GDG
GAVIN & DOHERTY
GEOSOLUTIONS

Illaunbaun Wind Farm - Environmental Impact Assessment Report

Appendix A09-02: Peat Stability Risk Assessment (PSRA)

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EXECUTIVE SUMMARY

JC Mont-Fort commissioned Gavin and Doherty Geosolutions (GDG) to undertake a Peat Stability Risk Assessment (PSRA) for the proposed Illaunbaun Wind Farm (the “Proposed Development”). A peat stability assessment is required in accordance with planning guidelines compiled by the Department of the Environment, Heritage and Local Government (DoEHLG), where peat is present on a proposed wind farm development.

The purpose of this report is to outline the potential for peat instability at the Proposed Development and to outline a quantitative peat stability risk assessment rating in line with the Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (PLHRAG, Scottish Government, 2017) for the proposed permanent development footprint.

The peat stability risk assessment findings showed that the site has an acceptable margin of safety and a low risk of peat failure and is suitable for the proposed renewable energy development.

Consultation with published GSI maps and the observations from site investigations indicate that significant areas of the site consist of thin blanket peat, cut over in places, with bedrock at or near the surface throughout much of the area. Peat is mapped across the site, typically interspersed with bedrock outcrop, with isolated deeper pockets (>4.5m in thickness) identified in lower-lying, forested ground in the east of the site between T2 and T6 and close to the northern boundary, north of T5. Recorded peat depths range from 0-6m across the site.

A desk study, site walkovers, ground investigation campaigns, stability analyses and a risk assessment were carried out to assess the risks posed by peat failures within the Proposed Development site. The risks were assessed following the principles in Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (Scottish Government, 2017).

The stability analysis aims to determine the Factor of Safety (FoS) of the peat slopes. The FoS provides a direct measure of the degree of stability of a peat slope. A FoS of less than 1.0 indicates that a slope is unstable; a target FoS for slopes is 1.3 or greater.

A risk assessment was carried out considering the FoS value calculated in the stability analysis and other factors that could influence peat stability, considering how damaging a peat slide would be to this site’s environment. Based on this assessment, the risk at all infrastructure elements has been classed as negligible.

The wind farm elements (turbines, hardstands, peat repository areas, access tracks, borrow pits, temporary construction compound and substation) of the Proposed Development were found to have acceptable safety factors and risk levels against peat instability. The stability assessment of the proposed development footprint indicates that areas where the Factor of Safety (FoS) is $1 \leq FoS < 1.3$ in the undrained scenario with a 10 kPa surcharge have been conservatively interpreted due to bedrock outcrops and isolated pockets of locally deep peat (1.0–2.0 m). The only location where peat depths of 3–4 m were recorded is approximately 80m north of PRA3, which has been designated as a safety buffer zone with no construction works proposed.

As part of the iterative design process, all infrastructure elements are located outside the Safety Buffer Zones (SBZs), outlined in Section 4.6.3. A total of 22 Safety Buffer Zones (SBZs) have been identified (Appendix L), within which construction activities will be restricted. Additionally, 96 Peat Stockpile Restriction Areas (PSRAs) have been designated, where no peat or other materials will be temporarily or permanently placed.

Localised peat within the turbine, access track, and borrow pit footprints will be excavated to achieve a suitable bearing stratum, mitigating stability concerns. Safety buffer zones outside the footprint will also be avoided for storage and access works.

1 INTRODUCTION

1.1 BACKGROUND

GDG were commissioned in August 2023 by JC Mont-Fort to undertake a PSRA for the proposed Illaunbaun Wind Farm. For this PSRA, the wind farm will hereafter be referred to as 'the Proposed Development', while the area within the red line boundary will be referred to as 'the Site'. The Proposed Development layout is presented in Figure A- 1 in Appendix A.

1.2 STATEMENT OF AUTHORITY

GDG has been involved in many wind farm developments in both Ireland and the UK at various stages of development, i.e. preliminary feasibility, planning, peat stability assessment, design and construction. In addition to this, the GDG team, made up of engineering geologists, geomorphologists, geotechnical engineers and environmental scientists, has developed expertise in landslide hazard mapping, including leading a recent national landslide hazard mapping pilot study which included extensive landslide runout and hazard mapping and calculation in Irish blanket peat.

GDG brings together state-of-the-art research and direct industry experience and offers a bespoke engineering service, delivering the most progressive, reliable, and efficient designs across a wide variety of projects and technical areas, including providing forensic engineering and expert witness services to the Insurance and Legal sectors. Our clients include large civil engineering contractors, renewable energy developers, semi-state bodies and engineering and environmental consulting firms.

The members of the GDG team involved in this assessment include:

- **Tim O'Shea – Project Director.** Tim holds an honours degree in Civil and Environmental Engineering from University College Cork and is a Chartered member of Engineers Ireland. He is an Associate Director at GDG with over 20 years post graduate experience in Civil Engineering. Tim is experienced in the consenting, design and construction of wind energy projects. He has been involved in the consenting of numerous wind energy projects in Ireland since his graduation in 2003. Tim has also led the design of several wind farms in Ireland and the UK, many with significant peat challenges.
- **Chris Engleman.** Chris is a Professional Geologist with a Master's degree in Geological Sciences from the University of Leeds. He is chartered with the Institute of Geologists Ireland (IGI) and the European Federation of Geologists. He has five years of industry experience within the onshore renewables sector and the field of geological mapping with a particular focus on Quaternary geology, predominantly working on projects for peat stability and management, ground investigation (GI), rock and soil logging, GIS mapping and geotechnical design. Chris has worked on many renewable energy projects, particularly wind and solar, for over two years. Chris carried out peat probing, walkovers, and supervised investigation works at the Proposed Development in 2023 and 2024.
- **Brian McCarthy**. Brian is a Civil Engineer with three years of post-graduate experience. Brian holds a Master's degree in Civil, Structural and Environmental Engineering from University College Cork and is a member of the Institution of Engineers of Ireland. Brian has worked on various renewable energy and infrastructural projects in Ireland and the UK and has carried out

peat probing on several projects throughout Ireland. Brian led peat probing investigation works at the Proposed Development in 2023.

- **Daniel Murphy.** Daniel is a Graduate Engineer with a Masters' degree in Civil Structural and Environmental Engineering from University College Cork and has been working with GDG since graduating in 2022. Daniel has carried out Proposed Development inspections, visual assessments of slopes, peat probing and water sampling on a number of projects throughout Ireland. Daniel carried out peat probing at the Proposed Development in 2023.
- **Johan Van Niekerk.** Johan is a senior design engineer. He holds a Bachelor's degree in Civil Engineering and an Honours degree in Geotechnical Engineering, both from the University of Pretoria. Johan has over 7 years of experience in civil design and construction and has been with GDG since 2023. Expertise includes 3D modelling, numerical analysis, GI and earthworks design. Johan was among the wider team involved in peat probing for the project in 2023.
- **Sowmya Reddy G.** Sowmya is a design engineer. She holds a Master's degree in Applied Environmental Sciences from University College Cork and has been with GDG since 2023. Her experience includes working on renewable energy projects, particularly in the wind and solar sectors, with expertise in GI, including Proposed Development inspections and peat probing, rock and soil logging, GIS mapping, and geotechnical design for projects in both Ireland and the UK.

1.3 Proposed Development

The Proposed Development is situated approximately 4.2 km northeast of Milltown Malbay in County Clare, within an area characterised by coniferous forestry and open peatland. The proposed planning boundary encompasses approximately 37 hectares, with the surrounding landscape comprising a mix of agricultural land, low-density residential development and commercial forestry.

The site lies approximately 2.9 km from the west coast of County Clare and 5.2 km southeast of Lahinch, encompassing the townlands of Tooreen, Slievenalicka, Illaunbaun, Lackamore, and Drumbaun.

Topographically, the site elevation ranges from 115 m above Ordnance Datum (mOD) in the east, rising to just over 200 mOD in the west and north, where two distinct hills are present. Lough Keagh, located in the southern portion of the site, lies between 180 mOD and 185 mOD.

The Proposed Development is drained by four watercourses, identified by the Environmental Protection Agency (EPA) as Illaunduff, Ballinphonta, Drumbaun, and Derrymore. Additionally, historical mapping indicates the presence of Lough Abullaunduff, which is no longer apparent in the current landscape as observed in satellite imagery. This waterbody was likely drained in the past.

The Proposed Development Description is detailed in Chapter 5 of the Environmental Impact Assessment Report (EIAR), which includes the works subject to a proposed planning application for An Bord Pleanála about the Proposed Wind Farm Site.

The Proposed Wind Farm Site will comprise the elements listed below:

- Construction of six wind Turbines with a maximum overall blade tip height of up to 150 meters and a Hub height of 91.5 m.

- Construction of 6 wind turbines with a maximum overall blade tip height of 150 m.
- Construction of associated turbine foundations, crane pad hardstand and assembly areas.
- Construction of one permanent 38 kV electrical on-site substation with one control building with welfare facilities, all associated electrical switchgear, security fencing, underground cabling, drainage infrastructure, and all ancillary works.
- All associated internal underground electrical and communications cabling connecting the wind turbines to the on-site Substation.
- Upgrade of existing tracks, roads and provision of new site access roads to facilitate construction & operation of the wind farm.
- Two borrow pits.
- Three peat repository areas for peat & spoil management.
- Construction of one temporary construction compound.
- Development of internal site drainage.
- Permanent & Temporary tree felling to accommodate the construction & operation.
- Signages and
- All associated site development works.

1.4 Overview of Peat Landslides

1.4.1 Peat Landslide Types

The literature typically refers to two general groups of peat landslides: peat slides and bog bursts. Some descriptions of each type are provided in Table 1-1.

Table 1-1: Peat landslide types (after Dykes and Warburton, 2007).

Peat landslide type	Definition	Typical slope range	Typical peat thickness
Bog burst	Failure of a raised bog (i.e. bog peat) involving the break-out and evacuation of (semi-) liquid basal peat.	2 – 5˚	2 – 5m
Bog flow	Failure of a blanket bog involving the break-out and evacuation of semi-liquid, highly humified basal peat from a clearly defined source area	2 – 5˚	2 – 5m
Bog slide	Failure of a blanket bog involving sliding of intact peat	5 – 8˚	1 – 3m

Peat landslide type	Definition	Typical slope range	Typical peat thickness
	on a shearing surface within the basal peat.		
Peat slide	Failure of a blanket bog involving sliding of intact peat on a shearing surface at the interface between the peat and the mineral substrate material or immediately adjacent to the underlying substrate.	5 – 8˚ (inferred)	1 – 3m (inferred)
Peaty debris slide	Shallow translational failure of a hillslope with a mantle of blanket peat in which failure occurs by shearing wholly within the mineral substrate and at a depth below the interface with the base of the peat such that the peat is only a secondary influence on the failure.	4.5 – 32˚	< 1.5m
Peat flow	Failure of any other type of peat deposit (fen, transitional mire, basin bog) by any mechanism, including flow failure in any type of peat caused by head-loading.	Any of the above	Any of the above

1.4.2 Controls of Peat Instability

The spatial and temporal occurrence of landslides, including peat landslides, is controlled by *conditioning* and *triggering factors*. The conditioning factors explain the spatial distribution of landslides and are related to the inherent properties of the terrain, such as soil type, slope angle, curvature (convex/concave) of the slopes, and drainage.

The triggering factors explain the frequency of landslides. They can be distinguished between fast and slow triggers:

- Fast triggers:
- Intense rainfall (the most frequent trigger);
- Snowmelt (very frequent trigger; Warburton, 2022);
- Rapid ground accelerations (e.g. from blasting rock);
- Undercutting of peat by natural processes (e.g. fluvial) or man-made; or
- Loading the peat.

- Slow triggers:
- Low intensity but constant rainfall;
- Afforestation / Deforestation (wildfires, pollution-induced vegetation change); or
- Weathering (physical, chemical, biological).

Slow triggers can start landslides by themselves and can also act as *preparatory factors* for fast triggers by lowering their threshold to start landslides.

1.4.3 Pre-failure Indicators

The presence of conditioning factors and low-pace triggers before failure is often indicated by ground conditions, features, and morphologies that can be identified remotely or during fieldwork by the geomorphologist or through basic monitoring techniques.

According to the updated guidelines provided by the Scottish Government (2017), the following critical features are indicative of the susceptibility or proneness to failure in peat environments:

- Presence of historical and recent failure scars and debris;
- Presence of features indicative of tension (e.g. cracks);
- Presence of features indicative of compression (e.g. ridges, thrusts, extrusion features);
- Evidence of peat creep (typically associated with tension and compression features);
- Presence of subsurface drainage networks or water bodies;
- Presence of seeps and springs;
- Presence of artificial drains or cuts down to substrate;
- Presence of drying and cracking features;
- The concentration of surface drainage networks;
- Presence of soft clay with organic staining at the peat and (weathered) bedrock interface; and
- Presence of iron pans or similar hardened layers in the upper part of the mineral substrate.

Other evidence of peat instability unrelated to landslides has been considered, namely quaking peat in horizontal areas with very low bearing capacity.

1.5 Peat Stability Risk Assessment Workflow

GDG has carried out the PSRA for the Proposed Development following the principles set out in the *Proposed Electricity Generation Developments: peat landslide hazard best practice guide* (Scottish Government, 2017). This guide has been used in this report as it provides best practice methods to identify, mitigate, and manage peat slide hazards and associated risks concerning consent applications for electricity generation projects.

Figure 1-1 shows a workflow diagram showing the general methodology for the PSRA. The methodology can be summarised into the following steps:

- Completion of the desk study, including:

- Geology and Quaternary sediments (subsoils);
- Soils;
- Moisture;
- Hydrogeology;
- Multi-temporal aerial / Satellite imagery;
- Topography;
- Landslide inventories and landslide susceptibility;
- Hydrology;
- Land cover and land use;
- Relevant academic literature and publications. Undertaking a walkover and fieldwork to:
- Carry out geo-investigations, especially concentrated at the proposed infrastructure areas, including peat probing, hand shear vane testing, and trial pitting;
- Record geological and geomorphological features, including exposures of the soil profile and evidence of peat instability; and
- Record hydrologic and vegetation features.
- Risk assessment, including:
  - Interpolation of the peat probe values and generation of the peat depth map;
  - Creation of the Factor of Safety (FoS) maps using a deterministic approach (Bromhead, 1986) for drained and undrained conditions;
  - Qualitative hazard assessment by combining the FoS with observations of the peat condition identified both on aerial imagery and during fieldwork.
  - Qualitative consequences assessment;
  - Calculation of the peat landslide risk by multiplying hazards and consequences;
  - Classification of the risk values into four classes:
- Negligible;
- Low;
- Medium; and
- Serious.
- Proposal of actions required for each infrastructure element.

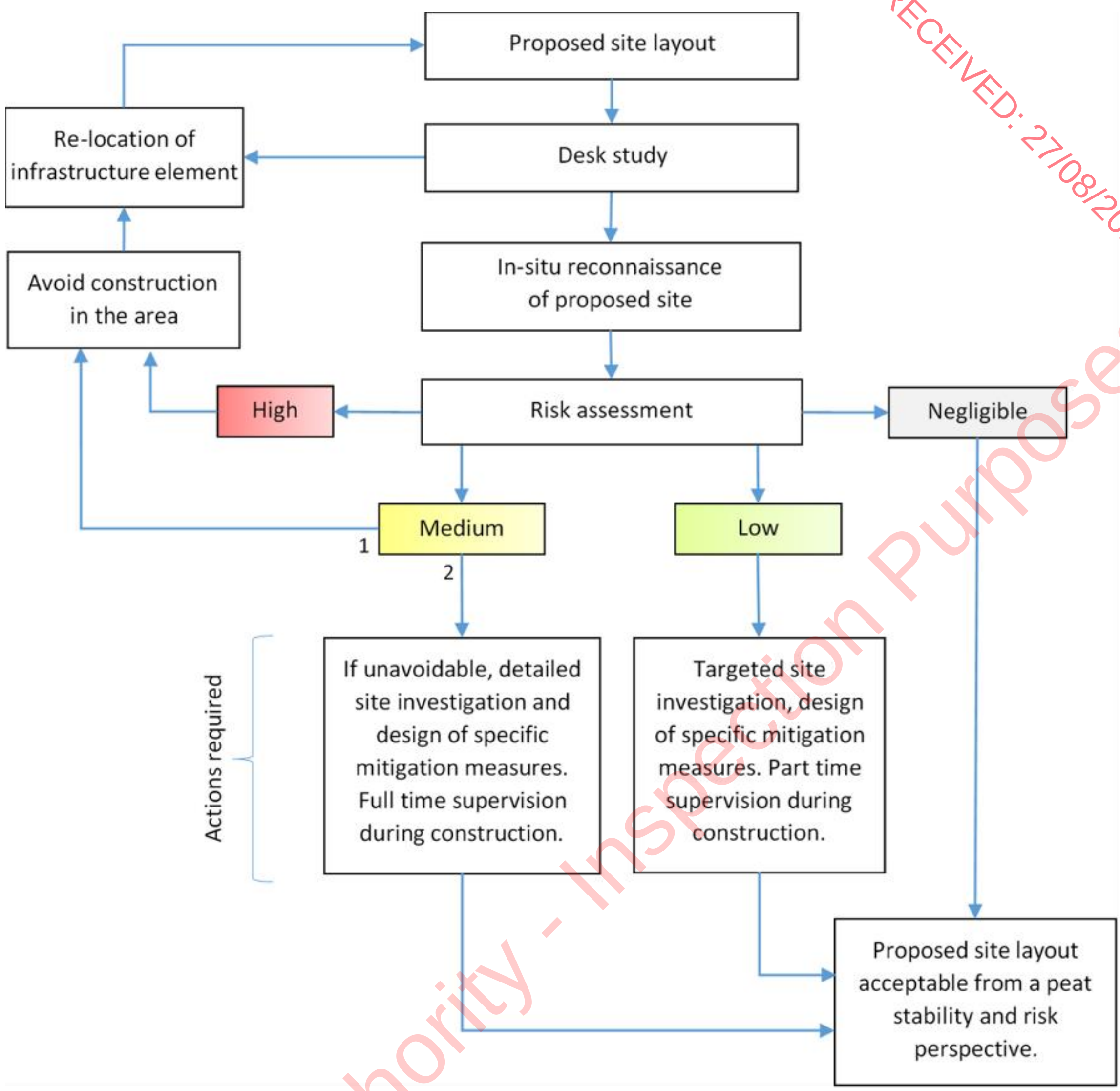


Figure 1-1: Workflow of the PSRA methodology for the acceptability of the proposed site layout (Scottish Government, 2017).

2 DESK STUDY

For a preliminary site suitability analysis and background knowledge of local peat stability and ground conditions, the following aspects have been considered:

- Geology and Quaternary sediments (subsoils);
- Soils;
- Moisture;
- Hydrogeology;
- Multi-temporal aerial / Satellite imagery;
- Topography;
- Landslide inventories and landslide susceptibility;
- Hydrology;
- Land cover and land use;
- Relevant academic literature and publications.

2.1 BEDROCK GEOLOGY

Geological Survey Ireland (GSI) 1:100,000 scale bedrock mapping shows the Proposed Development and surrounding area to be underlain entirely by a single bedrock formation, the Central Clare Group (CCG), which is Carboniferous in age (Namurian).

This lithology is characterised by grey/dark grey cyclothemic sequences of mudstone, siltstone, and sandstone of fluvio-deltaic & basinal marine (turbiditic) origin. The basal mudstone is usually 7-18m thick and laminated. In general, the mudstones are overlain by laminated to massive grey siltstones followed by thick, laminated and cross-bedded sandstones. Site walkovers indicate that CCG bedrock outcrops in topographic highs of the site, corroborating GSI outcrop mapping for the area. As limestone bedrock does not occur within the site boundary, karst features are not considered to be a risk.

The main bedrock unit and associated structural features within the Proposed Development boundary and surrounding area are shown in Figure B- 1 in Appendix B.

2.2 QUATERNARY SEDIMENTS

The map of Quaternary sediments at 1:50,000 scale shown in Figure B- 2 Appendix B (GSI, 2021) shows that the wind farm site is underlain by a mosaic of blanket peat and bedrock outcrop or subcrop, which indicates a combination of peat deposits interspersed between thin unsubstantial soils. Bedrock outcrop/sub-crop is generally located in the upland areas and topographic high points within the north and west of the site but is spatially extensive throughout. Tills derived from Namurian sandstones and shales are present at the boundaries of the Proposed Development area, especially in Drumbaun and Illaunnbaun townlands. Glacial till typically comprises a heterogeneous mix of sand, gravel, cobbles, and boulders, usually held in an overconsolidated clay matrix. This till classification indicates that the glacial tills are likely locally derived from the underlying Namurian age bedrock.

2.3 Soil Composition

The Irish soil map at a 1:250,000 scale is shown in Figure C- 1 Appendix C (EPA, Teagasc, & Cranfield University, 2018). The Proposed Development is mapped as containing soils classified as podzols (peaty), peat and gleys. EPA/Teagasc mapping indicates that peaty soils and near-surface bedrock dominate most of the site, with gleys located in the eastern and western peripheries (Soil classification 1130a). GSI mapping indicates that, in general, soils within the Proposed Development are poorly draining and display acidic mineralisation due to the prevalence of peat. The depth and extent of peat deposits may vary over short distances as a function of local underlying geology, past and ongoing geomorphological progression and management history.

It is noted that the presence or absence of peat cover in the regional scale maps in Figure C- 1 must not be taken as exact. The depth and extent of peat deposits may vary over short distances as a function of local underlying geology, past and ongoing geomorphological activity, and management history. Therefore, these maps have been complemented by peat probes and field observations described in Appendix J

2.4 Moisture

Water reaching a slope can produce the following processes:

- Lubrication. It reduces friction along rock or soil discontinuities (joints or stratification) (Wu, 2003). In clay soils, lubrication is due to water that produces a repulsion or separation between the clay particles.
- Softening. It mainly affects the physical properties of filler materials in fractures and fault planes in rocks.
- Pore pressure. Water in soil pores exerts pressure on soil particles, changing the effective pressure and the shear strength. The negative impact of pore pressure changes is particularly evident in partially saturated or unsaturated soils, where the increase in moisture content causes the development of a wetting front that converts beneficial negative suction stresses within the capillary structure of the soil to a fully saturated positive pore pressure. When soil is saturated, capillary stresses and adhesion between particles diminish, and, as a result, soil shear strength decreases.
- Confined water pressures. The confined underground water acts as an uplifting pressure on the impermeable layers, decreasing the shear strength and producing hydrostatic pressures on the layers where permeability changes. These lifting stresses can cause material deformation or failure, and pore pressure decreases soil resistance.
- Fatigue failure due to fluctuations in the water table. Some landslides occur in episodes of rain with lower intensity than previous ones. This phenomenon is explained by Santos et al. (1997) as a case of soil fatigue due to cyclical pore pressures. In temperate climates, seasonal temperature variations can lead to slight variations in the water table. These changes are much more significant in tropical climates (Xue & Gavin, 2008).

- Washing away of cement material. The groundwater flow can remove the soluble cement (e.g. calcium carbonate) from the soil and, thus, decrease the cohesion and the friction angle. This process is usually progressive.
- Density increase. The presence of water in soil pores increases the bulk density and weight of the materials in the slope. Therefore, shear stress increases, and the slope safety factor decreases.
- Internal hydraulic forces. The movement of groundwater currents creates hydrodynamic pressure on the ground in the direction of flow. This force acts as a destabilizing element on the groundmass and can appreciably decrease the safety factor of the slope. The hydrodynamic or seepage/flow force can also cause the movement of the particles and the destruction of the soil mass (piping).
- Collapse. Collapsible soils (alluvial soils deposited very rapidly and wind soils or loess) are very sensitive to changes in humidity. When water content increases, their volume decreases, and the microstructure collapses.
- Desiccation cracks. Changes in humidity can cause cracking, and these cracks can determine the extension and location of the surface of failure and have a significant effect on the safety factor or possibility of sliding.
- Piping in clays. Some clayey soils disperse and lose their cohesion when saturated. The result can be the total collapse of the soil structure and the activation of landslides.
- Chemical weathering: Processes of ion exchange, dissolution, hydration, hydrolysis, corrosion, oxidation, reduction, and precipitation (Wu, 2003).
- Erosion. The detachment, dragging, and deposition of soil particles by water flows modifies the relief and the stresses on slopes and can produce the activation of a landslide, especially when erosion undercuts slopes.

The *Normalized Difference Moisture Index Colorized* GIS service or the United States Geological Survey (USGS) has been used to estimate levels of moisture in the soil across the Proposed Development site. This service is based on the analysis of multispectral Landsat 8[1] OLI images. Using data processing, the raw digital number (DN) values for each Landsat band are transformed to scaled (0 - 10000) apparent reflectance values, and then, the Normalised Difference Moisture Index is obtained using Equation 2.4-1 (Gao, 1996):

NDMI = (Band 5[2] – Band 6[3]) / (Band 5 + Band 6) **Equation 2.4-1**

Figure D- 1 in Appendix D illustrates the levels of estimated soil moisture across the Proposed Development Site as calculated by the above method. Wetlands and other vegetated areas with high levels of moisture appear as dark blue. Regions of lower moisture values are represented as light

[1] Landsat 8 includes 8-band multispectral scenes at 30-meter resolution which are typically used for mapping and change detection of agriculture, soils, moisture, vegetation health, water-land features and boundary studies.
[2] Near Infrared (NIR)
[3] Short Wave Infrared 1 (SWIR1)

blue and green. The map indicates that the Proposed Development site as a whole displays a high moisture content.

2.5 HYDROGEOLOGY

2.5.1 AQUIFER TYPES

The bedrock aquifer type within the Proposed Development boundary and surrounding area is shown in Figure E- 1 in Appendix E.

According to GSI's groundwater map viewer, bedrock directly underlying the site is categorised as a Locally Important (LI) Aquifer Bedrock. This is defined as "Bedrock which is Moderately Productive only in Local Zones". This means groundwater flow occurs predominantly through fractures, fissures, and joints, giving a low fissure permeability, which tends to decrease with depth. Flow paths are thought to be between 30 – 300m in length, and locally important aquifers are generally capable of yielding enough water to supply single domestic wells only (10-20m3/d) (GSI, 2017). The bedrock aquifer has been categorised as a member of the 'Namurian Undifferentiated (NU)' Rock Unit Group (RUG). The regional groundwater flow direction in the aquifer will be westward, towards the Atlantic Ocean (2000a).

Localised groundwater flow paths within the Proposed Development will follow the orientation of surface water sub-catchments from topographic highs to lower elevation discharge points. Shallow groundwater in the south of the site will flow in the direction of Lough Keagh.

Hydraulic properties for the Central Clare Group are outlined in Table 2-1.

Table 2-1: Hydraulic properties for bedrock aquifer units at the Proposed Development.

Bedrock unit name	Rock Unit Group	Aquifer type	Best estimate transmissivity (m^2/d)	Transmissivity range (5^{th}-5%ile) (m^2/d)	Geometric Mean of Storativity (-)	Geometric mean of Specific yield (-)
Central Clare Group	NU	LI	7	0.5 - 152	0.00026	0.017

2.5.2 SUBSOIL PERMEABILITY

Subsoil permeability across the Proposed Development is categorised mostly as 'N/A' due to thin superficial deposits, where the depth to bedrock is less than 3m, including all WTG locations. Areas of 'Low' permeability, where superficial deposits are slightly thicker, surround the site to the East, West, and South. One of the access tracks in Illaunbaun townland is underlain by 'Low' permeability.

There are no superficial aquifers located within or adjacent to the Proposed Development boundary, although it is possible that localised perched groundwater is present at the base of peat deposits and within granular layers/ lenses within the glacial till matrix.

Subsoil permeability classifications within the Proposed Development boundary and surrounding area are presented in Figure E- 2 in Appendix E.

2.5.3 GROUNDWATER VULNERABILITY

Groundwater vulnerability in Ireland, as defined in the Water Framework Directive – Recharge and Groundwater Vulnerability, is a function of the thickness and permeability of the subsoil that overlies bedrock. These factors strongly influence the attenuation processes and the time it takes for contamination to be released into the subsurface. Groundwater vulnerability classifications within the Proposed Development boundary and surrounding area are presented in Figure E- 3 in Appendix E. The majority of the Proposed Development exhibits a mixture of 'Extreme' and 'X – Extreme' groundwater vulnerability, where bedrock is at or near the surface. The easternmost area of the site borders a zone of 'High' vulnerability in Illaunbaun townland. Due to the localised variability on-site, pre-development vulnerability observed at individual WTGs and other infrastructure, such as borrow pits, peat placement areas, site compounds, and access roads, will vary depending on location. Based on the site walkover, ecological surveys and likely shallow groundwater regime, sensitive GWDTEs are considered unlikely across this site. The areas of T03 and T06 have been mapped as ' Extreme' whereas other turbines have been mapped as 'Rock at or near Surface or Karst.

2.6 MULTITEMPORAL AERIAL/SATELLITE IMAGERY

The aerial / satellite imagery used for this report is Ordnance Survey Ireland (OSI) aerial imagery and Google Earth multitemporal imagery (1996 onwards). This imagery has been used to:

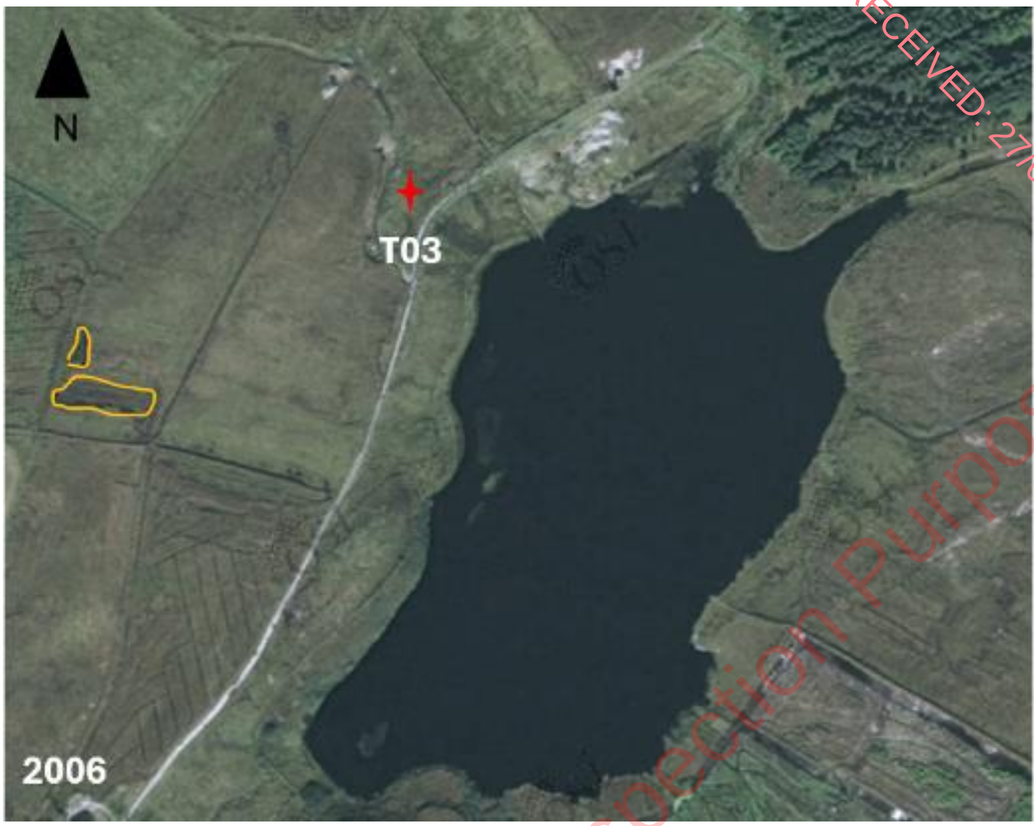
- Identify the presence of existing failure scars and the extent of debris runout;
- Identify pre-conditioning factors for failure (where visible at the resolution of the imagery);
- Identify evidence of other pre-development ground conditions of relevance to ground works but not exclusively associated with landslides, including vegetation cover, drainage regime, and dominant drainage pathways; and
- Identify evidence for land management practices that can influence ground conditions (e.g., burning, artificial drainage, peat cutting, forestry).

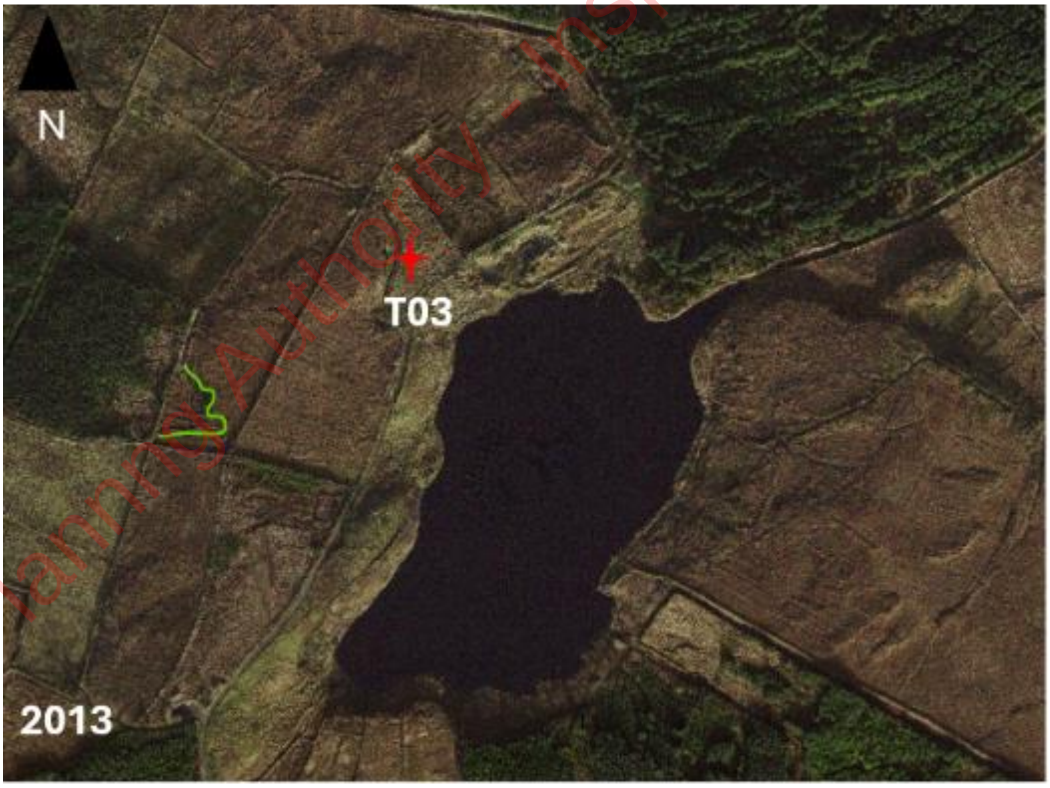
A review of satellite imagery spanning the period from 1996 to 2022 revealed evidence of peat harvesting (marked across the satellite imagery in Figure 2-1) which was only observed in a small area to the northwest and southwest of T03, approximately about 90m northwest and 160m southwest of the turbine location. However, it is noted that the locations of turbines T2 and T5 are situated within a forestry plot that has undergone changes in tree density over this time.

It should be noted that the time frame of the available imagery may be insufficient to identify historical peat instability, as such evidence may have eroded or been obscured by re-vegetation or land management changes over time.


N
T03
1996


N
T03
2001


N
T03
2006


N
T03
2013


N
T03
Lough Keagh
2017
Image © 2025 Maxar Technologies

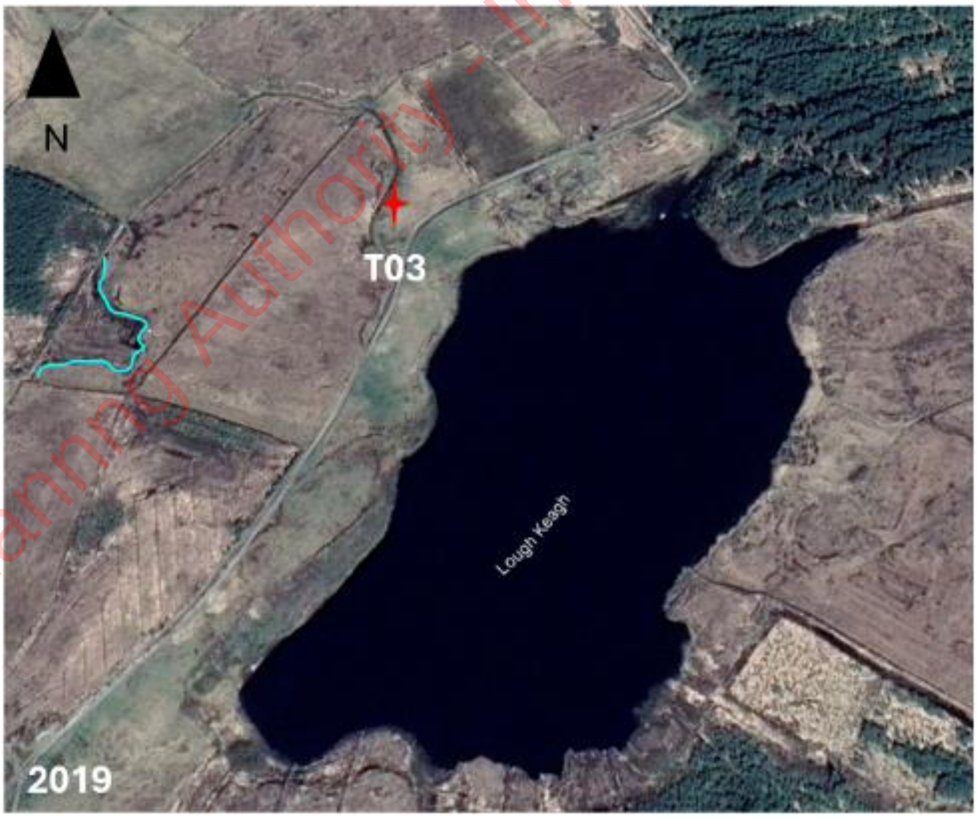

N
T03
Lough Keagh
2019

Figure 2-1: Peat cuts and harvesting of peat to the west of T03, Ordnance Survey Ireland (OSI) aerial imagery, (1996-2013), Google Earth (2017-2022)

Peat harvesting to the west of T03 was observed to progress at a slow rate until 2006, after which the intensity of harvesting notably increased. Despite this, the overall rate of harvesting is considered to be relatively low. This factor has been incorporated into the factor of safety analysis, with considerations made for section cuttings as part of the peat stability risk assessment

2.7 TOPOGRAPHY

The topography across the proposed development is described with reference to a drone LiDAR survey completed by GDG in 2023, augmented by a further drone survey completed by Drone Services Ireland in 2024. A 1m DEM has been generated from this survey (Figure 2-2, and Figure F- 1 in Appendix B. The topography within the site boundary ranges from 100m above Ordnance Datum (mOD) in the far west of the site, rising to over 195mOD on the hill of Knockabullaunduff in the west and north, where two hills are present in Drumbaun and Lackamore townlands (Figure 2-2). The site is generally undulating, with bedrock hills intermixed with flatter areas. Access routes from the south-southwest join the site at higher elevations, approximately 185mOD. The overall slope angle across the site varies from 5° to 45°, as illustrated in Figure F- 2 in Appendix F. The majority of the site exhibits a slope angle within the range of 5° to 10°, with steeper gradients of 30° to 45° observed in a few isolated areas, such as along drainage channels, ditches, and the banks of Lough Keagh. As part of the iterative design process, no infrastructure associated with the proposed development has been positioned within areas of high slope angles.

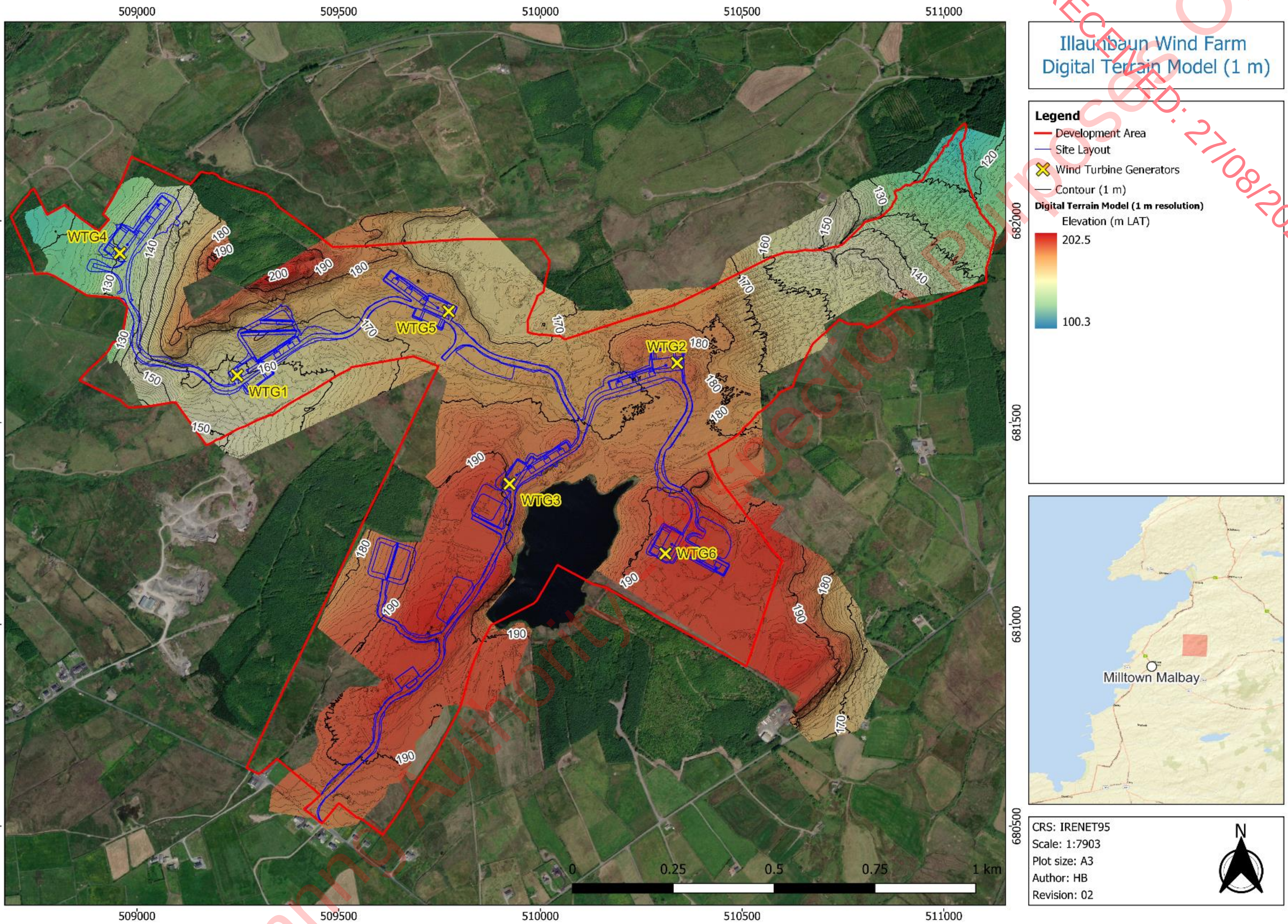


Figure 2-2: Digital Terrain Model for the Proposed Development (GDG and Drone Services Ireland, 2025).

