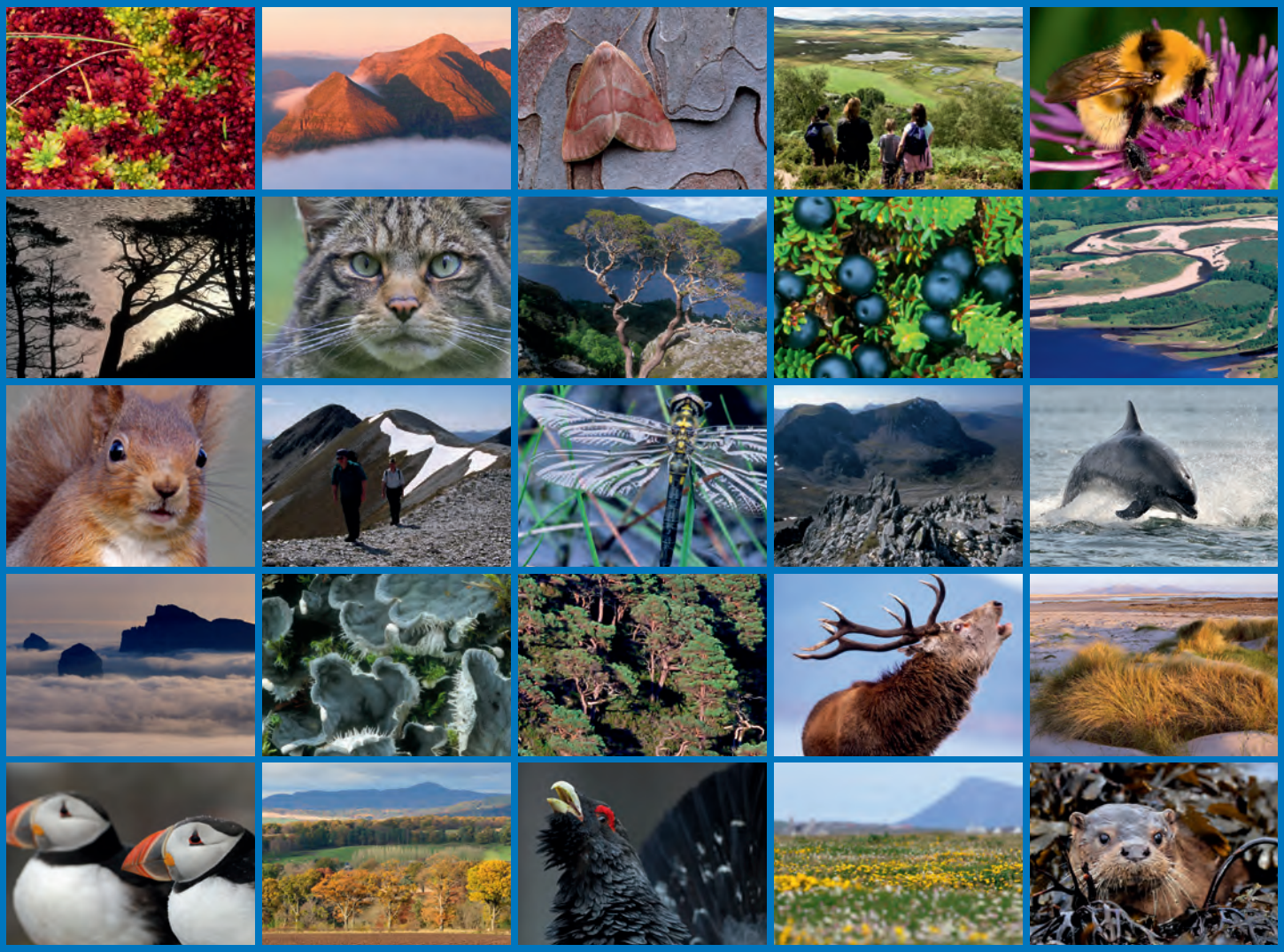
Scottish Natural Heritage
Commissioned Report No. 732

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



Scottish Natural Heritage
Dualchas Nàdair na h-Alba
All of nature for all of Scotland
Nàdar air fad airson Alba air fad

COMMISSIONED REPORT

Commissioned Report No. 732

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

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

This report should be quoted as:

EnviroCentre Ltd. Investigation of Standing Water and Wetland SSSIs thought to be under Diffuse Pollution Pressure: Spey Bay. *Scottish Natural Heritage Commissioned Report No. 732.*

COMMISSIONED REPORT

Summary

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

Commissioned Report No. 732
Project No: 13700
Contractor: EnviroCentre Ltd.
Year of publication: 2015

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 condition.

Main findings

- The desk study and site walkover identified potential existing and historical land use practices within the catchment that could adversely affect water quality and soil nutrient status. This included long-term changes resulting from agricultural management practices within the catchment and septic tanks in proximity of the site.
- Analytical data confirmed the presence of elevated nutrients. It should be noted that the sampling assessment was undertaken as a single visit and the limited scoped dataset and a lack of historical data constrains the ability to draw accurate conclusions to fully inform current site conditions.
- A series of recommendations are proposed to seek to aid the understanding of the site and afford a greater insight into the perceived changes taking place within the SSSI.

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

Table of Contents **Page**

Acknowledgements

EnviroCentre Ltd would like to thank the SNH Operations staff for their time and assistance in providing access to the site files held at the local office, providing land owner contact details, and in aiding the preliminary understanding of the site to assist with the health and safety evaluation prior to the initial visit.

Thanks are also extended to the site landowners for affording access to the site to enable the agreed scope of work to be undertaken.

1. INTRODUCTION

EnviroCentre Ltd was contracted by Scottish Natural Heritage (SNH) in August 2012 to deliver the 'Investigation of Standing Water and Wetland SSSIs under diffuse pollution pressure' project. The data collected from the project will be used to inform management decisions on wetland and standing water Sites of Special Scientific Interest (SSSI).

1.1 Site Location

Spey Bay is located on the south side of the Moray Firth, between Lossiemouth and Buckie. The site comprises a delta at the mouth of the River Spey, a narrow shingle beach to the east and west of the river mouth and a very large strandplain of shingle deposits to the west, the largest in Scotland. The site can be accessed from the local road network at a number of points. See Figure 1.1 in Annex 1.

Soil and water sampling was carried out in a portion of the site located south and west of Kingston on Spey and this report focuses on this area only (referred to as the 'sampling area', see Figure 2.5 in Annex 1).

1.2 Site Description

Spey Bay SSSI has been designated for its geological and biological features, including coastal geomorphology of Scotland, hydromorphological mire range, saltmarsh, shingle, wet woodland, vascular plant assemblage, Small Blue and Dingy Skipper butterflies. The measured area of site is 458.8 hectares (SNH, 2012a), extending over a narrow area to the west and east of the River Spey.

The Spey Bay area is the largest vegetated shingle complex in Scotland, and has been notified as a SSSI and designated a Special Area of Conservation (SAC) because of the wide variety of associated plant communities (SNH, 2012b).

