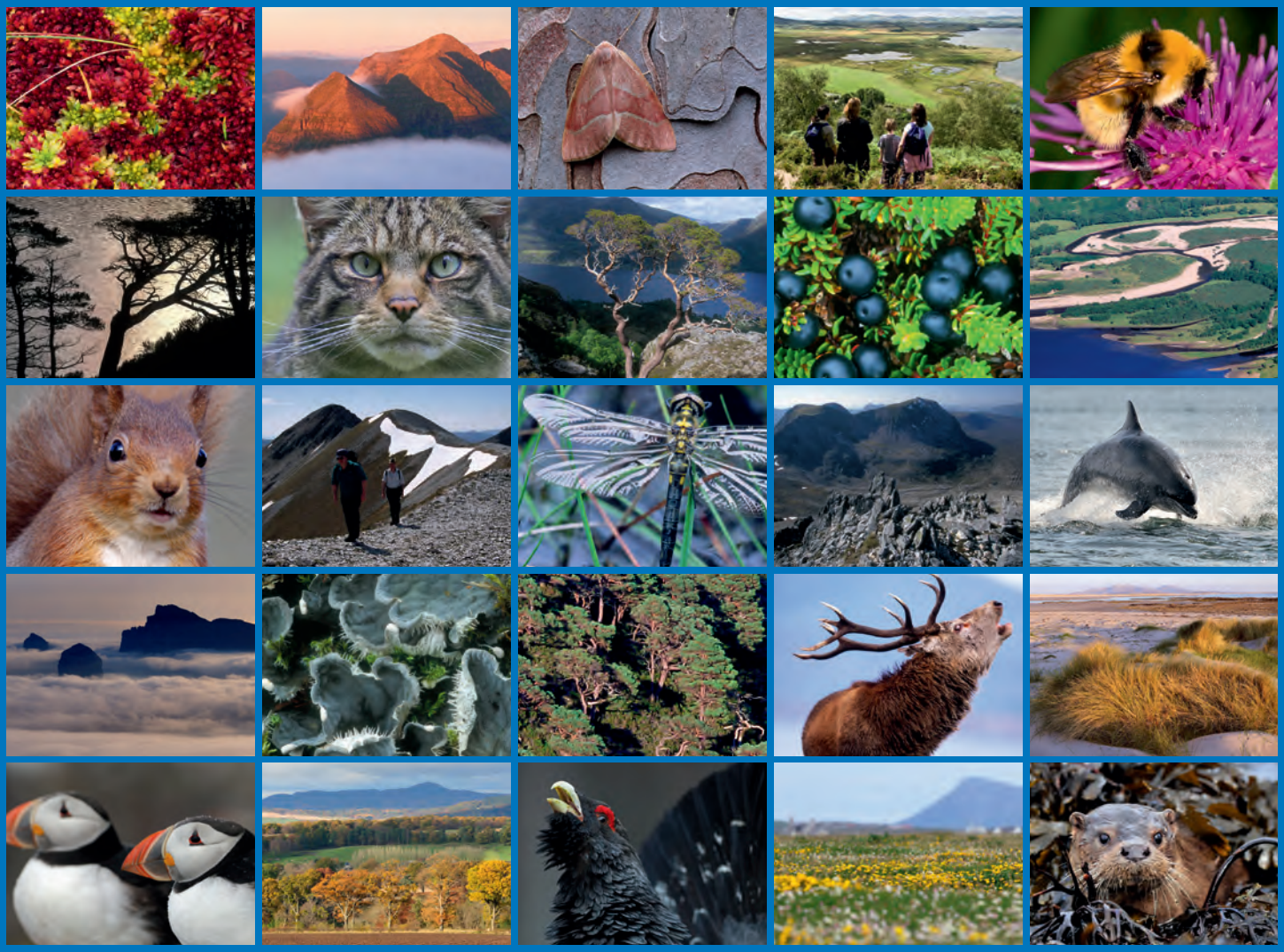
Scottish Natural Heritage
Commissioned Report No. 728

Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Lochmaben Lochs (Upper Loch and Blind Lochs)



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COMMISSIONED REPORT

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

Lochmaben Lochs (Upper Loch and Blind Lochs)

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COMMISSIONED REPORT

Summary

Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Lochmaben Lochs (Upper Loch and Blind Lochs)

Commissioned Report No. 728
Project No: 13700
Contractor: EnviroCentre Ltd.
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Keywords

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

Background

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

If sites are identified as being affected by diffuse pollution, SNH hope that the results of this report will 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.
- 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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Table of Contents **Page**

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 standing water and wetland Sites of Special Scientific Interest (SSSI).

1.1 Site Location

Lochmaben Upper and Blind Lochs are situated 2km northwest of the town of Lochmaben and approximately 10km north east of Dumfries. See Figure 1.1 in Annex 1. The lochs are situated 1km apart.

1.2 Site Description

Lochmaben Lochs are designated as a SSSI for their biological features, including eutrophic loch, open water transition fen, beetle assemblage and fly assemblage. Lochmaben Lochs SSSI comprises four lochs forming part of the most important complex of freshwater loch and marsh within the Annandale and Eskdale District. They are also noted for their populations of invertebrates. The documented area of the SSSI designation comprises an area of 38.79 hectares (SNH, 2009a).

Only the Upper Loch and Blind Lochs have been considered in this study (Mill Loch not included in the assessment).

Most of the lochs are shallow. A variety of plant communities occur ranging from dense stands of common reed *Phragmites australis*, to a littoral zone with reed canary-grass *Phalaris arundinacea* and common spike-rush *Eleocharis palustris*, to willow carr that merges into open water transition mire composed of bogbean *Menyanthes trifoliata, Sphagnum* mosses and bottle sedge *Carex rostrata*. Much of the vegetation is species-rich and some uncommon plants, such as cowbane *Cicuta virosa* and marsh stitchwort *Stellaria palustris*, occur. The SSSI supports a rich cranefly *Tipulidae* assemblage, with 47 species recorded including seven Nationally Scarce species. Other flies which can be regarded as part of a loch, fen and carr assemblage including three (proposed) Red Data Book species and two Nationally Scarce species occur. Rare water beetles species have been also recorded on the site (SNH, 2009a).

The bedrock geology consists of the Corncockle Sandstone Formation to the north, and the Lochmaben Formation to the south (Siltstone, Sandstone & Conglomerate). A superficial cover of alluvium is present around the water bodies, peat is present in lower lying marshy areas, with sand and gravel on higher areas (British Geological Survey, n.d.).

1.3 Site Hydrology

The site can be split into two distinct catchment areas, one draining to the Blind Lochs, and the other to the Upper Loch and Mill Loch. The Blind Lochs have a catchment area of 4.2km^2, and the Upper Loch a catchment area of 1.1km^2, with an annual average rainfall of 1083mm (Centre for Ecology and Hydrology, 2009).

