West Penwith Ecohydrological Investigation and Characterisation – Site Visit Report

Phase 3 2020-21

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Further information

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This document has 60 pages including the cover.

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Introduction

Natural England is considering designating land in the West Penwith peninsula, Cornwall, as a Site of Special Scientific Interest (SSSI) under the Wildlife and Countryside Act. The land under consideration includes 11 valley mire systems (wetlands) identified by Natural England. Other habitats notified during the selection of biological SSSIs are present in the area, but these are outside the scope of this study. In 2020 Natural England commissioned Atkins to undertake desk studies which have confirmed the hydrological catchments of the 11 valley mires and identified 'hydrological risk zones' within those catchments, based on open-source data (Atkins, 2021).

In 2021, Natural England also commissioned Atkins to undertake field visits of all 11 valley mire sites being considered for inclusion in the SSSI to verify the findings of the desk-study, in particular:

- to confirm farm and/or field scale hydrology mapped in the desk-study using open-source GIS and other data, especially with regards to different hydrological risk zones;
- identify field evidence of areas of groundwater exfiltration and flow pathways; and

to collect local knowledge, where possible, through discussions with local landowners and land managers to understand drainage history and how it currently affects the hydrology of the West Penwith mires. This document sets out the findings of those field visits. The information provided reflects the current hydrological functioning as observed in May 2021.

Site context

The West Penwith peninsula has more than 1000 mm annual rainfall and is underlain by Land's End Granite bedrock. The granite has low porosity so groundwater travels through fractures close to the surface. The mire habitats sit in valley bottoms where low permeability alluvium and/or head superficial deposits create a change in flow regime that means that groundwater upwellings (springs) are often present at the geological transition between bedrock and superficial geology. Their location at the bottom of valleys means that the mires may be hydrologically influenced by both groundwater and surface water runoff from the valley sides in the surrounding catchment.

The land cover in the catchments of the mires is a mix of arable land and rough, semi-natural, intensively managed and extensively managed grassland. Arable land is defined as cropland, freshly ploughed land or rotational set aside fallow according to the Broad Habitat definitions produced by JNCC (Jackson, 2000). Intensively managed grassland is managed as pasture or mown regularly for silage production. This may form part of an arable rotation. It is periodically re-sown and maintained with fertiliser treatments including slurry application and weed control, potentially leading to the regular release of nutrients and soil loss (Jackson, 2000). Extensively managed grassland has lower levels of fertiliser input than intensively managed land but may still be managed by grazing and/or hay crop or single-crop silage harvesting and rarely re-sown. Land cover was mapped in the desk-study using CEH's land cover map (2007) and CORINE (2018) open-source data (see Miles *et al*., 2021 report for details).

Many of the mires exhibit relic drainage systems (most of which are now unmanaged) that still exert a significant influence on hydrological processes. Some of the watercourses, streams and drainage ditches currently act as both habitat and catchment boundaries. At some of the sites, there are opportunities to improve the supporting conditions of these habitat conditions by activities such as gully/ditch blocking and other activities to restore the effects of historic drainage on mire hydrology. These types of restoration measures could relink parts of the landscape that are currently disconnected through historic drainage.

Field methods

The field visits were conducted between 23rd and 28th May 2021 by Atkins and Natural England specialists and coincided with Natural England's land cover mapping survey (Natural England, 2021) the results of which are reflected in this document. In most cases, access to land was with the prior permission of landowners and/or tenant farmers. In a minority of cases, access was gained using Natural England's legal powers of entry under section 51, Wildlife & Countryside Act. In other cases, access to the whole catchment was limited by time, weather or health and safety constraints.

For each mire a range of information was collected including mapping of hydrological features, photographic records, UAV imagery and records of landowner discussions in May 2021 (Table 1). This report collates all of the information available for each mire, summarised as a site table that considers the findings of the field visit and its implications for hydrological risk in the catchment. A map is also provided for each catchment locating the photographs and features mapped on site (e.g. watercourses, ditches, drainage) along with any changes to the hydrological catchment boundary, supported by a photographic log of images recorded during the field visit in May 2021.

Table 1 - Sources of information available for each mire catchment

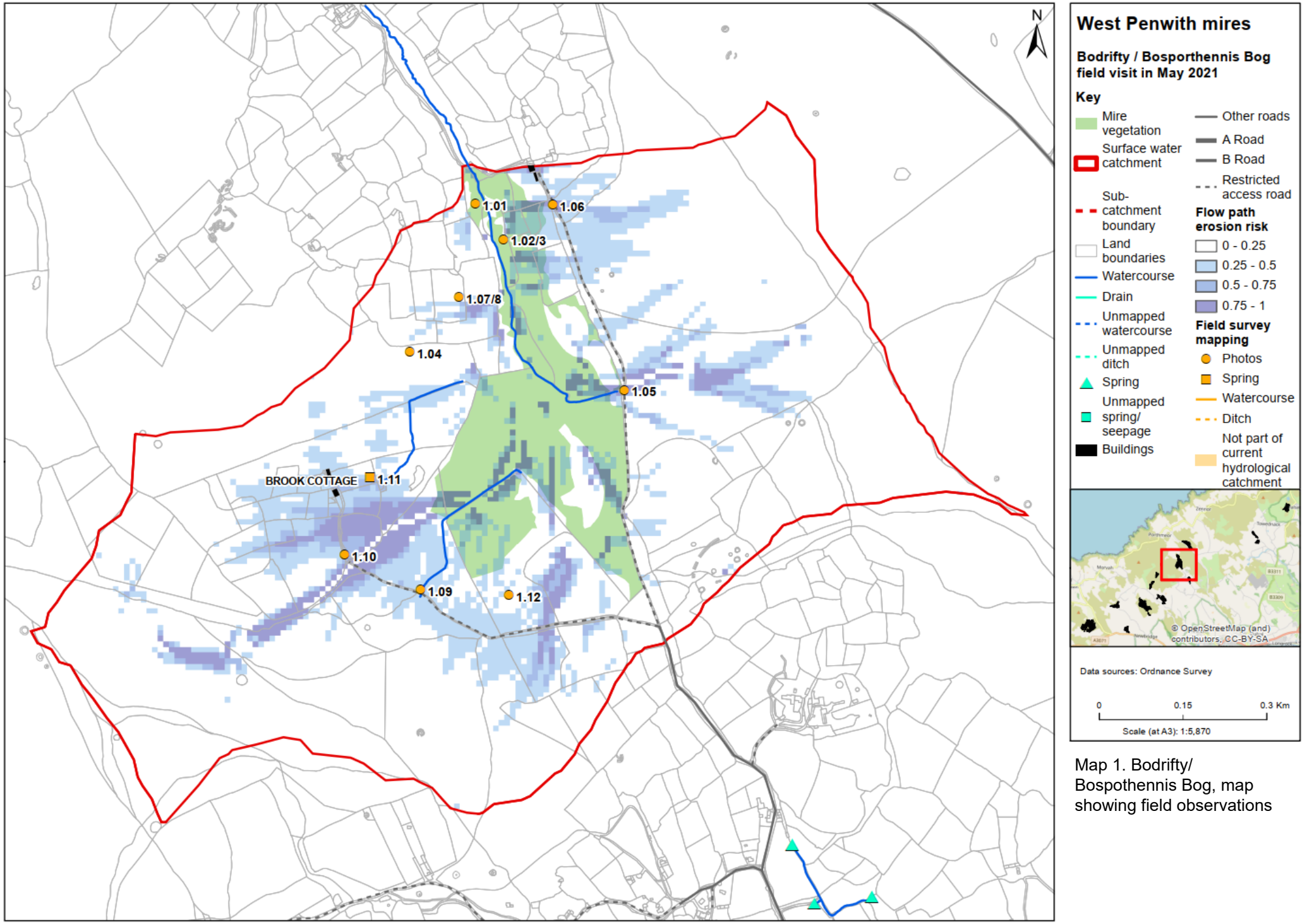
	Bodrifty/ Bospothennis Bog	Bosiliack Bog	Bostraze Bog	Boswarva Bog	Boswens Bog	Bussow Moor	Embla North and South	Gear	Lanyon	Tredinnick	Tregerest
Atkins 2021 desk-study	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ecohydrology studies prior to 2020	-	-	✓	✓	✓	✓	-	-	-	-	-
Mapped features	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Photographs	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
UAV* imagery	-	✓	-	✓	✓	-	-	✓	✓	-	-
Landowner discussions	-	✓	✓	-	✓	-	✓	-	✓	-	✓

**The UAV was only flown with landowner's permission obtained on day of field survey*

1. Bodrifty/Bospothennis Bog

Summary of field survey	
Date and time of field survey	Afternoon of Tuesday 25th May 2021
Survey route	A circular route was taken following public rights of way along the eastern edge of the mire before crossing the mire watercourse at the downstream end of the catchment and returning via a public right of way next to Brook Cottage.
Habitat location, extent and cover	The mire covers the base of the valley floor extending upstream towards the catchment boundary in the south. Lateral extent is limited by steeper slopes on the valley sides. The sections of mire near to the watercourse were a mixture of wet woodland, a mosaic of mire habitats including *Sphagnum* spp., orchids and other bog indicator species interspersed with standing water (Photos 1.01 – 1.03). The watercourse had a high water-level and had good connectivity with the valley bottom. Further upstream in the catchment, the area became drier with more grass species (Photo 1.04). There was evidence of cattle entering the fringes of the downstream section of the mire.
Features identified that could influence mire functioning	Flow pathways in the Bodrifty catchment are concentrated and radiate out from the mire on the steep valley sides to the east and west of the mire. To the east, the two main flow pathways (Photos 1.05, 1.06) flow into a ditch alongside the track and through pipes under the track towards the mire. The northern most flow path (Photo 1.06) drains a field that was being grazed by cattle on the day of survey with evidence of organic material movement through the field gate and under the track. Downstream of the track, this flow path crossed poached and muddy ground indicative of intensive cattle holding in a field adjacent to the mire. Similar field poaching was observed on the western side of the mire with unmapped flow pathways flowing towards the mire through field gates (Photo 1.07). The main western flow pathways are longer than to the east, leading from the plateau at the top of the catchment down towards the mire (Photo 1.08). On the track leading to Brook Cottage there was evidence of water flowing out of the hillslope through pipe drains, crossing under the track, and leading towards the mire (Photo 1.09). Water also flowed along the track towards the mire (Photo 1.10) The spring that was mapped using OS data was also observed during the field survey and flows towards the mire through an underground culvert (Photo 1.11). This spring used to be the water supply for Brook Cottage, however, a new borehole has been drilled to 64 m deep to provide water supply to the cottage. The impact of this borehole on groundwater flows and levels is unknown. The majority of the catchment is semi-natural scrub and grassland, part of which was common land to the east. There are fields of intensively managed grassland for cattle grazing and fields used for silage, one of which was observed adjacent to the southern edge of the mire (Photo 1.12). The runoff of any fertilisers used on such fields may transport nutrients to the mire.
Implications for hydrological risk	
Verified hydrological risk zones in field?	Hydrological risk zones were verified during the field survey; no new hydrologically significant features were identified that altered the hydrological risk zones previously as part of the desk study. Therefore, **no changes to the extent of any zone are proposed.**
Outcome of desk-based catchment risk assessment	The desk-study assessed the catchment risk as ‘low-medium’ due to arable land mapped adjacent to the mire and within the catchment.
Outcome of field-based catchment risk assessment	The arable land mapped adjacent to the west, south and east of the mire in the desk-study was not verified on site. Instead, the land to the west was primarily rough grassland and extensively managed grassland used for grazing by cattle. Parts of this land around Brook Cottage are within Higher Level Stewardship (HLS) which incentivises sustainable land management practices for the duration of the agreement. To the south, the land was a mix of intensively managed fields cropped for silage (Photo 1.12) and extensively managed grassland. The silage field may be re-seeded regularly, receive applications of

	fertilisers and/or be part of arable rotation. These inputs may degrade the water quality of the mire. The greatest risk to the catchment identified was from the flow pathways that drain from the intensive cattle use on the flow pathway at the eastern, downstream end of the catchment (Photo 1.06). Therefore, the **catchment risk rank remains unchanged at 'low-medium'**.
Opportunities identified	-
Other risks	*Gunnera* spp. invasive non-native species (INNS) in tributary in Brook Cottage woodland. No evidence in the mire itself but *Gunnera* spp. is aquatic and could travel downstream so potential risk of invasion of mire.



Map 1. Bodrifty/ Bospothennis Bog, map showing field observations

Bodrifty photographic record

1.01 – Wet woodland habitats present within mire.

1.02 – Mosaic of wetland habitats in the mire.

1.03 – *Sphagnum* spp. and cotton grass (inset) present within the mire.

1.04 – Grass, bracken and fern species in the upper areas of the mire.

1.05 – Flow pathway leading from semi-natural rough ground on the right of the image, through the culvert under the track, to the mire on the left of the image.

1.06 – First photo taken standing on track looking up towards the flow pathway. The field in the background had cows in on the day of survey. The second photo shows the water from the same flow pathway passing under the track leading towards the mire.

1.07 – Flow pathway through field gate on western side of the mire.

1.08 – Flow pathways through intensively managed grassland on western side of mire.

1.09 – Pipe drain flow through peat.

