Final Report to Natural England

Investigation into water level requirements of interest features at Over Water SSSI: Phase 3

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Executive summary

- Over Water is a small lake in the north west of the Lake District National Park. The Over Water SSSI was first notified because of the biodiversity of the aquatic macrophytes and marginal vegetation at the site, as well as the comparative productivity of the lake compared to surrounding water bodies.
- Recent aquatic macrophyte surveys suggest that the site has deteriorated, having lost "characteristic" species for which it was originally notified. Although Over Water was already subject to abstraction at the time of notification, reduced water levels as well as nutrient enrichment have been suggested as a cause of this change.
- Newly available data for 2007 and 2008 suggest that annual abstraction volumes have been relatively low in these years, when compared to peaks in 1995-1996, 2001 and 2003. On average, abstraction is highest between July and September.
- Though the length of severity of drawdown can be statistically related to annual abstraction totals, there is much variability in these relationships. "Naturalisation" of water levels would suggest that abstraction has not been a major driver of water level variation between 2007 and 2009. However, a lack of detailed data renders this conclusion uncertain. A comprehensive hydrological budget is urgently needed for the lake, to evaluate the extent to which abstraction can account for water level variation.
- A new macrophyte survey was carried out in August 2009. This recorded two notified species that had not been found in recent surveys: *Callitriche hermaphroditica* and *Elatine hexandra.* The overall recorded depth-distribution of macrophytes (depth for 50% species loss) was shallower than a previous survey in 2005 by about 1.2 m and the maximum colonisation depth was about 0.8 m shallower. There may be methodological reasons for these differences but the change is also consistent with a deterioration in the underwater light climate. No data are available to test this suggestion.
- The available data suggest that there has been an enrichment of Over Water between 1985-1989 and 2003-2009. Winter nitrate-nitrogen concentrations, spring/summer alkalinity and summer chlorophyll *a* concentrations have increased significantly. A recent palaeolimnological survey also suggests that total phosphorus concentrations have increased in the lake, particularly in recent years. Recent data suggest that Over Water is at the upper end of the trophic range of the lakes sampled in the Lakes Tour of 20 lakes carried out by CEH.
- Using the Trophic Ranking Score (TRS) approach, the emerged and submerged macrophytes suggest that Over Water has a mesotrophic water quality although the chlorophyll *a* concentration

suggests the lake is eutrophic: possible evidence for an increase in trophic status in the lake given the slower response-time for macrophyte species composition compared to water chemistry.

- A reduction in water level to 1.5 m below top water level (as happened in 1995) or 2.1 m (as happened in 1996) is likely to have a severe impact on the macrophyte community and could have been responsible for the noted loss of species such as *Isoetes lacustris* and *Myriophyllum alterniflorum*.
- By combining information on the percent water abstracted at different water levels over the last fifteen years, and the loss of macrophyte species at different water levels, we recommend that level should not be allowed to fall below 1 m below top water level. This will only restrict the resource removed by about 7% and will help safeguard the macrophyte community in Over Water.
- Using Water Framework Directive typologies, Over Water was categorised as Poor -Moderate status during the period 2004-2009. A programme of measures is urgently needed to improve the water quality of the lake. However, an essential first step is the construction of a nutrient budget for the site to identify the major sources and fluxes of phosphorus.

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Background

The Over Water SSSI, in the north west of the Lake District National Park, was first notified in 1965 under the 1949 National Parks and Access to the Countryside Act. The notification of the site was largely based on the biodiversity of the aquatic macrophytes and marginal vegetation as well as on the comparative productivity of the lake compared to other surrounding water bodies.

The results of recent aquatic macrophyte surveys suggest that the site is undergoing deterioration, with the loss of a number of the "characteristic" species for which the site was originally notified (Natural England 2006). This evidence is supported by the concerns of local residents, who have noticed a loss of both marginal vegetation and characteristic local fauna. The two key issues that have been identified as possible causes of this change are 1) the reduction of water levels in the lake and 2) nutrient enrichment. Despite the fact that Over Water was already subject to abstraction at the time of notification, it has been suggested that recent reductions in water levels have been the result of high levels of abstraction. There is concern that nutrient enrichment has been at least partially driven by high wildfowl numbers on Over Water, although these birds are seasonal visitors to the site and are not believed to contribute greatly to the total nutrient load (Thackeray & Maberly 2007).

Natural England identified a number of key objectives that should guide and structure an investigation into the extent to which water level fluctuation could be responsible for the observed ecological changes at Over Water SSSI. The decision was made to conduct the investigation in a series of distinct phases. In the first phase, now complete, the emphasis was on analysing the available data for evidence of links between abstraction, water levels and the loss of interest features in the SSSI (Thackeray & Maberly 2007). The conclusions of this work were that, in dry years, abstraction could potentially account for much of the observed variation in water level at this site and that these fluctuations may have had an adverse effect on the macrophyte community of Over Water.

In the second phase, two approaches were used to identify possible hydrological thresholds that would assist in the protection of the ecological interest features of the SSSI. Firstly, a hydroacoustic survey was conducted of the contemporary macrophyte community of Over Water in order to quantify the degree to which macrophyte beds would be exposed under a range of draw down scenarios (Thackeray, Maberly & Winfield 2008). Secondly, the available macrophyte survey data were analysed in order to estimate the likely loss of species under a range of possible draw down scenarios. Hydrological thresholds derived from each of these approaches were then compared in order to define a “hands-off” lake level, below which significant ecological deterioration might be expected. By further analysis of the available water level and abstraction data, the hands-off lake level was related to the cumulative abstraction in order to give an estimate of the volume of water that could be abstracted from Over Water without bringing about severe ecological deterioration.

At the completion of phase two of the investigation, hydroacoustic and conventional macrophyte survey data were used to recommend a “hands-off” lake level of 0.9 m below top water level, btwl (Thackeray, Maberly & Winfield 2008). It was estimated that this would result in an estimated loss of 12.5-16% of the macrophyte areal coverage and of approximately 10% of the macrophyte species present. However, in the absence of detailed depth distributions for many of the macrophyte species at the site, this recommendation necessarily relied upon extensive use of expert opinion. It was decided, therefore, that a contemporary macrophyte survey should be conducted to provide these missing depth distribution data. This would allow a more robust assessment of the potential for past water level change to have had a detrimental effect on the ecology of Over Water and confirmation or otherwise of the loss of the species for which the site was originally designated. In what follows, these newly collected macrophyte data are analysed along with water level, abstraction and water quality data collected since the phase 2 analysis. The aims of this work are to:

i) Re-assess, using data from 2007-2009, the potential role of abstraction-driven water level change in affecting the macrophyte community at Over Water
ii) Examine the possibility that changes in water quality are responsible for observed ecological changes at the site
iii) Determine a suitable “hands-off” lake level, and corresponding permissible abstraction volume, if this pressure is believed to have had a detrimental effect on the ecology of the site

The relationship between abstraction and water level at Over Water

Temporal variation in abstraction and water level

Thackeray & Maberly (2007) presented an analysis of water level and abstraction over the period 1994-2006. It is now possible to extend this analysis using additional data collected from 2007 to 2009 (Fig. 1). Annual abstraction volumes were low in 2007-2009, compared to previously identified peaks in 1995-1996, 2001 and 2003 (Fig. 2a). Data were not provided for the whole of 2009, and results for this year are based upon data collected up to 2nd August (water level) or 29th November (abstraction). Re-calculation of monthly mean abstraction volumes, using data from the extended time period, confirms that abstraction tends to be highest between July and September (Fig. 2b).

Over the whole period there has been marked interannual variation in the duration of the drawdown period and the severity of drawdown (Fig. 3a,b). Herein, the duration of the drawdown period is defined as the length of time during each year over which water levels were recorded as being below top water level. Severity is defined as the maximum level below top water level. Long (Fig. 3a) and extreme (Fig. 3b) drawdown periods occurred in the high abstraction years 1995 and1996. However, the association between abstraction and drawdown would appear rather variable. High abstraction in 2003 was coincident with a long drawdown period though not an exceptionally low water level, when compared with 1995-1996. Also, a comparatively low abstraction volume in 2007 coincided with a long drawdown period of over 100 days (Fig. 2a, 3a).

Examination of monthly mean water levels, based on all available data, would suggest lower mean levels between July and September i.e. during the months of peak abstraction (Fig 3c). The highest monthly maximum levels below top level (i.e. the most severe drawdown) occurred July-October, and there is also evidence that in some years significant drawdown occurred in the spring. Maxima of in excess of 0.5 m btwl occurred between April and June.

Relationships between abstraction and water level

A key issue to be resolved for Over Water is the extent to which observed water level variations have been driven by abstraction or natural variations in hydrological fluxes such as inflow and evaporation. Thackeray & Maberly (2007) attempted to address this issue using three complementary approaches:

1) Statistical analysis of the relationships between abstraction and observed water level variation.
2) "Naturalisation" of water levels by calculating what water levels would have been in the absence of abstraction.
3) Calculation of a water balance for the site.

Conclusions from this first phase of the Over Water investigation suggested that in dry, high abstraction years much of the variability in water level could be accounted for by abstraction. However, it was clear that there was much natural variability in water level too. Herein, and incorporating the newly available data from 2007-2009, we have repeated the analysis of the relationships between annual abstraction and water level parameters.

At the annual scale total abstraction, drawdown length and severity are significantly related to each other (Fig 4). The length of the drawdown period increases significantly in years with high total annual abstraction (Fig. 4a, $F_{1,11}$=10.72, P<0.01, R^2 = 0.45). The severity of drawdown is also greater in high abstraction years (Fig. 4b, $F_{1,11}$=9.51, P=0.01, R^2 = 0.42). Annual abstraction therefore explains 42-45% of the total variation in water level parameters; so there is clearly much variation in water level that cannot be explained as a function of annual total abstraction.

We have also attempted to "naturalise" water levels for 2007-2009, using the methodology from Thackeray & Maberly (2007). We repeat this approach here. Using the level data and the 2005 bathymetric data it was possible to produce a function to describe the dependence of reservoir volume on level. Using this function, the volume for the reservoir was calculated based on each level measurement to produce a time series of reservoir volume. During the drawdown period of each year, the cumulative abstraction volume was also calculated on each day (the total volume abstracted during the drawdown period of that year up to and including the day being considered). In order to "naturalise" the reservoir volume, the cumulative abstraction volume was added to the observed reservoir volume on each day. This produced an estimate of what the reservoir volume would have been, if the water had not been abstracted. From this new volume, the new lake level was calculated from the relationship between water level and lake volume. When the new lake volume exceeded the capacity of the reservoir, the lake level was set to 9 m (the maximum depth of Over Water). In reality, this would indicate that water would have been flowing over the spillway at this time, if there had been no abstraction. The flow of water over the spillway is not gauged and the dimensions of the spillway are not known. Therefore, once the naturalised volumes indicate that the reservoir is full, we must interpret subsequent water level data with caution.
Using this approach for 2007-2009 (Fig. 5), it would appear that abstraction accounted for little of the observed water level variation in the lake. However, this is only a crude approximation of the likely effects of abstraction at the site. The approach cannot account for rapid changes in water level at the site such as the 0.5m drop in level over the course of one day at the start of the 2007 drawdown period. The suggestion is that this large and sudden change in lake volume is driven by natural variations but we cannot test this assertion directly with the present data. The only robust method of evaluating the contribution of abstraction to water level variation would be to quantify all of the major hydrological fluxes to/from the lake and construct a water balance. Presently, insufficient data are available for this but their collection should be treated as a high priority. Only then will we be able to evaluate, with any confidence, the extent to which abstraction regime affects water level at Over Water.

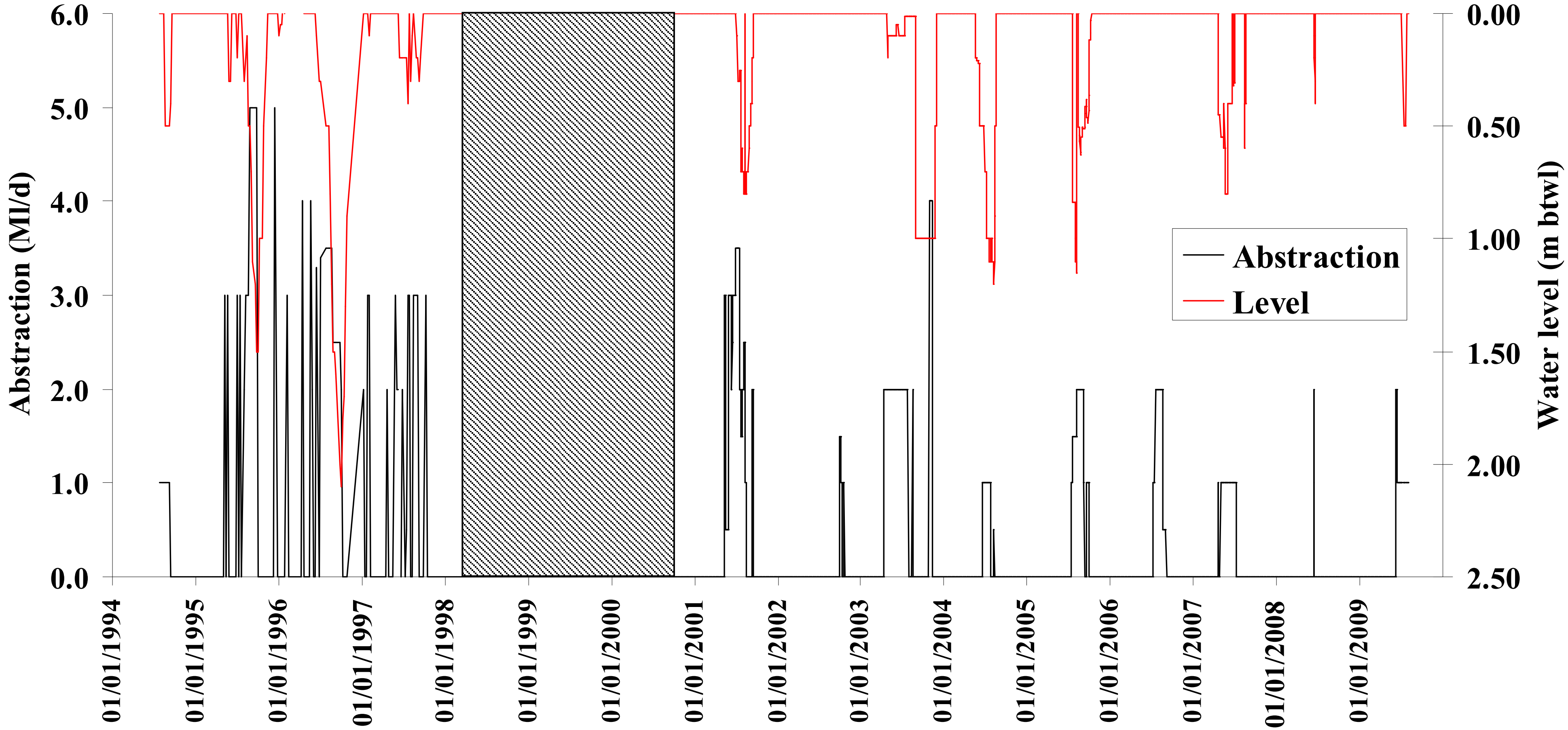


Figure 1. Water level (m below top water level, btwl) and daily abstraction rate for Over Water over the period July 1994 – August 2009. The hatched area indicates a period for which no water level data were available (March 1998-September 2000).

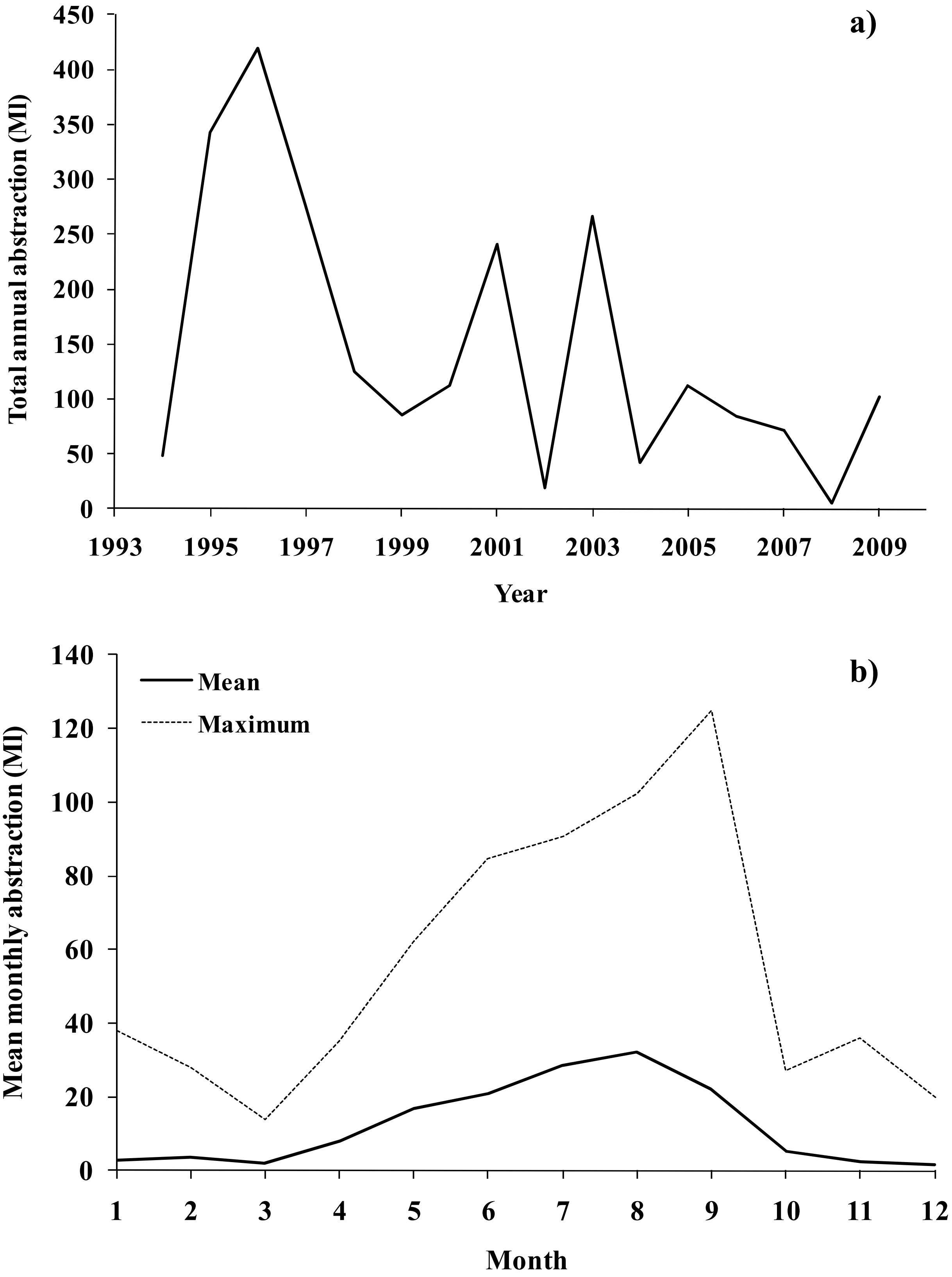


Figure 2. a) total annual abstraction for Over Water 1994-2009, b) the mean and maximum monthly abstraction from Over Water using data from the period 1994-2009. In panel b), the minimum monthly abstraction is zero in all months.

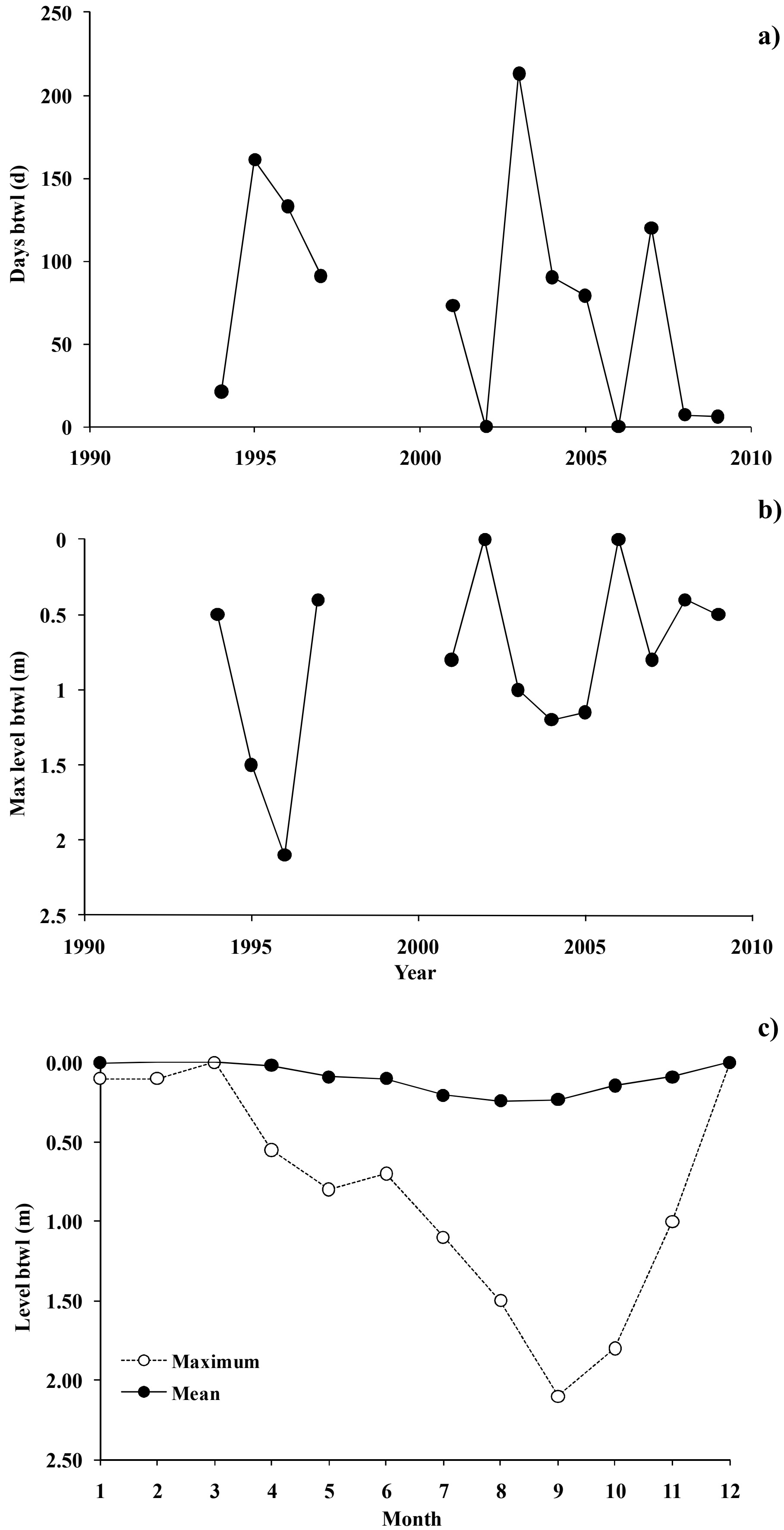


Figure 3. a) Duration of the drawdown period in Over Water 1994-2009, b) Maximum level below top water level (btwl) in Over Water 1994-2009 and c) Monthly mean and maximum levels below top water level (btwl) using data from 1994-2009 (excluding 1998-2000). In panel c), the minimum level below top water level is zero in all months.

