Cyfoeth Naturiol Cymru
Natural Resources Wales

Condition Assessment of Eight Standing Waters in Welsh Sites of Special Scientific Interest (SSSIs)

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ENSIS Ltd, London

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We work to support Wales' economy by enabling the sustainable use of natural resources to support jobs and enterprise. We help businesses and developers to understand and consider environmental limits when they make important decisions.

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1. Crynodeb Gweithredol

Mae Cyfoeth Naturiol Cymru yn gyfrifol am fonitro a rheoli Safleoedd o Ddiddordeb Gwyddonol Arbennig yng Nghymru. Mae Strategaeth Amgylcheddol Cymru wedi gosod targed i 95% o'r holl SoDdGA fod mewn cyflwr ffafriol erbyn 2015, ac i bob safle fod yn ffafriol erbyn 2026.

Yn yr adroddiad hwn, rydym yn defnyddio Monitro Safonau Cyffredin sy'n amlinellu fframwaith monitro manwl ar gyfer merddyfroedd gan ddefnyddio cyfuniad o newidynnau biolegol a ffisigocemegol i asesu cyflwr wyth SoDdGA yng Nghymru. Y safleoedd yw Pysgodlyn Mawr, Llyn Llech Owain, Llyn Pencarreg, Pwll Witchett, Llyn Treflesg, Llyn Cerrig-bach, Llyn Traffwll a Llys Glasfryn. Roedd y llynnoedd hyn o bob rhan o Gymru ac yn cynrychioli amrywiaeth eang o fathau o lynnoedd, o fawnaidd ac asidig (Llech Owain) i lyn tywod alcalïaidd (Pwll Witchett). Fodd bynnag, roedd pob un ohonynt yn llynnoedd iseldirol a oedd naill ai wedi eu dynodi'n gynefinoedd SoDdGA yn eu rhinwedd eu hunain, neu'n cynnal rhywogaethau dyfrol sy'n dibynnu ar gynefin llyn.

Mae'r asesiadau wedi eu seilio ar arolygon macroffyt dyfrol a mapio, arolwg bathymetrig, mesuriadau ffisigocemegol ac, ym mhedwar safle, dadansoddiadau paleolimnolegol. Yn gyffredinol, nid oedd llawer yn hysbys am y safleoedd; dim ond Llyn Glasfryn a oedd wedi bod yn destun asesiad cyflwr Monitro Safonau Cyffredin blaenorol.

Aseswyd bod pob un o'r llynnoedd mewn cyflwr anffafriol, â hyder uchel yn y rhan fwyaf o achosion. Mae tystiolaeth yn awgrymu y buont mewn cyflwr anffafriol ers blynyddoedd maith ac, mewn llawer o achosion, maent yn parhau i ddirywio. Roedd graddau'r difrod yn gyfnewidiol iawn ac roedd rhai safleoedd, fel Pysgodlyn Mawr a Llyn Pencarreg, mewn cyflwr gwael iawn. Nid oedd safleoedd eraill wedi eu heffeithio cymaint ac roeddent yn cynnal rhywogaethau planhigion pwysig a phrin, mewn rhai achosion, ond caiff y rhain eu bygwth gan ansawdd dŵr gwael.

Gellid priodoli achos hyn yn uniongyrchol i gyfoethogiad maetholion, yn benodol ffosfforws, ym mhob achos. Fodd bynnag, roedd effeithiol ecolegol cyfoethogiad maetholion yn gyfnewidiol iawn ac yn cynnwys cyfuniadau amrywiol o newidiadau i'r gymuned planhigion dyfrol; gorchudd uchel algâu ffilamtenaidd; blymau algaidd; diocsigenu'r golofn ddŵr; a cholli planhigion sensitif neu brin.

Yn yr un modd, roedd ffynonellau posibl maetholion yn amrywiol ac yn cynnwys amaeth, coedwigaeth, dyframaethu, gwaith trin carthion, ac adar dŵr (domestig a gwyllt). Mewn un achos, amlygwyd bod pysgodfa pysgod bras yn ffactor arwyddocaol o ran ail-symud maetholion presennol.

Mae angen cymryd camau ar unwaith i leihau llwytho maetholion ym mhob safle trwy amlygu ffynonellau maetholion y dalgylch a chydweithio â thirfeddianwyr lleol i reoli colli maetholion i nentydd mewnlif, dŵr daear neu'n uniongyrchol i'r llynnoedd. Mae angen i ymyrraeth reoli, fel yr argymhellir yn yr adroddiad hwn, gyd-fynd ag ymdrech o'r newydd i adfer cyflwr gwaelodlin y safleoedd, adolygu eu dynodiad SoDdGA er mwyn sicrhau y caiff targedau priodol eu gosod ar gyfer y dyfodol, a monitor parhaus o hyn ymlaen i olrhain newidiadau i'w cyflwr ac asesu effeithiolrwydd ymyriadau.

2. Executive Summary

Natural Resources Wales is responsible for the monitoring and management of Sites of Special Scientific Interest in Wales. The Welsh Environment Strategy has imposed a target of 95% of all SSSIs to be in favourable condition by 2015, and all sites to be favourable by 2026.

In this report we use the Common Standards Monitoring (CSM) that sets out a detailed monitoring framework for standing waters using a combination of biological and physico-chemical variables to assess the condition of eight Welsh SSSIs. The sites are Pysgodlyn Mawr, Llyn Llech Owain, Llyn Pencarreg, Witchett Pool, Llyn Treflesg, Llyn Cerrig-bach, Llyn Traffwll and Llyn Glasfryn. These lakes were from all parts of Wales and represented a wide variety of lake types, from peaty and acid (Llech Owain) to alkaline dune lake (Witchett Pool). However, all were lowland lakes that either were designated as SSSI habitat in their own right, or supported aquatic species dependant on lake habitat.

Assessments are based on aquatic macrophyte surveys and mapping, bathymetric survey, physico-chemical measurements, and at 4 sites, palaeolimnological analyses. The sites were generally poorly known; only Llyn Glasfryn has undergone a previous CSM condition assessment.

All of the lakes were assessed as being in unfavourable condition, in most cases with high confidence. Evidence suggests that they have been in unfavourable condition for many years and in many cases are continuing to deteriorate. The extent of damage was very variable, with some sites such as Pysgodlyn Mawr and Llyn Pencarreg being in very poor condition. Other sites were less impacted and still supported important and in some cases rare plant species, but these are threatened by poor water quality.

The cause of this was in all cases directly attributable to nutrient enrichment, in particular phosphorus. However, the ecological effects of nutrient enrichment were very variable and included various combinations of changes to the aquatic plant community; high cover of filamentous algae (‘blanket weed’); algal blooms; deoxygenation of the water column; and loss of sensitive or rare plants.

Potential sources of nutrients were likewise diverse and included agriculture, forestry, aquaculture, sewage works, and waterfowl (both domestic and wild). In one case, a coarse fishery was identified as a significant factor in remobilising existing nutrients.

Immediate steps need to be taken to minimise nutrient loading at all sites by identifying catchment sources of nutrients and working with local landowners to manage nutrient loss into inflow streams, groundwater or directly into the lakes. Management intervention as recommended in this report needs to be accompanied by a renewed effort to restore the baseline condition of the sites, a review of their SSSI designation to ensure that appropriate targets for the future are set and continuous monitoring from now on both to track changes in condition and assess the effectiveness of interventions.

3. Introduction

3.1. Background

Natural Resources Wales (NRW) is responsible for the monitoring and management of Sites of Special Scientific Interest (SSSIs) in Wales. SSSIs are the most widespread conservation designation in Britain and are the mainstay of the protected site network. Standing water SSSIs in Wales include a broad spectrum of different habitat types.

The Welsh Environment Strategy has imposed a target of 95% of all SSSIs to be in favourable condition by 2015, and all sites to be favourable by 2026. To reach this target, NRW first needs to monitor its SSSIs so that appropriate management action can be taken.

Standing water SSSIs are currently monitored according to JNCC Common Standards Guidance (JNCC 2005). This sets out a detailed monitoring framework for standing waters based on a combination of biological and physico-chemical variables.

Acidification and eutrophication are two of the major threats to freshwater SSSIs in the UK. Without historical water chemistry monitoring data, lake sediments can provide a record of past environmental change. In particular, the siliceous valves of diatoms (microscopic algae) preserved in the sediments can be used as indicators of past limnological conditions, especially lake pH and nutrient concentrations. By identifying the degree of pollution problems, this technique allows judgements on the ecological condition of sites. This report uses palaeolimnology to provide additional insights into environmental change at lake SSSIs.

3.2. Aim of the Report

The primary objective of this project is to monitor and report on the condition of a series of eight lakes in 7 different standing water SSSIs (Table 1) using a standard protocol (JNCC, 2005).

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4. Methods

4.1. Study sites

The data presented in Table 1 provides details of the 8 lakes included in this report, detailing habitat feature types, WFD typologies and CSM aquatic macrophyte survey dates.

Lake Name	SSSI Name	NGR	WFD Type*	Habitat Feature(s)	Survey date (2012)
Pysgodlyn Mawr	Pysgodlyn Mawr	ST041761	MA, V	Mesotrophic	25 June
Llyn Llech Owain	Llyn Llech Owain	SN568151	LA, V	Oligotrophic	28 June
Llyn Pencarreg	Llyn Pencarreg	SN537456	LA, S	Oligotrophic	27 June
Witchett Pool	Laugharne – Pendine Burrows	SN284076	HA, V	Hard water / Eutrophic	26 June
Llyn Traffwll	Llyn Traffwll	SH325769	HA, V	Eutrophic	21 June
Llyn Cerrig-bach	Llynnoedd y Fali / Valley Lakes	SH306766	HA, S	Eutrophic	20 June
Llyn Treflesg	Llynnoedd y Fali / Valley Lakes	SH307770	HA, V	Eutrophic	19 June
Llyn Glasfryn	Llyn Glasfryn	SH402421	MA, V	Mesotrophic?	22 June

LA, MA and HA = Low, Alkalinity, Medium Alkalinity and High Alkalinity respectively. S = shallow (Zmean = 3-15m); V = very shallow (Zmean <3m).

Table 1 Details of the lakes included in this report.

4.2. Previous Data

Although all these lakes have been designated as SSSIs for some years, these lakes are relatively poorly known. Pysgodlyn Mawr, Llyn Pencarreg, Witchett Pool, Llyn Cerrig-Bach and Llyn Treflesg have never been formally surveyed. Llyn Llech Owain was surveyed in 1995 (Monteith 1996) but this survey was conducted prior to the development of the lakes condition assessment method. Llyn Traffwll was the subject of monitoring by the Environment Agency in the 1990s (Millband 1999) and some water quality data has been collected by the RSPB. Llyn Glasfryn is to the only lake to have undergone a previous CSM condition assessment (see Burgess *et al*., 2006) and was also surveyed in 1996 (Monteith 1997). Some

4.3. Aquatic Macrophyte Surveys

The full description of the survey methods used to collect macrophyte data are detailed in the Joint Nature Conservation Committee publication for the CSM guidance for standing waters (see JNCC, 2005). In brief, the plant surveys consisted of four components; a strandline survey, emergent and marginal survey, shoreline wader survey and boat survey. These were carried out at each site on four discrete 100m sections of shoreline which were considered representative of the lake and gave good geographical coverage.

In order to reduce disturbance, a maximum of 25% of the shoreline was surveyed, resulting in less than four sections being selected at smaller lakes. Where possible, surveying was performed using a bathyscope, but a double-headed rake was used in deeper water or where poor water clarity restricted visibility. The locations of all survey sections and boat transects were recorded using a Global Positioning System (GPS), backed up with digital photographs where necessary.

These methods were devised to provide quantitative species-abundance data that can be obtained in a pragmatic and repeatable manner. The technique optimises the chance of recording those species most typical of a lake site and detecting marked changes in their frequency. However, they do not aim to produce a complete species list for a lake. Additional efforts such as sampling drift line flora were made to record other species which did not occur in any of the survey sections, but the absence of species expected or known to occur from a particular lake does not necessarily denote absence from the site.

The specified survey methods use a point-abundance approach, with abundance recorded on a scale of 1-3. However, for the purposes of data analysis for condition assessment, the presence/absence data only are utilized (except in the case of emergent and marginal species). Plant data are therefore presented as frequency of occurrence rather than abundance, and it should be noted that this is frequency within the survey sections.

The survey sections are assumed to be collectively representative of the site. However, to enable comparison with historic survey data, estimates of species abundance for each set of survey points at a site have been made from the total number of occurrences and these data have been converted to a DAFOR scale, where; D = Dominant, A = Abundant, F = Frequent, O = Occasional and R = Rare. For the submerged and floating-leaved species the DAFOR value was estimated from the total number of occurrences of each species in the wader and boat surveys as a proportion of the total number of vegetated survey points at the site, where an occurrence at >50% of points = D, 25-50% = A, 10-24% = F, 5 - 9% = O and <5% = R.

The CSM aquatic macrophyte surveys, upon which the condition assessments in this report are based, were carried out during June 2012 (Table 2.1). All field data were recorded onto standard forms printed onto waterproof paper and transferred onto a Microsoft Access database specifically designed to hold CSM records (Mike Hughes, UCL).

In-situ macrophyte identifications were made by Ben Goldsmith (JNCC accredited). Voucher specimens were collected for all taxonomically ambiguous species, unless very rare, and identifications confirmed either from fresh materials (usually in the evening of the survey) or at a later date from pressed specimens. Specimens of charophytes and *Utricularia* were preserved in IMS and sent to Nick Stewart for confirmation. Quality control was performed in-house with reference to previously collected herbaria specimens. Botanical nomenclature followed Stace (1997).

4.4. Mapping Aquatic Macrophytes

In addition to using Common Standard Monitoring methods, whole site data were also collected for aquatic macrophytes at each lake. Data were collected using similar survey techniques (double-headed rake and bathyscope) as described above, but sample locations were chosen to ensure representative data were collected from the entire site. In shallow sites, this involved evenly spaced sample points throughout the lake, whereas in deeper lakes, with depth-zoned vegetation, sample points were spaced to best capture the shifts in zonation.

All sample points were recorded using hand-held GPS and macrophyte species recorded onto a geo-reference, gridded lake outline. Species abundance was recorded on a 1-5 scale where: 1 = <2.5% cover (or one or two small individual), 2 = 2.5-10% cover (a few isolated individuals or small patch), 3 = 10-25% cover (several larger individuals, or a few patches), 4 = 25-50% cover (very obvious with many small individuals or substantial larger plans, but not dominant) and 5 = >50% cover (dominant). Consistency of scoring was maximised by Ben Goldsmith undertaking all the mapping surveys. The scores were in most parts decided by a combination of visual assessment (bathyscope) and rake sampling.

The extremely dynamic nature of aquatic plant distributions within a site means that no assumption should be made that any one species is growing between two or more other points where it is recorded. The use of single-species layers is not therefore appropriate and data are instead presented as geo-referenced abundance points for each species within a lake outline map. All data are included with the data appendix in suitable format for geographical information systems (Mapino, ArcGIS).

4.5. Physico-Chemical Survey

Dissolved oxygen temperature profiles were taken at the deepest recorded point of each site on the same dates as the macrophyte surveys, using a YSI 550 meter. These data were used to assess oxygen concentration within the water column. Secchi disc depths were recorded at the time of the macrophyte surveys from the deepest point of all lakes and further measurements were taken at each survey section at sites where variability in water clarity was observed. A standard 20 cm diameter Secchi plate was used and the Secchi depth (Z_s) expressed in metres.

CSM requires at least four quarterly samples for an assessment of water quality. The water quality data used in this report have been collated from various sources. Quarterly water samples were collected by ENSIS Ltd. from two lakes, Llyn Glasfryn and Witchett Pool between Sept 2011 and September 2012 and analysed by the Environment Agency’s National Laboratory Service (EA NLS) specifically for the purposes of CSM assessment. Chemistry data for the remaining sites were provided by NRW.

A list of determinands, their units of measurement, limits of detection (LOD) and the conversion equations used to convert ionic and alkalinity measurements from mg l^{-1} to µeq l^{-1} for ANC calculations are given in Table 2 .

Chemical Variable / Test	Code	Units	LOD	Conversion from mg l^{-1} to μeq l^{-1}
pH	pH	pH units	0.05	
Conductivity at 20ºC	Cond	μS cm^{-1}	10.0	
Alkalinity (to pH 4.5: Grans Plot)	Alk (Gran)	mg l^{-1}	-5	Alk in mg l^{-1} 5 20
Alkalinity (to pH 4.5 as CaCO3)	Alk (CaCO3)	mg l^{-1}	5	
Carbon, Organic, Dissolved as C	DOC	mg l^{-1}	0.2	
Chlorophyll a, Acetone extraction	Chl a	μg l^{-1}	0.5	
Phosphorus: Total as P	TP	μg l^{-1}	3	
Orthophosphate, reactive as P	SRP	μg l^{-1}	1	
Nitrogen: Total as N	TN	mg l^{-1}	0.2	
Nitrogen: Total Oxidized as N	TON	mg l^{-1}	0.005	TON in mg l^{-1} / 14 51000
Sodium, determined by ICPMS	Na^+	mg l^{-1}	0.02	Na in mg l^{-1}/23 51000
Potassium, determined by ICPMS	K^+	mg l^{-1}	0.02	K in mg l^{-1} / 39 51000
Magnesium, determined by ICPMS	Mg^{2+}	mg l^{-1}	0.02	Mg in mg l^{-1} / 12 51000
Calcium, determined by ICPMS	Ca^{2+}	mg l^{-1}	0.02	Ca in mg l^{-1} / 20 51000
Chloride	Cl^-	mg l^{-1}	1	Cl in mg l^{-1} / 35.5 51000
Sulphate, determined by OES	SO_4^{2-}	mg l^{-1}	0.5	SO4 in mg l^{-1} / 48 51000
Total Aluminium	Total Al	μg l^{-1}	10	
Active (labile) Aluminium	Active Al	μg l^{-1}	10	
Iron, dissolved	Fe	μg l^{-1}	3	
Silicate, reactive as SiO_2	SiO_2	mg l^{-1}	0.01	
Manganese, dissolved, determined by OES	Mn	μg l-1	10	
Copper	Cu	μg l^{-1}	0.5	
Suspended solids	S. Solids	mgl^{-1}	0.5	

Table 2 List of chemical variables analysed by the EA NLS and ENSIS Ltd. and conversion equations.

4.6. Shoreline Development Indices (SDIs) and other lake data

Lake surface area and perimeter data are derived from the UKLakes database (Hughes *et al.* 2004) and are quoted in hectares and kilometres respectively.

A Shoreline development index (SDI) has been calculated for each lake. The SDI is the ratio of the total length of the shoreline to the length of the circumference of a circle, the area of which is equal to the lake (Wetzel & Likens 1990) and has been derived from the UKLakes database (Hughes *et al.* 2004). This measurement is of interest within the context of this report because it reflects the potential availability of the littoral zone of a water body and thus the area within which plants can colonise. Lakes with a SDI near to 1.0 are generally close to being circular, whereas lakes with an SDI greater than 2 have more complex and convoluted shorelines and hence a greater potential to support a more diverse littoral community.

The collection of full Lake Habitat Survey (LHS) data for each lake was not undertaken as part of this study, but summary data were collected on a range of physical and habitat features in and around the lakes and are discussed in the condition assessment text and presented in the accompanying Microsoft Access database.

4.7. Palaeolimnological data

For many lakes, palaeolimnological evidence is used to assist with the assessment of current condition. Sedimentary diatom remains are used to reconstruct past and present environmental conditions, providing evidence for change or stability of individual lake ecosystems over time. Diatoms are used to estimate changes in total phosphorus (DI-TP) and acidity (DI-pH), and hence to compare the current status of the lakes with conditions in the past (Battarbee *et al*. 2012; Bennion *et al*. 2004; Bennion *et al*. 1996).

4.7.1. Sediment core dating

Radiometric dating was applied to four of the cores in order to place the observed biological changes in a time context. Lead-210 (half-life 22.3 years) is a naturally-produced radionuclide, derived from atmospheric fallout (termed unsupported ^{210}Pb). Caesium-137 (^{137}Cs, half-life 30 years) and americium-241 (^{241}Am, half-life 432 years) are artificially produced radionuclides, introduced to the study area by atmospheric fallout from nuclear weapons testing and nuclear reactor accidents. They have been extensively used in the dating of recent sediments.

Dried sediment samples from the four cores were analysed for ^{210}Pb, ^{226}Ra, ^{137}Cs and ^{241}Am by direct gamma assay in the Environmental Radiometric Facility at University College London, using ORTEC HPGe GWL series well-type coaxial low background intrinsic germanium detector. ^{210}Pb was determined via its gamma emissions at 46.5 keV, and ^{226}Ra by the 295 keV and 352 keV gamma rays emitted by its daughter isotope ^{214}Pb following 3 weeks storage in sealed containers to allow radioactive equilibration. ^{137}Cs and ^{241}Am were measured by their emissions at 662 keV and 59.5 keV (Appleby *et al.* 1986). The absolute efficiencies of the detector were determined using calibrated sources and sediment samples of known activity. Corrections were made for the effect of self absorption of low energy gamma rays within the sample (Appleby *et al*. 1992).

4.8. Bathymetric Survey

Sites were visited in December 2011 when plant growth was at its minimum, providing the best opportunity to collect accurate bathymetric data from lakes. Bathymetric maps and calculation of lake volume are determined using a boat-mounted, combined GPS receiver and echo sounder (Lowrance LMS240).

Many thousands of geo-referenced depths can be recorded from a lake by rowing or motoring along evenly spaced transects across the entire lake surface. These data have been stored electronically and can be used in various GIS packages to calculate lake volume and to produce high resolution contour maps (bathymetric maps) of the lakes. Protocols for the standardisation of bathymetric data collection, interpretation and output were developed by Turner *et al*. (2011) in line with NRW requirements.

4.9. Interpretation of the attribute data and overall assessment of site condition

The attribute data presented in this report has been used to assess each water body for its site condition based upon the Common Standards Monitoring (CSM) methods (JNCC, 2005). A summary table of the significance of the various attributes listed in the report is provided in Table 3. For the full method describing site condition assessment see JNCC (2005) and updated version (JNCC in prep.).

Where previous information exists for a site, this has been used to suggest possible temporal changes or stability at a site. The addition of diatom palaeolimnological data provides a powerful additional tool that can be used to set results in context. Diatom palaeolimnological data provides a temporal perspective and can reveal trends indicating stability or change in lake ecosystems. Therefore, in addition to stating whether a lake is in favourable or unfavourable condition, examination of diatom palaeolimnological data enables an assessment of whether its conservation interest is being maintained, is recovering, is declining or has been destroyed.

Bathymetric (depth) data similarly provides important contextual information that can be used to interpret the data in a more site-specific way. For example, shallow lakes tend to be less sensitive to nutrient enrichment, because they have a larger area where macrophytes can grow, and the macrophytes are able to absorb excess nutrients to a certain extent. However, they are more sensitive to increased numbers of fish and waterfowl, which tend to thrive in shallow warm water and uproot the macrophytes. Data on mean depth is used for several of the WFD reference models, notably to predict phosphorus and chlorophyll concentraions. An understanding of the depth profile of a lake is also helpful if the need arises to manage water levels, and to predict areas of suitable habitat for fish spawning or for certain rare plants.

Seven condition assessments in this report are from sites that have not been assessed before using the CSM method. They identify general categories of impact (e.g. acidification, eutrophication, management) and in the case of a site being in unfavourable condition, recommendations are made for further investigation and / or management action. Where sites have been previously surveyed, we have used the data to evaluate changes since the last survey.

Attribute	Significance and Interpretation
Extent	This attribute is to assess changes caused by active management, such as infilling or channel diversion resulting in loss of habitat. Loss of part of a lake (by reduction of the water level) may also have significant effects on the rest of the water body, since other areas will be shallower and warmer. Changes due to drying out or successional changes are covered under other attributes.

Attribute	Significance and Interpretation
Macrophyte community composition	Macrophytes are useful biological indicators in their own right, especially for nutrient enrichment. They are also an important structural component for other species. However, macrophytes are relatively poor indicators of acidification. At least a significant proportion of the vegetated area of the water body should have an expected frequency of characteristic aquatic species for a given lake type. Two aspects of composition are measured: whether overall taxonomic composition is representative of the lake type, and whether the most frequent macrophyte(s) are typical. There may be valid reasons why a characteristic species is not present at a site (such as biogeographic range or isolation from source populations) which are considered when applying targets to an individual site.
Negative indicator species	Highlights invasive non-native species and atypical species for the water body. A number of non-natives have such invasive potential that they should be assessed separately. Species of particular concern are: *Crassula helmsii*, *Hydrocotyle ranunculoides*, *Myriophyllum aquaticum* and *Azolla filiculoides*. If any of these species are present, a water body should be considered as being in unfavourable condition. This list is not exhaustive and should be updated as new threats become apparent. Colonisation since the previous field visit by *Elodea nuttallii* or *Elodea canadensis* is indicative of unfavourable condition, as is dominance of naturalised non-native species, such as *E. canadensis*. Occurrence of such species at >40% frequency in unproductive waters, and >50% frequency in more productive waters, is indicative of unfavourable condition. Excessive growths of filamentous algae on lake substrate or macrophytes are indicative of nutrient enrichment. Cover of benthic and epiphytic filamentous algae should be less than 10%
Macrophyte community structure	Most lakes have a characteristic zonation, with deep water submerged plants, shallow water submerged plants, floating leaved vegetation, swamp vegetation and marginal plants - with no plants at all in the deepest areas. The maintenance of this hydrosere is an important part of the functioning of a lake. The maximum depth at which submerged vegetation is able to grow is a direct indicator of water clarity and can be a useful indicator of nutrient enrichment or sedimentation, since increased water turbidity will kill plants growing in deepest water first. Maxiumum depth distribution is also a general indicator of the status of the macrophyte community and should be maintained during future visits.

Attribute	Significance and Interpretation
Water quality	Mean annual TP concentrations (based on at least quarterly measurements), should meet the targets appropriate for the lake type documented in the guidance, unless site-specific targets are available from hindcast or palaeoecological studies. There should be no evidence of excessive blue-green or green algal blooms. In low nutrient waters, blooms would not be expected to occur. Lakes should exhibit stable and characteristic pH values for their type and poorly buffered upland lakes should be assessed for signs of acidification. Sites should demonstrate adequate dissolved oxygen to support aquatic fauna.
Hydrology	There should be a natural hydrological regime. There should be no evidence of impact from lowered or artificially raised water levels due to abstraction or increased / reduced flows to in- / out-flows. Bank modifications should be limited to less than 5% of the shore length and the impact of grazing or erosion from boat wash assessed.
Lake substrate and sediment load	Natural substrates and shorelines should be maintained. Increased sediment loads may result in smothering of coarse substrates with fine sediments. Changes in plant community may result from enriched sediments without an accompanying change in water chemistry. Increases in siltation could result from increased lake productivity, changes in catchment land-use (particularly over-grazing), lake level fluctuations, climatic fluctuations, or changes in sewage treatment.
Indicators of local distinctiveness	Maintain rare species and habitat features at current extent/levels and/or in current locations. For “notable” species (e.g. nationally scarce plants), it is not intended that a target is set for detailed species monitoring. It is intended that a rapid indication of presence/absence and /or approximate extent should be provided. Allowing for natural fluctuations in population size. The same approach applies to “notable” habitats.
Diatom Palaeo-limnology	Diatoms are a group of ubiquitous microscopic algae with siliceous valves (shells) that persist in lake sediments. Unlike macrophytes, they are excellent dispersers and this means that changes in the diatom flora can be reliably linked to changes in environmental conditions rather than colonization effects. These algae are therefore good indicators of the health of a lake, both in the past and in the future, and therefore provide the best means of assessing trends in condition.

Table 3 Significance and interpretation of CSM attributes used for site condition assessment (from JNCC, in prep.).

4.10. Total Phosphorus limits

Total phosphorus (TP) is a key parameter used in the assessment of a water body. There is often a direct relationship between TP concentrations and increased phytoplankton biomass (OECD, 1982) and this algal growth can have significant impacts upon the lake ecosystem. Increased algal biomass suppresses plant growth through increased turbidity and nutrient competition and can alter a water body in other ways by influencing pH, oxygen concentrations as well as affecting other biotic and abiotic factors.

Some lake types have a greater resilience to nutrient enrichment as phosphorus is bound up in sediments (e.g. marl lakes) or on plant biomass (e.g. mesotrophic and natural eutrophic lakes), but beyond certain thresholds the lakes become susceptible to a range of factors which may result in the switch from clear water, plant dominated conditions to a more turbid, algal dominated state.

Lake Type	Corresponding Feature Type	Depth Category	Upper TP limit (μgl^{-1} as P)
Peat	Dystrophic	Deep	10 (?)
		Shallow	10 (?)
Low Alkalinity	Oligotrophic	Deep	10
		Shallow	10
Medium Alkalinity	Mesotrophic	Deep	15
		Shallow	20
High Alkalinity	Eutrophic	Deep	35
		Shallow	50
Marl	Hard water	Deep	20
		Shallow	35
Brackish	Brackish	Deep	35
		Shallow	35

Table 4 Total phosphorus targets for designated lakes (JNCC, 2005).

The upper limits for TP outlined for the different lake types in Table 2.4 represent the concentrations beyond which it is considered there is an unacceptable risk to the site integrity. The Core Management Plans for each SAC occasionally provide site-specific upper limit values for TP. Where provided, the site-specific values are used in place of the general lake type target values. The upper limits for TP in dystrophic / peat lakes are set at $10\mu gl^{-1}$, but site specific values may be necessary where other nutrients (e.g. N) are limiting (JNCC 2005).

We have also compared phosphorus concentrations to the site-specific morpho-edaphic index (MEI) model for phosphorus used by the UK for the Water Framework Directive. This model uses a combination of mean depth, alkalinity and altitude to predict a site-specific reference TP for every lake in Britain where relevant data are available. We used measured alkalinity and depth data from the current survey as predictor values, except where mean depth was <1m, in which case the mean depth was set to 1m. This is because the model tends to over-predict TP values in very shallow lakes (G. Phillips pers com). The model predicts class boundaries for the lake, so it is also possible to place annual mean data into an equivalent WFD phosphorus class.

4.11. Acidification environmental standards (ANC boundaries)

Acidification is the total outcome of a complex set of chemical processes. pH reflects acidity rather than acidification, although it is a good proxy for the toxic effects of labile aluminium (L-Al). Acid Neutralising Capacity (ANC) is typically taken as a measure of available buffering capacity in aquatic systems and is a direct measure of anthropogenic acidification. Two forms of ANC are currently used: Cantrell (ANC-C) and Ion balance / ionic (ANC-I). ANC-C requires less data (alkalinity and dissolved organic carbon) than ionic (all acid anions and base cations).

The current ANC-I standard consistent with the protection of natural waters is >20 μeql^{-1} (JNCC, 2005), except in cases where it is estimated that ANC has always been lower than this value, in which case the recommended standard is $0\mu eql^{-1}$ (DEFRA, 2004).

We recommend that future acidity targets for CSM assessments are based on the WFD High / Good boundary for C-ANC of $40\mu eql^{-1}$. This harmonized boundary will provide much better protection for protected sites. Current recovery rates generally suggest that this target is achievable, even at highly acidified sites.

In the current report, either ANC-I or ANC-C (or both) have been calculated dependent upon the availability of the necessary water quality data. Reference is made to ANC-I and/or ANC-C standards as appropriate. Equations used to calculate ANC-I and ANC-C are provided below:

$$\text{ANC-I} = (\text{base cations} - \text{acid anions}) \text{ in } \mu eql^{-1}$$
$$= (Ca^{2} + Mg^{2+} + Na^{+} + K^{+}) - (Cl^{-} + SO_4^{2-} + TON + SRP)$$

$$\text{ANC-C} = (\text{Alk in } \mu eql^{-1} + (4.5 \times \text{DOC in } mgl^{-1}))$$

4.12. Trophic scores (TRS and PLEX)

Trophic scores are a method designed to infer the ecological condition of standing waters using the composition of the submerged plant community. Scoring systems such as this use the known nutrient preferences of the plant community to infer the trophic status of the lake. These systems have been used in rivers with some success (e.g. Holmes *et al*. 1999, Schneider & Melzer, 2003), and in the UK, a modified form of this system (LEAFPACs) has recently been developed as a WFD tool for both rivers and lakes (Willby *et al*., 2009).

Trophic scores are not a formal part of the CSM methods, but have been presented here to provide additional contextual information. Two different trophic scores have been calculated: Trophic Ranking Score (Palmer, 1992) and the Plant Lake Ecosystem Index (PLEX) (Duigan *et al*., 2006).

Trophic Ranking Scores (TRS: Palmer, 1992) were calculated from presence / absence data. In additions to TRS scores, Plant Lake Ecosystem Index (PLEX) scores (Duigan *et al*., 2006) have been calculated for each lake. PLEX is essentially a development of the older TRS system, but has been developed using a larger dataset and incorporates a greater range of species. It can be used for comparing different sites and for detecting change over time at individual sites.

Although trophic scores may provide useful, easily accessible information, they need to be interpreted with caution. Macrophyte communities respond to various factors, of which nutrients are not always the most important (Demars & Harper, 1998). The ability of any macrophyte community to reflect changes in nutrient loading will depend on the species pool present and many macrophyte species have a broad nutrient tolerance, making them relatively poor indicators of trophic status (Holmes *et al*., 1999). Macrophyte populations in stressed communities may also fluctuate widely and unpredictably (Jeppesen *et al*., 2005).

Consequently, the trophic indices have not been used directly as part of the condition assessments, though where a change in a fertility score tracks a corresponding change in one of the key variables, this is discussed. The trophic scores also provide a means of general comparison between sites and between the current surveys and historic macrophyte survey data. Once further work has been carried out in this field, it may be possible to compare these results with future CSM data and place them in their proper context.

4.13. Changes to the CSM methods

Following the publication of the CSM guidance for standing waters (JNCC, 2005) and subsequent trials and implementations of these methods by the UK conservation agencies, subsequent review has recommended various changes to the assessment method. These have been incorporated into the assessments in discussion with NRW.

The methodology has been under further review in 2013 /14. While we have been unable to include all the recommendations of the as yet unpublished guidance, the removal of *Potamogeton pusillus* as a characteristic species for naturally eutrophic sites was included within this report. The fine leaved *Potamogeton* spp. are considered as being representative of more degraded eutrophic lakes and therefore the target species are focussed more towards broadleaved *Potamogeton* species.

4.14. List of Abbreviations Used.

Depths

- Z_{max} = Maximum recorded water depth
- Z_s = Secchi depth (recorded summer 2012)
- Z_v = Maximum macrophyte colonisation depth (recorded)

Limnological data

- TP = total phosphorus
- TN = total nitrogen
- Chl *a* = chlorophyll *a*
- Alk = total alkalinity
- DOC = dissolved organic carbon
- ANC-I = acid neutralising capacity – ion balance (base cations – acid anions)
- ANC-C = acid neutralising capacity – Cantrell (Alk μeql^{-1} + (4.5 × DOC in mgl^{-1}))

Water Framework Directive (WFD) lake typologies

- Alkalinity

- D = dystrophic (Any alkalinity but Colour > 30 Pt units)
- LA = low alkalinity <10 mgl^{-1} CO_3^{2-}
- MA = medium alkalinity 10-50 mgl^{-1} CO_3^{2-}
- HA = high alkalinity >50 mgl^{-1} CO_3^{2-}

- Depth
  - D = deep (Z_{mean} > 15 m)
  - S = shallow (Z_{mean} 3-15 m)
  - V = very shallow (Z_{mean} <3 m)

5. Site Condition Assessments

5.1. Pysgodlyn Mawr

Annex 1 type: H3130: Oligo-mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the Isoëto-*Nanojuncetea.* Listed as mesotrophic.

5.1.1. Site description

Table 5 Summary characteristics for Pysgodlyn Mawr.

Name:	Pysgodlyn Mawr
County:	Vale of Glamorgan
WBID:	42392
Grid reference:	ST041761
OS Grid reference (X,Y):	304125,176120
Latitude / Longitude	N51°28.55',W003°22.91'
Altitude (m):	112
Maximum recorded depth (m):	1.6
Mean depth (m):	1.01
Lake volume (m^3):	12128
Surface area – UKLakes (ha):	2.1
Surface area – measured (ha)	1.195
Perimeter of lake – UKLakes (km):	0.7
Shoreline Development Index (SDI):	1.433
WFD alkalinity based typology:	Med Alkalinity, V Shallow (MA, V)
Phase 1 habitat type:	Mesotrophic lake
Survey Date:	25 June 2012

Pysgodlyn Mawr (Big Fishlake) is a small lake which, along with the associated wetland habitats was designated as a SSSI in 1972. The lake itself is artificial in origin, and most likely dates back to the medieval period. It appears that by the 1970s the earth dam and sluice were in a poor repair and were replaced by the current structure in 1976, at the same time as the site was apparently dredged. The extent of the dredging has not been established. The site was notified due to the occurrence of several aquatic species including Pillwort (*Pilularia globulifera*), Downy emerald dragonfly (*Cordulia aenea*), and Medicinal leech (*Hirudo medicinalis*). According to the NRW management plan, pillwort has not been recorded from the site since 1971, and it is likely that the installation of the dam in 1976 stabilised the water depth at a level too high to support this priority species. In addition to the open water, there is an extensive area of wetland around the western margin with habitats ranging from floating reed swamp, through to willow carr.

The immediate catchment area is managed by the Natural Resources Wales (Forestry) and comprises mixed plantation woodland (Hensol Forest). The site is used as a coarse fishery by Glamorgan Anglers Club and while no longer actively stocked by the club, does include non-native common carp and grass carp in addition to a mixed native fish population (perch, tench, crucian carp, rudd, roach, bream and eels. The GAC web site reports that a wels catfish was landed in April 2012 (www.glamorgananglersclub.org.uk).

5.1.2. Condition Assessment and Discussion

Attribute	Target	Status	Comment
Extent	No loss of extent of standing water	✓	High water levels maintained by a dam.
Macrophyte community composition	Mesotrophic: ≥ 3 characteristic *Potamogeton* species and ≥ 8 characteristic in total from Box 2 (less if valid reasons exist)	X	No characteristic mesotrophic species recorded
	No loss of characteristic species (see Box 2)	X	*Pilularia globulifera* recorded in SSSI Citation (1971). No longer present.
	≥ 6/10 vegetated sample spots (boat / wader survey) have ≥ 1 characteristic spp.	X	No characteristic species present
Negative indicator species	Non-native species absent or present at low frequency	X	Site contains *Nymphoides peltata* (79% - non-native to Wales) and a cultivar variety of *Nymphaea* with pink flowers
	Benthic and epiphytic filamentous algae <10%.	✓	Very little filamentous algae recorded – all cover scores 0-1.
Macrophyte community structure	Characteristic vegetation zones should be present (site specific)	X	Site very shallow with almost no submerged aquatic vegetation. Floating leaved species (introduced) recorded to 120 cm.
	Maximum depth distribution should be maintained	✓	Z_{max} (recorded) = 1.6, Z_s = 0.37 m, Z_v = 1.2 m. Dredged in 1976.
	At least present structure should be maintained	**N/A**	No previous data against which to assess.
Water quality	Stable nutrients levels: TP target / limit: Mesotrophic < 20 $\mu g l^{-1}$	X	TP = 40.5 $\mu g l^{-1}$ (<20 – 62) TN = 0.77 $mg l^{-1}$ (range 0.46 – 1.26). WIMS Data 10/11 – 09/12 .
	Stable pH values: pH ~ 5.5 – circumneutral	✓?	pH = 6.70 (range = 6.3 – 7.0) WIMS Data 98/99
	Adequate dissolved O_2 for health of characteristic fauna (>5$mg l^{-1}$)	**?**	5.27 – 8.64 $mg l^{-1}$ from max depth to surface. Anoxia likely under calm conditions.
	No excessive growth of cyanobacteria / green algae	X	Chl *a* high - mean = 8.7 $\mu g l^{-1}$; range = 1.1 - 26.8.

Attribute	Target	Status	Comment
Hydrology	Natural hydrological regime	✓?	Site is created by an earth bank and concrete dam at outflow. Under natural control.
Lake substrate	Natural shoreline maintained	X	C. 40% of shoreline denuded by angling areas.
	Natural and characteristic substrate maintained	✓?	Unknown – site dredged in 1976
Sediment load	Natural sediment load maintained	X?	Potential for increased sediment loads from forestry, footpath and bank erosion. Re-suspension by carp.
Indicators of local distinctive-ness	Distinctive elements maintained at current extent / levels / locations	X	No *Pilularia globulifera* recorded. Downy emerald dragonfly recorded during survey.
Disturbance	No introduced species	X	*Nymphoides peltata* and *Nymphaea* cultivar spp. abundant and frequent at site.
	Minimal negative impacts from recreation and navigation. No fish farming	X?	Footpath and fishing areas appear to have caused disturbance to N and SE shores. Extent of problem unertain.
Palaeo evidence	No evidence of significant environmental change e.g. acidification or eutrophication	X	Di-TP suggests moderate enrichment

Status: ✓ = pass; X = fail; NA = Not assessed.

Table 6 Condition Assessment Summary Table for Pysgodlyn Mawr

Extent

The surface area of the lake was measured as 1.195ha, although it is listed as 2.1ha on the UKLakes database; the latter being an error in the auto-calculation from the 1:50,000 OS data and no doubt some loss of area from encroaching wetland. Other than this natural encroachment of the marginal vegetation around the western side, there is no evidence for any loss of the extent of open water. Since designation in 1972, the retaining dam has been strengthened with a concrete barrier with the effect of stabilising the water depth at a higher level and increasing the extent of open water slightly. This is likely to have reduced the habitat availability for pillwort, a species which was last recorded at the site in 1971 (BSBI distribution database, searched July 2014).

Macrophyte community composition

Table 7 summarises the results of the aquatic macrophyte survey. No submerged aquatic species were recorded in the site and of the native species present, *Lemna* *minor* was only recorded from the edge of the wetland fringes and within the lily beds. No pillwort Pilularia globulifera, for which the site is designated, was found.

A single plant of *Potamogeton natans* was found growing in 50 cm of water on the west side. *Nymphaea alba* was also present and it was assumed during the survey to be the native wild species, but given the introduction of other cultivar lilies to the site, it may in fact be an introduced white cultivar. This would require further investigation of fresh material to confirm.

Most common in the lake was *Nymphoides peltata* which was locally abundant at depths between 25-120 cm. This species is outside its native range within the UK (Preston & Croft 1997). In addition to the white water lilies, a pink *Nymphaea* hybrid was present. The two records from the CSM survey slightly under-represent the overall frequency of this plant in the site (see plant maps below). No characteristic mesotrophic species were recorded and the site is therefore unfavourable with respect to its aquatic flora.

Submerged and floating vegetation	TRS	PLEX	% occurrence (n=43)	DAFOR abundance[1]	Min depth (cm)	Max depth (cm)
Lemna minor	9.0	8.85	9.3	R	0	25
Nymphaea alba	6.7	3.08	18.6	O	80	80
Nymphaea spp. "cultivar"			4.7	R	75	90
Nymphoides peltata			79.1	A	25	120
Potamogeton natans	7.0	4.23	2.3	R	50	50
Average score	**7.56**	**5.38**				
Species richness	**5**	**5**				

Table 7 Aquatic macrophyte community composition for Pysgodlyn Mawr, June 2012

Negative indicator species

Although not classed as a negative indicator species within the CSM guidance (JNCC 2005) *Nymphoides peltata* is not native to Wales, and as such is in effect a negative element of the flora with respect to its naturalness. This is also true of the pink-flowered *Nymphaea* cultivar.

