Aquatic Macrophyte Survey of Fleet Pond

Report to Fleet Pond Society

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Dr Giles Groome CEcol CEnv MCIEEM
Consultant Ecologist

13 Park Road
Farnham
Surrey
GU9 9QN
giles.groome@btinternet.com

EXECUTIVE SUMMARY

Giles Groome, Consultant Ecologist was commissioned by Fleet Pond Society to conduct an aquatic macrophyte survey of Fleet Pond in July 2018. However, due to extensive toxic algal blooming soon after, the survey was deferred to June 2019.

106 sample points were recorded during the course of two days fieldwork, mostly using grapnel hook sampling undertaken from a boat. 92 samples were recorded from the open water of Fleet Pond; 12 from open water within islands; one from a stand of previously open water that has become so heavily silted over that it now supports surface dry land; and one from the outlier pond known as The Flash.

Twelve species of macrophyte (13 including a sample supporting submerged juvenile *Typha* sp.) were recorded: seven from the open water of Fleet Pond; nine (or 10) from open water within islands; two from the silted over stand; and three from The Flash.

Of the 92 grapnel samples recorded from the open water of Fleet Pond, 50% recorded at least one species of macrophyte (74% supported filamentous algae). *Zannichellia palustris* (Horned Pondweed) was far and away the most common species, being recorded from c.27% of samples. *Nitella flexilis* var. *flexilis* (Smooth Stonewort) was recorded from c.16%; *Lemna minuta* (Least Duckweed) from c.4%; and *Potamogeton crispus* (Curled Pondweed) from c.3%. Only single records were made of *Callitriche platycarpa* (Various-leaved Water-starwort), *Potamogeton berchtoldii* (Small Pondweed) and *Potamogeton pusillus* (Lesser Pondweed).

Zannichellia palustris was also the most common macrophyte of samples recorded from open water within islands (82% of samples that were recorded in full). *Lemna minuta* and *Callitriche stagnalis* (Common Water-starwort) were both recorded from two samples. *Crassula helmsii* (New Zealand Pigmyweed), *Lemna gibba* (Fat Duckweed), *Nitella flexilis* var. *flexilis, Potamogeton berchtoldii, Potamogeton obtusifolius* (Blunt-leaved Pondweed) and *Stuckenia pectinata* (Fennel Pondweed) were each recorded from one sample location. *Callitriche stagnalis* and *Lemna minuta* were recorded from the silted up sample. *Lemna gibba, Lemna minuta* and *Potamogeton berchtoldii* were recorded from The Flash.

Given that Fleet Pond is only very recently recovering from extensive restoration works, prior to which the pond had become almost entirely denuded of aquatic macrophytes for many years, survey results are very encouraging with several species recorded for the first time in decades. For example, prior to 2019 the last known record for *Potamogeton pusillus* was 1976; *Potamogeton crispus* and *Stuckenia pectinata* 1980; *Zannichellia palustris* 1985; and *Potamogeton obtusifolius* 1991.

At the same time as macrophyte recording, pond and Secchi depths were measured at the majority of sample locations. Across the open waters of Fleet Pond average pond depth was 63cm and Secchi depth 42cm. Interpolated pond bed and Secchi depth to pond base levels have been mapped in GIS and compared to the number of macrophytes recorded per sample. However, there are no patterns to suggest that either factor is currently related to macrophyte diversity. The results of correlation analyses similarly reveal no significant relationship.

Despite very encouraging results, Fleet Pond is known to have previously supported ‘perfectly clear’ water and the algal blooms of 2018 and siltation recorded close to the Gelvert Stream inlet are cause for concern. Recommendations are therefore given not only to continue macrophyte recording but also water quality monitoring, potentially with a view to undertaking additional management measures to tackle poor water quality. In the interim it is essential that stands of open water within islands be maintained.

CONTENTS

1 INTRODUCTION

1.1 Background

Fleet Pond was first notified as a Site of Special Scientific Interest (SSSI) in 1951 for, amongst other features, "a rich aquatic flora, including a number of locally distributed or rare species" (Anon 1984). This was still known to have been present in August 1976 when Tony Mundell first surveyed the pond and "water was perfectly clear and the bottom was covered in submerged aquatic plants" (T. Mundell, pers. comm.). However, at around the same time, Waters (1976 – cited by Hall 1991) warned of "biological impoverishments", largely as a result of silt being deposited from the inflowing Gelvert Stream.

In 1980, Palmer and Newbold (1980 – cited by Hall 1991), reporting "a general decline in aquatic flora", warned of the possibility of 'a total loss of submerged macrophytes". By 1984, their prediction had been realised when Hall and Mundell (1984 – cited by Hall 1991) reported a "catastrophic loss of aquatic plants". No aquatic plants were recorded from the open water in 1991 (Hall 1991). Other than a little filamentous algae, only a single plant, tentatively recorded as *Potamogeton berchtoldii*, was recorded in 2002 (Collingridge 2002). No aquatic plants were seen during the period 2008-2012 (Turner *et al* 2013).

Following extensive dredging of the pond, island creation (using dredged materials) and numerous other efforts to restore the habitat between 2010 and 2015, only a handful of aquatic plant records have been made since (Johns & Johns 2017).

The present study was commissioned in July 2018 to identify whether there has been any further recovery of aquatic macrophytes. However, due to extensive toxic algal blooming soon after, the survey was deferred to June 2019.

1.2 Study Objectives

- To conduct an aquatic macrophyte survey of the open waters of Fleet Pond, using grapnel hook sampling, and selected islands where there is still some open water, using walkover survey
- To record Secchi and pond depths at each sample location
- To record the locations of each sample using GPS/GIS
- To report results in both tabulated and map format

1.3 Personnel

Grapnel sampling, walkover survey, GPS recording, data digitisation, analysis and reporting were conducted by Dr Giles Groome CEcol CEnv MCIEEM. John Sutton of Fleet Pond Society piloted the boat and recorded Secchi and pond depths.

1.4 Report Presentation

Throughout this report all species are referred to by their scientific names following the nomenclature of Moore (1986) and Stace (2019). Where the latter differs from the previous edition (Stace 2010), old names are given in brackets. Appendix I provides a checklist with both Latin and common English names.

