Loe Pool SSSI Macrophyte Monitoring Boat and Grapnel Survey 2015

Report Date: December 2015

Survey Date: 11 September 2015

Surveyor: Dr Jan Dinsdale

NATURAL ENGLAND

National Trust

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Executive Summary

This report details the results of the 2015 Loe Pool boat and grapnel survey, part on an ongoing programme of macrophyte monitoring undertaken on this lake since 1999.

Loe Pool Site of Special Scientific Interest (SSSI) in Southwest Cornwall is located within the Penrose Estate, owned by the National Trust. The Loe is currently eutrophic and in unfavourable condition. It fails to meet Natural England's conservation objectives for the macrophyte community composition, macrophyte community structure and associated habitat conditions including the lake's elevated nutrient status.

The boat and grapnel survey method employed is semi-quantitative and uses a rake, or grapnel, thrown from a boat to retrieve plant material at set points along 14 fixed-location transects across Loe Pool. The survey methodology was developed by Nick Stewart and first undertaken in 1999; it has been repeated 10 times over the past 16 years. In 2015 this work was funded by Natural England's Conservation Enhancement Scheme.

The 2015 survey found rooted or floating macrophytes in just two of the 60 sample stations. Only the introduced non-native water lily *Nymphaea alba* was recorded within stations; 58 of the 60 sample stations were unvegetated. There continues to be a paucity of rooted macrophytes in Loe Pool.

There has been little overall change to the deep-water macrophyte beds within Loe Pool since 1999, despite dramatic improvements in the lake's water quality since 2004 (Dinsdale, 2009). Within the monitored period, an extensive population of Nuttall's Waterweed *Elodea nuttalli* was present from 1999 until 2007 and small amounts of Perfoliate Pondweed *Potamogeton perfoliatus* and the stonewort *Nitella flexilis* were recorded in 2003. These species have not been recorded at Loe Pool since 2007, neither as part of this ongoing boat and grapnel survey method, nor during the more extensive scuba dive survey undertaken in 2012 (Dinsdale, 2012).

The non-native macro-algae Water Net *Hydrodictyon reticulatum* was first recorded in Loe Pool in 1989 and was prolific over large areas of the lake each year from 1993-2006 (see Dinsdale, 2009). Water Net has only been recorded once in Loe Pool over the 8 years period since 2007: small quantities were present in the northern half of the lake during 2013 survey. Water Net was not recorded during this 2015 survey, however, significant quantities of filamentous algae, both of the *Cladophora glomerata* type and an encrusting filamentous algae (cf *Cladophora aegagropila*) were present on the stones on the lake floor across Carminowe Creek, the eastern arm of the lake. In addition, small flocculations of the blue-green algae genus *Microcystis* were present in both Carminowe Creek and the Penrose Inlet.

Successful lake rehabilitation from a eutrophic algal dominated condition to clear water relies heavily upon the re-establishment of submerged vegetation. The Loe Pool Forum is taking a collaborative multi-agency approach to addressing external sources of nutrients and sediment to the Lake. Alongside this important and successful catchment approach, in-lake management recommendations are proposed to help 'kick-start' the growth of macrophytes within Loe Pool.

1. Introduction

1.1 Loe Pool Site of Special Scientific Interest

Loe Pool is located within the National Trust's Penrose Estate near Helston, Southwest Cornwall SW649247. The Loe is the largest natural freshwater lagoon in Cornwall. The SSSI extends over 122 ha, and includes: The lake with an area of 56 ha, a coastal shingle bar and other associated wetland and coastal habitats (including BAP Wet Woodland, Reedbeds and Maritime Cliff and Slopes). The Loe provides a winter refuge for nearly 80 species of wildfowl including high counts of Shoveler *Anas clypeata*, Pochard *Aythya farina* and Tufted Duck *Aythya fuligula*. The coastal shingle bar that separates the Loe from the sea is of importance for geomorphology, flora and fauna; it is the only known British site for the Cornish subspecies of the Sandhill Rustic Moth *Luperina nickerlii leechi*. Other relevant SSSI information is provided as an Appendix to this report.

The Loe (National Trust)

The condition of the standing open water habitat at Loe Pool SSSI is currently defined as unfavourable (no change) (Natural England, 2010). The conservation objectives for the open water feature of Loe Pool SSSI, in terms of the macrophyte community composition and associated habitat conditions, are as follows:

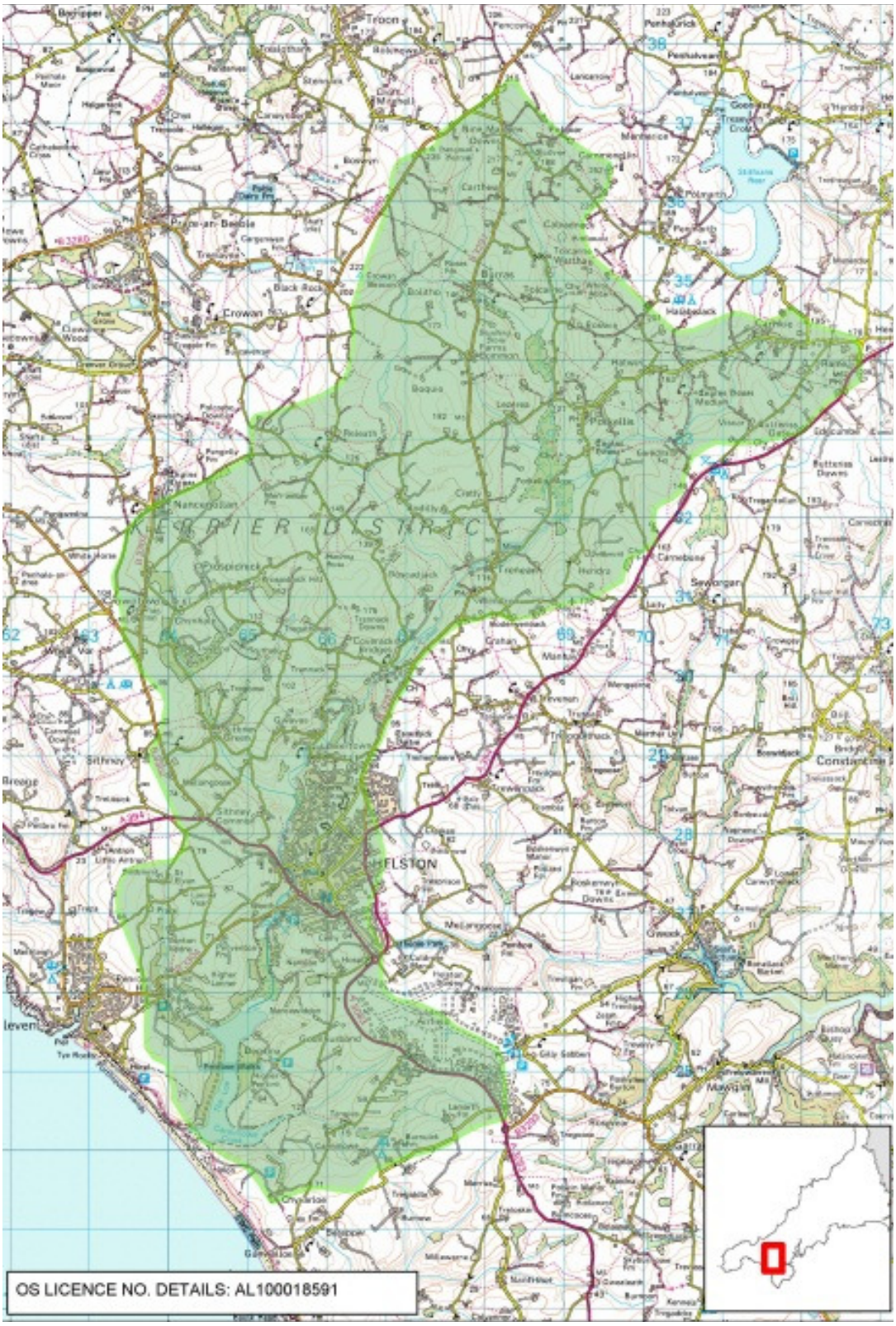
a. There should be no loss of characteristic species recorded from the site. Six out of ten sample spots should include at least one characteristic plant species.
[The full national list of characteristic plant species for a lake of this type comprises 35 species (see Appendix 1). The Loe SSSI citation sheet, however, lists just 3 of these 35 characteristic species, namely: *Littorella uniflora*, *Elatine hexandra* and *Potamogeton perfoliatus*].

