

**N4 Collooney to Castlebaldwin  
Oral Hearing**

**Compulsory Purchase Order**

**and**

**Environmental Impact Statement  
Oral Hearing**

**Brief of Evidence**

**Dr. Conor Quinlan  
of  
Minerex Environmental Ltd.**

## **1.0 INTRODUCTION**

My name is Conor Quinlan. I am the project manager for Minerex Environmental in relation to this road development. I have 9 years consultancy and research experience in hydrology and hydrogeology in Ireland which related to hydrology and hydrogeology focusing in particular on groundwater – surface water interactions. I have completed a wide range of projects including groundwater resource developments, flood risk assessments, dewatering projects and monitoring projects. I have completed over 30 Soil & Geology and Hydrology & Hydrogeology EIA submissions for a range of project types including wind energy developments, national roads and railway developments.

## **2.0 METHODOLOGY**

The proposed road design, road cut and fill depths, details of site investigation and water level data from monitoring boreholes installed along the proposed road route were supplied by Sligo County Council. A desk study was initially undertaken and was followed by a field study.

## **3.0 RECEIVING ENVIRONMENT**

### **Hydrology**

#### **Catchment areas and drainage**

Unshin River Catchment

The Proposed Road Development passes wholly through the Unshin River Catchment. The surface drainage within this catchment flows in a predominantly north-north easterly direction, before joining with the Owenmore River to form the Ballysadare River. The Office of Public Works (OPW) estimates the Unshin River catchment area to be 202km<sup>2</sup>, inclusive of Lough Arrow and the Unshin River. The PRD crosses a number of streams and rivers in the Unshin River catchment, namely; the Markree Demesne Stream, The Turnalaydan Stream, The Drumfin River, The Springfield Stream, The Lissycoyne Stream, the Drumderry Stream and its tributary.

#### **Wetland habitats**

The following wetland habitats were identified along the route; Toberscanavan Loughs, Lackagh Fen, The Boathole Lough and Lough Corran, Carrowkeel wet woodland, Cuileencroobagh, Aghalenane & Ardloy Loughs, The turlough at Tawnagh and the Tawnagh lake, The Unshin River cSAC and Lough Arrow cSAC.

#### **Surface Water Quality**

According to water quality mapping compiled by the EPA, the baseline water quality status within the study area is Moderate to high.

#### **Surface Water Hydrochemistry**

Baseline surface water quality monitoring was carried out downstream of all drainage outfalls and at the inflow and outflow points of all lakes or wetlands that could be impacted by the Proposed Road Development. The baseline water quality at various locations to which road runoff is to discharge show elevated levels of Ammonia, EPH, Dissolved Oxygen, pH, Phosphate and Total Suspended Solids; but the majority of outfalls are discharging to waters classified as having good or moderate status.

#### **Flooding**

According to the flood mapping compiled by the OPW, there are several locations within the study area prone to recurring flooding. However the Proposed Road Development does not cross any of these mapped areas.

## **Hydrogeology**

### **Groundwater Body Status**

The Proposed Road Development is underlain by three GWBs, the Lavagh-Ballintougher GWB, which is classified as having good status in terms of quality and quantity and the Ballymote and Ballygawley GWB's which are classified as having good status in terms of quantity but poor status in terms of quality.

### **Aquifer Classification**

According to the bedrock aquifer mapping compiled by the GSI, the Bricklieve Limestone Formation lower and the Oakport Limestone are classified as regionally important karstified bedrock aquifers. The Bricklieve Limestone upper and the Lisgorman Shale Formation are classified as locally important aquifers. According to the interim aquifer vulnerability mapping compiled by the GSI, the Proposed Road Development is underlain by areas mapped as having high to low vulnerability (H to L), with pockets of extreme vulnerability where bedrock is at or near the surface.

### **Groundwater Flow**

The monitored groundwater levels suggests that groundwater flow within the study area is generally in a north-westerly direction across the study area generally and flow in a south-easterly direction towards Lough Arrow at the southern end of the alignment.