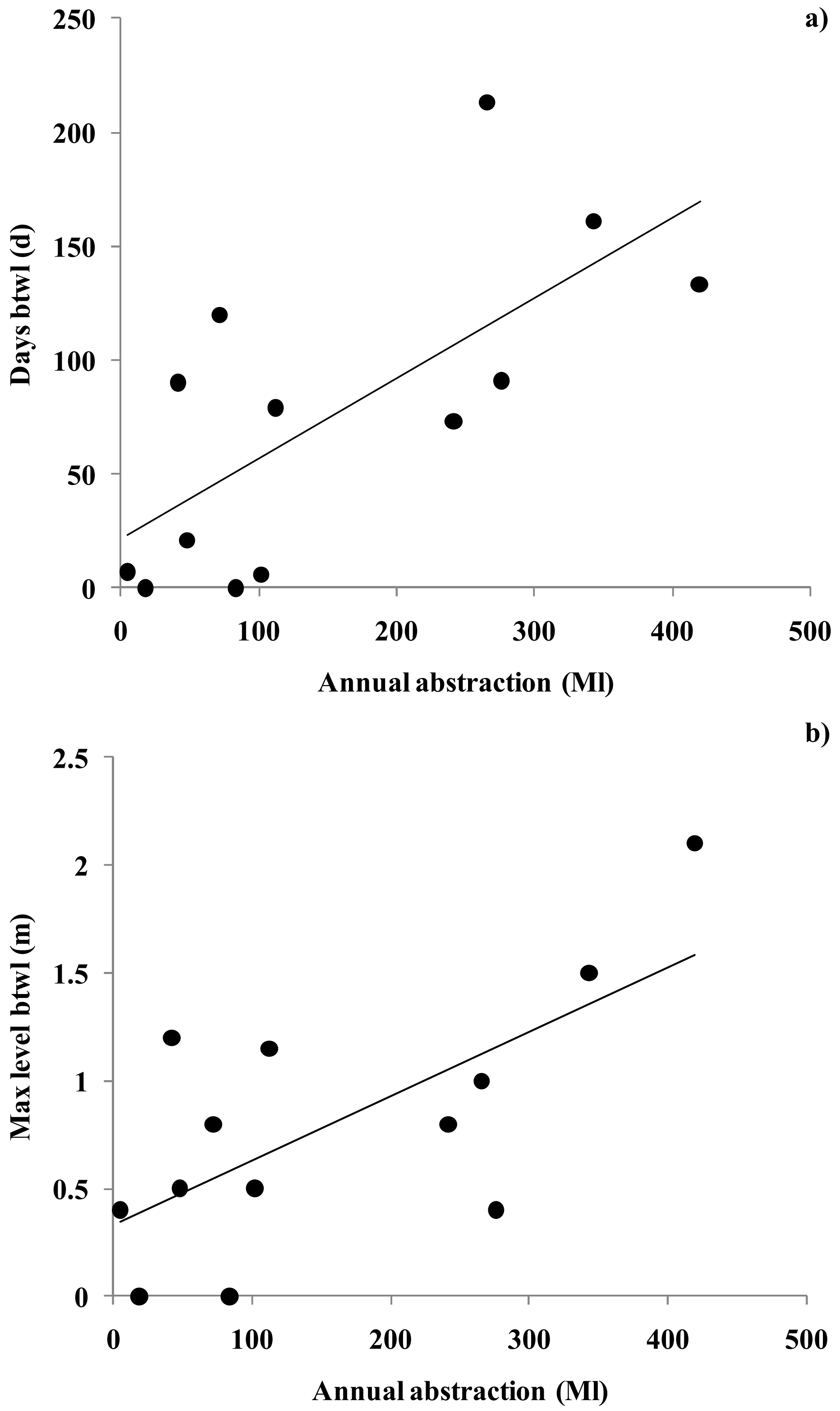


Figure 4. a) The relationship between annual total abstraction and the duration of the drawdown period in Over Water, using data from 1994-2009, b) The relationship between annual total abstraction and maximum level below top water level (btwl) in Over Water 1994-2009.

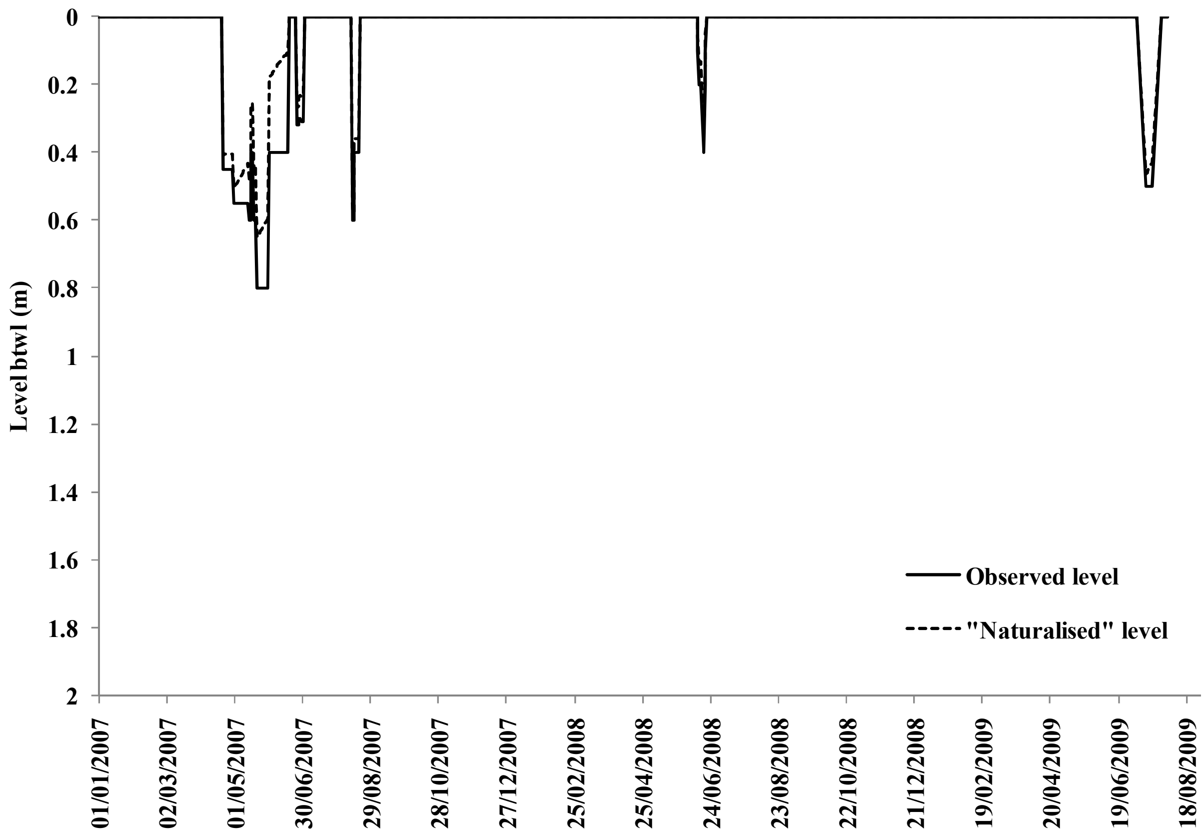


Figure 5. Observed and "naturalised" water levels for Over Water 2007-2009. All water levels are expressed in metres below top water level.

Macrophyte survey of Over Water in 2009

On 20 and 21 August 2009, a macrophyte survey was carried out at Over Water using a standard approach based on Site Condition Monitoring (SCM). This comprised four components; a strand-line survey, a wader survey, a boat transect and a general sweep. Ideally, following this protocol, strandline, wader and boat surveys would have been carried out at four sectors, each of 100 m length around the lake. However, time constraints resulting from bad weather, low light and high water levels meant that only two strandline and two wader surveys were possible. Since the main purpose of the survey was to determine depth ranges, the full four boat transects were performed. A brief description of the methods used is given in the appendices. The approximate location of the macrophyte surveys and a deep-water sampling point where temperature, oxygen and light profiles and samples for water chemistry were taken, are shown in Figure 6. On the survey dates, the water level was relatively high (0.25 at the level gauge by the outflow) and water was flowing over the weir.

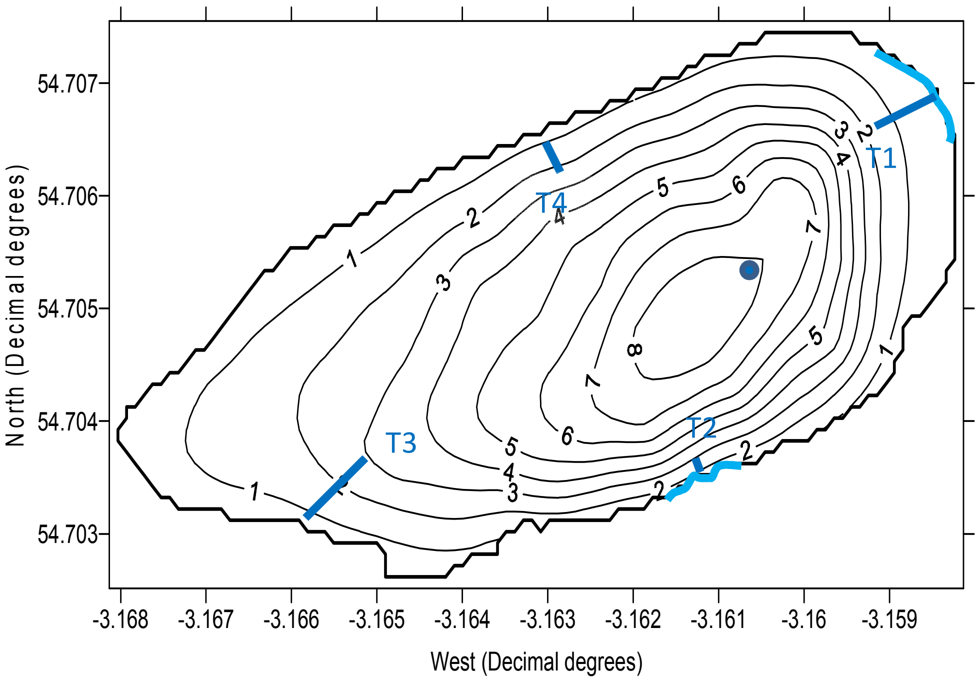


Figure 6. Map showing the approximate location of the four boat transects (T1 to T4), The two strand-line and wader surveys (pale blue line on shore) and the central water quality monitoring point. Precise locations are given in the Appendices.

At the time of the survey the lake was weakly stratified with a temperature difference throughout the water column of less than 1°C (Table 1) but there was a moderately large reduction in oxygen at depth suggesting that substantial oxygen depletion would have been likely when the stratification was stronger earlier in the summer. The light attenuation coefficient of 1.45 m^{-1} would have resulted in a reduction of underwater light to 1% of surface light at about 3.2 m. The pH was relatively low for the alkalinity, leading to a calculated concentration of CO_2 of 55 µmol L^{-1}, which is about 3.3-times the concentration in equilibrium with the atmosphere. The measured alkalinity and concentration of phytoplankton chlorophyll *a* are similar to contemporary values presented in the section below.

Table 1. Conditions in Over Water at the time of the macrophyte survey (see Appendices 9 and 10).

Variable	**Unit**	**Value**
Surface water temperature	°C	17.4
Deep water temperature (8.5 m)	°C	16.8
Surface O_2 concentration	mg L^{-1}	9.52
Deep O_2 concentration (8.5 m)	mg L^{-1}	6.07
Light attenuation (400 – 700 nm)	m^{-1}	1.45
Secchi depth	m	1.8
Conductivity	µS cm^{-1}	101
pH	-	7.33
Alkalinity	mequiv L^{-1}	0.558
Soluble reactive phosphorus	µg L^{-1}	1.2
Phytoplankton chlorophyll *a*	µg L^{-1}	15.2

Table 2. List of species recorded at Over Water on 20-21/08/2009

Largely emergent	**Largely submerged**
Alisma plantago-aquatica	*Callitriche hermaphroditica*
Carex rostrata	*Callitriche sp.*
Eleocharis palustris	*Elodea nuttallii*
Elatine hexandra	globular algae on stones
Equisetum sp.	*Lemna* sp.
Filipendula ulmaria	*Littorella uniflora*
Galium palustre	*Nitella flexilis*
Iris pseudacorus	*Nuphar lutea*
Juncus effusus	*Nuphar pumila* (based on leaf size- no flowers)
Lythrum salicaria	*Nuphar* seedling
Mentha aquatica	*Potamogeton berchtoldii*
Myosotis sp.	*Potamogeton crispus*
Persicaria hydropiper	*Potamogeton gramineus*
Phalaris arundinacea	*Potamogeton obtusifolius*
Phragmites australis	*Potamogeton perfoliatus*
Potentilla anserina	*Sparganium angustifolium*
Potentilla palustris	*Sparganium erectum*
Salix spp.	*Sparganium sp.* (no flowers)
Schoenoplectus lacustris	"sponge" (*Spongilla lacustris*?)

Nineteen emergent and nineteen submerged taxa were recorded during the survey (Table 2). These included two species for which the site was notified that were not recorded in a pervious survey: a small number of *Elatine hexandra* plants were identified during the strandline survey at sector 1 (Fig. 6; Appendix 1) and *Callitriche hermaphroditica* was found during the boat survey at sector 3 and the strandline survey at sector 1 (Fig. 6; Appendices 1, 7). However, *Isoetes lacustris, Myriophyllum alterniflorum* and *Nymphaea alba*, listed in the original designation were not observed in this or the 2005 survey of Goldsmith & Shilland (2005) and so may be lost from this site.

Using the Trophic Ranking Score (TRS) that links macrophyte distribution to nutrient status (Palmer *et al*. 1992), Over Water had an average TRS of 7.2, based on emergent and submerged species and a very similar score (7.3) based on submerged species alone. This TRS is indicative of a mesotrophic site. The OECD (1982) boundaries for a mesotrophic lake based on annual mean concentration are 10 to 35 $\mu g\ L^{-1}$ for total phosphorus and 2.5 to 8 $\mu g\ L^{-1}$ for phytoplankton chlorophyll *a*. The annual median values recorded for Over Water between 2003 and 2009 are 32 $\mu g\ L^{-1}$ for total phosphorus and 11.7 $\mu g\ L^{-1}$ for chlorophyll *a* (see next section). Therefore the lake would be classified as mesotrophic and close to the eutrophic boundary in terms of total phosphorus but eutrophic in terms of chlorophyll *a*. This is circumstantial evidence of an increase in trophic status since macrophyte species composition is likely to respond slower than water chemistry.

The depth-resolved survey data (boat survey and wader survey) were analysed by allocating each recorded water depth into one of 12 categories at 25 cm intervals from 0 to 275 cm. In the wader survey, the final depth category of >75 cm was allocated to the 75 to 100 cm depth category. For each species, the percent frequency of occurrence in each depth interval was calculated as one hundred times the number of locations with the species for a particular depth category divided by the total number of locations for that depth category.

The number of species recorded per depth category (corrected by subtracting 25 cm from the recorded depths to make them equivalent to depth below top water level) was lowest in the shallowest and deepest depth categories and was between six and eight species between 75 and 200 cm (Fig. 7a). New species were gained rapidly between 25 and 125 cm depth and no new species were found below 175 cm (Fig. 7b). Species were first lost in the 75 to 100 cm depth category and species loss continued roughly linearly with depth (Fig. 7c). The maximum frequency of macrophyte occurrence occurred between 75 and 200 cm (Fig. 7d).

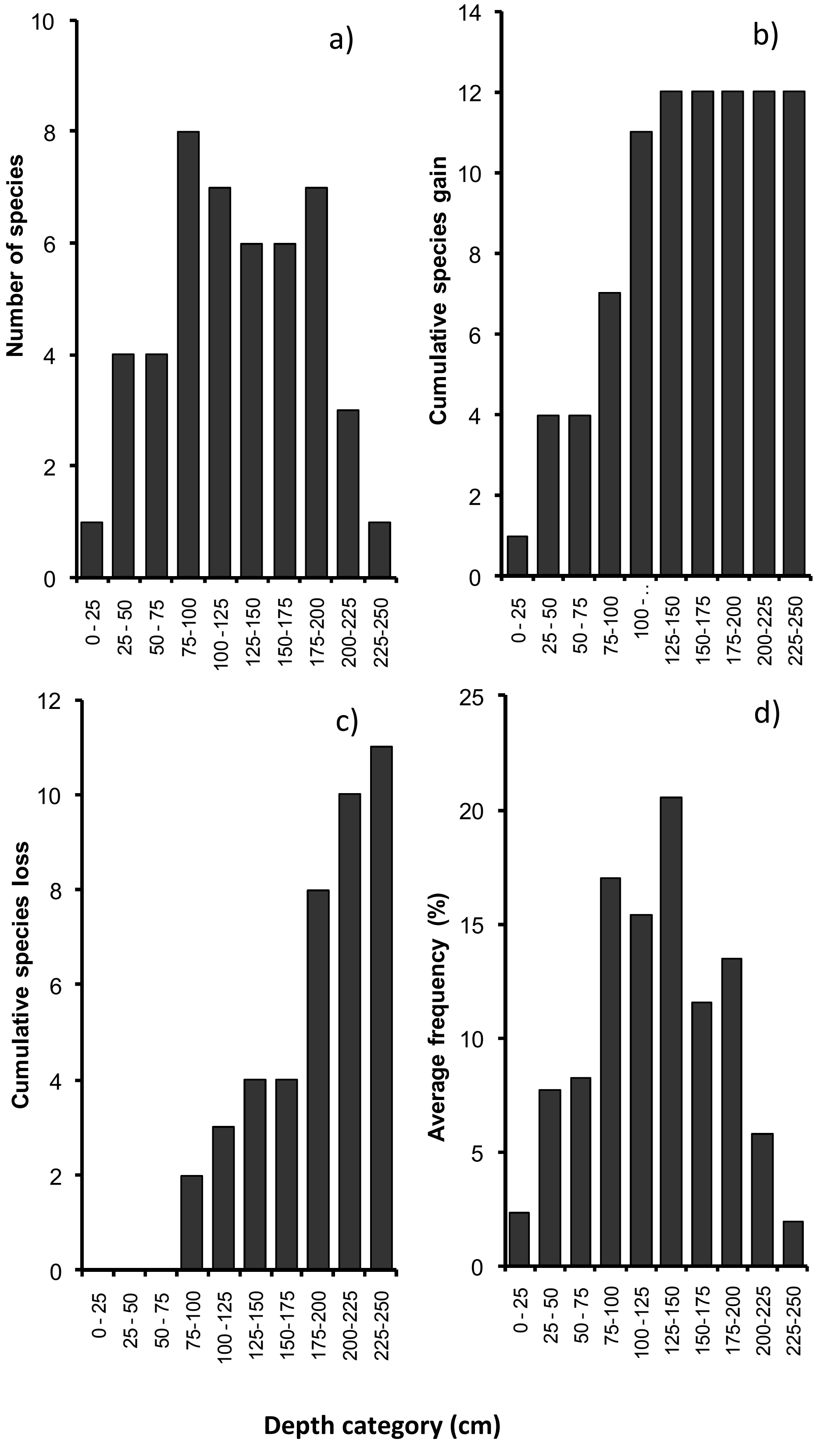


Figure 7. Changes in number of species (a) and cumulative gain (b) and loss (c) of species as a function of depth-category in Over Water. The average frequency of macrophyte occurrence by depth is also shown (d). Note that 25 cm has been subtracted from all the recorded depths so that they relate to depth below top water level.

This 'envelope' of macrophyte occurrence in Figure 7d was made up by a range of species with different depth tolerances. In shallow water, species such as *Littorella uniflora* were widespread (Fig. 8). These can tolerate emersion in air for part of the year but because of their short-stature and high investment in root biomass (with a respiratory cost) cannot grow into deep water. Species of *Nuphar* (largely *N. lutea* at Over Water) can also grow in relatively shallow water where the shore is relatively sheltered from strong waves but did not colonise below about 150 cm at this site. *Elodea nuttalii*, a non-native but naturalised species, was the most frequent species in Over Water and was found at all depth ranges apart from the most shallow and deep water. In contrast, species such as *Callitriche* sp., *Potamogeton perfoliatus* and *Sparganium angustifolium* tended to grow at intermediate water depths (Fig. 8). *Potamogeton obtusifolius* grew to the greatest depth of any species recorded here. This is likely to be because this species is highly flexible physiologically and particularly morphologically when growing at different light levels (Maberly 1993). The maximum depth recorded was 270 cm- equivalent to 245 cm below top water level. Based on the single light attenuation measurement made on this survey of 1.45 m^{-1}, 245 cm would be equivalent to 2.9% of surface light. This is likely to be deeper than would be expected on the basis of light availability. On average, elodeids such as *P. obtusifolius* grow to 12.9% of growing-season surface light (Middleboe & Markager, 1997) suggesting that at other times of the year in Over Water, water level was lower (cf Fig. 5) or light clarity was greater, or both. Based on these depth distributions, a reduction in water level to 1.5 m below top water level (as happened in 1995) or 2.1 m (as happened in 1996) is likely to have a severe impact on the macrophyte community and could have been responsible for the noted loss of species such as *Isoetes lacustris* and *Myriophyllum alterniflorum*.

