Environmental Scientific Services

ENSIS

Wandsworth Lakes

Annual report on lake monitoring and management

ECRC Research Report Number 189

Ben Goldsmith

February 2018

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Wandsworth Lakes:
Annual report on lake monitoring and management 2017

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Ensis Ltd.
Environmental Change Research Centre
University College London
Pearson Building, Gower St.
London, WC1E 6BT

Tel: +44 (0)20 7679 9248

info@ensis.org.uk
www.ensis.org.uk

Cover Photo: King Georges Park Lake. ENSIS 2017

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1. Introduction

Lakes and rivers form an important part of the urban landscape and provide a wide range of opportunities for both people and wildlife. Within the London Borough of Wandsworth, the park lakes have a long and varied history, culminating in them delivering a wide range of functions today, including wildlife sanctuaries, fishing lakes and boating lakes and above all, they provide an important part of the diversity and inherent value of the parks to the local communities.

Over the past 20 years, ENSIS has collected extensive data on the water quality and ecological potential of the Wandsworth lakes. Through careful and informed management, we have seen very significant improvements in some of the sites, and have developed a clear understanding of the functioning and potential for each of the sites. Key to many of the management goals is good water quality, something that is very difficult to achieve within an urban environment. In addition, where water quality cannot be controlled, other factors have been addressed, such as fish management and marginal planting to improve the aesthetic quality of the sites.

1.1. Monitoring in 2017

Table 1 Sampling matrix for the Wandsworth lakes in 2017

Site	Site Code	Sample period	Water quality	Invertebrates	Aquatic plants	Blue-green algae
Battersea Park Lake	**BATT**	**Spring**	✓	✓	×	×
		Summer	✓	×	✓	✓
Wandsworth Common (Wildlife)	**WAND**	**Spring**	✓	✓	×	×
		Summer	✓	×	✓	✓
Wandsworth Common (Angling)	**WANF**	**Spring**	✓	×	×	×
		Summer	✓	×	✓	✓
Three Island Pond	**WANS**	**Spring**	×	×	×	×
		Summer	✓	×	✓	×
King George's Park Lake	**KING**	**Spring**	✓	✓	×	×
		Summer	✓	×	✓	✓
Tooting Common Lake	**TOOT**	**Spring**	✓	✓	×	×
		Summer	✓	×	×	✓

In light of past monitoring and recent efforts to introduce aquatic vegetation to some of the lakes, the focus of the current monitoring programme has been directed towards the evaluation and assessment of recent lake management. Table 1 sets out the planned monitoring for spring and Summer sampling after which a full assessment will be reported. The main management issues are discussed for each site below, but two issues are of note:

Water levels within Ladies Pond have become increasingly difficult to maintain in

recent years, and we are no longer monitoring Ladies Pond as a separate site. Data are presented below that help to provide evidence of the extent of the leakage and management recommendations made.

Wandsworth Wildlife Lake and Angling Lake are being monitored separately. The shared water supply means the quality of the Wildlife Lake is dependent on the exclusion of fish, which is best assessed by monitoring the sites separately.

1.2. Water quality

One of the key requirements for good water quality in the lakes, is of course a high quality water supply. Where sites rely on run-off from the surrounding parks and urban areas, or are reliant on mains water supply, water quality will be poor. Run-off brings with it sediment and nutrients from the parkland, and mains water, although fine for drinking, is high in plant nutrients (mainly nitrogen and phosphorus) which in lakes, encourages the growth of planktonic algae and blanketweed which are detrimental to the ecological function of the lakes.

Inputs from the borehole water supply at the Main Lake in Battersea Park have had a significant positive impact on water quality over the past 20 years (see Table 2 chemistry). Total phosphorus concentrations have dropped from over 300 µg/l to current levels of around 100 µg/l. At King George's Park Lake, the borehole struggles to provide adequate volumes of water and there are concerns that the quality may no longer be as good as when analysed in 2014. Management at King George's Lake is complicated further due to leakage, which has meant that supply cannot keep up with demand, resulting in additional top-ups with mains water.

Table 2 Water chemistry from the Battersea Park and King Georges Park boreholes measured in 2014

pH	Conductivity μScm^{-1}	SRP μgl^{-1}	TP μgl^{-1}	Nitrate mgl^{-1}	TN mgl^{-1}
7.41	889	2.8	4.1	<0.005	0.50
7.91	520	2.3	2.6	0.014	0.62

Where lakes rely on mains-water supply, the loadings of nutrients (N & P) are inevitably higher (see Table 3) and the lakes will inevitably struggle to maintain the clearer waters needed to facilitate plant growth.

Table 3 Typical mains supply quality from the Battersea Park area (Thames Water 2014)

pH	Conductivity μScm^{-1}	SRP μgl^{-1}	TP μgl^{-1}	Nitrate mgl^{-1}	TN mgl^{-1}
7.90	596	No data	>500	5.6	No data

Under these circumstances, the presence of fish exerts additional pressures on the sites due to their impact on zooplankton population (through predation) and by

causing physical disturbance of the sediments (e.g. carp). Plants are unlikely to establish where fish stocks are high (e.g. Wandsworth Common Wildlife Lake and Tooting Common Lake), but with careful management and planting, successful establishment of plants has been achieved in Battersea Park Lake.

1.3. Aquatic plants

Where aquatic plants become established, they perform a number of key functions:

- plants help to regulate the dissolved oxygen content in the water,
- they provide habitat for invertebrates and so help to increase bio-diversity,
- they provide good habitat for zooplankton, which in turn help to maintain clear water by grazing on planktonic algae,
- plants take up nutrients from the water and so reduce the availability of nutrients for algae (including blanket weed),
- Some species provided added visual appeal to the lakes (e.g. water lilies, bog bean, marginal and emergent wetland plants).

To this end, ENSIS put forward a recommended planting regime for those lakes considered most suitable (Battersea Park and King George's Park Lake) and supported additional efforts to plant in Three Island Pond and the north end of The Wandsworth Common Wildlife Pond. Planting was carried out in 2015 and surveys conducted in 2016 showed the planting to have been highly successful at Battersea Park Lake, but less effective at other sites.

In 2017, ENSIS conducted routine water quality monitoring in spring and late summer and undertook comprehensive macrophyte surveys of all the lakes to monitor the success of the planting.

2. Results

2.1. Water Quality

Table 4 Water quality results for the Wandsworth Park lakes 2017

Site	pH	Cond	D.O.	Total N	Nitrate	SRP	TP	Chl a	SS	Secchi
April 2017										
BATT	8.56	554	10.7	0.81	0.05	<10	91	7.2	7.72	75
KING	8.71	461	13.2	1.02	<0.005	232	286	2.1	<3	>80
TOOT	7.77	453	7.1	2.02	<0.005	69	166	17.2	13.4	70
WAND	7.79	532	4.5	2.05	0.06	333	561	16.2	16.2	70
WANF	7.83	553	4.7	2.25	0.11	75	267	25.1	18.0	55
August 2017										
BATT	8.12	680	10.5	0.92	<0.004	40	99	5.2	7.12	>85
KING	8.35	491	14.3	0.64	<0.004	1140	1180	3.5	3.02	>75
TOOT	7.56	461	4.8	2.56	0.070	259	504	46.2	25.7	35
WAND	7.75	508	4.5	2.21	<0.004	551	837	23.2	20.7	50
WANF	7.82	513	4.6	2.68	0.004	565	857	28.6	22.7	45
WANS	8.21	558	10.2	1.79	0.020	1250	1540	24.5	19.5	>80

Key	Units
Conductivity (Cond.)	µS/cm
Dissolved Oxygen (D.O.)	mg/l
Nitrate and Total Nitrogen (as nitrogen)	mg/l
Soluble Reactive Phosphorus (SRP)	µg/l
Total Phosphorus (TP)	µg/l
Chlorophyll a (Chl. a)	µg/l
Suspended Solids (SS)	mg/l
Secchi disc depth (Secchi)	cm

All sites remain relatively stable in terms of water quality with no major changes seen when compared to previous years. In all cases, the summer values for TP were higher than in spring, which reflects the high rates of biological activity during the warmer months. Similarly, where supply is reliant on mains water and / or surface run-off, levels of P are high. It is encouraging to note that TP remained relatively low in Battersea Park Lake, with better water quality most likely influenced by aquatic plants in the site which help to stabilise nutrient levels by direct uptake of N & P and by providing better habitat for algal grazers (zooplankton). Nitrogen remains the limiting nutrient in most cases, a situation whereby uptake of nitrate by plants and algae reaches a maximum and soluble P is therefore unused and builds up in the water. This is most commonly seen in summer when water temperatures are at their highest. The lack of turnover (throughput of water) allows for the unused nutrients to

build up, and often they become sequested into the sediments and cause problems in the future when released back to the water. This emphasised the need for both quality and quantity for the water supply.