The Blind Lochs consist of two lochans, connected by a drainage channel. The southern lochan is fed by surface runoff from the adjacent land, whilst the northern lochan has one primary inflow in the form of the Belzies Burn which enters the lochan in the north eastern corner. The southern lochan drains to the northern lochan via the aforementioned drain, however during the first site visit it was noted that this was dry. The main outflow from the northern lochan is to the north, which confluences with the Water of Ae some 600m downstream.

The Upper Loch is located to the east of the Blind Lochs across a watershed. It is fed by surface runoff from surrounding land, and by a small stream to the north. The main outflow is controlled by a sluice, drains east from the southern end of the loch and forms the main inflow to the Mill Loch around 300m further east.

1.4 Site History

Lochmaben Lochs have a history of commercial and recreational fishing, water abstraction and boating. Water sports, including boating and angling, are mainly focussed on the Mill Loch but limited boating does occur on the Upper Loch. The water levels in the Upper Loch are maintained using sluices. Limited clearing of drains occurs and patches of willow are coppiced periodically. Light grazing occurs around all the lochs (SNH, 2009b).

Original clay drainage system was laid in the 1930s (McBride, 2012).

1.5 Recent Site Management Practices

The Site Condition Monitoring Form for the Open water transition fen feature (SNH, 2011) states that there are SNH Management Agreements with two landowners at Lochmaben Lochs.

Mr Kennedy, who owns the land adjacent to Blind Lochs and Upper Loch (south of the disused railway line), was in a section 15 Agreement until 2010. Under this agreement he was permitted to graze 52 livestock units within the SSSI boundary from April to November with winter grazing being limited to 10 livestock units. The agreement stated that he must clear drains flowing into the SSSI, by clearing up to 1m depth.

Mr Moore, who owns the land around the west side of Upper Loch has been under a management agreement with SNH for over 20 years, which aims to maintain water levels within the loch, by controlling grazing and not undertaking drainage.

The owner of the east side of Upper Loch is not currently in a management agreement. This area is described as very heavily grazed and requiring modification in management to reduce the grazing that occurs here to prevent any further damage to the SSSI mire community. An alleged issue is under investigation here as supposed scrub removal had been undertaken without SNH consent and this removal occurred during the bird breeding season.

During an SNH visit in April 2012 it was noted that unconsented drainage was taking place to the south east of the Blind Lochs. A new drainage system was put in place on behalf of the farmer (partly on SSSI) aimed at improving drainage conditions in the field immediately south east of the site. Runoff from this field will now be directed into the drainage system rather than directly into the wetland, reducing any impacts from nutrient rich water on this area, but providing a more direct route to other wetland features and the Blind Lochs. SNH recommended completion of drainage works outwith the site as well as some local improvements of the works within the site to minimise impacts. (McBride, 2012)

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 (termed Visit 2) 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

Site Visit	Date of Visit	Weather Conditions	Grid References
Visit 1	24 October 2012	Dry, cold and calm	NY 062838, NY 071834, NY 077831
Visit 2	19 February 2013	Dry, sunny and cold	NY 062838, NY 071834, NY 077831

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 were taken for each sampling location at the Upper Loch (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, outflows and open water. Samples were taken from the shore which can introduce a bias as it may not reflect average conditions in the water body.

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:

- This study covered the Upper Loch and Blind Lochs. Mill Loch was not included.

- No soil samples could be taken from the Blind Lochs as this was not permitted by the landowner.

- 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 western Scotland were 144%, 105% and 128% 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 run off, dilution and catchment water levels/throughput which have not been assessed. Met office data does not make provision for south Scotland and hence these figures are indicative of the nearest available data. This should therefore be taken into account in any climatic considerations.

- 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 Field Test Data

The following data was collected by a suitably qualified operative using the methods outlined in section 2. No soil samples could be taken from the Blind Loch due to landowner objections.

Table 4.1 (a): Water Samples - Field Data (Upper Loch)

Sample ID	Nat. Grid Reference		Temp (°C)	pH	Salinity (psu)	DO (%)	DO (ppm)	ORP (mV)	EC (µS/cm)	General Field Observations
Upper Loch 1	NY 07203	83357	10.48	10.68	0.09	65.3	8.07	248	0.177	Groundwater - very slightly discoloured; no odour; few very minor s/s
Upper Loch A1	NY 06971	83646	11.60	6.91	0.11	55.8	6.16	220	0.237	Surface water - additional in-flow sample; very slightly discoloured with some fine s/s very slow flow; no odour
Upper Loch SW1	NY 06991	83444	11.64	6.90	0.06	27.8	4.37	83	0.122	Surface water - dark, cloudy brown (peaty) very fine s/s; very mild sulphurous odour
Upper Loch SW2	NY 06942	83589	11.07	6.67	0.08	40.6	3.40	112	0.176	Surface water - dark brown with gritty s/s; fine grey sand in sample; Geosock ripped
Upper Loch 2	NY 07128	83439	12.31	8.09	0.10	83.4	8.17	248	0.217	Groundwater - clear with a few fine s/s; no odour
Upper Loch 3	NY 07092	83596	11.81	7.71	0.09	79.3	8.80	253	0.191	Surface water - clear only a few visible s/s; no odour; slow flow

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

Table 4.1(b): Water Samples – Field Data (Blind Lochs)

Sample ID	Nat. Grid Reference		Temp (°C)	pH	Salinity (psu)	DO (%)	DO (ppm)	ORP (mV)	EC (µS/cm)	General Field Observations
Blind Lochs 1	NY 06397	83785	11.63	6.64	0.04	64.7	6.16	240	0.083	Surface water - cloudy brown inflow ditch; very low flow; fine brown s/s; no odour
Blind Lochs 2	NY 06156	83900	11.69	6.78	0.07	66.2	6.15	236	0.158	Surface water - very slightly discoloured with some fine s/s; no odour
Blind Lochs 3	NY 05995	84163	11.43	6.83	0.12	72.6	7.41	229	0.248	Surface water - very slightly discoloured with only a few visible s/s no odour; low-moderate flow
Blind Lochs 4	NY 05966	83936	11.41	7.1	0.13	83.4	9.19	222	0.283	Surface water - clear with only a few minor s/s; no odour; moderate flow; channel 2.3m wide
Blind Lochs 5	NY 06254	83626	10.94	7.07	0.11	72.0	7.67	221	0.23	Surface water - clear but pond weed on surface; no discernible flow; no odour

Red figures denote samples that are above 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 (a): Water Samples – Laboratory Analysis (Upper Loch)

