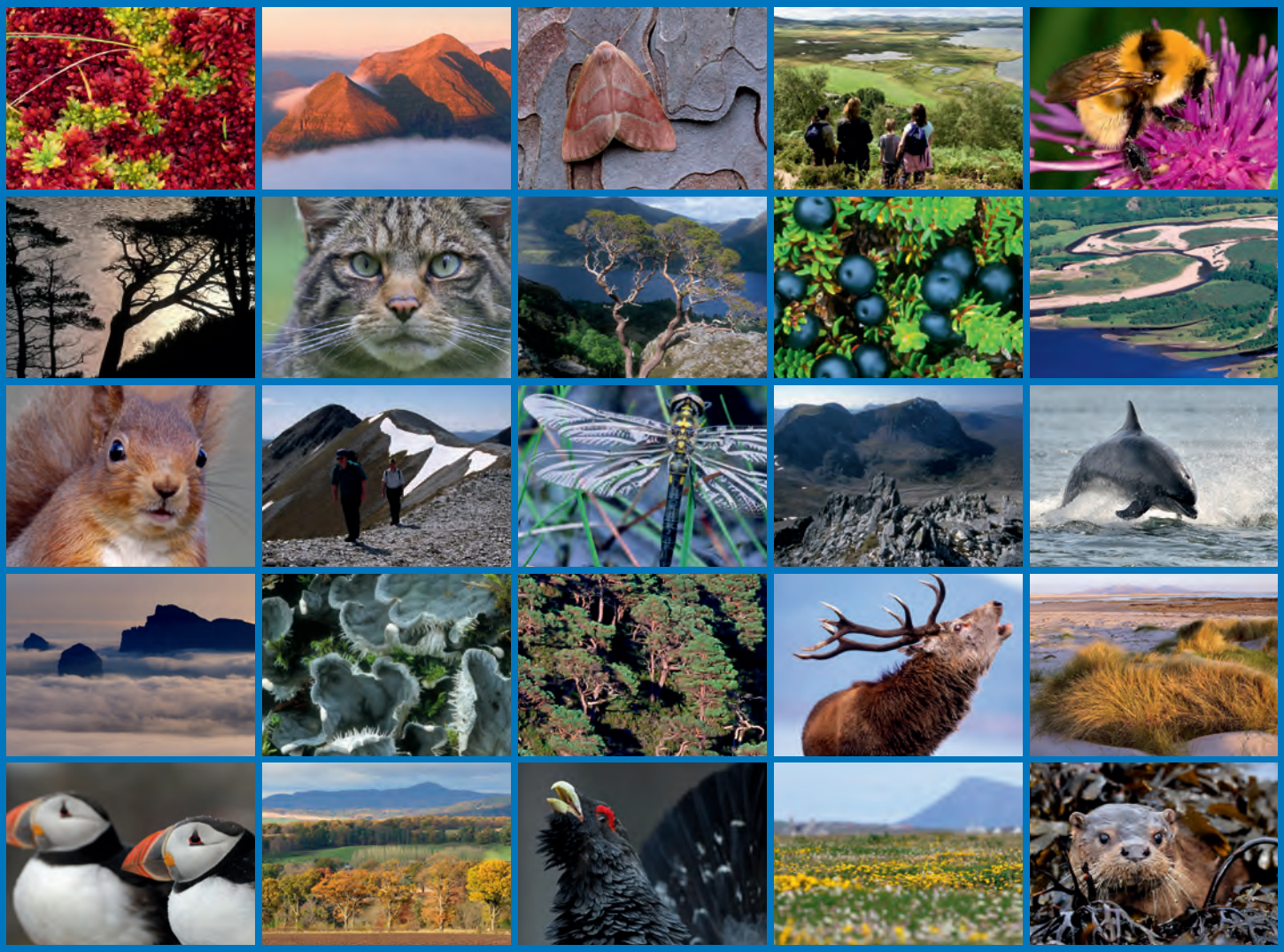
Scottish Natural Heritage
Commissioned Report No. 718

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



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COMMISSIONED REPORT

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

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COMMISSIONED REPORT

Summary

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

Commissioned Report No. 718
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 recorded high levels of inorganic nutrients within the site but was inconclusive in determining nutrient levels that would be typical of a mesotrophic waterbody. The sampling assessment was undertaken as a single visit and the limited dataset constrains the ability to draw accurate conclusions on current site conditions.
- 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.

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Acknowledgements

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

Carriston Reservoir is situated 5 kilometres (3 miles) east north east of Glenrothes, 1 kilometre (0.5 mile) east of the village of Star, in Fife. The site is accessed from an unnamed road off Stob Cross Road. See Figure 1.1 in Annex 1.

1.2 Site Description

Carriston Reservoir is a SSSI designated site due to its mesotrophic status which supports a wide variety of aquatic plants, including five pondweed species (the largest number of pond weed species recorded for any open water site within Fife). The site has been designated since 1984 (SNH, 2011a).

The site comprises a small reservoir with an earth embankment dam. It extends over an area of 11.81 hectares (29 acres) and is situated at an altitude of 92 metres. The reservoir has a surface area of 9.9 hectares (24.5 acres) and a perimeter of 1.4 kilometres (SNH, 2004).

The land surrounding the reservoir is intensively managed arable land except for a small tree plantation to the north east and Torloisk Wood further upstream the unnamed burn. Immediately to the east of the site lies the Donald Rose (or Upper Carriston) Reservoir which is connected hydraulically via a gravity feed - the operation of which is unconfirmed – and via an overflow which links to the combined spillway.

The reservoir was once considered an important site for Greylag Geese (*Anser anser*) but since the 1990s no geese are reported to have used the site during the winter months. This is thought to be due to increased human disturbance and changes in goose distribution in Scotland as a whole (SNH, 2011b).

The reservoir is also the only known site in Fife where the uncommon, and declining, freshwater snail *Lymnaea auricularia* is found (SNH, 2011a).

The reservoir and the western part of the catchment are underlain by sedimentary rock cycles of the Clackmannan Group while the eastern part of the catchment is underlain by an igneous intrusion (British Geological Survey, n.d.).

1.3 Site Hydrology

The catchment area draining to the reservoir is 4.37km^2 and receives an annual average rainfall of 808mm (Centre for Ecology and Hydrology, 2009). The main inflows to the site are the Carriston Burn flowing into the north western corner of the reservoir and an unnamed burn (controlled by a sluice) flowing into the north east. These watercourses may have been widened and deepened in the past. There are also likely to be field drains from surrounding farmland which drain directly to the reservoir or indirectly via these watercourses. The Donald Rose (Upper Carriston) Reservoir can also enter the reservoir at the eastern end via gravity through a sluice below the upper reservoir draw off tower.

The main outflow from the reservoir discharges to the Kennoway Burn.

Over the years there has been a change in flows at the site as a result of the two reservoirs no longer being operated for the purposes of water supply. It is reported that the reservoir experiences infrequent, temporary reductions in the volume of water inflow due to the occasional drying up of the feeder stream in summer (SNH, 2011b).

There are a series of wells in the upstream catchment which it is assumed are used for private potable supply. These are noted on the corresponding mapping but have not been assessed further as part of this assessment.

1.4 Site History

The reservoir was formed for the purpose of water supply by the construction of a long dam across a valley through which flows a tributary of the River Leven. The reservoir was designated as a SSSI in 1984 and is managed by Scottish Water. The reservoir is surrounded by improved grassland and arable land apart from a plantation woodland to the west (SNH, 1999).