### **Karst Features**

The Bricklieve Limestone Formation is extensively karstified with numerous karst features evident. The national karst feature database, compiled by the GSI, has records for 14 karst features within 2.5km of the Proposed Road Development. The karst feature survey identified an additional 43 karst features on the ground. Two lakes that drain via swallow holes and numerous springs were identified at approximately 160m north of Ch 10,600m. The largest of the lakes is fed by a surface stream which flows from Loughymeenaghan in the south.

### **Groundwater Supply Wells**

A well survey was conducted within 500m of proposed road cuts to take account of the typical zone of influence for a domestic supply well. The well survey identified five wells located within 500m of the Proposed Road Development. These wells are; the artesian Carrownagark spring well, a private borehole located near Ardloy Lough used for domestic and agricultural supply, a borehole at Doorly west of the existing N4, a borehole at Doorly east of the existing N4 and a spring well at Toberscanavan.

### **Groundwater Water Quality**

According to EPA groundwater quality monitoring data (2004-2006), the average faecal coliform count at Carrownagark Group Water Scheme, is 22 CFU/100ml. The drinking water limit for faecal coliform is zero.

### **Groundwater Dependent Terrestrial Ecosystems**

Groundwater Dependent Terrestrial Ecosystems (GWDTE's) are defined as ecosystems which use groundwater for survival, either partially or completely, and are designated for protection under Article 1 of the Water Framework Directive. There are six (6 no.) groundwater dependent terrestrial ecosystems (GWDTE's) identified within the study area, namely Lackagh Fen, Boathole Lough & Lough Corran, Carrowkeel wet woodland, Cuileencroobagh Lough, Aghalenane & Ardloy Loughs and the swallow hole complex at Tawnagh.

## 4.0 PREDICTED IMPACTS

### Impacts on Hydrology

#### Impacts on Drainage, Surface Water Flows & Quality

##### Construction phase

There is a possible risk of a reduction in water quality in streams receiving runoff from the proposed road. The magnitude is rated small adverse; and therefore the significance is rated moderate/ slight for the outfall locations on the scheme.

##### Operational

The reduction in water quality in streams receiving routine runoff from the proposed road is a possible indirect impact of the Proposed Road Development. The assessment of impacts from routine runoff was carried out using UK Highways Agency publication Road Drainage and the Water Environment HD45/09, which recommends using Highways Agency Water Risk Assessment Tool. The magnitude of this impact is rated as negligible resulting in an impact of insufficient magnitude to affect use or integrity of receiving watercourses; and therefore the significance of this impact is rated imperceptible.

The increase in the volume and rate of surface runoff discharging from the catchments as a result of an increase in impervious area is an impact of the Proposed Road Development. However, the area of impervious surface is insignificant compared to the upstream catchment areas, resulting in an insignificant increase in peak flows discharging to the receiving waters. The magnitude of this impact is rated as negligible, resulting in a negligible change in predicted peak flood level; and therefore the significance of this impact is rated imperceptible.

#### Impacts on Conservation Areas and Wetland Habitats

##### Construction phase

The reduction in water quality in streams receiving runoff from the proposed road, which feed into the conservation areas, is a possible impact of the Proposed Road Development. The magnitude of this impact is rated as negligible for Lough Arrow cSAC SPA resulting from an impact of insufficient magnitude to affect use or integrity and moderate adverse for the Unshin River cSAC pNHA having a moderate sensitivity to changes in water quality; and therefore the significance of this impact is rated imperceptible for Lough Arrow cSAC SPA and potentially significant for the Unshin River cSAC pNHA. The importance of the wetland habitats is rated high (Toberscanavan Lough, Boathole Lough, Lough Corran, Cuileencroobagh and Carrowkeel woodland), very high (Lackagh Fen, and Tawnagh) and extremely high (Ardloy & Aghalenane Loughs), based on the ecological study carried out as part of this assessment which rates these areas as being of high value on a county, national and international scale; the magnitude of this impact is rated as negligible resulting in an impact of insufficient magnitude to affect use or integrity of receiving watercourses; and therefore the significance of this impact is rated imperceptible.

