

Water Management Strategy in Tarenig Welsh Government Woodland Estate

Report No: 770

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Crynodeb gweithredol

Cefndir y prosiect

Comisiynwyd JBA Consulting gan Cyfoeth Naturiol Cymru (CNC) yn 2023 i gynnal astudiaeth o floc o Ystad Goetir Llywodraeth Cymru, sef Tarenig ym Mhowys, er mwyn ymchwilio i'r swyddogaeth geomorffolegol ac ecolegol bresennol ar draws yr ardal astudio er mwyn nodi ystod o ymyriadau ar gyfer rheoli'r dalgylch yn integredig. Mae JBA wedi datblygu strategaeth rheoli dŵr a chynllun cyflawni cyfatebol ar gyfer Coedwig Tarenig, a gyflwynir mewn adroddiad tystiolaeth ac allbynnau systemau gwybodaeth ddaearyddol cysylltiedig.

Mae'r adroddiad hwn yn rhan o raglen ehangach i sicrhau gweithrediad rheoli dalgylchoedd yn integredig mewn blociau coedwigaeth eraill ar draws Ystad Goetir Llywodraeth Cymru. Mae'n cynnig nifer o atebion ar sail natur ar gyfer yr amgylchedd afonol a dŵr i alluogi gwelliant, adferiad a gwell gwydnwch trwy fynd i'r afael â phwysau ac effeithiau ar draws y dalgylch, gan gynnwys addasiadau ffisegol, rhywogaethau estron goresgynnol a dirywiad llystyfiant glannau afonydd. Mae'r cynllun yn nodi cyfleoedd i arafu'r llif (arafu llifoedd dŵr a gwaddod) a hefyd i gyflawni manteision amgylcheddol eraill ar draws yr ardal astudio. Bydd angen mireinio'r opsiynau arfaethedig ar gyfer arafu llifoedd dŵr a gwaddod ymhellach trwy waith dichonoldeb a dylunio yn y dyfodol cyn eu rhoi ar waith ar lawr gwlad.

Bydd yr amserlenni ar gyfer gweithredu'r opsiynau a nodwyd yn dibynnu ar lwyddiant y cydweithrediad hwn ac argaeledd ffactorau fel cyllid ac adnoddau, yn ogystal ag ymateb geomorffolegol ac ecolegol i'r gwahanol opsiynau arafu ar gyfer dŵr a gwaddod.

Canfyddiadau allweddol

Pwysau allweddol ar yr amgylchedd dŵr	Disgrifiad
Amseru gweithrediadau llwyrdorri a theneuo yn y goedwig	Gall arferion torri coed sy'n defnyddio peiriannau trwm achosi aflonyddwch i'r ddaear, gan arwain at ddadleoli gwaddod mân a chywasgu priddoedd, gan arwain yn ei dro at lai o fandylledd a rhyddhau cyfansoddion ffosffad a nitrogen sy'n lleihau ansawdd y dŵr trwy asideiddio ac ewtroffeiddio.
Rhywogaethau estron goresgynnol	Gallai presenoldeb rhywogaethau estron goresgynnol arwain at iddynt ledaenu o fewn y coetir a'r ardal gyfagos. Byddai hyn yn newid cynefinoedd a chyfansoddiad y rhywogaethau sy'n bresennol yn y coetir.

Pwysau allweddol ar yr amgylchedd dŵr	Disgrifiad
Draeniau a ffosydd yn y goedwig	Mae draeniau coedwig yn cyfrannu at gludo'r llif a gwaddodion yn gyflymach i lawr y llethr, tuag at y brif afon. Gall hyn arwain at lefelau dŵr uwch yn y sianel a risg uwch o lifogydd i lawr yr afon.
Deunydd rhydd o'r ffordd	Gall mewnbynnau gwaddod mân i ffrydiau blaenddw'r a sianeli draenio arwain at ostyngiadau yn ansawdd dŵr a lefelau tyrfedd uwch yn y dŵr.
Draeniau ffyrdd	Mae dŵr o ddarn mawr o lethr yn cael ei ddargyfeirio trwy ddraeniau'r ffordd i geuffos, sy'n cyfeirio dŵr tuag at y brif afon, ac, o ganlyniad, gallai'r perygl o lifogydd gynyddu i lawr yr afon.
Cwlfertau	Gall disodli rhan o sianel agored ag adrannau wedi'u sianelu arwain at golled uniongyrchol o gynefin a diffyg cysylltedd hydredol ac ochrol ar gyfer poblogaethau pysgod os na chaiff mesurau lliniaru eu cyflwyno.
Diffyg llystyfiant / llystyfiant wedi'i ddiraddio ar hyd glannau afonydd	Ni fydd dŵr yn cael ei hidlo drwy barth clustogi glannau afonydd gweithredol â chysylltiadau da; o ganlyniad, bydd yn eithaf asidig, gan lygru a diraddio ansawdd y dŵr.
Deunydd ar ymyl y ffordd wedi'i ddyddodi	Yn ystod glaw trwm, gall rhywfaint o'r gwaddod hwn sydd wedi'i ddyddodi gael ei ailsymud ac ailymuno â'r cwrs dŵr a'r brif afon, gan arwain at ostyngiad yn ansawdd y dŵr a lefelau tyrfedd uwch yn y dŵr.
Deunydd wedi'i gloddio	Yn ystod glaw trwm, gall rhywfaint o'r deunydd hwn sydd wedi'i gloddio gael ei ailsymud ac ailymuno â'r cwrs dŵr a'r brif afon, gan arwain at ostyngiad yn ansawdd y dŵr a lefelau tyrfedd uwch yn y dŵr.

Cyfleoedd posibl i gyflawni amcanion y prosiect

- Ymgorffori arferion coedwigaeth cynaliadwy
- Clirio dalbyllau
- Gwella lleoliad deunydd ar ymyl y ffordd
- Gwaredu deunydd wedi'i gloddio
- Rheoli rhywogaethau estron goresgynnol
- Gostwng y glannau
- Gosod cwlferei newydd

- Ychwanegu rhwystrau mandyllog a deunydd prenaidd mawr
- Ychwanegu pyllau bas
- Gosod cwlferi lliniaru
- Cynyddu coetir (plannu coed llydanddail) ar lannau afonydd
- Creu tir agored

Isod mae cyfleoedd ychwanegol y gellid eu gweithredu o fewn yr ardal astudio a fyddai hefyd yn cyd-fynd ag amcanion y prosiect. Nid yw'r cyfleoedd hyn wedi'u cynnwys yn y tabl cyfleoedd mwy gan na chanfuwyd unrhyw leoliadau addas ar gyfer y nodweddion hyn yn ystod yr ymweliad â'r safle.

Cyfleoedd ychwanegol

- Cynllunio gweithrediadau coedwig ar raddfa dalgylch
- Cynhyrchu cynlluniau rheoli dŵr dalgylch
- Gosod draeniau siâp J

Executive summary

Project background

In 2023 JBA Consulting was commissioned by Natural Resources Wales (NRW) to undertake a study of a Welsh Government Woodland Estate (WGWE) block, Tarenig in Powys, to investigate existing geomorphological and ecological functioning across the study area in order to identify a range of Integrated Catchment Management interventions. JBA have developed a Water Management Strategy (WMS) and corresponding Delivery Plan (DP) for Tarenig Forest, presented in an evidence report and accompanying GIS outputs.

This report is part of a wider programme to implement integrated catchment management in other forestry blocks across the WGWE. It proposes a number of nature based solutions for the riverine and water environment to enable enhancement, recovery and improved resilience by addressing pressures and impacts across the catchment including: physical modifications, invasive non-native species (INNS) and riparian vegetation degradation. The plan identifies opportunities to slow the flow (attenuate water and sediment) and also deliver other environmental benefits across the study area. The options for water and sediment attenuation proposed will need to be further refined through future feasibility and design work prior to any implementation on the ground.

Timescales for implementation of the identified options will depend on the success of this collaboration and the availability of factors such as funding and resources, as well as geomorphological and ecological response to the different water and sediment attenuation options.

Key findings

Key pressures on the water environment	Description
Timing of clearfell and thinning forest operations	Felling practices with the use of heavy machinery can cause ground disturbances, resulting in fine sediment displacement, compaction of soils leading to reduced porosity and a release of phosphate and nitrogen compounds that deplete water quality through acidification and eutrophication.
Invasive Non-Native Species (INNS)	The presence of INNS could result in it spreading within the woodland and surrounding area. This would alter the habitats and composition of species present within the woodland.

Key pressures on the water environment	Description
Forest drains and ditches	Forest drains contribute to a quicker conveyance of flow and sediment transport downslope, towards the main river. Can result in increased in-channel water levels and an increased risk of flooding downstream.
Loose road material	Fine sediment inputs into headwater streams and drainage channels can result in decreases in water quality and increased water turbidity.
Road drains	Forestry roadside drains artificially concentrate and accelerate water draining from large sloping areas of woodland. These drains are often connected to streams and rivers and can lead to increased downstream flood risk and degradation of water quality from fine sediment dispersal.
Culverts	Replacing a section of open channel with culverted sections can result in a direct loss of habitat and a lack of longitudinal and lateral connectivity for fish populations if not mitigated for.
Lack of/degraded riparian vegetation	<p>Riparian vegetation, with a mix of broadleaf native trees, shrubs and grasses, creates an important transition zone between aquatic and terrestrial environments. Riparian woodlands are crucial for controlling erosion, improving water quality, providing habitat for wildlife, and supporting the food chain for aquatic ecosystems.</p> <p>Without riparian vegetation, polluted runoff from forestry operations can enter the watercourse directly, leading to acidic, polluted, and degraded water quality due to the lack of filtering capacity.</p>
Deposited roadside material	During heavy rainfall events some of this deposited sediment could be remobilised and re-enter and watercourse and the main river resulting in decreases in water quality and increased water turbidity.
Excavated material	During heavy rainfall events some of this excavated material could be remobilised and re-enter and watercourse and the main river resulting in decreases in water quality and increased water turbidity.

Potential opportunities to meet project objectives

- Embed Sustainable Forest Management practices
- Clear catch pits
- Improve placement of roadside material
- Remove excavated material
- Invasive Non-Native Species (INNS) control
- Bank lowering
- Culvert replacement
- Add leaky barriers and woody material
- Add scrapes
- Install relief culverts
- Increase riparian woodland (broadleaf planting)
- Open ground creation

Below are additional opportunities that could be implemented within the study area that would also align with project objectives. These opportunities have not been included within the larger opportunity table as there were no suitable locations found for these features during the site visit.

Additional opportunities

- Plan forest operations at catchment scale
- Produce catchment water management plans
- Implementation of J-shaped drains

1. Introduction

1.1 Study background

Natural Resources Wales (NRW) is the statutory organisation responsible for environmental management in Wales. These functions include the management of the freshwater environment including protected sites designated under UK legislation and of European/international (Sites of Special Scientific Interest (SSSIs), Special Protection Areas (SPAs) and Special Areas of Conservation (SACs)) and water bodies under the Water Framework Directive Regulations. An important duty of NRW is the requirement for the Sustainable Management of Natural Resources specified by the Environment (Wales) Act 2016.

The freshwater environment in Wales is under significant threat from multiple pressures, including land drainage, physical modification, water pollution, invasive non-native species and climate change. As with any land use, forestry can be managed and designed to improve and restore water quality, wetland habitats, and the hydromorphology of rivers in addition to providing further resilience to communities by reducing flood risk.

In Wales, there has been significant beneficial re-design of Welsh Government Woodland Estate (WGWE) woodlands and large-scale riparian improvements and projects over the last 20 years. This includes implementing the River Basin Management Plan (RBMP) requirements by changing forest design and felling through low impact and clear-fell systems and reduced pesticide and fertiliser use.

At the same time, it is recognised that there are opportunities on the WGWE and in the wider catchment to exceed the UK Forestry Standard and associated Practice Guides to “slow the flow” of water on the estate to deliver benefits for nature, climate and people and to improve watercourse habitat to benefit protected species, such as through enhanced riparian habitat and better hydrological connectivity through culvert modification/removal. The relevant practice guides include:

- Forest Research (2022). Designing and managing forests and woodlands to reduce flood risk. UK Forestry Standard Practice Guide.
- Forestry Commission (2019). Managing forest operations to protect the water environment. Practice Guide.

Integrated Catchment Management is a mechanism that can be used to address pressures on the water environment, such as those caused through Forestry management and other land management in the study area, to achieve multiple benefits. According to NRW, this includes a suite of natural flood management interventions and river and habitat restoration solutions.

It involves providing a suite of interventions that apply the principles of Sustainable Management of Natural Resources (SMNR) and thereby, enable the recovery and resilience of the water environment.

In 2023, Natural Resources Wales (NRW) commissioned JBA Consulting to undertake a study of the Tarenig WGWE block in Powys. The purpose of the study was to assess the

existing hydrological, geomorphological and ecological functioning of the area, and to use this evidence to develop a range of potential Integrated Catchment Management interventions to consider for future implementation.

1.2 Study aims and objectives

1.2.1 Aim

The aim of this study is provide proposals for nature based solutions that can aid the recovery and increase the resilience of the riverine and water environment in Tarenig Forest by restoring or enhancing natural features and function in the catchment, in line with, and where possible, going beyond the water management requirements set out in the UK Forestry Standard and associated Practice Guides. This will deliver multiple benefits, including flood attenuation, biodiversity and geomorphology enhancements, robust and resilient riparian zones and water quality improvements. This study will help to deliver Integrated Catchment Management through developing a Water Management Strategy (WMS) and corresponding Delivery Plan (DP) for Tarenig Forest. The WMS will set the long-term vision for managing water on the Tarenig Forestry Block, by bringing all the water management elements (see bullet points listed below) into one overarching strategy. This will then inform a Delivery Plan for the block, which can be easily adopted and used elsewhere to support ongoing forestry planning and operations.

1.2.2 Objectives

The primary objectives of the study are to:

- Carry out a Geomorphological and Ecological Assessment to identify opportunities, sensitivities, hazards to water quality/runoff, and ‘take stock’ of current conditions.
- Apply the principles, measures and objectives of the documents below in the Evidence Reports:
 - Draft Tarenig FRP
 - Relevant UK Forestry Standards
 - Forestry Practice Guides, (particularly Designing and managing forests and woodlands to reduce flood risk),
 - National Flood Risk Management Strategy
 - Powys Nature Recovery Action Plan
- Use the above to generate an overarching Water Management Strategy and Delivery Plan:
 - The WMS will be presented in a Map format similar to the FRP Maps:
 - The WMS will include a detailed map of all the watercourse and drainage network and infrastructure and assets.
 - The WMS will be extracted from a prioritised list of interventions. This will take into account the benefits, such as for habitat / species (which have been recorded in the local area or may have the potential to utilise the site) / water quality and flood reduction, how they deliver on the FRP objectives and the impacts such as commercial impact, and ease of delivery (i.e., access).
 - The DP will be presented in a table format:

- The DP will identify whether each WMS component is a Business-as-Usual (BAU) activity or a Restoration/Enhancement Opportunity for freshwater habitat or to minimise flood risk and downstream water quality impacts. BAU activity is considered complying with UKFS and practice guides. The Delivery Plan table will be a working document and should be updated by NRW to identify how each WMS component will be delivered, by whom and when.
- The DP will use the 5-year time periods of forestry planning starting with 2022-26.
- For the evidence report, include an explanation of the methodology and approximate costings for the interventions. It will also consider suitable low-cost monitoring of the effectiveness of the interventions.
- Inform relevant NRW colleagues of this project through delivering a presentation of the work undertaken and inviting feedback.

Table 1-1 shows a summary of the FRP deliverable objectives for Tarenig Forest (Myherin and Tarenig Forests Forest Resource Plan Objectives 2022-2042).

Table 1-1: Summary of the FRP deliverable objectives for Tarenig Forest

Activity identified through forest resource planning	Benefits from delivering	Risks from failing to deliver
Reduce the percentage of larch which could become infected with PR	Reduced impact to environment and visitor experience.	Risk of whole scale removal in a 6 month time period if the larch becomes infected.
Reduce clear fell coupe size and increased delivery time frame. Combined with some appropriate areas managed by LISS.	Reduce negative impact on water quality, soil exposure and landscape features. Sustainable timber production.	Increase risk of soil erosion, water runoff / acidification. Increased negative impact on landscape.
Increased successional / riparian woodland areas.	Increased biodiversity and habitat linkage through upland conifer forest. Increased buffer zones around watercourses.	Reduced biodiversity and habitat linkage. Increased risk of various river-focused problems, such as siltation.
Managed & protected archaeology sites.	Protection of the heritage features.	Degradation of heritage features. Can reduce possibility for future research projects.
Manage and protect areas of higher ecological value, such as peat bogs, ASNW and broadleaved areas.	Enhancement of native flora and fauna in a more stable environment.	Degrading of natural environments & reduced 'core habitat' availability for less mobile species.

2. Methodology

2.1 Overview

In order to develop sustainable geomorphological and ecological functioning throughout Tarenig Forest, any restoration options must recognise, understand and utilise the interlinkages between river/drainage channel form, function and ecology. A spatially integrated study has been conducted to gain the understanding necessary to describe system form and behaviour and focus efforts on recovering and increasing the resilience of the riverine and water environment within Tarenig Forest by restoring natural features and function. This study combines desk-based and targeted field-based components, to deliver the geomorphological analysis and ecological interpretation of the physical impacts on Tarenig Forest.

2.2 Desk-based assessment

The desk-based component involved reviewing a wide range of information provided for this study to investigate both the historic and natural environment. The supplied information has been summarised in Appendix A. In addition, other sources openly available through the internet (LiDAR, historical maps, geology and soils, WFD) have been utilised. The review and incorporation of this information is essential to understand the wider context of the study area and its headwater streams. This enables identification of local and forest-wide controls that may be influencing geomorphic processes and ecological functioning within Tarenig Forest.

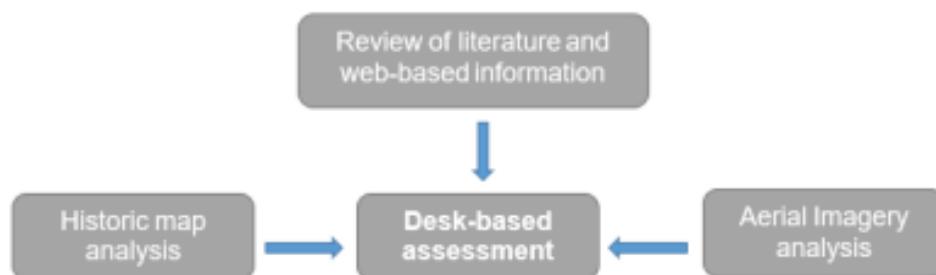


Figure 2-1: Desk-based assessment of a study area

2.3 Flow accumulation tool

To help identify drainage channels and preferential flow pathways throughout the site for the Drainage Plan and Water Management Strategy, a flow accumulation analysis was undertaken using the 1m bare earth LiDAR DTM and the Flow Accumulation (Spatial Analyst) tool in ArcMaps. The tool calculates the quantity of flow that passes into each downslope cell. It requires a Flow Direction Raster to be generated before the final Flow Accumulation raster. High flow accumulation areas, i.e. concentrated flow, can be used to identify the drainage channels and preferential flow pathways. Figure 2-2 shows that there

are many potential flow pathways across the study area, some being artificially modified due to, for example, roads/tracks within the DTM.

As LiDAR does not penetrate vegetation in densely covered areas well, such as in Tarenig Forest, then the underlying land surface topography may not have been accurately picked up. As a result, the output raster generated by the Flow Accumulator Tool (that uses the available bare earth LiDAR Digital Terrain Model) may not be representative of all true drainage channel locations, hence why ground truthing is required. It is also important to note that the Flow Accumulation Tool may identify drainage channels in areas where flow is not present. This is likely to occur in areas of depression within the LiDAR as the quantity of flow that passes into each downslope cell is calculated.

For the purposes of the planning the site visit during which drainage channel locations would be ground truthed, a Watershed (Spatial Analyst) Tool in ArcMaps was run using the Flow Direction Raster (generated from the Flow Accumulation Tool run) in order to delineate the sub-catchment boundaries within the study area and to inform the site assessments. The tool uses a point shapefile input at the location of the watercourse/stream where a sub-catchment boundary is required and the Flow Direction Raster. 12 sub-catchment boundaries were derived across Tarenig forest using this method (see Figure 2-3).

The tool only creates a sub-catchment boundary line for watercourses that are picked up in the initial Flow Direction Raster. Whether a watercourse is recognised during the raster creation is likely due to the size of the stream and the total weighting of cells. As a result, some watercourses that can be observed in present-day OS mapping may have not been picked up in the raster, therefore preventing the accurate delineation of a sub-catchment boundary for particular streams. This limitation did restrict the amount of boundaries derived across Tarenig Forest.

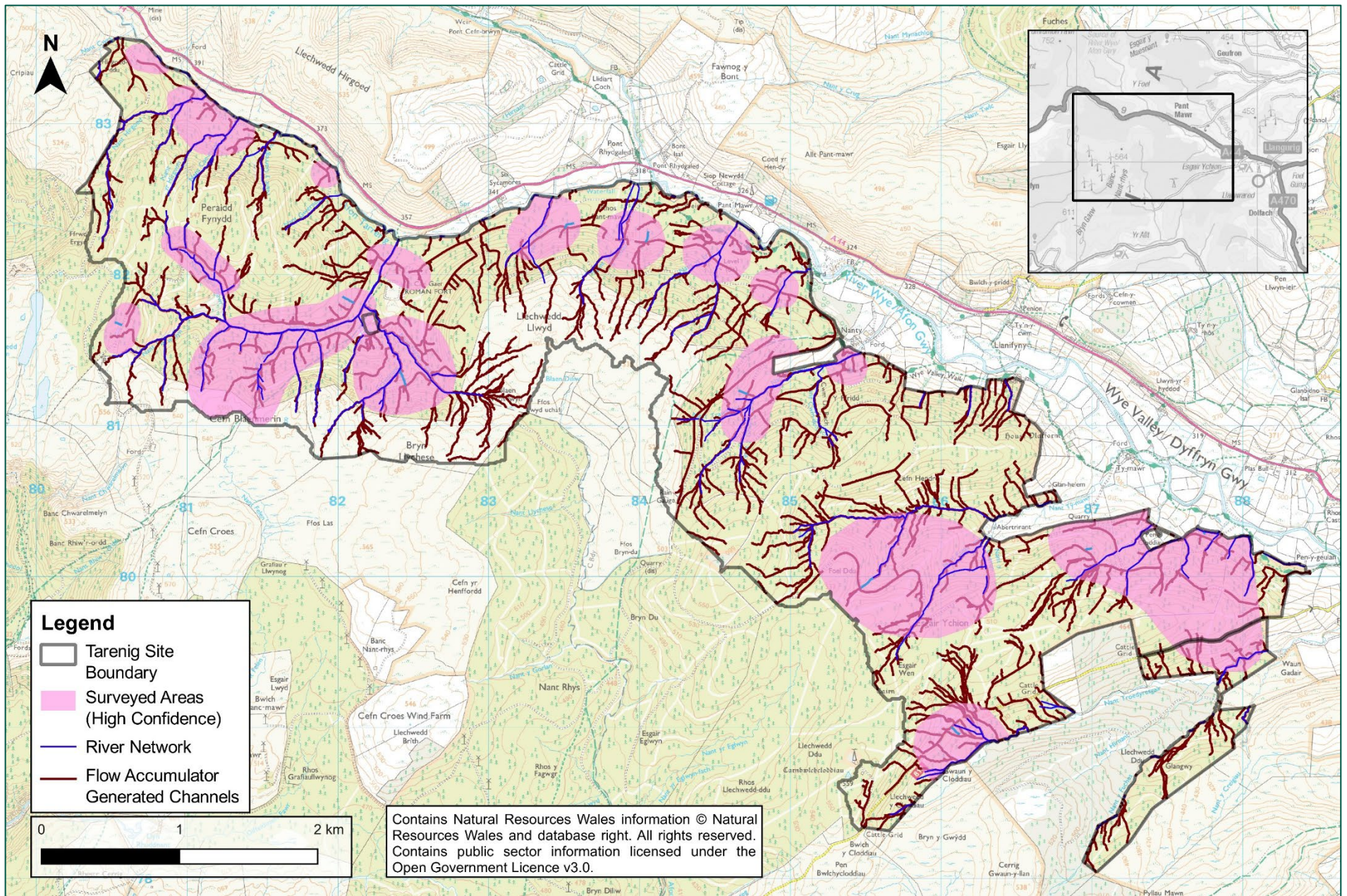


Figure 2-2: Tarenig Drainage Map

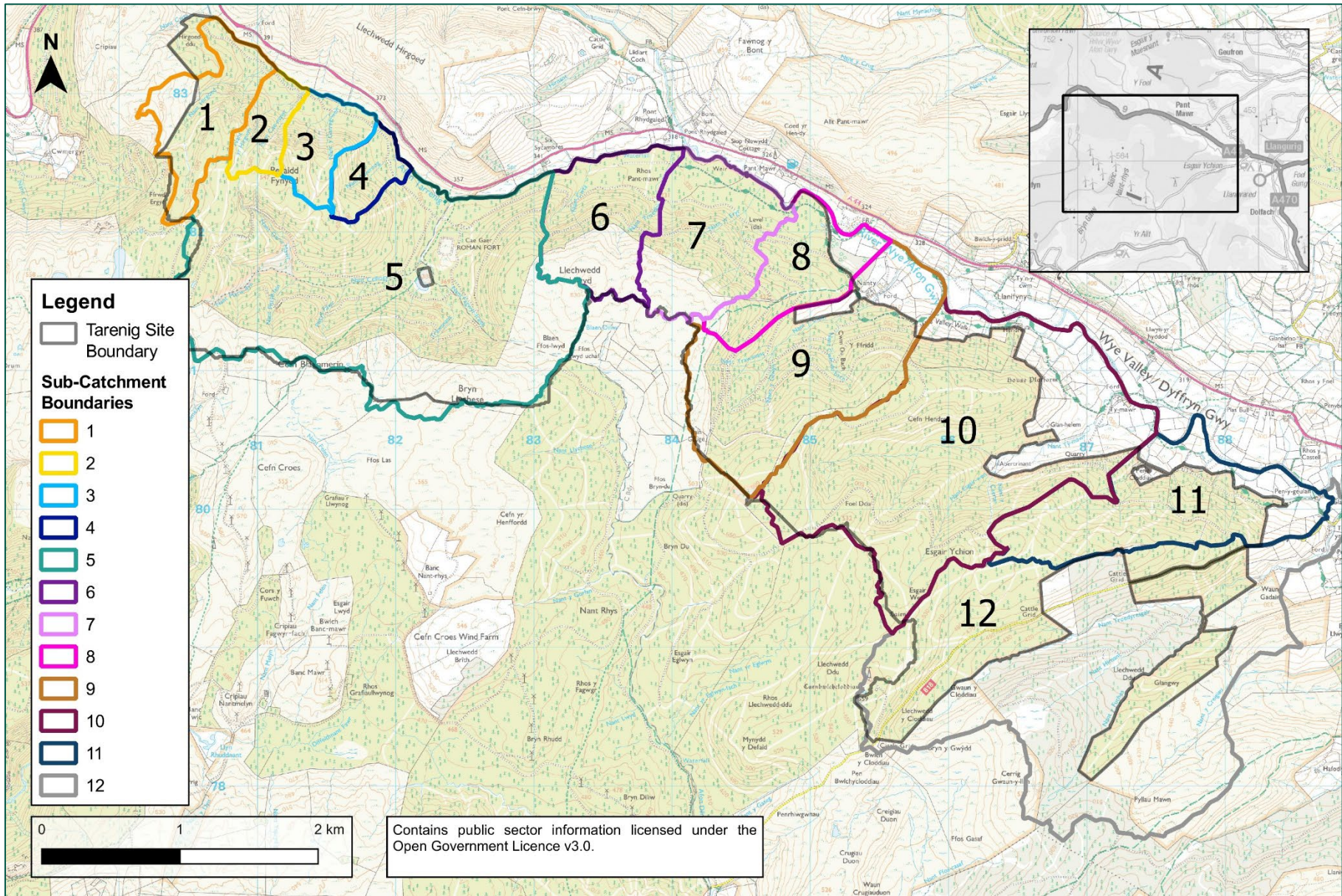


Figure 2-3: Tareinig Forest Sub-Catchment Boundaries

2.4 Inventory list

An Inventory List was also created prior to the site visit. The aim of the list was to help categorise site observations into different feature types, such as Forest Roads, Watercourses, Riparian Zone and Forest Drains. These feature types were selected as they were considered important to inform the development of the Water Management Strategy (WMS) and Drainage Plan.

