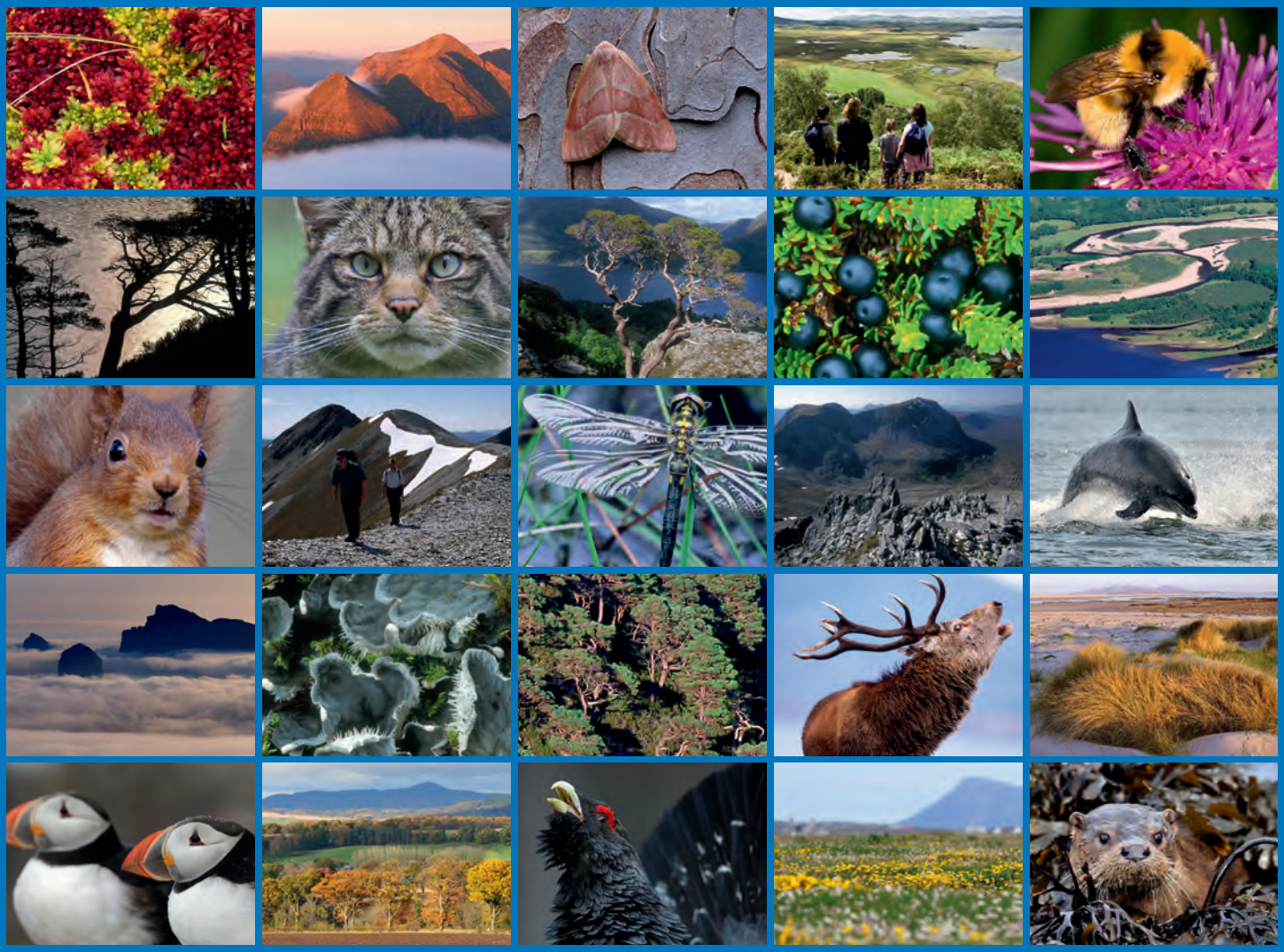
Scottish Natural Heritage
Commissioned Report No. 729

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



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COMMISSIONED REPORT

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

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COMMISSIONED REPORT

Summary

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

Commissioned Report No. 729
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

- Analytical data was inconclusive in determining nutrient levels that would be typical of a mesotrophic waterbody, however, there was evidence of possible nutrient enrichment within the sample dataset. The sampling assessment was undertaken as a single visit which was limited by access to parts of the site on health and safety grounds. The limited dataset constrains the ability to draw accurate conclusions on current site conditions.
- The desk study and site walkover revealed additional nutrient sources not previously identified and potential existing and historical land use practices within the catchment that could adversely affect water quality and loch dynamics.
- A series of recommendations are proposed to seek to aid the understanding of the site, the loch flow regime and the impact of variations in the water levels on eutrophication. It is considered that additional information will help further the understanding of the observed changes taking place at the site.

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Acknowledgements

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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

Lochmill Loch is located approximately 2 kilometres (1.2 miles) south west of Newburgh and 21 kilometres (13 miles) south east of Perth. The site is accessed off the A913 from a farm track running off Woodriffe Road (Newburgh to Pitcairlie). See Figure 1.1 in Annex 1.

1.2 Site Description

Lochmill Loch is a Site of Special Scientific Interest (SSSI). The site comprises of a small mesotrophic loch, neutral grassland, deciduous woodland (thought to be of ancient origin) and an extensive area of dwarf-shrub heath. The SSSI citation documents the site area as 41.53 hectares (SNH, 2010a).

The loch is primarily of interest for its aquatic flora including an unusually large number of pondweed species. The majority of the loch's catchment is included within the designation and comprises areas of hill pasture, whin and hawthorn scrub, deciduous woodland and dwarf-shrub heath. This diversity of habitats is reflected in the large number of vascular plant species present (SNH, 2010a).

Fields for grazing bound the site to the north, while heathland lies to the south and west. The heathland surrounding the loch is of considerable interest as a representative example of a habitat type, which was once widespread throughout the Fife region but which is now rare.

The site also has a good butterfly fauna and a range of breeding birds have previously been recorded on site. Otters have also on occasion been recorded.

The site is part owned by Scottish Water and the loch is currently used and managed as a water supply reservoir. Land to north of the loch is leased to a local farmer for grazing of stock and is subject to a licensed agreement with Scottish Water. To the south of the loch is land owned and managed by Forestry Commission Scotland (SNH, 2010b).

The underlying bedrock consists of the Ochil Volcanic Formation, predominantly heavily faulted Pyroxene Andesite and occasional Conglomerate. This is overlain in the lower lying areas of the catchment by either glacial till or alluvium. The topographic highs within the catchment are free from superficial deposits (British Geological Survey, n.d).