1.5 Electronic Data

The following have been supplied in electronic format:

- Report (PDF)
- Raw sample data (Excel workbook)

2 METHODOLOGY

2.1 Pre-survey Site Meeting and Purchase of Digital Aerial Photograph

A meeting between the contractor and Colin Gray and John Sutton of the Fleet Pond Society was undertaken on 6th July 2018 to discuss background to the survey, its scope and methodology.

Following the meeting orthorectified aerial photographic data (flown 2013), compatible with MapInfo v7.5 GIS (Section 2.3.2), were purchased covering the full extent of Fleet Pond. These were printed for field use at a scale of 1:2000.

Under the terms of purchase, aerial photographs can only be printed a maximum of ten times. One of these was when the photographs were printed for fieldwork. Therefore only nine copies of Map 1 (Section 6) can be printed.

2.2 Fieldwork

All fieldwork was undertaken during warm, dry, mostly sunny conditions over the course of 16 hours on 24th and 25th June 2019.

2.2.1 Orientation, Coverage and Location Recording

All recording of vegetation from open water was conducted from a boat, piloted on the first day to cover as much of the eastern portion of the pond as time allowed. Most recording from islands was also undertaken on the first day. Open water here was sampled by walking on to the islands or, when water/silt was too deep, recording a grapnel hook sample from its fenced margins.

More time was available on the second day and, in addition to covering western parts of the pond, eastern areas were re-visited to fill in any excessive gaps.

Throughout recording the aerial photograph was used for orientation and to mark the approximate locations of samples recorded from open waters. 'Precise' locations were recorded at the time of sampling using a hand-held Garmin Etrex GPS with an accuracy reported as +/-3-4m (although see Sections 2.3.3 and 2.4.2). For islands and the satellite pond known as The Flash (sample 54), the centre point of sampling was recorded onto the aerial photograph (co-ordinates being later extracted from GIS).

2.2.2 Grapnel Hook Sampling

A hand-made grapnel hook was used throughout recording of open waters. Designed and constructed by botanist Barry Phillips, this comprises a 23cm fine-toothed comb with weighted metal balancing plate, which ensures that the comb rests on the pond floor and that teeth point backwards when reeled in, affixed to a 50m length of twine. This form of device has been shown to capture fine-leaved species much better than traditional grapnel hooks.

At each sample location the grapnel was cast 20-30m, allowed to come to rest on the pond bed (readily felt when holding the twine) and slowly reeled in; all the time keeping the comb on the pond bed. All material captured was then identified (with any uncertain plant material retained for later examination under a dissecting scope) and species frequency/abundance (plus any leaves, twigs, etc.) assessed using the following criteria:

- A (abundant) Large number (too many to count) of stems (in the event only filamentous algae were recorded as abundant)
- F (frequent) Many (10 or more) stems
- O (occasional) Few (3-10) stems
- R (rare) Rare (1 or 2) stems

2.2.3 Walkover Survey Recording

With the exception of samples 20 and 36 (both recorded using grapnel hook sampling from island margins), all sample stops on islands comprised aquatic plant walkover surveys of the full extent of open water (i.e. standing water lacking or largely lacking emergents). The Flash (sample 54) was recorded by effective walkover survey as plants could be observed from its margins (although grapnel sampling was used to extract plants to confirm identification). Sample 12, shown on the 2013 aerial photograph as open water, is now a strip of surface dry land that has developed over rapidly accumulating silt. This too was assessed by walkover survey (recording only aquatic species). The walkover survey at sample 27 was stopped soon after commencement due to the discovery of nest-sitting birds.

For all walkover survey samples species frequency/abundance (twigs, litter, etc. were not recorded) was assessed using the more traditional DAFOR system:

- D Dominant
- A Abundant
- F Frequent
- O Occasional
- R Rare
- (L Locally)

2.2.4 Secchi Disk and Pond Depth Recording

At each sample stop, with the exception of samples 12, 20, 25, 27, 36 and 54, a Secchi disk measurement was recorded along with pond (island) depth. Sample 12 is surface dry land (Secchi and pond depths recorded as 'n/a'); island samples 20, 25 and 36 were recorded using grapnel hook sampling from island margins and therefore depths could not be measured (Secchi and pond depths recorded as 'NR'); walkover survey sample 27 was not completed (Secchi and pond depths recorded as 'NR'); no attempt was made to record measurements from effective walkover survey sample 54 (Secchi and pond depths recorded as 'NR').

2.3 Data Input and Analysis

2.3.1 Data Input

All field recorded species data were entered into a single Excel spreadsheet, along with sample point number, GPS location, GPS margin of error, pond depth and Secchi depth. Where sample points were marked on to the aerial photograph in the field, co-ordinates were extracted from GIS (GPS margin of error for these is given as 'n/a').

Mean Secchi depth, pond depth, and number of macrophytes per sample were calculated in Excel for 1) all samples and 2) all samples minus those recorded from islands (including sample 12) and The Flash.

2.3.2 Spearman Rank Correlation Tests

To determine whether there might be any statistically significant relationship between the number of submerged species and pond water depths and water clarity (as measured by Secchi disk) at each sample point Spearman Rank Correlation tests were performed using the calculator on the Wessa website (Wessa 2017).

2.3.3 GIS Mapping

The Excel spreadsheet was imported into MapInfo v7.5 GIS (MapInfo Corporation 2003a) and sample locations mapped as point data (data tables thus comprise all the information, minus mean averages, given in the Excel spreadsheet). Once sample points had been entered it was possible to see that GPS margins of error recorded in the field were very far from accurate, with for example some locations that had been recorded from open water appearing within islands. However, to maintain the integrity of field recorded data, these have not been corrected in GIS (see Section 2.4.2).

To allow recorded data to be presented in map form without printing limitations (Section 2.4.3), pond and island margins were mapped against aerial photographic data in GIS as geo-referenced polygons.

Largely for presentational purposes, Natural Neighbour interpolation analysis (where unknown data points are calculated, or rather interpolated, from known data points) of recorded pond base depths and recorded Secchi depths minus recorded pond depths was performed in GIS using the MapInfo add-on Vertical Mapper v3.0 (MapInfo Corporation 2003b). The "simple" Natural Neighbour interpolation method was chosen, along with the option "smoothed without over-shoot".

