

Wicklow County Council

**N11/M11 Junction 4 to Junction 14
Improvement Scheme**

Option Selection Report
Appendix C3 - Hydrogeology

265455-ARP-EGT-SWI-RP-ZX-0004

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1 Hydrogeology

1.1 Introduction

This section details the environmental assessment of the Stage 1 Preliminary Options Assessment for the N11/M11 Scheme with respect to the hydrogeology constraints identified in **Section 15** (Hydrogeology) of **Volume B**.

For the corridor assessment, the overall scheme has been split into two sections, i.e. the Northern Section and the Southern Section and the corridor options assessed are those discussed in **Section 6.1** of **Volume A**.

There are three zones associated with each corridor option referred to in this assessment:

- The potential road “footprint” which is the potential landtake required to construct or improve the road;
- The road “corridor” which is a 200m wide corridor centred around the alignment centre line for all off-line corridors. For the on-line Corridor Options 1 (North), 1 (South) and 5 (South), the width is variable, but is typically narrower than the width of the off-line corridors. The “footprint” sits inside the “corridor” boundary; and
- The road “assessment study area” which includes a 250m buffer zone from the road centre line and an overall width of 500m. This buffer zone may increase to consider attributes which extend beyond this zone e.g. along link roads.

Section 1.2 outlines the methodology that was used to carry out the study, and **Section 1.3** outlines the assessment criteria which were used. The Stage 1 assessment is presented in **Section 1.4**, the summary in **Section 1.5** and references are listed in **Section 1.6**.

1.2 Methodology

The assessment is undertaken in line with the requirements of the Transport Infrastructure Ireland (TII), formerly National Roads Authority, Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes¹ (TII Guidelines).

In line with these Guidelines¹, the assessment study area for this Stage 1 Corridor Options Assessment is a 250m buffer from the centre line of each of the corridors (an overall width of 500m). The assessment study area will therefore predominantly be used to assess the potential impacts to hydrogeological features.

¹ NRA (2009) Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes. Available from: <https://www.tii.ie/technical-services/environment/planning/Guidelines-on-Procedures-for-Assessment-and-Treatment-of-Geology-Hydrology-and-Hydrogeology-for-National-Road-Schemes.pdf>

There is one exception where the road footprint is used for the assessment of impact rather than the 500m assessment study area. When establishing if a corridor option may directly remove part of a groundwater dependent habitat i.e. cut through a marsh etc., it is the footprint that is relevant rather than the assessment study area.

The TII Guidelines¹ provide criteria for ranking of the identified hydrogeological constraints within the assessment study area. The criteria are presented in **Table 15.1** in **Section 15** (Hydrogeology) of **Volume B**. Criteria for rating an impact significance that may arise at each hydrogeological constraint are provided within Box 4.4 of the TII Guidelines¹ and in **Table 1.1**. The impact significance assessment takes into account the attribute importance and the predicted scale and duration of the likely impacts.

Table 1.1: Criteria for rating impact significance at route selection stage – rating of significant environmental impacts at route selection stage from Box 4.4 of the TII Guidelines¹

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

***In rating impacts on an 'European site' account must be taken of Article 6(3) and 6(4) of the Habitats Directive (Council Directive 92/43/EEC). Also see guidance contained within Guidelines for Assessment of Ecological Impacts of National Road Schemes (Rev 2, National Roads Authority, 2008)*

The TII Guidelines¹ qualitative significance rating of environmental impacts have been correlated with the equivalent qualitative and quantitative assessment scores from the TII Project Appraisal Guidelines for National Roads (PAG) Unit 7.0 - Multi-Criteria Analysis² (hereafter referred to as the TII PAG), as shown in **Table 1.2**. It should be noted that only negative potential impacts are considered in the TII Guidelines¹ whereas the TII PAG² multi-criteria assessment is based on the seven-point scale presented below:

- 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; or
- 1 – Major or highly negative.