Despite the high summer phosphorus, water clarity in Battersea Park Lake, King George's Lake and Three Island Pond remained good. This can be attributed to the plants in Battersea and low density of fish in the other two clear sites. Where fish are present in higher numbers, particularly those that feed on zooplankton (e.g. roach and juvenile perch, bream etc), water clarity was very poor, i.e. Tooting common, and the main Wandsworth Common lakes. At these sites, there is little hope in getting submerged plants established until either the water quality improves considerably, or fish stocks are thinned dramatically. At these sites, managing marginal vegetation offers the best chance of habitat improvements.

2.2. Blue-green algae

Blue-green algae were present in all lakes, with elevated cell counts at Tooting Common Lake and Wandsworth Main Lakes in the summer. Numbers were however well below the levels for concern (Table 5). High nutrients place the sites a risk of more severe blooms and future monitoring is therefore recommended.

Table 5 Blue-green algal cell concentrations in the Wandsworth Borough Lakes – April (top) and August (bottom). (EA safe limit 20,000)

Blue-green algal type	BATT	KING	TOOT	WAND	WANF	WANS
Microcystis spp.	150		200	0	0	0
Oscillatoria sp.	22	50	20	0	0	0
Amphanizomenon sp.	0	2	0	0	0	0
Total per ml Apr 17	**172**	**52**	**220**	**0**	**0**	**0**

Blue-green algal type	BATT	KING	TOOT	WAND	WANF	WANS
Microcystis spp.	280	0	2800	620	1250	0
Oscillatoria sp.	60	0	600	260	420	108
Amphanizomenon sp.	160	0	0	0	0	0
Total per ml Aug 17	**500**	**0**	**3400**	**880**	**1670**	**108**

Aquatic macroinvertebrates

Invertebrate samples were collected from a subset of the lakes in April. In an effort to give comparison between site, invertebrate samples are taken from similar habitats in all sites. This was, where possible alongside, an area of emergent / marginal vegetation where optimal habitat opportunities exist for invertebrates. A vigorous 30 second kick and scoop sample was taken at each location with a standard FBA net.

Samples were sorted on site and the larger invertebrates removed, counted and returned to the water. Samples were then placed into a container and the remaining invertebrates picked from the samples in the laboratory and identified under magnification where necessary. Identification was to family level. The results are presented in (Table 6).

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Table 6 Aquatic macroinvertebrates recorded in the Wandsworth Park lakes – April 2017

Type	Common name	Family	BATT	TOOT	WAND	KING
Water bugs	Water boatman	Corixidae	48	15	16	32
	Saucer bugs	Naucoridae				
	Greater backswimmers	Notonectidae	2			12
	Pond skater	Gerridae	1	2		8
		Nepidae				
	Lesser backswimmers	Pleidae				
	Water Measurer	Hydrometridae	1			3
Alderflies		Sialidae				2
Mayflies		Baetidae	6			21
		Caenidae				
Caddis Flies		Limnephilidae				1
		Molannidae				
		Leptoceridae	1		1	14
		Polycentropidae				
	Micro-caddisfly	Hydroptilidae				2
		Psychomyidae				
Damsel & Dragonflies	Damselfly nymph	Coenagrionidae	14			9
	Dragonfly nymph	Aeshnidae	1			3
True-Flies	Non-biting midge larvae	Chironomidae	24	34	29	8
	Phantom midge larvae	Chaoboridae				1
	Cranefly larvae	Tipulidae				2
	biting midge larvae	Ceratopogonidae				
	other dipteran larvae	other diptera	1		3	1
Beetles	Squeak beetle	Hygrobidae				2
	Diving beetle	Dytiscidae				1
		Haliplidae	1			17
Crustaceans	Hoglice	Asellidae	24	31	51	73
	Freshwater shrimp	Crangonyctidae	16	1	4	34
	Ostracod	Ostracoda		6		2
Leeches		Glossiphonidae	1	1	12	8
		Erpobdellidae	5	1		4
	Fish leech	Piscicolidae	1			
Molluscs	Ramshorn snails	Planorbidae	6		1	37
	Bladder snails	Physidae	5	5	6	4
	Pond snails	Lymnaeidae		1		8
	Spire shells	Hydrobidae	76			26
	Pea/Orb mussels	Sphaeridae				20
	Lake limpet	Ancylidae				1
	Operculate snail	Bithyniidae	7			2
	Valve snails	Valvatidae				
Worms		Lumbriculidae				3
		Tubificidae	1	8	1	
Flatworms		*Dugesia*	1			16
		Polycelis				
Others	Water mite	*Hydracarina*			1	3
	Total Individuals		**243**	**105**	**125**	**380**
	Number of Taxa		**23**	**12**	**12**	**33**

Species richness gives a crude assessment of habitat quality. King Georges Park

Lake has the highest number of invertebrate families present, reflecting the extensive areas of very good marginal habitat along the whole of the western edge. The site has also had high levels of blanket weed over the past year, which while detrimental to the site overall, does extend the habitat diversity for invertebrates within the site. Battersea Park Lake also appears to be benefiting from better habitat diversity, with extensive areas of marginal and emergent plants as well as the recently established submerged vegetation. It should be stressed that the invertebrate samples are from all sites are taken from areas considered to be representative of the best habitat within the site.

Although there are reasonable stands of emergent vegetation around the Wandsworth Common Lake, the invertebrate assemblage is relatively poor, and restricted to those species more tolerant of lower oxygen concentrations and mud-dwelling species. Tooting Common Lake is similar, with the assemblage being limited by water quality as well as a lack of submerged habitat, despite good emergent areas. The tree clearance and new planting around the north-western shore will help to extend the range of emergent habitats and so benefit aquatic invertebrates in the lake.

2.3. Aquatic macrophytes and general lake management

With the function of **Tooting Common Lake (TOOT)** primarily focussed on angling, including carp, there is little change of establishing submerged aquatic plants. Poor water quality is a function of supply (mains water and run-off), as well as disturbance of the sediment by fish and water fowl, which exacerbates the poor water clarity.

It is positive to note that the Hadlow College fish survey (1st November 2017), shows the site to have good numbers of pike and perch as well as small roach and carp. Carp are recruiting in the site and therefore it will be important to monitor the size and density of these fish to ensure stocking rates do not get too high. This is important for both fish health and the ecological health of the lake. The pike will hopefully maintain a top-down control on roach and small perch, and it would be good to see some of the individual perch exceeding 0.5 kg; the larger fish exerting a greater predation control. Gaining a good balance of fish, with lower numbers of small, zooplankivorous fish, will help to improve water clarity.