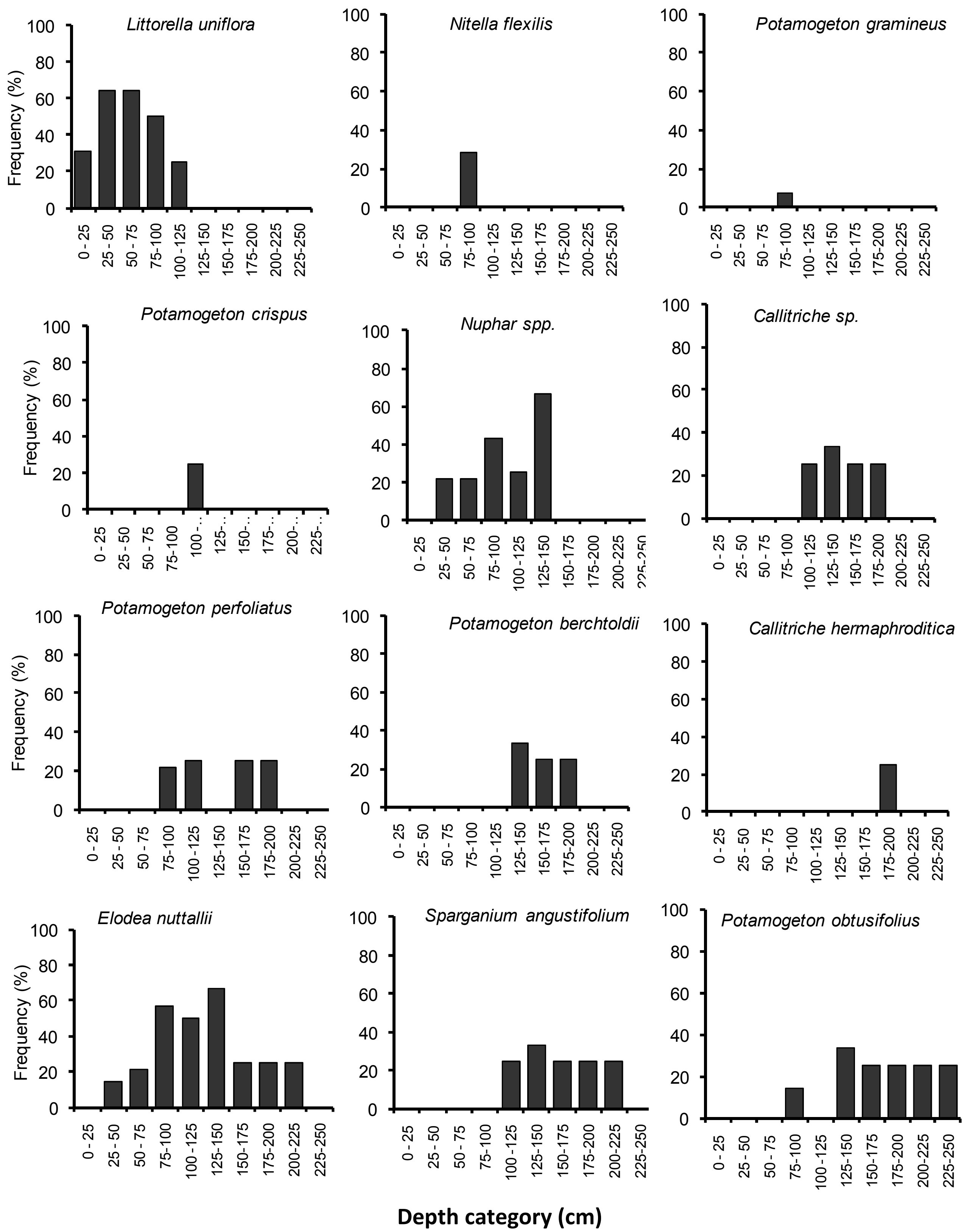


Figure 8. Changes in overall average frequency of macrophyte occurrence versus depth and the average frequency with depth. Note that 25 cm has been subtracted from all the recorded depths so that they relate to depth below top water level.

The main purpose of this new survey was to assess how reductions in water level might influence the macrophyte community in Over Water. The same approach was taken here as in the earlier report (Thackeray *et al*. 2008) of plotting number of species against depth, where depth is the minimum depth of the depth-zone. The results in Figure 9 show a very similar shape of curve to that found before, which fit a third-order polynomial equation well. It is striking however that, when these data are compared to similar data from a survey carried out four years earlier (September 2005) supplemented by expert opinion of the likely depth distribution of recorded species, the depth-distribution has shifted markedly towards shallower water. For example, the 50% species gain number occurred at about 2 m in 2005 and about 0.85 m in 2009. One explanation for this could be the precise sites surveyed: for example the depth distribution would be different in exposed vs sheltered sites. However the general methodology and sites visited in 2009 were deliberately similar to those in 2005 so this is unlikely to be the main explanation. Another explanation could be that the estimated depth ranges were incorrect. In Figure 10, the measured and, mainly, estimated, depth ranges for 2005 are compared with those measured in 2009. The species measured in both years show a relatively similar depth distribution although *Elodea nuttallii* was found 0.8 m deeper in 2005 than in 2009. For the estimated depth distributions, those for *P. perfoliatus* were very close to what was measured. We recorded *L. uniflora* to greater depths than those envisaged from the literature. This could possibly be a beneficial effect of drawdown on this species operating via increased light at depth. Conversely, *Nitella flexilis* was only found at one location, and less deep that envisaged it would grow, although this could be caused by a limited occurrence in Over Water rather than a restricted depth-distribution. Overall, the depth-distributions estimated for 2005 were not grossly incorrect. A third explanation is that there has been a deterioration in the light climate in Over Water, preventing growth at depth and shifting the macrophyte zonation to shallower water. The reduced observed depth-penetration of *E. nuttallii* is consistent with this but we are not aware of any recent light penetration (e.g. Secchi disc) data to test this idea. The main causes of low light penetration are typically high particle concentration-caused by input of material from the catchment or re-working of sediment in the lake, high coloured organic matter which is normally lost from the catchment and large populations of phytoplankton.

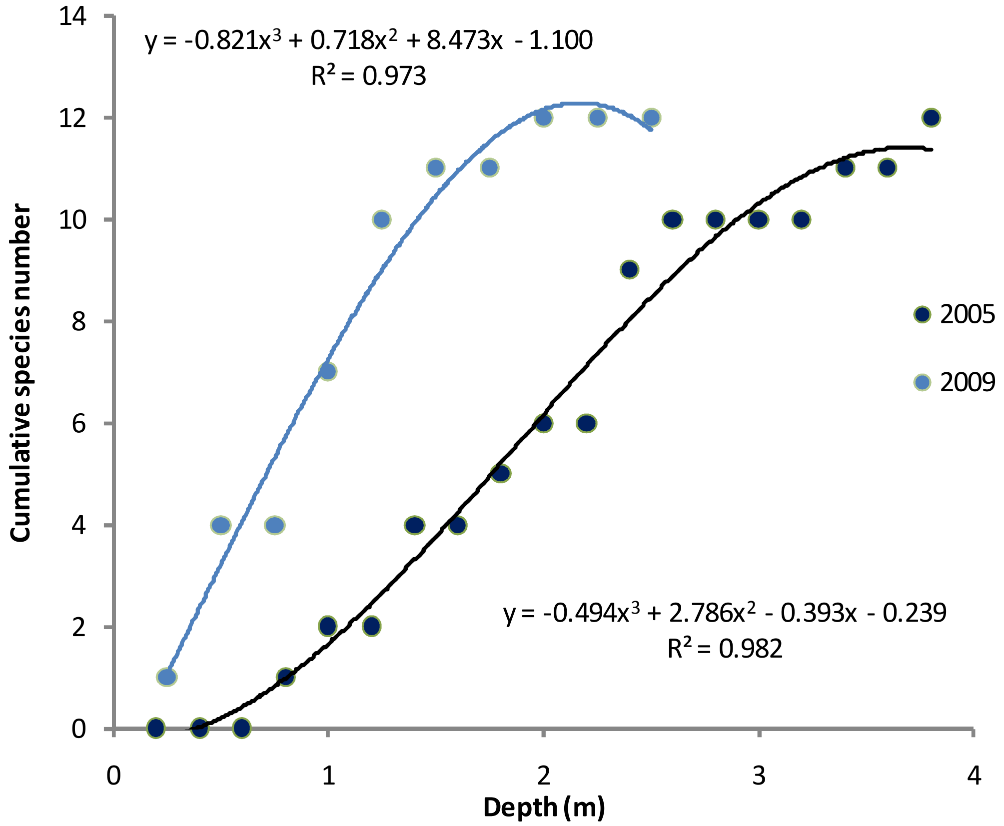


Figure 9. Number of species estimated to be lost as a function of depth of exposure below top water level based on surveys in 2005 (black) and 2009 (blue). Polynomial equations were fitted to the two sets of data.

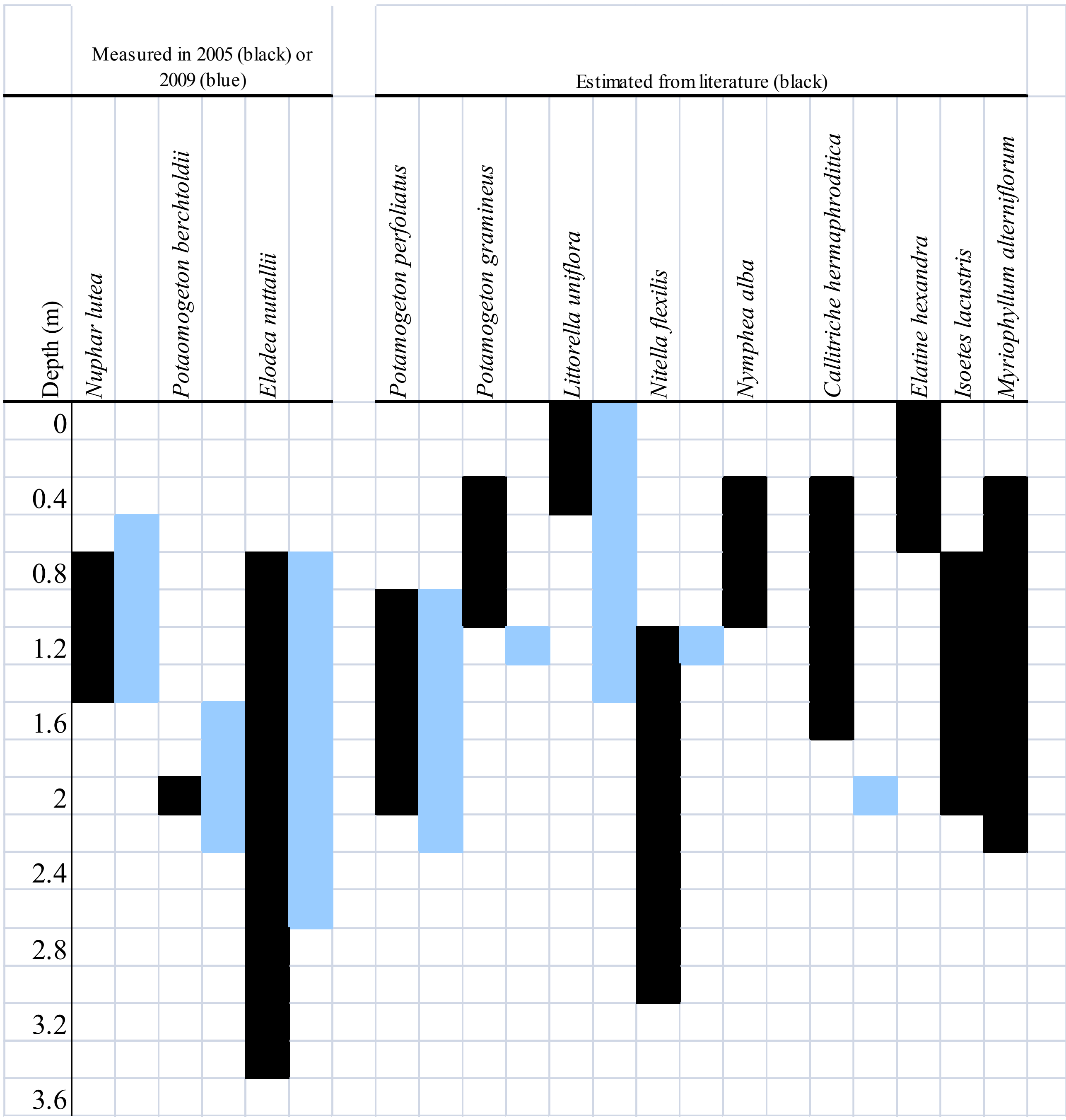


Figure 10. Comparison of depth distributions measured or estimated from the literature (black) and directly measured in 2009 (blue).

Changes in the water quality of Over Water

Data availability

Changes in water quality at Over Water were assessed by statistically analysing data collected by the Environment Agency and United Utilities (Table 3).

Table 3. Water quality data provided by stakeholders of the Over Water project.

Variable	Time Span	Mean (Minimum, Maximum) no. days between measurements	Source
Nitrate-N Soluble Reactive Phosphorus Alkalinity Turbidity Chlorophyll *a*	24/4/1985 – 12/12/1989	50 (8,154)	Environment Agency
Nitrate-N Total Phosphorus Alkalinity Turbidity Chlorophyll *a*	14/1/2003 – 7/10/2009	17 (1,145)	United Utilities

Sampling frequency was irregular in each data set, such that monthly means could not be calculated for each variable in all months of all years. Statistical analyses were necessarily conducted at a relatively coarse temporal resolution in what follows. Table 3 shows that whilst SRP was analysed during the first time period, TP was analysed in the second. In the following analysis, data from the first time period were converted to TP using a SRP:TP ratio of 0.52 (Thackeray & Maberly 2007) but it should be appreciated that this is a very rough approximation.

The available data were analysed for evidence of changing water quality between the two time periods. This was done at two temporal scales. Firstly, for each variable, all measurements within the first time period (1985-1989) were averaged and compared with the average of all measurements in the second time period (2003-2009). Secondly, the data in each time period were aggregated by season. In these analyses, the average of all winter measurements between 1985 and 1989 was compared with the average of all winter measurements 2003-2009, and so on for the remaining seasons. Seasons were defined as: winter (December-February), spring (March-May), summer (June-August) and autumn (September-November).

Preliminary analyses of the data showed that some variables (chlorophyll *a*, turbidity, total phosphorus) contained a small number of extreme values. Since these values would skew means of the variables and violate the assumptions of parametric statistical analyses, all comparisons were conducted by comparing medians using Kruskal-Wallis rank sum tests.

Nitrate-N

Seasonal variations in nitrate-N concentration for the period 2003-2009 were similar to those reported for 1985-1989 by Thackeray and Maberly (2007). In both periods, concentrations were highest during the winter months, with depletion occurring during the spring and summer months (Figure 11). Average concentrations, across all months and years within a monitoring period, were not significantly different when comparing the two monitoring periods (Figure 12; Kruskal-Wallis test, $\chi^2 = 1.2$, df = 1, P = 0.28).

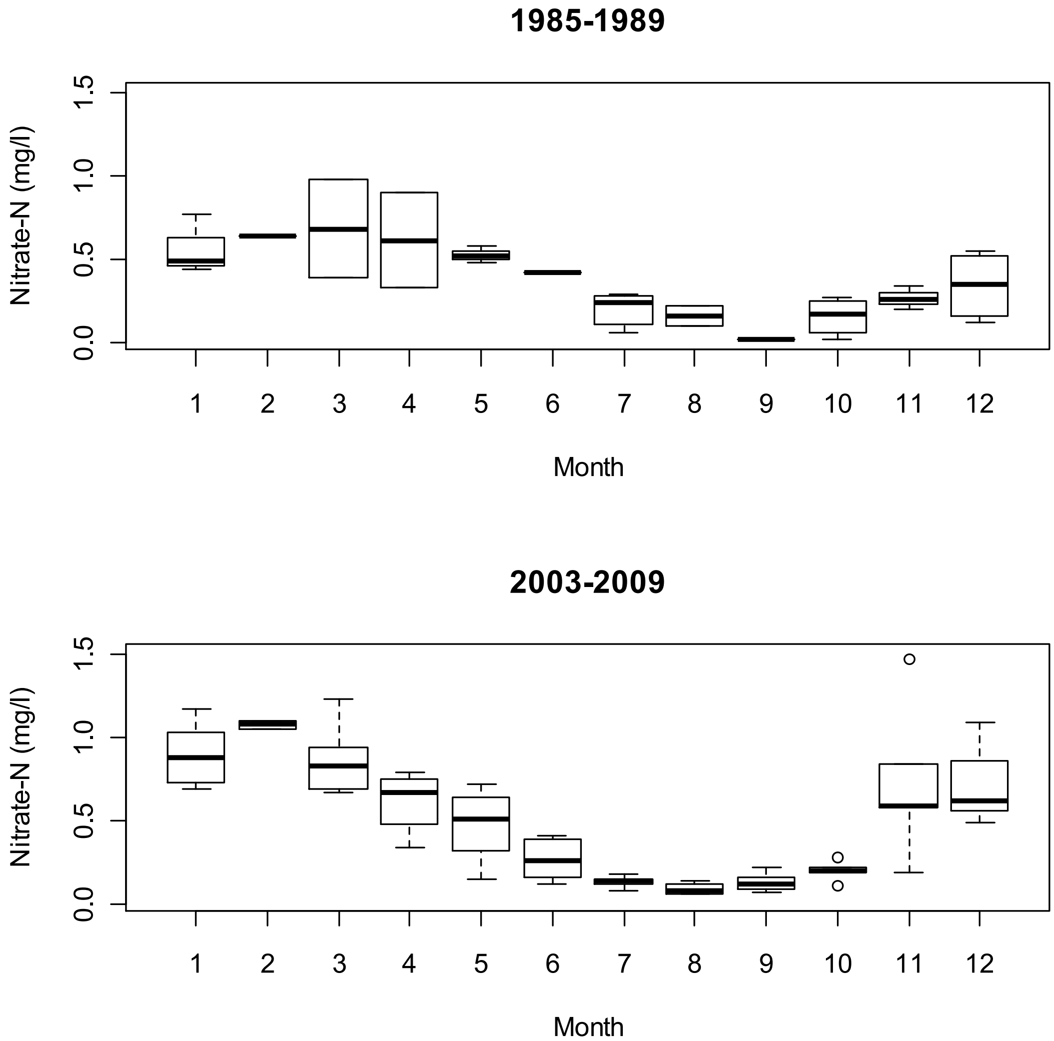


Figure 11. Seasonal changes in concentration of Nitrate-N in Over Water. Data are summarised as monthly box plots for each monitoring period. Within each box the thick black line represents the median concentration. The upper and lower edges of each box are the 75th and 25th percentiles of the data. The length of each whisker is 1.5 x the interquartile range (the difference between the 25th and 75th percentile observations). This formulation allows plotting of extreme concentration values.

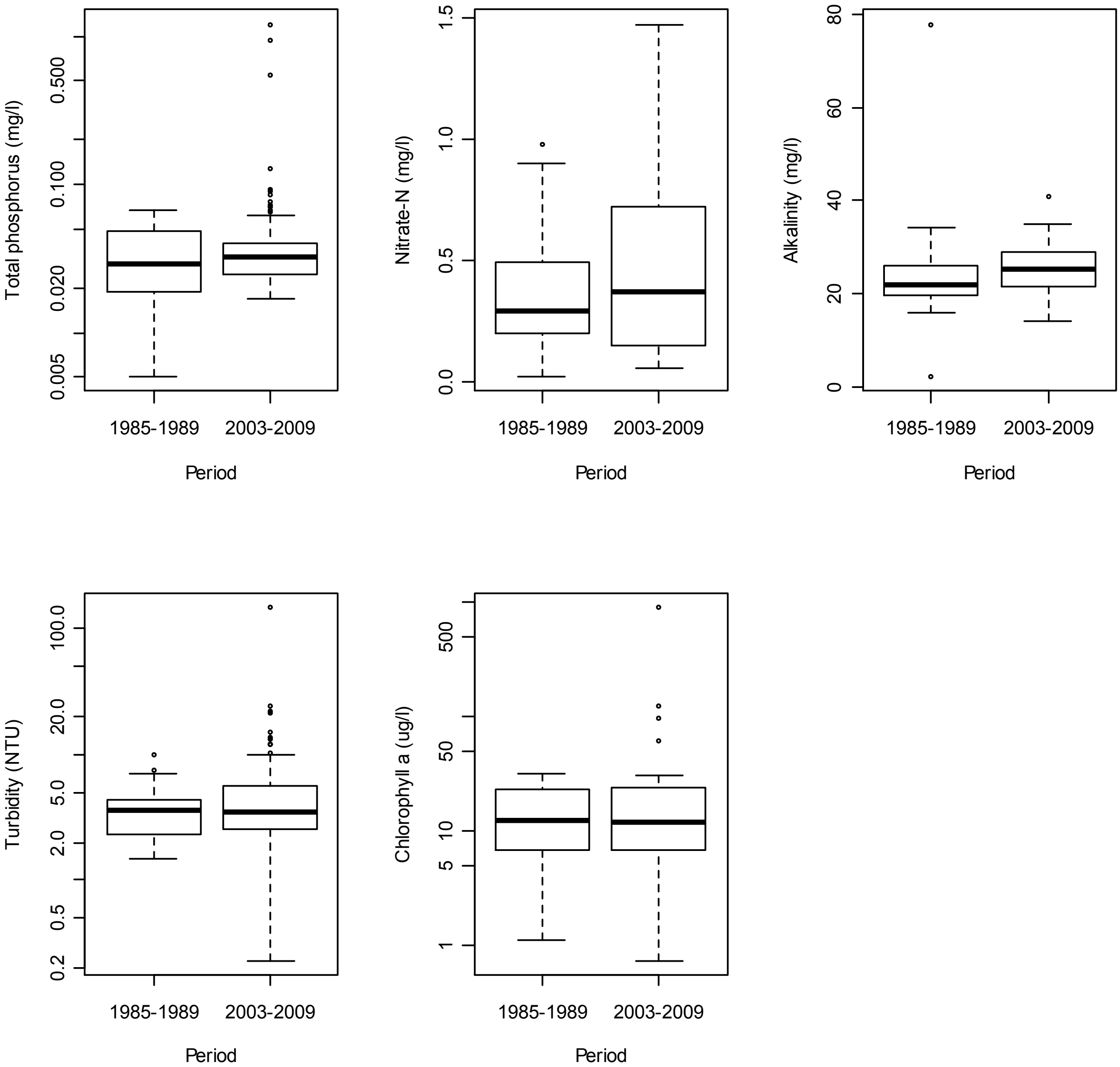


Figure 12. Differences in water quality variables between the two monitoring periods. Data are summarised as a box plot for each period. Note logarithmic scaling on the panels representing total phosphorus, turbidity and chlorophyll a concentration. Within each box the thick black line represents the median concentration. The upper and lower edges of each box are the 75th and 25th percentiles of the data. The length of each whisker is 1.5 x the interquartile range (the difference between the 25th and 75th percentile observations). This formulation allows plotting of extreme concentration values.

