# APPENDIX 8-4

***ENVIROLOGIC HYDROGEOLOGICAL ASSESSMENT DUNBLANEY***

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# Hydrogeological Assessment & Flood Risk Assessment

| | |
|---|---|
| Location: | Dunblaney, Dunmore, Co. Galway |
| Prepared for: | Finnegan Sand Ltd. |
| Prepared by: | Colin O'Reilly PhD (Hydrology) |
| Date: | 12/09/20 |
| Reference no. | 1813B |

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# Introduction

### Planning Context

The following hydrogeological assessment and flood risk assessment has been prepared by Envirologic Ltd. on behalf of Williams Planning and Environmental Ltd.

This report is intended to satisfy the requirements of Galway Council, relating to a proposed development at Dunblaney, Dunmore, County Galway. The applicant is Finnegans Sand Ltd. and works will consist of:

- Extraction, processing and sale of sand and gravel followed by restoration/rehabilitation of the land to agricultural use by the replacement of soils.
- There will be no buildings or fixed plant and machinery.

### Objectives

Extraction of material will take place above the localised seasonal groundwater table. The anticipated life of the extraction process is expected to take 18 months with an additional 9 months required to progressively restore the area and provide workable agricultural grassland.

The aim of this report is to establish the following:

- Conduct a review to establish current baseline conditions relevant to the hydrological and hydrogeological environment within the site boundary, and the local surrounding environs;
- Assess the potential impacts to the hydrological and hydrogeological environment, which can be reasonably expected to occur as a result of the proposed development.

### Methodology

The initial evaluation consisted of inspections of the site and adjacent lands by examination of aerial photography and Ordnance Survey plans, following by site walkover survey. Relevant hydrogeological data from the Geological Survey of Ireland was reviewed together with additional data collated from data sources at Galway County Council, Environmental Protection Agency (EPA), National Parks and Wildlife Service (NPWS), Ordnance Survey of Ireland (OSI) and Met Éireann.

The report has been compiled primarily taking cognisance of:

- The Planning System and Flood Risk Management - Guidelines for Planning Authorities (OPW, 2009);
- Guidelines on the information to be contained in Environmental Impact Assessment Reports. Environmental Protection Agency (2017);
- Guidelines for Planning Authorities and An Bord Pleanála on carrying out Environmental Impact Assessment. Department by the Department of Housing, Planning and Local Government (August, 2018).

Initial site walkover was carried out in May 2019. Follow-up site investigation in March 2020 involved trial pitting to establish groundwater levels and potential groundwater flow patterns. Groundwater and surface water level monitoring was carried on each occasion to interpret summer and winter hydrogeological regimes. Additional site surveying was carried out in July 2020 to provide information relating to potential flood risk at the proposed site entrance.

## Existing Environment

### Site Location

The site is located in the townland of Dunblaney, approximately 6.8 km south of Dunmore and 9.1 km northeast of Tuam. For the purposes of this report the site will be described as consisting of two components: (i) the main body of the site (i.e. the proposed extraction area), and (ii) the proposed internal access road which connects the main body of the site with a local road to the south.



The proposed extraction area lies on the eastern side of a local access road. This local road is connected to the R328 (Clonbern to Dunmore Road) approximately 3.9 km northeast of the site, and the N83, 3.8 km to the northwest. The southern end of the internal access road connects to a local road which provides a connection with the applicant processing area.

Regional topography is characterised by undulating landscape features in the form of hummocks which reach 90 – 100 mOD and lower-lying depressions, some of which are topographically enclosed, at 70 – 80 mOD. At a local level the nearest peak of note is a small ridge 360 m to the north, which reaches 100 mOD and wraps around to the east and south of the site in a horseshoe-shape pattern. In contrast, lands to the west of the site are depressed, having elevations below 83 mOD. Lands to the south of the internal access road are also topographically depressed, having elevations below 75 mOD.

Land use in the area is generally low to moderate grassland agriculture. The entrance to the compound where processing of extracted material takes place is located 270 m west of the proposed site entrance. Housing density in the area is very low with no dwellings mapped within 750 m of the main site area.

### Site Layout

The application area is 2.18 hectares. Extraction will take place within the 1.6 hectare portion at the northern end of the application area. The proposed extraction area is irregular in shape with a length of 300 m perpendicular to the western road and width ranging between 10 and 90 m (Figure 2A).

Envirologic performed a topographical survey of the main body of the site in May 2019 using Trimble RTK VRS; Surfer software was used to generate a topographical contour map of this area, which is presented as Figure 2B. In general the land parcel within which the proposed extraction area is situated slopes from northeast (95.1 mOD) to southwest (81.8 mOD), however the site is very hummocky with a short southwest trending ridge in the centre reaching 92.1 mOD, just west of which is an enclosed depression which falls to 84.9 mOD. Lands continue to decline into depressed ground west of the site where elevations are below 82 mOD.

The site is to be accessed via an internal access road which connects to the local road to the south (Figure 2C). This access road is approximately 900 m in length and runs in a relatively direct north-south direction along existing field boundaries. Elevations on the local road to the south at the proposed site entrance are between 74.75 and 74.85 mOD.

## Soils & Geology

### Soils

With reference to Teagasc soil maps, the soils beneath the main site area are a shallow and well-drained mineral with an alkaline signature (Figure 3). The thin soils in the vicinity of the site are linked to the presence of glaciofluvial deposits whereas soils in the wider area tend to be thicker.

The depressed area to the west of the site is classified as fen peat. Peats are generally formed when previously submerged lake beds dry out, or where previously dry soils have degraded due to seasonal or more persistent waterlogging. Some isolated pockets of lacustrine sediment are present in the area.

In the main, soils along the internal access route are shallow and well-drained. Cutover peat is mapped on the southern side of the local road that the access road emerges onto.



### Subsoils

Figure 4 shows that a narrow, linear band of esker gravels have been laid down close to the main site area, extending from 5 km southwest of the site and terminating a short distance to the east. Flanking this narrow belt of esker gravels are glaciofluvial outwash sands and gravels, derived mainly from calcareous parent material, which fan out for a distance of approximately 1 km. The site is underlain by these gravels. Subsoils in the wider area are composed of a till derived from limestone.

The internal access road is underlain by the same deposit of gravels, and crosses the slightly raised esker ridge about midway between the extraction area and the access point.

### Bedrock & Structural Geology

Based on the Geological Survey of Ireland (GSI) database Figure 5 shows that bedrock material in the area is mapped as belonging to the Burren Formation, described as a pale grey skeletal limestone. This formation has been divided into 10 members with the topmost member characterised as Paleokarst limestone. Bedrock surface is often typified by a 2-3 m layer of weathered material, referred to as epikarst. A nearby fault line located 2.5 km north of the site separates the Burren Formation from the Croghan limestone formation. These formations are classified as Dinantian pure bedded limestones.

## Hydrogeology

### Aquifer Classification

The Burren Formation is classified as a regionally important karstified aquifer (Rkd). Due to the massive, competent and infrequently fractured nature of Waulsortian Limestones, groundwater flow predominantly occurs through conduits and large cavities which are formed by solution weathering and abrasion of the sediments carried with groundwater movement through the formation. This bedrock aquifer unit is capable of supplying very high yielding groundwater sources.

There is a relatively high density of enclosed depressions mapped in the area, with two of these being indicated within the land parcel within which the proposed extraction area lies, though outside the application boundary. Another enclosed topographical depression is mapped adjacent to the access route. Given the hummocky nature of sand and gravel deposits in the vicinity it is assumed that these enclosed depressions are simply topographical features arising from glacial deposition (kame and kettle), as opposed to karst features which are caused by dissolution and collapse of the underlying limestone bedrock. Aside from the enclosed depressions the only other karst features of note in the vicinity are a swallow hole, 1 km to the north (Carrowroe East) and a small cluster of springs 2 km to the south at Tonrevagh.

The quaternary deposits at the site have been mapped as a locally important gravel aquifer (Lg). These units are typically less than 10 km$^2$ which limits total recharge. Groundwater within this material would flow between sand/gravel grains and smaller pore spaces, with the permeability of this overburden mainly determined by the grain size (larger grains give larger pore spaces), and the nature of ‘sorting’ (the more uniform, the higher the permeability). Groundwater gradients are typically low within sand and gravel deposits which can yield relatively low groundwater velocities. Groundwater yields within sand and gravel deposits are variable due to the nature of the material and the recharge area available to the formation.

There is generally a strong interaction between surface water and groundwater, with groundwater discharging into streams/ waterbodies as baseflow if the water table is high, or conversely, the surface water moving into the sand and gravel aquifer if the surface water level is high. At lower elevations and depressions, groundwater seepage may occur as springs. Discharge from sand and gravel aquifers as baseflow is not flashy and will be sustained through drier periods of the year. During flooding the inverse occurs, and the aquifer offers large storage potential for river/bog water to seep into it. When the

flooding and associated bog river flows subside, the hydraulic gradient is reversed and water will flow from the aquifer back into the bog. This phenomenon is known as bank storage and is indicative of a highly interactive surface water groundwater system. It also accounts for the fact that such watercourses and waterbodies bounded by gravel aquifers exhibit less 'flashy' flooding.



