Castlepollard Quarry, Deerpark, Castlepollard, Co. Westmeath

Castlepollard Quarry

Environmental Impact Assessment Report

Section 7

Water

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7.1 INTRODUCTION

This Environmental Impact Assessment Report (EIAR) pertains to a proposed development at an existing limestone quarry at Deerpark, Castlepollard, Co. Westmeath.

The development will consist of the continued use and operation of the existing quarry (permitted under P.A. Ref. 01/525), including deepening of the quarry, along with minor amendments to the permitted quarry layout comprising an extraction area of c. 4 ha within an overall application area of c. 11.4 ha. The development will include provision of new site infrastructure including water management system, and other ancillaries.

This section of the EIAR assesses the impact on the hydrological and hydrogeological environment of the proposed development at the quarry, which will be referred to as 'the site' for ease of reference throughout this chapter. Figure 7.1 presents the site location and its setting in a regional context.

The entire site is within the Derravaragh Groundwater Body (GWB), the report of which (GSI, 2004) suggests that the hydrogeological regime of the area is influenced by steep-sided hills.

In order to maintain a dry working environment on the floor of the quarry, some rainfall-runoff and groundwater will need to be discharged from site. Such waters will enter local surface water channels and drainage network. In terms of local hydrology, the Water Framework Directive (WFD) sub catchments delineate a surface water divide running broadly northwest-southeast a short distance north of the site. Lands south of this divide, including the application site, drain naturally to the Inny (Shannon) SC_030, whereas lands to the north drain to the Deel (Raharney) SC_010.

Waters leaving the site will enter a tributary of the Yellow River (Castlepollard) in an afforested area to the south. The Yellow River outfalls to Lough Derravaragh Natural Heritage Area (NHA Site Code 000684) and Special Protection Area (SPA Site Code 004043). Lough Derravaragh's primary inflow and outflow mechanisms are controlled by the River Inny, which itself outfalls to the River Shannon when entering Lough Ree Special Area of Conservation (SAC Site Code 000440), SPA (004064), proposed NHA (000440), near Ballymahon. The significance of the hydrological and hydrogeological setting is therefore acknowledged.

There is currently no pumped discharge of waters from the site as the quarry is worked dry and therefore no discharge license is required to regulate groundwater and/or surface waters at the site. This assessment will evaluate potential impacts from proposed works to the hydrological and hydrogeological regimes and will address the necessity or otherwise to submit a discharge licence application to Westmeath County Council.

To date, the only waters leaving the site are natural surface overland flows generated by rainfall. At present, there is no groundwater component to the site. A surface water management system has been designed with cognisance of the relevant national assessment guidelines (DoEHLG 2011, EPA 2011) and Regulations, namely the Groundwater Regulations

(2010, as amended 2011, 2012, 2016), Surface Water Regulations (2009, as amended 2019) and Birds and Natural Habitats Regulations (2011).

7.1.1 PLANNING CONTEXT

The site has permission to operate subject to conditions as issued by An Bord Pleanala under P.A. Ref. 01/525 (PL 25.128072). The quarry site occupies 11.4 ha and will contain an extraction area of c. 4 ha.

Relevant planning conditions set out by An Bord Pleanala under a decision to grant P.L. Ref. PL25.128072 are as follows:

3. *Water supply and drainage arrangements, including the disposal of water, shall comply with the requirements of the planning authority for such works and services.*

4. *Prior to commencement of development, the detailed requirements of the planning authority relating to the provision and completion of roads, waste disposal arrangements and other services in connection with this development shall be agreed in writing with the planning authority.*

7. *Extraction shall not take place lower than two metres above the wintertime water table level at the point of extraction.*

7.1.2 PROPOSED DEVELOPMENT

The development will consist of the continued use and operation of the existing quarry (permitted under P.A. Ref. 01/525), including deepening of the quarry, along with minor amendments to the permitted quarry layout comprising an extraction area of c. 4 ha within an overall application area of c. 11.4 ha. The development will include provision of new site infrastructure including water management system, and other ancillaries.

The floor of the existing quarry is at c. 88 m AOD. It is proposed to develop an additional extractive bench to c. 70 m AOD. The development will include upgrading of the Water Management System. Development of the quarry at depth below the current floor will require dewatering and discharge to surface water. The proposed discharge to surface water will be subject to a licence to discharge to surface water as required under Section 4 of the Local Government (Water Pollution) Act, 1977.

Quarrying at the site consists of extraction, processing and production of rock products. Rock is fragmented using conventional drilling and blasting method which reduces the rock into a manageable size. Blasted material is then transported to a mobile crushing and screening plant, located on the quarry floor, where material will be processed into various grades of aggregate depending on market demand and stored in designated stockpiles. Processed material will be sold as aggregate.

Plant and machinery that operate at the application area consist of tracked excavators, wheeled loaders and mobile processing plant. Ancillary plant, such as a drilling rig and a water bowser, will be deployed on an intermittent basis.

There are currently no sumps or settlement systems on site because they have not been required for operation. The Water Management Plan presented in this EIAR chapter includes design specifications for an extreme rainfall floor sump, a hydrocarbon interceptor, settlement tanks and a controlled mechanism for discharge.

A Landscape & Restoration Plan for the site has been compiled. Full details for the Restoration Plan are presented Section 3.4 of this EIAR. The final site restoration will contain a landscaped woodland / amenity with water feature. The intention is to create a habitat suitable for aquatic life and birds, such that the disused workings will eventually become of considerable amenity value. Some of the methods to be employed are detailed on the Restoration Plan Figure 3.3.

In summary, the final restoration will consist of the following:

- Landscaping works will be undertaken during the working life of the quarry, where required
- At the end of quarrying, all plant and machinery will be removed off the site, all site boundaries will be secured, additional planting of trees and shrubs may be necessary in some areas, and
- The water abstraction pumps will be switched off and groundwater levels will be allowed to recover to natural levels. Based on current background groundwater levels this will be in the order of 85 mOD.

7.1.3 STATEMENT OF EXPERTISE

The Water Chapter of the EIAR has been completed collaboratively between Dr. Pamela Bartley (Hydro-G) and Dr. Colin O'Reilly (Envirologic).

Dr. Pamela Bartley is a water focused civil engineer with 24 year's field-based practice in groundwater, surface water and wastewater. Upon completion of a Diploma in Water and Wastewater Technology at Sligo RTC, Pamela completed her primary degree in Civil Engineering at Queen's University, Belfast, followed by postgraduate education at the School of Civil Engineering at Trinity College, Dublin. While a postgraduate at TCD, she completed a MSc. in Environmental Engineering at the School of Civil Engineering, with geotechnical, hydrogeological, legislation and water specialities, and later a hydrogeologically focused Ph.D. As a result of her work in evaluating planning appeals, Pamela has become a specialist in quarry and discharge evaluations in the context of enacted Irish Regulation and EU Directives concerning the environment, such as the Groundwater Regulations (2010, 2011, 2012, 2016), Surface Water Regulations (2009, 2012, 2015), EU (Birds and Natural Habitats) Regulations (2011), and Water Framework and Habitats' Directives. She has completed water focused impact assessments for many regionally important quarries in SAC settings, including catchments with habitats for the designated species pearl mussel and vertigo. Pamela's significant quarry assessments of note include Bennettsbridge Limestone, Co. Kilkenny, McGrath's Limestone of Cong, Cos. Galway and Mayo, Cassidy's of Buncrana, Co. Donegal, Harrington's of Turlough, Co. Mayo, Ardgaineen, Co. Galway and Mortimer's of Belclare, Co.

Galway. Each of these quarries operate within SAC catchments and have successfully managed their discharges under licence, for many years.

Pamela's key work areas include the development of large-scale public supply water boreholes, surface water and groundwater assessments with a discharge focus, soil systems, soil hydrology and hydrogeological evaluations for quarries with a specific regulatory focus on water and ecological constraints. Pamela is qualified and IOSH certified to act as Project Supervisor Design Phase (PSDP) and Project Supervisor Construction Stage (PSCS) as defined in the Construction Regulations. The company is a registered Irish Water Supplier (no. 1855), while Pamela Bartley is HSQE approved within Irish Water and is one of their Hydrogeologist service providers. She is a professional member of Engineers Ireland and International Hydrogeologists (Irish Group).

Dr. Colin O'Reilly has over 15 years of professional experience as a hydrogeologist, coupled with a doctorate degree in hydrology, awarded by the Centre for Water Resources Research, School of Architecture, Landscape and Civil Engineering, UCD, while a recipient of a Teagasc Walsh Fellowship. Colin's company is Envirologic, which has key competencies in hydrogeology and hydrology, with expertise in flood assessments in addition to assessment of quarries across a range of diverse hydrogeological conditions across Ireland. Colin is a current and active member of Engineers Ireland and International Association of Hydrogeologists (Irish Group). Patrick Breheny MSc (Hydrogeology) PGeo. EurGeol. works with Colin O'Reilly in Envirologic. Patrick completed much of the monitoring, sampling, hydrogeological response investigation works and the analysis and interpretation of the field data at Castlepollard Quarry. Patrick Breheny has 12 years of post-graduate experience in environmental consultancy having worked extensively in Ireland and the UK, with a background specialising in hydrogeology, hydrology and contaminated land. Patrick holds a Master of Science Degree (MSc) in Hydrogeology, which he attained at the University of Leeds, UK. He is a member of the International Association of Hydrogeologists (IAH) and is a Chartered Geologist, as awarded by the Institute of Geologist Ireland (IGI). Working as a senior hydrogeologist, Patrick's key skills and experience include site investigation, groundwater resources, risk assessment, groundwater remediation, environmental permitting and management and liability assessment for soil and groundwater remediation projects.

Examples of recent relevant projects completed by Envirologic include:

1. Hydraulic capacity assessment and flood risk assessment relating to six crossings on the R181 prior to road upgrade works, Shantonagh, Co. Monaghan (client: Monaghan County Council);

2. Hydrological assessment relating to proposed drainage channel upgrade and maintenance works on a 5.3 km stretch of a river and its tributaries, Oranmore, Co. Galway (client: Galway County Council);

3. Design and specification of a flood alleviation scheme to include a new quarry discharge route from an active limestone quarry, Co. Galway.

Both Hydro-G and Envirologic hold the required Professional Indemnity Insurances, Employers and Public Liability Insurances.

7.1.4 OBJECTIVES

The objectives of this assessment are to:

- Provide baseline hydrogeological and hydrological conditions for the site and the surrounding area and update previous assessments based on additional drilling, aquifer testing, water quality monitoring and discharge route assessments.
- Assess the potential impact of the proposed development on the underlying groundwater aquifer and associated surface water bodies, including assimilation capacity simulations with respect to the proposed quarry water's arisings that will require discharge licensing.
- Identify potential risks and impacts and provide appropriate mitigation measures for any identified potential impacts, as deemed necessary.
- Consider and address hydrological & hydrogeological issues raised by all competent authorities and historic items identified in considerations by Westmeath County Council and An Bord Pleanála.

7.1.5 LEGISLATIVE INSTRUMENTS & PLANNING GUIDANCE

This report was prepared with consideration of the following Irish Regulations and Guidance, listed as follows:

- Groundwater Regulations: European Communities Environmental Objectives (Groundwater) Regulations, 2010. S.I. No. 9 of 2010, as amended 2019 as S.I. No. 366 of 2019;
- European Communities (Birds and Natural Habitats) Regulations, 2011. S.I. No. 477 of 2011, as amended 2021 as S.I. No. 293 of 2021;
- European Communities Environmental Objectives (Surface Waters) Regulations 2009 Statutory Instruments S.I. No. 272 of 2009, as amended 2012 (S.I. No. 327 of 2012), 2015 (S.I. No. 386 of 2015) and 2019 (S.I. No. 77 of 2019);
- Guidance on the Authorisation of Discharges to Groundwater (EPA 2011);
- Guidance on Licensing of Discharges to Surface Waters by Local Authorities (LASNTG 2011);
- Guidelines on the information to be contained in Environmental Impact Statements (EPA 2002);
- Geology in Environmental Impact Statements: A Guide (IGI 2002);

- Guidelines for the Preparation of Soils, Geology & Hydrogeology Chapters of Environmental Impact Statements, Institute of Geologists of Ireland (IGI 2013);
- Revised Guidelines on the Information to be contained in Environmental Impact Statements. EPA (2015);
- Guidelines on the Information to be contained in Environmental Impact Assessment Reports. EPA (2017);
- Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment. Department of Housing, Planning and Local Government (2018);
- Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes, NRA @ https://www.tii.ie/technical-services/environment/planning/Guidelines-on-Procedures-for-Assessment-and-Treatment-of-Geology-Hydrology-and-Hydrogeology-for-National-Road-Schemes.pdf
- Environmental Management Guidelines for the Extractive Industry (Non-Scheduled Minerals) (EPA 2006);
- Quarries and Ancillary Activities – Guidelines for Planning Authorities, Dept. of Environment, Heritage and Local Government (2004);
- Guidance Document no. GW3: The Calcareous/Non-calcareous (“siliceous”) Classification of Bedrock Aquifers in the Republic of Ireland. WFD Working Group (2004);
- Guidance Document no. GW5: Guidance on the Assessment of the Impact of Groundwater Abstractions. WFD Working Group (2004);
- Using Science to Create a Better Place: Hydrogeological Impact Appraisal for Dewatering Abstractions. Environment Agency, Science Report – SC40020/SR1. Bristol, UK. Boak, et al. (2007);
- Reclamation Planning in Hard Rock Quarries. Department of Civil & Structural Engineering, University of Sheffield, Edge Consultants & Mineral Industry Research Organisation (2004); and
- A Quarry Design Handbook. 2014 Edition. GWP Consultants and David Jarvis Associates Limited, UK (2014).

7.2 IMPACT ASSESSMENT METHODOLOGY

During this assessment, we have considered and integrated information relating to the region, local area and site, as follows:

- Desk study
- Site walkover and local area visual survey

- Site investigations including piezometer installations with continuous water level data loggers, drilling of large diameter wells for aquifer pumping tests, groundwater and surface water quality sampling for hydrochemical evaluations, groundwater and surface water level recording, flow measurements and cross-sectional survey of receiving survey waters, and
- Data analysis including quantification of aquifer characteristics to inform potential future dewatering requirements, establishment of groundwater and surface water level and flow regimes, design specifications for effective mitigation measures, e.g., settlement pond/tank system, determination of hydraulic capacity of receiving waters, determination of chemical status of receiving waters and ability to assimilate discharge waters.

Ultimately, each of the components listed above were used to develop a hydrogeological Conceptual Site Model for the site and the local surrounding area. The hydrogeological Conceptual Site Model was then used to populate a hydrogeological Risk Assessment Framework.

The assessment of impacts within this chapter was carried out with respect to the hydrogeological and hydrological environment. Within this chapter, potential impacts were considered to be the effects resulting from changes to the environment by the proposed development. Impacts were assessed in terms of scale, i.e., imperceptible, not significant, slight, moderate, etc., and mitigation measures were proposed, if necessary.

The significance of potential impacts on geological, hydrogeological and hydrological sensitive receptors was estimated by implementing an assessment as per the Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes (NRA 2008) and the Guidelines for the Preparation of Soils, Geology & Hydrogeology Chapters of Environmental Impact Statements (IGI 2013). Those assessment frameworks require input of the project's groundwater and geological type attributes and measures to determine the magnitude of the impact on the attribute.

In the absence of Irish Competent Authority guidance specific to hydrogeological impact assessment and quarry dewatering appraisals, the UK practical guidance as published by the UK Environment Agency (EA: the public body equivalent of the Irish EPA) has been adopted in this work: that guidance document is cited as Boak et al. (2007). Using science to create a better place: hydrogeological impact appraisal for dewatering abstractions (Environment Agency, Science Report – SC40020/SR1). The approach is succinctly outlined by the Environment Agency (2007) as follows:

"The methodology for hydrogeological impact appraisal (HIA) is designed to fit into the Environment Agency's abstraction licensing process. It is also designed to operate within the Environment Agency's approach to environmental risk assessment, so that the effort involved in undertaking HIA in a given situation can be matched to the risk of environmental impact associated with the dewatering. The HIA methodology can be summarised in terms of the following 14 steps:

- ***Step 1:*** Establish the regional water resource status.
- ***Step 2:*** Develop a conceptual model for the abstraction and the surrounding area.

- ***Step 3:*** Identify all potential water features that are susceptible to flow impacts.
- ***Step 4:*** Apportion the likely flow impacts to the water features.
- ***Step 5:*** Allow for the mitigating effects of any discharges, to arrive at net flow impacts.
- ***Step 6:*** Assess the significance of the net flow impacts.
- ***Step 7:*** Define the search area for drawdown impacts.
- ***Step 8:*** Identify all features in the search area that could be impacted by drawdown.
- ***Step 9:*** For all these features, predict the likely drawdown impacts.
- ***Step 10:*** Allow for the effects of measures taken to mitigate the drawdown impacts.
- ***Step 11:*** Assess the significance of the net drawdown impacts.
- ***Step 12:*** Assess the water quality impacts.
- ***Step 13:*** If necessary, redesign the mitigation measures to minimise the impacts.
- ***Step 14:*** Develop a monitoring strategy.

The steps are not intended to be prescriptive, and the level of effort expended on each step can be matched to the situation. Some steps will be a formality for many applications, but it is important that the same thought-process occurs every time, to ensure consistency. The methodology depends heavily on the development of a good conceptual model of the dewatering operation and the surrounding aquifer. The steps of the methodology are followed iteratively, within a structure with three tiers, and the procedure continues until the required level of confidence is achieved. Advice is also given on how to undertake HIA in karstic aquifers and fractured crystalline rocks." Boak et al. (2007).

While there are the Irish EPA's 'Environmental Management Guidelines for the Extractive Industry (Non-Scheduled Minerals)' (EPA 2006), Hydro-G and Envirologic also employ hard rock specific guidance, as follows:

- **Reclamation Planning in Hard Rock Quarries.** Department of Civil & Structural Engineering, University of Sheffield, Edge Consultants & Mineral Industry Research Organisation (2004).
- **A Quarry Design Handbook.** 2014 Edition. GWP Consultants and David Jarvis Associates Limited, UK.

Hydro-G has adopted and applied the thought process and applied knowledge of how groundwater moves in Irish aquifers in order to present a reasoned assessment of the potential for impact that might arise in response to deepening excavations at the site.

7.2.1 STUDY METHODOLOGY

For additional detail, the study areas listed above included the following components:

1. Comprehensive desk study including as follows:

   a. Review of all EPA, GSI and NPWS information for the local area and wider region including but not limited to:

      - EPA (2018) 2nd Cycle WFD Sub Basin Report;
      - EPA (2021) 3rd Cycle Draft Catchment Assessment;
      - NPWS (2021) Lough Derravaragh SPA 004043 Conservation Objectives ;
      - DoEHLG (2003) Lough Derravaragh NHA 000684 Order S.I. No. 582/2003; and
      - GSI (2003) Derravaragh GWB Synopsis Sheet.

   b. Available flow and level data from EPA/OPW hydrometric stations.

   c. Information relating to Public and Group Water Schemes.

   d. Evaluation of groundwater usage and water supplies in the area using Westmeath County Council's ePlanning system which provides comprehensive information of local houses and their water supply. Door to door well survey was later completed.

   e. Historical assessments under previous planning applications, evaluation by the Board under planning reference P.A. Ref. 01/525 (PL 25.128072) and any other information of local importance.

2. Site walkover and local area visual survey. A walkover survey of the application site and surrounding area was undertaken by Hydro-G and Envirologic on multiple occasions between February and November 2021. Assessment of the landscape position, surrounding lands and dwellings was undertaken to better understand topography and geological patterns. Features of hydrological and hydrogeological significance were identified and used as a basis for discussing sources, pathways and receptors that the study should focus on. The local area and locations of water schemes in the wider regional context was evaluated. There are no public drinking water sources at risk of impact from the proposed development. A third party well survey of properties within 500 m of the application site was performed to identify any potential groundwater receptors at risk of impact due to proposed development works. No domestic water supply boreholes were identified in the survey.

3. With respect to hydrology and hydrogeology, Hydro-G and Envirologic completed a field programme that involved surveying and description of groundwater and surface water systems in the vicinity of the site. Field-gathered information was combined with available State hydrometric and hydrochemical data. Intrusive site investigations were

undertaken between March 2021 and August 2021, and involved the following key components:

a. Hydro-G and Envirologic conducted a preliminary site walkover in March 2021 and agreed target locations for large diameter aquifer testing wells and narrow diameter monitoring wells;

b. Two large diameter (8") 'production' wells (PW1 & PW2) were drilled by Briody Well Drilling Ltd. on the current quarry floor in April 2021. These wells are to facilitate hydraulic testing of the bedrock aquifer. Dr. Pamela Bartley was in attendance for the duration of drilling to note and log lithology;

c. In addition, three narrow diameter monitoring wells (MWs) were drilled by Petersen Drilling Ltd. in April 2021 on the periphery of the active quarry floor. These wells are to facilitate long-term monitoring of groundwater level and groundwater quality. They were drilled at different elevations of the site;

d. The construction and borehole logs recorded during the 2021 well drilling programme are presented in Appendix 7.2;

e. Upon review of the drilling experiences and PW & MW Logs and evaluation of the evidence in the walls and bedrock exposures, a dewatering programme was designed to test, by pumping, the potential for future dewatering needs and local area impact;

f. Pumping tests were performed on each of the PWs to characterise the bedrock aquifer in terms of hydraulic conductivity and transmissivity. These values were used to inform future potential dewatering requirements;

g. Where feasible, slug testing was used to measure bedrock permeability in the MWs around the periphery of the active quarry footprint;

h. In August 2021, additional drilling was performed to evaluate an on-site sustainable source for dust management, wheelwash and other needs;

i. Sequential water quality sampling and analysis was conducted between July 2021 and September 2021 to inform baseline conditions and assimilative capacity of receiving waters;

j. Design and specification of a surface water management plan to include settlement pond/tanks and treatment of discharge waters; and

k. Envirologic surveyed channel cross sections and recorded streamflow characteristics in the local streams and surface water drainage network in order to compile a 1D-hydrological model. Simulations were then performed to quantify the hydraulic capacity of the receiving waters and their ability to safely transmit discharge from the application site.

7.2.2 DESK STUDY SITE INFORMATION RESOURCES

The following sources of information relating to published and mapped information for the site and its region were used in the compilation of this assessment:

- Ordnance Survey of Ireland, 1:50,000 Discovery Map Series;
- Morris, J.H., Somerville, I.D., MacDermot, C.V. (2003). *Sheet 12: Geology of Longford, Westmeath and Roscommon.* 1: 100,000 Bedrock Geology Map Series, Geological Survey of Ireland;
- GSI (2003). Derravaragh GWB Report 2nd Draft;
- GSI On-line. Groundwater database. Aquifer Classification, Aquifer Vulnerability, Teagasc Soil Classification. https://dcenr.maps.arcgis.com/apps/MapSeries/index.html?appid=a30af518e87a4c0ab2fbde2aaac3c228
- EPA On-line. Water Quality Mapping, Catchments.ie online monitoring records for regional GWBs & historical monitoring records for the site's water quality. https://gis.epa.ie/EPAMaps/;
- Teagasc (1977). Soils of Co. Westmeath;
- NPWS On-line. Database of Special Areas of Conservation, National Heritage Areas, National Parks, Special Protection Areas including Site Synopsis and Conservation Objectives;
- An Bord Pleanala (2002). Inspector's Report, PL 25.128072 (Previous assessment completed by An Bord Pleanala for the original planning for the site); and
- Westmeath County Council On-line. Evaluation of groundwater usage and water supplies in the area using Westmeath County Council's ePlanning system, which provides comprehensive information of local houses and their water supply to supplement information gathered during the door to door well survey.

7.2.3 CONSULTATION

7.2.3.1 Statutory Stakeholders

J Sheils Planning & Environmental Ltd. circulated a scoping document to relevant statutory stakeholders. Information on the scoping and responses is presented in Section1.5 of the EIAR.

Hydro-G discussed the site's bedrock and drilling experience with Ms. Taly Hunter Williams of the Groundwater Section of the Geological Survey of Ireland in advance of the GSI filming with RTE at the site in the late spring of 2021. The groundwater team were interested in the finding of little water below the bedrock floor. The GSI's response to consultation initiated by J Sheils Planning & Environmental Ltd. directed the team to the use of data on their web portal. The hydrogeological team had already completed their assessment in that way. The GSI's formal response raised no issues of concern for the Water Section.

7.2.3.2 Project Ecologist

The ecologist for the project is Ger O'Donohoe of Moore Consulting. He briefed the scope of the hydrological and hydrogeological assessment from the perspective that the site sits in the catchment of the Lough Derravaragh, which is a designated SPA for birds. The ecologist made the project's water team aware that management of discharge and suspended solids is critical and that any Water Management System on site must ensure that the discharge of suspended solids from site is controlled to ensure no impact on downstream designated site.

The water and ecological consultants were aware of the significance and interactions throughout the assessment period.

7.3 SITE DESCRIPTION

7.3.1 SITE LOCATION & TOPOGRAPHY

The site is located within the townland of Deerpark, 2 km southeast of Castlepollard, 3.7 km southwest of Fore, 4.4 km northwest of Collinstown and 15 km north of Mullingar (see Figure 7.1). The quarry is located on the southern side of Regional Road R395, which connects Castlepollard with Collinstown.

In terms of regional topography, the site is positioned on the western side of a linear tract of relatively steep-sided and isolated hills, ridges and valleys arranged along a broadly southwest-northeast orientation between Slieve na Calliagh (276 mOD) 13 km to the northeast, and Mullingar to the south. These ridges and valleys have been shaped by movement of the last ice sheet (Midlandian). Notable high points include the Ben of Fore (216 mOD) and Knockeyon Hill (215 mOD) to the north and south, respectively. The hills are separated by a number of parallel valleys. Where these are narrow they are drained by watercourses, as is the case for the Yellow and Gaine Rivers, while those that are deeper are not fully drained and contain bodies of water such as at Lough Lene and Lough Derravaragh, and similarly Lough Bane and Lough Glore.

This pattern is repeated more locally with the site being positioned on the northwestern end of a 4 km ridge that extends from near Collinstown. The raised ridge top is hummocky with the hills generally in the range 139–166 m, which narrow to a point where they terminate at Castlepollard.

The elongated hill at Deerpark, where the quarry is sited, is formed from two close but distinct peaks that reach 128 mOD and is surrounded by lower-lying ground (c. 90 mOD) drained by first order streams. The site boundary envelopes the northernmost of these two hilltops. The R395 routing also follows the valley floor as it passes the site.

7.3.2 LAND USE

Land in the area is mixed but in the main supports moderate-intensity agricultural grassland supporting livestock production.

The north-facing hillslope is covered with planted woodland which contains some areas of scrub vegetation. A large forestry plantation is present west of the Bratty road (L5739).

Residential development in the area consists of dispersed farmsteads and diffuse or sporadic ribbon development along roadsides and around towns and villages. The closest large residential settlement to the site is Castlepollard, which is located 2 km, approximately, to the northwest. There are approximately 10 residences within c.250 m, 16 residences within c.500 m and 42 residences within c.1 km of the site boundary (Refer Figure 4.1). There are several clusters of residential dwellings located near the site. A cluster of 6 residences are located within 250 m on the east side of the R395 across from the site entrance and north along the L5743 (i.e., nos. 5-10), while another cluster of 4 residences are located within 250 m west of the site adjacent to the drainage ditch into which it is proposed to discharge surface waters (i.e., nos. 1-4).

There are no occupied residences within the application site or landholding, and the closest is located 270 m, approximately, northeast of the quarry extraction area.

An Bord Pleanála Inspector's report (PL25.128072) relates to an application to reopen the quarry having remained dormant for 20 years (ABP 2002). Prior to this, the quarry is understood to have been used by Westmeath County Council, among others, since the early 1900s.

A recent history of activities on the application area was gained from aerial photography and historical mapping and is summarised in Table 7.1.

Table 7.1 Historical Land-Use at the Site and its Surroundings

Ordinance Survey Map Reference & / or dates	On-Site	Immediate Surroundings
OS 6 inch colour (1837-1842)		Road network significantly different. Previous road offset further northeast than current R395 routing.
OS 6 inch Cassini (1845)	Nothing clear with the exception of a track which wraps around the toe-slope of the hill; still present today. Several drains alongside, and parallel to the eastern boundary.	Wooded area to the east is shown to be prone to wetness. Forestry area to the west shown to be similarly wet.
OS 25 inch (1888-1913)	Gravel pit indicated north of current active area.	Separate drainage networks serving areas to the east and west suggesting different catchments.
Aerial Map (1995)	Quarrying has commenced on the current active area. No large yard as per present today.	
Aerial Map (2000)	Quarry appears not in use.	
Aerial Map (2005)	Quarry more closely resembles that present today with large yard, processing area and stockpiling..	
Aerial Map (2014)	Quarry more closely resembles that present today with large yard, processing area and stockpiling..	

7.3.3 SITE LAYOUT

The proposed quarry layout comprises an extraction area of c. 4 ha within an overall application area of c. 11.4 ha (Refer to EIAR Figures 1.2, 1.3 & 7.2). The existing quarry comprises disturbed ground in a level processing area located in the northern section of the site and a central horseshoe-shaped extraction area advanced into the northern end of the limestone ridge. The extraction area is bordered by corpses of trees on the flanks of the ridge with grassland atop, which has been stripped of overburden within the area proposed for extraction. A perimeter earthen berm has been constructed and seeded on the boundaries of the extraction area at the southern end of the site (Refer to Figure 1.3).

The topographical survey issued by JSPE in 2021 has been used to inform discussion of the site topography. The current floor has been quarried to c. 88 mOD and has a current footprint of c. 2 ha, extending 170 m south of the yard. Ground levels at the top of the perimeter faces are in the range c. 99–119 mOD.

The proposed extraction area extends southeastward of the current quarry floor towards the southeast boundary, taking in the hilltop, which peaks at 128 mOD. Elevations fall sharply to the northeast and southwest of this hilltop. A narrow ridgetop extends southeast from the hilltop, falling away just southeast of the application boundary.

The yard occupying the northern portion of the site comprises a compacted hardcore surface and is relatively flat at around 87–88 mOD. This opens out at the southeastern corner into the active quarry floor. An access track runs around the base of the hill providing access from the yard to the hilltop at the rear of the hill.

The site is accessed from the R395 at its northeastern corner via an internal access road.

7.3.4 SITE WATER MANAGEMENT

A topographically enclosed depression along the eastern boundary contains water and is referred to locally as the marsh. Historical OS maps indicate that this is a legacy of gravel extraction in the 1900's. Before the site's development, runoff from this marshy pond was diverted northwards, ultimately entering the Castlepollard Stream. During the site walkover, it was confirmed that this northern outlet ditch is now redundant.

A ditch also extended from the western edge of the marshy pond. At the commencement of quarrying at the site this western ditch was replaced with a 300 mm pipe which runs east-west beneath the flat yard area (Refer to Figure 1.3). Surveyed levels suggest that water level in this marshy area is controlled by the invert level of this culvert.

The centre of the current extraction area has an elevation of 88 mOD, approximately. The relatively level topography of this area means that it may be prone to containing some rainwater, though the overall slope is towards the sump and the catchment is small. Rainwater overflows towards the northern yard without any significant accumulation in the active quarried area. Rainwater does not accumulate in the yard area, which implies that there is infiltration through the gravel yard surface or managed drainage infrastructure

The site is supplied by mains water supply.

7.4 RECEIVING ENVIRONMENT

7.4.1 HISTORICAL OSI MAPPED WELLS

Historical 6" and 25" Ordnance Survey of Ireland (OSI) maps were consulted as a reference point for identifying domestic wells and springs. The historical maps show a relatively low housing density in the area. The only mapped hydrogeological feature of note within 500 m of the site is a spring 400 m to the northeast.

7.4.2 GEOLOGY

7.4.2.1 Soils

Figure 7.3 shows that original soils at the application site are predominantly shallow and well-drained, consistent with other elevated surrounding lands. Soils on surrounding lower-lying lands in the wider area tend to be deeper and less well-drained, with much unimproved land covered in rushes.

Peats are mapped in depressed areas that may be prone to seasonal or permanent waterlogging. Much of the local surface water drainage has been installed to drain low-lying topographically enclosed peat bog. Only sporadic stream sections are underlain and flanked by alluvial deposits.

Soils of County Westmeath (Finch & Gardiner 1977) describes soils at the site as a moderate-heavily textured grey brown podzolics belonging to the Elton Soil Series. These tend to be characterised by a dark-brown, friable, clay loam surface horizon overlying a yellowish-brown silt loam. The suitability of these soils for grazing and cultivation can be limited by wetness.

The geology report accompanying the P.A. Ref. 01/525 application describes soil cover in the immediate quarry area as being 10 cm deep, thickening marginally to 30 cm in places.

7.4.2.2 Quaternary Deposits

Prominent hills are topped with pure or cherty limestone in the area east of Castlepollard. The local lakes of Lough Derravaragh and Lough Lene appear to be ice-gouged lakes between the harder cherty hills on either side. Throughout these hills there are a number of meltwater channels.

The direction of ice retreat (Midlandian) through the region has a northwest to southeast orientation. This is reflected within the landscape setting of the site, which is set into a high crag-and-tail glacial feature. These tails of drift are aligned from northwest to southeast as are the rock ridges and the valleys, along the direction of ice flow.

The drift mantle laid down by the most recent of several ice sheets is derived from limestone bedrock which picked up chert debris during the retreat (Figure 7.4). This till is described as a dense boulder clay that results in a low inherent permeability. The impermeable nature of the parent material is the cause of the proliferation of rushes. The better drained soils occur on higher or steeper lands where this till has been eroded and soils instead sit directly upon bedrock. Thicker subsoil deposits are found in the valleys and lower ground. Extensive peat deposits have developed in the wide valleys. Lacustrine deposits are mapped in the flat yard area in the northern part of the site. Some narrow banks of esker sands and gravels occur 2 km to the west and beyond. Frequent lines of kame and kettle-hole topography are evident further west.

7.4.2.3 Bedrock Geology

The GSI 1:100,000 Sheet 12 Map of the Geology of Longford, Westmeath and Roscommon shows that the bedrock exposed at the site belongs to the Derravaragh Cherts, which consist of cherty limestone with a minor shale component. These rocks are grouped as Visean mudbank limestones, shales and cherts, estimated to be over 200 m thick and belong to the Dinantian Upper Impure Limestone groundwater rock unit.

The Derravaragh Cherts are an informally defined unit that occurs in the upper part of the Lucan Formation. They are differentiated by a much higher chert content and less shale when compared to the Lucan Formation. It formed from occasional flows of limey sediments from shallow water into the deeper submerged basins, with quiet periods of mud sedimentation in between each flow event. This led to beds of black and dark grey impure limestone varying in thickness from flags of a few inches to beds three to four feet thick, separated by thin black shale layers. The chert beds often form the summits of the hills in this region; shale and limestone occur intermittently between these beds.

The Derravaragh Cherts occupy the ground forming the Lough Owel syncline between Lough Owel and Castlepollard (Figure 7.5). Across the site, the geological maps show a 5° dip angle with a southwest strike orientation.

The geology report accompanying the P.A. Ref. 01/525 application reported that approximately 30–35 m of limestone beds are exposed in the main quarry, with each bed ranging in depth from 30 cm to 50 cm. The report concluded that there does not appear to be any obvious geological impediments to the development of the quarry and the extraction of the rock.

7.4.2.4 Geological Heritage

The application site has been included as a county geological heritage site in an audit of county geological sites in Westmeath conducted in 2019 (Meehan et al. 2019, presented as Appendix 6.2). It is referred to as Deerpark Quarry and is noted for its importance in terms of Lower Carboniferous (IGH8) and Economic Geology (IGH15). It is noted that there is a relative scarcity of Derravaragh Cherts exposures in the region.

The geological bedrock exposures within the existing quarry were considered of sufficient interest to warrant designation as a County Geological Site (CGS) that may be recommended for designation as a Geological NHA. CGSs do not receive statutory protection like Natural Heritage Areas (NHA) but receive an effective protection from their inclusion in the planning system, which should ensure that they are not inadvertently damaged or destroyed through lack of awareness. The designation also ensures that as quarrying progresses, key geological information that is uncovered is recorded by the GSI. This information may otherwise remain unknown if quarrying did not progress. The audit describes the rock as being *"a deep, impressive, working quarry, set into a high crag-and-tail ridge"* and its rock being "*tough and hard compared to many of the 'softer' limestones elsewhere in the midlands. Faces in the rock show relatively massive cherty limestones, which are dark grey and mostly unfossiliferous, with thinly-bedded wackestones and calcisilitites with thin shales forming the detailed lithologies.*

The bedrock in the sections is highly silicified (chert) in places, and the chert can be seen both as nodules as well as in thin seams and bands. Sedimentary structures show occasional evidence of slumping and weak lamination and bedding, set within the bedrock faces, but there are few other structures readily visible".

The geological heritage site report states that the geological heritage interest relies on ***continued working of the quarry as a place to see the strata that it exposes***.

Because the limestone itself is the feature of interest, and not any particular feature or location in the quarry), continued extraction will not affect the feature of interest but rather increase exposure for observation by geologists.

7.4.3 HYDROGEOLOGY

7.4.3.1 Aquifer Classification

Figure 7.6 shows that the bedrock unit in the area is mapped as a locally important aquifer – Karstified (Lk). 'Karstification' is the process whereby limestone is slowly dissolved away by percolating waters. It most often occurs in the upper bedrock layers and along certain fractures, fissures and joints, at the expense of others. Karstification frequently results in the uneven distribution of permeability through the rock, and the development of distinctive karst landforms at the surface (e.g., swallow holes, caves, dry valleys), some of which provide direct access for recharge/surface water to enter the aquifer. A karst landscape is characterised by largely underground drainage, with most flow occurring through the more permeable, solutionally-enlarged, interconnected fissure/conduit zones. Groundwater often discharges as springs, which range from regular and dependable to highly variable ('flashy'). The 'locally important' descriptor assigned to this aquifer means that it will have a relatively small continuous area (c. <25 km^2). The 'locally important' term equates to a smaller size as a hydrogeological classification tool to suggest that there is a limit to the amount of recharge available to meet abstractions.

There is a slight anomaly here, in that karsification requires high purity limestones. By contrast, the Derravaragh Cherts are distinguishable by their impure nature and high chert content. The GSI actually classify the Derravaragh Cherts GWB as a locally important aquifer which is generally moderately productive (Lm) and this is deemed more appropriate for the bedrock underlying the site. This is an aquifer class in which the network of fractures, fissures and joints, through which groundwater flows, is reasonably well connected and dispersed throughout the rock, giving a moderate permeability and groundwater throughput. Aquifer storage is moderate and groundwater flow paths can be up to several kilometres in length. There is likely to be a substantial groundwater contribution to surface waters ('baseflow') and large (>2,000 m³/d), dependable springs may be associated with these aquifers. The low permeability chert bands means that groundwater within parts of the Derravaragh Cherts may be confined.