2.8 SLOPE INSTABILITY MAPPING

The GSI landslide inventory (GSI, 2022a), the multi-temporal aerial/satellite imagery, the DEM and the landslide susceptibility map (GSI, 2016) have been used for this part of the desk study.

The study area is in a region of moderate rainfall, and despite the relatively steep topography in places, there is no record of past landslide events from the national landslide database nor from the desk study and fieldwork within the Proposed Development boundary. The nearest recorded landslide event is located 15km away from the site, occurring in a riverbank location close to Doolin. This does not necessarily mean that landslides have never occurred at the wind farm site. Geomorphological features associated with peat landslides (peat slides and bog bursts) are typically softened with time through erosion, drying, and re-vegetation (Feldmeyer-Christe & Küchler, 2002; Mills, 2003). Additionally, human activity (e.g., grassland activity and deforestation) may hamper the identification of possible landslides.

Figure G- 1 in Appendix G illustrates the landslide susceptibility (GSI, 2016) across the Proposed Development Site. This map was obtained by using an empiric probabilistic method at a regional scale and did provide input into site-specific scale engineering studies. The majority of the site is mapped as having moderate low susceptibility due to the low slope angles encountered. Patches of moderately low and moderately high susceptibility and a small area of high susceptibility are encountered, corresponding to local topographic highs and locally steeper slopes due to the presence of bedrock outcrops – particularly along the eastern and western margins of the site. The band mapped as high susceptibility corresponds to a steep bedrock slope located to the east of T4. The field visits of the project team support that the site is stable.

2.9 HYDROLOGY

According to the Ordnance Survey Ireland (OSI) shapefiles of rivers, lakes, and catchments/basins, (Figure H- 1 in Appendix H). The site is located within the watershed of two catchments (*Sinking 020* and *Levally Stream 010*). The erosive potential of the fluvial network at this location is likely to be low. T2 and T6 are located quite close (at 50 m or less) to a minor watercourse labelled as *Timadooaun*. The rest of the projected elements (e.g., turbines, borrow pits, etc.) are located more than 50m from any watercourse. These are further discussed in detail in Chapter 10: Hydrology and Water Quality and Flood Risk of the EIAR.

2.10 LAND COVER AND LAND USE

CORINE (2018) land use mapping at the Proposed Development (Figure I- 1 in Appendix I) indicates mixed land uses comprising peat, pastures, transitional woodland scrub, and land principally occupied by agriculture with significant areas of natural vegetation. Parts of the northeast of the site in the vicinity of T2 are covered by Coillte coniferous forestry plantation, with some areas of private coniferous plantation located in the vicinity of T5.

The proposed access routes extend from Toreen Road and an unnamed local road to the south-southwest and the L1074 to the northwest. Proposed access routes partially comprise existing forestry tracks.

3 SITE RECONNAISSANCE AND GROUND INVESTIGATION

GDG conducted site reconnaissance as part of the assessment, comprising five walk-over inspections (April 2022, July 2023, September 2023, October 2023, and March 2024) to record geomorphological features concerning the Proposed Development, peat depths, and peat strength. An additional site investigation was carried out by Irish Drilling Ltd in September- December 2024. The factual report for the ground investigation is included in Appendix A of the Ground Investigation Report (Appendix A09-03), referred to as "Appendix A09-03", hereafter. An indication of the site conditions is shown in Figure 3-1 to Figure 3-4. Access was restricted in certain areas, particularly around T4, which was inaccessible due to dense forestry, which limited both the number of peat probes taken and the ground investigation activities in this region. As a result, only trial pitting was possible within T4.

Figure 3-1: View of Lough Keagh from PRA3, looking west across the T6 hardstand. Open cut-over blanket peat.

Figure 3-2: T1 Location. Open blanket peat.

Figure 3-3: Eroding peat hag at the T6 location.

Figure 3-4: Afforested blanket peat close to T5.

Five ground investigations (GIs) were carried out on the site:

1) GDG (April 2022): 7 peat probes
2) GDG (July 2023): 85 peat probes and 4 hand shear vanes.
3) GDG (September 2023): 33 peat probes.
4) GDG (October 2023): 98 peat probes.
5) GDG (March 2024): 62 peat probes
6) Irish Drilling Ltd (September 2024): 84 peat probes, 19 hand shear vanes, 9 Russian gouge cores, 4 rotary core boreholes and 17 trial pits

In summary, intrusive ground investigations were carried out at a total of 422 locations. The site investigation locations (Figure J- 1 to Figure J- 5 in Appendix J) considered the following criteria:

- Spatial distribution of the proposed infrastructure;
- Distance between probe points to avoid interpolation of peat depths across large distances;
- Changes in slope angle, as peat depths are likely to be shallower on steeper slopes;
- Changes in vegetation, which can reflect changes in peat condition;

- Changes in hydrological conditions; and
- Changes in land use.

No evidence of any previous landslides or peat instability indicators, as described in Section 1.4.3were identified during the walkovers.

A raster map was created in GIS software, presenting the interpolated peat depth across a site from the peat probe points using the Inverse Distance Weighted (IDW) method. This interpolated raster of peat depth is represented in Figure J- 6 to Figure J- 10 in Appendix J.

Appendix J presents the observations made at the proposed infrastructure. The trial pit logs can be seen in Appendix A09-03.

3.1 GROUND INVESTIGATION SUMMARY AND PEAT CONDITIONS

The ground investigations conducted by IDL (Appendix A09-03) included peat probing, trial pitting, and Russian Core augering. As part of the investigation, Russian Core sampling was carried out at nine locations where peat was observed, classified, and recorded using the Von Post classification system. IDL applied the Von Post classification, with most locations recording a decomposition score of H4–H5 (slight to moderate decomposition). The trial pit data (Appendix A09-03) indicate that the superficial deposits across the site comprise peat underlain by silty, gravelly clay containing gravel and cobbles, extending to depths of up to 6m. The thickness of peat encountered during intrusive investigations ranges from 0m to a maximum of 3.30m, with the deepest peat recorded in TP111 at 3.30m below ground level (bgl). In the remaining trial pits, peat depths ranged between 0m and 2.5m bgl, with a median peat depth of 0.45m recorded across the site. The Ground Investigation Report (GIR, Technical Appendix A09-03) discusses geotechnical soil parameters, including Standard Penetration Test (SPT) N values, bulk unit weight of soil and rock materials, undrained shear strength of cohesive soils, effective friction angle, and the drained and undrained Young's moduli of the soil materials encountered.

Most areas of the site have little or no peat, with thin blanket peat (typically <1m thick) predominating. Peat depths at all turbine locations except for T03 are less than 1m, and no peat was recorded at T04. Two isolated areas of deeper peat or soft material were identified. The first is located approximately 40m north of T05, near the site boundary, and is associated with a permanent hydrological feature identified on the OSI 6-inch mapping as Aillbrack Lough. This area to the north of T05 does not interact with the proposed development elements. The second area is situated between T02 and T06 within a forestry region, where peat of depth up to 4.7m interacts with the alignment of the proposed access road.

The distribution of peat depth is illustrated in Figure 3-5. Of the recorded measurements, 82.7% indicate a peat depth of less than 1m, while 96.2% are less than 2m.

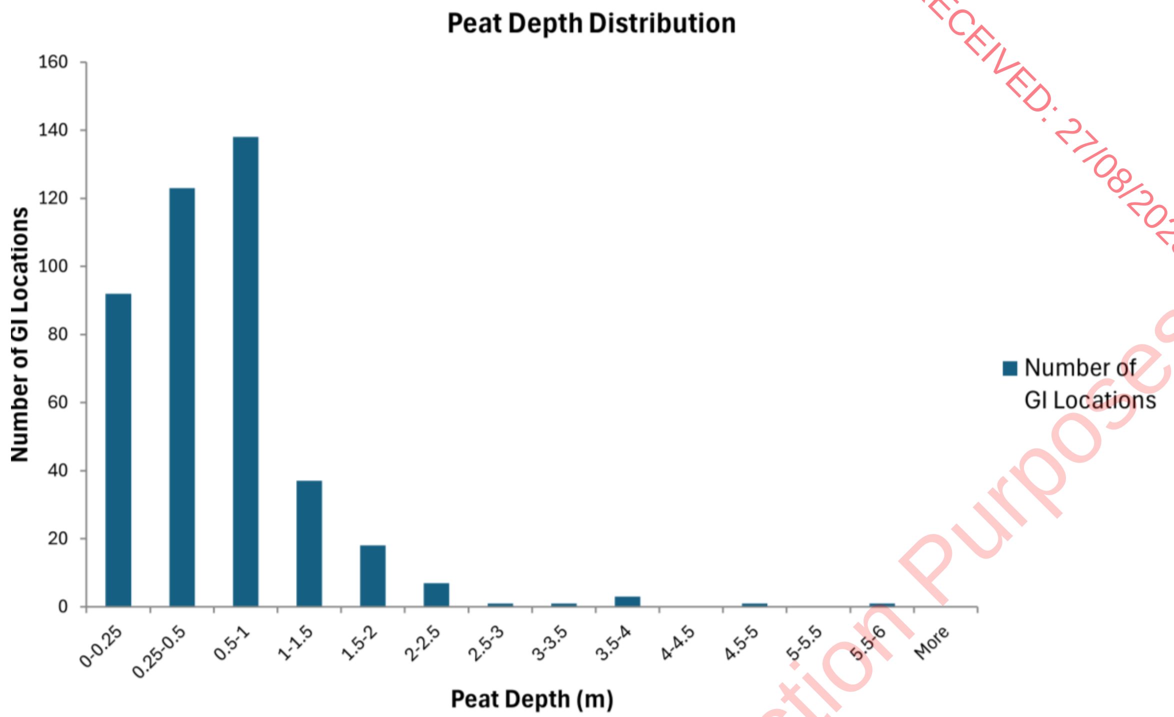


Figure 3-5: Histogram of peat depth results across the Proposed Development.

The walkover indicated that while there was no active peat extraction on-site, several areas across the proposed development had undergone significant drainage, with the observed peat classified as the catotelm. The surface condition of the peat is varied, with some areas having been drained for forestry plantation with no forestry planted, some areas having forestry planted, and some areas having been subject to historic peat harvesting – with heathland vegetation having regenerated over the peat surface. A large variation in the level of decomposition and humification was observed throughout the peat body. However, this generally appeared to increase with depth. Most of the peat material identified at the site is logged as fibrous and pseudo-fibrous, indicating that it is of a higher strength material and will be suitable for landscaping and reinstatement adjacent to proposed infrastructure locations. Hand shear vanes (HSVs) were carried out in 29 locations across the site, with strengths ranging from 4-50kPa. The HSV results are summarised in Table 3-1.

Table 3-1: Summary of hand shear vane (HSV) results.

Peat Shear Vane ID	Peat Depth	Shear Strength (kPa)	
HSV3	0.1	Refusal	**Irish Drilling Ltd (IDL) September 2024**
HSV4	1.4	32	
HSV5	0.2	50	
HSV6	0.1	Refusal	
HSV7	0.1	Refusal	
HSV8	0.1	Refusal	
HSV9	0.5	35	
HSV12	0.5	15	
HSV13	0.3	6	

Peat Shear Vane ID	Peat Depth	Shear Strength (kPa)	
HSV14	0.2	38	
HSV15	0.05	Refusal	
HSV16	0.6	15	
HSV17	0.7	40	
HSV18	0.6	14	
HSV19	0.07	Refusal	
TP101	0.8	10	
TP102	0.4	10	
TP105	1.2	10	
TP110	0.5	20	
TP111	1	30	
TP111	2	20	
TP111	3	15	
TP112	0.5	30	
TP113	1	5	
TP113	1.3	4*	
SV1	0.52	43	**GDG – July 2023**
SV2	1.5	22	
SV3	0.73	18	
SV4	1.12	24	
Minimum		**4***	
Maximum		**50**	
Average		**22**	

**Note: The 4 kPa undrained shear strength recorded in TP113 was measured in a standing pool of water at 1.20mbgl and is, therefore, not considered a representative result.*

4 PEAT STABILITY ASSESSMENT

The peat stability assessment is one of the inputs required for the peat hazard assessment and risk calculation. This section presents:

- A review of the general approaches to assess peat stability;
- The concept of FoS;
- The methodology adopted for this report and the parameters required; and
- The resulting FoS delineated safety buffers and peat stockpile restricted areas

It is to be noted that the design of infrastructure locations was developed through an iterative process undertaken in parallel with peat probing, ensuring that areas of deeper peat and higher risk were avoided wherever feasible.

4.1 MAIN APPROACHES TO ASSESS PEAT STABILITY

The main approaches for assessing peat stability for wind farm developments include the following:

1) Qualitative geomorphological judgement; and
2) Quantitative assessment:
    i) Empirical probabilistic approach.
    ii) Physically based deterministic approach (FoS).

Approach 1 is subjective and, thus, not adopted for this study. Approach 2a is objective and quantitative but is more appropriate for land planning and decision-making studies at a regional scale. Additionally, the method does not provide an engineering indication of physical stability as Approach 2b does. In this report, the peat stability assessment is carried out by using Approach 2b: deterministic (FoS) approach (Bromhead, 1986).

4.2 THE FOS CONCEPT

The FoS is a measure of the stability of a slope. For any slope, the degree of stability depends on the balance between the landslide driving forces (weight of the slope) and its inherent shear strength, illustrated in Figure 4-1.

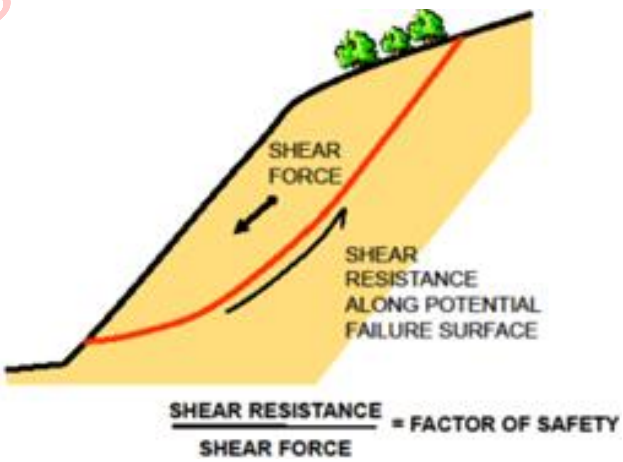


Figure 4-1: Balance of forces in a slope (Scottish Executive, 2017).

Therefore, the FoS provides a direct measure of the degree of stability of a slope by the ratio of the shear resistance along a potential surface of failure and the landslide driving forces acting on such a surface. Multiple potential surfaces of failure are possible, but the FoS assigned to a slope is that of the surface of failure with the lowest value of FoS.

- FoS < 1 indicates a slope is unstable and prone to failure.
- FoS = 1 indicates a slope is theoretically stable but not safe.
- FoS ≥ 1.3 indicates the acceptable safety threshold. The previous code of practice for earthworks, BS 6031:1981 (BSI, 1981), provided advice on the design of earthwork slopes. It stated that for a first-time failure with a good standard of site investigation, the design FoS should be greater than 1.3. The slope is, therefore, stable and safe.

As a general guide, the FoS limits for peat slopes assumed in this report are summarised in Table 4-1.

Table 4-1: Factor of Safety limits assumed in this report.

Factor of Safety limits	Slope stability
FoS < 1	Unstable
1 ≤ FoS <1.3	Stable but not robust
FoS ≥ 1.3	Stable and safe

Eurocode 7 (EC7) (I.S. EN 1997 1.2005+AC.2009) is now the reference document and basis for design geotechnical engineering works. The design philosophy used in EC7 applies partial factors to soil parameters, actions and resistances. Unlike the traditional FoS approach, EC7 does not provide a direct measure of stability, as global factors of safety are not used.

Therefore, to provide a direct measure of the peat stability across the site, the previous FoS method has been used for this assessment rather than EC7 partial factors.

4.3 Methodology Adopted and Parameters

The stability of a peat slope depends on several factors working in combination, namely the slope angle, the peat's shear strength, the peat, the depth of the peat, the pore water pressure and the loading conditions. An adverse combination of these factors could potentially result in peat failure. An adverse value of one of the factors mentioned above alone is unlikely to result in peat failure. The infinite slope model (Skempton and DeLory, 1957) combines these factors to determine a safety factor for peat sliding in the study area. This model is based on a translational slide, which is a reasonable representation of the dominant mode of movement for peat failures.

To determine the stability of the peat slopes in the study area, undrained (short-term stability during construction) and drained (long-term stability during operation) analyses have been carried out.

4.3.1 Undrained Conditions

The undrained loading condition applies in the short term during construction and until construction-induced pore water pressures dissipate.

Undrained shear strength values (c_u) for peat are used for the total stress analysis. Based on the findings of the Derrybrien failure (Lindsay and Bragg, 2004), undrained loading during construction was found to be the critical failure mechanism.

Among the shear strength values obtained by GDG by using the hand shear vane tests in the proposed site, the lowest registered value was 4 kPa (which is considered unrepresentative due to the nature of test conditions). However, based on GDG's experience in the assessment of similar blanket peats and values reviewed in the literature, a value of 5 kPa has been adopted for the undrained shear strength (C_u). The Shear Vane testing was carried out in the summer and is not considered to be representative of undrained winter conditions. This has been considered when selecting the design c_u value. The formula used to determine the factor of safety for the undrained condition in the peat (Bromhead, 1986) is as follows:

$$F = \frac{c_u}{\gamma z sin\alpha cos\alpha} \qquad \text{Equation 4.3-1}$$

Where,

F = FoS;

c_u = Undrained strength (5 kPa in the study area);

γ = Bulk unit weight of the material (assumed 10 kN/m^3);

z = Depth to failure plane assumed as the depth of peat (this is the interpolated raster of peat depth); and

α = Slope angle (in each pixel of 1 m. This is obtained from the 1-m DEM provided by the Client).

4.3.2 DRAINED CONDITIONS

The drained loading condition applies in the long term. The condition examines the effect of the change in groundwater level as a result of rainfall on the existing stability of the natural peat slopes.

A drained analysis requires effective cohesion (c') and effective friction angle (ø') values for the calculations. These values can be difficult to obtain because of the disturbance experienced when sampling peat and the difficulties in interpreting test results due to the excessive strain induced within the peat. A review of published information on peat was undertaken to determine suitable drained strength values. Table 4-2 shows a summary of the drained parameters used in published literature. Based on GDG's experience in the assessment of similar raised peats and the values reviewed in the literature, it was considered appropriately conservative to use design values below the averages, namely c' = 4 kPa and ø' = 25°.

The formula used to determine the factor of safety for the drained condition in the peat (Bromhead, 1986) is as follows:

$$F = \frac{c' + (\gamma z - \gamma_w h_w)\cos^2\alpha \tan\phi'}{\gamma z \sin\alpha \cos\alpha} \qquad \text{Equation 4.3-2}$$

Where,

F = FoS;

c' = Effective cohesion (4 kPa);

γ = Bulk unit weight of the material (10 kN/m^3);

z = Depth to failure plane assumed as the depth of peat (this is the interpolated peat depth);

γ_w = Unit weight of water (9.81 kN/m^3);

h_w = Height of the water table above the failure plane (= z, i.e. surface level);

α = Slope angle (in each pixel. This is obtained from the 1-m contour lines provided by the Client);

ϕ' = Effective friction angle (25°).

Table 4-2: Effective cohesion and friction angle values from the literature

Reference	Cohesion, c' (kPa)	Friction Angle, ø'
Hanrahan et al. (1967)	5 to 7	36 to 43
Rowe and Mylleville (1996)	2.5	28
Landva (1980)	2 to 4	27.1 to 32.5
Landva (1980)	5 to 6	-
Carling (1986)	6.5	0
Farrell and Hebib (1998)	0	38
Farrell and Hebib (1998)	0.61	31
Rowe, Maclean and Soderman (1984)	3	27
McGreever and Farrell (1988)	6	38
McGreever and Farrell (1988)	6	31
Hungr and Evans (1985)	3.3	-
Madison et al. (1996)	10	23
Dykes and Kirk (2006)	3.2	30.4
Dykes and Kirk (2006)	4	28.8
Warburton et al (2003)	5	23.9
Warburton et al (2003)	8.74	21
Entec (2008)	3.8	36.8
Komatsu et al (2011)	8	34
Zhang and O'Kelly (2014)	0	28.9 to 30.3

Several general assumptions were made as part of the analysis:

- Peat depths are based on the maximum peat depths recorded in each probe from the walkover surveys.
- The slope angles derived from the DEM (GDG, 2024), as outlined in Section 2.7, accurately represent slope angles on site.
- The surface of failure is assumed to be parallel to the ground surface.

- The peat stability is calculated in pixels of 1m across the fringe containing information on peat depth and the proposed infrastructure.

Two surcharging conditions are considered for the stability analysis:

- No surcharging load; and
- Surcharging load of 10 kPa, equivalent to 1 m of stockpiled or side-cast peat.

4.4 FoS Results

The FoS obtained for the two different conditions (undrained and drained) and for the two surcharge scenarios (no surcharge and 1 m of peat surcharge (10kPa)) are presented in both table format and map format. in. Appendix K, shows the FoS calculation process in the proposed turbine sites for undrained and drained conditions, respectively. The FoS calculation for the rest of the sites, i.e. the proposed substation, temporary construction compounds, and existing and upgraded access roads (more than 2000 pixels of 1 m), has been carried out semi-automatically in GIS by implementing Equation 4.3-1 and Equation 4.3-2 in the GIS raster calculator.

4.4.1 FoS for Undrained Conditions

The spatial distribution of the FoS values calculated for undrained conditions (no surcharge) is shown in Figure K- 1 to Figure K- 5 in Appendix K. Almost all of the pixels are shown to be stable and safe (FoS > 1.3, green), but there are some small areas beside the access track and the T3 and T5 hardstand which show FoS values between 1 and 1.3 (yellow: stable but not safe). A small number of pixels within and beside access tracks near BP2 and PRA3 show FoS values <1 (red: not stable).

These risk areas are caused by localised factors, which have been examined in more detail in Section 4.5. Where required, additional mitigation, including Safety Buffer Zones and Peat Stockpile Restriction Areas, have been scheduled, which the designer and contractor must adhere to at the construction stage.

4.4.2 FoS for Undrained Condition and Surcharge of 10 kPa

Figure K- 6 to Figure K- 10 in Appendix K depict the spatial distribution of the FoS values calculated for undrained conditions with a 10 kPa surcharge. The 10kPa simulated the placement of 1m of peat material on the ground surface. In terms of the factor of safety results, the undrained condition with the 10kPa surcharge is considered to be the critical stability scenario. The majority of the pixels are shown to be stable and safe (FoS > 1.3, green), but there are some small areas beside,<10m of the access track of T3, T5 and T6 hardstands along with BP 1 and BP2 show FoS values between 1 and 1.3 (yellow: stable but not safe). A small number of pixels within and beside access tracks and the T3 WTG footprint and hardstand show FoS values <1 (red: not stable). A large area to the east of T4 is calculated as having a FoS of <1 (red: not stable). This is caused by the simulated placement of 1m of peat on steep bedrock slopes.

These risk areas are caused by localised factors, which have been examined in more detail in Section 4.5. Where required, additional mitigation, including safety buffer zones and peat stockpile restriction areas, have been scheduled, which the designer and contractor must adhere to at the construction stage.

4.4.3 FoS for drained conditions

The spatial distribution of the FoS values calculated for drained conditions (no surcharge) is shown in Figure K- 11 to Figure K- 15 in Appendix K. Almost all of the pixels are shown to be stable and safe

(FoS > 1.3, green), but there are some small areas beside the access track and the T3 and T6 hardstand which show FoS values between 1 and 1.3 (yellow: stable but not safe). A small number of pixels within and beside access tracks show FoS values <1 (red: not stable).

These risk areas are caused by localised factors, which have been examined in more detail in Section 4.5. Where required, additional mitigation, including Safety Buffer Zones and Peat Stockpile Restriction Areas, have been scheduled, which the designer and contractor must adhere to at the construction stage.

4.4.4 FoS for Drained Condition and Surcharge of 10 kPa

The spatial distribution of the FoS values calculated for drained conditions with a 10 kPa surcharge is shown in Figure K- 16 to Figure K- 20 in Appendix K. Almost all of the pixels are shown to be stable and safe (FoS > 1.3, green), but there are some small areas beside the access track and the T3 and T6 hardstand which show FoS values between 1 and 1.3 (yellow: stable but not safe).

These risk areas are caused by localised factors, which have been examined in more detail in Section 4.5. Where required, additional mitigation, including Safety Buffer Zones and Peat Stockpile Restriction Areas, have been scheduled, which the designer and contractor must adhere to at the construction stage.

4.5 Assessment and Interpretation of FoS Results

The interpretation of the FoS analysis and assessment of the peat stability conditions is an approach that combines the developed polygon areas of the FoS results, areas of risk identified during the site walkovers, and potential risk areas identified from the examination of peat depths and site topography. It is noted that the results from all FoS analyses (drained/undrained, with and without surcharge) are used, highlighting any areas indicative as having a FoS of less than 1.3 in the worst-case surcharged condition with 10kPa. These areas were then cross-examined with the observations from the site visits and topographic models.

This analysis was used throughout the development process to aid in the siting and design of the Proposed Development layout including turbines, hardstands, and other key infrastructure locations. The undrained scenario with a 1m peat surcharge has been considered as the critical scenario. However, the FoS of all elements of the site was examined in both drained and undrained conditions.

The foundation and hardstand at T3 and T6 overlap with a small area where the FoS ranges between 1 and 1.3 in both undrained and drained scenarios without surcharge. This low FoS zone is linear, extending north-south along the access track and within the hardstand area. The reduced stability in these areas is primarily attributed to locally thick peat deposits, reaching up to 2m, in combination with steep slope angles and the presence of drains.

For T3, the area of reduced FoS is located approximately 30–40m north of the turbine footprint rather than within it. Additionally, TP113 encountered an undrained shear strength of 4 kPa at 1.20m below ground level (bgl). However, the Hand Shear Vane (HSV) test was conducted in a pit with standing water. Given these conditions, the recorded 4 kPa undrained shear strength at the T3 hardstand is not considered representative of the actual peat conditions.

For T6, the east end of the hardstand was found to be situated along an old road with exposed mineral soil. Analysis of aerial imagery (Section 2.6) revealed no evidence of peat-cutting within the turbine footprints of T3 and T6. The observed low FoS at T6 is attributed to the presence of peat drains, as confirmed by site observations.

In the case of T6, the east end of the hardstand was found to be situated along an old road with an exposed mineral soil. This is confirmed by site observations, which show that no peat cuttings were observed to interact with the turbine location, as seen in Appendix K.

The Proposed Development Site predominantly features undulating topography, with peat depths ranging up to 6m in some isolated areas. While drainage channels and ditches yield low factors of safety, they are generally considered to pose a negligible landslide risk. Blanket bog environments, such as this site, may be susceptible to peat slides, flow slides, and translational failures, which can occur even on shallow slopes. FOS calculations may not fully capture these failures, as they are primarily influenced by hydrological conditions and the inherently low shear strength of peat, though slope angle is also a contributing factor. Accordingly, on-site assessment and 'ground-truthing' are necessary to identify potential hazards. GDG site walkovers found no evidence of past slip features.

The lack of evidence for historical peat slides, and translational and flow slides does not preclude the possibility that these may occur. Further inspection will be required during the detailed design and construction stage to inspect for peat instabilities, including bog burst features. The design and construction teams will develop their own inspection and testing criteria to satisfy and de-risk the possibility of peat landslides at these locations. Further mitigation and monitoring measures are outlined in Section 6.

4.6 Safety Buffer Zones and Peat Stockpile Restriction Areas

From the site reconnaissance and the calculations of the FoS for the peat slopes, a series of safety buffer zones and peat stockpile restriction (PSR) areas are proposed and presented in Appendix L.

4.6.1 Safety Buffer Zones

From the site reconnaissance and the calculations of the FoS for the peat slopes, a series of safety buffer zones and peat stockpile restriction (PSR) areas are proposed and presented Figure L- 1 in Appendix L.

Safety Buffer zones are areas identified during the development phase of the wind farm layout that are highlighted as possessing a potential instability risk. The development of the safety buffer zones is a semi-automated approach that combines the developed polygon areas of the FoS results, areas of risk identified during the site walkovers, and potential risk areas identified from the examination of peat depths and site topography. It is noted that the results from all FoS analyses (drained/undrained, with and without surcharge) are used, highlighting areas indicative as having a FoS < 1 in the worst-case surcharged condition with 10kPa. This analysis was used throughout the development process to aid in the siting and design of the Proposed Development layout and ensure that turbines, hardstands, and other key infrastructure locations are only developed in stable and safe locations.

Where the Proposed Development layout and the safety buffer zone have overlapped or are in close proximity, further assessment of the localised risk has been assessed as outlined in Section 4.6.3, and where required, further mitigation measures have been scheduled, such as Peat Stockpile Restriction Areas.

Outside of the Proposed Development layout, where construction is not required as part of the Proposed Development, the safety buffer areas should be treated as peat placement and plant restriction areas, and construction activities should not be carried out in these areas without further assessment.

A total of 22 Safety buffer areas are outlined in Appendix L, Figure L- 1 .

4.6.2 Peat Stockpile Restriction Areas

Although the peat stability results and safety buffers have been considered in the design of the wind farm infrastructure, there are some locations where construction is required within a safety buffer zone. The stability assessment results at these locations suggest FoS values <1.3 in the surcharged scenario only and FoS results >1.0 in the analysis without the surcharge. This suggests that the areas are of a low instability risk in their natural state but are unsuitable for the storage of peat or other materials.

PSR areas are identified at some access roads and in areas at or adjacent to some turbine hardstands, along with the margins of areas proposed for peatland enhancement.

The risk at these locations can be examined by looking at the geometry of the local slope and the proposed construction methodology, and the hazards can be mitigated with restricted peat placement and the limiting of plant operations within the area.

PSR areas are outlined in Appendix L, Figure L- 1. Certain mitigations must be adhered to within the PSR areas in future stages of the Proposed Development:

- No peat or other materials will be temporarily or permanently placed in the areas within the PSR areas.
- Any peat excavated in the area will be immediately removed and placed/ stored in an appropriate storage location as outlined in the Peat and Spoil Management Plan (Technical Appendix 09-02).
- Plant used within these areas will be low ground bearing, and only the necessary plant will be used here. No excessive quantity or size of plant will be stored in these areas.

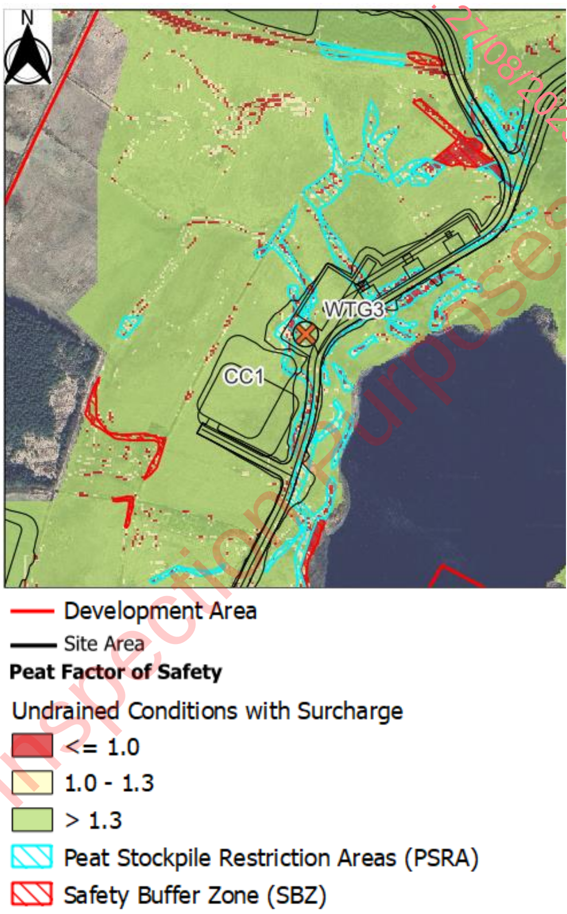
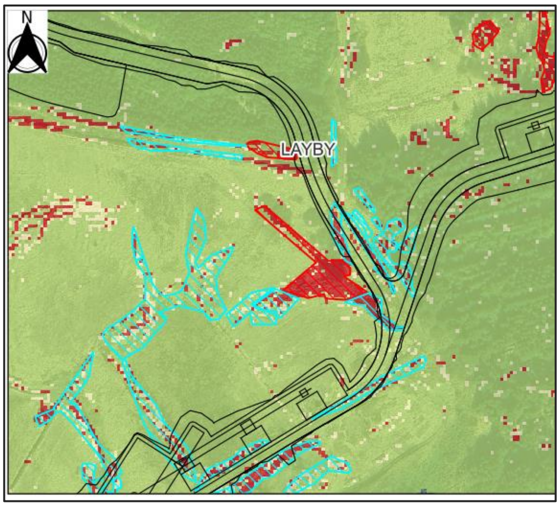
A total of 96 peat stockpile restriction areas are outlined in Figure L- 1 in Appendix L.

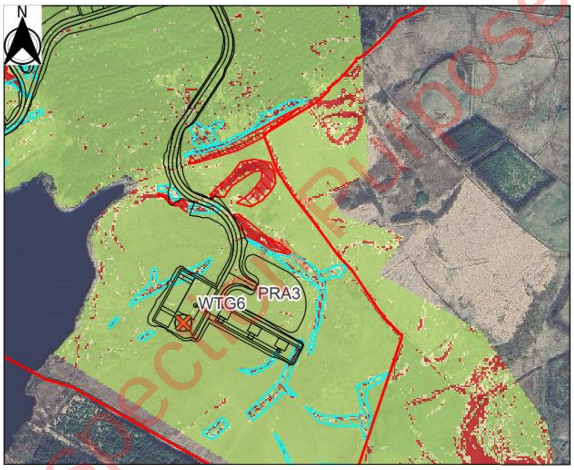
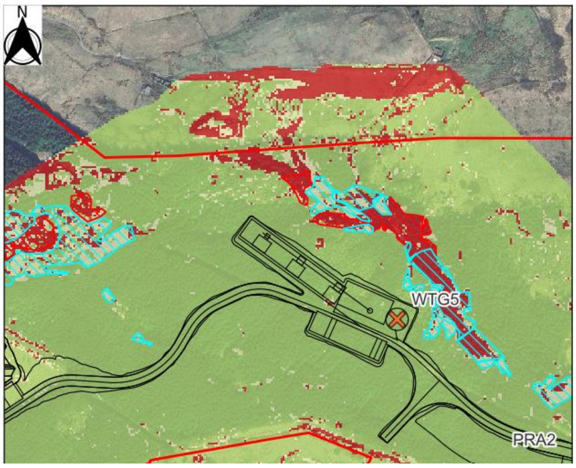
4.6.3 Safety Buffer Zones and Peat Stockpile Restriction Areas

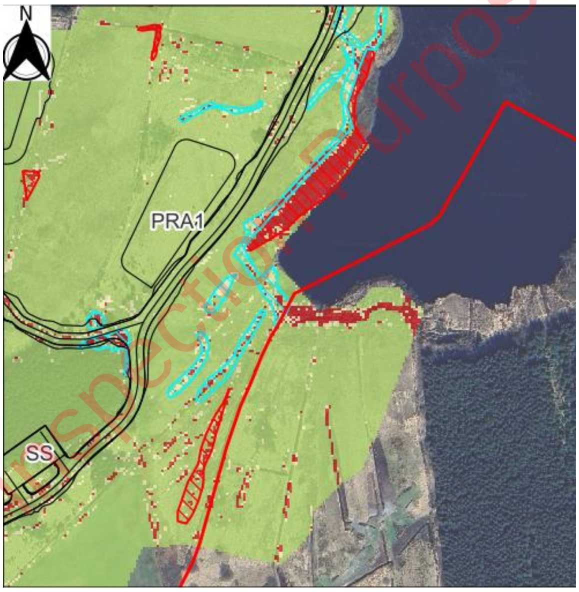
The safety buffer zones and peat stockpile restriction areas are shown in Figure L- 1 in Appendix L. Areas included in the safety buffer zone include:

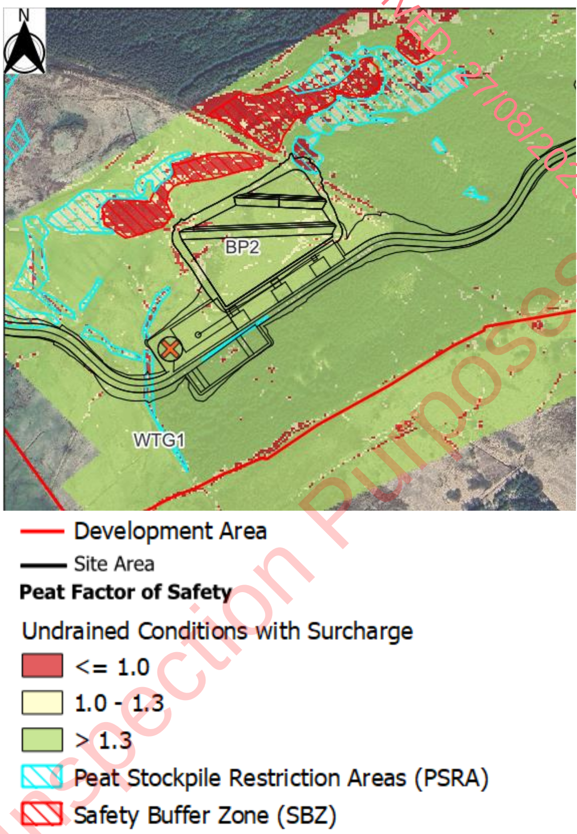
Areas where key infrastructures encounter safety buffer zones and peat stockpile restriction areas are outlined in Table 4-3.

Table 4-3: Safety Buffer Zones and Peat Stockpile Restriction Areas at Key Locations.

<table>
<tr><th>Risk and mitigation</th><th>Undrained surcharged FoS analysis</th></tr>
<tr><td>The area at the hardstand and foundation for T3 suggests a FoS of 1 ≤ FoS <1.3 with the application of a 10 kPa surcharge. Based on ground observations and a study of aerial imagery, it is determined that this region of low FoS is attributed to the presence of bedrock outcrops to both the east and west of T3, along with locally deep peat. A study of temporal aerial imagery (Section 2.6) indicates that no peat cutting was observed within the WTG footprint and hardstand area during the review of historic satellite imagery. The low FoS is attributed to the presence of bedrock outcrop rather than an active peat hazard at this location.. Peat within the turbine and hardstand footprint will be excavated as necessary to achieve a suitable bearing stratum. Additionally, the ground will be levelled and stabilised locally prior to construction, with appropriate drainage measures implemented to maintain ground stability and prevent peat drying. Any identified safety buffer zones (SBZ) and peat stockpile areas (PSA) will be strictly observed during construction, ensuring that no works are carried out within SBZ and no peat is stockpiled within PSRA.</td><td>
</td></tr>
<tr><td>A small section of the access road north of T3 falls within an area where the FoS is <1 in the undrained scenario with a 10 kPa surcharge. This is attributed to the presence of bedrock outcrops and locally deep peat adjacent to the access road rather than any indication of a peat hazard. While this area has been designated as a safety buffer zone, the peat is confined to a localised pocket with depths ranging from 1 m to 3 m. Given its limited extent, this peat will be excavated to establish a stable foundation for the access track, which will be a founded access track, ensuring a level road profile. Consequently, peat instability is not expected to be a significant hazard in this area. Any identified safety buffer zones (SBZ) and peat stockpile areas (PSA) will be strictly observed during construction, ensuring that no works are</td><td>
</td></tr>
</table>

Risk and mitigation	Undrained surcharged FoS analysis
carried out within SBZ and no peat is stockpiled within PSRA.	Site Area **Peat Factor of Safety** Undrained Conditions with Surcharge <= 1.0 1.0 - 1.3 > 1.3 Peat Stockpile Restriction Areas (PSRA) Safety Buffer Zone (SBZ)
A small section of the access road, located north of PRA3, falls within an area where the FoS is calculated to be 1 ≤ FoS <1.3 in the undrained scenario with a 10 kPa surcharge.. However, this is a result of interpolated peat depths over steep slopes near bedrock outcrops, likely overestimating the actual peat depth and producing a conservatively low FoS. The assessment does not indicate a significant peat landslide risk, as the calculated low FoS is an artefact of interpolation rather than reflective of site conditions. Given the presence of shallow bedrock, the slopes in this area do not present a stability concern. Any identified safety buffer zones (SBZ) and peat stockpile areas (PSA) will be strictly observed during construction, ensuring that no works are carried out within SBZ and no peat is stockpiled within PSA.	 Development Area Site Area **Peat Factor of Safety** Undrained Conditions with Surcharge <= 1.0 1.0 - 1.3 > 1.3 Peat Stockpile Restriction Areas (PSRA) Safety Buffer Zone (SBZ)
A small section, northeast of T5, falls within an area where the FoS is calculated to be 1 ≤ FoS <1.3 in the undrained scenario with a 10 kPa surcharge. This low FoS is attributed to the presence of locally deep peat north of T5 and a combination of bedrock outcrops and locally deep peat to the east of T5. However, the assessment confirms that this does not indicate an active peat hazard, and there is no risk of peat instability affecting the proposed infrastructure. The 0.68-hectare area with FoS <1 has been designated as a safety buffer zone, meaning no construction will take place within this area. While the FoS interpretation reflects conservative assumptions based on locally deep peat and bedrock outcrops, this does not	

Risk and mitigation	Undrained surcharged FoS analysis
present a concern for the stability of T5 or the proposed development. Any identified safety buffer zones (SBZ) and peat stockpile areas (PSA) will be strictly observed during construction, ensuring that no works are carried out within SBZ and no peat is stockpiled within PSA.	Development Area Site Area **Peat Factor of Safety** Undrained Conditions with Surcharge <= 1.0 1.0 - 1.3 > 1.3 Peat Stockpile Restriction Areas (PSRA) Safety Buffer Zone (SBZ)
A small section to the east of PRA1 falls within an area where the FoS is calculated to be 1 ≤ FoS <1.3 in the undrained scenario with a 10 kPa surcharge. This low FoS is attributed to the presence of bedrock outcrops near the edge of the lake rather than deep peat. However, the assessment confirms that this does not indicate a peat hazard, and there is no risk of instability affecting the proposed infrastructure. A 0.21-hectare area to the northeast, located approximately 30 m from the access track, has been identified as a safety buffer zone where no construction will take place. While the FoS interpretation reflects a conservative assessment due to the presence of bedrock outcrops, this area does not present a stability concern in relation to the development. Any identified safety buffer zones (SBZ) and peat stockpile areas (PSA) will be strictly observed during construction, ensuring that no works are carried out within SBZ and no peat is stockpiled within PSA.	 Development Area Site Area **Peat Factor of Safety** Undrained Conditions with Surcharge <= 1.0 1.0 - 1.3 > 1.3 Peat Stockpile Restriction Areas (PSRA) Safety Buffer Zone (SBZ)

<table>
<tr><th>Risk and mitigation</th><th>Undrained surcharged FoS analysis</th></tr>
<tr><td>A small section to the north of BP2 falls within an area where the FoS is calculated to be 1 ≤ FoS <1.3 in the undrained scenario with a 10 kPa surcharge. This low FoS is primarily attributed to the presence of bedrock outcrops, with only isolated areas of peat up to 1.0 m in depth. However, as this is a designated borrow pit, it will be excavated to source rock for the proposed development, effectively removing any localised peat and ensuring a stable formation. While the FoS interpretation reflects a conservative assessment due to the presence of bedrock outcrops, this area does not present a stability concern in relation to the development. Any identified safety buffer zones (SBZ) and peat stockpile areas (PSA) will be strictly observed during construction, ensuring that no works are carried out within SBZ and no peat is stockpiled within PSA.</td><td>
</td></tr>
</table>

It is to be noted that the interpretation of areas where the FoS is calculated to be 1 ≤ FoS <1.3 in the undrained scenario with a 10 kPa surcharge is based on a conservative assessment, primarily influenced by the presence of bedrock outcrops and isolated pockets of locally deep peat, typically ranging between 1.0 m and 2.0 m in depth. The only location where peat depths of 3–4 m were recorded is north of PRA3, which has been designated as a safety buffer zone, ensuring that no construction will take place within this area.

