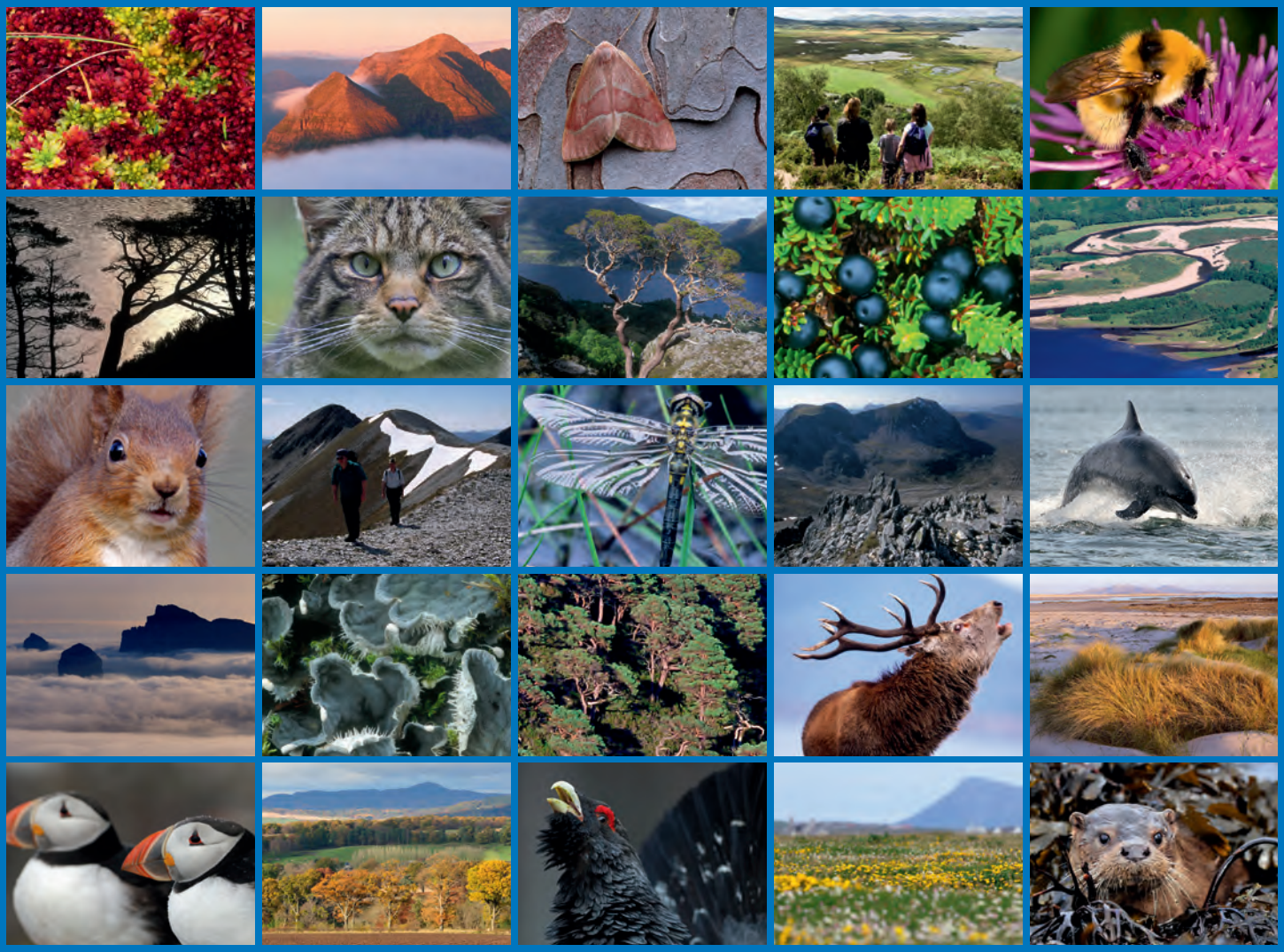
Scottish Natural Heritage
Commissioned Report No. 734

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

For further information on this report please contact:

Sarah Hutcheon
Scottish Natural Heritage
Silvan House, 3rd Floor East
231 Corstorphine Road
EDINBURGH
EH12 7AT
Telephone: 0131 316 2617
E-mail: sarah.hutcheon_edinburgh@snh.gov.uk

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COMMISSIONED REPORT

Summary

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

Commissioned Report No. 734
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

- Although limitations of the dataset constrain the ability to draw accurate conclusions on current site conditions, the analytical data obtained recorded elevated levels of inorganic nutrients within the site. These observations are typical of a eutrophic waterbody and are supported by evidence of nutrient enrichment within the catchment from land management and drainage practices.
- Site walkover revealed 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 aid the understanding of the loch flow regime and understand the impact of land management practices. It is considered that this additional information will help further the understanding of the observed changes taking place at the site.

For further information on this project contact:
Sarah Hutcheon, Scottish Natural Heritage, Silvan House, 3rd Floor East, 231 Corstorphine Road, Edinburgh, EH12 7AT.
Tel: 0131 316 2617 or sarah.hutcheon_edinburgh@snh.gov.uk
For further information on the SNH Research & Technical Support Programme contact:
Knowledge & Information Unit, Scottish Natural Heritage, Great Glen House, Inverness, IV3 8NW.
Tel: 01463 725000 or research@snh.gov.uk

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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 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

Yetholm Loch SSSI is located on the edge of the Cheviot Hills approximately 1.5km (1 mile) west of Town Yetholm, approximately 9.5km (6 mile) south east of Kelso.

The site is accessed from the B6352 via an unnamed access track to Lochtower steading. An alternate access is via the Scottish Wildlife Trust (SWT) car park off the B6352. Refer to Figure 1.1 in Annex 1.

1.2 Site Description

Yetholm Loch is a Site of Special Scientific Interest (SSSI) which comprises a shallow, eutrophic (naturally nutrient-rich) loch which supports a limited but characteristic range of aquatic vegetation, fen woodland and an open water transition fen over an area of 22.47 hectares(SNH, 2011a).

The site was declared a SSSI in 1972 due to being one of the largest natural eutrophic water bodies with associated fen vegetation in the Scottish Borders. The site was re-notified as a SSSI in 1983 with boundary changes which reduced its size by five acres (c. 2 hectares) (SNH, 2011a).

The wet fen woodland (or carr) lies mostly in the southern section of the site from where the fen extends into the loch. The carr is dominated by willow and is patchy in nature with some dense stands and other more open areas. The ground layer is dominated by reeds (*Phragmites spp.*) and sedges (*Carex spp.*), with greater species diversity occurring where the canopy is open. This is combined with a small area of willow in the northern part of the site and a thin strip of ash woodland along the western edge of the loch – both of which appear to be of plantation origin.

The loch also supports a wintering wildfowl population and is of local importance for its breeding bird species including Mute Swan (*Cygnus olor*) and Great Crested Grebe (*Podiceps cristatus*) (SNH, 2011b).

The loch, and the valley in which it sits, are underlain by alluvial and river terrace deposits (gravels, sands and silts). The Cheviot Volcanic Formation forms the underlying solid geology (British Geological Survey, n.d).

The catchment topography comprises low lying hills, which surround the intensively managed agricultural valley basin. The soils comprise coarse lacustrine and fluvioglacial sands which give rise to the Eckford series of freely draining brown forest soils – which are most prominent along the south east and western edges of the loch. To the east the Sourhope series of stony loams occurs, which although relatively free draining are quite acidic. The valley floor is of mixed alluvium with some colluvial material (Scottish Wildlife Trust, n.d.)