Table 1.2: Correlation of TII Guidelines significance rating to an equivalent TII PAG² score

Impact Level (TII Guidelines ¹)	Equivalent PAG ² (Description)	Equivalent PAG ² (Value)
Profound (Negative)	Major or highly negative	1
Significant (Negative)	Major or highly negative	1
Moderate (Negative)	Moderately negative	2
Slight (Negative)	Minor or slightly negative	3
Imperceptible	Not significant or neutral	4
Slight (Positive)*	Minor or slightly positive	5
Moderate (Positive)*	Moderately positive	6
Significant (Positive)*	Major or highly positive	7

The final stage of the assessment methodology was to ensure that the requirements of the TII PAG² were also met by assigning a score to each corridor option based on the scoring procedure within these Guidelines. Where a positive score is assigned, this score is from the TII PAG² scoring system.

² Transport Infrastructure Ireland Project Appraisal Guidelines for National Roads Unit 7.0 – Multi Criteria Analysis, 2016. Available from: <https://www.tiipublications.ie/library/PE-PAG-02031-01.pdf>

Using the impact scores and professional judgement, the ‘Preferred’, ‘Intermediate’ or ‘Least Preferred’ corridors were identified.

The Constraints Study for this stage of assessment was a desk study collating hydrogeological information available (**Section 15 (Hydrogeology) of Volume B**). Additional information obtained during public consultation is also included.

1.3 Assessment criteria

In line with TII Guidelines¹, the hydrogeological attributes which are considered in the corridor options assessment are presented in **Table 1.3**. This table also outlines the assessment criteria that will be applied to each of these features.

Table 1.3: Assessment criteria summary

Hydrogeological Features to be assessed	Means of assessment of potential impacts
High yielding water supply wells and springs and increased risk presented by the road scheme	The proximity to the feature. The length of the corridor within protection zone or zones of contribution.
The classification and extent of aquifers underlying each corridor and increased risk presented to them by road scheme	Aquifer classification. Extent of aquifer – provided as the length of the corridor as a percentage which is underlain by a particular aquifer classification. Aquifer vulnerability – provided as the length of the corridor, as a percentage, which is underlain by aquifer which is classified as extreme or high vulnerability. Removal of subsoil cover or part of aquifer (cuttings along corridors) which may give rise to changes in groundwater level and change in aquifer vulnerability.
Karst features along each corridor and the risk presented to them by the road scheme	The proximity to the feature. The length of the corridor within feature protection zone or zone of contribution.
Groundwater dependant habitats and the risk presented to them by the road scheme	The proximity and the position (upgradient or downgradient) to the feature. Removal of subsoil cover or part of aquifer (cuttings along corridor) which may give rise to changes in groundwater level. Removal of part of the habitat by the corridor option.

It should be noted that information on other low importance hydrogeological features was gathered during the desk study phase of the Constraints Study presented in **Section 15 (Hydrogeology) of Volume B**. This information was gathered to provide the wider context of the scheme, and the features are not as relevant or significant to be considered in detail in this assessment. The features listed in **Table 1.3** have been used in this assessment to compare the corridor options and identify a preferred corridor as per TII Guidelines¹.

1.4 Stage 1 corridor options assessment

1.4.1 Groundwater resources

Groundwater sources are not considered in the option comparison assessment as there are no high yield water supply springs and wells i.e. public water supplies, or National Federation of Group Water Scheme groundwater supplies along the corridors. No Source Protection Zones associated with public supplies are located along the corridor options.

The majority of groundwater abstraction wells identified within the corridors are of low importance. The TII Guidelines¹ suggest that little or no weighting should be given to the number of such wells along each corridor and/or their distance from the centre line when assessing relative impacts.

In the case of low yielding water supply wells, the ranking of the level of potential impact is unnecessary, as wells will either have to be replaced or removed.

1.4.2 Aquifers

The aquifers identified in the Constraints Study are presented in **Table 15.4 of Section 15 (Hydrogeology) of Volume B**. The potential impact on the aquifer along each corridor is a combination of the type and extent of the aquifer, aquifer vulnerability and requirement for deep cuttings along each corridor.

