Hydrogeological-Hydrological Risk Assessment Report

Carbury

August 2023

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

Hydrogeological/Hydrological Risk Assessment Report

Client: Kildare County Council

Location: Proposed Social Housing, Carbury Village, Co. Kildare

Date: 28th August 2023

Document Control

PROJECT NUMBER: IE2775		DOCUMENT REF: IE2775_Report 5826			
2.0	Issue	Jk	PMS	PMS	28-8-23
1.0	Draft	jk	PMS	PMS	17/7/2023
Revision	Purpose Description	Originated	Checked	Reviewed	Date

Contents

1. BACKGROUND

1.1. Introduction

IE Consulting was engaged by Kildare County Council to prepare a hydrological and hydrogeological risk assessment report concerning a proposed development of social housing at Carbury, Co. Kildare.

The report was requested by the Environment Section of Kildare County Council, because of the existing density of on-site wastewater treatment systems in the area, and the potential risk to groundwater resources and associated receptors

The report is based on (i) a desk review of available databases to establish a baseline hydrological and hydrogeological setting for the area (ii) Assessment of the site specific development and specific investigation reports undertaken to support the design (iii) the findings from a site visit made on 19th June 2023 which included sampling of a groundwater spring to establish the ambient groundwater quality in the area (iv) Interpretation of the findings to assess the potential impact on groundwater receptors from the use of an on-site wastewater treatment system discharging to ground to service the proposed development, in the context of a wider assessment of the impact from the proliferation of existing on-site wastewater treatment systems in the area.

1.2. Overview of proposed development

The project involves the construction of 5 No. new housing units on a site containing a disused health Dispensary. The overall site of 0.578 ha is located on the southeast of Carbury within a residential neighbourhood and is within the ownership of the Local Authority. It is proposed that the northern portion of the site (measuring approximately 0.364 ha) be developed for social housing as the remaining portion is encumbered with the existing Dispensary building. As there is no public sewer in the area, an on-site wastewater treatment system will be required.

1.3. Objectives

The key objectives of this report are

- Establish the hydrogeological and hydrological setting of the site.
- Identify the key groundwater and associated groundwater dependent receptors.
- Identify existing pressures on groundwater and surface water resources in the area.
- Develop a conceptual model to assess potential impacts on groundwater and surface water associated with key elements of the proposed development.

- Consider the existing quality of groundwater.
- Assess the cumulative impact of all adjacent wastewater systems both existing and proposed on the identified receptors.

2. HYDROGEOLOGICAL AND HYDROLOGICAL SETTING

2.1. Location

The site is located in the village of Carbury, adjacent to the R402 which links the M4 motorway to Edenderry in Co. Offaly.

The proposed development site is 0.364Ha in area, within a slightly larger land-holding of 0.578Ha.

The general topography of the area is dominated by Carbury Hill with a summit height of 142m O.D.

The ground slopes from the hill elevation 142m O.D towards the site flattening out to an elevation of 95m to 90m O.D with a slight slope towards the River Boyne.

The Boyne River runs N to S through Carbury approximately 300m east of the site, taking a dog-leg change in direction to the southwest just south of the site as shown in Fig 1.