b. At this site, occurrence of non-native species should be no more than 50% frequency.
c. Characteristic zones of vegetation should be present, maximum depth distribution should be maintained and at least the present structure should be maintained.
d. Mean annual total phosphorus concentration less than target for appropriate lake type, namely 20µg P l^{-1} (as total phosphorus).
e. Stable pH/ANC values appropriate to lake type: pH 7.00 (circumneutral between 6.00 and 8.00); adequate dissolved oxygen levels for health of characteristic fauna
f. No excessive growth of cyanobacterial or green algae.
g. There should be a natural hydrological regime.
h. No loss of marginal vegetation and maintain the natural shoreline of the lake with no more than 5% of lakeshore being heavily modified.
i. Maintain natural and characteristic substrate and maintain natural sediment load.

1.2 Addressing water quality at the catchment scale

Loe Pool has suffered from the effects of elevated nutrient levels, eutrophication, and excess silt deposition over many decades (Wilson and Dinsdale, 1998; Dinsdale 2003; Dinsdale, 2009). The Loe Pool Forum continues to take a collaborative multi-agency approach to addressing external sources of nutrients and sediment to the Lake. The Forum's Catchment Group (which includes representatives from Natural England, the Environment Agency, South West Water, the Rural Payments Agency and local Universities) is working to deliver an integrated programme of research, advice, regulation and capital grant incentives, at the catchment scale, in order to bring about the necessary improvements in water quality for the Lake (Clitherow, Dinsdale and Walker 2014).

The SSSI target condition is for a mean annual total phosphorus concentration less than 20µg P l^{-1} (listed as objective d above). In-lake total phosphorus concentrations have reduced by 75% since 2000 (Dinsdale, 2009; EA unpublished data). This huge improvement in water quality can largely be attributed to the installation of tertiary phosphorus stripping at South West Water's Helston Water Water Treatment Works. The new phosphate-stripping plant was completed at RNAS Culdrose STW in January 2015. Current in-lake phosphorus levels have been stable at around 80µg P l^{-1} for a number of years (Dinsdale, 2009; EA unpublished data), but the Loe Pool Forum expect to see a response from the lake during 2015/16 following the reduced inputs via Carminowe Stream. In addition, the Forum continues to working towards further reductions in nutrient inputs from both point and diffuse sources. During the period 2015-2020, the Cornwall Wildlife Trust aims to address agricultural sources of nutrients across the entire lake catchment through their Upstream Thinking work funded by South West Water and the Environment Agency (Clitherow, Dinsdale and Walker, 2014).



Loe Pool Catchment

1.3 Aim of the survey

The aim of this survey was to continue to build a long-term record of the changes to the deep-water macrophyte beds within Loe Pool.

2. Methodology

The deep-water macrophyte communities within Loe Pool have been monitored using a repeat boat-based grapnel survey along fourteen fixed-location transects across the lake since 1999 (Stewart, 2000; 2003; 2006; Dinsdale, 2007-2013; see also Wilson and Dinsdale, 1998).

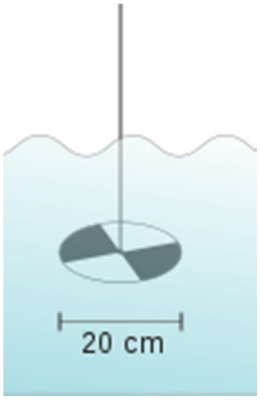
This survey method has been undertaken annually in September since 2006 (Dinsdale, 2011); a date originally selected as all current species of the inundation community are in a vegetative state and also the risk of poor water clarity due to algal blooms is low. In 2015 the survey was undertaken on September 11th.

The locations of the 14 boat transects within the lake are shown in Figure 1a-d. Each transect commences at the shore and runs either out into deep water, or across the entire lake, creek or inlet. Along the length of each transect, survey points are located at regular 5m intervals from the shore and, once the water depth is greater than 2m, at quarterly intervals across the waterbody.

At each survey point along the 14 transects, two grapnel trawls are thrown approximately 4 metres from the boat. The grapnel is constructed of two rake heads, wired together back-to-back. The total catch for each trawl is weighed *in situ* to the nearest 5 grams. Weights are wet weights with excess water gently shaken off higher plants, or squeezed from algae. The proportion of the catch occupied by each species is assessed visually. These must be considered very approximate, particularly since density varies between species.

The Secchi Depth, a measure of water clarity, is recorded at four sample stations within the lake. The standard 20 centimeter diameter black and white Secchi Disc is attached to a line and lowered slowly down in the water. The depth at which the pattern on the disk is no longer visible is taken as a measure of the transparency of the water.

