National Parks & Wildlife Service

Tóchar Midlands Wetland Restoration Scheme

Killaun Fen

NFS site No. 107006

Fen Restoration Plan

September 2026

Tóchar Athchóiriú Bogach Lár na Tíre Midlands Wetland Restoration

ARUP

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Fen Restoration Plan

Killaun Fen

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Executive Summary

Killaun Fen is located 5km west of Birr, Co. Offaly and consists of an area of remnant raised bog surrounded by areas of degraded bog habitat due to cutting. The site includes pockets of largely rank rich fen and patches of poor fen with some turf-cutting hollows supporting Annex quality 7230 Alkaline fens.

This assessment of Fen Restoration Plan (referred to hereafter as FRP) has been developed to set out proposals for the restoration of 7230 Alkaline fens habitat to contribute to the achievement of favourable conservation condition of the fen habitat at Killaun Fen.

This is a site-level plan that will be subject to refinement prior to implementation of restoration actions in each subsite. The assessment primarily considers the following pressures that may be impacting on the hydrological function and/or favourable condition of the fen habitat:

- Drainage works that have altered natural water levels;
- Nutrient enrichment from adjacent industrial and agricultural activities;
- Inappropriate grazing regimes; and
- Invasive species e.g. scattered self-seeding conifers

The FRP was developed using a desktop assessment of previous studies of Killaun Fen commissioned by NPWS, which includes surveys carried out in 2022 as part of the National Fen Survey (NFS). Detailed aerial imagery and topographic datasets were used to identify drainage features. Hydrological and ecological field surveys were undertaken to collect additional information and validate the findings from desktop assessment, supporting the proposed restoration actions.

Actions of the Fen Restoration Plan

The Fen Restoration Plan sets out a coordinated series of measures to address the key pressures affecting the site and to support the recovery of its wetland habitats. These measures include mainly:

- Vegetation management and;
- Drainage management.

Drainage management is proposed at two locations: in the west-east drain to restore and stabilise the wet conditions that are essential for the persistence of fen habitats and in the north-south drain to manage water balance of adjacent peatland habitats. The effectiveness of these hydrological measures will be tracked through monitoring of both groundwater and surface water across the site.

Vegetation management will include the targeted removal of scrub including gorse and trees of beech and pine within identified priority areas. Such measures will focus on limiting further

encroachment into open habitats, maintaining the habitats open structure. Removal will be progressive and guided by dedicated vegetation monitoring to track scrub extent, the dominance of *Molinia caerulea* grasses and habitat condition. Fly-tipped materials will be removed from the site also to address localised disturbance and reduce any potential nutrient inputs that may be affecting the habitats.

To address nutrient and pollution pressures, the plan emphasises collaboration with local landowners and farmers through established programmes and incentives. This includes efforts to reduce nutrient runoff from the surrounding peat extraction site, as well as the provision of alternative livestock watering solutions to prevent direct access to the fen. Regular water quality assessments will be conducted to monitor nutrient levels and inform adaptive management of the site.

The plan recognises the importance of stakeholder engagement and compliance. Active engagement with landowners, statutory bodies, and other local stakeholders will help ensure that restoration actions are practical, widely supported, and compliant with relevant legislation.

Benefits of the Fen Restoration Plan

The restoration plan is expected to deliver significant benefits for a range of habitats and species at Killaun Fen.

The implementation of the following measures: vegetation monitoring, scrub control, management of gorse and encroaching and removal dumped material within the southern, aligned to drainage management, including drain blocking and groundwater/surface water monitoring, are expected to improve the 7230 Alkaline fen habitats other associated peatland habitats.

These restoration actions will enhance habitat quality and resilience, supporting both biodiversity and the fen habitat condition.

Habitat and Restoration Map

The habitats recorded during the 2022 NFS and classified according to the Annex I Habitat Classification system is presented in Figure 1-1:.

The Restoration and Monitoring Map including both hydrological and ecological measures is presented in Figure 1-2:.



Figure 1-1: Annex I habitats recorded during the 2022 NFS. Note the % refers to the % of the Annex I quality habitat present within the mapped polygon. See Table 9-1 for the full directory of habitat codes and names

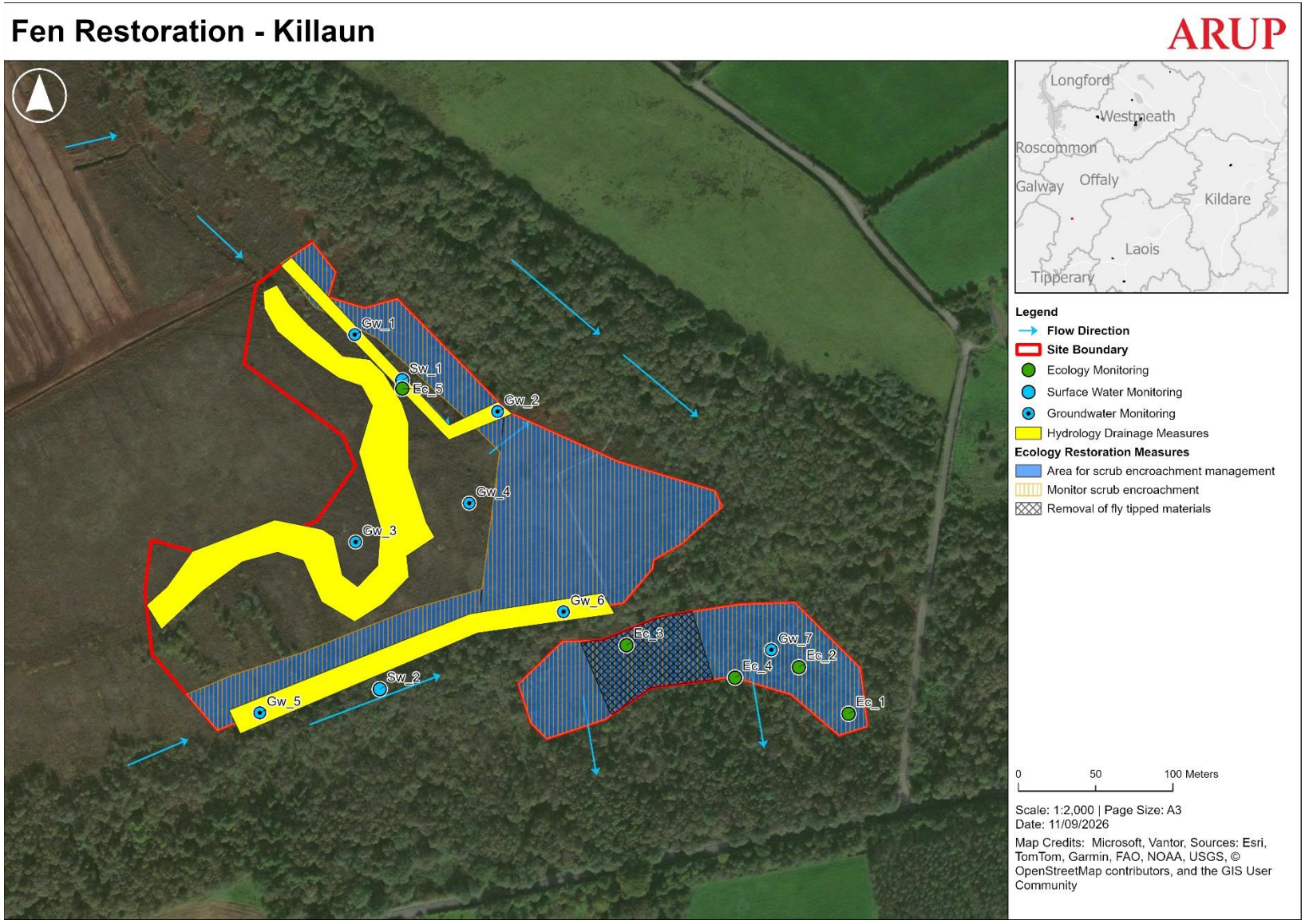


Figure 1-2: Restoration and Monitoring Map including both hydrological and ecological measures

Acknowledgements

This Restoration Action Plan was prepared following consultation with a broad range of groups and individuals involved in Peatland restoration, local residents and stakeholders through several workshops.

Thanks to the members of the SAR Directorate, NPWS Regional Staff, Ecological Assessment Unit (EAU), Ecological Guidance and Advisory Unit (EGAU), Wildlife Enforcement and Nature Protection Directorate, Conservations Measures Unit, Conservation Planning Unit, The FENCES Project team and the Tóchar Wetlands Project Team, including Shirley Clerkin (Project Manager), Monica Byrne (Project Administrator), Hazel Daly (Community Engagement Officer), and Emily Nolan (Community Engagement Officer).

Tóchar Wetlands is a wetlands restoration project, co-funded by the Government of Ireland and the European Union through the EU Just Transition Fund Programme. It is managed by the National Parks and Wildlife Service, of the Department of Housing, Local Government, and Heritage.

1 Introduction

1.1 Purpose of this Fen Restoration Plan

This Fen Restoration Plan (FRP) report has been developed by Arup on behalf of National Parks and Wildlife Service (NPWS) to set out proposals for restoration of Annex1 quality 7230 Alkaline fens (hereafter referred to as 7230 Alkaline fens) habitat within the site which contributes to favourable conservation condition of the fen habitat. Killaun Fen is not a designated site, however the site supports Annex I habitat and is referred to here as Annex I quality, meaning it conforms to the Annex I habitat description, but is not a designated Special Area of Conservation (SAC).

Killaun Fen (107006) is located approximately 5km west of Birr in Co. Offaly and covers a total area of 6.2 ha. The site is dominated by a fen habitat in its southern section although several other associated peatland habitats are also present (Brophy et al., 2022). According to the National Fen Survey carried out in 2022, the total extent of 7230 Alkaline fens habitat at Killaun is 0.06 ha.

The main aim of the restoration actions proposed as part of this assessment is to maintain or improve the quality of existing areas of fen or improve the hydrological conditions that will allow an expansion of the measurable area of fen. However, in some areas, it must be recognised that restoration to increase areas of existing fen will not be possible due to unsuitable hydrological conditions, and the objective may simply be to ensure no further deterioration.

Although the focus of the restoration plan is on fen habitat it is anticipated that restoration actions will also benefit other wetland habitats, including PF1 Rich fen and flush, PF2 Poor fen and flush, WN7 Bog woodland, PB1 Raised bog and PB4 Cutover bog, which were mapped at Killaun Fen during the NFS (Brophy et al., in prep). Figure 9-1: presented in Appendix B (Ecological Survey Maps) shows the Fossitt classified habitats identified at Killaun Fen.

The implementation of the actions proposed within this FRP report may also provide wider improvements to biodiversity, reduce carbon emissions and potentially improve water quality all of which may be demonstrable under eventual post implementation monitoring.

1.2 Wider benefits of peatland restoration

Fens are vital habitats due to their rich biodiversity, supporting a wide array of flora and fauna, many of which are rare or endangered. They act as natural water filters, purifying water by trapping pollutants and sediments, thus enhancing water quality downstream. Additionally,

[1] Each habitat and species type protected under the EU Habitats Directive (Council Directive 92/43/EEC of 21 May 1992) is given a unique numeric code so that all. Member States use the same reference in legislation, reporting and monitoring. Each habitat and species code is an index in the Annex lists with codes grouped by habitat family.

fens store significant amounts of carbon in their peat soils, contributing to climate change mitigation by reducing atmospheric carbon dioxide levels. Their ability to absorb and gradually release water helps regulate water flow and minimise flood risks. Beyond their ecological importance, fens hold cultural, historical, and recreational value, offering opportunities for education, research, and outdoor activities. Although some fens in Ireland are not protected as SACs or Natural Heritage Areas (NHAs), they remain crucial for biodiversity and climate resilience.

Peatland drainage and extraction transform a natural peatland which acts as a modest carbon sink into a carbon source (Waddington & McNeil, 2002; Alm et al. 2007; Wilson et al. 2015). The EPA- funded Carbon Restore Project (Wilson et al. 2012) found that rewetting of drained peatlands can lead to restoration of functional peatland, such as the return of typical plant and animal species, which in turn may lead to the restoration of peat-formation and the C-sink function.

It is expected that areas within Killaun will become a reduced carbon source/part carbon sink following implementation of the FRP will result in revegetation of cutover bog areas, development of fen habitats and improvement in hydrology via drain blocking.

The restoration of fen habitat at Killaun is likely to lead to improved water quality. Well-functioning fen habitat reduces the risk of dissolved organic carbon passing into water courses.

1.3 Key pressures on Fens

The overarching (National) key pressures and threats to Annex I fen habitats have been identified in the latest Status of EU Protected Habitats and Species in Ireland (Article 17 report) (NPWS 2025) in Table 1-1. The overall conservation status is assigned as Bad for 7230 Alkaline fens in the Article 17 report.

Table 1-1: National pressures to fen habitats

Habitat	Importance	Pressure
7230 Alkaline fens	High	PA23 Physical alteration of water bodies (including dams, channels, etc.) J01 Mixed source pollution to surface and ground waters
	Medium	PL02 Drainage (mixed or unknown drivers) to surface or ground waters

1.4 Legislative Context

There is a comprehensive system of legislation, both domestic and international, which aims to protect biodiversity at a landscape, habitat and species level in Ireland. This legislation exists within, and independently of, the planning process.

In Ireland, the most important pieces of legislation underpinning biodiversity and conservation are:

- Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora, hereafter referred to as the Habitats Directive.
- Regulation (EU) 2024/1991 of the European Parliament and of the Council of June 2024 on nature restoration and amending Regulation (EU) 2022/869.
- Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds, hereafter referred to as the Birds Directive.
- European Communities (Birds and Natural Habitats) Regulations, 2011 (S.I. No. 477 of 2011), as amended, hereafter referred to as the Birds and Habitats Regulations.
- Wildlife Acts 1976 to 2017, hereafter referred to as the Wildlife Acts; and
- Flora (Protection) Order, 2015 (S.I. No. 356 of 2015).

According to the EU Habitats Directive (92/43/EEC) and the EU Birds Directive (79/409/EEC), Member States are required to establish a Natura 2000 network of sites of highest biodiversity importance for rare and threatened habitats and species across the EU. In Ireland, the Natura 2000 network of European sites includes SACs and Special Protection Areas (SPAs).

SACs are selected for the conservation of Annex I habitats (including priority types which are in danger of disappearance) and Annex II species (other than birds). SPAs are selected for the conservation of Annex I birds and all migratory birds and their habitats. The Annex habitats and species, for which each site is selected, are the qualifying interests (QI) of the SAC and special conservation interest (SCI). Conservation objectives for the site are defined for these qualifying interests.

The EU Nature Restoration Regulation aims to restore damaged ecosystems and improve biodiversity with particular focus on capturing and storing carbon and reducing the impact of natural disasters. Specific targets include improving and re-establishing biodiverse habitats on a large scale and bringing back species populations by improving and enlarging their habitats. EU countries are required to submit National Restoration Plans to the European Commission showing how they will deliver on the targets and monitor their progress. Member States are required to implement restoration measures for specific habitats and species, including marine ecosystems, forests, wetlands, and pollinators.

Ireland is required to manage water resources in an integrated way under the Water Framework Directive (WFD, 2000/60/EC) and the European Communities (Water Policy) Regulations 2003 (S.I. No. 722 of 2003). Member States are required to submit River Basin Management Plans to the European Commission showing how they will protect and improve the water environment. Restoring surface and groundwater bodies to the equivalent of 'good status' or better and to protect water from any further deterioration requires collaboration at a local and national level. Implementing the WFD supports the achievement of site-specific conservation objectives for fen habitats, contributing to their favourable conservation status.

1.5 Outline of this FRP document

- Section 2 of this FRP report outlines details of Killaun Fen and the conservation objectives for 7140/7230 fen habitat.
- Section 3 outlines the findings from the land and water desktop and site monitoring surveys that were carried out to inform the development of this FRP.
- Section 4 outlines the findings from the ecological desktop and site monitoring surveys that were carried out to inform the development of this FRP.
- Section 5 provides a summary of the key pressures identified by this FRP report that are impacting on fen.
- Section 6 outlines the key restoration measures proposed by this FRP.
- Section 7 outlines additional considerations to inform the development of the FRP.
- Section 8 outlines key players in the FRP, summarises restoration actions proposed, habitats that will benefit and further steps required to prepare for implementation.

Restoration actions proposed by this FRP assessment have been mapped in GIS format and delivered to NPWS in accordance with NPWS data standards. This includes detailed mapping of the key pressures addressed by this assessment, detailed mapping of proposed restoration actions, ecological survey results and referenced sensitivity areas. GIS Shapefiles which accompany this report include all relevant data on referenced species.

2 Site Overview

2.1 Killaun Fen

Killaun Fen is located 5km west of Birr, Co. Offaly and is not designated at a European (SAC) or national level (NHA). Killaun comprises an area of remnant raised bog with industrial cutaway to the north, and extensive areas of cutover bog to the south and east. The site sits within a mixed landscape of peatland and agricultural grasslands, which contribute to its overall character and setting. To the north, the site adjoins areas of industrial peat extraction managed by Bord na Móna, while the immediate southern and eastern boundaries are bordered by extensive woodland. Beyond this, the surrounding landscape transitions into agricultural fields, further defining the site's context.

Killaun supports a small area (5%) of Annex I quality 7230 Alkaline Fen within the southeast of the site. The site also contains small areas of PB1 raised bog to the northwest, a large area of PB4 cutover bog in the northern section of the site and other habitats, including PF1 rich fen, PF2 poor fen and WN7 bog woodland. The limited extent of 7230 Alkaline Fen is represented by small, isolated areas of Black bog-rush (*Schoenus nigricans*) with associated purple moor-grass (*Molinia caerulea*) and brown mosses including *Scorpidium cososnii* alongside species such as Devil's-bit scabious (*Succisa pratensis*).

The majority of the cutover area supports developing woodland and scrub, mainly dominated by birch and willow. The fen area contains small patches of wetter ground, although much of this has become overgrown with dense grasses and scrub, and is gradually transitioning into drier vegetation. A limited number of open hollows from past turf cutting still support pockets of wetter fen vegetation. Closer to the higher bog, wet depressions occur within otherwise drier cutover areas, some of which still support typical peatland vegetation.

The site lies within lands benefitting from the Drainage District and falls within a designated Drainage District, at which local authorities are responsible for maintenance under the Arterial Drainage Act (1945). Surface water flow is predominantly southwards towards River Camcor. Historical maps (1829–1913) show evidence of drains running parallel to the site's eastern boundary. The current drainage network consists of the drain identified in historical maps and a drain that provides inflow to the site through its northeastern boundary.

Altitude at the site ranges from 61mOD to 64m, and the topography is mainly flat. Figure 2-1 outlines the location and extent of Killaun Fen.

The site is located within the Lower Shannon Catchment and is primarily drained by tributaries of the Camcor River. For the purposes of the Water Framework Directive most of the Killaun Fen is located within the Camcor_SC_010 sub-catchment.



Figure 2-1: Site Location Map

2.1.1 Fen Condition Assessment

Killaun Fen was surveyed as part of the NFS on the 13th of July 2022 (Brophy et al., In prep). During the NFS, the following observations were noted by the author:

- No conservation or restoration recommendations were provided in the NFS 2022 report.
- Site is unmanaged except for a boardwalk present for recreation. As highlighted during the initial site visit, potential restoration measures should factor in the possibility of increased water levels within the site impacting the boardwalk which is in use by recreational walkers with dogs.

The structure & functions of the following Annex I quality habitat was recorded as part of the NFS:

- 7230 Alkaline fens: Unfavourable-Bad (due to scrub encroachment).

2.2 Site-Specific Conservation Objectives

As Killaun Fen is not an SAC, it does not have SSCO. Attributes and targets for Annex I habitats vary and are specific to each site, therefore whilst they cannot be directly applied to Killaun Fen, general conservation objectives can be applied as a basis to inform favourable conservation status of the fen habitats. This includes measures such as maintaining appropriate

hydrological levels and quality or abundance of vegetation communities and appropriate physical structure relevant to Annex I habitats.

3 Land and Water

3.1 Desktop Study

3.1.1 Meteorological Conditions

Understanding meteorological patterns is essential for restoration planning. To evaluate seasonal rainfall variability at the site and surrounding areas, historical precipitation data from the nearest Met Éireann weather station (Gurteen), covering data over the past 18 years (2008-2026) has been reviewed (Met Eireann, 2025).

Two datasets have been visualised: (1) average monthly precipitation (mm), incorporating an 18-year period to show seasonal distribution patterns (Figure 3-1) and (2) total annual precipitation (mm) for each year within the 18-year record (Figure 3-2), to identify longitudinal trends. This information is important to assess water availability and to evaluate the feasibility and sustainability of restoration actions aimed at restoring or maintaining suitable hydrological conditions.

Average monthly rainfall peaks during winter (October to January) and is lower in late spring (April and May) (Figure 3-1). Minimum values follow a similar trend, while maximum monthly rainfall distinctly rises during winter months.

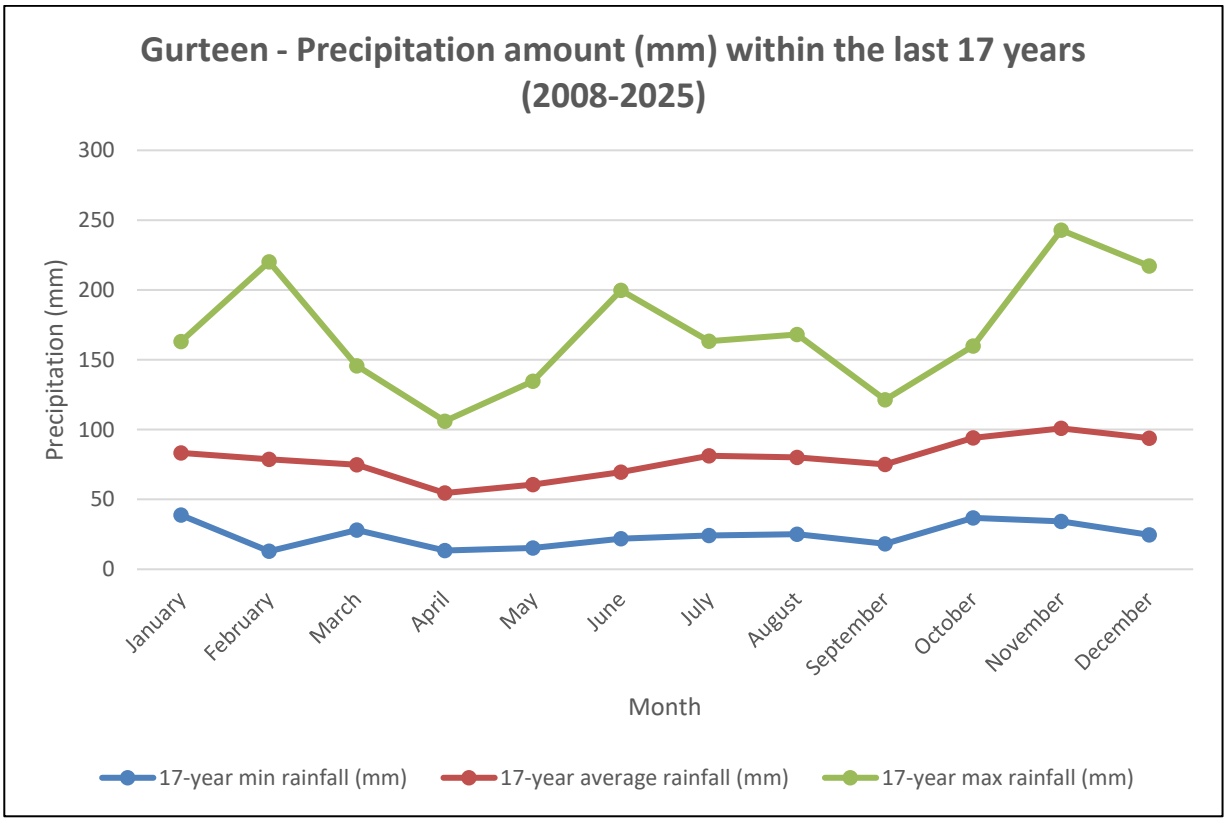


Figure 3-1: Gurteen weather Station – Average, minimum and maximum precipitation within the last 18 years (2008-2026) (Met Éireann, 2026)

Average annually shows that maximum rainfall fluctuates significantly more than average or minimum values (Figure 3-2). In particular, maximum precipitation surged to nearly 1080 mm in 2019. Both average and minimum rainfall vary slightly but remain relatively consistent throughout the 18 years.

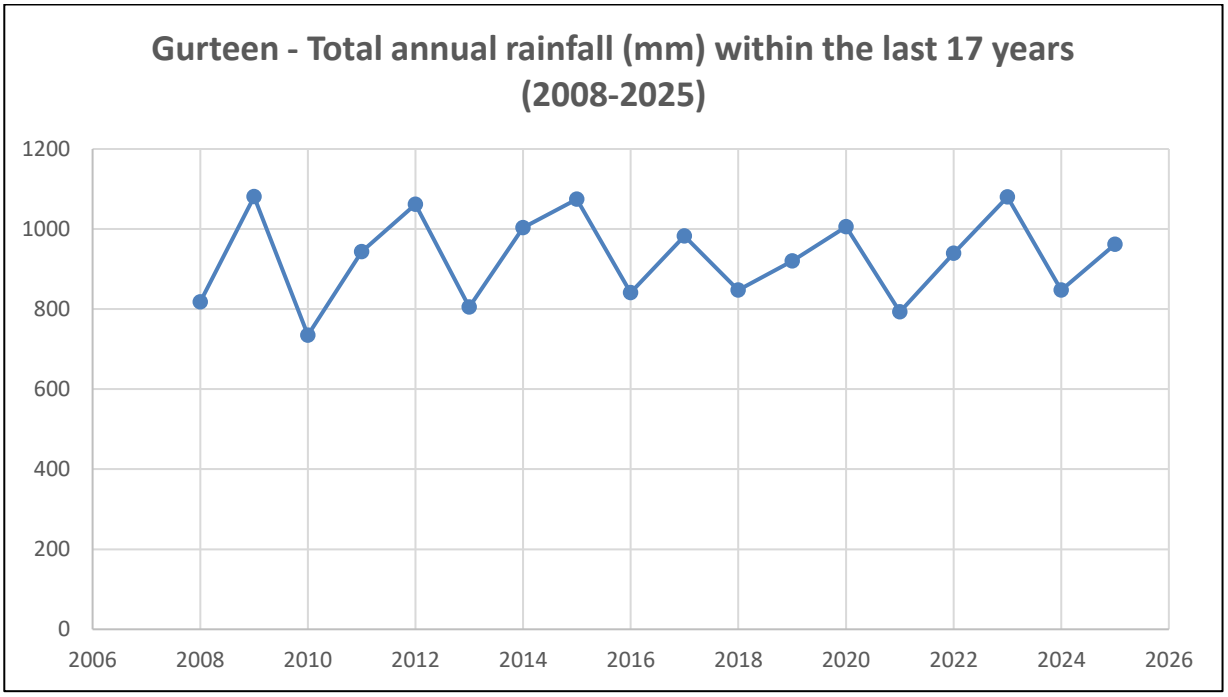


Figure 3-2: Gurteen weather Station – Total annual precipitation within the last 18 years (2008-2026) (Met Éireann, 2026)

3.1.2 Hydrogeological Setting

According to the Bedrock Geology 100K layer (GSI), the site is underlain by the Lucan Formation, which is characterised by dark limestone and shale, as shown in Figure 3-3. Waulsortian Limestones are underlain areas located approximately 270 m west of the site and are characterised by massive unbedded lime-mudstone.

