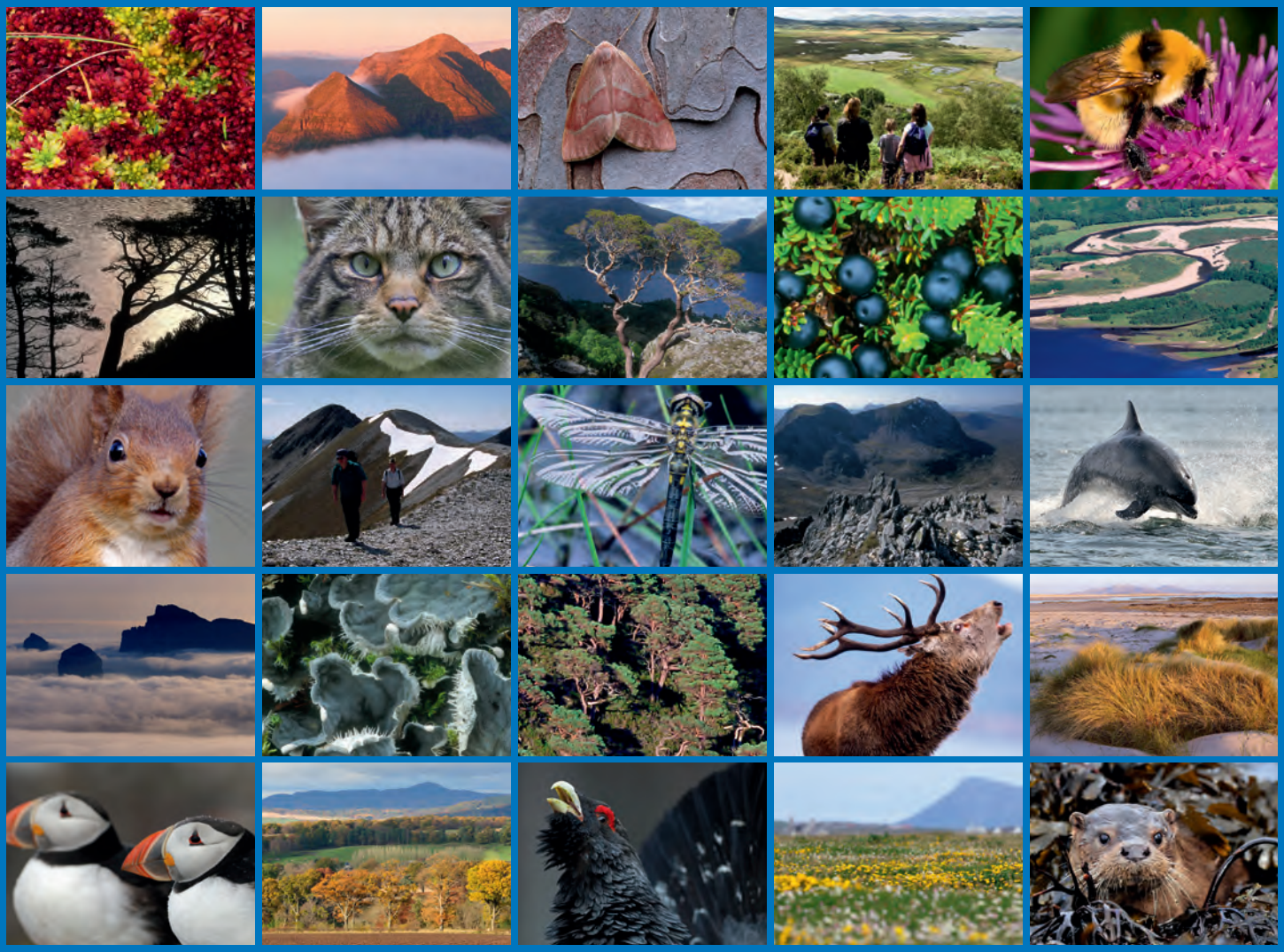
Scottish Natural Heritage
Commissioned Report No. 733

Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Wartle Moss



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COMMISSIONED REPORT

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Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Wartle Moss

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COMMISSIONED REPORT

Summary

Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Wartle Moss

Commissioned Report No. 733
Project No: 13700
Contractor: EnviroCentre Ltd.
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Keywords

Diffuse pollution; SSSIs; wetland; water; soil; samples; recommendation.

Background

SNH contracted EnviroCentre to look at a number of Sites of Special Scientific Interest across Scotland thought to be adversely affected by diffuse pollution. EnviroCentre was asked to carry out a number of tasks to help SNH understand better whether sites are being affected by diffuse pollution and if so, what activities might be contributing to this pressure and how SNH could improve the condition of the sites.

If sites are identified as being affected by diffuse pollution, SNH hope that the results of this report will help them to work with managers of the sites to improve their condition.

Main findings

- The desk study and site walkover identified potential existing and historical land use practices within the catchment that could adversely affect water quality and soil nutrient status. This included long-term changes resulting from agricultural management practices within the catchment and septic tanks in proximity of the site.
- Analytical data confirmed the presence of elevated nutrients. It should be noted that the sampling assessment was undertaken as a single visit and the limited scoped dataset and a lack of historical data constrains the ability to draw accurate conclusions to fully inform current site conditions.
- A series of recommendations are proposed to seek to aid the understanding of the site and afford a greater insight into the perceived changes taking place within the SSSI.

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Acknowledgements

EnviroCentre Ltd would like to thank the SNH Operations staff for their time and assistance in providing access to the site files held at the local office, providing landowner contact details, and in aiding the preliminary understanding of the site to assist with the health and safety evaluation prior to the initial visit.

Thanks are also extended to the site landowners for affording access to the site to enable the agreed scope of work to be undertaken.

1. INTRODUCTION

EnviroCentre Ltd was contracted by Scottish Natural Heritage (SNH) in August 2012 to deliver the 'Investigation of Standing Water and Wetland SSSIs under diffuse pollution pressure' project. The data collected from the project will be used to inform management decisions on standing water and wetland Sites of Special Scientific Interest (SSSI).

1.1 Site Location

Wartle Moss is located 2.5km south of the village Rothienorman in Aberdeenshire. The A920 runs along the southern border of the site and the B9001 on the eastern edge of the site. See Figure 1.1 in Annex 1.

1.2 Site Description

Wartle Moss is a SSSI designated for its basin mires. At 62.6 hectares it is one of the largest and least disturbed basin mires in north east Scotland (SNH, 2011a). It occupies a basin at an altitude of 116m, within predominately agricultural land (SNH, 2011b).

The mire is dominated by herb-rich beds of bottle sedge and marsh cinquefoil. Areas of dense and diffuse willow carr have developed throughout the moss. Birch woodland also occurs, however this is predominately found in the drier areas of the site adjacent to the drainage ditch in the north. Water horsetail is dominant throughout the wettest parts of the site, where it forms tall stands. In other areas of the site the vegetation is shorter, with a higher covering of mosses (SNH, 2011b).

A former railway line crosses the moss on an embankment. Roads run immediately to the east and south of the site. Historical Ordnance Survey (OS) maps for the site indicate that the railway and roads were built before 1873 (National Library of Scotland, n.d.).