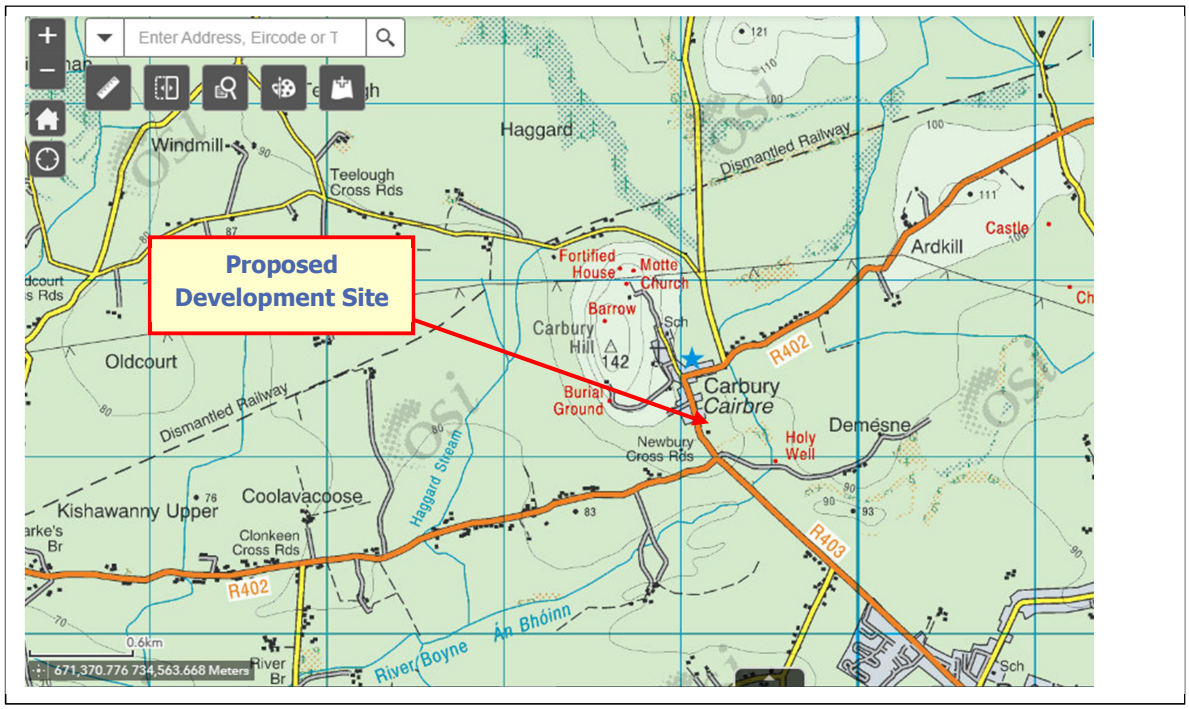


Figure 1 – Site Location

2.2. Rainfall and Climate

Reference to the EPA hydrometric maps indicates a SAAR value of 838mm/yr with an evapotranspiration value of 514mm/yr for the Boyne catchment at Carbury. This suggests an effective rainfall of approximately 324mm/yr.

2.3. Geology

Reference to the GSI maps indicates that the site is underlain by dark Limestone and Shale bedrock of the Lucan Formation, with relatively flat bedding dipping at 40° to the northwest. There is a fault running N-S approximately 1.5km from the site, which separates the Lucan Formation from the unbedded Waulsortian Formation. Rock does outcrop on the slopes of Carbury Hill and also along the course of the River Boyne.

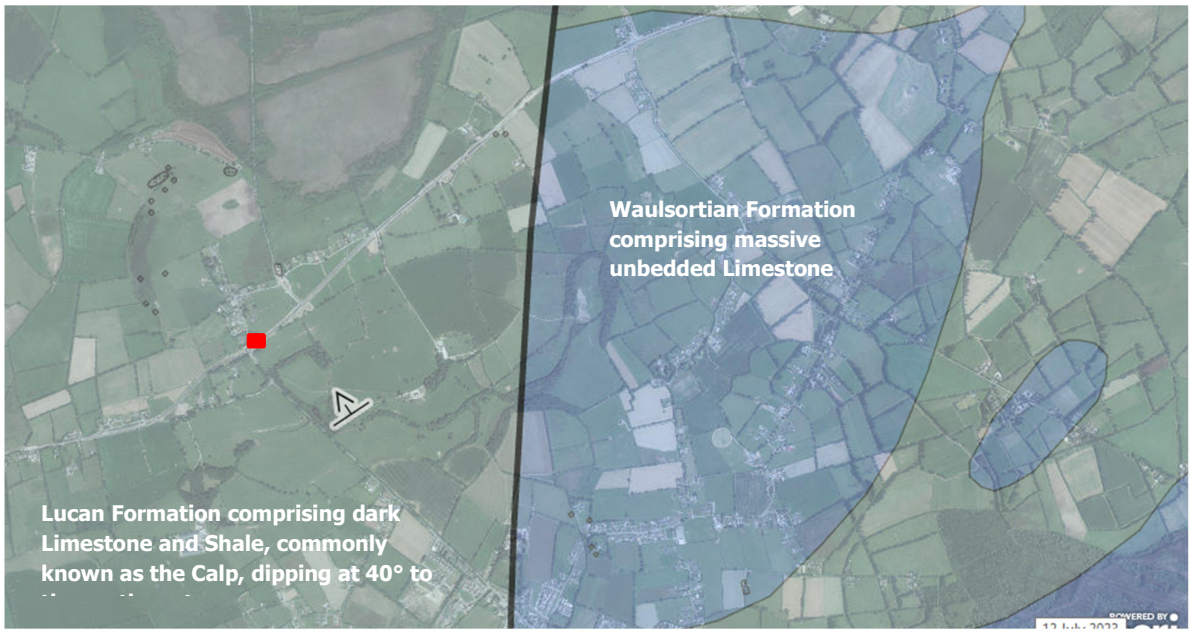


Figure 2 – Geology

2.4. Subsoils

The subsoils are generally thin on Carbury Hill, but are thicker away from the hill, comprising mainly Till derived from Limestone, but also areas of Limestone derived Gravel, areas of Peat, and some alluvium along watercourses. Rock becomes close to the surface again along the course of the River Boyne. The map below shows the general distribution of subsoils in the area.