The bedrock geology of the site consists of three distinct geological units, moving from the Elgin Calcrete Formation in the west, through the Scaat Craig Beds (Pebbly Sandstone) around the estuary, to the Fochabers Sandstone Formation in the west. The superficial geology grades from Marine Beach deposits at the coastal limit, through Storm Beach deposits (gravel), to Glaciofluvial Ice Contact deposits inland. Alluvium is the dominant superficial deposit in the Estuary area of the site (British Geological Survey, n.d.).

1.3 Site Hydrology

The River Spey Estuary forms the central feature of Spey Bay SSSI, a catchment area of 2,947km^2 drains to this point, with an annual average rainfall of 1109mm (Centre for Ecology and Hydrology (CEH), 2009). This is a coastal site, with a large portion of the site tidally influenced.

The sampling area forms part of two catchments; the Stripe catchment in the eastern section and an unnamed catchment in the western section. The main inflow is the Stripe Burn, which becomes the Drainer Burn once it enters the site boundary. The Drainer Burn has a catchment area of 20.3km^2 with an annual average rainfall of 728mm (CEH, 2009). Its base flow index (BFI) is 0.86, which is very elevated compared to comparable catchments in Scotland and indicates a very strong connection with groundwater. Within the sampling area several field drains feed into the main Drainer Burn channel which enters the site from the south before turning east to join the River Spey Estuary. The catchment in the western section of the sampling area has no obvious inflow.

The other hydrologically important features of the sampling area are a series of small ponds.

1.4 Site History

The following information on site history and management is taken from the Site Management Statement (SNH 2012b).

Much of the area of the SSSI to the west of the sampling area is forested (part of Lossie Forest). This area was planted prior to 1903 and is currently owned by the Forestry Commission Scotland (FCS) and managed by Forest Enterprise (FE). Replanting and extensive new planting was carried out during the 1940s and 50s, with additional smaller areas planted in the 1970s. This has greatly stabilised the sand dunes and sand capping of the shingle ridges, effectively 'freezing' dune forms *in situ.*

Gravel mining began in the west of Kingston during 1935, with extraction from the bare single beach. A stone crushing and pre-cast concrete plant were in operation until 1960, when they were closed due to severe flooding. This extraction created substantial human impact within the SSSI, it was estimated that around 60% of the shingle area has been reduced to damp shingle lows. In March 1998 the sea breached the active shingle ridge, inundating part of the extracted area. Events like this may start to increase in frequency with the rising sea levels. Sand has previously been quarried from the degraded Holocene cliff line near the east entrance to Lossie Forest.

Various different military activities were carried out in the Spey bay area during World War 2, the most notable impact of former activities is the line of pill boxes (approximately 300m) connected by concrete block. In recent times FCS has leased parts of the site to the Ministry of Defence (MOD) for training purposes and firing ranges.

Historically there has been growth in the westerly part of the Speymouth Spit, diverting the natural course of the river mouth westwards over time, this in turn constantly causes flooding and coastal erosion problems at Kingston. Due to the clear threat to land, property and life there have been several attempts to realign the river outlet. There have been eight recorded man made cuts in the last 100 years, the most recent of these being made in 1998. Previous coastal and river engineering works are likely to have influenced the natural geomorphology and the dynamic processes of the fluvial and coastal systems.

1.5 Recent Site Management Practices

The forest section of the site, part of Lossie Forest, is managed by FE. Management is carried out in accordance with a Conservation Management Plan (CMP), agreed between FE and SNH. The CMP prescribes clear objectives for the management of the forest section. Recently this has included the sensitive removal of gorse scrub from several shingle ridges. This is to increase the extent of open shingle and slow the spread of scrub onto adjacent open bare shingle. This project is an SNH case study example.

Sections of the SSSI owned by Forestry Commission Scotland (FCS) are leased to the Ministry of Defence (MOD) as firing and training ranges.

Part of the SSSI, known as the Lein, is managed by the Scottish Wildlife Trust (SWT) as Spey Bay Wildlife Reserve. SWT's management objectives for the reserve help secure and enhance the habitat and the rare plant and animal communities found on the shingle deposits at the Lein.

Spey Bay is popular with locals and tourists visiting Moray. Facilities at Tugnet have been significantly improved under the stewardship of the Whale and Dolphin Conservation Society (WDCS) and SWT, attracting more visitors and providing valuable educational resources.

2. METHODOLOGY

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

2.1 Pre-site Attendance Desk Study

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

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

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

2.2 Site Attendance

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

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

Table 2.1: Site Conditions

Spey Bay	Date of Visit	Weather Conditions	Grid References
Visit 1	13th November 2012	Dry, sunny and cold	NJ 325660
Visit 2	26th February 2013	Cold, clear and sunny	NJ 325660

2.3 Sampling Approach

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

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

2.4 Sample Equipment

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

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

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

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

2.5 Health and Safety

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

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

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

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

2.6 Water Samples

Surface water samples were collected from strategic locations within the site boundary to provide an understanding for the whole site, comprising inflows and outflows. No samples were taken from standing water.

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 (FEH) catchments (CEH, 2009) and Land Cover data (Land Cover Map 2007) to populate GIS mapping. The output was used to aid the interpretation of results and further inform the study conclusions.

3. STUDY LIMITATIONS

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

- This report was focused on the 'sampling area' in the centre of the site and did not include assessment of the western and eastern sections of Spey Bay SSSI (see Figure 2.5 in Annex 1).

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

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

- Sampling comprised a single set of samples from each of the pre-determined locations. Repeat or continuous sampling over an extended (seasonal) period would be preferred to enable a greater dataset to be collected. This would present a more representative assessment of the site and allow for seasonal/climatic variations.

- The dataset provides a 'snapshot' of the site condition. Due to the limited availability of historical data (see section 1.4) there is very limited scope for comparisons to be made with previous records or allowance for assessment of seasonal or climatic factors.

- The scope of work did not include the assessment of rainfall within the catchment, measured water levels or the inflow(s)/outflow(s) of associated watercourses.

- The limited dataset does not allow for any statistical analysis of the results to be undertaken. No adjustment has been made for anomalous results or to determine trends over time.

- The sampling methodology used to obtain groundwater samples (obtained from a circa. 1m depth coupled with geosock membrane for coarse filtration) typically results in these samples being heavily loaded with suspended solids and organic material meaning that the samples appear 'dirty' to the naked eye. To avoid interference with the laboratory analytical instrumentation and erroneous results, on receipt at the laboratory these are processed on a x10 dilution. It is this dilution process which explains why some of the results are reported as a less than value rather than the equivalent level of detection of 'clean' samples. The same dilution approach is applied to heavy silted surface water samples.

- The weather conditions prior to and during the site visit should be taken into consideration when reviewing the results. According to the Met Office (n.d.) the seasonal rainfall totals for summer, autumn and winter 2012 in eastern Scotland were 161%, 89% and 82% respectively of the annual average rainfall levels for the period 1981-2010. This should be taken into consideration when reviewing the results as it could result in bias when compared with years where average rainfall levels were recorded. The higher rainfall will directly influence runoff, dilution and catchment water levels/throughput which have not been assessed.

