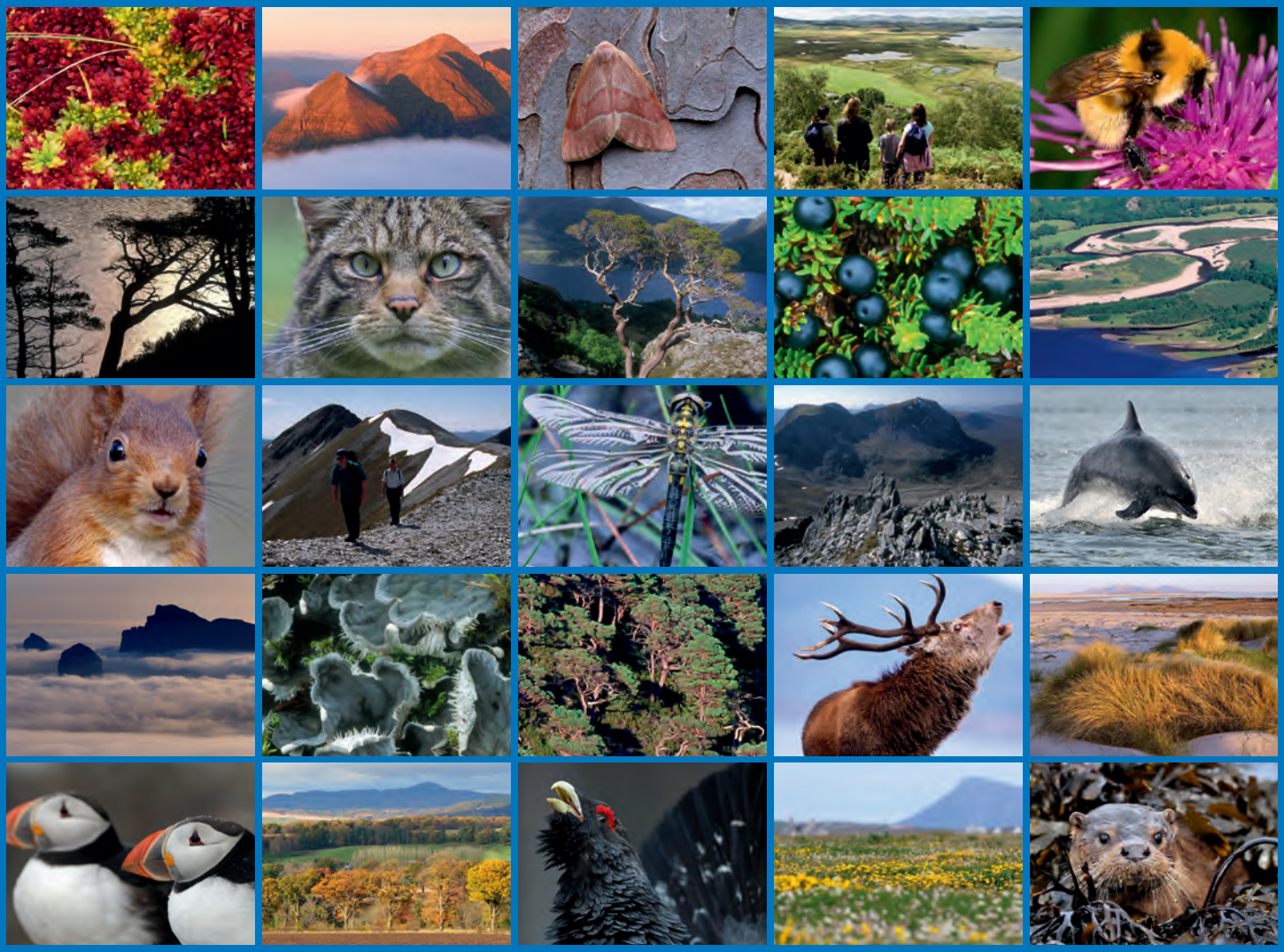
Scottish Natural Heritage
Commissioned Report No. 720

Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Connachan Marsh



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COMMISSIONED REPORT

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Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Connachan Marsh

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COMMISSIONED REPORT

Summary

Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Connachan Marsh

Commissioned Report No. 720
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 (SSSI) across Scotland that they thought may 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 limited 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 land owner 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 wetland and standing water Sites of Special Scientific Interest (SSSI).

1.1 Site Location

Connachan Marsh is located 6km north east of Crieff, adjacent to the A822. See Figure 1.1 in Annex 1.

1.2 Site Description

The 23.31 ha site is situated at an altitude of approximately 230m on a saddle on the Almond-Earn watershed. The site is important as an area of raised bog with peripheral lagg fen, a particularly rare habitat in Great Britain (SNH, 2007a and b).

The raised bog is dominated by heather *Calluna vulgaris* and common cotton-grass *Eriophorum angustifolium* with a number of *Sphagnum* mosses, including *S. magellanicum* as well as cranberry *Vaccinium oxycoccus*. The surrounding lagg fen, an integral part of the raised bog interest, is dominated by bottle sedge *Carex rostrata* but includes more local species such as slender sedge C*arex lasiocarpa* and lesser tussock sedge *Carex diandra*. Surrounding the bog are areas of scrub woodland, mainly birch *Betula pubescens* and willow *Salix cinerea.* A small area to the south of the bog has been invaded by *Phragmites* reeds, spreading via a culvert under the A822 road (SNH, 2007b).

The bedrock geology to the north and west of the site takes the form of Arbuthnott-Garvock Group Andesite and Basaltic Andesite. To the south and east of the site the geology is composed of conglomerates from the Arbuthnott-Garvock Group and Strathmore Group. Basalt dykes are present further west. There are no significant superficial deposits present on site (British Geological Survey, n.d.).