The map below, shows the general extent of subsoils across the area.,

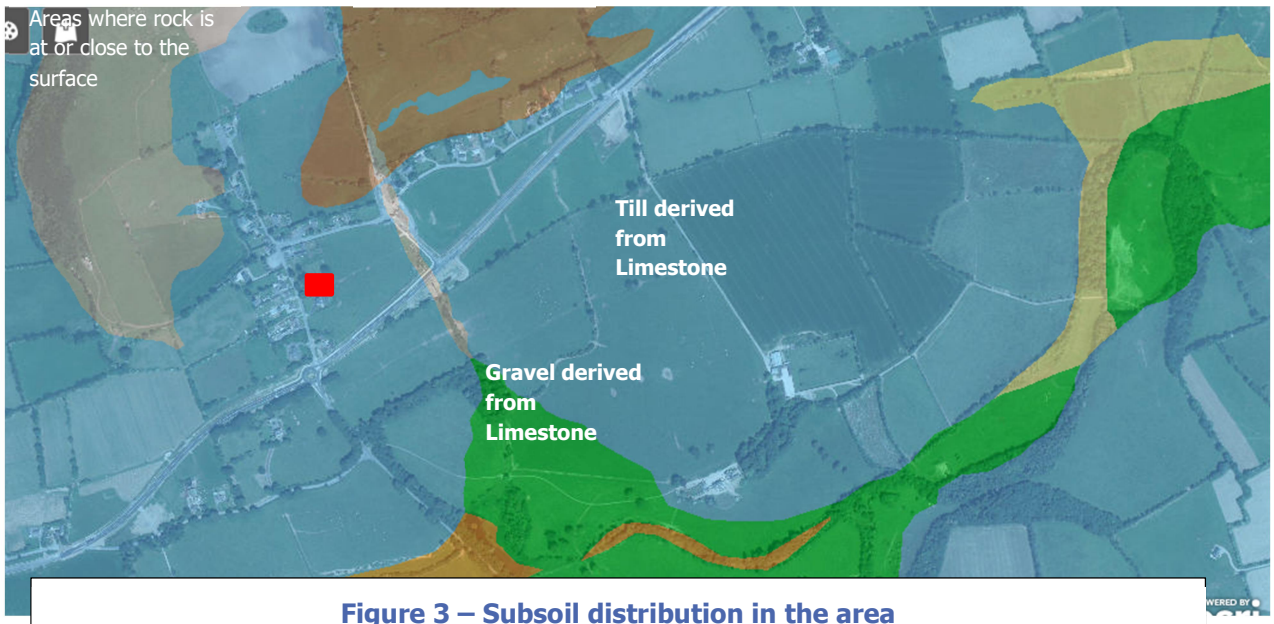


Figure 3 – Subsoil distribution in the area

2.5. Hydrogeology

The proposed development site is considered to overlie a Locally Important Aquifer (Lm generally moderately productive). The aquifer is not considered to be karstified, and no mapped karst features are noted in the area.

2.6. Groundwater Vulnerability

The extract from the GSI Map below shows the proposed development site in an area of High Vulnerability suggesting at least 3-5m of subsoil underlying the site over the bedrock. The map also shows areas where rock outcrop is mapped and where bedrock is less than 3m in depth (extreme). It can be noted that rock outcrops along the course of the River Boyne, and this is of significance in the overall assessment and is discussed in more detail below.