2.4 Constraints and Limitations

2.4.1 Sampling Limitations

It can be estimated that an average grapnel hook sample recorded during fieldwork captured submerged plants from an area of approximately 6.25m^2 (the width of the comb times the length of bed across which it was dragged). Given that Fleet Pond supports approximately 17.1ha of open water and that 92 grapnel hook samples were recorded, <0.5% of the pond was sampled during 2019 fieldwork.

2.4.2 Unreliable GPS Margins of Error

Margins of error (always either +/-3m or +/-4m) recorded by GPS have been shown to be unreliable, with some open pond samples appearing to have been taken from islands when in fact none were recorded within 5m of any island. There is no way of knowing what the actual margin of error should have been and therefore no attempt has been made to correct GPS location data. This does not present a significant problem (the same issue will occur should sample location recording be replicated in future), but it is important to remember that this is the case when looking at the maps in Section 6.

2.4.3 Restrictions on the Use of Map 1

Under the terms of purchase, the aerial photograph bought to facilitate fieldwork and used as a backdrop to Map 1 can only be printed a maximum of nine times.

3 RESULTS

3.1 Grapnel Hook Sampling and Walkover Survey Recording

106 sample points were recorded during fieldwork: 92 from the open pond; 13 from islands (including silted up sample 12); and one from The Flash. The full set of records is given in Appendix II. Table 1 provides a summary of recorded species.

Table 1 – Summary of species recorded from all sample locations and open pond samples (excluding The Flash) only

Species	All Recorded Samples		Open Pond Samples Only	
	Frequency	**% Frequency**	**Frequency**	**% Frequency**
Algae	80	75.5	68	73.9
Callitriche platycarpa	1	1.0	1	1.1
Callitriche stagnalis	3	2.9	0	0.0
Crassula helmsii	1	1.0	0	0.0
Lemna gibba	2	1.9	0	0.0
Lemna minuta	8	7.6	4	4.3
Nitella flexilis var. *flexilis*	16	15.2	15	16.3
Potamogeton berchtoldii	3	2.9	1	1.1
Potamogeton crispus	3	2.9	3	3.3
Potamogeton obtusifolius	1	1.0	0	0.0
Potamogeton pusillus	1	1.0	1	1.1
Stuckenia pectinata (*Potamogeton pectinatus*)	1	1.0	0	0.0
Typha sp. (juvenile)	1	1.0	0	0.0
Zannichellia palustris	34	32.1	25	27.2
Leaf/leaves	3	2.8	3	3.3
Twig/s	2	1.9	2	2.2
No. samples lacking macrophytes	49	46.2	46	50.0

As Table 1 shows, *Zannichellia palustris* was by far the most common macrophyte recorded during fieldwork. The only other macrophyte recorded in more than 10% of samples (5% if islands and The Flash are excluded) was *Nitella flexilis* var. *flexilis*. Five species were only recorded from islands; one only from The Flash.

3.2 Secchi Disk and Pond Depth Recording

Secchi disk and pond depths were recorded from 98 of the 106 sample points: all 92 from the open pond; 8 from islands. The full set of records is given in Appendix II. Table 1 provides a summary of recorded data.

Table 2 – Average Secchi disk and pond depths recorded from all sample locations and open pond samples only

	All Recorded Samples	**Open Pond Samples Only**
Pond depth (cm)	59.6	62.9
Secchi depth (cm)	40.3	42.0

As Table 2 shows, the average depth of water within Fleet Pond (thus excluding the islands and The Flash) at the time of June 2019 surveys was approximately 63cm. However, whilst the pond base could readily be seen at many shallow water sample locations, the average Secchi disk depth was only 42cm and the bed was almost never visible where waters exceeded this depth (the single greatest Secchi depth recorded was 54cm).

3.3 Spearman Rank Correlation Tests

Two Spearman Rank Correlation tests were performed using the calculator on the Wessa website (Wessa 2017). Results are given in Table 3.

Table 3 – Results of Spearman Rank Correlation tests to identify significant correlations between number of aquatic macrophytes and pond depth and Secchi depth

Variable	***r***	***p***
Pond depth	-0.043	0.687
Secchi depth	0.001	0.990

The results show there were no significant correlations between the number of aquatic macrophytes and water/Secchi depth. This suggests that neither pond depth nor water clarity are significant factors determining species frequency; although data are skewed by the fact that macrophyte diversity is so low (e.g. 46 of the 92 open water pond samples included in analysis supported no macrophytes; only four supported more than one species).

3.4 GIS Mapping

Six maps are presented in Section 6. Map 1 shows the location of all samples recorded during June 2019 surveys, set against the aerial photograph used during fieldwork.

Map 2 shows the number of aquatic macrophytes recorded at each open pond sample location set against interpolated pond depths (blank areas on some of the margins of Fleet Pond, notably to the far east, that are not within islands are beyond the limits that water depths could be interpolated). Whilst it is evident that the shallowest parts of the pond are close to margins and the deepest parts lie within the centre and toward the north, there is, as suggested by correlation tests, no clear relationship between water depth and macrophyte frequency. However, macrophytes do appear to be less frequent in the western half of the pond. Indeed, if a north-south line is drawn broadly through the centre of the pond so that half the recorded samples lie on one side and half on the other, only 18 of the 46 samples recorded from the western half supported macrophytes whereas 28 did so from the eastern half.

Map 3 shows the number of aquatic macrophytes recorded from all sample locations set against interpolated Secchi disk to pond base depths. Both are very similar to the patterns shown by Map 2. However here, macrophyte diversity on islands appears to be much greater than it is in open pond waters; although this is somewhat misleading as most island samples covered a considerably greater sampling area than those recorded from the open pond.

Map 4 shows the distribution of samples from which *Zannichellia palustris* was recorded set against interpolated pond depths. There is some suggestion that *Zannichellia* is more common in shallower waters and/or eastern parts of the pond.

Map 5 shows the distribution of samples from which *Nitella flexilis* var. *flexilis* was recorded set against interpolated pond depths. The species appears to be almost restricted to central pond waters between 50cm and 100cm deep.