The clearance of overhanging trees around the north-west shore and island will increase the light and reduce leaf-fall, and greatly improves this region of the site. The planting of a range of marginal species (stabilised in gabions) appears to have been effective, and with time these should spread to colonise the shore and provide a more natural edge. We recommend that the trees in this area receive regular trimming to prevent shading impacting the marginal plants.

Wandsworth Common Lakes

Water quality is rather poor in **Three Island Pond (WANS),** but the lack of fish is the most likely reason for the site maintaining good water clarity. This should have helped submerged plants to become established, but it seems the high density of filamentous algae and grazing by water fowl, prevented plants becoming established. Canada geese and coot are often abundant in the site, attracted

inevitably by feeding, but readily turning back to their natural food if available. No submerged plants were recorded in 2017.

The high levels of duckweed (*Lemna minuta* and *L. minor*) seen in the past have not persisted in the last two years. This in most likely due to the abundance of blanket weed in the site, which out-competes duckweed for nitrate, which is limited in the site. Keeping the fountain maintained and running will also help to prevent major build-ups of duckweed as well as increasing the aesthetic appeal of the site.

The areas of marginal vegetation to the east side of the pond has become very well established and continues to provide good habitat for invertebrates and birds as well as providing a good barrier between the water and the road.

The failure for plants, including potted water lilies, to establish is disappointing, and suggests further efforts are not likely to succeed under the current conditions. High nutrients favour the growth of filamentous algae and the small size of the site results in water birds having a significant impact. Without better protection and regular tending of potted lilies it may therefore be difficult to get them established.

When fully operational, the fountain provides a good visual feature on the lake and helps prevent duckweed reaching nuisance levels. The areas of marginal vegetation to the east side of the pond have become very well established and continue to provide good habitat for invertebrates and birds as well as providing a good barrier between the water and the road.

In terms of future management, we recommend efforts are focused on keeping the fountain running and maintaining the general appeal of the site by regular removal of litter, and if necessary, removal of duckweed.

Water quality in both the **Wildlife Lake** (WAND) and **Angling Lake** (WANF) remains poor, with high levels of phosphorus and turbid, green/brown water due to high algal biomass and suspended solids. These conditions are in part due to the reliance on a mains water supply to the site, but also indicative of disturbance of the sediments by carp and water fowl.

With the installation of the fish barrier under the bridge between the two sites, management needs to focus on a sustained effort to remove fish from the Wildlife side in order to achieve the necessary improvements on the wildlife side. A better-quality water supply is not currently an option here, and therefore the conditions can only be improved by focusing management on the control of fish with in the northern end. If carp can be eradicated from the Wildlife side, this should reduce sediment resuspension, and hopefully allow pike to have an increased impact on smaller, zooplanktivorous fish species, and gain a more balanced fish population. This will provide the best chance to improve water clarity in the Wildlife side and thus allow aquatic plants to become established. As part of the fish management, the current numbers of predatory fish should be assessed, and if necessary, pike and perch introduced to help control small fish and balance the fish population.

High density of wildfowl is also a major contributor to disturbance in shallow lakes such as these. We would therefore recommend numbers are monitored, and populations of Canada geese controlled where possible. Disruption of the habitat for Canada geese may also be effective, particularly fencing off the island to prevent the

larger birds moving from the water on to the island (small gaps being left for ducks, moorhens and coot).

Dissolved oxygen levels are often low in the Wandsworth Main Lake, with the lack of aquatic plants, leaf litter build-up and low turnover of water facilitating the problem. The use of bubblers will help support healthy fish populations in the site, and we would also expect to see better respiratory health within the Wildlife side once disturbance from benthic feeding fish (mainly carp) is reduced.

Marginal habitats and aquatic plants

There are some well-established areas of marginal wetland plants around the Wildlife lake and Angling Lake and these offer good potential habitat for invertebrates and birds. Conditions remain unsuitable for submerged aquatic plants however and none were recorded despite efforts to plant the isolated area at the northern end of the lake. Conditions at this end of the pond, while probably best suited to plants in terms of low fish disturbance, are rather shaded and this along with bird grazing are the most likely factors for failure.

Future Management

With water quality limited by the mains water supply, the focus for management should be to achieve clear water conditions through the bio-manipulation of fish populations in the Wildlife side. The vision for the Wildlife side will be for a site where carp remain absent (or in very low numbers), and the population of small zooplanktivorus fish (roach, bream, hybrids etc.) are effectively controlled by the introduction of pike and large perch to maintain a balanced fish population. Monitoring will hopefully see the Wildlife side improve, relative to the Angling side, despite the physical link being maintained.

Five species of water plant were introduced to the isolated area at the northern end of the lake in 2015: *Ceratophyllum demersum, Myriophyllum spicatum, Potamogeton crispus, Ranunculus aquatilis agg* and the hybrid water lily *Nymphaea "carnea".* Sadly, none of these were observed during our survey. Conditions at this end of the pond, while probably best suited to plants in terms of low fish disturbance, are rather shaded and this along with bird grazing are the most likely factors for failure.

Planned management of the Wildlife Pond, which will limit fish numbers, will hopefully improve conditions in the deeper, open water areas of the lake. One done, we recommend efforts are made to populate for site with plants. While tempting to suggest re-locating plants from Battersea, the presence of the non-native *Elodea nuttallii* there would preclude this. Movement of non-native species (deliberately or otherwise) goes against best practice and in some cases, is illegal.

King George's Park Lake (KING) remains clear, but the water quality is poor with respect to phosphorus concentrations and is detectable nitrate. This limitation of nitrogen is almost certainly because of uptake by the relatively high cover of blanket weed. The problems with water quality here are a direct result of supply, with the borehole unable to keep up with demand, thus requiring periodic top-ups with mains water. This is undoubtedly exacerbated by some leakage of water from the site as well as high levels of evapotranspiration from the emergent plants. Solving these issues will not be easy without a better borehole supply, and therefore management needs to focus on getting the best from the site despite poor water quality.

Efforts to plant submerged aquatic plants in 2015 were thwarted by an explosion of blanket weed (*Cladophora* sp.) in 2016, with no evidence found of any plants surviving in 2016 or 2017.

This situation is very disappointing, particularly given that we know the site has supported pants in the past. Good water clarity and a lack of any large fish in the lake should provide perfect conditions for plants. The high nutrients are also perfect for the growth of blanket weed however, which can quickly outcompete and smother higher plants. Efforts to control the blanket weed by the introduction of dye appears to be working, with the extent of the cover falling significantly since 2016. We therefore support the continues use of dye in the site into 2018.

We strongly recommend the bore-hole remains the primary water source whenever possible. If there is a leak in the site we support any works that can repair it and thus maximise the good quality of the bore-hole supply. Furthermore, if there is any way to increase the rate of flow from the bore-hole this would benefit the site.

In contrast to the poor open water habitat, the marginal vegetation along the west shore remains an excellent feature. This is good invertebrate habitat and adds considerable interest to the site for both wildlife and visual appeal.

We do not recommend any further efforts are made to plant submerged plants, until the blanket weed is cleared. We will review the status of the lake periodically and advise on the best approach for re-planting. We recommend the use of dye is continued.