Grapnel: Two rake heads wired together and attached to a line



Secchi disc

National Trust

Property: Penrose

Title: Figure 1a: Loe Pool boat & grapnel survey transect locations

Scale: 1:2500 @ A3

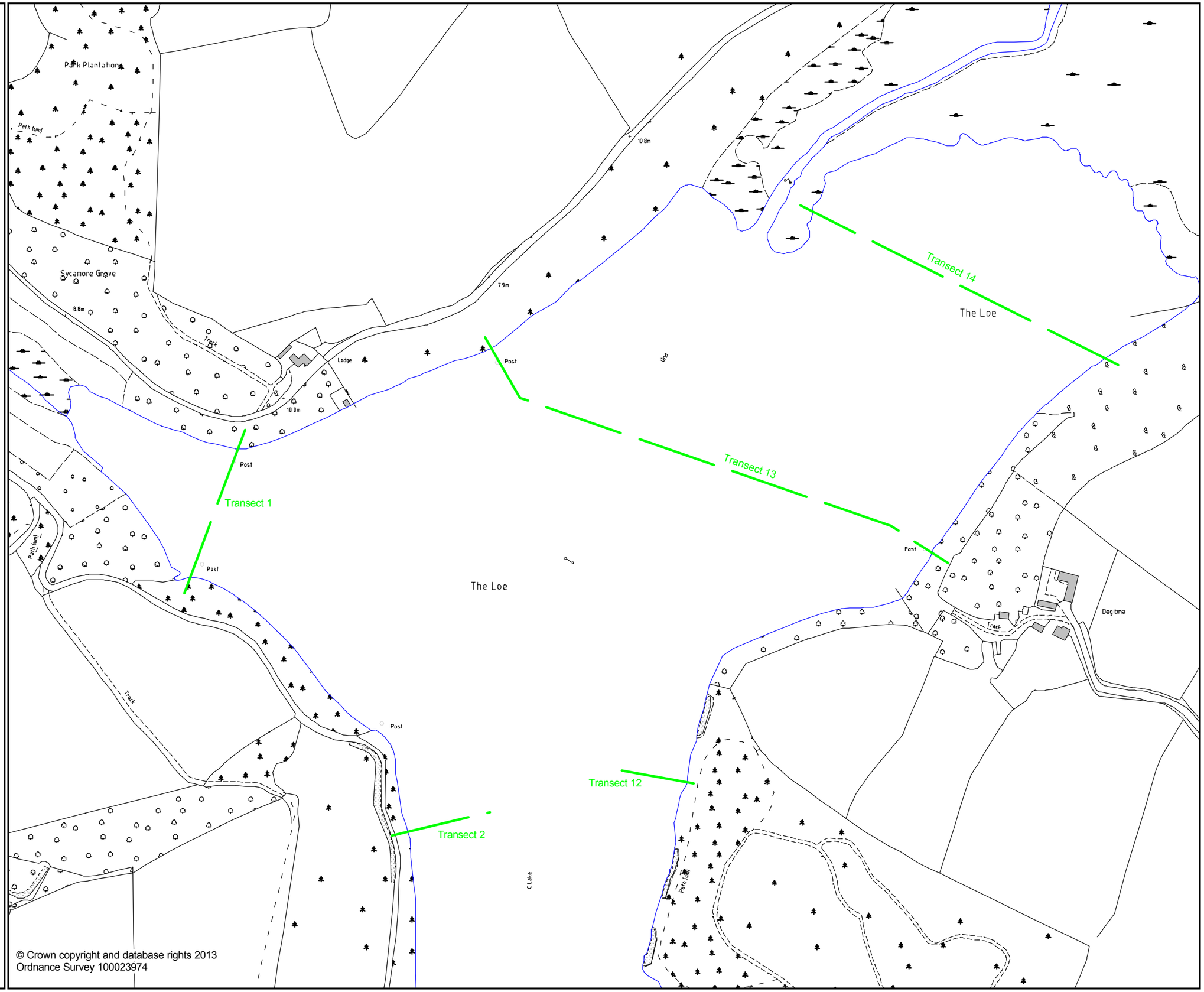
Date: 15/11/2013

Filename: loe survey transects A

South West: Exeter Consultancy Hub
Killerton House, Broadclyst, Exeter, Devon EX5 3LE
Telephone 01392 881691

Legend

Boat & Grapnel Transects



National Trust

Property: Penrose

Title: Figure 1b: Loe Pool boat & grapnel survey transect locations

Scale: 1:2500 @ A3

Date: 15/11/2013

Filename: loe survey transects B

South West: Exeter Consultancy Hub
Killerton House, Broadclyst, Exeter, Devon EX5 3LE
Telephone 01392 881691

Legend

Boat & Grapnel Transects

Transect 2

Transect 3

Transect 11

Bar Walk Plantation

Bar Walk Plantation

Degibna Wood

Degibna Wood

Keepers Cottage

Pond

Path (um)

Track

National Trust

Property: Penrose

Title: Figure 1c: Loe Pool boat and grapnel survey transect locations

Scale: 1:2500 @ A3

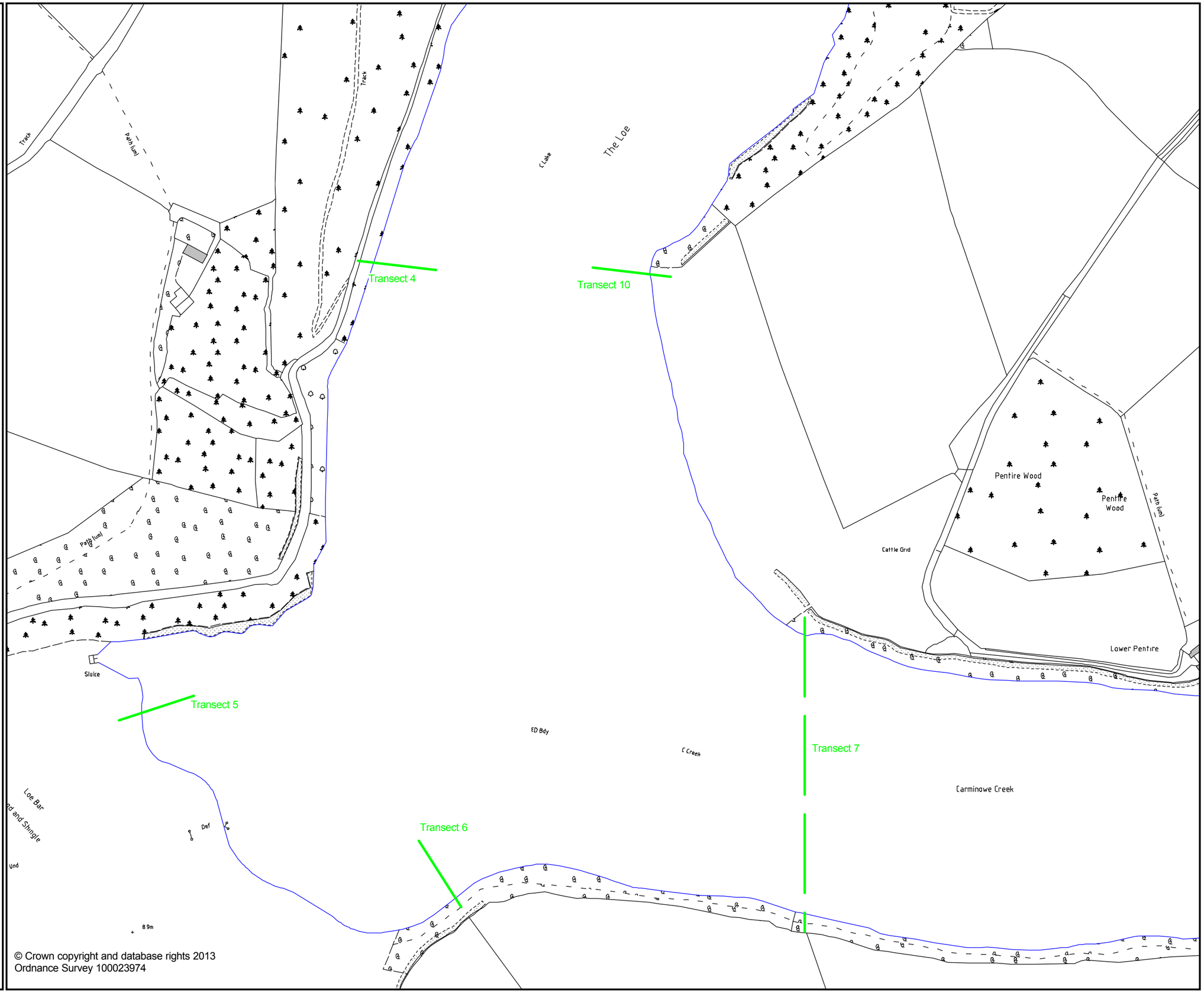
Date: 15/11/2013

Filename: loe survey transects C

South West: Exeter Consultancy Hub,
Killerton House, Broadclyst, Exeter, Devon EX5 3LE
Telephone 01392 881691