Despite the lack of a significant difference in overall median nitrate-N concentrations between the two time periods, median winter concentrations have significantly increased between 1985-1989 and 2003-2009 (Figure 13; Kruskal-Wallis test, $\chi^2 = 8.8$, df = 1, P = 0.003). This increase was not apparent in the three remaining seasons.

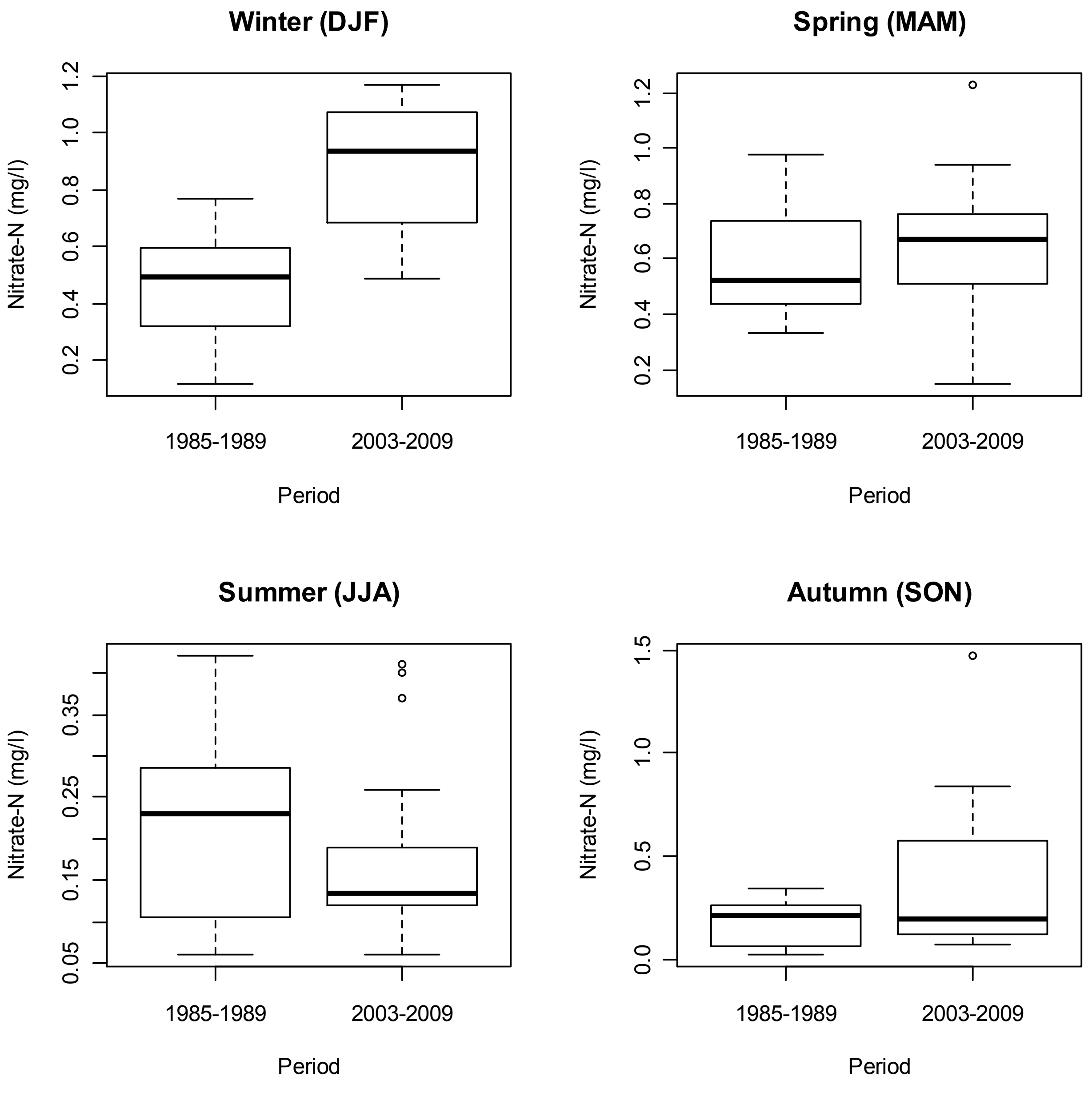
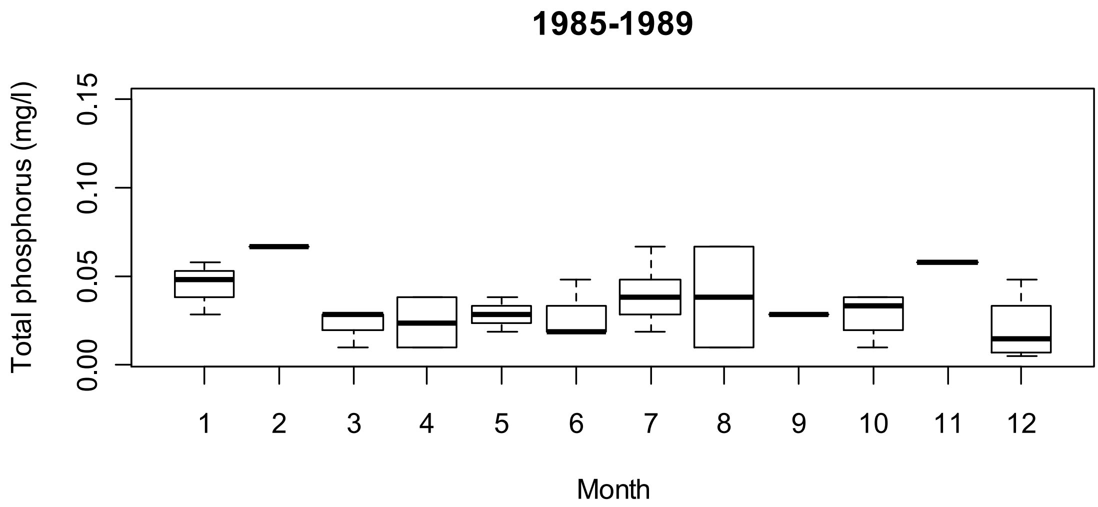


Figure 13. Differences in nitrate-N concentrations between the two monitoring periods, by season. Note difference in scales. Data are summarised as a box plot for each period. Within each box the thick black line represents the median concentration. The upper and lower edges of each box are the 75th and 25th percentiles of the data. The length of each whisker is 1.5 x the interquartile range (the difference between the 25th and 75th percentile observations). This formulation allows plotting of extreme concentration values.

Total Phosphorus (TP)

Thackeray & Maberly (2007) noted elevated TP concentrations throughout the year based on data from the period 1985-1989. This lack of seasonality is unusual for lakes in this region. Data from the period 2003-2009 would seem to suggest a seasonal increase in TP concentrations in the late summer and autumn months, absent in the earlier time period (Figure 14). One explanation for this could be internal loading of phosphorus from the sediments caused by release linked to anoxia at the sediment surface. Potentially low oxygen was tentatively suggested in the single depth profile reported here at the end of the summer: seasonal profiles would be helpful in the future.



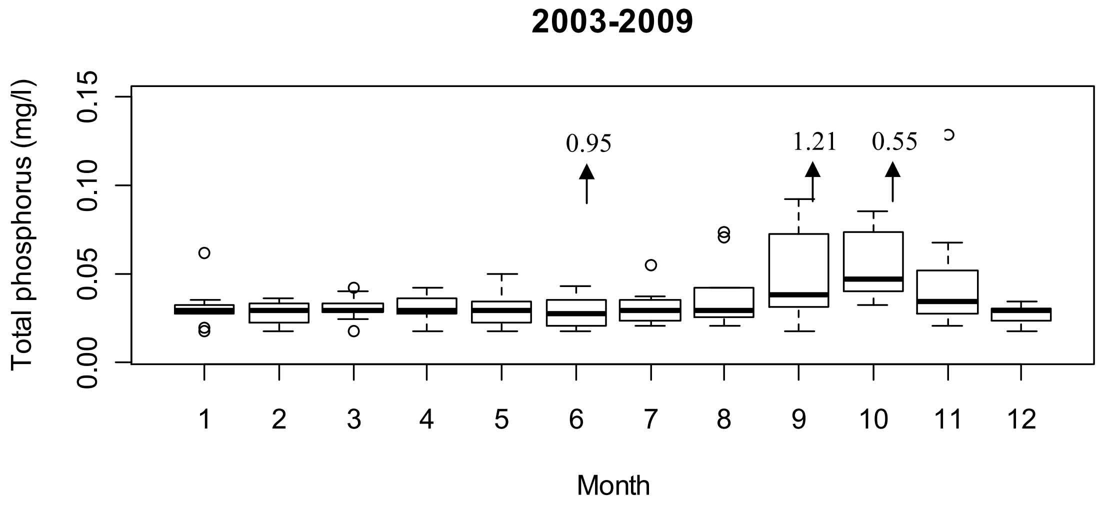


Figure 14. Seasonal changes in total phosphorus concentrations in Over Water. Data are summarised as monthly box plots for each monitoring period. Within each box the thick black line represents the median concentration. The upper and lower edges of each box are the 75th and 25th percentiles of the data. The length of each whisker is 1.5 x the interquartile range (the difference between the 25th and 75th percentile observations). This formulation allows plotting of extreme concentration values.

Using the available data there was no strong evidence for an increase in TP concentrations between monitoring periods. There was no significant difference in overall median TP concentrations between the two time periods (Figure 12; Kruskal-Wallis test, $\chi^2 = 0.5$, df = 1, P = 0.47). Median concentrations also did not differ significantly in any season (Figure 15; winter $\chi^2 = 0.4$, df = 1, P = 0.55; spring $\chi^2 = 0.8$, df = 1, P = 0.36; summer $\chi^2 = 0.0$, df = 1, P = 0.95; autumn $\chi^2 = 2.0$, df = 1, P = 0.16).

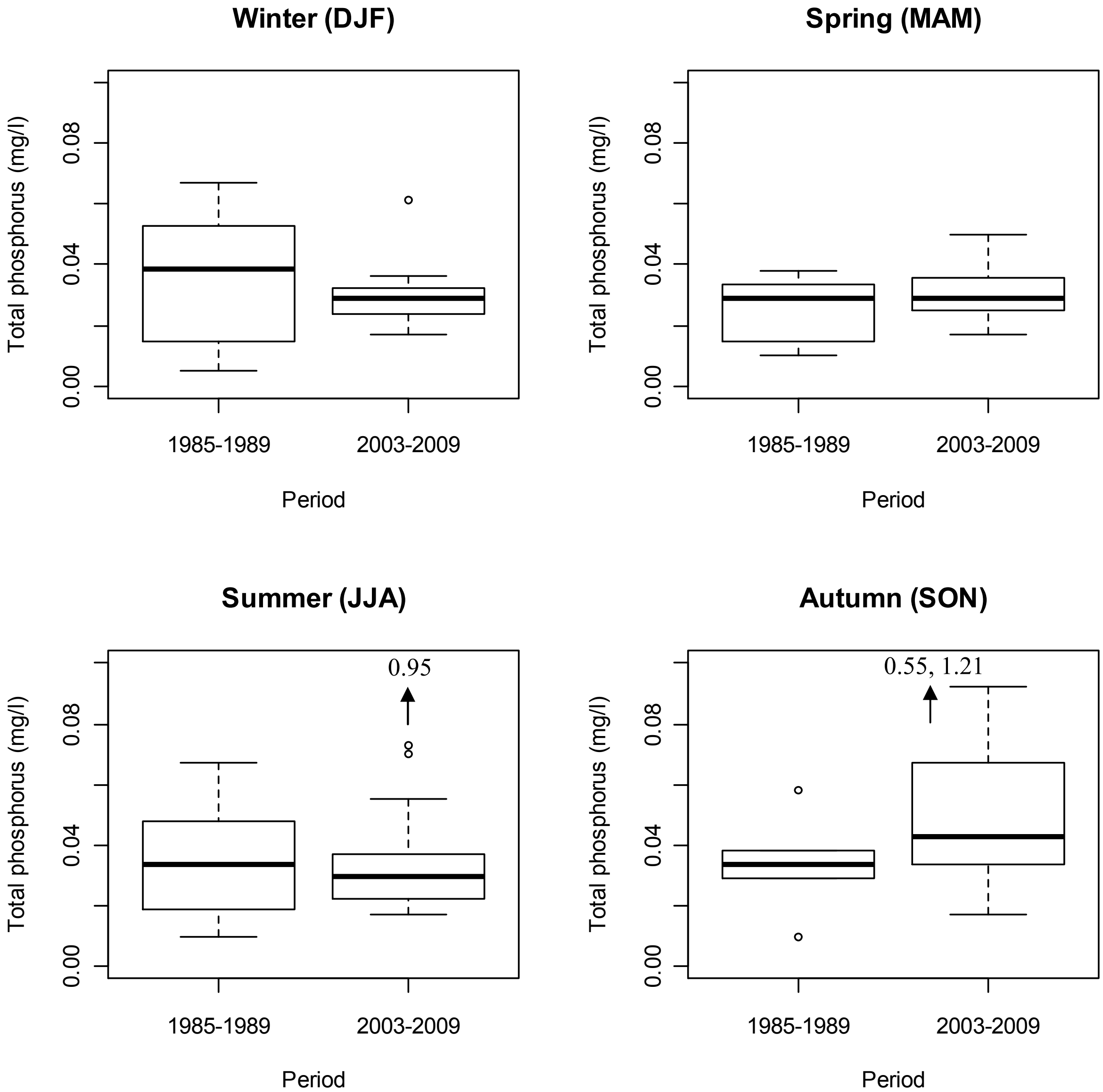


Figure 15. Differences in total phosphorus concentrations between the two monitoring periods, by season. Data are summarised as a box plot for each period. Within each box the thick black line represents the median concentration. The upper and lower edges of each box are the 75th and 25th percentiles of the data. The length of each whisker is 1.5 x the interquartile range (the difference between the 25th and 75th percentile observations). This formulation allows plotting of extreme concentration values.

Alkalinity

The alkalinity of Over Water showed some evidence of a seasonal pattern with higher concentrations in the summer months, particular in the 2003-2009 period (Figure 16). The overall median concentration was significantly higher in the second monitoring period (Figure 12; Kruskal-Wallis test, χ^2 = 6.7, df = 1, P = 0.01). This was due to significant increases in alkalinity in the spring (Figure 17; Kruskal-Wallis test, χ^2 = 11.0, df = 1, P < 0.001) and summer (χ^2 = 5.4, df = 1, P = 0.02), though not in the autumn (χ^2 = 0.9, df = 1, P = 0.34) and winter (χ^2 = 0.3, df = 1, P = 0.57).

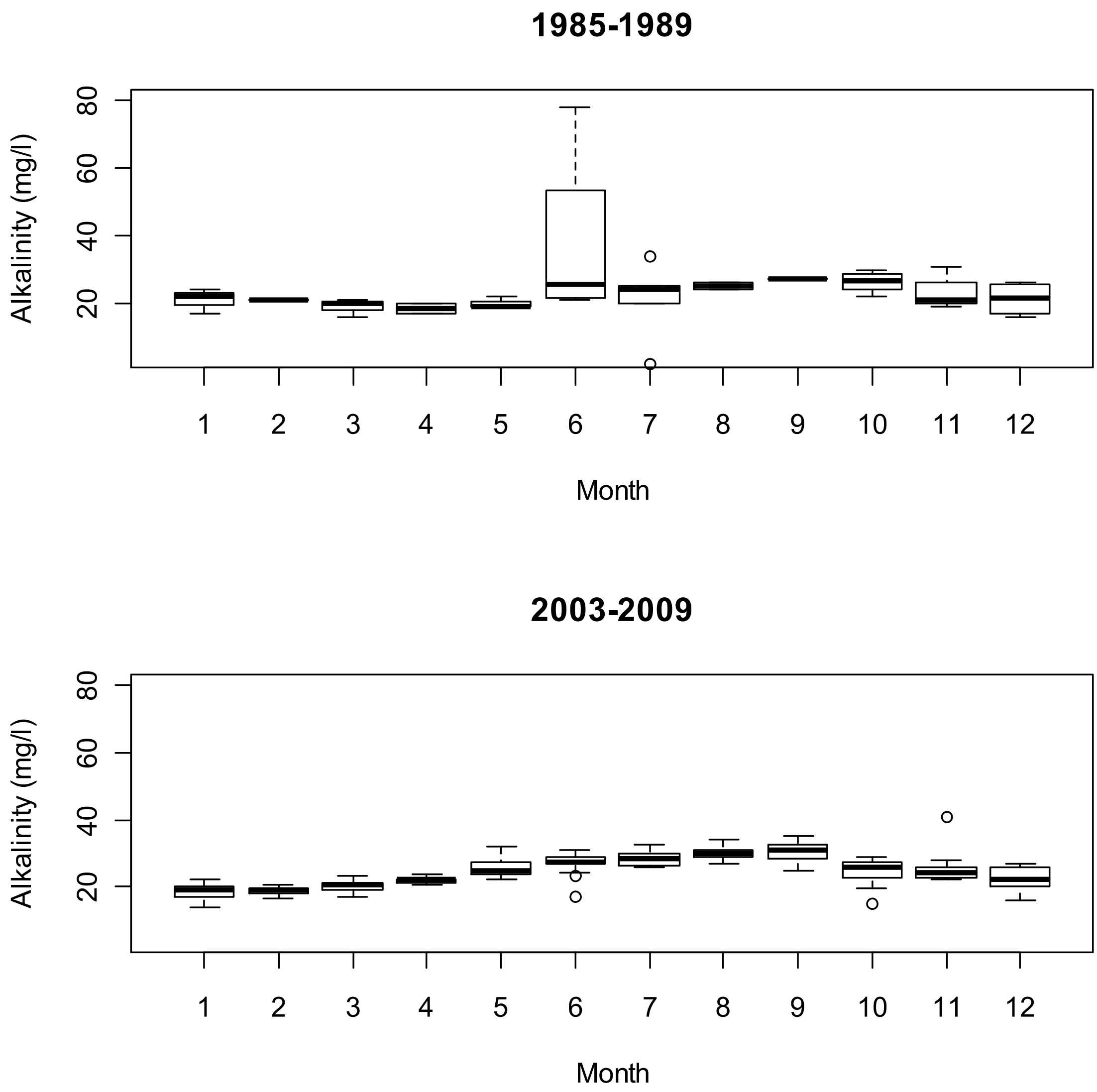


Figure 16. Seasonal changes in alkalinity in Over Water. Data are summarised as monthly box plots for each monitoring period. Within each box the thick black line represents the median concentration. The upper and lower edges of each box are the 75th and 25th percentiles of the data. The length of each whisker is 1.5 x the interquartile range (the difference between the 25th and 75th percentile observations). This formulation allows plotting of extreme concentration values.

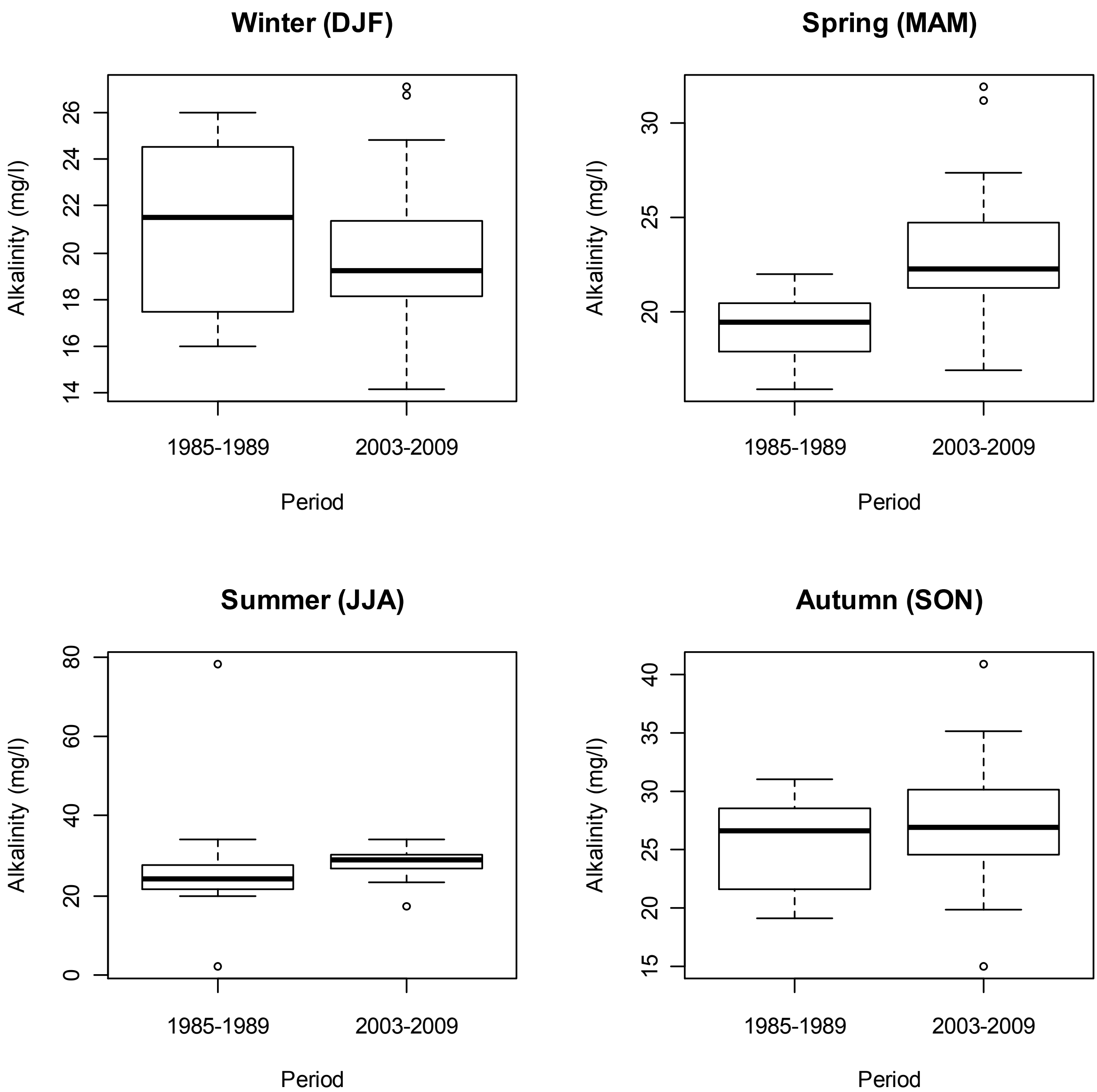


Figure 17. Differences in alkalinity between the two monitoring periods, by season. Data are summarised as a box plot for each period. Within each box the thick black line represents the median concentration. The upper and lower edges of each box are the 75th and 25th percentiles of the data. The length of each whisker is 1.5 x the interquartile range (the difference between the 25th and 75th percentile observations). This formulation allows plotting of extreme concentration values.

