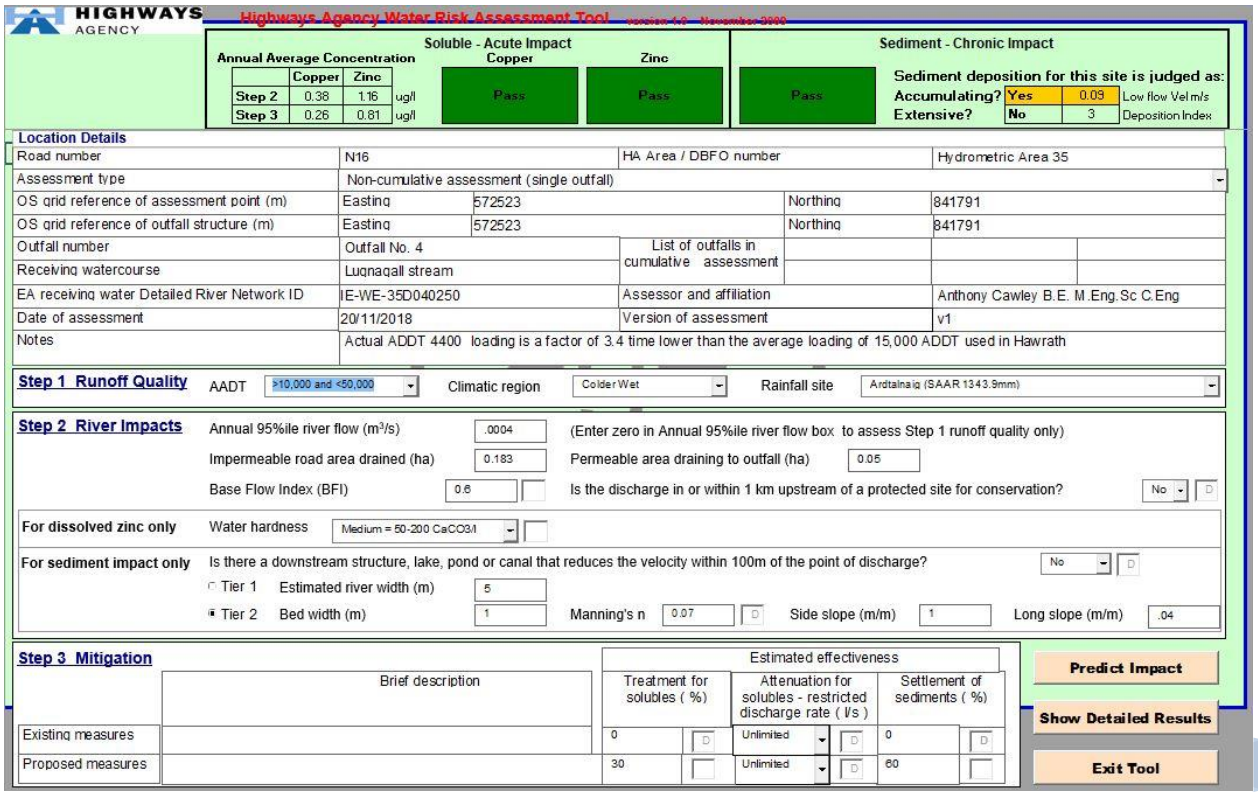
DI 52.88

10.3.2.4 Outfall 4

The final most northerly outfall discharges to a small water course referred to as the Lugnagall Stream draining a small section of road from Ch290 to 2525 representing a total impervious pavement area of 0.183ha and the mainline AADT of 3504. The HAWRAT results output are presented below in Figure 10-4 and show that the in-stream predictions of soluble copper and zinc and sediment deposition index pass the acute and chronic threshold limits without requiring any pre-treatment of the road runoff. Pre-treatment is also included for with the treatment performance of 60% reduction in sediments and 30% reduction in soluble pollutants of copper and zinc achieved by the retention pond.

The predicted increase in annual average concentration of soluble copper and zinc in receiving watercourse is 0.26 and 0.81 µg/l which are significantly lower than the Water quality Standards of 4 and 30 µg/l (Salmonid Waters for Hardness > 100mg/l CaCO3).

Figure 10-4: HAWRAT Results Outfall 4



HIGHWAYS AGENCY — Highways Agency Water Risk Assessment Tool

Annual Average Concentration	Copper	Zinc		Soluble - Acute Impact Copper	Soluble - Acute Impact Zinc	Sediment - Chronic Impact
Step 2	0.38	1.16	ug/l	Pass	Pass	Pass
Step 3	0.26	0.81	ug/l			

Sediment deposition for this site is judged as: Accumulating? Yes 0.09 Low flow Vel m/s; Extensive? No 3 Deposition Index

Location Details

Road number	N16		HA Area / DBFO number		Hydrometric Area 35
Assessment type	Non-cumulative assessment (single outfall)				
OS grid reference of assessment point (m)	Easting	572523		Northing	841791
OS grid reference of outfall structure (m)	Easting	572523		Northing	841791
Outfall number	Outfall No. 4		List of outfalls in cumulative assessment		
Receiving watercourse	Lugnagall stream				
EA receiving water Detailed River Network ID	IE-WE-35D040250		Assessor and affiliation		Anthony Cawley B.E. M.Eng.Sc C.Eng
Date of assessment	20/11/2018		Version of assessment		v1
Notes	Actual ADDT 4400 loading is a factor of 3.4 time lower than the average loading of 15,000 ADDT used in Hawrath				

Step 1 Runoff Quality AADT >10,000 and <50,000 Climatic region Colder Wet Rainfall site Ardtalnaig (SAAR 1343.9mm)

Step 2 River Impacts

Annual 95%ile river flow (m³/s) .0004 (Enter zero in Annual 95%ile river flow box to assess Step 1 runoff quality only)

Impermeable road area drained (ha) 0.183 Permeable area draining to outfall (ha) 0.05

Base Flow Index (BFI) 0.6 Is the discharge in or within 1 km upstream of a protected site for conservation? No

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) .5

Tier 2 Bed width (m) 1 Manning's n 0.07 Side slope (m/m) 1 Long slope (m/m) .04

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		30	Unlimited	60

Predict Impact | Show Detailed Results | Exit Tool

DETAILED RESULTS

In Runoff

Step 1

	Copper	Zinc
	RST24	
Allowable Exceedances/year	1	1
No. of exceedances/year	63.00	56.70
No. of exceedances/worst year	81	64
	RST6	
Allowable Exceedances/year	1	1
No. of exceedances/year	18.00	20.60
No. of exceedances/worst year	24	27
	(ug/l)	(ug/l)
Thresholds *RST24*	21	92
Thresholds *RST6*	42	184
Event Statistics Mean	23.36	67.70
90%ile	45.65	147.58
95%ile	54.99	194.62
99%ile	96.36	372.28

Step 1

	Copper	Zinc	Cadmium	Total PAH	Pyrene	Fluoranthene	Anthracene	Phenanthrene
				Toxicity Threshold				
	1	1	1	1	1	1	1	1
	83.80	112.10	2.20	48.30	111.00	48.30	23.00	91.00
	97	128	7	59	127	59	32	101
Toxicity	(mg/kg)	(mg/kg)	(mg/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
	197	315	3.5	16770	875	2355	245	515
	331	1165	1	16068	2780	2667	170	752
	733	2672	2	35481	6138	5890	376	1661
	962	3572	3	70795	12247	11752	750	3313
	1383	5637	4	89125	15419	14795	945	4171

In River (no mitigation)