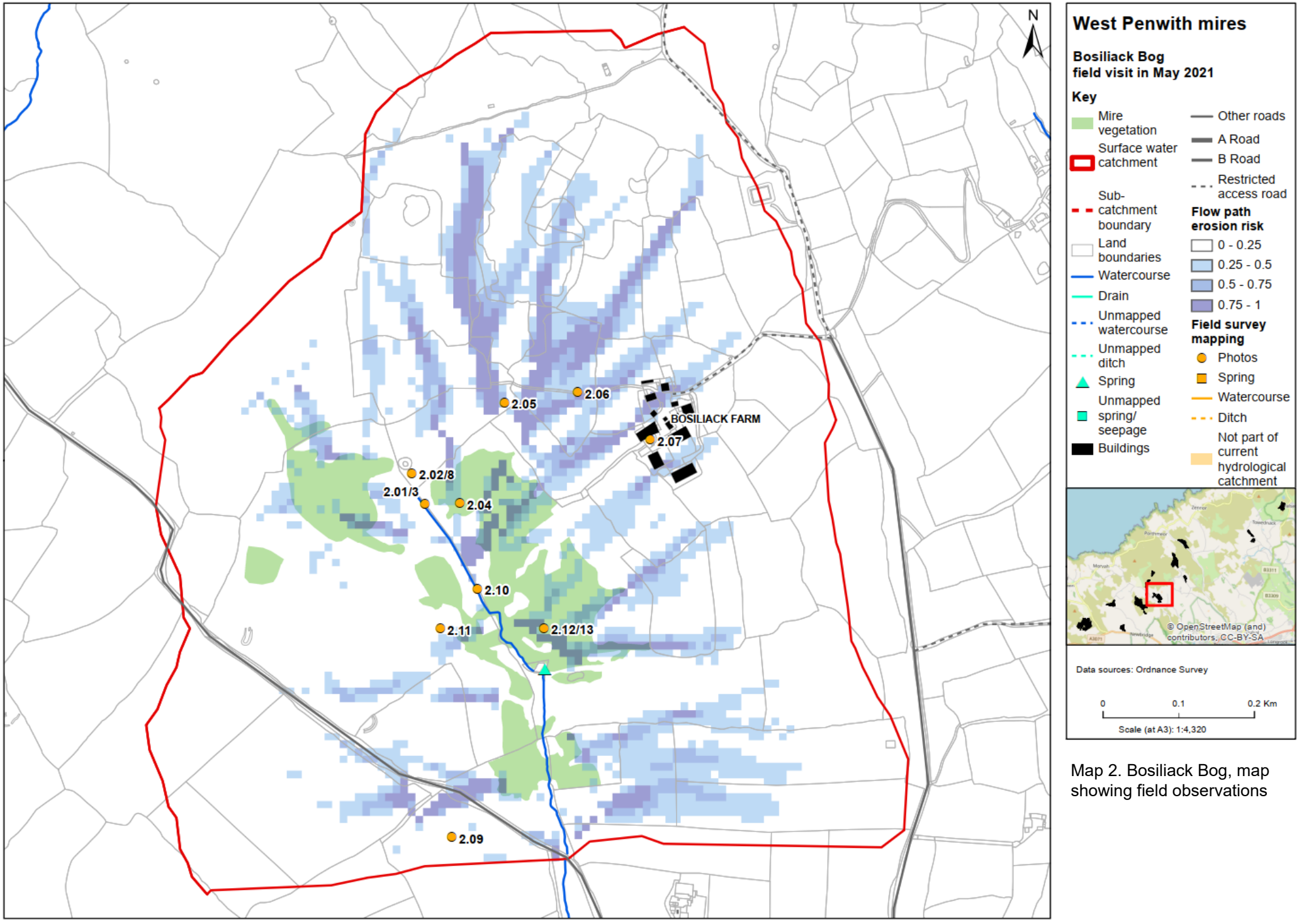
1.10 – Water flowing along track and down ditch towards the mire as an artificial flow pathway.

1.11 – Walk-in Spring near Brooks Cottage.

1.12 – Silage field to south of catchment.

2. Bosiliack Bog

Summary of field survey	
Date and time of field survey	Afternoon of Thursday 27th May 2021
Survey route	Circular route from Bosiliack Farm around the mire habitat with landowners' permission.
Habitat location, extent and cover	The mire covers a large proportion of the catchment in numerous patches along the valley floor. A watercourse (Photo 2.01) flows from a manmade pond on the edge of the superficial geology (Photo 2.02) to the outlet of the catchment. Areas near to the watercourse are drier, dominated by gorse and purple moor-grass (Photo 2.03) and are not classified as mire habitat from the NVC mapping. This suggests that the watercourse is draining the mire. Further from the watercourse, mire habitat is identified with purple moor-grass and sedges present (Photo 2.04).
Features identified that could influence mire functioning	Flow pathways in the Bosiliack catchment predominantly flow from the steep slopes in the north and east of the catchment. Much of this area was semi-natural habitat although there are fields of intensively managed grassland around Bosiliack Farm which were being grazed by approx. 60 beef cattle (Photo 2.05). There was some evidence of flow pathways through farm gates and past farm buildings (Photos 2.06 and 2.07) suggesting connectivity with the mire. Some cattle also graze within the mire itself (Photo 2.08). To the south west of the catchment, flow pathways are less extensive draining semi-natural habitat up to the public highway (Madron-Trevowhan). Upslope of the public highway, fields are cropped for silage. However, surface water from the fields indicated at Photo 2.09 on the map, is intercepted by the highway and diverted to the watercourse downstream of the mire. These fields are still within the groundwater catchment of the mire, but agricultural practises in the fields would only have a minimal impact on the condition of the mire, influencing only the downslope portion of the mire. The key influence on the condition of the mire is the extent of artificial alterations to the hydrology. The watercourse is artificially straightened and incised through the mire (Photo 2.01). Mid-way through the mire there is evidence of land drains which significantly increase the flow of water in the channel (Photo 2.10). There are also springs that feed the channel (Photos 2.11 and 2.12) and are likely the main source of water to the mire. However, some springs are altered with large bunds creating a series of cascading pools (Photo 2.12) to provide drinking water for cattle and there was evidence of cattle entering the pools (Photo 2.13). There is also a lateral bund downstream creating a step change in water levels to power a hydro-ram that is now defunct.
Implications for hydrological risk	
Verified hydrological risk zones in field?	Hydrological risk zones were verified during the field survey; no new hydrologically significant features were identified that altered the hydrological risk zones previously as part of the desk study. Therefore, **no changes to the extent of any zone are proposed.**
Outcome of desk-based catchment risk assessment	The desk-study assessed the catchment risk as 'high' due to the extensive amount of intensively managed grassland and slurry beds identified from satellite imagery that intersect the flow pathways leading to the mire. There was a record of two abstractions within the mire.
Outcome of field-based catchment risk assessment	The field survey recorded less intensively managed grassland in the catchment than mapped in the desk-based assessment. Most of the intensively managed grassland was associated with Bosiliack Farm. Slurry beds were not observable during the field survey but may still be present and would pose a risk to the mire if not effectively managed. The hydro-ram on site was likely one of the abstraction points that was mapped by the EA but is now defunct. The reduction in intensively managed land , has **lowered the catchment risk score to 'medium'**. This is because there are still some risks to the mire habitats through the use of fertilisers and the management of the land around Bosiliack Farm a main flow pathway to the mire.
Opportunities identified	There is an opportunity to block the incised watercourse to improve the connectivity of the watercourse with the mire habitat and reduce drainage of the mire towards the stream.
Other risks	-



Map 2. Bosiliack Bog, map showing field observations

Bosiliack photographic record

2.01 – Straightened ditch with limited flow (on left of image). Photo taken looking upstream. Habitat directly adjacent to the left bank of the ditch is not classified as mire habitat and is likely drained by the ditch.

2.02 – Manmade pond at top of watercourse with an inch of water in bottom.

2.03 – Drier habitat near to watercourse dominated by Molinia moor grasses and gorse.

2.04 – Purple moor grass and sedges indicating a wetter mire habitat set back from the watercourse.

2.05 – Cows grazing fields near to Bosiliack Farm.

2.06 – Flow pathway flowing through field gate.

2.07 – Flow pathway flowing through farm.

2.08 - Cows grazing rough grassland on edge of mire under HLS scheme.

2.09 – Intensively managed grass field mapped within catchment boundary but water from the flow pathway is captured by the road and redirected to the watercourse downstream of the mire.

2.10 – Field drain draining mire habitat towards watercourse.

2.11 – Seepage to west of watercourse that dries out in the summer. Bund covered with bracken to capture flow.

2.12 – Spring leading to watercourse. Watercourse is bunded to create a series of cascading pools.

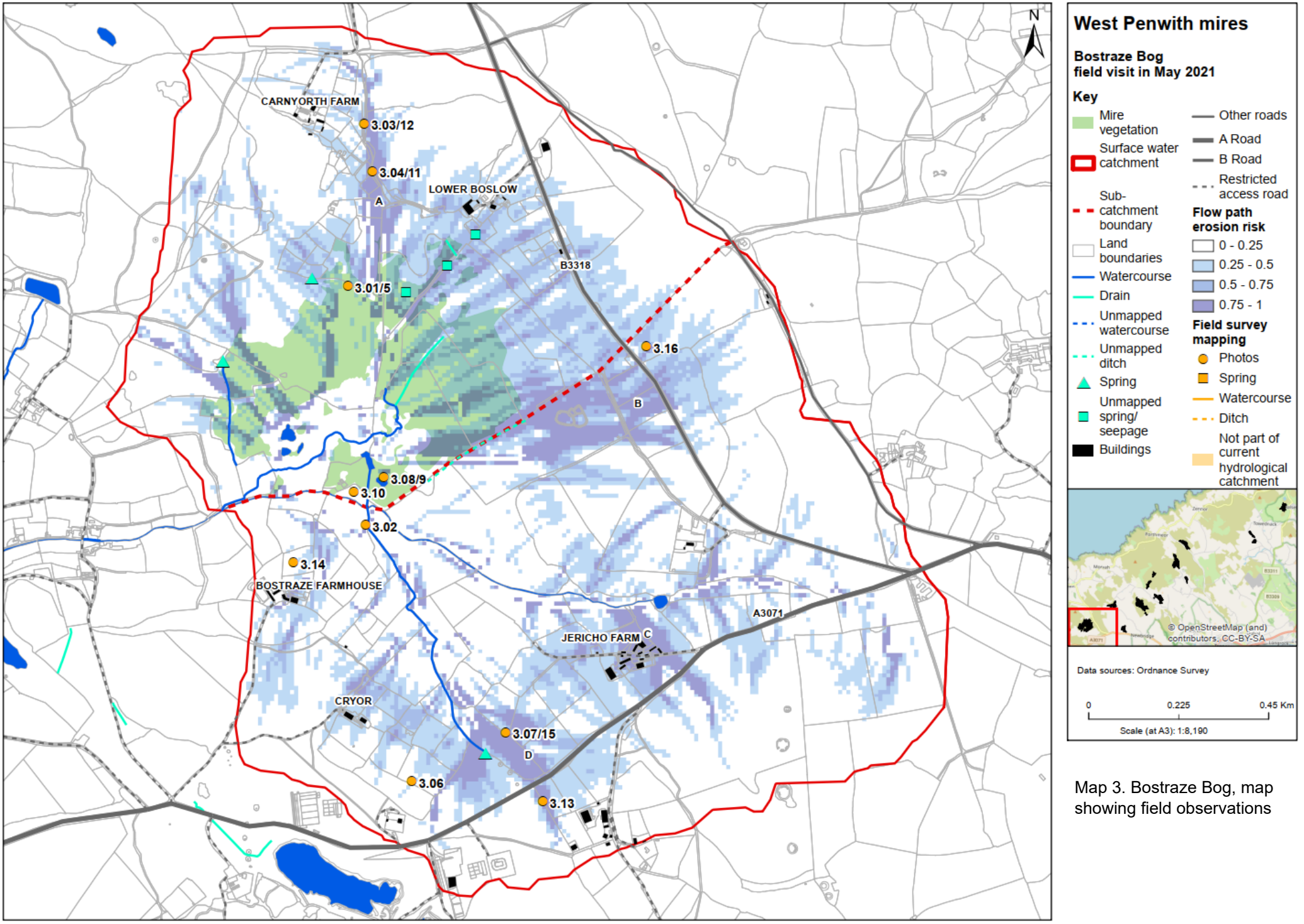
2.13 – Evidence of cattle entering spring pools.

2.14 –UAV photograph of Bosiliack catchment flying north, upstream along the watercourse. Location of photograph not shown on map.

3. Bostraze Bog

Summary of field survey	
Date and time of field survey	Afternoon of Wednesday 26th May 2021
Survey route	Routes covered included a transect walk down the northern side of the mire habitat between Carnyorth Farm and Lower Boslow Farm and a visit to a single farm holding on the southern edge of the mire habitat (Bostraze Farmhouse). The survey could not cover all areas of the catchment due to time constraints so also included a circular route around the eastern and southern edges of the catchment along the B3318 and A3071 respectively that provided elevated vantage points to help visualise the layout of key features and likely functioning of the catchment. The UAV/drone could not be flown due to proximity of Penzance airport.
Habitat location, extent and cover	Site is a valley side mire extending north and north east to south downslope (Photo 3.01) from Carnyorth Farm and Lower Boslow Farm. A watercourse in the base of the valley (Photo 3.02) acts as a hydrological boundary and potential landscape scale drain for the mire catchment. In the lower section of the mire, close to the ditch, stands of *Molinia* were associated with a significant extent of standing water (Photo 3.09). To the south of the ditch was an area of previously intensively managed pasture that shows evidence of regular inundation (Photo 3.10).
Features identified that could influence mire functioning	The mire habitat sits within a broad basin that is delineated broadly by the B3318 to the north and east, the A3071 to the south and a ridge of high ground to the west. The watercourse draining the catchment runs past Lower Bostraze Farmhouse, flowing to Tregeseal and Nancherrow due north of St Just, flowing into the sea at Boscean. There are four main flow pathways draining the Bostraze basin (see map overleaf): The **northern flow path (A)** runs between Carnyorth Farm and Lower Boslow Farmhouse and is visible in the field by the presence of a minor ditch (Photos 3.03) with tree cover along its length. It also includes the fields around and downslope of Lower Boslow Farm (Photo 3.04). Most of the mire habitat is present along this northern flow pathway. The northern extent of groundwater exfiltration is well defined by a Cornish hedge (Photo 3.05) giving way to some drier mire communities (Photo 3.01). The **north east flow path (B)** flows down a large drainage ditch that marks one of the boundaries of the mire habitat. The **south east (C)** and **southern flow paths (D)** both flow in a broadly northerly direction through land used to grow daffodils that extends down steep, peaty slopes towards the boundary of the mire (Photos 3.06 and 3.07). Flow pathways B-D drain to separate watercourses that converge at the southern end of the mire habitat (Photo 3.02) into an incised ditch (Photo 3.08) that continues to the basin outflow near Lower Bostraze Farmhouse. This is consistent with the findings from Low's (2018) ecohydrological report of Bostraze catchment. The artificially deepened watercourse is likely to increase the hydraulic gradient from the mire to the watercourse leading to a reduction in mire water levels, at least on the lower-lying parts of the mire.
Implications for hydrological risk	
Verified hydrological risk zones in field?	Where site access was possible, hydrological risk zones were verified during the field survey; no new hydrologically significant features were identified that altered the hydrological risk zones previously as part of the desk study. Therefore, **no changes to the extent of any zone are proposed.** However, based on the observations made during the site visit and the evidence from Low's (2018) ecohydrological report, flow paths B, C and D likely flow into the deepened watercourses and bypass the mire habitat. This reflects the conclusions of Low's (2018) report; that there are two key catchments in Bostraze that are

