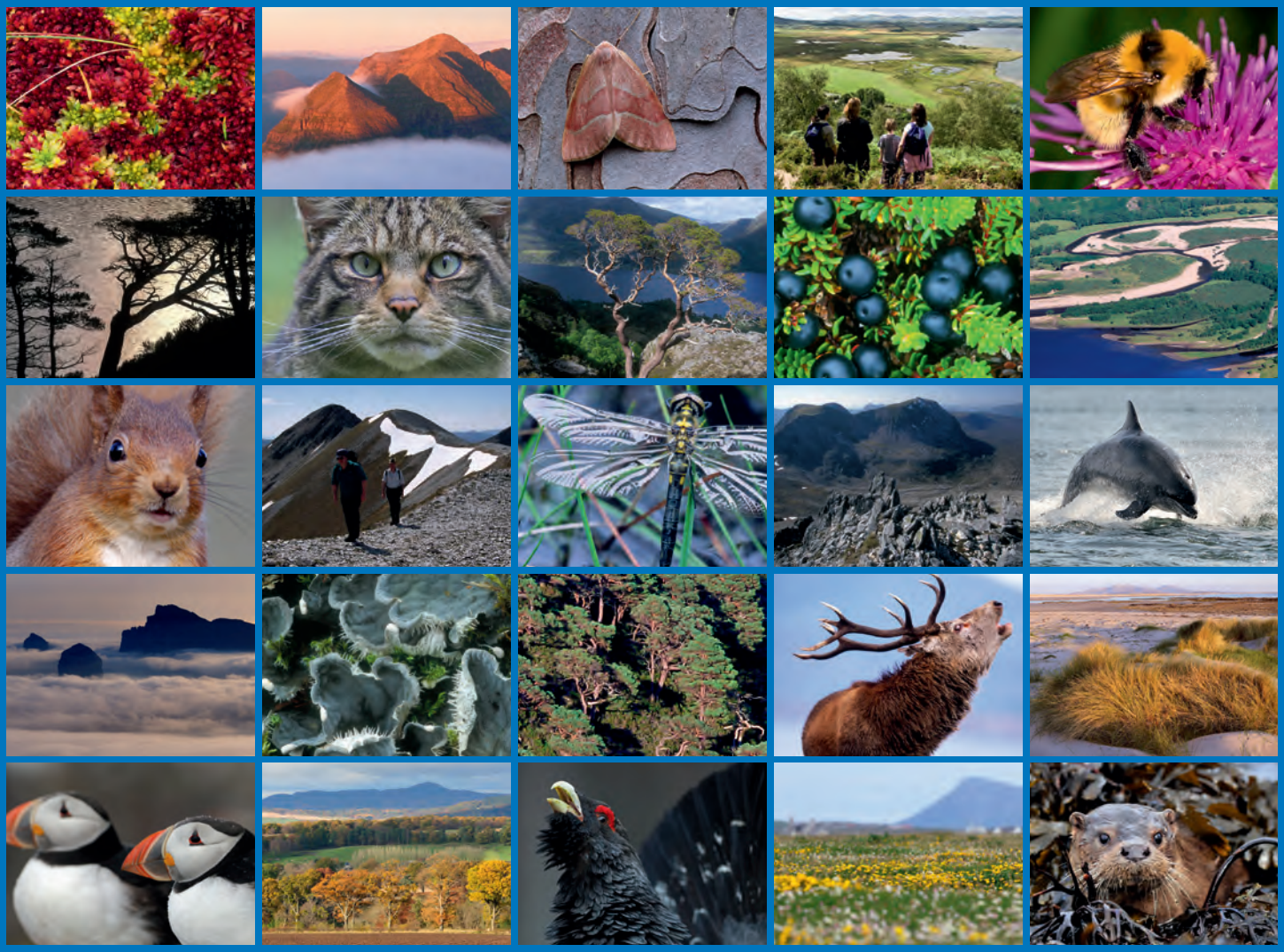
Scottish Natural Heritage
Commissioned Report No. 731

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



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COMMISSIONED REPORT

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

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COMMISSIONED REPORT

Summary

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

Commissioned Report No. 731
Project No: 13700
Contractor: EnviroCentre Ltd.
Year of publication: 2015

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 inform their work with managers of the sites to improve their conditions.

Main findings

- Analytical data supports claims of elevated nutrient status from potential sewage inputs. 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 constrain the ability to draw accurate conclusions to fully inform current site conditions.
- Site walkover also revealed possible additional field drain inflows not previously identified. This and the sewage inputs within the immediate catchment could adversely affect the hydrology and nutrient availability within the site.
- A series of recommendations are proposed to aid the understanding of the septic tanks, site hydrology, and the impact of newly identified inflow sources and infilled drainage. It is considered that this additional information will help further the understanding of the perceived changes taking place at the site.

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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

Moss of Kirkhill is located 12 kilometres (7.5 miles) south of Huntly in the village of Kennethmont, Aberdeenshire. The site is accessed via an unnamed road off the B9002. See Figure 1.1 in Annex 1.

1.2 Site Description

Moss of Kirkhill is a Site of Special Scientific Interest (SSSI) designated for a basin fen feature with a wide range of fen plant communities. The site comprises an area of 19.6 hectares and has been designated since 1991 (SNH, 2011a).

Part of the site was once a raised bog with most of the peat understood to have been removed by cutting. The site is now effectively two areas of fen (termed east and west sections) partially separated by a central spine of drier ground (SNH, 2011b).

The western fen expanse contains undisturbed primary fen communities. The northern part of this area has a local calcareous influence as reflected by the presence of the rich fen vegetation. The eastern fen has a more disturbed character, suggesting secondary development from the cut-over raised bog. Fen woodland occurs around the western and northern margins of the site. This is dominated by willow (*Salix spp.*) with birch (*Betula spp.*) on the drier areas (SNH, 2011b). The extent of tree cover has expanded on the site since it was originally notified as a SSSI (SNH, 2010).

The underlying solid geology at the site consists of an unnamed igneous intrusion while the drift geology consists of glacial till (British Geological Survey, n.d).

1.3 Site Hydrology

The site has a catchment area of 0.5km^2 which receives an annual average rainfall of 867mm (Centre for Ecology and Hydrology, 2009). The main inflows to the site are rainfall and localised surface water runoff. A drain flowing along the southern perimeter of the site may provide a further inflow to the southwest of the site and, at the same time, an outflow from the south east of the site. A series of drains in the north of the site form an outflow from the site, flowing in a northerly direction to a tributary of the Water of Bogie. These drains are shown in the OS 1st edition mapping (1867), highlighting that the site has been drained for at least 150 years (National Library of Scotland, n.d). Observations on site suggest that these drains have now become largely infilled within the site boundary through lack of maintenance. A number of small shallow ponds were also observed on the site.