1.3 Site Hydrology

A catchment area of 0.95km^2 drains to Lochmill Loch, with an annual average rainfall of 824mm (Centre for Ecology and Hydrology, 2009). The main inflow to the site is an unnamed watercourse which flows into the south western end of the loch. The watercourse is sourced from a series of springs on the slopes of both Pitcairlie and Lumbennie Hills. An additional inflow to the loch comes in the form of surface runoff from the surrounding hill slopes. The Bow Burn (flowing northeast) forms the main outflow from the loch; this is a controlled outflow through a dam structure.

1.4 Site History

The reservoir was built in 1885 creating a whole new water body. The water level of the reservoir was raised in 1950 which is presumed to cater for an increase in demand from the local population.

Since 1910 there have been significant increases in the nutrient levels of the loch in turn affecting the aquatic species diversity.

Newburgh Angling Club has been fishing the loch since 1943 (Gazetter for Scotland, n.d.). The loch is stocked with Brown (*Salmo trutta*) and Rainbow Trout (*Oncorhynchus mykiss*). During 1999 there was the construction of an unconsented fishing platform on the south-eastern shore which led to damage of the largest remaining area of reed bed (SNH, 1999).

Between 1973 and 1976 there were wide fluctuations in water levels due to remedial works that were undertaken on site. Draw down levels of the loch during 1989 and 1990 were at an all-time low with 1989 resulting in a major drop in levels as the year progressed. This is attributed to the then hot summer of 1989 and resulting high demand for water and considered to have contributed to a 20% reduction in the aquatic macrophyte cover in the early 1990s (Gibson, 1991).

To the south of the loch the land is owned and managed by Forestry Commission for Scotland. During the 1980s some areas of the heath to the south of the loch were planted with oak (*Quercus spp.*), larch (*Larix spp.*) and Scot's Pine (*Pinus sylvestris)* under consent from Nature Conservancy Council (SNH, 2010b).

Fife Regional Council concluded an access and management agreement with Newburgh Community Council in 1982 for the north and western sections of the site for recreational and nature conservation purposes. These sections were grazed by cattle until 1983 and resulted in significant damage to the heathland. Over the following years the site was only grazed in winter and intermittently during the summer months. This has resulted in the spread of gorse and broom which in 1986 were sprayed with herbicides. East of Scotland Water took over ownership of the northern section in 1994 (SNH, 1999).

Prior to 1990, algal blooms were recorded in the loch and posed problems for the receiving water treatment works. Permission was granted by Nature Conservancy Council (now SNH) for copper sulphate to be dosed to the water (at a rate of 0.05ppm copper) to treat such. This was undertaken using copper sulphate crystals in hessian bags being towed behind a boat throughout the waterbody (Badenoch, 1990).

1.5 Recent Site Management Practices

A review of the SNH site files coupled with internet research revealed limited information in addition to that within the Site Management Statements (SNH, 1999; SNH, 2010b). The SNH documents are therefore considered to be the main sources of historical information for the site and from which the following summary is taken.

In 1995 SNH agreed a management plan with the Forestry Commission to maintain and enhance the semi-natural vegetation and associated habitats within their ownership. The details of this agreement have not been reviewed as part of this study although it is understood that this included provision to ensure that the aquatic flora and other features of interest are not adversely affected through their activities (SNH, 1999).

In 1999 it is reported that the reed bed along the path to, and to the west of, the boathouse was cut to a width of 3m. This was done by consent. In addition, the report states that stock-

feeding was taking place just outside the SSSI boundary; cattle were observed grazing in the north western section of the site; and a decline in aquatic flora was linked to continuing eutrophication of the loch (SNH, 1999).

Between 2000 and October 2005 a five year management agreement was put in place between SNH and East of Scotland Water with reference to scrub removal and control; control of noxious weeds; grazing; and land management (SNH, 2010).

There is reference to gorse (*Ulex europaeus*) control having been undertaken in 2007 with the cut material being left *in situ*, and further scrub clearance being scheduled for Winter 2007/2008 (SNH, 2007). The same report references a management agreement having been signed with the Forestry Commission to undertake a three year programme to address the reasons for the unfavourable condition of the heathland interest. This included the removal of scrub and small trees and some small muirburn trials which are reported as having taken place in November 2007.

SNH Site Management Statement (SNH, 1999) refers to the potential decommissioning of the reservoir in the future with the associated need to significantly lower the water level. It is understood that this has not yet occurred, however it remains possible and would have a significant detrimental effect on the aquatic flora.

2. METHODOLOGY

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

2.1 Pre-site Attendance Desk Study

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

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

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

2.2 Site Attendance

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

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

Table 2.1: Site Conditions

Lochmill Loch	Date of Visit	Weather Conditions	Grid References
Visit 1	30 October 2012	Cold, overcast with light drizzle	NO 222162
Visit 2	20 February 2013	Overcast, cold with light drizzle	NO 222162

2.3 Sampling Approach

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

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

2.4 Sample Equipment

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

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

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

All samples were given unique identification names and packaged in cool boxes with ice packs so as to keep samples at appropriate temperatures prior to be 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. Collections were made from inflows, standing water areas and the loch outflow.

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.

- Establishing suitable sample locations in the western part of the site on health and safety grounds as well as finding groundwater at the sought depth constrained sampling at the predetermined locations. Where required, samples were collected from similar locations as close to the predetermined point as practicable.

- 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 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.

Table 4.1: Water Samples - Field Data and Observations

Sample ID	Nat. Grid Reference		Temp (°C)	pH	Salinity (psu)	DO (%)	DO (ppm)	ORP (mV)	EC (µS/cm)	Comments
LM01	NO 22589	16348	8.21	7.84	0.13	66.6	7.31	104	0.274	Surface water - clear with very minor suspended solids; no odour
LM02	NO 22319	16321	8.20	7.95	0.13	66.3	8.73	117	0.273	Surface water - clear with minor suspended solids; no odour
LM03	NO 21701	16032	8.50	7.70	0.22	N/A	N/A	151	0.47	Surface water - clear with very minor suspended solids; no odour
LM04	NO 21696	16135	8.60	7.66	0.21	62.3	7.36	109	0.442	Groundwater - dark, cloudy brown; fine suspended solids; no odour
LM05	NO 21976	16133	8.59	7.74	0.20	94.6	12.03	141	0.419	Surface water - clear; some very fine suspended solids; no odour
LM06	NO 21834	16158	*No water available - sampled five (5) pilot augurs without success.*							
LM07	NO 22190	16060	8.42	7.39	0.20	84.5	9.81	165	0.433	Groundwater - light cloudy brown; no odour

N/A – Probe Error. No result obtained.

