Chapter 8 Hydrogeology

8.1 Introduction

The aim of this study is to identify the impacts of the construction and operational phases of the proposed M7 Naas to Newbridge Bypass Upgrade Scheme and associated works on the hydrogeology of the study area and to identify possible mitigation measures to minimise these impacts.

The study has been carried out in accordance with the NRA's guidelines (National Roads Authority (2008) *Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes)* and includes:

- A survey, description, classification and assessment of the existing hydrogeology of the environment through which the bypass scheme is to be built;
- A description and assessment of the likely impacts of the bypass upgrade, both positive and negative, on these aspects of the environment;
- A description and assessment of the possible mitigation measures to minimise these impacts;
- A description and assessment of the residual impacts after mitigation;
- A description and assessment of the impact interactions and cumulative impacts.

8.2 Methodology

Relevant Guidance

This detailed study has been prepared using the following guidelines:

Table 8.1 Guidelines Considered

Guidelines
Environmental Protection Agency (2002) *Guidelines on Information to be Contained in an Environmental Impact Statement* – March 2002
Environmental Protection Agency (2003) *Advice Notes on Current Practice (in preparation of Environmental Impact Statements* – September 2003
DG Environment (2002) *Guidelines on the Assessment of Indirect & Cumulative Impacts as well as Impact Interactions*
National Roads Authority (2008) *Environmental Impact Assessment of National Road Schemes – A Practical Guide* – Rev 1, November 2008
National Roads Authority (2008) *Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes*
UK Highways Agency (2009) *Road Drainage and the Water Environment HD45/09*
CIRIA (2006) *Control of water pollution from linear construction projects, Technical guidance (C648)*
CIRIA (2000) *Groundwater Control – Design and Practice (C515)*

Desk Study

The desk based work items involved the following:

- Definition of the study area, in accordance with NRA guidelines as 250m beyond the landtake boundary of the proposed scheme and taking account of potentially significant impacts which could arise at a greater distance away;
- Compilation of all relevant plan maps relating to the study area and proposed road development;
- Acquisition and compilation of all available regional information on the hydrogeology of the study area, including:
- Interrogation of the Geological Survey of Ireland's (GSI) online mapping service, national well and karst feature databases and groundwater body descriptions;
- Acquisition and examination of the Ordnance Survey of Ireland's (OSI) mapping and aerial photography;
- Examination of the National Parks and Wildlife Service (NPWS) designations;
- Examination of the Office of Public Works (OPW) online flood and hydrometric mapping service;
- Acquisition of climatic data from Met Eireann;
- Examination of the Water Framework Directive River Basin Management Plans;
- Examination of the Environmental Protection Agency's (EPA) online hydrological and land use mapping service;
- Identification of possible karst features on OSI 1:50,000 and 1:10,560 scale maps and aerial photography.
- Consultation with the Geological Survey of Ireland as a statutory consultee and interested organisation in relation to the groundwater environment.

Field Investigations

The field investigations conducted for this study involved the following:

- A walkover survey of the entire road scheme immediately outside the road boundary and study area, which extends to 250m beyond the landtake boundary for the proposed route mainline. However this study area was extended to include any hydrogeological features of interest or concern, identified in the desk study or in the consultations;
- Karst feature survey to locate and examine any karst features and to identify where potentially karstifiable bedrock is located within the study area, which was extended beyond 250m where appropriate;
- Well audit to locate and examine recorded wells in the GSI national well database within 250m of the proposed road route (in cases where a property could not be accessed a letter explaining that a groundwater well survey was being carried out on behalf of Kildare County Council, detailing the reasons for the groundwater survey, and containing contact details of the surveyor was placed in the post box of each property);
- Survey and audit of protected water dependent conservation areas.

Limitations & Data Gaps

The identification of collapsed karst features buried beneath the subsoil geology often requires historic knowledge of an area, as these features are often not identified on OSI maps. Therefore, the presence of karst features near the proposed road alignment cannot be limited to those identified on a map or found during a site walkover. The findings should rather be taken as an indication of the susceptibility of the study area to karstification. However all practical efforts were made during the route walkover to identify karst features along and near the proposed road realignment and within the study area.