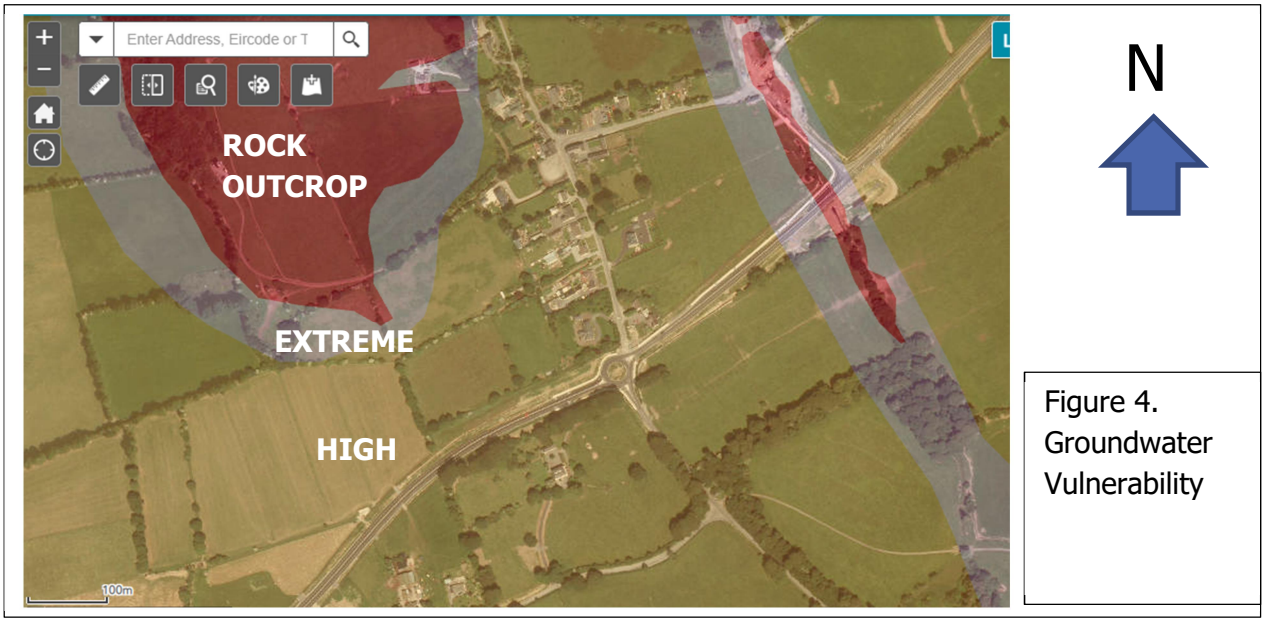


Figure 4. Groundwater Vulnerability

2.7. Groundwater Recharge

The recharge value for the area, is given as 275mm/yr on the GSI maps.

2.8. Groundwater Features

Analysis of the topography suggests a groundwater flow direction from NW to SE towards the River Boyne.

Carbury is supplied by a public water mains, so standalone borehole supplies are scarce in the area.

No Groundwater abstractions were identified downgradient of the site.

A structure that resembled a pump house was identified in a field to the north of the site, and anecdotal information suggests that there are some groundwater wells along a cul de sac to the east, however these are not considered to be relevant, because they are east of the River Boyne.

On this basis, it was decided to sample the Trinity well at first to determine the water quality, which is representative of groundwater from the Carbury village area. If it was found that this groundwater source was compromised, it was planned to try and identify further sampling locations.

2.8.1. Trinity Spring-Characteristics and catchment

The main feature of groundwater interest is the Trinity Well, a historical spring well considered to be the source of the River Boyne, and which discharges into the Boyne River. Since this is in the downgradient direction from the proposed development site, it is considered an important receptor.

Because it discharges into the River Boyne, it is significant in terns of baseflow at the headwaters of the Boyne.

For this reason it was decide to sample the Trinity Well.

The following images show the sampling location:

Trinity Well-exterior

Trinity Well Interior

The Trinity well is known to feed the River Boyne.

Reference to the Groundwater Vulnerability Map indicates that the well lies within an area, where rock is close to the surface. Because the water in the well is access via steps as sown in the image above, it is fair to assume that the water is derived from bedrock groundwater.

Analysis of the topography and the geology allows a catchment for the spring to be delineated.

The spring catchment is calculated to comprise approximately 360,000 m^2 in area. Using the recharge value of 275mm/yr, this gives a discharge volume of 98705m^3/yr, or 270m^3/day, which is a credible discharge volume for a spring in this groundwater body (Trim GWB).

2.8.2. Water Quality

A sample was taken on 19th June and submitted to the Waterlab in Celbridge 30 minutes after sampling. The sample was analysed for the following list of parameters. pH, Conductivity, Ammonia, Nitrate, Chloride, Potassium, Sodium, Total Coliforms, Faecal Coliforms.