The majority of the corridors are underlain by a Poor Aquifer (Pl). Part of the Northern Section is underlain by a Locally Important Aquifer where the bedrock is moderately productive only in local zones (L1). There are two Locally Important Gravel Aquifers (Lg) mapped; one is located in the Northern Section and the other one in the Southern Section.

In this assessment the aquifer extent and type for the corridors are compared by providing the percentage of the corridor option (total corridor length being 100%), which is underlain by each aquifer classification listed above. Corridors underlain by aquifers of lower importance i.e. Poor Aquifer, are considered preferred. Due to the corridor options being in close proximity in both the northern and southern sections, the percentage of each aquifer type underlying each option is the same across all options in the same section.

The majority of the corridors require cutting (removal of soil and/or rock to road design elevations). Roads constructed in deep cuttings can impact on the groundwater by causing dewatering of the groundwater in the vicinity. The deeper the cutting the more significant and more extensive the impact in this aquifer assessment. In addition, the removal of the soil and bedrock in the excavation will increase the vulnerability of the aquifer at that location, as vulnerability is largely dependent on the depth of subsoil above the aquifer. As such, where the vulnerability is rated as 'High' and the cut is greater than 3m the vulnerability will change to the 'Extreme' category.

In this assessment the aquifer vulnerability for the corridors are compared by providing the percentage of the corridor option (total corridor length being 100%),

which is underlain by an aquifer rated as ‘High’ and ‘Extreme’. It should be noted that the vulnerability distribution presented in the tables below has increased, where necessary, to account for cuttings greater than 3m depth which increased the vulnerability rating from High to Extreme. Construction of the road with the least length over High and Extreme vulnerability aquifers would be preferable as this will have a lesser potential impact on the underlying aquifer.

To assess the comparative cutting along each option, the length of cuttings greater than 10m were compared and the maximum depth of the cuttings listed.

In the Southern Section in particular, the overall qualitative assessment differentiated between *minor or slightly negative* impacts and *moderately negative* impacts based on the extent and depth of cut associated with the corridor options.

The aquifer impact assessment is presented in **Table 1.4** for the Northern Section and in **Table 1.5** for the Southern Section.

Table 1.4: Aquifer assessment Northern Section

Attribute	Attribute Importance	Corridor Option 1 (North)	Corridor Option 2 (North)	Corridor Option 3 (North)	Corridor Option 4 (North)
Poor Aquifer ⁱ (Pl)	Low	52% 0.3m – max cut depth No cuttings >10m deep	52% 40.5m - max cut depth 1120m – cutting length (>10m deep)	52% 21m – max cut depth 1460m – cutting length (>10m deep)	52% 21m – max cut depth 1040m – cutting length (>10m deep)
Impact Level		Not significant or neutral	Minor or slightly negative	Minor or slightly negative	Minor or slightly negative
Locally Important Aquifer ⁱ (Ll)	Medium	47% 0.2m - max cut depth No cuttings >10m deep	47% 0.2m - max cut depth No cuttings >10m deep	47% 0.2m - max cut depth No cuttings >10m deep	47% 0.2m - max cut depth No cuttings >10m deep
Impact Level		Minor or slightly negative	Minor or slightly negative	Minor or slightly negative	Minor or slightly negative
Locally Important Gravel Aquifer ⁱ (Lg)	Medium	1% 0.04m -max cut depth No cuttings >10m deep	1% 0.04m – max cut depth No cuttings >10m deep	1% 0.04m – max cut depth No cuttings >10m deep	1% 0.04m – max cut depth No cuttings >10m deep
Impact Level		Minor or slightly negative	Minor or slightly negative	Minor or slightly negative	Minor or slightly negative

Attribute	Attribute Importance	Corridor Option 1 (North)	Corridor Option 2 (North)	Corridor Option 3 (North)	Corridor Option 4 (North)
Extreme Vulnerability Aquifer ⁱⁱ (% underlying this corridor option)		4%	10%	17%	16%
High Vulnerability Aquifer ⁱⁱ (% underlying this corridor option)		51%	54%	51%	53%
Overall TII potential impact		Not significant or neutral	Minor or slightly negative	Minor or slightly negative	Minor or slightly negative
Notes:					
<ul style="list-style-type: none"> i. The percentages provided are the percent of the corridor option which is underlain by an aquifer type. The total corridor length being 100%. ii. The percentages provided are the percent of the corridor option which is underlain by an extreme or a high vulnerability aquifer. 					