8.3 Impact Assessment Methodology

The following assessments were undertaken, from the desk and field data acquired, to evaluate the potential impacts of the proposed development on sensitive locations such as groundwater supply wells:

- Characterise the sites current hydrogeological regime based on the topographical, geological, hydrological and hydrogeological data acquired.
- Determine and estimate the impact on groundwater supply wells within 250m of the road;
- If impacts are identified, consider measures that would mitigate, re-mediate or reduce the identified impact;
- Identify any residual impacts that would remain or arise from the mitigation measures identified;
- Present and report these findings in a clear and logical format that complies with EIS reporting requirements.

The above approach was undertaken following the EPA guidelines. The likely significant impacts were described using the five-tier system presented in the EPA advice notes, by reference to quality of impact, significance of impact, duration of impact and types of impact and using the criteria for rating site attributes and for rating impact significance as presented in the NRA guidelines.

8.4 Existing Environment

Bedrock Geology

According to the bedrock mapping compiled by the GSI, the southern end of the route from chainage 0+7,500 is underlain by the Ballysteen Formation consisting of dark muddy limestone and shale. The section from chainage 7+500-12+700 is underlain by the Rickardstown Formation which consists of cherty and often dolomitised limestone. The section from chainage 12+700-13+400 is underlain by Waulsortian Limestones which consists of massive unbedded limestone-mudstone. The section from chainage 13+400 - 15+725 is underlain by the Ballysteen Formation.

Superficial deposits

According to Teagasc subsoil mapping the majority of the road is underlain by Glacial Till.

Bedrock Aquifer Classification

According to the bedrock aquifer mapping compiled by the GSI, the Ballysteen Formation and the Waulsortian Limestone are classified as a Locally important aquifer, moderately productive only in local zones (LI), the Rickardstown Formation is classified as a Regionally important karstified aquifer dominated by diffuse flow (Rkd) (Refer **Figure 8.1, EIS Volume 3**).

Gravel Aquifer Classification

According to the gravel aquifer mapping compiled by the GSI, the southern part of the route from chainage 0 - 7,800 is underlain by a gravel aquifer. This aquifer is classified as a Regionally important Sand and Gravel Aquifer by the GIS.

Groundwater bodies

The Ballysteen Formation and the Waulsortian Limestones form part of the Dublin Groundwater body (GWB), while the Rickardstown Formation is classified as the Naas GWB. Along the southern part of the road from chainage 0-7,800 the bedrock GWB (the Dublin GWB) is overlain by the Curragh (East) GWB which is comprised of the superficial deposits in this location (Ref. **Figure 8.2, EIS Volume 3**).

The Naas GWB is dominated by fissure flow, transmissivities vary greatly though the aquifer with values of as little as 1m²/day recorded in poor yielding wells and up to 10 m²/day possible in other wells. Depth to bedrock is typically >10m and much of the southern part of the aquifer is overlain by the Curragh (East) GWB. No large groundwater abstraction takes place from this aquifer as the overlying Curragh (East) aquifer is usually used for extraction purposes (Ref. **Figure 8.3, EIS Volume 3**).

The Dublin GWB is dominated by fissure flow and transmissivities are likely to be in the region of 1-10 m²/day. Depth to bedrock varies over the aquifer with depths >10m commonly encountered in the area around the proposed bypass upgrade.

The Curragh (east) GWB is a gravel aquifer with a matrix comprising of typically <8% fines. Permeabilities of 15-50 m/day have been recorded in this aquifer. There are large areas of limestone till capping the aquifer, but this till is typically <3m deep. There are number of large springs discharging from the aquifer, and the Milltown feeder of the Grand Canal is supported by a daily flow of approximately 25,000 m³/day from Pollardstown fen to the northwest of the proposed bypass upgrade.

Aquifer Vulnerability

Vulnerability is a term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities. The vulnerability of groundwater depends on the connectivity between the land surface and the aquifer, therefore it is a function of subsoil permeability, subsoil depth and recharge type, i.e. diffuse or point recharge.

The following table (**Table 8.2**) summarises the GSI vulnerability ratings based on subsoil type, thickness and proximity to karst features.