Turbidity

During both 1985-1989 and 2003-2009 turbidity showed a seasonal increase during the late summer and autumn, though this was most pronounced in the latter period (Figure 18). During the 1985-1989 monitoring period there was also evidence of elevated turbidity values in the winter months. The overall median concentration was not significantly different between monitoring periods (Figure 12; Kruskal-Wallis test, $\chi^2 = 0.6$, df = 1, P = 0.45).

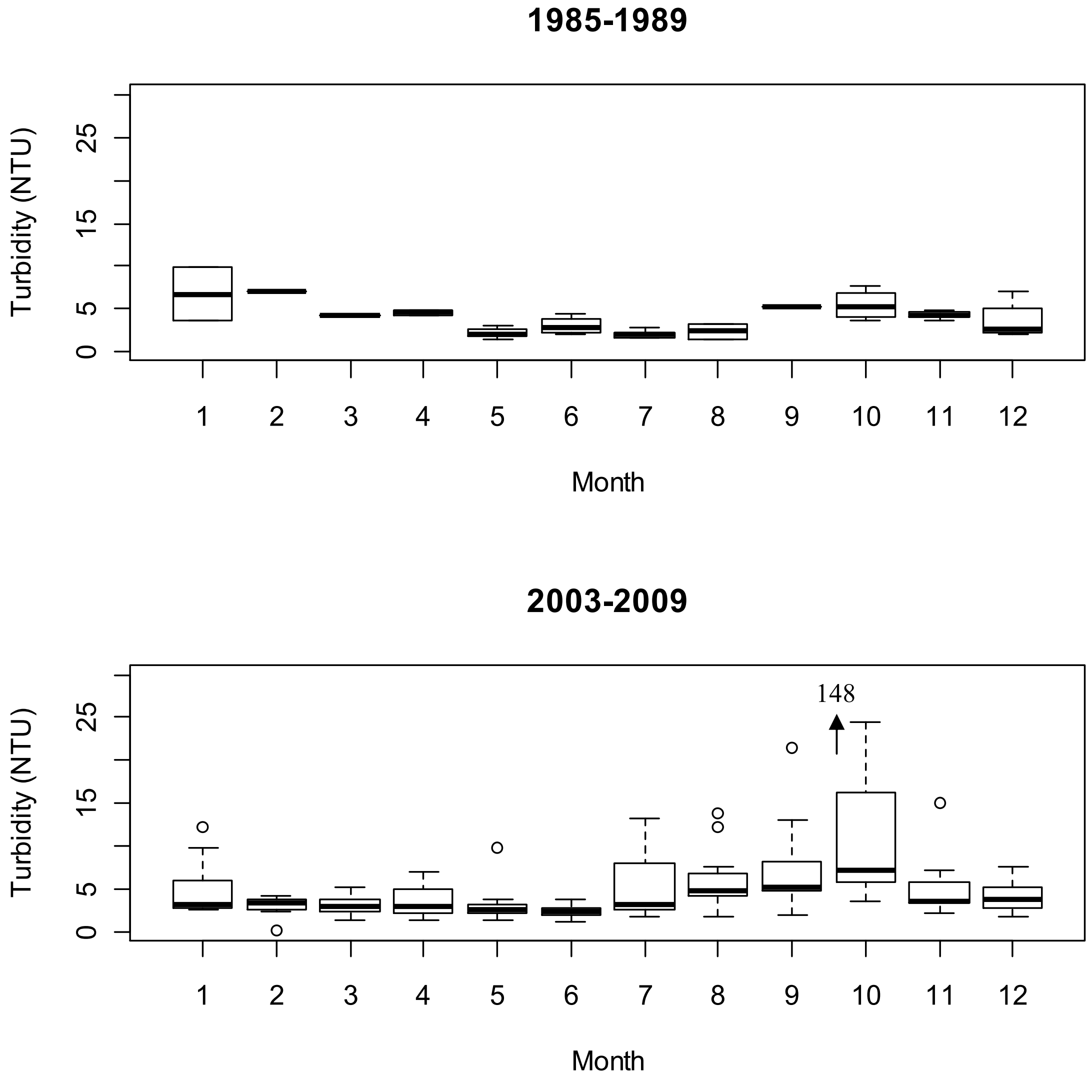


Figure 18. Seasonal changes in turbidity in Over Water. Data are summarised as monthly box plots for each monitoring period. Within each box the thick black line represents the median concentration. The upper and lower edges of each box are the 75th and 25th percentiles of the data. The length of each whisker is 1.5 x the interquartile range (the difference between the 25th and 75th percentile observations). This formulation allows plotting of extreme values.

Median turbidity values did not differ significantly in any season, though there was a weak suggestion of an increase in summer turbidity (Figure 19; winter $\chi^2 = 0.3$, df = 1, P = 0.57; spring $\chi^2 = 0.9$, df = 1, P = 0.34; summer $\chi^2 = 3.3$, df = 1, P = 0.07; autumn $\chi^2 = 1.1$, df = 1, P = 0.31).

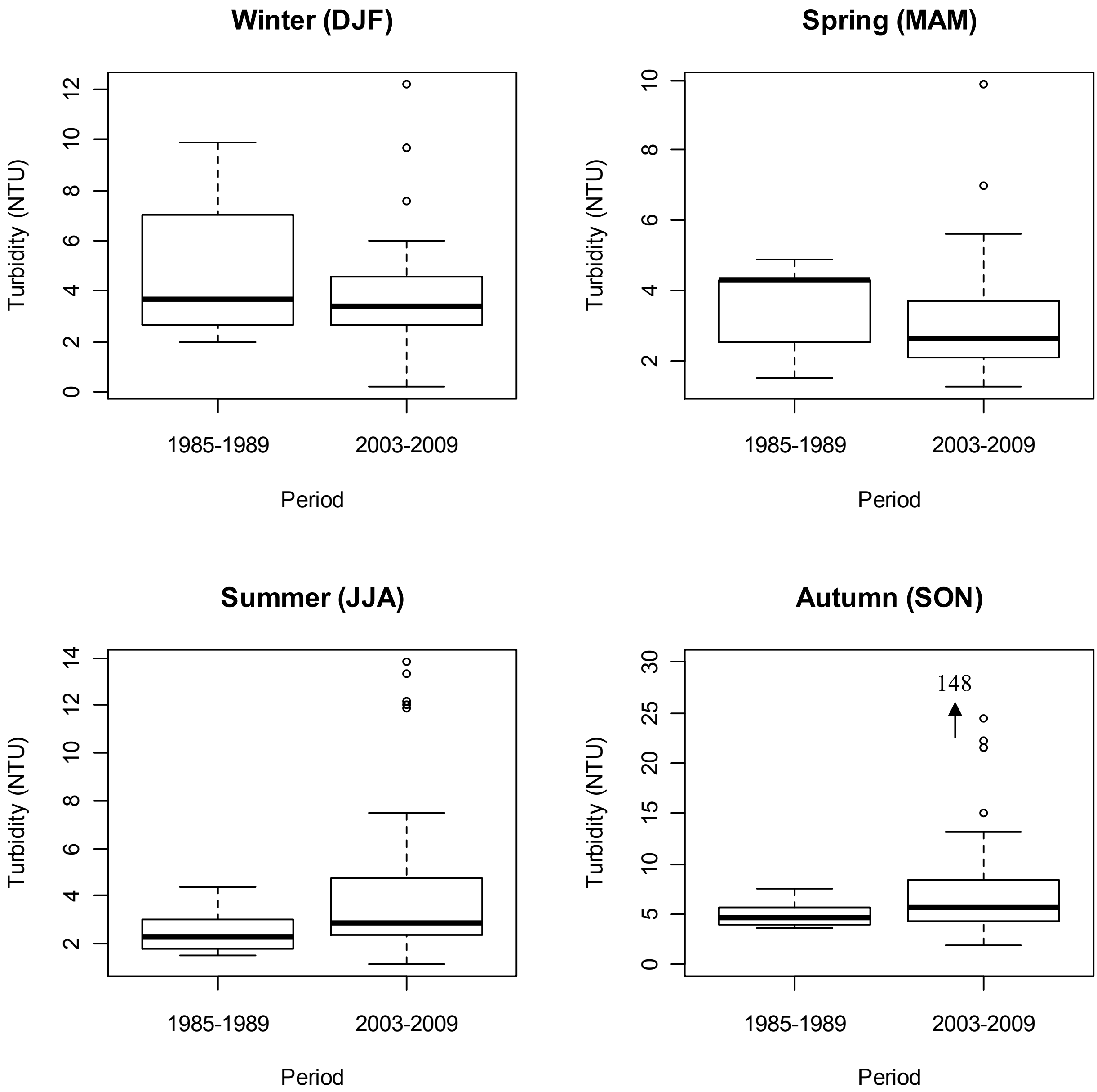


Figure 19. Differences in turbidity between the two monitoring periods, by season. Data are summarised as a box plot for each period. Within each box the thick black line represents the median concentration. The upper and lower edges of each box are the 75th and 25th percentiles of the data. The length of each whisker is 1.5 x the interquartile range (the difference between the 25th and 75th percentile observations). This formulation allows plotting of extreme values.

Although there was no evidence for a significant increase in average turbidity levels between the two monitoring periods, it was clear that there were more extreme high turbidity events in the 2003-2009 period, particularly in the summer and autumn (Figure 19). The maximum recorded value was 148 NTU, on 7th October 2005.

Chlorophyll a

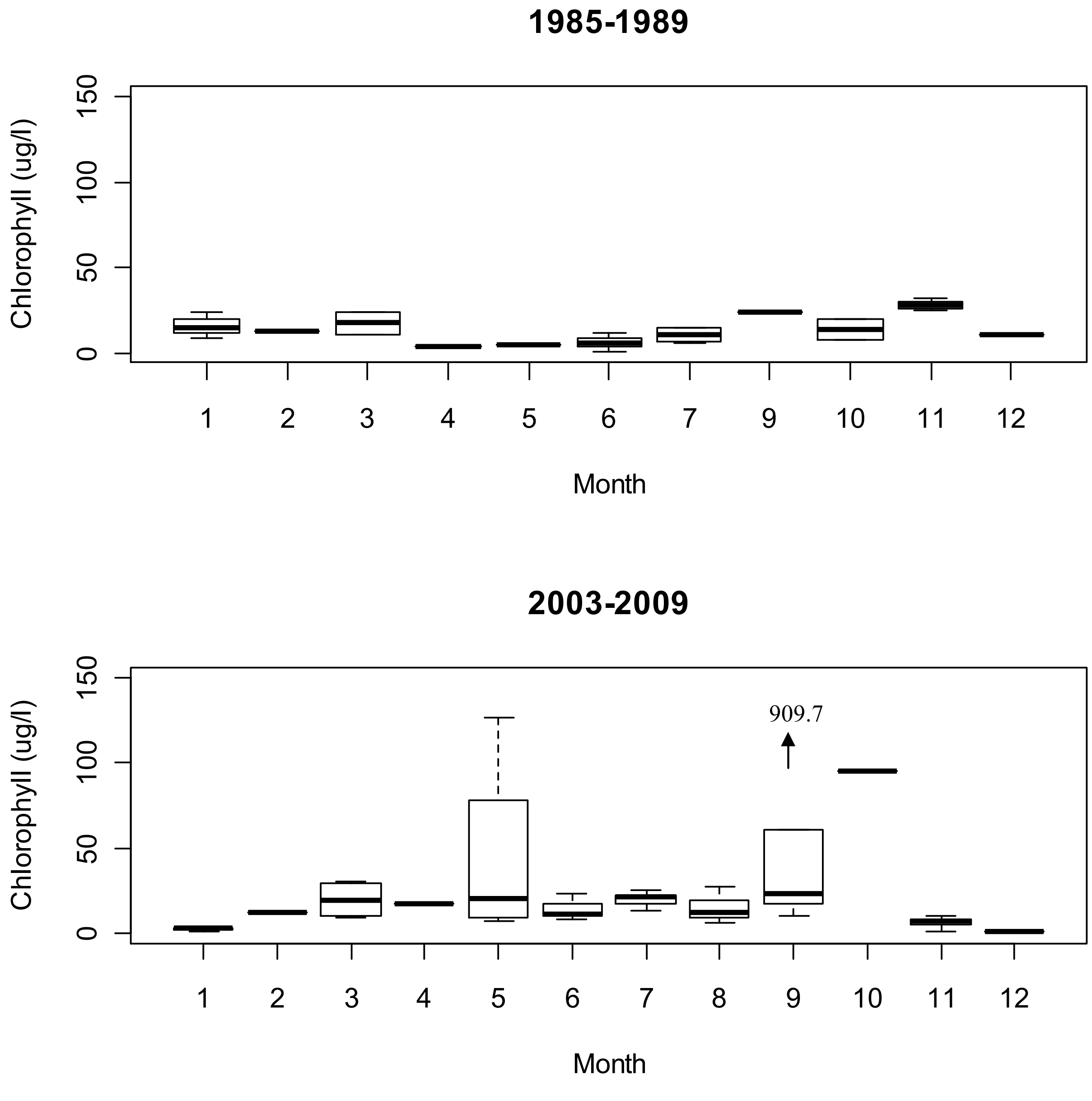


Figure 20. Seasonal changes in chlorophyll a concentration in Over Water. Data are summarised as monthly box plots for each monitoring period. Within each box the thick black line represents the median concentration. The upper and lower edges of each box are the 75th and 25th percentiles of the data. The length of each whisker is 1.5 x the interquartile range (the difference between the 25th and 75th percentile observations). This formulation allows plotting of extreme concentration values.

Using the 1985-1989 chlorophyll data, Thackeray & Maberly (2007) noted two seasonal phytoplankton peaks in Over Water; one in the winter/early spring and one in the late summer. The 2003-2009 data show a late summer/autumn peak at broadly the same time of year as observed during 1985-1989 (Figure 20). However, the spring peak in the later monitoring period had a somewhat later seasonal timing (March-May, rather than January to March).

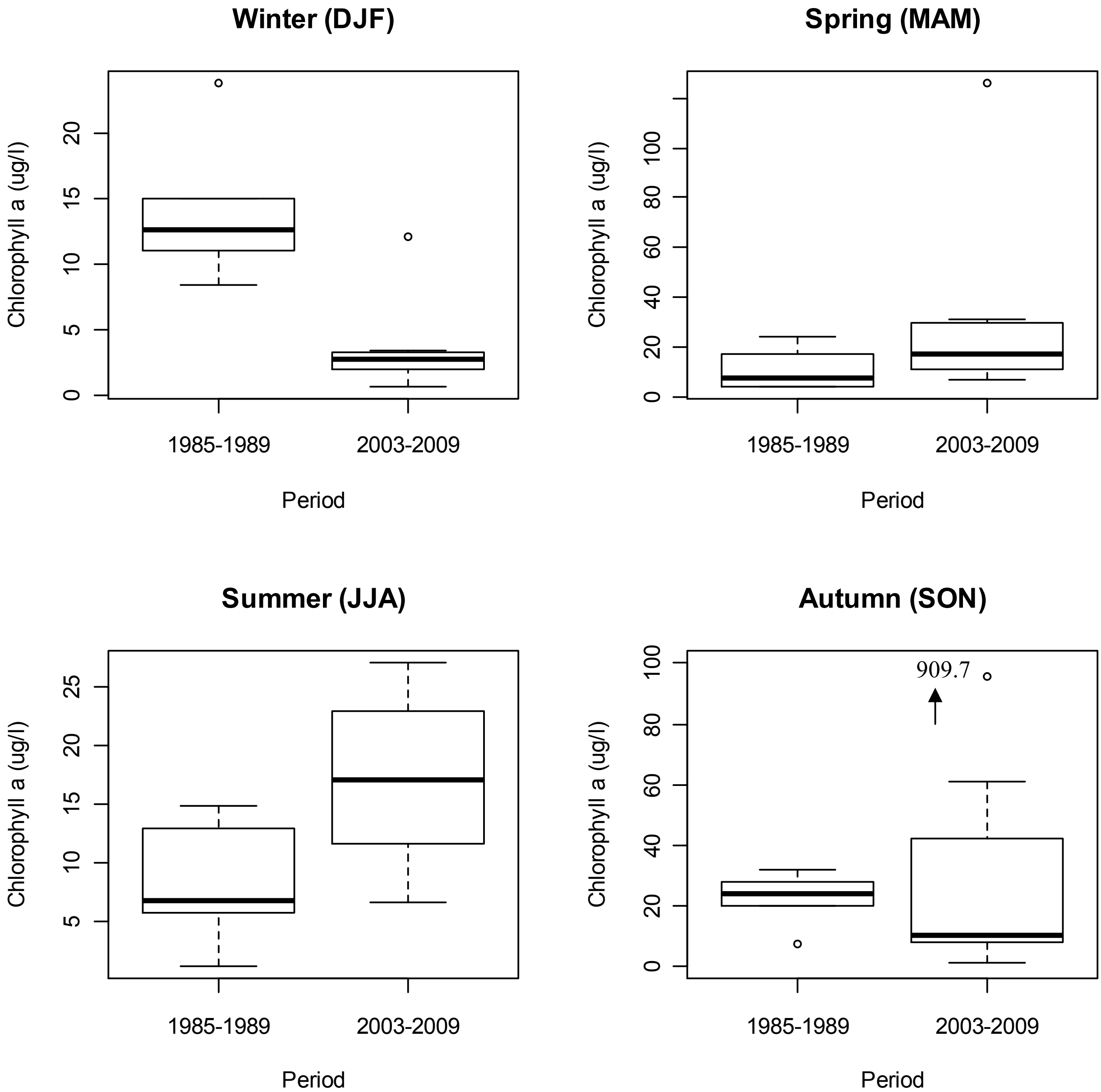


Figure 21. Differences in chlorophyll a concentration between the two monitoring periods, by season. Data are summarised as a box plot for each period. Within each box the thick black line represents the median concentration. The upper and lower edges of each box are the 75th and 25th percentiles of the data. The length of each whisker is 1.5 x the interquartile range (the difference between the 25th and 75th percentile observations). This formulation allows plotting of extreme concentration values.

Overall median chlorophyll *a* concentrations were not significantly different between the two monitoring periods (Figure 12; Kruskal-Wallis test, $\chi^2 = 0.0$, df = 1, P = 0.85), however summer concentrations were significantly higher during 2003-2009 (Figure 21; Kruskal-Wallis test, $\chi^2 = 4.9$, df = 1, P = 0.03), and spring concentrations showed a similar tendency (Kruskal-Wallis test, $\chi^2 = 2.9$, df = 1, P = 0.09). There was evidence for a significant decrease in winter chlorophyll *a* concentrations between 1985-1989 and 2003-2009 (Kruskal-Wallis test, $\chi^2 = 6.3$, df = 1, P = 0.01). Though autumn concentrations did not differ significantly between the two periods (Kruskal-Wallis test, $\chi^2 = 0.5$, df = 1, P = 0.48), high extreme chlorophyll *a* concentrations were recorded in the later monitoring period. The maximum recorded value was 909.7 µg/l, and corresponded to a surface dip sample collected on the 21st September 2005, when United Utilities personnel noted that the lake was "covered with green algae" (UU unpublished data). It seems likely that the lake may have been covered by a surface scum of cyanobacteria. In March 2007, National Trust personnel recorded a surface cyanobacteria scum at the site (Figure 22).

