3.4 WATER

3.4.1 Introduction

IE Consulting were engaged by Kildare Architects and Design Ltd., to assess hydrogeological impacts relating to the proposed infilling and restoration of a sand and gravel pit using inert Construction and Demolition (C&D) waste, mainly soil and stone, at Boherkill, Rathangan, Co Kildare. The proposal to restore the quarry in this fashion is technically classified as recovery of waste through deposition on land. The large volume of imported inert soil and stone required to complete this task requires a Waste Licence Application to be submitted to the Environmental Protection Agency, together with a supporting Environmental impact Statement.

This assessment has been undertaken as a desk based study as part of the Water Section of an Environmental Impact Statement (EIS), which will be submitted with a waste licence application and incorporates available background information and site-specific information.

3.4.2 Scope of Works

The scope of works for the assessment undertaken comprised the following:

- Desk Study
    - Collation of existing regional information regarding the geology, hydrology and hydrogeology of the site and surrounding area;
    - Review of available site information.
- Field Work
    - Site walkover conducted by IE Consulting on 18th November 2015 to review site water management practices;
- Reporting
    - Preparation of a hydrogeological report.

Reference was made to the following documents:

- Department of the Environment, Heritage and Local Government (2004) "*Quarries and Ancillary Activities – Guidelines for Planning Authorities*".
- Environmental Protection Agency (2006) "*Environmental Management in the Extractive Industry (Non-scheduled minerals)*".
- Environmental Protection Agency (1992) "*BATNEEC Guidance Notes for the Extraction of Minerals*".
- Institute of Geologists of Ireland (2007) "*Recommended Collection, Presentation and Interpretation of Geological Hydrogeological Information for Quarry Development*".
- Waste Management (Facility and Registration) Regulations 2007 (S.I. No. 821 of 2007).

- Waste Management (Facility and Registration) Amendment Regulations 2008 (S.I. No. 86 of 2008).
- Institute of Geologists of Ireland (2013) "*Guidelines in the Preparation of the Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements"*.

As part of the desk study assessment, the following organisations were consulted for information pertaining to the site hydrology and hydrogeology e.g., databases, studies, etc.:

- Geological Survey of Ireland;
- National Parks and Wildlife Service;
- Environmental Protection Agency;
- Met Éireann;
- Teagasc.

The primary objective of the hydrogeological assessment is to assess the impact posed to surface water and groundwater by the on-going extraction at the quarry pit and the proposed waste recovery of inert material and by the infilling and restoration of the existing quarry void using inert waste. Where appropriate, mitigation measures are recommended.

3.4.3 Site Location

The Kildare Sand & Gravel quarry is located at Boherkill on the R4011 Kildare/Rathangan road. The site is approximately 3 km southwest of the small town of Rathangan (*Drawing No. IE1105-001-A, Appendix A*). Operations at the facility involve the extraction of sand and gravel for supply to the construction market. The process involves the extraction of material from the western boundary of the facility. The material is then transported to the screeners, south of the facility, close to the entrance gate. The screeners are positioned at a lower elevation relative to the road, neighbouring lands and local dwellings. The strategic positioning of the plant helps dampen dust and noise levels by utilising the quarry embankments. Land usage around the facility is mainly agricultural tillage land. All materials washed and segregated are stored within and around the processing area.

The site is surrounded by lands which are primarily used for agricultural activities. According to the EPA Corine Land use Map 2012, land use in the area has been classified as 'Pastures and non-irrigated land`.

There are a number of residences in the vicinity of the site located along the public roads; as one-off rural dwellings and also associated with farm holdings. The closest residential property is located along the public road immediately northwest of the site.

3.4.4 Existing Site Activities

The nature of the development is the continued extraction of sand and gravel. The extraction scenario on site is that there is sufficient reserves to allow approximately 2 years workings of about 100 tonnes per day (approximately five loads) from the site.

Currently the excavated site area is 7.8 hectares. The worked out sand and gravel pit is proposed to be restored on a phased basis, from north to south over 10 years, using imported inert construction and demolition (C&D) waste, mainly soil and stone. The proposed restoration area extends to 10.7 hectares.

As shown on *Drawing IE1105-002-A*, *Appendix A* the site infrastructure includes a disused office, a toilet, a wheel wash, and a 2,000L bunded fuel tank. Wastewater from the toilet is discharged to a septic tank.

The washwater from the wheel wash facility percolates to ground. The settlement lagoon is cleaned periodically and the settled silt is used as part of the site restoration. This lagoon required dredging at the time of the site visit on 18th November 2015.