1.3 Site Hydrology

The loch has a surface area of 16.8 hectares and a maximum depth of approximately 1.6 metres (SWT, n.d.). The loch has a catchment area of 10.90km^2 which receives an annual

average rainfall of 713mm (Centre for Ecology and Hydrology, 2009). There are two main surface water inflows to the loch. The Thirlestane Burn drains the north-western part of the catchment and flows into the north of the loch. An unnamed watercourse originating near Primside Farm flows into the south of the loch. The Roy Military Map of the Lowlands, 1752-55, shows a third inflow entering the loch from the west, draining the area around Lochside. This historic inflow may correspond to the reports of a culverted inflow to the loch (National Library of Scotland, n.d.).

Surface water runoff from the surrounding catchment provides a further inflow. The catchment is almost entirely comprised of arable and short-term grassland, with woodland areas restricted to one or two conifer belts and fringing policy stands. Historic canalisation of the Thirlestane Burn, southern inflow and the outlet of The Stank (which only flows under flood conditions) is evident and the banks of the Thirlestane Burn have been raised.

The loch discharges at the north-eastern corner to The Stank which is a tributary of the Bowmont Water via a bypass channel. A sluice gate and mill lade appear to take the majority of the flow.

A man-made pond is located out with the northwest boundary of the loch. According to SWT (n.d.) this was designed to buffer the loch from farm effluent and receives a diverted flow from the Thirlestane Burn and discharges to the loch during times of high flow/flooding.

1.4 Site History

The loch itself does not appear to have been of great socio-economic importance although it is assumed that fishing and wildfowling have always provided extra food and sport for the local community (SWT, n.d.).

In Victorian times Yetholm Loch was a popular destination for both botanists and ornithologists and from the mid-19th century onwards, records of the loch's natural history were kept by the Berwickshire Naturalists' Club. As a result, extensive historical species documentation for the SSSI exists (SNH, 2011b).

1899 mapping indicates that the marsh to the south of the loch did not extend to the north as much as it does at present – with an encroachment of 40-50m calculated. The 1975 maps show the southern marsh to be in a similar position to the 1899 maps and the marsh not supporting scrub or trees (McBride, 2011).

Since 1968 SWT have managed the site as an unstaffed nature reserve by SWT under a reserve agreement with the three landowners. The agreement was renewed in 1994 and runs until 2019 (SNH, 2011b).

During 1982 there were breaches in the water levels of the Thirlestane Burn (Unnamed, 1982). The burn overflowed in three places into the north channel leading into the Stank which is located just behind the Lochtower Cottages. SWT carried out bank repairs with the breaches banked up and the burn given a new channel in one place away from the former breach to ensure water from the burn passed through the loch before entering into the Stank. All overhanging trees were removed to prevent future blockages. It is reported that this significantly improved water circulation within the loch.

In 1997 SWT erected a bird hide with associated access paths and boardwalk to provide improved public access to the site.

In 2003 the most recent of a series of farm buildings were erected adjacent to the northeast perimeter of the loch.

From 2011 a Rural Development Contract (RDC) run under the Scotland Rural Development Programme (SRDP) was implemented. The management associated with this includes the installation of a fenced water margin along the loch's eastern boundary and a reversion of the steeply sloping fields above from arable to grassland to offer better protection to the SSSI (SNH 2011b).

1.5 Recent Site Management Practices

In 1982 the eroded banks of the Thirlestane Burn were repaired which prevented water entering the Stank without ever having entered the loch. This is thought to have improved the water circulation of the loch (SWT, n.d.).

In 1995/6 broadleaf trees including oak, alder, willow, rowan, cherry and beech, were planted by Mr Hurst (landowner).

In 1995 two man-made islands were positioned in the south-west corner of the loch to increase predator free nesting opportunities for wildfowl (SWT, n.d.).

Outwith the information contained in the Site Management Statement (SNH, 2011b), and the understanding that the site is primarily managed as a wildlife reserve with dog walking, angling and bird watching activities permitted, there has been a lack of information available regarding existing management practices at the site.

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 meetings were 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 a 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

Yetholm Loch	Date of Visit	Weather Conditions	Grid References
Visit 1	07 November 2012	Cold, overcast with intermittent rain	NT 803280
Visit 2*	12 March 2013	Clear, cold	NT803280

* Additional sampling was undertaken during the second site visit from two newly identified locations (YET 11 and YET 12), not originally on the SNH sampling schedule.

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

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 are 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.

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 over two visits although no repeat samples were collected. 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 any analytical results obtained.

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

- Sampling comprised a single set of samples from each of the accessible 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 or measurement of the inflow(s)/outflow(s) of associated drainage ditches or 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.

4. ANALYTICAL DATA

The following tables show the results obtained from the two site visits 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 Samples - Field Data and Observations

Sample ID	Nat. Grid Reference		Temp (°C)	pH	Salinity (psu)	DO (%)	DO (ppm)	ORP (mV)	EC (µS/cm)	Comments
YET01	NT 80230	28354	10.07	7.65	0.51	*N/A*	*N/A*	215	1.047	Surface water - clear with only a few suspended solids; no odour
YET03	NT 80173	28079	9.83	7.85	0.27	*N/A*	*N/A*	215	0.568	Surface water - clear with some mixed suspended solids; no odour
YET04	NT 80119	27774	9.61	7.29	0.33	*N/A*	*N/A*	171	0.676	Groundwater - cloudy dark brown; fine brown suspended solids; no odour
YET05	NT 80202	27692	9.92	7.13	0.32	*N/A*	*N/A*	178	0.665	Groundwater - cloudy dark brown; fine brown suspended solids; no odour
YET06	NT 80310	27598	10.14	6.59	0.36	*N/A*	*N/A*	189	0.483	Groundwater - cloudy dark brown; fine brown suspended solids; no odour
YET07	NT 80398	27105	7.79	6.59	0.3	*N/A*	*N/A*	182	0.625	Surface water - clear with few suspended solids; no odour
YET08	NT 80412	27698	9.96	6.89	0.29	*N/A*	*N/A*	173	0.611	Surface water - slightly discoloured (brown); large suspended solids; no odour
YET09	NT 80431	27995	9.82	7.14	0.38	*N/A*	*N/A*	167	0.792	Surface water - clear with only few minor suspended solids; no odour
YET10	NT 80211	28490	9.91	7.35	0.38	*N/A*	*N/A*	165	0.777	Additional Inflow - clear only a few minor s/s; no odour
YET11	NT 80500	28400	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	Surface water - clear fast flowing with low suspended solids; no odour
YET12	NT 79900	27750	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	Surface water - cloudy dark brown; fine brown suspended solids; no odour

+ Surface water samples are designated either inflow (I), outflow (O) or open water (OW).
***Red figures indicates levels that exceed typical ranges.*
N/A – No result obtained due to field probe failure/error.