The bedrock geology for the majority of the site consists of Olivine-Gabbro of the Insch Pluton, with Quartz Microgabbro intrusions present in places. To the northern boundary of the site Micaceous Psammites, Semi-Pelites, and Pelites, of the Macduff Formation are present. Peat is the dominant superficial deposit on site, with Glacial Till present to the fringes, and Alluvium along the channel of the Red Burn to the north (British Geological Survey, n.d.). The catchment area is influenced by underlying plutonic basic rocks, which give Wartle Moss a mesotrophic character, in contrast to the predominantly acidic mires in this part of Scotland (SNH, 2011b).

1.3 Site Hydrology

A catchment area of approximately 9.7km^2 drains to the site, with an annual average rainfall of 846mm (Centre for Ecology and Hydrology (CEH), 2009). The main inflows to the site take the form of field drains and surface runoff. The aforementioned dismantled railway, orientated south west to north east, affects hydrological connectivity. The eastern portion of the site drains to the Red Burn in the north east, with a drainage ditch flowing through the centre of the site. The western portion of the site also drains to the Red Burn via a ditch that passes beneath the railway embankment. Further drains border the site to the east, west and south, collecting runoff and drainage from the wider catchment. The Red Burn runs along the north eastern boundary of the site, flowing from the east to the northwest.

1.4 Site History

The area was extensively cut over for peat extraction for fuel, with much of the peat being removed by the mid 1800s. When this ceased, the area became flooded, the influence of bedrock and agricultural runoff resulting in mineral-rich peat regenerating (SNH, 2011b).

1.5 Recent Site Management Practices

The site is not managed apart from low intensity game management on areas around the edge of the site which are used for rough shooting, with occasional drives of pheasant/partridge and roe deer stalking. There are two pheasant feeding pens (SNH, 2010). The central area is generally left undisturbed due to its boggy nature.

Pest control includes foxes, rabbits, pigeons and crows using Larson traps (SNH, 2010).

Sheep grazing occurs in a small, fenced-off, area to the southeast of the site which has been cultivated (SNH, 2011b).

The peripheral ditches that form the northern, southern and eastern boundaries of the moss have been cleaned and deepened in the last ten years. The spoil from the cleared drains has sometimes been dumped on the SSSI (SNH, 2011b)

A management plan was developed by SNH to address issues of water levels, scrub control and nutrient enrichment of drainage waters but there has not been agreement to implement it (SNH, 2010).

2. METHODOLOGY

The following sections outline the approach undertaken to fulfil the scope of works established by SNH in the Statement of Requirements (SOR).

2.1 Pre-site Attendance Desk Study

Before the initial site visit was undertaken the local SNH officer was contacted and a meeting held at the corresponding local office to discuss the local understanding of the site and review SNH records.

The meeting was also used to provide an insight into any health and safety constraints not readily apparent from the site maps.

Landowners of the site were notified of the planned site visit a week before the proposed visiting date. This allowed landowners the opportunity to ask any questions and also gave EnviroCentre staff a chance to gain a greater understanding to the workings of the site and the site surrounds. Landowner details are provided in Annex 2.

2.2 Site Attendance

The site was accessed and samples collected over a one day period – termed Visit 1. A follow up visit to the wider catchment – Visit 2 was undertaken once the analytical data was available and was appraised in context with the information obtained from the desk based exercise.

Table 2.1 below shows site conditions on the day of each visit.

Table 2.1: Site Conditions

Wartle Moss	Date of Visit	Weather Conditions	Grid References
Visit 1	14/11/2012	Cold, rainy and overcast	NJ 723324
Visit 2	26/02/2013	Cold, dry and sunny	NJ 723324

2.3 Sampling Approach

SNH had determined the preferred locations for the collection of soil and water samples – as detailed in Figure 2.1 in Annex 1. EnviroCentre was not involved in determining these locations and had not assessed the suitability to access such before Visit 1. Due to certain restrictions, the locations of samples that EnviroCentre collected had to be changed and are as detailed in Figure 2.2 in Annex 1. Changes to locations were kept to a minimum and are generally not deemed to have a significant impact on the sampling or conclusions.

All sampling methods were carried out by trained personnel. Photographs of each sampling location were taken (see Figure 2.3 in Annex 1) and grid references for each location recorded.

2.4 Sample Equipment

The following sample kit was used to undertake site field work:

- Handheld GPS to record specific grid references;
- Handheld soil augers;
- Plastic bailers;
- Sample bottles (all sample bottles were written on to record locations, date and time); and

- Personal Protection Equipment (in line with the requirements of the site specific health & safety risk assessment).

All samples were given unique identification names and packaged in cool boxes with ice packs so as to keep samples at appropriate temperatures prior to being despatched to a United Kingdom Accreditation Service (UKAS) accredited laboratory for analysis.

2.5 Health and Safety

Site specific risk assessments were carried out before attending site. The assessment was based on information obtained from the meeting with the local officer and from EnviroCentre's extensive experience of undertaking previous work of this nature.

The risk assessment, which was carried by staff attending the site visit, included details of the landowner, nearest emergency services and identified risks and proposed means of mitigation. Field operatives notified EnviroCentre head office when entering and leaving site and wore the following appropriate PPE at all times:

- Warm and waterproof clothing;
- Waders;
- Waterproof footwear; and
- Hi-vis vest.

Biosecurity measures were implemented when entering and leaving site. Boots and equipment were washed when leaving site so as not to cross contaminate subsequent sites.

2.6 Water Samples

Surface water samples were collected from strategic locations within the site boundary to provide an understanding for the whole site, comprising standing water, inflows and outflows.

Groundwater samples were collected using plastic bailers from slotted pipes installed with hand augered holes where soil samples were originally collected. The sampling methodology employed a geosock membrane for coarse filtration so as to minimise samples being heavily loaded with suspended solids and organic material.

Samples underwent initial on-site field tests using an OTT Quanta Handheld probe for the following parameters:

- pH;
- Temperature;
- Electrical Conductivity (EC);
- Dissolved Oxygen (DO);
- Oxidation-Reduction Potential (ORP); and
- Salinity.

The water samples were submitted for the following analyses to a UKAS accredited laboratory:

- Total calcium (Ca), magnesium (Mg) and sodium (Na);
- N Species – total nitrogen, nitrate and ammonium;
- P Species – orthophosphate and total phosphorus; and
- Total iron (Fe).

Dissolved and ferrous iron analyses were scheduled in but could not be undertaken by the laboratory due to insufficient sample. This data would have supported interpretation of results if available but is not considered critical for determining the presence or potential sources of diffuse pollution.

2.7 Soil Samples

Soil samples were collected from specific locations on site by hand augering holes into the ground. The soil samples were collected at two depths:

- The rooting zone; and
- A depth of approximately one metre below the rooting zone.

  NB - In the corresponding results tables the samples are differentiated by the suffix 'A' for the rooting zone; and 'B' for below the rooting zone.

Soil samples were analysed for the following suite:

- Moisture Content;
- Extractable nitrogen and phosphorus;
- Total nitrogen and phosphorus; and
- Total calcium (Ca); magnesium (Mg) and potassium (K).

Bulk density analysis was scheduled in but could not be undertaken by the laboratory due to insufficient sample. Total sodium (Na) and total organic carbon (TOC) were not scheduled in properly and analyses were not undertaken. The lack of this data is not considered to affect interpretation of results in terms of determining the presence and potential sources of diffuse pollution.