Coagulants used in the washing process are supplied by Abbeywater. The product name is Polygold Anionic/Non-Ionic Powders. It is used as a flocculation agent. According to the Safety Data Sheet supplied by Abbeywater (Appendix A) the product is not classified as hazardous to health or the environment in accordance with the classification according to EC Regulation (EC) NO. 1272/2008 (classification, labelling and packaging of substances and mixtures).

There is no surface water run-off or discharge from the site.

3.4.5 Topography

In a regional setting, the site is located at the foothills of Dunmurry Hill and Red Hill, on lands sloping gently towards the west. According to the 1 in 50,000 Discovery Series Map, the nearest topographical high is located approximately 1.5 km to the south at Dunmurry Hill (elevation of 223 mAOD), whilst the next nearest is located approximately 2.6 km to the south at Red Hill (elevation of 197 mAOD, *Drawing IE1105-001-A, Appendix A*). The site is set on land slightly elevated above Rathangan and the flat lands to the west, and at the foothills of Dunmurry Hill and Red Hill. The land slopes to the northwest towards the Slate River.

3.4.6 Meteorology and water balance

Rainfall data for the area was obtained from Met Éireann. The closest rainfall gauging station to the site is at Naas (Gowran Grange), approximately 18.5 km east of the site. The average annual rainfall (AAR), based on mean monthly rainfall data during the period 1973-1991, was calculated at 859 mm/yr. However, irrespective of this, for aquifers classed as poor (Pu/Pl) (or locally important (Ll)), there is an upper limit to the amount of recharge that they can accept. When that natural capacity is achieved all subsequent recharge will be rejected. It is recommended that recharge caps of 100 mm/yr should be applied to poor aquifers (and 200 mm/year for locally important aquifers). When the natural recharge capacity is exceeded then rejected recharge occurs and this adds to surface runoff (or interflow) (Hunter-Williams *et al*. 2008).

Long term Potential Evaporation (P.E.) data was obtained for the closest synoptic station at Casement Aerodrome, 16 km east of the quarry. The average P.E. for this synoptic station (based on 1971-1990 average monthly data) is 777 mm/year. The Actual Evaporation (A.E.) is taken to be 0.82 of P.E. Therefore, the A.E. at the quarry is estimated at 637 mm/yr. At the existing quarry, the AE will be much lower due to the absence of significant vegetation cover and therefore the AE is assumed to be approximately 100 mm/yr and therefore potential aquifer recharge at the quarry void is approximately 100 mm/yr (Recharge cap 200 mm/yr – AE 100 mm/yr = 100 mm/yr).

The effective precipitation (EP) is the amount of precipitation that is available to form recharge or runoff. The effective precipitation in the vicinity of the site boundary is estimated as follows:

EP = AAR – AE.

= 200 mm/yr – 100 mm/yr

EP = 100 mm/yr

An average surface water balance for the total application area of 7.8 ha (excavation and restored area) is presented in *Table 3.4.1* below. Water input to the existing quarry comprises rainfall and intercepted recharge. As the excavation is worked above the groundwater table it receives no inflows from groundwater. During extreme storm events some ponding will occur but it will be lost by combined seepage to ground and from open water evaporation. This calculation assumes that site area is bunded so that water ingress from outside of the existing quarry footprint does not enter the quarry area.

Table 3.4.1 Mean Water Balance for the Existing Excavation Area and Ancillary Activities Area

Existing Quarry Area (m^2)	Average Annual Rainfall (mm)	Mean Annual Potential Evaporation (mm)	Actual Evaporation (mm)	Effective Annual Precipitation (mm)	Annual Volume of Water Available for Recharge or Runoff (m^3)	Annual Volume of Water Available for Recharge or Runoff (m^3/day)
70,800	859	777	100	100	7,080	19.4

All effective precipitation formed within the quarry area recharges into the ground. The existing site water management is discussed in further detail in *Section 3.5.13*.

The hydrogeological controls determining the rate of groundwater recharge as indicated by the Geological Survey of Ireland (GSI) are provided in *Table 3.4.2* below.

Table 3.4.2 - Hydrogeological Control Determining Groundwater Recharge for the site

Hydrogeological Controls

Hydrogeological Setting:	2.ii *(source: GWWG, 2005)*
Hydrogeological Setting Description:	High permeability subsoils, sands and gravels overlain by well drained soils
Soil Drainage:	DRY
Subsoil Type:	GLPSsS
Subsoil Description:	Glaciofluvial sands and gravels
Subsoil Permeability:	H
Subsoil Permeability Description:	High
GW Vulnerability:	H
GW Vulnerability Description:	High
Aquifer Category:	LI
Aquifer Category Description:	Locally Important Aquifer – Bedrock which is moderately productive only in local zones
Recharge Coefficient (%):	85
Maximum Recharge Capacity (mm/yr):	100
Average Recharge (mm/yr):	491 (maximum recharge 200 mm as there is a recharge cap in place)

3.4.7 Hydrology

In a regional context, the site is situated in the South Eastern River Basin District (SERBD) within the Barrow River catchment.