1.4 Site History

A review of the SNH site files coupled with internet research revealed limited additional information above that within the Site Management Statement (SNH, 2011b). The SNH document is therefore considered to be the main source of historical information for the site and is that from which the following information is taken.

Moss of Kirkhill was once an area of raised bog, most of the peat in subsequent years has been removed through cutting.

Grazing of the site may have occurred in the 1980s but is now understood to have ceased.

Pheasants are present on site and are managed along the eastern edge of the site for shooting purpose. Pest control is also present throughout this area.

1.5 Recent Site Management Practices

Outwith the information contained in the SNH site file there has been a lack of additional information available regarding previous or existing management practices.

It is stated in the Site Condition Monitoring Form (SNH, 2010) that little or no active management occurs on site. Discussions have been held with one landowner about possible entry into the Scotland Rural Development Programme (SRDP) for funding. From the records made available, it is not known whether this has been progressed further.

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 was undertaken once the analytical data was available and 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

Moss of Kirkhill	Date of Visit	Weather Conditions	Grid References
Visit 1	14 November 2012	Cold, rainy and overcast	NJ 534289
Visit 2	26 February 2013	Clear, cold, sunny	NJ 534289

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 access 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 fieldwork:

- Handheld Global Positioning System (GPS) unit 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 (PPE - 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 completed 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 accessing 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 rigorously 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. As appropriate, collections were made from inflows, standing (open) water and outflows, to provide an understanding for the whole site.

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, measure loch 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 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 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 Water Quality Field Data

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

Table 4.1: Water Quality Field Data and Observations

Sample ID	Nat. Grid Reference		Temp (°C)	pH	Salinity (psu)	DO (%)	DO (ppm)	ORP (mV)	EC (µS/cm)	Comments
MK01	NJ 53599	28920	10.29	5.18	0.03	80.0	0.79	-164.7	71	Groundwater - cloudy orange brown with muddy silt suspended solids; no odour
MK02	NJ 53575	28920	8.89	5.46	0.03	47.1	5.05	148.1	67	Surface water - cloudy brown, with mixed sized suspended solids; mild organic (sulphur) odour
MK04	NJ 53453	28790	9.64	5.69	0.04	49.7	5.06	-148.3	83	Surface water - cloudy orange brown, with brown suspended solids; very strong earthy odour
MK05	NJ 53486	28980	9.96	6.25	0.05	40.9	4.38	-151.4	112	Surface water - clear with very minor peaty suspended solids; no odour
MK06	NJ 53587	29145	9.71	5.67	0.05	25.9	2.52	153.5	95	Groundwater - cloudy, dark brown suspended solids; very mild organic (sulphur) odour
MK07	NJ 53569	29194	10.05	6.67	0.64	54.8	5.60	-60.1	88	Surface water - clear with very slight suspended solids; no odour
MK08	NJ 53613	29156	10.17	6.55	0.08	52.0	5.47	-176.2	189	Surface water - cloudy orange brown with cloudy orange brown suspended solids; no odour
MK09	NJ 53600	29100	10.87	6.37	0.05	0	0	-253.8	105	Groundwater - dark brown with brown suspended solids; 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)
MK01	NJ 53599	28920	GW	15	3	6	24.6	0.06	0.3	<0.01	2.9	6
MK02	NJ 53575	28920	SW (OW)	10	4	6	40.7	0.01	<0.2	<0.01	1.4	<1
MK04	NJ 53453	28790	SW (I)	13	5	9	20	<0.01	<0.2	<0.01	1.6	1
MK05	NJ 53486	28980	SW (OW)	10	4	9	2.9	<0.01	0.2	<0.01	<0.1	<1
MK06	NJ 53587	29145	GW	13	4	7	13.8	0.52	1.4	<0.01	0.4	7
MK07	NJ 53569	29194	SW (O)	8	4	11	0.37	<0.01	<0.2	<0.01	<0.1	<1
MK08	NJ 53613	29156	SW (O)	23	7	13	3.63	<0.01	<0.2	<0.01	0.3	1
MK09	NJ 53600	29100	GW	31	8	8	62.0	0.3	<0.2	<0.01	3.6	15

+ 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 location MK03

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)
MK01A	NJ 53600	28900	High organic dark coloured wet sludge	2.2	16000	3080	550	3170	81.5	<2.4	<0.2	0.55	5.95
MK01B	NJ 53600	28900	High organic dark coloured wet sludge	<0.5	8680	1680	268	426	83.7	<0.7	<0.2	1.65	<2.0
MK03A	NJ 53400	28800	High organic with some small gravels	2.2	4070	560	456	213	71.0	2.6	0.4	2.24	<2.0
MK03B	NJ 53400	28800	High organic with some small gravels	5.0	8390	760	302	116	72.4	5.3	0.3	1.86	<2.0
MK06A	NJ 53500	29200	High organic no gravels	1.5	12700	2320	1260	1530	85.4	<1.7	<0.2	2.29	6.57
MK06B	NJ 53500	29200	High organic with some small gravels	0.5	13700	1770	372	246	73.1	<0.7	<0.2	2.1	4.0
MK09A	NJ 53600	29100	High organic with no gravels	3.2	11500	1670	1030	1420	87.0	<3.4	<0.2	1.9	2.16
MK09B	NJ 53600	29100	High organic with some gravels	<0.5	8260	2000	346	260	67.1	<0.7	<0.2	1.59	<2.0

** 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 the Moss of Kirkhill 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 habitat of the site, specifically the open fen expanse. There are a high number of drains on site and it is likely that these have contributed to the drying out of the southern part of the site.

Site Condition Monitoring of the Basin fen feature carried out in both 2002 and 2010 found the site to be in unfavourable condition due to the spread of willow and birch scrub into the important fen communities (SNH, 2011b).

The Site Condition Monitoring Form (SNH, 2010) states that tree cover has significantly increased at the site since it was designated a SSSI in 1991. There is concern that any changes to the water table could lead to a rapid expansion of trees over the remaining features of interest.

During a site visit in 2009 a septic tank soakaway was noted in the eastern area of the site. Nutrient enrichment in this area of the site was also noted with extensive areas of nettles present. This was deemed to be localised and not present in any of the other areas of interest (Cruickshank, 2009).

The SNH File Note (Cruickshank, 2009) refers to the presence of extensive vehicle tracks on the site possibly made by a quad bike or similar. It also suggests that runoff from the surrounding farmland is unlikely to have any influence on the site but we do not consider that to be correct.

The site lies within the Moray Aberdeenshire/ Banff and Buchan Nitrate Vulnerable Zone (NVZ), designated in 2002.

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.

- No grazing of stock was observed within the fields immediately bordering the site. Pasture land (improved) was present within the wider catchment, particularly on the slope to the west of the site. Arable land is present to the south west of the site, with variations to the natural drainage.