Across the proposed development footprint, there is no evidence to suggest the presence of an active peat hazard. Any localised peat deposits within the footprints of the turbines, access tracks, and borrow pits will be excavated to achieve a suitable bearing stratum, with access tracks being founded and borrow pits fully excavated, thereby eliminating any potential stability concerns. Furthermore, areas identified as safety buffer zones, located outside the development footprint, will be avoided for any construction-related activities, including storage and access works.

With these considerations, the ground conditions are not expected to impact the stability of the proposed development.

5 PSRA

A PSRA has been carried out at each of the proposed structures, considering the landslide hazard probability and potential consequences at each location. The peat stability factor of safety is the most significant factor in generating a risk rating. The production of a PSRA risk rating for the site access tracks is not possible as they are linear structures that cover significant distances, but the same considerations were used in the design and assessment of the stability of the access road alignment.

5.1 Risk Definition

Risk is the potential or probability of adverse consequences, including economic losses, environmental or social harm, or detriment. Risk is expressed as the product of a hazard (e.g. peat landslide) and its adverse consequences (Lee & Jones, 2004; Corominas et al., 2014) (Equation 5.1-1). Some use approximate synonyms and refer to risk as the product of the likelihood and the impact or the product of susceptibility and the exposure.

$$\text{Risk} = (\text{Hazard}) \times (\text{Adverse Consequences}) \qquad \text{Equation 5.1-1}$$

5.2 General Methods for Risk Assessment

There are various levels of risk assessment, ranging between:

- Detailed quantitative risk assessments (QRA) where the objective is to generate more precise measures of the risks (e.g. expressing risk as a specific probability of loss). These require a large amount of quantitative input and time, and
- High-level qualitative assessments where the objective is to develop an approximate estimate of the risks, particularly in relative terms (e.g. low, medium, and high levels of risk).

Qualitative risk assessments are typically used for PSRA reports, given the availability of information and the time frame. To apply Equation 5.1-1, the quantitative information (e.g. FoS) and the qualitative information (e.g. geomorphic observations relevant to peat stability) that determine the hazard and the consequences need to be transformed into subjective ratings. The following sections address the calculation of the two risk components: hazard and consequence.

5.3 Hazard Assessment

Landslide hazard is the likelihood or probability of landslide occurrence in each location and a given period. The likelihood or hazard of peat landslides has been determined according to the guidelines for geotechnical risk management given by Clayton (2001), taking into account the approach of MacCulloch (2005) and using the available data from the desk study, site reconnaissance, and site investigations.

The hazard is calculated from a variety of weighted factors, including the FoS and thirteen secondary factors related to geomorphic observations, topography, hydrology, vegetation, peat workings, existing loads, and slide history (Appendix A09-02A). These secondary factors are difficult to quantify in a stability calculation but may contribute to peat instability.

In accordance with the Scottish Guidance (2017), each hazard factor has been reclassified into one of four classes, with rating values ranging from 0 to 3 (Appendix A09-02A). A rating of 0 indicates that the hazard factor is not relevant; ratings 1, 2, and 3 indicate low, moderate, and high correlation to peat slide hazard, respectively.

These factors have been assigned weighting values to reflect their relative importance in peat stability. Both the rating and the weighting values have been assigned according to the expert criteria of the project team and are presented in Appendix A09-02A. The hazard score of each factor is the multiplication of its rating value and weight value. These factors and their corresponding weightings are presented in Table 5-1.

The hazard values for a given wind farm element are the sum of the scores of all the hazard factors divided by the maximum hazard value possible to obtain a normalised hazard value ranging from 0 to 1 (see tables in Appendix A09-02A). Hazard is grouped into four categories: Negligible, low, medium, and high.

Table 5-1: Factors affecting peat stability and hazard.

Hazard factors			Role in peat stability	Weight
Factor of Safety			This is the most critical factor, including the slope angle, the peat depth, the peat density, the peat cohesion in the drained and undrained conditions, as well as the effective friction angle. This is the complete factor. See Section 4 for further details.	10
Secondary factors	Topography	Curvature Plan (across the slope)	This represents the curvature across the slope and the funnelling/dispersion of the runoff.	1
		Curvature Profile (downslope)	This represents the curvature down-slope and, therefore, the capacity of water retention and infiltration. Convex slopes are typically more prone to landslides.	
	Hydrology	Distance from watercourse (m)	This tends to affect the likelihood of landslides, especially in sectors where this distance is short.	
		Evidence of piping	The presence of piping is clear evidence of potential peat instability.	
		The direction of existing drainage ditches	Drainage ditches that are aligned cross-slope can affect the overall stability of a slope face.	
	Vegetation	Bush	This is an indicator of the type of peat at the site and the hydrological nature of the site.	
		Forestry	The vigour of forestry is another indicator of peat stability, with stunted trees more frequent in unstable sectors.	
	Peat workings	Peat cuts presence	This factor evaluates the effect of various peat workings on the stability of the peat.	

Hazard factors			Role in peat stability	Weight
		Peat cuts vs contour lines	Where the peat cuts parallel the contour lines, the potential instability increases.	
	Existing loads	Roads	Side-cast of solid roads and floating roads pose a load to the peat blanket.	
	Slide history	Distance to previous slides (km)	This suggests that landslides at the site are likely if a peat slide has occurred at the site or within a 10-kilometre radius. The weight assigned doubles the weights for the other secondary factors	2
		Evidence of peat movement (e.g. tension cracks, compression features).	This factor evaluates the effect of any existing peat movement indicators on-site, such as tension cracks. The weight assigned doubles the weights for the other secondary factors.	

5.4 Adverse Consequences Assessment

The impacts of peat landslides on the wind farm elements, surrounding environment, and existing assets may typically generate a variety of adverse consequences. This report qualitatively assessed these consequences following the Peat Landslide Hazard and Risk Assessments: Best Practice Guide for Proposed Electricity Generation Developments (Scottish-Executive, 2017).

Table 5-2 summarises the consequences considered for the PSRA of the development.

Table 5-2: Consequences considered for the PSRA

Consequence factors	Description	Weight
Volume of potential peat flow (function of distance from the nearest watercourse and peat depth in the area)	This is the second most heavily weighted factor. It is estimated based on the distance from the nearest defined watercourse and the depth of peat in the area. The longer the distance and the deeper the peat depth, the larger the landslide.	3
Downslope features	This factor accounts for the type/shape of downslope features that may hamper or favour the propagation downhill of the peat flow.	1
Proximity from the defined valley (m)	This is the distance from the site to the nearest defined river valley. Rivers close to potential landslide sectors are more vulnerable to a landslide event.	
Downhill slope angle	This factor accounts for the runout distance as a matter of slope angle.	
Downstream aquatic environment	Reflects the severity of a peat slide event's impact on the receiving aquatic environment.	

Consequence factors	Description	Weight
Public roads in the potential peat flow path	Rates the impact of a peat slide striking a public road.	
Overhead lines in the potential peat flow path	Rates the impact of a peat slide striking a service line.	
Buildings in the potential peat flow path	Rates the impact of a peat slide striking a habitable structure.	
Capability to respond (access and resources)	Rates the capability of the site staff to respond to a peat instability event.	

The nine consequence factors considered have been reclassified in the same fashion the hazard factors were reclassified (Appendix A09-02A). A rating of 0 indicates that the consequence factor is not relevant, and a rating of 3 indicates high consequences.

'Volume of potential landslide' has been assigned a weight of 3 to reflect its relative importance in the potential consequences. The rest of the factors have been assigned a weight of 1. Both the rating and the weighting values have been assigned according to the expert criteria of the project team. The score of each consequence factor is the multiplication of its rating value and its weight value (Appendix A09-02A).

The consequences value for a given wind farm element is the sum of the nine consequences scores. This total value is then divided by the maximum consequence value possible to obtain a normalised consequence value ranging from 0 to 1 (see tables in Appendix A09-02A). Consequences are grouped into four categories: Negligible, low, medium, and high.

5.5 Risk Calculation

Risk in each wind farm infrastructure element is calculated in accordance with Equation 5.1-1, by multiplying the hazard scores and the consequences scores. The risk rating ranges between 0 and 1, and the following levels of risk rating have been distinguished (Figure 5-1 and Figure 5-2):

- High (0.6 to 1): Avoid project development at these locations. Mitigation is generally not feasible.
- Medium (0.4 to 0.6): The project should not proceed unless risk can be avoided or mitigated at these locations without significant environmental impact to reduce risk ranking to low or negligible.
- Low (0.2 to 0.4): Project may proceed pending further investigation to refine assessment and mitigate hazard through relocation or re-design at these locations.
- Negligible (0 to 0.2): The project should proceed with monitoring and mitigating peat landslide hazards at these locations as appropriate.

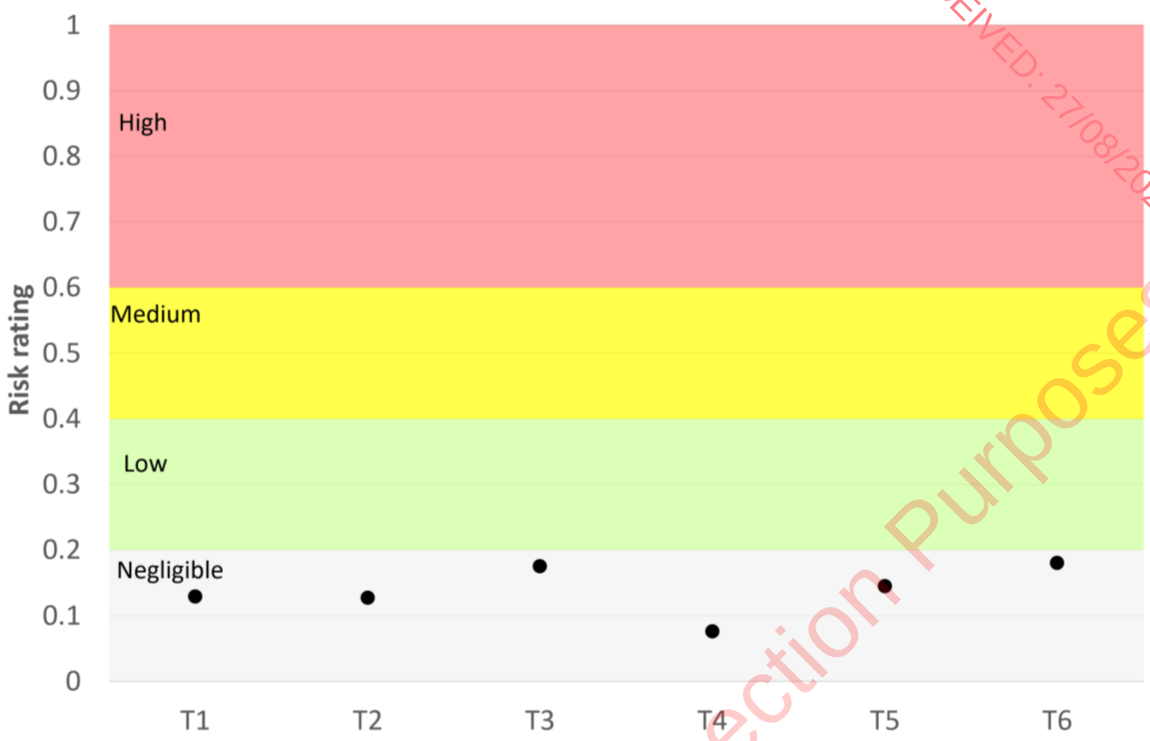


Figure 5-1: Risk ratings at the proposed turbine locations.

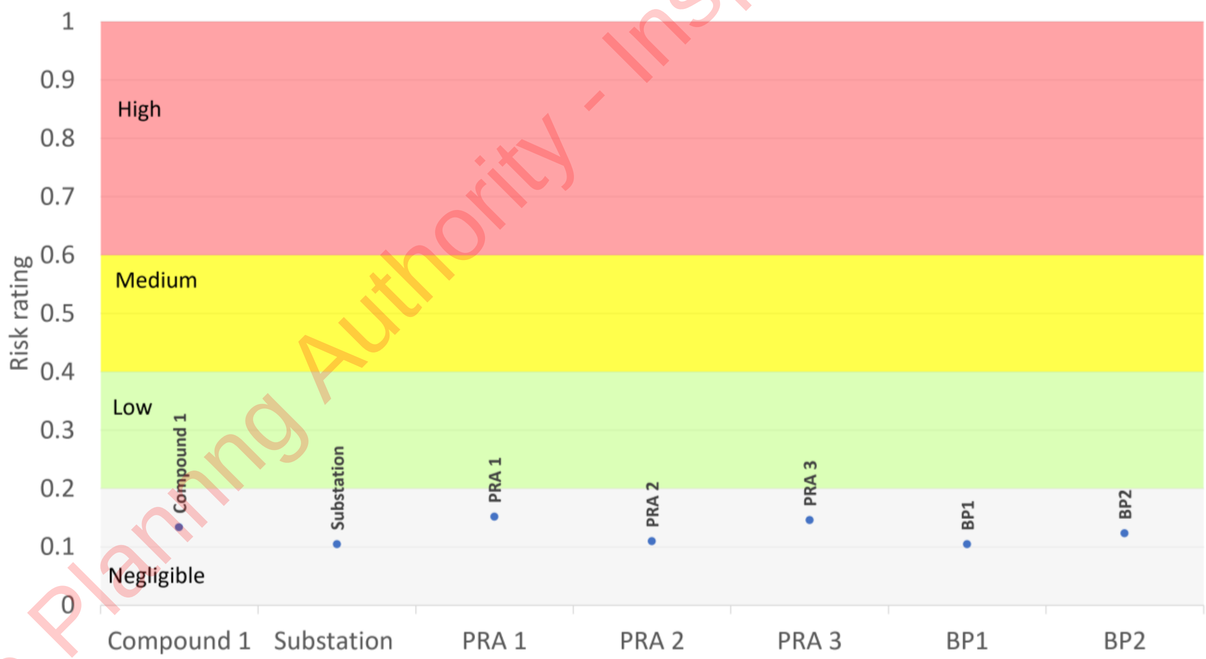


Figure 5-2: Risk ratings at the proposed infrastructure element sites.

The tables in Appendix A09-02A gather the risk calculation process at each turbine considering the four scenarios of hazard: undrained; undrained with a surcharge of 1 m; drained; and drained with a surcharge of 1 m. Figure 5-1 and Figure 5-2 summarise the risk rating obtained at the turbines and compound locations. All the turbines and infrastructure elements are classed as negligible.

It is stressed that the resulting risk rating does not indicate a probability of a landslide occurring; it simply expresses a rating of the potential risk.

6 Mitigation Measures

As outlined in Section 5.5, the PSRA has yielded a negligible risk rating for each infrastructure location. The Scottish Government Best Practice Guidelines (2017) state the following for areas with negligible risk level: "Project should proceed with monitoring and mitigation of peat landslide hazards at these locations as appropriate."

The risk at all infrastructure elements has been classified as negligible based on the assessment undertaken in Section 5. However, all earthworks will be designed by a competent geotechnical designer, informed by a post-consent detailed GI campaign. This investigation will include intrusive methods, such as trial pitting and borehole drilling, with a specified suite of in-situ and geotechnical laboratory testing to further assess the engineering characteristics of the infrastructure locations. Possible mitigation measures in relation to peat instability are considered below.

6.1 Mitigation by Avoidance

Site infrastructure has been sited to avoid areas of medium or high risk where possible, and all main infrastructure locations are assessed as being of negligible risk. Safety Buffer Zones (SBZs), which are to be avoided during construction, have been identified and are outlined in Section 4.6 Peat Stockpile Restriction Areas (PSRs) have also been identified and are outlined in Section 4.6. Stockpiling or placement of peat materials will not be carried out in these areas.

6.2 Engineering Mitigation Measures

Many of the site-specific (e.g. peat depth, slope angle) and site-independent variables (e.g. weather) that contribute to the incidence of natural peat landslides are beyond engineering control without significant damage to the peat itself. However, several engineering measures exist to minimise the risks associated with potential triggers (such as short-term peaks in hydrogeological activity).

6.2.1 Construction Management

Inappropriate storage of excavated peat and overburden, as well as uncontrolled loading of peat material, is considered one of the main causes of peat instability and landslide event triggers during the wind farm construction process. The management and control of these activities are key to de-risking peat stability at the Proposed Development site. It is required that the construction method statements for the project also take into account, but not be limited to, the guidance documents listed in Section 0 and the recommendations and requirements outlined throughout this document.

The general requirements for the management of peat and the mitigation of peat instability at the site are as follows:

- Appointment of experienced and competent contractors and detailed designers;
- The construction works on site will be supervised by experienced and qualified personnel;
- Allocate sufficient time for the project to be constructed safely with all peat stability mitigation measures included in the programme;
- Set up, maintain and report findings from monitoring systems, including sightline monitoring;
- Maintain vigilance and awareness through Tool-Box-Talks (TBTs) on peat stability;
- Prevent undercutting of slopes and unsupported excavations;

- Prevent placement of loads/overburden on marginal ground;
- Manage and maintain a robust drainage system. This will be the responsibility of the appointed contractor and their designer.
- Storage of peat material, including temporary and side casting be carried out in the permitted areas only.
- Acrotelm (upper) peat material may be used as landscaping material where topography allows and the detail designer has assessed the stability risk;
- Uncontrolled placement of peat or loading of peat material must be avoided;
- Water flows within drainage systems will be controlled. Velocities of slows must be controlled using check damns within drainage systems and the uncontrolled release of water onto slopes can create a landslide risk and must be avoided;
- All construction requiring cut and fill earthworks required a robust monitoring and inspection programme. The details of this inspection programme will depend on the purpose and methodologies of the works and the ground conditions;
- A risk assessment and method statement (RAMS) which considers the potential causes and mitigations of peat instabilities and landslide is required and must be regularly communicated to all site staff. An observational approach by all site staff to the ground conditions and the risks should be promoted, and any changes in the ground or site conditions should be reported and the risk dynamically assessed.
- The design and construction teams will develop their own inspection and testing criteria to satisfy and de-risk the possibility of peat landslides.

6.2.2 Drainage Measures

Installation of targeted drainage measures would aim to isolate areas of susceptible peat from upslope water supply, re-routing surface (flushes/gullies) and subsurface (pipes) drainage around critical areas. Surface water drainage plans should be implemented to account for modified flows created by construction, which in turn may affect peat stability, pollution and wildlife interests. Drainage measures need to be carefully planned to minimise any negative impacts.

6.3 Monitoring

The installation of movement monitoring posts is recommended for areas where works are taking place on or adjacent to identified peat depths greater than 2m.

Movement monitoring posts will be installed upslope and downslope of the works areas and will be as outlined:

- Posts will be 1m to 1.5m in length, installed at 5m intervals with no fewer than seven posts in each line of sight (~30m).
- A string line will in attached to the first and last post with all intermediate posts in contact with one side of the string line,

- A numbering system will be designed for the monitoring posts and a record will be kept of this numbering system.

Movement monitoring posts will be observed at least once a day, with more frequent inspections when adjacent works are ongoing. Should movements be recorded, the frequency of these inspections will be increased. Record will be kept of all monitor post inspections with reference to date, time and any relative movement between posts, if any. Any movement identified in the posts will be recorded with reference to the post numbering system.

The contractor will also develop a routine inspection of all areas surrounding work in peat, not just exclusively on the monitoring posts. These inspections will include an assessment of ground stability and drainage conditions. These inspections should identify any cracking or deformation on the peat surface, excessive settlement on structures, drain blockages or springs, etc.

6.4 Engineering Mitigation Measures to Control Landslide Impacts

The stability of the peat and overburden is considered to be safe for the construction activities proposed, and should the peat and spoil be managed in line with the details of this document, the risk of a peat failure or landslide is negligible to very low. However, it is important to consider the actions which will be carried out if signs of instability are identified during the outlined monitoring or should a failure occur at the site.

The full methodologies for these activities will be outlined in the Contractor's RAMS and include the methodologies for immediate and long-term response.

6.4.1 Movement or Instability Observed in Monitoring Areas

Where excessive movement has been observed in the installed monitoring outlined in Section 6.3 the following measures will be taken:

- All construction activities will be suspended in the area;
- The Contractor's Geotechnical Engineer will carry out an assessment of the peat instability, including drainage. The Contractor's Geotechnical Engineer will compile a report outlining the surveys undertaken, the potential cause of the instability, assessment of any increased risk caused by the instability, and the further measures required to manage this risk;
- An increased monitoring regime will be specified, including an increase in the number of monitoring post lines, a decrease in monitoring post spacing and an increase in the frequency of monitoring post observations;
- Should no further movement be detected, construction activities will be recommenced while maintaining the increased monitoring regime;
- Should further excessive movement be detected, the Contractor's geotechnical engineer will need to be informed, and the design of further reinstatement works will be required, such as excavation of the disturbed material, installation of granular berms or similar.

6.4.2 Emergency Response to a Landslide Event

Due to the high factors of safety and negligible risk of peat landslides identified on site, it is not anticipated that peat failure will occur on site. However, in the event of peat failure (e.g. tension cracking, surface rippling, sliding), the following measures will be implemented by the contractor:

- All members of the project team will be alerted immediately or as it is safe to do so;
- All site works will cease with immediate effect, and all available resources will be used for the management and mitigation of the risks posed by the event;
- Localised peat slides that do not present a risk to watercourses will be stabilised where possible by rock infill and granular material. The area will then be assessed by competent engineers, and further stabilisation measures will be implemented where necessary;
- The key initial activity will be to prevent displaced materials from reaching any watercourses or sensitive environments. Given the terrain of the Proposed Development Site, the key risk is the development of a propagation landslide or slip within topographic valleys and watercourses. Where possible, check barrage structures (Section 6.4.2.1) or catch ditches (6.4.2.1) on land or within these topographic valleys and watercourses will be constructed to prevent further run out of the disturbed peat or spoil material.
- The contractor will be responsible for providing suitable contingencies outlined within the construction stage CEMP. The contractor will additionally need to carry out a construction stage PSRA.

6.4.2.1 Check Barrages

Check barrages are permeable granular structures constructed within the path of a landslide to prevent the further downhill or downstream movement of the disturbed material. Typically, these will be constructed of locally generated stone material, often of large sizing. The large material sizing will allow water to pass through the check barrage material, avoiding a build-up in hydrostatic pressure while containing the debris within the slide. A check barrage is typically a dam structure between 1 and 1.5m high, with slopes between 1(V):1.5(H) or 2(H), and constructed across the full section of topographic valley and/or water course.

The check barrage is an emergency preventative measure only to restrict or reduce the movement of displaced material downslope and away from a watercourse. Further assessment and reinstatement works will likely be required should a landslide occur, and engagement and reporting of the incident will be required by all parties involved in the project. Should the check barrage no longer be required, it may be removed and the area reinstated.

The use of check barrages is only proposed for use in the unlikely event of a large landslide event. The proposed locations are only indicative, targeting potential topographic channels, but will vary depending on the location and nature of the slide event. The Contractors will need to include an assessment of potential check barrage locations and methods for their construction within the emergency procedures in their associated Method Statement documentation.

6.4.2.2 Catch Ditches

Similarly, ditches may also slow or halt runout, although it is preferable that they are cut in non-peat material. Simple earthwork ditches can form a useful, low-cost defence. Paired ditches and barrages have been observed (Tobin, 2003) to slow peat landslide runout at failure sites.

7 GEOTECHNICAL RISK REGISTER

This register lists significant potential peat geotechnical hazards and associated risks concerning the construction and operation of the Proposed Development, and recommended mitigations.

Table 7-1: Geotechnical risk register

Ref.	Risk	Contributing factor	Mitigation
1	The collapse of the dried peat berm/ peat slippage	Overestimation of soil strength parameters	The soil parameters are based on the hand shear vane tests carried out by GDG and IDL at each turbine location. Shear vane testing was carried out at 0.5m intervals through the peat to assess variation within the peat body. The interpreted undrained shear strength values take into account a conservative reduction factor for the influence of the fibres within the peat – see Section 3.1. Extensive sampling ground investigation at infrastructure location, including trial pitting to assess the composition and strength of the peat and collect samples for testing. The derived values were compared with a literature review of the most common general drained and undrained parameters for each type of soil and on the descriptions. The GI completed to date is considered to be thorough and robust for the purposes of the EIAR, however, it is expected that further testing and assessment of the peat during further ground investigation campaigns will be required before construction. This will allow for a robust understanding of the ground conditions and the detailed design of access roads and structures. An extensive testing protocol will be developed by the Construction stage contractor and the design team. These tests will be observed by a suitably qualified engineer and reported to the owner's engineer. It would be expected that an observational approach will be required when constructing on peat due to the limitations associated with testing and verifying its strength and the contractor is required to frequently inspect the peat material and provide proof of inspection.
2	The collapse of	Underestimation of peat depth	Extensive ground investigation, including trial pitting and peat probing, has been carried out

Ref.	Risk	Contributing factor	Mitigation
	berms/peat slippage		across the site. GI locations have been carried out at locations where access was possible. Access was limited to some areas of the site with restrictions relating to forestry and terrain limiting coverage. Access, in particular, was limited to the area of T04, allowing only limited peat probing and GI. Further GI will be required at these locations during the detail and construction stage to assess peat depths. This will be carried out by the detail designer and the Contractors' team. The design team will develop their own testing criteria to satisfy and de-risk the possibility of larger peat depth occurring at these locations.
3	Failure of peat slope due to loading or agitation of existing instability	Failure to identify existing instability/ peat deformation at the site	An assessment of satellite imagery and topographical data for evidence of past landslide events was carried out as part of the desk study, finding no evidence of past instabilities or landslide events within the site area. The Geological Survey of Ireland (GSI) landslide database was examined, identifying two landslide events in the local region within 5km of the site, the closest approximately. 3km from the site boundary. During the site walkovers, the site GDG engineers examined the landscape and the areas surrounding the proposed infrastructure for evidence of instability or past landslide events. No past landslide or instability events were identified. Although there is no evidence of landslides within the Proposed Development Site, this does not necessarily mean that landslides have never occurred at the proposed site location. It is noted that the geomorphological features associated with peat landslides (peat slides and bog bursts) are softened with time through erosion, drying, and re-vegetation, particularly given the forestry and peat harvesting activities that have taken place at this site. Based on the risk assessment undertaken as outlined in (Section 5). All Infrastructure elements along with the turbines are classed as negligible risk in terms of PSRA. Access was limited to some areas of the site with restrictions relating to the T4 location, allowing only limited peat probing and GI. Further inspection will be required during the detailed

Ref.	Risk	Contributing factor	Mitigation
			design and construction stage to inspect for peat instabilities. This will be carried out by the detail designer and the Contractors team. The design team will develop its own inspection and testing criteria to satisfy and de-risk the possibility of larger peat depth occurring at these locations.
4	The collapse of peat berm/peat slippage	Failure due to excessive loading of peat	The peat stability analysis factor of safety exercise examines the peat in the drained and undrained condition, both without and with the addition of a surcharge equating to 1m of peat loading. Areas indicative of a low or moderate FoS result with the 1m peat surcharge within or adjacent to the proposed site infrastructure have been designated as safety buffer zones, as outlined in Section 4.6. Requirements for the safe and sustainable storage of peat and spoil material are outlined in the associated Peat and Spoil Management Plan (PSMP, Technical Appendix A09-02) document (GDG, 2025). The requirements and restrictions for peat and spoil management outlined in this document must be adhered to during the construction stage.
5	Failure of peat slopes	Over/underestimation of exiting slope angles.	The peat stability analysis, including the factor of safety assessment, is based on data from a 2023 GDG drone survey. Evidence of peat harvesting was identified in small areas to the northwest and southwest of T03, around 90m and 160m from the turbine. Turbines T2 and T5 are within a forestry area that has seen changes in tree density over time. Most of the site has a slope angle between 5° and 10°, with steeper gradients (30° to 45°) in isolated areas such as drainage channels, ditches, and Lough Keagh banks. These isolated patches of deep peat and bedrock may have overestimated slope angles, but they are unlikely to pose a global risk and could lead to an underestimation of the factor of safety. A more detailed topographic survey should be conducted during the detailed design stage.

Ref.	Risk	Contributing factor	Mitigation
6	Instability of peat slippage	Variations in the groundwater conditions at the site	Groundwater conditions were assessed during the site walkovers and at the trial pit locations. Areas of drainage and dense forestry with limited access were identified during the walkovers, as outlined in Section 3, and these have been incorporated into the risk assessment and report findings. Water strikes, peat water content, and groundwater conditions were recorded at the trial pit locations (IDL, 2024)(A08-03-A). Groundwater levels and peat moisture content are likely to vary seasonally and may fluctuate with immediate weather conditions. A review of the trial pit notes indicates that water ingress was observed between 0-2.5m below ground level. Long-term groundwater monitoring should be considered as part of further design-stage investigations, and additional laboratory testing of the peat in its in-situ condition will be required for the construction design. To minimise potential impacts, the hydrology of the area should be maintained through the implementation and upkeep of an appropriate drainage system.

8 CONCLUSIONS AND RECOMMENDATIONS

Following the guidance of the Scottish Government, a review of the published thematic geographic information (e.g. geology, soils, protected areas) and relevant background literature was undertaken for the Proposed Development. Site reconnaissance and site investigations were carried out to validate and enhance the desk study information. Based on the available data, the fieldwork, and GDG's professional judgment, it is concluded that significant peat slides are unlikely on the site with diligent peat management and careful consideration of the peat conditions at the site at the design and construction stage.

A deterministic Factor of Safety was calculated across the proposed element locations, and from this, a robust PSRA was performed. The findings of the peat assessment showed that the site has an acceptable margin of safety and is suitable for the Proposed Development, provided appropriate mitigation measures, as outlined in Section 6, and below, are implemented:

- All earthworks will be designed by a competent geotechnical designer, informed by detailed ground investigation to confirm peat, mineral soil, and bedrock condition and properties.
- A detailed site investigation will be conducted by experienced geotechnical staff.
- The area's hydrology will be maintained as far as possible by implementing and maintaining an appropriate drainage system.
- Use of experienced contractors and trained operators to carry out the work.

The peat stability risk for the proposed infrastructure is negligible. However, the results of the factor of safety deterministic calculation and the site walkover allowed for the identification of safety buffer areas outlined in Section 4.6 and shown in Appendix L. As part of the iterative design process, all infrastructure elements have been positioned outside the safety buffer zones (SBZ). Mitigation measures outlined in Section 6 must be adhered to in future stages of the Proposed Development.

To minimise the risk of construction activity causing potential peat instability the Construction Method Statements (CMSs) for the project will implement in full, but not be limited to, the recommendations above.

Construction works will follow the recommendations of the Peat and Spoil Management Plan (Technical Appendix A09-01). During construction, it is strongly recommended to carry out frequent monitoring works, especially after heavy rainfall events or prolonged rainfall.

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Appendix A Location

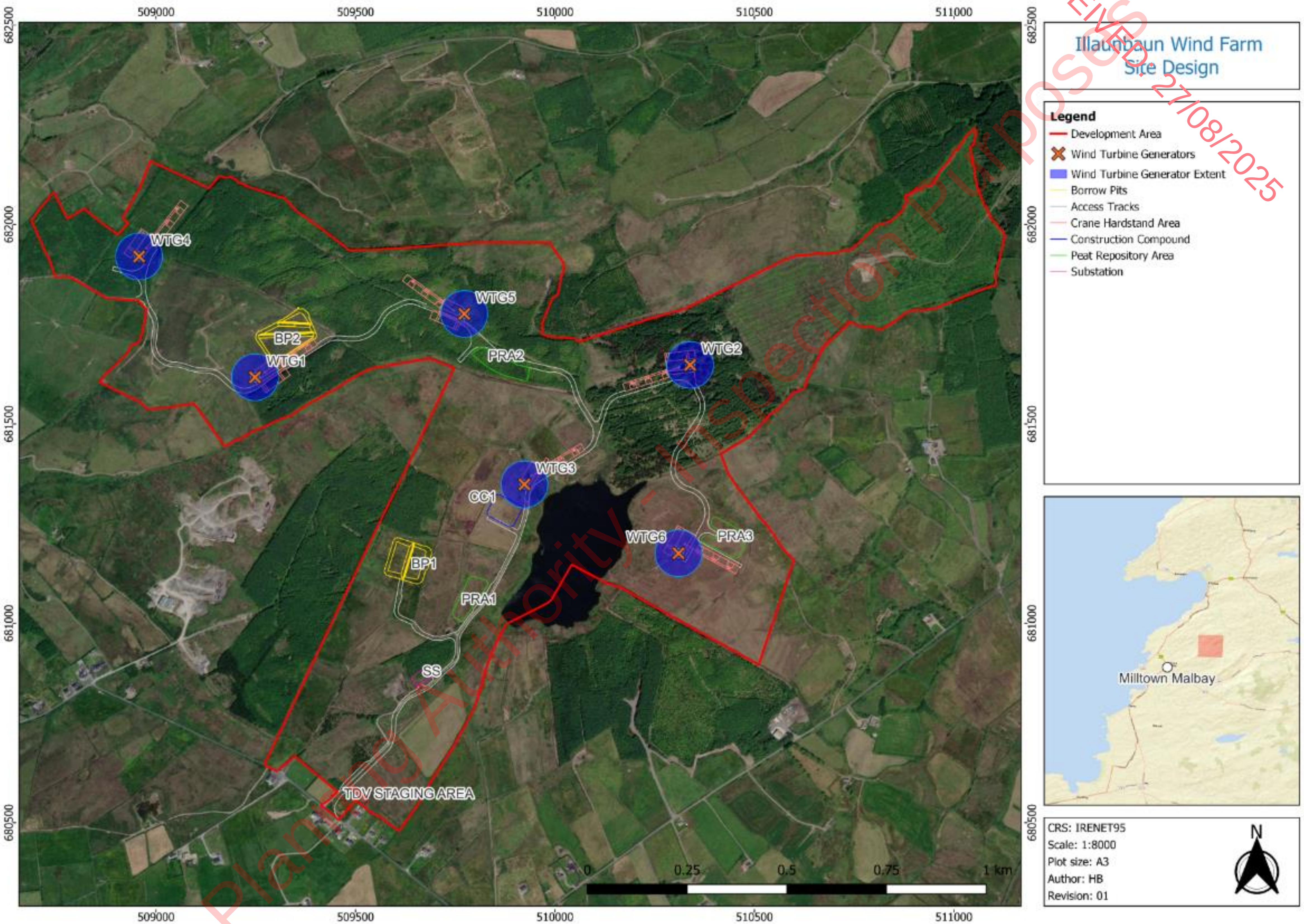


Figure A- 1: Proposed Development Location.

Appendix B Geology

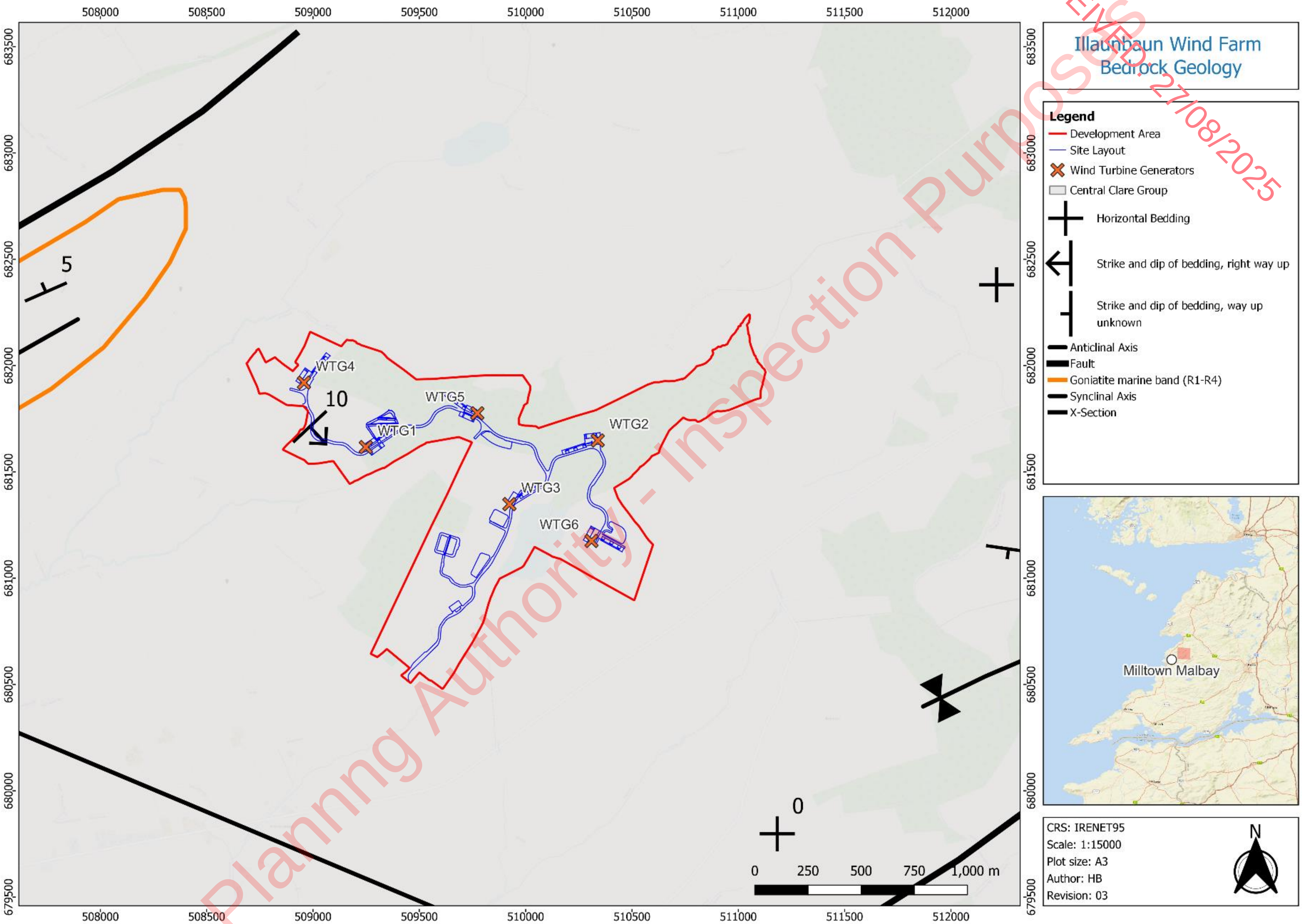


Figure B- 1: Bedrock Geology (GSI).

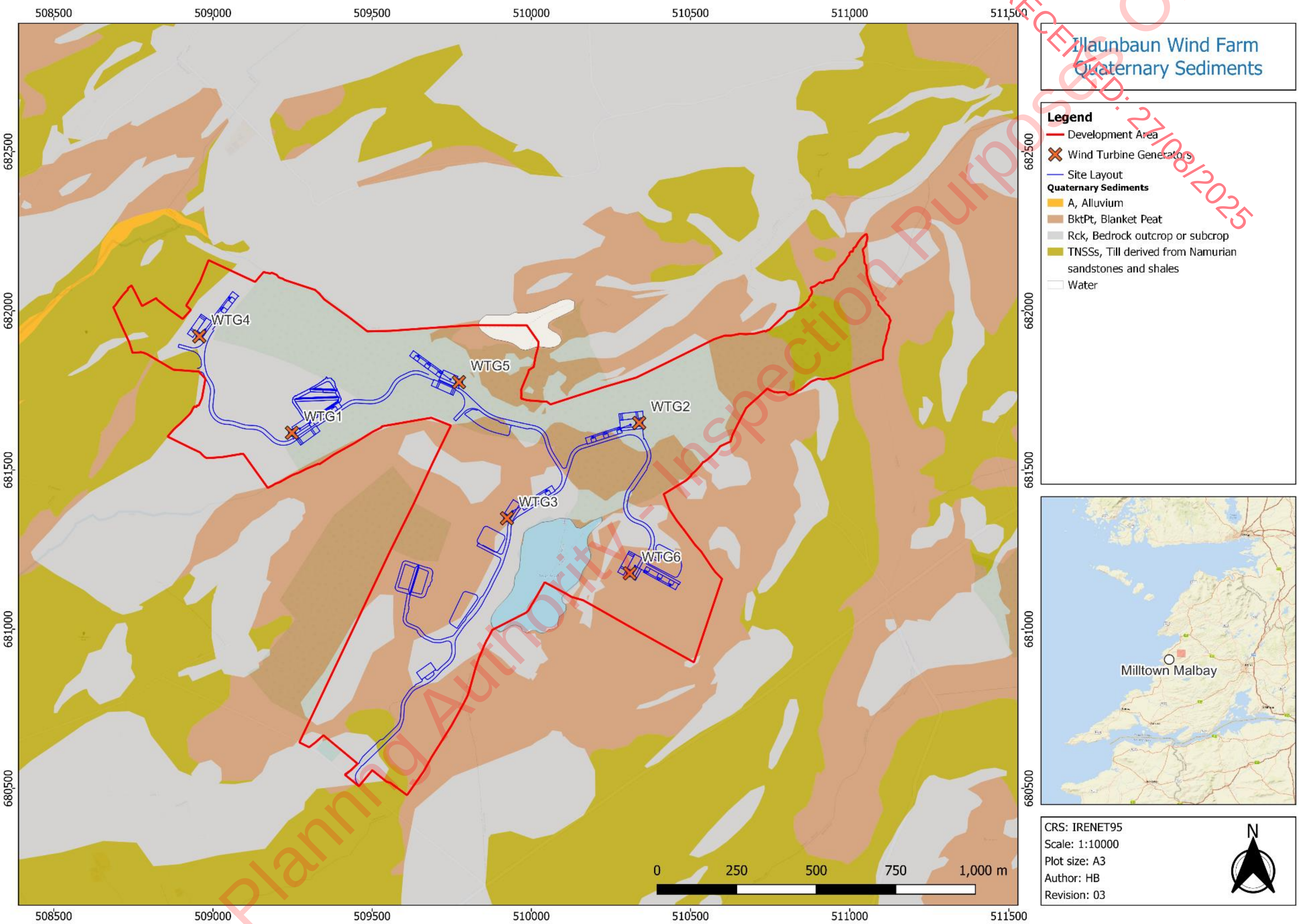


Figure B- 2: Quaternary Sediments (GSI).