The area is underlain by a Locally Important Aquifer (Ll), which is moderately productive only in local zones. Bedrock aquifer faultlines are observed crossing the southwestern section of the site from west to east, which may locally influence groundwater movement and permeability within the surrounding bedrock (Figure 3-4).

The site is part of the Shinrone groundwater body, which is currently classified with a good status and is assessed as not at risk of failing to meet its Water Framework Directive (WFD) objectives.

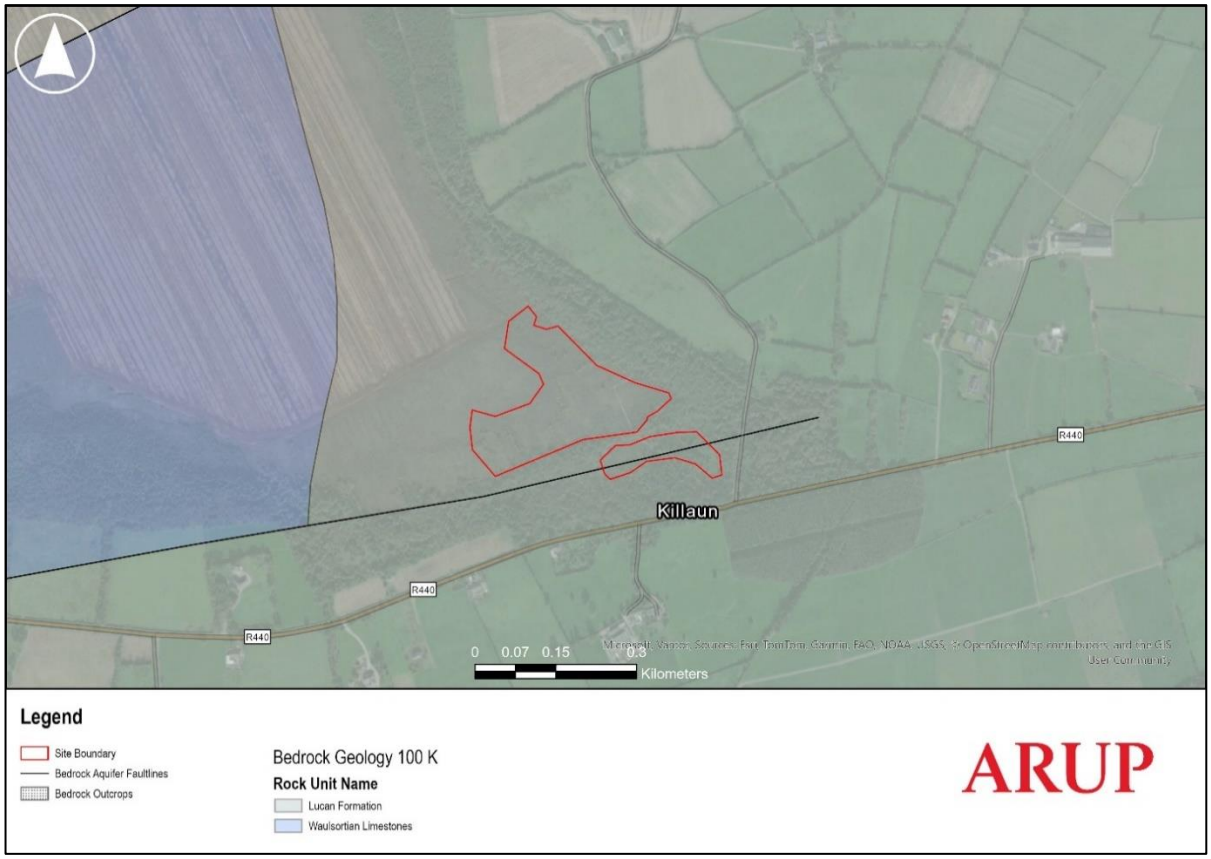


Figure 3-3: Bedrock Geology of Killaun Fen

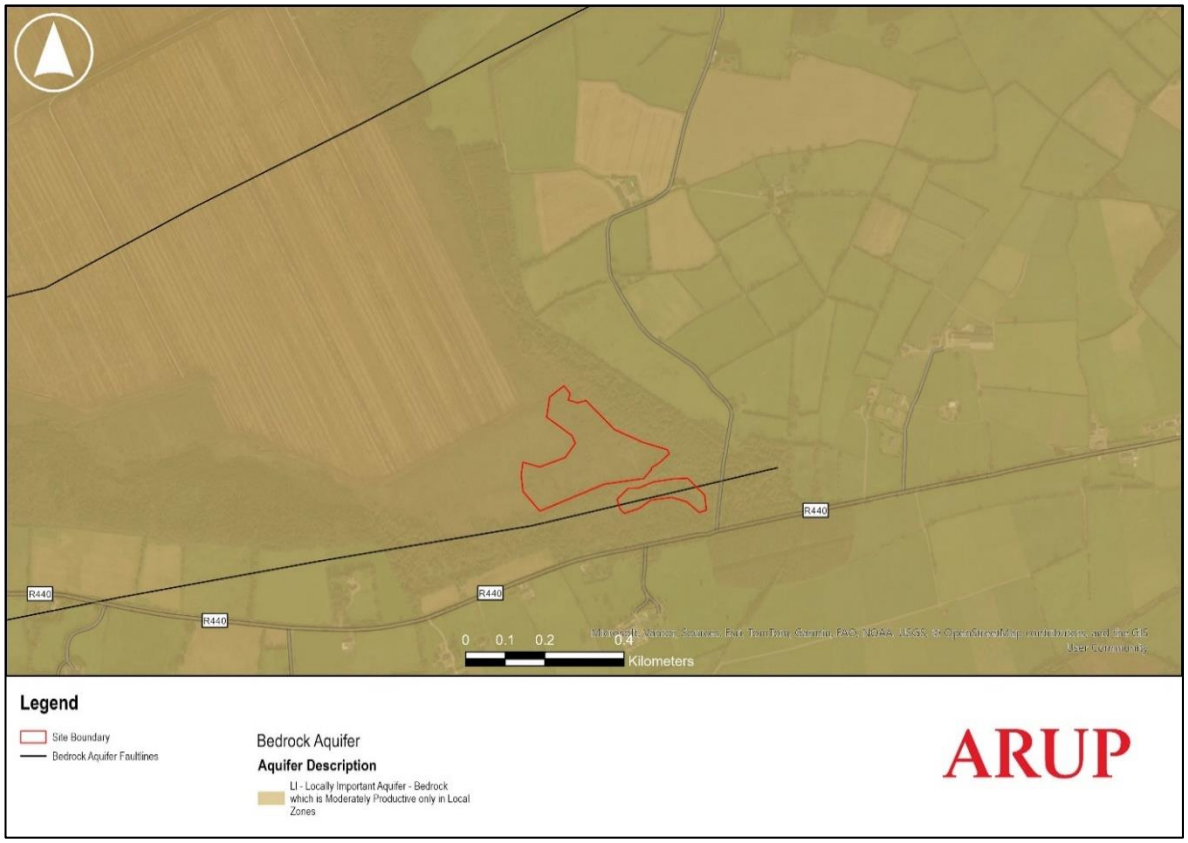


Figure 3-4: Aquifer classification underlying Killaun Fen

Quaternary sediments in the area comprise cut over raised peat and Fen Peat (Figure 3-5). Peat depth recorded during previous National Fen Surveys (Brophy et al., in prep), reached up to a depth of 2.5 m, confirming the presence of deep peat layers in parts of the site. Till derived from limestones are present in the surrounding areas, located approximately 100 m northeast and 100 m southwest of the site. There is also Alluvium sediments identified within approximately 300 m southwest of the site.

Groundwater vulnerability within the site is low. Approximately 45 m to the east and 65 m to the south of the site, the vulnerability is moderate (Figure 3-6). In areas where cut over raised peat overlies the bedrock, the vulnerability is low. In contrast, it becomes higher in regions where tills and alluvium are present.

Recharge rates follow a similar pattern, reflecting the influence of subsoil type on the water infiltration. Where the site is covered by peat, recharge rates are significantly lower, typically between 1 and 50 mm per year. In areas dominated by till and alluvium deposits, recharge rates raise from approximately 51 to 200 mm per year (Figure 3-7).

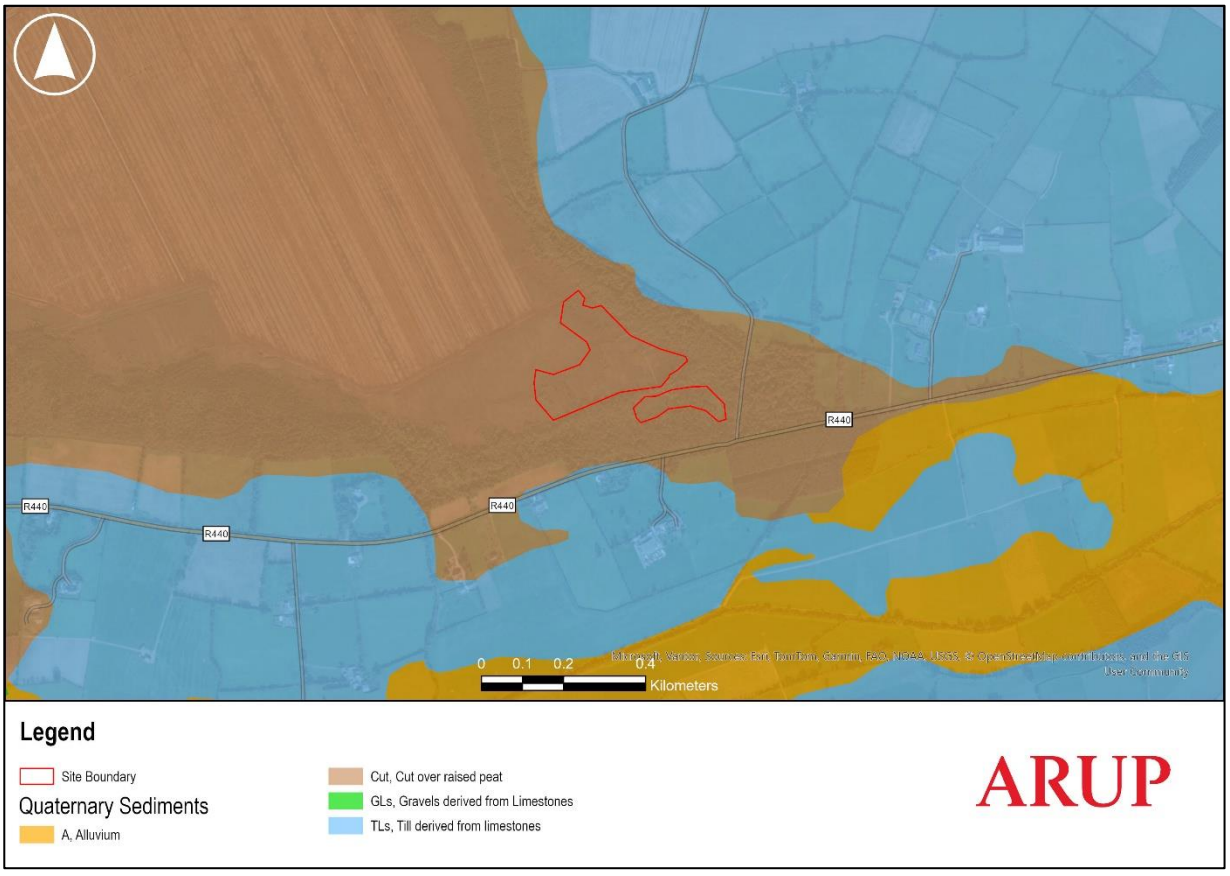


Figure 3-5: Sub-soil type underlying Killaun Fen (Source: GSI Quaternary map)

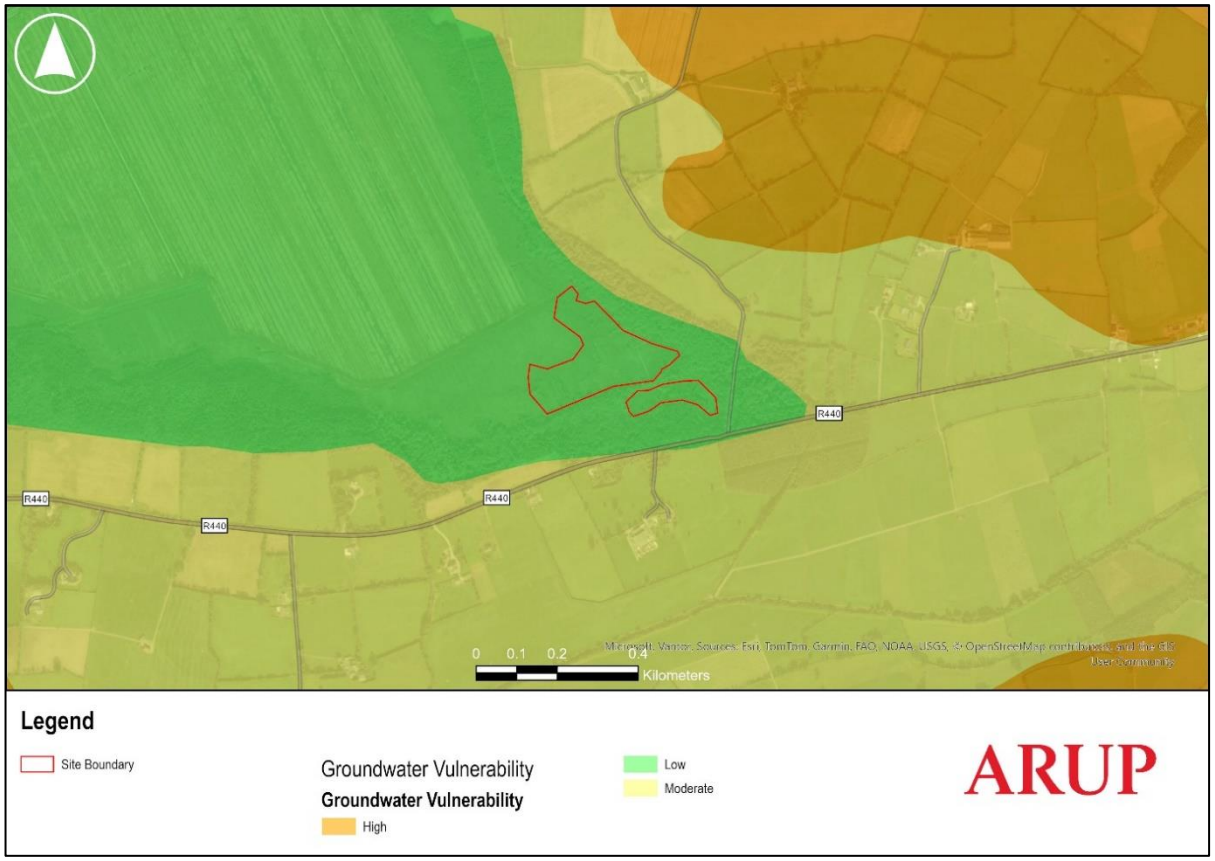


Figure 3-6: Groundwater vulnerability map for Killaun Fen (Source: GSI)

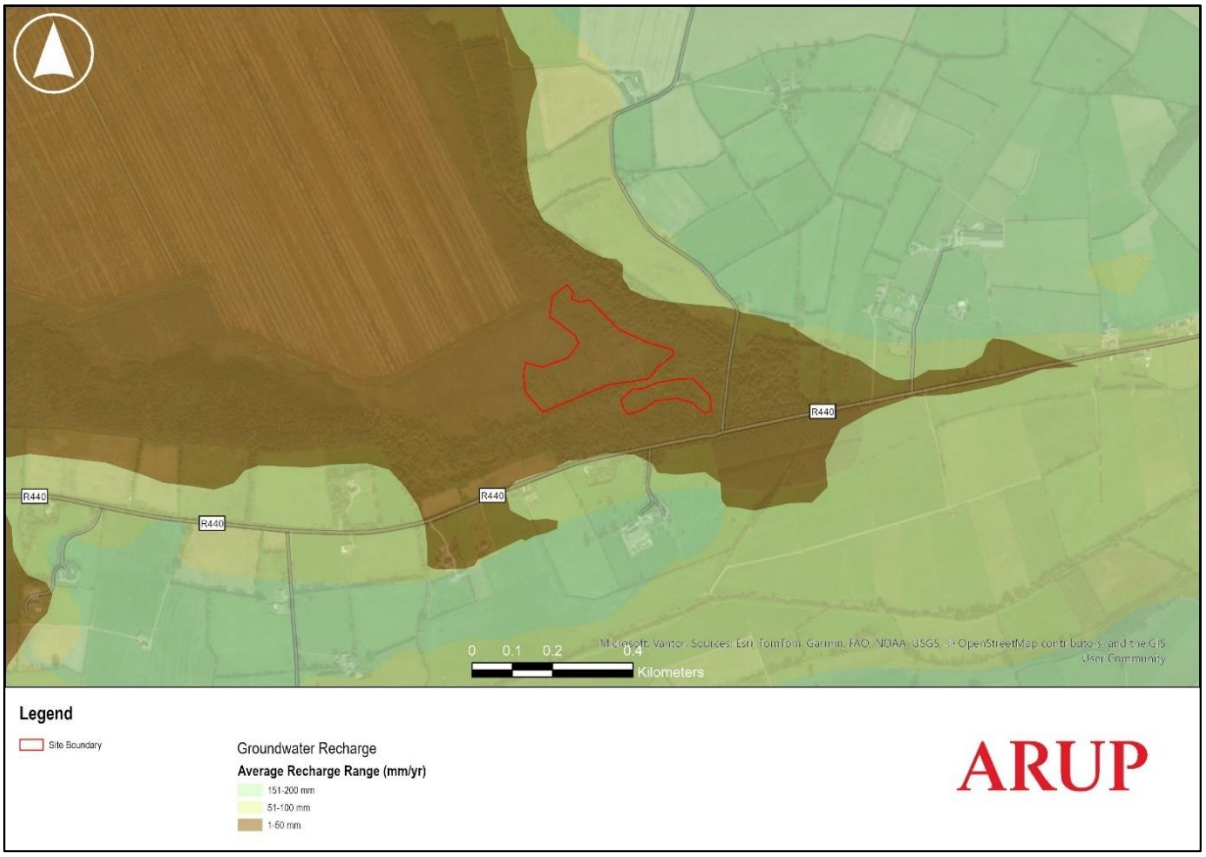


Figure 3-7: Groundwater recharge map for Killaun Fen (Source: GSI)

3.1.3 Topographic and Surface Water Drainage

The site is located within the 25B Lower Shannon WFD Catchment and the Camcor_SC_010 WFD sub catchment.

The Lower Shannon catchment drains towards the Shannon Estuary, and the Camcor_SC_010 River Sub-Basin drains the site to the southwest, towards Little Bronsna, Incherky and flowing towards River Shannon (Figure 3-8). The general water flow direction in the area is from north to southwest.

The Camcor_040 WFD River waterbody is classified with good status and not at risk of not achieving its WFD objective established by WFD Cycle 3 (EPA, 2024).

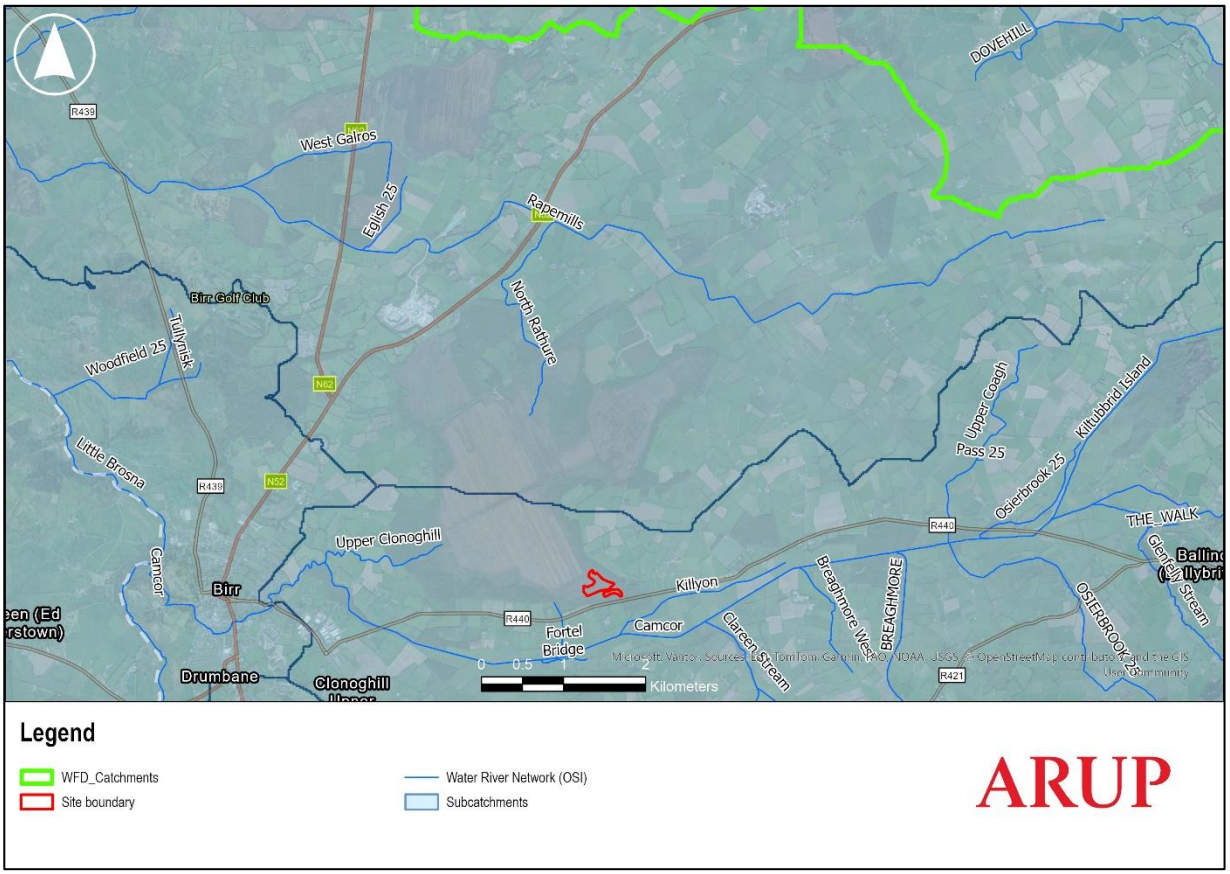


Figure 3-8: WFD Catchment and River sub-basin (EPA, 2025)

The topography of the site is mainly flat at approximately 63 mOD. Higher topographic areas are located within the northern edge of the site, reaching approximately 64 mOD, while lower areas are identified between the northern and southern sections of the site, where it ranges from 61 to 62 mOD.

The southern and northern sections of the site expose very different hydrological characteristics. In the southern, shallow water table has been identified in most of the areas within an existing boardwalk, but water flow is mostly not visible or very low. In the northern, water flows mainly to south and there is presence of cutover bog.

Beyond the site boundary, the landscape becomes notably elevated in the northwest (up to circa 66 mOD), northeast (up to 79 mOD) and southern (up to 69 mOD) regions. The northern boundary is adjacent to a peat extraction area, whose characteristics are likely to influence the hydrogeological and environmental conditions of Killaun.

An assessment of historical and current hydrological records indicates that the water regime of Killaun Fen has been affected primarily by drainage for peat extraction activities. Historical maps (1897–1913) show there is a visible drain located to the north of the site, outside the site boundaries, with a possible water intake crossing the site. They also indicate that the general flow is towards Camcor River and that there is a spring located approximately 300m southeast of the site boundary (Figure 3-9). In historic maps from 1910s to 1950s, this spring is not present. From 2012 to 2025, the vegetation in the site area has slightly fluctuated over the years, being the densest in the 2025 satellite image.

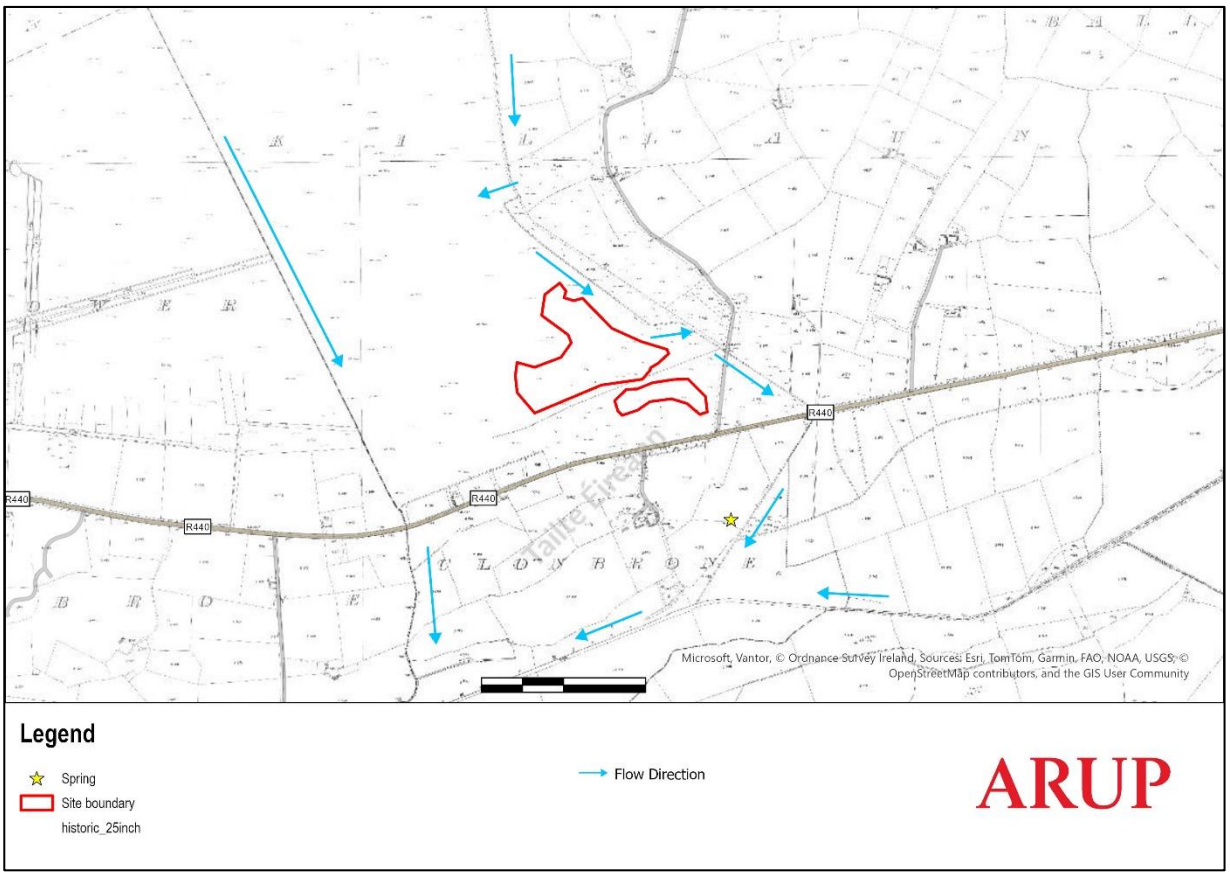


Figure 3-9: Historical water distribution and retention within wetland (Tailte Éireann Historical mapping) Historic Map- 25 Inch B&W (1897-1913)

The main drain within Killaun site was previously identified by NPWS in the Scoping Study and Pilot Survey of Fens from 2021 to 2023 (Figure 3-10) and flows from north to south. This drain is connected to other drains flowing from the peat harvested site northwest of Killaun Fen.

