Quarry at Glasbolie, Ballintra, Co. Donegal

SU0128

Review Comments[1] on the Hydrogeological Sections of:

1. Environmental Impact Statement – Section 37L Application; and
2. Revised Remedial Environmental Impact Statement

The hydrogeological sections and related appendices of the above-referenced documents draw conclusions from cursory desk-based work, supported by minimal field work, and has failed to:

1. Adequately address the karstified nature of the Ballyshannon Limestone Formation in the study area; and
2. Risks of impact to Lough Gorman as a potential receptor of pollution.

The relevant sections also make use of web-sourced information from public bodies, but the information is used on flawed premises (explained further below).

It is also noted that the hydrogeological review comments provided for the original Remedial EIS were not taken into consideration or responded to the revised EIS. These are, therefore, re-submitted as **Appendix 1** with this technical review.

Most significantly, the hydrogeological sections in the revised and new EIS documents acknowledge, but downplay, the potential significance of karst in the area surrounding the Glasbolie quarry. Checks of the karst database of the Geological Survey of Ireland (GSI) are referenced in the EIS documents, and the following statements are made:

a) *"Only one karst feature is mapped in the vicinity of the quarry. This is an 'enclosed depression', which is mapped at ~500 m to the NE of the quarry. This is not a significant karst feature".*

b) *"No evidence of karst features or conduits were identified by observations at the site….."*

c) *"There is no karstification within the quarry or in the immediate area surrounding the existing quarry site, meaning there are no pathways for rapid transfer of water to groundwater".*

These statements conflict with observations made during walkover surveys in August and November 2015. Whilst it is reasonable to describe the Ballyshannon Limestone as a karstified limestone aquifer which is "dominated by diffuse flow"[2], many indicators and features linked with karst conduits are present along the northern and western margin of Lough Gorman and seemingly also in the main (north) quarry (as observed from afar, at road level). The photographs in **Figure 1** document examples of a karst spring and a swallow hole at locations to the northwest of Lough Gorman, and also includes

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[1] The hydrogeological sections of the above referenced EIS documents are virtually identical. Thus, the comments provided in this review apply to both sets of EIS documents.

[2] Per the GSI classification of the Ballyshannon groundwater body.

a photograph of apparent preferential inflow to the main quarry along bedding-controlled horizons at multiple depths.

Based on these observations, it should be concluded that karst is present, a shallow groundwater flow system is present at the site (which is karstified), and a hydrogeological link between the quarry footprint and Lough Gorman is both hydrogeologically possible and feasible. This is of significance because Lough Gorman is:

- A source of public water supply for Donegal County Council; and
- A proposed Natural Heritage Area.

Lough Gorman is acknowledged and named as a Designated Site in Section 4.4.3 of the Section 37L application EIS, but is not afforded further consideration in the EIS on the basis of the following statement:

"There are no homogenous habitat types or hydrological connections between this NHA and the application site."

The technical review and associated information presented below contradicts this conclusion. It is argued that a hydrogeological link between the quarry site and Lough Gorman are both probable and feasible.

Appendix 1 of this technical review contains further relevant information on Lough Gorman. It also presents a conceptual hydrogeological model of the area between the quarry and the lake. Lough Gorman is a groundwater-dependent lake. It receives inflow from karst springs along its northern and western margins (possibly also at other locations not yet visited during the walkover surveys).

The statements in the EIS documents that karst is not significant in the immediate study area are based on the fact that karst features in the study area are not shown in the GSI karst database. This does, however, not mean that karst features are not present. Specifically, the GSI karst database contains features where detailed karst mapping has been undertaken. The quarry and Lough Gorman area has not yet undergone such mapping by the GSI. The features to the south near the Ballyshannon Public Water Supply (PWS), which are appropriately cited in the EIS documents, were mapped by the GSI specifically in the context of the delineation of the source protection zone for the Ballyshannon PWS.

Accordingly, an absence of karst features in the GSI karst database in the immediate study area does not imply that they are absent.

As mentioned above, walkover survey conducted as part of this technical review has identified several karst features in the area between the quarry and Lough Gorman. This is summarised in **Figure 2,** based on the details presented in **Appendices 1 and 2**. Dye tracer testing was also carried out in August and September 2015 (see **Appendix 2**). Optical brightener was injected in locally known and active swallow holes and monitored at several mapped limestone springs near Lough Gorman. Following a period of background monitoring (to establish potential sources of fluorescent 'noise' in the groundwater, e.g. detergents), the dye injection events have subsequently proven hydrogeological linkages, via karst conduits, in a southerly and southeasterly direction towards Lough Gorman. On this basis, it is reasonable to conclude that the quarry footprint, and especially the proposed extension in a westward direction, is likely located within the groundwater catchment of Lough Gorman, and

marginally also within the surface water catchment. It should be noted that karst flow systems are notoriously unpredictable with regard to flow patterns, and karst flow systems can (and do) cross hydrological divides.

Lough Gorman is at a higher elevation than the EIS-referenced water table elevation in the North quarry, where the EIS states that groundwater *"has found its rest level at 50 mOD"*. This statement is not supported by hydrographic data (*i.e.* time-series data of water level recovery following cessation of extraction activity in this pit). The final rest level has not been conclusively established. The rest water level will ultimately reflect regional groundwater levels, but even if this proves to be deeper than the Lough Gorman elevation, the quarry site and related operations can still be hydrogeologically connected to Lough Gorman, as:

a) Shallow groundwater flow (> 50 mOD) takes place near and at the quarry, as evidenced by multiple seeps and discharges along the exposed faces of the quarry walls;

b) Groundwater flow in karst systems occurs via fractures and open conduits which have complex and unpredictable geometries. In the case of Lough Gorman, a shallow flow system in the direction of the lake from the general direction of the quarry is present, as documented herein. Thus, any pollutants that are discharged would pose a risk of impact to the lake and its associated habitats.

This combined pathway and risk factor is currently not considered or quantified in the current EIS documents. The potential link to Lough Gorman as a source of public water supply is also missing from the impact assessment and description of relevant mitigation measures, as well as environmental monitoring. Fuel or other spills in areas of karst can have rapid consequences, as water in karst systems can travel long distances (100s m, kms) in short periods of time (hours, days).

Other Items of Concern:

1. The sections reviewed contain many factually imprecise statements which should be re-visited, corrected and or elaborated upon. There are simply too many to be able to list comprehensively, but examples are provided below:

   "drainage in the study area ultimately in a north westerly direction" – the above findings also indicate a second drainage component to the east and south (the quarry occupies a topographic saddle).

   "Permeability's…….are highest in the upper more weathered part of the aquifer. This is referred to as Epikarst" – this may be relevant in some places, but the epikarst is not always present at any given location in a karstified terrain, and there is no consideration or description of whether epikarst is present in the study area as part of the hydrogeological assessment.

   "the existing mitigation measures mitigated the impact in so far as possible on the surrounding environment" – the text *"in so far as possible"* is unclear.

   "An inspection of the Geological Survey of Ireland (GSI) records shows that the rock, which underlies the application site is underlain by Precambrian Quartzites, Gneisses & Schists of the Slieve Tooey Quartzite Formation……" – this text, quoted from Section 6.3.5.1 of the Revised Remedial EIS, does not describe the correct geology of the quarry site or even location in Co. Donegal.

"Therefore, it is estimated that approximately 33,708 m^3/year is contributed to recharge or is pumped to the discharge point on an annual basis" – this merits further definition, as in the context of application site, the quantities of water to be pumped and discharged would be significant. If this quantity would mainly be recharge, it could have an impact on the natural inflow to Lough Gorman.