Once a feature type was selected, the list revealed a detailed set of questions/prompts to help guide and record important primary data regarding the characteristics of the location (point/area) in question, together with potential NFM opportunities that could be documented in the WMS. After consultation with NRW, this list was refined, finalised and the template uploaded to the tablet-based GISmapp tool for use during the site walkover (see Appendix A).

GISmapp is an IOS-based mobile data capture tool that allowed full data capture of geolocated photographs and spatial data on the iPad in the field. The data was then synchronised in real time using the mobile phone network, allowing data and notes collected in the field to be uploaded instantly, ensuring no data loss.

The Inventory List was valuable on site to help steer observations and prompt the recording of large amounts of data. However, as the list was so extensive and to conserve time, it was not practical to complete a record for every spot check location where a change in geomorphic or ecological characteristics was identified. The degree of completeness of the inventory (and therefore the level of detail) increased at locations where there were possibilities to deliver multiple benefits (i.e. NFM, water quality/sediment, ecology) and at locations where there were clearly more significant pressures taking place that needed to be addressed. Many photos were taken, especially at these 'prime' sites, to provide more visual context.

To rectify this, a simplified inventory list has been created for use at other forest management locations, i.e., locations that do not include the trial WMS sites (see Appendix B). The list still ensures that sufficient information is recorded.

Also, the template did not accommodate for some features such as observed overland flow pathways that followed natural hill contours or open ground. Therefore, this should be added to the template if used at other forest management sites.

2.5 Geomorphological walkover and ecological survey

The targeted field-based component of the study comprises JBA's bespoke Integrated Riparian Survey (IRiS) methodology, which combines a geomorphological and ecological walkover of the study area. The geomorphologist records physical features of the river channel network (both natural and artificial channels, such as forest or road-side drains), their riparian strip, and (if present) associated floodplain. The ecologist made general observations at each stopping point, including the potential for any protected species including for fish species listed on the Environment (Wales) Act Section 7 list and observations of ecological habitat based upon the UKHab classification system. Observations of land cover and general condition of open ground areas were also made, given their potential to impact the river network and to support integrated catchment management interventions. Together, a detailed understanding of the functioning of the system and how this influences eco-geomorphology throughout the study area is developed.

A site walkover was conducted by JBA Consulting over the period 27th November to 1st December 2023 to record geomorphic and ecological features, ground truth the identified drainage channel locations and to assess the potential for NFM opportunities within priority areas predetermined by NRW. These included the following:

- Riparian woodland
- Approved Felling Coupes (areas that already have felling permission, between now and 2031)
- Planned Felling Coupes (areas identified in the draft Forest Resource Plan that are planned for felling between 2022 to 2041)
- Natural Reserves
- Major bridges/culverts
- Open Ground
- NRW Identified Areas of Interest
- Watercourses

To ensure sufficient coverage of the priority areas throughout Tarenig Forest, a certain number of sub-catchments (delineated using the Watershed Tool pre-site visit) were visited each day. A handheld clinometer was used on site to measure the gradient of the watercourses (see Section 5). Figure 2-4 shows the priority areas within Tarenig Forest as well as the extent of the walkover via site photo locations.

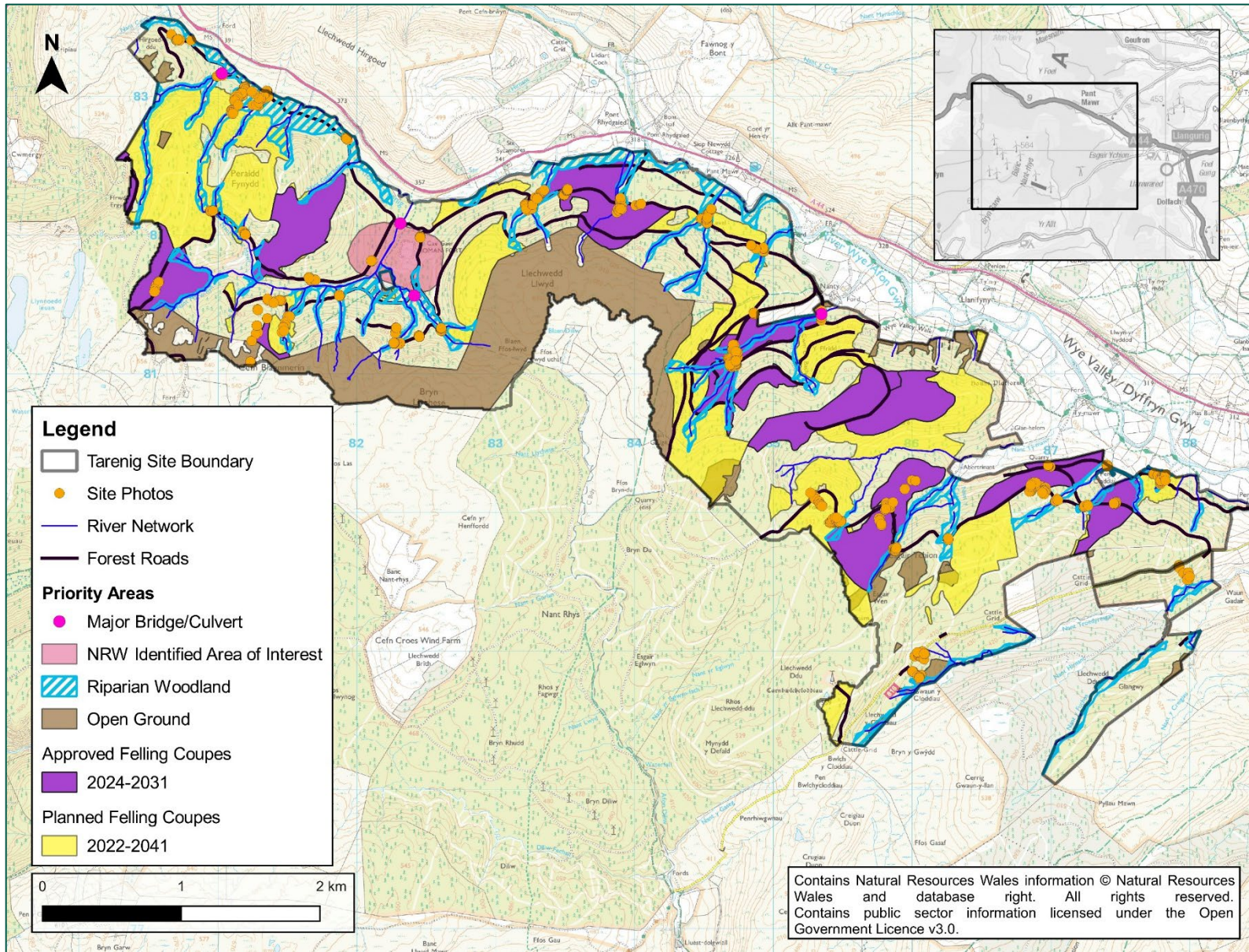


Figure 2-4: Priority Areas within Tareinig Forest

2.6 Identification of key pressures and options

An assessment of morphological and ecological character was undertaken for the catchment, based on a combination of data collected during site walkovers and desk-based research. Following the assessment, the key pressures influencing the morphology and ecology of the catchment were identified and options (including natural flood management and river restoration) to mitigate or eliminate these pressures have been recommended. The key pressures identified across the catchment are summarised in Section 5. The potential natural flood management and restoration options are presented in Section 7. The key geomorphological and ecological characteristics are summarised, and the key pressures and restoration options are listed. In addition, the restoration options are also visualised in a series of maps.

2.7 Implementation of the delivery plan

Implementation of integrated catchment management opportunities within Tarenig Forest must be a collaborative process. Evidence from this report should be combined with local knowledge and new information and research, as it comes to light.

3. Study area baseline

3.1 Study area topography

Tarenig forest topography is shown in Figure 3-1, using 1m resolution LiDAR. Tarenig forest is located within the Cambrian Mountain Range in Wales and covers an area of approximately 1,400ha (14km²). The forest extends from the north-west to south-east along the steep, right-hand valley slope to the valley floor of the upper River Wye catchment. The River Wye catchment has a total area of 4,136km² (UKECN, n.d.p).

The Afon Tarenig borders the northern boundary of the Tarenig forest for about 4.5km and flows down a 0.09-degree slope until its confluence with the River Wye approximately 400m downstream of Penrhiwgaled at an elevation of 314m AOD. The Wye continues on flowing adjacent to the forest in a south-easterly direction for 241km (Fisheries Habitat Restoration Plan: Welsh Wye Catchment) through several towns such as Rhayader and Hereford, before discharging into the River Severn near Chepstow. The Afon Tarenig and River Wye are fed by several headwater tributaries that run through Tarenig forest, including the Nant Hirgoed and Nant Ceiliogyn, which rise on the hillside of Peraidd Fynydd at an elevation of approximately 520m AOD. These headwater streams flow within a narrow V-shaped valley, confining the streams to a straight planform because of the narrow valley floor and steep valley sides. Many of the streams have a steep channel gradient and features are formed from vertical erosion (incision).

Due to the nature of land use within the Tarenig Forest study area i.e. primarily forestry management, the topography will have been influenced by human interventions to create superficial pathways to drain conifer plantation areas. These linear channels can be observed along slopes within Tarenig Forest.

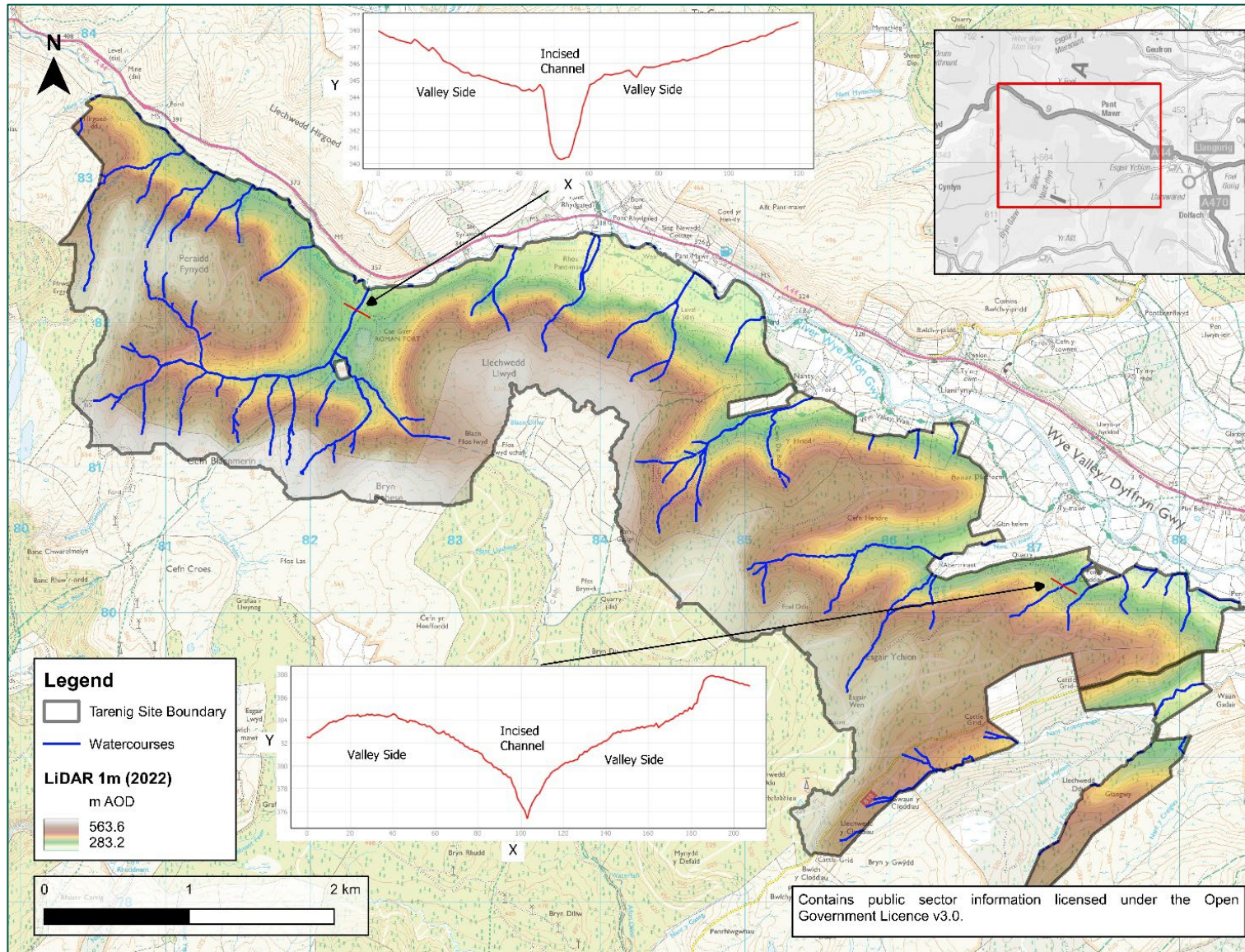


Figure 3-1: Topography within Tarenig Forest

3.2 Geology and soils

The bedrock geology of the Tarenig Forest study area is displayed in Figure 3-2 (British Geological Survey, 2023). Tarenig Forest is underlain by a variety of bedrock types. Towards the north-west of the forest boundary, near Cripiau, Ffrwd Ergyr and Peraidd Fynydd mountains, the forest is underlain by Devil's Bridge Formation comprised of interbedded mudstone, sandstone and turbidite sediments that are marine in origin. This sedimentary bedrock was formed during the Llandovery Epoch (433.4 million to 433.4 million years ago) within the Silurian period. In the central swathe, the forest is underlain by Blaen Myherin mudstones formation and Rhuddnant Grits formation comprised of mudstone-dominated turbidites and sandstone. Like the Devil's Bridge Formation, these sedimentary bedrocks were formed during the Silurian period. Towards the south-eastern end of the forest boundary, a number of sandstone and mudstone formations dominate the bedrock geology. This includes Glanyrafon Formation and Pysgotwr Grits Formation made during the Silurian period. Llandovery rocks act as minor, low productivity aquifers, therefore they contain very limited groundwater and have low permeability (Jeffries *et al.*, 2007).

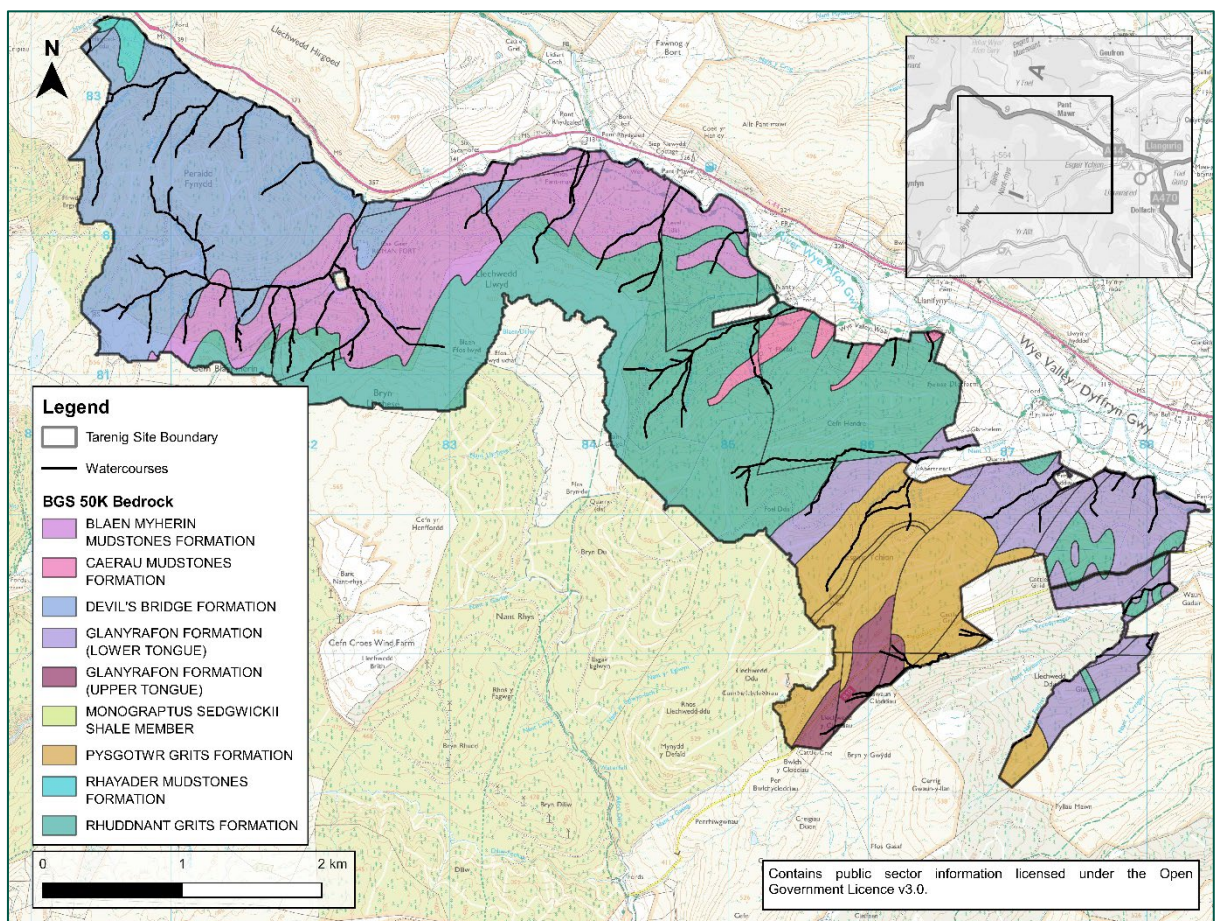


Figure 3-2: Bedrock Geology within Tarenig Forest

The superficial geology of the Tarenig Forest study area is displayed in Figure 3-3 (British Geological Survey, 2023). Within the vicinity of the Afon Tarenig, the valley floor is underlain with glacial till deposits formed during the Quaternary period, as well as some localised areas of diamicton, gravel, sand and silt that has accumulated as a result of hillwash and soil creep. Glacial till deposits are also identified along the main stem of the Nant Ceiliogyn tributary and along the River Wye downstream of its confluence with the Afon Tarenig. Headwater streams located in the south-eastern section of the forest are also underlain by glacial till deposits. Glacial till deposits are permeable and porous, therefore allowing sufficient groundwater connectivity.

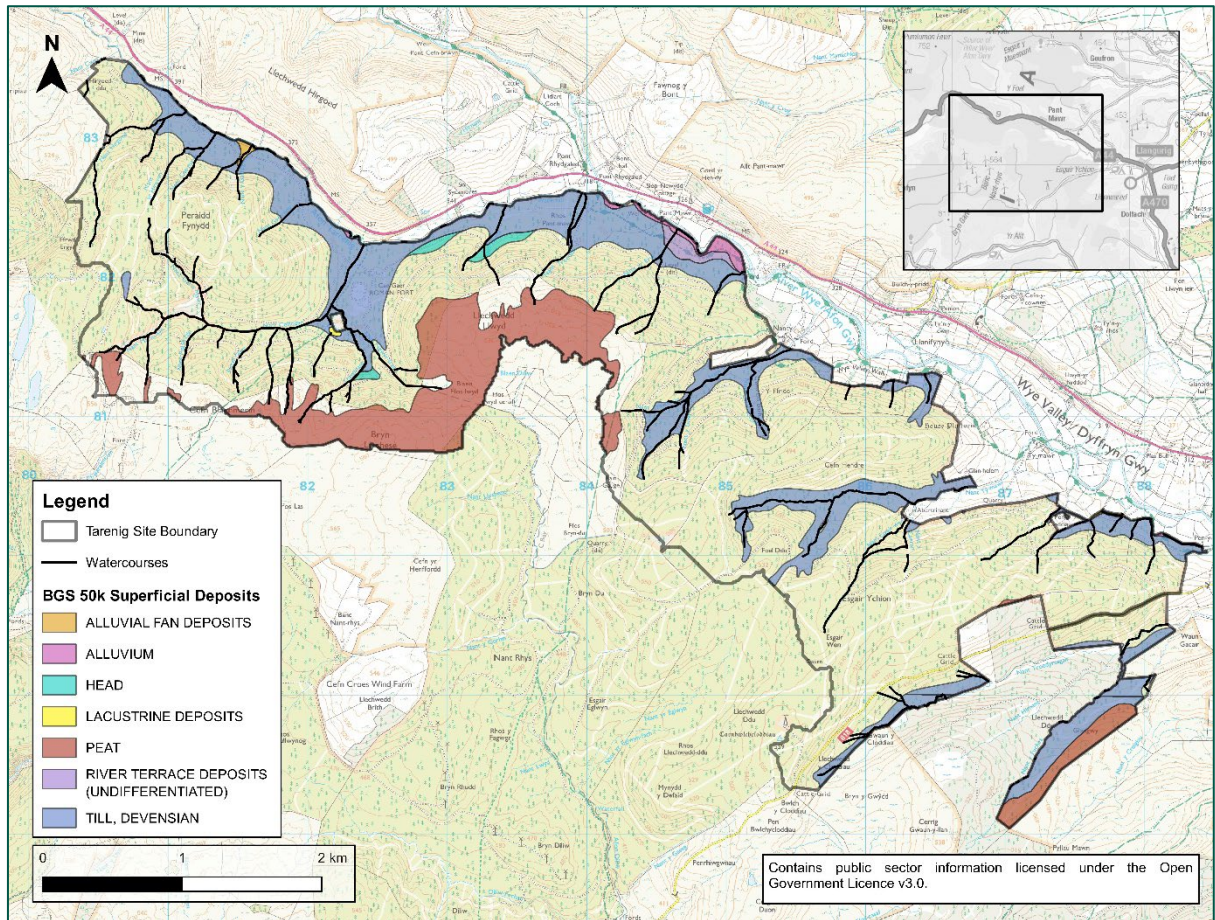


Figure 3-3: Superficial Deposits within Tarenig Forest

The soils in Tareinig Forest are dominated by ironpans and surface water-gleys (Myherin and Tareinig Forests Forest Resource Plan Objectives 2022-2042). Ironpan soil is dense and restricts the flow of water deeper into the soil. Surface water-gleys have impeded drainage often leading to waterlogging. These two soil types limit the growth of a number of plant species within the forest. In areas where brown earth is located, soils are well drained and fertile providing sufficient conditions for a diverse range of tree species. Blanket bog and peaty surface-water gleys cover large areas within the central to south-eastern region of the forest. These soil types are formed as a result of peat development (Myherin and Tareinig Forests Forest Resource Plan Objectives 2022-2042). Peatland also covers a large amount of the high elevation forest areas (see Figure 3-4) (DataMapWales, 2022). These locations will have significant amounts of organic matter, be frequently inundated and be dominated by sphagnum mosses. Under the dense tree cover the ground is dominated by bryophytes, including a range of sphagnum and clubmoss *Lycopodiaceae* species. In drier more open areas, Heather *Calluna vulgaris* and Bilberry *Vaccinium myrtillus* dominate, with small areas of Cross-leaved Heath *Erica tetralix* in the wetter areas.

Along riparian corridors outside of the conifer plantation are areas of scattered broadleaved trees including Birches *Betula* sp., Rowan *Sorbus aucuparia*, Pedunculate Oak *Quercus robur*, Willows *Salix* sp. And Alder *Alnus glutinosa*. On the high plateau, plantations transition into moorland vegetation dominated by Purple Moor-grass *Molinia caerulea*, with Soft Rush *Juncus effusus* in wetter areas. Peat hags are present, but with generally very limited peat erosion and no large area of exposed peat or grips present.