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)
YET01	NT 80230	28354	SW (I)	54	16	16	0.29	0.01	5.7	0.02	<0.1	6
YET03	NT 80173	28079	SW (OW)	23	7	8	0.42	0.01	1.6	0.04	<0.1	2
YET04	NT 80119	27774	GW	27	7	11	10.5	2.1	<0.2	0.32	1.5	6
YET05	NT 80202	27692	GW	25	7	9	2.47	0.8	<0.2	0.01	0.3	3
YET06	NT 80310	27598	GW	41	12	10	43.3	1.4	<0.2	0.05	2.7	5
YET07	NT 80398	27105	SW (I)	32	8	12	0.15	0.01	4.7	<0.01	<0.1	5
YET08	NT 80412	27698	SW (OW)	31	9	8	3.38	0.15	<0.2	0.13	0.3	1
YET09	NT 80431	27995	SW (OW)	31	8	15	0.5	0.08	2.1	0.03	0.1	2
YET10	NT 80211	28490	SW (I)	20	6	6	0.05	0.02	1.1	<0.01	<0.1	2
YET11	NT 80500	28400	SW(O)	31	10	15	0.08	0.05	3.8	0.10	<0.1	4
YET12	NT 79900	27750	SW(I)	27	9	9	0.08	<0.01	1.7	0.09	<0.1	2

+ Surface water samples are designated either inflow (I), outflow (O) or open water (OW)

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)
YET02A	NT 80220	28000	High organic brown coloured soil	1.1	7250	3160	1530	2610	87.1	<1.3	<0.2	1.59	25.1
YET02B	NT 80220	28000	No sample collected as substrate comprised gravel substrate with no organic/humus material										
YET04A	NT 80119	27774	High organic dark coloured wet sludge	<0.5	7820	2140	1020	1420	80	<0.7	<0.2	1.27	9.69
YET04B	NT 80119	27774	High organic dark coloured wet sludge	12.5	4380	2910	1520	1990	77.1	<12.7	<0.2	2.09	12.2
YET05A	NT 80202	27692	High organic dark coloured wet sludge	0.6	12700	2290	901	1250	81.0	<0.8	<0.2	1.47	16.8
YET05B	NT 80202	27692	High organic with some gravels	<0.5	7520	2700	748	1580	70.9	<0.7	<0.2	1.48	6.01
YET06A	NT 80310	27598	Firm organic with some gravels	2.9	6200	3350	1460	2060	68.2	<3.1	<0.2	1.00	6.73
YET06B	NT 80310	27598	Wet organic humus with few gravels	<0.5	3880	1920	736	1400	83.1	<0.7	<0.2	0.74	4.33

** Soil types are field observations*
*** Total Moisture = Water content*
*A/B suffix: **A** = Rooting Zone and **B** = Below Root Zone*

5. SITE OBSERVATIONS

To enhance understanding of Yetholm 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 Site Management Statement (SNH, 2011b) records 'Objectives for Management' of maintaining and enhancing the fen woodland, open water transition fen and eutrophic loch features through maintaining water levels within the site at an appropriate level; maintaining appropriate low nutrient and sediment input from the catchment area. A Rural Development Contract (RDC) was issued at the site. The management prescriptions associated with the RDC include fencing of the water margin along the loch's eastern boundary and a reversion of the steeply sloping fields above to grassland.

The Site Management Statement states that the nutrient supply to the loch appears to have increased over time however, there is no quantitative assessment to qualify such and it is based on the loss in the diversity of aquatic plants occurring within the loch. It also confirms the presence of Canadian Pondweed (*Elodea canadensis*) and historic algal blooms – both of which are unquantified.

A site visit undertaken in 2009 (SNH, 2009) has referred to high levels of nutrient runoff from the farm on the south side of the site. This runoff was assumed to be affecting plant diversity in open water and speeding up succession. Nutrient input also comes from the cropped fields which surround the loch on both sides.

The 2004 site condition monitoring (SCM) assessment of the 'eutrophic loch' feature found it to be in unfavourable condition (visit date 21 June 2004). The loch's nutrient status appears to have increased over time. This is indicated by a loss in the diversity of aquatic plants occurring within the loch. At the time of the last survey only 7 submerged and floating species were recorded and this included Canadian waterweed, a non-native invasive species, although the population of this species appeared to be stable and was not considered to be threatening the site.

The 2003 SCM assessment of the 'open water transition fen' feature found it to be in favourable condition (visit date 13 September 2003). This feature has been maintained in extent, remains free of significant browsing or trampling damage, and has a good range of indicator plant species. The 2003 SCM assessment of the 'fen woodland' feature (same visit date) found it to be in favourable condition. This feature has seen no net reduction in extent, no invasive non-native species were recorded, there is a good mix of closed canopy and more open areas, and no significant browsing or trampling damage was recorded.

5.2 Catchment Walkover

From the second site visit post-receipt of the analytical results, the following observations of the surrounding catchment were made:

- At the time of the site visit there were notable sources of fly tipping – with an extensive stockpile of waste material (metal, timber, etc.) on the south eastern bank of the loch and redundant farm machinery within Lochtower steading. There was evidence to suggest that this has been historically commonplace at the site.

- Surrounding catchment comprises arable and lowland improved pasture.

- Public access routes are available to the site. Car parking is available in the form of a lay-by, a path and board walk allow easy access to the bird hide on site.

- Drainage ditches are present in the adjacent fields. It was considered that these were directed to drain into the loch.

- There is evidence of re-routing of the outflow around the property at the northern end of the loch. It is understood this took place in 1982 (Badenoch, 1982), the overflow/sluice for which was not confirmed as operational.

- Large areas of reed (identified as *Phragmites spp.* and/or *Phalaris spp.*) were observed in the margins of the loch.

- Adjacent to the site there are areas of improved grassland for grazing purposes along with areas of heavily mechanised arable land.

- Broadleaved woodland has been planted along the western boundary to act as a buffer however, there are notable gaps within the treeline such as to limit the effectiveness.

- Sedimentation is evident within the loch and the outlet watercourse. The latter is heightened by the presence of man-made dam comprising felled trees and natural debris as well as deposited material including silt and gravels. This is related to the diverted course of the loch outflow.

- Unconfirmed history of dumping of rubble (stones and boulders) along the western bank of the loch. Access to this part of the site was inhibited by an overgrown pathway.

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	Site partially fenced. The standard and completeness of the fencing was not assessed as part of the site visit.
Fishing	No information was present at the site. Internet research indicates that loch is a coarse fishery comprising pike, perch and roach species with permits and (two) boats available from the landowner on the western shore of the loch. Internet searches indicated depth of loch to be 1-2metres at the deepest point.
Grazing	Site itself is not grazed however areas of the surrounding catchment grazed by cattle and sheep.
Monitoring	Site Condition Monitoring was last carried out in 2010. Water quality data from 1982 was reviewed for the purposes of this study.
Public Access	Path and board walk access to a bird hide, associated car parking. Scottish Power has wayleave access to the site and may visit to undertake periodic maintenance.
Shooting	None.
Pollution Sources	Runoff from the adjacent arable fields. The site is located within a Nitrate Vulnerable Zone (NVZ)
Properties in catchment	Several farms and residential properties are present in the site catchment. The closest being those at Lochside (north-western shore) and Lochtower (north and north-western) of the loch shore. Given the rural nature of the catchment it is suspected that these are served by septic tanks.
Unusual, Distinctive or Atypical Features	Disposal/breakage of discarded farm machinery present in vicinity of Lochtower steading; burning of waste on eastern shore of loch; main recreational uses of the loch comprise bird watching, dog walking and fishing; historic reference to re-routing of outflow from loch possibly as a result of access to the constructed property on the north shore.

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. A separate comparison is made with historical data obtained through the desk study and should be viewed in the context of the assigned caveats.

6.1 General Summary

The surface water quality at the site was consistent with a eutrophic waterbody, in that there are elevated concentrations of nutrients in the surface water inlet, open water and outlet samples obtained.

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

In a eutrophic system, phosphorus is likely to be the limiting factor over nitrogen. All bar one of the open water samples recorded concentrations of total phosphate at or above 0.10mg/l (the level of detection applied for total phosphorus samples was 0.10mg/l). The results do not afford a consistent level of detail to be able to determine whether such is representative of a eutrophic loch. However the values recorded at YET08, YET09, YET11 and Yet12 all indicate a notable level of nutrient enrichment within the surface water body, in both the inflow, open water sample and loch outflow.