2.8 Field Observations

On accessing the site for the first visit, and the wider catchment for the second visit, the following field observations were noted:

- Geo-referenced photograph locations of surrounding land use (refer to Figure 2.4 in Annex 1);
- Adjacent land use;
- Identified and potential pollution sources; and
- Atypical or unusual site features (*e.g.* fly tipping, vandalism, *etc*.).

In addition, mapping of the immediate surrounding catchment was completed following the second site visit (see Figure 2.5 in Annex 1). This process utilised the Flood Estimation Handbook (FEH) catchments (CEH, 2009) and Land Cover data (Land Cover Map 2007) to populate GIS mapping. The output was used to aid the interpretation of results and further inform the study conclusions.

3. STUDY LIMITATIONS

The scope of the commissioned study presented a series of limitations which should be borne in mind when reviewing this report. These are outlined below:

- Sampling was undertaken on a single visit. Whilst this afforded consistency for the samples collected, the weather conditions preceding and at the time of the visit may have directly influenced the observations made and the analytical results obtained.

- For the same reasons outlined above, access to certain parts of the site may have been restricted and limited access to the predetermined sampling locations.

- Sampling comprised a single set of samples from each of the pre-determined locations. Repeat or continuous sampling over an extended (seasonal) period would be preferred to enable a greater dataset to be collected. This would present a more representative assessment of the site and allow for seasonal/climatic variations.

- The dataset provides a 'snapshot' of the site condition. Due to the limited availability of historical data (see Section 5) there is very limited scope for comparisons to be made with previous records or allowance for assessment of seasonal or climatic factors.

- The scope of work did not include the assessment of rainfall within the catchment, measure water levels or the inflow(s)/outflow(s) of associated watercourses.

- The limited dataset does not allow for any statistical analysis of the results to be undertaken. No adjustment has been made for anomalous results or to determine trends over time.

- The sampling methodology used to obtain groundwater samples (obtained from a circa. 1m depth coupled with geosock membrane for coarse filtration) typically results in these samples being heavily loaded with suspended solids and organic material meaning that the samples appear 'dirty' to the naked eye. To avoid interference with the laboratory analytical instrumentation and erroneous results, on receipt at the laboratory these are processed on a x10 dilution. It is this dilution process which explains why some of the results are reported as a less than value rather than the equivalent level of detection of 'clean' samples. The same dilution approach is applied to heavy silted surface water samples.

- The weather conditions prior to and during the site visit should be taken into consideration when reviewing the results. According to the Met Office (n.d.) the seasonal rainfall totals for summer, autumn and winter 2012 in eastern Scotland were 161%, 89% and 82% respectively of the annual average rainfall levels for the period 1981-2010. This should be taken into consideration when reviewing the results as it could result in bias when compared with years where average rainfall levels were recorded. The higher rainfall will directly influence runoff, dilution and catchment water levels/throughput which have not been assessed.

- Due to limitations in the mapping data used to compile the FEH catchment boundary, the area defined in the Annex 1 maps does not necessary present an accurate reflection of the hydrological catchment for the site. Whilst this affords a valuable tool for the purposes of this study, the mapped boundary should be viewed as an indicative guide only and be subjected to detailed verification to be considered definitive.

4. ANALYTICAL DATA

The following tables show the results obtained from the initial site visit (Visit 1) in which samples from the pre-determined locations (or as close to as practically possible) were collected. Where the pre-determined locations were not accessible comparable alternative locations with the same habitat features were sampled.

Table figures in red indicate relative atypical (e.g. high or low values) or anomalous results relative to the remaining dataset or which would typically have been expected to be observed from a site of this nature. These are discussed further in section 6.2.

4.1 Field Test Data

Due to issues with the water quality meter, no field test data could be collected. Samples were sent to the laboratory for analysis of pH and electrical conductivity. No data is available for dissolved oxygen and the oxidation-reduction potential as these cannot be determined by the laboratory.

Table 4.1: Water Samples - Field Data and Observations

Temp (°C)	pH	Salinity(psu)	DO (%)	DO (ppm)	ORP (mV)	EC (µS/cm)	General Field Observations
FAILED WATER QUALITY METER / LAB UNDERTOOK pH AND EC							*Groundwater*
FAILED WATER QUALITY METER / LAB UNDERTOOK pH AND EC							*Surface water*
FAILED WATER QUALITY METER / LAB UNDERTOOK pH AND EC							*Surface water*
FAILED WATER QUALITY METER / LAB UNDERTOOK pH AND EC							*Surface water*
FAILED WATER QUALITY METER / LAB UNDERTOOK pH AND EC							*Groundwater*
FAILED WATER QUALITY METER / LAB UNDERTOOK pH AND EC							*Surface water*
FAILED WATER QUALITY METER / LAB UNDERTOOK pH AND EC							*Surface water*
FAILED WATER QUALITY METER / LAB UNDERTOOK pH AND EC							*Surface water*
FAILED WATER QUALITY METER / LAB UNDERTOOK pH AND EC							*Surface water*

4.2 Laboratory Results

The data in the following tables was collected by a suitably qualified operative using the methods outlined in Section 2.

Table 4.2: Water Samples- Laboratory Analysis

Sample ID	Nat. Grid Reference		Sample Type+	Total Ca (mg/l)	Total Mg (mg/l)	Total Na (mg/l)	Total Fe (mg/l)	Amm N (mg/l)	Nitrate as N (mg/l)	Phosphate as P (mg/l)	Total P (mg/l)	Total N as N (mg/l)	pH	EC (uS/cm)
WM01	NJ 72088	32512	GW	78	16	24	55.7	0.63	0.2	<0.01	4.6	12	6.5	278
WM02	NJ 72032	32510	SW (I)	19	6	16	63	<0.01	<0.2	<0.01	2.9	1	6.5	146
WM03	NJ 72200	32616	SW (I)	32	10	17	151	1.1	<0.2	<0.01	3.8	3	6.9	282
WM04	NJ 72466	32627	SW	12	5	13	0.84	<0.01	<0.2	<0.01	<0.1	<1	7.6	182
WM06	NJ 72218	32336	GW	37	9	11	41.3	0.4	<0.2	<0.01	2.9	2	6.8	176
WM07	NJ 72200	32320	SW (OW)	36	9	13	49.8	0.07	<0.2	<0.01	3.6	<1	6.9	187
WM08	NJ 72600	31900	SW (I)	36	12	88	1.79	<0.01	4.7	<0.01	1.2	5	6.8	655
WM09	NJ 72200	32600	SW (I)	42	14	46	2.03	0.06	4.6	<0.01	<0.1	5	7.5	500
WM10	NJ 72700	32800	SW	30	10	17	0.28	<0.01	6.4	<0.01	<0.1	7	7.6	303
													ANALYSED BY LAB	

+ Surface water samples are designated either inflow (I), outflow (O) or open water (OW)
Red figures denote samples that are above typical ranges for the observed dataset
No GW encountered at WM05