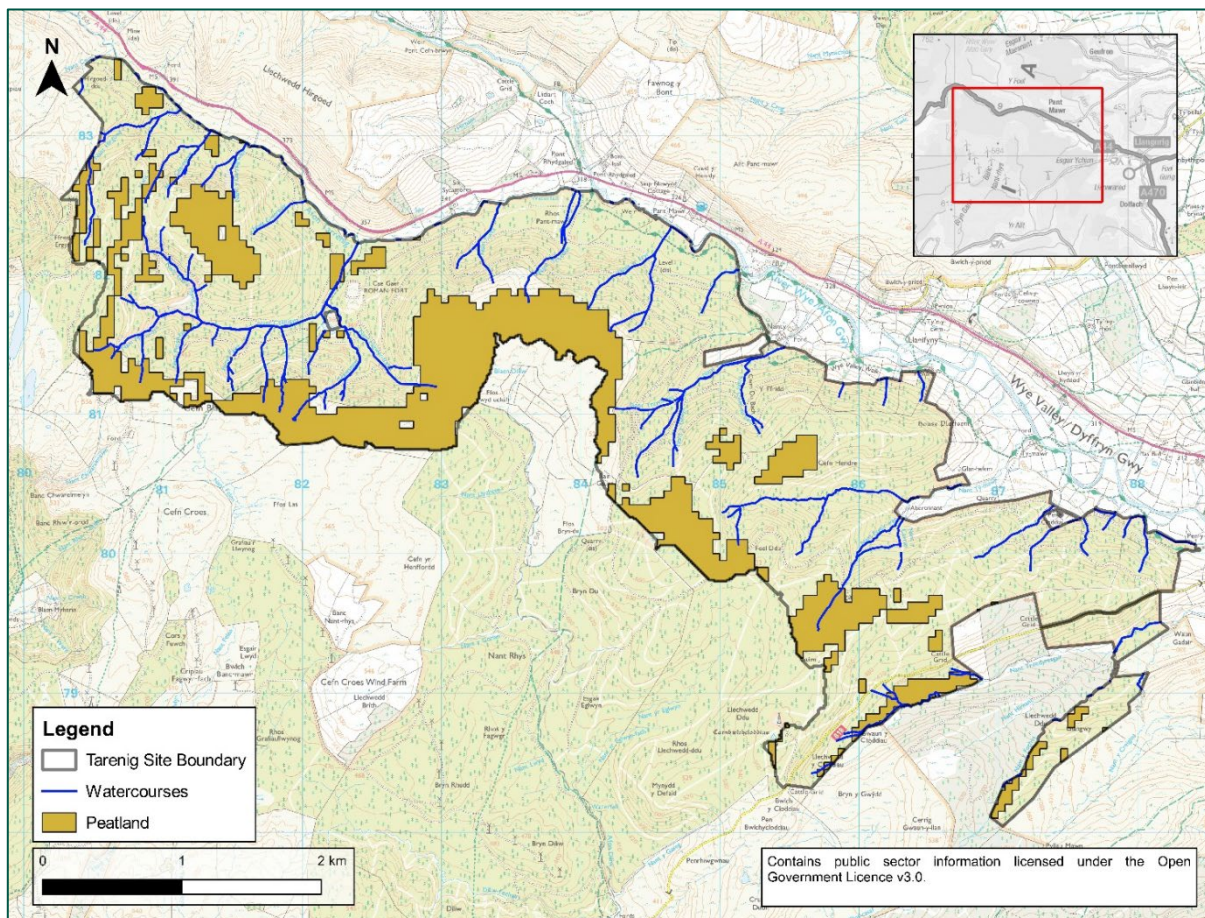


Figure 3-4: Peatland across Tareinig Forest Study Area

3.3 Land cover

Tarenig Forest is dominated by conifer plantations consisting of Sikta Spruce *Picea sitchensis*, Norway Spruce *Picea abies* and Pines *Pinus* sp. (Myherin and Tarenig Forests Forest Resource Plan Objectives 2022-2042). In areas, these plantations extend from the steep slopes to the valley floor. The plantations were originally established in the late 20th century and have been steadily felled and restocked ever since (Myherin and Tarenig Peatland Restoration Survey Report). Areas of Approved Felling Coupes between now and 2031 (areas that already have felling permission) and Planned Felling Coupes (areas that are highlighted in the Draft Tarenig Forest Resource Plan) between 2022 and 2041 have been provided by National Resources Wales, see Figure 3-5. Areas of Approved Felling Coupes cover approximately 13% of the total Tarenig Forest area, whilst Planned Felling Coupes cover approximately 30% of the total Tarenig Forest area.

Large amounts of open ground dominate the higher elevations within the forest study area. These rural areas are comprised of more open upland moorland and heathland and are often utilised by agricultural activity and grazing. Riparian woodland consisting of native broadleaved tree species border some headwater streams. It is noted that the coverage of broadleaved species within the forest has increased due to natural, successful regeneration in areas of conifer felling in some sub compartments leading to a gradual increase in riparian buffer strips and more open riparian area overtime (Myherin and Tarenig Forests Forest Resource Plan Objectives 2022-2042). NRW are actively planting some areas with native deciduous trees, as well as leaving more open areas to promote greater growth of broadleaved species and buffer zones.

A network of forest roads intersect forest drainage channels and headwater streams, some in multiple locations along the channel. Water is forced to flow through major culverts underneath bridges on route to the Afon Tarenig in the north-western part of the forest, and into the River Wye from the central to south eastern region.

NRW identified 4 abandoned mines within the central swathe of the study area. Glan Severn, Nanty South, Mine 27 and Fagwr Fraith).

In order to adhere to guidelines set out by the UK Forestry Standard, NRW are diversifying tree species within the Tarenig Forest to help make habitats more sustainable and resilient to climate change.

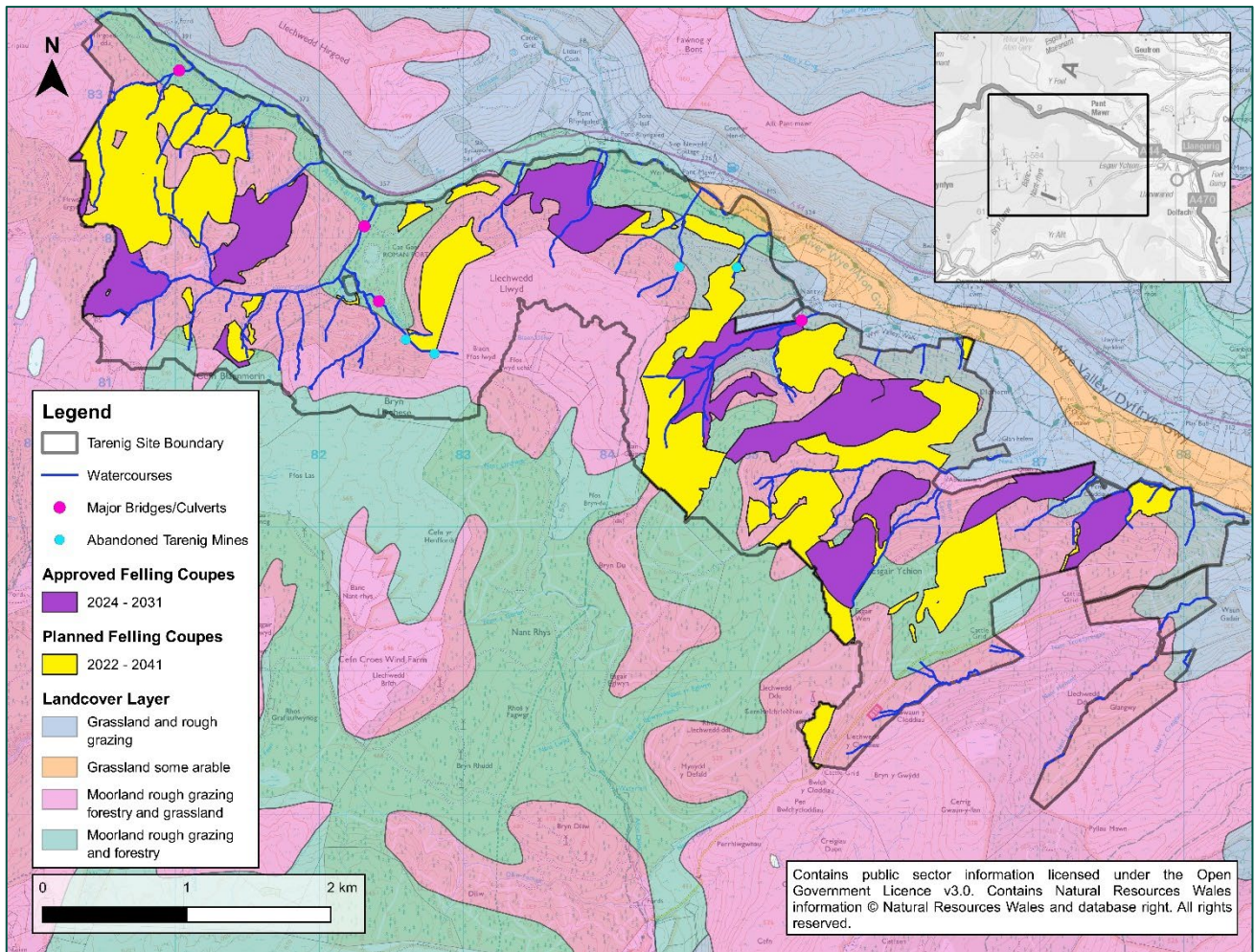


Figure 3-5: Land cover across Tarenig Forest Study Area

3.4 Hydrology and flow regime

No NRW gauging stations were identified along any of the headwater streams within Tarenig Forest. Consequently, the hydrological analysis of the watercourses is based upon the catchment characteristics.

It is likely that the headwater streams have a flashy response to rainfall events. LiDAR DTM analysis reveals that all headwater streams flow down steep, narrow valleys that confine water to the channel, which ultimately leads to high flow velocities. Even though the streams are underlain by permeable glacial till deposits and are covered by brown earth soils that allow good drainage, the presence of ironpans, surface water gleys and peaty soils greatly influences runoff production across the study area. In addition, the steep channel gradients will also influence the responses to rainfall as steep gradients encourage rapid overland runoff, thus preventing much infiltration to groundwater stores.

Rapid runoff is further exacerbated by land use practices within the forest that will have resulted in the creation of artificial drainage channels and linear depressions with the aim of directing water downslope from the conifer plantations, so that the young trees do not get submerged by water. Subsequently, discharge into the Afon Tarenig and River Wye will be

fast during rainfall events, likely leading to a fast rise to peak flows and an increase in high flow energy, resulting in increased erosion rates and accelerated sediment transport through these main rivers.

3.5 Fluvial flood risk

The Fluvial Flood Zones 2 and 3 across Tarenig Forest are presented in Figure 3-6. Flood Zone 2 areas have between 1% and 0.1% annual probability of fluvial flooding, including an allowance for climate change. Flood Zone 3 areas have a 1% or greater annual probability of fluvial flooding, including an allowance for climate change. Flood zone definitions and shapefiles have been obtained from DataMapWales (DataMapWales, 2023). Climate change information is included within the Flood Map for Planning to show how flood risk will affect river over the next 100 years.

The majority of the headwater streams that run through Tarenig Forest are excluded from the Flood Map for Planning as they are very small. Flood zones are therefore only visible along the Afon Tarenig and River Wye adjacent to the northern edge of the forest, as well as along the largest headwater stream, the Nant Ceiliogyn, just upstream of its confluence with the Afon Tarenig. The Afon Tarenig and Nant Ceiliogyn are confined by steep topography therefore flow is constrained to the channel. Flow within the channel is classified as Flood Zone 3. Downstream of the Afon Tarenig and River Wye confluence, flood extents propagate further onto the wider left and right bank floodplain (up to 130m in some areas) due to gentler sloping banks. These flood areas are classified as Flood Zone 2. The nearest downstream town is located approximately 3.2km from the south-eastern boundary of Tarenig Forest. Flood zones 2 and 3 are present within this area, however, fluvial flood risk to actual properties is very low. There are no flood defences within the vicinity of Tarenig Forest.

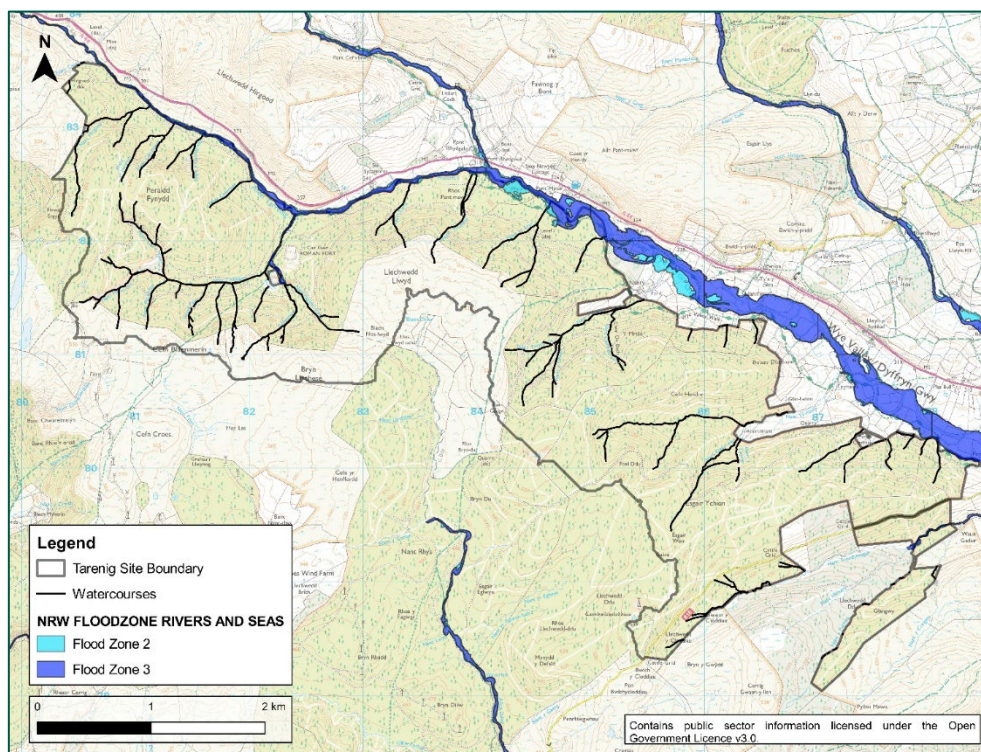


Figure 3-6: Flood Zones within the vicinity of Tarenig Forest

3.6 Surface water flood risk

Areas at risk of surface water flooding are shown in Figure 3-7 below. Areas at high risk of surface flooding are largely confined to the headwater streams that run through Tarenig Forest. However, along the right-bank floodplain, downstream of the confluence between the Afon Tarenig and River Wye, areas of high surface water flooding are also located on the shallower slopes between two headwater streams, Nant Troedlas and Nant yr Eryr.

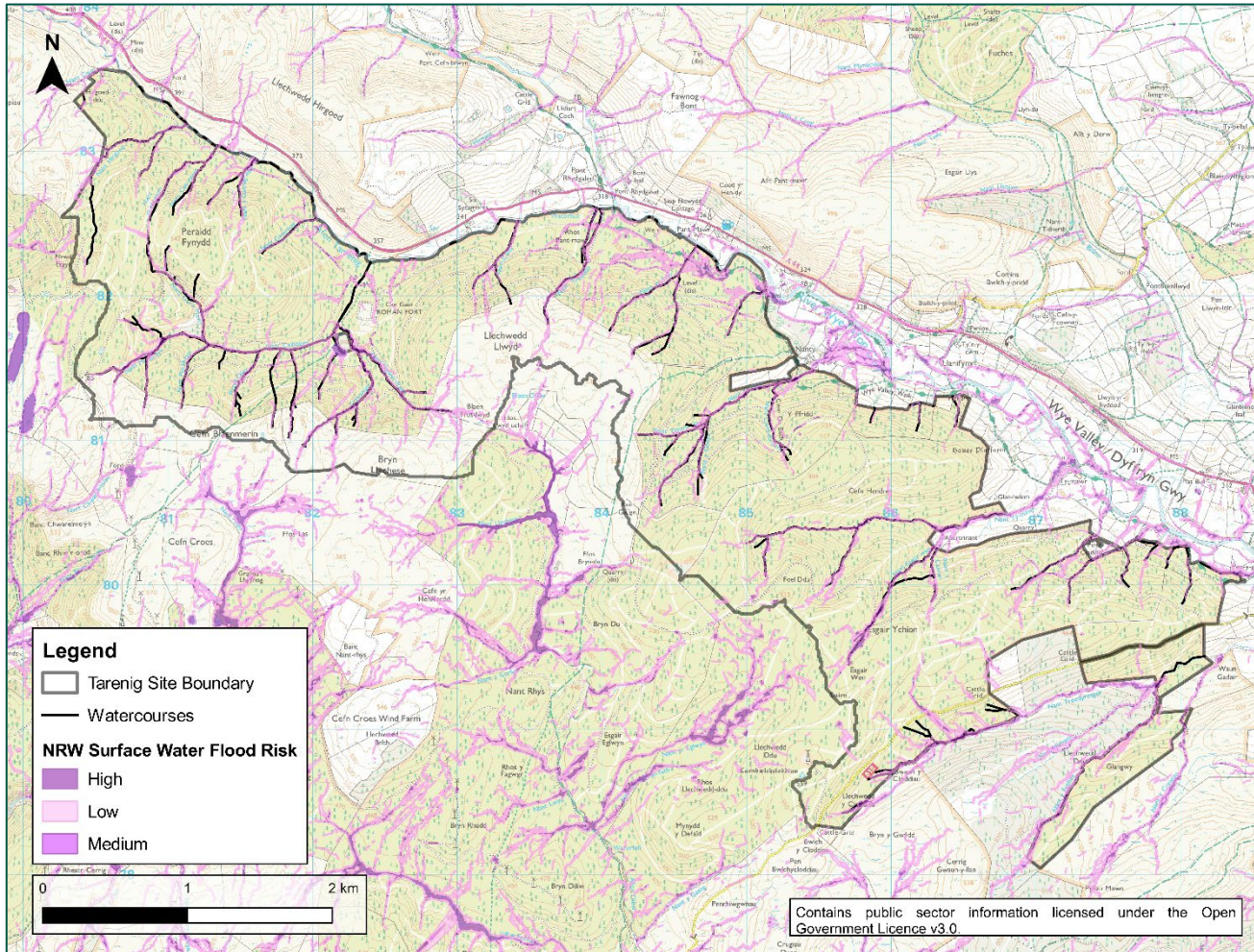


Figure 3-7: Surface Water Flood Risk within Tarenig Forest

3.7 Water Framework Directive

The headwater streams within Tarenig Forest are located within the Wye Management Catchment, which is part of the Severn River Basin District (RBD) and covered by its associated River Basin Management Plan (RBMP). There are two water bodies defined under the WFD within Tarenig Forest. The ecological status of the water bodies ranges from 'Poor' to 'Moderate' overall status.

All information is sourced from the Water Watch Wales website. The status of each of the WFD water bodies within Tarenig Forest is presented in Table 3-1.

Table 3-1: Current Status of WFD water bodies within Tarenig Forest

Water body ID	Name of water body	Hydromorphological designation	Current overall status / potential
GB109055042350	Afon Tarenig – source to conf R Wye	Natural / Not designated as a heavily modified water body (HMWB)	Poor
GB109055042330	Wye – conf Afon Tarenig to conf Afon Bidno	Natural / Not designated as a heavily modified water body (HMWB)	Moderate

3.7.1 Afon Tarenig – source to conf R Wye

The current overall status of the 'Afon Tarenig – source to conf R Wye' water body is identified as 'Poor' (2021 Cycle 3). The water body is classified as natural. The overall status objective for the water body is to reach 'Poor' by 2027 (Lower confidence (Metal mines)). The reasons that this water body is not achieving a Good overall status are listed below:

- A diffuse source of pollution associated with Atmospheric Deposition, exacerbated by Forestry Practices lowering the pH (acidification) of the watercourse and impacting Fish and invertebrates.
- A point and diffuse source of metals pollution associated with Abandoned Mines and impacting Fish. These mines are located within the headwaters of Tarenig.

However, despite being classified as 'poor' for fish under the WFD classifications, it should be noted that this waterbody does support populations of a number of protected fish species including Atlantic Salmon, Brown Trout and European Eel.

3.7.2 Wye – conf Afon Tarenig to conf Afon Bidno

The current overall status of the 'Wye – conf Afon Tarenig to conf Afon Bidno' water body is identified as 'Moderate' (2021 Cycle 3). The water body is classified as natural. The overall status objective for the water body is to reach Good by 2027. The reason that this water body is not achieving a Good overall status is due to a point and diffuse source of metals

pollution associated with Abandoned Mines in the headwaters of Tarenig and of the River Wye, impacting Invertebrates.

3.8 Environmental desk-based assessment

3.8.1 Designated sites

Tarenig Forest is located adjacent to the River Wye with the water bodies within the forest acting as tributaries to the river. The River Wye is an important ecological corridor that flows through Wales and England from the Cambrian Mountains to the Severn Estuary at Chepstow. Due to its importance for habitats and species, the river is designated as a Special Area of Conservation (SAC) and Site of Special Scientific Interest (SSSI).

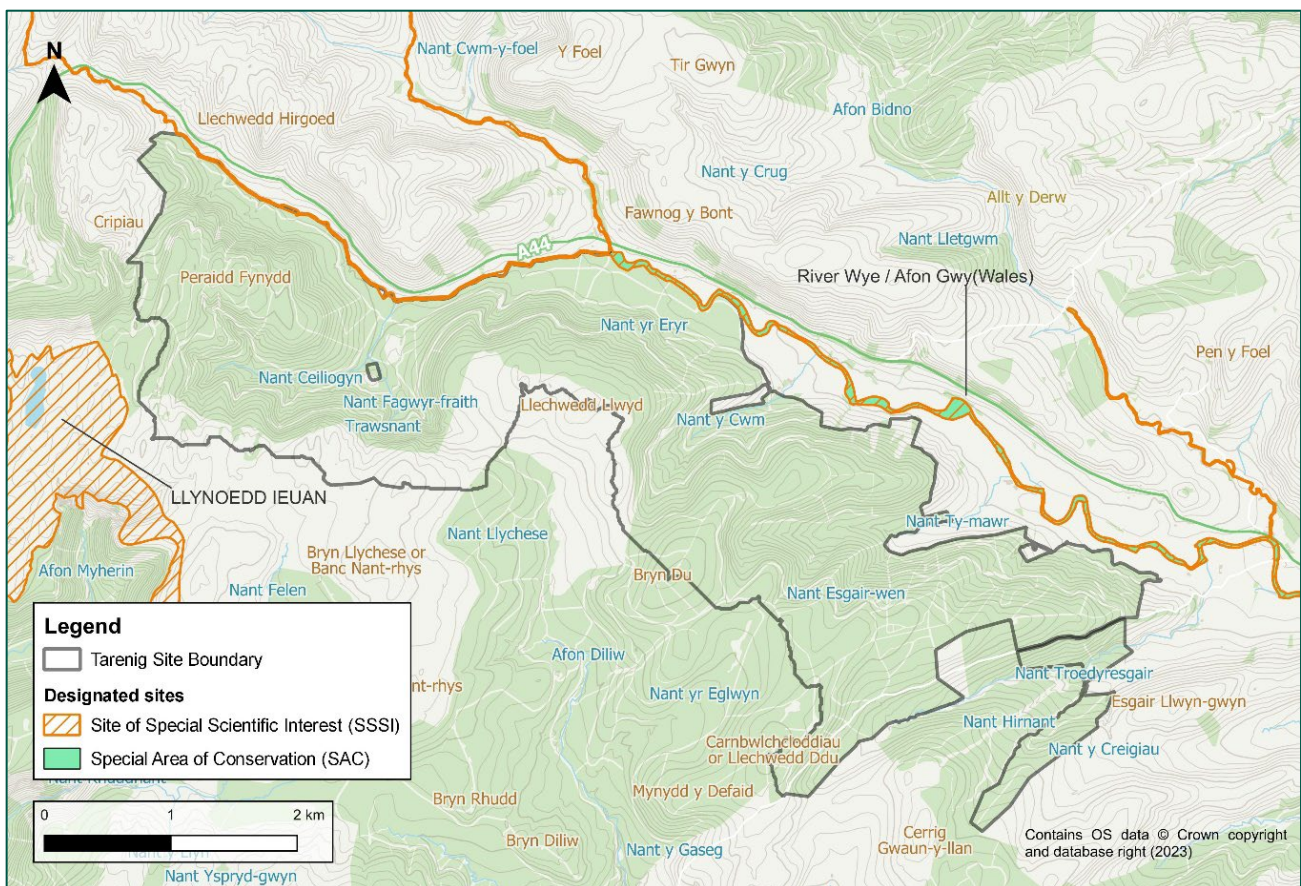


Figure 3-8: Designated sites in proximity to Tarenig forest

The River Wye SAC is designated for the Annex I habitats of transition mires and quaking bogs and watercourses of plain to montane levels with the *Ranunculus fluitantis* and *Callitriche-Batrachion* vegetation. The site is also designated for the following aquatic species:

- Allis Shad *Alosa alosa*
- Twaite Shad *Alosa fallax*
- White-clawed Crayfish *Austropotamibius pallipes*

- Bullhead *Cottus gobio*
- River Lamprey *Lampetra fluviatilis*
- Brook Lamprey *Lampetra planeri*
- Otter *Lutra lutra*
- Sea Lamprey *Petromyzon marinus*
- Atlantic Salmon *Salmo salar*

The River Wye SSSI is designated for its geology, flora, mammals, invertebrates and fish, and includes adjacent areas of riparian habitat and provides habitat for a range of breeding birds. The site supports the following protected species and habitats:

- Floating vegetation of *Ranunculus* of plain, submountainous rivers
- White-clawed crayfish *Austropotamobius pallipes*
- Otter *Lutra lutra*
- Atlantic Salmon *Salmo salar*
- Bullhead *Cottus gobio*
- Twaite Shad *Alosa fallax*
- Allis Shad *Alosa alosa*
- River Lamprey *Lampetra fluviatilis*
- Brook Lamprey *Lampetra planeri*
- Sea Lamprey *Petromyzon marinus*
- Grayling *Thymallus thymallus*
- Freshwater Pearl Mussel *Margaritifera margaritifera*

Pressures have been previously identified for the River Wye SSSI, including, from physical modification, pollution, recreational disturbance and Invasive Non-native species (INNS). In addition, the SAC management plan (NRW, 2023) highlights the role of water quality failures, INNS and pollution, in contributing to unfavourable status of some of the qualifying features, such as Sea and Brook Lamprey, Bullhead, watercourses of plain to montane levels with the *Ranunculion fluitantis* and *Callitriche-Batrachion* vegetation and White-clawed Crayfish.

A fluvial audit of the River Wye (Jeffries *et al.*, 2007) highlighted the issue of acidification within the upper catchment of the River Wye, in association with forestry plantations. This may be due to processes such as scavenging of acid deposition, where the stands height and structure increases the deposition of pollutants onto the forest surfaces (Forestry Commission, 2014).

3.8.2 Protected species

A 5-kilometre (km) buffer area from the study area has been drawn to understand the distribution of species in the wider area. The 5 km buffer has been used to clip the various datasets used in this report. When species in the buffer area are referred to in the report, this includes species recordings within the study area.

There are several duplicates within the tables in this report because of species' being seen in multiple places or in the same year. All invertebrate (spider and ally) and Lichen recordings are all before 2000 and further than 5km away from the study area so have not been included within the species tables in this report. Species recordings presented in this report are the most recent recordings, the closest recordings to the study area or both.

Key species have been identified by their frequency in the datasets assessed and, in some cases, their conservation status. These have been identified for each Taxon listed in the report.

It needs to be noted that within the plantation there may be several species that are reliant on the habitat such as:

- Goshawk (*Accipiter gentilis*)
- Nightjar (*Caprimulgus europaeus*)
- Red Squirrel (*Sciurus vulgaris*)
- Pole Cat (*Mustela putorius*)
- Pine Martin (*Martes martes*)

Birds

Table 3-2 shows bird species recorded within the 5km buffer period and after the year 2000. Some locations were not available so have not been listed.