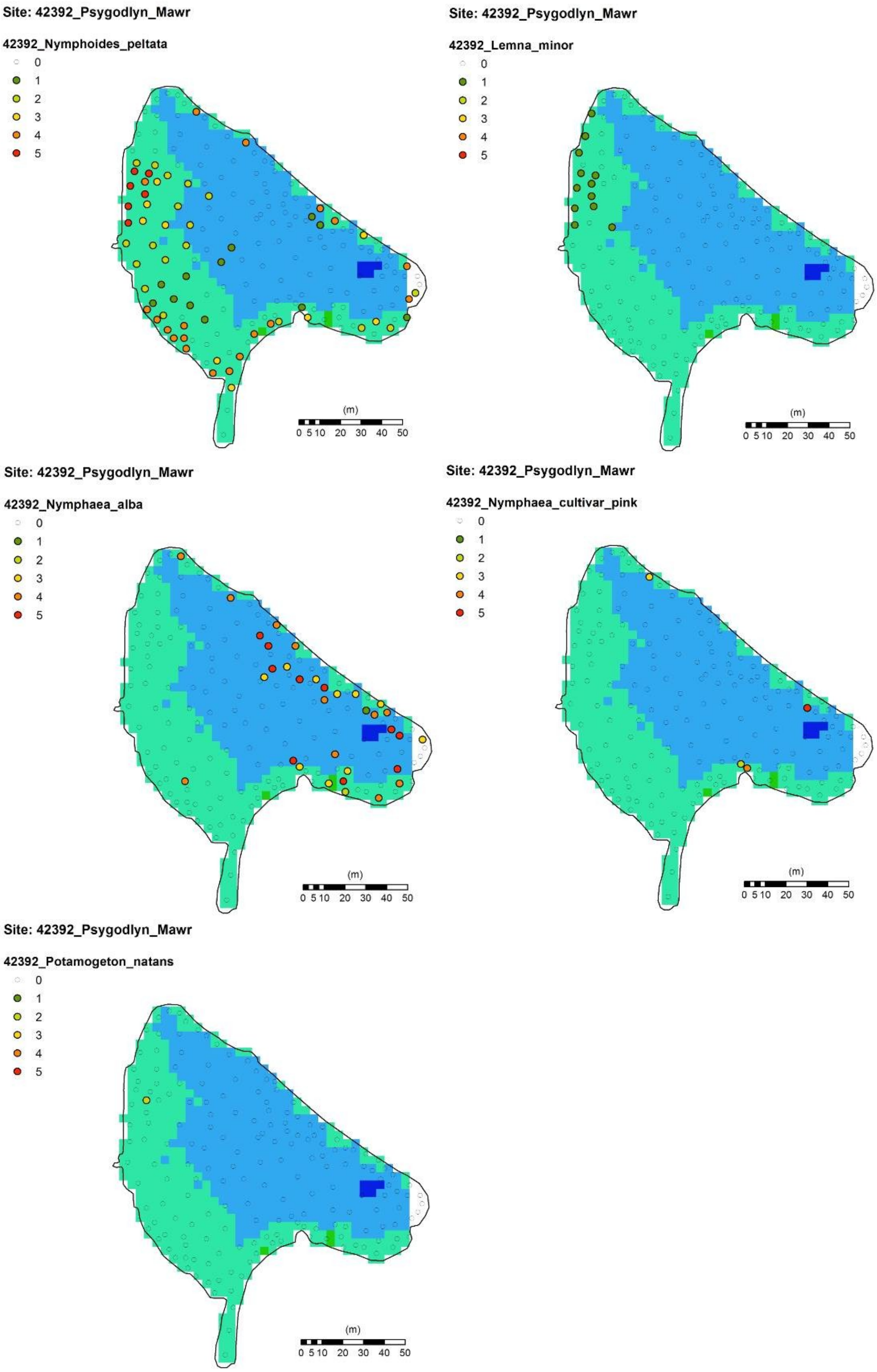
Macrophyte community structure

The lack of any submerged aquatic plant species is indicative of poor community structure. The presence of a number of floating-leaved species, while not all native, does at least provide habitat for aquatic invertebrates and gives the site some resilience as a habitat for dragonflies and damselflies for which the site is noted. The north and east of the lake offer little in the way of hydrosere, with steep banks

[1] Based on presence / absence data from all vegetated plots in the wader and boat based surveys. DAFORs are calculated from the total number of occurrences across the wader and boat surveys as a proportion of the total number of vegetated wader and boat survey points. A plus (+) denotes a taxon recorded as present at the site but not found growing in the wader or boat survey sections

grading directly into woodland with disturbance from angling areas and the path and additional problem along the north shore. The distribution of the aquatic vegetation is best seen from the mapping data presented in Figure 1.

Figure 1 Distribution maps of the aquatic plant species recorded in Llyn Pysgodlyn Mawr



By contrast, the wetland areas around the south and west margins are extensive and support a relatively rich flora grading from semi-floating vegetation dominated by *Hypericum elodes, Carex rostrata, Eqisetum fluviatile* and *Potentilla palustris,* through to stands of *Eupatorium cannibinum, Lycopus europaeus, Typha latifolia* and *Salix* spp. carr. The extent of the wetland area and habitat diversity therein makes these wetlands a notable feature within the SSSI. The open water macrophyte composition is however very poor.

Water quality

Pysgodlyn Mawr is a very shallow lake (Z_{max} recorded = 1.6 m, Z_{mean} = 1.01 m) which is well buffered (ANC-I = 439 µeq l^{-1}). The Environment Agency derived WIMS data (Table 8) show the mean (n=11) annual total phosphorus concentrations to have been double the acceptable limit for shallow mesotrophic lakes (20 µg l^{-1}) in 2011/12 and values are higher than the 1998/9 mean (n=12). The MEI model predicted a reference TP of 11 µg l^{-1} for Pysgodlyn Mawr. Both the 1998-99 and 2011-12 mean TP would have placed the lake in 'moderate' status, though the more recent reading is only just below the Moderate / Poor boundary of 42 µg l^{-1}.

At the time of survey, dissolved oxygen concentrations were adequate (5.27 – 8.64 mg l^{-1} and Figure 2), but the water was very turbid and brown in colour, with what appeared to be a high concentration of fine suspended matter. Mean DO was 7.12 which equates to Good Ecological Status for a cyprinid water. However, for such a shallow water body in Wales these values are relatively low and it is probable that Pysgodlyn Mawr is at risk of deoxygenation.

Based on the available data the water quality falls below expected standards for TP and is probably deteriorating. Pysgodlyn Mawr therefore fails with respect to water quality.

Table 8 Water chemistry data for Llyn Pysgodlyn Mawr (for units see methodology)

Determinand	Annual mean 1998-99	Annual mean 2011-12
pH	6.67	-
Cond	125	-
SRP	3.8	4.6
TP	29.9	40.5
Chl a	-	8.75
TN	-	0.77
TON	0.10	0.06
Na^+	-	16.75
K^+	-	0.82
Mg^{2+}	-	2.01
Ca^{2+}	-	8.57
Cl^-	26.37	27.52
$SO4^{2-}$	-	6.08
ANC-I (ionic)	No data	438.7
ANC-C (Cantrell)	No data	No data

Hydrology

Two small inflows enter the site from the north and south, both draining areas of coniferous and mixed broadleaf plantation. The outflow discharges over a small dam (c. 1.5 m high) and forms a tributary of the Afon-Elái. The building of the dam (and lake dredging) lake in 1976 greatly reduced the natural water level fluctuation at the site. The dam is a fixed structure and water levels in the lake are not otherwise managed.

Dissolved Oxygen Profile

GPS Location	ST0418676117
Maximum Depth (m)	1.2 m
Secchi Depth (cm)	37 cm

Notes: Deepest point 150 @ ST0422276122

Depth (m)	DO (mg/l)	Temp (°C)
0	8.64	18.3
0.5	7.44	16.3
1	5.27	14.9

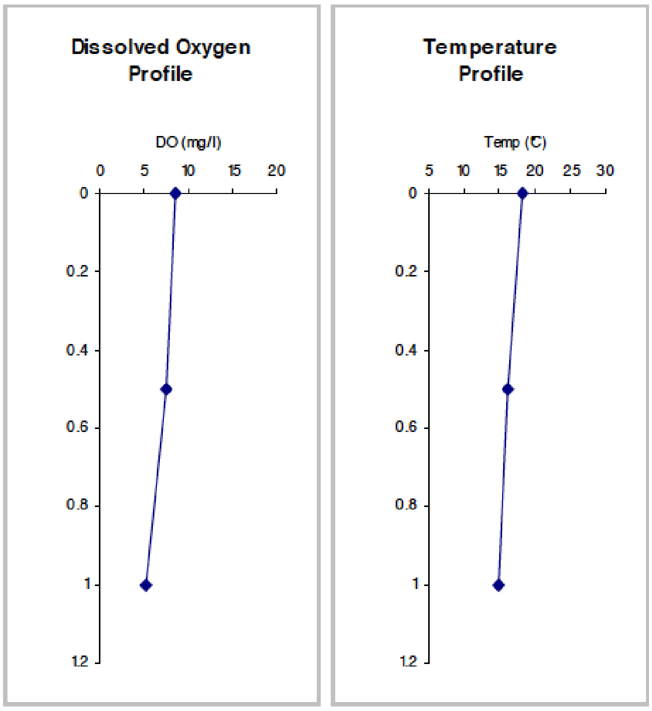


Figure 2 Dissolved oxygen (DO) profile for Llyn Pysgodlyn Mawr, June 2012.

Lake substrate and sediment load

The lake sediments appeared relatively unconsolidated and were noticeable more organic around the wetland compared with the north shore. Fishing areas along the bank, as well as the footpath can be seen to have caused erosion of the banks.

The effect of the forestry may also have had a historic impact on the site during periods of planting and harvest. The area was first planted between 1920 and 1947 (OS map data) and a ten-fold increase in sediment accumulations rate was observed between approximately 1945 to 1957 falling back to pre-war rates by 1960 (see sediment core dating below). This would suggest period of harvesting or high disturbance in the area at that time, with a resultant impact on the natural sediments of the site.

Current sedimentation rates are relatively high, and may result from not only higher input, but also re-suspension of sediments by the carp in the lake. The high turbidity in June 2012 appeared to be due to re-suspended material. The current situation is unfavourable pending further investigation.

Indicators of local distinctiveness

The site once supported Pillwort, *Pilularia globulifera.* BSBI records show that this BAP Priority aquatic fern was first recorded at Pysgodlyn Mawr in 1807, and there are 15 records in the 20th Century between 1904 and 1971. However, there are no subsequent records and this was also the last record of *Pilularia* from Glamorganshire. Pysgodlyn Mawr does however remain one of the few sites in the country for the Downy Emerald dragonfly (confirmed during the June 2012 survey) and has records for over 15 other dragonflies and damselflies. The site is also reported to be one of only 20 to support medicinal leeches. The current status of this species at the site is unknown.

Lake Bathymetry

The bathymetric survey confirms the site to be very shallow with the deepest point of 1.6 m lying towards the dam at the eastern end (Figure 3)

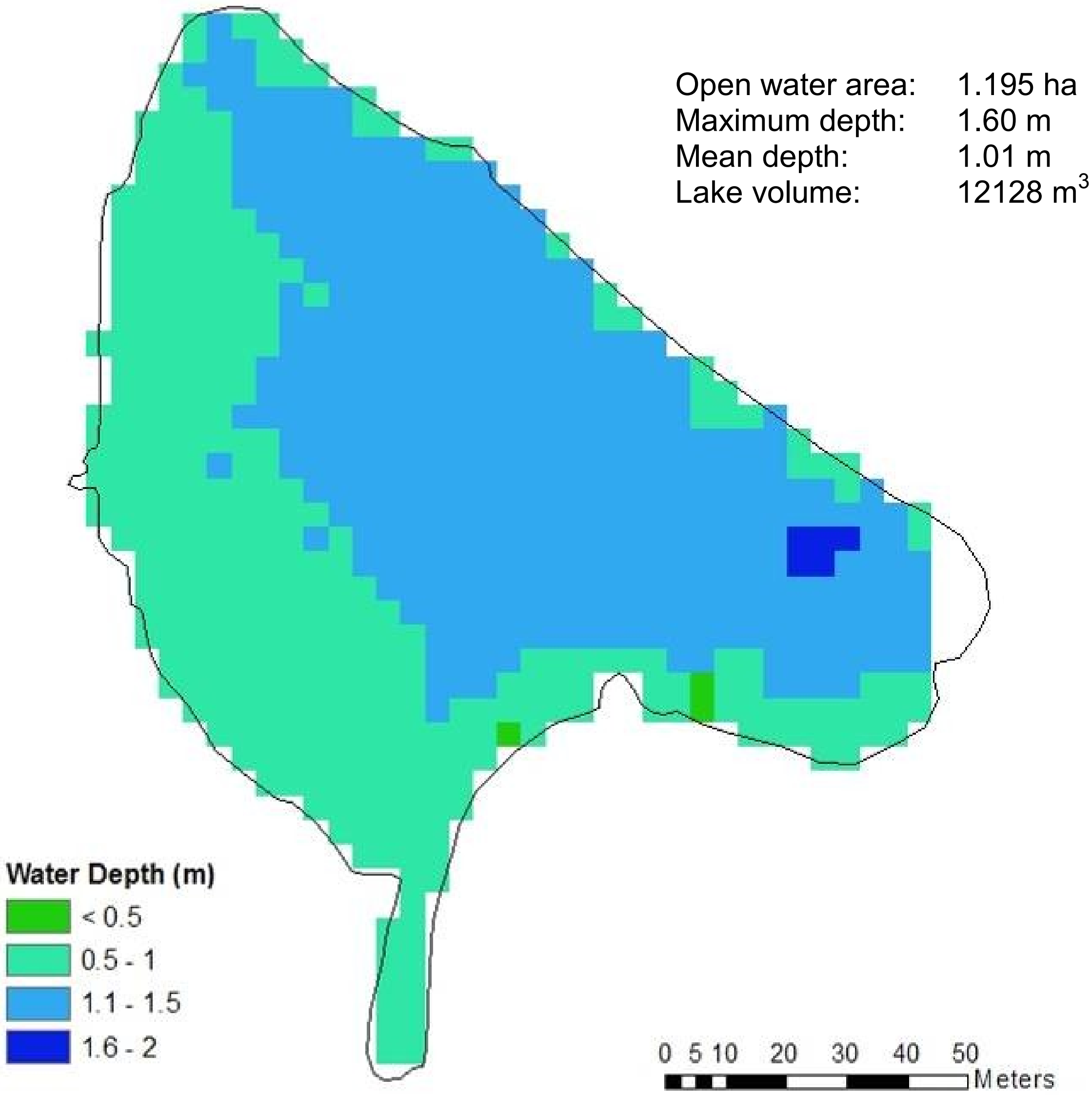


Figure 3 Bathymetric map of Llyn Pysgodlyn Mawr, December 2011

Palaeolimnological evidence

A 31 cm sediment core (PYSG1) was taken from the deep point (1.6 m at ST0423476109) using a Renberg gravity corer. The core was sliced at 1 cm intervals in the field and analysed for dry weight, organic content and carbonate content. A subset of samples were dried and subjected to radiometric dating. The physical analysis of the core shows a very distinct change in the organic content (%LOI) between 25 – 15 cm (Figure 4). The dating suggests this to correspond with the period from approximately 1930 to 1972 and thus the increase in organic matter is most likely due to afforestation and the resultant inwash of organic matter from the catchment.

This interpretation is complicated by the knowledge that the site has been dredged. The extent of the dredging is not known, but the rapid extinction of unsupported lead 210 (^{210}Pb) below 23 cm does suggest a major disturbance or non-continuous sequence. This pre-dates 1976 however and it is therefore likely that the site has been dredged or drained on more than one occasion. Above 15 cm (c. 1972) there is little change in the sediment composition, but sedimentation rates have increased from 0.03 g cm^{-2} yr^{-1} to 0.07 g cm^{-2} yr^{-1}. The increased sedimentation may reflect increased productivity in the lake, but it is more likely the result of sediment re-suspension and re-distribution caused by bottom feeding fish (carp and grass carp) in the lake.

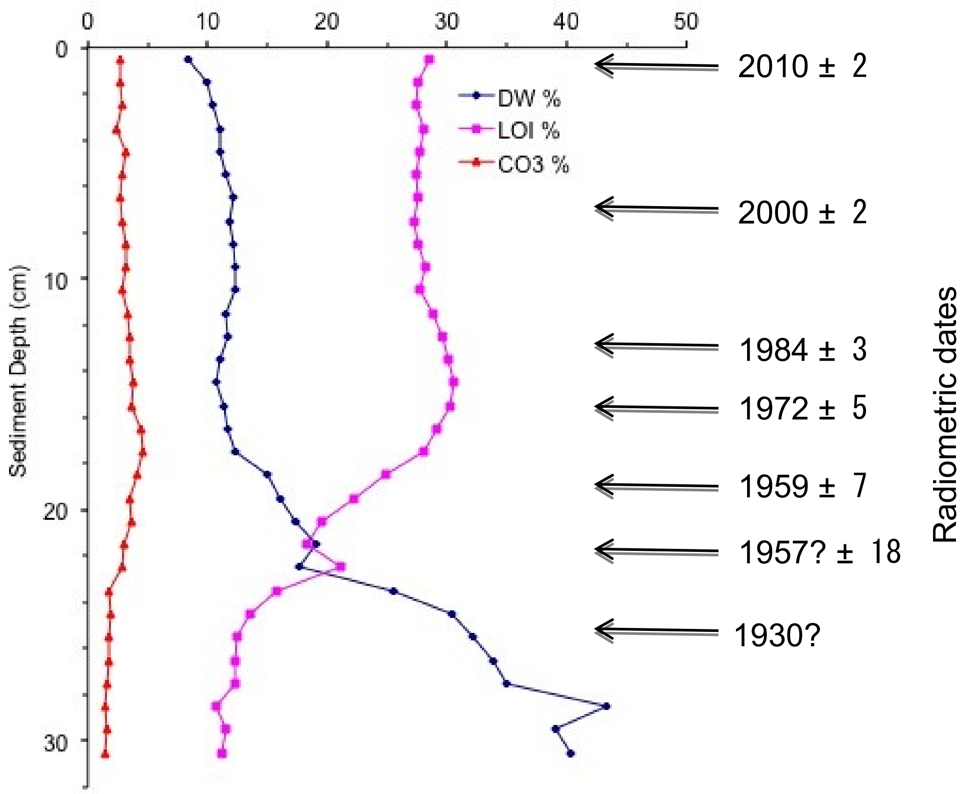


Figure 4 Physical characteristics and radiometric dates from core PYSG1

The diatom flora is dominated by benthic taxa, consistent with the lake being shallow. The surface sediments are dominated by *Achnanthes minutissima,* and *Eunotia* spp. as well as *Tabellaria flocculosa.* The basal sample was dominated by *Fragilaria construens* var. *venter* and motile species including *Navicula* spp. and *Gomponema* *spp.* Species turnover between the two samples was relatively high, with squared chord distance (SCD) between the samples of 0.95 (Table 9).

Sample Code	Depth (cm)	1998/99 mean pH	DI-pH	2011/12 mean TP	DI-TP	SCD
PYSG1-0	0	6.67	6.71	40.5	32.2	0.95
PYSG1-27	27		6.87		15.6	0.00

Table 9 Results of Llyn Pysgodlyn Mawr sediment core analysis

Reconstructions of diatom-inferred pH (DI-pH) were produced using the SWAP training set (RMSEP = 0.32 pH units). Fossil assemblages from both samples were dominated by benthic species typical of circum-neutral shallow lakes. As a result, the DI-pH was in good agreement with the most recent measure pH (1998/99) and there appears to be little change over the time period covered by the core.

Reconstructions of diatom-inferred TP (DI-TP) suggests the site to have become enriched with a doubling of modeled TP from the core bottom and top (15.6 to 32.2 µg l^{-1}). There were no major analogue problems with the core samples, with fossil assemblages being well represented in the NW European training set. The current annual mean TP based on quarterly water samples was 40.5 µg l^{-1} and therefore the diatom model slightly underestimates current conditions, but does suggest the site to have become enriched.

The relatively high species turnover between the top and bottom sample is thought likely to be a result of changes in water clarity at the site. Many of the diatom species recorded in the base of the core are motile taxa that are found living within the fine sediments and biofilms on the lake bed. This indicates that light penetration was good, whereas the uppermost sediments lack these motile species and are dominated by species more often associated with hard surfaces (marginal habitats) and plant stems). The lack of motile species is indicative of low light penetration to the lake bed. Alternatively the motile taxa in the basal sediments may result from the site having had greater water level fluctuation and hence periods of low water level during which light penetration to the lake bed was higher.

In summary, although the diatom flora indicates enrichment to have occurred within Pysgodlyn Mawr, the primary driver of species chance is thought more likely to have been due to a deterioration water clarity and / or water level fluctuation within the site. Changes to water clarity are likely to be due to fish stocking, particularly carp, which are a primary cause of sediment re-suspension in shallow lakes. Furthermore, we know water levels have been stabilized at the lake with the instillation of a fixed barrier at the outflow in 1976.

Site condition summary and overview

Pysgodlyn Mawr is **unfavourable**, with **high confidence**, both with respect to macrophyte species composition / structure and water quality. The lake has no characteristic mesotrophic species and there is evidence that species have been lost from the site. Water quality is relatively poor with respect to phosphorus concentrations and the water was very turbid at the time of survey. The presence of non-native fish species (including common and grass-carp and reports of wels catfish) is likely to exacerbate this problem by disturbance of the sediments while feeding.

The current flora is dominated by *Nymphoides peltata,* which although native to the UK is not native to Wales. A pink cultivar variety of water lily has also been introduced to the site. The presence of cultivated lilies increases the likelihood that the white water lily recorded at the site may also have been introduced from non-native stock. With the exception of *Lemna minor* and a single plant of *Potamogeton natans* no other aquatic species were recorded. The floating mats of marginal vegetation which grade into *Salix* carr around the western shore of the lake are by contrast relatively species rich and provide a diverse array of wetland habitats.

While the current aquatic flora is clearly impoverished and dominated by non-native species, we doubt that it ever supported a diverserse mesotrophic flora as defined in the CSM guidance (JNCC 2005). A search of the BSBI database suggests that few, if any other aquatic species have been recorded there. Therefore, the current designation which is focused on two rare species (pillwort and downy emerald) is appropriate. In order to justify the setting of appropriate restoration targets it would be necessary to determine more accurate baseline data by the analysis of plant macrofossil remains from a long core and perhaps the examination of old herbarium records. A better knowledge of the previous flora could help to define site-specific targets for the lake for either restoration management or natural recovery.

Table 10 Pysgodlyn Mawr overview

Water Body	Status	Reason(s) for Failure	Comments
Pysgodlyn Mawr	**Unfavourable (high confidence)**	*Pilularia* absent. No characteristic species. Poor water quality Non-native plants species dominant. Poor hydrology for Pillwort. Non-native fish species	While clearly unfavourable with respect to both flora and water quality, it is doubtful if the site has ever achieved the floristic targets as defined for mesotrophic lakes. Management should focus on requirements for species.

Recommendations for monitoring and management:

Pysgodlyn Mawr would benefit from site specific targets being set. Its classification as a mesotrophic standing water is considered to be justified, but as an artificial water body (of some age) which has almost certainly been subject to periodic draining, it may never have supported a characteristic mesotrophic flora as defined within the JNCC guidance (2005). Therefore, attention should be paid to the species features of the site, specifically downy emerald (*Cordulia aenea*) and pillwort (*Pilularia globulifera*).

Nutrient levels are above mesotrophic targets and additional water quality monitoring would help to ascertain if the site is degrading, stable or improving. The current fishery is considered to be a potential threat to the site. Carp and grass carp are destructive feeders and in a small water body such as Pysgodlyn Mawr will be a major contributor to the re-suspenion of sediment and high turbidity. An assessment will be required by a species specialist as to the likely impacts of nutrient enrichment on downy emerald.

The loss of pillwort (*Pilularia globulifera*) from the site would appear to be due, at least in part, to the more stable water levels following the remedial work on the dam. Pillwort requires disturbed wetland habitats free from excessive competition from other plants and therefore does well in sites with fluctuating water levels where a drawdown zone occurs periodically. It can survive for long periods as spores, so restoration may be possible using habitat management alone. Where water level management is not possible, the creation of suitable habitat by clearing scrub and implementing managed disturbance are recognized means of encouraging this species (Plantlife 2006).

The following recommendations are based on the evidence collected for this report:

- Monitor water quality – minimum of quarterly sampling
- Undertake plant macrofossil analysis to determine a site-specific baseline flora
- Assess fish stocks and remove carp, grass carp (and cat-fish if present)
- Create suitable habitat for pillwort within the wetland area
- Assess habitat quality for downy emerald.

CSM Database output

Site Condition Assessment: Llyn Pysgodlyn Mawr (25/06/2012)

Lake Details		**Survey Details**		
Lake Name	Llyn Pysgodlyn Mawr	Survey Date	25/06/2012	
SSSI Name	PYSGODLYN MAWR	Surveyors	BG, ES & JS	
SAC Name		Shore Surveys	3	out of
Grid Ref	ST041761	Wader Surveys	3	3
WBID / NI No.	42392 /	Boat Surveys	3	sections

Site Notes:
Site raised by a low dam of c. 1.5 m at the outflow.

Survey Notes:
FC owned & SSSI, but also managed as a fishery, including carp, grass carp and bream. No submerged plants, but cultivar Nymphaea present, also Nymphoids peltata also present (introduced). Downy Emerald DF seen - and many others.

Section Summaries

Section 1	Maximum depth of colonisation (cm)	100 cm
	Compass bearing of boat transect (°)	330 °
	Lateral distance from waters edge to 75cm depth (m)	2 m
	Notes:	
Section 2	Maximum depth of colonisation (cm)	90 cm
	Compass bearing of boat transect (°)	220 °
	Lateral distance from waters edge to 75cm depth (m)	5 m
	Notes:	
Section 3	Maximum depth of colonisation (cm)	120 cm
	Compass bearing of boat transect (°)	120 °
	Lateral distance from waters edge to 75cm depth (m)	5 m
	Notes:	

Section Locations

	Shore Survey GPS Co-ords start	end	Boat Survey GPS Co-ords start (shore)	end (lake)
Section 1	ST0412576176	ST0419476166	ST0414976194	ST0417376126
Section 2	ST0418476084	ST0412176126	ST0414776075	ST0407876112
Section 3	ST0424076134	ST0422776090	ST0426076102	ST0422276122

Section Photos

	Start of Section	Whole Section	End of Section
Section 1	0105	0106	0108
Section 2	0111	0113	0112
Section 3	0114	0117	0116

Species Abundance - Boat Survey

Total number of sample plots 60
Total number of vegetated sample plots 10

Plant Species	Occurrence n	%
Nymphaea alba	1	10
Nymphoides peltata	10	100

Species Abundance - Wader Survey

Total number of sample plots 60
Total number of vegetated sample plots 33

Plant Species	Occurrence n	%
Carex rostrata	4	12
Equisetum fluviatile	3	9
Lemna minor	4	12
Nymphaea alba	7	21
Nymphaea spp. "cultivar"	2	6
Nymphoides peltata	24	73
Potamogeton natans	1	3
Typha latifolia	3	9

Note: Species abundance % = ((number of plots / total number of vegetated sample plots) * 100) *n*

Plant Scores

Total plant species 42 **Filamentous algae (%)** 0.4% WADER 0% BOAT

SURVEY SCORES

PLANT SPECIES	PERIMETER	WADER	BOAT	COVER %	DAFOR	ABUNDANCE
Nymphoides peltata	0	0.1867	0.2283	32.16	A	4
Salix sp.	0.75	0	0	18.75	F	3
Equisetum fluviatile	0.3667	0.0154	0	9.94	O	2
Hypericum elodes	0.3667	0	0	9.17	O	2
Carex rostrata	0.3167	0.0195	0	8.89	O	2
Potentilla palustris	0.3333	0	0	8.33	O	2
Mentha aquatica	0.25	0	0	6.25	O	2
Oenanthe crocata	0.25	0	0	6.25	O	2
Typha latifolia	0.1667	0.0191	0	5.12	O	2
Lycopus europaeus	0.2	0	0	5	R	1
Alnus glutinosa	0.2	0	0	5	R	1
Galium palustre	0.2	0	0	5	R	1
Eriophorum latifolium	0.1667	0	0	4.17	R	1
Nymphaea alba	0	0.064	0.0083	4.03	R	1
Eupatorium cannabinum	0.15	0	0	3.75	R	1
Carex nigra	0.15	0	0	3.75	R	1
Juncus effusus	0.15	0	0	3.75	R	1
Juncus acutiflorus	0.15	0	0	3.75	R	1
Phalaris arundinacea	0.1167	0	0	2.92	R	1
Epilobium palustre	0.1167	0	0	2.92	R	1
Hydrocotyle vulgaris	0.1167	0	0	2.92	R	1
Lemna minor	0.0667	0.0193	0	2.63	R	1
Epilobium hirsutum	0.1	0	0	2.5	R	1
Angelica sylvestris	0.1	0	0	2.5	R	1
Ranunculus flammula	0.1	0	0	2.5	R	1
Carex echinata	0.0667	0	0	1.67	R	1
Myosotis laxa	0.0667	0	0	1.67	R	1
Solanum dulcamara	0.0667	0	0	1.67	R	1
Sphagnum sp.	0.0667	0	0	1.67	R	1
Cirsium palustre	0.0667	0	0	1.67	R	1
Lotus pedunculatus	0.0667	0	0	1.67	R	1
Carex curta	0.0333	0	0	0.83	R	1
Cardamine pratensis	0.0333	0	0	0.83	R	1
Eleocharis palustris	0.0333	0	0	0.83	R	1
Epilobium montanum	0.0333	0	0	0.83	R	1
Filipendula ulmaria	0.0333	0	0	0.83	R	1
Glyceria fluitans	0.0333	0	0	0.83	R	1
Iris pseudacorus	0.0333	0	0	0.83	R	1
Potentilla anserina	0.0333	0	0	0.83	R	1
Hypericum tetrapterum	0.0333	0	0	0.83	R	1
Nymphaea spp. "cultivar"	0	0.0125	0	0.62	R	1
Potamogeton natans	0	0.0042	0	0.21	R	1

5.2. Llyn Llech Owain

Annex 1 type: H3136: Natural dystrophic lakes and ponds. Previously listed as oligotrophic.

5.2.1. Site description

Name:	Llyn Llech Owain
County:	Carmarthenshire
WBID:	40571
Grid reference:	SN568151
OS Grid reference (X,Y):	256867,215102
Latitude / Longitude	N51°48.97',W004°4.68'
Altitude (m):	238
Maximum recorded depth (m):	1.8
Mean depth (m):	1.21
Lake volume (m^3):	65880
Surface area – UKLakes (ha):	5.3
Surface area – measured (ha)	5.42
Perimeter of lake (km):	1.0
Shoreline Development Index (SDI):	1.185
WFD alkalinity based typology:	Low Alkalinity, Very Shallow (LA, VS)
Phase 1 habitat type:	Standing water: Dystrophic: G1.4
Survey Date:	28 June 2012

Table 11 Summary characteristics for Llyn Llech Owain

Llyn Llech Owain is a very shallow lake draining an area of acid heath and grassland. Part of the catchment was planted with coniferous forest during the 1960s – much of which has recently been cleared. The site is owned and managed by Carmarthenshire County Council as a Country Park which has a small visitor centre located on the north shore. Previously, the lake was used for water abstraction, which at times resulted in the lake being almost emptied (Simon Morris, CCC, *pers. comm.*).

The site was designated as a SSSI in 1993 with the lake and associated acid grasslands being the primary features for notification; both being relatively rare habitats within Carmathernshire. Llyn Llech Owain is listed within the SSSI citation and by Palmer and Roy (2001) as being oligotrophic, but with extensive peat development in the catchment the water is very brown giving the site many similarities with the dystrophic lake type.

On examination of the data within this report and in consultation with NRW staff this assessment has been made under the guidance for dystrophic lakes.

5.2.2. Condition Assessment and Discussion

Attribute	Target	Status	Comment
Extent	No loss of extent of standing water	✓	None noted.
Macrophyte community composition	Dystrophic: presence of at least 4 species previously recorded.	✓	5 characteristic: *Sparganium angustifolium, Nuphar lutea, Nymphaea alba, Potamogeton polygonifolius* and *Menyanthes trifoliata*.
	No loss of characteristic species (see Box 2)	**NA**	No previous survey, but similar to SSSI citation
	No loss of extent of characteristic species	✓	71% of vegetated sample spots have at least one characteristic species
Negative indicator species	Non-native species absent or present at low frequency	✓	None detected
	Benthic and epiphytic filamentous algae <10%.	✓	Overall, low filamentous algae cover across wader & boat transects (0-1).
Macrophyte community structure	Characteristic vegetation zones should be present (site specific)	✓	Submerged aquatic plants restricted to the margins. Only water lilies in open water. More typical of dystrophic lake type
	Maximum depth distribution should be maintained	✓	Z_{max} (recorded) = 1.8 m, Z_s = 50 cm, Z_v = 1.3 m.
	At least present structure should be maintained	**?**	No previous data against which to assess.
Water quality	Stable nutrients levels: TP target / limit: Oligotrophic = 10µgl^{-1}	**X**	TP = 21.5 µg l^{-1} (range 15 - 33) TN = 0.68 mg l^{-1} (range 0.61–0.74). WIMS data 2011 - 2012.
	Stable pH values: pH below 5.5	**?**	pH = 6.06 (range = 5.69 – 6.77) Data limited to 3 values.
	Adequate dissolved O_2 for health of characteristic fauna (> 5 mgl^{-1})	✓	0.51 – 8.31 mg l^{-1} from max depth to surface. Anoxic at maximum depth.
	No excessive growth of cyanobacteria / green algae	✓	Chl *a* concentrations relatively low (mean = 3.5 µg l^{-1}; range = 1.3 - 5.7)
Hydrology	Natural hydrological regime	✓**?**	Past use for abstraction resulted in major water level fluctuation. Currently under natural regime.

Attribute	Target	Status	Comment
Lake substrate	Natural shoreline maintained	✓	Natural shoreline maintained.
	Natural and characteristic substrate maintained	✓	No evidence of change.
Sediment load	Natural sediment load maintained	✓?	Appears natural, although forestry may have caused an increase to the site
Indicators of local distinctiveness	Distinctive elements maintained at current extent / levels / locations	✓	*Littorella uniflora* present and white/yellow water lilies remain.
Disturbance	No introduced species	✓	None recorded
	Minimal negative impacts from recreation and navigation. No fish farming	✓	No evidence of negative impacts.
Palaeo evidence	No evidence of significant environmental change e.g. acidification or eutrophication	✓	Site shows no significant down-core floristic changes in fossil diatom record

Status: ✓ = favourable; X = unfavourable; NA = not assessed.

Table 12. Condition Assessment Summary Table for Llyn Llech-Owain

Extent

The surface area of the lake is 5.3 ha. There is no evidence for loss of extent .

Macrophyte community composition

Where it occurred *Littorella uniflora* was mostly restricted to very shallow water (< 50 cm), reaching a maximum of 90 cm in survey section 1. *Sparganium angustifolium* was recoded growing between 75 – 90 cm but beds were generally small and rather sparse. No other characteristic species were recorded (Table 13). Water lilies dominated the aquatic flora of Llyn Llech Owain with *Nuphar lutea* being more common than *Nymphaea alba*. *Potamogeton polygonifolius* occurred sporadically in the shallow, mainly associated with inflows ad seaps. A single plant of *Potamogeton natans* was recorded in the north-east of the lake in 50 cm of water.

Areas of emergent Water horsetail (*Equisetum fluviatile*) dominated the south shore and a smaller portion of the north-west shore. *Carex rostrata* was common in the western margin and *Eleocharis palustris* also common on the north-west and southern shore. A single plant of Royal fern (*Osmunda regalis*) was also recorded on the NW shore and *Menyanthes trifoliata* occurred in the wetland area around the lake outflow.

The eastern shore of the lake has eroded peat cliff, in places over a metre high, and is mostly without any marginal or emergent vegetation and only occasional plants of *Nuphar lutea* in the littoral zone. See Figure 5 for plant maps. There is no evidence of any significant change at the site. The PLEX score of 3.8 corresponds closely of that given for the site by Duigan *et al.* (2006) of 3.65. The site is however classified as type B by Duigan *et al.* whereas the current assemblage places the site into group C1 and therefore within the oligotrophic rather than dystrophic grouping based on aquatic macrophytes. This difference is due to either *Littorella uniflora* or *Sparganium angustifolium* not being recorded in the data used by Duigan *et al.* The C1 grouping is primarily confined to the north of the UK with only a handful of sites in England and Wales.

Submerged and floating vegetation	TRS	PLEX	% occurrence (n=43)	DAFOR abundance[2]	Min depth (cm)	Max depth (cm)
Juncus bulbosus	3.7	3.08	9.1	O		
Littorella uniflora	6.7	4.23	7.8	R	0	80
Menyanthes trifoliata	**-**	**-**	**7.8**	**R**	**0**	**80**
Mosses (aquatic)	-	1.54	9.1	R	0	140
Nuphar lutea	**8.5**	**6.92**	**50.6**	**F**	**25**	**130**
Nymphaea alba	**6.7**	**3.08**	**19.5**	**O**	**75**	**120**
Potamogeton natans	7.0	4.23	1.3	R	25	25
Potamogeton polygonifolius	**3.0**	**3.08**	**13.0**	**O**	**0**	**75**
Sparganium angustifolium	**3.0**	**4.23**	**19.5**	**O**	**75**	**90**
Average score	**5.51**	**3.80**				
Species richness				**8**		

Table 13 Aquatic macrophyte community composition for Llyn Llech-Owain in June 2012. Characteristic dystrophic species are highlighted in **bold**.

Negative indicator species

No non-native or introduced species were recorded in 2012 and there were no negative indicator species recorded.

Macrophyte community structure

There was no evidence of the zonation normally associated with oligotrophic lakes. This is perhaps not surprising for a lake with very brown water and poor light penetration limiting plant growth. The Secchi depth during the survey was only 50 cm and due to water colour rather than particulates in the water column. *Littorella* was mainly restricted to areas of firm substratrum along the north shore and within *Equisetum fluviatile* beds on the south shore. Where present it formed quite dense ‘lawns’, but it was mostly restricted to water depths of less than 50 cm. The open water was dominated by water lilies in the west and south side of the lake to a maximum depth of 1.3 m (*N. lutea*).

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[2] Based on presence / absence data from all vegetated plots in the wader and boat based surveys. DAFORs are calculated from the total number of occurrences across the wader and boat surveys as a proportion of the total number of vegetated wader and boat survey points.

Although lacking the typical zonation seen in clear-water oligotrophic lakes, Llyn Llech Owain does have extensive areas of water lilies and maintains a population of *Littorella uniflora*, albeit in shallow water.

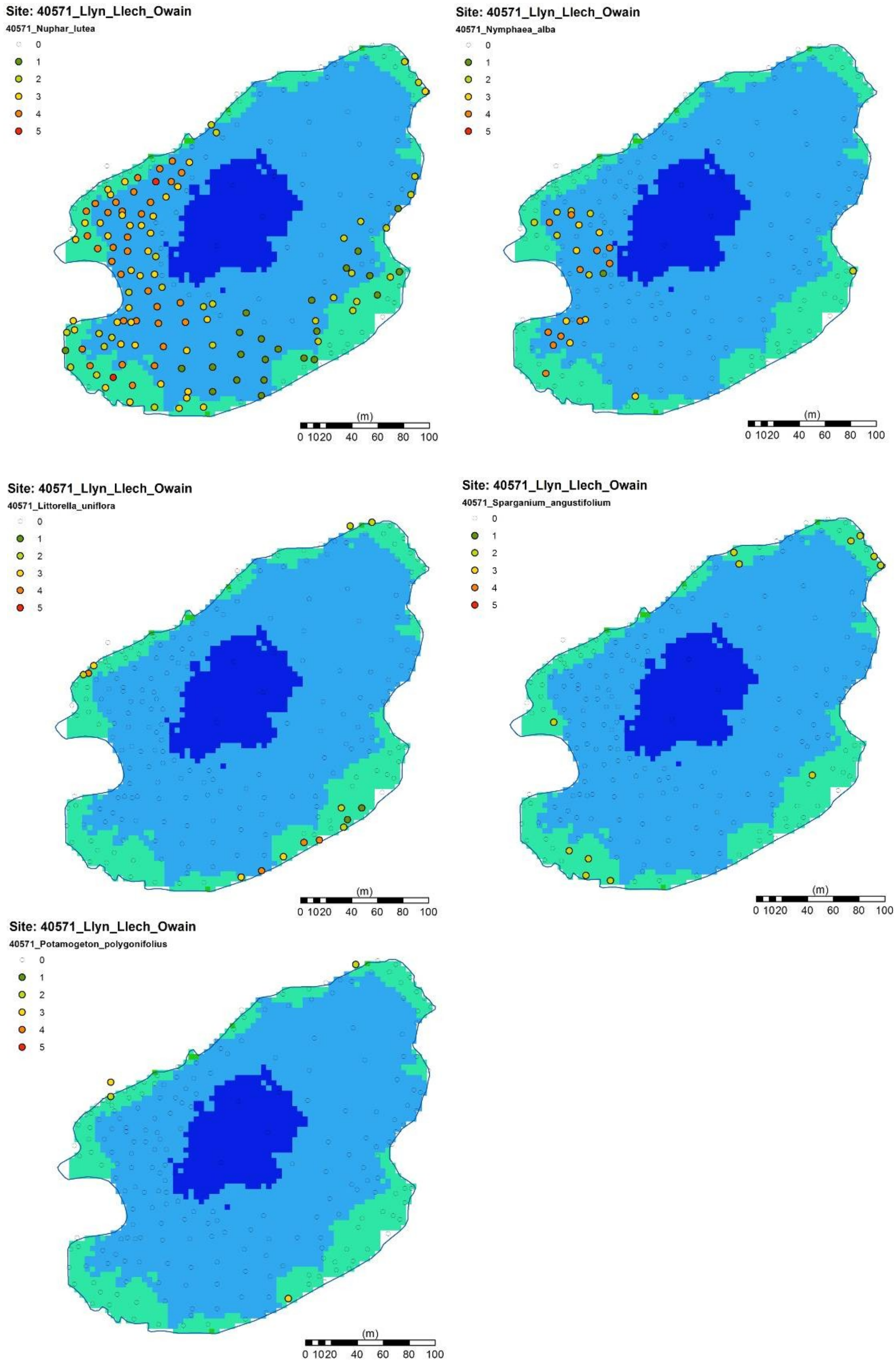

Figure 5 Distribution maps of the aquatic plant species recorded in Llyn Llech Owain

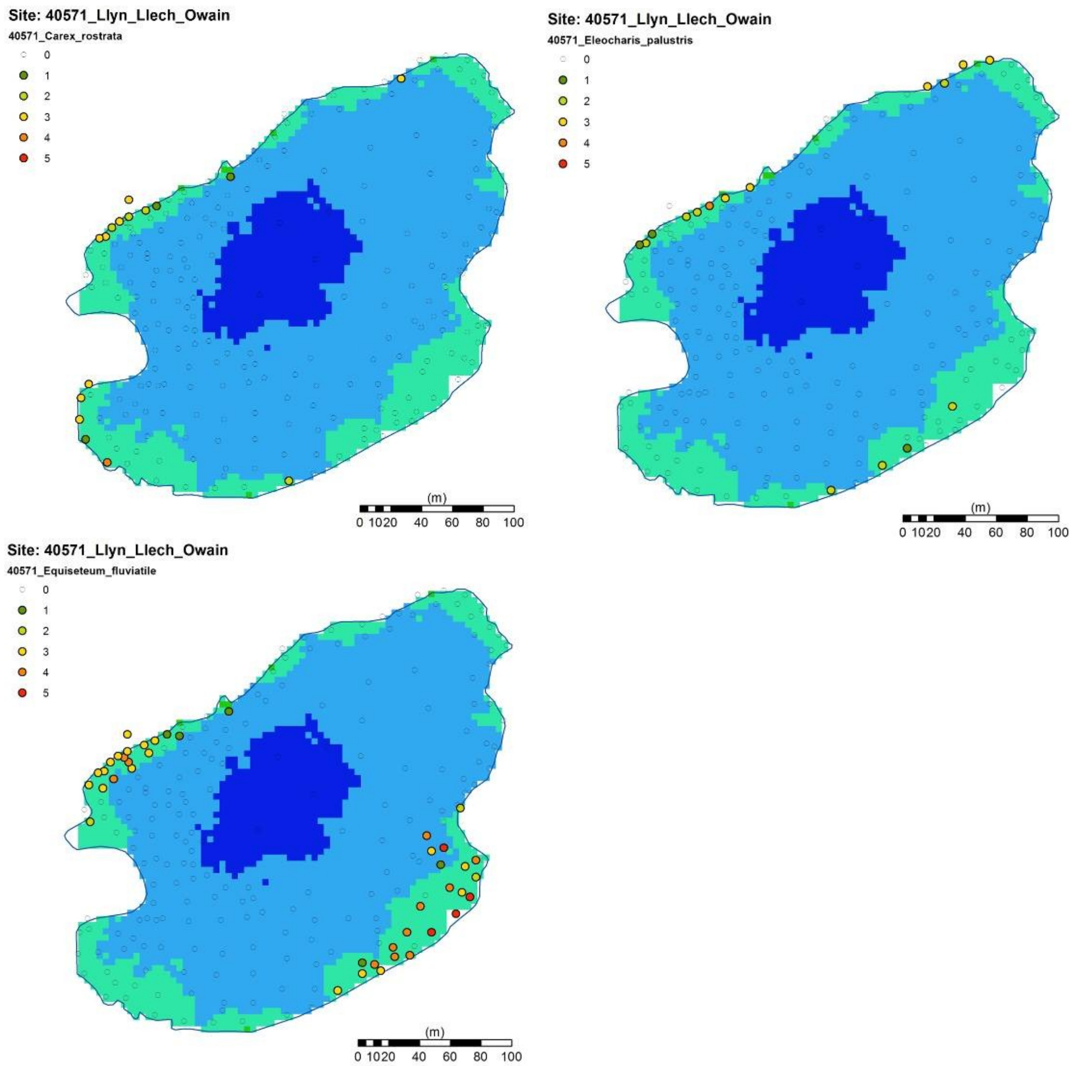

Figure 5 (Contd.)