Battersea Park

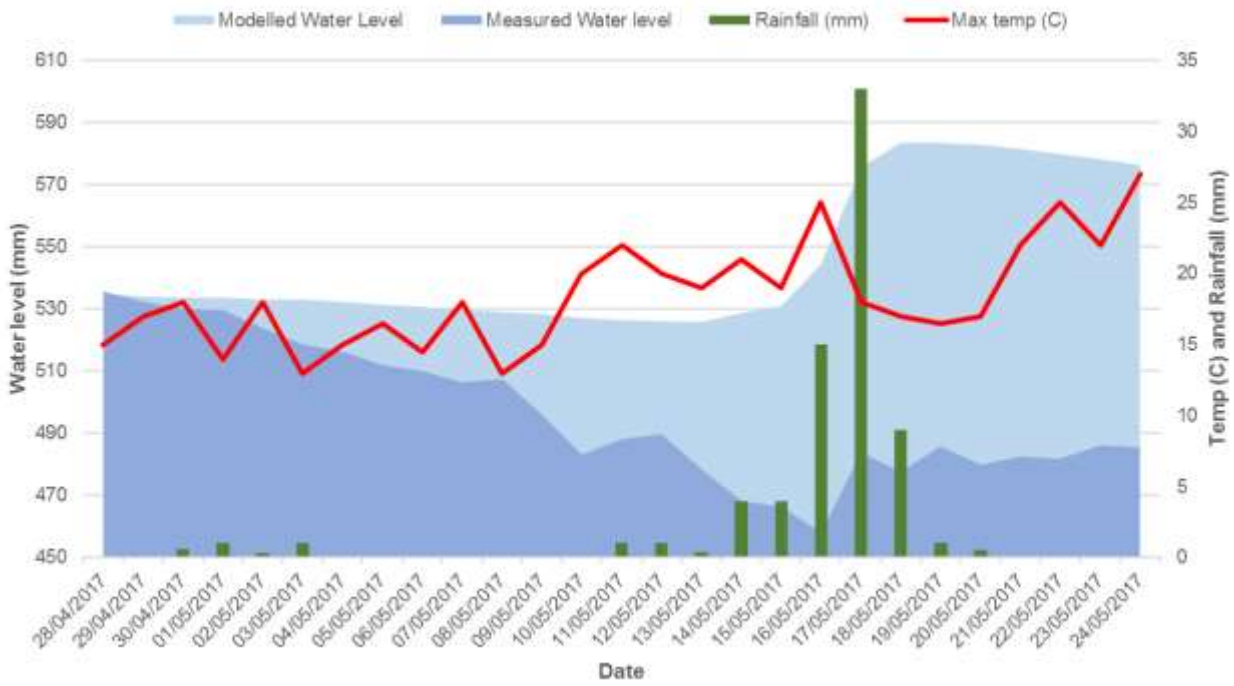
Monitoring the water levels at **Ladies Pool** suggest it to have a significant leak and we support the decision not to divert water to it from the Main Lake, with water resources best used to maintain the Main Lake in optimal condition.

In order to quantify the extent of the leak, ENSIS installed a water level monitor on 27th April, and collected water level data at 15 minute intervals over a period of four weeks (removed 25th May 2017). Additional data on rainfall and daily temperatures were taken from the nearest available meteorological site (Heathrow Airport) in order to model the expected water level against our measured readings (http://www.weatheronline.co.uk).

The calculations are based on the assumption that no water entered Ladies Pool from the Main Lake during the four week recording period, and that run-off from the surrounding park is negligible during and after rainfall. The Pool has no outflow

(when below top water level) and should therefore only lose water via evaporation, if there is no leak, and receive water directly from rainfall. Under these conditions the rate of expected evaporation can be calculated from basic meteorological data using a simplified version of the Penman formula (Linacre 1977[1]).

Although there are errors (as with any numeric model), it should be expected that measured water levels should resemble the modelled values if water loss is due to evaporation alone. Furthermore, during rainfall, one would expect to see the water level rise because of direct input. The graph below summarises the findings.



During the four-week period, the measured water level dropped by a total of 50.2 mm; this was despite an approximate 72 mm of rainfall between 14th – 18th May. Based on the modelled evaporation and rainfall, there should have been a net increase of 41 mm. While there are significant factors not accounted for in the modelled data (e.g. the effect of evapotranspiration), this is unlikely to account for such a large disparity and therefore we conclude the Ladies Pool is almost certainly losing a substantial amount of water through leakage.

There are a number of significant management impacts that a leak will have on the site:

- The first is that it is not feasible to divert water from the Main Lake when a significant proportion will be lost. That said, if maintaining water levels in Ladies Pool is desirable for aesthetic reasons, then blocking the main outflow of the Main Lake and diverting water into Ladies Pool may be an option. This assumes the leakage is not causing problems elsewhere in the park.
- Loss of water in Ladies Pool has an undesirable impact on the biology of the Pool. This is shame given the recent recovery of the macrophytes in the site.

[1] Linacre, E.T. (1977) A simple formula for estimating evaporation rates in various climates, using temperature data alone. *Agricultural Meteorology.* **18:** 409-424

- Low water levels also have a serious negative impact on the aesthetic of the Pool. Vistas across the Ladies Pool are quite rightly regarded as some of the more desirable views of the Battersea Park Lakes. This is an important cultural and historic part of the park, which, without water, loses its identity.

Based on our initial findings, we would recommend a more comprehensive hydrological survey is undertaken to determine the location (s) and severity of the leak (s) in Ladies pool and a "Vision" created from which a restoration plan can be made. If significant funds are to be sought to undertake the restoration, we would recommend they also include the sinking of a bore-hole to feed Ladies Pool directly, and turn the flow from the Pool, to the Main Lake. This would have significant benefits for water quality for both Ladies Pool and the Main lake.

Water quality in **Battersea Park Main Lake** (BATT) appears to have stabilised since the elevated concentrations of TP seen in 2016. Spring and summer values for TP remained below 100 μgl^{-1}, a value that is considered good for an urban lake of this nature. Water clarity was generally good, but showed some variation within the site, with the water noticeably clearer where plant cover was highest. This demonstrates the effect plants have by providing habitat for zooplankton (which feed on planktonic algae) as well as stilling the water column and preventing re-suspension of sediments in shallow water.

The supply of high quality borehole water is key to maintaining this good water quality and maintenance of this supply should be a key management goal. Dissolved oxygen (DO) levels were good, with both the plants and bubblers helping to keep levels high. It is also encouraging to note that suspended solids (SS) were relatively low and well within the limit set for coarse fisheries.

We would always encourage a low density of carp and should the opportunity allow, a shift towards native fish species, particularly perch and pike which will help to reduce fry numbers and maintain a more balanced fishery. Working together with angling groups to promote native fisheries may be necessary if fish stocks are to be manipulated away from a dominance by carp.

Aquatic plants – Main Lake

We are pleased to report that aquatic plants once again dominated in the open water areas throughout most of the Main Lake. This is certainly testament to the successful introduction of plants in 2015, but the distribution of plant species has changed over successive years and the non-native Nuttall's water weed (*Elodea nuttallii*) remains dominant – a species not planted, but one that appears to have benefited from the increased abundance of plants.

In Summary, the species list was similar to last year with *Elodea nuttallii* abundant, rigid hornwort (*Ceratophyllum demersum*) locally abundant, and spiked milfoil (*Myriophyllum spicatum*) common, as well as *Potamogeton pusillus* and *P. pectinatus* present in good quantities, particularly where these species were planted, but also in other areas, which is encouraging, and demonstrates the dynamic nature of aquatic plants. Curled pondweed (*Potamogeton crispus*), which was planted in 2015, but not seen in 2016, was found at one location in the lake this year. Water lilies (*Nymphaea alba*) were present, but only in the margins where previously

established. Two species of free-floating duckweed were present; the native *Lemna minor* and non-native *Lemna minuta.* These were mainly restricted to sheltered areas or very sparsely distributes in open water.

Although the assemblage appears similar, the overall distribution of plants has changed slightly and while the majority of open water areas had plants present, the total plant cover was lower by approximately 25% compared to 2016. The aquatic plants are summarized in Table 7 and maps are presented in Appendix I below.