The site is within the Clare-Corrib Groundwater Body. This groundwater unit is too large to contain specific hydrogeological information relevant to the site.

**Vulnerability**

Groundwater vulnerability is dictated by the nature and thickness of the material overlying the uppermost extent of the saturated zone (see Table 1). The vulnerability categories, and methods for determination, are presented in Groundwater Protection Schemes (1999). 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 6 illustrates that groundwater vulnerability at the site is High, inferring that the high permeability sands and gravels present have a minimum thickness of 3 metres. This classification is typical of lands on sand and gravel deposits. This classification applies also along the length of the access route.

Two isolated locations within the site have been classified as having extreme vulnerability, which implies bedrock is within 3 m of the surface (see Table 1). These locations coincide with the topographical low points described above, and shown in Figure 2B.

Table 1 - Vulnerability Mapping Criteria (DELF/EPA/GSI, 1999)

| Subsoil Thickness | Hydrogeological Requirements | | | | |
|---|---|---|---|---|---|
| | Diffuse Recharge | | | Point Recharge | Unsaturated Zone |
| | Subsoil Permeability & Type | | | (Swallow holes, losing streams) | (Sand & gravel aquifers only) |
| Subsoil thickness | 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 |
| > 10m | High | Moderate | Low | n/a | High |

Note: (i) n/a = not applicable

(ii) Permeability classifications relate to the material characteristics as described by the subsoil description and classification method.

**Source Protection Areas**

The extraction area is not indicated to be within source protection areas to any public groundwater abstractions, as mapped by the GSI or EPA.

The zone of contribution (ZOC) to the Gallagh GWS source comes to within 550 m south of the main body of the site (Figure 1). The southern half of the access route is within the ZOC. The Gallagh GWS source is 3.7 km to the south of the proposed extraction area. The spring used as the source for Gurteen Cloonmore GWS is located 2.4 km to the east of the site and the ZOC to this source extends eastwards away from the site.



**Rainfall Data**

Monthly gridded rainfall data was sourced from Met Éireann (Walsh, 2012) and is presented in Table 2.

Table 2 – Long term mean monthly rainfall data (mm) (*Met Éireann)*

| J | F | M | A | M | J | J | A | S | O | N | D | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 119 | 88 | 98 | 69 | 74 | 81 | 75 | 97 | 89 | 122 | 115 | 121 | 1147 |

The closest synoptic station to the site is at Claremorris, 25 km to the northwest, where average potential evapotranspiration (PE) is 497 mm $yr^{-1}$. This value is used as a best estimate of the site PE. 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 472.34 mm $yr^{-1}$ (0.95 PE).

The Effective Rainfall (ER) for the site is determined from:

ER = AAR – AE

= 1147 mm $yr^{-1}$ – 472 mm $yr^{-1}$

ER = 675 mm $yr^{-1}$

The proposed extraction area is 1.6 ha. Hence, the volume of water from precipitation that is available for runoff or recharged directly is given by:

Site area runoff-recharge:

= area x ER

= 16,000 $m^2$ x 0.675 m $y^{-1}$

= 10,800 $m^3$ $yr^{-1}$ (30 $m^3$ $d^{-1}$)

**Recharge**

Recharge coefficients can be utilised to estimate the proportion of water infiltrating vertically, against that moving laterally as shallow subsurface flow and surface overland flow. The recharge coefficient applicable to high groundwater vulnerability and sand and gravel overburden thicker than 3 m is 85% (as per the Recharge Coefficient Calculation Method developed by the Geological Survey of Ireland (Water Framework Directive, 2004)). The volume of groundwater recharge generated by precipitation falling within the site area can thus be estimated as:

Annual Recharge = (area x ER) x recharge coefficient

= 10,800 $m^3$ $yr^{-1}$ x 0.85

= 9,180 $m^3$ $yr^{-1}$ (25 $m^3$ $d^{-1}$)

There is no recharge cap so where bedrock head is above groundwater level there will be no limitation on infiltration to the bedrock aquifer.

# Hydrology



### Catchment Description

The main body of the site is not clearly within the surface water catchment of a defined watercourse. General topography in the area is such that runoff generated from excess precipitation on the site is likely to drain generally westwards towards Drumbulcaun Bog, which occupies the topographical depression to the west. Historical maps show that the bog is, or may have been, drained previously, with reference made to the drainage channels emanating from the western periphery of the wetland.

Local springs to the south and southwest of the Drumbulcaun Bog (2.3 km southwest of the site) discharge into open channels which form the headwaters of the Brockagh Stream, this subsequently becoming the River Nanny a short distance downstream. The Nanny is a major tributary of the River Clare.

### EPA Water Quality

EPA data is available for chemical and biological water quality since 2007. A water monitoring station is present on the Nanny River, 4.1 km downgradient of the site, however there is no biological or chemical water quality data for this station. An additional monitoring point is located further downstream at Tuam. The River Nanny at this point has a Q-value rating of 4 which is described as 'Good'.

### Designated Areas

Designated areas within 10 km of the site are shown in Table 3. Levally Lough pNHA is in a different catchment to the site. There is no direct hydrological connectivity between the site and Lough Corrib or its tributaries.

Table 3 – Designated Areas of hydrogeological importance within a 10 km radius of the site

| Designation | County Galway |
|---|---|
| Proposed NHA | Drumbulcaun Bog (000263); adjacent to western boundary |
| NHA | Knockavanny Turlough (000289); 5 km southwest |
| SAC / Proposed NHA | Levally Lough (000295); 4 km south |
| SAC | River Clare - Lough Corrib (004042), 9 km south; 9 km north |

Drumbulcaun Bog which lies to the west of the site encompasses an area of 42 ha and has been designated by National Parks and Wildlife Service (NPWS) as a proposed Natural Heritage Area (pNHA).

The limits of the designated area coincide broadly with the fen peat extents as shown in Figure 3 though the area of interest is described as a small complex of raised bog, fen peat, open water and flooded grassland which is surrounded by low limestone hills.

Drumbulcaun Bog itself is a fen peat-substrate wetland fed by mineral-rich, basic groundwater. It is of conservation significance primarily because it is the only intact raised bog in the catchment of the Nanny River. It supports a variety of habitat types and a diversity community of flora and fauna.

Fen peat typically occurs on undulating lowlands, predominantly carboniferous limestone glacial drifts. Within this geological landscape fens tend to form in river valleys and poorly drained hollows, as well as adjacent to raised bogs, and have an average depth of 1-2m (Hammond, 1981). Sphagnum peat is not found on fen peats because of the continued flushing with groundwater. Fen peat bogs exhibit evidence of mineral enrichment, probably due to flooding from mineral-rich groundwater during periods of high water-table each winter. Local hydrogeology is therefore an important element in fen peat formation as the wetland conditions are maintained by groundwater levels in the low-lying area being close to, or above, ground surface.

It is important to note that in relatively recent times the area has undergone significant arterial drainage. This is typical in Ireland where undisturbed fens are very rare, with most having been drained and cultivated.



## Flood Risk

### Historical Mapping

Historical OSI 6" and 25" mapping show the following areas marked as 'liable to floods':

- eastern margins of Drumbulcaun Bog, this area does not encroach onto the site;
- Peat bog area to south of road at access point. The local road broadly defines the northern extent of the area prone to inundation.

### Benefitting Lands

Both of the areas listed above are denoted as benefitting lands, which implies that they have been influenced by OPW arterial drainage works. Much of these works took place in the 1960's – 70's under the Corrib-Clare Drainage Scheme. Neither areas of benefitting lands encroach onto the extraction area. The southern area of benefitting lands extends approximately 80 m north of the local road and coincides with the proposed site access point.

### Historical Flood Events

With respect to the above flood risk areas minutes recorded at a Galway County Council meeting in 2005 state the following:

(i) Dunblayney (recurring) - low lying lands 1 km north of the main body of the site are prone to flooding following heavy rain every year. A property at this location is affected and the road is liable to flood.

This is presumably due to expansion of the wetted extents of Drumbulcaun Bog, either due to increased surface water entering the bog, or rising groundwater levels, or a combination of the two.

(ii) Shanvally - water flows off land after heavy rain every year. The road is liable to flood from Turlough on one side of the road.

There is no turlough registered in the area south of the entrance point. The site was inaccessible during any of the site visits but aerial imagery does show a possible swallow hole 400 m south of the proposed site entrance. The road is not reported as being impassable.

## Site Investigation

### Trial Pitting

A tracked excavator was used to excavate three trial pits (TP1, TP2 and TP3) across the site to between 1.3 – 2.0 m below ground level (mbgl) and typically 1m by 2m in plan. The positions, surface and base elevations of the completed trial pits were surveyed to Malin Head using RTK VRS technique. Trial pits locations are shown on Figure 2A and were targeted in the lowest parts of the site in an attempt to intercept groundwater.

