16 Hydrogeology

16.1 Introduction

This chapter of the Environmental Impact Statement consists of a hydrogeological assessment of the proposed M7 Osberstown and R407 Sallins Bypass Scheme. The methodology followed in the assessment is set out initially (Section 16.2) and this is followed by a description of the existing hydrogeological environment (Section 16.3). The predicted hydrogeological impacts associated with the proposed road development are then reviewed (Section 16.4), proposed mitigation measures are set out (Section 16.5), and anticipated residual impacts are examined (Section 16.6).

16.2 Methodology

16.2.1 Legislation and Guidelines

This chapter is prepared having regard to the requirements of Section (50), Sub-Sections 2 and 3 of the Roads Act 1993 as amended, and with the following guidance:

- Environmental Impact Assessment of National Road Schemes – A Practical Guide (NRA, 2008).
- Guidelines on the Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes, (NRA, 2009).
- Advice Notes on Current Practice in the preparation of Environmental Impacts Statements, (EPA, 2003).
- Guidelines on the Information to be contained in Environmental Impact Statements, (EPA, 2002).
- Advice Notes on Current Practice in the Preparation of Environmental Impact Statements, (EPA, 2003).
- Geology in Environmental Impact Statements - A Guide, (IGI, 2002).
- Geology of Kildare–Wicklow (Sheet 16)", 1:100,000 Bedrock Geology Series (GSI, 1995).

16.2.2 Water Framework Development

The assessment of the potential hydrogeological impacts of the proposed road development was undertaken with reference to the requirements and objectives of the EU Water Framework Directive (2000/60/EC), the subsequent EU Groundwater Directive (2006/118/EC) and Draft River Basin Management Plans (RBMPs) for the Eastern River Basin District (ERBD) 2009 – 2015.

The fundamental objective of the Water Framework Directive aims at maintaining the “high status” of waters where it exists, preventing any deterioration in the existing status of waters (including groundwater) and achieving at least “good status” in relation to all waters by 2015. This is achieved through the implementation of management plans for each River Basin District (RBD).

There are no Groundwater Bodies within the study area which are classified as being at “poor status”. The route crosses the Grand Canal, a proposed Natural Heritage Area (pNHA) and the River Liffey at two separate locations.

16.2.3 Consultation

Consultation was carried out with relevant bodies to identify any hydrogeological features which may be impacted upon by the proposed road development. The consultees for the hydrogeology impact assessment were:

- Geological Survey of Ireland (GSI) – The GSI responded that there are no sites of geological interest within the study area. The audit of County Geological Sites for Kildare was carried out in 2005 and no sites were identified in the vicinity. The release of all geological heritage data, including Kildare, is planned for release by the GSI shortly.
- Local Authorities – In particular the Environment and Water Services Sections of Kildare County Council. Local Area engineers were consulted. Kildare County Council, Water Services Section confirmed the location of the nearest public supply schemes.
- Department of Arts, Heritage and the Gaeltacht (DAHG) was consulted and responded that impacts on water table levels or groundwater flows had the potential to impact wetland sites some distance away. They also noted that the crossings of the Grand Canal (pNHA) and the two bridge crossings of the River Liffey have the potential to have a negative impact on a number of protected species as discussed in Chapter 14 - *Ecology*.
- Private landowners within the study area potentially affected by the proposed road development were consulted. The key issue for these stakeholders, in relation to groundwater, is access to private wells and concern regarding drainage from a cul-de-sac in Castlesize.
- Consultation with Inland Fisheries (IFI), Inland Waterways Association of Ireland, Eastern Regional Fisheries Board (ERFB) and National Parks and Wildlife Services (NPWS) raised concerns with respect to accidental spills and/or pollution to the local waterways and deemed that the proposed scheme was not likely to affect groundwater supplies to waterways or wetlands of ecological importance.
- Environmental Protection Agency (EPA) – EPA was consulted to determine the location of any waste licence or groundwater monitoring locations within the study area. There are no EPA monitoring sites within the CPO line of the proposed road development. There are a number of EPA monitoring sites on the River Liffey as outlined in Chapter 17 - *Hydrology*.

Consultation was also undertaken with other specialists on the project team in order to assess the impact of the interaction with other environmental factors. This included discussions on the following issues.

- Ecology – Consultation on the potential impact on local ecology.
- Soils and Geology – Cross referencing on contaminated land issues.
- Hydrology – Consultation on the potential impact on rivers and wetlands.
- Drainage – Consultation held on drainage design issues, particularly in relation to mitigation measures for potential hydrogeological impacts.
- Material Assets – Consultation on the impact on private wells.

16.2.4 Study Area and Baseline Data Collection

For the purposes of this chapter the study area extends 500 m beyond the CPO line for the proposed road development and was also locally extended in areas of link roads and junctions.

Data was gathered from the following sources of information for this report:

- Feedback from consultations with statutory consultees, interested organisations and affected third parties.
- Review of earlier work on Constraints and Route Selection.
- A walkover survey of the entire route and adjacent areas, to 500 m beyond the CPO line for the proposed road development, was undertaken by a geologist. Additionally, a hydrogeological walkover was undertaken to take account of impacts which could arise locally and at a greater distance away (e.g. source protection areas associated with significant groundwater abstractions or groundwater dependent ecosystems).
- A well survey of all affected landowners along, and in close proximity to the proposed road development was undertaken to assess any impact on local domestic wells. Wells closest to sections of cut and features of interest were dipped during the survey. Monitoring of the water level measurements in 10 Stand Pipes installed following the site investigation programme is on-going. Any domestic wells that were identified by the well survey were dipped.
- Groundwater well database of the Geological Survey of Ireland (GSI).

The preliminary site investigation for the proposed road development was completed in June 2013. The scope of this investigation which is relevant to hydrogeology includes:

- Shell and auger boreholes.
- Rotary core boreholes.
- Trial pits.
- Groundwater level monitoring.
- Laboratory chemical testing on soil and groundwater samples.

Site investigation information available includes:

- Groundwater level monitoring conducted on 18/06/2013, 04/07/2013 and 13/11/2013.

The groundwater level monitoring of standpipes installed along the route is on-going, see 16.3.4 for details. All the information available at the time of writing has been used to describe and evaluate the hydrogeological environment in the vicinity of the proposed road development. The likely impacts of the proposed road development on this environment have been identified and a mitigation strategy proposed.

The assessment of the likely impacts of the proposed road development on hydrogeology, and the groundwater flow regime takes the following specific topics into consideration:

- Any high yielding springs and wells used for water supply and their surrounding Source Protection Area (SPA).
- Any natural hydrogeological features of importance (including large springs or groundwater fed Special Area of Conservation (SAC), Natural Heritage Area (NHA), Special Protection Areas (SPA) wetland sites. These features are collectively termed as Groundwater Dependant Terrestrial Ecosystems (GWDE). This also included candidate SACs and proposed NHAs.
- The dominant hydrogeological characteristics (aquifer classification) of the underlying strata.

16.2.5 Impact Assessment Methodology

The rating of the potential impact of the proposed road development on the hydrogeological environment has been assessed by classifying the importance of the relevant attributes and quantifying the likely magnitude of any impact on these attributes. The NRA guidance document 'Environmental Impact Assessment of National Road Schemes – Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes, NRA 2009' has been used to provide the criteria for the impact assessment.

The criteria for rating the importance of hydrogeological features within the study area are outlined in Table 16.1 whilst the criteria for rating the magnitude of impacts are outlined in Table 16.2. The significance rating of potential environmental impacts on the hydrogeological environment is based on the matrix presented in Table 16.3. This takes account of both the importance and the magnitude of the potential environmental impacts of the proposed road development on an attribute.

The impact assessment methodology is in accordance with the guidance outlined in Section 5.4 of the NRA Guidance (2009). Impact categories, impact duration and type/nature of impacts have been taken into account in this assessment as per those guidelines.

These impact ratings are also in accordance with impact assessment criteria provided in the EPA publication Guidelines on the Information to be contained in Environmental Impact Statements (EPA, 2002). The criteria apply to potential impacts during both the construction and operational phases.

The magnitude of each impact was considered from negligible to large adverse. Negligible impacts are impacts that result in an impact on an attribute but of insufficient magnitude to affect either use or integrity. A large adverse impact results in loss of attribute and/or quality and integrity of an attribute.

The significance of each impact was considered as having either an Imperceptible, Slight, Moderate, Significant, Severe or Profound impact.

The duration of each impact was considered to be either temporary, short-term, medium term, long-term or a permanent impact. Temporary impacts are considered to be those which are construction related and last less than one year. Short term impacts were seen as impacts lasting one to seven years. Medium-term impacts are impacts lasting seven to fifteen years. Long-term impacts are impacts lasting fifteen to sixty years and permanent impacts are impacts lasting over sixty years.