2. Diesel range organics (DRO) were detected in two groundwater samples in October 2014, but were attributed to *"a natural organic" on the basis that "the signal is not a 'known pattern' for the laboratory's library of 'fingerprints' for organics – it means that the signal is not an oil or diesel or petroleum product"*. This statement is made:

    a) Without including the laboratory's 'fingerprints' for organics (as part of the documentation to justify the statement made);

    b) Without proving what the DROs actually are or represent; or

    c) Without acknowledging that DROs were also reported in surface water samples in 2008, specifically in the North quarry sump, at the discharge point from the North quarry, and at the discharge point from the main quarry.

3. Flood Assessment – flooding occurs regularly to the north of the site, but is not referenced in the EIS.

4. References to hydrogeological conditions at the Ballynacarrick quarry are of interest, but do not replace the need for location-specific characterisation at Glasbolie. Each quarry site and operation has its own characteristics and features to be considered in an EIS.

5. Remedial measures – expanded study and monitoring of Lough Gorman and its connection with the quarry site requires further work, and must be taken into account in future expanded monitoring programmes.

6. Interactions/Inter-relationships – the connection and interdependence of between flora/fauna and water is missing from consideration in the EIS documents.

7. Bird activity at the quarry site is described as 'low'. It is unclear if this statement includes Lough Gorman and its associated wetland margins. Quarry expansion westward and towards Lough Gorman would increase the potential to disrupt associated ecosystems.

8. Water balances presented in the Section 37L application EIS ignore the groundwater component of flow. There are also no direct flow measurements of springs and swallow holes, or placement of the quarry site in a hydrological context of Lough Gorman (including its water balance and eco-hydrological needs).

9. It is stated in the Section 37L application EIS that *"a groundwater level and quality monitoring programme will be implemented in order to obtain accurate groundwater monitoring levels and quality results."* No further details are provided, rendering the statement of intent both incomplete and without context. Any such monitoring should be preceded by appropriate hydrogeological study and identification of relevant pathways and potential receptors, so that relevant monitoring can be carried out. The current EIS does not provide an adequate basis on which to determine monitoring details at the present time.

In summary and conclusion, the hydrogeological sections in the respective EIS documents leave the impression of rushed preparation of two documents in parallel, with heavy use of cut and paste functions, without adequate description of site hydrogeology, identification of source-pathway-receptor risk factors or linkages, or appropriate conceptual hydrogeological models. As such, the referenced EIS documents do not provide the information necessary to be able to judge, with confidence, potential risks, impacts and relevant mitigation measures.

Notwithstanding, the proposed quarry expansion and remediation activities do not appear to meet the specific objectives of the Donegal County Development Plan that are listed in the introduction section of the EIS documents, notably objectives EX-O-2 and EX-O-3.

Prepared by: Kieran O'Gorman (informally advised by Henning Moe, hydrogeologist)

Date: 11 February 2016

North quarry—south face—seeps/discharges along multiple bedding horizons

Spring to the northwest of Lough Gorman (water cress vegetation, characteristic of karst limestone water)

Active swallow hole, in ponded/flooded area, to the east of the N15 and east of the Gorman residence

Figure 1:

Evidence of karst and groundwater flow at multiple horizons

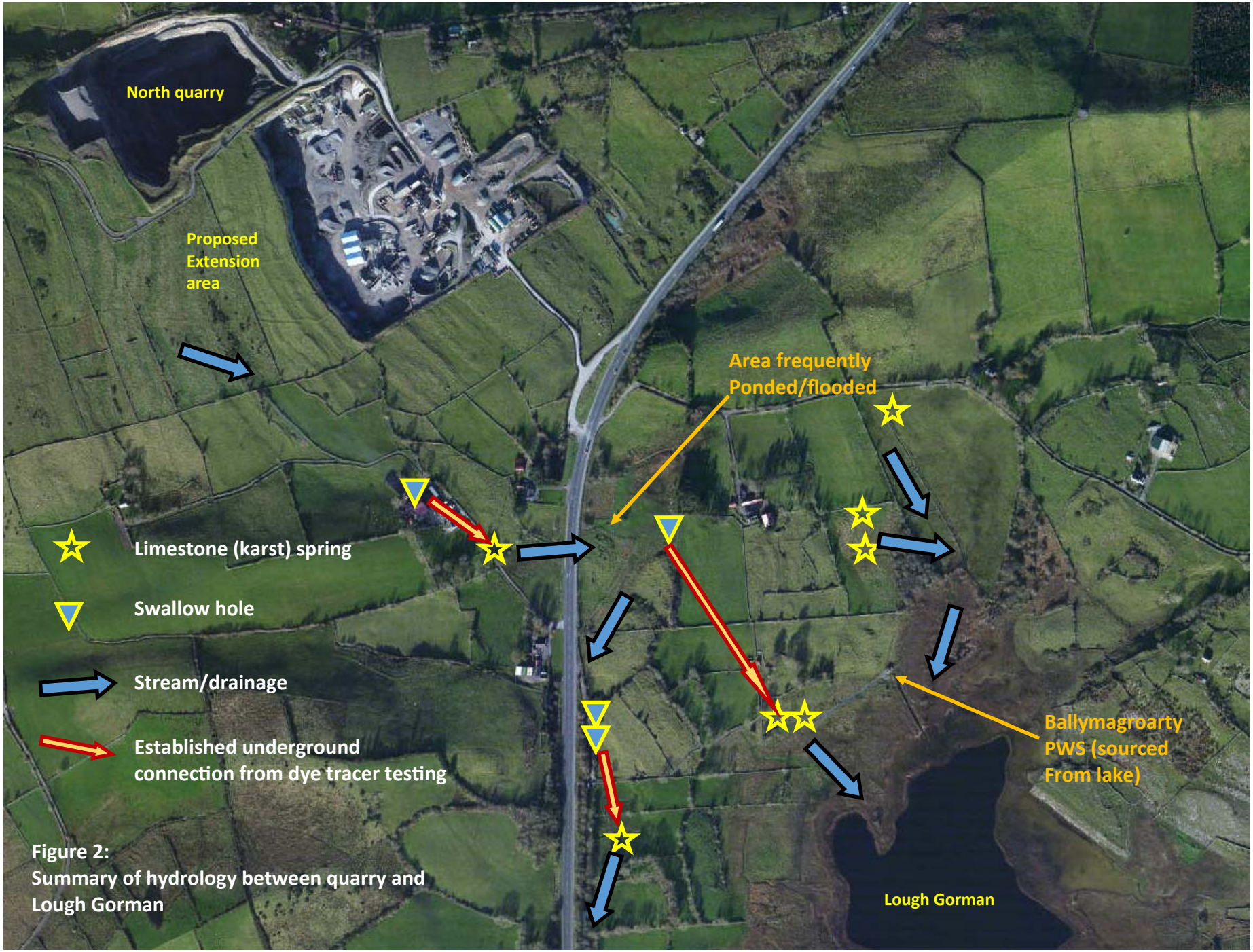

Figure 2:
Summary of hydrology between quarry and Lough Gorman

APPENDIX 1:

REVIEW OF HYDROGEOLOGY SECTION – ORIGINAL EIS

Hydrogeological Assessment Report for Mr. James Gorman

Reference No. SU0128 –
"Remedial Environmental Impact Assessment" for quarry located at
Townlands of Ballymagrorty Irish and Glasbolie, Ballintra, Co. Donegal –
P. McCaffrey & Sons Ltd.

The "North quarry" at Glasbolie Hill is located on a topographical and hydrological divide between the surface water catchments of Lough Durnesh and Lough Gorman. To the north and west of the Glasbolie Hill, surface drainage is towards Lough Durnesh. To the south and east of the Glasbolie Hill, surface drainage is towards Lough Gorman.