The karst features map (Figure 7.6) suggests that purity of the Derravaragh Cherts varies areally. There is a high density of karst features occurring 4–8 km to the northeast of the site, which suggests a different limestone purity there. There is only one karst feature mapped within 4 km of the site, this being a Spring at Kinturk Demesne, 1.5 km northwest. A swallow hole on the northern shore of Lough Lene has been identified as having a direct pathway which emerges a further 2 km north at Fore Spring near Fore Abbey (flow rate = 80 m hr-1). The springs and sinks dry up in summer indicating that a high level connection only exists and that the bed of Lough Lene is likely impermeable (Drew, 1992). There are no mapped karst features at the site even though the site has been thoroughly examined by GSI geologists (Appendix 6.2). Additionally, no karst features were identified onsite during the extensive hydrogeological field investigation which included site walkovers and the drilling of 6 no. drill holes (3 no. large diameter production bores, and 3 no. smaller diameter monitoring wells).

The nearest wells mapped on the GSI database are 4.2–5 km northeast of the site, as shown in Table 7.2. The wells are generally only capable of providing low yields suitable for domestic supplies.

Table 7.2 GSI Well Database

Ref	Location	Depth, m	Yield, $m^3\ d^{-1}$	Yield Class	Specific Capacity, $m^3\ d^{-1}\ m^{-1}$
ILC 1091	4.2 km NE	60	10.9	Poor	0.68
Martinstown	6 km NE	40	32.7	Poor	5.36
ILC 1090	5 km NE	30.2	38.2	Poor	13.6
ILC 1092	5 km NE	41.4	10.9	Poor	4.5
ILC 1089A	5 km NE	34.1	32.7	Poor	54.5
ESB	5 km NE	18.3			
ILC 1089	5 km NE	27.4	43.6	Moderate	72.6
Meath Co. Co.	7 km NE	37.8	6.5	Poor	

7.4.3.2 Groundwater Body Report

The GSI maps the site as being underlain by the Derravagh Groundwater Body (GWB) (GSI 2003, see Appendix 7.1), which is reported to have an approximate area of 107 km². From the Derravaragh GWB report (GSI 2003):

- The rocks are generally devoid of intergranular permeability. Groundwater flows instead along fissures, joints, bedding planes and conduits.
- Most groundwater flow is thought to occur in the upper 30 m of the rock, in a highly weathered layer a couple of metres thick, and a zone of interconnected fissures below this. However deeper strikes are possible. There is some karstification in the highly

weathered upper layer, however this is variable on an areal basis, presumably related to limestone purity.

- The bedrock aquifer will discharge to first order streams, rivers and lakes.
- Although a Dinantian Upper Impure Limestone, karstification has been recorded. It has been suggested that there may be some reactivated palaeokarst conduits as well as present-day active post-glacial karstic drainage (Drew 2002). Based primarily on the known karstification and the evidence of a regional groundwater flow system, the aquifer classification for the Derravaragh Cherts is a locally important aquifer which is generally moderately productive (Lm).
- Recharge to the aquifer is generally diffuse, percolating through the chert tills.

7.4.3.3 Public Water Supplies & Source Protection Areas

The nearest mapped source protection area serving an Irish Water public groundwater water supply source (PWS) is 17 km northwest of the application at Ballymachugh source.

The nearest mapped source protection area serving a National Federation of Group Water Schemes (NFGWS) groundwater source is 31 km northwest at Fosta GWS. Each of the listed schemes are within different topographical catchments.

Hence it can be deduced that there are no groundwater sources for public supply at risk of impact from the proposed development.

7.4.3.4 Groundwater Vulnerability

Groundwater vulnerability is a measure of the risk that a potential groundwater contamination event may have on the groundwater beneath. It is a measure of how vulnerable groundwater is to a potential contamination event and is a function of the nature of the overlying soil cover, the presence and nature of the subsoil, the nature of the strata, and the thickness of overburden above the water table.

The vulnerability categories, and methods for determination, are presented in Groundwater Protection Schemes (GSI 1999), while the GSI's Groundwater Vulnerability Criteria are reproduced in Table 7-3. The guidelines state that *'as all groundwater is hydrologically connected to the land surface, it is the effectiveness of this connection that determines the relative vulnerability to contamination. Groundwater that readily and quickly receives water (and contaminants) from the land surface is considered to be more vulnerable than groundwater that receives water (and contaminants) more slowly and in lower quantities. The travel time, attenuation capacity and quantity of contaminants are a function of the following natural geological and hydrogeological attributes of any area:*

1. The subsoils that overlie the groundwater.
2. The type of recharge - whether point or diffuse.
3. The thickness of the unsaturated zone through which the contaminant moves.

Figure 7.7 shows that groundwater vulnerability for that part of the site within which extraction is proposed is mapped by the GSI as Extreme (X) and Extreme (E) due to the occurrence of rock at or near surface. Due to the nature of quarrying, which requires removal of overburden, the groundwater vulnerability rating at all quarry sites will be extreme. The flatter, low-lying part of the quarry where the settlement pond is to be sited is mapped as High groundwater vulnerability.

Table 7.3 Groundwater Vulnerability Criteria (GSI 1999)

Subsoil Thickness	Hydrogeological Requirements				
	Diffuse Recharge			Point Recharge	Unsaturated Zone
	Subsoil Permeability & Type			(Swallow holes, losing streams)	(sand & gravel aquifers *only*)
	High permeability (sand & gravel)	Moderate permeability (sandy subsoil)	Low permeability (clayey subsoil, clay, peat)		
0–3 m	Extreme	Extreme	Extreme	Extreme (30 m radius)	Extreme
3–5 m	High	High	High	N/A	High
5–10 m	High	High	Moderate	N/A	High
> 10 m	High	Moderate	Low	N/A	High

Notes: (i) N/A = not applicable
(ii) Permeability classifications relate to the material characteristics as described by the subsoil description and classification method

7.4.3.5 Groundwater WFD Status

The site lies within the Derravaragh GWB. Information presented by the EPA confirms that for the reporting period 2013–2018, the Derravaragh GWB (European Code IE_SH_G_077) is mapped as **Good Status** but At Risk. WFD reports for the area (EPA 2018, 2021) suggest that the primary pressure affecting the groundwater risk classification is agriculture (https://gis.epa.ie/EPAMaps/).

7.4.4 HYDROLOGY

The hydrological component of the assessment requires an understanding of surface water drainage patterns in the area and clarification of the surface water catchments contributing flow to the various watercourses in the area.

7.4.4.1 Regional Hydrology

The site is a hill sitting on the landscape and the topography falls on all sides from the hilltop. The site position and surrounding topography is such that the site appears to straddle the catchments of two streams (see Figure 7.8). Each of the streams that drain these small catchment areas flow southwest towards the Yellow (Castlepollard) River, which rises in Collinstown and outfalls into the northern end of Lough Derravaragh.

Lough Derravaragh is fed by other small streams at its southern end, along with the River Gaine, but the primary inflow to this waterbody is the Inny River, which is fed by Lough Sheelin near Finea. The Inny River also serves as the primary outflow from Lough Derravaragh and this watercourse continues through Lough Iron near Bunbrosna before ultimately entering the River Shannon system at Lough Ree near Ballymahon. The site and immediate surrounds, the Yellow (Castlepollard) River and Lough Derravaragh are all within WFD Catchment & Hydrometric Area 26: Upper Shannon.

The upper (northern) boundary of the small sub-catchments within which the site lies coincides with a 120 mOD northwest-southeast ridgetop 600 m northeast of the site. Rainfall landing north of this catchment divide flows northwards into Lough Lene. Lough Lene has no discrete surface water inflow, which implies that it is fed by a regional groundwater system (GSI 2003). Lough Lene is drained at its eastern end by the River Deel, which joins the River Boyne at Donore, 3 km to the southeast. There are also groundwater discharges from the northern shore towards Fore Spring. Lough Lene is within WFD Catchment & Hydrometric Area 07: Boyne.

7.4.4.2 Local Hydrology

There are several first order streams in the vicinity of the quarry that feed the Yellow River. Following a walkover survey and a review of drainage drawings in previous planning documentation, the stream routings and resultant contributing catchments were amended against that shown on the EPA's mapped river network, HydroTOOL's contributing catchments and OS 1:50,000 maps. The amended catchments are presented in Figure 7.8.

The sub-catchments referred to above are described below in additional detail:

1. Castlepollard Stream – this is the northernmost of the streams in the vicinity of the site and Castlepollard village is located within its catchment. Historical mapping shows that the pond adjacent to the northern boundary previously outfalled at its northwestern end to the headwater of the Castlepollard Stream. This northern outfall ditch has become inactive. The stream is now mapped by the EPA as rising 300 m north of the site entrance. It travels westwards from this point towards the village, and is culverted below the R395, 1 km northwest of the site entrance. The Castlepollard Stream outfalls to the Yellow River 2.6 km west of the site.

2. Deerpark Stream – This is a small stream / drainage channel that connects the site to the Yellow (Castlepollard)_030. The northwestern corner of the site is connected to this drainage channel. The Deerpark Stream passes a tract of forestry before joining the Yellow (Castlepollard)_030 at a distance of almost 400 m from the site. The marshy pond to the east of the working quarry reaches the northwestern corner of the site by overflow through an underground 300 mm diameter culvert that traverses the northern part of the site. There is a steep sided drain at the northwestern site boundary that transmits waters to the Deerpark Stream, which then flows beneath the local road (L5739).

3. Rainfall landing on the southern side of the undeveloped hilltop naturally runs off land and flows south by gravity into a steep-sided valley that is drained by a channel which flows west then southwest before joining the Yellow River near Milltown.

4. Central tributary. An additional watercourse drains the forestry area southwest of the application site. This channel is culverted beneath the R394 before joining the Yellow River near Benisonlodge.

All of the above tributaries of the Yellow (Castlepollard) River merge and become the Inny_070's northeastern contribution to Lough Derravaragh (IE_SH_26_708). Lough Derravaragh's primary inflow and outflow mechanisms are controlled by the River Inny, which itself outfalls to the River Shannon when entering Lough Ree Special Area of Conservation (SAC Site Code 000440), SPA (004064), proposed NHA (000440), near Ballymahon at approximately 35 km from the site. The EPA's HydroTOOL model node on the Inny_110's influent to Lough Ree shows that the contributing catchment to Lough Ree is 1,231 km^2. The significance of presenting the catchment size here is that the quarry sits of the far eastern boundary of a >1,000 km^2 contributing catchment of Lough Ree and its significance is low because of all of the other interactions and surface waters in the wider catchment.

No part of the site is hydrologically connected to Lough Lene. The nearest part of the catchment that drains to Lough Lene is 570 m to the northeast of the site under consideration here.

7.4.4.3 Surface Water WFD Status

The application site is situated in the Inny (Shannon) Sub-Catchment (SC_030), part of the Upper Shannon Catchment (Hydrometric Area 26F). Ireland is now one RBD, such that there are no regional RBDs anymore (River Basin Management Plan for Ireland, 2018–2021; Department of Housing, Planning and Local Government). EPA (2019) provides the 2nd Cycle WFD Report for the subcatchment and EPA (2021a) provides a very detailed 3rd Cycle Draft Upper Shannon Catchment Report. Status, reasons for Risk, Pressures and actions are listed those reports. Both reports are available at:

https://www.catchments.ie/data/#/waterbody/IE_SH_26Y020250.

The two streams with the highest interaction with the site *i.e.,* the Castlepollard Stream (YELLOW (CASTLEPOLLARD)_030 IE_SH_26Y020250) and Deerpark Stream, are within a catchment classified as having Moderate Status. The Primary pressure is published as Agriculture (EPA 2019). Published catchments.ie and WFD data relating to surface waters near the site are summarised in Table 7.4.

As previously stated, the streams near to the site eventually merge to the Inny_070's northeastern contribution to Lough Derravaragh (IE_SH_26_708). The Inny_070 (IE_SH_26I010800) is mapped as Good Status and Under Review Lough Derravaragh (IE_SH_26_708) is mapped as Good Status and Not at Risk (https://gis.epa.ie/EPAMaps/Water).

The Yellow (Castlepollard)_020 stream flows south of the site. EPA maps an IE licensed pig-rearing (P0893) facility 300 m south of the quarry, within this southern stream's catchment https://gis.epa.ie/EPAMaps/. This stream (IE_SH_26Y020100) is mapped as Good Status and Not at Risk.

Table 7.4 WFD Surface Water Data

Station	Yellow_030: Western stream draining wetland	Yellow_030: Central stream receiving runoff	Yellow_030: Yellow River	Yellow_020: Southern stream
Monitoring Station	Kiltoom Bridge, 2nd bridge u/s Derragvaragh			Bridge north of Milltown
Ecological Status 2013-2018	Moderate			Good
WFD 3rd Cycle Risk Status	At Risk			Not At Risk
Primary Pressure	Agriculture			n/a
Trend: ammonia	Downward			Downward
Trend: TON	Upwards			Upwards
Trend: orthophosphate	Downwards			Downwards

7.4.4.4 EPA Q-Ratings

There are several EPA biological monitoring stations on the local river network. EPA published Q Ratings are provided in Table 7.5 (https://gis.epa.ie/EPAMaps/Water). The closest station to the site persistently returns Q Ratings of 4, which indicates Good Ecological Status.

Table 7.5 Recent Biological Water Quality Monitoring Results

Watercourse	Yellow River	Yellow River
Location	900 m u/s of confluence with central stream (Castlepollard_030)	3 km d/s of confluence with central stream (Castlepollard_030)
Station	Milltown Bridge	Kiltoom Bridge
2020	4	3
2017	4	
2014	4	3-4
2011	4	3-4
2008	-	3-4
2005	3-4	3-4
2002	4	3
1999	4	
1996	4	3-4
1992	4	3-4
1987	4	4
1984	4	

u/s = upstream

d/s = downstream

7.4.4.5 Designated Areas

Designated sites were also presented in Figure 7.1. Both Lough Lene and Lough Derravaragh are denoted as designated sites.

No part of the site drains to a catchment hydrologically connected to Lough Lene. Lough Lene is a Special Area of Conservation (Site Code: 002121) described as a deep (20 m maximum depth), clear, hard-water lake with marl deposition. The site is designated due to it being a hard water lake habitat [3140] supporting white-clawed crayfish [1092], which are a species listed on Annex I/II of the Habitats Directive (this species disappeared from the site in 1987). Unpolluted hard-water lakes, such as Lough Lene, are becoming increasingly rare in Ireland and in Europe.

The sub-catchments into which the site naturally drains all join the Yellow (Castlepollard) River which flows into Lough Derravaragh Special Protection Area (Site Code: 004043) and Natural Heritage Area (Site Code: 000684). This body of water is described as a medium to large sized lake of relatively shallow water (maximum 23 m) which extends along a southeast-northwest axis for approximately 8 km. The majority of the designated site comprises the lake but it also includes a variety of wetland, grassland and woodland habitats. It is a typical limestone lake with water of high hardness and alkaline pH and is classified as a mesotrophic system. The site is an SPA under the EU Birds Directive for the following species: whooper swan, pochard, tufted duck and coot and is considered one of the most important midland lakes for wintering wildfowl. There is only a small area of raised bog in the site, but formerly it comprised a very large bog complex, which extended to the northwest of the lake. Most of this has now been cutover and large areas have been reclaimed for agriculture. The remaining area of intact bog has hummock and hollow complexes but no pools. There is anecdotal history of concerns regarding unwanted silt release and peat harvesting in some catchments of Lough Derravaragh, not the catchment in which the quarry sits. However, correct management of silt is noted for the assessment of potential impacts from the proposed development, as it is with all quarries now in the improved legislative system of the WFD and catchment management.

The lake is an important amenity for anglers as it holds a population of brown trout. The Yellow River acts as a spawning stream for the brown trout in Lough Derravaragh.

The wetland just east of the active quarry is not considered to be a wetland of county value for biodiversity (Westmeath County Council 2020), nor is it a designated area.

7.4.4.6 Abstractions

Castlepollard Regional Water Supply Scheme is sourced from Lough Lene and as previously stated, the quarry is not hydrologically connected to Lough Lene.

There are no mapped PWS or GWS's within significant proximity to the site.

7.4.4.7 Hydrometric Stations & Low Flows

There are active hydrometric gauges on Lough Lene (EPA: 07074) and Lough Derraghvarra (OPW: 26082) and an active level/flow gauge on the Yellow River (EPA: 26252).

In terms of site layout, historical site drainage and catchment mapping confirms that waters leaving the site will enter the Deerpark Stream.

Streamflows in the receiving waters were measured by Envirologic using an Aqua Data Fluvial RC3 Electromagnetic Velocity Meter. Post-processing of data yielded the streamflow rates presented in Table 7.6. The initial dataset suggests that both catchments have a 'flashy' Hydro-Graph response, which means that they respond rapidly to rainfall.

The method used availed of the ratio of derived low flow rate estimated per unit catchment upstream of the relevant hydrometric gauge. The variation between the two methods was not significant and the average from the two approaches was taken.

Table 7.6 Streamflow Information and Rates

Waterbody	Yellow (Castlepollard)_030 River	Potential mixing point, Castlepollard	Potential mixing point, Deerpark Stream	Lough Derravaragh	Lough Lene
Station Number	26252			26082	07074
Operator	EPA			OPW	EPA
Status	Active			Active	Active
Type	Level			Level	Level
Datum	Malin			Poolbeg	Malin
Location	Whitehall			South shore	South shore
Catchment area, km^2	23.60	6.57	1.05	600	13
Gauge datum	64.03			60.34 Poolbeg	92.45 Malin
95%ile/Low level	64.16			1.14	92.60
Median flood				2.77	
Highest flood level	64.68			3.91	93.44
95%ile flow (EPA HydroNET), m^3/s	0.087				
Specific 95%ile flow $m^3/s/km^2$ using ratio at hydrometric gauge	0.0037				
95%ile flow (inferred from catchment ratio), m^3/s		**0.0242**	0.004		
Flowrate on 30/09/21, m^3/s		0.0487	0.0106		

With respect to information presented in Table 7.6, the appropriate 95%ile flow value to be adopted for the mixing point for the discharge, when it reaches the Yellow (Castlepollard)_030 is 0.024 m^3/s.

Additional information was gained from the EPA HydroTOOL model node on the Inny_070 river immediately before it enters Lough Derravaragh. That EPA model node RWSEG_CD 26_1091 on the Inny_070 immediately before Lough Derravaragh shows the following flow rates:

- 95%ile = 0.196 m^3/s

- 50%ile = 0.631 m^3/s
- NATAMF = 0.909 m^3/s

The significance of this information is that although the river receiving the quarry's discharge has a 95%ile flow rate of 0.0242 m^3/s (Table 7.6), which was inferred from catchment ratio and HydroNET gauge information, the combined river systems total low flow rate is almost ten times this at 0.196 m^3/s. For the purpose of clarity, expanding these data to daily flow rates, gives the following 95%ile flow rates:

- @ mixing point for the discharge from the quarry, **0.024 m^3/s = 2,074 m^3/d**
- @ flow of the Inny_070 to NE of Lough Derravaragh, **0.196 m^3/s = 16,934 m^3/d**

7.4.4.8 Flood Risk

7.4.4.8.1 Historical OSI Maps

The historical 6" OSI maps, dated c. 1830–1840 and 25" OSI maps, dated c. 1888–1913 show a high density of drainage channels and watercourses on low-lying lands, suggesting these areas are poorly-drained. This includes the wetland to the northeast of the active quarry and parts of the forestry tract west of the site and southwest of the L5739.

7.4.4.8.2 OPW Flood Maps

The OPW database does not contain any historical records of flood events having occurred on the Yellow River or any of its tributaries.

7.4.4.8.3 Benefitting Land Maps

Plate 7.1 shows that all of the mapped watercourses in the area are maintained as part of the Inny (East) Arterial Drainage Scheme and that extensive areas of land have benefitted from these arterial drainage works.

Drainage/discharge from the site is routed towards the Yellow River via C43/3, which joins C43/3/1 1.7 km downstream of the site.

7.4.4.8.4 Catchment Flood Risk Assessment and Management (CFRAM)

Detailed CFRAM modelling was not performed, nor necessary, on the Yellow River or any of its tributaries.

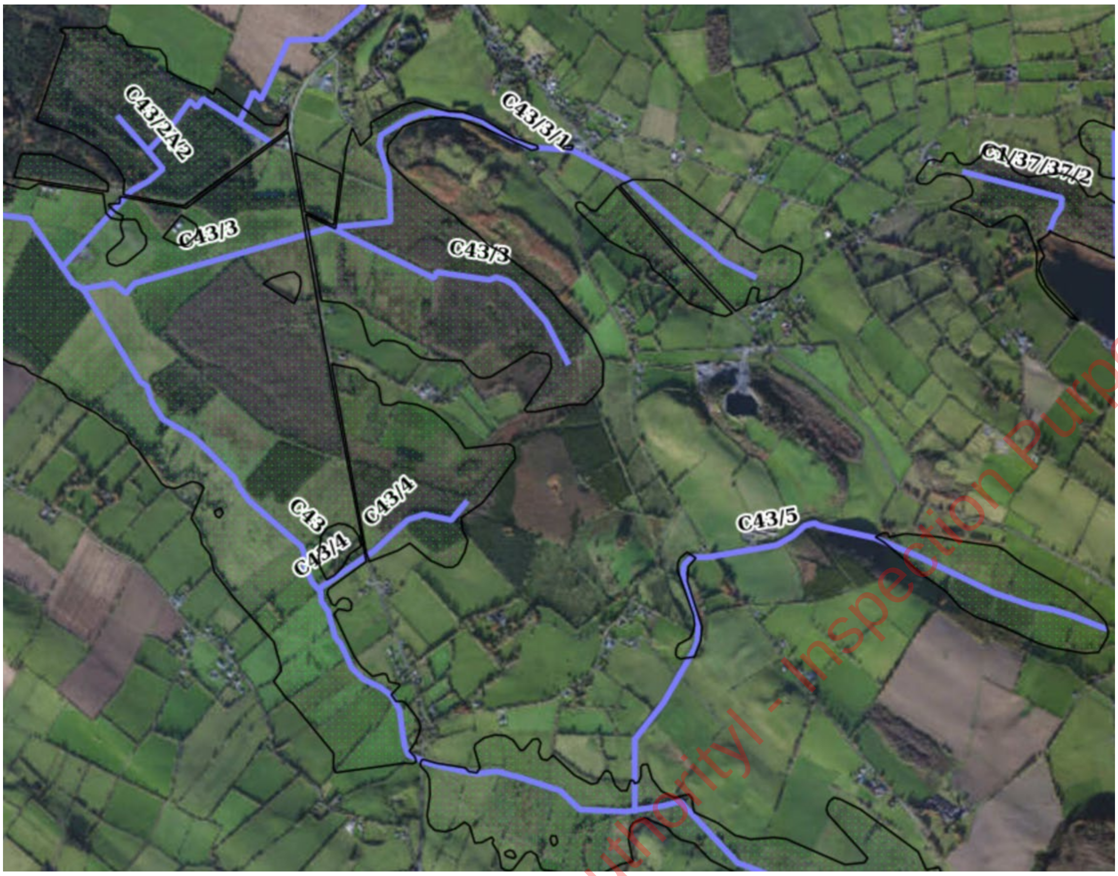


Plate 7.1 OPW Benefitting Lands Map

7.4.5 RAINFALL, RUNOFF & RECHARGE

A preliminary, general, and unrefined surface water runoff calculation for the entire 11.4 ha area of the site is outlined below using Met Eireann rainfall and evapotranspiration values along with GSI recharge coefficients.

7.4.5.1 Rainfall

Monthly gridded rainfall data was sourced from Met Éireann (Walsh 2012) and is presented in Table 7.7.

Table 7.7 Long Term Mean Monthly Rainfall Data (mm) (Met Éireann)

J	F	M	A	M	J	J	A	S	O	N	D	Annual
92	69	77	66	66	75	73	87	78	101	91	97	974

Average Annual Rainfall (AAR) over a 30-year period is 974 mm. Average annual potential evapotranspiration rates for Mullingar are given by Met Eireann as 491 mm across the period 2018–2021. Actual evapotranspiration (AE) is estimated by multiplying PE by 0.95, to allow for the reduction in evapotranspiration during periods when a soil moisture deficit is present (Water Framework Directive 2004). Actual evapotranspiration is therefore 466 mm/yr (0.95 PE).

The Effective Rainfall (ER) for the site, using Met Eireann AAR data, is determined as follows:

ER = AAR – AE

= 974 mm/yr – 466 mm/yr

ER = 508 mm/yr

The GSI database estimates effective rainfall to be 556 mm/yr (https://dcenr.maps.arcgis.com/).

Given that the calculation using the Met Eireann Effective Rainfall value and the GSI mapped value are similar, the more conservative GSI mapping values shall be adopted in the rainfall-runoff calculation, as follows:

Overall site area runoff-recharge:

= area x ER

= 114,000 m^2 x 0.556 m/y

= 63,384 $m^{3/}$yr

= approximately equivalent to 174 m^3/d

The volume of water generated directly from rainfall runoff on the entire site is therefore 174 m^3/d, on average.

Repeating the calculation for only the active quarry area yields as follows:

Overall site area runoff-recharge:

= area x ER

= 40,000 m^2 x 0.556 m/y

= 22,240 $m^{3/}$yr

= approximately equivalent to 61 m^3/d

7.4.5.2 Recharge

Using vulnerability classifications and hydrogeological settings, recharge coefficients can represent the ratio of precipitation that theoretically infiltrates vertically to the water table to that which moves as surface overland flow. Based upon the vulnerability classification of extreme, the GSI presents rainfall and recharge information and maps the site area as follows:

- GSI Effective Rainfall (mm/yr): 556
- Quarry recharge coefficient: 85 % where bedrock is exposed
- Yard recharge coefficient: 22.5 % where infill gravel sits on moderate permeability subsoil and gley soil

- Ponded area recharge coefficient: 4 % for fen peat

- There are no topographically upgradient lands

7.4.5.3 Site Water Balance

A water balance derived from rainfall landing on the proposed entire working area of the site is presented as Table 7.8. All other areas outside those listed will be undisturbed, and in terms of rainfall-recharge patterns, will be in line with current greenfield runoff rates.

Table 7.8 Rainfall Derived Water Balance

Parameter	Unit	Active Quarry Area	Flat Yard Area	Total
Area	m^2	40,000	18,650	58,650
Effective rainfall	m/yr	0.556	0.556	0.556
Rainfall volume	m^3/yr	22,240	10,369	32,609
Rainfall volume	m^3/d	60.93	28.4	89.34
Recharge coefficient	%	85	22.5	
Recharge reaching bedrock head	m^3/yr	18,904	2,333	21,237
Surface runoff (recharge rejected at surface)	m^3/yr	3,336	8,036	11,372
Recharge cap	m/yr	No cap	No cap	
Recharge to bedrock aquifer	m^3/yr	18,904	2,333	5,669
Shallow subsurface flow (recharge rejected at bedrock head)	m^3/yr	0	0	0
Surface runoff plus shallow subsurface flow	m^3/yr	3,336	8,036	**11,372**
	m^3/d	**9.14**	**22.02**	**31**
	l/s	0.11	0.25	**0.36**
Current Destination		Deerpark Stream	Deerpark Stream	

Note:

Within the quarry area itself, the aquifer classifications in Figure 7.6 show that the exposed Derravaragh Cherts are locally important and moderately productive. Hence, no recharge cap has been applied by the GSI.

Rainfall rejected either at ground surface or at bedrock head will move laterally as surface runoff or shallow subsurface flow. The current active quarry floor is not topographically enclosed and rainfall does not tend to accumulate within it. The current quarry floor does not intercept groundwater.

Rainfall-runoff and shallow subsurface flows generated in the active quarry area will likely flow downgradient towards the flat yard area. The yard is covered in gravel and any runoff generated here, or flowing onto the yard, will infiltrate. It is assumed that this water will subsequently flow towards the western boundary. This retains the pre-development drainage pattern.

Based on the final determinations of information presented in Table 7.8, **the combined total of runoff and shallow subsurface flow that needs to be managed by the site is 11,372 m^3/yr, equivalent to 31 m^3/d (0.0004 l/s)**. All other rainfall-runoff flows within the site do not need to be managed and can remain as greenfield runoff. The value of 31 m^3/d will be added to any envisaged groundwater that might be encountered.

The proposed development involves deepening, and minor amendments to, the current permitted extraction area. Under that scenario, any groundwater encountered must be removed to maintain a dry working environment. This requires site-specific data describing hydraulic properties of the bedrock, which is analysed and discussed later in the chapter.

This preliminary water balance is a 'first run', desk-based exercise and it is acknowledged that the approach has certain limitations, such as:

- The recharge coefficients and recharge caps are derived from literature sources that may differ from actual values.
- Bedrock permeability in the Derravaragh Cherts could feature some fracture flow. In this sense, it may be appropriate to invoke a recharge cap to represent lack of infiltration at bedrock head, and bedrock currently exposed on the quarry floor.

Acknowledgement of these limitations facilitates the development of a more robust conceptual model and water management plan for the proposed development.

7.5 SITE INVESTIGATIONS

7.5.1 GEOPHYSICS SURVEY

Lagan Materials Ltd. commissioned Apex Geophysics to undertake a geophysical survey of the site in December 2018 (Refer to Appendix 6.1). The survey involved 2D-ERT and Seismic Refraction Profiling. The key findings from the survey are summarised as follows:

- Soil cover on the undisturbed ground on the hilltop area in the southern part of the site is thin, in the range 0.5–1.5 m;
- Overburden depth on the yard area north of the active extraction area = 16 to 20 m. Interpreted data suggests it is lacustrine clay; and
- Bedrock in the active quarry floor is limestone. This extends south through the area of raised ground. It is inferred that there is 5 m of moderately weathered rock with tight joints over generally strong bedrock. This limestone extends to at least 30 m below ground level.

7.5.2 THIRD PARTY WELL SURVEY

Information on wells and springs in the area was gained during the desktop study using a combination of historical mapping, aerial photography and the information contained in the Westmeath County Council online planning system. The resolution of the GSI well location database is very poor across the general area, with the nearest mapped domestic well 4 km away.

The Westmeath County Council online planning system provided location information regarding local domestic wells. Accessible applications linked to the housing cluster on the local road (L5734) extending northeastwards across from the site entrance show these properties to be connected to an existing public water supply. Similarly, the property at Drumman to the north, and the linear cluster of houses on the local road west of the site (L5739), are connected to the local public water mains.

A third party well survey was carried out by an environmental scientific officer of Breedon, under direction and telephone assistance from one of the project's hydrogeologists. Dr. Pamela Bartley visited all properties within 600 m of the application site during October 2021. Of the 11 houses visited, all were confirmed to be connected to the Irish Water mains network and did not abstract from a well source. A piggery 300 m to the south was also confirmed, in telephone conversation with Pamela Bartley, as being connected to the Irish Water mains network. The locations of the dwellings surveyed is presented as Figure 7.9.

7.5.3 QUARRY BEDROCK EXPOSURES

The Project Hydrogeologists and Chartered Geologist inspected the quarry faces in various seasons and rainfall recharge events on numerous occasions in 2021. Two benches are currently exposed with the upper bench being thicker in places due to topography on the hilltop.

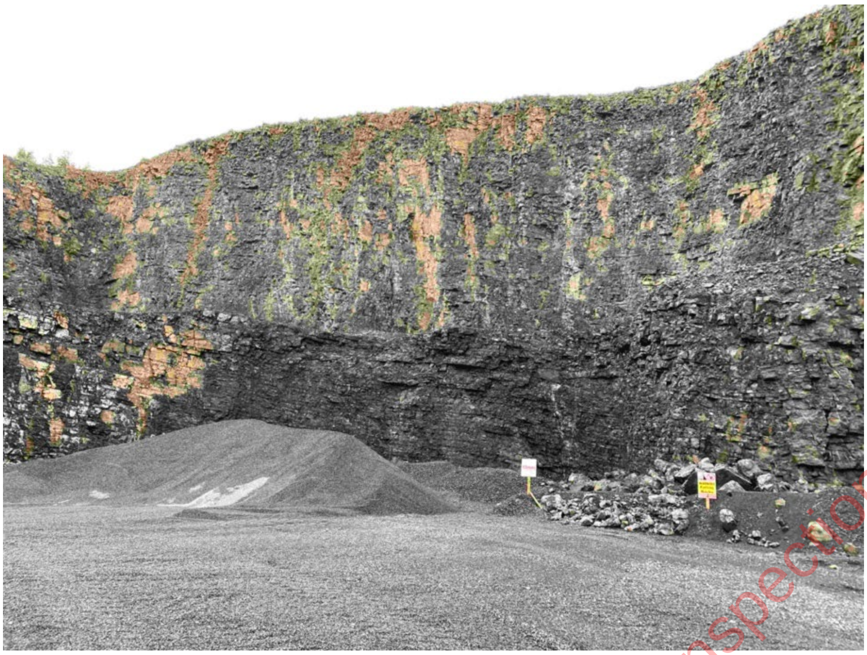


Plate 7.2 Bedrock Exposure on Eastern Face of Active Quarry

The limestone was noted to contain clay infilling of open joints in the upper bench, with weathering and infill decreasing with depth. Some minor, discontinuous calcite veining is present in the lower bench. The beds are between 200–600 mm thick and dip at a very shallow angle on an inconsistent plane across the exposure. Jointing is frequent, within a meter in places, and tight. Clay was observed along some of the joints.

Bedrock just below local area ground level, *i.e.,* on the upper exposed face, displays slightly more weathering but no epikarst was observed. The floor is dry and competent bedrock is exposed in places.

Bedrock exposures in the quarry are described in the Geophysical Investigation report (Apex 2018 – Refer to Appendix 6.1) as follows: '*Examination of the exposed rock face showed minimal presence of shale. Clay infilling of open joints and possible clay wayboards visible in the faces. Weathering and infill decrease with depth down the face.*'

7.5.4 BEDROCK INVESTIGATIONS

Site Investigations for the bedrock at the site included drilling of 200mm diameter Production Wells to facilitate conventional pumping tests, should water be encountered, and conventional Monitoring Well installations with 50mm diameter piezometers.

Summary details and lithologies encountered at all drilling locations are presented Table 7.9 with water strike depths and estimated yields encountered during drilling.

The drilling experiences for each well are discussed under separate headings for the Production Wells and Monitoring Wells in subsequent sections.

Table 7.9 Summary Details of All Drilling Locations

Castlepollard Quarry	PW1	PW2	PW3	MW1	MW2	MW3
Easting	647,726	647,686	647,712	647,839	647,589	647,724
Northing	768,393	768,396	768,549	768,149	768,430	768,508
BH Depth (m)	21	21	78	51	18	18.5
GL @ BH Elevation (m OD)	87.54	87.92	88.79	115.93	89.28	86.93
BH Base Elevation (m OD)	66.54	66.92	10.79	64.73	71.14	68.43
Screen interval (m btoc)	open hole BHs		63 to 78	36 - 51	13 – 18	9.5 – 18.5
Water Strikes (m OD)	68	68	49	None	4.5 m (slow)	Dry during drilling but WL ingress overnight

7.5.4.1 Production Well Drilling

Two large diameter ‘Production Wells’ (PWs) were drilled in April 2021 for the purposes of a hydraulic evaluation of the underlying bedrock to a depth 5 m below the proposed floor level. The diameters of the PWs were chosen to facilitate pumping tests and to evaluate potential for impact on local groundwater resources. The hydrogeological information gathered from the conventional well drilling and testing was used to calculate likely future water management volumes arising at the site.

The PWs were drilled to a target depth of 21 m to ensure the well base would be below the proposed final floor level, which is proposed to be 70 mOD.

Design and drilling supervision was undertaken by Dr. Pamela Bartley of Hydro-G. Drilling was conducted by Briody Well Drilling Ltd. The boreholes were located as close to the proposed extraction as practicable with the intention of retaining the boreholes as monitoring points in the future.

In general, construction involved opening with a 210 mm diameter drill bit and inserting 4.8 m of 200 mm diameter OD steel casing to seal off surface water ingress. Drilling progressed below the steel casing using a 200 mm bit in an open hole. Each well was developed by airlifting for 3-4 hours during which well yields were estimated. The remainder of the borehole was left unlined because the rock is competent. Raised lockable steel headworks completed the installation.

No discernible water strikes were encountered with groundwater ingress described as being very slow overnight. It appeared that neither of these wells would be capable of supporting sustained pumping.

An additional large diameter well was drilled in August 2021 (PW3). The target location was close to MW3, alongside the internal access road in the northern portion of the site. No quarrying is proposed at this location in the future. The drill location was relatively close to the marshy area between the existing quarry and the access road.

This borehole (PW3) was drilled to a depth of 78 m. Unstable drilling conditions meant that a 200 mm steel liner was installed to 23 m, with an inner 150 mm steel liner drop-fitted within this to hold open bedrock at depths between 20 and 50 m. Drilling conditions remained difficult to the base of the hole. Hand slotted 125 mm slotted PVC casing was installed from surface to the base of the hole.

Brown clayey, sandy gravels were encountered from surface to 21 m, underlain by white, broken soft limestone/mudstone to 50 m. A 4 m band of light brown clay was reported at 51–55 m, before a lithology change at 60 m consisting of intermittent bands of rock and sand filled cavities, which collapsed readily. A light grey sand-filled cavity at 59.5 m was likely water-bearing. The subsurface conditions encountered at PW3 were completely different to those encountered in PWs 1 & 2, where rock excavation is proposed.

Borehole locations are shown in Figure 7.2. The borehole logs and additional notes from drilling are presented in Appendix 7.2.

7.5.4.2 Monitoring Well Drilling

Three small diameter monitoring wells (MWs) were drilled between 19 and 24th April 2021 for the purposes of a hydraulic evaluation, long-term groundwater level monitoring and groundwater quality monitoring points.

The wells were drilled and completed using Rotary ODEX technique with reference to industry guidelines (Guidance on the design and installation of groundwater quality monitoring points, EA, 2006). The drilling diameter was 120 mm within the bedrock. Installation consisted of 50 mm ID HDPE standpipe with slotted casing used in the water-bearing sections. The annulus around the slotted casing was filled using 10 mm gravel. Bentonite clay was used as a seal to surface. Temporary ODEX casing withstanding subsoil was used during the drilling process and was removed upon completion after the HDPE standpipe was installed. Raised lockable headworks set within a concrete plinth, which extended to 0.5 m below ground, completed the installation.

Borehole locations are shown in Figure 7.2; lithology and construction logs from monitoring well drilling in Appendix 7.2. Summary well details were outlined in Table 7.9.

MW1 was drilled close to the southern boundary, on the southern face of the hilltop. This well is 51 m deep because the ground level is significantly elevated above the proposed floor level. Drilling in MW1 encountered limestone which becomes increasingly strong with depth. Pockets of chert, particularly along joints, was recorded. No water was encountered during drilling and overnight response in groundwater levels was extremely slow.