1.3 Site Hydrology

A catchment area of 1.99km^2 drains to the site, with an annual average rainfall of 1,183mm (Centre for Ecology and Hydrology, 2009). The main inflows to the site are from two springs on the southern hillslope, and two on the northern hillslope. Additional inflow to the site is provided by field drains and overland flow from adjacent farmland. The main outflows from the site are two drains that flow east into the Fendoch Burn, a tributary of the River Almond. One runs across the middle of the site, the other along the northern edge.

1.4 Site History

Parts of the SSSI are grazed by sheep, cattle and ponies, although this has been reduced in recent years. As a consequence, and in conjunction with the drying out of the bog through drainage, birch scrub is starting to colonise the bog surface. Grazing to help control scrub was discussed with the tenant in November 2006, but it seems unlikely that there will be any increase in current levels. (SNH, 2008)

In 1999, under an SNH Management Agreement, some birch and willow scrub within the lagg fen was felled and the stumps treated (SNH, 2007b).

1.5 Recent Site Management Practice

The tenant has consent for grazing (SNH, 2008). The site does not appear to be currently within any SNH Management Agreement or other agri-environment scheme.

There is a wayleave across the eastern end of the site, and scrub is regularly cleared from this area (SNH, 2007b).

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

Connachan Marsh	Date of Visit	Weather Conditions	Grid References
Visit 1	15 November 2012	Cold, overcast, drizzle	NN 895268
Visit 2	20 February 2013	Cold, overcast, dry	NN 895268

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 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 (Centre for Ecology and Hydrology, 2009) catchments 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 location.

- 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 1.4) 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, measured 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 Flood Estimation Handbook (FEH) catchment boundary, the area defined in the Annex 1 maps does not necessarily 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 Water Quality Field Data

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

Table 4.1: Field Data

Sample ID	Nat. Grid Reference		Temp (°C)	pH	Sal (%)	DO (%)	DO (ppm)	ORP (mV)	EC (mS/ cm)	Comments
CM01	NN 89034	26713	10.64	7.4	0.09	78.9	8.11	225	0.173	Surface water - clear; no visible s/s; no odour
CM02	NN 88984	26692	10.98	6.85	0.05	60.5	7.43	170	0.098	Surface water - very light brown discolouration with only very few fine s/s; no odour
CM03	NN 89108	26583	10.31	6.15	0.03	65.9	8.11	237	0.060	Groundwater - light cloudy brown with fine brown s/s; very mild organic (sulphur) odour
CM04	NN 89870	26894	10.29	6.47	0.10	88.0	9.77	241	0.208	Surface water - clear with a few fine s/s; no odour
CM05	NN 89782	26841	10.63	6.32	0.04	40.4	4.64	165	0.093	Groundwater - dark cloudy brown, large brown s/s; very mild organic (sulphur) odour; limited water available
CM06	NN 89682	26872	10.51	6.49	0.09	81.7	9.00	151	0.200	Surface water - clear with few minor s/s; no odour
CM07	NN 89598	26647	10.48	7.00	0.04	88.8	9.84	136	0.074	Surface water - very slight brown discolouration; no odour; some very fine s/s
CM09	NN 89500	26696	10.4	5.31	0.02	23.8	2.48	255	0.048	Groundwater - dark, cloudy brown with fine brown s/s; very mild organic (sulphur) odour

Red figures denote samples that are above or below typical ranges for the observed dataset

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 Analysis

Sample ID	Nat. Grid Reference		Flow 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)
CM01	NN 89034	26713	SW (I)	21	5	5	<0.01	<0.01	1	<0.01	<0.1	1
CM02	NN 88984	26692	SW (I)	9	3	4	6.17	0.22	<0.2	<0.01	0.2	1
CM03	NN 89108	26583	GW	4	1	4	1.3	0.6	<0.2	<0.01	0.8	5
CM04	NN 89870	26894	SW (O)	20	6	7	0.28	<0.01	1.2	<0.01	<0.1	2
CM05	NN 89782	26841	GW	16	4	10	24.3	1.8	<0.2	<0.01	1.5	15
CM06	NN 89682	26872	SW (O)	21	6	8	0.32	<0.01	1.1	<0.01	<0.1	1
CM07	NN 89598	26647	SW(I)	7	2	4	0.26	<0.01	<0.2	<0.01	<0.1	<1
CM09	NN 89500	26696	GW	5	2	3	8.08	0.1	<0.2	<0.01	1.3	13

+ Surface water samples are designated either inflow (I) or outflow (O)
Red figures denote samples that are above typical ranges for the observed dataset.
No shallow groundwater was encountered at CM08 and therefore no sample could be taken at this location.

Table 4.3: Soil Sample 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)
CM03A	NN 89100	26500	Fibrous peat	1.8	5920	1370	553	433	78.1	<2	<0.2	1.6	7.35
CM03B	NN 89100	26500	Fibrous peat	0.6	2850	937	288	121	74.1	<0.8	<0.2	1.45	5.56
CM05A	NN 89800	26800	Wet dark grey/black organic silt	1	3890	3160	1170	944	74.9	<1.2	<0.2	1.8	2.04
CM05B	NN 89800	26800	Wet dark grey/black organic silt	0.7	5810	3160	947	650	67.7	<0.9	<0.2	2.01	<2
CM08A	NN 89600	26700	Wet dark grey/black organic silt	1.1	3090	13400	786	1670	51.2	1.8	0.7	0.72	<2
CM08B	NN 89600	26700	Wet dark grey/black organic silt	0.9	4290	8800	1040	1180	66.5	<1.1	<0.2	1.17	<2
CM09A	NN 89500	26600	Fibrous peat	1	1950	2540	577	519	85.1	<1.2	<0.2	1.24	4.28
CM09A	NN 89500	26600	Fibrous peat	0.9	1930	934	293	162	81.1	<1.1	<0.2	1.45	3.27

** 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 Connachan Marsh 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, 2007b) records an 'Objective for management' of maintaining the extent and condition of the raised bog and lagg fen by controlling scrub and tree regeneration on the raised bog, and by maintaining the water table. This document also states that land use pressures such as agricultural runoff were not deemed to be an issue at Connachan Marsh.