Appendix C Soils

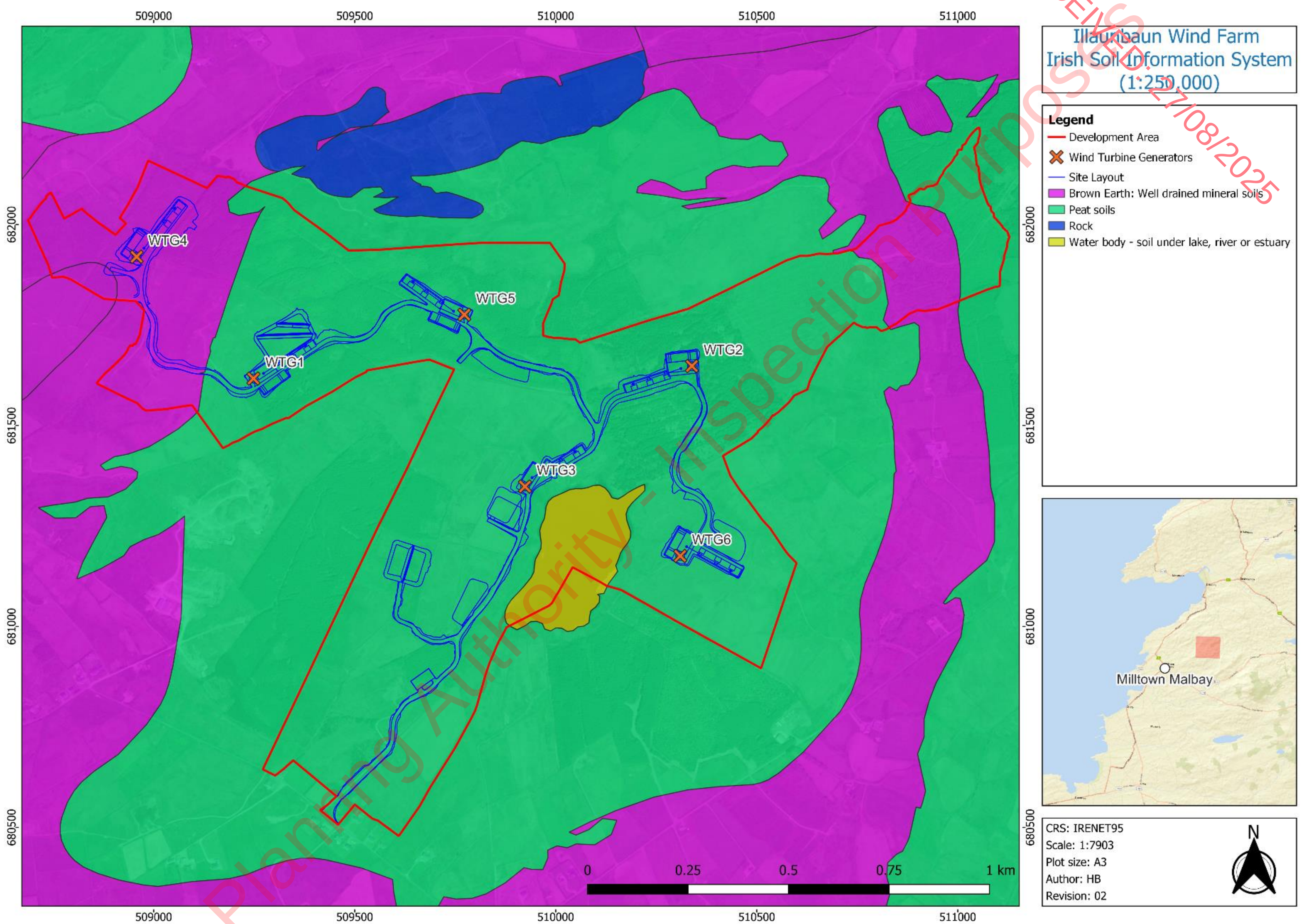


Figure C- 1: Soil Associations (EPA/Teagasc).

Appendix D Moisture

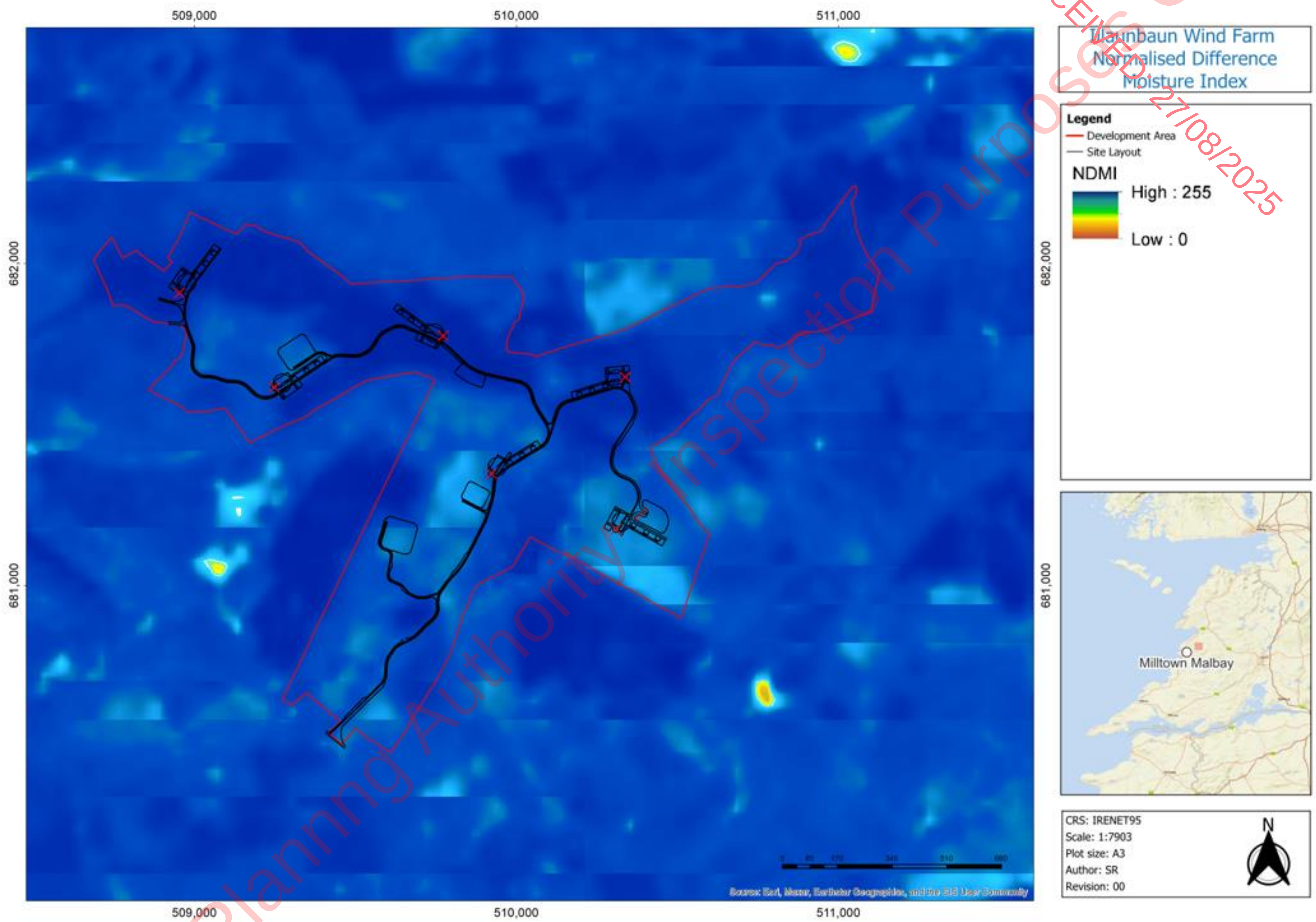


Figure D- 1: Normalised Difference Moisture Index (Landsat 8/USGS).

Appendix E Hydrogeology

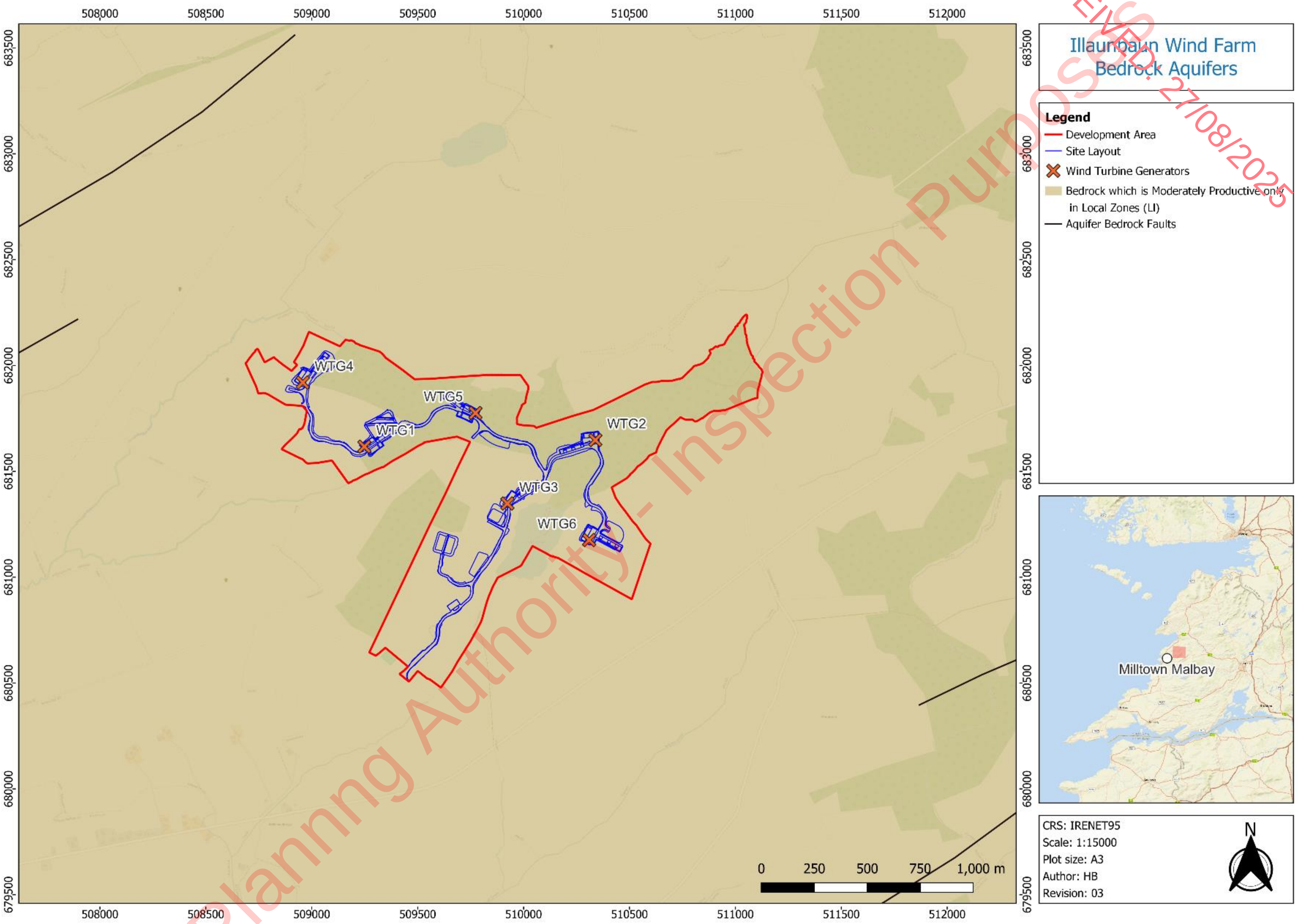


Figure E- 1: Bedrock Aquifers (GSI).

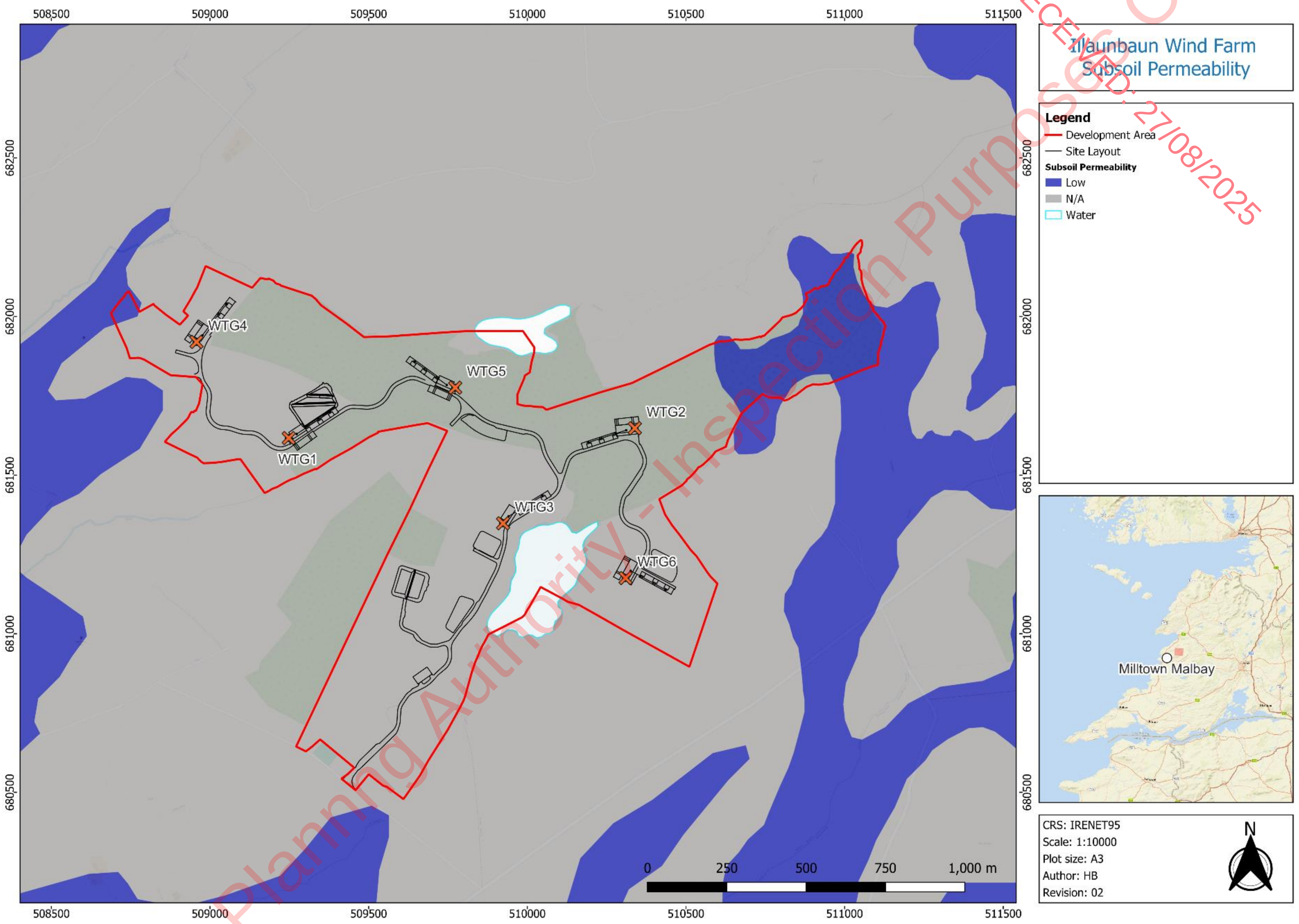


Figure E- 2: Subsoil Permeability (GSI).

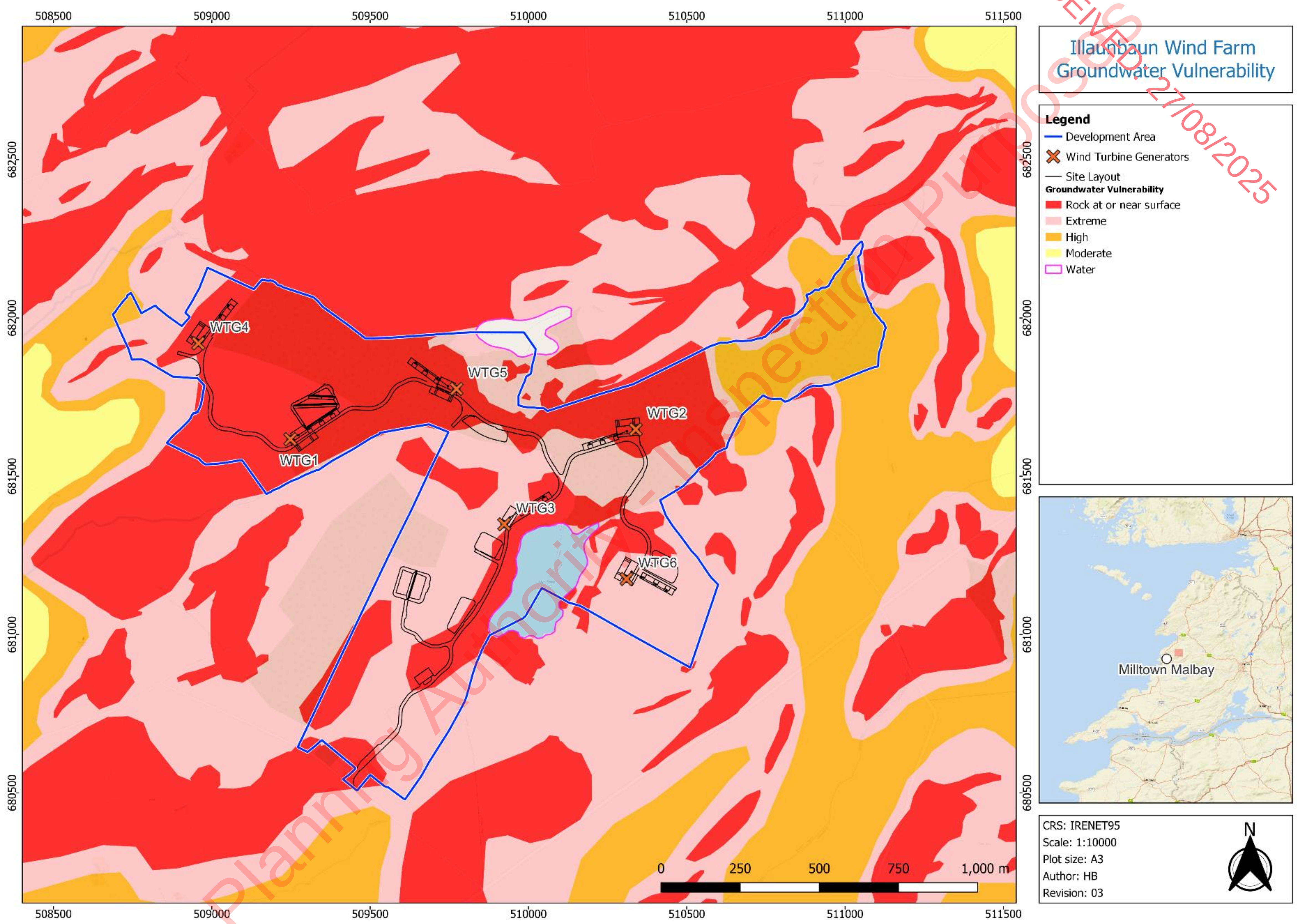


Figure E- 3: Groundwater Vulnerability (GSI)

Appendix F Topography

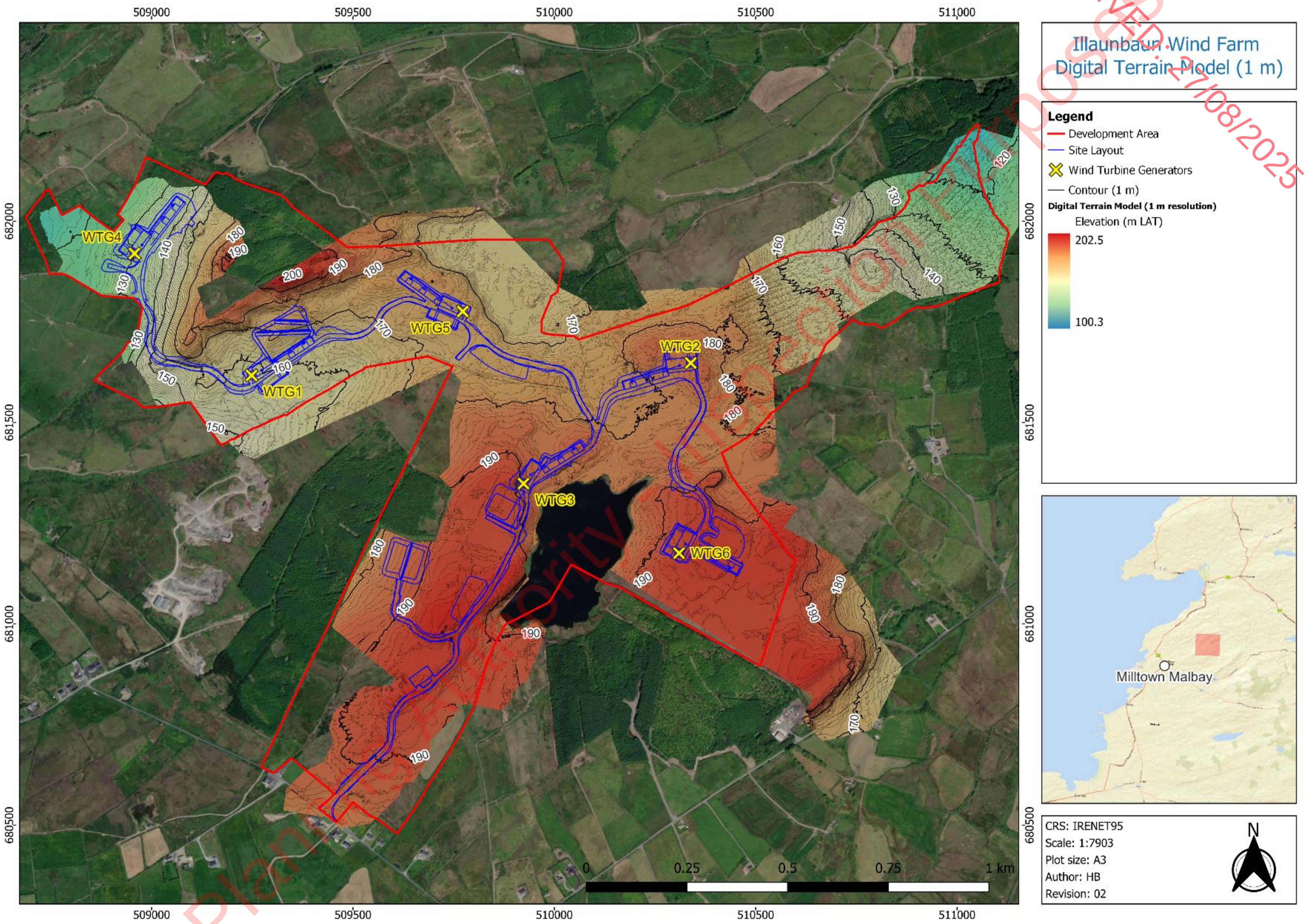


Figure F- 1: Digital Terrain Model (GDG and Drone Services Ireland Drone Survey, 2024).

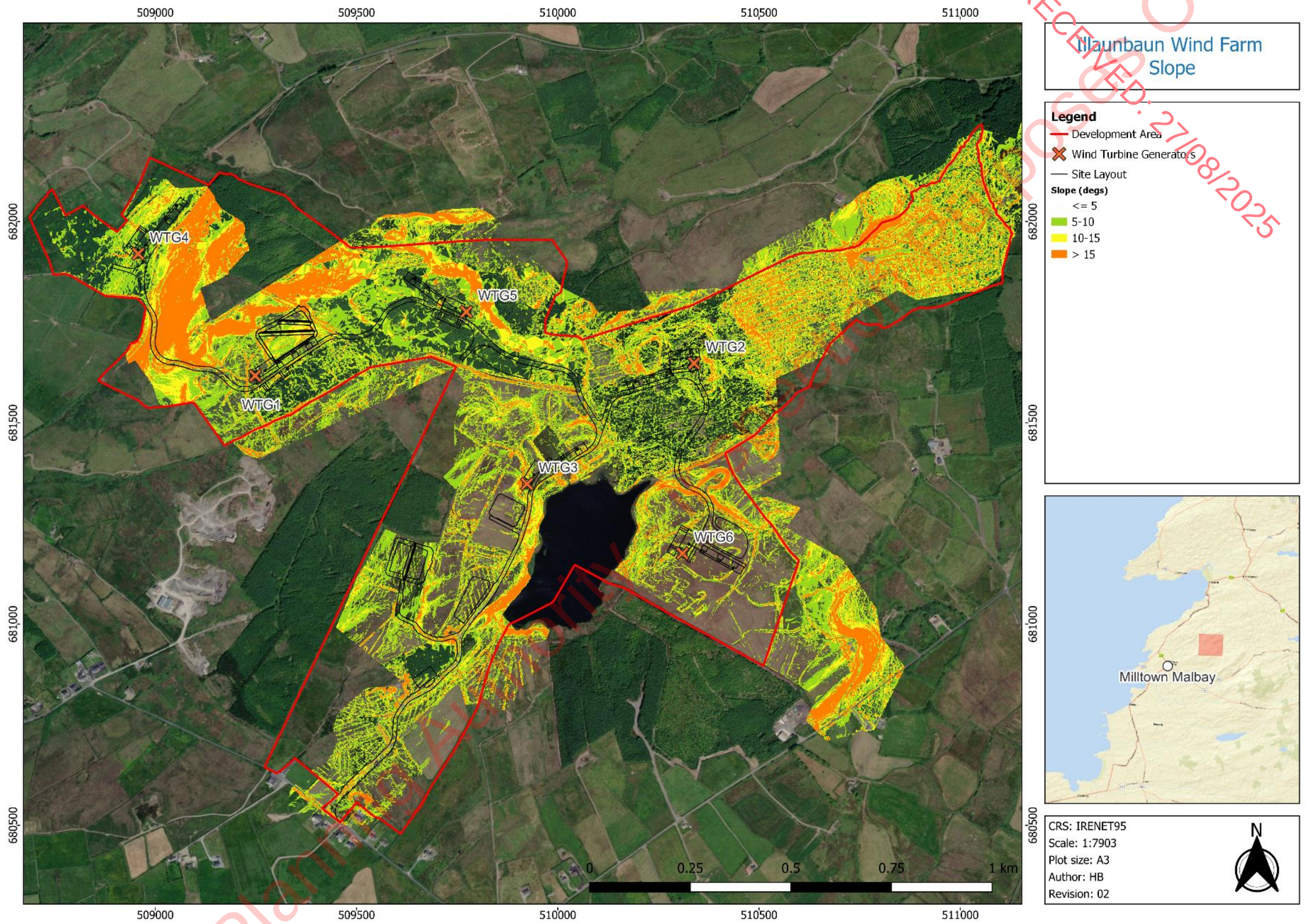


Figure F- 2: Slope Angles (Derived from GDG and Drone Services Ireland Drone Survey)

Appendix G Slope Instability Mapping

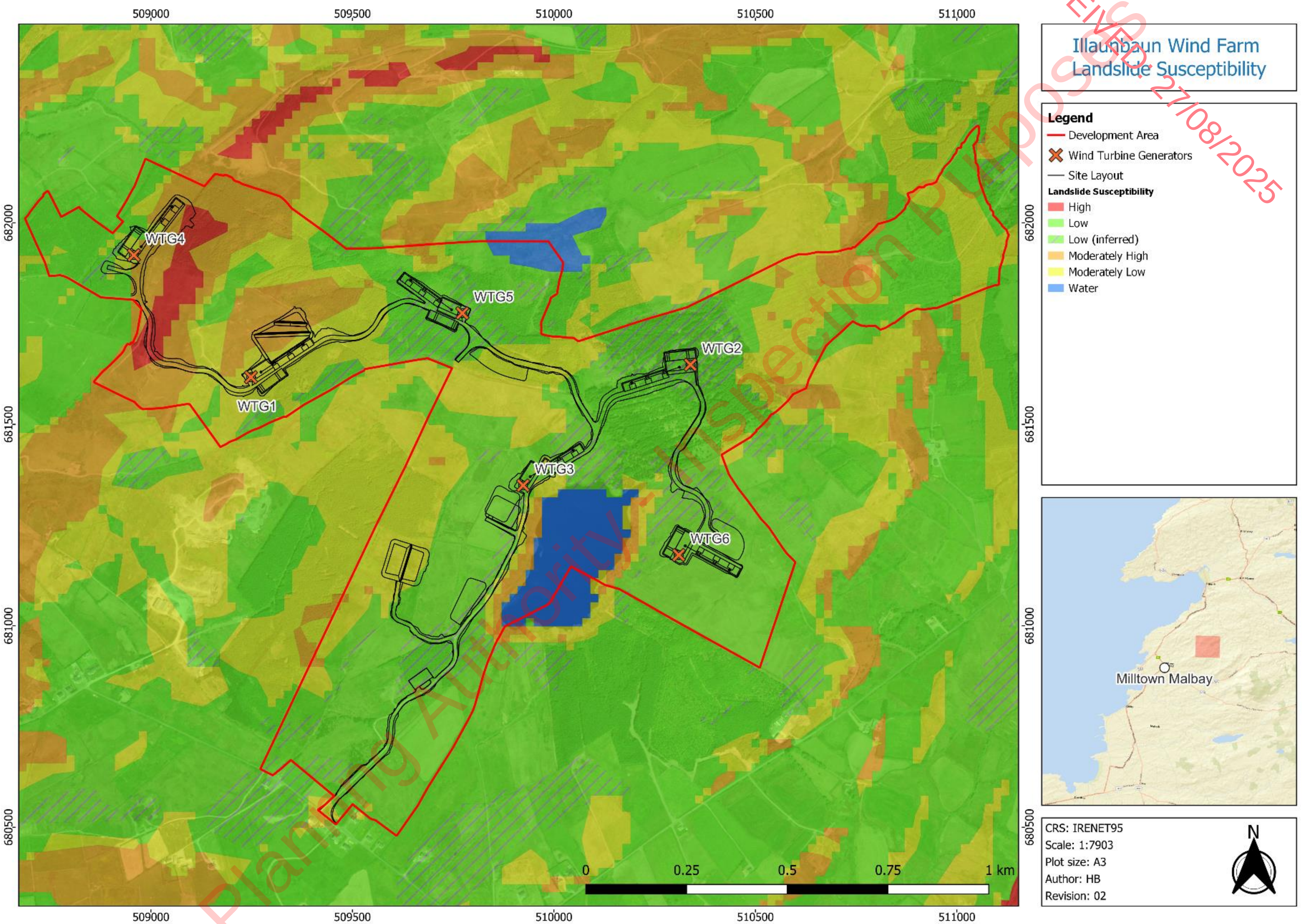


Figure G- 1: Landslide Susceptibility (GSI).

Appendix H Hydrology

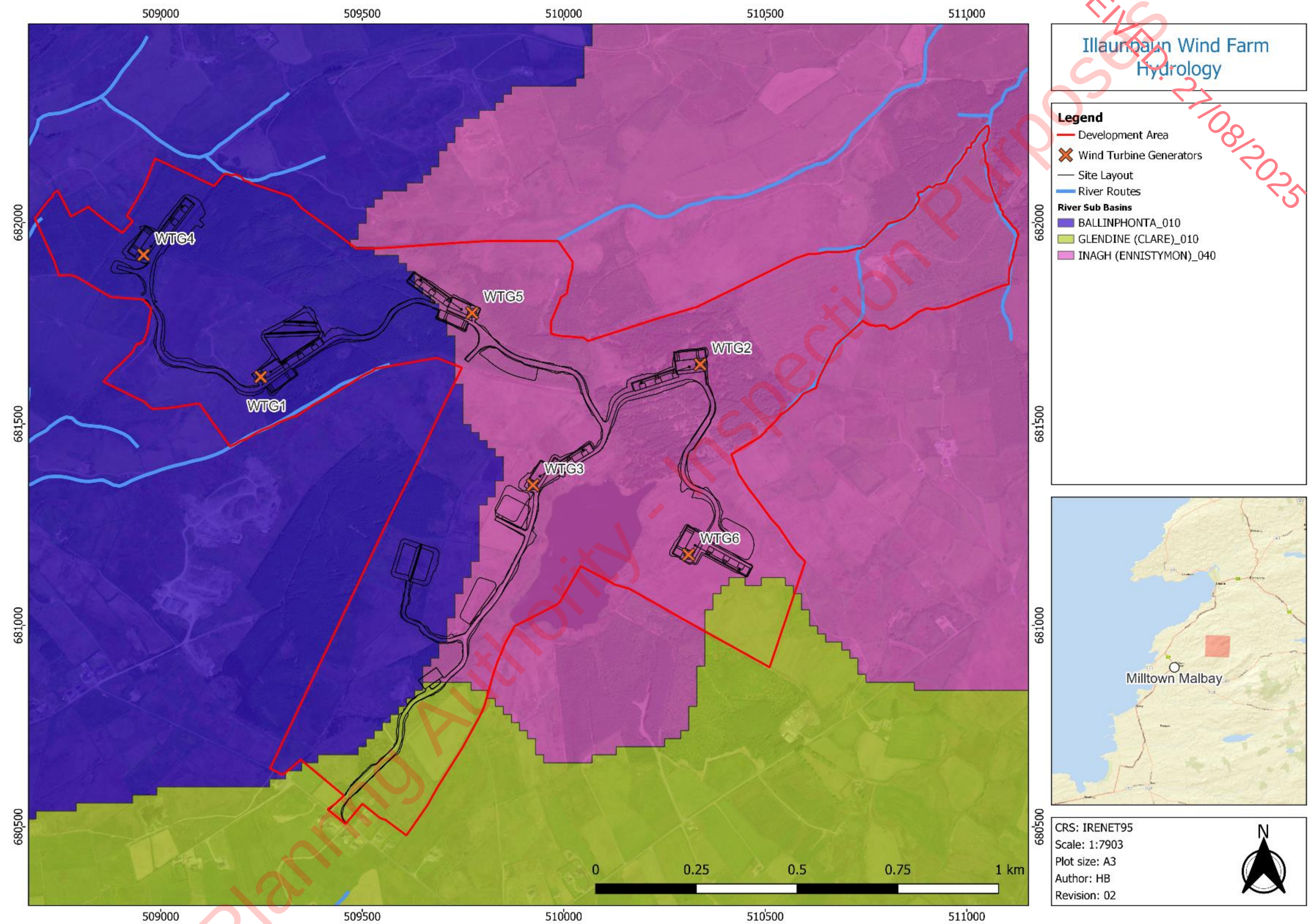


Figure H- 1: Hydrology (EPA).

Appendix I LANDCOVER

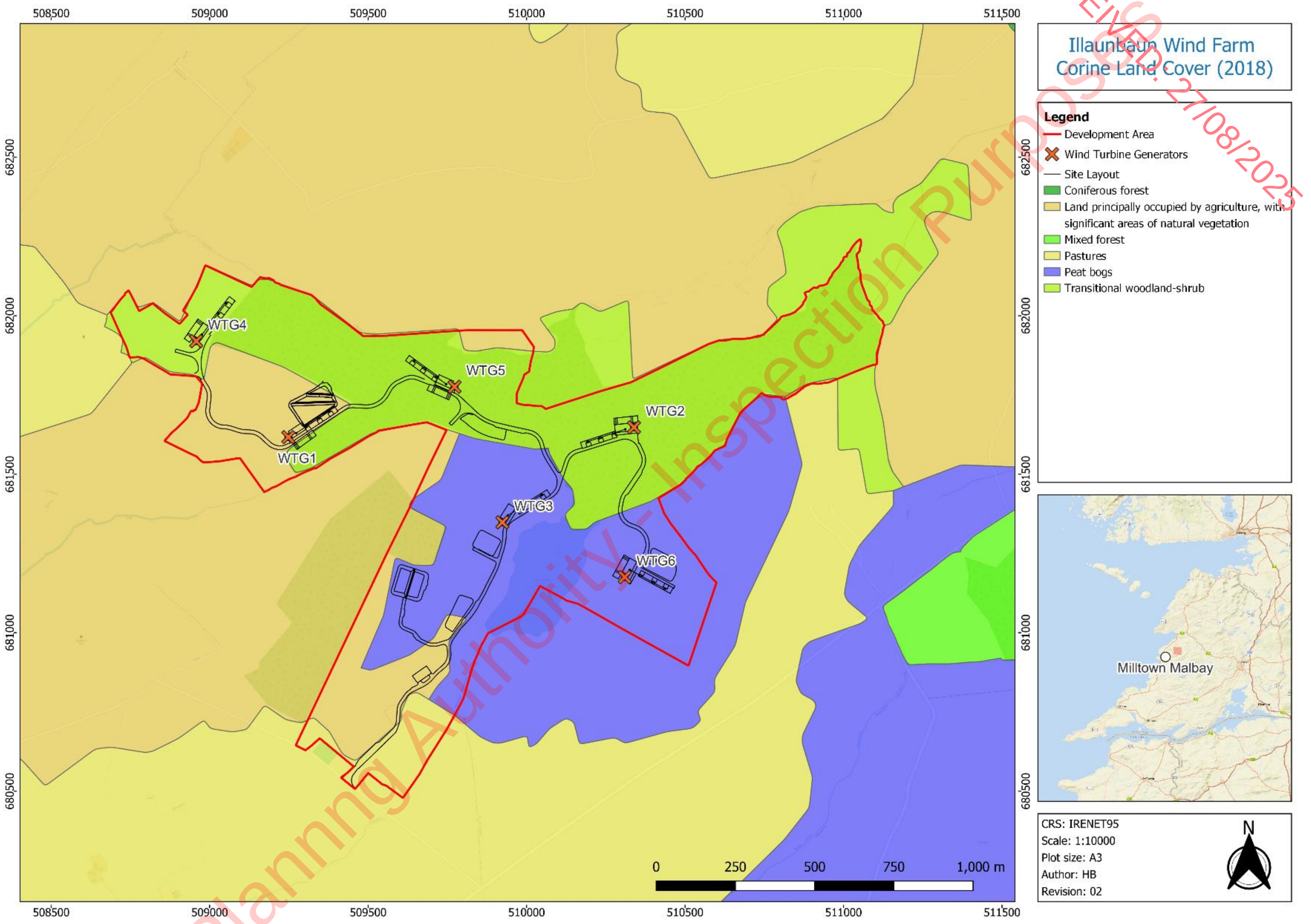


Figure I- 1: Landcover (Corine, 2018).