Table 1.5: Aquifer assessment Southern Section

Attribute	Attribute Importance	Corridor Option 1 (South)	Corridor Option 2 (South)	Corridor Option 3 (South)	Corridor Option 4 (South)	Corridor Option 5 (South)
Locally Important Gravel Aquifer ⁱ (Lg)	Medium	20% 0.2m - max cut depth No cuttings >10m deep	20% 6.24m - max cut depth No cuttings >10m deep	20% 5.81m - max cut depth No cuttings >10m deep	20% 6.22m - max cut depth No cuttings >10m deep	20% 0.2m - max cut depth No cuttings >10m deep
Impact Level		Minor or slightly negative	Moderately negative	Moderately negative	Moderately negative	Minor or slightly negative
Poor Aquifer ⁱ (Pl)	Low	80% 0.7m – max cut depth No cuttings >10m deep	80% 40.3m - max cut depth 1160m – cutting length (>10m deep)	80% 36.6m – max cut depth 1800m – cutting length (>10m deep)	80% 53.4m – max cut depth 2400m – cutting length (>10m deep)	80% 0.7m – max cut depth No cuttings >10m deep
Impact Level		Not significant or neutral	Minor or slightly negative	Minor or slightly negative	Minor or slightly negative	Not significant or neutral
Extreme Vulnerability Aquifer ⁱⁱ (% underlying this corridor option)		37%	39%	32%	41%	37%
High Vulnerability Aquifer ⁱⁱ (% underlying this corridor option)		57%	51%	59%	48%	57%
Overall TII potential impact		Minor or slightly negative	Moderately negative	Moderately negative	Moderately negative	Minor or slightly negative
Notes:						
<ul style="list-style-type: none"> i. The percentages provided are the percent of the corridor option which is underlain by an aquifer type or vulnerability rating. The total corridor length being 100%. ii. The percentages provided are the percent of the corridor option which is underlain by an extreme or a high vulnerability aquifer. 						

1.4.3 Karst features

There are no karst features present in the assessment study area.

1.4.4 Groundwater dependant habitats

All groundwater dependant habitats identified in the Constraints Study are presented in **Section 15.3.5** of **Section 15** (Hydrogeology) of **Volume B**.

Groundwater dependent habitats which are present within the assessment study area of the corridors comprise two proposed Natural Heritage Areas (pNHA), alluvial woodland and several calcareous springs and Priority Annex I habitat [91E0*] Alluvial woodland in Glen of the Downs SAC. This priority habitat is valued on an international scale, so is of extremely high importance.

Biodiversity impacts on groundwater dependent habitats are assessed as part of the Biodiversity Corridor Options Assessment, refer to **Appendix C1** (Biodiversity) of **Volume C**. Petrifying springs, although priority Annex I habitat, are groundwater features, and the hydrogeological assessment of groundwater dependent habitats focuses on the groundwater components of the features i.e. changes to groundwater level which may impact recharge to the feature, or changes to groundwater quality.

The proximity of the habitat to the corridor is considered with regard to increased pollution risk from untreated surface water run-off or accidental spillage of fuel from the road affecting groundwater quality. However, as per Section 4.4 of the TII¹ Guidelines, the assessment has considered where the application of standard mitigation and best practice during construction is unambiguous and success is highly likely. Therefore, it is assumed that standard drainage measures will be put in place to reduce the risk of run-off from the road affecting groundwater quality, reducing this risk.

The presence of deep cuttings in conjunction with the corridor location up or down gradient of the habitat has been assessed for the potential impacts to groundwater level. It is preferable that the habitat be upgradient from the road and with no cuttings, as it is less likely to affect either the water quality or groundwater recharge to the feature.