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)
Upper Loch 1	NY 07203	83357	GW	20	4	5	0.87	0.02	<0.2	0.02	<0.1	1
Upper Loch A1	NY 06971	83646	SW (I)	26	5	6	0.91	0.07	1.5	0.02	<0.1	2
Upper Loch SW1	NY 06991	83444	SW (OW)	149	33	<10	150	0.3	<0.2	0.03	2.9	5
Upper Loch SW2	NY 06942	83589	SW (OW)	19	13	7	29.2	0.4	<0.2	0.06	0.4	4
Upper Loch 2	NY 07128	83439	GW	24	5	6	1.03	0.02	<0.2	0.04	<0.1	1
Upper Loch 3	NY 07092	83596	SW (I)	26	5	5	0.16	0.01	1.8	0.01	<0.1	2

+ 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

Table 4.2 (b): Water Samples - Laboratory Analysis (Blind Loch)

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)
Blind Loch 1	NY 06397	83785	SW (I)	10	3	4	1.55	0.3	<0.2	0.05	0.2	2
Blind Loch 2	NY 06156	83900	SW (OW)	20	5	5	0.54	0.02	0.3	0.04	<0.1	<1
Blind Loch 3	NY 05995	84163	SW (O)	28	9	5	0.3	0.01	1.1	0.02	<0.1	2
Blind Loch 4	NY 05966	83936	SW (I)	34	11	6	0.28	0.01	2	0.02	<0.1	2
Blind Loch 5	NY 06254	83626	SW (I)	30	8	9	0.22	0.02	3.5	<0.01	<0.1	3

+ 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

Table 4.3: Soil Samples – Laboratory Analysis (Upper Loch)

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)
Upper Loch 01A	NY 07203	83357	Very loose black organic matter with plant	0.7	6100	1260	535	553	82.1	<1.2	<0.2	2.13	3.66
Upper Loch 01B	NY 07203	83357	Loose black organic matter	<0.5	7930	1880	405	494	83.6	<0.7	<0.2	1.68	2.16
Upper Loch 02A	NY 07128	83439	Slightly organic sand with roots	0.9	3230	2080	337	819	54.9	<1.5	<0.2	1.13	<2
Upper Loch 02B	NY 07128	83439	Grey sand	<0.5	1220	8270	275	1450	17.2	<0.7	<0.2	<0.04	2.16

** 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 Lochmaben Lochs and the surrounding area, preliminary research was undertaken and complemented with a second site walkover to further understand the landforms and configurations, potential environmental sensitivities and possible diffuse pollution sources influencing the site from the catchment.

5.1 Desk Study

There have been four Site Condition Monitoring (SCM) assessments of the SSSI between 2003 and 2011.

- Fly assemblage monitoring (SNH, 2003): The site was assessed as being in favourable maintained condition.
- Eutrophic loch monitoring (SNH, 2004): The site was assessed as being in unfavourable no change condition.
- Beetle assemblage monitoring (SNH, 2010): The site was assessed as being in favourable maintained condition.
- Open water transition fen monitoring (SNH, 2011): The site was assessed as being in favourable declining condition.

It is not fully clear whether the 'eutrophic loch' feature only includes the Mill Loch, as the other lochs were not covered by the relevant site condition monitoring assessment.

The Site Management Statement (SNH, 2009b) records an 'Objective for Management' of maintaining the lochs and their marginal transitions, in turn maintaining the populations of rare and uncommon species of plants and animals.

The Site Condition Monitoring Form for the Open water transition fen feature (SNH, 2011) notes that the area located to the east of Upper Loch 'is too heavily grazed and requires a modification in management'. At the same time, 'the lack of grazing or scrub cutting to the west of this loch may result in the fen to succeed to carr woodland to the detriment of the fen habitat'. This note also refers to an incident in 1985 where the main outflow burn from the Blind Lochs was reported to be infested with sewage fungus. This was not confirmed during the 2011 survey, however the potential for nutrient enrichment through fertiliser runoff was noted, particularly in the northwest side with improved farmland sloping down towards the loch.

During the SCM visit in 2011 it was noted that there was evidence of gorse clearance around the Blind Lochs and the adjacent fields had recently been ploughed, including possibly some land within the SSSI). There were also drains leading into the mire with flowing or standing water of dubious quality, it would appear that the mire is being used a filter and receiving polluted water.

During an SNH visit in April 2012 it was noted that unconsented drainage was taking place to the south east of the Blind Lochs (McBride, 2012). A new drainage system was put in place on behalf of the farmer (partly on SSSI) aimed at improving drainage conditions in the field immediately south east of the site. Runoff from this field will now be directed into the drainage system rather than directly into the wetland, reducing any impacts from nutrient rich water on this area, but providing a more direct route to other wetland features and the Blind Lochs. SNH recommended completion of drainage works outwith the site as well as some local improvements of the works within the site to minimise any impacts.

The SCM form for Beetle assemblage (SNH, 2010) notes the presence of an algal bloom producing high pH readings (9.8 to 10.4) in Mill Loch. The form suggests that such blooms

occur within all the lochs and may be linked to diffuse pollution from agricultural activities within the catchment.

A Site Condition Monitoring Form for the Eutrophic loch feature (SNH, 2004) provides the following information for the Mill Loch:

Total phosphorus concentration (TP) has been inferred from the diatom stratigraphy in a sediment core taken in 1998 for SNIFFER project `Palaeolimnological Investigation of Scottish Freshwater Lochs. This analysis indicated TP roughly 30 g/litre before 1970, rising to roughly 90 g/litre in early-1990s but falling in late-1990s to a contemporary value of roughly 33 g/litre. While not `stable, TP therefore appears to have returned to a level in line with the target given in the guidance for eutrophic lochs of 35 g/litre. According to the SNIFFER report, the mean depth of Mill Loch is 7.7 m, so it falls into the `Deep category in relation to TP targets and no upper threshold applies. A water sample was taken for analysis in 2004, however no result is available. […]analysis of a sediment core taken in 1998 as part of SNIFFER project `Palaeolimnological Investigation of Scottish Freshwater Lochs suggested that sedimentation rate had increased fairly continuously from c.0.03 g/cm/yr (c.0.2 cm/yr) in 1930s to more than 0.06 g/cm/yr (1 cm/yr) in mid-1990s. Siltation may have increased as a result of increased loch productivity and therefore may be decreasing again as nutrient levels have fallen in recent years.

It should be noted that the units of concentration detailed within the SCM are assumed to be erroneous. After reviewing current levels it is assumed that the SCM units should be ug/L rather than g/L.

No information was available for the Upper Loch or Blind Lochs but this trend could be relevant, particularly in the case of the Upper Loch, which provides the main inflow to the Mill Loch. The above monitoring form also indicated that a slight blue-green algal bloom was occurring at the time of the survey in 2004, suggesting that Mill Loch is at risk from eutrophication.

