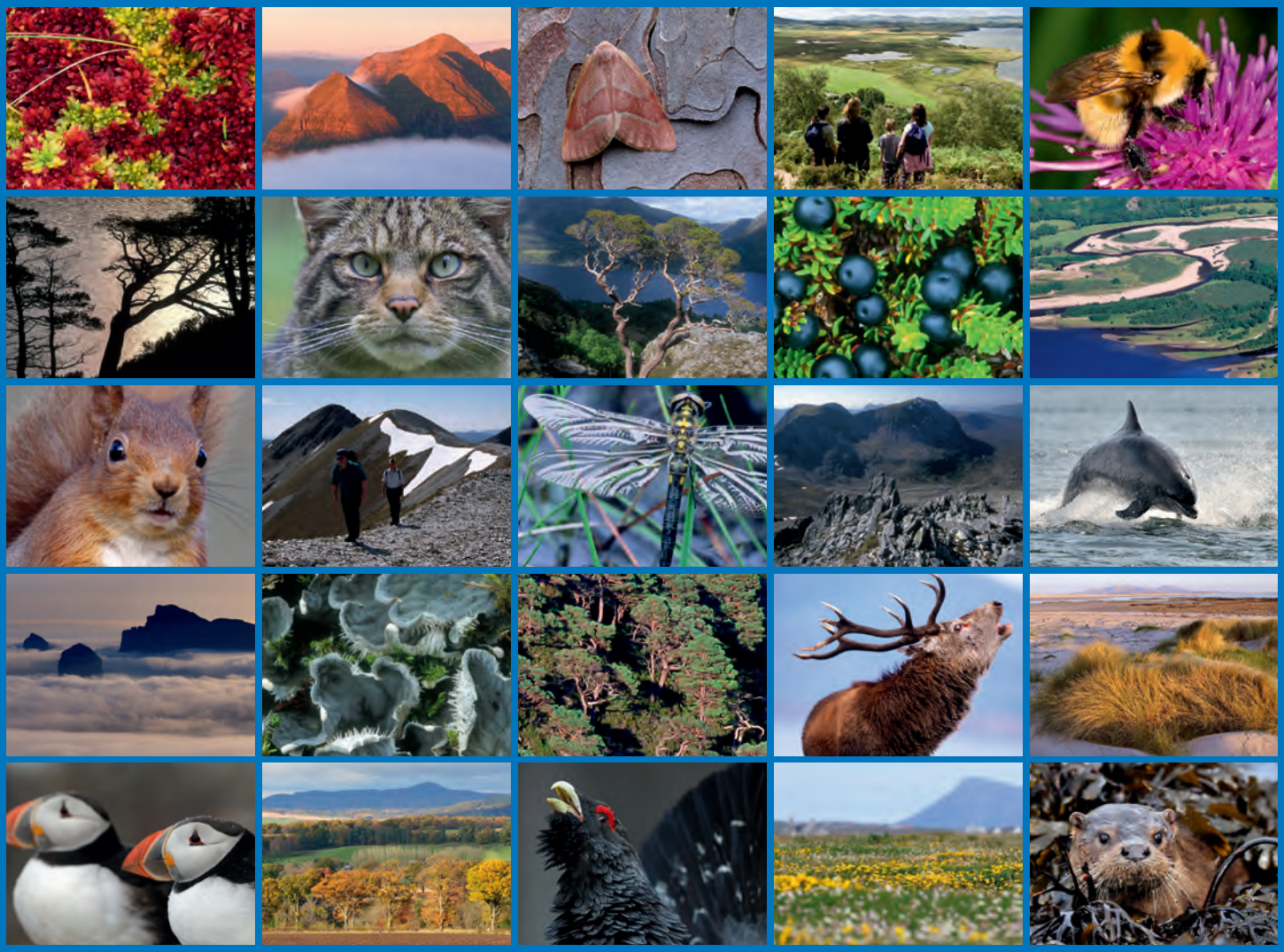
Scottish Natural Heritage
Commissioned Report No. 716

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

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COMMISSIONED REPORT

Summary

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

Commissioned Report No. 716
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 typically expected of a meso-eutrophic 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 resulting 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 loch flow regime and understand the impact of variations to the loch levels on the transition mire. 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

EnviroCentre Ltd would like to thank the SNH Operational staff for their time and assistance in providing access to the site files held at the local office, providing landowner 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 landowner 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

Camilla Loch is situated approximately 1 kilometre (0.5 mile) north of Auchtertool and approximately 6.5 kilometres (4 miles) west of Kirkcaldy. The site is accessible via a track through Clentrie Farm which itself is accessed via the B925. See Figure 1.1 in Annex 1.

1.2 Site Description

Camilla Loch is a small naturally occurring meso-eutrophic water body of approximately 4.8 hectares, lying in undulating countryside (SNH, 2004). The main feature of interest is the extensive and diverse area of freshwater transition mire at the western end of the loch which is relatively undisturbed and is the best example of its type in West Fife. The documented area of the SSSI designation comprises an area of 8.02 hectares (SNH, 2009a).

The loch is enclosed to the north and south by two scrub dominated ridges. The site is bordered by grasslands (cultivated or grazed) to the north, east and south. The area to the north of the site is now used for grazing water buffalo (SNH, 2009b).

The underlying solid geology at the site consists of Sedimentary Rock Cycles of the Pathhead Formation (predominantly mudstone and siltstone), while the ridges to the north and south of the loch are underlain by igneous bedrock. Drift deposits consist of glacial till where present (British Geological Survey, n.d).

1.3 Site Hydrology

The main inflow to the loch is understood to be a spring source(s) on the north western side coupled with overland flow from surface runoff. A catchment area of 0.40km^2 drains to the loch and the annual average rainfall for this catchment is 841mm (Centre for Ecology and Hydrology, 2009). A small unnamed watercourse forms the outlet from the south-western end of the loch and flows as an open channel in a south-westerly direction to the minor road. It is likely that the channel is culverted from this road to the Dronachy Burn at Auchtertool, based on the alignment shown in The Roy Military Map (National Library of Scotland, n.d.).

No records exist on SNH files to confirm the depth of the loch and an internet search has not revealed any further information to confirm such.

1.4 Site History

Most of the information in this section is based on the Site Management Statement (SNH, 2009b). The grasslands on the northern, eastern and southern boundaries of the loch have been grazed, and the adjoining fields used for arable, since at least 1982.

The mire on the western boundary is believed to have significantly decreased in extent since 1910, when a first survey of the loch was carried out. It is deduced that this is most probably as a result of agricultural improvement.

In the early 1980s, the fence on the western boundary of the loch was moved eastwards and a further part of the marsh opened up to grazing. Around the same time the loch was known to have been stocked with brown and/or rainbow trout.

During the 1980s spray applications of Caseron G (a herbicide banned in 2009 due to its oxygen depletion characteristics) were made to reduce the amount of aquatic vegetation which was causing problems for fishing. It is understood that this exercise had minimal effect on the quantity of vegetation but is believed to have reduced the variety of pondweeds present.

Up until 1987 the loch was used for irrigation purposes after which time this practice ceased.

The dense stand of gorse, which forms the northern boundary of the site, has been selectively burnt in the past but this has not prevented significant encroachment within the calcareous grassland pockets. Adjoining this boundary, dry lowland grassland was created in 1995 under the Scottish Executive's Habitats Scheme and this area is now used for grazing water buffalo as part of a new farm business venture. An SNH media statement in 2007 claimed that if managed correctly, the introduction of buffalo can have a positive outcome on the site through significantly reducing scrub vegetation from the area (SNH, 2007).

A five year management agreement between the landowner and SNH was signed in 2005 (SNH, 2005). This controlled grazing along the north and south shoreline of the loch and was introduced to reduce trampling and overgrazing of these sections and help improve plant species diversity.