With the exception of nitrogen and phosphorus parameters, the surface water results indicated no significant changes in concentrations of the monitored parameters from the inlet source waters to the outlet. Elevated total nitrogen (as N) and nitrate results were recorded in all the inlet samples with results ranging from 2-6mg/l and 1.7-5.7mg/l respectively. This would suggest that there is nitrogen and phosporous enriched surface water runoff from the surrounding fields, potentially due to grazing of livestock, or the use of artificial fertilisers. The open water samples were typically lower in total nitrogen than any of the inlet samples or the outlet.

With the exception of iron concentrations in the groundwater samples, none of the analysed metals values were deemed to be elevated or above expected concentrations. The elevated iron values were consistently high in all three groundwater samples with values of up to 43.3mg/l recorded (YET06). As these are groundwater samples where conditions are such that dissolution of iron is likely to occur under low oxygen conditions, these results are not unexpected. However, the elevated value of 3.38mg/l in the open surface flow of YET08 is markedly higher than the other surface waters. It is deduced that this is likely to be influenced by a groundwater source.

The soil samples highlight consistently high levels of phosphorus, nitrogen and potassium across the site but particularly in samples YET02, 04 and 05 where levels were amongst the highest observed at any site during the study. These parameters are the primary constituents of artificial fertilisers which are understood to be applied to the adjacent catchment. The values recorded in the three stated samples were at levels which would indicate a significant enrichment from that which would be present naturally. With the exception of YET04B this is supported by the values being highest in the upper (root zone) reaches of the soil samples obtained. The distribution of these samples is geographically consistent, aligning with the western shore of the loch. It is possible that this is a result of

direct runoff or are ‘sinks’ whereby the topography and drainage lead to a build-up of concentrations at these locations.

It is of interest to note that the nitrate level in all the soil samples were below the detectable levels whereas elevated extractable nitrogen, % nitrogen and total nitrogen were elevated. This potentially indicates that the nitrogen is predominantly in the elemental form (and therefore consistent with the application of artificial fertilisers) or in a bound form not analysed - *e.g.* ammonia – which would indicate the application of animal wastes to the adjacent land.

6.2 Comparison with Historical Analytical Data

The desk study revealed limited historical data held on SNH site files (Unnamed, 1981). Whilst the specific location and the sampling and analytical methods are unknown, the following water quality parameters were recorded (it is assumed from open water) from the loch in what is assumed to be a series of visits during 1982. No comparative soils sample data was available.

Table 6.1: Summary of comparable water quality data from 1982 at Yetholm Loch

Visit	Soluble Reactive Phosphorus (mg/l)	Total Soluble Phosphorus (mg/l)	Total Phosphorus (mg/l)	Nitrate (mg/l)	Chlorophyll a
1	0.05	0.02	0.07	2.89	20
2	(0.33) 0.33	(0.36) 0.36	(0.46) 0.47	(<0.01) <0.01	(32) 32
3	0.25	0.27	0.32	<0.01	9.0
4	0.15	0.17	0.24	0.29	<20
5	(0.05) 0.05	(0.03) 0.03	(0.12) 0.12	*Not analysed*	*Not analysed*
6	(0.02) 0.02	(0.05) 0.05	(0.13) 0.14	0.54	*Not analysed*
7	0.04	0.04	(0.13) 0.13	*Not analysed*	*Not analysed*
9	0.05	0.02	0.09	*Not analysed*	*Not analysed*

NB – Figures in brackets indicate samples were filtered. All results rounded to 2 decimal places.

A study (Jones, 1987) of lochs in the Scottish Borders revealed that Yetholm had one of the highest mean pHs at *c.*8 and the highest mean level of nitrates of any loch in the region. Although phosphate values averaged 0.17mg/l, the status was acknowledged as indicative of enrichment. This is further demonstrated by the loss of *Daphnia magna* between 1983/4 and 1985/6.

Due to the aforementioned limitations, as well as the advancements in analytical assessment, the accuracy and relevance of these results should be viewed with caution. There are however interesting comparisons to be drawn with the observed pH being higher than the 1987 average and phosphate (as P) values typically lower for the general surface water samples collected for this study.

It is difficult to draw accurate conclusions (notably due to wider climatic influences and probable sampling variables) but the variations may be attributed to a direct result of land management practices – *e.g.* a change in land use from pasture to arable having taken place since the 1987 study.

6.3 Atypical Results

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

- The elevated conductivity reading for YET01 of 1.047µS/cm is higher than the other sample results but not atypical for surface water. It may be attributable to the level of suspended solids in the sample.

- Elevated iron value for YET06 of 43.3mg/l is notably higher than for any other sample collected. As this is a groundwater sample where conditions are such that precipitation of iron is likely to occur this is not unexpected.

- The elevated calcium value in YET05A may be attributed to soil conditioning activities within the fields at the southern end of the site – and is consistent with the relative high pH values observed in the corresponding groundwater at this part of the site.

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

Despite the limitations outlined in section 3, the analytical results show a definite trend of elevated nutrients in the soil, surface and groundwater samples. The desk study findings and site walkover observations indicate that in addition to site conditions being influenced by geographic setting, the nutrient concentrations are elevated due to land use management practices in the immediate catchment.

Due to the surrounding steep ploughed topography, low lying position of the loch and underlying permeable geology, it is expected that the site will be heavily influenced by the quality and quantity of water which flows to the site. These flows, which will vary seasonally, will leach nutrients from the surrounding catchment to the loch which therefore acts as a sink for the surrounding landform. The nutrients encourage plant growth which over time decay and, coupled with the inflow of suspended solids from the wider catchment, create a nutrient rich substrate. It is this continued infilling and accumulation furthering successional change that is presently observed as likely to be to the detriment of the designated site condition.

The historical information on the site is limited but it is assumed that the surrounding catchment is largely unchanged. It is therefore concluded that the drainage of the adjacent wetlands, modifications to the Thirlestane Burn, and land management practices resulting from the intensification of agriculture have influenced the SSSI in recent years and are attributed to the changing status.

The greatest potential impact to the site, as deduced from the observations made during the study, is the land management approaches employed on the adjacent arable land and the adjacent woodland. This finding is heightened by the repeat observations in the SNH Condition Monitoring Statements outlining such. The most notable observation which does not appear to have been fully assessed is the potential for runoff and nutrient enrichment affecting the inflow to the SSSI and loch from the immediate catchment. The permeable nature of the underlying sandstone geology is expected to aid migration of nutrients to groundwater from the intensively managed arable land and potential less frequent grazing of stock. This will be enhanced through losses of vegetation during the harvesting cycle, increased runoff from ploughed land and the seasonal application of soil conditions, artificial fertilisers and herbicides – the extent and volumes of which are unknown. Coupled to this there are questions to be raised with the corresponding landowners regarding the management of wastes (*i.e.* burning practices and vehicle maintenance) immediately adjacent to the loch.

Additional sources of nutrients could be the wastewater discharges from the catchment properties and visiting wildfowl populations. Given the number and proximity of residential properties adjacent to the site and the remote location, it is expected that these dwellings may be served by septic tanks and hence the foul water flows would drain to the site. Engagement with Scottish Environment Protection Agency (SEPA) and additional monitoring within the fields out with the site boundary is required to corroborate this. The potential for additional nutrient input from the visiting wildfowl populations should also be considered. Whilst current numbers were not provided by SNH, a significant population descending on the loch could potentially add a significant nutrient load to the catchment and sediments of the loch.

The desk study references to the widening and deepening of the site drains and watercourses will have led to changes in the flow regime within the site. Given the expected inflows, and the associated sediment from ploughed fields, these channels are also likely to have been either slowly infilled or accumulated nutrient rich silts which would in turn be flushed into the loch. No records exist of any maintenance having taken place in this regard. Correspondingly, whilst there is likely to be some ‘short-circuiting’ of input at the north end of

the loch, the levels of deposition are expected to be significant in the areas around the inlet flows. These will aid further settlement and due to the high nutrient loadings, there will aid plant growth and the observed successional changes.