Table 4 below summaries the quaternary geology encountered at each trial pit location. Topsoil is shown to be thin and underlain by 0.3 - 0.6 m of sandy gravelly clay subsoil. Uncompact, permeable sandy gravels were then present between subsoils and bedrock. At the selected trial pit locations bedrock was noted as being at a relatively shallow depth and digging was terminated upon reaching competent rock.

Two of the trial pit locations were targeted to confirm the nature of the two enclosed depressions indicated as being within the site boundary on Figure 5. The presence of mineral subsoil and competent bedrock suggests that these are simply depressions in glacial deposition patterns and not karst features resulting from undermining of dissolved limestone.



No peat was encountered during on-site trial pitting.

Table 4 – Trial Pit Logs

| ID | Coordinates | Location | Ground Level, mOD | Base Level, mOD | Depth Inter-val, m | Lithological Description |
|---|---|---|---|---|---|---|
| TP1 | 551,421/ 756,674 | Western end | 83.31 | 81.81 | 0 - 0.22 | Very soft light brown silty sandy CLAY (sand is fine, damp with fine rootlets) |
| | | | | | 0.22 - 0.59 | Firm brown very fine damp sandy gravelly CLAY (Sand is fine with some reddish-brown mottling) |
| | | | | | 0.59 - 1.32 | Firm damp light grey sandy GRAVEL with some clay (Sand is fine damp with occasional rounded to sub rounded cobbles and medium – large gravels) |
| | | | | | 1.32 - 1.5 | Weathered limestone bedrock becoming competent |
| TP2 | 551,528/ 756,751 | Centre | 85.42 | 84.03 | 0 - 0.03 | Very soft light brown sandy CLAY (sand is coarse with fine rootlets and organic matter) |
| | | | | | 0.03 - 0.47 | Brown sandy gravelly CLAY. (Gravel is medium to large, sub-rounded to angular with occasional large cobbles) |
| | | | | | 0.47 - 1.5 | Firm, brown GRAVEL with some sand. Sand is fine to medium. Gravel is medium to large sub angular to sub rounded with occasional large cobbles. |
| | | | | | 1.5 - 2.0 | Weathered limestone rock (End) |
| TP3 | 551,716/ 756,756 | Eastern end | 88.61 | 86.81 | 0 - 0.16 | Very soft light brown sandy CLAY (sand is fine, slightly damp with fine rootlets) |
| | | | | | 0.16 - 0.34 | Brown sandy gravelly Clay. (Gravel is medium to large, sub-rounded to angular with occasional large cobbles) |
| | | | | | 0.34 - 0.5 | Brown sandy GRAVEL. (Gravel is medium to large, rounded to sub- rounded with occasional large cobbles) |
| | | | | | 0.5 - 1.8 | Weathered limestone rock becoming competent |
| | | | | | | |

**Site Hydrogeology**

The site lies in an area where there is a notable absence of mapped surface water courses and drainage channels which implies all rainfall percolates freely to the underlying sand and gravel and bedrock aquifers. Lithology encountered at the site corresponds with that for which the GSI recharge rates of 80 – 90% are applied, i.e. thin soil over sands/gravels. Trial pit logs suggest that groundwater flow is within the fractured/heavily weathered limestone bedrock, though it is more likely that groundwater table traverses bedrock and the sand and gravel deposits as it moves across the landscape.

Where there is excess infiltration following rainfall this will flow in a general westwards direction as runoff. However, the undulating nature and the presence of naturally enclosed topographical depressions within the site means that not all overland flow will reach the western boundary. Runoff that flows overground will do so towards lower ground, i.e. into the enclosed topographical depressions within the site. Upon reaching these areas surface water will mostly infiltrate to the gravel aquifer over time. Heavy rainfall throughout the history of the site means that some fine sediment will have been washed off higher ground into these depressions. This sediment blocks pores at the surface causing a reduction in permeability at these low points, resulting in an accumulation of small amounts of rainwater. This is perched water and not in continuity with groundwater in the area. Figure 2B shows one such area potentially prone to ponding within the site boundary, one immediately north of the site boundary and two similar areas on the land parcel to the immediate north.

That portion water which does make it the western boundary will drain naturally by gravity towards the depressed area to the west of the site, this being Drumbulcaun Bog. It is believed that surface water generated on site flowing to the bog will be negligible due to groundwater being the dominant flowpath. There is no hydrological connectivity between the site and the headwaters of the River Nanny or River Clare.



**Groundwater Levels**

Water levels were surveyed in Drumbulcaun bog on two separate occasions as follows:

- 09/05/19 = 80.57 mOD;
- 03/03/20 = 81.79 mOD.

The data collected in 2019 and 2020 is considered to be broadly representative of summer and winter groundwater levels, respectively. Seasonal winter water levels in the bog are approximately 81.8 mOD, with the summer water levels approximately 80.5 mOD. Water levels shouldn't fluctuate massively outside this range due to the phenomenon of bank storage described above.

The 2020 water level in Drumbulcaun was surveyed following a prolonged period of wet weather. This is evidenced by a brief review of groundwater levels at the nearest groundwater hydrometric station at Corbally (EPA), 30 km to the southwest. Plates 1 and 2 show groundwater levels at Corbally over the previous 12 months, and since monitoring commenced in 2008, respectively. These graphs show that groundwater levels in March 2020 are representative of seasonal maxima.

Plate 1 – Corbally groundwater levels over previous 12 months

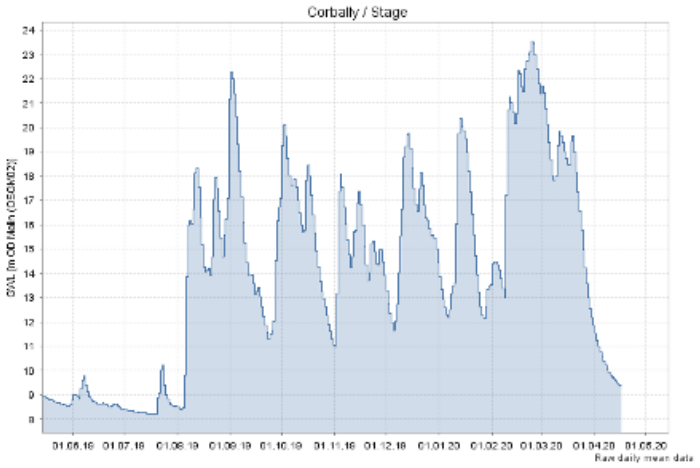
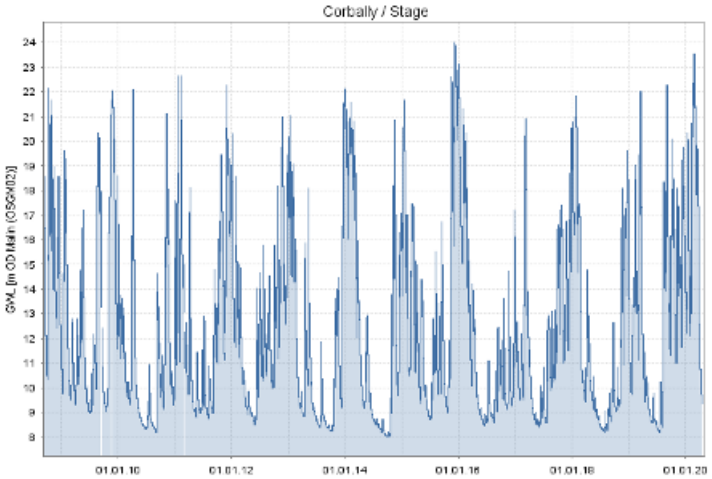



Plate 2 – Corbally groundwater levels 2008 - 2020



### Groundwater Flow Direction

Hydraulic gradients in sand and gravel aquifers and highly permeable rock are typically very low. Although the piezometric groundwater level beneath the site was not accurately determined during site investigation works it is reasonable to assume that water levels recorded within Drumbulcaun Bog are representative of the groundwater table within the site. This is validated by the groundwater level in TP1 being below 81.81 mOD.



The marginal gradient that is present will drive flow in a general west/southwest direction towards Drumbulcaun Bog. This means that Drumbulcaun Bog acts as the local groundwater sink. This is validated by the movement of groundwater through the limestone sands and gravels having led to the development of fen peat specifically. Groundwater flowing beneath the site is in continuity with groundwater within the Drumbulcaun Bog.

The regional groundwater sink is considered to be the River Nanny, though this can be complicated by the presence of preferential flow paths in the underlying regionally important karst aquifer.

### Site Hydrology

There are no surface water features within the proposed extraction area.