Table 16.1: Criteria for Rating Site Attributes - Estimation of Importance of Hydrogeology Attributes (NRA, 2009)

Importance	Criteria	Typical Example
Extremely High	Attribute has a high quality or value on an international scale	Groundwater supports river, wetland or surface water body ecosystem protected by EU legislation e.g. SAC or SPA status
Very High	Attribute has a high quality or value on a regional or national scale	Regionally important aquifer with multiple well fields. Groundwater supports river, wetland or surface water body ecosystem protected by national legislation – NHA status Regionally important potable water source supplying >2500 homes Inner source protection area for regionally important water source
High	Attribute has a high quality or value on a local scale	Regionally Important Aquifer Groundwater provides large proportion of baseflow to local rivers Locally important potable water source supplying >1000 homes Outer source protection area for regionally important water source Inner source protection area for locally important water source
Medium	Attribute has a medium quality or value on a local scale	Locally Important Aquifer Potable water source supplying >50 homes Outer source protection area for locally important water source
Low	Attribute has a low quality or value on a local scale	Poor Bedrock Aquifer Potable water source supplying <50 homes

Table 16.2: Criteria for rating impact significance at EIA stage – Estimation of magnitude of impact on hydrogeology attributes (NRA, 2009)

Magnitude of Impact	Criteria	Typical Examples[1]
Large Adverse	Results in loss of attribute and /or quality and integrity of attribute	Removal of large proportion of aquifer Changes to aquifer or unsaturated zone resulting in extensive change to existing water supply springs and wells, river baseflow or ecosystems Potential high risk of pollution to groundwater from routine run-off[2] Calculated risk of serious pollution incident >2% annually[3]
Moderate Adverse	Results in impact on integrity of attribute or loss of part of attribute	Removal of moderate proportion of aquifer Changes to aquifer or unsaturated zone resulting in moderate change to existing water supply springs and wells, river baseflow or ecosystems Potential medium risk of pollution to groundwater from routine run-off[2] Calculated risk of serious pollution incident >1% annually[3]
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute	Removal of small proportion of aquifer Changes to aquifer or unsaturated zone resulting in minor change to water supply springs and wells, river baseflow or ecosystems Potential low risk of pollution to groundwater from routine run-off[2] Calculated risk of serious pollution incident >0.5% annually[3]
Negligible	Results in an impact on attribute but of insufficient magnitude to affect either use or integrity	Calculated risk of serious pollution incident <0.5% annually[3]

[1] Additional Examples are provided in the NRA Guidance Document
[2] refer to Method C, Annex 1, Annex 1 of HA”16/06
[3] refer to Method D, Appendix B3/Annex 1of HA216/06

Table 16.3: Rating of Significant Environmental Impacts at EIA Stage (NRA, 2009)

		Magnitude of Impact			
		Negligible	**Small**	**Moderate**	**Large**
Importance of Attribute	**Extremely High**	Imperceptible	Significant	Profound	Profound
	Very High	Imperceptible	Significant/ Moderate	Profound/ Significant	Profound
	High	Imperceptible	Moderate/ Slight	Significant/ Moderate	Profound/ Significant
	Medium	Imperceptible	Slight	Moderate	Significant
	Low	Imperceptible	Imperceptible	Slight	Slight/Moderate

Following the assessment of impacts, specific mitigation measures have been developed in the course of the Design phase to avoid, reduce and remedy any negative impacts on the hydrogeological environment. These are described in Section 16.5 below. Residual impacts which are the final or designed impacts which result after mitigation measures have been fully established and are described in Section 16.6 below. The length of time it takes for each mitigation measure to take effect varies but they are designed to ensure that predicted impacts are minimal.

16.3 Receiving Environment

16.3.1 Introduction

The following sections provide an overview of the regional hydrogeological environment. Further detail is provided within the study area (which extends 500m away from the proposed CPO line). Aquifer classification, vulnerability and hydrogeological features of importance such as public groundwater abstractions, karst features and Groundwater Dependent Ecosystems are documented. Aquifer classification, aquifer vulnerability and hydrogeological features discussed and listed below are shown in **Figures 16.1 V3, 16.2 V3** and **16.3 V3** respectively.

16.3.2 Regional Overview of Hydrogeology

The proposed M7 Osberstown Interchange and R407 Sallins Bypass Scheme involves the construction of a grade separated interchange on the M7, a regional road comprising the R407 Sallins Bypass and associated link roads and side roads. The interchange will connect to the R407 Sallins Bypass to the north and the existing local and regional road network to the south. The bypass will be approximately 3.6 km in length.

The 1:100,000 GSI bedrock geology map of Kildare – Wicklow (16) shows the area to overlie Lower Carboniferous limestones. There are two Dinantian limestone aquifers crossed by the proposed road development. More specifically the route is shown to overlie the Rickardstown Formation; a cherty, often dolomitised limestone which is classified as being a Dinantian Pure Bedded Limestone. This is a Regionally Important aquifer. The Waulsortian Limestone is a massive Dinantian Unbedded fine grained Limestone classified as a Locally Important aquifer. On a regional scale, the site is enclosed to the north and south by two northwest – southeast trending faults with Lower Carboniferous limestones occurring throughout. To the east beyond the Waulsortian the Ballysteen limestones are encountered. The Ballysteen are a fossiliferous dark grey muddy limestone.

Much of the area is low-lying and the bedrock is overlain by Quaternary sediments of variable thickness and lithology. Permeabilities of these strata are a function of the lithology, extent of dolomitization, faulting/fracturing and degree of karstification (GSI, 1994).

Groundwater Vulnerability maps highlight the ease with which groundwater may be contaminated in a certain area, based on the intrinsic geological and hydrogeological properties at that point.

According to the GSI Aquifer Vulnerability map the area underlying the proposed scheme is classified as being of Moderate vulnerability (see **Figure 16.2 V3**).

There are no major groundwater abstractions within or adjacent to the study area. The two closest Public Water Schemes are Tullylost, Rathangan which is circa 20 km from the study area and the Scheme at Ballykelly, Monasterevin is circa 25 km away. According to the GSI Source Protection Area map, there are no Protection Areas in the vicinity of the study area. Source Protection Plans are created to define the groundwater catchment for large public water supplies and state appropriate land use practices within the catchment. The Source Protection Areas include Inner (SI) and Outer (SO) Protection areas in order to give an indication of the likelihood of contamination from activities in the area reaching an abstraction point. However, as stated above, there are no Source Protection Areas in the vicinity of the study area.

The primary surface water features in the wider area are the River Liffey which is crossed by the proposed scheme at two locations which flows in a north easterly direction towards Dublin and the Naas branch of the Grand Canal which flows to the north. There are small drainage ditches and water courses in the area which act as tributaries for the Liffey. The Curragh Aquifer is known to be a feeder for the Grand Canal and to support the baseflow to many of the rivers and streams in the wider area. The regional groundwater flow direction in the wider area is known to be to the north-west towards the Liffey and the groundwater is unconfined (EPA, 2006).

Flanking the south east of the M7 Osberstown Interchange, there is a man-made pond which was created so that surface water runoff from the Millennium Park could be diverted into it prior to being discharged to the River Liffey. It is likely that the levels in the pond represent the piezometric head of the groundwater table. The nearest rain gauge to the site is located at Dublin Airport where the thirty year average annual rainfall from 1981-2010 is recorded as 758 mm/yr.

In lowland areas in the greater area, the water table is generally within 10 m of the surface with an annual fluctuation of less than 5 m except for the more elevated parts of the limestone and sand and gravel aquifers (GSI,1994). In the immediate study area groundwater monitoring wells show groundwater levels at approximately 0.5m to 4m below ground surface level. The proposed road development is occurring in low lying areas only. A detailed study of the nearby Curragh aquifer was conducted in 2002 and seasonal variations in water level of 1.25 to 2.5 m were observed from well hydrographs (Kelly and Fitzsimons, 2002).

The land use in the surrounding area is predominantly agricultural indicating that there is the potential for a high level of recharge to the underlying aquifers. The limiting factor for the recharge will be the low permeability of the cohesive glacial soils above the aquifer. There are several roads in the vicinity of the study area, and these represent areas where the recharge may vary due to hard-standing areas and drainage systems associated with the roads.

The description of the hydrogeological environment along with the proposed road development uses the GSI aquifer classification system. The system contains three main classifications which are Regionally Important Aquifers (RI), Locally Important Aquifers (LI) and Poor Aquifers (P).

Each of these types of aquifer has been further subdivided and has a specific range of criteria such as transmissivity, productivity, yield etc. associated with it. The full list of aquifer classifications is as follows.

16.3.2.1 Regionally Important Aquifers (R)

Regionally Important (R) Aquifers can be subdivided into:

- Karstified bedrock dominated by diffuse flow (R_{kd}).
- Karstified bedrock dominated by conduit flow (R_{kc}).
- Fissured bedrock (R_f).
- Extensive sand and gravel (R_g).

Regionally important Aquifers are important groundwater resources. A Regionally Important bedrock aquifer is capable of supplying regionally important abstractions (e.g. large public water supplies), or ‘excellent’ yields (>400 m^3/d). The continuous aquifer unit generally has an area of >25 km^2. Groundwater flow predominantly occurs through fractures, fissures and joints.

16.3.2.2 Locally Important Aquifers (L)

Locally Important (L) Aquifers can be subdivided into:

- Sand and Gravel (Lg).
- Bedrock which is Generally Moderately Productive (Lm).
- Bedrock which is Moderately Productive only in Local Zones (LI).
- Locally Important karstified bedrock (Lk).

16.3.2.3 Poor Aquifers (P)

Poor (P) Aquifers can be subdivided into:

- Bedrock which is generally Unproductive except for Local Zones (PI).
- Bedrock which is Generally Unproductive (Pu).

Poor Aquifers generally provide little groundwater for water supply or for baseflow to surface water bodies. However they are sometimes used for local supplies to individual houses/farms.

The classification of an aquifer is a reasonable indication of the regional scale properties of the aquifer (i.e. transmissivity, permeability and storage). Irish aquifers are highly variable in nature due to the fact that permeability is derived from secondary features (faults, fissures and fractures) rather than intrinsic permeability of the rock. Therefore, although the aquifer classification may indicate the bedrock is productive, detailed site specific information is required to confirm this is the case along the proposed road development.

The GSI National Draft Bedrock Aquifer Map states that there are two bedrock aquifer types underlying the study area. These are a Regionally Important bedrock aquifer (RKd), which is karstified in areas with diffuse flow and good development potential (Rkd), and a Locally Important Aquifer which is moderately productive in local zones only (LI). There are no RKc, Rf or R aquifers, nor are there any Poor (P) aquifers within the area.

The GSI National Draft Gravel Aquifer Map states that the shallow aquifer underlying the majority of Kildare is the Curragh Aquifer (also known as the North Kildare Gravel Aquifer). On the GSI maps the Curragh Aquifer is indicated to occur approximately 2.5 km to the southwest of the most south westerly section of the proposed scheme. This is one of the most extensive sand and gravel deposits in Ireland and is classed as a Regionally Important sand and gravel aquifer (Rg). It is composed of glacial outwash plain deposits with till horizons in places (EPA, 2006). The aquifer is roughly ovoid in shape and its extent is defined as those areas of the aquifer where the deposit is more than 5 m thick.

Outside of the defined extents of this aquifer, there are many parts of Kildare which are classified as being Locally Important or others that are currently Not Mapped.

16.3.3 Hydrogeology within the Study Area

As outlined above, the proposed road development is underlain by two different bedrock aquifer types as identified in the GSI National Draft Bedrock Aquifer Map as follows:

- Regionally Important bedrock aquifer (RKd), the Rickardstown Formation, which is karstified in areas with diffuse flow and good development potential (Rkd)
- Locally Important Aquifer which is moderately productive in local zones only (LI), the Waulsortian limestone.