Table 4.3: Soil Samples- Laboratory Analysis

Sample ID	Nat. Grid Reference		Soil Type*	Extractable N (mg/Kg)	Total Ca (mg/Kg)	Total Mg (mg/Kg)	Total P (mg/Kg)	Total K (mg/Kg)	Tot Moisture** 105°C (%)	Total N (mg/Kg)	Nitrate (mg/l)	Nitrogen (%)	Extractable P (mg/l)
WM01A	NJ 72088	32512	Black organic silt	0.6	11000	1730	395	125	79.6	<0.8	<0.2	2.24	3.38
WM01B	NJ 72088	32512	Slightly sandy organic silt	<0.5	9060	1650	280	73	77.1	<0.7	<0.2	1.96	<2
WM05A	NJ 72500	32700	Black organic silt	1.2	5940	1760	924	431	64.7	1.5	0.3	1.78	<2
WM05B	NJ 72500	32700	Slightly sandy organic silt	0.8	7510	4010	384	872	72.1	<0.7	<0.2	0.88	<2
WM06A	NJ 72218	32336	Black fibrous peat	0.6	10900	1840	459	226	74	<0.8	<0.2	2.33	<2
WM06B	NJ 72218	32336	Slightly sandy organic silt	<0.5	10100	1820	355	248	85.9	<0.7	<0.2	2.11	<2

** Soil types are field observations*
*** Total Moisture = Water content*
*A/B suffix: **A** = Rooting Zone and **B** = Below Root Zone*
Red figures denote samples that are above typical ranges for the observed dataset

5. SITE OBSERVATIONS

To enhance understanding of Wartle Moss and the surrounding area, preliminary research was undertaken and complemented with a second site walkover to further understand the landforms, drainage configurations, potential environmental sensitivities and possible diffuse pollution sources influencing the site.

5.1 Desk Study

The Site Management Statement (SNH, 2011b) records an 'Objective for Management' of retaining the wetland habitats of the basin mire. It says attempts should be made to slow down, or even reverse the drying out of the moss in order to maintain the swamp and fen vegetation present on site.

Site Condition Monitoring was undertaken for the Basin Fen feature in 2010, and concluded that Wartle Moss remained in unfavourable declining condition due to encroaching scrub. Possible contributing factors would be a reduced water table, natural succession and nutrient inputs. Raising of water levels through damming, scrub control and addressing nutrient enrichment issues were recommended (SNH, 2010).

Clearing out the drainage ditches that border the moss is believed to have contributed to lowering its water table. Longer term nutrient enrichment through drainage ditches is also believed to have affected the spread of scrub on the moss and the plant communities (SNH, n.d.). Spoil from the clearance of drains has sometimes been dumped on the SSSI (SNH, 2011b).

Raising of water levels through damming, scrub control and addressing nutrient enrichment issues has been considered to improve conditions. No management agreement is in place at the site (SNH, 2010).

5.2 Catchment Walkover

From the second site visit post-receipt of the analytical results, the following observations of the surrounding catchment were made:

- The site was free of litter. No visible pollution sources were observed within the site boundary.
- Drainage ditches run through the site and are present along the site boundaries. They appear to be for agricultural purposes.
- During the visit to site, surface runoff from the B9001 was observed.
- Stagnant water was observed in the ditch to the west of the railway which traverses the western section of the site.
- A wind turbine was in proximity to the site but it is located downstream of the site.
- The fields to the east of the site boundary are used for arable purposes. Fields to the south of the site are improved pasture for grazing purposes.
- There are a series of farms and properties located adjacent to the eastern and southern site boundaries. Private septic tanks are therefore assumed to be present.

5.3 Summary

The following table provides a summary the key site features which were observed during the site visits or identified in the desk study undertaken as part of the initial study.

Table 5.1: Summary of key observations

Activities	Observations
Ditches	Agricultural drainage ditches are present on site.
Fencing	The site is partially fenced.
Fishing	N/A
Grazing	South eastern corner of the site is grazed by sheep. Fields adjacent to southern boundary also used for grazing purposes. Grazing and arable land in wider catchment
Monitoring	Site Condition Monitoring was carried out in 2001 and 2010.
Public Access	The site has no formalised public access.
Shooting	Rough pheasant and partridge shooting takes place on site. The site is also used for Roe Deer stalking.
Point Pollution Sources	None observed within the SSSI boundary. Highway drainage from the B9001 and A920. Drainage from the dismantled railway.
Properties in Catchment	There are no properties within the site boundary. Colyhill, Toll House, Drum of Cartle, Moss Side Croft and Northfield are located in proximity of the site.
Unusual, Distinctive or Atypical Features	A dismantled railway traverses the western section of the site. Properties surrounding the western site boundary are likely to have private septic tanks present.

A mapped summary of the perceived catchment pressures is detailed in Figure 5.1 (see Annex 1).

6. INTERPRETATION OF RESULTS

The following assessment is based on the field tests and laboratory analytical results only.

6.1 General Summary

Nitrate levels were generally elevated in the surface water samples of inflowing water, while the groundwater samples saw elevated ammonium levels which reflect the typical prevailing redox conditions in both these distinct environments (ammonium generally present in anaerobic conditions). This would be mainly associated with agricultural practices in the catchment. Nitrate levels within the inflows are generally higher than within the wetland, which would suggest migration of nitrate from offsite and storage of nutrients on the site.

The water quality probe failed whilst on site. pH and electrical conductivity were analysed by the laboratory, with regards to dissolved oxygen due to the transient nature of this parameter it was not possible to accurately obtain this from the subsequent laboratory analysis. pH across the site is generally uniform ranging from slightly acid at 6.5 to slightly alkaline at 7.6, which is consistent with the basic nature of underlying bedrock.

The highest calcium and total phosphorus levels in groundwater samples are noted to coincide with the same samples e.g. WM01 which may suggest the presence of insoluble calcium phosphate minerals, as expected in the presence of basic rock. Phosphate levels are noted to be below the analytical level of detection in all samples, indicating low bio-availability.

Iron levels in water samples were elevated, specifically of note, in the surface water samples, with sample WM03 reaching a level of 151mg//l which is considerably higher than groundwater samples recovered across the site and may reflect localised variations in geochemistry. It is noted that this sampling location is located in close proximity to the former railway line and may be a result of leaching of materials used for the embankment. It is also noted that the next two highest iron readings (WM02 and WM01) are in close proximity to the former railway.

Although relatively high levels of total phosphorus were recorded in the soil samples, all samples with the exception of WM01 recorded low levels of available phosphorus indicating the majority is immobile within the soils. WM01 only recorded available phosphorus within the root zone.

6.2 Atypical Results

No obviously atypical results were recorded from the soil or water samples at Wartle Moss, with the exception of the significantly elevated iron recorded at WM03. From the limited data set the only observations of note are discussed below:

- The highest calcium and magnesium were recorded within the groundwater sample WM01 indicating natural mineral enrichment from groundwater, reflecting the basic, nutrient rich nature of underlying bedrock.

- The highest sodium value was recorded at WM08 and may indicate the influence of road runoff in surface water within this area.

- The highest total iron levels were recorded at WM03 within the drainage ditch in proximity to the former railway line which suggests that there may be leaching of iron from materials associated with the railway.

- The highest total phosphorus and nitrogen are both recorded within WM01 on the western side of the former railway and may be attributed to agricultural and forestry drainage in the surrounding area.