Legend

Boat and Grapnel Transects



National Trust

Property: Penrose

Title: Figure 1d: Loe Pool boat & grapnel survey transect locations

Scale: 1:2500 @ A3

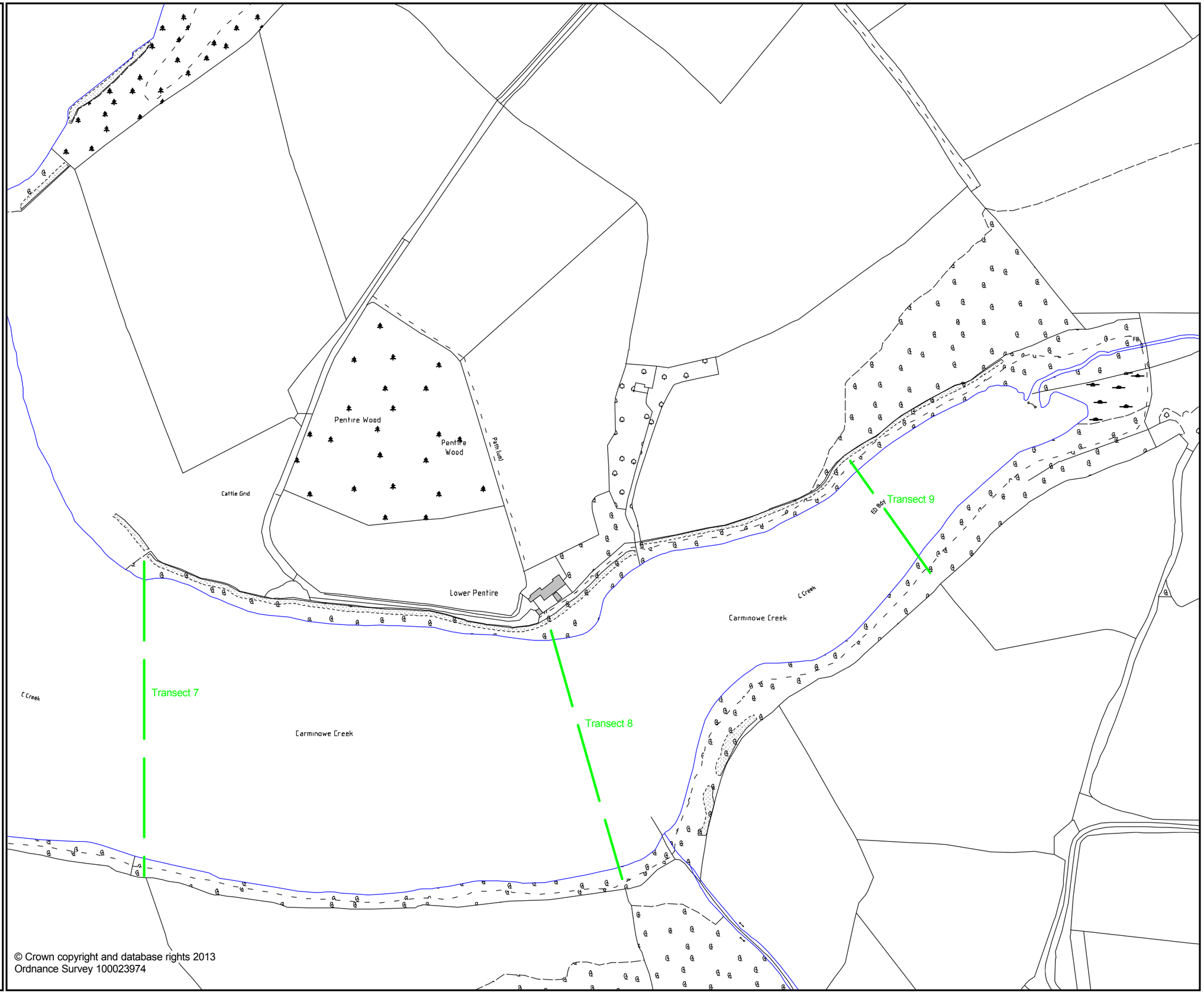
Date: 15/11/2013

Filename: loe survey transects D

South West: Exeter Consultancy Hub
Killerton House, Broadclyst, Exeter, Devon EX5 3LE
Telephone 01392 881691

Legend

Boat & Grapnel Transects



3. Results

3.1 Summary of boat and grapnel transect survey results 1999-2012

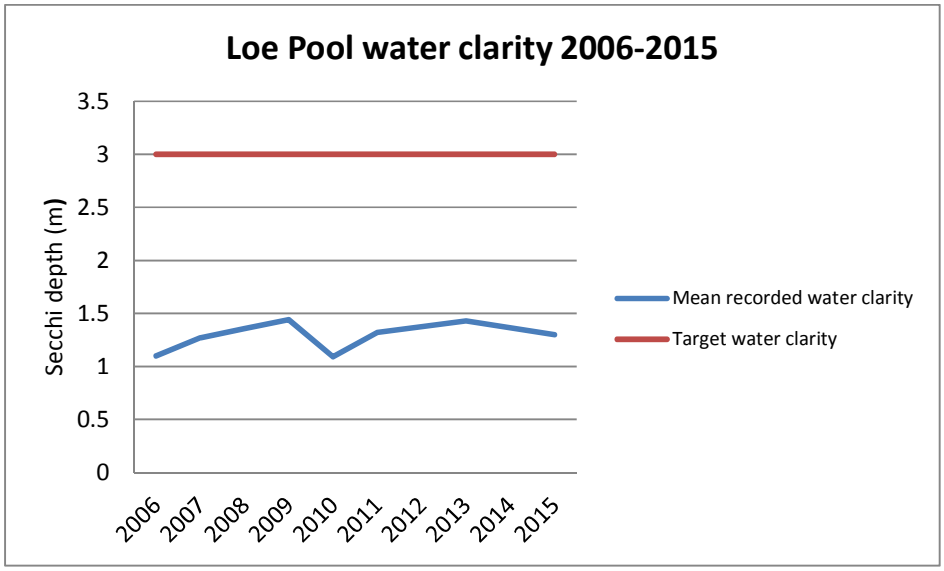
Boat-based grapnel surveys of the macrophyte communities within Loe Pool have been undertaken on a regular basis since 1998 (Wilson and Dinsdale, 1998; Stewart, 2000; 2003) and annually since 2006 (Dinsdale, 2007-2013). The raw survey data from 2006-2015 are shown in Appendix 2.

In summary, the results of the full 14 year monitoring period indicate that:

- There has been a single boom-and-bust of the Nuttall's Waterweed *Elodea nuttallii* during the survey period. *Elodea nuttallii* was prolific across the lake between 1999 to 2006. At its peak in 2006, the population extended to both the Penrose inlet and the Cober inlet and occurred in 60% of the boat and grapnel survey sample stations across the lake. The population of this non-native Waterweed crashed in 2007 and has not been observed within the lake, nor recorded in any of the boat and grapnel survey's 14 transects since that time.
- There is a general paucity of submerged, rooted aquatic vegetation within Loe Pool. Since the decline of the Waterweed population in 2007, rooted plants have been absent from an average of 97% of the boat and grapnel survey stations each year. The only rooted plant recorded during the 2007-2015 boat and transect surveys were the planted water lily, Common Reed *Phragmites australis* and Shoreweed.
- There has been some concern regarding the threat of other invasive non-native aquatic plants to the ecology of Loe Pool. Small quantities of Parrot's Feather *Myriophyllum aquaticum* were recorded in 1999 and 2003, however, this species has not been recorded in the Loe in recent years.
- Perfoliate Pondweed *Potamogeton perfoliatus,* one of the old inhabitants of Loe Pool, is likely to still be present within the Loe; there are three records for this species between 2003-2007 (Stewart, 2003; Knight, 2003; Dinsdale, 2007). Loe Pool is its only Cornish locality and this native pondweed was present in large quantities in the mid-nineteenth century (Johns, 1848) and was still abundant in 1964 (Turk and Turk, 1976). *Potamogeton perfoliatus* was then not recorded until 1983 (record: RJ Murphy) and subsequently was not seen again until 2003, when a small number of plants were recorded in Carminowe Creek. Stewart (2003) suggested that the reappearance of *Potamogeton perfoliatus* 'must be due to local stabilisation of conditions by the abundant growth of the *Elodea nuttallii*'. Following the decline of *Elodea nuttallii* only small amounts of drift material of *Potamogeton perfoliatus* were recorded during the annual macrophyte surveys of 2006 and 2007, both within Carminowe Creek. The Pondweed has not been recorded more recently, despite a thorough search with the help of Cornwall BSBI plant recorder Ian Bennallick (Dinsdale, 2010) and a comprehensive scuba dive macrophyte survey (Dinsdale, 2012).
- The annual algal blooms, which had been a feature of the lake's ecology for many years, abated in 2006. The previously abundant algal species, Water Net *Hydrodictyon reticultum* and the blue-green alga *Microcystis aeruginosa,* were not recorded over a five year period 2007 until 2012. There was, however, a small bloom of *Hydrodictyon reticultum* in 2013 and flocculation of *Microcystis* sp were present in 2015 (see section 3.2 below).
- There is an established inundation community around the shores of the Loe which comprises three species: Shoreweed, Needle Spike Rush *Eleocharis acicularis* and Six-

stamened waterwort *Elatine hexandra* (Stewart, 2000; 2003). It is not possible to accurately record changes to this inundation community using the boat and grapnel survey (Dinsdale, 2011; 2012). A separate inundation community bathyscope transect survey methodology has been established recently and was first surveyed in 2012 and repeated in 2014 (Dinsdale, 2012; 2014).

