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Ecological Surveys of Welsh Lakes 2016

Shilland EM¹, Goldsmith B¹, Hatton-Ellis TW.

¹ ENSIS Ltd. London

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1. Crynodeb Gweithredol

Nod y prosiect hwn oedd casglu, prosesu a chyflenwi data ecolegol ac amgylcheddol i Cyfoeth Naturiol Cymru o rwydwaith o 14 o safleoedd llynnoedd ledled Cymru, i ategu rhaglen fonitro integredig Cyfoeth Naturiol Cymru ar gyfer safleoedd gwarchoddedig (ACA a SoDdGA), y Gyfarwyddeb Fframwaith Dŵr, y Gyfarwyddeb Nitradau, Cynlluniau Gweithredu Bioamrywiaeth a sbardunau deddfwriaethol a pholisi eraill. Yn arbennig, nod yr arolygon yw llywio gwaith i reoli ac adfer safleoedd gwarchoddedig a hwyluso'r broses o gyflawni Cynlluniau Rheoli Basn Afon.

Gan ddefnyddio dulliau safonol, arolygwyd llynnoedd er mwyn asesu rhywogaethau a chyflenwad y planhigion dyfrol sy'n tyfu oddi mewn i'r llynnoedd ac yn uniongyrchol o'u cwmpas, a mesur gloywder y dŵr, ocsigen toddedig a'r tymheredd yn y llynnoedd. Mewn dau safle, sef Llyn y Gader a Llyn Nantlle Uchaf, cynhaliwyd arolygon bathymetrig hefyd a chaiff y canlyniadau eu cyflwyno mewn fformatau safonedig.

- Mae'r rhywogaethau planhigion dyfrol wedi eu rhestr yn yr adroddiad a chyflenwyd canlyniadau cyflawn yr arolwg i Cyfoeth Naturiol Cymru ar ffurf cronfa ddata MS Excel.
- Caiff cyfrifiadau eu cyflwyno i'w defnyddio o hyn ymlaen i bennu statws ecolegol y llynnoedd mewn perthynas â'r Gyfarwyddeb Fframwaith Dŵr.

Mae canlyniadau'r arolygon planhigion dŵr yn addas at ddibenion asesu cyflwr safle ar gyfer nodweddion merddwr y Gyfarwyddeb Cynefinoedd a statws SoDdGA. Mae mesuriadau metrig y llynnoedd yn berthnasol ar gyfer cynhyrchu cymarebau ansawdd ecolegol y gellir eu defnyddio i ddsbarthu'r llynnoedd, yn unol â gofynion y Gyfarwyddeb Fframwaith Dŵr (2000/60/EC).

2. Executive Summary

This project set out to collect, process and supply to NRW ecological and environmental data from a network of 14 lake sites across Wales, in support of NRW's integrated monitoring programme for protected sites (SACs and SSSIs), the Water Framework Directive, Nitrates Directive, Biodiversity Action Plans and other legislative and policy drivers. In particular the surveys are aimed at informing management and restoration of protected sites and facilitating delivery of River Basin Management Plans.

Using standard methods, lakes were surveyed to assess the species and abundance of aquatic plants growing within and directly around the lake and to measure water clarity, dissolved oxygen and temperature within the lakes.

- The aquatic plant species are listed within the report and the complete survey results supplied to NRW as MS Excel spreadsheets.
- Calculations are presented for the onward use of determining the ecological status of the lakes with respect to the Water Framework Directive (LEAFPACS).

The results of the aquatic plant surveys are suitable for the purposes of assessing site condition for Habitats Directive standing water features and SSSI status. The lake metrics are applicable for the production of ecological quality ratios from which the lakes may be classified in accordance with the requirements of Water Framework Directive (2000/60/EC).

3. Introduction

3.1. Background

Natural Resources Wales (NRW) is responsible for the management and monitoring of the freshwater environment in Wales including protected sites designated under UK and European legislation (SSSIs and SACs) and environmental monitoring for the Water Framework (WFD) and Nitrates Directives. This includes monitoring of lakes.

A key aspect of the structure and function of lakes is their aquatic plant community. Lake plant communities are considered defining aspects when identifying lake types (e.g. European Community 1992; Duigan *et al.* 2006; Hatton-Ellis 2014) and play an important role in providing habitat structure for other biota (Jeppesen *et al.* 1998). Lake plants are also important indicators of pressures on the freshwater environment, especially eutrophication (Willby *et al.* 2010; WFD-UKTAG 2014) and to a lesser extent acidification (Shilland & Monteith 2010). For these reasons, aquatic plants are widely used in Britain for monitoring against several different drivers, notably the Habitats Directive and Water Framework Directive. Although data are analysed differently, monitoring for the two Directives uses a single standardised protocol (JNCC 2015).

Eutrophication is one of the key drivers of freshwater quality in the UK (Bennion *et al.* 2014) and, in addition to chemical monitoring, a number of biological methods have been used to determine the status of freshwaters in terms of both eutrophication (e.g. Willby *et al.* 2010; Bennion *et al.* 2014) and more generally for conservation (see JNCC 2015). One of these methods, LEAFPACS (Willby *et al.* 2010), has been developed to detect the impact of nutrient enrichment in lakes on the plants that grow there and is now used routinely by the UK Environment Agencies (NRW, EA, SEPA) to monitor and evaluate the status of standing waters. Using standard methods to collect the data (JNCC 2005; 2015), lakes can be assessed against their type and location to derive site condition status and also to calculate metrics which allow WFD classification.

3.2. Aim of the Report

The aim of the project is to collect, process and supply to NRW ecological and limnological data from a network of 14 lake sites across Wales, in support of NRW's integrated monitoring programme for lakes. Other relevant data (notably water chemistry) is being collected separately and will be used in combination with the data collected here to generate condition assessment reports for protected sites and classification data for Water Framework Directive monitoring. Indicative element level classifications based on the LEAFPACS tool have been generated, although it is possible that these may be amended following internal checks and / or combining survey data, so these should not be seen as final classification results.

Detailed descriptions of most of the lakes surveyed including water chemistry, environmental history and other parameters of interest can be found in Burgess *et al.* (2006, 2009, 2013) and Goldsmith *et al.* (2006, 2010, 2014a) and are not repeated here.

Of the 14 lakes surveyed for this report, all but one have had at least one CSM survey conducted in the past, thus allowing for comparisons to be drawn and possible improvement or decline in the aquatic flora of a site. At Llyn Dwythwch, where no previous structured data exists, the survey provides a valuable insight into the current status of the lake and a baseline against which future surveys can be compared. It should be stressed that data presented here are based only on macrophytes and additional information on water quality is required to fully assess the condition of the lakes under CSM guidance (JNCC 2015).

4. Methods

4.1. Sites

Table 1 provides details of the 14 lakes included in this report (See Figure 1 for locations), detailing the primary purpose for survey and CSM aquatic macrophyte survey dates. All sites were subject to aquatic macrophyte surveys using standard methods based on the current JNCC guidance (JNCC 2015).

Lake Name	WBI D	Grid ref.	Purpose of survey*	Survey date	Lake Type**
Llyn Cadarn	32792	SH492811	SSSI / SAC / ND	13/09/2016	HC
Llyn yr Wyth Eidion	32761	SH474819	SSSI / SAC / ND	14/09/2016	HC
Cefni Reservoir	32926	SH443774	WFD-O	15/09/2016	N/A
Llys-y-Fran Reservoir	40087	SN036251	WFD-O	16/09/2016	N/A
Llyn Anafon	33374	SH698699	SSSI / SAC / BAP	16/09/2016	OML
Llyn Morwynion	34613	SH737424	SSSI / SAC	17/09/2016	OML
Llyn Dwythwch	33920	SH570580	BAP	18/09/2016	OML?
Llyn Eiddwen	38422	SN606670	SSSI	19/09/2016	OML
Llyn Eiddew-Mawr	35056	SH646338	SSSI / SAC	19/09/2016	OML
Llyn Fanod	38544	SN602643	SSSI	20/09/2016	OML
Llyn Padarn	33730	SH570615	SSSI / WFD-S	20/09/2016	OML
Llyn Cwm Bychan	35180	SH641313	SSSI / SAC/ WFD-S	21/09/2016	OML
Llyn Tryweryn	34854	SH789385	SSSI / SAC/ WFD-S	22/09/2016	D
Eglwys Nunnydd Reservoir	42079	SS794848	SSSI / WFD	03/10/2016	N/A

Table 1 Details of the lakes included in this report.

Purpose: SAC = Special Area Conservation; SSSI = Site of Special Scientific Interest; WFD-S = WFD Surveillance; WFD-O = WFD Operational; ND = Nitrates Directive; BAP = Priority Biodiversity Action Plan habitat. Lake Type: HC = Hard oligo-mesotrophic waters, OML = Oligo-mesotrophic waters, D = Dystrophic.

4.2. 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 (JNCC 2015). In brief, the plant surveys consisted of four components: a strandline survey of species uprooted and washed to the shore; a survey of the emergent and marginal species; a wader survey of the shallow littoral zone to approximately 1.0 m; and a boat survey encompassing species in open water and extending to the point of maximum colonization. These were carried out at each site on up to four discrete 100 m 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 fewer than four sections being surveyed at smaller lakes.

Where possible, surveying was performed using a bathyscope, but a double-headed rake was used in deeper water, where material needed to be collected for identification, or where poor water clarity restricted visibility. Where lakes had previously been surveyed, transect locations used in the past were re-surveyed in order to maximise comparability between surveys. The locations of all survey sections and boat transects were recorded using a Global Positioning System (GPS), backed up with digital photographs where necessary. The grid references and photo numbers of survey sections are listed in Appendix 7.2.



Figure 1. Map of Wales showing the location of the 2016 survey lakes.

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. Although they do not aim to produce a complete species list for a lake, comparison with a more thorough mapping approach generally show

that the transect method consistently detects more than 90% of the macrophyte species richness within a lake (e.g. Burgess *et al.* 2009). Additional efforts such as sampling drift line flora were made to record other species which did not occur in any of the survey sections.

The CSM aquatic macrophyte surveys, upon which the data assessments in this report are based, were carried out between June and September 2015. *In-situ* macrophyte identifications were made by Ben Goldsmith or Ewan Shilland. Specimens of *Luronium natans* were collected under Protected Species Licence 59401:OTH:SP:2014 (B. Goldsmith with E. Shilland as accredited agent). Voucher specimens were collected for all taxonomically ambiguous species and identifications confirmed either from fresh materials (usually in the evening of the survey) or at a later date from pressed specimens. Vouchers of charophytes and *Utricularia* were preserved in alcohol and sent to Nick Stewart (BSBI Charophyte Referee and expert on aquatic botany) for confirmation. Quality control was performed in-house with reference to previously collected herbaria specimens. Botanical nomenclature follows Stace (1997) for higher plants, Moore (1986) for Stoneworts (updated by N. Stewart, pers. comm.) and Atherton *et al.* (2010) for bryophytes.

All field data were recorded onto standard forms printed onto waterproof paper and transcribed into standard MS Excel spreadsheets designed to calculate values for the following metrics (see Willby *et al.* 2010 and WFD-UKTAG 2014):

- Lake Macrophyte Nutrient Index (LMNI)
- Number of Functional Groups (NFG)
- Number of Macrophyte Taxa (NTAXA)
- Mean per cent cover of hydrophytes (COV)
- Relative per cent cover of filamentous algae (ALG)

In addition the following observations and metrics were recorded:

- Maximum depth of macrophyte colonisation (MAXD)
- Number of typical taxa for habitat type (NTYP) based on JNCC CSM guidance (2015)
- Relative per cent cover of non-native species (INV)

The relative per cent cover of invasive alien macrophyte species (INV, Willby *et al.* 2010) is expressed relative to the overall COV score. The full list of these species is given in Willby *et al.* (2010).

4.3. Physico-Chemical Survey and Other Data Sources

Dissolved oxygen concentration and 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 availability within the water. Secchi disc depths were recorded at the time of the macrophyte surveys from the deepest point of all lakes and further measurements 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.

Catchment data, land cover and general lake data that are quoted in the text are taken from the original UK Lakes database (Hughes *et al.* 2004) and the new UK Lakes administered by CEH (CEH 2017). Ordnance Survey maps are taken from OS OpenData™ (© Crown copyright 2017) and Aerial photographs from Google Maps (© Google 2017).

4.4. Element Level WFD Classification Results

For interpretation purposes we have reported element level WFD classification results together with a short commentary on each classification. These are published for comparative purposes, in particular so that LEAFPACS results can be compared with the accounts of the data. LEAFPACS results have been published both for WFD water bodies and lakes that are not WFD water bodies, though in the latter case this result is illustrative only. Nevertheless, LEAFPACS results can be useful in these situations to help identify nutrient pollution issues.

It should be emphasised that since these are based on the LEAFPACS tool only they therefore do not represent final NRW water body classifications, which will be carried out separately according to our formal classification processes. It is also possible that the final macrophyte classification may change, for example as a result of additional survey data or changes to the method.

LEAFPACS is only designed to measure nutrient pressures (eutrophication). The tool mainly does this using the Lake Macrophytes Nutrient Index (LMNI) a trophic ranking approach that assigns a nutrient score to each aquatic plant species found in the UK. Scores for each species found in the lake are averaged to give an LMNI score and this is then compared to a predicted score for the lake based on reference conditions. Four other metrics, NTAXA, Number of Functional Groups (N_FG), Cover (COV) and filamentous algal cover (ALG) are also used but these play a subsidiary role.

Of the other key pressures on lakes, the tool is uninformative for assessing acidification pressure. Macrophyte invasive species have been detected using the tool and text on these has been included in the individual lake accounts to help guide management. Hydrological pressures (i.e. water level fluctuation associated with abstraction) can cause large changes to aquatic plant communities resulting in failures of LEAFPACS. In general these can be detected because (i) very few species are present and / or (ii) metrics other than LMNI are causing LEAFPACS failures. Where water bodies are Heavily Modified, likely reasons for any failures are discussed in the text.

5. Survey Results and Metrics.

5.1. Lake metrics

The following table summarises the results of the aquatic macrophyte-derived metrics and limnological data. A full list of species for each site is given in Appendix 7.1.

Site	LMNI	NTAXA	NFG	COV	ALG	INV	MAXD	NTYP	Secchi
Llyn Cadarn	5.87	10	6	4.89	0.02	0	4.9	1	1.55
Llyn yr Wyth Eidion	6.23	11	8	8.22	0.16	0	4.8	0	2.60
Cefni Reservoir	6.42	15	10	5.36	0.14	0.28	3.4	3	3.05
Llys-y-Fran Reservoir	5.53	4	3	5.84	0.04	0	2.6	1	2.65
Llyn Anafon	3.77	22	11	5.16	0.20	0	3.4	10	2.90
Llyn Morwynion	3.40	10	5	5.81	0.19	0	4.0	4	3.25
Llyn Dwythwch	3.86	20	11	6.13	0.37	0	4.4	9	2.60
Llyn Eiddwen	3.45	19	9	4.51	0.24	0	2.4	9	1.65
Llyn Eiddew-Mawr	2.99	14	8	6.68	0.42	0	4.0	7	3.05
Llyn Fanod	4.11	22	9	4.87	0.10	0	2.3	9	1.60
Llyn Padarn	4.11	17	10	4.67	0.28	0.14	5.4	7	4.55
Llyn Cwm Bychan	3.39	15	9	6.96	0.46	0	4.0	7	3.30
Llyn Tryweryn	4.45	7	4	3.42	0.10	0	1.9	2	0.21
Eglwys Nunnydd Reservoir	5.87	10	6	5.14	0.03	0.20	4.3	1	1.65

Table 2. Summary of the LEAFPACS lake metrics, typical taxa, non-native species and maximum depth of macrophyte colonisation for the 14 lakes

5.2. Sites

5.2.1. Llyn Cadarn



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Figure 2. Site map and aerial photograph of Llyn Cadarn.



Figure 3. Llyn Cadarn site photo; from the south-west edge looking east.

Llyn Cadarn is a very small (1 ha), shallow (mean. depth 4.6 m) high alkalinity lowland lake located on the Isle of Anglesey, North Wales. It lies within the Cors Goch SSSI and NNR and Corsydd Môn/ Anglesey Fens SAC. The catchment is predominantly improved grassland but the lake itself sits in an alkaline fen and is surrounded on all sides by reeds, in an assemblage dominated by *Typha*

angustifolia, *Phragmites australis* and *Cladium mariscus*. The lake was cored in 2007 by Davidson *et al.* (2009) in order to explore the aquatic vegetation history of the site.

The aquatic flora (Table 3) consists of a floating layer of *Nuphar lutea*, with occasional *Nymphaea alba*, underneath which the benthic species are comprised almost completely of *Lemna trisulca* and the moss *Fontinalis antipyretica*, interspersed between the submerged leaves of *Nuphar lutea*. The maximum depth of *N. lutea* colonisation is 3.9 m. After considerable searching a single specimen of *Chara rudis* was located at the start of Section 3 at around 80cm depth. A small amount of *Utricularia minor* was found behind the edge of Section 1 but no *Utricularia* species could be located in the lake itself. At the edge of the reed-swamp behind Section 3, a small amount of *Chara vulgaris* was present in an inflow runnel. There are no alien invasive aquatic macrophyte species present and levels of filamentous algae are low. The maximum depth of colonisation, at 4.9 m for *Lemna trisulca* in Section 3, is similar to that of the last survey of the site, undertaken in 2013 (Goldsmith *et al.* 2014a).