It is highly probable that there are significant sediment accumulations within the loch. These will afford a plentiful supply of nutrients through disturbance by, and variations in, seasonal inflows. The shallow depth of the loch means it is unlikely to release nutrients through stratification however, 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 and how this in turn impacts on the transition fen. 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. However, the limited information of algal blooms (re: frequency, composition *etc.*) and historic water quality data restricts the conclusions which can be drawn.

Unknown maintenance of outflow controls, and the variation to flows in the Thirlestane Burn (Badenoch, 1982) will influence the flow dynamics of the loch. The loch appears to have a variable level of throughput and this will lead to changes in the marginal flora communities. Consideration should be given to understanding how a change in throughput of the loch may afford flushing to remove retained nutrients within the present margins. The outlet sluice operation/control/maintenance is unknown. It is possible that variations in operation could significantly alter the nutrient output from the loch and its associated margins. There is therefore value in understanding how the sluice operates and engaging with SEPA to understand the limitations of the downstream catchment for a potential increased flow.

There is a requirement to manage the inflow of nutrient to the loch through runoff and direct inflows (themselves impacted from runoff and field drainage flows). This requires proactive engagement with landowners and tenants and the implementation of best practice measures including buffer strips and improved use and storage of fertilisers. It is noted in the 2011 Site Management Statement that the catchment area is under separate management from the SSSI. As a result, SWT do not have any direct control over the quality of the water entering the site from the surrounding land. As such, efforts should be focussed on informing and educating the landowners and seeking means to improve cooperation for the future benefit of all parties.

8. RECOMMENDATIONS

Based on the limited understanding gained from the sampling exercise and catchment visits, the following recommendations are proposed. 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 catchment including the inflow burns and field drains (xii) and (xiii), the potential pollution from the fly tipping (ii) and domestic sewage (xvia), the contribution from the accumulated sediments (v), and the water balance/loch throughput (iv).

8.1 Monitoring

i. It would be of value to the long term status of the SSSI to understand whether the loch is classified as eutrophic. For this to be determined, a more extensive seasonal monitoring programme is necessary. This should include qualitative and quantitative assessment of algal blooms and chlorophyll a concentrations.

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). This should include the areas where fly tipping has been observed to assess for any resulting leachate. 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. The data from this study should be compared with historical data available.

iii. In conjunction with (i), assess the seasonal flow and nutrient loads of the two inflow burns to the south of the site and that in the north, and compare these with those of the outflows from the northern end of 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.

iv. Undertake hydrological and hydrogeological assessment of the catchment to determine the source water of the loch. To include map and monitor the field drains on site and integrate these findings into the loch dynamics assessment; and understanding the operation of the sluice and outflow configuration at the northern end of the loch.

v. Undertake core sampling of loch sediments to understand the concentration of retained nutrients. Although the loch is understood to be 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 plant margins. It is considered likely that there will be a significant volume of nutrient bound up in the loch sediments this may be being slowly released into the water column and aiding successional change.

vi. Review the loss of standing water within the loch and determine the extent of vegetation ingress over time. The Condition Monitoring Report (SNH, 2008) states that there has been no change to the extent of open water habitat however, this does not appear to be a quantitative assessment against historical data. If such were routinely quantified, over time this would aid the understanding of loch dynamics. This information would also be directly beneficial to aiding the understanding of, and potential operation of, the sluice in the loch outflow (see xi).

8.2 Other commissioned studies

vii. Consideration should be made to understand the functioning and management of the sluice on the outlet flow from the loch. This may be subject to regulatory control from SEPA and variations to such would therefore be likely to require consultation and approval.

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. To include records of previous studies as identified in the SWT Management Plan 1997-2002. This should be used in conjunction with (i) and (ii) to determine historical changes associated with the findings of (ix)

ix. Commission a bathymetry survey of the loch to confirm depth and sediment profiles. This would aid the understanding of inflow and retained sediment volume.

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

xi. Where future in-loch management practices require vegetation to be treated instead of chemical applications, consideration should be given to the removal at the root zone rather than cutting of above ground stem. This should be followed by appropriate off-site disposal as this will lead to a net reduction in nutrients from the catchment, minimise regrowth and avoid the need for the use and reapplication of potentially harmful chemicals. This is particularly applicable to marginal and aquatic vegetation.

8.3 Landowners/Tenants

xii. Proactively engage with catchment landowners to understand the historical land use practices and the existing and (foreseeable) proposed changes to the immediate catchment including field usage, crop type and soil conditioning approaches. This should include access of livestock to the site. Consider appropriate management strategies accordingly - for example, nutrient management planning, buffer strips, exclusion zones, routine spot monitoring, improved fencing *etc*. Where introduced these need to be proactively managed.

xiii. Review the use of fertilisers and soil conditioning techniques within the landholding immediately adjacent to the loch. Land managers should be keeping records of these measures as the site lies within a Nitrate Vulnerable Zone (NVZ).

xiv. Review the fish stocks and associated policies of the fishery. By understanding the existing fish stocks and management practices, consideration can be made to the likely disturbance of sediments with regards nutrient release and if catch records are known, this would further aid the understanding of the health of the loch. Albeit anecdotal, engagement with regular anglers could also provide an 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*.

8.4 External consultations

xv. Liaise with SWT to understand whether a management plan is in place for the site. Where such exists, SNH to input to plan and oversee its implementation.

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

a. Sewerage provision (and compliance with any regulatory provision) for the properties within the catchment;
b. Sluice management/operation (see viii above);
c. Any permitted or historic water abstraction (link to changes in loch levels); and
d. Identified/reported pollution incidents at the site – including the burning of wastes and vehicle maintenance on the eastern shore of the loch.