Table 8.2 Aquifer vulnerability ratings

Vulnerability Rating	Hydrogeological Conditions				
	Subsoil Permeability & Thickness			Unsaturated Zone	Karst Features
	High permeability (sand/ gravel)	Moderate permeability (e.g. sandy subsoil)	Low permeability (e.g. clayey subsoil, peat)	(Sand/ gravel aquifers only)	(<30m radius)
Extreme (E)	0-3.0m	0-3.0m	0-3.0m	0-3.0m	-
High (H)	>3.0m	3.0-10.0m	3.0-5.0m	>3.0m	N/A
Moderate (M)	N/A	>10.0m	5.0-10.0m	N/A	N/A
Low (L)	N/A	N/A	>10.0m	N/A	N/A

According to the interim aquifer vulnerability mapping compiled by the GSI, the aquifers crossed by the proposed road scheme are; moderate vulnerability from chainage 0-7+800, low vulnerability from chainage 7+800-11+800 and 13+700-15+725, and low vulnerability from chainage 11+800-13+700. The significance of the aquifer vulnerability is that it is reflective of the protection afforded by the subsoil geology to groundwater contamination (Refer **Figure 8.3, EIS Volume 3**).

Groundwater Body Status

According to interim classification work carried out as part of the Water Framework Directive, the Naas, Dublin and Curragh (East) GWB's are classified as having good status in terms of quality and quantity.

The significance and sensitivity of the groundwater body status is that the proposed road upgrade passes through three groundwater bodies, which has the potential to impact water quality and groundwater flows.

Groundwater Flow

Groundwater flow in the Curragh (East) GWB is characterised by unconfined groundwater flow though sand and gravel deposits which are assumed to average around 5m in thickness. The aquifer is in hydraulic connectivity with the underlying Naas GWB aquifer and discharges diffusely down to the Naas GWB. Recharge to the aquifer is disperse and autogenic, as a result of the highly permeable nature of the aquifer. Regional groundwater flow is towards the north of the aquifer either directly into the River Liffey or into springs which flow into tributaries of the River Liffey.

Groundwater flow in the Naas GWB is characterised by fissure flow through high permeability karstified and dolomitised pure bedded limestone. The aquifer is in hydraulic connectivity with the overlying Curragh (East) sand and gravel aquifer and receives diffuse recharge from this aquifer in the locations where it is overlain by the Curragh (East) aquifer. Groundwater flow in the Naas GWB is generally unconfined but may become locally confined in places where the aquifer is overlain by low permeability glacial tills. Regional groundwater flow is towards the north of the aquifer where the River Liffey acts as a discharge point for the aquifer.

Groundwater flow in the Dublin GWB is characterised by fissure flow through impure bedded limestone. Groundwater flow in the Dublin GWB is generally unconfined but may become locally confined in places where the aquifer is overlain by low permeability glacial tills. Groundwater flowpaths in the aquifer are assumed to be generally <1km in length due to the relatively low permeability of the aquifer. In the area of the proposed road scheme groundwater in the Dublin GWB is assumed to discharge into the surface drainage network which flows into the River Liffey.

Groundwater levels

The groundwater well survey did not identify any groundwater monitoring boreholes or in-use groundwater wells within 250m of the road from which groundwater levels could be measured. Based on the published literature relating to the Naas, Curragh (East) and Dublin GWBs it is likely that the water table is shallow and <5m below ground level along the proposed road scheme. Near the southern end of the planned upgrade the Canal Feeder channel at Corbally harbour is fed by a spring which is located at 88.7maOD which indicates that the water table is shallow in this area.

Karst Features

No karst features were identified within 250m of the road corridor during the site survey or in GSI databases.

Groundwater Supply Wells

According to the national well database compiled by the GSI, there are 23 groundwater wells located within 250m of the proposed road realignment (Refer **Figure 8.4, EIS Volume 3**). These wells are a mixture of 19th Century dug wells, site investigation boreholes from the original construction of the Naas Bypass, and a small number of groundwater supply boreholes. There is no evidence that any of the wells located within 250m of the proposed road scheme are currently in use and the entire area appears to be supplied with public mains water. According to the GSI online mapping service, there are no source protection areas delineated within the study area. The results of the site well survey are presented in the Table 8.3 below.

Table 8.3 Summary of groundwater well survey results

Groundwater well ID	Construction method (Dug/Drilled)	In use (yes/no)	Aquifer (GWB)	Conclusion
GW1	Drilled	no	Dublin	Golf course irrigation well. Actual location >250m from the road upgrade.
GW 2	Drilled	no	Dublin	Golf course irrigation well. Actual location >250m from the road upgrade.
GW 3	Drilled	no	Dublin	Golf course irrigation well. Actual location >250m from the road upgrade.
GW 4	Drilled	no	Dublin	Golf course irrigation well. Actual location >250m from the road upgrade.
GW 5	Drilled	no	Dublin	Golf course irrigation well. Actual location >250m from the road upgrade.
GW 6	Drilled	no	Dublin	Golf course irrigation well. Actual location >250m from the road upgrade.
GW 7	Drilled	no	Naas	Naas bypass SI borehole. Not located
GW 8	Drilled	no	Naas	Naas bypass SI borehole. Not located
GW 9	Drilled	no	Naas	Naas bypass SI borehole. Not located
GW 10	Dug	no	Naas	C.19th dug well. Obliterated by modern development.
GW 11	Dug	no	Naas	C.19th dug well. Obliterated by modern development.
GW 12	Dug	no	Naas	C.19th dug well. Obliterated by modern development.
GW 13	Drilled	no	Naas	C.19th well. Obliterated by modern development.