The "South quarry" on the southeastern aspect of Glasbolie Hill is located within the surface water catchment of Lough Gorman which is the source of water for the Ballymagroarty public water supply (PWS). The total daily abstraction rate from the lake is approximately 720 m^3/d (pump capacity of 36 m^3/hr). The PWS serves approximately 2,000 people. The South quarry is, therefore, situated directly within the catchment of a major public water supply. Even though surface streams do not directly link the quarry and lake, subsurface pathways between the two may be present, as described below.

From observation during a site visit in October 2014, Lough Gorman is considered to be a groundwater-dependent lake. It receives inflow from three sources: a) surface runoff during heavy rainstorms; b) diffuse groundwater flow (throughout the year); and c) contributions from karstic springs which are located along the lake margins. Lough Gorman was also flagged as a potential groundwater-dependent lake in a preliminary national assessment of abstraction pressures on lakes conducted for the EPA in 2008 (CDM, 2009).

Several karst features, notably springs and swallow holes, are present in the area between Glasbolie Hill and Lough Gorman. Examples of features which have been identified and mapped during site walk-over surveys along the lake's eastern and northern margins (in October 2014 and January 2015) are included in **Attachment 1**. The springs and swallow holes are hydrogeologically significant. Not only do the springs provide water to support the lake and its associated ecosystem(s), but the springs and swallow holes are evidence of a karstic flow system in which groundwater moves through open conduits underground. As surface manifestation of groundwater discharges, each of the springs has a groundwater catchment which is at a higher elevation than the spring itself. The candidate catchment areas of the springs at the western and northern margins of Lough Gorman are the hills to the west and northwest, *i.e.* towards the quarry at Glasbolie Hill.

For these reasons, any pollutants that escape the quarry, either via overland or subsurface pathways, represent a threat to the water quality of, and ecosystems associated with, Lough Gorman. This 'susceptibility' of the lake to pollution is highlighted by the fact that groundwater vulnerability in the entire catchment of Lough Gorman has been mapped as "*Extreme*", which implies that protective subsoils are thin or absent in the "*Extreme*" mapped areas. This is the case both for the quarry location and the area between the quarry and the lake.

Lough Gorman has been designated by the National Parks and Wildlife Service (NPWS) as being part of the "*Carricknahorna Lough and Lough Gorman*" proposed Natural Heritage Area (pNHA). According to the NPWS, a pNHA represents a "*basic designation for wildlife"* and a pNHA is *"an area considered important for the habitats present or which holds species of plants and animals whose habitat needs protection*."

Thus, Lough Gorman, as a pNHA, is deemed by the NPWS to be of significance for wildlife and habitats. The pNHA designations were published nationally on a non-statutory basis in 1995. They have since not been statutorily proposed or designated, but this is a matter of process, not intent. Until they receive statutory designation, which is ongoing work by the NPWS, pNHAs are subject to limited protection, as follows:

a) The objective is to maintain and enhance the conservation status of pNHAs;
b) The ecological value of pNHAs should be recognized by Planning and Licencing Authorities; and
c) Under the Wildlife Amendment Act (2000), pNHAs are legally protected "*from damage*" from the date they are formally proposed for designation (in the case of Lough Gorman, since 1995).

The Carricknahorna Lough and Lough Gorman pNHA is designated as being "*the best examples of marl lakes and flats in Co. Donegal*", comprising "*a rich fen vegetation*". The latter includes variegated horsetails, which is mostly a feature of central Ireland, and thus of interest in the Donegal setting.

The fen vegetation implies that Lough Gorman may also have qualifying interests as a groundwater-dependent terrestrial ecosystem (GWDTE), although it has not yet been officially studied or designated as such. GWDTEs are significant wetland sites. Under Annex I of the EU Habitats Directive, priority habitats for conservation (EPA, 2011) include alkaline fens and calcareous fens (with *Cladium mariscus* and *Carex davalliana*).

Lough Gorman is part of a hydrogeological system in which groundwater flows both via: a) fractures and fissures; and b) open solution conduits underground. The bedrock aquifer that is associated with the quarry and lake is a karstified limestone aquifer. As such, the underground conduits represent preferential pathways of groundwater flow. Pollutants that enter a karstic flow system can travel large distances in short periods of time without any attenuation other than dilution and mixing. Established and reported flow velocities in karst systems elsewhere in Ireland range from a few metres per hour to several hundreds of metres per hour, depending on site-specific hydrogeological conditions. Minimum flow rates between c.15-38 m/hr are reported for tracer tests carried out at Parkhill Spring, which is one of the sources of water to the Ballyshannon PWS (GSI, 2009).

Numerous karst features are visible in the catchment area of Lough Gorman. The swallow holes represent points where surface stream sink underground, only to re-appear as resurgences at springs further downstream. The fact that these features appear in the catchment of Lough Gorman, and in the direction of the quarry, strongly implies that there is a hydrogeological connection between the two. Detailed mapping of karst features in the area has not yet been carried out. Such mapping is expected to reveal additional features to those shown in Attachment 1.

The lake level of Lough Gorman is at an approximate elevation of 77 mOD. The reported water level in the exposed, open North quarry is approximately 50 mOD. Even if the latter is still in recovering (post-dewatering), the difference is significant and raises questions about the hydrogeological characteristics of the area. Specifically, it raises the question if the shallow karst system of Lough Gorman is hydraulically separate from a deeper regional flow system indicated by the North Quarry. If this is the case, then the karst associated with Lough Gorman could be a localised, perched flow system which is superimposed on a regional and separate flow system. This, however, would imply that supporting conditions of other major lakes in the region, such as Carricknahorna Lough (elevation 80 mOD) and Ardpattan Lough (elevation 73

mOD) are also perched. In combination with Lough Gorman, these form a regional drainage system which ultimately discharges at the estuary in Ballyshannon.

Such perched groundwater conditions can only occur if there is a stratigraphic/lithological control which partly prevents or slows down vertical movement of water. This implies the presence of a lower-permeability unit in the underlying relatively low-dipping bedrock formations. Perching could be associated with interbedded calcareous shale units which are known to be present in the Ballyshannon Limestone Formation.

Numerous seeps at several different elevations are also visible high up on the exposed cliff faces of the existing quarries. These support the possible presence of perched water. Some of the seeps occur at discrete cm-scale points rather than along bedding or other horizons. This indicates that rainwater which infiltrates on higher ground may partly be transported laterally in a shallow karst. It can partly also recharge a deeper regional flow system which would be inferred to flow towards Lough Durnesh and the coastline. A conceptual hydrogeological cross-section between Glasbolie Hill and Lough Gorman is shown in **Figure 1**.

It should be noted that the transient recovery of the water level in the North quarry is a slow process, and there are no discussions in the rEIS of how long this might take or what elevation the 'steady-state' water level might reach. It should further be noted that there is an apparent significant difference also in elevations between standing surface water in the South quarry and the lake. The water level of the settling pond water in the South quarry is shown in the rEIS documents to be at an elevation of 85 mOD, *i.e.* 8 m higher than Lough Gorman.

In conclusion, the groundwater-dependency of Lough Gorman and its vulnerability to pollution are factors which places the lake at risk of being impacted by ongoing quarry operations and further expansion. Any future expansion of the quarry, especially in a south or southerly direction, could be detrimental to the lake's role in public water supply and function as an ecosystem.

The hydrogeological assessments that have been carried out to date do not recognise the issues described above. For example, the original assessment which was conducted in 2008 concluded that "*There is no karstification within the quarry or in the immediate area surrounding the existing quarry site meaning there are no pathways for rapid transfer of water to groundwater*". The subsequent rEIS of 2014 acknowledges the karst, but: a) relies on the existing GSI karst database, which is incomplete and a work in progress (*i.e.* the absence of features in an area does not mean they are absent, it could simply mean the area has not yet been mapped); and b) it does not specifically name or address Lough Gorman, a source of public water supply, as a potential receptor of pollution from the quarry operations. It also does not recognise the hydrogeological significance of the surface catchment of Lough Gorman in the direction of the quarry, which is a recharge area to the springs that discharge to the lake.

