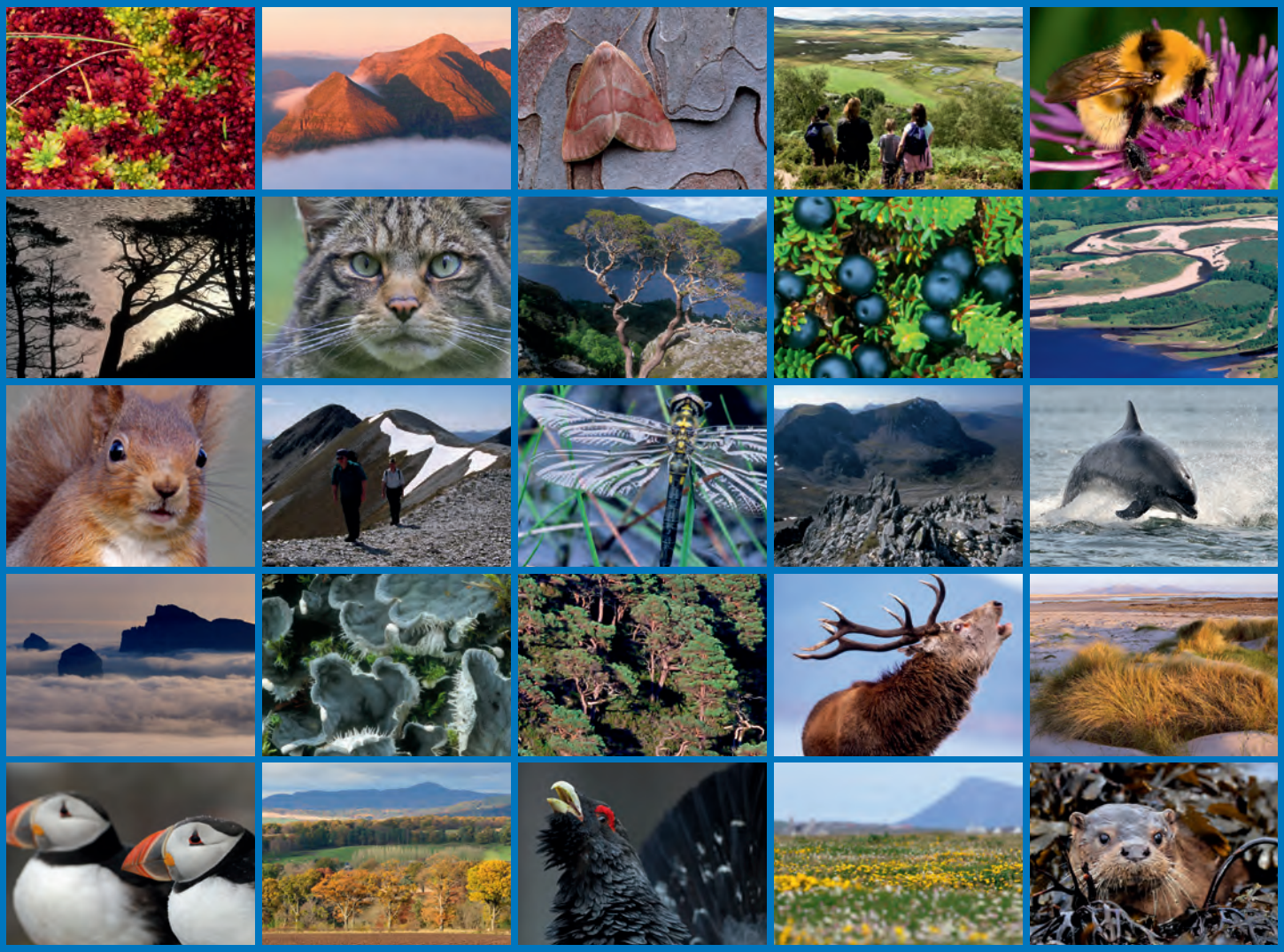
Scottish Natural Heritage
Commissioned Report No. 713

Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Ardblair and Myreside Fens



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COMMISSIONED REPORT

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COMMISSIONED REPORT

Summary

Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Ardblair and Myreside Fens

Commissioned Report No. 713
Project No: 13700
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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 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 inform their work with managers of the sites to improve their conditions.

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 and also, potentially, urban sources from Blairgowrie.
- 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

Ardblair and Myreside Fens is located approximately one kilometre west of Blairgowrie, immediately south of the A923 in Perth and Kinross. See Figure 1.1 in Annex 1.

1.2 Site Description

The site is split into two sections, Moss of Ardblair in the west and Myreside in the east. It has been designated for its basin fen and fen meadow features. The measured area of site is 13.12 hectares (SNH, 2010a).

The site is an undisturbed wetland site consisting of four shallow basins and is important for its range of fen communities which are uncommon within the Perth and Kinross area, in particular areas of basin fen and fen meadow. For such a small site there is a wide range of plant communities including sedge swamp and fen, willow carr and reed swamp as well as the sedge-dominated fen meadow (SNH, 2010b).

The areas of basin fen within the site have formed in hollows left after the last glaciation. They contain a wide range of vegetation types including alder/willow carr, species-rich sedge swamp dominated by bottle sedge C*arex rostrata*, and unimproved grassland. This habitat diversity is reflected in the large number of higher plant species which includes several rarities. Moss of Ardblair is the only rich-fen basin mire in the district containing greater tussock sedge *Carex paniculata.* There are good examples of hydroseral succession to a range of swamp and mire communities. The fen meadow at Myreside is one of very few in Perth and Kinross and is unusual in northern Britain (SNH, 2010a).

The bedrock geology across the majority of the site consists of the Teith Sandstone Formation. Sandstone from the Scone Sandstone Formation is present to the north west of the site. Peat is the dominant superficial deposit across the site, with Glaciofluvial sands, gravel and silt present elsewhere (British Geological Survey, n.d.). The peat deposits in the moss overly a blue-grey lake clay (Wheeler and Tratt, 1995).

1.3 Site Hydrology

A catchment area of 1.77km^2 drains to the site with an annual average rainfall of 781mm (Centre for Ecology and Hydrology, 2009). The main inflows to the site are from field drainage and overland flow from adjacent farmland. The general flow direction through the site is from east to west. An area of standing water is present to the south of Ardblair Castle. The main outflow from the site is in the north western corner, draining to Rae Loch further west.