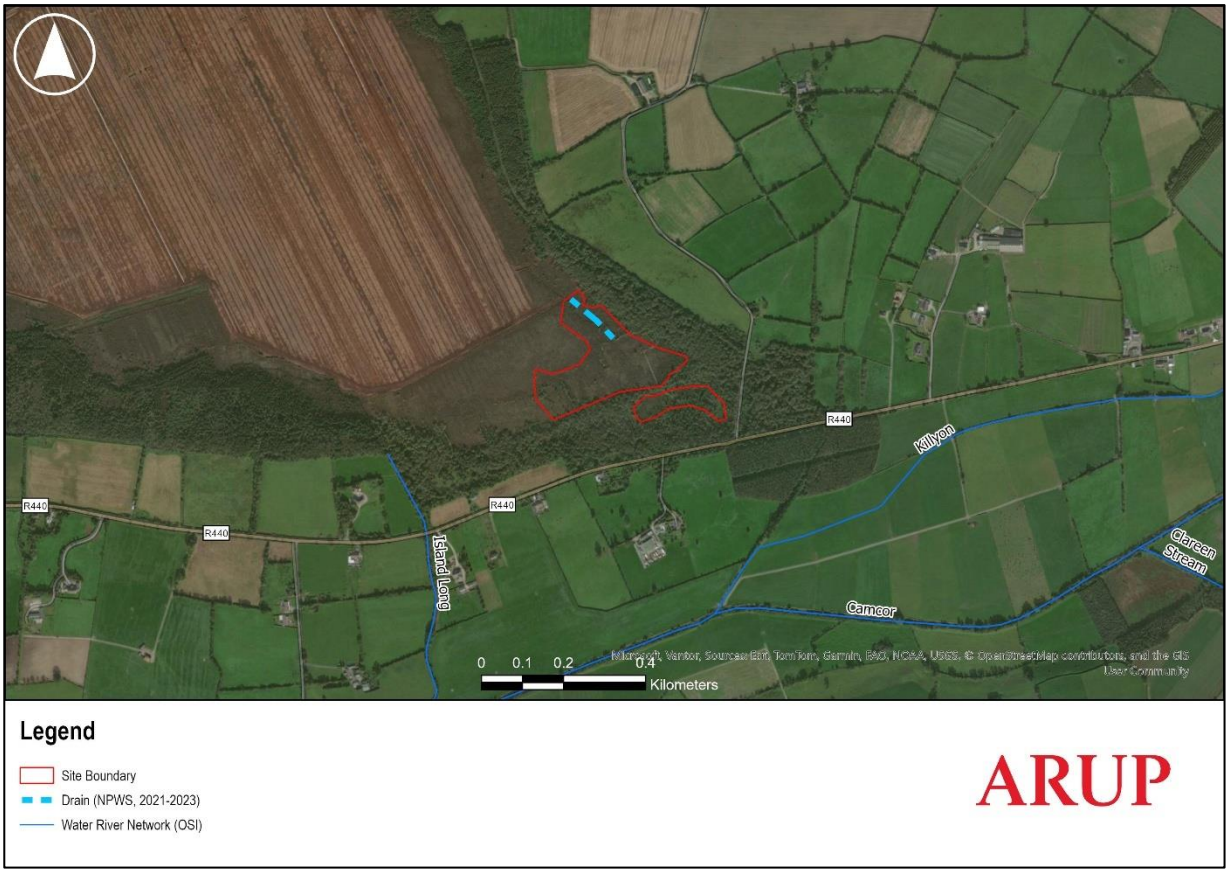


Figure 3-10: Mapped drainage network of Killaun Fen

The mapped Wetness Index[2] classifies the northern section of the site as permanently wet and the southern as temporarily wet, indicating alternating periods of saturation and dryness over the period of 2012 to 2018. The pattern in the southern of the site suggests a mosaic of variable soil moisture conditions, supporting intermittent wetland characteristics across the site (Figure 3-11).

Total productivity map of Killaun Fen further illustrates the site's hydrological variation (Figure 3-12). Most of the area is classified as having moderate productivity, typically associated with semi- degraded peatland habitats impacted by drainage and vegetation encroachment. In contrast, the northern section of the site shows low productivity, which is characteristic of relatively intact peatland. These areas exhibit nutrient-poor and water-saturated soils indicating a functioning peatland system.

[2] Dataset available at 10m resolution indicating the occurrence of water and wet surfaces over the period from 2012 to 2018.

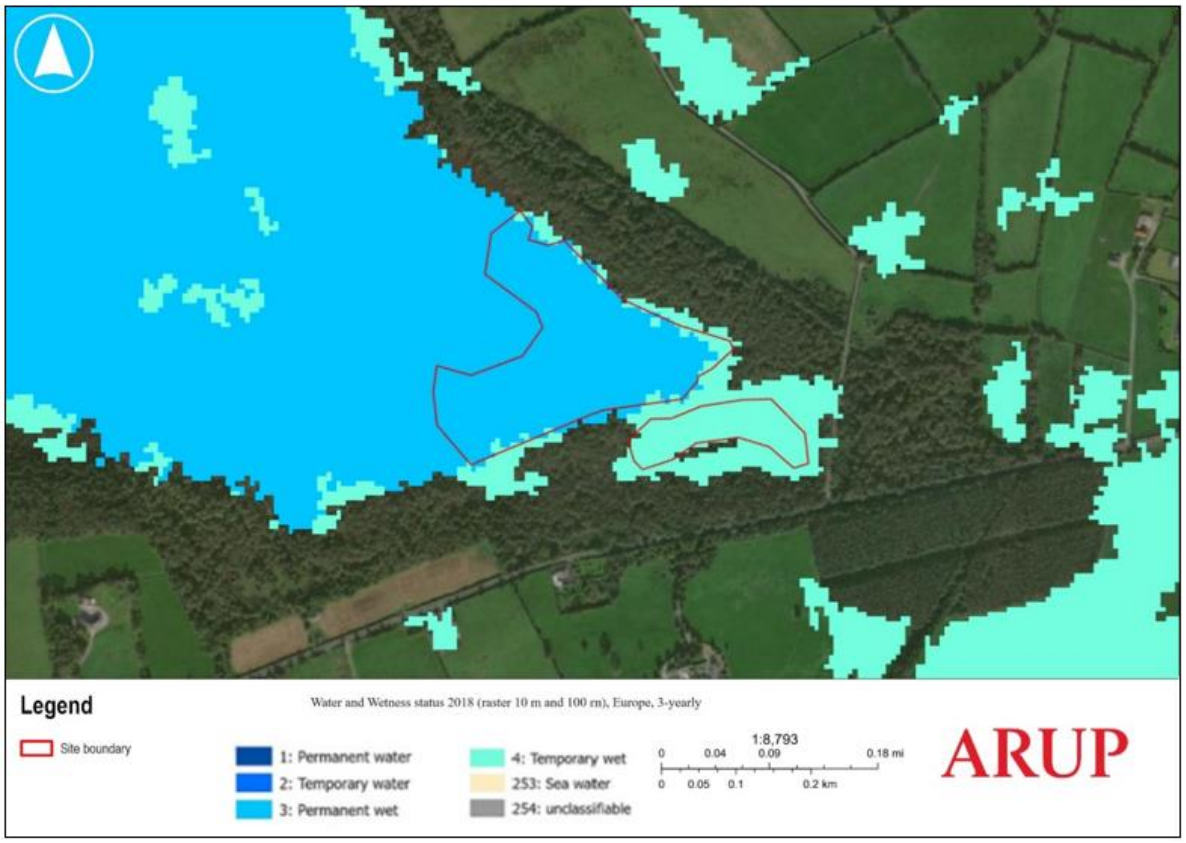


Figure 3-11: HRL Water and Wetness – 2018 of Killaun Fen (Copernicus, 2025)

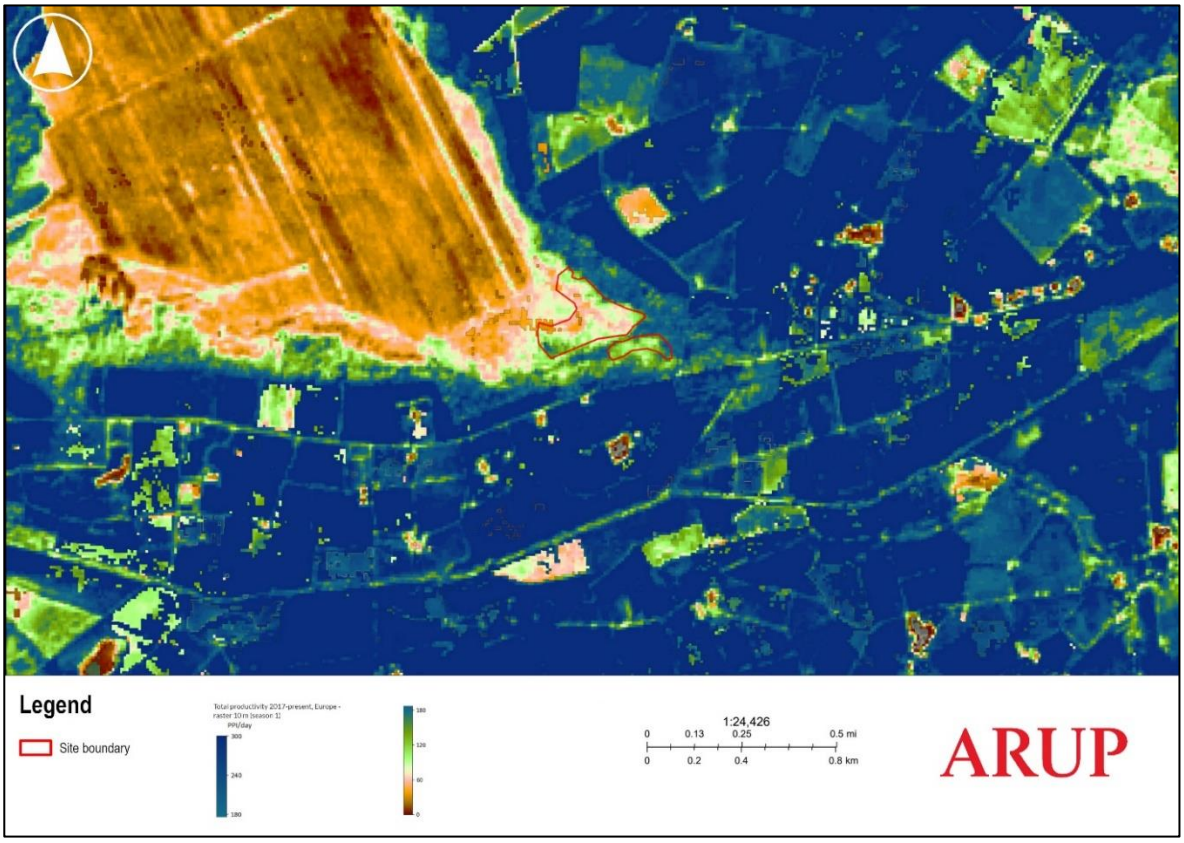


Figure 3-12: Total Productivity 2017 -present, Europe – raster 10m (season 1) of Killaun Fen (Copernicus, 2025)

Figure 3-13 to Figure 3-15 show the site photogrammetry and Digital Terrain Model (DTM) map of Killaun Fen, respectively. Both have been generated from LiDAR imagery. The image indicates one main drain entering the northeastern site boundary with northwest-southeast flow and approximately 0.4 m depth. This drain flows towards a larger drain that follows the eastern boundary of the site, flowing from northwest to southeast. Additionally, a drain flows from west to east separating the northern and southern sections of the site. The system outflow is believed to be a combination from the north-south drain and west-east drain flowing towards the drain parallel to the eastern boundary and the surface flow from the southern portion of the site, flowing towards the southern section and eventually to Camcor River.

Topographically, the site slopes at approximately 0.25 % from north to south along the main drain running northwest-southeast. The slope is higher where there is a transition from the high fen previously extracted from the area northwest of the site and the low vegetation present in the site, reaching a maximum of 4.2 %.

From west to east, in the northern portion of the site, the sites lower at a slope of approximately 0.25 %. Additionally, there are patches of higher terrain of approximately 30 m width in the centre of the northern portion of the site. In the southern portion, the slope west to south is circa 1.3 %, with many small lower points in the topography that could behave as drains.



Figure 3-13: Site Photogrammetry map of Killaun Fen

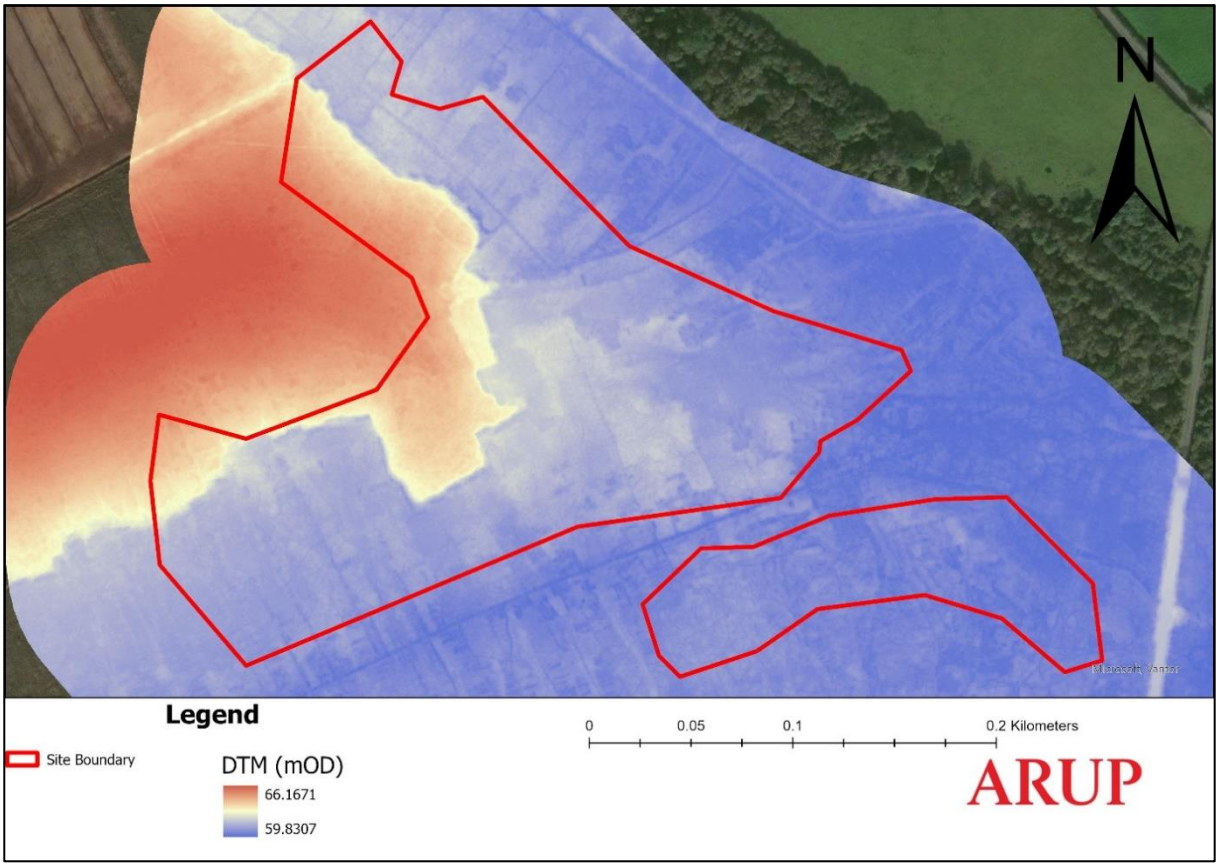


Figure 3-14: DTM Topographic (LiDAR) map of Killaun Fen

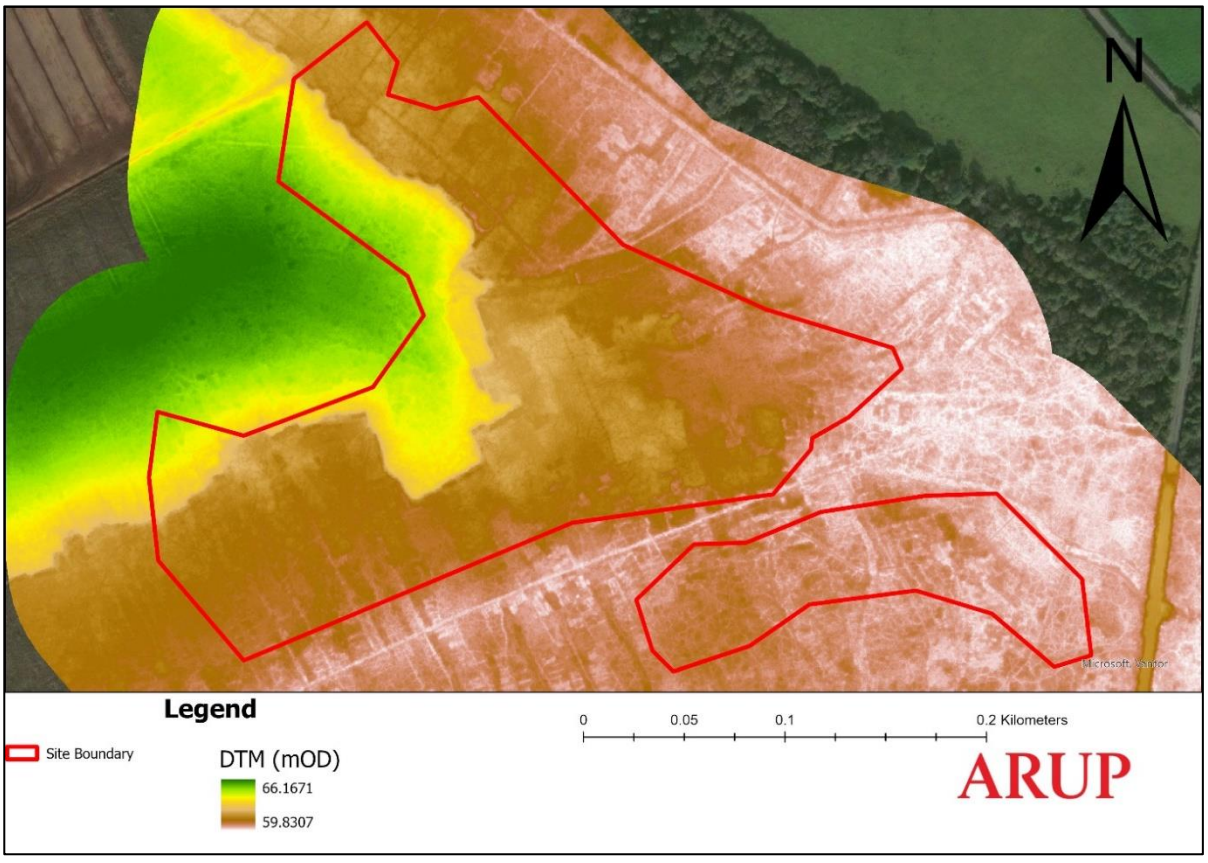


Figure 3-15: DTM Topographic (LiDAR) map of Killaun Fen

3.1.4 Land use Pressures and Water Quality

Pollution Impact Potential (PIP) maps (EPA 2025) show the highest risk areas in the landscape for losses of Nitrate and Phosphorus to waterbodies. The PIP models estimate the annual nutrient losses from agricultural land using spatial data on farm management, soil and hydrogeology. This information is relevant to the SSCO attribute “water quality and nutrients” and assess this against the SSCO target to maintain nutrient levels and support favourable conservation condition.

Areas identified as high risk for phosphorus loss are typically characterised by poorly draining soils and dominant overland flow pathways. These conditions facilitate the movement of phosphorus from the land surface into nearby waterbodies. PIP phosphorus mapping indicates that the risk of nitrate loss is very low within the immediate vicinity of the site (50m in all directions). Low risk nitrate classes are present near surface within 60 m of the site to the north and 120m to the south, indicating a low vulnerability to nitrate leaching in the immediate catchment of the lake to the soil layer (Figure 3-16).

The susceptibility of nitrate loss in the subsurface layer, connected to groundwater, is very low within a 250 m radius of the site (Figure 3-17). High risk areas for phosphorus loss typically have poorly draining soils and dominant overland flow pathways. Phosphorus PIP mapping identifies areas of elevated phosphorus risk in proximity to the site boundary to the south and northeast, typically associated with poorly draining soils and dominant overland flow pathways (Figure 3.1 15).

The maps indicate that phosphorus flow paths across the site range from medium to very risk, with areas of higher risk particularly noted in the southeast section of the site, near the bedrock aquifer faultlines. There are potential preferential pathways identified in the northwest and southeast boundary of the site where a drain was identified. Flow delivery paths and PIP for Phosphorus are presented in Figure 3-16.