Of the JNCC (2015) characteristic species for “hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp”, *Chara rudis* is still persisting since the last survey in 2013 (Goldsmith *et al.* 2014a) but at a similar very low abundance. Llyn Cadarn therefore continues to fail the target for this lake type. No fine or broad leaved *Potamogeton* sp. were found in the current survey, nor any of the other historically present *Chara* sp. thus there is no evidence that the site is making progress towards the reference conditions established by Davidson *et al.* (2009) and Goldsmith *et al.* (2013). It is recommended that efforts to reduce the nutrient inputs to Llyn Cadarn are continued (Hatton Ellis 2014).

Submerged and floating vegetation	% cover
<i>Chara rudis</i>	1.0
<i>Chara vulgaris</i>	1.0
<i>Fontinalis antipyretica</i>	3.8
<i>Lemna minor</i>	1.0
<i>Lemna trisulca</i>	18.2
<i>Nymphaea alba</i>	4.0
<i>Nuphar lutea.</i>	16.9
<i>Menyanthes trifoliata</i>	2.1
<i>Utricularia minor.</i>	1.0
Species richness	9

Table 3. CSM Survey results from Llyn Cadarn 2016.

Dissolved oxygen and temperature profiles showed the lake to be mixed during summer with no thermocline evident and only a slight decline in dissolved oxygen with increasing depth (Figure 4).

Dissolved Oxygen Profile

GPS Location SH4920581114
 Maximum Depth (m) 5.9 m
 Secchi Depth (m) 1.55 m

Notes:

Depth (m)	DO (mg/l)	Temp (°C)
0	8.48	17.1
0.5	8.47	17.1
1	8.58	17.2
1.5	8.47	17.2
2	8.25	17.1
2.5	7.96	17.1
3	7.85	17.1
3.5	7.67	17
4	7.39	16.9
4.5	7.39	16.9
5	7.28	16.8
5.5	7.38	16.7

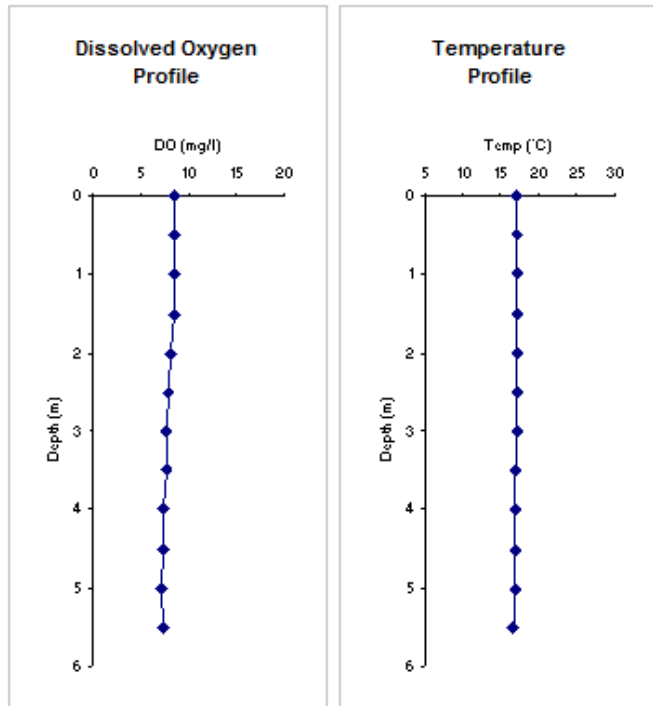


Figure 4. Dissolved oxygen and temperature profiles at Llyn Cadarn (13/09/2016).

5.2.2. Llyn yr Wyth Eidion



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Figure 5. Site map and aerial photograph of Llyn yr Wyth Eidion.



Figure 6. Llyn yr Wyth Eidion site photo; from the south-west shore looking north-east.

Llyn yr Wyth Eidion a very small (1 ha), moderately shallow (mean depth 6 m) but steeply shelving lowland glacial kettle-hole lake located on the Isle of Anglesey, North Wales. It forms part of the Cors Erddreiniog NNR and SSSI and Corsydd Môn/ Anglesey Fens SAC. Similar to the nearby Llyn Cadarn, the catchment is predominantly improved grassland but the lake itself sits in an alkaline fen.

The aquatic macrophyte flora (Table 4). is dominated by beds of *Nuphar lutea*, interspersed with occasional *Nymphaea alba*, both growing above the moss *Fontinalis antipyretica*. Submerged species present at lesser abundances include *Lemna trisulca* and *Potamogeton berchtoldii* and there are also patches of *Hippuris vulgaris*. *Callitriche* sp. is rare, being found at only one in-lake sample point during the survey. A floating-leaved aquatic *Sparganium* sp. is also present, recorded at depths up to 2.3 m, but no inflorescences were found during the survey to enable identification to species level. No alien invasive aquatic macrophyte species are present and levels of filamentous algae are low.

The maximum depth of colonisation, at 4.8 m for *Fontinalis antipyretica* in Section 2, is slightly shallower than that of other recent surveys of the site, with the maximum depth being 5.7m in 2008 (Burgess *et al.* 2013) and 5.5m in 2013 (Goldsmith *et al.* 2014a).

The current species assemblage, with all qualifying characteristic species being absent, would place the site in unfavourable condition with respect to its flora under JNCC CSM Guidelines (JNCC 2015) for Hard oligo-mesotrophic waters with benthic stoneworts (*Chara* spp.). No *Chara* species or broad-leaved *Potamogeton* species were recorded in the 2016 survey, with *Chara virgata*, *Chara vulgaris*, *Potamogeton perfoliatus* and *Potamogeton crispus* last found in the survey of 2003 (Goldsmith *et al.*, 2006) and absent from subsequent surveys in 2008 (Burgess *et al.* 2013) and 2013 (Goldsmith *et al.* 2014a). The flora remains considerably different to the charophyte-dominated reference assemblage identified from palaeolimnological evidence by Goldsmith *et al.* (2013). It is recommended that efforts to reduce the nutrient inputs to Llyn yr Wyth Eidion are continued (Hatton-Ellis 2014 and 2016).

Submerged and floating vegetation	% cover
<i>Callitriche</i> sp.	1.8
<i>Fontinalis antipyretica</i>	19.7
<i>Hippuris vulgaris</i>	4.7
<i>Lemna minor</i>	3.0
<i>Lemna trisulca</i>	6.4
<i>Menyanthes trifoliata</i>	1.4
<i>Nuphar lutea</i>	20.2
<i>Nymphaea alba</i>	12.1
<i>Potamogeton berchtoldii</i>	4.9
<i>Sparganium</i> (aquatic indet.)	2.1
Species richness	10

Table 4. CSM Survey results from Llyn yr Wyth Eidion 2016.

Dissolved oxygen and Llyn yr Wyth Eidion temperature profiles show the lake to be stratified during summer with a thermocline at approximately 6.5 m, below which temperatures fall to 11.6 °C. Dissolved oxygen concentrations also fall to nearly zero by the bottom of the profile (Figure 7). This thermal stratification at the site was also observed by Monteith (ed.1997).

Dissolved Oxygen Profile

GPS Location SH4741681883
 Maximum Depth (m) 8.9 m
 Secchi Depth (m) 2.6 m

Notes:

Depth (m)	DO (mg/l)	Temp (°C)
0	8.5	17.3
0.5	8.47	17.2
1	8.46	17.2
1.5	8.47	17.1
2	8.32	17.1
3	8.19	16.7
4	7.73	16.5
5	7.31	16.3
6	7.18	16.1
7	5.3	15.4
8	0.62	12.1
8.5	0.38	11.6

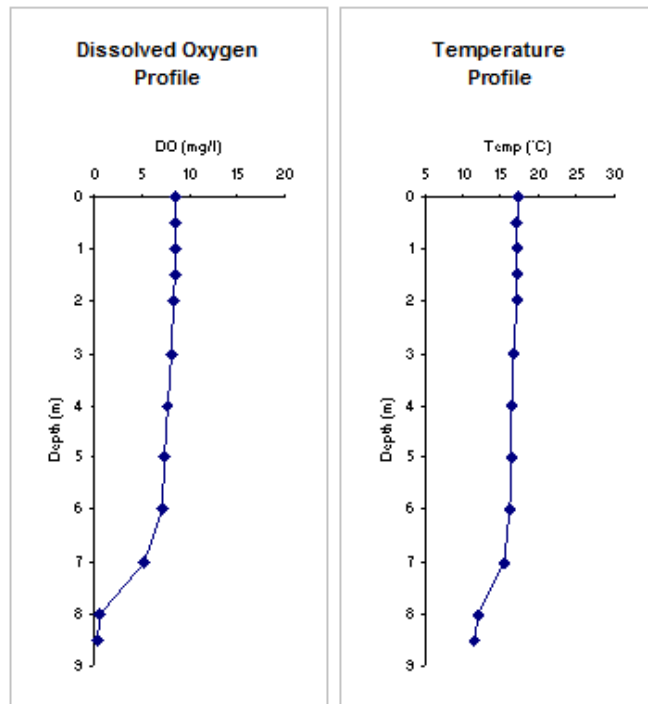


Figure 7. Dissolved oxygen and temperature profiles at Llyn yr Wyth Eidion (14/09/2016).

5.2.3. Cefni Reservoir



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Figure 8. Site map and aerial photograph of Cefni Reservoir.



Figure 9. Cefni Reservoir site photo; from the south shore looking east.

Cefni Reservoir is a large (68 ha), shallow (max. depth 4.5 m) lowland reservoir located on the Isle of Anglesey, North Wales. It is owned by Dŵr Cymru / Welsh Water and was constructed in 1940s to improve the water supply to the island. The reservoir is separated into two parts by the causeway of an abandoned railway line, although an opening allows the exchange of water between the two sections. Cefni Angling Association is based near the dam and members fish for wild brown trout and stocked rainbow trout from both boats and the shore. The large catchment is dominated by agriculture, primarily improved grassland but with some calcareous grassland and arable horticulture. There are also areas of broadleaved and coniferous woodland, some of which surround much of the perimeter of the site itself.

The aquatic macrophyte flora (Table 5) is relatively rich for a lowland reservoir and there is little sign of significant water level change which can detrimentally affect aquatic species. The most abundant taxon is the alien species *Elodea nuttallii*, forming extensive beds in some sections of the site. Another invasive alien, *Crassula helmsii* was found in the strand-line of Section 3. In areas of less dense *E. nuttallii* a mixed assemblage of native species is present, including *Littorella uniflora*, *Eleocharis acicularis* and *Elatine hydropiper* in shallower areas and *Lemna trisulca*, *Nitella flexilis* agg., *Ranunculus aquatilis* agg., *Chara globularis* and *Potamogeton berchtoldii* in deeper sections. *Persicaria amphibia* is also frequent around the edges of the site. Widespread presence of *Elatine hydropiper*, a species of conservation value, is especially of note. The maximum depth of colonisation (*Lemna trisulca*) in the reservoir is 3.4 m. The abundance of filamentous algae was relatively low at the time of survey.

The aquatic macrophyte assemblage has remained consistent since the last survey in 2010 (Goldsmith *et al.* 2011), although the appearance of highly invasive *Crassula helmsii* in 2016 provides significant cause for concern. There is little evidence that water level fluctuations significantly affect the LEAFPACS tool classification at this site.

Submerged and floating vegetation	% cover	Submerged and floating vegetation	% cover
<i>Chara globularis</i>	0.4	<i>Littorella uniflora</i>	8.1
<i>Crassula helmsii</i>	0.7	<i>Nitella flexilis</i> agg.	1.2
<i>Elatine hydropiper</i>	2.7	<i>Persicaria amphibia</i>	4.3
<i>Eleocharis acicularis</i>	3.1	<i>Potamogeton berchtoldii</i>	0.4
<i>Elodea nuttallii</i>	22.3	<i>Potamogeton perfoliatus</i>	2.8
<i>Lemna minor</i>	5.0	<i>Ranunculus aquatilis</i> agg.	0.9
<i>Lemna trisulca</i>	17.2	<i>Sparganium</i> (aquatic indet.)	0.3
Species richness			14
WFD LEAFPACS Classification			Good Status
Confidence in Class			70.7%
Certainty < Good			29.2%

Table 5. CSM Survey results from Cefni Reservoir 2016.

The LEAFPACS tool gave a classification of Good Status with 70.7% confidence in class and 29.2% certainty that the water body is worse than good. These results are similar to the 2010 survey when the classification was also Good and Certainty < Good was 5.3%. However, high cover of *Elodea nuttallii* and presence of *Crassula helmsii* suggests that the lake should be downgraded to worse than Good due to Invasive Non-Native Species.

Dissolved oxygen and temperature profiles showed the reservoir to be mixed during summer with no thermocline evident and only a slight decline in dissolved oxygen with increasing depth (Figure 10).

Dissolved Oxygen Profile

GPS Location SH4460077365
 Maximum Depth (m) 4.7 m
 Secchi Depth (m) 3.05 m

Notes:

Depth (m)	DO (mg/l)	Temp (°C)
0	9.74	19
0.5	9.75	19
1	9.52	19
1.5	9.66	19
2	9.74	19
2.5	9.63	18.9
3	9.08	18.6
3.5	9.08	18.3
4	9.16	18.3
4.5	8.26	17.9

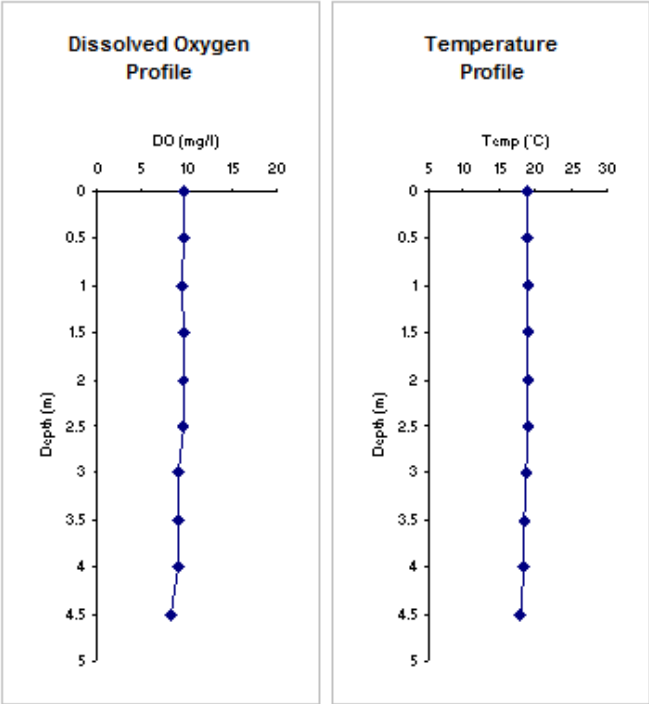


Figure 10. Dissolved oxygen and temperature profiles at Cefni Reservoir (15/09/2016).

5.2.4. Llys-y-Fran Reservoir



Figure 11. Site map and aerial photograph of Llys-y-Fran Reservoir.



Figure 12. Llys-y-Fran Reservoir site photo; from the deep point looking east.

Llys-y-Fran Reservoir is a large (74 ha), moderate alkalinity reservoir located in Pembrokeshire, South-West Wales. The reservoir forms part of the Afonydd Cleddau / Cleddau Rivers SAC and the Afon Cleddau Dwyreiniol/astern Cleddau River SSSI. It is managed by Dŵr Cymru / Welsh Water and was constructed between 1968 and 1972 to provide drinking water. It hosts a trout fishery and is used recreationally for boating, sailing, windsurfing and canoeing. The extensive catchment is largely agricultural, the majority of which consists of improved grassland but there are also areas of coniferous woodland and acid grassland.

The aquatic macrophyte flora is both poor and thinly distributed, and consists of only three species (Table 6). Of these, *Littorella uniflora* is the most abundant, occurring in all four survey sections and unusually to a depth of 2.6m in Section two.

Potamogeton crispus, a species not found in the survey of 2010 (Goldsmith *et al.* 2011) is the next most common taxon and there are small amounts of *Fontinalis antipyretica* at the edge of Section one. No alien invasive aquatic macrophyte species were present at the time of survey and the levels of filamentous algae were extremely low.

Fulfilling part of the recommendations in Hatton-Ellis (2016) for further ecological data from the site, the current survey demonstrates that Llys-y-Fran Reservoir does not meet the JNCC (2015) criteria for macrophytes of “oligotrophic to mesotrophic

standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoeto-Nanojuncetea” possessing only one of the characteristic species required: *Littorella uniflora* and therefore cannot be considered to contribute to the Welsh resource of this habitat type.

