Assessment of Tufa Springs

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Coolnabacky Sub-station site, Timahoe

March 2022

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

Client: ESB Networks

Location: Coolnabacky Sub-station site, Timahoe

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1. Introduction

IE Consulting were appointed by ESB Networks to conduct an assessment of the Tufa springs and Tufa Deposits on and adjacent to the proposed ESB substation at Coolnabacky Co. Laois. The proposed substation is an element of a network improvement scheme for the Laois-Kilkenny Area.

1.1. Tufa (Petrifying) Springs

Petrifying springs (tufa springs) as described by Lyons and Kelly (2016), are springs with lime-rich water that deposit tufa (porous calcareous rock). This water is rich in carbon dioxide and calcium carbonate, resulting in a high pH environment with a constant source of water and precipitated calcium carbonate.

The tufa can also be deposited along outflow streams from the springs. The unique conditions of these springs means the flora and fauna that inhabit them are highly specialised.

Petrifying springs and the associated tufa are designated as a priority habitat under Annex I of the European Union Habitats Directive (92/43/EEC). This establishes that member states are obligated to monitor and report on the conservation status of these habitats. A significant condition within the Monitoring Guideline (Lyons and Kelly, 2016), in reference to tufa springs is that "in order to preserve this habitat of very limited expanse in the field it is essential to preserve its surroundings and whole hydrological system concerned."

Therefore it is important that any effect the proposed substation construction may have on the hydrogeological environment is considered in reference to these springs.

1.2. Summary of Hydrogeological Environment

The site is in a low lying, relatively flat area which becomes hummocky 150-200m south and west of the site. The location of the site is shown below in Figure 1.

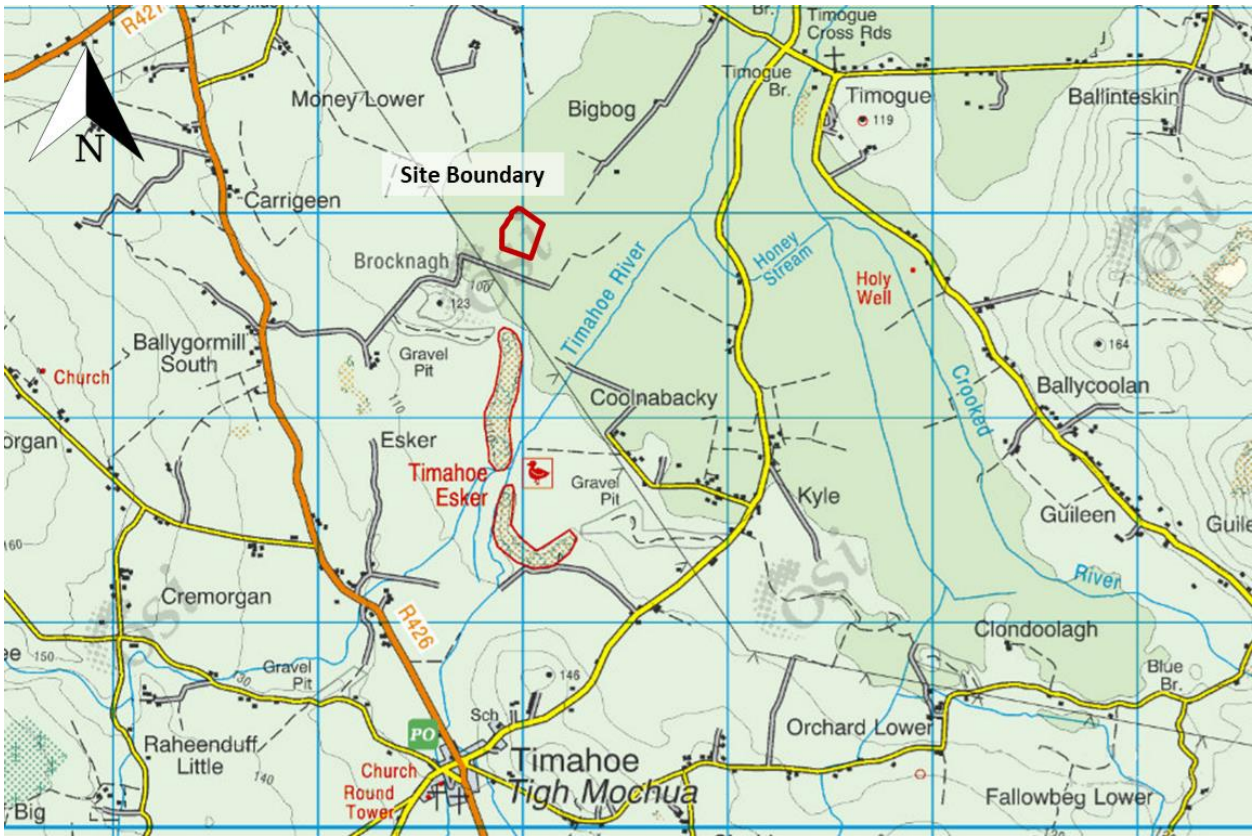

Figure 1: Location of site

The main surface water drainage feature in the area is the Timahoe River which flows 500m east of the site, which later becomes the Bauteoge River. The un-named stream that borders the site to the north eventually joins the Timahoe River. The majority of the surface water courses in the area are canalised or modified and there is extensive drainage in the low lying area. There are field drains on the western, eastern and southern borders of the Sub-station site.

The bedrock aquifer below the site is mapped as an Rkd (Regionally Important Aquifer – Karstified-diffuse). The GSI maps the area as being in a sand and gravel aquifer, but site specific studies have confirmed that the sand and gravel deposits on site do not comprise an aquifer (EIAR chapters 9 and 10, 2013; Tobins Report, 2007; SLR, 2018; IE Consulting, 2021).

The underlying bedrock geology of the site comprises limestone of the Ballyadams Formation which is described as thick bedded to massive wackestones and packstones (GSI, 2022). Subsoils consist of Alluvium under the site, with gravels derived from limestones mapped to the north, west, and south of the site (GSI, 2022). The GSI maps mineral alluvium as the soils beneath the site and shallow poorly drained mineral (manly basic) (BminSP) to the north, west, and south of the site (Teagasc, 2022).

For more detailed information on the hydrological and hydrogeological setting see Appendix A.

1.3. Recommendations for Tufa Study

In February 2021 IE consulting issued a hydrogeological report to assess the potential impact from the proposed substation on the hydrological and hydrogeological environment. This report made the following recommendations.

1. A geophysical survey using electromagnetic surveying to map the subsurface shallow deposits to better understand the subsoil profile and enhance the original ground model.
2. 5 No. shallow groundwater monitoring points be installed around the site locations away from the proposed footprint. These should be levelled to a common datum and groundwater levels measured every six hours using level transducers and this monitoring should continue over two seasons to help improve the understanding of groundwater hydraulics of the shallow deposits on the site and inform the further assessment of the tufa springs.
3. Groundwater samples should be taken from the shallow wells and analysed for Nitrate, Nitrite, Phosphorous, Ammonia, Chloride, Potassium and Sodium, Conductivity, pH. to provide a baseline for future monitoring. Future monitoring should continue twice a year for the same parameters. This will assist in the protection of tufa spring habitats as they are very sensitive to nutrient loading.
4. A more in depth ecological assessment of the tufa springs should be undertaken using the above data in the context of it being an Annex I habitat and following NPWS guidelines to enhance understanding of the tufa springs and their connectivity to the site.
5. Once items 1-4 are completed, the storm water management system should be reviewed to ensure the existing hydrological system is optimised to support the tufa springs as required under the habitats directive.
6. Once drilled, groundwater quality from the proposed supply well should be monitored twice per year.

1.4. Approach to study

This report is based on the review of the data and findings from the following:

- Hydrogeological and Hydrological Review (IE consulting, 2021)
- Geophysical Survey (Minerex Geophysics Limited, 2021)
- Borehole logs (Priority Geotechnical Ltd, 2021)
- Onsite Groundwater Level Data-undertaken by IE Consulting (2021-2022)

- Onsite Raw Water Quality Data from samples taken by IE Consulting (2021)
- Met Eireann Rainfall Teagasc, Oak Park Carlow (2021)
- Ecological Assessment Tufa Spring (Denyer Ecology, 2021)
- Monitoring Guidelines for the Assessment of Petrifying Springs in Ireland. Irish Wildlife Manual No. 94 NPWS (Lyons & Kelly, 2016)

2. Geophysical Survey

A geophysical survey comprising an EM31 ground conductivity survey was conducted by Minerex Geophysics Ltd. (MGX) on April 23rd 2021. The survey was undertaken to better understand the ground conditions beneath the site and along the access road, survey relative variations in subsoil and material type and to establish permeability and how it changes across the site. This survey technique penetrates up to 6m bgl.

Boreholes on the site show that bedrock is deeper than 6m and therefore all variation in conductivity is due to soil and subsoil. The boreholes and trial puts on the site indicated sandy, gravelly, clay and some sand or gravel lenses. This information was used to interpret changes in conductivity across the site.

Lower conductivities are typical of dry clean sands and gravels, while higher conductivities are typical of peats and clays. This in the context of the previously collected information on the subsoil helped with the interpretation of the variation in conductivity across the site.

The geophysical interpretation indicates that conductivity less than 5 mS/m represents clayey, silty Sand and Gravel, conductivity between 5 - 10 mS/m is sandy, gravelly Clay and Silt, and conductivity higher than 10 mS/m are for slightly sandy and slightly gravelly Clay and Silt. The permeability is highest in areas with low conductivity (more sand and gravel) and lowest in areas of high conductivity (higher clay and silt content).

The ground underlying the proposed substation site was found to be relatively homogenous (7-11 mS/m) while the access road shows larger variation, with sand and gravel occurring closest to the quarry. The substation site is mostly underlain by sandy and gravelly clay and silt with slightly gravelly clay and silt around the western and eastern edges of the field. There are patches with higher sand and gravel content (low conductivity) under the site, especially towards the north, with expected higher permeability.

These higher permeability sand and gravel rich lenses that were targeted for monitoring boreholes to be drilled.

Detailed results of the geophysical survey are presented in Appendix B. Figure 2 shows the relative variation in conductivity across the site.

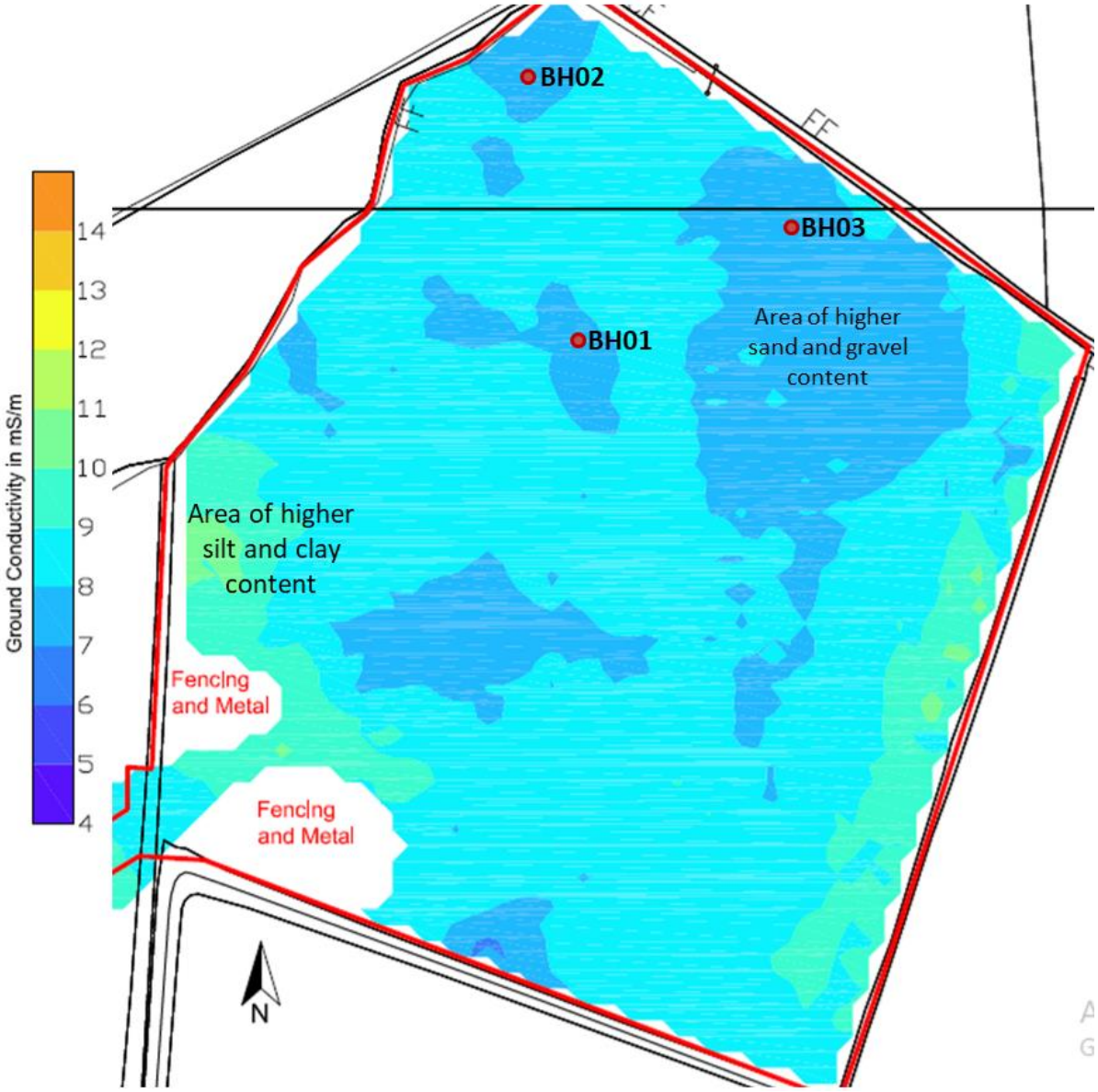

Figure 2: Conductivity variation across substation site (adapted from Minerex report, 2021)

3. Boreholes

Three Cable Percussion Boreholes were drilled on the site on 26/05/2021, each to a depth of 3m (BH1, BH2, BH3). There were a further two boreholes on the site from previous investigations, which were found to be usable to make up the required compliment of 5. The locations of the three new boreholes are shown above in Figure 4. A Bentonite seal was placed at the base of each borehole and from 0.3m to

ground level to prevent ingress of surface water. Each borehole was fitted with a 50mm casing with a bottom cap, slotted up to 0.5m from ground level and surrounded by pea gravel.