- The highest ammonia and nitrate levels in surface water are found in inflows on the eastern side of the railway track and would be attributable to underlying bedrock (phosphorus only) and agricultural drainage in the surrounding area.

- The highest extractable and total nitrogen was recorded in WM05 within the root zone sample. There is no obvious sources for this and may reflect either the effects of nitrate rich surface water enriching the soils or natural variation.

- WM01A recorded the highest calcium and is likely to reflect the natural geology of the area.

- Highest total phosphorus in soils was noted in the below root zone of WM05 and the highest available phosphorus noted in the below root zone of WM01, both within the wetland, also suggesting accumulation of nutrients on the site.

7. CONCLUSIONS

The analytical results showed a trend of elevated nutrients within the site, particularly at the inflows and in soils. This would mainly be a consequence of agricultural activities in the catchment and a basic, nutrient-rich underlying geology.

The site sits in a basin and collects drainage from a 10km^2 catchment, dominated by arable land with extensive field drainage. It is split into two parts by a dismantled railway line (built before 1873), with birch woodland to the west and basin mire moss to the east. The area was extensively cut over for peat extraction until the mid-1800's and was then flooded. Drainage from a large part of the catchment is diverted north along the railway embankment and enters the eastern part of the site at the northern corner, by-passing most of the wetland. The Red Burn flows along the northern boundary of the site, without entering the wetland during normal flow conditions.

Nitrogen levels are typically elevated in inflows, and lower in water within the site, suggesting accumulation/storage of nutrients in the wetland. Evidence of agricultural improvements and limited forestry in the wider catchment – and particularly to the west - is expected to have resulted in an accelerated nutrient inflow to the site. Nutrients and suspended solids have been flushed down to the site and partially 'filtered' by the wetland as solids settled and nutrients were fixed by vegetation. This, combined with a reduced water table, is leading to woodland encroachment at the site.

Whilst high levels of total phosphorus were recorded in the soil samples, low levels of bio-available phosphorus were encountered, indicating the majority is immobile within the soils. This is likely in part associated with the nutrient-rich underlying geology.

Several properties with septic tanks located in close proximity of the site are potentially contributing further nutrients. There will be some runoff from roads to the south and east, which could contribute solids and other contaminants.

Elevated levels of iron were recorded in proximity of the dismantled railway, suggesting pollution from this source.

8. RECOMMENDATIONS

Based on the understanding gained from the sampling exercise and catchment visits, the following recommendations are proposed:

8.1 Monitoring

i. Undertake a long-term targeted monitoring study at selected locations within the site for key nutrients – to include orthophosphate and bioavailable (extractable) nitrogen. Ideally this would be undertaken over the course of several seasons (ideally for a minimum of one year). This should be compared alongside groundwater levels, rainfall data and seasonal abnormalities to seek to understand the nutrient dynamics taking place within the site.

ii. In conjunction with (i), assess the seasonal flow and nutrient loads of the main unnamed inflows and groundwater to the west and south of the site.

8.2 Other Commissioned Studies

iii. Undertake hydrological and hydrogeological assessment of the contributing catchment in order to determine the quality and quantity of the source flows. Assess the potential effects on hydrology and nutrient regime of raising the water table on the site and/or re-directing drainage under the railway line, mimicking original drainage patterns.

iv. Assess the link between vegetation encroachment and diffuse pollution and the impact of managing vegetation.

v. Undertake a detailed library review, including historical mapping and local data sources, to seek to understand historical land use and information relating to the site, including peat cutting, railway construction and drainage on the site and its surrounds.

8.3 Landowners

vi. Proactively engage with local landowners to understand the existing and (foreseeable) proposed changes to the immediate catchment including field usage, crop type and fertiliser/soil conditioning approaches. Consider appropriate management strategies accordingly - for example, nutrient management planning, buffer strips, exclusion zones, routine spot monitoring, improved/repaired fencing, improved use of fertilizers, treatment of outflows e.g. constructed wetlands *etc*.

vii. Review issues with removal and disposal of accumulated material from adjacent drains. Investigate offsite disposal options, so as not to recirculate the removed nutrients, and the potential impact of drainage works on water levels within the site.

viii. Proactively engage with catchment landowners to understand the historical land use practices to determine any changes which are likely to have influenced the site.

ix. Review the existing road drainage network surrounding the site, and determine the feasibility of integrating appropriate SUDS measures (e.g. Swales) for retention and treatment of runoff in line with current road drainage guidance (WSP, 2009).

x. Review the forestry management practices undertaken within the wider catchment.

xi. Engage with surrounding households to ensure septic tanks are adequately maintained.

8.4 External Consultations

xii. Engage with SEPA to discuss the options regarding regulatory controls on the use of nutrients in the catchment for agricultural purposes (site is in a Nitrate Vulnerable Zone).

From the stated conclusions and identified pressures (Figure 5.1) the key actions to seek to reverse the present declining status of the site are to:

1. Ascertain the link between this decline and diffuse pollution (i, iii, iv);
2. Assess potential impacts of raising the water table and/or removing vegetation (iii, iv); and
3. Address the inputs to the surface water and groundwater from agricultural (and other) activities within the wider catchment as required (vi, vii, ix, xi).