Accordingly, it is concluded that the rEIS is incomplete in its hydrogeological assessment of potential receptors and impact. To provide greater clarity and certainty to the issues raised in this letter, additional hydrogeological study of Lough Gorman is required. This would have to include the quarry and surrounding areas, and would have to involve detailed karst mapping, flow measurements, piezometry, and possibly involving dye tracer testing to verify karstic pathways. Pending results, additional and new monitoring of the lake, and possibly the springs feeding the lake, is considered prudent.

Yours Sincerely,

Henning Moe, Eur. Geol, P.Geo.

References

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GSI (2009). Donegal Groundwater Protection Scheme. Volume II. Ballyshannon PWS Source Protection Zones. Geological Survey of Ireland, Dublin.

EPA (2011). Environmental Supporting Conditions for Groundwater Dependent Terrestrial Ecosystems (GWDTEs). EPA Funded Project: STRIVE 2007-2013.

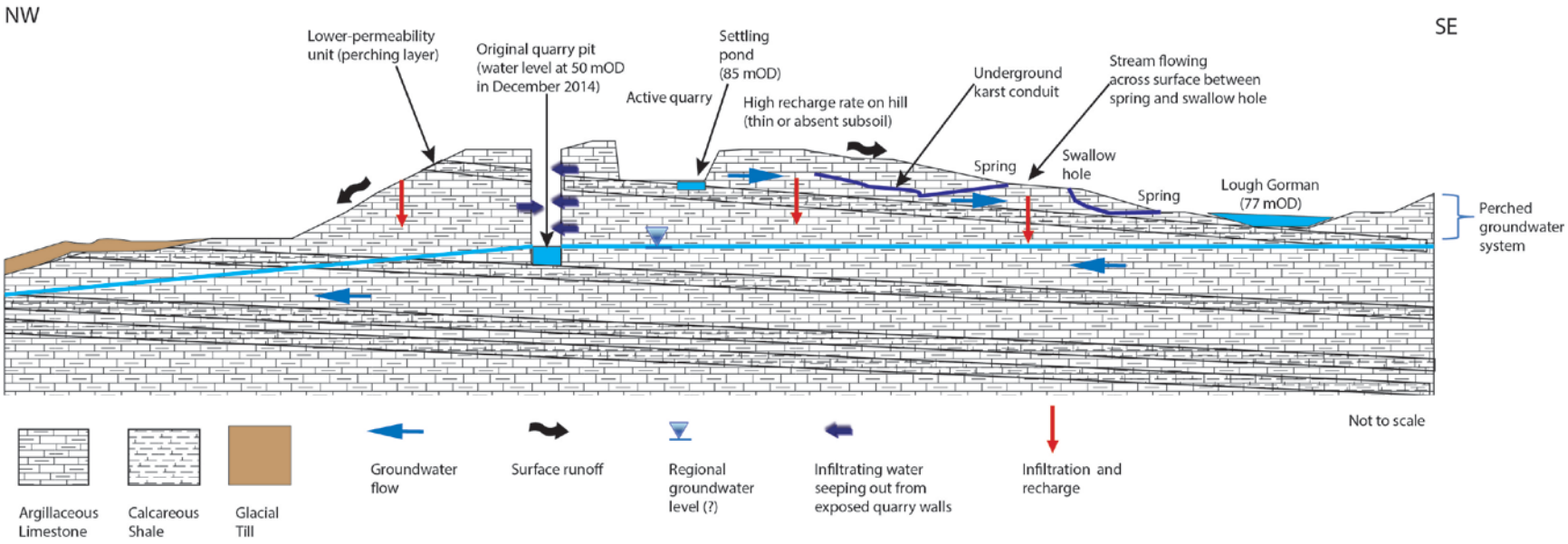


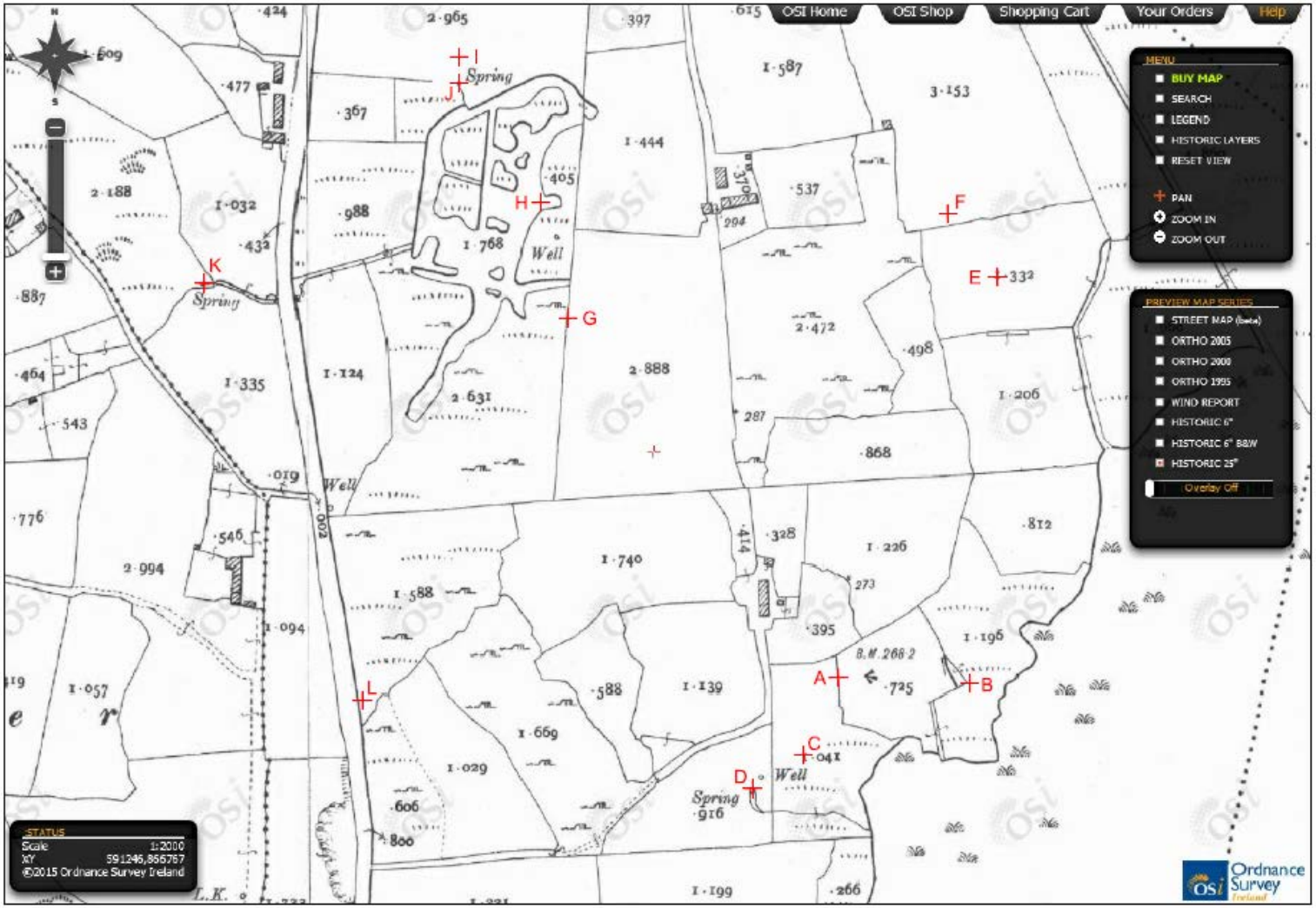
Figure 1: Conceptual hydrogeological cross-section between Glasbolie Hill and Lough Gorman