Water quality

Llyn Llech Owain is a very shallow (Z_{max} = 1.80 m), low alkalinity lake that drains a relatively small area of acidic geology (Namurian quartzite) covered by thin soils and peat. As a consequence, the water is slightly acid and very brown due to dissolved organic carbon from the peat. The measured 2011-12 colour value of 138 Pt Units places the lake within the ‘polyhumic’ WFD lakes category (Carvalho *et al*. 2006). DOC has not been measured, but colour values of 138 (2011-12 mean) are typical of dystrophic lakes in Northern Ireland (Goldsmith *et al.* 2008) and result in very poor light penetration (Secchi depth 50 cm).

TP concentrations exceeded the target value for oligotrophic lakes and place the site in unfavourable condition with respect to nutrient chemistry. Total nitrogen and oxidised nitrogen remained relatively low throughout the year, but there was no evidence of nitrogen limitation during the summer growing season. Other water quality parameters are consistent with the lake type (Table 14) and the lake was well oxygenated except at the sediment water interface (Figure 6).

Determinand	Annual mean 2011-12
pH	6.08
Cond	63
Alk (Gran)	4.204
Colour (Hazen)	138
SRP	3.4
TP	21.5
Chl a	3.49
TN	0.68
TON	0.10
Na^+	5.93
K^+	0.47
Mg^{2+}	0.83
Ca^{2+}	4.05
Cl^-	11.52
$SO4^{2-}$	4.04
ANC-I (ionic)	125.1
ANC-C (Cantrell)	No data

Table 14 Water chemistry data for Llyn Llech Owain (for units see methodology)

Dissolved Oxygen Profile

GPS Location	SN5686815142
Maximum Depth (m)	1.8 m
Secchi Depth (cm)	50 cm

Notes:

Depth (m)	DO (mg/l)	Temp (°C)
0	8.31	17.8
0.5	8.11	17.8
1	8.04	17.8
1.5	5.16	16.4
1.7	0.51	15.6

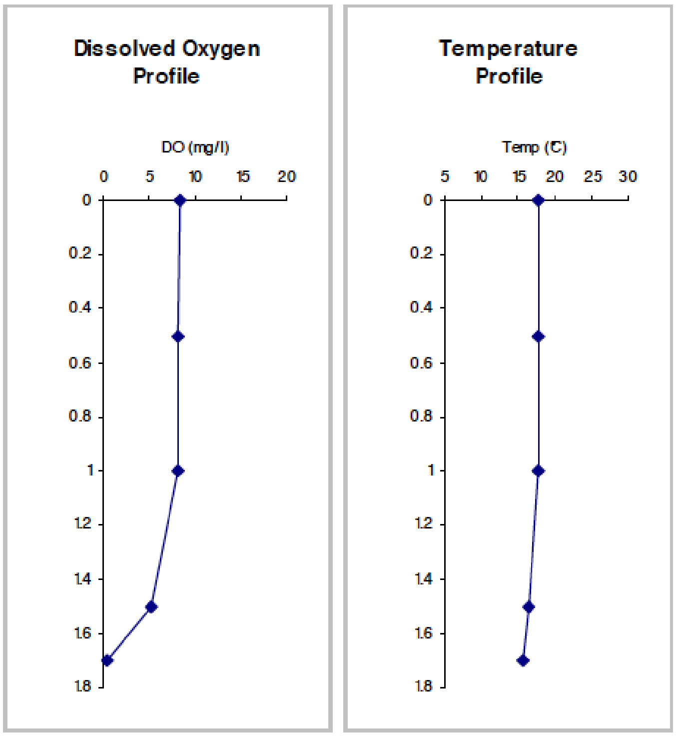

Figure 6 Dissolved oxygen (DO) profile for Llyn Llech Owain (28/06/2012).

Hydrology

The lake is no longer used for abstraction and is under a natural hydrological regime

Lake substrate and sediment load

Marginal substrates range from peat to consolidated stony areas. Beyond approximately 75 cm water depth, the lake substrate is predominantly silt with high organic content (c. 50% by dry weight) derived from inwashed peat. Analysis of the sediment core showed sediment accumulation rates to have increased over the past 100 years from 0.017 g cm^{-2} yr^{-1} at around 1910 to 0.027 g cm^{-2} yr^{-1} in 2011. The increase is not uniform however, with increases seen to peak 0.06 g cm^{-2} yr^{-1} at around 12.5 cm, a point corresponding with the mid 1970s. Water abstraction may have resulted in the re-working of exposed sediments during repeated draw-down and refilling. This period was also when the area was afforested and thus giving rise to additional sources of external sediments from the catchment during planting and management work. It is thought that the site was first planted with conifers just after 1945 with additional planting in the 1960s around the eastern side of the lake. These trees have recently been felled.

The organic content of the core shows a distinct change at 12.5 cm (Figure 7). Above this point the %LOI is relatively stable, whereas below 12.5 cm it shows considerable variability. Again this may be due to disturbance both within the lake from abstraction and from the catchment with forestry.

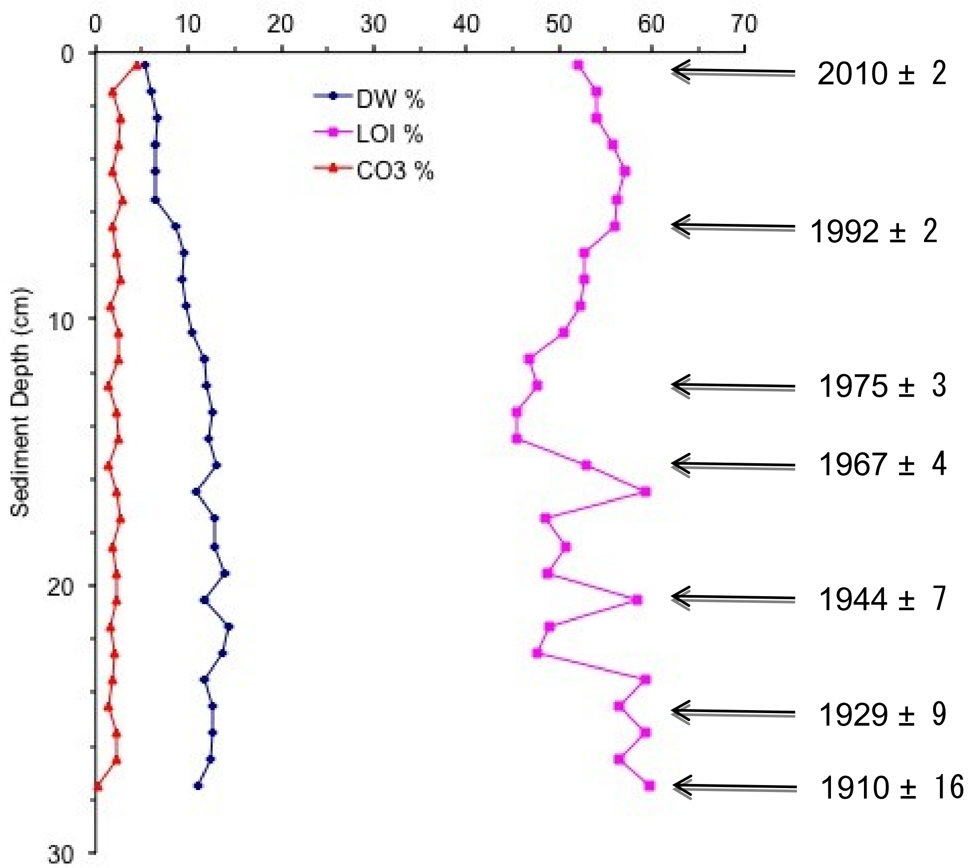

Figure 7 Physical characteristics and radiometric dates from core CZSN51

Palaeolimnological evidence

A 28 cm sediment core (CZSN51_1) was taken from the deep point at SN5685715138 using a Renberg gravity corer. The core was sliced at 1 cm intervals in the field and analysed for dry weight, organic content and carbonate content. A subset of samples were dried and subjected to radiometric dating. The physical analysis and dating of the core are discussed above and presented in Figure 7. The diatom flora of the surface sediment was dominated by benthic taxa, consistent with the lake being very shallow. *Eunotia incisa* (25%), *Cymbella perpusilla* (13%) and *Navicula soehrensis* (9%) dominated the flora. The diatom assemblage of the deepest sediments was very similar with *Eunotia incisa* (32%), *Cymbella perpusilla* (11%) and *Navicula soehrensis* (6%). *Frustulia rhomboides* was more common in tha basal sediments (only 5% in the surface sample and 11% at the core base). The SCD between the samples was only of 0.24, suggesting there to have been no significant floristic change over the period covered by the sediment core.

Sample Code	Depth (cm)	2011/12 mean pH	DI-pH	2011/12 mean TP	DI-TP	SCD
CZSN51_1-00	0	6.08	5.54	21.5	5.7	0.24
CZSH51_1-27	27		5.60		6.1	0.00

Table 15 Results of Llyn Llech-Owain sediment core analysis

Reconstructions of diatom-inferred pH (DI-pH) were produced using the SWAP training set (RMSEP = 0.32 pH units). A high percentage of the taxa in the fossil samples were present in the SWAP training set and there were no major analogue problems. The DI-pH results are consistent with a lack of floristic change and suggest there to have been no significant change in pH at the site over the time period covered by the core.

The current surface sediment assemblage estimates pH to be slightly lower than measured pH. This difference is only slightly greater than the model errors and most likely to reflect a combination of pH measurement error and model estimation error.

Reconstructions of diatom-inferred TP (DI-TP) show low modelled TP from the core bottom and top (6.1 to 5.7 µg l^{-1}). A high percentage of the taxa in the fossil samples were present in the NW European training set and there were no major analogue problems. The annual mean current TP based on quarterly water samples collected during 2011-12 was 21.5 µg l^{-1} and therefore the diatom model significantly underestimates the current measured value. This possibly reflects the complex nature of phosphorus in humic lakes where much of the measured TP is bound within humic acids and not therefore biologically available and hence the modeled TP may therefore be a good estimate of 'active' P in the lake. Furthermore, it is well recognised that there are problems associated with modeling diatom-based TP in sites with high DOC (Bennion, pers. comm.) with confidence in the modeled results being compounded by poor coverage of this lake type within the training set.

In summary, there has been no significant floristic change in the sediment core from Llyn Llech Owain and hence no evidence of any change relative to baseline conditions. The modeling of TP at the site is not considered appropriate due to the high DOC concentration.

Indicators of local distinctiveness
This standing water type is uncommon in Carmarthenshire.

Lake Bathymetry
The bathymetric survey confirms the site to be shallow with the deepest point of 1.8 m being slightly north of centre within the lake (Figure 8)

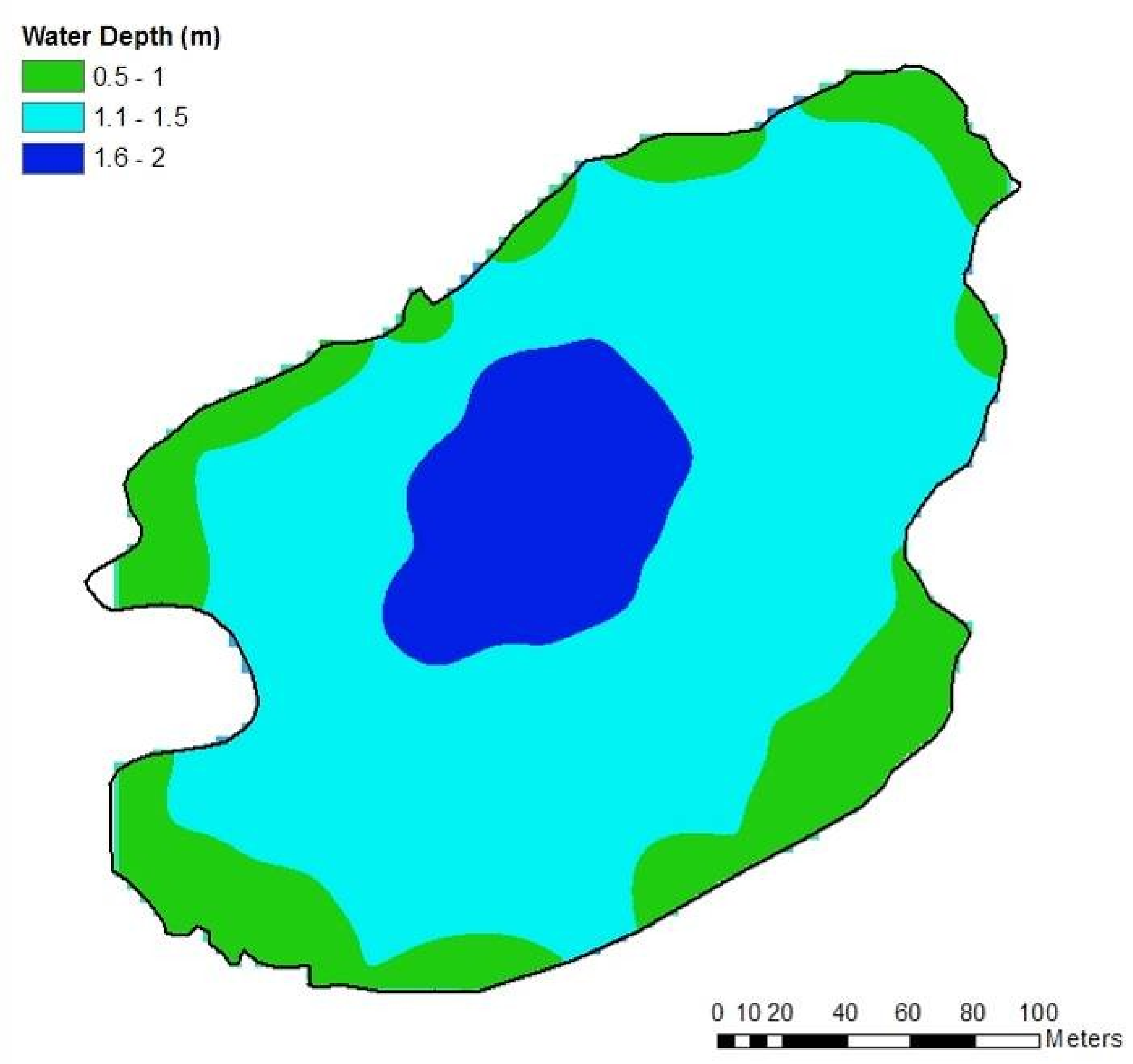

Figure 8 Bathymetric map of Llyn Llech Owain, December 2011

Site condition summary and overview
In accordance with the JNCC guidance, Llyn Llech Owain is **unfavourable** with respect to its water quality, due to phosphorus levels being higher than expected. Confidence in this assessment is **low** however, due to the lack of evidence for floristic change at the site and because of the high DOC concentration. The very brown water appears to be the primary factor limiting plant growth and in the absence

of any evidence for higher plant diversity or a greater extent of the characteristic flora in the past, it has to be assumed that this is the natural condition of the site.

There are no historic records for any other characteristic oligotrophic species listed for the 10 km grid square (SN51) by Preston *et al*., (2002) which, although not conclusive, is further evidence for the justification to classify the site as dystrophic rather than oligotrophic. It also suggests the site is unlikely to have supported a more diverse flora.

The diatom record is dominated by benthic taxa and shows very little floristic turnover in the past 100 years - if water quality and more importantly, water clarity, have remained similar over this period it is thought unlikely that any submerged aquatic species would have ever attained a much wider distribution in the site. This is complicated by the past management of the site and catchment. Water level fluctuation due to abstraction is unlikely to have affected *L. uniflora* which is not only tolerant of exposure, but relies on it to reproduce by seed. *Sparganium angustifolium*, although less tolerant of low water levels, can nonetheless survive out of water on damp sediments. If other characteristic oligotrophic isoetids were present in the past, water level fluctuation could have been responsible for their loss.

Similarly, the effects of catchment disturbance due to afforestation in the past 70 years may potentially have impacted on the site. Increased sedimentation rates and possibly higher DOC concentrations from exposed peats may have changed the lake substrate and further reduced light penetration in the site, both of which can potentially impact on the lake flora. The predominance of relatively flocculent organic sediments throughout the open water areas today, coupled with poor light penetration due to the brown water is thought likely to inhibit the growth of submerged aquatic plants beyond the current range of *Littorella uniflora* in the lake.

Mean annual TP concentration (2011/12) were double the upper limit for dystrophic lakes. In the absence of any historic TP data, the higher TP values may simply be due to the high DOC content of the water. It is not unusual for brown water lakes to have elevated levels of TP as a result of complex P chemistry and lower algal productivity due to low light. While this cannot be ruled out, it is recommended that external sources are also investigated and the lake water quality monitored at a minimum of quarterly intervals.

In summary, although unfavourable, there are site specific factors that require further investigation in order to ascertain if Llyn Llech Owain has deteriorated or if it is in fact naturally species-poor dystrophic lake. The extensive water lily beds and other characteristic dystrophic species, as well as the presence of *Littorella uniflora,* make this site distinctive within Carmarthernshire and management should focus on preserving the current status of the lake by minimizing any additional inputs of nutrients to the site and minimizing the sediment loading.

Water Body	Status	Reason(s) for Failure	Comments
Llyn Llech Owain	**Unfavourable (Low confidence)**	Water quality exceeds dystrophic thresholds for TP	Good aquatic flora for a dystrophic lake and no evidence to support greater species richness in the past. Although TP is high, there is no obvious anthropogenic sources of phosphorus from the catchment and this may reflect the poor uptake of P by surrounding peaty soils and unavailable P bound in complex humic compounds. External nutrient sources should be investigated to confirm this.

Table 16. Llyn Llech Owain overview.

Recommendations for monitoring and management:

Llyn Llech Owain would benefit from further investigation to allow site specific targets to be set TP levels. Its classification as a dystrophic standing water is considered to be justified and its geographical isolation from similar sites and very brown water suggest it may never have supported a more diverse flora.

The current water quality is above dystrophic targets and clarification is required as to whether this is due to natural processes or anthropogenic inputs. Additional water quality monitoring would help to ascertain this and catchment walk-over studies would be beneficial in identifying any potential sources of nutrients within the catchment.

The following recommendations are based on the evidence collected for this report:

- Monitor water quality – minimum of quarterly sampling
- Undertake catchment walk-over to identify any potential sources of external nutrients
- Undertake plant macrofossil analysis to determine a site-specific baseline flora.
- Monitor the aquatic flora every 3-5 years to ascertain any increase or decline.
- Investigate possible sources of sediment from the catchment and remedial action as required.

CSM Database output

Site Condition Assessment: Llyn Llech Owen (28/06/2012)

Lake Details		**Survey Details**		
Lake Name	Llyn Llech Owain	Survey Date	28/06/2012	
SSSI Name	LLYN LLECH OWAIN	Surveyors	BG, JoS & JS	
SAC Name		Shore Surveys	4	out of
Grid Ref	SN568151	Wader Surveys	4	4
WBID	40571	Boat Surveys	4	sections

Site Notes:
Supply res until late 70's (?). But shallow 1.8 m. Used to be drained Completely when in use.

Survey Notes:
Very brown water - more typical of dystrophic water than oligotrophic.

Section Summaries

Section 1	Maximum depth of colonisation (cm)	130 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	10 m
	Notes:	
Section 2	Maximum depth of colonisation (cm)	80 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	5 m
	Notes:	
Section 3	Maximum depth of colonisation (cm)	130 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	8 m
	Notes:	
Section 4	Maximum depth of colonisation (cm)	140 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	2 m
	Notes:	

Section Locations

	Shore Survey GPS Co-ords start	end	Boat Survey GPS Co-ords start (shore)	end (lake)
Section 1	SN5690415000	SN5696615105	SN5693315038	SN5690115071
Section 2	SN5699215203	SN5693815248	SN5697715246	SN5696015225
Section 3	SN5676015077	SN5673415135	SN5673515109	SN5681315126
Section 4	SN5684015207	SN5691515237	SN5688315232	SN5689615193

Section Photos

	Start of Section	Whole Section	End of Section
Section 1	157	158	159
Section 2	160	161	162
Section 3	164	166	165
Section 4	167	169	170

Species Abundance - Boat Survey

Total number of sample plots	80
Total number of vegetated sample plots	16

Plant Species	Occurrence *n*	%
Equisetum fluviatile	3	19
Littorella uniflora	1	6
Mosses aquatic	1	6
Nuphar lutea	12	75
Nymphaea alba	4	25
Sparganium angustifolium	1	6

Species Abundance - Wader Survey

Total number of sample plots	80
Total number of vegetated sample plots	61

Plant Species	Occurrence *n*	%
Carex nigra	3	5
Carex rostrata	20	33
Eleocharis palustris	8	13
Equisetum fluviatile	28	46
Juncus acutiflorus	2	3
Juncus bulbosus	7	11
Littorella uniflora	5	8
Menyanthes trifoliata	6	10
Mosses aquatic	6	10
Nuphar lutea	27	44
Nymphaea alba	11	18
Potamogeton natans	1	2
Potamogeton polygonifolius	10	16
Sparganium angustifolium	14	23
Typha latifolia	2	3

Note: Species abundance % = ((number of plots / total number of vegetated sample plots) * 100)

Plant Scores

Total plant species 22 **Filamentous algae (%)** 5.9 % WADER 1% BOAT

Total plant cover (%) 96.52

SURVEY SCORES

PLANT SPECIES	PERIMETER	WADER	BOAT	COVER %	DAFOR	ABUNDANCE
Nuphar lutea	0	0.1055	0.1358	18.86	F	3
Equisetum fluviatile	0.375	0.1158	0.0232	17.48	F	3
Carex rostrata	0.375	0.0771	0	13.23	F	3
Juncus bulbosus	0.2625	0.0227	0	7.7	O	2
Hydrocotyle vulgaris	0.25	0	0	6.25	O	2
Nymphaea alba	0	0.0374	0.0382	5.69	O	2
Eleocharis palustris	0.15	0.0259	0	5.04	O	2
Menyanthes trifoliata	0.0875	0.0239	0	3.38	R	1
Mosses aquatic	0	0.0209	0.0125	2.3	R	1
Littorella uniflora	0.025	0.0163	0.0083	2.27	R	1
Sparganium angustifolium	0	0.0391	0.0025	2.2	R	1
Potamogeton polygonifolius	0	0.0404	0	2.02	R	1
Juncus acutiflorus	0.0625	0.0071	0	1.92	R	1
Carex nigra	0.0625	0.0061	0	1.87	R	1
Carex hirta	0.0625	0	0	1.56	R	1
Eriophorum vaginatum	0.05	0	0	1.25	R	1
Typha latifolia	0.025	0.0073	0	0.99	R	1
Osmunda regalis	0.025	0	0	0.62	R	1
Alisma plantago-aquatica	0.025	0	0	0.62	R	1
Potentilla palustris	0.025	0	0	0.62	R	1
Mentha aquatica	0.025	0	0	0.62	R	1
Potamogeton natans	0	0.0006	0	0.03	R	1

5.3. Llyn Pencarreg

Annex 1 type: H3130: Oligo-mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the Isoëto-*Nanojuncetea*.

5.3.1. Site description

Name:	Llyn Pencarreg
County:	Carmarthenshire
WBID:	39303
Grid reference:	SN537456
OS Grid reference (X,Y):	253706,245639
Latitude / Longitude	N52°5.38',W004°8.21'
Altitude (m):	115
Maximum recorded depth (m):	12.2
Mean depth (m):	5.69
Lake volume (m^3):	491059
Surface area – UKLakes (ha):	8.5
Surface area – measured (ha)	8.637
Perimeter of lake (km):	1.2
Shoreline Development Index (SDI):	1.158
WFD alkalinity based typology:	Low Alkalinity, Shallow (LA, S)
Phase 1 habitat type:	Standing water: Oligotrophic: G1.3
Survey Date:	27 June 2012

Table 17. Summary characteristics for Llyn Pencarreg.

Llyn Pencarreg is a kettle-hole lake lying within the Teifi Valley to the south-west of Lampeter. The lake was designated as a SSSI in 1973, the primary feature being its oligotrophic waters, which are rare in this region of lowland Wales, and its populations of overwintering waterfowl and breeding pochard. With respect to the flora, the SSSI citation notes *Littorella uniflora* as the only aquatic species present. The lake has no significant inflows and no surface outflows and is assumed to be primarily groundwater fed.

The lake is surrounded by improved pasture which slopes down steeply to the shore around much of the lake, buffered to some degree to the west and north by a narrow strip of in trees and hawthorn scrub. An old disused railway cutting runs close (20 m) to the south shore. This was once part of the Pencadar to Aberystwyth railway built in the 1860s. The line ran passenger and freight trains from 1867 until floods destroyed part of the line in 1964 when passenger trains were discontinued. The line remained open to freight until finally being closed and decommissioned in 1973.

Besides the SSSI citation there appear to be no historic records for the aquatic vegetation of Llyn Pencarreg and neither *Elatine hexandra* or *Isoetes lacustris* are recorded from the 10 km grid square (SN54) by Preston *et al.* (2002). A Recent Ph.D. thesis (Yates-Sabren 2009) collected long sediment cores from Llyn Pencarreg and reported the littoral zone to be "…dominated by *Potamogeton* spp. and *Littorella uniflora…*". *Potamogeton* pollen was also found in the core, but only in much deeper sediments dating back over 2500 years BP. *Isoetes lacutris* and *I. echinospora* pollen was also recorded throughout the core alongside *Ranunculus aquatillis.*

5.3.2. Condition Assessment and Discussion

Attribute	Target	Status	Comment
Extent	No loss of extent of standing water	✓	None noted.
Macrophyte community composition	Oligotrophic: ≥ 3 characteristic *Littorelletea* species listed in Box 2 (≥ 2 if valid reasons suggest otherwise)	✓	2 characteristic *Littorelletea* spp in 2012: *Isoetes lacustris* & *Littorella uniflora* & 1 other characteristic oligotrophic spp: *Elatine hexandra*.
	No loss of characteristic species (see Box 2)	**NA**	SSSI citation reports only *L. uniflora*
	≥ 6/10 vegetated sample spots (boat / wader survey) have ≥ 1 characteristic spp.	✓	Aquatic plant cover is limited, but 88% of vegetated sample spots comply (86% wader, 100% boat)
Negative indicator species	Non-native species absent or present at low frequency	✓	None noted
	Benthic and epiphytic filamentous algae <10%.	✓	No filamentous algal was recorded in June 2012
Macrophyte community structure	Characteristic vegetation zones should be present (site specific)	**X**	*I. lacustris* is restricted to <1.2 m with *L . uniflora* reaching only 1.5 m. Atypical for oligotrophic waters.
	Maximum depth distribution should be maintained	**X**	Z_{max} (recorded) = 12.2 m, Z_s = 1.8 m, Z_v = 1.3 m (3.0 m in citation)
	At least present structure should be maintained	**NA**	Limited data
Water quality	Stable nutrients levels: TP target / limit: Oligotrophic = 10 $\mu g l^{-1}$	**X**	TP (mean 2011/12) = 214 $\mu g\ l^{-1}$ (Range 125 - 448) TN = 0.86 mg l^{-1} (Range 0.54 - 1.21) WIMS Data 2011 -12
	Stable pH values: pH ~ 5.5 – circumneutral	**X**	Mean pH 2006-11 = 7.8 (Range 6.8 – 9.23).
	Adequate dissolved O_2 for health of characteristic fauna (> 5 mgl^{-1})	**X**	> 5.0 mg l^{-1} from 0 – 6 m, but water column stratified with low DO below 6 m.
	No excessive growth of cyanobacteria / green algae	**X**	Cyanobacterial bloom present in June 2012) Chl *a* high (mean = 49.3 $\mu g\ l^{-1}$, range 11.4 – 274 $\mu g\ l^{-1}$)

Attribute	Target	Status	Comment
Hydrology	Natural hydrological regime	✓	Appears natural.
Lake substrate	Natural shoreline maintained	**X**	Site ploughed to within 1.0 m of shore on NE margin and recent change to track on SW shore has damaged littoral habitat.
	Natural and characteristic substrate maintained	**X**	Sediment core analysis shows significant changes to sediment
Sediment load	Natural sediment load maintained	**X**	Poor buffering of site from tilled land (NE shore) is likely to increase inwash of soil.
Indicators of local distinctive-ness	Distinctive elements maintained at current extent / levels / locations	**NA**	None noted.
Disturbance	No introduced species	✓	None recorded
	Minimal negative impacts from recreation and navigation. No fish farming	**✓?**	Limited recreation
Palaeo evidence	No evidence of significant environmental change e.g. acidification or eutrophication	**X**	Site shows significant changes to sediment type and diatoms indicate eutrophication

Status: ✓ = favourable; X = unfavourable; NA = Not assessed.

Table 18. Condition Assessment Summary Table for Llyn Pencarreg.

Extent

The surface area of the lake is 8.6 ha. There is no evidence of any recent loss of extent of open water.

Macrophyte community composition

Llyn Pencarreg is species-poor and has quite large areas of the littoral zone without any aquatic vegetation (Figure 9). The site does however support three characteristic species: *Littorella uniflora*, *Isoetes lacustris* and *Elatine hexandra* (Table 19). Of the vegetated sample points, 88% had one or more characteristic species, but this does not reflect the relatively large areas of littoral habitat without any submerged vegetation; 37% of littoral sample points had no vegetation in the CSM survey and 41% of the plant mapping points sampled at less than 1.5 m had no plants.

The assemblage places the lake into group C2 as defined by Duigan *et al*. (2006) and the TRS and PLEX scores are consistent with oligotrophic lakes. Llyn Pencarreg passes its aquatic macrophyte composition target, but the flora is very species-poor.

Table 19 Aquatic macrophyte community composition for Llyn Pencarreg in June 2012. Characteristic oligotrophic species are highlighted in **bold**.

Submerged and floating vegetation	TRS	PLEX	% occurrence (n=77)	DAFOR abundance[3]	Min depth (cm)	Max depth (cm)
Elatine hexandra	**7.0**	**5.38**	**79.1**	**F**	**25**	**180**
Isoetes lacustris	**5.0**	**4.23**	**9.0**	**R**	**50**	**120**
Littorella uniflora	**6.7**	**4.23**	**64.2**	**F**	**0**	**180**
Average score	**6.23**	**4.61**				
Species richness				**3**		

Negative indicator species

No aquatic negative indicator species were recorded and the site was without any noticeable filamentous algae. There was however a cyanobacterial bloom in evidence at the time of survey in June 2012.

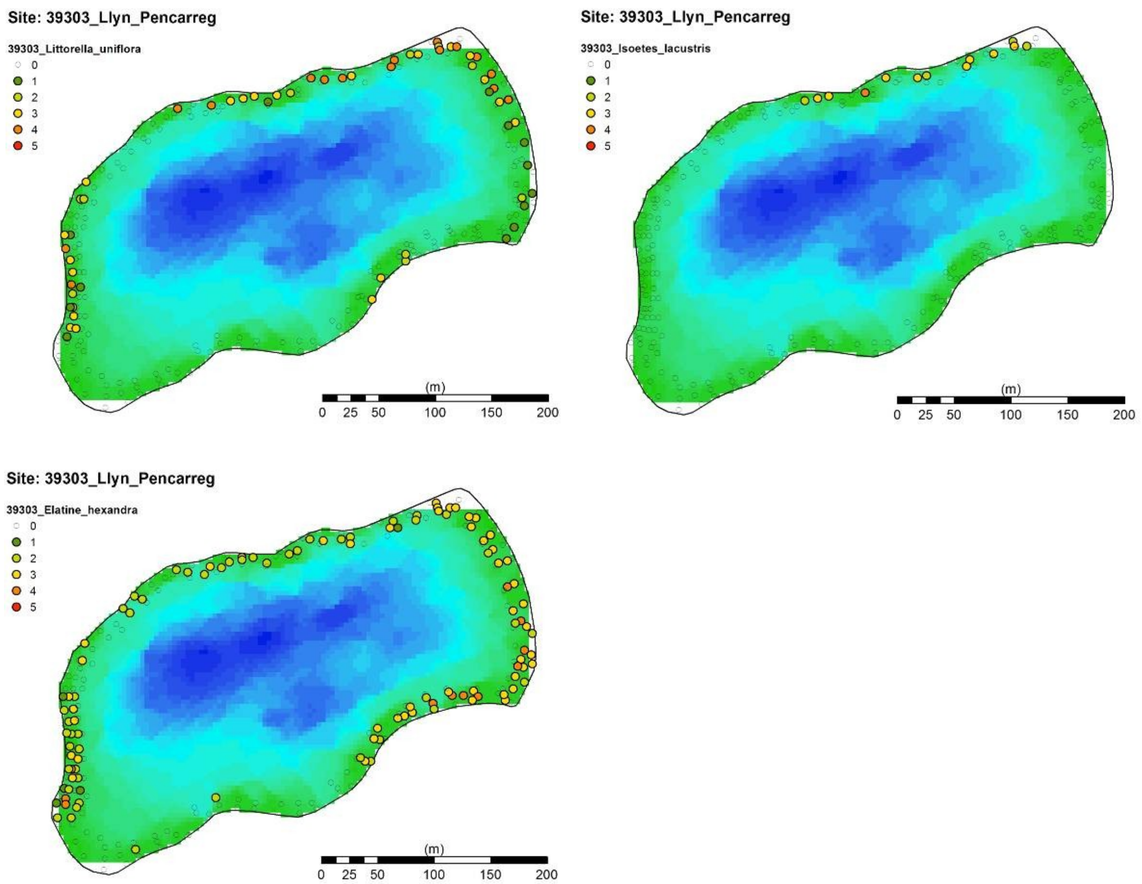

Figure 9 Distribution maps of the aquatic plant species recorded in Llyn Pencarreg

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[3] Based on presence / absence data from all vegetated plots in the wader and boat based surveys. DAFORs are calculated from the total number of occurrences across the wader and boat surveys as a proportion of the total number of vegetated wader and boat survey points.

Macrophyte community structure
Normally in a clear-water oligotrophic lake with *Littorelletea uniflorae* vegetation it would be expected that an overlapping vegetation zone would occur with *L. uniflora* dominant in the shallower zone and *I. lacustris* extending into deeper water, often up to 5 m. In Llyn Pencarreg *Littorella uniflora* and *Elatine hexandra* were most frequent, and both attained a maximum depth of 1.8 m. *Isoetes lacustris* was less common in the site and restricted to the north-east side (Figure 9), and where it did occur it was confined to a relatively narrow depth zone between 0.5 – 1.2 m. The SSSI citation reports the maximum depth of plant growth at 3.0 m, suggesting a significant reduction in the maximum depth of colonization at the site has occurred over the past 40 years. The lake fails the macrophyte community structure target.

Water quality
The most striking component of the chemistry results is the extremely high phosphorus measurements which classify the lake as hypereutrophic and thus fails its water quality target. The high phosphorus is reflected in high chlorophyll *a* concentrations, and algal blooms, and higher than expected pH (Table 20). At the time of sampling there was a cyanobacterial bloom present in the water column and Secchi depth was only 1.8 m. Alkalinity remains low and thus the high pH is likely to be a result of high levels of photosynthesis driven by the high concentration of available P and N. The site is fails its TP, pH and Chl *a* targets.

Dissolved oxygen levels were good down to approximately 6 m, below which the water was anoxic (Figure 10). This situation is typical for small and relatively deep nutrient-rich lakes during summer. ANC-I ANC values are low and suggest the lake is vulnerable to acidification.

Determinand	Annual mean 2011-12	Range
pH	7.26	6.88 – 9.23
Cond	47.6	Limited data
Alk (Gran)	3.6	2.5 – 5.8
Colour (Hazen)	8.1	5.0 – 10.0
SRP	111	62 - 163
TP	214	125 - 448
Chl a	49.3	11.4 - 274
TN	0.86	0.54 – 1.21
TON	0.22	Limited data
Na^{+}	4.52	4.36 – 4.68
K^{+}	1.91	1.87 – 2.01
Mg^{2+}	0.70	0.63 – 0.74
Ca^{2+}	1.39	1.13 – 1.61
Cl^{-}	9.15	8.3 – 13.5
$SO4^{2-}$	2.88	2.60 – 3.06
ANC-I (ionic)	36.3	-
ANC-C (Cantrell)	No data	-

Table 20. Water chemistry data for Llyn Pysgodlyn Mawr (for units see methodology).

Dissolved Oxygen Profile

GPS Location	SN5376745676
Maximum Depth (m)	12.2 m
Secchi Depth (cm)	182 cm
Notes:	

Depth (m)	DO (mg/l)	Temp (°C)
0	10.67	17.9
0.5	10.61	17.9
1	10.59	17.9
1.5	10.5	17.8
2	10.42	17.6
3	8.57	15.7
4	7.82	15.6
5	7.2	15.3
6	5.87	14.9
7	0.15	11.8
8	0.17	10.6
9	0.17	10.4
10	0.19	10.3
11	0.27	10.3
12	0.22	10.2

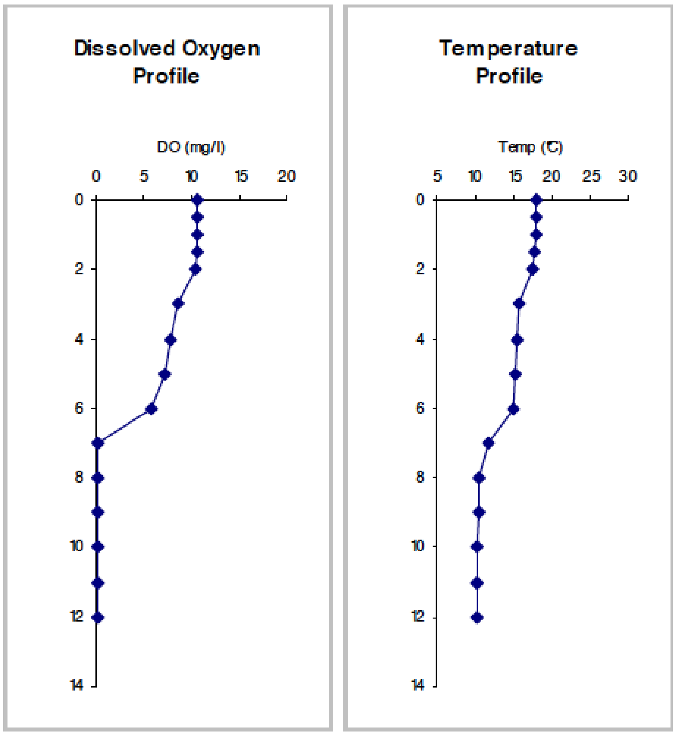


Figure 10. Dissolved oxygen (DO) profile for Llyn Pencarreg (09/09/2009).

Hydrology

Llyn Pencarreg is without any obvious surface in- or outflow and is assumed to rely primarily on ground-water as well as receiving surface flow from the immediate catchment. The hydrology is not known, but it is likely that lake retention times are high and therefore internal nutrient cycling may increase the vulnerability of the site to external inputs.

Lake substrate and sediment loads

The littoral substrates comprised mainly of consolidated gravels and pebbles covered by a thin layer of fine silt. Beyond approximately 1.5 m the substrate was silt. Poor buffering from the tilled land to the north east of the lake place it at risk of increased sediment load, one field having been cultivated to within a meter of the lake shore.

The sediment core showed an increase in organic content in the upper 15 cm (approximately 1932) of the core, but also higher organic content towards the base of the core (Figure 11). The increase in LOI at the top of the core is consistent with increased productivity both with in the lake and the immediate catchment. The high values towards the base also appear to reflect higher productivity, either due to land use or possibly coinciding with disturbance caused by the construction of the railway in the 1860s. The radiometric dates suggest the peak in organic matter predates the railway, but it does lie within the errors of the model which are relatively high in these older sediments.

The increase in organic content in the upper section of the is core almost certainly due to increased productivity which is reflected by the diatom assemblage with much high numbers of the *Aulacoseira granulata* (a eutrophic indicator) in the surface sediment than seen at 12.5 cm.