An open drainage channel is mapped as rising in a low-lying area 60 m northeast of the proposed site entrance. This open drain is not listed on the EPA river network database. The drain traverses the low-lying area such that it will pass under the proposed access route (see Figure 2C). The channel has summary dimension: channel depth = 0.9 m; bed width = 1.5 m; bank-to-bank width = 4.0 m; water depth = 0.6 m. It is currently mapped as being culverted beneath an adjacent site entrance to the west, though a culvert was not identified at this location. Figure 2C shows that hydraulic gradient is shallow and in a westerly direction on the northern side of the road, before being culverted via a stone arch culvert 165 m west of the proposed site entrance (Plate 3). This culvert is 0.6 m wide, 0.4 m high, with an invert level of 73.94 mOD. Flow rate was negligible on the day of the survey.

The site survey on 30th July 2020 confirmed that an area extending 100 m north of the proposed site entrance is relatively flat and low-lying and vegetation here suggests it is prone to seasonal waterlogging. This area corresponds with the area denoted as being benefitting lands, and appears to be served by the drainage channel described above.

Plate 3 - Culvert beneath local road close to proposed site entrance (IL = 73.94 mOD)

## Characteristics of the Development



### Site Preparation

Topsoil will be stripped across the proposed excavation area and stored in stockpiles. Stockpiles will be vegetated to enhance stability. Site perimeter contours will be such that any runoff generated within the excavation area and on stockpiles will remain within the site boundary and infiltrate unimpeded to ground.

### Sand & Gravel Extraction

The applicant proposes to extract sands and gravels above groundwater. The pit will be worked as a dry sand & gravel pit and it will not be necessary to pump water from the site to maintain the workings in a dry condition. Excavation of bedrock is not a proposed activity.

Haulage vehicles will travel on designated internal haulage routes to prevent excessive compaction across the site.

### Pit Floor Level

Based on the above information the minimum design level of the final pit floor is 81.8 mOD. A protective layer of unsaturated overburden should be maintained across the site to act as a buffer against contamination at surface. In order to maintain a groundwater vulnerability classification of High it is recommended that 3 m of unsaturated overburden be maintained across the site. This equates to a final recommended pit floor level of 84.8 mOD.

### Use of Hydrocarbons

There will be no storage of fuels, lubricants, waste products, or other chemicals within the site. Haulage vehicles will be refuelled off site. There will be no mobile processing plant at the application site. Refuelling of the excavator will be carried out by a licensed third party using a mobile, double-skinned and bunded bowser. All maintenance of machinery will take place in the workshop within the main processing compound to the south. Emergency repairs will make use of spill kits.

### Reinstatement

Removal of topsoil will make the area unsuitable for agricultural production for the duration of the excavation phase. By removing the large hummocks on the site the applicant intends to leave the site in an improved condition for agricultural production, when compared to the current status. Restoration will involve reinstating the stockpiles of stripped indigenous soils. This method has been successfully practiced by the applicant elsewhere. Reinstatement will maintain the minimum 3 m unsaturated zone at the site. Upon completion, compacted areas of the pit floor or internal haulage routes will be ripped to a depth of 0.5 m to restore original permeability.

### Site Entrance: Culvert Installation

It is proposed to access the site from the local road to the south. In order to ensure no disturbance to surface water flows in the area of the site entrance it proposed that a rectangular precast culvert with dimensions: width 1.0 m and height 0.8 m (i.e. larger than downstream culvert), be installed beneath the proposed entrance, set at an invert elevation of 73.35 mOD, i.e. 300 mm below the current minimum stream bed elevation at this location. These culvert dimensions are in line with the existing downgradient road crossing. The upgradient surface water catchment is extremely small and water levels in the drain are consistent with groundwater levels in the area. Hence surface catchment calculations to size the culvert for extreme flood flows are not applicable. Works will be carried out in accordance with 'Guidelines on Protection of Fisheries during Construction Works in and Adjacent to Waters (IFI, 2016).

### Raising of Ground Levels at Proposed Entrance

Following culvert installation current ground levels at this location will be raised to ensure safe access and egress to the site. Ground levels will be raised at the proposed site entrance to an elevation of 74.85 mOD, consistent with the local road at this point. This raised route will extend north from the road for approximately 100 m, to a point where existing field elevations are at this level (Figure 2C).

### Compensation Storage

To ensure no increase in flood risk resulting from the proposed infilling, an equivalent or greater volume of compensation storage must be provided. The volume of infill required to accommodate the entrance and first 100 m of internal access road was calculated using Surfer software. The calculation was based on a mean access road width of 5 m. The volume of fill required to bring the first 100 m of internal roadway above the flood level (i.e. level with the local road) is 94 $m^3$. In reality the infill volume will be less than the above stated volume given infill material will be coarse (50 mm washed stone) with a porosity of 30%, and the open nature of the culvert.

Compensation storage will be provided in the area directly east of the proposed entrance. Removed material will be deposited outside the potential flood zone (i.e. on ground above 75 mOD), most likely as screening berms around the proposed extraction area.

## Conceptual Site Model

The conceptual site model was developed using the source-pathway-receptor (S-P-R) model, as outlined below. The S-P-R model is used to identify the sources of water and potential contamination, the receptors which can be potentially affected by proposed activities, and the pathways by which the sources and receptors can be connected. Consideration will be given to the predominant sources, pathways and receptors in terms of the influence they have on the local hydrological and hydrogeological environment, and the manner in which they may be impacted.

| source | pathways | receptors |
|---|---|---|
| precipitation | surface overland flow | groundwater in sand and gravel aquifer |
| sediment | infiltrating water | groundwater in Rkc bedrock aquifer |
| hydrocarbons: refu-elling, maintenance | Sand and gravel aquifer flow | Drumbulcaun Bog pNHA |
| Domestic wastewater from dwellings | deeper bedrock aquifer flow | third party wells |
| reinstatement | throughflow from up-gradient lands | Local road |

The conceptual model applicable to the proposed extraction area can be summarised as follows:

- The majority of precipitation landing within the proposed site area will penetrate the surface and infiltrate vertically through the unsaturated sands and gravels.
- Infiltrating water will then enter the saturated zone in the form of the sand and gravel aquifer and/or the limestone aquifer via the upper weathered bedrock. Groundwater is unconfined.
- Groundwater will move laterally towards Drumbulcaun Bog pNHA driven by a low hydraulic gradient. During winter conditions water levels in local watercourses and waterbodies will gradually rise. This will lead to a rise in groundwater levels at the site. The high storage capacity of the bog and the sand and gravel aquifer means that this rise will only be slight. Local groundwater will continue to discharge to Drumbulcaun Bog pNHA as baseflow.
- Groundwater is currently within 3 - 5 m of ground level at the site, equivalent to a groundwater vulnerability classification of High (H). The final pit floor has been recommended such that a vulnerability classification of High will be maintained upon completion of extraction and restoration.
- The proposed finish floor level is at an elevation of 84.8 mOD which is 3 m above the measured winter surface water level within the Drumbulcaun Bog (81.8 mOD).

A graphical interpretation of the CSM was subsequently compiled to demonstrate the topographic relationship between groundwater and existing site topography (Figure 7). The line of section is along a southwest-northeast plane through the central axis of the site.



## Impact Assessment

The procedure for determination of potential impacts on the receiving hydrological and hydrogeological environment is to identify potential receptors within the site boundary and surrounding environs and use the information gathered during the desk study and site investigation to assess the degree to which these receptors will likely have been impacted upon. Impacts are discussed in terms of quality, significance, duration and type in accordance with current EIAR guidelines (EPA, 2017).

In accordance with the NRA Guidelines (2009) (as included in 'Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements' (IGI, 2013)), the site is deemed to be an attribute of High importance which signifies it has a high quality, significance or value on a local scale. Groundwater passing through the site supports a wetland which is designated as a proposed NHA. The site is also underlain by a regionally important aquifer.

### Direct Impacts

The key activities at the proposed extraction area include stripping and stockpiling of soils, excavation of sands and gravels, haulage of material off site, and restoration of site to agricultural grassland using stripped soils. The primary potential impacts to the hydrological and hydrogeological regime arising from such activities are considered to be:

- Groundwater quality in Drumbulcaun Bog due to alteration in vulnerability classification and use of hydrocarbons;
- Groundwater flow patterns due to change in surface infiltration patterns.

The maintenance of a 3 m unsaturated zone below the pit floor will ensure no discernible impact to groundwater quality in Drumbaulcan Bog. Limiting movements of haulage vehicles to designated internal haulage routes will ensure no deterioration of recharge rates across the site.

The key activities at the proposed entrance include installation of a precast concrete culvert and infilling of low-lying ground using coarse stone to provide safe and access and egress of haulage vehicles. Compensation storage must be created in close proximity to balance the volume of potential floodplain storage that will be lost due to infilling.



The primary potential impacts to the hydrological and hydrogeological regime arising from such activities are considered to be:

- Increase in surface water levels during flooding due to loss of potential floodplain storage;
- Increase in surface water levels during flooding due to impedance of surface water flows through new culvert.

The creation of compensation storage will ensure no net loss of floodplain storage in the area where minor infilling is proposed. The proposed culvert will have larger cross-sectional dimensions than existing downgradient culverts.

Overall, direct negative impacts to identified hydrogeological and hydrological receptors in the study area are deemed to be negligible.