The LEAFPACS tool gave an overall classification of Moderate with 64% confidence. This is predominantly driven by the low NTAXA and NFG at the site. Although this represents a face value improvement since 2010 when the macrophytes gave a face value classification of Poor, the 2010 survey also estimated that there was a 44.2% probability of the site being Moderate.

Low taxon richness at this site is likely to be due to water level fluctuation rather than a nutrient pressure. If only the LMNI metric was used, the lake would have been classified as Good status. The macrophyte community is therefore likely to be responding to changes in water levels and this data could perhaps be used as a means of assessing the impact of hydrological pressures and the effectiveness of any mitigation measures.

Submerged and floating vegetation	% cover
<i>Fontinalis antipyretica</i>	0.7
<i>Littorella uniflora</i>	18.2
<i>Potamogeton crispus</i>	3.5
Species richness	3
WFD LEAFPACS Classification	Moderate
Confidence in Class	64.4%
Certainty < Good	97.4%

Table 6. CSM Survey results from Llys-y-Fran Reservoir 2016.

Dissolved oxygen and temperature profiles show the lake to be stratified during summer with a thermocline at approximately 9.5 m, below which temperatures fall to 9.7 °C by 25 m. Dissolved oxygen concentrations also fall to nearly zero by the bottom of the profile (Figure 13).

Dissolved Oxygen Profile

GPS Location SN0366724426
 Maximum Depth (m) 27.8 m
 Secchi Depth (m) 2.65 m

Notes:

Depth (m)	DO (mg/l)	Temp (°C)
0	9.22	17.9
1	9.24	17.9
2	9.24	17.9
3	9.22	17.9
4	9.18	17.9
5	9.16	17.8
6	9.13	17.8
7	9.11	17.8
8	9.06	17.8
9	8.97	17.7
10	8.04	17.3
11	7.54	16.9
12	6.33	16.2
13	4.51	14.9
14	2.33	13
15	1.66	11.5
16	0.95	10.5
17.5	0.52	9.9
20	0.56	9.7
25	0.5	9.7

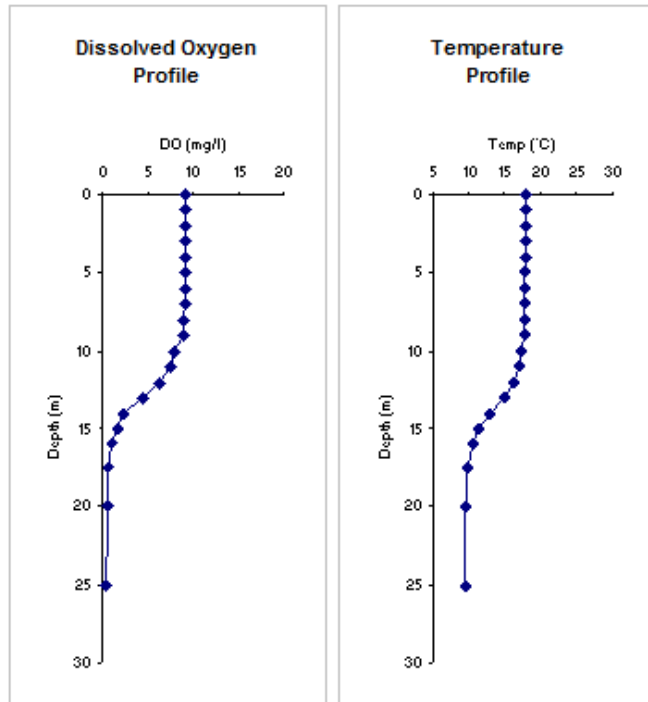


Figure 13. Dissolved oxygen and temperature profiles at Llys-y-Fran Reservoir (16/09/2016).

5.2.5. Llyn Anafon

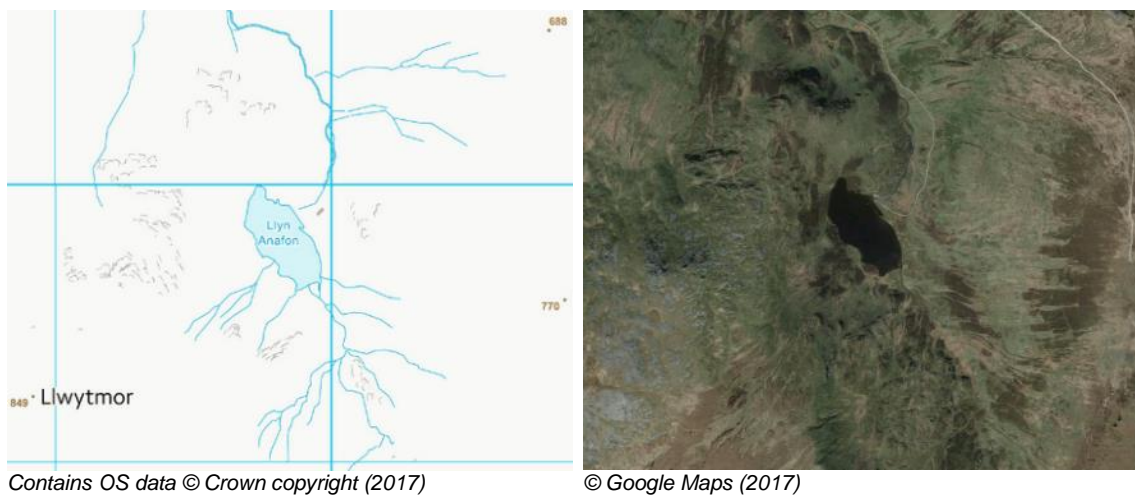


Figure 14. Site map and aerial photograph of Llyn Anafon.



Figure. 15 Llyn Anafon site photo; from the south end looking north-west.

Llyn Anafon is a small (4 ha), mid altitude lake with a maximum depth of 10.5 m located in Gwynedd, North Wales. A dam, built in 1929 to provide a water supply, maintains water levels at around 1.5m higher than the original lake. The site is surrounded by moorland, and falls within the Eryri SSSI, Eryri/Snowdonia SAC and the Snowdonia National Park.

Llyn Anafon is classified as mesotrophic and has a rich submerged aquatic macrophyte assemblage of 21 species (Table 7). The flora is probably unique in the United Kingdom however, with the site hosting populations of two rare broad-leaved *Potamogeton* hybrids: *Potamogeton x griffithii* and *Potamogeton x gessnacensis*. These form part of the SAC feature and in recent years efforts have been made to maintain water levels in the lake for their benefit (Goldsmith et al. 2009), with the

former inhabiting deeper water and the latter occurring in shallow water habitat threatened by lowered water levels.

The shallow area at the south-west end of the site plays host to the majority of the population of *Potamogeton x gessnacensis*, where it forms mixed beds primarily with *Juncus bulbosus*. Nearby, at the south-eastern corner next to the inflow, is the restricted area of distribution for *Potamogeton alpinus* and *Ranunculus aquatilis* agg., possibly reflecting the inflow chemistry. Around the often bouldery edges of the lake the plant assemblage is more typical, consisting of *Littorella uniflora* and *Lobelia dortmanna* in the shallower water, transitioning through *Isoetes lacustris*, *Sparganium angustifolium*, *Myriophyllum alterniflorum*, *Juncus bulbosus* and *Callitriche brutia* var. *hamulata* as the depth increases, with *Nitella translucens*, *Potamogeton x griffithii* and *Chara virgata* on silty substrates in the deeper water, reaching a maximum depth of 3.4 m.

Relative to the surveys discussed in the site assessment by Burgess *et al.* (2013) and a further CSM survey performed in 2013 (Goldsmith *et al.* 2014a), the assemblage and macrophyte abundances remain relatively consistent, with elevated stable water levels clearly benefitting *Potamogeton x gessnacensis*. Noteworthy species additions over the survey period include records for *Subularia aquatica* in 2013 and 2016 and *Fontinalis antipyretica* in 2016. Conversely, the lack of evidence for *Elatine hexandra* in 2013 and 2016 provides some cause for concern.

Llyn Anafon is favourable with respect to macrophyte species composition and possesses 10 target species (Table 7) for mesotrophic lakes (JNCC 2015). Filamentous algae is widespread but occurs at relatively low levels of abundance. No alien invasive macrophyte species were recorded in the 2016 survey.

Submerged and floating vegetation	% cover	Submerged and floating vegetation	% cover
<i>Callitriche brutia</i> var. <i>hamulata</i>	8.35	<i>Potamogeton alpinus</i>	0.91
<i>Chara virgata</i>	7.67	<i>Potamogeton berchtoldii</i>	3.10
<i>Fontinalis antipyretica</i>	0.80	<i>Potamogeton polygonifolius</i>	0.77
<i>Isoetes lacustris</i>	3.83	<i>Potamogeton x griffithii</i>	7.20
<i>Juncus bulbosus</i>	19.25	<i>Potamogeton x gessnacensis</i>	2.17
<i>Littorella uniflora</i>	10.39	<i>Ranunculus aquatilis</i> agg.	1.93
<i>Lobelia dortmanna</i>	3.76	<i>Sparganium angustifolium</i>	4.44
<i>Menyanthes trifoliata</i>	0.71	<i>Sphagnum (aquatic indet.)</i>	0.10
<i>Myriophyllum alterniflorum</i>	3.34	<i>Subularia aquatica</i>	1.12
<i>Nitella flexilis</i> agg.	2.16	<i>Utricularia vulgaris</i>	8.20
<i>Nitella translucens</i>	0.54		
Species richness			21
WFD LEAFACS Classification			High
Confidence in Class			91.3%
Certainty < Good			0%

Table 7. CSM Survey results from Llyn Anafon 2016.

The LEAFACS tool does not formally apply at Llyn Anafon because the lake is too small to be designated a WFD water body. However, the lake would have been

classified at High status with 91.3% confidence, and 100% certainty that the lake is Good or better. This result closely matches the result for 2013 when the lake would also have classified as High Status with 93.9% confidence. These results are consistent with the diverse plant community and excellent water quality previously reported from the lake (Goldsmith *et al.* 2009).

Dissolved oxygen and temperature profiles showed the lake to be mixed at the time of survey with no thermocline evident and only a slight decline in dissolved oxygen with increasing depth (Figure 16).

Dissolved Oxygen Profile

GPS Location SH6975769834
 Maximum Depth (m) 10.9 m
 Secchi Depth (m) 2.9 m
 Notes:

Depth (m)	DO (mg/l)	Temp (°C)
0	8.56	15.4
0.5	8.63	15.4
1	8.66	15.5
1.5	8.66	15.5
2	8.69	15.5
2.5	8.69	15.5
3	8.49	14.7
3.5	8.2	14.5
4	8.07	14.5
4.5	8.22	14.4
5	7.94	14.3
6	8.04	14.2
7	8.43	14.1
8	8.02	14
9	7.39	13.9
10	7.53	13.9
10.5	6.58	13.8

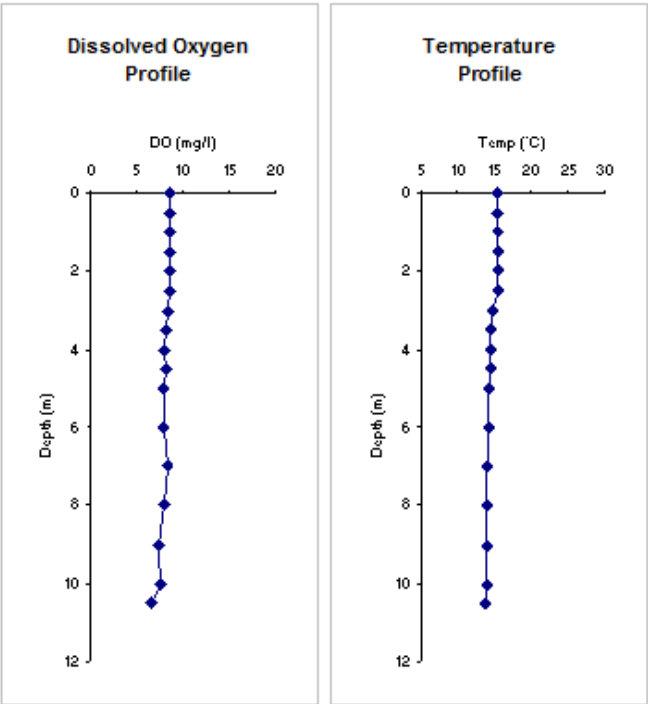


Figure 16. Dissolved oxygen and temperature profiles at Llyn Anafon (16/09/2016).

5.2.6. Llyn Morwynion

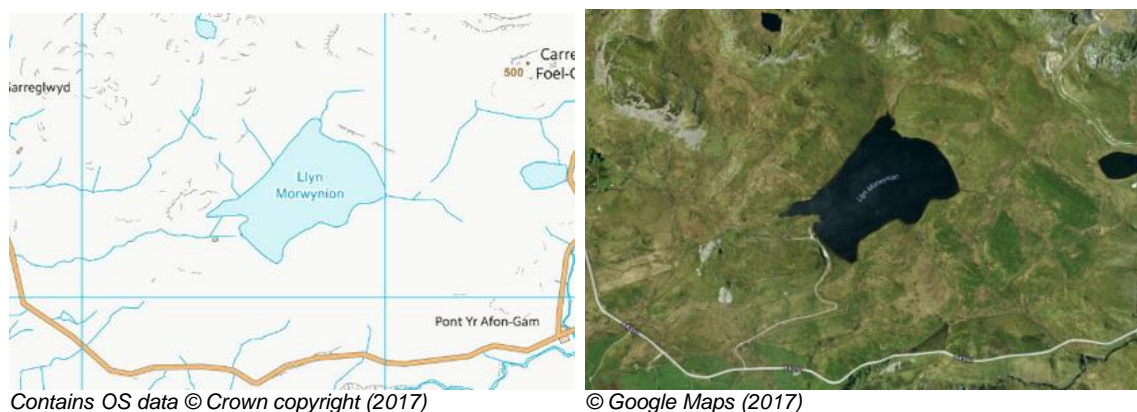


Figure 17 Site map and aerial photograph of Llyn Morwynion



Figure 18. Llyn Morwynion site photo; from the north-west shore looking east.

Llyn Morwynion is a small (11 ha), generally shallow (mean. depth 5.5 m) oligotrophic, mid altitude lake located in Gwynedd, North Wales, and lies within the Snowdonia National Park. It is owned by Dŵr Cymru / Welsh Water and has been dammed and raised to provide a drought protection reservoir. A fishing club stock the site with rainbow trout. The lake is surrounded by acid grassland with some heath and bogs.

Present in all four sections and from 25 cm to 2.3 m deep, the most abundant component species of the aquatic flora (Table 8) is *Isoetes echinospora*. A significant population of *Nitella gracilis* dominates in deeper water, down to a maximum depth of 4.0 m. *Littorella uniflora* grows at lesser abundances in the shallows, *Sparganium angustifolium* is present in Section one in the more sheltered bay at the South of the site and *Juncus bulbosus* also occurs, especially at the western side of the lake in Sections one and two. *Callitriche brutia* var. *hamulata*, *Glyceria fluitans*, *Fontinalis antipyretica* and aquatic *Sphagnum* sp. complete the species list. Unusually, *Lobelia*

dortmanna does not occur. Filamentous algae is present at low levels in most sampling points in shallower areas but is not found below 1.4m depth. No alien invasive species were found during the current survey.

There has been no change in assemblage composition and very little change in species abundances since that reported by both Goldsmith (2010) and Burgess *et al.* (2013). Llyn Morwynion maintains three characteristic macrophyte taxa that fulfil the JNCC (2015) target levels for “Oligo-mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*” and a population of the priority BAP charophyte species *Nitella gracilis*.

The WFD LEAFPACS tool gave a classification of High Status, with 86.5% confidence in class and 100% certainty of being Good or better. No chemical data are available from Llyn Morwynion but this result is consistent with the survey results and surrounding land use. A previous survey in 2010 also classed the lake as High status, but very close to the High/Good boundary.

Whereas a Secchi reading of 3.5 m was recorded in very challenging weather in 2009, 3.25 m was measured in almost ideal conditions during the 2016 survey.

Submerged and floating vegetation	% cover
<i>Batrachospermum sp.</i>	0.5
<i>Callitriche brutia</i> var. <i>hamulata</i>	4.3
<i>Fontinalis antipyretica</i>	5.8
<i>Isoetes echinospora</i>	12.7
<i>Juncus bulbosus</i>	5.2
<i>Littorella uniflora</i>	4.6
<i>Nitella gracilis</i>	5.8
<i>Sparganium angustifolium</i>	1.3
<i>Sphagnum</i> (aquatic indet.)	6.5
Species richness	9
WFD LEAFPACS Classification	High
Confidence in Class	86.5%
Certainty < Good	0%

Table 8. CSM Survey results from Llyn Morwynion 2016.

At the time of survey, the lake was mixed and was well oxygenated throughout the water column (Figure 19).