	separated along a red dashed line on the map below (sub-catchment boundary drawn based on Low's 2018 report). The **northern catchment**, that includes flow path A, likely has surface and groundwater catchments that feeds the majority of the mire habitat. This catchment is the dominant hydrological control on the Bostraze mire. The **southern catchment is likely to have some influence on the mire in Bostraze** albeit less than the northern catchment. This is because ground and surface water derived from the southern catchment likely only influence the lower-lying parts of the mire. Surface water likely only influences this portion of the mire during wetter periods when water may spill onto the mire from the artificially deepened ditch and watercourse fed by flow paths B, C and D. The spill is likely to only influence the lower lying reaches of the mire closest to the watercourse and ditch, and the likely frequency of this is unknown. The Bostraze catchment boundary is therefore unchanged as in the southern catchment groundwater likely continues to influence part of the mire and surface water run off may influence the mire during high flow or if natural connectivity between the mire and watercourse were increased through hydrological restoration.
Outcome of desk-based catchment risk assessment	The desk-study assessed the catchment risk as 'high' due to the extensive amount of arable land mapped on flow pathways leading to the mire and the potential influence of the A3071 and B3318 roads.
Outcome of field-based catchment risk assessment	In terms of risks, the Bostraze Basin can be broadly split into three main zones. To the **north of the mire habitat**, there are two landholdings used for grazing. At the time of the field visit, in the region of 20 White Park cattle were grazing around Lower Boslow and 20 jersey cattle around Carnyorth farm (Photo 3.11). A number of horses were also observed (Photo 3.12). Some fields at the top of the catchment were being cropped for silage, as part of an arable rotation. The **south eastern part of the basin** was dominated by daffodil crop, grown on peat soils in some cases on steep slopes where soils were exposed leading down towards the valley floor (Photos 3.06 and 3.07). To the **south and west** are a number of farm holdings (Jericho Farm, Cryor, and Bostraze Farmhouse) mostly managed for low-intensity grazing (e.g. livestock holdings, grazed areas - Photo 3.13, active farmyards – Photo 3.14) and all share an elevated position in the catchment with flow pathways down towards the valley floor. Although not all of the catchment could be accessed during the field visit, it was apparent from various vantage points around the catchment that there are risks from current land management (agricultural practices) across the catchments and particularly in the southern section. For this reason, the **catchment risk score is maintained at 'high'.**
Opportunities identified	Although unconfirmed in the field, the desk-study has shown that the site is characterised by a series of watercourses that contribute to drainage of the mire and catchment. As with many of the sites considered as part of the study, blocking of artificial ditches and drains present across the site would serve to restore the natural hydrology of the Bostraze basin. Due regard should be given to potential effects on local landholdings if this is pursued. There is also potential that these types of activities could activate a more frequent influence of other parts of the catchment on mire habitat, although mainly those most downslope that are adjacent to the watercourse.
Other risks	-



Map 3. Bostraze Bog, map showing field observations

Bostraze Photographic record

3.01 – View downslope.

3.02 – Main watercourse on valley floor.

3.03 – Ditch down northern flow pathway.

3.04 – Area around Lower Boslow (in background).

3.05 – Edge of mire habitat showing exfiltration and Cornish hedge.

3.06 – View across the south of the Bostraze basin where Daffodils are grown.

3.07 – View of sloping daffodil fields with mire habitat on opposite side of valley.

3.08 – View of artificially deepened and straightened watercourse to the south of mire habitat.

3.09 – View of mire habitat to the south.

3.10 – View of habitat south of watercourse and mire habitat.

3.11 – Cattle grazing at Carnyorth Farm.

3.12 –Horse grazing around Carnyorth Farm.

3.13 – Livestock in southern part of basin.

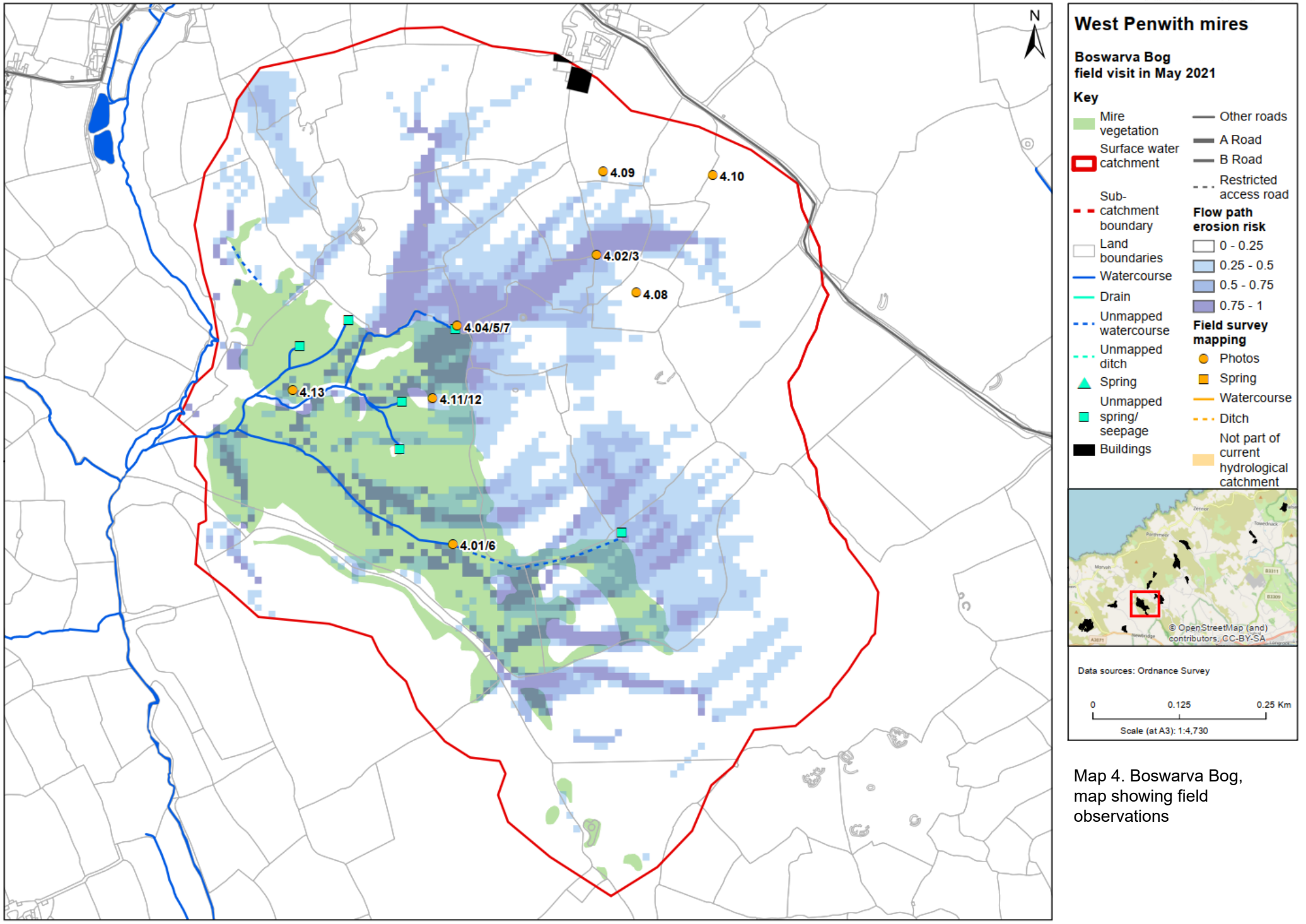
3.14 – Farmyard.

3.15 – Bostraze catchment panoramic photograph taken in the south catchment looking north towards the mire.

3.16 – Bostraze catchment panoramic photograph taken looking south west on the boundary between catchments (south catchment on the left and north catchment on the right).

4. Boswarva Bog

Summary of field survey	
Date and time of field survey	Morning of Friday 28th May 2021
Survey route	Route focussed on the two main flow pathways extending along the north eastern and south eastern parts of the site. Due to time constraints the survey did not cover the western part of the catchment, including the outflow and its connection to the watercourse that forms the western mire habitat boundary. Areas to the west were surveyed by use of a UAV/drone (https://youtu.be/n9Gl11lDxTw), alongside additional detail regarding the habitats present across the site.
Habitat location, extent and cover	Site is a valley side mire extending from the north and east downslope (Photo 4.01) to a watercourse that acts as a natural boundary and landscape scale drain for the mire. The watercourse draining the site ultimately runs to Drift Reservoir.
Features identified that could influence mire functioning	There are two main flow pathways evident on the site, hereafter termed north and south. The break between different hydrological risk zones is very well defined in the field and corresponds to a field boundary demarcated by a low Cornish hedge/bank (Photo 4.02). **Northern flow pathway** (https://youtu.be/2zF_tXQQJO8) - located on a steep slope down the valley side (Photo 4.01) north east to south west. There are three main locations of groundwater exfiltration, identified by the presence of *Sphagnum* and standing water (Photo 4.03). These lead to distinct channels (Photo 4.04 and Photo 4.05) that converge in the central part of the bog. **Southern flow pathway** (https://youtu.be/VdjdfuHpC6A) - follows a gentler gradient from east to west (Photo 4.06) and was observed to be considerably drier than the northern flow pathway. Channel less clearly defined but in its lower reaches converges with channels flowing from the northern part of the site in what appears to be a very wet area on drone footage but was not visited. Both flow pathways are clearly visible by linear tree block cover along their length (Photo 4.06). Further down slope the stands of *Molinia* turn drier (Photo 4.07) and water flows are focussed within a network of channels that have in places likely been modified for drainage, especially where the mire is drier. A herd of ten ponies are used by the landowner to manage the mire as part of an HLS agreement (Photo 4.08).
Implications for hydrological risk	
Verified hydrological risk zones in field?	Hydrological risk zones were verified during the field survey; no new hydrologically significant features were identified that altered the hydrological risk zones previously as part of the desk study. Therefore, **no changes to the extent of any zone are proposed.**
Outcome of desk-based catchment risk assessment	The desk-study assessed the catchment risk as 'medium' due to arable and intensively managed fields on the flow pathways in the north of the catchment.
Outcome of field-based catchment risk assessment	Whilst general agricultural activity in the catchment appeared low, there was intensively managed grassland in the north of the catchment (although the extent was more limited than mapped in the desk-study). One of the main cattle grazing fields was adjacent to one of the main flow pathways towards the mire (Photo 4.09). At the time of survey in the region of 70 heifers were grazing in this field. Fields in the vicinity also along the flow pathway were managed for silage (Photo 4.10). The presence of large, natural pipes in the peat upstream of exfiltration areas (Photo 4.11 and 4.12) indicates that the connectivity between the site and groundwater is high. However, as the extent of intensively managed land was significantly less than mapped in the desk-study, **catchment risk score is lowered for Boswarva to 'low-medium'**.
Opportunities identified	Restoration of mires and associated species by blocking of grips and ditches present across the site that have undoubtedly been modified historically for drainage.
Other risks	-



Map 4. Boswarva Bog, map showing field observations

Boswarva Photographic record

4.01 – View looking downslope across mire habitat.

4.02 – Break of slope.

4.03 – Area of groundwater exfiltration.

4.04 – Watercourse along flow pathway.

4.05 – Vegetation along flow pathway.

4.06 – View along southern flow pathway, showing woodland.

4.07 – Typical view of mire habitat in the core of the site.

4.08 – Ponies used to graze the mire as part of an HLS agreement.

4.09 – Cattle grazing upstream of the northern flow pathways.

4.10 – Silage fields across the upper reaches of the northern flow pathway.

4.11 – Chamber of collapsed large peat pipe carrying water along flow pathway.

4.12 – Detail of large peat pipe from within chamber.

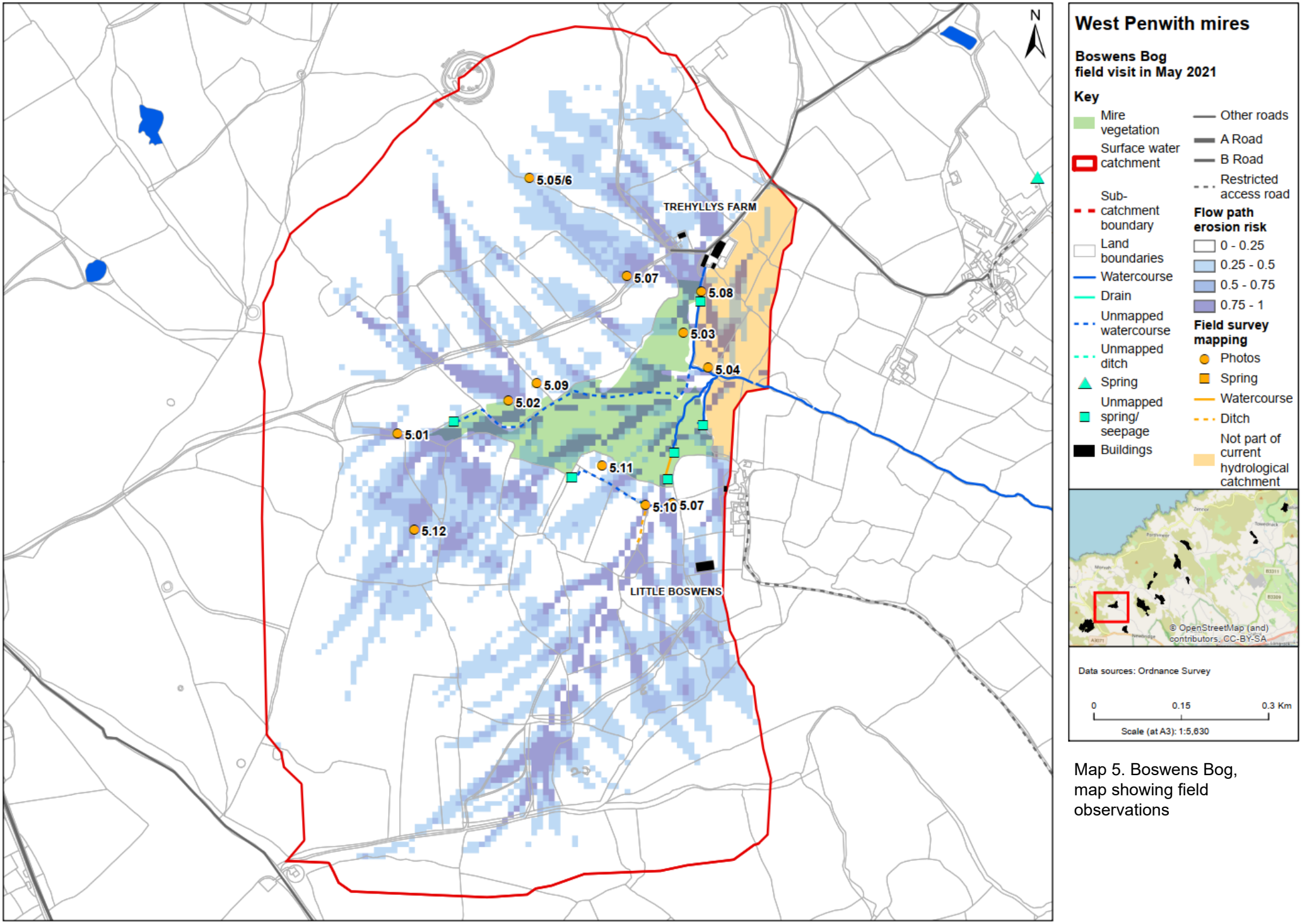
4.13. Aerial view of habitat.