The major surface water feature in the vicinity of the site is the River Slate, approximately 3 km north of the site. The River Slate flows in a westerly direction discharging into the Figile River approximately 9 km west of the site.

Aside from the River Slate there is one small unnamed stream approximately 2.3 km to the west of the site, which flows northwards discharging to the River Slate.

The Environmental Protection Agency (EPA) monitors the biological quality of rivers and other water bodies on an on-going basis. They use an assessment scale known as a Q-Value where Q1 indicates gross pollution and Q5 indicates pristine conditions (Toner et al., 2005). These values are based on the communities of macroinvertebrates in a stream as different species display varying sensitivities to pollution. The nearest monitoring station on the Slate is just east of Rathangan. Ecological water quality was most recently assessed here (2004-present) as Q3-Q4 which is Moderate Status (slightly polluted). The nearest station west of Rathangan also registers as Q3-Q4. Overall, for the 2010-2012 reporting period, the Water Framework

Directive (WFD) status of the River Slate in this region is assessed as 'moderate' upstream of Rathangan and "good" downstream of Rathangan.

3.4.8 Geological Setting

3.4.8.1 Bedrock Geology

The rock units within c.1 km of the site were identified from the 1:100,000 scale map of the Geology of Kildare-Wicklow: Sheet 16 (GSI 1994) and online mapping (GSI 2015). The rocks belong to the Boston Hill Formation which comprises rather uniform, thick successions of nodular and diffusely bedded, argillaceous Fossiliferous limestones (and their dolomitized equivalents) and subordinate thin shales.

3.4.9 Soils and Subsoils

3.4.9.1 Regional Data

The Teagasc/EPA soils map (2006) describes the soils underlying the majority of the site as BminSW described as mainly derived from calcareous material.

The Teagasc/GSI ERBD Subsoil Map (*Figure 2, Appendix B*) describes the natural subsoil material at the site as Carboniferous Sands and gravels (GLs); the majority of this subsoil cover has been excavated at the site to date.

3.4.10 Depth to Bedrock

The groundwater vulnerability map (*Figure 4, Appendix B*) suggest that the depth to bedrock within the area of investigation is >3 m below ground level. This is based on a High (H) vulnerability classification and high permeability subsoil (DoELG/EPA/GSI 1999). As the subsoil has been excavated at the site the groundwater vulnerability is revised to Extreme (E & X).

3.4.11 Hydrogeological Setting

3.4.11.1 Aquifer Classification

The rock underlying the northern and principal area of the site is mapped as part of the Kildare groundwater body (GWB) and classified as a **locally important aquifer -** bedrock which is moderately productive only in local zones (*Figure 3, Appendix B*).

The key characteristics of the Kildare groundwater body have been identified as follows:

- This aquifer is located northwest of Kildare town. The area is defined by the SERBD - ERBD boundary to the northeast and elsewhere by the extent of the Waulsortian and Boston Hill formations.
- This GWB is considered to comprise local or poor aquifers. Nevertheless the lithologies are limestone and therefore groundwater flow may be karstic to some degree and more so in local zones where purer limestones exist. This implies the groundwater flow may be fast if concentrated in conduits along openings in the rock e.g. fractures and faults.
- The main recharge mechanisms for this groundwater body are from areas exposed to the surface where subsoil is thin and also from surrounding groundwater bodies. The topography and surface drainage show flow from the Bagenalstown GWB into this GWB. It is also likely that some karstic conduits may also carry flow across the geological boundary where structural fractures are more important than lithology in determining groundwater flow.
- Discharge from this groundwater body will be to the associated surface water bodies and also, in local zones, to adjacent groundwater bodies. Discharge may be in the form of karstic springs, which then flow into nearby rivers.
- The interaction between surface water and groundwater will differ throughout the area depending largely on the overlying strata type. In areas of outcrop the surface water and groundwater will be very closely linked at streams etc. Where there are areas of till covering the bedrock the interactions may be more subdued depending on the thickness of the over burden. In areas where there are deposits of peat this may completely seal off the surface water from the groundwater. Where the gravel aquifers occur there will be little or no interaction between the bedrock groundwater and the surface water bodies
- There are numerous hydrogeological settings in the area due to the variation in the following:
    - Subsoil (Bog, till, outcrop and major gravel aquifers)
    - The degree of structural deformation (from intense faulting in the area of Allenwood to little or none in the south)
    - The variety of rock type and hence aquifer types.