The invasive species *Elodea nutalli*, *Elodea candensis* and *Nymphoides peltata* were all found in Mill Loch

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 discernible algal blooms were present at the time of the visit, this is not atypical given the time of year the site visits were undertaken.

- When observing the surrounding landform it would appear that the Upper Loch's water body is now smaller in size than it has previously been. The loch appears to have silted up, particularly on the eastern side.

- Dead gorse bushes were present throughout the site. The more likely explanation is that of controlled burning, although possible mite infection may be present.

- During the second site visit there was a very strong smell of manure, there was also evidence of muck spreading having recently occurred on the neighbouring fields.

- Both lochs are surrounded by grazed pasture land. The catchments are dominated by improved grassland, with some areas of arable land, particularly in proximity of the Upper Loch. Forestry was also observed to the north of the Upper Loch and in the upper catchment of the Blind Lochs, as shown on Ordnance Survey mapping.

- Farms are located to the north and south of Upper Loch and to the south of Blind Lochs. Both septic and slurry tanks/slurry pits are most likely present.

- There is no formalised public access to the sites.

- A dismantled railway line traverses the northern boundary of the lochs.

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.
Fishing	Currently used for recreational fishing.
Grazing	Site grazed by both sheep and cattle.
Monitoring	Condition monitoring was carried out in 2003, 2004 (Mill Loch), 2010 and 2011. The only previous physico-chemical monitoring results made available are pH values recorded in the Beetle assemblage SCM form (SNH, 2010).
Public Access	No formalised access.
Shooting	None.
Point Pollution Sources	None observed within the SSSI boundary. Muck spreading occurring on fields adjacent to site boundary.
Properties in Catchment	Four residential properties are located in close proximity of Upper Loch, to the south. A farm is located to the west of the Blind Lochs. Other properties are also located within the catchments of the lochs. Given the rural nature of the catchment is it speculated that these properties will likely be served by septic tanks and silage pits/ slurry tanks are present which depending on their maintenance could lead to nutrient enrichment.
Unusual, Distinctive or Atypical Features	Recreational boating occurs on Upper Loch. Dismantled railway traverses the northern site boundary. Forestry in wider catchments.

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 were noted to contain elevated levels of phosphorus and moderate levels of nitrogen, indicating an influence from agricultural activities in the wider catchments. Nutrient levels were generally higher at the Upper Loch, indicating eutrophic conditions. This could be due to more intensive agricultural and forestry activities present in proximity of the site.

Upper Loch

Surface water was noted to be slightly acidic to neutral with groundwater noted as being alkaline. pH ranged from 6.7 in surface water to 10.7 in groundwater at the site.

Dissolved oxygen was noted to be highest in surface water and groundwater to the east of the loch. Levels were noted to be low (<4.5mg/l) in the Upper Loch, likely due to degradation of organic matter.

Calcium was noted to be fairly uniform throughout all surface and groundwater monitoring points, with the exception of Upper Loch SW1 which recorded an elevated calcium value. Iron levels were generally noted to be low for all water samples. The highest values recorded were both in open water samples (Upper Loch SW1 and Upper Loch SW2).

Total nitrogen was highest in open water and lowest in groundwater. Nitrate levels were recorded highest at surface water inflow points and below the analytical detection level in all other samples. Ammonium levels were elevated in open water, also suggesting low dissolved oxygen conditions and degradation of organic matter.

Total phosphorus was noted to be highest in the open water samples correlating with the highest total nitrogen and the highest phosphate was recorded in the open water sample at Upper Loch 2. Phosphate was generally low with the highest value again recorded in the open water.

For a eutrophic water body, the water column typically contains at least 0.035mg/l total phosphorus (which includes phosphorus bound up in plankton) and 0.5mg/l or more total inorganic nitrogen (mainly in the form of dissolved nitrates) (Environment Agency, 2012). Whilst such levels simplify the complex interaction between plant nutrients and the hydrological and physical characteristics of individual water bodies, they serve to show the sensitivity of the trophic state to artificially increased levels of nitrogen and phosphorus. The open water samples recorded elevated levels of total phosphorus (0.4mg/l and 2.9mg/l) and total nitrogen (4mg/l and 5mg/l), reflecting eutrophic conditions.

Total phosphorus in soils was noted to be generally higher in the root zone than below. The highest extractable phosphorus was recorded in the root zone as well. Nitrate was below detectable limits in all samples as was total nitrogen. The highest calcium levels were recorded at Upper Loch 01A.

Blind Lochs

pH was generally uniform across the monitoring locations, all being slightly acidic to neutral. Dissolved oxygen was typically moderate with the highest value recorded at Blind Lochs 4, the main inflow.

Calcium levels showed slightly higher levels in the inlets on the west side compared to the eastern side. Iron was generally low in all samples, with the highest value recorded in the open water sample.

Total nitrogen was highest in Blind Lochs 5, on the south western side inlet, with all other results very similar. Nitrogen in almost all of the samples from the western side was present as nitrate suggesting runoff from agricultural lands. Highest phosphate levels were recorded on the eastern side of the Blind Lochs.

Blind Loch 1, located in an area described as having 'dubious' water quality in the 2012 condition assessment (SNH, 2012), recorded elevated pH, ammonium, phosphate and total phosphorus levels.

In the single open water sample appropriate for establishing the trophic status of the water body (Blind Lochs 2), the concentration of total phosphorus was below the 0.10mg/l level of detection and the total nitrogen concentration was <1.0mg/l. According to the aforementioned thresholds for a eutrophic water body, this sample alone is insufficient to confirm the status of the water body.

No soil samples could be taken at the Blind Lochs as this was not permitted by the landowner.

6.2 Atypical Results

Upper Loch

- Low dissolved oxygen was recorded in both Upper Loch SW1 and SW2, this may be attributable to the presence of decaying organic matter. A sulphurous odour was noted at SW1 which would suggest anaerobic conditions attributable to low oxygen environment.

- The reason for the high pH level recorded in Upper Loch 1 (groundwater) is not known. A potential explanation is liming of the soils but there is no other evidence for this.

- The elevated iron in Upper Loch SW1 (open water sample) may be entrainment of iron rich sediments into the sample, as the conditions in this area are considered to preclude very high dissolved iron. Under the prevailing conditions it would be anticipated that the iron would be present as an insoluble solid mineral within the sediments. Additionally, this value is significantly higher than the groundwater samples, which could in theory have the highest iron levels. It was also noted that this sample also had the highest calcium and magnesium and total phosphate, which indicates that this sample itself may be anomalous.

- The high total nitrogen and ammonia in sample Upper Loch SW1 may be a result of degradation of organic matter or potential surface run off from surrounding land.

- Elevated calcium in Upper Loch 01B soil sample and magnesium and potassium in Upper Loch 02B is likely attributed to natural variations in the soil chemistry.