Table 7 Aquatic plant species reported in Battersea Park Main Lake August 2017

Botanical name	Common Name	Planted 2015?	Recorded 2016?	Recorded 2017?
Elodea nuttallii	Nuttall's waterweed	No	Dominant	A
Ceratophyllum demersum	Rigid hornwort	Yes	Frequent	F
Myriophyllum spicatum	Spiked milfoil	Yes	Occasional	O
Potamogeton pusillus	Small pondweed	No	Occasional	R
Potamogeton pectinatus	Fennel pondweed	No	Rare	R
Potamogeton crispus	Curled pondweed	Yes	No	R
Ranunculus aquatilis agg	Water crowsfoot	Yes	No	No
*Nymphaea alba**	White water lily	Yes	Occasional	O
Lemna minor	Common duckweed	No	Rare	O
Lemna minuta	Least duckweed	No	Occasional	O

**N. alba* – possibly some or all of these are cultivated / hybrid species

Overall management – Battersea Park Lake

While the extent of aquatic plant cover has dropped slightly compared to 2016, the overall abundance remains high and the impact on both water quality and habitat quality was very noticeable. We would like to see lower levels of the non-native Nuttall's waterweed, but without costly removal / management, we don't see this as plausible if budgets are limited, and therefore recommend that the vegetation be monitored annually and native species re-introduced if lost. The aim will be to maintain a mixed species assemblage with at least two native species present in the lake. In particular, *M. spicatum* and *C. demersum* appear to do particularly well in these conditions and we hope to see them remain in the site into the future.

It would appear that the white water lilies planted out in 2015 did not survive. Possibly they were more susceptible to fish and / or bird damage during early growth, or simply the change of conditions did not suit them. While from an aesthetic perspective it would be good to have water lilies in open water, the experimental planting suggests the likelihood of them becoming established is low and therefore not suitable at this time.

The continued management of fish is recommended. We encourage a low density of carp and the focus transferred towards a mixed native fishery. The increase in aquatic vegetation will favour perch and pike, and these in turn will to reduce fry numbers and maintain a more balanced fishery. Working together with angling groups to promote native fisheries may also be necessary if fish stocks are to be manipulated away from a dominance by carp.

The current situation within the Main Lake is very positive and we hope to see the

aquatic plants thrive into the future. It is particularly encouraging to see the impact of pro-active management having such a positive effect on the lake.

We stress the importance of maintaining the bore-hole to ensure the site has a good quality water supply and support the continued diversion of water away from Lady's Pond until such time as the leakage issues can be addressed.

Battersea Park Aquatic Plant Maps

The vegetation was mapped using multiple geo-referenced points. At each point, the vegetation around the boat was identified and the abundance assessed on a 1-5 scale based on the "DAFOR" system, whereby: 5 = > 50% cover (**D**ominant); 4 = 25 – 50 % cover (**A**bundant); 3 = 10 - 25% cover (**F**requent); 2 = 2.5 – 10% cover (**O**ccasional); 1 = <2.5% cover (**R**are). For clarity, species are mapped individually. The maps are presented below in Appendix I – Battersea Park Aquatic Plant Maps.

3. Appendix I – Battersea Park Aquatic Plant Maps

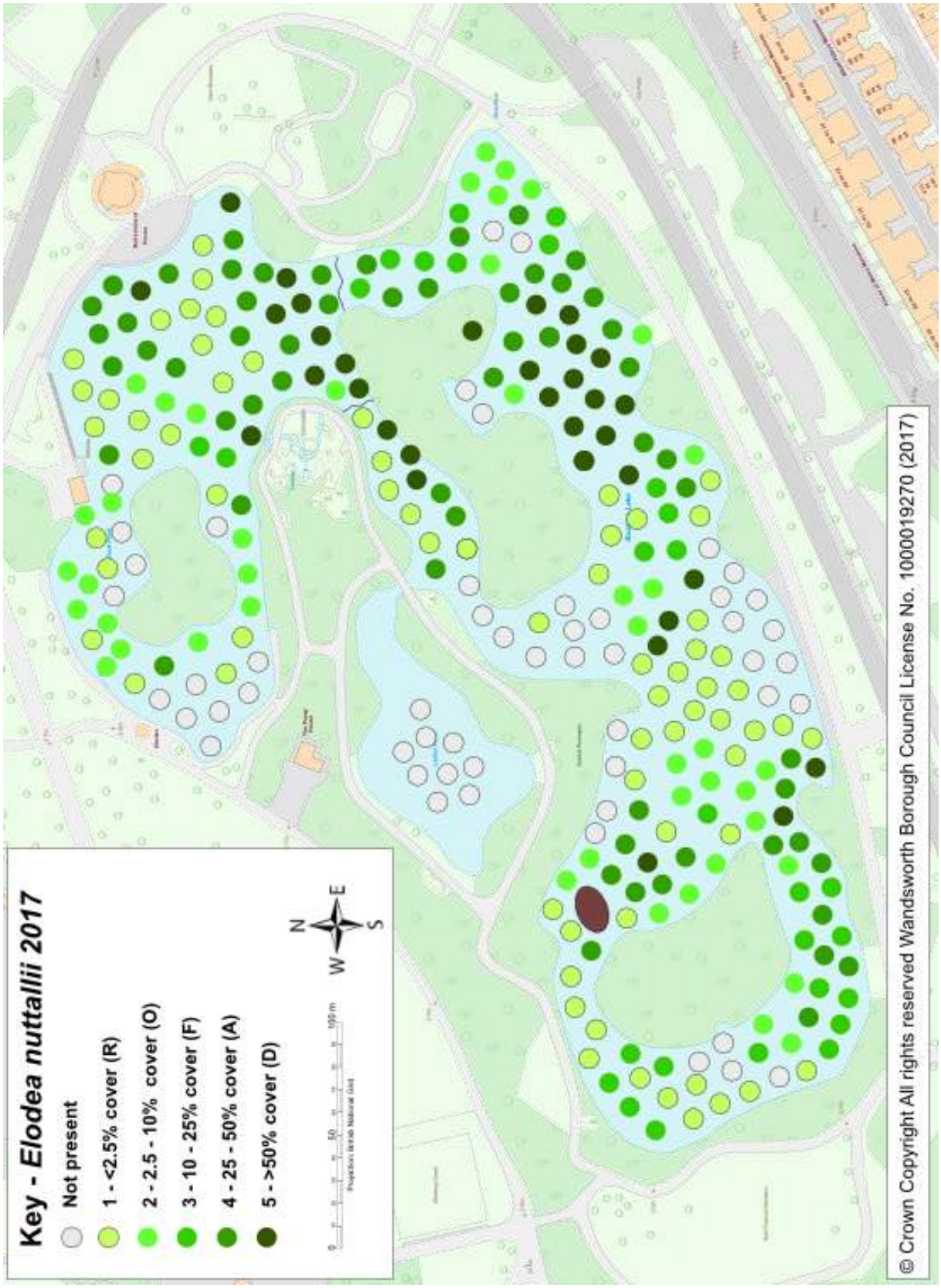


Figure 1. Abundance and distribution of *Elodea nuttallii* in Battersea Park Lakes