##### Operational

The reduction in water quality in streams receiving routine runoff from the proposed road, which feed into the conservation areas, is a possible impact of the Proposed Road Development. The magnitude of this impact is rated as negligible resulting from an impact of insufficient magnitude to affect use or integrity of the conservation areas; and therefore the significance of this impact is rated imperceptible.

The increased risk to surface and groundwater as a result of a serious accidental spillage is a possible indirect impact of the Proposed Road Development on the conservation areas. The magnitude of this impact is rated as negligible; and therefore the significance of this impact is rated imperceptible.

According to the Working Group on Groundwater guidelines, the impact potential of <5% reduced recharge as a % of average recharge is low for a GWDTE with high dependency on groundwater, such as a Fen. This is considered appropriate for the opposite i.e. increased runoff. The importance of the wetland habitats is rated high (Boathole Lough, Lough Corran, Cuileencroobagh and Carrowkeel woodland), very high (Lackagh Fen and Tawnagh) and extremely high (Ardloy & Aghalenane Loughs) as per above; the magnitude of this impact is rated as small adverse; and therefore the significance of this impact is rated moderate except for Ardloy & Aghalenane Loughs which are rated as significant.

## Impacts on Flooding

Computer-based flood risk modelling carried out as part of the Flood Risk Assessment (FRA) for the Proposed Road Development has identified two areas where flooding may occur. One area is located at the outflow of Lough Corran and the other is located around Carrowkeel Wet Woodland at the point where the road alignment crosses the Drumfin River.

The importance of these areas is rated low, due to the remoteness from residential or commercial properties; the magnitude of this impact is rated moderate to large adverse, as detailed above; and therefore the significance of this impact is rated slight to slight/moderate.

## Impacts on Fisheries Value

### Construction phase

The reduction in water quality in streams receiving runoff from the proposed road is a possible impact of the Proposed Road Development on the fisheries value. The majority of outfall locations flow into the Unshin River cSAC/pNHA. The magnitude of this impact is rated as small adverse, as a minor loss of fishery may occur; and therefore the significance of this impact is rated slight.

The re-sectioning of stream channels at road crossings is a direct impact of the Proposed Road Development on the fisheries value. This may result in changes to the existing geomorphological processes, indirectly impacting water quality or fisheries value of the watercourse. The rivers of fisheries value are the Markree Demesne Stream, Turnalaydan Stream, Drumfin River, Lissycoyne Stream, Springfield Stream, Drumderry Stream and the tributary of the Drumderry Stream. The magnitude of this impact is rated as small adverse, as a minor loss of fishery may occur; and therefore the significance of this impact is rated slight.

### Operational phase

The reduction in water quality in streams receiving routine runoff from the Proposed Road Development is a possible impact of the Proposed Road Development on the fisheries value. The magnitude of this impact is rated as negligible; and therefore the significance of this impact is rated imperceptible.

The increase in the volume and rate of surface runoff is an indirect impact of the Proposed Road Development on the fisheries value. The magnitude of this impact is rated negligible, resulting in a negligible change in predicted peak flood level; and therefore the significance of this impact is rated imperceptible.

## Impacts on Hydrogeology

### Impacts on Groundwater Body Status

#### Construction phase

The reduction in groundwater quality receiving runoff from the proposed road is a possible impact of the Proposed Road Development on the local hydrogeology. The infiltration of runoff to ground is likely to naturally mitigate this potential impact. However if exposed during development, the karstified bedrock will be extremely vulnerable to contamination and has the potential to rapidly transmit contamination to the subsurface. The magnitude of this impact is rated as moderate adverse, resulting in an impact on the integrity or moderate changes to the aquifer or unsaturated zone; therefore the significance of this impact is rated significant/moderate.

#### Operational phase

The increased risk to groundwater as a result of a serious accidental spillage is a possible impact of the Proposed Road Development on the groundwater body status. The magnitude of this impact is rated as negligible, as the calculated risk of serious pollution incidence is <0.5% annually; and therefore the significance of this impact is rated imperceptible.

