Chapter 9 Hydrogeology

9.1 Introduction

This Chapter presents an assessment of the construction and operational phases of the proposed development in relation to hydrogeology. The proposed development will predominantly be located on the mainland however, some limited works are also proposed for Dursey Island. The development incorporates the provision of a new cable car, a visitor centre, including amenities and retail, new vehicular access arrangements including parking, and the provision of waiting and welfare facilitates on Dursey Island. A new groundwater supply is proposed for potable use together with the provision of two new On-Site Wastewater Treatment Systems with disposal of secondary treated effluent to groundwater.

In addition to the cable car and the visitor centre, the proposed development also includes upgrades to the approach road, the R572, from the junction with the R575 to the cable car. These upgrades will include the widening of the carriageway at 11 locations (10 no. passing bays and 1 no. visibility splay) and further road improvements to include pavement and verge works at a number of other locations. A full description of the proposed development can be found in Chapter 4.

9.2 Methodology

This chapter has been prepared in accordance with the following guidelines:

- Institute of Geologists of Ireland (IGI) (2013). *Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements*;
- Transport Infrastructure Ireland (TII; formerly National Roads Authority (NRA)) (2008) *Environmental Impact Assessment of National Roads Schemes – A Practical Guide*;
- TII (2008). *Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes*;
- TII (2015). *Road Drainage and the Water Environment*;
- Environmental Protection Agency of Ireland (EPA) (1999). *Wastewater Treatment Manuals - Treatment Systems for Small Communities, Business, Leisure Centres and Hotels*;
- EPA (2009). *Code of Practice: Wastewater Treatment Systems for Single Houses*;
- EPA (2011). *Guidance on the Authorisation of Discharges to Groundwater*;
- EPA (2015). *Draft Advice Notes for Preparing Environmental Impact Statements*; and
- EPA (2017). *Draft Guidelines on the Information to be contained in Environmental Impact Assessment Reports*.

9.2.1 Desk Study

A desk study of the study area of the Proposed Development was carried out in order to establish baseline conditions. The desk study involved collecting all relevant geological, hydrological, hydrogeological and meteorological data for the area. This included consultation with the following:

- Geological maps, Geological Survey of Ireland (GSI) (www.gsi.ie);
- Groundwater quality status maps (watermaps.wfdireland.ie);
- Teagasc Subsoils map (gis.epa.ie/Envision);
- Water Features, Rivers and Streams, EPA (gis.epa.ie/Envision);
- National Parks and Wildlife Services Map Viewer (webgis.npws.ie/npwsviewer/);
- Historic Maps from the Ordnance Survey of Ireland (www.geohive.ie);
- Aerial Photography from the Ordnance Survey of Ireland (www.geohive.ie);

9.2.2 Site Investigations

A walkover survey of the site was undertaken by Roughan & O'Donovan in February/March 2019 and subsequently ground investigations were undertaken by Priority Geotech Ltd at the development site in April 2019. These ground investigations included the drilling of 6 No. cable percussion boreholes with rotary core follow on along with the excavation of 4 No. slit trenches and 2 No. Trial pits. In-situ field tests were also carried out during this investigation in order to establish existing hydrogeological conditions. This included falling head permeability tests, constant head pumping tests and soil infiltration tests in accordance with the EPA Code of Practise (2009). Environmental sampling of soil and groundwater was also carried out to establish baseline conditions.

9.3 Description of Receiving Environment

9.3.1 Soils & Subsoils

GSI Mapping

The Teagasc soil mapping identifies mainly shallow soils and exposed rock across the site. Some shallow soil deposits derived from non-calcareous rock or gravels with/without peaty surface horizon are mapped for the area On higher ground both on Dursey Island and further east on the mainland, Quaternary sediments are mapped as Tills derived from Devonian sandstones and any shallow soil/subsoil present across the area likely originate from these sediments.

Intrusive Site Investigations

Site Investigations identified peat and cobbles/bounders from weathered bedrock deposits with depths varying from 0.7m to 2.25m Below Ground Level (BGL) across the site.

In accordance with the EPA Code of Practise (EPA, 2009) a site suitability assessment was carried out. Falling head tests were carried out in the overburden adjacent to the location of the proposed polishing filter for disposal of effluent to groundwater. This enabled the standard "T" and "P" values for the soil to be established and enable an appropriate design to be progressed. Table 9.1 below summarises the results of the site suitability assessment.

Table 9.1 Summary of falling head test results

Parameter	Test Results (min/25mm)
T value	43.33
P value	12.38

The results of the site suitability assessment indicate that the site is suitable for a Secondary Wastewater Treatment System which could either be a:

- Septic tank and filter system constructed on-site and polishing filter; or,
- Packaged wastewater treatment system and polishing filter

Disposal of the treated effluent is, therefore, to groundwater via a polishing filter.

9.3.2 Bedrock Geology

GSI Mapping

According to GSI mapping for the proposed development site, the area is underlain by the Caha Mountain Formation which is described as Purple & green sandstone & siltstone. A fault line is mapped a short distance to the east of the proposed mainline development extending northeast to southwest across the headland running generally parallel to the development site. Further and less extendive faults are mapped on Dursey Island in a similar orientation extending from the direction of the centre of the island towards Dursey Sound. It is likely that historic faulting in the vicinity of the site has either extended existing fracturing and/or has created additional fractures in the rock. Refer to Figure 8.2 of Volume 3 of this EIAR for GSI bedrock geology mapping of the area.