4 DISCUSSION

4.1 Reappearance of Submerged Macrophytes

Given the abject paucity of recent macrophyte records, results of the survey are very encouraging with at least half of all recorded samples yielding at least one aquatic species. Moreover, whilst none of the nationally/vice-county rare/scarce species (Rand & Mundell 2011, Stroh *et al* 2014, JNCC 2019) recorded in the past were re-recorded, many of those that were have not been seen for decades (Hall 1991). For example, the last known record for the far from common *Potamogeton pusillus* was in 1976. *Potamogeton crispus* and *Stuckenia pectinata* (*Potamogeton pectinatus*) are last known to have been recorded in 1980; *Zannichellia palustris* (recorded in almost a third of 2019 samples) in 1985; and *Potamogeton obtusifolius* in 1991. *Callitriche platycarpa* appears to have only ever been confirmed in 1951; although it has doubtlessly been overlooked (in favour of recording *Callitriche stagnalis* sens. lat.). *Lemna gibba* has never been previously recorded, but this too is likely to be an error (previously having been lumped within *Lemna minor*).

It is hoped that many of the other previously recorded aquatic species were missed (see Section 2.4.1) and/or that they will reappear in future.

4.2 Species Distributions in Relation to Water Depth and Water Clarity

Pond depth and water clarity are critical factors affecting aquatic macrophytes. However, no significant relationship between diversity and depth/clarity has been recorded. This is likely to be because 1) submerged species are only very recently becoming re-established; 2) Fleet Pond is sufficiently shallow to support all the submerged species recorded; and 3) water clarity is broadly similar across the pond. Nevertheless, despite clarity having improved since restoration, prior to which there was little or no light penetration below 30cm (Turner *et al* 2013), waters are evidently significantly more turbid than they appear to have been in 1976 when they were “perfectly clear” (Section 1.1). Dense algal blooming in 2018 suggests they may be considerably more eutrophic.

Whilst macrophyte diversity does not appear to be associated with either pond depth or water clarity, records for *Nitella flexilis* var. *flexilis* suggest that this species favours central pond stands where water is between 50cm and 100cm deep. *Zannichellia palustris* appears to be more common in the eastern half of the pond. It is possible that a greater seed bank lies here and/or has been carried here via the Gelvert Stream inflow. The only *Callitriche platycarpa* recorded was from close to the inflow of the Brookly Stream, which, as evidenced during a break in sample recording during fieldwork, supports large patches of the species.

4.3 The Value of Open Water within Islands

Whilst sample locations within islands often covered whole stands rather than single grapnel hook samples, thereby making comparisons between diversity here and across the wider pond expanse unreliable, a number of species, including *Potamogeton obtusifolius* and *Stuckenia pectinata* (*Potamogeton pectinatus*), were only recorded from islands. It is therefore vital that open water here be maintained and excessive wildfowl use controlled. Provided conditions are suitable, all species can be expected to colonise open pond waters (assuming they have not already done so) in future.

5 RECOMMENDATIONS

5.1 Pond Management

The current study was not commissioned for the purpose of making management recommendations and insufficient data has been recorded to make anything other than generalised observations. However, it is worth making some of these.

Perhaps the most important observation made during fieldwork is that pond depth is entirely compatible with supporting a rich macrophyte assemblage. Water clarity is very far from perfect but it is evidently sufficient to allow submerged macrophyte growth and will, other factors aside, improve as macrophyte density increases. However, other factors such as sediment inflow and resuspension of particulates resulting from the behaviour of certain fish (and the exotic Signal Crayfish) are more important and both need to be at the forefront of management considerations.

Silt deposition has been highlighted as having been a significant problem in the past and it is evident from surveys that considerable quantities of silt are being deposited close to the Gelvert Stream inflow. Smaller material entering the pond will inevitably remain in suspension and it is this that is likely to be the single most important factor affecting water quality. Several silt traps in the Gelvert catchment, which includes the MOD Long Valley Driver Training Area, and silt curtains close to the confluence of the Stream and Fleet Pond have already been installed in an attempt to control inputs, but they appear to have little effect capturing colloids and fine particles during heavy rainfall (J. Sutton, pers. com.). It would therefore appear that, unless silt traps and curtains can be made more effective, the only method to ensure prevention of excessive colloids and fine particles entering Fleet Pond is to prevent their release at source; notably by changing how the Driver Training Area is managed. This will require liaison between Fleet Pond Society, statutory agencies (Natural England and Environment Agency) and the Ministry of Defence.

Unless it has already been undertaken, a detailed survey of the fish and crayfish population should be undertaken to determine numbers of bottom-feeding species such as Carp, Bream and Signal Crayfish. Subject to results, consideration should be given to removing undesirable species and/or introducing natural predators such as Pike.

Wildfowl grazing is undoubtedly having an impact on emergent species regeneration on some margins and across some islands. However, their impact on aquatic macrophytes may be more advantageous than disadvantageous in terms of maintaining stands of open water within islands; although the most important factor here is on-going cutting. Nevertheless, control of excessive numbers of species such as Canada Geese may be beneficial.

5.2 Surveys and Monitoring

5.2.1 Macrophyte Monitoring

It is recommended that repeat surveys using the same methodology as 2019, but not sampling the exact same locations other than on islands and The Flash, be conducted at least every two years for the next six years. If required, a streamlined approach, whereby recording is limited to a single day, could be adopted whereby only open pond samples are recorded. It should be possible to record at least 30-50 samples. This would be sufficient for data comparisons (using 2019 data as the baseline) to be made, which in turn will help determine how the pond continues to respond to recent restoration measures.

5.2.2 Water Quality Monitoring

It is essential that water quality is monitored at least annually (preferably monthly, at least in summer) to determine how the pond is responding to restoration measures and whether factors that led to its initial impoverishment remain/reoccur. Parameters to record should include suspended solids, BOD, pH and species of nitrogen and phosphorus. Sampling locations should include both the Gelvert Stream and the Brookly Stream, as well as Fleet Pond itself.