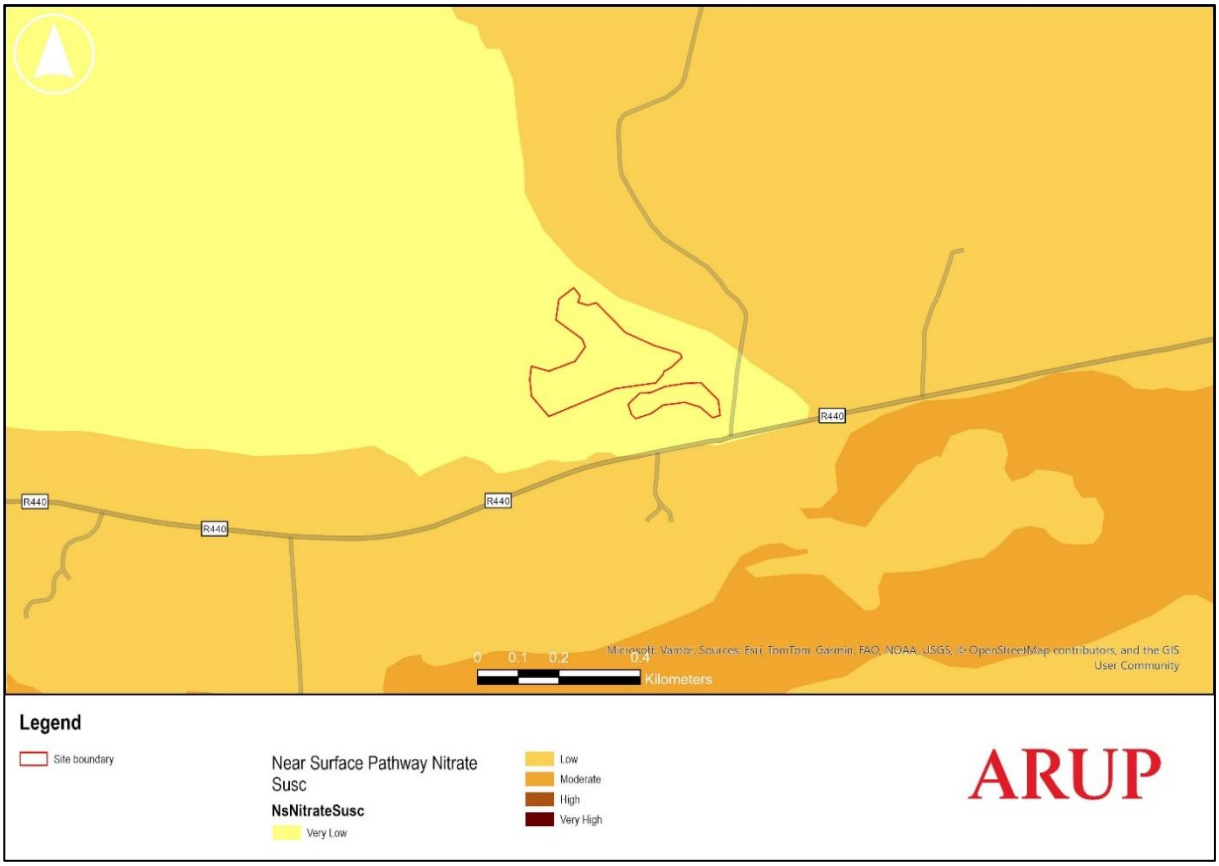


Figure 3-16: PIP maps – Near surface (Nitrate) of Killaun Fen

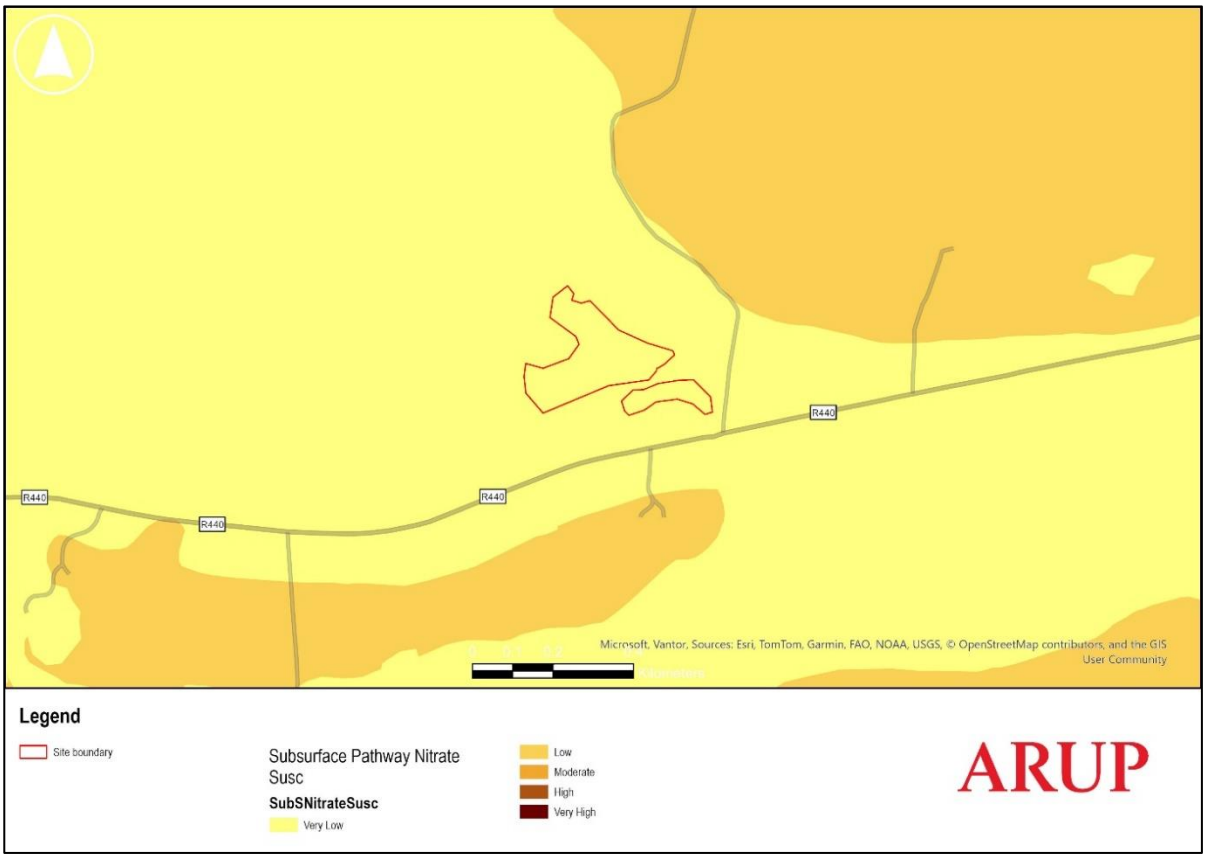


Figure 3-17: PIP maps – Subsurface (Nitrate) of Killaun Fen

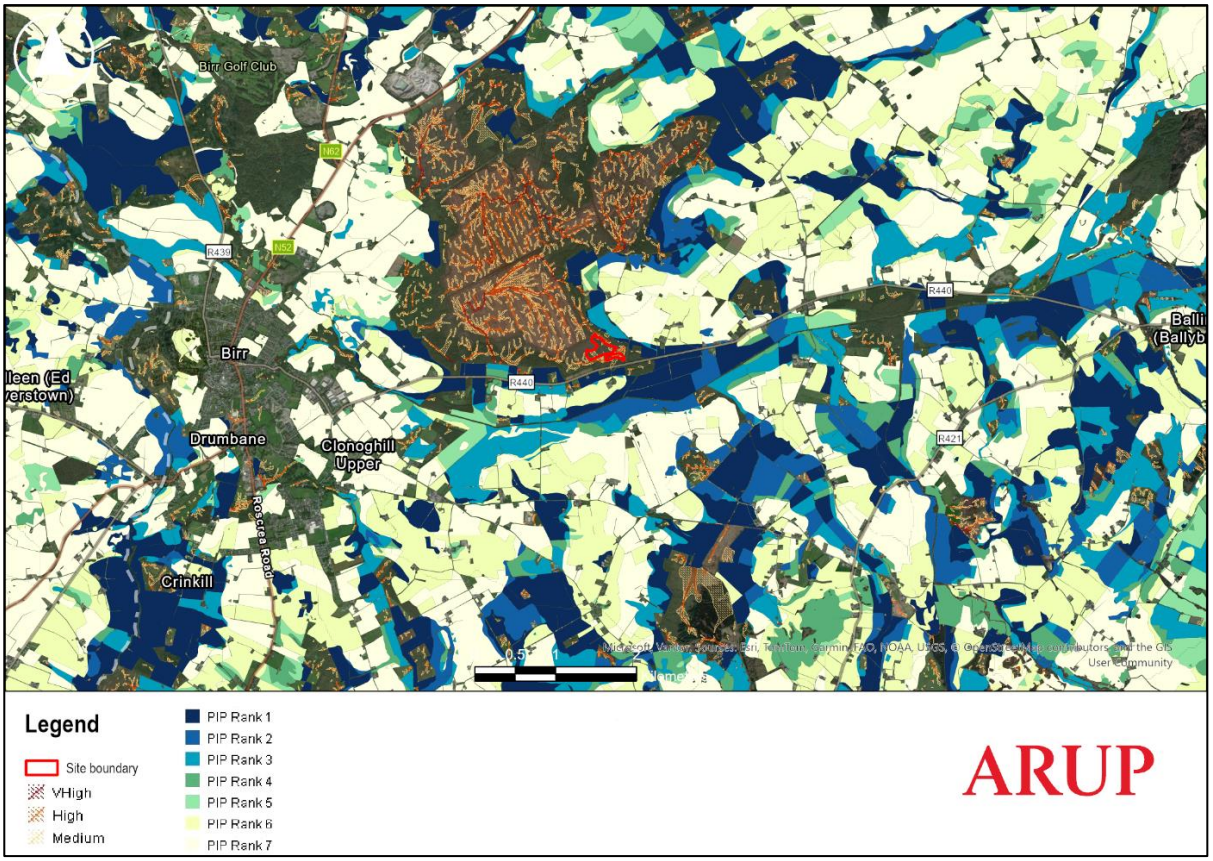


Figure 3-18: PIP maps + Flow delivery paths (Phosphorus) of Killaun Fen (EPA, 2021)

3.2 Field Survey

Electrical Conductivity (EC), pH and peat depth data were recorded as part of the NFS published on the 17th of August 2022 (Brophy et al., In Prep). The location of the water sample was not specified, but the recorded EC and pH at the site were 77 µS/cm and 4.75, respectively. Peat depth was also recorded at one location with a depth of 250 cm

Site monitoring, including peat depth probing, water quality and drainage network mapping, focused on developing the understanding of the water regime, pressures and implementation of restoration measures within the habitat.

Water quality data were collected from several areas within the site and its surroundings. Samples were obtained from the drains located in the northern area, as well as from the drains located along the southern and western boundaries. pH, EC, temperature, dissolved oxygen (DO), nitrate, and phosphate were recorded during the monitoring. Observations of water flow were made throughout the site's drainage network to further understand hydrological dynamics. Peat depths were measured at various locations across the site to assess substrate characteristics.

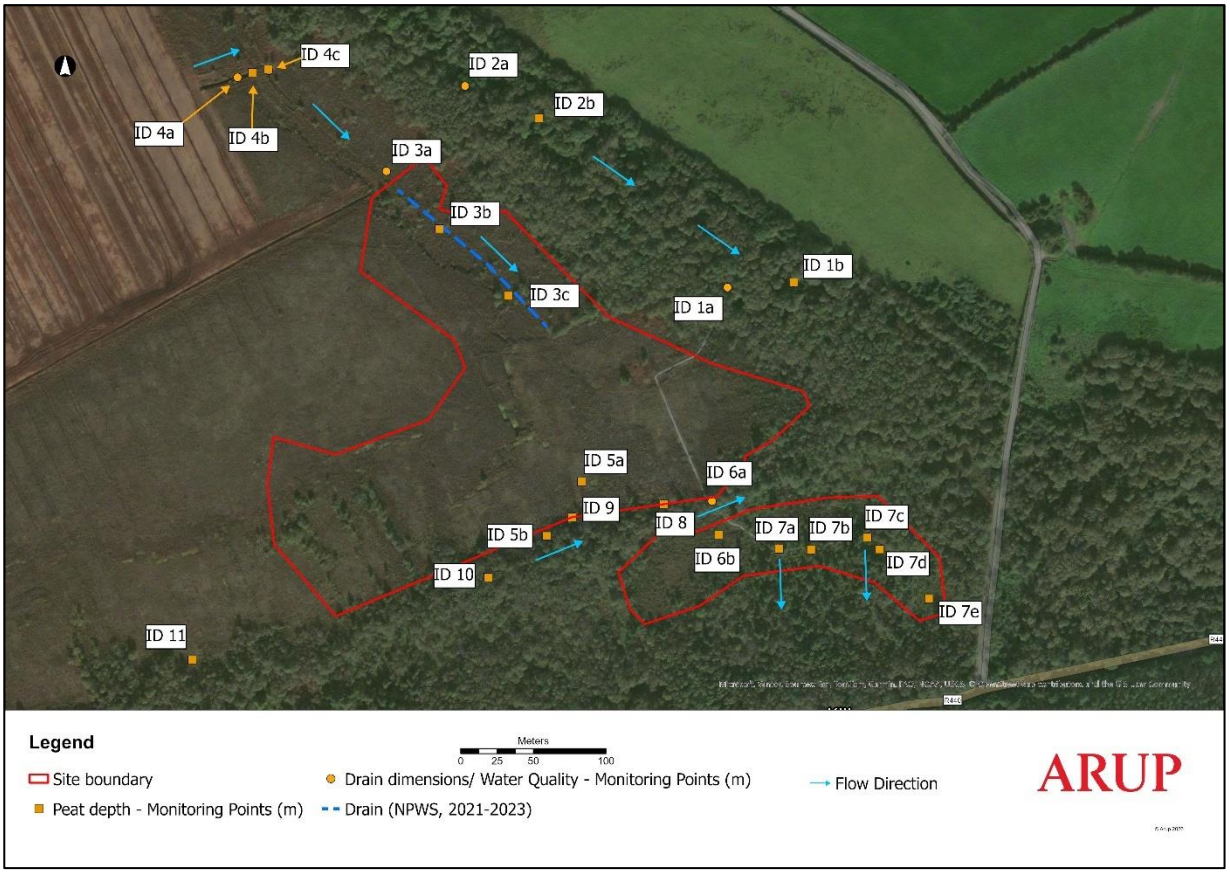


Figure 3-19: Baseline monitoring locations of Killaun Fen

3.2.1 Peat Depth Probing and Ground Investigations

Peat depth probing was conducted throughout the site to assess substrate characteristics (Table 3-1 and Figure 3-20).

Three peat depth measurements were taken in February 2026 and all showed deep peat, varying from 2.8 m (Point 4, collected northwest of the site close to the area where fens turn into fields) to 3.5 m (Point 7, collected at the beginning of the boardwalk in the southeast boundary of the site). The third measure taken registered a depth of 3 m and is correspondent to Point 5, located in the middle of the site.

Seven peat depth measurements were taken in May 2026 showing a variable depth across the site, but mostly deep peat. In the northern and southern regions, peat depths varying from 2.15 and 2.5 m. Two peat depth measurements were taken on the drain that runs parallel to the eastern boundary of the site, which have shown shallower depths. The first, located 55m downstream of point 2, registered a depth of 0.5 m in the drain bed and the second, located 200m downstream of the first point, registered a depth of 1 m.

Seven peat depth measurements were taken in June 2026 showing a variable depth across the site, but mostly deep peat within the site boundary and shallower peat across the west-east drain. Within the site, in the centre of its northern section, the two peat depth measurements taken were of 2.5 m. Northeast of the site, along the northwest-southeastern

drain, a peat depth of 0.5 m was recorded. Across the west-east drain, which starts west of the site and goes below the bridge that connects the northern and southern sections of the site, peat depths from 0.5 to 1 m were measured.

Table 3-1: Peat depth measurements at Killaun Fen

Location	Date of measurement	Peat depth (m)
ID 4b	May 2026	2.5
ID 4c	February 2026	2.8
ID 3b	May 2026	2
ID 3c	February 2026	2.15
ID 2b	February 2026	0.5
ID 1b	May 2026	1
ID 5a	February 2026	3
ID 5b	May 2026	2.25
ID 6b	February 2026	2.45
ID 7a	May 2026	2.15
ID 7b	May 2026	3.5
ID 7c	February 2026	2.5
ID 7d	February 2026	1.07
ID 7e	February 2026	1.90
ID 8	June 2026	1
ID 9	June 2026	0.5
ID 10	June 2026	0.75
ID 11	June 2026	0.5
ID 12	June 2026	2.5
ID 13	June 2026	2.5
ID 14	June 2026	0.5

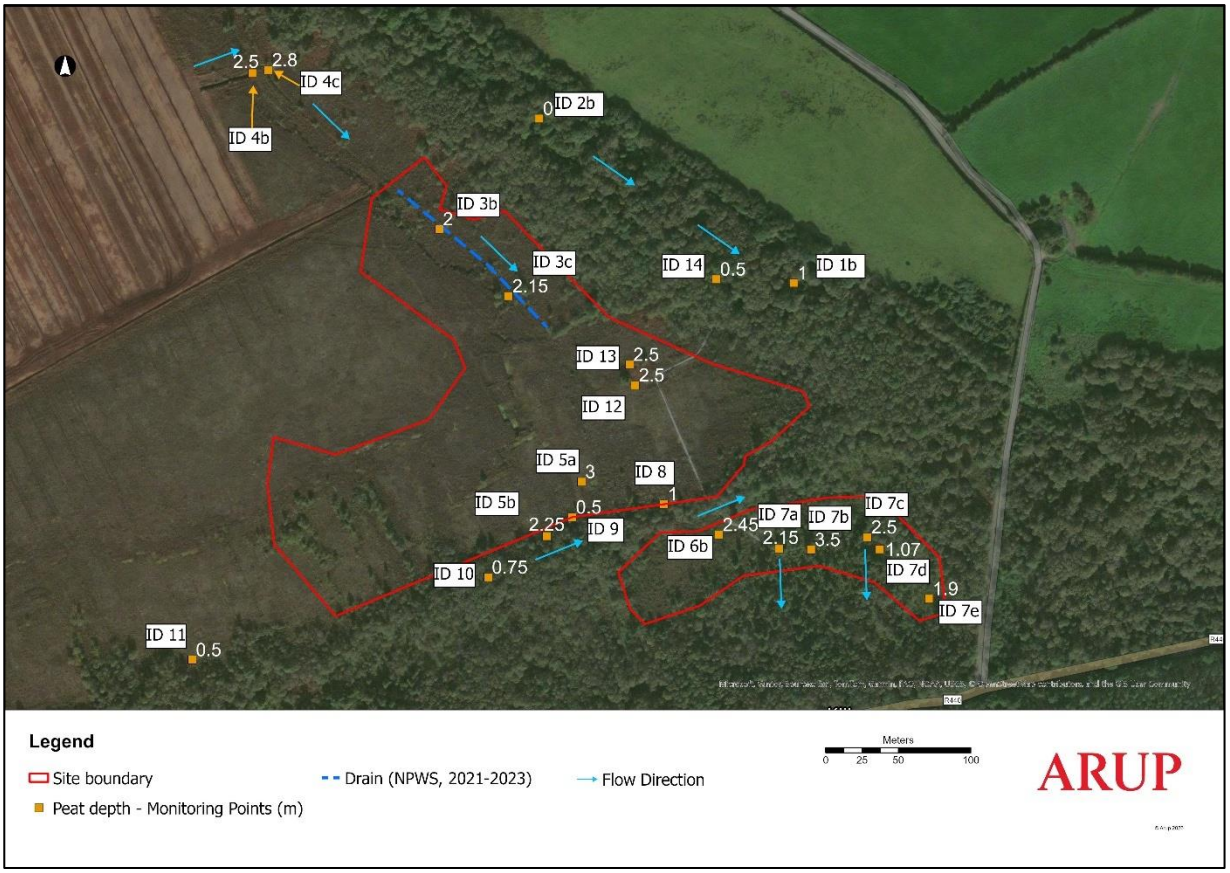


Figure 3-20: Baseline peat monitoring locations of Killaun Fen

3.2.2 Surface Water Drainage

Surface water conditions across the site showed the main flow paths are located along the site boundaries; towards the eastern boundary, from west to east and at the northeast corner, from north to south, parallel to a tree line.

Surface water conditions varied across the site, particularly with respect to flow regimes and drainage features, where the southern section present more stagnant water and shallower water table. Water measurements taken during the site visits is presented in Table 3-2 and these monitoring locations are presented in Figure 3-21.

The west-east drain that bisects the two sections of the site measure approximately 0.5 to 1.5 m in width and 0.5 to 1.25 m in depth (Points 6a, 5b, 8, 9, 10 and 11). A very low water flow was observed within this drain.

The north-south drain that is connected to the adjacent peat extraction drainage system and has shown different measures: in its northern part the measurements were 1.5 m in width and 1.5 m in depth (Point 3a); in the central it was 1.2 m in width and depth couldn't be measured (Point 3b); and in the south it was 2.5 m in width and 0.5 m in depth (Point 3c). The water level varies from 0.1 to 0.5 m in depth. Water flow was present along this drain.

A drain located outside the site boundary at the east has shown larger measurements, varying from 2 to 3 in depth and with 3 in width at two points (1b and 2b), in the northern and southern parts of the drain. Water flow was noted along this drain.

Table 3-2: Drain dimension measurements at Killaun Fen[3]

Location	Date of measurement	Water Level (m)	Drain depth (m)	Drain width (m)
ID 4a	February 2026	0.1	2	1.5
ID 4b	May 2026	0.1	1.5	1.5
ID 4c	February 2026	0.2	NI	1
ID 3a	February 2026	0.15	NI	1.2
ID 3b	May 2026	0.5	0.5	2.5
ID 2a	February 2026	NI	NI	2
ID 2b	May 2026	0.15	2.5 - 3	3
ID 1a	February 2026	0.3	NI	1.8
ID 1b	May 2026	0.3	2	3
ID 5b	May 2026	0.1	0.75	1.5
ID 6	February 2026	0.1	NI	1
ID 7a	February 2026	0.1	NI	NI
ID 8	June 2026	0.25	0.5	1
ID 9	June 2026	0.3	0.75	1
ID 10	June 2026	0.15	1	1
ID 11	June 2026	0.05	1	0.5

[3] NIT – Not Identified

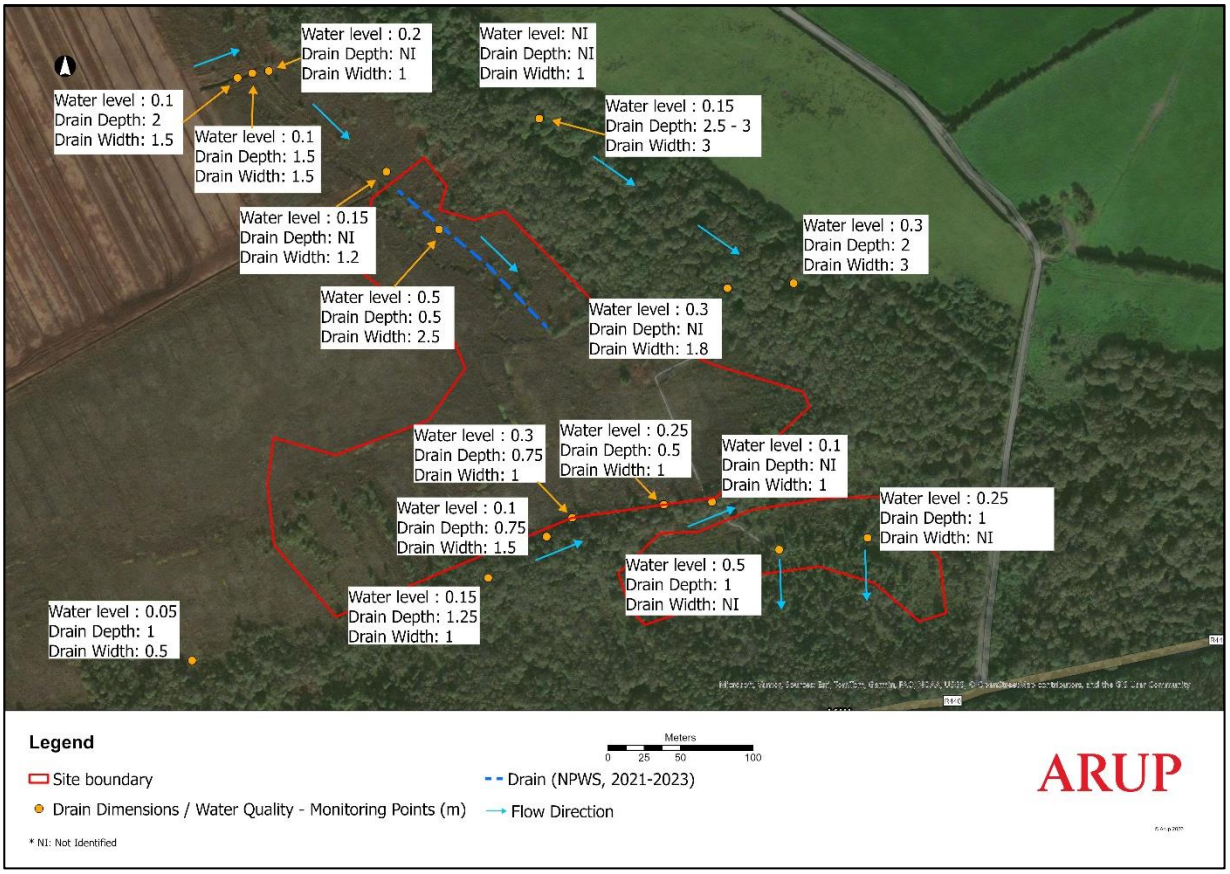


Figure 3-21: Drain dimension monitoring locations of Killaun Fen

3.2.3 Water Quality

Water quality monitoring shows spatial variation in nutrient concentrations across the site with potential sources of enrichment. Water quality measurements were taken in May and June 2026 and are summarised in Table 3-3.

Phosphate (PO_4^{3-}) concentrations are variable across the site (Figure 3-22), with most measurements exceeding the WFD good status environmental quality standard of (0.035 mg/L PO_4^{3-}). Higher phosphate concentrations of 2.71 mg/L were identified within the south section of the site at Point 7a and of 2.14 mg/L within the central part of the north-south main drain at Point 3b. The lowest concentration of 0 mg/L was registered outside the site boundary along the west-east drain that separate the northern and southern sections of the site at Point 9. This was the only measurement that complied with the WFD good status environmental quality standard of (0.035 mg/L PO_4^{3-}). Other concentrations at Killaun Fen varying from 0.04 to 1.2 mg/L.

Nitrate concentrations (NO_3^-) are also variable across the site (Figure 3-23). No measurements above the regulatory European groundwater threshold of 50 mg/L NO_3^- (Directive 2006/118/EC) were registered at the visited points. Although there is no regulatory surface water threshold for nitrate, concentrations of greater than 1.8 mg/L NO_3^- (8 mg/L NO_3^-N) may impact the ecological health of rivers (EPA, 2025b). Nitrate concentrations were generally

higher in the north where it ranged from 11 (Point 1b) to 3.7 (Point 3b). The highest nitrate concentration of 11 mg/L was recorded in the drain that runs parallel to the eastern boundary of the site. The lowest concentration of 0 mg/L was measured in the southern section, 80 m within the Killaun Fen boardwalk, at Point 7c, and at points 8, 9 and 10 along the west-east drain.

As fens are naturally nutrient-poor systems with respect to nitrogen and phosphorus, the recorded concentrations suggest potential nutrient enrichment, specifically in the eastern area, that may influence the achievement of the conservation targets. Additionally, several phosphate measurements exceeded the thresholds typically associated with Water Framework Directive (WFD) good or high ecological status.

pH values ranged from 5.78 to 7.81 (Figure 3-24), presenting more acidic conditions within the main north-south drain, starts outside the site boundary adjacent to the peat extraction area (Points 3b and 4b) and slightly basic conditions in the parallel drain to the eastern boundary of the site (Points 1b and 2b). The west-east drain that separate the northern and southern sections of the present slightly acid to neutral conditions.

Within the north-south drain, EC values (Figure 3-25) presented extremely low values of 76 µS/cm (Point 3b) and 78 µS/cm (Point 4b) where the pHvalues were acidic. , In the parallel drain at the eastern boundary of the site, conductivity values were more compatible with groundwater, ranging from 668 (Point 1b) to 721 µS/cm (Point 2b). At the west-east drain that separates the northern and southern sections of the site from the southern area of the site, conductivity values were very low indicating evidence of surface water conditions, where it ranges from 169 to 389 µS/cm.

Temperature (Figure 3-26) was also higher within the north-south drain, presenting 15.4 °C at Point 3b and 15.5 °C at Point 4b. At the parallel drain at the eastern boundary, it was lower at Point 1b (10.7 °C) and Point 2b (11.1 °C). Along the west-east drain, the temperature varied from 10.3 to 13.2°C whereas in the southern area it ranges from 11.5 to 13.7 °C.