The raised bog is in unfavourable declining condition due to the increase in birch scrub on the mire and common reed within the lagg (SNH, 2008). There has been no reduction in the area of bog, and plants indicative of an active raised bog (i.e. one still accumulating peat) are present.

The most recent Site Condition Monitoring assessment (SNH, 2008) indicated that scrub encroachment on the raised bog and spreading of common reed within the lagg are the main pressures identified at the site.

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 northern boundary. They were noted to be partially infilled with sediments and vegetation.
- An unnamed burn runs along the western boundary, without entering the raised bog under normal flow conditions.
- During the visit to site surface runoff from the A822 was observed.
- There is no formalised public access to the site.
- The area immediately to the west of the site was noted to be very wet and artificially drained, with presence of cattle and significant trampling. This could be leading to transport of sediments and infilling of nearby drains.
- The fields surrounding the site and within the site catchment are used for grazing, with improved pasture mainly to the north and rough pasture to the south.
- The Foulford Inn is located immediately to the south east of the site and Connachan Farm is located to the north west. Private septic tanks are assumed to be present.
- A disused quarry is located in proximity of the north western corner of the site.
- A golf course is located to the south east of the site, outwith the site catchment.

5.3 Summary

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

Table 5.1: Summary of key observations

Activities	Observations
Fencing	The site is mostly fenced.
Fishing	N/A
Grazing	Part of the site is grazed by sheep, cattle and ponies (reduced in recent years, insufficient to help control scrub). Improved pasture in wider catchment, mainly in northern part and to the south. Significant trampling by cattle to the west of the site
Monitoring	Condition Monitoring was carried out in 1999 and 2008.
Public Access	The site has no formalised public access.
Shooting	None on site.
Point Pollution Sources	None observed within the SSSI boundary. Road drainage from the A822 and limited runoff from track to the west.
Properties in Catchment	There are no properties within the site boundary. Connachan Farm and Foulford Hotel are located in proximity of the site and are expected to have septic tanks.
Unusual, Distinctive or Atypical Features	Golf course to the south east but located outwith the site catchment. A disused quarry is located in the catchment of the site, to the northwest. Drainage ditches cross the site.

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

The surface water quality at the site was deemed to be generally good with moderate levels of nutrients. Groundwater showed elevated levels of both nitrogen and phosphorus, particularly in the central and eastern part of the site.

pH values were typically slightly acidic (6.15) to slightly alkaline (7.4) with the lowest pH recorded in groundwater at CM09 (5.31). Groundwater dissolved oxygen levels were typically lower as would be expected.

Calcium levels were noted to be highest in the eastern part of the site (CM04, CM05 & CM06) with similar levels recorded in groundwater and surface water. Iron was notably higher in the majority of the groundwater samples, which is likely a consequence of more reducing conditions given low dissolved oxygen concentrations. The highest iron was recorded in CM05 in the eastern part of the site.

The highest levels of total nitrogen were recorded in groundwater samples, with CM05 and CM09 recording particularly elevated levels. The highest levels of nitrate were recorded in the surface water samples and were all recorded around the same level at each location. The highest ammonia levels were recorded within groundwater samples. The distribution of nitrate and ammonia reflects the prevailing geochemical conditions in these environments (oxidising in surface water, reducing in groundwater).

Total phosphorus was generally low in surface water, with elevated levels recorded in groundwater, again highest at CM05 and CM09. Phosphate was below the level of detection in all samples, indicating low bioavailability.

In soils, the highest total phosphorus was noted in the root zone of CM05A with the highest available phosphorus recorded in CM03A also in the root zone. Samples CM05B, CM08A and CM08B were all below the detection levels of available phosphorus.

6.2 Atypical Results

Although not necessary atypical, the following values were noted to be significantly higher than their counterparts at other site locations:

- The lowest pH and dissolved oxygen were both recorded in groundwater sample collected at CM09. The low oxygen is expected in such environments isolated from the atmosphere. The acidic pH recorded is likely attributed to the presence of peat within the sample.

- Total Nitrogen and phosphorus in CM05 was noted to be the highest at 15mg/l and 1.5 respectively. The highest ammoniacal nitrogen level of 1.8mg/L is also recorded in this location. It is unclear what the source of the elevated nitrogen may be, but horses were grazing in this area which could be one source, and there may be septic tanks associated with the hotel to the south. High nitrate values in surface water samples (CM04 and CM06) may also be attributable to these sources.

- Elevated extractable nitrogen and phosphorus were recorded at CM03A within the root zone samples. This may highlight the influences of cattle grazing on site.

- Calcium was also noted to be elevated in CM03A, but this is considered to reflect the influence of local geology on the soils. This influence is also noted for potassium and magnesium at CM08A where the highest levels were recorded.

- Total nitrogen and nitrate recorded highest levels at CM08A this may indicate enrichment through grazing of the land in this area.

6.3 Additional considerations

The site is not within a SEPA ‘priority catchment operational area’ and SEPA do not plan to carry out inspections in this area.

7. CONCLUSIONS

The analytical results showed a trend of low nutrient levels in surface water at the site. Soil pore water on the site showed elevated levels of both nitrogen and phosphorus, albeit bioavailable fractions were generally low.

The site sits in a basin and collects drainage from a 2km^2 catchment, dominated by improved and rough pastures. There are only two properties in proximity of the site, which could potentially contribute nutrients through septic tanks. There is also some runoff from a road to the south and a track to the west, which could contribute solids and other contaminants. Trampling by cattle to the west of the site could also be a source of solids and nutrients.

Total nitrogen and phosphorus levels were generally low in surface water, including inflows at the time of monitoring. The highest levels of these substances were recorded in groundwater samples, particularly in the central and eastern part of the site. Phosphate was below the level of detection in all samples, indicating low bioavailability.

Elevated levels of nutrients in groundwater in the bog suggest historical accumulation from nutrients derived from grazing on the site and in the wider catchment. Grazing was noted to have reduced in recent years, which could have reduced the input of nutrients.