4.14 – UAV photograph of Boswarva catchment flying east from the outlet of the catchment (location of photograph not shown on map).

5. Boswens Bog

Summary of field survey	
Date and time of field survey	Morning of Wednesday 26th May 2021
Survey route	Circular route from Trehyllys Farm downstream of the mire, through Little Boswens Farm with the landowner's permission. The upper catchment was surveyed from Public Rights of Way.
Habitat location, extent and cover	The mire covers the base of the valley floor extending east to west. A watercourse flows from a spring at the upstream end of the mire (Photo 5.01) through the mire collecting water from ditches at the downstream end of the mire habitat. The sections of mire near to the watercourse are identified as wet woodland (Photo 5.02) and cover a large extent of the site. The remaining mire habitat comprises species-rich purple moor-grass (*Molinia*) mire and drier areas dominated by bracken, heather and gorse (Photo 5.03). This may be because the mire habitat is being drained by an incised watercourse (Photo 5.04).
Features identified that could influence mire functioning	Flow pathways in the Boswens catchment radiate out from the mire on the steep valley sides to the north and south of the mire. To the **north** the two main flow pathways cross semi-natural moorland (Photo 5.05 and 5.06) before being intercepted by a steep track transporting the surface water towards Trehyllys Farm (Photo 5.07). This water enters the watercourse south of Trehyllys Farm (Photo 5.08), bypassing the majority of the mire habitat. The land in the northern section of the catchment has been farmed by the same family for 80 years with only twelve cattle currently. Therefore, the area to the north of the catchment is identified as a low risk area under current hydrological conditions, due to the current low-intensity land cover and limited hydrological impact of surface runoff on the mire. However, groundwater from this northern section of the catchment may reach the mire via subsurface flow. The land adjacent to the mire, downslope of the track was lightly grazed but there was also a field of barley (Photo 5.09) which may pose a risk to mire habitat due to its proximity to the mire. The flow pathway to the **south** of the mire closest to Little Boswens Farm flows towards a cross-slope drain (Photo 5.10) that in turn flows briefly through the mire to the outflow. The land in this area of the catchment is currently used to graze fewer than ten shire horses. The landowners indicated that the fields are not fertilised to reduce the risk of laminitis in the horses. The current low-intensity land cover and diversion of water away from the mire by the cross-slope drain suggest that surface water in this section of the catchment is unlikely to impact the water quality of the mire under current conditions. However, the cross drain is disrupting the surface water that would naturally feed the mire which may limit the extent and/or condition of the mire habitat. If the natural connectivity between the watercourse and the mire habitat was restored (e.g. by blocking the cross-drain),surface water from this section of the catchment may have a greater influence the mire functioning. Grazing downstream of the drain may pose a risk to mire habitat due to the proximity to the mire if not managed correctly (Photo 5.11), as may the flow pathway leading directly to the mire near the top of the catchment (Photo 5.12). The desk-study mapped fields downstream of the mire as within the catchment boundary. Upon site inspection they are deemed to not influence the mire as any water is captured by the drains (Photo 5.08) or flows into the watercourse downstream of the mire outlet. These areas should be removed from the current hydrological catchment. The watercourse itself downstream should remain included in the designation as per SSSI guidance.
Implications for hydrological risk	
Verified hydrological risk zones in field?	The majority of hydrological risk zones for Boswens catchment were verified in the field. However, the **hydrological catchment should exclude the indicated fields downstream of the mire** as the runoff from these fields would not enter the mire. However, these fields and the downstream watercourse are adjacent to the mire so may still influence the functioning of the mire (see 'Other Risks' section below).

Outcome of desk-based catchment risk assessment	The desk-study assessed the catchment risk as 'medium' due to arable land and intensively managed grassland mapped adjacent to the mire and within the catchment. Rough and/or semi-natural habitats were mapped in the upper sections of the catchment.
Outcome of field-based catchment risk assessment	There was little arable land identified within the catchment with a barley field adjacent to the catchment. Intensively managed grassland was identified in the field visit adjacent to the mire and within the catchment to the north. Much of the land cover of the southern catchment was extensively managed grassland rather than arable or intensively managed grassland as mapped in the desk-study. Although there was a reduction in arable and intensively managed grassland land cover identified in the catchment through conversations with landowners there are still potential risks to the mire habitats through the use of fertilisers and/or slurry, particularly in the fields adjacent to the mire, although use may currently be limited. Therefore, the **catchment risk score remains unchanged at 'medium'**
Opportunities identified	Opportunity to block the watercourse at the outflow of the mire to increase drainage base by approx. 1.5 m. This would reconnect the mire with the watercourse increasing the wetland species present in the mire. Opportunity to block/fill-in the cross-slope drain to restore surface water runoff into the mire from the southern flow pathways.
Other risks	If increased drainage were implemented within the fields adjacent to the mire downstream it could potentially lower water table within the mire. If the watercourse downstream of the mire was deepened this could also increase the hydraulic gradient from the mire to the watercourse leading to a reduction in mire water levels with an adverse impact upon the mire habitat. Therefore, whilst not part of the hydrological catchment, these fields may still be considered to influence the functioning of the mire.



Map 5. Boswens Bog, map showing field observations

Boswens photographic record

5.01 – Spring feeding watercourse identified further upstream than mapped by the ecohydrology report in 2019 (Pendleton Hydro, 2019). Photograph taken looking upstream, with water flowing from spring downstream.

5.02 – Wet woodland on northern edge of mire habitat.

5.03 – Drier mire species such as bracken, gorse and heather at the downstream end of the mire.

5.04 – Incised ditch (1.5 to 2 m deep) at mire outflow. This ditch is likely draining the mire.

5.05 – Flow pathway leading through semi-natural vegetation to Trehyllys Farm on the left hand side of the photograph.

5.06 – Flow seepage on steep footpath.

5.07 – Track intercepting water from northern flow pathways and redirecting it towards Trehyllys Farm.

5.08 – Watercourse flowing from Trehyllys Farm towards outflow of mire.

5.09 – Evidence of grazing and barley crop in fields adjacent to mire.

5.10 – Cross-slope drain along field boundary flowing towards watercourse downstream of mire.

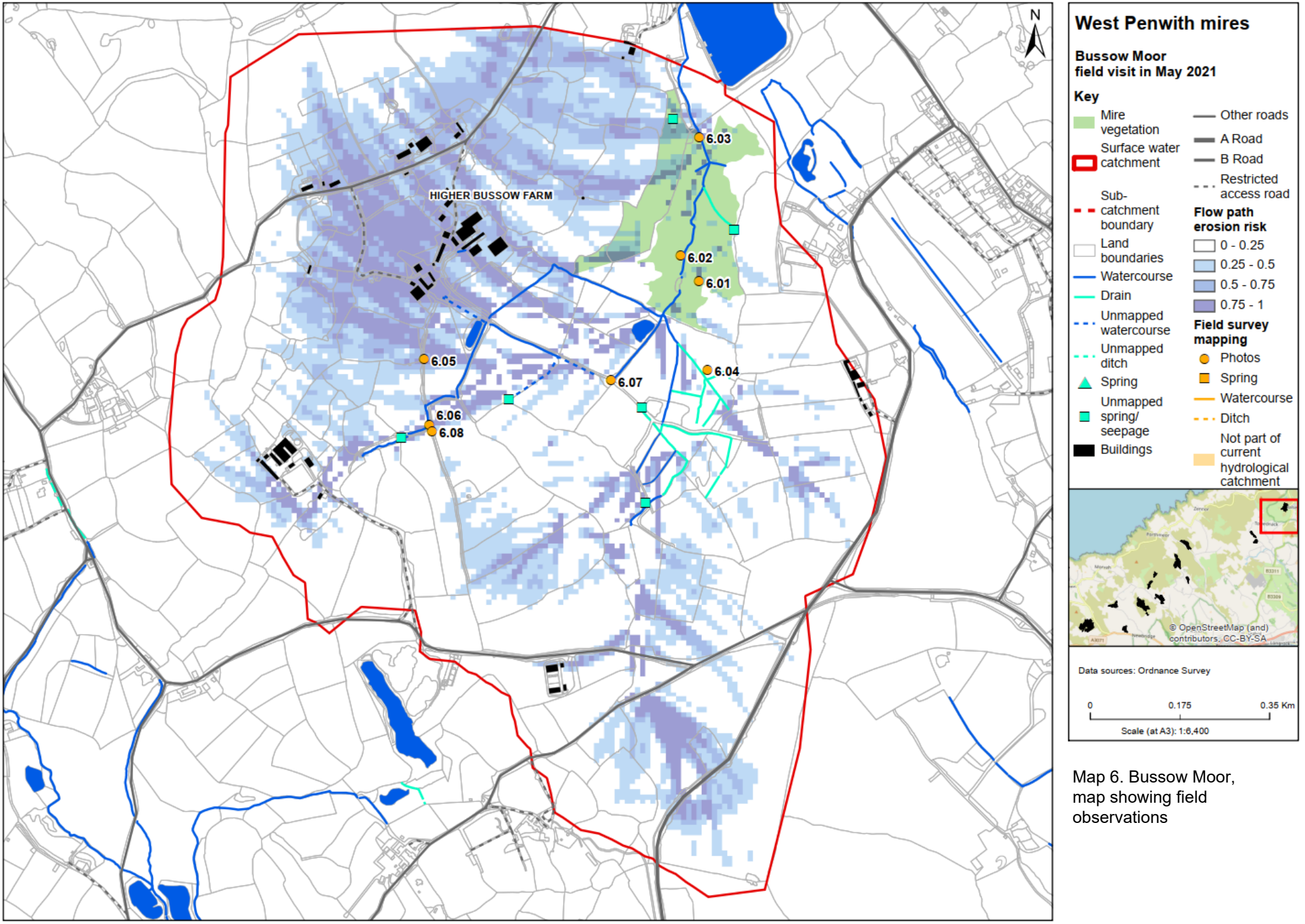
5.11 – Shire horse grazing in the long field adjacent to the mire, downstream of the cross-slope drain.

5.12 – Flow pathway leading directly to mire (pale vegetation at bottom of slope).

5.13 – UAV image looking up the Boswens Bog catchment in a north westerly direction from the catchment outlet. Location of photograph not shown on map

6. Bussow Moor

Summary of field survey	
Date and time of field survey	Morning of Monday 24th May 2021
Survey route	Circular route following public rights of way and land where permission had been granted. Route covered western flow pathways, watercourses upstream and the mire habitat itself.
Habitat location, extent and cover	The mire covers the base of the valley floor south of Bussow Reservoir and is dominated by rushes grazed by livestock including sheep (Photo 6.01). This provides grazing to prevent succession of the mire habitat. A watercourse runs through the centre of the mire habitat that is incised by up to 2 m (Photo 6.02). This watercourse likely drains the mire. There is also evidence of livestock entering the channel creating a poached bank (Photo 6.03). Adjacent to the upstream boundary of the mire is an area of wet woodland supporting a range of wetland species and areas of standing water within the superficial geological boundary (Photo 6.04).
Features identified that could influence mire functioning	Flow pathways in the Bussow catchment are highly concentrated on the western valley edge which is much steeper than the east. There are areas of seepage at the bottom of the western flow pathways (Photo 6.05) that feed a network of watercourses that run alongside field boundaries leading to the watercourse that flows through the mire. Farm tracks and footpaths also form hydrological pathways that flow towards the watercourses and are additional to those mapped using SCIMAP (Photo 6.06). The fields surrounding the mire and wet woodland are predominantly associated with cattle farming with the majority appearing to be intensively managed grassland for silage or grazing and evidence of a dairy at Higher Bussow Farm. Processes such as slurry spreading also likely occur although no evidence of this was observed on the day of survey. On the day of survey, ca. 80 head of cattle were observed in the catchment. The movement of organic material associated with cattle farming was observed on flow pathways in fields, on tracks and in field gates in Bussow catchment (photos 6.05 to 6.08) which could lead to increased nutrient input to the mire. There was also evidence of poaching in fields around the mire. The flow pathways to the south east of the valley are less concentrated. They are also dominated by intensively managed grassland and may pose a similar risk to that observed on the western flow paths.
Implications for hydrological risk	
Verified hydrological risk zones in field?	Hydrological risk zones were verified during the field survey; no new hydrologically significant features were identified that altered the hydrological risk zones previously as part of the desk study. The main flow pathways can be seen in Photo 6.05 with wetter habitats and seeps present within the groundwater emergence and valley floor zones (6.01, 6.04 and 6.05). **No changes to the extent of any zone are proposed.**
Outcome of desk-based catchment risk assessment	The desk-study assessed the catchment risk as 'high' due to farms and arable land located on flow pathways and adjacent to the mire. Other risks such as Towednack Road crossing the catchment and the consented discharge where also suggested to pose a risk to the mire habitat.
Outcome of field-based catchment risk assessment	The arable land mapped adjacent to the mire in the desk-study was confirmed as intensively managed grassland during the field survey. The agricultural practises associated with intensively managed grassland will likely involve the application of fertilisers and/or slurry and may be regularly cultivated as part of arable rotation. The greatest risk to the catchment identified was from the flow pathways that drain from the cattle near High Bussow Farm that lead to watercourses that feed the wet woodland upstream of the mire. Therefore, **catchment risk rank is retained as 'high'.**
Opportunities identified	Blocking and/or re-naturalising the deepened watercourse in the mire would result in a reduction in the drainage of the mire. This would create a wetter habitat and likely both a greater extent and improved quality of the mire and stream habitat.
Other risks	-



Map 6. Bussow Moor, map showing field observations

Bussow photographic record

6.01 – Mire habitat dominated by rushes.

6.02 – 2 m incised watercourse running through mire habitat.

6.03 – Poaching of watercourse banks in mire habitat by livestock. Note the brown colour of the water indicating peat upstream.

6.04 – Wet woodland area upstream of the mire.

6.05 – Area of seepage as the flow pathway gradient becomes less steep. Seepage area is a field frequented by cattle.

6.06 – Flow pathway running along track and into field upstream of mire.