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)
LM01	NO 22589	16348	SW (O)	31	14	8	0.02	0.05	<0.2	<0.01	<0.1	<1
LM02	NO 22319	16321	SW (OW)	25	12	6	0.03	0.05	<0.2	<0.01	<0.1	<1
LM03	NO 21701	16032	SW (I)	32	11	8	0.45	0.01	1.2	<0.01	<0.1	1
LM04	NO 21696	16135	GW	71	45	<10	49.20	0.70	<0.2	0.01	2.2	2
LM05	NO 21976	16133	SW (I)	29	12	9	<0.01	0.01	0.7	<0.01	<0.1	<1
LM06	NO 21834	16158	GW	*No water available - sampled five (5) pilot augurs without success.*								
LM07	NO 22190	16060	GW	39	18	9	2.86	1.40	<0.2	0.01	0.2	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 4.3: 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)
LM04A	NO 21696	16135	Organic brown soil with small gravels	<0.5	3960	4160	378	790	73.9	<0.9	<0.2	1.29	6.29
LM04B	NO 21696	16135	Limited brown earth with gravels	<0.5	5020	14800	643	2040	40.4	<1.3	0.8	0.32	<2.0
LM06A	NO 21834	16158	Limited brown earth with gravels	1.3	1650	20700	789	1810	39.2	4.6	3.7	0.35	5.84
LM06B	NO 21834	16158	Limited brown earth with gravels	<0.5	2900	21300	599	1490	24.4	<1.0	0.5	0.14	<2.0
LM07A	NO 22190	16060	Organic brown soil with small gravels	23.5	2610	4090	402	697	64.6	<1.1	<0.2	0.60	2.27
LM07B	NO 22190	16060	Limited brown earth with gravels	1.2	2550	4130	623	1090	33.4	<2.7	<0.2	0.11	4.89

** 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 Lochmill Loch 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 2010b SNH Site Management Statement records the following three key 'Objectives for management' to enhance the conditions of the site.

- 'To maintain the extent and improve the condition of the dry heath habitat'
- 'To reduce the levels of Canadian pondweed present within the loch thereby encouraging increased levels of previously recorded pondweed (Potamogeton) species'
- 'To manage the loch catchment area of neutral grassland and scrub to benefit plant species'

There are three SNH commissioned site conditioning monitoring reports for the site. An SCM for the Mesotrophic loch feature was carried out in 2004, assessing the condition of the feature as unfavourable declining (SNH, 2004). The SCM for the Lowland dry heath feature was carried out in 2002 and 2007, assessing the feature as unfavourable declining and then unfavourable recovering (SNH, 2002; SNH 2007). Substantial beds of Canadian Pondweed (*Elodea canadensis)* were recorded and deemed locally dominant in 2004. The 2002 Condition Monitoring Form states that there has been measurable loss of the heath when compared to the 1992 NVC map namely that 'an isolated area of heath recorded in 1992 to the east of the site could not be refound … the main stand has decreased in size due to the encroaching scrub and loss of heath to grassland'. The loss of extent was noted as continuing in 2007.

The 2007 SCM form (SNH, 2007) states that "A Management Agreement has now been signed with Forestry Commission to undertake a 3 year programme of work to address the reasons for the unfavourable condition of the heathland interest. The work includes removal of scrub and small trees and some small muirburn trials. The work commenced in November 2007. In view of necessary management being in place the condition is recorded as Recovering".

It is noted that in October 2012 it was verbally reported by the local SNH Officer (Gavin Johnson) that the angling club advised SNH that they have never had an algal bloom during their tenure. This would appear to directly contradict the information provided by Badenoch as detailed in section 1.4 but may align with changes in the water levels at the loch if it is no longer used for potable supply.

A site visit by SNH in 1999 reported that 'For the southern section of the site, management of the heathland is now priority' (Thiel, 1999).

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 observed however, this is not unexpected given the time of year the site visits were undertaken.

- Around the eastern and northern perimeter of the loch there is evidence of reed encroachment. This was not formally monitored as part of this study.

- There are tracks bounding both northern and southern boundaries of the site, a car park is also present at the eastern site boundary by the boathouse.

- Boats are present on the northern banks of the loch. These appear to be owned by the angling club for fishing purposes.

- Tree planting was evident to the north of the site boundary within an area fenced off for what is assumed protection from grazing by deer.

- Bounding the southern boundary are grazed fields. Historically there have been management agreements in place between East of Scotland Water (now Scottish Water) and the local farmer to manage grazing within site.

- No evidence of accelerated sediment transport into the loch was observed from any of the catchment locations/features assessed.

5.3 Summary

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

Table 5.1: Summary of key observations

Activities	Observations
Fencing	The boundary of the site is partially fenced - the standard and completeness of which was not assessed as part of this study.
Fishing	The loch holds populations of Brown and Rainbow Trout and is stocked by Newburgh Angling Club with Rainbow Trout. Limitations are understood to include a 600lb annual stocking limit and use of up to four boats/eight rods.
Grazing	No grazing was evident at the site during either site visit and desk study records indicate that grazing ceased in 1987. Historically grazing management agreements between East of Scotland Water and a tenant farmer have been in place but are likely to have expired or not been recently updated. Given the location and nature of the site it is expected to be grazed by deer but this has not been confirmed during the site visits.
Monitoring	Condition monitoring was carried out in 2004 and 2007. Very limited water data records exist despite reference to algal monitoring. No known soil monitoring.
Public Access	Vehicle access tracks exist to the southern and northern boundaries of the site. Footpath access is available around the northern and western perimeter of the loch.
Shooting	None.
Point Pollution Sources	None observed within the SSSI boundary.
Properties in Catchment	There are no known residential properties within the site boundary or defined catchment.
Unusual, Distinctive or Atypical Features	Site is a water supply reservoir and water levels are controlled for such; gorse control (through cutting) has been undertaken within the western parts of the site; tenant farmer has leased rights to land adjacent to loch; history of algal blooms reported; extensive reed (*Phragmites spp.*) encroachment evident along northern shore of the loch.

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

6. INTERPRETATION OF RESULTS

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

6.1 General Summary

The surface water quality at the site was deemed to be good with low-moderate concentrations of bioavailable nutrients observed. Whilst consistencies were observed between sample types, the surface water results indicated a notable variation in the concentration of nitrate between the inlet and outlet samples. Although simplified, and based on a limited number of samples, this indicates the source of nitrate is from the prevailing catchment and is most probably attributed to agricultural practices.