Since the early 1980s the reservoir has been stocked for recreational fishing. It is understood this was initially with Brown Trout (*Salmo trutta*), but since the late 1980s the fishery was managed by Lower Carriston Fishing Club, and now Methilhaven and District Angling Club, and is stocked with non-native rainbow trout (*Oncorhynchus mykiss*). The club claim to not have experienced any weed and eutrophication problems. However whilst limited records exist, there are notes on the SNH files which state there to have been noted algal blooms in 1986, 1992 and 2004. These have resulted in decreases in fish stocks (SNH, 1993 and 2011b).

There have been a number of cut and burn activities on the site over the years. It is recorded that during the mid-1970s the willows on the eastern embankment were coppiced. In 1986, a number of willows on the same side were cut and burnt by consent. The following year (1987) more willows and around three hectares of reed bed on the northern shore were cut and burnt without consent which affected the main nesting area for waterfowl (SNH, 2011b).

Over the years, there has historically been clearance of the wooded areas immediately around the reservoirs and reports of the unauthorised burning of wastes, notably tyres, causing damage to existing vegetation (SNH, 2011b). Further damage resulted after work took place on a small dam at the north eastern inflow in the 1980s when soil was tipped on an adjacent area of approximately 30m x 3m of reed canary swamp. This was subsequently colonised by tall ruderal plants.

1.5 Recent Site Management Practices

Outwith the information contained in the SNH site file, as summarised above, there is no information available regarding previous or existing management practices. It is understood that there is no management agreement currently in place for the site.

Anecdotal information gained during the second site visit from fishery staff contradicted the latest SNH Site Management Statement (SNH, 2011b) in that it is understood that the site is no longer managed by Scottish Water and the sluice gates now no longer allow water to flow between the two reservoirs. It was further intimated that during the summer months marginal weed growth poses a problem to the fishery.

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. Access to non-publically available data held by other regulators, including SEPA, was not available.

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 of the workings of the site and the site surrounds.

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

Carriston Reservoir	Date of Visit	Weather Conditions	Grid References
Visit 1	20 October 2012	Dry, overcast and calm	NO 327037
Visit 2	20 February 2013	Mild, dry and dull	NO 327037

2.3 Sampling Approach

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

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

2.4 Sample Equipment

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

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

- Personal Protection Equipment (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 carried by staff attending the site visit, included details of the landowner, nearest emergency services and identified risks and proposed means of mitigation. Field operatives notified EnviroCentre head office when entering and leaving site and wore the following appropriate PPE at all times:

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

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

2.6 Water Samples

Surface water samples were collected from strategic locations within the site. As appropriate, 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) and magnesium (Mg) and sodium (Na);
- N Species – total nitrogen, nitrate and ammonium;
- P Species – orthophosphate and total phosphorus; and
- Total Iron.

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 run off, dilution and catchment water levels/throughput which have not been assessed.

- Due to limitations in the mapping data used to compile the Flood Estimation Handbook (FEH) catchment boundary, the area defined in the Annex 1 maps does not necessary present a fully accurate reflection of the hydrological catchment for the site. Whilst this affords a valuable tool for the purposes of this study, the mapped boundary should be viewed as an indicative guide only and be subjected to detailed verification to be considered definitive.

4. ANALYTICAL DATA

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

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

4.1 Field Test Data

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

Table 4.1: Field Data

Sample ID	Nat. Grid Reference		Temp (°C)	pH	Salinity (psu)	DO (%)	DO (ppm)	ORP (mV)	EC (mS/cm)	Comments
CR01	NO 32833	03542	7.79	8.36	0.32	107.6	12.78	312	0.320	Surface water - clear with only a few very minor suspended solids; no odour
CR02	NO 32818	03917	7.62	7.21	0.21	100.8	12.43	317	0.438	Surface water - clear with some fine and medium suspended solids; no odour
CR03	NO 32758	03802	7.63	7.19	0.09	34.7	4.23	45	0.201	Groundwater - dark cloudy brown, fine brown suspended solids; no odour
CR04	NO 32744	03690	7.74	7.47	0.17	93.0	10.46	32	0.358	Surface water - lightly discoloured with some minor suspended solids; no odour
CR05	NO 32677	03702	8.12	7.13	0.08	32.3	3.93	124	0.177	Groundwater - milky brown, with fine suspended solids; no odour
CR06	NO 32590	03792	7.80	7.22	0.16	70.3	8.24	118	0.348	Surface water - clear with light suspended solids; no odour
CR07	NO 32572	03802	7.88	7.09	0.26	8.1	0.88	-48	0.550	Groundwater - cloudy brown with fine suspended solids; very faint organic (sulphur) odour
CR08	NO 32525	03870	7.98	7.36	0.21	69.9	8.45	35	0.412	Surface water - clear with minor suspended solids; no odour
CR09	NO 32471	03788	7.87	7.27	0.17	57.0	6.33	80	0.361	Groundwater - light brown discoloured with fine brown suspended solids; no odour

4.2 Laboratory Results

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

Table 4.2: Water Sample - 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)
CR01	NO 32833	03542	SW (O)	27	11	13	0.02	0.01	3.3	0.02	<0.1	4
CR02	NO 32818	03917	SW (I)	57	16	14	<0.01	<0.01	7.7	0.03	<0.1	9
CR03	NO 32758	03802	GW	21	5	6	10.30	0.30	<0.2	0.06	<0.1	<1
CR04	NO 32744	03690	SW (OW)	37	10	8	<0.01	0.06	2.5	<0.01	<0.1	3
CR05	NO 32677	03702	GW	24	16	9	45.70	1.00	<0.2	<0.01	1.4	4
CR06	NO 32590	03792	SW (OW)	33	9	6	0.07	0.07	2.4	<0.01	<0.1	3
CR07	NO 32572	03802	GW	58	17	10	106.0	0.80	<0.2	<0.01	0.4	2
CR08	NO 32525	03870	SW (I)	41	13	10	0.03	0.01	9.1	0.01	<0.1	9
CR09	NO 32471	03788	GW	44	13	9	10.10	0.01	2.5	0.02	0.4	3

+ Surface water samples are designated either inflow (I), outflow (O) or open water (OW)
Red figures denote samples that exceed typical ranges

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)
CR03A	NO 32758	03802	Dark organic, wet sludge	<0.5	4110	3400	629	1240	79.2	<0.7	<0.2	0.63	5.67
CR03B	NO 32758	03802	Low organic brown soil with gravels	<0.5	2180	4800	343	1060	32.0	<0.7	<0.2	0.04	5.28
CR05A	NO 32677	03702	Dark organic, wet sludge	0.6	4210	2590	477	1030	71.4	<0.8	<0.2	0.55	3.05
CR05B	NO 32677	03702	Low organic brown soil with gravels	2.5	2290	5040	467	1090	26.8	<2.7	<0.2	0.12	<2.0
CR07A	NO 32572	03802	Organic brown soil with small gravel	1.0	6710	1720	948	1870	45.3	<1.2	<0.2	1.06	2.32
CR07B	NO 32572	03802	Low organic brown soil with gravels	1.0	2510	2820	404	679	29.1	<1.2	<0.2	0.08	<2.0
CR09A	NO 32471	03788	Organic brown soil with small gravel	0.7	2770	2290	391	1150	49.7	<0.9	<0.2	0.18	<2.0
CR09B	NO 32471	03788	Low organic brown soil with gravels	<0.5	1860	1680	317	921	18.2	<0.7	<0.2	<0.04	<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 the understanding of Carriston Reservoir 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 the long-term goal for Carriston Reservoir is to 'maintain the loch, swamp, marshy grassland and other semi-natural habitats in a favourable condition, and to maintain the populations of associated rare and uncommon plant species'. This is to be achieved by 'controlling the spread of undesirable emergent plants and scrub, and maintain the medium nutrient status of the reservoir through water quality monitoring identifying the source(s) of any nutrient enrichment and where applicable, promoting the creation of buffer zones along watercourses draining into the loch to reduce the input of nutrients'.