Aquifer classification for the bedrock underlying the study area is shown in **Figure 16.1 V3** and Table 16.4.

Table 16.5 presents details of the depth of cuts (i.e. difference between existing ground level and finished road level) along the proposed scheme and Table 16.6 presents details of the cuts for structures along the proposed scheme.

Table 16.4: Aquifer Characterisation

Aquifer Classification	**Chainage**	
	From	**To**
Regionally Important	Ch. 0+000	Ch. 2+050
	Ch. 3+300	Ch. 3+669
Locally Important	Ch. 2+050	Ch. 3+300

Table 16.5: Aquifer Characterisation in cut sections

Cut	Chainage	Aquifer Type	Length	Max Depth	Approx. Average Depth
1	Ch. 0+360 – Ch. 0+520	Regionally Important	160 m	1.17 m	0.37 m
2	Ch. 0+550 – Ch. 0+640	Regionally Important	90 m	1.1 m	0.51 m
3	Ch. 0+740 – Ch. 0+950	Regionally Important	210 m	1.45 m	0.67 m
4	Ch. 1+060 – Ch. 1+340	Regionally Important	280 m	3.1 m	1.22 m
5	Ch. 3+550 – Ch. 3+640	Regionally Important	90 m	1.17 m	0.64 m

Table 16.6: Aquifer Characterisation in cut sections for structures

Bridge Name	Chainage	Aquifer Type	Structure Type	Max Depth
S1- Interchange Osberstown Overbridge	Ch. 0+000	Regionally Important	Two-span. Bank seat abutment on piled foundations. Central Pier mono-piles	1.4 m to underside of pile cap at abutments
S2-Osberstown Road Overbridge	Ch. 1+050	Regionally Important	Single span Spread footing	2.7 m
S3-Sallins Bypass Railway Bridge	Ch. 1+257	Regionally Important	Twin cell jacked Box with secant pile wingwalls to the north	3.1 m
S4-Grand Canal Underbridge	Ch. 1+577	Regionally Important	Single span Spread footing	2.25 m
S5-River Liffey Underbridge No. 1	Ch. 1+980	Locally Important	Two-span Bank seat abutment on piled foundations. Central Pier mono-piles	2.1m to underside of pile cap at abutments
S6-River Liffey Underbridge No. 2	Ch. 3+050	Locally Important	Two-span Bank seat abutment on piled foundations. Central Piers mono-piles	2.2m to underside of pile cap at abutments

The shallow strata beneath the proposed scheme are classified as being Not Mapped on the current GSI National Draft Gravel Aquifer Map. The Curragh Aquifer is delineated by the GSI as commencing approximately 2.5 km south west of the study area.

There are two relatively thick sand and gravel deposits located to the northeast and northwest of the site. These deposits are no longer classified as locally important groundwater bodies but were previously known as the Digby Bridge groundwater body and the Sallins groundwater body. Their delineation was determined by the presence of gravel sequences greater than 10 m thick. As mapped they did not extend into the area of study. The borehole logs along the proposed scheme confirm that gravel deposits are generally less than 10 m thick.

Twenty seven boreholes were drilled and twenty four trial pits were dug along the proposed scheme as part of the preliminary investigation as indicated on **Figure 15.3 V3**. Twelve of the percussion boreholes were rotary cored into bedrock and developed as monitoring wells. Gravel deposits were encountered within 4m of surface in all boreholes except BH17A which bottomed in clay at 4.2 m below ground level (m BGL) and BH18A where clay deposits extended to 5.3 m BGL. A number of the shallower percussion boreholes and many of the trial pits did not extend as far as the sand and gravel sequences. TP09 encountered a thin sand layer from 2.5 to 2.7 m BGL with clay to 3.9 m BGL.

We see that in the twelve fully developed boreholes, rotary cored to bedrock, the average thickness of the sand and gravel deposits was 8.7m varying from a minimum thickness of 5 m to a maximum of 14.7 m. These gravel deposits were generally described as medium dense grey silty sandy fine to coarse gravels with variable boulder content. In boreholes BH11 and BH13 two distinct gravel layers were indicated the lower of which contained lenses of boulder clay.

The surficial strata play an important role both in terms of the groundwater flow regime and in terms of the degree of protection they offer. Their hydrogeological significance is variable and is largely a function of their permeability, thickness and extent. Low permeability material (clays and tills) protects underlying bedrock aquifers, restricts recharge and where sufficiently thick may confine them. High permeability materials (sands and gravels) allow a high level of recharge, provides additional storage to the underlying bedrock aquifers and where sufficiently thick can be an aquifer in its own right (GSI, 1994).

Groundwater overlain by permeable subsoils with a thickness of less than 3m, are considered as being of Extreme vulnerability by the GSI. Much of the area along the proposed scheme is well protected by thick impermeable deposits. These deposits however do thin to less than 3 m in specific areas as outlined below.

- (Subsoils <3 m): In the area adjacent to the M7 Osberstown Interchange the gravels lie close to surface with either a thin, sand or sandy, clay surface layer topped with topsoil or made ground. Trial pits and boreholes in the area of the proposed interchange indicate that there is less than 3 m of impermeable cover. This area is treated in this assessment as of Extreme vulnerability.
- (Subsoils>3 m): By Ch. 0+400 impermeable deposits have thickened affording protection to underlying groundwater, clay and silt deposits extend to 4.3m BGL by TP13. Thick deposits (>3 m) are evidenced as far as TP09 at Ch. 1+420 beyond which deposits again thin as the canal is approached.
- (Subsoils <3 m): In the area immediately adjacent to the canal, at BH09, gravels extend to surface topsoil.
- (Subsoils>3 m): By BH10 at Ch. 1+570 there is thick silt cover. The area between the canal and the southern Liffey crossing, have thick clay deposits, greater than 3 m, as far as BH13 at Ch. 1+930 just south of the Liffey crossing.
- (Subsoils <3 m): In the area immediately adjacent to the Liffey gravels are close to surface with little protection, the requisite 3 m cover has not been proven from the Liffey north until confirmed at Ch. 2+400 at TP06.

- (Subsoils>3 m): By TP06 at Ch. 2+400 the impermeable cover has thickened to greater than 3 m and this is confirmed as far as BH18a at Ch. 2+980
- (Subsoils <3 m): Beyond Ch. 2+980 to the Clane Road Roundabout deposits of less than 3 m were encountered.
- (Subsoils <3 m): R407 Clane Road Ch. 0+000 – Ch. 0+150 the requisite 3 m cover has not been proven.
- (Subsoils <3 m): Along the Sallins Link Road beyond BH16 the requisite 3m cover has not been proven.

For the purpose of this report a conservative approach is adopted. The length of the area considered as having thin cover, heightened vulnerability, is extended until overburden thickness of greater than 3m is proven from site investigation data. The areas designated as having potentially less than 3 m cover are as follows: (i) Ch. 0+000 - Ch. 0+400; (ii) either side of the Grand Canal; (iii) either side of the River Liffey; (iv) Ch. 2+980 – to Clane Road Roundabout; (v) R407 Clane Road Ch. 0+000 – Ch. 0+150; (vi) Sallins Link Road.

While the groundwater regionally has been classified by the GSI as of Moderate vulnerability, groundwater underlying the above listed areas where gravels sequences are not protected by 3 m cover are treated in this assessment as being of Extreme vulnerability.

16.3.4 Hydraulic Conditions

The bedrock aquifer beneath the study area is predominantly unconfined in the greater area but is confined along sections underlying the proposed scheme.

An aquifer is unconfined when it does not have an impermeable layer above it and the water table can vary with surface water contributions.

In bedrock aquifers of this type the water table is generally a subdued reflection of the topography. A confined aquifer is one whose natural water level would lie above the top of the aquifer except there is a low permeability material above it which prevents it from moving upwards. In this case the groundwater is contained within the aquifer except for in areas where the overlying low permeability material is removed. Where aquifers are confined this will primarily be by thick low permeability deposits.

Groundwater level monitoring is completed by the EPA throughout Ireland. There are no EPA monitoring points located within 500m of the proposed road development. In addition, there are a number of EPA monitoring sites on the River Liffey as outlined in detail in Chapter 17 - *Hydrology*.

A programme of groundwater level monitoring began following the completion of groundwater monitoring installations. Monitoring results were available for June, July, 2013 and November 2013 at the time of writing this chapter. Further monitoring is programmed for early 2014. The data available shows the water table to be within 5m of the ground level across the site.

Groundwater levels are presented in Table 16.7, with borehole locations indicated in **Figure 15.3 V3**.

Table 16.7: Groundwater Level Monitoring Data

Borehole No.	Date	Depth to Water (m)	Water level (mOD)
Reading 1 – June 18th, 2013			
RC01	18/06/2013	1.80	74.89
RC04	18/06/2013	1.93	74.14
RC07	18/06/2013	1.16	74.65
RC09	18/06/2013	1.31	74.02
RC10	18/06/2013	0.91	74.17
RC11	18/06/2013	1.32	72.97
RC13	18/06/2013	2.68	68.99
RC14	18/06/2013	2.73	67.69
RC19	18/06/2013	3.80	65.90
RC20	18/06/2013	3.64	65.41
Reading 2 – July 4th, 2013			
RC01	04/07/2013	1.98	74.71
RC04	04/07/2013	2.02	74.05
RC07	04/07/2013	1.24	74.57
RC09	04/07/2013	1.3	74.03
RC10	04/07/2013	1.36	73.72
RC11	04/07/2013	Dry - Blocked at 2.0m.	
RC13	04/07/2013	2.89	68.78
RC14	04/07/2013	3.01	67.41
RC19	04/07/2013	3.87	65.83
RC20	04/07/2013	3.54	65.51
Reading 3 – November 13th, 2013			
RC01	13/11/2013	1.55	75.14
RC04	13/11/2013	Damaged	Damaged
RC07	13/11/2013	0.75	75.06
RC09	13/11/2013	0.83	74.5
RC10	13/11/2013	0.66	74.42
RC11	13/11/2013	Blocked	Blocked
RC13	13/11/2013	1.12	70.55
RC14	13/11/2013	1.92	68.5
RC19	13/11/2013	2.74	66.96
RC20	13/11/2013	1.69	67.36

Groundwater levels will vary during the year and the level of variability will be largely dependent on the specific yield (i.e. storage) of the aquifer and the recharge. The programme of groundwater level monitoring will allow the variability of the groundwater levels to be quantified in the future. The recharge varies greatly throughout the area due to variations in the effective rainfall and the thickness and permeability of the subsoils over the aquifers.