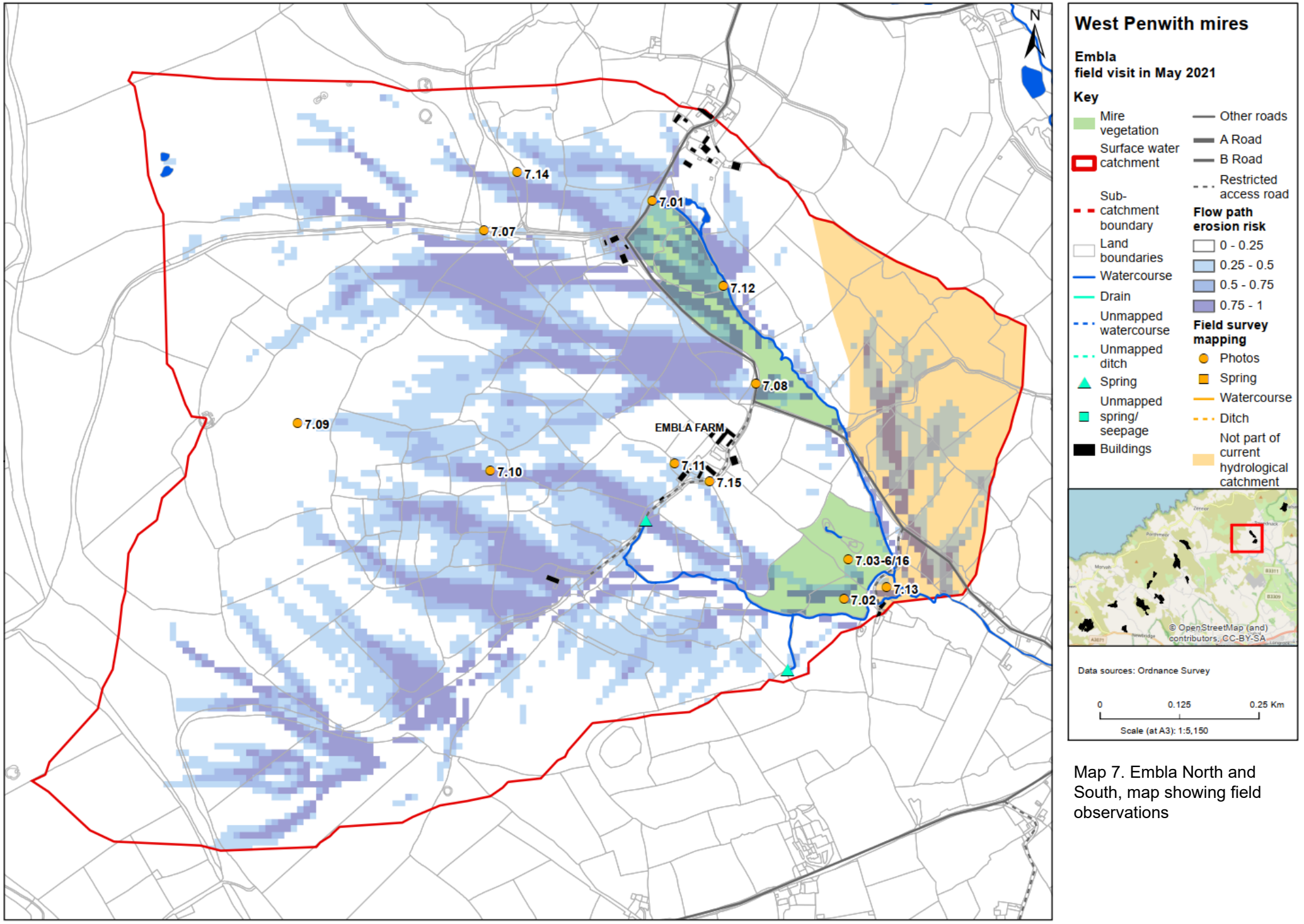
6.07 – Flow pathway along track entering watercourse and creating an accumulation of fine material to the right of the photo.

6.08 – Evidence of poached ground as a result of managing the land for cattle including heavy machinery tracks and ring feeders creating a concentration of cattle.

7. Embla North and South

Summary of field survey	
Date and time of field survey	Afternoon of Monday 24th May 2021
Survey route	Circular route following public footpaths covered the whole catchment. Specific visits made to the hamlet of Amalveor and the western mire (both off the circular route).
Habitat location, extent and cover	Site is a mire complex consisting of two valley mires (hereafter termed north and south) and an extensive heathland with mire elements in upper reaches of the catchment. **Valley Mire north –** Mostly wet woodland, with the remainder used as grazing for horses (Photo 7.01). **Valley mire south –** Similarly, much of the mire area is wet woodland (Photo 7.02), with remaining areas appearing largely ungrazed with cuckoo flower, ragged robin and water forget-me-not (photos 7.03 - 05). A pond has also been constructed (Photo 7.06) intercepting one of the flow pathways upstream of the mire.
Features identified that could influence mire functioning	**Valley Mire north –** lies at the downstream end of a series of converging flow pathways, most of which are shown on existing maps. However, the public footpath (which is steeply sloping) is also an active flow pathway (Photo 7.07). The road also acts as an active flow pathway as evidenced by the multiple and regular cuts in the roadside verge (Photo 7.08) to convey water off the road into watercourses. The upper reaches of the catchment are a flat plateau showing numerous areas of seepage and groundwater emergence downslope creating a dense network of pools and rivulets that converge on aforementioned pathways, including the footpath (Photo 7.07). **Valley Mire south –** Mire is at the confluence of a number of localised spring fed flow pathways, and one larger catchment scale flow pathway that runs down the catchment from the higher moors (Photo 7.09).
Implications for hydrological risk	
Verified hydrological risk zones in field?	The majority of hydrological risk zones for the Embla catchment were verified in the field. However, the **hydrological catchment should exclude the indicated fields downstream of the mire to the north of the watercourse** as the surface water runoff from these fields and groundwater from this portion of the catchment would not enter the mire. However, the fields immediately downstream of the mires (at the same location as Photo 7.13) and the downstream watercourse may still influence the functioning of the mire (see 'Other Risks' section below).
Outcome of desk-based catchment risk assessment	The desk-study assessed the catchment risk as 'medium-high' due to the large extent of intensively managed grassland and the farms mapped on flow pathways leading to the mire.
Outcome of field-based catchment risk assessment	**Valley Mire north –** The risk of enrichment from current agricultural activity on this mire is low as extensively managed grassland was observed upstream and adjacent to this mire during the field survey. The main likely risk is from populations at the village of Amalveor that are presumably outside mains sewerage and are likely to be associated with on-site Wastewater Treatment Works (WwTW). **Valley Mire south –** The risk of enrichment from current agricultural activity on this mire is low as the majority of the catchment is extensively managed grassland. A single farmstead (Embla Farm) is located along this flow pathway, presumably outside mains sewerage and likely to be associated with on-site WwTW. The Farmstead includes the farm itself and two cottages. A large proportion of the Embla catchment is also under an HLS agreement. Conversations with the local landowner indicate that livestock is limited to a herd of 20 White Park sucklers. These cows are de-pastured during spring and summer but are housed in a small cattle storage facility within the farm (Photo 7.11). As there were only limited extents of intensively managed grassland observed on site compared to the desk-study, **catchment risk is lowered to 'medium'**.
Opportunities identified	Restoration of natural hydrological pathways in mire by blocking of grips and ditches present across the site that have undoubtedly been modified historically to accelerate land drainage.

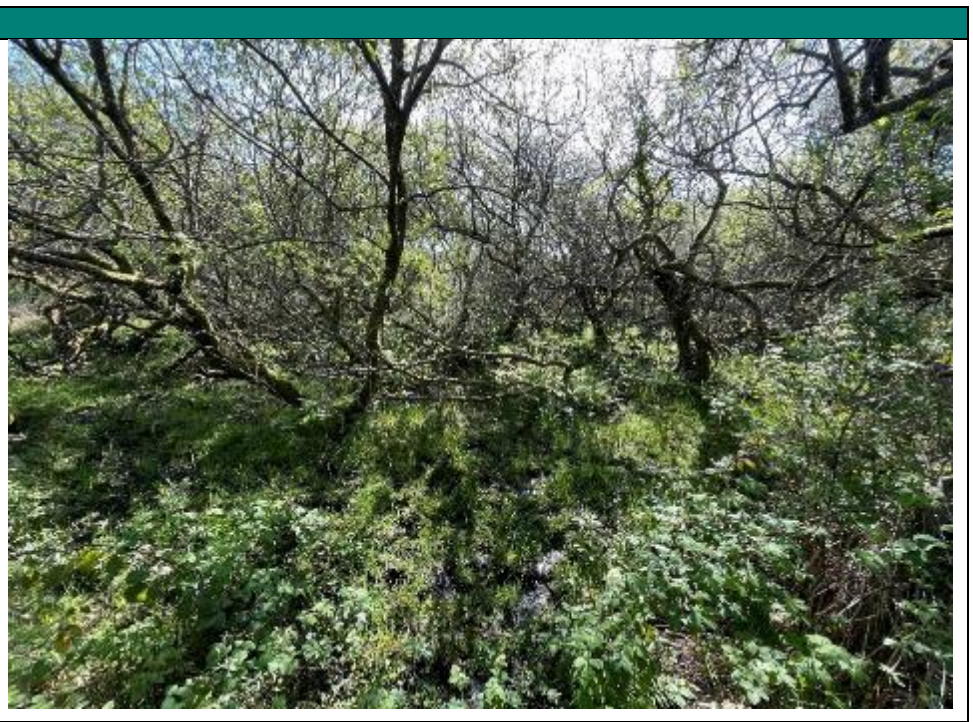
Other risks	If increased drainage were implemented within the field downstream of the mire it could potentially lower the water table within the mire. If the watercourse downstream of the mire was deepened this could also increase the hydraulic gradient from the mire to the watercourse leading to a reduction in mire water levels within the mire. Therefore, whilst not part of the hydrological catchment, these fields may still be considered to influence the functioning of the mire. Invasive non-native species (INNS) are present in the valley of the eastern mire with significant and large stands of *Gunnera* spp. within the main flow pathway (Photo 7.12). The eastern mire has also been used as a tipping location (Photo 7.01). Areas south of the west mire have a cover of INNS *Rhododendron ponticum* (Photo 7.13).



Map 7. Embla North and South, map showing field observations

Embla Photographic record

7.01 – Horse grazing.



7.02 – Wet woodland.

7.03 – Cuckoo flower.

7.04 – Ragged robin.

7.05 – Water forget me not.

7.06 – Pond.

7.07 – Footpath as active flow pathway.

7.08 – Road verges cut to provide road drainage.

7.09 – Upper reaches of the catchment.

7.10 – Flow pathway leading to southern section of mire.

7.11 – Cattle handling facility.

7.12 – *Gunnera* spp.

7.13 – *Rhododendron ponticum.*

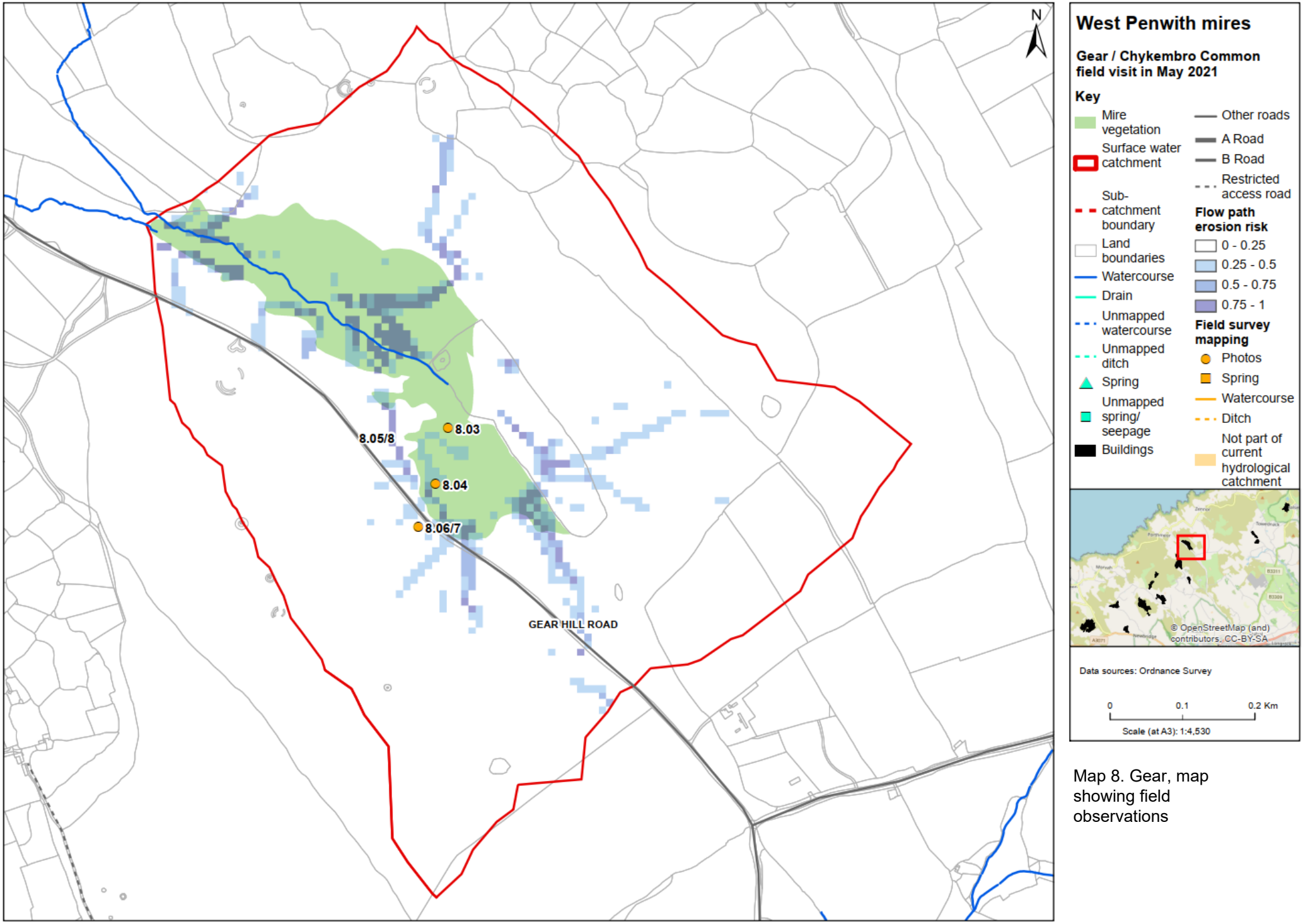
7.14 – Embla catchment panoramic.

7.15 – Biosecurity.

7.16 – Vegetation in southern mire.