- Residential properties were evident adjacent to the eastern boundary of the site with a new housing development observed being under construction. It was not confirmed whether these dwellings were to be on mains sewerage or served by septic tanks.

- Located to the north of the site there is a dairy farm. Evidence observed of the application of slurry to neighbouring fields albeit not fields in the site catchment and not immediately adjacent to the SSSI.

- Surrounding the site to the south there is extensive rough pasture.

- Evidence of rearing of Common Pheasant (*Phasianus colchicus)* in southern areas of the site through presence of pens and feeding troughs. It is assumed, but not confirmed, this is for the purposes of recreational shooting.

- There is no defined public access to or through the site.

5.3 Summary

The following table provides a summary of the key site features which were observed during the 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	Partial fencing around site (the condition of which was not assessed as part of the study).
Fishing	Not applicable.
Grazing	No grazing is understood to occur within the site boundary with the possible exception of deer. The grazing of sheep has been practiced in the past. Pastures present within catchment to the west and south of the site.
Monitoring	SNH Site Condition Monitoring was carried out in 2002 and 2010. No other monitoring data was available from the desk study.
Public Access	None.
Shooting	Evidence of pens and feed troughs for game birds (most probably pheasant) on the south eastern boundary of the site.
Point Pollution Sources	None identified.
Properties in Catchment	None within the site – several residential properties (including new development) adjacent to eastern boundary (Kennethmont village) which may be served by septic tanks.
Unusual, Distinctive or Atypical Features	Soil conditioning and crop spraying in fields along the western boundary; and a series of land drains (not all mapped) are present on the site, several of which are infilled. Dairy farm present to the north of the site (outwith site catchment).

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 dataset indicates nutrient enrichment within the site most notably on the northern and eastern boundary where there is considered to be an increased nitrogen and phosphorus load entering the site. This observation supports the existing concerns regarding septic tank discharges.

Despite a limited understanding of the flow regime(s) on site, it is considered that the site acts as a sink with nutrients being retained (and used) within, rather than being 'flushed' from, the site. This is largely attributed to the infilled site drains and may be a seasonal observation which requires a more detailed understanding of the flow dynamics of the site to be confirmed.

Elevated total nitrogen and total phosphorus were observed in all the water samples taken from the eastern and northern part of the site - namely MK01, MK02, MK06 and MK09. Each of these locations abuts the residential boundary where the septic tank discharges are believed to emanate. These are supported by the elevated presence of comparative parameters in the soil samples of MK01A and MK06A.

Elevated total phosphorus levels are observed in the majority of samples obtained from the eastern part of the site. The low phosphate results suggest that this is sewage derived and more than likely from detergents (in which phosphorus will be present in a different form - sodium tripolyphosphate (or STPP) and hence not detected phosphate as P but will be recorded as a portion of the total phosphorus analysis). This could be confirmed through further monitoring and requesting a variation in the type of analysis performed.

Excluding MK07, possibly due to dilution of flows prior to exiting the site, elevated iron results were observed across the site as a whole. It is considered that the iron results are a result of precipitation due to the acidic and low oxygen conditions. This would correspond with the orange-brown visual observations in samples MK06 and MK08 in which orange brown colouration was determined.

The inorganic concentrations of bioavailable nutrients were highest in the groundwater samples when compared with the surface water samples. With the exception of iron concentrations in the groundwater samples, none of the analysed metals were recorded as being elevated or above expected concentrations. The presence of elevated total nitrogen and ammonia in MK09, coupled with low nitrate and low dissolved oxygen results, indicates anoxic conditions and nitrification taking place. Whilst this is most notable at MK09, this is potentially replicated to some degree in all the groundwater sample results.

Total phosphorus levels were elevated in the upper (root zone) of all collected soil samples, namely MK01, MK06 and MK09. Unlike the water samples, extractable phosphorus values were also elevated in the same samples. This may be explained through the relative properties (particularly solubility) of the phosphorus variants and the associated reactions which naturally occur within the upper soil zone. The same trend is not evident with the corresponding nitrogen results.

6.2 Atypical Results

No consistent atypical or anomalous results were recorded from the soil or water samples at the Moss of Kirkhill. Of the limited data set the only observations of note are discussed below:

- A mild organic (sulphur) odour was detected in samples MK02, MK04, MK06 and MK09. These locations included both groundwater and surface water samples and were all located within the site. These typically corresponded with the lowest dissolved oxygen readings and hence considered to be indicative of organic degradation. This observation is consistent with the visual observations of decaying organic matter in the corresponding soil samples.

- The dissolved oxygen results for MK09 are unusual in that it would be expected to obtain a reading rather than a 'zero'. It is possible that this is attributable to a probe error. However, this is discounted as all the other readings obtained using the same field instrument appear to be valid. The corresponding laboratory analyses indicate the presence of elevated ammonia and iron. The reduction of these compounds may have placed a high chemical oxygen demand such as to remove the oxygen completely. It is therefore considered that the result is genuine but should be treated with caution and confirmed through further monitoring.

- The high moisture and descriptions of the soil samples obtained across the site indicate that the soil is not freely draining. This would support the aforementioned observations and corresponding conclusions that the site is poorly draining from the infilled drains and that the organic decay that results is leading to anoxic conditions.

- The analytical data contradicts the site management statement that the northern part of the site has a calcareous influence reflected in the presence of a rich fen community (SNH, 2011b). The pH data shows that the soils in this area are acidic whereas they would be expected to be more alkaline. This is expected to be due to anoxic conditions from degrading organic matter, leading to more acidic conditions than would naturally occur and could be a limiting factor to the proliferation of the natural notified communities. Also, low levels of electrical conductivity were recorded in water at the site, confirming that it does not have a significant groundwater influence.

6.3 Additional Considerations

See study limitations presented in section 3.

It is understood that this site is outwith the SEPA priority catchment operational area and that farms will not be visited as part of this scope of work.

7. CONCLUSIONS

Despite the limitations outlined in section 3, the analytical results appear to show a definitive trend of elevated inorganic nutrients within the northern and eastern parts of the site. There are observations that indicate that the site is being influenced by discharges from septic tanks and from agricultural practices within the wider catchment (including soil improvements and changes in drainage of the adjacent land holding). It is considered that in conjunction with the infilled drainage channels, these will have a direct influence on site vegetation and habitat types.

Residential dwellings are located in close proximity on the northern and eastern boundaries of the site and these are likely to be served by septic tanks. The phosphorus results for the site are elevated in these areas and this view is supported by the presence of nettles in this area. This suggests that the nutrient input from septic tanks is having a notable effect on the site. The poor draining of the site will afford a retention time for the nutrients to be used within the site and the continuous supply from the tanks furthers the successional changes observed within the SSSI. It should be noted that the assumption made in the SNH file note (Cruickshank, 2009) that the impact of septic tanks will be localised is not correct as it makes no provision for the continuous nature of the polluting inflow or the flow of water through the site.