- Elevated total and extractable phosphorus was recorded in Upper Loch 01A root zone sample. This could be attributable to either nutrient enrichment/accumulation or natural geological influences.

Blind Lochs

The Blind Lochs recorded generally uniform levels for all parameters with no significantly atypical results with the exception of the following:

- Nitrate and total nitrogen were elevated, compared to the rest of the samples at the site, in Blind Lochs 5 (south western inflow) which may indicate nitrogen inputs from agriculture to the west of the loch, augmented by the upgraded drainage system in this area.

- The elevated ammonia in Blind Lochs 1 may just be a result of natural variation of environmental conditions (lower oxygen environment) in this area.

6.3 Additional considerations

Apart from the brief mention in the Eutrophic loch Condition Monitoring Form (SNH, 2004), no records or reports (anecdotal or otherwise) of algal blooms or fishing records were reviewed during this study. Information of this nature could be of value in understanding long-term trends and changes within the site.

7. CONCLUSIONS

The analytical results show a trend of elevated nutrients within the site, particularly at the Upper Loch. This would mainly be a consequence of agricultural activities in the catchment.

The study area has two parts; Upper Loch and Blind Lochs. These lochs are shallow and located in different sub-catchments, with a surface area of 1.1km^2 and 4.2 km^2 respectively. Both areas are used for grazing, with gorse control being carried out. The catchments are dominated by improved grassland with extensive field drainage, with areas of arable land and forestry, particularly in proximity of the Upper Loch. A dismantled railway line borders both lochs to the north.

Water levels in the Upper Loch are maintained using sluices. This loch is also used for water sports. The Blind Lochs consist of two lochans, with the northern lochan receiving most of the drainage from the catchment through the Belzie Burn and discharging to the north, and the southern lochan having limited direct inflow through runoff from the surrounding slopes and an intermittent outflow.

SNH reports highlighted excessive grazing to the eastern side of the Upper Loch within the SSSI. However, it was also mentioned that livestock exclusion from all presently grazed areas would not be desirable and would lead to vegetation encroachment (SNH, 2012). Ploughing and scrub clearance to the north east of the Blind Lochs has led potentially to damage of the fen. Unconsented drainage works have been recently undertaken to the southwest of the Blind Lochs, partially on the site, increasing the connectivity with the southern lochan (McBride, 2012).

Surface water and groundwater at the study area was noted to contain elevated levels of phosphorus and moderate levels of nitrogen, indicating an influence from agricultural activities in the wider catchments. Nutrient levels were generally higher at the Upper Loch, which reflected eutrophic conditions at the time of monitoring. This could be due to more intensive agricultural activities present in proximity of the site. More elevated nitrogen levels in the south west of the Blind Lochs could be indicating an influence from recent drainage works undertaken in this area.

An assessment undertaken at the site in 1985 reported poor water quality in the Belzies Burn, main inflow to the Blind Lochs (SNH, 2012). Nutrient levels recorded for this study were relatively low, albeit this stream could be subject to seasonal variations. An assessment carried out in 2012 observed poor water quality conditions in ditches that flow into the mire communities on the north eastern side of the lochs (SNH, 2012). Analytical results for this area confirmed these observations, recording elevated levels of ammonium and phosphorus.

Evidence of agricultural improvements and forestry in the wider catchment are expected to have resulted in an accelerated nutrient inflow to the site. Nutrients and suspended solids have been flushed down to the site and partially been captured by the wetland and deposited in the lochs.

Farms and households with septic and slurry tanks located in close proximity of the lochs are potentially contributing nutrients, particularly to the south of the Upper Loch. Sampling results were not conclusive in terms of the significance of this potential source.

Previous studies undertaken at the site indicated that phosphorus levels in the Mill Loch, immediately downstream of the Upper Loch, increased from 1970 to early-1990s but then fell in late-1990s, returning to a level in line with the threshold given in the guidance for

eutrophic lochs. No information was available for the Upper Loch, however this trend could be relevant as the loch provides the main inflow to the Mill Loch.

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 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. one year). The data from such should be compared alongside water levels, rainfall data and seasonal abnormalities to seek to understand the nutrient dynamics taking place within the site.

ii. In conjunction with i, assess the seasonal flow and nutrient loads of the inflow streams, including the Belzies Burn, and compare these with those of the outflows from both lochs. This data would be of direct value in being able to assess the flow dynamics of the loch and to understand retention times and season variations in throughput.

8.2 Other Commissioned Studies

iii. Undertake core sampling of loch sediments to understand historic source pollution and retained nutrients and confirm trends observed at the Mill Loch. It is considered likely that there will be a significant volume of nutrient bound up in the loch sediments this may be being slowly released into the water column.

iv. Undertake hydrological and hydrogeological assessment of the catchment to determine the hydrological regime of the lochs. Consideration should be made to understand the functioning and management of the sluice on the outlet flow from the loch. This may be subject to regulatory control from SEPA and variations to such would therefore be likely to require consultation and approval.

v. Review the potential loss of open water in the study area (particularly Upper Loch) and determine whether this was due to siltation, changes in water level and/or vegetation encroachment.

vi. Undertake a detailed library review, including historical mapping and local data sources, to seek to understand historical land use and information relating to loch use, size and depth. Where such is not available, commission a bathymetry survey of the loch to confirm depth and sediment profiles. This would aid the understanding of inflow and retained sediment volume.

8.3 Management

vii. 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 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. This approach 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. This is particularly applicable to marginal and aquatic vegetation.

8.4 Landowners

viii. 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. This should include access of livestock to the site. Consider appropriate management strategies accordingly - for example, nutrient management planning, buffer strips, exclusion zones, routine spot monitoring, improved/repaired fencing, improved use of fertilizers, treatment of outflows e.g. constructed wetlands *etc*.

ix. Review the operation of new drainage network to the south west of the Blind Lochs, considering any impacts on water levels, nutrients and vegetation in this area.

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

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

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

8.5 External Consultations

xiii. Engage with SEPA to further the understanding of the site in terms of the sluice management/operation.

From the stated conclusions and identified pressures (Figure 5.1), the key actions to maintaining the lochs and their marginal transitions are to:

1. Confirm the trend of diffuse pollution and nutrient concentrations within the wetlands and lochs (i, iii);
2. Address the inputs to the surface water and groundwater from agricultural (and other) activities at the site in its surrounds and within the wider catchment (viii, ix, x, xi); and
3. Assess the potential loss of open water, particularly at the Upper Loch (iv, v).