Step 2

	Copper	Zinc
	RST24	
Allowable Exceedances/year	2	2
No. of exceedances/year	0.3	0.5
No. of exceedances/worst year	1	2
No. of exceedances/summer	0.3	0.5
No. of exceedances/worst summer	1	2
	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)	0.38	1.16
	(ug/l)	(ug/l)
Thresholds *RST24*	21	92
Thresholds *RST6*	42	184
Event Statistics Mean	1.10	3.41
90%ile	3.11	7.77
95%ile	6.08	14.94
99%ile	12.50	56.21

Step 2

Velocity 0.09 m/s Tier 2 is used for the calculation

DI 8.25

% settlement needed 0 %

In River (with mitigation)

Step 3

	Copper	Zinc
	RST24	
Allowable Exceedances/year	2	2
No. of exceedances/year	0.00	0.00
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	0.00	0.00
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)	0.26	0.81
	(ug/l)	(ug/l)
Thresholds *RST24*	21	92
Thresholds *RST6*	42	184
Event Statistics Mean	0.77	2.39
90%ile	2.18	5.44
95%ile	4.25	10.46
99%ile	8.75	39.34

DI 3.30

10.4 Conclusions

In conclusion, the HAWRAT analysis of the routine road drainage discharge from the N16-Lugatober Road project passes the acute and chronic pollutant impact assessment for soluble and sediment deposition at its four proposed outfalls. The water quality status of the receiving streams, both locally and downstream, will not be impacted negatively as a result of the road drainage discharges. Pre-treatment is provided upstream of each outfall which reduces further any potential impacts during the operational phase of the project. The annual average loading of road drainage pollutants using dissolved copper and zinc as an indicator result in predicted low concentrations in the receiving stream at the outfalls indicating that long term impacts of such pollutants on the receiving waters will be minor to insignificant.

11 Appendix 13.1: Chapter 13 (Main Report Ref)

Archaeological and Cultural Heritage Sites

11.1 Archaeological and Cultural Heritage Sites

ID No.	AAP 07 (see Plate 14-1)
Legal Status	N/A
Reference number	N/A
Townland	Drumkilsellagh/Castlegal
Site Type	River
ITM	571775, 840335
Description	Narrow and shallow river, it is c. 1m wide and set within a deep cut/ravine. There is a lot of stone visible in the base of the channel and there are a number of stone steps in the channel. Each bank is lined by mature trees. The river forms the townland boundary between Drumkilsellagh and Castlegal (TB 06).
Sources	Aerial photography
Distance to CPO	0
Perceived Significance	Regional
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	A wade survey, photographic survey and written record of the impacted section of the stream will be undertaken prior to development.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	AAP 15
Legal Status	N/A
Reference number	N/A
Townland	Lugatober
Site Type	Stream
ITM	571798, 840956
Description	Narrow stream forming field boundary. Ground slopes up significantly to north and south. Bounded by marshy ground to north and south.
Sources	Aerial photography
Distance to CPO	0
Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	A wade survey, photographic survey and written record of the impacted section of the stream will be undertaken prior to development.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	AAP 16 (see Plate 14-14)

Legal Status	N/A
Reference number	N/A
Townland	Collinsford/Lugatober
Site Type	Stream
ITM	572195, 841506
Description	Shallow stream located at base of slope. The stream is c. 1 – 1.5m in width with areas of rushes to the north and south sides. The stream forms the townland boundary between Collinsford and Lugatober (TB 09).
Sources	Aerial photography
Distance to CPO	0
Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	A wade survey, photographic survey and written record of the impacted section of the stream will be undertaken prior to development.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	AAP 17
Legal Status	N/A
Reference number	N/A
Townland	Collinsford
Site Type	Area of settlement potential
ITM	572199, 841639
Description	The summit of the ridge has potential for settlement evidence as it is relatively flat land with a local water source (AAP 17).
Sources	Field survey
Distance to CPO	0
Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	The area within the CPO will be subject to geophysical survey and targeted test excavation prior to development. Further mitigation including archaeological excavation may be required.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	AAP 18
Legal Status	N/A
Reference number	N/A
Townland	Drumkilsellagh
Site Type	AAP
ITM	571869, 840103
Description	Slightly raised circular area with shallow depression to centre, with curving channel running to east. Possible paleo-channel.
Sources	Aerial photography

Distance to CPO	50
Perceived Significance	Local
Type of impact	No impact
Significance and quality of Impact	No predicted impact
Mitigation measures	No further mitigation required
Impact after mitigation	None

ID No.	AAP 19 (see Plate 14-12)
Legal Status	N/A
Reference number	N/A
Townland	Lugatober
Site Type	AAP (Area of wet rushy ground
ITM	571982, 841386
Description	Three roughly circular areas of wetter, rushy ground within Field 15.
Sources	Aerial photography, field survey.
Distance to CPO	0
Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	The area within the CPO will be subject to targeted test excavation prior to development. Further mitigation including archaeological excavation may be required.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	AAP 12 (see Plate 14-13)
Legal Status	N/A
Reference number	N/A
Townland	Lugatober
Site Type	Quarry
ITM	571982, 841386
Description	Evidence of historic quarrying comprising scarped area with pile of limestone to centre, mature trees growing within the quarried area and on the edge of the scarped area. While this feature is not indicated on the 1st or later edition Ordnance Survey maps, the Ordnance Survey Name Books record a quarry in the southern part of the townland of Collinsford and the northern part of the townland of Lugatober which may correspond with this location.
Sources	Aerial photography, field survey.
Distance to CPO	0
Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	The area within the CPO will be subject to targeted test excavation prior to development. Further mitigation including archaeological excavation may be required.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	CHC 01 (see Plate 14-5)
Legal Status	RMP
Reference number	SL009-028
Townland	Drum East
Site Type	Megalithic tomb - wedge tomb
ITM	571651, 840453
Description	Description from RMP, site is currently completely overgrown. This monument was first shown on the 1913 edition of the OS 6-inch map. It lies about 5km to the northeast of Sligo town and is situated immediately to the west of the Sligo-Manorhamilton road. The monument is on flat pasture at the foot of Castlegal Mountain. The tomb is ruined but retains a single roofstone. It consists of a long, apparently wedge-shaped gallery flanked at either side by the remains of outer-walling. A single façade stone adjoins the north side of the gallery. The structure is incorporated om a low mound measuring about 11m east-west and 6m north-south. The gallery is 8.15m long and narrows from 1.30m wide near the middle to 1m near the back. The north side is represented by four stones. That next to the façade measures 1.40m by 35cm by 1m high and the small side stone east of this, 45cm by 15cm by 10cm high. This third side stone leans heavily inwards. It measures 2.20m by 45cm and if erect would be 85cm high. The last side stone here is 35cm by 25cm and 10cm high. The stone marking the east of the gallery measures 80cm by 50cm b7y 30cm high. Beyond this is a prostrate stone 1.70m in maximum dimension. The five stones representing the south side of the gallery are 45cm to 60cm high. That at the west leans heavily inwards under the roofstone. This measures 2.55m by 2.15m by 40cm thick. The outer-walling at the north is represented by a line of three stones. That at the west measures 95cm by 15cm by 30cm high and the stone next to this 90cm by 25cm by 65cm high. The third stone appears to be the stump of an orthostat and is 30cm by 5cm by 5cm high. The three surviving outer-wall stones at the south are largely concealed by the roots of a tree. The tallest protrudes 40cm above the roots. The façade stone measures 1.20m by 30cm by 1m high. The prostrate stone beside it is 1.70m in maximum dimension.
Sources	RMP
Distance to CPO	8
Perceived Significance	National
Type of impact	Indirect
Significance and quality of Impact	Moderate, negative
Mitigation measures	The area within the CPO will be subject to geophysical survey and targeted test excavation prior to development. Further mitigation including archaeological excavation may be required. Landscape screening will be provided to minimise the visual impact on the monument.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR. Permanent impact on setting of monument.