The potential reduction in groundwater body status with regard to water quantity is a possible impact of the Proposed Road Development. The Proposed Road Development will increase the impervious area in the surface catchments and therefore increase the runoff rate from these impervious areas by

30% from 70% to 100% and thereby slightly reduce groundwater recharge. The magnitude is rated as negligible in accordance with Working Group on Groundwater Methodology for risk characterisation of Ireland's groundwater whereby impacts of <2% of groundwater abstractions on average recharge to groundwater bodies are rated as having no impact potential; and therefore the significance of the impact is rated imperceptible.

### Impacts on Aquifer Vulnerability

#### Construction phase

The reduction in the level of protection afforded to underlying groundwater resources is a likely indirect impact of the removal of geological materials. The magnitude of this impact is rated as small adverse and temporary, resulting in the removal of a small proportion of the aquifer, and therefore the significance of this impact is rated moderate.

#### Operational phase

The increase in the level of protection afforded to underlying groundwater resources is a certain indirect impact of the placement of embankments and an impervious cover along the Proposed Road Development. The magnitude of this impact is rated as minor beneficial, and therefore the significance of this impact is rated minor beneficial.

### Impacts on Groundwater Flow

#### Construction phase

The potential interception of shallow groundwater flow at proposed road cuts is a possible direct impact of the Proposed Road Development. The total volume of groundwater likely to be intercepted during road construction in subsoil and bedrock is estimated at potentially up to 481m<sup>3</sup>/ day or 6 l/s (worst case scenario). The magnitude of this impact is rated as negligible and therefore the significance of this impact is rated moderate.

The potential interception of shallow groundwater flow at areas of soft ground to be removed and activity at the borrow pit sites is a possible direct impact of the Proposed Road Development. The total volume of groundwater that could be intercepted during soft ground excavation and borrow pit construction in subsoil is estimated at 697m<sup>3</sup>/day or 8 litres/second or potentially under a worst case scenario up to 2,583 m<sup>3</sup>/day or 30 litres/second during borrow pit excavation. The magnitude of this impact is rated as negligible and therefore the significance of this impact is rated moderate.

### Impacts on Groundwater Levels

#### Construction phase

The likely impact of the Proposed Road Development on groundwater levels is the potential localised lowering of water table for the construction of road cuts, of which there are twelve (12 no.) and at the borrow pit sites. The proposed road cuts 3, 5, 7, 11 and 12 are likely to intercept the water table. The magnitude of this impact is rated as negligible at road cuts resulting in an impact on groundwater levels is of insufficient magnitude to affect either its use; and therefore the significance of this impact is rated imperceptible to slight.

#### Operational phase

The potential long-term reduction of the water table at the proposed road cuts where groundwater is intercepted is a possible impact of the Proposed Road Development on groundwater levels. The magnitude of this impact is rated as negligible, and therefore the significance of this impact is rated imperceptible.

### Impacts on Karst Features

#### Construction phase

The potential entry and rapid transfer of contaminants in the subsurface is a possible indirect impact of the Proposed Road Development. The magnitude is rated as moderate adverse, resulting in an impact on the integrity or loss of part of the attribute; and therefore the significance of the impact is rated significant/ moderate.

The potential collapse of karst features is a possible direct impact of the Proposed Road Development. Dewatering of unconsolidated subsoil deposits is the most important cause of induced doline or sinkhole formation. The magnitude of this impact on the karst features is rated small adverse, resulting in loss of a small part of the karst features, and therefore the significance of this impact is rated moderate/ slight.

## Impacts on Groundwater Supply Wells

### *Carrownagark well*

The Proposed Road Development is unlikely to pass through the water table within the zone of contribution or groundwater catchment area to the Carrownagark group water scheme based on assessment of the local topography and rockhead elevations; however the spring-fed well is located at approximately 100m from the proposed road. The importance of protecting the groundwater supply at Carrownagark is rated as high, the magnitude of this impact is rated as slight, and therefore the significance of this impact is rated as slight/imperceptible.

### Toberscanavan well

The Proposed Road Development will obliterate the current spring well at Toberscanavan. It must be noted that this spring well was moved during previous widening works on the N4 and is not in its original location. The magnitude of this impact is rated as large, and therefore the significance of this impact is rated as significant.