**Indirect Impacts**

There are no predicted indirect impacts to the hydrological or hydrogeological environment.

**Cumulative Impacts**

The site is small in terms of scale when considered in the context of the quarrying industry. However, aerial photography reveals significant quarrying activity in the area, with the majority of this being 0.6 - 3.5 km south of the proposed extraction area and centred around a processing site. The site and Drumbulcaun Bog pNHA are considered to be upgradient of this other quarrying activity in terms of groundwater flow. Hence the cumulative impact to Drumbulcaun Bog pNHA resulting from additional quarrying at the proposed site is considered to be negligible.

Quarrying activities in the area are long established and there is no evidence of these activities as having a detrimental impact to groundwater flows or groundwater quality in the surrounding area. Proposed activities are in accordance with the objectives of the Galway County Development Plan 2015 – 2021.

Restoration has taken place following extraction of sand and gravel material on other sites in the locality, whereby upon closure the land is restored to workable agricultural grassland. This practice has proven to be successful in terms of mitigating potential impacts to the receiving water environment.

Drainage channels are frequently culverted in the area to provide access to agricultural land parcels. There is no evidence to suggest these have a cumulative detrimental impact on surface water flows, nor are they considered to be a contributing factor to flooding in the area as groundwater is the dominant flow path in the area. The surface water catchment to the proposed drain crossing is low and hydraulic gradients in the area are so low that surface water flows are impeded by rising groundwater levels in the downgradient (southern) bog rather than insufficient culvert capacities.

**Unplanned Events**

Consideration has been given to the likely environmental impacts that may have arisen in association with unplanned events such as accidents, floods, etc. Intense rainfall events during the operational phase may give rise to increased runoff and hence increased sediment mobilisation.

The perimeter of the site being confined by elevated perimeter berms in combination with the very high permeability characteristics of overburden, means that no overland flow should leave the site boundary. Unplanned events such as high-

speed winds would have the potential to generate dust. It is assumed that works will cease during excessively high winds. It is also assumed that dust suppression techniques will be enabled during activities as required.



**Residual Impacts**

It is predicted that there will be no residual impacts to the hydrological and hydrogeological environment associated with the proposed development works.

**Monitoring**

A designated person from the project management team will have overall responsibility for ensuring that all operations are carried out in such a way as to minimise potential impacts to hydrological and hydrogeological receptors. This person will also have responsibility of monitoring the performances of any pollution control measures adopted.

A project-specific Construction and Environmental Management Plan (CEMP) will be established and maintained by the contractor during all phases of work. The CEMP will cover all potentially polluting activities and include an emergency response procedure. All personnel working on the site will be trained in the implementation of the procedures during a site induction meeting.

## Summary

Finnegan Sand Ltd. are seeking planning permission to develop a sand and gravel pit situated on the northern extent of a significant deposit of quaternary sands and gravels near Dunblaney, Co Galway. It is proposed that following extraction of material the existing working pit will be restored for use as agricultural grassland.

The findings of the desk study and an initial site survey in May 2019 were used to inform intrusive investigation which was subsequently carried out in March 2020. This included topographical survey, trial pitting, groundwater level monitoring and review of historical groundwater level data at an EPA monitoring well in Galway. Additional survey works were carried out in July 2020. The objective was to identify potential groundwater receptors, confirm groundwater flow direction and establish seasonally high water table, and ensure no increase in flood risk to local surface water receptors.

Impacts to hydrological and hydrogeological receptors identified within the study area were assessed. The primary receptor was identified as Drumbulcaun Bog pNHA. Given the high permeability of sand and gravel substrate, and the connectivity between groundwater beneath the site and the bog, groundwater quality is also a key receptor requiring protection. The sand and gravel pit will be worked above groundwater table. A final pit floor elevation of 84.8 mOD is recommended to ensure a protective layer of unsaturated overburden is maintained above groundwater, and that groundwater vulnerability classification of High is maintained. There will be no excavation of bedrock. There are several minor enclosed surface water ponds situated in the topographical hollows at the proposed extraction area. These ponds appear to be small perched surface water features and they are not representative of localised groundwater elevations.

Crossing of an open drain is necessary to accommodate a site entrance on to the local road to the south. An appropriately sized precast concrete culvert will be installed in the existing drainage channel and covered with coarse stone infill. This stone infill will continue along the access route to a point where field elevations are equal to the local road elevation. To counterbalance the potential loss of floodplain due to this proposed activity, compensation storage will be provided by removing an equivalent amount of overburden in the adjoining area.

There will be no significant impacts to the hydrogeological and hydrological regime in terms of flow and quality, and as such there will be no discernible impacts to the groundwater supply to Drumbulcaun Bog pNHA, or increase in flood risk to identified receptors. A Source-Pathway-Receptor approach has been followed and a hydrogeological conceptual model has been presented in graphical format to clearly demonstrate these findings.

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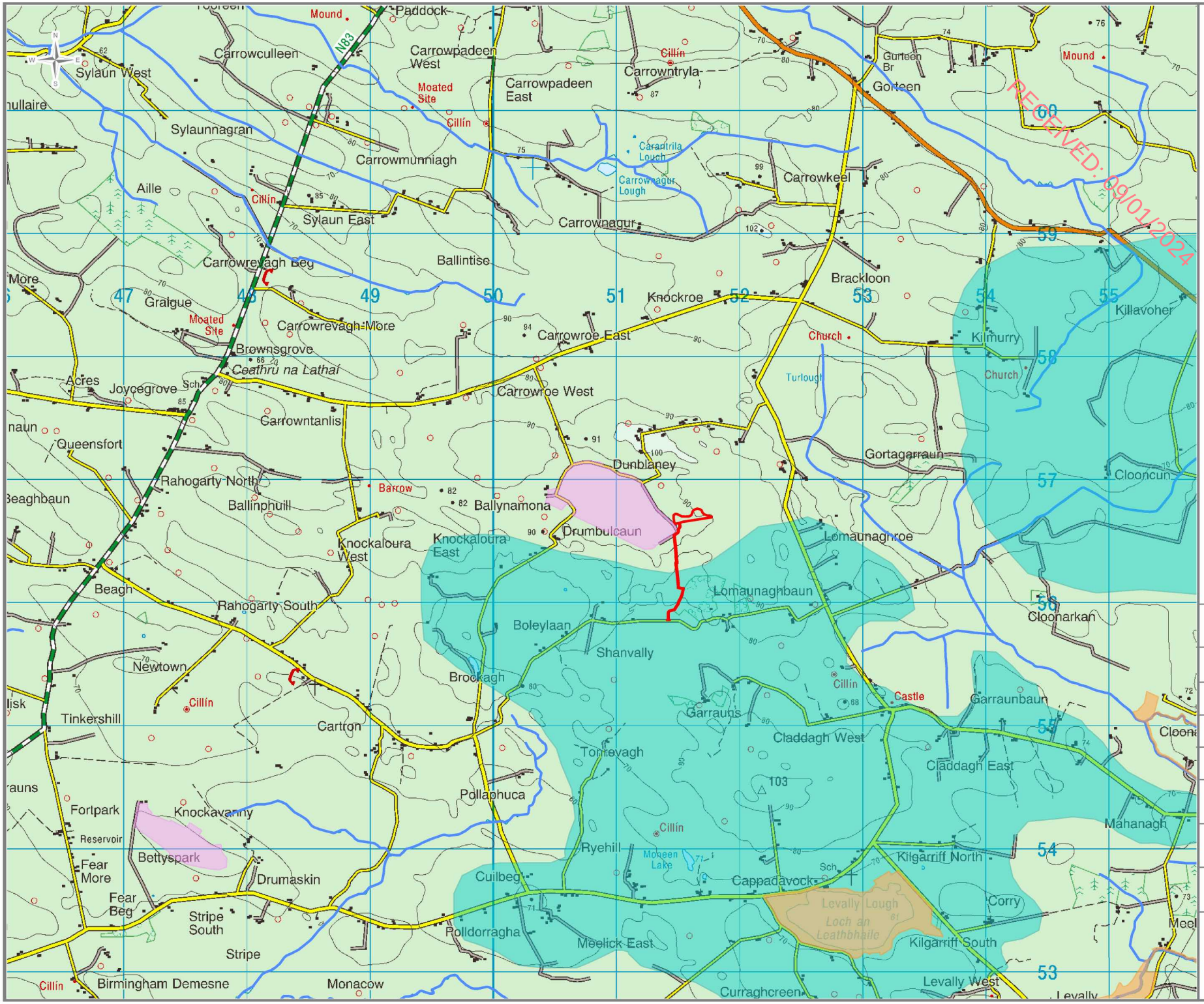
## Figures




| | |
|---|---|
| Fig. 1: | Site Location & Desigated Areaas |
| Date: | August 2020 |
| No.: | 1813B |
| Author: | C. O'Reilly |
| Scale: | 1 : 40,000 |
| Client: | Finegan Sand Ltd. |
| Project: | Hydrogeological Assessment |
| Location: | Dunblaney, Dunmore, Co. Galway |