Table 3-3: Water quality measurements at Killaun Fen

Location	Date of measurement	Phosphate (mg/L)	Nitrate (mg/L)	EC (µS/cm)	pH	Temperature (C)
ID 4b	May 2026	0.11	5.6	78	5.78	15.5
ID 3b	May 2026	2.14	3.7	76	5.78	15.4
ID 2b	May 2026	1.2	3.9	721	7.81	11.1
ID 1b	May 2026	0.62	11	668	7.47	10.7
ID 5b	May 2026	0.48	2.8	389	6.71	10.3
ID 7a – Sample 1	May 2026	2.71	0.0	175	6.21	13.7

Location	Date of measurement	Phosphate (mg/L)	Nitrate (mg/L)	EC (µS/cm)	pH	Temperature (C)
ID 7a - Sample 2	May 2026	0.08	3.2	177	6.29	12.3
ID 7c - Sample 1	May 2026	0.26	0	365	6.9	11
ID 7c - Sample 2	May 2026	0.08	0	367	7.03	11.3
ID 8	June 2026	0.65	0	215	7.06	12.2
ID 9	June 2026	0.04	0	206	6.83	13.2
ID 10	June 2026	0	0	169	6.87	13.2
ID 11	June 2026	0.06	3.4	180	6.73	12.5

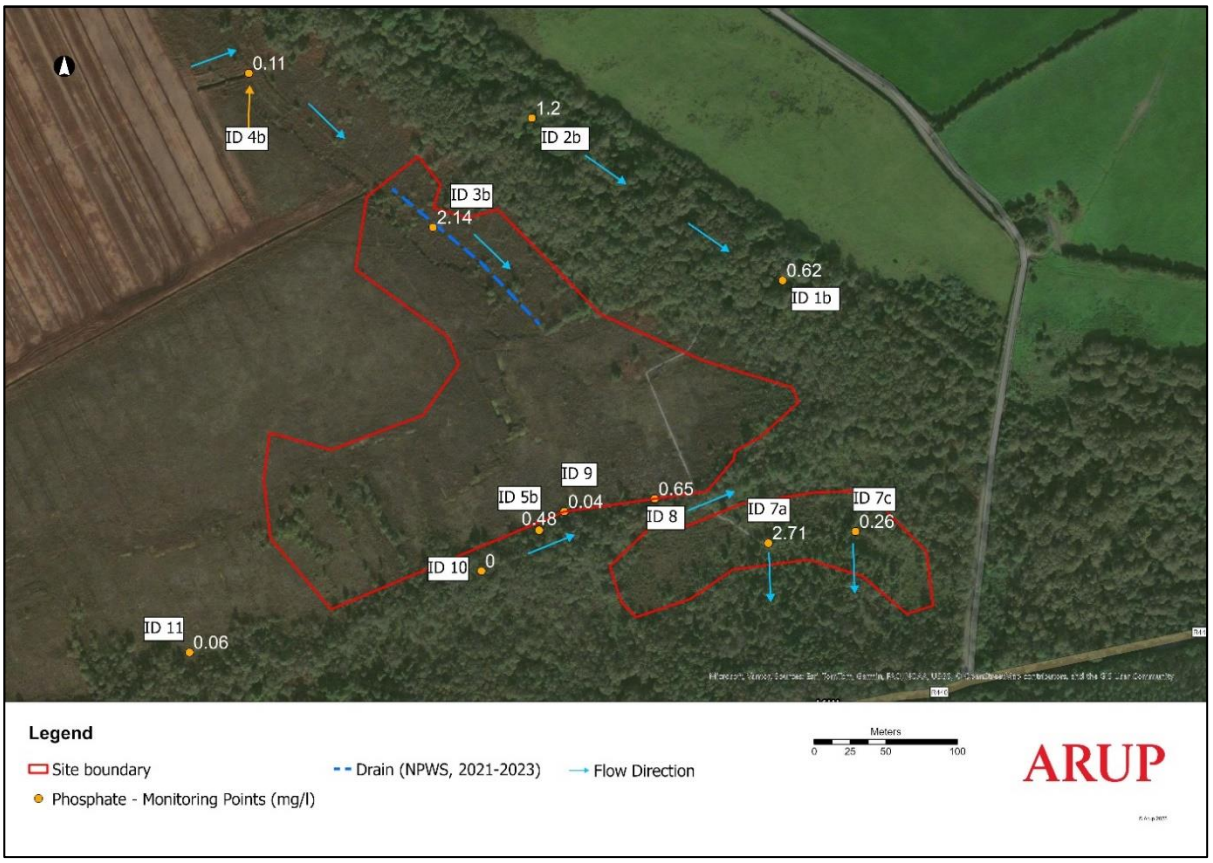


Figure 3-22: Phosphate monitoring locations of Killaun Fen

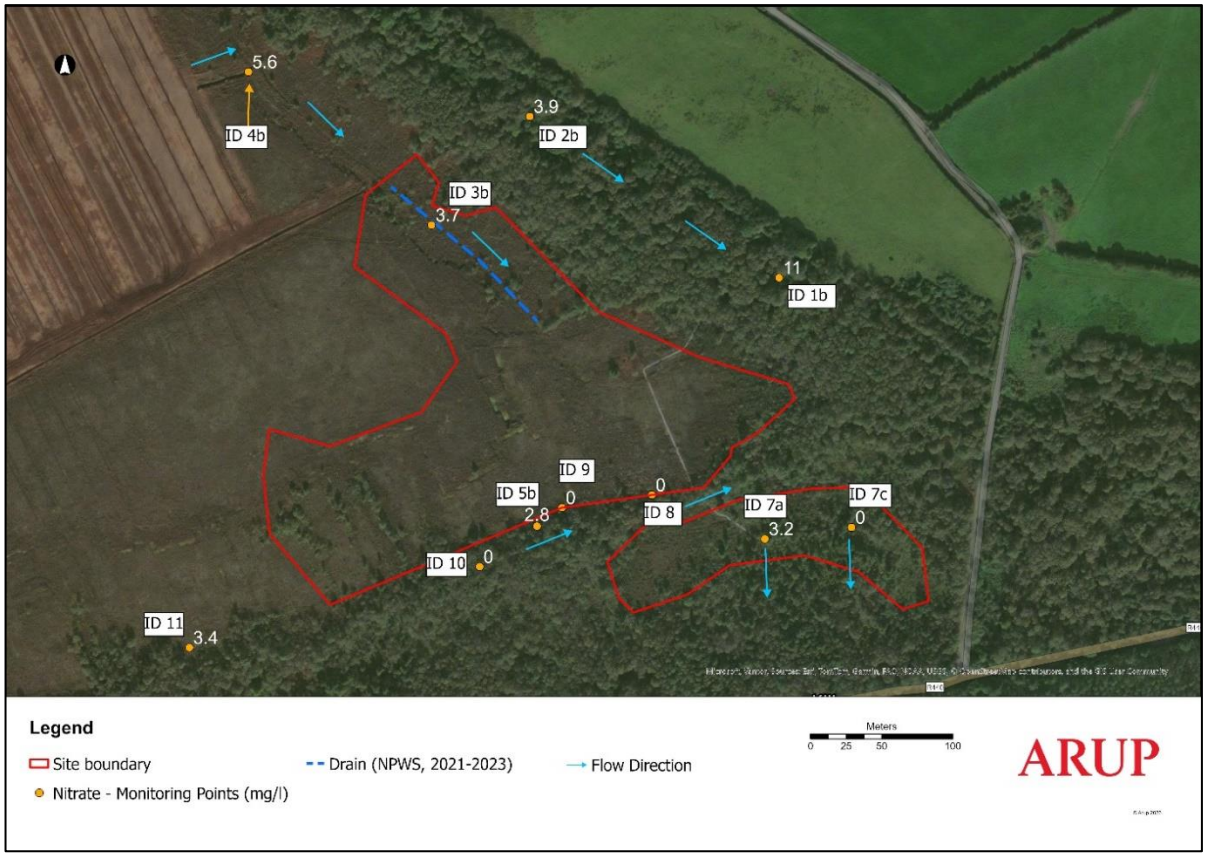


Figure 3-23: Nitrate monitoring locations of Killaun Fen

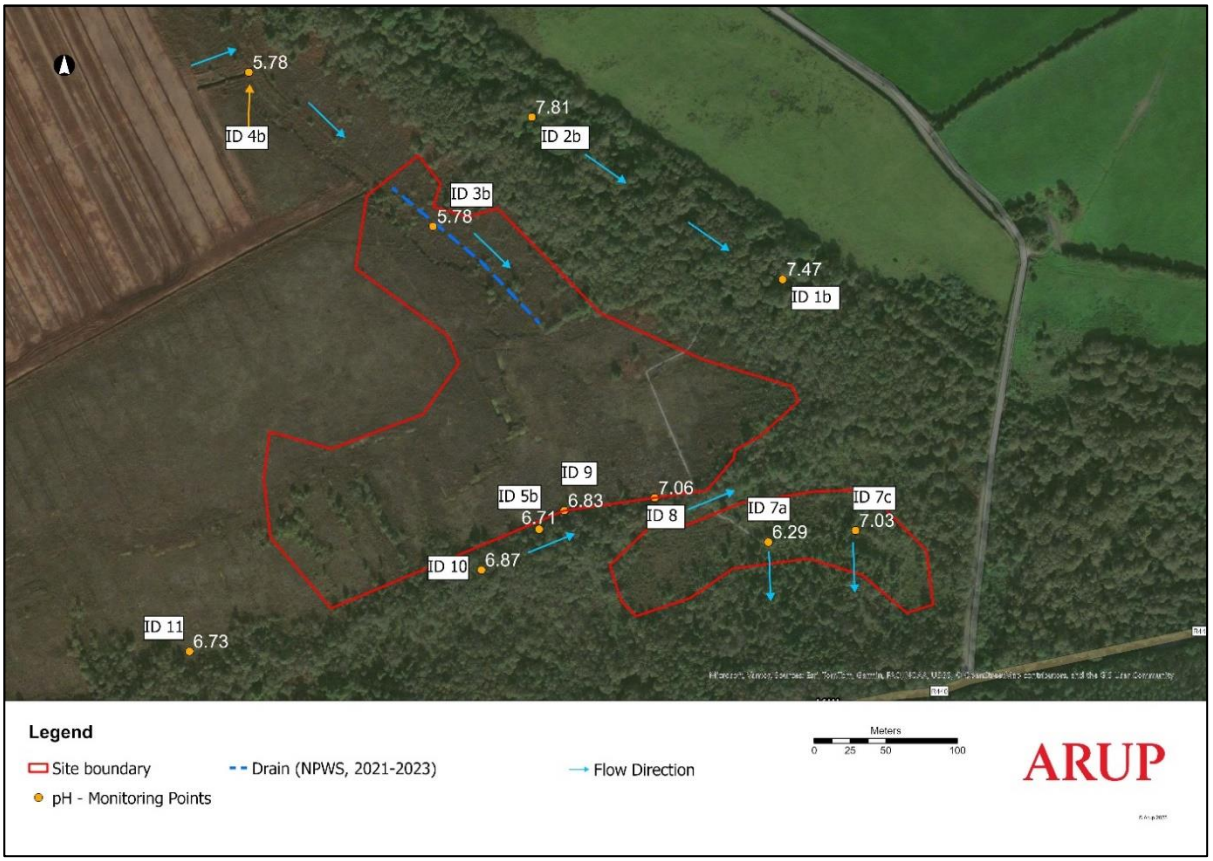


Figure 3-24: pH monitoring locations of Killaun Fen

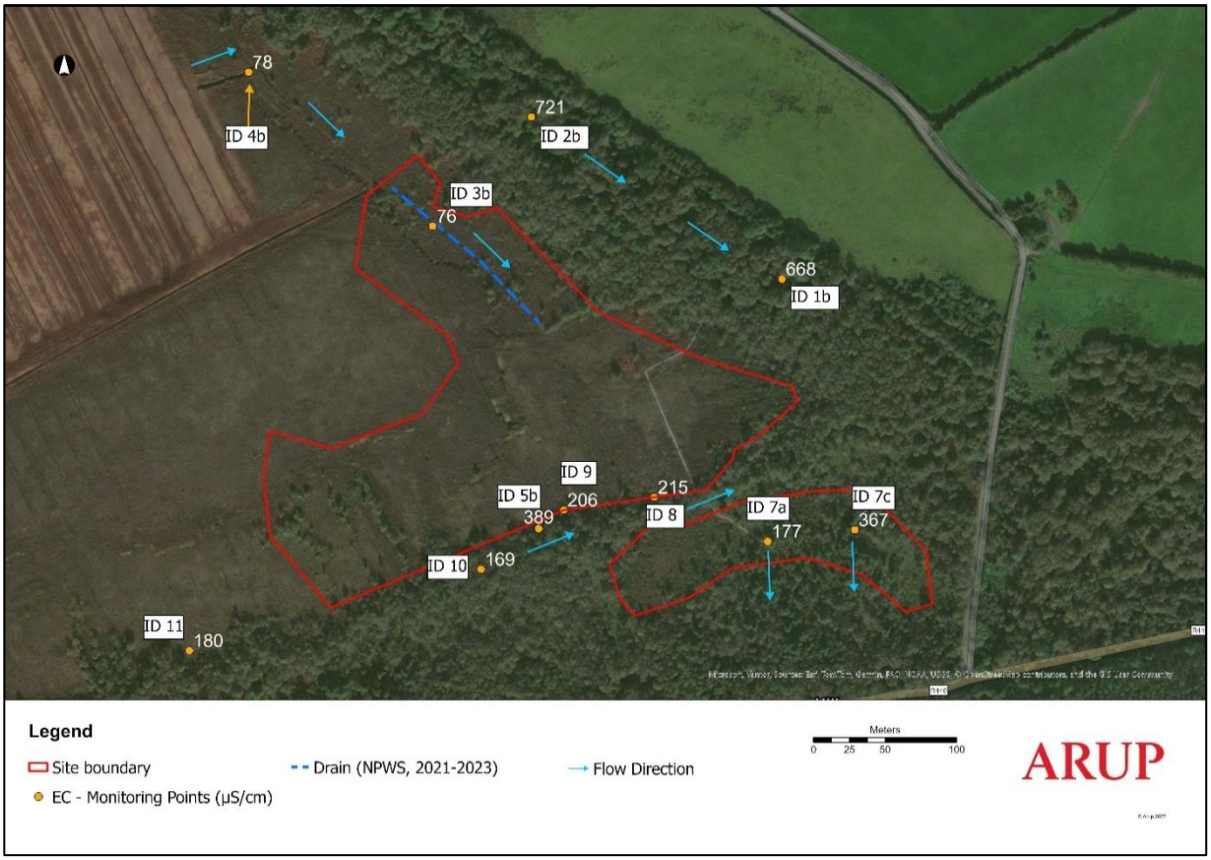


Figure 3-25: Electrical Conductivity monitoring locations of Killaun Fen

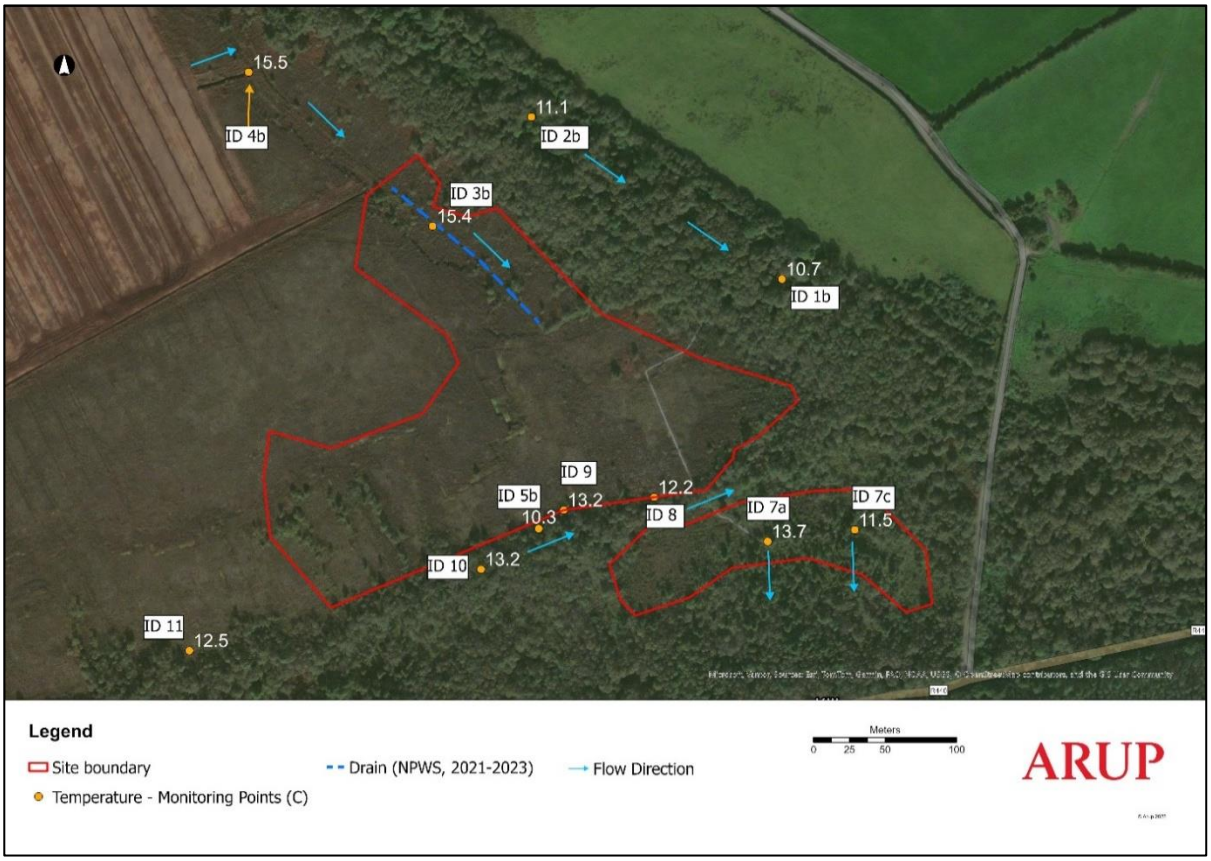


Figure 3-26: Temperature monitoring locations of Killaun Fen

3.3 Conceptual Site Model

Under the WETMEC framework defined by Wheeler, Shaw & Tanner (2009), Killaun Fen has different classifications across, between the southern and northern sections.

Due to historical drainage impacts, the fen in the southern section of the site aligns most closely with WETMEC Type 12 (Fluctuating Seepage Basins). This wetland type is typically associated with valley heads and shallow depressions where water levels fluctuate in response to groundwater conditions, resulting in shallow standing water for part or all of the year and limited directional flow.

Following the Fossitt classification system for the northern part of the site, the PB1 areas comprise the WETMEC Type 1 (Domed Ombrogenous Surfaces), while the PB4 areas comprise the WETMEC Type 4a (Drained Ombrogenous Bog). The WETMEC 1 areas correspond to raised bog habitat that remains predominantly rain-fed, whereas the WETMEC 4a areas represent historically drained and cutover peat where the natural hydrological regime has been modified by peat extraction and drainage activities.

The characteristics of the site are:

- Killaun Fen is not designated as a SAC, SPA, NHA or pNHA; however, it supports a range of ecologically valuable wetland habitats, including Annex I 7230 Alkaline Fen, which occupies approximately 5 % of the site. The site also comprises raised bog, cutover bog, rich fen, poor fen, bog woodland, wet willow woodland and scrub habitats.

- The topography of the site is relatively flat, ranging from 61 to 64 mOD. A slight descending slope is identified from northwest to southeast.

- Geologically, the site is underlain by the Lucan Formation, which comprises dark limestone and shale. The area west of the site is underlain by the Waulsortian Limestones Formation, consisting of massive limestones with submarine banks rich in lime mud. Within the site boundary, quaternary sediments are primarily cut-over raised peat. The layer below the cut-over peat is composed by till derived from limestone.

- Beneath the site lies a Locally Important Bedrock Aquifer which is moderately productive only in Local Zones (LI).

- Killaun Fen is divided into two sections: north and south, which exhibits distinct characteristics observed on site and evident from water quality monitoring. The northern comprises an area with previous peat extraction and cutover bog areas, with deep and wide drains and visible water flow. The southern is a more vegetated area, with shallow water table and predominantly stagnant water with slower flow at some portions and where Alkaline Fen is present.

- The base hydrochemistry confirms the differences between the northern area and the southern and also eastern area where the drain runs parallel and outside the site boundary. This drain clearly reflects groundwater contribution (pH 7.47 to 7.81, EC 668 to 721 µS/cm and temperature 10.7 to 11.1 °C), where the southern point presented higher values for both pH, EC and temperature. The north-south drain presented very acidic pH, extremely low conductivities and high temperature, which is probably a reflect of the adjacent peat extraction site and expected for cutover raised bog areas.

- The alkaline fen habitat in the southern section is characterised by species such as Black bog-rush *(Schoenus nigricans),* Purple moor-grass *(Molinia caerulea), Scorpidium cossonii* moss and Devil's-bit scabious *(Succisa pratensis).* The site is considered environmentally sensitive due to the presence of Annex-quality alkaline fen and other groundwater-dependent wetland habitats that may be susceptible to changes in groundwater quality and hydrological conditions.

- A drain on the northern boundary of the site, which is connected to the drainage system of the adjacent peat extraction site provides surface water inflow into the site and runs north-south. This drain continues to flow into the site in the same direction until the flow direction changes to east-west and joins a bigger drain parallel to the site, along its eastern boundary. Another drain between the northern and southern section of the site flows from west-east direction, however, it presents a much slower flow when compared to the northern drain. This drain continues flowing in the southeastern direction until it reaches road R 440, where it possibly keeps flowing to the southwest until reaches the Camcor River.

- Hydrological modifications to the site occurred through peat extraction at the northern section and extensive cutover bog to the south and east. The adjacent peat extraction site located in the northern boundary has also modified natural conditions of the site. These elements have influenced habitat development and the spatial distribution of springs and seepages over recent decades.

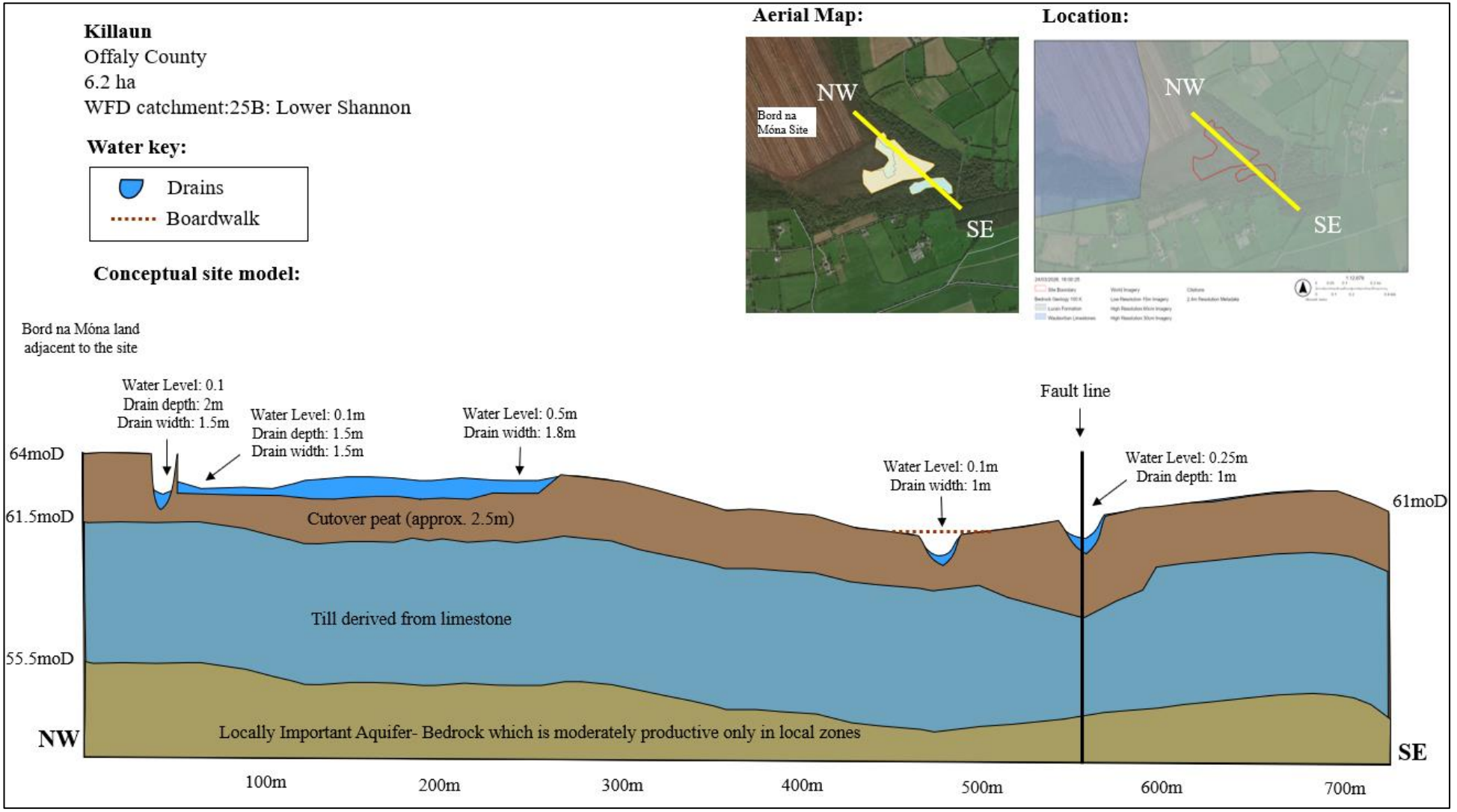


Figure 3-27: Conceptual site model of Killaun Fen - northwest to southeast (following the north-south drain)

4 Ecology

4.1 Desk Study

A review of available desktop information on the ecological baseline for Killaun was reviewed from the below information sources:

- NPWS Protected Sites – Special Areas of Conservation – River Nore and River Barrow SAC;
- NPWS Article 17 habitats distribution datasets;
- National Fen Survey (O'Neill, 2022);
- Biodiversity Maps - National Biodiversity Data Centre (NBDC);
- World Imagery Wayback - ArcGIS;
- Plant Atlas 2020 website - Botanical Society of Britain & Ireland (BSBI);

The NFS was commissioned to develop and test a standardised methodology for assessing the conservation status of fen habitats across Ireland. As part of this study, was selected as one of the sites for field survey. The site was surveyed in August 2022, with a focus on Annex quality wetland and fen habitats. The survey methodology included:

- Detailed vegetation assessments using quadrats to record species composition and structure.
- Hydrological observations such as water levels and flow.
- Documentation of disturbance indicators including drainage, grazing, and invasive species.

GPS mapping and photographic records were also used to support habitat boundary delineation and condition assessment. While the primary emphasis was on habitat quality, vascular plants and bryophytes were recorded as part of the vegetation surveys, contributing to an understanding of species diversity and habitat integrity at the site.

4.1.1 Habitats

The desk study of Killaun, which included the results of the 2022 NFS of the site, revealed that the site itself comprises Annex quality 7230 Alkaline fen alongside raised bog, cutover bog, bog woodland, scrub, rich fen and flush, and poor fen and flush. There is a drain that runs in the northern part of the site.

4.1.1.1 Annex Habitats

The following Annex quality habitat was identified and mapped:

- **7230 Alkaline fens** covering approximately 0.06 ha. Located within an area of rich fen and flush as well as poor fen and flush, this Annex quality habitat is present in several unshaded turf-cutting hollows. Species recorded include *Schoenus nigricans*, *Molinia caerulea* and *Scorpidium cossonii*.

4.1.1.2 Non-Annex/Fossitt habitats

- Non-Annex I fen and other habitats were also recorded, with mapping based on Fossitt (2000) classification. These include raised bog, cutover bog, bog woodland, scrub, rich fen and flush, poor fen and flush, and drains.