ID Ref.	CHC 02
Legal Status	RMP
Reference number	SL009-027
Townland	CASTLEGAL (Carbury By., Glencar ED)
Site Type	Barrow - ring-barrow
ITM	571912, 840728
Description	Situated on a slight NW-facing slope near summit of hillock, in gently undulating pasture. Circular slightly raised area (diam. 11m) defined by a low bank of earth (Wth 2.65m; int. H 0.3m). At the external foot of the bank is a fosse (Wth 2.2m; D 0.35m). A break in the bank (Wth 1.15m) with an irregular causeway across the fosse appears to be modern. At the centre of the interior is a slightly raised area (diam. 4m), defined by a faint scarped edge, which may mark the remains of a central mound.
Distance to CPO	52

Perceived Significance	National
Type of impact	No predicted impact
Significance and quality of Impact	No impact
Mitigation measures	No further mitigation required
Impact after mitigation	None

ID No.	CHC 11 (see Plate 14-6 and Plate 14-7)
Legal Status	RMP
Reference number	SL009-026
Townland	Castlegal/Lugatober
Site Type	Ringfort - rath
ITM	571681, 840765
Description	Situated on a slight NW-facing slope in gently undulating pasture. Circular raised area (diam. 15m) enclosed by a bank of earth (Wth 6.4m; int. H 0.4m). There is no fosse visible at ground level. The bank encloses the site W-S. From S-SW the bank has been removed by a small quarry. From SW-W the edge of the site is defined by an irregular scarp. The original entrance is not recognisable. An ENE-WSW orientated field boundary bank with a drain crosses the interior to N of centre cutting through the bank at W and at NE. The interior to the S of this boundary is heavily disturbed by quarrying.
Sources	RMP
Distance to CPO	0
Perceived Significance	National
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	Part of the monument is included in the CPO for severance reasons however it will be excluded from the LMA for construction and thus preserved in situ. The area within the CPO will be subject to geophysical survey. Any archaeology discovered within the LMA will be subject to targeted test excavation prior to development. Further mitigation including archaeological excavation may be required.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR. Permanent impact on setting of monument.

ID No.	CHC 12 (see Plate 14-19 and Plate 14-20)
Legal Status	RMP
Reference number	SL009-035
Townland	Doonally
Site Type	Ringfort - rath
ITM	571607, 839729
Description	On a level summit of a slight rise in gently undulating pasture. Slightly raised circular area (diam. 22m) enclosed by a low broad bank of earth (Wth 5m; int. H 0.3m) with an external fosse (Wth 2.6m; D 0.3m). Both the bank and the fosse enclose the entire site having a consistent profile along the entire circuit. A break (Wth 2.3m) in the bank with a causeway across the fosse at SE marks the position of the original entrance.
Sources	RMP
Distance to CPO	12
Perceived Significance	National
Type of impact	Indirect
Significance and quality of Impact	Moderate, negative impact on setting of monument.

Mitigation measures	The area within the CPO will be subject to geophysical survey and targeted test excavation prior to development. Further mitigation including archaeological excavation may be required.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR. Permanent impact on setting of monument

ID No.	CHC 72
Legal Status	N/A
Reference number	N/A
Townland	Castlegar/Lugatober
Site Type	Old road
ITM	571699, 840333 to 571973, 840668
Description	An abandoned road located to the east of the existing N16, clearly depicted on the 1st ed. OS maps as tree-lined. Preserved within current field boundaries. Not depicted on later OS maps.
Sources	1st ed. OS map
Distance to CPO	0
Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	A topographic and photographic survey of the impacted section of the road will be undertaken prior to development.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	CHC 80
Legal Status	N/A
Reference number	N/A
Townland	Drumkilsellagh
Site Type	Building
ITM	571646, 839810
Description	Site of buildings indicated on 1st ed. OS map. Nothing visible above ground at site.
Sources	1st ed. OS map
Distance to CPO	0
Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	The area within the CPO will be subject to targeted test excavation prior to development. Further mitigation including archaeological excavation may be required.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	CHC 82
Legal Status	N/A
Reference number	N/A

Townland	Castlegal
Site Type	Building
ITM	571736, 840359
Description	Site of building indicated on 1st ed. OS map. Nothing visible above ground at site.
Sources	OS 1st ed. map
Distance to CPO	0
Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	The area within the CPO will be subject to targeted test excavation prior to development. Further mitigation including archaeological excavation may be required.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	CHC 83
Legal Status	N/A
Reference number	N/A
Townland	Lugatober
Site Type	Building
ITM	571734, 841056
Description	Site of buildings indicated on 1st ed. OS map. Nothing visible above ground at site. Have been replaced by a number of modern agricultural outbuildings.
Sources	1st ed. OS map
Distance to CPO	0
Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	The area within the CPO will be subject to targeted test excavation prior to development. Further mitigation including archaeological excavation may be required.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	CHC 84 (see Plate 14-21)
Legal Status	N/A
Reference number	N/A
Townland	Doonally
Site Type	Mass rock, possible current site of.
ITM	571750, 839644
Description	Large earthbound limestone boulder, possibly not in original location. Local landowner indicated that the boulder was known locally as a mass rock. May originally have been located further to the west within a copse of trees or trees ring. Not indicated on 1st ed. OS map.
Sources	Pers. Comm. local landowner (E. Collis)
Distance to CPO	0
Perceived Significance	Local

Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	The area within the CPO will be subject to targeted test excavation prior to development. Further mitigation including archaeological excavation may be required.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	CHC 85 (see *Plate 14-2*)
Legal Status	N/A
Reference number	N/A
Townland	Castlegal
Site Type	Well
ITM	571745, 840358
Description	A well, marked on the 25" Ordnance Survey map, was located along the north bank of the river. Concrete slabs for the west, south and east sides and there is a concrete slab covering the top of the well. It is 0.95m wide.
Sources	Field survey
Distance to CPO	0
Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	The area within the CPO will be subject to targeted test excavation prior to development. Further mitigation including archaeological excavation may be required.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	TB 05
Legal Status	N/A
Reference number	N/A
Townland	Doonally/Drumkilsellagh
Site Type	Townland boundary
ITM	571690, 839765
Description	Townland boundary between Doonally and Drumkilsellagh comprising earthen bank covered in mature trees and hedgerow.
Sources	1st ed. OS map
Distance to CPO	0
Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	A topographic and photographic survey of the impacted section of the townland boundary will be undertaken prior to development. Targeted test excavation of a cross-section of the townland boundary will be undertaken prior to development. Further mitigation including archaeological excavation may be required.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	TB 06 (see Plate 14-1)
Legal Status	N/A
Reference number	N/A
Townland	Drumkilsellagh/Castlegal
Site Type	Townland boundary
ITM	571775, 840335
Description	Townland boundary between Drumkilsellagh and Castlegal, comprising shallow and narrow river (AAP 07), it is c. 1m wide and set within a deep cut/ravine. There is a lot of stone visible in the base of the channel and there are a number of stone steps in the channel. Each bank is lined by mature trees.
Sources	Aerial photography
Distance to CPO	0
Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	A wade survey, photographic survey and written record of the impacted section of the townland boundary will be undertaken prior to development.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	TB 07 (see Plate 13.X)
Legal Status	N/A
Reference number	N/A
Townland	Drum East/Castlegal
Site Type	Townland boundary
ITM	571655, 840500
Description	Townland boundary between Castlegal and Drum East (TB 07) runs along the western side of the road. It comprises a shallow wet ditch with mature trees and hedgerow.
Sources	1st ed. OS map
Distance to CPO	0
Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	A photographic survey and written record of the impacted section of the townland boundary will be undertaken prior to development.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	TB 08
Legal Status	N/A
Reference number	N/A
Townland	Castlegal/Lugatober
Site Type	Townland boundary
ITM	571738, 840771