Table 3-2: Bird species point data within 5km of Tarenig

Common name	Scientific name
Common Reed Bunting	<i>Emberiza schoeniclus</i>
Eurasian Bullfinch	<i>Pyrrhula pyrrhula</i>
European Pied Flycatcher	<i>Ficedula hypoleuca</i>
Golden Plover	<i>Pluvialis apricaria</i>
Goldeneye	<i>Bucephala clangula</i>
Goshawk	<i>Accipiter gentilis</i>
Grasshopper Warbler	<i>Locustella naevia</i>
Hobby	<i>Falco subbuteo</i>
Kestrel	<i>Falco tinnunculus</i>
Kingfisher	<i>Alcedo atthis</i>
Lapwing	<i>Vanellus vanellus</i>
Lesser Redpoll	<i>Acanthis cabaret</i>
Linnet	<i>Linaria cannabina</i>
Merlin	<i>Falco columbarius</i>
Red Grouse	<i>Lagopus lagopus</i>
Red Kite	<i>Milvus milvus</i>
Spotted Flycatcher	<i>Muscicapa striata</i>
Tree Pipit	<i>Anthus trivialis</i>
Willow Tit	<i>Poecile montanus</i>

Key species identified in the area are:

- Red Kite, *Milvus milvus*
- Eurasian Bullfinch, *Pyrrhula pyrrhula*
- European Pied Flycatcher, *Ficedula hypoleuca*
- Lesser Red Poll, *Acanthis cabaret*

The Red Kite population is likely linked to the A44 because of there being carrion on the road. After previously being extinct in the UK, Red Kite are currently listed as ‘green’ under the Birds of Conservation Concern.

Eurasian Bullfinch have a conservation status of ‘Amber’ under the Birds of Conservation concern red list (British Trust for Ornithology, 2021). Five recordings of Bullfinch are present in the buffer area occurring between 2005-2017. Another species listed above is the Lesser Red Poll which has a conservation status of ‘Red’. There are 31 recordings of Lesser Red Poll within the buffer area.

Bryophyte

Table 3-3 shows the bryophyte species found within the 5km buffer area of the study area.

Table 3-3: Bryophyte species point data within 5km of Tarenig

Common name	Scientific name
Brown Grimmia	<i>Grimmia elongata</i>

Fish

Tarenig has steep headwater courses that run through it as well as dense forestry. The river Wye (Afon Gwy) and Taranig covers the northern boundary of the study area where both Trout and Salmon are known to inhabit. Concerns over fish habitat at the site include:

- Acidification.
- Sediment run off.
- Small riparian buffer zones.
- Limited connectivity for fish to higher up watercourses.

Electro fishing data

Salmon

Electro fishing survey data was provided by NRW. Fishless (F) data entries have been taken out as well as any recordings of ‘0’ Salmon and recordings before 2000. Highest counts of Fry and Parr can be found at the locations Youth Hostel (DE5) (568.43m) and Henfaes (30m). The next highest count of Fry can be found at Henfaes (1311.76m) and the next highest count for Parr is ‘at fence line’ (21m).

Youth Hostel (DE5) can be found on the Llangurig Rhayader tributary of the river Wye to the southeast of the 5km buffer.

Table 3-4: Salmon data within 5km of Tarenig

Location	Count of 0+ classification (Fry)	Count of >0+ classification (Parr)
200m u/s start of forest	3	1
250m downstream forestry	9	6
250m u/s of tunnel	0	5
50m u/s flume	0	4

Location	Count of 0+ classification (Fry)	Count of >0+ classification (Parr)
Aberbidno	35	1
Above Penrhos Farm	17	7
At fence line	0	21
Below Eistedella Gurig	0	8
Between Bidno and track	0	1
Bidno mill d/s bridge	20	1
Bottomside-ford	4	4
D/s Hirgoed	0	1
D/s Nant Gwernog	5	3
D/s of tunnel	2	6
D/s w025 plasbwl	135	2
Dolfach	2	1
Downstream of roman fort	6	5
Eisteddfa Gurie	0	1
End of fallen forestry	21	7
Glanbidno isaf footbridge	110	5
Glanbidno isaf track u/s house	18.91	1
Grand total	5769	367
Gwy 3, above fenceline	0.4	14
Halfway between road bridge and track bridge	1	6
Henfaes	1312	30
Immediately upstream of flume	1.4	15
In forestry	0	4
In Penrhos Farm yard	7	5
Llangurig	219	6
Nant lletgwm confluence	7	7
Nanty	56	8
Nanty farm	3	2
Near hafren forestry	9	7
Pant-y-drain	50	6
Pany-y-drain	0	2
Penrhos farm	28	5
Plasbwl	654	19
Pont rhydgaled	69	14
Pont rhydgoed	300	17
Pontbrenllwyd d/s bridge	82	6
Trafel-gwen 400m u/s farm (de9)	0	1
Trafel-gwyn d/s of farm (de7)	66	4
Ty mawr, forest site	6	4
Ty-mawr farm	21	5
Ty-mawr, d/s bridge	132	6

Location	Count of 0+ classification (Fry)	Count of >0+ classification (Parr)
Ty-mawr, u/s Nant Ty Mawr confl.	35	4
U/s forestry bridge	4	1
U/s Nant Cyff	8	8
Up above gates	2	5
Upstream farm at track bridge	0	1
Upstream from wye confluence (d/s weir)	1	1
Upstream of bridge, Pontbrenllwyd	12	4
Upstream of gauging weir	0	1
Upstream of Nant Iago confluence	1	4
Upstream of track	0	3
Upstream of tunnel, at gauging station	0	2
Waun Gadair	0	4
Youth hostel (de5)	2062	20

Trout

Fishless (F) data entries have been taken out as well as any recordings of '0' Salmon and recordings before 2000. Highest counts of Fry and Parr can be found at the location Youth Hostel (DE5) (2061.93m and 20m). The next highest count of Fry can be found at Henfaes (184.52m). The second highest count for Parr can be found at the location called 'Immediately upstream of flume' (54.06m).

~~Table 3-5: Trout data within 5km of Tarenig~~

Location	Count of 0+ classification (Fry)	Count of >0+ classification(Parr)
250m downstream forestry	2	2
250m u/s of tunnel	21	5
50m U/S Flume	10	13
Aberbidno	2.3	0
Above Penrhos Farm	11	7
At fence line	18	52
Below Eistedella Gurig	16	10
Bidno mill d/s bridge	6	3
Bottomside-ford	2	5
D/s Hirgoed	3	0
D/s Nant Gwernog	16	2
D/s of tunnel	19	11
D/s w025 Plasbwl	1.3	0
End of fallen forestry	7	2
Glanbidno Isaf footbridge	10	1
Glanbidno Isaf track u/s house	9	7

Location	Count of 0+ classification (Fry)	Count of >0+ classification(Parr)
Gwy 3, above fenceline	8	37
Halfway between road bridge and track bridge	26	5
Henfaes	185	47
Immediately upstream of flume	34	54
In forestry	0	2
In penrhos farm yard	14	5
Llangurig	7.2	0
Nant Lletgwm confluence	7	3
Nanty	12	1
Nanty farm	5	1
Near hafren forestry	4	1
Pant-y-drain	0	1
Pany-y-drain	0	1
Penrhos farm	46	10
Plasbwl	17	2
Pont Rhydgaled	14	2
Pont Rhydgoled	26	2
Pontbrenllwyd d/s bridge	35	5
Trafel-gwyn d/s of farm (DE7)	118	43
Ty mawr, forest site	23	6.7
Ty-mawr farm	3.73	2
Ty-mawr, d/s bridge	6.47	0.2
Ty-mawr, u/s Nant Ty Mawr confl.	5	0
U/s Nant Cyff	24	2
Under and upstream of Road Bridge	0	0.3
Up above gates	8	5
Upstream farm at track bridge	2	1
Upstream from Wye Confluence (D/S weir)	0	0
Upstream of Bridge, Pontbrenllwyd	13	8
Upstream of Gauging Weir	0	1
Upstream of Nant Iago confluence	1	3
Upstream of tunnel, at gauging station	8	1
Waun Gadair	0	4
Youth hostel (de5)	568	144

Relevant species within the 5km buffer from both data sets are:

- Brown/ sea trout, *Salmo trutta/ trutta*
- Atlantic Salmon, *Salmo salar*
- European Eel, *Anguilla Anguilla*

The two main rivers in the study are the river Wye (Afon Gwy) and the River Taranig that run along the northern boundary of the study area. Some sections of the river have no to little riparian buffer zones, meaning there are trees encroaching on the banks of the river. This can have detrimental impacts on river health as well as the species that live in it. Main concerns about the rivers health are acidification and sediment runoff.

Other species listed in the electro fishing data include:

- Bullhead, *Cottus gobio*
- Minnow, *Phoxinus phoxinus*
- Stone Loach, *Barbatula barbatula*
- European Eel, *Anguilla Anguilla*

Invertebrate (Insect)

Table 3-6 shows the invertebrate species found within the 5km buffer.

Table 3-6: Invertebrate (insect) species point data within 5km of Tarenig since 2011

Common name	Scientific name
Buff Ermine	<i>Spilosoma lutea</i>
Dark Brocade	<i>Mniotype adusta</i>
Forester	<i>Adscita statices</i>
Necklace Ground Beetle	<i>Carabus monilis</i>
Oblique Carpet	<i>Orthonama vittata</i>
Shoulder-striped Wainscot	<i>Leucania comma</i>
Small Heath	<i>Coenonympha pamphilus</i>
Small Pearl-bordered Fritillary	<i>Boloria selene</i>
Small Phoenix	<i>Ecliptopera silaceata</i>
White Ermine	<i>Spilosoma lubricipeda</i>

Key species identified are:

- Forester, *Adscita statices*
- Small Heath, *Coenonympha pamphilus*
- Shoulder-striped Wainscot, *Leucania comma*
- White Ermine, *Spilosoma lubricipeda*

Mammal (terrestrial)

Table 3-7: Mammal (terrestrial) Protected Species point data within 5km of Tarenig since 2012

Common name	Scientific name
Brandt's Bat	<i>Myotis brandtii</i>
Brown Hare	<i>Lepus europaeus</i>
Eurasian Red Squirrel	<i>Sciurus vulgaris</i>
Eurasian Badger	<i>Meles meles</i>
European Water Vole	<i>Arvicola amphibius</i>
Roe Deer	<i>Capreolus capreolus</i>
Myotis Species Bats	<i>Myotis</i>

When looking at the protected species data clipped to a 5km of the study area there is a distinct cluster of mammal recordings across the study area. The species within this cluster include:

- European Water Vole, *Arvicola amphibius*
- Eurasian Red Squirrel, *Sciurus vulgaris*
- Roe Deer, *Capreolus capreolus*
- Eurasian Badger, *Meles meles*

Reptile and Amphibian

Table 3-8: Reptile and Amphibian Protected Species point data within 5km of Tarenig since 2019

Common name	Scientific name
Common Frog	<i>Rana temporaria</i>
Common Lizard	<i>Zootoca vivipara</i>
Common Toad	<i>Bufo bufo</i>

Key reptiles and amphibians identified include:

- Common Toad, *Bufo bufo*
- Common Frog, *Rana temporaria*
- Common Lizard, *Zootoca vivipara*

All three of the above listed species are protected by the Wildlife and Countryside Act 1981.

Vascular Plant

Table 3-9: Vascular Plant Protected Species point data within 5km of Tarenig

Common name	Scientific name
Bog Orchid	<i>Hammarbya paludosa</i>
Stag's-horn Clubmoss	<i>Lycopodium clavatum</i>
Wood Bitter-vetch	<i>Vicia orobus</i>

Two main species within the recordings are:

- Stags Horn Club Moss, *Lycopodium clavatum*
- Wood Bitter-Vetch, *Vicia orobus*

3.9 Historic trend analysis

Historic OS mapping has been used to examine the extent of historical channel change within the vicinity of Tarenig Forest. The watercourse routes illustrated in the 1888 OS mapping (the earliest OS mapping available online) have been compared to current watercourses to identify areas of channel migration.

There has been minimal change to the planform of the headwater streams within Tarenig Forest since 1888 (see Figure 3-9). The narrow and steep valleys which the watercourses flow through have confined the water to the channel, encouraging incision and a lack of floodplain connectivity. As a result, the channels have not migrated over time.

Some of the channels identified in present day mapping are absent in the historic 1888 OS mapping. This is likely due to improvements in map resolution and surveying, resulting in better documentation of watercourses.

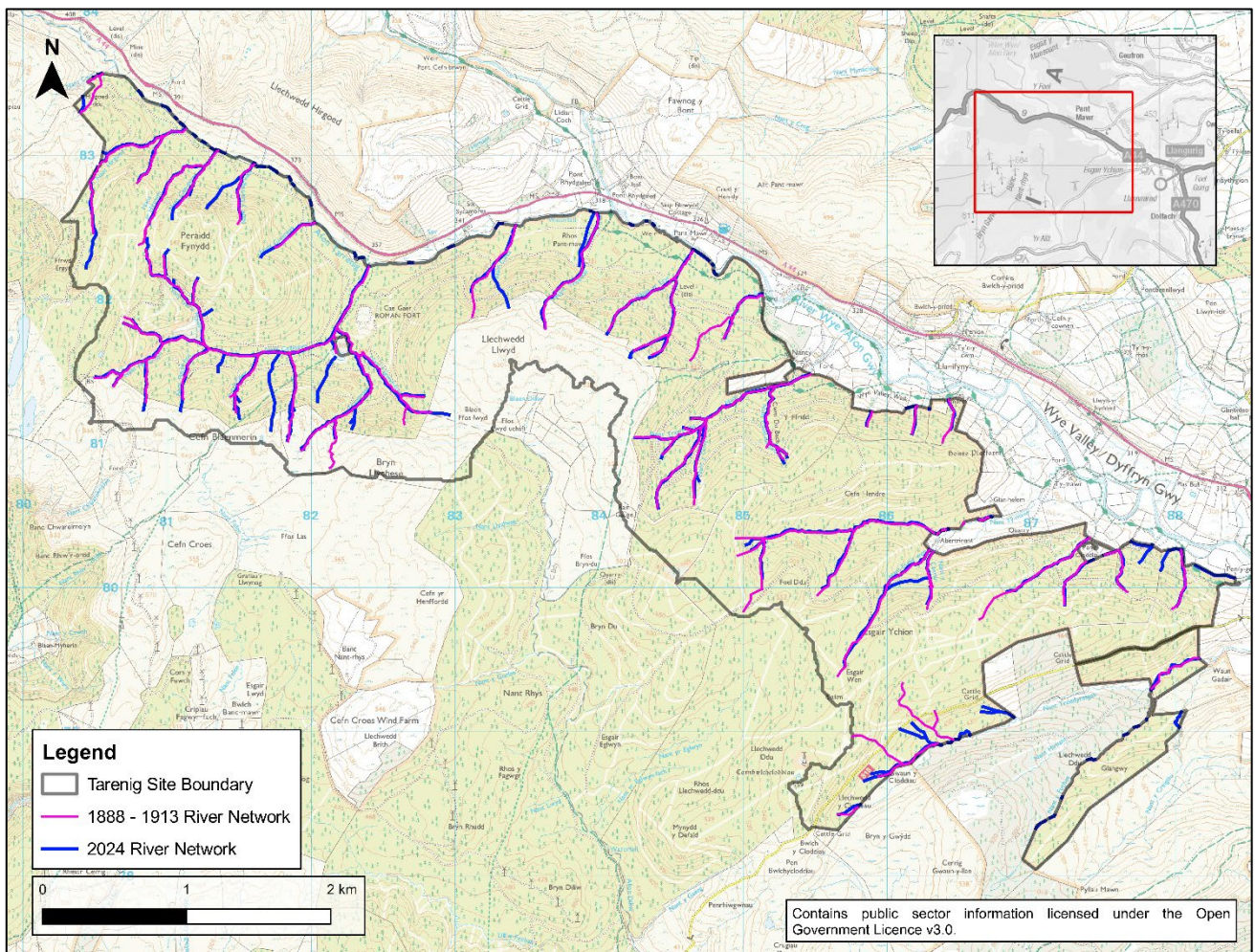


Figure 3-9: Historic Mapping of watercourses within Tarenig Forest

4. Site assessment

4.1 Baseline conditions

Watercourse type: Step pool channels/cascades

Example river type and sub-catchment location

Sub-catchment 2:



Sub-catchment 5:



Characteristics

The channel is steep and flows through a narrow, V-shaped valley with banks heights of approximately 4m. This topography creates high stream power following heavy rainfall events. The river has incised historically and has cut down to the bedrock layer along the channel bed. Significant vertical erosion has resulted in the formation of a stepped profile that encourages cascading, broken wave flow. Subsequently, channel planform is relatively straight and widths are small, ranging from 0.5m to 1m.

The headwater streams interchangeably exhibit step-pool and bedrock cascade features.

Along step-pool sections, disorganised clusters of sediment are stored in pockets of lower energy created by the larger clasts upstream of each bedrock step where there is a small gradient plateau. Smaller sediment is also observed behind angular sediment (cobbles and boulders) and bedrock outcrops that jut out into the channel from the bank toe. Although these step-pool channels are relatively stable, variation in channel width can be observed at locations where woody material has fallen into the channel and pushed flow laterally towards the banks.

Along bedrock cascade sections, there is an absence of loose sediment as the high flow velocities, generated by the smoother, bedrock lined channel and steep channel gradient, has resulted in a high transport capacity.

The channel is well connected to the base of the valley slope, which forms a limited riparian zone.

The incised nature of the watercourse, results in a narrow riparian zone being present. The valley sides are dominated by conifer trees that shade the forest floor which prevents the growth of smaller, less emergent shrubs/plants, limiting the riparian zone further, this contributes to a lack of heterogeneity of the habitats to support species. Whilst the high power of the watercourse limits which species are able to establish themselves in the watercourse without being carried downstream by the flow. Where pools are formed, due to lower energy levels a higher number of species, such as invertebrates, may be able to inhabit these areas. Due to the gradient, it is likely only specialised fauna will be able to consistently utilise these watercourses. The incised nature prevents the creation or establishment of wetland habitats bordering the watercourse.

Much of the forest floor surrounding the watercourses in the plantation are dominated by thick layers of Sphagnum species which retain a lot of moisture.

This river type is typical of steep, upland watercourses.

Watercourse type: plane bed

Example river type and sub-catchment location

Sub-catchment 1:



Characteristics

The channel flows through a V-shaped valley with a 1.5m to 2m wide valley floor. The channel is moderately steep with a slope angle of 3.6 degrees over 12m, which encourages high flow energy during heavy rainfall events, resulting in some incision and dysconnectivity with the floodplain. The channel is featureless, straight and has a continuous width of 1m for the majority of its length, which encourages a run flow biotype. However, in areas where large woody material has fallen into the channel, there are localised increases in width resulting in minor depositions (due to a reduction in flow velocity) and some connectivity with the floodplain where erosion inputs small amounts of sediment into the channel.

The channel bed is comprised of an assortment of angular and more rounded cobbles, suggesting that sediment is transported from upstream and eroded on route as sediment is transported downstream, (hence a more rounded appearance), as well as inputted from the banks, supplying more angular cobble material to the channel bed. Finer gravels and silts are winnowed out by the high-energy run flow.

The shallower gradient of the watercourse is suitable to support a higher number of aquatic species, compared to the steeper watercourses found higher up the slopes. This is due to the slower flows allowing for gravel and cobbles to settle on the riverbed, providing habitat suitable to support species such as Atlantic Salmon, Bullhead and European Eel due to the suitability for spawning and invertebrates which use gravels such as Caddisflies. The location of these watercourses with close hydrological connectivity to the Afon Tarenig and Afon Wye mean species present in the main rivers have the opportunity to utilise these tributaries if barriers such as culverts have not been installed.

The floodplain is dominated with scrub and deciduous tree species (inc. Willows, Rowan and Birches) scrub vegetation as a result of there being fewer coniferous trees shading the ground and the increased connectivity of the watercourse to the banks. This provides greater connectivity to other areas of the site and provides some stability to the watercourse and surrounding habitats as the area is not subjected to rotational felling. Due to the surrounding forestry, its likely however, that these streams will be fairly acidic in nature which is generally more favourable for Brown Trout and Bullhead.

This watercourse type is often located immediately upstream of the confluence with the main river (both Afon Tarenig and River Wye) where slope gradients are slightly slacker.

Forest road and road drains: Vegetated road material

Example forest road and sub-catchment location

Sub-catchment 5:



Characteristics

The forest road is constructed on aggregate and are often coated in muds/clay from vehicle movements-- which mainly sits on the surface. Roads are occasionally 'blinded' with a layer of fines (which may include some organics such as moss) to provide a smoother running surface for vehicles and help seal the road, making the material more stable and less susceptible to being displaced by vehicles or heavy rainfall events.

Forest road and road drains: Loose road material

Example forest road and sub-catchment location

Sub-catchment 5:



Characteristics

The forest road is constructed of aggregate, however there may be some residual soil/clay in the mix from the excavation and processing phase.

Due to the nature of the forest road unbound construction design, water ingress combined with certain loading can result loose stone being ejected from the road surface, resulting in potholes forming. These potholes fill with water, which exacerbates the stability issue, and causes further increase in pothole sizes. NRW have a road defect system whereby potholes are supposed to be reported to the Integrated Engineering teams, for them to carry out road repairs. Potholes are often not reported (as hauliers are concerned it may mean a temporary road closure— which may affect their ability to collect timber) and consequently, large potholes or road failures occur.

It is likely that during heavy rainfall events, loose road material will be mobilised and moved downslope, eventually reaching a stream that will transport and discharge it into the main river (both Afon Tarenig and River Wye), or a relief culvert that will discharge it onto the bank below the road. As a result, this will deteriorate water quality conditions in the watercourse, due to increased sediment levels, which can impact the species inhabiting the watercourse.

Forest road and road drains: Very loose road material

Example forest road and sub-catchment location

Sub-catchment 7:



Characteristics

The forest road is comprised of clay and gravels. As a result of significant pressure from heavy loaded vehicles using the road, the road aggregate breaks down and forms fine particles within the road formation. In the summer, this can present as dust, and in the wetter periods, this dust mixes with the rain and can cause discoloured surface water 'wash off'.

It is evident that surface water collects on the road during heavy rainfall events as material has been excavated on some road edges to create small pathways in order to prevent the ponding or the running of surface water. This excavation was identified at locations where road maintenance (in the form of re-establishing the road camber) had not been carried out and ruts have formed, resulting in water failing to shed the road surface and instead travelling longitudinally along the road, causing erosion and further scour.

Forest road and road drains: Road drains

Example forest road and sub-catchment location

Sub-catchment 5:



Sub-catchment 11:



Characteristics

A drain runs alongside the forest road, directing overland flow from the surrounding hills towards a culvert that flows underneath the road. Water from the culvert then spills out onto lower ground. Drains within the study area have been artificially constructed to match the road geometry.

The road drains are often overlain with smaller gravels and silt that has been transported down from higher areas within the forest, as well as off the adjacent roads. They also tend to be well vegetated, narrow with a width approximately ranging between 0.25m to 0.5m and following a maximum road gradient of 10%, encouraging fast flow during rainfall events. As a result, the road drains are largely ephemeral. Road drains were only inundated in areas where slope gradient was slacker.

Soft rush was frequently observed along the drains which contained water.

At locations where high volumes of overland flow, from upstream forest drains, converge before entering a culvert, catch pits have been dug to widen the road drain to encourage a reduction in flow velocity and the deposition of finer sediments. This prevents the transportation of finer sediment downstream and into the main river (both Afon Tarenig and River Wye).

Several catch pits were observed to be full of fine sediment.

Open ground: Areas with no conifer plantation

Example open ground and sub-catchment location

Sub-catchment 5:



Characteristics

Areas of open ground are found infrequently across the study area. Larger clusters are predominantly located at the top of the study area. At the highest sections of the study area the habitats transition into high moorland with near continuous cover of Purple Moor Grass *Molinia caerulea* and Soft Rush in the wetter hollows. Natural depressions in the topography provide pathways for overland flow to move downslope, but little bare ground or peat erosion is present.

These habitats appear to be relatively undisturbed. These open habitats at the top of the site provide connectivity to the upland heathland and may support species, such as Red Grouse and Merlin.

At the top of the study area, in areas where flow is concentrated and has cut down into the peat, a small number of isolated peat hags are formed, these show a more varied vegetation with patches of Heather present.

In the lower open ground areas, incised drainage channels continue to cut through the topography, channelising water towards the main river (both Afon Tarenig and River Wye). The presence of open areas interspersed in the forestry plantation can provide beneficial habitat diversity to support alternative species. It also allows for the regeneration of native

species, with species such as Silver Birch and Downy Birch observed in some areas of clearing, although conifer sapling regeneration was also observed.

4.2 Channel slope gradient

31 clinometer measurements were recorded during the site visit to Tarenig Forest. These measurements reflect gradients within a number of natural watercourses and drainage channels and were used to help inform river types and observed processes. Majority of the readings were taken looking upstream. Gradient measurements have been recorded in degrees. Channel slope gradients can help aid discussions around the implementation of features to attenuate flow and sediment transport. For example, channel slope is an important factor to consider when assessing the suitability of leaky barriers.