Table 4-1 Habitats recorded at Killaun in accordance with the Fossitt classification system (see Appendix B for map)

Habitat Type	Location	Notes
FW4 – Drainage ditches	Located in the northern area of the site.	Runs through an area of cutover bog.
PB1 – Raised bog	Located in the northern area of the site.	Adjacent to cutover bog habitat within the site.
PB4 – Cutover bog	Located in the northern area of the site.	This area also contains some scrub, bog woodland, and poor fen and flush.
PF1 – Rich fen and flush	Located in the southern area of the site.	Non-annex quality areas in the southern area of the site where the Annex-quality 7230 Alkaline fens habitat is located.
PF2 – Poor fen and flush	Located in the northern area of the site.	A small amount within an area dominated by cutover bog.
WS1 - Scrub	Located in the northern area of the site.	A small amount within an area dominated by cutover bog. Also present outside of but adjacent to the site boundary in which 7230 Alkaline fens habitat is present.
WN7 – Bog woodland	Located in the southern and northern areas of the site.	Located largely in the southern area of the site with a small amount in the north.

4.1.2 Species

The following subsections outline the presence of species recorded at or within the zone of influence of the Killaun site. This includes protected species listed under relevant legislation and conservation frameworks such as the EU Habitats and Birds Directives (Annex I, II, IV, and V), the Irish Red Lists, and the Wildlife Acts (including species protected under the Flora Protection Order. Where available, maps of recorded sightings will be provided to support spatial understanding of species distribution. Records are limited to those from the past ten years, reflecting the most plausible timeframe for continued presence and ecological relevance

to the site - excepting where invasive species have been historically recorded and there has been no indication since of their elimination.

4.1.2.1 Species Within the Site

The species within the Table 42 below were identified using the NBDC interactive maps service, reviewing the NFS documentation and from the ecological walkover conducted in 2026.

Table 4-2 Species records within Killaun

Common Name	Latin name	Description	Most recent record
Black bog-rush	*Schoenus nigricans*	A sedge species that grows in calcareous and base-rich fens, it is associated with 7230 Alkaline fens.	2022
Purple moor-grass	*Molinia caerulea*	A widespread and often locally abundant grass species which occurs on wetland habitats.	2022
Marsh helleborine	*Epipactis palustris*	Widespread but declining orchid Occurs in fens, damp grassland, marshes and dune slacks, typically on calcareous wetland soils.	2022
Intermediate hook-moss	*Scorpidium cossonii*	A brown moss associated with calcareous fens and flushes.	2022
Grey wagtail	*Motacilla cinerea*	A red-listed bird on the Birds of Conservation Concern Ireland list. Associated with wetland habitats and aquatic environments.	2024
Dark tussock	*Dicallomera fascelina*	A near threatened species of moth.	2022
Smooth newt	*Lissotriton vulgaris*	A protected amphibian	2022

4.1.2.2 Species within the Zone of Influence

Table 4-3 outlines the functionally linked species recorded within the 2 km distribution zone of influence around Killaun within the last ten years from NBDC. A notable species returned from this NBDC data search was Geyer's whorl snail *Vertigo geyeri*, which was recorded in adjacent agricultural lands to the east of the site.

Table 4-3 Species records within 2km of Killaun

Legislative Protection	Common name	Latin Name
EU Birds Directive	Kingfisher	*Alcedo atthis*
EU Birds Directive	Mallard	*Anas platyrhynchos*

Legislative Protection	Common name	Latin Name
EU Habitats Directive	Common Frog	*Rana temporaria*
EU Habitats Directive	Geyer's Whorl Snail	*Vertigo geyeri*
EU Habitats Directive	Acute-leaved Bog-moss	*Sphagnum capillifolium s.l.*
EU Habitats Directive	Papillose Bog-moss	*Sphagnum papillosum*
EU Habitats Directive	Otter	*Lutra lutra*
EU Habitats Directive	Pine Marten	*Martes martes*
Wildlife Acts	Goldcrest	*Regulus regulus*
Wildlife Acts	Greenfinch	*Chloris chloris*
Wildlife Acts	Grey Wagtail	*Motacilla cinerea*
wildlife Acts	Meadow Pipit	*Anthus pratensis*
Wildlife Acts	Mistle Thrush	*Turdus viscivorus*
Wildlife Acts	Robin	*Erithacus rubecula*
Wildlife Acts	Sparrowhawk	*Accipiter nisus*
Wildlife Acts	Stonechat	*Saxicola rubicola*
Wildlife Acts	Swallow	*Hirundo rustica*
Wildlife Acts	Willow Warbler	*Phylloscopus trochilus*
Wildlife Acts	Yellowhammer	*Emberiza citrinella*
Wildlife Acts	Badger	*Meles meles*
Wildlife Acts	Hedgehog	*Erinaceus europaeus*
Wildlife Acts	Pygmy Shrew	*Sorex minutus*
No legislative protection	Dipper	*Cinclus cinclus*
No legislative protection	Grey Heron	*Ardea cinerea*
No legislative protection	House Sparrow	*Passer domesticus*
No legislative protection	Starling	*Sturnus vulgaris*
No legislative protection	Least Bur-reed	*Sparganium natans*
No legislative protection	Himalayan Balsam	*Impatiens glandulifera*
No legislative protection	Three-cornered Garlic	*Allium triquetrum*
No legislative protection	Copper Diver	*Ilybius chalconatus*
No legislative protection	Dark Tussock	*Dicallomera fascelina*
No legislative protection	Common Whorl Snail	*Vertigo pygmaea*
No legislative protection	Jenkins' Spire Snail	*Potamopyrgus antipodarum*
No legislative protection	Marsh Whorl Snail	*Vertigo antivertigo*
No legislative protection	Slippery Moss Snail	*Cochlicopa cf. lubrica sensu Anderson 2008*

4.2 Field Survey

Following a comprehensive review of available desktop data, a targeted follow-up ecological survey was undertaken on the site in April 2026. The field surveys concentrated on key areas highlighted during the desk-based assessment, specifically those with potential for restoration activities. These locations were investigated in detail to verify and further assess ecological conditions and parameters, ensuring that any recommended restoration measures would be both appropriate and effective in the identified zones.

Two survey forms were created to collect data relevant to:

- Monitoring data; and
- Pressures and threats.

4.2.1 Monitoring Points

To inform the restoration plan for Killaun, a targeted walkover survey was undertaken. This was a focused assessment designed to gather site-specific data at pre-identified locations. The walkover was designed to assess ecological condition at two pre-identified monitoring points (Monitoring Points 1 and 2), selected based on hydrological features, habitat potential, and restoration feasibility. The locations were determined through expert discussion and review of baseline data and will serve as fixed monitoring stations post-restoration. A map of survey points is provided in Appendix B.

These monitoring points now serve a dual purpose:

- Baseline characterisation of current site conditions.
- Long-term monitoring stations to assess ecological change following restoration.

The surveys focused on three key components:

- Target Notes: Qualitative observations at each monitoring point, capturing site condition, vegetation structure, hydrological features, and legacy management.
- Pressures and Threats Identification: Systematic recording of anthropogenic and natural pressures affecting each location.

The surveys confirmed the presence of several fen habitat types, notably the Annex quality habitats of:

- 7230 Alkaline fens: Detected at monitoring points 2, failed at monitoring point 1.

4.2.2 Pressure & Threats

This section outlines the historical and current pressures and threats affecting fen habitats at Killaun, with emphasis on Annex quality 7230 Alkaline fens.

4.2.2.1 7230 Alkaline fens

Historical Pressures

The NFS determined that the structure and functions of the Annex quality 7230 Alkaline fen habitat at Killaun was 'Unfavourable – Bad', with negative pressures relating to problematic native species (rank vegetation).

- **Scrub encroachment** is arising from the ongoing spread of gorse across the southern area of the site, leading to shifts in species composition and a decline in characteristic fen species.
- **Drainage** is present on site and is considered to be facilitating scrub encroachment.
- **Rank vegetation** persists within areas of rich fen and flush on site. This form of natural succession is leading to an altered community composition in areas containing Annex quality 7230 Alkaline fens which can be remedied with a suitable grazing period by appropriate stock (e.g. Kerry blue or droimeann cattle).
- **Material waste** has been noted in the southern area of the site which contains Annex-quality 7230 Alkaline fens habitat.

Current Observations

Recent walkover surveys and pressure/threat monitoring data recorded at monitoring points where Annex I quality 7230 Alkaline fen is present indicate the following site-specific pressures:

- **Drainage** is recorded as affecting the site at monitoring points associated with alkaline fen habitat, including both direct drainage impacts and broader hydrological modification. These features are contributing to altered water levels and localised drying, which in turn influences vegetation structure and species composition
- **Scrub encroachment**: Encroachment by beech, gorse and pine trees is occurring within and adjacent to remnant alkaline fen vegetation, resulting in increased shading, drying and loss of open fen structure. Additionally, encroachment from adjacent areas of cutover bog is acting as sources of scrub and rank species.
- **Rank vegetation** in the form of Molinia caerulea is in a high abundance within and surrounding the 7230 Alkaline fen, indicating the development of rank, competitive swards which suppresses characteristic fen species.

4.2.3 Additional Observations

In addition to the pressures and threats identified in the area mapped for 7230 Alkaline fen, additional observations on pressures and/or threats to the whole site were made in April 2026:

- **Drainage and altered hydrology**: Drainage channels and culverts occur across the site and are influencing water movement, with evidence of both standing water in low-lying areas and drying on elevated ground. This indicates hydrological imbalance,

where drainage is contributing to water loss and local drying, particularly in cutover areas, while restricting natural water retention. This promotes peat oxidation and reduces suitability for wetland habitats.

- **Scrub and woodland encroachment**: Scrub and woodland species, including beech, willow, pine, holly and gorse, are widespread across the site, with both mature stands and regenerating individuals recorded. Encroachment from surrounding woodland and cutover areas is resulting in increased shading and drying, driving succession towards scrub and woodland habitats.
- **Rank vegetation (Molinia dominance):** *Molinia caerulea* dominates large areas, particularly along the boardwalk and across open ground, forming dense, tussocky swards with limited bryophyte cover. This reflects low management and/or drying conditions, suppresses characteristic wetland species, and promotes further vegetation homogenisation.
- **Peat cutting legacy and cutover influence**: Extensive cutover bog areas (PB4) are present, heather vegetation and limited Sphagnum development. These degraded areas act as a source of scrub colonisation and drier vegetation communities, contributing to fragmentation and reducing overall habitat quality.
- **Recreational disturbance and access** are evident across the site. Unauthorised paths extending from the boardwalk into adjacent peatland areas indicate regular foot traffic, forming desire lines through the bog. Repeated use of these routes has led to the trampling and loss of vegetation, resulting in linear areas of exposed bare peat at the surface. This process contributes to localised erosion and degradation of sensitive peatland habitats.
- **Nutrient enrichment and competitive species**: The dominance of competitive species (e.g. Molinia and grasses) and limited moss development in places indicate nutrient imbalance or enrichment, favouring fast-growing species and reducing habitat quality and diversity.

4.3 Site Conservation Priority Matrix for Killaun

The restoration actions proposed (Table 4-3) for the Annex quality 7230 Alkaline fens habitat at Killaun are expected to deliver broader ecological benefits beyond their target habitat types. If these measures are successfully implemented and sustained, they may positively influence associated features such as European priority species, nationally important species, and locally significant habitats and species. In such cases, the additional restoration interventions outlined for these other features may become unnecessary or only partially required. However, to validate and understand the extent of these mutual benefits, ongoing post-restoration monitoring will be essential. This will ensure that improvements are not limited to Annex quality habitat alone but will also extend to the wider ecological network within and around the site.

Table 4-4 Site Conservation Priority Matrix for Killaun

Level	Feature Type	Feature Name	Extent/Population	Pressure/threat	Restoration Measure on-site	Restoration Measure off-site
1	SAC Habitat	7230 Alkaline fens	0.06ha	Scrub Encroachment Drainage Rank vegetation Material waste	Vegetation monitoring Drain blocking and hydrological monitoring Scrub removal (where necessary) Removal of dumped waste material	Buffer zone management (Management of scrub encroachment)
2	NHA Habitat	N/A	N/A	N/A	N/A	N/A
3	European priority species	N/A	N/A	N/A	N/A	N/A
4	Nationally important species	See Table 4-2 and Table 4-3	See Table 4-2 and Table 4-3	Habitat degradation via scrub encroachment	Vegetation monitoring Scrub removal (where necessary)	Buffer zone management (Management of scrub encroachment)
5	Habitats and species of local interest	PB1 – Raised bog	See Appendix B	Drainage Scrub encroachment	Vegetation monitoring Scrub removal (where necessary) Drain blocking and hydrological monitoring	Buffer zone management (Management of scrub encroachment and drainage)
		PB4 – Cutover bog	See Appendix B	Drainage Scrub encroachment	Vegetation monitoring Scrub removal (where necessary) Drain blocking and hydrological monitoring	Buffer zone management (Management of scrub encroachment and drainage)
		PF1 – Rich fen and flush	See Appendix B	Rank vegetation Drainage Scrub encroachment Material waste	Vegetation monitoring Scrub removal (where necessary) Drain blocking and hydrological monitoring Removal of dumped waste material	Buffer zone management (Management of scrub encroachment and drainage)

Level	Feature Type	Feature Name	Extent/Population	Pressure/threat	Restoration Measure on-site	Restoration Measure off-site
		PF2 – Poor fen and flush	See Appendix B	Drainage Scrub encroachment	Vegetation monitoring Scrub removal (where necessary) Drain blocking and hydrological monitoring	Buffer zone management (Management of scrub encroachment and drainage)
		WN7 – Bog woodland	See Appendix B	Drainage Scrub encroachment	Vegetation monitoring Scrub removal (where necessary) Drain blocking and hydrological monitoring	Buffer zone management (Management of scrub encroachment and drainage)

4.4 Impact Assessment Notes

Restoration actions proposed for Killaun aim to improve the ecological condition of sensitive wetland and fen habitats, particularly the Annex I quality 7230 Alkaline fen. These actions are designed to support favourable conservation status and enhance habitat resilience. However, potential impacts, both direct and indirect, must be carefully assessed to ensure no inadvertent negative impacts occur.

Potential Impacts

- **Habitat loss** – low risk - Restoration actions (i.e. scrub removal) are designed to enhance existing habitats rather than remove them. However, minor loss of degraded habitat may occur during scrub clearance.
- **Habitat degradation –** moderate risk - Potential degradation could occur if restoration measures are poorly implemented or monitored. This could occur where scrub removal without follow-up could lead to erosion or colonisation by invasive species or access to the site for continued ecological and hydrological monitoring is undertaken without due care.
- **Species disturbance** – very low risk – where required works will be appropriately timed to minimise risk of disturbance, with supervision by an Ecological Clerk of Works where necessary.
- **Accidental pollution release** – very low risk - No chemical inputs are proposed. However, machinery use (if any) could pose a risk of fuel/oil leaks. This is mitigated by avoiding machinery in sensitive areas and using hand tools where possible.
- **Introduction and/or spread of invasive non-native species** – moderate risk - Restoration activities (e.g. soil disturbance, water movement) could facilitate dispersal of invasive species. Monitoring and biosecurity protocols will be embedded into the site plan to avoid such risks

4.5 Good Practice Recommendations

Several good practice measures are recommended based on the requirement for compliance with legislation but also the occurrence of sensitive receptors and possible pathways for negative effects during preparation for or implementation of restoration actions. These are summarised in Table 4-1 below and should be taken as generally applicable in the planning of FRP.

Consultation with relevant NPWS staff should be undertaken prior to implementation to obtain more recent or up to date information on the locations of sensitive receptors, and buffers revised accordingly. Any further requirements outlined by NPWS at pre implementation stage should also be adhered to.

Table 4-5: Good Practice Recommendations

Receptor	Measure
Ground nesting birds	No vegetation clearance or activity which might contravene Section 40 of the wildlife act (consolidated) should be undertaken.
Invasive Alien Species	All vehicles should undergo stream cleaning before site entry. Identified buffers on IAS should be avoided during site preparation and restoration implementation. Consideration should be given to confirmatory survey to identify the latest *Rhododendron* infestation extent along with ecological oversight regarding works proximal to larger infestations.
Protection of European Sites	Any required mitigation measures to avoid potentially adverse effects on European Sites should be incorporated into an Environmental Management Plan or Checklist of Environmental Commitments. Implementation should be overseen by a suitably qualified ecologist.
Protection of Sensitive Habitats	High sensitivity habitats should be protected from long term damage by the use of low-pressure vehicles. Extensive repeated tracking over fen habitat or any other identified priority habitat should be avoided. The storage locations of any materials should avoid high & medium sensitivity habitats.

5 Key Pressures – Field Validation and Evaluation

The FRP considers pressures on Killaun Fen through an initial desktop assessment of existing information on the site (including previous NPWS commissioned surveys), assessment of land, water and topographic data and aerial imagery, followed by field surveys to characterise and confirm key pressures mapped through desktop assessment. Consultation with NPWS Regional Staff was also undertaken, including a visit with the Conservation Ranger for the area to inform identification of pressures.

The National Fen Survey undertook a site evaluation and ranking which determined the conservation value of the site. This evaluation considered 15 criteria as outlined which included naturalness, non-recreatability, potential value, typicality, educational value, size, diversity, fen value, rarity of species, rarity of habitats, viability, recorded history, management needs, intrinsic appeal and expert opinion. These criteria then informed the overall conservation status assessment was applied based.

The conservation status assessment results for Killaun Fen are summarised in Table 5-1.

Table 5-1: Conservation Status Assessment

OVERALL CONSERVATION STATUS ASSESSMENT				
Annex I habitat	**Area**	**Structure & functions**	**Future prospects**	**Overall Conservation Status**
7140	Not present	Not present	Not present	Not present
7210	Not present	Not present	Not present	Not present
7230	0.06ha	Unfavourable-bad	Not recorded	Unfavourable-bad

5.1 Field surveys of key pressures

Following completion of desktop mapping of key pressure, field surveys were carried out by personnel to verify the findings of the desktop assessment and characterise conditions of the pressures to inform selection of appropriate restoration actions required. The site surveys are discussed in Sections 3.2 and 4.2. These surveys aimed to capture information on the land and water environment such as drainage features, peat depth and water quality and the ecology.

As part of the ecology monitoring surveys, pressures and threats associated with the monitoring point were recorded. A summary is provided within Section 5.2.

5.2 Key Pressures

An overview of the key pressures identified on site, following desktop review and site visits are summarised in this section.

5.2.1 Fen Hydrology Pressures

The following hydrological pressures were identified within Killaun Fen:

- Drainage has been identified as a pressure in both southern and northern areas of the site: in the southern affecting directly the development of 7230 Alkaline fen habitats and in the northern affecting the water balance of other peatland habitats and indirectly the fen habitats in the southern portion, due to the existent hydrological connection. At both areas, water loss is compromising the species development and improving scrub encroachment. Therefore, key features include:
    - The west-east drain in the southern section and;
    - The north-south drain in the north-east section of the site.
- Lowering and fluctuations of water levels:
    - Shallow water table but very low flow visible in the water input drain (west-south drain) within the northern section
    - Evidence from heavily degraded and dry areas with cutover bog within the northern section.
- Modification of natural groundwater -surface water interactions due to the existence of the cutover bog and adjacent peat extraction site.

5.2.2 Flora and Fauna Pressures

The following key pressures have been identified from NFS data and site walkover observations. These represent the primary drivers of habitat degradation across the site.

- **Drainage**: Drainage is evident through the presence of open drains, culverts and modified flow pathways across the site. Although standing water is present in low-lying areas, drainage is contributing to hydrological imbalance, with drying observed on slightly elevated and cutover areas. This results in lowered water tables, reduced peat saturation and altered vegetation patterns, limiting the extent and quality of wetland habitats and facilitating succession towards drier communities.
- **Scrub encroachment:** Scrub encroachment is widespread and includes *Betula pubescens, Salix spp., Pinus sylvestris* and *Ulex europaeus,* with both mature stands and regenerating individuals recorded. Encroachment is particularly evident in cutover areas and along site margins, where it is spreading into open habitats. This leads to increased shading, evapotranspiration and litter accumulation, driving drying conditions and a transition from open wetland habitats to scrub and woodland.
- **Rank vegetation (Molinia dominance):** The site is characterised by extensive dominance of *Molinia caerulea*, forming dense, tussocky swards with limited bryophyte development. This reflects low management and/or drying conditions,

and results in suppression of characteristic species, reduced structural diversity and inhibited regeneration of wetland vegetation. Rank *Molinia* also facilitates further scrub establishment, reinforcing successional change.

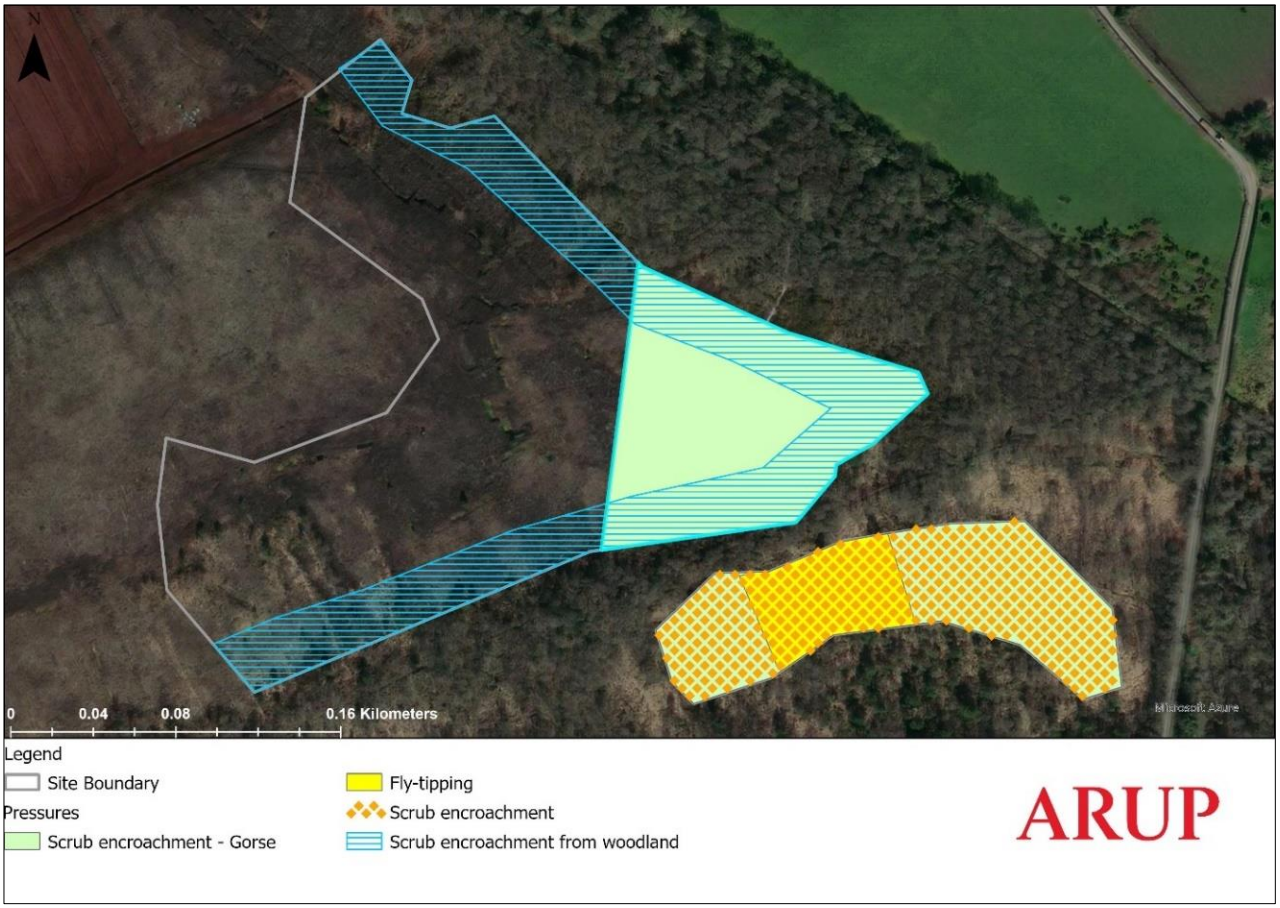


Figure 5-1: Flora & Fauna Pressures mapped within Killaun Fen

5.2.3 Fen Nutrient Pressures

The following nutrient pressures were identified within Killaun Fen:

- Nutrient enrichment in a few areas within the northern section are due to diffuse and/or localised nutrient input from adjacent agricultural activities, which is probably related to surrounding catchment and localised water inflow; and from adjacent industrial activities (peat extraction site in the northern boundary). Additionally, lowered and fluctuating water levels are potentially contributing to the release of nutrients previously stored within peat soils, which of process is consistent with drying conditions.
- Nutrient enrichment identified particularly in two points within the southern section area likely due to internal nutrient enrichment linked to hydrological change and vegetation composition/structure.

These conditions have the potential to alter vegetation composition and impact the low-nutrient, calcium-rich conditions required to maintain favourable alkaline fen habitat and associated qualifying species.

6 Restoration Measures

6.1 Introduction

The restoration actions proposed by the FRP will help to maintain or improve the quality of existing areas of fens and improve the conditions that will allow an expansion of the area of fen. In some areas it must be recognised that restoration to fen habitat will not be possible, and the objective may simply be to improve the habitat condition.

Selection of the most appropriate restoration action depends on a range of factors including peat depth, hydrological conditions (flow rates, existing and expected flow paths after restoration), substrate type, existing ecological conditions, potential ecological constraints and practicality of access for machinery.

Each of the factors was considered based on a combination of desktop analysis combined with site-specific field surveys to select the most appropriate restoration technique to address each pressure considered by the FRP. The restoration measures proposed are outlined in Section 6.2 to Section 6.3, with detailed mapping of proposed measures illustrated in the maps provided in Appendix B.

6.2 Hydrology Measures

6.2.1 On-site Hydrology Measures

Lidar images and site survey identified the main drains within the area which are located along the site boundaries; towards the eastern boundary, from west to east and at the northeast corner, from north to south, parallel to a tree line.

The west-east drain influences the water balance and conditions of the Fen habitat located to the south. The measures obtained along this drain at Point 11, 10, 5b, 9, 8 and 6a, showed that the drain width ranges from 0.5 to 1.5 m and drain depth ranges from 0.5 to 1.25 m.

The north-south drain influences the northern section, where the water inflow is connected to the drainage water system of the adjacent peat extraction area to the north. This drain dissipates through the site and is partially connected to another drain that runs west-east and is therefore connected to another drain, outside the site boundary, flowing north-south. The measures obtained at Point 4c, 3a, 3b and 3c showed that the drain width ranges from 1 to 2.5 m and drain depth ranges from 0.5 to 1.5 m.

It is recommend blocking drains, where they occur, at the facebank between PB1 Raised bog and PB4 Cutover Bog in an effort to restore peat conditions. Locations would be informed by both review of LiDAR, flow paths and site walkover at the appropriate phase of restoration. Following drain blocking, measures including reprofiling and laying of geotextile matting, where steep face bank and bare peat occurs, are recommended to enhance restoration actions. Such measures can improve conditions for positive peatland indicator species, including sphagnum species to colonise.