Site investigations undertaken for nearby Millennium Park in 1999 showed that, in the vicinity of the proposed scheme, piezometric groundwater level is typically approximately 1m BGL.

The groundwater levels available at time of writing are two sets of summer levels readings and one winter level data set and as such no assumptions can be made about fluctuations in water level from site investigation data collected to date. However, a study of the nearby Regionally Important unconfined Curragh Aquifer was undertaken by Kelly and Fitzsimons in 2002. This study showed seasonal fluctuation in water level of 1.25 m to 2.5 m. Any such seasonal variation would be dampened in a confined system.

The monitoring boreholes installed for the site investigation showed the aquifer as unconfined beneath the proposed interchange itself where clay was absent from many of the trial pit and borehole logs. The thick gravel layer is overlain by thin sand or silty sand deposits, made ground or topsoil, with occasional clay lenses. However, as you move east we see that the aquifer is locally confined by clay deposits. These clay layers disappear under the Grand Canal and River Liffey and extend to over 5 m away from the watercourses.

The Quaternary gravel deposits in this area of Kildare are not classified as a groundwater body in their own right by the GSI, however, it is possible that the sand and gravel deposits beneath the study area are hydraulically connected to the regionally important extensive sand and gravel Curragh aquifer mapped 2.5 km to the southwest or other local sand and gravel aquifers.

In terms of vertical connectivity it is important to note that the gravel deposits that directly overlie the bedrock aquifer vary from coarse to medium dense with bands of boulder clay. Where the gravels are coarse, and free of boulder clay, there is direct vertical connectivity with the underlying bedrock aquifer. As such groundwater beneath the study area is treated in this report as a Regionally Important Aquifer (RKd) where the gravel deposits over lie the Rikardstown Formation and Locally Important where they overlie the Waulsortian Limestone.

16.3.5 Groundwater Vulnerability

The vulnerability of the groundwater body is the term used to describe the ease with which the groundwater in the area can be contaminated by human activities. The vulnerability is determined by many factors including the travel time, the quantity of contaminants and the capacity of the deposits overlying the bedrock to attenuate contaminants. These factors in turn are based on the thickness and permeability of the overburden e.g. groundwater in bedrock which is exposed at the surface. The criteria for determining groundwater vulnerability, as described by the GSI, are shown in Table 16.8 below.

Table 16.8: GSI Groundwater Vulnerability Mapping Guidelines (DoELG 1999)

Vulnerability Rating	Hydrogeological Conditions				
	Subsoil Permeability (Type) and Thickness			Unsaturated Zone	Karst Feature
	High permeability (sand/gravel)	Moderate permeability (e.g. Sandy subsoil)	Low permeability (e.g. Clayey subsoil, clay, 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

Notes: (1) N/A = not applicable.

(2) Precise permeability values cannot be given at present.

(3) Release point of contaminants is assumed to be 1-2m below ground surface.

It should be noted that full vulnerability mapping of all vulnerability categories (Extreme – X (Rock near surface or karst), Extreme – E (<3m of subsoils), High (H), Moderate (M), and Low (L)) is available in the Kildare area. Groundwater vulnerability within the study area is classed as Moderate as shown in **Figure 16.2 V3.**

16.3.6 Hydrogeological Features

16.3.6.1 Water Supplies

Water Supplies refer to any large springs, groundwater abstractions for local authorities, commercial/industrial, holy wells or Group Water Schemes. Source Protection Plans are created to define the groundwater catchment for large public water supplies and state appropriate land use practices within the catchment. The Source Protection Areas include Inner (SI) and Outer (SO) Protection areas. In consultation with Kildare County Council the two closest Public Water Schemes are approximately 20 km- 25 km from the study area. Both of these public supply schemes are operated by Veolia. The nearest Tullylost, Rathangan is circa 20 km from the study area and the Scheme at Ballykelly, Monasterevin is circa 25 km away. Both well fields have Inner and Outer Protection Zones.

The proposed road development does not intersect any groundwater source protection zones (SI or SO).

The GSI database and the well survey identified a number of private wells within 500 m that are in use, some of which are within100 m of the route. The site walkover also identified a spring.

16.3.6.2 Karstification and Karst Features

Karstic areas are those where the rock present is relatively soluble by water over time in comparison to other rock types. Distinctive karstic features are formed along preferential groundwater flow paths such as fractures, fissures or joints. Karst features include caves, dolines, turloughs, swallow holes and large springs. The Geological Survey of Ireland (GSI) have undertaken mapping of karst features.

Karstic aquifers are amongst the most productive aquifers in Ireland. In these aquifers groundwater flow is dominated by fissure flow, leading to potentially high yields, higher groundwater velocities, greater vulnerability to contamination and the potential for point recharge from dolines and swallow holes. Features such as springs are common in karst areas and provide a ready source of groundwater on a local scale. The underlying bedrock aquifer the Rickardstown Formation is a karstic, cherty, dolomotised limestone. The karst nature of the limestone may provide locally poor foundation conditions for the road particularly at localised karst features.

There was no evidence of voids encountered during the site investigations. This list of features presented by the GSI is not exclusive and other sources of information on potential karst features include local landowners and OS maps. The GSI map of karstic features showed no karstic features in the study area though a hydrogeological site walkover and consultation with landowners indicated the presence of springs and seepage fronts.

There were no large springs identified within the study area. There is a spring that feeds a drain used by cattle and has flow year round. This spring was located during the site walkover west of Ch. 2+550.

Groundwater seepage from the extremities of the gravels at lower elevations was observed along the Grand Canal, the River Liffey and at low elevations. Springs and seepages observed in the site walkover were interpreted to be seepage from the gravel deposits, as is common in this area, rather than deep karstic springs.

16.3.6.3 Groundwater Dependant Ecosystems & Natura 2000 Sites

A full review of ecological features and designated ecological heritage areas in the study area are discussed in detail in Chapter 14 – *Ecology*. There are no Natura 2000 sites in the vicinity of the proposed works. The major Groundwater Dependent Ecosystem (GDE) is the River Liffey which supports species protected under the Habitats Directive. The Grand Canal which is of great ecological importance and is designated as a pNHA, is not groundwater fed in the study area though it is fed from Pollardstown Fen, circa 14 km to the southwest. The only other GDEs identified are the Osberstown Pond, a eutrophic artificial attenuation pond and the Osberstown stream.

16.3.6.4 Legacy Landfills

Consultation has confirmed that there are no legacy landfills in the study area.

16.3.6.5 Waste Permitted Site

Large-scale industrial and agriculture activities have been licensed by the EPA since 1994. Originally this licencing system was known as Integrated Pollution Control (IPC), but was amended by the Protection of the Environment Act, 2003 and is currently referred to as the Integrated Pollution Prevention Control (IPPC) licence. Consultation has confirmed that there are no waste permitted sites in the study area. There are no waste licenced facilities in the study area.

There is one IPPC licenced facility, Boran Plastic Packaging Limited (P0819-01), close to the study area. This facility is located at the end of the proposed tie-in to the existing M7 Motorway, approximately 250 m southeast of the existing M7 bridge which crosses over Canal Road.

The principal class of activity for this IPPC licence is 'Surface Coatings' which is described as the manufacture or use of coating materials in processes with a capacity to make or use at least 10 tonnes per year of organic solvents, and powder coating manufacture with a capacity to produce at least 50 tonnes per year.

16.3.7 Site Importance Rating of Hydrogeological Features

The Importance rating of the hydrogeological characteristics and features within the study area are based on the criteria described in Table 16.3 and is listed below in Table 16.9.

Table 16.9: Ranking of Importance of Hydrogeological features

Importance	Feature	Chainage	Basis
Aquifer Type and hydraulic conditions			
High	Regionally Important Aquifer	Ch. 0+000 - Ch. 2+050 Ch. 3+300 – Ch. 3+669	Regionally Important Aquifer
Medium	Locally Important Aquifer	Ch. 2+050 – Ch. 3+300	Locally Important Aquifer
Private wells and springs			
Low	Domestic and agricultural wells	Within 500m of CPO line	Agricultural supply and/or Domestic supply
Groundwater dependent Ecosystems			
High	River Liffey	Ch. 1+960 – Ch. 2+000 Ch. 3+030 – Ch. 3+060	Groundwater supports river of national importance
Very High	Grand Canal	Ch. 1+560- Ch. 1+600	Groundwater supports NHA
Low	Osberstown Pond	Osberstown Interchange	Man-made
Low	Osberstown Stream	Osberstown Interchange	Minor stream
Karst			
Extremely High	Karst features, if present, at time of writing none identified		Karst feature- extreme groundwater vulnerability

16.4 Predicted Impacts on Hydrogeology

16.4.1 Do Nothing Scenario – Impact Assessment

In the absence of the proposed road development traffic density will continue to increase on the existing roads. This increased traffic may result in additional accidental spillages along the route due to vehicle crashes.

16.4.2 Do Something Scenario – Impact Assessment

An analysis of the predicted impacts of the proposed road development on hydrogeology during the construction and operation are presented in the following sections.

The assessment was considered under the following headings:

- Aquifer Type and Hydraulic Conditions (16.4.2.1).
- Water Quality (16.4.2.2).
- Water Supply (16.4.2.3).
- Karst Features (16.4.2.4).
- Groundwater Dependent Ecosystems (16.4.2.5).

The resulting impact assessment for construction and operation phases is outlined below and are summarised in Tables 16.12, 16.13 respectively. The impact assessments outlined in this section are pre-mitigation impacts. Residual impacts are outlined in Section 16.6.

16.4.2.1 Potential Impacts on Aquifer Type and Hydraulic Conditions

The importance of each aquifer type is outlined in Table 16.1. The importance of the aquifer, as defined by the NRA Guidelines, is based on three main criteria: the aquifer classification, whether the aquifer supports a designated groundwater dependant ecosystem and the quantity of groundwater abstracted for human consumption.