Such variations make broad statements fallible and individual site investigation will be essential to understanding any given location of interest. The majority of groundwater flow in this area is considered to take place in the upper weathered zone of the aquifer.

3.4.11.2 Karst Features

Reference to the Geological Survey of Ireland karst database indicates that there are no karst landforms located within the vicinity of the site. No karst features have been mapped within the site perimeter. Nevertheless the bedrock underlying the site is limestone and therefore groundwater flow may be karstic to some degree and more so in local zones where purer limestones exist.

3.4.11.3 Groundwater Abstractions

A well survey was not carried out as part of this assessment. Three nearby disused wells were audited as part of this investigation on the 18th November 2015. Two of these were stoned lined wells (Well 2 and Well 1). Well 4 appeared to have been a stone lined well similar to the wells 1 and 2, but was subsequently modified with a concrete lining to the base. Summary details for the wells are tabulated below. Wells 2 and 4 are located south of the site and were both dry. Well 1 is located north of the site and the static water level in this well was 18.38 mbgl (*Drawing IE1105-003-A, Appendix A*).

Reference to the Geological Survey of Ireland (GSI) well database indicates the nearest recorded groundwater supply is the Monasterevin/Rathangan public supply, approximately 1.3 km to the east of the site (*Figure 5, Appendix B*). The database also a number of groundwater supplies within a 2 km radius of the site (*Drawing No. IE1105-004-A, Appendix A*).

Table 3.4.3 – Well audit summary

Well	Well Type	Depth (m)	Approximate Ordnance Datum (m AOD)	Water depth (mbgl)	Approximate Reduced Levels (m AOD)	Usage	Distance from site
Well 1	Hand dug – stone lined	14	90	18.38	76.62	Disused	Approximately 0.1 km to S
Well 2	Hand dug – stone lined	21.6	105	DRY >21.6	>83.4	Disused	Approximately 0.37 km to SW
Well 4	Hand dug – stone lined, modified	23.6	105	DRY >23.6	>81.4	Disused	Approximately 0.9 km to N

3.4.11.4 Groundwater Levels and Flow Direction

The water table appears to be deep in the vicinity of the site. Static (non-pumping) groundwater levels in the nearby disused wells, were measured on the 18th November 2015 in an effort to establish groundwater flow direction, and are shown in *Table 3.4.3* above.

It is anticipated that the groundwater gradient is likely to reflect the surrounding topography with groundwater discharging to the local streams and rivers. Based on the topography and surface water drainage, groundwater infiltrating from the higher ground to the south of the site flows in the vicinity towards the Slate River to the northwest.

3.4.11.5 Groundwater Vulnerability

Groundwater vulnerability is a term used to represent the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities. Where the subsoil thickness is <3 m, the vulnerability is rated as Extreme (the highest risk situation). Where the subsoil thickness is >3 m, the vulnerability is rated as High, Moderate or Low (depending on the nature and thickness of the subsoil).

The groundwater vulnerability map (*Figure 4, Appendix B*) suggests that the depth to bedrock within the area on investigation is >3 m below ground level. This is based on a High (H) vulnerability classification and high permeability subsoil (DoELG/EPA/GSI, 1999).

The DoELG / EPA / GSI has developed a scheme (Groundwater Protection Response Matrix for Landfills) to assessing potential landfill sites on the basis of groundwater vulnerability and aquifer status. However, it should be noted that this scheme has largely been developed for new non-hazardous landfills (i.e. receiving a 'traditional' waste stream of municipal solid wastes, and commercial and industrial wastes). It is therefore not a directly applicable tool for assessment of inert soil recovery facilities such as proposed at Boherkill.

Notwithstanding this, a review of the Groundwater Vulnerability Map (*Figure 4, Appendix B*) and the Aquifer Map (*Figure 3, Appendix B*) in accordance with the DoELG / EPA / GSI methodology indicates that the Boherkill site is located within an area of High vulnerability and a Locally Important Bedrock Aquifer. Due to the removal of subsoil over the current worked area the vulnerability classification is revised to Extreme. These classifications have been compared against the matrix for non-hazardous landfills; which indicates that the site setting falls within a response category of R2[1], which is described as being 'acceptable subject to guidance in the EPA Landfill Design Manual or conditions of a waste licence' and R2[2] also `acceptable subject to guidance outlined in the EPA Landfill Design Manual or conditions of a waste licence`.

The proposed backfilling of the existing quarry with inert C & D including predominantly cohesive inert glacial till can provide an enhanced degree of protection, over and above that which exists at present. Given the limited risk to groundwater associated with the placement and compaction of inert soil compared to those presented by non-hazardous landfills, it is considered that the site setting is appropriate for an inert soil recovery facility.