Appendix J GROUND INVESTIGATION

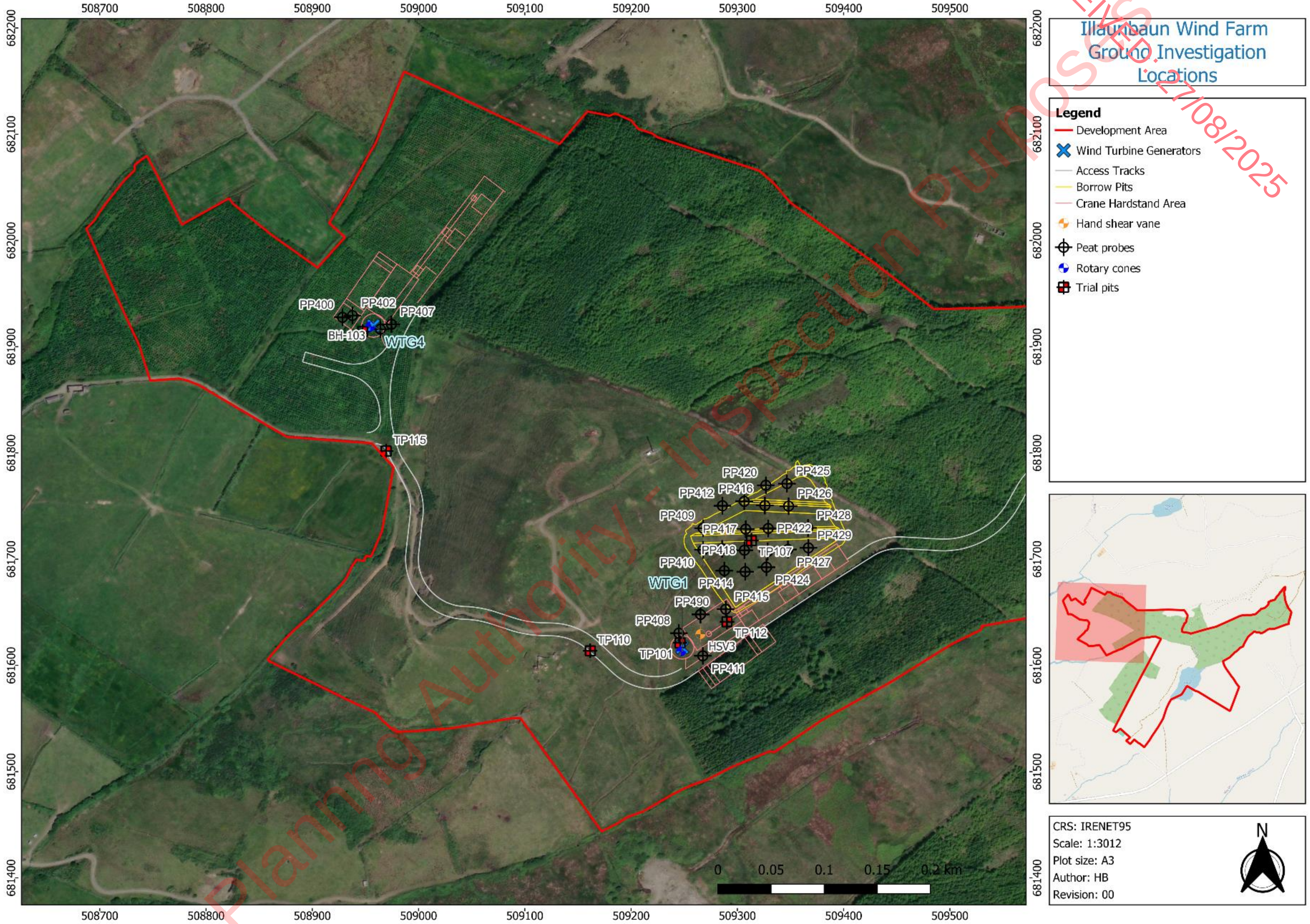


Figure J- 1: Ground Investigation Locations (Map 1 of 5)

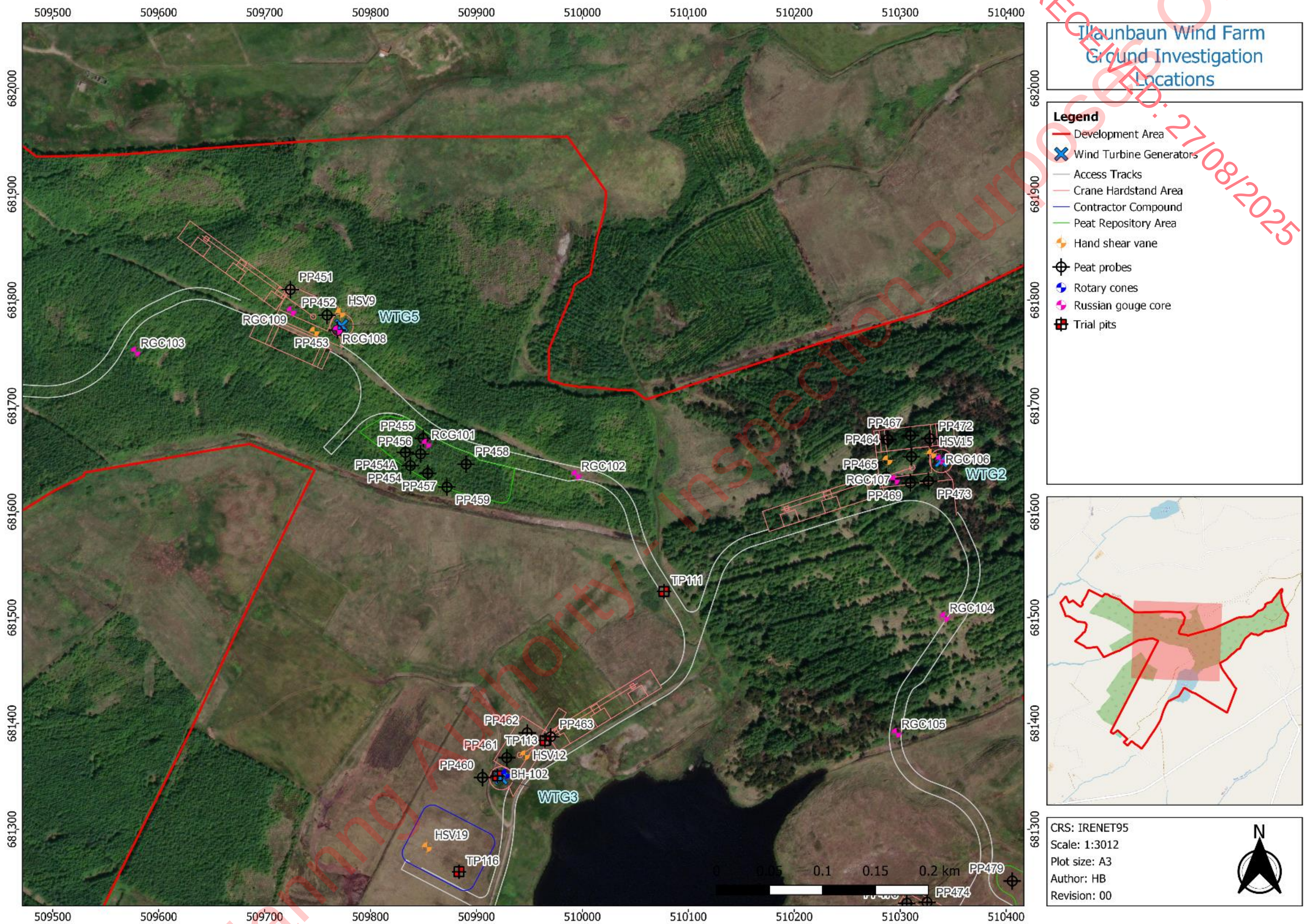


Figure J- 2: Ground Investigation Locations (Map 2 of 5)

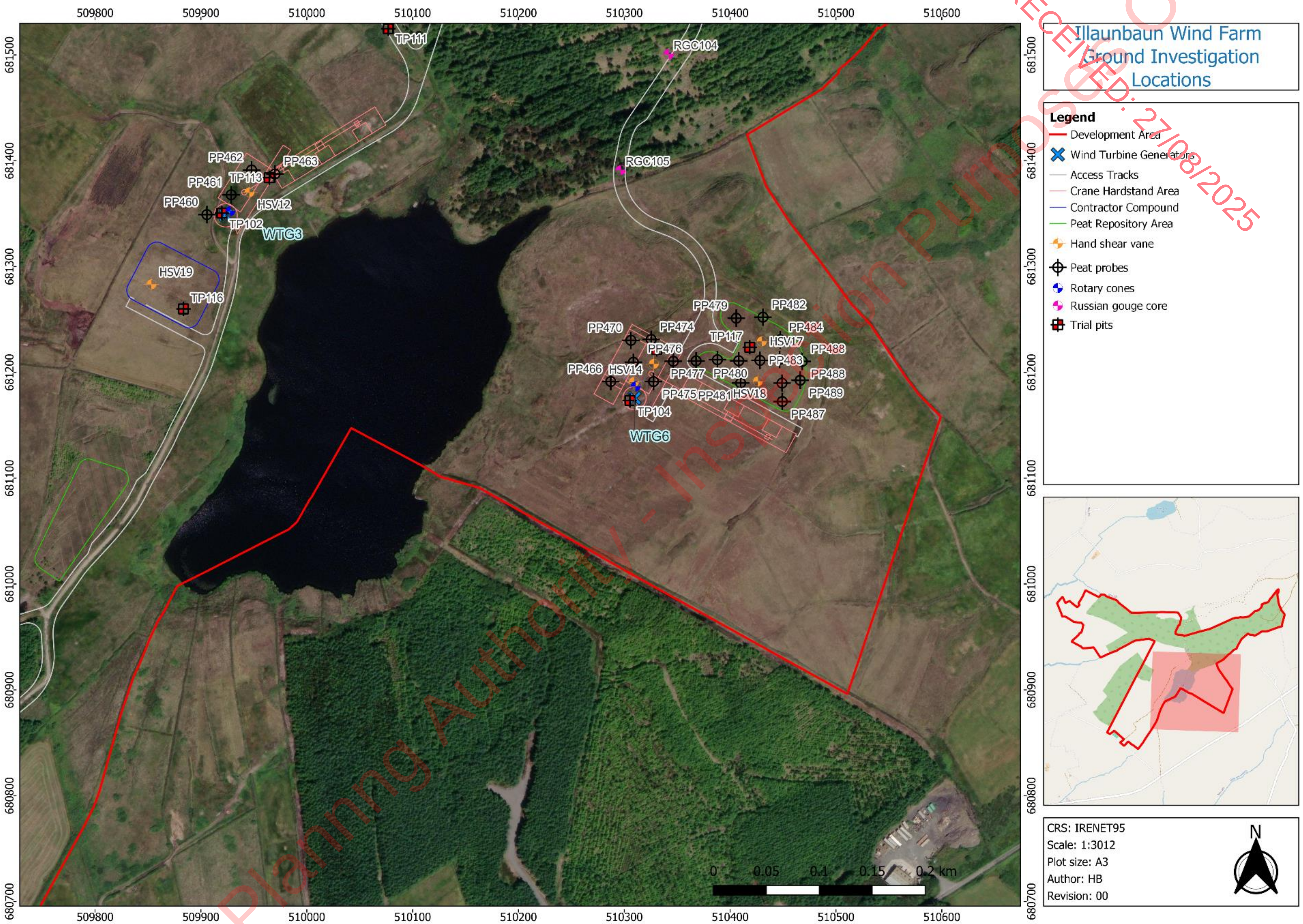


Figure J- 3: Ground Investigation Locations (Map 3 of 5)

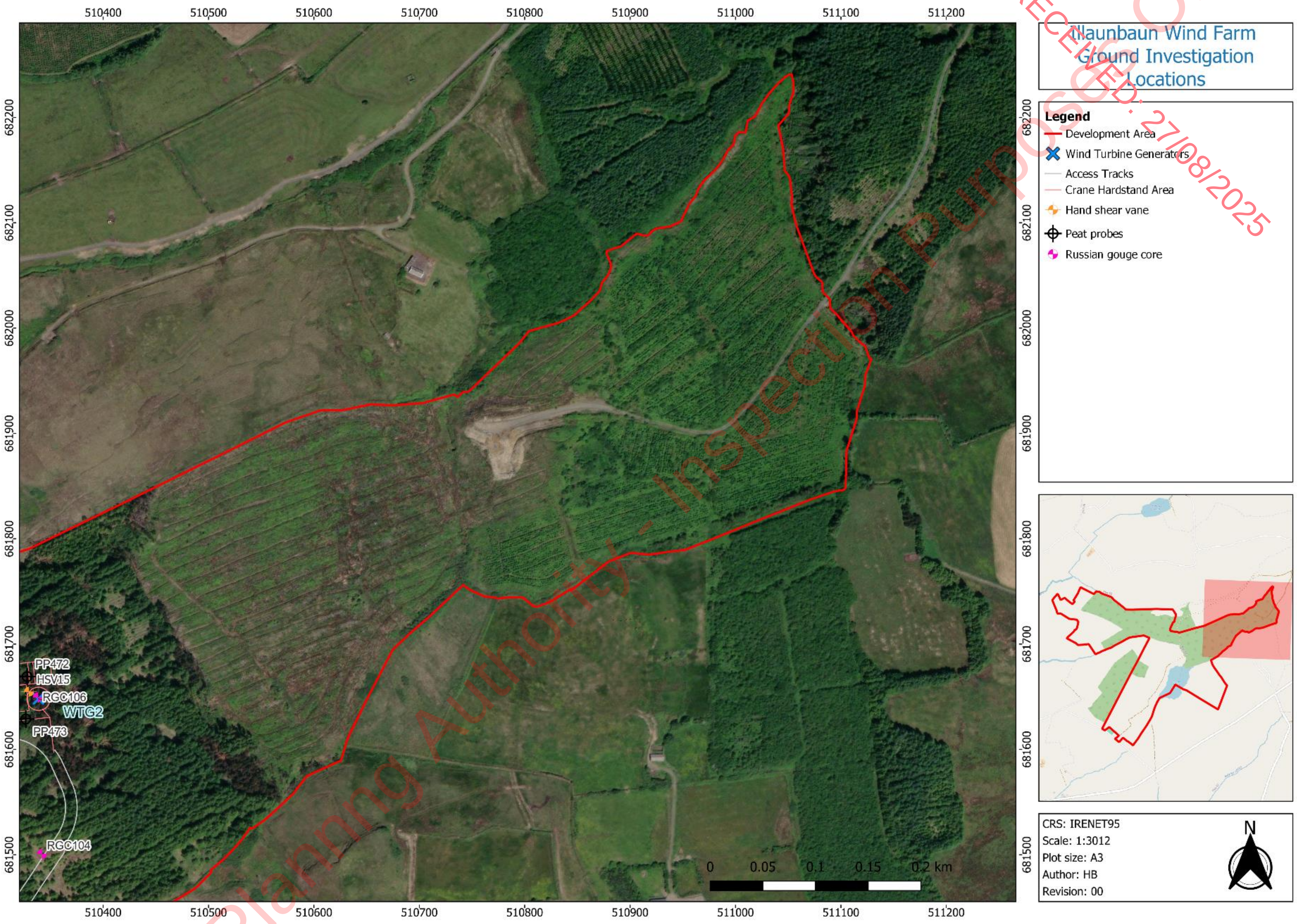


Figure J- 4: Ground Investigation Locations (Map 4 of 5)

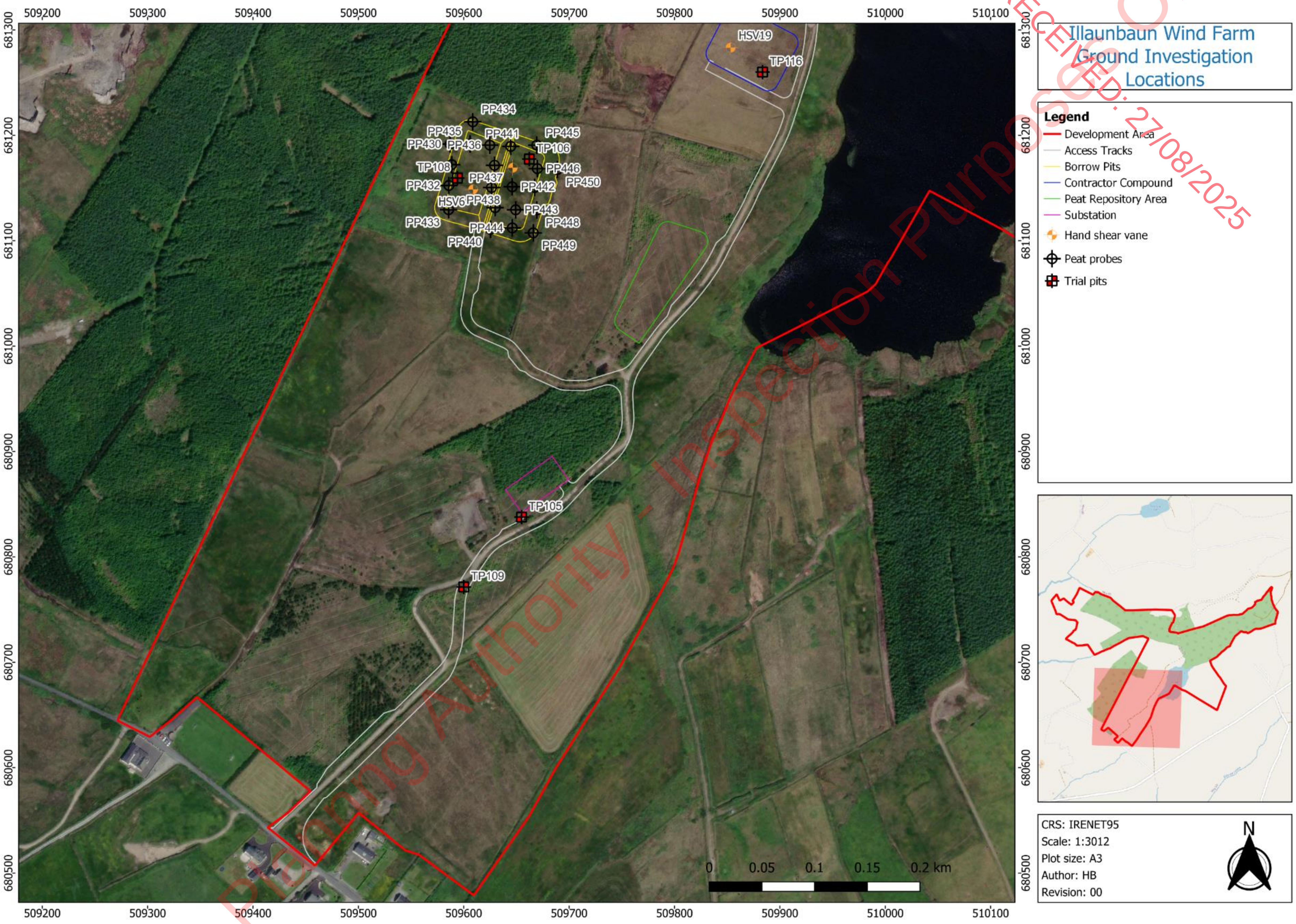


Figure J- 5: Ground Investigation Locations (Map 5 of 5)

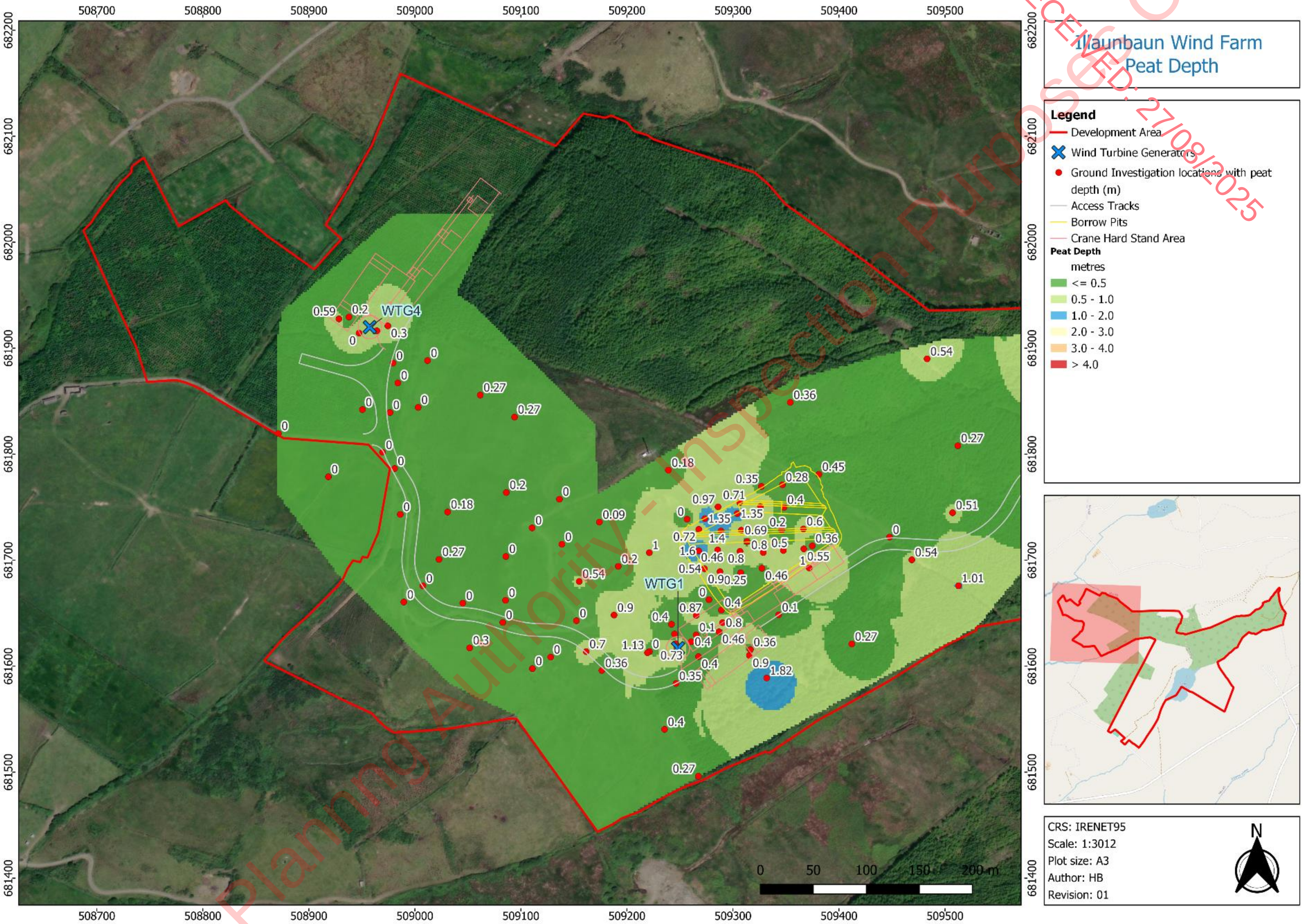


Figure J- 6: Interpolated Peat depth (Map 1 of 5)

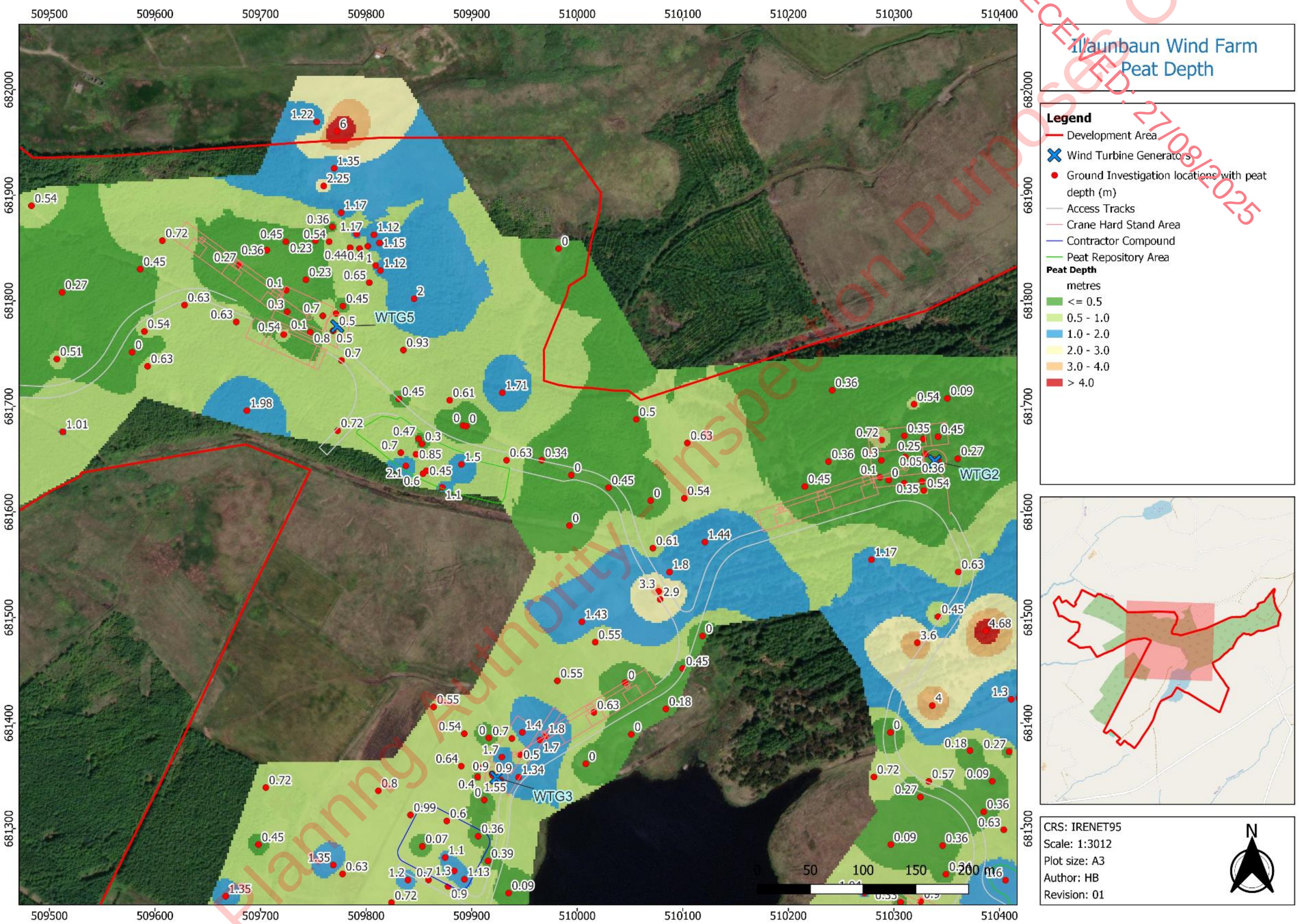


Figure J- 7: Interpolated Peat depth (Map 2 of 5)

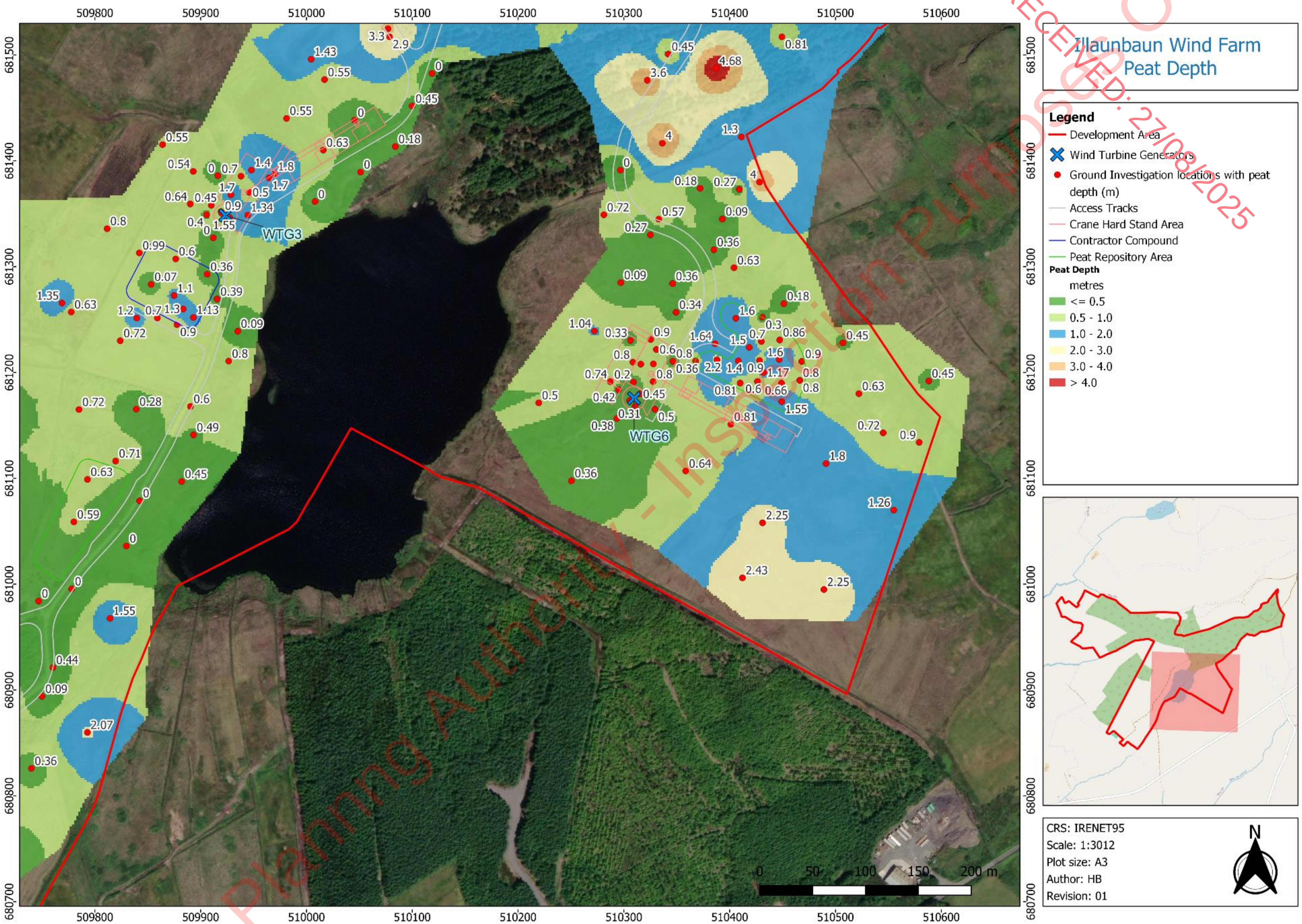


Figure J- 8: Interpolated Peat depth (Map 3 of 5)

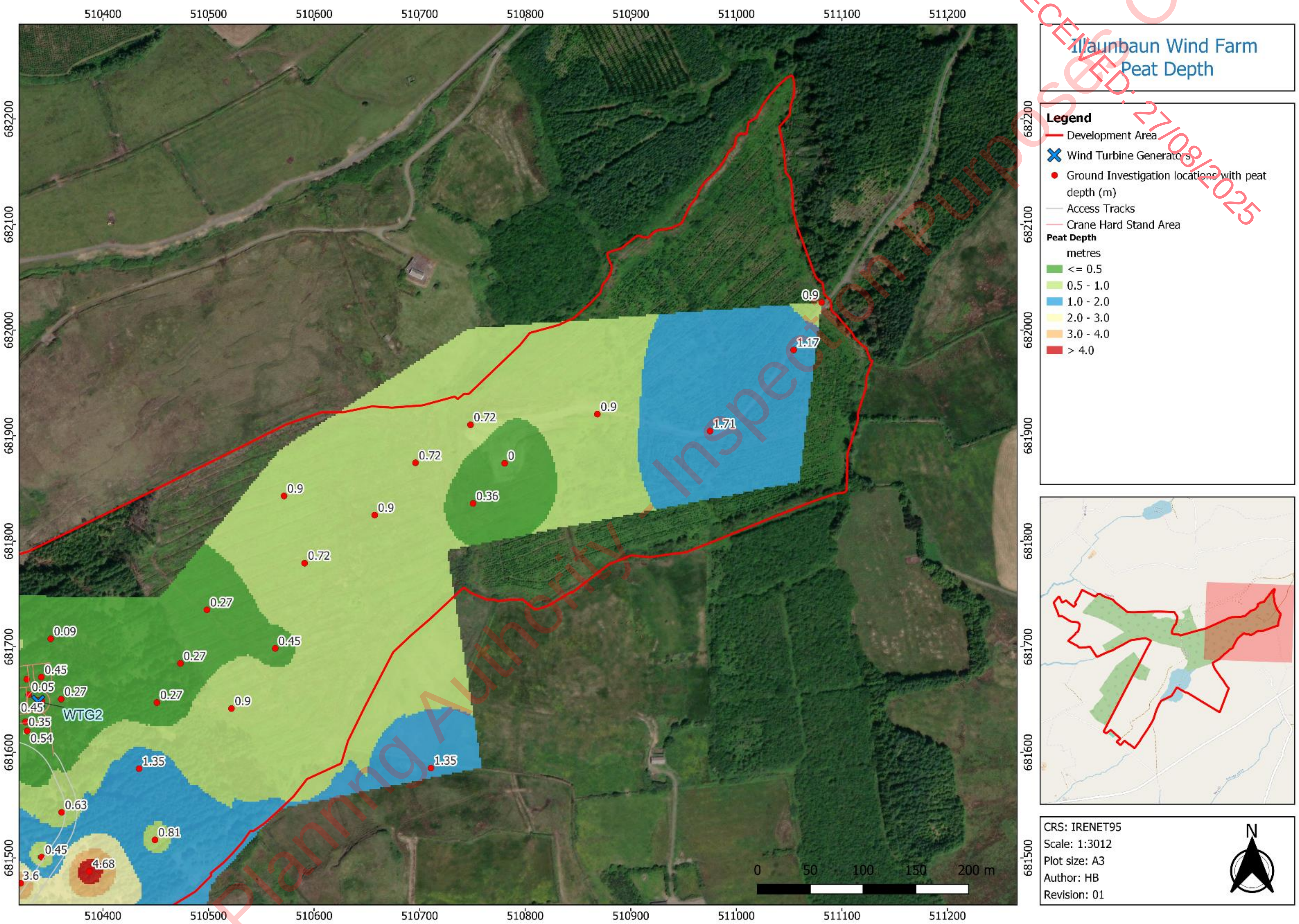


Figure J- 9: Interpolated Peat depth (Map 4 of 5)

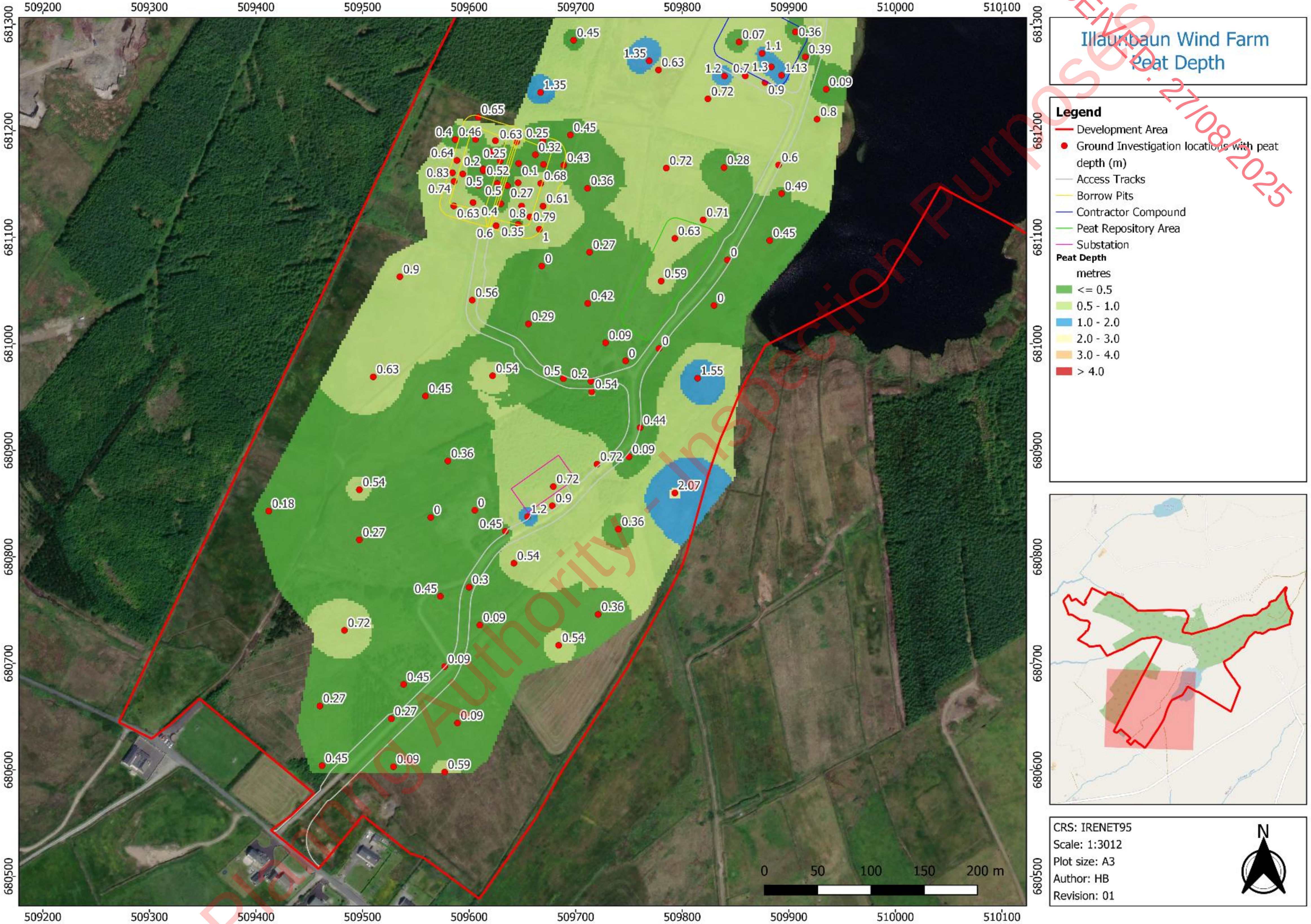
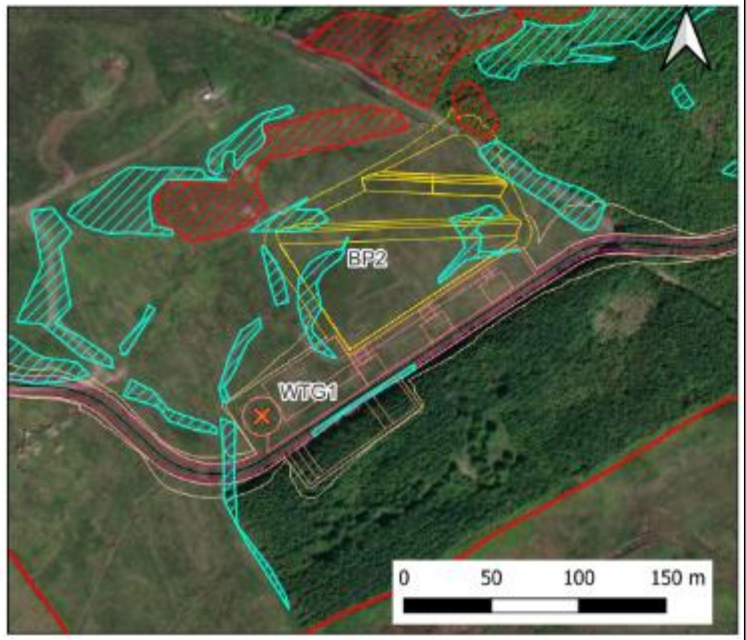


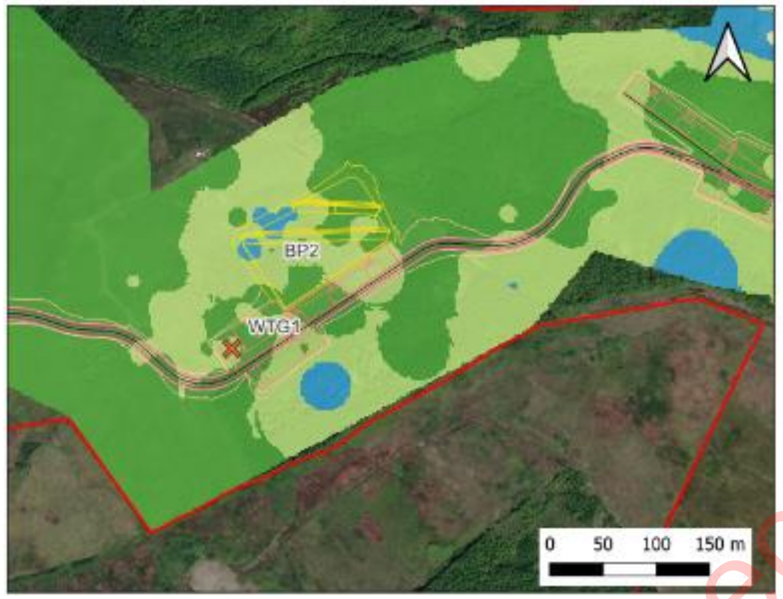
Figure J- 10: Interpolated Peat depth (Map 5 of 5)

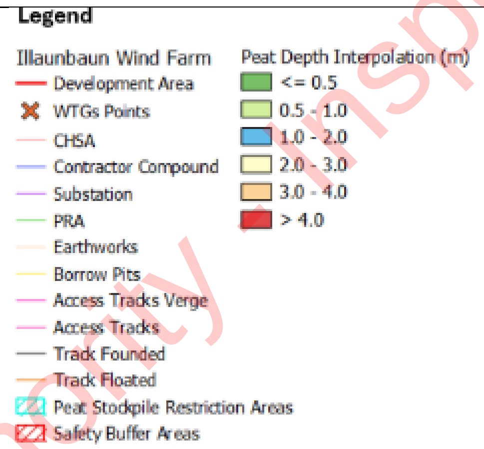
Table J- 1: Site reconnaissance of the Turbine 1 site.

Imagery



Peat geo-investigation





Description

Date of the satellite images: January , 2025. [Maxar/Esri].

Date of the ground-based pictures: July 2023 [GDG].

Geomorphology: T1 is located on blanket peat and bedrock outcrops. The topography is flat.

Peat: The peat depth at T01 is 0.7 m and slope angle of 6.1degrees.

Instability evidence: No.

Figure 1 H:\2024\24CE108 Clare 4N\Trial Pit Pictures\TP-101 (1).JPG

Figure 2 H:\2024\24CE108 Clare 4N\Trial Pit Pictures\TP-101 (2).JPG

Table J- 2: Site reconnaissance of the Turbine 2 site.

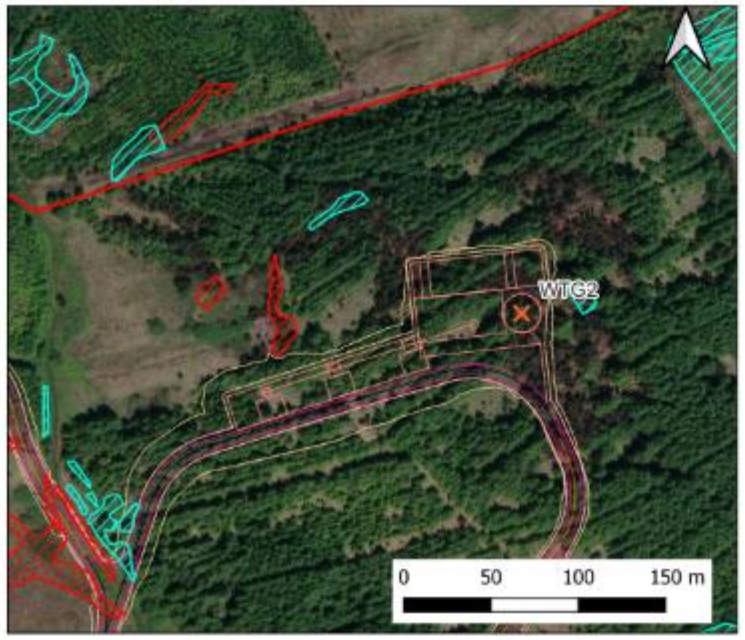
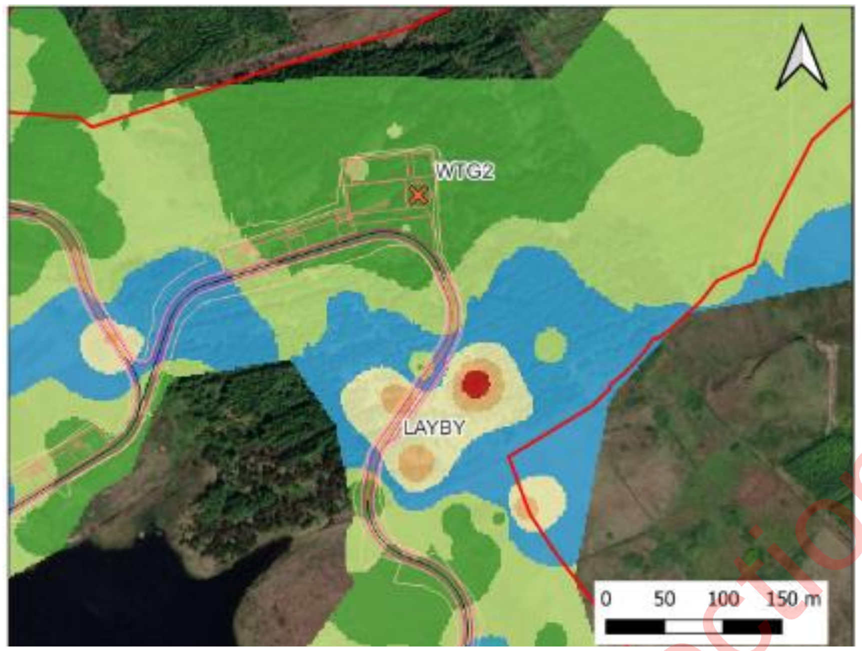
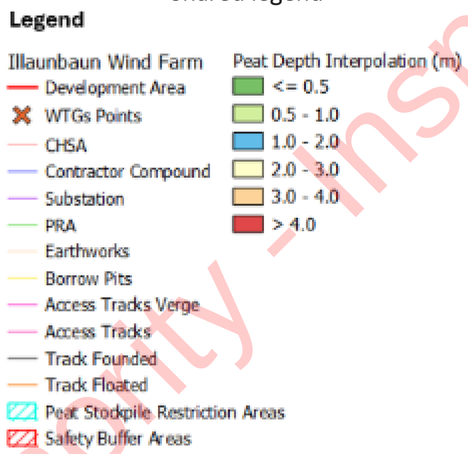
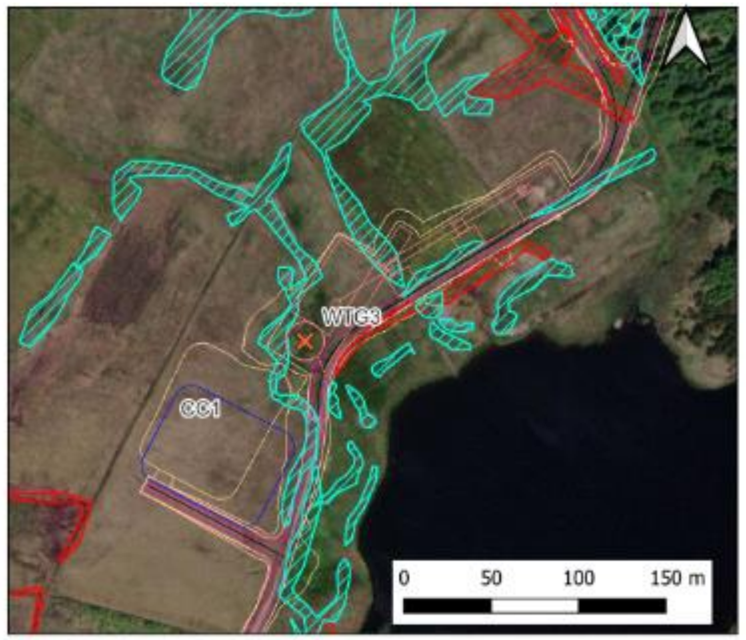
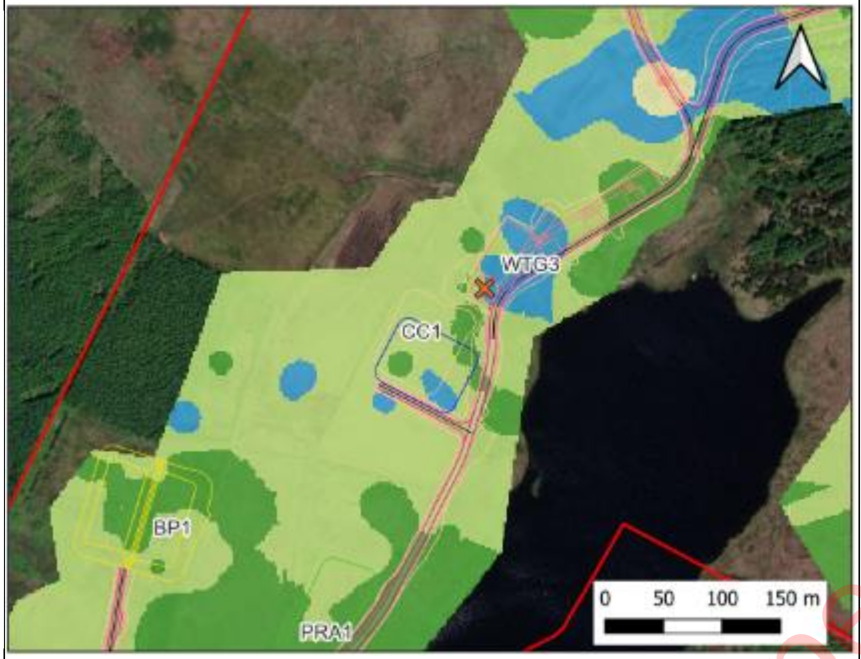
Imagery	Peat geo-investigation	
		
Shared legend 		
Description **Date of the satellite images:** January 2025. [Maxar/Esri]. **Date of the ground-based pictures :** July [GDG]. **Geomorphology**: The topography is flat. **Peat**: The peat depth at T02 is 0.4m, with a slope angle of 1.9 degrees **Instability evidence**: No.		