6 SITE MAPS

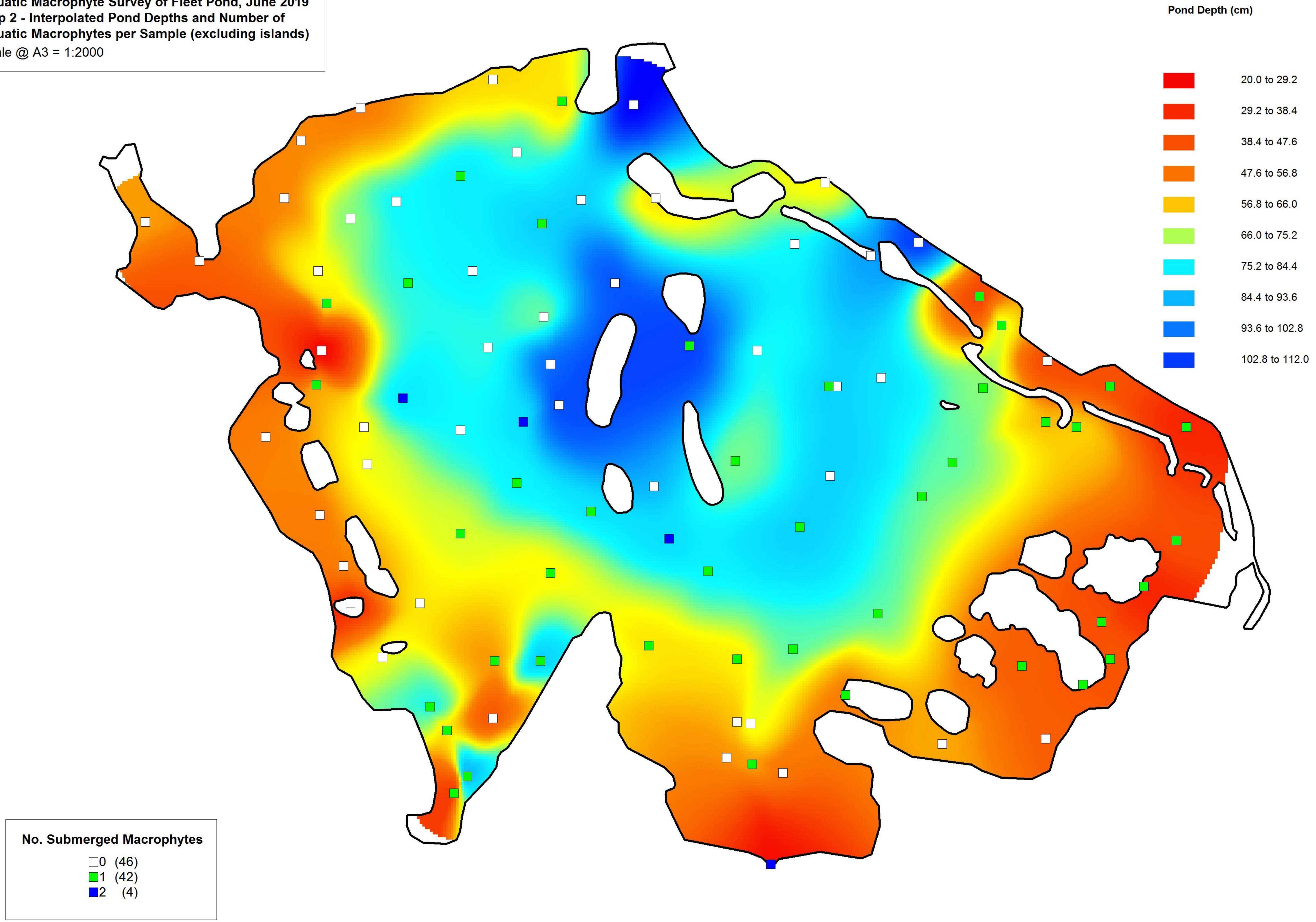
6.1 List of Maps

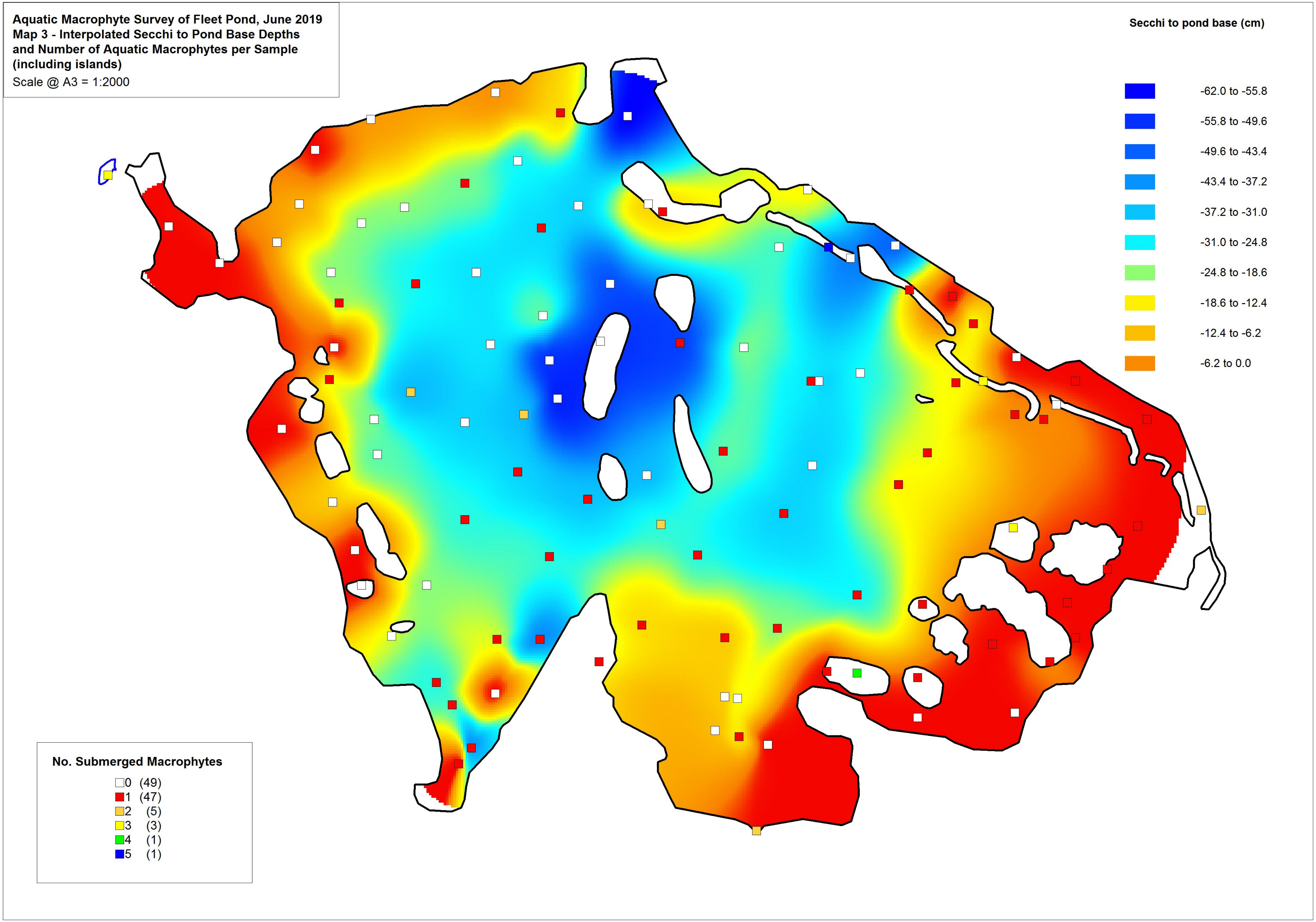
Aquatic Macrophyte Survey of Fleet Pond, June 2019
Map 1 - Location of Samples