All wells were described as having clay with cobble content to 1m bgl and gravel from 1-3m bgl. BH1 and BH2 were recorded as having dense gravel.

Figure 2 shows the location of these boreholes. Drilling logs for the boreholes are in Appendix C.

3.1. Water Level Monitoring

Water level monitoring was undertaken at all three wells using transducers from 24/06/2021 to 12/12/2021. All wells were levelled to common datum and water level was measured every six hours using water level recorder pressure transducers.

Water levels at BH1 ranged from 1.3442m depth (below top of casing) (08/12/21) to 0.39m depth (below top of casing). (27/10/21). At BH2 water levels ranged from 1.173m depth (below top of casing) (09/12/21) to 0.3404m depth (07/10/21) (below top of casing) . At BH3 water levels ranged from 0.8016m (below top of casing) (08/12/21) to 0.0625m (05/10/21).

Manual groundwater level readings were also taken by an IE Consulting hydrologist four times between August 2021 and January 2022. The reduced levels m.O.D are shown in Table 1. This data show a fluctuation of about 0.3m to 0.4 from dry period to a few weeks of rain. The reduced levels also confirms the groundwater gradient from southwest to northeast.

Table 1: Groundwater level as measured by IE Consulting Hydrologist (m.O.D)

BH	12-Aug-2021	15-Nov-2021	14-Dec-2021	6-Jan-2022
1	97.585	97.655	97.885	97.91
2	97.339	97.609	97.859	97.941*
3	96.624	96.564	96.904	96.984

* Borehole had collapsed

The water levels are lowest at well BH3 which shows a gradient towards BH3, from southwest to northeast. Figure 3 shows groundwater contours for the site. This would suggest that the source spring for the tufa deposits, is fed from off-site to the southwest.

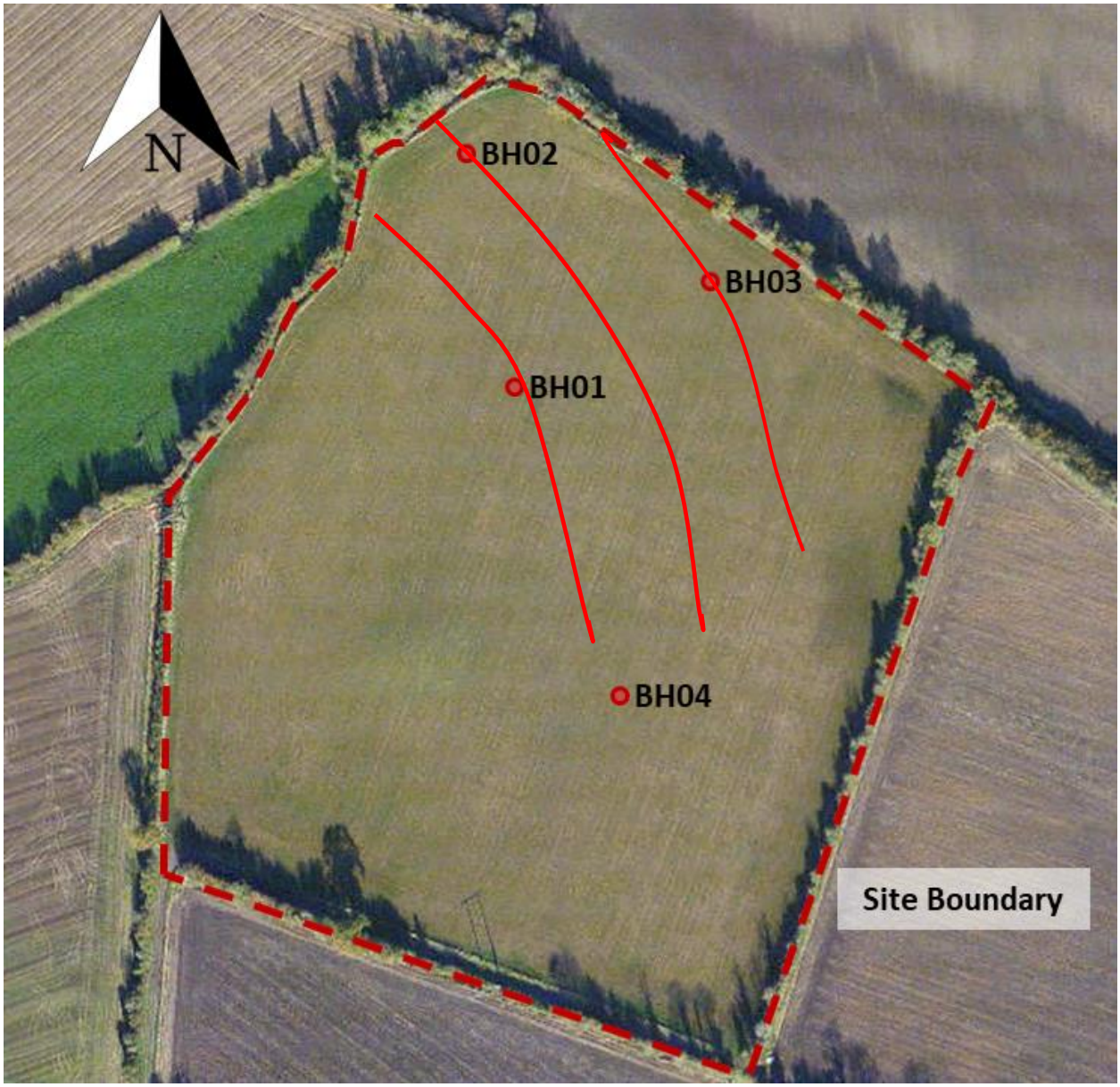

Figure 3: Groundwater contours for site

The long term transducer data was examined to understand how changes in rainfall effect changes in groundwater levels at the site. Met Eireann rainfall records from Teagasc, Oak Park, Carlow were used to investigate this relationship. Figure 4 below shows rainfall graphed against groundwater levels at each of the three boreholes. This data shows that water levels are closely connected to rainfall and rise after extensive rainfalls. The data shows a steady decline in water levels through the late summer into

Autumn, with sporadic increases associated with rainfall events. However, the expected low SMD (soil moisture deficit) and below average monthly rainfall for the three month period (July August and September), could not avert the downward trend. The above average (120% of LTA) rainfall from October, starts to overcome the positive SMD and perched groundwater levels start to rise.

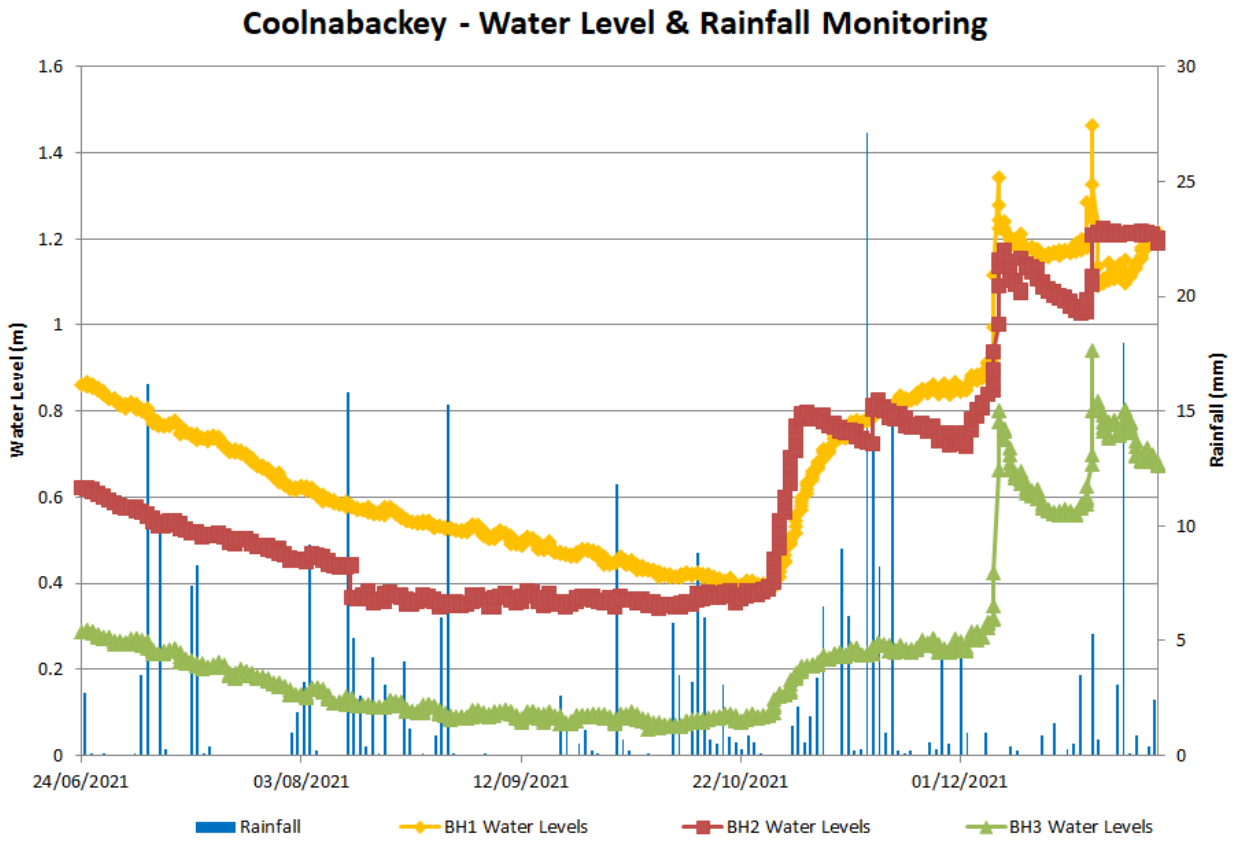

Figure 4: Variation in groundwater level and rainfall

Overall, the data shows a dynamic perched groundwater system, that has a definite groundwater gradient, with water levels that respond to sustained rainfall periods, that overcome the positive SMD.

3.2. Water Quality

Water quality was sampling was undertaken on 14/12/2021 by an IE Consulting hydrogeologist. Four groundwater wells across the site were sampled. In addition to the three drilled boreholes BH04 (drilled as part of a ground investigation by Causeway Geotech) was also sampled. The borehole is located further south than the other three. It is 9.5m deep and does not reach bedrock.

The location of the boreholes is shown below in Figure 5.