- Due to limitations in the mapping data used to compile the FEH catchment boundary, the area defined in the Annex 1 maps does not necessarily present an accurate

reflection of the hydrological catchment for the site. Whilst this affords a valuable tool for the purposes of this study, the mapped boundary should be viewed as an indicative guide only and be subjected to detailed verification to be considered definitive.

4. ANALYTICAL DATA

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

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

4.1 Water Quality Field 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)	General Field Observations
SB01	NJ 32544	65441	10.09	7.11	0.19	81.5	9.10	42	0.405	Surface water - clear with only a few floating green leaves; no odour
SB02	NJ 32879	65517	9.74	7.09	0.18	37.1	4.21	63	0.386	Surface water - very slight discolouration; very fine suspended solids; no odour
SB03	NJ 32851	65681	10.20	6.71	0.14	26.7	2.36	37	0.308	Groundwater - dark cloudy brown; fine brown suspended solids; very faint organic (sulphur) odour
SB04	NJ 32092	65761	10.20	6.80	0.16	24.4	3.15	73	0.341	Groundwater - dark coffee brown with fine brown suspended solids; faint odour
SB05	NJ 33634	65406	9.71	6.99	0.19	80.0	8.28	89	0.400	Surface water- clear with fine suspended solids; no odour
SB06	NJ 33531	65423	9.93	7.14	0.19	73.9	8.33	103	0.405	Surface water - clear with fine suspended solids; no odour
SB07	NJ 33204	65402	10.23	6.67	0.20	25.6	2.50	-37	0.447	Groundwater - dark cloudy brown with fine brown suspended solids; mild organic (sulphur) odour
SB08	NJ 33055	65469	9.53	6.68	0.21	16.1	1.94	0	0.452	Groundwater - dark cloudy brown with fine brown suspended solids; mild organic (sulphur) odour
SB09	NJ 32933	65321	9.80	6.92	0.18	59.3	6.47	41	0.380	Surface water - clear with fine 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 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)
SB01	NJ 32544	65441	SW (I)	30	5	14	0.09	<0.01	6.4	<0.01	<0.1	7
SB02	NJ 38819	65317	SW (O)	32	6	19	0.33	<0.01	<0.2	<0.01	<0.1	1
SB03	NJ 32851	65681	GW	26	7	20	15.7	0.3	2.7	1.08[*]	0.6[*]	6
SB04	NJ 32092	65761	GW	68	11	22	12.3	1.0	1.3	<0.01	0.8	3
SB05	NJ 33634	65406	SW (O)	38	6	19	0.5	<0.01	4.7	<0.01	<0.1	5
SB06	NJ 33531	65423	SW (O)	33	5	16	0.43	<0.01	4.8	<0.01	<0.1	5
SB07	NJ 33204	65402	GW	64	5	22	36.6	<0.01	4.4	<0.01	2.4	9
SB08	NJ 33055	65469	GW	54	7	28	95.8	0.71	2.0	<0.01	5.0	4
SB09	NJ 32933	65321	SW (O)	28	6	14	0.86	<0.01	<0.2	<0.01	<0.1	<1

+ Surface water samples are designated either inflow (I) or outflow (O)
[*] Analytical error (phosphate level should be equal or less than Total P)
Red figures denote samples that are above typical ranges for the observed dataset

Table 4.3: Soil Sample 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)
SB03 A	NJ 32851	65681	Silty sand and gravel with organic matter.	1.4	1770	1300	229	1080	69.4	<1.6	<0.2	0.14	<2.0
SB03 B	NJ 32851	65681	Silty sand and gravel.	<0.5	857	822	75	743	21.6	<0.7	<0.2	<0.04	<2.0
SB04 A	NJ 32092	65761	Silty sand and gravel with organic matter.	0.5	11000	1230	570	894	77.5	<0.7	<0.2	1.65	<2.0
SB04 B	NJ 32092	65761	Silty sand and gravel.	<0.5	2580	602	160	1370	74.6	<1.2	0.7	0.23	<2.0
SB07 A	NJ 33204	65402	Silty sand and gravel with organic matter.	<0.5	14500	1290	972	1260	86.2	<0.7	<0.2	1.68	9.02
SB07 B	NJ 33204	65402	Silty sand and gravel.	0.6	8380	1440	1060	760	65.1	0.8	0.2	1.04	4.05
SB08 A	NJ 33055	65469	Silty sand and gravel with organic matter.	0.6	13400	1140	1970	898	86.2	0.9	0.3	2.28	2.88
SB08 B	NJ 33055	65469	Silty sand and gravel.	<0.5	4690	2790	635	1030	53.0	<0.7	<0.2	1.12	<2.0

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

5. SITE OBSERVATIONS

To enhance the understanding of Spey Bay 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, 2012b) records an 'Objective for Management' of maintaining the extent and diversity of habitats within the site; ensuring the continuation of natural coastal and river processes as far as practically possible; maintaining the physical and visual integrity of the landforms, including the ancient shingle ridges; and promoting public understanding & enjoyment of Spey Bay where appropriate and to manage visitor pressure sensitively.

The following site condition monitoring (SCM) assessments have been undertaken at the site:

- SCM for Saltmarsh in 2001 found the site condition to be favourable maintained (SNH, 2001a)
- SCM for Shingle in 2001 found the site condition to be favourable maintained (SNH, 2001b)
- SCM for Coastal Geomorphology of Scotland in 2001 found the site condition to be unfavourable no change (SNH, 2001c)
- SCM for Hydromorphological Mire Range in 2004 found the site condition to be unfavourable declining (SNH, 2004)

The remaining features have not been assessed to date (SNH, 2012b). The extent of open wetland on the SSSI is declining and the area of fen woodland is currently increasing. This indicates that the feature is drying out. The wetland may also be suffering from nutrient enrichment. More recent visits to the site have confirmed that the feature is still declining (SNH, 2012b).

Information on pressures provided by SNH in a spread sheet (SNH, n.d.) indicated that there is possible nutrient enrichment from general diffuse pollution and/or a neighbouring pig farm.

Outwith the information contained in the SNH documents, as outlined above, there has been limited information available regarding previous or existing management practices. Unless stated, 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 sampling area was free of litter. No visible pollution sources were observed within the sampling area.

- There are dense bands of gorse throughout the sampling area (constraining access), interspersed with gravel bars.

- Open water was observed in low-lying areas, generally surrounded by wet woodland.

- The fields adjacent to the southern boundary of the sampling area comprise a mixture of grazed and arable land.

- In the north western area of the site there is a rifle range, used by the MOD for training purposes.

- There is public access throughout the sampling area. There are footpaths for general public access, and vehicle tracks used by the MOD.

- Properties located to east of site, possible septic tank leakages. New development is occurring to the south east of the sampling area. Anecdotal evidence from the construction company indicates that houses will have septic tanks.

- The Stripe Burn, main inflow to the site, is a small stream despite the size of its catchment (~20km^2). This is due to a significant loss to groundwater, given the high permeability of drift deposits at the site and its surrounds. This stream spreads over the ground as it enters the ground and is then conveyed by drains through the site.