The following results of analysis were provided by WaterLab- Celbridge

Client:	Kildare CC				**Relevant groundwater and surface water standards against which results were checked.**			
Client ref:	IE2775		**Sample Type**	Ground Water				
Location:	Carbury Housing project		**Sampled Date**	19/06/2023				
Contact	sampled by JK		**Sample Received Date**	19/06/2023	Interim Guideline Value (EPA, 2003)	Groundwater Regulations S.I. No. 9 of 2010	Drinking Water MAC (SI No. 122 of 2014)	Groundwater Threshold Value (SI No. 366 of 2016)
	Dissolved Potassium #	mg/l		1.11	5	-	-	-
	Dissolved Sodium #	mg/l		7.42	150	150	200	-
	Chloride #	mg/l		8	30	24 - 187.5	250	24 - 187.5
	Nitrate as NO3 #	mg/l		2.9	25	37.5	-	37.5
	Total Ammonia as NH3 #	mg/l		<0.08	-	-	-	-
	Electrical Conductivity @25C #	uS/cm		747	1000	800 - 1875	-	800 - 1875
	pH #	pH units		7.03	>-6.5 and <-9.5	-	-	-
	Total Coliforms			>200				
	Faecal Coliforms			0				

The results indicate an excellent groundwater quality, with low pollution indicator parameters. The results indicate very low anthropogenic impact from upgradient potential sources of contamination. It can be noted that no faecal coliforms were detected, although some total coliforms were detected. The total coliforms are considered to be naturally occurring bacteria in the soil around the well and not related to contamination.

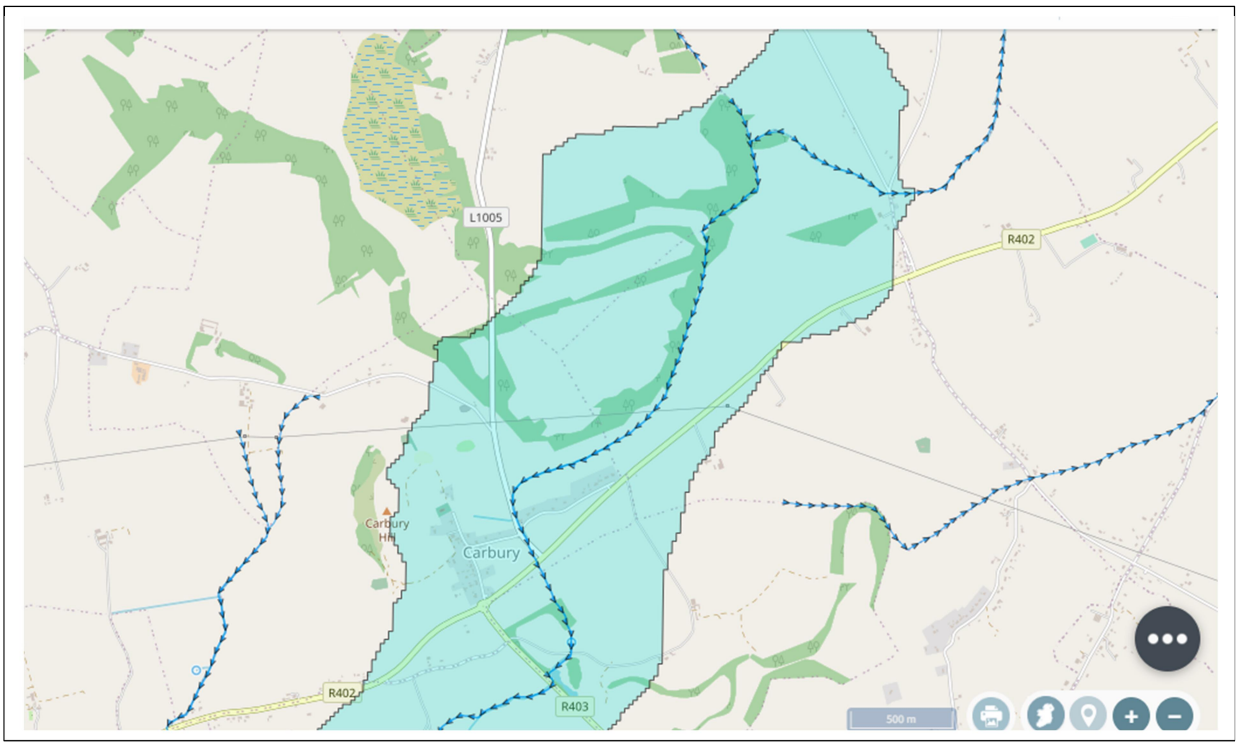
Sodium and Chloride would be typically good indicators of contamination from septic tanks, and their relatively low concentrations, particularly after a dry period, do not indicate any impact. Similarly the low Nitrate and Potassium values indicate no significant impact from agriculture.