Table J- 3: Site reconnaissance of the Turbine 3 site.

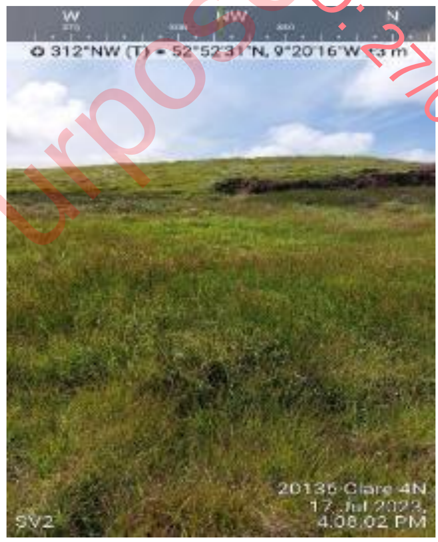
Imagery



Peat geo-investigation



20136_Clare6N_39



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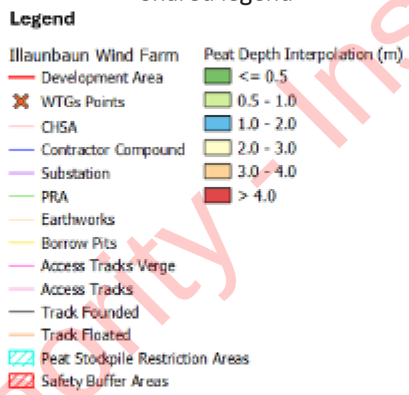


Description

Date of the satellite images: January 2025. [Maxar/Esri].

Date of the ground-based pictures: 14th September 2023 [GDG] and TP photographs clicked during GI campaign (IDL).

Geomorphology: T03 is located on blanket peat and bedrock outcrops. The topography is mostly flat.

Peat: The peat depth is ~1.1m at the T03 location. The slope angle is 10.5 degrees.

Instability evidence: No.

20136_Clare6N_44

Figure 3 H:\2024\24CE108 Clare 4N\Trial Pit Pictures\TP-102 1].JPG

Table J- 4: Site reconnaissance of the Turbine 4 site.

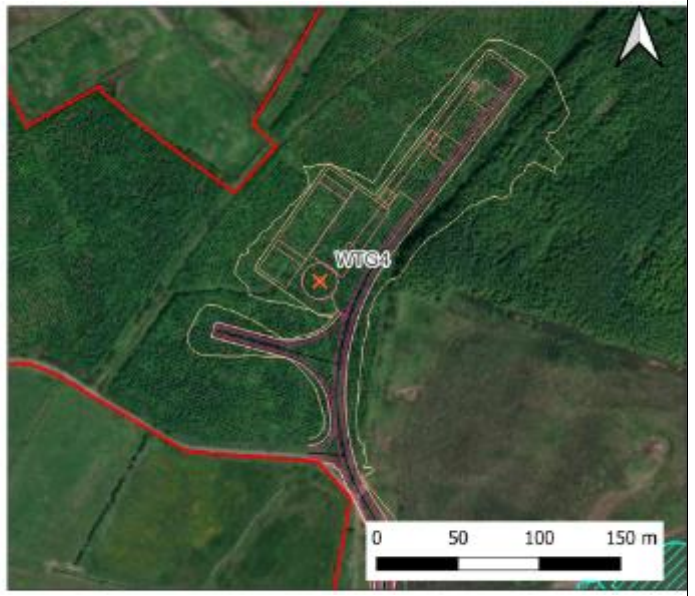
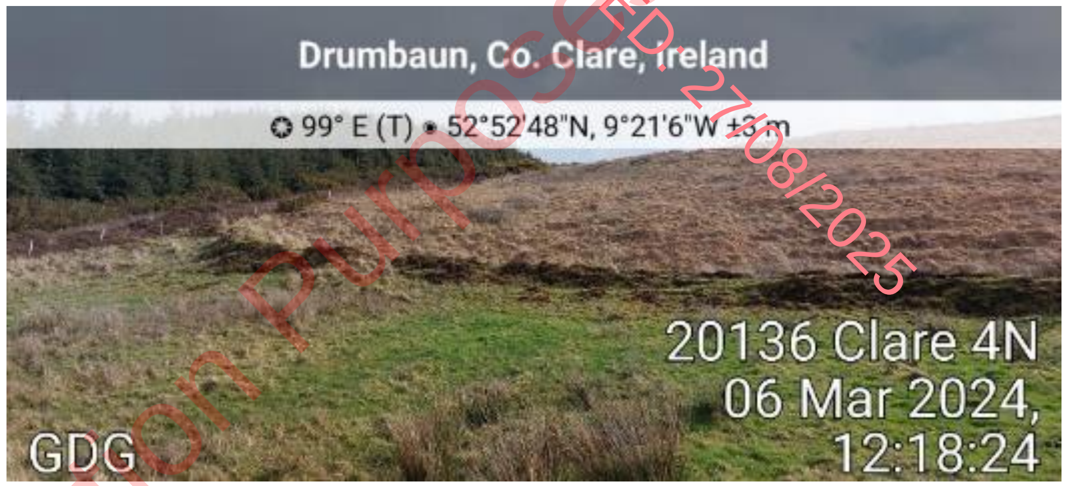
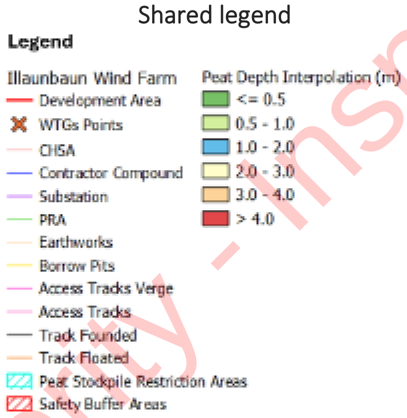
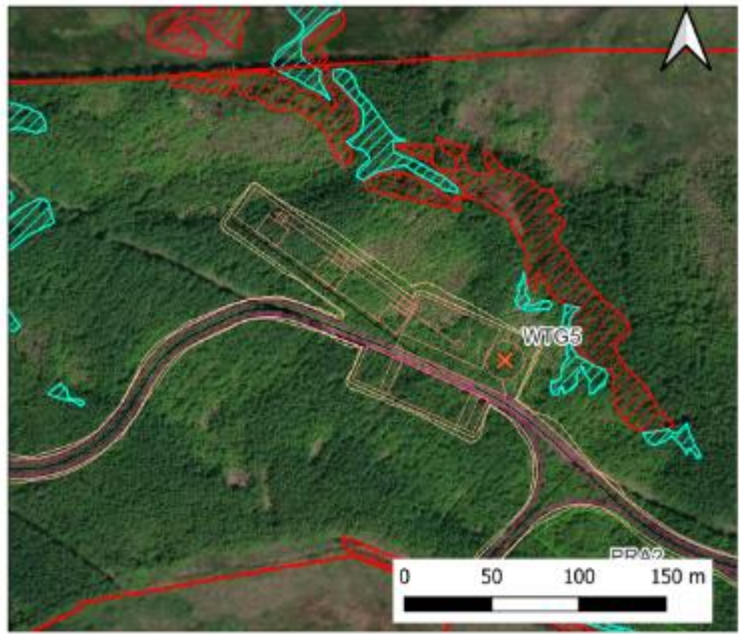
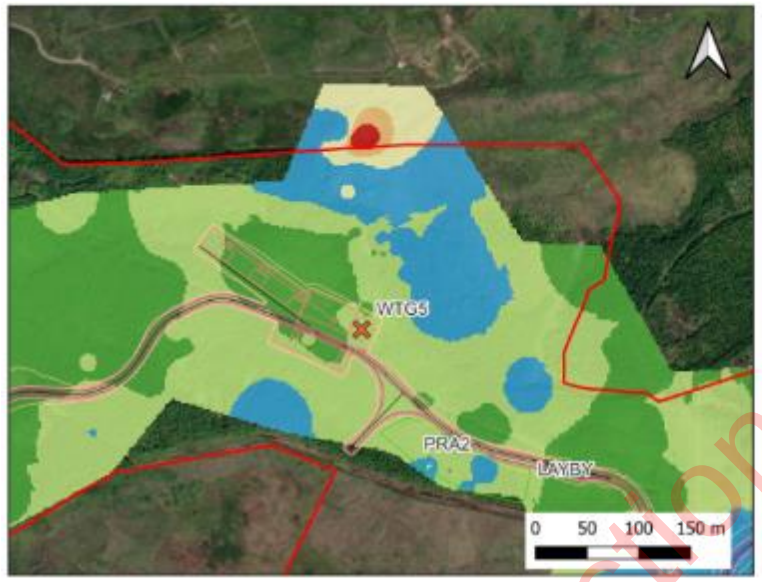
Imagery	Peat geo-investigation		
			
Shared legend 			
Description **Date of the satellite images:** January , 2025. [Maxar/Esri]. **Date of the ground-based pictures:** 28th of March 2020 and 15th of September 2023. [GDG]. And Photographs clicked during the GI Campaign of IDL. **Geomorphology**: The topography is generally flat with bedrock outcrops. **Peat**: The peat depth in this location is 0.68m. **Instability evidence**: No.		 Figure 5 H:\2024\24CE108 Clare 4N\Trial Pit Pictures\TP-103	 Figure 6 H:\2024\24CE108 Clare 4N\Trial Pit Pictures\TP-103 (2).JPG

Table J- 5: Site reconnaissance of the Turbine 5 site.

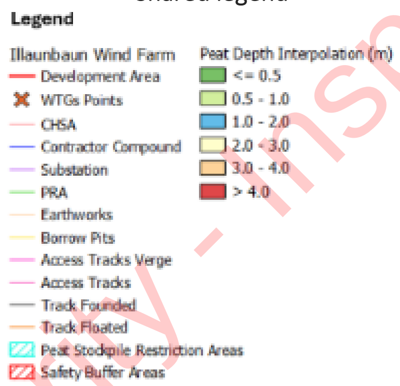
Imagery



Peat geo-investigation



Shared legend



Description

Date of the satellite images: January 2025[Maxar/Esri].

Date of the ground-based picture: July 2023[GDG].And Photographs clicked during the GI Campaign of IDL.

Geomorphology: Located within the forestry area.

Peat: Depths of 0.6 m at the turbine location. Slope angle is 2.0 degrees.

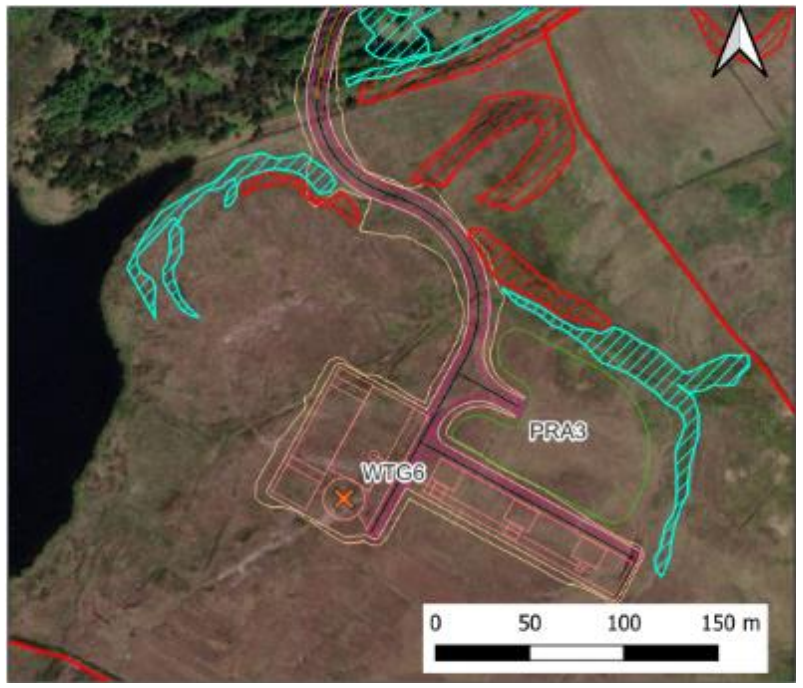
Instability evidence: No.

0.50-0.80- Firm grey CLAY

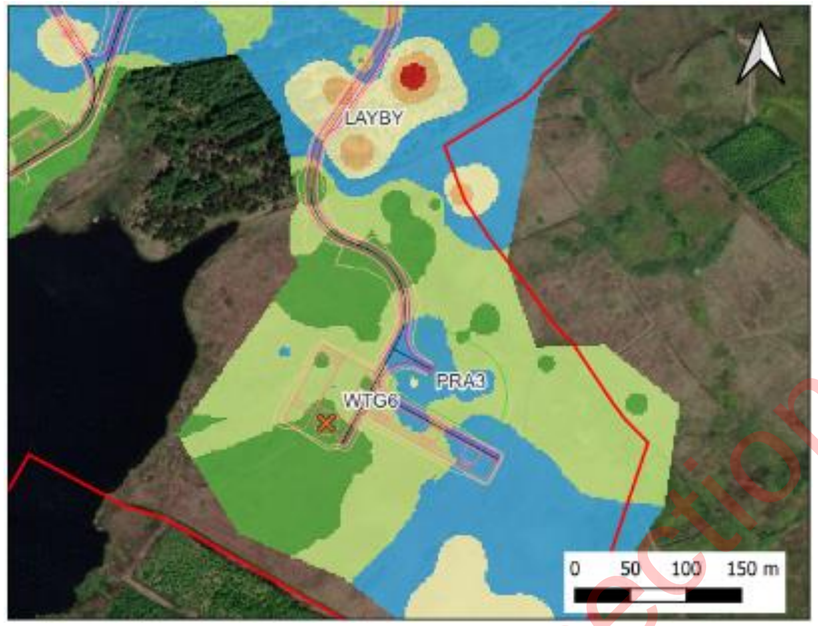
0.80- Possible ROCK or GRAVEL.

Table J- 6: Site reconnaissance of the Turbine 6 site.

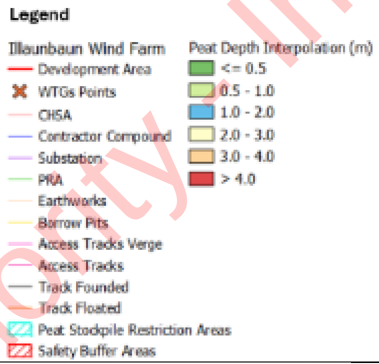
Imagery



Peat geo-investigation



Shared legend



Description

Date of the satellite images: January, 2025. [Maxar/Esri].

Date of the ground-based pictures: July 2023. [GDG].And Photographs clicked during GI Campaign of IDL.

Geomorphology: Topography is flat Peat is underlain by glacial till.

Peat: Peat depth at T06 is 0.32m, with a slope angle of 3.0 degrees.

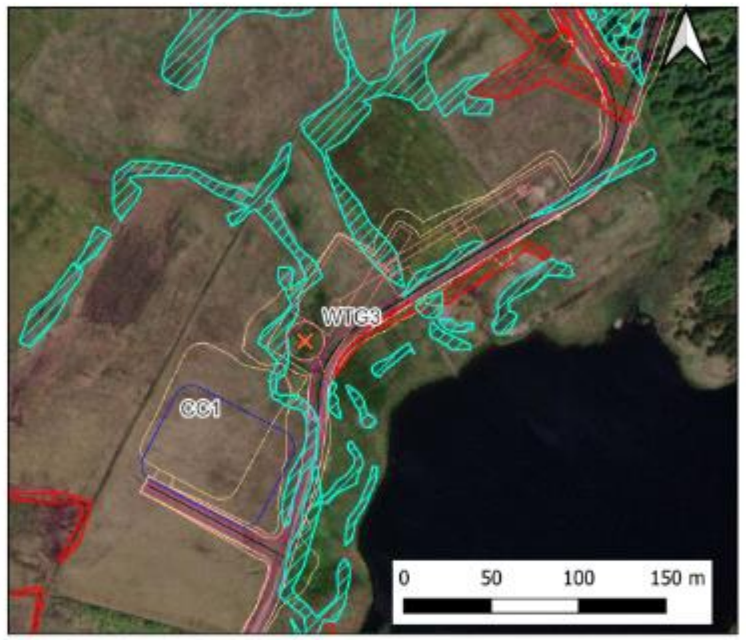
Instability evidence: No.

Figure 7 H:\2024\24CE108 Clare 4N\Trial Pit Pictures\TP-104 (1).JPG

Figure 8 H:\2024\24CE108 Clare 4N\Trial Pit Pictures\TP-104 (2).JPG

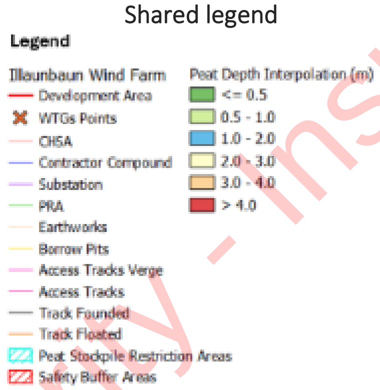
Table J- 7: Site reconnaissance of the Construction Compound site.

Imagery



Peat geo-investigation

Shared legend



Description

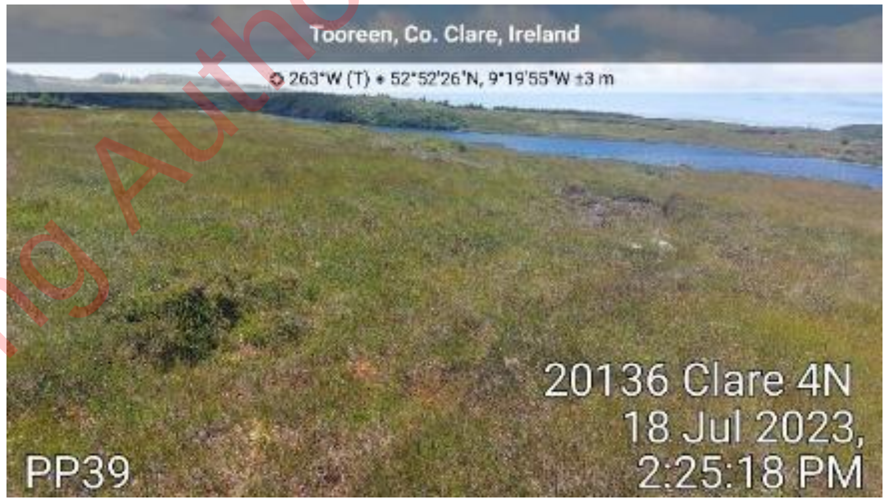
Date of the satellite images: January 2025. [Maxar/Esri].

Date of the ground-based pictures July 2023 [GDG]

Geomorphology: Topography is generally flat , underlain by peat and bedrock outcrops

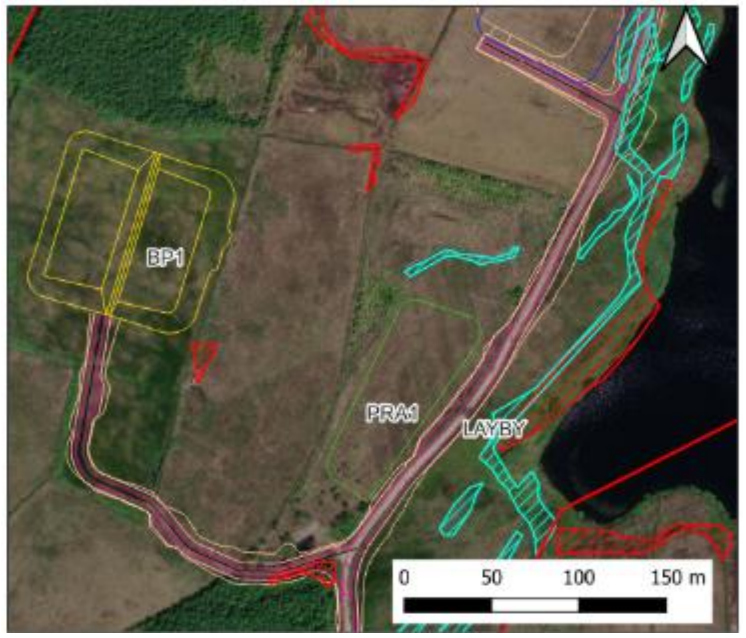
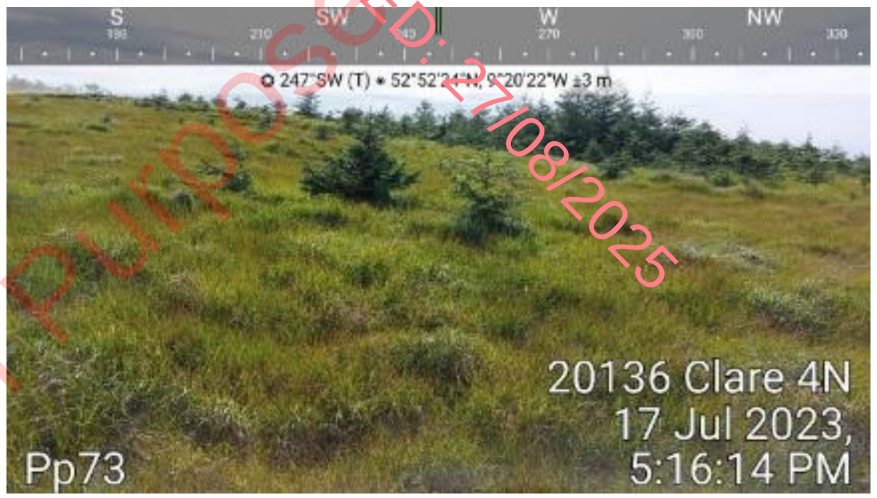
Peat: Peat depth is 0.88m, with a slope angle of 1.8 degrees.

Instability evidence: No.



igure 29 H:\2024\24CE108 Clare 4N\Trial Pit Pictures\TP-116 i).JPG

Table J- 8: Site reconnaissance of the PRA 1 site.

<table>
<tr><td>Imagery
</td><td>Peat geo-investigation
</td><td></td></tr>
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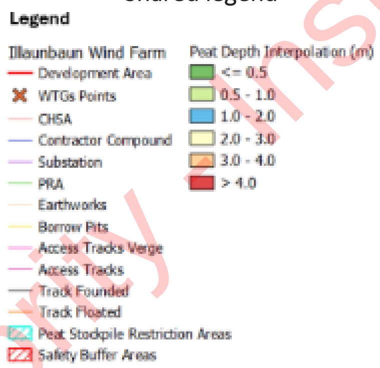
</td></tr>
<tr><td>Description

Date of the satellite images: January 2025. [Maxar/Esri].

Date of the ground-based pictures: July 2023[GDG].

Geomorphology: Topography at site is mostly flat cut over peat bog. Peat cuts are set back from the site and there are drains perpendicular to contour lines.

Peat: Peat depth is 0.74m, with a slope angle of 0.4 degrees.

Instability evidence: No.</td><td colspan="2"></td></tr>
</table>

Table J- 9: Site reconnaissance of the PRA 2 site.

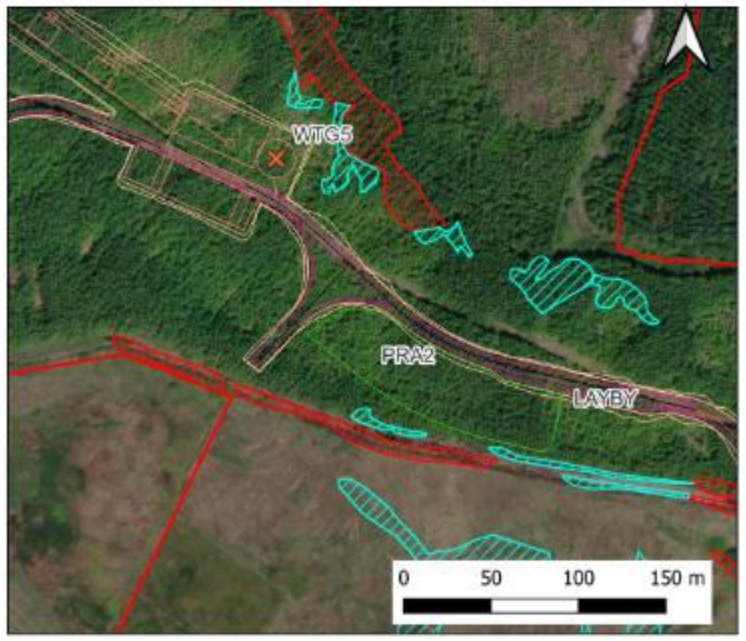
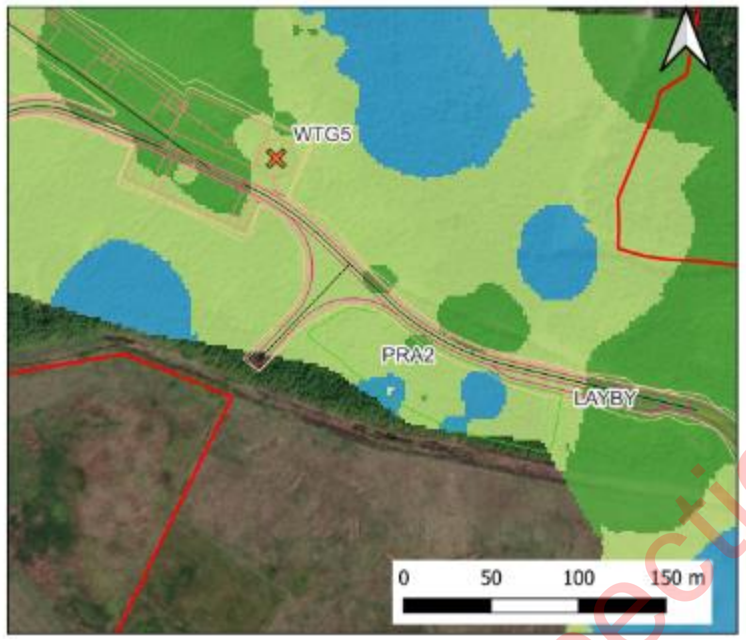
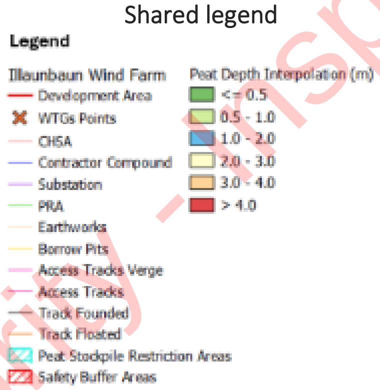
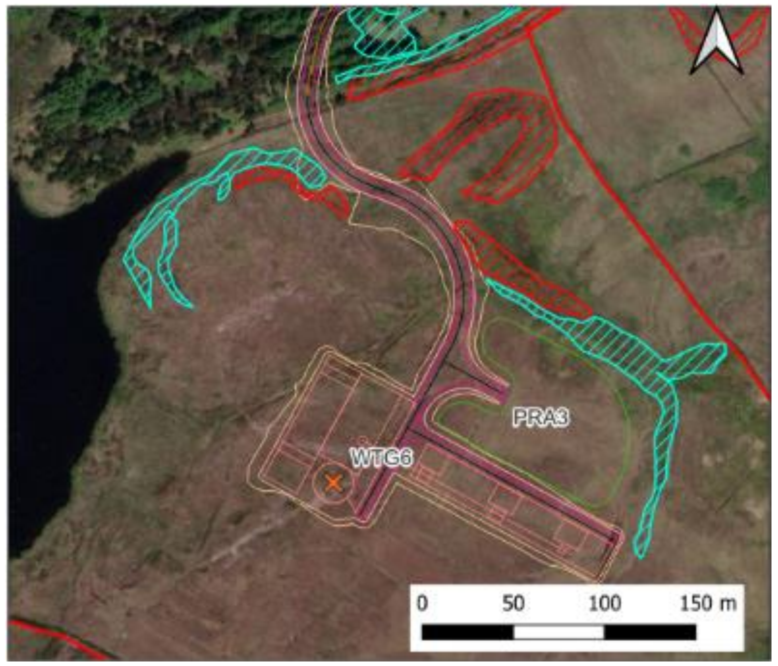
Imagery	Peat geo-investigation	
		
Shared legend 		
Description Date of the satellite images: January 2025. [Maxar/Esri]. Date of the ground-based pictures: July 2023[GDG]. And photographs clicked during IDL GI campaign Geomorphology: The Topography at the site is mostly flat, cut over peat bog. Peat cuts are set back from the site, and there are drains perpendicular to contour lines. Peat: Peat depth is 0.48m, with a slope angle of 3.8 degrees. Instability evidence: No.	RCG101 -(E 509852.864) (N 681654.47) (L 174.633m 0.0) Reduced level may be incorrect due to heavy tree cover. GI-0.30m-Firm black H4,B2,F2,R2,W0 ,TV1,Th1,A0,P1 PEAT 0.30-0.40- Grey sandy GRAVEL 0.40- Possible rock 	

Table J- 10 : Site reconnaissance of the PRA 3 site

<table>
<tr>
<td>Imagery

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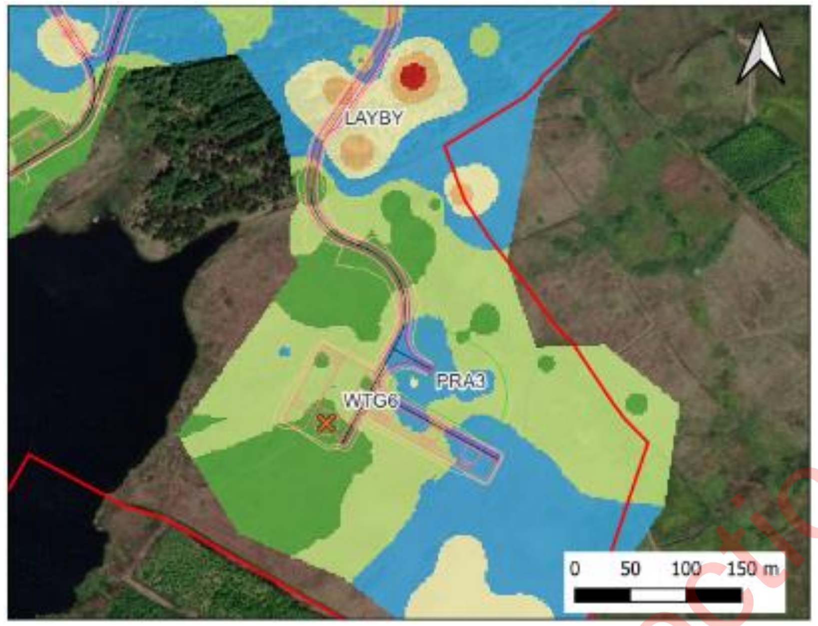
<td>Peat geo-investigation

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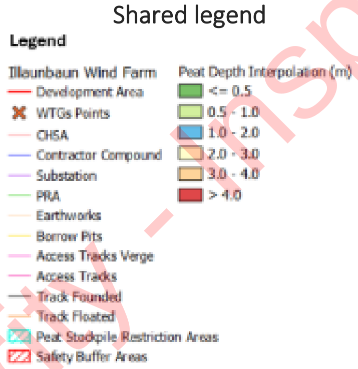
<td colspan="3">Shared legend

</td>
</tr>
<tr>
<td>Description

Date of the satellite images: January 2025. [Maxar/Esri].

Date of the ground-based pictures July 2023[GDG]. And photographs clicked during IDL GI campaign

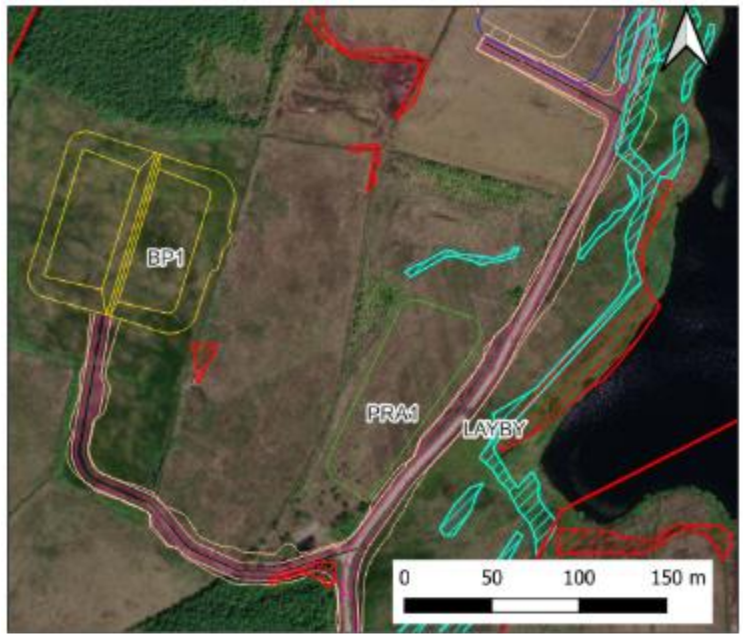
Geomorphology: The Topography at the site is mostly flat, cut over peat bog. Peat cuts are set back from the site and there are drains perpendicular to contour lines.

Peat: Peat depth is 1.37m, with a slope angle of 0.4 degrees.

Instability evidence: No.</td>
<td>
Figure 33 H:\2024\24CE108 Clare 4N\Trial Pit Pictures\TP-117 (2).JPG</td>
<td>
Figure 32 H:\2024\24CE108 Clare 4N\Trial Pit Pictures\TP-117 (1).JPG</td>
</tr>
</table>

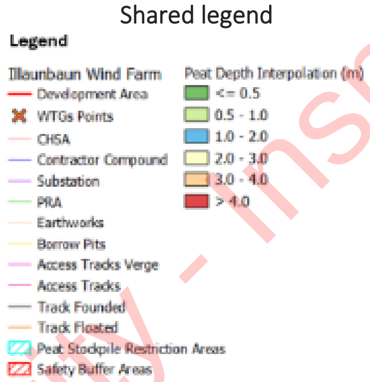
Table J- 11: Site reconnaissance of BP 1

Imagery



Peat geo-investigation

Shared legend



Description

Date of the satellite images: January 2025. [Maxar/Esri].

Date of the ground-based pictures July 2023[GDG]. And photographs clicked during IDL GI campaign

Geomorphology: The Topography at the site is mostly flat. with bedrock outcrops

Peat: Peat depth is 0.62m, with a slope angle of 4.9 degrees.

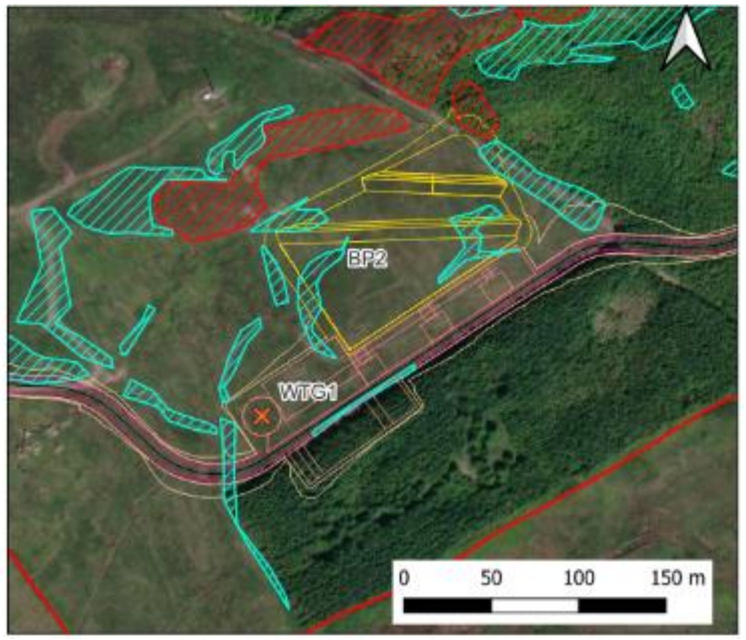
Instability evidence: No.

Figure 16 H:\2024\24CE108 Clare 4N\Trial Pit Pictures\TP-108 (2).JPG

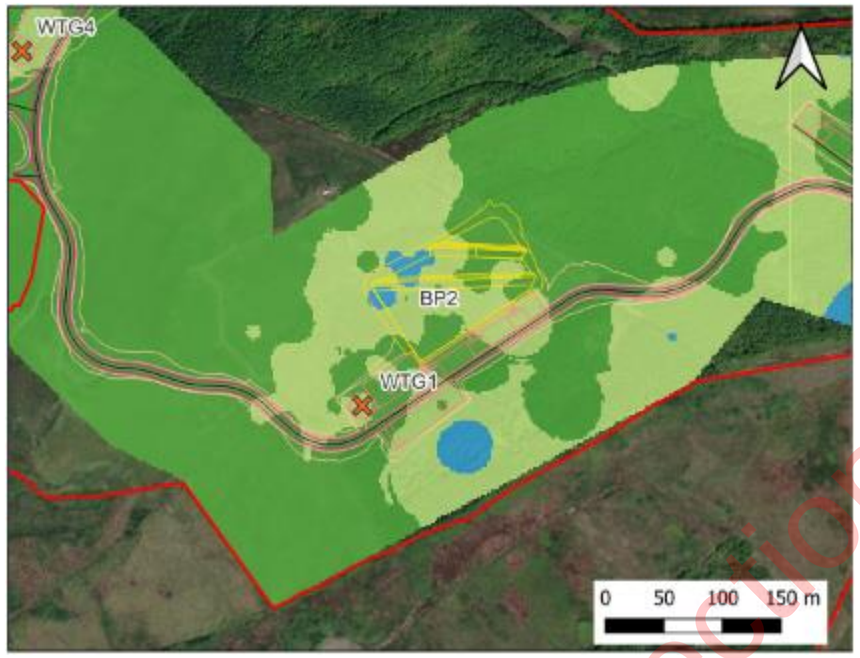
Figure 12 H:\2024\24CE108 Clare 4N\Trial Pit Pictures\TP-106 (2).JPG

Table J- 12: Site reconnaissance of BP 2

Imagery



Peat geo-investigation



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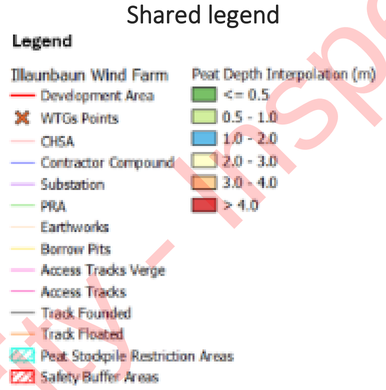


Description

Date of the satellite images: January 2025. [Maxar/Esri].

Date of the ground-based pictures: July 2023[GDG]. And photographs clicked during IDL GI campaign

Geomorphology: The Topography at site is mostly flat with bedrock outcrops
Peat: Peat depth is 0.32m, with a slope angle of 3.8 degrees.

Instability evidence: No.

Figure 14 H:\2024\24CE108 Clare 4N\Trial Pit Pictures\TP-107 (2).JPG

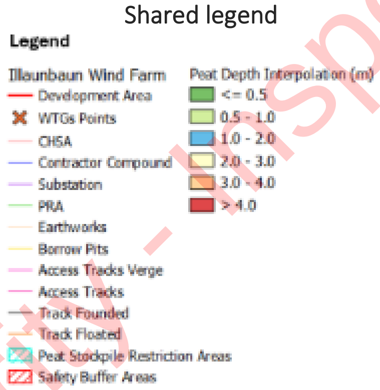
Figure 13 H:\2024\24CE108 Clare 4N\Trial Pit Pictures\TP-107

Table J- 13: Site reconnaissance of the Substation

Imagery

Peat geo-investigation

Shared legend



Description

Date of the satellite images: January 2025. [Maxar/Esri].