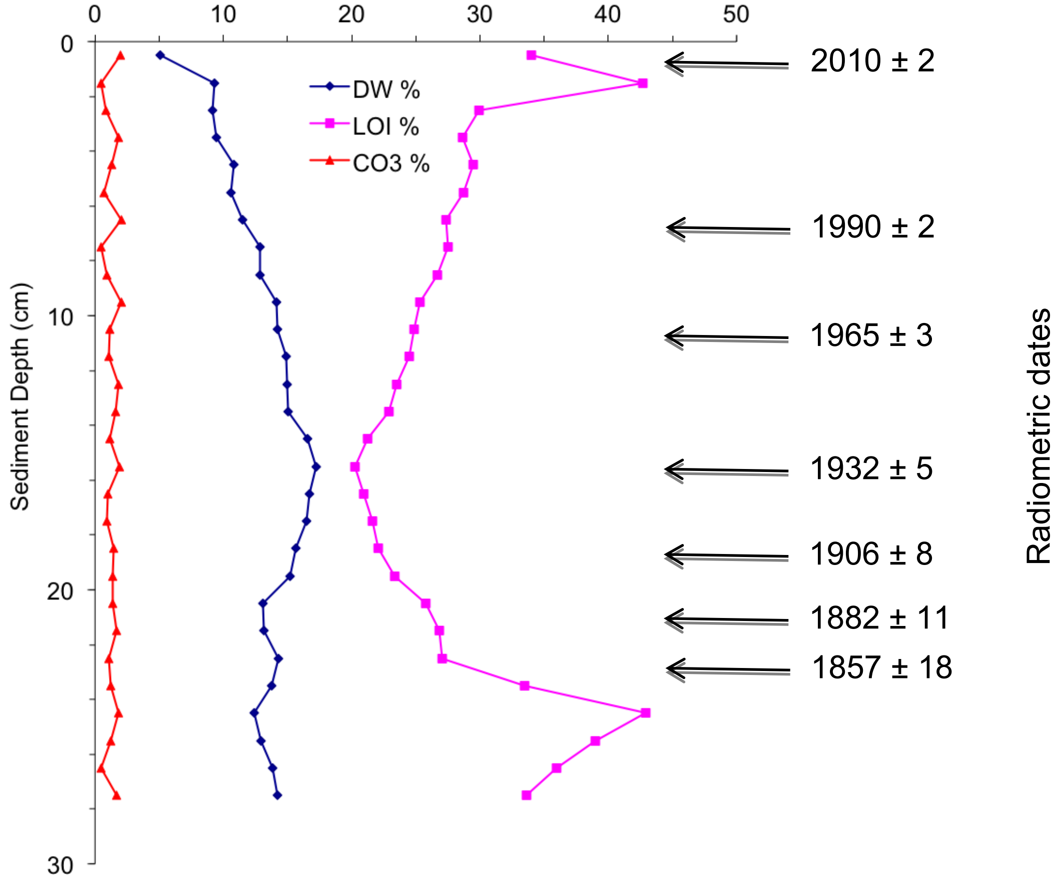


Figure 11 Physical characteristics and radiometric dates from core UKAU4

Indicators of local distinctiveness

The oligotrophic species *Isoetes lacustris, Littorella uniflora* and *Elatine hexandra* are uncommon in south Wales.

Bathymetry

The lake shelves relatively steeply from the margins, particularly along the north and south shore to a maximum depth of 12.2 m (Figure 12). Under favourable conditions it would be expected that *Isoetes lacustris* would grow to at least 4 m and thus there is a large area of potential habitat within the lake.

Palaeolimnological evidence

A 28 cm sediment core (UKAU4) was taken from the deep point (12.2 m at SN5376745676) using a Renberg gravity corer. The core was sliced at 1 cm intervals in the field and analysed for dry weight, organic content and carbonate content. A subset of samples were dried and subjected to radiometric dating. The physical analysis of the core is discussed above and presented in Figure 11. The dating shows the core to span a period of approximately 160 years, from 1850 to present day.

Fossil diatoms were poorly represented in the base of the core, the reason for which is unclear. Samples were better preserved higher up the core and the level at 12-13 cm (approximately 1950) was dominated by benthic species typical of slightly acidic lakes (e.g. *Frustulia rhomboides, Cymbella gracillis, Fragilaria exigua, Pinnularia* spp.

and *Eunotia* spp.). The surface sediment was very different and contained a high proportion of planktonic species, (mainly *Aulacoseira* spp. and *Asterionella formosa*) which are indicative of higher algal turbidity and enrichment.

Species turnover was high between the two samples and the SCD was highly significant at 1.19 (Table 21).

The basal sediments also had *Achnanthes minutissima* (6%), but were dominated by a small *Gomphonema* species (cf. *pumilum*) at 11% and *Eunotia incisa* (8%). *Cyclotella distinguenda* var. *unipunctata* was present at 4.5%. Based on the accumulation rates of c.AD 1850, the age of this sample is likely to be very old (>500 years BP).

Sample Code	Depth (cm)	2011/12 mean pH	DI-pH	2011/12 mean TP	DI-TP	SCD
UKAU4-00	0	7.26	6.85	214	42.3	1.19
UKAU4-12	12		6.15		8.2	0.00

Table 21 Results of Llyn Pencarreg sediment core analysis

Reconstructions of diatom-inferred pH (DI-pH) were produced using the SWAP training set (RMSEP = 0.32 pH units). A high percentage of the taxa in the fossil samples were present in the SWAP training set and there were no major analogue problems. The DI-pH results suggest the site has become slightly less acid over the time period covered by the upper half of the core (approximately 60 years). The current surface sediment assemblage estimates current pH to be lower than measured pH which is probably due to high pH measurements resulting from high levels of photosynthesis within the lake.

Reconstructions of diatom-inferred TP (DI-TP) show relatively low modelled TP from the lower part of the core (8.2 µg l^{-1}), but a five-fold increase in the surface from the surface sediment suggesting relatively rapid enrichment over the past 60 years. A high percentage of the taxa in the fossil samples were present in the NW European training set and there were no major analogue problems. The annual mean TP based on monthly water samples collected during 2011-12 was however 214 µg l^{-1} and therefore the diatom model gives considerable underestimate of current conditions. The reason for this underestimate is unclear.

In summary, there has been a major shift in floristic composition in the sediment core diatoms from Llyn Pencarreg. The surface diatom assemblage is indicative of a significant enrichment in the lake over the past 60 years. Over the same period the site has become slightly more alkaline, a probable result of agricultural improvement in the catchment. High resolution diatom analysis of the upper sediments of this dated core would be beneficial to better understanding the timings of this change and potentially help inform future management.

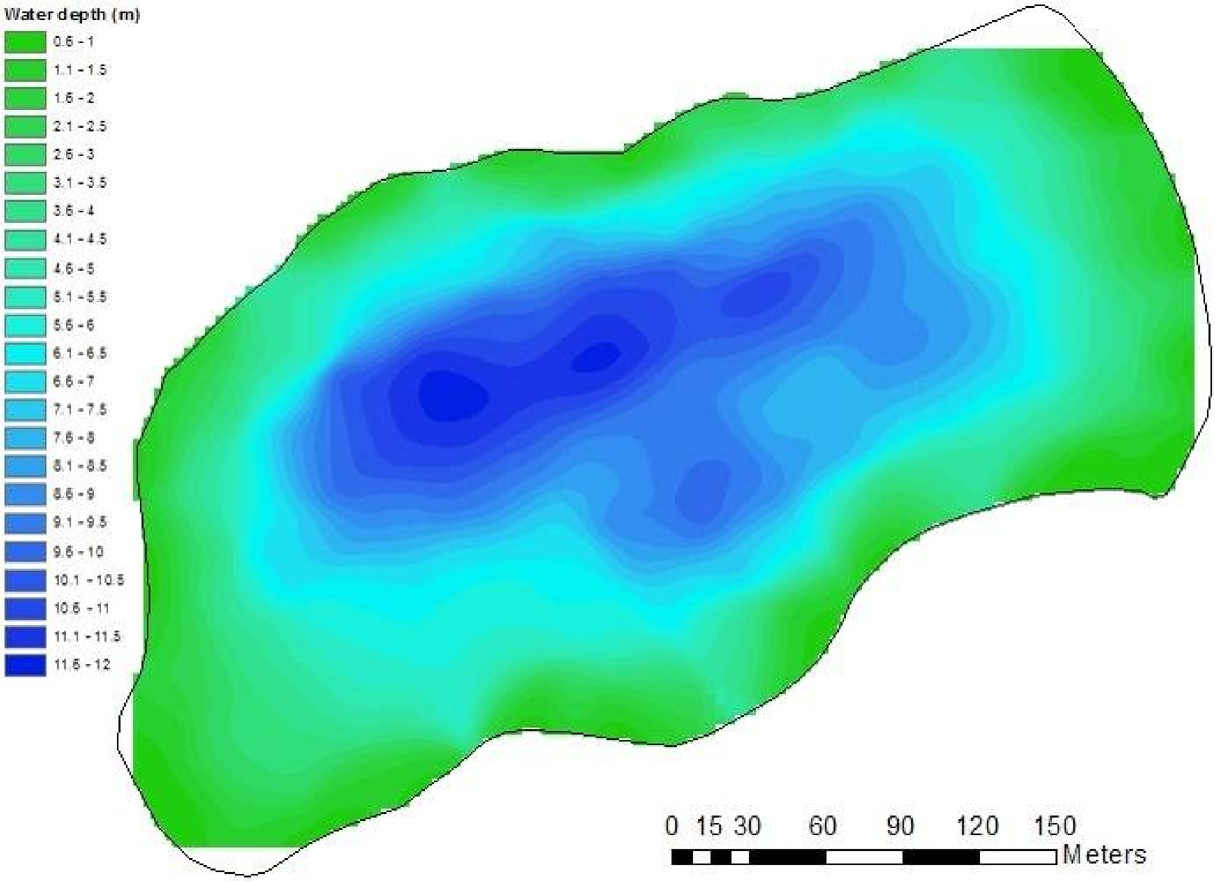


Figure 12 Bathymetric map of Llyn Pencarreg, December 2011

Site condition summary and overview

Llyn Pencarreg is in **unfavourable condition** with **high confidence**. The lake does support three characteristic oligotrophic species, but these are restricted to shallow waters (1.8 m maximum) and there remains extensive areas of the littoral habitat without any macrophytes. Although no previous CSM survey has been conducted at the site, the SSSI citation reports *L. uniflora* growing to 3 m and there has therefore almost certainly been a significant reduction in the maximum depth of colonisation in the lake.

The mean annual TP in 2011/2 exceeded the limit for oligotrophic lakes by a factor of 20, placing well into the hypereutrophic classification. This was accompanied by high chlorophyll *a* concentrations (and the occurrence of cyanobacterial blooms) causing poor water clarity. Alkalinity was relatively low and stable during 2011/2, but pH was well above that expected for oligotrophic lakes and is most likely being driven up by the high rates of algal photosynthesis.

With no surface inflow stream it is most likely that the nutrients are derived from the immediate ground-water catchment. Eutrophication is exacerbated by the closed hydrology of the lake, which is assumed to have very low turnover and hence any nutrients arriving at the site will be cycled internally rather than being flushed out via an outflow. The surrounding land is mostly improved pasture as well as recently tilled land, with little or no buffer strip to prevent fertilizer and sediment run-off reaching the water. This was evident in the extreme in June 2012, with the field to the northeast of the lake having recently been cultivated to within 1 m of the lake edge (Figure 13).

Figure 13 Northeast margin of Llyn Pencarreg showing cultivation of adjacent field

There are a number of residential properties, including recent developms, within the immediate catchment of the lake and poorly maintained sewerage systems could be a potential source of nutrients to the lake. This requires further investigation.

Given the current nutrient status of the site it is surprising that any characteristic species remain. Colonisation by more competitive, nutrient tolerant aquatic macrophytes, particularly non-native species (e.g. *Crassula helmsii, Elodea* spp. and *Lagarosiphon major*), would put the current flora at additional risk.

Water Body	Status	Reason(s) for Failure	Comments
Llyn Pencarreg	**Unfavourable (high confidence)**	Poor depth and spatial distribution of *Littorelletea* species. Very high P and pH. Poorly buffered from agricultural land. High planktonic algal biomass including cyanobacterial blooms	Llyn Pencarreg is remarkable for hanging on to the remnants of an oligotrophic flora despite very high nutrient levels. Management needs to focus on the improvement of agricultural practice in the immediate vicinity of the lake and also identify other potential sources of nutrients from the catchment.

Table 22 Llyn Pencarreg overview

Recommendations for monitoring and management:

Llyn Pencarreg appears to be clinging on to the remnants of its characteristic oligotrophic flora despite extremely high nutrients. Action is required to investigate the primary sources of nutrients (agricultural and residential) to the site and where necessary take action to prevent any further inputs through the implementation of improved catchment management.

The site would benefit greatly from fenced buffer strips to the north, east and south of the lake to limit bank erosion by livestock and help to reduce sediment and nutrient inputs from the surrounding farmland. Further knowledge of the extent and timing of the eutrophication could be gained by the additional analysis of the dated sediment core from the site.

A minimum of quarterly (of monthly) water quality monitoring is recommended to ascertain any directional change in water quality and annual checks should be made of the aquatic flora to monitor any changes to species composition and depth distribution. This would be best targeted along the north-east shore where both *L. uniflora* and *I. lacustris* are known to occur.

The following recommendations are based on the evidence collected for this report:

- Monitor water quality – minimum of quarterly sampling, but given the severity of the problem monthly sampling would be more informative.
- Investigate possible sources of nutrients and sediment from the catchment and take remedial action as required.
- Work with local land owners to improve marginal habitats with buffer strips that limit livestock access to the shore and reduce surface inputs to the lake.
- Monitor the aquatic flora every year to ascertain any increase or decline of the characteristic flora.
- Analyse the full sequence of diatom samples from the dated core to help identify the timing and magnitude of change within the site.
- Work with land owners and lake users to minimize the risk of non-characteristic aquatic plants (native or non native) colonising the site.

CSM Database output

Site Condition Assessment: Llyn Pencarreg (27/06/2012)

Lake Details		**Survey Details**		
Lake Name	Llyn Pencarreg	Survey Date	27/06/2012	
SSSI Name	LLYN PENCARREG	Surveyors	BG, JoS & JS	
SAC Name		Shore Surveys	4	out of
Grid Ref	SN537456	Wader Surveys	4	4
WBID / NI No.	39303 /	Boat Surveys	4	sections

Site Notes:
No inflow or outflow observed

Survey Notes:
Cyanobacterial bloom. Site poorly buffered from gricultural effects particularly on NE shore where ploughed to within 1 m of beach. Photo 312. Possible residential drainage problems

Section Summaries

Section 1	Maximum depth of colonisation (cm)	130 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	6 m
	Notes: POORLY BUFFERED	
Section 2	Maximum depth of colonisation (cm)	170 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	4 m
	Notes:	
Section 3	Maximum depth of colonisation (cm)	180 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	2 m
	Notes:	
Section 4	Maximum depth of colonisation (cm)	50 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	4 m
	Notes: NEW TRACK ALONG SHORE	

Section Locations

	Shore Survey GPS Co-ords		Boat Survey GPS Co-ords	
	start	end	start (shore)	end (lake)
Section 1	SN5388445776	SN5378645753	SN5383445766	SN5384445766
Section 2	SN5387345599	SN5379045542	SN5381645582	SN5381445586
Section 3	SN5353245640	SN5352445533	SN5352645582	SN5352745583
Section 4	SN5370845499	SN5360945474	SN5366545512	SN5366845515

Section Photos

	Start of Section	Whole Section	End of Section
Section 1	143	144	145
Section 2	146	147	148
Section 3	149	150	151
Section 4	152	153	154

Species Abundance - Boat Survey

Total number of sample plots 60
Total number of vegetated sample plots 8

Plant Species	Occurrence n	%
Elatine hexandra	6	75
Littorella uniflora	5	62

Species Abundance - Wader Survey

Total number of sample plots 80
Total number of vegetated sample plots 59

Plant Species	Occurrence n	%
Elatine hexandra	47	80
Iris pseudacorus	1	2
Isoetes lacustris	6	10
Juncus effusus	6	10
Littorella uniflora	38	64
Persicaria amphibia	1	2
Phalaris arundinacea	7	12

Note: Species abundance % = ((number of plots / total number of vegetated sample plots) * 100)

Plant Scores

Total plant species 14
Total plant cover (%) 85.6

Filamentous algae (%) 0% WADER 0% BOAT

PLANT SPECIES	SURVEY SCORES PERIMETER	WADER	BOAT	COVER %	DAFOR	ABUNDANCE
Elatine hexandra	0.05	0.2555	0.1095	24.98	F	3
Littorella uniflora	0.1	0.2203	0.1065	24.16	F	3
Juncus effusus	0.375	0.0375	0	11.25	F	3
Phalaris arundinacea	0.2625	0.0406	0	8.59	O	2
Lysimachia vulgaris	0.15	0	0	3.75	R	1
Solanum dulcamara	0.1	0	0	2.5	R	1
Isoetes lacustris	0.025	0.0269	0	1.97	R	1
Lythrum salicaria	0.075	0	0	1.88	R	1
Persicaria amphibia	0.0625	0.0025	0	1.69	R	1
Mentha arvensis	0.0625	0	0	1.56	R	1
Mentha aquatica	0.05	0	0	1.25	R	1
Iris pseudacorus	0.025	0.0031	0	0.78	R	1
Senecio aquaticus	0.025	0	0	0.62	R	1
Eleocharis palustris	0.025	0	0	0.62	R	1

5.4. Witchett Pool

Annex 1 type: 3150 Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation / Annex 1 type: 3140 Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.

5.4.1. Site description

Name:	Witchett Pool
County:	Carmarthenshire
WBID:	No WBID
Grid reference:	SN284076
OS Grid reference (X,Y):	228400,207570
Latitude / Longitude	N51°44.24',W004°29.8'
Altitude (m):	3
Maximum recorded depth (m):	1.05
Mean depth (m):	0.49
Lake volume (m^3)	22364 (46890)
Surface area - measured (ha):	5.29
Perimeter of lake (km):	c. 1.2
Shoreline Development Index (SDI):	Not calculated
WFD alkalinity based typology:	High Alkalinity, Very Shallow (HA,V)
Phase 1 habitat type:	Standing water: Eutrophic: G1.1
Survey Date:	26 June 2012

Table 23 Summary characteristics for Witchett Pool.

Witchett Pool is a low-lying lake within the Laugharne-Pendine Burrows SSSI. The lake is within the Ministry of Defense Pendine range managed by QinetiQ and as a consequence of this and its extensive reed beds, receives very little disturbance. The SSSI citation reports the lake as bieng formed from the damming of Witchett Pill. This is certainly the case with regard to the current extent of the lake and reed beds, but old maps show there to have already been an existing wetland and possibly open water occupying the area to the south side of Witchett Pill dating back to at least 1891(OS OpenSpace 2014).

Exactly when Witchett Pill was dammed is unclear. The 1964 Ordnance Survey map still shows Witchett Pill as a stream or ditch, distinct from the small water body to the south of it, and the 1972 map rather less helpfully shows this areas as only grey shading, presumably to mask the military activity in the area during the cold war era. It appears Her Majesties cartographers were behind the times however. Thomas (1955) describes “the Witchett” as being a pool of 600 x 300 yards already in existence in 1954, a description which accords with the full extent of the outer margin of the current lake. He also describes the pool as being formed by “blown sand” blocking the mouth of Witchett Pill and from his account which describes the margins as “….becoming covered with sedges and rushed etc.…” it can be assumed that the enlarged lake had not been too long in existence when he visited in 1954.

Today the lake is extremely shallow (<1 m) and has an extensive and expanding fringe of *Phragmites* dominated reedbed extending 50-150 m out into the open water.

5.4.2. Condition Assessment and Discussion

Table 24 Condition Assessment Summary Table for Witchett Pool

Attribute	Target	Status	Comment
Extent	No loss of extent of standing water	**X**	Natural encroachment of reed beds is on-going and possibly exacerbated by high nutrients.
Macrophyte community composition	Eutrophic species: ≥ 6 characteristic eutrophic species (inclusive of site specific targets for *C. submersum* and *N. opaca* – see text)	**X**	3 *Magnopotamion* spp: *Potamogeton crispus, Chara. globularis* & *C. virgata. Ceratophyllum submersum* and *Nitella opaca* also present.
	No loss of characteristic species (see Box 4)	**NA**	SSSI citation reports *C. hispida* as present in the past, but no other characteristic spp. Recorded
	≥ 6/10 vegetated sample spots (boat / wader survey) have ≥ 1 characteristic spp.	**X?**	51 % of vegetated sample points comply (40% wader, 73% boat) (only 51% of mapping points)
Negative indicator species	Non-native species absent or present at low frequency	✓	None recorded
	Benthic and epiphytic filamentous algae <10%.	✓	Filamentous algae only locally abundant, most points had 10% or less. 4% of sample points had >75% cover.
Macrophyte community structure	Characteristic vegetation zones should be present (site specific)	✓	Mixed species beds occurred throughout the open water area of the site.
	Maximum depth distribution maintained	✓	Z_{max} (recorded) = 1.05 m, Z_s = >site, Z_v = 1.05 m.
	At least present structure should be maintained	**NA**	Previous survey data lacking.
Water quality	Stable nutrients levels: TP target / limit: Oligotrophic = 10 $\mu g l^{-1}$	**X**	TP = 333 $\mu g\ l^{-1}$ TON = <0.4 $mg\ l^{-1}$ ENSIS / NLS 2011/12 mean
	Stable pH values: pH ~circumneutral - 10	**✓?**	pH = 6.98 – 11.5 Highly variable, but not atypical for very high alkalinity lakes.
	Adequate dissolved O_2 for health of characteristic fauna (> 5 mgl^{-1})	✓	~ 10 $mg\ l^{-1}$ and water column well mixed.

Attribute	Target	Status	Comment
	No excessive growth of cyanobacteria / green algae	✓?	Mean Chl *a* concentrations 13 µg l^{-1}, range 5 – 24. Summer values are low, suggesting water remains clear throughout growing season.
Hydrology	Natural hydrological regime	**NA**	Unknown
Lake substrate	Natural shoreline maintained	✓	Site within extensive area of low management dune system on closed military base.
	Natural and characteristic substrate maintained	✓	No evidence of change.
Sediment load	Natural sediment load maintained	**X?**	Concerns over a nearby lugworm farm need to be investigated.
Indicators of local distinctive-ness	Distinctive elements maintained at current extent / levels / locations	✓	*Ceratophyllum submersum* is common in the site. This species is rare in the UK and found <5 hectads in Wales.
Disturbance	No introduced species	✓	None recorded
	Minimal negative impacts from recreation and navigation. No fish farming	✓	None

Status: ✓ = favourable; X = unfavourable; NA = Not assessed

Extent

The current extent of open water at Witchett Pool is threatened by encroachment of the surrounding reed beds. The face of the reed edge is in shallow water with many active new shoots observed growing into open water. The area occupied by the lake inclusive of the surrounding reed bed measures approximately 16.6 ha with the present open water area accounting for only 5.29 ha. The SSSI Management Statement suggests that the open water area should not fall below 9 ha. During this project an application was made to NRW (CCW) to cut back areas of reed, but it is not know to what extent, if any, this was achieved. High nutrients are thought likely to accelerate reed growth and cause a significant loss of open water habitat.

Macrophyte community composition

Witchett Pool is very shallow and the extensive reed beds extend from the margins to approximately 50 cm water depth. *Phragmites australis* dominates with *Bolboschoenus maritimus, Sparganium erectum* and *Schoenoplectus tabernaemontani* occasional to frequent (locally abundant). The open water is dominated by *P. pectinatus* with *C. demersum* abundant, and *P. pusillus, Chara globularis* and *Ceratophyllum submersum* frequent, the latter tending to be found in more sheltered areas close to the edge of the reeds and within clearings within the reed beds. *Myriophyllum spicatum* and *Zannichellia palutris* were less frequent within the site, but where they did occur they were locally common. The *Lemna* species were mostly confined to within the reed beds, and due to access problems within the reeds the full extent of these species may not be recorded. Other species were rare within the site (see Table 25). The *Nitella* was fertile and confirmed by Nick Stewart as *N. opaca.* A single patch of *Chara virgata* was recorded during the CSM survey, but not picked up in the plant mapping.

Although it has not been systematically surveyed before, Witchett Pool has been regularly visited by botanists and there are previous records for most of the species recorded here on the BSBI distribution database. All of the charophytes and both *Lemna* spp. are new records for the site. *Potamogeton berchtoldii* was recorded in 1998 and could have been overlooked here due to its close resemblance to *P. pusillus*. *Myriophyllum alterniflorum* was recorded in 1967. Little data exists on previous plant assemblages, the SSSI citation records some species in common with the 2012 survey, but also mentions *Chara hispida* and *Utricularia vulgaris,* neither which were recorded in this survey. *U. vulgaris* agg. was recorded in 1998.

Table 25 Aquatic macrophyte community composition for Witchett Pool in June 2012; Characteristic eutrophic species are highlighted in **bold**.

Submerged and floating vegetation	TRS	PLEX	% occurrence (n=120)	DAFOR abundance[4]	Min depth (cm)	Max depth (cm)
Ceratophyllum demersum	10	8.85	55.0	A	25	105
Ceratophyllum submersum	**-**	**-**	**22.5**	**F**	**25**	**105**
Chara globularis	**7.3**	**7.69**	**33.3**	**F**		**105**
Chara virgata	**7.3**	**7.69**	**0.8**	**R**	**85**	**85**
Fontinalis antipyretica	6.3	5.38	+	R	70	80
Lemna minor	9	8.85	19.2	O	0	85
Lemna trisulca	10	8.85	9.2	R	25	85
Myriophyllum spicatum	9	8.85	15.0	O	50	105
Nitella opaca	**6.7**	**5.38**	**0.8**	**R**	**60**	**85**
Potamogeton crispus	**9**	**7.95**	**2.5**	**R**	**60**	**75**
Potamogeton pectinatus	10	8.85	56.7	A	40	105
Potamogeton pusillus	9	7.95	25.8	F	40	105
Zannichellia palustris	10	8.85	10.0	O	50	90
Average score	**8.63**	**7.93**				
Species richness				**13**		

Given the rarity of *Ceratophyllum submersum*, this species is considered to be an important component of the flora of the site and should be included as a site-specific target species. Similarly, *Nitella opaca* is rare in this site type and has also been included as a site-specific target species. Inclusive of these taxa, the CSM survey recorded one or more characteristic eutrophic species in only 51% of the survey plots

[4] Based on presence / absence data from all vegetated plots in the wader and boat based surveys. DAFORs are calculated from the total number of occurrences across the wader and boat surveys as a proportion of the total number of vegetated wader and boat survey points.

and 49% of the mapping points. This falls below the target value of 60% for favourable condition.

The 2012 assemblage classifies the lake in Group I (Duigan 2006) which consists mainly of high alkalinity lakes in the Eutrophic and Hard water EC habitats classification. Witchett Pool is more closely aligned with the former of these.

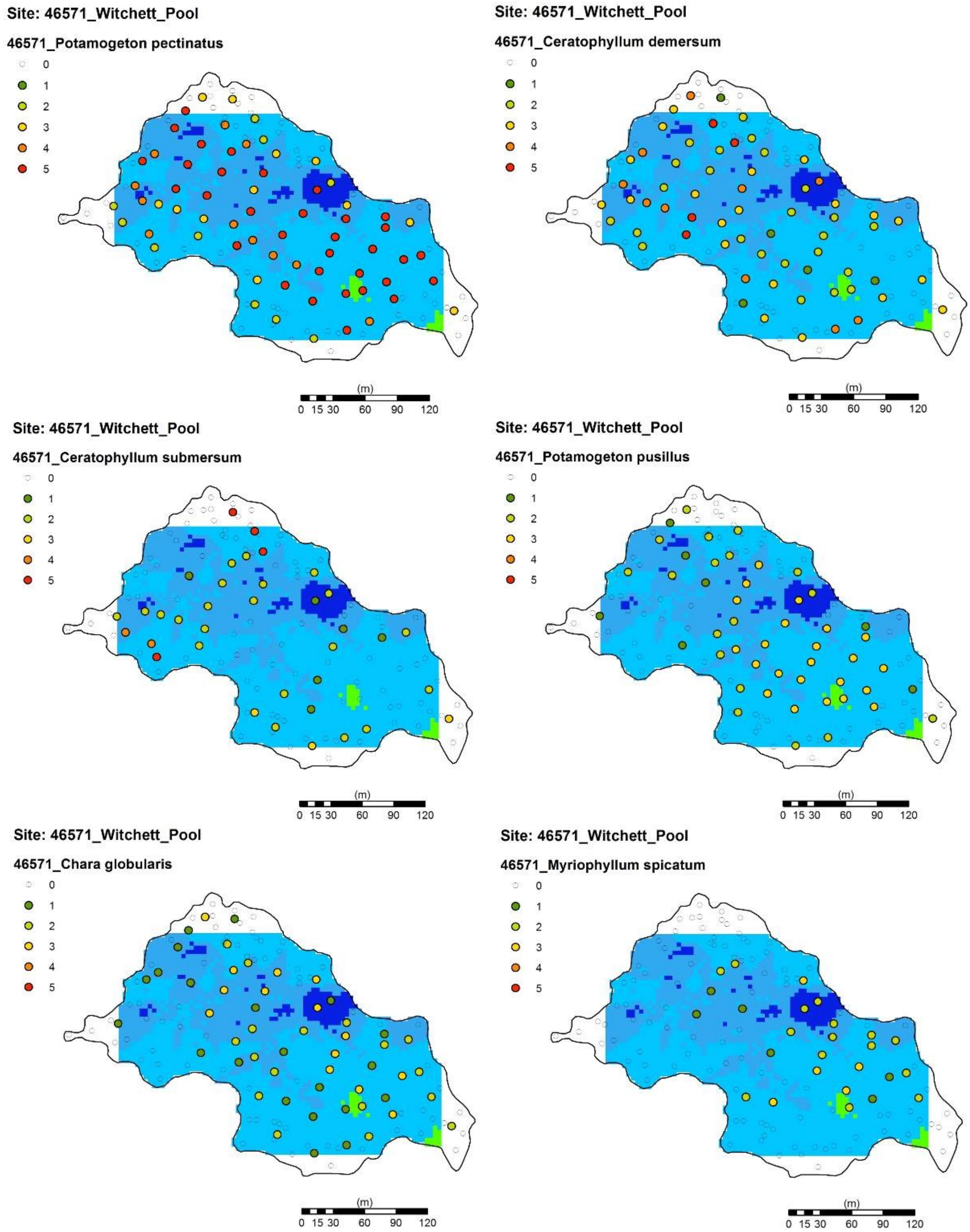


Figure 14 Distribution maps of the aquatic and emergent plant species recorded in Witchett Pool

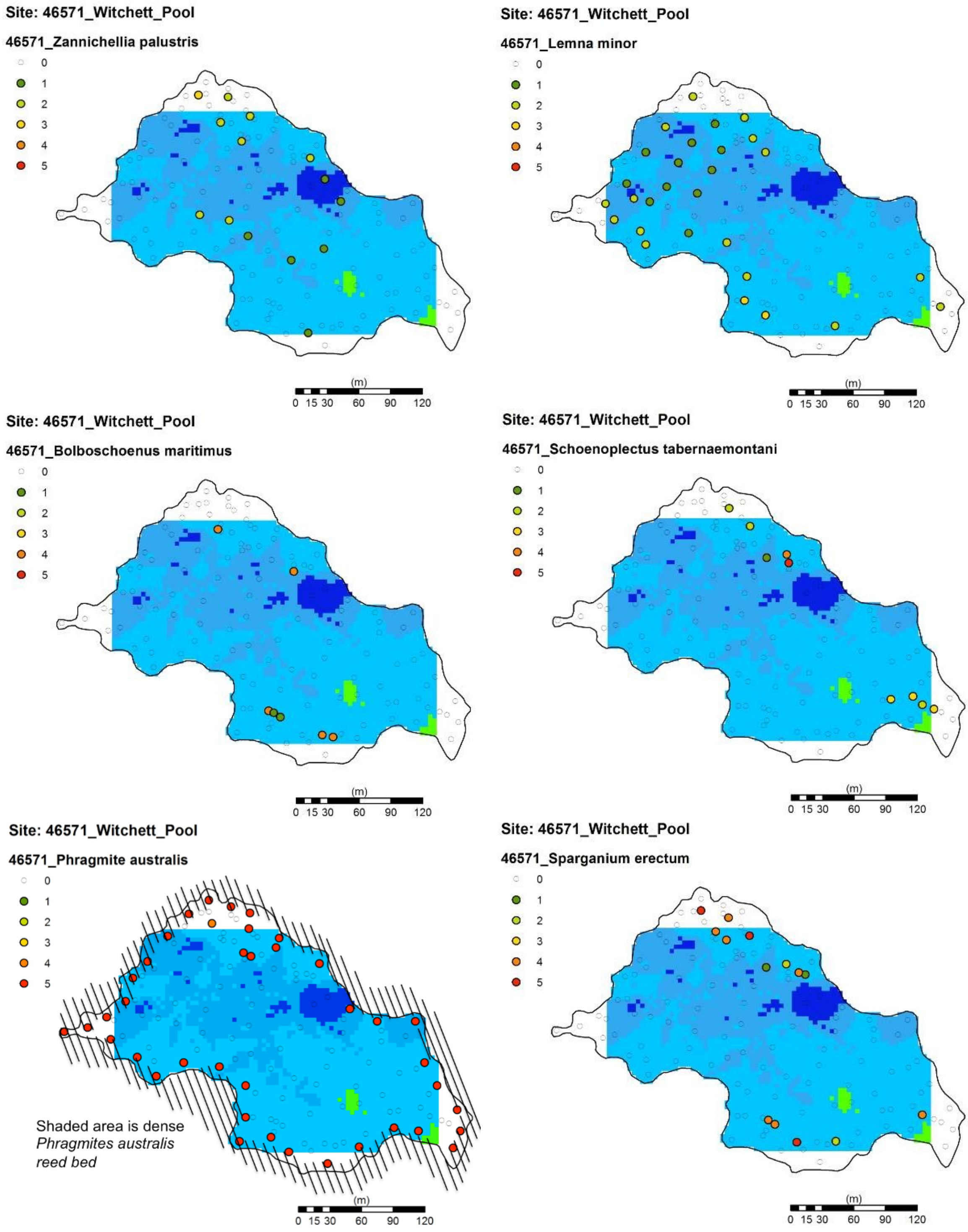


Figure 14 (Contd.)

Negative indicator species

Potamogeton pectinatus and *Ceratophyllum demersum* are both abundant at the site and are indicative of high nutrients. Most likely these species, and *Zannichellia palustris*, have a competitive advantage over many of the characteristic species, and particularly *Chara* spp., found at the site. The JNCC guidance (2005) recommends that sites dominated by these species be classified as unfavourable.

Macrophyte community structure

The open water had almost 100% plant cover with very dynamic stands of vegetation ranging from areas dominated by single species beds to, more commonly, quite species rich areas of dense vegetation. Even where *P. pectinatus* dominated it was usually within a complex mosaic of other species (Figure 14). As expected from such a shallow lake, there was no significant variation of species with water depth.

Water quality

Phosphorus concentrations are well above the upper limit for eutrophic lakes and classify the lake as hypereutrophic and thus unfavourable with respect to water quality. Using the MEI model the predicted reference TP was 27 µg l^{-1} with the High/Good and Good/Moderate boundaries being 34 and 47 µg l^{-1} respectively. Current TP values are equivalent to 'Bad' Ecological Status. This is may be an overly pessimistic conclusion as Witchett Pool does retain high macrophyte cover and clear water.

Water quality was otherwise relatively good and consistent with a high alkalinity lowland lake. (Table 26). At the time of survey the water was clear and dissolved oxygen levels high (9.68 mg l^{-1} at 50 cm).

Determinand	Dec 11	Mar 12	Jun 12	Oct 12	Annual mean 2011-12
pH	11.50	7.98	9.55	8.22	**8.38**
Cond	1220	429	309	358	**579**
Alk (Gran)	124	172	127	143	**142**
Alk (Total)	134	178	127	148	**146.8**
DOC	9.14	9.28	8.01	7.92	**8.59**
SRP	229	341	307	86.6	**241**
TP	318	489	368	156	**333**
Chl a	11	24	5	12	**13**
TN	-	-	-	-	**-**
TON	0.94	<0.2	<0.2	<0.2	**<0.4**
Na^+	6.49	25.2	20.2	19.9	**17.9**
K^+	1.35	5.42	1.34	1.36	**2.4**
Mg^{2+}	1.92	7.04	5.38	5.4	**4.9**
Ca^{2+}	20.4	63.9	44.5	52.5	**45.3**
Cl^-	49.4	45.2	33.1	36.2	**41.0**
$SO4^{2-}$	<10	<10	<10	<10	**<10**
SiO_2	5.03	1.14	7.93	1.2	**3.8**
Sus Solids	4.85	4.5	<3	<3	**<3.8**
ANC-I (ionic)					**3087**
ANC-C (Cantrell)					**2864**

Table 26. Water chemistry data for Witchett Pool (for units see methodology).

Soluble reactive phosphorus concentrations were high throughout the year, whereas nitrate (and TON) fell below detection in all but the winter sample, suggesting the site to be nitrogen limited for much of the year. It is therefore crucial the nitrogen, as well as phosphorus, is monitored and controlled effectively within the lake catchment.

Samples taken in December 2011 had very high pH and conductivity. It has been suggested that seawater can infiltrate the site via Witchett Pill on high spring tides (Thomas 1955), but the December samples were in fact noticeably lower in sodium (but not chloride) than samples with more than half the conductivity, so this is thought unlikely. Calcium was also lower in the December and it is unclear what ionic components were driving conductivity up and why the pH was so high.

Hydrology

The lake is reportedly the natural outcome of shifting sand dunes blocking the outflow stream, Witchett Pill, which raised the level of the existing wetland area to form the present extent of the lake. The full extent of the catchment is difficult to ascertain from maps due to the complex array of natural and artificial waterways which lie to the north and west of the lake dissecting the grazing marshes. The permeability of the surrounding sand further complicates the hydrology and the extent of subterranean flow through the dune system and Witchett Pool is unknown, but should not be discounted. The site would benefit from a clearer understanding of the hydrology in order to determine any potential sources of nutrients to the lake.

Lake substrate and sediment load

Within the open water, the lake sediments were sand and areas of consolidated silts. Being coastal and in a flat and exposed location the site is wind stressed and accumulation of sediment on the open water did not appear to be significant. By contrast, the expansive areas of surrounding reed beds sit upon deep unconsolidated silt measuring at least 80 cm in depth where assessed. The settlement of fine material within the more sheltered areas of the reed beds is facilitating the natural encroachment of reeds into open water. There is was no evidence of increased external sediment loads to the site, but sedimentation within the Pool will be accelerated by high nutrient levels.

Indicators of local distinctiveness

Although probably thriving at the site because of the elevated nutrients, *Ceratophyllum submersum* is rare in Wales, being recorded in fewer than 10 hectads. This species favors enriched, and often slightly brackish waters, making Witchett Pool an ideal site. The plant also prefers sheltered areas which explains its distribution in the site which is primarily close to the reeds and less common out in the open water.

Bathymetry

The bathymentric survey confirmed Witchett Pool to be very shallow and flat (Figure 15). Even in December there were remnants of the aquatic flora within the lake and this resulted in the echo-locator reading slightly shallower (c. 25 cm). During the survey, the deepest recorded depth was 1.05 m, whereas the bathymentric readings topped out at just over 70 cm. It should also be noted that the lake outline used is that of the open water, not the full extent of the lake that includes the large area of reed bed.

Access through the reeds was not possible in the most part, but from the limited observations that were possible it is assumed that most of the *Phragmites* reed is standing in 20-50 cm of water. Taking into account the under-reading of bathymetric equipment and the expense of water within the reeds the real volume of the lake is estimated to be 46890 m^3 rather than the 22364 m^3 calculated by the bathymetric analysis.

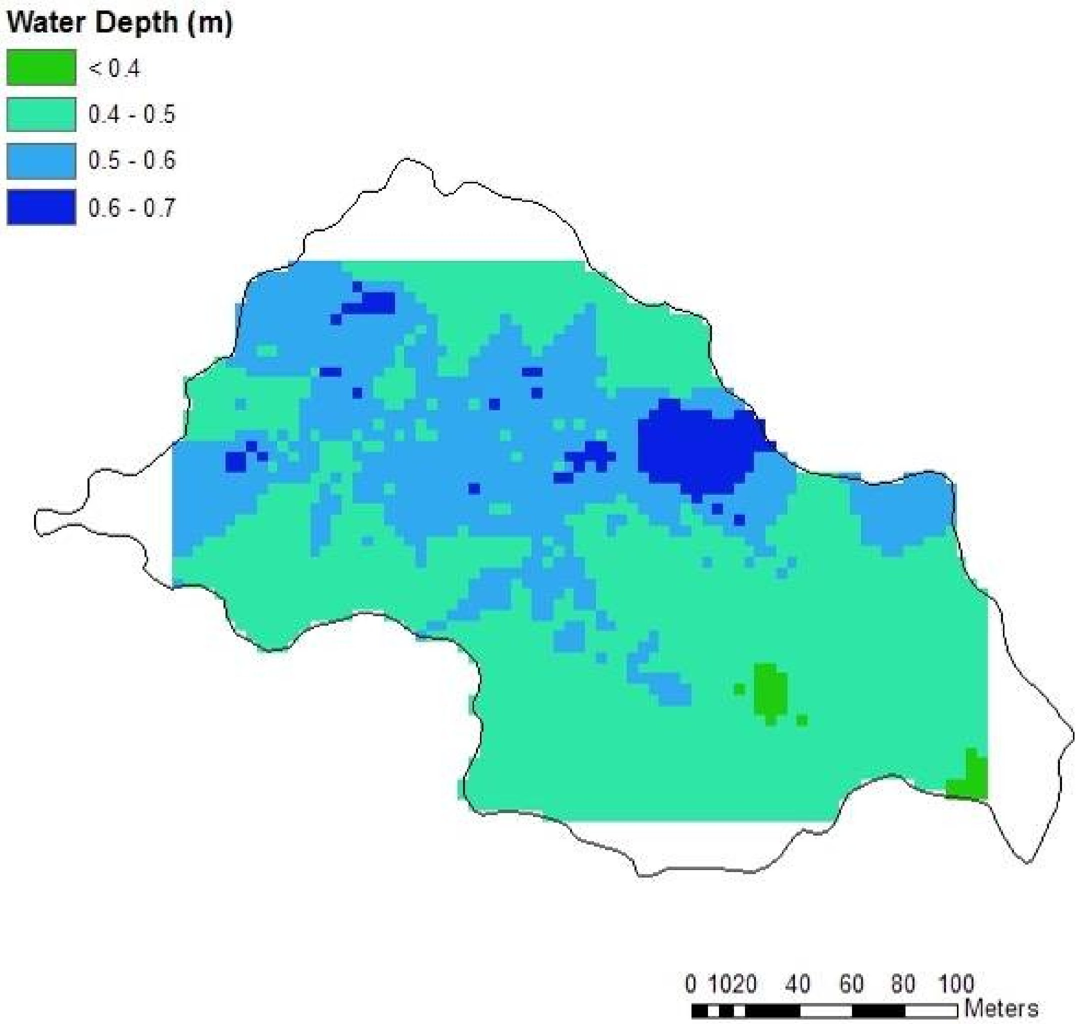


Figure 15 Bathymetric map of Witchett Pool, December 2011

Site condition summary and overview

Withchett Pool is **Unfavourable** with **high confidence**, primarily due to the very high phosphorus concentrations at the site and dominance of plants associated with high nutrient levels (e.g. *Ceratophyllum demersum* and *Potamogeton pectinatus*). The dynamic structure of the vegetation is typical of very shallow eutrophic lakes, with dense beds of mixed species occurring throughout most of the open water. The current structure provides excellent habitat for invertebrates and will be a major food source for the overwintering and breeding populations of waterfowl which frequent the site.

Active encroachment of the reeds is threatening the extent of open water and reed-cutting will be required to prevent any further loss of open water. It should however be stressed that the reeds are a vital part of the site habitat and significant areas of reed bed should be maintained. The opening up of “clearings” within the reed beds is likely to favour *Ceratophyllum submersum* and increase the habitat diversity by providing sheltered areas to contrast with the more exposed areas of open water.

External nutrient sources warrant further investigation. The water quality analysis shows the site to have extremely high concentrations of phosphorus, but also show it is probable that nitrogen is the limiting nutrient in the site. Much of the nitrogen within the catchment is likely to be sequestered within the drainage ditches and marginal reed beds before reaching the open water, but it remains important to identify and reduce all potential sources of N and P in the catchment.

It is thought likely that the site once supported a more extensive *Chara* community, including *Chara hispida.* The lake is however relatively young, and charophytes would have been early colonists when water levels first rose. *Chara globularis* remains frequent in the site and *C. virgata* was also recorded and thus these element are preserved in the current flora, albeit in competition with more vigorous species such as of *P. pectinatus*. In the absence of regular survey records from the site, examination of the plant macrofossils from the sediment record would provide the best means of establishing the baseline flora for the site. This would be dependent on finding areas of reliable sediment accumulation in the site.