1.4 Site History

Until 1963 the Myreside area of the site, including the fen meadow, was actively managed by hay making and extensive grazing with cows. From then to the 1990's there was little active management of the site as a whole. The Moss of Ardblair is too wet to graze with stock. Although various attempts at drainage are believed to have been made in the past, water levels appear to have risen in the last 50 to 100 years. Most recently a new drain was dug around the south edge of Ardblair Moss on the inside of the new fence and parallel to the old

drain. This is a catch drain to prevent water logging of the adjacent fields. In 1984 the boundary fence for Moss of Ardblair was realigned. In 2003 Japanese knotweed was found growing on the southern side of the Myreside site which is part of the fen meadow feature. This was treated with a glyphosate based herbicide to eradicate it (SNH, 2010b).

It is not clear whether peat has been removed from the site. It does seem, however, that the peat level has been reduced by shrinkage or peat removal and that this may have facilitated the maintenance of the present wetness of the site. Prior to drainage the vegetation consisted of lawns of brown mosses. When the site was drained the moss lawns and pools were lost, being replaced by a sedge dominated plant community and tree cover of the surrounding area also increased. The site then re-flooded, probably due to gradual blocking of the drains, and the vegetation became dominated by sedges (Wheeler and Tratt, 1995).

1.5 Recent Site Management Practices

Previous site condition monitoring was undertaken in 2003. During this monitoring period the basin fen was classed as being in unfavourable declining condition, this was mainly due to scrub invasion. Some scrub has been removed and this has helped move the basin fen back towards favourable condition.

A recent management agreement funded fencing, gates and a water source to help facilitate grazing within the Myreside section of the site; Moss of Ardblair being too wet to graze with stock.

In 1999 nineteen sheep grazed the Myreside section for 6 weeks. Due to the loss of one sheep, cattle were thought to be more suitable so in autumn 2000 two cows grazed the site for 2 months. In 2001 there was no stock grazing as a result of foot and mouth. Since then it was intended that the Myreside section of the SSSI should be grazed by a few cattle every autumn for about 6 weeks, but in recent years this has not proved possible. Other site land uses include; bee keeping, pheasant rearing and shooting and dumping of inert agricultural waste (SNH, 2010b).

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 of 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

Site Visit	Date of Visit	Weather Conditions	Grid References
Visit 1	15/11/2012	Cold, overcast with drizzle	NO 164445
Visit 2	27/02/2013	Clear, mild and sunny	NO 164445

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. No samples were taken from standing water.

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 (CEH), 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 (Site 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 or observations relative to the collected dataset or which would typically be expected from a site of this nature. These are discussed further in section 6.2.

4.1 Field Test Data

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

Table 4.1: Water Samples - Field Data

Sample ID	Nat. Grid Reference		Temp (°C)	pH	Salinity (psu)	DO (%)	DO (ppm)	ORP (mV)	EC (mS/cm)	General Field Observations
AM01	NO 16791	44622	11.09	7.16	0.13	65.9	8.59	264	0.290	Surface water - clear with some minor s/s; no odour
AM03	NO 16874	44470	10.81	6.98	0.23	19.8	2.18	295	0.479	Groundwater - dark, cloudy brown with fine brown s/s; very mild organic (sulphur) odour
AM04	NO 16882	44480	10.77	7.02	0.13	51.5	5.83	293	0.284	Surface water - light brown discolouration with some fine s/s; slight organic (sulphur) odour
AM05	NO 16665	44455	10.83	7.93	0.09	89.0	10.2	307	0.183	Surface water - clear with a few very fine s/s; no odour
AM06	NO 16139	44581	11.20	7.48	0.23	61.2	6.61	284	0.481	Surface water - clear with no visible s/s; no odour
AM07	NO 16431	44440	11.34	7.60	0.23	72.9	7.82	270	0.484	Surface water - clear, with no visible s/s; no odour
AM08	NO 16520	44392	10.95	7.02	0.26	22.0	-	272	0.261	Groundwater - dark, cloudy brown with fine brown s/s; very mild organic (sulphur) odour
AM09	NO 16358	44378	10.74	6.81	0.22	28.1	3.06	245	0.464	Groundwater - dark, cloudy brown s/s; mild organic (sulphur) odour

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)
AM01	NO 16791	44622	SW (I)	51	6	15	0.05	<0.01	6.1	<0.01	<0.1	6
AM03	NO 16874	44470	GW	67	6	16	1.74	1.4	0.3	<0.01	0.5	4
AM04	NO 16882	44480	SW (I)	68	6	11	13.3	<0.01	<0.2	0.8	1.2	1
AM05	NO 16665	44455	SW (I)	65	6	19	<0.01	<0.01	6.5	<0.01	<0.1	6
AM06	NO 16139	44581	SW (O)	82	7	21	0.02	<0.01	3.6	<0.01	<0.1	4
AM07	NO 16431	44440	SW (I)	66	6	19	<0.01	<0.01	5.3	<0.01	<0.1	5
AM08	NO 16520	44392	GW	68	6	10	33.8	0.5	<0.2	<0.01	1.5	6
AM09	NO 16358	44378	GW	169	9	17	34.9	0.4	<0.2	<0.01	2.4	6

+ 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 AM02 and hence no sample could be taken.

Table 4.3: Soil Samples – Laboratory Analysis

Sample ID	Nat. Grid Reference		Soil Type*	Extrac-table 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)	Nitro-gen (%)	Extrac-table P (mg/l)
AM02A	NO 16788	44615	Dark brown sailty slightly organic soil with roots	0.5	1100	2320	780	773	63.2	<0.7	<0.2	1.78	<2
AM02B	NO 16788	44615	Greyish brown silt	<0.5	6730	4620	615	1510	42.5	<0.7	0.2	0.43	<2
AM03A	NO 16874	44470	Very wet black organic silt	1	16700	1610	1020	952	90.3	<1.2	<0.2	2.32	3.77
AM03B	NO 16874	44470	Black organic silt	0.5	29600	949	431	542	74.7	0.9	0.4	2.25	<2
AM08A	NO 16520	44392	Wet organic silt with roots	0.5	16600	771	590	632	75.9	<0.7	<0.2	2.46	<2
AM08B	NO 16520	44392	Very wet loose organic silt with roots	<0.5	11800	977	481	502	90.1	<0.7	<0.2	2.04	3.33
AM09A	NO 16358	44378	Dark brown wet organic silt with roots and vegetation	0.6	19000	802	521	497	87.8	<0.8	<0.2	2.14	5.67
AM09B	NO 16358	44378	Very wet dark brown organic silt	<0.5	23800	853	390	179	81.9	<0.7	<0.2	2.12	5.39

** 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 Ardblair and Myreside Fens 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, 2010b) records an 'Objective for management' of maintaining the condition and extent of the basin fen and carr woodland as well as the fen meadow vegetation. Current land management is broadly compatible with maintaining the conservation interest of the site. Measures proposed to achieve these objectives included re-instating cattle grazing at low levels on the fen meadow to prevent scrub invasion; controlling the spread of common reed into the basin fen by cutting; controlling water levels in the basin mire with a sluice gate to help to localise nutrient enrichment and continue to control any alien weed species such as Japanese knotweed or rhododendron.