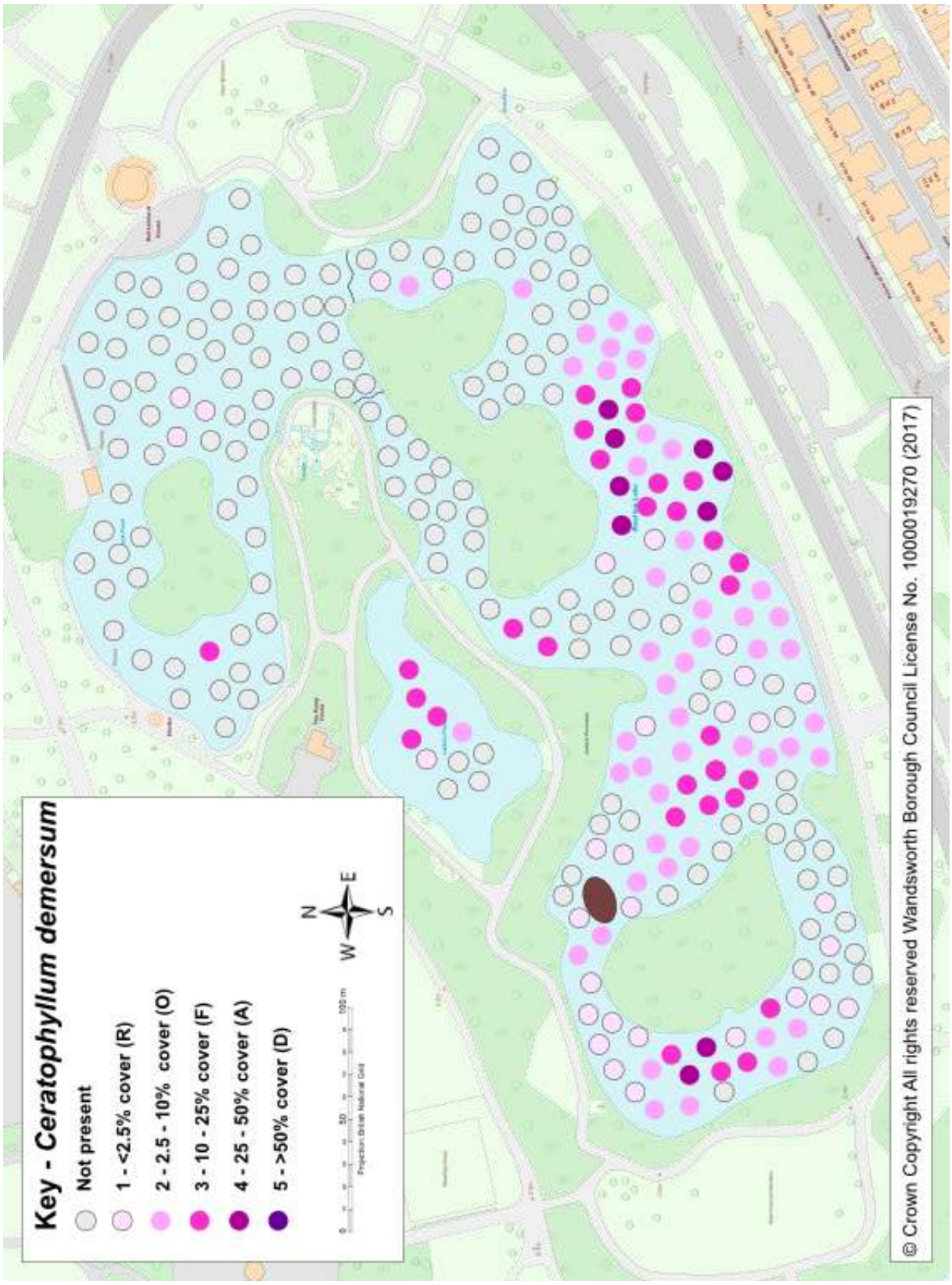


Figure 2. Abundance and distribution of *Ceratophyllum demersum* in Battersea Park Lakes

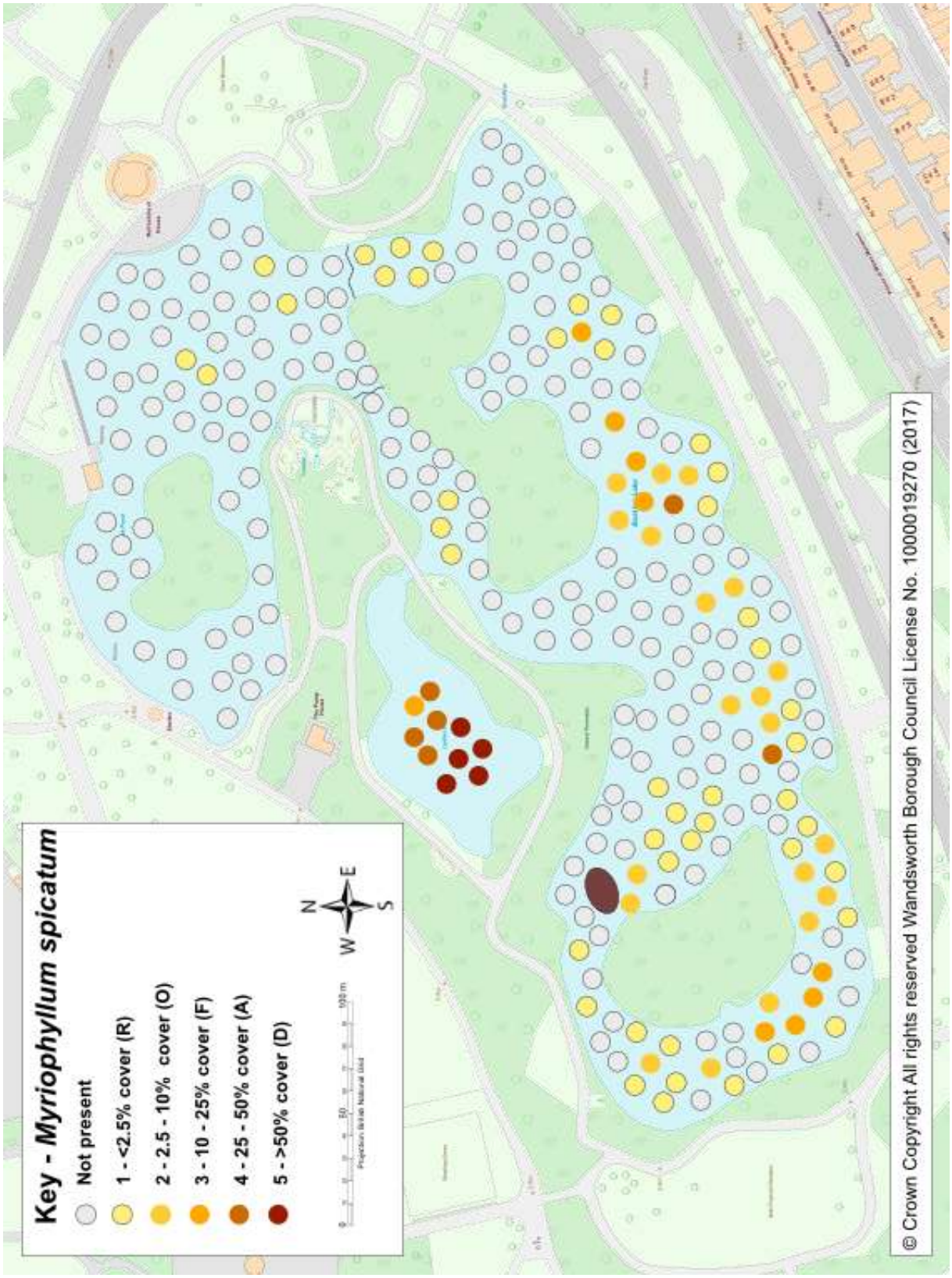


Figure 3. Abundance and distribution of *Myriophyllum spicatum* in Battersea Park Lakes