If part of the habitat may be removed by a corridor option, impact to the general groundwater regime in this area is considered. Note: the corridor option “footprint” has been used to establish if an option may directly cross the habitat.

Deep cuttings and habitat removal are therefore considered the primary potential impact to groundwater dependent habitats and the local groundwater regime. The assessed impacts to groundwater dependent habitats and the areas considered in this assessment are outlined below and summarised in **Table 1.6**.

The two proposed Natural Heritage Areas (pNHA) are Kilmacanoge Marsh (pNHA), and Dargle River Valley (pNHA). Kilmacanoge Marsh is valued on an international scale, so is of extremely high importance. Two priority Annex I habitats were identified by the Project Biodiversity Specialist in Kilmacanoge Marsh pNHA. These are Alluvial woodland [91E0*] and Orchid-rich calcareous grassland [6210*]. These habitats are valued on an international scale, so are of extremely high importance. Dargle River Valley is valued on a national scale and is therefore of very high importance.

A conservative approach was taken regarding Glen of the Downs Annex I Alluvial Woodland, Kilmacanoge Marsh pNHA and Dargle Valley (pNHA). In advance of detailed survey at environmental impact assessment stage, these features have been assessed as if they are dependent on surface water and groundwater, refer to **Appendix C4** (Hydrology) of **Volume C**.

The hydrogeological assessment of these habitats focuses on the groundwater components of the features i.e. changes to groundwater level which may impact recharge to the feature, or changes to groundwater quality.

Calcareous springs mapped in the north-eastern corner of Glen of the Downs SAC, in Druids Glen and along Ballywaltrim Lane are considered by the Project Biodiversity Specialist to be priority Annex I habitat Petrifying springs with tufa formation (Cratoneurion) [7220*]. These springs are valued on an international scale and are of extremely high importance. There is also another priority Annex I habitat Alluvial woodland [91E0*] in the same ecological site as the springs, the Ballywaltrim Lane Ecological Site (numbered EC45 in **Section 12 of Volume B**).

As part of the hydrogeological assessment of the priority Annex I habitat Petrifying springs with tufa formation (Cratoneurion) [7220*], a preliminary zone of contribution (PZOC), which is the area that contributes water to the spring, has been delineated. These are explained in further detail in **Section 15.3.5, Groundwater dependent habitats of Section 15 (Hydrogeology) of Volume B**.

The proximity of groundwater dependent habitats with respect to the corridor options is described as one of the following:

- Within footprint i.e. directly within the road footprint;
- Within study area i.e. the assessment study area 500m total width from the centre line of the corridor;
- Within a PZOC i.e. the land area that contributes water to the spring;
- Upgradient or downgradient of the corridor (the preference is for the habitat to be upgradient of the corridor). Note, for the springs this is of importance if the corridor option is within the PZOC; and
- Outside the assessment study area but still ‘in close proximity’ to the corridor.

Table 1.6: Summary of assessed impacts to groundwater dependent habitats and areas considered as part of that assessment.

Impact to groundwater dependant habitat	Cause	Area Considered	Level of Impact
Changes to groundwater level	Road cuttings	Assessment study area (500m +). PZOC of spring. Areas outside the assessment study area but in close proximity to road can also be considered.	Permanent negative (NRA ¹) TII ² - Major or highly negative)
Changes to groundwater quality	Spills or run-off (reduced risk due to mitigation measures)	Assessment study area (500m +). PZOC of spring. Pollution flows downgradient so nearby habitats outside the assessment study area but	Temporary impact (NRA ¹) TII ² – Minor or slightly negative or Moderately negative depending on attribute importance)

Impact to groundwater dependant habitat	Cause	Area Considered	Level of Impact
		downgradient of the road can be considered.	
Removal of part of groundwater dependent habitat (localised change in groundwater regime)	Road footprint directly crosses feature	Road footprint	Permanent negative (NRA ¹) TII ¹ - Major or highly negative)

The results of this assessment are provided in **Table 1.7** for the Northern Section and in **Table 1.8** for the Southern Section.