Dissolved Oxygen Profile

GPS Location SH7377342323
 Maximum Depth (m) 11.2 m
 Secchi Depth (m) 3.25 m
 Notes:

Depth (m)	DO (mg/l)	Temp (°C)
0	9.11	16.7
0.5	9.19	16.6
1	9.24	16.3
1.5	9.24	16.3
2	9.09	16.1
2.5	9.16	16
3	9.15	15.9
3.5	9.07	15.9
4	9.07	15.9
4.5	9.07	15.9
5	9.07	15.8
6	9.07	15.8
7	9.05	15.7
8	9.01	15.6
9	8.81	15.5
10	8.91	15.5
11	8.89	15.4

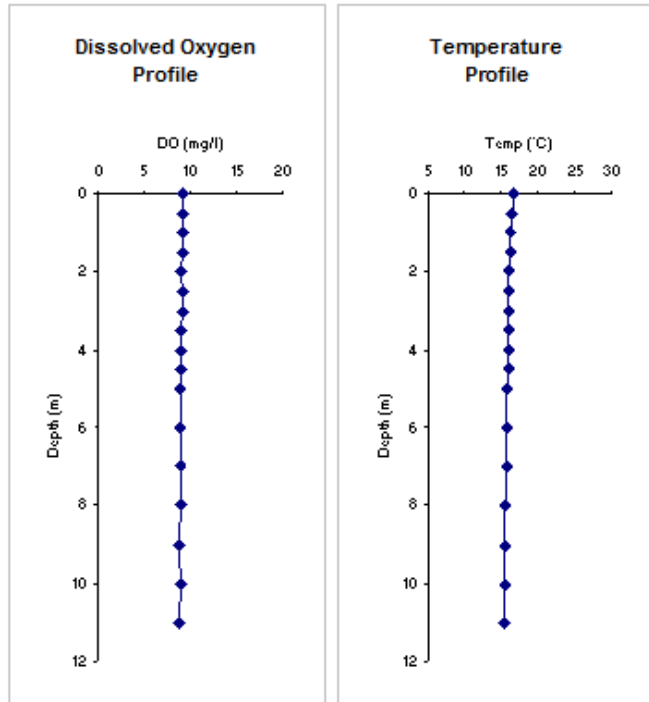
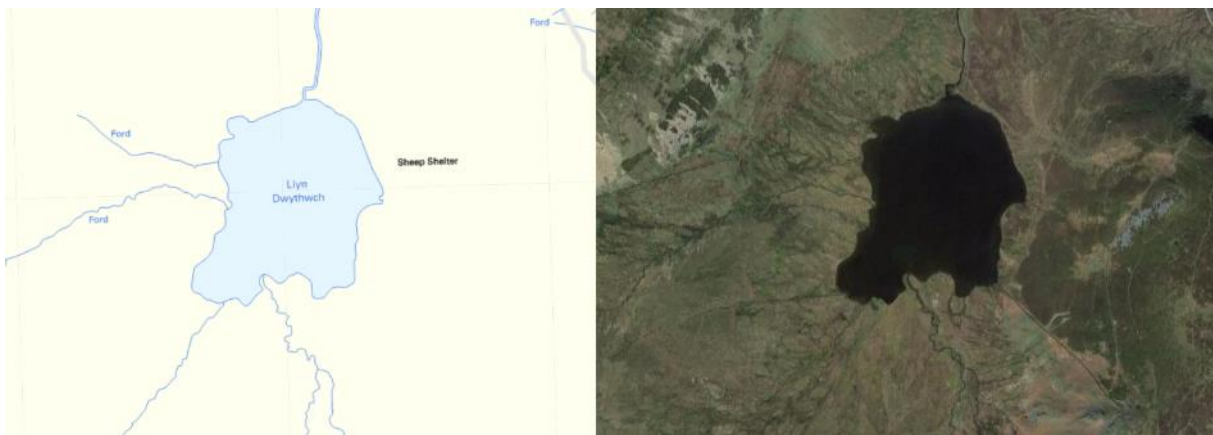


Figure 19. Dissolved oxygen and temperature profiles at Llyn Morwynion (17/09/2016).

5.2.7. Llyn Dwythwch



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Figure 20. Site map and aerial photograph of Llyn Dwythwch.



Figure 21. Llyn Dwythwch site and catchment photo; from the north looking south.

Llyn Dwythwch is a small (9 ha), generally shallow (but with a max. depth of 9.0 m) mid altitude lake located in Gwynedd, North Wales. It forms part of the Cwm Dwythwch SSSI and lies within the Snowdonia National Park. The site is surrounded by moorland, mostly characterised by acid grassland, and there is cattle and sheep grazing right up to the shore.

The aquatic macrophyte flora of Llyn Dwythwch is very diverse for a clear-water, oligotrophic lake (Table 9), and 19 species of submerged and floating taxa are present. A large proportion of the southern part of the lake is shallower than the maximum depth of colonisation (4.4 m) and therefore plants are present over a significant overall area of lake-bed. Of particular note is that this area hosts the majority of the population of the protected species *Luronium natans* observed in the lake, with specimens occurring from around 1.0 m – 1.7 m depth. In the shallower areas of the site there are good populations of *Littorella uniflora*, *Lobelia dortmanna*, *Subularia aquatica* and *Isoetes spp.* Microscopic examination of megaspores

revealed that both species of *Isoetes*, *Isoetes lacustris* and *Isoetes echinospora*, are present, but it is difficult to ascribe the relative abundances of the two and it may be that the amount of *I. echinospora* is underreported here.

Isoetes also grows in the deeper water where it is found alongside patches of *Elatine hexandra* and under a mosaic of *Potamogeton berchtoldii*, *Callitriche brutia* var. *hamulata* and *Myriophyllum alterniflorum*. In the more sheltered southern end of the site *Nuphar lutea*, *Menyanthes trifoliata* and *Sparganium angustifolium* are present whereas the aquatic moss *Fontinalis antipyretica* is more abundant on the boulder substrate at the northern end. Two specimens of *Nitella gracilis* were recorded. This uncommon taxon was last found at the site in the 1970s (N. Stewart, *pers. comm.*).

Juncus bulbosus was not recorded at a high frequency, suggesting that enrichment may not be especially problematic at the site, although this should be confirmed chemically as relatively high amounts of filamentous algae were present in all survey sections.

The current species assemblage would place the site in favourable condition with respect to its flora under JNCC CSM Guidelines (JNCC 2015). No alien invasive species were found during the 2016 survey.

Also noteworthy is the presence of a population of large sponges at around 75 cm depth on the surface of boulders in Section four, at the north-east of the lake.

Submerged and floating vegetation	% cover	Submerged and floating vegetation	% cover
<i>Callitriche brutia</i> var. <i>hamulata</i>	6.1	<i>Menyanthes trifoliata</i>	1.1
<i>Callitriche</i> sp.	2.1	<i>Myriophyllum alterniflorum</i>	3.7
<i>Elatine hexandra</i>	5.0	<i>Nitella gracilis</i>	0.4
<i>Fontinalis antipyretica</i>	7.0	<i>Nuphar lutea</i>	1.1
<i>Isoetes echinospora</i>	0.1	<i>Potamogeton berchtoldii</i>	7.7
<i>Isoetes lacustris</i>	11.4	<i>Potamogeton polygonifolius</i>	0.7
<i>Juncus bulbosus</i>	0.2	<i>Sparganium angustifolium</i>	4.3
<i>Littorella uniflora</i>	8.9	<i>Sphagnum</i> (aquatic indet.)	1.1
<i>Lobelia dortmanna</i>	8.3	<i>Subularia aquatica</i>	6.0
<i>Luronium natans</i>	2.3		
Species richness			19
WFD LEAFPACS Result			Good
Confidence in Class			88.1%
Certainty < Good			0.3%

Table 9 CSM Survey results from Llyn Dwythwch 2016

Llyn Dwythwch is not a WFD water body and therefore LEAFPACS results are reported for information only. No water chemistry data are available so an estimated alkalinity of 50 µeq l⁻¹ was used, based on the alkalinity of similar lakes in the Snowdonia area. The lake was classed as Good Status with 88% confidence and only extremely low confidence that it was worse than Good status. Since there are no nutrient sources in the catchment this is considered rather pessimistic, and reflects relatively high filamentous algal cover in the lake, the presence of some macrophytes with wide ecological tolerances (*Potamogeton berchtoldii* and *Nuphar lutea*) and the

presence of an unidentifiable *Callitriche* sp, which is assigned a high LMNI score by LEAFPACS.

The site is relatively shallow and exposed and at the time of survey the water was well oxygenated throughout the water column (Figure 22).

Dissolved Oxygen Profile

GPS Location SH5706758060
 Maximum Depth (m) 9.6 m
 Secchi Depth (m) 2.6 m
 Notes:

Depth (m)	DO (mg/l)	Temp (°C)
0	9.13	15.1
0.5	9.13	15.1
1	9.11	15.1
1.5	9.11	15.1
2	9.11	15.1
2.5	9.08	15.1
3	9.08	15.1
3.5	9.1	15.1
4	9.09	15.1
4.5	9.05	15.1
5	9	15.1
6	9.04	15
7	9.02	15
8	9	15
9	9	14.9

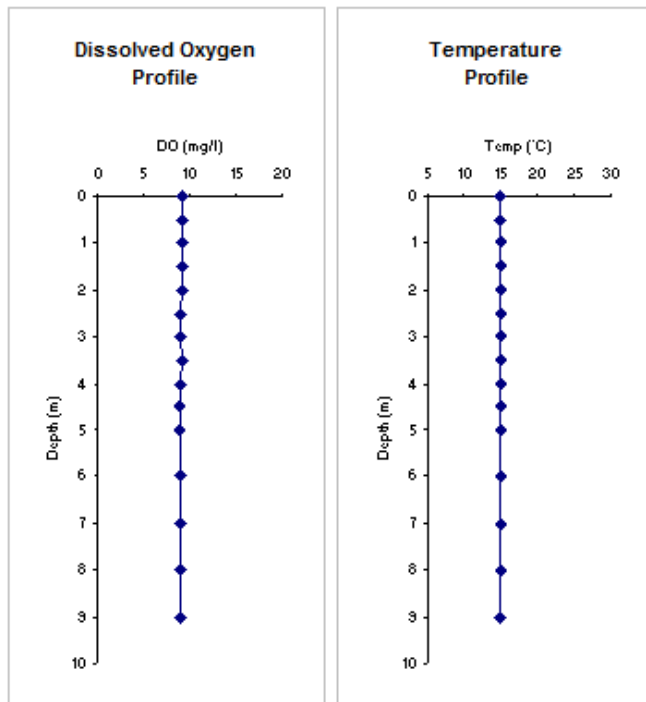


Figure 22. Dissolved oxygen and temperature profiles at Llyn Dwythwch (18/09/2016).

5.2.8. Llyn Eiddwen



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Figure 23. Site map and aerial photograph of Llyn Eiddwen.



Figure 24 Llyn Eiddwen site photo; from west shore looking south-east

Llyn Eiddwen is a small (10 ha), shallow (max. depth 7.2 m), mesotrophic mid altitude lake located in Ceredigion, mid Wales. It is designated as the Llyn Eiddwen SSSI and NNR. The catchment is largely acid grassland with areas of improved grassland and coniferous woodland.

Llyn Eiddwen has a relatively rich aquatic macrophyte flora typical for a mesotrophic lake (Table 10). Eighteen submerged or floating species are present, including the protected taxon *Luronium natans*. The greatest species diversity is found in Section one at the southern end of the site, which is more sheltered with a peaty and silty substrate. *Juncus bulbosus* and *Utricularia minor* are present in the shallows,

supplanted by *Littorella uniflora*, *Lobelia dortmanna*, *Subularia aquatica*, *Isoetes echinospora* and *Luronium natans* in the slightly deeper water followed by *Sparganium angustifolium*, *Potamogeton natans*, *Potamogeton berchtoldii*, *Callitriche brutia* var. *hamulata* and finally *Nitella translucens* moving further from the shore. Also of note in this section is an abundance of freshwater sponges at around 75cm depth.

Sections two and three, and much of Section four, have substrates comprised of cobbles, especially around the edges. These sections are characterised by *Littorella uniflora*, *Lobelia dortmanna*, *Isoetes* spp. and *Luronium natans* with occasional *Potamogeton berchtoldii* then *Nitella translucens* tending to dominate in the deeper water, reaching a maximum depth of 2.4 m.

Both species of *Isoetes* were recorded and confirmed in the site with *I. echinospora* more frequent than *I. lacustris*.

Notable changes since the survey of 2013 (Goldsmith *et al.* 2014a) are somewhat increased abundances of *Luronium natans*, now found in all four sections, and a decrease in abundances of *Subularia aquatica*, absent from three sections compared to 2013. *Utricularia minor* was not recorded in the previous survey. Of some concern, however, the JNCC (2015) target species *Elatine hexandra* was absent in 2016. Both the maximum depths of colonisation (2.3 m v. 2.4 m) and the Secchi depths (1.65 m each time) remained consistent between the surveys.

The site hosts nine of the target species for mesotrophic lakes, which would place it in favourable condition with respect to its flora under JNCC CSM Guidelines (JNCC 2015). Filamentous algae was present in almost all sampling points to a depth of around 1.4 m. No alien invasive macrophyte species were recorded in the 2016 survey.

Submerged and floating vegetation	% cover	Submerged and floating vegetation	% cover
<i>Callitriche brutia</i> var. <i>hamulata</i>	1.9	<i>Menyanthes trifoliata</i>	1.5
<i>Eleocharis multicaulis</i>	0.7	<i>Nitella translucens</i>	14.7
<i>Fontinalis antipyretica</i>	2.1	<i>Potamogeton berchtoldii</i>	1.5
<i>Isoetes echinospora</i>	6.0	<i>Potamogeton natans</i>	2.7
<i>Isoetes lacustris</i>	2.0	<i>Potamogeton polygonifolius</i>	1.4
<i>Juncus bulbosus</i>	0.1	<i>Sparganium angustifolium</i>	5.4
<i>Littorella uniflora</i>	9.1	<i>Sphagnum</i> (aquatic indet.)	0.1
<i>Lobelia dortmanna</i>	6.0	<i>Subularia aquatica</i>	1.3
<i>Luronium natans</i>	5.3	<i>Utricularia minor</i>	2.9
Species richness			18
WFD LEAFPACS Result			High
Confidence in Class			100%
Certainty < Good			0%

Table 10. CSM Survey results from Llyn Eiddwen 2016.

Llyn Eiddwen is not a WFD Water Body and the LEAFPACS result is therefore indicative only. Llyn Eiddwen was classed as High Status with 100% confidence, indicating an absence of nutrient pressures affecting the lake. This is in line with the

high aquatic plant diversity and previous water quality and plant survey data (Goldsmith *et al.* 2006).

Dissolved oxygen and temperature profiles showed the lake to be mixed at the time of the 2016 survey with no thermocline evident and only a slight decline in dissolved oxygen towards the bottom of the profile (Figure 25).

Dissolved Oxygen Profile

GPS Location SN6072767088
 Maximum Depth (m) 7.1 m
 Secchi Depth (m) 1.65 m
 Notes:

Depth (m)	DO (mg/l)	Temp (°C)
0	8.93	15.9
1	8.93	15.8
2	8.83	15.8
3	8.7	15.7
4	8.59	15.7
5	8.55	15.6
6	7.69	15.6
6.5	7.63	15.5

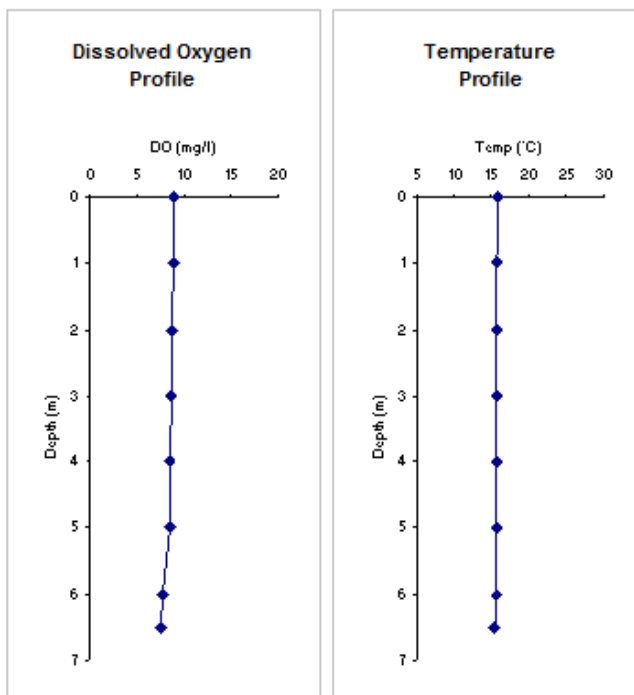
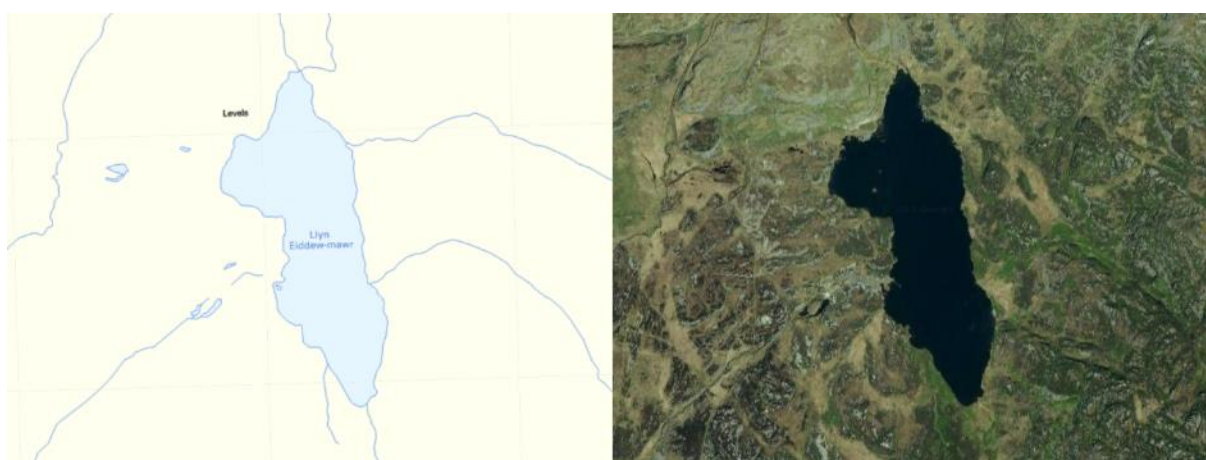


Figure 25. Dissolved oxygen and temperature profiles at Llyn Eiddwen (19/09/2016).