A number of small straw bales were introduced to the loch between 2005 and 2007 in order to control algal blooms. These bales were removed at the end of 2007, with no comment provided on the effectiveness of this measure (SNH, 2009b).

1.5 Recent Site Management Practices

Since 2005 SNH has been working with the landowner to implement positive management activities. These are summarised in the table below:

Table 1.1: Past Management Practices

Past Management	
1995-2005	Area of dry lowland grassland created under the Scottish Executive's Habitats Scheme
2005 and 2007	Straw bales (#15) introduced to the loch to control algal blooms
2005-2010	Five year management agreement to control grazing
2005-present	Introduction of Water Buffalo onto site
2007	Fencing off of the loch and provision of a new water source for water buffalo to help protect the plant species surrounding the loch and create new habitats for birds.
2011	Application of herbicide (glyphosate) to control Reed Canarygrass (*Phalaris arundinacea*) following approval from SEPA. Comprised application to bankside vegetation only.

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 available in Annex 2.

2.2 Site Attendance

The site was accessed and samples collected over a one day period – termed Visit 1. A follow up visit to the wider catchment was undertaken once the analytical data was available and appraised in context with the information obtained from the desk based exercise. Table 2.1 below shows site conditions on the day of each visit.

Table 2.1: Site Conditions

Camilla Loch	Date of Visit	Weather Conditions	Grid References
Visit 1	31 October 2012	Overcast, constant rain	NT 220915
Visit 2	20 February 2013	Clear, sunny, mild	NT 220915

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 suitably to access such before Visit 1. Due to certain access restrictions the locations of samples that EnviroCentre collected had to be changed and are as detailed in Figure 2.2 in Annex 1. Changes to locations were kept to a minimum and are generally not deemed to have a significant impact on the sampling or conclusions.

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

2.4 Sample Equipment

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

- Handheld Global Positioning System (GPS) unit to record specific grid references;
- Handheld soil augers;
- Plastic bailers;
- Sample bottles (all sample bottles were written on to record locations, date and time); and
- Personal Protection Equipment (PPE - in line with the requirements of the site specific health & safety risk assessment).

All samples were given unique identification names and packaged in cool boxes with ice packs so as to keep samples at appropriate temperatures prior to being despatched to a United Kingdom Accreditation Service (UKAS) accredited laboratory for analysis.

2.5 Health and Safety

Site specific risk assessments were carried out before attending site. The assessment was based on information obtained from the meeting with the local officer and from EnviroCentre's extensive experience of undertaking previous work of this nature.

The risk assessment, which was completed by staff attending the site visit, included details of the landowner, nearest emergency services, and identified risks and proposed means of mitigation. Field operatives notified EnviroCentre head office when accessing and leaving site and wore the following appropriate PPE at all times:

- Warm and waterproof clothing;
- Waders;
- Waterproof footwear; and
- Hi-vis vest.

Biosecurity measures were rigorously implemented when entering and leaving site. Boots and equipment were washed when leaving site so as not to cross contaminate subsequent sites.

2.6 Water Samples

Surface water samples were collected from strategic locations within the surface watercourses on site. Collections were made from inflows, standing (open) water and outflows, to provide an understanding for the whole site. 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;
- Identified and potential pollution sources; and
- Atypical or unusual site features (*e.g.* fly tipping, vandalism, *etc.*).

In addition, mapping of the immediate surrounding catchment was completed following the second site visit (see Figure 2.5 in Annex 1). This process utilised the Flood Estimation Handbook (Centre for Ecology and Hydrology (CEH), 2009) catchments and Land Cover data (Land Cover Map 2007) to populate GIS mapping. The output was used to aid the interpretation of results and further inform the study conclusions.

3. STUDY LIMITATIONS

The scope of the commissioned study presented a series of limitations which should be borne in mind when reviewing this report. These are outlined below:

- Sampling was undertaken on a single visit. Whilst this afforded consistency for the samples collected, the weather conditions preceding and at the time of the visit may have directly influenced the observations made and the analytical results obtained.

- For the same reasons outlined above, access to certain parts of the site may have been restricted and limited access to the predetermined sampling locations.

- 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 FEH catchment boundary, the area defined in the Annex 1 maps does not necessary present a true reflection of the hydrological catchment for the site. Whilst this affords a valuable tool for the purposes of this study, the mapped boundary should be viewed as an indicative guide only and be subjected to detailed verification to be considered definitive.

4. ANALYTICAL DATA

The following tables show the results obtained from the initial site visit (Site Visit 1) in which samples from the pre-determined locations (or as close to as practically possible) were collected. Where the pre-determined locations were not accessible comparable alternative locations with the same habitat features were sampled.

Table figures in red indicate relative atypical (*e.g.* high or low values) or anomalous results or observations relative to the collected dataset or which would typically be expected from a site of this nature. These are discussed further in section 6.2.

4.1 Water Quality Field Data

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

Table 4.1: Water Quality Field Data and Observations

Sample ID	Nat. Grid Reference		Temp (°C)	pH	Salinity (psu)	DO (%)	DO (ppm)	ORP (mV)	EC (mS/cm)	General Field Observations
CL01	NT 22235	91629	2.26	8.49	0.45	*N/A*	*N/A*	140	0.921	Surface water - clear with fine suspended solids; no odour
CL03	NT 22100	91618	2.13	8.84	0.20	*N/A*	*N/A*	173	0.555	Surface water - clear with fine suspended solids; no odour
CL04	NT 21935	91584	2.44	5.43	0.12	*N/A*	*N/A*	-18.7	0.244	Groundwater - dark cloudy brown with fine brown suspended solids; no odour
CL05	NT 21909	91619	2.53	5.90	0.16	61.6	7.86	-46.1	0.326	Surface water - clear with very fine suspended solids; no odour
CL06	NT 21945	91465	2.51	5.67	0.17	17.1	1.83	-49.0	0.349	Groundwater - dark, cloudy brown with fine suspended solids; slight organic (sulphur) odour
CL07	NT 21868	91332	2.64	6.15	0.10	53.9	6.85	-56.3	0.205	Surface water - clear; fine suspended solids; no odour
CL08	NT 21969	91348	3.23	5.52	0.12	5.7	0.70	-56.7	0.252	Groundwater - dark, cloudy brown with fine suspended solids, slight organic (sulphur) odour
CL09	NT 22043	91465	2.82	7.00	0.10	67.4	8.68	-61.8	0.202	Surface water - clear; very fine suspended solids; no odour

NB - DO meter failed to calibrate for samples CL01-03

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)
CL01	NT 22235	91629	SW (OW)	25	13	6	0.05	0.01	0.3	0.04	<0.1	<1
CL03	NT 22100	91618	SW (OW)	27	14	7	0.05	0.01	<0.2	0.03	<0.1	<1
CL04	NT 21935	91584	GW	44	18	9	10.30	1.30	<0.2	0.02	0.3	4
CL05	NT 21909	91619	SW (I)	44	21	11	0.09	0.01	4.1	0.01	<0.1	4
CL06	NT 21945	91465	GW	63	30	8	57.20	0.50	<0.2	<0.01	1.3	2
CL07	NT 21868	91332	SW (O)	30	15	7	0.14	0.01	0.4	<0.01	<0.1	<1
CL08	NT 21969	91348	GW	41	18	6	4.54	0.30	<0.2	<0.01	<0.1	2
CL09	NT 22043	91465	SW (OW)	28	15	7	0.12	0.01	<0.2	0.01	<0.1	<1

+ Surface water samples are designated either inflow (I), outflow (O) or open water (OW)
Red figures denote samples that are above typical ranges for the observed dataset.
No shallow groundwater table was encountered at CL02 and therefore no sample could be taken.