### Doorly well (west)

The Proposed Road Development does pass through the zone of contribution or groundwater catchment area to the Doorly well (west); The importance of protecting the groundwater supply at Doorly well (west) is rated as high, the magnitude of this impact is rated as slight, and therefore the significance of this impact is rated as slight/imperceptible.

### Doorly well (east)

The spring flow rate at the Doorly well (east) is approximately 0.2l/s. The Proposed Road Development passes through the zone of contribution or groundwater catchment area to this well. The importance of protecting this groundwater supply is rated as high, the magnitude of this impact is rated as slight, and therefore the significance of this impact is rated as slight/imperceptible.

### Kingsbrook well

The abstraction rate from the Kingsbrook well is unknown but the well is used to supply approximately 70 head of cattle with drinking water. The recharge area for this well is likely to extend west towards the top of the hill in Kingsbrook townland. The Proposed Road Development does pass through the zone of contribution or groundwater catchment area to the Kingsbrook well; The importance of protecting the groundwater supply at Kingsbrook well is rated as high, the magnitude of this impact is rated as small, and therefore the significance of this impact is rated as slight.

## Impacts on Groundwater Quality

### Construction phase

The reduction in groundwater quality receiving runoff from the proposed road, is a possible indirect impact of the Proposed Road Development. The magnitude of this impact is rated as moderate adverse; therefore the significance of this impact is rated significant/ moderate.

### Operational phase

The reduction in groundwater quality receiving routine runoff discharges to the ground from the proposed road is a possible impact of the Proposed Road Development. The magnitude of this impact is rated as moderate adverse, resulting in medium risk to groundwater, and therefore the significance of this impact is rated significant/ moderate. The increased risk to groundwater as a result of a serious accidental spillage is a possible indirect impact of the Proposed Road Development. The magnitude of this impact is rated negligible, as the calculated risk of serious pollution incidence is <0.5% annually; and therefore the significance of this impact is rated imperceptible.

## Impacts on GWDTE's

### Construction phase

The reduction in groundwater quality receiving runoff from the proposed road is a possible indirect impact of the Proposed Road Development. The importance of the wetland habitats is rated high (Boathole Lough, Lough Corran, Cuileencroobagh and Carrowkeel woodland), very high (Lackagh Fen and Tawnagh Swallow Hole Complex) and extremely high (Ardloy & Aghalenane Loughs). The magnitude of this impact on the GWDTE's is rated as small adverse; therefore the significance of this impact is rated Moderate for Lackagh Fen, the Boathole and Lough Corran, Cuileencroobagh and Carrowkeel wet woodland, and the lake at Tawnagh and swallow hole complex, and significant for the Ardloy & Aghalenane Loughs.

The potential interception of shallow groundwater flow is a possible direct impact of the Proposed Road Development. The importance of the wetland habitats is rated very high; the magnitude of this impact is rated as small adverse for Lackagh fen; and therefore the significance of this impact is rated as moderate. The importance of the Boathole Lough and Lough Corran is rated high; the magnitude is rated negligible as the impact potential of <5% reduced recharge as a % of average recharge is low for GWDTE's with high dependency on groundwater; and therefore the significance of this impact is rated imperceptible. The importance of the Cuileencroobagh Lough is rated high; the magnitude is rated small adverse as the impact potential of <20% reduced recharge as a % of average recharge is moderate for GWDTE's with high dependency on groundwater; and therefore the significance of this impact is rated slight/moderate. The importance of the Aghalenane & Ardloy Loughs habitats is rated extremely high; the magnitude is rated negligible as the impact potential of <5% reduced recharge as a % of average recharge is low for GWDTE's with high dependency on groundwater; and therefore the significance of this impact is rated imperceptible. The importance of the lake and swallow hole complex (at Tawnagh) habitat is rated very high; the magnitude is rated negligible as the impact potential of <5% reduced recharge as a % of average recharge is low for GWDTE's with high dependency on groundwater; and therefore the significance of this impact is rated imperceptible.