3.4.11.6 Groundwater Quality

Under the Water Framework Directive (Directive 2000/60/EC) groundwater bodies and surface water bodies were assigned a status rating (Bad – Poor – Moderate – Good – High) based on chemical and ecological status. The Kildare Groundwater Body is classified as "Good" status.

3.4.12 Conceptual Model of the Aquifer

The current understanding of the hydrogeological setting is described below.

An estimated 859 mm/yr effective rainfall is available for recharge or runoff in the vicinity of the site. However, LI Aquifers, such as the aquifer beneath the majority of the site, are not considered to be capable of accepting all the recharge that may be available due to the limited capacity of the bedrock to both store and transmit the infiltrated water. Therefore, a maximum

25% of effective rainfall is considered to contribute to groundwater recharge in the bedrock (200 mm/yr).

The majority of groundwater in this aquifer type would be considered to flow in the upper 10 m – 15 m of the weathered and fractured bedrock, with groundwater flow through occasional interconnected fractures or faults at depths below this. However the well survey conducted indicated that the water table is at a greater depth in this area. There were no logs available for these wells.

The water table appears to be deep (>18 mbgl) in the vicinity of the site.

Topography indicates that the groundwater flow direction is to the northwest, where it discharges to the Slate River as baseflow.

The vulnerability of groundwater beneath the site is classified as High (H) and the subsoil permeability is also mapped as High. However, most of the natural subsoil has been excavated at the site which will increase the vulnerability category to Extreme.

3.4.13 Site Water Management

The locations of the site water management components are presented in Appendix 3.4.2. The water supply for the site is sourced from the mains where it is utilised for the wheel wash, washing of the excavated material and for dust suppression on the site. All wheel washwater either evaporates from the surface or percolates to ground. Any excess water from the circulation system is pumped to the settlement lagoon on the western perimeter of the site. Currently this lagoon is undredged and water pumped to it flows over the top of the accumulated silt and flows by gravity to the natural sump at the northern perimeter of the site. This sump allows the silt to collect and settle. The water then percolates to ground.

There is an existing septic tank system off site for the treatment of wastewater.

Water management within the site can be divided into the components summarised in *Table 3.4.4* below.

Table 3.4.4 Summary of Site Water Management Components

Component	Description
Direct Input	*Effective precipitation falling onto the site within the site boundary. *Pumped supply from the mains supply.

Uses	*Toilet and canteen facilities. *Dust suppression. *Aggregate washing. *Operation of restoration of site.
Outputs	*Evaporation from lagoon, natural sump, existing pit floor and restored areas. *Seepage to ground through existing pit floor, restored and unrestored areas of site. *Seepage through base and sides of site lagoons. *Discharge to ground via off-site septic tank and percolation area.

3.4.13.1 Surface water runoff – treatment and discharge

The screener used on-site includes, a process water treatment plant which recycles all silt laden water from the screening process. The use of coagulants and settlement tanks ensure that clean recycled water is put back into the process so as to maximise efficiencies and reduce the water demand of the site. Processed waters, that are not recycled, are pumped to the settlement pond located on the eastern boundary. Following silt settlement the clean water percolates to ground. The use of both the process water treatment plant and settlement pond ensures mitigation measures are taken to protect ground and surface waters.

3.4.14 Risk Assessment

3.4.14.1 Introduction

The concepts of Risk, Risk Assessment and Risk Management have become important tools in the area of environmental protection. The philosophical basis and language of risk is useful in that it provides a logical framework for considering the impact of potentially polluting activities on the environment.

This framework enables a more rigorous systematic approach to decision making. In reality it is putting a recognised framework to what is done intuitively, but by being systematic. In addition, it is an aid in conceptualising the potential impact of the discharge of effluent on the wider environment.

A **hazard** (**source**) presents a risk when it is likely to affect something of value (the **target/receptor**), which in this case is groundwater and/or surface water, which in turn may impact on humans. It is the probability of the hazard occurring and its consequences that is the basis of Risk Assessment.

The conventional Source-Pathway-Receptor model for environmental management can be applied to identify potential sources, receptors and pathways, and hence potential pollutant linkages relating to the site.

For a particular contaminant to present a risk to receptors, three components must be present:

Source An entity or action that releases contaminants into the environment

Pathway A mechanism by which receptors can become exposed to contaminants

Receptors The human or ecological component at risk of experiencing an adverse response following exposure to a contaminant

The qualitative risk assessment presented in *Tables 3.4.5-8* below is based on the hydrogeological and hydrological information collected to date in relation to the site, and incorporated into previous sections of this report.