5.2.9. Llyn Eiddew-Mawr



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Figure 26. Site map and aerial photograph of Llyn Eiddew-Mawr.



Figure 27 Llyn Eiddew-Mawr site photo; from the north shore looking south

Llyn Eiddew-Mawr is a small (10 ha), shallow (max. depth 10.5 m) mid altitude lake located in Gwynedd, North Wales. It lies within the Rhinog SSSI and SAC and the Snowdonia National Park. The catchment is entirely moorland, comprised mostly of heath but also areas of acid grassland. There are historic manganese mine workings at the north end of the site. Dŵr Cymru / Welsh Water have an abstraction license for limited quantities of water, taken off via structures on the western edge of the lake.

The aquatic macrophyte flora is typical of a low alkalinity, oligotrophic lake with minor humic influence (Table 11). *Littorella uniflora*, *Lobelia dortmanna* and *Isoetes lacustris* are present throughout much of the littoral zone, with *I. lacustris* reaching a maximum depth of 4.0 m. Microscopic examination of megaspores revealed that *Isoetes echinospora* is also present in the site. Other characteristic oligotrophic species present are *Utricularia vulgaris* agg., *Sparganium angustifolium* and *Isolepis fluitans*, the latter being present in the strandline in 2004 (Goldsmith *et al.*, 2006) but not found in the survey of 2013 (Goldsmith *et al.*, 2014a). *Myriophyllum alterniflorum* and *Callitriche brutia* var. *hamulata* occur away from the shallows and *Potamogeton polygonifolius* is occasional amongst submerged boulders around the lake shore. The current species assemblage, including seven target species for oligotrophic lakes, would place the site in favourable condition with respect to its flora under

JNCC CSM guidelines (JNCC 2015). Of some concern however, are the amounts of filamentous algae present in the site; it was recorded at almost all survey points to a depth of 2.2 m. No alien invasive species were found during the 2016 survey.

Submerged and floating vegetation	% cover
<i>Batrachospermum</i> sp.	2.2
<i>Callitriche brutia</i> var. <i>hamulata</i>	3.5
<i>Isolepis fluitans</i>	0.8
<i>Isoetes echinospora</i>	0.8
<i>Isoetes lacustris</i>	7.3
<i>Juncus bulbosus</i>	4.4
<i>Littorella uniflora</i>	7.3
<i>Lobelia dortmanna</i>	8.7
<i>Myriophyllum alterniflorum</i>	6.7
<i>Potamogeton polygonifolius</i>	2.9
<i>Sparganium angustifolium</i>	2.9
<i>Sphagnum</i> (aquatic indet.)	3.1
<i>Utricularia vulgaris</i>	3.6
Species richness	13
WFD LEAFPACS Classification	High
Confidence in Class	98.8%
Certainty < Good	0%

Table 11 CSM Survey results from Llyn Eiddew-Mawr 2016

The LEAFPACS tool classified Llyn Eiddew-Mawr as High status for macrophytes with 98.8% confidence. This is very similar to previous results from 2004 and 2013, indicating that there are no significant nutrient pressures on the lake. This is supported by water chemistry data (Burgess *et al.* 2013; Hatton-Ellis 2016).

Dissolved oxygen and temperature profiles showed the lake to be mixed during the survey period with stable temperature and only very slightly declining DO values down through the water column (Figure 28).

Dissolved Oxygen Profile

GPS Location SH6464633643
 Maximum Depth (m) 10.9 m
 Secchi Depth (m) 3.05 m

Notes:

Depth (m)	DO (mg/l)	Temp (°C)
0	8.84	15.6
0.5	8.86	15.6
1	8.84	15.6
1.5	8.82	15.6
2	8.76	15.6
3	8.76	15.6
3.5	8.75	15.5
4	8.75	15.5
4.5	8.78	15.5
5	8.77	15.5
6	8.67	15.4
7	8.65	15.3
8	8.66	15.3
9	8.13	15.3
10	8.13	15.2
10.5	8.14	15.2

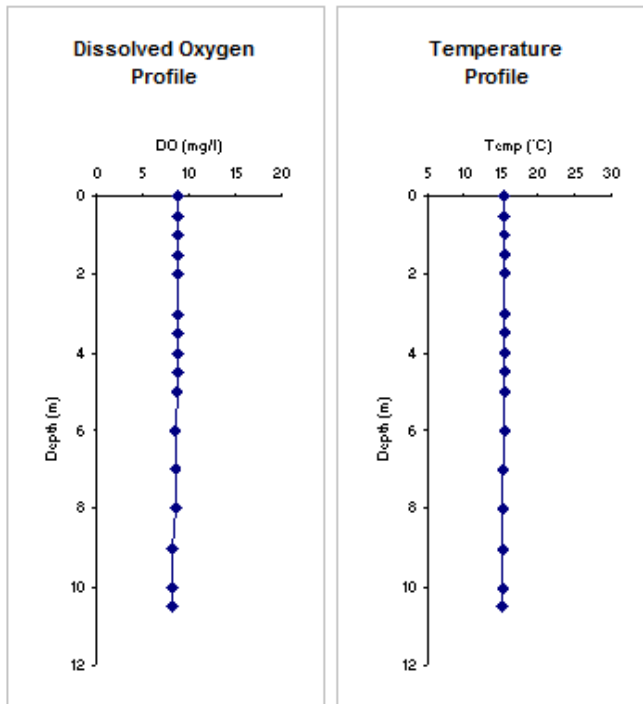


Figure 28 Dissolved oxygen and temperature profiles at Llyn Eiddew-Mawr (19/09/2016)

5.2.10. Llyn Fanod



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Figure 29 Site map and aerial photograph of Llyn Fanod



Figure 30 Llyn Fanod site photo; from the north-east end looking south-west

Llyn Fanod is a very small (5 ha), shallow (max. depth 8.7 m), low alkalinity, mid-altitude lake located in Ceredigion, mid Wales. It forms part of the Cors Llyn Farch a Llyn Fanod SSSI. The relatively small catchment is comprised of a mixture of acid and improved grassland with areas of heath.

The aquatic macrophyte flora is typical for a mesotrophic lake and the site supports a total of 20 species (Table 12). A notable component of the assemblage is the Schedule 8 species *Luronium natans*. Similar to the nearby Llyn Eiddwen, described above, the southern end of the lake is more sheltered from South-westerlies and has a less stony substrate. Section two, in that area, contains a somewhat richer species assemblage than the other sections and all the nine highlighted mesotrophic target taxa in Table 12 are present. Additionally, there are beds of yellow (*Nuphar lutea*) and white (*Nymphaea alba*) water lily, beyond which *Nitella translucens* dominates in the deeper water to a maximum depth of 2.3 m.

In sections one and three the near-shore substrates are less organic. Here *Littorella uniflora* and *Isoetes echinospora* are found in the shallows, *Elatine hexandra*, *Lobelia dortmanna*, *Subularia aquatica*, *Luronium natans*, *Isoetes echinospora* and *Nitella*

flexilis agg. characterise the zone between 0.5 m and around 1.2 m and *Nitella translucens* with occasional *Subularia aquatica* inhabit the deeper water.

Microscopic examination of megaspores from the *Isoetes* voucher specimens confirmed that all the collected material was *Isoetes echinospora*.

Special checks outside the surveys sections were made for the presence of *Luronium natans*. It was found to be absent from the majority of the northern and southern long edges of the lake but occasional to locally abundant at the south-west end and within the fixed survey sections.

Llyn Fanod was also surveyed in 2007 and 2013 (Burgess *et al.* 2009 and Goldsmith *et al.* 2014a). The overall assemblage and species abundances have remained mostly similar, although the maximum depths of colonisation for all three sections were significantly deeper in 2013 than in 2007 or 2016. Key differences in species composition include increased amounts of *Luronium natans* in 2016 relative to 2007 and especially 2013 (when none was recorded), the lack of records of *Chara virgata* after 2007, *Utricularia minor* occurring in 2013 only and the appearance for the first time of *Sparganium angustifolium* in 2016.

The current species assemblage would place the site in favourable condition with respect to its flora under the JNCC CSM Guidelines (JNCC 2015) for mesotrophic lakes. Filamentous algae is present at low amounts in most sampling points to a depth of around 1.3 m. No alien invasive macrophyte species were found during the current survey.

Submerged and floating vegetation	% cover	Submerged and floating vegetation	% cover
<i>Batrachospermum</i> sp.	0.1	<i>Menyanthes trifoliata</i>	3.0
<i>Callitriche brutia</i> var. <i>hamulata</i>	1.0	<i>Nitella flexilis</i> agg.	3.9
<i>Callitriche</i> sp.	1.0	<i>Nitella translucens</i>	19.8
<i>Elatine hexandra</i>	2.8	<i>Nuphar lutea</i>	8.2
<i>Fontinalis antipyretica</i>	3.2	<i>Nymphaea alba</i>	2.9
<i>Isoetes echinospora</i>	10.4	<i>Potamogeton natans</i>	1.9
<i>Littorella uniflora</i>	7.8	<i>Potamogeton polygonifolius</i>	1.0
<i>Lobelia dortmanna</i>	8.1	<i>Ranunculus omiophyllus</i>	1.0
<i>Luronium natans</i>	6.6	<i>Sparganium angustifolium</i>	1.0
<i>Lythrum portula</i>	1.0	<i>Subularia aquatica</i>	11.7
Species richness			20
WFD LEAFPACS Result			Good
Confidence in Class			72.8%
Certainty < Good			0%

Table 12. CSM Survey results from Llyn Fanod 2016.

Llyn Fanod is not a WFD Water Body and the LEAFPACS result is therefore indicative only. Llyn Fanod was classed as Good Status with 72.8% confidence, but there was 100% confidence that the lake is Good or better. This is similar to the 2013 survey. Although these data suggest an absence of nutrient pressures, CSM data has shown evidence of elevated nutrient levels, deoxygenation of the hypolimnion and some instability of the plant community in Llyn Fanod, especially when compared

to the nearby Llyn Eiddwen. Regular monitoring and management of nutrient levels in the improved fields adjacent to the lake are required.

Dissolved oxygen and temperature profiles showed the lake to be mixed during summer with no thermocline evident and only a slight decline in dissolved oxygen and temperature with increasing depth (Figure 31).

Dissolved Oxygen Profile

GPS Location SN6030364314
 Maximum Depth (m) 8.5 m
 Secchi Depth (m) 1.6 m
 Notes:

Depth (m)	DO (mg/l)	Temp (°C)
0	8.8	16
1	8.72	15.7
2	8.41	15.6
3	8.34	15.5
4	8.51	15.5
5	8.38	15.5
6	8.36	15.4
7	8.27	15.3
8	7.8	15.3

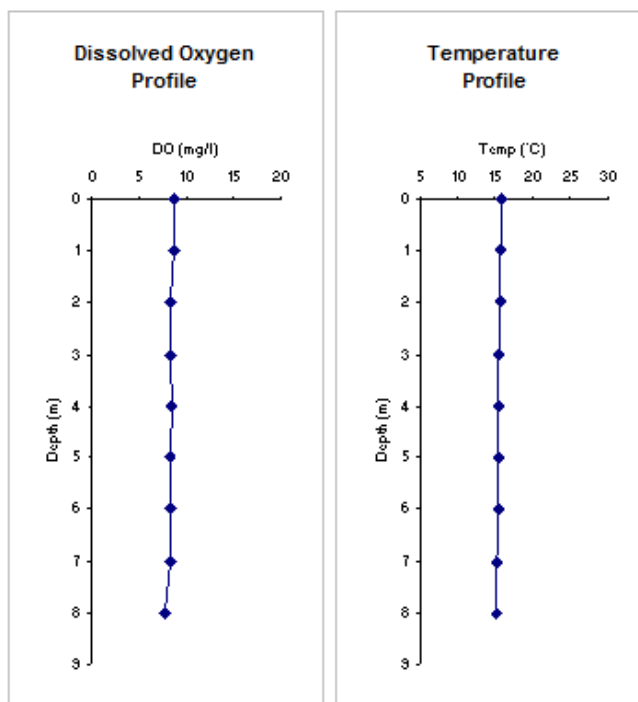


Figure 31. Dissolved oxygen and temperature profiles at Llyn Fanod (20/09/2016).

lake is used extensively for water sports and recreation, and is a designated inland bathing water. There have been historic issues at the site with respect to nutrient levels, deoxygenation of the hypolimnion and algal blooms (Hatton-Ellis, 2016). Llyn Padarn is a WFD surveillance site and hosts notable populations of Arctic charr (*Salvelinus alpinus*) and floating water-plantain (*Luronium natans*).

A *Luronium natans* snorkelling survey by Goldsmith *et al.* (2014b) demonstrated that whilst only one out of the four fixed CSM sections established at Llyn Padarn for WFD surveillance purposes overlaps the distribution of the taxon in the lake, the population is distributed sporadically along approximately half of the Southern shore. NRW requested that for the 2016 survey a fifth section be established in an area of known *Luronium natans* occurrence in order to better monitor population change. A new section was set up in a sheltered bay on the western side of the lake. Unfortunately engine difficulties on the day of survey meant that there was only time to survey four sections, and fixed Section three was not characterised on this occasion.

The submerged aquatic macrophyte flora is typical for a low alkalinity, clear water lake and the survey in 2016 recorded 16 species (Table 13). The benthic habitats vary considerably through the site and this is reflected in the results from the different sections.

Section one is near the inflow at the southern end of the site and has a mostly sandy substrate. It is the most botanically diverse section and *Luronium natans* has been recorded here on every survey. The population in 2016 was similar to that found historically, occurring in a zone between 75 cm and 2 m depth and apparently healthy. With the exception of *Nitella translucens*, all the JNCC target species highlighted in Table 13 are present and *Subularia aquatica* was recorded for the first time in a CSM survey at the site.

Section two is on the north side of the lake and has a substrate of steeply shelving boulders. Representative of a large section of the shore, it is however very poor with respect to aquatic macrophytes and only the moss *Fontinalis antipyretica* was recorded as being present. This is consistent with previous CSM surveys.

Section four is at the northwest end of the lake near the outflow and is dominated by *Isoetes lacustris* from depths of 50 cm to around 1.6 m, beyond which *Myriophyllum alterniflorum*, *Potamogeton berchtoldii* and *Elodea nuttallii* occur. Deeper still, *Nitella translucens* grows to 5.4 m furthest from the shore.