- A network of open drains was observed to the south of Lein House. Several dog graves were observed in this area.

- Cutting of vegetation to form a network of paths was observed to the south of Lein House.

- No evidence of any buffer zones with the neighbouring fields was noted however, gorse on the site would act as a buffer along most of the southern boundary.

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	Partial fencing around site boundary.
Fishing	Angling occurs on the mouth of the Spey for Salmon, the rights are owned by the Crown Estate and are let to the Speymouth Angling Association.
Grazing	Site is not currently grazed, (evidence of previous grazing on site). Land adjacent to southern boundary is grazed by sheep/cattle. SNH records indicate presence of a pig farm.
Monitoring	Condition monitoring of the hydrological mire range feature was carried out in 2004. SWT undertake regular monitoring of the site.
Public Access	Site has footpath access, the public can access the beach and Shingle areas.
Shooting	A rifle range is present on site, it is used for training purposes by the MOD.
Point Pollution Sources	None observed within the SSSI boundary.
Properties in Catchment	There are no properties within the sampling area. Lein House and several properties in Kingston on Spey (including a new housing development) are located in very close proximity around the eastern section of this area. Gladhill farm and Corbiewell are located to the southwest. Based on anecdotal evidence it would appear that many/ all of these properties have septic tanks.
Unusual, Distinctive or Atypical Features	The MOD use the site for training purposes.

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

6. INTERPRETATION OF RESULTS

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

6.1 General Summary

The surface water at the site was noted to contain high levels of nitrogen and elevated phosphorus was noted within groundwater samples.

Groundwater typically yielded the lowest dissolved oxygen content with surface water recording higher values, as normally expected. The lowest surface water results were recorded at SB02 and may be attributed to degrading organic matter and low flow/stagnant water body in this area.

pH and electrical conductivity were noted as being generally uniform throughout the site. pH was noted as circum neutral (pH7) at all monitoring locations. Levels of electrical conductivity do not indicate any influence from tidal intrusion.

Total nitrogen was noted highest at the inlet sampling point on SB01 and in groundwater near Kingston on Spey (SB07), with fairly consistent levels recorded between monitoring locations. Total phosphorus was not recorded above the analytical level of detection in surface water samples but was above this level in all groundwater samples, with generally higher levels observed in the east. This geographic distribution could be associated with nutrient enrichment from the Stripe Burn and/or septic tanks in this area but data is not conclusive. Ammonia was below detectable levels in the majority of samples, and positive results were noted within groundwater samples.

With the exception of iron concentrations in the groundwater samples, none of the analysed metals were recorded as being elevated or above expected concentrations and were all similar in value between samples. The inorganic concentrations of bioavailable nutrients were typically higher in groundwater samples when compared to the surface water samples.

The majority of soil samples recorded were below the level of detection for phosphorus, with highest values recorded within the root zone. The three samples which returned positive results for extractable phosphorus also returned the highest total phosphorus levels from the site. This also ties in with higher levels of total calcium and magnesium in these areas and suggests that the low bioavailability is potentially a result of the presence of insoluble calcium, magnesium and iron insoluble/low solubility phosphate minerals.

6.2 Atypical Results

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

- Faint organic (sulphur) odours were detected in the groundwater samples, which is typical of anaerobic sediments where hydrogen sulphide is generated through natural biogeochemical processes.

- The highest calcium and magnesium levels in soils correlate with the highest total phosphorus results which may reflect the presence of insoluble calcium and magnesium minerals deposited within the wetland soils.

- The highest nitrate in water samples was noted within SB01 (Inflow Water) and SB07 which may indicate nitrate runoff from agricultural fields in the Stripe catchment. Surface water samples were generally noted to have higher nitrate

than groundwater samples. Sample SB04 (groundwater) demonstrated elevated ammonium levels compared to the remainder of the samples.

- Elevated iron was recorded within SB07 and SB08 groundwater samples and is considered to reflect natural geochemical processes in waterlogged/anaerobic conditions whereby iron solubility is increased.

- SB07 and SB08 demonstrate elevated extractable phosphorus levels which are considered to be attributed to the high total phosphorus levels in these samples which results in a higher proportion of available phosphorus overall.

- Total nitrogen in surface water was recorded at the highest level in SB01 with almost all of the nitrogen present as nitrate. SB05 and SB06 total nitrogen data are also noted to be primarily present as nitrate. These data would suggest that the source of the nitrate is from nitrate-rich agricultural runoff from the fields to the south of the wetland.

- The highest total nitrogen in groundwater was recorded in SB07 with approximately 50% present as nitrate. Elevated nitrogen and its compounds may be attributed to a combination of agricultural runoff-influenced surface water percolating into the shallow groundwater at the site as well as the influences from septic discharges in proximity to the site, particularly to the east of the wetland.

- The highest extractable nitrogen was recorded in SB03 in the root zone sample. This may be attributable to the high nitrate inflow noted at SB01 but not enough spatial data to confirm this.

- The highest total calcium and extractable phosphorus were both recorded in SB07 root zone sample. The elevated calcium may just reflect localised background levels, but also indicates the presence of low solubility calcium phosphate minerals.

- The highest nitrate level was recorded at SB04 in the below root zone sample. This sample location is quite remote when compared to the other locations and may be influenced by both agricultural runoff and septic tank discharge from the property to the south.

- Total phosphorus was noted to be highest in SB07 & SB08 which are both fairly centrally located. These elevated values may be reflecting a combination of natural background levels of high phosphorus low solubility minerals.

6.3 Additional Considerations

See study limitations presented in section 3.

No records or reports (anecdotal or otherwise) of algal blooms in standing water in the sampling area were reviewed during this study. Information of this nature could be of value in understanding long-term trends and changes within the site.

7. CONCLUSIONS

The analytical results indicated elevated levels of nutrients in the surface and groundwater samples across the sampling area of Spey Bay SSSI. Surface water and groundwater chemistry was relatively uniform across the site. From the desk study and site walkovers it was concluded that the main sources of nutrients are agricultural (and forestry) activities in the wider catchment and septic tanks located in proximity of the site. As a result of the aforementioned practices and its flat topography, the site will have acted as a sink for the excess nutrients from the catchment and surrounding higher ground.

The high permeability of the sediments, uniform chemistry of waters and low flows of the Stripe Burn suggest that this watercourse has a strong connection with groundwater on the sampling area and its surrounds. The sampling area therefore receives nutrients both through surface water and groundwater from the wider catchment, which comprises arable land, forestry and improved grassland. The presence of a pig farm in proximity of the site has also been highlighted by SNH. It is expected that the small water features in the sampling area are connected to the wider groundwater body but this could not be confirmed as no samples were taken from standing water.

Higher levels of phosphorus in the western section of the site suggest an influence from septic tanks in and to the south of Kingston on Spey but data was not conclusive.

Man-made drainage in the eastern section of the site affects the hydrology in this area but its management regime and impact on nutrient balance and ecosystem dynamics is not known.