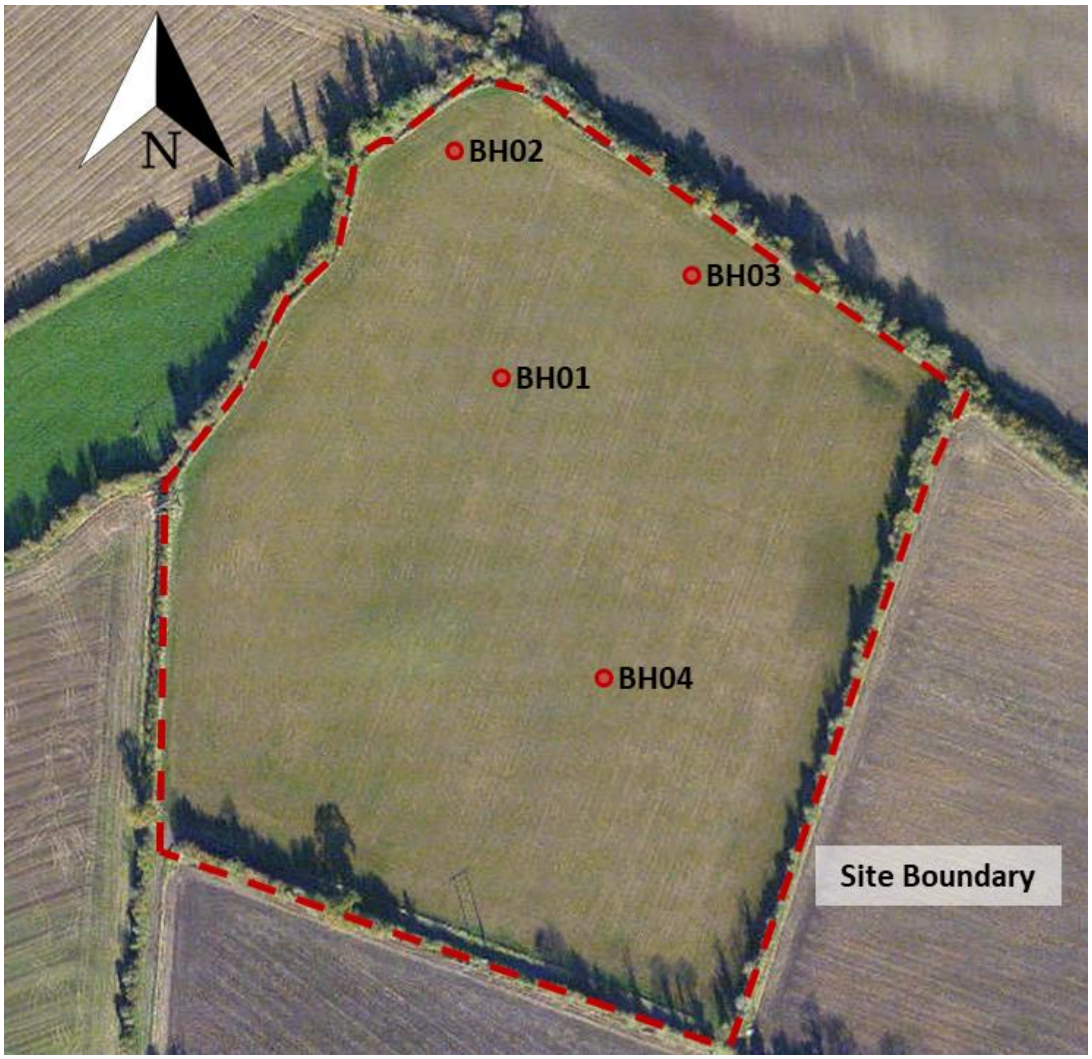

Figure 5: Location of sampling boreholes (OSi, 2022)

Data from the four wells was compared to:

- S. I. No. 366/2016 – European Union Environmental Objectives (Groundwater) (Amendment) Regulations 2016.
- EPA Guideline Values (EPA, 2003).

This is shown in Table 2 below.

pH is between 6.97 (BH03) and 7.72 (BH02). The reading from BH03 is considered to be anomalous when compared with the other values.

Electrical conductivity is generally indicative of good quality water, between 516 uS/cm (BH02) and 976 uS/cm (BH01) – only rising above the lower GTV in BH01. This may be due to a localised naturally elevated sulphate and sodium concentration, or a residual of borehole drilling.

Nitrate as NO_3 ranges from <0.2 mg/l (BH02, BH03, BH04) to 1.1 m/gl (BH01). These values are very low and safely below the EPA IGV (25 mg/l) and GTV (37.5 mg/l) and do not indicate any issues with excess nitrogen in the system.

Orthophosphate as PO4 ranges from <0.03 mg/l (BH02, BH03, BH04) to 0.04 mg/l (BH01). BH01 is the only well to rise above guideline values and breaches both the GTV (0.03 mg/l) and EPA IGV (0.035 mg/l). The slight exceedance at BH1 is an anomaly when compared to the other values and overall there is no indication of excess nutrients in the shallow groundwater environment that would impact the Tufa deposits.

Ammoniacal nitrogen as NH_4 ranges from 0.04 mg/l (BH02) to 0.36 mg/l (BH03). Well BH04 (0.12 mg/l) surpasses the GTV (0.084 mg/l) and BH03 (0.36 mg/l) surpasses the GTV and EPA IGV (0.15 mg/l). The occasional anomaly such as at BH4 would warrant further assessment with monitoring, but generally the values show no sign of organic contamination.

Chloride ranges from 3.7 mg/l (BH02) to 9.6 mg/l (BH04) in the wells. These values are generally low for groundwater and may suggest rapid throughput of rainfall and limited sources of contamination. This remains well below the GTV of 24 mg/l and EPA IGV of 30 mg/l.

Potassium is between 0.9 mg/l (BH04) and 1.2 mg/l (BH02). This is low and does not surpass the EPA IGV of 5 mg/l, again suggesting little impact from farmyard/agricultural activities.

Sodium ranges between 4.3 mg/l (BH02) and 14.9 (BH01). This is well below the EPA IGV of 150 mg/l.

Sodium Potassium ratio is less than 10:1, suggesting no influence from pollution sources such as septic tanks or farmyards

Calcium is between 191.9 mg/l (BH01) and 102.1 mg/l (BH02). These levels are elevated, but consistent with the limestone provenance of the subsoils, and supports some connectivity with the Tufa deposits along the adjoining stream

The data is good quality with low values of nutrients and significantly calcium mineralisation, suggestive of rapid throughput of rainfall recharge,

Table 2: Groundwater Quality Results

Groundwater Quality Data						
	S.I. 366/2016 (Groundwater)	EPA IGV 2003	**BH01**	**BH02**	**BH03**	**BH04**
Dissolved Calcium (mg/l)	-	200	191.9	102.1	114.5	111.2
Dissolved Magnesium (mg/l)	-	50	6.6	2.2	10.8	10.0
Dissolved Potassium (mg/l)	-	5	1.1	1.2	1.0	0.9
Dissolved Sodium (mg/l)	-	150	14.9	4.3	6.3	7.3
Sulphate as SO4 (mg/l)	187.5	200	245.0	4.2	6.7	13.3
Chloride (mg/l)	24	30	6.9	3.7	6.0	9.6
Nitrate as NO3 (mg/l)	37.5	25	1.1	<0.2	<0.2	<0.2
Orthophosphate as PO4 (mg/l)	0.035	0.03	0.04	<0.03	<0.03	<0.03
Ammoniacal Nitrogen as NH4 (mg/l)	0.084	0.15	0.06	0.04	0.36	0.12
Dissolved Alkalinity as CaCO3 (mg/l)	-	-	-	-	372	-
Total Alkalinity CaCO3 (mg/l)	-	-	846	3050	17580	2922
Electrical conductivity @25C (uS/cm)	800-1875	1000	976	516	638	629
pH		≥ 6.5 and ≤ 9.5	7.71	7.72	6.97	7.65

4. Ecologists Report

On 24/06/2021 Ecologist Dr Joanne Denyer of Denyer Ecology visited the site with an IE Consulting hydrogeologist and undertook a survey of the petrifying springs.

The survey examined several small streams Figure 6 around the site that had good flow, even in a dry season, and are likely groundwater fed.

They were found to have high pH (8.30, 8.16, 8.22). These streams were also found to support tufa formations which varied (stream crust, paludal tufa, oncoids, ooids, and cascade tufa). The cover of tufa ranged from absent to covering 90% of the stream bed.

Images of tufa cover on stream base

There were few positive indicator species for the Annex I priority habitat. This is likely because the streams also act as drainage ditches for surrounding fields and receive surface water and contaminants from adjacent fields which changes water depth and chemistry during the year.

Following the methodology of Lyons and Kelly (2016) and Denyer (In press) two survey plots were undertaken. The first (CB01) had significant tufa formation and only one positive indicator species and is therefore only considered to have affinity to Annex I priority Petrifying spring habitat. The second (CB02) had significant tufa formation and three positive indicator species, therefore this section of the stream is considered an example of an Annex I priority Petrifying spring habitat. This section is wholly on ESB lands, and exits the site, via a gap in the boundary ditch, joining the larger stream as indicated in the image above (yellow box) about 40 m along the ditch from the corner of the field.

In summary the streams around the site are groundwater fed and tufa producing but mostly lack the species needed to be a clear example of an Annex I priority petrifying spring habitat. The ecological

report recommends suitable measures are employed to reduce surface water run-off from the site so that the streams are not diluted.

For more detailed results of the ecological assessment see Appendix E.

Figure 6: Streams with tufa formation and location of survey sites (adapted from Denyer, 2021)

5. Conclusions

This report results in the following conclusions:

- The site is in a low lying flat area with a natural stream on the north border and small drains on the western, eastern and southern borders. Some of these bordering water bodies have tufa deposits.
- The site is located over a regionally important bedrock aquifer (Karstified - diffuse).
- A geophysical survey on the site confirmed the ground underlying the substation was relatively homogenous, mostly underlain by sandy and gravelly clay and silt with slightly gravelly clay.
- No bedrock was indicated on the geophysical survey to a depth of 6m, and boreholes have confirmed no bedrock to depths of 9m below ground level.
- Three boreholes were drilled in sand and gravel rich lenses, meeting stiff boulder clay at 3m depth.
- There is a shallow perched aquifer, which is hydraulically isolated from the underlying bedrock aquifer, and this forms the source waters for Tufa formation on the site.
- Water level monitoring over the course of 6 months showed a groundwater gradient from southwest to northeast. It also showed water levels are closely connected to rainfall and rise after extensive periods of rainfall, when any positive soil moisture deficit is overcome.
- If the groundwater flow direction is consistent off-site, then the tufa deposits on the site are probably recharged from lands to the southwest, beyond the sub-station site.
- It is suspected that the drains around all four sides of the site, will have intercepted a significant portion of any incoming shallow groundwater flow, so the opportunity for the groundwater on the site to become highly mineralised on the site is not available.
- Water quality monitoring was undertaken at four boreholes. Overall water quality was good.
- Although there are some unexplained anomalies, the general overview is of groundwater on the site mineralised with calcium, and with very low nutrient concentrations, which will be supportive of the tufa deposits.
- The Ecologist report mapped streams with tufa deposits on the western and northern border of the site.
- Two survey plots along the streams found these streams to be groundwater fed and tufa producing, but mostly lacking in species needed to be a clear example of an Annex I priority petrifying spring habitat.

- It is more likely that the closest tufa spring CB01 is fed from ground to the west of the site, whereas CB02 does probably receive some groundwater feed from the site via the nearby spring.
- CB02 flows inside the site boundary for most of its course, exiting the site through a gap in the boundary ditch, to join the larger stream that skirts the northern boundary of the site.

6. Recommendations

The tufa streams surrounding the site do not qualify as a clear example of an Annex I priority petrifying spring habitat apart from CB02. However these streams should still be protected to prevent further degradation. The following are recommendations from the conclusions of this report.

- Suitable measures should be employed to reduce surface water run-off from the site to prevent dilution of the streams upstream of the identified Tufa sites.
- There should be no outfalls of surface water from the site into the drains west and north (as far as the point where the tufa stream joins the main stream 40m from the corner of the field). The outfalls should be to the main stream beyond this point.
- Groundwater monitoring should continue at the site to ensure there is no excessive nutrient loading, this should also occur at the proposed supply well twice a year.
- Surface water samples should be taken from each of the side streams and from the main stream and analysed for the same parameters as groundwater samples.
- A further assessment should be undertaken by the ecologist to advise on further management of the habitat.

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Appendix A

Hydrogeological and Hydrological Review

Hydrogeological and Hydrological Review

Proposed Coolnabacky Sub-station site Timahoe

February 2021

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

Hydrogeological and Hydrological Review

Location: Proposed Coolnabacky Sub-station site, Timahoe

Date: 16th February 2021

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1. INTRODUCTION

IE Consulting were engaged to conduct an independent audit of the process undertaken (during planning) to assess the potential impact on the hydrological and hydrogeological environment from the proposed construction of a substation at Coolnabacky, near Timahoe, Co. Laois. The Substation is an element of an overall network improvement scheme for the Laois-Kilkenny Area.

IE Consulting were invited by Irish Rural Link to submit a Tender for the following brief

The scope for the independent review for Coolnabacky (also known as Laois-Kilkenny) would broadly involve reviewing the planning documentation, in particular:

- *To review scheme as planned from a hydrological/ hydrogeologic risk point of view*
- *Review of relevant planning information*
- *Recommendations on any gaps in the scheme as planned (e.g. Bunding arrangements, dealing with contaminated runoff, flooding risk etc.)*
- *Comment on whether the scheme is in line with best international practice*
- *Assessment of risk to aquifer*
- *Additional areas to focus on or any further pre-construction site investigations etc.*
- *Provide information of site specific mitigation measures for construction stage*

The main issues of concern are the potential risks to the groundwater water supply.

Irish Rural Link, requested that IE Consulting confirm that they had not undertaken work for Eirgrid or ESB in the recent past or in any way connected to the proposed scheme. This we were happy to confirm.