According to the latest Site Condition Monitoring assessments the basin fen is in unfavourable recovering condition (SNH, 2009) and the fen meadow is in a favourable maintained condition (SNH, 2003). It should be noted that the Site Management Statement (SNH, 2010b) needs amended to correct an error in the SCM result recorded for the basin fen.

A study undertaken in 1995 at the site (Wheeler and Shaw, 1995) stated that the development of dense reed at the Moss of Ardblair is almost certainly a product of three interacting factors: a high water table, modest nutrient enrichment and lack of vegetation management. The sources of nutrient enrichment are not known with certainty. The main source of water and nutrients appeared to be groundwater, albeit some nutrients would also enter the moss from the stream draining Myreside. Potential sources of nutrients identified were agricultural fertilisers applied in adjacent fields but also some non-agricultural sources within the groundwater catchment. It was however recognised that the Moss of Ardblair is not excessively nutrient-enriched and the site could be maintained by managing the vegetation (e.g. management of margins using a motorised scythe). There was no evidence to suggest nutrient enrichment in Myreside. It was suggested that the reduction in water levels of a few centimetres might help reduce the spread of nutrients and make management easier.

The most recent Site Condition Management note (SNH, 2009) indicates that the spread of reeds across the site in the last 25 years is a reflection of the free draining soils around the site and intensity of land use within the catchment. It suggests that the fields to the south of Moss of Ardblair are cropped with carrots. It also identifies another potential source of nutrients from housing to the east of the site. It was suggested that overflows from sewage systems from these houses entered the moss. The advice from SNH freshwater specialist, Andrew McBride was to leave the willow carr in its current condition (as a good example of the transition to carr woodland) and that nothing is done to reduce the water levels within the basin as it would encourage terrestialisation to the detriment of the swamp communities.

5.2 Catchment Walkover

- The sampling area was free of litter. No visible pollution sources were observed within the sampling area. Dumping of cut crops was observed at the western boundary of Moss of Ardblair.

- The fields surrounding the site comprise a mixture of grazed and arable land, generally to the north and south of the site respectively, with Rae Loch to the west

(downstream). Dung piles were observed in the fields to the south of Moss of Ardblair. A buffer zone was observed to the south of the site in this area.

- Field drains were observed around the site, including an open drain entering Moss of Ardblair at the north eastern corner.

- The site is fenced and there is no public access.

- There are three properties in close proximity of the site (Ardblair Castle, Mains of Ardblair and Myreside) and several other properties were observed within 500m of the site. It is understood that these properties have septic tanks but this has not been confirmed.

- The town of Blairgowrie (including industrial works) is within ~500m of the site.

- Open drains traverse the site, particularly Moss of Ardblair.

5.3 Summary

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

Table 5.1: Summary of key observations

Activities	Observations
Fencing	Entire boundary of site is fenced (condition variable/not fully assessed)
Fishing	N/A
Grazing	Site not grazed. Land to the north of the site boundary grazed by cattle and arable land observed to the south.
Monitoring	Condition monitoring was carried out in 2003 and 2009. An ecological study, which included water sampling, was undertaken at the site in 1995 (Wheeler and Shaw, 1995).
Public Access	No public access.
Shooting	None observed although historically pheasant rearing and hunting took place on the site.
Point Pollution Sources	None observed within the SSSI boundary. Cut vegetation observed on western boundary. Road drainage from the A923 is thought to enter the site.
Properties in Catchment	There are no properties within the sampling area. Ardblair Castle, Mains of Ardblair and Myreside are located in close proximity of the site and several other properties were observed within 500m. It has been assumed that most of these properties have septic tanks.
Unusual, Distinctive or Atypical Features	The town of Blairgowrie is located within ~500m of 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

Surface water and groundwater at the site was noted to contain moderate to elevated levels of nitrogen and low to moderate levels of phosphorus in groundwater, indicating an influence from agricultural activities and septic tanks in the wider catchment, particularly in the western section of the site.

The surface water quality at the site was deemed to be good with moderate to high levels of dissolved oxygen. Groundwater samples typically had much lower levels of oxygen as would be expected. All samples recorded pH levels close to neutral with surface water samples noted to be slightly alkaline. Electrical conductivity in surface water samples was noted to increase to the west, which would also suggest mineral/nutrient enrichment in this direction.

Total nitrogen was noted to be highest in the western portion of the site with similar levels up to 6mg/l noted in both groundwater and surface water. The level of total nitrogen at the outflow was slightly lower than most locations. The lowest level was recorded at the eastern boundary of Myreside at AM04. The highest nitrate levels were recorded at AM05 in the inflow from the field to the south which may suggest agricultural runoff. Nitrate levels were uniformly elevated in the surface water samples and below detectable limits in the groundwater samples. The lowest nitrate level recorded was at AM04. Ammonia was detected in groundwater samples only, with the highest recorded at AM03 on the eastern boundary. The distribution of nitrate and ammonia reflects the prevailing geochemical conditions in these environments (oxidising in surface water, reducing in groundwater).

Nitrate levels were in general 2-4 times higher than those recorded in November 1994 by Wheeler and Shaw (1995). This does not necessarily reflect a temporal trend as it could be due to timing (season) of sampling, sampling locations, prevailing redox conditions and other factors. Ammonia levels were typically comparable for groundwater and lower for surface water.

Total phosphorus was generally low with the highest values recorded in groundwater samples. The highest surface water sample value was recorded in AM04 on the eastern boundary. Phosphate was below detectable limits in all samples with the exception of AM04 which also corresponds with the highest total phosphorus. This may be a result of agricultural practises on the adjoining fields.

Iron was recorded at low levels with the exception of the groundwater samples which recorded up to 35 mg/l. These high levels are expected in anaerobic environments. The majority of samples recorded similar levels of calcium with the highest value being recorded in groundwater samples AM09 in the centre of the site.

In soils, all total nitrogen results were recorded below the limit of detection (LOD) with the exception of AM03 below root zone sample. It is also noted that the LOD varies between samples. Extractable nitrogen results were fairly uniform with the highest recorded in AM03 Root zone sample, the remainder of the samples were recorded at around 0.5mg/kg or less.

Total phosphorus levels in soils were typically higher in the root zone samples. Extractable phosphorus was noted to be highest in the south central part of the site in AM09. Total calcium was noted to be high across the site with the lowest noted in the north eastern corner at AM02. The highest values were typically recorded in the below root samples.