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)	Total Moisture* * 105°C (%)	Total N (mg/Kg)	Nitrate (mg/l)	Nitrogen (%)	Extractable P (mg/l)
CL02A	NT 22154	91623	Organic rich dark wet sludge	2.9	11000	16600	1250	1110	60.4	<2.0	<0.2	0.89	<2.0
CL02B	NT 22154	91623	Lower organic content w/gravel substrate	0.7	12700	21600	1000	843	36.5	3.3	0.6	0.20	2.16
CL04A	NT 21935	91584	Organic rich dark wet sludge	1.8	10100	3200	1170	2020	89.7	<1.7	<0.2	2.27	5.06
CLO4B	NT 21935	91584	Organic rich dark wet sludge	<0.5	9370	3010	697	633	85.1	<0.7	<0.2	1.74	<2.0
CL06A	NT 21945	91465	Organic rich dark wet sludge	<0.5	3430	1900	401	507	74.1	<1.4	<0.2	0.89	<2.0
CL06B	NT 21945	91465	Lower organic content w/gravel substrate	0.6	2510	2970	360	1050	36.0	<0.8	<0.2	0.09	<2.0
CL08A	NT 21969	91348	Organic rich dark wet sludge	<0.5	7140	4510	766	1380	73.9	<0.7	<0.2	1.09	7.63
CL08B	NT 21969	91348	Lower organic content w/gravel substrate	0.7	8080	11200	599	1030	42.0	0.9	0.2	0.47	<2.0

** Soil types are field observations*
*** Total Moisture = Water content*
*A/B suffix: **A** = Rooting Zone and **B** = Below Root Zone*
Red figures denote samples that are above typical ranges for the observed dataset.

5. SITE OBSERVATIONS

To enhance understanding of Camilla 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 Meso-eutrophic loch was monitored on 8 September 2004 and found to be unfavourable declining (SNH, 2004). The visit identified a loss of aquatic species since the 1997 SNH Loch Survey, a blue-green algal bloom was present and there was a high measurement of Total Phosphorus of 197.5µg/l, although low confidence should be attributed to this as it was a single sample. The north and south shores of the loch were heavily poached and there were signs of faecal input to the loch. The Open water transition fen feature was monitored in 2009 (visit date 1 August 2009) and found to be unfavourable declining (SNH, 2009c). *Phalaris* was found to be encroaching on the swamp communities which suggested that the site was suffering from nutrient enrichment. There was no evidence of poaching by stock. The Springs feature was monitored on the same date and was found to be favourable recovered, with the signs of poaching seen in the previous monitoring visit (2004) no longer evident (SNH, 2009d).

A positive management agreement for the site (SNH, 2005) indicated that there had been historical nutrient enrichment but this appeared to have reduced prior to 2005 probably due to the reduction in pig slurry input above the escarpment to the north of the loch.

In 2005 a Positive Management Agreement between the landowner and SNH was put in place to encourage positive management of the site through the controlled introduction of water buffalo to the site. It is stated that if managed correctly, water buffalo will benefit the long-term condition of the site as it will allow the site to be cleared of some of the coarse scrub. Electric fencing along the southern boundary was agreed to prevent sheep grazing along the southern shore of the loch (SNH, 2005).

The Site Management Statement (SNH, 2009a) records an 'Objective for Management' of enhancing the conditions of the site by continuing to positively manage grazing which was previously undertaken in the management agreement which expired in 2010.

Correspondence from SEPA in August 2011 (SEPA, 2011) approved and set out guidelines for the application of herbicide at the site. The guidelines specified that the application should only be carried out in correct weather conditions and that only bankside vegetation be treated. Site remedies information data provided by SNH in a spreadsheet (SNH, n.d. b) indicates that stands of *Phalaris* were treated successfully with glyphosate (note dated 5 September 2011). This document notes that water quality is very difficult to control as the catchment is intensively farmed with improved pasture grazed by livestock including water buffalo and concludes that the site would benefit from identifying sources of nutrient input and nutrient budgeting. It notes that cattle have been prevented from accessing the edge of the loch (note dated 30 March 2012).

5.2 Catchment Walkover

From the second site visit the following observations of the surrounding catchment were made:

- The site was free of litter. No visible point 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 visit was undertaken.

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

- A sluice and a silt trap are located at the outlet of the loch. It was not confirmed whether these are operational or appropriately maintained.

- No formal buffer strips were observed to be in place along the shores of the loch or transition mire area.

- The land surrounding the eastern boundary was heavily grazed by South Asian water buffalo. At the time of the site visit these were contained within a gated pen within Clentrie Farm. The area and extent of roaming within the site is not confirmed or readily apparent. Trampling was observed along ~25m of the edge of the loch in the north-east where livestock access the loch for water (see Figure 2.3). This contradicts the information obtained through the desk study in the previous section.

- At the time of the site visit it was observed that various areas of arable land around the south east of the boundary accumulated standing water. This has been historically mentioned in the SNH site management statement previously referred to in section 1.3.

- Stockpiles of manure were visible along the southern boundary adjacent to the access road, ~210m up-gradient of the loch.

- Clentrie Farm also rears pigs. Aside the historical reference to the spreading of wastes, no record of such is documented within the SNH records. Pig farming is an intensive process and results in a nutrient rich and highly organic waste which requires considered disposal. No observations were made of the management or disposal routes for the wastes from this farming practice.

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 (observed damaged) around large parts of the site boundary. It is understood that this is not as complete as the SNH file notes suggest for the management control for water buffalo.
Fishing	Private fishing - loch stocked with trout on an annual basis at levels of 500-2000 per season; use of two row boats and occasional use of outboard motors consented. (SNH, n.d. a).
Grazing	Grazing of livestock can be found within the site boundary.
Monitoring	SNH last monitored the site in July 2009.
Public Access	Existing farm track to the east of the site is a public right of way. This is understood to pass through the transitional mire when loch levels flood this part of the site.
Shooting	None.
Point Pollution Sources	None observed within the SSSI boundary.
Properties in Catchment	No properties lie within the site or catchment boundary. Clentrie Farm is located very close to the south eastern boundary and hence depending on location, a septic tank discharge could impact the site.
Unusual, Distinctive or Atypical Features	Historical records of algal blooms in loch with associated application of control methods; a sluice and silt trap are present in the outlet reach of the loch (unconfirmed whether operational); South Asian water buffalo graze the site; farm also rears pigs; evidence of stockpiling of manure within catchment; historic ruins lie to far west of site catchment. *Phalaris* in the loch has been treated with glyphosate recently.

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.

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 highlight a variation in the concentration of nitrate and total nitrogen from the inlet source to the outlet. Although simplified, and based on a limited number of samples, this indicates nutrient enrichment through runoff and groundwater from agricultural sources in the catchment.

For a meso-eutrophic 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. (Environment Agency, 2012). 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 open water samples at Camilla Loch were all below the 0.1mg/l level of detection and total nitrogen below 1.0mg/l. As phosphorus is likely to be the limiting factor over nitrogen in a eutrophic system, these samples are insufficient to confirm the status of the waterbody. Phosphate levels in the loch ranged between <0.01mg/l and 0.04mg/l. Sampling locations at a spring (CL05) and groundwater (CL04) to the north-west of the loch recorded elevated total nitrogen levels (4mg/l) and moderate levels of phosphate (0.1-0.2mg/l) suggesting nutrient enrichment from agricultural activities in this part of the catchment.

With the exception of iron concentrations in the groundwater samples, none of the analysed metals in the surface water or groundwater samples were considered to be elevated or above expected concentrations. This aligns with, and is justified by, the observed lower dissolved oxygen concentrations and lower pH values of the sampled groundwater creating conditions for precipitation to solution.