Date of the ground-based pictures photographs clicked during IDL GI campaign

Geomorphology: Topography at site is mostly flat with bedrock outcrops
Peat: Peat depth is 0.72m, with a slope angle of 3.8 degrees.

Instability evidence: No.

Figure 10 H:\2024\24CE108 Clare 4N\Trial Pit Pictures\TP-105 (2).JPG

Figure 9 H:\2024\24CE108 Clare 4N\Trial Pit Pictures\TP-105 (1).JPG

Appendix K Factor of Safety

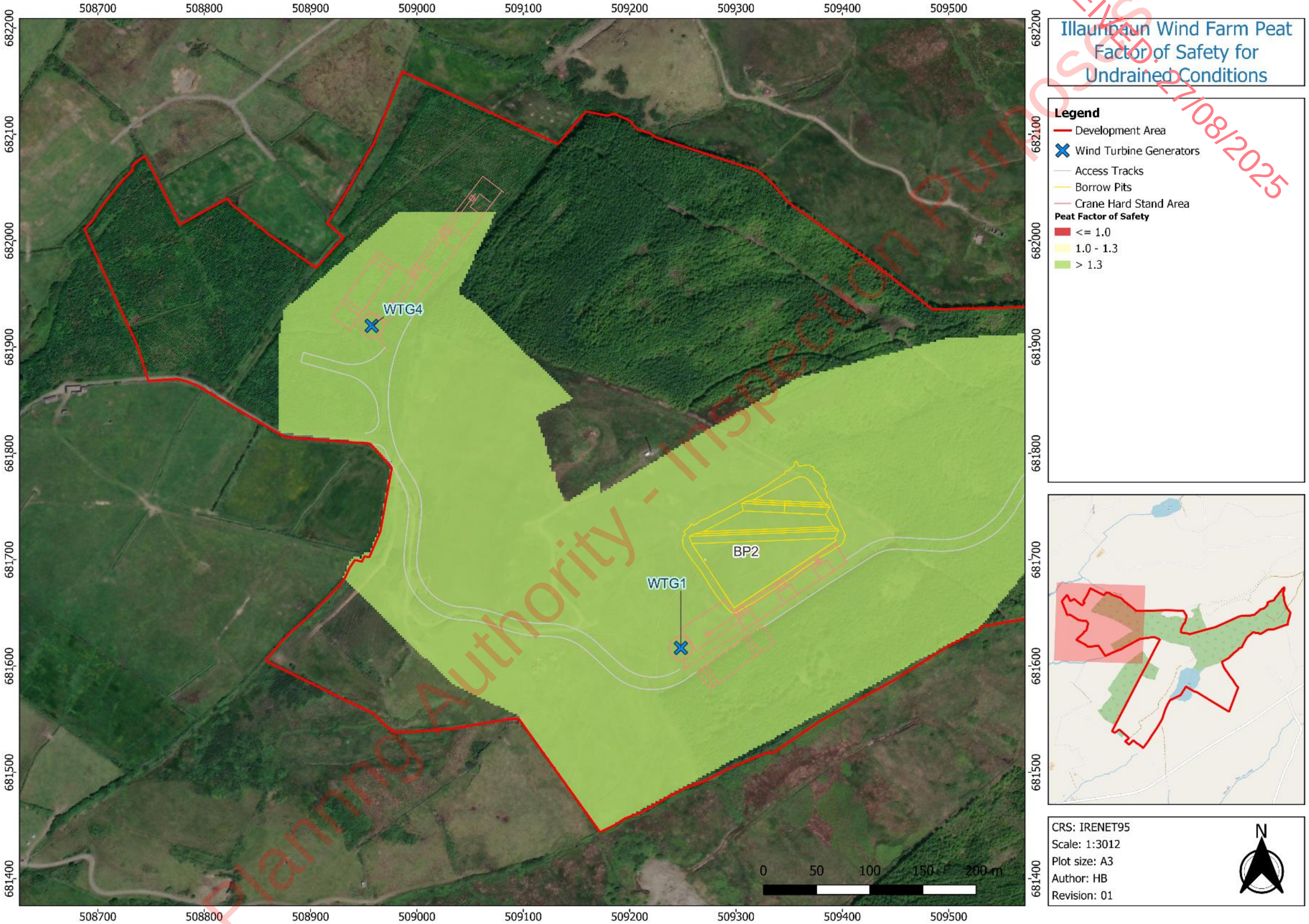


Figure K- 1: Peat Factor of Safety for Undrained Conditions (1 of 5)

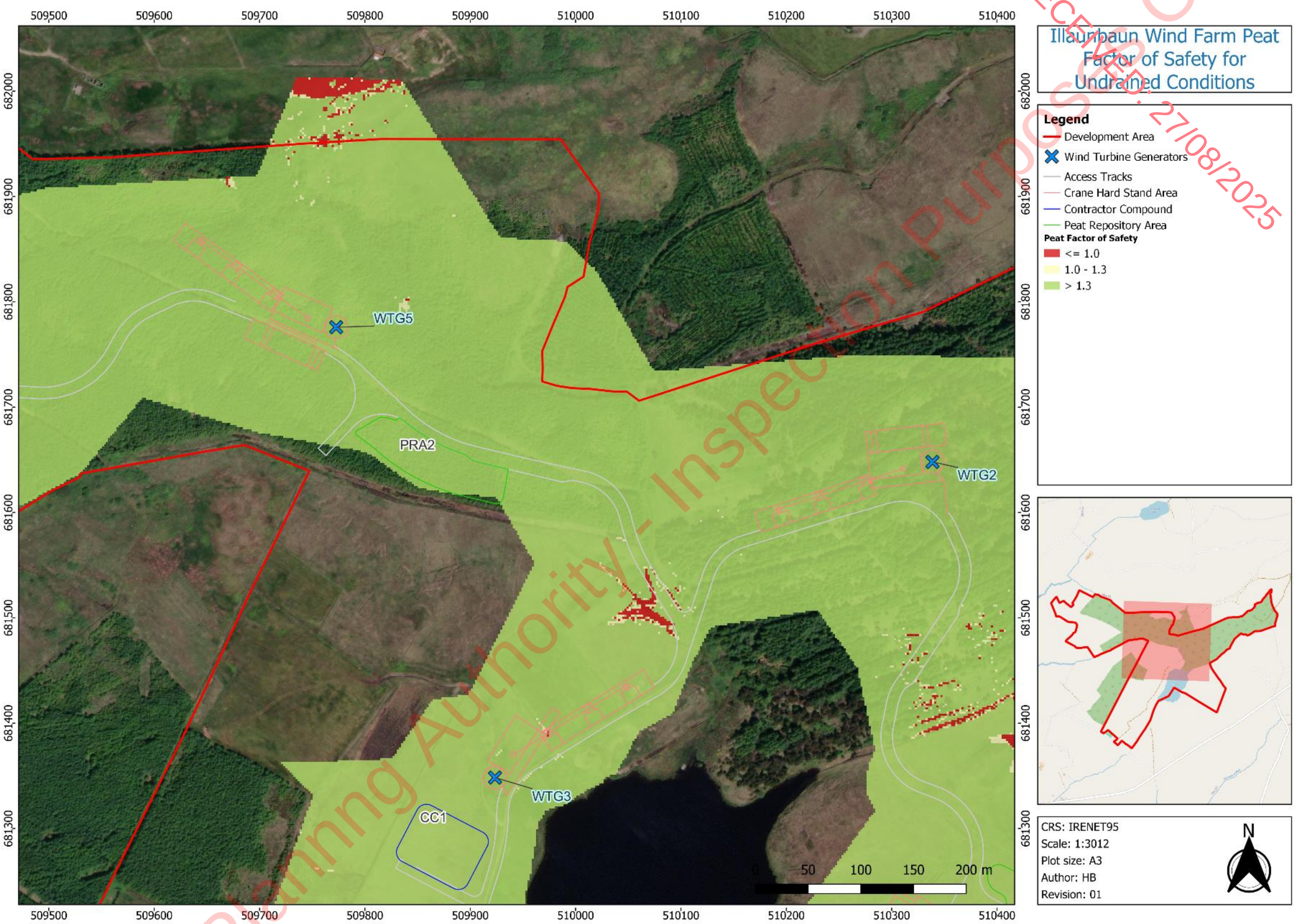


Figure K- 2 Peat Factor of Safety for Undrained Conditions (2 of 5)

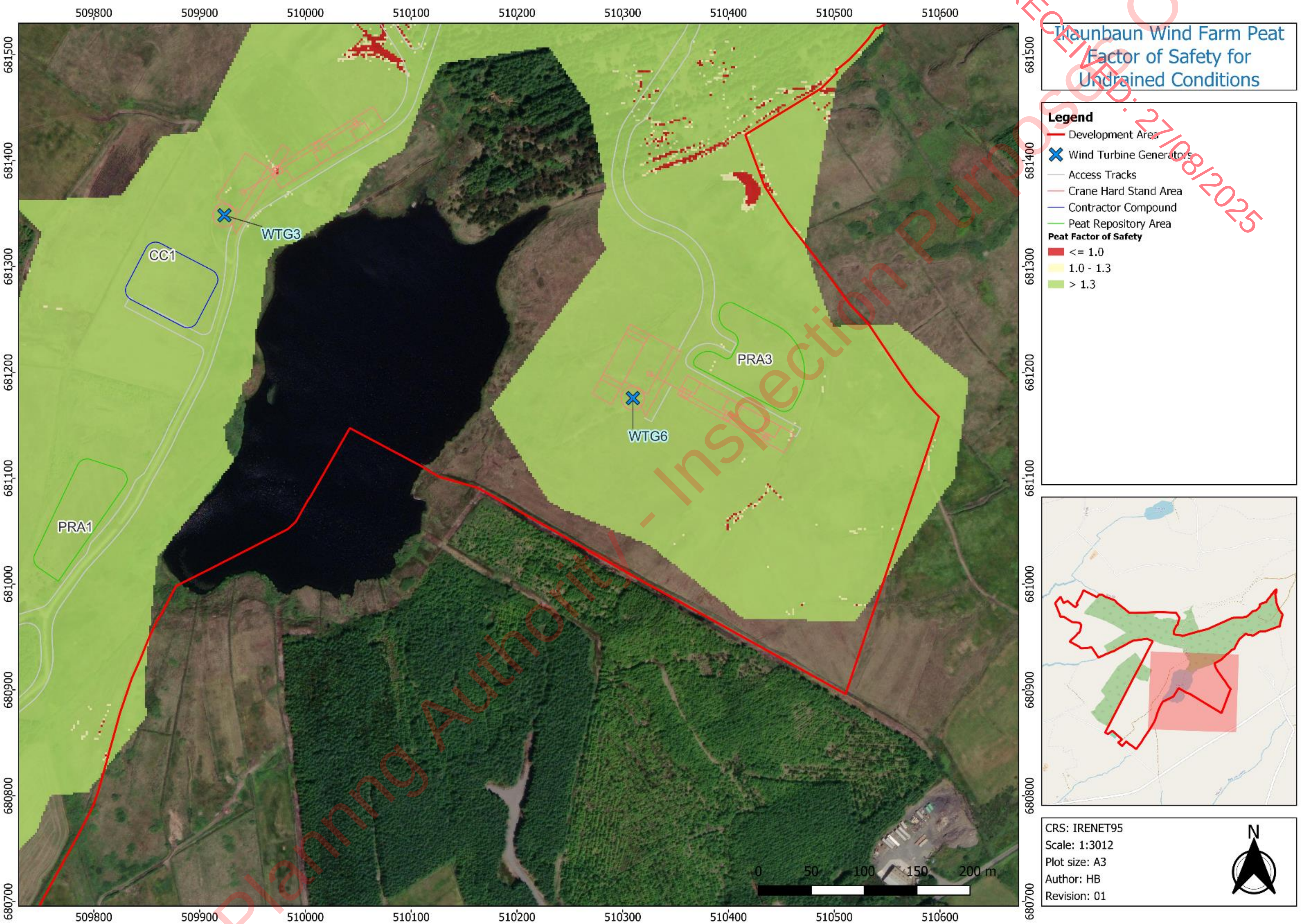


Figure K- 3: Peat Factor of Safety for Undrained Conditions (3 of 5)

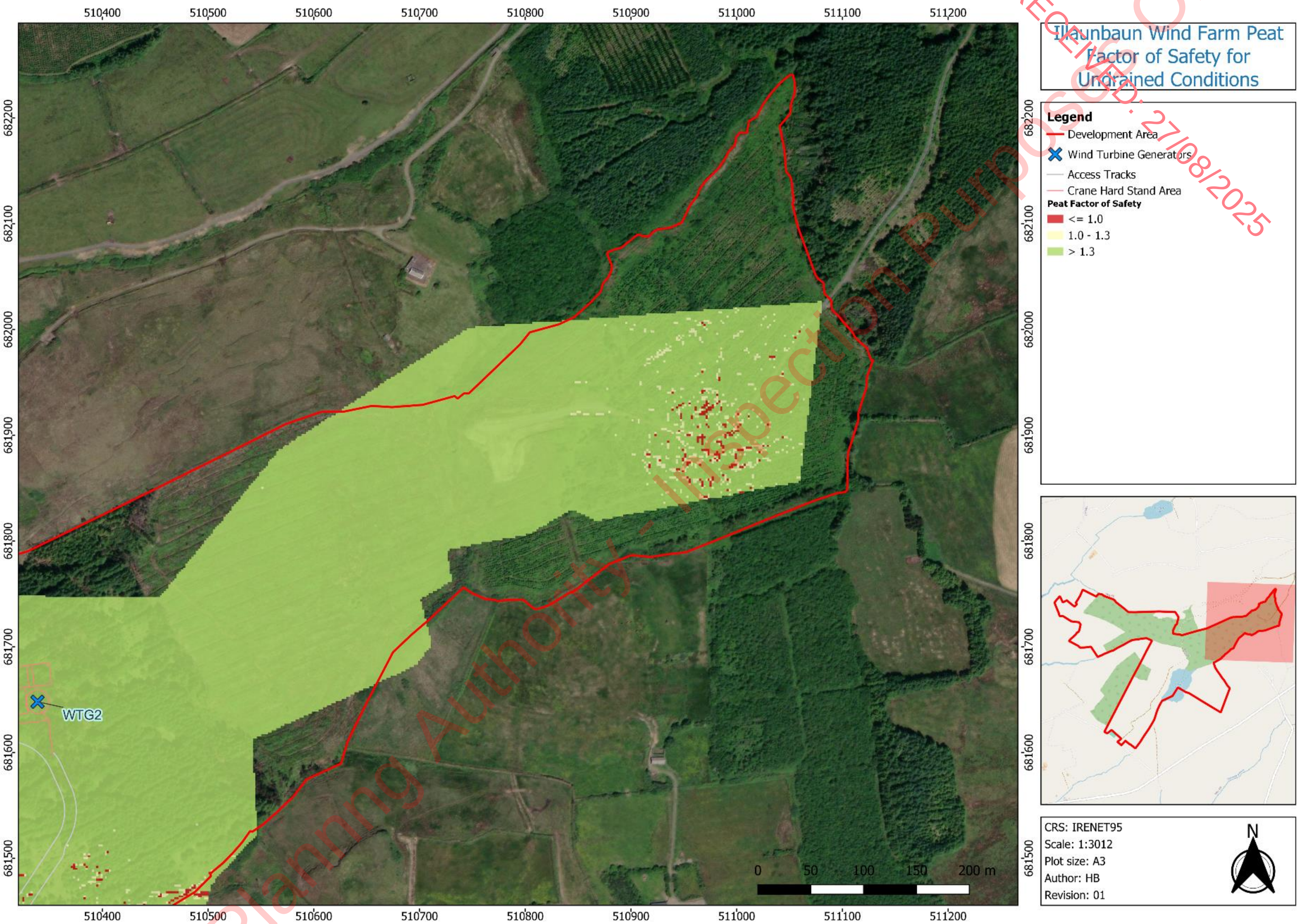


Figure K- 4: Peat Factor of Safety for Undrained Conditions (4 of 5)

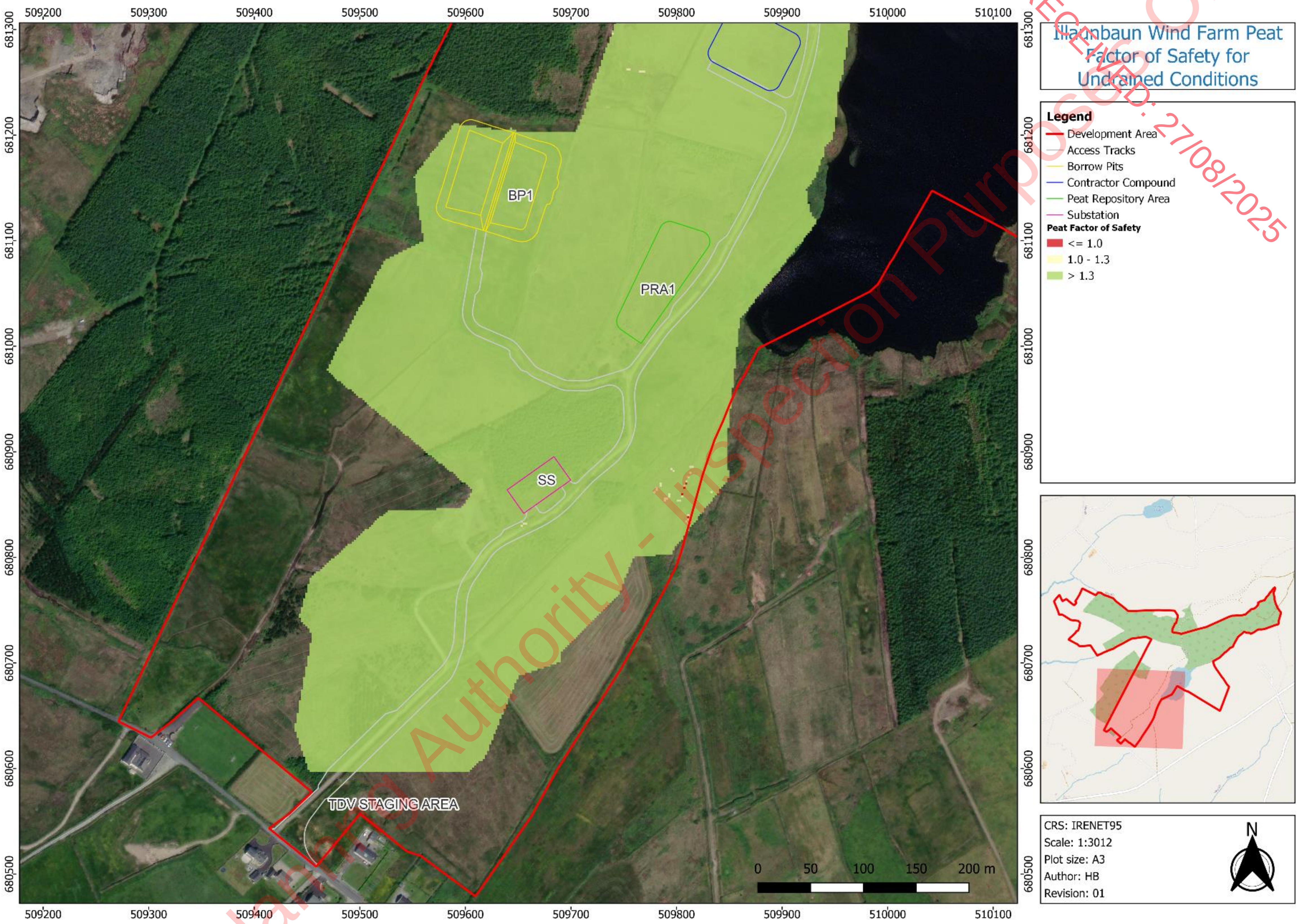


Figure K- 5: Peat Factor of Safety for Undrained Conditions (5 of 5)

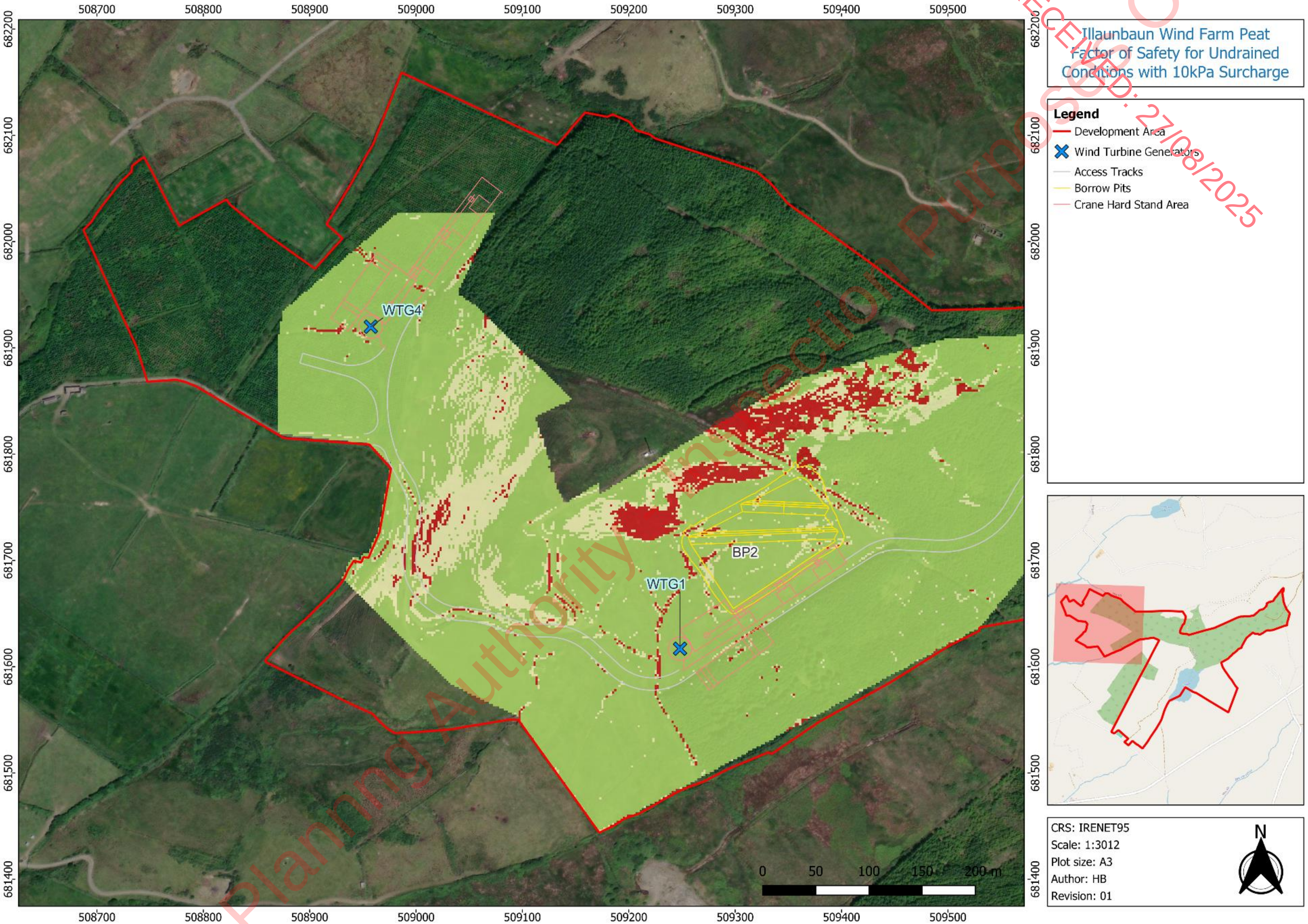


Figure K- 6: Peat Factor of Safety for Undrained Conditions with 10kPa Surcharge (1 of 5)

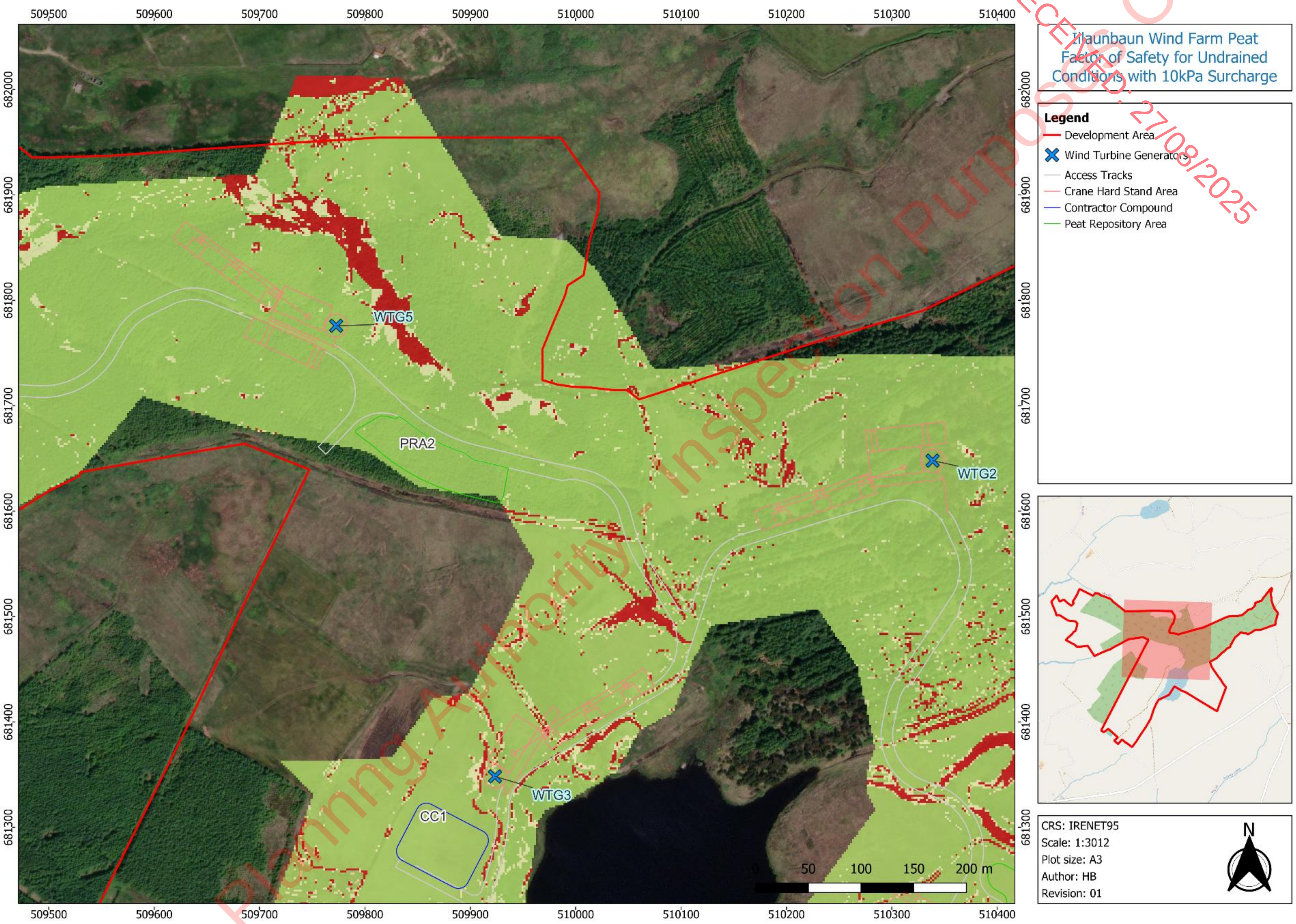


Figure K- 7: Peat Factor of Safety for Undrained Conditions with 10kPa Surcharge (2 of 5)

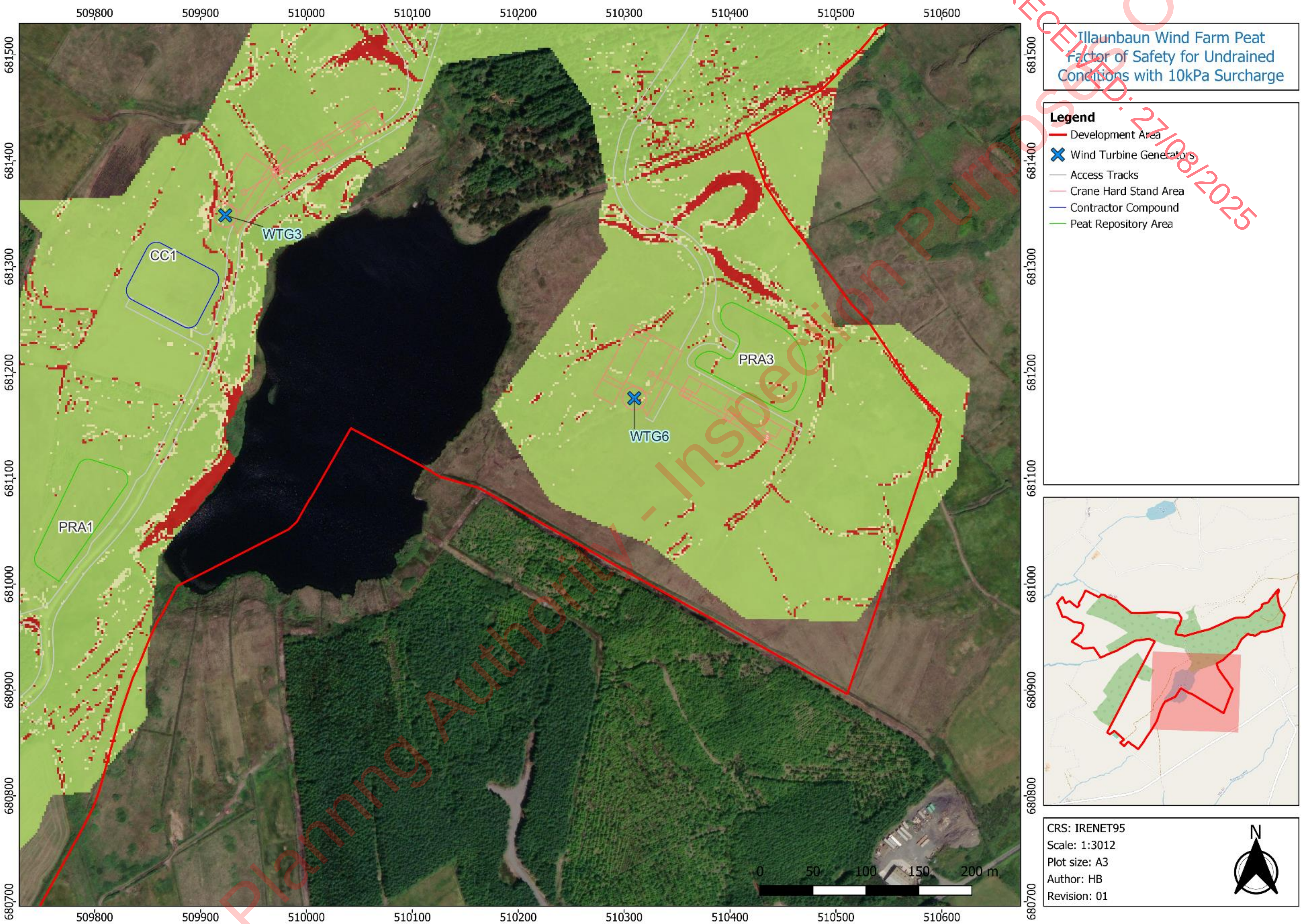


Figure K- 8: Peat Factor of Safety for Undrained Conditions with 10kPa Surcharge (3 of 5)

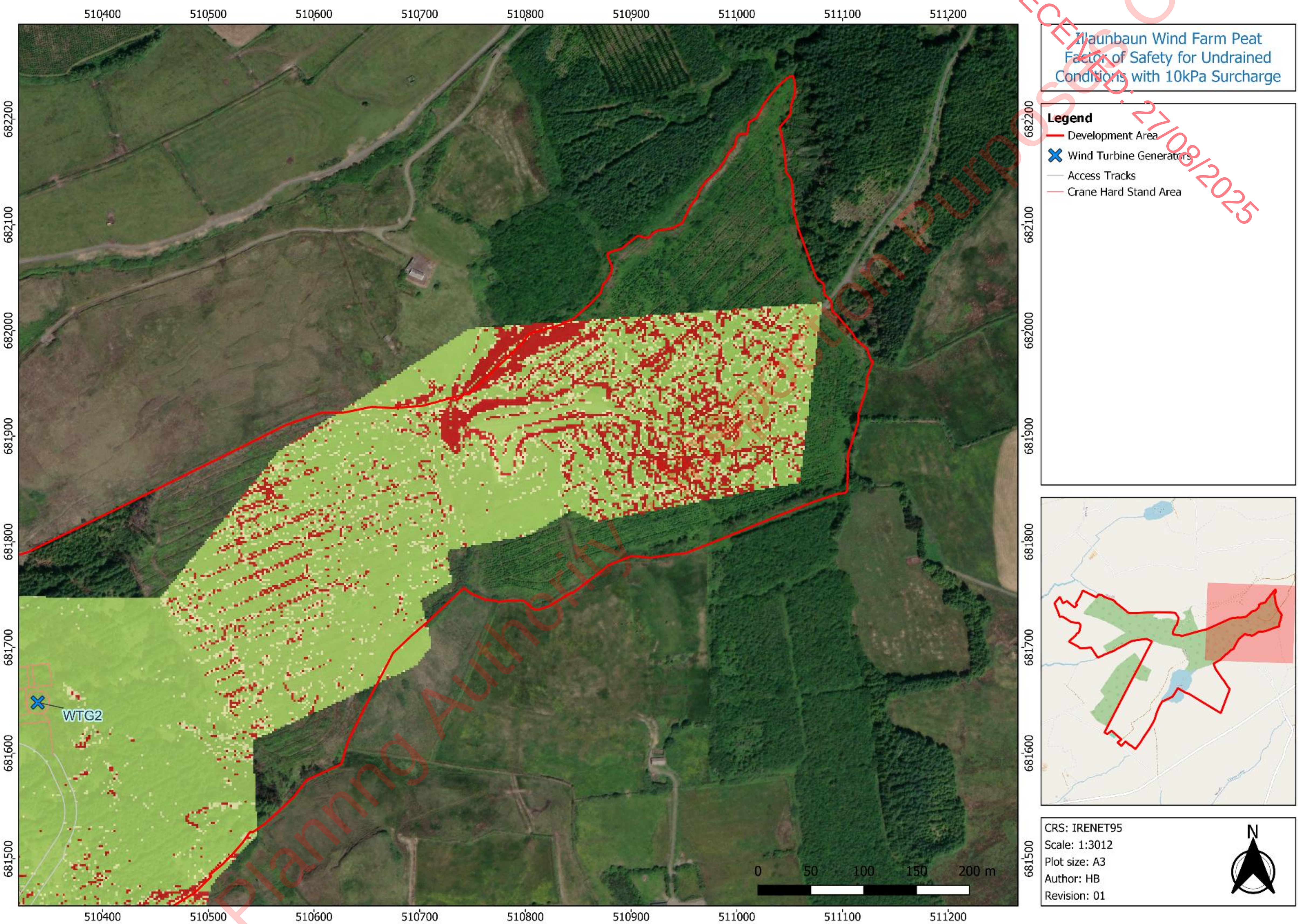


Figure K- 9: Peat Factor of Safety for Undrained Conditions with 10kPa Surcharge (4 of 5)

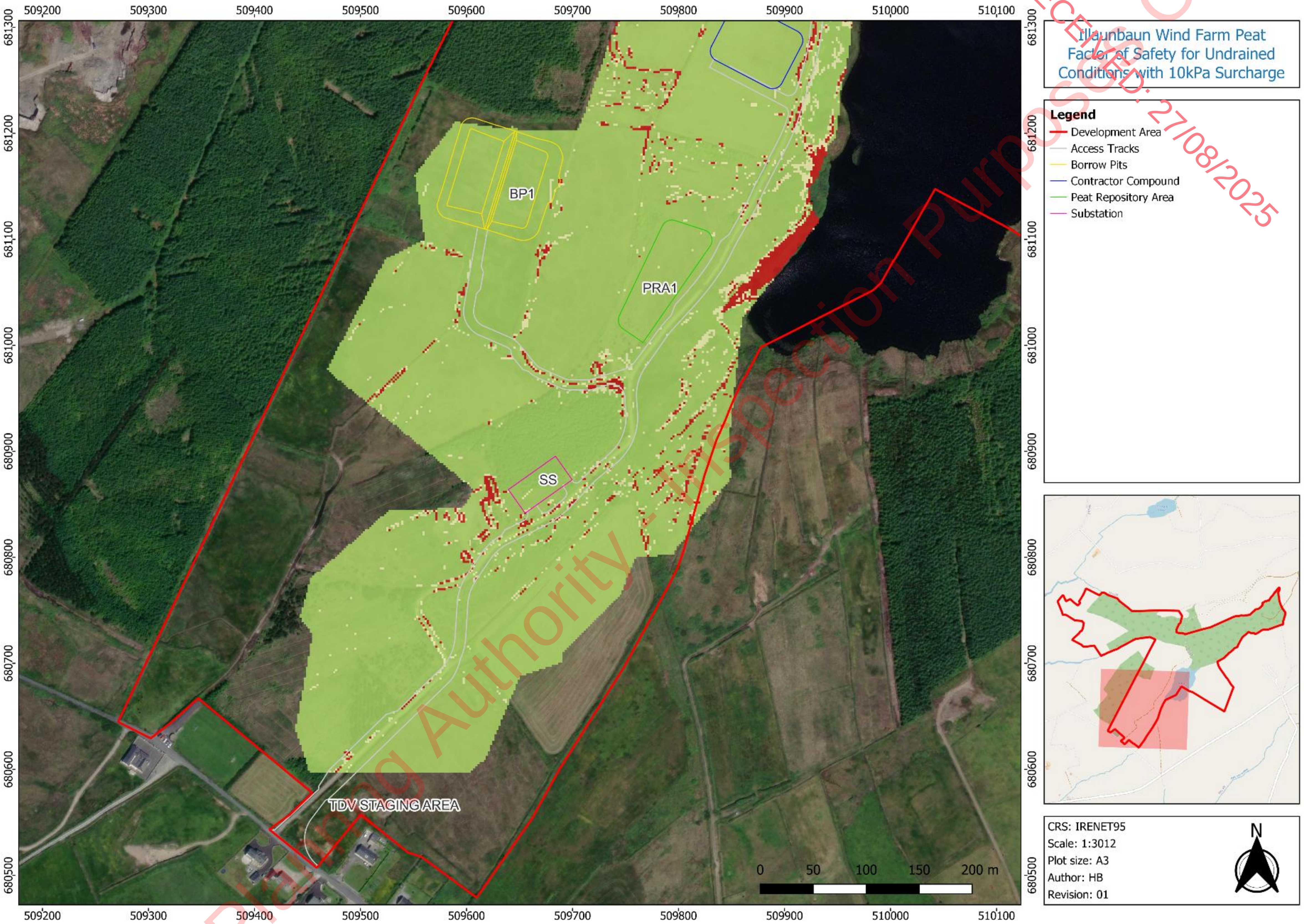


Figure K- 10: Peat Factor of Safety for Undrained Conditions with 10kPa Surcharge (5 of 5)

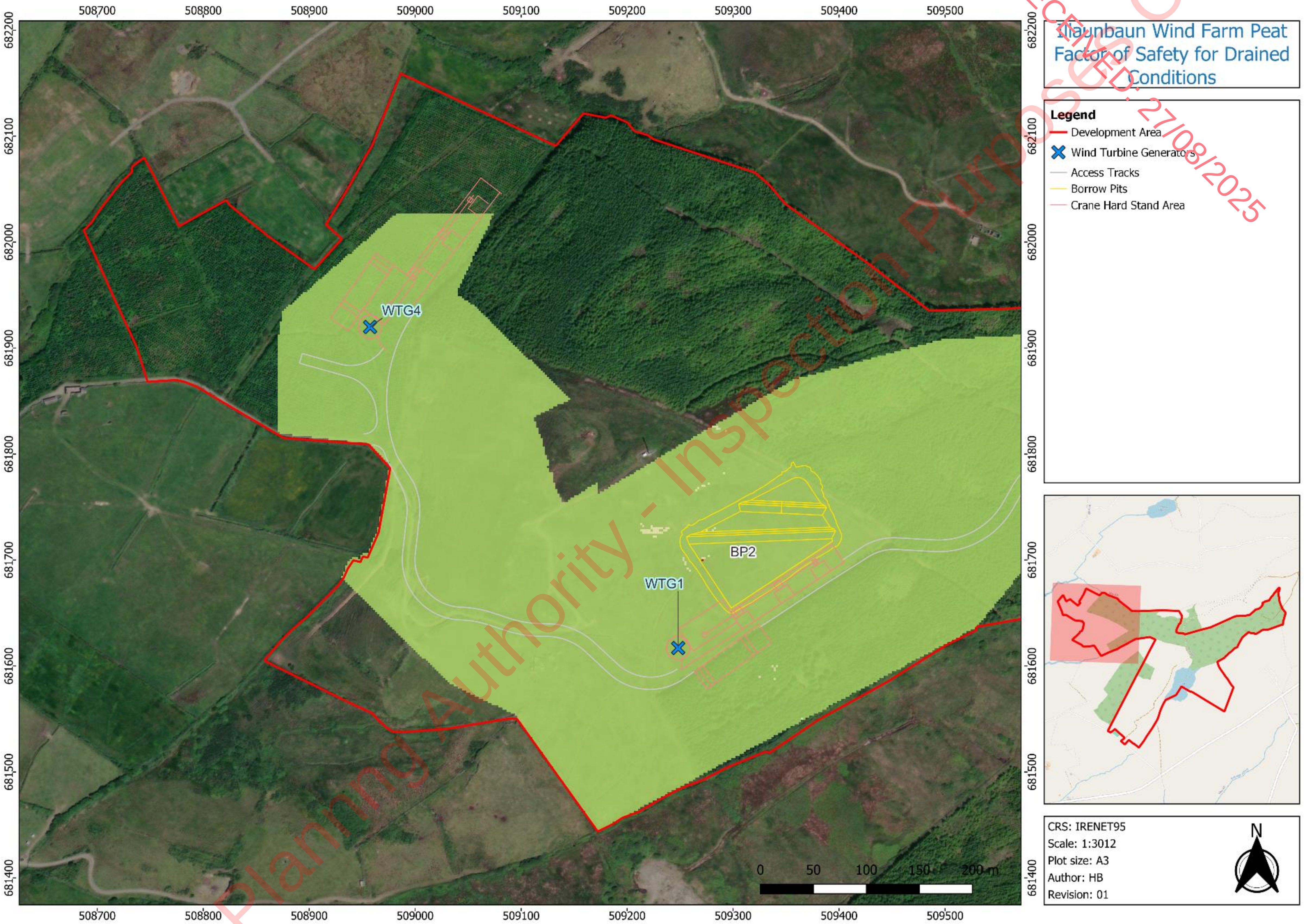


Figure K- 11: Factor of Safety for Drained Conditions (1 of 5)