The 2008 condition assessment undertaken by SNH indicated that there has been no reduction in the area of bog, and plants indicative of an active raised bog are present, which also suggests that there are no significant nutrient enrichment issues at the site. However, the raised bog is in unfavourable declining condition due to the increase in birch scrub on the mire and common reed within the lagg. Given the history of the site, it is considered likely that this increase in vegetation is due to reduced grazing, albeit the expansion of common reed is often attributed to raised nutrient concentrations in water. Any drying out of the site due to the presence of the drains crossing the site would also contribute to an expansion of scrub.

Analysis undertaken on the site only provided a snapshot of water quality conditions and further monitoring should be undertaken at the site for more definitive conclusions.

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 (e.g. for 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. In conjunction with this, assess the seasonal flow and nutrient loads of the inflows.

8.2 Other Commissioned Studies

ii. Undertake hydrological and hydrogeological assessment of the contributing catchment in order to determine the quality and quantity of the source flows.

8.3 Management

iii. Review the policy for the removal of site vegetation and the methods used to control/manage such. Where future management practices require such, vegetation should be cut and removed from site instead of chemical applications or burning. Consideration should be given to the removal at the root zone rather than the cutting of above ground stem and should be followed by appropriate off-site disposal.

8.4 Landowners

iv. Proactively engage with local landowners to understand the existing and (foreseeable) proposed changes to the site and immediate catchment including grazing intensity, drainage and fertiliser/soil conditioning approaches. Consider appropriate management strategies accordingly - for example, scrub control, ditch blocking, nutrient budgeting, re-routing of road runoff, buffer strips, exclusion zones, reduced load of cattle in very wet areas, routine spot monitoring *etc*.

v. Proactively engage with catchment landowners to understand the historical land use practices to determine any changes which are likely to have influenced the site, particularly the reduction of grazing.

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

From the stated conclusions and identified pressures (Figure 5.1) the key action to seek to reverse the present declining status of the site is liaison with landowners over actions to reduce birch scrub (cutting or grazing and maintenance of water levels on site) and maintaining low nutrient input to the site (no poaching/trampling and nutrient budgeting, buffer strips etc) (iv).