MW2 was drilled on the southern side of the yard, west of the active extraction area, to a depth of 18 m so as to target below the proposed floor level. MW2 revealed a very gravelly clay (boulder clay) to 4.6 m, below which occurred an orange clay which varied from soft to firm and contained angular limestone fragments. The driller logged this as clay infill in what is possibly a fault infill. Drilling was terminated in this zone at 18 m.

MW3 was sited at the northeastern corner, close to the site entrance to a depth of 18.5 m to bring its base to a depth below the proposed floor level. Lithology was noted as 1 m of peat, underlain by 6 m of boulder clay. Beneath the boulder clay a firm orange/brown clay with limestone fragments was again reported. This was logged as fault infill, consistent with findings at MW2. The PW3 profile confirms depth to bedrock as 21 m. It is noted that MW3 had dry drilling conditions, but the water level rose overnight to above ground level. This MW is outside the proposed excavation area and is adjacent to the marshy pond area.

7.5.5 AQUIFER TESTING

7.5.5.1 Production Wells

Aquifer testing was performed with the aim of:

(i) establishing the hydraulic properties of each of the geological formations in terms of transmissivity, specific capacity, hydraulic conductivity and storage coefficient; and

(ii) informing the conceptual understanding of the groundwater regime at the site.

The two 8" diameter PWs were evaluated (PW1 & PW2) using a series of pumping tests following installation. The tests planned included as follows:

1. Multi-stage step tests. Step tests involve pumping the well at three to five discrete pumping rates for periods of equal duration. The duration of each step is generally between 60 and 180 minutes, depending on the drawdown/discharge characteristics of the well. Multi-stage step tests are used at the start of an aquifer test to indicate the most appropriate pumping rate for the subsequent constant rate test. Step tests are also used to give an indication as to the performance of the well and the level at which to set the pump, amongst other things. The usual hydrogeological testing assumptions and conditions underlying the analysis of the step test are:
    - The aquifer from which groundwater is pumped has a seemingly infinite extent
    - The hydraulic permeability of the aquifer is equal in all directions, the aquifer is of a certain thickness and homogeneous in rock composition over the area influenced by the step-pumping test
    - Prior to pumping, the water level is (nearly) horizontal, and
    - The aquifer is pumped stepwise at increased discharge rates.
2. Constant rate pumping test. The constant discharge test is used to determine hydraulic properties of the well, and to investigate the potential for drawdown in nearby wells. Transmissivity is the rate water is transmitted through an aquifer in terms of a unit width and a unit hydraulic gradient. It equals the aquifer's hydraulic conductivity (permeability) times the aquifer thickness. The higher the transmissivity, the more prolific the aquifer is considered. The purpose of the constant discharge test was also to establish the stability of the hydrochemistry of the groundwater.

3. Recovery test. Monitoring and analysis of groundwater levels following completion of test pumping. This phase facilitates the application of formulae without any potential interference from the pump and the act of pumping to further characterise the groundwater body.

Groundwater levels were recorded in each PW, both intermittently using a manual dipmeter and continuously with the use of submerged pressure transducers (dataloggers). Stilling tubes were installed temporarily to facilitate a groundwater level dipmeter. Pumps, control valves and pumping rates were calibrated on the day preceding each step test. Flowrates were measured in real time using a flowmeter and checked manually on an intermittent basis.

Although the PWs were drilled at large diameters in case significant strikes were encountered, no significant water strikes were actually encountered. Therefore, a 3” Grundfos SQ 55-3 submersible pump sufficed for the pump testing. The pump was installed in PW1 at 19 mbgl. The pump is rated to lift 4.4 m^3/h (105 m^3/d) at a head of 20 m. Saturated thickness at start of the test was 17.64 m.

On the 29th June 2021, Envirologic personnel visited the site and performed a calibration of the pump. During the calibration stage, it became clear that well yield was too low to sustain an accurate step-test.

To prevent the pump from running dry it was decided to abandon the step test increments, allow the well to recover and proceed straight to constant discharge rate test.

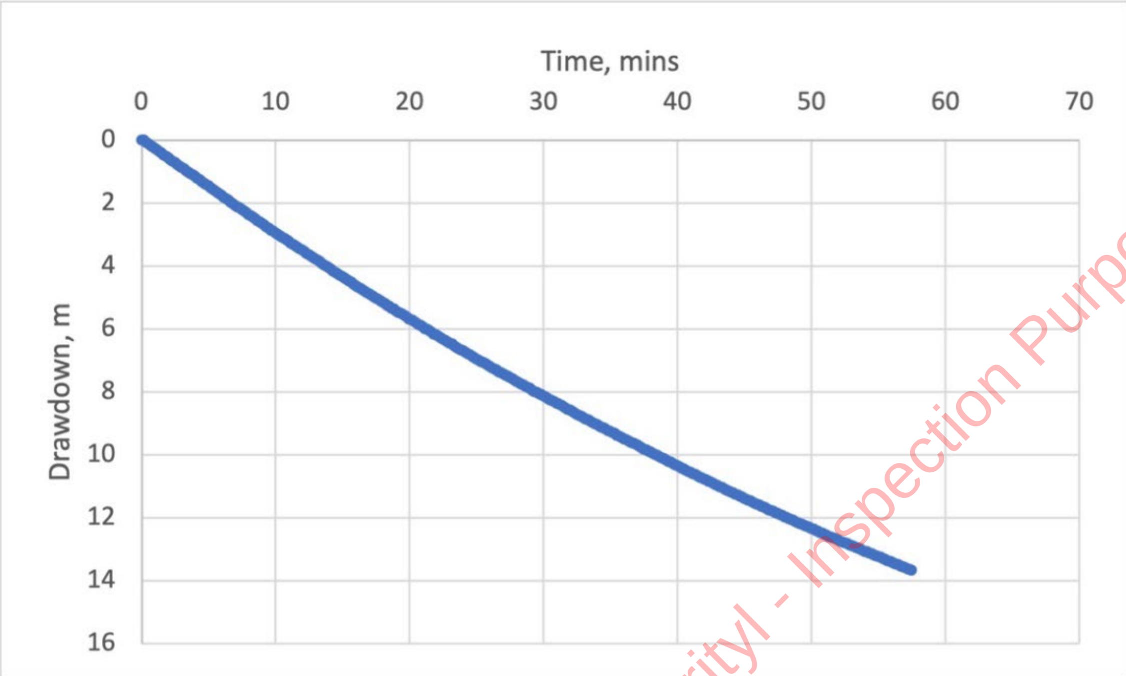
7.5.5.1.1 PW1 Tests

PW1’s constant discharge pumping test commenced on 1st July 2021, at a discharge rate of 0.18 l/s (16.3 m^3/d). The starting groundwater level was 4.34 m below datum (top of the steel casing), equivalent to 84.38 mOD. Manual level readings indicated a rapid drawdown of 13.6 m in water level (70.72 mOD) within the first 58 minutes of the test.

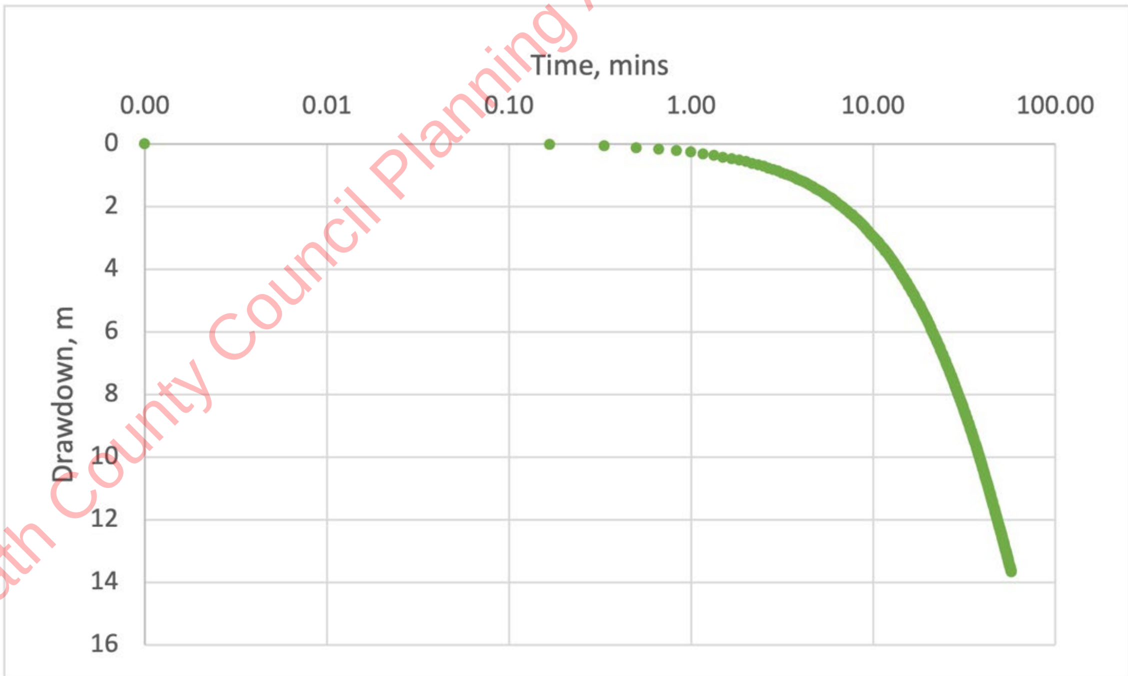
Groundwater levels during the PW1 constant discharge test are shown in Graph 7.1. A review of the drawdown data reveals that the drawdown increases at a constant rate over time. This would indicate a very low permeability bedrock unit where water level response reflects simple emptying of the bored hole with no connection to a ‘groundwater body’.

When plotted against time on a log scale a curve is indicated, rather than a typically expected straight line (Graph 7.2).

Graph 7.1 – PW1 Constant Discharge Test Drawdown over Time



Graph 7.2 – PW1 Constant Discharge Test Drawdown over Log Time



Transmissivity was calculated using the Cooper Jacob's Method (Cooper & Jacob 1946):

$$T = (2.30\ Q) / (4\ \pi\ \Delta s)$$

where: Q = discharge = 16.27 m^3/d = 0.0113 m^3/min

Δs = drawdown over one log cycle (m) = 2.69 (1–10 mins)

= 15.05 (10–100 mins)

For the initial 1–10 minute phase:

$$T = 2.3 \times 0.0113 / 4 \times \pi\ (2.69)$$

$$T = 0.0008\ m^2/min$$

Repeating for the 10–100 minute phase yields T = 0.0001 m^2/min

An average T value of 0.0004 m^2/min, equivalent to 0.65 m^2/d was calculated.

This is a low transmissivity and suggests that water is not easily transmitted through the aquifer.

Permeability was calculated by dividing the transmissivity by the saturated thickness of the aquifer. The saturated portion of the borehole is unlined and fully exposed to the aquifer.

Hydraulic conductivity = K = 0.65 m^2/day / 17.64 m = 4.3 x 10^{-7} m/s

The K value result is similar to the Hydraulic Conductivity value of a CLAY, as might be prescribed for a natural impermeable liner under an integrated constructed wetland. Hence, as the K-value derived for PW1 is comparable to impermeable clay liners, it can be accepted that the surrounding bedrock has poor, if any, permeability, which is a key property in aquifer classification.

Water level recovery at PW1 was monitored at the end of the constant rate test. The response of residual drawdown was recorded until the groundwater level in the well recovered back to normal pre-test levels (Graph 7.3).

The Cooper Jacob's Method was used to estimate aquifer properties, this procedure involves fitting a straight line on a residual drawdown plot of s' (residual drawdown) versus log t/t' (ratio of time since pumping began to time since pumping stopped), as shown in Graph 7.4. This method is commonly used to estimate transmissivity (T) of an aquifer (Cooper & Jacob 1946 - Straight Line Solution).

Δs = drawdown over one log cycle (m) = 12.23 (1–10 mins)

= 0.05 (10–100 mins)

As the majority of drawdown occurred in the initial 10 minutes, this phase will be used to determine Transmissivity, T, as follows:

$$T = (2.30 \times 0.0113) / (4 \times \pi \times 12.23)$$

$$T = 0.00017\ m^2/min$$

$$T = 0.24\ m^2/d$$

And the consequent calculated Hydraulic Conductivity follows as:

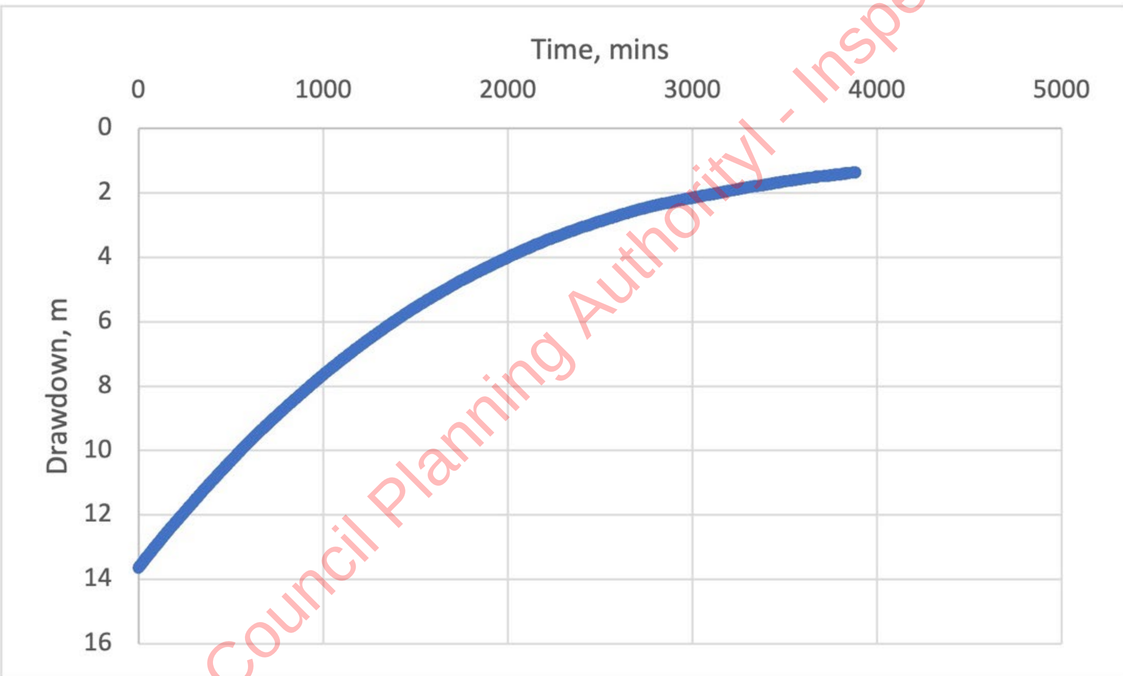
$$K = 0.24\ m^2/d\ /\ 17.64\ m$$

$$\mathbf{K = 1.6 \times 10^{-7}\ m/s}$$

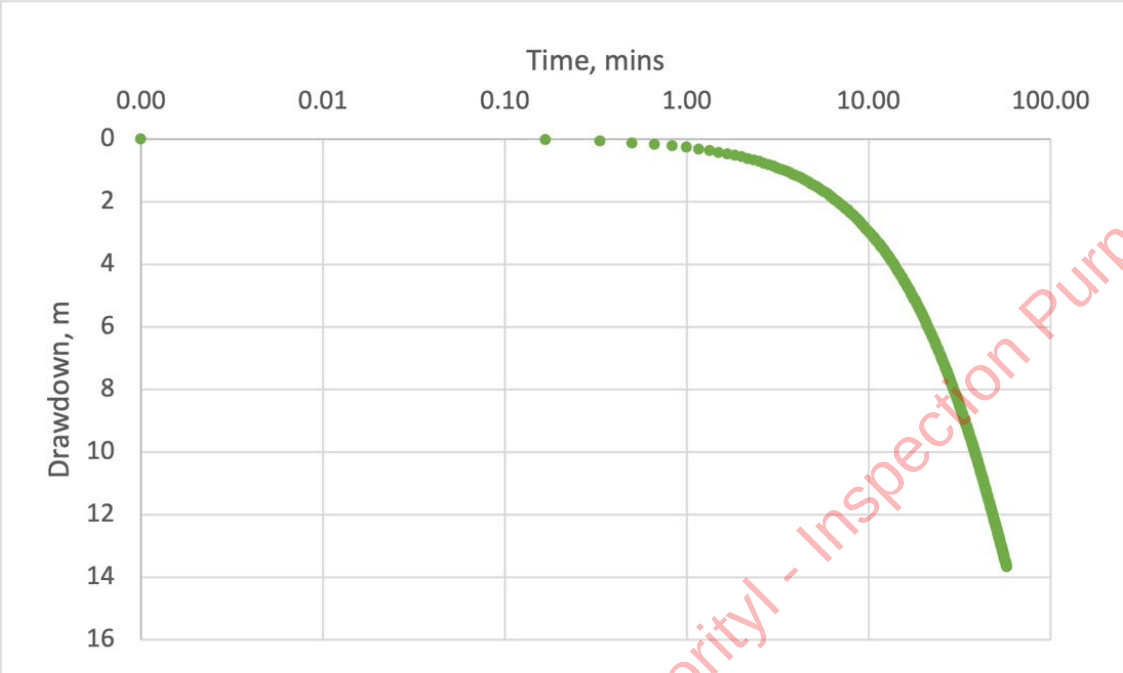
Which is, again, suggesting little permeability in the rock.

The results for K, determined by analysis of the pumping response, and the value of K determined by the analysis of the recovery response, both suggest $K = 10^{-7}$ m/s.

Graph 7.3 – PW1 Drawdown Recovery following Cessation of Constant Discharge Pumping Test



Graph 7.4 – PW1 Drawdown Recovery following Cessation of Constant Discharge Pumping Test over Log Time



7.5.5.1.2 PW2 Tests

Similarly, a 3" Grundfos SQ 55-3 submersible pump was installed in PW2 at 19 mbgl because the drilling time estimate of yield was very low and did not suggest that a bigger pump was necessary. Saturated thickness at start of the test was 17.6 m.

On the 2nd July 2021, Envirologic personnel visited the site and performed a calibration of the pump. During the calibration stage, it became clear that well yield was too low to support an accurate step-test.

To prevent the pump from running dry it was decided to abandon the step test increments, allow the well to recover and proceed straight to constant discharge rate test.

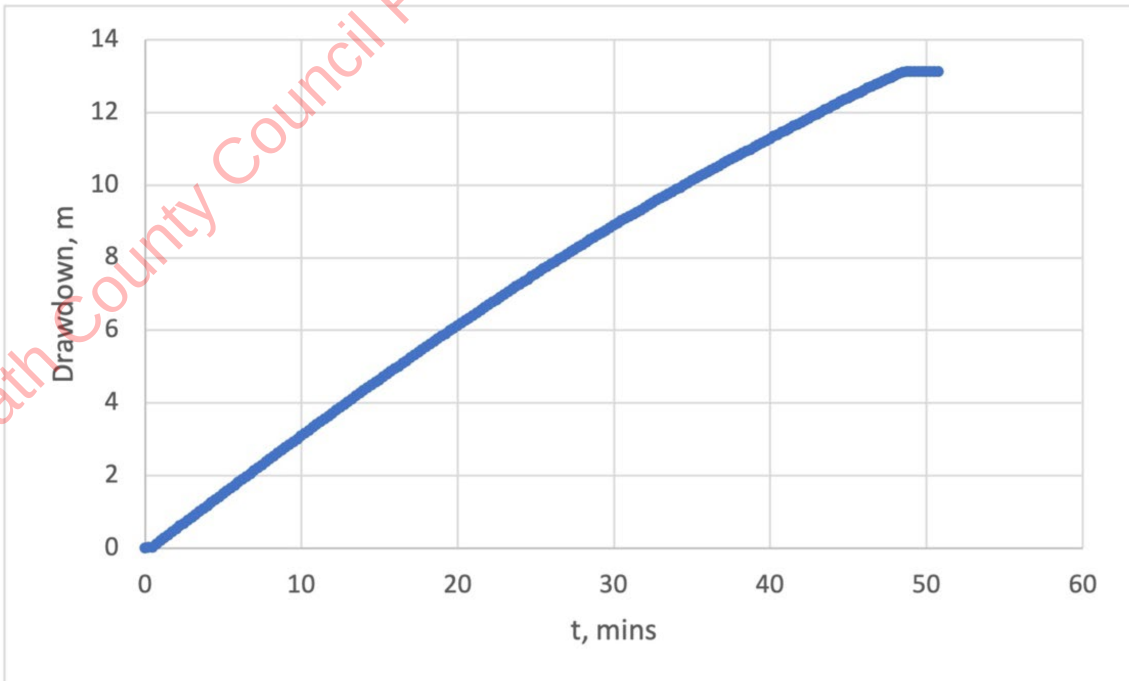
PW2's constant discharge pumping test commenced on 6th July 2021, at a discharge rate of 0.2 l/s (17.4 m^3/d).

The starting groundwater level was 4.46 m below datum (top of the steel casing), equivalent to 84.46 mOD. Manual level readings indicated a rapid drawdown of 13.1 m in water level (17.66 mbtoc, 71.25 mOD) within the first 51 minutes of the test.

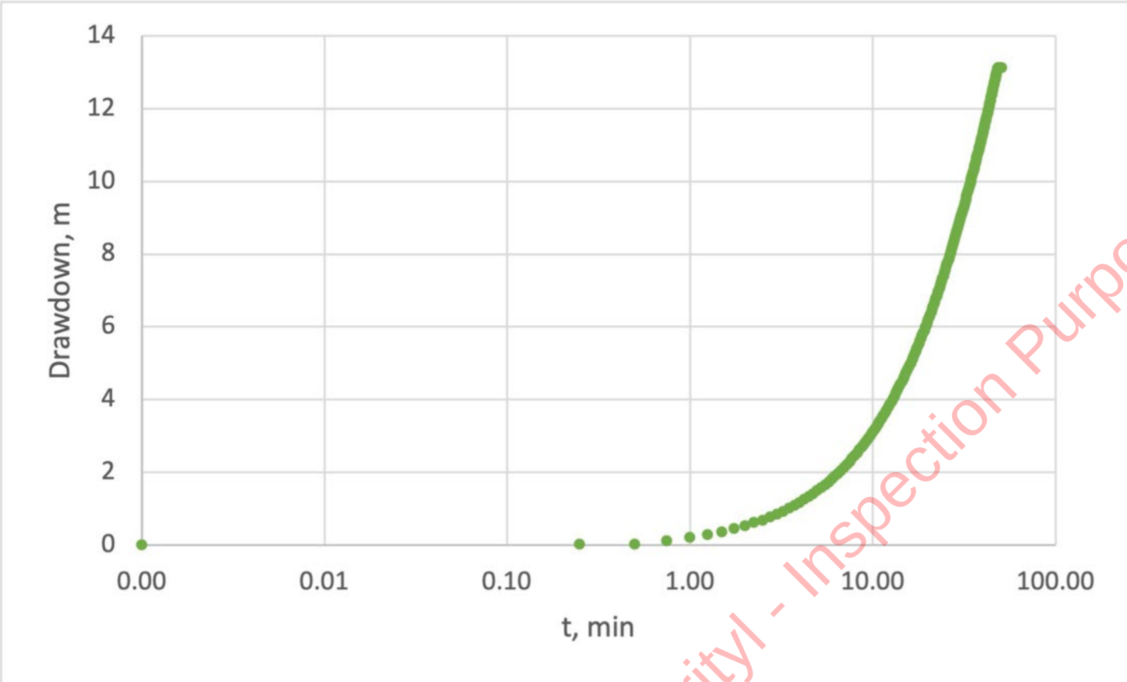
Groundwater levels during the PW2 constant discharge test are shown in Graph 7.5. A review of the drawdown data reveals that the drawdown increases at a constant rate over time. This would indicate a very low permeability bedrock unit where response is dominated by the simple emptying of the well void.

When plotted against time on a log scale, a curve is given rather than a typically expected straight line (Graph 7.6).

Graph 7.5 – PW2 Constant Discharge Test Drawdown over Time



Graph 7.6 – PW2 Constant Discharge Test Drawdown over Log Time



Transmissivity was calculated using the Cooper Jacob's Method (Cooper & Jacob 1946):

$$T = (2.30\ Q) / (4\ \pi\ \Delta s)$$

where: Q = discharge = 17.42 m^3/d = 0.0121 m^3/min

Δs = drawdown over one log cycle (m) = 2.72 (1–10 mins)

= 14.1 (10–100 mins)

For the initial 1–10 minute phase:

$$T = 2.3 \times 0.0121 / 4 \times \pi\ (2.72)$$

$$T = 0.0017\ m^2/min$$

Repeating for the 10–100 minute phase yields T = 0.0003 m^2/min

An average T value of 0.0005 m^2/min (0.7 m^2/d; 8.1 x 10^{-6} m^2/s).

This is a low transmissivity and suggests that water is not easily transmitted through the aquifer.

Permeability is calculated by dividing the transmissivity by the saturated thickness of the aquifer. The saturated portion of the borehole is unlined and fully exposed to the aquifer.

Hydraulic conductivity, K = 0.7 m^2/day / 16.54 m = **9.8 x 10^{-7} m/s**

Again, these data suggest little permeability in the rock.

Recovery observation was performed at the end of the constant rate test, where the response of residual drawdown is recorded until the groundwater level in the well recovered back to normal pre-test levels (Graph 7.7).

The Cooper-Jacob Method was used to estimate aquifer properties, this procedure involves fitting a straight line on a residual drawdown plot of s' (residual drawdown) versus log t/t' (ratio of time since pumping began to time since pumping stopped) (see Graph 7.8). This method is commonly used to estimate transmissivity (T) of an aquifer (Cooper & Jacob 1946 - Straight Line Solution).

Δs = drawdown over one log cycle (m) = 13.1 (1–10 mins)

= 0.06 (10–100 mins)

As the majority of drawdown occurred in the initial 10 minutes, this phase will be used to determine T, as follows:

$$T = (2.30 \times 0.0121) / (4 \times \pi \times 13.01)$$

$$T = 0.0002 \text{ m}^2/\text{min}$$

$$T = 0.25 \text{ m}^2/\text{d}$$

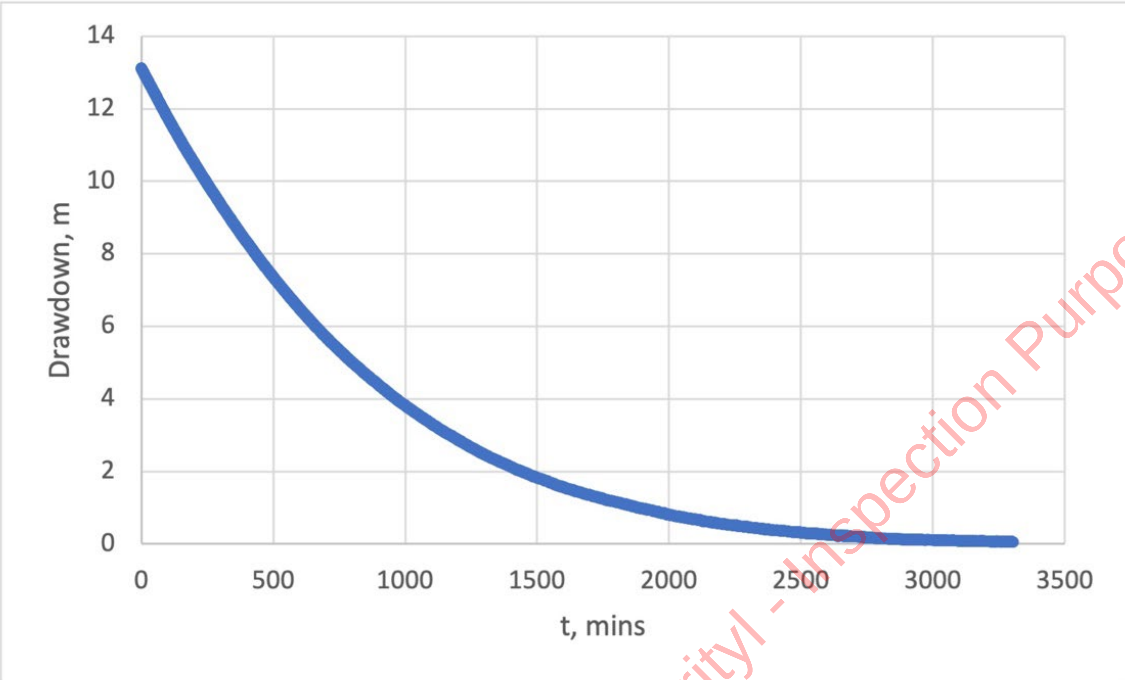
And the consequent calculated Hydraulic Conductivity follows as:

$$K = 0.25 \text{ m}^2/\text{d} / 16.54 \text{ m}$$

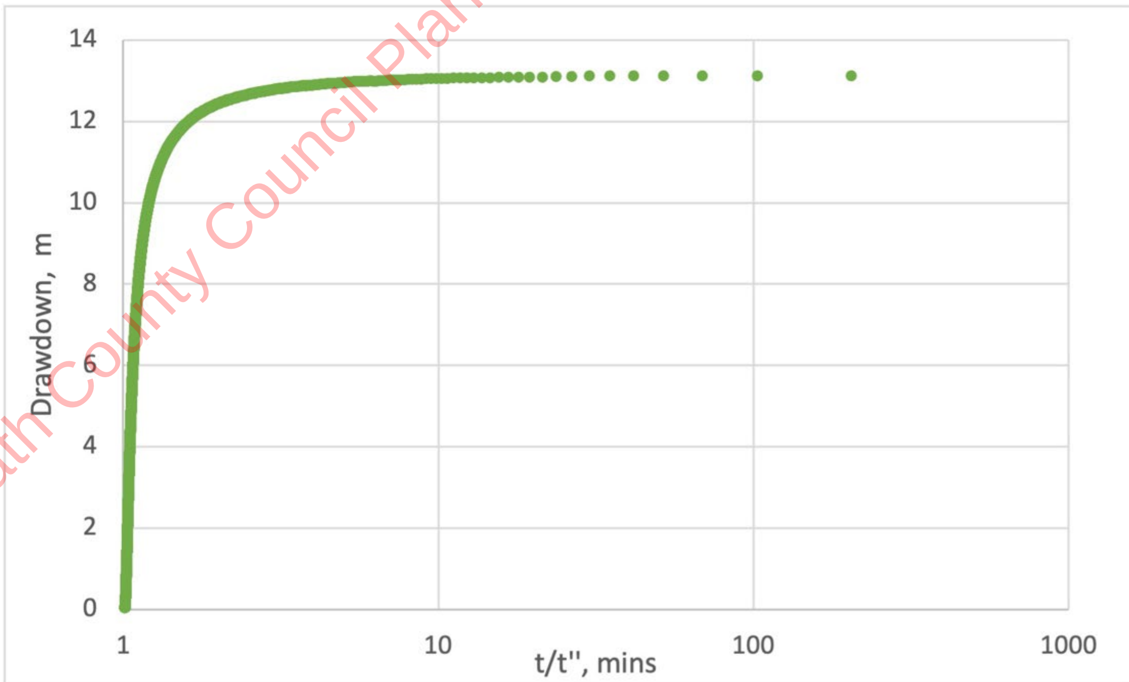
$$\mathbf{K = 1.7 \times 10^{-7} \ m/s}$$

Which is, again, suggesting little permeability in the rock. Similar to PW1's test results, the two methods used to determine PW2's hydraulic conductivity suggest 10^{-7} m/s characteristics. As stated previously, this is in the range of very low permeability like a CLAY liner, rather than a potential aquifer.

Graph 7.7 – PW2 Drawdown Recovery following Cessation of Constant Discharge Pumping Test



Graph 7.8 – PW2 Drawdown Recovery following Cessation of Constant Discharge Pumping Test over Log Time



7.5.5.2 Monitoring Wells

Slug testing using the displacement rod method (3 m HDPE) was performed on each of the three installed MWs to estimate hydraulic conductivity of the geological formation(s) exposed in the screened sections of the piezometer installations.

Using the industry standard approach, drawdown was plotted against time since insertion of slug on a log scale. The Bouwer and Rice approach (1976) was then applied for each monitoring point with calculated values calculated as follows:

- MW1 K = 6.8 x 10^{-9} m/s
- MW2 K = 5.1 x 10^{-5} m/s
- MW3 K = 5.2 x 10^{-7} m/s

Slug test results show that bedrock permeability in the undisturbed area south of the current extraction area is extremely low. The permeabilities determined in MW2 and MW3 represent the rate at which groundwater flows through the boulder clay and strata logged as fault infill. The rate at MW3 is sufficiently low to function as a hydraulic barrier restricting groundwater flow between the marshy pond area and the bedrock aquifer. This is important information because a possible fault infill, when logged during drilling, could be perceived as a potential transmitter of groundwater. However, the 10^{-6} m/s average Hydraulic Conductivity values suggest low permeability and barrier conditions for the Conceptual Site Model.

Thus far, the aquifer testing facilitates conclusions of low permeability bedrock with a low permeability barrier infill of clay from MW2 to MW3.

7.5.5.3 Aquifer Testing Summary

The results from hydraulic testing of the large diameter boreholes are summarised as follows:

- PW1 pumping test K = 4.3 x 10^{-7} m/s
- PW1 recovery test K = 1.6 x 10^{-7} m/s
- PW2 pumping test K = 9.8 x 10^{-7} m/s
- PW2 recovery test K = 1.7 x 10^{-7} m/s

For the purposes of dewatering calculations, the mean K value for the quarry floor is taken to be 10^{-7} m/s.

Hydraulic properties of the Derravaragh Cherts at Deerpark were at the lower end of the range for limestones and confirm that the primary porosity is low, with no discrete water-bearing fractures encountered.

7.6 SITE MONITORING

7.6.1 GROUNDWATER LEVELS

Groundwater levels are presented in Table 7.10.

Table 7.10 Groundwater Levels

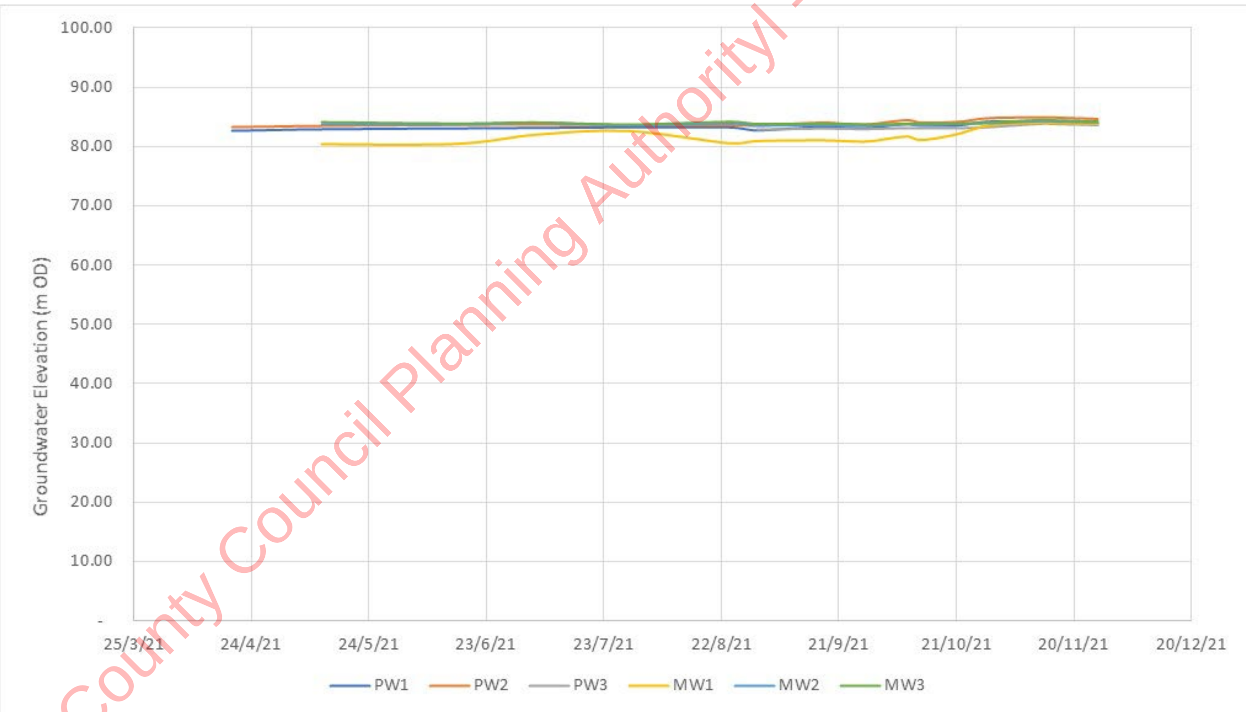
Castlepollard Quarry	PW1		PW2		PW3		MW1		MW2		MW3	
Easting	647,726		647,686		647,712		647,839		647,589		647,724	
Northing	768,393		768,396		768,549		768,149		768,430		768,508	
BH Depth (m)	21		21		78		51		18		18.5	
GL @ BH Elevation (m OD)	87.54		87.92		88.79		115.93		89.28		86.93	
BH Base Elevation (m OD)	66.54		66.92		10.79		64.73		71.14		68.43	
Height of casing above GL (m)	0.92		1.23		0.97		0.66		0.58		0.58	
Top of Steel Casing (toc) (m OD)	88.72		88.91		88.92		116.34		89.76		87.39	
Screen interval (m btoc)	open hole BHs				63 to 78		36 - 51		13 – 18		9.5 – 18.5	
Water Strikes (m OD)	**68**		**68**		**49**		**None**		**4.5 m (slow)**		**Dry during drilling but WL ingress overnight**	
Water Level Manual Dip Date	SWL (mbtoc)	**WL m OD**	SWL (mbtoc)	**WL m OD**	SWL (mbtoc)	**WL m OD**	SWL (mbtoc)	**WL m OD**	SWL (mbtoc)	**WL m OD**	SWL (mbtoc)	**WL m OD**
19/4/21	5.88	**82.84**	5.90	**83.01**	not drilled	**n/a**	not drilled	**n/a**	not drilled	**n/a**	not drilled	**n/a**
12/5/21	5.60	**83.12**	5.68	**83.23**	not drilled	**n/a**	35.88	**80.46**	5.99	**83.77**	3.33	**84.06**
15/6/21	5.45	**83.27**	5.52	**83.39**	not drilled	**n/a**	35.83	**80.51**	6.02	**83.74**	3.59	**83.80**
6/7/21	5.35	**83.37**	5.45	**83.46**	not drilled	**n/a**	34.27	**82.07**	5.74	**84.02**	3.40	**83.99**
29/7/21	5.26	**83.46**	5.56	**83.35**	not drilled	**n/a**	33.68	**82.66**	6.16	**83.61**	3.78	**83.61**
24/8/21	5.27	**83.45**	5.57	**83.34**	not drilled	**n/a**	35.70	**80.64**	5.82	**83.94**	3.27	**84.12**
31/8/21	5.80	**82.92**	5.63	**83.28**	6.97	**81.95**	35.34	**81.00**	6.21	**83.55**	3.66	**83.73**
16/9/21	5.16	**83.56**	5.15	**83.76**	6.77	**82.15**	35.22	**81.12**	6.13	**83.63**	3.64	**83.75**
24/9/21	5.37	**83.35**	5.41	**83.50**	6.85	**82.07**	35.39	**80.95**	6.25	**83.51**	3.69	**83.70**
29/9/21	5.19	**83.53**	5.18	**83.73**	6.90	**82.02**	35.37	**80.97**	6.24	**83.52**	3.76	**83.63**
8/10/21	4.67	**84.05**	4.71	**84.20**	6.68	**82.24**	34.60	**81.74**	6.04	**83.72**	3.64	**83.75**
12/10/21	4.93	**83.79**	5.12	**83.79**	6.72	**82.20**	35.17	**81.17**	6.18	**83.58**	3.59	**83.80**
21/10/21	4.95	**83.77**	5.02	**83.89**	6.69	**82.23**	34.23	**82.11**	5.91	**83.85**	3.57	**83.82**
29/10/21	4.25	**84.47**	4.38	**84.53**	6.51	**82.41**	32.80	**83.54**	5.83	**83.93**	3.43	**83.96**
11/11/21	4.25	**84.47**	4.24	**84.67**	5.87	**83.05**	32.29	**84.05**	5.47	**84.29**	2.96	**84.43**
16/11/21	4.29	**84.43**	4.29	**84.62**	5.91	**83.01**	32.36	**83.98**	5.54	**84.22**	3.03	**84.36**
26/11/21	4.54	**84.18**	4.51	**84.40**	6.12	**82.80**	32.53	**83.81**	5.69	**84.07**	3.19	**84.20**

Groundwater levels surveyed on 29th September 2021 are illustrated in Figure 7.10. Well heads were surveyed using a Trimble GPS. Water levels were dipped with a dipmeter, and the well head elevations (mOD) used to convert the dipped water levels to elevations for the purposes of determining groundwater gradients and probable flow direction.