- Overall, there has been very little measurable change to the macrophyte communities during the survey period, despite the dramatic improvements seen in the nutrient status in of the lake water in 2003-2004 and the decline of algal blooms since 2007.
- The mean recorded water clarity has remained relatively stable since 2006 at 1.2-1.4 m. In the absence of algal blooms, water clarity improved year-on-year over the period 2006 to 2009. This annual 'snapshot' of water clarity does not indicate any measurable improvement over the monitoring period and it is clear that there is a long way to go to reach the Loe Pool Forum's target Secchi depth of 3.0 m (Wilson and Dinsdale, 1998; Dinsdale, 2009).



3.2 Boat and grapnel transect survey results 2015

The results of the 2015 survey are shown in Appendix 2.

It is clear from this programme of boat and grapnel monitoring along permanent transects that the Loe supports a severely impoverished macrophyte community. In 2015, the extent of established macrophyte beds within Loe Pool remained pitifully low. Rooted or floating macrophytes were recorded in just 2 of the 60 sample stations: Only the introduced non-native water lily was recorded within the stations. There were no rooted or floating macrophytes in 58 of the 60 sample stations.

Strapwort *Corrigiola litoralis* was reintroduced to Loe Pool in May 2015. A detailled history of this species at Loe Pool is available in Byfield (1992) and more information is available on loepool.org. There was no planting of this species within the permanent transects of this boat and grapnel survey.

A small bloom of the non-native macroalgae Water Net was recorded in the northern half of the lake during the 2013 survey, after an absence of 5 years. While there was no sign of Water Net within the Lake in 2015, there were flocculations of the blue-green genus Microcystis. This algae was not identified to species level as part of this macrophyte survey. It was present in both the Penrose Arm and Carminowe Creek (Figure 1a and 1d).

4. Lake and Catchment Management Recommendations

This section outlines recommendations for further survey work and for management both within the SSSI and across the catchment, based on the findings of the survey.

4.1 Further macrophyte survey recommendations

The boat and grapnel survey method is considered to be adequate to record rooted macrophytes in deep water within Loe Pool. It is, therefore, recommended that this survey method is repeated bi-annually in September for the foreseeable future.

The boat and grapnel survey is not deemed to be suitable to monitor changes to the shoreline inundation community at Loe Pool because:

- the grapnel is too coarse to retrieve the diminutive plant species which make-up the inundation community at this site
- the changes to this community are likely to occur at too finer scale to be captured by the boat and grapnel survey sample stations, which are positioned at 5 metre intervals

(Dinsdale, 2010; 2012)

A separate fixed-location transect survey methodology has been established to monitor changes to this inundation community along 4 permanent transects using a combination of a bathyscope and scuba diving (Dinsdale, 2012; 2014). It is proposed that this dive and bathyscope inundation community survey is also repeated bi-annually.

The reintroduction of the critically endangered strapwort to Loe Pool included planting on one of these permanent transects and so this survey will provide some measure of the long-term success of this re-introduction programme.

4.2 Working at the catchment scale

The work of the Loe Pool Forum to reduce both sediment and nutrient inputs from diffuse and point sources across the Lake's catchment is considered to be critical to the successful rehabilitation of Loe Pool. In particular, the work of the Loe Pool Catchment Group to reduce nutrient inputs from the two water treatment works within the catchment and address agricultural inputs through farm advisory and grant assistance will be invaluable, working to deliver improvements to water quality and benthic sediment structure within the Lake SSSI.

4.3 In-lake management

Delivery of improvements to water quality towards the SSSI target nutrient levels may alone, in time, provide the required conditions for recovery of the macrophyte communities within the SSSI, in order to meet the conservation objectives listed in Section 1.3. Great progress towards these macrophyte conservation objectives has been seen to date with a huge reduction in phosphorus inputs and a corresponding decline in algal blooms. The minimal occurrence of non-native invasive plant species is also seen as favourable, but the extent of established rooted aquatic vegetation remains very low.

In terms of the Lake's broader ecology, successful lake rehabilitation from a eutrophic algal dominated condition relies heavily upon the re-establishment of submerged vegetation. Results of multi-lake studies have shown that where macrophytes are slow to respond to clear water conditions, lake rehabilitation becomes a longer process and is less likely to be ultimately successful (e.g. Moss, 1990; Jeppesen *et al*., 1990; Meijer, 2000; Jeppesen, 1998; Hosper *et al*., 2005; Phillips, 2005; Broads Authority, 2009). The positive effect of submerged, rooted vegetation on lake rehabilitation is the result of a number of mechanisms including:

- The provision of refugia for phytoplankton-grazing zooplankton
- The increase in habitat structural complexity which can promote a switch in the fish population balance towards a dominance of piscivory. This leads to less pressure on the zooplankton community and so promotes top-down control on algal growth
- Improved stability of the lake's benthic sediments, leading to a reduction in the availability of nutrients for phytoplankton and also reducing wind- and fish- induced re-suspension of sediments (Hosper *et al*. 2005)

Philips (2005) found the relative density of piscivorous to planktivorous fish to be of critical importance to lake rehabilitation success. The recent fishery survey of the Loe found that the Lake's fish population is currently dominated by Roach *Rutilus rutilus* (Harwood, Tomlinson and Perrow, 2015). While no Trout *Salmo trutta* were recorded within the Lake itself, the trout population within the catchment remains strong.

The Loe Pool Forum could now consider opportunities for biomanipulation of the current fish community in order to trigger a switch from the current turbid-water state to clear water conditions. Is this an appropriate management tool at the current lake nutrient and suspended sediment status? Or at what stage (e.g. target nutrient level) could biomanipulation be considered at Loe Pool?

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APPENDIX 1

Natural England SSSI citation and excerpt from SSSI condition statement

SSSI Citation

COUNTY: CORNWALL SITE NAME: LOE POOL
DISTRICT: KERRIER
Status: Site of Special Scientific Interest (SSSI) notified under Section 28 of the Wildlife and Countryside Act 1981 (as amended)
Local Planning Authority: KERRIER DISTRICT COUNCIL; CORNWALL COUNTY COUNCIL
National Grid Reference: SW 647250 Area: 128.7 (ha) 318.0 (ac)
Ordnance Survey Sheet 1:50,000: 203 1:10,000: SW 62 SW SE NW NE
Date Notified (Under 1949 Act): 1951 Date of Last Revision: 1973
Date Notified (Under 1981 Act): 1986 Date of Last Revision: –

Other Information:
Cornwall Area of Outstanding Natural Beauty and Cornwall Heritage Coast. Site boundary amended by extension and deletion. Mainly National Trust owned.

Description and Reasons for Notification:
Loe Pool, located south of Helston on the South Cornish coast, is the largest freshwater lagoon in Cornwall covering an area of approximately 50 hectares and with maximum depth of 6 metres. The underlying rock is composed of Devonian shales and siltstones, locally overlain by head deposits. Soils developed over the surrounding area are mainly acidic brown earths. Both the pool and the shingle bar provide scarce habitat not found elsewhere in Cornwall, with rare species of higher plants, bryophytes, and algae, together with many rare and local insect species. The area is also important to wintering birds. The pool supports several locally rare aquatic plant species including Six-stamened Waterwort *Elatine hexandra*, Perfoliate Pondweed *Potamogeton perfoliatus*, Shoreweed *Littorella uniflora,* Horned Pondweed *Zannichellia palustris*, and Amphibious Bistort *Polygonum amphibium*. One noteworthy species of alga, Stonewort Alga *Nitella hyalina*, has also been recorded. The shingle bar supports local plant species including Sea Holly *Eryngium maritimum*, Sea Fern-grass *Catapodium marinum*, Yellow Horned-poppy *Glaucium flavum*, Sea Sandwort *Honkenya peploides*, Sea Mayweed *Tripleurospermum maritimm*, and the very rare Strapwort *Corrigiola litoralis*.