Groundwater well ID	Construction method (Dug/Drilled)	In use (yes/no)	Aquifer (GWB)	Conclusion
GW 14	Dug	no	Naas	C.19th dug well. Obliterated by modern development.
GW 15	Dug	no	Naas	C.19th dug well. Could not access location. Unlikely to be in use as area served by mains supply
GW 16	Drilled	no	Naas	Backup borehole for Kildare waste water treatment works. Capped and locked. Unaccessable.
GW 17	Drilled	no	Naas	Drilled 1983, well lost as now site covered with hardcore and in use as a hauliers yard.
GW 18	Dug	no	Naas	C.19th dug well. Could not access location. Unlikely to be in use as area served by mains supply
GW 19	Dug	no	Curragh (East)	C.19th dug well. Obliterated by modern development.
GW 20	Dug	no	Curragh (East)	C.19th dug well. Obliterated by modern development.
GW 21	Dug	no	Curragh (East)	C.19th dug well. Could not access location. Neighbour said site derelict and well not in use
GW 22	Dug	no	Curragh (East)	C.19th dug well. Could not access location. Neighbour said site derelict and well not in use
GW 23	Dug	no	Curragh (East)	C.19th dug well. Obliterated by modern development.

Groundwater Hydrochemistry

As there are no known drinking water supply wells along the proposed route, within the landtake boundary, or within 250m of the proposed route, no baseline groundwater quality testing for drinking water purposes was conducted. Published hydrochemistry data for the Curragh (East) GWB indicates that groundwater in this aquifer is hard to very hard (251->350 mg/l $CaCO_3$) with electrical conductivity values of around 665 μS/cm. There are no published hydrochemistry data for the Naas GWB but according to the GSI groundwater in this aquifer is likely to be hard with high electrical conductivity values similar to the Curragh (East) GWB. Published hydrochemistry data for the Dublin GWB indicates that groundwater in this aquifer is very hard (350-480 mg/l $CaCO_3$), with a high alkalinity (300 - 350 mg/l $CaCO_3$). Conductivities are also very high, ranging 550-900 μS/cm.

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 no GWDTEs within 250m of the proposed road upgrade. The closest

GWDTE is Pollardstown Fen which is located approximately 5km northwest of the southern end of the proposed upgrade. The upgrade is not located within the Pollardstown Fen groundwater catchment and will therefore not have any impact on this site.

8.5 Description & Assessment of Impacts

The following sections detail the potential Impacts of the proposed road realignment on the hydrological and hydrogeological aspects of the environment. These potential impacts are the impacts of the proposed development before mitigation measures are fully established.

"Do Nothing" Scenario

According to NRA, as rainfall patterns in Ireland are changing, the NRA recommends an adjustment of 20% for use in water balance calculations or drainage design of new roads to account for the predicted increase in rainfall levels across Ireland. This is also recommended by the UK Highways Agency publication *Road Drainage and the Water Environment HD45/09*. The likely impact on the local groundwater system under the do nothing scenario is that there would likely be greater fluctuation in summer water table levels due to evapotranspiration exceeding rainfall for a greater part of the year than at present.

Impacts on Groundwater Body Status

The likely impacts of the proposed road realignment on the groundwater body (GWB) status are as follows.

Construction Phase

The reduction in groundwater quality receiving runoff from the proposed road is a possible indirect impact of the road development on the drainage during the construction phase. The main potential contaminant during the construction phase is Suspended Solids, which with the deposition of SILT; however the infiltration of runoff to ground is likely to naturally mitigate this potential impact. The importance of the Dublin, Naas and Curragh (East) GWBs is rated high, due to the good chemical status,; the magnitude of this impact is rated as small 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 moderate/slight.