The most recent site condition monitoring assessment in 2004 found the mesotrophic loch feature of the reservoir to be in unfavourable condition due to nutrient enrichment (SNH, 2004). This was indicated by the presence of a blue-green algal bloom and absence of some of the characteristic plants associated with mesotrophic conditions.

The desk study identified that historical water quality sampling has been undertaken albeit that the records are not particularly detailed in terms of location, depth *etc*. The Condition Monitoring Form (SNH, 2004) records a single total phosphorus result of 20.9mg/l and states that target limits for mesotrophic sites is 15-20mg/l. It concludes that the sample is broadly in line with the upper limits. EnviroCentre do not consider this to be correct and this is discussed further in section 6.3. No other parameters were recorded but a comment is included that 'a blue-green algal bloom was present'.

SNH correspondence with Fife Council (Davis, 1994) indicates that the control of sluices above the reservoirs is an important part of water level management and the through flow 'flushing' of water has a bearing on the algal bloom growth problems.

EnviroCentre has not been made aware of any work in regards to addressing the identified issues.

5.2 Catchment Walkover

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

- The site was free of litter. No visible pollution sources were observed within the site boundary.

- Agricultural land bounding the site was ploughed at the time of the site visit. No clear buffer zones were observed along the northern perimeter of the site.

- The wider catchment comprises extensive areas of agricultural land. The upper catchment is connected to the site by the unnamed burn and this provides hydraulic connectivity with the SSSI. The land management practices and residential sewage provision in the upstream catchment are likely to have a direct influence on the quality and quantity of flows in the unnamed burn.

- No discernible algal blooms were observed however, this is not unexpected given the time of year the site visits were undertaken.

- In recent years there has been a change to the flow dynamics as the reservoir is no longer used for public water supply. It is understood to presently only provide compensation flow to the Kennoway Burn and is a nature reserve with associated recreational amenities.

- The inflows to the reservoir comprised a discernible and visibly clear flow of water. No measurements of flow rates were taken.

- A hydraulic connection exists between the Upper (Donald Rose) reservoir and the site. This comprises a draw off tower and sluice on the western dam wall – the latter was not operating at the time of the site visits. The Upper Reservoir also has a sluice on the north eastern boundary which diverts flow from the reservoir via a concrete channel to the Kennoway Burn. This flow does not appear to enter Carriston Reservoir.

- Public access routes are available throughout the site and it appears that the site encourages recreational use for walking. Dog walkers were observed using the site at the time of the second visit. No angling was observed.

- Southern and eastern banks of the loch are bounded by a high reservoir concrete dam wall.

- The wells identified from the desk study were not readily evident from the brief walkover undertaken and would require further engagement with landowners to confirm their operation.

- An active quarry is operating in the catchment to the north of the site. This appears to be of a reasonable scale and may directly influence groundwater quality and/or the quantity/quality of the flows in the unnamed burn.

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	Site boundary is not fenced.
Fishing	Both Carriston Reservoir and Donald Rose (Upper Carriston) Reservoir are understood to have a natural population of Brown Trout and are stocked with Rainbow Trout. Both sites are managed by Methilhaven and District Angling Club.
Grazing	The site is not grazed. Ploughed land is immediately present to the north and west of the site. The wider catchment is intensively managed for agricultural purposes.
Monitoring	Condition monitoring was carried out in 2004. Limited water data records exist. No known soil data records.
Public Access	Site has formal footpath access around the west, south and eastern perimeter of the reservoir.
Shooting	None known in proximity of site however, SNH records report some taking place on the swamp area within the northern boundary in 1986.
Properties in Catchment	The residential properties of Meddowside, Carriston and Langdyke lie approximately 400m, 300m and 1000m respectively to the north-west and to the north-east of the site – and close to two inlet feeds to the reservoir. Given the remote location of the site it is expected that these dwellings will be on septic tanks and hence the resulting foul water flows could drain into the site. In addition, there are a series of properties in the upper reaches of the catchment and it is considered that if these have septic tanks, these could also exert a direct influence on the water quality in the unnamed burn. Properties in the upper catchment are potentially fed by wells. At times of low flow these may have the potential to influence the catchment hydrology and may impact the flows within the unnamed burn which feeds the loch.
Point Pollution Sources	None observed within the SSSI boundary.
Unusual, Distinctive or Atypical Features	Historic record of algal blooms (no details); historic record of notable geese populations (no details but understood to no longer be present in same numbers); sluice gate on incoming flow to north east arm of reservoir and on gravitational connection with adjacent Upper (Donald Rose) Reservoir (operations unknown); recently ploughed arable land adjacent to site with suspected application of soil enhancers (*e.g.* fertilisers and muck spreading - although not observed taking place at time of site visit); the woodland surrounding the Donald Rose reservoir is considered to provide a buffer to the water quality however no such buffer exists for the lower reservoir; wider forestry activities take place in the upper catchment (Torloisk Wood); there are active quarry operations within the catchment at Devon Quarry.

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

6. INTERPRETATION OF RESULTS

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

6.1 General Summary

Analytical data was inconclusive in determining nutrient levels that would be typically expected of a mesotrophic waterbody. The collected dataset does highlight elevated concentrations of bioavailable nutrients and whilst consistencies were observed between sample types, the surface water results indicated a notable variation in the concentration of nitrate between the inlet and outlet samples. Although simplified, and based on a limited number of samples, this indicates the likely source to be from the agricultural practices in the catchment. The overall health of the waterbody was considered to be acceptable with dissolved oxygen levels in the surface water being consistently at levels above 6ppm which align to the Freshwater Fisheries Directive (2006/44/EC) standards to support salmonid fish.

For a mesotrophic waterbody, the water column typically comprises inorganic nitrogen concentrations of 0.3-0.65 mg/l and 0.01-0.03mg/l of total phosphorus (Biodiversity Reporting and Information Group, 2008). Whilst such levels simplify the complex interaction between plant nutrients and the hydrological and physical characteristics of individual waterbodies, they serve to show the sensitivity of the trophic state to artificially increased levels of nitrogen and phosphorus. The concentrations of total phosphorus recorded in the surface water samples at Carriston Reservoir were all less than 0.10mg/l. In the two open water samples appropriate for establishing the trophic status of the waterbody, the concentration of total phosphorus was below the 0.10mg/l level of detection whilst the total nitrogen concentration was 3.0mg/l. As phosphorus is likely to be the limiting factor over nitrogen in a freshwater system, and the samples were taken from the margins of the waterbody, these samples are considered insufficient to confirm the status of the waterbody.

With the exception of nitrogen 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 results of 3.0-9.0mg/l were recorded. The inlet samples of CR02 and CR08, comprising the inflows on the northern boundary which pass through agricultural land, were the highest with the open water samples being the lowest values. This confirms an expected inflow of nutrients from the upstream catchment and subsequent dilution within the waterbody.

The nitrogen and phosphorus values in the groundwater samples were largely consistent with the surface water observations with elevated total nitrogen and nitrate values. CR09 had the higher concentration of total phosphorus whereas CR06 the higher level of ammonia. 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 10.3-106mg/l recorded. Given that these are groundwaters where conditions are such that dissolution of iron is likely to occur under low oxygen conditions this is not unexpected. The low oxygen concentrations may also explain the high nitrogen values.

The soil samples highlight consistently elevated levels of phosphorus, nitrogen and potassium across the site but particularly in samples CR03 and CR07 – and typically the highest values were observed in the upper (root) samples. These parameters are the primary constituents of artificial fertilisers which are understood to be applied to the adjacent land. The values recorded for the two stated samples were at levels which would indicate a significant enrichment from that which would be present naturally. The values at CR03, located on the north shore of the reservoir, indicate enrichment from the adjacent agricultural land which abuts the perimeter of the reservoir.