At the northern inflow area is an extensive area of willow carr, mainly Grey Willow *Salix cinerea*, with Common Reed *Phragmites australis* locally dominant within the willow. There is a wide fringe of Reed around the northern border of the lake. An area of relatively undisturbed ancient oakwood, mainly Pedunculate Oak *Quercus robur,* occurs in the west of the site. Areas of maritime grassland occur along the cliff edge with Red Rescue *Festuca rubra* forming an extensive mat. Other species include Thrift *Armeria maritima*, Wild Carrot *Daucus carota*, Wild Thyme, *Thymus drucei*, Spring Squill *Scilla verna*, and Western Clover *Trifolium occidentale.*

Loe Pool is the only known site in Britain for the Cornish subspecies of the Sandhill

Rustic Moth *Luperina nickerlii leechi*, which feeds on Sand Couch Grass *Agropyron junceiforme*. Nine species of Odonata, including the Keeled Skimmer *Orthetrum coerulescens* have been recorded here. The nutrient rich status of the pool has encouraged an abundance of benthic invertebrates, and there are also many rare or local species of Coleoptera and Hymenoptera. Loe Pool has the only recent record in Cornwall of the rare woodlouse, *Porcellio dilatatus.*

Loe Pool supports nearly 80 species of wintering birds with up to 1,200 wildfowl. Numbers of Shoveler *Anas clypeata* can reach nationally important levels and regionally important counts of Teal *Anas crecca* are not unusual.
There are also high counts for Pochard *Aythya ferina*, Tufted Duck *Aythya fuligula*, Mallard *Anas platyrhynchos*, Goldeneye *Bucephala clangula*, Cadwall *Anas strepera*, and Coot *Fulica astra*. Several rare birds have been recorded here in winter and on autumn migration. There is a breeding colony of about 20 pairs of Sand Martins *Riparia riperia* a species not well represented in Cornwall.

Loe Bar encloses a lagoon occupying part of a former ria, and forms an integral part of a beach system extending from Porthleven to Gunwalloe. The site is important for coastal geomorphology on two accounts. First, Loe Bar is a classic coastal landform; and second, the beach system is an essential member of a suite of major beaches formed and maintained by predominantly south-west wave regimes. The beach is formed mainly of flint shingles and coarse sand. Current inputs from adjacent cliffs are small, and overall, the beach is in deficit. The Bar is washed-over during periods of high wave energy as demonstrated by a series of washover fans. The annually laminated sediments composed of classic material are unique in Great Britain.

SSSI condition statement excerpt

Box 1. Characteristic species of oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Iseoto-Nanojuncetea.* ** mesotrophic species only		
Characteristic species: *Littorelletea* flora:	**Other characteristic species:**	**Associates:**
Littorella uniflora	*Pilularia globulifera*	*Callitriche hamulata*
Isoetes lacustris	*Elatine hexandra*	*Callitriche brutia*
Isoetes echinospora	*Baldellia ranunculoides*	*Myriophyllum alterniflorum*
Lobelia dortmanna	*Carex rostrata*	*Potamogeton polygonifolius*
Subularia aquatica	*Utricularia* spp.	*Potamogeton berchtoldii*
Sparganium angustifolium	** *Nitella* spp.	*Potamogeton natans*
Luronium natans	***Sparganium natans*	*Nymphaea alba*
Potamogeton rutilis	**Broadleaved *Potamogeton* species:	*Juncus bulbosus*
	P. alpinus	*Eleogiton fluitans*
	P. praelongus	*Equisetum fluviatile*
	P. perfoliatus	*Nuphar lutea*
	P. gramineus	*Menyanthes trifoliata*
	P x nitens (and any other established hybrid of these species)	*Eleocharis acicularis*
	***Najas flexilis*	***Persicaria amphibia*

APPENDIX 2

Results of 2006-2013 Loe Pool Boat and Grapnel Survey: Vegetation Wet Weights

2006

Transect	Sample station	Depth (m)	Total weight (grams)	*Hydrodictyon reticulatum (g)*	*Elodea nuttallii (g)*	*Cladophora balls (g)*	*Filamentous algae (g)*	*Lemna minor (g)*	*Lemna minuta (g)*	*Azolla filiculoides (g)*	*Fontinalis antipyretica (g)*	*Callitriche sp. (g)*	*Nymphaea alba (g)*	*Potamogeton perfoliatus (g)*
1	5m S	0.95	72	68	<5			+					not weighed	
	1/4	1.2	178	9	169									
	1/2	1.3	390	98	292									
	3/4	1.3	486	243	243									
	5m N	1	424	310	104									
2	5m	1.6	273	136	136									
	10m	2	70	56	14									
	15m	2.1	23	21	<5									
3	5m	1.3	1	+	+									
	10m	2.5	335	<5	332									1 stem in drift material
	15m	3.4	0.5		+									
4	5m	1.6	205		205									
	10m	2.6	0											
5	5m	1.6	730	36	694									
	10m	2	460	5	455									
	15m	2.1	1200	12	1188									
	30m	2.1	1130	11	1119									
	50m	2.1	1180	12	1168									
	80m	2.7	0											
6	5m	1.4	95	19	76									
	10m	1.8	70	+	69									
	15m	2.5	0											
7	5m S	1.4	505		505									
	10m S	3.1	0											
	centre	5.5	0											
	15m N	2.7	0											
	10m	1.6	180	5	175									
	5m N	1.1	8.5	+	+	8								
8	5m S	0.4	0											
	10m	1.1	1			<5								
	15m	1.9	19		19									
	20m S	2.9	0											
	15m N	3.6	0											
	10m	2	7.5		7.5									
	5m N	0.9	3		<5									
9	5m S	0.8	670	201	469					+				
	1/4	1.1	3500		3500		<5		<5					
	1/2	1	3500		3500		<5		<5					
	3/4	1	3455		3450		<5		<5					
	5m N	0.6	3260	<5	3255			<5	<5	<5				
10	5m	0.6	2	+	<5									
	10m	2.5	43	<5	34	6								
	15m	3.4	0											
11	5m	1.2	4	+	<5									
	10m	2	16	+	16				+		0.2			
	15m	3	5	5										
12	5m	1.5	160	160	+									
	10m	1.8	175	70	105									
	15m	2	380	38	342									
	20m	2.2	18	<5	14									
13	5m SE	0.5	265	265	+			+	+			+		
	10m	0.5	<5	<5										
	20m	0.8	20	20										
	1/4	1.1	197	197	+									
	1/2	1.3	215	215	+									
	3/4	1.3	143	143										
	20m	1.5	78	78										
	10m	1.3	115	115	+									
	5m NW	1.1	21	20	+									
14	15m SE	0.4	43	43										
	1/4	0.7	80	80										
	1/2	0.8	95	95										
	3/4	1.1	103	103										
	10m NW	0.7	83	83										