Extractable phosphorus concentrations in the soil samples were typically elevated in the upper (root zone) with higher concentrations observed at the western end of the loch compared with the single sample obtained from the eastern side. This typically corresponded with the higher nitrogen values and could be associated with the aforementioned nutrient enrichment in this area (CL04 and CL05).

Higher pH values were recorded in samples CL01 and CL03. The slightly alkaline values are consistent with the underlying calcareous geology (as represented in the neighbouring CL02 soil sample) although this contrasts with the acidic groundwater values. This may be explained through the latter being located in the margins of the loch where the soils were influenced by the breakdown of organic materials. The influence of surface water flows, directly or indirectly, on the surface water may serve to explain the more neutral values at CL07 and CL09.

6.2 Atypical Results

No consistent atypical or anomalous results were recorded from the soil or water samples at Camilla Loch. From the limited dataset presented in section 4, the highlighted figures are those observations of note and are individually detailed below:

- Although lower than the only comparable sample, the low dissolved oxygen result in CL08 is not considered atypical as it is from a groundwater source. This could indicate pollution of the groundwater source exerting ‘an oxygen demand’ at this

location, however this is not supported by the other analytical results at this location.

- Low surface water pH value was recorded for CL05. This result is atypical given that surface waters in a calcareous catchment would typically be alkaline – as is the case for samples CL01 and CL03. For CL05 this may be explained by the fact that it was collected in the vicinity of the spring sources and is therefore a groundwater derived surface flow or alternatively, that it is influenced by anaerobic conditions resulting from the degradation of organic material.

- The organic (sulphur) odour detected in groundwater samples CL06 and CL08 is indicative of organic degradation and is consistent with the corresponding low dissolved oxygen, acidic pH and elevated iron concentrations. For CL06 this could be indicative of contamination of the groundwater inflow, as a result of the elevated ammonia and total nitrogen recorded, however it is more likely to be attributed to the decomposition of organic matter which is consistent with the visual observations of decaying organic matter in the corresponding soil sample.

- Variations in the concentrations of total iron in the groundwater samples obtained range from 4.54mg/l to 57.3mg/. This may be attributable to the source water being derived from different depths which give rise to different chemical conditions or an influence of the aforementioned anaerobic conditions within the loch margins.

- An elevated ammonia value was recorded in CL04. The value is notable as it is elevated compared with all the other results obtained and corroborated by the other nitrogen derived analyses from this sampling location (*i.e.* total nitrogen, %nitrogen and extractable nitrogen). It may therefore be indicative of groundwater contamination or the direct influence of degrading organic material in the soil layers.

- An elevated nitrate value of 4.1 mg/l was recorded in CL05 and could be associated with nutrient enrichment in this part of the catchment as described in the previous section.

6.3 Additional Considerations

See study limitations presented in section 3.

No records of previous water or soil samples were obtained through the desk study exercise to enable an assessment to be made with the data collected.

No records or reports (anecdotal or otherwise) of fishing records or algal blooms 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 of nutrients which would be typical of a meso-eutrophic loch however, they are deemed of a suitably high quality to support a trout fishery. There are desk study and field observations that indicate there have been changes within the catchment which will have directly influenced water quality and are typical of the observed agricultural management practices.

The historical information on the site is limited. With the exception of the use of the loch for irrigation purposes and, bar variations in land management resulting from developments in agricultural practices, it is assumed that the site is largely unchanged. One such agricultural practice is the grazing of non-native water buffalo on site. The effects of the grazing by water buffalo appear to be unknown and unquantified despite the Positive Management Agreement (SNH, 2005) stating that monitoring of the site would be required to appraise the effects.

Other notable observations which do not appear to have been previously assessed are the potential for runoff and nutrient enrichment affecting the spring sources and loch inflow from the surrounding steep sided catchment, and the storage and application of animal wastes within the catchment. The fractured nature of the underlying limestone geology is expected to aid migration of nutrients to the groundwater. This is expected to be enhanced through loss of vegetation cover and ground compaction (particularly during the summer months) resulting from the effects of the water buffalo and to a lesser extent the vehicle access track. The faecal matter from the water buffalo (and potentially from pigs which is unquantified/unknown) and stockpiling of manure is expected to lead to enrichment of soils and elevated nutrients within the catchment. The installation of fencing for the buffalo will have restricted access to the loch. However, during the site visits the fencing was observed to be damaged in places. Contact with the landowner/farmer implied the water buffalo had free access to roam across the site as a whole.

The volumetric flow of the spring (groundwater) supply to the loch is not quantified. It is speculated that this may be of greatest value during the summer months when surface water flows are likely to be lower. The quality of the groundwater was not fully assessed (see section 3) and samples taken within the vicinity of the loch/transition fen may not be representative of the source water. As discussed in section 6, results suggested nutrient enrichment through runoff and groundwater from agricultural activities in the north-west of the catchment catchment. This is highlighted by elevated levels of total nitrogen in surface water (spring) and groundwater in this area

The use of the loch for irrigation would have led to a direct impact on the level of water within the loch. Whilst volumes of abstraction are not known, it would have influenced the water balance within the transition mire and may have accelerated nutrient enrichment through ‘flushing’. It could also have aided algal blooms through lowering the loch depth during the summer months when demand for water would have been greatest. Historical records suggest this practice ceased in 1987 and whilst no reason is given, it is likely that this was due to a change in land management practice or potentially a change in the drainage of the previously irrigated land. The outlet sluice control methodology is not known but it is considered that variations in such could account for additional nutrient input to the loch and its associated margins.

It is also reported that a silt trap exists on the outlet. Unless this is appropriately maintained, it could further the accumulation of nutrient-rich sediment in the upstream channel. This would impact on the transition mire dynamics - through *e.g.* reverse flushing (net export of nutrient from the loch to the surrounding land through overtopping).

It is highly probable that there are significant sediment accumulations within the loch. These will afford a plentiful supply of nutrients through disturbance by fishing activity and variations in seasonal inflows. There is no evidence to suggest that the loch is deep and hence it being subject to algal blooms is not a result of stratification. Quantification of the volumes of sediment and concentration of nutrients in the sediment would help to establish a more complete picture of the loch, how water quality is seasonally influenced and how this in turn impacts on the transition mire. The limited information on algal blooms (frequency, composition *etc.*) constrains drawing conclusions under the terms of this study but based on the recorded observations from SNH monitoring, there is a need to understand and stabilise nutrient levels and restrict the growth of cyanobacteria and/or green algae.

8. RECOMMENDATIONS

Based on the 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 meso-eutrophic. 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 several seasons (ideally for a minimum of one year). The data from such should be compared alongside rainfall data and seasonal abnormalities to seek to understand the nutrient dynamics taking place within the site. This exercise should seek to differentiate between the spring sources, the adjacent pasture and the arable land on the north and north-western aspects of the loch.

iii. In conjunction with ii, assess the seasonal flow variations within the loch. This data would be of value in assessing the flow dynamics of the loch and aiding the understanding of retention times and season variations in throughput which directly affect the wetland mire at the western end.

8.2 Other commissioned studies

iv. Undertake a detailed qualitative and quantitative hydrological and hydrogeological assessment of the known spring sources on the north-western bank which are thought to be a key supply to the loch. Of particular interest are the dissolved oxygen and ammonia concentrations and how these vary with time and ambient weather conditions.

v. Undertake core sampling of loch sediments to understand historic source pollution and retained nutrients. Although the loch is shallow, and therefore unlikely to stratify, artificial disturbance of the sediments could result in extensive nutrient release and significantly alter the nutrient availability within the loch and margins. It is considered likely that there will be a significant volume of nutrient bound up in the loch sediments. These nutrients may be being slowly released into the water column aiding successional change.