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ANNEX 1: FIGURES

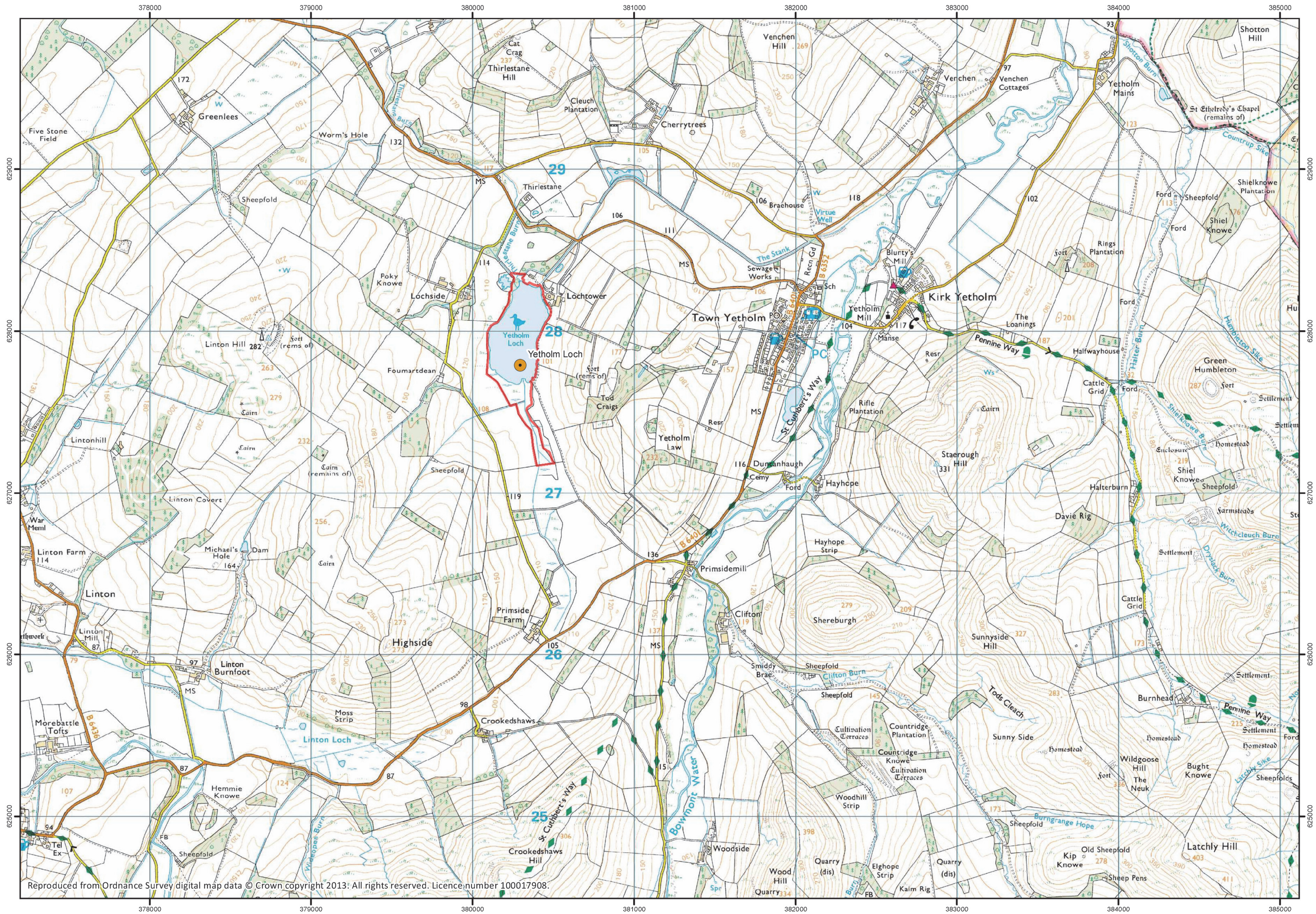
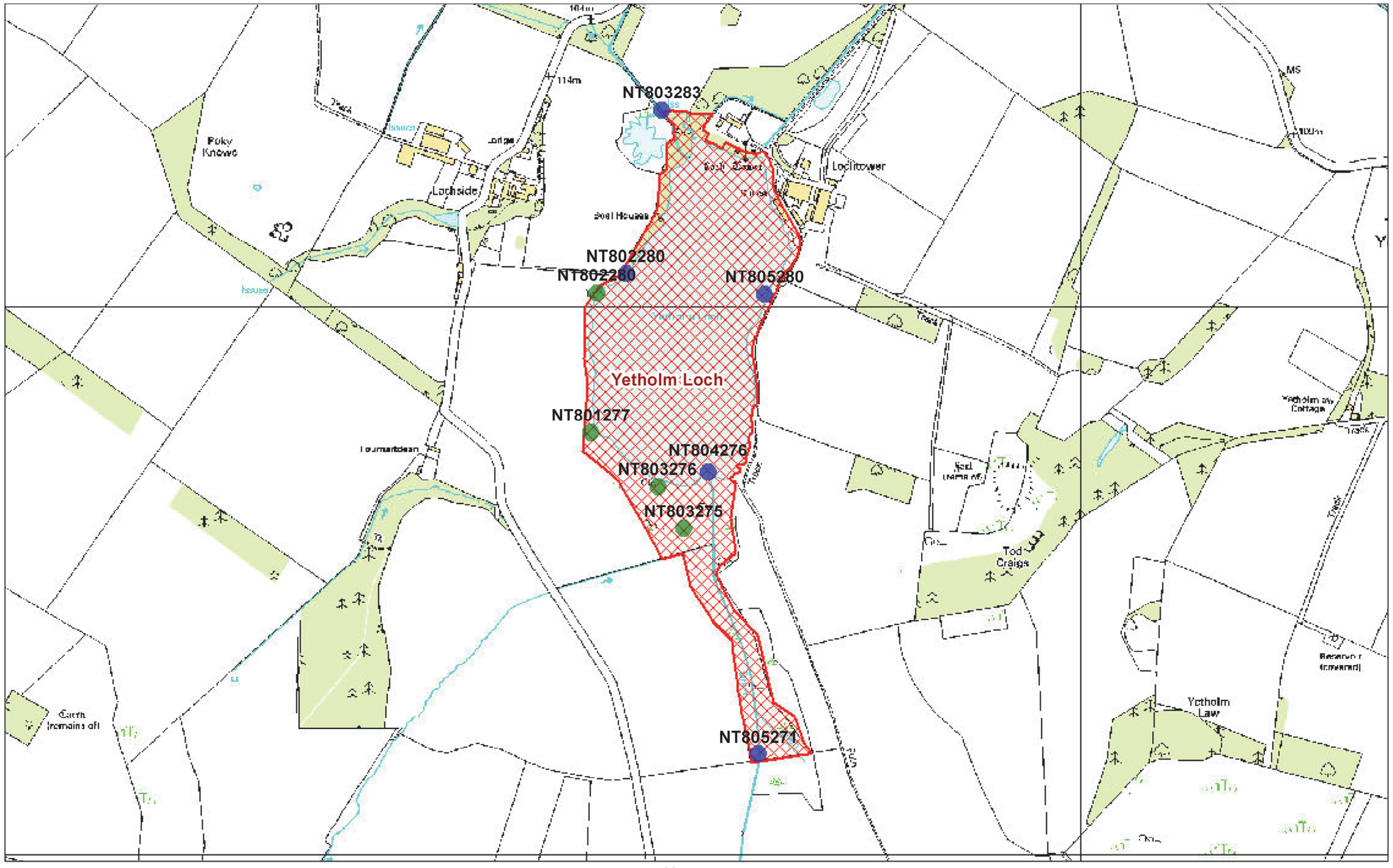