Because of the high quality of this sample and the representative nature of the well in the context of groundwater passing beneath Carbury village, it was decided not to pursue further samples, and to attempt to explain the high quality by interpretation of the hydrogeological conditions.

The low Nitrate value, is indicative of confined conditions and is testimony to the efficiency of denitrification in the bedrock aquifer.

2.9. Hydrology

The main surface water feature is the Boyne River. Trinity well has historically been nominated as the source of the River Boyne, which means Carbury is close to a major catchment watershed. There is a stream, that passes close to the well, and its catchment is mapped by the EPA as extending slightly further to the North, than Trinity well.



2.10. Protected sites

There are no mapped European (SAC, SPA) or NHA's mapped within 5km of the site.

3. EXISTING PRESSURES ON GROUNDWATER AND SURFACE WATER

3.1. Aquifer water levels and quantity

There are no existing water level and groundwater quantity pressures on groundwater and surface water resources from existing activities.

Groundwater levels are expected to be controlled by river level of 85m O.D approx, The proposed development will not involve any abstraction of groundwater or interference with the watertable, so there will be no change to the existing status.

3.2. Agriculture

Reference to aerial photographs indicates significant tracts of tillage land, as well as pasture. It is assumed that organic slurries are applied to the farmland.

The farming activity in the immediate area around the Trinity well, appears to be low intensity. The water quality reflects this, with low concentrations of typical indicator parameters. There is indication of tillage within the catchment of the spring.

3.3. On site wastewater treatment systems

There are approximately 35 domestic type dwellings within a $1km^2$ area around the proposed development. This represents a high density of systems, which has prompted Kildare County Council Environment Department to request a hydrogeological assessment. Of these there are probably 20 which would be considered upgradient.

Without examining each system to determine the integrity, only a qualitative worse case scenario can be presented.

If it is assumed that the 20 units are on average 4P.E, then the hydraulic load will be 20 x $0.6m^3$/day = $12m^3$.day. This value will be utilised in relevant calculations below.

The chemical composition of treated effluent will depend on the source characteristics, type of treatment system and its condition.

Reference to "Guidance on the Authorisation of Discharges to Groundwater" Part II 2011 from the EPA provides a framework to assess the potential impacts from on-site systems. The following extract explains the concepts relied upon in the preparation of this Assessment.

Upon discharge, effluents (and leachates) infiltrate vertically towards groundwater. While infiltration capacity and rates are controlled by subsoil permeability, chemical substances in the effluent are subjected to physical-chemical processes, during their passage, which may reduce the chemical loading to groundwater.

These processes include filtration, dilution, dispersion, degradation, transformation, and retardation. Combined, they describe the "attenuation" of substances as they migrate through the subsoil environment. Attenuation invariably results in the reduction of chemical concentrations.

Attenuation in Subsoils

Soils and subsoils offer the main opportunity for pollutant attenuation. The degree of attenuation that takes place is a function of many variables, including subsoil thickness, permeability, organic and mineral content, and even the nature of the chemicals themselves. Certain substances attenuate less and are commonly referred to as "conservative tracers" (e.g. chloride). Other substances do attenuate under favorable conditions, such as nitrogen, phosphorus and, in terms of hazardous substances, volatile organic compounds.

Ammonium and total nitrogen attenuation is sensitive to subsoil lithology, notably clay content, soil organic carbon, the availability of oxygen, and the chemical composition of the effluent itself. Recent research in both Ireland (Ó Súilleabhaín, C., 2004 and Gill et al., 2005; 2009) and the UK (BGS, 2007) indicates that ammonium and total nitrogen can be significantly reduced through denitrification beneath infiltration areas for conventional septic tank systems, and less so for advanced disposal systems. The degree of attenuation that occurs is strongly linked to the formation of a biomat at the base and along infiltration (percolation) trenches.

Specifically, Gill et al. (2005; 2008) concluded from field experiments that septic tank systems provided treatment performance comparable to those of packaged secondary treatment system in subsoils with relatively fast infiltration characteristics. Nitrogen and viral indicators underwent enhanced attenuation in subsoils receiving septic tank effluent. Nitrogen loads were halved after less than 1 m of subsoil depth. Phosphorus removal rates were equally high, although a relationship between removal rates and soil mineralogy was noted. Table D5 summarises the results of Gill et al. (2009) and Table D6 (included below) presents recommended attenuation factors for both nitrogen and phosphorous. While phosphorus is relative immobile in subsoils such as glacial tills, attenuation in sands/gravels will be limited, and where the subsoil is thin, the capacity of the subsoil to continue to attenuate may be finite.