The intensive agricultural activities within the surrounding catchment are also likely to influence site hydrology and the inflow of nutrients to the site. The location of the site exacerbates the aforementioned observations as it sits at a low level within the catchment and receives flows from the elevated areas which lie to the south and west. This means that the site acts as a sink for the surrounding landform.

The drainage within the site (namely that on the southern boundary) is considered to have a direct effect on the site. The southern boundary receives flow from managed agricultural land and the unnamed service road. The need for the drains is confirmed by a consistently high water table and poor draining soils. Samples from the various drains at both extremes of the site would have significantly aided this study. It is reported that the southern drain is likely to have led to a drying out of the southern part of the site (SNH, 2010). Whilst this is possible, the infilling over time would limit the effects of this. It is also not understood where this channel drains to and how this affects the site as a whole.

It is considered likely that there are historical nutrient accumulations within the site and the adjacent land which will continue to influence the vegetation. Quantification of the volumes of sediment and concentration of nutrients in the infilled field drains would help to establish a more complete picture of the site and how water quality is seasonally influenced – *e.g.* whether 'flushing' of these sediments occurs during periods of high flows/intense rainfall.

Whilst direct rainfall will have a notable influence, the site appears to be predominantly supplied by a series of field drains which are located on the southern boundary. Subtle changes in the site water levels are likely to lead to direct changes in vegetation types so understanding the seasonal and annual variations in site hydrology will help understand how this is influenced. Whilst results indicate that the site is wet all year round, no detailed hydrological assessment of such was made during this study. This should be addressed and the findings assessed in accordance with known changes in adjacent land practices.

The management of birch and willow scrub on site is noted in the Site Condition Monitoring Form (SNH, 2010). No details are stated as to how this is being controlled, but if manual cutting techniques are employed then the resulting waste should be removed from site to minimise the build-up of leaf litter and ensure that the nutrients are not simply recycled within the soil through microbial activity.

There is a need to understand both the current (modified) and the natural drainage of the site so as to be able to determine the extent to which the field drains support the designated feature. It may be that the infilled ditches perform an important role in maintaining the existing water table and consequently the viability of the notified feature.

8. RECOMMENDATIONS

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

8.1 Monitoring

i. Undertake an immediate investigation into the perceived level of contamination entering the site from the septic tanks along the north eastern and eastern boundary (re: results for MK01, Mk02 & MK06 as detailed in Section 6.2). It is considered that this would be best performed in conjunction with support from SEPA.

ii. Undertake a long-term targeted monitoring study at selected locations within the site for key nutrients – to consider variants of phosphorus analysis as detailed in section 6.1. Ideally this would be undertaken over the course of several seasons (ideally for a minimum of one year). The data from such should be compared alongside rainfall data, water table levels and seasonal abnormalities to seek to understand the nutrient dynamics taking place within the site.

iii. In conjunction with i, assess the seasonal flow and nutrient loads of the inflow and outflows to and from the site. This should include regular visits to understand whether the field drains are flowing or infilled. The resulting findings would be of direct value in being able to assess the flow dynamics of the site and to understand retention times and season variations in throughput and for these to be best managed accordingly.

8.2 Other Commissioned Studies

iv. Review and determine the extent of vegetation and woodland encroachment. If validated, this is likely to have resulted in a reduced through flow and heightened deposition – accelerating successional change. Consideration should be made to monitoring and managing this.

v. Undertake hydrological and hydrogeological assessment of the catchment to determine the water regime at the site, including variation of water table levels on the site.

8.3 Management

vi. Review the consultation for the neighbouring housing development with Aberdeenshire Council and seek improvements to the mechanisms to assess and input to future consultation responses accordingly.

vii. Review the policy for the removal of site vegetation and the methods used to control/manage such. Where future management practices require vegetation to be removed this should be removed at the root zone rather than cutting off above ground stem, and should be followed by appropriate off-site disposal as this will lead to a net reduction in nutrients from the catchment, minimise regrowth and avoid the need for the use and reapplication of potentially harmful chemicals.

8.4 Landowners

viii. Engage with landowners to convey the action programme rules (Scot.Gov., n.d.) for landowners/agriculture within a Nitrate Vulnerable Zone (NVZ). The implementation of these guidelines should result in a net reduction of Nitrate entering the site over time.

ix. Proactively engage with catchment landowners to understand the historical land use practices to determine changes which are likely to have influenced the site. Consideration should be made to appraise how this may have led to changes at the site and the corresponding nutrient and habitat status.

x. Proactively engage with local landowners to understand the existing and (foreseeable) proposed changes to the immediate catchment including field usage, crop type and soil conditioning approaches. Consider appropriate management strategies accordingly - for example, nutrient management planning, buffer strips, exclusion zones, routine spot monitoring *etc*. This exercise should seek to corroborate the aforementioned references to spraying and spray drift (of unconfirmed herbicides), and vehicle access of the site, which could have a notable effect on the site vegetation.

xi. Review of the ownership of the identified land drains and the future management and maintenance of such.

8.5 External Consultations

xii. Where shown to be inhabited, engage with SEPA to understand the sewage disposal methods in place for the identified properties within the catchment and the corresponding controls in place to limit nutrient enrichment to the SSSI.

In conjunction with the above, it would be advisable to attend site during/immediately after a period of low rainfall to seek to observe whether visible pollution akin to sewage effluent was present on the site in the identified areas. Where the septic tanks are deemed to be at fault, in addition to the regulatory approaches, a targeted letter drop may help educate owners and explain the need to avoid the use of bleach and the benefits of using of low phosphate products, in combination with regular maintenance of septic tanks.

Given that SEPA do not plan to attend the farms in the catchment as it lies outwith the priority catchment operational area, it would be of value to understand the process that SEPA would undertake if it were and for SNH to seek to replicate such to highlight any regulatory or managerial concerns at these facilities.

From the stated conclusions and identified pressures (Figure 7.1) the key actions to reverse the present declining status of the site are to address the inputs to the site from adjacent septic tanks and the agricultural catchment and better understand the hydrological regime and its link to woodland encroachment at the site. The former should focus on the potential contribution from domestic sewage (xii & vi) and the agricultural catchment (viii, ix & x), as well as the site hydrology/hydrogeology (v) and vegetation encroachment (iv)/management (vii).