Scale @ A3 = 1:2000

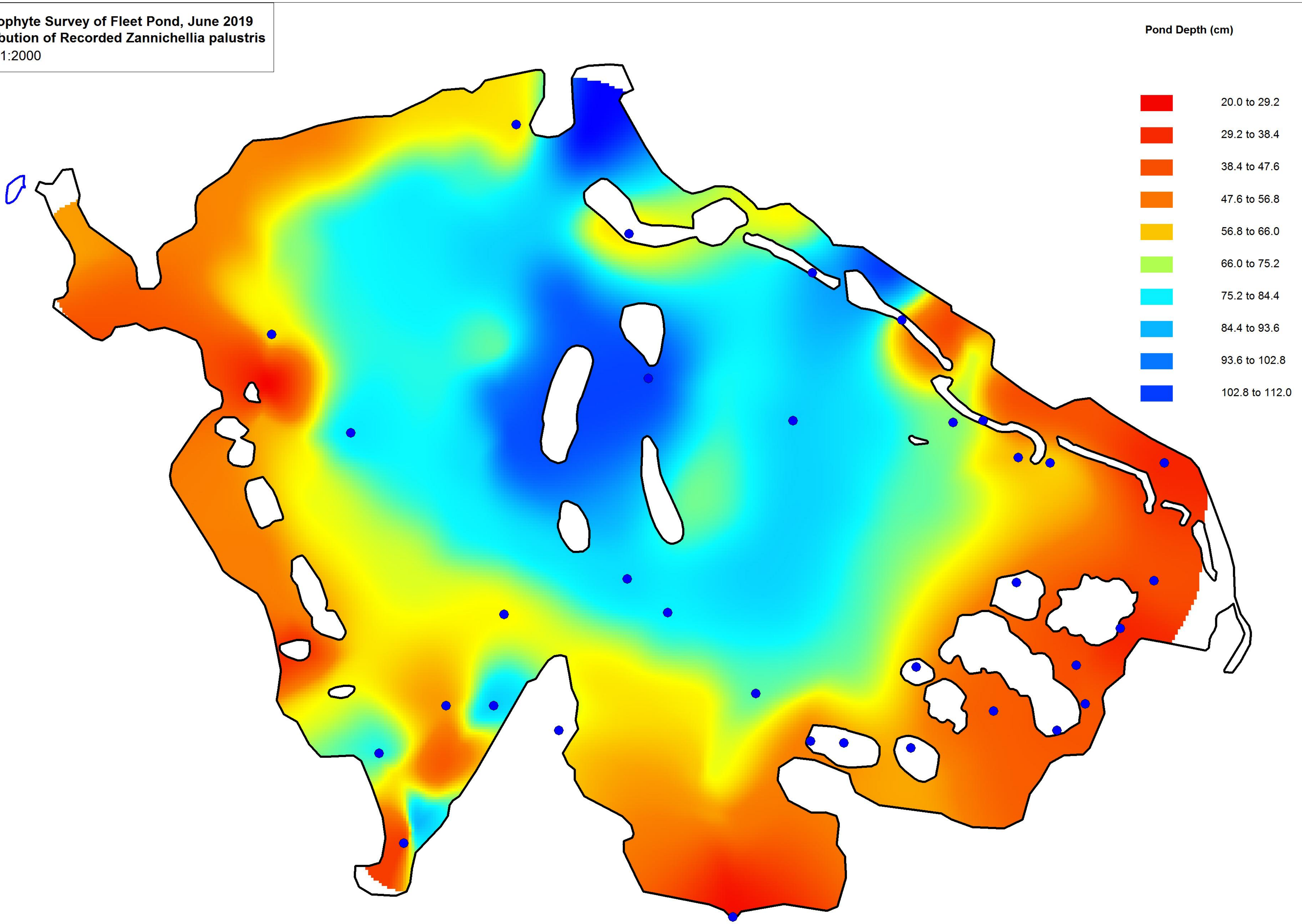
NOT FOR REPRODUCTION

Aquatic Macrophyte Survey of Fleet Pond, June 2019
Map 2 - Interpolated Pond Depths and Number of Aquatic Macrophytes per Sample (excluding islands)
Scale @ A3 = 1:2000