The nitrate values in all the soil samples were below the detectable levels whereas extractable nitrogen, % nitrogen and total nitrogen were all elevated. This 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.

6.2 Comparison with Historical Analytical Data

The Site Condition Monitoring Form for the Mesotrophic loch feature (SNH, 2004) records a single total phosphorus result of 20.9mg/l however no details are provided as to where or how this sample was obtained. No other parameters were recorded but a comment is included that 'a blue-green algal bloom was present'. Furthermore, water clarity was generally good however, there were areas of fine sediments which were readily disturbed impeding visibility.

Contrary to the claim that this sample was broadly in line with the upper limits for a mesotrophic waterbody, this is incorrect as the units are a thousand times higher than would be expected. It is considered that the assigned unit is incorrect and that this should in fact refer to micrograms – *i.e.* 20.9µg/l. It is however acknowledged that 'low confidence should be attached to this datum as it was based on a single sample' (SNH, 2004).

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

6.3 Atypical Results

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

- The high dissolved oxygen result for CR01, CR02 and CR04 are typical of a waterbody which is capable of supporting salmonid fish. The values at CR06 and CR08 are lower than expected for comparison surface waters but are not atypical. The values for CR03 and CR07 are considerably lower but being groundwater are also not considered to be atypical.

- Faint organic (sulphur) odour from groundwater sample CR07 was observed. As this corresponds with very low dissolved oxygen and elevated iron concentrations it is considered to be indicative of organic degradation. This observation is consistent with the visual observations of decaying organic matter and anoxic conditions in the corresponding soil sample.

- The presence of elevated ammonia in CR05, a groundwater sample, is indicative of either organic degradation or pollution from soil conditioning (namely the application of animal wastes). As this corresponds with an elevated total phosphorus result (of 1.4mg/l – the highest value recorded in all the collected samples) it indicates that the latter is the most logical explanation. However, as the values for all three of the groundwater samples were notably higher than the surface water samples, and all had very low dissolved oxygen values, it indicates that the former may be applicable when considering the site as a whole.

- Elevated iron values were recorded in all three groundwater samples with values of 10.3-106.0 mg/l recorded. As these are groundwater samples where conditions are such that precipitation of iron is likely to occur this is not unexpected. The value of

106.0mg/l for CR07 is markedly higher than the other samples and warrants further assessment as this may indicate other contamination and directly influence plant growth in this part of the site.

6.4 Additional Considerations

See study limitations presented in section 3.

No detailed 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. The single total phosphorus sample from 2004 has been discounted due to the limited supporting data and assumed unit error.

7. CONCLUSIONS

Despite the limitations outlined in section 3, the analytical results show a definitive trend of elevated nutrients in the soil, surface and groundwater samples. However, for the reasons detailed in section 6.1, these are inconclusive of whether the loch is of mesotrophic or eutrophic status. In conjunction with the desk study and site walkovers, there are also observations that indicate that there have been changes in land use management in the immediate catchment, which will have directly influenced the reservoir. It is expected that continued nutrient enrichment would lead to a change from mesotrophic to eutrophic status,

Due to the surrounding topography and low lying position of the site, it is expected that it will be heavily influenced by the quality and quantity of water inflows. These flows vary seasonally and will leach nutrients from the surrounding catchment to the reservoir which in turn acts as a sink for the surrounding landform. The most notable observation which does not appear to have been fully assessed prior to this study is the potential for run off and nutrient enrichment affecting the inflow to the SSSI from the immediate catchment. The permeable nature of the underlying geology is expected to aid migration of nutrients to groundwater from the intensively managed arable land. 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 unquantified. The desk study identified historic management to the inflow burns, and the walkover identified land management practices (ploughed fields) which are likely to lead to the burns accumulating nutrient rich silts which would in turn be flushed into the reservoir. No records exist to confirm any maintenance having taken place in this regard with only an anecdotal file note dating from 1993 referencing such (SNH, 1993).

The use of the reservoir for potable supply would have led to a direct impact on water levels. The catchment sluice control methodologies are not known. It is possible that variations in such could account for additional nutrient input to the loch and changes to the associated margins. There is value to the long term management of the site in understanding how the sluice on the upstream unnamed burn operates, the compensation flow requirements and the needs of the downstream catchment for the resulting flow. By maintaining the levels it is likely that there would be minimal drying of the loch margins thus minimising further flushing of nutrients into the waterbody and would also afford a constant dilution of nutrients in (and entering) the reservoir.

The residential properties of Meddowside, Carriston and Langdyke lie approximately 400m 300m and 1000m respectively to the north west and to the north east of the site – and close to two inlet feeds to the reservoir. Given the remote location of the site it is expected that these dwellings will be on a septic tanks and hence the resulting foul water flows could drain into the site. Data within the fields outwith the site boundary, or the boundary itself, would be needed to corroborate this. Depending on the extent of use, the wells in the upper reaches of the catchment may also exert an influence on the site through the hydrological connectivity with the unnamed burn or the groundwater. Whilst it is considered that this is likely to be minimal under typical conditions, if there is connectivity then this could present a significant effect during period of low flow in the burn.

It is highly probable that there are significant sediment accumulations within the reservoir. These will afford a plentiful supply of nutrients through disturbance by, and variations in, seasonal inflows. Given the former use for potable supply, the reservoir is assumed to be of a moderately deep construction meaning it has the potential for the sediment to release nutrients through stratification. Quantification of the volumes of sediment and concentration of nutrients therein would help to establish a better understanding of the reservoir and how water quality is seasonally influenced. The limited information of algal blooms (re: frequency, composition *etc.*) and historic water quality data restricts the conclusions which can be

drawn in proving whether the loch has changed from meso-eutrophic in the 1980s to eutrophic status at present.

The historical information on the site is limited. With the exception of the use of the reservoir for water supply purposes and possible variations in land management resulting from developments in agricultural practices, it is assumed that the surrounding catchment is largely unchanged. It is therefore the changes in the aforementioned practices which have influenced the SSSI in recent years.

Site condition monitoring does not appear to have been undertaken since 2003. It would be of value for this to be undertaken as a priority to aid the understanding of any changes to the catchment, the site and the plant communities therein over the intervening period. There is limited understanding of the current and historical land management practices, in both the surrounding arable land and the 'buffer' woodland immediately adjacent to the SSSI. From the observations made during the study, the greatest potential influence on the site is the land management approaches employed on the adjacent arable land.

8. RECOMMENDATIONS

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

8.1 Monitoring

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

ii. Undertake a long-term targeted monitoring study at selected locations within the site for key nutrients – to include orthophosphate and bioavailable (extractable) nitrogen. Ideally this would be undertaken over the course of several seasons (ideally for a minimum of one year). The data from such should be compared alongside loch levels, rainfall data and seasonal abnormalities to seek to understand the nutrient dynamics taking place within the site.

iii. In conjunction with (i), assess the seasonal flow and nutrient loads of the Carriston Burn and unnamed burn (that flows into the north east corner) and compare these with those of the reservoir itself. This data would be of direct value in being able to assess the flow dynamics of the reservoir and to understand retention times and season variations in throughput.

iv. Monitor for algal populations (including species types). Use this data to assess for the potential for blooms and adopt appropriate controls as required to protect the water quality and aquatic habitats.