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ANNEX 1: FIGURES

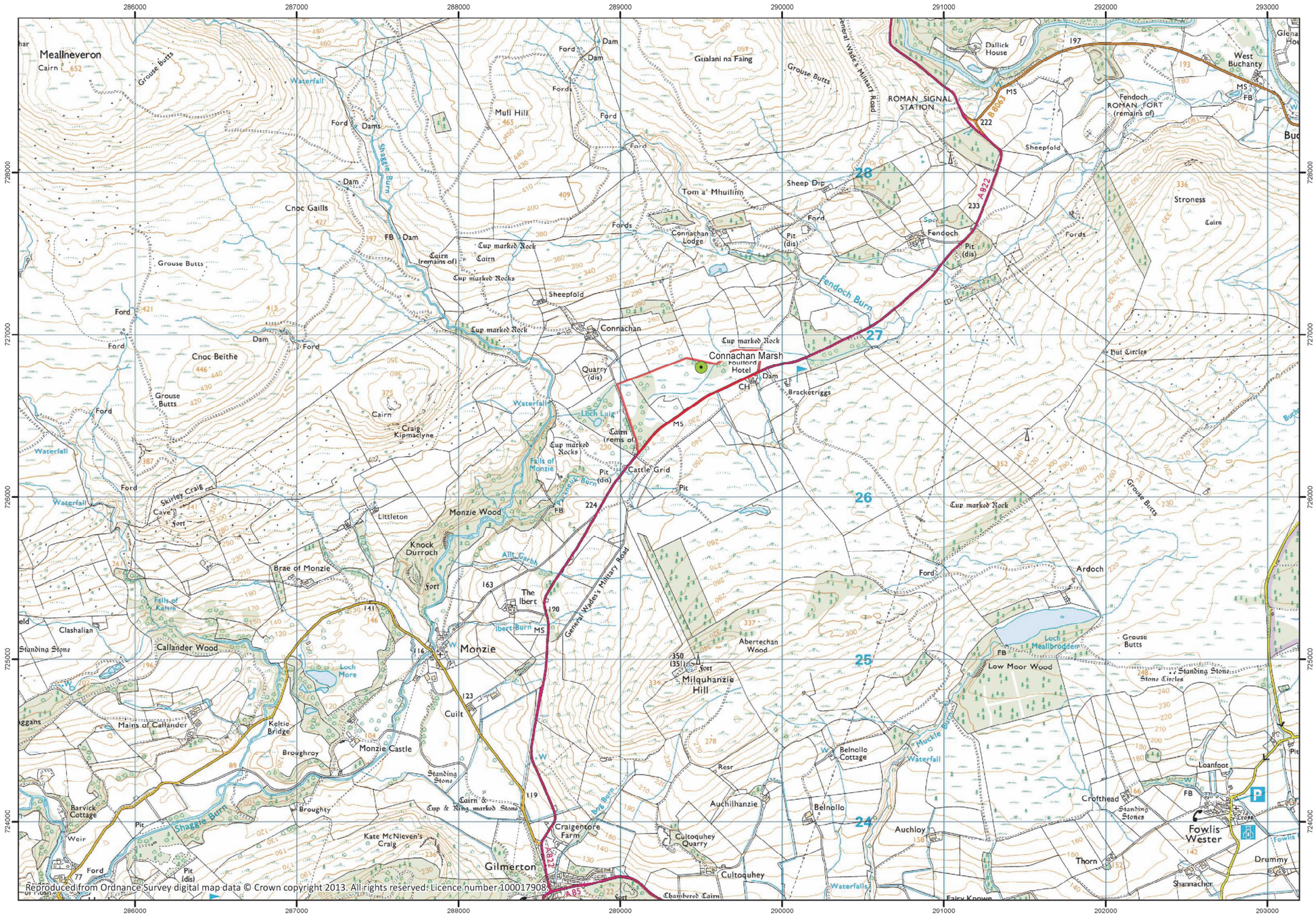

Figure 1.1: Site Location Map

Connachan Marsh

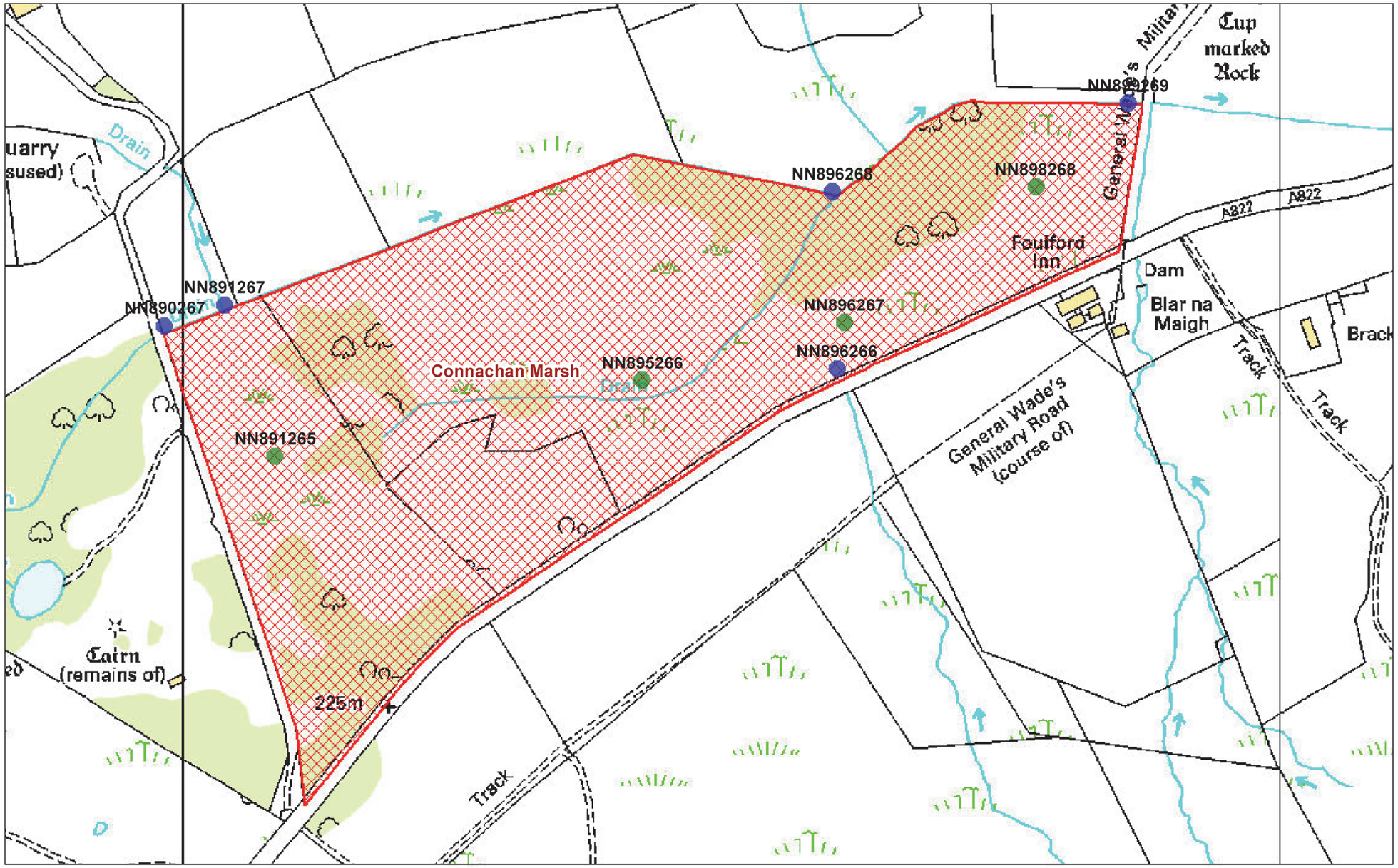