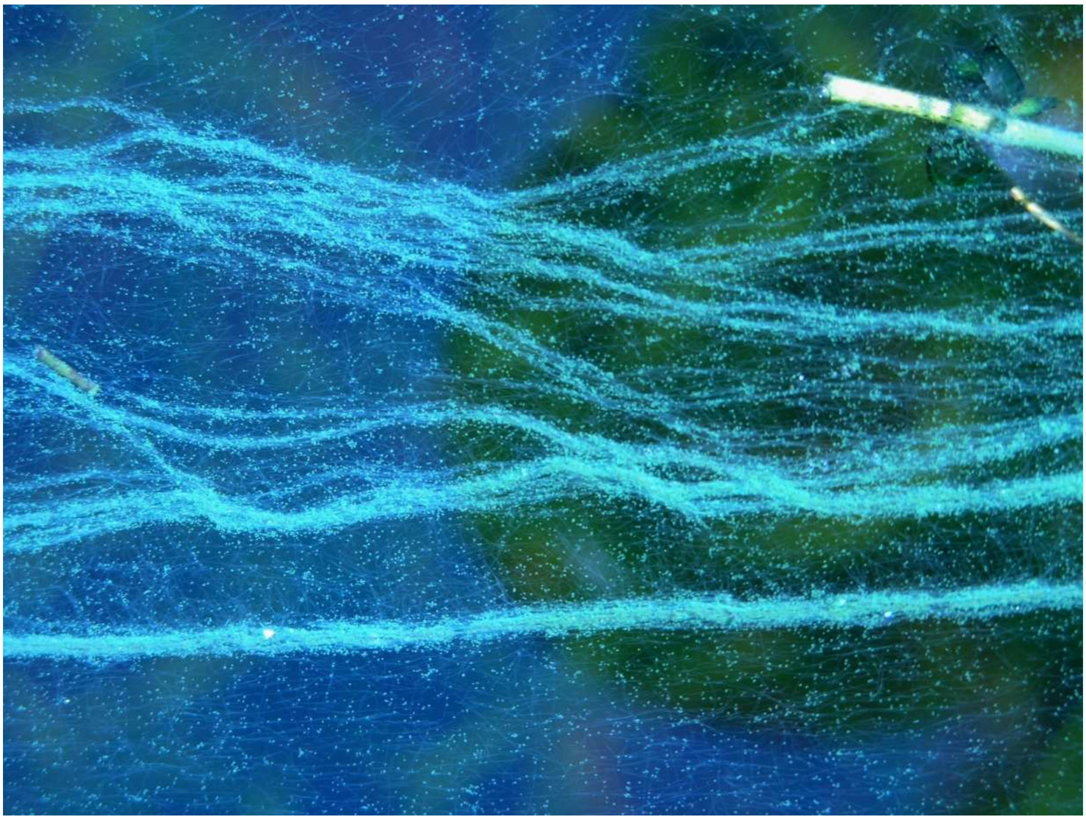


Figure 22. Cyanobacteria bloom recorded by National Trust staff during March 2007. Taxa was subsequently identified as Oscillatoria agardhii var isothrix (Planktothrix isothrix). Photograph provided by John Malley, National Trust.

Summary: water quality change at Over Water

Table 4. Statistically significant changes in water chemistry in Over Water between 1985-1989 and 2003-2009. o, not significant; - or + decline or increase significant at P<0.05; - - or + +, decline or increase significant at P<0.01; - - - or + + +, decline or increase significant at P<0.001.

	Winter	Spring	Summer	Autumn
Nitrate	++	o	o	o
Total P	o	o	o	o
Alkalinity	o	+++	+	o
Turbidity	o	o	o	o
Chlorophyll *a*	- -	o	+	o

The available data suggest that there have been some changes in the water quality of Over Water between 1985-1989 and 2003-2009 (Table 4). Though average total phosphorus (TP) concentrations have not increased significantly, winter nitrate-nitrogen concentrations and spring/summer alkalinity have both increased over time. Summer chlorophyll *a* concentrations also increased significantly, and spring concentrations weakly so. This was accompanied by a significant decrease in winter chlorophyll *a* concentrations. The result was a difference in the seasonality of phytoplankton biomass development between the two monitoring periods, with more pronounced seasonal peaks during the 2003-2009 period. The increased chlorophyll *a* concentrations do not seem to have resulted in higher average turbidity values in the later time period, though there has been an increased incidence of episodic high values.

Though we cannot detect a change in median TP concentrations between the two monitoring periods, we must interpret this negative result cautiously. It was necessary to estimate TP concentrations from soluble reactive phosphorus (SRP) concentrations in the earlier monitoring period, in order to permit a temporal comparison. The SRP:TP ratio used in this estimate is of course an approximation. In reality this ratio will be a variable property. The results of a recent paleolimnological survey (Bennion *et al* 2009) suggest that the lake has undergone nutrient enrichment in recent years, particularly since approximately 2000; an assessment based specifically upon diatom-inferred TP data. In this study the diatom-inferred TP concentration in surface sediments, indicative of 2008 conditions, was in the range 38-45 μg/l (0.038-0.045 mg/l), a little higher than the mean of concentrations measured by United Utilities in the lake during 2008 (0.029 mg/l) though well within the range of concentrations recorded in that year (0.017-0.046 mg/l).

Based upon the 1985-1989 data, Thackeray & Maberly (2007) compared the water quality of Over Water to the Cumbrian lakes sampled in the 2005 Lakes Tour (Maberly *et al* 2006). Now that 2005 water quality data are available for Over Water, we are able to run a more meaningful comparison. We extracted the values of water quality parameters measured at Over Water for the months in 2005 when all of the Lakes Tour lakes were monitored (January, April, July and October) and then calculated from these annual mean TP, NO_3-N, alkalinity and chlorophyll *a* concentrations. Where more than one measurement was taken in a particular month, the mean value was used. We then ranked Over Water among the Lakes Tour lakes using it's concentrations of these determinands. The results of this analysis confirm the assertion of Thackeray & Maberly (2007) that Over Water is at the upper end of the trophic range when compared to the Lake's Tour lakes (Table 5). If the data are analysed in their entirety, Over Water has higher annual mean TP, chlorophyll *a* and alkalinity concentrations than any of the Lakes Tour lakes. However, the high ranks for TP and chlorophyll *a* are each influenced by one exceptionally high value (909.7 μg/l chlorophyll *a* on the 21st September 2005, see above; 0.55 mg/l total phosphorus on the 7th October 2005). If we remove each of these values, the TP concentrations remain comparatively high and annual mean chlorophyll *a* concentrations are in the mid range of values shown by the Cumbrian lakes. This ranking is confirmed when leaving in the more extreme values for TP and chlorophyll *a* and basing the ranking upon annual median concentrations.

Table 5. The rank position of Over Water in comparison to the 20 Lakes Tour lakes, based upon annual means and medians for key water quality variables. Where extreme values exist in the data, the rank is given when these are included in the analysis (outside parentheses) and when they are omitted (in parentheses).

Water quality variable	**Rank based on mean (1 is high, 21 is low)**	**Rank based on median (1 is high, 21 is low)**
Nitrate-N	2	2
Total phosphorus	1 (3)	3
Alkalinity	1	2
Chlorophyll *a*	1 (9)	7

Using the available water quality data we have assigned Over Water to a Water Framework Directive typology, and have assessed its status using class boundaries in the 2008 UK TAG report (UK TAG, 2008). Between 2003 and 2009 annual mean alkalinity values for Over Water range from 23.7 to 28.6 mg/l, placing the lake in the moderate alkalinity category. The mean depth of the lake (3.2 m) places the lake in the shallow category, as noted by Thackeray & Maberly (2007). For this typology, UK TAG give class boundaries of 11 µg/l TP (High-Good), 16 µg/l TP (Good-Moderate), 32 µg/l TP (Moderate-Poor) and 64 µg/l TP (Poor-Bad). Comparison of geometric annual mean TP concentrations with these class boundaries would suggest that the lake could be categorised as Poor status 2004-2007 and Moderate status 2008-2009 (Fig. 23). The current designation as moderate status, based on our analysis, is in agreement with that determined by the Environment Agency i.e. moderate ecological potential, given the heavily modified nature of the site (http://www.maps.environment-agency.gov.uk/wiyby). Our current categorisation of Poor-Moderate status differs from the Moderate-Good status proposed originally in Thackeray & Maberly (2007) as class boundaries were updated in the 2008 UK TAG report.

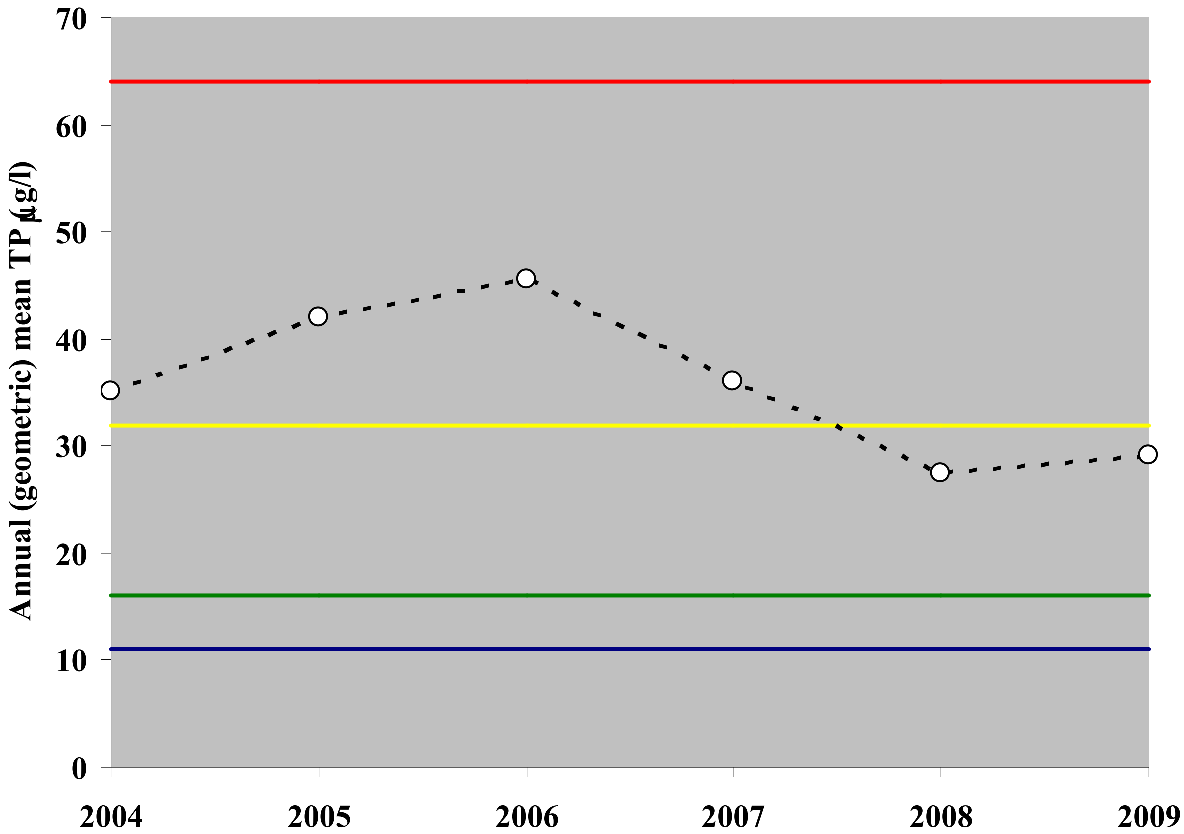


Figure 23. Changes in the annual geometric mean total phosphorus concentration of Over Water, based upon contemporary United Utilities water quality monitoring data (dashed line). Water Framework Directive class boundaries are shown for High-Good status (blue line), Good-Moderate (green line), Moderate-Poor (yellow line) and Poor-Bad (red line). Note that the datum for 2009 is based upon a partial monitoring year (data up to 7th October 2009).

Natural England have set a total phosphorus target of 15 μg/l for this lake in order to meet its conservation objectives (Appendix 12). Current concentrations are nearly twice this value, underscoring the elevated phosphorus concentrations are this site.

Clearly, a programme of measures would be needed to improve the water quality of the lake. However, an essential first step is the construction of a nutrient budget for the site that will allow the identification of significant sources and fluxes of phosphorus.

Conclusions

A key issue for Over Water is the extent to which abstraction-driven water level variation poses a threat to the ecological community. Since the site was originally notified as a SSSI, at least partly as a result of the diversity of the aquatic macrophyte community, this group has been a focus of our ongoing investigation. In order to relate the macrophyte depth distribution to water abstraction capacity, cumulative water extraction was estimated as a function of water depth btwl, using data plotted in Figure 1 covering the period July 1994 to August 2009, and expressed as a percentage of the total. This was combined with the macrophyte data on species loss with depth (Fig. 7c). The results (Fig. 24) allow the effect of drawdown on macrophyte species number to be compared with the reduction in water resource based on the actual amount of water extracted from Over Water over the last 15 years. The results show that about 72% of the available resource can be removed without any direct impact on the number of macrophyte species. On average, one macrophyte species would be lost for a draw-down to 1.0 m and at this draw-down, about 93% of the resource is available. Similarly, two species would be lost at a draw-down of 1.22 m which equates to 98% of resource availability. However, this level of draw-down could lead to the complete loss of *Littorella uniflora,* a characteristic shore-line species, with unpredictable consequences for the ecology of the lake. We therefore recommend that draw-down is restricted to less than 1 m to help protect the macrophyte community in Over Water.

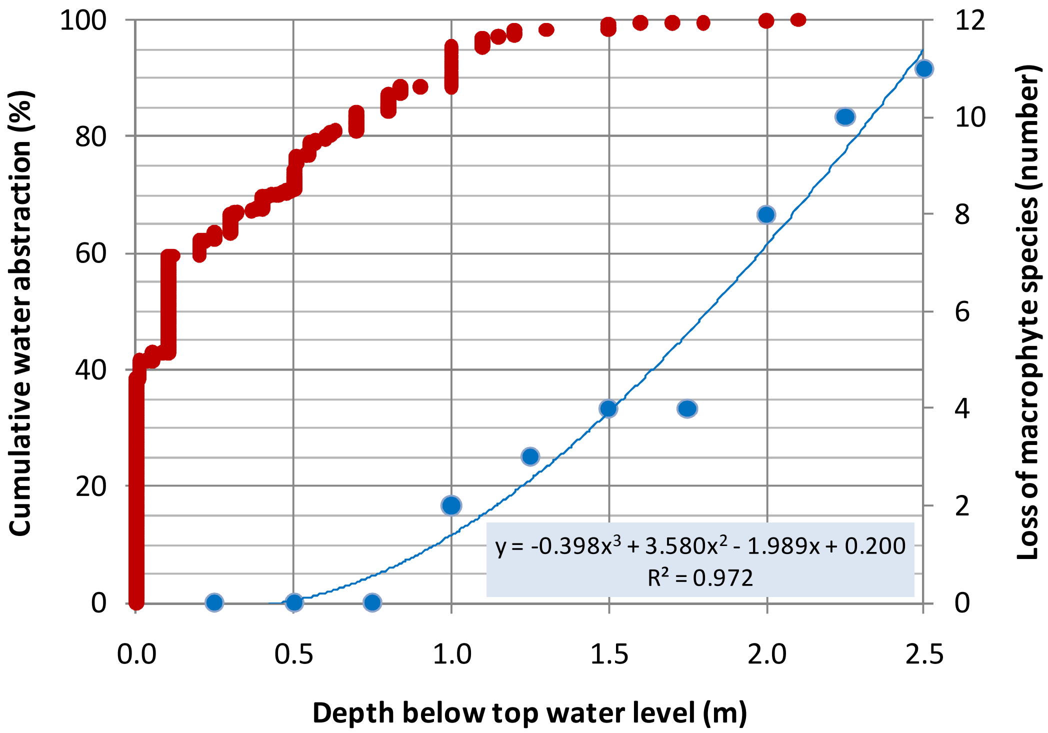


Figure 24. Comparison of cumulative water abstraction as a percent of total abstracted (red symbols) and loss of species (blue), plotted against depth below top water level. The thin blue line shows the third-order polynomial fit, with equation, for the relationship between macrophtyte loss and depth.

It is clear however that the abstraction regime is not the only pressure facing this site. Analysis of water quality data and palaeolimnological evidence suggest enrichment of Over Water in recent years. Furthermore, both our analysis of the available data and the current Environment Agency Water Framework Directive designation for the site show that the site currently falls below good ecological potential. Given the apparent deterioration of water quality in the lake, continued limnological monitoring is an essential bare minimum action that should be taken. This will allow us to judge whether the recent shift from poor to moderate potential, based upon TP concentrations, is a sign of ongoing improvement. If not, this will assist in planning specific investigations that will identify particular pressures facing the site, and inform likely programmes of measures. Below, we list the current priorities for future investigation at Over Water.

<u>Recommendations for further work</u>

We suggest that the following areas of work be considered as priorities for Over Water. We will be happy to produce detailed costings on request.

1) A **detailed nutrient budget** for Over Water, in order to identify significant sources and fluxes of phosphorus, nitrogen and silica. This would involve field surveys to collect water samples from major inflows, the lake outflow and from the lake itself. Samples would be analysed for key limiting nutrients (total/soluble reactive phosphorus, total nitrogen and nitrate-nitrogen, soluble reactive silica) and flow measurements would be made at inflows and outflows to convert concentration data into nutrient fluxes. Water column variations in nutrient concentrations, temperature and oxygen concentrations will be recorded to examine the evidence for internal nutrient loading to Over Water. Sediment samples should also be collected to establish the magnitude of this internal store. This would produce data that could be used to direct a programme of measures aimed at improving the WFD status of the lake.
2) A programme of **investigative monitoring** should be initiated at the site, with the specific purpose of determining the ecological reasons for Over Water being classified below Good status. This monitoring should include determinations of both total and soluble reactive phosphorus concentrations in the lake, in order to facilitate comparison of contemporary and historical phosphorus concentrations. Secchi depths are also essential, in order to understand changes in the pattern of depth zonation of the macrophyte community. Depth-profiles of temperature and oxygen should be made to evaluate the potential for anoxic-release of phosphorus from the sediment to the water.
3) A **comprehensive hydrological budget** for the lake. This is an essential precursor to establishing the extent to which abstraction can account for observed water level fluctuations. This should quantify major inflows, outflows, abstraction volumes and estimate evaporative losses.

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Appendices: Raw results from field survey on 20 and 21 August 2009 and brief methodology

Appendix 1. Strandline survey 1.

PERIMETER STRANDLINE SURVEY

Site Name	OVERWATER			**Date**	20/08/2009
Surveyors	Stephen Maberly & Mitzi DeVille				
Survey Sector No.	1				
Sector start point (GPS)	NY 25464 35242				
Sector end point (GPS)	NY 25381 35332				

Sample sub-section	**0-20m**	**20-40m**	**40-60m**	**60-80m**	**80-100m**
Substrate type	G	G	G/P/CO	G	G
Filamentous algae (0-3 cover)	0	0	0	0	0
Submerged/floating leaved spp (0-3 cover)	0	1	0	0	0
Species list (presence)					
Nuphar lutea	+	+	+	+	+
Littorella uniflora	+	+	+	+	-
Potamogeton perfoliatus	+	+	+	+	+
Elodea nuttallii	+	+	+	+	+
Potamogeton obtusifolius	+	+	+	+	+
Callitriche sp.	+	+	+	+	+
Potamogeton berchtoldii	+	+	+	+	+
Potamogeton crispus	-	-	-	+	-
Sparganium sp. (no flowers)	-	-	-	-	+
Callitriche hermaphroditica	-	-	-	-	+
		continued overleaf?			NO
Amphibious/emergent/marginal spp list (1-3 cover)					
Eleocharis palustris	3	3	3	2	2
Phalaris arundinacea	1	1	1	1	1
Alisma plantago-aquatica	1	1	1	0	0
Persicaria hydropiper	1	1	1	0	0
Potentilla anserina	0	1	1	0	0
Galium palustre	0	1	0	0	0
Lythrum salicaria	0	1	1	1	0
Myosotis sp.	0	0	1	0	0
Mentha aquatica	0	0	1	1	0
Equisetum sp.	0	0	0	0	1
Elatine hexandra	1				
		continued overleaf?			NO
Distance (m) HWM to water's edge	1	0.1	0.3	1	0
Shoreline modification (1-5 scale)	3	3	4	4	2
Adjacent vegetation type	IG	IG	IG	IG	IG
Photo taken?	1:1	x	1:3	1:4	x

NOTES

3 m of sample sub-section 3 (40-60 m) was outflow
3 m of sample sub-section 4 (60-80 m) was outflow
Outflow water level was 0.25
Evidence of dredged material dumped close to outflow (sample sub-section 4 (60-80 m).

Appendix 2. Strandline survey 2.

PERIMETER STRANDLINE SURVEY

Site Name	OVERWATER	**Date**	20/08/2009
Surveyors	Stephen Maberly & Mitzi DeVille		
Survey Sector No.	2		
Sector start point (GPS)	NY 25338 34907		
Sector end point (GPS)	NY 25206 34848		

Sample sub-section	**0-20m**	**20-40m**	**40-60m**	**60-80m**	**80-100m**
Substrate type	CL	SI	SI	SI	SI
Filamentous algae (0-3 cover)	0	0	0	0	0
Submerged/floating leaved spp (0-3 cover)	1	1	0	*NOTE	*NOTE
Species list (presence)					
Callitriche sp.	-	+	-	-	-
Nuphar lutea	-	+	-	+	+
Nuphar pumilla (based on leaf size- no flowers)	+	-	-	+	-
		continued overleaf?			NO
Amphibious/emergent/marginal spp list (1-3 cover)					
Phragmites australis	2	1	1	2	1
Filipendula ulmaria	1	1	1	0	0
Juncus effusus	1	1	0	0	0
Phalaris arundinacea	1	2	2	0	0
Potentilla palustris	1	0	1	0	0
Salix spp.	1	0	1	0	0
Iris pseudacorus	0	1	0	0	0
Galium palustre	0	1	0	0	0
Carex rostrata	0	0	0	2	1
Schoenoplectus lacustris	0	0	0	0	2
		continued overleaf?			NO

Distance (m) HWM to water's edge	0	0	0	0	0
Shoreline modification (1-5 scale)	1	1	1	1	1
Adjacent vegetation type	Salix/Betula	Mix Wood	Mix Wood	Mix Wood	Mix Wood/IG
Photo taken?	2:1	2:2	x	x	Nuphar bed

NOTES

*NOTE survey completed on 21/8/09 from boat due to inaccessability of shore

Sample sub-section 5 (80 - 100 m) had fringe of trees flanked by improved grassland

Appendix 3. Shore-based Survey 1.

SHORE BASED SURVEY (c. 100 m)

Site Name	OVERWATER	**Date**	20/08/2009
Surveyors	Stephen Maberly & Mitzi DeVille		
Survey Sector No.	1	**Water sample taken**	YES
Sector start point (GPS)	NY 25464 35242	**Lateral distance from edge to 75 cm (in m)**	37
Sector end point (GPS)	NY 25381 35332	**Photos taken (note overleaf)**	see strand 1

	NY2546435242				NY2545635261				NY2545035278				NY2543035305				NY2539535324							
Sample sub-section	1				2				3				4				5							
Sample point	1a	1b	1c	1d	2a	2b	2c	2d	3a	3b	3c	3d	4a	4b	4c	4d	5a	5b	5c	5d	overall			
Water depth (cm)	25	50	75	>75	25	50	75	>75	25	50	75	>75	25	50	75	>75	25	50	75	>75	25	50	75	>75
Substrate type	G	P	P		SI	G	G		G	G	G		G/P	G	G		G	G	G					
Aquatic plant biomass rating (0-3)	3	2	2	1	3	1	2	1	1	2	2	1	1	3	3	1	3	3	3	1				
Filamentous algae (0-3)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0				
Species list (presence/absence)																								
Eleocharis palustris	+	-	-	-	+	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-				
Littorella uniflora	+	+	+	+	-	+	+	+	-	+	+	+	-	+	+	+	+	+	+	+				
Nitella flexilis	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	+	-	-	-	+				
Elodea nuttallii	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	+				
Potamogeton obtusifolius	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-				
Potamogeton perfoliatus	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-				
"sponge"	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	+				
globular algae on stones	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				

NOTES

Water deeper at shore then shallower before getting deeper again.