6.2 Atypical Results

The data from the Ardblair site were generally fairly uniform with the exception of the following results:

- Calcium was recorded at 169mg/l in AM09 and is considered to be the result of mineralised groundwater influx in this area or the influence of natural geology on the surrounding soils. This is also considered to be the source of the elevated calcium, magnesium and potassium in several of the soil samples. Elevated total phosphorus was also noted in this sample and may suggest the presence of calcium and phosphorus based minerals within the soils or the retention of mobile phosphorus through the precipitation of low solubility calcium phosphorus complexes.

- Magnesium and potassium were noted to be at their highest in soil sample AM02 within the root zone, which is probably due to geological influences in soils.

- Elevated iron in AM08 and AM09 are associated with the low oxygen environment present within the sub soils and are naturally occurring.

6.3 Additional Considerations

SEPA have confirmed that the site falls within the Lunan sub catchment and the corresponding proposed operational area for the Tay diffuse pollution priority catchment.

7. CONCLUSIONS

The analytical results showed a trend of moderate to elevated nutrients within the site, particularly at the Moss of Ardblair. This would seem to be mainly a consequence of agricultural activities and septic tanks in the catchment. There is also a potential for urban sources to be affecting regional groundwater quality.

The site sits in a basin and collects drainage from a 1.8km^2 catchment, dominated by arable land (to the south) and grazing (to the north), with extensive field drainage. It comprises two separate parts: Myreside in the east and Moss of Ardblair in the west. It is not known whether there was any peat extraction at the site but peat level has been reduced historically and was then re-flooded, probably due to gradual blocking of the drains.

The spread of reeds across the site in the last 25 years has been attributed by previous assessments to high water levels and lack of vegetation management (Wheeler and Shaw, 1995) and free draining soils around the site and intensity of land use within the catchment (SNH, 2009). Wheeler and Shaw (1995) undertook water sampling at the site and concluded that nutrient enrichment was modest in Moss of Ardblair and did not affect Myreside.

Total nitrogen was noted to be highest in the western portion of the site with similar levels up to 6mg/l noted in both groundwater and surface water, indicating nutrient enrichment. A slightly lower level at the outflow would be suggesting ‘polishing’ (i.e. attenuation) by the wetland. Nitrate levels were uniformly elevated in the surface water samples and below detectable limits in the groundwater samples. Total phosphorus was generally low with the highest values recorded in groundwater samples. Phosphate was below detectable limits at all locations with the exception of another sampling point at the eastern boundary. This may be a result of agricultural practises on the adjoining fields.

The site drains to the west with man-made drains traversing both sections and receives drainage and runoff from surrounding fields. It is underlain by a productive aquifer, however, it is not known whether groundwater at the site is perched (held by local peat and clay deposits) or connected with the regional aquifer. Should they be connected, groundwater could be acting as a pathway for nutrients from agricultural and urban activities in a wider hydrogeological catchment.

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.

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 main inflows and regional groundwater.

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, including connectivity with the regional aquifer.

iii. Assess the potential effects on vegetation, hydrology and nutrient regime of raising or reducing the water table on the site.

iv. Further assess the link between vegetation encroachment and diffuse pollution.

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, 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 budgeting, buffer strips, exclusion zones, routine spot monitoring, improved/repaired fencing, improved use of fertilisers, treatment of agricultural outflows e.g. constructed wetlands *etc*.

vii. Review issues with removal and disposal of cut vegetation at western boundary (with offsite disposal so as not to recirculate the removed nutrients).

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

8.4 External Consultations

x. Engage with SEPA to discuss the options regarding regulatory controls on the use of nutrients in the catchment for agricultural purposes (operational area of diffuse pollution priority catchment). Seek to draw on comparisons of sites where nitrate vulnerable zone have been introduced.

xi. Engage with SEPA to better understand potential urban sources if hydraulic connectivity with this area is confirmed.

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

1. Ascertain the link between reed encroachment and diffuse pollution (i, iii, iv);
2. Assess the hydraulic connectivity of groundwater at the site with the regional aquifer and potential input of nutrients through this pathway (ii); and
3. Address the inputs to the surface water and groundwater from agricultural (and other) activities within the wider catchment as required (vi, ix, x, xi).