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.

vii. Undertake a review as to the effectiveness of the straw bale applications made in 2005 and 2007 within the waterbody. Recommendations for future applications should be considered with corresponding assessment made for optimising bale siting and calculations undertaken for loading rates.

viii. Improve understanding of the functioning and management of the sluice and silt trap mechanisms. These may be subject to regulation from SEPA and variations to such would therefore be likely to require regulatory consultation and approval.

ix. As no other study has been reviewed during the desk based assessment, and given that water buffalo are not native to Scotland, it is advised that a study be commissioned to appraise their effects on the site since 2005. A detailed library study should be undertaken to appraise the options and relevance of existing available scientific studies and reference information. It may be that the findings of existing studies conducted in England, such as that conducted by Natural England on Chippenham Fen NNR (Natural England, n.d.) or at recently created wetlands at Kingfishers Bridge (Gulickx *et.al.*, 2007), are of direct interest.

x. Review the effectiveness of existing fencing for the water buffalo. It is understood that due to the physical size of water buffalo and their herding nature, as well as an ability to lift traditional fencing using horns, that a variation in fencing provision may be needed to be effective at keeping them out of the required parts of the SSSI site. Internet research indicates that electric fencing may be suitable for this purpose and that further information may be available through the aforementioned library search (ix).

xi. Assess the effect of changes in management practices including the cessation of the gorse burning. The Site Management Statement (SNH, 2009b) refers to encroachment of the gorse within the calcareous grassland pockets (see section 1.3).

xii. Where future land management practices require vegetation to be treated (*e.g. Phalaris spp.*), consideration should be given to the removal at the root zone with appropriate off-site disposal rather than cutting of above ground stem only, as an alternative to chemical herbicide application. The removal from site of the 'cut' vegetation 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.

xiii. Assess the impact that humans have within the site through the activities of the fishing syndicate and open footpath access along the southern shore of the loch. This should include an appraisal of the footpath route, and adherence to it, by walkers during variations in loch levels.

8.3 Landowners/Tenants

xiv. Proactively engage with the main landowner to further understand the grazing habits and movements of the water buffalo across the site. Although they have been present on site for over ten years, from the desk study research there are inconsistencies in the number of cattle permitted to graze on the site and it is unconfirmed whether they can access the loch. In conjunction with this, there is also a need to assess the effectiveness of the existing fencing and whether this is adequate and appropriately maintained to restrict their access to sensitive parts of the SSSI site. It should be noted that the greater the number of cattle permitted on the site, the greater the tramping effect and grazing of vegetation, and volume of faecal matter (nutrient load) within the catchment.

xv. Proactively engage with catchment landowners to understand the noted pig farming practices. Particular focus should be given to understanding the animal waste storage and disposal options employed at (and on) the site. This is of significant value to the study as it is widely accepted that pigs are not as efficient as cattle in utilising the phosphorus derived from their feed. A build-up of soil phosphorus in land treated with animal waste can result when equivalent cattle application rates are applied, due to an imbalance between nitrogen and phosphorus of the manure, compared to the requirements of the corresponding crop.

xvi. Proactively engage with catchment landowners to understand the historical land use practices and determine differences which could have influenced the site. This should include the irrigation practices pre-1987 and known herbicide applications of the 1980s. This would help provide a more detailed picture of how the surrounding land use and changes in management practices have influenced the current loch and transition mire status over time.

xvii. Proactively engage with catchment landowners to understand the existing and (foreseeable) proposed changes to field usage, crop type and soil conditioning approaches. Consider appropriate management strategies accordingly - for example (but not exclusive to) nutrient management planning, buffer strips, treatment of agricultural runoff (e.g. constructed wetland), controlled livestock load, exclusion zones, routine monitoring *etc*.

xviii. The stockpiles of manure observed during the site visits should be assessed for leaching and the potential to impact the loch and mire through associated runoff (through overland flow and via groundwater). Where these are identified as posing a risk to the loch/mire, these could be moved, bunded, covered and/or placed on impermeable surfaces to prevent nutrients leaching to the soil and groundwater.

xix. Review the fish stocks and associated policies of Glentrie angling syndicate. By understanding the existing fish stocks and management practices, consideration can be made of the likely disturbance of sediments (see v above) with regard to nutrient release. If catch records are known, this would further aid the understanding of the health of the loch. Albeit anecdotal, engagement with the club members could also provide an insight into the algal blooms and changes in loch levels. If cooperative, the fishing club members may also be of value in recording future conditions of water quality during their attendance. Such information would provide a valuable no-cost approach to additional data collation on seasonal variations to water quality, loch levels *etc*.

8.4 External Consultations

xx. Engagement with SEPA may benefit catchment understanding in terms of the following:

a. Sluice management/operation (see viii above);
b. Value of retaining the silt trap for downstream catchment and management of the silt trap; and
c. Known/reported pollution incidents at the site.

From the stated conclusions and identified pressures (Figure 5.1) the key actions to seek to reverse the present declining status of the site are to address the inputs to the loch from the agricultural activities within the catchment (ix/x/xiv, xv, xvii) and pollution risk from the stockpiling and spreading of animal wastes (xviii), understand the seasonal nutrient input of the inflow springs (iv), and the water level/loch throughput (viii).