Water level dataloggers were installed for the purposes of continuously recording groundwater levels. The compensated water level data suggests a relatively stable water level response with a slight drop in groundwater levels observed as is expected in a normal hydrogeological recession. All borehole water level responses are presented in Graph 7.9 and the continuous datalogger records are presented in Graph 7.10. Both water level records, whether manually dipped or continuous datalogger record, show the same steady water level response and no big peaks in response to the start of the recharge season in late September/early October.

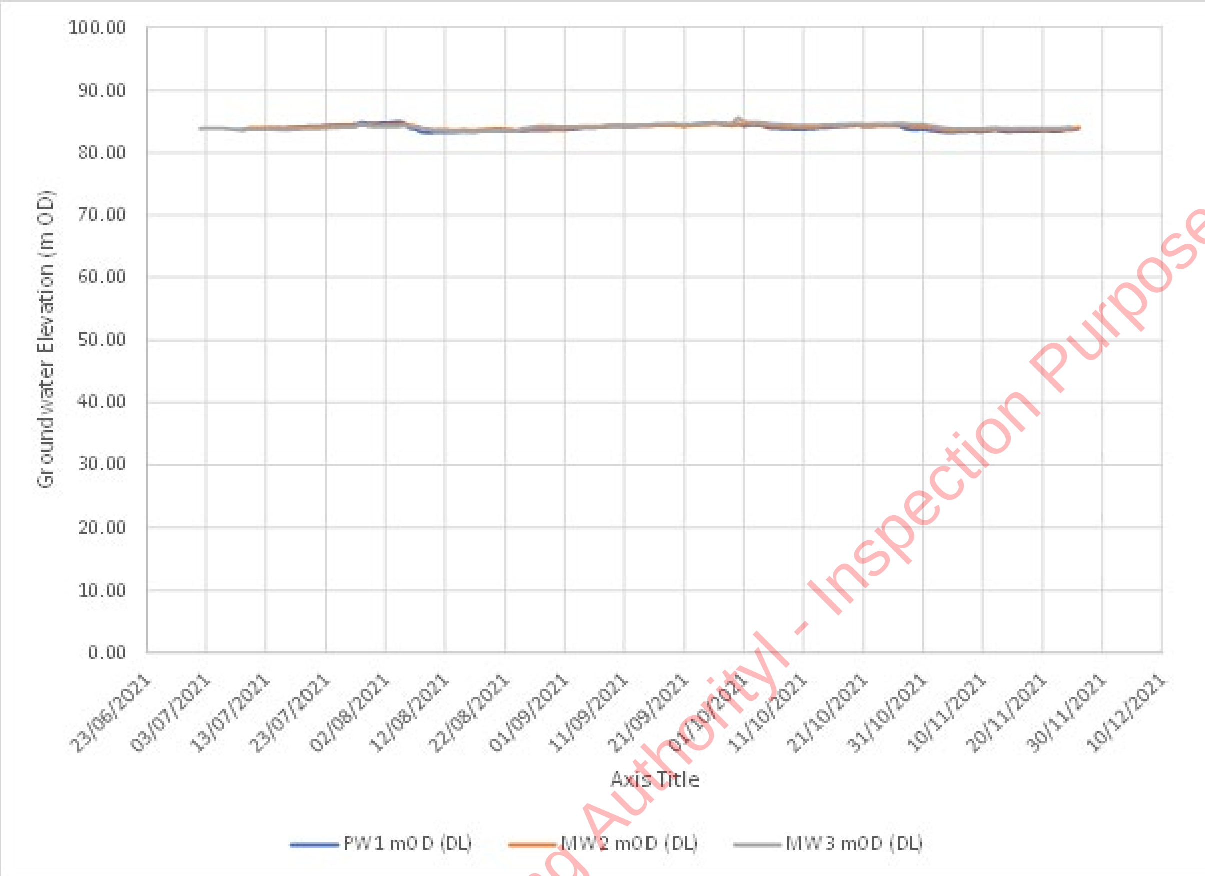
With reference to Graph 7.9 the difference in elevation at MW1 is because it is the other side of the hill.

Graph 7.9 – Groundwater level variation across site in 2021



Manually Dipped Water Levels in All Monitoring Points

Graph 7.10 – Groundwater level variation across site in 2021 (Continued)



Continuous Datalogger record for Water Levels in Selected Monitoring Points

7.6.2 GROUNDWATER FLOW DIRECTION

Groundwater levels across the quarried part of the site are relatively level, being within a narrow range. The marginal hydraulic gradient within the northern part of the site, in the working area, implies that groundwater flow direction is towards the west-northwest. Groundwater flow direction on the southern side of the hilltop is likely to be to the south and this is reflected in the persistently lower water level elevation at MW1 at the southern boundary (Graph 7.9).

Surface water elevations suggest that the water contained within the adjacent marshy area to the east is not hydraulically connected to groundwater in the area and represents a perched surface water system independent of the surrounding hydrogeological regime. This is presumably a result of the thick lacustrine clay layer between the active extraction area and the marshy pond which acts as a confining layer and provides a hydraulic barrier to groundwater flow.

7.6.3 GROUNDWATER FLOW REGIME

Based on the drilling experiences the conceptual model for the site is that there is not a groundwater flow regime as commonly understood in the karst conduits, sandstones, or gravel aquifer types. The rock at this site is, as described by Meehan et al. (2019), tight and hard and its exposure by quarrying is valued by geologists to have the opportunity to observe its density. If it is that dense, as experienced during drilling, then there is little ability for water to move and flow through it. In dense, tight geological formations such as encountered at this site, the creation of a groundwater contour map has limited conceptual value, as any groundwater that is encountered in monitoring wells is most likely highly localised to that area, and not representative of a local or regional water table level. Water strikes in the boreholes were below the proposed floor elevation. The holes were drilled to evaluate the underlying strata. Small strikes were encountered at elevations below the proposed floor. The water levels subsequently recorded in the boreholes represent hydrostatic pressure in the bedrock below the proposed floor elevation. The water strikes were small in all cases.

7.6.4 GROUNDWATER QUALITY

Groundwater quality sampling was undertaken in July 2021 and September 2021. As the pumping test did not sustain a yield long enough to retrieve a sample, a combination of low flow sampling (PW1, MW2, MW3) and bailer retrieval (MW1) was utilised.

Field recordings for physiochemical parameters, temperature, dissolved oxygen, pH, conductivity and oxidation-reduction potential (ORP) had stabilised at the time of water sampling using the low-flow technique.

Samples were delivered to ALS on the day of sampling for analysis of microbiological parameters and biochemical oxygen demand (BOD). Remaining samples were filled into the appropriate sample containers that contained the appropriate fixation substance per parameter, stored in cooler boxes and dispatched by courier on the sampling day for analysis of remaining hydrochemical parameters to ALS (Round 1) or Element Laboratories, Deeside, UK (Round 2).

Groundwater quality results are presented in Table 7.11. Certificates of Analysis are presented in Appendix 7.3. The results presented in Table 7.11 suggest the following:

- Electrical Conductivity, pH, Alkalinity and Total Hardness are as expected for the limestone bedrock hydrogeology.
- No hydrocarbons were detected in any samples. Results suggest < Limit of Detection of the laboratory analyser. This suggests no historical impacts reside at the site.
- Total Phosphorus and Ortho-phosphate concentrations are below the limit of detection of the analyser and hence suggest excellent groundwater quality.
- Nitrate concentrations are below the expected national baseline, nitrites are low and, on the whole, Ammonia levels are much lower than the Threshold Values specified in the Groundwater Regulations. While the final sampling event for MW3 has slightly elevated

Ammonia, MW3 is located immediately adjacent to a peat boggy marshy water body, and therefore the elevated Ammonia is not suspected of being associated with a contamination source. It is therefore concluded that there is no historic residue from explosives used for blasting, no impact from private on-site wastewater treatment systems in the local area and no agricultural impact from the wider area.

- Overall, it is concluded that nutrient concentrations are all very low.
- Faecal coliforms were not detected in any of the PW groundwater samples. Groundwater sampled at PW1 adjacent to the active quarry area contained no counts of bacteria. MW2 presents faecal coliforms and this is a monitoring point close to agricultural lands.
- With respect to metals, all the Groundwater Regulation's specified metals are within Regulatory values for the open PWs in the Bedrock. For example, Aluminium, Cadmium and Zinc concentrations in the groundwater are low, which is good because those parameters have potential to threaten the ecology of waters receiving the discharge of quarry waters. At this site there is no potential for harm. While there are some exceedances in the MWs, those piezometer installations are completed with gravel packs at their screened sections and hydrochemistry should settle in time.

Based on the results in Table 7.11, groundwater quality at the site complies with the European Communities Environmental Objectives (Groundwater) Regulations 2010 (as amended 2011, 2012, 2016) and discharge of these waters should not have a detrimental impact on receiving waters. Hydrochemical assimilation capacity simulations, presented later, will test this. The analyses for hydrochemical parameters completed at the site is greater than specified in the Groundwater Regulations because the results for the groundwater and outfall sump will be used in conjunction with the receiving surface water's characteristics to evaluate hydrochemical assimilation capacity.

Table 7.11 Summary Groundwater Quality Results

[Refer to Appendix 7.3 for Laboratory Certificates of Analysis]

	Units	PW1	PW1	MW1	MW2	MW2	MW3	MW3	Groundwater Regulation Threshold Values (2010, as amended 2016) *
Date		29/07/21	30/09/21	30/09/21	29/07/21	30/09/21	29/07/21	30/09/21	
Field Temperature	°C	11.4	11.7	10.4	10.8	11.4	12.1	11.6	
Field Electrical Conductivity	µS/cm	661	682	503	591	646	672	646	800 - 1875
Field pH	pH units	8.0	8.4	8.6	7.6	7.8	7.7	8.1	Not specified
Field DO	mg/l	0.43	3.21	3.77	2.9	3.26	1.3	3.36	Not specified
Aluminium	µg/l	<100	<20	<20	**227**	<20	**579**	<20	150
Cadmium	µg/l	<0.6	<0.5	<0.5	<0.6	<0.5	0.8	<0.5	3.75
Chromium	µg/l	<2.0	<1.5	<1.5	3.70	1.5	<2.0	<1.5	
Iron	µg/l	275	<20	<0.5	**3600**	316	**2100**	**2733**	Not specified
Manganese	µg/l	127	113	9	499	704	543	596	Not specified
Mercury	µg/l	<0.01	<1	<1	0.03	<1	0.02	<1	0.75
Zinc	µg/l	<18	5	6	2.64	422	36.1	<3	75
Calcium	mg/l	116	127	60	116	140	101	122	Not specified
Magnesium	mg/l	25.5	27	24	7.63	10	11.7	13	50
Potassium	mg/l	7.07	0.6	7.4	1.28	1.3	3.11	2.6	Not specified
Sodium	mg/l	7.26	7.8	29.4	7.78	8.3	20.5	25.6	150
Sulphate	mg/l	**236**	**226.5**	20.4	51.7	26.6	16.7	17.6	187.5
Chloride	mg/l	9.7	10.7	11.5	16.2	16.5	42.7	42.7	187.5
Nitrate (NO_3)	mg/l	<3.1			<3.1		<3.1		37.5
Nitrate as N	mg/l	<0.7	0.50	1.59	<0.7	<0.05	<0.7	<0.05	
Nitrite (NO_2)	mg/l	0.26			0.26		**2.13**		0.375 ug/l
Nitrite as N	mg/l	<0.08	<0.006	<0.006	<0.08	0.052	0.65	0.052	
Inorganic N	mg/l		0.50	1.64		0.10		1.97	
Ammonium as N	mg/l		<0.03	0.05		0.05		**1.96**	0.065 to 0.175
Orthophosphate as P	mg/l	<0.02	<0.01	0.027	<0.02	<0.01	<0.02	<0.01	Not specified
Total P	mg/l	<0.12	<0.005	0.757	0.14	0.061	<0.12	0.071	Not specified
Alkalinity ($CaCO_3$)	mg/l	166	172	726	300	384	334	338	Not specified
Total Hardness	mg/l	395			321		301		Not specified
TOC	mg/l	<0.7	<2	<2	5.1	<2	4.6	<2	Not specified
EPH (C8-C40)	µg/l		<10	<10		<10		<10	
TPH (C5-C35)	µg/l	<10	<10	<10	<10	<10	<10	<10	7.5 ug/l TV ^
PAH Total	µg/l	0.016	<LOD	<LOD	**0.184**	<LOD	0.015	<LOD	0.075 ^
Suspended Solids^^	mg/l	16	<10	1356	**67**	**44**	**163**		Not specified
BOD	mg/l	<2	<2	2	**3**	2	<2	2	Not specified
Total coliforms	MPN/ 100 ml	0	0	14	10	1	0	0	Not specified
Faecal coliforms	MPN/ 100 ml	0	0	14	0	1	0	0	Not specified

* Threshold values relevant to an assessment of the general quality of groundwater in a groundwater body in terms of its ability to support human uses has been significantly impaired by pollution. Where this threshold was not stated, that relevant to an assessment of whether groundwater intended for human consumption in drinking water areas is impacted by pollutants and/or is showing a significant and sustained rise in pollutant levels was applied.

^ The Irish EPA acknowledge that no laboratory can achieve the TPH and PAH TVs. It is generally accepted that a <LOD result shall suffice to demonstrate no hydrocarbon content in the waters.

^^ Suspended Solids' Limit of Detection in the UK Laboratory is relatively high. It is most likely that results are a fraction of the <10 mg/l reported.

7.6.5 SURFACE WATER QUALITY

Surface water quality monitoring results, representing receiving waters in the vicinity of the site are tabulated in Table 7.12. Certificates of Analyses are attached in Appendix 7.3.

Sampling points are shown on Figure 7.13 and are described as follows:

- SW1 = Surface Water closest to the site boundary
- SW2 = Castlepollard Stream

(Note: SW2 is upstream of the future mixing point of the Deerpark Stream carrying the discharge to the Castlepollard Stream, this is the point of evaluation for hydrochemical assimilation in the surface water systems).

The results for sampling point SW2 are considered to represent the characteristics for assimilation capacity simulation and mixing point applicable to the proposed discharge route.

Results presented in Table 7.12 suggest that similar to the results for groundwater at the site (Table 7.11), the nutrient concentrations in the surface waters are very low and suggest that neither diffuse agriculture, nor on-site wastewater treatment systems are significant pressures. While the results for SW1 present elevated ammonia and ortho-P, the Total Organic Carbon value for this sampling point is 22 mg/l TOC, and this in itself is evidence for either peat or agricultural organic matter of some sort and it is not a natural surface water TOC concentration. Therefore, the results for SW2 must be adopted as the receiving water's representative hydrochemical quality.

BOD at SW2 is 2 mg/l.

While both faecal and non-faecal coliforms are elevated in samples of surface water in both catchments, this is typical of all surface waters in Ireland because of agriculture and on-site wastewater treatment systems.

The results for the surface water quality reflect the Fen Peat soils and subsoils and the extent of forestry upgradient of the sampling location. Refer to Figures 7.3 and 7.4 and the aerial photography of Figure 7.13.

Table 7.12 Surface Water Quality

[Surface Water Regulation Specified Parameters and compliance highlighted]

Parameter	Units	SW2, Castlepollard Stream	SW1	SW2, Castlepollard Stream	Surface Water Regs (2009, as amended 2012, 2015, 2019)
Date		29/07/21	30/09/21	30/09/21	
Temperature	℃	11.9	11.3	11.1	
Field Electrical Conductivity	µS/cm	598	601	588	
Field pH	pH units	8.3	8.44	8.1	4.5 – 9.0
DO	mg/l	9.1	6.99	9.2	95 to 120 % saturation
Aluminium	µg/l	<100	<20	<20	
Cadmium	µg/l	<0.6	<0.5	<0.5	1.5
Chromium	µg/l	<2.0	<1.5	<1.5	
Iron	µg/l	<230	460	24	
Manganese	µg/l	8.2	151	21	
Mercury	µg/l	<0.01	<1	<1	
Zinc	µg/l	<18.0	<3	<3	
Calcium	mg/l	122	66	130	
Magnesium	mg/l	8.84	3.1	9.4	
Potassium	mg/l	1.88	1.3	1.7	
Sodium	mg/l	8.96	10.3	9.8	
Sulphate	mg/l	12.4	<0.5	16	
Chloride	mg/l	17.1	18.7	16.9	
Nitrate (as NO_3)	mg/l	6	<1	6	
Nitrate (as N)	mg/l	1.7	<0.05	1.67	
Nitrite (as N)	mg/l	<0.08	<0.006	<0.006	
Ammoniacal Nitrogen as N	mg/l		1.12	<0.03	0.4 to 0.9 mg/l High Status
Orthophosphate as P	mg/l	<0.02	0.074	0.022	0.025 to 0.0445 mg/l MRP-P High Status
Total P	mg/l	<0.12	0.145	0.027	
Alkalinity ($CaCO_3$)	mg/l	339	174	322	
TPH (C5-C35)	µg/l	<10	<10	<10	
PAH Total	µg/l	<0.010	<LOD	<LOD	
Total Hardness	mg/l	341			
TOC	mg/l	1.6	22	<2	
Suspended Solids^^	mg/l	26.0	37	<10	Not specified in Surface Water Regulations but Salmonid Regulations = 25 mg/l
BOD	mg/l	2	4	2	High Status 1.3 to 2.2 mg/l BOD
Total coliforms	MPN/ 100 ml	4986	548	1414	
Faecal coliforms	MPN/ 100 ml	345	548	1414	

^^ Suspended Solids' Limit of Detection in the UK Laboratory is relatively high. It is most likely that results are a fraction of the <10 mg/l reported.

7.7 DEWATERING ESTIMATIONS

Groundwater seepage into an open quarry void has the potential to initiate a hydraulic response in the surrounding bedrock that can be conceptualised as radial flow towards a pumping well. Where the surrounding bedrock has low hydraulic conductivity, inflow rates and water management can be handled using sumps on the quarry floor. Site investigations for PWs, MWs and the aquifer testing completed suggests low permeability and potentially low water volumes requiring water management in the future at this site.

As the current quarry floor has not intersected groundwater there has been no previous dewatering at the site. Hence, projected dewatering rates are estimated for the proposed development using recommended formulae and site-specific data collected from drilling investigations. The site's future dewatering demands and consequent water management needs are determined using the characteristics encountered at PW1 and PW2. This is considered a conservative approach given the permeability values at MW3 are two orders of magnitude lower than that being applied. This is judged to be an appropriate strategy because geophysics and aquifer testing displayed consistency across the proposed extraction area.

The methodology to determine the potential radial effect and the possible quantity of water requiring management at the site in the future is now presented in calculation steps, as follows:

1. Determine the Radius of Influence
2. Determine the potential volume of Groundwater Inflows to the Sump
3. Alternatively evaluate volumes that might occur by applying the concept of Recharge from the Upgradient Aquifer, and
4. Conclude on the Total Dewatering Volumes that might arise in the future

The principles for estimating groundwater flows are typically based on radial inflows, so a preliminary step is required to convert the extraction area to its circular equivalent having the same area.

The proposed rock extraction area has an area of c.4 ha or 40,000 m^2, approximately. This area has an equivalent radius of 113 m.

The area is to be deepened to 70 mOD. As the final floor must be dewatered the final drawdown is estimated as 15 m (based on maximum resting groundwater levels at PW1 and PW2 between July to October 2021 of 84.5 mOD).

7.7.1 RADIUS OF INFLUENCE

Even though borehole drilling, piezometer installations and aquifer testing suggest little groundwater continuity at the site, it is convention to calculate, for the worst case possible future scenario, the radius of influence of site dewatering.

The Radius of Influence can be estimated using Sichardt's Empirical equation as follows:

$$R_0 = C(H - h_w)\sqrt{K}$$

Where

R_0 = radius of influence (excluding radius of theoretical well = final sump = 113 m radius)

C = constant = 3000

$H - h_w$ = proposed final drawdown to sump

= 85 mOD (PW1) – 70 m OD (average final floor wl) = 15 m

K = bedrock permeability = 4.4 x 10^{-7} m/s = 0.0285 m/d

Which suggests that the Radii of Influence R_0 are as follows:

R_0 = 30 m from edge of the proposed excavation area

R_0 = 143 m from centre the proposed excavation area

The potential radius of influence upon completion of works is illustrated in Figure 7.11.

There are no active groundwater receptors that may be at risk of impact from groundwater drawdown within 30 m of the centre of the proposed excavation area.

In theory, the marshy pond to the east is within the area of influence. However, site surveying shows that the surface water level in the marshy pond is perched 2 m above groundwater level in the quarry area. This, coupled with the drilling programme undertaken onsite suggests that the marshy pond water is separated from groundwater by underlying impermeable peats. Water level in the marshy pond is controlled by an artificial drainage outlet and were it not for this structure pond water level would likely continue to accumulate to higher levels. The low permeability subsoil barrier between the marshy pond and the active quarried area restricts hydraulic connectivity. Therefore, the marshy pond is not, in fact, within the radius of potential future dewatering at the site and is hydraulically disconnected from the underlying groundwater regime.

7.7.2 GROUNDWATER INFLOWS TO SUMP

When the floor of an open quarry is excavated below the water table, there is potential for groundwater to enter the quarry through seepage faces in the walls of the void and/or as upward flow through the excavated floor base. There are commonly two components to the inflow as follows:

1. diffuse inflow widely distributed through the general rock mass; and
2. focused flow where permeable fractures intersect the exposed quarry faces.

Using these principles, the analytical solution put forward by Marinelli & Niccoli (2000) is derived from the Dupuit-Forcheimer approximation to estimate radial groundwater inflows to open pit quarries. Their solution incorporates a time-dependent factor.

$$Q(t) = (4 \pi K b s_w) / (2.3 \log (2.25 K b t / r_p^2 S))$$

where:

K = hydraulic conductivity in active quarried area (0.038 m/d)

b = thickness of the fractured bedrock horizon (50 m)

S_w = design drawdown (85 m OD – 70 m OD) = 15 m

r_p = equivalent radius of the active quarry (113 m)

S = specific storage (1 x 10^{-5} m^{-1}), textbook value

t = time since 'instantaneous' placement of the open pit

The application of the Marinelli & Niccoli (2000) solution equation suggests potential future groundwater dewatering rates as follows:

- Dewatering Rate Q = 54 m^3/d after one month from the time that the site is brought to 70m OD, and the quarry plan predicts that that bench will start 14 years from the commencement of activities proposed in the application under consideration here.
- Dewatering Rate Q = 43 m^3/d after six months after one month from the time that the site is brought to 70m OD.

7.7.3 RECHARGE FROM THE UPGRADIENT AQUIFER

One could argue that the radial approach may not be entirely appropriate to the uniqueness of Irish hydrogeological features and that it can overestimate inflows from lands downgradient of the site in terms of groundwater flow and underestimate inflows from lands hydraulically upgradient. Therefore, an alternative approach was applied, which is typically used to delineate zones of contribution (ZOCs) to public water supply wells. This approach estimates the rate or volume of water to be removed from the quarry by assuming it will be equivalent to the rate of groundwater flow through the site that will be intercepted by excavation below static groundwater level.

The regional landscape suggests that groundwater recharge to the Lm aquifer will be from the more elevated areas to the south and west of the site. The ZOC has been estimated as extending southeast from the current active area and is presented in Figure 7.11. This ZOC has an overall area of 107,838 m^2.

The information presented in Figure 7.11 highlights the different recharge coefficients within this ZOC; the areas applicable to each recharge coefficient are shown in Table 7.13.

Recharge coefficients in the ZOC are either 60 % or 85 % depending on presence and depth of subsoil. As presented in Table 7.13, this approach yields a total recharge to the upgradient Lm area (in terms of groundwater flow) in the order of 139 m^3/d.

Table 7.13 Recharge Upgradient of the Site in Terms of Groundwater Flow

Recharge coefficient	Area, m^2	Effective Rainfall, mm	Aquifer	Recharge cap, mm/yr	Recharge, mm/yr	Recharge, m^3/yr	Recharge, m^3/d
85 %	95,922	573	Lm	0	487	46,714	128
60 %	11,916	573	Lm	0	344	4,099	11
					Total Recharge	50,813	**139**

7.7.4 FUTURE TOTAL DEWATERING VOLUMES

Based on all the preceding calculations, the amount of rainfall runoff to be managed at the site is equal to **31 m^3/d** (refer to Table 7.8). It can be assumed that this is a volume that will always require management.

In addition to the rainfall runoff component, two distinct methods for estimating groundwater inflows to the site as extraction nears completion were applied. The results of which are summarised as follows:

1. Based on an empirical formula, which utilizes permeability and final drawdown, the potential amount of water to be managed is as follows:

   (a) Groundwater inflow based on drawdown and bedrock hydraulic conductivity = 54 m^3/d

   plus

   (b) Surface runoff and recharge rejected at bedrock head = 31 m^3/d

   Yields a Total = 85 m^3/d = 0.001 m^3/s

   Or

2. Based on rainfall and recharge coefficients:

   (a) Recharge to Lm aquifer at the site and in the area upgradient of the site in terms of groundwater flow = 139 m^3/d

   plus

   (b) Surface runoff and recharge rejected at bedrock head within site = 31 m^3/d

   Yields a Total = 170 m^3/d = 0.002 m^3/s

It is therefore concluded that the total discharge could be between 85 m^3/d and 170 m^3/d. These values equate to between 0.001 and 0.002 m^3/s. It is acknowledged that this might appear to be a large range. However, the value depends on the calculation method chosen. The significance of the results obtained is that they are very small volumes for an 11.4 ha site. The potential total water management volumes being ~200 m^3/d is an order of magnitude lower than experienced at some limestone quarries of similar acreage. The low values reflect the density of the rock and the fact that beneath the current hill being quarried, there is little groundwater in a bedrock with very low hydraulic conductivity.

These values are intended to be representative of maximum discharge rates that are only likely to be realised close to completion of rock extraction operations. Interim discharge rates will respond to the phasing scheme. The phased development will involve the development of the upper quarry benches to the southeast i.e. dry working. Development of the bench below the current quarry floor to 70m OD will not take place until the latter part of the expected 20 year life of the quarry. The maximum possible future dewatering volume of 0.002 m^3/s will later be employed to evaluate the ability of the receiving waters to accept and assimilate the site's discharge from a hydraulic and hydrochemical perspective. Firstly, the baseline hydraulic capacity of the receiving waters must be determined in order to confirm that the system can receive the proposed discharge from the site.

7.8 HYDRAULIC CAPACITY OF RECEIVING WATERS

Sustainable quarry operation requires that the local natural surface water drainage network has adequate capacity to receive and safely transmit the potential discharge rates outlined above. Receipt in the natural watercourse system must be assessed from hydraulic (flood potential) and hydrochemical (Surface Water Regulations compliance) perspectives.

This chapter has already described how runoff generated at the site is diverted towards the headwaters of the Deerpark Stream. The hydrological evaluations include an assessment as to whether quarry discharge has the potential to increase the risk of flooding in downstream receptors and adjoining lands.

7.8.1 CATCHMENT FLOWS

The first step in hydraulic capacity assessment is to calculate the existing stream flows that arise during extreme return period events (Q_{100}).

Calculations are first presented for flood flows in the Deerpark Stream to the point where it outfalls to the Castlepollard Stream. These rates will be input into a hydraulic model to predict flood levels at various locations along the drainage network.

In order to assess the impact posed by potential dewatering at the site, two separate flood risk scenarios have been considered:

1. Pre-development - The streams were modelled in their existing form using natural catchment flood flows, this model includes all of the existing in-situ downstream engineered culverts and road bridges.
2. Post-development - The streams were modelled using the cross sections as per (1) plus the inclusion of an additional flow input to the model. This additional flow is intended to represent future proposed dewatering activities during development of the quarry and will be used to assess the remaining hydraulic capacity of the stream during a Q_{100} flood event.

7.8.1.1 OPW Advice

In selecting appropriate formulae, reference has been made to an advisory response from OPW Hydrology Section and Work Package 4.2:

- *'For catchments between 5 km^2 and 25 km^2 the preferred equation is the 'FSU small catchments' equation. When using the small catchment equation we generally advocate not using a pivotal site adjustment seeing as there is a very small pool of other small catchments from which to source a pivotal site.*
- *For catchments less than 25 km^2 we would always say that at least three methods should be explored and that the choice of the flow to be used is up to the practitioner.*
- *The WP4.2 report is intended to provide a further methodology for small catchment flood estimation. As far as we are concerned, it is the preferred method.*

- *For catchments less than 5 km² there is no FSU method applicable. For such 'small' catchments we would suggest that maybe the rational method or modified rational method could be used.'*

7.8.1.2 OPW FSU - 7 Variable Equation

The ungauged method can be used to determine flood flows at the site using catchment characteristics, which are then corrected using a correlation against descriptors for gauged catchments. The median annual maximum flood magnitude (QMED), as outlined in the Flood Studies Update (FSU) (Nicholson & Bree 2013) is now preferred over the mean annual flood flow rate (Qbar) parameter described in the Flood Studies Report (FSR) (NERC 1975). The preferred median method is less sensitive to large extreme floods and to flood measurement error in general. The estimation method for ungauged locations is based on a regression analysis relating observed QMED to physical catchment descriptors (PCDs) at gauged locations in Ireland, given by the following equation:

$$QMED_{rural} = 1.237\text{x}10^{-5} \,.\, AREA^{0.937} \,.\, BFI_{soil}^{-0.922} \,.\, SAAR^{1.306} \,.\, FARL^{2.217} \,.\, DRAIND^{0.341} \,.\, S^{0.185} \,.\, (1 + ARTDRAIN2)^{0.408}$$

The PCDs applicable to the subject site are shown in Table 7.14.

Table 7.14 Physical Catchment Descriptors Applicable to Deerpark Stream

PCD	Description	Units	Value
AREA	Catchment area	km²	0.92
SAAR	Average annual rainfall	mm	918
BFIsoil	Baseflow index derived from soils data		0.6117
FARL	Flood attenuation from reservoirs and lakes		1
DRAIND	Ratio of river network to catchment area	Km/km²	0.982
S_{1085}	Slope of the main stream between the 10 and 85 percentiles	m/km²	0.1
ARTDRAIN2	Proportion of river network included in drainage schemes		0.2119
URBEXT			0
	Calculated QMED	m³/s	0.094

A principal of the FSU is the concept of a pivotal site, which is defined as the gauging station that is considered most relevant to a particular flood estimation problem at the subject site and is used to adjust the QMED rural estimate. There is no suitable pivotal site for this small catchment.

The return-period flood flow (Q_T) is determined by an index flood method, whereby a growth factor as determined from an EV1 distribution plot is applied. In this case:

$$Q_T = QMED \times 2.55$$

$$Q_{100} = 0.094\ m^3/s \times 2.55$$

$$Q_{100} = 0.239\ m^3/s$$

Finally, a climate change growth factor of 20 % is applied:

$$Q_{100} = 0.239 \times 1.2$$

$$\mathbf{Q_{100} = 0.286\ m^3/s}$$

7.8.1.3 OPW FSU - Small Catchments Equation

The updated Flood Studies Update (Nicholson & Bree 2013) presents a revised formula more suited to catchments less than 25 km^2

$$QMED_{rural} = 2.0951 \times 10^{-5} \,.\, AREA^{0.9245} \,.\, BFI_{soil}^{-0.9030} \,.\, SAAR^{1.2695} \,.\, FARL^{2.3163} \,.\, S^{0.2513}$$

This yields a $QMED_{rural}$ value of 0.311 m^3/s.

As per the OPW Guidelines, a pivotal site adjustment factor is not being applied to the outcome of the small catchment's equation.

The return-period flood flow (Q_T) is again determined by an index flood method, whereby a growth factor as determined from an EV1 distribution plot is applied. In this case:

$$Q_T = QMED \times 2.55$$

$$\mathbf{Q_{100}} = 0.311\ m^3/s \times 2.55$$

$$\mathbf{Q_{100}} = 0.794\ m^3/s$$

Finally, a climate change growth factor of 20 % is applied:

$$\mathbf{Q_{100}} = 0.794 \times 1.2$$

$$\mathbf{Q_{100} = 0.952\ m^3/s}$$

7.8.1.4 OPW FSU - 3 Variable Method

The FSU 3-variable equation was developed as part of the FSU. It was developed as a 'short cut' equation for the estimation of flow in ungauged catchments.

$$QMED = 0.000302.AREA^{0.829} \,.\, SAAR^{0.898} \,.\, BFI^{1.539}$$

$$QMED = 0.061\ m^3/s$$

Application of the relevant growth factors as per above and 20% climate change adjustment factor results in:

Q_{100} = 0.185 m^3/s

7.8.1.5 Flood Studies Report, FSR (NERC 1974)

This is the original FSR method, with the regression coefficient for Ireland. Estimates from this equation should be treated with extreme caution. It is recommended that these equations should be used only for preliminary flood estimates.

$$QBAR = 0.0172 . AREA^{0.94} . STMFRQ^{0.27} . S1085^{0.16} . SOIL^{1.23} . RSMD^{1.03} . (1 + LAKE)^{-0.85}$$

Table 7.15 Calculations of Q_{100} – FSR Ungauged Catchments

Area, km^2	STMFRQ, jn/km^2	S1085, m/km	SOIL	RSMD	LAKE	Q_{BAR} m^3/s	Q_{BAR} x 1.96 gf m^3/s	Q_{100} x 1.47 sfe m^3/s	Q_{100} x x cc (1.2), m^3/s
0.92	1.09	0.1	0.35	35.14	0.0	0.12	0.24	0.35	**0.42**

Growth factor of 1.96 was applied to determine **Q_{100}**.

The value obtained using this method is **Q_{100}** = 0.42

Reminder: Estimates from this equation should be treated with extreme caution.

7.8.1.6 Institute of Hydrology Report 124 (1994)

Report No. 124 derives an equation to estimate flood flows for small rural catchments (less than 25 km^2). The equation has a standard factorial error (SFE) of 1.65.

$$Qbar_{rural} = 0.00108 (AREA^{0.89} x SAAR^{1.17} x SOIL^{2.17})$$

Table 7.16 Calculations of Q100 – IH124

Area, km^2	SAAR	SOIL	Q_{BAR} m^3/s	Q_{BAR} x 1.96 gf m^3/s	Q_{100} x 1.65 sfe m^3/s	Q_{100} x x cc (1.2), m^3/s
0.92	918	0.35	0.30	0.59	0.97	1.17

This method was developed for small catchments (< 25 km^2) in the UK. It's derivation did not include any Irish catchments. The equation tends to overestimate QBAR for the smallest of the UK catchments used.

Without implementing the SFE, the Q_{100} rate plus 20% climate change factor was

Q_{100} = 0.59 m^3/s * 1.2 **= 0.71** m^3/s

This value is comparable to results derived from other formulae.

7.8.1.7 Modified IH 124 (Cawley & Cunnane 2003)

Irish researchers at NUIG (Cawley & Cunnane 2003) developed a Modified Institute of Hydrology 124 methodology and formula as follows:

$$Qbar_{rural} = 0.000036\ (AREA^{0.94} \times SAAR^{1.58} \times SOIL^{1.87})$$

Table 7.17 Calculations of Q_{100} – Modified IH124

Area, km^2	SAAR	SOIL	Q_{BAR} m^3/s	Q_{BAR} x 1.96 gf m^3/s	Q_{100} x 1.65 sfe m^3/s	Q_{100} x x cc (1.2), m^3/s
0.92	918	0.35	0.22	0.44	0.72	0.87

Without implementing the SFE, the Q_{100} rate plus 20% climate change factor was

$$\mathbf{Q_{100}} = 0.44\ m^3/s * 1.2 = 0.53\ m^3/s.$$

Again, the unadjusted value is reasonably consistent with the FSU and FSR results above.

7.8.1.8 TRRL & ADAS

The method developed by the Agricultural Development and Advisory Service (ADAS), which is a precursor to Transport and Road Research Laboratory (TRRL), is only applicable for catchments smaller than 0.4 km^2. This methodology shall not, therefore, be applied.