For a mesotrophic waterbody, the water column typically contains nutrient levels of 0.3-0.65mg/l of total nitrogen and 0.01-0.03mg/l of total phosphorus (B.R.I.G (ed. Maddock), 2008). Whilst such levels simplify the complex interaction between plant nutrients and the hydrological and physical characteristics of individual waterbodies, they serve to show the sensitivity of the trophic state to artificially increased levels of nitrogen and phosphorus. The concentrations of total phosphorus recorded in the surface water samples at Lochmill Loch were all below 0.10mg/l. An elevated total nitrogen result of 1.0mg/l was recorded for one of the surface inflow samples with the corresponding outlet flow being lower than the 1.0mg/l level of detection. Whilst phosphorus is likely to be the limiting factor over nitrogen, the level of detection applied for total phosphorus samples does not conclusively demonstrate that nutrient levels in the surface water samples are typically those expected of a mesotrophic waterbody.

Dissolved oxygen levels in the surface water were consistently at levels above 6ppm and in accordance with the Freshwater Fisheries Directive (2006/44/EC) are acceptable to support salmonid fish.

Only two groundwater samples were collected for reasons explained in section 6.2. With the exception of iron concentrations in the groundwater samples, none of the analysed metals were considered to be elevated or above expected concentrations however the inorganic nutrients in LM04 were elevated and these are also discussed in section 6.2.

Extractable phosphorus concentrations in the soil samples were elevated in the upper (root zone) with higher concentrations observed at the western end of the loch compared with the sample obtained from the southern aspect. This may simply be attributable to the limited dataset but as the latter corresponds with the highest extractable nitrogen value, it may correspond with the groundwater source and upstream land use.

No odours associated with organic degradation or organic degraded soils were observed.

6.2 Atypical Results

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

- The lack of data at LM06 was attributable to the lack of accessible groundwater in this area. The sampling exercise undertaken during the first visit sought to probe five boreholes in this area to obtain a suitable sample but found all of them to be dry. This may be attributable to the time of year that the site was visited but it is more feasible that the water table is sat at a greater depth than that accessed and that the upper soils in this area are free draining.

- The highest series of overall results was detected at LM04. At this location elevated iron, total phosphorus and total nitrogen were all observed as being the highest in the collected water dataset, and nitrogen % and extractable phosphorus the highest of the collected soil samples. This sample location was on the steep slopes of the western perimeter of the site, within the hydrological catchment, and is considered to be directly influenced by the adjacent land use. With this location being in close proximity to the main surface water inflow, it is expected that this will be contributing to the nutrient levels within the site as a whole.

6.3 Comparison with Historical Analytical Data

The Condition Monitoring Form for the Mesotrophic loch feature (SNH, 2004) records a single total phosphorus result of 6.6mg/l however no details are provided as to where or how this sample was obtained. No other parameter values are given. It is further stated that water quality was clear and colourless, some filamentous algae was noted in the shallows at the western end of the loch and some brown algal scum was present on vegetation.

Contrary to the claim that this sample was broadly in line with the upper limits for a mesotrophic waterbody, the units are a thousand times higher than would be expected. It is considered that the assigned unit is therefore incorrect and that this should in fact refer to micrograms – *i.e.* 6.6µg/l. It is further acknowledged that low confidence should be attached to this datum as it was based on a single sample.

Given the limited information on the location, depth and weather conditions at the time of the monitoring, and any repeat or consistency of data, confidence in the water quality data is low. This data has been discounted for the purposes of this study.

No comparative soils sample data was available.

6.4 Additional Considerations

See study limitations presented in section 3.

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

Accounting for the limitations outlined in section 3, the analytical results are not conclusive in confirming water quality which would be typical of a mesotrophic loch. The desk study and field observations described in section 5 indicate there have been changes within the catchment which will have directly influenced water quality. These are associated with the land use practices in the wider catchment, namely the tenant farming of land on the western shore, and the forested slopes of the southern boundary.

The historical information on the site is limited. With the exception of the use of the loch for water supply purposes and variations in land management resulting from developments in agricultural practices, it is assumed that the site is largely unchanged. There is potential for runoff and nutrient enrichment to impact the spring sources and loch inflow from the surrounding steep sided catchment. This will be influenced by the free draining soils and underlying geology which will aid migration of nutrients to groundwater, and be exacerbated by the felling of trees by the Forestry Commission which will aid the leaching of nutrients from exposed soils. There is also potential for the application of soil conditioners which will further the nutrient load in the catchment. Whilst there will be nutrient additions to the site through dunging by livestock, given the numbers observed at present across the site, it is not considered that this will have a profound effect on the waterbody.

The volumetric flow of the springs (groundwater) on the south-western side of the loch has not been quantified. It is speculated that this may afford the greatest contribution during the summer months when surface water flows are likely to be lower. The variable water quality observed in the groundwater samples indicates nutrient enrichment which may pose a risk to the health of the waterbody – and more so during the summer months when surface flows are typically at their lowest. This is highlighted by the groundwater feed to the loch which has elevated nitrogen species (notably ammonia) and may exert an oxygen demand through nitrification. Coupled with the history of algal blooms, during the summer months any additional oxygen demand could pose a significant risk to aquatic life within the loch.

It is highly probable that there are significant sediment accumulations within the loch. These will afford a plentiful supply of nutrients through variations in seasonal inflows. The deep depth of the loch means it may release nutrients through stratification and hence the quantification of the volumes of sediment and concentration of nutrients therein would help to establish a more complete picture of the loch and how water quality is seasonally influenced. The limited information on algal blooms (re: frequency, composition *etc.*) significantly restricts drawing conclusions under the terms of this study. Based on the known inclusion in this study and recorded decline from the SNH monitoring forms, there is a need to understand and stabilise nutrient levels and restrict the growth of cyanobacteria or other blue green algae. It is considered highly likely that the phosphorus accumulations within the loch pose the greatest risk to the aquatic flora when released through stratification or artificial disturbance.

The use of the loch for water supply purposes would lead to a direct impact on the level of water within the loch. Whilst levels and depths are not known it is likely that variations may have accelerated nutrient enrichment through ‘flushing’ and also aided algal bloom developments through the lower loch depth aiding light penetration *etc*. There appear to be no recent reports of algal blooms and hence this may be a direct result of lesser variation to water levels. This should be further explored and where practicable, the findings incorporated into any future management regime.