Appendix 4. Shore-based survey 2.

SHORE BASED SURVEY (c. 100 m)

Site Name	OVERWATER	**Date**	20/08/2009
Surveyors	Stephen Maberly & Mitzi DeVille		
Survey Sector No.	2	**Water sample taken**	NO
Sector start point (GPS)	NY 25338 34907	**Lateral distance from edge to 75 cm (in m)**	5
Sector end point (GPS)	NY 25206 34848	**Photos taken (note overleaf)**	YES

NY2533834907 NY2532434896 NY2531334890 NY2529034874

Sample sub-section	**1**				**2**				**3**				**4**				**5**			
Sample point	1a	1b	1c	1d	2a	2b	2c	2d	3a	3b	3c	3d	4a	4b	4c	4d	5a	5b	5c	5d
Water depth (cm)	35	50	75	>75	40	50	75	>75	25	50	75	>75	25	50	75	>75	25	50	75	>75
Substrate type	CL	CL	CL		SI	SI	SI		NO	SI	SI		NA	SI	SI		NA	SI	SI	
Aquatic plant biomass rating (0-3)	0	1	1	1	1	1	1	1	NO	0	0	1	NA	2	2	1	NA	0	3	3
Filamentous algae (0-3)	0	0	0	0	0	0	0	0	NO	0	0	0	NA	0	0	0	NA	0	0	0
Species list (presence/absence)																				
Littorella uniflora	-	+	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
Elodea nuttallii	-	-	+	+	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-
Nuphar pumilla	-	-	+	-	-	-	-	+	-	-	-	+	-	+	-	+	-	-	-	-
Carex rostrata	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
Phragmites australis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
Schoenoplectus lacustris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
Nuphar lutea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+

overall			
25	50	75	>75

NOTES

NA - Not accessible

NO - water too deep

Shady at sample sub-section 3 due to overhanging trees

Appendix 5. Boat survey 1

BOAT BASED SURVEY

Site Name	OVERWATER	**Date**	21/08/2009
Surveyors	Stephen Maberly & Mitzi DeVille	**Depth of maximum colonisation (cm)**	220
Survey Sector No.	1	**Secchi depth (cm)**	180
Position of shore-end transect line (GPS)	NY 25441 35279	**Compass bearing of transect line**	NE/SW
Position of o/w transect line (GPS)	NY 25381 35197	**Length of transect line (m)**	97

SAMPLE POINT	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
Water depth (cm)	280	260	220	210	205	195	190	160	130	100	75	65	49	34	34	33	46	39	37	25	
Substrate type																		G	G	G	
Aquatic plant volume (0-3)	0	0	2	3	2	3	1	0	1	1	2	2	2	3	3	3	1	2	3	3	
Filamentous algae (0-3)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Species list (presence)																					**TOTAL**
Eleocharis palustris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	
Littorella uniflora	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	-	
Potamogeton perfoliatus	-	-	+	+	+	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-	
Elodea nuttallii	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	
Potamogeton obtusifolius	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	

NOTES

Outflow water gauge level =0.26

Appendix 6. Boat survey 2

BOAT BASED SURVEY

Site Name	OVERWATER	**Date**	21/08/2009
Surveyors	Stephen Maberly & Mitzi DeVille	**Depth of maximum colonisation (cm)**	140
Survey Sector No.	2	**Secchi depth (cm)**	180
Position of shore-end transect line (GPS)	NY 25284 34881	**Compass bearing of transect line**	SE/NW
Position of o/w transect line (GPS)	NY 25283 34889	**Length of transect line (m)**	15

SAMPLE POINT	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
Water depth (cm)	140	105	90	108	75	70	65	55	50	50	50	50	50	45	40	40	40	40	40	40	
Substrate type	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	
Aquatic plant volume (0-3)	1	2	2	2	1	1	2	1	1	0	1	0	1	1	1	1	1	1	2	3	
Filamentous algae (0-3)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Species list (presence)																					**TOTAL**
Littorella uniflora	+	+	+	+	+	+	+	+	+	-	+	-	+	-	-	-	-	-	-	-	
Elodea nuttallii	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	
Nuphar pumilla	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	
Carex rostrata	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	-	-	
Phalaris arundinacea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	

Appendix 7. Boat survey 3.

BOAT BASED SURVEY

Site Name	OVERWATER	**Date**	21/08/2009
Surveyors	Stephen Maberly & Mitzi DeVille	**Depth of maximum colonisation (cm)**	270
Survey Sector No.	3	**Secchi depth (cm)**	180
Position of shore-end transect line (GPS)	NY 24967 34841	**Compass bearing of transect line**	SW/NE
Position of o/w transect line (GPS)	NY 25036 34885	**Length of transect line (m)**	80

SAMPLE POINT	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
Water depth (cm)	270	250	235	210	220	200	195	185	170	160	160	155	140	130	120	110	100	80	80	70	
Substrate type	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	SI	
Aquatic plant volume (0-3)	1	1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	2	
Filamentous algae (0-3)	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	
Species list (presence)																					**TOTAL**
Potamogeton obtusifolius	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	
Elodea nuttallii	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	
Sparganium angustifolium	-	-	+	-	+	+	-	+	+	+	+	+	+	+	-	-	-	-	-	-	
Callitriche sp.	-	-	-	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	
Potamogeton berchtoldii	-	-	-	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	
Callitriche hermaphroditica	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Nuphar lutea	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	
Potamogeton crispus	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	
Schoenoplectus lacustris	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	
Carex rostrata	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	
Lemna sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	

NOTES

Sparganium erectum present but not in transect.

Distance from shore about 6 m extra but Salix impenetrable

Appendix 8. Boat survey 4.

BOAT BASED SURVEY

Site Name	OVERWATER	**Date**	21/08/2009
Surveyors	Stephen Maberly & Mitzi DeVille	**Depth of maximum colonisation (cm)**	160
Survey Sector No.	4	**Secchi depth (cm)**	180
Position of shore-end transect line (GPS)	NY 25070 35190	**Compass bearing of transect line**	NW/SE
Position of o/w transect line (GPS)	NY 25097 35142	**Length of transect line (m)**	60

SAMPLE POINT	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
Water depth (cm)	160	150	140	140	140	125	125	120	120	110	110	115	95	80	75	60	40	35	33	25	
Substrate type	P	P	G	G/SI	G	G/SI	G/SI	G/SI	G/SI	SI	SI	SI	SI	SI	SI	SI	P/SI	P/SI	P	P	
Aquatic plant volume (0-3)	1	1	0	2	0	1	1	1	1	3	2	1	1	2	2	2	2	3	3	2	
Filamentous algae (0-3)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	
Species list (presence)																					**TOTAL**
Elodea nuttallii	+	-	-	+	-	+	+	+	-	+	-	-	-	-	-	-	-	-	-	-	
Nuphar seedling	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Schoenoplectus lacustris	-	-	-	-	-	-	+	+	+	+	+	-	-	-	-	-	-	-	-	-	
Potamogeton gramineus	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	
Nuphar lutea	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	
Littorella uniflora	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	

NOTES

None

Appendix 9. Measurements made at approx deepest point at Over Water on 20/8/2010.

OVERWATER		deep point 8.5 m			GPS NY 25334 35055			
DATE	LAKE	NAME	PROBE	DEPTH	TEMP	OXY(mg/L)	OXY(%)	OXY(µM/L)
20090820	OVER	MDEV	WTWD	0.0	17.4	9.52	99.7	297
20090820	OVER	MDEV	WTWD	2.0	17.4	9.44	98.8	295
20090820	OVER	MDEV	WTWD	4.0	17.4	9.42	98.6	294
20090820	OVER	MDEV	WTWD	6.0	17.1	8.52	88.7	266
20090820	OVER	MDEV	WTWD	8.0	16.8	7.22	74.7	226
20090820	OVER	MDEV	WTWD	8.5	16.8	6.07	62.8	190
DATE	**LAKE**	**NAME**	**METER**	**DEPTH**	**LIGHT PAR/µmol**	**LIGHT PAR/µmol m^2 s^{-1}**		
20090820	OVER	MDEV	LES2	AIR	62.92			
20090820	OVER	MDEV	LES2	0	32.02	137.00		
20090820	OVER	MDEV	LES2	0.5	10.82			
20090820	OVER	MDEV	LES2	1	4.52	22.30		
20090820	OVER	MDEV	LES2	1.5	3.14			
20090820	OVER	MDEV	LES2	2	1.69	5.80		
20090820	OVER	MDEV	LES2	2.5	1.01			
20090820	OVER	MDEV	LES2	3	0.63	1.70		
20090820	OVER	MDEV	LES2	3.5	0.48			
20090820	OVER	MDEV	LES2	4	0.35	0.35		
					downwards	upwards (ie starting from the bottom)		
				Notes	getting brighter d	More reliable		
Secchi depth = 1.8 m @ 09:40 SCM								
Conductivity = 101.0 µS cm-1								
Wind = 4.7 m/sec Gusty SSW wind, showers following heavy overnight rain								
CLOUD/8	8							

Appendix 10. Water chemistry from 20/8/2009 at Over Water. Sample collected at deepest point.

Water chemistry from deepest point- 5 m integrated sample				
Variable	Unit	Value		
pH	-	7.33		
Temp of pH	oC	19.7		
CO2-aciditity	mmol L-1	-0.071		
Alk	mequiv L-	0.558		
CT	mmol L-1	0.629		
Chla	µg L-1	15.2		
SRP-P	µg L-1	1.2		

Appendix 11. Brief methodology for macrophyte survey at Overwater in August 2009

General points

- At small simple lakes, examine 4 x 100 m sectors.
- Sectors should be where characteristic macrophyte communities are likely to occur or where previous surveys have taken place.
- One sector should be on a sheltered shore where plant fragments are likely to accumulate.
- Use GPS to record co-ordinates and take photos.
- Three components: *strandline survey*, *wader survey*, *boat survey, general sweep*.

Strandline Survey

- At each 100 m sector record presence/absence of growing (G) or strandline (S) species
- Repeat at each of the 5 sub-sectors every 20 m.

Wader Survey

- At each 100 m sector examine 20 quadrats each covering 1 m^2.
- Five transects every 20 m along sector at 0.25, 0.5, 0.75 and > 0.75 m depth using a bathyscope and/or grapnel.
- At each quadrat record:
  - All species present
  - Total vegetation abundance (0 - 3)
  - Algal abundance (non-Chara) (0 - 3).
- Scoring:
  - 0 = absent
  - 1 = <25% cover
  - 2 = 25 - 75% cover
  - 3 - > 75% cover

Boat Survey

- One transect at each sector from deep to shallow water at 50 m position.
- At 20 evenly spaced positions on transect record for a 1 m^2 area (use a grapnel if necessary):
  - Water depth
  - All species present
  - Total vegetation abundance (0 - 3)
  - Algal abundance (non-Chara) (0 - 3).
- Record maximum colonisable depth.

General Sweep

- Perform a general sweep of suitable areas to check for other species.

Conservation objectives and definitions of favourable condition for designated features of interest

These Conservation Objectives relate to all designated features on the SSSI, whether designated as SSSI, SPA, SAC or Ramsar features.

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Name of Site of Special Scientific Interest (SSSI)	
Over Water	
Names of designated international sites	
Special Area of Conservation (SAC)	**N/A**
Special Protection Area (SPA)	**N/A**
Ramsar	**N/A**
Relationship between site designations	

Version control information		
Status of this Version (Draft, Consultation Draft, Final)	Consultation Draft (note that an NVC is required for this site to be able to further tailor these objectives)	
Prepared by	P. KIRKHAM	
Date of this version	23 March 2009	
Date of generic guidance on favourable condition used	Joint Nature Conservancy Committee (JNCC) Common Standards Monitoring Guidance (CSM): Standing Waters (March 2005) Woodland Habitats (February 2004)	
Other notes/version history	Draft 1: 19/03/09. Amendments made by PK and KS on 23 March 2009.	
Quality assurance information		
Checked by	**Name Karen Slater**	**Date 23 March 2009**
	Signature Karen Slater	

Conservation Objectives and definitions of Favourable Condition: notes for users

Conservation Objectives
SSSIs are notified because of specific biological or geological features. Conservation Objectives define the desired state for each site in terms of the features for which they have been designated. When these features are being managed in a way which maintains their nature conservation value, then they are said to be in 'favourable condition'. It is a Government target that 95% of the total area of SSSIs should be in favourable condition by 2010.

Definitions of Favourable Condition
The Conservation Objectives are accompanied by one or more habitat extent and quality definitions for the special interest features at this site. These are subject to periodic reassessment and may be updated to reflect new information or knowledge; they will be used by Natural England and other relevant authorities to determine if a site is in favourable condition. The standards for favourable condition have been developed and are applied throughout the UK.

Use under the Habitats Regulations
The Conservation Objectives and definitions of favourable condition for features on the SSSI may inform the scope and nature of any 'appropriate assessment' under the Habitats Regulations. An appropriate assessment will also require consideration of issues specific to the individual plan or project. The habitat quality definitions do not by themselves provide a comprehensive basis on which to assess plans and projects as required under Regulations 20-21, 24, 48-50 and 54 - 85. The scope and content of an appropriate assessment will depend upon the location, size and significance of the proposed project. Natural England will advise on a case by case basis.

Following an appropriate assessment, competent authorities are required to ascertain the effect on the integrity of the site. The integrity of the site is defined in paragraph 20 of ODPM Circular 06/2005 (DEFRA Circular 01/2005) as the coherence of its ecological structure and function, across its whole area, that enables it to sustain the habitat, complex of habitats and/or the levels of populations of the species for which it was classified. The determination of favourable condition is separate from the judgement of effect upon integrity. For example, there may be a time-lag between a plan or project being initiated and a consequent adverse effect upon integrity becoming manifest in the condition assessment. In such cases, a plan or project may have an adverse effect upon integrity even though the site remains in favourable condition.

The formal Conservation Objectives for European Sites under the Habitats Regulations are in accordance with paragraph 17 of ODPM Circular 06/2005 (DEFRA Circular 01/2005), the reasons for which the European Site was classified or designated. The entry on the Register of European Sites gives the reasons for which a European Site was classified or designated.

Explanatory text for Tables 2 and 3

Tables 2, 2a and 3 set out the measures of condition which we will use to provide evidence to support our assessment of whether features are in favourable condition. They are derived from a set of generic guidance on favourable condition prepared by Natural

England specialists, and have been tailored by local staff to reflect the particular characteristics and site-specific circumstances of individual sites. Quality Assurance has ensured that such site-specific tailoring remains within a nationally consistent set of standards. The tables include an audit trail to provide a summary of the reasoning behind any site-specific targets etc. In some cases the requirements of features or designations may conflict; the detailed basis for any reconciliation of conflicts on this site may be recorded elsewhere.

Conservation Objectives

The Conservation Objectives for this site are, subject to natural change, to maintain the following habitats and geological features in favourable condition (*), with particular reference to any dependent component special interest features (habitats, vegetation types, species, species assemblages etc.) for which the land is designated (SSSI, SAC, SPA, Ramsar) as individually listed in Table 1.

Habitat Types represented (Biodiversity Action Plan categories)

Standing Open Water
Wet Woodland
Fen, marsh and swamp

Geological features (Geological Site Types)

N/A

(*) or restored to favourable condition if features are judged to be unfavourable.

Standards for favourable condition are defined with particular reference to the specific designated features listed in Table 1, and are based on a selected set of attributes for features which most economically define favourable condition as set out in Table 2, Table 2a and Table

Table 1 Individual designated interest features

BAP Broad Habitat type / Geological Site Type	Specific designated features	Explanatory description of the feature for clarification	SSSI designated interest features	SAC designated interest features	SPA bird populations dependency on specific habitats			Ramsar criteria applicable to specific habitats			
					Annex 1 species	Migratory species	Waterfowl assemblage	1a Wetland characteristics	2a Hosting rare species &c	3a 20000 waterfowl	3c 1% of population
Standing open water and canals	Oligotrophic to mesotrophic standing water with vegetation of the *Littorelletea uniflorae* and/or *Isoeto-Nanojuncetea*	Oligotrophic to mesotrophic lake ecosystem	Yes								
Broadleaved, mixed and yew woodland	Mixed scrub on fen peat: NVC survey is urgently required for this site, but communities present may include: W3 *Salix pentandra – Carex rostrata* woodland	Wet woodland	Yes								
Fen, marsh and swamp	Mesotrophic/ eutrophic valley mire NVC survey is urgently required for this site, but communities present may include: M23 *Juncus effusus / acutiflorus – Galium palustre* rush pasture S4 *Phragmites australis* swamp S8 *Scirpus lacustris* swamp S9 *Carex rostrata* swamp	Fen and swamp communities	Yes								

Table 2 Habitat extent objectives

Conservation Objective for habitat extent	To maintain the designated features in favourable condition, which is defined in part in relation to a balance of habitat extents (extent attribute). Favourable condition is defined at this site in terms of the following site-specific standards.
Extent - Dynamic balance	On this site favourable condition requires the maintenance of the extent of each habitat type (either designated habitat or habitat supporting designated species). Maintenance implies restoration if evidence from condition assessment suggests a reduction in extent.

Habitat Feature (BAP Broad Habitat level, or more detailed level if applicable)	Estimated extent (ha) and date of data source/estimate	Site Specific Target range and Measures	*Comments*
Standing waters, Wet woodland, Fen and swamp communities	Habitat extent: **Open water 22ha** **Associated grassland, fen and carr 7.3ha** **Total: 29.3ha** Assessment against baseline map. Aerial photographs may be useful.	No loss of extent of standing water. No loss of wet woodland and fen/swamp communties.	This attribute is to assess changes caused by active management, such as infilling or channel diversion. Changes due to drying out or successional change are covered under other attributes.

Audit Trail
Rationale for habitat extent attribute **(Include methods of estimation (measures), and the approximate degree of change which these are capable of detecting).**
Measurements of area are figures stated in the SSSI 'Reasons for Notification'
Rationale for site-specific targets (including any variations from generic guidance)
Survey data for Over Water is not comprehensive enough to allow for determination of NVC types, so general targets have been selected for its broad habitat types which will have to be reviewed once an NVC survey has been completed.
Other Notes

Table 3 Site-Specific definitions of Favourable Condition

CONSERVATION **OBJECTIVE FOR THIS HABITAT / GEOLOGICAL SITE-TYPE**	To maintain the **Oligotrophic To Mesotrophic Standing Waters** at **Over Water SSSI** in favourable condition, with particular reference to relevant specific designated interest features. Favourable condition is defined at this site in terms of the following site-specific standards:
Site-specific details of any geographical variation or limitations (where the favourable condition standards apply)	
The lake is Unit 9.	

Site-specific standards defining favourable condition

Criteria feature	Attribute term in guidance	Measure	Site-specific Targets	Comments	Use for CA?
Oligotrophic to mesotrophic standing waters	**Extent**	Assessment against baseline map. Aerial photographs may be useful.	No loss of extent of standing water	This attribute is to assess changes caused by active management, such as infilling or channel diversion. Changes due to drying out or successional change are covered under other attributes.	Yes
Oligotrophic to mesotrophic standing waters	**Vegetation composition: macrophyte community composition**	Fixed point sector/transect sampling (boat or shore-based methods)	Mesotrophic standing waters: i) Presence of at least 3 of the characteristic Potamogeton species listed in Box 2 for mesotrophic waters. ii) Presence of at least 8 of the characteristic species listed in Box 2 in the notes except where valid reasons (see comments) suggest otherwise. iii) No loss of characteristic species (see Box 2) recorded from the site. iv) 6 out of 10 sample spots (boat or	The mesotrophic community has a clinal range of species as the trophic state increases. These richer trophic states cannot support *Subularia aquatica* but are indicated by the presence of broad-leaved *Potamogeton* spp. *Potamogeton perfoliatus, P. gramineus, Nitella* spp. *Sparganium natans* is indicative of an increased trophic state. (N.B. *Subularia* may be naturally absent from some regional areas.) *Persicaria amphibia* can be present as an associate. As this interest feature covers a wide range of trophic states it is essential to establish which community type	Yes

Criteria feature	Attribute term in guidance	Measure	Site-specific Targets	Comments	Use for CA?
			wader survey) should include at least one characteristic species from Box 2 in the notes .	represents the feature for the site in question. The presence of *Myriophyllum alterniflorum* at >40% frequency in mesotrophic waters, is indicative that a lake is not in favourable condition. The presence of non-characteristic species such as *Zannichellia palustris, Potamogeton pectinatus, Lemna* spp. And fine-leaved *Potamogeton* spp. (except *P. berchtoldii*) would indicate possible eutrophication of the water body.	
Oligotrophic to mesotrophic standing waters	**Vegetation composition: negative indicator species**		Non-native species should be absent or present at low frequency. Algal dominance: Cover of benthic and epiphytic filamentous algae should be less than 10%.	Introduced species should be identified. A number of non-natives have such invasive potential that they should be assessed separately. Species of particular concern are: *Crassula helmsii, Hydrocotyle ranunculoides, Myriophyllum aquaticum and Azolla filiculoides*. If any of these species are present, a water body should be considered as being in unfavourable condition. This list is not exhaustive and should be updated as new threats become apparent. Occurrence *of Elodea nuttallii* or *Elodea canadensis* at >40% frequency in unproductive waters, and >50% frequency in more productive waters, is indicative of unfavourable condition. Excessive growths of filamentous algae on lake substrate or macrophytes are	Yes

Criteria feature	Attribute term in guidance	Measure	Site-specific Targets	Comments	Use for CA?
				indicative of nutrient enrichment.	
Oligotrophic to mesotrophic standing waters	**Vegetation composition: macrophyte community structure**	Fixed point sector/transect sampling (boat or shore-based methods) Check against Phase 1 habitat map and subsequent survey data.	Characteristic zones of vegetation should be present: *Littorella*, then overlapping zones of *Littorella* with *Lobelia*, then *Isoetes*. Maximum depth distribution should be maintained. At least the present structure should be maintained, including the surrounding areas of wet grassland and fen which grade into willow scrub and closed canopy woodland.	*L. uniflora* and *L. dortmanna* dominant in depths <1.5 m; *Isoetes* dominant > 1.5 m. It is very sensitive to wave action, setting a shallow depth limit particularly in exposed sites. The maximum depth of *Isoetes* colonisation should be examined, but also the depth of colonisation of other taxa in richer waters within this range e.g. *Potamogeton* spp.. Where present, well defined hydroseres should be maintained.	Yes
Oligotrophic to mesotrophic standing waters	**Water quality**	Existing data or develop a water sampling regime. This should be carried out quarterly, ideally monthly. As a minimum samples should be taken in early spring.	Stable nutrient levels appropriate to lake type. For deep (>3m), mesotrophic lakes, total phosphorus target is: 15µg P 1-1	Mean annual TP concentrations (based on at least quarterly measurements), or spring TP levels, should meet the targets appropriate for the lake type documented in the guidance, unless site-specific targets are available. If palaeolimnological techniques or hindcast modelling have been employed to reconstruct natural background TP concentrations for a particular lake these can be used to set targets, although it may be necessary to accept a small deviation from these background conditions. Alternatively, historical water chemistry data may exist for individual lakes.	Yes

Criteria feature	Attribute term in guidance	Measure	Site-specific Targets	Comments	Use for CA?
				Where existing, site-specific TP concentrations are consistently lower than the standard appropriate for the habitat type, a lower target should be applied to prevent deterioration from current status.	
			Stable pH/ANC values: < 8.00	As a guide, for mesotrophic waters, pH circumneutral to < 8.00	
				There is a wide clinal range of community types embraced in this feature. Water quality targets should be set for individual SAC lakes and an acceptable range established.	
				The acceptable range of chemical conditions (especially total P, other forms of phosphorus, pH/ANC, and where appropriate NO3-N,) should be set from recent or historical water chemistry data.	
				Check for changes in land-use in the catchment causing diffuse pollution and/or siltation and check point sources of pollution. Aerially applied agro-chemicals have a high potential to change plant communities, and to move them out of favourable condition.	
				Other methodologies involving trophic scoring can contribute to the assessment of favourable condition.	
			Adequate dissolved oxygen levels for	Levels of dissolved oxygen should support the invertebrate and vertebrate taxa associated with this lake type.	