SNH reports indicate that the site is drying out. The strong connection of surface water with groundwater in the sampling area would suggest that this is due to vegetation encroachment and/or successional change process and not a change in water levels. Elevated nutrients in surface water and groundwater will have promoted plant growth. Localised changes in water levels could have occurred in the south eastern corner of the sampling area, due to the management/infilling of drains.

8. RECOMMENDATIONS

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

8.1 Monitoring

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

ii. In conjunction with (i), assess the seasonal flow and nutrient loads of the Stripe Burn and groundwater to the south of the site.

8.2 Other Commissioned Studies

iii. Undertake hydrological and hydrogeological assessment of the Stripe catchment and unnamed catchment to the west – to include a detailed assessment of the contribution of the Stripe Burn and hydrological regime at the outflow.

iv. Assessment of the link between vegetation encroachment and diffuse pollution.

v. Undertake a detailed library review, including historical mapping and local data sources, to seek to understand historical land use and information relating to the site.

8.3 Management

vi. Review the policy for the removal of site vegetation and the methods used to control/manage such. Where future management practices require such, vegetation should be cut and removed from site instead of chemical applications (*i.e.* herbicide - SNH, 1999) or burning. Consideration should be given to the removal at the root zone rather than the cutting of above ground stem and should be followed by appropriate off-site disposal. This approach will lead to a net reduction in nutrients from the catchment, minimise regrowth and avoid the need for the use and reapplication of potentially harmful chemicals. This is particularly applicable to marginal and aquatic vegetation.

8.4 Landowners

vii. Proactively engage with catchment landowners to understand the historical land use practices to determine changes which are likely to have influenced the site. The operation of a pig farm in proximity of the site should be investigated further.

viii. Proactively engage with local landowners to understand the existing and (foreseeable) proposed changes to the immediate catchment including field usage, crop type and fertiliser/soil conditioning approaches. This should include an assessment of the storage and disposal of animal waste within the site; and an understanding of the existing and (foreseeable) proposed changes to the immediate catchment including field use and soil conditioning approaches. Consider appropriate management strategies accordingly - for example (but not exclusive to) nutrient management planning, exclusion zones, buffer strips, fencing of sensitive areas, location of feed areas, limiting stock numbers, routine spot monitoring *etc*.

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

x. Engage with surrounding households to ensure septic tanks are adequately maintained.

8.5 External Consultations

xi. Undertake a detailed review of the sewerage network in Kingston on Spey and the upstream catchment particularly for the nearby properties. This could also be aided through engagement with Scottish Water and/or SEPA.

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:

1. Ascertain the link between this decline and diffuse pollution (i,iii, iv);
2. Determine whether septic tanks are a significant source (i,x); and
3. Address the inputs to the surface water and groundwater from the agricultural (and other) activities within the wider catchment as required (vii, viii, ix, xi).

9. REFERENCES

British Geological Survey, n.d. DiGMapGB-625 Data download. Available at: http://www.bgs.ac.uk/products/digitalmaps/dataInfo.html

Centre for Ecology and Hydrology, 2009. *Flood Estimation Handbook (FEH).* CD-Rom Version 3.0. Wallingford, Oxfordshire.

Met Office, n.d. 2012 Weather summaries – Regional values. [Online] Available at: http://www.metoffice.gov.uk/climate/uk/2012

Scottish Natural Heritage, 2001a. *Spey Bay - Saltmarsh - Site Condition Monitoring Form.* Inverness, Scottish Natural Heritage.

Scottish Natural Heritage, 2001b. *Spey Bay - Shingle - Site Condition Monitoring Form*. Inverness, Scottish Natural Heritage.

Scottish Natural Heritage, 2001c. *Spey Bay - Coastal Geomorphology of Scotland - Site Condition Monitoring Form.* Inverness, Scottish Natural Heritage.

Scottish Natural Heritage, 2012a. *Spey Bay Site of Special Scientific Interest - Citation*. Inverness, Scottish Natural Heritage.

Scottish Natural Heritage, 2012b. *Spey Bay - Site Management Statement*. Inverness, Scottish Natural Heritage.

Scottish Natural Heritage, n.d. SNH SCM results, pressures and remedies spread sheet - information provided to contractors.