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ANNEX 1: FIGURES

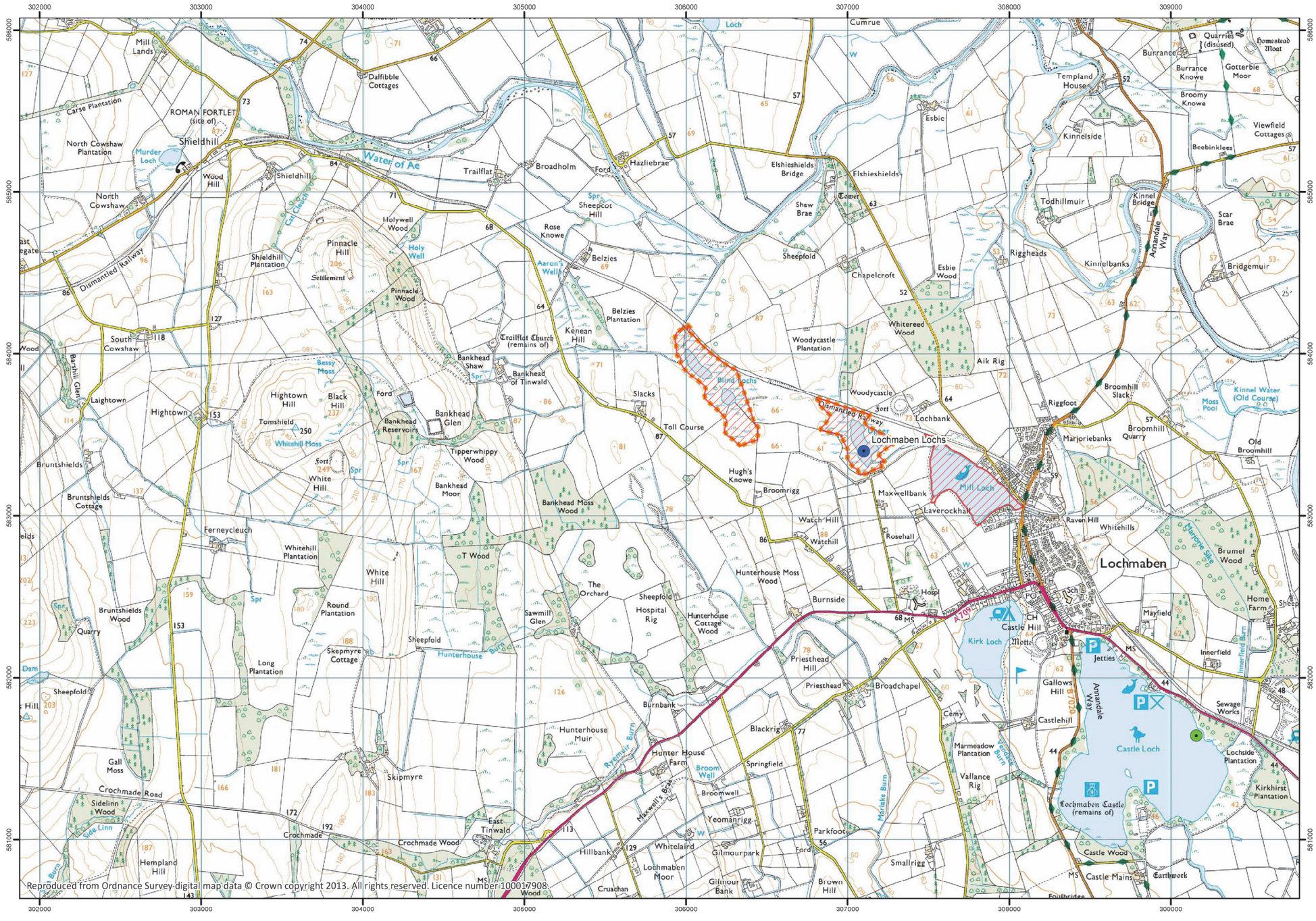
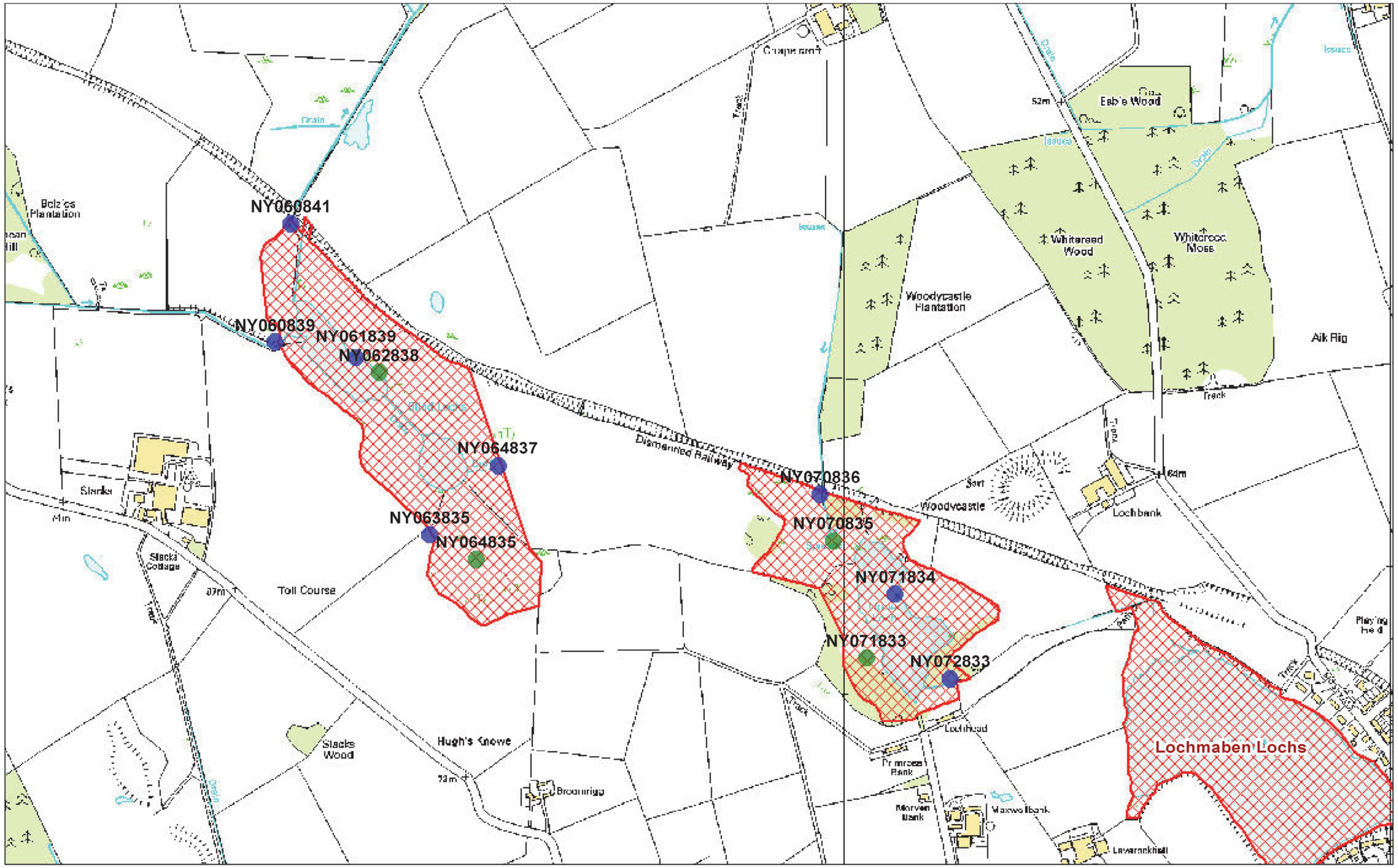