Figure 1.1: Site Location Map

Yetholm Loch



Map produced using geo.View 3.0
Printed: Sep 20, 2012 16:32:21

Figure 2.1: SNH Proposed Sampling Location Plan

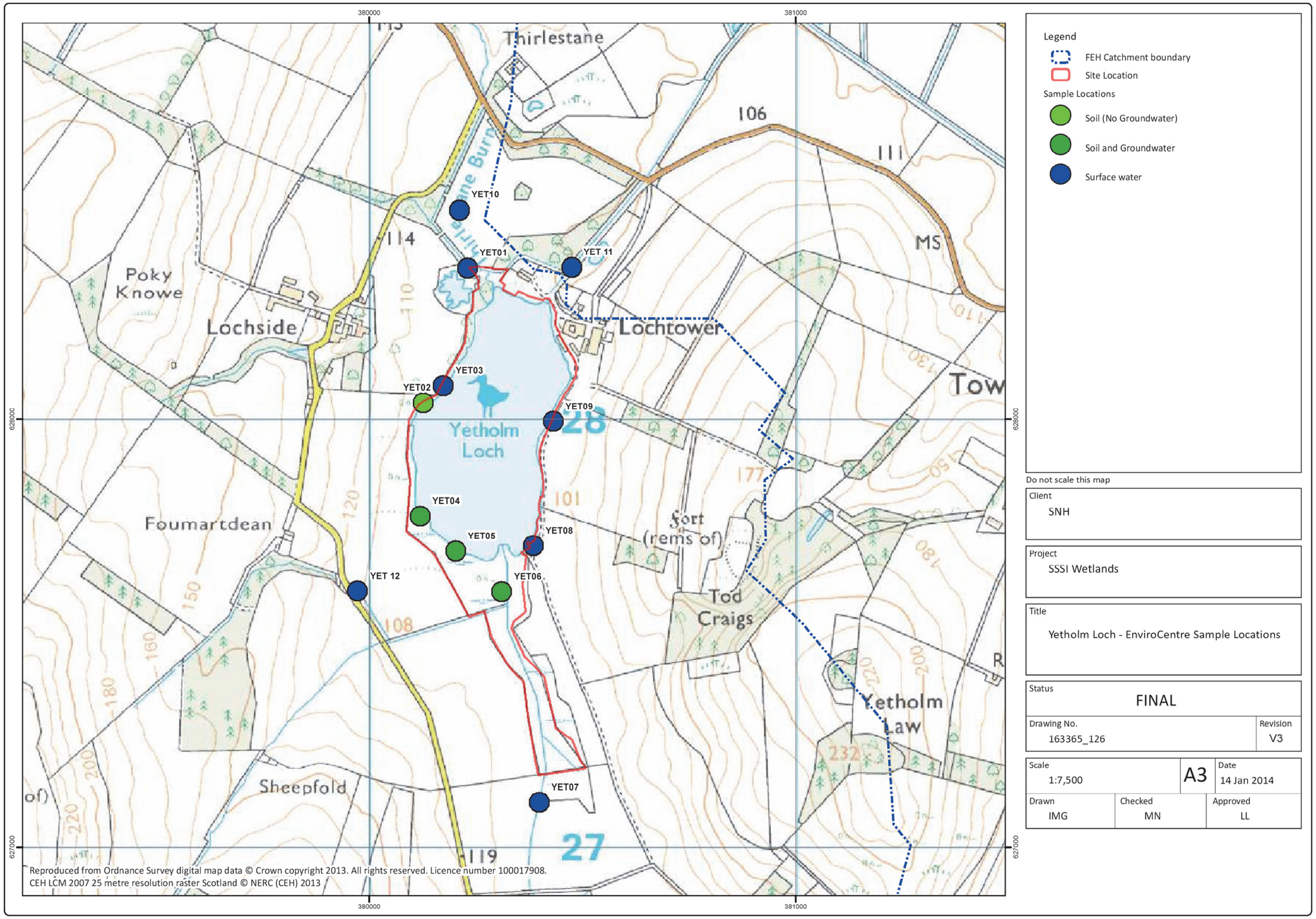
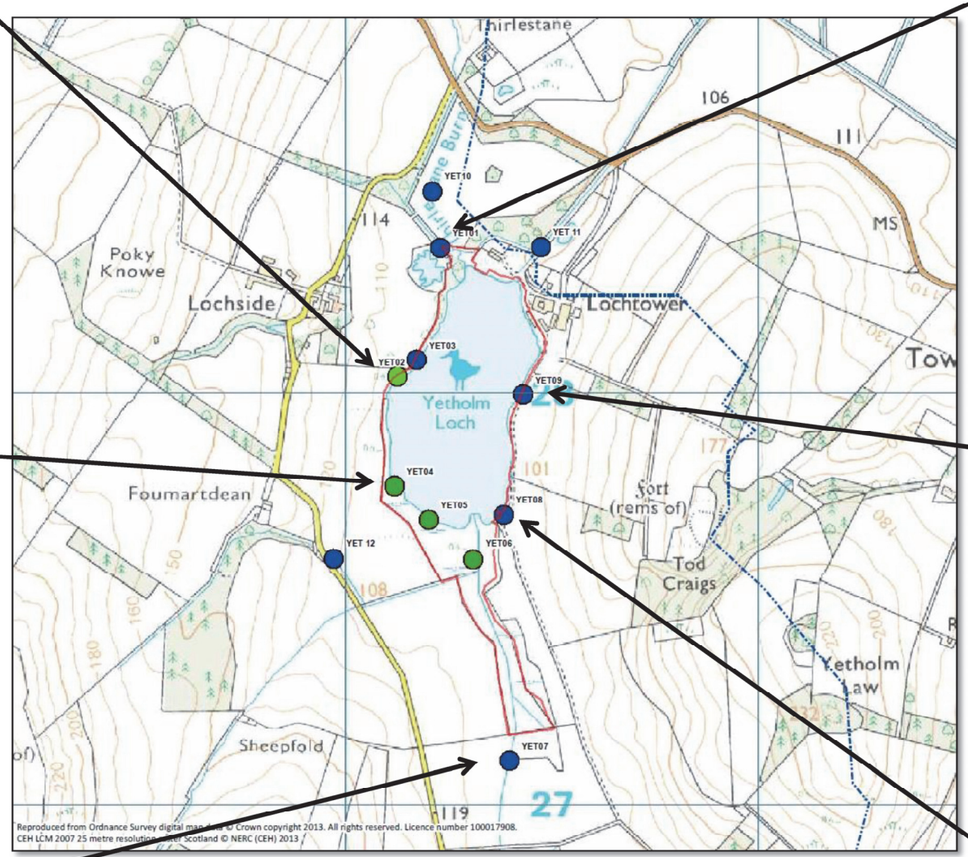
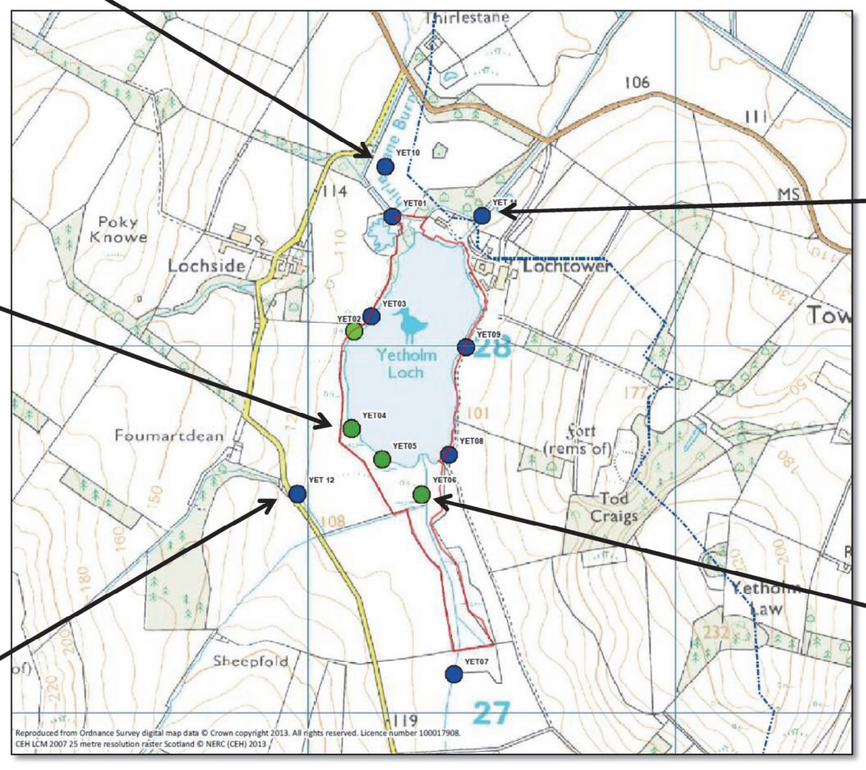


Figure 2.2: Plan of Actual Sampled Locations



Photograph Log (A) - Sample Locations
(Photographs taken on 7th November 2012)

Figure 2.3a: Photographs of each Sampling Location



Photograph Log (B) - Sample Locations
(Photographs taken on 7th November 2012 & 12th March 2013)