The impacts on aquifers with respect to groundwater resources are now considered. Water quality will be assessed in Section 16.4.2.2. The impacts on the resources are considered both during the construction phase and during the operational phase of work. A road development can impact an aquifer by removing storage through cuts, alterations to natural drainage patterns and by reducing recharge through replacing permeable surface with hard-standing.

Potential Impact on Groundwater Resources – Construction Phase

During the construction phase temporary dewatering will be required in some localised areas. Local dewatering will be required during construction for a range of activities that may include the installation of foundations for bridges and culverts and the construction of some pipelines crossing beneath the motorways or deep manholes. More extensive dewatering will be required in areas where there will be a cut below the water table. The significance of the impact from dewatering will be defined by the depth and length of the cut section below the water table and the aquifer characteristics. Applying the cautionary principle the groundwater underlying the proposed scheme will be treated in this Environmental Impact Statement as a Regionally Important aquifer (RKd) due to the absence of any continuous aquitard (i.e. a confining low permeability layer that retards but does not prevent the flow of water to or from an adjacent aquifer) between the gravels and the bedrock aquifer where the route is underlain by the Rickardstown Formation.

According to the NRA Criteria for rating Importance of Site Attribute, Table 16.1, this Regionally Important aquifer which feeds a pNHA (the Grand Canal) is rated as of Very High importance. The aquifer underlying the section of the proposed scheme within the Waulsortian Formation is ranked as of High Importance.

The NRA Guidelines define the impact magnitude in relation to the proportion of the aquifer removed and the aquifer type. A small impact relates to a small portion of the aquifer being removed. The underlying aquifer is extensive in comparison to the area of cut for the proposed road development.

If there are significant sections of cut in productive aquifers which are below the water table the dewatering can alter the groundwater flow regime and can potentially impact adjacent groundwater water supplies, surface water features and groundwater dependant ecosystems, springs and domestic wells. Given the distance of greater than 20 km to the nearest public supply and the fact that there is only a very small section of shallow cut on this scheme, the public water supply would not be affected by any dewatering.

There is the potential for any mapped or unmapped private wells located directly adjacent to a cut where dewatering takes place to be temporarily affected by the dewatering. Some wells have been identified as within the potential area of influence but this will depend strictly on the radius of influence of the actual drawdown during construction dewatering. This potential impact on private wells is examined below in terms of Water supply and Water Quality. Groundwater baseflow to the Osberstown Pond could be temporarily slightly impacted upon, though any impact would be negligible. The proposed road development crosses the River Liffey at two separate locations and also crosses the Grand Canal which is a proposed Natural Heritage Area. The baseflow to the Liffey or the Grand Canal will not be discernibly impacted by any dewatering during construction.

The majority of the proposed road development will see no cut at all as it will be primarily constructed on fill. The small number of cuts along the proposed scheme, are shallow and relatively short in length. Most importantly none of the cuts intercept the bedrock. The shallow depth of the cut coupled with the fact that the bedrock aquifer is overlain by considerable thickness of overburden negates any concerns of dewatering from the bedrock aquifer. Any potential impact from the cuts on groundwater flow regimes, where local shallow dewatering is required during construction, drawdown will be within the Quaternary deposits. The radius of influence from the cuts that are proposed for the proposed road development are unlikely to be extensive. For the purpose of assessing impacts from the cuts, in terms of the potential for ingress of contaminants, the units are considered to be hydraulically connected.

The quantitative status of Groundwater Bodies is considered under the Water Framework Directive (WFD).

The Irish Working Group on Groundwater has provided a risk assessment methodology to determine the potential impact of abstraction on groundwater bodies (IWGG 2005). The method is based on comparing the recharge to the groundwater body to the sum of groundwater abstractions. The potential impact categories are defined by the percentage of recharge abstracted and are as follows:

- Negligible Potential Impact = < 2% of recharge is abstracted.
- Small Potential Impact = 2 – 10%.
- Moderate Potential Impact = 10 – 20%.
- Large Potential Impact = >20%.

These potential impact classifications are below used where a quantitative assessment of dewatering is completed.

The cuts in the proposed scheme are so shallow in nature that the volumes of groundwater involved in any dewatering are minimal. The location and depth of each cut are presented in Table 16.5. The deepest and longest cut is described in detail below. Cut 4 at 280 m long (Ch. 1+060 – Ch. 1+340) has an average depth of 1.22 m and a maximum depth of 3.1 m below existing ground level. The location and depth of cuts associated with bridge structures is presented in Table 16.6. Dewatering for all cuts will be from the surface deposits as no cut intercepts the bedrock.

Potential Impact on Cut 4 in Productive Aquifer (Rkd)

This section of cut occurs from Ch. 1+060 – Ch. 1+340 and is underlain at depth by the Rickardstown Limestone. The average depth of this cut is 1.22 m and the maximum depth is 3.1 m. The length of the cut is 280 m. The cut does not intercept the underlying bedrock aquifer which is recorded at 8.1 m BGL in the nearest borehole log. Table 16.10 provides details of the boreholes and trial pits most adjacent to the cut.

The borehole log for the nearest well, borehole (BH), BH07, shows a stiff silt layer (2.6 m thick). This surficial deposit is described as slightly sandy, slightly gravelly, clayey Silt and extends from beneath the thin topsoil layer to a depth of 2.7m BGL. Beneath the silt are more permeable deposits. Boulders/cobbles were encountered from 2.7m BGL to 3.2m BGL and from 5 m BGL to 5.4 m BGL with a clay and gravel layer between the boulder/cobbles. There are clean gravels from 5.4 m BGL to bedrock at 8.1 m BGL.

Trial pit (TP) TP10 shows clays and silts to 3 m BGL and TP09 shows silt and clay layers to 3.9 m BGL with a thin gravel lens from 2.5 to 2.7 m BGL.

The deepest section of this cut may be contained within the surficial stiff Silt deposits. However the potential exists, given natural variability in depositional thickness, for the confining silt deposits to be breached and more permeable deposits to be intercepted. It can be assumed, therefore, that dewatering may occur. If the cut is contained within the confining layer only small volumes of water will be dewatered during excavation from the low permeability underlying subsoils. If, however, the base of the low permeability subsoil is breached a rapid increase in water ingress should be expected as the piezometric head is above the base of the cut.

Table 16.10: Details of Borehole/Trial pit Information near Cut 4

Borehole / Trail Pit	Chainage	Deposits to Max Depth of Cut	Max Depth (m) Cut 4
BH07	Ch. 1+050	Silt to 2.7mbgl Boulders and cobbles (from 2.7 to 3.2mbgl)	3.1m
TP10	Ch.1+140	Clays and silts to 3m (base at 3mbgl)	
TP09	Ch.1+400	Clays and Silt to 3.9	

Groundwater level for BH 07 was recorded at 1.16m BGL, 1.24m BGL and 0.75 m BGL on 18/06/2013, 04/07/2013 and 13/11/2013 respectively. This gives an average water level in BH07 of 74.76 mOD. The piezometric level (summer average 74.61 mOD) and winter reading (75.06 mOD) is thus above the base level of the cut (72.735 mOD). The degree of dewatering will be a function of local ground conditions encountered, groundwater level at the time of works, ingress from any unmapped springs and method of cut. The impact magnitude is considered to be Small Adverse. The significance rating is Significant /Moderate. In summary the following conclusions can be drawn for the section of cut in the Regionally Important Aquifer.

- Ch. 1+060 – Ch. 1+340 - Results of the hydrogeological assessment indicate that the route will not cut into bedrock at any point of this section of cut. The confining layer extends approximately 2.7m BGL. The deepest section of cut is 3.1 m BGL. Dewatering will be required if the confining layer is breached. The summer recordings of groundwater levels in BH07 indicated a piezometric head at approximately 1.2 m BGL with a winter level recorded at 0.75 m BGL. Applying the cautionary principle, in the case where the confining layer is breached, the magnitude of impact is rated as small adverse and the significance rating for this cut on the groundwater resource is significant/ moderate.

There are no sections of cut proposed for the alignment in the Locally Important Aquifer.

Potential Impact of Bridge Footings in Productive Aquifer

The cuts proposed for bridge footings tend to be relatively shallow, though somewhat deeper than the cuts for the alignment detailed above. The cuts for foundations tend to be short in length. All the proposed cuts for abutments along the proposed scheme have the potential to intercept the water table.

Four of the six abutments will be piled into gravels namely structures S1, S4, S5 and S6. S2 reaches close to the base of the impermeable deposits and could breach the confining layer. S3 is a jacked box within the existing railway embankment and is contained within Cut 4 detailed above. The magnitude of the impact has been determined for each bridge footing location and the significance rating for this cut on the groundwater resource is then assessed and given in Table 16.11 below, depending on the following:

- Extent of penetration of foundations into gravel;
- Water table level, and
- Extent of overburden to protect the gravels.

Table 16.11: Potential Impacts from Cuts for Bridge Foundations

Bridge Name	Chainage (approx.)	Deposits to Max Depth of Cut	Max Depth of Cut	Magnitude of Impact	Significance Rating on Groundwater Resource
S1- Interchange Osberstown Overbridge	Ch. 0+000	Gravels (BH5A, TP14)	1.4 m	Small Adverse	Significant/ Moderate
S2-Osberstown Road Overbridge	Ch. 1+050	Clay to 3.3 m BGL (TP10,TP11)	2.7 m	Negligible	Imperceptible
S3-Sallins Bypass Railway Bridge	Ch. 1+257	Clay (TP09, TP10) Silt (BH07)	3.1 m	Small Adverse	Significant/ Moderate
S4-Grand Canal Underbridge	Ch. 1+577	Clay (BH10) BH09, BH11	2.25 m	Small Adverse	Significant/ Moderate
S5-River Liffey Underbridge	Ch. 1+980	Sand (BH14) BH13, BH15	2.1m	Small Adverse	Significant/ Moderate
S6-River Liffey Underbridge	Ch. 3+050	Sand (BH19, BH20)	2.2m	Small Adverse	Moderate/ Slight

Potential Impact on Groundwater Resources – Operational Phase

During the operational phase of the proposed road development, the impact on the groundwater resources will be the potential for the presence of the proposed road development to cause alterations to groundwater flow patterns. Recharge is reduced by replacing permeable surface area with hard-standing. By removing parts of the aquifer permanently, groundwater within the system is being removed through drainage and the aquifer storage potential is being reduced. The presence of the footing of the bridges can cause localised changes to flow patterns. The significance of these impacts is based on the aquifer classification and also on the depth of the cut or impediment relative to the water table.