Description	Townland boundary between Castlegal and Lugatober comprises a significant double earthen bank measuring up to 1m in height on the northern side with an internal ditch and slight external ditches. Bisects ringfort (CHC 11) to east of N16 road.
Sources	1st ed. OS map
Distance to CPO	0
Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	A topographic and photographic survey of the impacted section of the townland boundary will be undertaken prior to development. Targeted test excavation of a cross-section of the townland boundary will be undertaken prior to development. Further mitigation including archaeological excavation may be required.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	TB 09 (see Plates 13-14, 13-15 and 13-16)
Legal Status	N/A
Reference number	N/A
Townland	Lugatober/Collinsford
Site Type	Townland boundary
ITM	572191, 841508
Description	Townland boundary between Lugatober and Collinsford comprising shallow stream located at base of slope. The stream is c. 1 – 1.5m in width with areas of rushes to the north and south sides.
Sources	1st ed. OS map
Distance to CPO	0
Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	A wade survey, photographic survey and written record of the impacted section of the townland boundary will be undertaken prior to development.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	TB 20
Legal Status	N/A
Reference number	N/A
Townland	Lugatober/Lugnagall
Site Type	Townland boundary
ITM	571268, 841610
Description	The townland boundary between Lugnagall and Lugatober comprises an earthen bank to the south and wet ditch to the north covered in mature trees and hedgerow.
Sources	1st ed. OS map
Distance to CPO	0
Perceived Significance	Local
Type of impact	Direct

Significance and quality of Impact	Moderate, negative
Mitigation measures	A topographic and photographic survey of the impacted section of the townland boundary will be undertaken prior to development. Targeted test excavation of a cross-section of the townland boundary will be undertaken prior to development. Further mitigation including archaeological excavation may be required.
Impact after mitigation	Positive residual impact, any archaeological features will be recorded prior to construction. If required site will be notified to the Archaeological Survey of Ireland (DCHG) for inclusion in the SMR.

ID No.	TB 21 (see Plate 13-17)
Legal Status	N/A
Reference number	N/A
Townland	Collinsford/Lugnagall
Site Type	Townland boundary
ITM	572320, 841640
Description	The townland boundaries between Lugnagall and Collinsford comprises an earthen bank to the south and wet ditch to the north covered in mature trees and hedgerow.
Sources	1st ed. OS map
Distance to CPO	8
Perceived Significance	Local
Type of impact	Indirect
Significance and quality of Impact	No predicted impact
Mitigation measures	No further mitigation required
Impact after mitigation	None

12 Appendix 13.2: Chapter 13 (Main Report Ref)

Architectural Heritage Sites

12.1Architectural Heritage

ID No.	AHC 41 (Castlegal House) (see Plate 14-3 and Plate 14-4)
Legal Status	N/A
Reference number	N/A
Townland	Castlegal
Site Type	House and outbuildings
ITM	571817, 840528
Description	Castlegal House comprises a four-bay, two-storey house, built c. 1820 and extended or rebuilt in the mid-nineteenth century. It is located on the site of an earlier house, marked on the 1st edition Ordnance Survey map. Roughcast rendered walls with smooth rendered plinth. Single-span pitched roof with rendered chimneystacks. Square-headed window opening with painted masonry sills and timber single-pane sliding sash windows. Round-headed door opening with rendered reveals, timber panelled door and plain glazed fanlight to front (south) elevation. Single-storey porch to rear (north) elevation. Rubble limestone boundary wall with wrought-iron gates to entrance. To the west of the house is a three-bay, two-storey barn, built c. 1820. It is constructed of coursed squared rubble masonry and is roughcast rendered in places, with a red brick string course to the eaves and barrel-vaulted corrugated-iron roof. Square-headed door openings to front (east) and west elevations with stone reveals and timber doors. Infilled square- and segmental-headed openings to north elevation with stone voussoirs. Small slit openings to loft. Shuttered concrete-built extension to south end with lean-too roof to west end and barrel-vaulted corrugated iron roof to east end, on squared rubble foundation.
Sources	1st ed. OS map, 25" OS map
Distance to CPO	2
Perceived Significance	Regional
Type of impact	Indirect
Significance and quality of Impact	Slight, negative impact on setting
Mitigation measures	The landscape screening being provided for the Proposed Road Development (see Ch. 12) will minimise the visual impact on the building.
Impact after mitigation	Slight negative on the setting.

ID No.	AHC 42 (see Plate 14-8 and Plate 14-9)
Legal Status	N/A
Reference number	N/A
Townland	Lugatober
Site Type	House, partial remains of
ITM	571735, 840958
Description	The site of a house marked on the 1st edition Ordnance Survey located in the southeast corner of the field to the north of the stream. The northeast corner of the structure is all that now remains. The standing section is constructed of coursed squared rubble and survives to a height of four courses. The foundations of the remainder of the house can be traced as a raised grassy platform running southwest of the upstanding corner. The house was accessed from a laneway, marked on the 1st edition map. This now comprises a pair of earthen banks covered in mature trees with a flat trackway in between.
Sources	1st ed. OS map
Distance to CPO	0

Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	The building will be subject to architectural recording prior to development. The area within the CPO will be subject to targeted test excavation prior to development. Further mitigation may be required.
Impact after mitigation	Slight negative

ID No.	AHC 43 (see Plate 14-10)
Legal Status	N/A
Reference number	N/A
Townland	Lugatober
Site Type	House
ITM	571845, 841063
Description	House, marked on the 1st edition Ordnance Survey located on south side of local road. The house is in a derelict condition, covered in trees and other vegetation. It is constructed of coursed squared rubble masonry with dressed quoins to the corners. It has a single-span pitched corrugated-iron roof. There are two openings in the front (north) elevation with stone reveals.
Sources	1st ed. OS map
Distance to CPO	0
Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	The building will be subject to architectural recording prior to development.
Impact after mitigation	Slight negative.

ID No.	AHC 44 (see Plate 14-11)
Legal Status	N/A
Reference number	N/A
Townland	Lugatober
Site Type	House
ITM	571902, 841082
Description	House marked on the first edition Ordnance Survey map. It is a single-storey with loft house, built c. 1820. It has a single span pitched natural slate roof. It is constructed of squared rubble masonry with dressed quoins to the corners. Square-headed door opening to front with timber frame. Infilled square-headed window opening with stone sill to east elevation. Concrete water trough to front (north) elevation. Barrel-vaulted corrugated-iron barn to southwest. Remains of squared rubble masonry outbuildings to south.
Sources	1st ed OS map
Distance to CPO	10
Perceived Significance	Local
Type of impact	Indirect
Significance and quality of Impact	Slight, negative on setting
Mitigation measures	The landscape screening being provided for the Proposed Road Development (see Ch. 12) will minimise the visual impact on the building.
Impact after mitigation	Slight negative on setting.