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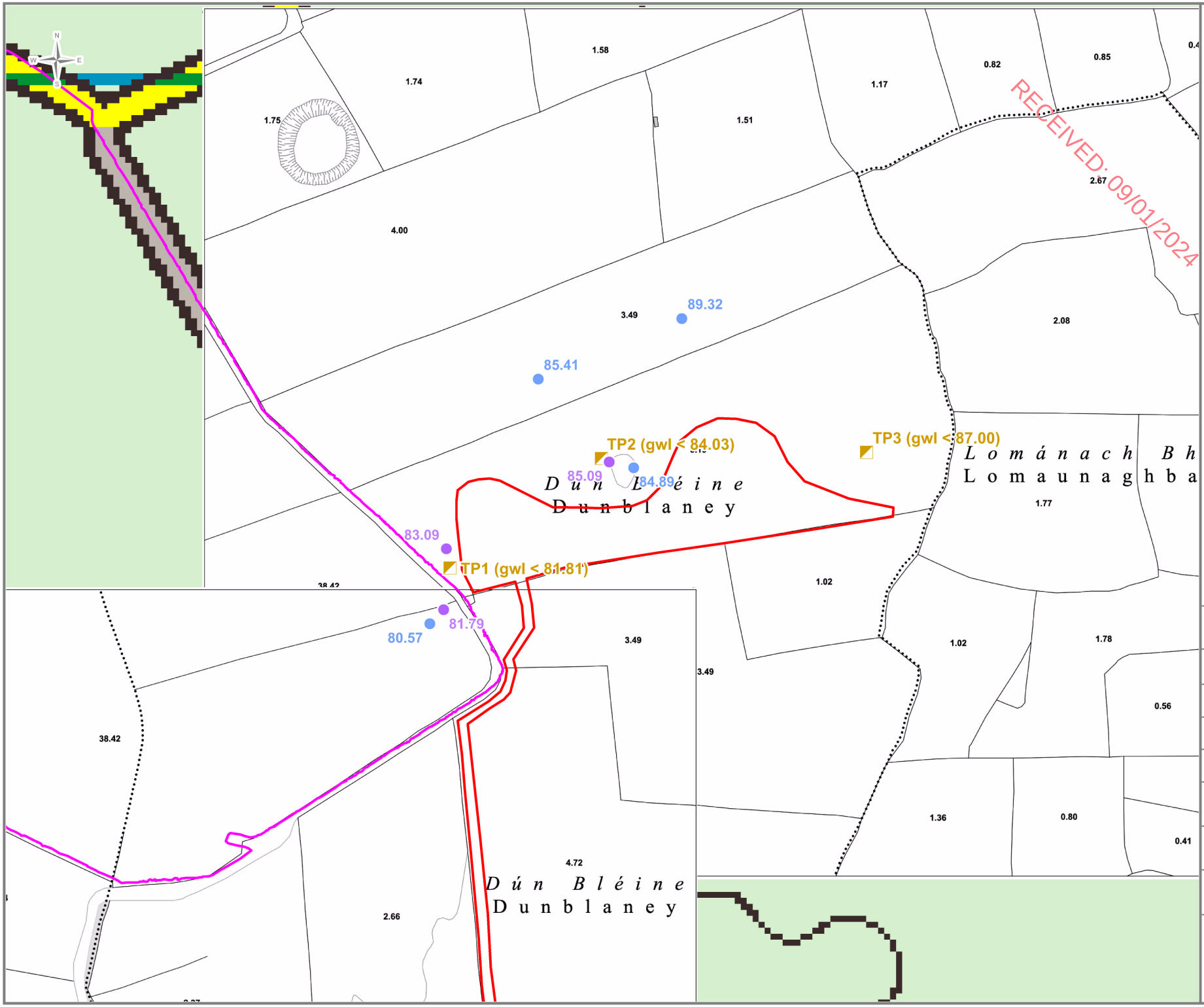




| | |
|---|---|
| Fig. 2A: | Site Layout |
| Date: | August 2020 |
| No.: | 1833B |
| Author: | C. O'Reilly |
| Scale: | 1 : 3 500 |
| Client: | Finnegan Sand Ltd. |
| Project: | Hydrogeological Assessment |
| Location: | Dunblaney, Dunmore, Co. Galway |

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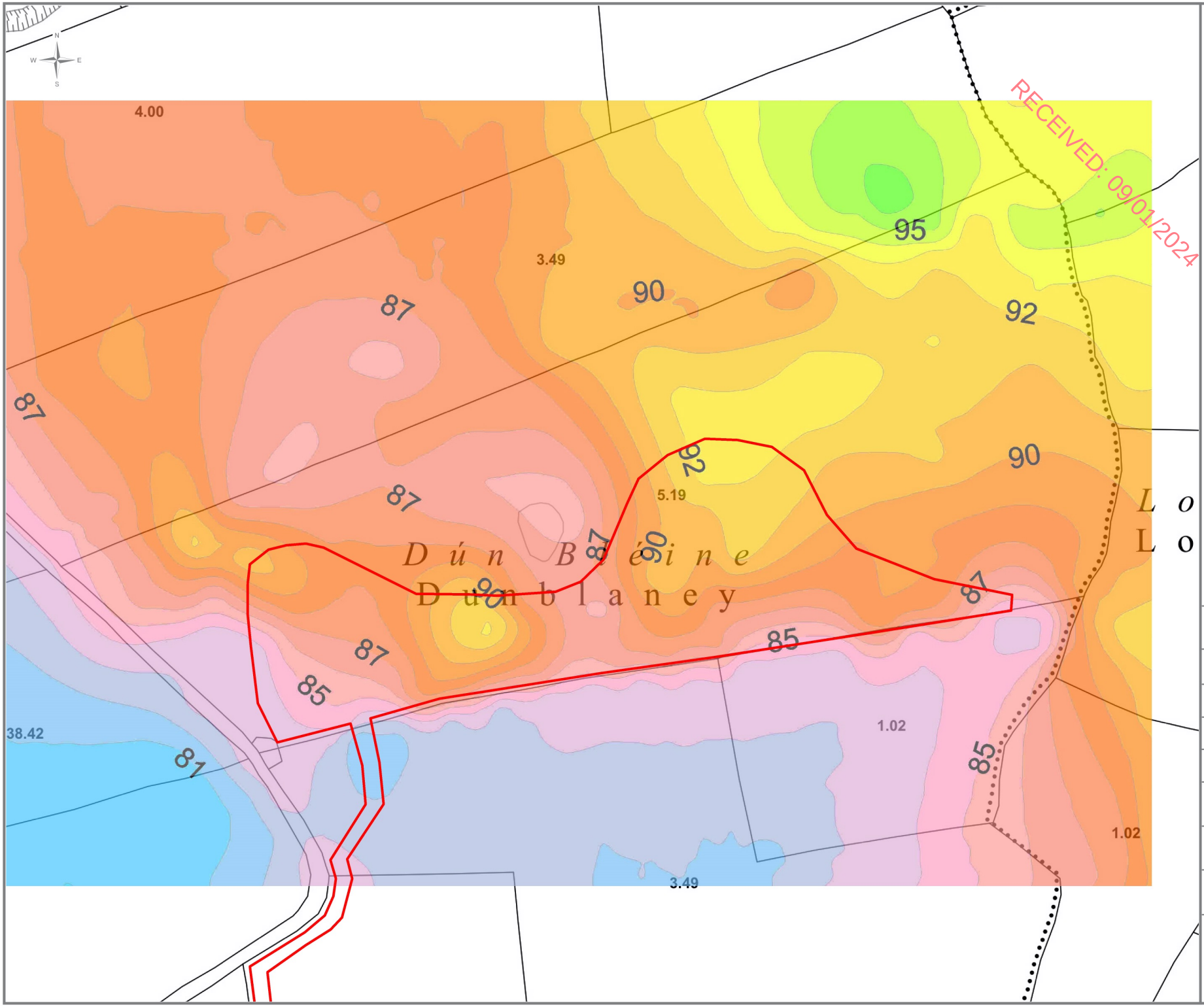




| | |
|---|---|
| Fig. 2B: | Topographical Contour Map |
| Date: | August 2020 |
| No.: | 1833B |
| Author: | C. O'Reilly |
| Scale: | 1 : 2 500 |
| Client: | Finnegan Sand Ltd. |
| Project: | Hydrogeological Assessment |
| Location: | Dunblaney, Dunmore, Co. Galway |

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Legend:

- Site Boundary
- Open Drainage Channels

Water Levels, mOD

- 30/07/20
- Area to be raised to 74.85 mOD
- Proposed 0.4m x 0.6m culvert

0 40

metres



| | |
|---|---|
| Fig. 2C: | Site Entrance Layout |
| Date: | August 2020 |
| No.: | 1833B |
| Author: | C. O'Reilly |
| Scale: | 1 : 1 000 |
| Client: | Finnegan Sand Ltd. |
| Project: | Hydrogeological Assessment |
| Location: | Dunblaney, Dunmore, Co. Galway |