Attachment 1

No.	Location	Top Water Level mOD Malin Head	Easting	Northing	Feature Type	Comment
A	Stream approx. 10m to west of BM 268.2 at Lough Gorman	78.62	591 256	866 777	Spring	Seepage from ground and flows into Lough Gorman
B	Stream approx. 40m to east side of BM 268.2 at Lough Gorman	77.91	591 322	866 776	Spring	Seepage from ground and flows into Lough Gorman
C	Stream on west side of BM268.2 at Lough Gorman and on south side of access road	78.56	591 238	866 738	Spring	Seepage from ground and flows into Lough Gorman
D	Spring	79.39	591 211	866 720	Spring	Good spring with good flow into Lough Gorman
E	Spring in Bogs	78.37	591 335	866 986	Spring	Water rising in spring and flows into Lough Gorman
F	Spring in field to north of bogs	79.17	591 312	867 019	Spring	Seepage from ground and flows along drain into well at E
G	Swallow Hole under ditch between Sheep field and wet field	83.57	591 115	866 959	Swallow Hole	Swallow Hole working well and taking water. Swallow hole under ditch with Sheep field and 33.5m to south of garden field
H	Swallow Hole/Spring in wet field	83.88	591 103	867 025	Swallow Hole/Spring	Area flooded, 9m to west of ditch and centreline of Gorman bungalow
I	Spring in wet field	84.40	591 062	867 104	Spring	Spring around 20m to north of Spring shown on north side of OS map in wet field
J	Spring in wet field		591 059	867 085	Spring	Spring as shown on OS map
K	Spring at Gorman's dwelling	84.98	590 929	866 982	Spring	Good spring to south of dwelling with good flow into wet field
L	Swallow Hole		591 010	866 767	Swallow Hole	Swallow hole adjoining N15 and working well and taking water from wet field
M	Lough Doo		591 226	867 369	Lake	No direct indication of springs but large fen around lake. Surface water outflow from lake parallel to N15 towards north.
N	Barnyderg		591 186	867 395	Low area	Area parallel to N15 with no outfall and discharging underground

Lough Gorman

Bench Mark at Lough Gorman 268.2 feet Poolbeg		79.047mOD Malin
Surface of Lough Gorman on 8th November 1888	264.0 feet Poolbeg	77.767mOD Malin
Surface of Lough Gorman on 6th January 2015		77.153mOD Malin
Gauge reading at pumphouse 6th January 2015 (top of black line)		0.7m
Top of gauge at 1.5m (top of black line)		77.953mOD Malin
Floor of chemical room in pumphouse		77.772mOD Malin


OSI Home
OSI Shop
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Your Orders
Help
MENU
BUY MAP
SEARCH
LEGEND
HISTORIC LAYERS
RESET VIEW
PAN
ZOOM IN
ZOOM OUT
PREVIEW MAP SERIES
STREET MAP (beta)
ORTHO 2005
ORTHO 2000
ORTHO 1995
WIND REPORT
HISTORIC 6"
HISTORIC 6" B&W
HISTORIC 25"
Overlay Off
STATUS
Scale 1:2000
XY 591246,866767
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A
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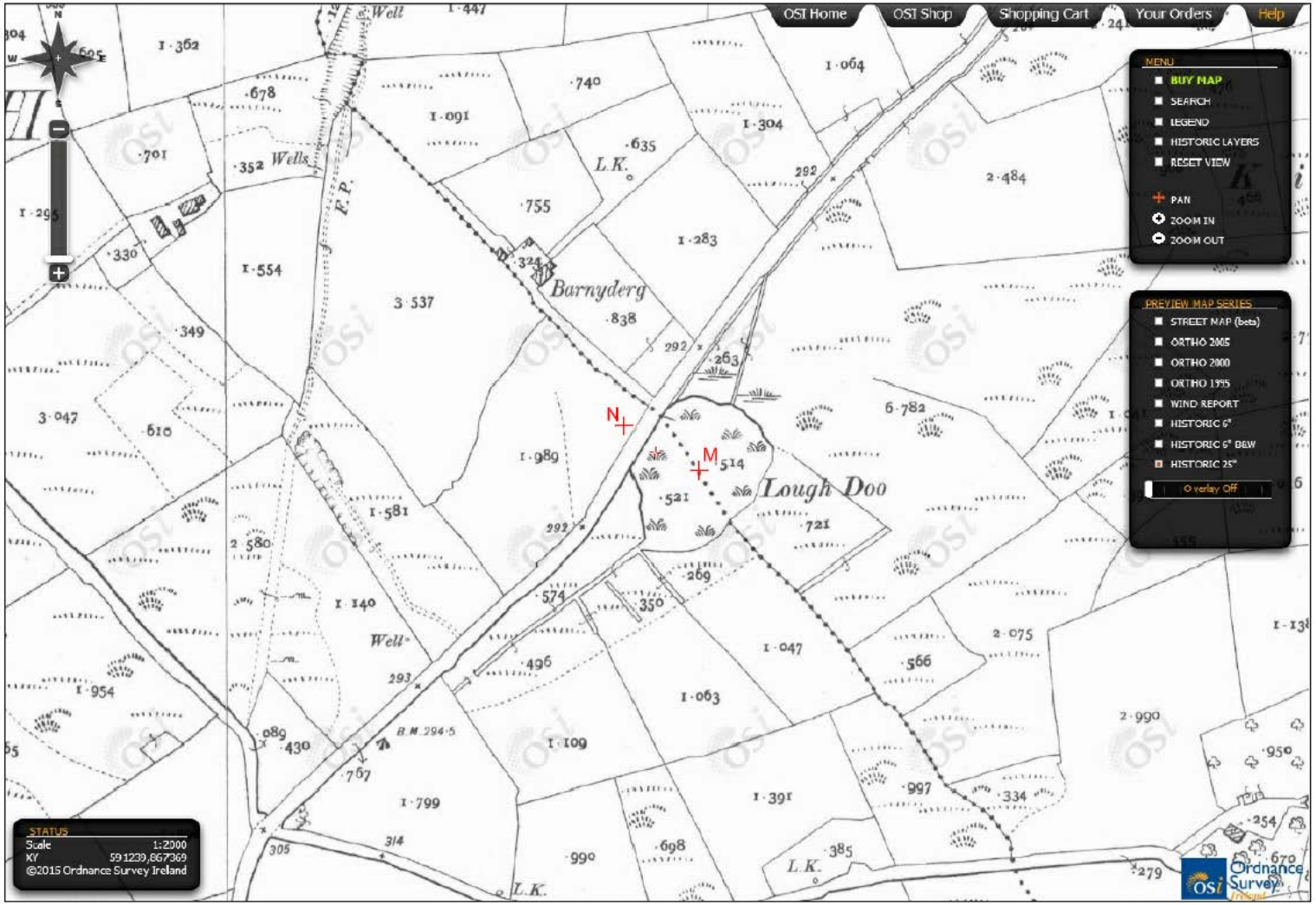


Kieran O'Gorman B.E CEng
8th January 2015

Location L: Active Swallow Hole

Location K: Spring at Gorman's

Location F: looking south towards Lough Gorman
In the foreground is the spring at Location E which drains into Lough Gorman. Visible in the background is the pumping station for the Ballymagroarty Water Supply and fen vegetation surrounding Lough Gorman

Location G: Active Swallow Hole

Location G: Active Swallow Hole

Location K: Stream flowing from Spring at Gorman's (subsequently sinks underground)