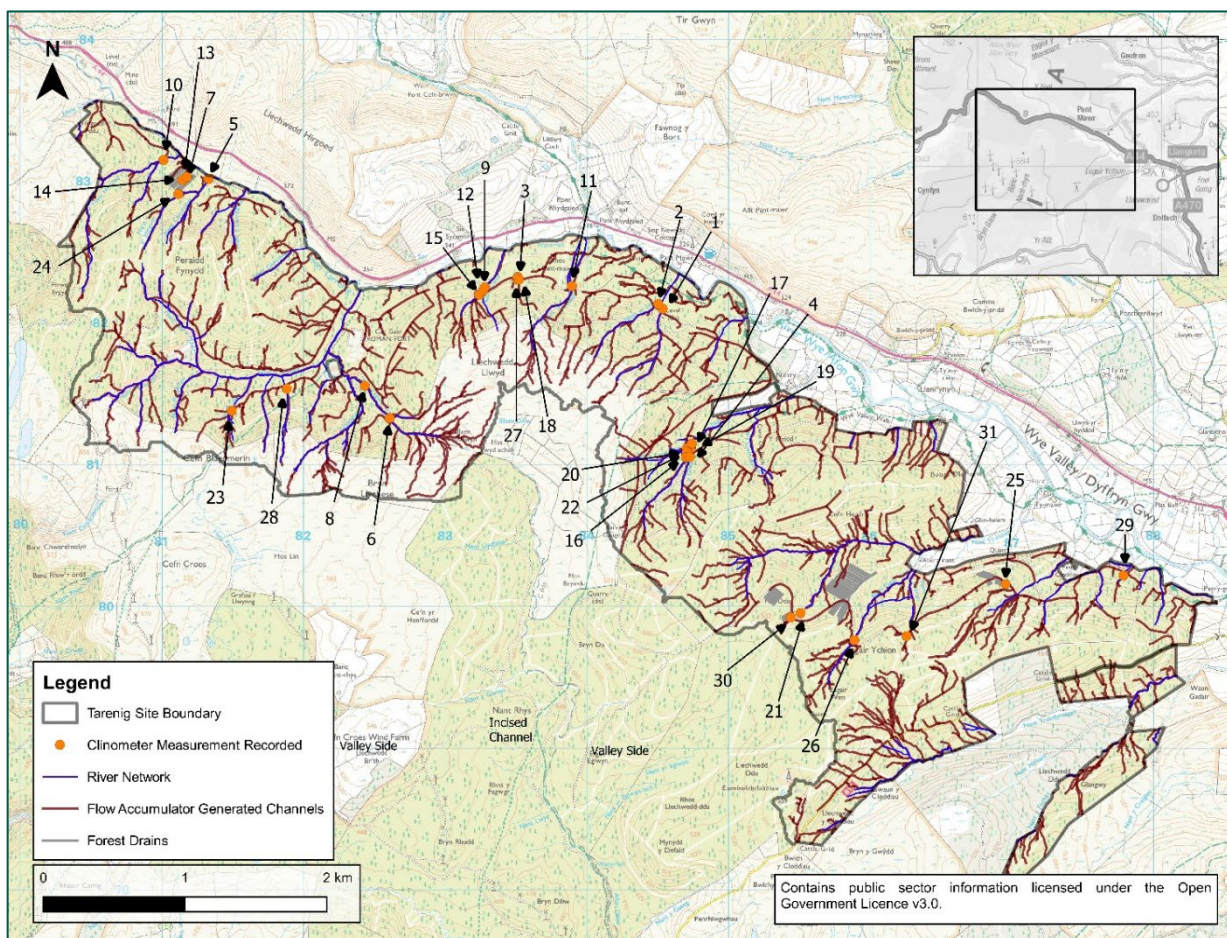


Figure 4-1: Clinometer measurements recorded in watercourses and drainage channels across Tarenig Forest

Table 4-1: Channel slope gradients recorded within Tarenig Forest

ID	Channel slope gradient in degrees	Channel slope gradients in percentages (1.d.p)
1	1 degree over 15m of channel	1.7%
2	1 degree over 15m of channel	1.7%
3	1.2 degrees over 8m of channel, downstream from culvert outfall	2.1%
4	1.4 degrees over 4m of channel, upstream of culvert inlet	2.4%
5	2 degrees over 12m of channel	3.5%
6	2 degrees over 10m of channel, downstream of culvert outfall	3.5%
7	2.4 degrees over 10m of channel	4.2%
8	3 degrees over 20m of channel	5.2%
9	3 degrees over 10m of channel	5.2%
10	3.2 degrees from culvert inlet to 20m upstream of culvert inlet along channel	5.6%
11	3.6 degrees over 12m of channel, downstream of culvert outfall	6.3%
12	4 degrees over 10m of channel, downstream of culvert outfall	6.9%
13	4.8 degrees over 8m of channel	8.4%
14	5.2 degrees over 10m of channel	9.1%
15	6 degrees over 12m of channel, downstream of culvert outfall	10.5%
16	6.2 degrees over 10m of channel	10.86%

ID	Channel slope gradient in degrees	Channel slope gradients in percentages (1.d.p)
17	6.8 degrees over 8m of channel	11.9%
18	7 degrees over 10m of channel	12.3%
19	7.2 degrees along right tributary channel-- over 5m of channel from the confluence	12.6%
20	7.6 degrees over 7m of channel, upstream of confluence	13.3%
21	8.4 degrees over 15m of channel, downstream of culvert outfall	14.8%
22	9 degrees over 10m of channel	15.8%
23	10.8 degrees over 7m of channel	19.1%
24	11 degrees over 20m of channel	19.4%
25	11.2 degrees over 15m of channel, upstream of culvert inlet	19.8%
26	11.8 degrees over 10m of channel	20.8%
27	13 degrees over 12m of channel	23.1%
28	18.4 degrees over 10m of channel	33.3%
29	20 degrees over 10m of channel, upstream of culvert inlet	36.4%
30	23.2 degrees over 9m of channel	42.9%
31	34.4 degrees over 5m of channel, upstream of culvert inlet	68.5%

5. Pressure identification

Together, the desk-based assessment and site walkovers have enabled the development of a holistic understanding of the existing conditions within the Tarenig Forest study area, and the identification of key system pressures which have impacted sediment dynamics and habitats. As a result, this has helped guide the formation of integrated catchment management opportunities to target/mitigate the existing key pressures (Section 7).

Pressures have been mapped across the Tarenig Forest. This data is provided separately as a series of feature classes within a geodatabase for display within a Geographic Information System (GIS). It is important to note that these pressures only reflect the current conditions within Tarenig Forest.

5.1 Summary of key pressures

The following identified pressures are a combination of study-area wide and localised pressures.

Key pressure: Timing of clearfell and thinning forest operations

Within the study area, certain forest coupes have been felled and large quantities of windrow left behind. This was particularly evident along a recently felled 300m wide (approximately) slope within Sub-Catchment 2.

More forest coupes have been approved for felling in the next few years.

Not mapped as it is a forest-wide pressure and is predominantly the cause of the other pressures identified below.

Impacts on study area

- Machinery used to fell and process the trees can add pressure to the soils and make them more compact and less porous. Areas of compaction were difficult to identify during the site walkover due to majority of the study area being dominated by Sphagnum moss. Frosty conditions on 2 out of the 5 survey days also made identifying areas of compaction as a result of felling practices hard to identify.
- Tree removal could result in ground disturbances, leading to increased silt inputs into drainage channels, headwater streams and subsequently, the main river (both Afon Tarenig and River Wye). This has the potential to impact species in the watercourses due to the impacts through alterations in the pH and increased levels of sediment leading to potential impacts including, increased turbidity, alteration in oxygen levels and reduction in suitable spawning habitat,
- Tree removal will also reduce the amount of woody material that naturally falls into watercourses, hence why limited large woody material was observed in headwater streams throughout Tarenig Forest.
- Phosphate and nitrogen compounds can be released into streams via surface/subsurface flow through tree removal, depleting water quality and impacting freshwater species. Water quality will also be depleted in the main Afon Tarenig and River Wye as a result of the poor-quality water discharging into it. In the Afon

Tareinig, inputs of diffuse source pollution associated with Atmospheric Deposition, exacerbated by Forestry Practices lowering the pH (acidification) has already contributed to an overall Poor waterbody classification.

- Felling can also cause increased acidic flushes, impacting on the mobilisation of heavy metals and affecting aquatic biota.
- Felling can result in areas of open habitat within the forest, whilst this will result in a reduction in conifer habitat, it will create variety in the structure of the woodland to increase habitat diversity.

Example of pressure identified through field survey

Sub-catchment 2:



Sub-catchment 5:



Opportunities to mitigate (see Section 7.1)

- Embed Sustainable Forest Management practices
- Increase riparian woodland
- Add leaky barriers and woody material
- Clear catch pits
- Add scrapes

Key pressure: Forest drains

In areas of dense conifer plantation, artificial drainage channels have been excavated downslope to encourage water to drain quickly.

Impacts on study area

- If peat is being drained, then there will be an impact on the carbon sink and lowering of the water table and has the potential to lead to peat erosion. This could alter the habitats present with a move towards species tolerant of drier conditions.
- A greater drainage density helps to increase speed and amount of run off to the main river (both Afon Tarenig and River Wye). Can lead to an increase in-channel water levels and increased risk of flooding in the Afon Tarenig and River Wye downstream. Can also lead to increased levels of potential washout of habitat, aquatic biota and fish spawn (within the headwater streams, channels and main rivers).
- Water that reaches the main river (both Afon Tarenig and River Wye) will not be filtered through an active and well-connected riparian buffer zone (such as along the downslope- spanning sub-catchments 1 to 4- adjacent to the Afon Tarenig where

limited riparian vegetation has grown), therefore the water will be quite acidic. This could lead to depleted water quality of the main rivers and an impact on the freshwater species, through alterations in the pH and increased levels of sediment leading to potential impacts including, increased turbidity, alteration in oxygen levels and reduction in suitable spawning habitat.

- The species likely to be impacted are fish species including Atlantic Salmon, Lamprey species, and invertebrates.

Example of pressure identified through field survey
Sub-catchment 2:



Opportunities to mitigate (see Section 7.1)

- Add leaky barriers and woody material

Key pressure: Loose road material

Unconsolidated road material will be displaced during heavy rainfall events and by vehicles that use the road. The fine sediment will enter the headwater streams and drainage channels and be washed downstream into the main river (both Afon Tarenig and River Wye) or conveyed to a relief culvert and discharged below the road into vegetated areas.

Impacts on study area

- Fine sediment inputs into headwater streams and drainage channels can result in decreases in water quality and increased water turbidity. This can affect dissolved oxygen levels, therefore impacting freshwater species. As this water is discharged

into the Afon Tarenig and River Wye, declines in water quality, turbidity and dissolved oxygen levels within these main rivers will also occur.

- Loose road material inputs will also affect the quality of gravels and subsequent habitat within the watercourse. This could affect species utilising the watercourses including fish species dependent upon gravel habitats and invertebrates.
- Loose road material inputs were seen particularly in Sub-Catchment 7 where small flow pathways were excavated perpendicular to the lay of the road and fine sediment (e.g. gravels) could be seen scattered along the downslope after being mobilised in flow and then no longer being entrained.

Example of pressure identified through field survey
Sub-catchment 5:



Opportunities to mitigate (see Section 7.1)

- Clear catch pits
- Add leaky barriers and woody material

Key pressure: Road drain

Surface run off draining the forest slopes will flow into the road drain and be directed towards a culvert to allow the passage of water underneath the road.

Impacts on study area

- Sediment and material transported during heavy rainfall events can block the under-road culverts, resulting in a large pooling of water behind the structure. However, if this occurs, flow will often continue along the road to the next relief culvert or will overtop the road and wash sediment onto the bank below.

- The road drain will direct water from a large expanse of slope, towards a convergence point (a culvert) often located along every 100m of road within Tarenig Forest (adhering to UKFS guidance), where it will continue flowing down a drainage channel/stream towards the main river or onto a vegetated area. Therefore, overland flow is not able to disperse along the lower floodplain area and be attenuated or filtered before reaching the main rivers, both Afon Tarenig and River Wye. As a result, flood risk could be increased downstream and water quality will decrease.
- As shown in the Flow Accumulator Map, overland flow is directed along a road drain and out through one relief culvert onto the lower floodplain area between two headwater streams in Sub-Catchment 11 (NGR: SN 87864 80234). The road drain and culvert has prevented the dispersal of flow along the whole 100m floodplain area. This was validated during the site walkover.

Example of pressure identified through field survey

Sub-catchment 5:



Opportunities to mitigate (see Section 7.1)

- Clear catch pits
- Add leaky barriers and woody material
- Floodplain reconnection/bank lowering
- Install relief culverts

Key pressure: Culvert

There have been physical modifications to the headwater streams and drainage channels involving replacement of open channel with culverted sections to direct flow downstream, underneath the forest roads.

Some culverts, observed on site, had failed or were perched above watercourses leading to increased scour risk downstream of the structure.

Impacts on study area

- Direct loss of habitat.
- Lack of longitudinal and lateral connectivity.
- Barrier to fish migration if fish are using the watercourse and suitable modifications have not been included in the culvert design.
- Scour of the bed downstream of the culvert and bed incision in the reach downstream (as observed in many places) resulting from a reduced sediment supply.
- Potential impacts on fish and invertebrate populations.

Example of pressure identified through field survey

Sub-catchment 1:



Opportunities to mitigate (see Section 7.1)

- Culvert replacement

Key pressure: Lack of / degraded riparian vegetation

In sections along the headwater streams within Tarenig Forest, the riparian corridor is limited with only narrow strips of woodland and vegetation confined to the banks of the stream, or altogether absent due to conifer planting. Riparian habitat potential is limited within conifer plantation areas as conifer trees outcompete native tree species and also prevent the growth of emergent understorey vegetation due to significant shading.

Impacts on study area

- Potential pollution; degrading water quality.
- Acidification within the main river channels (Afon Tarenig and River Wye), leading to changes in water pH with impacts upon flora and fauna using the watercourses.
- Reduced quality of ecological corridors through the forestry to allow species to travel.
- Lack of habitat stability due to felling occurring at set periods.
- Fine sediment release.
- Bank erosion and bank instability.
- Limited habitat potential.
- Lack of woody material resupply due to a lack of riparian vegetation.
- Example of pressure identified through field survey

Sub-catchment 9:



Opportunities to mitigate (see Section 7.1)

- Increase riparian vegetation

- Create buffer between watercourse and areas of conifer plantation
- Add woody material
- Add scrapes
- Bank lowering

Key pressure: Deposited roadside material

Within the Forestry Block, it is common practice to import type 1 aggregate in bulk preparation for road maintenance operations. This aggregate is deposited on the side of roads. These will be located throughout the block to minimise haulage distance during actual road maintenance operations, thereby reducing CO2 emissions from having vehicles travelling back and forth.

Impacts on study area

- During heavy rainfall events some of this deposited sediment could be mobilised and enter the watercourse and the main river (both Afon Tarenig and River Wye), resulting in decreases in water quality and increased water turbidity. This can affect dissolved oxygen levels, therefore impacting freshwater species. This has the potential to impact designated species in the watercourses downstream such as Bullhead, European Eel, Atlantic Salmon.

Example of pressure identified through field survey

Sub-catchment 6:



Opportunities to mitigate (see Section 7.1)

- Add leaky barriers and woody material
- Clear catch pits
- Add scrapes
- Improve placement of roadside material

Key pressure: Excavated material

Excavated material/sediment removed from catchpits (typically located on upstream side of forest track culvert) often just left on bankside of catchpit rather than being properly extracted from the area and disposed of in a more appropriate location away from the watercourse.

Impacts on study area

- During heavy rainfall events some of this excavated sediment could be remobilised and re-enter and watercourse and the main river (both Afon Tarenig and River Wye) resulting in decreases in water quality and increased water turbidity. This can affect dissolved oxygen levels, therefore impacting freshwater species.

Example of pressure identified through field survey

Sub-catchment 10:



Opportunities to mitigate (see Section 7.1)

- Remove excavated material
- Add leaky barriers and woody material
- Add scrapes

Key pressure: Invasive Non-Native Species (INNS)

The surveyed areas were largely observed to be absent of INNS, however, a couple of stands of *Rhododendron ponticum* were noted around the woodland edges in areas.

Impacts on study area

- The presence of INNS could result in it spreading within the woodland and surrounding area. This would alter the habitats and composition of species present within the woodland. *Rhododendron* can form dense areas of shrub which shades out and out competes native species. It is also highly spreadable and if not controlled will spread to dominate the understorey habitats of the woodland.

Examples of pressure identified through field survey

Sub-catchment 12:



Opportunities to mitigate (see Section 7.1)

- Invasive Non-Native Species (INNS) control

Focus area scale pressure maps have been created to show examples of site-specific pressures (see Figure 5-1, Figure 5-2 and Figure 5-3).

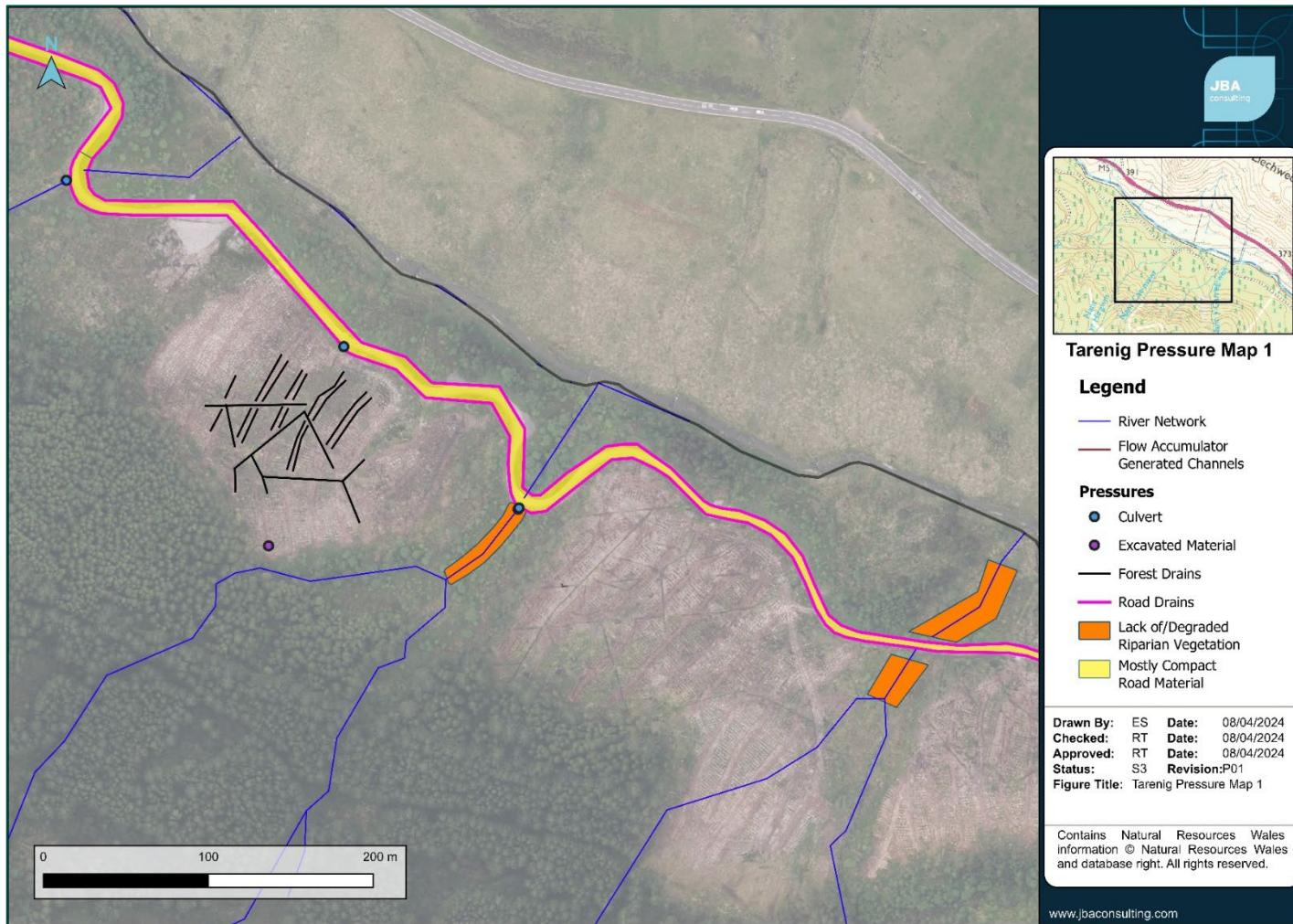


Figure 5-1: Pressures identified at NGR SN 81180 83037 and NGR: SN 81301 82964 (Sub-Catchment 2, Area 2, Area 3 and Area 4 in Summary of Baseline Conditions Map)

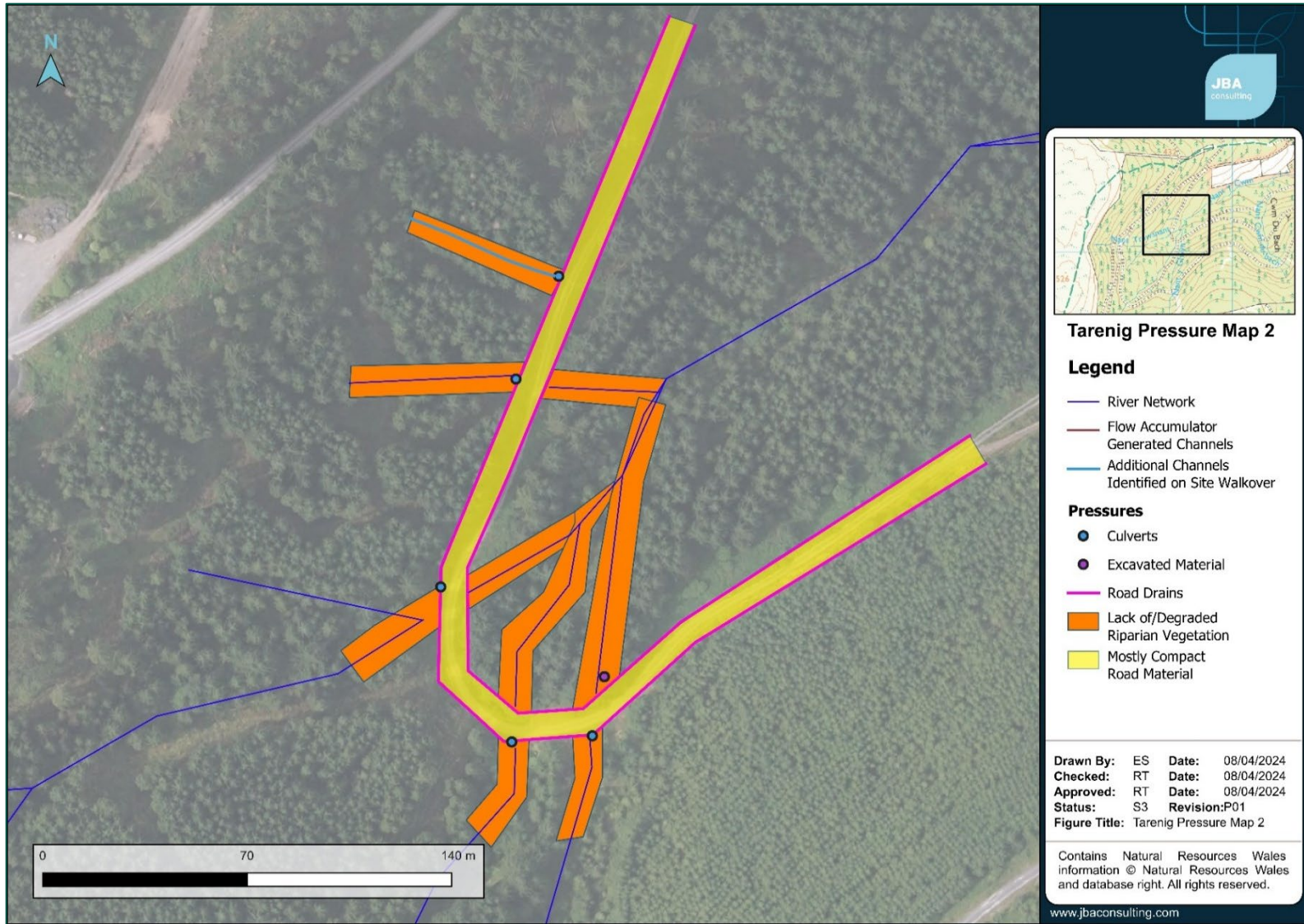


Figure 5-2: Pressures identified at NGR: SN 84714 81106 (Sub-Catchment 9, Area 18 in Summary of Baseline Conditions Map)

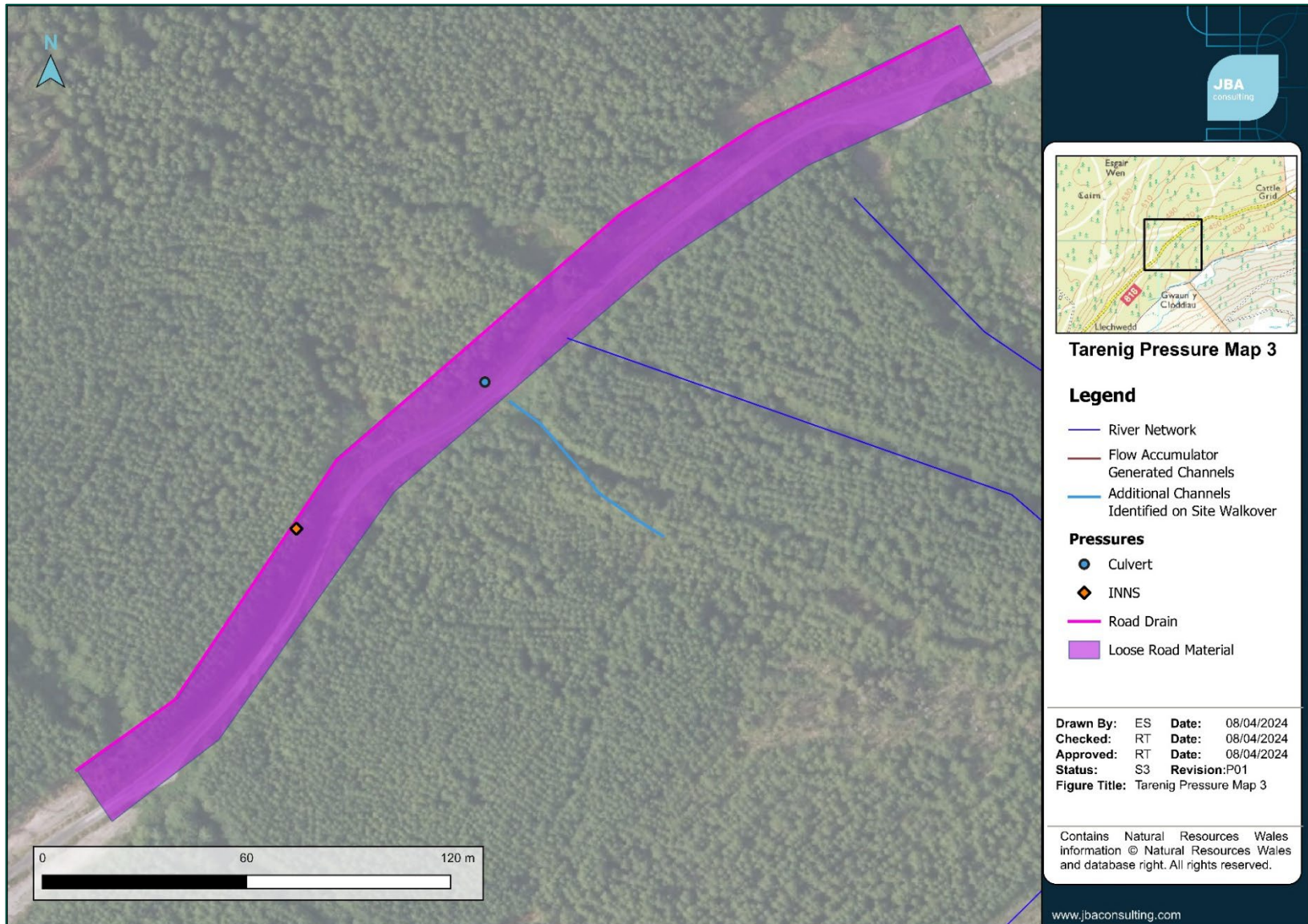


Figure 5-3: Pressures identified at NGR: SN 86051 78974 (Sub-Catchment 12, Area 26 in Summary of Baseline Conditions Map

6. Summary of baseline conditions

Information collected during the desk-and site-based assessments has been integrated and analysed to develop a summary of baseline conditions, which is presented in Figure 6-4 and Figure 6-5. This summarises the key processes, form and ecological function across the study area, as well as sediment sources and sinks generated from both natural processes and from artificial influences (i.e. physical modification, land use) which constitute system pressures.