Irish Rural Link also stressed that IE should confirm that the audit was independent and not influenced in any way by Eirgrid or ESB. This we are happy to confirm.

2. APPROACH TO STUDY

This report is based on a review of the following;

- Documents at the public link: http://eirgridlaoiskilkenny.ie/environmental.html
- A review of the information provided on the An Bord Pleanala website, when a search for VA0015 was made http://www.pleanala.ie/search/index.php?q=va0015&case_scope=all&include_reports_etc=0
- Eirgrid and ESB reports and drawings-provided on request.
- Assessment reports By SLR and Tobins associated with the unauthorised development in
- 2017 Tobins report (Report to assess the impact of the unauthorized development on the Aquifer at Coolnabacky Construction site) 2017
- 2018 SLR Hydrogeological assessment of excavations for the construction of a substation prepared for: Eirgrid SLR Ref: 180720 00357 00004
- GSI 2000- Kyle & Orchard Springs Source Protection report
- GSI 2018 assessment and response to RTS presentation to Minister Naughten
- GSI public viewer maps
- Site walk-over visit under taken by J Keohane on 18th December 2020
- Lyons & Kelly 2016 Monitoring Guidelines for the Assessment of Petrifying Springs in Ireland. Irish Wildlife Manual No. 94 NPWS
- ESBI site drainage report PE687-F0261-R261-016 which included Traynor Environmental Site suitability assessment 2012
- 2012 Soil Mechanics Report No Y2012-12A factual report on ground investigation.

3. TOPOGRAPHY AND SURFACE WATER DRAINAGE

The site lies in a low lying, mostly flat area which extends to the east and north of the site. The surrounding land to the south and west becomes hummocky within 150m to 200m of the site. The geomorphology appears to be glacio-fluvial in origin.

The main surface water drainage feature in the area is the Timahoe River which flows in an approximately northerly direction 500m east of the site. The Timahoe River in turn joins the Honey Stream which flows in from the east and the combined flow becomes the Bauteoge River.

The watercourses in the area appear to have been modified and canalised in places, and arterial drainage has been used to improve the land and direct run-off towards the streams and rivers.

A natural unnamed watercourse skirts the northern boundary of the site, and there are also drains along the western southern and eastern boundaries of the site which were noted to be carrying some flow on the day of the site visit. The perimeter drains are typically 1.0m to 1.5m deep, and seem mainly to run to the North towards the stream.

Apart from occasional water logging after heavy rain, I am satisfied that there is no evidence of a flood risk to site from fluvial or groundwater sources. The modified drainage network in the area, does appear to work efficiently to remove water from the land.

There is surface water hydraulic connectivity between the site and an SAC (The River Barrow and River Nore SAC site code 002162), and I am satisfied that this has been adequately considered through the EIAR and consideration by the An Bord Pleanala Inspector.

I am satisfied that the proposed safeguards for surface water quality management during construction and the operational phase surface water management approach for managing run-off from paved and covered areas for the proposed development is robust. Any new information arising out of the recommended further works detailed below or the construction works when they commence should be reviewed, in the context of surface water management to ensure ultimate protection for water resources.

4. GROUNDWATER

An Bord Pleanala has approved the proposed development after an oral hearing and review of documentation. The Inspectors report (11.VA0015) states that "It appears that the substation at Coolnabacky can be constructed without undue risk to local groundwater sources. The development could be carried out and operated satisfactorily from an ecological standpoint". I have considered this decision in the context of both bedrock and shallow aquifers.

4.1 Bedrock Aquifer

I do agree that there is no significant risk posed by the development to the Kyle spring, because of the following factors

- Significant consistent thickness (8m approx.) of low permeability cohesive subsoil overlying the rock aquifer. This effectively isolates any on-site activities from the bedrock aquifer, since

there will be no excavations deeper than 2m. I am satisfied that site tests have demonstrated very low permeability for this Clay material.

- The GSI source protection report (2000- Kyle & Orchard Springs Source Protection report) concludes that the Kyle Spring is generically a bedrock derived spring, (although the output may flow through overlying gravel for a short period).
- There is no groundwater pathway linking the site and the spring.
- The site is outside of the mapped source protection zone, eventhough the GSI report does state that that some groundwater may pass beneath the Timahoe/Bauteoge River through bedrock en route to the Kyle Spring.
- There is no hydraulic connectivity between the surface water features in the area and the Kyle Spring since all surface water from the site ultimately enters the Timahoe River System and the GSI report (2000- Kyle & Orchard Springs Source Protection report) states that surface water features are hydraulically isolated from the bedrock Aquifer.

4.2 Sand and Gravel Aquifer

The GSI have mapped a locally important Sand and Gravel Aquifer (Timahoe-Stradbally Aquifer) in the area, which includes the site. The GSI have stated in their review (response 2018) that work is in progress on better defining the boundaries and characteristics of this aquifer as part of the Groundwater 3D project.

I understand that the information available to the Hydrogeology Team preparing the EIS in 2013, suggested that the site was outside of the mapped Sand and Gravel aquifer area at the time. The Inspectors report confirms and accepts this. The fact that this has been changed by and is under further review by the GSI does warrant some scrutiny.

The 2017 Tobins report (Report to assess the impact of the unauthorized development on the Aquifer at Coolnabacky Construction site) prepared for ESB acknowledges this boundary change but argues that "*no significant saturated sand and gravel deposit was encountered in the vicinity of the sub-station site".*

This is consistent with the 2018 report by SLR (Hydrogeological assessment of excavations for the construction of a substation) prepared for Eirgrid which states:

"*the site investigation showed that granular sand and gravel deposits at the site are very thin, laterally impersistent and contain limited groundwater; they are not therefore a significant groundwater source or aquifer. This conclusion is supported by GSI advice that states that gravel deposits must exceed 10m to be considered an aquifer. The subsoils at the site are not classified as an aquifer or a groundwater body due to their low permeability characteristics, shown to be typical of silt. This reflects the description of the subsoils as granular gravelly clay / clayey sand and gravel deposits and cohesive stiff – very stiff gravelly clay deposits*". "*The site investigations at the site have shown that there is no gravel aquifer (i.e. sands and gravels to a thickness exceeding 10m) at the site.*

Therefore, the shallow water ingress encountered in the subsoils at the site is representative of pore water or isolated pockets of groundwater that are not connected to the bedrock aquifer".

The GSI (GSI www.gsi.ie) does indeed state that the sand and gravel deposit must be 10m in thickness to be considered an aquifer. I therefore expect, based on this observation, that the GSI will not include this site within a revised sand and gravel aquifer boundary.

Apart from the thickness constraint which appears to be definitive, the EIAR (Chapters 9 and 10 2013) presents a number of other pieces of evidence to state why the sand and gravel deposits on the site do not comprise an aquifer.

The sand and gravel deposits at the site not found to be saturated during the site investigation of 2012.

In most cases, groundwater strikes were not recorded in the Sand and Gravel deposits.

It is noted that, due to the presence of low permeability Clay deposits beneath the sand and gravel, the inflow volumes of groundwater encountered during drilling was minimal.

As the sand and gravel was not saturated, this indicates that the quantities of groundwater present are not significant.

During a subsequent intrusive site investigation carried out by AWN Consulting in 2013, 4 no. boreholes were installed around the boundary of the site, up gradient and down gradient of the

predicted groundwater flow direction. (Appendix 10.1 Site Investigation and Hydrogeological report).

The ground conditions consisted of soft to stiff sandy gravelly Clay and silty sandy Clay to approximately 3m bgl. At approximately 3m bgl, low permeability stiff to firm boulder Clay was encountered. At borehole BH4 Boulder Clay was found to extend to 8.6m bgl when returns were of angular rock suggesting boulders or bedrock.

No fast inflow groundwater strikes were recorded during the site investigation.

Data loggers were installed to record the static groundwater levels at hourly intervals. Based on data, to date the groundwater level at the site is typically less than c.1m bgl. (See Appendix 10.1 for more detailed information)

Permeability tests carried out at each groundwater monitoring well (borehole) indicate that the hydraulic conductivity is typical of silt and clay soils.

Therefore, the water present in the deposits represents pore water, rather than groundwater. The Sand and Gravel deposits at the centre of the site which would be expected to have a higher permeability were also found to be unsaturated.

The 2018 SLR report suggests based on this information

> *"therefore, the shallow groundwater present in the subsoils represents pore water or isolated pockets of groundwater, rather than a groundwater resource, as defined by the EPA. It may not be feasible to define a water table in the subsoils as lateral movement is impeded, and so a shallow water table is not shown on the Conceptual Site Model. Should there be any flow in the granular subsoils, this flow is expected to follow the topography to the south east."*

I have reviewed the site investigation undertaken in February-March 2012. I examined the borehole and trial pit logs, which indicates reasonably consistent ground conditions across the site, comprising topsoil of approximately 300mm underlain by upto 1.9m of varying grades of granular material, which is described as Alluvium on the GSI maps. Alluvium because it is deposited by rivers (in this case probably glacial outwash rivers), often tends to be haphazard in a lateral sense.

It is accepted that the four groundwater monitoring borehole logs (from the 2013 investigation) show no granular material. However it does appear anomalous that these four boreholes around the periphery of the site encountered no granular material, and the boreholes and trial pits excavated in the middle of the site as part of a previous investigation phase did. The possible reasons for this anomaly may be of glacial origin and therefore natural, or may be related to a variation in the drilling methodology deployed in each phase. I am recommending that further investigation is undertaken to

confirm the original findings. It is suggested that a geophysical survey would be the most appropriate approach to clarifying this anomaly.

I note that groundwater strikes were recorded in 8 out of 10 boreholes in 2012. In most cases no inflows were recorded, but the mode of drilling (Shell and Auger) can effectively seal out the water with casing, particularly when the granular interval is thin, thus giving the impression of no inflows.

I consider that because the method of drilling can quickly case out water, the trial pits give a better view of shallow groundwater conditions as follows

TRIAL PIT	GROUNDWATER OBSERVATIONS
S1	ROSE
S2	NONE
S3	STEADY INFLOW
1	SLIGHT SEEPAGE
2	STEADY INFLOW
3	NONE
4	NONE
5	STEADY INFLOW
6	NONE
7	STRUCK
8	STRUCK
9	SLOW TRICKLE
10	QUICK INFLOW
11	BASE OF PIT FILLED
12	NONE

I would suggest that these observations suggest some groundwater activity.

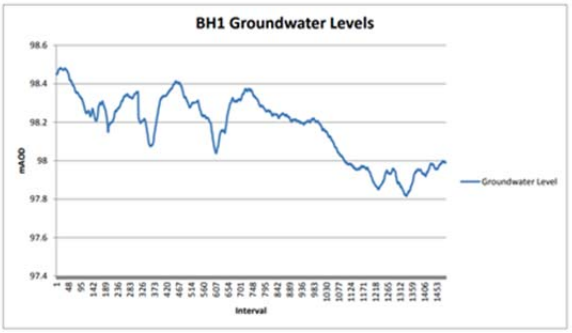
It is accepted that the borehole logs from 2013 indicate that no groundwater was encountered. However it is noted that February and March 2013, and indeed the same months in the previous year (2012) were dry months. I suspect that the Sands and Gravels on this site are actually quite free draining, and drain quite readily when there is little to no rain. The hydraulic controlling horizon is the stiff low permeability CLAY layer at 1.5m to 3m depth, which does not allow any vertical percolation.

I note the comments made by GSI in their review of the RTS presentation which highlighted the connection between the dry period and the lack of groundwater, but I suggest that conditions on this site comprise relatively free draining material close the surface, which is readily recharged by incident

rainfall, but drains away quickly. The mainly dry condition of the field on the day of my site visit, with only minor water logging supports this view.

It is noted that the site assessment undertaken by Traynor Environmental (2012) noted T values and P of 16 and 29 respectively, which indicates excellent percolation. However it is also noted that the soakaway tests did not indicate available infiltration capacity for soakaways.

The 2013 boreholes were fitted with standpipes to allow groundwater levels to be measured. It is stated in the EIAR report that the boreholes were fitted with data logger water level transducers. I examined the data in appendix 10.1 and I noted that the boreholes were instrumented for June and July 2013. Data for BH4 was not presented, but plots for boreholes 1-3 do seem to indicate some fluctuations in groundwater levels as shown below and in fact BH1 and BH2 display very similar patterns. I am surprised that no comment was made on this in the EIAR, although it does have more significance in the context of the hydrological system supporting the Tufa Springs than any significance in the overall impact assessment on drinking water supplies.



I therefore do not fully agree with the conclusion, that the Sands and Gravels on the site are not active in the groundwater sense because;

- The T and P tests indicate permeable deposits
- The groundwater monitoring undertaken indicates fluctuations in groundwater levels, albeit in the small range.
- The relatively dry topsoil layer suggests that incident rainfall does percolate into the sand and gravel layer

I expect that there will be a gradient towards the un-named watercourse to the north east, with some lateral movement to drains. I suspect that the groundwater throughput has some influence on the

tufa springs, and I have recommended that further work is undertaken on this to understand it better.