Location N: Exposed bedrock (limestone) in background

Location M: Fen around Lough Doo

Location M - Fen around Lough Doo

APPENDIX 2:

DETAILS OF DYE TRACER TESTING – AUGUST/SEPTEMBER 2015

Background Test					
Location Number	**Location Description**	**Day and Date**	**Test being carried out**	**Date Test Completed**	**Result**
1	Gorman's Well	Thursday 6th August 2015	Cotton Wool sample installed to establish background readings	Friday 14th August 2015	Small number of individual green and blue flecs in cotton wool. Check on unused cotton wool roll shows similar flecs
2	Swallow Hole No 1 adjacent to N15	Thursday 6th August 2015	Cotton Wool sample installed to establish background readings	Friday 14th August 2015	Small number of individual green and blue flecs in cotton wool. Check on unused cotton wool roll shows similar flecs
3	Underpass	Thursday 6th August 2015	Cotton Wool sample installed to establish background readings	Friday 14th August 2015	Small number of individual green and blue flecs in cotton wool. Check on unused cotton wool roll shows similar flecs
4	Yankees Spring	Thursday 6th August 2015	Cotton Wool sample installed to establish background readings	Friday 14th August 2015	Small number of individual green and blue flecs in cotton wool. Check on unused cotton wool roll shows similar flecs
5	Drain in field on west side of access road	Thursday 6th August 2015	Cotton Wool sample installed to establish background readings	Friday 14th August 2015	Small number of individual green and blue flecs in cotton wool. Check on unused cotton wool roll shows similar flecs
6	Drain in field on east side of access road	Thursday 6th August 2015	Cotton Wool sample installed to establish background readings	Friday 14th August 2015	Small number of individual green and blue flecs in cotton wool. Check on unused cotton wool roll shows similar flecs
7	Pumphouse inlet	Thursday 6th August 2015	Cotton Wool sample installed to establish background readings	Friday 14th August 2015	Small number of individual green and blue flecs in cotton wool. Check on unused cotton wool roll shows similar flecs
8	Bogs - drain on eastern side	Thursday 6th August 2015	Cotton Wool sample installed to establish background readings	Friday 14th August 2015	Small number of individual green and blue flecs in cotton wool. Check on unused cotton wool roll shows similar flecs
9	Spring in Maggie's	Thursday 6th August 2015	Cotton Wool sample installed to establish background readings	Friday 14th August 2015	Small number of individual green and blue flecs in cotton wool. Check on unused cotton wool roll shows similar flecs
10	Pipe crossing N15 and discharging into drain from Spring	Thursday 6th August 2015	Cotton Wool sample installed to establish background readings	Friday 14th August 2015	Clear - probably due to volume of water discharging through pipe

Gorman's Well
Cotton Wool sample installed to establish background readings
Collecting: 14/08/2015

Swallow Hole No 1 adjacent to N15 at Location 2
Cotton Wool sample installed to establish background readings
Collecting: 14/08/2015

Underpass
Cotton Wool sample installed to establish background readings
Collecting: 14/08/2015

Yankees Spring
Cotton Wool sample installed to establish background readings
Collecting: 14/08/2015

Drain in field on west side of access road
Cotton Wool sample installed to establish background readings
Collecting: 14/08/2014

Drain in field on east side of access road
Cotton Wool sample installed to establish background readings
Collecting: 14/08/2015

Pumphouse inlet
Cotton Wool sample installed to establish background readings
Collecting: 14/08/2015

Bogs - drain on eastern side
Cotton Wool sample installed to establish background readings
Collecting: 14/08/2015

Spring in Maggie's
Cotton Wool sample installed to establish background readings
Collecting: 14/08/2015

Pipe crossing N15 and discharging into drain from Spring
Cotton Wool sample installed to establish background readings
Collecting: 14/08/2015

Swallow Hole No 1 @N15 - 12.5 litres of Ultrabrite poured into Swallow Hole No 1 at 14:30 hours on 15th August 2015					
Location Number	**Location Description**	**Day and Date**	**Test being carried out**	**Date Test Completed**	**Result**
1	Gorman's Well	Saturday 15th August 2015		Saturday 29th August 2015 Samples retrieved and tested with UV lamp	Clear
2	Swallow Hole No 1 adjacent to N15	Saturday 15th August 2015	12.5 litres of ultrabrite poured in Swallow Hole No 1 at 14:30	Saturday 29th August 2015 Samples retrieved and tested with UV lamp	Clear
3	Underpass	Saturday 15th August 2015		Saturday 29th August 2015 Samples retrieved and tested with UV lamp	Clear
4	Yankees Spring	Saturday 15th August 2015		Saturday 29th August 2015 Samples retrieved and tested with UV lamp	Clear
5	Drain in field on west side of access road	Saturday 15th August 2015		Saturday 29th August 2015 Samples retrieved and tested with UV lamp	Clear
6	Drain in field on east side of access road	Saturday 15th August 2015		Saturday 29th August 2015 Samples retrieved and tested with UV lamp	Clear
7	Pumphouse inlet	Saturday 15th August 2015		Saturday 29th August 2015 Samples retrieved and tested with UV lamp	Clear
8	Bogs - drain on eastern side	Saturday 15th August 2015		Saturday 29th August 2015 Samples retrieved and tested with UV lamp	Clear
9	Spring in Maggie's	Saturday 15th August 2015		Friday 28th August 2015 Samples retrieved and tested with UV lamp	Entire cotton wool ball glowing under UV lamp
10	Pipe crossing N15 and discharging into drain from Spring	Saturday 15th August 2015		Friday 28th August 2015 Samples retrieved and tested with UV lamp	Clear

Yankees Spring
Cotton Wool sample collected to establish flow from Swallow Hole No 1
Collecting: 29/08/2015

Drain in field on west side of access road
Cotton Wool sample collected to establish flow from Swallow Hole No 1
Collecting: 29/08/2015

Drain in field on east side of access road
Cotton Wool sample collected to establish flow from Swallow Hole No 1
Collecting: 29/08/2015

Pumphouse inlet
Cotton Wool sample collected to establish flow from Swallow Hole No 1
Collecting: 29/08/2015

Bogs – drain on eastern side
Cotton Wool sample collected to establish flow from Swallow Hole No 1
Collecting: 29/08/2015

Spring in Maggie's
Cotton Wool sample collected to establish flow from Swallow Hole No 1
Collecting: 28/08/2015

Pipe crossing N15 and discharging into drain from Spring
Cotton Wool sample collected to establish flow from Swallow Hole No 1
Collecting: 28/08/2015

Background Test					
Location Number	**Location Description**	**Day and Date**	**Test being carried out**	**Date Test Completed**	**Result**
1	Gorman's Well				
2	Swallow Hole No 1 adjacent to N15				
3	Underpass				
4	Yankees Spring				
5	Drain in field on west side of access road				
6	Drain in field on east side of access road				
7	Pumphouse inlet				
8	Bogs - drain on eastern side				
9	Spring in Maggie's	Saturday 29th August 2015	Cotton placed to check clear	Saturday 5th September 2015	Light glow of cotton wool ball under UV lamp
10	Pipe crossing N15 and discharging into drain from Spring	Saturday 29th August 2015	Cotton placed to check clear	Saturday 5th September 2015	Clear

Spring in Maggie's
Cotton placed to check clear
Collecting: 05/09/2015

Spring in Maggie's and Pipe crossing N15 Cotton placed to check clear
Collecting: 05/09/20