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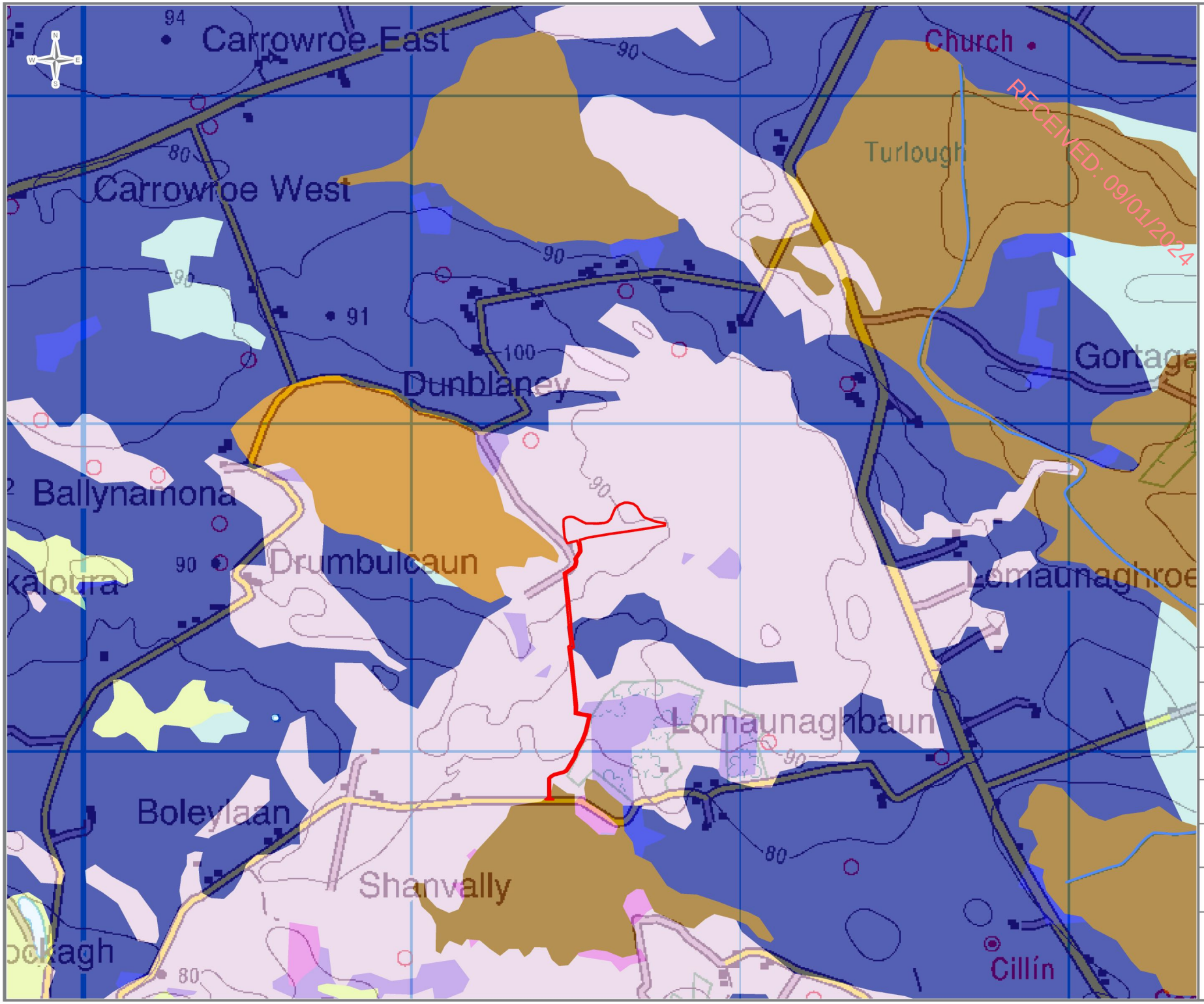


Legend:

- Site Boundary
- EPA River Network
- Deep well drained
- Shallow well drained
- Deep poorly drained
- Poorly drained with peaty topsoil
- Shallow poorly drained
- Shallow peaty gley
- Cutover peat
- Fen peat
- Lacustrine type soils

0 500

metres



| | |
|---|---|
| Fig. 3: | General Soils Classification Map |
| Date: | August 2020 |
| No.: | 1813B |
| Author: | C. O'Reilly |
| Scale: | 1 : 15,000 |
| Client: | Finnegan Sand Ltd. |
| Project: | Hydrogeological Assessment |
| Location: | Dunblaney, Dunmore, Co. Galway |

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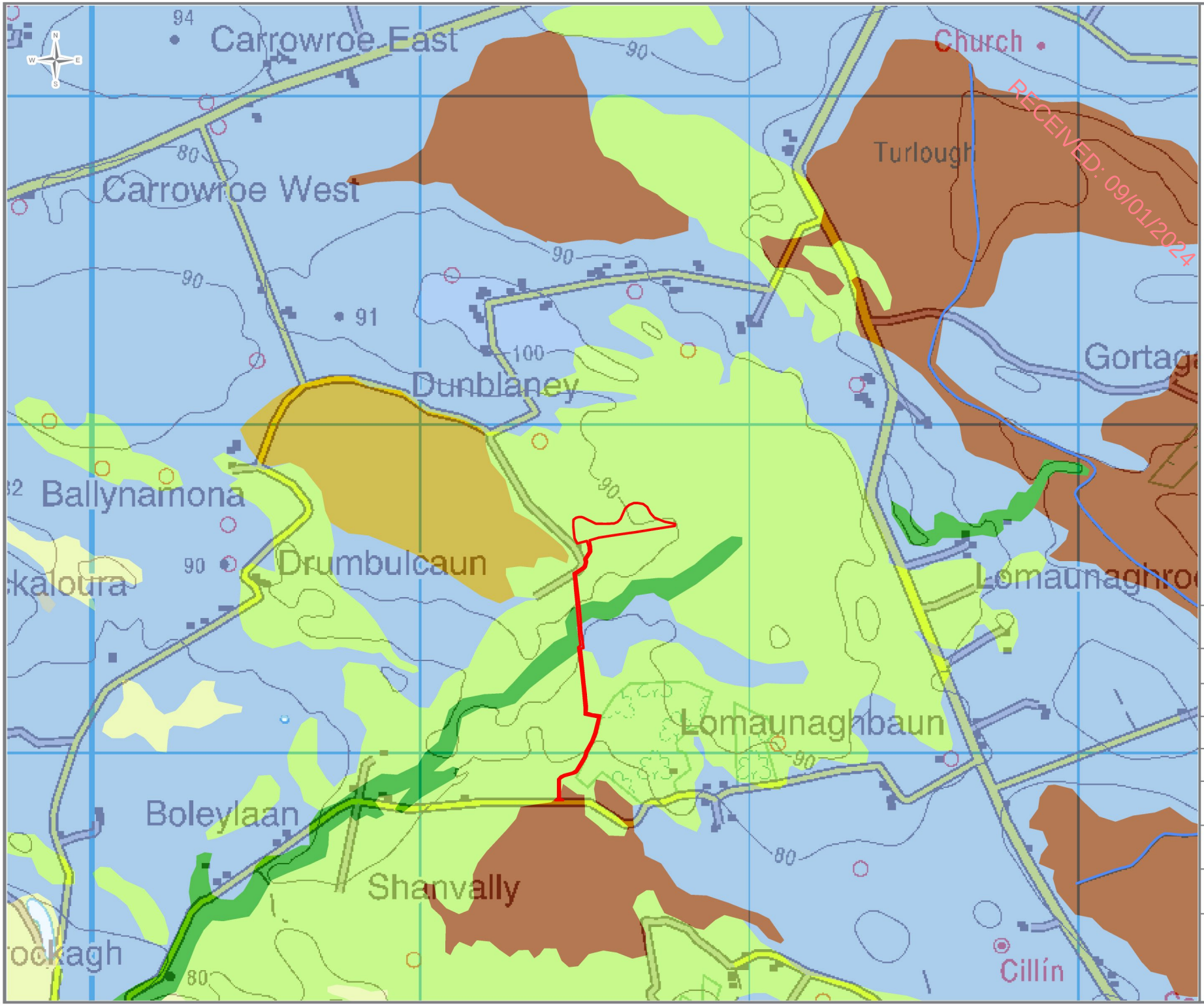


Legend:

- Site Boundary
- EPA River Network
- Esker Gravels
- Limestone Gravels
- Limestone Till
- Cutover Peat
- Fen Peat
- Lacustrine sediments
- Karstified bedrock outcrop/subcrop

0 500

metres



| | |
|---|---|
| Fig.4: | Quaternary Deposits Map |
| Date: | August 2020 |
| No.: | 1813B |
| Author: | C. O'Reilly |
| Scale: | 1 : 15,000 |
| Client: | Finegan Sand Ltd. |
| Project: | Hydrogeological Assessment |
| Location: | Dunblaney, Dunmore, Co. Galway |