8. RECOMMENDATIONS

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

8.1 Monitoring

i. It would be of value to the long-term status of the SSSI to understand whether the loch is still classified as mesotrophic. For this to be determined, a more extensive seasonal monitoring programme is necessary.

ii. Undertake a long-term targeted monitoring study at selected locations within the site for key nutrients – to include orthophosphate and bioavailable (extractable) nitrogen. Ideally this would be undertaken over the course of several seasons (ideally for a minimum of one year). The data which should also assess water quality at varying depths within the loch, should be compared alongside rainfall data 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 springs/burns and compare these with those of the outflow from the loch. 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

iv. Undertake hydrological and hydrogeological assessment of the catchment to determine all of the source waters to the loch.

v. Undertake core sampling of loch sediments to understand historic source pollution (including copper from the historic algal dosing) to understand the potential future impacts to aquatic life as stratification or artificial disturbance of the sediments could result in extensive nutrient release and significantly alter availability within the loch and plant margins. It is considered likely that there will be a significant volume of nutrient bound up in the loch sediments and that this may be slowly released into the water column providing a supply for plant growth.

vi. Review the variation in draw down of the loch water level and the extent of vegetation ingress over time. The 2002 and 2007 SNH Condition Monitoring Reports make reference to there being no change to the extent of open water habitat however, neither appear to comprise a quantitative assessment. If such were routinely quantified, over time this would further aid the understanding of loch dynamics and impacts of successional change.

vii. Consideration should be made to understand the functioning and management of the flow at the outlet of the loch. This should include the compensatory provision for the downstream watercourse which is expected to be subject to regulatory control from SEPA and variations to such would therefore be likely to require consultation and approval.

viii. 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 this is not available, commission a bathymetry survey of the loch to confirm depth and sediment profiles. This would aid the understanding of inflow, stratification, plant growth and retained sediment volume.

ix. As it is understood that there have been no regular counts of waterfowl at the site in recent years, undertake a detailed library review to further understand the seasonal activity and seek to determine how this could affect the loch vegetation and sediment through feeding, disturbance and nutrient load from droppings.

8.3 Management

x. Review the fish stocks and associated policies of the angling club. Engagement with the angling club could also provide an anecdotal insight into the algal blooms and changes in loch levels. If cooperative, this may present options for recording future conditions of water quality during attendance by the anglers. Such information would provide a valuable no-cost approach to additional data collation on seasonal variations to water quality, loch levels *etc*.

xi. Review the tree management approach across the site and immediately adjacent to the loch. It is not understood from the site management reports whether the new tree planting within the catchment has been undertaken for commercial or environmental gain. The appropriate siting of such has the potential to benefit the catchment in terms of nutrient uptake, but conversely, may alter inflows to the loch in terms of quality and quantity.

xii. Review the forestry management practices undertaken within the wider catchment. Deforestation within the catchment has the ability to significantly alter the hydrology and can alter the composition of water and soils through leaching of nutrients. Particular consideration should be given to understand the historical operation, times of planting and felling, and application of any soil improvers so as to manage the impacts on the SSSI.

xiii. Review the policy for the removal of site vegetation and the methods used to control/manage such. Where future management practices require such, vegetation should be cut and removed from site instead of chemical applications (*i.e.* herbicide - SNH, 1999) or burning. Consideration should be given to the removal at the root zone rather than the cutting of above ground stem and should be followed by appropriate off-site disposal. 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.

xiv. Review the biomass of *Elodea canadensis* within the loch and the methods used to control/manage such. Determine the limiting factors for its growth and proliferation within the loch. Such studies should seek to understand the seasonal growth characteristics, nutrient uptake profile and successful control measures observed from other impacted waterbodies.

It is understood that SNH and SEPA have conducted research in this area (2008) and although a detailed literary study has not been undertaken, notable publications which may be of interest include:

Vernon, E. and Hamilton, H. 2011. Literature review on methods of control and eradication of Canadian pondweed and Nuttall's pondweed in standing waters. *Scottish Natural Heritage Commissioned Report No. 433.*

Thiebaut, G., Di Nino, F., Peltre, M.C. and Wagner, P. 2008. *Management of Aquatic Exotic Plants: The case of Elodea Species.* Proceedings of Taal2007: The 12th World Lake conference: 1058-1066.

8.4 Landowners

xv. 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 and consider appropriate management strategies accordingly including for example, nutrient management planning, buffer strips, exclusion zones, routine spot monitoring, improved fencing *etc*.

xvi. Proactively engage with catchment landowners to understand the historical land use practices to determine changes which are likely to have influenced the site. It is speculated that the catchment was more densely wooded than it is at present and particularly the area immediately surrounding the loch. Consideration should be made to appraise how this may have led to changes at the site and the corresponding nutrient status of the loch.

8.5 External Consultations

xvii. Engage with Scottish Water to understand:

a. The existing and future operational requirements for abstraction from the loch for water supply – whether serving as a primary or emergency raw water source, or for compensatory flows to the downstream watercourse. To include an understanding of the long-term objectives for the loch and whether the proposed decommissioning is to be undertaken in the foreseeable future, and if retained, the options for minimising fluctuations in water level;
b. Whether a bathymetric survey of the loch exists to confirm depth and the potential for stratification;
c. The term and details of the tenancy agreement in place on the landholding adjacent to the loch; and
d. Details of any routine or historical water quality and/or algal monitoring records which may be held on file.

xviii. Engage with SEPA to understand:

a. The regulatory requirements for any given compensation flow from the reservoir and implications to vary such given the desire to maintain stable water levels within the loch.

From the stated conclusions and identified pressures (Figure 5.1) the key actions to seek to reverse the present declining status of the aquatic species in the loch are to address the inputs from the agricultural catchment (xv) including the contributing springs (iv) and woodland management (xii); determine the potential for nutrient release from the sediments (v); control the encroachment of reeds (xiii); and the water levels/through flow at the site (xvii.a.).