Swallow Hole No 2 at Sheep Field - 12.5 litres of ultrabrite poured into Swallow Hole No 2 at 16:00 hours on 5th September 2015					
Location Number	**Location Description**	**Day and Date**	**Test being carried out**	**Date Test Completed**	**Result**
1	Gorman's Well	Saturday 5th September 2015		24th September 2015	Clear
2	Swallow Hole No 1 adjacent to N15	Saturday 5th September 2015		24th September 2015	Clear
3	Underpass	Saturday 5th September 2015		24th September 2015	Clear
4	Yankees Spring	Saturday 5th September 2015	Three cottons placed here 4a, 4b, 4c	24th September 2015	Extremely bright cotton - glowing
5	Drain in field on west side of access road	Saturday 5th September 2015		24th September 2015	Slightly bright
6	Drain in field on east side of access road	Saturday 5th September 2015		24th September 2015	Clear
7	Pumphouse inlet	Saturday 5th September 2015		24th September 2015	Clear
8	Bogs - drain on eastern side	Saturday 5th September 2015		24th September 2015	Clear
9	Spring in Maggie's	Saturday 5th September 2015		24th September 2015	Clear
10	Pipe crossing N15 and discharging into drain from Spring	Saturday 5th September 2015		24th September 2015	Clear
11	Bogs - drain flowing nortt south	Saturday 5th September 2015		24th September 2015	Clear
	Swallow Hole at Sheep Field				

Gorman's Well
Cotton installation on 05/09/2015

Swallow Hole No 1 adjacent to N15
Cotton installation on 05/09/2015

Underpass
Cotton installation on 05/09/2015

Yankees Spring
Cotton installation on 05/09/2015

Drain in field on west side of access road
Cotton installation on 05/09/2015

Drain in field on east side of access road
Cotton installation on 05/09/2015

Pumphouse inlet
Cotton placed to check clear
Installing: 05/09/2015

Spring in Maggie's
Cotton placed to check clear
Installing: 05/09/2015

Pipe crossing N15 and discharging into drain from Spring
Cotton placed to check clear
Installing: 05/09/2015

Bogs - drain flowing nort south
Cotton placed to check clear
Installing: 05/09/2015

Swallow Hole No 2 at Sheep Field

12.5 litres of ultrabrite poured in Swallow Hole No 2 at 16:00 hours on Saturday 05th September 2015

Gorman's Well
Cotton Wool sample collected to establish groundwater flow from Swallow Hole No 2
Collecting: 25/09/2015

Swallow Hole No 1 adjacent to N15
Cotton Wool sample collected to establish groundwater flow from Swallow Hole No 2
Collecting: 25/09/2015

Underpass
Cotton Wool sample collected to establish groundwater flow from Swallow Hole No 2
Collecting: 25/09/2015

Yankees Spring
Cotton Wool sample collected to establish groundwater flow from Swallow Hole No 2
Collecting: 25/09/2015

Drain in field on west side of access road
Cotton Wool sample collected to establish groundwater flow from Swallow Hole No 2
Collecting: 25/09/2015

Drain in field on east side of access road
Cotton Wool sample collected to establish groundwater flow from Swallow Hole No 2
Collecting: 25/09/2015

Pumphouse inlet
Cotton Wool sample collected to establish groundwater flow from Swallow Hole No 2
Collecting: 25/09/2015

Bogs - drain on eastern side
Cotton Wool sample collected to establish groundwater flow from Swallow Hole No 2
Collecting: 25/09/2015

Spring in Maggie's
Cotton Wool sample collected to establish groundwater flow from Swallow Hole No 2
Collecting: 25/09/2015

Pipe crossing N15 and discharging into drain from Spring
Cotton Wool sample collected to establish groundwater flow from Swallow Hole No 2
Collecting: 25/09/2015

Bogs - drain flowing north south
Cotton Wool sample collected to establish groundwater flow from Swallow Hole No 2
Collecting: 25/09/2015

Cottons 1 - 11 collected on 25th September 2015
Cotton Wool sample collected to establish groundwater flow from Swallow Hole No 2

Background Test					
Location Number	**Location Description**	**Day and Date**	**Test being carried out**	**Date Test Completed**	**Result**
1	Gorman's Well				
2	Swallow Hole No 1 adjacent to N15				
3	Underpass				
4	Yankees Spring	26th September 2015	Cotton placed here	10th October 2015	Still glowing
5	Drain in field on west side of access road	26th September 2015	Cotton placed here	10th October 2015	Clear
6	Drain in field on east side of access road				
7	Pumphouse inlet				
8	Bogs - drain on eastern side				
9	Spring in Maggie's				
10	Pipe crossing N15 and discharging into drain from Spring				

Yankees Spring location No. 4
Cotton placed to check clear
Installing: 26/09/2015

Drain from Yankee's spring at Location 4 flowing towards Lough Gorman

Drain from Yankee's spring at Location 4 flowing towards Lough Gorman – taken at stone ditch
Colour and type of vegetation indicates ground water

Drain from spring at Cotton 5 flowing towards Lough Gorman
Pumphouse for Ballymagroarty Group Water Supply at Lough Gorman in background
Colour and type of vegetation indicates ground water

Drain at Cotton 9

Drain at cotton 9 looking east towards Lough Gorman

Dry Swallow Hole adjacent to SW No 1 (invert level 83.481mOD)

Swallow Hole No 1 (invert level 83.266mOD)

Drain flowing towards Swallow Hole No 1

Drain flowing towards Swallow Hole No 1

Drain flowing towards Swallow Hole No 1
Colour and type of vegetation indicates ground water

Drain flowing towards Swallow Hole No 1
Colour and type of vegetation indicates ground water

Drain flowing towards Swallow Hole No 1

Drain flowing towards Swallow Hole No 1

31st December 2015

2nd January 2016

View of Lough Doo looking north east January 2015

View of Barnaderg looking north January 2015

View of Lough Doo looking north east January 2015

Lough Doo January 2015

Drain at Barnaderg January 2015

Drain at Barnaderg January 2015

Possible swallow hole at Barnyderg – south of quarry

Exposed rock face in field at Barnyderg – south of quarry and north of N15

Swallow Hole No 2 at Sheep Field - January 2015

Swallow Hole No 2 at Sheep Field - January 2015

Swallow Hole adjacent to Swallow Hole No 1- Point ID 81 invert level 83.481mOD
Swallow Hole working January 2015

Swallow Hole adjacent to Swallow Hole No 1- Point ID 81 invert level 83.481mOD
Swallow Hole dry on 26th September 2015

Access road into north quarry with deposition from dumping
07/08/2015

West face of north quarry
07/08/2015

Access road into north quarry with deposition from unauthorised dumping on cliff face
07/08/2015

Access road into north quarry with deposition from unauthorised dumping on cliff face
07/08/2015