8.2 Other Commissioned Studies

v. Undertake hydrological and hydrogeological assessment of the whole catchment – to include a detailed assessment of the contribution of the unnamed burn; and an assessment of whether flows from Donald Rose (Upper Carriston) Reservoir can be used to increase the through flow to Carriston Reservoir. Where not available from Scottish Water or SEPA, commission a bathymetry survey of the reservoir loch to confirm depth and sediment profiles. This would aid the understanding of inflow and retained sediment volume.

vi. Undertake core sampling of reservoir sediments to understand historic source pollution and retained nutrients. The depth of the reservoir is not known but is considered deep enough to stratify. As a result seasonal disturbance of the sediments could result in extensive nutrient release and significantly alter the nutrient availability within the water column and plant margins. It is considered likely that there will be a significant volume of nutrient bound up in the sediments this may be being slowly released into the water column and aiding successional change.

vii. Review the variations to the standing water level in the loch and determine the extent of vegetation encroachment. No record of assessment for either was made available during the desktop study. If validated, changes in through flow will influence flushing/deposition and ultimately the rate of successional change. Consideration could be made to monitoring and managing the loch from the findings.

viii. Undertake a detailed library review, including historical mapping and local data sources, to seek to understand historical land use and information relating to reservoir use, size and depth. This should also include accessing of historical Fife

Council data relating to water quality records for algal blooms at the site (re: Davis, 1994).

ix. Consideration should also be made to understand the functioning and management of the two sluices (i.e. the flow control throttle on the outflow from Donald Rose Reservoir and that upstream on the unnamed burn). These may be subject to regulation from SEPA and variations to such would therefore be likely to require regulatory consultation and approval.

x. Review the biomass of marginal vegetation within the loch and the methods used to control/manage such. Such studies should seek to understand the seasonal growth characteristics, nutrient uptake profile and successful control measures observed from other impacted waterbodies.

xi. As it is understood that there have been no regular counts of waterfowl at the site in recent years, undertake a detailed library review to further understand the changes in such activity (notably of the 'historical' Greylag (*Anser anser*) and Pinkfoot Geese (*Anser brachyrhynchus*) populations) and seek to determine how this could affect the reservoir vegetation and sediment through feeding, disturbance and nutrient load from droppings.

8.3 Management

xii. Review the fish stocks and associated policies of Methilhaven and District Angling Club. By understanding the existing fish stocks and management practices, (including weed control methods, particularly chemical applications) consideration can be made to the likely disturbance of sediments. If catch records are known, this would further aid the understanding of the health of the reservoir. Albeit anecdotal, engagement with the club members could also provide an insight into the algal blooms and changes in reservoir levels. If cooperative, the fishing club members may also be of value in the recording of 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, reservoir levels *etc*.

xiii. 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 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 application of potentially harmful chemicals. This is particularly applicable to marginal and aquatic vegetation.

8.4 Landowners

xiv. Proactively engage with local landowners to understand the existing and (foreseeable) proposed changes to the whole upstream 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*.

xv. Proactively engage with catchment landowners to understand the historical land use practices to determine changes which are likely to have influenced the site. It is speculated that the catchment was more densely wooded than it is at present and particularly the area immediately surrounding the loch. Consideration should be

made to appraise how this may have led to changes at the site and the corresponding nutrient status of the loch.

xvi. Engage with the quarry operator to understanding the controls in place for the drainage at the facility.

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

8.5 External Consultations

xviii. Undertake a review of the sewerage network in the upstream catchment particularly for each of the named properties. This could also be aided through engagement with Scottish Water and/or SEPA.

xix. Confirm ownership of the site and future operation of the reservoir (including any changes related to recent changes to reservoir legislation);

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

a. The sluice management/operation (see viii above);
b. The compensatory requirements for the Kennoway Burn;
c. Water quality data held for the inflow tributaries and/or the Kennoway Burn;
d. The benefits of installing a silt trap on burns entering Carriston Reservoir;
e. Any knowledge on the quarrying activities at Devon Quarry and any off-site water quality monitoring; and
f. Any identified/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 wider catchment and notably those which impact on the unnamed burn (xiv). In addition, this should also include the septic tanks (xviii), quarry (xvi) and forestry activities (xvii); and the water levels/through flow at the site (ix, xix & xx.a).