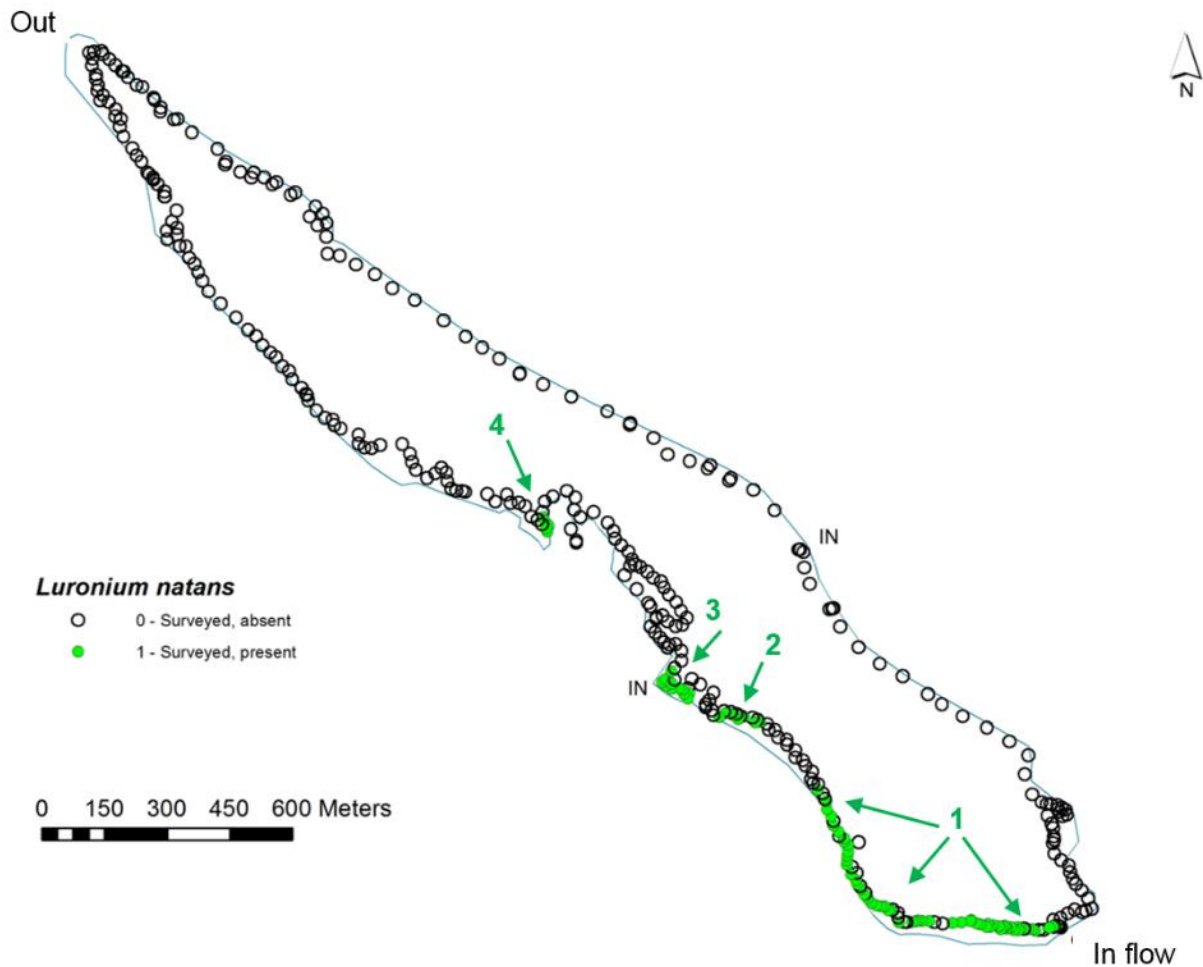


Figure 34. Distribution of *Luronium natans* in Llyn Padarn (from Goldsmith et al, 2014b).

Section five is new and was established in a sheltered bay identified as *Luronium natans* “population 3” (Figure 34) by Goldsmith et al (2014b). Of note is that “population 2” was the intended location for the section but the target species could not be re-found despite an extensive search. To the consternation of the surveyor, whilst traveling between these two areas a specimen of the alien invasive species *Lagarosiphon major* was encountered (and removed!). The record has been added to the “strand line” for section five and the specimen pressed. *L. major* has recently colonised Tal-y-Llyn Lake, where it has proved to be very invasive, so its appearance in Llyn Padarn is a major cause for concern.

The *Luronium natans* population encountered in the section was healthy and found growing between 75 cm and 1.5 m, perhaps benefitting from the disturbance resulting from the nearby jetty and watersports activity. Co-occurring species include *Littorella uniflora*, abundant *Elodea nuttallii*, *Myriophyllum alterniflorum*, *Potamogeton berchtoldii*, *Callitriche brutia* var. *hamulata*, *Nitella flexilis* agg. and *Nitella translucens*.

The current species assemblage, including seven target species, would place the site in favourable condition with respect to its flora under JNCC CSM Guidelines (JNCC 2015). Levels of filamentous algae were reasonably high during the 2016 survey. The newly identified presence of the invasive alien species *Lagarosiphon major* is extremely worrying and it is recommended that efforts are made to identify any extant

in-lake or external source populations and to limit or stop its spread within Llyn Padarn.

Submerged and floating vegetation	% cover	Submerged and floating vegetation	% cover
<i>Callitriche brutia</i> var. <i>hamulata</i>	1.74	<i>Luronium natans</i>	6.73
<i>Elatine hexandra</i>	1.85	<i>Lythrum portula</i>	0.71
<i>Elodea nuttallii</i>	10.46	<i>Myriophyllum alterniflorum</i>	5.03
<i>Fontinalis antipyretica</i>	2.53	<i>Nitella flexilis</i> agg.	4.58
<i>Isoetes lacustris</i>	8.03	<i>Nitella translucens</i>	2.45
<i>Juncus bulbosus</i>	0.25	<i>Potamogeton berchtoldii</i>	2.75
<i>Lagarosiphon major</i>	0.71	<i>Ranunculus aquatilis</i> agg.	1.58
<i>Littorella uniflora</i>	7.59	<i>Subularia aquatica</i>	0.02
Species richness			16
WFD LEAFPACS Classification			Good
Confidence in Class			89.2%
Certainty < Good			10.1%

Table 13. CSM Survey results from Llyn Padarn 2016.

The LEAFPACS survey classified Llyn Padarn as Good status with 89.2% confidence. This represents the best result for the lake to date: previous surveys in 2005, 2009, 2012 and 2014 reclassified using the current method gave results of either Moderate or Good with lower levels of confidence: only the 2003 result is similar. This may reflect recent efforts to reduce nutrient levels in the lake, but further data is required for confirmation. This result also does not take into account the appearance of the invasive *Lagarosiphon major*.

Dissolved oxygen and temperature profiles show the lake to be stratified at the time of sampling with the main boundary in temperature and oxygen occurring at approximately 15 m, below which temperatures fall to 10.2 °C by 27 m. Dissolved oxygen concentrations also fall to nearly zero by the bottom of the profile (Figure 35). This is in line with previous monitoring results for the lake.

Dissolved Oxygen Profile

GPS Location SH5812660495

Maximum Depth (m) 27.4 m

Secchi Depth (m) 4.55 m

Notes:

Depth (m)	DO (mg/l)	Temp (°C)
0	9.55	16.2
0.5	9.52	16.2
1	9.5	16.2
1.5	9.5	16.2
2	9.55	16
3	9.49	15.9
4	9.57	15.9
5	9.52	15.8
6	9.5	15.8
7	8.65	15.1
8	8.61	14.9
9	8.58	14.8
10	8.48	14.7
12	8.31	14.4
14	6.87	13.8
16	3.28	11.7
18	2.33	10.9
20	1.89	10.8
22	1.72	10.6
24	1.19	10.5
26	0.37	10.3
27	0.3	10.2

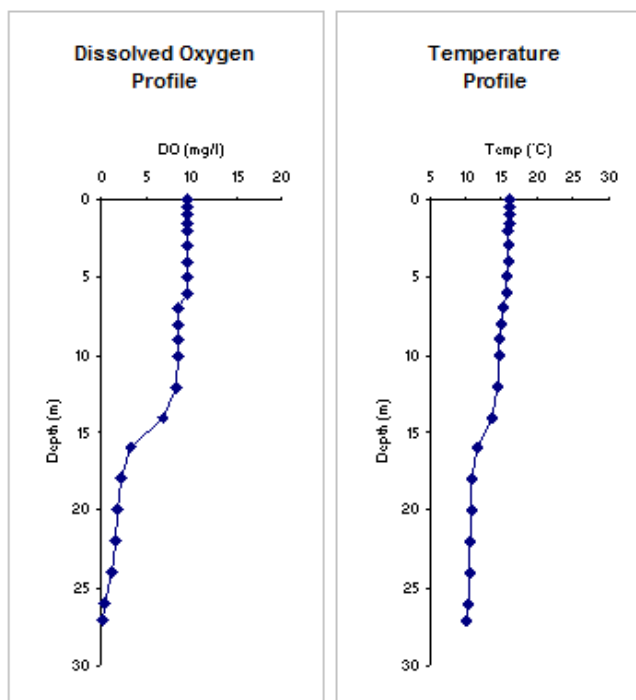


Figure 35. Dissolved oxygen and temperature profiles at Llyn Padarn (20/09/2016).

5.2.12. Llyn Cwm Bychan



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Figure 36 Site map and aerial photograph of Llyn Cwm Bychan

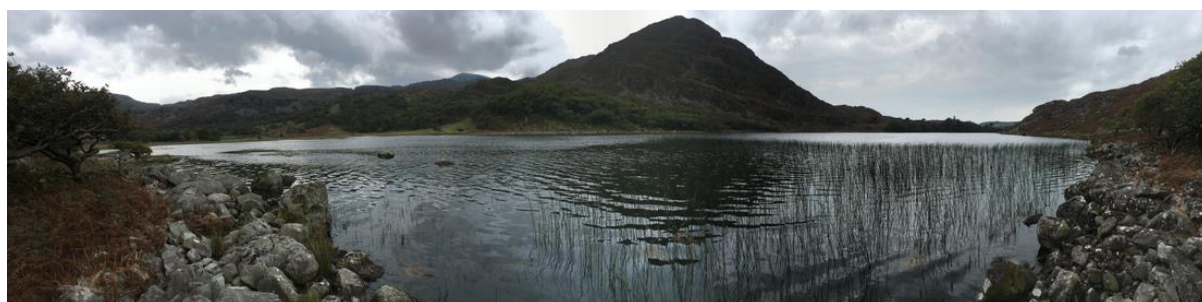


Figure 37 Llyn Cwm Bychan site photo; from the north-east shore looking south-west

Llyn Cwm Bychan is a small (14 ha), relatively shallow (max. depth 14.0 m) low altitude lake situated in Gwynedd, North Wales. It lies within the Rhinog SSSI and SAC and the Snowdonia National Park. The catchment is predominantly upland heath, with some acid grassland and a very small amount of agriculture at the eastern end of the lake. A road runs along much of the north shore and there are patches of woodland next to the South shore.

The aquatic macrophyte flora is typical for an oligotrophic lake and the site supports 14 species (Table 14). The submerged assemblage of the shallow and silty eastern end of the site is relatively rich, and is dominated by *Lobelia dortmanna*, *Littorella uniflora* and *Juncus bulbosus* with *Isoetes echinospora*, *Utricularia vulgaris*, aquatic *Sphagnum* sp., *Eleogiton fluitans*, *Myriophyllum alterniflorum*, *Potamogeton berchtoldii*, *Sparganium angustifolium* and a little *Luronium natans* also present.

The shoreline substrate of the survey sections in the rest of the lake is predominantly boulders, in amongst which grow pockets of *Lobelia dortmanna*, *Littorella uniflora*, *Isoetes echinospora*, *Myriophyllum alterniflorum* and *Eleogiton fluitans*. Section two on the south of the site has a more silty substrate and greater densities of plant growth, particularly of *Myriophyllum alterniflorum*, *Juncus bulbosus* and *Eleogiton fluitans* up through the water column and *Luronium natans* and aquatic *Sphagnum* sp. on the lake bed.

The population of *Luronium natans*, an SAC feature of the site, appears to be secure, and in the 2016 survey the species was only absent from the steeply shelving section three next to the road. Dive surveys (CCW, unpublished data) suggest that *L. natans* is more widespread in the lake than is usually detected by the CSM survey.

The aquatic macrophyte flora remains consistent with previous surveys. There appears to be little change in the species assemblage and relative abundances since the surveys of 2004 (Goldsmith *et al.*, 2006), 2009 (Goldsmith & Shilland 2010) and 2013 (Goldsmith *et al.* 2014a). The current species list includes seven target species for oligotrophic lakes and would place the site in favourable condition with respect to its flora under JNCC CSM guidelines (JNCC 2015). However, filamentous algal cover is high, especially in shallower water. No alien invasive macrophyte species were found during the 2016 survey.

Submerged and floating vegetation	% cover	Submerged and floating vegetation	% cover
<i>Batrachospermum</i> sp.	2.2	<i>Menyanthes trifoliata</i>	1.7
<i>Eleogiton fluitans</i>	7.4	<i>Myriophyllum alterniflorum</i>	6.9
<i>Isoetes echinospora</i>	5.7	<i>Potamogeton berchtoldii</i>	0.8
<i>Juncus bulbosus</i>	5.4	<i>Potamogeton polygonifolius</i>	2.2
<i>Littorella uniflora</i>	5.4	<i>Sparganium angustifolium</i>	1.5
<i>Lobelia dortmanna</i>	5.4	<i>Sphagnum</i> (aquatic indet.)	6.7
<i>Luronium natans</i>	2.5	<i>Utricularia vulgaris</i>	2.9
Species richness			14
WFD LEAFPACS Classification			Good
Confidence in Class			64.5
Confidence < Good			0%

Table 14. CSM Survey results from Llyn Cwm Bychan 2016.

The LEAFPACS tool classified Llyn Cwm Bychan as Good with 65% confidence or High with 35% confidence. Although this is the worst result for this lake since surveys commenced in 2004 and represents a face value deterioration in class, LEAFPACS results have always been close to the High-Good boundary. Llyn Cwm Bychan is also recovering from acidification, and the resulting increase in alkalinity also means that the LEAFPACS reference values may no longer accurately reflect conditions in the lake. This would result in the LEAFPACS result being slightly pessimistic.

Dissolved oxygen and temperature profiles show the lake to be stratified at the time of sampling with a thermocline at approximately 7 m, below which temperatures fall to 13.8 °C by 14 m. Dissolved oxygen concentrations also fall to only 2.2 mg/l by the bottom of the profile (Figure 38).

Dissolved Oxygen Profile

GPS Location SH6394831265
 Maximum Depth (m) 14 m
 Secchi Depth (m) 3.3 m

Notes:

Depth (m)	DO (mg/l)	Temp (°C)
0	9.12	16.4
0.5	9.17	16.4
1	9.15	16.3
2	9.14	16.3
3	9.08	16.2
4	9.1	16.1
5	8.67	16.1
6	8.73	16
7	8.24	15.3
8	7.18	14.8
9	5.54	14.4
10	4.59	14.1
11	4.18	14
12	3.67	14
13	3.03	13.9
14	2.2	13.8

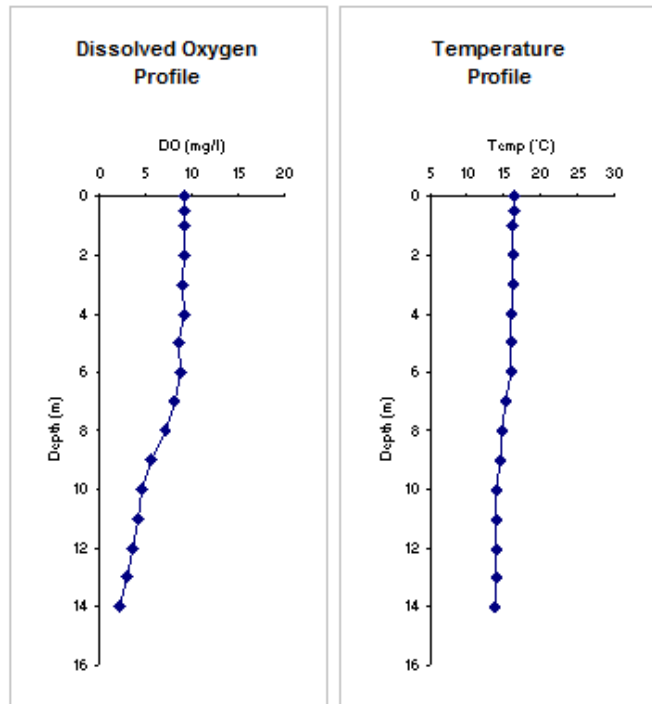
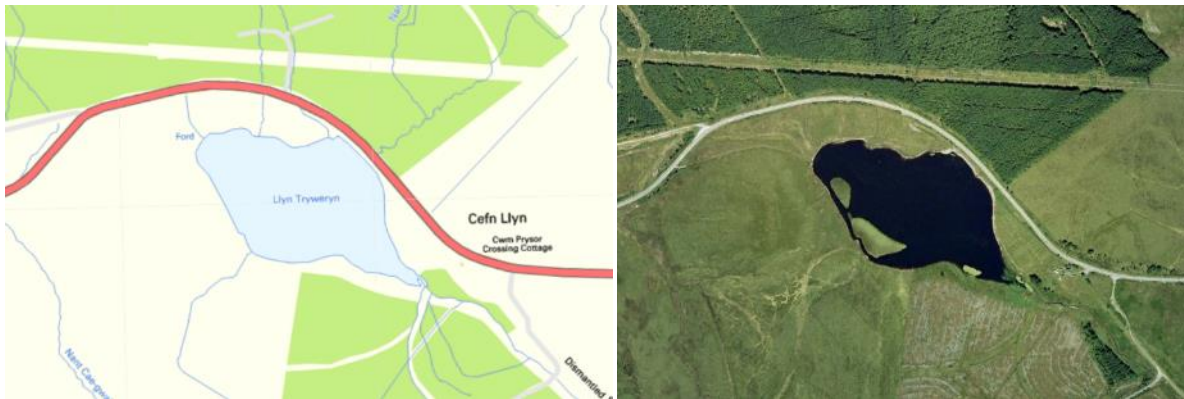


Figure 38. Dissolved oxygen and temperature profiles at Llyn Cwm Bychan (21/09/2016).