9. REFERENCES

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ANNEX 1: FIGURES

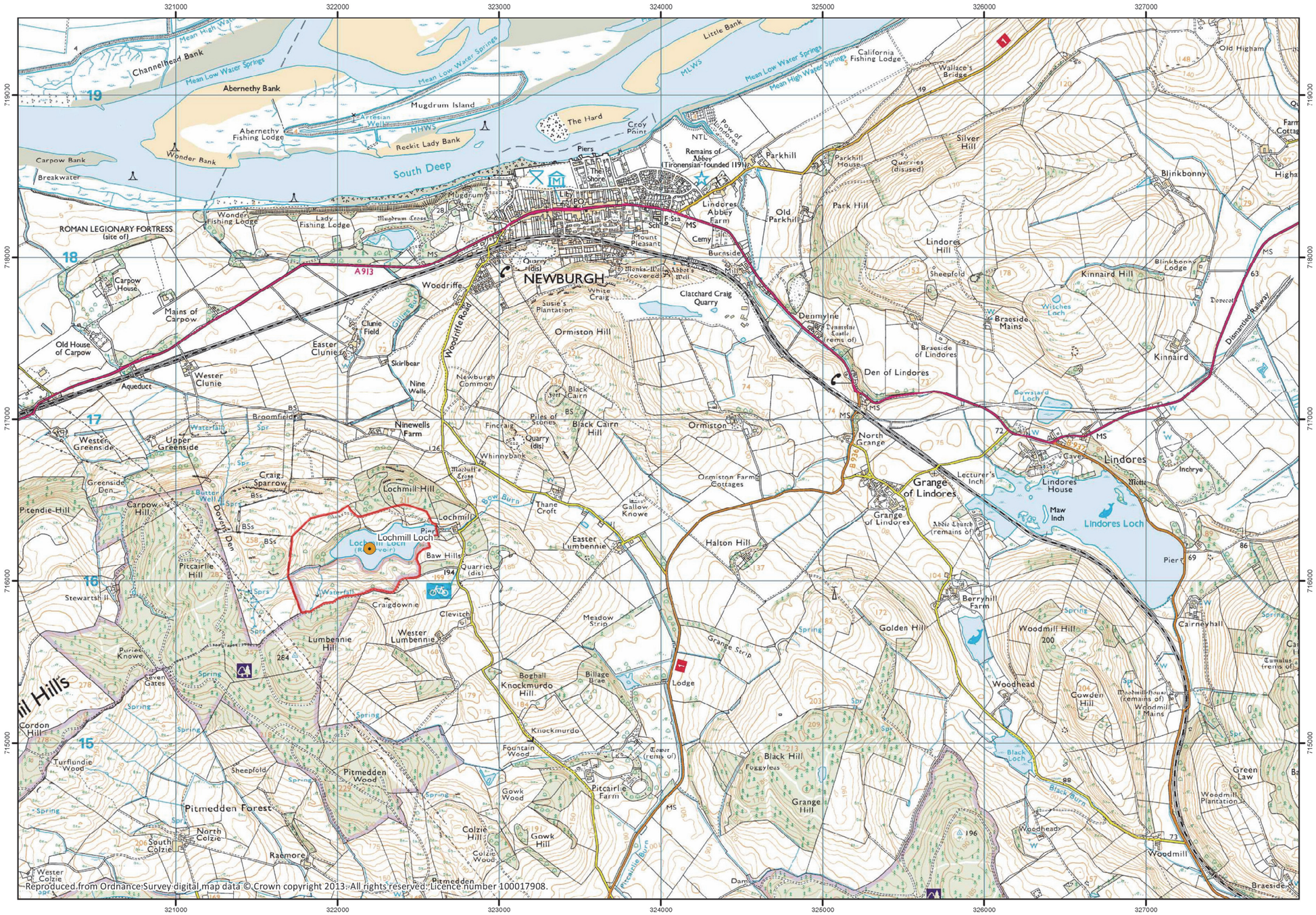
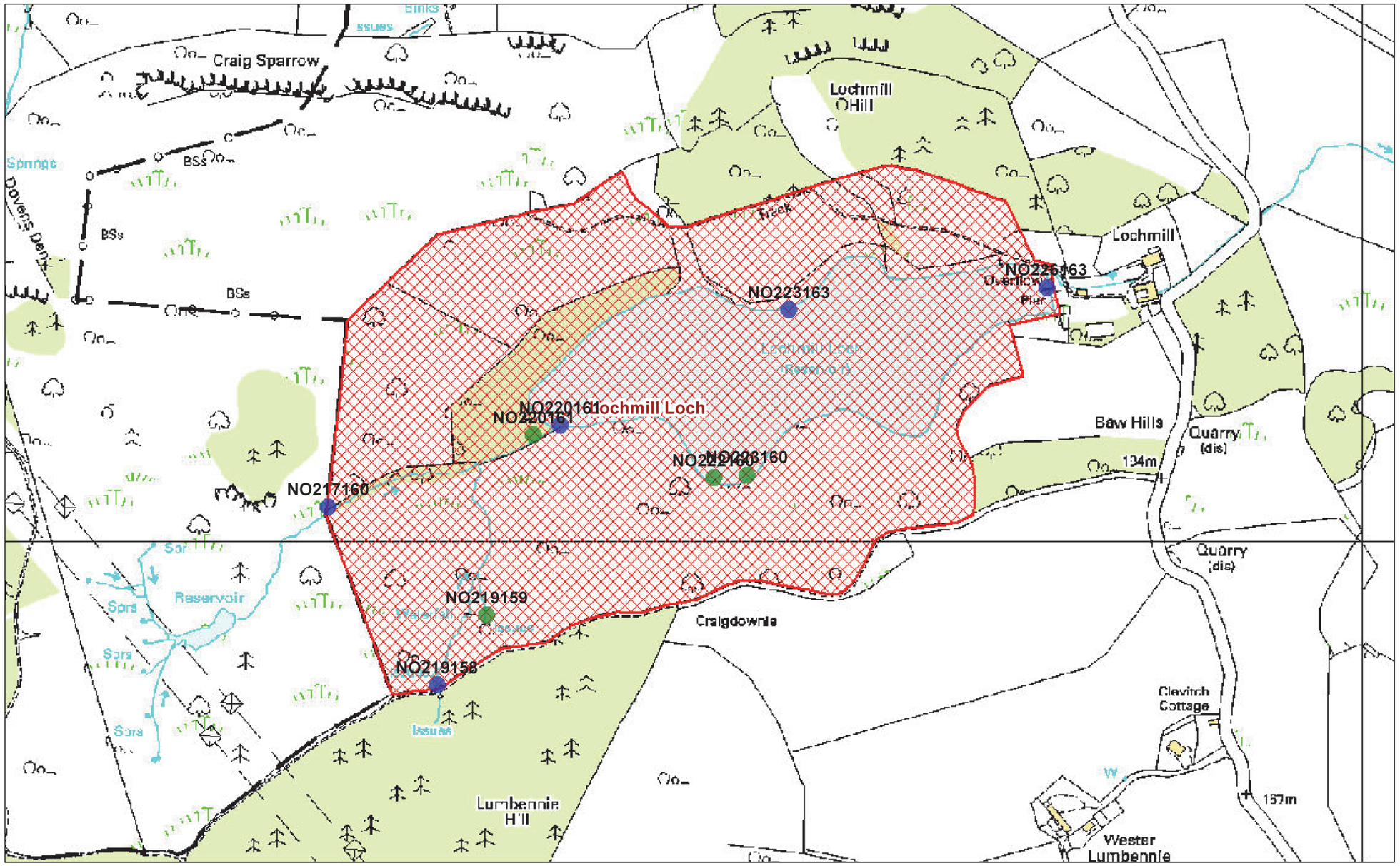