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ANNEX 1: FIGURES

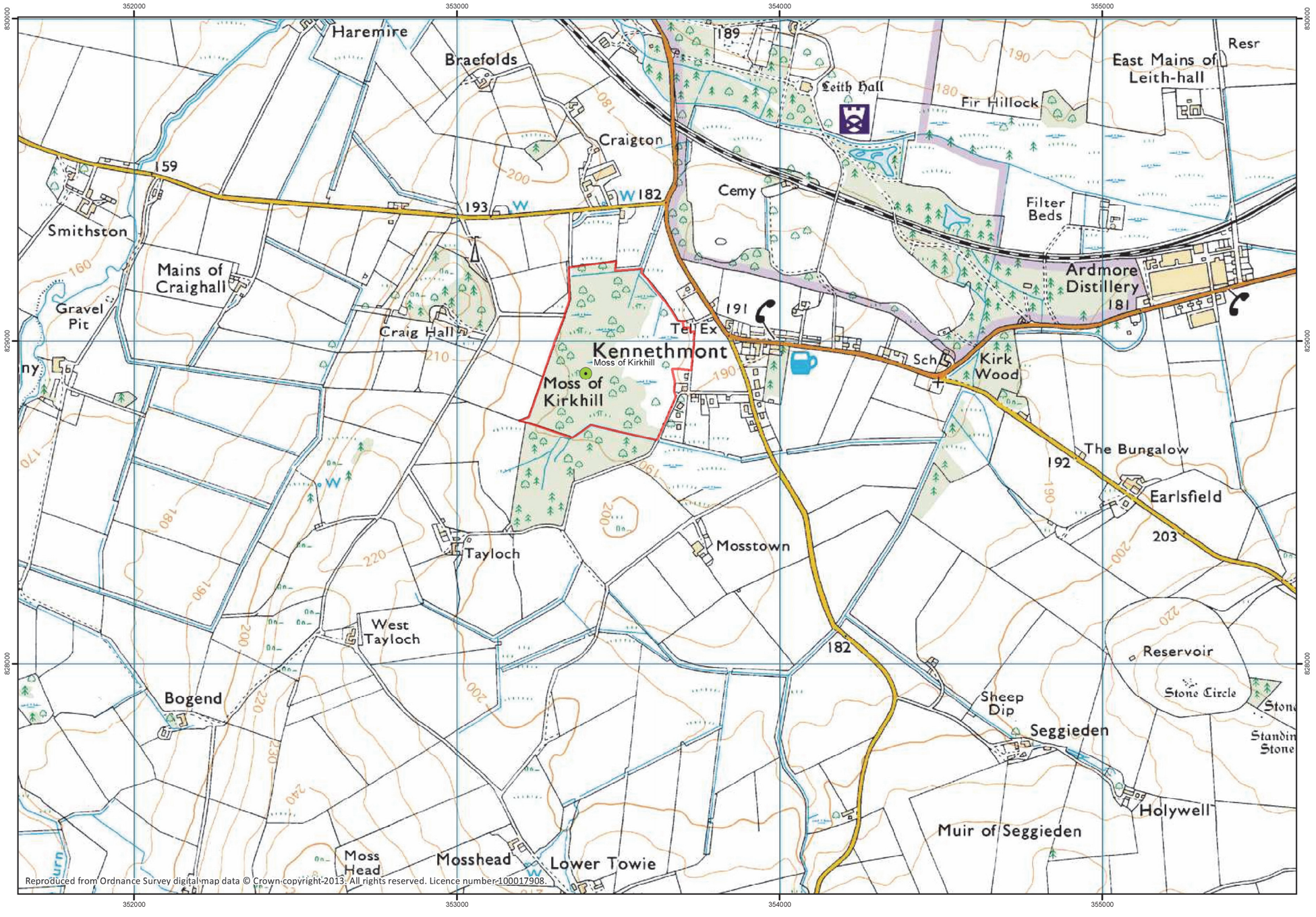
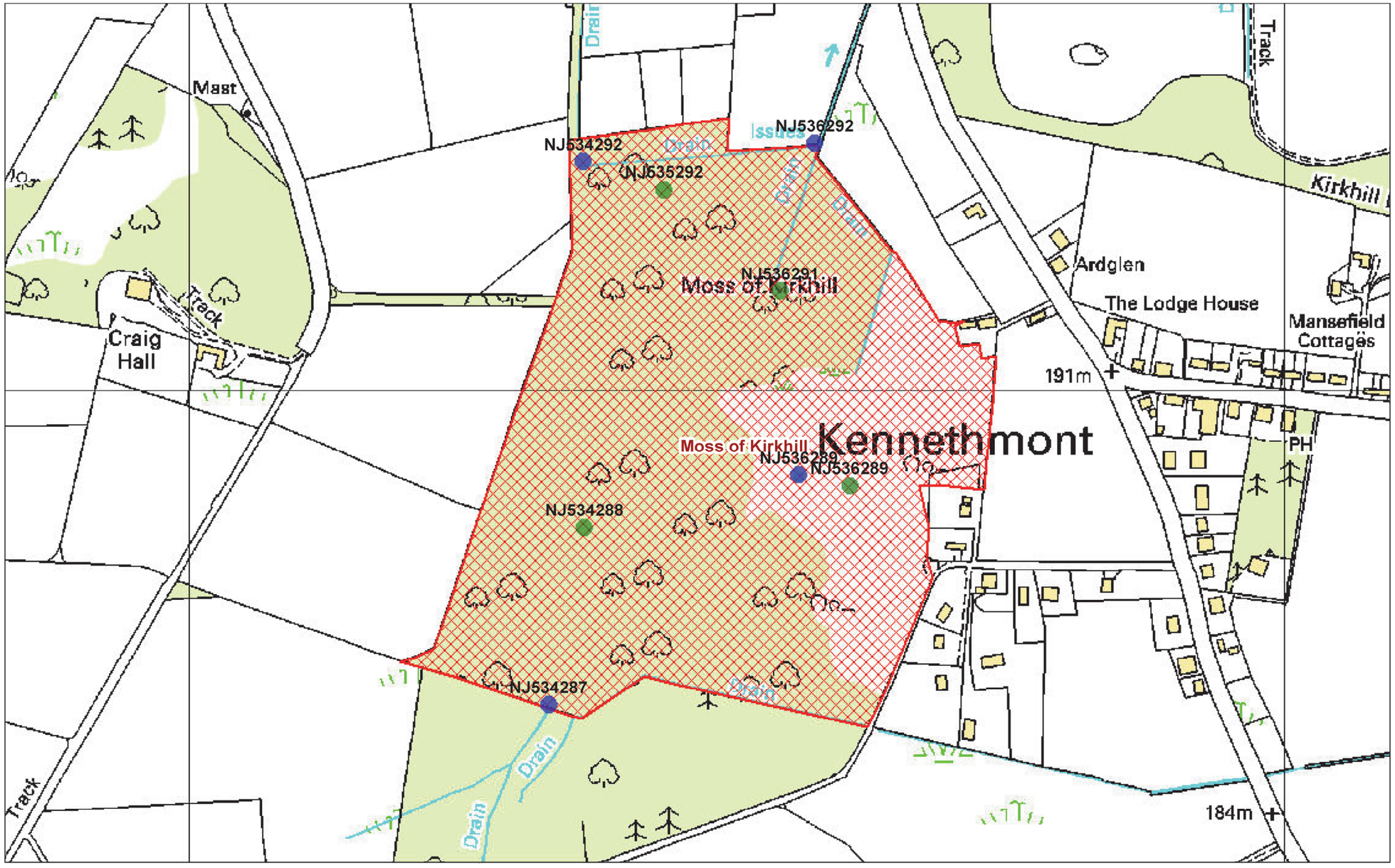