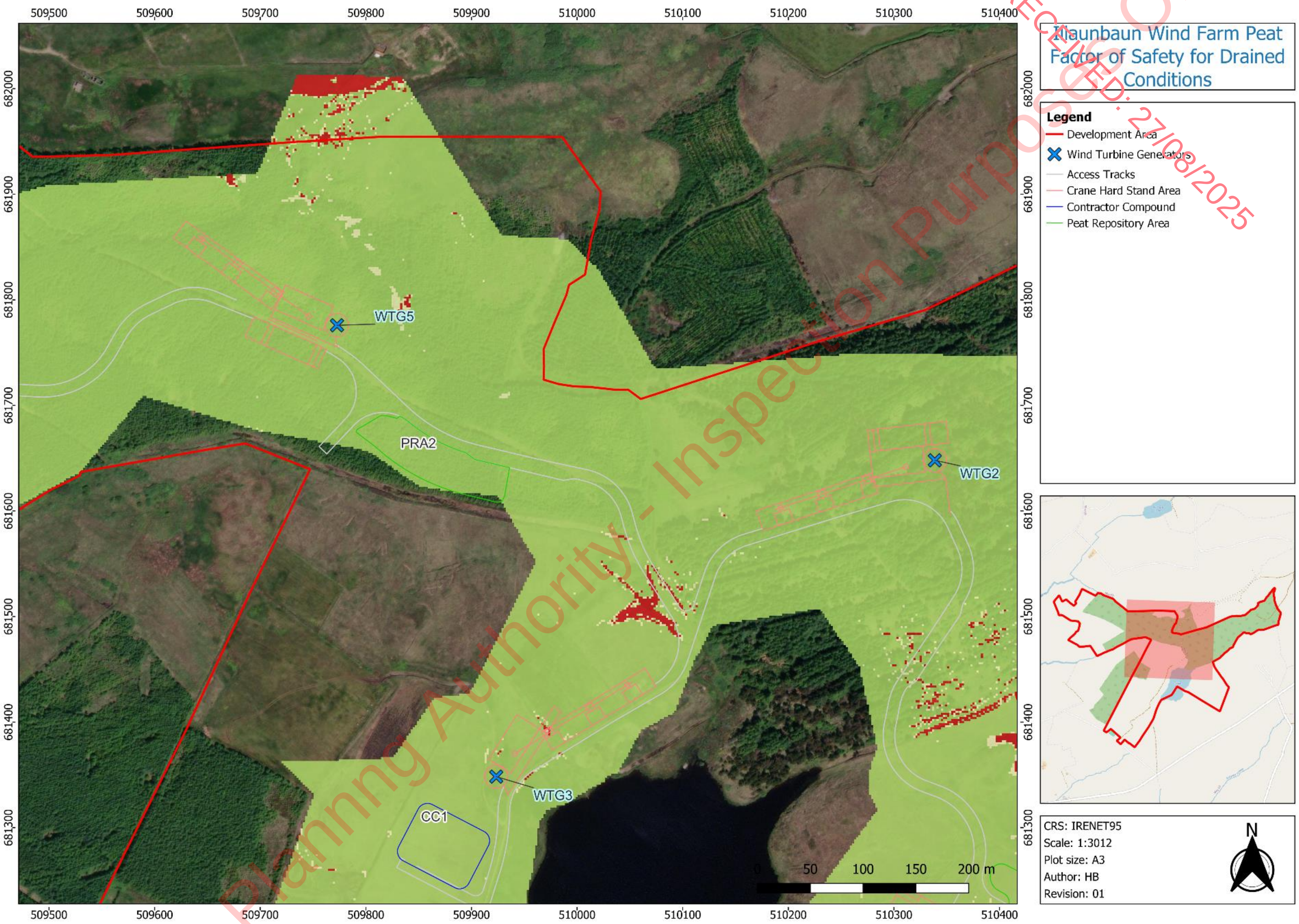


Figure K- 12: Factor of Safety for Drained Conditions (2 of 5)

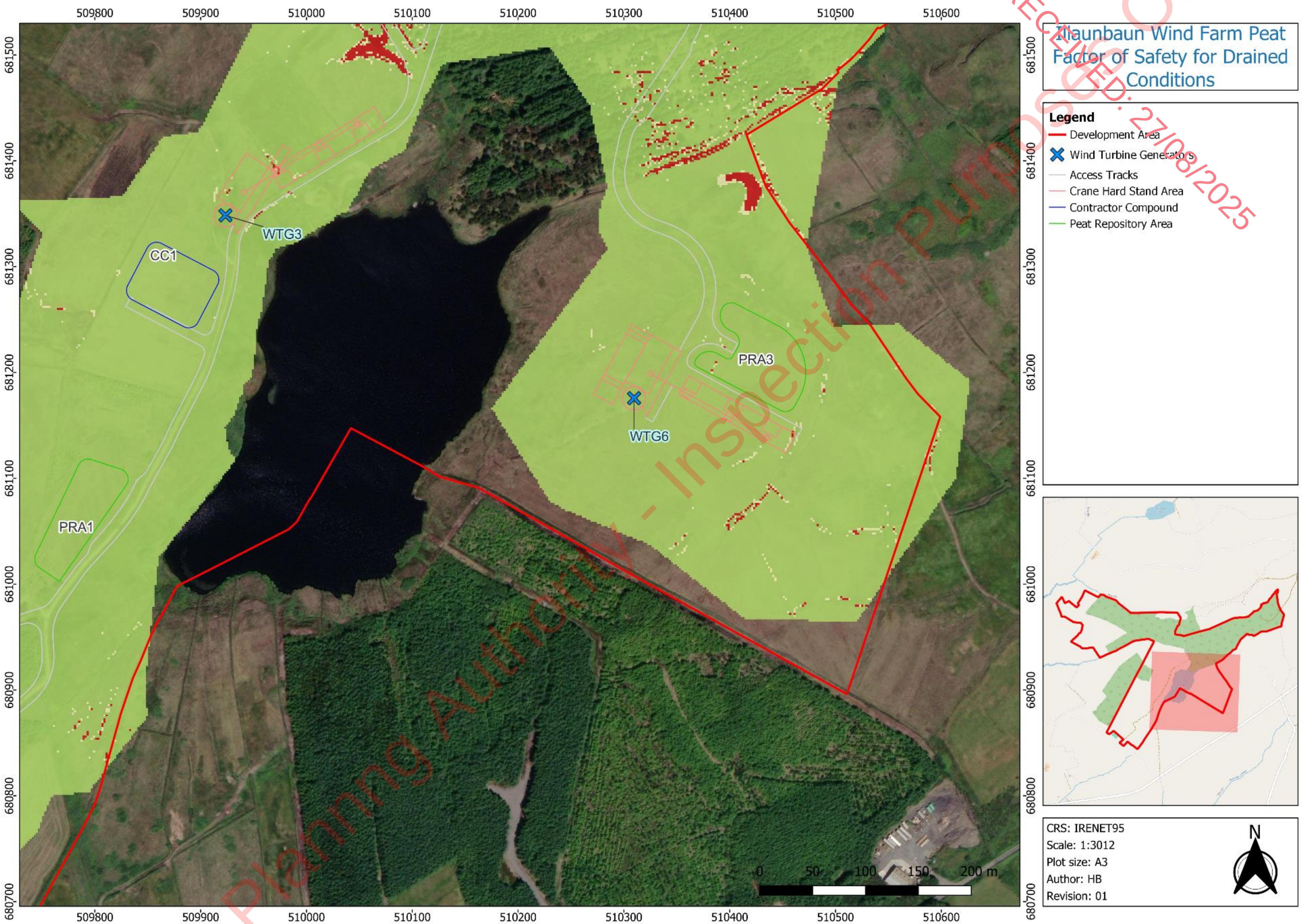


Figure K- 13: Factor of Safety for Drained Conditions (3 of 5)

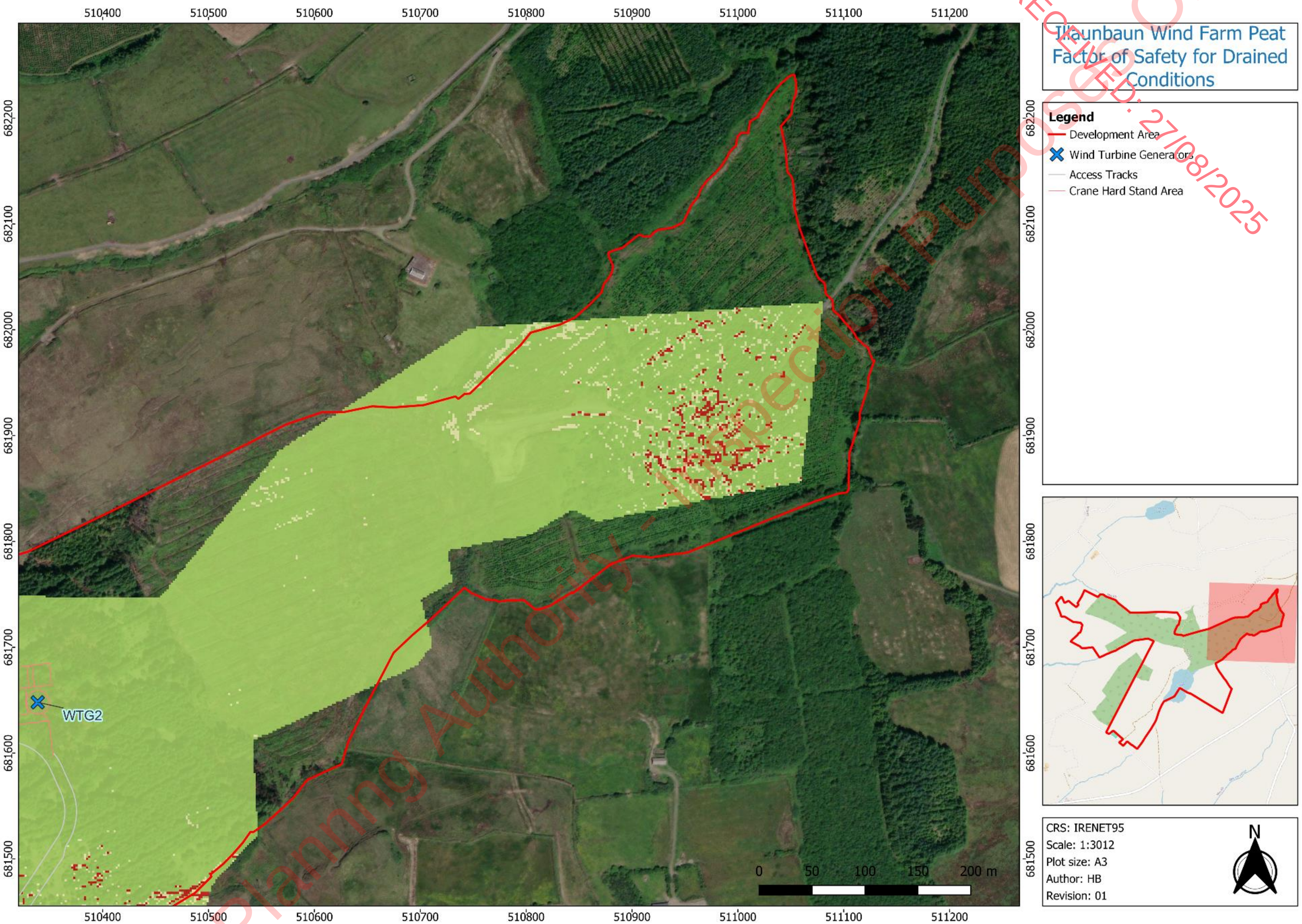


Figure K- 14: Factor of Safety for Drained Conditions (4 of 5)

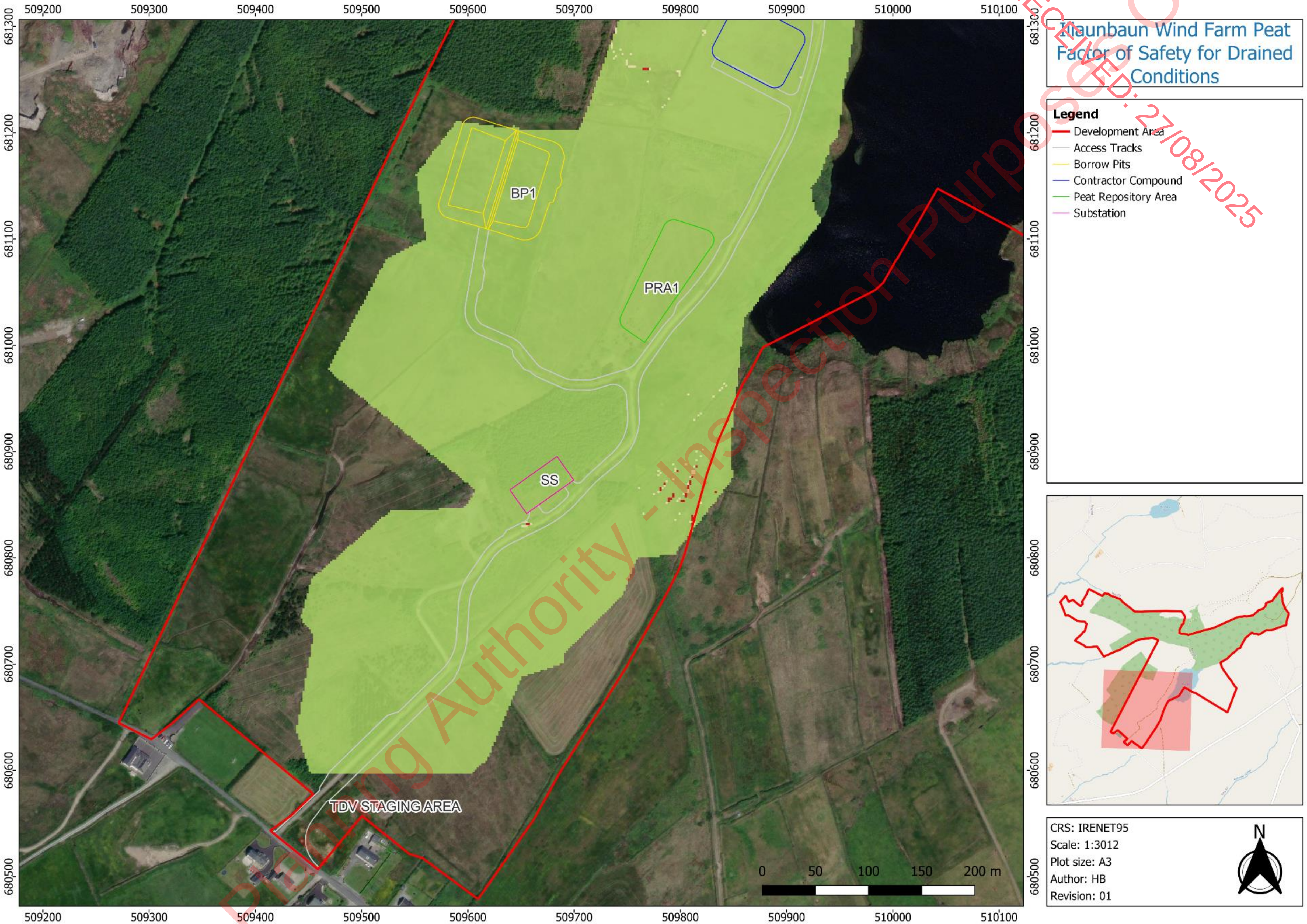


Figure K- 15: Factor of Safety for Drained Conditions (5 of 5)

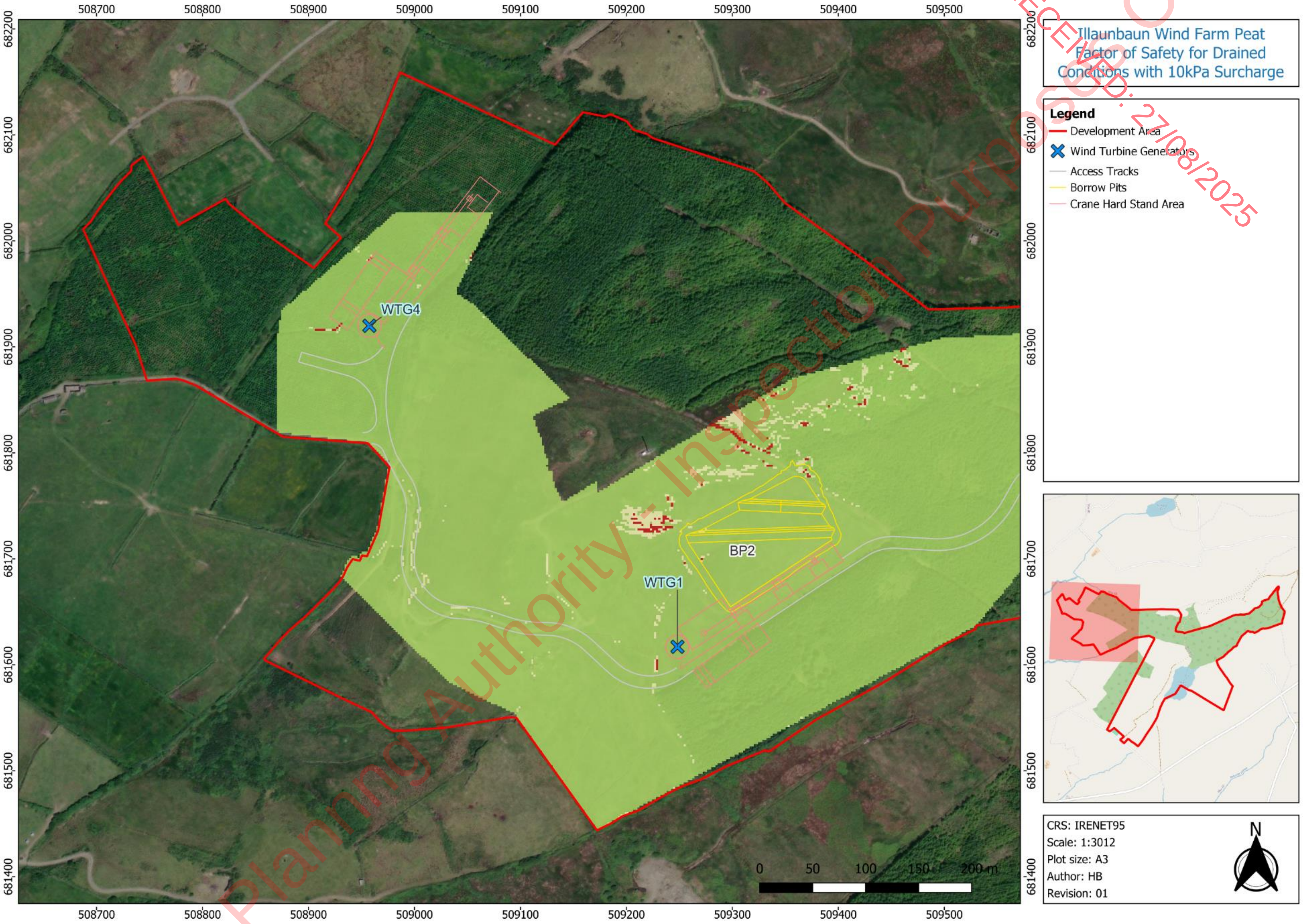


Figure K- 16: Peat Factor of Safety for Drained Conditions with 10kPa Surcharge (1 of 5)

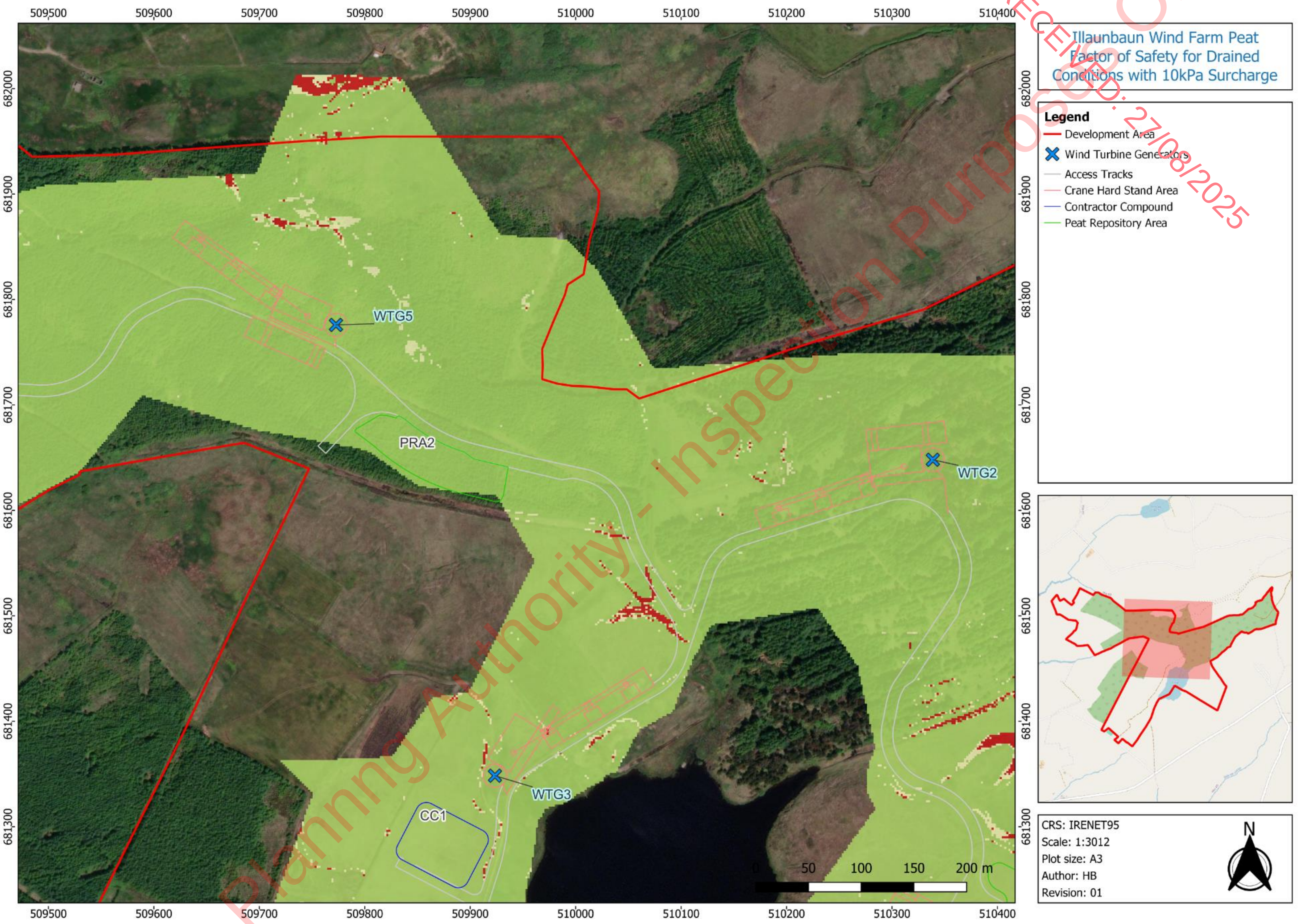


Figure K- 17: Peat Factor of Safety for Drained Conditions with 10kPa Surcharge (2 of 5)

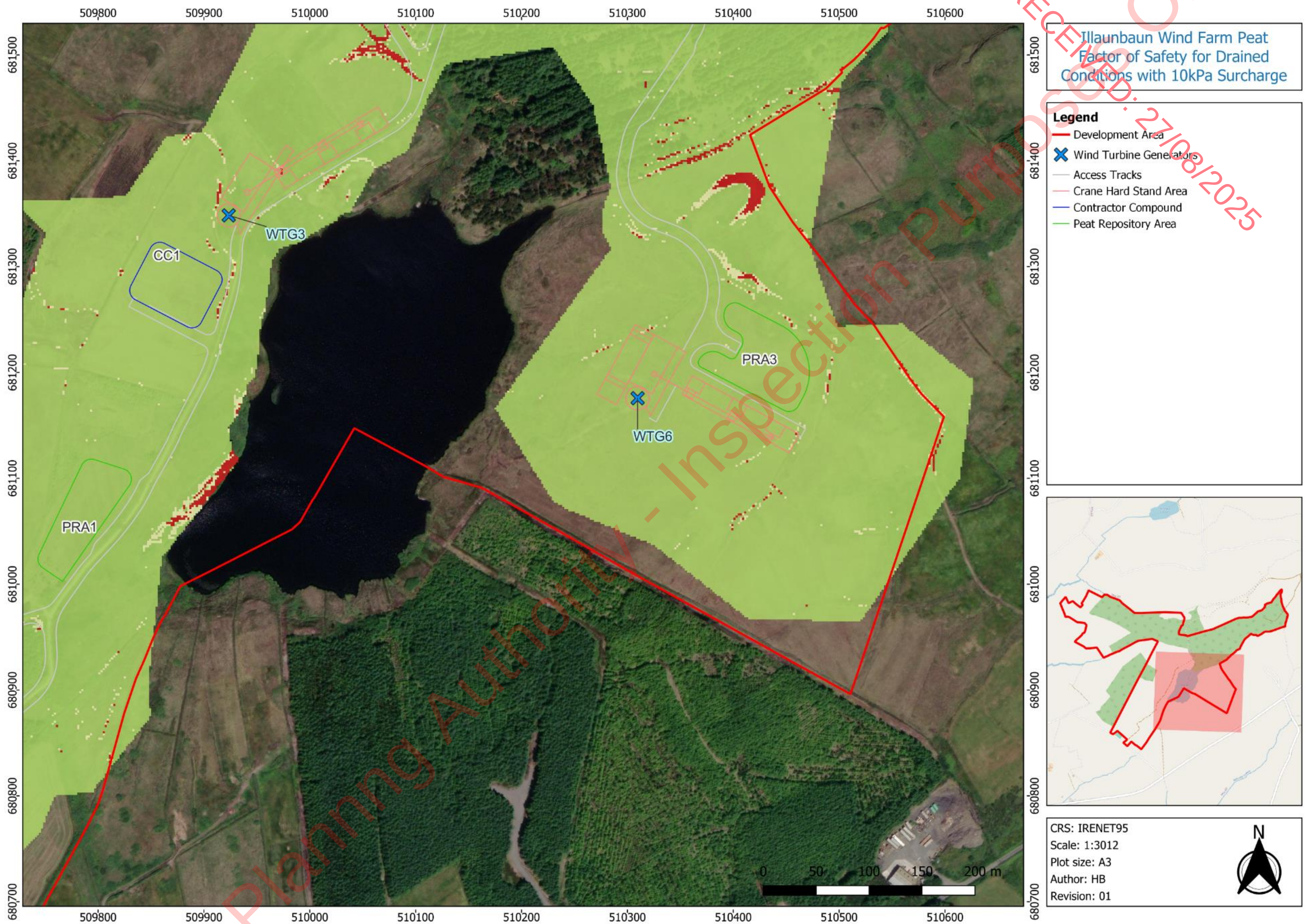


Figure K- 18: Peat Factor of Safety for Drained Conditions with 10kPa Surcharge (3 of 5)

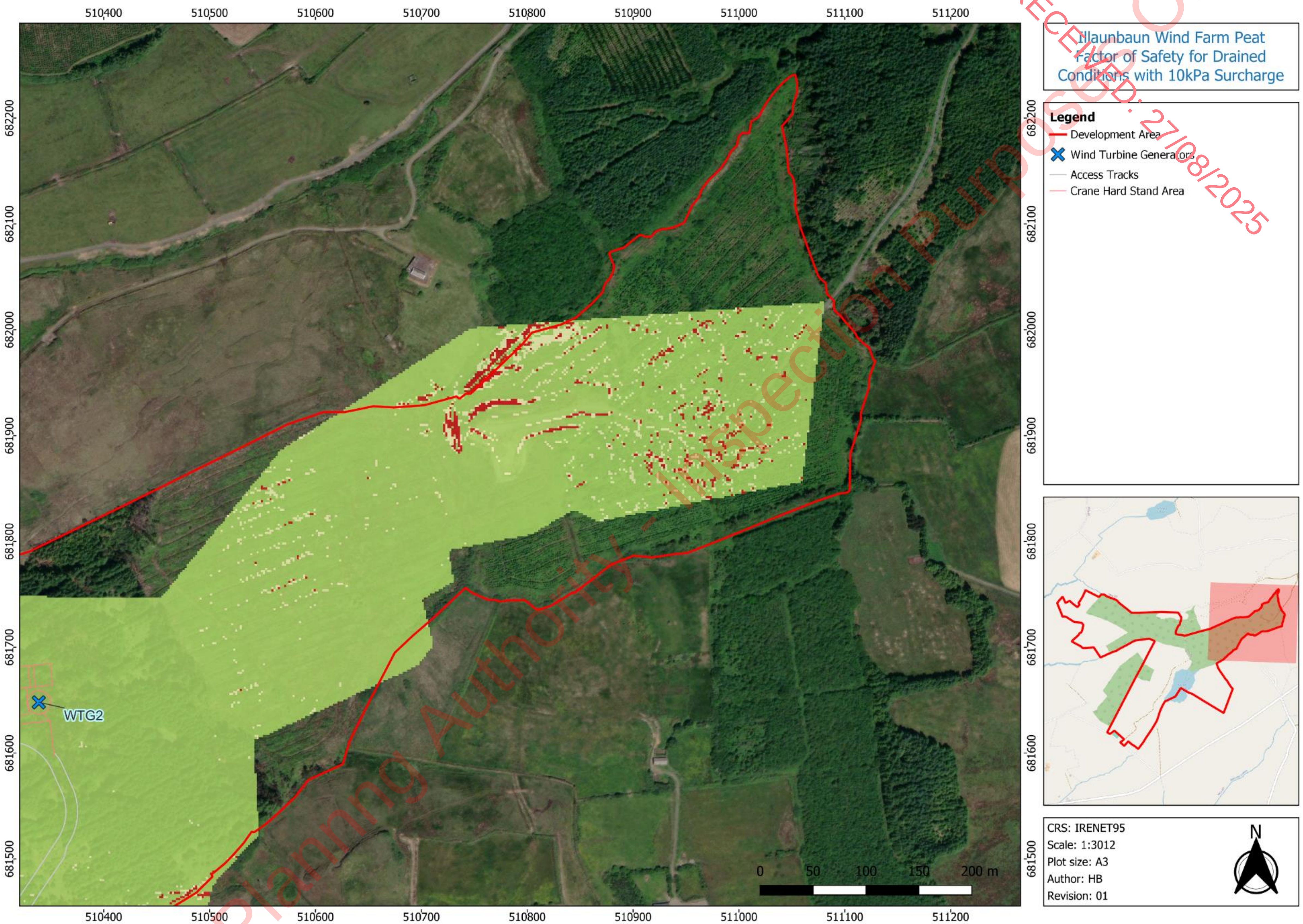


Figure K- 19: Peat Factor of Safety for Drained Conditions with 10kPa Surcharge (4 of 5)

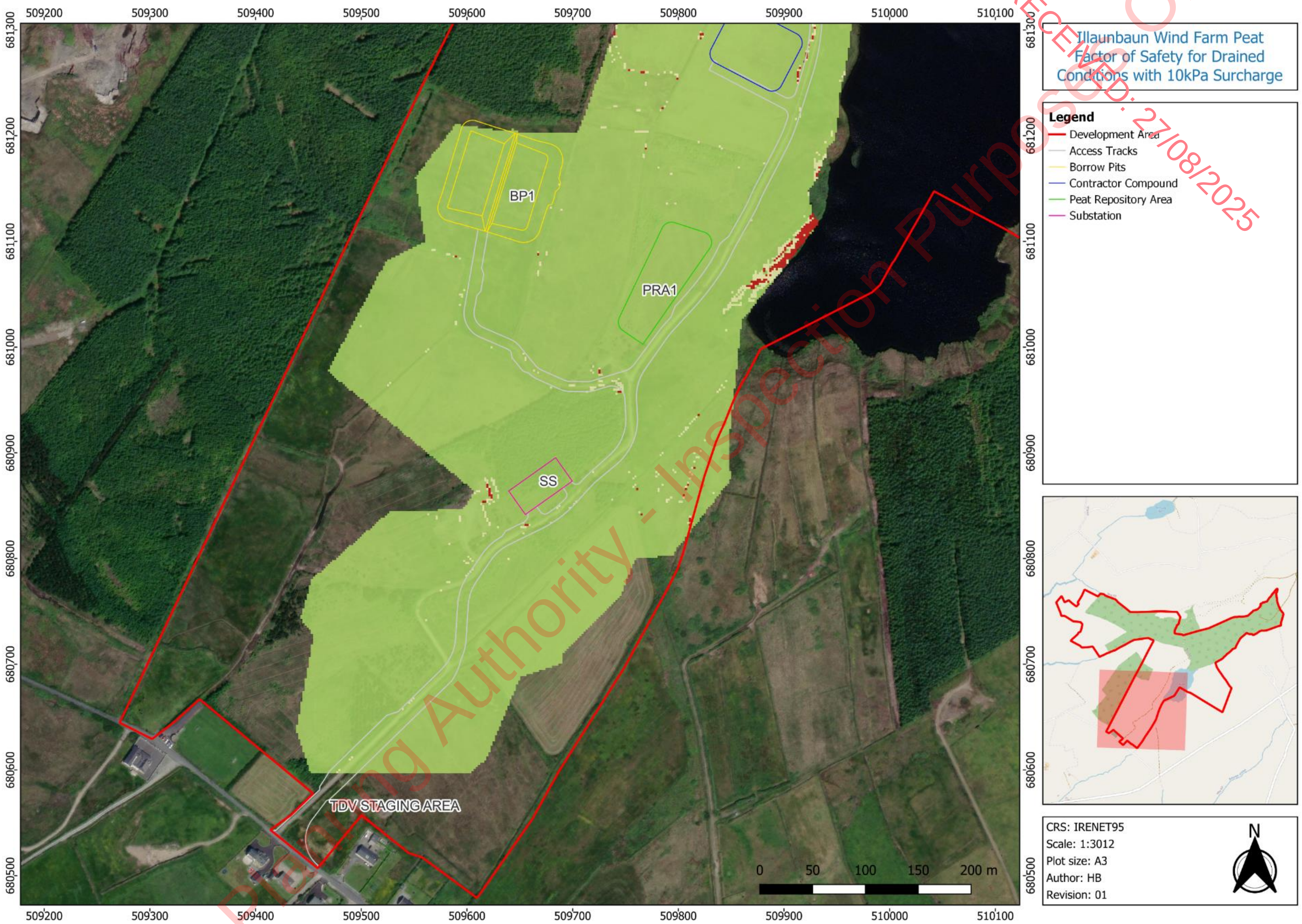


Figure K- 20: Peat Factor of Safety for Drained Conditions with 10kPa Surcharge (5 of 5)

Table K- 1: Factor of Safety Calculation for Undrained Conditions.

Proposed infrastructure	Slope	Cos Slope	Sin Slope	Undrained shear strength	Bulk unit weight of Peat	Peat depth	Factor of Safety	Surcharge	Factor of Safety with Surcharge	Slope
	(º)			Cu (kPa)	Y (kN/m^3)	(m)		(m)		Rad
T1	2.0	0.999	0.035	5	10	0.73	**19.49**	1	**8.22**	0.035227
T2	4.6	0.997	0.079	5	10	0.41	**15.28**	1	**4.47**	0.079571
T3	7.1	0.992	0.124	5	10	1.10	**3.72**	1	**1.95**	0.123859
T4	5.8	0.995	0.101	5	10	0.20	**24.79**	1	**4.13**	0.101549
T5	6.5	0.994	0.113	5	10	0.61	**7.30**	1	**2.77**	0.113077
T6	3.1	0.999	0.054	5	10	0.32	**28.46**	1	**6.96**	0.05436
BP1	4.9	0.996	0.086	5	10	0.62	**9.39**	1	**3.60**	0.086218
BP2	3.8	0.998	0.066	5	10	0.32	**24.00**	1	**5.76**	0.066206
PRA1	0.4	1.000	0.008	5	10	0.74	**87.14**	1	**37.15**	0.00772
PRA2	3.8	0.998	0.066	5	10	0.48	**15.72**	1	**5.11**	0.066312
PRA3	0.4	1.000	0.007	5	10	1.37	**49.63**	1	**28.67**	0.007365
Construction Compound	1.8	1.000	0.031	5	10	0.88	**17.97**	1	**8.43**	0.031503
Substation	3.8	0.998	0.067	5	10	0.74	**10.17**	1	**4.31**	0.066943

Undrained conditions

$$F = \frac{c_u}{\gamma z \sin\alpha \cos\alpha}$$

Where,

F = Factor of Safety
c_u = Undrained strength
γ = Bulk unit weight of material
z = Depth to failure plane assumed as depth of peat
α = Slope angle

Table K- 2: Factor of Safety Calculation for Drained Conditions.

Proposed infrastructure	Peat depth	Bulk unit weight of water	Height of water table above failure surface	Slope	Cos Slope	Cos^2 Slope	Sin Slope	ϕ'	Tan ϕ'	**FoS**	Surcharge (m)	**FoS Surcharge**
	(m)	Y (kN/m³)	(m)	(º)								
T1	0.73	9.8	0.73	2.0	0.999	0.999	0.035	25	0.466	**15.86**	1	**14.34**
T2	0.41	9.8	0.41	4.6	0.997	0.994	0.079	25	0.466	**12.34**	1	**7.75**
T3	1.10	9.8	1.10	7.1	0.992	0.985	0.124	25	0.466	**3.05**	1	**3.38**
T4	0.20	9.8	0.20	5.8	0.995	0.990	0.101	25	0.466	**19.92**	1	**7.13**
T5	0.61	9.8	0.61	6.5	0.994	0.987	0.113	25	0.466	**5.92**	1	**4.79**
T6	0.32	9.8	0.32	3.1	0.999	0.997	0.054	25	0.466	**22.94**	1	**12.08**
BP1	0.62	9.8	0.62	4.9	0.996	0.993	0.086	25	0.466	**7.62**	1	**6.25**
BP2	0.32	9.8	0.32	3.8	0.998	0.996	0.066	25	0.466	**19.34**	1	**9.99**
PRA1	0.74	9.8	0.74	0.4	1.000	1.000	0.008	25	0.466	**70.92**	1	**64.89**
PRA2	0.48	9.8	0.48	3.8	0.998	0.996	0.066	25	0.466	**12.71**	1	**8.87**
PRA3	1.37	9.8	1.37	0.4	1.000	1.000	0.007	25	0.466	**40.97**	1	**50.40**
Construction Compound	0.88	9.8	0.88	1.8	1.000	0.999	0.031	25	0.466	**14.67**	1	**14.74**
Substation	0.74	9.8	0.74	3.8	0.998	0.996	0.067	25	0.466	**8.27**	1	**7.51**

Drained conditions

$$F = \frac{c' + (\gamma z - \gamma_w h_w)\cos^2\alpha \tan\phi'}{\gamma z \sin\alpha \cos\alpha}$$

Where,

F = Factor of Safety
c' = Effective cohesion
γ = Bulk unit weight of material
z = Depth to failure plane assumed as depth of peat
γ_w = Unit weight of water
h_w = Height of water table above failure plane
α = Slope angle
ϕ' = Effective friction angle

Appendix L Safety Buffer Areas and Peat Stockpile Restriction Areas

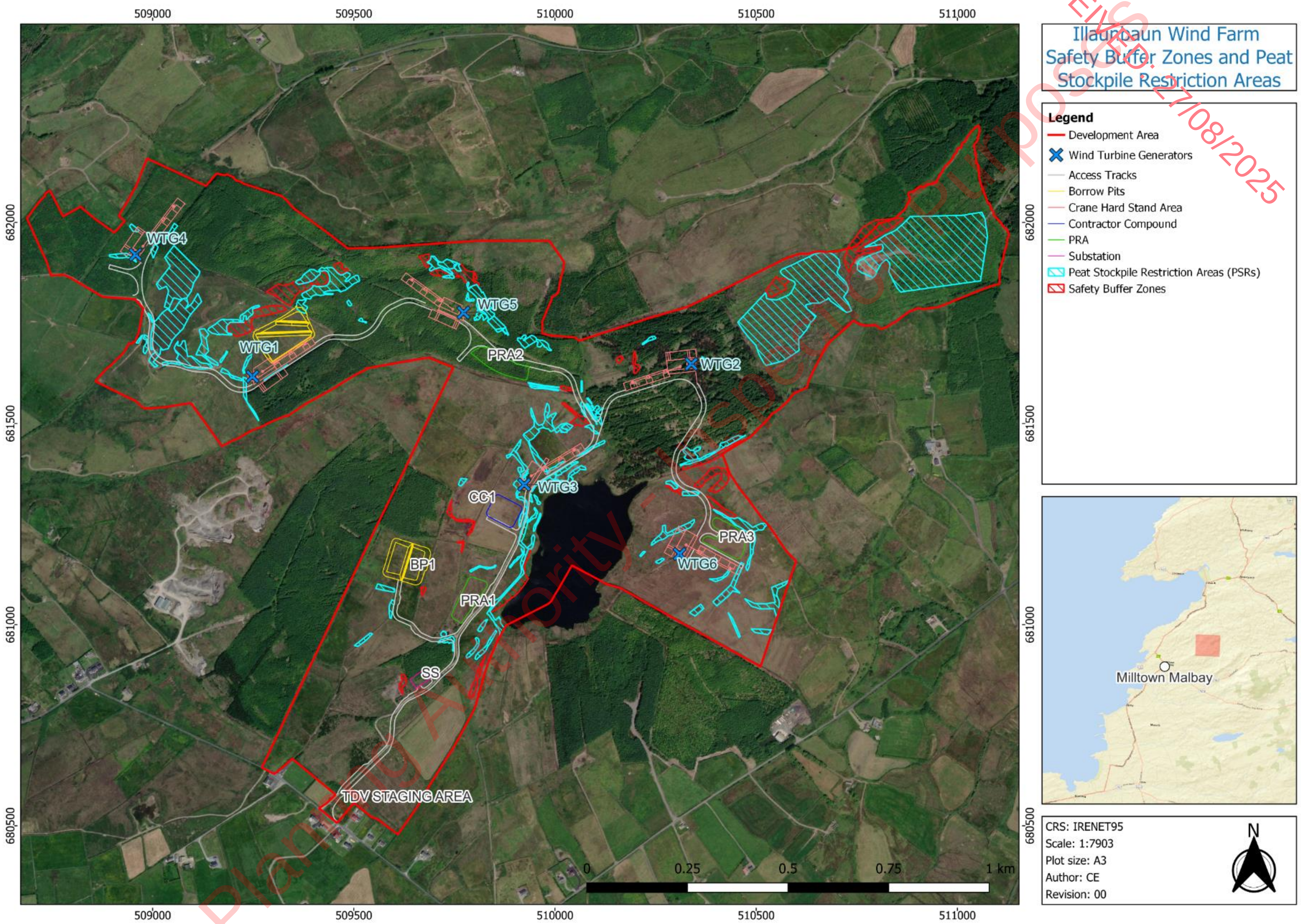


Figure L- 1: Safety Buffer and Peat Stockpile Restriction Areas

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