Intrusive Site Investigations

Siltstone was encountered at depths varying from 0m to 2.25m Below Ground Level (BGL) across the site during the intrusive site investigations. A highly weathered zone of up to 2m thickness was generally encountered during the intrusive investigations.

9.3.3 Groundwater Bodies & Bedrock Aquifers

The site is located with the Beara Sneem Groundwater Body (IE_SW_G_019). The bedrock aquifer underlying the site is classified as a Poor Aquifer (PI) – Bedrock which is generally unproductive except for local zones. Refer to Figure 9.1 of Volume 3 of this EIAR for GSI Aquifer and Groundwater Body (GWB) mapping of the area.

9.3.4 Groundwater Vulnerabilities

Groundwater vulnerability mapping for the site indicates that groundwater is extremely vulnerability to pollution at the ground surface as a result of human activities. This is due to either a very shallow or absent moderately permeable overburden above the bedrock. Refer to Figure 9.2 of Volume 3 of this EIAR for GSI vulnerability mapping of the area. The intrusive site investigations generally encountered 0 – 2.25m of overburden at the site which is consistent with the GSI mapping.

The GSI has combined the importance of the groundwater resource (the aquifer) with the vulnerability of the resource to the potential contamination to produce a Groundwater Response Matrix for On-site Treatment Systems (see Plate 9.1). Given the fact that the site is underlain by a Poor Aquifer and is located in an Extreme Vulnerability area, the area is within the Resource Protection Zone Pl/E

The groundwater protection response for the site is therefore R2[1] – "*Acceptable subject to normal good practice. Where domestic water supplies are located nearby, particular attention should be given to the depth of subsoil over bedrock such that the minimum depths required (EPA, 2000) are met and that the likelihood of microbial pollution is minimised*". The proposed development incorporates a sand polishing filter for the discharge of treated effluent. The proposed sand polishing filter is therefore located in an appropriate location and the required 1.2m of unsaturated subsoil beneath the distribution layer will be provided.

VULNERABILITY RATING	SOURCE PROTECTION AREA *		RESOURCE PROTECTION Aquifer Category					
			Regionally Important		Locally Important		Poor Aquifers	
	Inner (SI)	Outer (SO)	Rk	Rf/Rg	Lm/Lg	Ll	Pl	Pu
Extreme (E)	R3[2]	R3[1]	R2[2]	R2[2]	R2[1]	R2[1]	R2[1]	R2[1]
High (H)	R2[4]	R2[3]	R2[1]	R1	R1	R1	R1	R1
Moderate (M)	R2[4]	R2[3]	R1	R1	R1	R1	R1	R1
Low (L)	R2[4]	R1	R1	R1	R1	R1	R1	R1

Plate 9.1 Groundwater Response Matrix for On-site Treatment Systems (GSI, 1999)

9.3.5 Groundwater Recharge

Given that bedrock is either at, or very near, the ground surface high recharge coefficients of up to 0.85 are mapped for the area. However, given the relativity low storativity of the Caha Mountain formation and additionally the extremely steep nature of the surrounding topography, locally a lower rate of infiltration may occur annually.

9.3.6 Groundwater Abstractions

There are no recorded public groundwater supplies or group water schemes within the GSI database in the vicinity of the site. The existing visitor site on the mainland has a groundwater supply via a borehole located north of the existing cable car terminus. Potable water for Dursey Island is also supplied via groundwater with an existing spring located close to the village piped to a small water holding tank before distribution via the existing piped network. A new groundwater supply borehole is proposed for the mainland development.

9.3.7 Groundwater Quality

Under the requirements of the Water Framework Directive (WFD), the Beara Sneem Groundwater Body is classified as having an overall 'Good' status for water quality and quantity 2009-2015.

Routine groundwater sampling is carried out by the water services department of Cork County Council at the groundwater supply well on the mainland. Sampling of the public water supply on Dursey Island which is a groundwater spring is also carried out on a routine basis. The results from the most recent sampling event (15/10/2018) at both locations were obtained and are summarised in Table 9.2 below. It can be seen that groundwater quality both at the mainland and on Dursey Island is generally good with no visible signs of degradation present; however, it must be noted that not all applicable parameters of interest were analysed.

Table 9.2 Groundwater Water Monitoring Results (Cork Co. Co. – 15/10/2018)

Parameter	Sample Location		Limit Values	
	Mainland Station	Dursey Island Spring	Groundwater Regulations 2010 (S.I. 9 of 2010)	Drinking Water Directive (98/83/EC)
pH	7.4	6.8	N/a	6.5 < pH <9
Electrical Conductivity (µS/cm)	917	441	N/a	2500
Coliforms MPN/100ml	<1	<1	N/a	0
E.Coli MPN/100ml	<1	<1	N/a	0

In addition, groundwater sampling was also carried at the site by Priority Geotech Ltd. during the site investigation in April 2019. Samples were taken from the existing well on the mainland and also from the trial wells drilled during site investigations (TW01 & TW02) adjacent to the locations of the proposed polishing filters (mainland & Dursey Island sites) on the 16th of April 2019. The samples were analysed for chemical and bacteriological parameters in line with Drinking Water Regulations (SI 278 of 2007) and tested in an INAB accredited laboratory. The results of the groundwater sampling are compared against the Drinking Water Standards (S.I. No 278 of 2007) and the Groundwater Regulation Threshold Levels (as per S.I. No 9 of 2010). The key results applicable to this hydrogeological assessment are detailed below in Table 9.3.