Figure 2.1: SNH Proposed Sample Location Plan

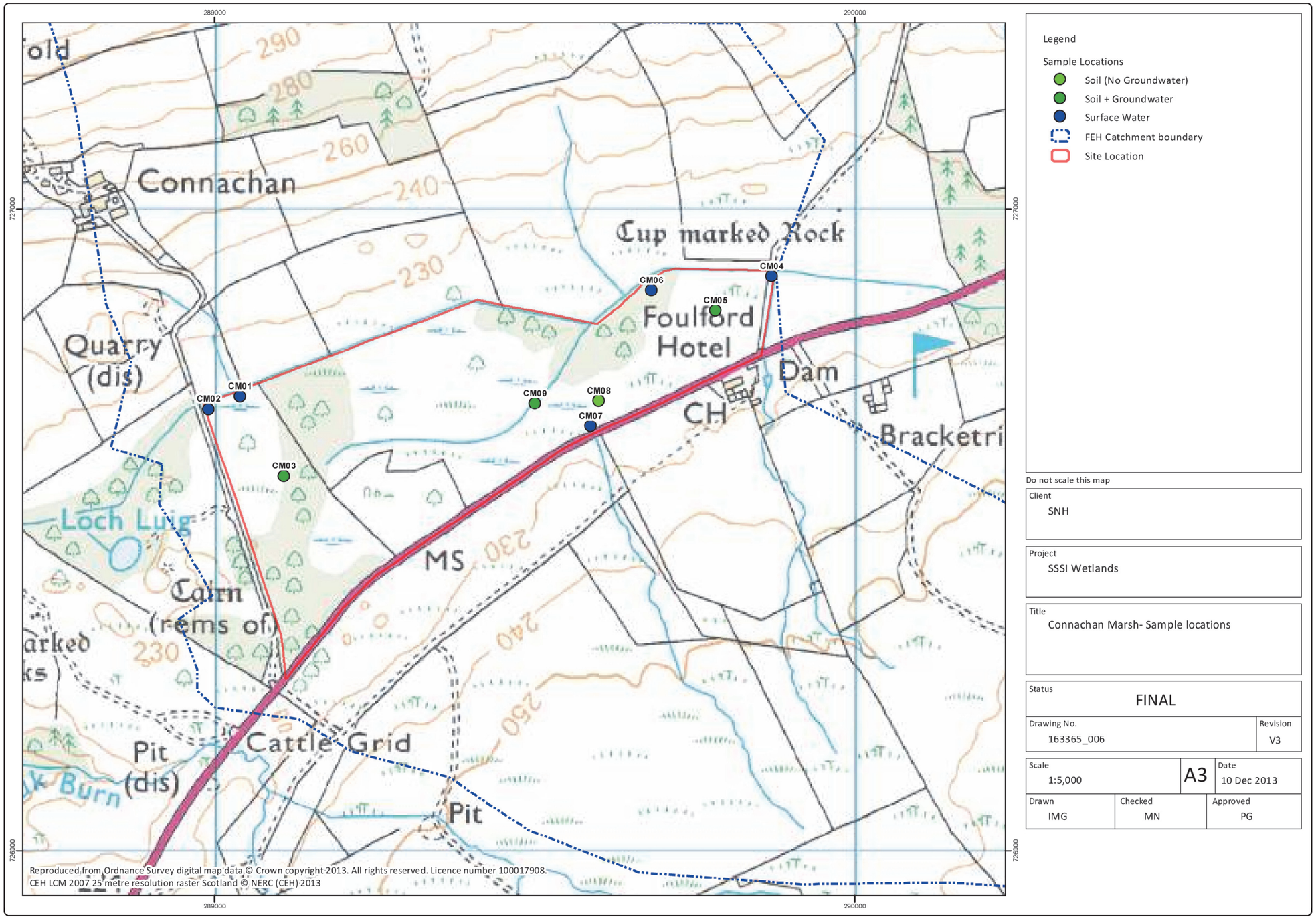

Figure 2.2: Plan of Actual Sampled Locations

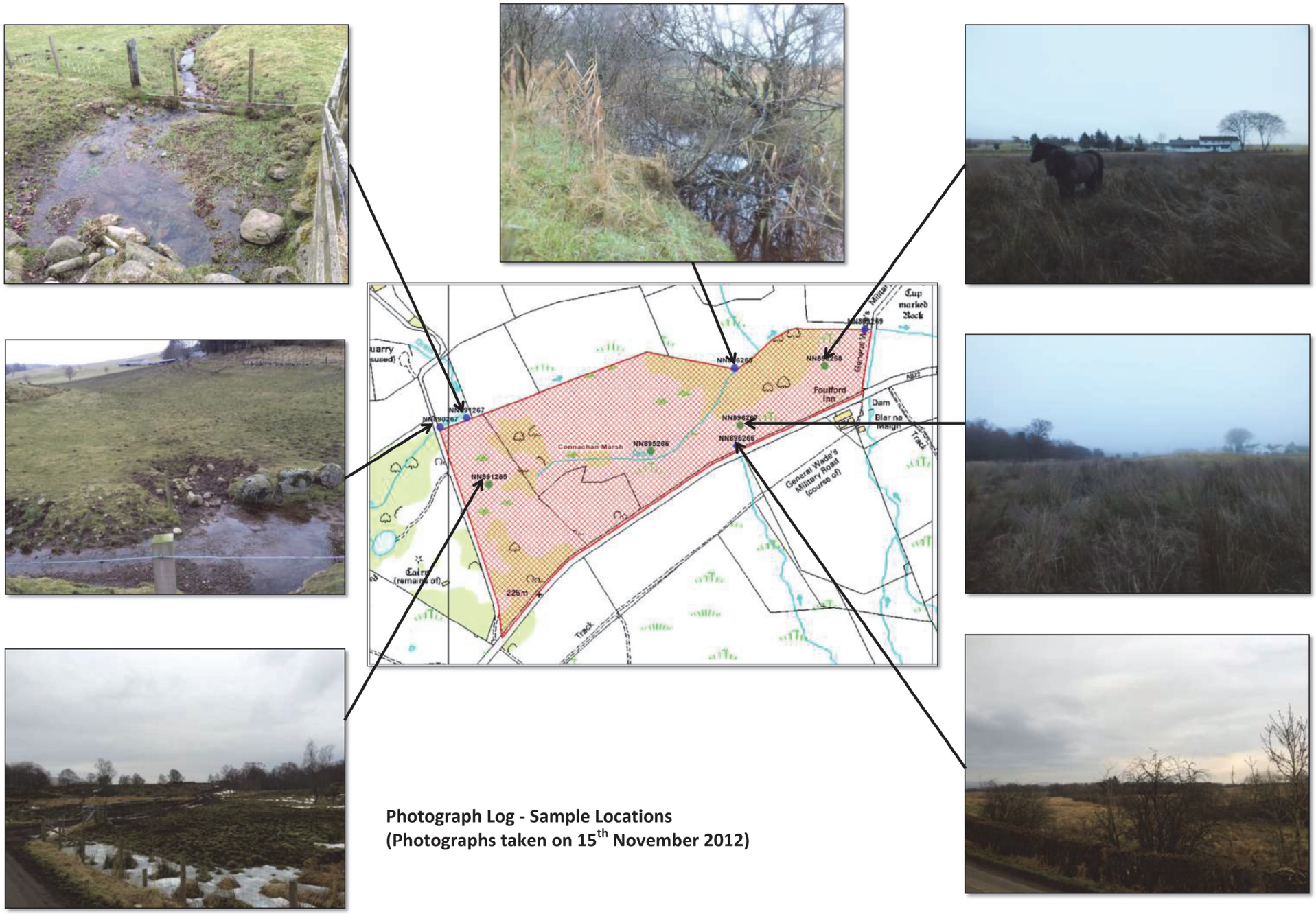