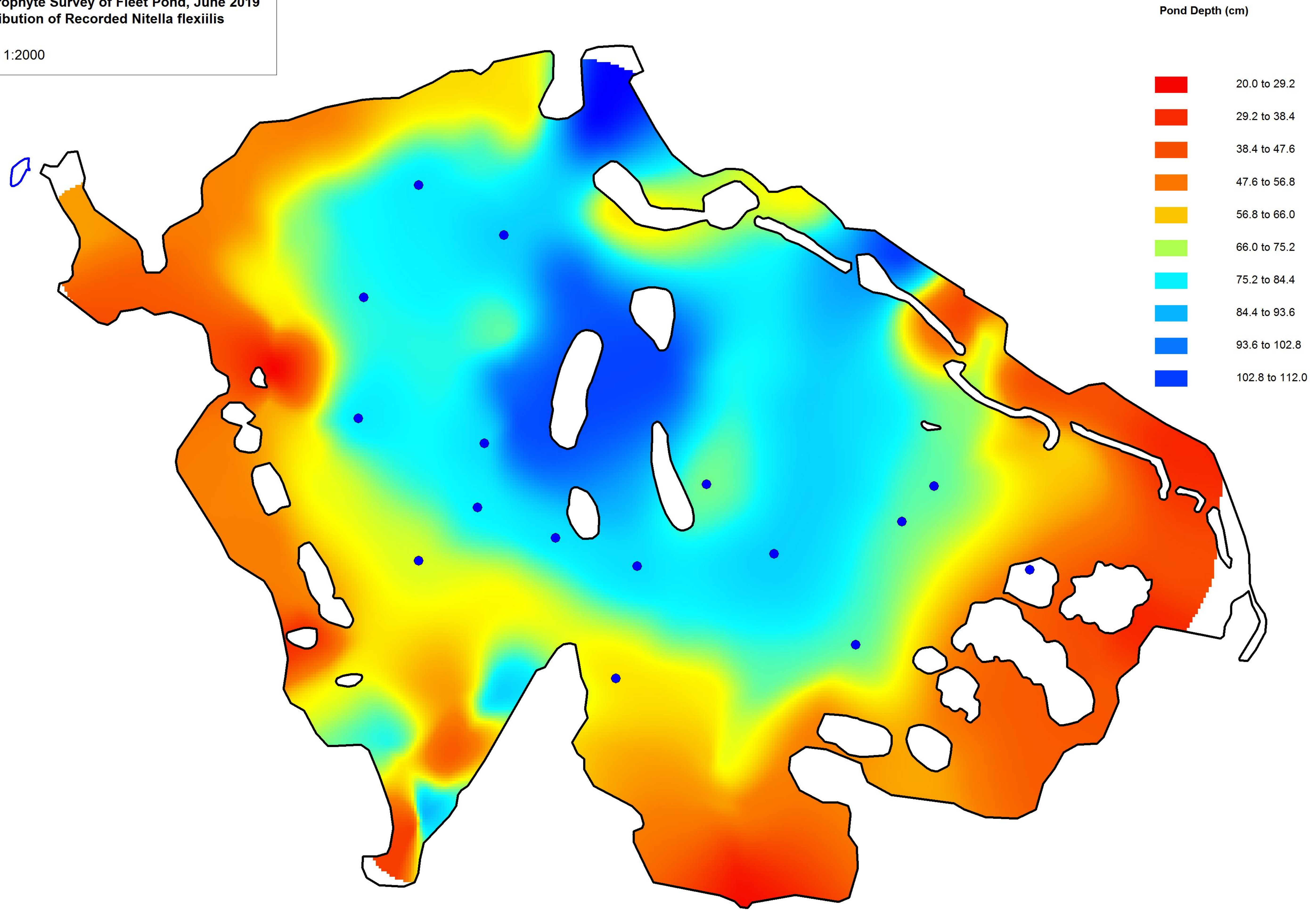



Aquatic Macrophyte Survey of Fleet Pond, June 2019
Map 3 - Interpolated Secchi to Pond Base Depths
and Number of Aquatic Macrophytes per Sample
(including islands)
Scale @ A3 = 1:2000
Secchi to pond base (cm)
-62.0 to -55.8
-55.8 to -49.6
-49.6 to -43.4
-43.4 to -37.2
-37.2 to -31.0
-31.0 to -24.8
-24.8 to -18.6
-18.6 to -12.4
-12.4 to -6.2
-6.2 to 0.0
No. Submerged Macrophytes
0 (49)
1 (47)
2 (5)
3 (3)
4 (1)
5 (1)

Aquatic Macrophyte Survey of Fleet Pond, June 2019
Map 4 - Distribution of Recorded Zannichellia palustris
Scale @ A3 = 1:2000



Aquatic Macrophyte Survey of Fleet Pond, June 2019
Map 5 - Distribution of Recorded Nitella flexiilis var. flexilis
Scale @ A3 = 1:2000



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APPENDIX I – CHECKLIST OF RECORDED SPECIES

Recorded 24th and 25th June 2019 by Giles Groome. Nomenclature follows Moore (1986) and Stace (2019). Names in brackets follow Stace (2010).

Taxon	**Common (English) Name**
Callitriche platycarpa	Various-leaved Water-starwort
Callitriche stagnalis	Common Water-starwort
Crassula helmsii	New Zealand Pigmyweed
Lemna gibba	Fat Duckweed
Lemna minuta	Least Duckweed
Nitella flexilis var. *flexilis*	Smooth Stonewort
Potamogeton berchtoldii	Small Pondweed
Potamogeton crispus	Curled Pondweed
Potamogeton obtusifolius	Blunt-leaved Pondweed
Potamogeton pusillus	Lesser Pondweed
Stuckenia pectinata (*Potamogeton pectinatus*)	Fennel Pondweed
Typha sp. (juvenile)	Bulrush sp.
Zannichellia palustris	Horned Pondweed

APPENDIX II –RECORDED SAMPLE DATA

Date of recording, GPS co-ordinates and margins of error have been excluded (for full data see Excel spreadsheet). As no records were made for sample 27 before it had to be abandoned this too is excluded.

Underlined samples were recorded from islands. The sample covering The Flash is underlined and in italics.