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ANNEX 1: FIGURES

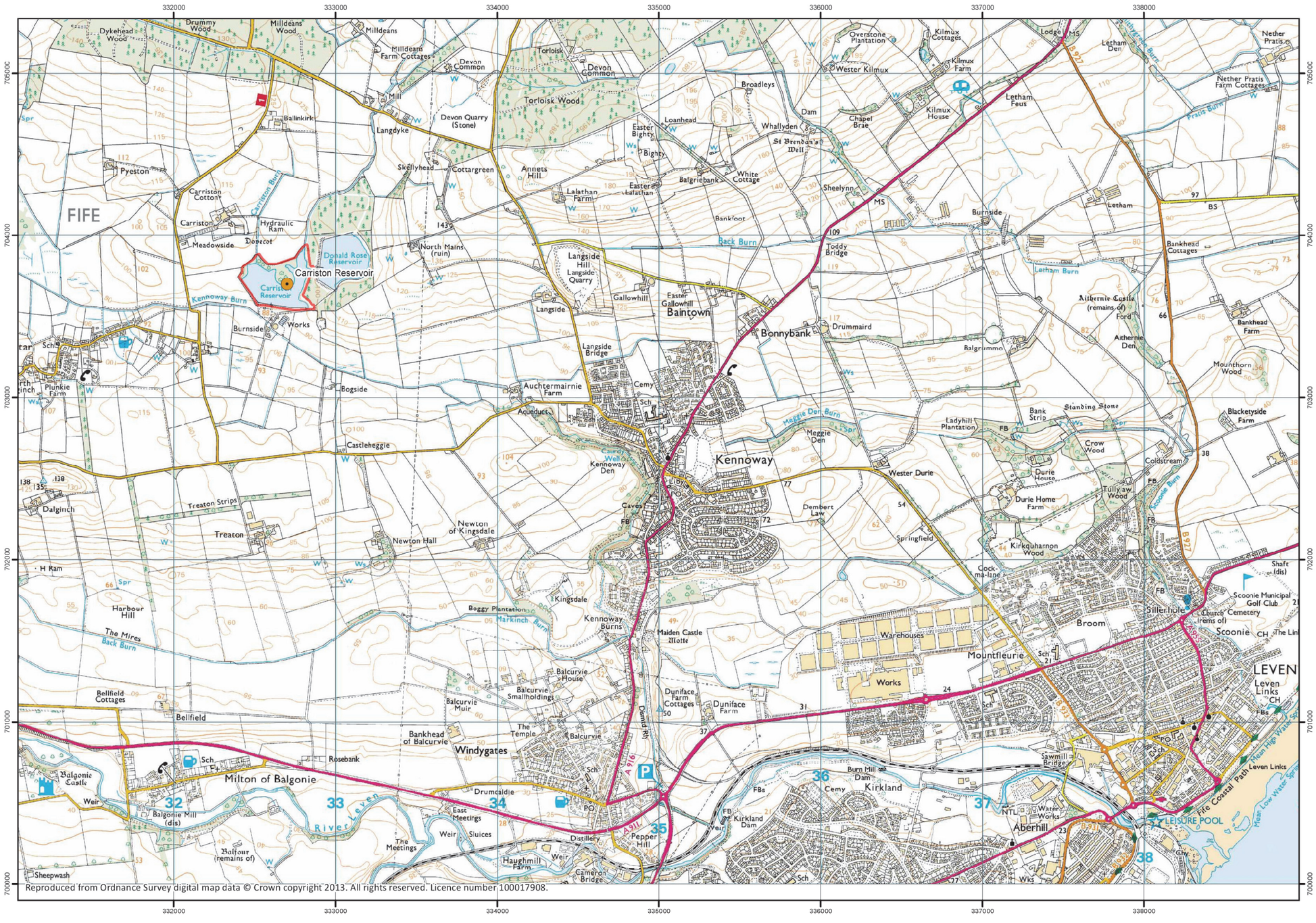


Figure 1.1: Site Location Map

Carriston Reservoir

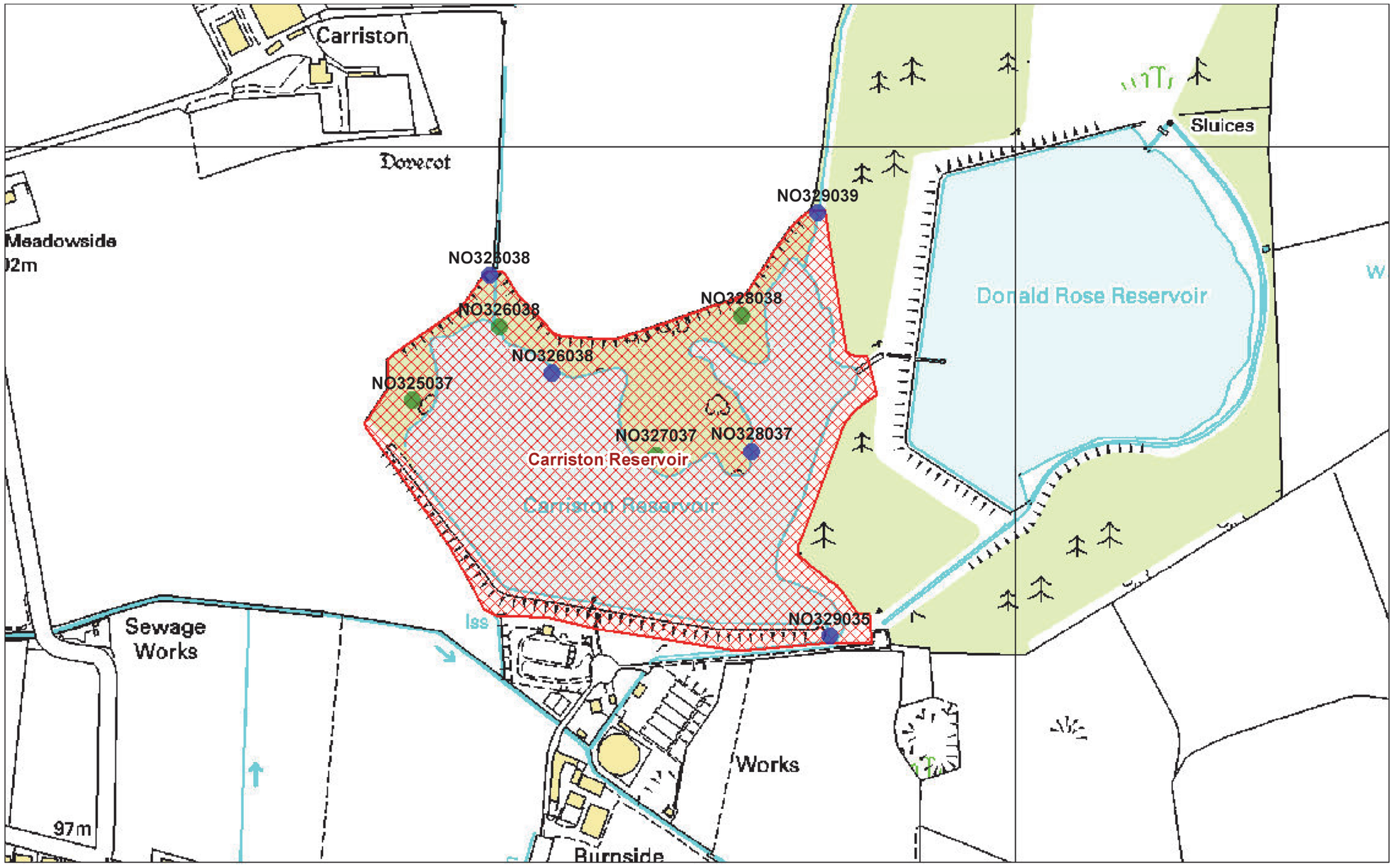