8. Gear

Summary of field survey	
Date and time of field survey	Evening of Thursday 27th May 2021
Survey route	Southern section only, surveyed from road and with use of the UAV/drone
Habitat location, extent and cover	Mire habitat is located in a shallow valley running along an extensive flow pathway that dissects the catchment (see Photo 8.01 and 8.02). The majority of the habitat surveyed was characterised by stands of *Molinia* (Photo 8.03) intersected by small wetter pockets identified by the presence of cotton grass (Photo 8.04) and *Sphagnum* mosses. Wetter areas in the core of the site were characterised by tree cover (see Photo 8.01 and 8.02).
Features identified that could influence mire functioning	The catchment is located on a hilltop plateau and is characterised by shallow slopes and gradients. The flow pathway extends in a north westerly direction across a small local road (Photo 8.05). There appears to be a culvert (unconfirmed) under the road identified by a small, ponded area on the upstream side of the road (Photo 8.06). A number of locations were also identified where water was seeping through under the road (Photo 8.07). The catchment was predominantly dry heath and bracken (Photo 8.08).
Implications for hydrological risk	
Verified hydrological risk zones in field?	Hydrological risk zones were verified during the field survey; no new hydrologically significant features were identified that altered the hydrological risk zones previously as part of the desk study. In the northern part of the site the area of groundwater emergence is likely to be narrower and of more limited extent based on drone footage obtained. However, **no changes to the extent of any zone are proposed.**
Outcome of desk-based catchment risk assessment	The desk-study assessed the catchment risk as 'low' as the catchment is currently dominated by semi-natural landcover.
Outcome of field-based catchment risk assessment	**The catchment risk remains low risk**. There is no intensive agricultural activity in the Gear catchment and the area is dominated by heath communities (moors). The only agricultural activity is limited to grass fields on the north east and south east margins where there are extensively managed grassland fields but there were no obvious flow pathways connecting them to the mire.
Opportunities identified	Blocking of grips and ditches present across the site that have undoubtedly been modified historically for drainage to restore extent, quality and resilience of mire system.
Other risks	It is known that this area has been subject to recent unmanaged moorland fires and due regard should be given to the likely frequency of this practice and effects on mire communities. Several stands of the invasive non-native invasive species (INNS) *Rhododendron ponticum* (Photo 8.03) were identified within the area mapped as mire vegetation.



Map 8. Gear, map showing field observations

Gear Photographic record

8.01 – View looking down the catchment in a north westerly direction. Areas in pale white tones are stands of *Molinia.* Location of photograph not shown on map.

8.02 – View looking up the catchment in a south easterly direction. Areas in pale white tones are stands of *Molinia*. Location of photograph not shown on map.

8.03 – *Rhododendron ponticum* within mire habitat.

8.04 – Mire species include cotton grass, purple moor grass and gorse.

8.05 – Gear Hill Road running across slopes leading to mire.

8.06 – Roadside ditch.

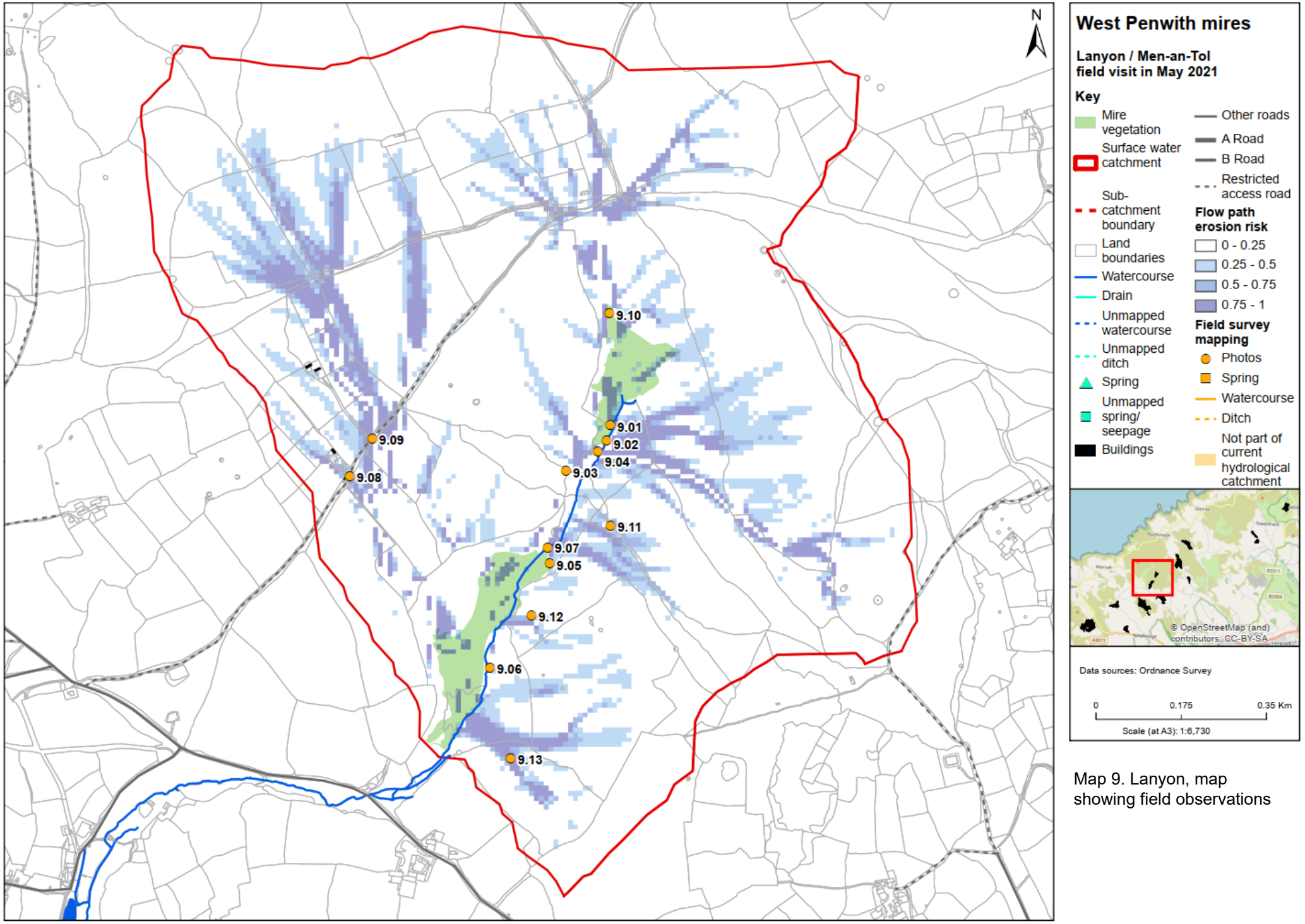
8.07 – Wet habitat upslope of road suggesting that road ditch may be blocked.

8.08 – View over mire habitat taken from Gear Hill Road.

9. Lanyon

Summary of field survey	
Date and time of field survey	Morning of the 27th May 2021
Survey route	A circular route was taken following tracks and public rights of way crossing the main flow pathway to the northwest of the mire before crossing between the two sections of mire and continuing south.
Habitat location, extent and cover	There are two sections of mire, one to the north of the valley and one to the south. Valley sides are steep, laterally confining the mire extent. The **northern section** of the mire is on the headwaters of a watercourse that joins the Newlyn River downstream of Lanyon catchment. This section is dominated by *Molinia* with water flowing towards the watercourse (Photo 9.01) with wet woodland at the downstream end of this section of the mire (Photo 9.02). The mire habitat is fed by seepage at the edge of the superficial geology (Photo 9.03). However, the mire is being actively drained by the watercourse which has been historically reprofiled (potentially related to mining activities in the area) into a 2 m deep trapezoidal channel with large stones acting as reinforcement resulting in drier bracken habitat near to the watercourse (Photo 9.04). Due to the incised cross-section of the watercourse, the northern section of the mire is not currently influenced by the water quality of the river. Most of the **southern section** of the mire is located on the right bank of the watercourse and supports bracken, rush, sedges, cotton grass, cross-leaved heath and milkwort (Photo 9.05). Wet woodland interspersed with *Molinia* mire is present close to the watercourse. There is evidence of a spring line with multiple seepage locations on the left side of the watercourse (Photo 9.06) associated with wet heath communities. On the left side of the watercourse there are former mine shafts in close proximity to the southern mire, some of which hold water and wetland vegetation (Photo 9.12). These may have an impact on local hydrology. Whilst between the mires the ditch becomes less incised (Photo 9.07), it becomes more artificially incised to the south. The drier habitat may reflect the draining effect of the incised watercourse.
Features identified that could influence mire functioning	Flow pathways in Lanyon catchment are relatively concentrated on the east and west of the mire habitat. The dominant **western flow pathway** flows past a farm building and crosses a track before leading to the mire. The farm building was abandoned, and the surrounding fields were pasture of moderate species diversity and apparently low intensity management. Most of these flow pathways to the west have semi-natural land covers (Photo 9.10). The track is ditched by an interceptor drain that carries some of the water from this flow pathway away from the mire (Photo 9.08). While this section of the catchment contributes less surface water to the mire, the groundwater from this section of the catchment may still feed the mire. During heavy rainfall events, the interceptor drain may also spill out overtopping the bank with water flowing along other field drains that do lead towards the mire (Photo 9.09). The **eastern flow pathways** drain mostly semi-natural land (Photo 9.11) and are intercepted by the watercourse so do not impact the mire habitats to the east of the watercourse (right bank). Some water is trapped in numerous mineshafts to the east of the watercourse creating isolated pockets of wetland vegetation (Photo 9.12). It was therefore determined that the land in the east of the catchment is currently of lower risk to the mire habitat than the flow pathways to the west. A small number of intensively managed grassland fields managed for silage were identified in the most downstream (southern) end of the catchment (Photo 9.13). Field observations identified an interceptor drain carrying surface water from these fields downstream and bypassing the mire habitats. Whilst they may have a limited influence on the downstream end of the mire, these fields are retained within the

	catchment boundary as the groundwater from this section of the catchment may still feed the mire. Also, if water levels were raised in the incised watercourse as part of mire restoration activities, this part of the mire may become more hydrologically connected to the hillslope.
Implications for hydrological risk	
Verified hydrological risk zones in field?	Hydrological risk zones were verified during the field survey; no new hydrologically significant features were identified that altered the hydrological risk zones previously as part of the desk study. Therefore, **no changes to the extent of any zone are proposed.**
Outcome of desk-based catchment risk assessment	The desk-study assessed the catchment risk as 'medium-high' due to arable land and intensively managed land mapped on the main flow pathways. The southern section of the mire was identified as higher risk than the north due to the higher intensity of land management.
Outcome of field-based catchment risk assessment	The high intensity land management identified as arable and intensively managed land through the desk-study was not verified during the field survey, with many of these fields instead being enclosed grasslands of moderate species diversity or rough grassland. Therefore, the **catchment risk rank is lowered to 'low-medium'**.
Opportunities identified	The opportunity to block/re-naturalise the watercourse that is actively draining both sections of the mire would have a positive effect on the mire, increasing the quality of the drier sections of mire habitat and likely increasing the extent of the mire. If the drainage of the mire were reduced then flow pathways to the east of the catchment may start to influence the functioning of the mire habitat, hence their continued inclusion in the catchment boundary.
Other risks	The catchment shows features associated with historic mining. The water quality implications of these features are not currently understood.



Map 9. Lanyon, map showing field observations

Lanyon photographic record

9.01 – Northern section of the mire dominated by purple moor grass and actively flowing water.

9.02 – Wet woodland at the downstream end of the northern section of the mire.

9.03 – Example of seepage feeding the northern mire habitat. The exposed profile on the left of the photograph reveals a top layer of darker peat organic material with lighter coloured gravels at the base of the profile at the height of the water table.

9.04 – Watercourse in the upstream section of the mire with drier bracken habitat on either bank. Photograph taken looking upstream highlighting the incised trapezoidal cross-section.

9.05 – Southern section of the mire with bracken, rush and sedges present.

9.06 – Southern mire looking upstream with the watercourse that is artificially incised on the left. Zone of seepage leading to watercourse on left bank of river (right of photo) whereas right bank is steeper with drier mire vegetation at a higher elevation.

9.07 – Habitat between mires with grass and bracken and less incised river channel.

9.08 – Runoff from fields near abandoned farm buildings running down track to track-side ditch on left of photograph. Photo taken looking south west towards the catchment boundary.

9.09 – Flow from large flow pathways channelled into field drain which passes under track into drain flowing towards mire.

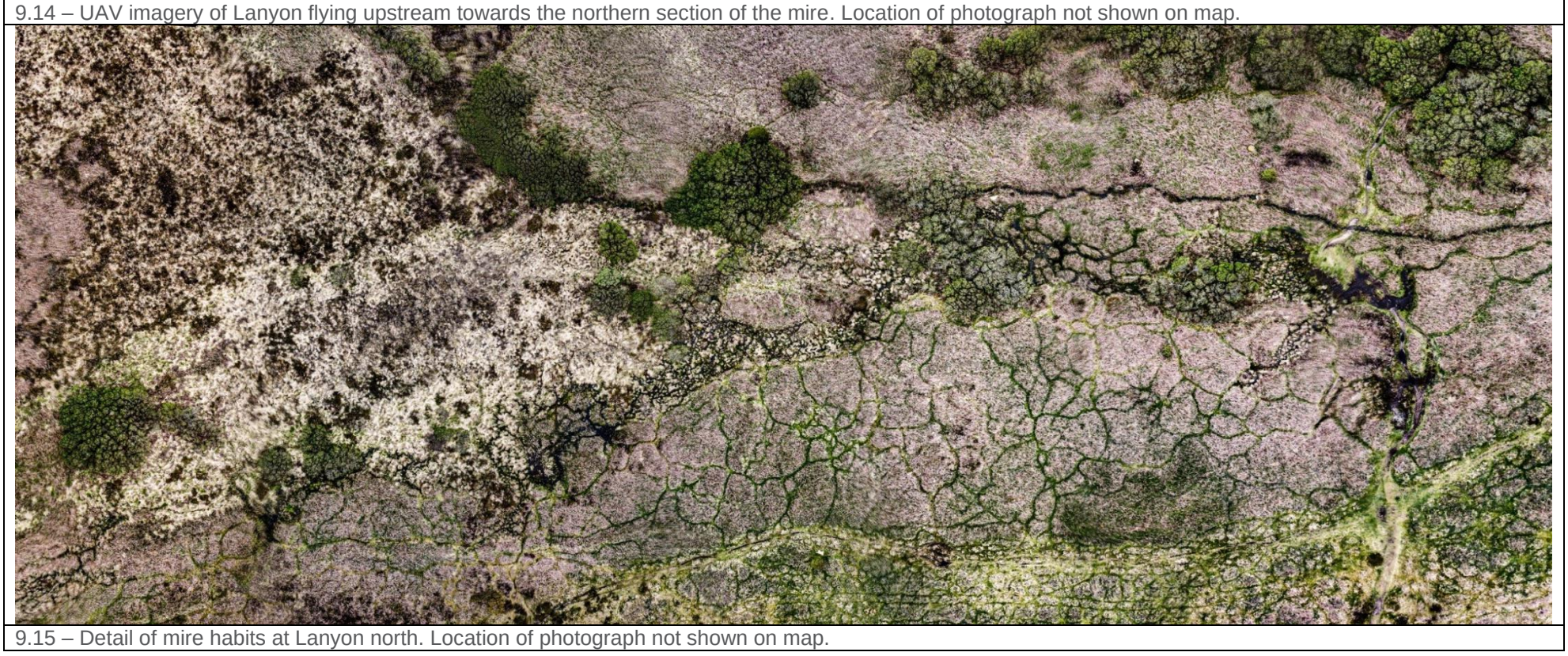
9.10 – Semi-natural vegetation on north western flow pathway leading to northern mire.