Figure 1.1: Site Location Map

Moss of Kirkhill



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Notes:

0 0.035 0.07 0.14 0.21 0.28 km

N

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Figure 2.1: SNH Proposed Sampling Location Plan

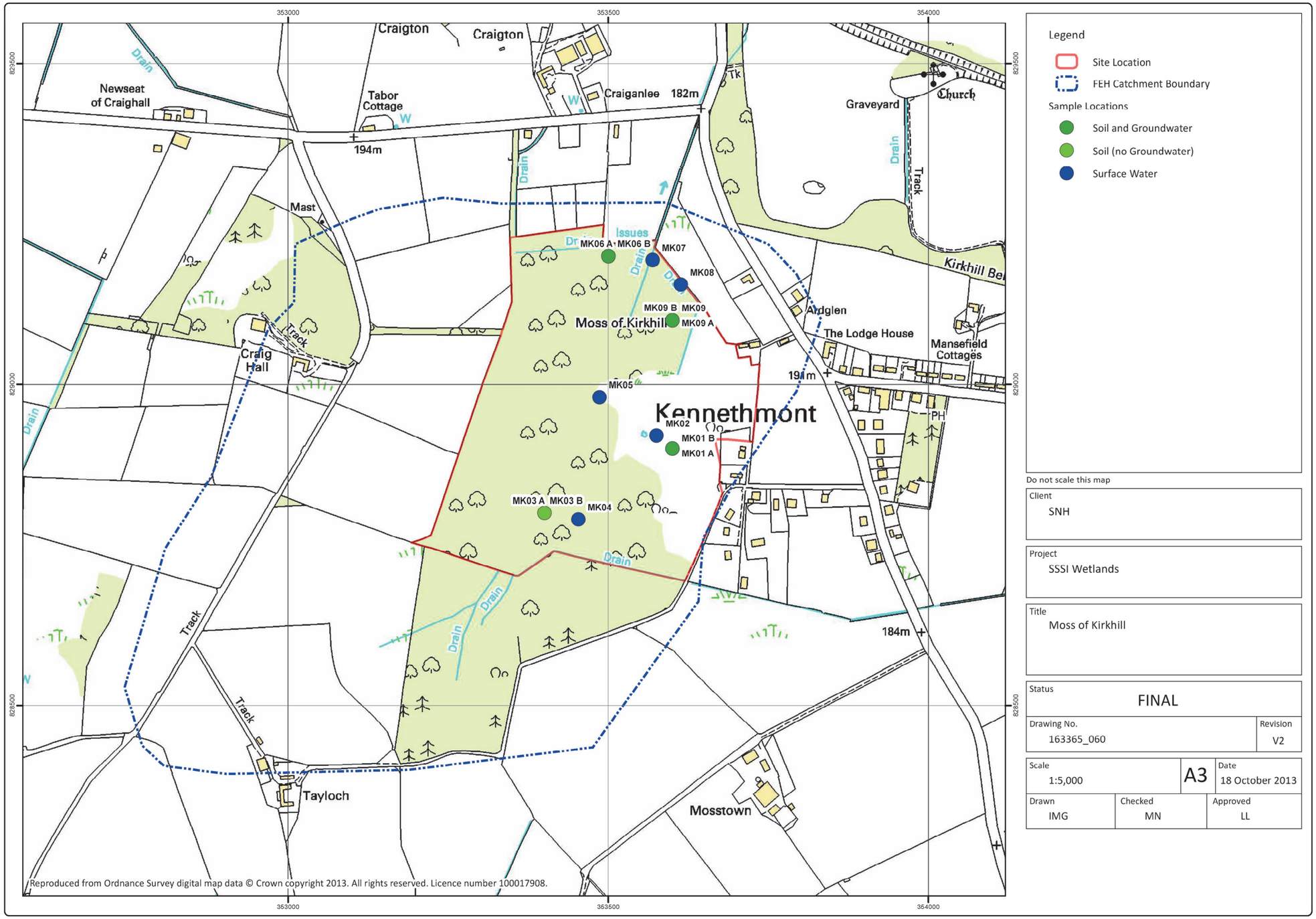

Figure 2.2: Plan of Actual Sampled Locations

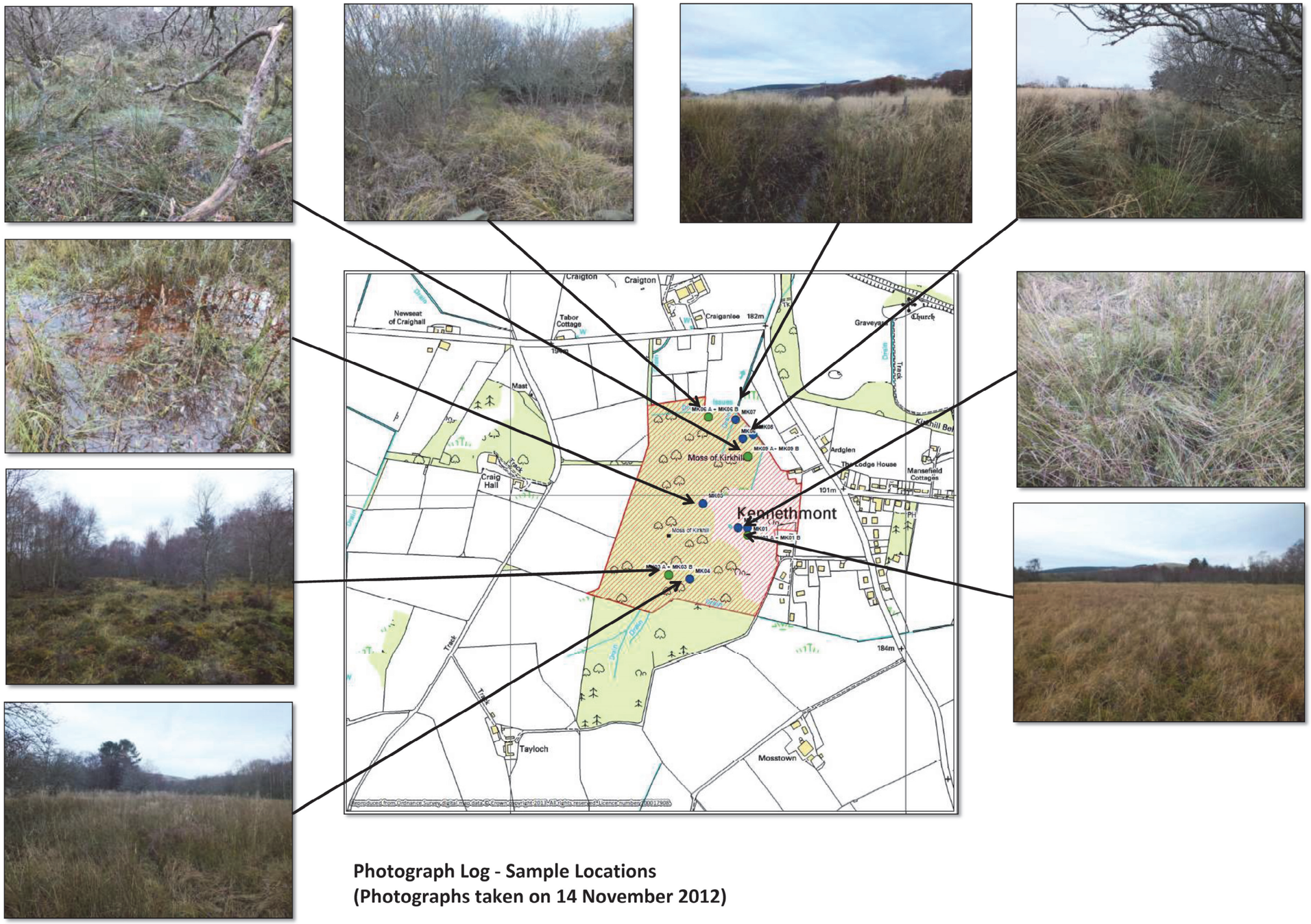

Figure 2.3: Photographs of each Sampling Location

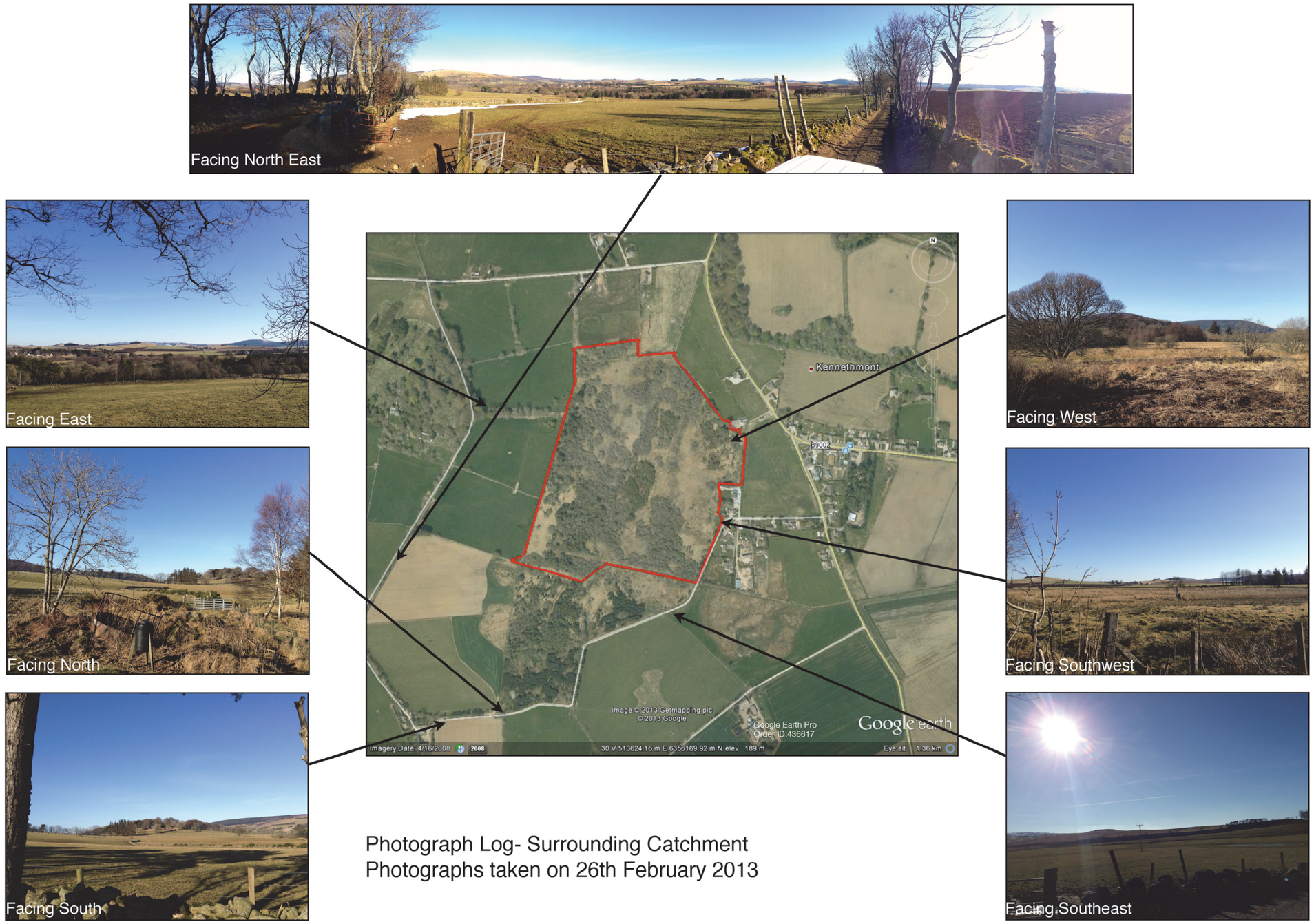

Figure 2.4: Photographs of Surrounding Land Use