5.2 Existing conditions

The drainage of water within the Tarenig Forest, from the hillslopes to the confluence with the main river, has been largely impacted by both natural steep topography and forestry practices. Superficial pathways in the form of linear drainage channels and road drains have been artificially created to encourage faster conveyance of flow and sediment downslope towards the main watercourse and away from conifer plantations during heavy rainfall events. The steep topography greatly controls the typical river types observed in the Tarenig Forest. The majority of the headwater streams are typical of step-pool river systems and bedrock cascade river types, characterised by steep channels that flow through narrow, V-shaped valleys and have stepped profiles due to significant vertical erosion exposing bedrock. Other watercourses within the study area are typical of plane bed systems as slope gradients reduce and channels transition towards more dynamic river types. These channels continue to be confined by moderately steep V-shaped valleys; however, valley floors are marginally wider, allowing better connection to the riparian zones. The channel morphology tends to be featureless and straight but can be more prone to change than the steeper bedrock and step pool/ cascade channels. The gentler sloped watercourses at the bottom of the study area are well connected to the Afon Wye and Afon Tarenig and due to the gradient contain material such as gravels which are likely to support the designated species present within the main river networks, as well as invertebrates. Further up the forestry blocks the transition to steeper watercourses and the use of culverts are likely to limit the connectivity and therefore use by fish species. Records of fish species are limited to outside of the site boundary with the exception of two points just within the lower boundary of the site. These points indicate that fish including Atlantic Salmon and Trout have been recorded in the lower reaches. Due to the surrounding forestry, the higher watercourse reaches are likely to be fairly acidic in nature which is generally more favourable for Brown Trout and Bullhead if they are able to access them.

As described, the watercourses higher up the site were predominantly steep with little to no riparian zone present and bordered by forestry plantation leading to high levels of shading and little in-channel vegetation. The limited areas of broadleaved trees within the riparian zone are not widespread enough throughout the forest to form a network of good quality ecological corridors, with only discrete patches or areas observed.

The site is characterised by significant areas of coniferous plantation woodland, with small areas of largely self-set broadleaved trees along the more open riparian areas. Much of the habitat even on the steeper slopes is blanket bog, moving into transition mire in riparian areas where gradients reduce and allow for water to spread away from the watercourses. These areas are characterised by patches of extensive Sphagnum grading into rush

dominated mire. At the highest reaches of the site, above the plantation tree line, the site has an open moorland character with areas dominated by Purple Moor-grass, with Soft Rush in the wetter sections. Though peat hags are present in these areas, in general very little bare peat or erosion was observed. The dense coniferous plantation on the steeper slopes allows for very little ground layer or understorey vegetation to develop and instead these areas were dominated by a dense blanket of bryophytes. Opportunities to cause water to move on to nearby habitats dominated by Sphagnum would likely not result in major habitat shifts. The permanent increase in moisture levels into areas of broadleaved tree species, would likely result in the alteration of species composition towards species more tolerant of waterlogged conditions, such as Alder and Willow.

In areas where felling had occurred, areas of natural regeneration were observed with Silver Birch, Downy Birch and Willow species observed, although conifer saplings were also widespread in open areas and along the forestry road network. Opportunities to rejoin watercourses to the floodplain could result in a shift of broadleaved species, with some species not being able to cope with more frequent inundation.

Other species recorded in the wider area which may utilise the forest habitats include Badger, Bats and Red Squirrel.

5.3 Sediment sources and sinks

Although small, localised areas of erosion were evident along the banks of the headwater streams and drainage channels that discharge into both Afon Tarenig and River Wye, particularly in areas where woody material had fallen across the channel, the main sediment sources identified within the walkover extent include felling, hillslope failure and excavated material.

Conifer felling can provide large amounts of fine-grained silt and sediment (less than 2mm) to drainage channels through significant ground disturbance when trees are cut down and trunks are removed from site. The disturbed fines are transported towards the main river during heavy rainfall events and, as a result, degrade the water quality. The input of this sediment to the watercourses has the potential to impact the habitats and the freshwater species by increasing the turbidity, altering oxygen levels and reducing suitable spawning habitat. This forestry practice has occurred in many locations across the study area and is likely to continue to occur during the felling of coupes in the future, therefore fine sediment release will continue to be an issue. On site, fine sediment smothering was frequently observed in catch pits and road drains throughout Tarenig Forest and infrequently in headwater streams (due to the bedrock cascade/step-pool nature of the watercourses) and smaller drainage channels (due to these channels being largely ephemeral). Felling as a catchment pressure and sediment source has not been mapped on the figures below as it occurs forestry wide.

Hillslope failure has occurred as a result of weathering along hillslopes, which has caused coarser material (e.g. mix of earth, small cobbles and sand (greater than 2mm) to dry out and become unconsolidated and easily erodible. Weathering has also resulted in the deformation of gravel and slate-composed slopes (coarse-grained material) in some areas of the forest. Material from the slopes is likely to be mobilised during heavy rainfall events and transported via road drains and forest drains into headwater streams and the main

river, Afon Tarenig and River Wye. Gravel inputs into the main rivers are likely to support suitable spawning habitats for native aquatic species, such as Atlantic Salmon and invertebrates which specialise in gravel habitats and therefore these inputs may contribute to creating habitats if retained within the gentler forest watercourses.

Mounds of lime chips have been deposited near the inlet of some culverts so that flowing water can mix with the lime and react to alter the pH of the water in order to mitigate acidification of headwater streams and the main river (Afon Tarenig and River Wye) within the vicinity of Tarenig Forest. Material has also been cut and deposited above roads within Sub-Catchment 5 in order to create a 'stacking shelf' to enable timber to be stacked at roadside.



Figure 6-1: Stacking shelf above road.
NGR: SN 81452 81521

Throughout the Forestry Block, it is common practice to import type 1 aggregate in bulk preparation for road maintenance operations. Therefore, frequent deposits of this aggregate were observed on the side of roads, during the walkover. Some material within the deposit and from road surfaces is likely to become mobilised during heavy rainfall events and enter nearby streams and the main river, both the Afon Tarenig and River Wye, resulting in decreases in water quality and increased water turbidity.

Small depositions of coarse sediment, such as gravels and small cobbles (likely sourced from the river banks), are evident behind woody material in headwater streams, due to reductions in flow velocities, and downstream of small waterfalls as a result of scour and flow recirculation causing the bed substrate to be entrained and then deposited slightly downstream. However, as these sediment stores are very localised and small, they are not considered to be a main sink identified within the walkover extent. Main sediment sinks include catch pits.

Catch pits were observed upstream of culverts in headwater streams and drainage channels. These catch pits have been dug to reduce flow velocities on approach to the culvert to encourage deposition of sediment and prevent it from being entrained downstream and discharged into the main river (both the Afon Tarenig and River Wye). Several of the catch pits on site were full of both fine and coarse sediment, including gravels and silt. Where catch pits had been cleared out, excavated material (mainly composed of small gravels and silt) could be found located within the vicinity of the catch

pit. Where possible, the source(s) of the fine sediment should be investigated and addressed.



Figure 6-2: Catch pit. NGR: SN 87733 80263



Figure 6 3: Deposited material. NGR: SN 81262 83018

Litter has been observed along some of the headwater streams as well as scattered within some conifer plantations in the study area. Litter can lead to a degraded water quality and impacts on fish and invertebrate populations. It also has a negative impact on the visual appearance of a landscape. This should be removed from Tarenig Forest.

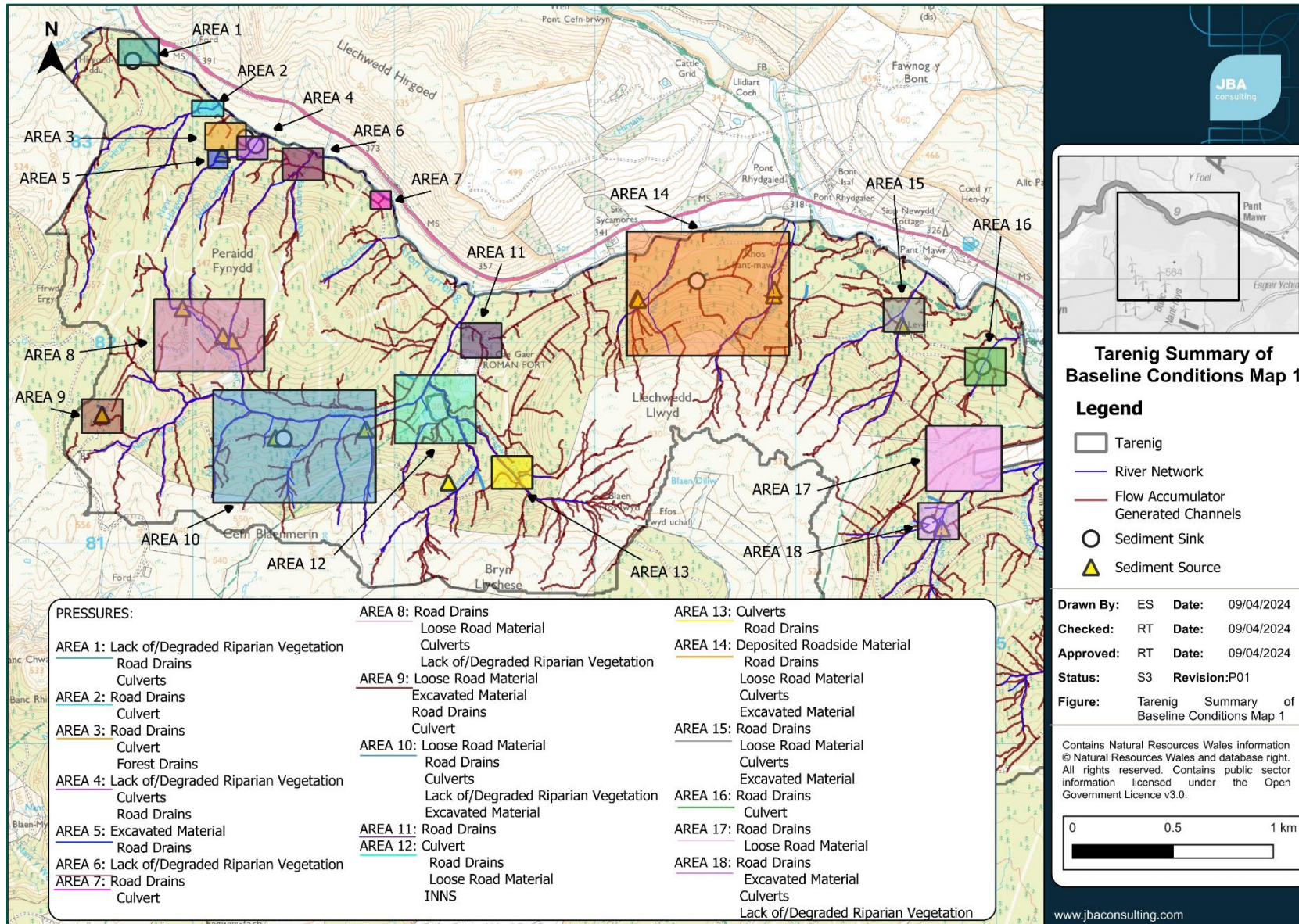


Figure 6-3: Summary of Baseline Conditions Map of the western Tareinig Forest Study Area

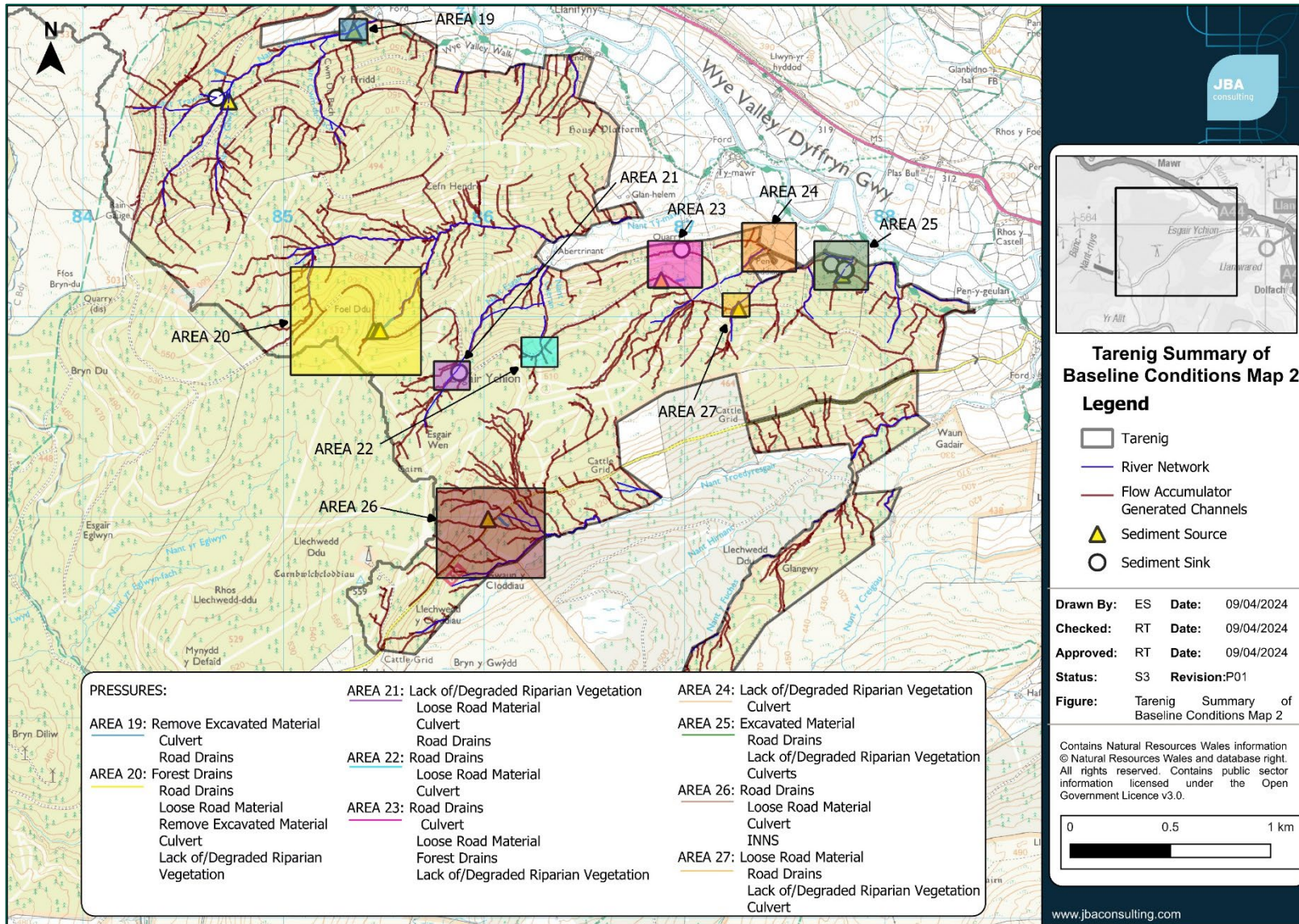


Figure 6-4: Summary of Baseline Conditions Map of the eastern Tarenig Forest Study Area

PRESSURES	KEY IMPACTS	INTEGRATED CATCHMENT MANAGEMENT OPPORTUNITIES												
		Install relief culverts to discharge to hillslope disconnecting road drains from watercourses	Replace culverts with oversized box, or bottomless culverts or clear span bridges to facilitate fish passage	Reconnect streams with their floodplain or hillslopes using channel features to elevate flow to floodplain (e.g. woody material in watercourse or lowering banks where there is an opportunity to increase water transfer from river to floodplain)	Increase planting vegetation within riparian zone	Increase the width of the buffer zone to deliver multiple benefits and near main river to buffer from sediment and peak flows.	Add woody material to attenuate flows, improve natural functioning of the stream and create wet habitat by pushing water onto the riparian zone (if present) in higher flows. Includes brush and windrow.	Remove INNS	Leaky barriers may form naturally or be constructed across streams or drains. Leaky barriers are most effective if they are formed naturally and are placed / built in series.	Add scrapes	Embed Sustainable Forest Management Practices.	Clear catch pits	Remove excavated material	Improved placement of roadside material
Timing and practise of clearfell and thinning forest operations	Increased soil compaction from machinery. Increased runoff and sediment entrainment. Tree removal.													
Presence and hydrological connectivity of road drains to watercourses	Forces accumulation of sediment that can cause localised flooding, impacting functionality of road for forest operations. Enhanced transfer of fine sediment into the watercourse network. Changes to flow conveyance during storm events and the potential to impact flooding mechanisms.													
Culverts in watercourses for road crossings	Restricted fish passage. Fine sediment input via overland flows from road crossings above. Scour of the bed downstream, disrupted sediment transport and loss of longitudinal connectivity.													
Loose road material	Input of fine sediment/ pollutants into watercourse network, both direct (nearby roads) and indirect (sediment transport from drain network).													
Deposited roadside material	Potential for fine sediment/ pollutants to enter watercourse if entrained via overland flows.													
Lack of degraded riparian zone	Limited buffer between forestry operations and watercourse; enables pathway for pollutants. Reduced biodiversity. Loss of natural functioning in areas where riparian zones should be present. Lack of shading (no riparian vegetation) or overshading (non-native riparian woodland).													
INNS	Loss of native species.													
Presence and hydrological connectivity of forest drains to watercourses	Potential loss of peat through lowered water table. Enable fine sediment transfer and increased flow conveyance. Increased pollutants may degrade downstream aquatic habitats in river network.													
Excavated material	Potential for fine sediment/ pollutants to enter watercourse if entrained via overland flows.													

Figure 6-5: Pressures vs opportunities matrix

6. Opportunities

6.1 Overview

To meet the objectives of this study and improve the management of water, potential integrated catchment management opportunities have been identified across the Tarenig Forest. Options include local scale interventions that, if applied within priority areas, have the potential to benefit the broader scale geomorphic and ecological environment and improve water management. The flow and sediment attenuation options identified in this section are a direct response to the pressures identified, with the overall aim of managing the conveyance of water and sediment across Tarenig Forest study area, so that it is more aligned with natural processes.

An overview of each flow and sediment attenuation opportunity has been given below to provide a general insight into the purpose of each opportunity along with associated benefits and constraints.

Table 7-1: Key opportunities within Tarenig Forest

Key opportunity	Technique overview/benefits	Constraints
<p>Embed Sustainable Forestry Management practices</p> <p>Note this has not been mapped due to it being a forest-wide opportunity.</p>	<p>Where possible, felling across the Tarenig Forest could occur across slope and windrow scattered in lines perpendicular to headwater streams/drainage channels to help intercept and attenuate overland surface water flow pathways. As a result, this will encourage a reduction in downslope flow velocities and deposition of fine sediment, preventing inputs to headwater streams and the Afon Tarenig and River Wye further downstream.</p> <p>The disconnection of forest and road drain and the establishment of intact riparian buffer strip would also help to reduce the input of sediments into the watercourses. Hand-felling could also be introduced near all headwater streams and main rivers (Afon Tarenig and River Wye) to minimise disturbance and the displacement of fine sediment. This would go above the industry standard recommendations to reduce disturbance and sediment input.</p> <p>Vehicle movements for the purposes of cultivation and harvesting operations should aim to limit road sediment displacement and should avoid riparian areas. Could reduce the amount of traffic on roads and improve road conditions where many potholes are evident to reduce fine sediment entrainment, such as in sub-catchment 7.</p> <p>Would contribute to the 'Reduce negative impact on water quality, soil exposure and landscape features and sustainable timber production' FRP objective.</p>	<p>Felling across slope may be too dangerous on steep-sloping areas as gravitational forces combined with a high slope angle could cause machinery to topple.</p> <p>There will still be a release of fine sediment and displacement of road material. Therefore, machinery and haulage operations need to always follow best practice to reduce/minimise risk of sediment transport at all times.</p> <p>The balance between the health and safety requirements of using more mechanical felling and extraction needs to be considered against the potential impacts to the watercourses.</p>

Key opportunity	Technique overview/benefits	Constraints
Clear catch pits	<p>Removal of the fine sediment and material that has accumulated overtime within the excavated depression, will help to restore catch pit functioning. As a result, there will be a reduction in the amount of fine sediment that reaches watercourses, preventing degraded water quality and impacts upon fauna in the watercourses.</p> <p>It has been acknowledged that the clearing out of catch pits is an element of general road maintenance; however, site observations identified a lack of ongoing maintenance, therefore a lot of the catch pits are due for clearing out.</p> <p>Where possible, the source(s) of the fine sediment should be investigated and addressed.</p> <p>Would contribute to the 'Reduce negative impact on water quality, soil exposure and landscape features and sustainable timber production' FRP objective.</p>	<p>Requires regular inspection and long-term maintenance to ensure sufficient functioning.</p> <p>Carbon emissions associated with machinery needed for long-term maintenance.</p>
Improve placement of roadside material	<p>Throughout the Forestry Block, it is common practice to import type 1 aggregate in bulk preparation for road maintenance operations, therefore this material will not be removed from the Forest. Focus should therefore investigate how to improve the storage of this material and to reduce run off from it, i.e. could store the material in a localised low spot in topography whilst making sure that it is not intercepting any overland flow pathways to reduce the amount of material that could be mobilised during a heavy rainfall event. As a result, this would reduce the amount of sediment that is transported towards headwater streams and the Afon Tarenig and River Wye, and improve water quality.</p> <p>Would contribute to the 'Reduce negative impact on water quality, soil exposure and landscape features and sustainable timber production' FRP objective.</p>	<p>As LiDAR does not penetrate vegetation in densely covered areas well, such as in Tarenig Forest, then the underlying land surface topography may not have been accurately picked up. Therefore, identified localised low spots in topography will have to be ground truthed.</p>

Key opportunity	Technique overview/benefits	Constraints
Remove excavated material	<p>Removal of excavated material will prevent this sediment from being transported towards watercourses during heavy rainfall events, subsequently reducing the amount of fine sediment that is inputted into watercourses and improving water quality.</p> <p>Would contribute to the 'Reduce negative impact on water quality, soil exposure and landscape features and sustainable timber production' FRP objective.</p>	<p>Machinery will be required to remove deposited excavated material which may result in temporary disturbances to habitats and the displacement of more fine material.</p>

Key opportunity	Technique overview/benefits	Constraints
<p>Bank lowering (lowering appropriate sections of banktop)</p>	<p>Encouraging water to flow onto the local floodplain where it can be slowed and temporarily stored means that the floodplain habitats will become wetter. This will encourage the development and enhancement of wetland habitats, such as wet woodland, if species such as Alder and Willow were allowed to develop.</p> <p>Creating wetter floodplains areas will help to reduce the risk of drought and wildfires within these parts of the study area.</p> <p>There are two opportunities to implement this within the forest at locations where observed water levels within a headwater stream and flow pathway are at the same height as the banks, therefore floodplain reconnection could be encouraged through banktop lowering. There is the opportunity to go above the industry standards by reconnecting the floodplain to the watercourses.</p> <p>Leaky barriers can be constructed from locally won woody material</p>	<p>Lowering the banktop requires physical manipulation to riparian and bankside habitats, which can be temporarily damaging via direct disturbance or harm or indirectly by input of sediment or pollution to macrophytes, fish and aquatic invertebrates. Therefore, works would require appropriate mitigation to be implemented.</p> <p>The dominant habitats recorded around the proposed interventions were noted to be widespread in the areas of forestry, being dominated by forestry plantation bordering steep watercourses, the works would result in the transition of some existing terrestrial habitats into wetter communities. Dependent upon the site this may lead to the creation of wet woodland with species present such as Alder and Willow or areas of rushes. In areas where the forest floor is dominated by moss species, there may be no permanent transition of habitats as a result of floodplain reconnection.</p> <p>It is anticipated this would mainly impact areas of plantation and as such it would increase the diversity of habitats present across the forest area and lead to supporting a higher number of species . This would be most effective when combined with other opportunities such as increasing riparian zones along watercourses which can alter habitats through the addition of dead wood and leaf litter to the aquatic system.</p> <p>There are limited opportunities to implement this elsewhere, apart from in places identified, as a lot of the headwater streams are largely incised and bedrock lined.</p> <p>Leaky barriers constrained by local channel, bed and bank characteristics (e.g, size, shape, dimensions, bed slope).</p>

Key opportunity	Technique overview/benefits	Constraints
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Key opportunity	Technique overview/benefits	Constraints
Culvert replacement	Culverts will ideally be removed where possible to improve the connectivity for fish populations, where this is infeasible, culverts being replaced with a clear span bridge or bottomless arch culvert set below bed level (>0.5m), as set out in the fish pass guidance is recommended.	The cost of the works would need to be weighed up with the benefits of opening up the watercourse. This will need to be informed by the undertaking of fish surveys up and down stream of the culverted sections to confirm fish presence or absence
Add leaky barriers (i.e. large logs) and woody material (i.e. brash and windrow)	<p>Depending on its positioning in a channel, woody material (including brash, windrow and large tree/trunk pieces) can be used to help hold water upstream to delay the rise to a flood peak downstream; to divert water onto the local floodplain to increase floodplain connectivity and enhance wetland areas, and to encourage/enhance geomorphic processes such as scour and deposition to create localised diversity in flow dynamics and sediment transport. Woody material would need to be fixed between bedrock outcrops (observed in many streams throughout Tarenig Forest) to ensure stability.</p> <p>As a result of implementing woody material to encourage overtopping and the enhancement/creation of wetland areas, the risk of drought and wildfires will be reduced as water will be retained for much longer in the riparian and local floodplains within the study area.</p> <p>Woody material can create a variation in flow types and increase the extent of shelter for fish and conditions for aquatic and saprophytic invertebrates. Fine sediment (displaced by felling practices) will also be trapped by woody material that is fixed across the channel, improving water quality and dissolved oxygen levels to support native wildlife.</p> <p>Would contribute to the 'Reduce negative impact on water quality, soil exposure and landscape features and sustainable timber production' FRP objective. This opportunity agrees with recommendations outlined in the UK Forestry Standards (2023).</p>	<p>Introducing large woody material to the channel could trigger some erosion, although the extent of this will be determined by the composition of the channel bed and banks.</p> <p>Woody materials could become dislodged in high flows or may require 'topping up' in a few years when the wood has decomposed or washed downstream. Would need periodic inspection to ensure sufficient functioning, especially after a large storm event as this is where woody material could get displaced and mobilised downstream and cause blockages at culverts.</p> <p>It is best practice to only consider the installation of suitably designed leaky barriers in watercourses that are less than 5m wide UK Forestry Standard Practice Guide (2022)¹ and CIRIA NFM Manual (2022).</p> <p>The size of the woody material used in channels should be considered before their implementation. Smaller woody material will decompose quicker than bigger material. Fresh brash, if used, could supply a significant source of phosphate to the headwater streams and main river (Afon Tarenig and River Wye).</p>

¹ UK Forestry Standard Practice Guide (2022) *Designing and managing forests and woodlands to reduce flood risk*. Forestry Commission Practice Guide.