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ANNEX 1: FIGURES

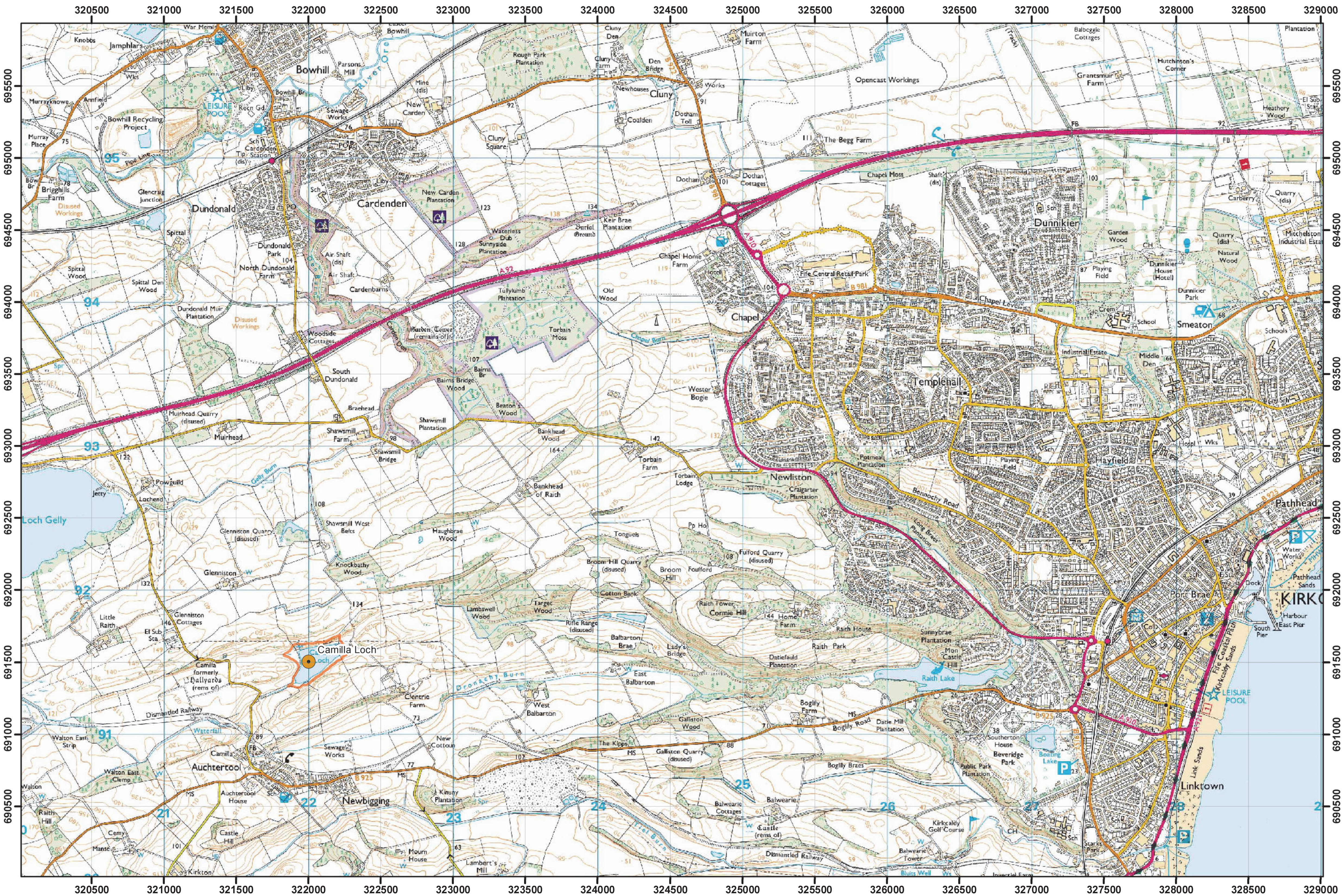


Figure 1.1.Site Location Map

Camilla Loch

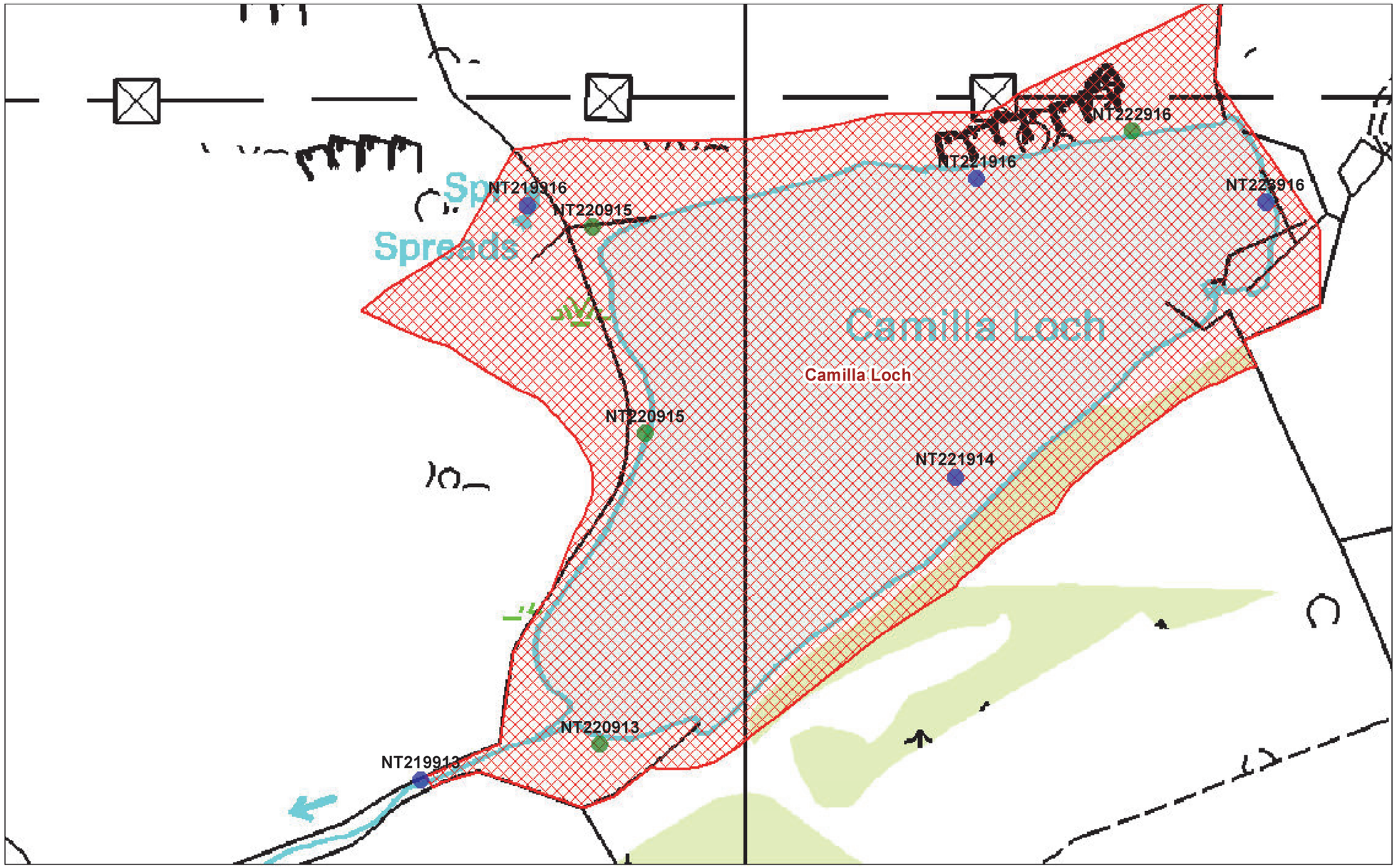
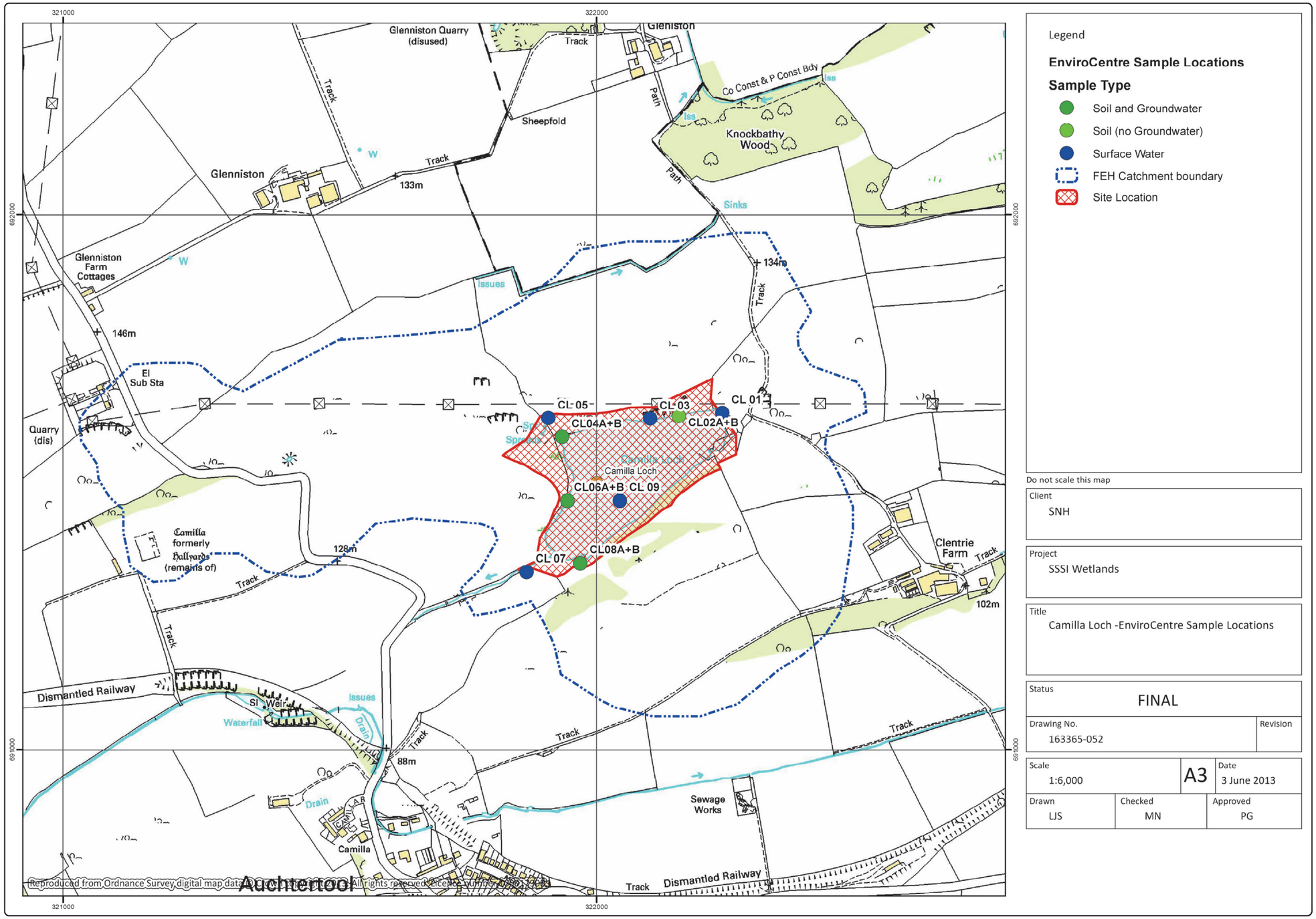