Table 1.7: Groundwater dependant habitats assessment Northern Section

Groundwater dependant Habitats	Attribute Importance	Corridor Option 1 (North)	Corridor Option 2 (North)	Corridor Option 3 (North)	Corridor Option 4 (North)
Dargle River Valley (pNHA)	Very High	In close proximity Habitat is upgradient. No cuttings	Within footprint No cuttings	Within study area No cuttings	In close proximity Habitat is upgradient. No cuttings
Impact Level		Not significant or neutral	Major or highly negative	Minor or slightly negative	Not significant or neutral
Kilmacanoge Marsh (pNHA)	Extremely High	Within footprint No cuttings	Within footprint No cuttings	Within study area* Deep cuttings	Within study area* Deep cuttings
Impact Level		Major or highly negative	Major or highly negative	Major or highly negative	Major or highly negative
Calcareous springs and potential Alluvial woodland (Ballywaltrim Lane)	Extremely High	Spring/habitat is within footprint PZOC is within footprint. Springs and PZOC are primarily upgradient. No cuttings	Spring/habitat is not in close proximity Outside PZOC. Deep cuttings.	Spring/habitat is not in close proximity Outside PZOC. Deep cuttings.	Spring/habitat is within study area* PZOC is within study area*. Springs/habitat and PZOC are upgradient. Deep cuttings
Impact Level		Major or highly negative	Not significant or neutral	Not significant or neutral	Major or highly negative

Groundwater dependant Habitats	Attribute Importance	Corridor Option 1 (North)	Corridor Option 2 (North)	Corridor Option 3 (North)	Corridor Option 4 (North)
Overall TII Potential Impact		Major or highly negative	Major or highly negative	Major or highly negative	Major or highly negative
Within study area* -When the habitat is not located directly in the road footprint but is within the 500m assessment study area					

Table 1.8: Groundwater dependant habitats assessment Southern Section

Ground water dependant Habitats	Attribute Importance	Corridor Option 1 (South)	Corridor Option 2 (South)	Corridor Option 3 (South)	Corridor Option 4 (South)	Corridor Option 5 (South)
Alluvial Woodland [91E0]* (Glen of Downs)	Extremely High	Habitat is within footprint. No cuttings.	Habitat is outside study area*. Habitat is downgradient of road. Deep cuttings.	Habitat is outside of study area*. Deep cuttings.	Habitat is outside study area*. Deep cuttings.	Habitat is within footprint. No cuttings.
Potential Impact		Major or highly negative	Moderately negative	Not significant or neutral	Not significant or neutral	Major or highly negative
Calcareous springs (Glen of Downs)	Extremely High	Spring is within study area* PZOC is within study area* Spring and PZOC are upgradient. No cuttings.	Spring is not in close proximity Outside PZOC.	Spring is not in close proximity Outside PZOC. Deep cuttings.	Spring is in close proximity. PZOC is within footprint Spring and PZOC are downgradient. Deep cuttings	Spring is within study area* PZOC is within study area* Spring and PZOC are upgradient. No cuttings.
Potential Impact		Moderately negative	Not significant or neutral	Not significant or neutral	Major or highly negative	Moderately negative
Calcareous springs (Druids Glen)	Extremely High	Spring is within study area. PZOC is within footprint. Springs and PZOC are downgradient. No cuttings	Spring is within study area. PZOC is within footprint Springs and PZOC are downgradient. No cuttings	Spring is within study area. PZOC is within footprint Springs and PZOC are downgradient. No cuttings	Spring is within study area. PZOC is within footprint Springs and PZOC are downgradient. No cuttings	Spring is within study area. PZOC is within footprint Springs and PZOC are downgradient. No cuttings

Ground water dependent Habitats	Attribute Importance	Corridor Option 1 (South)	Corridor Option 2 (South)	Corridor Option 3 (South)	Corridor Option 4 (South)	Corridor Option 5 (South)
Potential Impact		Moderately negative	Moderately negative	Moderately negative	Moderately negative	Moderately negative
Overall TII Potential Impact		Major or highly negative	Moderately negative	Moderately negative	Major or highly negative	Major or highly negative
Within study area* -When the habitat is not located directly in the corridor path but is within the 500m assessment study area of the corridor						

1.5 Summary

The assessment of the options has been made primarily on the basis of the environmental setting along each of the options and the significance of potential impacts. The hydrogeological features that were considered at corridor option assessment stage are:

- The potential impact to the aquifer along each corridor option, the type and extent of the aquifer, aquifer vulnerability and presence of deep cuttings.
- The groundwater dependent habitats within or in proximity to each corridor option, the position (upgradient or downgradient) to the feature and presence of deep cuttings along the corridor.