Table 27 Witchett Pool overview

Water Body	Status	Reason(s) for Failure	Comments
Witchett Pool	**Unfavourable (High confidence)**	Very high Phosphorus. High frequency of negative indicator species. Encroachment of surrounding reed beds	Although failing the condition assessment, Witchett Pool still maintains a relatively rich aquatic flora and includes a nationally rare species (*C. submersum*). The site maintains very good habitat for invertebrates and waterfowl. Nutrient inputs – both P and N – require investigation Reed encroachment needs to be managed to prevent further loss of open water. The analysis of plant macrofossils would provide the best means of establishing the baseline flora of the site and allow for site specific restoration targets to be set.

Recommendations for monitoring and management:

Despite being in unfavourable condition, Witchett Pool remains an excellent freshwater habitat resource within the Laugharne-Pendine Burrows SSSI. Informed management will be key to maintaining this habitat and to ensure the site moves back towards favourable condition.

Action is required to investigate the primary sources of nutrients (agricultural and residential) to the site and where necessary take action to prevent any further inputs through improved catchment management. Phosphorus levels are extremely high at the site and while some of this likely to be internal, external sources from residential wastewater disposal (including the military range) should be investigated to ensure full compliance with treatment and disposal. While phosphorus is important, the apparent nitrogen limitation at the site makes N the primary driver of eutrophication at the site in the short term and therefore a priority for reduction. Any potential sources of nitrogen, including applications to agricultural land and any effluent from the nearby bait farm, should be carefully controlled.

The NRW management plan for the Laugharne-Pendine Burrows SSSI recognises natural reed encroachment as a threat to the lake and recommends the area of open water not be allowed to fall below 9 hectares. The current expanse of open water is now well below this threshold (5.29 ha) and active management should therefore be considered a priority. A balance between the extensive reed beds and the open water area is likely to maximize the habitats within the SSSI. The cutting of “back-waters” into the reeds would further enhance the habitat by providing more sheltered areas, a habitat that favours *Ceratophyllum submersum*, and would offer greater protection for dragonflies and damselflies. Reed cutting should be restricted to periods when it will minimize disturbance to breeding and overwintering birds. Disturbance to the site is minimal and this situation would be good to maintain. Use of the site for angling or other recreational activities is not considered to be appropriate.

With the primary reason for failure being water quality, it would be beneficial to implement regular water quality monitoring(minimum of quarterly sampling) at the site to ascertain any directional chance with which to assess the success of site management and help to inform future management of the lake. Similarly the aquatic flora should be monitored on a 3 or 5 year cycle to assess any directional change.

The following recommendations are based on the evidence collected for this report:

- Investigate possible sources of nutrients (N & P) from the immediate catchment and take remedial action as required.
- Monitor water quality – minimum of quarterly sampling.
- Devise a schedule for reed cutting to maintain the extent of open water in accordance with NWR recommendations (9 ha).
- Monitor the aquatic flora on a 3 or 5 year cycle to evaluate any directional changes within the site.
- The analysis of aquatic plant macrofossils from a sediment core would help to set site specific targets at the site.

CSM Database output

Site Condition Assessment: Witchett Pool (26/06/2012)

Lake Details

Lake Name	Witchett Pool
SSSI Name	Laugharne-Pendine Burrows
SAC Name	
Grid Ref	SN284076
WBID.	50708

Survey Details

Survey Date	26/06/2012	
Surveyors	BG, ES & JS	
Shore Surveys	4	out of
Wader Surveys	4	4
Boat Surveys	4	sections

Site Notes:
Very shallow (,1.0 m) site surrounded by dense reed swamp. Access to open water very difficult.

Survey Notes:
Ceratophyllum submersum and C. demersum present. Plants present throughout lake. Access to marginal areas not possible through reeds.

Section Summaries

Section 1

Maximum depth of colonisation (cm)	85 cm
Compass bearing of boat transect (°)	-
Lateral distance from waters edge to 75cm depth (m)	-

Notes: No access into reeds. Plants to max depth of trans

Section 2

Maximum depth of colonisation (cm)	100 cm
Compass bearing of boat transect (°)	-
Lateral distance from waters edge to 75cm depth (m)	-

Notes: No access into reeds. Plants to max depth of trans

Section 3

Maximum depth of colonisation (cm)	-
Compass bearing of boat transect (°)	-
Lateral distance from waters edge to 75cm depth (m)	-

Notes: No access into reeds. Plants to max depth of trans

Section 4

Maximum depth of colonisation (cm)	-
Compass bearing of boat transect (°)	-
Lateral distance from waters edge to 75cm depth (m)	-

Notes: No access into reeds. Plants to max depth of trans

Section Locations

	Shore Survey GPS Co-ords		Boat Survey GPS Co-ords	
	start	end	start (shore)	end (lake)
Section 1	SN2851707562	SN2851507511	SN2852307532	SN2837907585
Section 2	SN2842907470	SN2836907533	SN2838807506	SN2842407570
Section 3	SN2837507646	SN2845607599	SN2841707631	SN2839907887
Section 4	SN2827307555	SN2825707626	SN2824807589	SN2834107606

Section Photos

	Start of Section	Whole Section	End of Section
Section 1	121	122	124
Section 2	127	126	125
Section 3	129	134	135
Section 4	140	142	141

Species Abundance - Boat Survey

Total number of sample plots	80
Total number of vegetated sample plots	40

Plant Species	Occurrence *n*	%
Bolboschoenus maritimus	1	2
Ceratophyllum demersum	32	80
Ceratophyllum submersum	10	25
Chara globularis	23	57
Chara virgata	1	2
Lemna minor	4	10
Lemna trisulca	1	2
Myriophyllum spicatum	13	32
Nitella opaca	1	2
Potamogeton pectinatus	34	85
Potamogeton pusillus	17	42
Zannichellia palustris	10	25

Species Abundance - Wader Survey

Total number of sample plots	80
Total number of vegetated sample plots	80

Plant Species	Occurrence *n*	%
Bolboschoenus maritimus	1	1
Ceratophyllum demersum	34	42
Ceratophyllum submersum	17	21
Chara globularis	17	21
Lemna minor	19	24
Lemna trisulca	10	12
Myriophyllum spicatum	5	6
Phragmites australis	61	76
Potamogeton crispus	3	4
Potamogeton pectinatus	34	42
Potamogeton pusillus	14	18
Schoenoplectus tabernaemontani	2	2
Sparganium erectum	4	5
Zannichellia palustris	2	2

Note: Species abundance % = ((number of plots / total number of vegetated sample plots) * 100)

Plant Scores

Total plant species 16 **Filamentous algae (%)** 7.4 % WADER 12.2 % BOAT

Total plant cover (%) 191.03

SURVEY SCORES

PLANT SPECIES	PERIMETER	WADER	BOAT	COVER %	DAFOR	ABUNDANCE
Phragmites australis	0.75	0.5524	0	46.37	A	4
Potamogeton pectinatus	0.1	0.0864	0.247	31.52	A	4
Ceratophyllum demersum	0.1	0.0914	0.2302	30.09	A	4
Chara globularis	0	0.0424	0.1462	16.74	F	3
Potamogeton pusillus	0.1	0.0352	0.1038	14.64	F	3
Ceratophyllum submersum	0	0.0426	0.08	10.13	F	3
Myriophyllum spicatum	0.075	0.011	0.0702	9.44	O	2
Lemna minor	0.1	0.0441	0.0268	7.38	O	2
Zannichellia palustris	0.075	0.0052	0.0515	7.28	O	2
Sparganium erectum	0.2125	0.0084	0	5.73	O	2
Bolboschoenus maritimus	0.15	0.0012	0.003	4.11	R	1
Schoenoplectus tabernaemontani	0.15	0.0046	0	3.98	R	1
Lemna trisulca	0	0.0242	0.0062	1.83	R	1
Potamogeton crispus	0.025	0.0065	0	0.95	R	1
Chara virgata	0	0	0.0042	0.42	R	1
Nitella opaca	0	0	0.0042	0.42	R	1

5.5. Llyn Treflesg

Annex 1 type: 3150 Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation.

5.5.1. Site description

Table 28 Summary characteristics for Llyn Treflesg

Name:	Llyn Treflesg
County:	Isle of Anglesey
WBID:	32970
Grid reference:	SH307770
OS Grid reference (X,Y):	230765,377068
Latitude / Longitude	N53°15.81',W004°32.33'
Altitude (m):	9
Maximum recorded depth (m):	4.85
Mean depth (m):	Not recorded
Lake volume (m^3)	Not recorded
Surface area - measured (ha):	3.1
Perimeter of lake (km):	1.2
Shoreline Development Index (SDI):	1.994
WFD alkalinity based typology:	High Alkalinity, Very Shallow (HA,V)
Phase 1 habitat type:	Standing water: Eutrophic: G1.1
Survey Date:	19 June 2012

Llyn Treflesg is one of the smaller lakes lying within the Llynnau y Fali - Valley Lakes SSSI, of which Llyn Dinam, to the north (now an SAC in its own right) and Llyn Penrhyn to the east make up the larger areas of water. The area was notified as an SSSI for its biological interest and specifically the freshwater habitats which are described in the citation as hosting species associated with mesotrophic to eutrophic conditions and base-rich water.

While the larger lakes are natural in formation, Llyn Treflesg and a number of smaller water bodies were created during the building of the RAF Valley airfield. The airfield was formed by the leveling of the Tywyn Trewan sand dunes and the peat which was dredged from the channel draining Llyn Dinam was used to stablise the sand on which the airfield was constructed (Duigan and Ellis 2002). The resultant excavations filled with water which now form permanent lakes and ponds within the SSSI. The level in Llyn Treflesg is controlled by a fixed sluice at the south-west end before the outflow passes under the railway line.

Eutrophication has been identified as the a major threat to lakes within the SSSI, with sewage effluent from RAF Valley Sewage Treatement Works and the settlement of Llanfihangel yn Nhowyn discharging directly into Llyn Penrhyn being the primary cause. The sewage treatment works was enlarged in 1964 but phosphate stripping only came into effect in 1994 (Haworth *et al.* 1996). Llyn Treflesg receives water from Llyn Penrhyn via a small surface channel as well from L. Dinam to the north which is also eutrophic, but hydrologically separate from L. Penrhyn (Burgess *et al. 2006*).

There has been no previous CSM site condition survey, but a number of previous site visits over the years have generated a comprehensive species list for the site, summarised in the report by Lansdown (2013) who also surveyed the site in 2012.

5.5.2. Condition Assessment and Discussion

Attribute	Target	Status	Comment
Extent	No loss of extent of standing water	✓	None.
Macrophyte community composition	Eutrophic species: ≥ 6 characteristic eutrophic species listed in Box 4 1 broadleaved *Potamogeton* species should be present.	X	4 *Magnopotamion* spp recorded in total: *Potamogeton crispus, P. obtusifolius, Callitriche truncata* & *Ranunculus circinatus.* No broadleaved pondweeds. 2 spp. of *Hydrocharition: Lemna trisulca* & *L. minor*
	No loss of characteristic species (see Box 4)	NA	No CSM data, but old records of *P. lucens* (1964) otherwise appears stable
	≥ 6/10 vegetated sample spots (boat / wader survey) have ≥ 1 characteristic spp.	✓	78% of vegetated sample points comply (only 54% in plant mapping data)
Negative indicator species	Non-native species absent or present at low frequency	✓	*Elodea canadensis* present at 18% frequency – and present since at least 1989
	Benthic and epiphytic filamentous algae <10%.	✓	Filamentous algae only occasional - most points had 10% or less.
Macrophyte community structure	Characteristic vegetation zones should be present (site specific)	✓	Mixed species beds occurred throughout the site with plants common to 1.7 m. poor distribution of some species.
	Maximum depth distribution maintained	✓	No previous data, but Z_v is acceptable. Z_{max} (recorded) = 3.7 m, Z_s = 1.09 m, Z_v = 3.20 m.
	At least present structure should be maintained	NA	No previous data
Water quality	Stable nutrients levels: TP target / limit: Eutrotrophic = 50 μgl^{-1}	X	TP = 396 μgl^{-1} SRP = 364 μgl^{-1} TON = <0.05 mgl^{-1} Summer mean 2004 & 2005
	Stable pH values: pH ~circumneutral - 10	✓	pH = 7.6 – 7.8 Summer 2004/5 only
	Adequate dissolved O_2 for health of characteristic fauna (> 5 mgl^{-1})	✓	> 10 mgl^{-1} and water column well mixed.
	No excessive growth of	NA	Insufficient data to assess.

Attribute	Target	Status	Comment
	cyanobacteria / green algae		
Hydrology	Natural hydrological regime	✓	Controlled at outflow – appears stable
Lake substrate	Natural shoreline maintained	✓	Site within extensive area of low management grass and wetland
	Natural and characteristic substrate maintained	✓	No evidence of change
Sediment load	Natural sediment load maintained	✓?	No evidence of change
Indicators of local distinctive-ness	Distinctive elements maintained at current extent / levels / locations	✓	None noted
Disturbance	No introduced species	X	*Elodea candensis* present
	Minimal negative impacts from recreation and navigation. No fish farming	✓	None

Status: ✓ = favourable; X = unfavourable; NA = not assessed.

Table 29. Condition Assessment Summary Table for Llyn Treflesg.

Extent

There is no evidence of any loss of extent. Natural encroachment of common reed has occurred at several points around the lake, but the site shelves quite steeply beyond the current reed face and any further encroachment will be very slow.

Macrophyte community composition

A total of 14 species of aquatic macrophyte were recorded from Llyn Treflesg, of which 4 are classified as characteristic eutrophic species within the updated CSM guidance (JNCC, in draft) (Table 30). It should be noted that only three characteristic eutrophic species were recorded during the CSM survey, with *Potamogeton obtusifolius* found only during the mapping. No braordleaved *Potamogeton* species were found. The current assemblage classifies the site as a Group G lake according to Duigan with a corresponding PLEX score of 7.24.

The marginal and emergent vegetation ranged from areas of dry, un-managed grassland and scrub vegetation along the west shore, to quite extensive areas of *Phragmites* dominated reed bed to the north and east shores and in the south-western arm. The area round the northern inlet channel was relatively species rich and included *Butomus umbellatus, Carex riparia, Carex elata, Typha latifolia, Iris pseudacorus,* and *Phragmites australis.* Other notable emergent species included *Rumex hydrolapathum, Thelypteris palustris* and *Ranunculus lingua*.

Table 30 Aquatic macrophyte community composition for Llyn Treflesg in June 2012; Characteristic eutrophic species are highlighted in **bold**.

Submerged and floating vegetation	TRS	PLEX	% occurrence (n=59)	DAFOR abundance[5]	Min depth (cm)	Max depth (cm)
Callitriche truncata	**-**	**-**	**3.4**	**R**	**50**	**120**
Elodea canadensis	7.3	7.95	18.6	O	75	320
Fontinalis antipyretica	6.3	5.38	15.3	R	50	330
Lemna minor	9	8.85	42.4	O	25	140
Lemna trisulca	10	8.85	3.4	R	60	200
Myriophyllum spicatum	9	8.85	6.8	R	60	210
Nitella flexillis agg.	6.7	5.38	+		70	70
Nuphar lutea	8.5	6.92	23.7	R	50	220
Nymphaea alba	6.7	3.08	11.9	R	25	220
Persicaria amphibia	9.0	7.95	13.6	R	50	170
Potamogeton berchtoldii	7.3	7.69	+		70	120
Potamogeton crispus	**9**	**7.95**	**8.5**	**R**	**50**	**150**
Potamogeton obtusifolius	**8.0**	**6.54**	**+**		**70**	**130**
Ranunculus circinatus	**10**	**8.85**	**47.5**	**F**	**25**	**270**
Average score	**8.21**	**7.24**				
Species richness				**14**		

Negative indicator species

Elodea canadensis was present in the site at 18 % frequency in the CSM survey and 20% frequency in the mapping survey. There is evidence of it having been at the site since at least 1989 (Preston, cited by Lansdown 2013). Current levels are acceptable, but any significant increase would be deemed unfavourable.

Macrophyte community structure

Much of the site shelves quite steeply from the margins to depths in excess of 3 m which was beyond the depth of colonisation and thus macrophyte growth is restricted mainly to the littoral zone with only sparse growth beyond 1.7 m. *Nuphar lutea* and *Nymphaea alba* mostly occurred in small, often discrete beds of one or just a few plants. With the exception of *Ranunculus circinatus* and the two *Lemna* speices which occurred throughout much of the site, species were mainly confined to just a few locations in the site rather than having extensive beds of plants as suggested for this site type in the JNCC guidance (see maps Figure 16).

[5] Based on presence / absence data from all vegetated plots in the wader and boat based surveys. DAFORs are calculated from the total number of occurrences across the wader and boat surveys as a proportion of the total number of vegetated wader and boat survey points. A plus (+) denotes a taxon recorded as present at the site but not found growing in the wader or boat survey sections

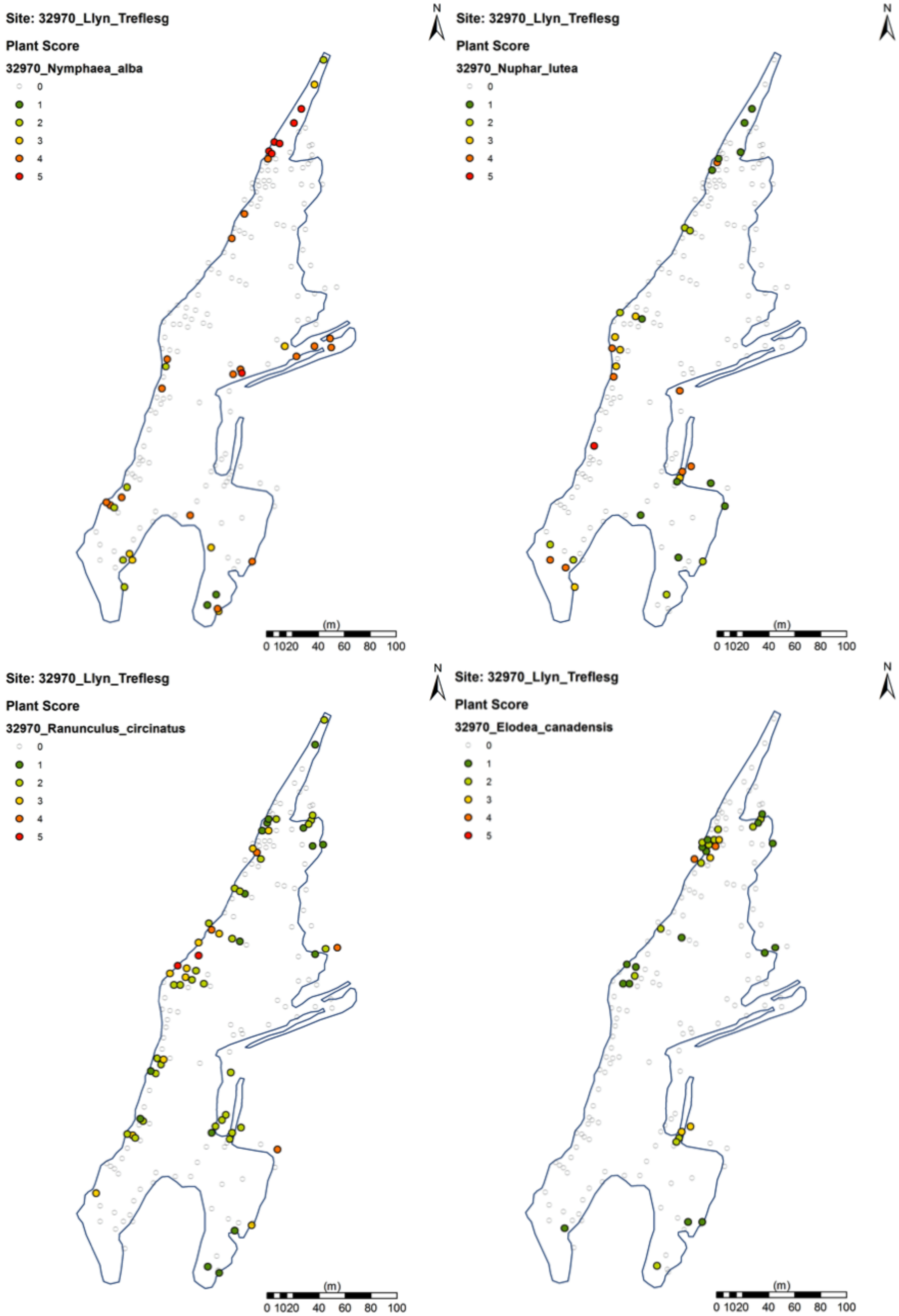
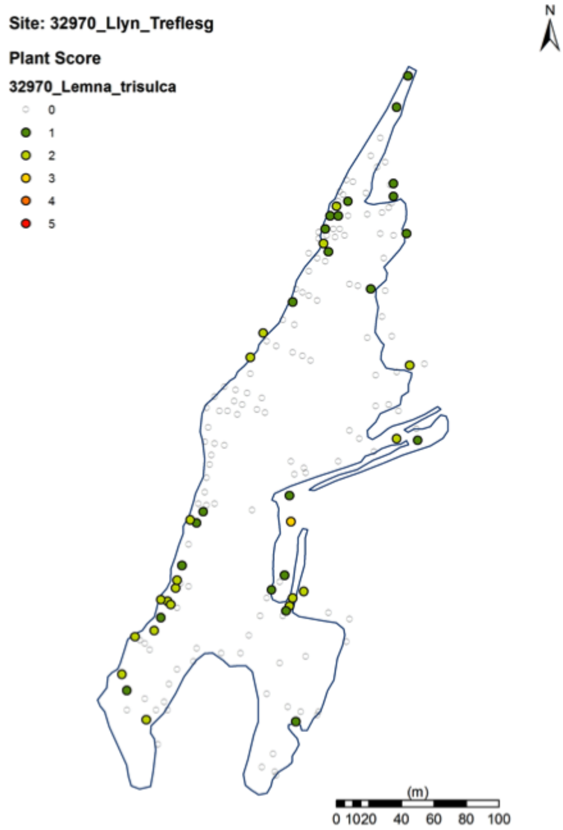
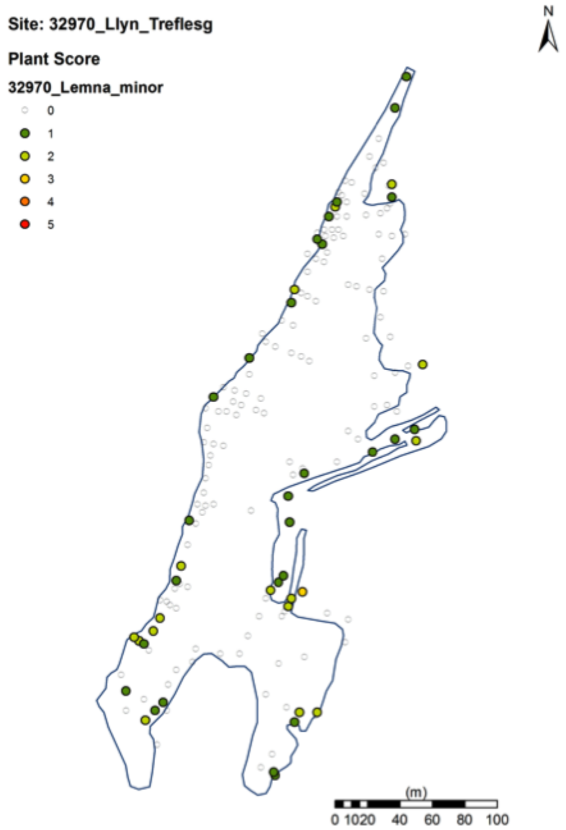
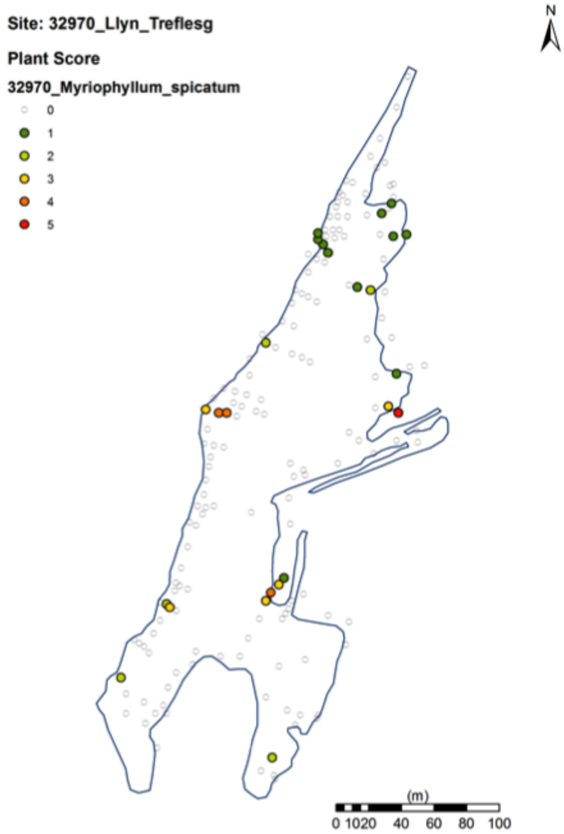


Figure 16 Distribution maps of the aquatic plant species recorded in Llyn Treflesg







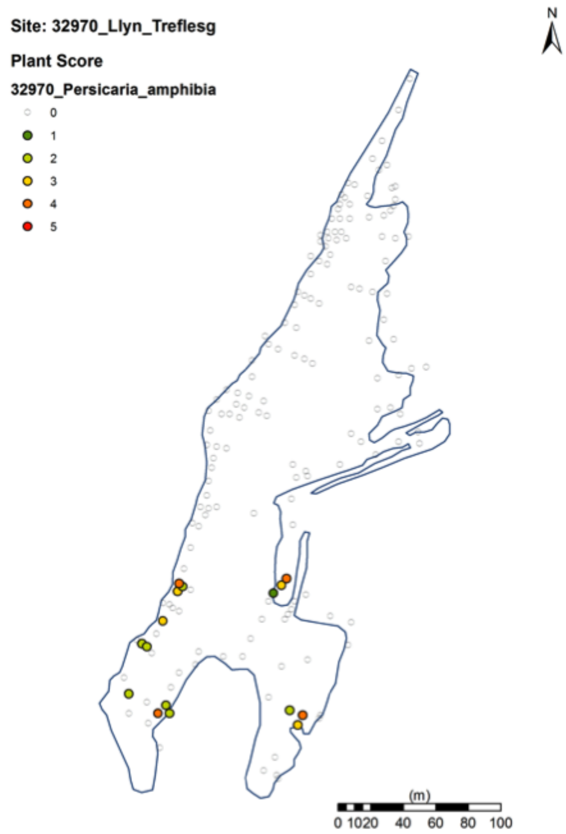


Figure 16 (Contd.)

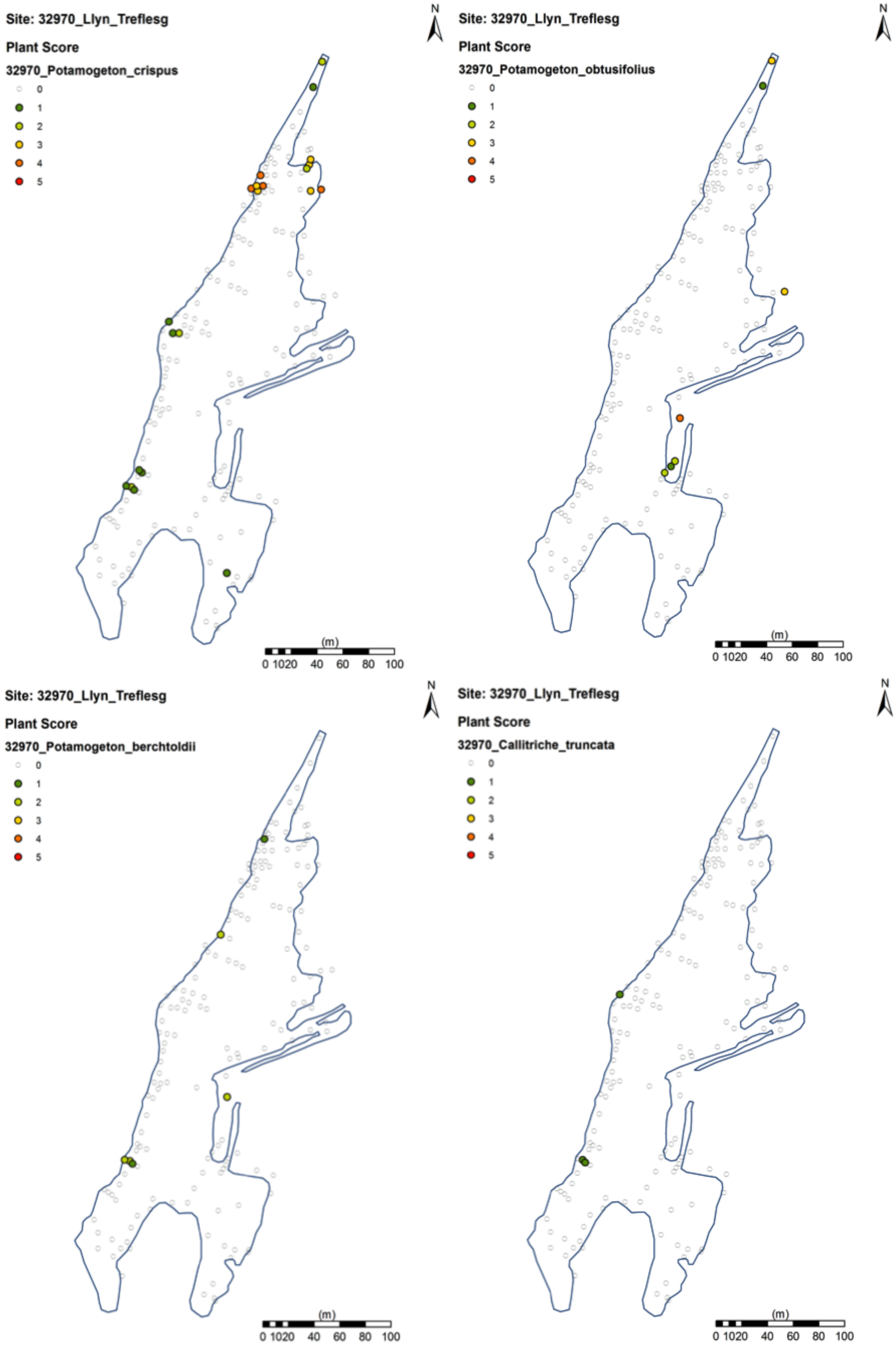
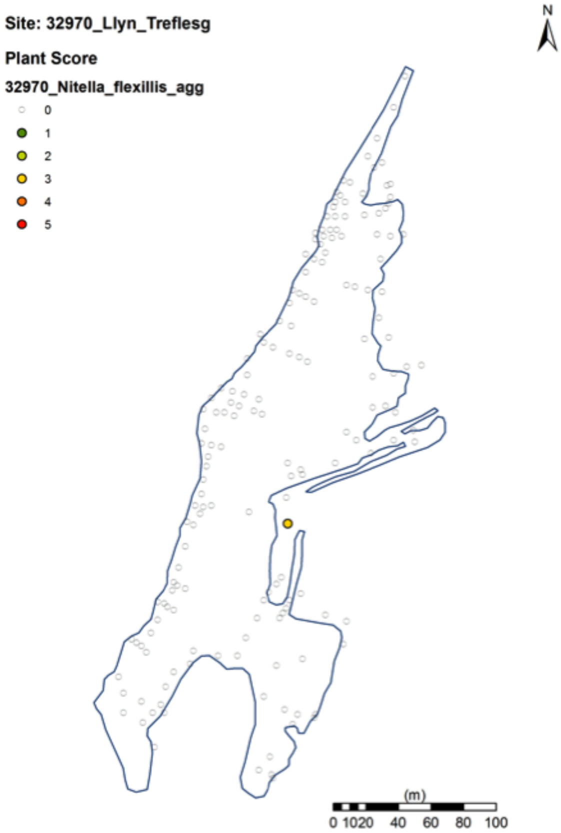
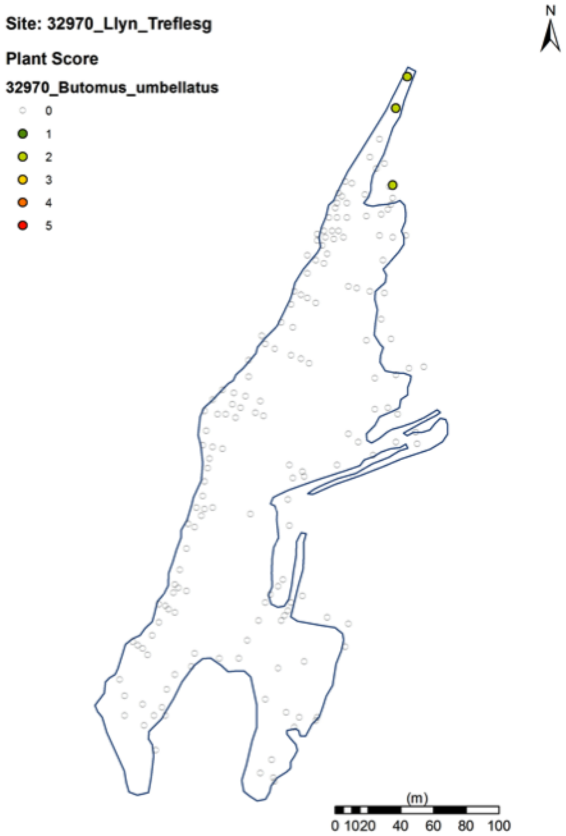


Figure 16 (Contd.)





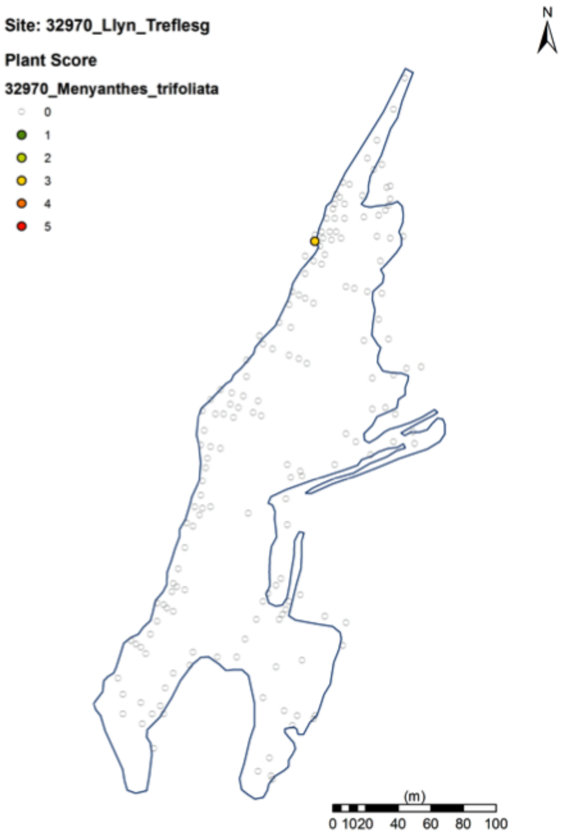


Figure 16 (Contd.)

Water quality

There is no recent water chemistry data from Llyn Treflesg. Samples from the outflow taken in August and September 2004 and 2005 (Source RSPB) show the site to have been hypereutrophic with orthophosphate (as P) concentrations in excess of 350 µg l^{-1}. The lake receives its water from both Llyn Dinam and Llyn Penrhyn. Llyn Dinam has mean annual TP concentrations that consistently exceed its target by a factor of around 2 (annual means: 2008 91 µg l^{-1}; 2009 113 µg l^{-1}; 2010 100 µg l^{-1} (Hatton-Ellis 2011). Llyn Penrhyn has monthly water quality data for much of the past 22 years (provided by NRW) which show it to have been in slow recovery since P stripping was installed at the STW in 1994 (Figure 17). Mean annual soluble P concentrations were 162 µg l^{-1} in 2012, so although improving, Llyn Penrhyn also remains hypereutrophic. Since both inflow sources have phosphorus concentrations that significantly exceed the target, it is considered extremely unlikely that Llyn Treflesg would pass the target.

The data suggest Llyn Penrhyn to be nitrogen limited during the summer month and therefore it is crucial that nitrogen, as well as phosphorus, are monitored and controlled effectively within the entire SSSI.

At the time of survey the dissolved oxygen levels were high throughout the water column (>10 mgl^{-1}), but water clarity was poor (Secchi depth = 1.09 m) due to slight algal turbidity and light brown colouration of the water from the surrounding peat.

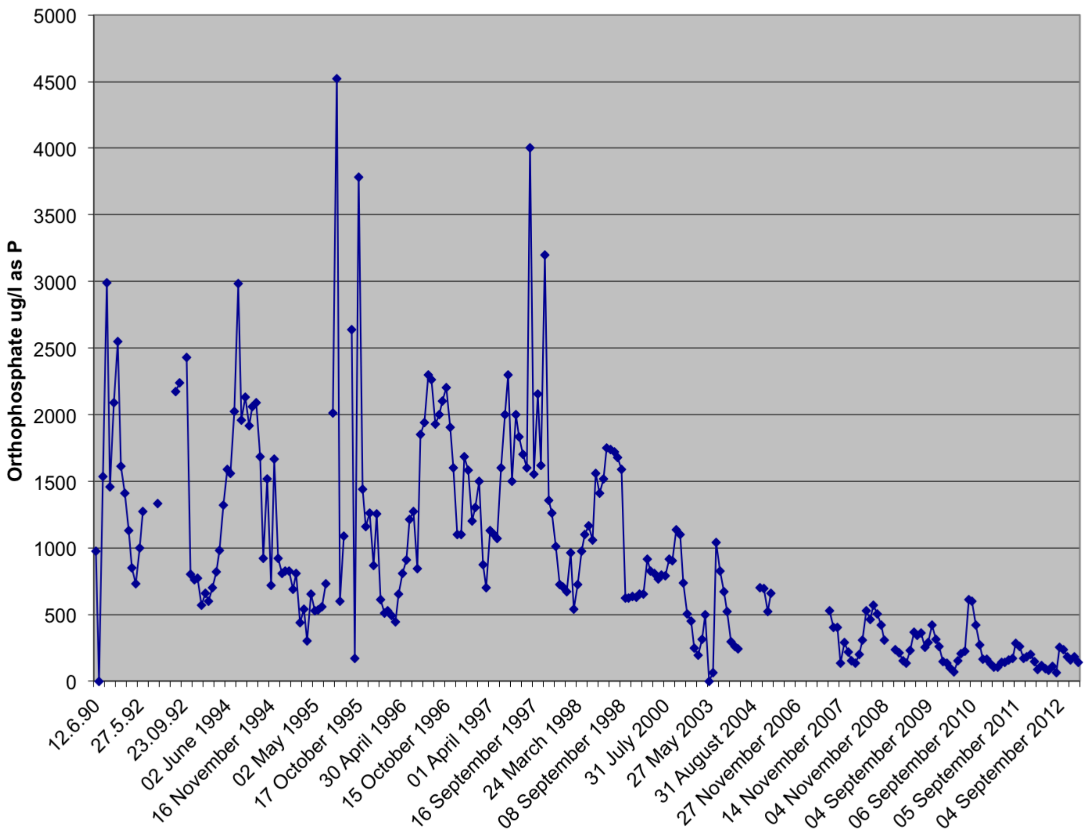


Figure 17 Orthophosphate concentrations in Llyn Penrhyn 1990-2013 (data from RSPB)

Hydrology

The lake has two main inflows, one from the north where it links with Llyn Dinam and another to the east from Llyn Penrhyn. The outflow is controlled by a fixed concrete sill in the southwestern arm of the lake. The outflow runs under the railway line and links into the wetland system that feeds Llyn Cerrig Bach.

Lake substrate and sediment load

Within the open water, the lake sediments were comprised of fine organic silt, consistent with the immediate catchment. Marginal areas had a mix of exposed bed-rock and areas of peat where there was established wetlands. Although close to the coastal sand dune, sand was not noted within the lake substrates. Disturbance around the site is low and the lake is well buffered by rough grassland and scrub vegetation from the pasture immediately to the northwest of the site. There is was no evidence of increased sediment loads to the site but increased algal productivity is likely to have increased sedimentation.

Indicators of local distinctiveness

The reedswamp and mire communities that border the lake were among the reasons for the SSSI notification. Species such as *Thelypteris thelypteroides, Ranunculus lingua, Butomus umbellatus* and *Rumex hydrolapathum* are notable species recorded during the survey.

Site condition summary and overview

Llyn Treflesg is **Unfavourable** with **high confidence**, primarily due to the very high phosphorus concentrations within the upstream water bodies that feed into the site. Much of the current problem stems from the discharge of poorly treated sewerage in to Llyn Penrhyn during the latter half of the twentieth Century but diffuse pollution from the Llyn Dinam catchment is also likely to be significant. The monitoring data for Llyn Penrhyn show a slow recovery in water since P stripping was installed at the STW in 1994, but the site is still well above the limits set for favourable water quality. What data exist for Llyn Treflesg show similar problems with hypereutrophy. The data also suggest that the lake is nitrogen limited during the summer growing season and therefore control of nitrogen within the catchment should be a priority alongside a continued reduction of P.

The aquatic flora is unfavourable with respect of the species composition. The community is relatively species-poor, the majority of the four characteristic species are rare and there is poor depth distribution. The maximum recorded depth for plants was 3.2 m, but below approximately 1.7 m macrophyte growth was very sparse. There is evidence to suggest the lake once supported *Potamogeton lucens* (Seddon 1964), a broad-leaf species that typically grows in deeper water and is therefore susceptible to increased turbidity. Remarkably Lansdown recorded a population of this species in L. Penrhyn in 2012, the first confirmed record from the site for over 100 years.

Water Body	Status	Reason(s) for Failure	Comments
Llyn Treflesg	**Unfavourable (High confidence)**	Very high Phosphorus and likelihood of high internal P loadings. Aquatic flora appears to be stable, but at risk due to the high trophic status of the site.	The primary concern at Llyn Treflesg is the high nutrients. The aquatic flora appears to be relatively stable, but populations of many of the characteristic species are small and the flora is therefore deemed to be at risk from the high trophic status of the site. Nutrient concentrations – both P and N – require monitoring. Ultimately Llyn Treflesg is reliant on the water quality of the upstream lakes and management should encompass all the waterbodies within the SSSI

Table 31. Llyn Treflesg overview.

Recommendations for monitoring and management:

Management of Llyn Treflesg is integral with the other water bodies of the Llynnau y Fali SSSI. Water quality is key to future improvements in the biology and it is clear from the monitoring in Llyn Penrhyn, that while the situation has improved greatly since the gross eutrophication pre-1994, there is still a long way to go before P levels are reduced below the 50 µg l^{-1} target for eutrophic waters. Action is required to investigate the primary sources of nutrients (agricultural and residential) to the SSSI and where necessary take action to prevent any further inputs through improved catchment management.

Control of the external inputs in vital, but water quality is likely to continue to be adversely impacted in future years by the release of phosphorus from the lake sediments of all the water bodies in the SSSI. Furthermore, there is evidence to suggest these sites are nitrogen limited during the summer months and thus, while the soluble phosphorus concentrations are high, it is essential than nitrogen is also kept low in order to minimise the negative impact of eutrophication on these sites. Better monitoring of oxidised N as well as TP and SRP at all the water bodies would help to inform the lake management and understand the key drivers of any observed changes in the biology in the lakes.

With the primary reason for failure being water quality, it would be beneficial to implement regular water quality monitoring (minimum of quarterly sampling) in Llyn Treflesg, as well the larger lakes in order to ascertain any directional chance with which to assess the success of site management and help to inform future management of the lake. Similarly the aquatic flora should be monitored on a 3 or 5 year cycle to assess any directional change.