Despite this anomaly, my conclusion is that the sands and gravels on this site, are not substantially hydraulically connected with the Locally Important Sand and Gravel aquifer, for the following reasons.

1. The deposits are thin and underlain by an impermeable layer and
2. The perimeter drains and the permanent watercourse effectively intercept any flow.

The potential risk of impacts on groundwater resources beyond the site are therefore not considered significant, as a result of this lack of connectivity.

However I do feel that the groundwater from the site does have some influence/connection with the Tufa formations. Petrifying springs are lime-rich water sources that deposit tufa, a porous calcareous rock. They constitute a specialised habitat with a distinctive flora, typically dominated by bryophytes and often containing rare species. Their small extent and their vulnerability are recognised by their designation as a priority habitat in Annex I of the European Union Habitats Directive (92/43/EEC); whereby member states are obliged to monitor and report on the conservation status of such annexed habitats.

5. PETRIFYING SPRINGS-with TUFA FORMATION

The Tufa Springs were mentioned in the An Bord Pleanala Inspectors report which notes that an observer to the Oral hearing stated that a screening of these should have been undertaken in the context of the habitats directive on the basis of petrifying springs being designated a priority habitat under Annex 1 of the habitats directive. The Inspector did not agree with the argument and I fully concur with the conclusion of the Inspector, but nonetheless, I do feel that a more in depth assessment of the springs should be undertaken in the context that groundwater from the site, may have some influence on them as discussed above. This recommendation does not suggest any lacunae in the EIAR or NIS, that would have influenced the overall decision, but is a recommendation that ESB adopts an enhanced awareness of the connectivity of the site with a priory habitat.

Member states are required to monitor and report on the conservation status of such annexed habitats. An important stipulation within the habitats directive manual (Lyons and Kelly 2016) when

referring to Petrifying Springs is that " in order to preserve this habitat of very limited expanse in the field it is essential to preserve its surroundings and whole hydrological system concerned" . The presence of Tufa deposits in close proximity (along the watercourse that forms the northern boundary) to the site, and their dependence on the hydrological conditions on the site, suggests that there is a requirement to better understand the interrelationship between the site conditions and the deposits. The 2016 NPWS publication "monitoring guidelines for the protection of petrifying springs in Ireland" should be referred to for guidance.

6. PROPOSED CONSTRUCTION AND OPERATIONAL CONTROLS TO PROTECT GROUNDWATER AND SURFACE WATER

The proposed mitigation measures for dealing with potential impacts to groundwater and surface water are best international practice, provided they are adhered to and overseen and signed off by a competent person during construction.

One of the key concerns (expressed by the RTS group) relates to the storage and use of oil in the proposed transformers. I am satisfied that the proposed infrastructure and operational protocols afford the optimum security for the prevention of loss to the environment. No absolute guarantees can be provided that there will never be accidental loss of oil to the environment.

In the event of any environmental incident the ESB Networks Emergency Response Procedure will be activated.

For minor spillages that enter the drainage network, the oil water separator will provide an adequate mitigation control measure.

For other spillages, on the basis of the proposed site topography, it is expected the oil will be easy to control on the site, and an appropriate remediation strategy would involve recovery and disposal of any free product, and appropriate disposal of any oil contaminated soil, backed up by validation sampling and analysis.

If some oil were to run across the surface or become mobilised in the shallow groundwater, it will migrate towards the surrounding drainage ditches approximately 40m from the nearest proposed transformer, and ultimately the natural Stream and surface water network. Again, appropriate oil remediation strategies will limit any environmental damage. I am satisfied that any loss of oil on the site will not present a significant risk to the either the Bedrock or Sand and Gravel aquifers and as a result the proposed use of oil on the site, does not present a significant risk to any drinking water supplies.

Dewatering may be required for foundations, but inflows are expected to be manageable and will not create any lasting impacts.

7. CONCLUSIONS

- I am satisfied that the proposed development does not present a significant risk to drinking water sources in the area.
- I am satisfied that adequate controls have been proposed to mitigate any potential accidental spillages or discharges, and to ensure that the proposed site development does not present any on-going impacts.
- The substantial thickness of low permeability CLAY on the site eliminates any significant pathway developing to the bedrock aquifer, and hence the Kyle spring.
- The shallow depth of the sand and gravels on the site and the fact that they are effectively intercepted by drainage ditches, means they are not hydraulically connected to off-site sand and gravel deposits.
- The sands and gravels on this site cannot be considered an aquifer and are not considered to be more widely connected to the mapped Sand and Gravel Aquifer.
- I suspect the GSI will not include the site in the Locally Important Aquifer when they consider the boundary of the Timahoe-Stradbally Sand and Gravel Aquifer.
- I am not convinced that the lateral extent and hydraulic properties of the granular material above the CLAY is fully understood and I am therefore recommending further investigation to better understand the dynamics.
- The information from this investigation, should be reviewed by the site drainage designers to ensure full compatibility with the proposed design approach to surface water management.

- I consider that the petrifying springs-tufa deposits are not fully understood, in the context of their dependence on site hydrology and hydrogeology, and in the context that the Sands and Gravels on site may be more active than previously understood. This warrants further investigation.

8. RECOMMENDATIONS

1. I would recommend that a geophysical survey is undertaken using electromagnetic surveying (such as EM31) to map the subsurface shallow deposits to better understand the subsoil profile and to enhance the original ground model.
2. I would recommend that 5 No. shallow groundwater monitoring points are installed around the site at locations away from the proposed footprint. These can comprise simple standpipes installed in trial pits, or shallow drilled boreholes to maximum 3m depth away from the building footprint or any areas where accommodation works are planned. These should be levelled to a common datum, and groundwater levels measured every six hours using water level transducers. This monitoring period should extend over two seasons at least ideally from the Winter period into Spring until construction of the substation proper commences. This will help to better understand the groundwater hydraulics of the shallow deposits on the site and inform the further assessment of the Tufa Springs.
3. A round of groundwater samples should be taken from the shallow wells and analysed for Nitrate, Nitrite, Phosphorous, Ammonia, Chloride, Potassium and Sodium, Conductivity, pH. This will provide a baseline for any future monitoring. The wells should be sampled twice per year, for the same range of parameters. The tufa springs are very sensitive to nutrient loading, and this monitoring will provide information to assist in the protection of the habitat.
4. A more in depth ecological assessment of the tufa springs should be undertaken in the context of it being an Annex 1 habitat using the above data, and following the NPWS guidelines. This will enhance the understanding of the tufa springs and their connectivity to the site.
5. Once items 1-4 are completed I would recommend that the design of the stormwater management system be reviewed in the context of ensuring the existing hydrological system is optimised to support the tufa springs as required under the habitats directive.
6. Once drilled, groundwater quality from the proposed supply well should be monitored twice per year.

IE CONSULTING
WATER-ENVIRONMENTAL-CIVIL

Appendix B

Geophysical Survey

Proposed Substation

Coolnabacky, Co. Laois

Geophysical Survey

Report Status: Draft

MGX Project Number: 6555

MGX File Ref: 6555d-005.doc

30th April 2021

Confidential Report To:

ESB Networks Projects Delivery
Two Gateway
East Wall Road
Dublin 3
D03 A995

Report submitted by :
Minerex Geophysics Limited

Unit F4, Maynooth Business Campus
Maynooth, Co. Kildare, W23X7Y5
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Tel.: 01-6510030
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Issued by:

Author: Hartmut Krahn (Senior Geophysicist)

Reviewer: John Connaughton (Geophysicist)

Minerex
Geophysics Limited

Subsurface Geophysical Investigations

EXECUTIVE SUMMARY

1. Minerex Geophysics Ltd. (MGX) carried out a geophysical survey consisting of EM31 Ground Conductivity surveying for the ground investigation for the proposed ESB substation at Coolnabacky, Co. Laois.
2. The main objectives of the survey were to determine ground conditions under the substation site and access road, to determine relative variations in subsoils and material type, to establish relative permeability and areas of higher and lower permeability.
3. Ground conductivities were measured and displayed on maps.
4. The interpretation shows that the subsoils vary in the material content between clayey silty Sand and Gravel (lowest conductivities) and slightly sandy and slightly gravelly Clay and Silt (highest conductivities).
5. At the substation site is has been shown that the ground is quite homogeneous with measurements representing a small change in overburden material between sandy and gravelly Clay and Silt and slightly sandy and slightly gravelly Clay and Silt.
6. The access road shows a larger variations of materials with Sand and Gravel occurring closest to the quarry.
7. The lowest ground water permeabilities occur at the highest conductivity values because the clay and silt content is highest here. The highest permeabilities occur where the conductivities are lowest because there the subsoils have the largest amount of Sand and Gravel.

CONTENTS

List of Tables, Maps and Figures:

1. INTRODUCTION

1.1 Background

Minerex Geophysics Ltd. (MGX) carried out a geophysical survey for the proposed ESB substation at Coolnabacky, Co. Laois. The survey consisted of EM31 ground conductivity measurements. The survey was requested by ESB based on recommendations of their hydrogeological consultant.

1.2 Objectives

The main objectives of the geophysical survey were:

- Determine the ground conductivities under the substation site and access road
- Map shallow subsoils to determine lateral variations and relative type (clay/silt or sand/gravel)
- Determine relative permeability of the subsoils
- Identify zones with higher and lower intergranular permeability

1.3 Geology

The online bedrock geological map of Ireland (GSI, 2021) indicates that the survey area is underlain by the Ballyadams Formation described as crinoidal wackestone/packstone limestone. The quaternary sediments are described as alluvium under the substation site and as gravels along the access road.

A previous geotechnical report (Soil Mechanics, 2012) describes the ground investigation work done and the results of direct investigation and laboratory testing. Boreholes show that rock is deeper than 6 m and does not play a tole in the current investigation with the EM31.

Ten boreholes on the substation site indicate mainly sandy gravelly clay with some lenses of sand or gravel. Most trial pits also show sandy gravelly clay with some silt, sand and gravel lenses. Trial pits 10 and 11 indicate sand while trial pit 12 indicates silt over sand.

1.4 Report

This report includes the results and interpretation of the geophysical survey. Maps and a table are included to illustrate the results of the survey. More detailed descriptions of geophysical methods and measurements can be found in GSEG (2002), Milsom (1989) and Reynolds (1997).

The description of soil, rock and the use of geotechnical terms follows Eurocode (2007) and BSI (2015) standards. The terms are defined in the standards and the physical parameters are related from experience.

This geophysical survey has been acquired, processed, interpreted and reported in accordance with these guidelines.

The client provided maps of the site and the digital version was used as the background map in this report. Elevations were surveyed on site and are used in the vertical sections.

The interpretative nature and the non-invasive survey methods must be taken into account when considering the results of this survey and Minerex Geophysics Limited, while using appropriate practice to execute, interpret and present the data, give no guarantees in relation to the existing subsurface.

2. GEOPHYSICAL SURVEY

2.1 Methodology

The methodology was outlined in the tender documents and consisted of EM31 Ground Conductivity measurements.

The survey locations are within the colour contoured areas in the maps.

2.2 EM31 Ground Conductivity

The EM31 ground conductivity survey was carried out in the field containing the proposed substation (approx. 7 ha) and along the access road (approx. 3 ha).

The survey was done on lines nominally 10 m apart. Along each line a reading of ground conductivity was taken every second while walking along, thereby resulting in a survey grid of nominally 10 x 2 m. The locations were measured with a sub-meter accuracy SERES DGPS system attached to the EM31 and all data was jointly stored in a data logger. The conductivity meter was a GEONICS EM31 with Allegro data logger and NAV31 data acquisition software. The instrument was compared to base station readings and no EM drift was recorded.

The conductivity is typical for certain geological material types. Dry and clean Sand and Gravel and most rock types (Granite, Sandstone and clean Limestone) have relatively low conductivities while peat, clay and clay-rich rock types (mudstone, shale) have high conductivities.

EM31 ground conductivity determines the bulk conductivity of the subsurface over a typical depth between 0 and 6m bgl. and over a radius of approx. 5m around the instrument. In areas of thick overburden the instrument distinguished between clay/silt and sand/gravel.

The measurements can be disturbed by metal and other conductive objects in close proximity to the instrument, and therefore no geological interpretations can be made in the vicinity of such man-made objects. Either readings were not taken near sources of interference, or notes were taken by the surveyor in order to remove these during processing or to account for these in the interpretation.

The survey was done on the 23rd of April 2021 in good weather conditions. The instrument was checked repeatedly at a base station and the reading were very stable.

3. RESULTS AND INTERPRETATION

The interpretation of geophysical data was executed utilizing the known response of geophysical measurements, typical physical parameters for subsurface features that may underlay the site, and the experience of the authors.

The EM31 ground conductivity values were merged into one data file for the entire survey area and contoured and gridded with the SURFER contouring package. The contours are created by gridding and interpolation and care must be taken when using the data. The contour map is overlaid over the location and base map (Map 1) and the values in milliSiemens/metre (mS/m) are indicated on the colour scale bar.