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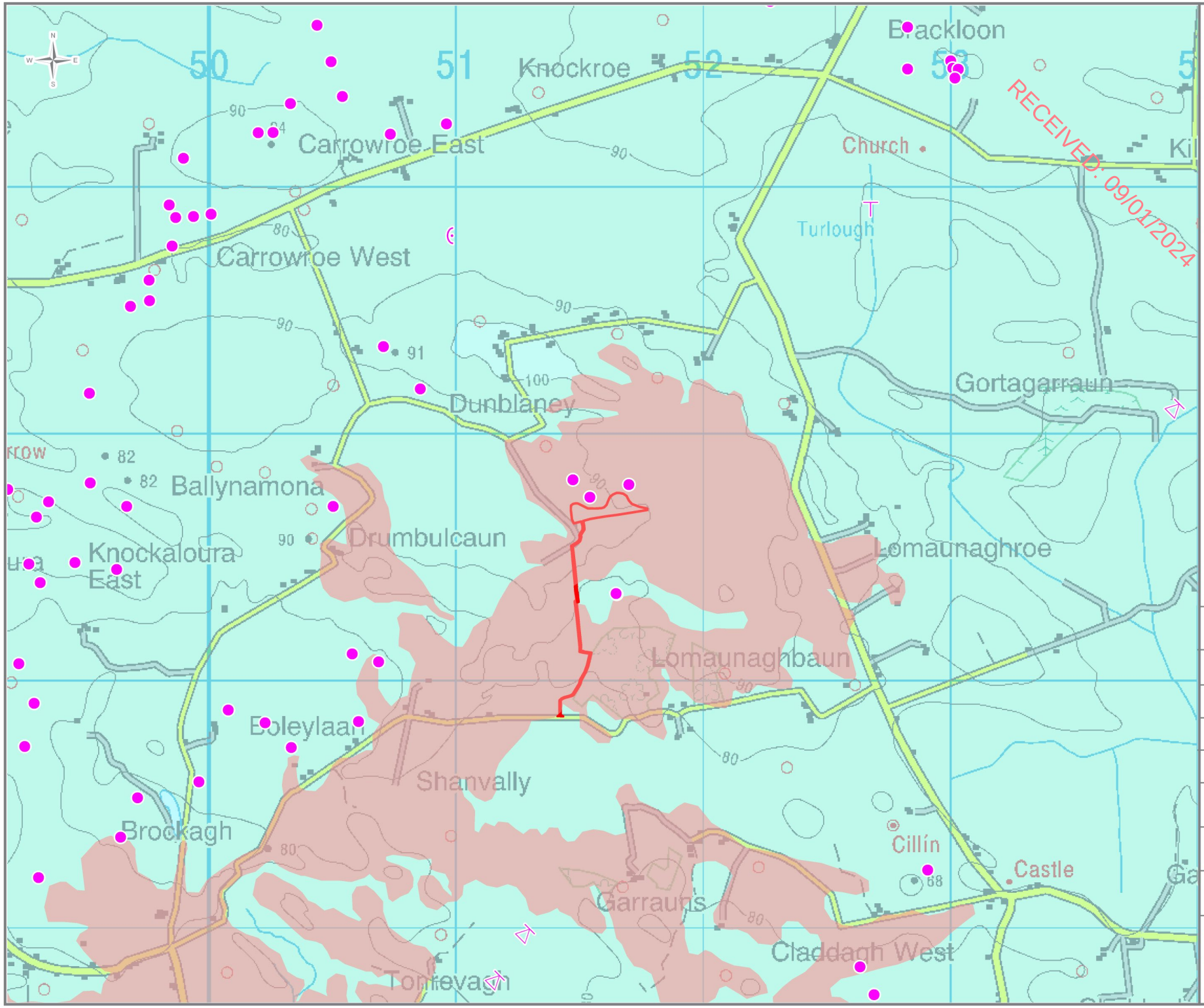


Legend:

Site Boundary

Bedrock Legend:

Burren Limestone Formation

Structural Faulting

Aquifer Legend:

Locally Important Gravel Aquifer

RKc — Regionally Important Bedrock Aquifer

Enclosed Depression

Spring

Turlough

Swallow Hole

0 750

metres



| | |
|---|---|
| Fig. 5: | Bedrock & Aquifer Classification Map |
| Date: | August 2020 |
| No.: | 1813B |
| Author: | C. O'Reilly |
| Scale: | 1 : 20,000 |
| Client: | Finegan Sand Ltd. |
| Project: | Summary Hydrogological Investigation |
| Location: | Dunblaney, Co. Galway |

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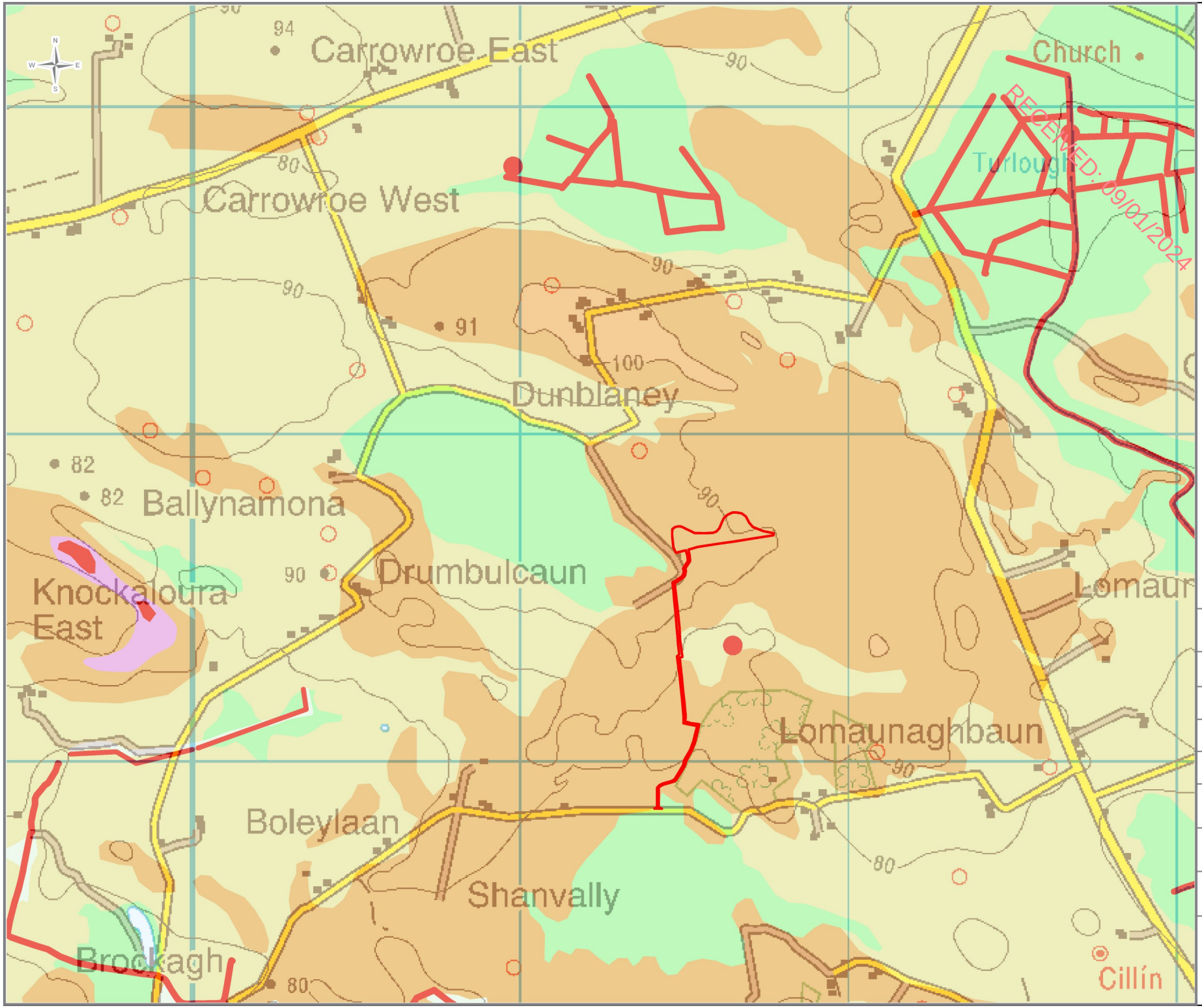


Legend:

- Site Boundary
- Arterial Drainage
- Extreme (X)
- Extreme (E)
- High (H)
- Moderate (M)
- Low (L)

0 500

metres



| | |
|---|---|
| Fig. 6: | Groundwater Vulnerability Map |
| Date: | August 2020 |
| No.: | 1813B |
| Author: | P. Breheny |
| Scale: | 1 : 15,000 |
| Client: | Finegan Sand Ltd. |
| Project: | Hydrogeological Assessment |
| Location: | Dunblaney, Dunmore, Co. Galway |

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