Once in groundwater, pollutants are further attenuated, primarily through mixing which results in dilution (an attenuation process). The degree of mixing that occurs is a function of the hydraulic and chemical loading of effluent and the natural flux and concentrations in groundwater.

Table D6 Estimates of N and P Loading from Septic Tanks and Package Treatment Plants

Source	Parameter	Concentration mg/l (as N or P)	Loading Kg N or P/Person/Year	Percentage Reduction in Loading at 1 m Depth of Suitable Subsoil
Septic Tank	Nitrogen	70	2.7	70
	Phosphorus	17	0.5	90[2]
Package Treatment Plant	Nitrogen	62	1.8	10
	Phosphorus	20	0.5	90[2]
Sewage Treatment Plant[1]	Nitrogen	20	1.1	Dependent on design
	Phosphorus	7	0.4	Dependent on design

1. Data from Entec (2010)
2. These percentage reductions assume that the capacity of the subsoil to attenuate phosphorus is infinite. However, where the subsoil is thin, the capacity is likely to be finite and the subsoil alone should not be relied on in nutrient sensitive areas.

4. IMPACT ASSESSMENT

4.1. Site Suitability Assessment

A site specific assessment was undertaken by Wastewater Technical Services, with the site works undertaken in November 2018.

The trial hole was excavated to 2m depth and did not encounter rock. No water table of mottling that might suggests a higher seasonal water table was found.

The material encountered was consistent with depth and described as Sandy Clay becoming gravelly Silt/Clay at 1.6m depth. The first impression of a T value was 20.

This was borne out by the percolation test, which resulted in a T value of 12, suggesting free draining material.

The proposed design is for a 28PE package treatment plant discharging through a 210m^2 pressurised soil polishing filter

The outcome of the site assessment indicates at least 900mm of unsaturated material beneath the filter.

The assessment indicates ideal conditions for the attenuation of effluent and will allow optimal treatment.

4.2. Conceptual ground model

Reference to the groundwater vulnerability map, suggests that all c.20 properties with on-site systems considered to be within the catchment of the Trinity Well will have similar ground conditions to the site. For simplicity, the following ground model is proposed.

0.0 to 4.0m Sandy Clay

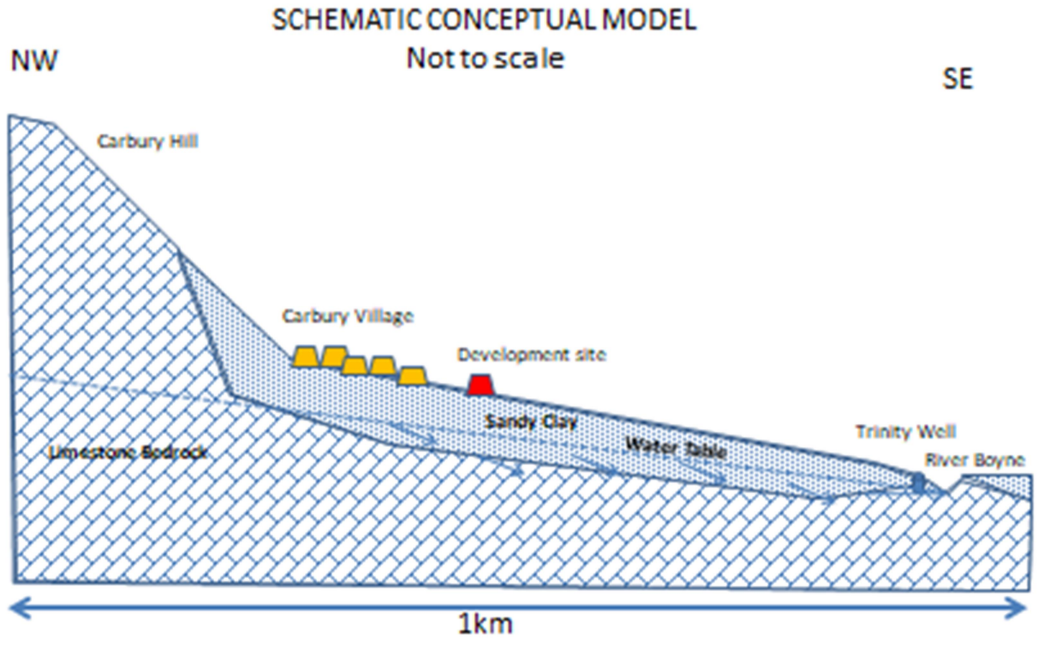
4.0m Weathered bedrock layer, taking majority of groundwater flow.