Figure 2.1: SNH proposed Sampling Locations



Legend

EnviroCentre Sample Locations

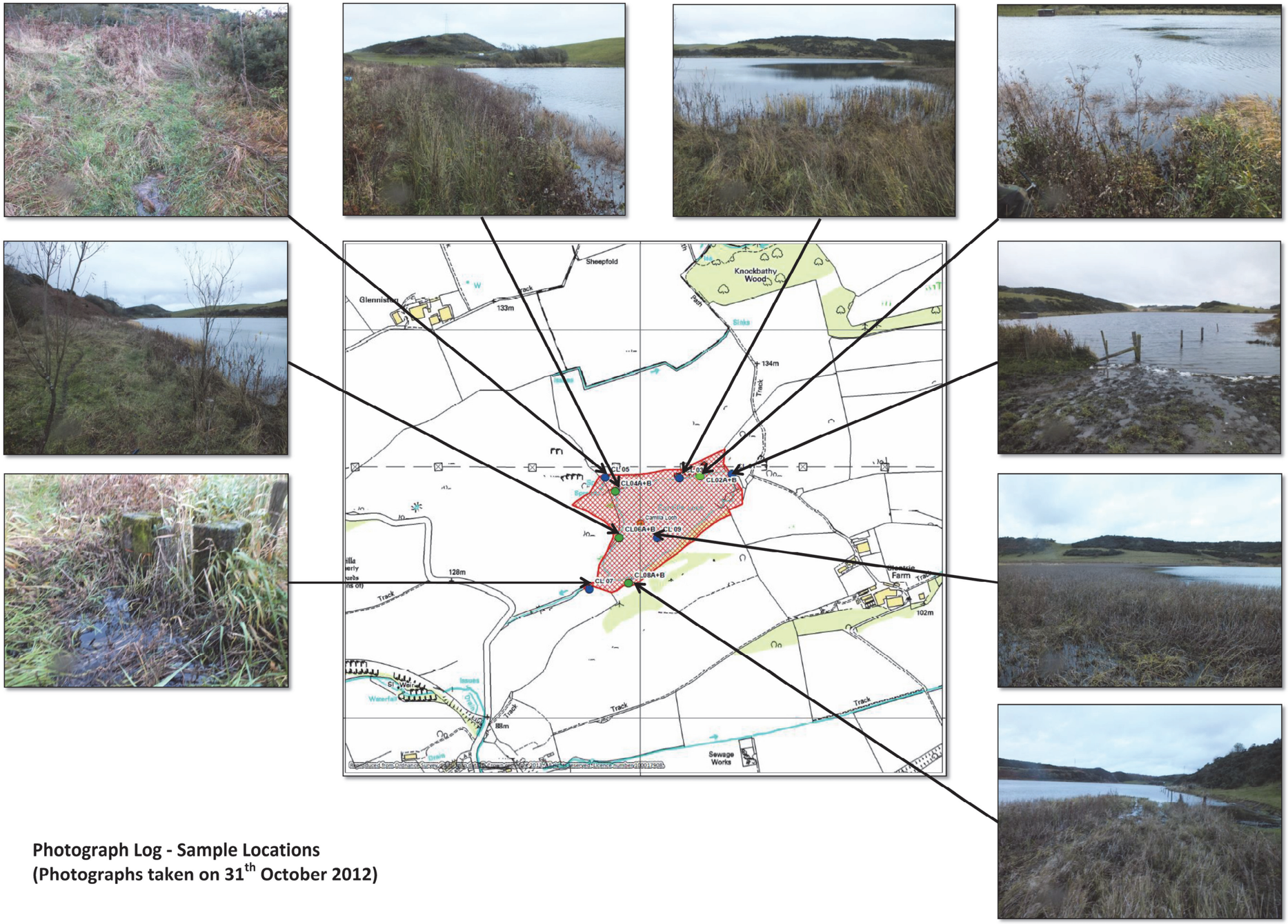
Sample Type

- Soil and Groundwater
- Soil (no Groundwater)
- Surface Water
- FEH Catchment boundary
- Site Location

Do not scale this map

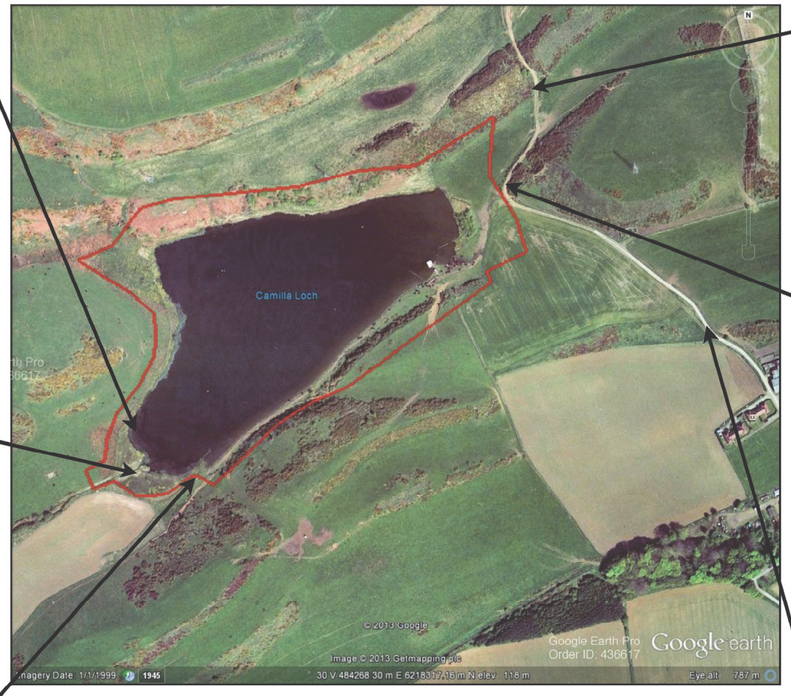
Client: SNH			
Project: SSSI Wetlands			
Title: Camilla Loch -EnviroCentre Sample Locations			
Status: FINAL			
Drawing No.: 163365-052			Revision:
Scale: 1:6,000	A3		Date: 3 June 2013
Drawn: LJS	Checked: MN		Approved: PG

Figure 2.2: Plan of Actual Sample Locations



Photograph Log - Sample Locations
(Photographs taken on 31th October 2012)