A hydrological monitoring network will be established to assess site conditions. Monitoring will include the installation of piezometers and standpipes at five selected locations and two surface water monitoring points.

To manage the water balance in the southern section of the site, raise the water table, and consequently reduce scrub encroachment while promoting favourable conditions for the development of the 7230 Alkaline fen habitats, drain blocking of the west-east drain is proposed. This measure will also support the establishment and persistence of characteristic fen species which are indicative of good ecological status.

To manage the hydrological regime in the north-east section of the site, reduce localised drying within the PB4 cutover bog, and support the overall water balance of adjacent peatland habitats, drain blocking of the north-south drain is proposed. While this area does not currently support Annex I fen habitat, its hydrological connectivity, proximity to PB1 raised bog, and position within the wider peatland system mean it plays a key functional role in regulating water levels and facilitating conditions favourable for future habitat development and associated characteristic species (Figure 9-1:).

The locations for measures and monitoring are presented in Appendix C and Figure 6-1.

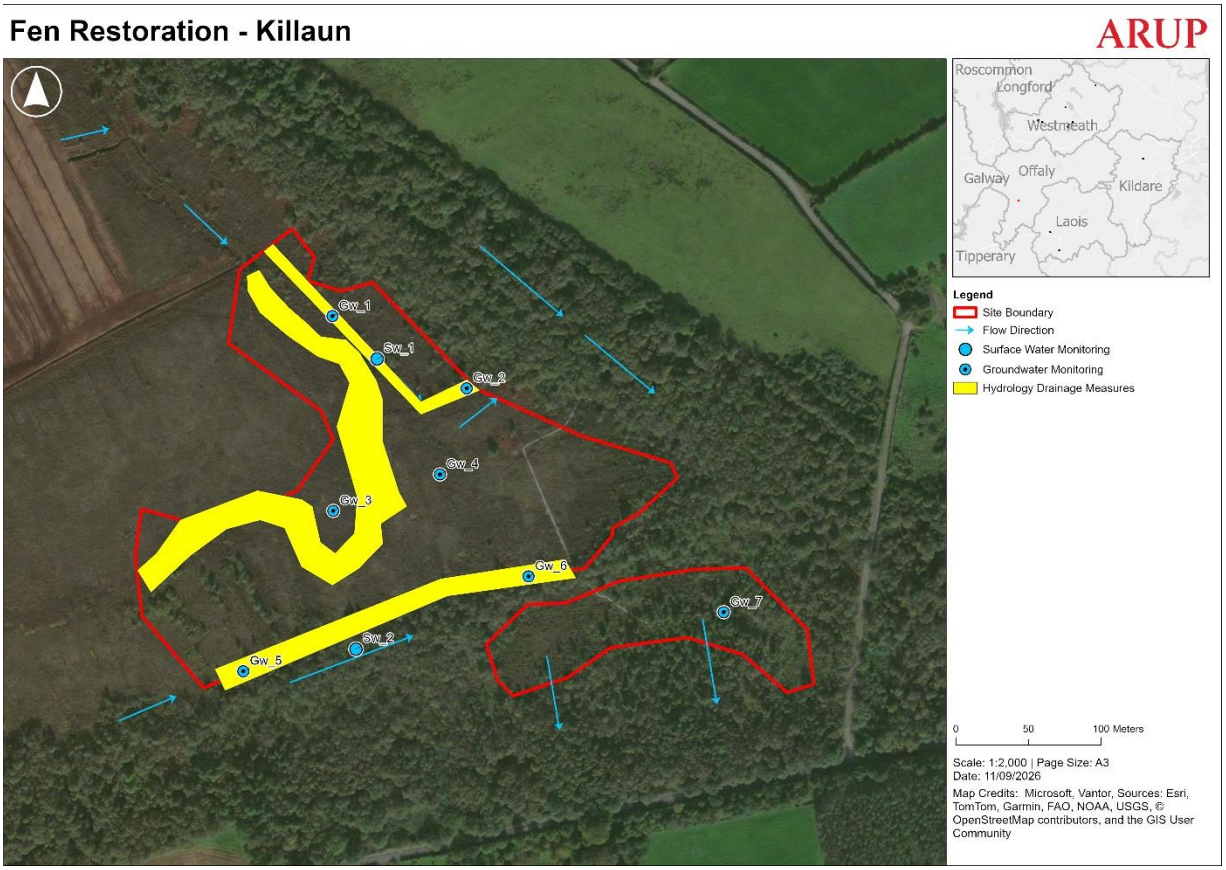


Figure 6-1: Proposed hydrological management and monitoring for Killaun Fen

6.2.2 Off-site Hydrology Measures

Engagement with adjacent landowners will be undertaken to avoid the introduction of new drainage works or the deepening of existing drains where hydrological connectivity to Killaun Fen. In particular, landowner engagement will be important to allow the drainage management within the north-south drain which is partially outside the site boundary and is connected to the adjacent drainage system from the peat extraction site from Bord na Moná.

6.3 Nutrient Measures

The primary aim of the nutrient measures is to maintain appropriate water quality, particularly nutrient levels, to support the natural structure and functioning of the habitats. For water quality the target is to maintain, or where necessary restore, appropriate water quality, particularly pH and nutrient levels, to support the natural structure and functioning of fen habitat.

6.3.1 On-site Nutrient Measures

On-site nutrient measures will focus on the monitoring of water quality to improve understanding of nutrient dynamics within the site and to assess the effectiveness of any future off-site measures.

Water quality monitoring will include nitrate, phosphate, electrical conductivity (EC), pH and temperature.

Monitoring locations will include the piezometers to be installed in five areas across the site, within the southern and northern section. The objectives are to:

- Assess the efficiency of drainage management measures;
- Identify spatial and temporal trends in nutrient concentrations;
- Improve understanding of nutrient sources and pathways (surface water vs groundwater).

The results of monitoring will be used to determine whether further intervention is required and to guide the selection of appropriate nutrient management measures.

6.3.2 Off-site Nutrient Measures

Elevated nutrient concentrations are likely indicative to inputs from the surrounding agricultural and particularly industrial activities (peat extraction site) within northern site boundary. These are probably promoting nutrient enrichment via both surface and groundwater pathways.

Catchment-scale measures should target both phosphorus and nitrogen pathways based on observed spatial patterns. Measures should include source control through nutrient management planning, pathway interception to reduce nutrient transport.

6.4 Vegetation Measures

6.4.1 On-site Vegetation Measures

Proposed vegetation measures focus on addressing scrub encroachment and rank vegetation development, which are key pressures identified across the site. Given the variability in habitat condition and the limited and fragmented extent of Annex I quality vegetation, a monitoring-led and adaptive management approach is proposed.

Table 6-1 Recommended On-Site Restoration Measures for Killaun

Priority	Measure	Description	Responsibility
1	Vegetation monitoring	Establish a site-wide ecological monitoring programme to track scrub extent, *Molinia* dominance and habitat condition, with focus on mapped management zones (Figure 6-3). Monitoring will inform the location, timing and scale of interventions, ensuring measures are targeted to areas under greatest pressure and adapted over time.	Tóchar
2	Targeted scrub control (manual removal)	Undertake targeted manual removal of scrub and trees (including *Betula pubescens*, *Pinus sylvestris* and *Ulex europaeus*) within identified priority areas. Works will focus on limiting further encroachment into open habitats and maintaining open structure, while avoiding damage to underlying peat. Removal will be progressive and guided by monitoring outputs.	Tóchar
3	Management of gorse and encroaching scrub	Implement focused gorse removal and control of regenerating scrub within defined zones (Figure 6-3), particularly where advancing from cutover or woodland areas. This will reduce shading and evapotranspiration, helping to stabilise open wetland conditions and limit further succession.	Tóchar
4	Removal of dumped material	Remove deposited material in the southern section of the site to address localised disturbance and substrate modification. This will restore underlying ground conditions and reduce potential nutrient inputs affecting vegetation structure.	Tóchar
5	Visitor awareness and educational signage	Install discreet educational signage at key access points (e.g. boardwalk entrances) to inform visitors of the sensitivity of peatland habitats and the impacts of leaving designated paths. Signage should clearly explain that trampling creates informal desire lines, leading to vegetation loss, exposure of bare peat, and subsequent erosion. The measure aims to encourage users to remain on the boardwalk, thereby reducing ongoing	Tóchar

Priority	Measure	Description	Responsibility
		recreational disturbance and preventing further degradation of sensitive peat-forming habitats.	
6	Facebank Management (see text below for further detail)	Targeted restoration of the facebank at the high bog–cutover interface, including drain blocking (where present), selective reprofiling of steep/unstable sections and localised stabilisation of bare peat (e.g. geotextile matting). The proposed intervention is anticipated to improve hydrological condition, reduce scrub encroachment on the facebank and enhance overall habitat quality.	NPWS

Recommended Facebank Management

At the interface between the cutover bog (PB4) and the raised bog (PB1) at Killaun, the presence of steep and, in places, well-established heather-dominated facebanks represents a localised pressure on hydrological function and habitat quality. These facebanks are typically associated with drying of the peat profile along the bog margin, leading to increased aeration, peat decomposition and potential carbon loss, as well as promoting scrub and dwarf shrub encroachment. In addition, steep or vertical facebanks are structurally unstable and may be prone to cracking and slumping, which can exacerbate edge drying effects extending into the high bog. Where present, facebank drains further reinforce this pressure by lowering the local water table and restricting rewetting potential of adjacent cutover areas.

It is recommended that, where feasible, a programme of targeted facebank management measures be considered as a restoration intervention. Primary actions should focus on blocking any facebank drains to raise the local water table, thereby supporting rewetting of adjacent cutover and increasing the hydraulic “floor” beneath the high bog margin. In addition, selective reprofiling of steep or vertical facebanks may be undertaken in areas identified as structurally unstable, with the aim of reducing slope angles, limiting slumping risk, and facilitating improved moisture retention at the bog edge. Where areas of bare or eroding peat are present on or adjacent to the facebank, the localised application of geotextile matting may be considered to stabilise the surface and promote natural revegetation. These measures are expected to reduce scrub encroachment, improve overall wetland habitat condition, and indirectly support *Sphagnum* recolonisation where suitable hydrological conditions are restored. While not essential to the core restoration programme, inclusion of this recommendation provides a strategic basis for potential future implementation by the NPWS, contributing incrementally to improved habitat condition.

The extent, condition, and variability of facebank features at Killaun are not fully characterised based on the provided information. Detailed field verification along the entire bog margin would be required to target measures appropriately and to confirm the presence/absence of drains, erosion features, and areas requiring intervention.

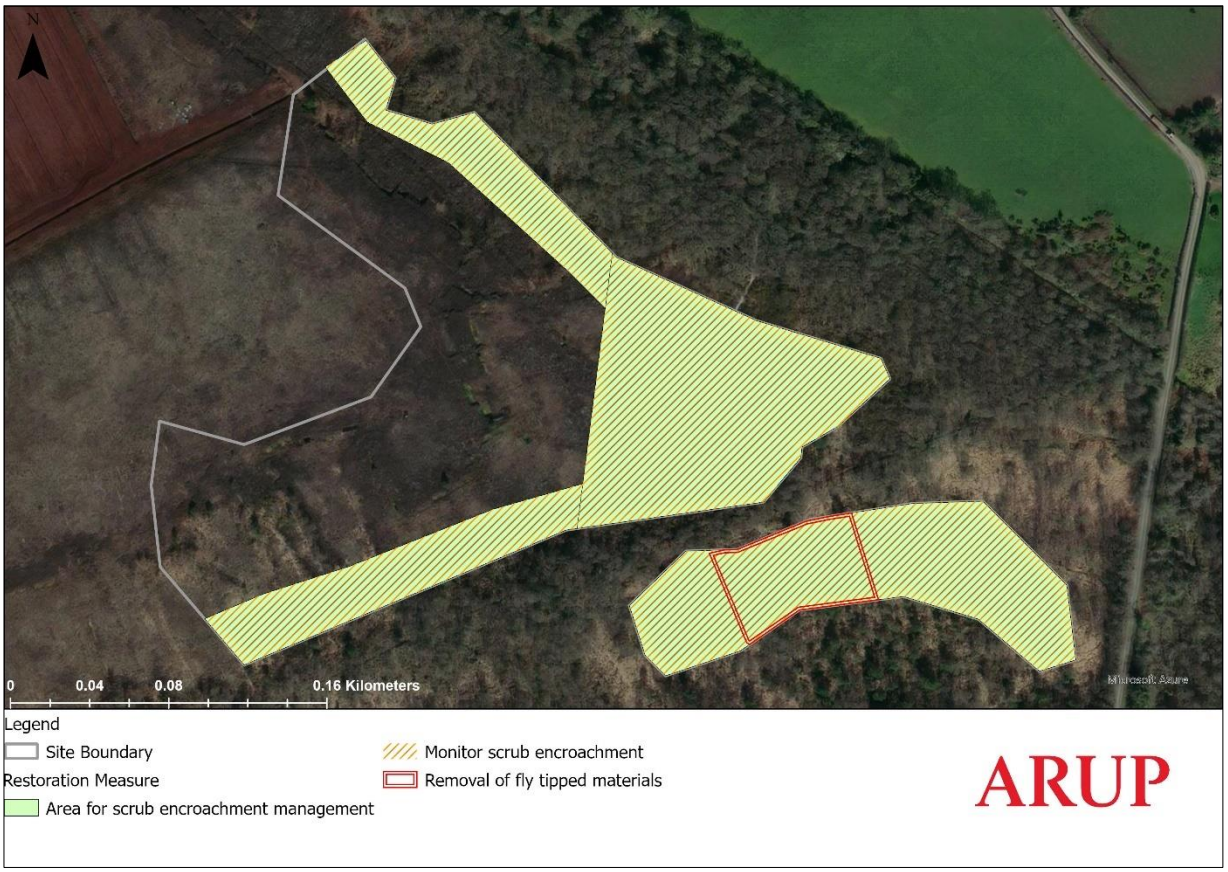


Figure 6-2: Proposed vegetation management measures and monitoring for Killaun Fen

7 Additional Considerations

7.1 Drainage Management Plan

Arterial Drainage Schemes were carried out under the Arterial Drainage Act, 1945 to improve land for agriculture and to mitigate flooding. Rivers, lakes weirs and bridges were modified to enhance conveyance, embankments were built to control the movement of flood water and various other work was carried out under Part II of the Arterial Drainage Act, 1945. The purpose of the schemes was to improve land for agriculture, to ensure that the 3 – year flood was retained in bank this was achieved by lowering water levels during the growing season to reduce waterlogging on the land beside watercourses known as callows. Flood protection in the benefiting lands was increased as a result of the Arterial Drainage Schemes.

The Brosna (Westmeath, Offaly and Laois) was the first scheme, which commenced in 1947. The last schemes were completed in the 1990s. Arterial Drainage schemes cover approximately 20 % of the country, typically the flattest areas. The OPW is required to maintain Arterial Drainage schemes under sections 37 and 38 of the Arterial Drainage Act, 1945. The Act was amended on a number of occasions, e.g. to transpose EU Regulations and Directives such as the EIA, SEA, and Habitats Directives and the Aarhus Convention.

Drainage Districts were designated by the Commissioners of Public Works to improve land for agriculture and to mitigate flooding. Channels and lakes were deepened and widened, weirs removed, embankments constructed, bridges replaced or modified and various other work was carried out. Local authorities are charged with responsibility to maintain Drainage Districts. The Arterial Drainage Act, 1945 contains a number of provisions for the management of Drainage Districts in Part III and Part VIII of the act.

The Killaun Fen is part of a Drainage District managed by Offaly County Council. Consultation required with Offaly County Council on the maintenance and function of the channel and the impact of future drainage plans on the fen and the impact of the proposed restoration measures on the objectives of the drainage district.

The north-south drain at the northern section of Killaun site is located a few meters west of an outer drain running from the same direction and which of is part of a Drainage District managed by Offaly County Council. Therefore, blocking the north-south drain as part of the restoration measures, may require an anticipated engagement with this authority.

The preliminary drainage management plan for Killaun Fen is presented in Appendix C.

7.2 Peat Stability Assessment

Restoration activities have the potential to introduce additional risk of peat stability issues. The combination of additional loading (e.g. when excavators are used) and a higher water

table has the potential to increase risk. At present, no specific guidance is available in Ireland detailing how peat stability risks should be managed in restoration projects.

Undertaking detailed geotechnical assessments is beyond the scope of the FRP. However, preliminary peat stability analysis was undertaken to inform the level of assessment required prior to the implementation of restoration actions. This includes a review of the landslide susceptibility map and historic landslide events produced by the Geological Survey of Ireland (GSI). The GSI landslide susceptibility map provides a preliminary indication of the susceptibility of a landslide based on several contributing factors, including where previous landslides have occurred and what caused them (slope, soil type and the impact of the flow of water in an area).

The proposed approach to peat stability is a tiered approach that aims to filter out low risk sites that can proceed with limited ground investigation, followed by more complex sites that require a more detailed quantitative assessment. Where risks cannot be excluded following these steps it may be necessary to progress to more detailed geotechnical studies.

The GSI landslide susceptibility map for Killaun Fen is presented in Figure 7-1.



Figure 7-1: Geological Survey of Ireland Landslide Susceptibility mapping for Killaun Fen

7.3 Archaeology

The locations of proposed restoration measures and access routes were reviewed against the Archaeological Survey of Ireland datasets. No Recorded Monuments (or associated buffer

zones) were identified within the footprint of the proposed works, access routes or associated work buffer areas. Accordingly, no additional archaeological constraints are anticipated in relation to the implementation of the proposed restoration measures, and a dedicated archaeological constraints map has not been included.

It should be noted that a total of seven Sites and Monuments Record (SMR) entries occur within 2.5 km of Killaun Fen:

- OF01513: Ringfort
- OF01578: Bawn (Killyon Abbey (in ruins))
- OF01579: House - fortified house (Killyon Abbey (in ruins))
- OF01522: Castle – unclassified (Site of O'Carrolls Castle)
- OF01581: Designed landscape - tree-ring
- OF01580: Enclosure
- OF01535: Castle - tower house (Fortel Castle)



Figure 7-2: Archaeological Sites for Killaun Fen (NMS, 2025)

8 Summary of Fen Restoration Plan Actions

Prior to proceeding with the implementation of the restoration measures outlined in the FRP, consultation with landowners and key stakeholders with an interest in the site is essential (Table 8-1). While this FRP identifies the key pressures and actions to be implemented, consultation with landowners and stakeholders may identify the need to amend or alter restoration actions. There may also be opportunities to provide additional benefits to the wider community. Consultation with local NPWS staff will be crucial to informing implementation planning.

Table 8-1: Role players in fen restoration plan

Measures	Stakeholder	Description
On-site	Landowners	Parts of Killaun Fen are under Commonage ownership by private individuals
Off-site	Bord na Moná	Adjacent landowners of neighbouring commercial peat site.
	Landowners & farmers	Engagement for uptake of catchment measures.
Capacity building	NPWS	NPWS engaging in community education and events

This section provides the summary of the Fen Restoration Plan Actions for Killaun Fen (Table 8-2).

Table 8-2: Implementation plan for Killaun Fen Restoration

	Activity	Location	Monitoring/ implementation indicator	Timeframe	Key role player			Possible funding source
					National	Regional/ Local	Other	
1	**Required preliminary actions**							
1.1	**Screening for Appropriate Assessment report.**							
	This report must outline all restoration measures that shall be undertaken as part of the project at Killaun. The Screening for AA must conclude whether a likely significant effect is anticipated to arise from the implementation of the project.	Sitewide	Screening report	Pre-restoration	NPWS			NPWS
1.2	Drainage management plan							
	Consultation with Offaly County Council on the drainage management plan is required to ensure compliance with legislation and local authority objectives.	Sitewide	Drainage management plan	Pre-restoration	NPWS	Offaly County Council	Arup	Within Tóchar project scope
1.3	Archaeological assessment							
	Consultation with Offaly County Council on the archaeology is required to ensure compliance with legislation and local authority objectives.	Sitewide	Archaeological assessment report	Pre-restoration	NPWS	Offaly County Council	Arup	Within Tóchar project scope
2	**Enabling Works**							
2.1	**Pre-restoration Works Surveys**							

	Activity	Location	Monitoring/ implementation indicator	Timeframe	Key role player			Possible funding source
					National	Regional/ Local	Other	
	Pre-site walkover with Ecologist/Ecological Clerk of Works (ECoW) to ensure proposed measures are appropriate and whether alterations are required.	Sitewide	ECoW report	Pre-restoration			Arup	Within Tóchar project scope
2.2	**Implementation of Mitigation Measures**							
	Ecological Impact Assessment Considerations – identification of necessary mitigation measures. Such measures may include, but are not limited to, the utilisation of hand machinery to avoid impact on sensitive habitats	Sitewide	ECoW report	Pre-restoration			Arup	Within Tóchar project scope
2.3	**Breeding Bird Considerations**							
	Prior to restoration works, where any restoration measures are identified to have the potential to interfere with breeding birds e.g. scrub removal, these works shall occur outside the breeding bird season (1 March – 31 August inclusive).	Sitewide	ECoW report	Pre-restoration			Arup	Within Tóchar project scope
2.4	**Good Practice Recommendations and CEMP**							

	Activity	Location	Monitoring/ implementation indicator	Timeframe	Key role player			Possible funding source
					National	Regional/ Local	Other	
	Good Practice Recommendations – Includes, but not limited to, avoidance of sensitive ecological receptors, pollution prevention procedures, biosecurity measures etc. The preparation and provision of a Construction Environmental Management Plan (CEMP).	Sitewide	ECoW report	Pre-restoration			Arup / Contractor	Within Tóchar project scope
3	**On-Site Restoration measures**							
3.1	**Hydrology measures**							
	Monitoring groundwater and surface water at key site locations using piezometers and standpipes (at five locations).	Within the north-south drain (northern section), west-east drain and an additional location (southern section)	Water level	Long term	NPWS to facilitate access			NPWS
	Drain blocking	1) North-south drain (northern section), 2) West-east drain (southern section) 3) Drains at the facebank	Water management balance	Appropriate season following hydro monitoring	NPWS & Stakeholder engagement (Bord na Moná)	Offaly County Council	Arup / Contractor	Within Tóchar project scope
3.2	**Nutrient measures**							

	Activity	Location	Monitoring/ implementation indicator	Timeframe	Key role player			Possible funding source
					National	Regional/ Local	Other	
	On-site nutrient measures will focus on the monitoring of water quality to improve understanding of nutrient dynamics within the site and to assess the effectiveness of any future off-site measures. This will be completed within the piezometers to be installed where nitrate, phosphate, electrical conductivity (EC), pH and temperature will be monitored.	Within the north-south drain (northern section), west-east drain and an additional location (southern section)	Water level	Long term	NPWS to facilitate access			NPWS
3.2	**Vegetation measures**							
	Proposed measures to address vegetation succession and scrub encroachment include: 1. Establishment of vegetation monitoring programme; 2. Targeted manual removal of scrub (birch, pine, gorse); 3. Progressive scrub clearance informed by monitoring; 4. Removal of dumped material in southern section. 5. Facebank management Measures will be implemented on a phased basis using a monitoring-led adaptive management approach.	Site-wide, with focus on mapped areas (Figure 6-3).	Site records, repeat habitat surveys and fixed monitoring points tracking scrub extent, *Molinia* cover and vegetation composition	Restoration 2026	NPWS		Arup/Contractor	Tóchar / NPWS funding streams / relevant peatland restoration funding
4	**Off-Site Restoration measures**							

	Activity	Location	Monitoring/ implementation indicator	Timeframe	Key role player			Possible funding source
					National	Regional/ Local	Other	
4.1	**Hydrology measures**							
	Engagement with adjacent to avoid the introduction of new drainage works or the deepening of existing drains where hydrological connectivity to Killaun Fen. In particular, landowner engagement about the north-south drain which is partially outside the site boundary and is connected to the adjacent drainage system from the peat extraction site from Bord na Moná.	Surrounding landowners, particularly Bord na Moná	Uptake of measures by landowners.	Long-term	NPWS, LAWPRO, Farming for Water EIP		Landowners	Catchment measures to be funded through Farming for Water EIP / other similar
4.2	**Nutrient measures**							
	Targeted nutrient control measures should be implemented across the catchment to address both phosphate and nitrogen pathways. Measures may include engagement on best-practice nutrient management, avoidance of drainage works that enhance nutrient delivery pathways, and targeted interception of surface or shallow subsurface flows where monitoring identifies risks to fen or lake water quality.	Surrounding landowners	Uptake of measures by landowners	Long-term	NPWS, LAWPRO, Farming for Water EIP		Landowners	Catchment measures to be funded through Farming for Water EIP / other similar
5	**Monitoring progress**							
5.1	**Hydrology monitoring**							

	Activity	Location	Monitoring/ implementation indicator	Timeframe	Key role player			Possible funding source
					National	Regional/ Local	Other	
	Groundwater and surface water will be monitor through a network of piezometers at key locations within the site (as described above) to assess the efficiency of drainage measures, identify spatial and temporal trends in nutrient concentrations and improve understanding of nutrient sources and pathways (surface water vs groundwater).	Various locations across site	Water level	Long-term	NPWS	Offaly County Council		Within Tóchar project scope
5.2	**Nutrient monitoring**							
	Ongoing monitoring of habitats, drainage channels and piezometers for water quality parameters is proposed within the northern and southern sections of the site.	Various locations within the site	Nutrients (Nitrate and phosphate), electrical conductivity and pH	Long-term	NPWS	Offaly County Council		Within Tóchar project scope
5.3	**Vegetation monitoring**							
	Habitat condition assessments will be included to track restoration progress.	Sitewide	Habitat condition	Long-term	NPWS	Offaly County Council		Within Tóchar project scope
6	**Capacity building and training**							

	Activity	Location	Monitoring/ implementation indicator	Timeframe	Key role player			Possible funding source
					National	Regional/ Local	Other	
	Public meeting: To engage stakeholders on developments and results from the restoration measures.			Long-term	NPWS			NPWS
	Farmer training: Training such as that provided by the Farming for Water EIP will provide farmers with knowledge of alternative and habitat sensitive measures			Long-term	NPWS/ Farming for Water EIP / LAWPRO / Teagasc			Farming for Water EIP / other similar

8.1 Habitats Benefiting from Implementation of Restoration Actions

The implementation of restoration measures at Killaun will benefit a range of Annex I quality and associated peatland and wetland habitats across the site. These measures primarily address vegetation succession, scrub encroachment and hydrological modification, with outcomes aligned to improving habitat structure, species composition and hydrological functioning.