ANNEX 1: FIGURES

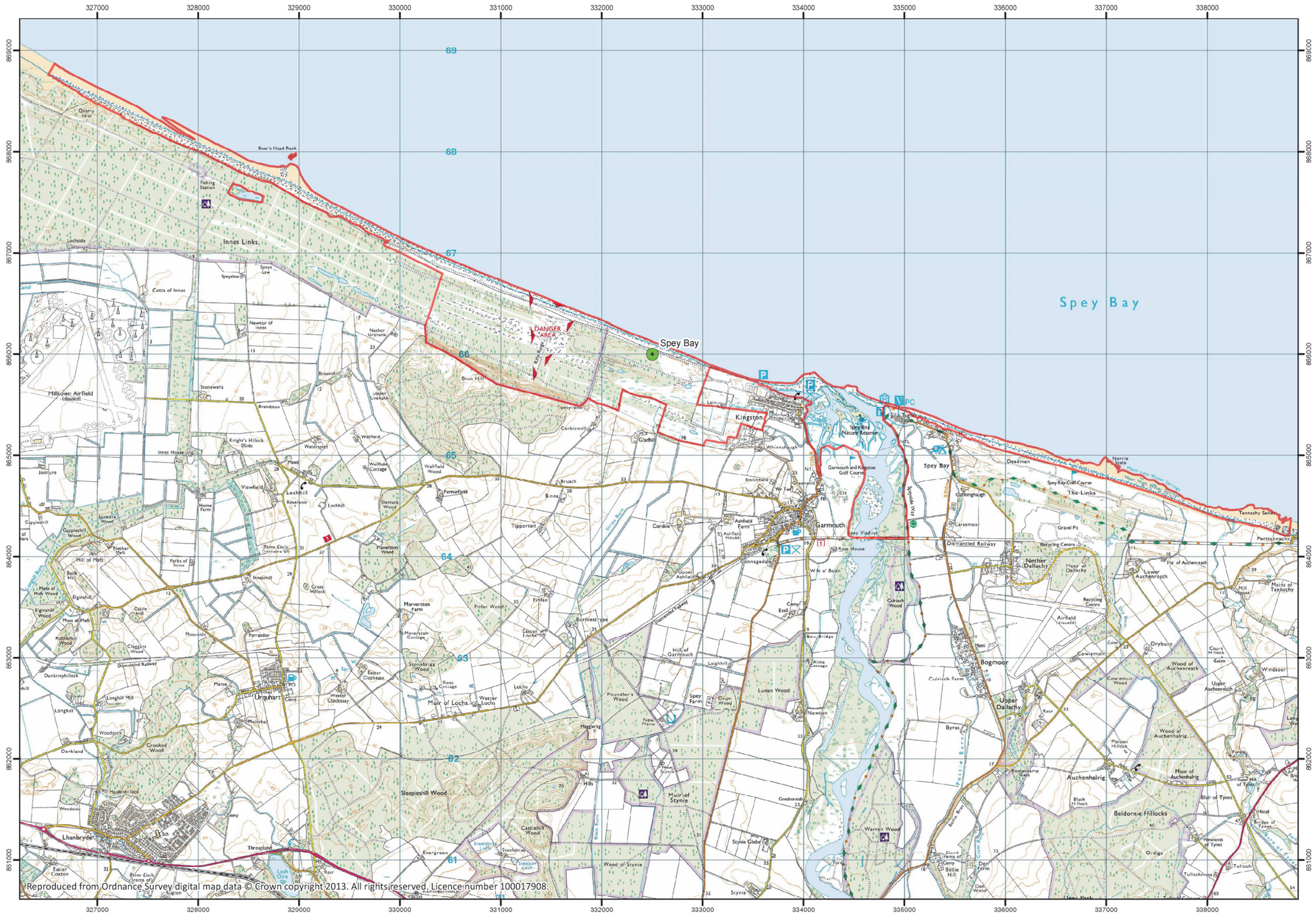
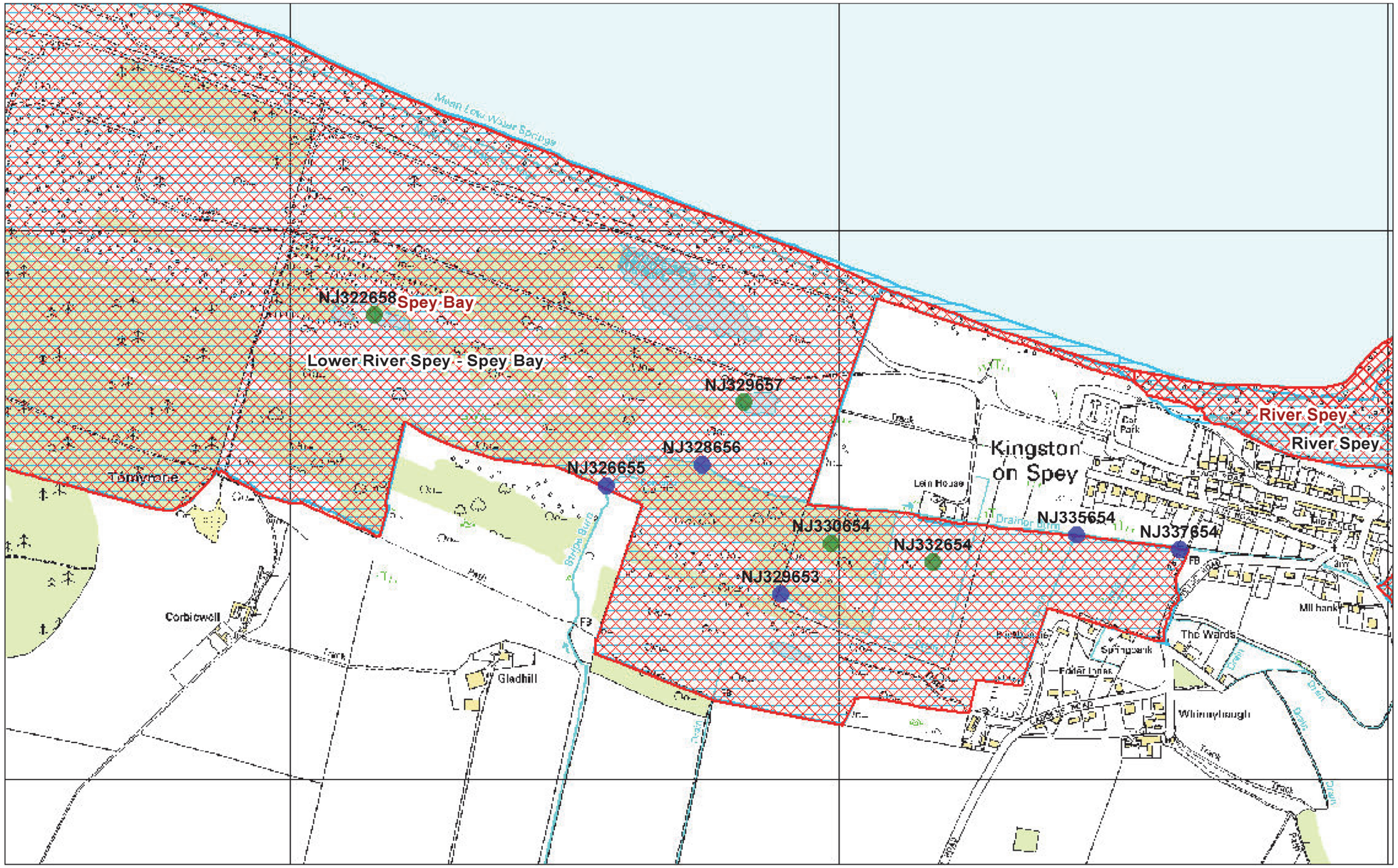