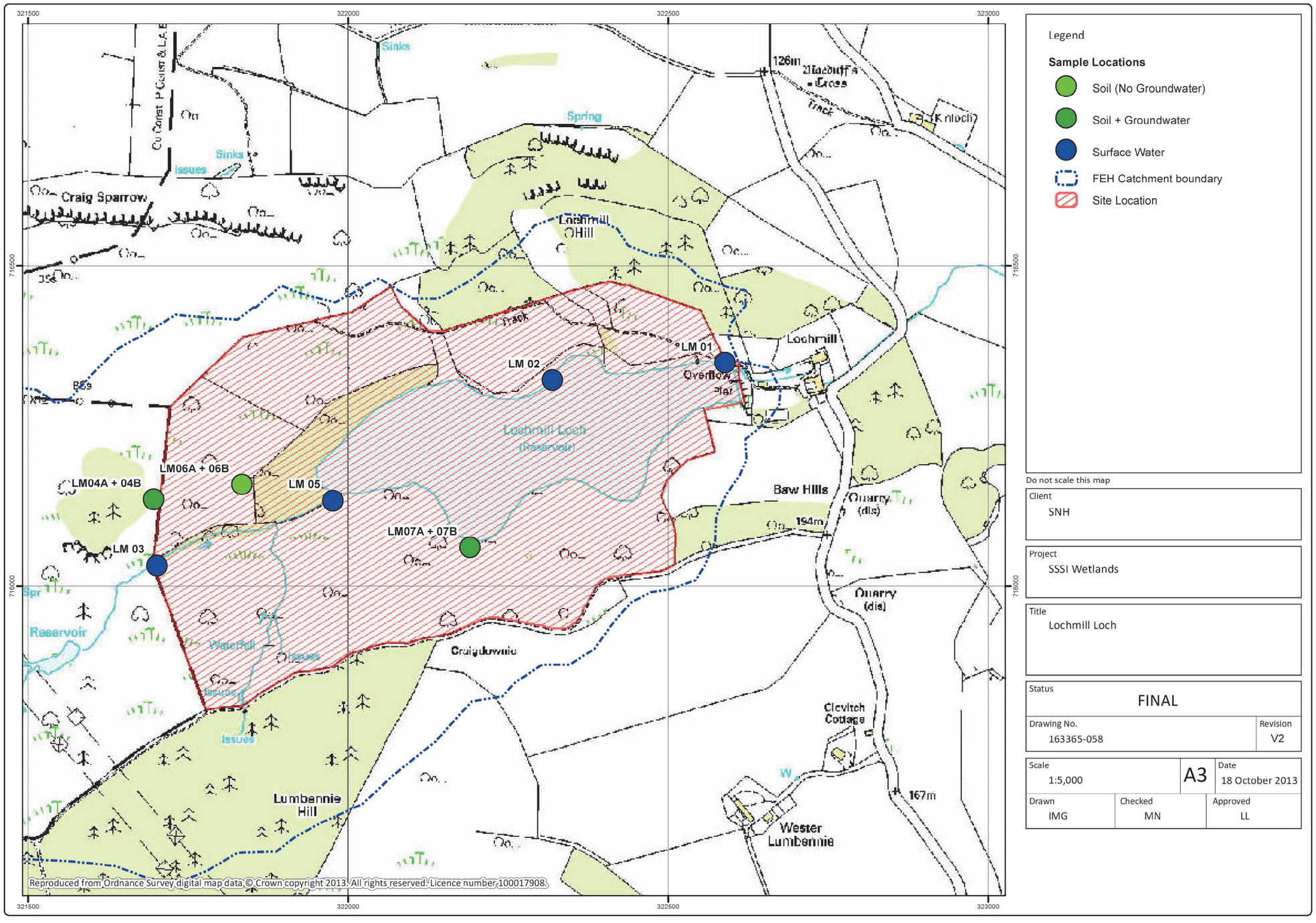
Figure 1.1: Site Location Map



Notes:

Map produced using geo.View 3.0
Printed: Sep 25, 2012 10:35:06

Figure 2.1: SNH Proposed Sampling Location Plan



Legend

Sample Locations

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

Do not scale this map

Client: SNH

Project: SSSI Wetlands

Title: Lochmill Loch

Status: FINAL

Drawing No.: 163365-058

Revision: V2

Scale: 1:5,000

A3

Date: 18 October 2013

Drawn: IMG

Checked: MN

Approved: LL

Figure 2.2: Plan of Actual Sampled Locations

Photograph Log - Sample Locations
(Photographs taken on 30th October 2012)