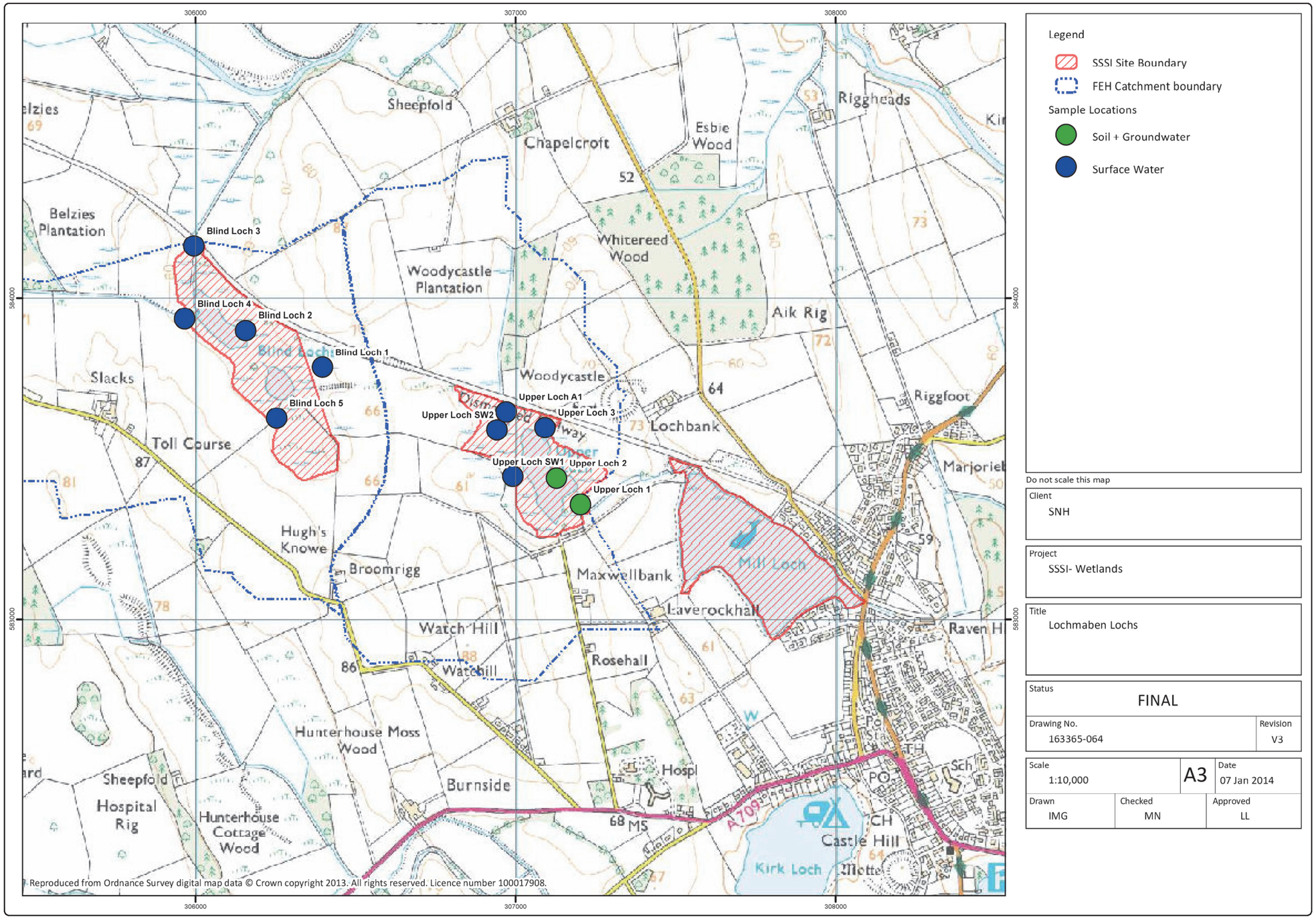
Figure 1.1: Site Location Map

Lochmaben



Map produced using geo.View 3.0
Printed: Sep 20, 2012 15:55:17

Figure 2.1: SNH Proposed Sampling Location Plan



Legend

SSSI Site Boundary

FEH Catchment boundary

Sample Locations

Soil + Groundwater

Surface Water

Do not scale this map

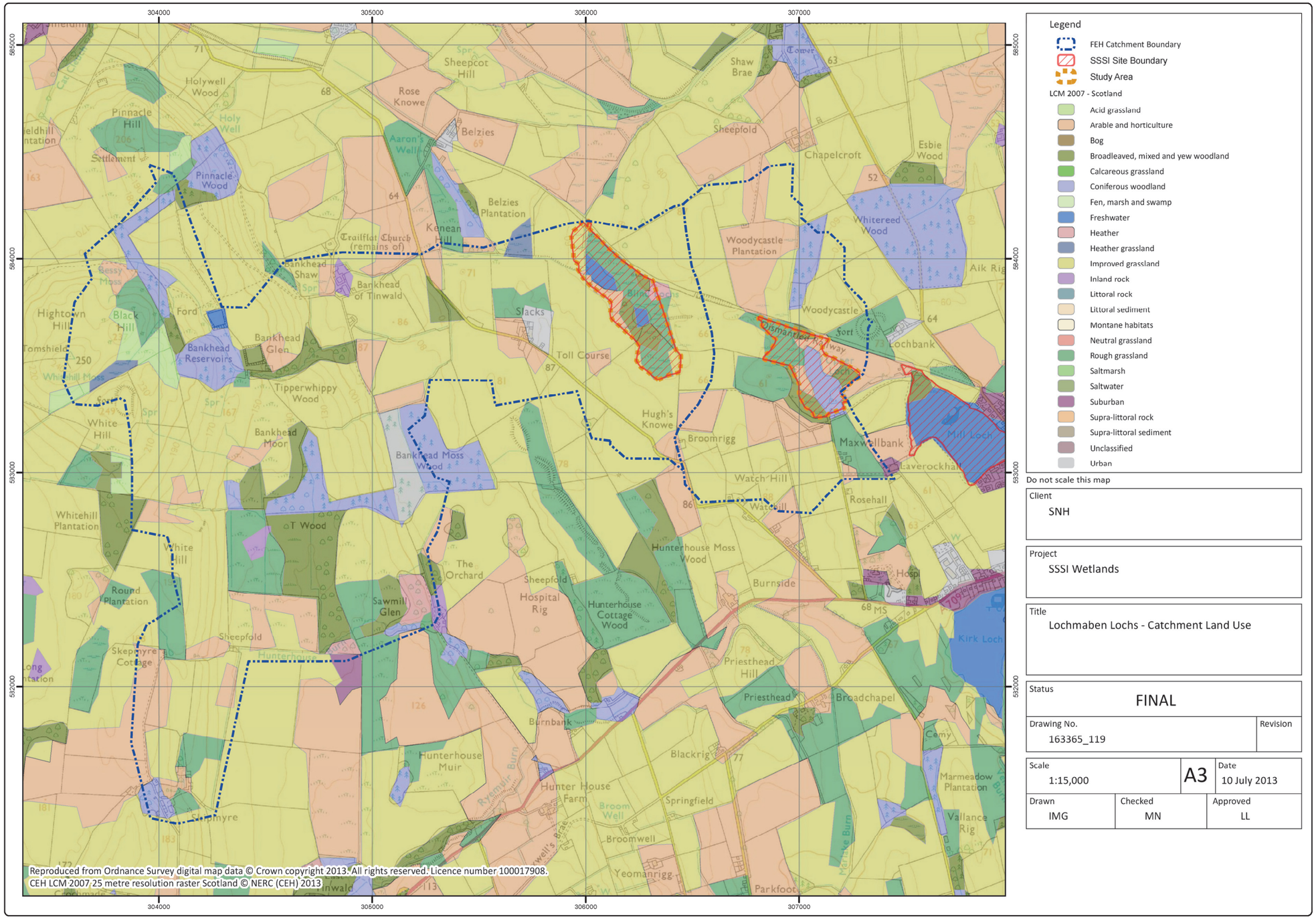
Client	SNH
Project	SSSI- Wetlands
Title	Lochmaben Lochs
Status	FINAL
Drawing No.	163365-064
Revision	V3
Scale	1:10,000
A3	
Date	07 Jan 2014
Drawn	IMG
Checked	MN
Approved	LL

Figure 2.2: Plan of Actual Sampled Locations

Photograph Log - Sample Locations