3.4.14.2 Sources

The potential sources of groundwater/surface water contamination that are associated with the existing site activities are presented in *Table 3.4.5* below.

Table 3.4.5 Potential Site Contamination Sources

Contaminant	Associated Activities
Hydrocarbons Diesel Fuel Oils	Refuelling of machinery. Accidental spillages. Machinery maintenance/repair.
Silt	Arising from backfill material placed into the quarry. Aggregate washing.
Low permeability inert backfill material	Infilling former high permeability material with low permeability inert fill material could create a low permeability zone altering groundwater recharge. Reduction in recharge due to the potentially low permeability inert infill material.

3.4.14.3 Pathway

The pathways into the groundwater and surface water and the likelihood of the occurrence of potential groundwater contamination associated with a particular pathway, are presented in *Table 3.4.6* below.

Table 3.4.6 Possible Site Pathways

Pathway	Description
Infiltration through quarry floor	Infiltration of rainfall in quarry excavation area through subsoils. Infiltration of rainfall through backfilled area. Infiltrations of rainfall through underlying bedrock. Infiltration to ground after water has passed through the silt lagoon.
Surface water drainage	After surface water has passed through the lagoon, surface water run-off from the site overflows to the natural sump and percolates to ground. Runoff from compacted hardcore areas. Runoff from the site wheelwash. Runoff from stockpiled topsoil material. Through backfilled material into sub surface drainage system.

3.4.14.4 Receptors

The potential receptors to contamination sources from the quarry are presented in *Table 3.4.7* below.

Table 3.4.7 Potential Receptors to Site Contaminants

Receptor	Description
Groundwater	Groundwater flow beneath the site. Groundwater users downgradient of the site.
Surface water	There are no surface water bodies on–site or within the vicinity of the site.

3.4.14.5 Source-Pathway-Receptor Model

A summary of the Source-Pathway-Receptor model for the site, in the absence of mitigation measures in place, is presented in *Table 3.4.8* below.

Table 3.4.8 Qualitative Risk Assessment

Source	Pathway	Receptor	Risk
Hydrocarbons	Infiltration to ground.	Groundwater beneath site.	HIGH due to groundwater vulnerability.
	Direct pathway from base of recovery/restoration areas.		HIGH during periods of seasonally high water table where mitigation measured not adhered to.
Nitrates Faecal Coliforms Chloride etc.	Manure spreading – following infilling land used as agricultural land. Infiltration to ground.	Groundwater beneath the site. Groundwater seepage/upflow.	HIGH where manure application is excessive or applied at inappropriate times of the year.
	Surface water runoff from the site.	Surface waters.	MODERATE where manure application (upon restoration to agricultural land) is excessive or applied at inappropriate times of the year.
Silt	Surface water runoff from the site.	Surface waters.	HIGH where no silt settlement measures are in place.

Unsuitable low permeability inert backfill material	Restoration area.	Groundwater recharge.	HIGH where unsuitable (very low permeability) inert backfill material is placed at base of restoration area.
Slope Instability	Exposed slopes.		Slope instability was noted during the site visit and during proposed concurrent site restoration activities and on-going quarry operations the risk is HIGH of slope failure.

3.4.15 Potential Impacts

3.4.16 Surface water

There are no surface water bodies on-site or within the vicinity of the site.

3.4.17 Groundwater

The continued operation of the quarry site and the proposed recovery facility has the potential to impact on groundwater in terms of both the groundwater quality and the groundwater flow regime.

Infilling former high permeability material with low permeability inert fill material could create a low permeability zone altering groundwater recharge.

Possible groundwater mounding/flooding could occur if the fill acts as a barrier to normal groundwater flow patterns. However this is thought unlikely as the groundwater table appears deep in the vicinity of the site and the site has been worked dry to date. In the event of any mounding since the permeability of the surrounding subsoil is mapped as high it is anticipated that recharge will flow freely around the restored site and it is unlikely to cause significant mounding/flooding. In addition, the size of the filled area will be significantly less than the overall width of the aquifer in this location therefore the fill does not have the potential to entirely impede the normal groundwater flow patterns of the aquifer as groundwater flow will still be occurring around the site. Immediately downgradient of this potential flow diversion there is a possibility of lowering groundwater levels before the normal groundwater flow patterns converge again. Groundwater flow path diversion is expected to result in a *neutral permanent slight long-term impact* on the groundwater flow.

The importation of soils and material can influence the chemical composition of underlying groundwater. This is primarily through potential changes to the pH - e.g. by importing base-rich mineral soil to a primarily acidic catchment. Any alteration of the chemical composition as a result of improper placement of soil would result in a direct *negative short-term moderate impact* on the underlying groundwater. This is unlikely to occur however as imported material will be from the Kildare hinterland and is likely to be similar in composition to the existing soil.