2007

Transect	Sample station	Depth (m)	Total weight (grams)	*Hydrodictyon reticulatum (g)*	*Elodea nuttallii (g)*	*Cladophora balls (g)*	*Filamentous algae (g)*	*Lemna minor (g)*	*Lemna minuta (g)*	*Azolla filiculoides (g)*	*Fontinalis antipyretica (g)*	*Callitriche sp. (g)*	*Nymphaea alba (g)*	*Potamogeton perfoliatus (g)*	*Elatine hexandra (g)*	*Eleocharis acicularis (g)*
1	5m S	1.09	not weighed										not weighed			
	1/4	1.29	0													
	1/2	1.29	0													
	3/4	1.36	0													
	5m N	1.06	0													
2	5m	1.78	0													
	10m	2	0													
	15m	2	0													
3	5m	0.94	not weighed										not weighed			
	10m	1.1														
	15m	1.59														
4	5m	1.59	0													
	10m	2.39	0													
5	5m	0.58	0													
	10m	1.38	0													
	15m	1.7	12			12					+					
	30m	2.1	+			+										
	50m	2.45	0													
	80m	2.2	0													
6	5m	1.7	+								+					
	10m	2.05	0													
	15m	2.56	0													
7	5m S	0.83	0													
	10m S	1.62	0													
	centre	6.2	0													
	15m N	2.82	0													
	10m	1.69	+			+										
	5m N	1.29	+			+										
8	5m S	0.39	0													
	10m	0.84	+													
	15m	1.5	<5			<5										
	20m S	1.7	16				16									
	15m N	2.5	0													
	10m	1	5													
	5m N	0.53	+												5	+
															+	
9	5m S	0.78	+											+		
	1/4	1.55	+		+		+									
	1/2	1.5	0													
	3/4	1.3														
	5m N	0.78	+		+											
10	5m	0.6	<5	+	<5											
	10m	2.5	43	<5	34	6										
	15m	2.7	0													
11	5m	1.2	<5	+	<5											
	10m	2	16	+	16				+							
	15m	3	5	5												
12	5m	1.5	160	160												
	10m	1.8	175	70	105											
	15m	2	380	38	342											
	20m	2.2	18	,5	14											
13	5m SE	0.5	265	265												
	10m	0.5	<5	<5												
	20m	0.8	20	20												
	1/4	1.1	197	197												
	1/2	1.3	215	215												
	3/4	1.3	143	143												
	20m	1.5	78	78												
	10m	1.3	115	115												
	5m NW	1.1	21	20	<5											
14	10m SE	0.3	0													
	1/4	1	+				+									
	3/4	1.1	0													
	10m NW	0.54	0													

2008

Transect	Sample station	Depth (m)	Total weight (grams)	*Hydrodictyon reticulatum (g)*	*Elodea nuttallii (g)*	*Cladophora balls (g)*	*Filamentous algae (g)*	*Lemna minor (g)*	*Lemna minuta (g)*	*Azolla filiculoides (g)*	*Fontinalis antipyretica (g)*	*Callitriche sp. (g)*	*Nymphaea alba (g)*	*Potamogeton perfoliatus (g)*	*Elatine hexandra (g)*	*Eleocharis acicularis (g)*	*Phragmites australis (g)*
1	5m S	1.1	not weighed										not weighed				
	1/4	1.4	0														
	1/2	1.4	0														
	3/4	1.35	0														
	5m N	1.1	0														
2	5m	1.65	0														
	10m	2.1	0														
	15m	2.5	0														
3	5m	1.2	not weighed										not weighed				
	10m	2.1	0														
	15m	2.9	0														
4	5m	3.3	0														
	10m	6.2	0														
5	5m	1.35	<5														
	10m	2.8	0														
	15m	2.8	+														
	30m	2.8	0														
	50m	2.8	0														
6	5m	1.4	0														
	10m	1.9	0														
	15m	2.4	0														
7	5m S	1.3	+												+		
	10m S	2.5	0														
	centre	6.7	0														
	15m N	3	+			+											
	10m	1.9	0														
	5m N	0.95	0														
8	5m S	1	0														
	10m	1.4	0														
	15m	2.1	+			+											
	20m S	3.3	+			+											
	15m N	3.4	0														
	10m	2	0														
	5m N	0.85	0														
9	5m S	1.35	0														
	1/4	1.6	+			+											
	1/2	1.5	0														
	3/4	1.3	0														
	5m N	0.9	0														
10	5m	0.9	0														
	10m	1.8	+			+											
	15m	3	+			+											
11	5m	1.3	0														
	10m	2.7	0														
	15m	4	0														
12	5m	2	0														
	10m	2.2	0														
	15m	2.4	0														
	20m	2.5	0														
13	5m SE	0.65	+				+										
	10m	0.8	0														
	1/4	1.5	0														
	3/4	1.7	0														
	10m	1.5	0														
	5m NW	1.3	not weighed														not weighed
14	10m SE	0.6	0														
	1/4	1	0														
	3/4	1.1	0														
	10m NW	0.6	0														

2009

Transect	Sample station	Depth (m)	Total weight (grams)	*Hydrodictyon reticulatum (g)*	*Elodea nuttallii (g)*	*Cladophora balls (g)*	*Filamentous algae (g)*	*Lemna minor (g)*	*Lemna minuta (g)*	*Azolla filiculoides (g)*	*Fontinalis antipyretica (g)*	*Callitriche sp. (g)*	*Nymphaea alba (g)*	*Potamogeton perfoliatus (g)*	*Elatine hexandra (g)*	*Eleocharis acicularis (g)*	*Phragmites australis (g)*
1	5m S	0.91	not weighed										not weighed				
	1/4	1.13	0														
	1/2	1.3	0														
	3/4	1.22	0														
	5m N	1.06	0														
2	5m	1.5	0														
	10m	2.1	0														
	15m	2.4	0														
3	5m	1.15	not weighed										not weighed				
	10m	2.1	0														
	15m	3.1	0														
4	5m	4.2	0														
	10m	6.5	0														
5	5m	1.2	0														
	10m	2.3	0														
	15m	2.8	0														
	30m	2.9	0														
	50m	2.9	0														
6	5m	too windy	0														
	10m	too windy	0														
	15m	too windy	0														
7	5m S	1.4	+												+		
	10m S	2.6	0														
	centre	6.8	0														
	15m N	2.9	0														
	10m	2.05	0														
	5m N	1	0														
8	5m S	1.32	0														
	10m	1.69	0														
	15m	2.1	0														
	20m S	3.4	0														
	15m N	3.4	0														
	10m	1.75	0														
	5m N	0.85	0														
9	5m S	1.07	0														
	1/4	1.16	0														
	1/2	1.22	0														
	3/4	1.32	0														
	5m N	0.85	0														
10	5m	1	0														
	10m	2.56	0														
	15m	3.42	+														
11	5m	1.4	+			+											
	10m	1.44	0														
	15m	2.1	0														
12	5m	1.25	0														
	10m	1.82	0														
	15m	2.4	0														
	20m	2.5	0														
13	5m SE	0.65	0														
	10m	0.75	0														
	1/4	1.3	0														
	3/4	1.7	0														
	10m	1.55	0														
	5m NW	1.3	0														
14	10m SE	0.37	0														
	1/4	0.78	0														
	3/4	0.9	0														
	10m NW	0.72	0														

2010

Transect	Sample station	Depth (m)	Total weight (grams)	*Hydrodictyon reticulatum (g)*	*Elodea nuttallii (g)*	*Cladophora balls (g)*	*Filamentous algae (g)*	*Lemna minor (g)*	*Lemna minuta (g)*	*Azolla filiculoides (g)*	*Fontinalis antipyretica (g)*	*Callitriche sp. (g)*	*Nymphaea alba (g)*	*Potamogeton perfoliatus (g)*	*Elatine hexandra (g)*	*Eleocharis acicularis (g)*	*Phragmites australis (g)*
1	5m S	0.77	not weighed										not weighed				
	1/4	0.97	0														
	1/2	1.02	0														
	3/4	1.04	0														
	5m N	0.7	0														
2	5m	1.936	0														
	10m	1.74	0														
	15m	2	0														
3	5m	0.98	not weighed										not weighed				
	10m	2.15	0														
	15m	2.95	0														
4	5m	4.5	0														
	10m	6.23	0														
5	5m	2.1	0														
	10m	2.35	+				+										
	15m	2	0														
	30m	2.29	0														
	50m	2.39	0														
6	5m	1.25	0														
	10m	1.76	0														
	15m	2.43	0														
7	5m S	1.6	0														
	10m S	2.58	0														
	centre	6.34	0														
	15m N	2.9	0														
	10m	2.27	0														
	5m N	1.36	0														
8	5m S	1.3	+			+											
	10m	2.1	+			+											
	15m	2.41	0														
	20m S	2.95	0														
	15m N	3.1	0														
	10m	2.35	0														
	5m N	1.16	0														
9	5m S	1.06	0														
	1/4	1.15	0														
	1/2	1.07	0														
	3/4	0.96	0														
	5m N	0.55	0														
10	5m	1.26	+			+											
	10m	2.76	+			+											
	15m	3.23	0														
11	5m	1.33	+								+						
	10m	2	+			+											
	15m	2.23	0														
12	5m	1.59	0														
	10m	1.64	0														
	15m	1.77	0														
	20m	2	0														
13	5m SE	0.31	0														
	10m	0.39	0														
	1/4	0.88	0														
	3/4	1.26	0														
	10m	1.27	0														
	5m NW	0.98	0														
14	10m SE	0.47	0														
	1/4	0.8	0														
	3/4	0.84	0														
	10m NW	0.46	0														