### Operational phase

The reduction in groundwater quality receiving routine runoff discharges to the ground from the proposed road is a possible indirect impact of the Proposed Road Development on the GWDTE's. The magnitude of this impact is rated as moderate adverse, resulting in medium risk to groundwater, and therefore the significance of this impact is rated significant/ moderate.

The potential long-term reduction in groundwater contributions to the Lackagh fen, the Boathole and Lough Corran, Carrowkeel wet woodland, Cuileencroobagh Lough, Aghalenane & Ardloy Loughs, and the lake and swallow hole complex (Tawnagh) habitats is a possible indirect impact of the Proposed Road Development. The Proposed Road Development will increase the impervious area in the groundwater catchment areas, increasing the runoff rate to 100% over the road area and denying groundwater this recharge. The importance of the wetland habitats is rated high; the magnitude of this impact is rated as negligible for all of the wetland habitats; and therefore the significance of this impact is rated imperceptible for all of the wetland habitats.

## Complex type impacts

### Cumulative impacts

The removal of soil and subsoil material to increase the aquifer vulnerability from high to extreme at some proposed road cuts, at the spoil treatment sites, and the potential introduction of contaminants during construction are considered to have a cumulative impact on the water quality in the streams and feeding into the wetland habitats. These impacts are considered negligible and imperceptible in nature.

## **5.0 MITIGATION MEASURES AND RECOMMENDATIONS**

### Mitigation by avoidance

The design is considered the best possible, in terms of minimising the impact to the hydrological and hydro-geological environment. Mitigation by avoidance has been actively applied to the alignment design as the Impact Assessment progressed.



## **Mitigation by reduction**

### Drainage Design

The drainage system includes containment for accidental spillages at each outfall, petrol/ oil interceptors, and attenuation ponds. The drainage system is designed so that surface runoff, where possible, remains in the same surface catchment area as under pre-construction conditions, and that surface runoff flows through suitable attenuation infrastructure. The containment of the proposed drainage system is a positive impact of the Proposed Road Development compared to the existing N4 road. The attenuation balancing ponds are designed to accommodate a 100-year return period flow and are designed to have adequate storage to allow a permissible outlet flow similar to the maximum existing flow from the catchment.

The design of embankments at Lackagh Fen includes a drainage layer at the base of the embankment, rockfill below the water table to allow the through flow of groundwater, and vertical hydraulic barriers to stop groundwater from flowing along the embankment. These measures will reduce the hydrogeological impacts on the fen as a result of the development.

The design of embankments at Ardloy and Aghalenane Loughs and adjacent to the Boathole Lough incorporates a drainage layer at the base of the embankment and vertical hydraulic barriers to prevent groundwater movement along the embankment. Also provided at Ardloy and Aghalenane Loughs is traverse embankment drainage measures. These measures will reduce the hydrogeological impacts on the site as a result of the development.

## **Construction Phase**

### Water Quality

To minimise the impact on surface water and groundwater quality during construction a detailed operating procedure is contained in the Outline Erosion and Sediment Control and the following general mitigation measures are to be adopted: Streams and groundwater monitoring boreholes are to be monitored during construction on a monthly basis and for up to one year after construction; Strict adherence to an agreed approach to pumping and surface runoff and the emergency spill plan is to be operated; Silt traps, settlement lagoons, wetlands or hydrocarbon interceptors are to be placed at sensitive outfalls.

### Groundwater Levels

Groundwater level monitoring is to be undertaken at all available groundwater monitoring boreholes during construction on a monthly basis and for up to one year after construction and compared to the available pre-construction monitoring data. To minimise the impact on groundwater flow during construction, all construction activity in bedrock cuts is to be closely monitored by a karst expert to identify any subsurface karst collapse features or active karst conduits in the unlikely event of encountering such features; if such active karst conduits are found, additional drainage of sufficient capacity is to be incorporated into the existing drainage design for the road, in order to allow the water to flow freely during periods of high precipitation, thus preventing flooding potential.

### Groundwater Supply Wells

To minimise the impact on groundwater supply wells groundwater levels are to be monitored in the identified spring-fed well of Carrownagark group water scheme well at c. Ch. 7,900m during the construction phase. Should the well be impacted by the Proposed Road Development, the replacement or access to an equivalent water supply is to be dealt with as part of the accommodation works.