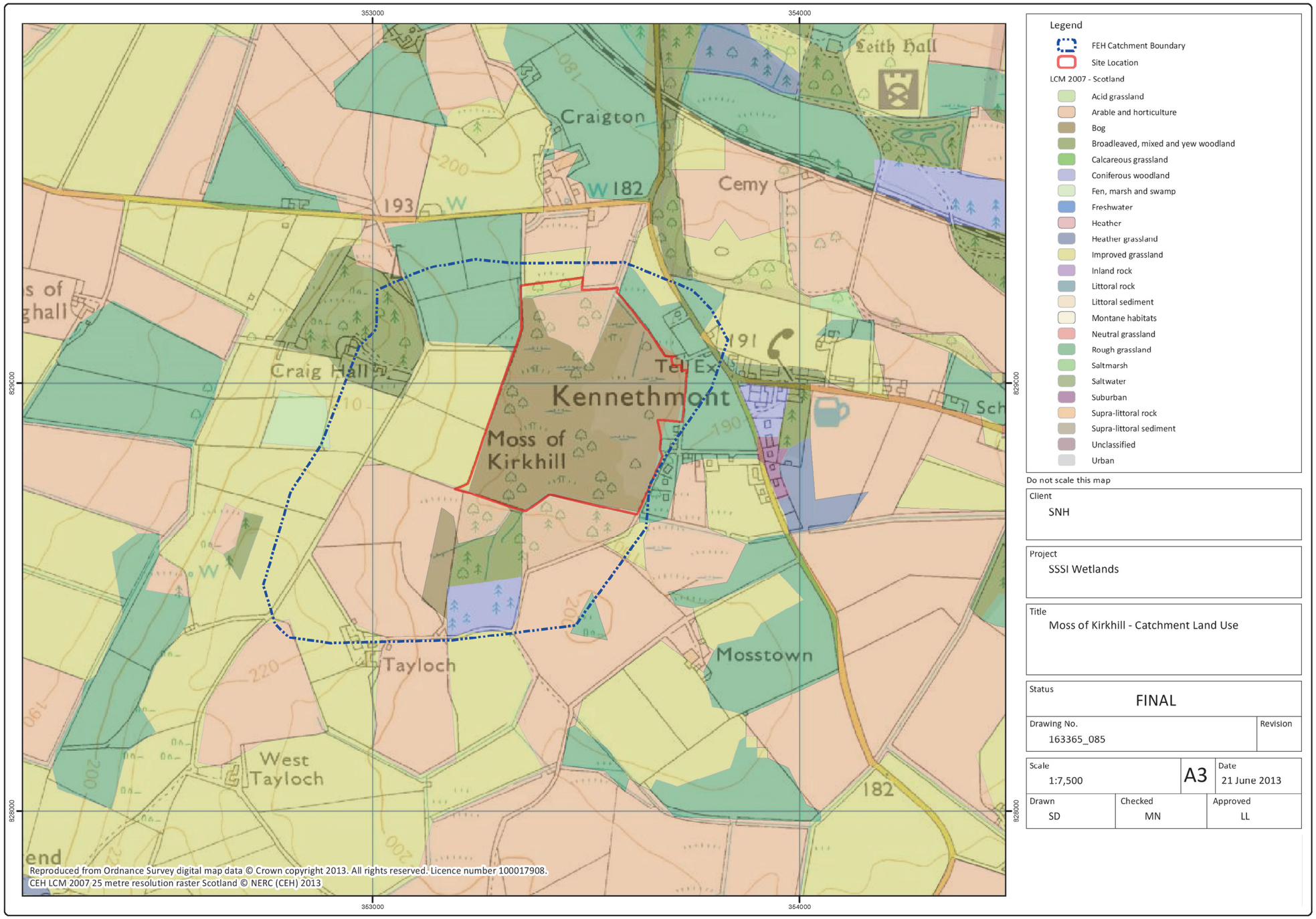

Figure 2.5: Catchment Land Use Characteristics

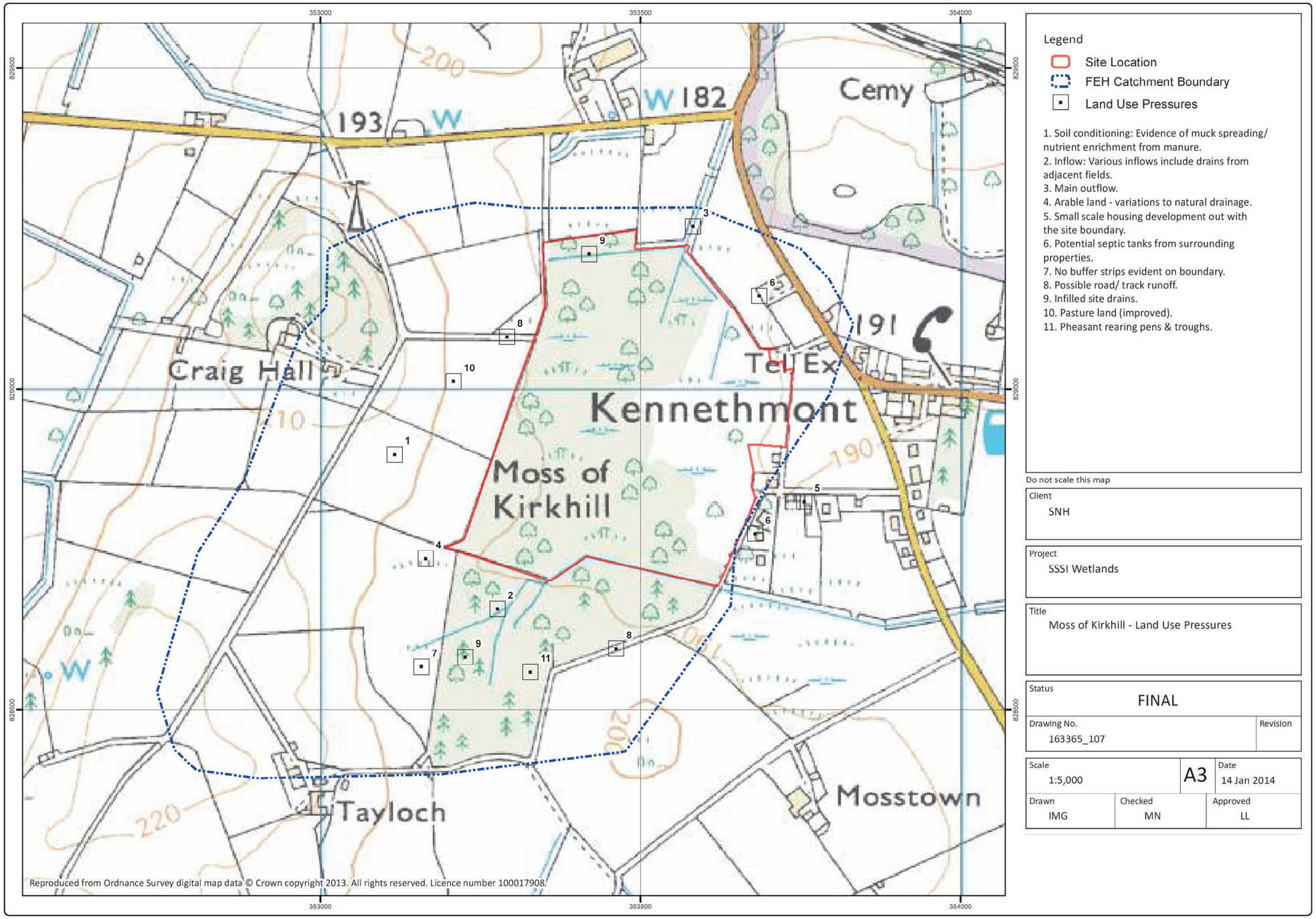

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Figure 5.1: Catchment Pressures Summary

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