ID No.	AHC 45
Legal Status	N/A
Reference number	N/A
Townland	Lugatober
Site Type	Milestone, site of
ITM	571999, 841270
Description	Milestone marking distance between Sligo and Manorhamilton. Feature has been removed.
Sources	25" OS map
Distance to CPO	11
Perceived Significance	Local
Type of impact	No predicted impact
Significance and quality of Impact	No impact
Mitigation measures	No further mitigation required
Impact after mitigation	None

ID No.	AHC 46
Legal Status	N/A
Reference number	N/A
Townland	Drumkilsellagh
Site Type	Milestone, site of
ITM	871793, 840030
Description	Milestone marking distance between Sligo and Manorhamilton. Feature has been removed.
Sources	25" OS map
Distance to CPO	0
Perceived Significance	Local
Type of impact	No predicted impact
Significance and quality of Impact	No impact
Mitigation measures	No further mitigation required
Impact after mitigation	None

ID No.	AHC 47 (see Plate 14-18)
Legal Status	N/A
Reference number	N/A
Townland	Drumkilsellagh
Site Type	House
ITM	571775, 840045
Description	House marked on 25" Ordnance Survey map. It is a three-bay single storey house, built c. 1900. It has a single span roof and is currently uncovered. It is constructed of squared limestone masonry with dressed quoins to the corners. It has square-headed window openings with red brick reveals.
Sources	25" OS map
Distance to CPO	0

Perceived Significance	Local
Type of impact	Direct
Significance and quality of Impact	Moderate, negative
Mitigation measures	The building will be subject to architectural recording prior to development.
Impact after mitigation	Slight, negative

13 Appendix 13.3: Chapter 13 (Main Report Reference)

Field Survey Results

13.1Field Survey

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Drumkilsellagh
Conditions	Cloudy and wet
Access	Field gate in western boundary.
Field No. (Map ref.)	F1
Physical Environment	Relatively flat to west end of field, slopes up steeply to east. Wet rushy pasture, particularly along western boundary (571697, 840291).
Features	Infilled depression along western boundary with large blocks of concrete (IM 571797, 840124).
Areas of Archaeological Potential	Slightly raised circular area noted on aerial photographs (ITM 571876, 840102) with curving linear feature or dry channel running along eastern side (AAP 18).
Constraints	N/A
Photographs	F1.1 Field 1, infilled depression.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Drumkilsellagh
Conditions	Cloudy and wet
Access	Field gate in western boundary
Field No. (Map ref.)	F2
Physical Environment	Field slopes up sharply to east. Very wet, rushy field in pasture. River forms northern boundary, set in deep cut/ravine.
Features	Limestone boulder in north-western corner of field, c. 0.5m high.
Areas of Archaeological Potential	Potential for burnt mounds, particularly in wetter ground along river bank.
Constraints	The northern boundary is a shallow and narrow river (AAP 07). It is c. 1m wide and set within a deep cut/ravine. There is a lot of stone visible in the base of the channel and there are a number of stone steps in the channel. Each bank is lined by mature trees. The river forms the townland boundary between Drumkilsellagh and Castlegal (TB 06).
Photographs	F2.1 Field 2, looking south from north end of field. F2.2 Field 2, looking south from north end of field. F2.3 Field 2, looking east along river and townland boundary. F2.4 Field 2, stream, looking north. F2.5 Field 2, stream, looking north. F2.6 Field 2, bridge in north-western corner of field. F2.7 Field 2, large boulder in north-western corner of field.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Castlegal
Conditions	Cloudy and wet
Access	From northwest boundary, across field bank.
Field No. (Map ref.)	F3
Physical Environment	Relatively good pasture, slopes down to west.
Features	A well, marked on the 25" Ordnance Survey map was located along the north bank of the river. Concrete slabs for the west, south and east sides and there is a concrete slab covering the top of the well. It is 0.95m wide. Along the north-western boundary of the field (ITM 571788, 840458). This is a single-bay, single-storey agricultural outbuilding. It is constructed of shuttered concrete and is currently unroofed. There are possible feeding boxes along the southern wall.
Areas of Archaeological Potential	
Constraints	The southern boundary is a narrow and shallow river (AAP 07). It is c. 1m wide and set within a deep cut/ravine. There is a lot of stone visible in the base of the channel and there are a number of stone steps in the channel. Each bank is lined by mature trees. The river forms the townland boundary between Drumkilsellagh and Castlegal (TB 06).
Photographs	F3.1 Field 3, river, looking south. F3.2 Field 3, river, looking south. F3.3 Field 3, river, looking south. F3.4 Field 3, river, looking southwest. F3.5 Field 3, river, looking southwest. F3.6 Field 3, well, looking north. F3.7 Field 3, well, looking north. F3.8 Field 3, well, looking north. F3.9 Field 3, looking south. F3.10 Field 3, looking west. F3.11 Field 3, area of rough ground to north of river. F3.12 Field 3, remains of concrete built outbuilding along north-western boundary.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Castlegal
Conditions	Cloudy and wet
Access	Gap in western boundary
Field No. (Map ref.)	F4
Physical Environment	Wet pasture with rushes in places, slopes up to north. Field boundary to south comprises earthen bank covered in mature trees.
Features	N/A
Areas of Archaeological Potential	N/A
Constraints	N/A

Photographs	F4.1 Field 4, looking north along western field boundary. F4.2 Field 4, southern field boundary.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Castlegal
Conditions	Cloudy, overcast.
Access	Field gate in eastern boundary
Field No. (Map ref.)	F5
Physical Environment	Field in pasture, wet and rushy in places, particularly at western end of field. Ground slopes down to west. Northern boundary comprises slight earthen bank covered in mature trees.
Features	N/A
Areas of Archaeological Potential	N/A
Constraints	Castlegal House (AHC 41) is located in the northeast corner of the field. It comprises a four-bay, two-storey house built c. 1820 and extended or rebuilt in the mid-nineteenth century. Roughcast rendered walls with smooth rendered plinth. Single-span pitched roof with rendered chimneystacks. Square-headed window opening with painted masonry sills and timber single-pane sliding sash windows. Round-headed door opening with rendered reveals, timber panelled door and plain glazed fanlight to front (south) elevation. Single-storey porch to rear (north) elevation. Rubble limestone boundary wall with wrought-iron gates to entrance. To the west of the house is a three-bay, two-storey barn, built c. 1820. It is constructed of coursed squared rubble masonry and is roughcast rendered in places, with a red brick string course to the eaves and barrel-vaulted corrugated-iron roof. Square-headed door openings to front (east) and west elevations with stone reveals and timber doors. Infilled square- and segmental-headed openings to north elevation with stone voussoirs. Small slit openings to loft. Shuttered concrete-built extension to south end with lean-too roof to west end and barrel-vaulted corrugated iron roof to east end, on squared rubble foundation.
Photographs	F5.1 Field 5, looking south to field boundary. F5.2 Field 5, eastern boundary. F5.3 Field 5, looking west. F5.4 Field 5, looking north. F5.5 Field 5, looking north to northern boundary. F5.6 Field 5, Castlegal House, front (south) elevation. F5.7 Field 5, Castlegal House, front (south) elevation. F5.8 Field 5, Castlegal House, side and rear (north) elevation. F5.9 Field 5, Castlegal House, side and rear (north) elevation. F5.10 Field 5, Castlegal House, gate. F5.11 Field 5, barn, east and north elevations. F5.12 Field 5, barn, north elevation. F5.13 Field 5, barn, west elevation F5.14 Field 5, barn, extension. F5.15 Field 5, barn, extension F5.16 Field 5, barn, south elevation. F5.17 Field 5, northern boundary.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober

Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Castlegal Drum East
Conditions	Cloudy and overcast.
Access	Entrance gate in eastern boundary
Field No. (Map ref.)	F6
Physical Environment	Relatively flat field in pasture, with wetter rushy patches in places. Containing house and agricultural outbuildings.
Features	Two dressed stones were noted built into the gate piers at the entrance to the farm.
Areas of Archaeological Potential	The area around the wedge tomb (CHC 01) is considered to be an area of archaeological potential which may contain settlement evidence associated with the tomb.
Constraints	Townland boundary between Castlegal and Drum East (TB 07) runs along the eastern boundary of the field. It comprises a shallow wet ditch with mature trees and hedgerow. A wedge tomb (CHC 01) is located in the northeast corner of the field along the road boundary. The site of the tomb has been colonised by a number of mature trees and brambles.
Photographs	F6.1 Field 6, wedge tomb from southeast. F6.2 Field 6, vegetation covered gallery. F6.3 Field 6, vegetation covered gallery. F6.4 Field 6, wedge tomb from southwest. F6.5 Field 6, wedge tomb from southeast. F6.6 Field 6, dressed stone in northern pier. F6.7 Field 6, dressed stone in southern pier. F6.8 Field 6, townland boundary between Castlegal and Drum East.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Castlegal
Conditions	Cloudy and wet
Access	Over western field boundary, or from gap in southern boundary.
Field No. (Map ref.)	F7
Physical Environment	Large field in pasture, wetter with rushes in places, particularly to lower ground along southern boundary. Slopes up significantly to northern boundary. Southern boundary comprises earthen bank covered in matures trees.
Features	A slight linear depression was noted during the field survey running south through the field from the northern field boundary (ITM 571726, 840761). This corresponds with a removed field boundary noted on OSI aerial photographic coverage.
Areas of Archaeological Potential	Potential for additional features in north-western corner in vicinity of ringfort (CHC 11).
Constraints	The southern portion of the ringfort (CHC 11) is located in the north-western corner of the field. It comprises a raised area It has been heavily impacted in the past by quarrying and the construction of a significant townland boundary which bisects the ringfort from northeast to southwest. The ringfort is covered in long grass and rushes. The northern field boundary is the townland boundary between Castlegal and Lugatober (TB 08). It is a significant boundary comprises a double earthen bank measuring up to 1m in height on the northern side with an internal ditch and slight external ditches.
Photographs	F7.1 Field 7, southern boundary.

	F7.2 Field 7, southern boundary. F7.3 Field 7, southern portion, looking north. F7.4 Field 7, looking south. F7.5 Field 7, looking south. F7.6 Field 7, looking south. F7.7 Field 7, linear depression, removed field boundary. F7.8 Field 7, ringfort (CHC 11).

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Lugatober
Conditions	Cloudy and wet
Access	Field gate in western boundary.
Field No. (Map ref.)	F8
Physical Environment	Field in wet pasture, rushy in places, particularly in northwest. Slopes down to north and west.
Features	N/A
Areas of Archaeological Potential	Potential for additional features in south-western corner in vicinity of ringfort (CHC 11).
Constraints	The northern portion of the ringfort (CHC 11) is located in the south-western corner of the field. It comprises a d-shaped area surround by a slight bank and ditch. As in field F7 it has been heavily impacted by the construction of the townland boundary. A linear earthwork is noted on the top of the ringfort which may comprise upcast from the construction of the townland boundary. The ringfort is covered in long grass and rushes. The southern field boundary is the townland boundary between Castlegal and Lugatober. It is a significant boundary comprises a double earthen bank measuring up to 1m in height on the northern side with an internal ditch and slight external ditches.
Photographs	F8.1 Field 8, townland boundary between Castlegal and Lugatober F8.2 Field 8, townland boundary between Castlegal and Lugatober F8.3 Field 8, ringfort from east. F8.4 Field 8, ringfort from east. F8.5 Field 8, ringfort from north.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Lugatober
Conditions	Cloudy and wet
Access	Accessed from southern boundary
Field No. (Map ref.)	F9
Physical Environment	Field in rough pasture, wet and rushy. Slopes down steeply to north and west. Field boundary to west comprises high earthen bank with slight ditch to east, covered in mature trees.

Features	N/A
Areas of Archaeological Potential	Narrow stream (AAP 15) along northern field boundary. Ground slopes up significantly to north and south. Bounded by marshy ground to north and south.
Constraints	N/A
Photographs	F9.1 Field 9, looking north.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Lugatober
Conditions	Cloudy and overcast.
Access	Accessed from south-eastern corner.
Field No. (Map ref.)	F10
Physical Environment	Field in pasture, wetter and rushy in lower ground to south. Slopes down to south.
Features	N/A
Areas of Archaeological Potential	Narrow stream (AAP 15) along southern field boundary. Ground slopes up significantly to north and south. Bounded by marshy ground to north and south.
Constraints	The site of a house (AHC 42) marked on the 1st edition Ordnance Survey was noted in the southeast corner of the field to the north of the stream. The northeast corner of the structure is all that now remains. The standing section is constructed of coursed squared rubble and survives to a height of four courses. The foundations of the remainder of the house can be traced as a raised grassy platform running southwest from the upstanding corner. The house was accessed from a laneway, marked on the 1st edition map. This now comprises a pair of earthen banks covered in mature trees with a flat trackway in between. A second group of buildings (CHC 83) marked on the 1st edition Ordnance Survey maps has been replaced by a number of modern agricultural outbuildings.
Photographs	F10.1 Field 10, looking northwest. F10.2 Field 10, laneway looking north. F10.3 Field 10, stream (AAP 15) along southern boundary of field. F10.4 Field 10, upstanding corner of house (AHC 42) F10.5 Field 10, southwest end of house platform (AHC 42). F10.6 Field 10, remains of house (AHC 42) and associated foundation platform. F10.7 Field 10, modern agricultural outbuildings on site of CHC 83.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Lugatober
Conditions	Cloudy and overcast.
Access	Accessed from field gate in northern boundary.
Field No. (Map ref.)	F11
Physical Environment	Field in pasture, wetter and rushy in lower ground to south. Slopes down to south.
Features	
Areas of Archaeological Potential	Narrow stream (AAP 15) along southern field boundary. Bounded by marshy ground to north and south.

Constraints	A house (AHC 43) marked on the 1st edition Ordnance Survey was noted in the north-eastern corner of the field along the local road. The house is in a derelict condition, covered in trees and other vegetation. It is constructed of coursed squared rubble masonry with dressed quoins to the corners. It has a single-span pitched corrugated-iron roof. There are two openings in the front (north) elevation with stone reveals. Further to the east is another house (AHC 44) marked on the first edition Ordnance Survey map. It is a single-storey with loft house, built c. 1820. It has a single span pitched natural slate roof. It is constructed of squared rubble masonry with dressed quoins to the corners. Square-headed door opening to front with timber frame. Infilled square-headed window opening with stone sill to east elevation. Concrete water trough to front (north) elevation. Barrel-vaulted corrugated-iron barn to southwest. Remains of squared rubble masonry outbuildings to south.
Photographs	F11.1 Field 11, stream with rough wet ground to north. F11.2 Field 11, looking northeast. F11.3 Field 11, outbuilding at AHC 43 complex. F11.4 Field 11, house (AHC 43), west elevation. F11.5 Field 11, house (AHC 43), west elevation. F11.6 Field 11, house (AHC 43), front (north) elevation. F11.7 Field 11, house (AHC 43), front (north) elevation. F11.8 Field 11, house (AHC 43), east elevation. F11.9 Field 11, house (AHC 43), from west. F11.10 Field 11, house (AHC 43), wall to west. F11.11 Field 11, house (AHC 44), west elevation. F11.12 Field 11, house (AHC 44), west elevation quoins F11.13 Field 11, house (AHC 44), front (north) elevation. F11.14 Field 11, house (AHC 44), roof. F11.15 Field 11, house (AHC 44), east elevation. F11.16 Field 11, house (AHC 44), water trough. F11.17 Field 11, house (AHC 44), barrel-vaulted barn to south. F11.18 Field 11, house (AHC 44), outbuilding to south. F11.19 Field 11, house (AHC 44), outbuilding to south. F11.20 Field 11, house (AHC 44), outbuilding to south. F11.21 Field 11, house (AHC 44), modern house at site.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Lugatober
Conditions	Cloudy and overcast.
Access	Field gate in southern boundary
Field No. (Map ref.)	F12
Physical Environment	Field in pasture, slopes down to west. Field boundary to north consists of earthen bank covered in mature trees. Field boundary to east to road consists of rubble limestone wall.
Features	N/A
Areas of Archaeological Potential	N/A
Constraints	N/A
Photographs	F12.1 Field 12, looking north.