Figure 1.1: Site Location Map

Spey Bay



Map produced using geo.View 3.0
Printed: Sep 20, 2012 14:24:33

Figure 2.1: SNH Proposed Sampling Location Plan

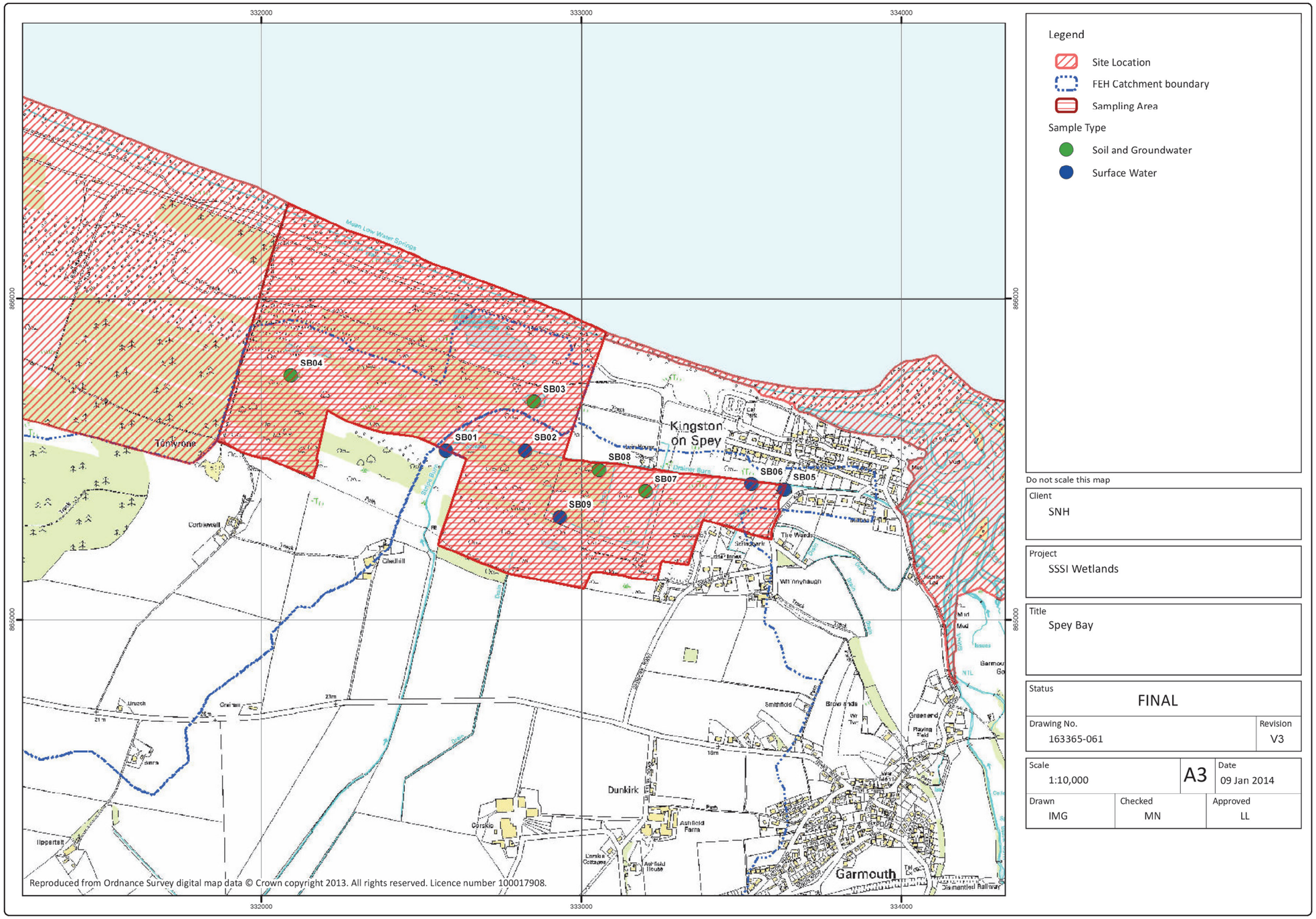


Figure 2.2: Plan of Actual Sampled Locations

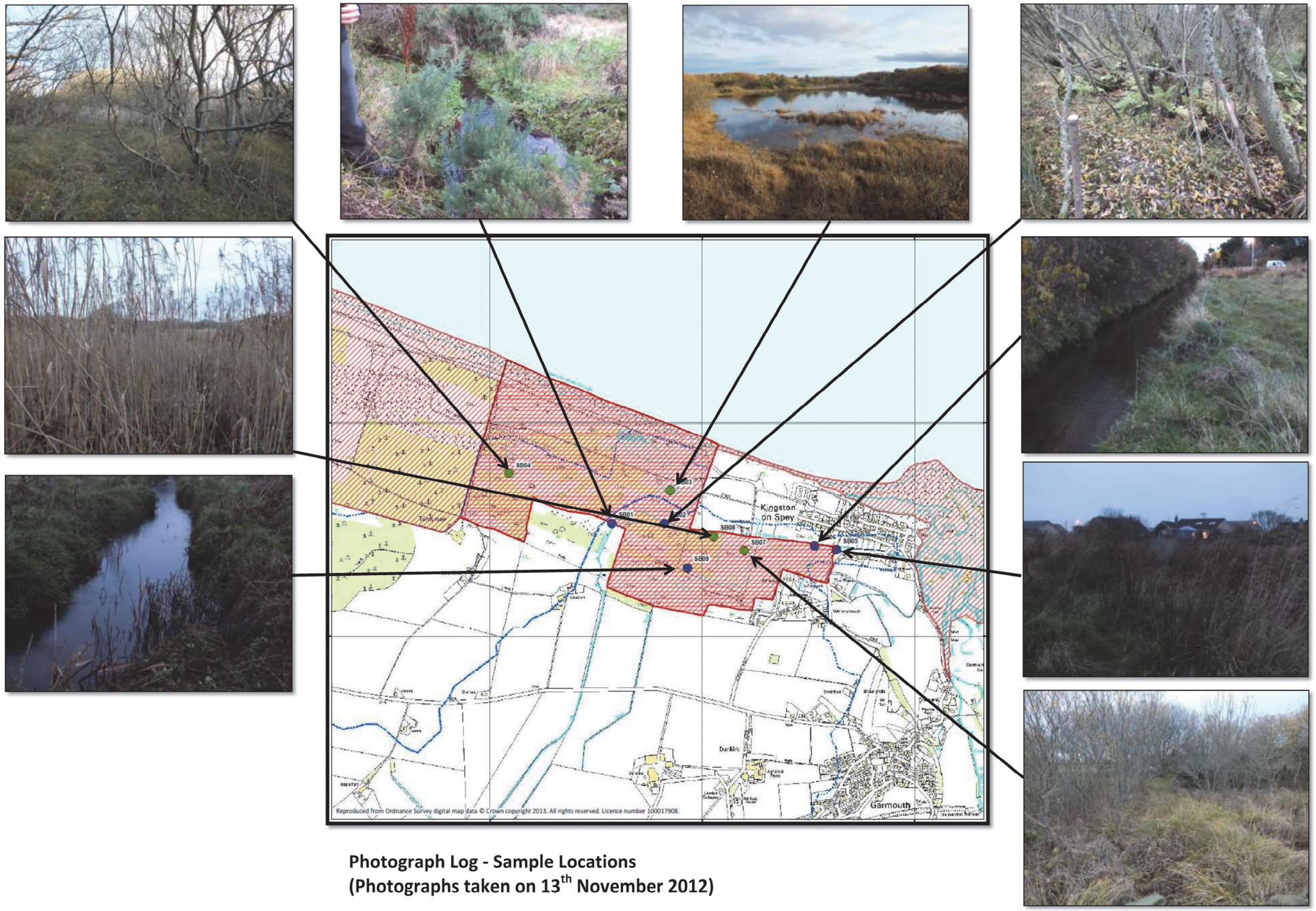


Figure 2.3: Photographs of each Sampling Location

Photograph Log- Surrounding Catchment
Photographs where taken 26th February

Figure 2.4: Photographs of Surrounding Land Use