A schematic of the conceptual model ground model is shown below.

This model shows topography sloping towards the River Boyne, with discharge from all treatment systems into the sandy clay, in which it is attenuated, as described above.

Groundwater flow through the Calp, will be concentrated in the top weathered section of the rock.

The groundwater will emerge, where the bedrock comes close to the surface along the course of the River Boyne, and Trinity well is the main discharge feature identified along the reach close to Carbury.



4.3. Source and fate of contaminants

The discharge from on-site wastewater treatment systems will be approximately 12m^3/day

Assuming a worse case scenario that a value of N of 56mg/l is achieved after treatment

The loading will comprise approximately 0.67kg of N per day. There will also be phosphorous and bacteria released. With reference to table D6, the phosphorous concentrations entering groundwater are expected to be negligible.

As discussed in Section 3.3 above, there will be attenuation in the subsoils and dilution in the groundwater.

The ground conditions in Carbury have been shown to be close to ideal for attenuation of contaminants, ie relatively deep free draining subsoil, a significant unsaturated zone above the water-table, The likelihood is that phosphorous will be absorbed onto the clay, and become immobilised. Similarly enteric faecal bacteria will not survive passage through the subsoils, so none will enter bedrock.

There will be an available dilution of 22.5:1 when the treated effluent reaches the watertable.

Furthermore, the confined low oxygen aquifer conditions and the muddy nature of the Limestone, will provide ideal conditions for denitrification.

The lack of upgradient water quality data, the uncertainty of input values, and the expected optimal ground conditions means that any assimilative capacity calculations would be inaccurate. It is considered that the water quality at the Trinity Well is adequate to quantify the lack of impact on the groundwater receptor and the associated surface water receptor.

4.4. Impact on Receptors

Trinity Well is considered to be the key receptor, and is also the most representative sampling point to assess the anthropogenic impact on the groundwater receptor. The sample indicates high quality and no significant impact.

Trinity well discharges into the River Boyne, and has been historically recorded as the source of the River Boyne.

Based on the high quality of the Trinity sample, there will be no knock-on impact to the River Boyne receptor.

No groundwater abstractions were identified downgradient of the proposed development, so no impact was determined.

5. SUMARY AND CONCLUSIONS

The hydrogeological and hydrological setting of the site has been established from available published data on the GSI and EPA websites.

The bedrock comprises Limestone, overlain by approximately >2m of Sandy Clay at the proposed development site.

The GSI map the depth to bedrock in the area as 3-5m

Rock outcrops on the high ground of Carbury Hill and again along the course of the River Boyne.

The site sits on the headwater catchment of the Boyne River.

Trinity Well has historically been identified as the source of the River Boyne,

Trinity well is considered to be a bedrock discharge point, which emerges in an area, where bedrock is closer to the surface.

Trinity well is downgradient of Carbury Village, and so the water quality in this well is considered to be representative of the groundwater quality beneath Carbury.

A sample of water was taken for analysis from Trinity well, and found to be of high quality.

The high quality can be attributed to the enhanced natural attenuation properties;

- Free draining Sandy CLAY subsoil of upto 4m in thickness which will retard and attenuate effluent.
- Phosphorous will be retained in the Clay, bacteria will not survive in the clay. Nitrogen will pass through, but will be attenuated to a high degree.
- Water table below 2m, which means there is a significant unsaturated zone to allow enhanced attenuation before any effluent reaches the water table.
- A dilution of approximately 1:22.5 of all effluent discharged in groundwater
- Denitrification in the confined low oxygen muddy limestone bedrock conditions.

The overall impact of the cumulative agglomeration of on-site wastewater treatment plants on the key groundwater receptors is negligible, due to the enhanced attenuation properties of the ground conditions in the area.

The nature and extent of the proposed development along with the proposed high level treatment and discharge infrastructure will mean that the impact on groundwater from the proposed development will be negligible

6. REFERENCES

Guidance on the Authorisation of Discharges to Groundwater Part 1 and Part 2-EPA 2011

Geological Survey of Ireland map and data WWW.GSI.ie

EPA map viewer www.EPA.ie

Monuments of Ireland-Trinity Well https://maps.archaeology.ie/HistoricEnvironment/+