The magnitude of the impact of the proposed road development on groundwater resources during the operational phase of the proposed scheme in terms of the underlying aquifers are rated as negligible. Cuts are shallow and dewatering will be temporary. The significance of these impacts is imperceptible. The magnitude of the impact on groundwater resources in terms of GDEs and local wells and springs is considered below in terms of water quality and water supply.

It is considered that some of the private wells close to the scheme have the potential to be impacted by the proposed road development. However, any affected wells will be assessed and if necessary replaced or re-bored for landowners to a similar standard.

16.4.2.2 Potential Impacts on Water Quality

Potential Impact on Water Quality – Construction Phase

During the construction phase, the water quality of an aquifer can be negatively impacted. The GSI vulnerability classification of the aquifer can be used to assess the risk of activities on the water quality.

The significance of this impact is highly dependent on the thickness and permeability of the unsaturated zone (i.e. the vulnerability). The vulnerability of the aquifer increases where subsoil thickness is reduced.

Water quality can be impacted by the spillage of fuels or cleaning fluids of machinery on site through accidental spillage or leakage of fuel/fluid storage tanks. There is the potential for downward migration of construction fuels to the Regionally Important bedrock aquifer where overlying deposits are free of impermeable clay bands or, indeed, where any cut would remove the protection offered by surface clays. Construction fuels could enter Quaternary deposits and migrate to the underlying bedrock aquifer which directly underlies the gravels unprotected by any aquitard. This impact is rated small adverse and its significance rated as significant/moderate.

The storage of excavated material could potentially lead to leachate being generated and impacting soil as rainwater percolates through the stockpile. This may result in soil or groundwater contamination in the unlikely event that any contamination is present in the excavated material. The site investigation undertaken to date has not encountered any indications of ground contamination.

The greatest potential impact on water quality during construction relates to the construction of the abutments of the M7 Osberstown Interchange, the Grand Canal and the River Liffey where the gravels are not protected by impermeable subsoils. Construction fuels could migrate to the underlying bedrock aquifer which directly underlies the gravels unprotected by any aquitard. The magnitude of the potential to impact the water quality of the groundwater during construction through leakage and spillages is rated as small adverse.

Most cuts along the proposed scheme are in areas of thick relatively impermeable subsoil deposits. The cut that could potentially breach the confining layer is Cut 4. The magnitude of the impact for this cut is rated small adverse. The significance rating for Cut 4 is significant /moderate.

The cuts for structures (S1, S3, S4, S5 and S6) will require dewatering. The magnitude of the impact for each of these cuts is rated small adverse. The significance rating for those overlying the Regionally Important Aquifer is significant / moderate and for those overlying the Locally Important Aquifer is moderate / slight.

The magnitude of the potential to impact the water quality of the Grand Canal groundwater dependent ecosystems during construction through leakage and spillages is rated as negligible as the canal is crossed by an underbridge and groundwater does not provide baseflow to the canal at this location. The significance of the impact is rated imperceptible.

The magnitude of the potential to impact the water quality of the River Liffey groundwater dependent ecosystems during construction through leakage and spillages is rated as small adverse. The significance of the impact is rated moderate/slight.

The attenuation ponds and swales along the proposed scheme will be designed to ensure that sufficient attenuation occurs in the unsaturated zone such that no contamination enters from these features. Where the water table is high and/or overburden thickness is insufficient the ponds or swales will be lined.

Construction spillage, were it to reach any domestic well, would have a large adverse impact on the domestic supply. The significance of the impact would be rated slight/moderate.

Potential Impact on Water Quality – Operational Phase

The main potential impact on water quality of the groundwater resource during the operational phase of the proposed road development will be from contaminated road run-off. This run off could be in the form of petrol or diesel from accidents or leakages from cars. The significance of the impact on the water quality is dependent upon the thickness and permeability of the unsaturated zone and whether the road is in cut or fill. The duration of the impacts can range from short to long term depending on the level of contamination that occurs.

Operational impacts from the cuts along the route that breach the confining layer and areas of fill where impermeable surficial deposits are thin or absent have the potential to have an adverse impact on groundwater quality. The six areas along the proposed scheme where 3 m cover has not been proven are listed above in Section 16.3.3. These areas do not ensure attenuation of any contaminant entering the aquifer. The magnitude of the impact on the groundwater is small adverse. The significance of this potential impact where these areas overlie the Regionally Important aquifer is rated significant/moderate and where they overlie the Locally Important aquifer the significance of the small adverse impact is Moderate/slight.

The groundwater in the study area acts as baseflow to the River Liffey and any quality impairment of the groundwater can impact the river water quality. The magnitude of this impact is small Adverse. There is also a Small Averse potential impact from direct spill from the bridged roadway to the river. The significance of this potential impact is rated significant/moderate.

The groundwater in the study area does not act as baseflow to the Grand Canal and the canal is crossed by an underbridge. There is no potential impact on the water quality of the canal.

Due to the presumed shallow nature of the groundwater seepage fronts and springs, the magnitude of the impact of pollution from contaminated road run-off, on adjacent springs is rated as large adverse. The significance of this potential impact is rated slight/moderate.

Local wells may be potentially impacted from contaminated run-off. The magnitude of the potential impact of pollution from contaminated road run-off, on adjacent wells is rated as large adverse. The significance of this potential impact is rated slight/moderate.

Drainage points and any attenuation ponds on the road system may contain contaminated water. These are outlined in Chapter 4 *Description of the Proposed Scheme*. The drainage on the proposed scheme has been designed to ensure no impacts on the vulnerable section of the aquifer. Run-off pollutants shall be assessed at all outfall locations and appropriate methods of treatment shall be applied in accordance with the NRA requirements. SuDs systems should be considered in the first instance and only where there is insufficient space may other conventional methods such as priority systems be used.

Bridges provide a pathway to potentially negatively impact surface water as dealt with in Chapter 17 - *Hydrology*. When river levels are high and surface waters recharge groundwater systems the potential exists for surface water to negatively impact groundwater quality.

16.4.2.3 Potential Impacts on Water Supply

Potential Impact on Water Supply – Construction Phase

It is considered the nearest public water supplies (the nearest at Tullylost, Rathangan and Ballykelly, Monasterevin located circa 20 km and 25 km beyond the study area) are beyond the potential range of influence. There are no recorded large abstractions in the immediate vicinity. There are some domestic wells identified in the well survey within 100 m of the proposed route. The complete well survey is presented in **Appendix A16.1**. Drawdown from dewatering during construction could potentially temporarily impact supplies to these groundwater wells. Water supply to seepage fed drains and/or local springs along the Liffey could be also be temporarily impacted. The magnitude of the impact is small adverse and the significance of this impact is rated as imperceptible.

Potential Impact on Water Supply – Operational Phase

The presence of the bridges and the presence of hardstanding results in loss of recharge but in terms of supply to either aquifer or reduction in baseflow the impact is negligible. The significance is imperceptible.

Any impact on water supply in local wells could only occur if the constructed road intercepted a spring fed supply or perched groundwater. There will be no permanent dewatering associated with the proposed scheme, thus there is no long term impact on baseflow to GDEs or supply to local domestic wells. The significance of this impact is rated as imperceptible.

16.4.2.4 Potential Impacts on Karst Features

The GSI Karst database does not indicate any karst features along the proposed scheme. Seepage fronts and springs identified in the site walkover appear to be seepages at the extremities of gravels deposits rather than karstic in nature.

16.4.2.5 Potential Impacts on Groundwater Dependent Ecosystems

Groundwater dependent habitats may be impacted by road developments through accidental contamination, the alteration of groundwater levels and the reduction in the groundwater contribution to the ecosystem. The characteristics which determine the potential impact are:

- The proximity to the feature.
- The level of hydraulic connection between the feature and the section of aquifer at the road i.e. is the feature in the same aquifer unit as the road, or is there a hydraulic divide between the feature and the route.
- The groundwater flow direction in the vicinity.

- The level of cut at the road, which may determine the degree of variation in the groundwater level and also the extent of dewatering which may occur both during construction and in operation.
- The water quality of the feature and the groundwater from which it receives its baseflow.

These factors are considered below in relation to individual Groundwater Dependant Ecosystems along the proposed road development.

Potential Impact on the River Liffey – Construction Phase

The proposed road development crosses the River Liffey in two locations. During the construction phase of the crossing there is the potential to contaminate groundwater by opening up pathways to the aquifer when bridge foundations are being constructed. Any contamination which occurs in the area during construction, through accidental spillage or runoff, from construction stockpiles, that is either contaminated or has a high suspended solid concentration may percolate through exposed soil to the water table where it will be readily transported to the river as baseflow and pose a risk to the water quality in the Liffey. Thus, a potential small adverse impact on an attribute of High importance results in a potential significance rating of moderate/slight.

Potential Impact on the River Liffey – Operational Phase

During the operational phase the water quality of the River Liffey water can be impacted by contaminated baseflow of directly from the bridge crossings from accidents or spills. This represents a small adverse impact. The significance of the impact during the operational stage is moderate/slight.

The potential exists for some imperceptible reduction in baseflow to the river due to the presence of the embankment at both crossings of the river and the presence of hardstanding. This represents a negligible impact. The significance of the impact during the operational stage is imperceptible.

Potential Impact on the Grand Canal – Construction Phase

The proposed road development crosses the Grand Canal pNHA at one location. The groundwater at this location does not act as baseflow to the canal. The proposed road development crosses over the Grand Canal via an underbridge. There is no potential impact on the water quality of the canal.

Potential Impact on the Grand Canal – Operational Phase

During the operational phase there is no predicted impact on the Grand Canal.

Potential Impact on the Osberstown Pond and Stream – Construction Phase

The Osberstown Pond is a man-made attenuation pond used for the existing Millennium Park Development site surface run-off. During construction there is the potential to impact the water quality of the attenuation pond water though spillage and run off from stockpiles. The potential impact on this attenuation pond and other attenuation ponds are detailed in Chapter 17 - *Hydrology*.