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ANNEX 1: FIGURES

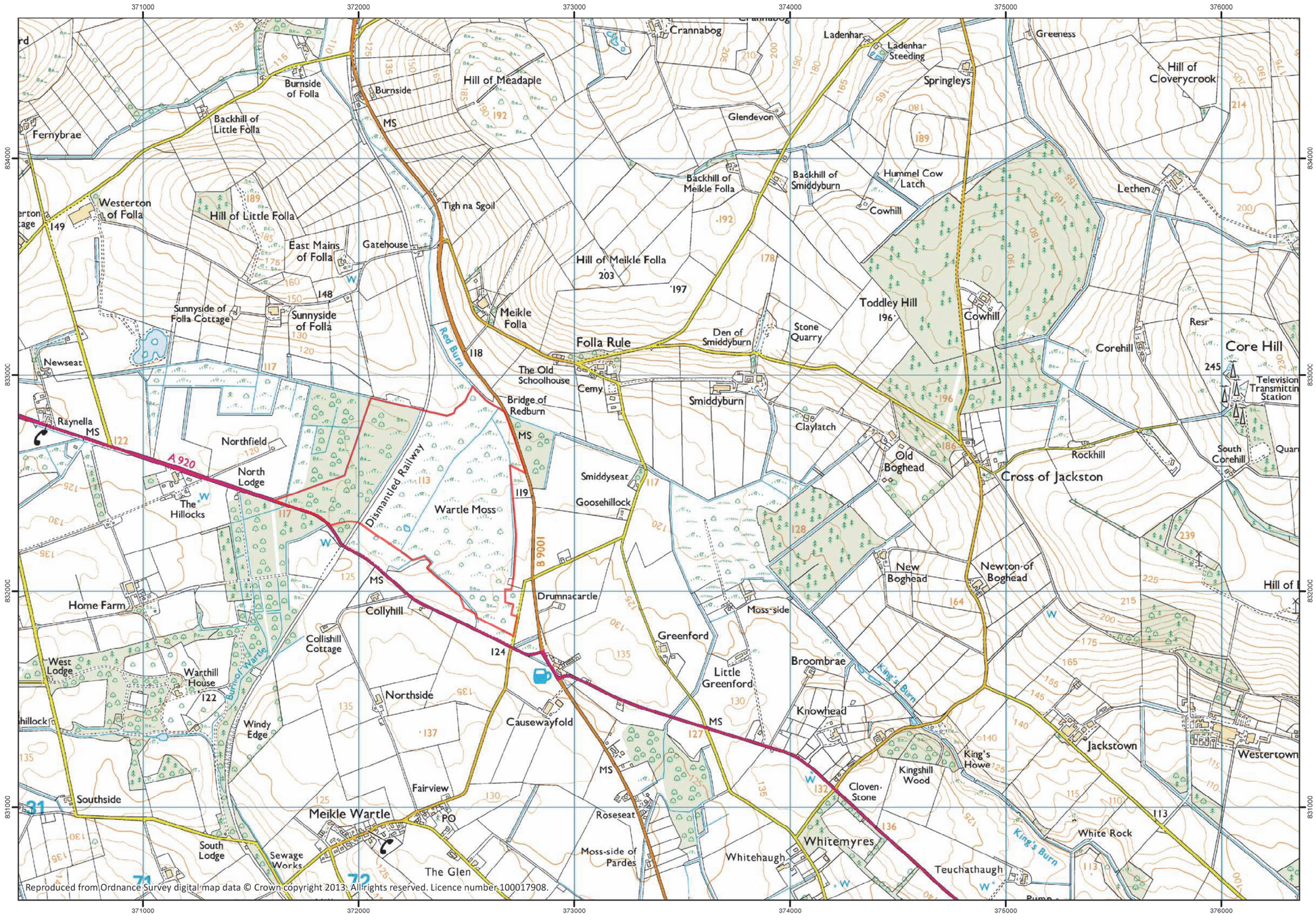
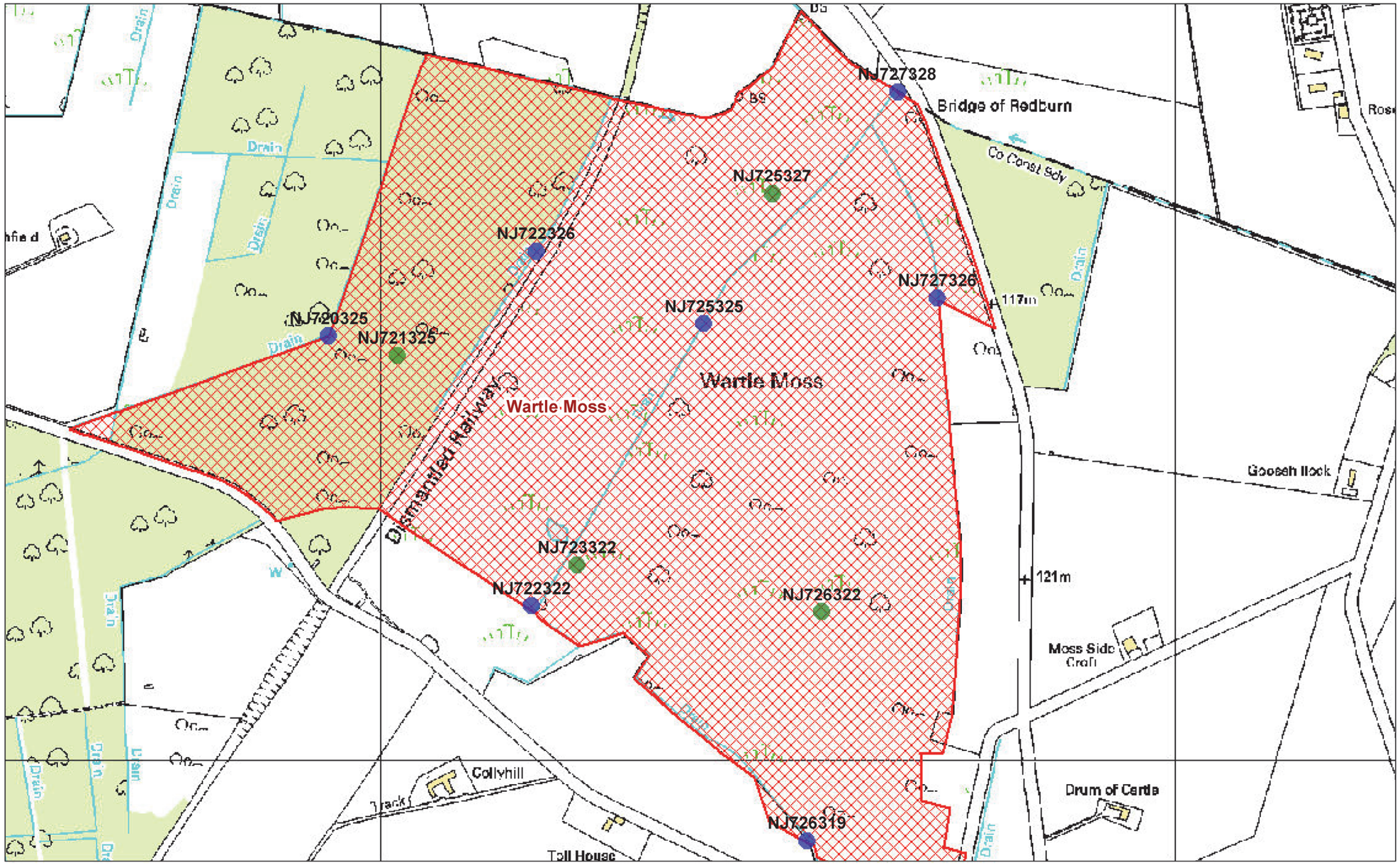


Figure 1.1: Site Location Map



Notes:

Map produced using geo.View 3.0
Printed: Sep 19, 2012 14:28:58

Figure 2.1: SNH Proposed Sample Location Plan

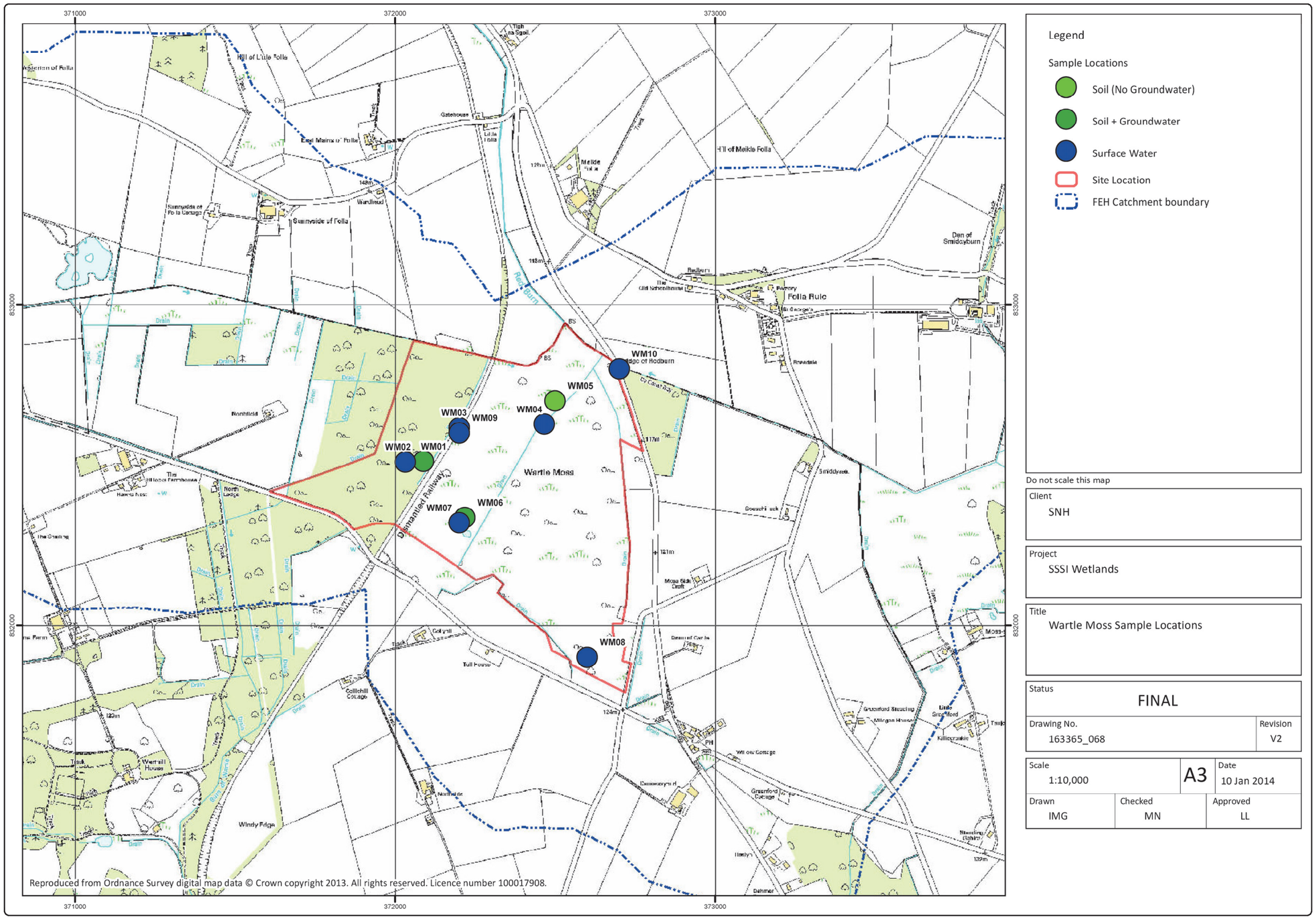
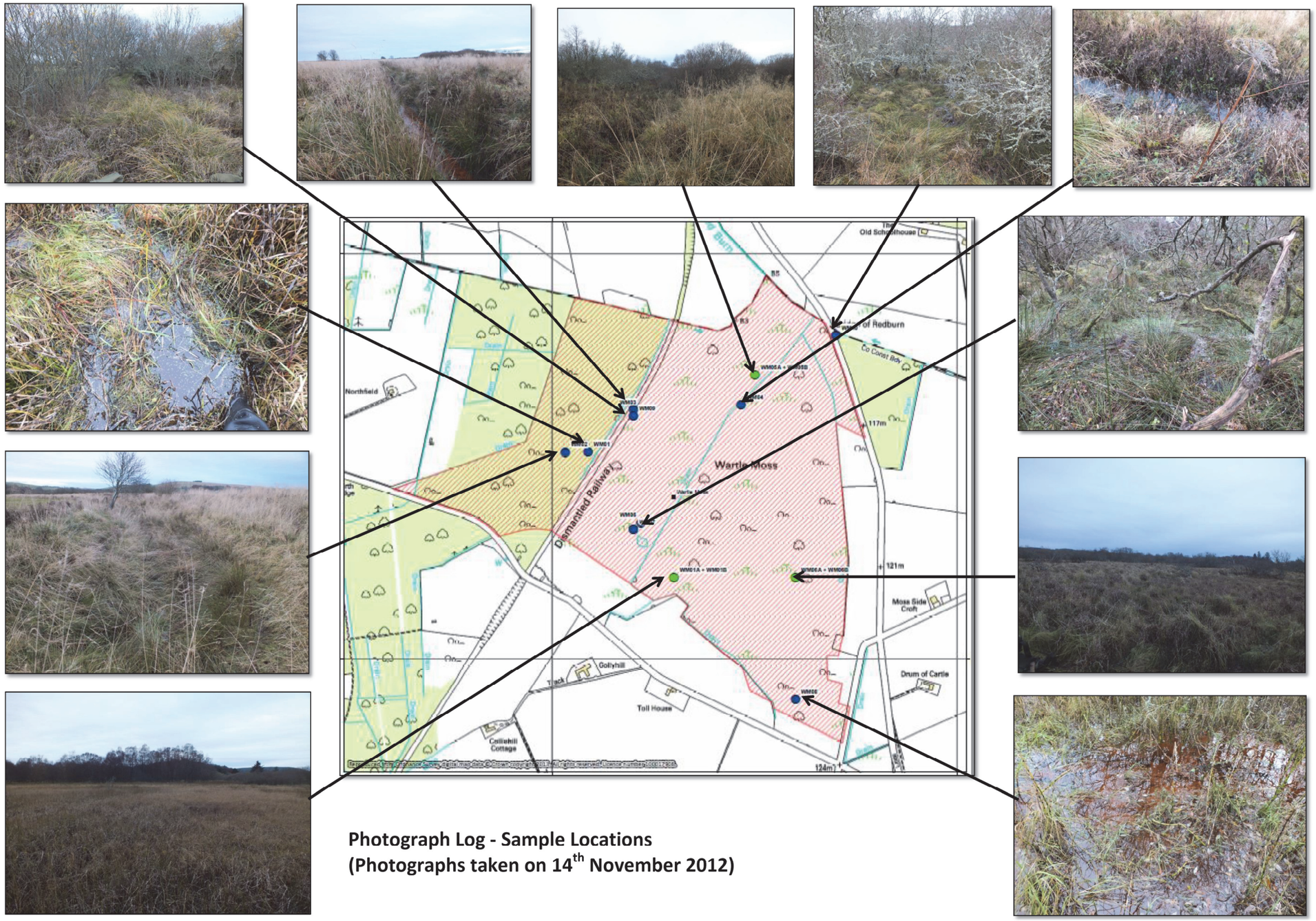


Figure 2.2: Plan of Actual Sampled Locations



Photograph Log - Sample Locations
(Photographs taken on 14th November 2012)