	F12.2 Field 12, looking north. F12.3 Field 12, looking north. F12.4 Field 12, northern field boundary. F12.5 Field 12, northern field boundary. F12.6 Field 12, eastern field boundary to road.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Lugatober
Conditions	Cloudy and overcast
Access	Field gate in eastern boundary
Field No. (Map ref.)	F13
Physical Environment	Field in pasture, slopes down to west. The area to the south of the entrance gates appears to be built up with spoil and is covered in rougher grass and rushes. The OSI aerial photographic coverage of 2000 shows the dumped spoil which may have been associated with house building on the east side of the N16 road.
Features	N/A
Areas of Archaeological Potential	N/A
Constraints	The milestone (AHC 45) marked on the 25" map is no longer extant.
Photographs	F13.1 Field 13, built up area in northeast corner of site.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Lugatober
Conditions	Cloudy and wet
Access	Accessed from southern boundary.
Field No. (Map ref.)	F14
Physical Environment	Field in pasture, slopes down to west. Bounded to north and south by earthen banks covered in mature trees. That to north has slight ditch to interior, south side.
Features	Single-bay single-storey building to east end of field. Constructed of concrete with corrugated iron roof. Square-headed door opening to front (east) elevation with concrete reveals. Square-headed window opening to north elevation with concrete reveals. Pedestrian gate to east with concrete piers and cast-iron gate. A slight linear feature comprising a shallow ditch and slight bank runs north south through the field. This corresponds with a field boundary marked on the 1st edition Ordnance Survey map. The field boundary was subsequently removed and is not indicated on the 25" or later Ordnance Survey maps.
Areas of Archaeological Potential	N/A
Constraints	N/A
Photographs	F14.1 Field 14, looking north along line of remove field boundary. F14.2 Field 14, looking south. F14.3 Field 14, looking north. F14.4 Field 14, looking north to removed field boundary.

	F14.5 Field 14, field boundary to north. F14.6 Field 14, field boundary to north. F14.7 Field 14, concrete building to east end of field. F14.9 Field 14, field gate along eastern boundary. F14.10 Field 14, field gate along eastern boundary.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Lugatober
Conditions	Cloudy and overcast
Access	Accessed from gap in southern boundary, access laneway to northeast corner.
Field No. (Map ref.)	F15
Physical Environment	Field in pasture, slopes down to west. Field boundaries to north and south comprise earthen banks covered in mature trees.
Features	N/A
Areas of Archaeological Potential	Areas of wetter ground covered in flat irises.
Constraints	There is a three-bay single storey with loft house, built c. 1950 in the southeast corner of the field (ITM 572033, 841345). Possibly on site of earlier building. Concrete built walls on squared rubble limestone foundations. Single-span pitched corrugated iron roof. Square-headed window openings with concrete sills and casement windows. Square-headed door opening with rendered reveals and timber plant door to south end. Remains of corrugated-iron barn to east. The house is accessed from the N16 via a short laneway in the northeast corner of the field, bounded by a rubble limestone wall on the west side.
Photographs	F15.1 Field 15, southern field boundary. F15.2 Field 15, looking north. F15.3 Field 15, looking west. F15.4 Field 15, marshy area to centre. F15.5 Field 15, looking northeast. F15.6 Field 15, looking south. F15.7 Field 15, northern boundary. F15.8 Field 15, house in southeast corner. F15.9 Field 15, house in southeast corner. F15.10 Field 15, house, west elevation. F15.11 Field 15, house, south elevation. F15.12 Field 15, house, stone foundations. F15.13 Field 15, house, remains of barn to east. F15.14 Field 15, steps to road to north of house.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Lugatober
Conditions	Overcast.

Access	Gate in western boundary
Field No. (Map ref.)	F16
Physical Environment	Field in pasture, slopes down slightly to west and north. Some wetter areas covered in flag irises. Field boundary to west comprises an earthen bank covered in mature trees with some stone to south end. The southern boundary comprises a wide earthen bank with a slight ditch to the south side covered in mature trees. A double bank survives to the centre of the boundary.
Features	N/A
Areas of Archaeological Potential	N/A
Constraints	N/A
Photographs	F16.1 Field 16, western field boundary. F16.2 Field 16, western field boundary. F16.3 Field 16, western field boundary. F16.4 Field 16, southern field boundary F16.5 Field 16, looking northeast. F16.6 Field 16, double bank to centre of southern field boundary. F16.7 Field 16, looking northeast. F16.8 Field 16, eastern boundary. F16.9 Field 16, looking north. F16.10 Field 16, looking north to northeast corner. F16.11 Field 16, looking west.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Lugatober
Conditions	Overcast.
Access	Gate in western boundary
Field No. (Map ref.)	F17
Physical Environment	Field in wet pasture, slopes down steeply to north to small stream.
Features	Evidence of quarrying in northwest corner, scarped area with pile of limestone to centre, mature trees growing within the quarried area and on the edge of the scarped area. This feature is not indicated on the 1st or later edition Ordnance Survey maps.
Areas of Archaeological Potential	Shallow stream (AAP 16) at base of slope to northern end of field. The stream is c. 1 – 1.5m in width with areas of rushes to the north and west sides. The stream forms the townland boundary between Collinsford and Lugatober (TB 09).
Constraints	The stream noted above forms the townland boundary between Collinsford and Lugatober (TB 09).
Photographs	F17.1 Field 17, northeast corner. F17.1 Field 17, north end. F17.1 Field 17, quarry. F17.1 Field 17, limestone. F17.1 Field 17, stream to north end forming townland boundary.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018

Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Collinsford
Conditions	Overcast.
Access	Accessed from stream at southern boundary.
Field No. (Map ref.)	F18
Physical Environment	Field in pasture, slopes down to steeply to south to small stream. The northern end of the field comprises a relatively flat area at the summit of a ridge of higher ground. The eastern portion of the field comprises rougher ground with a number of stream channels bisecting it.
Features	
Areas of Archaeological Potential	Small stream (AAP 16) at base of slope to northern end of field. The stream is shallow and c. 1 – 1.5m in width with areas of rushes to the north and south sides. The stream runs along the eastern boundary of the field in a narrow deeper channel. The stream forms the townland boundary between Collinsford and Lugatober (TB 09). The summit of the ridge has potential for settlement evidence as it is relatively flat land with a local water source (AAP 17).
Constraints	The stream noted above forms the townland boundary between Collinsford and Lugatober (TB 09).
Photographs	F18.1 Field 18, summit of ridge. F18.2 Field 18, summit of ridge. F18.3 Field 18, stream channel along eastern side of field. F18.4 Field 18, possible quarry feature.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Collinsford/Lugatober
Conditions	Overcast
Access	Entrance in eastern boundary
Field No. (Map ref.)	F19
Physical Environment	Field in rough pasture, slopes down to west to roadside. Areas of wetter ground covered in rushes at base of slope.
Features	N/A
Areas of Archaeological Potential	N/A
Constraints	The townland boundary between Lugatober and Collinsford (TB 09) runs along the eastern side of the field and comprises a wet ditch with a slight earthen bank to the east and rushy ground to the west side. The townland boundary between Lugnagall and Lugatober runs along the northern boundary of the field. It comprises an earthen bank and wet ditch to the north covered in mature trees and hedgerow.
Photographs	F19.1 Field 19, looking north.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Lugnagall
Conditions	Cloudy and wet
Access	Field gate in north-eastern boundary.
Field No. (Map ref.)	F20