Potential Impact on the Osberstown Pond and Stream – Operational Phase

The Osberstown Pond is a man-made attenuation pond used for the existing Millennium Park Development site surface run-off.

Run off from the proposed scheme will discharge into the inlet stream of the Osberstown Pond and other specially constructed attenuation ponds along the proposed scheme. The potential impact on this attenuation pond and other attenuation ponds are detailed in Chapter 17- *Hydrology*.

16.4.2.6 Potential Impacts on Legacy Landfills

There are four legacy landfills identified through consultation. There is no impact predicted on these landfills as they are distant from the proposed scheme. The locations of the legacy landfills are presented n Figure 15.2.

16.4.2.7 Potential Impacts on Waste Permitted Site

It is not considered that the proposed road development will impact the IPPC license site located 250 m to the southeast of the route. There is no impact predicted.

16.5 Mitigation Measures

Mitigation measures are summarised in Tables 16.14 and 16.15. Mitigation Measures are set out to mitigate against the predicted hydrogeological impacts arising from the proposed road development under the following headings:

- Aquifer Type and Hydraulic Conditions (16.5.1.1).
- Water quality (16.5.1.2).
- Water supply (16.5.1.3).
- Karst features (16.5.1.4).
- Groundwater dependent ecosystems (16.5.1.5).

In order to protect the aquifers both in terms of groundwater resources and water quality, mitigation measures will be put in place during the construction and operational phases of the road.

16.5.1 Mitigation Measures

16.5.1.1 Proposed Mitigation for Aquifer Type and Hydraulic Conditions

In order to protect the aquifer the proposed road design aims to minimise loss of aquifer storage by keeping cuts to a minimum. The volume of aquifer storage being removed is negligible when compared to the storage potential of the aquifer.

Proposed Mitigation Measures for the Construction and Operational Phase

During the construction phase the groundwater resources are potentially at risk from the dewatering process. In general, when significant dewatering is proposed by a development, groundwater level monitoring is put in place 12 months before construction, during the construction phase and 24 months following construction to enable effects from dewatering to be identified. In the shallow cuts of the proposed scheme there will be minimal dewatering required; nonetheless, a monitoring programme will be in place.

The proposed scheme has been designed to ensure minimal alteration to groundwater flow regimes, cuts are generally above water table and abutments and bridge footings are shallow. The M7 Osberstown Interchange and River Liffey crossings will on bank seated abutments minimising any impact. Proposed mitigation for impacts on domestic wells and springs due to localised effects is addressed below in mitigation for water supply.

16.5.1.2 Proposed Mitigation for Water Quality

Proposed Mitigation Measures for the Construction and Operational Phase

Negative impacts on water quality that occur due to stockpiling of contaminated material and leachate generation will be prevented by not storing contaminated material on site. If any suspected contaminated material is encountered it will be tested and disposed of in an appropriate manner and in line with current water management legislation. If it is not possible to immediately remove contaminated material, then it will be stored on, and covered by, polythene sheeting to prevent rain water infiltrating through the material. The time frame between excavation and removal will be kept to an absolute minimum.

Run-off will be controlled through silt/sediment traps as appropriate to minimise the turbidity of water in outfall areas. Care will be taken to ensure that the bank surfaces are stable to minimise erosion. There will always be some run-off from excavations / earthworks and it cannot be prevented entirely. Earthworks operations shall be carried out such that surfaces slopes are designed with adequate falls, profiling and drainage to promote safe run-off and prevent ponding and flooding.

Once in operation, sealed drainage will be provided where the Quaternary deposits provide insufficient protection to the underlying groundwater. Five new attenuation ponds and six new swales will be constructed along the proposed scheme, see **Figure 4.11 V3**. Run-off pollutants shall be assessed at all outfall locations and appropriate methods of treatment to be applied in accordance with the NRA requirements. SuDs systems should be considered in the first instance and only where there is insufficient space may other conventional methods such as priority systems be used.

For the purpose of this report a conservative approach is adopted. The length of the area considered as having thin cover, heightened vulnerability, is extended until overburden thickness of greater than 3 m is proven from site investigation data. The areas designated as having potentially less than 3 m cover are as follows: (i) Ch. 0 +000 - Ch. 0+400; (ii) either side of the Grand Canal; (iii) either side of the River Liffey; (iv) Ch. 2+980 – to Clane Road Roundabout; (v) R407 Clane Road Ch.0+000 – Ch.0 +150; (vi) Sallins Link Road.

Attenuation ponds and swales in areas where cover has not been proven to a depth of 3 m will be lined where suitable. Where concerns exists that pressure from high water table would cause uplift on a lined system, shallow swales will be designed with sufficient capacity to accommodate predicted run off rates where possible.

16.5.1.3 Proposed Mitigation for Water Supply

Proposed Mitigation Measures for the Construction and Operational Phase

The mitigation for water supplies in terms of water quality has been outlined above. The predicted impact on water supply in terms of public supply scheme and baseflow to GDEs is imperceptible. The only water supply that could potentially be significantly impacted are private wells identified in the well survey located within 100 m of the route, other uncharted wells and springs, and seepage fronts at low elevations which are used for watering cattle. The mitigation measures to ensure the proposed road development has no adverse impact on these local supplies involves monitoring of groundwater level and quality of any private wells located within 100 m of the CPO line on a monthly basis 12 months before construction, during and 24 months after construction.

Where private water supply wells are affected these will be replaced or households connected to mains supply where available. Where wells have to be abandoned as part of the proposed road development they will be sealed and abandoned in general accordance with Well Drilling Guidelines produced by the Institute of Geologists of Ireland (IGI 2007). Any wells that are abandoned because of the proposed scheme will be backfilled using bentonite or cement bentonite grout in accordance with the Specification and Related Documentation for Ground Investigation published by the Institution of Engineers of Ireland.

16.5.1.4 Proposed Mitigation for Karst Features

Proposed Mitigation Measures for the Construction and Operational Phase

No karst features have been identified within 500 m of the CPO line. Any springs that are encountered during construction will need to be incorporated into the drainage network of the route. Sealed drainage will be provided where the Quaternary deposits provide insufficient protection to the underlying karstic aquifer if the alignment is in cut section.

16.5.1.5 Proposed Mitigation for Groundwater Dependent Ecosystems

Proposed Mitigation Measures for the Construction and Operational Phase

The primary impact that affects the watercourses is the potential for accidental spillage or collapse of stockpiles during construction of the bridge footings. An Environmental Operating Plan will be implemented for the construction of the bridge footings in the river gravels both for the crossings of the River Liffey and of the Grand Canal. Best construction practice will be outlined and incorporated into the Environmental Management Plan.

Fuels will not be stored within 100 m of the River Liffey. All fuel containers and diesel operated plant must be positioned on flat bunded surfaces as far from the river as is feasible. Stockpiles will be graded and shall not be located within 100 m of the River Liffey. Special care will be taken to ensure that the bank surfaces are stable to minimise erosion. All practical measures will be taken to prevent eroded sediments from entering open watercourses (adequate falls, battened slopes, polythene sheeting etc.).

The other GDE impacted is Osberstown Pond and stream. Run-off will be controlled through silt/sediment traps as appropriate to minimise the turbidity of water in outfall areas.

16.6 Residual Impacts

The residual impacts are those that will occur after the proposed mitigation measures have taken effect and are shown in Tables 16.14 and 16.15 below. There are no significant negative residual impacts from the proposed road development.

16.6.1 Residual Impacts for the Construction Phase

The more significant predicted impacts on hydrogeological features during the construction phase arise from the potential for contamination of groundwater through accidental spillages, from dewatering where the road is in cuts and from construction of the bridge footings. The predicted impacts before mitigation measures are considered range from Significant/Moderate to Imperceptible. The mitigation measures relating to the potential for groundwater contamination are described in section 16.5 above, e.g. the implementation of an environmental operating plan, safe storage of contaminants, and silt traps etc., will ensure the risk of groundwater contamination is minimised.

The predicted residual impacts on hydrogeological features after these mitigation measures are put in place are reduced to Imperceptible.

16.6.2 Residual Impacts for the Operational Phase

The predicted impacts before mitigation range from significant/moderate to Imperceptible depending on the importance of the feature, the extent of cut, if any, and groundwater vulnerability. The mitigation measures as described in section 16.5 above will reduce the predicted impacts with respect to the Aquifer Type and Water Quality for groundwater and for groundwater fed ecosystems to imperceptible. There is the possibility that some local wells will need to be replaced or rebored.

16.6.3 Summary of Impact Assessment

An assessment of the predicted impacts, mitigation measures and residual impacts during construction are shown in Table 16.12 and Table 16.13 below. There are no likely significant negative hydrogeological impacts predicted as result of the proposed road development. Residual Impacts are all classed as imperceptible.