Table 9.3 Groundwater Water Monitoring Results (16/04/19)

Parameter	Sample Location			Limit Values	
	Mainland Well	TW01	TW02	Groundwater Regulations 2010 (S.I. 9 of 2010)	Drinking Water Directive (98/83/EC)
Water Depth (mBGL)	4.55	0.53	0.08	-	-
pH	8.3	7.5	7.7	N/a	6.5 < pH <9
Electrical Conductivity (µS/cm)	980	690	540	N/a	2500
Total Ammoniacal Nitrogen as N (mg/l)	0.28	0.074	0.11	N/a	N/a
Nitrate as N (mg/l)	<0.50	<0.50	0.010	37.5	50
Nitrite as N (mg/l)	0.011	0.011	<0.5	N/a	N/a
Orthophosphate as P	<0.020	<0.020	<0.020	N/a	N/a
E.Coli MPN/100ml	<1	<1	<1	N/a	0

The groundwater quality results taken show clean unpolluted groundwater with low levels of ammonia, nitrate, phosphorus and bacteriological parameters. In this regard the underlying aquifer is shown to have adequate assimilative capacity to receive treated effluent from a polishing filter.

9.3.8 Groundwater Flow

The underlying rock has very limited primary porosity and, therefore, groundwater flow will occur through fractures, fissures and joints within the bedrock. These fractures and fissures would have developed during periods of deformation during historical geological events. Typically, an upper weathered zone of bedrock will exist which can be up to 2.25m in thickness. These weathered zones generally exhibit higher permeability rates when compared to deeper into the rock formation. Fracture and fault zones associated with deformation events will extend from the top of the rock and diminish with depth. The degree of interconnectivity between these zones will determine the flow paths and distances and also provides storage within the aquifer. Water was encountered at depths of 3.4 - 9m below ground level during drilling at the site with moderate water yields illustrating a non-homogenous distribution of fracturing within the rock with moderate to low interconnectivity.

A falling head infiltration test was carried out at borehole RC01 (mainland site) that resulted in a bedrock permeability (K) of $3.93x10^{-3}$ ms^{-1} being determined. This suggests a moderate to high bedrock permeability indicating relatively high acceptance of infiltrating water. Whist a falling head test was not carried out on the island, the bedrock encountered was similar and an examination of the cores indicated a similar degree of fracturing. Conservatively a bedrock permeability of $1x10^{-3}$ ms^{-3} is assumed for the island site.

The nature of the aquifer, with flow restricted to interconnected fissures, fractures and voids, restricts the flow of groundwater. Flow paths will, therefore, typically extend less than 300 metres. However, given the proximity to the sea a good level of connectivity discharged to the coast is expected. The steep nature of the mainland site towards the sea and Dursey Island itself, indicates that groundwater is moving in a south-westerly direction, reflecting both the regional topographical gradient and local surface water catchment with a calculated gradient of 0.1 m/m.

Using the aquifer flow and permeability characteristics described above, groundwater flow through the aquifer underlying the proposed sand polishing filter (see Section 9.4) can be estimated using Darcy's equation as summarised below:

Q_{gw}	= KiA	4.9×10^3 m^3/day
Where:	K is the aquifer permeability:	339 m/d
	i is the hydraulic gradient:	0.1 m/m
	A is the aquifer cross sectional area m^2:	145 m^2
	(Sand filter width: 14.5m width; assumed 10m deep saturated zone)	

The width of the proposed sand polishing filter will be 14.5m x 14.5m in breath. The maximum potential groundwater flow beneath the sand polishing filter is estimated at over 4.9×10^3 m^3/day. This assumed saturated conditions which likely do not exist. In a similar manner and for a cross-sectional area of $80m^2$ beneath the island site, a maximum potential groundwater flow beneath the sand polishing filter is estimated at over 1×10^3 m^3/day.

9.3.9 Site Hydrology

The mainland site is bounded to the east by the Ballaghboy Stream. This stream does not form part of the EPA river network and discharges directly to the sea. The EPA, in meeting their obligations under the WFD, have categorised this stream as 'Not at Risk' from a quality perspective. There are a number of smaller mapped (and unnamed) local streams on Dursey Island which are generally short and discharge to the sea at a number of locations along the island's perimeter. None of these mapped local streams is located east of Knockaree Hill which is the side of the island on which the proposed cable car is to be located.

9.3.10 Groundwater Dependant Terrestrial Ecosystems (GWDTEs) and Special Areas of Conservation (SACs)

Sites designated under the Natura 2000 and within 2km are listed in Table 9.3.4 below:

Table 9.4 Designated Sites

Natura 2000 Sites	Distance from Site
Kenmare River SAC (002158)	Immediately adjacent to site
Beara Peninsula SPA SPA (004155)	Within site extents
Nationally Designated Sites	**Distance from Site**
Dursey Island NHA (000086)	Within site extents

None of the above sites are designed relating to groundwater attributes nor are any groundwater dependant (GWDTE). Water quality within the Kenmare River SAC (essentially the Atlantic Ocean in the vicinity of the subject site) could be impacted by any significant deterioration in groundwater quality beneath the island or mainline sites given that groundwater is likely discharged to the coast via submarine springs/seepages.

The Atlantic Ocean within the Dursey Sound (Kenmare River SAC) forms part of the South Western Atlantic Seaboard (HAs 21;22) Coastal Waterbody. This has been categorised as 'Not at Risk' by the EPA under the WFD RBMP 2009 – 2015.

9.3.11 Ground Contamination

As part of the intrusive ground investigations undertaken at the site, samples of the made ground (sample depth 0.25m below ground level) at the existing mainland development at the historic location of a diesel generator were taken within trial pit TP02 and were tested at a *Chemtest* accredited Laboratory facility in the UK.