Key opportunity	Technique overview/benefits	Constraints
<p>Add scrapes</p>	<p>Excavating depressions within the floodplain, where present, to intercept overland flow pathways will help to retain water during rainfall events.</p> <p>Scrapes can also act as fine sediment sinks during the receding limb of a flood event, capturing the fine sediment in the system and reducing turbidity in watercourses.</p> <p>The ephemeral scrapes can provide valuable habitat and can support a diverse range of fauna and flora.</p> <p>The best locations for scrapes were in areas where topography wasn't steep, such as within sub-catchment 2 at NGR SN 81205 83033 and within sub-catchment 5 at NGR SN 82138 81781.</p> <p>Would contribute to the 'Reduce negative impact on water quality, soil exposure and landscape features and sustainable timber production' FRP objective.</p>	<p>Minimal loss of existing habitat is to be expected when excavating depressions on to the floodplain. Therefore, it is important to evaluate whether the existing habitat is of high value or rarity before feature implementation. The areas proposed for scrapes were considered due to the local land gradient and that they would not degrade ecologically important habitats.</p> <p>Care needed during construction to minimise risk of fine sediment erosion and transportation.</p>
<p>Install relief culverts</p> <p>UKFS guidance suggests that relief culverts are installed every 100m along a road network.</p>	<p>Adding relief culverts along road/track networks will help to encourage a greater dispersion of flow across floodplain and hillslope areas. Water will no longer be channelised down one culvert, but instead be distributed downstream via a larger drainage network onto different areas of land following heavy rainfall events. Subsequently, this will help to attenuate flow and encourage the creation of wetland habitat if frequently inundated. There is the opportunity to go above the industry standards by installing additional relief culverts in areas where increased pressures have been identified.</p>	<p>The construction of a relief culvert will result in temporary disturbance to surrounding land.</p> <p>Good access to the site is required as construction will involve the use of plant machinery.</p>

Key opportunity	Technique overview/benefits	Constraints
<p>Increase native riparian vegetation</p>	<p>Introducing locally native riparian tree and scrub species (such as species already found in areas of the woodland, including Willow species, Silver and Downy Birch, Rowan and Pedunculate Oak) along the banks of a channel/pond or enhancing existing riparian buffer zones can help to intercept overland flow and rainfall, slowing flow as it moves towards a body of water.</p> <p>Marginal and bankside vegetation can help to filter out pollutants from agricultural and felling surface run-off, resulting in water quality improvement which is beneficial to the biota of the river.</p> <p>The more dappled shading provided by broadleaved species in contrast with conifer species, is likely to provide benefits by allowing more macrophytes to establish in the watercourse which would have knock-on benefits upon water quality and fauna.</p> <p>UK Forestry Standards (2023) identify a riparian buffer zone width of 10m for watercourses that have a width of less than 2m. A riparian buffer zone width of 20m is suitable for a watercourse with a width greater than 2m². There is the opportunity to go beyond these standards by implementing larger buffer zones along watercourses in and adjacent to the site, such as along the main tributaries in the forestry and along the lower boundary of the forest along the Afon Tywi and Afon Tarenig.</p> <p>Implementing a wide riparian buffer zone will help to mitigate wildfire risks within the study area.</p> <p>Would contribute to the 'Increased successional/riparian woodland areas' and 'Increased buffer zones around watercourses' FRP objectives.</p> <p>This can also help create ecological corridors through the site for species to use and link the site to the wider landscape.</p> <p>This opportunity corresponds with actions outlined in the Powys Nature Recovery Action Plan.</p>	<p>Utilise low impact cultivation methods.</p> <p>Adversely, disturbing the soil when planting riparian vegetation could cause the loss of or damage to existing sensitive species. However, the majority of habitats recorded bordering the watercourses on site were dominated by dense forestry plantation. Therefore, loss of these trees to introduce to native species is anticipated to be a positive ecological change.</p> <p>If Red Squirrel are on site, then increases in broadleaf planting may result in Grey Squirrels outcompeting Red Squirrels. No ecological records were identified of Red Squirrel in the site boundary, but their potential presence should be considered.</p>

Key opportunity	Technique overview/benefits	Constraints
INNS Control	<p>Programmes for the control and eradication of invasive non-native species such as <i>Rhododendron</i> should be designed to be implemented (e.g. Edwards, 2006). To prevent INNS re-establishing from local source areas, boot wash stations could be installed.</p> <p>This opportunity corresponds with actions outlined in the Powys Nature Recovery Action Plan and agrees with recommendations outlined in the UK Forestry Standards (2023).</p>	Long-term maintenance will be required to prevent re-establishment.
<p>Open Ground Creation</p> <p>Note this has not been mapped due to it being a forest-wide opportunity.</p>	<p>The creation of areas of open ground within the forestry plantation can increase the diversity of habitats and provide opportunities for a wider number of species.</p> <p>Research has shown areas of open ground can be beneficial for a number of species, including for birds, invertebrates and flora.</p> <p>When deciding the location and type of open land, the habitat preferences of the target species should be taken into account, along with ecological connectivity to other habitats and existing populations. This opportunity agrees with recommendations outlined in the UK Forestry Standards (2023).</p>	The creation of open ground in areas of existing forestry would result in the loss of some existing habitats, predominantly forestry plantation with a sphagnum and moss floor covering. However, these habitats are widespread on the site and the creation of open areas would increase the diversity of habitats present in the forestry and provide habitat for additional species such as reptiles by providing areas for basking which have been recorded in the wider landscape.

²Forestry Commission (2019) *Managing forest operations to protect the water environment*. Forestry Commission Practice Guide. Forestry Commission, Edinburgh. I-iv + 1-48pp.

6.1.1 Prioritisation

It is recommended that opportunities are initially implemented in clear felled areas, as this is where significant sources of sediment will originate from. In areas to be felled, it is important to have an idea of the interventions that could be implemented once felling has taken place. However, there may need to be a review of these options as the process of felling could reveal other channel characteristics or topographical modifications, e.g. drainage channels, where further opportunities could be identified.

It will be more sustainable to prioritise the management of sediment sources throughout the study area, instead of implementing options that will rely on long-term maintenance and removal such as catch pits, as this could result in significant carbon emissions being generated due to machinery use.

It would also be beneficial to prioritise implementing opportunities within the larger sub-catchments such as sub-catchment 5, where a large number of options were identified. Targeting these bigger areas will result in a greater benefit to the management of water and sediment transport throughout the study area, whilst also providing a wider range of environmental benefits.

Any culvert removal or modification carried out with an aim to improve fish passage should take place from the bottom of the site (closest to the Afon Wye and Afon Tarenig) upstream, to ensure connectivity is achieved and should be carried out on the main tributaries first. Therefore, the culverts lower down the site should be prioritised for modification or removal.

Options involving the placement of natural material (such as that found within Tarenig Forest) across headwater streams to increase flow heterogeneity are considered to be 'low risk' proposals according to NRW's Low Risk Impoundment Position Statement (Natural Resources Wales, 2024). Low risk proposals do not require a licence application. It is important that the design of the options does not cause detriment to the environment, water uses and protected rights during the planning phase.

Opportunities identified across the whole of the Tarenig Forest study area have been mapped in Figure 7-1 and Figure 7-2. To show examples of site-specific opportunities, four focus area scale maps have been created to aid understanding and rationale behind suggested opportunities (see Figure 7-3, Figure 7-4, Figure 7-5 and Figure 7-6).

6.1.2 Indicative costings of 'slow the flow' measures

Derived from: Highways England – Natural Flood Management: Design Specification Catalogue (2021).

- **Leaky barriers** – if made of wood, the typical cost will be £500-£2,000 per barrier. This includes equipment, materials and time. This excludes design, planning and consenting. They typically have a 5-10 year design life. The proximity of appropriate wood/timber material to use at each location will influence the unit cost.
- **Offline storage areas and scrapes** – the typical cost will be £10-£50 per m³ of earth excavation. This includes equipment, labour and materials. This excludes

design, planning, consenting and any requirements to spread or remove spoil. They typically have a design life of 10 years.

All measures would require periodic inspections and maintenance to ensure continued structural integrity and functionality, preferably every 6-12 months and after any significant storm events.

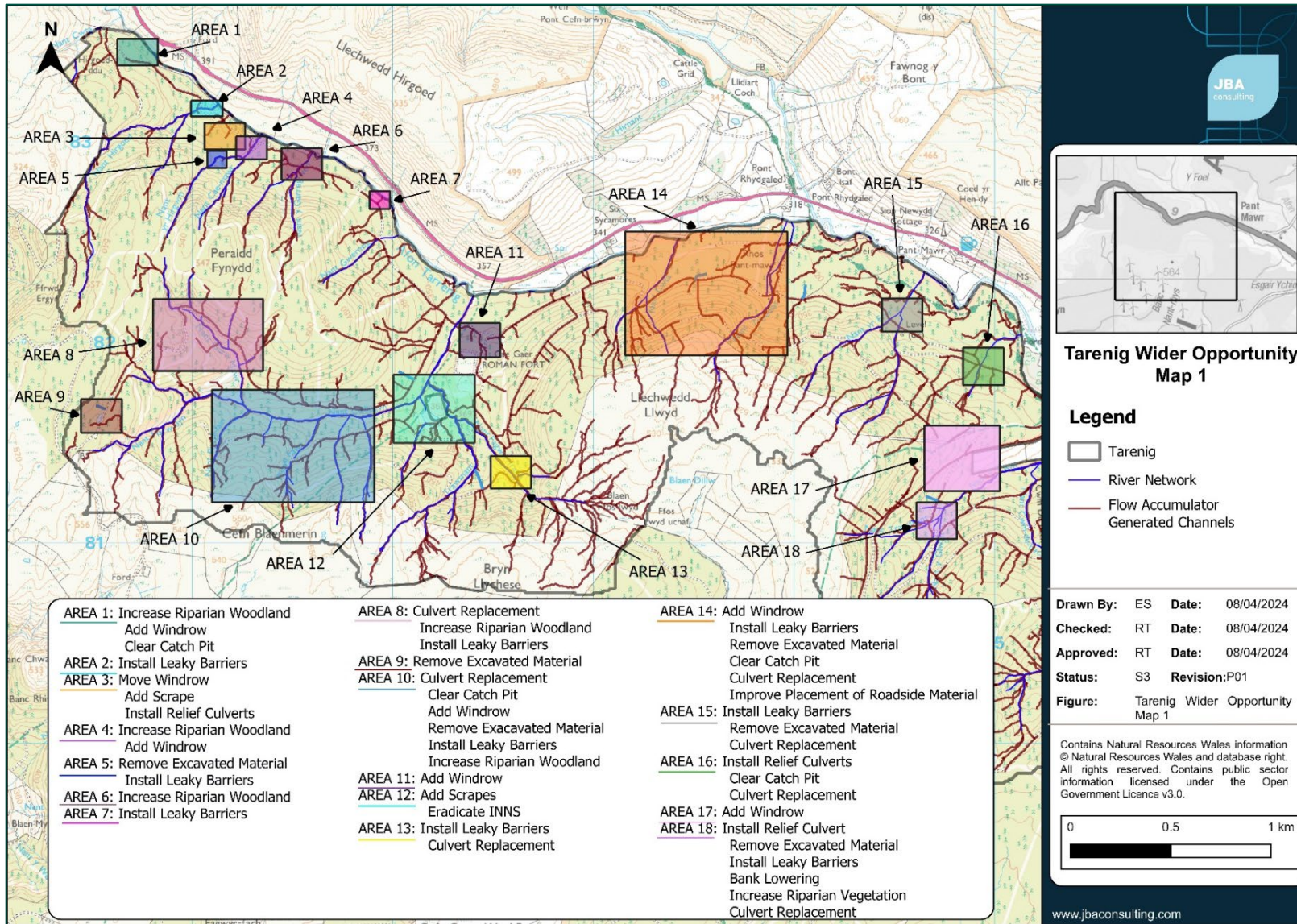


Figure 7-1: Wider Opportunities Map across the western Tarenig Forest

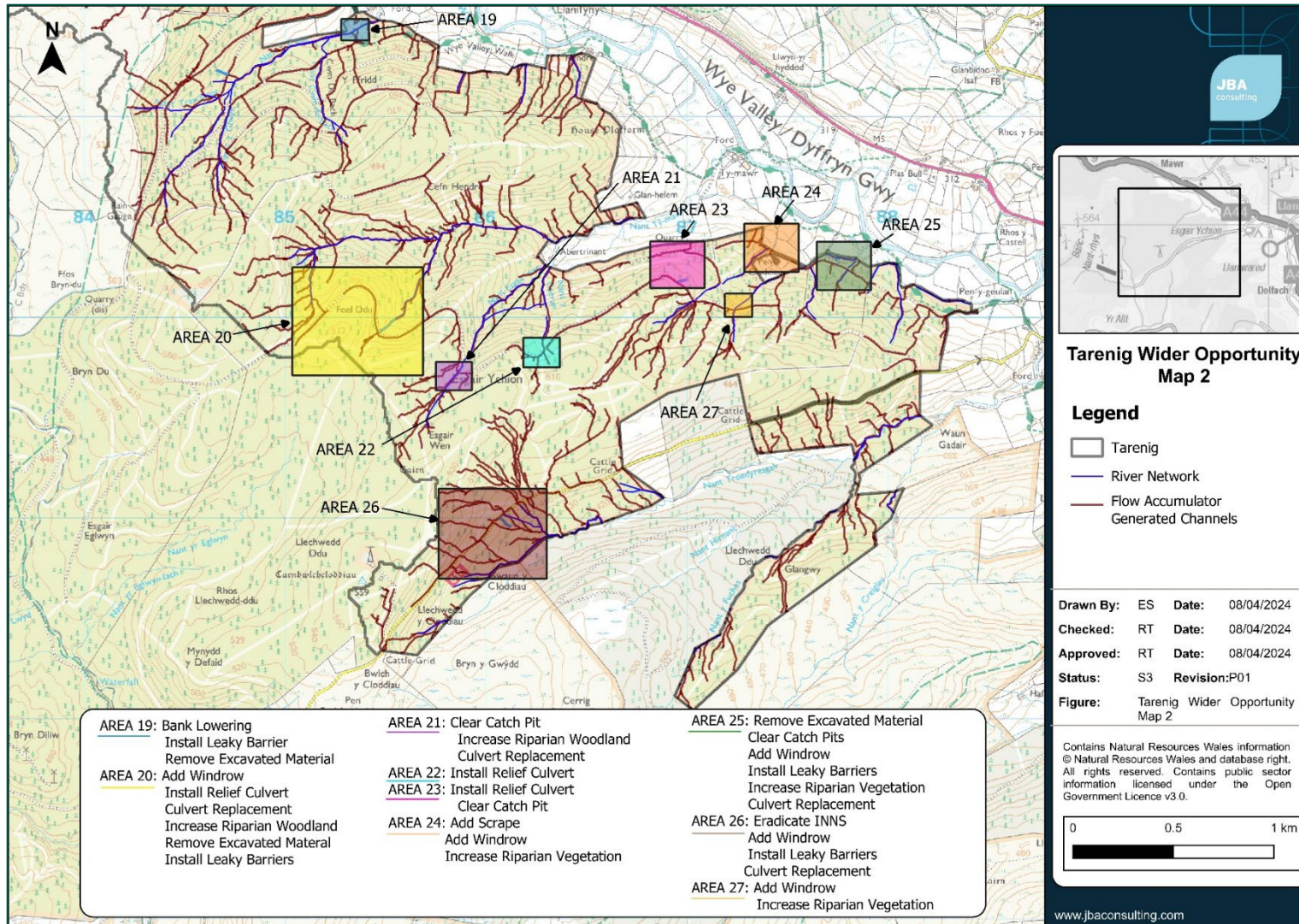


Figure 7-2: Wider Opportunities Map across the eastern Tareng Forest

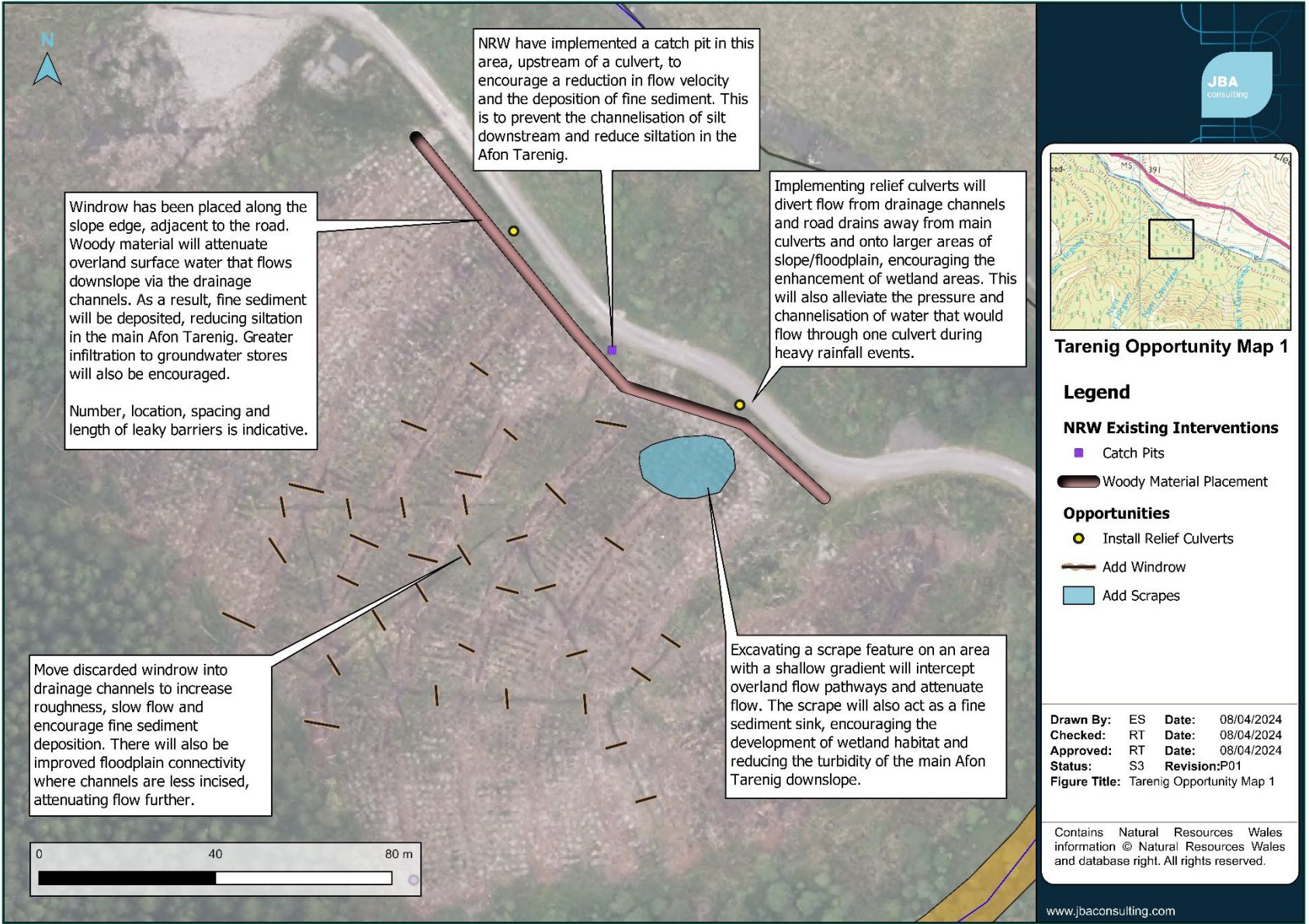


Figure 7-3: Opportunities identified at NGR SN 81180 83037 (Sub-Catchment 2, Area 3 in Wider Opportunity Map)

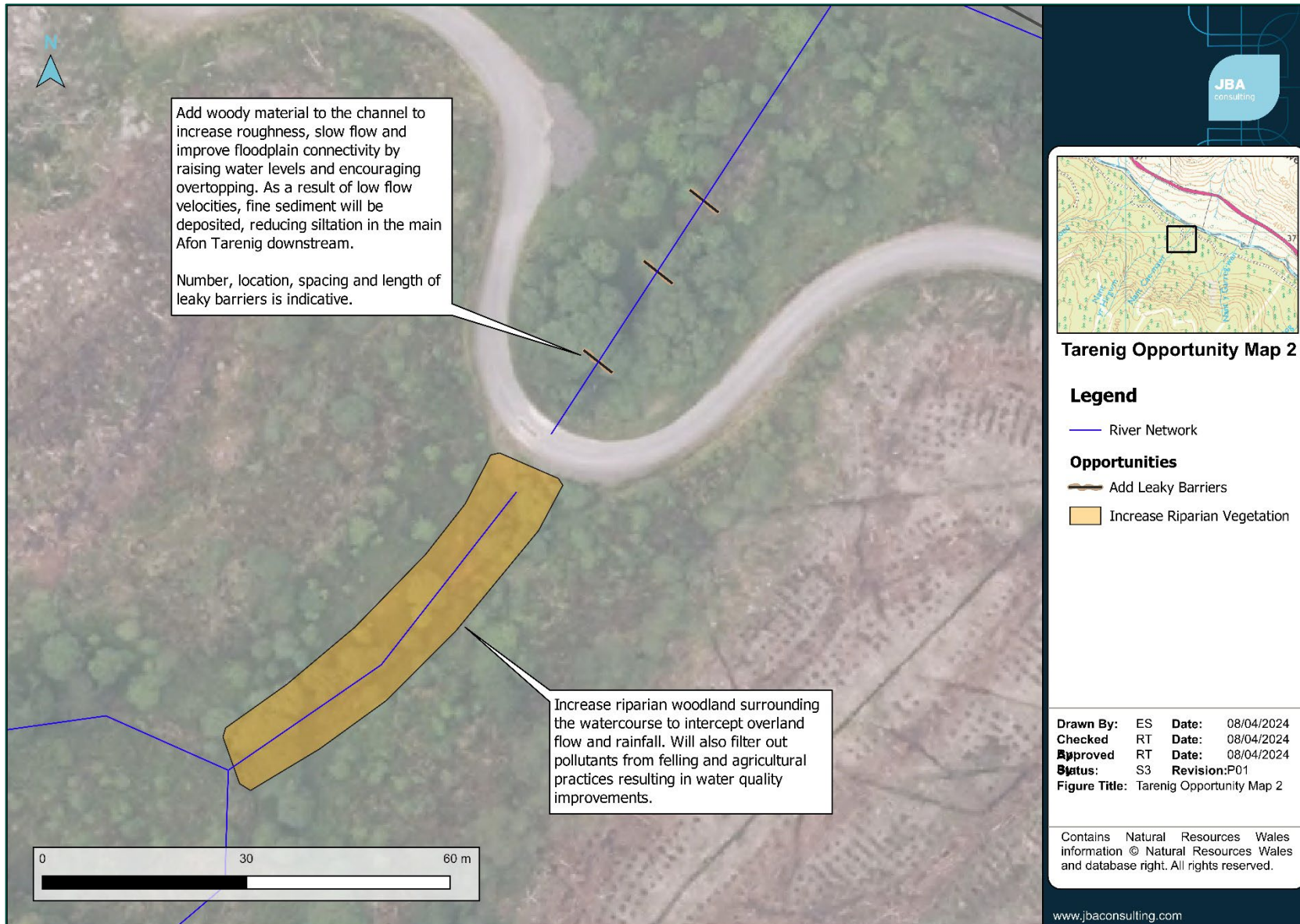


Figure 7-4: Opportunities identified at NGR: SN 81301 82964 (Sub-Catchment 2, Area 4 in Wider Opportunity Map)

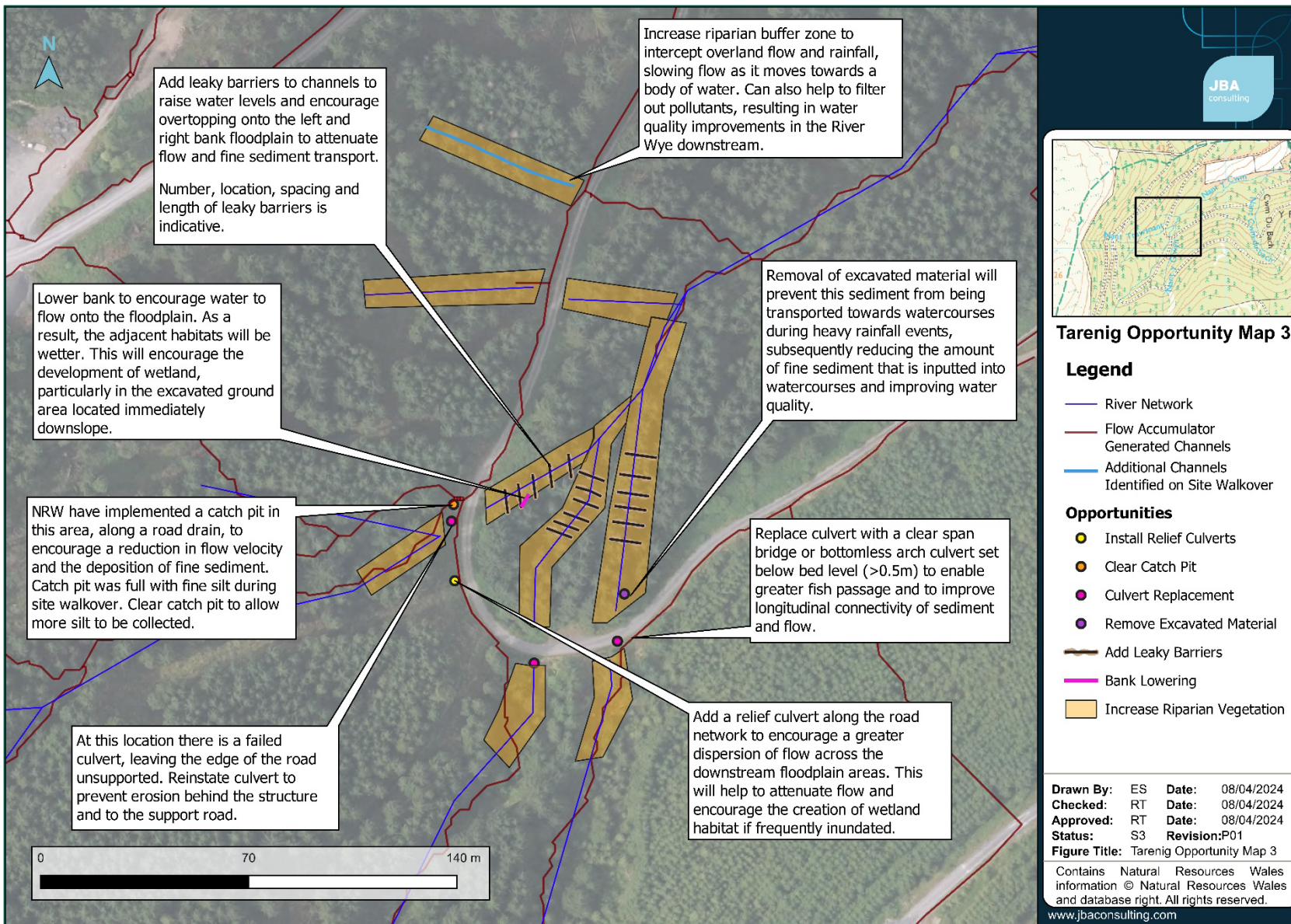


Figure 7-5: Opportunities identified at NGR: SN 84714 81106 (Sub-Catchment 9, Area 22 in Wider Opportunity Map)



Figure 7-6: Opportunities identified at NGR: SN 86051 78974 (Sub-Catchment 12, Area 27 in Wider Opportunity Map)

6.2 Limitations

Due to the large Tarenig Forest study area (1,369h²km²), JBA were not able to survey all priority areas. Some windblow of trees across roads/tracks also prevented access to some parts of the forest. Opportunities identified in surveyed areas could be assumed to work in non-surveyed areas that exhibit similar physical characteristics; however, these areas would still need ground truthing as constraints such as public footpaths, electrical pylons and fencing could prevent implementation. Opportunities could not be generated for areas that were particularly steep (i.e. greater than about 15%) as access and feature implementation would be too dangerous. Options should also not be installed within close proximity to culverts and bridges to reduce blockage and destruction risk during heavy rainfall/storm events. For leaky barriers, the most downstream barrier closest to the inlet of a structure should be the most robust so that it can catch any debris that has been washed out from a breached barrier further upstream (CIRIA, 2022).