Table 16.12: Impact Assessments – Construction phase

Constraint			Construction Phase				
Name	**Importance**	**Chainage**	**Magnitude of Impact**	**Criteria for Impact Assessment**	**Significance of Impact**	**Mitigation Measure**	**Residual Impact**
Aquifer Type:							
Regionally Important Aquifer	Very High	Ch. 0+000 (S1M7 Osb. Interchange) Ch. 1+050 (S2 Osbers. Rd) Ch. 1+060 -Ch. 1+340 (Cut 4) Ch. 1+257 (S3 Railway) Ch. 1+577 (S4 Canal) Ch. 1+950 (S5 Liffey 1)	Small adverse	Cuts for structures or for alignment, have the potential to impact the aquifer during construction dewatering, causing alteration of groundwater flow and drainage patterns.	Significant/ Moderate	Shallow design of footing minimizes change to flow regime	Imperceptible
Locally Important Aquifer	High	Ch. 3+050 (S6 Liffey 2)	Small Adverse	Cuts for structures or for alignment, have the potential to impact the aquifer during construction dewatering causing alteration of groundwater flow and drainage patterns.	Moderate/ Slight	Shallow design of footing minimizes change to flow regime	Imperceptible
Water Quality:							
Regionally Important Aquifer	Very High	Ch. 0+000 - Ch. 0+400 Ch.1+420- Ch.1+600 Ch. 1+930-Ch.2+400 Ch. 2+980 – Ch. 3+669 R407 Clane Road Ch0+000 – Ch.0 +150 Sallins Link Road	Small adverse	Thin surface protection, sands no clay. Potential for contamination of the aquifer through accidental spillage during road construction	Significant/ Moderate	Fuels and plant in bunded storage. Battened slopes on stockpiles.	Imperceptible

Constraint			Construction Phase				
Name	**Importance**	**Chainage**	**Magnitude of Impact**	**Criteria for Impact Assessment**	**Significance of Impact**	**Mitigation Measure**	**Residual Impact**
		Ch. 0+000 (S1M7 Osb. Interchange) Ch. 1+050 (S2 Osbers. Rd) Ch. 1+060 -Ch. 1+340 (Cut 4) Ch. 1+257 (S3 Railway) Ch. 1+577 (S4 Canal) Ch. 1+950 (S5 Liffey 1)	Small adverse	Cuts for structures or for alignment, have the potential for contamination of the aquifer through accidental spillage during road construction	Significant/ Moderate	Fuels and plant in bunded storage. Battened slopes on stockpiles. No storage within 100m of watercourse.	Imperceptible
		Ch1+300- Ch.1+450 Ch. 1900-Ch.1+950 Ch.2+050-Ch.2+200 Ch.3+110-Ch.3+200 Sallins Link Rd Ch.0+550-Ch.0+580	Small Adverse	Attenuation ponds. Potential for contamination of the aquifer through accidental spillage during road construction	Significant/ Moderate	Where unsaturated zone thickness insufficient for attenuation, appropriate ponds and swales will be designed. These will be lined if suitable.	Imperceptible
Locally Important Aquifer	High	Ch. 3+050 (S6 Liffey 2)	Small adverse	Cuts for structures have the potential for contamination of the aquifer through accidental spillage during road construction.	Moderate/ Slight	Fuels and plant in bunded storage. Battened slopes on stockpiles	Imperceptible
Grand Canal	Very High	Ch. 1+580 – Ch. 1+600	Neglible	The canal is crossed by an underbridge. No groundwater baseflow. No pathway for quality impact	Imperceptible	n/a	Imperceptible
River Liffey	High	Ch. 1+960 – Ch. 1+990	Small adverse	Potential for contamination of River Liffey through accidental spillage during	Moderate/ Slight	Environmental Management Plan. No fuel storage	Imperceptible

Constraint			Construction Phase				
Name	**Importance**	**Chainage**	**Magnitude of Impact**	**Criteria for Impact Assessment**	**Significance of Impact**	**Mitigation Measure**	**Residual Impact**
		Ch. 3+030 – Ch. 3+060		construction of footing		within 100m of watercourse. Fuels and plant in bunded storage. Battened slopes on stockpiles.	
Wells	Low	Varies	Large adverse	Potential for contamination of groundwater through accidental spillage during road construction.	Slight/ Moderate	All impacted wells will be replaced/rebored if needed.	Imperceptible
Water Supply:							
Wells	Low	Varies	Small adverse	Potential temporary drop in local water table during construction dewatering.	Imperceptible	n/a	Imperceptible
Spring	Low	Ch. 2+550	Negligible	Potential temporary drop in local water table during construction dewatering.	Imperceptible	n/a	Imperceptible
Groundwater Dependent Terrestrial Ecosystems:							
River Liffey	High	Ch. 1+960 – Ch. 1+990 Ch. 3+030 – Ch. 3+060	Small adverse	Potential for contamination of River Liffey through accidental spillage during construction of bridge footings, runoff from stockpiles. Potential for loss of baseflow during construction dewatering	Moderate/ Slight	Environmental Management Plan. No fuel storage within 100m of watercourse. Fuels and plant in bunded storage. Battened slopes on stockpiles	Imperceptible

Constraint			**Construction Phase**				
Name	**Importance**	**Chainage**	**Magnitude of Impact**	**Criteria for Impact Assessment**	**Significance of Impact**	**Mitigation Measure**	**Residual Impact**
Grand canal	Very High	Ch. 1+580 – Ch. 1+600	Negligible	Potential for contamination of grand canal through accidental spillage during construction of bridge footings, runoff from stockpiles	Imperceptible	n/a	Imperceptible
Osberstown Pond and stream	Low	Ch. 0+000 – Ch. 0+200	Small adverse	Potential for contamination of pond or stream through accidental spillage during road construction	Imperceptible	Discharge directed to the existing pond will pass through Silt/sediment traps	Imperceptible

Table 16.13: Impact Assessments – Operational phase

Constraint			Operational Phase				
Name	**Importance**	**Chainage**	**Magnitude of Impact**	**Criteria for Impact Assessment**	**Significance of Impact**	**Mitigation Measure**	**Residual Impact**
Aquifer Type:							
Regionally Important Aquifer	Very High	Along route	Negligible Negligible Negligible	Potential for alteration of drainage due to presence of road and bridge foundations. Potential for reduction in storage due to permanent removal of storage. Reduction in recharge due to presence of hard-standing.	Imperceptible Imperceptible Imperceptible	Design of footing minimizes change to flow regime Design minimizes depth of cuts. n/a	Imperceptible Imperceptible Imperceptible
Locally Important Aquifer	High	Along route Ch. 0+000 – Ch. 0+200 Ch.1+750 (Sallins Link Road)	Negligible Negligible Negligible	Potential for alteration of drainage due to presence of road and bridge foundations. Potential for reduction in storage due to permanent removal of storage. Reduction in recharge due to presence of hard-standing	Imperceptible Imperceptible Imperceptible	Design of footing minimizes change to flow regime Design minimizes depth of cuts. n/a	Imperceptible Imperceptible Imperceptible

Constraint			**Operational Phase**				
Name	**Importance**	**Chainage**	**Magnitude of Impact**	**Criteria for Impact Assessment**	**Significance of Impact**	**Mitigation Measure**	**Residual Impact**
				Water Quality:			
Regionally Important Aquifer	Very High	At areas of thin cover (i) – (vi)	Small adverse	Where surface protection is thin there is potential for contamination of the aquifer through accidental spillage and road run off	Significant /Moderate	Sealed drains will be installed where cover is thin	Imperceptible
		At Cuts	Small adverse	Where surface protection has been altered at bridge footings there is potential for contamination of the aquifer through accidental spillage and road run off	Significant/Moderate	Design of bridge footings will ensure no contaminant pathway created	Imperceptible
		At attenuation ponds	Small adverse	Where attenuation ponds are present there is potential for contamination of the aquifer through accidental spillage and road run off	Significant/Moderate	Pond design will ensure suitable protection	Imperceptible
Locally Important Aquifer	High	At areas of thin cover	Small adverse	Cut only. Cut may intercept water table. Potential for contamination of aquifer through accidental spillage and road run off	Moderate/Slight	Sealed drains will be installed where cover is thin	Imperceptible
		At Cuts	Small adverse	Potential for contamination of watercourses through accidental spillage and road run off where surface protection is thin	Moderate/Slight	Design of bridge footings will ensure no contaminant pathway created	Imperceptible

Constraint			Operational Phase				
Name	**Importance**	**Chainage**	**Magnitude of Impact**	**Criteria for Impact Assessment**	**Significance of Impact**	**Mitigation Measure**	**Residual Impact**
		At attenuation ponds	Small adverse	Potential for contamination of watercourses through accidental spillage and road run off where surface protection is thin	Moderate/Slight	Pond design will ensure suitable protection	Imperceptible
Grand Canal	Very High	Ch. 1+580 – Ch. 1+600	Negligible	No potential for contamination of canal through accidental spillage road crosses as underbridge	Imperceptible	n/a	Imperceptible
River Liffey	High	Ch. 1+960 – Ch. 1+990 Ch. 3+030 – Ch. 3+060	Small adverse	Potential for contamination of aquifer through accidental spillage and road run off directly into Liffey and through groundwater baseflow	Moderate/Slight	Design of bridge footings will ensure no contaminant pathway created	Imperceptible
Wells	Low	Varies	Large adverse	Potential for contamination of groundwater through accidental spillage and road run off	Slight/Moderate	Supply will be replaced if well is impacted	Imperceptible
Osberstown Pond and Stream	Low	Ch. 0+000 – Ch. 0+200	Large adverse	Potential for contamination of groundwater through accidental spillage and road run off	Slight/Moderate	Silt/sediments traps will be maintained and serviced	Imperceptible
Water Supply:							
Regionally Important Aquifer	Very High	Along route	Negligible	Potential for loss of recharge due to presence of hard-standing	Imperceptible	n/a	Imperceptible
Locally Important Aquifer	High	Along route	Negligible	Potential for loss of recharge due to presence of hard-standing	Imperceptible	n/a	Imperceptible

Constraint			Operational Phase				
Name	**Importance**	**Chainage**	**Magnitude of Impact**	**Criteria for Impact Assessment**	**Significance of Impact**	**Mitigation Measure**	**Residual Impact**
Grand Canal	Very High	Ch. 1+580 – Ch. 1+600	Negligible	Loss of baseflow due to presence of road	Imperceptible	n/a	Imperceptible
River Liffey	High	Ch. 1+960 – Ch. 1+990 Ch. 3+030 – Ch. 3+060	Negligible	Loss of baseflow due to presence of road	Imperceptible	n/a	Imperceptible
Groundwater Dependent Terrestrial Ecosystems:							
River Liffey	High	Ch. 1+960 – Ch. 1+990 Ch. 3+030 – Ch. 3+060	Small adverse Negligible	Potential for contamination of water supply through contaminated road run-off and during accidents, fuel tanker spills etc Loss of baseflow due to presence of road	Moderate/Slight Imperceptible	Sealed drains will be installed adjacent to the watercourse. n/a	Imperceptible Imperceptible
Grand Canal	Very High	Ch. 1+580 – Ch. 1+600	Negligible Negligible	Potential for contamination of canal through contaminated road run-off and during accidents, fuel tanker spills. Loss of baseflow due to presence of road	Imperceptible Imperceptible	n/a n/a	Imperceptible Imperceptible
Osberstown Pond and stream	Low	Ch. 0+000 – Ch. 0+200	Small adverse	Potential for contamination of pond or stream through accidental spillage and through road run-off	Imperceptible	Silt/sediments traps will be maintained and serviced	Imperceptible

16.7 References

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