No evidence of surface contamination was found surrounding the generator site.

9.4 Description of Potential Impacts

9.4.1 Construction Phase

During the construction phase the following activities may pose a potential impact:

- Excavation of made ground and bedrock;
- Contamination of soils; and
- Aquifer Contamination

9.4.1.1. Excavation of Made Ground

Excavation of made ground will take place during construction. The excavation of any localised areas of ground contamination will constitute a permanent, positive impact on the soil environment due to the requirement to remove the material off-site and dispose or treat it in accordance with relevant legislation. During the construction phase, any excavated contaminated material which is stored on-site awaiting removal for disposal will present a risk due to contaminated surface runoff. This would represent a moderate to significant impact due to the downstream receptor being a European Site. Any improvement to the quality of soils will have a corresponding benefit to the underlying groundwater resources due to the removal of a potential source of contamination for percolating water. Therefore, the magnitude of this impact is **Slight Permanent Positive** due to a minor improvement to the attributes quality.

9.4.1.2. Contamination of Soils

There is a potential risk of localised contamination from construction materials leeching into the underlying soils by exposure, dewatering or construction related spillages resulting in a Permanent Negative impact on the soils. In the case of soils, the magnitude of this impact is Small Adverse as the requirement of good construction practices will necessitate the immediate excavation/remediation of any such spillage resulting in a very low risk of pollution to the soils and consequently the underlying aquifers. The significance of this impact is **Slight Temporary**.

9.4.1.3. Aquifer Contamination

There is a potential risk of localised contamination of the surface water and groundwater bodies due to construction activities i.e. construction spillages, leaks from construction plant and material etc. resulting in a Permanent Negative impact on these water bodies. The main surface water body that would be affected is the Atlantic Ocean (Kenmare River SAC) which is immediately adjacent to the development site.

The excavation of material at the site will have the effect of locally increasing the vulnerability rating of the underlying aquifer (although the vulnerability rating is already X- Extreme); however, the majority of the areas where the material will be excavated will be covered in hardstanding, which will mitigate the potential for contaminants to enter the underlying aquifer from the surface. As such the potential impact may be deemed **Slight Temporary**.

9.4.2 Operational Phase

9.4.2.1 Road Runoff

The proposed development incorporates new entrance roadways together with parking facilitates. It is proposed to allow runoff from the entrance roads to drain to permeable parking bays where it will percolate through porous media and subsequently be collected via a subsurface collector drain. This drain will discharge to the adjacent Ballaghboy Stream via a petrol interceptor. The potential for contaminated road runoff to percolate and enter the underlying aquifer presents a very low risk due to the presence of the collector drain and the pre-treatment which will occur within the permeable porous media. The potential impact is therefore assessed as ***Permanent Slight***.

9.4.2.2 Foul Drainage

Domestic wastewater from the existing Dursey Island mainland development is currently treated on-site by means of a septic tank with the final treated effluent discharged directly to the sea via a short-piped outfall.

It is proposed that domestic wastewater at the proposed development be treated on-site by means of a proprietary Wastewater Treatment Plant (WWTP) with the final treated effluent discharged to groundwater through a sand polishing filter. The removal of primary treated effluent entering the Kenmare River SAC will therefore result in a ***Permanent Positive Impact*** in water quality.

The criteria for estimating the maximum additional wastewater hydraulic and BOD load based on the potential capacity of the proposed development was carried out having regard to expected growth and maximum allowable visitor numbers, approx. 25,000 monthly visitors in the peak summer season. The design criteria were in accordance with "EPA Wastewater Treatment Manual – Treatment Systems for Small Communities, Business, Leisure Centres and Hotels" using the design loading factors shown in Table 9.5, below.

The maximum monthly visitors to Dursey Island are to be limited to 12,835 (as detailed in Chapter 7 - Section 7.81). It was assumed that 50% of all visitors would use the proposed island toilet facilities which is considered reasonable given that the main development focus, including food and drink offerings, are to be located at the mainland site.

Table 9.5 Extract from Table 3 of the EPA Code of Practice (CoP) for Small Communities, Business, Leisure Centres and Hotels.

Situation	Source	Flow litres/day per person	BOD_5 grams/day per person
Amenity Sites	Restaurants (per visitor)	15	15
Pub/Restaurant	Day Staff (assume 10 full time)	60	30
Amenity Sites	Toilet Blocks (per use)	5	10

Table 9.6 Breakdown of estimated foul loading at the development site

Description	No.	Hydraulic Loading (litres/day)	Organic Loading (gBOD/day)
Mainland Development Site			
Staff – 10 full time	10	600	300
Visitors – (peak allowable)	807	12,105	12,105
Total Loading Rate		**12,705**	**12,405**
Dursey Island Development Site			
Toilet use (50% of peak allowable island visitors)	207	1,035	2,070
Total Loading Rate		**1,035**	**2,070**

Design Proposal – Mainland Development Site

Given the hydraulic loading rates established above, it proposed to install a WWTP on the mainland site with a Population Equivalent of 207PE which can cater for a maximum hydraulic load of 12.705m^3/day and a maximum organic load of 12.405kg BOD per day.

A design proposal for the proposed WWTP has been prepared by Wastewater Solutions and it is proposed to install this (or a similar approved system) as part of the development. The proposed system is a Denitrifying Wastewater Treatment Plant (DSAF) which incorporates anaerobic and biozone treatment with phosphate and alkalinity dosing systems. A maintenance agreement will be put in place between Cork County Council and Wastewater Solutions (or other approved installer) and this maintenance agreement will be subject to the relevant ongoing compliance checks by the Water Services Department of Cork County Council and the EPA.