Operational phase

The reduced risk to groundwater as a result of a serious accidental spillage is a possible indirect impact of the road upgrade on the groundwater body status during the operational phase as a result of the capping of the aquifer along the central median of the motorway. The importance of the GWBs is rated high; the magnitude of this impact is rated as negligible, 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 indirect impact of the road development during the operational phase. The proposed road realignment will increase the impervious area in the surface catchments and therefore increase the runoff rate by 20-30% from 70-80% to 100% over these areas and thereby denying groundwater recharge. The following table summarises these reductions for the Naas, Curragh (East) and Dublin GWBs and the relative paved road area to groundwater body area.

Based on rainfall data recorded over 30 years (1961-1990), the annual rainfall average for the area, obtained from the nearest Met Eireann synoptic meteorological station, which is located at Casement Aerodrome, to the northeast, is 711mm. The average annual evapotranspiration, also obtained from Casement Aerodrome, is 510mm. This means that annual effective rainfall along the road is 211mm/year. Recharge to groundwater has been estimated as 80% of effective rainfall (169 mm/year) for the Curragh (East) GWB, approximately 70% (148mm/year) for the Naas GWB and approximately 70% (148 mm/year) for the Dublin GWB. Based on the proposed area to be paved in each of the GWBs as a result of the road upgrade, which is an average of 6.4m wide per meter of road chainage (road chainage in Curragh East GWB=7,800m, in Nass GWB= 4,900m and in Dublin GWB=3,025m) recharge to the Curragh (East) GWB will be reduced by 14,093m^3/year (0.169m x 7,800m x 6.4m + 24021m^2 for the newhall interchange +9450 m^2 for 3 attenuation ponds), recharge to the Naas GWB will be reduced by 5,107m^3/year (0.148m x 4,900m x 6.4m + 3150 m^2 for 1 attenuation pond) and recharge to the Dublin GWB will be reduced by 2,865m^3/year (0.148m x 3,025m x 6.4m) (refer Table 8.4).

The importance of the groundwater bodies is rated high; 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.

Table 8.4 Estimated reductions in recharge to groundwater body

GWB ID	New paved road area (m^2)	New paved road as a % groundwater body	Reduction in recharge (m^3/ year)
Naas	34,510	0.001	5,107
Curragh (East)	83,391	0.001	14,093
Dublin	19,360	0.00001	2,865

Impacts on Aquifer Vulnerability

The likely impacts of the proposed road realignment on aquifer vulnerability are as follows:

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 during the construction phase. The excavation of and removal of geological materials has the potential to increase aquifer vulnerability to groundwater contamination. However this impact is considered to remain localised at these proposed road cuts and temporary, exposing the subsoil during the construction phase only. The importance of the groundwater, as a regionally important aquifer, is rated high, the magnitude of this impact is rated as small adverse, 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 an impervious cover along the proposed road upgrade. However this impact is considered to remain localised at along the proposed road upgrade. The importance of the groundwater, as a regionally important aquifer, is rated high, 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

The likely impacts of the proposed road realignment on groundwater flow are as follows:

Construction Phase

There are no anticipated impacts of the proposed road upgrade on groundwater flow during the construction phase.

Operational Phase

There are no anticipated impacts of the proposed road upgrade on groundwater flow during the operational phase.

Impacts on Groundwater Levels

The likely impacts of the proposed road realignment on groundwater levels are as follows:

Construction Phase

There are no anticipated impacts of the proposed road scheme on groundwater levels during the construction phase.

Operational Phase

There are no anticipated impacts of the proposed road scheme on groundwater levels during the operational phase.

Impacts on Groundwater Supply Wells

There are no anticipated impacts of the proposed road realignment on groundwater supply wells during the construction or operational phases.

Impacts on Groundwater Quality

The likely impacts of the proposed road realignment on groundwater quality are as follows:

Construction phase

The reduction in groundwater quality receiving runoff from the proposed road is a possible indirect impact of the road scheme on the groundwater system during the construction phase. The main potential contaminant during the construction phase is Suspended Solids, which with the deposition of SILT; the infiltration of runoff to ground is likely to naturally mitigate this potential impact. However, where exposed during development the exposed subsoil/bedrock will be vulnerable to contamination and has the potential to transmit contamination in the subsurface to connected springs or to surface water bodies. The importance of the groundwater, as a regionally important aquifer, is rated high, the magnitude of this impact is rated as small adverse, due to the relatively limited area concerned; therefore the significance of this impact is rated moderate/slight.