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ANNEX 1: FIGURES

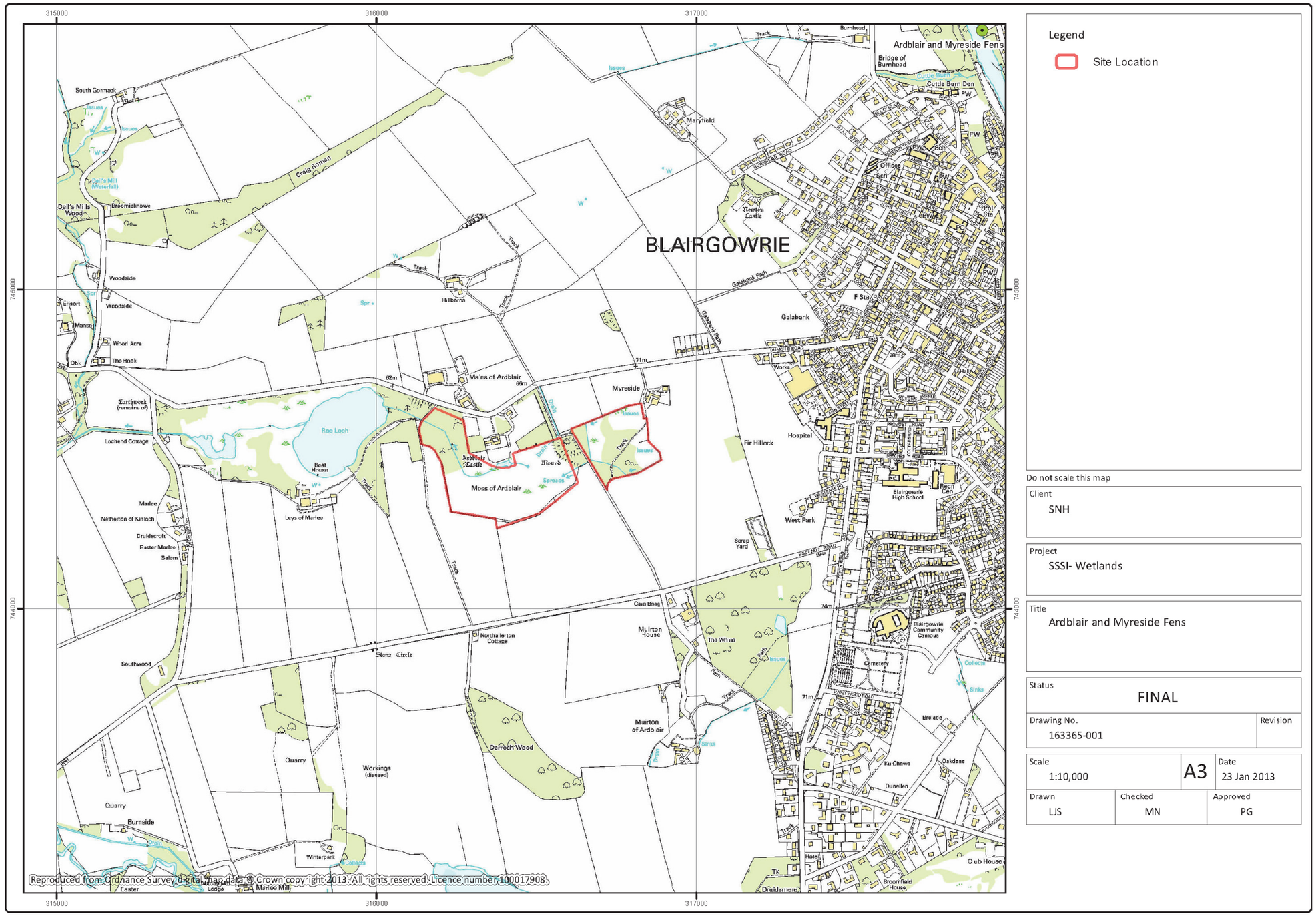


Figure 1.1: Site Location Map

Ardblair and Myreside

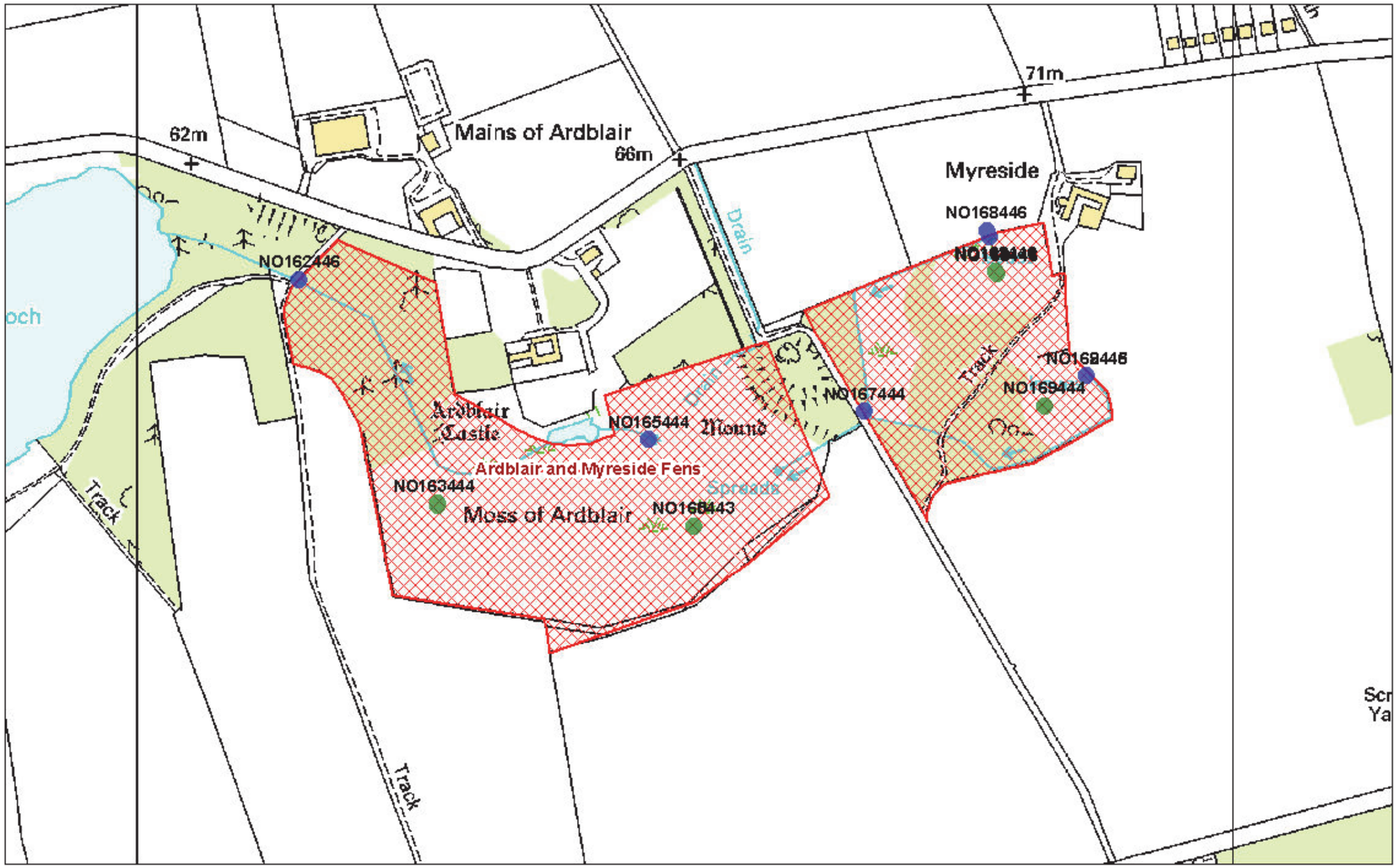
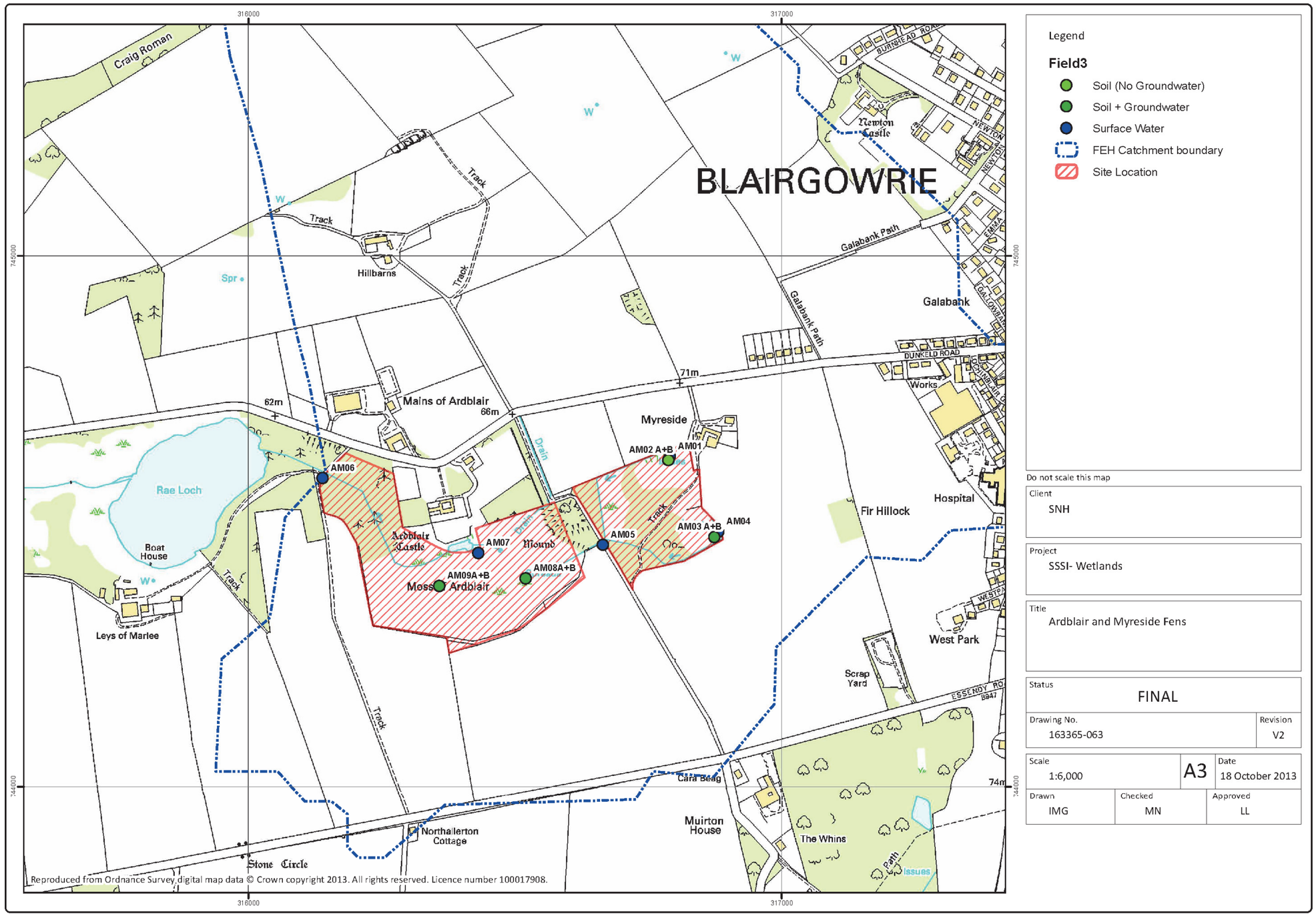