Figure 2.3: Sampling Location Photographs

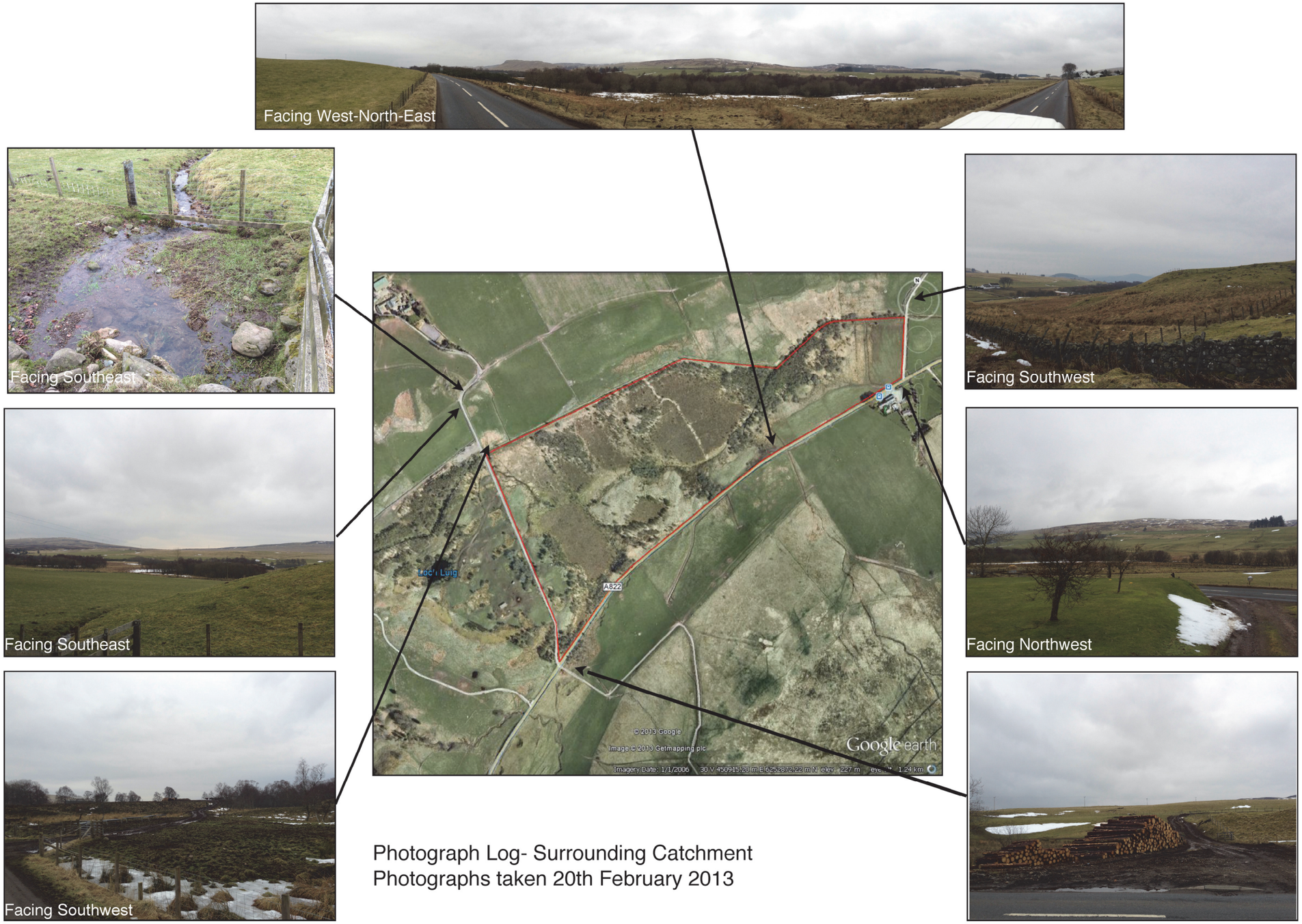

Figure 2.4: Surrounding Land Use Photographs

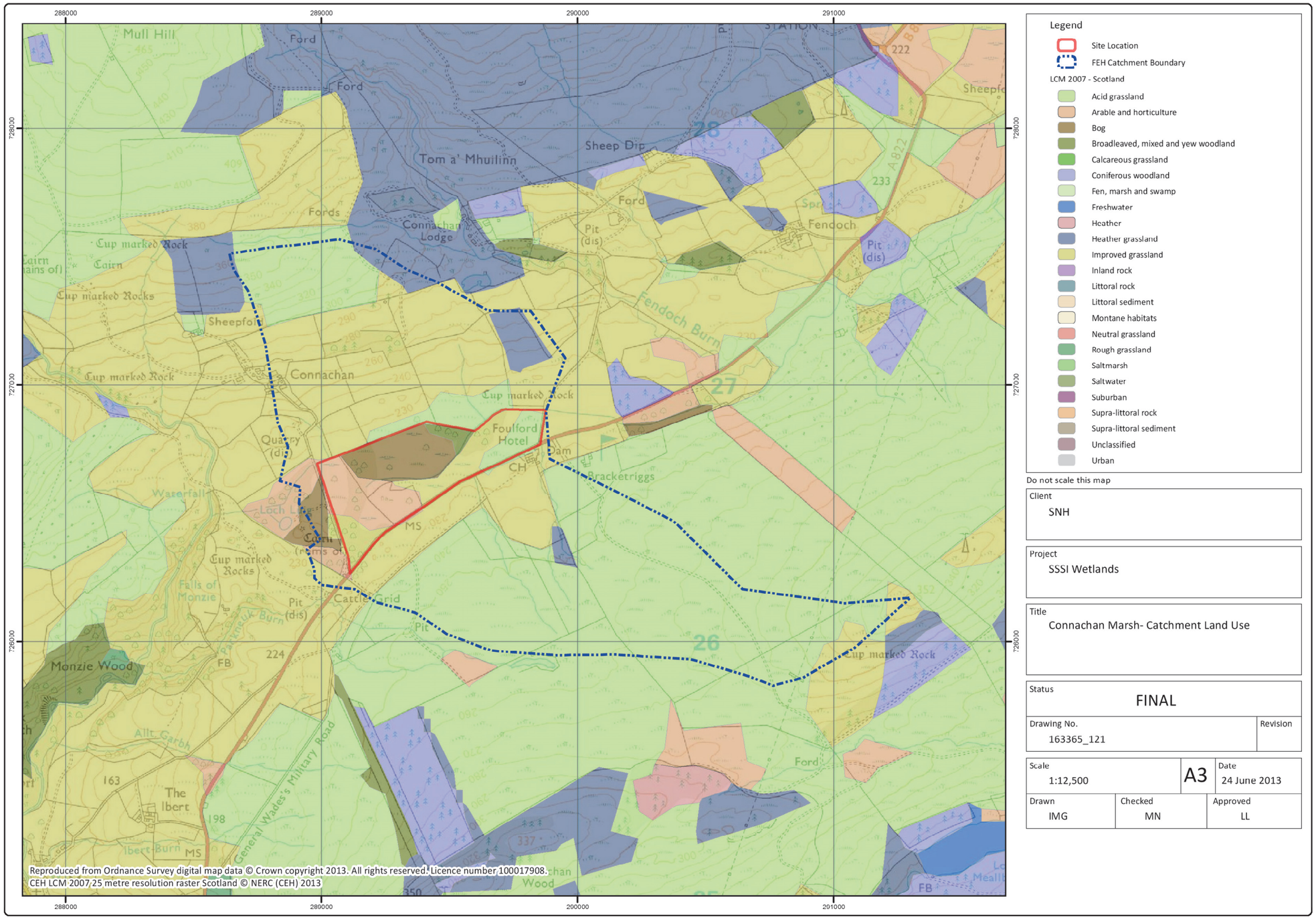