Figure 2.3b: Photographs of each Sampling Location

Figure 2.4: Photographs of Surrounding Land Use

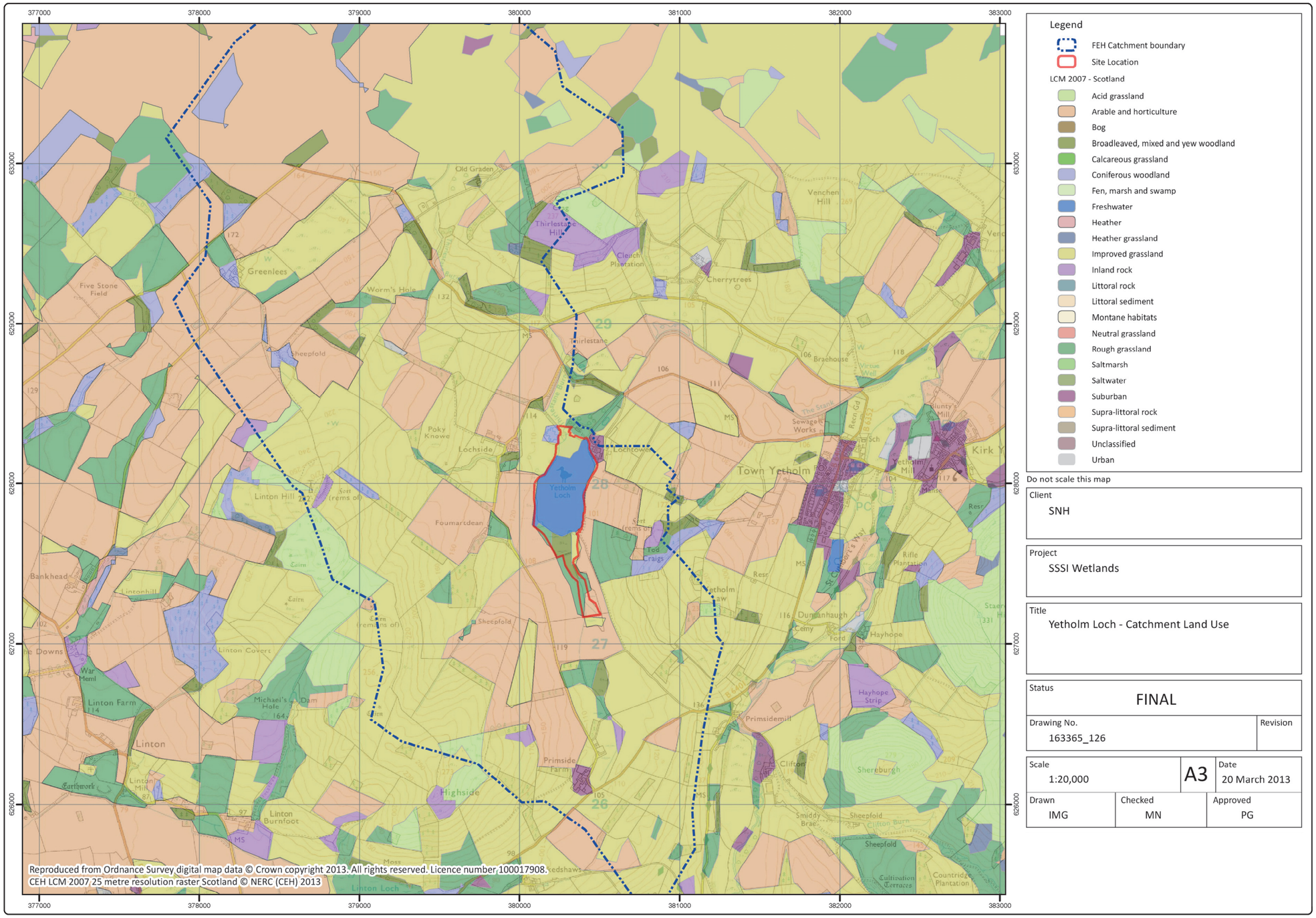


Figure 2.5: Land Use Characteristics Map

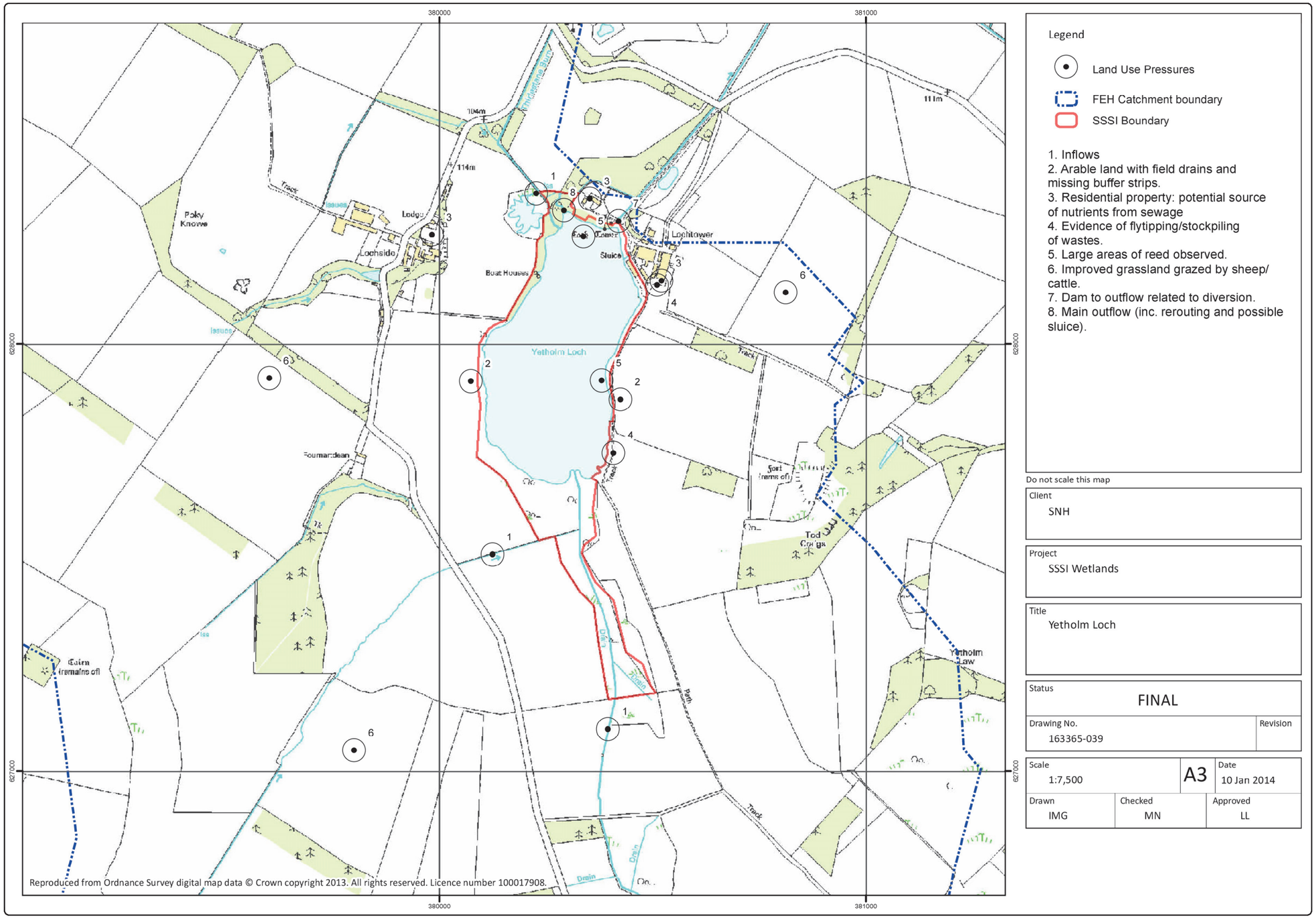


Figure 5.1: Catchment Pressures Summary

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Policy and Advice Directorate, Great Glen House,
Leachkin Road, Inverness IV3 8NW
T: 01463 725000

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