Operational phase

An improvement in groundwater quality receiving routine runoff discharges to the ground from the proposed road is a possible indirect impact of the road development during the operational phase. This could result from the fact that the aquifer would be capped by an impermeable layer which would prevent pollutants from the road surface which overflow the road drainage into the central median during periods of heavy rainfall from entering the aquifer. The importance of the groundwater, as a regionally important aquifer, is rated high, the magnitude of this impact is rated as moderate positive, resulting in medium risk to groundwater, and therefore the significance of this impact is rated moderate.

Impacts on GWDTE's

There are no anticipated impacts of the proposed road realignment on Ground-Water Dependent Terrestrial Ecosystems (GWDTE's) during the construction or operational phases.

8.6 Mitigation Measures & Environmental Commitments

Mitigation by avoidance

The proposed scheme is considered the best possible, in terms of minimising the impact to the hydrogeological environment. Mitigation by avoidance has been actively applied to the preliminary alignment design as the Impact Assessment progressed. This includes avoiding the construction of new fills or excavation of new cuts along the route of the proposed scheme, limiting the footprint of the upgraded road to within the existing landtake, and utilising the existing drainage system to convey road runoff from the proposed newly paved surfaces.

Groundwater levels & quality

To minimise the potential impacts on groundwater levels and quality during and post construction, the following mitigation measure should be adopted:

Backfill or decommission any obsolete ground investigation pits and/or boreholes in accordance with Institute of Geologists of Ireland (IGI) publication *Well Drilling Guidelines* to avoid groundwater contamination.

Groundwater flow

The proposed scheme design including drainage systems and the mitigation measures detailed in this chapter are considered to also mitigate the likely impacts on groundwater levels, flows and quality of the operational phase.

8.7 Residual Impacts

Reduction in groundwater body status

The reduction in groundwater contributions is a possible indirect impact of the road development on groundwater body status. This impact is considered to remain residual, imperceptible and permanent in nature.

Increase in level of protection

The increase in the level of protection afforded to groundwater resources is a possible indirect impact of the road development on aquifer vulnerability. This impact is considered to remain residual, minor beneficial and permanent in nature.

Improved groundwater quality

The sealing of the ground surface in the central median of the existing road will ensure that no infiltration of road runoff occurs during periods of heavy rainfall and that the existing groundwater quality is maintained. The impact is considered to remain residual, minor beneficial and permanent.

8.8 References

No.	Description
1.	Environmental Protection Agency (2002) *Guidelines on Information to be Contained in an Environmental Impact Statement* – March 2002
2.	Environmental Protection Agency (2003) *Advice Notes on Current Practice (in preparation of Environmental Impact Statements* – September 2003
3.	DG Environment (2002) *Guidelines on the Assessment of Indirect & Cumulative Impacts as well as Impact Interactions*
4.	National Roads Authority (2008) *Environmental Impact Assessment of National Road Schemes – A Practical Guide* – Rev 1, November 2008
5.	National Roads Authority (2008) *Guidelines of Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes*
6.	UK Highways Agency (2009) *Road Drainage and the Water Environment HD45/09.*
7.	Ciria (2006) *Control of water pollution from linear construction projects, Technical guidance (C648)*
8.	Ciria (2000) *Groundwater Control – Design and Practice*
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10.	Teagasc (2006) Forest Inventory and Planning System – Irish Forest Soils, Subsoil Mapping Element, Methodology for Subsoil Mapping
11.	Geological Survey of Ireland (GSI) online geological & hydrogeological mapping service – www.gsi.ie
12.	Geological Survey of Ireland (2004) Curragh (East) groundwater body description – www.gsi.ie
13.	Geological Survey of Ireland (2004) Naas groundwater body description – www.gsi.ie
14.	Geological Survey of Ireland (2004) Dublin groundwater body description – www.gsi.ie
15.	Environmental Protection Agency (EPA) online mapping service – www.epa.ie
16.	Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive)
17.	Sustainable Energy Ireland website - www.sei.ie
18.	Working Group on Groundwater (2005) *Methodology for risk characterisation of Ireland's groundwater, GW8*
19.	IGI (2007) *Well Drilling Guidelines*
20.	Met Eireann (1991) *Mean Monthly Pot Evapotranspiration & monthly & annual rainfall 1961-1990.*
21.	Working Group on Groundwater (2004) *Guidance document GW8:* *Methodology for risk characterisation of Ireland's groundwater*.