9.12 – Mine shaft topped with bracken with wetland species such as Juncus and ferns growing in the water captured by the shaft.

9.11 – Footpath on flow pathway showing evidence of erosion.

9.13 – Silage field in background of photograph. Drainage from these fields bypasses the mire habitats.

9.14 – UAV imagery of Lanyon flying upstream towards the northern section of the mire. Location of photograph not shown on map.

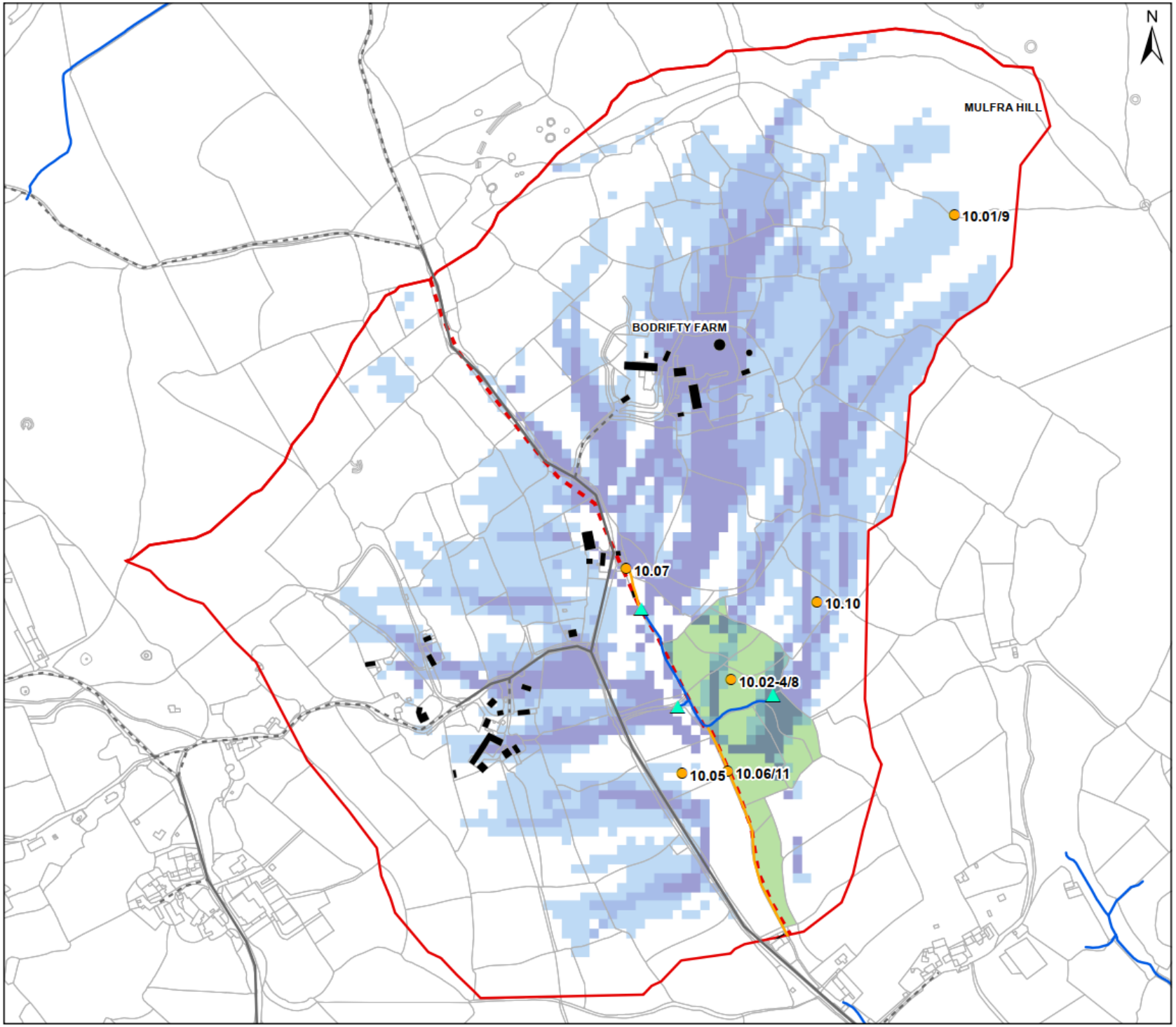


9.15 – Detail of mire habits at Lanyon north. Location of photograph not shown on map.

10. Tredinnick

Summary of field survey	
Date and time of field survey	Morning of Tuesday 25th May 2021
Survey route	Linear route following road adjacent to mire habitat. Specific visits made to the village of Tredinnick and Bodrifty Farm that is now a complex of mainly residential properties. A transect from Mulfra Hill (in the north eastern corner of the catchment and providing good views of the entire catchment – see Photo 10.1) down to and across the mire habitat was also surveyed.
Habitat location, extent and cover	Mire is located in a headwater catchment of the Trevaylor Stream and runs parallel to a small road. Mire habitat is located at the base of the break of the steep slope running down from Mulfra Hill (Photo 10.2) and consists of a patchwork of grassland, exposed peat (Photo 10.3) and bog vegetation communities, including bog pondweed in wetter parts with open water (Photo 10.4). A series of extensively managed grassland fields of moderate species diversity are located between this watercourse and the road; these fields have some rush cover and indicators such as cuckoo flower and are grazed by cattle (Photo 10.5)
Features identified that could influence mire functioning	This mire lies at the downstream end of a series of converging flow pathways downslope from Mulfra Hill, most of which have been mapped during previous parts of the project. The main flow pathway is clearly visible in the field demarcated by a corridor of woodland and scrub running downslope. The western boundary of the mire habitat is a watercourse (Photo 10.6) that runs broadly north to south, parallel to the road. The watercourse shows signs of having been historically altered and deepened and currently appears to act as a drain to the mire habitat. The watercourse itself is thought to be sourced from a spring close to a stone barn (Photo 10.7), although it was not running at the time of the survey. Conversations during walkovers with local land managers (Photo 10.8) indicate that the mire habitats are used for summer grazing of approximately 20 Hereford sucklers that are de-pastured and left free to roam the area. Evidence of bank poaching from cattle and grazing was evident on the edges of the mire habitat.
Implications for hydrological risk	
Verified hydrological risk zones in field?	Hydrological risk zones were verified during the field survey; no new hydrologically significant features were identified that altered the hydrological risk zones previously as part of the desk study. Therefore, **no changes to the extent of any zone are proposed.** However, the influence of drainage from the north-south watercourse suggests that the watercourse is itself acting as a catchment boundary under current conditions. Any flow paths due west of the watercourse will flow into the deepened watercourse and away from the mire habitat that is at a level of approximately 1.0-1.5m above the watercourse water level, although this has not been formally confirmed by topographic survey. Habitat on the western bank of the watercourse showed little evidence of wetland species. However, if the bed-level of the watercourse was raised as part of a mire/stream restoration in the future this may change.
Outcome of desk-based catchment risk assessment	The desk-study assessed the catchment risk as 'medium-high' due to the presence of farms, arable land and intensively managed grassland mapped on flow pathways leading to the mire.
Outcome of field-based catchment risk assessment	The **risk of enrichment from agricultural activity on this mire remains 'medium-high'**. Most of the land due east of the mire is open heath moor (Photo 10.9). Closer to the mire to the east, two fields are under arable land cover (Photo 10.10), used to grow barley for cattle feed. There are also some intensively managed grassland/silage fields that are fertilised once per year using chemical fertilisers. No slurry is applied - the land managers run a herd of 200 dairy cattle (cross of red Norwegian Friesian-dairy, Friesian and Jersey cross that gives smaller animals more suited to local ground conditions) that can be de-pastured 11 month of the year so that slurry production is limited.

	The mire habitat and adjacent extensively managed small fields are used for summer grazing of approximately 20 Hereford sucklers that are de-pastured and left free to roam the area. The majority of this land is within an existing HLS agreement.
Opportunities identified	As with many of the sites considered as part of the study, restoration of mire and natural streams by blocking of grips and drains present across the site would serve to restore the natural hydrology of the Tredinnick basin. Due regard should be given to potential effects on the local road if this is pursued.
Other risks	Whilst the north-south drain is expected to represent the current boundary of the existing mire catchment at Tredinnick (Photo 10.11), any efforts to restore the effects of drainage and the natural hydrology of the Tredinnick basin could reconnect flow paths to the west of the catchment. If drainage in this area was reversed, it is expected that further aquatic and semi-aquatic habitats might develop in areas such as the three meadow fields between the watercourse and the road. A number of potential catchment risks would likely be activated in this scenario including: • **The village of Tredinnick** is presumably outside mains sewerage and likely to be associated with on-site WwTW. • The **minor road to Tredinnick** actually acts as an active flow pathway as evidenced during an intense storm when water was observed flowing across the road and into the north south drain. • A series of **intensively managed (re-seeded and fertilised) silage/pasture fields** may drain towards the north-south drain. Whilst no observable runoff pathways from them were identified during the surveys (including during an intense storm event on the late morning of 25th May) the presence of some form of artificial field drainage cannot be discounted.



West Penwith mires

Tredinnick
field visit in May 2021

Key

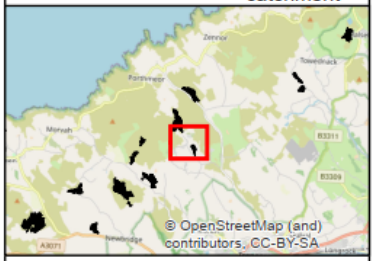
- Mire vegetation
- Surface water catchment
- Sub-catchment boundary
- Land boundaries
- Watercourse
- Drain
- Unmapped watercourse
- Unmapped ditch
- Spring
- Unmapped spring/ seepage
- Buildings
- Other roads
- A Road
- B Road
- Restricted access road

Flow path erosion risk

- 0 - 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1

Field survey mapping

- Photos
- Spring
- Watercourse
- Ditch
- Not part of current hydrological catchment



Data sources: Ordnance Survey

0 0.1 0.2 Km

Scale (at A3): 1:3,950

Map 10. Tredinnick, map showing field observations

Tredinnick Photographic record

10.01 – Tredinnick catchment panoramic.

10.02 – Mire habitat with Mulfra Hill in distance.

10.03 – Exposed peat.

10.04 – Bog Pondweed.

10.05 – Meadow.

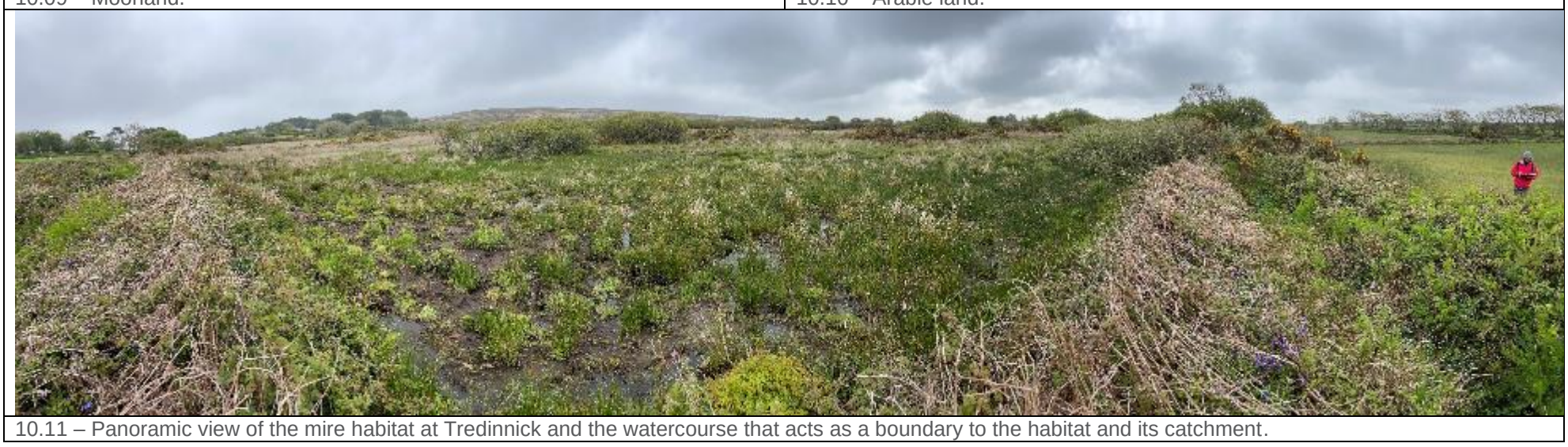
10.06 – Watercourse.

10.07 – Location of spring source.

10.08 – Walkover survey with land managers.

10.09 – Moorland.