7.8.1.9 Modified Rational Method

FSU Work Package 4.2 shows that the UK only apply the Rational Method to catchments from 2 to 4 km^2. In Ireland, this method is more commonly used to determine stormwater attenuation requirements.

$$Q_T = 2.78 \times C_y \times C_r \times I \times A$$

where:

Q_T = design peak flow, l s^{-1}

T = return period in years = 100

C_v = runoff coefficient = 0.84 (winter)

C_r = peaking/routing factor = 1.3 (arbitrary value)

A = 0.92 km^2

$I_{tc,\,T}$ = hourly rainfall intensity for design duration of t_c (hours) and return period T (years) = 32.7 mm * 2 = 65.4 mm

t_c = time of concentration defined as the travel time from the furthest point on the catchment to the outlet (mins)

$$t_c = 0.0195 \times L^{0.77} \times S^{-0.385}$$

L = length of stream = 1,500 m

S = catchment gradient, m m^{-1} = 0.01 (Table 7-18)

t_c = 33 minutes = 0.5 hours

Hence:

$$Q_{100} = 2.78 \times 0.84 \times 1.3 \times 65.4 \times 0.92$$

$$Q_{100} = 0.18\ m^3\ s^{-1}$$

$$\mathbf{Q_{100} + 20\%\ cc = 0.22\ m^3\ s^{-1}}$$

That concludes the application of nine methodologies to compute the extreme flow in the receiving water **Q_{100} + 20% climate change**. The results are now summarised.

7.8.2 SUMMARY OF FLOOD FLOW CALCULATIONS

Results from the OPW recommended methods are summarised below in Table 7.18. The OPW recommend that the Modified Rational Method is used for catchments smaller than 5 km^2. This equation yields flood flow rates below the average. IH124 is excluded as it was derived using non-Irish catchments. The average extreme storm flow instream **Q_{100}** value of 0.65 m^3/s was used in the hydraulic capacity assessment and this includes a 20% factor for climate change.

Table 7.18 Summary of Calculated Flood Flows (incl.'s 20 % Climate Change Factor)

Methodology	Q100 + 20% cc (m^3/s)
FSU Standard	0.29
FSU small catchments	0.95
FSU – 3 variable	0.19
FSR 6 – including SFE	0.42
IH124 – including SFE	1.17
Modified IH124 – including SFE	0.87
Modified Rational	0.22
Minimum	0.19
Maximum	1.17
Average Q100 + 20% cc	**0.65**

7.8.3 SITE SPECIFIC HYDRAULIC MODEL

A hydraulic model was developed specifically for the site and receiving waters using *Flood Modeller Pro* software, which was then used to simulate water levels at different points along the Deerpark Stream. The model was compiled using 19 surveyed cross sections, surveyed by Envirologic along the watercourse using Trimble RTK VRS technique. Cross section locations are shown in Figure 7.12 and extended downgradient of the site by approximately 1,700 m, terminating at the confluence with the Castlepollard Stream.

Manning's coefficient of 0.03 was applied to open river channel bed sections and a value of 0.045 applied to riverbanks and field surfaces. Bridge crossings were surveyed beneath the L5739 (CSA = 600 mm concrete culvert, IL = 75.14), and a field crossing a further 150 m downstream (CSC). An example of a cross-sectional profile is shown below for CSB (Plate 7.3), with the view looking through the upgradient to downgradient plane. There are many other sections and model outputs. These are too numerous to present here, are retained at the Envirologic office and are available if needed.

All other surveyed sections were unimpeded open channel, with most of these through a tract of forestry. A flow of 0.01 m^3/s was adopted for the validation procedure and based on field work this is a reasonable estimate for validation of the simulation. Under this flow scenario, the predicted river level error on the Deerpark Stream was up to 200 mm. This is attributed to the very low hydraulic gradients through parts of the forestry area. The model output values are not sensitive to flood levels at the downgradient boundary (CSQ). Surface water levels as observed on 15th July 2021 are presented in Table 7.19 with the Envirologic developed Model Output in the adjacent column. Refer to Figure 7.12 for Cross Section locations on the receiving water. The final column of Table 7.18 presents the river elevation at Q_{100} Flood Flow, with 20% climate change and the quarry's maximum future discharge rate of 0.002 m^3/s.

Plate 7.3 Cross Section Profile at CSB

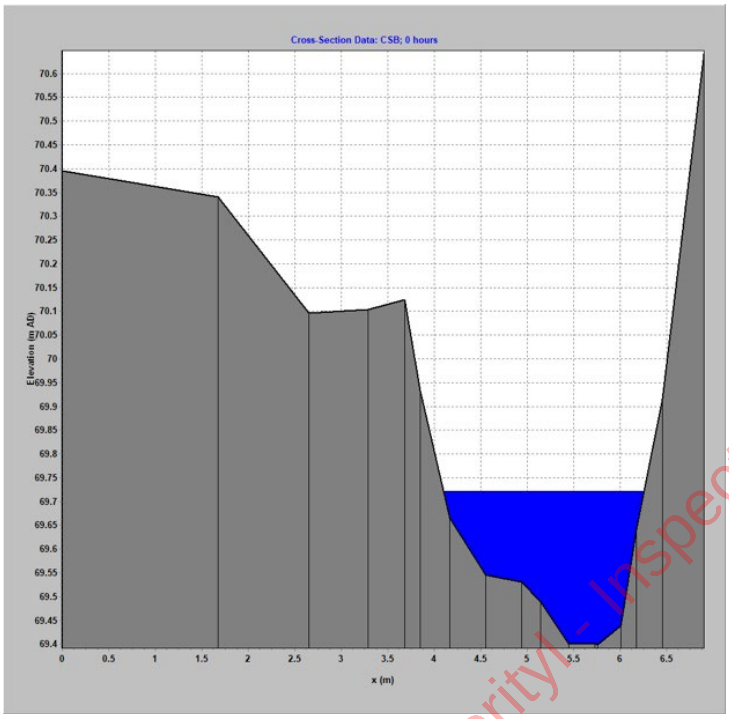


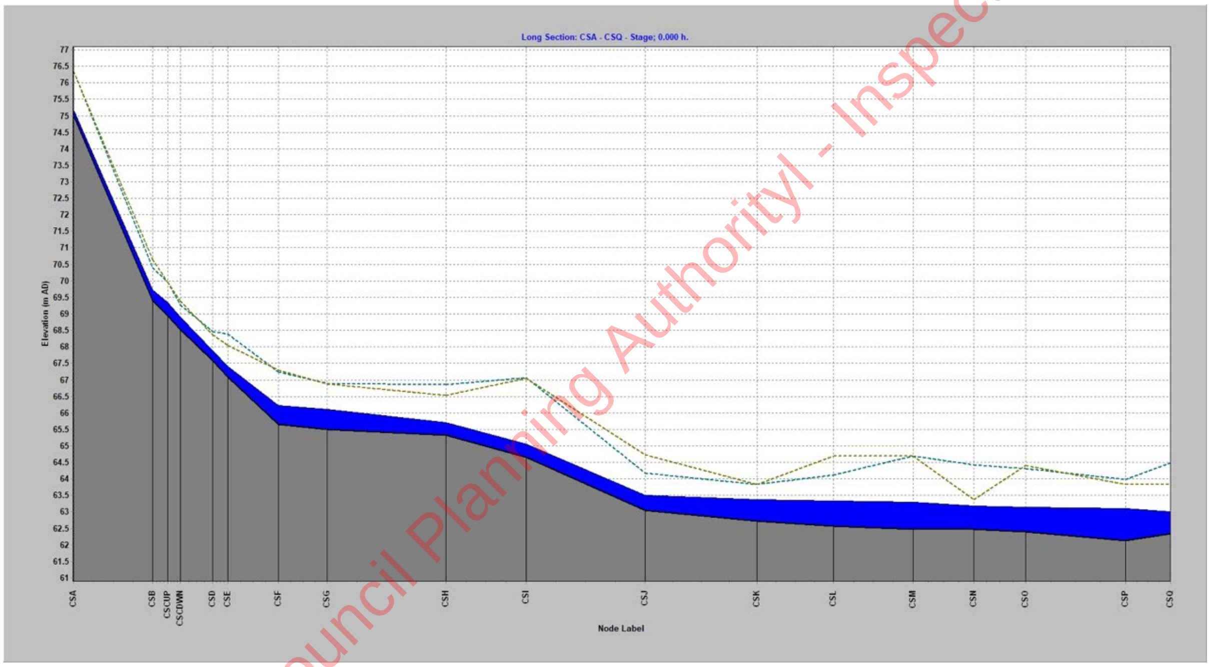
Table 7.19 Hydraulic Model Simulation Outputs for Deerpark Stream

Section	Gradient, m/m	Validation, 15th July 2021			Q_{100} flood flow ($0.65\ m^3/s$)	Q_{100} flood flow + max. discharge ($0.002\ m^3/s$)
		Surface water level, m OD	Envirologic Model Output	Difference, m		
CSADn	0.051	75.25	75.18	0.07	75.56	75.56
CSB	0.026	69.47	69.50	-0.03	69.72	69.72
CSCUp	0.019	69.05	69.08	-0.03	69.35	69.5
CSCDn	0.024	68.71	68.71	0	68.90	68.90
CSD	0.020	67.60	67.71	-0.11	67.89	67.89
CSE	0.017	67.15	67.19	-0.04	67.41	67.42
CSF	0.004	65.88	65.82	0.06	66.22	66.22
CSG	0.004	65.85	65.72	0.13	66.12	66.12
CSH	0.001	65.4	65.42	-0.02	65.71	65.71
CSI	0.015	65.75	64.75	0	65.06	65.06
CSJ	0.001	63.19	63.16	0.03	63.51	63.51
CSK	0.003	62.83	62.84	-0.01	63.36	63.37
CSL	0.003	62.95	62.76	0.19	63.33	63.33
CSN	0.0005	62.87	62.70	0.17	63.17	63.17
CSO	0.0005	62.82	62.68	0.14	63.14	63.14
CSP	0.0016	62.76	62.67	0.09	63.11	63.11
CSQ	0.0016	62.66	62.66	0	63.00	63.00

The results presented in Table 7.19 show the predicted levels under the Q_{100} flow scenario and separately the Q_{100} plus maximum projected quarry discharge. It is clear that the discharge does not cause a discernible rise in water levels along the discharge route during an extreme storm event, including allowance for climate change.

The longitudinal section along the discharge route for the Q_{100}, with the climate change factor, plus the quarry discharge is included below as Plate 7.4. The profile shows that under flood conditions, the stream does not overtop the banktops. **The discharge can therefore be adequately accommodated by the receiving stream route and shall cause only a negligible increase in stream water levels. Hence, upgrade works are not deemed necessary on the route to facilitate the predicted discharge during a storm event.**

Plate 7.4 Longitudinal Profile of Discharge Route under Flood Conditions



7.8.4 STREAM HYDRAULIC CAPACITY SUMMARY

The primary purpose of the assessment was to determine the capacity of the local surface water drainage network to receive flows from future proposed dewatering activities during quarry development.

Generally, the inclusion of an additional input to represent maximum predicted quarry discharge did not result in a perceptible increase in water levels during a flood event. The input from the quarry discharge is small relative to the stormflows and will become smaller as the catchment size increases progressing downstream.

7.9 CONCEPTUAL SITE MODEL

A preliminary conceptual site model (CSM) was developed using all the information collected. The purpose of the CSM is to incorporate results from the different strands of testing and to present a coherent understanding of the hydrological and hydrogeological regimes in an around the site as they are understood to date. The site and two cross sections are presented in Plate 7.5 (a, b, c).

Overall, it is concluded that the limestone bedrock beneath the site has little groundwater, measured hydraulic conductivities are low and the site seems to be a self-contained low yielding hydrogeological unit. This concurs with the GSIs interest in the geology of the site and the continued extraction to explore the formation.

Information employed in the development of the conceptual understanding of the site is summarised as follows:

The site is positioned on the northern side of a steep hilltop. Bedrock at the site is a limestone belonging to the Derravaragh Cherts. Immediately north of where bedrock is exposed at surface the limestone is covered by approximately 20 m of boulder clay.

Internally, the quarry has three distinct areas: (i) the active quarry which has been cut into the northern side of a local hill. The base of this active quarry has not intersected groundwater; (ii) the undisturbed central and southern part of the hilltop which reaches the southern site boundary; and (iii) the flat northern part of the site which serves as a yard for stockpiling crushed stone.

Proposed works involve continued extraction of bedrock by blasting and mechanical means as an open quarry void. The current active quarry floor is at 88m OD and it is proposed to deepen this by one bench only and this usually results in an excavation depth of 18m, when access routes and slopes are accounted for. This will bring the floor to a future elevation to 70m OD. Works will progress, as dry workings, from the current floor in a south-eastern direction towards the site’s boundary and the quarry’s plan for phased development suggests that it will be over a decade before the final bench will be excavated from the current floor level to the proposed final level of 70m OD.

In terms of hydrogeology, the limestone bedrock in the area has a low matrix permeability and supports only low yields. Exposed faces around the active area show the limestones have a high frequency of bedding and jointing though no discrete inflows were observed. The formation appears to get tighter and cleaner with increasing depth.

A survey of recently installed on-site groundwater monitoring points shows groundwater flow direction is north-northwest from the hilltop. The upgradient groundwater catchment is negligible.

The locally important bedrock aquifer is unconfined where rock is at or close to surface, *i.e.,* the central and southern area. The boulder clays covering lower ground may confine groundwater in the underlying bedrock aquifer and the subsoils also appear to restrict hydraulic connectivity between groundwater in the bedrock aquifer and surface water in the adjacent marshy pond area to the east of the working area.

The site is devoid of karst features.

Groundwater catchments are likely to be subdued representations of overlying surface water catchments, which means that the site poses no threat to the PWS source at Lough Lene. There is no hydrological connection between the site and Lough Lene. Cross sections for the site show the distinct surface water catchment for Lough Lene (Plate 7.5 (b)). The cross sections also show that the local rivers sit in peat subsoil and even the mapped karst spring to the north emerges at a peat contact with rock.

Two production wells (PWs) of 8" diameter were drilled within the quarry in order to facilitate large diameter pumps, if required, and pumping tests were attempted to quantify the aquifer characteristics. No water strikes were encountered in either well and neither well was capable of supporting a pumping test of sufficient duration to aid useful analysis. Hydraulic conductivity of the bedrock, as determined from recovery tests, was low, in the order of 1×10^{-7} m/s. This is akin to CLAY with little potential for groundwater flow. PW3 is outside the proposed working area.

Three small diameter monitoring wells (MWs) were installed to further characterise subsurface lithology. Hydraulic testing of the well close to the southern boundary (MW1) returned hydraulic conductivity of 1×10^{-9} m/s. On this basis, it is not expected that there will be any significant groundwater inflows following extension or deepening of the existing quarry.

The flat area at the foot of the northern hillside is used for stockpiling processed material. Drilling showed that bedrock in this part of the site is covered with approximately 20 m of boulder clay. Drilling logs described this material as fault infill. While significant clay infills were encountered in MW2 and MW3 (north-eastern boundary), subsequent field testing and analysis of results suggest no potential for groundwater movement across site boundaries. The site is contained within itself.

- MW1 $K = 6.8 \times 10^{-9}$ m/s
- MW2 $K = 5.1 \times 10^{-5}$ m/s
- MW3 $K = 5.2 \times 10^{-7}$ m/s

The above ground water level and the hydrochemistry of waters sampled from MW3 suggest that it is influenced by the adjacent saturated marshy pond, which seems to sit elevated above the quarry on a barrier bed of clays. The marshy pond is not hydraulically connected to the bedrock in the quarry.

Empirical and conventional theoretical hydrogeological formulae suggest that the potential volume of water to be managed on the average day at the site will be in the order of 85 m^3/d. However, adopting a different groundwater evaluation method, by application of the GSI's ZOC rationale, suggested a potential daily groundwater volume arising from the excavation of one more bench will be 230 m^3/d, including rainfall runoff from the hard rock areas of the site. The ZOC methodology conceptualised the future void as a water supply well to determine the potential zone of recharge from the upgradient groundwater catchment. The understanding regarding groundwater flow direction and topographical controls for the area is applied in that approach.

The final radius of influence of future dewatering is calculated to be 30m from the edge of the excavation and this will not impact local wells because there are none. Neither will it affect the saturated marshy pond between the quarry and the road because that area is perched above the quarry on a bed of clay and therefore hydraulically disconnected from the groundwater regime at the site.

Hydraulic modelling of the surface water system, based on cross sections and surveying, has demonstrated that the local area's surface water network can accommodate the envisaged dewatering amounts, in combination with flood flows and allowances for climate change.

With respect to surface water monitoring, surface water in the receiving Castlepollard Stream complies with Environmental Quality Objectives of the Surface Water Regulations (2009, as amended 2012, 2015, 2019) for the specified and significant parameters of BOD, Ammonia-N, ortho-P, pH and DO. Our experience and conceptual understanding of catchment hydrology is that surface waters close to quarries can be of higher quality than those surface waters in proximity to agroforestry and livestock grazing systems. This is supported by the WFD characterisation of the Castlepollard Stream, downstream of the site, being classified as 'At Risk' from agricultural sources.

With respect to groundwater quality, which will contribute some of the site's discharge volume, in addition to rain falling on the site, the groundwater underlying the site contains no hydrocarbons, the groundwater is pure with a TOC <2 mg/l and all the pure bedrock borehole nutrients comply with the requirements of the Groundwater Regulation Threshold Values (2010, as amended 2016).

The understanding of the hydrogeological regime at the site and surrounding area now enables advancement to design the appropriate site water management scheme.

Plate 7.5 Hydrogeological Cross Sections through West to East and Northwest to Southeast Planes

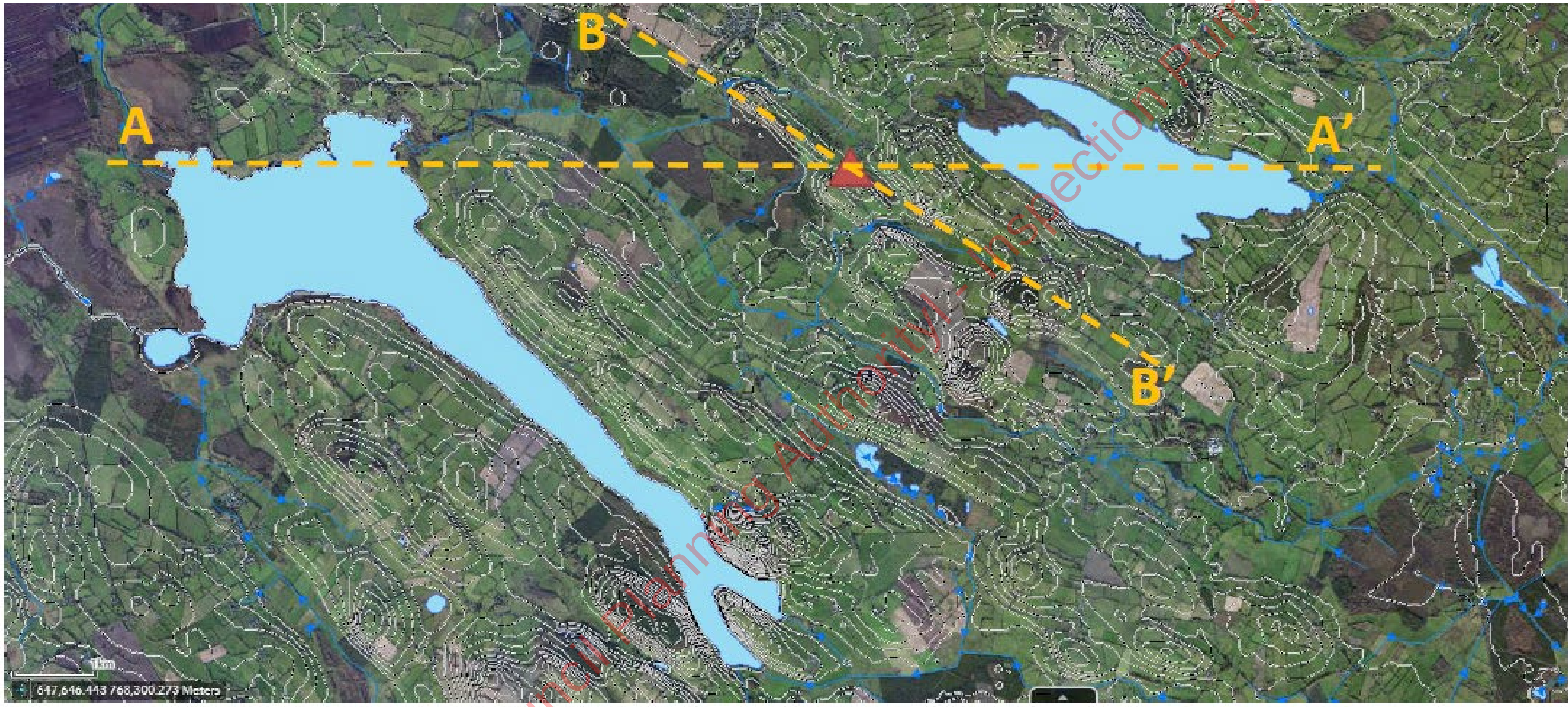


Plate 7.5 (a) Hydrogeological Cross Sections through West to East and Northwest to Southeast Planes

Site Location = ()

JSPE

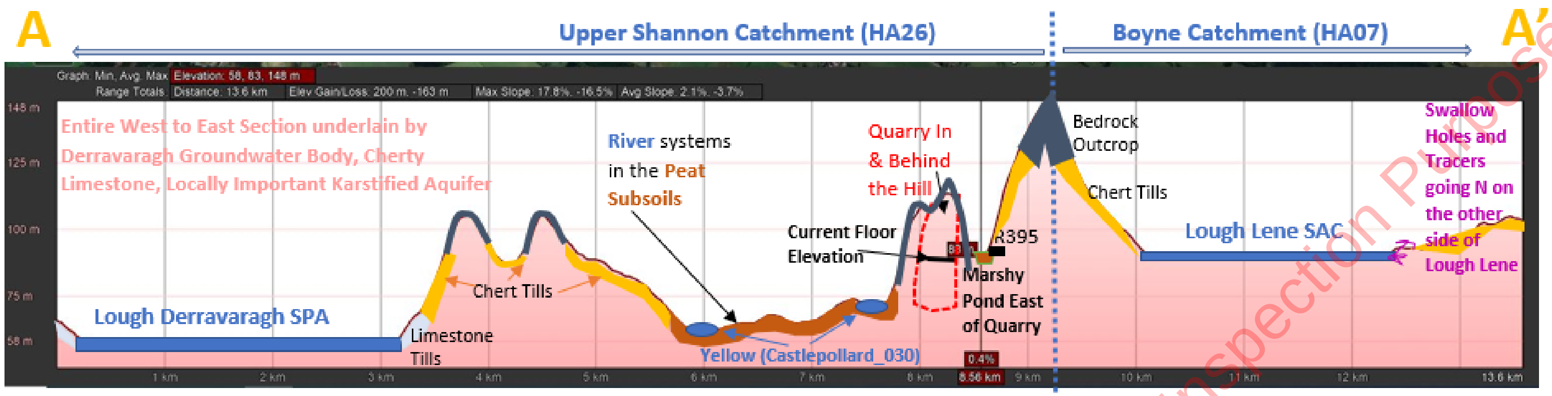


Plate 7.5 (b) Cross Section west to East A-A' (base section source Google Earth Pro, annotated by Hydro-G)

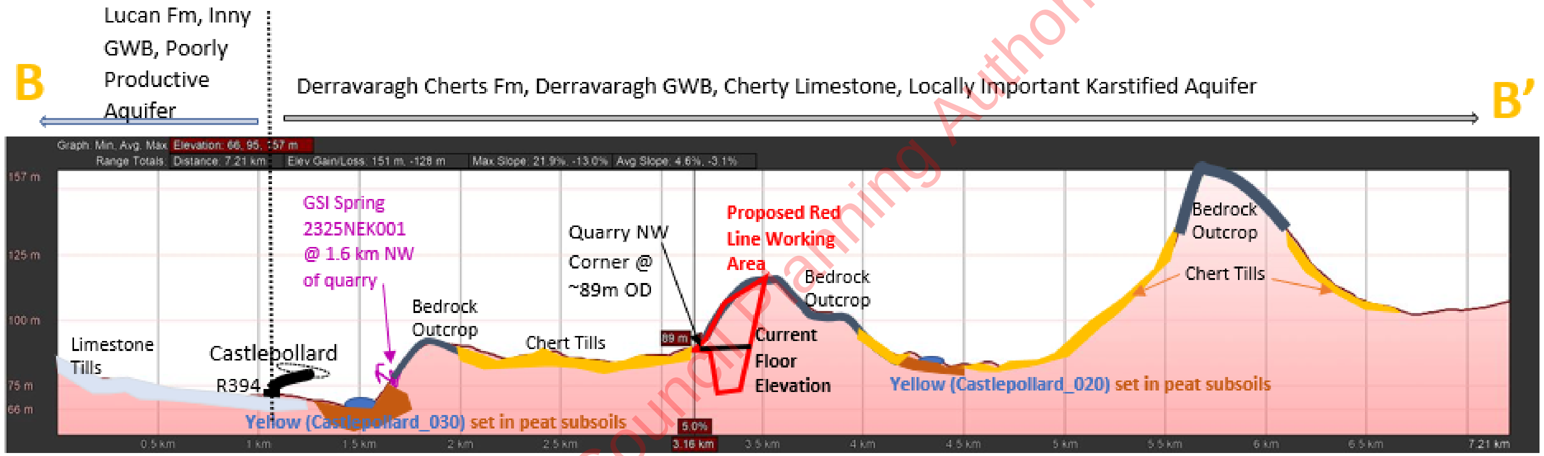


Plate 7.5 (c) Cross Section Northwest to Southeast B-B' (base section source Google Earth Pro, annotated by Hydro-G)

7.10 WATER MANAGEMENT PLAN

7.10.1 EXTREME RAINFALL EVENTS

An assessment is required to size the quarry's sump in order that it is capable of temporarily storing stormwater that drains to it during intense rainfall events. Stormwater volumes draining to the sump are based on the contributing area of the proposed bare rock working quarry area of 40,000 m^2. From mapping and site walkover there is no upgradient surface water catchment to the proposed quarry working area.

Using the Met Eireann Depth Duration Return Period data table for extreme rainfall at the site, calculations presented in Table 7.20 show that the 1 in 100-year rainfall contribution to the sump over a 24-hour period is 3,712 m^3.

Table 7.20 Potential Rainfall-Runoff Inflows to the Quarry Sump during Extreme Rainfall Events

Considered Catchment m^2	Rate	1 in 1 year	1 in 10 year	1 in 50 year	1 in 100 year
	24-hour event				
	mm	31	55.7	79.9	92.8
	m	0.031	0.0557	0.0799	0.0928
	Rainfall-runoff to sump, m^3/d	1240	2228	3196	3712
	(m3) Required with +20% Climate Change	**1,488**	**2,674**	**3,835**	**4,454**
40,000					
	6-hour event				
	mm	19.2	30.7	56.6	67.2
	m	0.0192	0.0307	0.0566	0.0672
	Rainfall-runoff to sump, m^3/d	768	1228	2264	2688
	(m3) Required with +20% Climate Change	**922**	**1474**	**2717**	**3226**

The document supporting the Depth Duration model tables (Fitzgerald 2007) suggests that with respect to "*General indicators of the effects of global warming on the precipitation regime …… appropriate adjustments are not included in the estimates of the return period rainfalls as it appears that for quite a number of years into the future the indications of the effects of global warming on precipitation regime will change from assessment to assessment. The latest advice on the probable effects of climate change on extreme rainfalls should be sought.*"

Hydrologists conclude that it is more reasonable to apply the conventional +20% factor for Climate Change to the final determined volume of 3,712 m^3, rather than to the mm depth of rainfall. Therefore, a future-proof sump capacity of 4,454 m^3 is required for the site.

Therefore, in order to store the Q_{100} rainfall event, with a climate change factor, the following indicative sump dimensions, or variations, could provide the 4,454 m^3 storage:

- Radius = 37 m, for a depth = 1 m (4,454 m^3); or
- Radius = 20 m, for a depth = 3.5 m (4,454 m^3).

These areas are available on the site. Variations in dimensions are possible.

7.10.2 ATTENUATION STORAGE REQUIREMENTS

It has been shown that the bedrock to be quarried has a low permeability, so it can be reasonably assumed that during extreme storm events the contribution from groundwater seepages is low relative to the overall contribution from precipitation as runoff. It is therefore necessary to attenuate stormwater generated on site, such that it leaves the site at a rate less than or equal to greenfield runoff rates. This is an important feature of the quarry in that it provides large attenuation capacity storage, which will provide significant protection from flooding to downgradient receptors. An allowance needs to be made to allow a certain amount of precipitation to leave the site at a controlled rate.

Pre-development greenfield runoff rate is given by:

$$QBAR_{rural} = 0.00108\ (AREA)^{0.89} \times (SAAR)^{1.17} \times (SOIL)^{2.17}$$

where

$QBAR_{rural}$ = mean annual flood flow from a rural catchment (m^3/s)

AREA = exposed quarry floor upon completion (km^2) = 40,000 m^2 = 0.04 km^2

SAAR = standard annual average rainfall depth (mm) = 974 mm

SOIL = soil index, a composite index determined from soil survey maps that accompany the Flood Studies Update

= 0.3, representing SOIL 2, applicable to permeable soils over rocks

It is recommended that flood risk assessment based on the methodology in Volume 2 of the Greater Dublin Strategic Drainage Strategy (2005) is not applied to an area of less than 50 hectares. It suggests that the runoff from smaller areas is then linearly interpreted. A theoretical catchment area of 0.5 km^2 (50 ha) was used for initial calculations. The Q_{BAR} rate applicable to the theoretical catchment area of 0.5 km^2 is:

$$QBAR_{rural} = 0.00108\ (0.5)^{0.89} \times (974)^{1.17} \times (0.30)^{2.17}$$

$$QBAR_{rural} = 0.134\ m^3/s\ (134\ l/s) \text{ for the 50 ha catchment}$$

The linear interpolation of Q_{BAR} from a catchment of size 50 ha down to gross site area (11.4 ha) and net hard standing (final quarried area = 4 ha) is shown in Table 7.21. The limiting discharge rates for the 75 and 100 year return period storm events are presented in Table 7.20 using growth factors of 1.87 and 1.96, respectively, in accordance with relevant TII guidance (TII, 2015). The Climate Change growth factor is accounted for in the sump attenuation calculations and not the allowable Greenfield Runoff Rate. It would be counterproductive to allow a growth factor to the allowable runoff rate.

Table 7.21 Linear Interpolation of QBAR for On-Site Hardstanding

Item	Area, ha	Q_{BAR} (m^3/s)	Q_{75} (m^3/s)	Q_{100} (m^3/s)
Unit	1	0.0027	0.0050	0.0053
50 ha as calculated	50	0.1341	0.251	0.263
Total site area	11.4	0.031	0.0572	0.060
Final quarried area	4	**0.011**	**0.02**	**0.02**

The applicant does not intend to vary the discharge rate in response to the return period greenfield runoff rate. The discharge rate will instead be fixed. The maximum potential pumping rate from the sump to the settlement tanks will be limited to Q_{BAR} (0.011 m^3/s = 950 m^3/d = 11 l/s), this being less than the pre-development greenfield runoff rates during extreme rainfall events for the excavation area (**0.02 m^3/s = 20 l/s**). Therefore, the quarry discharge will not increase flood risk to downgradient receptors.

In its most restrictive approach, attenuation storage is calculated when outflow is limited to Q_{BAR}. The sump must be capable of storing the balance of the stormwater during intense rainfall events.

Table 7.22 presents the return period rainfall depths for a range of durations, as provided by OPW FSU online portal. Design rainfall rates were obtained from the OPW FSU facility. A 20 % increase in design rainfall depths was adopted to account for climate change.

In line with standard practice, discharge surface water should be limited to the pre-quarrying discharge rate to mitigate against downstream flooding. The attenuation storage requirements when the outflow is restricted to Q_{BAR}, *i.e.,* 11 l/s, are shown in Table 7.22.

Information presented in Table 7.22 shows that the stormwater generated during a 1 in 100-year event of 24 hours duration is I = 4,448 m^3. Restricting the outflow to greenfield runoff rate, Q_{BAR}, results in a permissible outflow of O = 950 m^3. The balance, i.e., (I-O) = 3,494 m^3, must be withheld via attenuation, and released at greenfield runoff rate or less. As quarrying progresses, a sump with a minimum available volume of 3,704 m^3 shall be maintained. A sump volume in excess of that has already been specified in earlier calculations.

Table 7.22 Design Rainfall Rates and Attenuation Storage using Outflow of 11 l/s

Duration, D, hrs	R, mm	R x 1.2, mm	I, m^3	O, m^3	I – O, m^3
0.25	27.1	32.5	1301	10	1291
0.5	32.7	39.2	1570	20	1550
1	39.5	47.4	1896	40	1856
2	47.7	57.2	2290	79	2210
4	57.6	69.1	2765	158	2606
6	64.4	77.3	3091	238	2854
12	77.8	93.4	3734	475	3259
18	86.9	104.3	4171	713	3458
24	92.6	111.1	4448	950	**3494**
48	102.1	122.5	4901	1901	3000
72	111.4	133.7	5347	2851	2496
96	120.2	144.2	5770	3802	1968
144	128.6	154.3	6173	4752	1421

7.10.3 SETTLEMENT TANK DESIGN

Waters will be pumped from the quarry's sump to a settlement tank system, which must be designed to ensure drop out of any suspended solids prior to discharge from the site.

Designs for the site are based on the recommendations in 'Environmental Management in the Extractive Industry' (EPA 2006) and '*CIRIA Report C532: Control of Water Pollution from Construction Sites and Quarries'* (CIRIA 2001). The formulae below will be used to determine the optimal dimensions of the settlement pond/tank such that any discharged quarry water is free of suspended solids above a threshold size.

Calculations previously presented identified that the discharge from the site should be limited to 11 l/s, which is equivalent to a daily rate of 950 m^3/d. The settlement tanks are usually passive overflow devices and that is why the sump to system pump rate is limited to the permissible discharge rate.

The overflow rate through the settlement tank should be equal to the settling velocity of the smallest particle the tank is designed to remove. The tank will be specified to remove particles of bedrock-derived sediment down to a diameter of 0.015 mm, i.e., dust and suspended solids. This is the particle size for silt which is significantly smaller than the size of most rock fragments. The method for determining the size required for the settlement tanks is based on Stoke's Law. The following equation is used to calculate the settlement velocity of particles:

$$V_s = g \cdot (\rho_s - \rho_w)\, d^2 / 18\mu_w$$

Where:

g = acceleration due to gravity is 9.81 m/s^2

ρ_s = density of the bedrock particle = 2.65 g/cm^3 or 2.65 x 10^3 kg/m^3

ρ_w = density of fluid = 1.00 g/cm^3 or 1 x 10^3 kg/m^3

μ_w = dynamic viscosity of water = 1.002 x 10^{-3} kg/ms @ 20˚C (or 1.519 x 10^{-3} @ 5˚C and 0.797 x 10^{-3} @ 30˚C)

d = particle diameter = 0.000015 m

The temperature of the fluid, in this case water, is dependent on the ambient temperature. In the following calculations, 5°C was used as a conservative temperature. A conservative particle density was taken as 2.65 g/cm^3.

Using Stokes' Law, the settling velocity of particles of 0.015 mm, assumed spherical, in water was calculated for the 5°C water temperature and particle density is as follows:

$$V_s = 0.000133 \text{ m/s} = 1.33 \times 10^{-4} \text{ m/s}$$

The minimum surface area of the settlement tank are then sized so as to facilitate the settling velocity as follows:

$$A = Q / V_s$$

Where:

A = minimum pond surface area, m^2

Q = maximum inflow pump **rate** from sump = Q_{BAR} (0.011 m^3/s)

V_s = Settling velocity of the selected particle size = 0.000133 m/s

$$\mathbf{A = 0.011\ m^3/s\ /\ 0.000133\ m/s = 83\ m^2}$$

Tank Dimensions

A minimum depth of 1m is adopted for settlement. Informed by the above equations, the required minimum settlement tank dimensions for the required surface area of 83 m^2 could be, or a variation on the planar dimensions and the retention of the 1 m depth, as follows:

- **Length = 21 m, Width = 4 m, Depth = 1.0 m**

The settlement tank shall be constructed from materials to ensure that it is impermeable.
The settlement tank total area will be divided into three sections with baffle boards.

Overflow Rate

Surface overflow rate is given by:

$$V_o = Q / A$$

$$V_o = 0.011 \text{ m}^3\text{/s} / 84 \text{ m}^2$$

$$V_o = 0.000131 \text{ m/s}$$

At this overflow rate, particles smaller than 0.000015 m diameter with a settling velocity of 0.000133 m/s will settle out. This meets the requirements for appropriate management.

7.10.4 PROCESS WATER

Relatively small amounts of water will be used for the purpose of process water, as follows:

- dust suppression, in the order of ≤1 m^3/d;
- mobile plant sprinklers for washing of chips of ≤2 m^3/d;
- additional waters used on site ≤0.5 m^3/d.

Water for dust suppression can be sourced from the sump. Given the nature of site topography any excess water from the above processes shall drain by gravity back to the water management system proposed.

7.10.5 HYDROCARBONS

7.10.5.1 Fuel Storage

There will be no bulk storage of fuel on site. Servicing of vehicles will take place off site. Lubricants and any other hydrocarbons will be stored on spill pallets with containment.

All hydrocarbons will be handled and stored in accordance with the Environmental Management Guidelines - Environmental Management in the Extractive Industry (Non-Scheduled Minerals) (EPA 2006).

7.10.5.2 Refuelling

Refueling of mobile plant will be carried out entirely by a licensed third party using a double-skinned mobile bowser/road tanker which will be mobilised to site on an as needs basis. As a result, there will be no storage of any fuels onsite.

An impermeable hardstanding pad is located in the northern part of the site adjacent to the stockpiling area. All hardstanding runoff shall be diverted to the hydrocarbon interceptor for the site, which will also have silt storage capacity, prior to outfall. Runoff from the refuelling hardstanding area will drain by gravity to the hydrocarbon interceptor. The hardstanding is therefore appropriate for refueling of mobile plant (e.g., loading shovel), haulage vehicle(s) and emergency repairs, where necessary.

Spill kits are stored on site and site operatives trained in their appropriate usage.

A final protection measure will be provided by means of a hydrocarbon Interceptor on the inlet to the final element of the water management system, which is the proposed settlement tanks in the northwestern area of the site (Refer to EIAR Figure 3.1).

7.10.6 WELFARE FACILITIES

7.10.6.1 Domestic Effluent

The wastewater from the welfare facility is sent to the septic tank and percolation area of an adjacent, unoccupied house in the ownership of the applicant. The house is located immediately north of the site. The septic tank and discharge area of the house previously served a family and is therefore deemed to be appropriately sized for the site. EPA (1999) assigns a 40 l/p/d hydraulic loading to staff for quarries with no canteen loading, and this means that the 3 workers at the site are equivalent to one person as per the 150 l/p/d specified by EPA (2021).

7.10.6.2 Potable Water

The site is supplied by mains water. Additionally, potable water dispensers from bottled water suppliers are supplied at company sites.

With respect to dust suppression and any spray waters in the conveyor belts of the crushers/screening units, the onsite PW3 and/or the site's stormwater sump shall provide the waters that do not need to be of potable water quality.