Maps 2a and 2b display the same data as Map 1 but are displayed at a larger scale split for the substation site and access road.

The data indicates ground conductivities between 4 and 14 mS/m (MilliSiemens/meter). Because the electrical conductivity is the inverse of the electrical resistivity this can be also expressed as ground resistivity with 70 to 250 Ohmm (Ohmmeter).

Low conductivities indicate mainly sandy and gravely overburden while high conductivities indicate clayey and silty overburden. The highest readings on the contour map occur close to the quarry and the main road, there may be some component caused by metal of fencing and other object involved.

An interpretation can be made by allocating the overburden material to conductivity and resistivity ranges. Values of conductivity less than 5 mS/m (resistivity > 200 Ohmm) represent clayey silty Sand and Gravel within the depth reach (6m) of the EM31. Values between conductivity 5 - 10 mS/m (resistivity 100 – 200 Ohmm) can be described as sandy gravelly Clay and Silt. Values of conductivity higher than 10 mS/m (resistivity < 100 Ohmm) are typical for slightly sandy and slightly gravelly Clay and Silt.

4. CONCLUSIONS

The following conclusions and recommendations are made:

- The EM31 survey was done over the substation site and the access road while avoiding some small areas with metal fencing.
- The subsoils under the site vary in the content between clayey silty Sand and Gravel (lowest conductivities) and slightly sandy and slightly gravelly Clay and Silt (highest conductivities).
- At the substation site ground conductivity values between 7 and 11 mS/m (resistivities from 90 to 143 Ohmm) have been determined. This shows that the site is quite homogeneous. Rock occurs deeper than 6 m bgl (as is known from the boreholes) so that the measurements are representing the change in overburden material.
- The interpretation shows sandy and gravelly Clay and Silt over most of the field with the proposed substation site. Some slightly sandy and slightly gravelly Clay and Silt occurs around the western and eastern edges of the field.
- The access road shows a larger variations of conductivities. The lowest occur closest to the quarry indication a high content of Sand and Gravel in the overburden.
- The lowest ground water permeabilities occur at the highest conductivity values because the clay and silt content is highest here. The highest permeabilities occur where the conductivities are lowest because there the subsoils have the largest amount of Sand and Gravel.

5. REFERENCES

1. **BSI, 2015.** BS5930, Code of Practice for Ground Investigations, British Standards Institute 2015.

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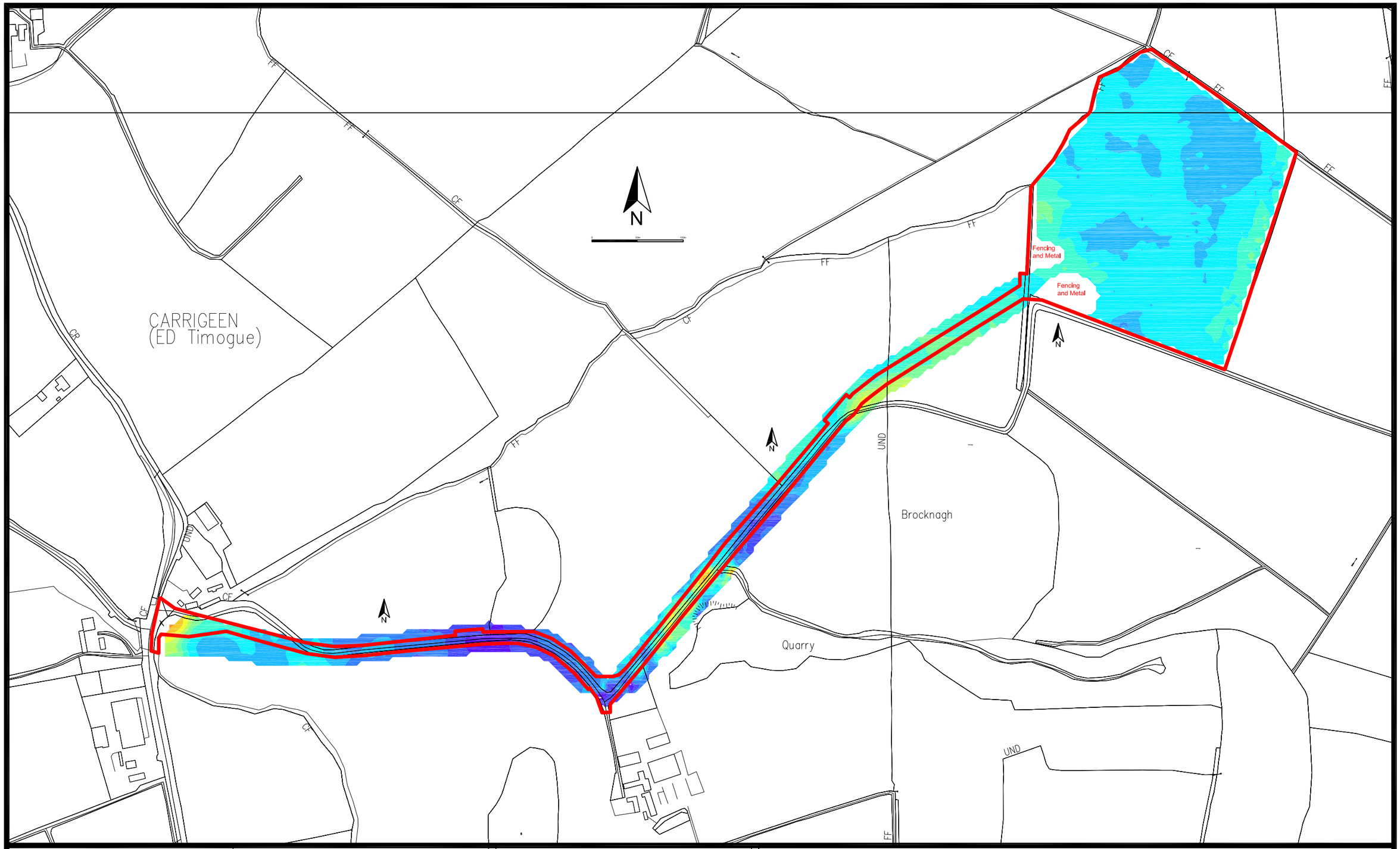

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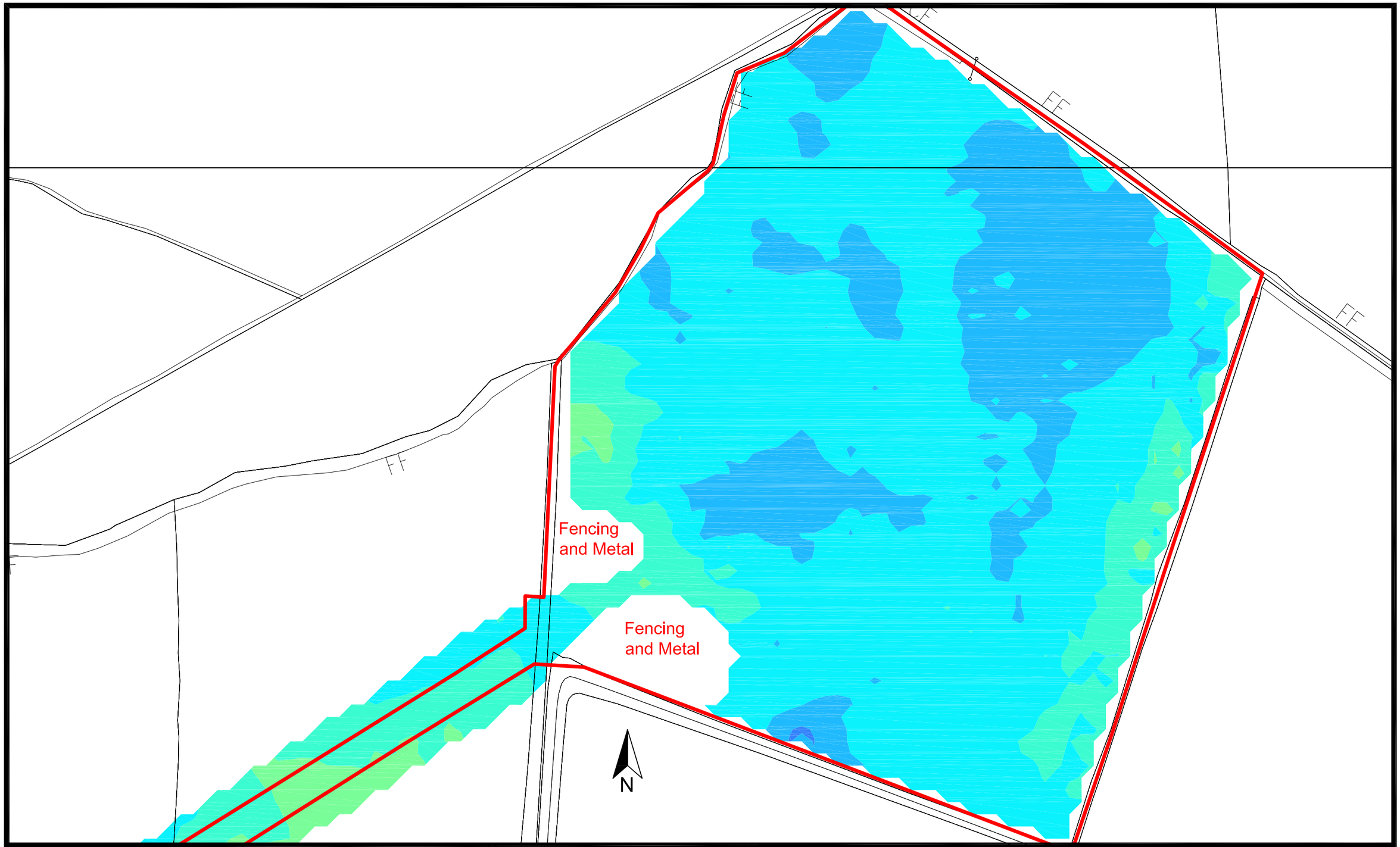
CLIENT	ESB Networks Projects Delivery
PROJECT	Coolnabacky, County Laios Geophysical Survey
TITLE	Map 1: EM31 Ground Conductivity Contour Map

SCALE:	1:4000 @ A3
PROJECT:	6555
DRAWN:	HK
DATE:	28/04/2021
MGX FILE:	6555d_Maps.dwg
STATUS:	Draft

LEGEND: EM31 Ground Conductivity Results:

Ground Conductivity in mS/m

4 5 6 7 8 9 10 11 12 13 14



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CLIENT	ESB Networks Projects Delivery
PROJECT	Coolnabacky, County Laios Geophysical Survey
TITLE	Map 2a: EM31 Ground Conductivity Contour Map (Substation Site)

SCALE:	1:1500 @ A3
PROJECT:	6555
DRAWN:	HK
DATE:	28/04/2021
MGX FILE:	6555d_Maps.dwg
STATUS:	Draft

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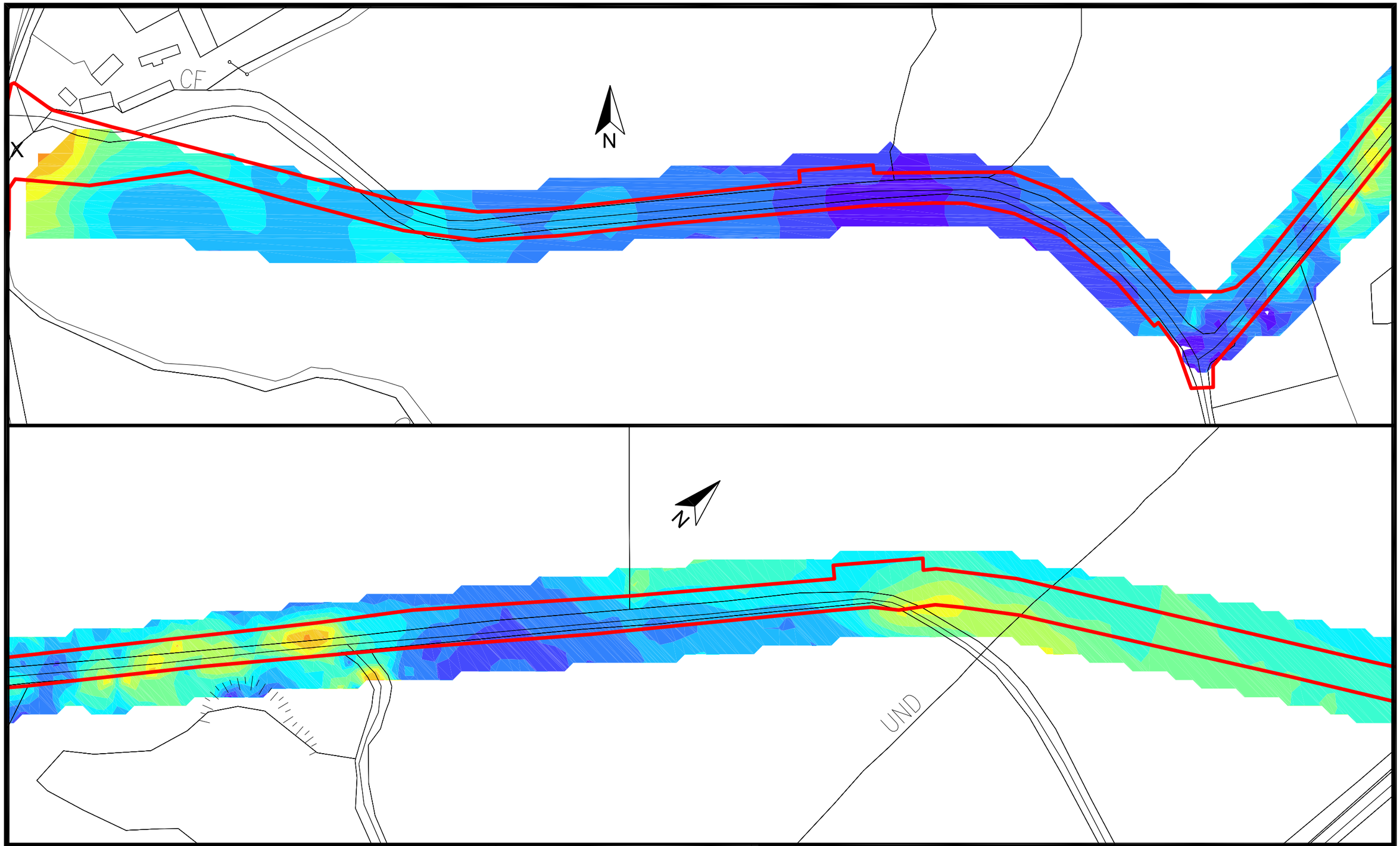
Ground Conductivity in mS/m