Figure 2.1: SNH Proposed Sampling Location Plan



Legend

Field3

- Soil (No Groundwater)
- Soil + Groundwater
- Surface Water
- FEH Catchment boundary
- Site Location

Do not scale this map

Client	SNH
Project	SSSI- Wetlands
Title	Ardblair and Myreside Fens
Status	FINAL
Drawing No.	163365-063
Revision	V2
Scale	1:6,000
A3	
Date	18 October 2013
Drawn	IMG
Checked	MN
Approved	LL

Figure 2.2: Plan of Actual Sampled Locations

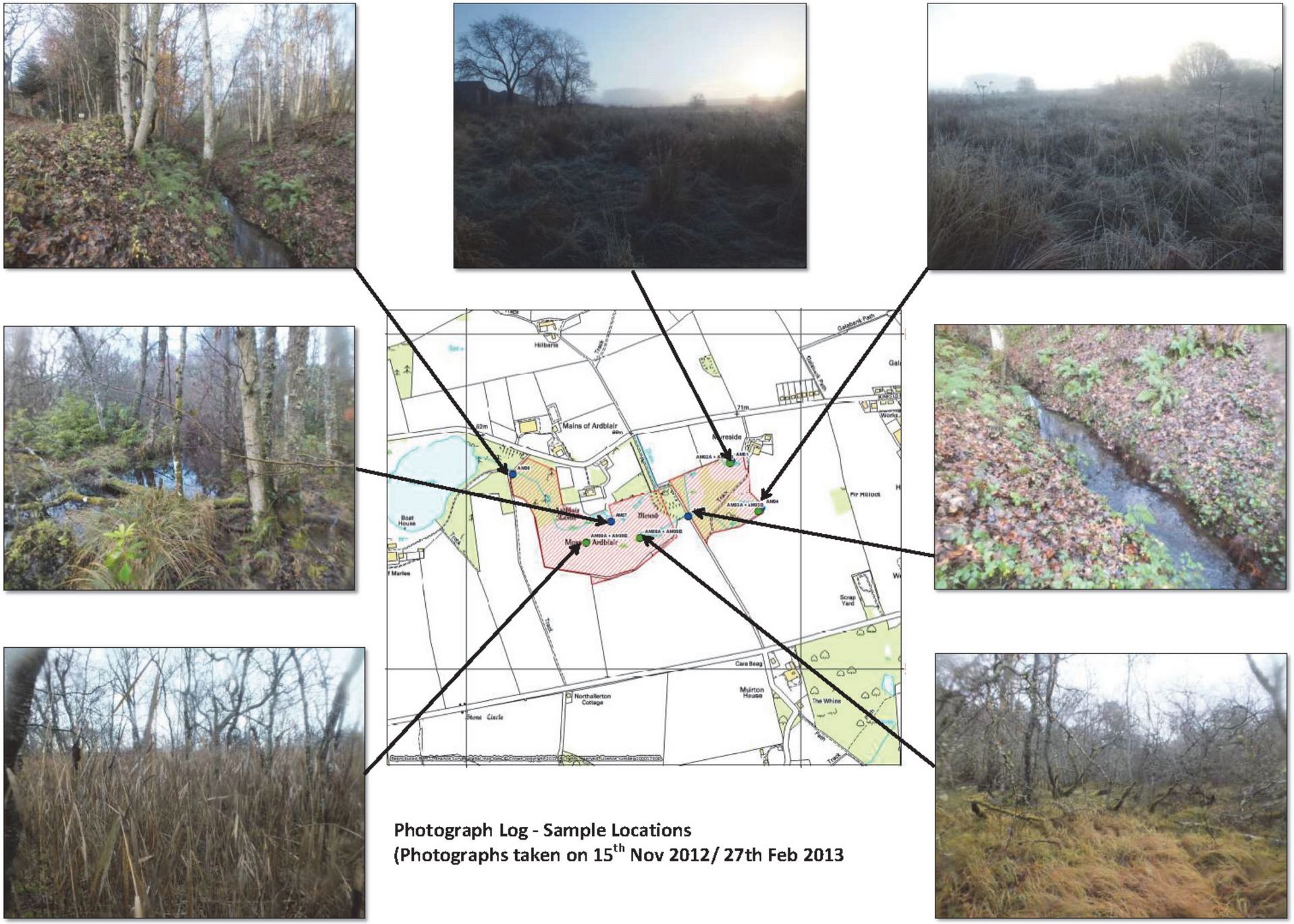


Figure 2.3: Photographs of each Sampling Location

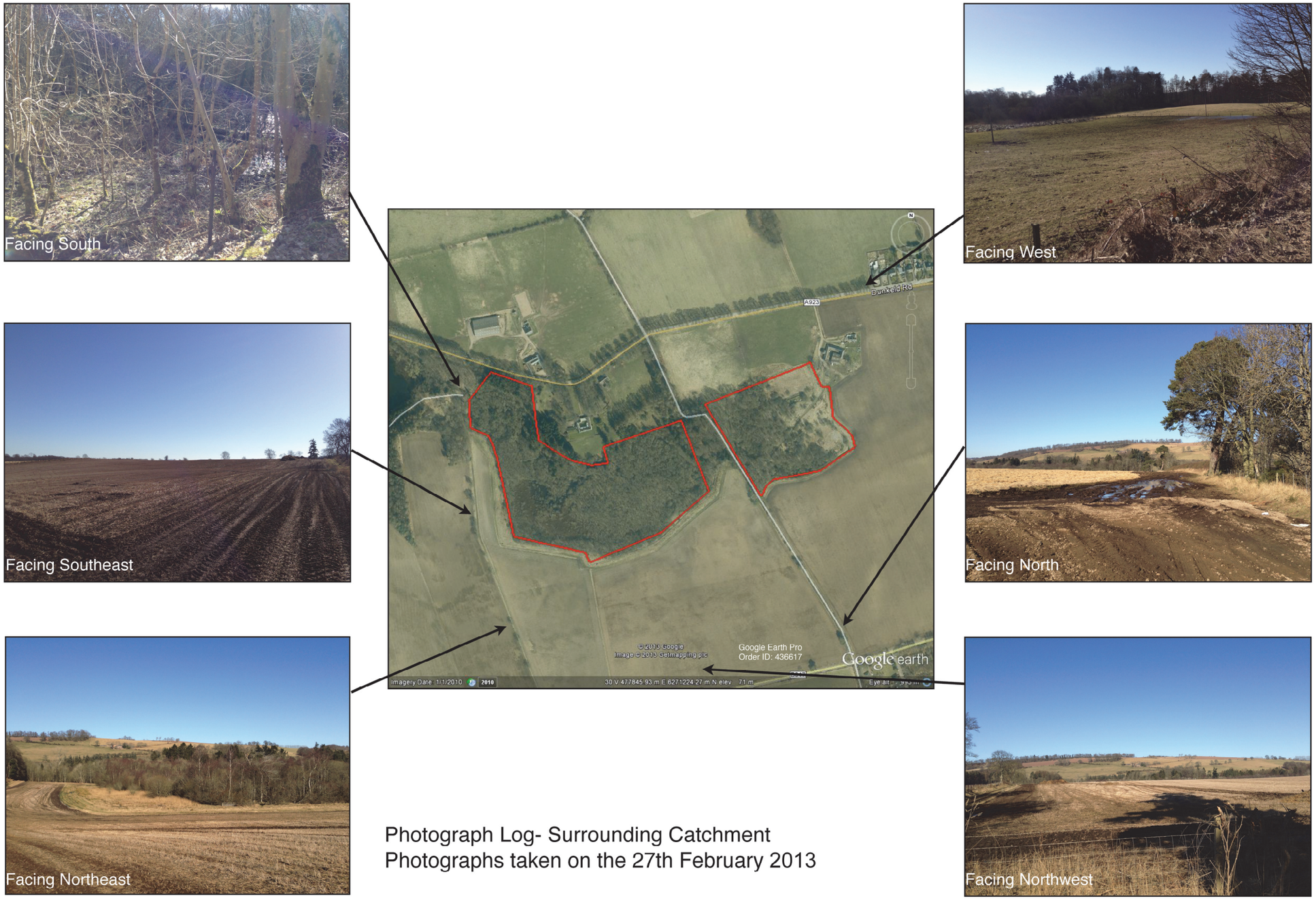
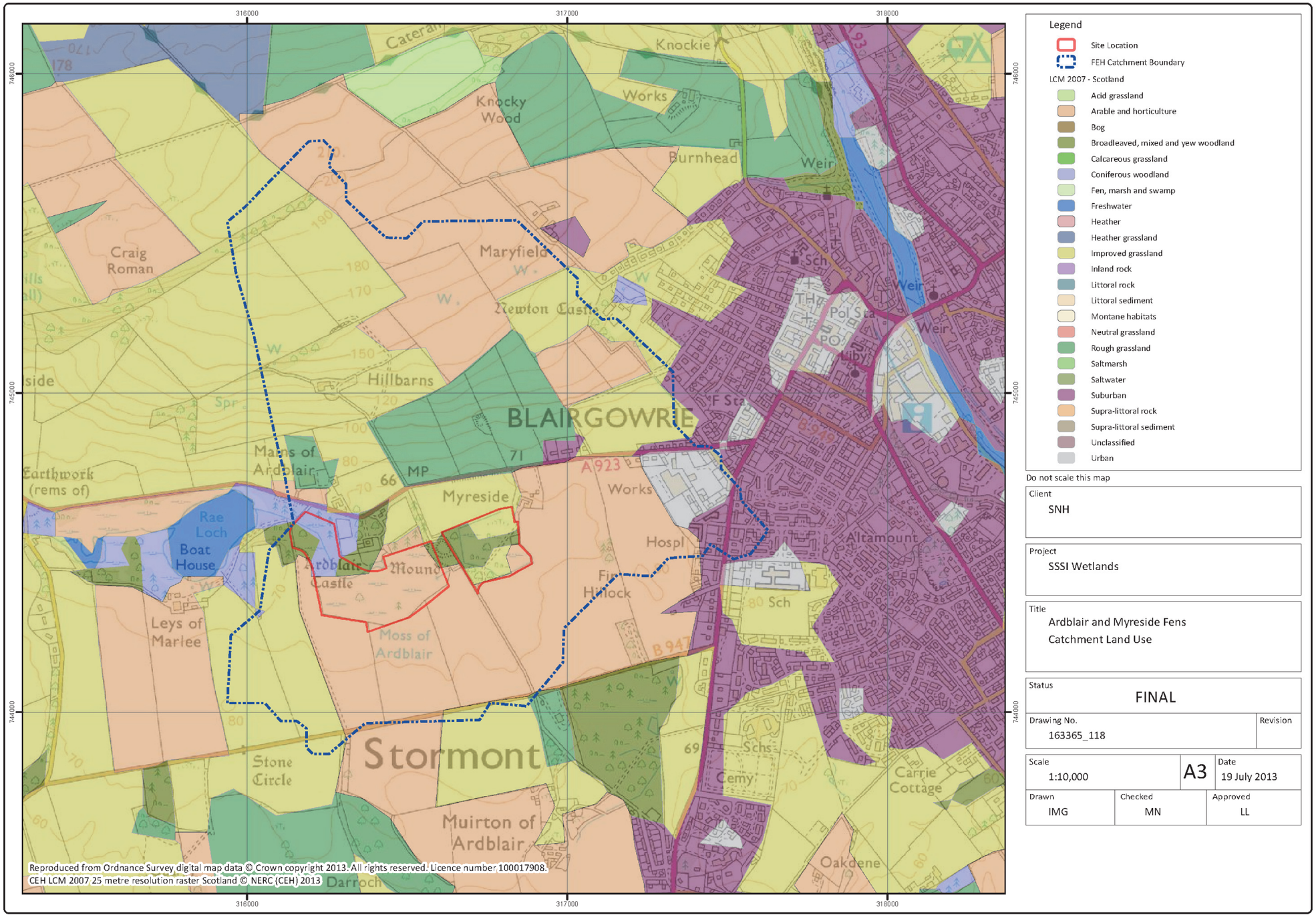