- **7230 Alkaline fen**: Although currently limited and fragmented, the remaining 7230 habitat will benefit indirectly from restoration actions through adjacent scrub control and management of rank *Molinia,* combined with hydrological restoration measures. Drain blocking works in surrounding areas are expected to raise and stabilise water tables, maintaining base-rich conditions required for fen species such as *Schoenus nigricans* and brown moss communities. Reduction in scrub and rank vegetation will improve light availability and open structure, supporting recovery and expansion of alkaline fen vegetation where conditions remain suitable.
- **Cutover bog (PB4):** Cutover bog habitats are widespread across the site and will benefit significantly from restoration measures, particularly drain blocking and vegetation management. Hydrological interventions are expected to increase water retention and re-wetting, supporting the development of Sphagnum mosses and peat-forming vegetation. Vegetation measures, including control of scrub and rank species, will help prevent further succession to woodland and improve the potential for active peatland recovery and stabilisation of exposed peat surfaces. These measures contribute to improved habitat condition and support a transition towards more functional peatland systems.
- **Raised bog (PB1)**: Areas of raised bog and associated features will benefit from improved hydrological connectivity through drain blocking, reducing water loss and supporting the re-establishment of peat-forming vegetation and bog species assemblages. Limiting scrub expansion and controlling rank vegetation will help maintain open bog structure, contributing to long-term habitat resilience.
- **Bog woodland (WN7):** Bog woodland areas will benefit from targeted management of encroaching and non-characteristic species, particularly in transitional zones with open habitats. While woodland structure will be retained where appropriate, reducing the spread of scrub into adjacent habitats will help maintain habitat boundaries and ecological gradients, preserving structural diversity across the site.

8.2 Species Benefiting from Implementation of Restoration Actions

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Appendix A – Non-Technical Summary

NPWS Tóchar Midlands Wetland Restoration Scheme Fen Restoration Plan Non-Technical Summary			
Site Name	Killaun Fen	**NFS site no.**	107006
County	Offaly	**Designations**	
Fen habitats present (area)	7230 Alkaline fens (0.06ha)	**Species of note**	*Sphagnum spp.*

Site Description

Killaun Fen is located 5km west of Birr, Co. Offaly. Although the site is not designated as an SAC, SPA or NHA, it supports a small area (5%) of Annex I quality 7230 Alkaline Fen located within the southeast of the site. The site also contains small areas of PB1 raised bog to the northwest, a large area of PB4 cutover bog in the northern section and other habitats, including PF1 rich fen, PF2 poor fen and WN7 bog woodland. The limited extent of 7230 Alkaline Fen is represented by small, isolated areas of Black bog-rush (*Schoenus nigricans*) with associated purple moor-grass (Molinia caerulea) and brown mosses including *Scorpidium cososnii* alongside species such as Devil's-bit scabious (*Succisa pratensis*).

Conceptual Site Model (CSM)

The topography of the site is relatively flat, ranging from 61 to 64 mOD. A slight descending slope is identified from northwest to southeast. Under the WETMEC framework defined by Wheeler, Shaw & Tanner (2009), Killaun Fen is classified as a groundwater-fed valley-bottom fen, where hydrological inputs are dominated by groundwater emerging from adjacent elevated terrain and moving through the site that represents a discharge zone.

The site is underlain by the Lucan Formation and locally by Waulsortian Limestone, with cut-over raised peat and limestone-derived till forming the superficial deposits. Killaun Fen is divided into distinct northern and southern sections. The northern area is characterised by historical peat extraction, extensive drainage and active water flow, while the southern section supports shallow groundwater conditions, slower-moving waters and the occurrence of alkaline fen habitat. Hydrochemical monitoring confirms these differences, with groundwater-influenced conditions evident in the southern and eastern areas, reflected by circumneutral to alkaline pH, elevated electrical conductivity and lower water temperatures. In contrast, the northern drains exhibit acidic, low-conductivity waters typical of cutover raised bog environments. The site contains a network of artificial drains that influence surface water movement and hydrological connectivity. Historical peat extraction within and adjacent to the site has significantly modified natural hydrological conditions, influencing habitat distribution, groundwater discharge patterns and the development of springs and seepages across the fen system.

Key Pressures

Hydrology Pressures	Drainage in both the west-east drain in the southern section and the north-south drain in the north-east section of the site, disrupting hydrological connectivity, lowering water levels, and degrading alkaline fen habitats while promoting scrub encroachment. Additional pressures include fluctuating and reduced water levels, evidenced by low flow in input drains and extensive dry, degraded peat areas in the northern section.

	There were also modifications of natural groundwater -surface water interactions due to the existence of the cutover bog and adjacent peat extraction site.
Nutrient Pressures	Nutrient enrichment in Killaun Fen occurs mainly in the northern section due to agricultural runoff, industrial peat extraction, and drying conditions that release stored nutrients, while in the southern area it is linked to internal changes in hydrology and vegetation.
Ecology Pressures	Drainage, scrub encroachment, and dominance of rank Molinia vegetation, all of which contribute to drying conditions and altered hydrology. These pressures reduce peat saturation, suppress characteristic wetland species, and promote succession towards scrub and woodland, diminishing the extent and quality of wetland habitats.
Objective of Restoration Plan	
The objective of the Killaun Fen Restoration Plan is to maintain or improve the quality of existing areas of fens and improve the conditions that will allow an expansion of the area of fen. In some areas it must be recognised that restoration to fen habitat will not be possible or preferable, and the objective is to improve the habitat condition.	
Restoration Measures	
Hydrology Measures	**On-Site Measures:** Water level management through blocking of the west-east and north-south drains. **Off-Site Measures:** Avoid the creation of new agricultural drains and deepening of existing drains where hydrological connectivity to Killaun Fen.
Nutrient Measures	**Off-Site Measures:** Source control through nutrient management planning, pathway interception to reduce nutrient transport.
Ecology Measures	**On-Site Measures:** Targeted scrub control (manual removal), management of gorse and encroaching scrub and removal of dumped material
Monitoring Progress	
Hydrology Monitoring	Groundwater and surface water monitoring within a few proposed areas along Killaun Fen.
Nutrient Monitoring	Ongoing monitoring of habitats and drainage channels for water quality parameters within the fen

NPWS Tóchar Midlands Wetland Restoration Scheme Fen Restoration Plan Non-Technical Summary	
Ecology Monitoring	Habitat condition assessments to track restoration progress.
More information	
Fen Restoration Plan Report Tóchar website: https://www.tocharwetlands.ie/fen-restoration/	



Figure 1: Site Habitat Map

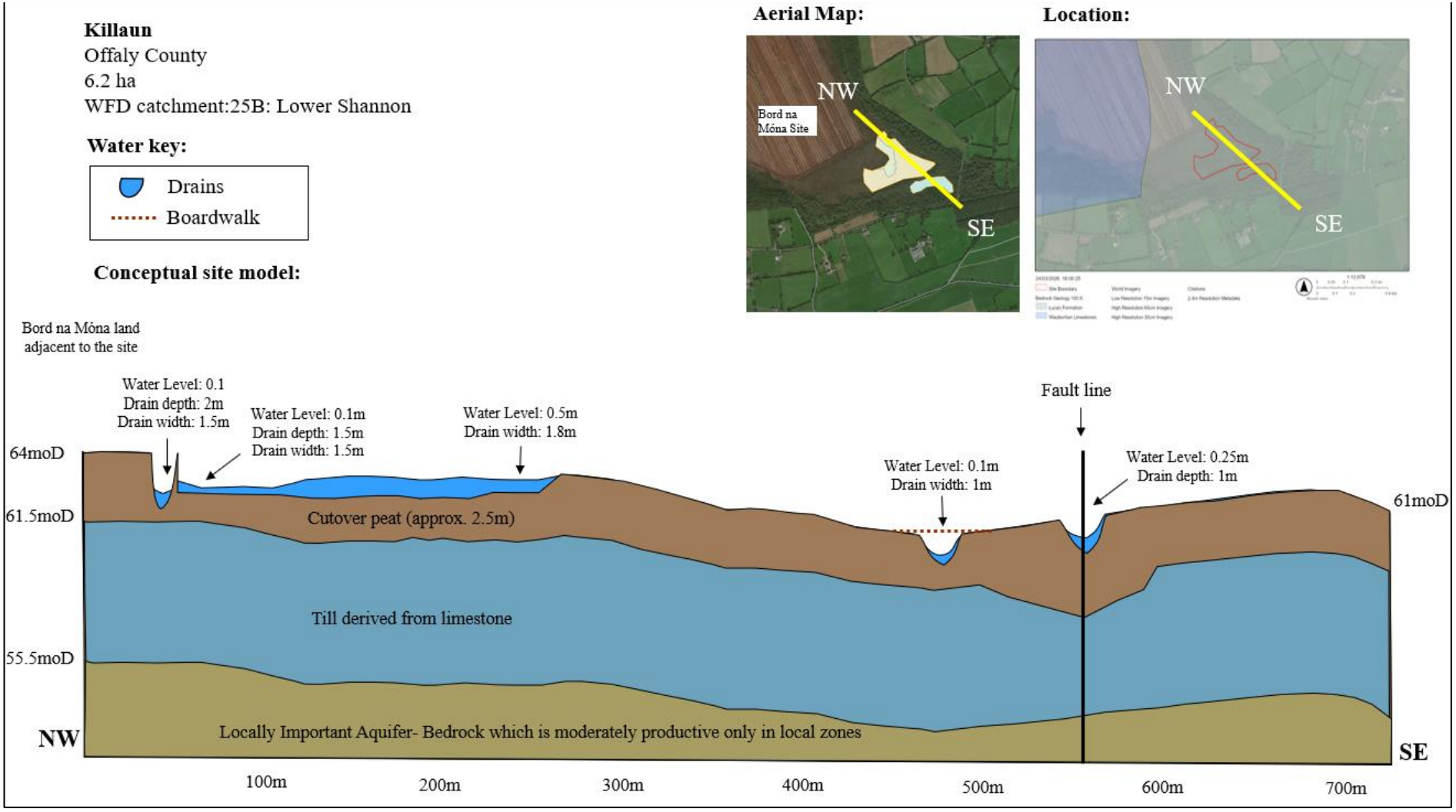


Figure 2: Conceptual Site Model

Appendix B – Ecological Survey Maps



Figure 9-1: Habitats identified during the 2022 NFS Survey and classified according to Fossitt Habitat Classification.

Table 9-1 Annex I habitat codes and Fossitt habitat code directory

Annex I habitat code	Annex I habitat name	Fossitt Habitat Code	Fossitt Habitat Name
3110	Oligotrophic Isoetid lake habitat	FL1	Dystrophic lakes
3130	Slender Naiad-type lakes	FL2	Acid oligotrophic lakes
3140	Hard-water lakes	FL3	Limestone/marl lakes
3150	Rich pondweed lake habitat	FL4	Mesotrophic lakes
3160	Acid oligotrophic lakes	FL5	Eutrophic lakes
3180	Turloughs	FL6	Turloughs
3260	Vegetation of flowing waters	FL7	Reservoirs
3270	Chenopodion rubri	FL8	Other artificial lakes and ponds
4010	Wet heaths	FW1	Eroding/upland rivers
4030	Dry heaths	FW2	Depositing/lowland rivers
4060	Alpine and subalpine heath	FW3	Canals
5130	Juniper scrub	FW4	Drainage ditches
6130	Calaminarian grasslands	FP1	Calcareous springs
6210	Orchid-rich calcareous grassland	FP2	Non-calcareous springs
6230	Species-rich Nardus grassland	FS1	Reed and large sedge swamps
6410	Molinia meadows	FS2	Tall-herb swamps
6430	Hydrophilous tall-herb swamp	GA1	Improved agricultural grassland
6510	Hay meadows	GA2	Amenity grassland (improved)
7110	Raised bog (active)	GS1	Dry calcareous and neutral grassland
7120	Degraded raised bogs	GS2	Dry meadows and grassy verges
7130	Blanket bog (active)	GS3	Dry-humid acid grassland
7140	Transition mires	GS4	Wet grassland
7150	Rhynchosporion depressions	GM1	Marsh
7210	Cladium fens	HH1	Dry siliceous heath
7220	Petrifying springs	HH2	Dry calcareous heath
7230	Alkaline fens	HH3	Wet heath
8110	Siliceous scree	HH4	Montane heath
8120	Calcareous scree	HD1	Dense bracken
8210	Calcareous rocky slopes	PB1	Raised bog
8220	Siliceous rocky slopes	PB2	Upland blanket bog
8240	Limestone pavement	PB3	Lowland blanket bog

Annex I habitat code	Annex I habitat name	Fossitt Habitat Code	Fossitt Habitat Name
8310	Caves	PB4	Cutover bog
8330	Sea caves	PB5	Eroding blanket bog
91A0	Old oak woodland	PF1	Rich fen and flush
91D0	Bog woodland	PF2	Poor fen and flush
91E0	Alluvial woodland	PF3	Transition mire and quaking bog
91J0	Yew woodland	WN1	Oak-birch-holly woodland
		WN2	Oak-ash-hazel woodland
		WN3	Yew woodland
		WN4	Wet pedunculate oak-ash woodland
		WN5	Riparian woodland
		WN6	Wet willow-alder-ash woodland
		WN7	Bog woodland
		WD1	(Mixed) broadleaved woodland
		WD2	Mixed broadleaved/conifer woodland
		WD3	(Mixed) conifer woodland
		WD4	Conifer plantation
		WD5	Scattered trees and parkland
		WS1	Scrub
		WS2	Immature woodland
		WS3	Ornamental/non-native shrub
		WS4	Short rotation coppice
		WS5	Recently-felled woodland
		WL1	Hedgerows
		WL2	Treelines
		ER1	Exposed siliceous rock
		ER2	Exposed calcareous rock
		ER3	Siliceous scree and loose rock
		ER4	Calcareous scree and loose rock
		EU1	Non-marine caves
		EU2	Artificial underground habitats
		ED1	Exposed sand, gravel or till

Annex I habitat code	Annex I habitat name	Fossitt Habitat Code	Fossitt Habitat Name
		ED2	Spoil and bare ground
		ED3	Recolonising bare ground
		ED4	Active quarries and mines
		ED5	Refuse and other waste
		BC1	Arable crops
		BC2	Horticultural land
		BC3	Tilled land
		BC4	Flower beds and borders
		BL1	Stone walls and other stonework
		BL2	Earth banks
		BL3	Buildings and artificial surfaces

Appendix C –Restoration and Monitoring Map

Table C-1: Long-term monitoring points for fen restoration at Killaun Fen

Point	Measure	Objective	Timeframe	Frequency of monitoring
Gw_1	Hydrological	Groundwater levels and quality monitoring	Long-term	Quarterly for year 1 Annual for year 2-5
Gw_2				
Gw_3				
Gw_4				
Gw_5				
Sw_1		Monitoring of surface water levels and quality	Long-term	Quarterly for year 1 Annual for year 2-5
Sw_2				
Ec_1	Ecological	Monitoring within areas of 7230 Alkaline fens	Long-term	Seasonal for year 1 Every 3 years for year 2-5
Ec_2				
Ec_3				
Ec_4				

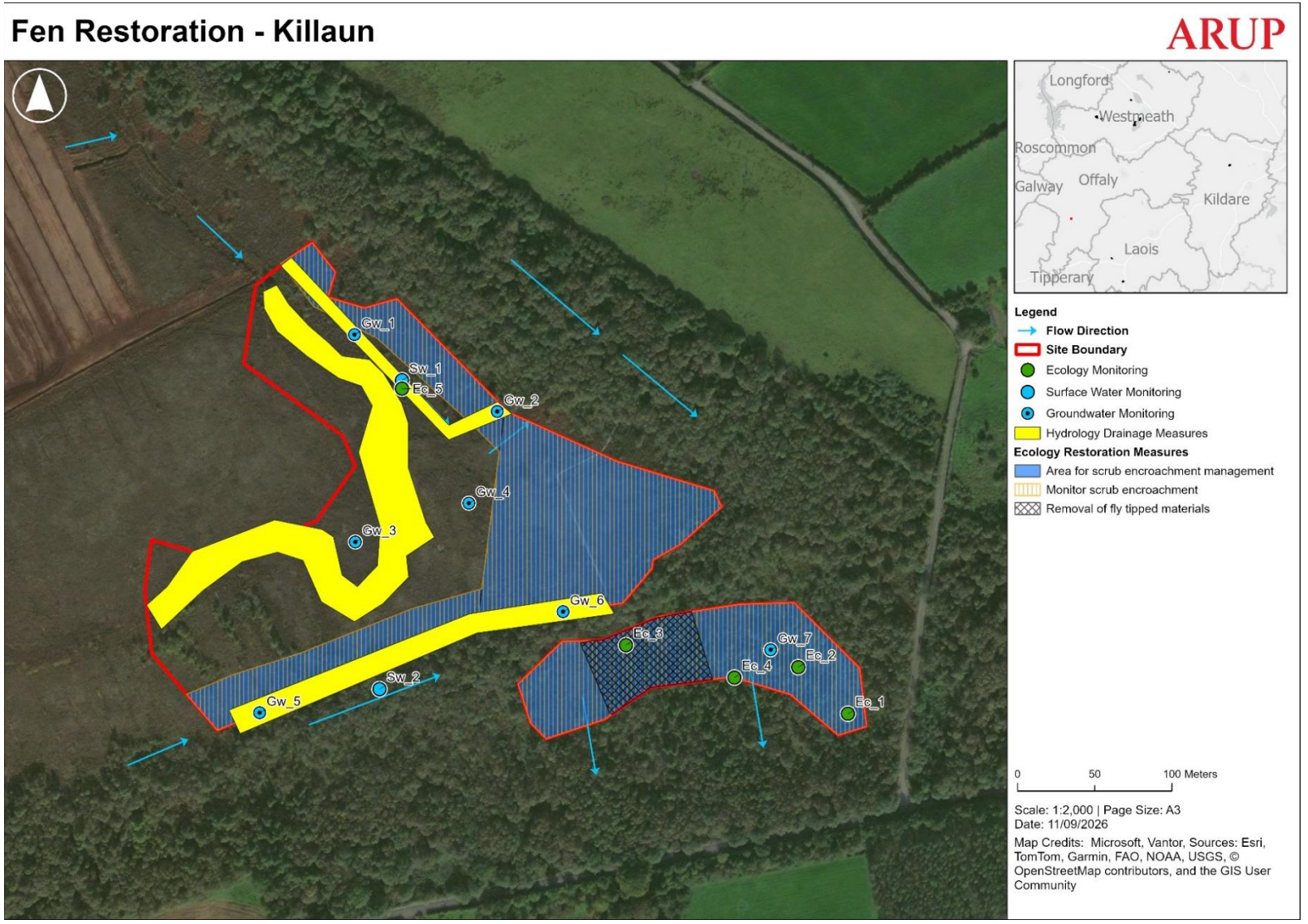


Figure 9-2: Killaun Fen Restoration Map

Appendix D - Drainage Management Plan

NPWS Tóchar Midlands Wetland Restoration Scheme Fen Restoration Plan: Drainage Management Plan			
Site name	Killaun Fen		
County	Offaly	NFS site No.	107006
Catchment overview:			
The topography of the site is mainly flat at approximately 63 mOD. Higher topographic areas are located within the northern edge of the site, reaching approximately 64 mOD, while lower areas are identified between the northern and southern sections of the site, where it ranges from 61 to 62 mOD. Beyond the site boundary, the landscape becomes notably elevated in the northwest (up to circa 66 mOD), northeast (up to 79 mOD) and southern (up to 69 mOD) regions. The northern boundary is adjacent to a peat extraction area, whose characteristics are likely to influence the hydrogeological and environmental conditions of Killaun.			
WFD catchment	25B- Lower Shannon	WFD Sub-catchment	Camcor_SC_010
Drainage Area	None	Drainage District	Yes
Responsible authority	Offaly County Council	Maintenance date	TBD
Surrounding landowners	Bord na Móna, landowners		
Wetland drainage			
An assessment of historical and current hydrological records indicates that the water regime of Killaun Fen has been affected primarily by drainage for peat extraction activities. Historical maps (1897–1913) show there is a visible drain located to the north of the site, outside the site boundaries, with a possible water intake crossing the site. They also indicate that the general flow is towards Camcor River and that there is a spring located approximately 300m southeast of the site boundary (Figure 3 9). In historic maps from 1910s to 1950s, this spring is not present. From 2012 to 2025, the vegetation in the site area has slightly fluctuated over the years, being the densest in the 2025 satellite image. Hydrological modifications to the site occurred through peat extraction at the northern section and extensive cutover bog to the south and east. The adjacent peat extraction site located in the northern boundary has also modified natural conditions of the site. These elements have influenced habitat development and the spatial distribution of springs and seepages over recent decades. A drain on the northern boundary of the site, which is connected to the drainage system of the adjacent peat extraction site provides surface water inflow into the site and runs north-south. This drain continues to flow into the site in the same direction until the flow direction changes to east-west and joins a bigger drain parallel to the site, along its eastern boundary. Another drain between the northern and southern section of the site flows from west-east direction, however, it presents a much slower flow when compared to the northern drain. This drain continues flowing in the southeastern direction until it reaches road R440, where it possibly keeps flowing to the southwest until reaches the Camcor River.			
Surface water inflow	Possibly west water feature (Camcor River (0_50) flowing through adjacent peatland extraction site	Surface water outflow	Camcor River (0_40)
Groundwater inflow	Not identified		
Internal drains	Two drains through site	Perimeter drains	One drain to the east

NPWS Tóchar Midlands Wetland Restoration Scheme Fen Restoration Plan: Drainage Management Plan					
On site hydrology measures					
On-site measure 1	Drain blocking Hydrological monitoring		Role player	NPWS/ Bord na Móna to facilitate site access	
Drain blocking is proposed in both the southern and north-eastern sections of Killaun Fen to improve site hydrology, raise water levels and support peatland habitats. In the south, blocking the west-east drain will help restore conditions favourable for Annex I 7230 Alkaline Fen and its characteristic species, while reducing scrub encroachment. In the north-east, blocking the north-south drain will reduce localised drying within the cutover bog and improve the water balance of adjacent peatland habitats. The effectiveness of the measures will be assessed through post-installation monitoring, followed by ongoing seasonal monitoring by NPWS.					
Off-site hydrology measures					
Off-site measure 1	Avoid creating new pits or ditches		Role player	NPWS/Surrounding landowners	
Engagement with adjacent landowners will be undertaken to avoid the introduction of new drainage works or the deepening of existing drains where hydrological connectivity to Killaun Fen. In particular, landowner engagement will be important to allow the drainage management within the installation of the plastic piling dams within the north-south drain which is partially outside the site boundary and is connected to the adjacent drainage system from the peat extraction site from Bord na Moná.					
Proposed Water Monitoring:					
Groundwater monitoring in a network of piezometers at key locations within the site to monitor changes to water levels.					
Indicator	Water level	Location	Various locations across site	Role players	NPWS/ Bord na Móna to facilitate site access
Rainfall and evaporation monitoring using site-specific or nearby stations.					

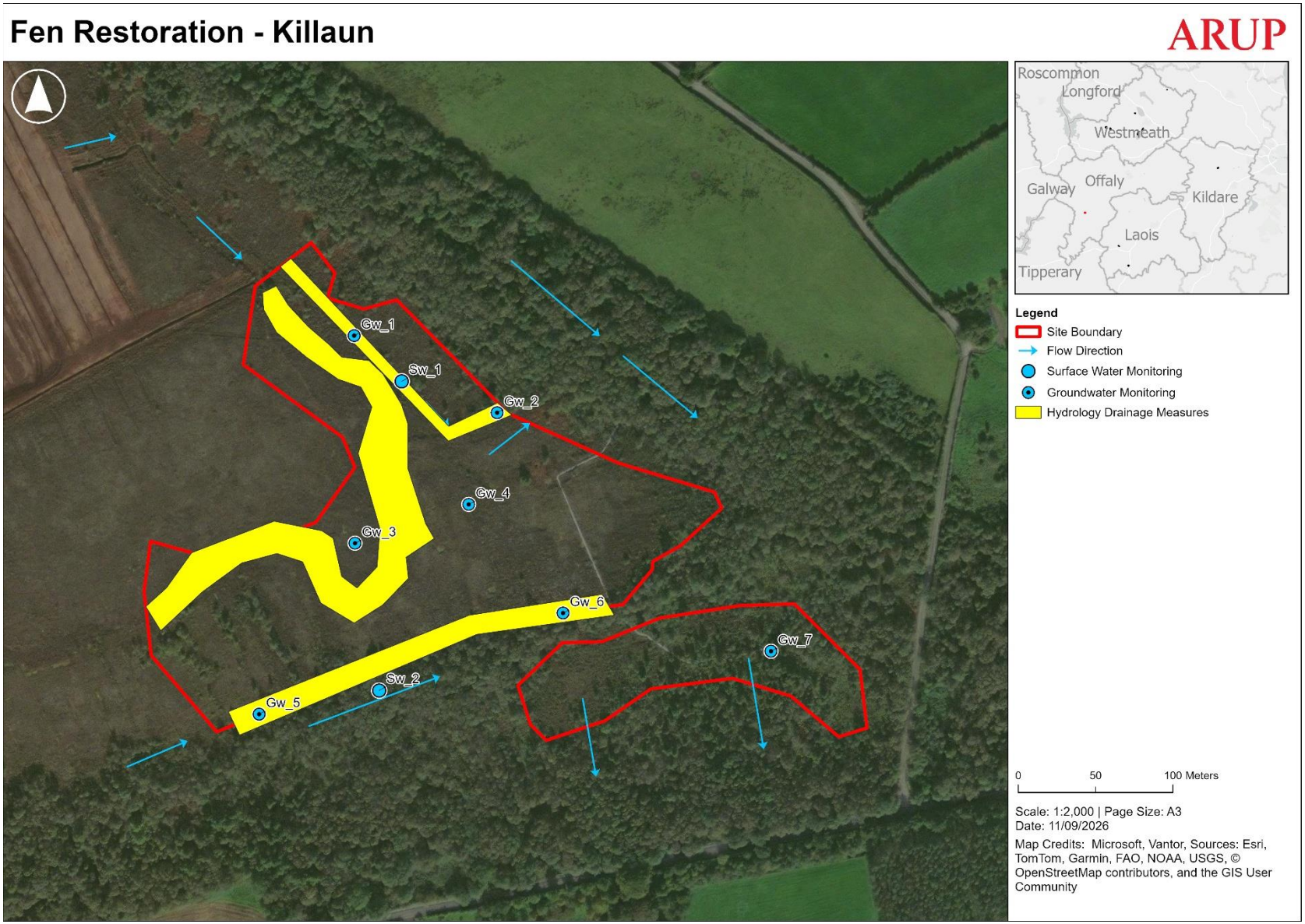


Figure 1: Hydrology measures and monitoring at Killaun Fen