Criteria feature	Attribute term in guidance	Measure	Site-specific Targets	Comments	Use for CA?
		Existing data or temperature/ dissolved oxygen profiles Existing data, shoreline walk, sample of bloom	health of characteristic fauna No excessive growth of cyanobacterial or green algae.	There should be no evidence of blue-green or green algal blooms.	
Oligotrophic to mesotrophic standing waters	**Hydrology**	Shoreline walk. Where necessary, develop a hydrological model and sampling regime. This should initially be carried out quarterly as a minimum, ideally monthly. Shoreline walk	There should be a natural hydrological regime	The natural flushing rate and seasonal water level fluctuations of the lake should not be affected by abstractions from inflow streams, groundwater or the lake or by changes to outflows. Online lakes can be assessed by reference to changes in inflow stream flows and changes in lake residence times. Data to assess the targets should be available from the Environment Agency and United Utilities and should be linked to current AMP4 investigation process. There should be no evidence of impact from lowered or artificially raised water levels. Evidence of lowered water levels include: loss of marginal or littoral vegetation or large areas of exposed lake substrate. Artificially raised water levels may result in the drowning of trees and other terrestrial vegetation above the lake shore. Grazing or erosion from boat wash may reduce marginal vegetation cover.	Yes

Criteria feature	Attribute term in guidance	Measure	Site-specific Targets	Comments	Use for CA?
				L. uniflora can tolerate extreme inter-annual fluctuations in water level and long periods of exposure. *L. dortmanna* is tolerant of short periods of exposure but intolerant of desiccation.	
Oligotrophic to mesotrophic standing waters	**Lake substrate**	Shoreline walk	Maintain natural shoreline. Maintain natural and characteristic substrate for lake type.	There should be no increase in lakeshore modifications. Substrate is typically sand, gravel, stones and boulders with low organic content but sometimes locally high peat content. Sediment quality and quantity when enriched can cause excessive growths of Juncus bulbosus var. fluitans or growths of algae.	Yes
Oligotrophic to mesotrophic standing waters	**Sediment load**	Direct observation and/or establish sedimentation rate from sediment cores.	Maintain natural sediment load.	Increases in siltation could result from increased lake productivity, changes in catchment land-use (particularly over-grazing), lake level fluctuations, climatic fluctuations, or changes in sewage treatment. Increased sediment loads may result in smothering of coarse substrates with fine sediments. Fine sediments will be readily disturbed by movements in the overlying water column or passage of a plant sampling grapnel. Changes in plant community may result from enriched sediments without an accompanying change in water chemistry.	Yes

Criteria feature	Attribute term in guidance	Measure	Site-specific Targets	Comments	Use for CA?
Oligotrophic to mesotrophic standing waters	**Disturbance**	**Visual assessment**	Minimal negative impact from artificial structures. Minimal negative impact from recreation. Direct application of lime to the water column as an acidification amelioration strategy should not be carried out No fish farming	Artificial structures could include boat-mooring facilities, dams, fish reefs. Negative impacts from recreational activities can include enrichment caused by ground baiting, introduction of bottom feeding fish and other organisms not characteristic of the habitat, increased disturbance from water-sports. Efforts should be directed towards reducing atmospheric emissions and implementing catchment management strategies, especially in relation to coniferous forestry. Catchment area changes affecting the lake, such as flood defences and infrastructure schemes, should be considered.	
Oligotrophic to mesotrophic standing waters	**Indicators of local distinctiveness**	Specialist survey required.	Maintain presence of cladoceran crustacean *Illyocryptus acutifrons*. Maintain presence of breeding and overwintering birds. Maintain presence of *Callitriche hermaphroditica* and *Elatine hexandra*	Over Water is locally important for its population of breeding birds, including great crested grebe, grey heron, and reed warbler. Its wintering wildfowl includes little grebe, wigeon, tufted duck, pochard, goldeneye, goosander and whooper swan. Both species are listed as notable in the SSSI citation.	No

Audit Trail
Rationale for limiting standards to specified parts of the site
Rationale for site-specific targets (including any variations from generic guidance)
Rationale for selection of measures of condition (features and attributes for use in condition assessment) **(**The selected vegetation attributes are those considered to most economically define favourable condition at this site for the broad habitat type and any dependent designated species).

Other Notes

Box 2. Characteristic species of oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Iseoto-Nanojuncetea*. **mesotrophic standing waters only.

Characteristic species: ***Littorelletea* flora:** *Littorella uniflora* *Isoetes lacustris* *Isoetes echinospora* *Lobelia dortmanna* *Subularia aquatica* *Sparganium angustifolium* *Luronium natans* *Potamogeton rutilis* **Other characteristic species:** *Pilularia globulifera* *Elatine hexandra* *Baldellia ranunculoides* *Carex rostrata* *Utricularia* spp. ** Nitella spp. ***Sparganium natans* **Broadleaved *Potamogeton* species: *P. alpinus* *P. praelongus* *P. perfoliatus* *P. gramineus* *P x nitens* (and any other established hybrid of these species) ***Najas flexilis*	**Associates:** *Callitriche hamulata* *Callitriche brutia* *Myriophyllum alterniflorum* *Potamogeton polygonifolius* *Potamogeton berchtoldii* *Potamogeton natans* *Nymphaea alba* *Juncus bulbosus* *Eleogiton fluitans* *Equisetum fluviatile* *Nuphar lutea* *Menyanthes trifoliata* *Eleocharis acicularis* ***Persicaria amphibian* *Species highlighted in red have been recorded in surveys (Charter, L. 1994, and UCL, 2005)* From 1984 survey (notification) by Liz Charter, two notable species were: *Callitriche hermaphroditica* and *Elatine hexandra* (see NE A file, habitat section) mentioned under criteria for selection.

Table 3b Site-Specific definitions of Favourable Condition

CONSERVATION **OBJECTIVE FOR THIS HABITAT / GEOLOGICAL SITE-TYPE**	To maintain the **swamp, marsh and fen** and **wet woodland** at **Over Water SSSI** in favourable condition, with particular reference to relevant specific designated interest features. Favourable condition is defined at this site in terms of the following site-specific standards:
Site-specific details of any geographical variation or limitations (where the favourable condition standards apply)	
SSSI units containing swamp, marsh and fen (NVC types unknown): 1, 3, 8, 9 SSSSI units containing wet woodland (NVC types unknown): 2, 3, 4, 5, 6, 7, 8	

Site-specific standards defining favourable condition

Criteria feature	Attribute term in guidance	Measure	Site-specific Targets	Comments	Use for CA?
Swamp, marsh and fen (S4, 8, 9, M23)	**Habitat extent**	A baseline map showing the boundary of the habitat should be used to assess any changes in extent. Aerial photographs can offer a convenient means of rapidly assessing extent in some cases.	No reduction in the total combined extent of wetland in relation to the established baseline.	Where there is a loss in the area of the wetland feature then condition should be recorded as unfavourable.	Yes
Swamp, marsh and fen (S4, 8, 9, M23)	**Habitat composition**	A baseline map showing the boundary of the components (where appropriate), should be used to assess any changes in extent. Aerial photographs can	The component fen and swamp vegetation types should be present around Over Water. These should be in appropriate proportion (i.e. at the approximate same extent and distribution of mix of habitats) as described in the Target Notes For Over Water SSSI by Liz Charter 3.9.82 (NE file: NY23/2 Sc)		Yes

Criteria feature	Attribute term in guidance	Measure	Site-specific Targets	Comments	Use for CA?
		offer a convenient means of rapidly assessing extent in some cases.			
Swamp, marsh and fen (S4, 8, 9, M23)	**Habitat structure**	Aerial photographs can offer a convenient means of rapidly assessing these. It may also be necessary to make a visual assessment of % cover using a structured walk or transects.	There should be no obvious modification to structural features and natural drainage. Exposed substrate should not exceed 2% cover.	A high frequency and cover of exposed substrate will usually be undesirable and may indicate, *inter alia*, over-grazing and water scour. More than 25% litter cover indicates insufficient removal of biomass by grazing.	Yes
Swamp, marsh and fen (S4, 8, 9, M23)	**Vegetation composition:** positive indicators	Use of visual assessment and modified DAFOR.	**For the S4** *Phragmites australis* swamp: • *Phragmites australis* forming a closed or open stand; >70% cover **For the S8 *Scirpus lacustris* ssp. *lacustris* swamp** (sub-communities to be determined) *Sparganium erectum* sub-community: • *Schoenoplectus lacustris*: <2m in height • *Sparganium erectum*: present *Equisetum fluviatile* sub-community: • *Schoenoplectus lacustris*: <2m in height • Associated species e.g. *Equisetum fluviatile, Carex rostrata, Menyanthes trifoliata*: at least one species present, combined cover <50% **For the S9 *Carex rostrata* swamp**: • *Carex rostrata* constant. **For the M23 Juncus effusus/acutiflorus rush**	The vegetation communities need to be confirmed by completing a detailed NVC survey of the site. We do not currently have this information – these are a best estimate.	Yes

Criteria feature	Attribute term in guidance	Measure	Site-specific Targets	Comments	Use for CA?
			pasture: At least 2 of the following species frequent and 4 occasional: *Achillea ptarmica, Angelca sylvestris, Caltha palustris, Fillipendula ulmaria, Galium palustre, Hydrocotyle vulgaris, Lotus pedunculatus, Lychnis flos-cuculi*, *Lysimachia vulgaris, Lythrum salicaria,* Orchid spp, *Mentha aquatica, Menyanthes trifoliatia, Potentilla palustris, Scutellaria galericulata, Stachys palustris Viola palustris, Valeriana dioica, V. officinalis*.		
Swamp, marsh and fen (S4, 8, 9, M23) **Wet Woodland**	**Vegetation composition**: indicators of negative change - Invasive non-native species	Use of visual assessment and modified DAFOR.	Invasive non-native species (e.g. *Crassula helmsii, Acorus calamus, Mimulus* spp., *Impatiens glandulifera, Fallopia japonica, Heracleum mantegazzianum, Lysichiton americanum*) should be absent, or no more than rare if present.	Spread of invasive alien species can often be very rapid once established. The dynamics are important, as is the apparent health of the indicators. *Lysichiton americanum* (skunk cabbage) is becoming dominant in unit 6.	Yes
Swamp, marsh and fen (S4, 8, 9, M23)	**Vegetation composition:** indicators of negative change - woody species	Use of visual assessment and modified DAFOR. Aerial photography may be a useful aid but will not pick up small saplings and seedlings.	**In swamp and fen areas**: woody species (*Betula, Salix*) should be no more than scattered, predominantly <1.5m high. Cover should be <10% on open fen and less than 2% on fen meadow (unit 4). Saplings/ seedlings should be no more than rare.	Scrub and woodland are integral parts of the fen systems and are particularly important for invertebrates. However, invasion of the predominantly open habitats around Over Water by woody species and their development to maturity may indicate drying out, dereliction, disturbance and/or enrichment. Trees and shrubs will exacerbate drying out.	Yes
Swamp, marsh and fen M23 only	**Sward composition:** cover and	Structured observation or sampling	25-80% *Juncus* cover with <30% *J. effusus* cover		Yes

Criteria feature	Attribute term in guidance	Measure	Site-specific Targets	Comments	Use for CA?
	frequency of bulky *Juncus* and *Phalaris*	Direct measurements at points across the stand			
	negative indicators: agricultural weeds	Direct measurements at points across the stand	No species individually more than 10% cover, or collectively more than 20% cover.	Examples of negative indicators (agricultural weeds): *Anthriscus sylvestris, Cirsium arvense, Cirsium vulgare, Rumex crispus, Rumex obtusifolius, Urtica dioica*	Yes
	negative indicators: agriculturally favoured species	Direct measurements at points across the stand	No species more than occasional throughout sward or together more than 5% cover.	Examples of negative indicators (agriculturally favoured species): *Lolium perenne, Phleum pratense, Glyceria fluitans, Holcus lanatus,* *Poa trivialis, Ranunculus repens, Trifolium repens*	Yes
	Sward structure: average height	Direct measurements at points across the stand	Sward height in the range 5-80cm	Sward structure not dominated by dense tussocks of *J. effusus* or *Molinea caerulea*	Yes
Wet woodland (W3)	Habitat extent	Field survey and/or aerial photography, in relation to baseline map.	No loss of ancient semi-natural stands. At least current area of recent semi-natural stands maintained, although their location may alter.	Stand destruction may occur if the understorey and ground flora are irretrievably damaged even if the canopy remains intact. As a guideline, loss can be defined as at least 0.5 ha or 0.5% of the stand area, whichever is the smaller. 20% canopy cover is conventionally taken as the lower limit for an area to be considered as woodland.	Yes
Wet woodland (W3)	Structure and natural	Assess by field survey using structured walk	Canopy cover present over 30-90 % of stand area	Wet woodlands naturally have a sparse understorey.	Yes

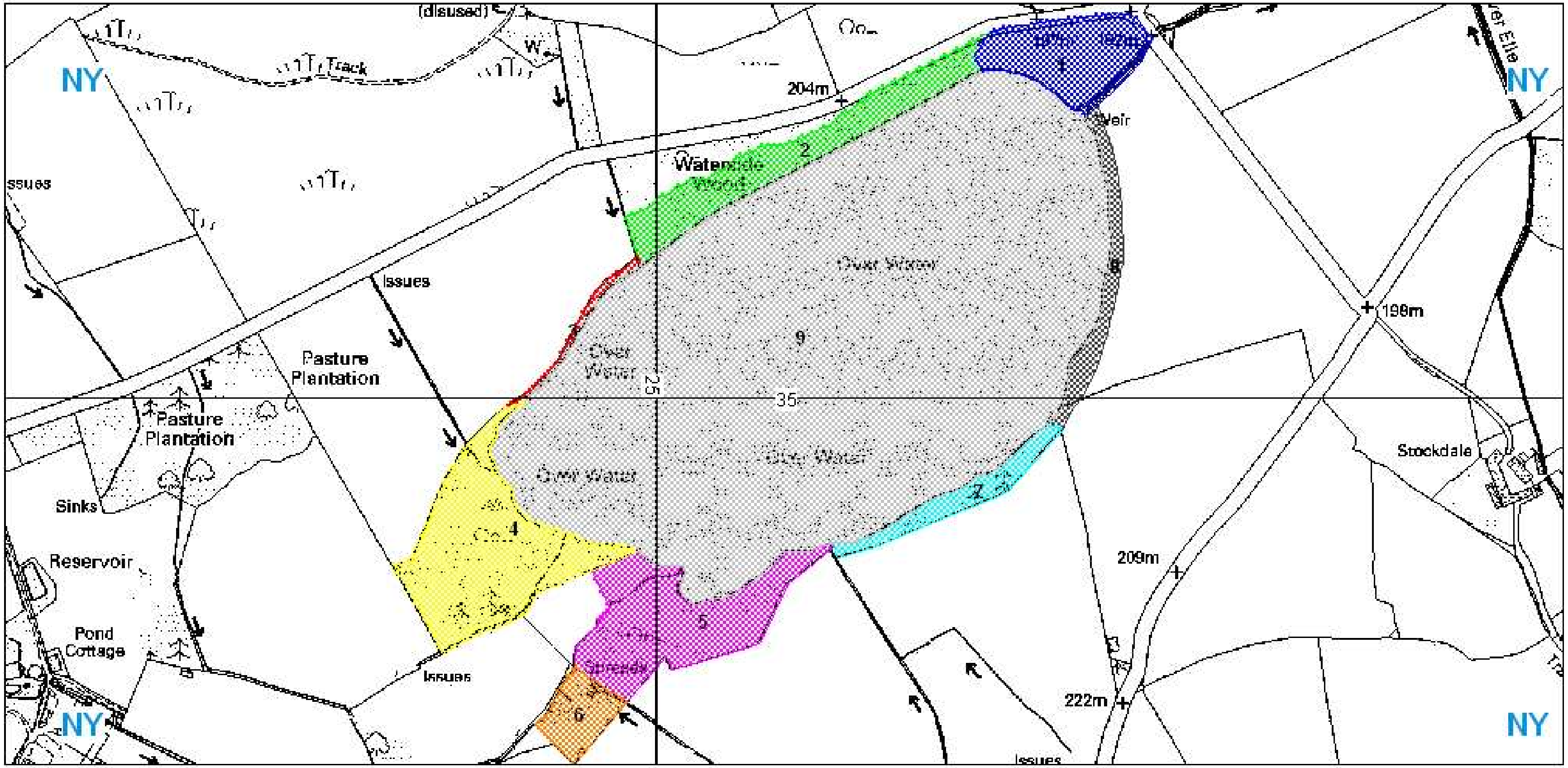
Criteria feature	Attribute term in guidance	Measure	Site-specific Targets	Comments	Use for CA?
	processes	and/or transects.	Some areas of relatively undisturbed mature/old growth stands allowed to grow to overmaturity/ death on site (e.g. a minimum of 10% of the woodland or 5-10 trees per ha). A minimum of 7 fallen lying trees >20 cm diameter per ha. W7: Understorey (2-5m) present over at least 10% of total stand area		
Wet woodland (W3)	Regeneration potential	Assess by field survey using structured walk and/or transects.	Signs of seedlings growing through to saplings to young trees at sufficient density to maintain canopy density over a 10 yr period. No planting	Regeneration may often occur on the edges of woods rather than in gaps within it. The adjacent open swamp and fen habitats are also important and woodland should not spread onto these areas.	Yes
Wet woodland (W3)	Composition: tress and shrubs	Assess by field survey using structured walk and/or transects.	95% of the canopy to comprise native species. The canopy is predominantly alder and willow species. At least 95% of cover in any one layer of site-native or acceptable naturalised species (except skunk cabbage). Death, destruction or replacement of native woodland species through effects of introduced fauna or other external unnatural factors not more	Where cover in the canopy is less than 100% then the 95% target applies to the area actually covered by that layer. In 2008 an invasion of *Lysichiton americanum* (skunk cabbage) in the woodland at the south-east end, unit 6 was identified. Work has begun with the EA to eradicate it. Factors leading to the death or replacement of woodland species could include pollution or new diseases.	Yes

Criteria feature	Attribute term in guidance	Measure	Site-specific Targets	Comments	Use for CA?
			than 10% by number or area in a five year period.	Damage to tree species by non-native species that does not lead to their death is not necessarily unacceptable. Excessive browsing/grazing, even by native ungulates, may be undesirable if it causes shifts in the composition/structure of the stand.	
Swamp, marsh and fen and wet woodland	Indicators of local distinctiveness	Presence / absence	Transitions between open water, swamp marsh, fen and wet grassland/ wet woodland communities (particularly in units 3, 4, 5 & 7).	One of the main features of interest for Over Water is the transition from open water to fen/ swamp/ marsh/ wet woodland although this is patchy and restricted to the s/w and s/e quadrants.	Yes

Audit Trail
Rationale for limiting standards to specified parts of the site
Rationale for site-specific targets (including any variations from generic guidance)
Rationale for selection of measures of condition (features and attributes for use in condition assessment) (The selected vegetation attributes are those considered to most economically define favourable condition at this site for the broad habitat type and any dependent designated species).
Other Notes
NVC is urgently required. In 2009, the impact of the existing abstraction will be assessed as part of reviews of licences under AMP4.

Annex 1 - Maps

Over Water SSSI



Scale 1:5000 Map 1 of 1

0 100 200 300m
0 250 500 750ft.

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Date: 19/3/2009
Ref: ny25123501
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Grid North

Natural England
Juniper House, Murley Moss
Oxenholme Road
Kendal
Cumbria
LA9 7RL

Key
Units 1-9 colour coded and labelled