The treated effluent will be discharged to a sand distribution area to be located in the northern portion of the site. It is proposed that this sand distribution area will have a plan area of 212m^2. The proposed plan area of the sand distribution area will provide adequate assimilative capacity in the underlying groundwater – see risk assessment below for details. It is proposed to construct the sand polishing filter at a depth of 300mm below the existing ground level at this area (P-value = 12.38). It is proposed to discharge the treated effluent to groundwater via the sand distribution area and underlying subsoil at a hydraulic loading rate of 29l/m^2/day over an area of 440m^2. The sand polishing filter will consist of 900mm of suitably graded sand. The upper layer will consist of coarse sand with effective sizes (D10) 0.25–0.75 (mm) and D60/D10 (Cu) < 4. The intermediate and lower layers of fine sand will comprise effective grain sizes (D10) 0.15 – 0.25mm; D60/D10 (CU) < 4) separated by pea gravel (10-20mm). The sand layers will be overlain by 100mm of washed gravel (distribution layer) and covered by 300 mm of topsoil which will be grassed. The final effluent at the base of the polishing filter will be discharged to a 300mm deep gravel distribution layer (pea gravel, 10-20mm). The existing material beneath the base of the gravel distribution layer has been shown to have a suitable permeability to receive the effluent during the site suitability assessment (P value = 12.38). This will provide a minimum of 1.2m of unsaturated suitable subsoil beneath the base of the gravel distribution area. The proposed sand polishing filter will be in designed and installed in accordance with the EPA CoP (2009) taking into account subsequent clarifications. Design details on how the system will be adequately pressurised together with plans/cross-sections have been provided by Wastewater Solutions and were reviewed during this assessment.

Design Proposal – Dursey Island Development Site

The Dursey Island development incorporates the required landing facilities for the new Cable Car with toilet facilities also provided for passengers use. It is anticipated that the majority of visitors will utilise the mainland toilet facilities before using the cable car given that all food and drink offerings are located at the mainland development site. For the purposes of this assessment, conservatively it was assumed that 50% of peak allowable island visitor numbers would utilise toilet facilities on Dursey Island.

Given the hydraulic loading rates established above, it is proposed to install a WWTP on the island site with a Population Equivalent of 35PE which can cater for a maximum hydraulic load of 1.035m^3/day and a maximum organic load of 2.07kg BOD per day. The proposed system will be a similar scaled down version of the proposals for the mainland site and will incorporate secondary treatment.

Given the limited subsoil present on Dursey Island at the location of the proposed landing site, the proposed sand polishing filter will be raised and bunded above existing ground level and formed from imported suitable material. The lack of subsoil negated the need to establish a permeability value through a conventional 'P-test' and, therefore, discharge of treated effluent will be to the weathered bedrock/water table via the sand polishing filter. The proposed sand distribution area is located in the northern portion of the site. It is proposed that this sand distribution area will have a plan area of 64m^2 (8m x 8m). The proposed plan area of the sand distribution area will provide adequate assimilative capacity in the underlying groundwater – see risk assessment below for details. The proposed construction details of the sand polishing filter (0.9m depth) will be as outlined in the preceding section for the mainland development site.

The final effluent at the base of the polishing filter will be discharged to a 300mm deep gravel distribution layer (pea gravel, 10-20mm). The existing material beneath the base of the gravel distribution layer will be excavated down to the weathered bedrock to allow sufficient infiltration capacity – this is likely close to the existing ground surface. The gravel distribution layer combined with the sand polishing filter will provide a minimum of 1.2m of unsaturated suitable subsoil beneath the base of the gravel distribution area. The proposed sand polishing filter will be designed and installed in accordance with the EPA CoP (2009) taking into account subsequent clarifications. It is proposed that discharge to the polishing filter will be achieved by gravity.

Assessment Methodology

As stated previously, the proposed WWTPs have been sized to accommodate potential future increases in foul loading associated with future growth in visitor numbers; the proposed sizing of both the WWTP and sand polishing filter were based on expected growth and maximum allowable visitor numbers. This EIAR assessment follows the required methodology for a Tier 2 Groundwater Risk Assessment as required by the EPA (EPA, 2011).

Groundwater Risk Assessment

The basis for this risk assessment is the Source-Pathway-Receptor (SPR) Model. Treated effluent from the proposed facilities will be discharged to ground via a sand polishing filter. Once it reaches the subsurface, the effluent infiltrates through the underlying unsaturated subsoil into the groundwater, within the bedrock. Once it reaches groundwater, dissolved contaminants can potentially migrate in the direction of groundwater flow towards potential receptors. This assessment identifies the potential risk of the proposed discharge from impacting on the identified receptors. The fate and transport of pollutants along the pathways determines the relative risk of impacts at the receptor (EPA, 2011).

Source - Pathway – Receptor

Source

The source of contamination from the proposed development is the discharge of treated effluent into the underlying bedrock/groundwater via a new sand polishing filter. The proposed new sand polishing filters are designed in accordance with the EPA Code of practice (EPA, 2009) with a maximum hydraulic loading of 60l per m^2 extending over an area of 212 m^2 (14.5 x 14.5m) on the mainland and 64 m^2 (8 x 8 m) on the island. The anticipated quality of the effluent from the sand polishing filters is set out in Table 9.7, below.