2011

Transect	Sample station	Depth (m)	Total weight (grams)	*Hydrodictyon reticulatum (g)*	*Elodea nuttallii (g)*	*Cladophora balls (g)*	*Filamentous algae (g)*	*Lemna minor (g)*	*Lemna minuta (g)*	*Azolla filiculoides (g)*	*Fontinalis antipyretica (g)*	*Callitriche sp. (g)*	*Nymphaea alba (g)*	*Potamogeton perfoliatus (g)*	*Elatine hexandra (g)*	*Eleocharis acicularis (g)*	*Phragmites australis (g)*
1	5m S	0.87	not weighed										not weighed				
	1/4	1.03	0														
	1/2	1.07	0														
	3/4	1.05	0														
	5m N	0.87	0														
2	5m	1.75	0														
	10m	1.97	0														
	15m	2.08	0														
3	5m	1.03	not weighed										not weighed				
	10m	1.73	0														
	15m	1.9	0														
4	5m	2.4	0														
	10m	6.09	0														
5	5m	1.72	0														
	10m	1.89	0														
	15m	2.23	0														
	30m	2.35	0														
	50m	2.64	0														
6	5m	1.72	0														
	10m	1.92	0														
	15m	3.18	0														
7	5m S	2.25	0														
	10m S	3.67	0														
	centre	6	0														
	15m N	2.74	0														
	10m	2.39	0														
	5m N	1.54	0														
8	5m S	2.25	+				+										
	10m	3.64	0														
	15m	3.27	+				+										
	20m S	4.06	0														
	15m N	3.18	0														
	10m	2.27	+				+										
	5m N	0.92	+				+										
9	5m S	0.83	+				+										
	1/4	1.16	0														
	1/2	1.2	+				+										
	3/4	0.94	+				+										
	5m N	1.02	0														
10	5m	1.07	0														
	10m	1.25	+			+											
	15m	2.65	+			+											
11	5m	1.24	0														
	10m	2	+								+						
	15m	3.53	0														
12	5m	1.62	0														
	10m	1.84	0														
	15m	2	0														
	20m	2.17	0														
13	5m SE	0.54	0														
	10m																
	1/4	1	0														
	3/4	1.42	0														
	10m																
	5m NW	1.27	0														
14	10m SE	0.58	0														
	1/4	0.75	0														
	3/4	0.75	0														
	10m NW	0.41	0														

2013

Transect	Sample station	Depth (m)	Total weight (grams)	*Hydrodictyon reticulatum (g)*	*Elodea nuttallii (g)*	*Cladophora balls (g)*	*Filamentous algae (g)*	*Lemna minor (g)*
1	5m S	0.63	25	25				
	1/4	0.77	145	145				
	1/2	0.85	240	240				
	3/4	0.77	400	400				
	5m N	0.66	200	200				
2	5m	1.17	200	200				
	10m	1.3	<5	<5				
	15m	1.47	0	0				
3	5m	1.03	0.82					
	10m	1.73	1.78					
	15m	1.9	1.9					
4	5m	1.56	0					
	10m	5.92	0					
5	5m	1.47	<5			<5		
	10m	2.14	0					
	15m	2.27	0					
	30m	2.35	0					
	50m	2.46	0					
6	5m	0.88	0					
	10m	1.6	0					
	15m	2.47	0					
7	5m S	1.11	0					
	10m S	2.38	+				+	
	centre	6	0					
	15m N	2.3	0					
	10m	1.83	5				5	
	5m N	1.25	80			75	5	
8	5m S	0.86	0					
	10m	1.5	2300			80	2220	
	15m	2.32	500			240	260	
	20m S	2.95	230			70	160	
	15m N	2.58	0					
	10m	2.31	40				40	
	5m N	0.7	290				290	
9	5m S	0.35	0					
	1/4	0.53	0					
	1/2	0.78	<5				<5	
	3/4	0.89	<5	'+			<5	
	5m N	0.84	+				+	
10	5m	0.81	30				30	
	10m	1.57	550			25	525	
	15m	2.76	+				+	
11	5m	0.75	10	10				
	10m	1.75	600	400		80	120	
	15m	2.2	900			100	800	
12	5m	1.06	10	10				
	10m	1.52	40	40				
	15m	1.55	5	5				
	20m	1.82	<5	<5				
13	5m SE	0.2	20	20				
	10m	0.27	10	10				
	1/4	0.74	1014	1014				
	3/4	0.77	26	26				
	10m	0.36	300	300				
	5m NW	0.27	10	10				
14	10m SE	too shallow for boat		present				
	1/4	too shallow for boat		present				
	3/4	too shallow for boat		present				
	10m NW	too shallow for boat		present				

Lemna minuta (g)	*Azolla filiculoides (g)*	*Fontinalis antipyretica (g)*	*Callitriche sp. (g)*	*Nymphaea alba (g)*	*Potamogeton perfoliatus (g)*	*Elatine hexandra (g)*	*Eleocharis acicularis (g)*	*Phragmites australis (g)*
				not weighed				
		<5						
		+						

Littorella uniflora (g)
+

2015

Transect	Sample station	Depth (m)	Total weight (grams)	*Hydrodictyon reticulatum (g)*	*Elodea nuttallii (g)*	*Cladophora balls (g)*	*Filamentous algae (g)*	*Lemna minor (g)*	*Lemna minuta (g)*	*Azolla filiculoides (g)*	*Fontinalis antipyretica (g)*	*Callitriche sp. (g)*	*Nymphaea alba (g)*	*Potamogeton perfoliatus (g)*	*Elatine hexandra (g)*	*Eleocharis acicularis (g)*	*Phragmites australis (g)*	*Littorella uniflora (g)*
1	5m S	0.78	not weighed										not weighed					
	1/4	1.02	0															
	1/2	0.97	0															
	3/4	1.03	0															
	5m N	0.83	0															
2	5m	1.45	0															
	10m	1.67	0															
	15m	2	0															
3	5m	1.15	not weighed										not weighed					
	10m	1.64	0															
	15m	2.8	0															
4	5m	3.05	0															
	10m	5	0															
5	5m	2.28	0															
	10m	2.16	0															
	15m	2.26	0															
	30m	2.3	0															
	50m	2.45	0															
6	5m	1.16	5			5												
	10m	1.67	<5			<5												
	15m	2.15	0															
7	5m S	0.89	0															
	10m S	2	0															
	centre	5.9	0															
	15m N	4.2	<5			<5												
	10m	2.3	10			10												
	5m N	1.2	<5			<5												
8	5m S	0.7	0															
	10m	0.95	<5			<5												
	15m	1.7	20			20												
	20m S	2.35	15			15												
	15m N	2.9	0															
	10m	2.15	0															
	5m N	0.9	0															
9	5m S	0.8	0															
	1/4	1.1	0															
	1/2	1.15	0															
	3/4	1.02	0															
	5m N	0.75	0															
10	5m	0.78	5			5												
	10m	2.1	10			10												
	15m	3.3	0															
11	5m	1	5			5												
	10m	1.6	20			20												
	15m	2.1	15			15												
12	5m	1.3	0															
	10m	1.7	0															
	15m	1.85	0															
	20m	2	0															
13	5m SE	0.35	0															
	10m	0.4	0															
	1/4	0.87	0															
	3/4	1.24	0															
	10m	1.21	0															
	5m NW	1.1	0															
14	10m SE	0.44	0															
	1/4	0.78	0															
	3/4	0.82	0															
	10m NW	0.22	0															