4 5 6 7 8 9 10 11 12 13 14



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CLIENT	ESB Networks Projects Delivery
PROJECT	Coolnabacky, County Laios Geophysical Survey
TITLE	Map 2b: EM31 Ground Conductivity Contour Map (Access Road)

SCALE:	1:1500 @ A3
PROJECT:	6555
DRAWN:	HK
DATE:	28/04/2021
MGX FILE:	6555d_Maps.dwg
STATUS:	Draft

LEGEND: EM31 Ground Conductivity Results:

Ground Conductivity in mS/m

4 5 6 7 8 9 10 11 12 13 14

Appendix C

Borehole Logs

Priority Geotechnical Ltd.
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www.prioritygeotechnical.ie

Drilled By	Borehole No.
KC	**BH01**
Logged By	Sheet 1 of 1

Project Name:	Coolnabackey - Groundwater	**Project No.** P21124	**Co-ords:**		**Hole Type** CP
Location:	Co. Laois		**Level:**	m OD	**Scale** 1:50
Client:	ESB		**Date:**	26/05/2021 - 26/05/2021	

Well Backfill	Water Strike (m bgl)	Sample and In Situ Testing: Depth (m bgl)	Type	Results	Depth (m bgl)	Level (mOD)	Legend	Stratum Description
								Driller described: CLAY with cobble content.
					1.00			Driller described: Dense GRAVEL.
					3.00			End of Borehole at 3.000m

Groundwater:

Struck (m bgl)	Rose to (m bgl)	After (mins)	Sealed (m bgl)	Comment
				None encountered.

Hole Information:

Depth (m bgl)	Hole Dia (mm)	Casing Dia (mm)
3.00	200	200

Equipment: Dando 2000

Chiselling Details:

Top (m)	Base (m)	Duration (hh:mm)	Tool
2.40	2.60	01:00	Chisel.

Remarks:

Borehole terminated at 3.00m bgl, required depth. 50mm standpipe installed. Response zone from 0.50m to 3.00m bgl.

Shift Data:

GW (m bgl)	Shift	Depth (m bgl)	Remarks
	26/05/2021 08:00	0.00	Start of shift.
Dry.	26/05/2021 18:00	3.00	End of borehole.

Priority Geotechnical Ltd.
Tel: 021 4631600
Fax: 021 4638690
www.prioritygeotechnical.ie

Drilled By	Borehole No.
KC	**BH02**
Logged By	Sheet 1 of 1

Project Name:	Coolnabackey - Groundwater	**Project No.** P21124	**Co-ords:**		**Hole Type** CP
Location:	Co. Laois		**Level:**	m OD	**Scale** 1:50
Client:	ESB		**Date:**	26/05/2021 - 26/05/2021	

Well Backfill	Water Strike (m bgl)	Sample and In Situ Testing: Depth (m bgl)	Type	Results	Depth (m bgl)	Level (mOD)	Legend	Stratum Description
								Driller described: CLAY with cobble content.
					1.00			Driller described: Dense GRAVEL.
					3.00			End of Borehole at 3.000m

Groundwater:

Struck (m bgl)	Rose to (m bgl)	After (mins)	Sealed (m bgl)	Comment
				None encountered.

Hole Information:

Depth (m bgl)	Hole Dia (mm)	Casing Dia (mm)
3.00	200	200

Equipment: Dando 2000

Chiselling Details:

Top (m)	Base (m)	Duration (hh:mm)	Tool
2.60	2.80	00:30	Chisel.

Remarks:

Borehole terminated at 3.00m bgl, required depth. 50mm diameter standpipe installed. Response zone from 0.50m - 3.00m bgl.

Shift Data:

GW (m bgl)	Shift	Depth (m bgl)	Remarks
	26/05/2021 08:00	0.00	Start of shift.
Dry	26/05/2021 18:00	3.00	End of borehole.

Priority Geotechnical Ltd.
Tel: 021 4631600
Fax: 021 4638690
www.prioritygeotechnical.ie

Drilled By	Borehole No.
KC	**BH03**
Logged By	Sheet 1 of 1

Project Name:	Coolnabackey - Groundwater	**Project No.** P21124	**Co-ords:**		**Hole Type** CP
Location:	Co. Laois		**Level:**	m OD	**Scale** 1:50
Client:	ESB		**Date:**	26/05/2021 - 26/05/2021	

Well Backfill	Water Strike (m bgl)	Sample and In Situ Testing: Depth (m bgl)	Type	Results	Depth (m bgl)	Level (mOD)	Legend	Stratum Description
								Driller described: CLAY with cobble content.
					1.00			Driller described: GRAVEL.
					3.00			End of Borehole at 3.000m

Groundwater:

Struck (m bgl)	Rose to (m bgl)	After (mins)	Sealed (m bgl)	Comment
				None encountered.

Hole Information:

Depth (m bgl)	Hole Dia (mm)	Casing Dia (mm)
3.00	200	200

Equipment: Dando 2000

Chiselling Details:

Top (m)	Base (m)	Duration (hh:mm)	Tool
1.90	2.00	01:00	Chisel.

Remarks:

Borehole terminated at 3.00m bgl, required depth. 50mm diameter standpipe installed. Response zone from 0.50m to 3.00m bgl.

Shift Data:

GW (m bgl)	Shift	Depth (m bgl)	Remarks
	26/05/2021 08:00	0.00	Start of shift.
Dry	26/05/2021 18:00	3.00	End of borehole.

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Appendix D

Onsite Raw Water Quality Data

Element Materials Technology
Unit 3 Deeside Point
Zone 3
Deeside Industrial Park
Deeside
CH5 2UA

P: +44 (0) 1244 833780
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W: www.element.com

IE Consulting
Innovation Centre
Green Road
Carlow
Co Carlow

Attention :	Kevin Murphy
Date :	19th January, 2022
Your reference :	IE2219
Our reference :	Test Report 21/20239 Batch 1
Location :	ESB Coolnabacky
Date samples received :	16th December, 2021
Status :	Final Report
Issue :	1

Four samples were received for analysis on 16th December, 2021 of which four were scheduled for analysis. Please find attached our Test Report which should be read with notes at the end of the report and should include all sections if reproduced. Interpretations and opinions are outside the scope of any accreditation, and all results relate only to samples supplied.
All analysis is carried out on as received samples and reported on a dry weight basis unless stated otherwise. Results are not surrogate corrected.

Authorised By:

Hayley Prowse
Project Manager

Element Materials Technology

Client Name: IE Consulting
Reference: IE2219
Location: ESB Coolnabacky
Contact: Kevin Murphy
EMT Job No: 21/20239

Report : Liquid

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

EMT Sample No.	1-3	4-6	7-9	10-12							LOD/LOR	Units	Method No.
Sample ID	BH1	BH2	BH3	BH4									
Depth													
COC No / misc													
Containers	H HN P	H HN P	H HN P	H HN P									
Sample Date	14/12/2021	14/12/2021	14/12/2021	14/12/2021									
Sample Type	Ground Water	Ground Water	Ground Water	Ground Water									
Batch Number	1	1	1	1									
Date of Receipt	16/12/2021	16/12/2021	16/12/2021	16/12/2021									
Dissolved Calcium #	191.9	102.1	114.5	111.2							<0.2	mg/l	TM30/PM14
Dissolved Magnesium #	6.6	2.2	10.8	10.0							<0.1	mg/l	TM30/PM14
Dissolved Potassium #	1.1	1.2	1.0	0.9							<0.1	mg/l	TM30/PM14
Dissolved Sodium #	14.9	4.3	6.3	7.3							<0.1	mg/l	TM30/PM14
Sulphate as SO4 #	245.0	4.2	6.7	13.3							<0.5	mg/l	TM38/PM0
Chloride #	6.9	3.7	6.0	9.6							<0.3	mg/l	TM38/PM0
Nitrate as NO3 #	1.1	<0.2	<0.2	<0.2							<0.2	mg/l	TM38/PM0
SRP Ortho Phosphate as PO4	0.04	<0.03	<0.03	<0.03							<0.03	mg/l	TM38/PM0
Ammoniacal Nitrogen as NH4 #	0.06	0.04	0.36	0.12							<0.03	mg/l	TM38/PM0
Dissolved Alkalinity as CaCO3 #	-	-	372	-							<1	mg/l	TM75/PM0
Total Alkalinity as CaCO3 #	846	3050	17580	2922							<1	mg/l	TM75/PM0
Electrical Conductivity @25C #	976	516	638	629							<2	uS/cm	TM76/PM0
pH #	7.71	7.72	6.97	7.65							<0.01	pH units	TM73/PM0

Please see attached notes for all abbreviations and acronyms

Element Materials Technology

Client Name: IE Consulting
Reference: IE2219
Location: ESB Coolnabacky
Contact: Kevin Murphy
EMT Job No: 21/20239

Report : Liquid (Duplicate results)

Liquids/products: V=40ml vial, G=glass bottle, P=plastic bottle
H=H_2SO_4, Z=ZnAc, N=NaOH, HN=$HN0_3$

EMT Sample No.	7-9										LOD/LOR	Units	Method No.
Sample ID	BH3												
Depth													
COC No / misc													
Containers	H HN P												
Sample Date	14/12/2021												
Sample Type	Ground Water												
Batch Number	1												
Date of Receipt	16/12/2021												
pH #	8.07										<0.01	pH units	TM73/PM0

Please see attached notes for all abbreviations and acronyms

Client Name: IE Consulting

Reference: IE2219

Location: ESB Coolnabacky

Contact: Kevin Murphy

Matrix : Liquid

EMT Job No.	Batch	Sample ID	Depth	EMT Sample No.	Analysis	Reason
21/20239	1	BH3		7-9	Alkalinity, pH	Sample holding time exceeded

Please note that only samples that are deviating are mentioned in this report. If no samples are listed it is because none were deviating.

Only analyses which are accredited are recorded as deviating if set criteria are not met.

NOTES TO ACCOMPANY ALL SCHEDULES AND REPORTS

EMT Job No.: 21/20239

SOILS and ASH

Please note we are only MCERTS accredited (UK soils only) for sand, loam and clay and any other matrix is outside our scope of accreditation.

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation has been performed on clay, sand and loam, only samples that are predominantly these matrices, or combinations of them will be within our MCERTS scope. If samples are not one of a combination of the above matrices they will not be marked as MCERTS accredited.

It is assumed that you have taken representative samples on site and require analysis on a representative subsample. Stones will generally be included unless we are requested to remove them.

All samples will be discarded one month after the date of reporting, unless we are instructed to the contrary. Asbestos samples are retained for 6 months.

If you have not already done so, please send us a purchase order if this is required by your company.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

All analysis is reported on a dry weight basis unless stated otherwise. Limits of detection for analyses carried out on as received samples are not moisture content corrected. Results are not surrogate corrected. Samples are dried at 35°C ±5°C unless otherwise stated. Moisture content for CEN Leachate tests are dried at 105°C ±5°C. Ash samples are dried at 37°C ±5°C.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

Where a CEN 10:1 ZERO Headspace VOC test has been carried out, a 10:1 ratio of water to wet (as received) soil has been used.