5.2.13. Llyn Tryweryn



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Figure 39. Site map and aerial photograph of Llyn Tryweryn.



Figure 40 Llyn Tryweryn site photo; from the north-west shore looking south-east

Llyn Tryweryn is a small (7 ha), shallow (max. depth 8.0 m), dystrophic, mid altitude lake located in Gwynedd, North Wales. It lies within the Migneint-Arenig-Ddualit SAC and SSSI, and the Snowdonia National Park. The relatively small catchment consists largely of coniferous plantation forestry and acid grassland, with some areas of heath. The A4212 runs around the north and east of the lake.

The assemblage of aquatic macrophytes is poor, but typical of dystrophic lakes (Table 15). As can be seen in Figure 39, the most apparent component of the flora are the beds of white water-lily, *Nymphaea alba*, forming two large floating mats in the more sheltered west of the lake (maximum depth of colonisation 1.9 m) and smaller patches in the south-east corner. The yellow water-lily, *Nuphar lutea*, is also present in smaller amounts in-between the two *Nymphaea* mats in the west and in the shallower area near the outflow. *Isoetes echinospora* grows in the western and eastern edges of the site, at depths of between 50 cm and 1 m. One small patch of *Sparganium angustifolium* was located in section one and a single specimen of aquatic *Sphagnum* sp. was present in section two.

Some of the *Nuphar* surveyed in 2016 was unusually small. A leaf voucher brought back and examined exhibits some of the characteristics of the hybrid *Nuphar* x

spenneriana and we recommend revisiting the site during the flowering period of the species for further investigation.

The Secchi depth at the site has always been low but has generally decreased over the period of recent surveys, from 70 cm in August 2002 (Carvalho *et al.*, 2003), to 1.0 m in September 2004 (Goldsmith *et al.*, 2006), then 40 cm in August 2009 (Burgess *et al.* 2013).and most recently, in September 2016, to only 21 cm. In the survey discussed here the transparency was limited by the brown and humic nature of the water.

Supporting three of the characteristic species for dystrophic lakes (*Nymphaea alba*, *Sparganium angustifolium* and aquatic *Sphagnum* sp.) Llyn Tryweryn fulfils the JNCC (2015) macrophyte criteria for this lake type, although targets can be set on a site by site basis. However, decreases in the amounts of *Sparganium angustifolium*, aquatic *Sphagnum* sp. and aquatic liverworts since the last survey (Burgess *et al.*, 2013), the absence of *Fontinalis antipyretica*, decreasing maximum depth of *Isoetes echinospora* colonisation (from 1.4 m to 1.0 m) and decreasing water transparency levels give cause for concern. Very little filamentous algae and no alien invasive macrophyte species were found during the current survey.

Submerged and floating vegetation	% cover
<i>Isoetes echinospora</i>	6.61
<i>Nuphar lutea</i>	4.50
<i>Nymphaea alba</i>	9.31
<i>Sparganium angustifolium</i>	1.19
<i>Sphagnum</i> (aquatic indet.)	0.06
Species richness	5
WFD LEAFPACS Classification	Moderate
Confidence in Class	70.1%
Certainty < Good	71.4%

Table 15. CSM Survey results from Llyn Tryweryn 2016.

The LEAFPACS tool classified Llyn Tryweryn as Moderate with 70.1% confidence. This is very similar to previous results for the lake (Burgess *et al.* 2006, 2013). This failure is not due to a direct nutrient impact as there are no major nutrient sources in the catchment, but forestry drains and peat cutting are likely to have reduced water quality and caused nutrient enrichment and siltation.

Dissolved oxygen and temperature profiles showed the lake to be mixed at the time of sampling with no thermocline evident and only very slight declines in dissolved oxygen and temperature with increasing depth (Figure 41). This is not unexpected for a site that is relatively exposed.

Dissolved Oxygen Profile

GPS Location SH7894138498
 Maximum Depth (m) 8 m
 Secchi Depth (m) 0.21 m

Notes:

Depth (m)	DO (mg/l)	Temp (°C)
0	7.87	15
0.5	7.88	15
1	7.88	15
1.5	7.86	15
2	7.86	15
2.5	7.84	15
3	7.77	14.9
3.5	7.78	14.9
4	7.78	14.9
4.5	7.78	14.9
5	7.7	14.9
6	7.68	14.9
7	7.72	14.9
8	7.71	14.7

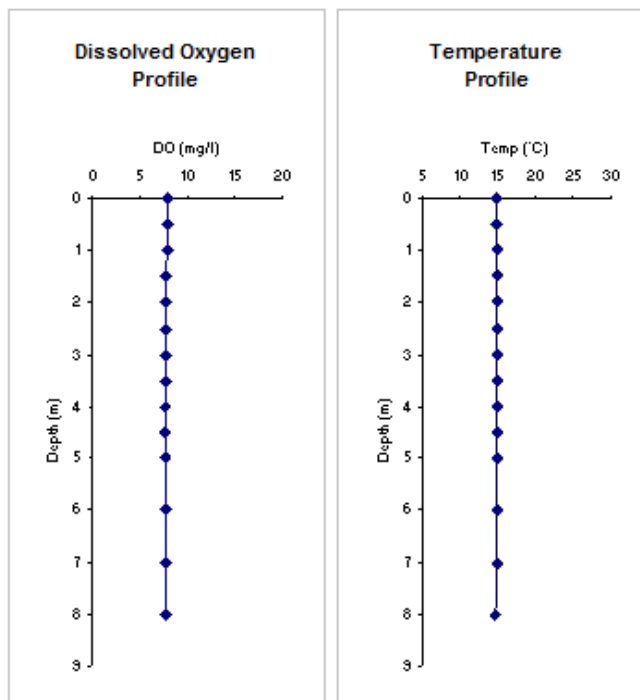


Figure 41. Dissolved oxygen and temperature profiles at Llyn Tryweryn (22/09/2016).

5.2.14. Eglwys Nunnydd Reservoir



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Figure 42. Site map and aerial photograph of Eglwys Nunnydd Reservoir.



Figure 43. Eglwys Nunnydd Reservoir site photo; from the east shore looking north-west.

Eglwys Nunnydd Reservoir is a large (91 ha), shallow (max. depth 3.6 m), moderate alkalinity lowland reservoir located in Neath Port Talbot, Wales. The site was originally constructed as a supply reservoir for the adjacent Port Talbot steelworks. It is now also used for leisure activities and there is a sailing club on the east of the site as well as shore angling. The M4 motorway runs close to the east of the reservoir

and the site is designated as the Eglwys Nunnydd Reservoir SSSI on account of the bird fauna. Nutrient concentrations at the site have been investigated by Natural Resources Wales (Hatton-Ellis, 2016).

The reservoir hosts a population of the alien invasive species killer shrimp (*Dikerogammarus villosus*) and thus for biosecurity reasons was left until last in the survey schedule.

With a maximum depth of 3.5 m and transparency (Secchi depth 1.65 m) to the bottom of the reservoir seemingly throughout, the area of aquatic macrophyte colonisation encompasses the entire bed of the site (maximum depth of colonisation 4.3 m). The aquatic macrophyte flora (Table 16) across the majority of the site is characterised by abundant *Potamogeton perfoliatus* and *Nitella flexilis* agg, interspersed with patches of *Myriophyllum spicatum* and both species of alien invasive *Elodea*, *E. canadensis* and *E. nuttallii*. Small amounts of *Chara virgata* are also found at depth. *Chara aspera* is present in the shallower area (0.75 m-1.4 m) in front of *Phragmites australis* beds at the northern end of the reservoir.

The survey date was possibly slightly too late in the season to capture the abundance of some of the fine-leaved *Potamogeton* species, although *Potamogeton trichoides* was recorded in three sections. In the survey of August 2010 (Goldsmith *et al.* 2011) *Potamogeton berchtoldii* and *Potamogeton pusillus* were present, however in October 2016 only unidentifiable small scraps of what may have been senescing fine-leaved *Potamogeton* sp. were recovered and no turions located. In this case absence of evidence is most probably not evidence of absence.

Whilst not necessary pertinent for such a heavily-modified water-body, the current species assemblage would place the site in unfavourable condition with respect to its flora under JNCC CSM Guidelines for mesotrophic lakes (JNCC 2015), having a single characteristic species present, *Potamogeton perfoliatus*. Nevertheless, the lake contains a reasonable diversity of aquatic plants. Very low amounts of filamentous algae were observed during the 2016 survey. Despite the artificial nature of the site, the results of the LEAFPACS tool are considered applicable.

Submerged and floating vegetation	% cover
<i>Chara aspera</i>	2.1
<i>Chara virgata</i>	0.4
<i>Elodea canadensis</i>	4.8
<i>Elodea nuttallii</i>	5.4
<i>Myriophyllum spicatum</i>	4.2
<i>Nitella flexilis</i> agg.	10.5
<i>Persicaria amphibia</i>	2.1
<i>Potamogeton perfoliatus</i>	15.8
<i>Potamogeton trichoides</i>	4.8
Species richness	9
WFD LEAFPACS Classification	Moderate
Confidence in Class	72.9%
Certainty < Good	95.7%

Table 16. CSM Survey results from Eglwys Nunnydd Reservoir 2016.

LEAFPACS gave a classification of Moderate with 72.9% confidence, and 95.7% certainty that the water body is worse than Good. The lake also contains both of the widespread invasive *Elodea* spp. Nevertheless, for a concrete lined artificial water body, the reservoir contains a reasonable assemblage of aquatic plants including substantial beds of *Potamogeton perfoliatus* and the relatively uncommon *Chara aspera*. This can be considered to represent Good Ecological Potential at this site.

There was a strong breeze during the survey and as a consequence the water column was well mixed to maximum depth and with no appreciable decline in dissolved oxygen concentration or temperature (Figure 44).

Dissolved Oxygen Profile

GPS Location SS7935885078
 Maximum Depth (m) 3.5 m
 Secchi Depth (m) 1.65 m
 Notes:

Depth (m)	DO (mg/l)	Temp (°C)
0	10.34	15.1
0.5	10.33	15.1
1	10.32	15.1
1.5	10.32	15.1
2	10.3	15.1
2.5	10.28	15
3	10.27	15
3.5	10.24	15

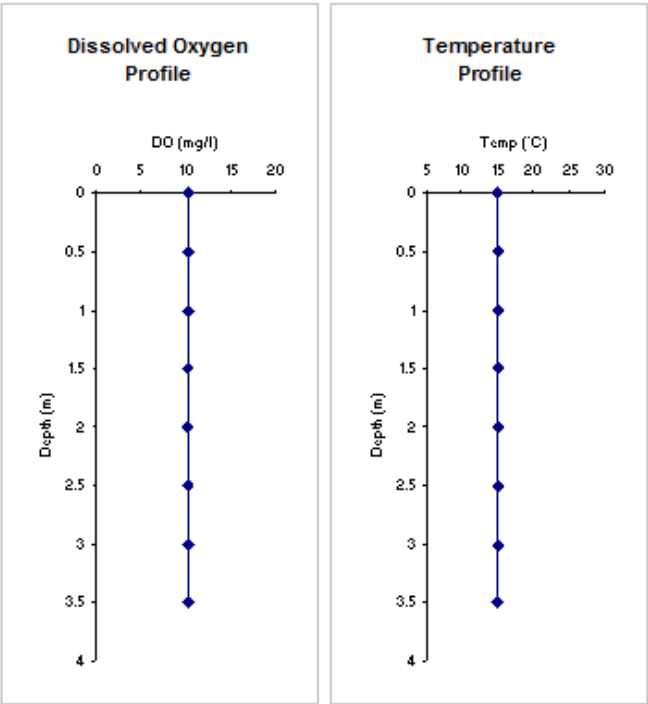


Figure 44. Dissolved oxygen and temperature profiles at Eglwys Nunnydd Reservoir (03/10/2016).

6. Conclusions

The fourteen lakes surveyed cover a wide area of Wales and are broadly representative of the main water body types in the country, with a majority of upland, low alkalinity waters. In general this is reflected in the floras which tend to be dominated by isoetid vegetation.

The results of this survey work will be used by NRW to generate formal WFD classifications and Condition Assessments for the Habitats Directive. It is not the aim of this report to replicate this process and so this is not taken further: key metrics for this purpose are listed in Table 2 and outline classifications in the site accounts. However, the following remarks are relevant to the management and understanding of the lakes surveyed and are therefore included for

6.1. Threatened Native Plant Biodiversity

A range of uncommon and threatened plant species were found or confirmed as still present during this work. These include:

Rugged stonewort *Chara rudis* was still present but very rare at its only Welsh site, Llyn Cadarn. This species was refound in the lake in 2013 (Goldsmith *et al.* 2014) after an absence of more than half a century, having presumably germinated from dormant oospores.

Floating water-plantain *Luronium natans* is listed on Annexe II of the Habitats Directive and is protected under the Wildlife and Countryside Act. Wales has special responsibility for this species and good populations were found in five lakes: Cwm Bychan; Dwythwch; Eiddwen; Fanod; and Padarn. These are all known sites for this species although Llyn Dwythwch is the first structured survey. *L. natans* tends to be under-represented in grapnel throws and therefore the true cover in these lakes is likely to be higher.

There are still good populations of **Griffiths's pondweed *Potamogeton x griffithii*** and ***P. x gessnacensis*** at Llyn Anafon. This lake also contains a small population of **red pondweed *P. alpinus***, considered Critically Endangered in Wales (Dines 2009).

Slender stonewort *Nitella gracilis* is a Biodiversity Action Plan priority species found predominantly in nutrient-poor, often slightly peaty lakes. It was found in two lakes: Morwynion and Dwythwch. There is only one previous (1979) record from Llyn Dwythwch.

Eight-stamened waterweed *Elatine hydropiper* was found in Cefni Reservoir. This nationally scarce species is fairly common on Anglesey and has presumably colonised from existing populations in adjacent lakes.

Spring quillwort *Isoetes echinospora* is considered Nationally Scarce, though it is probably under-recorded due to its similarity to the commoner *I. lacustris*. Spring

quillwort was found in seven lakes: Cwm Bychan; Dwythwch; Eiddew-Mawr; Eiddwen; Fanod; Morwynion and Tryweryn.

6.2. Invasive Non-native Species

Invasive non-native species (INNS) are an increasing threat to native biodiversity, especially in aquatic systems where they can spread very rapidly and outcompete native vegetation. In general, invasive species are correlated with human activity and so tend to be found disproportionately close to settlements and / or in lakes where intensive recreational activity occurs. The following INNS were found during the survey:

Australian swamp stonecrop *Crassula helmsii* was found in small quantities in section 3 of Llyn Cefni (around SH434771). Reservoirs can be highly suitable environments for this plant as it is tolerant of fluctuating water levels. However, it is possible that this population is still fairly small and controllable, so further survey followed by control measures if possible is recommended.

Canadian pondweed *Elodea canadensis* was found in fairly low abundances in Eglwys Nunnydd Reservoir, together with the related **Nuttall's water-thyme *E. nuttallii***. The latter species was also abundant in Cefni Reservoir where it was the dominant aquatic plant, and frequent in Llyn Padarn. It is unlikely that either species can be controlled in any of these sites but suitable biosecurity measures should be put in place.

Curly pondweed *Lagarosiphon major* was found for the first time this year in Llyn Padarn. The appearance of this highly invasive species here is a cause for concern, and it is likely that conditions in Llyn Padarn are suitable for its establishment, as it has rapidly spread in Tal-y-Llyn Lake where it became established around 2010. Further survey to establish its extent in the lake, followed by removal if possible is recommended to prevent it taking hold.

6.3. General Observations on the Plant Communities

Species Richness in most of the lakes surveyed was good, with all but two lakes having ten or more species and four lakes (Anafon and Fanod: 22 species; Dwythwch 20 species; Eiddwen 19 species) being notably species-rich. Only one lake (Llys-y-Fran Reservoir) had an unusually low plant diversity, which is likely to be caused by water level fluctuation. Consequently WFD classification with these data is not recommended. The **number of functional groups (N_FG)** showed a strong positive correlation with species richness, with N_FG being around 40% of NTaxa (Figure 45).

The WFD **algal metric ALG** showed evidence of a poor relationship with nutrient pressure. Whilst direct water chemistry data are not available for a comparison, the three highest ALG values were in Llyn Cwm Bychan (0.46); Eiddew-Mawr (0.42) and Dwythwch (0.37). All of these are upland lakes with no identifiable nutrient pressures and where previous water chemistry data has indicated very low nutrient concentrations. ALG also showed a negative relationship with LMNI (Figure 46), the most important eutrophication metric in LEAFPACS. This may perhaps be explained

by the tendency of upland lakes with a high proportion of rocky substrates to support higher filamentous algal cover, but nonetheless supports the low weighting given to the ALG metric in the LEAFPACS tool.