Figure 2.3: Sampling Location Photograhs

Figure 2.4: Surrounding Land Use Photographs

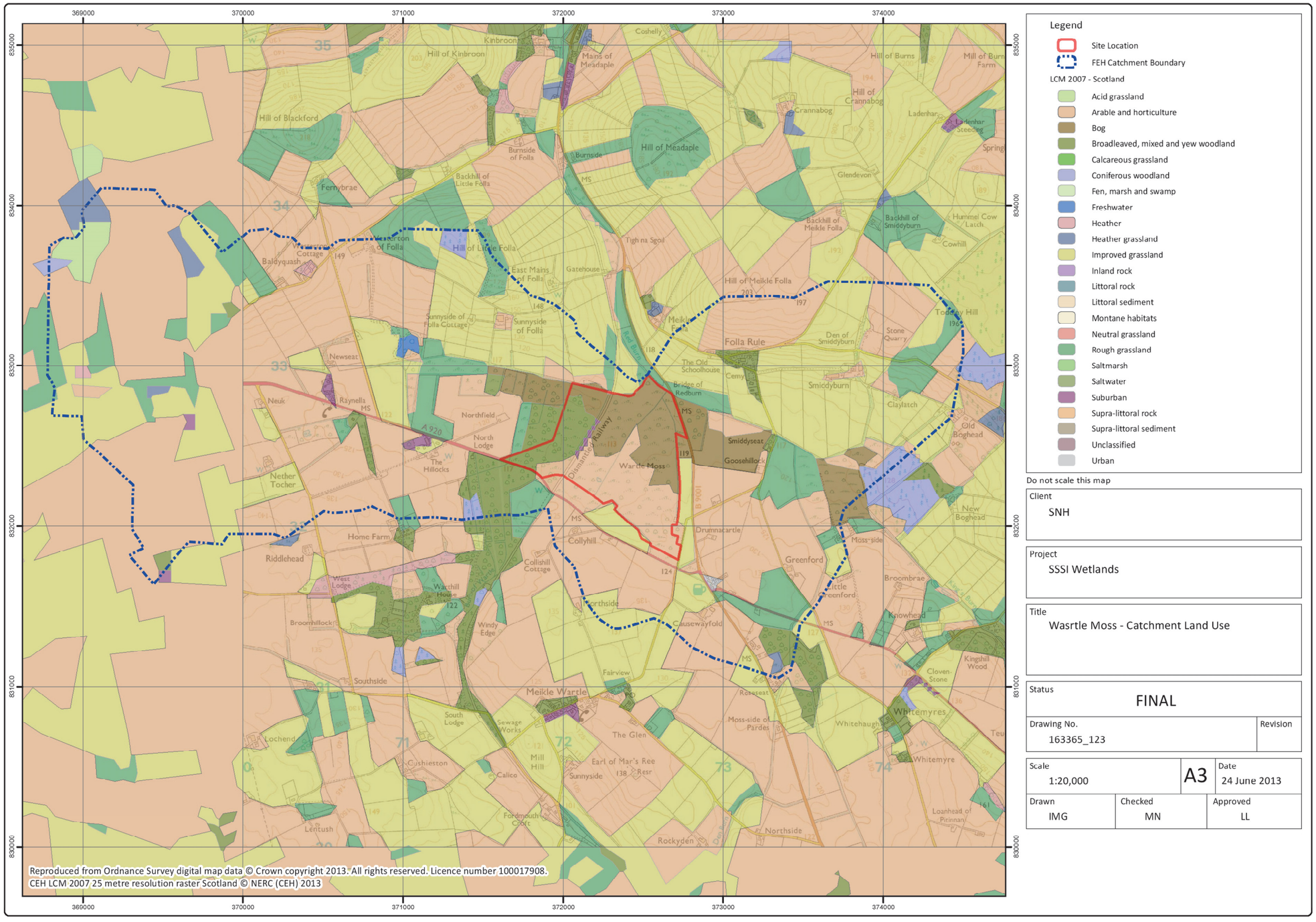


Figure 2.5: Catchment Land Use Characteristics

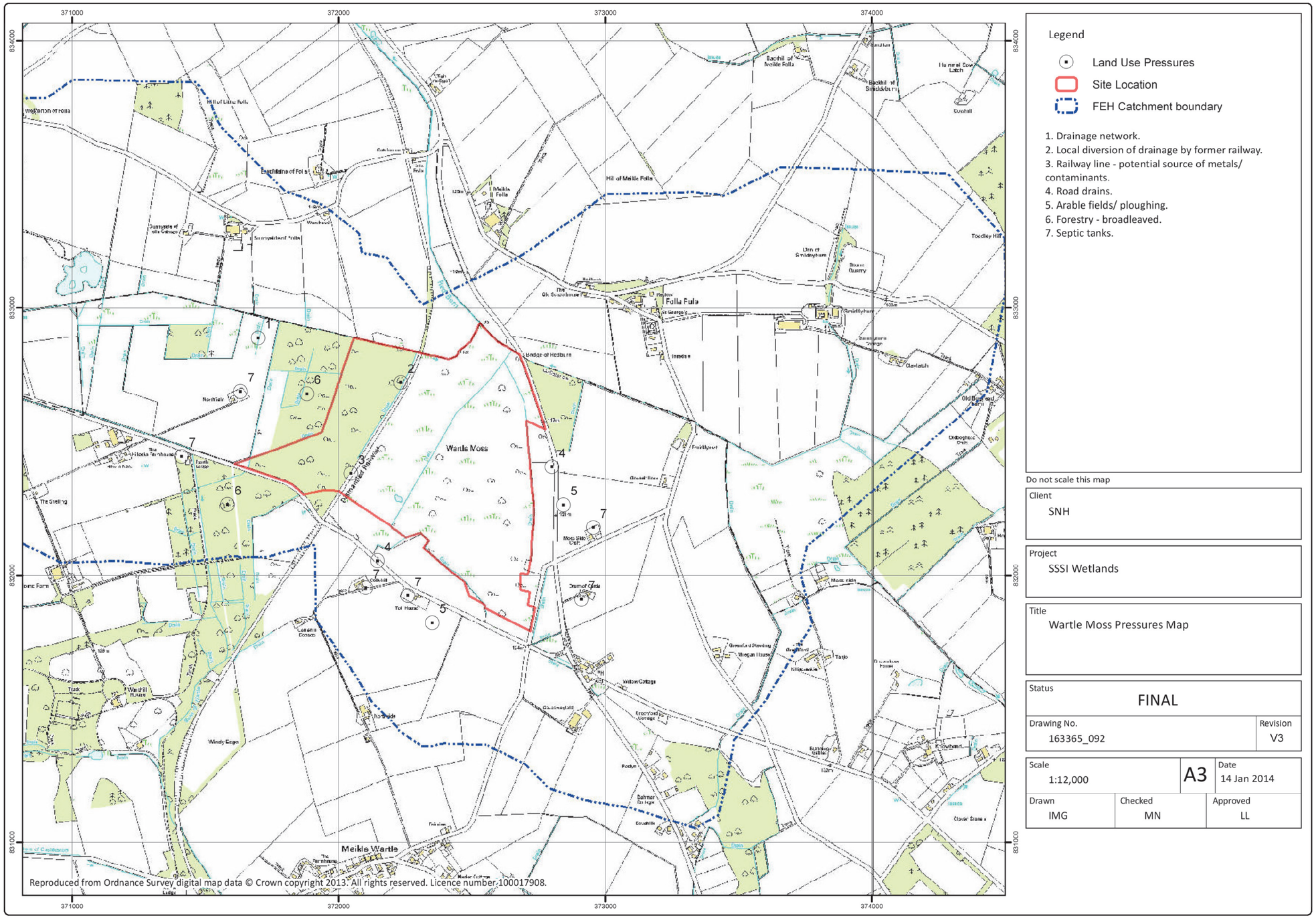


Figure 5.1: Catchment Pressures Land Use Summary

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