(Photographs taken on 24th October 2012)

Figure 2.3: Photographs of each Sampling Location

Figure 2.4: Photographs of Surrounding Land Use



Legend

- FEH Catchment Boundary
- SSSI Site Boundary
- Study Area

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: Lochmaben Lochs - Catchment Land Use

Status: FINAL

Drawing No.	Revision
163365_119	

Scale		Date
1:15,000	A3	10 July 2013

Drawn	Checked	Approved
IMG	MN	LL

Figure 2.5: Catchment Land Use Characteristics

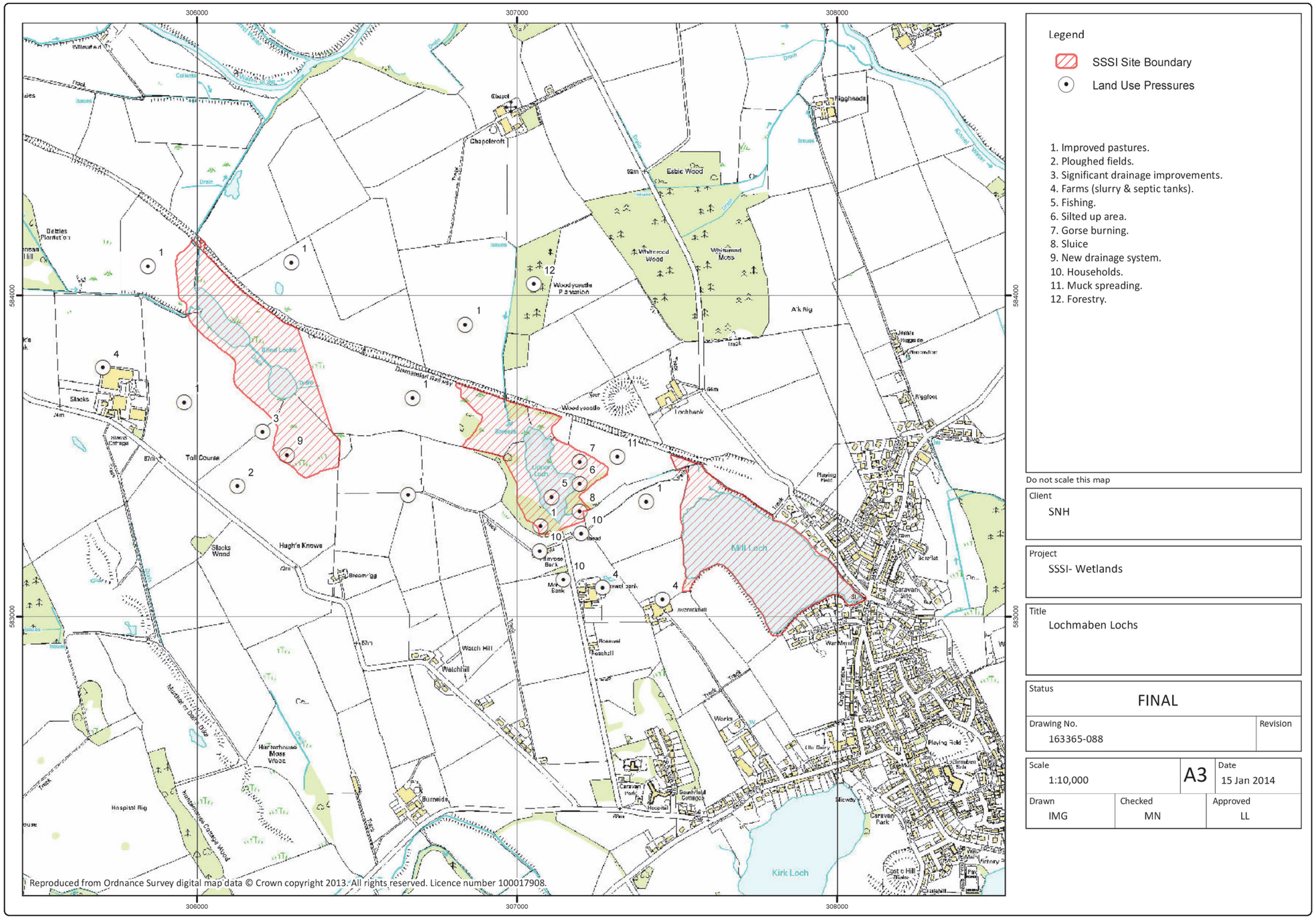


Figure 5.1: Catchment Pressures Summary

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