As per Section 4.4 of the TII¹ Guidelines, the assessment discounted hydrogeological receptors where the risk of significant impacts is unlikely given the application of standard mitigation and best practice during construction is unambiguous and success is highly likely. Therefore, it is assumed that standard drainage measures will be put in place to mitigate the risk of run-off from the road affecting groundwater quality, reducing this risk.

1.5.1 Northern Section

The qualitative assessment for all the options is *major or highly negative*.

The same extent and type of aquifers underlie all the corridors. Corridor Option 1 (North) has no deep cuttings proposed whereas the rest of the options have cuttings greater than 10m deep and over more than 1km in length. The corridor option which is underlain by the least proportion of aquifer with extreme or high vulnerability rating is Corridor Option 1 (North). The corridors which intersect the largest amount of extreme and highly vulnerable aquifer are Corridor Option 3 (North) and Corridor Option 4 (North). Corridor Option 3 (North) is the least preferred option as it contains the largest amount of deep cutting.

Each option may significantly impact the groundwater dependent habitats. Corridor Options 1 and 4 (North) have a *not significant or neutral* impact on the Dargle River Valley (pNHA) as the corridors are downgradient of the habitat and no road cutting is proposed.

The footprint of Corridor Option 2 (North) directly crosses the outer edge of this habitat; therefore, the impact is considered *major or highly negative*. The Dargle River Valley is within the 500m assessment study area of Corridor Option 3 (North), so it is considered *minor or slightly negative*.

The footprints of Corridor Options 1 (North) and 2 (North) impact Kilmacanoge Marsh pNHA therefore the potential impact is *major or highly negative*. Kilmacanoge Marsh pNHA is within the 500m assessment study area of Corridor Options 3 (North) and 4 (North) where both have deep cuttings proposed resulting in a *major or highly negative* for both options.

Corridor Option 2 (North) and Corridor Option 3 (North) have a *not significant or neutral* impact on calcareous springs and potential alluvial woodland located along Ballywaltrim Lane as the corridors are located downgradient, outside the PZOC, and, are not in close proximity to the springs. The PZOC is located within the footprint of Corridor Option 1 (North) and the spring is located in the 500m assessment study area, however the potential alluvial woodland is located within the road footprint, therefore it has a *major or highly negative* impact. Corridor Option 4 (North) is located close to these springs and potential alluvial woodland (i.e. they are located in the 500m assessment study area) and deep cuttings are proposed along the corridor, therefore it too has a *major or highly negative* impact.

Summarising the impacts of the proposed corridor options to the groundwater dependent habitats, Corridor Option 3 (North) is the preferred option, followed by Corridor Options 1 (North), 2 (North) and 4 (North) which are rated equally.

From the review of the potential impacts of the proposed Northern Section corridor options on the hydrogeological assessment criteria, Corridor Option 3 (North) is the preferred corridor. The least preferred are Corridor Options 2 (North) and 4 (North).

The summary assessment and option preference is outlined in **Table 1.9**.

Table 1.9: Summary assessment table Northern Section

Assessment Criteria	Corridor Option 1 (North)	Corridor Option 2 (North)	Corridor Option 3 (North)	Corridor Option 4 (North)
Aquifer Classification	Not significant or neutral	Minor or slightly negative	Minor or slightly negative	Minor or slightly negative
Groundwater Dependant Habitats	Major or highly negative	Major or highly negative	Major or highly negative	Major or highly negative
Qualitative Assessment	Major or highly negative	Major or highly negative	Major or highly negative	Major or highly negative
Score / Impact Level	1	1	1	1
Preference	Intermediate	Least Preferred	Preferred	Least Preferred

1.5.2 Southern Section

The qualitative assessment for Options 1, 4 and 5 is *major or highly negative* and for Options 2 and 3 is *moderately negative*.