South face of north quarry
07/08/2015

North Quarry water level

North Quarry water level

North Quarry water level

West face of north quarry
07/08/2015

West face of north quarry 07/08/2015

Photograph of west face of north quarry with cracks through rock face
07/08/2015

West face of north quarry with cracks through rock face
07/08/2015

North quarry with vertical cliff faces
07/08/2015

South Quarry
07/08/2015

South Quarry
07/08/2015

South Quarry with Lough Gorman in background
07/08/2015

South Quarry – additional pond recently excavated in floor of quarry
07/08/2015

South Quarry
07/08/2015

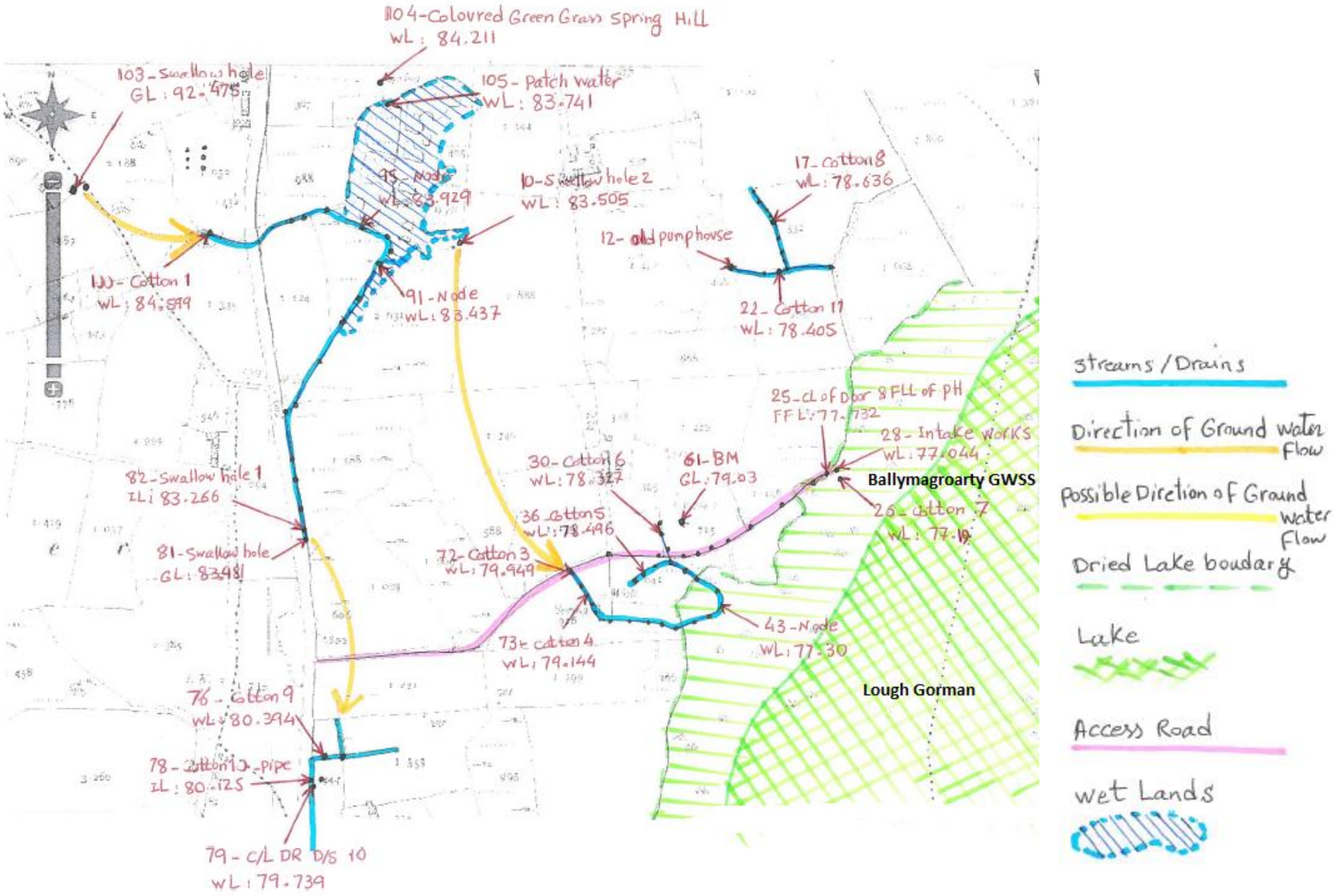
South Quarry
07/08/2015

Conclusion

The purpose of the survey was to establish groundwater flows in the vicinity of P McCaffrey & Sons Ltd Quarry. Cottons were placed in streams and springs to first determine background levels of detergents in the water which may cause the cottons to glow and interfere with the test results. The cottons were left in place for a number of days and removed and examined under ultraviolet light. Twelve and a half litres of Ultrabrite was poured into two swallow holes during two different test periods, the ultrabrite flows in the direction of the groundwater and is collected in the cottons. These cottons glow when examined under ultraviolet light and this confirms the direction of groundwater flow. The report includes coordinates and photographs of a number of water features in the locality. The results of the tests are shown plotted on the maps overleaf.

Point ID	Easting (Local)	Northing (Local)	Elevation (Local)	Description
10	591115.632	866974.028	83.505	C/L & TOP WATER LEVEL (TWL) of SWALLOW HOLE NO 2
12	591305.824	866955.611	81.872	C/L OF OLD PUMPHOUSE
17	591335.051	866989.226	78.636	C/L OF DRAIN IN BOGS COTTON NO 8
22	591339.759	866954.549	78.405	COTTON N0 11
25	591374.881	866812.565	77.732	C/L OF DOOR AND FINISHED FLOOR LEVEL (FFL) OF PUMPHOUSE
26	591382.602	866808.602	77.19	COTTON NO 7 - 2m EAST of PUMPHOUSE
28	591380.685	866814.944	77.044	C/L OF INTAKE AND TWL
30	591258.581	866769.579	78.327	COTTON NO 6
36	591243.858	866742.45	78.496	DRAIN 5 COTTON NO 5 - 100mm depth WATER
61	591270.189	866776.674	79.03	OS BENCH MARK (268.2 feet poolbeg = 79.047mOD Malin)
72	591194.363	866740.982	79.949	COTTON NO 3
73	591211.248	866721.174	79.144	COTTON NO 4C TOP
76	591021.114	866610.54	80.394	COTTON NO 9 MAGGIES
78	591013.07	866596.033	80.125	COTTON NO 10 IL 300MM PIPE
79	591013.746	866594.807	79.739	C/L DR D/S COTTON 10
81	591008.633	866765.056	83.481	IL OF DRY SW HOLE
82	591007.744	866769.028	83.266	IL SW NO 1 MOUTH
91	591061.781	866961.17	83.437	SOYAH 4
95	591051.874	866984.718	83.929	SOYAH TOWARDS HOUSE GEN LEVEL
100	590942.27	866979.526	84.599	COTTON NO 1
103	590843.822	867005.302	92.475	SWALLOW HOLE AT MC SHEAS
104	591060.033	867083.046	84.211	COLOURED GREEN GRASS SPRING - HILL
105	591064.605	867068.199	83.741	PATCH WATER CRESS SOYAH OFF HILL
243	590979.091	867360.739	88.845	SOAKPIT BARNADERG
244	590993.944	867328.213	89.221	SWALLOW HOLE AT BARNADERG
245	591075.703	867280.041	86.515	DRAIN AT N15 BARNADERG
246	591261.926	867369.152	85.4	WL IN MCGEE AT FOXS LOUGH


243 - Soak pit
GL : 88.845
244 - Swallow hole
GL : 89.221
245 - Drain D NIS
WL : 86.515
246 - WL @ Foxs Laigh
WL : 85.40
Lough Doo


104-Coloured Green Grass Spring Hill
WL: 84.211
103-Swallow hole
GL: 92.475
105-Patch water
WL: 83.741
95-Node
WL: 83.929
10-Swallow hole 2
WL: 83.505
17-Cotton 8
WL: 78.636
12-old pumphouse
100-Cotton 1
WL: 84.599
91-Node
WL: 83.437
22-Cotton 11
WL: 78.405
25-CL of Door & FLL of pH
FFL: 77.732
28-Intake Works
WL: 77.044
Ballymagroarty GWSS
30-Cotton 6
WL: 78.327
61-BM
GL: 79.03
82-Swallow hole 1
IL: 83.266
36-Cotton 5
WL: 78.496
26-Cotton 7
WL: 77.19
81-Swallow hole
GL: 83.98
72-Cotton 3
WL: 79.949
43-Node
WL: 77.30
73-Cotton 4
WL: 79.144
Lough Gorman
76-Cotton 9
WL: 80.394
78-Cotton 10-Pipe
IL: 80.125
79-C/L DR D/S 10
WL: 79.739
Streams / Drains
Direction of Ground water Flow
Possible Direction of Ground water Flow
Dried Lake boudary
Lake
Access Road
wet Lands