7.11 DISCHARGE ROUTE

The discharge route and mixing point in the receiving water are presented in Figure 7.13.

Surface water currently leaves the site predominantly through infiltration to ground. It is understood that some rainfall-runoff generated on the processing area leaves the site in the vicinity of the exit of a 300 mm culvert that outfalls at the northwestern corner of the site. This culvert transmits overflow water from the marshy pond on the eastern side of the site. Subject to the granting of a discharge license, pumped waters from the active quarry shall also leave the site at this point, having passed through a settlement tank and hydrocarbon interceptor. The current natural site discharge mechanism shall be retained.

7.11.1 HYDROCHEMICAL CAPACITY OF RECEIVING WATERS

Water sampling and flow monitoring results are now employed to assess the ability of the surface water system to assimilate the predicted discharge and thereby ensure compliance with the Surface Water Regulations 2009 (as amended 2015, 2019) and the objectives of the Water Framework Directive.

Mass balance and assimilative capacity calculations have been completed in order to assess whether the receiving waters are capable of safely assimilating the discharge. Taking a conservative approach, surface water assimilation capacity assessment is carried out by employing:

1. The 95%ile flow conditions for the receiving water.
2. The Maximum Scenario discharge from quarry = 170 m^3/d = 0.002 m^3/s.

The value of 170m^3/d was calculated in previous sections where rainfall and subsurface water would amount to an **equivalent to 31 m^3/d (0.0004 l/s), on average**.

In addition to the rainfall runoff component, two distinct methods for estimating groundwater inflows to the site as extraction nears completion were applied. Groundwater inflow empirical formula, based on drawdown and bedrock hydraulic conductivity, suggests an end-of-life groundwater inflow value of **54 m^3/d.** However, application of an adapted methodology similar to the GSI's ZOC concept, which is based on recharge to the Lm aquifer at site and in the area upgradient of the site, suggests daily groundwater flow of **139 m^3/d** at the end of the proposed development. The higher value was adopted and the addition of **rainfall runoff and groundwater inflow suggests a future maximum discharge volume of 170 m^3/d (0.002 m^3/s). Extreme rainfall events are stored in the specifically designed floor sump(s) and those volumes are discharged slowly in times of no rainfall.** These values are intended to be representative of maximum discharge rates that are only likely to be realised close to completion of rock extraction operations. Interim discharge rates will respond to the phasing scheme. The phased development will involve the development of the upper quarry benches to the southeast i.e. dry working. Development of the bench below the current quarry floor to 70m OD will not take place until the latter part of the expected 20-year life of the quarry. Therefore, there is room in the allocated 170m3/d maximum simulated volume in the initial years of the quarry.

For the purposes of informing appropriate discharge licence limits, assimilation capacity calculations are presented for the Surface Water and Salmonid Regulation parameters of significance, as follows:

- Orthophosphate
- BOD
- Ammoniacal Nitrogen
- Suspended Solids, and
- pH

While there is no suspended solids Environmental Quality Objective (EQO) specified in the Surface Water Regulations, parameter simulation is included here because of the Conservation Objectives for Lough Derravaragh. The Salmonid Regulations suggest a limit of 25 mg/l for suspended solids. Neither do the Surface Water Regulations (2009) specify an EQO for Nitrate and there is no drinking water abstraction downstream of the discharge point.

The current gravity flow, natural stormwater outfall from the site forms the headwaters of the Deerpark Stream. Therefore, there is no upgradient surface water. The primary receptor in terms of quality is deemed to be the Yellow River, which is connected to the site via the Castlepollard Stream. Hence, the outfall of the Deerpark Stream to the Castlepollard Stream is determined to be the key mixing point for assimilation capacity simulation calculations.

The calculations adopted the most conservative scenario, whereby low flow conditions in the local river network coincide with maximum predicted quarry discharge. The scenario also assumes the Deerpark Stream is approaching no flow conditions during the simulations for worst case scenario evaluation. This is unrealistic but does provide a conservative assessment of potential impacts. The discharge from the site is stormwater runoff. Therefore, the receiving water is unlikely to be at the low flow condition. The Guidance for the Assessment of Discharges to Surface Water (DoEHLG 2011) was written for wastewater assessment. Quarry discharge does not contain the BOD, SS or other constituents of wastewater.

7.11.2 ASSIMILATION CAPACITY SIMULATIONS

The Department of the Environment (DoEHLG 2011) mixing equation is, as follows:

$$C_{sw} = [(C_{qd} \times Q_{qd}) + (C_{swu} \times Q_{sw})] / Q_{sw} + Q_{qd})$$

Whereby

C_{sw} = predicted resultant downstream concentration in Castlepollard Stream

C_{qd} = concentration in discharge from quarry (taken as GW quality in PW1)

Q_{qd} = Maximum Scenario discharge from quarry = 170 m^3/d = 0.0020 m^3/s =2 l/s

C_{swu} = background concentration in Castlepollard Stream upgradient of the mixing point

Q_{sw} = 95%ile flow at the simulation mixing point in Castlepollard Stream = 0.0242 m^3/s = 24 l/s (as presented in Table 7-6).

A simple indicative way of evaluating the discharge is to consider that the maximum proposed discharge from the quarry is 2 l/s, whereas the minimum flow in the river will be over ten times that at 24 l/s. In addition, as previously stated, it is unlikely that the maximum discharge will occur at the minimum river flow condition.

The proposed maximum discharge and average surface water concentrations for the Castlepollard Stream were employed to iteratively evaluate calculated resultant hydrochemical concentrations in the receiving waters. Compliance with the EQOs of the Surface Water Regulations therefore enabled specification of justifiable Emission Limit Values (ELV). Data employed in the simulations are presented in Table 7.23. The Assimilation Capacity Simulations for each parameter simulated are presented as Table 7.24.

Table 7.23 Data employed in the Assimilation Capacity Simulations

Hydrochemical Parameter	Units	AVERAGE Baseline Receiving Water Quality @ Mixing Point in Castlepollard Stream	Surface Water Regs EQOs (2009, as amended 2012, 2015, 2019)
Temperature	°C	11.5	< 1.5oC rise outside the mixing zone
Field pH	pH units	8.2	6 to 9
DO	mg/l	95	95 to 120 % saturation
Nitrate (as NO_3)	mg/l	6	Not Specified in the SW Regs
Ammoniacal Nitrogen as N	mg/l	<0.03	0.065 to 0.14 mg/l High Status
Orthophosphate as P	mg/l	0.016	0.025 to 0.0445 mg/l MRP-P
Suspended Solids	mg/l	15	Not specified in SW Regs, Salmonid Regulations = 25 mg/l
BOD	mg/l	2	2.6 mg/l BOD

Table 7.24 Assimilation Capacity Simulation Results for each Parameter

Proposed Discharge Licence ELVs for Q = Maximum 0.002l/s & 95%tile Streamflow @ 0.0242 m3/s							
T = (FC+fc)/(F+f)				Surface Water Regulations 2009 as ammended Surface WATER EQS's (mg/l)			
	MRP-P						
T = RESULTANT concentration in the receiving water	T	0.016	mg/l	0.035	0.075	0.025	0.045
F = RECEIVING river flow, (m3/s)	F	0.0240	m3/s	Good Status Mean	GOOD STATUS 95%tile	High Status Mean	High Status 95%tile
C = Baseline concentration in receiving water (mg/l)	C	0.0160	mg/l				
f = Flow discharging to receiving waters (m3/s)	f	0.0020	m3/s	Surface Water Regulation Compliant & A discharge concentration of <0.02mg/l MRP-P will result in no change in the Receiving Water's concentration			
ITERATIVELY DERIVED ELV = c = concentration in discharge	c	0.02	mg/l				
	BOD			Surface Water Regulations 2009 as ammended Surface WATER EQS's (mg/l)			
T = RESULTANT concentration in the receiving water	T	2	mg/l	1.5	2.6	1.3	2.2
F = RECEIVING river flow, (m3/s)	F	0.0240	m3/s	Good Status Mean	GOOD STATUS 95%tile	High Status Mean	High Status 95%tile
C = Baseline concentration in receiving water (mg/l)	C	2	mg/l				
f = Effluent flow discharging to receiving waters (m3/s)	f	0.0020	m3/s	Surface Water Regulation Compliant & A discharge concentration of <4 mg/l BOD will result in no change in the Receiving Water's concentration			
ITERATIVELY DERIVED ELV = c = concentration in discharge	c	4	mg/l				
	Ammonia-N			Surface Water Regulations 2009 as ammended Surface WATER EQS's (mg/l)			
T = RESULTANT concentration in the receiving water	T	0.03	mg/l	0.065	0.14	0.04	0.09
F = RECEIVING river flow, (m3/s)	F	0.0240	m3/s	Good Status Mean	GOOD STATUS 95%tile	High Status Mean	High Status 95%tile
C = Baseline concentration in receiving water (mg/l)	C	0.030	mg/l				
f = Effluent flow discharging to receiving waters (m3/s)	f	0.0020	m3/s	Surface Water Regulation Compliant & A discharge concentration of <0.065 mg/l Total Ammonia As N i.e. the Good Status Mean Cocntration, will result in no change in the Receiving Water's concentration			
ITERATIVELY DERIVED ELV = c = concentration in discharge	c	0.065	mg/l				
	Suspended Solids			Suspended Solids			
T = RESULTANT concentration in the receiving water	T	15	mg/l	No Change in Resultant Concentration			
F = RECEIVING river flow, (m3/s)	F	0.0240	m3/s				
C = Baseline concentration in receiving water (mg/l)	C	15	mg/l	25 mg/l SS Limit complied & A discharge cocnentration of <10mg/l SS will result in no change in the Receiving Water's concentration			
f = Effluent flow discharging to receiving waters (m3/s)	f	0.0020	m3/s				
ITERATIVELY DERIVED ELV = c = concentration in discharge	c	10	mg/l				
	pH			pH			
T = RESULTANT concentration in the receiving water	T	8.2	mg/l	No Change in resultant pH Concentration			
F = RECEIVING river flow, (m3/s)	F	0.0240	m3/s	Surface Water Regulatory 6 to 9 pH Complied With			
C = Baseline concentration in receiving water (mg/l)	C	8.2	mg/l				
f = Effluent flow discharging to receiving waters (m3/s)	f	0.0020	m3/s				
ITERATIVELY DERIVED ELV = c = concentration in discharge	c	8.5	mg/l				

7.11.2.1 Assimilative Capacity & Headroom

The proposed ELVs have been selected to result in no change in the receiving water's concentrations. The discharge will therefore not use any of the Headroom or available assimilative capacity load. Therefore, a conclusion of no potential for impact is definitive.

7.11.2.2 Assimilative Capacity Conclusion & Monitoring

The mass balance and headroom calculations demonstrate that all predicted concentrations of all parameters downstream of the proposed discharge point satisfy the Surface Water Regulations (2009, as amended 2012, 2015 and 2019). The information provided shows that there is sufficient basis for Lagan applying for permission to continue operations at the quarry.

As part of proposed long-term compliance monitoring, it is now standard practice for the applicant to install an in-line flowmeter fitted with a datalogger to constantly measure discharge rates in real-time. A telemetry unit will allow the datalogger information to be observed remotely by the operator and their hydrogeologist. This will provide accurate data linked to daily flows and the seasonal pattern of flows. It is expected that the Discharge Licence will specify the required frequency deemed acceptable to Westmeath County Council.

7.11.2.3 Emission Limit Values Proposed

Results for assimilation capacity simulations (Table 7.24) suggest Surface Water Regulation EQO compliance and no resultant change in the receiving water's hydrochemical parameters, under the low flow 95%tile flow condition in the receiving water for ELVs, as follows:

- Maximum Daily Discharge ELV = 0.002 m^3/s (170 m^3/d),
  - which is the maximum calculated rainfall runoff and groundwater component for the final phase of the proposed development
- MRP-P @ ≤ 0.02 mg/l
- BOD @ ≤ 4 mg/l
- Total Ammonia as N @ ≤ 0.065 mg/l
  - *i.e.*, limit ammonia to the Good Status Mean Concentration will result in 'High' Status Mean resultant concentration & compliance.
- Suspended Solids @ ≤ 10 mg/l
- pH @ 6 to 9 pH units

With respect to the site's ability to achieve these ELVs, the site's groundwater concentrations are below the respective detection limits of the laboratory analyser in all cases for all hydrochemical parameters returned for the open hole in bedrock PW1 (Table 7.11). Therefore, considering that the site's baseline concentrations are low and that good management is proposed, full compliance is envisaged.

7.12 ASSESSMENT OF IMPACTS

7.12.1 CRITERIA FOR DETERMINATION OF IMPACTS

The significance of potential impacts on geological, hydrogeological and hydrological sensitive receptors was estimated by implementing an assessment as per: (a) the Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes (NRA 2008); and (b) the Guidelines for the Preparation of Soils, Geology & Hydrogeology Chapters of Environmental Impact Statements (IGI 2013). These documents use groundwater and geological type attributes and measures to determine the magnitude of the impact on an attribute.

Table 7.25 illustrates the criteria for determining the importance of the geological and hydrogeological sensitive receptors at the site. Table 7.26 demonstrates the criteria for estimating the magnitude of the impact on an attribute.

Table 7.27 presents the resulting estimation of the significance of potential impacts.

Table 7.25 Estimation of Importance of Sensitive Attributes

Importance	Criterion	Typical Examples
Extremely High	Attribute has a high quality or value on an international scale.	Groundwater supports river, wetland or surface water body ecosystem protected by EU legislation, e.g., SAC or SPA status.
Very High	Attribute has a high quality and rarity on regional or national scale.	River, wetland or surface water or groundwater body ecosystem protected by EU legislation. Aquifer providing a regionally important drinking water resource or supporting site protected under wildlife legislation.
High	Attribute has a high quality or value on local scale.	Aquifer providing locally important resource or supporting peat ecosystem – undesignated.
Medium	Attribute has a medium quality or value on local scale.	Aquifer providing water for agricultural or industrial use with limited connection to surface water. Eroding bog.
Low	Attribute has a low quality or value on local scale.	Non-aquifer. Cutover blanket bog.

Table 7.26 Estimation of the Magnitude of a Potential Impact on an Attribute

Magnitude	Criterion	Typical Example
Large Adverse	Results in loss of attribute and/or quality and integrity of attribute.	Loss of aquifer water supply by dewatering or major contamination event. Potential high risk of pollution to groundwater from routine run-off. Loss or change to non-SAC status, etc., SAC Annex 1 habitat loss.
Moderate Adverse	Results in impact on integrity of attribute, or loss of part of attribute.	Partial loss or change to aquifer characteristics. Potential medium risk of pollution to groundwater from routine run-off. Loss to a potential SAC Annex 1 habitat.
Small Adverse	Results in minor impact on integrity of attribute or loss of small part of attribute.	Potential low risk of pollution to groundwater from routine run-off. Risk of pollution from accidental spillages. Localised impact.
Negligible	Results in effect on attribute, but of insufficient magnitude to affect the use or integrity.	No measurable impact upon aquifer and no perceivable risk of pollution from accidental spillages. Slight impact. etc.

Table 7.27 Estimation of the Significance of Potential Impacts

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

7.12.2 DESCRIPTION OF THE LIKELY IMPACTS

The procedure for determination of potential impacts on the receiving hydrogeological environment involves identifying potential receptors within the site boundary and surrounding environment and using the information gathered during the field work and desk study to assess the degree to which these receptors will be impacted.

When the full site is considered, it is small in size. The site is therefore considered to be an attribute of high importance. In line with best practice, the individual impacts will be considered with respect to the application site, plus the cumulative impacts with respect to the application site and surrounding area.

No part of the site is hydrologically connected to Lough Lene SAC 002121 and so this designated site, important water supply and overall natural resource is NOT a potential receptor.

Surface waters are potential receptors. There are several first order streams in the vicinity of the quarry that feed the Yellow River. The EPA Q Rating is 4 for the closest downstream monitoring stations on the Yellow River.

Lough Derravaragh SPA 004043 is a potential receptor because the stream receiving the site's discharge is one of the tributaries of the Yellow (Castlepollard)_030 River that merge to form the Inny_070 NE influent to the lake. The lake has important tourism, angling and other recreational uses. Within the project team, the ecologist provided guidance that peat harvesting, drainage and sediments in other parts of the lake's catchment, unrelated to quarrying, had previously been a matter for concern but those issues have now been addressed in works outside this project. The significance is that silt and sediment management are important for the control of likely impacts from the proposed development and designs incorporate this.

Groundwater as a resource is always a receptor.

Groundwater as a source of water supply is not a receptor because there are no domestic wells and no public water supply wells in proximity.

The Planning and Development Regulations 2001-2021 require Impact Assessment under the headings of Do Nothing, Transboundary, Direct, Indirect, Cumulative, Residual and Worst Case. Impacts are also assessed in relation to construction, operational and decommissioning stages.

7.12.2.1 'Do Nothing' Impacts

If the development did not proceed, the ground of the proposed development would remain a quarry floor within the existing quarry void excavated in the north-western half of the site and the elevated south-eastern half of the site would remain in its current steep topography rough scrubland and grassland. Under the 'Do Nothing' scenario, all quarrying and ancillary activities would cease. The site would be restored as per the requirements of the existing planning permission (P.A. Ref. 01/525). Investigations completed as part of this work suggest little groundwater currently occurs at the site and also negligible groundwater occurs in the proposed deeper bench below the current floor. It is therefore assessed that to 'go deeper' is unlikely to differ from the 'do-nothing' scenario in terms of impacts.

7.12.2.2 Transboundary Impacts

EIA Directive 2014-52-EU invokes the Espoo Convention on Environmental Impact Assessment in a Transboundary Context, 1991, and applies its definition of transboundary impacts. Given the location of the site at 50 km due south of the border with Northern Ireland, the nature, size and scale of the proposed development, and the fact that water from the catchment in which the site sits does not flow north, it is expected that the development will not have any significant transboundary effects with respect to water bodies.

7.12.2.3 Potential Direct Impacts

Aspects identified as giving rise to Potential Impacts include the following:

1. Fuel storage & use;
2. Excavation works;
3. Surface water runoff & discharge from the site;
4. Dewatering; and
5. Blasting (use of explosives at the site).

The assessment of potential impacts from the proposed development are summarised in Table 7.28 using the headings discussed under the criteria for determination of impacts. The main anticipated impact associated with the proposed quarry development, in relation to hydrology and hydrogeology, relates to the potential contamination of groundwater from quarrying activities and the risk posed to surface water receptors that receive that groundwater or the site's managed surface water runoff. The proposed development of a floor sump and settlement tanks for surface water management system are described earlier in this work.

Assimilation capacity simulations for a potential **maximum** daily discharge volume of 170 m^3/d (0.002 m^3/s) and hydrochemical ELVs are proposed for use in Westmeath's consideration of a discharge licence for the site. The ELVs proposed are justifiable in the context of ensuring compliance with the Surface Water Regulations and are also justifiable in the context of water quality at the quarry. The site's receiving surface water environment has been tested for its hydrological ability to accept the discharge and no flood effects are envisaged.

Potential Impacts arising from the use of explosives at the site (*i.e.,* 5. Blasting) are quantitatively evaluated in a later section of this assessment.

7.12.2.3.1 Potential Impacts of the Site's Discharge Waters

Refuelling will be controlled and a hydrocarbon interceptor will be installed on the line conveying waters from the quarry floor to the settlement tanks. Therefore, no impacts are envisaged for the site's waters as a result of refuelling.

Refer to Sections 7.10.3, 7.11.2 and associated Tables, in which the design of settlement systems and specification of ELVs proposed for the site have been discussed. These were designed in order to give rise to no change in any hydrochemical concentrations in the receiving waters and to ensure compliance with the requirements of the Surface Water Regulations (2009, as amended).

In addition, cross sectional surveying and the development of a site-specific flow model for the channel of the receiving water demonstrated no potential for downstream flooding impact.

Therefore, no impact at all is envisaged with respect to the site's discharge waters. A Section 4 Discharge Licence will be required and this can be Conditioned as part of the Planning Decision.

Table 7.28 Potential Impacts

Activity	Attribute	Character of Potential Impact	Importance of Attribute	Magnitude of Potential Impact	Significance of Potential Impact
1. Fuel storage & use	Groundwater Subsoils Local Rivers Yellow (Castlepollard)_030 , Inny_070 & Lough Derravaragh	There will be no bulk fuels stored at the application site. Plant and equipment that operate at the quarry will be refueled by competent fuel companies that dispense fuel directly into plant and equipment. Procedures will be in place for dispensing fuel with drip trays used during refueling. Accidental spillage of contaminants, if not stored and used in an environmentally safe manner during site operations, could cause short to long term, moderate to significant impacts to soils, groundwater, and the surface water environment, if not stored and used in an environmentally safe manner. Leakages from the hydrocarbon interceptor could occur if the interceptor is not correctly maintained.	Extremely High	Large Adverse	Profound
2. Excavation works		Excavation works will result in the same vulnerability of groundwater at the site as is now experienced by the same area of open bedrock. Procedures are in place for dealing with accidental spillages.	Extremely High	Moderate Adverse	Profound
3. Surface water Runoff & Discharge from the site		Quarry floor and internal road surface runoff or drainage systems have potential, if not correctly designed, to result in contamination of surface waters and groundwater. Accidental spillage could contaminate the aquifer by direct percolation or via the superficial water network. Changing the nature of surface water and groundwater dynamics in the catchment could affect downstream ecosystems. Downstream ecological receptors such as fish life and habitats could be affected.	Extremely High	Large Adverse	Profound
4. Dewatering	Derravaragh GWB	Lowering the quarry floor could lead to a groundwater component, as well as ordinary everyday rainfall runoff, in the sump, which will need to be dewatered. Dewatering leads to a requirement for a Regularisation of the site through a formal Section 4 Discharge Licence. Lowering the quarry floor and an increased groundwater component associated with the void could lead to a resultant lowering of the water table outside the quarry, which might affect domestic wells or wetlands.	Extremely High	Large Adverse	Profound
5. Blasting	Surface Waters & Groundwater Environment	Use of explosives at the site could add Nitrogen residuals and suspended solids to the water environment.	Extremely High	Moderate Adverse	Profound

7.12.2.3.2 Dewatering

To assess whether the proposed quarrying activities and associated dewatering activities are likely to have an impact on regional water resources, a macro scale regional groundwater water balance has been calculated and is presented as Table 7.29. The entire site is underlain by the Derravaragh GWB. Both the information pertaining to the latter published by GSI (2003) and the mapped recharge data published by the GSI https://dcenr.maps.arcgis.com/apps/MapSeries can be used to evaluate the potential for interaction with the regional groundwater regime.

Given that the Derravaragh GWB is reported to have an approximate area of 107 km^2 (GSI 2003) and that the GSI assigns a groundwater recharge value of 350 mm/yr (based on an average of mapped groundwater recharge rates of approximately 60% across the GWB), the volume of groundwater associated with the entire 107 km^2 groundwater body is approximately 37,450,000 m^3/yr. The volume of groundwater flowing below the entire quarry area is similarly calculated as 39,900m^3/yr. This is approximately 1/1000th the volume of groundwater assigned to the entire GWB. The water balance is further developed in Table 7.29.

Table 7.29 Regional Water Balance

	Groundwater Balance		
	HYDROGEOLOGICAL WATER BALANCE: Regional Locally Important Karstified Aquifer & Local GWB		
	Aquifer AVERAGE GSI Effective Rainfall (mm/yr)	580	
	Aquifer AVERAGE GSI Groundwater Recharge (mm/yr)	350	
	Aquifer AVERAGE GSI Groundwater Recharge (m/yr)	0.35	
	GSI assigned area for 'Derravaragh Groundwater Body' (km2)	107	
	Derravaragh ' Groundwater Body' (m2)	107,000,000	
	GSI Stated Total Aquifer Area (km2)	147	
	Total Aquifer Area (m2)	147,000,000	
	WATER BALANCES		
A	Rainfall Recharge to Total Aquifer area = [0.35m x 147,000,000m2 area] (m3/yr)	51,450,000	
	Annual: Proposed Site Area 11.4ha * 0.35m/yr GW Recharge (m3/yr)	39,900	
	Proportion of Site's Groundwater Recharge as % of the total aquifer area's annual recharge to groundwater from rainfall (%)	**0.1**	**%**
B	Groundwater Recharge to Derravaragh Groundwater Body GWB = [0.35m x 107,000,000m2 area] (m3/yr)	37,450,000	
	Annual: Proposed Site Area 11.4 * 0.035m/yr GW Recharge (m3/yr)	39,900	
	Proportion of Site's Groundwater Recharge as % of Carrick on Shannon GWB's annual rechange amount to groundwater from rain falling on its catchment (%)	**0.1**	**%**

Water balance calculations presented in Table 7.29 show that at a local scale, rainfall derived recharge at the site represents 0.1% of the volume of groundwater discharging from the Derravaragh GWB. Given that the 0.1% value for waters intercepted at the quarry is significantly below the 5 % threshold value of the Water Framework Directive Working Group (GW5), it is therefore deemed to be of 'Low Potential Impact' and 'Not at Significant Risk' by WFD characterisation methods (GW5 2005). These water balance data provide the confidence to assert that there will be no adverse impact on the regional groundwater regime.

7.12.2.3.3 Blasting at the site

Mass balance calculations are presented to demonstrate the potential for blasting to impart nitrogen residues in the discharge waters, which would have the potential to impact groundwater quality. The risk to groundwater and surface water is assessed by quantifying the resultant concentrations for the potential residual nitrogen compounds, Nitrate (NO_3), Ammonia (NH4) and Nitrite (NO_2).

Peak activity rates of the extraction activities, blasting frequency and the type of explosives proposed were supplied to Hydro-G. Lagan operate a network of sites throughout the country and their handling and explosives use meets industry standards. The explosive used at Lagan sites is the usual Kemex emulsion, which is produced by Irish Industrial Explosives (IEE). The industry range suggests that 0.15 kg/tonne – 0.20 kg/tonne of explosives is used across all quarries.

Kemex is a site-mixed bulk emulsion explosive produced from an emulsion matrix. An emulsion matrix is essentially an aqueous solution of ammonium nitrate emulsified in oil. Kemex products may also contain ammonium nitrate prills, fuel oil, aluminium and/or gassing agents. The Technical Data Sheets (TDS's) and Material Safety Data Sheets (MSDS's) for explosives, primers and detonators to be used at the site were employed by Hydro-G in the calculation of potential residues, and those data sheets are held on file at Hydro-G and by Lagan.

The literature suggests that small percentages of N compounds can remain as residual coatings on bedrock following blasting. This has the potential to be dissolved when it comes into contact with water, albeit the potential concentrations are low. The most frequently referenced study was published by Environment Canada in 1988 (Ferguson & Leask 1988). That study outlines a procedure for determining the residual N compounds for various mine site types. The stepwise procedure for predicting aqueous concentrations of N species used in the 1988 study is as follows:

1. Calculate the annual leached nitrogen loading (kg/yr) for the entire site based upon annual explosive mass usage and residual N fraction associated with the explosive type, e.g., Kemex leaves 6% of the Total N Mass behind;
2. Separate into loadings of N compounds (Nitrate, Nitrite and Ammonia), and;
3. Calculate the flow concentrations.

The concentrations of N species in discharge water from the proposed development at the application site quarry were calculated using this procedure. These data are presented in Table 7.30 below.

In the calculations presented here, the highest residual is for nitrate (94%), and the upper limit of the range is used in all cases to determine the concentration of N species in pumped water. In this way, the most conservative, *i.e.*, worst case, assessment is presented. The calculation also assumes that 100% of residual N is dissolved in drainage waters and is subsequently pumped from the quarry by dewatering.

The results of the calculations presented in Table 7.30 clearly show that the residual N compounds would each have concentrations of less than 0.01 mg/l N.

Table 7.30 Concentrations of N Compounds from Explosives in Dewatering Discharge

EXPLOSIVE MASS BALANCE		
11.4	Total Site Area	ha
114,000	Total Area	m2
2,000,000	Approximate Volume of rock to be extracted	tonnes
800,000	Approximate Volume of rock to be extracted	m3
800,000	USUAL for 15% losses to be applied but the 2 million tonnes data accounted for losses already	m3
0.2	Explosive Mass Required	kg/m3
160,000	Explosives Mass Required	kg
20	Planned Duration of extraction	years
8,000	Explosives Mass Required per year	kg/yr
NITROGEN MASS BALANCE Facts		
94%	% Explosive mass as Ammonium Nitrate	%
35%	% Ammonium Nitrate as N	%
2,632	Mass of N	kg/yr
0.06	Residual Fraction	
158	Residual N left behind	kg/yr
Total N Species Generated by explosive's residues (areal annual loading rate)*	***13.85***	***Kg/ha/yr***
*facilitates comparison with agricultural inputs [total quarry area used]. Compare to 170 kg N/ha/yr Total Nitrogen loadings permitted in the Good Agricultural Practice Regulations (SI 605 of 2017)		
Residual N COMPOUNDS**		
156	Residual NO_3 *(75-99% of Residual N value)*	**kg/yr**
38	Residual NH_4 *(0.5 - 24% of Residual N value)*	**kg/yr**
9	Residual NO_2 *(0-6% of Residual N value)*	**kg/yr**
****Highest possible % Residuals Adopted from the available ranges, as conservative measure.**		
WATER BALANCE		
170	Envisaged MAX Daily Quarry Discharge (max)	m^3/day
62,050,000	Quarry Discharge	litres/yr
INCREASE IN NITROGEN COMPOUND CONCENTRATIONS***		
Additional Residual NO_3	***0.01***	*mg/l/d*
Additional Residual NH_4	***0.002***	*mg/l/d*
Additional Residual NO2	***0.0004***	*mg/l/d*
*** Calculation of Residual Concentrations = (kg/yr*10^6 = mg/yr)/(litres/yr)		
MASS OF NITROGEN COMPOUNDS GENERATED Over the Whole SITE Area (kg/ha/yr)***		
Total N	**13.85**	***Kg/ha/yr***
Residual NO_3	***13.71***	*Kg/ha/yr*
Residual NH_4	***2.53***	*Kg/ha/yr*
Residual NO2	***0.0001***	*Kg/ha/yr*

Specifically, the resultant concentrations in waters within the quarry, if impacted by explosives within the entire quarry site area, would result in increases of 0.01 mg/l NO_3, 0.002 mg/l NH_4 and 0.0004 mg/l NO_2. For the purpose of context, the following is offered:

- The limit for nitrate in waters affected by agriculture is 50 mg/l NO_3 (Nitrate & Good Agricultural Practice Regulations), while it is also 50 mg/l NO_3 for the Freshwater Fish Directive (2006/44/EC). Therefore, the simulated resultant addition of **0.01 mg/l NO_3 to the quarry's groundwater or discharge** resulting from its use of explosives is massively lower than any regulatory Environmental Quality Objective.
- The EQO for Ammonia in **High Status** Waters (Surface Water Regulations 2009) is 0.04 mg/l NH_4 and the predicted resultant increase that might occur as a residual from the use of controlled explosives is 0.002 mg/l. Therefore, an environmental impact is not envisaged because the resultant concentration calculated is at least an order of magnitude lower than the High Status EQSs of the Surface Water Regulations (2009).
- The calculated increase in residual Nitrite concentration is miniscule at 0.0004 mg/l NO_2.
- Overall, the residual concentrations meet the requirements of the Threshold Values of the Groundwater Regulations (2010) and the targets set out in both the Freshwater Fish Directive and Salmonid Waters Regulations.

The risk of impact to local water quality arising from the use of explosives at the site is therefore non-existent, based on industry standard method of calculation. These calculations are based on PEAK abstraction rates.

7.12.2.3.4 Potential Impact to Third Party Wells or Water Supplies

- There are no domestic wells within 600 m of the quarry.
- There are no PWS in proximity to the site. Lough Lene is the closest PWS but the site is located in a different catchment and there is no hydrological connection between the site and Lough Lene.
- There are no mapped GWS wells in proximity.
- No impacts on wells or any water supply sources are envisaged.

7.12.2.4 Worst Case Impacts

For the purposes of evaluating the worst-case scenario evaluation, the following strategy was adopted:

1. 'End of life' maximum water management scenario was used to specify sump storage for extreme weather events over the entire working area proposed;
2. The settlement tank was sized to constrain discharge to an appropriate discharge rate, cognisant of predevelopment greenfield runoff rates permitted;
3. Likely dewatering volumes were calculated; and
4. Resultant concentrations and impacts on the receiving surface waters were determined.

Hydrological survey of receiving waters capacity suggests that the proposed discharge rate can be accommodated with no risk of flooding.

Hydrochemical assimilation capacity simulation of the receiving waters capacity suggests that discharge to the Deerpark stream to the northwest of the site, for the worst-case scenario maximum discharge volume of 170 m^3/d (0.002 m^3/s) can be accommodated at the mixing point with the Yellow (Castlepollard)_030 when the river is at its lowest flow condition, which is the calculated equivalent low flow 95%tile flow rate, and compliance with the Surface Water Regulation's Good Status Environmental Quality Objectives (2009, as amended) is maintained. In fact, the maximum worst case, end of development discharge volume, can be accepted by the receiving water and cause no increase at all in the resultant concentrations for the range of simulated ELVs, which were selected based on iterative simulations using the DoEHLG (2011) mass balance method, as specified in the Guidance to Local Authorities in the Licensing of Discharges to Surface Waters.

7.12.2.5 Cumulative & In-Combination Impacts

There are no other significant projects including extractive or industrial developments within 3 km of the site. The absence of any extractive or industrial developments within 3 km renders the likelihood of significant negative cumulative impacts arising from multiple quarries.

The EPA maps an IE licensed pig-rearing (P0893) facility 300 m south of the quarry, within the catchment of the southern stream (https://gis.epa.ie/EPAMaps/). This stream (IE_SH_26Y020100) is mapped as being of Good Status and Not at Risk. Therefore, the pig farm is adequately managed from a water perspective and does not have potential to be an in-combination pressure or resulting impact.

Tools on the EPA's Envision portal allow 17 Pressure Tabs to be enabled each for River Pressures, Groundwater Pressures and Lakes & Transitional Coastal Water Pressures. Of the 17 x 3 = 51 layers of Pressure information, the only Pressure mapped for the area is Agriculture for the local surface water system (IE_SH_26Y020250 YELLOW (CASTLEPOLLARD)_0300 and the underlying groundwater system (IE_SH_G_077 Derravarragh GWB). The proposal for development at the site does not involve agriculture, fertiliser use, animal husbandry or any of the other potential pressures associated with agriculture. Therefore, no cumulative or in-combination Pressure or Impact is envisaged.

7.13 MITIGATION MEASURES

The predicted impacts presented in Table 7.28 can be resolved under the mitigation measures set out in Table 7.31.

Table 7.31 Mitigation Measures

Construction Activity	Attribute	Character of Impact	Mitigation	Residual Impact
1. Fuel storage & use	Groundwater Subsoils Local Rivers Yellow (Castlepollard)_030, Inny_070 & Lough Derravaragh	Accidental spillage of contaminants during site operations could cause short to long term, moderate to significant impacts to soils, groundwater and the surface water environment, if not stored and used in an environmentally safe manner.	• Lagan's SOPs have been designed to ensure responsible activity on their sites. • There will be no bulk fuels stored on-site. Hazardous wastes, such as waste oil and chemicals will be stored in sealed containers. Fuelling, lubrication and storage areas will not be located within 30 m of drainage ditches or settlement sumps. • All waste containers (including all ancillary equipment such as vent pipes) will be stored within a secondary containment system (*e.g.,* a bund for static tanks or a drip tray for mobile stores and drums). The bunds will be capable of storing 110 % of the tank capacity. Where more than one tank is stored, the bund must be capable of holding 110 % of the largest tank or 25 % of the aggregate capacity (whichever is greater). Drip trays used for drum storage must be capable of holding at least 25 % of the drum capacity. Where more than one drum is stored the drip tray must be capable of holding 25 % of the aggregate capacity of the drums stored. • Regular monitoring of water levels within drip trays and bunds due to rainfall will be undertaken to ensure sufficient capacity is maintained at all times. • A wheel wash facility will be installed on the site and the roads have sprinkler systems. • Regular monitoring and maintenance of silt traps will be undertaken in accordance with the manufacturer's specifications. • Oil that accumulates within hydrocarbon interceptors shall be regularly removed by an appropriately licenced contractor. In addition, the hydrocarbon interceptor shall be appropriately maintained in accordance with the manufacturer's specifications. • Regular visual monitoring of the attenuation sump will be undertaken to ensure no visual oil or fuel contamination is present. • An oil interceptor shall be fitted with the capacity to deal with the throughflow rate to the settlement tanks limited to 0.02 m^3/s and a maximum daily discharge volume of 170 m^3/d (0.002 m^3/s). The location of the hydrocarbon interceptor is presented in Figure 7.14.	Neutral
2. Excavation works	Groundwater Subsoils Bedrock Local Rivers Yellow (Castlepollard)_030, Inny_070 & Lough Derravaragh	Excavation works will result in the same vulnerability of groundwater at the site as is now experienced by the open bedrock.	• Excavation works will be completed using Best Practice maintenance of machinery &blasting methods • There will be no bulk fuels stored on-site. • Spoil heaps will be safely sloped and situated away from surface waters.	Neutral
3. Surface water Runoff & Discharge from the site	Groundwater Local Rivers Yellow (Castlepollard)_030, Inny_070 & Lough Derravaragh	Road surface runoff or drainage systems have potential, if not correctly designed, to result in contamination of surface waters and groundwater. Accidental	The volumetric capacity of the settlement sump on the floor of the quarry has been specified to accommodate the required extreme rainfall storm event waters for the required residence time. A Hydrocarbon Interceptor has been proposed for the line to the discharge control settlement tanks The overflow rate from the final settlement tank is designed to be the same or less than the permissible predevelopment Greenfield Runoff Rate. Assimilation capacity simulations have been completed and appropriate Emission Limit Values have been proposed.	Neutral

Construction Activity	Attribute	Character of Impact	Mitigation	Residual Impact
		spillage could contaminate the aquifer by direct percolation or via the superficial water network. Monitoring results and existing system evaluation suggest that this is not the case at the site.	The Emission Limit Value (ELV) proposed for the daily maximum discharge volume, worst case, end of life amount of 170 m^3/d (0.002 m^3/s) is an order of magnitude lower than the calculated 95%ile low flow river condition of 0.024 m^3/s at the mixing point of the Deerpark Stream and the Yellow (Castlepollard)_030. Discharge will be of a quality that will not impact water quality. The Emission Limits proposed for the site are better quality for Suspended Solids than currently exists in the natural environment receiving the water and the Ammonia ELV proposed is the same as the EQO for Good Status water bodies as specified in the Surface Water Regulations. A flow meter has been proposed for the discharge.	
4. Dewatering	Derravaragh GWB	Lowering the quarry bench could lead to a small groundwater component in the sump, which will need to be dewatered. This could lead to an increase of groundwater intercepted at the site.	The quarry floor and its sump settlement system are to be adequately sized to handle the water volumes they will receive. The groundwater component has been calculated to intercept < 0.1 % of the regional groundwater flow volume in the Regional Aquifer AND in the underlying GWB. This is a low potential for impact 0.1% (according to GW5 Impact assessment WFD Working Group 2004) and is deemed by the project's hydrogeologists to be insignificant in catchment water balance. Water management and discharge have been designed in cognisance of enacted Irish Regulations concerning Groundwater, Surface Water, Birds and Habitats. Hydraulic response testing of the bedrock suggests that the radial effect will not impact the groundwater body, local wells, PWS's nor important wetlands.	Neutral
5. Blasting	Water Environment	Use of explosives at the site could add Nitrogen to the water environment.	Blasts are Industry Standard Regulated and controlled. Modern methods ensure controlled systems. Calculations have been completed to demonstrate no potential for impact. The predicted, calculated, resultant residual N species increases are miniscule and insignificant.	Neutral

7.14 RESIDUAL IMPACTS

Residual impacts on the hydrological or hydrogeological environment are not envisaged to result from the proposed quarry extension in the vertical plane and given the site's mitigation measures. The bedrock in the proposed one bench beneath the working area has no groundwater, little porosity and limited hydraulic conductivity. This has been demonstrated by field measurement in the course of this work. The sump area will be managed by duty and standby pumps at the site. Residual Impacts are presented for all phases in Table 7.32.