All five corridor options are underlain by the same extent and type of aquifers. Corridor Options 1 (South) and 5 (South) have no deep cuttings proposed. The remaining options (Corridor Options 2 (South), 3 (South) and 4 (South)), have cuttings greater than 10m deep over more than 1km length. The deepest cuttings (over 50m deep), are proposed in Corridor Option 4 (South). The corridor option which is underlain by the least amount of extreme and high vulnerability rated aquifer is Corridor Option 4 (South).

Overall, for the aquifer classification assessment, Corridor Options 1 (South) and 5 (South) are considered the preferred and Corridor Option 4 (South) the least preferred along the Southern Section.

Corridor Option 3 (South) and 4 (South) have a *not significant or neutral* impact on the Alluvial Woodland in the Glen of the Downs SAC. Corridor Option 2 (South) has deep cuttings and is upgradient of the habitat, therefore, although outside the study area, has a potentially *moderately negative* impact. The footprints of Corridor Options 1 (South) and 5 (South) impact the habitat and are considered *major or highly negative*.

Corridor Option 2 (South) and 3 (South) have a *not significant or neutral* impact on calcareous springs in the Glen of the Downs as the corridors are not in close proximity, outside the PZOC. The habitat is upgradient of Corridor Option 1 (South) and 5 (South), but the springs and PZOC are within the corridor options' 500m study areas, therefore are considered *moderately negative*. The footprint of Corridor Option 4 (South) is within the PZOC and upgradient of the springs and so is considered *major or highly negative*.

All the corridor options converge at Druids Glen. The potential impact is considered *moderately negative* for all springs due to potential temporary impacts during construction as the footprint is within the PZOC but does not encroach on the spring features. As there are no deep cuts or expected changes to groundwater flow or quality following construction no permanent impacts are expected.

Overall, Corridor Option 2 (South) and 3 (South) have the least significant impact on the groundwater dependent habitats for the Southern Section.

From the review of the potential impacts of each proposed corridor option for the Southern Section, Corridor Option 3 (South) is the preferred option. Corridor Option 2 (South) scores second in the quantitative assessment so is intermediate. Corridor Options 1 (South), 4 (South) and 5 (South) have the same quantitative score, however, as Corridor Option 1 (South) has no cuttings and the smaller footprint, it has been included as intermediate. Corridor Options 4 (South) and 5 (South) are considered the least preferred.

The summary assessment and option preference in the Southern Section is outlined in **Table 1.10**.

Table 1.10: Summary assessment summary table Southern Section

Assessment Criteria	Corridor Option 1 (South)	Corridor Option 2 (South)	Corridor Option 3 (South)	Corridor Option 4 (South)	Corridor Option 5 (South)
Aquifer Classification	Minor or slightly negative	Moderately negative	Moderately negative	Moderately negative	Minor or slightly negative
Groundwater Dependant Habitats	Major or highly negative	Moderately Negative	Moderately negative	Major or highly negative	Major or highly negative
Qualitative Assessment	Major or highly negative	Moderately negative	Moderately negative	Major or highly negative	Major or highly negative
Score / Impact Level	1	2	2	1	1
Preference	Intermediate	Intermediate	Preferred	Least Preferred	Least Preferred

1.6 References

NRA (2009) Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes. Available from: <https://www.tii.ie/technical-services/environment/planning/Guidelines-on-Procedures-for-Assessment-and-Treatment-of-Geology-Hydrology-and-Hydrogeology-for-National-Road-Schemes.pdf>

Transport Infrastructure Ireland Project Appraisal Guidelines for National Roads Unit 7.0 – Multi Criteria Analysis, 2016. Available from: <https://www.tiipublications.ie/library/PE-PAG-02031-01.pdf>