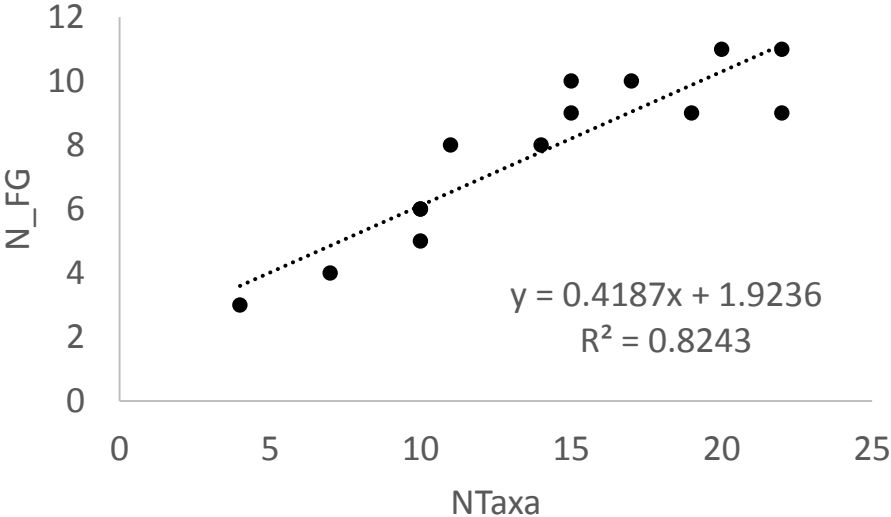


Figure 45 Relationship between NTaxa and N_FG for the 14 lakes surveyed

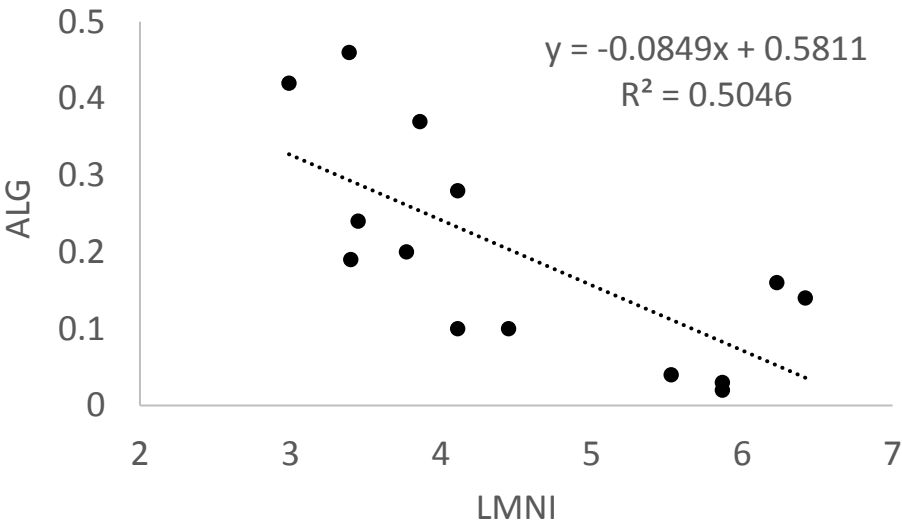


Figure 46 Relationship between LMNI and ALG for the 14 lakes surveyed.

Maximum depth of colonization is a well-established lake metric used in site condition monitoring but not for WFD. It is particularly useful as a measure of ecosystem structure. The majority of lakes surveyed had a good maximum colonization depth of between 3 and 5 m, consistent with clear water conditions and reasonably low algal loadings. The only lake with a maximum colonization depth <2 m was Llyn Tryweryn, but this is a dystrophic lake with naturally peat-stained water. It should be noted that the maximum colonization depth at this lake is not representative as it refers to *Nymphaea alba* and not a submerged species.

For SSSIs and SACs, the **number of typical species** is an important consideration. Whilst this varies depending on lake type, in general 4 or more typical species is sufficient and 7 or more indicates a good quality lake. Most of the protected lakes surveyed here had 7-10 typical species, but Llyn Cadarn and Llyn yr Wyth Eidion both had very low numbers of typical species (1 and 0 respectively). Llyn Tryweryn had only two typical species but this is of less concern at a dystrophic site as these are often naturally species-poor.

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7. Appendices

7.1. Appendix I: Aquatic species data for all sites

Table 17. Summary of all aquatic and macrophyte species for the 14 lakes. Figures represent per cent frequency at a site based on the LEAFPACS method; invasive alien species (INV) are shaded in orange.

	Cefni Reservoir	Eglwys Nunnydd Reservoir	Llyn Anafon	Llyn Cadarn	Llyn Cwm Bychan	Llyn Dwythwch	Llyn Eiddew-Mawr	Llyn Eiddwen	Llyn Fanod	Llyn Morwynion	Llyn Padarn	Llyn Tryweryn	Llyn yr Wyth Eidion	Llys-y-Fran Reservoir
<i>Batrachospermum</i> sp.					2.2		2.2		0.1	0.5				
<i>Callitriche brutia</i> var. <i>hamulata</i>			8.35			6.1	3.5	1.9	1	4.3	1.74			
<i>Callitriche</i> sp.						2.1			1				1.8	
<i>Chara aspera</i>		2.1												
<i>Chara globularis</i>	0.4													
<i>Chara rudis</i>				1										
<i>Chara virgata</i>		0.4	7.67											
<i>Chara vulgaris</i>				1										
<i>Crassula helmsii</i>	0.7													
<i>Elatine hexandra</i>						5			2.8		1.85			
<i>Elatine hydropiper</i>	2.7													
<i>Eleocharis acicularis</i>	3.1													
<i>Eleocharis multicaulis</i>								0.7						
<i>Eleogiton fluitans</i>					7.4		0.8							
<i>Elodea canadensis</i>		4.8												
<i>Elodea nuttallii</i>	22.3	5.4									10.46			
<i>Fontinalis antipyretica</i>			0.8	3.8		7		2.1	3.2	5.8	2.53		19.7	0.7

	Cefni Reservoir	Eglwys Nunnydd Reservoir	Llyn Anafon	Llyn Cadarn	Llyn Cwm Bychan	Llyn Dwythwch	Llyn Eiddew-Mawr	Llyn Eiddwen	Llyn Fanod	Llyn Morwynion	Llyn Padarn	Llyn Tryweryn	Llyn yr Wyth Eidion	Llys-y-Fran Reservoir
<i>Hippuris vulgaris</i>													4.7	
<i>Isoetes echinospora</i>					5.7	0.1	0.8	6	10.4	12.7		6.61		
<i>Isoetes lacustris</i>			3.83			11.4	7.3	2			8.03			
<i>Juncus bulbosus</i>			19.25		5.4	0.2	4.4	0.1		5.2	0.25			
<i>Lagarosiphon major</i>											0.71			
<i>Lemna minor</i>	5			1									3	
<i>Lemna trisulca</i>	17.2			18.2									6.4	
<i>Littorella uniflora</i>	8.1		10.39		5.4	8.9	7.3	9.1	7.8	4.6	7.59			18.2
<i>Lobelia dortmanna</i>			3.76		5.4	8.3	8.7	6	8.1					
<i>Luronium natans</i>					2.5	2.3		5.3	6.6		6.73			
<i>Lythrum portula</i>									1		0.71			
<i>Menyanthes trifoliata</i>			0.71	2.1	1.7	1.1		1.5	3				1.4	
<i>Myriophyllum alterniflorum</i>			3.34		6.9	3.7	6.7				5.03			
<i>Myriophyllum spicatum</i>		4.2												
<i>Nitella flexilis</i> agg.	1.2	10.5	2.16						3.9		4.58			
<i>Nitella gracilis</i>						0.4				5.8				
<i>Nitella translucens</i>			0.54					14.7	19.8		2.45			
<i>Nuphar lutea</i>						1.1			8.2			4.5	20.2	
<i>Nuphar lutea.</i>				16.9										
<i>Nymphaea alba</i>				4					2.9			9.31	12.1	
<i>Persicaria amphibia</i>	4.3	2.1												
<i>Potamogeton alpinus</i>			0.91											
<i>Potamogeton berchtoldii</i>	0.4		3.1		0.8	7.7		1.5			2.75		4.9	
<i>Potamogeton crispus</i>														3.5
<i>Potamogeton natans</i>								2.7	1.9					
<i>Potamogeton perfoliatus</i>	2.8	15.8												
<i>Potamogeton polygonifolius</i>			0.77		2.2	0.7	2.9	1.4	1					

	Cefni Reservoir	Eglwys Nunnydd Reservoir	Llyn Anafon	Llyn Cadarn	Llyn Cwm Bychan	Llyn Dwythwch	Llyn Eiddew-Mawr	Llyn Eiddwen	Llyn Fanod	Llyn Morwynion	Llyn Padarn	Llyn Tryweryn	Llyn yr Wyth Eidion	Llys-y-Fran Reservoir
<i>Potamogeton trichoides</i>		4.8												
<i>Potamogeton x gessnacensis</i>			2.17											
<i>Potamogeton x griffithii</i>			7.2											
<i>Ranunculus aquatilis</i> agg.	0.9		1.93								1.58			
<i>Ranunculus omiophyllus</i>									1					
<i>Sparganium</i> (aquatic indet.)	0.3												2.1	
<i>Sparganium angustifolium</i>			4.44		1.5	4.3	2.9	5.4	1	1.3		1.19		
<i>Sphagnum</i> (aquatic indet.)			0.1		6.7	1.1	3.1	0.1		6.5		0.06		
<i>Subularia aquatica</i>			1.12			6		1.3	11.7		0.02			
<i>Utricularia minor</i>				1				2.9						
<i>Utricularia vulgaris</i>			8.2		2.9		3.6							

7.2. Appendix II: Macrophyte Survey Section Locations

Common Standards Monitoring methods require that all transects (sections) are recorded with GPS, backed up by digital photographs. Table 18 details the wader survey start and end point, and the shore end and outer end of the boat sections. Photo numbers refer to the last 4 digits of the photo file name stored in folder “NWR_2016_Setion_Photos” the NRW data archive (see Appendix 7.3)

Table 18. Survey section OS Landranger grid references and photo numbers for the 14 lakes.

Site	WBID	Survey ID	Section Number	Wader start GPS	Wader end GPS	Boat Shore GPS	Boat Lake GPS	Start Photo	Section Photo	End Photo
Llyn Cadarn	32792	644	1	SH4925981114	SH4918981073	SH4922681087	SH4921780817	8480	8481	8482
			2	SH4928581188	SH4920781163	SH4924281181	SH4923881174	8485	8484	8487
			3	SH4917981142	SH4915881078	SH4915581115	SH4918181107	8489	8488	8491
Llyn yr Wyth Eidion	32761	643	1	SH4747181838	SH4741481808	SH4745681806	SH4744281828	8504	8505	8507
			2	SH4739181921	SH4745581937	SH4741381955	SH4741981939	8513	8512	8515
Cefni Reservoir	32926	645	1	SH4484377602	SH4479877503	SH4481577558	SH4478177593	8539	8540	8542
			2	SH4400477078	SH4411977100	SH4405677100	SH4405077210	8522	8523	8530
			3	SH4338677098	SH4347677143	SH4343377112	SH4363277102	8518	8519	8520
			4	SH4435577647	SH4444877612	SH4440677628	SH4437477567	8531	8532	8536
Llys-y-Fran Reservoir	40087	646	1	SN0417826402	SN0419126501	SN0420226443	SN0419626446	479	480	481
			2	SN0395225714	SN0397725820	SN0396825778	SN0395825767	482	483	484
			3	SN0400624904	SN0410524924	SN0405624917	SN0405924940	485	486	487
			4	SN0285924784	SN0295824784	SN0290624778	SN0291024784	488	489	490
Llyn Anafon	33374	647	1	SH6996469721	SH6992869655	SH6989769708	SH6978669848	8575	8574/73	8572
			2	SH6988569621	SH6985269667	SH6988569645	SH6980769801	8565	8566/67	8568
			3	SH6976569961	SH6972169961	SH6974269996	SH6975469855	8546	8545	8547
			4	SH6972769794	SH6978969735	SH6974469765	SH6978269777	8552	8553	8556

Site	WBID	Survey ID	Section Number	Wader start GPS	Wader end GPS	Boat Shore GPS	Boat Lake GPS	Start Photo	Section Photo	End Photo
Llyn Morwynion	34613	648	1	SH7366542120	SH7357142166	SH7360342135	SH7363742194	8618	8619	8620
			2	SH7357642375	SH7362942444	SH7360942407	SH7363742392	8613	8614	8616
			3	SH7395342460	SH7388842503	SH7392442474	SH7390342477	8584	8585	8586
			4	SH7381142239	SH7388842263	SH7385642233	SH7384542346	8588	8589	8609
Llyn Dwythwch	33920	649	1	SH5692857793	SH5683357829	SH5687957796	SH5701758012	8630	8631	8632
			2	SH5712857827	SH5705557811	SH5708257814	SH5706858014	8634	8635	8636
			3	SH5691057983	SH5688858099	SH5689558031	SH5689558031	8637	8638	8639
			4	SH5713558137	SH5717558045	SH5715758093	SH5713258090	8646	8647	8662
Llyn Eiddwen	38422	650	1	SN6050066779	SN6042766802	SN6045166788	SN6055066895	492	498	497
			2	SN6053067027	SN6060167089	SN6056667070	SN6058467044	499	500	501
			3	SN6069166929	SN6076166973	SN6073866935	SN6071466973	502	503	504
			4	SN6083367186	SN6078167233	SN6081367241	SN6077967167	505	506	507
Llyn Eiddew-Mawr	35056	651	1	SH6463034024	SH6469833948	SH6467234004	SH6462833968	8678	8679	8696
			2	SH6474533598	SH6470633468	SH6472333529	SH6464133593	8666	8667	8668
			3	SH6459533575	SH6452833641	SH6457433621	SH6461033630	8669	8670	8671
			4	SH6447433856	SH6442333917	SH6444033883	SH6457833970	8674	8675	8676
Llyn Fanod	38544	652	1	SN6040764362	SN6041464314	SN6045364346	SN6040464337	607	611	612
			2	SN6020164158	SN6011264155	SN6015464135	SN6017364194	613	616	621
			3	SN6042064453	SN6036864499	SN6041264497	SN6038364455	622	624	623
Llyn Padarn	33730	653	1	SH5825260235	SH5815560238	SH5820060246	SH5820860267	8699	8700	8701
			2	SH5811560777	SH5802660825	SH5807060796	n/a	8703	8704	8705
			4	SH5599762301	SH5603162213	SH5602062258	SH5606462281	8711	8712	8719
			5	SH5745260796	SH5737460859	SH5741460829	SH5744760873	8706	8707	8708
Llyn Cwm Bychan	35180	654	1	SH6430731427	SH6421931421	SH6426531415	SH6427531309	8748	8749	8754
			2	SH6406631135	SH6401331087	SH6404531111	SH6399031200	8742	8743	8744
			3	SH6397731344	SH6390031317	SH6393931330	SH6393931322	8745	8746	8747

Site	WBID	Survey ID	Section Number	Wader start GPS	Wader end GPS	Boat Shore GPS	Boat Lake GPS	Start Photo	Section Photo	End Photo
			4	SH6375631130	SH6369231234	SH6371431175	SH6376431228	8739	8740	8741
Llyn Tryweryn	34854	655	1	SH7881838631	SH7890538626	SH7885538615	SH7884838595	8764	8765	8766
			2	SH7870538508	SH7874438440	SH7872238469	SH7876138484	8757	8758	8759
			3	SH7906138385	SH7903038477	SH7904238428	SH7902038414	8761	8762	8763
			4	SH7974085218	SS7971485074	SS7974185143	SS7936685059	8889	8890/92	8891
Eglwys Nunnydd Reservoir	42079	656	1	SS7996384148	SS7986384060	SS7995384096	SS7984784154	8867	8868	8869
			2	SS7947585508	SS7955785422	SS7950485466	SS7935885087	8881	8882	8888
			3	SS7915684616	SS7912984716	SS7913684666	SS7936784681	8873	8874	8876
			4	SS7974085218	SS7971485074	SS7974185143	SS7936685059	8889	8890/92	8891

7.3. Appendix III: Data Archiving

Data outputs associated with this project are archived on server-based storage at Natural Resources Wales.

The data archive contains:

[A] The final report [NRW_Ecological_Surveys_of_Welsh_Lakes_2016_Final.docx] in Microsoft Word and Adobe PDF formats.

[B] Leafpacs calculator files within folder [NRW_2016_Leafpacs_Data] in Microsoft Excel format [Lake_name_LEAFPACS 2 0_metriccalculator_Month_Year] and summary information in MS Excel format [Site_metrics_Summary_2016.xls]

[C] A full set of digital photographs from the surveys in [jpg] format in folder [NRW_2016_Section_Photos] and sub-folders [<site_name_WBID>].

[D] A species list for all sites in MS Excel format suitable for upload to Recorder [NRW_2016_Lake_Species_Data_Recorder.xls].

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 [119140]



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