Due to the scope of the survey, which was completed by carrying out rapid assessments at spot locations, a comprehensive ecological species list was not able to be produced and detailed habitat mapping was not undertaken. However, a general ecological overview of the site was achieved.

As a result of the dense tree cover within the study area, there was interference with the georeferencing of some photos taken using the GISMapp application. Subsequently, this will have affected the locational accuracy of the pressure and opportunity mapping within certain locations. Therefore, ground truthing is recommended before any feature implementation.

7. Conclusions and recommendations

7.1 Summary

A desk-based and targeted, site-based geomorphological and ecological assessment has been undertaken to understand in more detail the current conditions within Tarenig Forest. The assessment included surveying headwater streams, forest drainage channels, forest roads, road drains and open ground within identified priority areas and recording any processes and pressures controlling flow and sediment dynamics and ecological habitats within the system.

This understanding of existing baseline conditions alongside the identification and assessment of physical pressures on watercourses within the study area has allowed a plan for water and sediment attenuation across Tarenig Forest to be developed in order to meet project aims and objectives. The options for water and sediment attenuation proposed will need to be further refined through future feasibility and design work prior to any implementation on the ground.

This report is part of a wider programme to implement integrated catchment management in other forestry blocks across the Welsh Government Woodland Estate (WGWE)

Key pressures on the water environment	Description
Timing of clearfell and thinning forest operations	Felling practices with the use of heavy machinery can cause ground disturbances, resulting in fine sediment displacement, compaction of soils leading to reduced porosity and a release of phosphate and nitrogen compounds that deplete water quality through acidification and eutrophication.
Invasive Non-Native Species (INNS)	The presence of INNS could result in it spreading within the woodland and surrounding area. This would alter the habitats and composition of species present within the woodland.
Forest drains and ditches	Forest drains contribute to a quicker conveyance of flow and sediment transport downslope, towards the main river. Can result in increased in-channel water levels and an increased risk of flooding downstream.
Loose road material	Fine sediment inputs into headwater streams and drainage channels can result in decreases in water quality and increased water turbidity.

Key pressures on the water environment	Description
Road drains	Forestry roadside drains artificially concentrate and accelerate water draining from large sloping areas of woodland. These drains are often connected to streams and rivers and can lead to increased downstream flood risk and degradation of water quality from fine sediment dispersal.
Culverts	Replacing a section of open channel with culverted sections can result in a direct loss of habitat and a lack of longitudinal and lateral connectivity for fish populations if not adequately mitigated.
Lack of/degraded riparian vegetation	<p>Riparian vegetation, with a mix of broadleaf native trees, shrubs and grasses, creates an important transition zone between aquatic and terrestrial environments. Riparian woodlands are crucial for controlling erosion, improving water quality, providing habitat for wildlife, and supporting the food chain for aquatic ecosystems.</p> <p>Without riparian vegetation, polluted runoff from forestry operations can enter the watercourse directly, leading to acidic, polluted, and degraded water quality due to the lack of filtering capacity.</p>
Deposited roadside material	During heavy rainfall events some of this deposited sediment could be remobilised and re-enter the watercourse and the main river resulting in decreases in water quality and increased water turbidity.
Excavated material	During heavy rainfall events some of this excavated material could be remobilised and re-enter the watercourse and the main river resulting in decreases in water quality and increased water turbidity.

Potential opportunities to meet project objectives

- Embed Sustainable Forestry Management practices
- Clear catch pits
- Improve placement of roadside material
- Remove excavated material
- Invasive Non-Native Species (INNS) control
- Bank lowering
- Culvert replacement

- Add leaky barriers and woody material
- Add scrapes
- Install relief culverts
- Increase riparian woodland (broadleaf planting)
- Open ground creation

Below are additional opportunities that could be implemented within the study area that would also align with project objectives. These opportunities have not been included within the larger opportunity table as there were no suitable locations found for these features during the site visit.

Additional opportunities

- Plan forest operations at catchment scale
- Produce catchment water management plans
- Implementation of J-shaped drains

7.2 Recommendations and next steps

All the opportunities identified during the course of this project have been reviewed within the context of the objectives defined in the Forest Resource Plan (FRP) for the Tarenig Forest and with wider NRW policies and plans including the Salmon and Sea Trout Plan of Action. Many of the opportunities correspond with actions outlined in the Powys Nature Recovery Action Plan. Some further surveys and investigations may need to be carried out before certain options can be progressed (e.g. ground investigations, contaminated land surveys, archaeological assessments etc.) and certain consents/licences may need to be sought depending on the design stage and the option being considered (e.g. flood risk activity permits, ordinary watercourse consents, protected species licencing, Habitats Regulations Assessment, planning permission etc.).

In addition, due to the lack of data points for fishery records within the site, it is recommended electro-fishing surveys are undertaken of more of the watercourses on the site that are connected to the river network to better understand the spread of species in the area. Any culvert removal or modification to improve fish passage should take place from the bottom of the site (closest to the Afon Wye and Afon Tarenig) upstream, to ensure connectivity is achieved.

Observations about road drains, especially their connectivity (to watercourses) and condition, were common throughout the site visit, indicating a need to ensure the continued application of good practice. According to the UKFS (2023): "Forest drainage (including road drains) should be planned and, where necessary, existing drains should be realigned and disconnected from waterbodies to ensure that water is discharged before the edge of a buffer area, and never directly into a waterbody". In addition, Forestry Commission Operations Note 25 (2011) states that "road drains should not discharge directly into watercourses. Road drains on the upper side of the running surface should use cut off or relief culverts to direct water to the lower side of the track a short distance before any stream crossings. Water from any road drain that carries a high sediment loads must be discharged into a buffer area of adequate size, or into a silt trap or catch pit that have been constructed to allow sediment to settle out before it enters the watercourse".

No enhancement or restoration actions should be undertaken without refinement through future feasibility work and/or design. Any actions should not negatively impact the conservation objectives of the designated sites, including the River Wye SSSI. Furthermore, habitats of principal importance should be retained as a priority, ensuring no net loss, along with species and habitats that support them that are listed on Section 7 of the Environment (Wales) Act.

An identification and assessment of local constraints is required, and all interventions will require consultation with local stakeholders (e.g. tenant farmers, graziers, etc.) prior to construction. This could be easier if the enhancement can be implemented by local people and stakeholders. Some measures will require design and construction to be implemented together with a long-term management and maintenance plan, but others can be done locally, such as riparian planting.

We understand that it is the intention of NRW to apply the principles of the site survey methodology, including the completion of the simplified inventory list, to other WGWE locations in the future. A version of the MS Excel inventory list was developed and implemented into an in-house data collection app (GISMapp), loaded onto a rugged tablet device, that allowed all the point/area-based data (including metrics, descriptions, opportunities, constraints and photos) to be recorded, georeferenced and securely stored during the site visits. For the initial trial application of this assessment method there were three specialist staff out on site together covering the topics of NFM, geomorphology and ecology, all informed by the pre-visit desk-based assessments. This allowed the data collection, opportunity, actions and constraints identification to benefit from the combined skills and experience of three individuals, both during the on-site discussions and the subsequent interpretation and reporting tasks.

The application and availability of three individual specialists might not be possible for all further surveys of this type across the wider WGWE going forwards. However, it should be possible for the completion of the inventory list, together with the capture of a comprehensive set of point/area photos all suitably georeferenced, to be undertaken by a pair of operatives (to address lone working risks in remote areas) suitably informed about the objectives of the work, skilled in one or two of the key disciplines, and who also have a reasonable knowledge of the other discipline(s). This should allow the identification of a good set of potential NFM/restoration opportunities and possible constraints to take place during a site visit. The subsequent interpretation of the data captured, together with the photo record, can then be reviewed by the site operatives taking advice from appropriate NRW specialists in order to determine an agreed set of potential opportunities and actions for the point/areas in question for consideration by the relevant NRW forestry management and operational staff.

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Appendices

Data Archive Appendix

Data outputs associated with this project are archived in NRW's Document Management System and server-based storage.

The data archive contains:

[A] The final report in Microsoft Word and Adobe PDF formats.

[B] An excel spreadsheet of Tarenig Water Management Strategy and Delivery Plan Table

[C] A series of GIS layers on which the maps in the report are based with a series of word documents detailing the data processing and structure of the GIS layers. These are archived in x:\\Resource Management\\River Restoration

[D] A full set of images produced in jpg format.

Metadata for this project is publicly accessible through Natural Resources Wales' Data Discovery Service <https://metadata.naturalresources.wales/geonetwork/srv> (English version) and <https://metadata.cyfoethnaturiol.cymru/geonetwork/cym/> (Welsh Version). The metadata is held as record no NRW_DS161383.

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Appendix A. Inventory list

Proposed inventory and methodology for sites/reach/area information

Sub-catchment	Feature type	Frequency of survey/ collection notes	Characteristic	Drop down value - Y/ N	Things to include in drop-down box	Larger text box - Y/N	Examples/ more information
Sub-catchment 01, 02, 03 etc	Forest Roads	Spot check. To be surveyed from the car or on foot on route to and from sub-catchment headwaters. New entry to be made if conditions change.	Road surface/ condition/ presence of vegetation	N		Y	Describe the road surface and physical character, include whether any vegetation is present
			Evidence of road erosion (overbanking) or hillslope erosion; if yes, could flow dispersal options be considered?	N		Y	Caused by the physical characteristics of the road. Flow dispersal interventions could include increasing the number of culverts, installing 'splashpads' at culvert outlets, or realigning the culvert to discharge to land
			Condition and evidence of management of roadside drains	N		Y	Are roadside drains being managed? Is it a 'hit and miss' clearance techniques (partial clearance of drain vegetation and/ or sediment), or 'strimming'?
			Evidence of existing features present within the drains to slow/ disperse flow	Y	Check dams; relief culverts; other	N	E.g. check dams, relief culverts. Absence of data implies no
			Inappropriate culvert/ outfall placement?	N		Y	e.g. directly feeding into a channel with no sediment catchpit, relief culverts installed too close to the watercourse - instead of discharging at the inlet of the culvert, merely discharge on the bank at the outlet, where the water flows directly into the watercourse anyway.
			Evidence of residual water management produce in-situ?	Y	Silt fencing, straw bales, other	N	E.g. sediments, silt-fencing, straw bales
			NFM/ restoration opportunities	N		Y	
	Watercourses	To be surveyed from upstream to downstream from the river bank, if access permits. New entry to be made if conditions change. Information collected at the local scale, expected to represent sub-catchment.	Top channel width and bank heights	N		N	Estimate of width from left bank top to right bank top, bank heights from bank top to channel bed
			Wetted channel width and depth	N		N	Based on winter flow conditions, assuming flow is present
			Watercourse type (according to UKFS)	Y	Main River; Large watercourse; Medium watercourse; Small watercourse; Very small watercourse; Ephemeral	N	Main River (as defined by NRW maps), Large watercourse (channel >2m), Medium watercourse (channel 1-2m), Small watercourse (channel <1m), Very small watercourse (channel <0.5m), Ephemeral (natural channel but only activated in high/ seasonal flows)
			Channel slope gradient	N		N	Measured along the bank top using a clinometer
			River type and planform	N		N	i.e. single thread alluvial/ bedrock, multi-thread/ anastomosed, braided, straight, sinuous or meandering.
			Bed sediment type	N		N	Description of bed material and grain size estimate (i.e. silt, sand, gravels, cobbles)
			Bank composition and profile	N		N	Description of bank material and profile (linked with processes)
			Flow types/ hydraulic habitat	N		N	List flow biotopes present (i.e. rapid, riffle, run, glide, pool)
			In-channel vegetation	Y		Y	List species present if found
			Riparian vegetation and condition (if present)	N		Y	Describe vegetation type and condition (i.e. likely to be wetted frequently, biodiversity value). Riparian zone might not be present if the channel banks are particularly high
			Geomorphic features and processes	N		Y	i.e. evidence of bed/bank erosion (scour, undercutting, incision) or deposition (bars, siltation)?
			Geomorphic and ecological pressures	N		Y	Perceived connectivity with riparian zone/ floodplain (if present)? E.g. Physical modification (weirs/ barriers/ other in channel structures, embankments, evidence of channel straightening/ realignment, evidence of dredging), siltation, pollution, intensive riparian management
			NFM/ restoration opportunities	N		Y	Are there opportunities to slow the flow, make the riparian habitat wetter, and improve wetland habitats (for biodiversity, capture suspended sediments, reduce downstream flood risk)?
	Riparian Zone	To be surveyed alongside the watercourse.	Distance between bank top and forestry management area	N		N	Estimate of distance from managed forests to channel bank top, based on vegetation type. Note if it is consistent across study area or variable.
			Size of riparian zone	Y	Absent; <1m; 1-3m; >3m	N	Limited (<1m), Average (1-3m), Extensive (>3m) FROM WATERS EDGE. Riparian zone based on vegetation communities, landforms (i.e. bank height and steepness) and any physical modification (i.e. tracks)
			Vegetation types present	N		Y	Description of key vegetation types present on the bank top and stretching back from the channel edge.
			Condition of riparian zone	Y	Good; Poor; Other*	N	Good/ poor - to be determined from ecological assessment. *Other to be used if more description is needed
			NFM/ restoration opportunities	N		Y	i.e. does the buffer zone needs to be expanded to limit forestry practices in the riparian zone? Can the condition of the riparian zone be improved?
	Forest Drains	To be surveyed on a 'spot check' basis within each sub-catchment that features a priority area.	Geometry and hydraulic habitat	N		Y	i.e. Channel width and depth, flow biotopes (or dry)
			Evidence of existing NFM	N		Y	i.e. has the drain been blocked and prevented from freely discharging into a more natural watercourse, is it effective? Has the forest drain been deflected to a J-drain or the adjacent hillslope where water can spread out and infiltrate.
NFM/ restoration opportunities			N		Y		

Appendix B. Simplified inventory list

Proposed inventory and methodology for site/reach/area information

Sub-catchment	Feature type	Frequency of survey/ collection notes	Characteristic	Drop down value - Y/ N	Things to include in drop-down box	Larger text box - Y/N	Examples/ more information		
Sub-catchment 01, 02, 03 etc	Forest Roads	Spot check. To be surveyed from the car or on foot on route to and from sub-catchment headwaters. New entry to be made if conditions change.	Road surface/ condition/ presence of vegetation	N		Y	Describe the road surface and physical character, include whether any vegetation is present		
			Condition and evidence of management of roadside drains	N		Y	Are roadside drains being managed? Is it a 'hit and miss' clearance techniques (partial clearance of drain vegetation and/ or sediment), or 'trimming'? Any check dams/relief culverts present?		
			Evidence of residual water management measures in-situ?	Y	Silt fencing; straw bales; other	N	E.g. silt-fencing, straw bales		
			NFM restoration opportunities	N		Y	Are there opportunities to slow the flow, divert to local land surface (for multiple benefits, e.g. capture suspended sediments, reduce downstream flood risk)?		
	Watercourses	To be surveyed from upstream to downstream from the river bank, if access permits. New entry to be made if conditions change. Information collected at the local scale, expected to represent sub-catchment areas.	Channel dimensions: - Top channel width and bank heights - Wetted width and depth	N		N	Estimate of width from left bank top to right bank top, bank heights from bank top to channel bed Based on winter flow conditions, assuming flow is present Measurements can be used to help inform watercourse type Main River (as defined by NRW maps), Large watercourse (channel >2m), Medium watercourse (channel 1-2m), Small watercourse (channel <1m), Very small watercourse (channel <0.5m), Ephemeral (natural channel but only activated in high/ seasonal flows)		
			Channel slope gradient	N		N	Measured along the bank top using a clinometer (ensure units of measurements are stated (e.g. degrees, %, m/m), typically over a 5m-20m reach length dependant on channel characteristics)		
			River type and planform	N		N	i.e. single thread alluvial/ bedrock, multi-thread/ anastomosed, braided, straight, sinuous or meandering.		
			Bed and bank composition/profile	N		N	Description of bank material and profile (linked with processes) Description of bed material and grain size estimate (i.e. silt, sand, gravels, cobbles, boulders)		
			In-channel vegetation	N		Y	List species present if found		
			Geomorphic features, flow types and processes	N		Y	i.e. evidence of bed/bank erosion (scour, undercutting, incision) or deposition (bars, siltation)? Perceived connectivity with riparian zone/ floodplain (if present)? List flow biotopes present (i.e. rapid, riffle, run, glide, pool)		
			Geomorphic and ecological pressures	N		Y	E.g. Physical modification (weirs/ barriers/ other in channel structures, embankments, evidence of channel straightening/ realignment, evidence of dredging), siltation, pollution, intensive riparian management		
			NFM restoration opportunities	N		Y	Are there opportunities to slow the flow, reconnect with the local floodplain, make the riparian habitat wetter, and improve wetland habitats (for biodiversity, capture suspended sediments, reduce downstream flood risk)?		
			Riparian Zone	To be surveyed alongside the watercourse.	Distance between bank top and forestry management area	N		N	Estimate of distance from managed forests to channel bank top, based on vegetation type. Note if it is consistent across study area or variable.
					Size of riparian zone	Y	Absent; <1m; 1-3m; >3m	N	Limited (<1m), Average (1-3m), Extensive (>3m), measured from waters edge. Riparian zone based on vegetation communities, landforms (i.e. bank height and steepness) and any physical modification (i.e. tracks)
	Forest Drains	To be surveyed on a 'spot check' basis within each sub-catchment that features a priority area.	Vegetation types present	N		Y	Description of key vegetation types present on the bank top and stretching back from the channel edge.		
			Condition of riparian zone	Y	Good; Poor; Other*	N	Good/ poor - to be determined from ecological assessment. *Other to be used if more description is needed		
			NFM restoration opportunities	N		Y	Should the buffer zone be expanded to limit forestry practices in the riparian zone? Can the condition of the riparian zone be improved?		
	Open Ground and Overland Flow Pathways	Box to be filled in on a 'spot check' basis within each sub-catchment that features open ground or an area with a natural overland flow pathway.	Geometry and hydraulic habitat	N		Y	i.e. Channel width and depth, flow biotopes (or dry)		
			Evidence of existing NFM (artificially implemented)	N		Y	i.e. has the drain been blocked and prevented from freely discharging into a more natural watercourse, is it effective? Has the forest drain been deflected to a J-drain or the adjacent hillslope where water can spread out and infiltrate.		
			NFM restoration opportunities	N		Y	Are there opportunities to slow the flow, divert/reconnect with the local floodplain or local land surface (for multiple benefits, e.g. capture suspended sediments, reduce downstream flood risk)?		
			Open ground and overland flow pathways	N		Y	Are there any open ground areas? What is the dominant vegetation type? Is there any evidence of erosion? Are there any gullies? How does water travel through these areas i.e. does water follow natural topographic contours?		

Appendix C. Available data

The data provided by Natural Resources Wales is listed in Table 0-1.

Table 0-1: Supplied Data

Supplied data	Author(s)
Historic LiDAR Archive	Welsh Government and Natural Resources Wales (DataMapWales)
LiDAR Composite Dataset	Welsh Government and Natural Resources Wales (DataMapWales)
OS Base Data	OS Data Hub
Landmark/ OS Historic Mapping	National Library Scotland
Areas benefiting from Flood Defences	Welsh Government and Natural Resources Wales (DataMapWales)
Flood Defences with standardised attributes	Welsh Government and Natural Resources Wales (DataMapWales)
Geology (Solid and Superficial)	British Geological Society
Soils (e.g. NATMAP vector)	British Geological Society
Detailed River Network	Welsh Government and Natural Resources Wales (DataMapWales)
Flood Risk – Main Rivers	Welsh Government and Natural Resources Wales (DataMapWales)
Hydrometry & Telemetry Data	Welsh Government and Natural Resources Wales (DataMapWales)
Peatland Survey from Myherin and Tarenig Forests. Peat Survey Point Data (for peat depths) and Peat Survey Data (Metadata – excel)	Siviculture
Myherin & Tarenig Peatland Restoration Survey Report	Siviculture
Draft Peatland restoration sites in Tarenig “Open After Felling On Peat”	Siviculture
Low risk Impoundment Position Statement	NRW
Forest Restock Coupes	NRW
NRW Forest Legal Boundaries	NRW
NRW Forest Roads	NRW
NRW Forestry Priority Catchments 2016	NRW
Water Watch Wales	Water Watch Wales (naturalresourceswales.gov.uk)
Welsh Peatland Data Portal, including Peatland of Wales Thickness	NRW
Forest Resource Plan draft layers for Myherin and Tarenig	NRW
Myherin and Tarenig draft Forest Resource Plan (Objectives 2022-2042)	NRW
Project Study Areas	NRW
Fisheries Habitat Restoration Plan: Welsh Wye Catchment Report	NRW
Fluvial audit of the River Wye and tributaries: geomorphological assessment and Shapefiles	Jeffries, R., Thomas, R., German, S. Bray, S., Cross, J., Guay, A., White, C. and Hillman P. paper
Assessment of physical habitat condition and development of restoration actions for the River Wye SAC in Wales	NRW
Forestry Core Asset Layer (Roads, Bridges / Major Culverts)	NRW
River levels, rainfall and sea levels	NRW

Supplied data	Author(s)
Rainfall Data	NRW
NRW Forestry Blocks	NRW
NRW Forest Bridges	NRW
Flood Map for Planning TAN15 Defended Zones	Welsh Government and Natural Resources Wales (DataMapWales)
National Flood Risk Map	Welsh Government and Natural Resources Wales (DataMapWales)
National Flood Hazard Map	Welsh Government and Natural Resources Wales (DataMapWales)
Environment (Wales) Act Section 7 Terrestrial Habitats of Principle Importance	Welsh Government and Natural Resources Wales (DataMapWales)
Habitat Networks	Welsh Government and Natural Resources Wales (DataMapWales)
National Parks	Welsh Government and Natural Resources Wales (DataMapWales)
Sites of Special Scientific Interest	Welsh Government and Natural Resources Wales (DataMapWales)
Special Areas of Conservation	Welsh Government and Natural Resources Wales (DataMapWales)
Dee Water Protection Zone	Welsh Government and Natural Resources Wales (DataMapWales)
Ramsar Wetlands of international importance	Welsh Government and Natural Resources Wales (DataMapWales)
Special Protection Areas	Welsh Government and Natural Resources Wales (DataMapWales)
Open Access - Open Country	Welsh Government and Natural Resources Wales (DataMapWales)
20 years of aerial photography to help create a Drainage Map	NRW
Tarenig.zip	NRW
ATI-26082a PART A	NRW
Third Party mines and quarries GRA	NRW
TarenigRiparian	NRW
Approved Management Coupes shapefile	NRW
Forest Management and Felling Strategy	NRW
Forest Type and Restocking	NRW
Landcover Map 2018	NRW
Local Record Centre records	NRW
Forest Compartments	NRW
Forest Thinning Coupes	NRW
Wye SAC Assessment of habitat condition shapefiles	NRW
Myherian and Tarenig draft peatland restoration sites	NRW
NRW Woodland sub-compartment data	Welsh Government and Natural Resources Wales (DataMapWales)
Ordnance Survey Basemaps, (3rd Party Data).	NRW
British Geological Survey (BGS): 50k Onshore Geology, (3rd Party Data).	NRW
UK Centre for Ecology and Hydrology (UK CEH): Landcover Map, 1990, (3rd Party Data).	NRW
UK Centre for Ecology and Hydrology (UKCEH): Land Cover Map 2000 and 2007, (3rd Party Data).	NRW

Supplied data	Author(s)
UK Centre for Ecology and Hydrology (UKCEH): Land Cover Map 2015, (3rd Party Data).	NRW
UK Centre for Ecology and Hydrology (UKCEH): Landcover Map, 2018, (3rd Party Data).	NRW
Landcover Map 2020.	NRW
Landcover Map 1990.lyr	NRW
Landcover Map 2018.lyr	NRW
Tarenig_Coupes.zip	NRW

Appendix D. Glossary

Buffer area	An area of land that protects the watercourse or heritage feature from activities on the adjacent land, such as by intercepting polluted run-off. The buffer area will usually include the riparian zone and may extend into adjacent land.
Planform	A river's special configuration in terms of path, sinuosity, number of channels and their width, and the assemblage of in-channel geomorphic units (Nardini <i>et al.</i> , 2023).
Riparian	Relating to, or situated adjacent to, a watercourse or water body.
Run flow biotype	Flow that is deep with fast water and little to no turbulence.
Major culvert	A culvert that has a diameter greater than 1500mm (1.5m) and located along named watercourses where designated forestry tracks cross.