Given the nature of the discharge, the parameters of concern from a water quality perspective are nutrients (nitrogen and phosphorus) and faecal bacteria. It is expected that natural attenuation will occur within the unsaturated subsoil. The majority of phosphorus, bacteria and nitrogen will be broken down and attenuated within the first meter of unsaturated subsoil (EPA, 2011). The sand filter provides 0.9m of unsaturated granular material in partially aerobic conditions and thus facilitates a high level of treatment. The concentrations of the parameters of concern beneath the sand polishing filter will be significantly reduced compared to those in the treated effluent – the anticipated concentrations beneath the sand filter have been calculated below. Further breakdown will also occur in the subsoil beneath the sand filter through both attenuation and natural biodegradation. The final effluent which will reach the water table/weathered bedrock will be of high quality with significantly reduced levels of potentially harmful parameters. A site suitability assessment was carried out by Priority

Geotech Ltd. and the area was found to be suitable for such a discharge – see Section 9.3.1 above.

Table 9.7 Wastewater Treatment Emission Values

Parameter	Concentration in Effluent from WWTP (mg/l)
B.O.D.	20
T.S.S.	30
Total Ammoniacal Nitrogen as N (NH_3-N)	20
Nitrate as N (NO_3-N)	5
Ortho-Phosphate as P (P)	2

Pathway

The pathway of the treated effluent beneath the sand polishing filter is through the underlying subsoil. The underlying subsoil consists of peat and weathered rock of moderate permeability. Attenuation and biodegradation of potential contaminants occurs as the treated effluent flows through the subsoils both vertically and horizontally. The effluent is assumed to travel vertically through the unsaturated zone unless it meets a more impermeable layer where it may travel horizontally for a period.

Once the potential contaminates reach groundwater/weathered bedrock within the upper horizons of the bedrock formation they will become more mobile. Groundwater movement is through fissures, factures and faults within the bedrock and the extent and interconnection of these determines the permeability of the rock. Permeability characteristics of the bedrock beneath the site are demonstrated to be good with a permeability rate of 3.93×10^{-3} m/s found within the upper horizons. This is expected to reduce with depth. The bedrock aquifer is classified as poor aquifer (Pl) and as such the groundwater flow paths are expected to be in the order of a couple of hundred of metres (to the coast). The potential contaminates will travel horizontally in the direction of groundwater flow with further attenuation occurring through the process of dilution (mixing of pollutants with groundwater).

Receptor

There are two possible receptors for mobilised contamination within infiltrating water:

- The Atlantic Ocean (Kenmare River SAC) located along the south-western site boundary. This is a European Site, which is of Extremely High Attribute Importance.
- The bedrock aquifer beneath the site (Siltstone bedrock overlain by shallow (~2m) weathered zone). This is a poorly productive aquifer which is of Low Attribute Importance.

There is one proposed groundwater supply to the site, located on the mainland. The proposed supply borehole for the mainland development is located cross-gradient (and marginally up-gradient) to the sand polishing filter. It must be noted that the associated zone of contributions for the groundwater supply source does not extend across the proposed location of the polishing filter and, therefore, the on-site groundwater supply is not considered as a receptor.

Conceptual Site Model (CSM)

Groundwater flow primarily occurs in the upper weathered zone of the bedrock and in faults/fractures at greater depths. Groundwater gradients follow the steep topography of the area towards the Atlantic Ocean (Kenmare River SAC) with both the mainland and island sites only a few hundred meters from the likely discharge zone. Existing groundwater quality beneath the site is high due to the lack of intensive development or agriculture in the surrounding region and the high recharge rates. The Conceptual Site Model is shown in Plate 9.2 below.