Figure 2.3: Sampling Location Photographs

Photograph Log- Surrounding Catchment
Photographs taken 20th February 2013

Figure 2.4: Surrounding Land-use Photographs

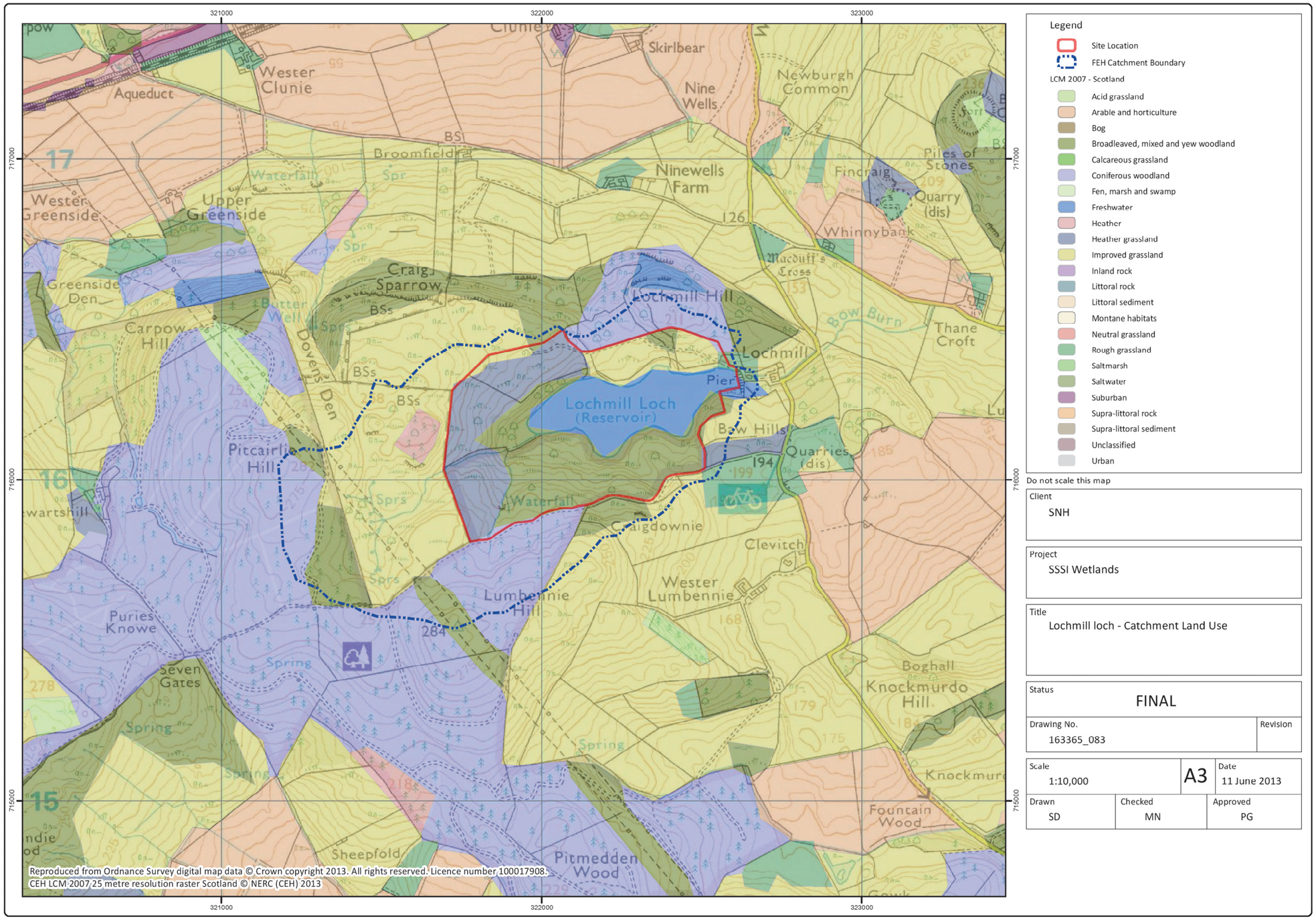
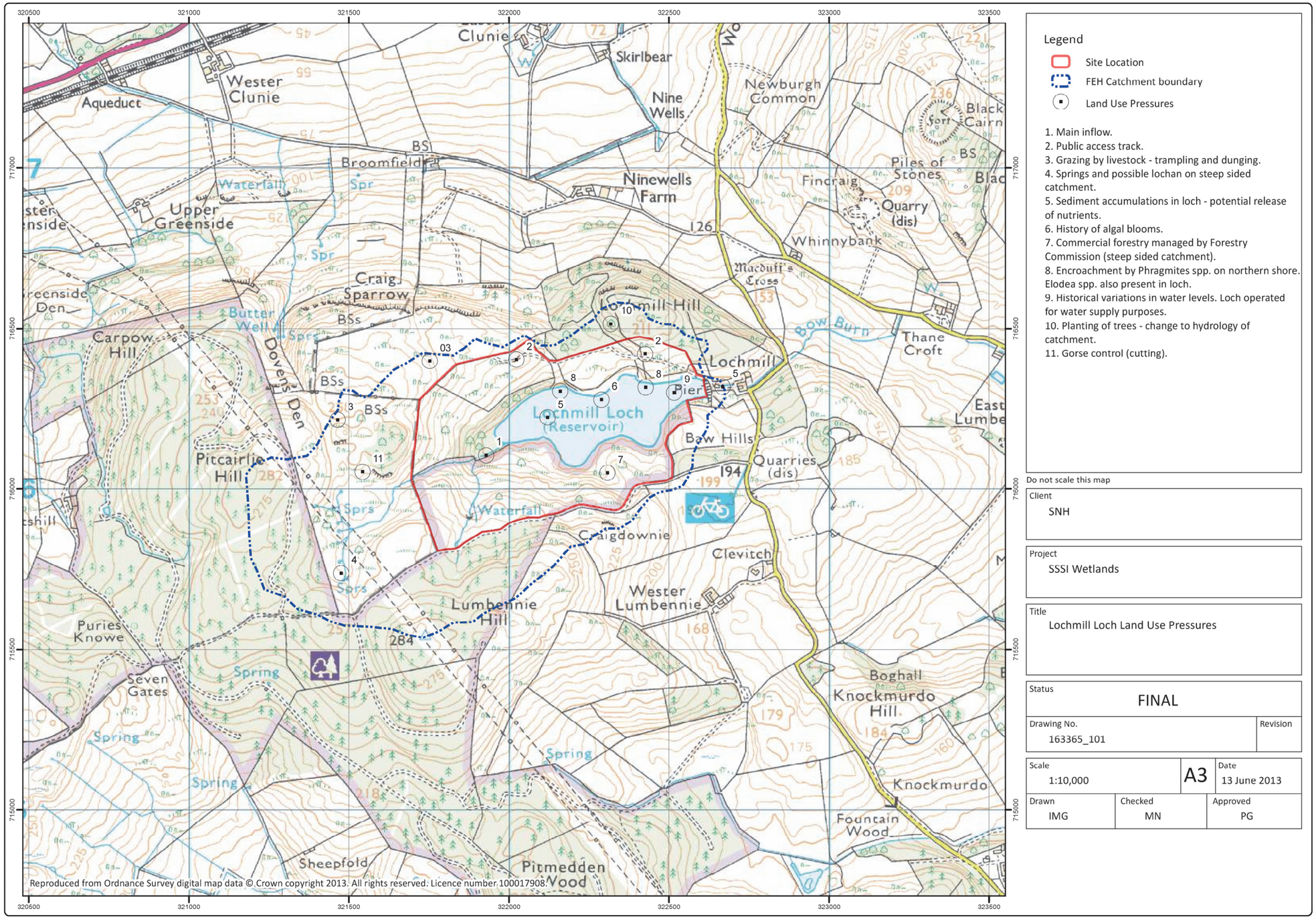


Figure 2.5: Land Use Characteristics



Legend

- Site Location
- FEH Catchment boundary
- Land Use Pressures

1. Main inflow.
2. Public access track.
3. Grazing by livestock - trampling and dunging.
4. Springs and possible lochan on steep sided catchment.
5. Sediment accumulations in loch - potential release of nutrients.
6. History of algal blooms.
7. Commercial forestry managed by Forestry Commission (steep sided catchment).
8. Encroachment by Phragmites spp. on northern shore. Elodea spp. also present in loch.
9. Historical variations in water levels. Loch operated for water supply purposes.
10. Planting of trees - change to hydrology of catchment.
11. Gorse control (cutting).

Do not scale this map

Client: SNH

Project: SSSI Wetlands

Title: Lochmill Loch Land Use Pressures

Status: FINAL

Drawing No.: 163365_101

Revision:

Scale: 1:10,000

A3

Date: 13 June 2013

Drawn	Checked	Approved
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Figure 5.1: Catchment Pressures Summary

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