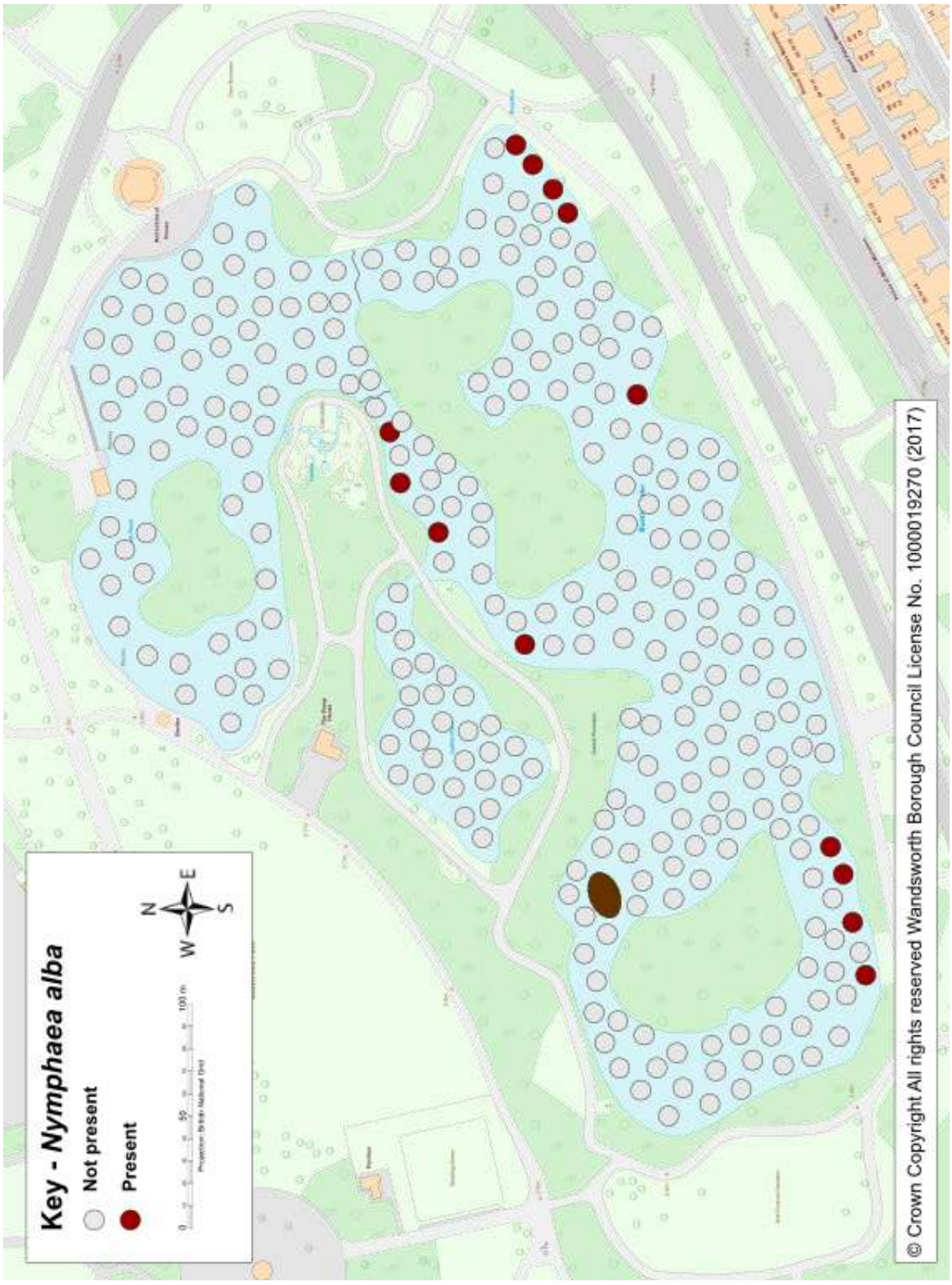


Figure 4. Abundance and distribution of *Nymphaea "alba"* in Battersea Park Lakes

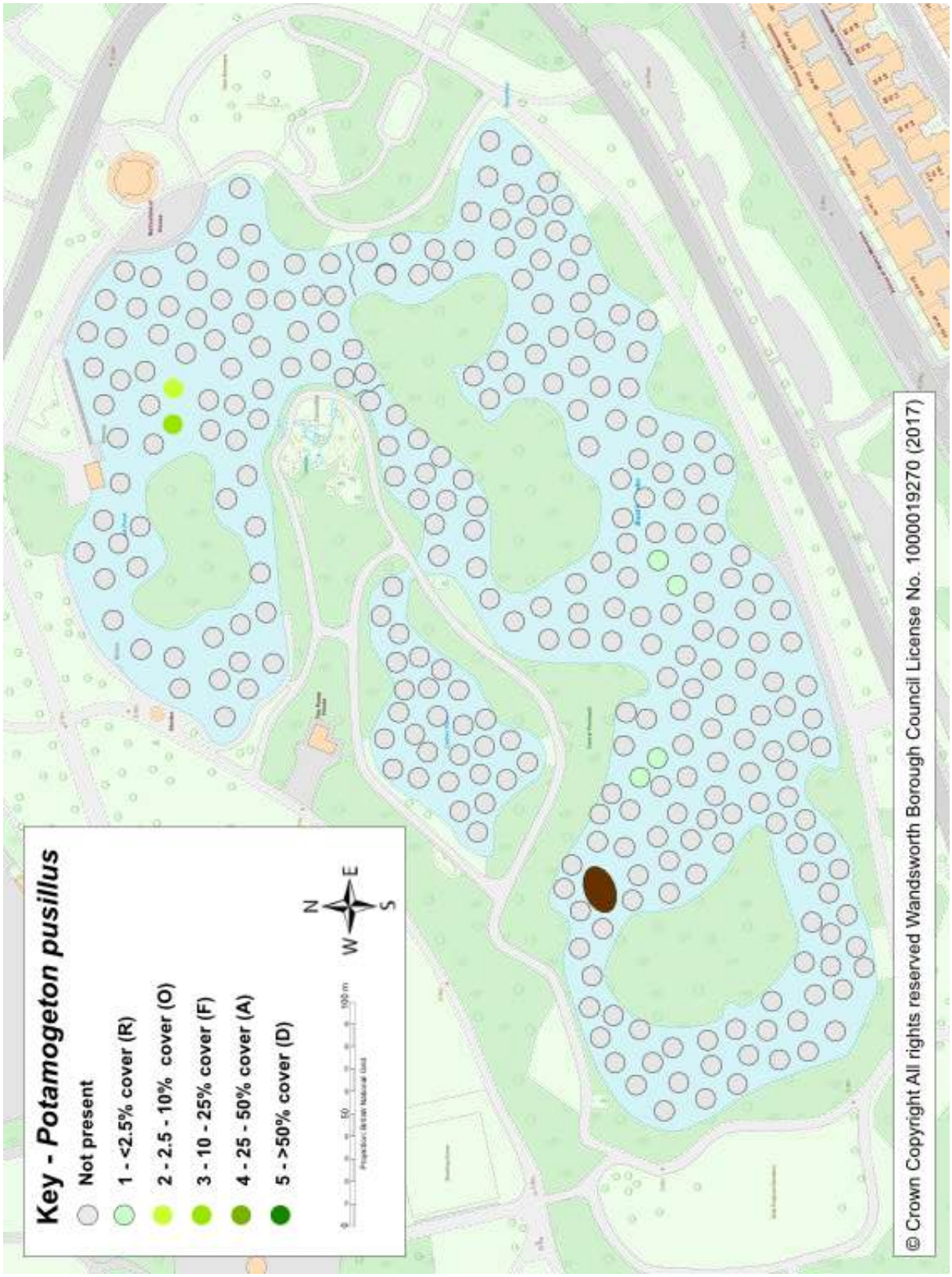


Figure 5. Abundance and distribution of *Potamogeton pusillus* in Battersea Park Lakes