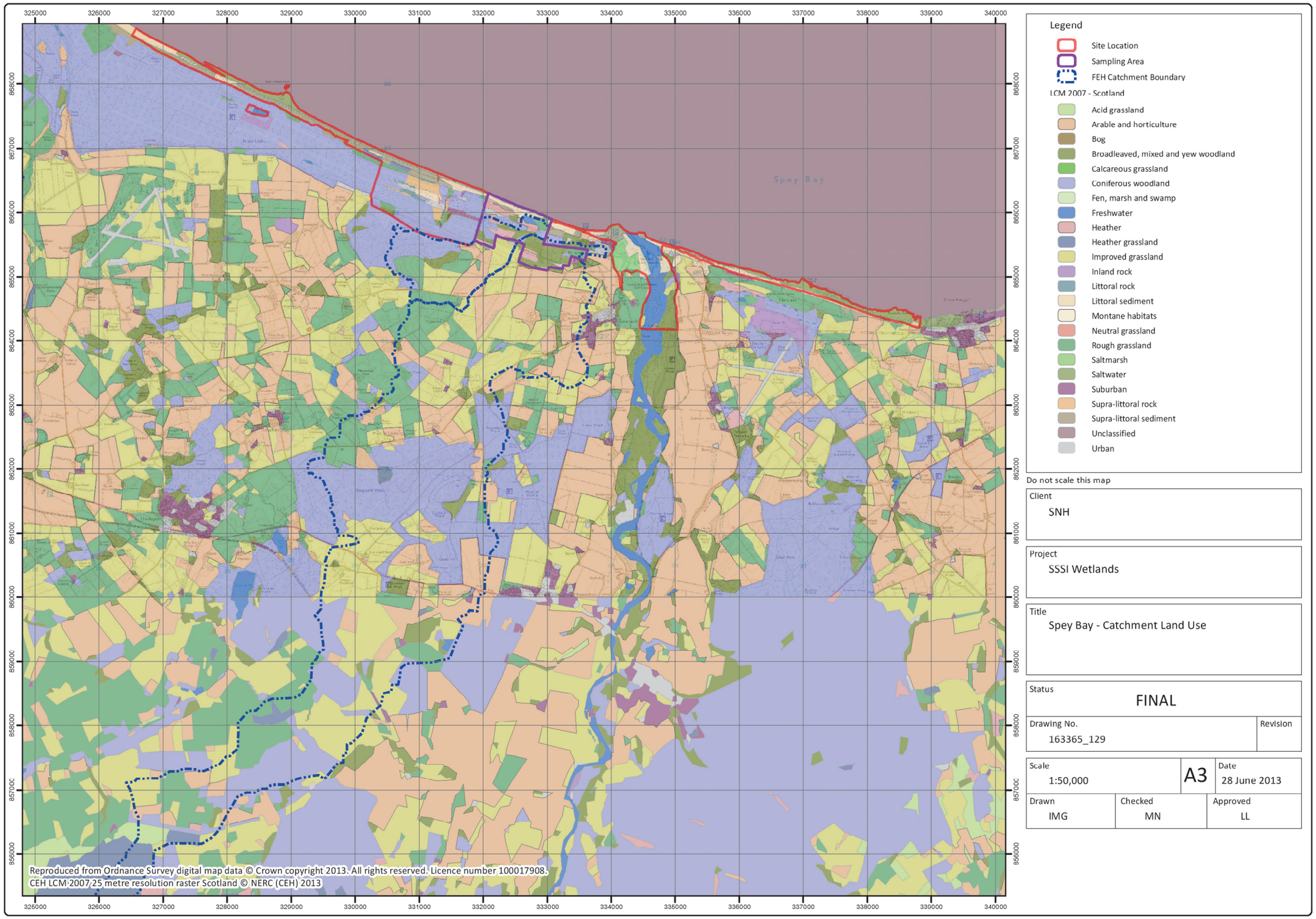


Figure 2.5: Catchment Land Use Characteristics

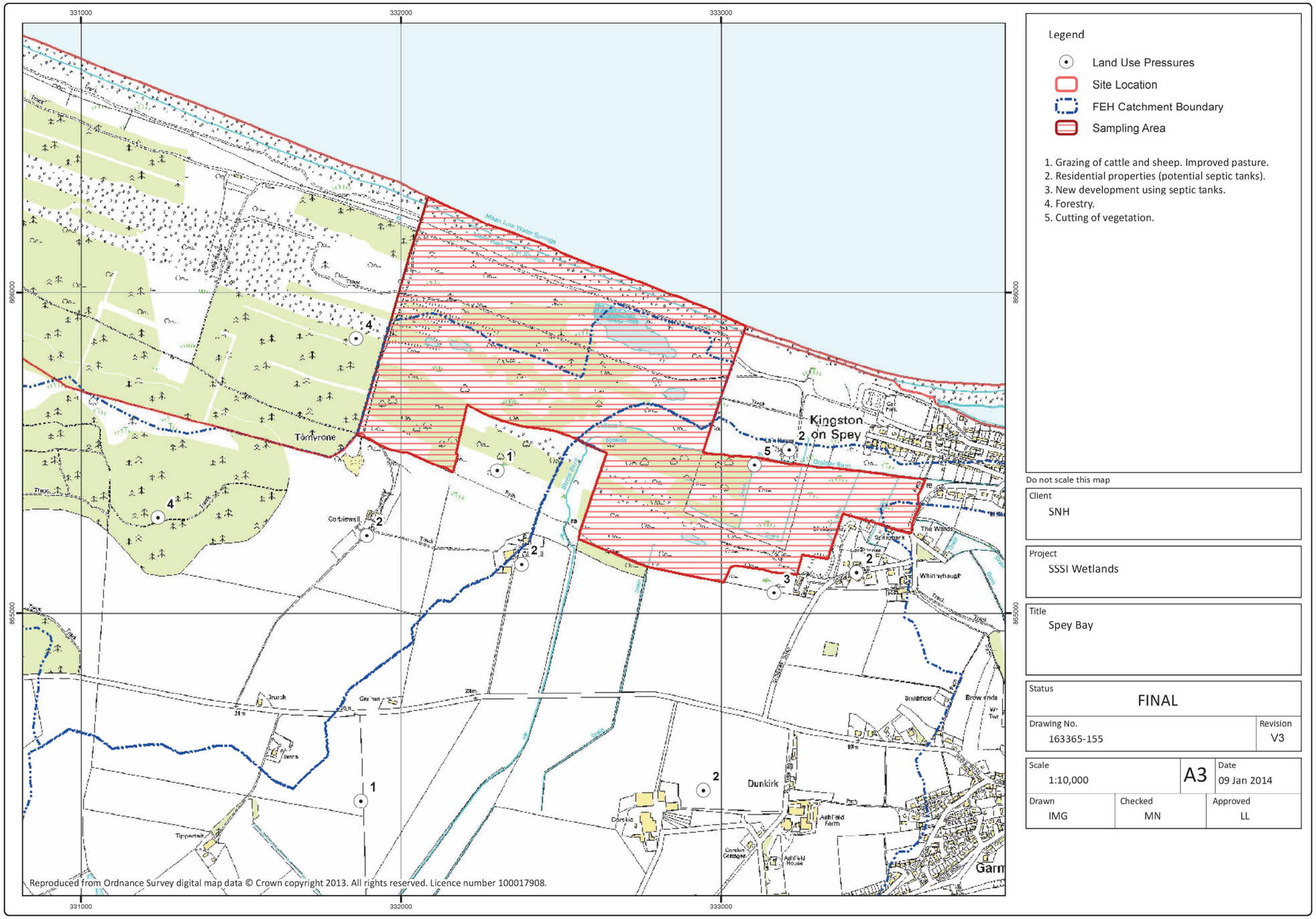


Figure 5.1: Catchment Pressures Summary

www.snh.gov.uk

ISBN: 978-1-78391-128-8

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

You can download a copy of this publication from the SNH website.

recycle

Scottish Natural Heritage
Dualchas Nàdair na h-Alba
All of nature for all of Scotland
Nàdar air fad airson Alba air fad