The following recommendations are based on the evidence collected for this report and apply not only to Llyn Treflesg, but all the larger water bodies within the SSSI:

- Investigate possible sources of external nutrients (N & P) from the immediate catchment and take remedial action as required.
- Monitor water quality – minimum of quarterly sampling.
- Monitor the aquatic flora on a 3 or 5 year cycle to evaluate any directional changes within the site.

CSM Database output

Site Condition Assessment: Llyn Treflesg (19/06/2012)

Lake Details		Survey Details		
Lake Name	Llyn Treflesg	Survey Date	19/06/2012	
SSSI Name	LLYNNAU Y FALI - VALLEY	Surveyors	BG, JoS & SR	
SAC Name		Shore Surveys	2	out of
Grid Ref	SH307770	Wader Surveys	2	2
WBID / NI No.	32970 /	Boat Surveys	2	sections

Site Notes:

Survey Notes:
Channel between Dinam and Trefleg with P. obs, P. cris, R. cir and Butomus. Site access difficult and therefore site has low disturbance and no angling.

Section Summaries

Section 1	Maximum depth of colonisation (cm)	320 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	2 m
	Notes:	
Section 2	Maximum depth of colonisation (cm)	250 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	2 m
	Notes:	

Section Locations

	Shore Survey GPS Co-ords		Boat Survey GPS Co-ords	
	start	end	start (shore)	end (lake)
Section 1	SH3072676836	SH3077076916	SH3074276873	SH3074476907
Section 2	SH3068977067	SH3074377131	SH3072177101	SH3070877089

Section Photos

	Start of Section	Whole Section	End of Section
Section 1	70	71	72
Section 2	73	74	75

Species Abundance - Boat Survey

Total number of sample plots	40
Total number of vegetated sample plots	22

Plant Species	Occurrence *n*	%
Elodea canadensis	5	23
Fontinalis antipyretica	8	36
Lemna minor	2	9
Lemna trisulca	1	5
Myriophyllum spicatum	4	18
Nuphar lutea	5	23
Persicaria amphibia	2	9
Potamogeton crispus	2	9
Ranunculus circinatus	11	50

Species Abundance - Wader Survey

Total number of sample plots	40
Total number of vegetated sample plots	35

Plant Species	Occurrence *n*	%
Callitriche truncata	2	6
Carex acutiformis	12	34
Carex elata	4	11
Carex paniculata	2	6
Elodea canadensis	6	17
Fontinalis antipyretica	1	3
Iris pseudacorus	10	29
Lemna minor	23	66
Lemna trisulca	1	3
Nuphar lutea	9	26
Nymphaea alba	7	20
Persicaria amphibia	6	17
Phragmites australis	15	43
Potamogeton crispus	3	9
Ranunculus circinatus	17	49
Ranunculus lingua	1	3
Sparganium erectum	3	9

Plant Scores

Total plant species 22 **Filamentous algae (%)** 5% WADER 3.5% BOAT

Total plant cover (%) 115.13

SURVEY SCORES

PLANT SPECIES	PERIMETER	WADER	BOAT	COVER %	DAFOR	ABUNDANCE
Ranunculus circinatus	0	0.126	0.1231	18.61	F	3
Phragmites australis	0.5	0.0931	0	17.16	F	3
Carex acutiformis	0.25	0.0815	0	10.32	F	3
Iris pseudacorus	0.25	0.0698	0	9.74	O	2
Lemna minor	0	0.1682	0.0121	9.62	O	2
Carex elata	0.25	0.0231	0	7.4	O	2
Elodea canadensis	0	0.0518	0.0306	5.65	O	2
Sparganium erectum	0.175	0.0112	0	4.94	R	1
Nuphar lutea	0	0.051	0.0206	4.61	R	1
Mentha aquatica	0.175	0	0	4.38	R	1
Fontinalis antipyretica	0	0.0025	0.0384	3.96	R	1
Nymphaea alba	0	0.0619	0	3.1	R	1
Persicaria amphibia	0	0.0275	0.0121	2.58	R	1
Lycopus europaeus	0.1	0	0	2.5	R	1
Myriophyllum spicatum	0	0	0.0228	2.28	R	1
Carex paniculata	0.05	0.0103	0	1.76	R	1
Ranunculus lingua	0.05	0.0062	0	1.56	R	1
Potamogeton crispus	0	0.0107	0.0097	1.5	R	1
Epilobium hirsutum	0.05	0	0	1.25	R	1
Lysimachia vulgaris	0.05	0	0	1.25	R	1
Lemna trisulca	0	0.0062	0.0024	0.55	R	1
Callitriche truncata	0	0.0082	0	0.41	R	1

5.6. Llyn Cerrig-bach

Annex 1 type: 3150 Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation.

5.6.1. Site description

Name:	Llyn Cerrig-bach
County:	Isle of Anglesey
WBID:	32989
Grid reference:	SH306766
OS Grid reference (X,Y):	230639,376655
Latitude / Longitude	N53°15.59',W004°32.43'
Altitude (m):	8
Maximum recorded depth (m):	5.1
Mean depth (m):	Not recorded
Lake volume (m^3)	Not recorded
Surface area - measured (ha):	1.1
Perimeter of lake (km):	0.8
Shoreline Development Index (SDI):	1.287
WFD alkalinity based typology:	High Alkalinity, Very Shallow (HA,V)
Phase 1 habitat type:	Standing water: Eutrophic: G1.1
Survey Date:	20 June 2012

Table 32 Summary characteristics for Llyn Cerrig-bach

Llyn Cerrig-bach is a small lake lying towards the south of the Llynnau y Fali - Valley Lakes SSSI. The lake, like Llyn Treflesg and the other small lakes within the SSSI, was created in the 1940s when peat was excavated and used to stabilize the sand on the newly formed RAF Valley airfield (Duigan and Ellis 2002). Llyn Cerrig-bach received particular notoriety during its digging due to a series of important archaeological finds dating back to the iron age when is speculated that the area was of significant importance to the Druids (Museum of Wales 2014).

The site is fed via a network of small wetland areas either side of the railway embankment, by water draining from Llyn Tresflesg The area was notified as an SSSI for its biological interest and specifically the freshwater habitats which are described in the citation as hosting species associated with mesotrophic to eutrophic conditions and base-rich water. Eutrophication has been identified as the a major threat to lakes within the SSSI, with sewage effluent from RAF Valley and the settlement of Llanfihangel yn Nhowyn discharging directly into Llyn Penryn and then draining down to Llyn Cerrig-bach via Llyn Treflesg.

The site is fished by local anglers and was apparently stocked in the 1970s by the RAF, but now only has natural recruitment of tench, roach, rudd, crucian carp and perch (anon angler, *pers comm*). There has been no previous CSM site condition survey and we were unable to find any information regarding the aquatic flora in the lake.

5.6.2. Condition Assessment and Discussion

Table 33 Condition Assessment Summary Table for Llyn Cerrig-bach

Attribute	Target	Status	Comment
Extent	No loss of extent of standing water	✓	None.
Macrophyte community composition	Eutrophic species: ≥ 6 characteristic eutrophic species. 1 broadleaved *Potamogeton* species to be present.	X	2 *Magnopotamion* spp *Potamogeton crispus and P. obtusifolius*
	No loss of characteristic species (see Box 4)	NA	Unknown
	≥ 6/10 vegetated sample spots (boat / wader survey) have ≥ 1 characteristic spp.	✓	7 % of vegetated sample points comply
Negative indicator species	Non-native species absent or present at low frequency	✓	Small patch *of Elodea canadensis* in outflow channel
	Benthic and epiphytic filamentous algae <10%.	✓	No filamentous algae recorded
Macrophyte community structure	Characteristic vegetation zones should be present (site specific)	X?	Good emergent hydrosere, but steeply sheving in open water to 3+ m and aquatic plant restricted to a narrow littoral zone with plants (*N. lutea*) to 2.7 m.
	Maximum depth distribution maintained	✓	Z_{max} (recorded) = 5.1 m, Z_s = 1.50 m, Z_v = 2.70 m. Z_v is acceptable.
	At least present structure should be maintained	NA	No previous data
Water quality	Stable nutrients levels: TP target / limit: Eutrotrophic = 50 μgl^{-1}	NA	No data, but upsteam sites are hypereutrophic and therefore considered unlikely to be favourable
	Stable pH values: pH ~circumneutral - 10	NA	No water quality data. However, likely to be similar to other Valley Lakes.
	Adequate dissolved O_2 for health of characteristic fauna (> 5 mgl^{-1})	✓	Stratified at 3 m. > 8 mg l^{-1} in surface water
	No excessive growth of cyanobacteria / green algae	NA	None during survey. No Chl *a* data

Attribute	Target	Status	Comment
Hydrology	Natural hydrological regime	✓	No evidence for concern
Lake substrate	Natural shoreline maintained	✓	Site with extensive area of *Phragmites* reed fringe and surrounding wetland
	Natural and characteristic substrate maintained	**✓?**	No evidence of change
Sediment load	Natural sediment load maintained	**✓?**	No evidence of change, However, elevated nutrients will increase sedimentation rate.
Indicators of local distinctive-ness	Distinctive elements maintained at current extent / levels / locations	**NA**	None noted
Disturbance	No introduced species	✓	*E. canadensis* present in outflow
	Minimal negative impacts from recreation and navigation. No fish farming	**✓?**	Only native species reported by angler. One access point for fishing – low disturbance. But – 250 m from RAF Valley runway

Status: ✓ = favourable; X = unfavourable; NA = not assessed

Extent

There is no evidence of any loss of extent. Natural encroachment of common reed and other wetland species is limited by the steeply shelving littoral zone.

Macrophyte community composition

A total of 9 species of aquatic macrophyte were recorded from Llyn Cerrig-bach, of which only two classify as characteristic eutrophic species within the updated CSM guidance (JNCC, in draft) (Table 34). The water lilies *Nymphaea alba* and *Nuphar lutea* were the most abundant species, forming a narrow ring around much of the site, with *N. alba* more common in the western half and *N. lutea* along the more steeply shelving eastern margin. Of the characteristic species, *Lemna trisulca* was the most frequent, but it was rarely abundant and *Lemna minor* (less frequent), was mainly recorded within the reeds and lily beds. *Potamogeton obtusifolius* was rare in the site and with the exception of one record, was restricted to the outflow channel and another channel on the east side that was possibly an inflow. A small bed of *Potamogeton crispus* was recorded at the north end of the lake and a slightly larger expense at the south end growing under mixed lily beds. *Sparganium emersum* was rare in the site and *Elodea canadensis* found only in the outflow channel.

The current assemblage falls short of the characteristic species target for eutrophic lakes. The species present classify the site as a Group G lake (Duigan 2006) with a corresponding PLEX score of 7.29.

The marginal and emergent vegetation was dominated by *Phragmites australis*, but at the reed face there was a rich assemblage of other emergent species including *Carex riparia, Carex elata, Carex paniculata, Schoenoplectus lacustris, Typha latifolia and Potentilla palustris.* Other notable emergent species included *Thelypteris palustris* and *Ranunculus lingua*.

Submerged and floating vegetation	TRS	PLEX	% occurrence (n=59)	DAFOR abundance[6]	Min depth (cm)	Max depth (cm)
Elodea canadensis	7.3	7.95	+	R	0.75	75
Lemna minor	9	8.85	7.3	R	0.25	120
Lemna trisulca	10	8.85	38.2	F	50	175
Nuphar lutea	8.5	6.92	56.4	A	50	270
Nymphaea alba	6.7	3.08	56.4	F	50	260
Persicaria amphibia	9.0	7.95	3.6	R	50	75
Potamogeton crispus	**9**	**7.95**	**3.6**	**R**	**75**	**230**
Potamogeton obtusifolius	**8.0**	**6.54**	**3.6**	**R**	**50**	**90**
Sparganium emersum	10	7.5	3.6		25	80
Average score	**8.6**	**7.29**				
Species richness				**9**		

Table 34 Aquatic macrophyte community composition for Llyn Cerrig-bach in June 2012; Characteristic eutrophic species are highlighted in **bold**.

Negative indicator species

Elodea canadensis was recorded only in the outflow channel only and not considered to be a threat to in the site at current levels. Any significant increase would cause a failure, however.

Macrophyte community structure

Much of the site shelves quite steeply from the margins to depths in excess of 3 m which was beyond the depth of colonisation and thus macrophyte growth is restricted mainly to the littoral zone with the majority of the site too deep for plants under current water quality conditions. *Nymphaea alba* and *Nuphar lutea* typically extended from the reed face (c. 50 cm) to a maximum depth of 2.7 m, but more often to 2.5 m. Other species were more commonly recorded growing in shallower water (*P. crispus* to 2.3 m and *L. trisulca* to 1.75 m). *Potamogeton obtusifolius* was found only in the inflow and outflow channels and in areas sheltered by reeds (see Figure 18).

[6] Based on presence / absence data from all vegetated plots in the wader and boat based surveys. DAFORs are calculated from the total number of occurrences across the wader and boat surveys as a proportion of the total number of vegetated wader and boat survey points. A plus (+) denotes a taxon recorded as present at the site but not found growing in the wader or boat survey sections

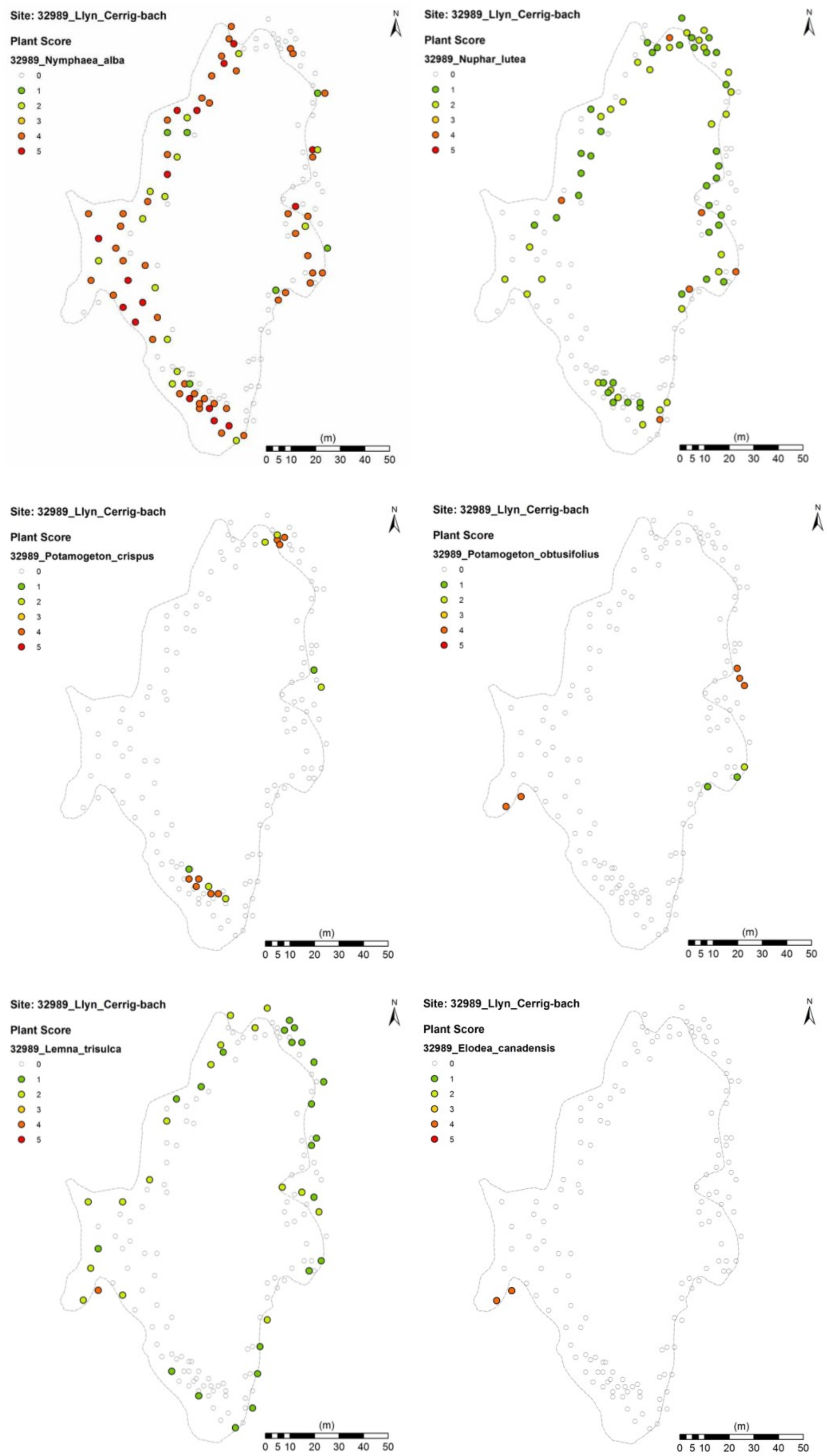


Figure 18 Distribution maps of the aquatic plant species recorded in Llyn Cerrig-bach

Water quality

There is no recent water chemistry data from Llyn Cerrig-bach, but given that the lake receives water from Llyn Penrhyn and Llyn Dinam, via Llyn Treflesg, it is assumed that the phosphorus concentrations are likely to significantly exceed CSM and WFD targets for natural eutrophic lakes (see water quality section for Llyn Treflesg). It is possible that it is of some benefit to the site that the outflow channel (or possibly 2 channels) from Llyn Treflesg passes through an area of wetland prior to entering Llyn Cerrig-bach, resulting in the potential for nutrient up-take and cycling through the wetland rather than direct transfer to the lake. This is untested, but certainly Llyn Cerrig-bach had clearer water in June (Secchi 1.50 m in Cerrig-bach compared to 1.10 m at Llyn Trefleg) and more consistent and abundant water lily growth in deeper water.

Based on the evidence of water quality from other sites elsewhere on the SSSI, and without any current water quality data from Llyn Cerrig-bach, the site is classified as unfavourable due to the upstream conditions. Further water quality analysis is recommended.

At the time of survey the lake was anoxic below approximately 3 m with the surface water well oxygenated (Figure 19). Water clarity was moderate, with slight algal turbidity and light brown colouration from the peat.

Dissolved Oxygen Profile

GPS Location	SH3063376659
Maximum Depth (m)	5.1 m
Secchi Depth (cm)	150 cm
Notes:	

Depth (m)	DO (mg/l)	Temp (°C)
0	9.01	19.1
0.5	8.51	17.5
1	8.26	17.1
1.5	8.09	16.5
2	8.64	14.9
2.5	6.9	14.5
3	4.8	14.4
3.5	1.51	14.2
4	0.14	14.1
4.5	0.2	14

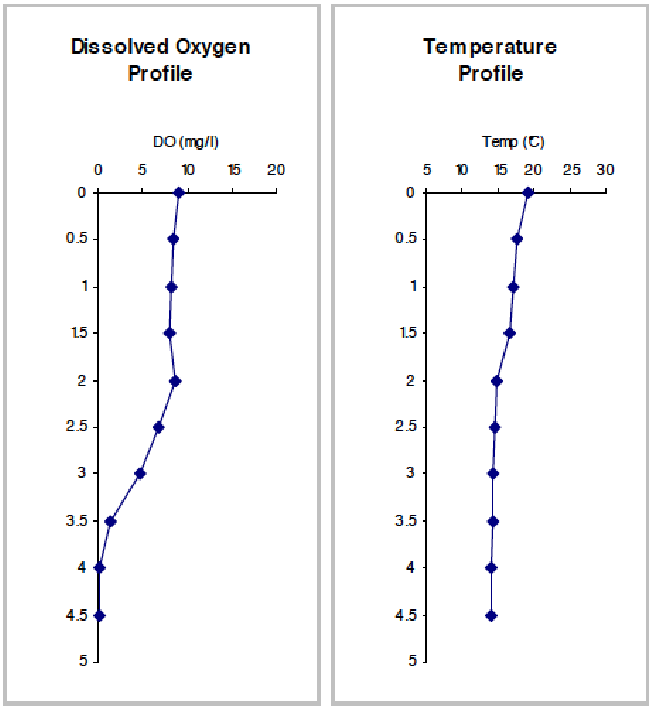


Figure 19 Dissolved oxygen (DO) profile for Llyn Cerrig-bach, June 2012.

Hydrology

The lake appears to have an inflow channel on the east side, but it was not possible to follow it to ascertain from where it came. There is no clear channel marked on the map (Ordnance Survey 1:2500), or evident from aerial photography (Google Maps), but it appears that water flows from Llyn Treflesg (possibly from both of the ‘arms’), under the railway embankment. The more easterly route flows first into a series of small ponds before (it is assumed) entering Llyn Cerrig-bach. There may even be a direct link to Llyn Penrhyn, which if present would increase the likelihood of high nutrients reaching the site. The outflow runs southwest under the road to another small lake at the southern limit of the SSSI.

Lake substrate and sediment load

The littoral areas were dominated by peat with brown organic sediments in shallow water. To the south and southeast of the site there are areas of exposed bed rock along the shore which extend into open water. Deeper sediments were not sampled. Although close to the coastal sand dune, sand was not noted within the lake substrates. There is was no evidence of increased sediment loads to the site. Disturbance to the site is limited by access to all but the south side, where a short track affords access to a small area used by anglers. The remainder of the site is well buffered by extensive wetlands. The impact of the lake’s proximity to the end of one of the RAF Valley runway is unknown beyond the obvious noise pollution and the potential for contamination with oil and fuel.

Indicators of local distinctiveness

The reedswamp and mire communities that border the lake were among the reasons for the SSSI notification. Species such as *Thelypteris palustris* and *Ranunculus lingua* are rare in Wales and thus worthy of note at the site.

Site condition summary and overview

Llyn Cerrig-bach is **Unfavourable** but data availability is limited for water quality and any past macrophyte survey and therefore the assessment has **low confidence** pending the assessment of water quality as a minimum.

The site does not support a characteristic eutrophic flora, and the current assemblage is dominated by mixed water lily beds with only sparse submerged species throughout the littoral zone. The site is very small however, and relatively newly formed (1942) and therefore may never have supported a more diverse flora. Were this to be the case, the current flora may be considered favourable, particularly as it contributes to the integrity of the larger site. It is possible that water quality is improving within the SSSI but further monitoring is required to demonstrate this. More accurate baseline data could be established by the analysis of plant macrofossil remains from the lake sediments. The emergent and marginal plant communities are species rich and of high conservation value.

Recommendations for monitoring and management:

Due to its down-stream location, the management of Llyn Cerrig-bach is dependent on the condition of the upstream water bodies of the Llynnau y Fali SSSI (see recommendation for Llyn Treflesg). Better water quality is likely to be key to maintaining or improving the biology within the sites and it is recommended that water quality monitoring is undertaken (minimum of quarterly sampling) in Llyn Cerrig-bach, as well the larger lakes, in order to ascertain any directional chances within the SSSI. Similarly the aquatic flora should be monitored on a 3 or 5 year cycle to assess any change in species composition and depth of colonisation.

While this survey provided a baseline against which to assess future change, it would be beneficial to know what, if any, other characteristic species have occurred in the past. The analysis of aquatic plant macrofosils would determine a more realistic baseline and if necessary, allow for site specific species macrophyte targets to be set.

Water Body	Status	Reason(s) for Failure	Comments
Llyn Cerrig-bach	**Unfavourable (Low confidence)**	Potentially high phosphorus and likelihood of high internal P loadings (requires further investigation). Aquatic flora appears to be stable, but only 2 characteristic *Magnopotanion* species.	The primary concern at Llyn Cerrig-bach is the high nutrients, and water quality monitoring (N & P) is recommended. The aquatic flora is restricted by depth, but the littoral zone has good coverage of water lilies and excellent marginal vegetation and habitats. Contemporary water quality data is required to assess the condition with higher confidence and in the absence of any other records, plant macrofossil analysis could help ascertain the past flora.

Table 35 Llyn Cerrig-bach overview

The following recommendations are based on the evidence collected for this report and apply not only to Llyn Cerrig-bach, but all the larger water bodies within the SSSI:

- Investigate possible sources of external nutrients (N & P) from the immediate catchment and take remedial action as required.
- Monitor water quality – minimum of quarterly sampling.
- Monitor the aquatic flora on a 3 or 5 year cycle to evaluate any directional changes within the site.
- Analyse aquatic plant macrofossils to determine a more realistic baseline for the lake and set site specific targets.

CSM Database output

Site Condition Assessment: Llyn Cerrig-bach (20/06/2012)

Lake Details		**Survey Details**		
Lake Name	Llyn Cerrig-bach	Survey Date	20/06/2012	
SSSI Name	LLYNNAU Y FALI - VALLEY	Surveyors	BG & SR	
SAC Name		Shore Surveys	2	out of
Grid Ref	SH306766	Wader Surveys	2	2
WBID / NI No.	32989 /	Boat Surveys	2	sections

Site Notes:
Palaeo-lake - re-excavated for peat to grass over nearby airstrip in 1942.

Survey Notes:
Small site - only 2 sections completed. Stocked with coarse fish in '70s, but not since. Tench, rudd, crusian carp, roach & perch.

Section Summaries

Section 1

Maximum depth of colonisation (cm)	260 cm
Compass bearing of boat transect (°)	-
Lateral distance from waters edge to 75cm depth (m)	2 m

Notes:

Section 2

Maximum depth of colonisation (cm)	270 cm
Compass bearing of boat transect (°)	-
Lateral distance from waters edge to 75cm depth (m)	2 m

Notes: shelves steeply to 2.5 m

Section Locations

	Shore Survey GPS Co-ords start	end	Boat Survey GPS Co-ords start (shore)	end (lake)
Section 1	SH3063576735	SH3058176654	SH3061176688	SH3062476686
Section 2	SH3067676630	SH3066476724	SH3067276682	SH3066676676

Section Photos

	Start of Section	Whole Section	End of Section
Section 1	255	257	256
Section 2	261	262	258

Species Abundance - Boat Survey

Total number of sample plots	40
Total number of vegetated sample plots	17

Plant Species	Occurrence *n*	%
Lemna trisulca	3	18
Nuphar lutea	16	94
Nymphaea alba	8	47

Species Abundance - Wader Survey

Total number of sample plots	40
Total number of vegetated sample plots	38

Plant Species	Occurrence *n*	%
Carex elata	2	5
Carex riparia	21	55
Carex rostrata	3	8
Eleocharis palustris	1	3
Equisetum fluviatile	1	3
Iris pseudacorus	1	3
Lemna minor	4	11
Lemna trisulca	18	47
Menyanthes trifoliata	1	3
Nuphar lutea	15	39
Nymphaea alba	23	61
Persicaria amphibia	2	5
Phragmites australis	21	55
Potamogeton crispus	2	5
Potamogeton obtusifolius	2	5
Ranunculus lingua	3	8
Schoenoplectus lacustris	12	32
Sparganium emersum	2	5
Sparganium erectum	2	5
Typha latifolia	8	21

Note: Species abundance % = ((number of plots / total number of vegetated sample plots) * 100) *n*

Plant Scores

Total plant species 40 **Filamentous algae (%)** 0 % WADER 0 % BOAT

Total plant cover (%) 234.23

S U R V E Y   S C O R E S

PLANT SPECIES	PERIMETER	WADER	BOAT	COVER %	DAFOR	ABUNDANCE
Nuphar lutea	0	0.0891	0.2749	31.94	A	4
Carex riparia	0.75	0.1482	0	26.16	A	4
Phragmites australis	0.75	0.1482	0	26.16	A	4
Nymphaea alba	0	0.1536	0.1354	21.22	F	3
Carex elata	0.75	0.0165	0	19.58	F	3
Lemna trisulca	0	0.1318	0.0565	12.24	F	3
Schoenoplectus lacustris	0.25	0.0595	0	9.22	O	2
Menyanthes trifoliata	0.25	0.0069	0	6.6	O	2
Salix sp.	0.25	0	0	6.25	O	2
Ranunculus lingua	0.175	0.0195	0	5.35	O	2
Typha latifolia	0.1	0.0488	0	4.94	R	1
Galium palustre	0.175	0	0	4.38	R	1
Mentha aquatica	0.175	0	0	4.38	R	1
Solanum dulcamara	0.175	0	0	4.38	R	1
Juncus acutiflorus	0.125	0	0	3.12	R	1
Carex paniculata	0.125	0	0	3.12	R	1
Potentilla anserina	0.125	0	0	3.12	R	1
Lychnis flos-cuculi	0.125	0	0	3.12	R	1
Sparganium erectum	0.1	0.01	0	3	R	1
Potamogeton crispus	0.1	0.0085	0	2.92	R	1
Iris pseudacorus	0.1	0.0047	0	2.74	R	1
Filipendula ulmaria	0.1	0	0	2.5	R	1
Lysimachia vulgaris	0.1	0	0	2.5	R	1
Phalaris arundinacea	0.1	0	0	2.5	R	1
Scutellaria galericulata	0.1	0	0	2.5	R	1
Epilobium hirsutum	0.1	0	0	2.5	R	1
Angelica sylvestris	0.1	0	0	2.5	R	1
Carex rostrata	0.05	0.0144	0	1.97	R	1
Eleocharis palustris	0.05	0.0047	0	1.48	R	1
Equisetum fluviatile	0.05	0.0047	0	1.48	R	1
Lemna minor	0	0.0278	0	1.39	R	1
Hydrocotyle vulgaris	0.05	0	0	1.25	R	1
Myosotis laxa	0.05	0	0	1.25	R	1
Potentilla palustris	0.05	0	0	1.25	R	1
Ranunculus flammula	0.05	0	0	1.25	R	1
Rhinanthus minor	0.05	0	0	1.25	R	1
Caltha palustris	0.05	0	0	1.25	R	1
Thelypteris palustris	0.05	0	0	1.25	R	1
Persicaria amphibia	0	0.0125	0	0.62	R	1
Potamogeton obtusifolius	0	0.0112	0	0.56	R	1
Sparganium emersum	0	0.0058	0	0.29	R	1

5.7. Llyn Traffwll

Annex 1 type: 3150 Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation.

5.7.1. Site description

Name:	Llyn Traffwll
County:	Isle of Anglesey
WBID:	32964
Grid reference:	SH325769
OS Grid reference (X,Y):	232572,376965
Latitude / Longitude	N53°15.79',W004°30.7'
Altitude (m):	8
Maximum recorded depth (m):	4.66
Mean depth (m):	2.51
Lake volume (m^3)	974032
Surface area - UKLakes (ha):	36.8
Surface area - measured (ha):	38.7
Perimeter of lake (km):	3.6
Shoreline Development Index (SDI):	1.676
WFD alkalinity based typology:	High Alkalinity, Very Shallow (HA,V)
Phase 1 habitat type:	Standing water: Eutrophic: G1.1
Survey Date:	19 June 2012

Table 36 Summary characteristics for Llyn Traffwll

Llyn Traffwll is a relatively large, base rich, shallow lake lying within the Crigyll catchment. The lake is close to those of the Valley Lakes SSSI just to the west, but is separated from Llyn Penrhyn by a low ridge. The entire lake and associates wetland to the south-west and outflow to the south is designated as a SSSI on the basis of biological interest. Rarities such as eight-stamened waterwort (*Elatine hydropiper*) and flowering rush (*Butomus umbelatus*) are of particular interest. The lake is also notable as important site for overwintering wildfowl, particularly shoveler, but also gadwall, widgeon, pochard and goldeneye, as well as more common species such as tufted duck and mallard.

The past management of the site has been varied. After the turn of the 20th Century, the Holyhead Waterworks Company requisitioned the lake for use as a water supply revervoir and built a small waterworks and pumping station on the northwest shore following the compulsory purchase of the land and pipeline routes (London Gazette 1905). It is unclear to what extent the water level was raised at the site. There is a small weir on the outflow (not assessed in 2012), but maps pre-dating 1900 show no appreciable change in the lake outline or area (OS OpenSpace 2014)

The low lying position of the site within a mixed agricultural and semi-developed rural area, give rise to concern about the threat to the site from eutrophication. A partial CSM survey was carried out by CCW and RSPB in 2011 (Hatton-Ellis, unpublished data) and the site was also surveyed informally by CCW in 2006 (Hatton-Ellis 2006)

However, older data are sparse, consisting mainly of isolated plant records (for a collation, see Garnett and Blackstock 1983).

5.7.2. Condition Assessment and Discussion

Attribute	Target	Status	Comment
Extent	No loss of extent of standing water	✓	None.
Macrophyte community composition	Eutrophic species: ≥ 6 characteristic eutrophic species. 1 broadleaved *Potamogeton* species should be present.	X ✓	4 *Magnopotamion* spp : *Potamogeton crispus, P. perfoliatus Callitriche truncata* & *Chara globularis.* *Littorella uniflora also present*
	No loss of characteristic species (see Box 4)	✓?	Appears stable
	≥ 6/10 vegetated sample spots (boat / wader survey) have ≥ 1 characteristic spp.	✓	90 % of vegetated sample points comply.
Negative indicator species	Non-native species absent or present at low frequency	X	*Elodea canadensis* present at 25% frequency – and present since at least 1989
	Benthic and epiphytic filamentous algae <10%.	X	53 % of sample points had filamentous algae score of 3 (75% cover)
Macrophyte community structure	Characteristic vegetation zones should be present (site specific)	✓	Mixed species beds occurred throughout the site with plants common to 2.4 m.
	Maximum depth distribution maintained	✓?	Z_{max} (recorded) = 4.66 m, Z_s = 1.60 m, Z_v = 3.00 m.
	At least present structure should be maintained	**NA**	Previous data are not sufficient to assess.
Water quality	Stable nutrients levels: TP target / limit: Eutrotrophic = 50 $\mu g l^{-1}$	X	TP = 149 $\mu g\ l^{-1}$ SRP = 90 $\mu g\ l^{-1}$ TON = 0.34 $mg\ l^{-1}$ 2011 data (RSPB)
	Stable pH values: pH ~circumneutral - 10	✓	pH = 7.49 – 8.45 (2011 mean = 7.85)
	Adequate dissolved O_2 for health of characteristic fauna (> 5 $mg l^{-1}$)	✓	>8.6 $mg l^{-1}$ and water column well mixed (June 2012).
	No excessive growth of cyanobacteria / green algae	?	Insufficient data – 1992-97 mean Chl a = 30.3 $\mu g l^{-1}$
Hydrology	Natural hydrological regime	✓	Controlled at outflow – appears stable
Lake substrate	Natural shoreline maintained	✓?	Some areas lack effective buffer, but generally good

Attribute	Target	Status	Comment
	Natural and characteristic substrate maintained	✓?	No evidence of change.
Sediment load	Natural sediment load maintained	✓?	No evidence of change.
Indicators of local distinctive-ness	Distinctive elements maintained at current extent / levels / locations	✓?	*Elatine hydropiper* – common in the site. No *Butomus umbellatus* recorded.
Disturbance	No introduced species	**X**	*E. canadensis* at 25% frequency. Site attracts large numbers of Canada and feral greylag geese
	Minimal negative impacts from recreation and navigation. No fish farming	✓?	None

Status: ✓ = favourable; X = unfavourable; NA = not assessed

Table 37. Condition Assessment Summary Table for Llyn Traffwll.

Extent

There is no evidence of any loss of extent.

Macrophyte community composition and structure

A total of 16 species of aquatic macrophyte were recorded from Llyn Traffwll of which 5 were characteristic eutrophic species (Table 38). *Potamogeton pusillus* was also present, but the fine-leaved *Potamogetons* will no longer constitute characteristic species under updated guidelines in preparation. *Callitriche truncata* was abundant in the site, with extensive populations found at a range of depths up to 2.2 m, (confirmed from cruciform, wingless seed). This species is relatively rare in the UK, and in Wales occurs only on Anglesey, where Llyn Traffwll is one of its strongholds. Previous surveys have recorded *C. hermaphroditica* here as well (e.g. Hatton-Ellis 2011); it is likely that both species occur in this and other Anglesey Lakes.

Other characteristic species (the broadleaved pondweeds *Potamogeton perfoliatus* and *P. crispus*) were rare. In addition to the characteristic taxa, other species of note were *Elatine hydropiper* and *Littorella uniflora. Elatine hydropiper* is relatively rare in Wales, but is recorded in the Llyn Traffwll citation (1980) and has therefore been constant in the site for at least 30 years. Filamentous green algae (*Cladophora* sp.) was common in the littoral zone in hence *Elatine* was probably under-recorded. The presence of *Littorella uniflora,* recorded from a number of regions around the north-east littoral, confirms the findings of Fisher in 1999 (cited in Lansdown 2013). This species is more commonly associated with oligo/mesotrophic waters and rarely remains in degraded eutrophic sites. It was not recorded within the CSM survey sections, but at multiple locations in the map survey (Figure 21). It tends to persist in the Anglesey lakes on sandy or stony wave-washed shorelines that remain well oxygenated in spite of high nutrient concentrations.

Potamogeton pusillus was frequent and locally abundant. Material from deeper water was superficially different and recorded initially as *P. berchtoldii*, but all voucher material proved to have tubular stipules and hence only *P. pusillus* is confirmed as present.

Potamogeton pectinatus was frequent and in places locally abundant, but usually within a mosaic of species rather than forming mono-specific stands. Its dominance is often indicative of enrichment and while not considered as unfavourable in the 2012 survey, any increase in frequency would point to deterioration of the site.

Submerged and floating vegetation	TRS	PLEX	% occurrence (n=43)	DAFOR abundance[7]	Min depth (cm)	Max depth (cm)
Callitriche truncata			**71.4**	**A**	**20**	**260**
Ceratophyllum demersum	10	8.85	**+**	R	90	140
Chara globularis	**7.3**	**7.69**	**7.1**	**R**	**60**	**280**
Elatine hydropiper			12.7	O	20	200
Elodea canadensis	7.3	7.95	25.4	F	25	260
Lemna minor	**9**	**8.85**	**4.8**	**R**	**20**	**50**
Littorella uniflora	6.7	4.23	**+**	R	50	70
Myriophyllum spicatum	9	8.85	0.8	R	140	200
Nitella flexilis agg.	6.7	5.38	0.8	R	140	140
Nymphaea alba	6.7	3.08	+	R	90	110
Persicaria amphibia	9	7.95	1.6		25	160
Potamogeton crispus	**9**	**7.95**	**2.4**	**R**	**80**	**200**
Potamogeton pectinatus	10	8.85	42.1	F	25	210
Potamogeton perfoliatus	**7.3**	**7.69**	**15.1**	**O**	**20**	**180**
Potamogeton pusillus	9	7.95	**42.1**	F	25	300
Zannichellia palustris	10	8.85	23.8	O	25	250
Average score	**8.36**	**7.44**				
Species richness				**16**		

Table 38. Aquatic macrophyte community composition for Llyn Traffwll in June 2012. Characteristic eutrophic species are highlighted in **bold**.

Community structure was good with a maximum colonization depth of 3 m and species well distributed across a depth gradient (Figure 20). Lansdown (2013) reported only sparse aquatic vegetation in the limited area he was able to assess along the north shore, but in deeper waters and to the west and east of the lake, there were areas of relatively dense, mixed plant beds. Much of the western portion of the lake (accounting for c. 75% of the area) shelves rather steeply in most areas to

[7] Based on presence / absence data from all vegetated plots in the wader and boat based surveys. DAFORs are calculated from the total number of occurrences across the wader and boat surveys as a proportion of the total number of vegetated wader and boat survey points. A plus (+) denotes a taxon recorded as present at the site but not found growing in the wader or boat survey sections

depths of 3.5 - 4.5 m and the aquatic flora rarely extended beyond 2 - 2.3 m in depth. The north-eastern quarter consists of a shallower, flat basin of 2 - 2.3 m and in places supported (particularly at 2.0 m) abundant and mixed beds of plants, often dominated by *Callitriche truncata.* Broad-leaf *Potamogeton* species were infrequent, but both *P. perfoliatus* and *P. crispus* were present in the site. The CCW/RSPB survey in 2011 also recorded *Chara virgata*, *C. aspera*, *Potamogeton trichoides* and *Lemna trisulca*.

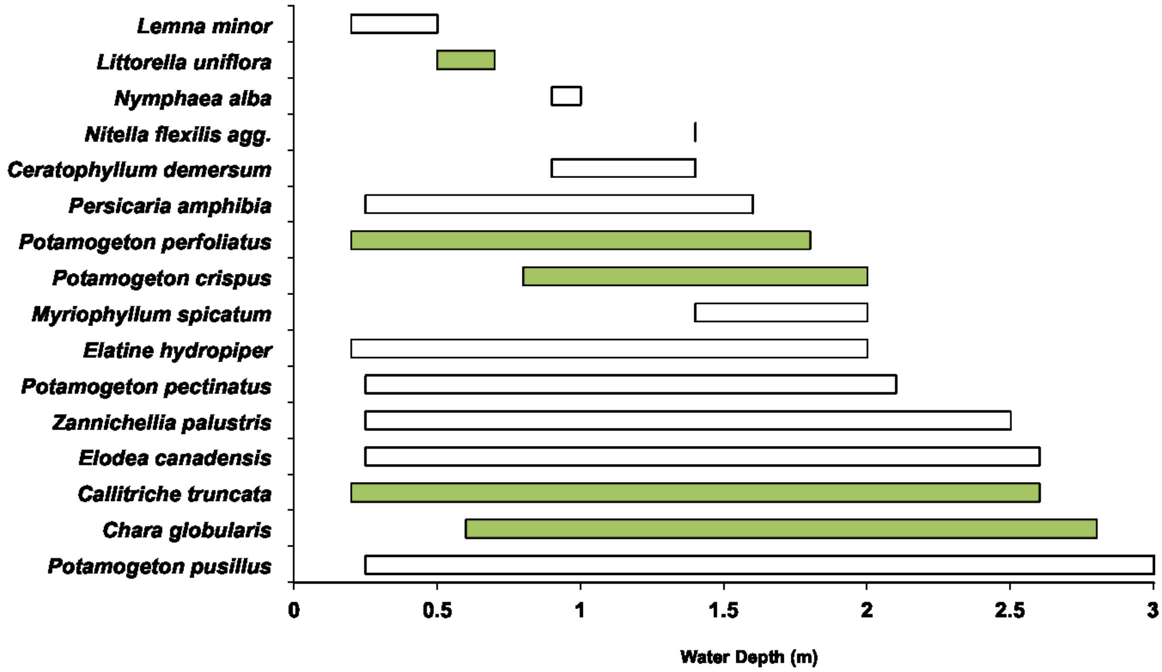


Figure 20 Depth distribution of the aquatic plant species recorded in Llyn Traffwll

The 2012 survey results are considered to be favourable in terms of species composition and community structure. The current assemblage classifies the site as a Group I lake according to Duigan *et al.* (2006) with a corresponding PLEX score of 7.33.