Table 7.32 Residual Impacts Assessment

Residual Effect Evaluation	No.	Potential Impact	Potential Effect	Description of Effect						Mitigation Required?	Residual Effect
				Quality	Significance	Extent	Probability	Duration	Type		
Construction Phase	1	Generated suspended solids in runoff	Discharge water & groundwater quality	Negative	Significant	Local	Likely	Temporary	Irreversible	Yes. Water Management System must be constructed to include Extreme RF storm event sump on quarry floor PLUS Hydrocarbon Interceptor on the line to the Settlement Lagoons. A Discharge Licence with Appropriate Conditions will be required.	**No**
	2	Accidental leaks/spills of fuels or oils	Discharge water & groundwater quality	Negative	Significant	Local	Unlikely	Temporary	Irreversible	Yes. No fuel storage on site. Refuelling with licensed aoperator with Spill Controll. Hydrocarbon interceptor specified for the line to the Settlement Lagoons.	**No**
Operational Phase	1	Increased drawdown	Groundwater Body	Negative	Imperceptible	Local	Possible	Medium-Term	Reversible	No	**No**
				Negative	Imperceptible	Local	Possible	Medium-Term	Reversible	No	**No**
				Negative	Imperceptible	Local	Possible	Medium-Term	Reversible	No	**No**
	2	Discharge	Discharge water & groundwater quality	Negative	Imperceptible	Local	Unlikely	Medium-Term	Irreversible	Yes. Water Management System must be constructed to include Extreme RF storm event sump on quarry floor PLUS Hydrocarbon Interceptor on the line to the Settlement Lagoons. A Discharge Licence with Appropriate Conditions will be required.	**No**
	3	Blasting	Water quality	Negative	Significant	Local	Unlikely	Medium-Term	Irreversible	No, National Standards have built in Mitigation.	**No**
	4	Accidental leaks/spills of fuels or oils	Discharge water & groundwater quality	Negative	Significant	Local	Unlikely	Temporary	Irreversible	Yes. No fuel storage on site. Refuelling with licensed operator with Spill Controll. Hydrocarbon interceptor specified for the line to the Settlement Lagoons.	**No**
Post-Operational Phase	1	**None identified**									

7.15 SPA PROTECTION MEASURES

The main risk associated with the proposed development at depth for the existing quarry is the potential adverse impact it could have on receiving surface and groundwaters. The ultimate downstream receptor is the Lough Derravaragh SPA. The works completed here with respect to quantification of dewatering and the ability of the receiving waters to accept and assimilate the envisaged discharge suggest no potential for impact and no special measures are required other than those associated with all quarries, which are the appropriately specified floor sump, settlement tanks and the Section 4 Discharge licence.

7.16 APPLICATION OF EA HYDROGEOLOGICAL RISK ASSESSMENT METHODOLOGY

In addition to the usual impact assessment, description of likely impacts and mitigation measures presented above, Hydro-G presented the UK EA's 'best practice' approach to a hydrogeologically focused assessment for quarries (Boak et al. 2007) in the 'Study Methodology' Section. The following represents the application of the best practice hydrogeological methodologies in this assessment. There is no Irish based hydrogeological risk assessment guidance for quarries and water. As previously outlined, the approach of Boak et al. (2007) suggests a step-wise thought process. Following on from the completed desk and field studies, Hydro-G answers to each of the steps can now be summarised as follows:

- *Step 1:* Establish the regional water resource status:
  - Locally Important karstified Aquifer. Site is underlain by the Derravaragh GWB, which is mapped as being of Good Status & Not at Risk (EPA 2013–2018 https://gis.epa.ie/EPAMaps/Water).

- *Step 2:* Develop a conceptual model for the abstraction and the surrounding area:
  - The area proposed for rock extraction sits above the local landscape as a hilltop of solid limestone that is notable as a Geological Heritage Site because of the density of its limestone.
  - No conduits or fractures were encountered in the proposed working area of the site.
  - The application site will be extracted down to final proposed floor levels in a step wise fashion.
  - The current floor elevation in the working zone is 88 m OD, approximately, and the perimeter of the top of the current working area has an elevation peak of 119 m OD, approximately.
  - The rock will be taken from the current floor to a depth of one bench and the final floor will be 70 m OD.
  - Part of the hill to the south of the current floor will be taken out and down to 70 m OD but the perimeter ring will remain at an elevation of 120m OD in the eastern part of the site and at 115 m OD, approximately, in the western part of the site.

- There is no real 'groundwater' in the hill. Some water will be encountered in the subsoil to bedrock interface, but it will be more associated with the subsoil than the bedrock.
- Beneath the current floor, in the one bench proposed, there is negligible 'groundwater', low porosity, very low hydraulic conductivity and no sustained groundwater 'flow' to any of the wells drilled. The wells can be emptied with a small pump and they will refill overnight, but there is negligible actual 'groundwater' flow.
- The Conceptual Model for the abstraction and surrounding area is that there will be no net loss of water to the hydrological regime and the groundwater balance suggests that the groundwater intercepted will represent 0.1% of the ground water flowing in the entire Aquifer and the Derravaragh GWB. That percentage is of no significance and supports the finding that the site poses no risk.
- The conceptual model, based on drilling and hydraulic response testing, envisages that there will be a range of groundwater flow encountered from 85 to 170 m^3/d. The porosity of the bedrock in the proposed deepening zone is 10^{-6} m/d. This is very low. The surrounding area's groundwater flow continues as usual because the groundwater that enters the void is recharged back to the hydrological system at ground level. Groundwater that may have been flowing under the site to contribute to the surface water systems and their delivery of water to the downstream Lough Derravaragh SPA will continue to recharge the surface water systems by way of a Section 4 Discharge Licence.

- *Step 3:* Identify all potential water features that are susceptible to flow impacts:
  - *Derravaragh GWB*
  - *Deerpark Stream*
  - *Yellow (Castlepollard)_030*
  - *Inny_070*
  - *Lough Derravaragh SPA*
  - *Lough Ree SAC (38km away, >1,000 km^2 catchment includes the proposed development site = highly unlikely).*
  - *Note: There is no hydrological link between the quarry and Lough Lene SAC & PWS. Therefore, there is no risk to Lough Lene.*

- *Step 4:* Apportion the likely flow impacts to the water features.
  - *None,*
    - *Overriding figure of significance is that the interception amount at the quarry represents 0.1 % of the Derravaragh groundwater body's water balance.*
    - *With respect to surface water, the sites Maximum end of life, worst case, dewatering volume of 0.002 m^3/s is an order of magnitude smaller than the 95%tile low flow condition at the mixing point on the downstream river where the Deerpark Stream meets the Yellow (Castlepollard)_030 River. These flow ratios ensure that the discharge will cause no change in the surface water's Status.*

- *Detailed hydrological survey, monitoring and evaluation have determined that there is hydraulic and hydrochemical assimilation capacity in the proposed receiving waters.*
- *The finding is that there will be no likely flow impact on any water receptors.*

- *Step 5:* Allow for the mitigating effects of any discharges to arrive at net flow impacts:
  - *The only mitigations proposed are the specification of a sump capacity to accommodate and hold back extreme storms and the specification and design of the settlement systems to ensure particle settlement and a site discharge rate less than the predevelopment greenfield runoff rate.*
  - *No net flow impacts are envisaged.*

- *Step 6:* Assess the significance of the net flow impacts.
  - *No net flow impacts = no significance.*

- *Step 7:* Define the search area for drawdown impacts.
  - Area of 600 m radius assessed by door to door well survey and catchment walk over.
  - With respect to the final development impact and calculated radii of influence R_0, the impact will extend as follows:
    R_0 = 30 m from edge of the proposed excavation area
    R_0 = 143 m from centre the proposed excavation area
  - The potential radius of influence upon completion of works is illustrated in Figure 7.11. There are no active groundwater receptors that may be at risk of impact from groundwater drawdown within 30 m of the centre of the proposed excavation area.
  - In theory, the marshy pond to the east is within the area of influence. However, site surveying suggests that the surface water level in the marshy pond is above water levels in the bored holes in the quarry area. This suggests that the marshy pond water is separated from groundwater by underlying impermeable peats. Water level in the marshy pond is controlled by an artificial drainage outlet and were it not for this structure pond water level would likely continue to accumulate to higher levels. The low permeability subsoil barrier between the marshy pond and the active quarried area restricts hydraulic connectivity. Therefore, the marshy pond is not, in fact, within the radius of potential future dewatering at the site.

- *Step 8:* Identify all features in the search area that could be impacted by drawdown.
  - *None. The radius of influence of 30 m from the edge of the site suggests that there is no feature that could be impacted.*
  - *The discharge of waters from the site, under the required Section 4 Discharge Licence, will enable no net loss and a controlled discharge of waters arising at the site to the local surface water network.*

- *Step 9:* For all these features, predict the likely drawdown impacts.

  - *None predicted.*

- *Step 10:* Allow for the effects of measures taken to mitigate the drawdown impacts.
  - *Not relevant.*

- *Step 11:* Assess the significance of the net drawdown impacts.
  - *Not applicable.*

- *Step 12:* Assess the water quality impacts.
  - *Surface water assimilation capacity simulations have been completed to design ELVs that will result in no significant change in resultant concentrations, compliance with the Surface Water Regulations and assist in the achievement of Good Status.*
  - *Additional calculations have been completed with respect to explosive residues and no water quality impact is predicted.*
  - *Laboratory analysis of the receiving waters and potential discharge water supports the contention that there has been no impact on either surface or groundwater quality over the past lifespan of the quarry. Management measures are proposed for future environmental protection*.

- *Step 13:* If necessary, redesign the mitigation measures to minimise the impacts.
  - *Not necessary.*

- *Step 14:* Develop a monitoring strategy.
  - *Refer to Section 7.17 for the Monitoring Programme proposed.*

7.17 MONITORING

The Monitoring Programme propose will include Groundwater at the site and the Discharge Quality. Proposed Monitoring Locations are presented in Figure 7.15.

7.17.1 GROUNDWATER

PW2 and MW1 can be retained as Monitoring Points. No excavation is planned in any of those areas.

Groundwater Monitoring is suggested to have a seasonal frequency and therefore, quarterly Groundwater Monitoring is usually proposed.

Groundwater monitoring parameters of relevance are specified in Schedule 5 of the Groundwater Regulations (2010, as amended). The parameters of specific relevance to Quarry Assessments and the Groundwater Regulation Threshold Value (TV) ranges, could be specified so that the groundwaters at the site must comply with the Threshold Values, as follows:

- Electrical Conductivity — TV = 1875 ug/l @ 25℃
- Chloride — TV = 187.5 mg/l Cl

- Sulphate TV = 187.5 mg/l SO_4
- Nitrate TV = 37.5 mg/l NO_3
- Nitrite TV = 375 ug/l NO_2
- Ammonium N TV = 175 ug/l N
- Total Petroleum Hydrocarbons TV = 7.5 ug/l

7.17.2 SURFACE WATER DISCHARGE:

Quarterly Monitoring of the discharge waters is proposed for the parameters and suggested appropriate ELVs, as follows:

- Maximum Daily Discharge ELV = 0.002 m^3/s (170 m^3/d),

  which is the maximum calculated rainfall runoff and groundwater component for the final phase of the proposed development. The line to the settlement tanks will be fitted with a flow meter.
- 6–9 pH
- Ambient Temperature 10^{o}C
- < 4 mg/l BOD
- < 10 mg/l SS
- < 0.065 mg/l Ammonium N as NH_4 N

  i.e., limit ammonia to the Good Status Mean Concentration will result in 'High' Status Mean resultant concentration & compliance.
- < 0.02 mg/l MRP-P
- < 10 ug/l DRO

Monitoring results should be reported to Westmeath County Council in an Annual Environmental Report. Accidents or unusual results should be reported to Westmeath County Council.

7.18 DISCUSSION

The site is not hydrologically connected to Lough Lene SAC & PWS. Therefore, no potential for impact exists. The site is upgradient of Lough Derravaragh SPA and proposals for the site account for the requirement to limit the release of sediment from the site. In that regard, published catchment information and site investigation results were employed to ultimately define appropriate Emission Limit Values for the site's discharge in order to result in no change in the receiving water's hydrochemical quality, assist efforts to improve the water's status to the required WFD Good Status and ensure full compliance with the Surface Water Regulations.

Based on the final determinations of annual rainfall, evapotranspiration and runoff information, the combined total of **runoff and shallow subsurface flow** that needs to be managed by the site is 11,372 m^3/yr, **equivalent to 31 m^3/d (0.0004 l/s), on average**.

In addition to the rainfall runoff component, two distinct methods for estimating groundwater inflows to the site as extraction nears completion were applied. Groundwater inflow empirical formula, based on drawdown and bedrock hydraulic conductivity, suggests an end of life groundwater inflow value of **54 m^3/d.** However, application of an adapted methodology similar to the GSI's ZOC concept, which is based on recharge to the Lm aquifer at site and in the area upgradient of the site, suggests daily groundwater flow of **139 m^3/d** at the end of the proposed development. The higher value was adopted and the addition of **rainfall runoff and groundwater inflow suggests a future maximum discharge volume of 170 m^3/d (0.002 m^3/s).**

These values are intended to be representative of maximum discharge rates that are only likely to be realised close to completion of rock extraction operations. Interim discharge rates will respond to the phasing scheme. The phased development will involve the development of the upper quarry benches to the southeast i.e. dry working. Development of the bench below the current quarry floor to 70m OD will not take place until the latter part of the expected 20-year life of the quarry.

With respect to extreme rainfall events, calculations suggest that for the Depth Duration storm rainfall amounts for the site, as supplied by Met Eireann, a future-proof sump capacity of **4,454 m^3** is required for the proposed working floor of the site. That volumetric capacity includes a +20% factor for changes associated with Climate Change. These are the waters that will be retained on site in an extreme weather scenario.

When the volume of water collected in the floor's sump is greater than **4,454 m^3**, which is the stormwater capacity of the sump, it will be pumped to the site's constructed settlement tank, which are proposed for the northwestern corner of the site. The sump therefore has a large retention time capacity for the average daily operational scenario at the site.

The pre-development greenfield runoff rate during extreme rainfall events for the extraction area is calculated as **0.02 m^3/s**. The maximum pumping rate from the sump to the settlement tank will be limited to **Q_{BAR} (0.011 m^3/s)**, this being less than the pre-development greenfield runoff rate.

The required minimum settlement tank dimensions were calculated and a surface area of **83 m^2 with a minimum of 1 m depth** will settle all particles of greater diameter than 0.015 mm.

A hydrocarbon interceptor shall precede the settlement tank. It is preferable to have the interceptor located before the tank in order to protect the infrastructure from being contaminated, in the unlikely event of a hydrocarbon spill, as well as protecting the receiving environment.

The maximum possible future dewatering volume of 170 m^3/d or 0.002 m^3/s was employed to evaluate the ability of the receiving waters to accept and assimilate the site's discharge from a hydraulic and hydrochemical perspective. The receiving water can accommodate the future discharge. No risk of flooding is predicted in the site-specific model developed for the site. The hydraulic capacity model for the receiving stream was built using surveyed cross sections for this project. Application of DoEHLG (2011) Guidance for the Assessment for Discharges to Surface Waters suggests that the discharge is justified and defensible. ELVs are proposed in this assessment. A Monitoring Programme is proposed for both Surface Water and Groundwater.

There is an established drain at the northwestern corner of the site and this is how the landscape is naturally drained. Subject to the granting of a discharge license pumped waters from the active quarry shall also leave the site at this point, having passed through a settlement tank, preceded by a hydrocarbon interceptor. Therefore, the quarry has been designed to maintain the current natural site and local area discharge mechanism.

As the current quarry floor has not intersected groundwater there has been no previous dewatering at the site. The project's hydrogeologists suggest that the published information on the hardness and tightness of the rock at the site (Meehan et al., 2019) and the measured hydraulic conductivities in the order of 10^{-7} m^3/s (similar to the permeability of natural CLAY liners), suggest that the Water Table concept is not necessarily appropriate to the site. No significant water strikes were encountered. Any groundwater strikes encountered were below the proposed 70 m OD elevation of the future floor base of the excavation. Therefore, the water level elevations currently observed in the 80m OD range represent the hydrostatic pressure in the water strike 60m OD range. Although the site is mapped as Locally Important – karstified, there are no karst features at the site.

Using empirical formulae and the measured hydraulic characteristics of the underlying bedrock and groundwater, the Radius of Influence calculated for the site is 30m from the edge of the proposed excavation area and 143m from the centre the proposed extraction area.

There are no private wells within 600m of centre of the site. There are no PWS sources and no GWS sources.

All potential impacts have been assessed—the potential impact of blasting has been quantitively assessed, as has the potential impact of dewatering on the underlying aquifer and groundwater body. Mitigation measures have been specified. Residual impacts have been clearly outlined, and none are envisaged.

There are no Water Environment impediments to the proposed further development of the quarry at Deerpark, Castlepollard, Co Westmeath, which will include one further bench below the current floor level of 88m OD to a future proposed floor elevation of 70m OD.

7.19 CONCLUSIONS

With respect to the usual primary question of note:

> ***Will continuation of quarrying and deepening of the quarry present any risk of an adverse effect on groundwater flow, local groundwater wells or the downstream regional receptors?***

The overall conclusion of this Water Section is that there is ***no potential for impact***.

This conclusion is supported by the following:

a) Groundwater Body and Total Aquifer water balance calculations suggests a < 0.1% value, which places the site in the 'insignificant' and 'unlikely to pose risk' categories using WFD hydrogeological Assessment methodologies—Guidance on the Assessment of the Impact of Groundwater Abstractions) (WFD 2004);

b) Water quality monitoring presents a high-quality water arising on the floor;

c) Drilling experience and hydraulic conductivity results: These suggest a solid competent bedrock in the application zone and low primary porosity. For the purposes of conservative evaluation, assimilation capacity simulations have been conducted for the maximum envisaged future volume of 170 m^3/d, which is justifiable in terms of Regulatory compliance.

d) Flow Modelling and Flood Assessments suggest that the surface waters surrounding the site can accommodate the maximum envisaged discharge in addition to extreme flow events, including a factor for Climate Change.

The finding of no potential for impact is a confident assertion because no significant net loss of water is envisaged. Waters arising in the sump are recirculated, after treatment by settlement for suspended solids, to the natural systems. Only a minor amount is used in dust suppression.

No potential for significant drawdown nor potential for impact on local wells is predicted. No PWS nor GWS abstractions within the radius of influence of the quarry have been identified. No other quarry nor other developments are within a significant distance to affect a cumulative impact.

It is concluded that all risks are mitigated and that the proposed development shall have no impact on receiving waters and designated sites, if mitigating measures are implemented.

Hydro-G and Envirologic support this evaluation by virtue of the following works:

- Desk study & consideration of previous assessments and comments by competent authorities.
- On-site evaluation, by bedrock drilling and hydraulic conductivity response testing, of the characteristic of the bedrock.
- Supporting information from Apex Geophysics.
- On-site evaluation of the walls and floor of the excavation.

- The development of a confident Conceptual Groundwater Site and Regional Flow Model.
- Local catchment area survey and channel surveying for carrying capacity and Flood Risk Assessment.
- Water quality data.
- Assimilation capacity simulation results for the resultant groundwater concentrations for the discharge at the site.
- Settlement systems and proposed ELVs for the discharge so as to ensure no change in the proposed receiving water's quality (namely the Yellow (Castlepollard_030, to the west of the site).
- Natural setting suggests that the quarry and the discharge point's surface water catchment is 1%, approximately, of the >1,000 km^2 surface water catchment of the closest hydrologically connected downstream SAC, which is Lough Ree close to Ballymahon, 35km, approximately, from the site, in the neighbouring County Longford. No impact is possible at this ratio, distance and the magnitude of the land mass in between the site and the designated SAC receptor.
- Discharge is proposed to the surface water systems to the northwest of the site. This surface water system will be protected by the Quarry Management Plan and the Conditions of the Discharge Licence.

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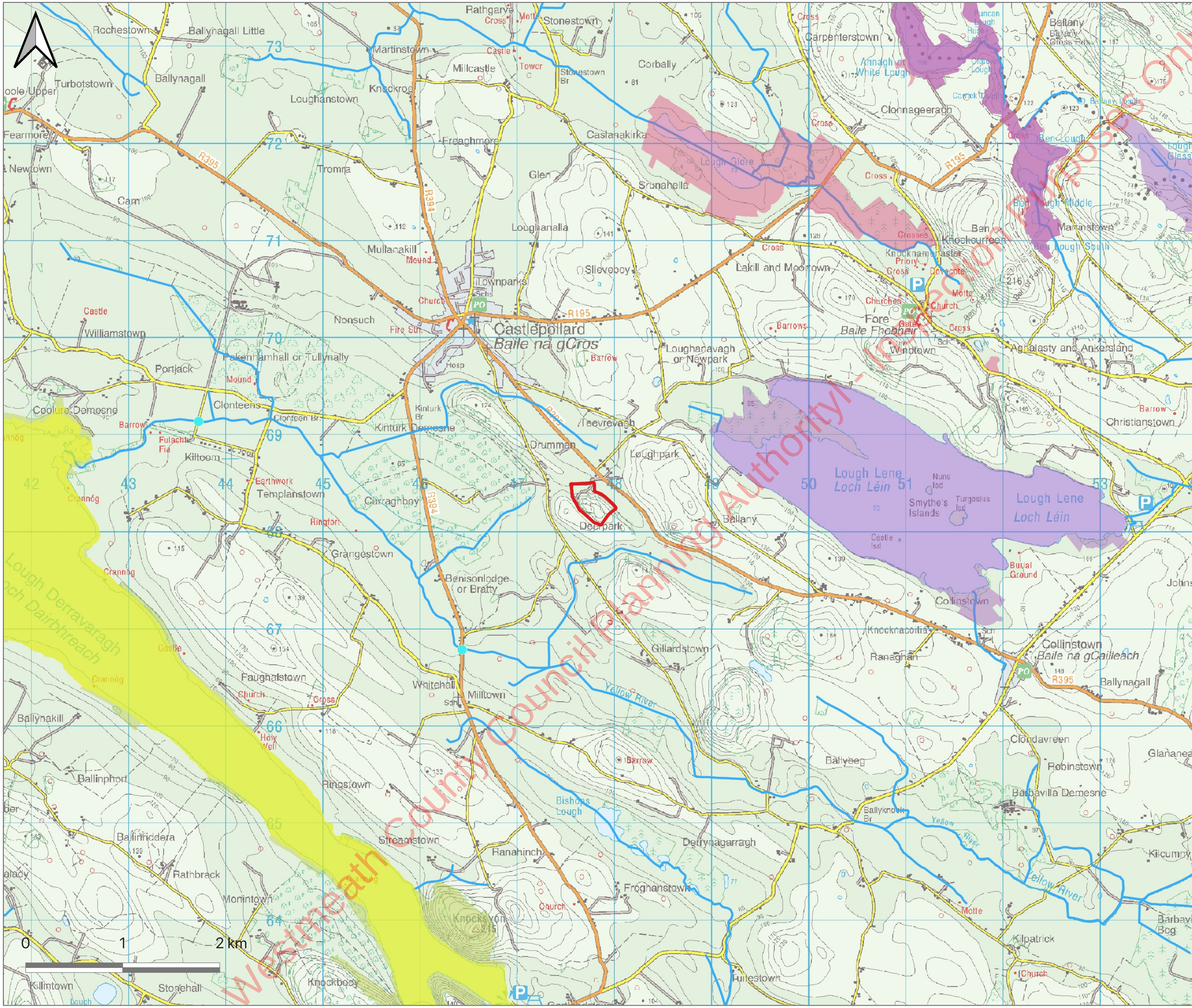
7.21 FIGURES

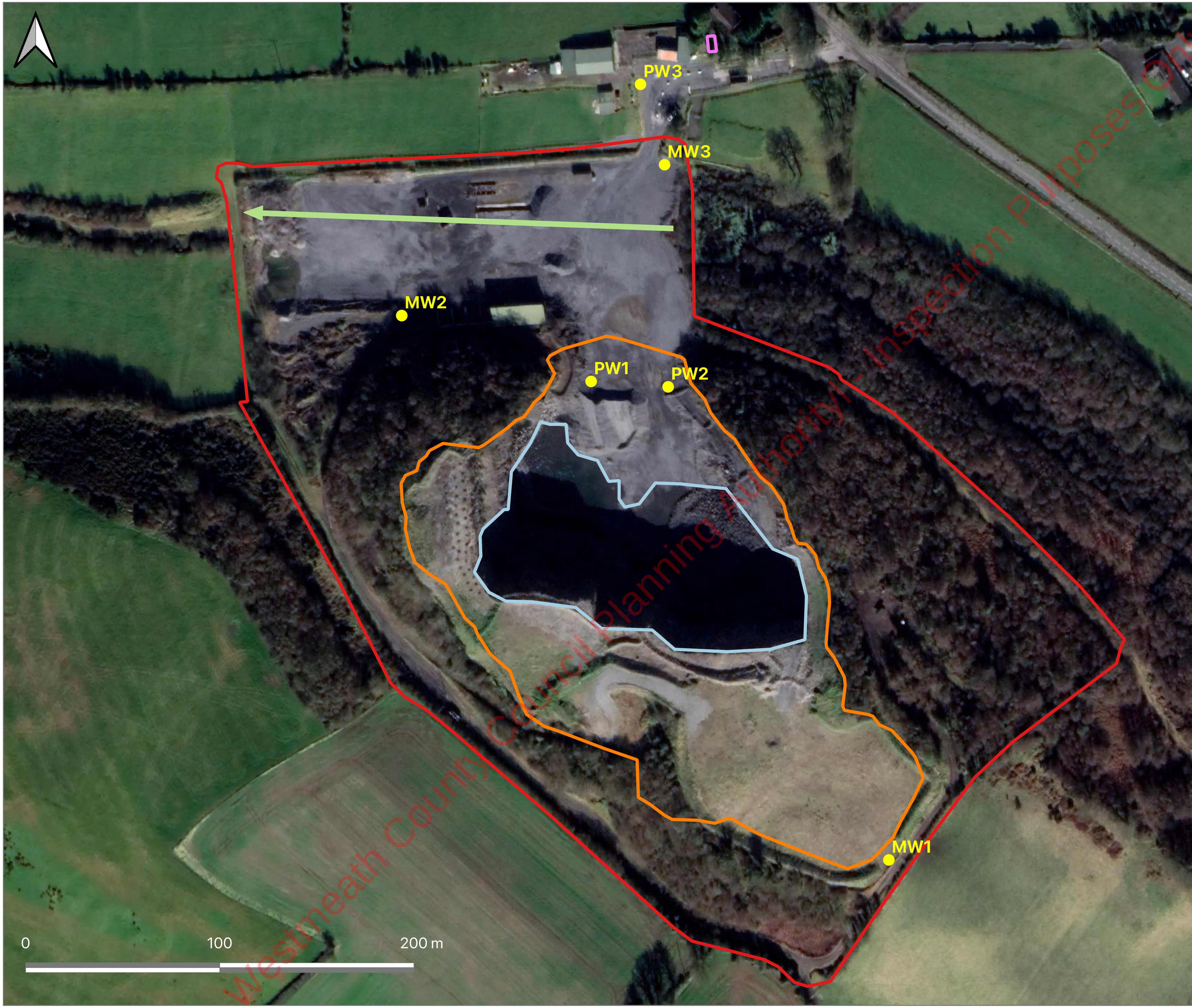


Legend:

- Site Boundary
- EPA River Network
- Q Rating Stations
- SAC
- SPA
- NHA
- pNHA

Figure 7.1:	Site Location
Date:	November 2021
Project:	21-P15/1968
Author:	COR
Scale:	1: 50,000 @ A4
Client:	Lagan
Project:	EIAR Chapter: Water
Location:	Deerpark, Castlepollard, Co. Westmeath

Hydro-G

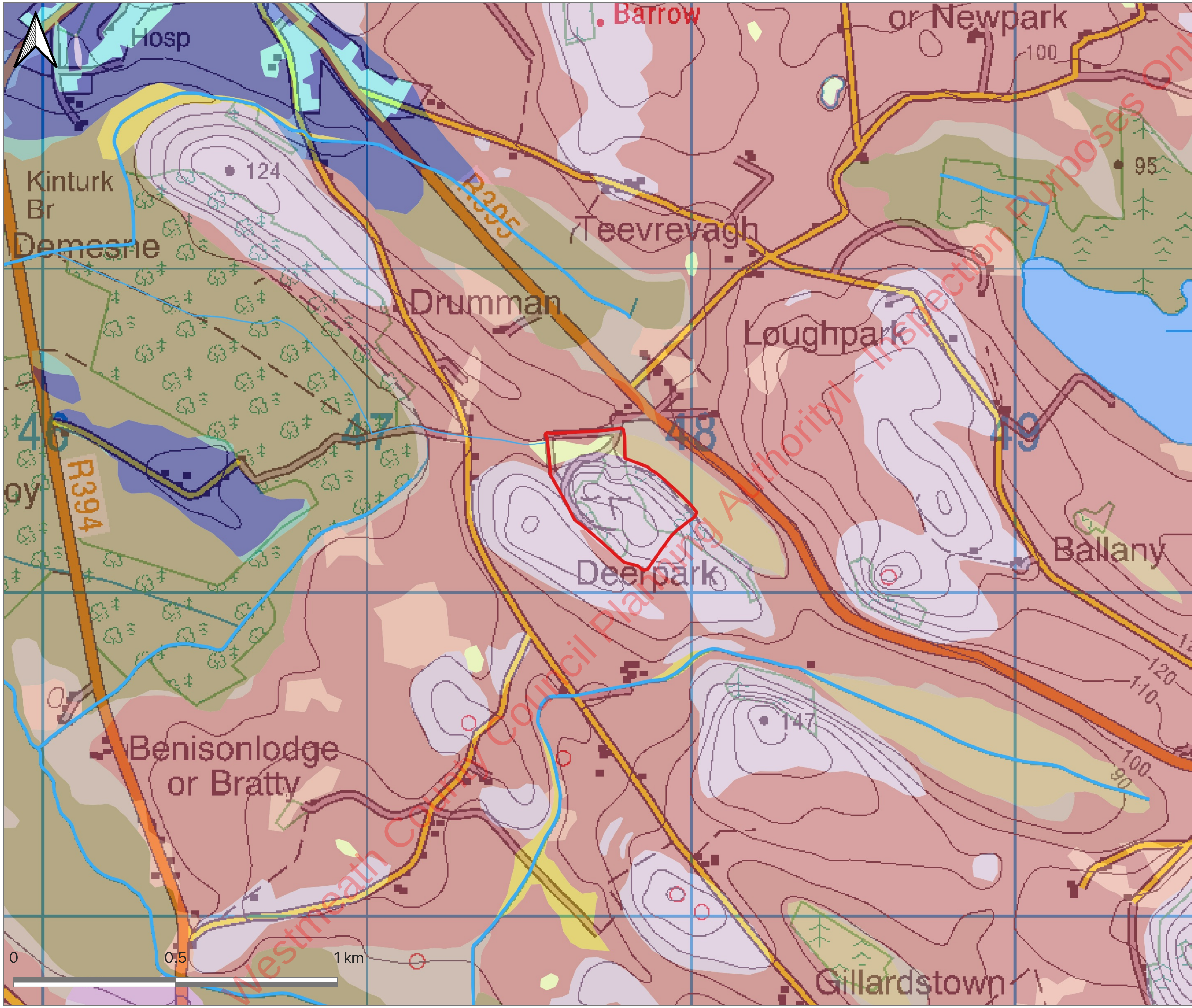


Legend:

- Site Boundary
- Extraction Area, c. 4 ha
- Current Quarry Floor
- Groundwater Wells
- Biocycle & Percolation Area
- 300 mm Culvert

Figure 7.2:	Site Layout
Date:	November 2021
Project:	21-P15/1968
Author:	COR
Scale:	1: 2,500 @ A4
Client:	Lagan
Project:	EIAR Chapter: Water
Location:	Deerpark, Castlepollard, Co. Westmeath

Hydro-G



Legend:

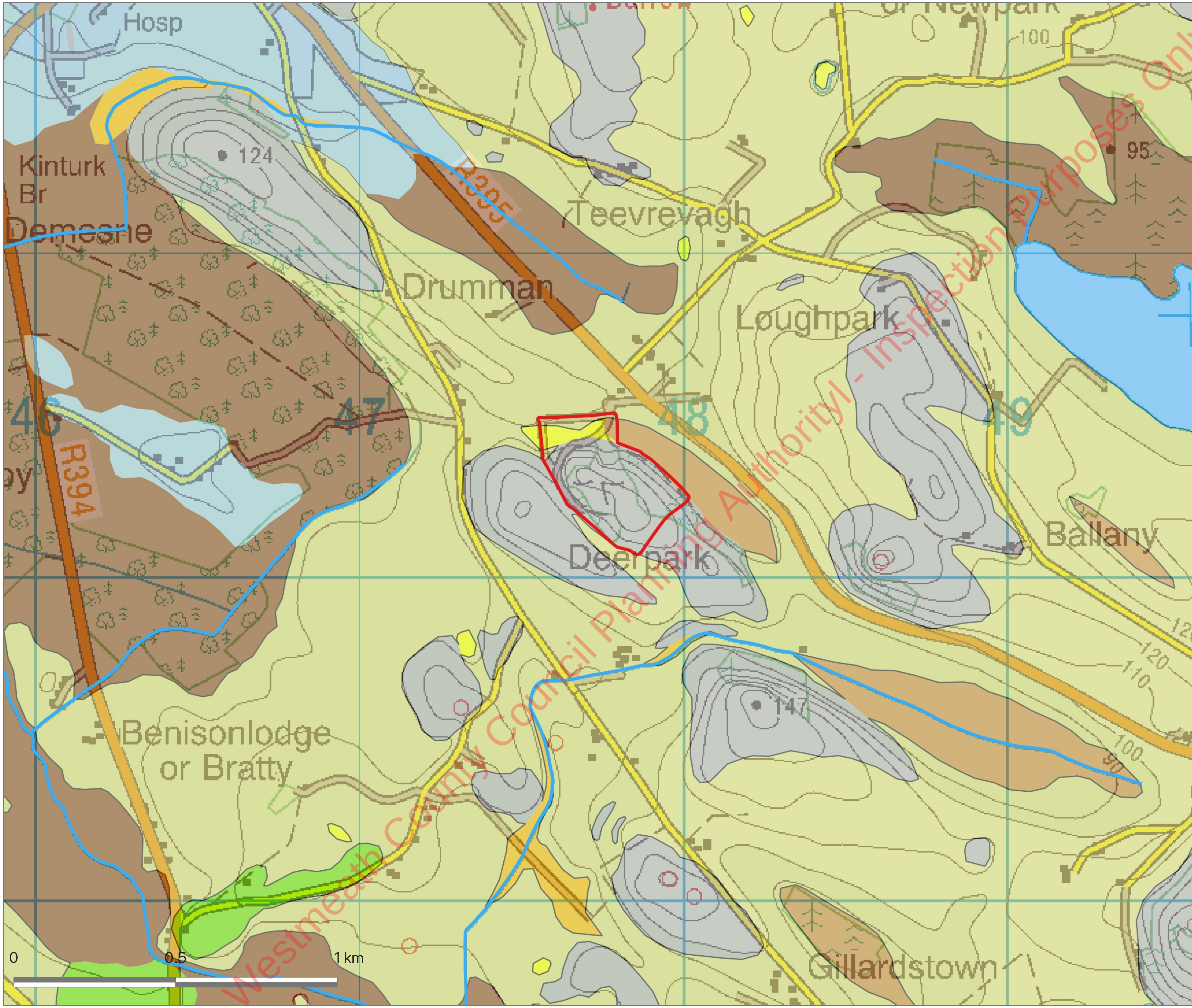
Site Boundary

Soils

- Alluvium (mineral)
- Deep, well-drained, acidic
- Deep, poorly-drained, acidic
- Peaty,poorly-drained, acidic
- Deep, well-drained, basic
- Deep, poorly-drained, basic
- Peaty, poorly drained, basic
- BminSRPT
- Shallow, well-drained, acidic
- Cut peat
- Fen Peat
- Lacustrine
- Made Ground
- Water

Figure 7.3:	General Soils Classification
Date:	November 2021
Project:	21-P30/1968
Author:	COR
Scale:	1: 15,000
Client:	Lagan
Project:	EIAR Chapter: Water
Location:	Deerpark, Castlepollard, Co. Westmeath

Hydro-G



Legend:

Site Boundary

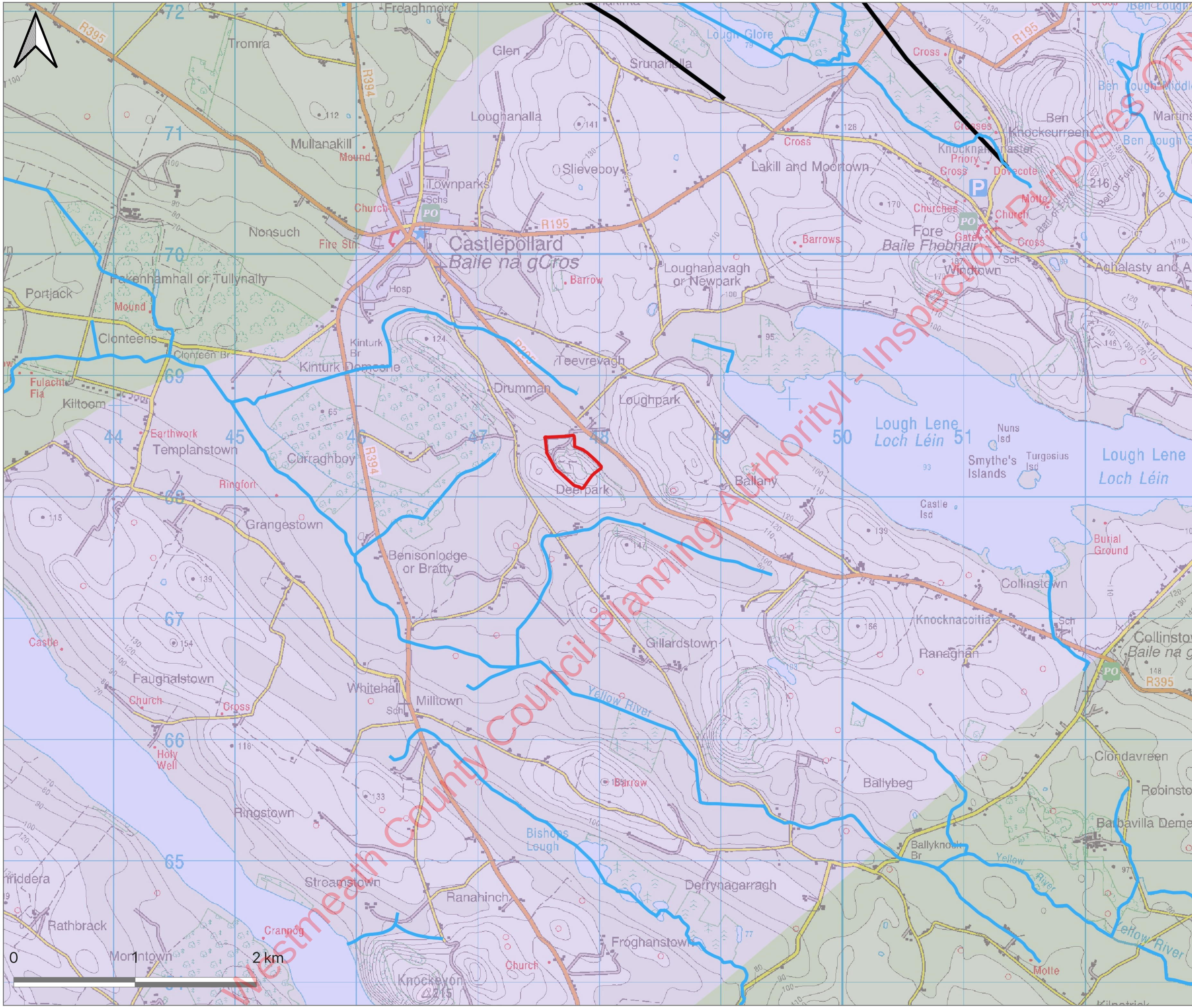
EPA River Network

Quaternary Sediments

- Alluvium
- Bedrock outcrop
- Cut over raised peat
- Fen Peat
- Limestone Gravels
- Lacustrine sediments
- Limestone till
- Water

Figure 7.4:	Quaternary Deposits
Date:	November 2021
Project:	21-P30/1968
Author:	COR
Scale:	1: 15,000
Client:	Lagan
Project:	EIAR Chapter: Water
Location:	Deerpark, Castlepollard, Co. Westmeath

Hydro-G



Legend:

Site Boundary

EPA River Network

Structural Faulting

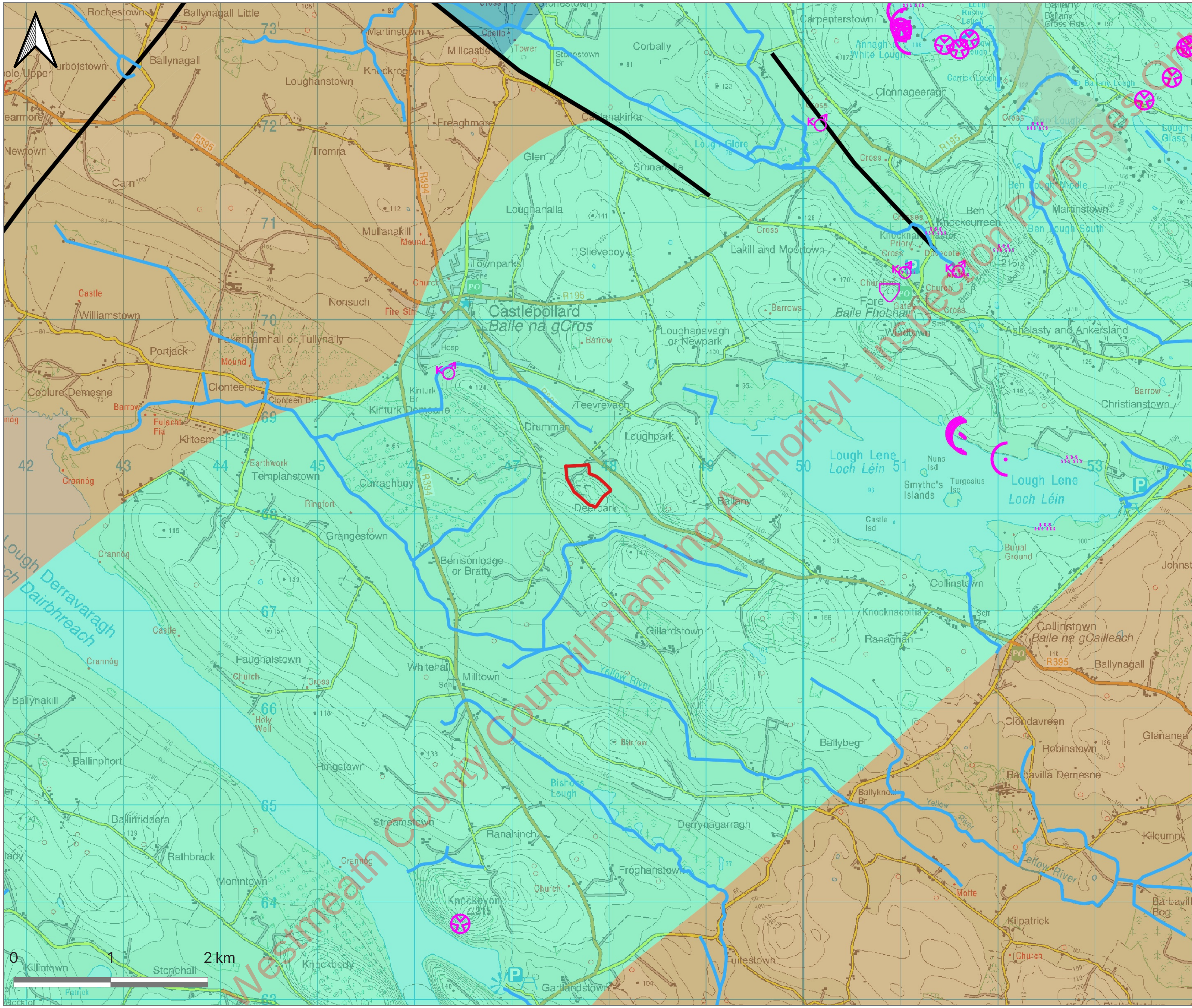
Bedrock Units

Derravaragh Cherts

Lucan Formation

Figure 7.5:	Bedrock Geology
Date:	November 2021
Project:	21-P30/1968
Author:	COR
Scale:	1: 40,000
Client:	Lagan
Project:	EIAR Chapter: Water
Location:	Deerpark, Castlepollard, Co. Westmeath

Hydro-G



Legend:

- Site Boundary
- EPA River Network

Bedrock Aquifer

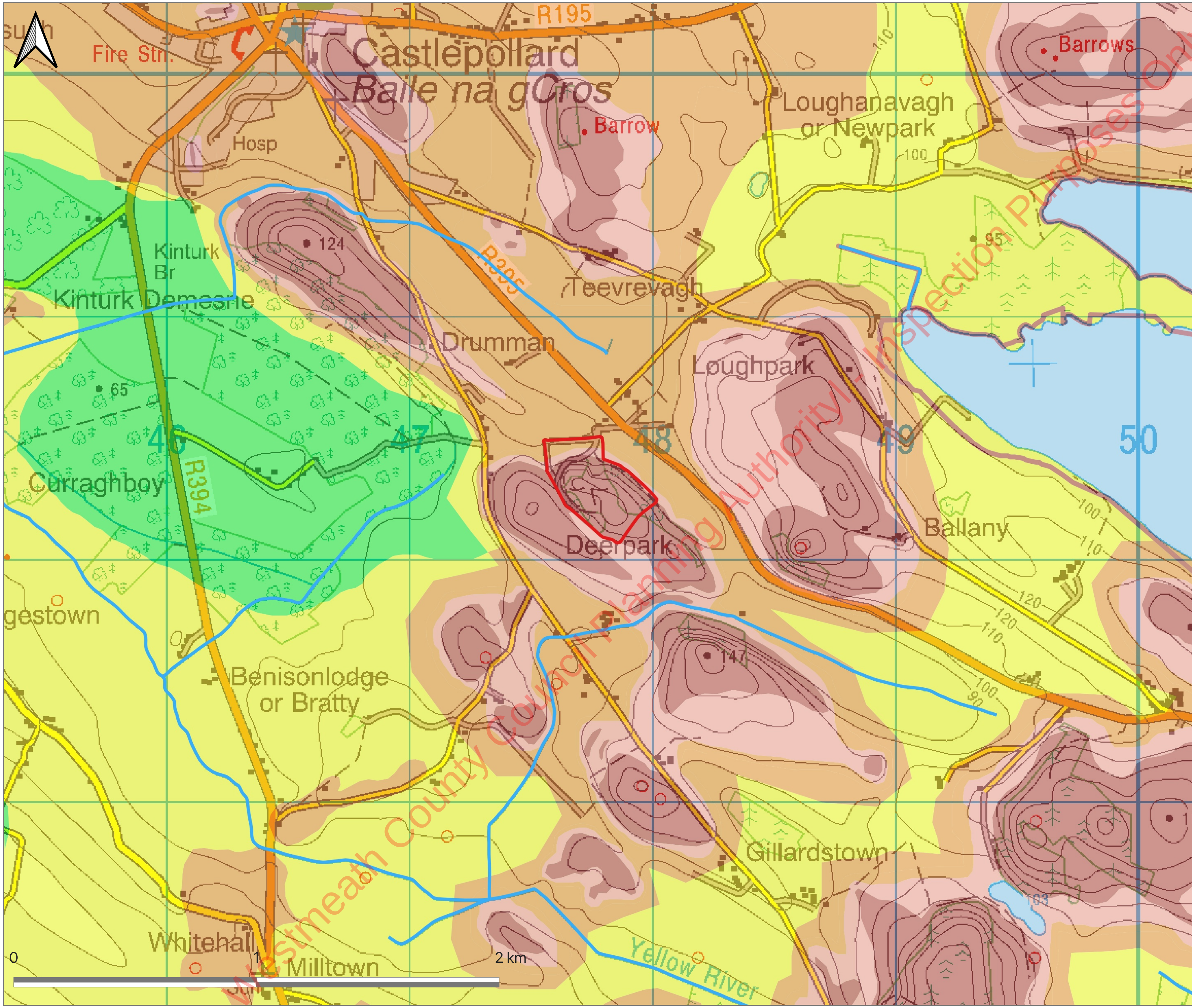
- Lk
- Ll
- Rkd
- Structural Faulting

Karst

- Cave
- Enclosed Depression
- Spring
- Superficial Solution Features
- Swallow Hole

Figure 7.6:	Bedrock Aquifer & Karst
Date:	November 2021
Project:	21-P30/1968
Author:	COR
Scale:	1: 50,000
Client:	Lagan
Project:	EIAR Chapter: Water
Location:	Deerpark, Castlepollard, Co. Westmeath

Hydro-G



Legend:

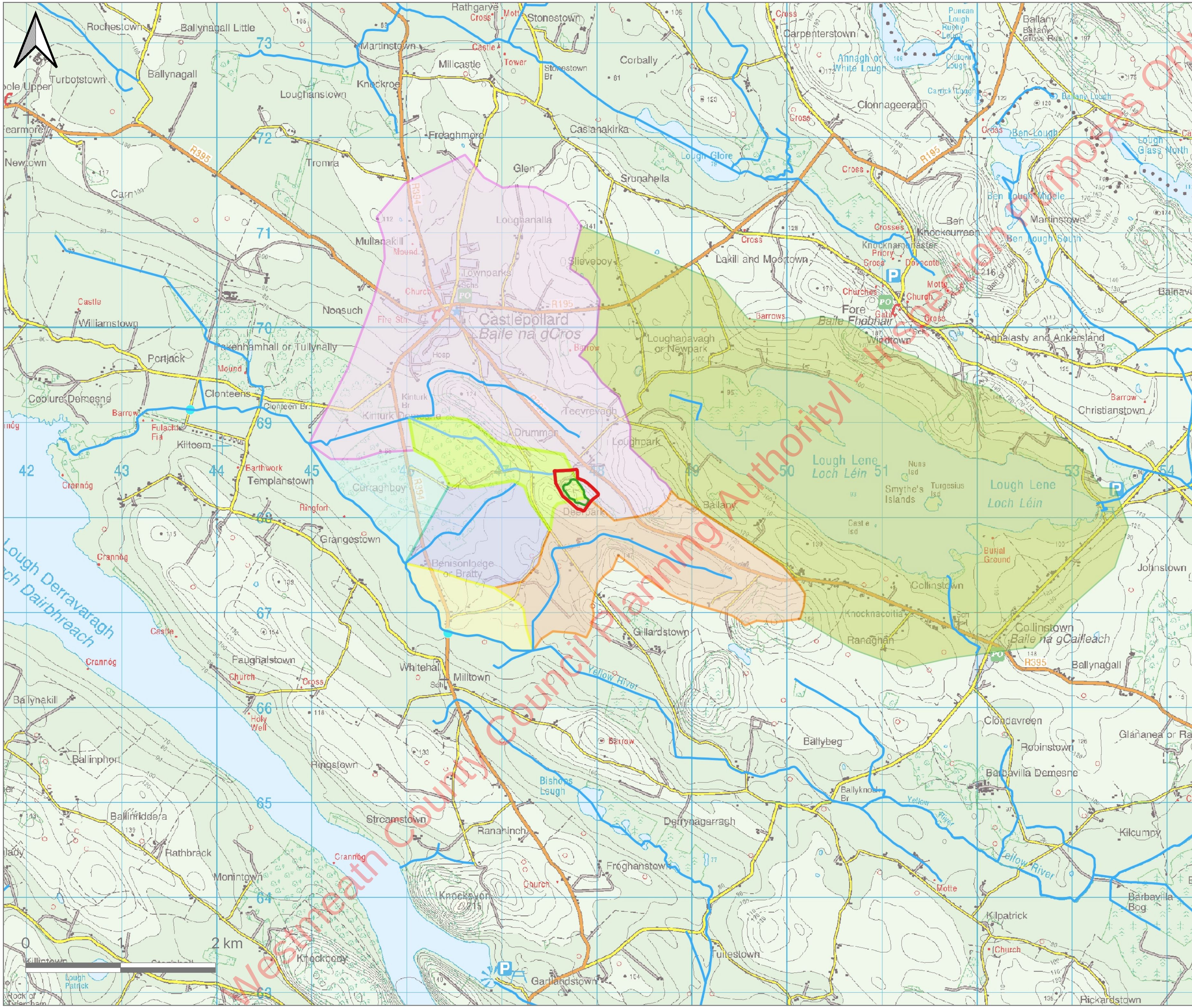
- Site Boundary
- EPA River Network

Vulnerability

- Extreme (X)
- Extreme (E)
- High (H)
- Low (L)
- Moderate (M)
- Water

Figure 7.7:	GW Vulnerability
Date:	November 2021
Project:	21-P30/1968
Author:	COR
Scale:	1: 20,000
Client:	Lagan
Project:	EIAR Chapter: Water
Location:	Deerpark, Castlepollard, Co. Westmeath

Hydro-G



Legend:

Site Boundary

Extraction Area,c.4ha

EPA River Network

Catchments

Yellow (Castlepollard) 26_3553

Castlepollard Stream 26C16

Yellow (Castlepollard) 26_2519

Yellow (Castlepollard) 26Y02

Yellow (Castlepollard) 26_13286

Figure 7.8: Catchments

Date:	November 2021
Project:	21-P30/1968
Author:	COR
Scale:	1: 50,000 @ A4
Client:	Lagan
Project:	EIAR Chapter: Water
Location:	Deerpark, Castlepollard, Co. Westmeath

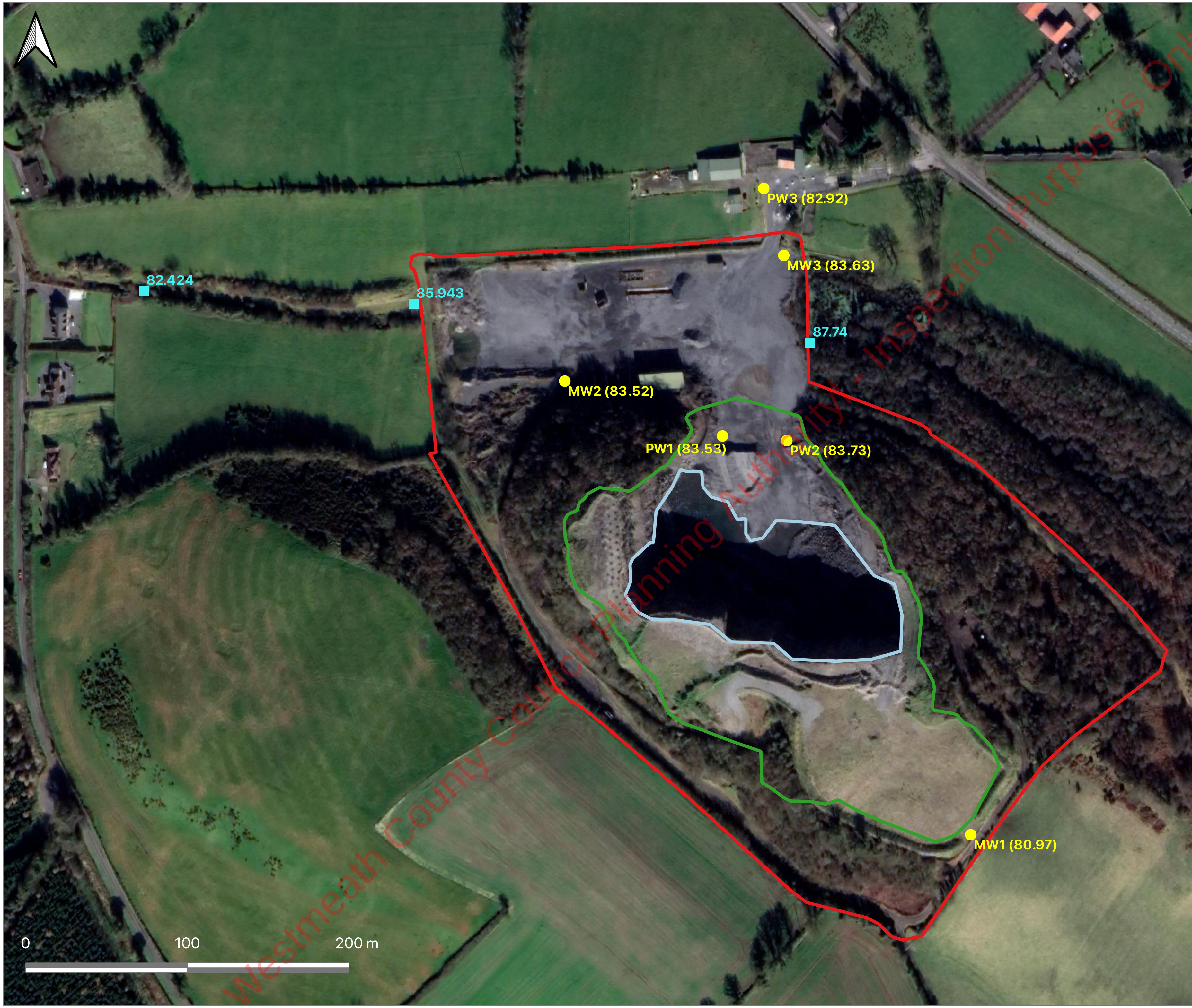
Hydro-G

Legend:

- Site Boundary
- EPA River Network
- Drainage Networks
- Current Quarry Floor
- 3rd Party Wells
- 600m radius from sump

Figure 7.9:	Third Party Well Survey
Date:	November 2021
Project:	21-P15/1968
Author:	COR
Scale:	1: 5,000 @ A4
Client:	Lagan
Project:	EIAR Chapter: Water
Location:	Deerpark, Castlepollard, Co. Westmeath

Hydro-G



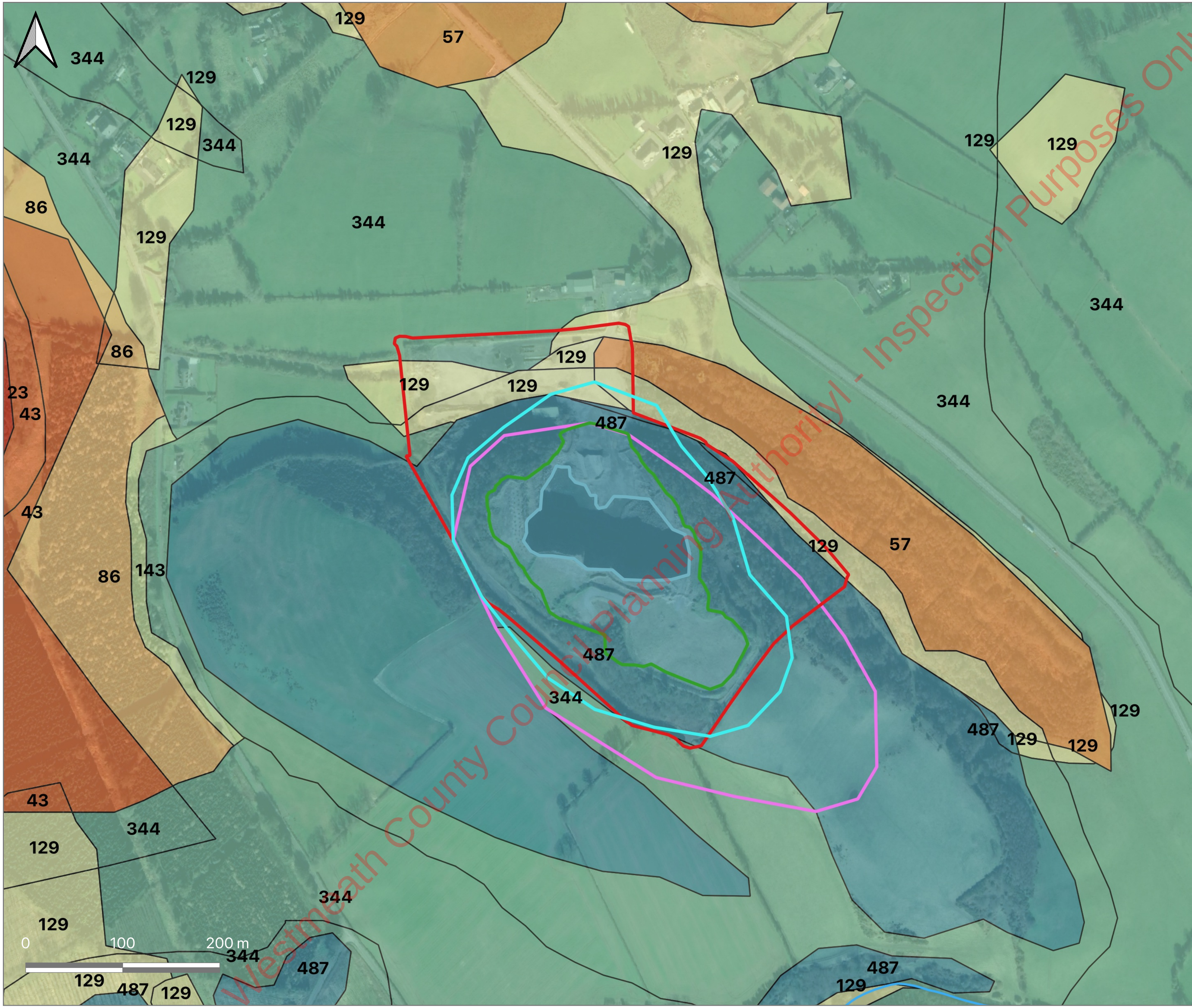
Legend:

- Site Boundary
- Current Quarry Floor
- Extraction Area,c.4ha
- Groundwater Level, mOD 29/09/21
- Surface Water Level, mOD 29/09/21

Figure 7.10: Water Levels

Date:	November 2021
Project:	21-P30/1968
Author:	COR
Scale:	1: 3,000 @ A4
Client:	Lagan
Project:	EIAR Chapter: Water
Location:	Deerpark, Castlepollard, Co. Westmeath

Hydro-G



Legend:

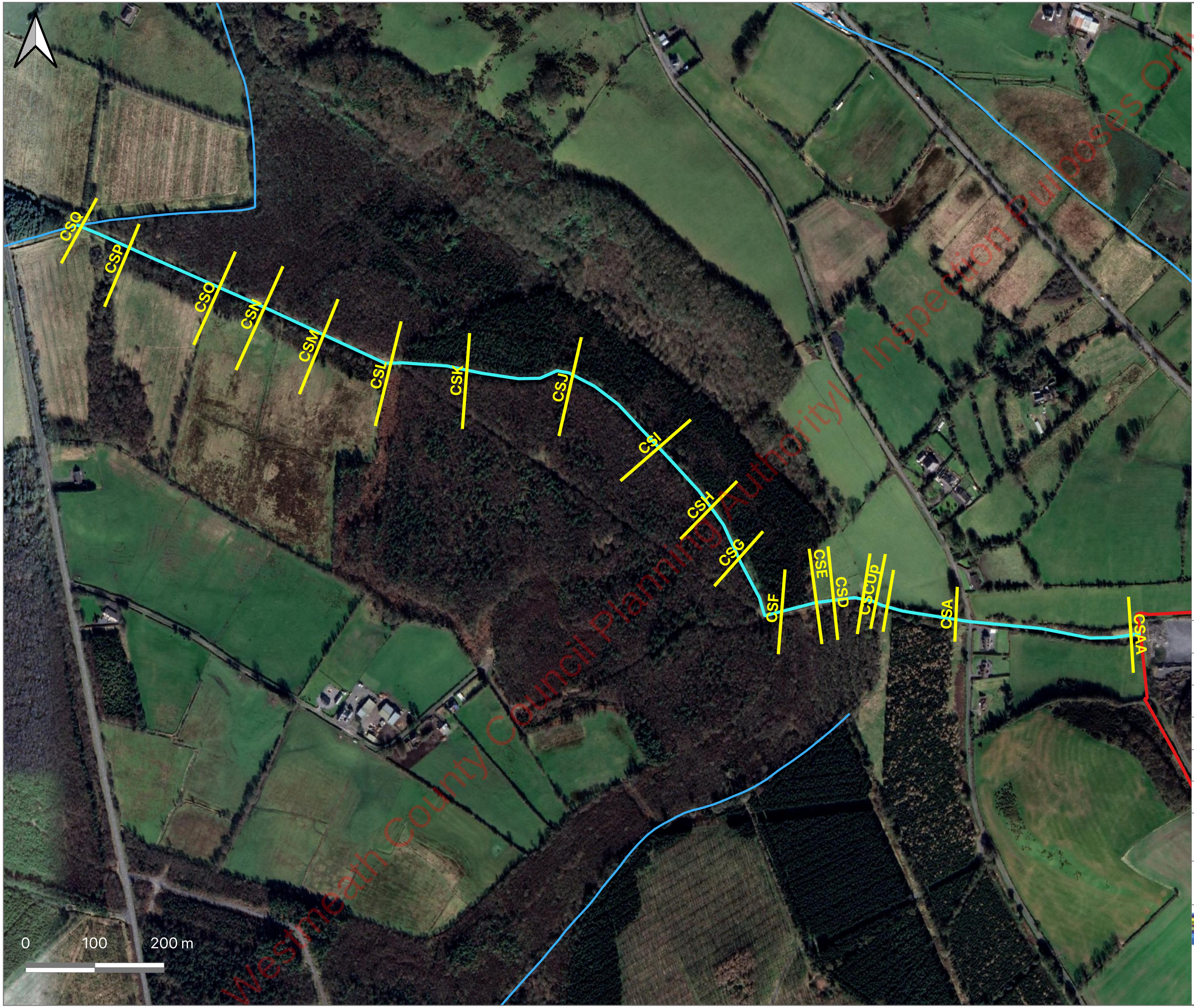
- Site Boundary
- Extraction Area,c.4ha
- ZOC
- Radius of Influence

Recharge Coefficient (%), Recharge Rate on Map (mm)

- 0
- 4
- 7.5
- 10
- 15
- 20
- 22.5
- 25
- 42.5
- 60
- 85

Figure 7.11:	Recharge & ZOC
Date:	October 2021
Project:	21-P30/1968
Author:	COR
Scale:	1: 5,000 @ A4
Client:	Lagan
Project:	EIAR Chapter: Water
Location:	Deerpark, Castlepollard, Co. Westmeath

Hydro-G



Legend:

- Site Boundary
- Extraction Area,c.4ha
- Current Quarry Floor
- EPA River Network
- Drainage Networks
- Cross Sections

Figure 7.12:	Hydrology Cross Sections
Date:	November 2021
Project:	21-P30/1968
Author:	COR
Scale:	1: 7,000 @ A4
Client:	Lagan
Project:	EIAR Chapter: Water
Location:	Deerpark, Castlepollard, Co. Westmeath

Hydro-G

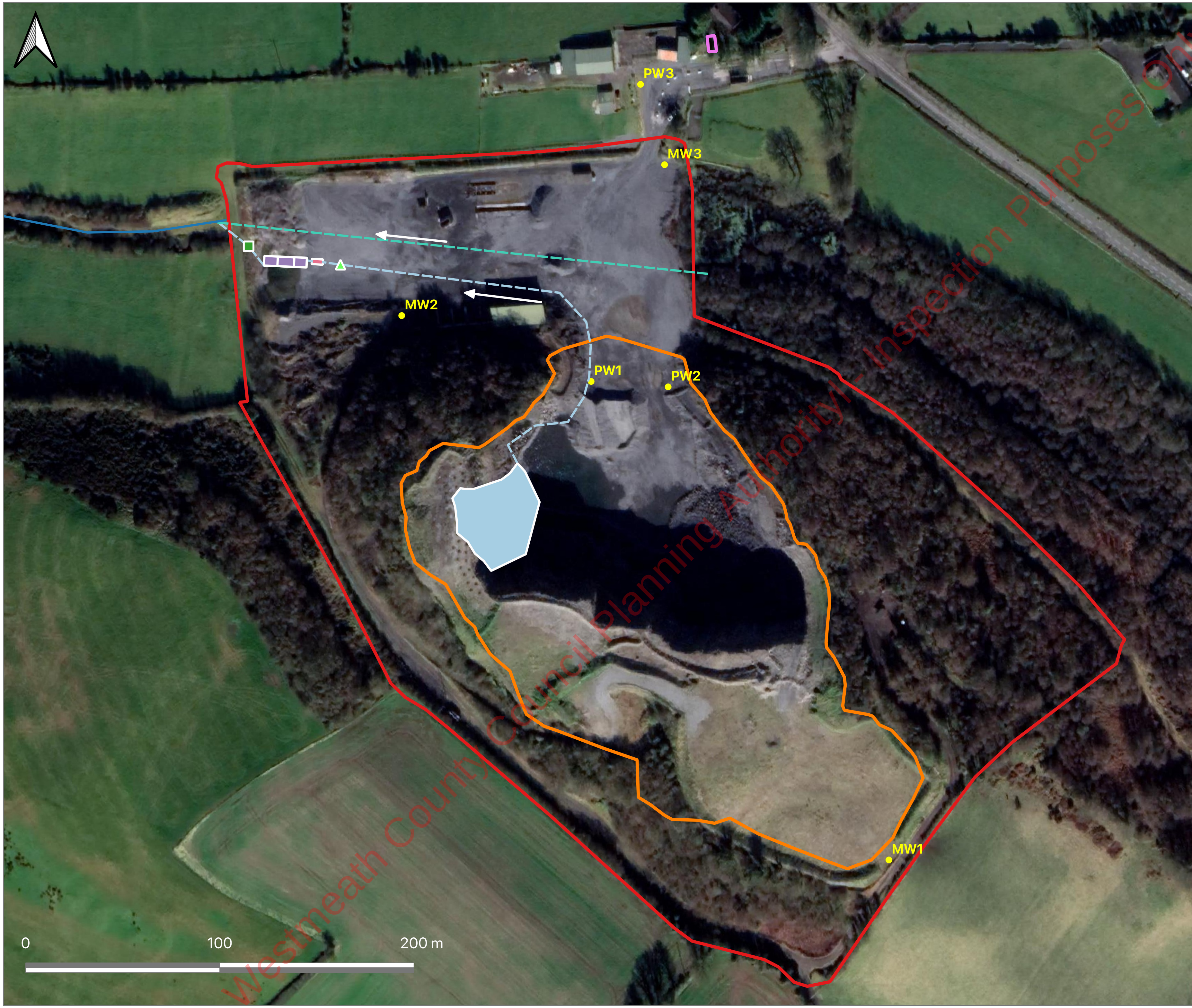
Legend:

- Site Boundary
- EPA River Network
- Drainage Networks
- SW Sampling Points
- Current Quarry Floor

Figure 7.13:SW Sampling Points

Date:	November 2021
Project:	21-P15/1968
Author:	COR
Scale:	1: 10,000 @ A4
Client:	Lagan
Project:	EIAR Chapter: Water
Location:	Deerpark, Castlepollard, Co. Westmeath

Hydro-G

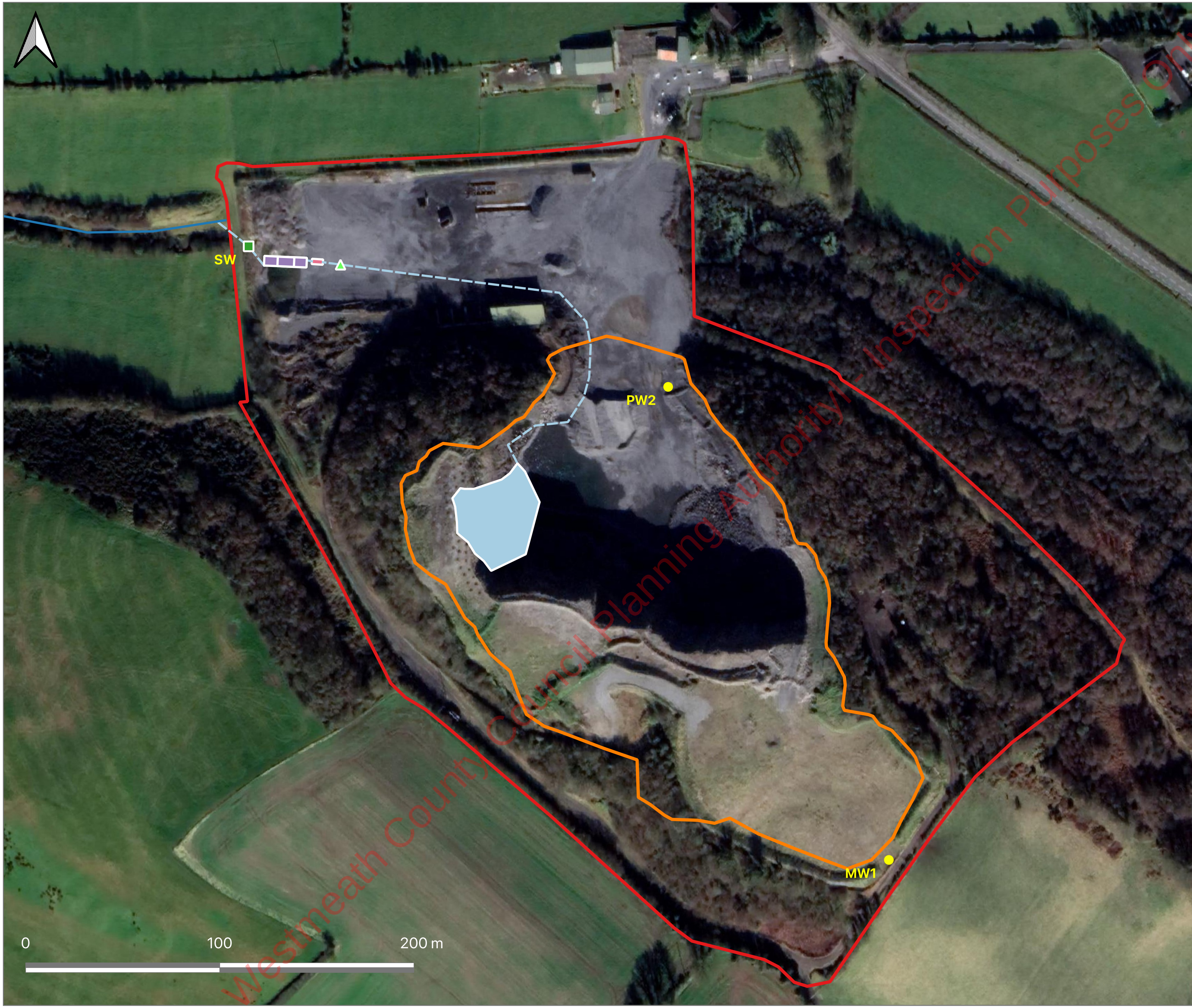


Legend:

- Site Boundary
- Extraction Area,c.4ha
- Local Drainage Network
- Marsh Area Overflow Culvert
- Sump Outflow
- Final Sump
- Discharge Flowmeter
- Hydrocarbon Interceptor
- Settlement Lagoons
- Discharge Water Quality Sampling Point
- Biocycle & Percolation Area
- Wells

Figure 7.14:	Schematic Water Management System
Date:	November 2021
Project:	21-P15/1968
Author:	COR
Scale:	1: 2,500 @ A4
Client:	Lagan
Project:	EIAR Chapter: Water
Location:	Deerpark, Castlepollard, Co. Westmeath

Hydro-G



Legend:
- Site Boundary
- Extraction Area,c.4ha
- EPA River Network
- Final Sump
- Sump Outflow
- Discharge Flowmeter
- Settlement Lagoons
- Hydrocarbon Interceptor
- Discharge Water Quality Sampling Manhole
- Proposed Monitoring Points

Figure 7.15:	Proposed Monitoring Points
Date:	November 2021
Project:	21-P15/1968
Author:	COR
Scale:	1: 2,500 @ A4
Client:	Lagan
Project:	EIAR Chapter: Water
Location:	Deerpark, Castlepollard, Co. Westmeath

Hydro-G