3.4.18 Hydrocarbon Leakage/Spillage

Possible contamination of soil and subsoil, by leakage or spillage from machinery and associated equipment, may occur during the construction phase. Any accidental hydrocarbon spillage would have a *negative short-medium term moderate impact* on groundwater quality at the site.

3.4.19 Soil Removal

Any removal of soils will temporarily increase the groundwater vulnerability during construction. This would have a *negative short-term moderate impact* on the groundwater.

3.4.20 Bedrock

It is not expected that bedrock will be exposed during the majority of the development works. Any soil excavations that expose the underlying bedrock to the atmosphere can result in weathering of the bedrock, which is considered to be a *slight negative long-term moderate impact.*

The impact associated with the removal of weathered bedrock is considered to be a *neutral permanent impact.*

Possible contamination of bedrock, by leakage or spillage from machinery and associated equipment, may occur during the construction phases. Leakages or spillages associated with any temporary waste water facilities would have a *negative short-term moderate impact* on groundwater quality.

The implementation of mitigations measures specified in *Section 3.4.16* will reduce the overall risk of groundwater contamination beneath, and downgradient of, the quarry in addition to reducing the risk of altering the groundwater recharge beneath the site during the restoration works at the quarry.

3.4.21 Slope Stability

The available site investigation data (p. comm RME Environmental) indicates that the area to be backfilled is underlain by relatively competent sand and gravel strata. The increase in loading applied to these soils (below existing formation level) will not exceed that which existed prior to extraction of sand and gravel. As a consequence, no deep seated failure of temporary slopes is anticipated.

Temporary slopes in backfilled soils (above formation level) will be graded at an angle no steeper than 35^0, sufficient to ensure no instability arises. It is envisaged that a stability assessment of side slopes at the application site will be undertaken on an annual basis. In the longer-term, there will be no risk of instability as the restored site will be graded to a relatively flat, shallow slope.

3.4.22 Mitigation Measures

3.4.23 Overview

In order to reduce the impact of the existing site activities and proposed restoration works on groundwater and surface water receptors, the following are proposed details of measures/procedures to be implemented at the site in order to ensure that the source and/or the pathway is removed. In this way, the potential risk for groundwater/surface water contamination and groundwater flow regime alteration at the site is minimised.

Many of these recommendations are in accordance with the publication "*Environmental Management Guidelines – Environmental Management in the Extractive Industry (Non-scheduled Minerals)*" (EPA, 2006).

The most effective means by which to implement the proposed measures is to condition the mitigation measures as part of permission for the waste licence at the site. The most effective mitigations measures for the site are:

- Containment of site fuels and oils, to prevent any accidental spillages which may migrate to the subsoils and underlying groundwater;
- Wherever possible a traffic management system would be put in place to reduce the potential conflicts between vehicles, thereby reducing the risk of a collision;
- A site speed limit would be enforced to further reduce the likelihood and significance of collisions;
- Refuelling of vehicles would either be undertaken in a surfaced compound area from a fuel tank(s) that is bunded or be undertaken off-site to minimise the risk of uncontrolled release of polluting liquids/liquors;
- A double skinned mobile fuel bowser is used to refuel plant and machinery. Spill trays and spill kits will be provided at all times;
- Strict control measures to ensure only suitable material is allowed onto the site, i.e., thorough inspection of waste loads entering the site to confirm inert nature prior to deposition on-site;
- Only granular wastes will be deposited into areas immediately above the groundwater table to prevent the influx of suspended solids into groundwater;
- Maintenance of plant and machinery would be undertaken within a site compound area or offsite, as appropriate, to minimise the risk of uncontrolled release of polluting liquids;
- The specific mitigation measures could be included in an Environmental Management Plan as part of the conditions for the site waste licence.

3.4.24 Surface Water

There are no surface water bodies on-site or within the vicinity of the site.

3.4.25 Groundwater

Only suitably permeable and inert material will be used in the restoration, thereby reducing the potential to create a low permeability zone which could hinder local/ regional groundwater recharge and/or creating an impermeable barrier to groundwater recharge.

Any slurry spreading and/or organic fertiliser spreading on the restored agricultural ground will adhere strictly to the Good Agricultural Regulations S.I. No. 31 of 2014. Appropriate buffer zones will be maintained from all watercourses as stipulated in the Regulations when applying fertiliser and other chemicals to the land.

It is proposed that groundwater monitoring is conducted at the site in order to monitor the groundwater quality.

3.4.26 Settlement Lagoon

The settlement lagoon will be dredged to allow it to operate without overflowing to the natural sump at the northern boundary of the site. Regular dredging will maintain the functional operation of the lagoon.