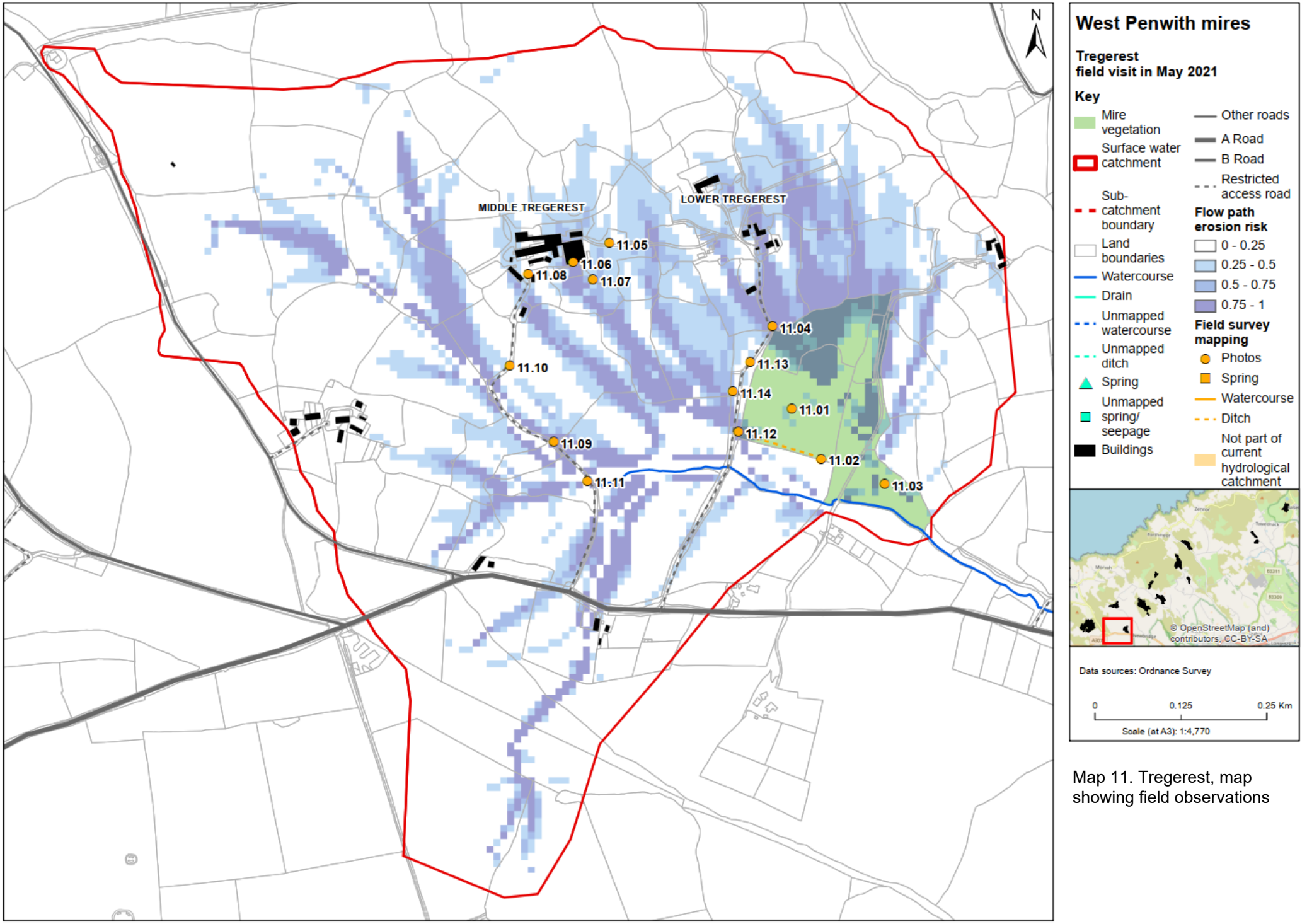
10.10 – Arable land.



10.11 – Panoramic view of the mire habitat at Tredinnick and the watercourse that acts as a boundary to the habitat and its catchment.

11. Tregerest

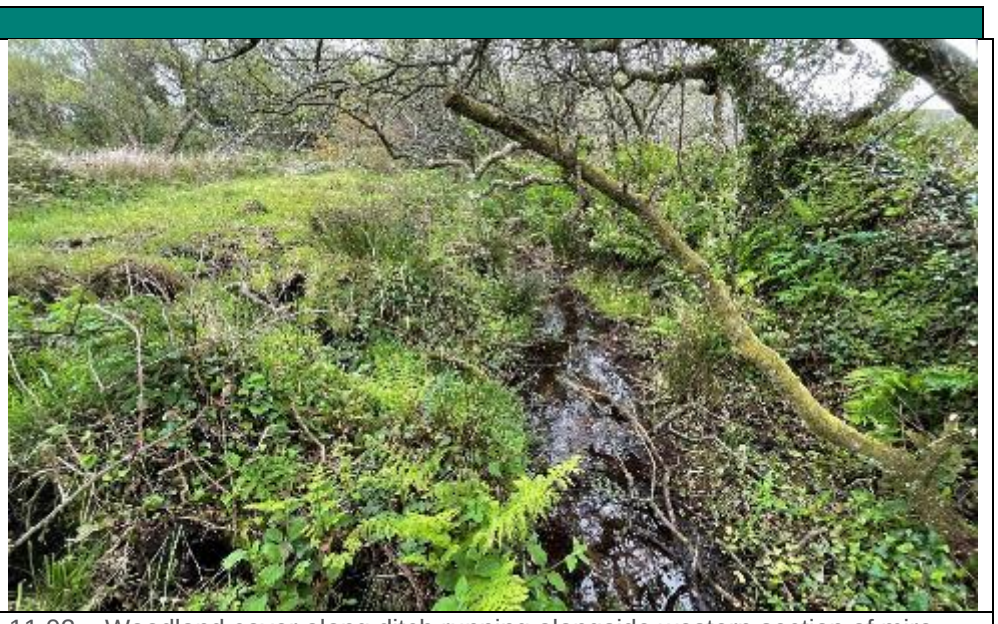
Summary of field survey	
Date and time of field survey	Afternoon of Friday 28th May 2021
Survey route	A circular route was taken across the fields around Lower Tregerest Farm, Middle Tregerest Farm and around the mire habitat.
Habitat location, extent and cover	The mire covers the valley floor on the left bank of a watercourse. It is dissected by a track leading from the A3071 road past Prospect House. The **western section** is an area of rush pasture (Photo 11.01). There is evidence of significant cattle grazing and poaching on the mire (Photo 11.01). A large portion of the defined mire habitat was covered by woodland extending along an incised watercourse (Photo 11.02) draining the mire habitat. The **eastern section** is smaller and is also rush pasture (Photo 11.03). It is separated from the watercourse by a large bank and is likely fed from the large flow pathway running into the field from the north.
Features identified that could influence mire functioning	Flow pathways in the Tregerest catchment are concentrated mainly on the steep slopes to the north and west of the mire. Hydrological pathways to the **north** flow directly to the mire habitat (Photo 11.04). To the **west**, pathways flow through an area with a significant dairy farm at Middle Tregerest housing ca. 160 cattle according to local landowners. Surrounding fields have evidence of some poaching (Photo 11.05) and the dairy unit itself has a large slurry tank draining to an underground pipe (Photos 11.06 and 11.07) with evidence of surface runoff from the farmyard down the slope (Photo 11.08) and along farm tracks (Photos 11.09 and 11.10). These hydrological pathways all flow in a south-westerly direction into a watercourse that currently bypasses and drains the mire habitat. A wet depression on the edge of the superficial habitat also feeds the watercourse (Photo 11.11). A track from Lower Tregerest Farm also acts as a hydrological pathway, observed during the site visit (Photo 11.12). Flows arise from a spring, but water showed active algal growth (Photo 11.13) and was also connected to heavily poached cattle tracks (Photo 11.14).
Implications for hydrological risk	
Verified hydrological risk zones in field?	Hydrological risk zones were verified during the field survey; no new hydrologically significant features were identified that altered the hydrological risk zones previously as part of the desk study. Therefore, **no changes to the extent of any zone are proposed.**
Outcome of desk-based catchment risk assessment	The desk-study assessed the catchment risk as 'medium-high' due to the presence of farms, arable land and intensively managed grassland mapped on flow pathways leading to the mire.
Outcome of field-based catchment risk assessment	The field survey identified less arable land than mapped in the desk-based assessment. Field-based land cover mapping confirmed that most of the catchment was intensively managed grassland. Whilst existing land covers and dairying could pose a significant risk to the mire if mapped flow pathways were connected to it, under current conditions water from these sources flow into the main watercourse upstream of the mire habitats and bypass them. However, the **catchment risk score has been maintained at 'medium-high'** as if connectivity between the mire and watercourse were improved, they may then pose an increased risk. There are also still some residual risks to the mire habitats including those posed by fertiliser/slurry use on surrounding fields.
Opportunities identified	-
Other risks	-



Map 11. Tregerest, map showing field observations

Tregerest photographic record

11.01 – Rush pasture in poor condition in the western section of the mire. Evidence of ground poaching by cattle.

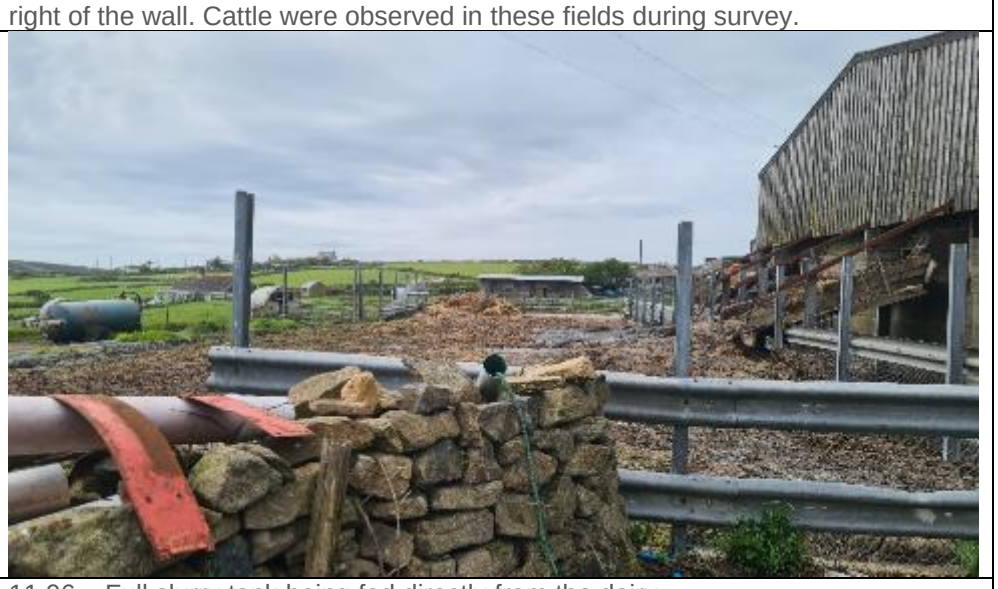


11.02 – Woodland cover along ditch running alongside western section of mire. Photo taken looking downstream with mire to the left.

11.03 – Rush pasture in poor condition in eastern section of mire.

11.04 – Northern flow paths over pasture to the left of the wall feeding mire to right of the wall. Cattle were observed in these fields during survey.

11.05 – Pasture near Middle Tregerest Farm with ring feeders next to dairy.



11.06 – Full slurry tank being fed directly from the dairy.

11.07 – Drain at bottom of slurry tank (slurry tank in background) with brown water dripping into an underground pipe.

11.08 – Run-off from yard flowing towards fields.

11.09 – Run-off along track leading from Middle Tregerest Farm.

11.10 – Sediment deposited on path during rainfall events. Hole in field wall (filled with fine sediment) and sandbag in foreground used to direct water into field.

11.11 – Depression on edge of superficial geology. Wetland vegetation is present.

11.12 – Water from track flowing and into ditch (inset) that flows alongside mire habitat (pale vegetation in background).

11.13 – Water from spring (behind trees to left of photograph) crossing track covered with farm material. Water leads to ditch that runs alongside the mire. Algae can be seen growing on the water to the left and on the track.

11.14 – Muddy poached field gateway on flow pathway leading to track.

Summary and conclusions

The table below summarises the results of the field survey and how it has been used to inform, verify and update the catchment risk assessment undertaken as part of the desk-based assessment. The table shows all the sources of information that were available for each site and whether the catchment boundary previously defined for each mire changed following the collection of field-based evidence. For 2 out of the 11 mire sites, catchment boundaries were changed to reflect the land that influences the mire. The field visit served to identify artificial drainage features that changed the relative influence of areas within the catchments on the mire systems, emphasising the extent of historic drainage management that many of these sites have been subject to, mainly for the purposes of agricultural management.

The table below also summarises how the catchment risk assessment was verified or moderated based on Atkins field investigations and the associated field-scale land-cover mapping undertaken by Natural England. The additional site understanding provided by these surveys has helped to verify and, in some cases, reduce the catchment risk status identified during the initial desk-based study. Where changes have been made, the justification for them is also provided.

	Evidence base for assessment						**Any changes to proposed hydrological catchment?**	**Catchment risk assessment**	
	Atkins 2021 desk-study	Ecohydr-ology study	Mapped features	Photographs	UAV imagery	Landowner discussions		**Initial desk-based study**	**Revised risk assessment based on field survey**
Bodrifty Bog	✓	-	✓	✓	-	-	No	Low-medium	Maintained as Low-medium *Majority of catchment is rough grassland*
Bosiliack Bog	✓	-	✓	✓	✓	✓	No	High	Changed to Medium *There was less intensively managed grassland identified during the field visit than mapped during the desk-study. Instead, most of the catchment was rough grassland with some intensively managed grass for grazing and silage within a single landholding.*
Bostraze Bog	✓	✓	✓	✓	-	✓	No	High	Maintained as High *Arable and intensively managed grassland throughout the catchment.*
Boswarva Bog	✓	✓	✓	✓	✓	-	No	Medium	Changed to Low-medium *There was less arable and intensively managed grassland identified during the field visit than mapped during the desk-study. Instead, the majority of the catchment was rough grassland with grazing and silage production on a single landholding within a large catchment.*
Boswens Bog	✓	✓	✓	✓	✓	✓	Yes –fields downstream of the mire excluded from the catchment as surface and groundwater from them does not directly feed the mire.	Medium	Maintained as Medium *There was a cereal crop field and intensively managed grassland adjacent to the field as mapped during the desk-study. The rest of the catchment was intensively or extensively managed grassland used for grazing horses or cattle with low to no fertiliser inputs.*
Bussow Moor	✓	✓	✓	✓	-	-	No	High	Maintained as High *There majority of the catchment was intensively managed grassland (e.g. silage fields and dairy unit) including fields adjacent to the mire.*
Embla North and South	✓	-	✓	✓	-	✓	Yes –fields downstream and north of the mire excluded from the catchment as surface and groundwater from them does not directly feed the mire.	Medium-high	Changed to Medium *There was less intensively managed land identified during the field visit than mapped during the desk-study. Instead, mainly semi-improved grassland was identified. Residual risks are from on-site WwTW in Amalveor and Invasive Non-Native Species (INNS).*
Gear	✓	-	✓	✓	✓	-	No	Low	Maintained as Low *Virtually no agricultural activity. Mainly natural and semi-natural upland habitats*
Lanyon	✓	-	✓	✓	✓	✓	No	Medium-high	Changed to Low-medium *There was less intensively managed land identified during the field visit than mapped during the desk-study. Instead, the majority of the catchment was semi-natural vegetation. Areas of more intensive agricultural activity are associated with artificial drainage carrying surface water away from mire habitats.*
Tredinnick	✓	-	✓	✓	-	-	No	Medium-high	Maintained as Medium-high *Majority of catchment intensively and extensively managed grassland used for grazing with some arable fields adjacent to the mire.*
Tregerest	✓	-	✓	✓	-	✓	No	Medium-high	Maintained as Medium-high *Intensively managed land identified in the desk-study and the dairy farm were identified on site. Runoff from this land may flow into a watercourse that bypasses the mire but if the watercourse were restored to function naturally, water from these fields could influence the mire. There was limited groundwater exfiltration or mire habitat.*

Acknowledgements

Thank you to the landowners and tenant farmers who allowed access to their land and, in some cases, gave their time to discuss their land management practices with us. Thanks also to Iain Diack (Senior Specialist for terrestrial wetlands, Natural England) for his comments on a draft version of this report.

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