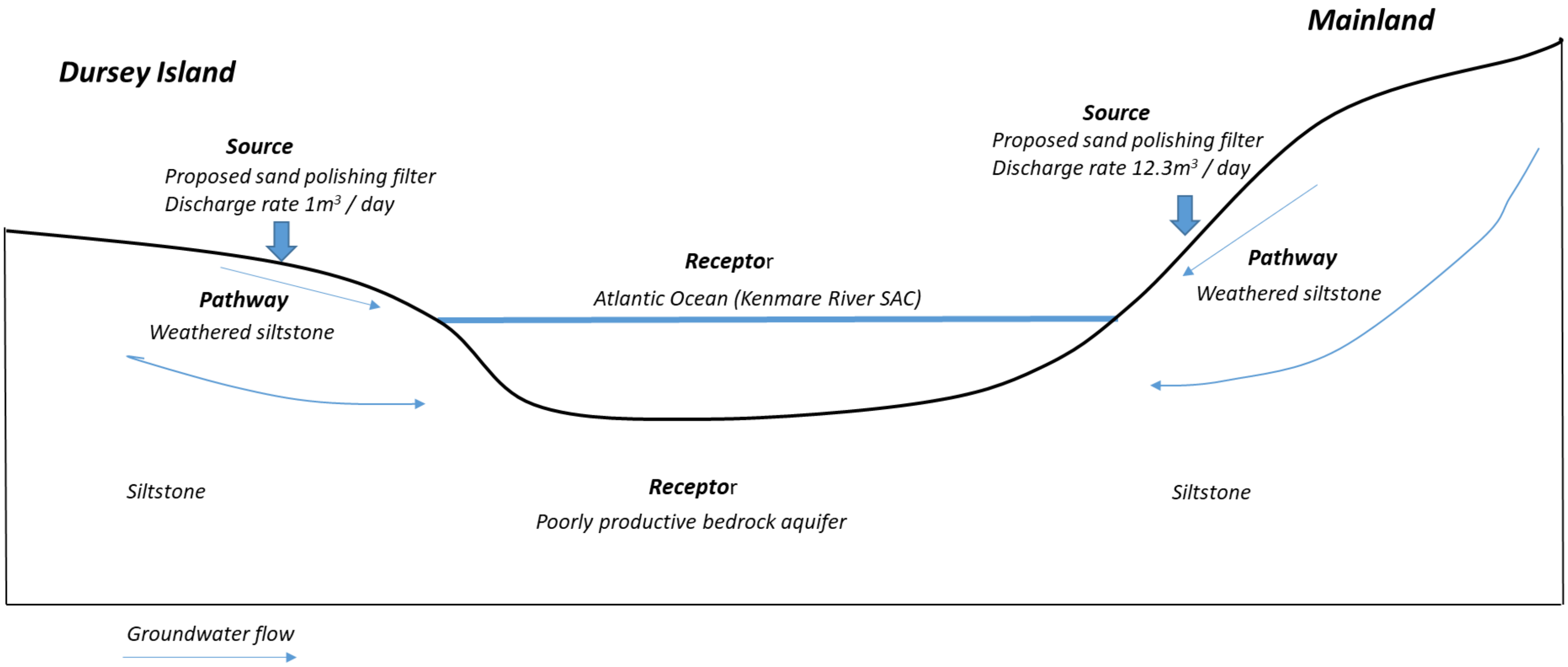
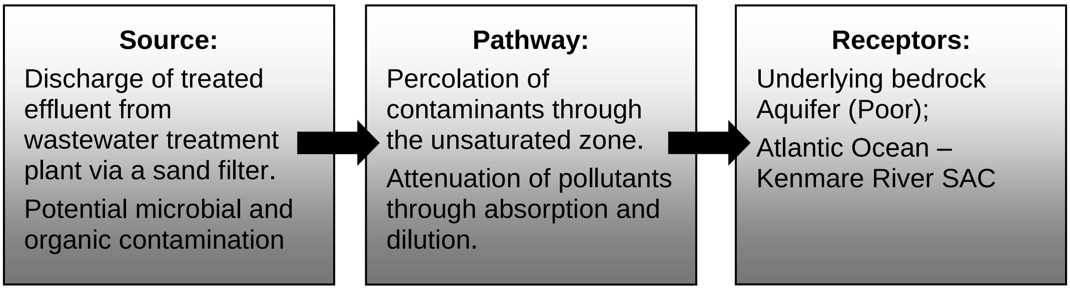


Plate 9.2 **Conceptual Site Model (CSM) for the proposed development**

The risk assessment included as part of this study identifies the potential sources of pollution, the pathways and the potential receptors and utilised the principals of the S-P-R model as illustrated below:

RISK ASSESSMENT



Mainland Development Site

The maximum potential flow of groundwater beneath the sand distribution area on the mainland site is estimated at 4.9 x 10^3 m^3/day – see Section 9.3.8 for details. The proposed development will involve a discharge rate of 12.3 m^3/day of high quality treated effluent. There is, therefore, adequate capacity for attenuation through the process of dilution.

Dursey Island Development Site

The flow of groundwater beneath the sand distribution area on the Dursey Island site is estimated to be > 1 x 10^3 m^3/day – see Section 9.3.8 for details. The proposed development will involve a discharge rate of 1 m^3/day of high quality treated effluent. There is again, therefore, capacity for attenuation through the process of dilution.

Both sites are situated immediately upgradient of the Atlantic Ocean and as such it is unlikely that groundwater will be abstracted immediately down-gradient of either site. Given the large capacity for dilution in the ocean and the high level of treatment which will have occurred prior to submarine discharge, the risk to water quality in the ocean (Kenmare River SAC) is considered ***Extremely Low***.

In order to determine the impacts of the proposed discharges an assimilative capacity calculation was carried out taking into account the maximum discharge from each of the proposed developments. Assimilative capacity calculations are used to determine potential increases that may occur in the background concentration of a specific contaminant. A summary of assimilative calculations carried out as part of this assessment are given in Table 9.8, below.

The individual parameter levels are assessed in accordance with their normal background concentrations found in the groundwater against proposed discharge concentrations from the treatment facility. This is based on the following equation:

$$C_{gw} = [(C_{in} \times Q_{in}) + (C_{gwu} \times Q_{gw})]/(Q_{in} + Q_{gw})$$

Where:

C_{gw} Resulting concentration in groundwater mg/l

C_{in} Concentration in infiltrating water mg/l

Q_{in} Volumetric rate of infiltrating water m^3/day

C_{gwu} Concentration in the aquifer mg/l

Q_{gw} Groundwater flow rate through the aquifer m^3/day

Using this equation, the groundwater concentrations resulting from the discharge to groundwater activity were calculated and the results at each of the proposed sites are shown in Table 9.8 below.

Table 9.8 Calculated Groundwater Concentrations Beneath each of the proposed sand filters

Parameter	Calculated C_{gw} (mg/l)
Mainland Site	
BOD	0.050
NH_3-N	0.050
MRP-P	0.025
NO_3-N	0.023
NO_2-N	0.003
Dursey Island Site	
BOD	0.020
NH_3-N	0.020
MRP-P	0.022
NO_3-N	0.016
NO_2-N	0.001

The calculations above indicate what the resulting concentration in groundwater beneath the sand distribution filter will be. It can be seen that all of the resultant concentrations are below the required limits for drinking water quality. It is noted that further dilution will occur as the contaminates travel through the groundwater, prior to reaching any identified potential receptors.