Figure 2.5: Catchment Land Use Characteristics

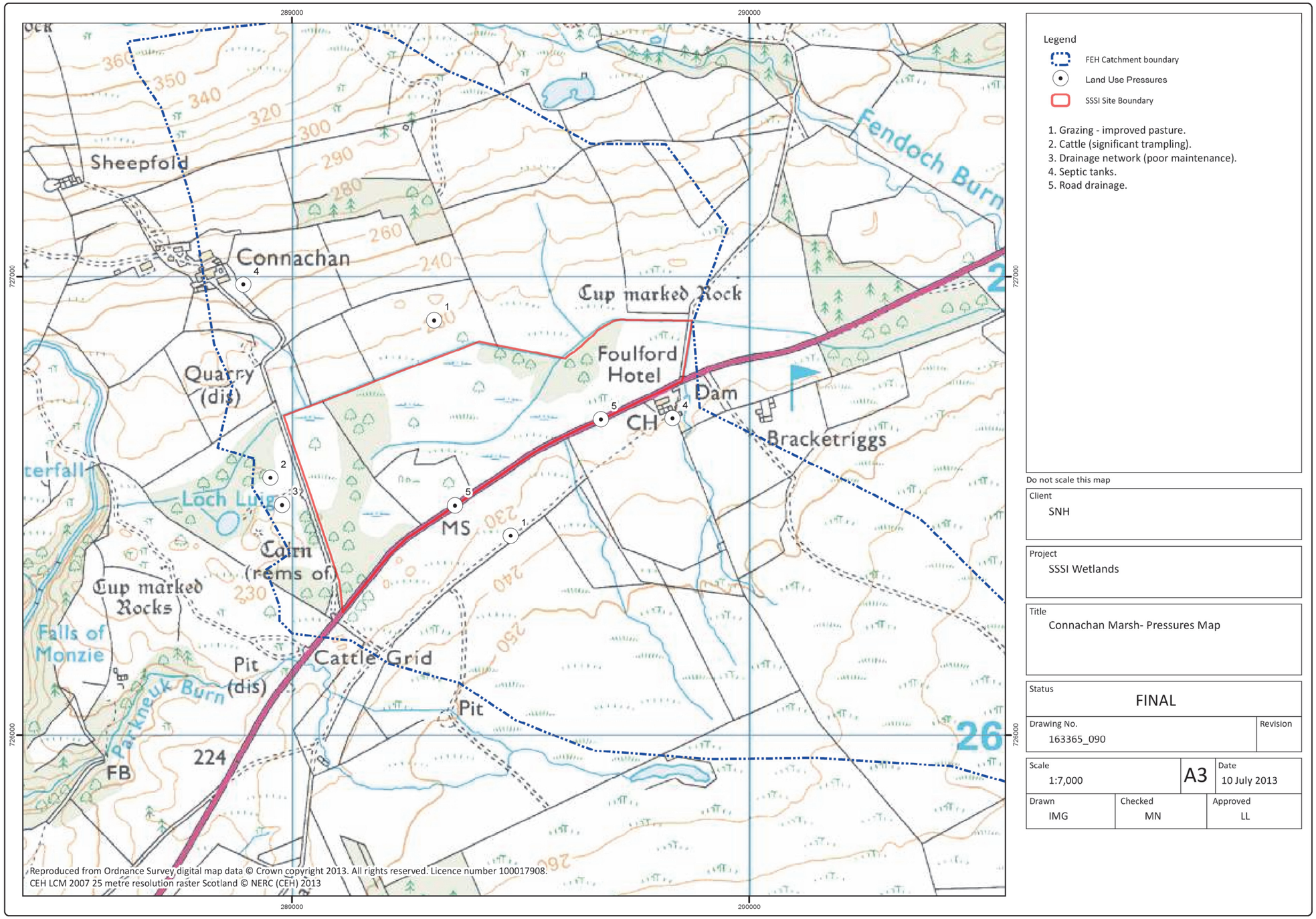

Figure 5.1: Catchment Pressures Land Use Summary

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