The lake has extensive areas of improved pasture to the north, east and south shores, but where fenced, there is a narrow band with wetland species present. To the west of the site there are areas of more extensive *Phragmites australis* dominated reed bed and small stands of *Schoenoplectus tabernaemontani* and *S. lacustris, Typha latifolia, Alisma plantago-aquatica, Eupatorium cannabinum, Phalaris arundinacaea, Rumex hydrolapathum* and *Ranunculus lingua.*

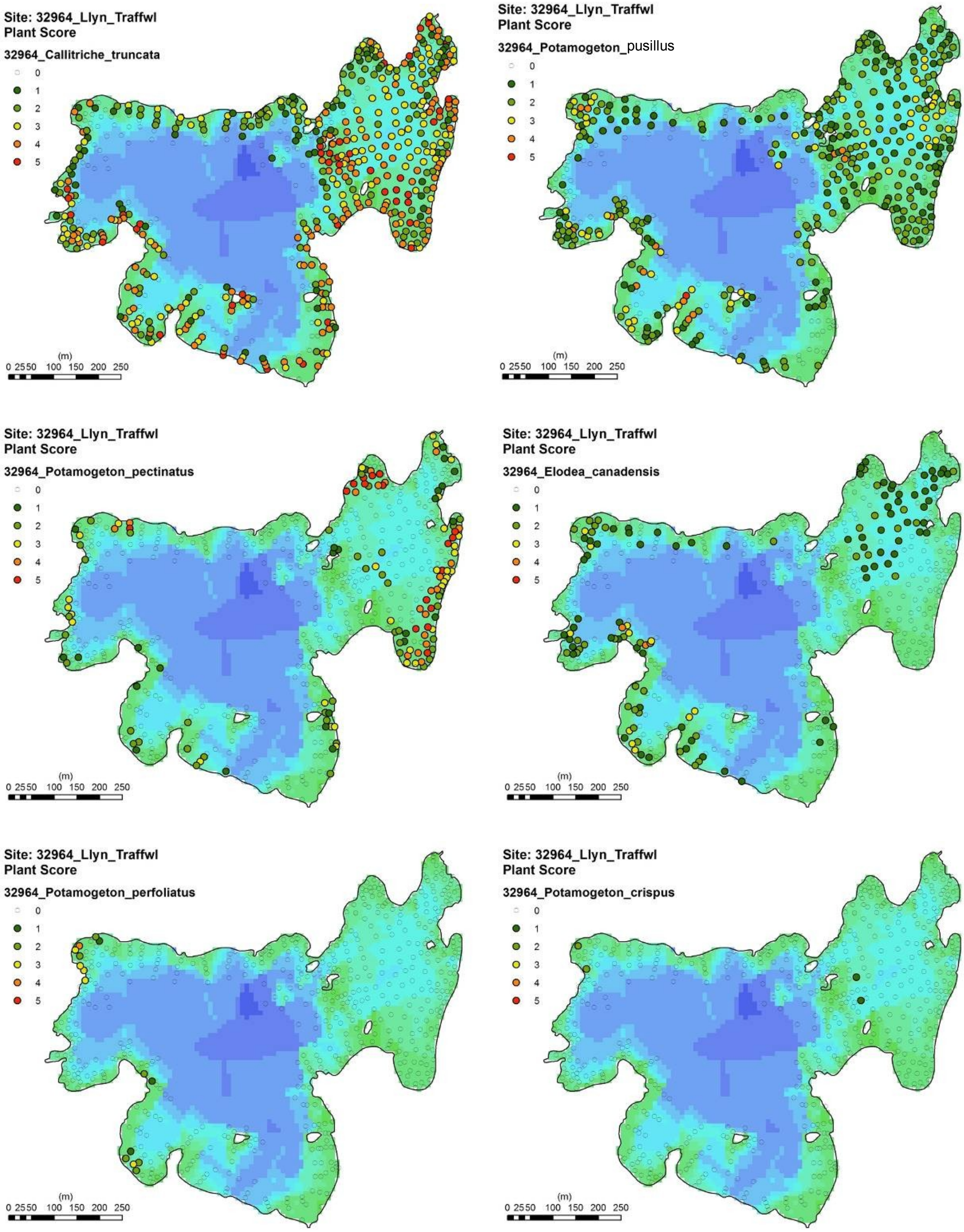


Figure 21 Distribution maps of the aquatic plant species recorded in Llyn Traffwll

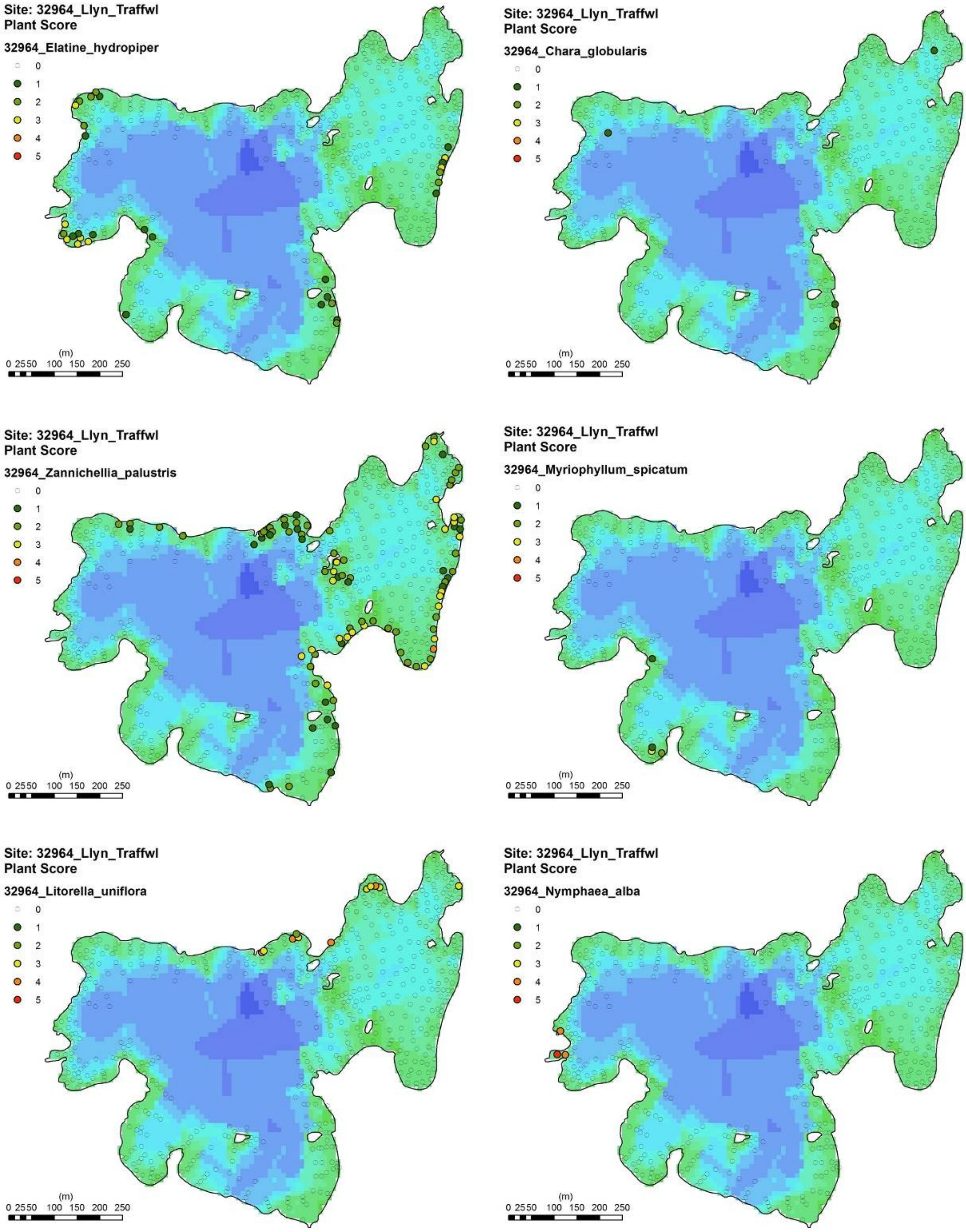


Figure 21 (Contd.)

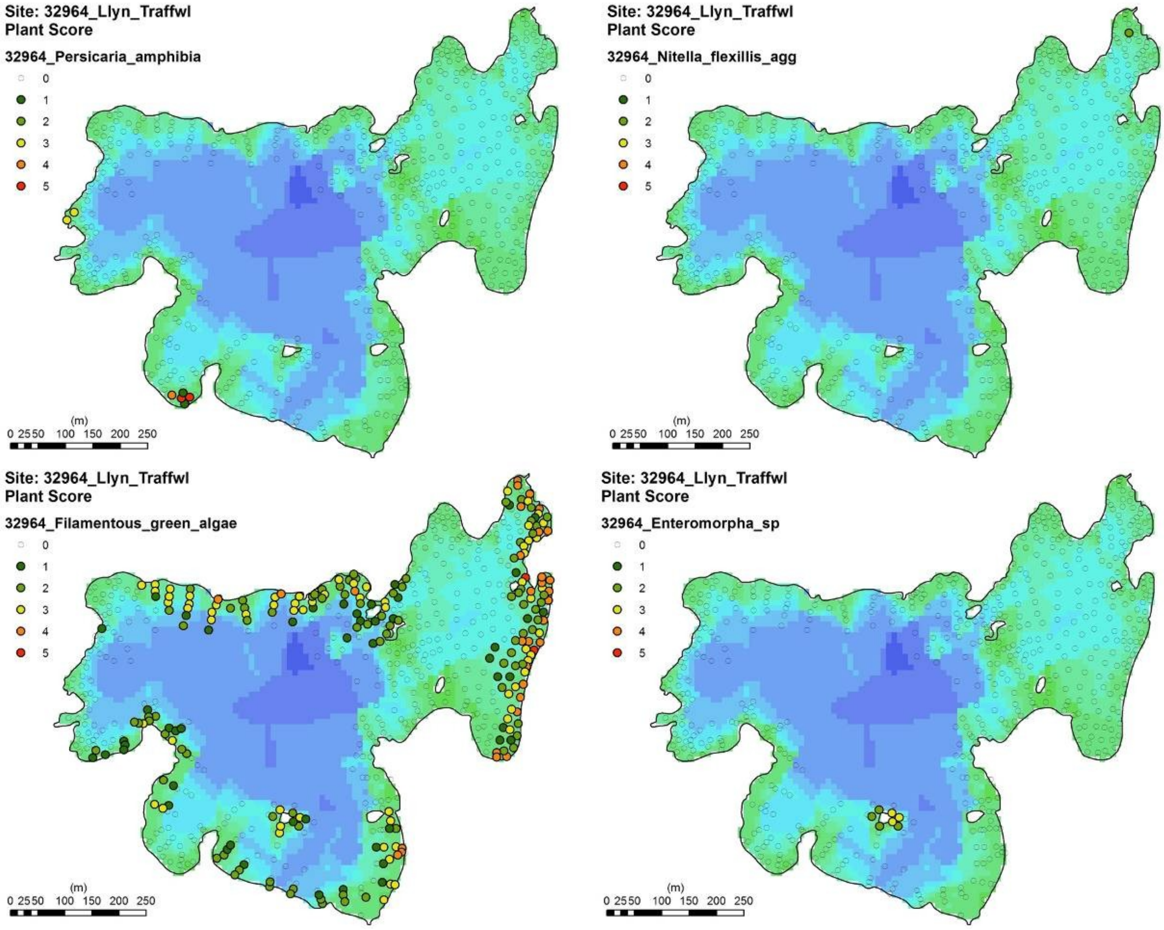


Figure 21 (Contd.)

Negative indicator species

Elodea canadensis was recorded at 25 % frequency in 2012. Any significant increase would be unfavourable. Filamentous algal cover was high in many areas of the lake Thick mats of *Cladophora* sp. smothered low growing vegetation and with over 50% of the sample points having in excess of 75% cover the site is unfavourble. Filamentous algal growth was highest along the south-eastern margin where improved pasture slopes down to the lakes with no or only very narrow buffer strips.

Water quality

Llyn Traffwll is a very shallow (Z_{max} = 4.66 m), high alkalinity lake that drains an agricultural catchment supporting a number of rural developments. Chemistry data are limited to TP, SRP, TON and pH sampled monthly during 2011 and fortnightly during 1995-7. The data show the site to have stable pH, just above 7, but high concentrations of phosphorus which classify the site as hypereutrophic and therefore unfavourable with respect to water quality (Table 39). Total oxidized nitrogen is depleted in the summer months which suggests the site is N limited during the spring.

It is encouraging to note that the mean annual SRP and TON are somewhat lower in 2010 than mean values for 1997. This dataset is very limited and therefore one cannot conclude that nutrient levels are falling, and it highlights the need for better chemical monitoring with which to evaluate management within the catchment.

Moreover, the measured TP of 149 µg l^{-1} in 2010 would place the lake in 'Bad' ecological status according to the class boundaries modelled by the MEI model (Reference = 18 µg l^{-1}; H/G boundary = 23 µg l^{-1}; G/M = 32 µg l^{-1}). The lake is prone to algal blooms and these nutrient levels are reflected in the high filamentous algal cover and in the relatively poor Secchi depth of 1.6m.

Table 39 Water chemistry data for Llyn Traffwll (for units see methodology)

Sample date	pH	Total P	SRP	TON
02/02/2010	7.77	147	82	0.789
10/03/2010	8.45	88	20	<0.2
07/04/2010	7.49	138	20	0.237
05/05/2010	7.89	52	20	0.218
08/06/2010	7.68	84	32.2	0.249
05/07/2010	7.94	123	88.7	<0.2
06/08/2010	7.81	163	90.6	<0.2
06/09/2010	7.85	214	146	<0.2
04/10/2010	8.31	189	176	<0.2
02/11/2010	7.95	26	120	0.277
14/12/2010	7.90	172	115	0.55
10/01/2011	7.93	159	119	0.707
2010 mean	**7.85**	**150**	**90**	**<0.34**
1997 Mean	**7.98**	**No data**	**134**	**0.96**

Dissolved Oxygen Profile

GPS Location	SH3261476752
Maximum Depth (m)	4.1 m
Secchi Depth (cm)	161 cm
Notes:	

Depth (m)	DO (mg/l)	Temp (°C)
0	10.2	17.5
0.5	10.2	17.5
1	10.17	17.5
1.5	10.07	17.5
2	9.95	17.4
2.5	9.79	17.4
3	8.94	17.2
3.5	8.59	17.1

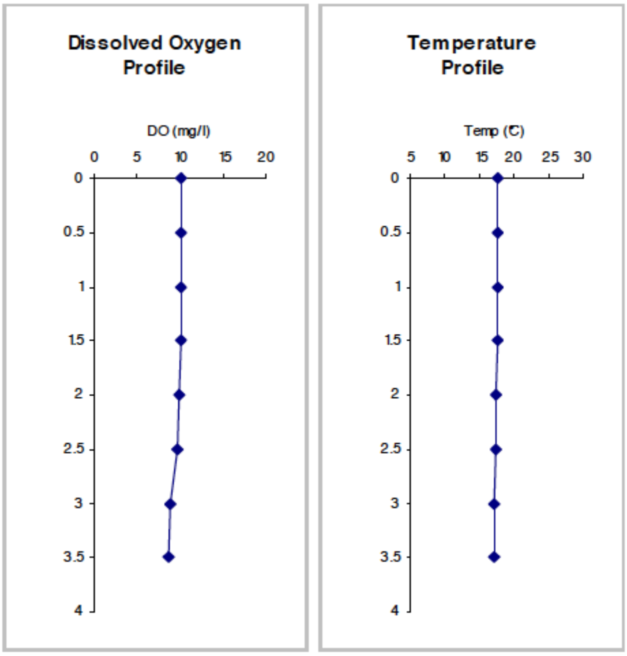


Figure 22 Dissolved oxygen (DO) profile for Llyn Traffwll (28/06/2012).

Other water quality parameters are consistent with the lake type and the lake was well oxygenated and mixed (Figure 22), reflecting its shallow depth and exposed, coastal location.

Hydrology

The lake is no longer used for abstraction and is under a natural hydrological regime.

Lake substrate and sediment load

The lake substrate appears natural, but high nutrients are likely to increase sedimentation rates and a buffer zone would be beneficial to the lake to lessen any potential sediments from farmland.

Indicators of local distinctiveness

Elatine hydropiper and *Calitriche truncata* are rare in wales and therefore their presence in the site is of note.

Lake Bathymetry

The bathymetric survey confirms the site to be shallow with the deepest point of 4.66m being slightly north of centre within the lake (Figure 23). Much of the south-west basin is very uniform in depth of approximately 4m, with the littoral zone shelving quite steeply. The north-eastern portion of the lake is also very flat, but shelves less steeply and the majority of the lake bed is less than 2.3m deep, putting it within the colonisation range of plants.

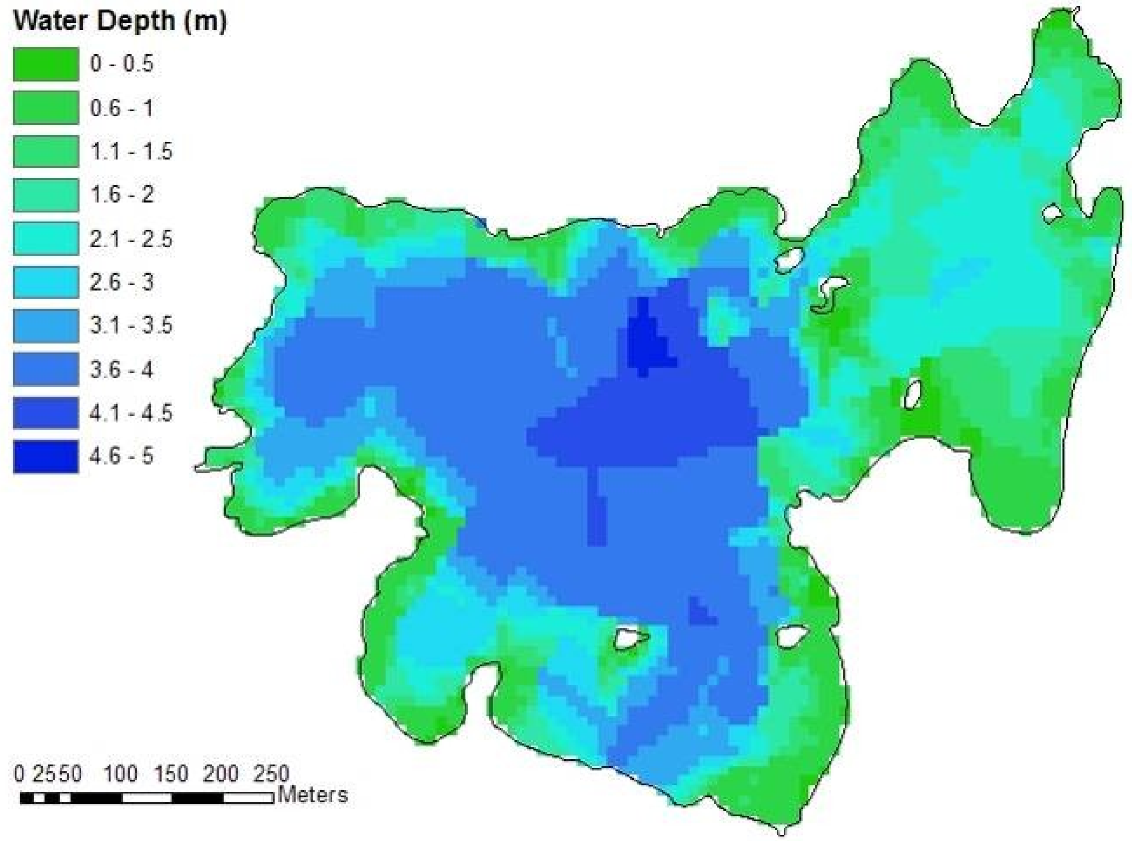


Figure 23 Bathymetric map of Llyn Traffwll, June 2012

Site condition summary and overview

In accordance with the JNCC guidance, Llyn Trafwll is **unfavourable** overall due to high nutrient concentrations and the excessive growth of filamentous green algae in the site. Total Phosphorus concentrations were 3 times the target limit for eutrophic waters in 2010 and therefore confidence in this assessment is **high**. Since there is still a relatively diverse flora, including distinctive elements and species that are normally only recorded in less eutrophic systems (e.g. *Littorella uniflora*), it is particularly important that nutrients are controlled within the catchment and where possible prevented from reaching the lake.

Water quality monitoring within the lake and also at strategic points within the catchment could help to inform management by identifying the extent of the nutrient pollution and also identify potential sources. The likelihood that the site is N limited during summer means nitrogen reduction will be a key factor in the successful management of water quality in the lake. Adjacent pasture is likely to export N and P to the lakes and the site would benefit from wider buffer strips where improved pasture borders the lake.

The lake attracts large numbers of wildfowl, no doubt as a result of the plentiful supply of aquatic plants and invertebrates. In addition to the native and migrant species, there are large numbers of Canada and feral greylag geese using the site, especially during the summer moult. More than 1000 were recorded on the lake in July 2011 (RSPB, unpublished data). In June 2012 there were over 200 grazing in adjacent pasture, which moved on to the lake on our arrival. In addition to the completion with native wildfowl, these birds will be adding significant levels of nutrients to the lake (guanotrophy). Active control of this invasive, non-native is therefore encouraged.

Table 40 Llyn Traffwll overview

Water Body	Status	Reason(s) for Failure	Comments
Llyn Traffwll	**Unfavourable (High confidence)**	Water quality exceeds eutrophic thresholds for TP. Extensive filamentous algal growth smothering littoral plants. Fails to meet expected species targets	Llyn Traffwll supports a relatively diverse flora including 5 characteristic eutrophic species and notable rarities which make the site an important plant habitat. Water quality improvements, at a catchment scale, will be necessary to ensure no further deterioration occurs in the site.

Recommendations for monitoring and management:

The current aquatic flora at Llyn Traffwll is relatively rich, but it fails to meet the updated CSM target foreutrophic sites. the site also fails the condition assessment due to poor water quality, a problem which if un-checked is likely to cause the flora to deteriorate. Conversely, improved water quality is likely to result in improved structure and diversity of the aquatic plant community and catchment-wide nutrient reduction should therefore be the primary focus for site management.

The following recommendations are based on the evidence collected for this report:

- Monitor water quality – minimum of quarterly sampling of inflow and outflow.
- Monitor the aquatic flora every 3-5 years to ascertain any increase or decline.
- Investigate possible sources of nutrients from the catchment and take remedial action as required.
- Where necessary and with land owner co-operation extend buffer zones .
- Monitor and control Canada geese populations.

CSM Database output

Site Condition Assessment: Llyn Traffwll (21/06/2012)

Lake Details		**Survey Details**		
Lake Name	Llyn Traffwll	Survey Date	21/06/2012	
SSSI Name	LLYN TRAFFWLL	Surveyors	BG, JoS & SR	
SAC Name		Shore Surveys	4	out of
Grid Ref	SH325769	Wader Surveys	4	4
WBID / NI No.	32964 /	Boat Surveys	4	sections

Site Notes:
Old water supply res - no longer used.

Survey Notes:
Huge numbers of geese use the site. Canada and Greylag. Elatine recorded - all as hydropiper. Wind stressed site.

Section Summaries

Section 1	Maximum depth of colonisation (cm)	300 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	10 m
	Notes:	
Section 2	Maximum depth of colonisation (cm)	250 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	10 m
	Notes:	
Section 3	Maximum depth of colonisation (cm)	240 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	12 m
	Notes: Plants to max depth of section	
Section 4	Maximum depth of colonisation (cm)	250 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	10 m
	Notes: Plants to max depth of section	

Section Locations

	Shore Survey GPS Co-ords start	end	Boat Survey GPS Co-ords start (shore)	end (lake)
Section 1	SH3217477130	SH3220877194	SH3216377165	SH3228377095
Section 2	SH3272276759	SH3274476683	SH3273576729	SH3268576724
Section 3	SH3295477378	SH3299577327	SH3295977352	SH3295377294
Section 4	SH3300977112	SH3298977049	SH3298377073	SH3292777078

Section Photos

	Start of Section	Whole Section	End of Section
Section 1	78	79	80
Section 2	81	82	83
Section 3	84	85	86
Section 4	87	88	89

Species Abundance - Boat Survey

Total number of sample plots	80
Total number of vegetated sample plots	46

Plant Species	Occurrence *n*	%
Callitriche truncata	25	54
Chara globularis	3	7
Elatine hydropiper	4	9
Elodea canadensis	16	35
Myriophyllum spicatum	1	2
Nitella flexilis agg.	1	2
Potamogeton pectinatus	12	26
Potamogeton perfoliatus	4	9
Potamogeton pusillus	32	70
Zannichellia palustris	4	9

Species Abundance - Wader Survey

Total number of sample plots	80
Total number of vegetated sample plots	80

Plant Species	Occurrence *n*	%
Alisma plantago-aquatica	1	1
Callitriche truncata	65	81
Chara globularis	6	8
Elatine hydropiper	12	15
Eleocharis palustris	8	10
Elodea canadensis	16	20
Equisetum fluviatile	2	2
Iris pseudacorus	11	14
Lemna minor	6	8
Persicaria amphibia	2	2
Phragmites australis	19	24
Potamogeton crispus	3	4
Potamogeton pectinatus	41	51
Potamogeton perfoliatus	15	19
Potamogeton pusillus	21	26
Schoenoplectus tabernaemontani	3	4
Sparganium erectum	5	6
Zannichellia palustris	26	32

Note: Species abundance % = ((number of plots / total number of vegetated sample plots) * 100)

Plant Scores

Total plant species 34 **Filamentous algae (%)** 63.2 % WADER 36.5 % BOAT

Total plant cover (%) 149.74

SURVEY SCORES

PLANT SPECIES	PERIMETER	WADER	BOAT	COVER %	DAFOR	ABUNDANCE
Callitriche truncata	0	0.2628	0.148	27.94	A	4
Potamogeton pusillus	0	0.0456	0.1448	16.76	F	3
Phragmites australis	0.375	0.1084	0	14.8	F	3
Potamogeton pectinatus	0	0.139	0.07	13.95	F	3
Juncus effusus	0.5	0	0	12.5	F	3
Elodea canadensis	0	0.0342	0.0714	8.85	O	2
Iris pseudacorus	0.2125	0.0325	0	6.94	O	2
Zannichellia palustris	0	0.0986	0.0099	5.92	O	2
Eleocharis palustris	0.1875	0.0194	0	5.66	O	2
Oenanthe crocata	0.2125	0	0	5.31	O	2
Lythrum salicaria	0.1375	0	0	3.44	R	1
Potamogeton perfoliatus	0	0.0315	0.0145	3.02	R	1
Lycopus europaeus	0.1125	0	0	2.81	R	1
Elatine hydropiper	0	0.0291	0.0121	2.66	R	1
Phalaris arundinacea	0.1	0	0	2.5	R	1
Sparganium erectum	0.05	0.0141	0	1.96	R	1
Mentha aquatica	0.075	0	0	1.88	R	1
Equisetum fluviatile	0.05	0.007	0	1.6	R	1
Ranunculus flammula	0.0625	0	0	1.56	R	1
Chara globularis	0	0.0142	0.0085	1.56	R	1
Epilobium hirsutum	0.05	0	0	1.25	R	1
Lemna minor	0	0.0177	0	0.88	R	1
Schoenoplectus tabernaemontani	0.025	0.0046	0	0.86	R	1
Alisma plantago-aquatica	0.025	0.0025	0	0.75	R	1
Angelica sylvestris	0.025	0	0	0.62	R	1
Potentilla anserina	0.025	0	0	0.62	R	1
Rumex hydrolapathum	0.025	0	0	0.62	R	1
Ranunculus lingua	0.025	0	0	0.62	R	1
Schoenoplectus lacustris	0.025	0	0	0.62	R	1
Nitella flexilis agg.	0	0	0.0052	0.52	R	1
Potamogeton crispus	0	0.0078	0	0.39	R	1
Persicaria amphibia	0	0.0045	0	0.22	R	1
Myriophyllum spicatum	0	0	0.0015	0.15	R	1
Enteromorpha sp.	0	0	0	0	R	1

5.8. Llyn Glasfryn

Annex 1 type: H3130: Oligotrophic to mesotrophic standing water with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*. Assessed as mesotrophic

5.8.1. Site description

Table 41 Summary characteristics for Llyn Glasfryn

Name:	Llyn Glasfryn
County:	Gwynedd
WBID:	34622
Grid reference:	SH402421
OS Grid reference (X,Y):	240254,342181
Latitude / Longitude	N52°57.19',W004°22.76'
Altitude (m):	129
Maximum recorded depth (m):	1.44
Mean depth (m):	0.88
Lake volume (m^3)	50502
Surface area - UKLakes (ha):	5.8
Surface area - measured (ha):	5.72
Perimeter of lake (km):	1.1
Shoreline Development Index (SDI):	1.274
WFD alkalinity based typology:	Med Alkalinity, Very Shallow (MA,V)
Phase 1 habitat type:	Standing water: Mesotrophic: G1.2
Survey Date:	22 June 2012

Llyn Glasfryn is a small shallow lake situated on acid soils (Arfon series) within the gently undulating countryside of the Lleyn peninsula. The site was designated as a SSSI in 1989 due to due to the biological interest within the lake, primarily the aquatic flora, and because open water habitats are scarce on the Lleyn peninsula. Previous studies on the site have revealed the lake to be enriched (Monteith 1997; Burgess *et al.* 2006) and palaeoecological evidence suggested there to have been significant species turnover attributed to eutrophication (Allott *et al.* 2001, Bennion 2004).

Although the lake has continued to support a relatively diverse flora in recent years, including notable rarities such as *Elatine hydropiper* and *E. hexandra*, the site appears to have lost *Luronium natans* which was last recorded in the site in 1987 (Lockton 2009). Also apparently lost from the site is the isoetid flora that is characteristic of many mesotrophic lakes. Seddon (1972) reports the presence of *Littorella uniflora, Isoetes echinospora* and even *Subularia aquatica* from surveys conducted in the early 1960s, although did not find *Luronium natans*.

The previous site condition report (Burgess *et al.* 2006) recoded a relatively diverse flora, but one that lacked a typical mesotrophic assemblage and the site was classified as being unfavourable with respect to the flora and the poor water quality. There was however evidence that the site had improved since 1996.

5.8.2. Condition Assessment and Discussion

Table 42 Condition Assessment Summary Table for Llyn Glasfryn

Attribute	Target	Status	Comment
Extent	No loss of extent of standing water	✓	None.
Macrophyte community composition	Mesotrophic: ≥ 8 characteristic species listed in Box 2 (unless valid reasons suggest otherwise)	X X	No characteristic *Potamogeton* spp. 2 other characteristic species present: *E. hexandra* & *N. flexilis (agg.)*
	No loss of characteristic species (see Box 2)	X	Multiple losses – see text
	≥ 6/10 vegetated sample spots (boat / wader survey) have ≥ 1 characteristic spp.	X	47 % of vegetated sample points in the CSM survey.
Negative indicator species	Non-native species absent or present at low frequency	✓	None recorded
	Benthic and epiphytic filamentous algae <10%.	X	75 % of sample points had filamentous algae score of 3 (75% cover)
Macrophyte community structure	Characteristic vegetation zones should be present (site specific)	✓?	Mixed species beds occurred throughout the site with plants to maximum depth
	Maximum depth distribution maintained		Z_{max} (recorded) = 1.44 m, Z_s = >1.44 m, Z_v = 1.44 m.
	At least present structure should be maintained	✓?	No change since 2004 survey, but significant change since 1960s
Water quality	Stable nutrients levels: TP target / limit: Mesotrophic = 20 $\mu g l^{-1}$	X	TP = 48 $\mu g\ l^{-1}$ SRP = 9 $\mu g\ l^{-1}$ TON = <0.2 $mg\ l^{-1}$ 2012 mean (n = 4 - quarterly)
	Stable pH / ANC values: pH ~ 5.5 – 7.0 ANC > 20	✓ ✓	pH = 6.63 - 7.03 (2012 mean = 6.85) ANC-I = ~235, ANC-C = 296
	Adequate dissolved O_2 for health of characteristic fauna (> 5 mgl^{-1})	✓	>8.6 $mg\ l^{-1}$ and water column well mixed (June 2012).
	No excessive growth of cyanobacteria / green algae	✓	No blooms reported and mean Chl *a* = 7.4 $\mu g\ l^{-1}$.
Hydrology	Natural hydrological regime	✓	Appears largely natural. Some input from underground springs.

Attribute	Target	Status	Comment
Lake substrate	Natural shoreline maintained	✓?	Some areas lack effective buffer, but generally good.
	Natural and characteristic substrate maintained	✓?	Silt, cobbles & gravels dominate marginal zone. Silt beyond.
Sediment load	Natural sediment load maintained	X?	Areas of improved grassland to shore – risk of increased run-off to lake.
Indicators of local distinctive-ness	Distinctive elements maintained at current extent / levels / locations	X?	*Elatine hydropiper* – common in the site. But *L. natans* lost as well as isoetid flora.
Disturbance	No introduced species	✓	None recorded.
	Minimal negative impacts from recreation and navigation. No fish farming	X?	Mallard are reared / fed for shooting at the site. Added input from food.
Palaeo evidence	No evidence of significant environmental change e.g. acidification or eutrophication	X	Site shows significant changes to sediment type and diatoms indicate eutrophication

Status: ✓ = favourable; X = unfavourable; - = unable to assess

Extent

There is no evidence of any loss of extent.

Macrophyte community composition and structure

A total of 11 aquatic species were recorded in 2012 of which only two (*Elatine hexandra* and *Nitella flexilis* agg.) are considered to be characteristic species for mesotrophic waters. The species assemblage is very similar to that recorded in 2004 (Burgess *et al.* and Table 43), with only *Ceratophyllum demersum* and *Fontinalis antipyretica* not seen in 2012, but both were rare in 2004).

While the species list was similar, the abundance of the dominant species was dramatically different. In 2004, *Myriophyllum alterniflorum* was dominant in the site and *Callitriche hamulata* and *Nitella flexilis* agg. recorded only rarely. The reverse was true in 2012, with *N. flexilis* dominanting the southern half of the lake and *C. hamulata* more abundant towards the NW and SE margins, often under waterlilies (see Figure 24). The two *Elatine* species appear to show a separation in their distribution (Figure 24), but some of this may have been a result of the survey conditions. Much of the lake bed and low growing plants was covered by filamentous green algae, making accurate identification of *Elatine* spp. difficult without up-rooting it, which was not always done for both practical reasons and to limit disturbance. *Elatine hydropiper* was certainly more common in open water areas, whereas plants growing within the littoral zone were more often identified as *E. hexandra.*

Of the Water lilies, *Nuphar lutea* was more widely distributed in the lake, but often interspersed with *Nymphaea* alba around the west and north shore. Other aquatic species were rare (Table 43, Figure 24)

The margins were dominated by *Menyanthes trifoliata,* which forms a narrow ring around much of the littoral area of the lake and larger beds around the inflow on the NE shore. Stands of *Iris pseudacorus* and *Carex rostrata* were common and away from the more densely shaded *Alnus* along the north, *Juncus effusus* was dominant. No non-native species were recorded from the lake, but *Rhododendron* sp. is present on the two more southerly islands in the lake and there is a large stand of montbretia (*Crososmia* sp.) between the track and the NW shore of the lake.

Submerged and floating vegetation	TRS	PLEX	% occurrence (n=43)	DAFOR abundance[8] 2012	DAFOR 2004
Callitriche hamulata	6.3	6.15	82.5	D	R
Ceratophyllum demersum	10	8.85		-	R
Elatine hexandra	**7**	**5.38**	**11.7**	**R**	**R**
Elatine hydropiper			11.7	F	O
Eleocharis acicularis	-	7.95	0.8	R	O
Fontinalis antipyretica	6.3	5.38	-	-	R
Myriophyllum alterniflorum	6.7	4.23	2.5	R	D
Nitella flexilis agg.	**6.7**	**5.38**	**35.0**	**A**	**R**
Nuphar lutea	8.5	6.92	14.2	O	F
Nymphaea alba	6.7	3.08	10.0	O	F
Persicaria amphibia	9	7.95	5.0	R	R
Potamogeton berchtoldii	7.3	7.69	+	R	R
Potamogeton obtusifolius	8	6.54	0.8	R	F
Average score	**7.36**	**6.13**		**PLEX =**	**6.29**
Species richness				**11**	**13**

Table 43 Aquatic macrophyte community composition for Llyn Glasfryn in June 2012. Characteristic mesotrophic species are highlighted in **bold**.

The 2012 survey results are unfavourable in terms of species composition and although the community structure is good for those species present, it does contain the characteristic elements normally associated with mesotrophic lakes (e.g. broad-leaf *Potamogeton* spp.). Dominance by *Callitriche hamulata* and *Nitella flexilis* agg. although very different to the 2004 community, nonetheless provides very similar community structure in terms of lake function. The current assemblage classifies the site as a Group D lake according to Duigan *et al.* (2006) which is typified by *Callitriche hamulata,* but usually also an isoetid flora, at least with *Littorella uniflora*. *Littorella uniflora* was quite extensive in the 1996 survey (Monteith 1997), but has not been detected since. The site PLEX score of 6.13, compared to 6.29, shows a very

[8] Based on presence / absence data from all vegetated plots in the wader and boat based surveys. DAFORs are calculated from the total number of occurrences across the wader and boat surveys as a proportion of the total number of vegetated wader and boat survey points.

slight improvement since 2004, towards more typical mesotrophic scores, but the change is too small to be significant.

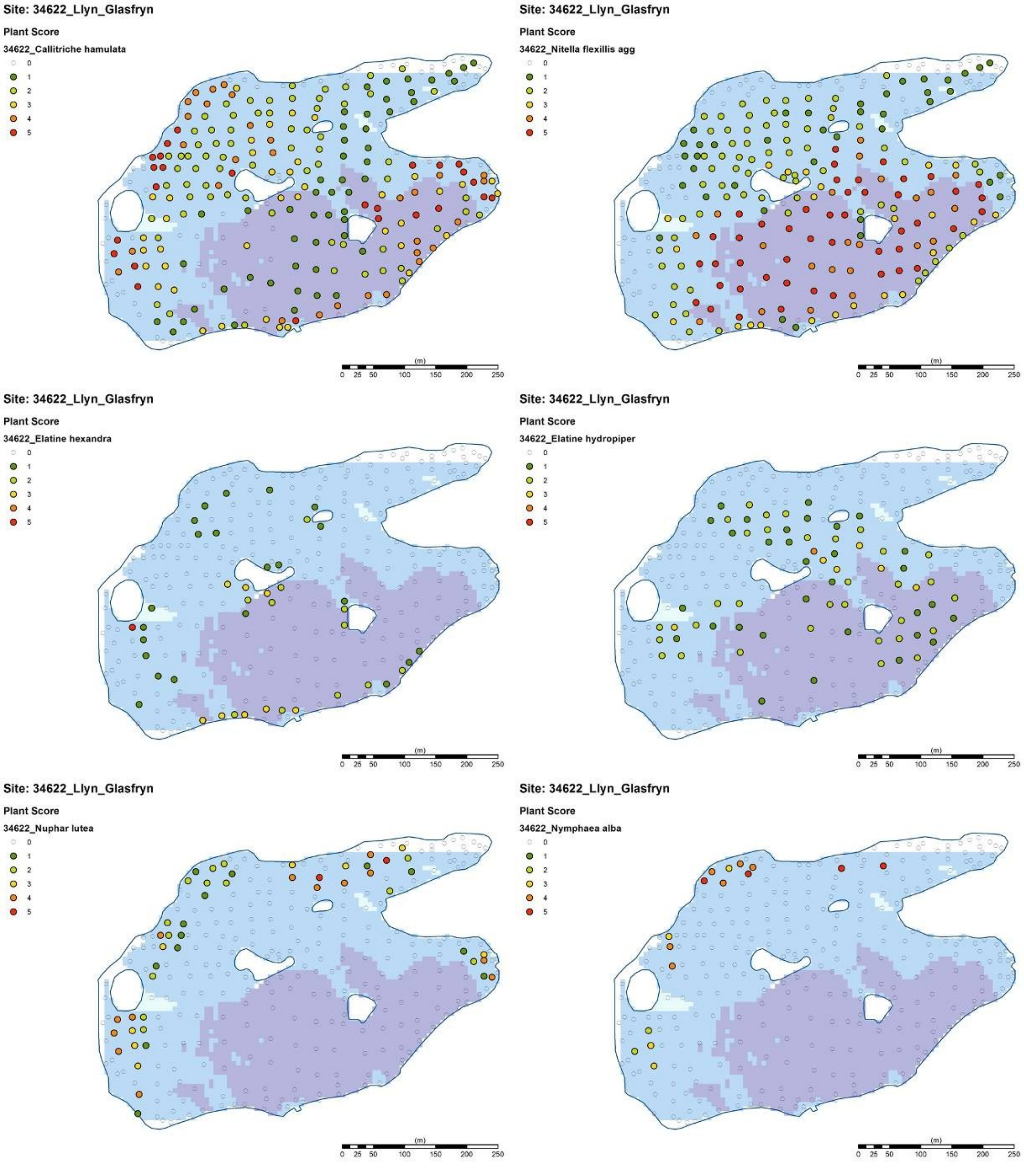


Figure 24 Distribution maps of the aquatic plant species recorded in Llyn Glasfryn

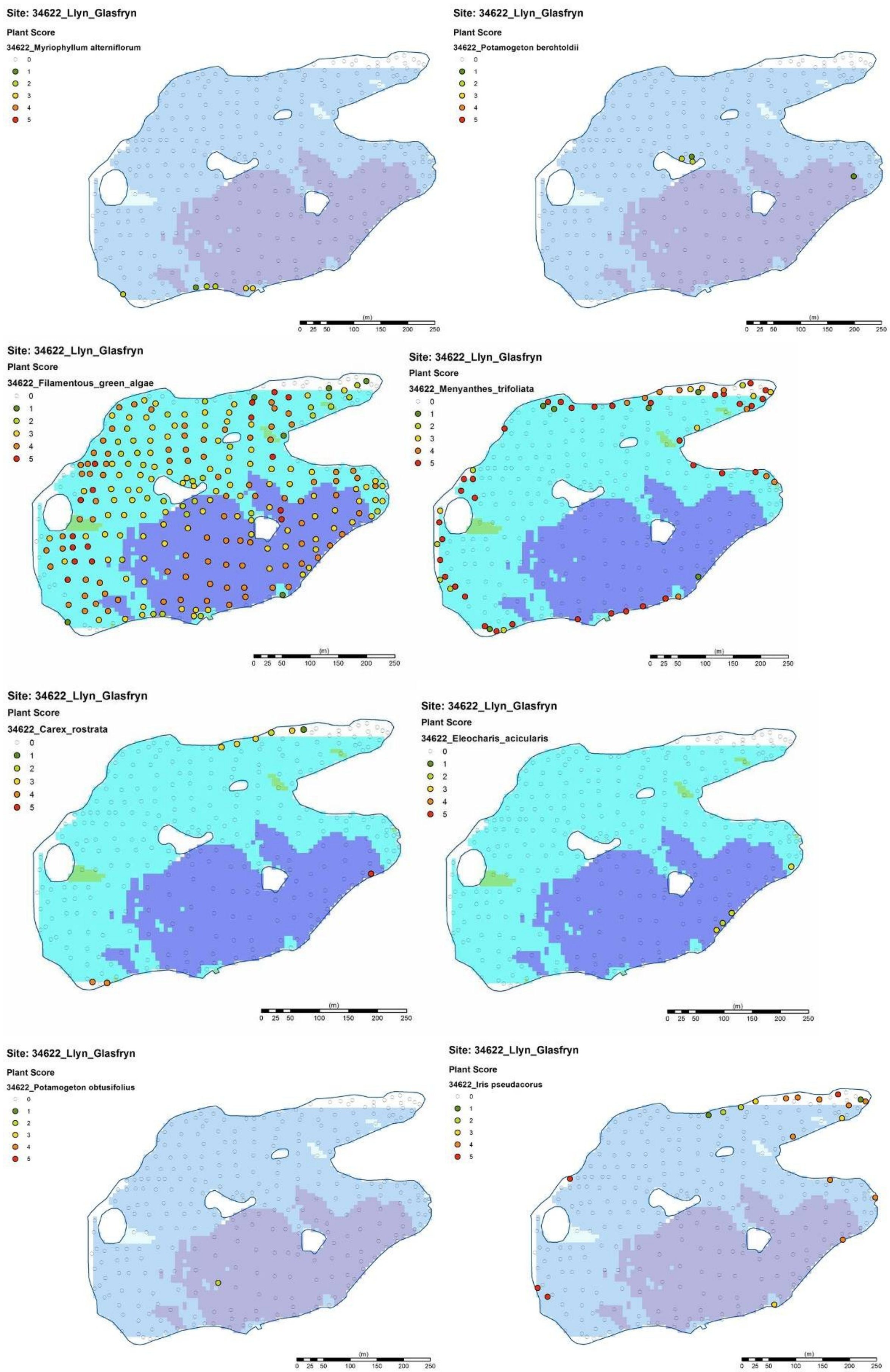


Figure 24 (Contd.)