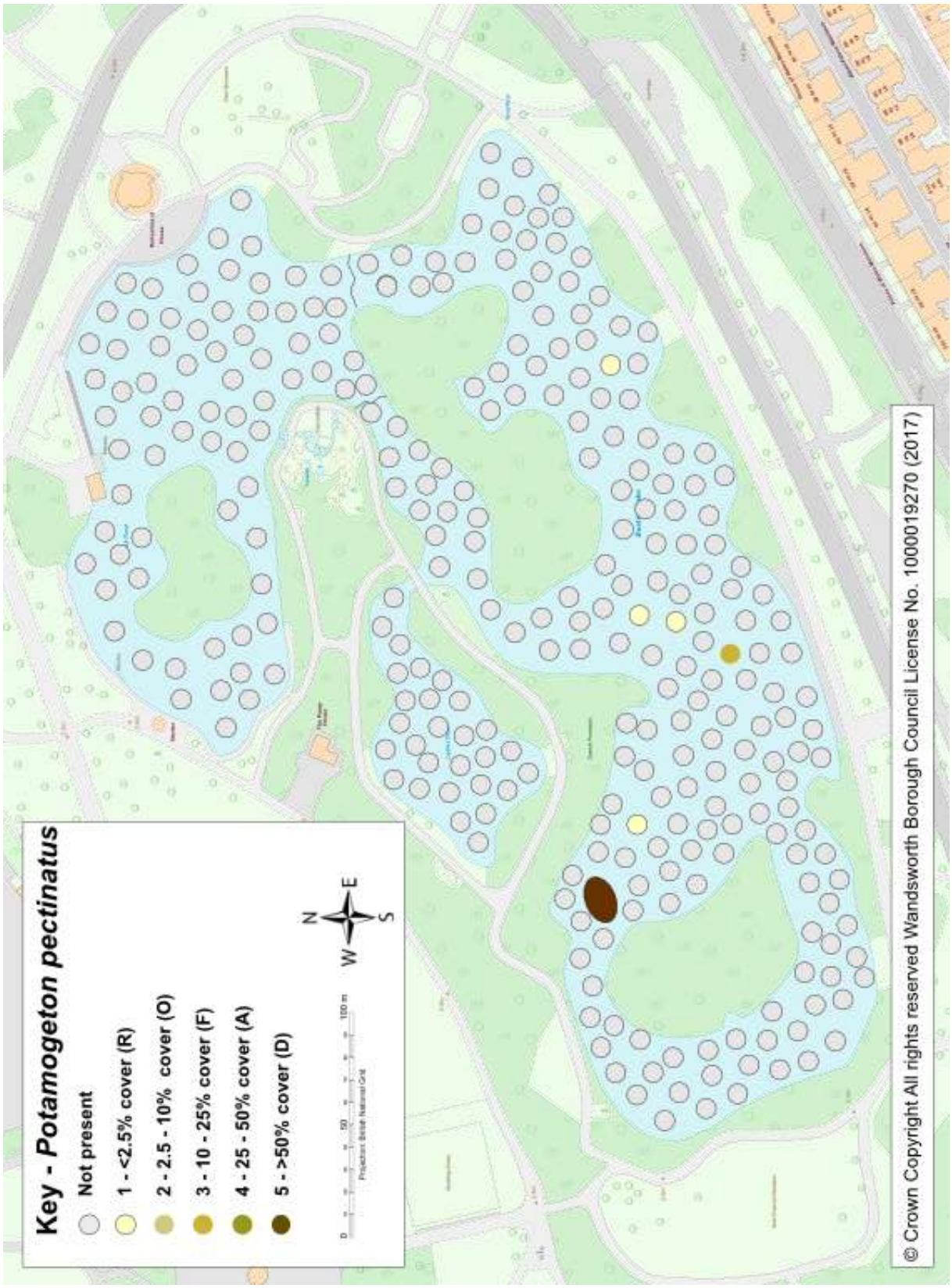


Figure 6. Abundance and distribution of *Potamogeton pectinatus* in Battersea Park Lakes

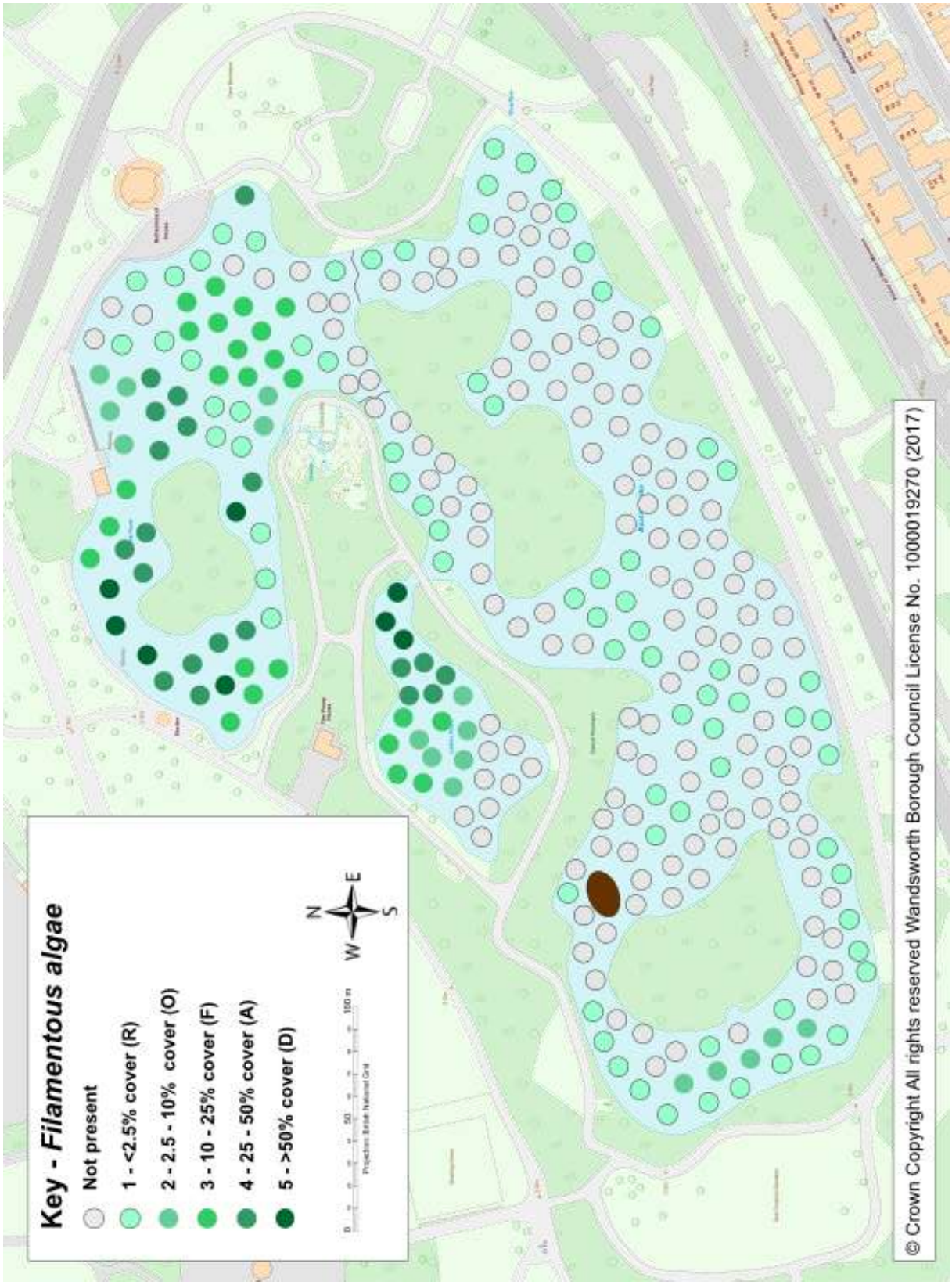


Figure 7. Abundance and distribution of Filamentous green algae in Battersea Park Lakes

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