Figure 2.4: Photographs of Surrounding Land Use



Legend

- Site Location
- FEH Catchment Boundary

LCM 2007 - Scotland

- Acid grassland
- Arable and horticulture
- Bog
- Broadleaved, mixed and yew woodland
- Calcareous grassland
- Coniferous woodland
- Fen, marsh and swamp
- Freshwater
- Heather
- Heather grassland
- Improved grassland
- Inland rock
- Littoral rock
- Littoral sediment
- Montane habitats
- Neutral grassland
- Rough grassland
- Saltmarsh
- Saltwater
- Suburban
- Supra-littoral rock
- Supra-littoral sediment
- Unclassified
- Urban

Do not scale this map

Client: SNH

Project: SSSI Wetlands

Title: Ardblair and Myreside Fens Catchment Land Use

Status: FINAL

Drawing No.: 163365_118

Revision:

Scale: 1:10,000

A3

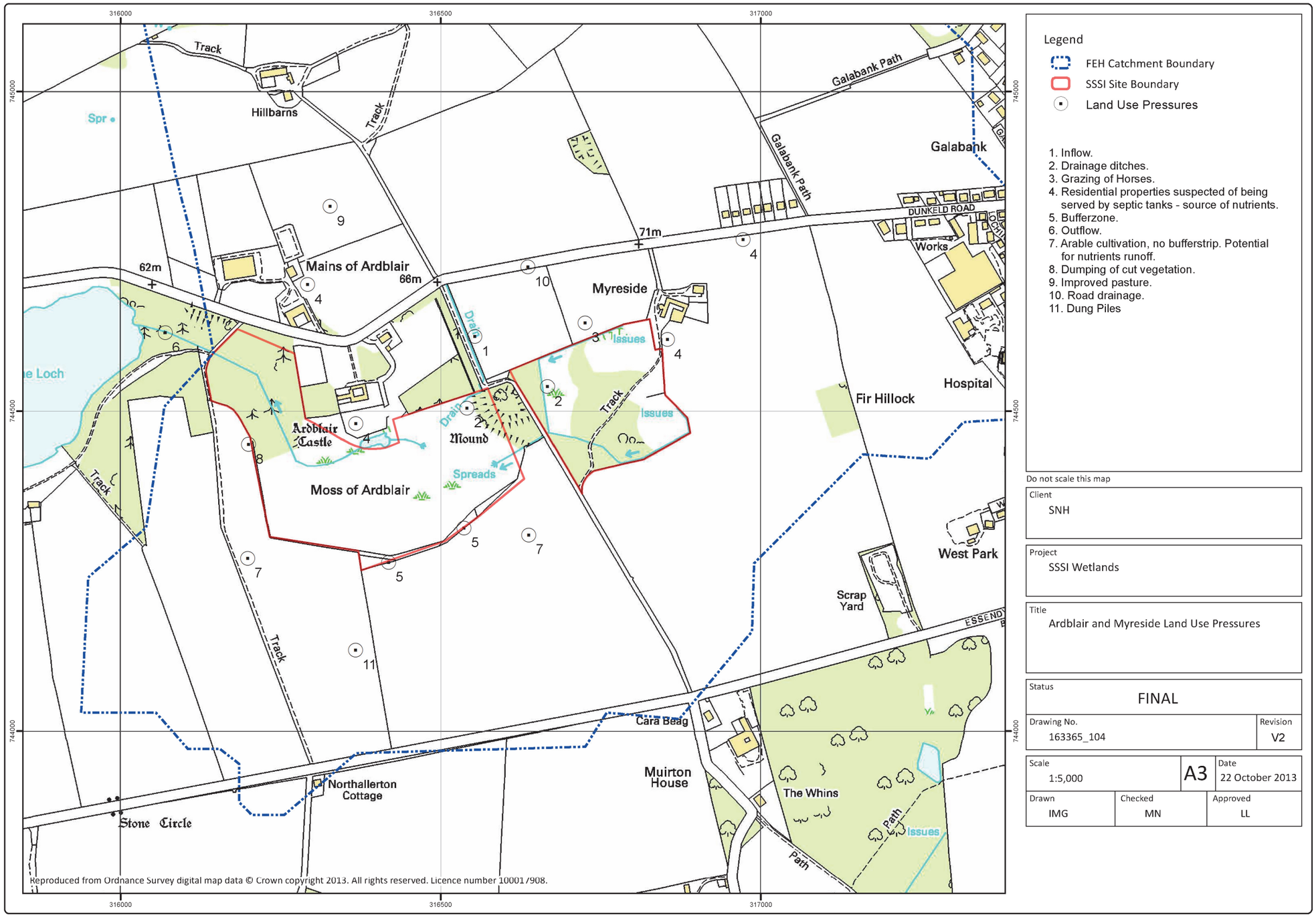
Date: 19 July 2013

Drawn: IMG

Checked: MN

Approved: LL

Figure 2.5: Catchment Land Use Characteristics



Legend

- FEH Catchment Boundary
- SSSI Site Boundary
- Land Use Pressures

1. Inflow.
2. Drainage ditches.
3. Grazing of Horses.
4. Residential properties suspected of being served by septic tanks - source of nutrients.
5. Bufferzone.
6. Outflow.
7. Arable cultivation, no bufferstrip. Potential for nutrients runoff.
8. Dumping of cut vegetation.
9. Improved pasture.
10. Road drainage.
11. Dung Piles

Do not scale this map

Client: SNH

Project: SSSI Wetlands

Title: Ardblair and Myreside Land Use Pressures

Status: FINAL

Drawing No.: 163365_104

Revision: V2

Scale: 1:5,000

A3

Date: 22 October 2013

Drawn: IMG

Checked: MN

Approved: LL

Figure 5.1: Catchment Pressures Summary

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