Negative indicator species

A high abundance of filamentos green algae was indicative of the high nutrients in the site. Total cover is estimated to be in the region of 60 % for the whole site, with many areas having 100 % cover over low growing species such as *Elatine* spp. and *Eleocharis acicularis* (Figure 24). Such high abundance of filamentous algae is atypical for mesotrophic lakes and is unfavourable.

Water quality

Llyn Glasfryn is classified as a mesotrophic lake which is consistent with its geology and its historic plant community. The water is currently circumneutral (2012 mean pH 6.85) although slightly more acid than reported in 2004 (pH 7.11) (Burgess *et al*. 2006). The site is well buffered and of not risk of acidification (ANC = 297 µeq l^{-1}).

Mean annual TP concentrations are over double the upper limit for shallow mesotrophic lakes (Table 44) and there is no evidence of change in nutrient levels since 2004 (42 µg l^{-1}), although levels have dropped dramatically since 1996 when TP was recorded at 146 µg l^{-1} (Monteith 1997). The MEI model used for calculating lake phosphorus predicts a reference TP of 12 µg l^{-1}, with High / Good and Good / Moderate boundaries of 16 and 24 µg l^{-1} respectively. The current TP places the lake just in 'Moderate' status (the Moderate / Poor boundary is 47 µg l^{-1}) which reflects the high algal cover and atypical flora.

Table 44 Water chemistry data for Llyn Glasfryn (for units see methodology)

Determinand	Dec 11	Mar 12	Jun 12	Oct 12	Annual mean 2011-12
pH	6.93	6.63	7.03	6.93	**6.85**
Cond	86.5	94.1	95.1	88	**90.9**
Alk (Gran)	10.4	7.7	8.4	16.3	**10.7**
Alk (Total)	13.9	9.4	10.2	17.6	**12.8**
DOC	6.56	19.30	5.55	5.32	**9.18**
SRP	21.0	4.7	3.4	5.2	**8.6**
TP	87.5	30.1	31.3	41.9	**47.7**
Chl a	9.0	14.1	5.5	1.1	**7.4**
TN	-	-	-	-	**-**
TON	<0.20	0.29	<0.20	<0.20	**<0.22**
Na^+	9.56	9.67	10	8.25	**9.37**
K^+	1.77	1.76	1.72	1.16	**1.60**
Mg^{2+}	1.47	1.5	1.61	1.67	**1.56**
Ca^{2+}	5.25	5	5.65	6.35	**5.56**
Cl^-	18.5	19.3	19.7	14.9	**18.1**
$SO4^{2-}$	<10.0	<10.0	<10.0	<10	**<10.0**
SiO_2	0.589	0.743	0.2	1.33	**0.76**
Sus Solids	13.2	<3	<3	<3	**<5.6**
ANC-I (ionic)					**235**
ANC-C (Cantrell)					**297**

Phytoplankton concentrations appear to remain relatively low in the site (mean Chl a 7.4 µg l^{-1}), but there were extensive growths of filamentous algae throughout the lake with are indicative of the elevated nutrients. This is in contrast to the findings of Monteith et al (1997) who recorded chlorophyll in excess of 100 µg l^{-1}, reflecting the serious nutrient problems at that time.

Oxidised nitrogen is low in the site throughout the year and soluble (bio-available) phosphorus lowest during the warmer months. This suggests the site has a roughly balanced nutrient supply, rather than being limited by only one nutrient. Control of both N & P within the catchment is therefore advisable. Other water quality parameters are consistent with the lake type and the lake was well oxygenated and mixed.

Hydrology

The lake level is under natural control and there was no evidence of any significant water level fluctuation. Surface run-off was noted entering the lake at the far north-east of the site, but no other inflows were observed and no inflow streams are marked on the map. The catchment area is small, and in addition to surface flow, the lake is thought to receive water via natural springs and surface drains.

Lake substrate and sediment load

There are consolidated gravel, pebble and cobble substrates on some of the more exposed areas of shoreline (particularly around the south shore), but where *Menyanthes trifoliata* and other emergent vegetation grow deeper silts have accumulated in the littoral one. The open water areas are dominated by silt.

The primary risk to the site of increased sediment load comes from the improved pasture that surrounds much of the site. The site is generally very well buffered however, with fenced areas allowing natural hydroseral development. The only exception is the pasture along the south west portion of shore where there is little or no buffer and evidence of cattle poaching. This should be monitored, but is not considered a major threat to the site.

A sediment core, 85 cm in length (GLRF3) was taken using a piston corer from the deepest area of the lake (1.3 m at SH4033342147). Radiometric dating was used to determine the core chronology which placed 40 cm in the core at approximately AD 1850. Sediment accumulation rates were relatively constant, but the sediment composition changed dramatically. From approximately 1850 to 1900 there was quite a sharp decline in the amount of organic matter in the sediment, followed by an even steeper increase in organic matter from 1900 to approximately 1950 with a continued trend, with minor dips, of increasing organic matter up to the present day (Figure 25).

The increase in loss on ignition (LOI) towards the top of the core can be broadly interpreted as increased productivity within the lake and surrounding catchment and provides evidence of nutrient enrichment at the site. The reason for a decline in organic matter before AD 1900 is less clear. It is most likely as a result of changes in land management in the immediate catchment; possibly a shift from permanent pasture or meadow to arable around the lake. The increased productivity from the land changes then released nutrients which in turn increased productivity within the lake and hence the increase in organic matter. Further analysis on this sediment core could identify the historic plant community that existed during the more stable condition before AD 1850 and what triggered changes to the biology and when. This would help to set site specific target for the lake.

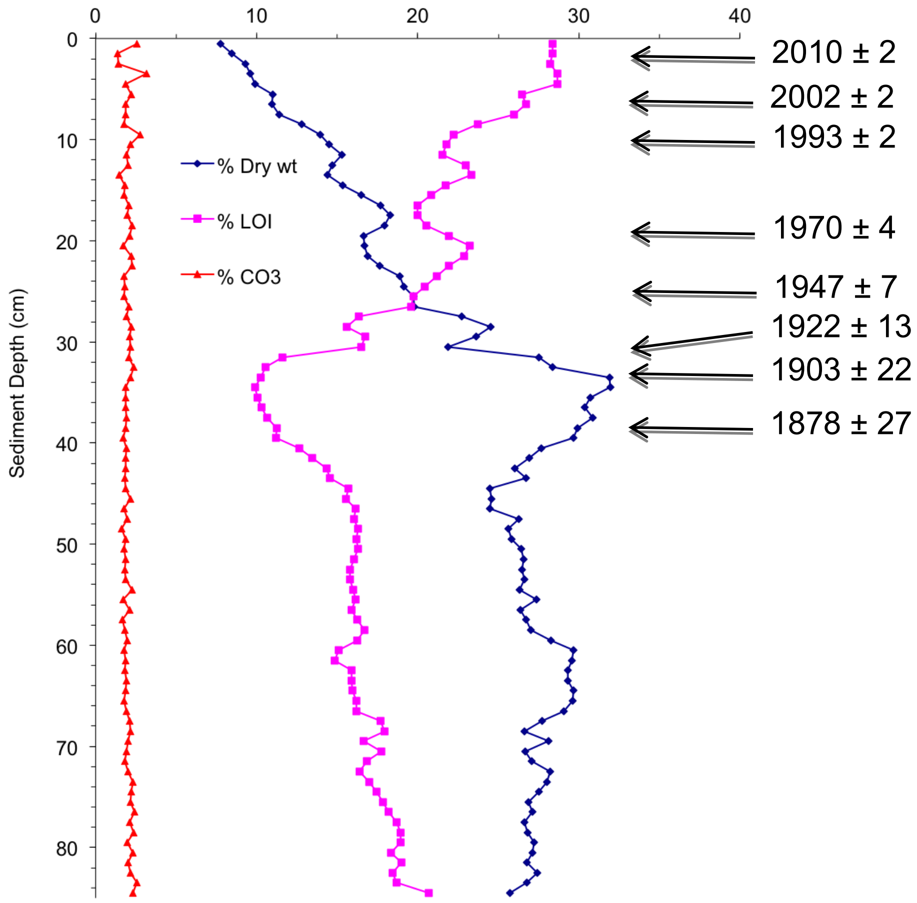


Figure 25 Physical characteristics and radiometric dates from core GLFR3

Palaeolimnological evidence

The diatom flora of bother the surface and basal sediments was dominated by benthic taxa, consistent with the lake being shallow and plant dominated. The surface sediment was dominated by *Cocconeis placentula* var. *euglypta, Fragilaria* species (*F. construens* var. *venter, F. elliptica* and *F. capucina* varieties) and *Gomphonema parvulum.* The basal sample was dominated by *Fragilaria virescens* var. *exigua, Eunotia* species (mainly *E. incisa*), *Cymbella gracillis* and *Gomphonema gracillis.* Species turnover between the two samples was high, with squared chord distance (SCD) between the samples of 1.09 (Table 45).

Sample Code	Depth (cm)	1998/99 mean pH	DI-pH	2011/12 mean TP	DI-TP	SCD
GLFR1-0	0	6.85	6.81	47.7	38.7	1.09
GLFR1-81	81		6.33		7.2	0.00

Table 45 Results of Llyn Glasfryn sediment core analysis

Reconstructions of diatom-inferred pH (DI-pH) were produced using the SWAP training set (RMSEP = 0.32 pH units). Fossil assemblages from both samples were dominated by benthic species typical of slightly acidic to circum-neutral shallow lakes. The DI-pH was in good agreement with the measured pH and the model suggests thre to have been a increase of approximately 0.5 of a pH unit over the the time period covered by the core.

Reconstructions of diatom-inferred TP (DI-TP) suggests there to have been a significant increase in the trophic status of the lake between the perriods represented by the core bottom and the surface sediment (7.2 to 38.7 µg l^{-1} TP). There were no major analogue problems with the core samples, with fossil assemblages being well represented in the NW European training set. The current annual mean TP based on quarterly water samples was 47.7 µg l^{-1} and therefore the diatom model only slightly underestimates current conditions.

In summary, there has been a major shift in floristic composition in the sediment core diatoms from Llyn Glasfryn. The surface diatom assemblage is indicative of a shallow eutrophic lake with clear water and shows the site to have undergone a significant change in trophic status relativel to the period represented by the base of the core. Over the same period the site has become slightly more alkaline, a probable result of agricultural improvement in the catchment. High resolution diatom analysis of the dated sediments of this core would be beneficial to better understanding the timings of this change and potentially help inform future management.

Indicators of local distinctiveness

Elatine hydropiper is rare in Britain but remains common in Llyn Glasfryn whereas other other distinctive features have been lost. *Luronium natans* was last recorded in the site in the 1980s (Lockton 2009). Also apparently lost from the site is the isoetid flora that is characteristic of many mesotrophic lakes. In addition to *Littorealla uniflora,* Seddon (1972) reports the presence of *Isoetes echinospora* and *Subularia aquatica* from surveys conducted in the early 1960s, and BSBI data show records of both *I. echinospora* and *I. lacustris* in the 19^{th} and 20^{th} centuries.

Lake Bathymetry

The bathymetric survey confirms the site to be very shallow with the deepest point of only 1.44 m, and the majority of the site less than 1.0 m (Figure 26).

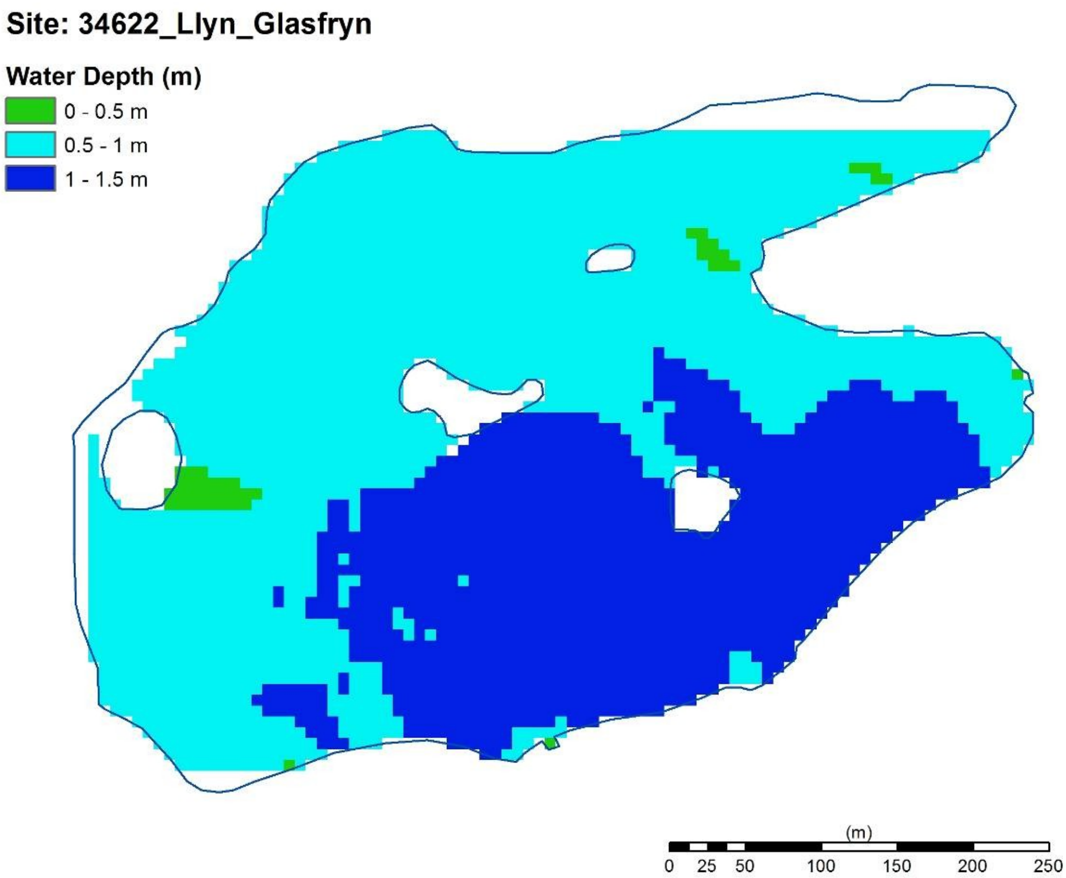


Figure 26 Bathymetric map of Llyn Glasfryn, December 2011

Site condition summary and overview

Llyn Glasfryn is in **Unfavourable** condition with **high confidence**. The aquatic species assemblage falls well short of the requisite eight mesotrophic species and there are no broad-leaf *Potamogeton* species present. Being very shallow, it is possible the site has a lower capacity for species richness than the more dynamic habitats found in larger, deep sites, but even so there is past evidence that the site has had at least five other characteristic species (Seddon 1972) as well as *Luronium natans*. It is quite probable the lake was already in decline when Seddon visited in the early 1960s[9]. In addition to the isoetids listed, he also recorded a number of more typically eutrophic taxa in from the site including *Ceratophyllum demersum, Lemna minor* and *Ranunculus circinatus* as well as many of the species still there today, although not *Callitriche hamulata.* Seddon recorded *Potamogeton perfoliatus,* but there are no other records of broad-leaf *Potamogeton* species from the site.

There is evidence to suggest that the nutrient concentrations have dropped in the lake over the past two decades, with Monteith (1997) reporting TP of 146 $\mu g l^{-1}$ coupled with an algal bloom. Data are limited, but it appears the TP concentrations fell between 1996 and 2004 (Burgess *et al.*), and then remained relatively stable at

[9] In this context it is interesting to note that the great 19th century botanist J.E. Griffith, who also visited Llyn Glasfryn, did not record *C. demersum*, even though it was at that time a rarity in North Wales (Griffith 1895). He did however record *R. circinatus*.

around 45 µg l^{-1} since then. Nitrogen remains relatively low at the site suggesting it is not in excess, but neither is there any evidence that it is limiting.

It is recommended that management endeavours to restrict the use of nitrogen fertilizers and excessive use of manure within the catchment. Adjacent pasture is likely to export N and P to the lakes and while there are good buffer zones around much of the lake, these are lacking in the SE margin and some means to increase buffering should be sought.

If catchment sources of N & P can be controlled, internal loadings will decline over time and TP concentrations should eventually fall back within the mesotrophic target limits. This is dependent on good catchment management and the identification and management of any potential sources nearby, including rural sewage arrangement, particularly at nearby holiday cottages which potentially have increased per-capita volume of wastewater generation. Regular monitoring of water quality is required to assess change at the site and to increase the evidence-base for better informed site management. Additionally, further investigation of the groundwater catchment is recommended as it is possible that nutrient sources outside the surface water of the lake affect the nutrient concentrations (Monteith 1997).

The traditional practice of raising mallard for shooting requires careful management at the site if it still continues. Numbers should be restricted (with further advice on carrying capacity required) and feeding should be done away from the lake and off the ground, to prevent excess food adding nutrients to the lake. Any fish stocking should be strictly controlled and fish densities kept to a minimum.

Water Body	Status	Reason(s) for Failure	Comments
Llyn Glasfryn	**Unfavourable (High confidence)**	Water quality exceeds mesotrophic thresholds for TP. Extensive filamentous algal growth smothering plants. Evidence of characteristic species loss.	Llyn Glasfryn is enriched and as a result has lost many of its characteristic aquatic species. Better water quality will be key to improving the site by reducing filamentous algal growth and giving advantage to less competitive plant species.

Table 46 Llyn Glafryn overview

Recommendations for monitoring and management:

There is very little evidence of improvement at Llyn Glasfryn since the previous condition assessment based on 2004 data. It is perhaps encouraging however that there has also been no decline. The priorities for management are to minimise any further nutrient inputs to the lake.

The following recommendations are based on the evidence collected for this report:

- Monitor water quality – minimum of quarterly sampling at outflow
- Monitor the aquatic flora every 3-5 years to ascertain any changes in species composition and assess directional change.
- Investigate possible sources of nutrients from the surface water and groundwater catchments and take remedial action as required
- Where necessary and with land owner co-operation extend buffer zones
- Work with land owners to ensure traditional practices are managed with a minimal environmental impact (e.g. duck rearing).

CSM Database output

Site Condition Assessment: Llyn Glasfryn (22/06/2012)

Lake Details		**Survey Details**		
Lake Name	Llyn Glasfryn	Survey Date	22/06/2012	
SSSI Name	LLYN GLASFRYN	Surveyors	BG, J0S & SR	
SAC Name		Shore Surveys	4	out of
Grid Ref	SH402421	Wader Surveys	4	4
WBID.	34622	Boat Surveys	4	sections

Site Notes:
Shallow lake with brown trout stocked (?). Nitella opaca recorded. L. natans last recorded in 1987 or 1983 (?)

Survey Notes:
Nitella recorded as N. flexillis agg. Elatine hydropiper and E. hexandra
recorded with E hydropier being most common in open water.

Section Summaries

Section 1	Maximum depth of colonisation (cm)	105 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	10 m
	Notes:	
Section 2	Maximum depth of colonisation (cm)	100 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	10 m
	Notes:	
Section 3	Maximum depth of colonisation (cm)	100 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	8 m
	Notes:	
Section 4	Maximum depth of colonisation (cm)	100 cm
	Compass bearing of boat transect (°)	-
	Lateral distance from waters edge to 75cm depth (m)	10 m
	Notes:	

Section Locations

	Shore Survey GPS Co-ords start	end	Boat Survey GPS Co-ords start (shore)	end (lake)
Section 1	SH4041442213	SH4040542163	SH4042142182	SH4038342194
Section 2	SH4022642276	SH4032442294	SH4023242269	SH4029242189
Section 3	SH4023742062	SH4017142065	SH4019742075	SH4021542140
Section 4	SH4011642211	SH4017842290	SH4015642248	SH4017642213

Section Photos

	Start of Section	Whole Section	End of Section
Section 1	090	091	092
Section 2	093	094	095
Section 3	096	097	098
Section 4	102	103	104

Species Abundance - Boat Survey

Total number of sample plots	80
Total number of vegetated sample plots	40

Plant Species	Occurrence *n*	%
Callitriche hamulata	28	70
Elatine hydropiper	12	30
Eleocharis acicularis	1	2
Nitella flexilis agg.	34	85
Nuphar lutea	1	2
Potamogeton obtusifolius	1	2

Species Abundance - Wader Survey

Total number of sample plots	80
Total number of vegetated sample plots	80

Plant Species	Occurrence *n*	%
Callitriche hamulata	71	89
Carex rostrata	12	15
Elatine hexandra	14	18
Elatine hydropiper	2	2
Iris pseudacorus	14	18
Menyanthes trifoliata	28	35
Myriophyllum alterniflorum	3	4
Nitella flexilis agg.	8	10
Nuphar lutea	16	20
Nymphaea alba	12	15
Persicaria amphibia	6	8
Phalaris arundinacea	3	4
Potentilla palustris	6	8

Note: Species abundance % = ((number of plots / total number of vegetated sample plots) * 100)

Plant Scores

Total plant species 27 **Filamentous algae (%)** 81.5 % WADER 89 % BOAT

Total plant cover (%) 227.1

PLANT SPECIES	SURVEY SCORES PERIMETER	WADER	BOAT	COVER %	DAFOR	ABUNDANCE
Callitriche hamulata	0.1	0.3772	0.3355	54.91	D	5
Nitella flexilis agg.	0	0.0344	0.4805	49.77	A	4
Juncus effusus	0.75	0	0	18.75	F	3
Menyanthes trifoliata	0.375	0.1091	0	14.83	F	3
Potentilla palustris	0.4625	0.0205	0	12.59	F	3
Mentha aquatica	0.4625	0	0	11.56	F	3
Elatine hydropiper	0	0.0039	0.1118	11.38	F	3
Iris pseudacorus	0.3375	0.0498	0	10.93	F	3
Lycopus europaeus	0.4	0	0	10	O	2
Phalaris arundinacea	0.175	0.0065	0	4.7	R	1
Carex rostrata	0.0875	0.0445	0	4.41	R	1
Nuphar lutea	0	0.0604	0.0125	4.27	R	1
Elatine hexandra	0	0.0678	0	3.39	R	1
Nymphaea alba	0	0.0466	0	2.33	R	1
Solanum dulcamara	0.0875	0	0	2.19	R	1
Galium palustre	0.075	0	0	1.88	R	1
Eleocharis acicularis	0	0	0.0125	1.25	R	1
Ranunculus flammula	0.05	0	0	1.25	R	1
Potamogeton obtusifolius	0	0	0.0125	1.25	R	1
Persicaria amphibia	0	0.0204	0	1.02	R	1
Myriophyllum alterniflorum	0	0.0145	0	0.72	R	1
Lythrum salicaria	0.025	0	0	0.62	R	1
Persicaria hydropiper	0.025	0	0	0.62	R	1
Achillea ptarmica	0.025	0	0	0.62	R	1
Crocosmia pottsii x aurea = C. x	0.025	0	0	0.62	R	1
Senecio aquaticus	0.025	0	0	0.62	R	1
Juncus acutiflorus	0.025	0	0	0.62	R	1

6. Discussion

This section provides a summary and more general interpretation of the results presented in the previous chapter. An overall summary of the current conservation status of the eight SSSI lakes is provided. Consideration is given to the key environmental variables affecting site condition and any site-specific issues affecting confidence in assessment outcomes are highlighted. Where current and previous condition assessment outcomes differ, possible explanations for these are considered. This section concludes by making overall recommendations for future monitoring and assessment priorities at Welsh protected sites.

6.1. Summary status of the eight Welsh lakes

All of the SSSI lakes surveyed for this report are in unfavourable condition with respect to one or more of the attributes within the CSM favourable condition tables (JNCC 2005). Table 47 summarises the results of the site condition assessments for the eight lakes included in this report.

Table 47 Overview of the site condition of eight SSSI lakes. 2012.

Water Body	Status	Reason(s) for Failure	Comments
Llyn Pysgodlyn Mawr	**Unfavourable (High confidence)**	No characteristic species. Poor water quality Non-native plants species dominant. Poor hydrology for Pillwort. Non-native fish species	While clearly unfavourable with respect to both flora and water quality, it is doubtful if the site has ever achieved the floristic targets as defined for mesotrophic lakes. A better understanding of past flora would help to define site specific restoration targets
Llyn Llech-Owain	**Unfavourable (low confidence)**	Water quality exceeds oligotrophic thresholds for TP	High DOC classifies this lake as dystrophic and makes it less likely that the site will support a diverse submerged flora. There is no evidence to support greater species richness in the past. High TP may simply reflect the poor uptake by surrounding peaty soils. Addition information on the historic flora would help to inform the current classification of the site. The lake is most closely aligned to the dystrophic habitat type under which classification the vegetation is favourable

Water Body	Status	Reason(s) for Failure	Comments
Llyn Pencarreg	**Unfavourable (high confidence)**	Poor depth and spatial distribution of *Littorelletea* species. Very high P and pH. Poorly buffered from agricultural land. High planktonic algal biomass including cyanobacterial blooms	Llyn Pencarreg is remarkable for hanging on to the remnants of an oligotrophic flora despite very high nutrient levels. Management needs to focus on the improvement of agricultural practice in the immediate vicinity of the lake and also identify other potential sources of nutrients from the catchment.
Witchett Pool	**Unfavourable (high confidence)**	Very high Phosphorus. High frequency of negative indicator species. Encroachment of surrounding reed beds	Witchett Pool has a relatively rich aquatic flora including a nationally rare species (*C. submersum*). The site maintains very good habitat for invertebrates and waterfowl. Nutrient inputs – both P and N – require investigation and it is recommended that reed encroachment is managed to prevent any further loss of open water.
Llyn Treflesg	**Unfavourable (high confidence)**	Receives high inputs of nutrients from upstream sites. Likely to have high internal nutrient loadings. Aquatic flora at risk of further deteriotation.	The primary concern at Llyn Treflesg is the high nutrients. The aquatic flora appears to be relatively stable, but populations of many of the characteristic species are small and the flora is therefore deemed to be at risk from the high trophic status of the site. Nutrient concentrations – both P and N – require monitoring. Llyn Treflesg is reliant on the water quality of the upstream lakes and management should encompass all the waterbodies within the SSSI

Water Body	Status	Reason(s) for Failure	Comments
Llyn Cerrig-bach	**Unfavourable (low confidence)**	Potentially high phosphorus and likelihood of high internal P loadings (requires further investigation). Aquatic with only 2 characteristic *Magnopotanion* species.	The primary concern at Llyn Cerrig-bach is the high nutrients, and water quality monitoring (N & P) is recommended. The aquatic flora is restricted by depth, but the littoral zone has good coverage of water lilies and excellent marginal vegetation and habitats. Plant macrofossil analysis would help ascertain the past flora.
Llyn Traffwll	**Unfavourable (high confidence)**	Water quality exceeds eutrophic thresholds for TP. Extensive filamentous algal growth smothering littoral plants. High numbers of Canada geese.	Llyn Traffwll supports a relatively diverse flora including 5 characteristic eutrophic species and notable rarities which make the site important as an aquatic habitat. Water quality improvements at a catchment scale will be necessary to ensure no further deterioration occurs in the site.
Llyn Glasfryn	**Unfavourable (high confidence)**	Water quality exceeds mesotrophic thresholds for TP. Extensive filamentous algal growth smothering plants. Evidence of characteristic species loss.	Llyn Glasfryn is enriched and as a result has lost many of its characteristic aquatic species. Better water quality will be key to improving the site by reducing filamentous algal growth and giving advantage to less competitive plant species.

It is evident from the findings in this report that the principal factor causing failure within these sites is eutrophication.

Only Llyn Llech Owain had no obvious sources of catchment nutrients and here the concern was directed more towards catchment management of the coniferous forest plantations. Furthermore, the original classification of this lake as oligotrophic ignores the very humic brown waters which exert a much greater influence on plant distribution within the site than trophic levels, and hence its reassessment as a dystrophic lake. Mean annual total phosphorus concentrations of 21 μgl^{-1} are not atypical for dystrophic lakes where internal and catchment uptake is generally lower than clear water sites. While there remain concerns with catchment management in the form of plantation forestry, the site should be classified as favourable if it can be shown that there are no significant no external nutrient sources.

Llyn Glasfryn is the only one of the eight lakes to have undergone a full CSM assessment in the past. While there has been no deterioration since 2004, there is little evidence to support any improvement at the site and this highlights the need to implement active management and monitoring to ensure progress is made towards the Welsh Environmental Strategy targets for SSSIs.

All six of the remaining lakes appear to have deteriorated when compared to their SSSI citations due to either species losses (e.g. *P. lucens* from Llyn Treflesg and *Pillularia globulifera* from Pysgodlyn Mawr) or reduced depth of colonization (e.g. Llyn Pencarreg). These sites all exceed the CSM target for phosphorus and immediate steps therefore need to be taken to minimise nutrient loading at all sites by identifying catchment sources and working with local landowners to manage nutrient loss into inflow streams or directly into the lakes. Some poor or inappropriate management practices were noted during the surveys, but many unfavourable assessments also reflect a longer term problems.

From a positive perspective, there are favourable elements at most sites, especially the presence of important and in some cases rare plant species (e.g. *Elatine* spp. at Llyn Glasfryn, Llyn Pencarreg and Llyn Treffwll) and *Ceratophyllum submersum* at Witchett Pool), but these are unlikely to be retained within the sites unless significant improvements can be made to water quality.

Management intervention, as recommended in this report, needs to be accompanied by a renewed effort to establish the past baseline condition of the sites to properly inform site specific targets which can be used to review their SSSI designation. These reports also highlight the importance of monitoring at all standing water SSSI sites, both to track changes in condition and assess the effectiveness of any management interventions. Assessment of the biological attributes on a 4-6 year rotation should also be mandatory at all SSSI sites with more frequent monitoring where issues are identified.

7. References

Allott TEH, Monteith DT, Duigan CA, Bennion H, Birks HJB. 2001. *Conservation classification of lakes in Wales, with implications for the EU Water Framework Directive.* CCW Contract Science Report No. 426. Countryside Council for Wales, Bangor

Appleby PG, Richardson N, Nolan PJ 1992. Self-absorption corrections for well-type germanium detectors. *Nuclear Instruments and Methods in Physics Research, Section B*, 71**:** 228-233.

Appleby PG, Nolan PJ, Gifford DW, Godfrey MJ, Oldfield F, Anderson NJ, Battarbee RW. 1986. ^{210}Pb dating by low background gamma counting. *Hydrobiologia*, 141**:** 21-27.

Battarbee RW, Simpson GL, Shilland EM, Flower RJ, Kreiser A, Yang H, Clarke G. 2012. Recovery of UK lakes from acidification: An assessment using combined palaeoecological and contemporary diatom assemblage data. *Ecological Indicators*, doi: 10.1016/j.ecolind.2012.10.024.

Bennion H. (Ed.) 2004. *Identification of reference lakes and evaluation of palaeoecological approaches to define reference conditions for UK (England, Wales, Scotland & Northern Ireland) ecotypes*. SNIFFER Research Report WFD08: 149 pp. Scottish and Northern Irish Forum for Environmental Research (SNIFFER), Edinburgh

Bennion H, Fluin J, Simpson G. 2004. Assessing eutrophication and reference conditions for Scottish freshwater lochs using subfossil diatoms. *Journal of Applied Ecology*, 41**:** 124-138.

Bennion H, Allott TEH, Appleby PG, Hunt M, Olive E, Patrick ST. 1996. *A study of recent environmental change within selected standing waters proposed as Special Areas of Conservation (SAC) in Wales – Llyn Idwal, Llyn Cwellyn and Llyn Safadden (Llangorse Lake) Phase II.* CCW Research Report No.187. Countryside Council for Wales, Bangor.

Burgess A, Goldsmith B, Hatton-Ellis T. 2006. *Site condition assessments of Welsh SAC and SSSI standing water features.* CCW Contract Science Report No. 705. Countryside Council for Wales, Bangor.

Carvalho L, Phillips G, Maberly SC, Clarke R. 2006. *Chlorophyll and Phosphorus Classifications for UK Lakes*. SNIFFER Report WFD38. Scottish and Northern Irish Forum for Environmental Research, Edinburgh.

DEFRA. 2004. Freshwater Critical Loads Workshop.

Demars BOL, Harper DM. 1998. The aquatic macrophytes of an English lowland river system: assessing response to nutrient enrichment. *Hydrobiologia*, 384: 75–88.

Duigan CA, Ellis S. 2002. A photographic record of a pre- and post-lake creation event from World War II at Valley, Isle of Anglesey UK. *Freshwater Forum,* 19: 21-27.

Duigan C, Kovach W, Palmer M. (2006) *Vegetation communities of British lakes: a revised classification scheme*. JNCC, Peterborough. 106pp.

Garnett SE, Blackstock TH. 1983. *A Review of Open Water Sites in West Gwynedd*. Nature Conservancy Council Report.

Goldsmith B, Davidson TA, Burgess A, Hughes M, Madgwick G, Rawcliffe R, Rippey B, Tyler J. 2008. Site *Condition Assessments of Standing Water Features in SACs and ASSIs: Northern Ireland*. Final Report to the Northern Ireland Environment Agency

Griffith JE. 1895. *The Flora of Anglesey & Carnarvonshire.* Nixon & Jarvis, Bangor.

Hatton-Ellis TW. 2011. *Condition Assessment: Llyn Dinam SAC. Feature 3150 Natural Eutrophic Lakes with* Magnopotamion *or* Hydrocharition-*type vegetation*. Countryside Council for Wales, Bangor.

Hatton-Ellis, TW. 2006. *Llyn Traffwll SSSI Site Visit*. CCW unpublished file note.

Haworth EY, Pinder LCV, Lishman JP, Duigan CA. 1996. The Anglesey Lakes, Wales, UK – A palaeolimnological study of the eutrophication and nature conservation status. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 6**:** 61-80.

Holmes NTH, Boon PJ, Rowell TA. 1999. *Vegetation communities of British rivers: a revised classification*. Joint Nature Conservation Committee, Peterborough.

Jeppesen E *et al*. (2005). Lake responses to reduced nutrient loading – an analysis of contemporary long-term data from 35 case-studies. *Freshwater Biology*, **50:** 1747-1771.

Lansdown RV. 2013. *A Vascular Plant Survey for the Valley Lakes, Anglesey*. Unpublished report to the RSPB.

Monteith DT. (ed.) 1996. *Integrated classification and assessment of lakes in Wales: Phase III*. CCW Contract Science Report No. 167. CCW, Bangor.

Monteith DT. (ed.) 1997. *Integrated classification and assessment of lakes in Wales: Phase IV*. CCW Contract Science Report No. 214. CCW, Bangor.

Joint Nature Conservation Committee (JNCC). 2005. *Common Standards Monitoring Guidance for Standing Waters*. Joint Nature Conservation Committee, Peterborough. Available online from: http://www.jncc.gov.uk.

Museum of Wales 2014. Artefacts from Llyn Cerrig-bach. [online] [Accessed online March 2014]

Lockton, A. 2009. *Luronium natans* update. *BSBI Recorder,* 13, 12-16

London Gazzette. 1905. In Parliament – Session 1906. London Gazette, 21 November 1905 p. 1801.

OS OpenSpace 2014. Coordinates 22840,207570 [online] www.oldmaps.co.uk [Accessed online March 2014]

Palmer MA, Roy DB. 2001. *An estimate of the extent of dystrophic, oligotrophic, mesotrophic and eutrophic standing fresh water in Great Britain*. JNCC Report No. 317. Joint Nature Conservation Committee, Peterborough.

Plantlife 2006. Pillwort *Pilularia globulifera* briefing sheet. [Accessed online March 2014]

Schneider S, Melzer A. 2003. The Trophic Index of Macrophytes (TIM) – a new tool for indicating the trophic state of running waters. *International Review of Hydrobiology*, 88**:** 49-67.

Seddon B. 1964. Aquatic Plants of Welsh Lakes. *Nature in Wales*, 9, 3-8.

Stace CA. 1997. *A New Flora of the British Isles*, 2nd Edition. Cambridge University Press, Cambridge, UK.

Thomas JF. 1955. The Laugharne-Pendine Burrows. *Nature in Wales*, 1, 72-74.

Turner SD, Simpson GL, Hughes MJ. 2011. *Standardised bathymetric data generation and statistical analysis of Welsh Lakes*. CCW Contract Science Report No. 955, Countryside Council for Wales, Bangor

Willby NJ, Pitt J-A, Phillips G. 2009. *The ecological classification of UK lakes using aquatic macrophytes.* Environment Agency Science Report No. SC010080/SR. Environment Agency, Bristol.

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9. Appendices

9.1. Data Archive Appendix

Data outputs associated with this project are archived as project 449 and media 1493 on server–based storage at Natural Resources Wales.

The data archive contains:

[A] The final report in Microsoft Word and Adobe PDF formats.

[B] A database named NWRsca_database_v2.1_2014.mdb in Microsoft Access format (H:\Science\MFSG\Fresh Water Science\ENSIS Lake Survey Data\)

[C] A full set of images produced in jpg format. (H:\Science\MFSG\Fresh Water Science\ENSIS Lake Survey Data\Photos\)

[D] Bathymetry in xlsx format with images in jpg format. Bathymetry metadata in xlsx format. (H:\Science\MFSG\Fresh Water Science\ENSIS Lake Survey Data\Bathymetry)

[E] Leafpacs data spreadsheets in xls format (derived data using environment Agency methods to calculate metrics for water quality) H:\Science\MFSG\Fresh Water Science\ENSIS Lake Survey Data\Leafpacs

[F] Water Chemistry data in xls fomat - SSSI Lakes Chemistry 2012.xls H:\Science\MFSG\Fresh Water Science\ENSIS Lake Survey Data

[G] Plant mapping spreadsheet in xlsx fomat H:\Science\MFSG\Fresh Water Science\ENSIS Lake Survey Data

Metadata for this project is publicly accessible through Natural Resources Wales' Library Catalogue http://194.83.155.90/olibcgi by searching 'Dataset Titles'. The metadata is held as record no 115704.

9.2. Collection and structure of Bathymetric Data

Bathymetric data were collected from the selected lakes using the standardised methods detailed in Turner et al. (2011), CCW Contract Science Report No. 955. To improve monitoring and effect of lake level change on bathymetries, details of water level during the survey were also recorded – primarily the measurement of water level to a temporary bench mark (TBM). Due to the remoteness of the lakes and absence of OS bench marks, absolute level above sea level was not recorded and all depths are presented as depth below surface in metres. Site details are found in the _docs folder in the GIS folder structure. Depth data was also collected independently at each of the plant survey point using an hand held echo sounder or measuring staff in shallow, plant rich areas.

Folder structure for bathymetric maps

The data are organised into folder **- CCW_SSSI_2011**
All bathymetric data returned to CCW are stored in separate sub-folders named accordingly: **WBID_Name,** e.g. 32964_Llyn_Traffwl, where WBID is the UKLakes (www.UKLakes.net) water body ID and Name is the accepted UKLakes water body name. Lakes not included in the WBID database (Hughes et al. 2004) are numbered **99999_Name** to allow a future update. Two lakes here are not assigned WBID number: 99999_Llyn Coch-hywad and 99998_Witchett Pool.

Bathymetric data folders

Each bathymetric data folder follows the same format including raw data, interpolated grids, basic ARCMap (.mxd) files and morphometric statistical outputs:

- **d<datasetid>_<WBID>_xyz.csv** - Raw data (comma delimited). Column headings Index, OS_X, OS_Y, Depth where depth is in metres (m).
- **d<datasetid>_<WBID>_xyz.shp** - Shape file collection (with .prj files) from .csv data.
- **<foldername>_lake_polyline.shp -** Lake outline polyline (derived from OS raster data, required for confining bathymetric raster).
- **<foldername>.mxd** - Basic ArcGIS project file. Document set to relative path names.
- **b<bathygridid>_WBID** - ESRI grid folder, bathygridid relates to individual bathymetric grid outputs. May be multiple folders. This allows flexibility to have multiple outputs dependent on settings inputted for grid calculation.
- **b<bathygridid>_WBID.asc** - ASCII export of ESRI grid. Standard export format of raster data. Used for R: software outputs.

Also included in the separate bathymetric lake folders are the morphometric statistic outputs:

- **b<bathygridid>_WBID_hypsographic_curve.pdf** - Hypsographic curve (Depth; %area, m2)
- **b<bathygridid>_WBID_depth_-_volume_curve.pdf** - Depth volume curve (Depth; %volume, m3)

- **b<bathygridid>_WBID_composite_display.pdf** - Composite diagram from R: script output
- **b<bathygridid>_WBID_curve_data.csv** - Volume (m3), Area (m2) values for 0.5m depth intervals calculated from raster grid.
- **Shapefiles** - Folder containing polygon shapefiles for individual 0.5m depth intervals generated from the raster grid.

In the _Doc folder there is an Excel file summarising the lake morphometry, bathymetry and grid details for the lakes.

9.3. Structure of macrophyte mapping data

Plant data folders

Plant data for each lake is contained in separate sub-folders **WBID_Name_plants,** e.g. 32964_Llyn_Traffwl_plants. Within these folders are found subfolders:

- **WBID_name_plant_jpegs** - Folder containing simple jpeg images of plant species using the File>Export Map> procedure in ArcMap. This allows multiple formats to be exported depending on output requirements.
- **WBID_name_plants_xyz** - Folder containing text files of the raw plant species data in rows and columns with the following headings; Object_ID, Waypoint, OS Grid Ref, X coordinate (6 fig OS), Y coordinate (6 fig OS), Depth_m and plant species (plant score). Also included is an 'All plant' text file.
- **WBID_name_plant_shapefiles -** Folder containing shapefiles of the plant species data.

9.4. Macrophyte Database – MS Access

File name: sca_database_v2.1_Macrophytes_NRW_2014.db

The database is saved as MS Access 2000 and MS Access 2007 and contains all Welsh Sites surveyed by ENSIS from 2007 to 2013.

Basic guidance on use.

- Copy the database to a trusted location on to your computer (it will have limited / no functionality if run from a CD)
- You may receive a "Security warning" message saying "Certain content in the database has been disabled" - This is because the db contains macros. These are safe, and you will need to click on options and "Enable content". If you click on "Open the trust centre" you can then click on "Trusted locations" and "Add new location" and browse for the directory where the database is stored. Click OK and exit the Trust centre and now the db should start without the warning message.

Open database and find a site

- You will be presented with the "Main Switchboard"
- Click "View survey list and edit survey data"

- You can now either scroll through the survey data or better still search for a site using the “binoculars” button – search by Look in: “SCA Survey Selector” and Match: “Any part of Field” – you can then type in the name (or part of) and click Find Next.
- The SCA Survey Selector should now show the required site – you can cancel the find tool.
- To open the site information click on the bottom right (Open Form) button – you should now have a form entitled “Survey Details”

You can now add, edit or view data – all changes you make will be live – i.e. automatically saved.

- Within the initial page there are 4 tabs “Pressures”, “Shoreline”, “DO/Temp” and “Sections”
- Click “Sections” to take you to all the plant data.
- Note the big “1” – all data below refers to **section 1** – until you click the arrow to show a big “2” – all data will now be for **section 2**.
- Below the big “1” there are another series of tabs which are hopefully self explanatory (with the exception of “Shore Survey Submerged – which is strandline data)
- To export data – open the database and repeat the find process to get back to the required site in the SCA Survey Selector – but no need to open the forms this time.
- This time click on the left-hand button of the two bottom right icons – the “Mail Report” button.
- A text report should leap out on to the screen.
- To get the data – In pre 2007 versions of Access - go to the file menu and select “Export” and export it as “file type” rich text format (*.rtf). In MS Access 2007 and later, simply click the MS Word icon in the “Data” menu. This produces all the data in a summary format where it can (mostly) be copies into both word and Excel for any additional data manipulation.

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