Recorded Parameter	**Sample**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Pond depth (cm)	48	50	10	54	42	42	40	40	38	28	38	n/a	28	20	20
Secchi depth (cm)	48	50	10	54	42	42	35	40	38	28	38	n/a	28	20	20
Algae	R	R	O	A	A	O	A	A	A	R	F		R	F	O
Callitriche platycarpa															
Callitriche stagnalis			R									R			R
Crassula helmsii			F												
Lemna gibba															
Lemna minuta												R			R
Nitella flexilis var. *flexilis*															
Potamogeton berchtoldii															
Potamogeton crispus															
Potamogeton obtusifolius															
Potamogeton pusillus															
Stuckenia pectinata															
Typha sp. (juvenile)			R												
Zannichellia palustris		R	R			R	R	O	O	R	O		R		R
Leaf/leaves															
Twig/s															
No. Macrophytes	0	1	4	0	0	1	1	1	1	1	1	2	1	0	3

Recorded Parameter	**Sample**														
	16	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**28**	**29**	**30**	**31**
Pond depth (cm)	58	25	22	25	NR	70	30	20	62	NR	112	100	74	80	80
Secchi depth (cm)	52	25	22	25	NR	50	30	20	42	NR	50	42	48	45	45
Algae	F	F	A	F	F	A	F	F	A	F			R		F
Callitriche platycarpa															
Callitriche stagnalis															
Crassula helmsii															
Lemna gibba								R							
Lemna minuta								LF							
Nitella flexilis var. *flexilis*		R				R									
Potamogeton berchtoldii								R							
Potamogeton crispus															
Potamogeton obtusifolius		R													
Potamogeton pusillus			R												
Stuckenia pectinata								O							
Typha sp. (juvenile)															
Zannichellia palustris	R	R	R	R	O		R	LF		O					
Leaf/leaves									R						
Twig/s			R												
No. Macrophytes	1	3	2	1	1	1	1	5	0	1	0	0	0	0	0

Recorded Parameter	**Sample**														
	32	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**
Pond depth (cm)	80	75	78	60	NR	63	70	52	80	41	84	34	60	63	30
Secchi depth (cm)	45	46	49	44	NR	43	45	40	36	41	41	34	32	41	30
Algae	F	F		A	A	R	F	R	O	O				F	A
Callitriche platycarpa											O				
Callitriche stagnalis															
Crassula helmsii															
Lemna gibba															
Lemna minuta													R		
Nitella flexilis var. *flexilis*	R		O	R											
Potamogeton berchtoldii															
Potamogeton crispus															
Potamogeton obtusifolius															
Potamogeton pusillus															
Stuckenia pectinata															
Typha sp. (juvenile)															
Zannichellia palustris		R	R		R		R		R			R			
Leaf/leaves												R			
Twig/s												R			
No. Macrophytes	1	1	2	1	1	0	1	0	1	0	1	1	1	0	0

Recorded Parameter	**Sample**														
	47	**48**	**49**	**50**	**51**	**52**	**53**	***<u>54</u>***	**<u>55</u>**	**56**	**57**	**58**	**59**	**60**	**61**
Pond depth (cm)	50	50	50	54	20	42	53	NR	20	51	51	50	59	60	72
Secchi depth (cm)	50	36	50	34	20	42	53	NR	20	41	51	42	52	44	42
Algae	R			R		F	A	A	R		R				
Callitriche platycarpa															
Callitriche stagnalis															
Crassula helmsii															
Lemna gibba								R							
Lemna minuta				R				F							
Nitella flexilis var. *flexilis*															
Potamogeton berchtoldii								O							
Potamogeton crispus															
Potamogeton obtusifolius															
Potamogeton pusillus															
Stuckenia pectinata															
Typha sp. (juvenile)															
Zannichellia palustris														R	
Leaf/leaves					R										
Twig/s															
No. Macrophytes	0	0	0	1	0	0	0	3	0	0	0	0	0	1	0

Recorded Parameter	**Sample**														
	62	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**
Pond depth (cm)	76	74	68	62	60	73	75	80	80	60	74	88	103	36	64
Secchi depth (cm)	50	49	43	37	36	43	42	46	45	45	46	42	54	36	45
Algae	R				O	O	R	R		A	A	A	R	F	O
Callitriche platycarpa															
Callitriche stagnalis															
Crassula helmsii															
Lemna gibba															
Lemna minuta															R
Nitella flexilis var. *flexilis*	R					R		R							
Potamogeton berchtoldii														R	
Potamogeton crispus															
Potamogeton obtusifolius															
Potamogeton pusillus															
Stuckenia pectinata															
Typha sp. (juvenile)															
Zannichellia palustris					R										
Leaf/leaves															
Twig/s															
No. Macrophytes	1	0	0	0	1	1	0	1	0	0	0	0	0	1	1

Recorded Parameter	Sample														
	77	**78**	**79**	**80**	**81**	**82**	**83**	**84**	**85**	**86**	**87**	**88**	**89**	**90**	**91**
Pond depth (cm)	38	39	56	68	78	80	102	99	70	73	76	62	63	74	96
Secchi depth (cm)	38	39	50	48	48	48	48	47	43	40	38	36	36	39	40
Algae	F	F	F	F	F	F	O		R	R	O		R	O	
Callitriche platycarpa															
Callitriche stagnalis															
Crassula helmsii															
Lemna gibba															
Lemna minuta		R													
Nitella flexilis var. *flexilis*											R				
Potamogeton berchtoldii															
Potamogeton crispus															
Potamogeton obtusifolius															
Potamogeton pusillus															
Stuckenia pectinata															
Typha sp. (juvenile)															
Zannichellia palustris			R	R		R	R				R				
Leaf/leaves															
Twig/s															
No. Macrophytes	0	1	1	1	0	1	1	0	0	0	2	0	0	0	0

Recorded Parameter	Sample														
	92	**93**	**94**	**95**	**96**	**97**	**98**	**99**	**100**	**101**	**102**	**103**	**104**	**105**	**106**
Pond depth (cm)	78	75	64	60	73	53	62	77	84	69	70	70	61	57	53
Secchi depth (cm)	40	40	35	35	44	31	33	40	46	42	49	40	47	43	35
Algae	O	F	F		F	R	R	O		O	A	A	R	R	R
Callitriche platycarpa															
Callitriche stagnalis															
Crassula helmsii															
Lemna gibba															
Lemna minuta															
Nitella flexilis var. *flexilis*	O	R	R					O		R	R	F			
Potamogeton berchtoldii															
Potamogeton crispus	O												R		O
Potamogeton obtusifolius															
Potamogeton pusillus															
Stuckenia pectinata															
Typha sp. (juvenile)															
Zannichellia palustris					R	F	R								
Leaf/leaves															
Twig/s															
No. Macrophytes	2	1	1	0	1	1	1	1	0	1	1	1	1	0	1