3.4.27 Stockpiling Area

High absorbency mats, pig tails and drums are to be added/ maintained in the stock-piling areas of the site and in quarry vehicles to clean up any leaks from plant or machinery.

3.4.28 Machinery Maintenance and Repair

No servicing or maintenance of any plant or machinery takes place within the proposed restoration areas. All plant and machinery is driven or tracked to the hardstanding area associated with the site entrance and between the entrance and the wheel wash for service or maintenance works.

High absorbency mats are provided to contain any spills that may occur.

3.4.29 Storage of Fuel/Chemicals

A double skinned mobile fuel bowser is used to refuel plant and machinery on site. This is due to the fact that the bunded fuel storage tank has been subject to burglary.

Hydrocarbon spill kits and drip trays will be maintained on site. The operator has in place an Emergency Response Procedure for hydrocarbon spills and appropriate training of site staff in its implementation. All waste oils are collected and removed off-site by an approved licensed waste collection contractor in the area.

High absorbency mats are provided to contain any spills that may occur.

3.4.30 Restoration Area

All material to be used for the restoration will be thoroughly inspected to ensure only suitably permeable, inert material is deposited. Soil importation will be monitored by a competent site operative to monitor soil composition in order to avoid any impact on the underlying groundwater.

3.4.31 Water Quality Monitoring

It is proposed that groundwater monitoring be carried out biannually. This is recommended to ensure that the restoration of the site is not impacting on the groundwater beneath the site and to establish on-going trends in any groundwater monitoring boreholes.

3.4.23 Do-Nothing Scenario

The site is currently a large void. To do nothing with the existing site, the worked out quarry would remain a significant visual intrusion, and the range of future land-uses for the site would remain severely restricted. On-going vigilance would also be required to ensure no potential contaminating activities occur on or in the vicinity of the quarry floor.

The proposal involves the recovery of significant quantities of inert soil and stone through backfilling in the quarry void.

To do nothing with the existing site, if the application site is not restored completely to former ground level as proposed, and it remains essentially unchanged from its existing layout; it will have the following implications for soil and geology:

- Failure to recover soil and stone for beneficial use of land improvement, specifically reinstatement of a quarry, could result in unnecessary extraction of natural resources and exhaustion of landfill space;
- the reduced soil cover overlying the sand and gravel aquifer will result in a potential risk to groundwater quality;
- there is the potential for continued degradation of existing slopes, leading to possible slope failures;
- the site may be a target for unauthorised disposal / fly-tipping of waste by unscrupulous operators.

Given that a locally important aquifer underlies the site, and the important role soils and subsoil plays in the protection of aquifers, leaving the quarry void unrestored would cause the increased vulnerability of the aquifers caused by the quarry operations to remain.

3.4.24 Interaction with other Impacts

There are no negative cumulative impacts on the hydrogeological environment identified.

It is considered that there are no significant interactions at the proposed site between groundwater and surface water, as the local river, the River Slate, is located 3 km to the north of the site.

The previous quarry development did not involve excavation below the water table and, as such, there is no evidence of a significant physical impact on groundwater.

3.4.25 Conclusions

There are no surface water bodies directly connected to the proposed site area. The proposed development will not discharge directly to any water bodies and will therefore have no significant impact on the water quality or hydrology of the surrounding area.The evidence to date indicates that the groundwater level is deep in this area (> 18 m bgl). It is recommended that groundwater monitoring is commenced for the duration of the restoration works and for a short aftercare period.

Any potential and existing risks to groundwater and surface water from the proposed restoration works in this location will be minimised/ prevented through the adherence to the proposed mitigation measures detailed in *Section* ***Error! Reference source not found.***.

3.4.26 References

European Communities Environmental Objectives (Groundwater) Regulations 2014 (S.I. No.122 of 2014).

European Communities Environmental Objectives (Surface Water) Regulations 2009 (S.I. No. 272 of 2009).

European Communities (Drinking Water) (No. 2) Regulations 2007 (S.I. No. 278 of 2007) Geological Survey of Ireland Online Mapping Service www.gsi.ie

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Geological Survey of Ireland (1994) "*Geology of Kildare-Wicklow, 1:100,000 Series Map*". Sheet 16.

Working Group on Groundwater, March (2005) "WFD Pressures and Impacts Assessment Methodology–Guidance on the Assessment of the Impact of Groundwater Abstractions". Guidance Document No. GW5.

Working Group on Groundwater (2005) "The Calcareous/Non-calcareous ("Siliceous") Classification of Bedrock Aquifers in the Republic of Ireland" Guidance Document No. GW3.