Figure 2.1: SNH Proposed Sampling Location Plan

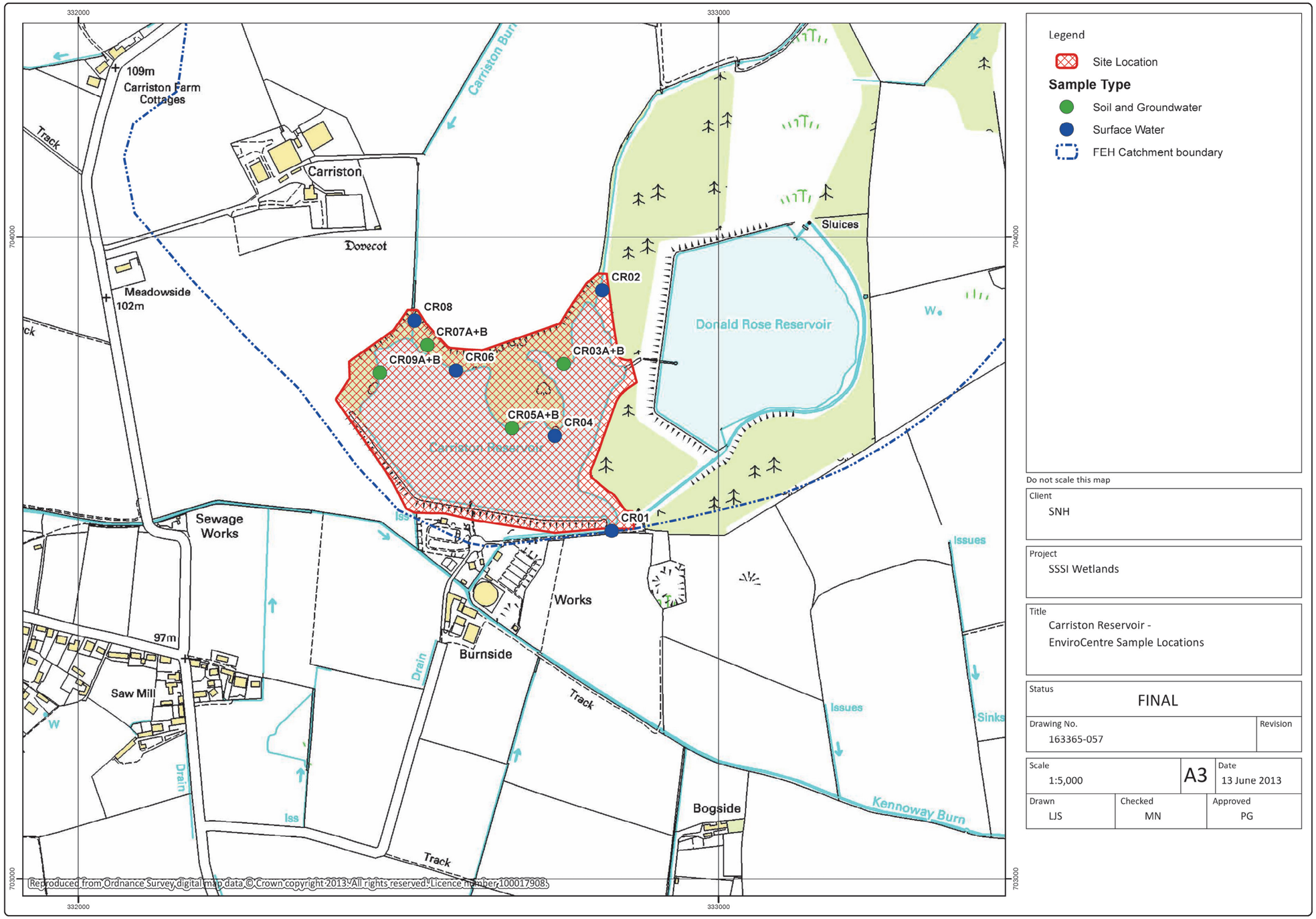


Figure 2.2: Plan of Actual Sampled Locations

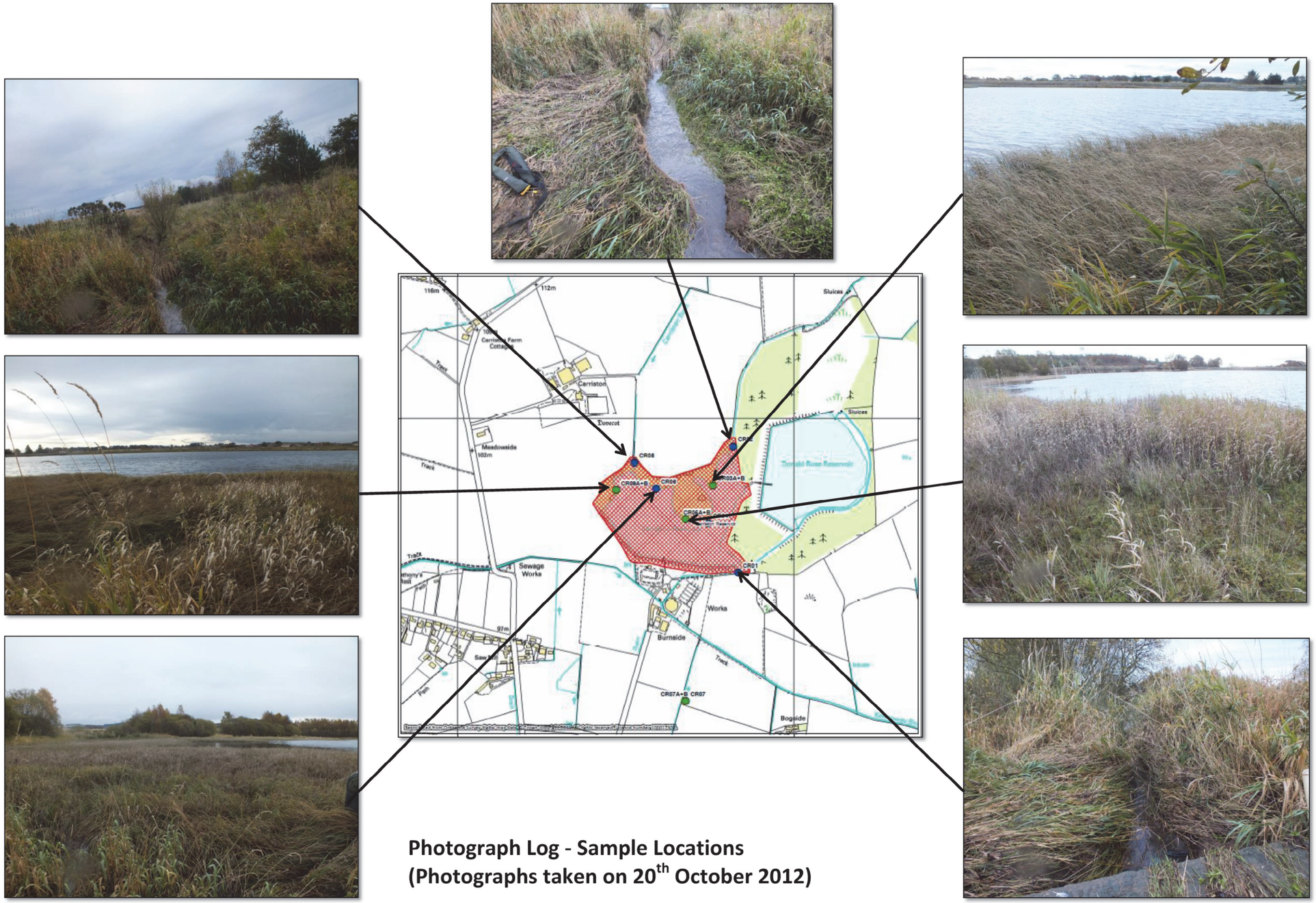
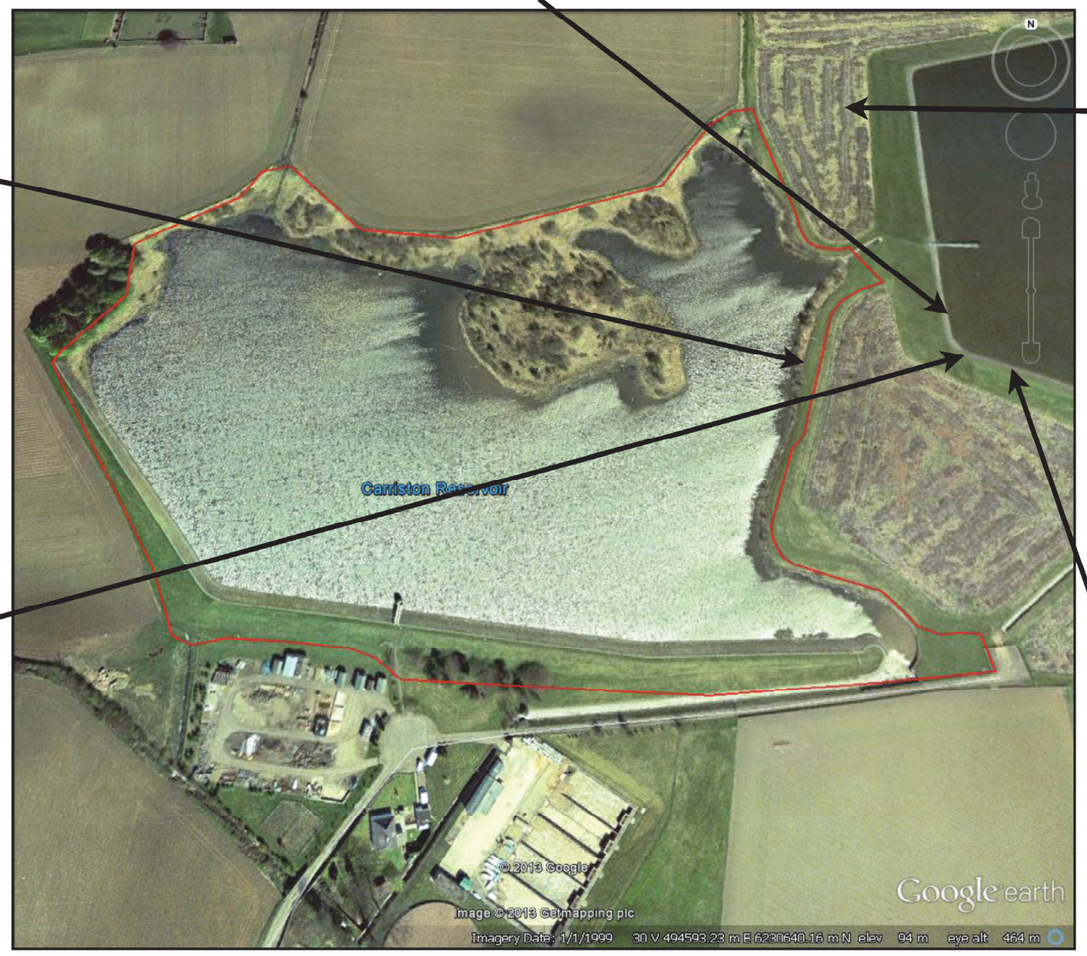