## **Operation Phase**

### Drainage

Drainage outfalls are designed to be served by suitably sized attenuation ponds which will limit the runoff rate to that of existing Greenfield runoff (based on QBAR) rates for the site at all of the outfalls.

### Water Quality

To minimise the impact on surface water and groundwater quality during the operational phase, spill containment measures and constructed wetlands will be constructed at all outfalls. In addition hydrocarbon interceptors will be constructed at all outfalls from the mainline (national primary)

carriageway. The existing N4 road has no attenuation, containment for accidental spillages and petrol interceptors, and is considered a positive impact of the proposed road development.

## **6.0 RESIDUAL IMPACTS**

### **Impacts on Hydrology**

#### Reduced surface water quality

The temporary reduction in water quality in streams receiving construction runoff from the proposed road is a possible indirect impact of the Proposed Road Development. These impacts are considered to remain residual but to remain at or reduce to imperceptible. The impacts of the reduction in water quality in streams receiving routine runoff and the increased risk to surface water as a result of a serious accidental spillage on local hydrology, on conservation areas and on wetland habitats are considered to remain residual, imperceptible and permanent.

#### Re-sectioning of stream channels

The re-sectioning of stream channels is a certain direct impact of the Proposed Road Development. Following the implementation of mitigation measures, these impacts are considered to remain residual, moderate/ slight and permanent in nature. The impacts on flooding are considered to remain residual, slight to slight/ moderate and permanent in nature, while the impacts on fisheries value are considered to remain residual, slight and permanent in nature.

#### Increased attenuation & containment

The increased attenuation and containment is a certain indirect impact of the Proposed Road Development. Following the implementation mitigation measures, these impacts are considered to remain residual, minor beneficial and permanent in nature.

#### Increased surface water contributions

The indirect impact of the Proposed Road Development of increasing runoff within the surface water catchment area is mitigated by ensuring that runoff is attenuated before being discharged into the same catchment from which it was derived. The impact is considered to remain slight/imperceptible and permanent.

### **Impacts on Hydrogeology**

#### Reduction in groundwater body status

The reduction in groundwater contributions is a possible indirect impact of the Proposed Road Development on groundwater body status. Following the implementation of mitigation measures detailed in this chapter, these impacts are considered to remain residual, imperceptible and permanent in nature.

#### Changes in level of groundwater protection

The impacts of increased level of protection by the placement of embankments and an impervious cover are considered to remain residual, minor beneficial and permanent in nature.

#### Localised lowering of water table

The potential localised lowering of the water table for the construction of road cuts and for the removal of areas of soft ground is a certain indirect impact of the Proposed Road Development on groundwater flow. Following the implementation of mitigation measures, these impacts are considered to remain residual, imperceptible.

#### Entry & rapid transfer of contaminants

The potential entry and rapid transfer of contaminants in the subsurface is a possible indirect impact of the Proposed Road Development on karst features. Following the implementation of mitigation measures, these impacts are considered to remain residual, moderate and temporary in nature.

#### Collapse of identified or unidentified karst features

The potential collapse of identified or unidentified karst features is a possible indirect impact of the Proposed Road Development. Following the implementation of mitigation measures, these impacts

are considered to remain at or reduce to residual, moderate/ slight for karst features and for the Proposed Road Development and temporary in nature.

#### Reduced groundwater contributions

The collection and conveyance of groundwater (if any) encountered in the cuts within the wetland catchments has been offset by the contribution of attenuated road runoff to the catchments and there is unlikely to be a significant change in the net water flow into any of these catchments as a result. The importance of the wetlands are rated high to very high to extremely high; the magnitude of the groundwater impact is reduced by the proposed mitigation measures from moderate adverse to small adverse in the worst cases; and therefore the significance of this impact is reduced from significant/ moderate to moderate/ slight. The magnitude of the surface water impact is reduced from moderate adverse to negligible; and therefore the significance of this impact is reduced from significant/ moderate to imperceptible. The impact is considered to remain residual, imperceptible and permanent.