Groundwater Response Matrix

As outlined previously, the groundwater responses matrix for on-site Wastewater Systems for Single Houses indicates a Response of R2[1] (underlying Bedrock Aquifer) for the site indicating that it is suitable for discharge to ground.

The recommended minimum distance from a receptor (i.e. supply well) and a Polishing Filter is 60 m for a public water supply. The sand polishing filter will be located approximately 200m cross gradient from proposed groundwater abstraction location on site and is not located within the Zone of Contribution.

Overall, this assessment is considered to be a **Neutral Risk Scenario**. The effluent has low levels of non-hazardous pollutants and is treated to a high level through primary and/or secondary and tertiary treatment. The proposed discharge is located a sufficient distance from identified receptors, and sufficient dilution is available to attenuate potential contaminates.

Cumulative Impacts

Cumulative impacts result from the interaction of a number of activities in the study area which may impact on the quality of the underlying groundwater. Within the study area, there are no other polluting activities other than limited low intensity agriculture. The groundwater quality monitoring undertaken at the site indicated no evidence of groundwater pollution with very high-quality groundwater found. It is, therefore, considered that groundwater in the area has not been impacted upon by existing pressures.

It should be noted that the mainland site is already discharging primary treated effluent directly to the ocean. There is, therefore, likely to be a positive cumulative impact on the quality of surface water in the bay in the site vicinity as a result of this proposed development with the removal of same.

Impact Assessment

A groundwater Discharge Licence for the above developments will be sought and obtained from the Local Authority once planning consent has been achieved – this is in accordance with EPA guidance. The proposed design for the treatment of foul discharge at the proposed development is deemed to be appropriate given the hydrogeological setting. Given that, small increases in groundwater parameters are calculated immediately downstream of each of the sand polishing filters (which in reality will be virtually imperceptible) the overall foul discharges from the proposed development are assessed as a ***Slight Permanent Impact***.

9.4.2.3 Groundwater Supplies

The proposed development will not impact existing groundwater supplies and therefore there will be an imperceptible impact. A risk assessment has been carried out for the proposed groundwater supply, which is located up-gradient of the proposed sand polishing filter. There is a negligible risk to it from the proposed discharge.

9.4.2.4 Surface Water Drainage

The surface water drainage system will comprise of sustainable drainage systems (SuDS). The proposed drainage system will comprise of SuDS components that will provide treatment to runoff and allow for limited infiltration to groundwater, as deemed acceptable by the groundwater risk assessment undertaken.

9.4.2.5 Contaminated Land

Preliminary Intrusive Ground Investigations undertaken at the site have identified no contaminated material present across the site. There is an imperceptible impact relating to contaminated land.

9.4.2.6 Aquifer Recharge

As a result of the proposed development, there will be an increase in the total impermeable area of the site and correspondingly a potential reduction in aquifer recharge. Permeable paving in lightly trafficked areas such as cul-de-sacs and parking areas will be provided along with infiltration SuDS components that will allow for a proportion of surface water to infiltrate to ground thus minimising the potential reduction in aquifer recharge. The potential impact to aquifer recharge is seen as imperceptible given the small reduction in overall catchment recharge.

9.5 Mitigation and Monitoring Measures

9.5.1 Construction Phase

A project-specific Environmental Operating Plan (EOP) will be prepared for the development. It will be maintained by the Contractor for the duration of the construction phase. The EOP will cover all potentially polluting activities and include an emergency response procedure. All personnel working on the site will be trained in the implementation of the procedures. As a minimum, the EOP for the proposed development will be formulated in consideration of the standard best practice. The EOP will include a range of site-specific measures which include:

- *Earthworks shall be carried out such that surfaces promote runoff and prevent ponding and flooding.*
- *Runoff will be controlled and treated to minimise impacts to surface and groundwater.*
- *All hazardous materials will be stored within secondary containment designed to retain at least 110% of the storage contents. Temporary bunds for oil/diesel storage tanks will be used on the site during the construction phase.*
- *Safe materials handling of all potentially hazardous materials will be emphasised to all construction personnel employed during construction.*
- *Mitigation measures during the construction phase will include implementing best practice during excavation works to avoid sediment entering the Atlantic Ocean (Kenmare River SAC).*

9.5.2 Operational Phase

All conditions of the Groundwater Discharge Licence (once granted) shall be adhered to in full including any and all compliance monitoring specified.

A maintenance agreement shall be entered into between the operator of the site and a suitably qualified wastewater provider for both On-Site Wastewater Treatment Systems. This maintenance agreement shall include for regular checks, up-keep and maintenance and on-going desludging.

All other potential impacts have been identified as slight in the operational phase and as such no long-term mitigation measures are proposed.

9.6 Residual Impacts

The incorporation of the mitigation measures outlined in Section 9.5 results in the magnitude of any impacts either during construction or operation to be considered as Negligible. As a result, the significance of all residual impacts is Imperceptible.

9.7 Difficulties Encountered

No difficulties were encountered in undertaking this hydrogeological assessment.

9.8 References

Geological maps, Geological Survey of Ireland (GSI) (www.gsi.ie);

Groundwater quality status maps (watermaps.wfdireland.ie);

Teagasc Subsoils map (gis.epa.ie/Envision);

Water Features, Rivers and Streams, EPA (gis.epa.ie/Envision);

National Parks and Wildlife Services Map Viewer (webgis.npws.ie/npwsviewer/);

Historic Maps from the Ordnance Survey of Ireland (www.geohive.ie);

Aerial Photography from the Ordnance Survey of Ireland (www.geohive.ie);

Priority Geotech Ltd. Ground Investigation Draft Factual Report – June 2019.