% Asbestos in Asbestos Containing Materials (ACMs) is determined by reference to HSG 264 The Survey Guide - Appendix 2 : ACMs in buildings listed in order of ease of fibre release.

Sufficient amount of sample must be received to carry out the testing specified. Where an insufficient amount of sample has been received the testing may not meet the requirements of our accredited methods, as such accreditation may be removed.

Negative Neutralization Potential (NP) values are obtained when the volume of NaOH (0.1N) titrated (pH 8.3) is greater than the volume of HCl (1N) to reduce the pH of the sample to 2.0 - 2.5. Any negative NP values are corrected to 0.

The calculation of Pyrite content assumes that all oxidisable sulphides present in the sample are pyrite. This may not be the case. The calculation may be an overesitimate when other sulphides such as Barite (Barium Sulphate) are present.

WATERS

Please note we are not a UK Drinking Water Inspectorate (DWI) Approved Laboratory .

ISO17025 accreditation applies to surface water and groundwater and usually one other matrix which is analysis specific, any other liquids are outside our scope of accreditation.

As surface waters require different sample preparation to groundwaters the laboratory must be informed of the water type when submitting samples.

Where Mineral Oil or Fats, Oils and Grease is quoted, this refers to Total Aliphatics C10-C40.

STACK EMISSIONS

Where an MCERTS report has been requested, you will be notified within 48 hours of any samples that have been identified as being outside our MCERTS scope. As validation for Dioxins and Furans and Dioxin like PCBs has been performed on XAD-2 Resin, only samples which use this resin will be within our MCERTS scope.

Where appropriate please make sure that our detection limits are suitable for your needs, if they are not, please notify us immediately.

DEVIATING SAMPLES

All samples should be submitted to the laboratory in suitable containers with sufficient ice packs to sustain an appropriate temperature for the requested analysis. The temperature of sample receipt is recorded on the confirmation schedules in order that the client can make an informed decision as to whether testing should still be undertaken.

SURROGATES

Surrogate compounds are added during the preparation process to monitor recovery of analytes. However low recovery in soils is often due to peat, clay or other organic rich matrices. For waters this can be due to oxidants, surfactants, organic rich sediments or remediation fluids. Acceptable limits for most organic methods are 70 - 130% and for VOCs are 50 - 150%. When surrogate recoveries are outside the performance criteria but the associated AQC passes this is assumed to be due to matrix effect. Results are not surrogate corrected.

DILUTIONS

A dilution suffix indicates a dilution has been performed and the reported result takes this into account. No further calculation is required.

BLANKS

Where analytes have been found in the blank, the sample will be treated in accordance with our laboratory procedure for dealing with contaminated blanks.

NOTE

Data is only reported if the laboratory is confident that the data is a true reflection of the samples analysed. Data is only reported as accredited when all the requirements of our Quality System have been met. In certain circumstances where all the requirements of the Quality System have not been met, for instance if the associated AQC has failed, the reason is fully investigated and documented. The sample data is then evaluated alongside the other quality control checks performed during analysis to determine its suitability. Following this evaluation, provided the sample results have not been effected, the data is reported but accreditation is removed. It is a UKAS requirement for data not reported as accredited to be considered indicative only, but this does not mean the data is not valid.

Where possible, and if requested, samples will be re-extracted and a revised report issued with accredited results. Please do not hesitate to contact the laboratory if further details are required of the circumstances which have led to the removal of accreditation.

REPORTS FROM THE SOUTH AFRICA LABORATORY

Any method number not prefixed with SA has been undertaken in our UK laboratory unless reported as subcontracted.

Measurement Uncertainty

Measurement uncertainty defines the range of values that could reasonably be attributed to the measured quantity. This range of values has not been included within the reported results. Uncertainty expressed as a percentage can be provided upon request.

ABBREVIATIONS and ACRONYMS USED

#	ISO17025 (UKAS Ref No. 4225) accredited - UK.
SA	ISO17025 (SANAS Ref No.T0729) accredited - South Africa
B	Indicates analyte found in associated method blank.
DR	Dilution required.
M	MCERTS accredited.
NA	Not applicable
NAD	No Asbestos Detected.
ND	None Detected (usually refers to VOC and/SVOC TICs).
NDP	No Determination Possible
SS	Calibrated against a single substance
SV	Surrogate recovery outside performance criteria. This may be due to a matrix effect.
W	Results expressed on as received basis.
+	AQC failure, accreditation has been removed from this result, if appropriate, see 'Note' on previous page.
>>	Results above calibration range, the result should be considered the minimum value. The actual result could be significantly higher.
*	Analysis subcontracted to an Element Materials Technology approved laboratory.
AD	Samples are dried at 35°C ±5°C
CO	Suspected carry over
LOD/LOR	Limit of Detection (Limit of Reporting) in line with ISO 17025 and MCERTS
ME	Matrix Effect
NFD	No Fibres Detected
BS	AQC Sample
LB	Blank Sample
N	Client Sample
TB	Trip Blank Sample
OC	Outside Calibration Range

HWOL ACRONYMS AND OPERATORS USED

HS	Headspace Analysis.
EH	Extractable Hydrocarbons - i.e. everything extracted by the solvent.
CU	Clean-up - e.g. by florisil, silica gel.
1D	GC - Single coil gas chromatography.
Total	Aliphatics & Aromatics.
AL	Aliphatics only.
AR	Aromatics only.
2D	GC-GC - Double coil gas chromatography.
#1	EH_Total but with humics mathematically subtracted
#2	EU_Total but with fatty acids mathematically subtracted
_	Operator - underscore to separate acronyms (exception for +).
+	Operator to indicate cumulative e.g. EH+HS_Total or EH_CU+HS_Total
MS	Mass Spectrometry.

EMT Job No: 21/20239

Test Method No.	Description	Prep Method No. (if appropriate)	Description	ISO 17025 (UKAS/SANAS)	MCERTS (UK soils only)	Analysis done on As Received (AR) or Dried (AD)	Reported on dry weight basis
TM30	Determination of Trace Metals by ICP-OES (Inductively Coupled Plasma – Optical Emission Spectrometry): WATERS by Modified USEPA Method 200.7, Rev. 4.4, 1994; Modified EPA Method 6010B, Rev.2, Dec 1996; Modified BS EN ISO 11885:2009: SOILS by Modified USEP 6010B, Rev.2, Dec.1996; Modified EPA Method 3050B, Rev.2, Dec.1996	PM14	Preparation of waters and leachates for metals by ICP OES/ICP MS. Samples are filtered for Dissolved metals, and remain unfiltered for Total metals then acidified	Yes			
TM38	Soluble Ion analysis using Discrete Analyser. Modified US EPA methods: Chloride 325.2 (1978), Sulphate 375.4 (Rev.2 1993), o-Phosphate 365.2 (Rev.2 1993), TON 353.1 (Rev.2 1993), Nitrite 354.1 (1971), Hex Cr 7196A (1992), NH4+ 350.1 (Rev.2 1993) – All anions comparable to BS ISO 15923-1: 2013I	PM0	No preparation is required.				
TM38	Soluble Ion analysis using Discrete Analyser. Modified US EPA methods: Chloride 325.2 (1978), Sulphate 375.4 (Rev.2 1993), o-Phosphate 365.2 (Rev.2 1993), TON 353.1 (Rev.2 1993), Nitrite 354.1 (1971), Hex Cr 7196A (1992), NH4+ 350.1 (Rev.2 1993) – All anions comparable to BS ISO 15923-1: 2013I	PM0	No preparation is required.	Yes			
TM73	Modified US EPA methods 150.1 (1982) and 9045D Rev. 4 - 2004) and BS1377-3:1990. Determination of pH by Metrohm automated probe analyser.	PM0	No preparation is required.	Yes			
TM75	Modified US EPA method 310.1 (1978). Determination of Alkalinity by Metrohm automated titration analyser.	PM0	No preparation is required.	Yes			
TM76	Modified US EPA method 120.1 (1982). Determination of Specific Conductance by Metrohm automated probe analyser.	PM0	No preparation is required.	Yes			

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Appendix E

Ecological Assessment of Tufa Spring

Memo

To: Jerome Keohane

From: Dr Joanne Denyer (Denyer Ecology)

Cc:

Date: 24 June 2021

Subject: Summary of Coolnabacky, Co. Laois site visit and petrifying springs survey

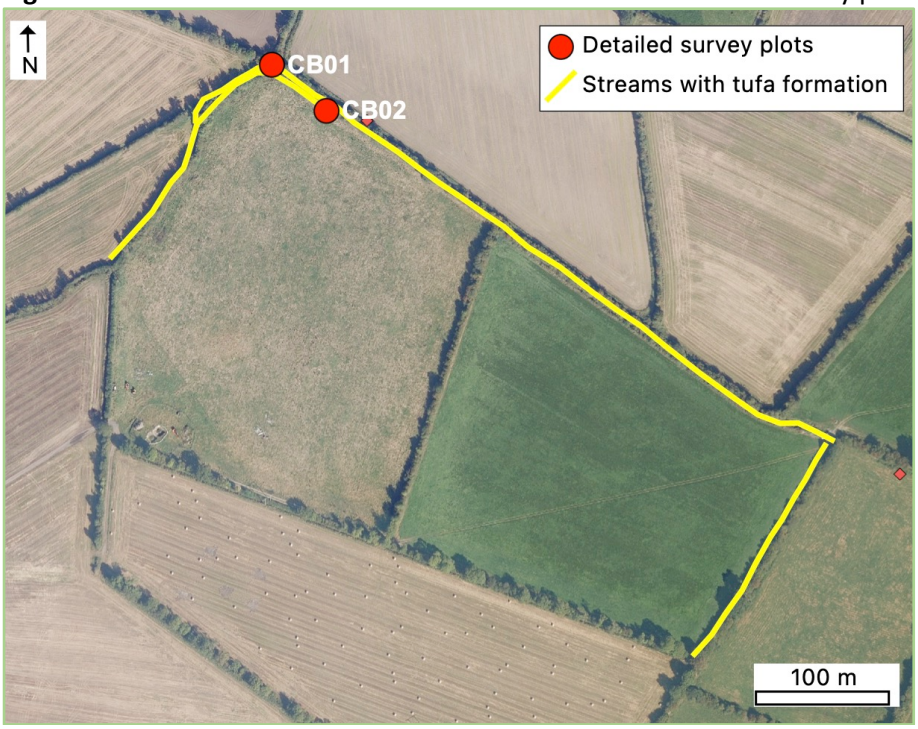
---

Today I visited the above site with Jerome Keohane (hydrogeologist) and undertook a petrifying spring survey. Petrifying springs with tufa formation (Cratoneurion) [*7220] are an EC Habitats Directive Annex I priority habitat.

Several small streams surrounding the site (Figure 1.1) were found to have a high pH and to support tufa formation as stream crust, paludal tufa, oncoids and ooids and cascade tufa. pH values of 8.30, 8.16 and 8.22 were recorded which is high for lowland streams. Cover of tufa ranged from absent to 90% of the stream bed. The streams had a good flow, despite the season and are highly likely to be largely groundwater fed. Positive indicator species for the Annex I priority habitat were rare. This is likely to be because the streams also act as drainage ditches and receive some surface water (and nutrients) from adjacent lands, increasing water depth at certain times of the year.

The surveyed streams with tufa deposition along some/ all of their length are shown in Figure 1.1.

Figure 1.1. Location of streams with tufa formation and detailed survey plots



RGB Aerial Photography - © Bluesky Geospatial Limited

Two detailed survey plots were undertaken following the methodology of Lyons and Kelly (2016) and Denyer (In press) (CB01 and CB02, Figure 1.1).

- CB01 had significant tufa formation (total 45% of cascade, stream crust and paludal tufa) but only one positive indicator species for *7220 habitat was recorded. Although this plot would not be considered a clear example of the *7220 habitat, it has high tufa formation and therefore has affinity to Annex I priority Petrifying spring habitat [*7220]
- CB02 had significant tufa formation (total 85% oncoids and ooids) and three positive indicator species for *7220 habitat were recorded. This section of stream is considered to be an example of Annex I priority Petrifying spring habitat [*7220]

The streams surrounding the site are groundwater fed and highly tufa producing. They are mostly lacking the species required to be clear examples of Annex I priority Petrifying spring habitat [*7220], but these species are present occasionally throughout the system.

A full report will be produced. Recommendations for the spring/ stream system include suitable measures to control surface water run-off from the site so that the groundwater in the spring/ stream system is not diluted, which would reduce it's tufa forming capacity.

References:

Denyer, J. (In press) Guidelines for the Assessment of Annex I Priority Petrifying Springs in Ireland. *Irish Wildlife Manuals*, No. XXX. National Parks and Wildlife Service, Department of Housing, Local Government and Heritage, Ireland.

Lyons, M.D. & Kelly, D.L. (2016) Monitoring guidelines for the assessment of petrifying springs in Ireland. *Irish Wildlife Manuals*, No. 94. National Parks and Wildlife Service, Department of Arts, Heritage, Regional, Rural and Gaeltacht Affairs, Ireland