Physical Environment	Very rough ground with areas of scrub throughout and mature trees along southern boundary. Slopes down slightly to northwest.
Features	N/A
Areas of Archaeological Potential	N/A
Constraints	The townland boundaries between Lugnagall and Lugatober (TB 20) and Lugnagall and Collinsford (TB 21) run along the southern boundary of the field. They comprise an earthen bank to the south and wet ditch to the north covered in mature trees and hedgerow.
Photographs	F20.1 Field 20, looking south. F20.2 Field 20, looking southeast.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Lugnagall
Conditions	Overcast.
Access	Field gate in southern boundary.
Field No. (Map ref.)	F21
Physical Environment	Field in rough pasture, slopes down slightly to northwest.
Features	N/A
Areas of Archaeological Potential	N/A
Constraints	N/A
Photographs	F21.1 Field 21, looking northeast. F21.2 Field 21, looking northeast.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Lugnagall
Conditions	Overcast
Access	Field gate in south-eastern boundary
Field No. (Map ref.)	F22
Physical Environment	Field in pasture, bounded by wet ditch lined with mature trees and hedgerow to northwest and earthen bank covered in mature trees and hedgerow to northeast.
Features	N/A
Areas of Archaeological Potential	N/A
Constraints	N/A
Photographs	F22.1 Field 22, looking south F22.2 Field 22, northeast

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober

Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Lugnagall
Conditions	Overcast
Access	Field gate in south-eastern boundary.
Field No. (Map ref.)	F23
Physical Environment	Field in pasture, slopes down to northwest. Bounded by earthen bank covered in mature trees and hedgerow to southwest.
Features	N/A
Areas of Archaeological Potential	N/A
Constraints	N/A
Photographs	N/A

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Lugnagall
Conditions	Overcast
Access	Access from N16.
Field No. (Map ref.)	F24
Physical Environment	Ground covered in mature trees and vegetation, some areas show evidence of recent clearing and removal of possible stone boundary wall to north side of N16.
Features	N/A
Areas of Archaeological Potential	N/A
Constraints	N/A
Photographs	F24.1 Field 24, northern portion.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Drumkilsellagh
Conditions	Cloudy and wet
Access	Field ate in eastern boundary
Field No. (Map ref.)	F25
Physical Environment	Field in pasture, relatively flat. Bounded to roadside my mature hedgerow.
Features	N/A
Areas of Archaeological Potential	N/A
Constraints	House marked on 25" Ordnance Survey map (AHC 47). It is a three-bay single storey house, built c. 1900. It has a single span roof which is currently uncovered. It is constructed of squared limestone masonry with dressed quoins to the corners. It has square-headed window openings with red brick reveals.

	The site of a milestone (AHC 46) is noted on the 25" Ordnance Survey map, this is no longer extant.
Photographs	F25.1 Field 25, house marked on 25" Ordnance Survey map.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Drumkilsellagh
Conditions	Cloudy and bright
Access	Field gate in western boundary
Field No. (Map ref.)	F26
Physical Environment	Relatively flat field in wet, rushy pasture. Field boundary to the north consists of a wet ditch.
Features	N/A
Areas of Archaeological Potential	The field is rushy along its western boundary.
Constraints	N/A
Photographs	F26.1 Field 26, looking east. F26.2 Field 26, looking east.

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Doonally
Conditions	Cloudy and bright.
Access	Field gate in northern boundary.
Field No. (Map ref.)	F27
Physical Environment	Relatively flat field in pasture, slopes down slightly to south. Wetter rushier ground in places, particularly around ringfort (CH|C 12) in north-eastern corner.
Features	N/A
Areas of Archaeological Potential	There is a small waterfilled oval depression to the north of the ringfort (CHC 12).
Constraints	Ringfort in north-eastern corner of field (CHC 12). On a level summit of a slight rise in gently undulating pasture. Slightly raised circular area (diam. 22m) enclosed by a low broad bank of earth (Wth 5m; int. H 0.3m) with an external fosse (Wth 2.6m; D 0.3m). Both the bank and the fosse enclose the entire site having a consistent profile along the entire circuit. A break (Wth 2.3m) in the bank with a causeway across the fosse at SE marks the position of the original entrance. The site is currently covered in rushes.
Photographs	F27.1 Field 27, ringfort from south F27.2 Field 27, shallow waterfilled depression to north of ringfort. F27.3 Field 27, looking south towards ringfort. F27.4 Field 27, ringfort from north

Job No. and Title	CRDS ref. 1218, TII/Sligo Co. Co. N16 Lugatober
Date	18/04/2018
Surveyors	Aislinn Collins, Ros O'Maolduin
Location	Doonally
Conditions	Cloudy and bright

Access	Entrance gate in northern boundary
Field No. (Map ref.)	F28
Physical Environment	Relatively flat field in pasture, bounded by earthen banks covered in mature trees to east and west.
Features	N/A
Areas of Archaeological Potential	N/A
Constraints	Townland boundary between Doonally and Drumkilsellagh runs along the eastern boundary of the field. It consists of a slight ditch covered in vegetation. A large earthbound limestone boulder, was noted along the townland boundary. The local landowner indicated that the boulder was known locally as a mass rock. May originally have been located further to the west within a copse of trees or tree ring. It is not indicated on 1st ed. OS map.
Photographs	F28.1 Field 28, looking towards remains of former copse of trees or tree ring. F28.2 Field 28, possible mass rock. F28.3 Field 28, possible mass rock.

14 Appendix 13.4: Chapter 13 (Main Report Reference)

Plates

Plate 14-1 Field 3 river looking south (AAP 07/TB 06)

Plate 14-2 Field 3 well marked on 25" OS map (CHC 85)

Plate 14-3 Field 5 Castlegal House (AHC 41)

Plate 14-4 Field 5 Castlegal House, outbuilding (AHC 41)

Plate 14-5 Field 6 wedge tomb, Drum East (CHC 1 - RMP SL009-028)

Plate 14-6 Field 7 Ringfort from southeast (CHC 11 - RMP SL009-026)

Plate 14-7 Field 8, ringfort from northeast (CHC 11 - RMP SL009-026)

Plate 14-8 Field 10 standing remains of building (AHC 42)

Plate 14-9 Field 10 laneway to house (AHC 42)

Plate 14-10 Field 11, house (AHC 43) from southwest

Plate 14-11 Field 11, house (AHC 44) from north

Plate 14-12 Field 15, areas of wetter ground (AAP 19)

Plate 14-13 Field 17, possible quarry (AAP 20)

Plate 14-14 Field 17 - Field 18, stream (AAP 16 - TB 09)

Plate 14-15 Field 18, stream to east side (TB 09)

Plate 14-16 Field 18, townland boundary between Collinsford and Lugatober (TB 09)

Plate 14-17 Field 20, townland boundary between Lugnagall and Collinsford to rear (TB 21)

Plate 14-18 Field 25, house on 25" OS map (AHC 47)

Plate 14-19 Field 27, ringfort from south (CHC 12 - RMP SL009-035)

Plate 14-20 Waterfilled depression to north of ringfort (CHC 12 - RMP SL009-035)

Plate 14-21 Possible mass rock (CHC 84)