Figure 2.3: Sample Location Photographs



Photograph Log- Surrounding Catchment
Photographs taken on 20th February 2013

Figure 2.4: Surrounding Land Use Photographs

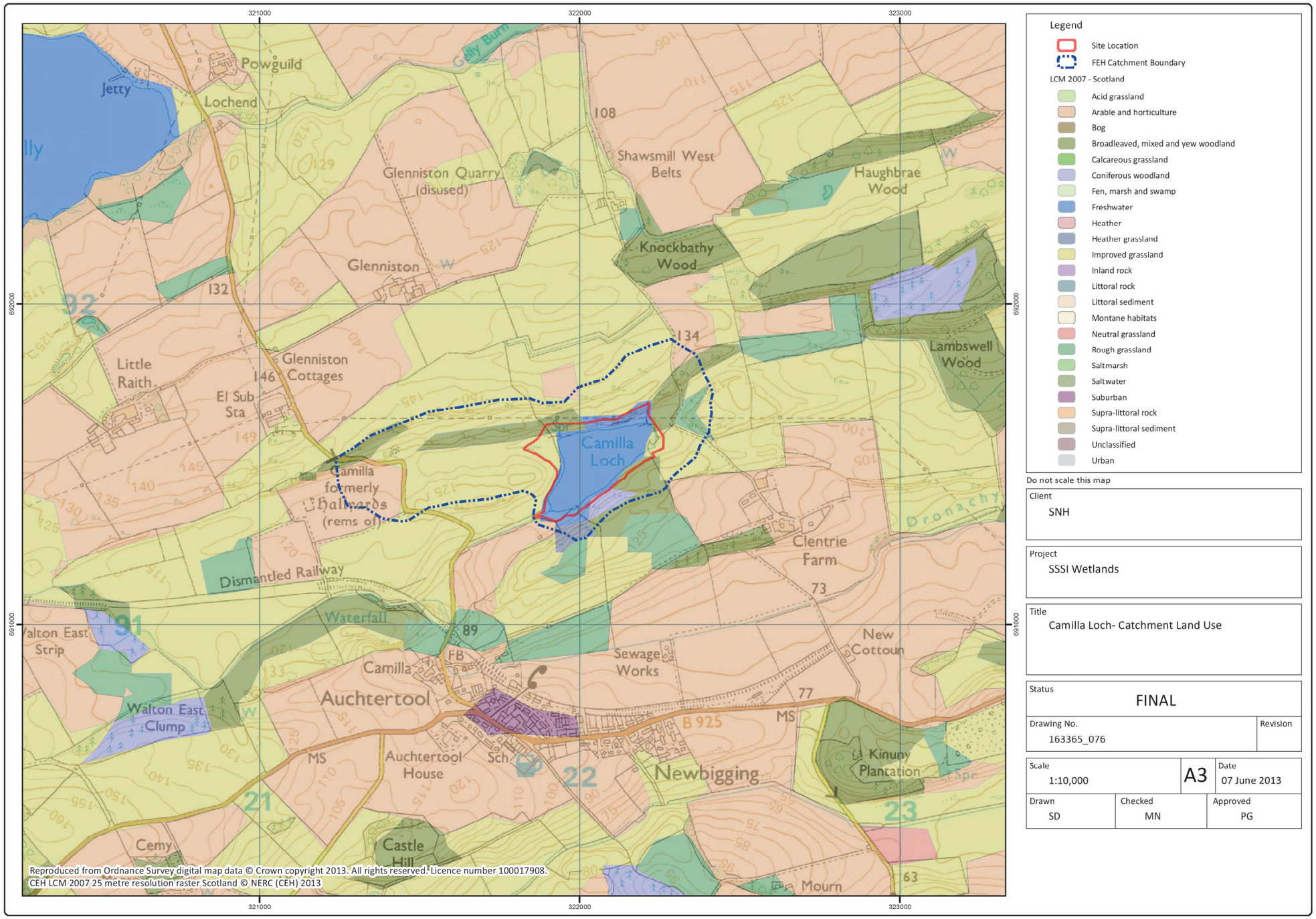


Figure 2.5: Catchment Land Use Map

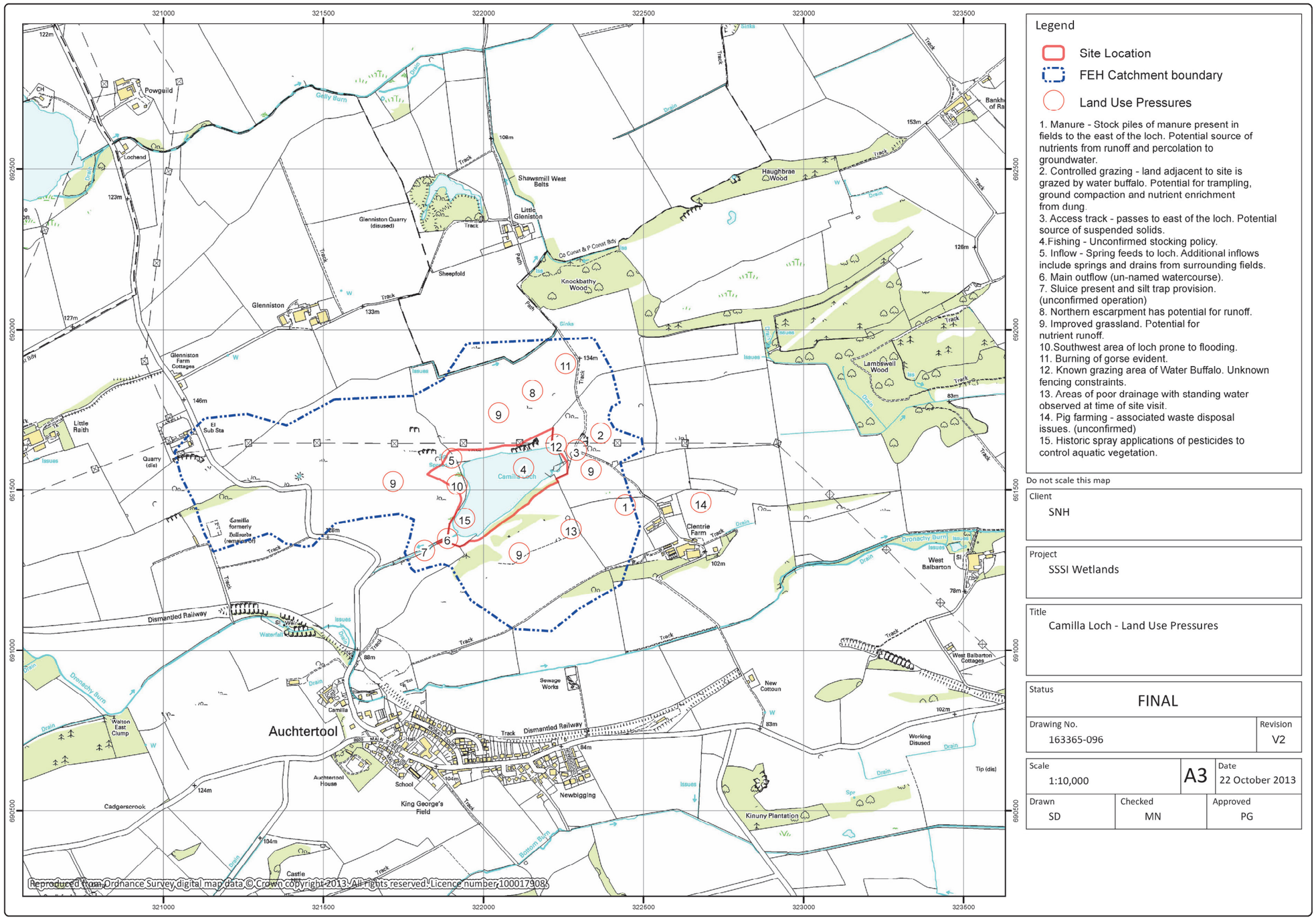


Figure 5.1: Catchment Pressures Map

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