Figure 2.3: Sample Location Photographs

Facing North

Facing West



Facing West

Facing Northeast

Facing North

Photograph Log- Surrounding Catchment
Photographs taken 20th February 2013

Figure 2.4: Surrounding Land Use Photographs

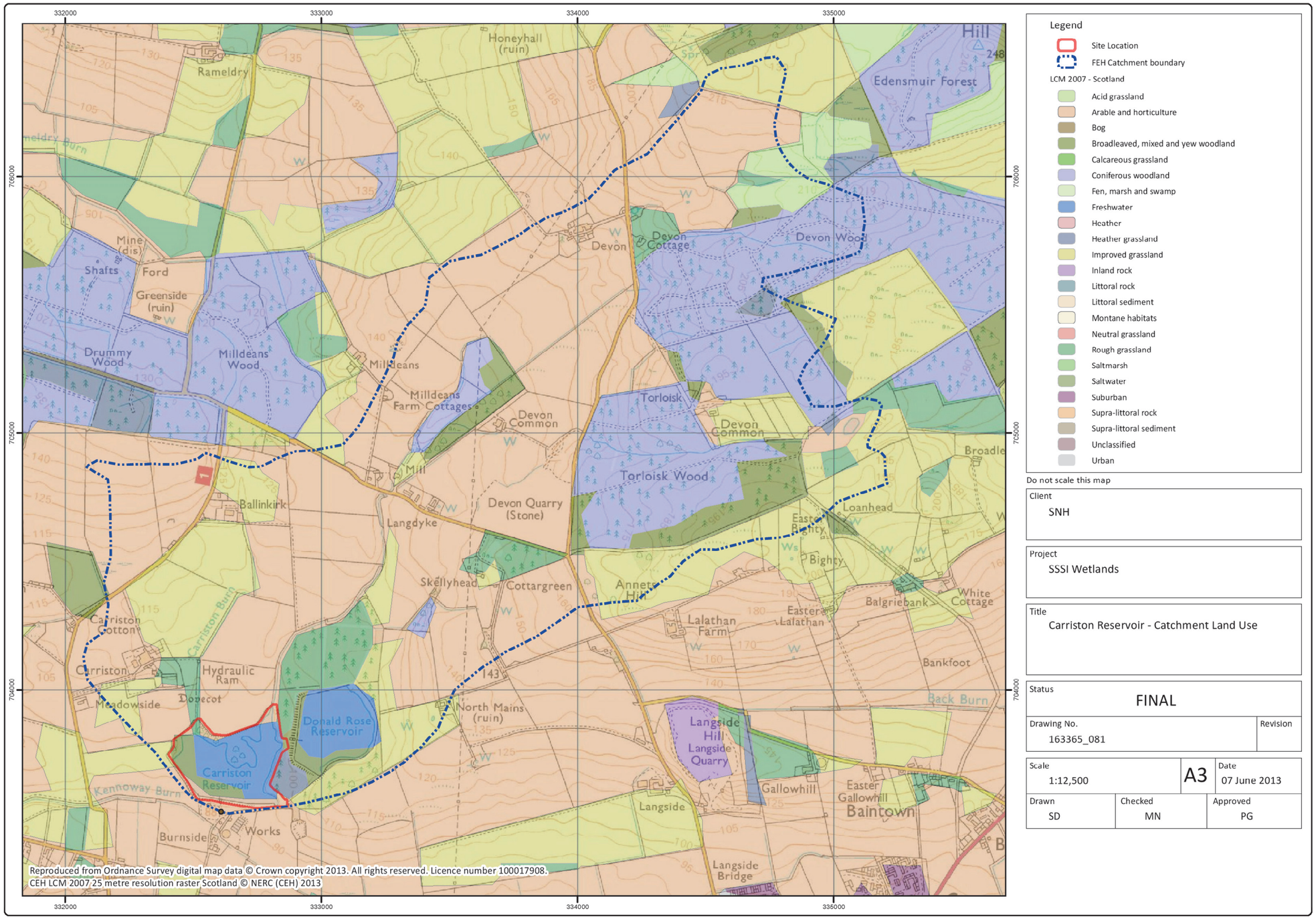


Figure 2.5: Land Use Characteristics Map

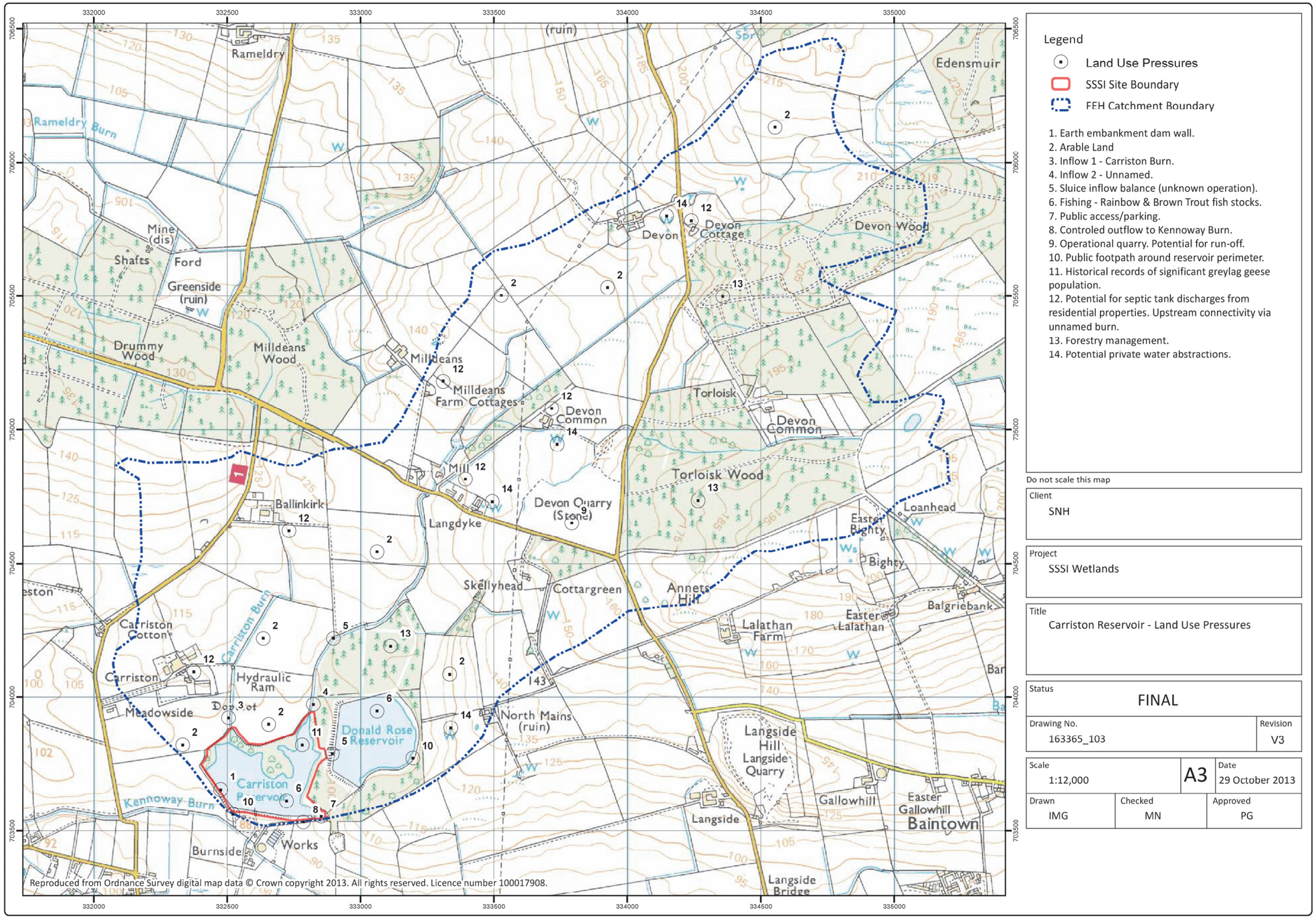


Figure 5.1: Land Use Pressures Map

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