TECHNICAL REPORT - 1010

LAGUNA SCIENCE

ASHFORD BOROUGH COUNCIL

Conningbrook Lake
Baseline Assessment and Rehabilitation Plan

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Final Report Version 1.2

ASHFORD BOROUGH COUNCIL

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1 INTRODUCTION

Laguna Science Ltd was commissioned by Ashford Borough Council to undertake an assessment and prepare a report for the Main Lake in Conningbrook Lakes Country Park at Ashford in Kent.

The purpose of this assessment was to determine the current chemical and biological conditions in the Main Lake, with emphasis on its nutrient status and water quality conditions, to allow formulation of a long-term management strategy that fits with the waterbody's current and future designated recreational amenity uses.

The lake had been suffering from issues associated with excessive growth of Canadian Pondweed (*Elodea canadensis*) and the development of potentially toxic blue-green algae (cyanobacteria) blooms. These are common symptoms of the process of nutrient enrichment and are impacting on the current use of the lake for water-based recreational activities. Therefore, the primary objective of the assessment has been to formulate approaches to address the excessive growth of submerged aquatic plants and the development of algae blooms together with an outline long-term maintenance strategy for the waterbody.

2 BACKGROUND

Conningbrook Main Lake is a mature gravel pit located in Conningbrook Lakes Country Park in Ashford, Kent. This site is under the management of Ashford Borough Council and Kent Wildlife Trust. There are three lakes in the Country Park and it is the Main Lake which is the waterbody that has been focus of this assessment. These lakes were formed through extraction of aggregates from alluvial deposits associated with the River Great Stour corridor which flows along the eastern border of the site. The quarried areas subsequently were inundated with groundwater, present in the superficial geological deposits, to form the waterbodies currently present within the Country Park.

The use and management of lakes is at present based on a 5-year lease arrangement by the local authority from Brett that commenced in 2015, with a view to a subsequent extended lease being agreed to secure the long-term future of the Country Park. In addition, there are proposals for the future development of a 300 property, residential development together with commercial activities on areas of land that continues to be quarried immediately to north of the main lake. Therefore, the waterbodies within the Country Park will be of importance in terms of the landscape context, drainage management and provision of recreational amenity for these proposed developments.

Historically, the main use of the Main Lake was for recreational specimen angling and it was a Nationally important fishery, being the site of capture for the current British carp record. The main lake is currently being developed by the local authority as a recreational amenity lake to support a range of water-based activities that include non-powered water sports, such as paddle boarding, rowing, canoeing and sailing, and open water swimming including the hosting of triathlon events. These activities are controlled on the lake by Ashford Leisure Trust. Recreational angling continues at the lake on a limited syndicate ticket basis under the control of Mid-Kent Fisheries.

Currently water-based recreational activities on the main lake are being significantly impacted by interference caused by excessive growth of submerged aquatic plants and the development of potentially toxic blooms of blue-green algae (cyanobacteria). The latter has led to closure of the lake to water-sports activities during the summer of 2016 to protect site users from the potential harmful effects of algae contact and ingestion.

The primary goal of the long-term management strategy is to create a safe environment for water-based activity and provide a lake of high water quality status, good aesthetic appearance that supports a diverse ecology with associated low maintenance requirements.

3 ASSESSMENT METHODOLOGY

The baseline assessment of the lake was based on:

- A review of historical reports and water quality monitoring data provided by Ashford Borough Council; and
- A site survey visit undertaken on 23rd September 2016.

It should be noted that the optimal period for undertaking chemical and biological baseline surveys of lakes is from the beginning of July through to the end of September. This is the period when water temperatures and biological activity are at a peak and the worst-case water quality conditions and ecological management issues tend to be displayed by a waterbody.

3.1 Historical Reports and Data

A range of historical reports and water quality monitoring data were collated and supplied by Ashford Borough Council for the lake and its surrounding area. The range of information provided is detailed below:

- Conningbrook Lakes Country Park Information Leaflet produced by Ashford Borough Council.
- Figure showing the Water Depths in the Main Lake.
- Land at Conningbrook Lakes - Ecological Management Strategy Report by Bioscan Oct 2012 (ref E1353R5fv)
- Land at Conningbrook Lakes - Ecology and Nature Conservation Report by Bioscan Oct 2012 (ref E1353R3fv)
- Geo-Environmental and Geotechnical Site Assessment by Ecologia Jan 2012 (ref 11.136.0 v3)
- Supplementary Site Investigation Report by Ecologia Jan 2012 (ref (ref 11.136.1 v3)
- Site Sensitivity Map by WSP 2012
- Topographical Survey Map by BDB May 2012
- River Stour: Rehabilitation Recommendations by Alconbury Environmental Consultants Feb 2012
- Flood Risk Assessment by RMB Consultants (Civil Engineering) Ltd Oct 2012
- Surface Water Management Strategy by RMB Consultants (Civil Engineering) Ltd Oct 2012
- Conningbrook Lakes Ground Conditions Assessment by WSP Sept 2012
- Conningbrook Lakes Country Park Management Plan 2016 – 2020 by Kent Wildlife Trust May 2016
- Water Quality and Algae Monitoring Data from 2015 – 2016 including letter responses from the Environment Agency; and
- Site Visit Letter Report by Environment Agency Sept 2016

This information and data were reviewed to provide background historical information on the lake and aid in formulation of a tailored management and monitoring strategy.

3.2 Field Survey Visit

During the site visit the following assessments were undertaken from a boat and the lake banks:

- Visual appraisal of the lake and its surrounds;
- Collection of composite surface water and discrete lower water column samples for chemical analyses;
- Collection of composite surface phytoplankton (algae) samples and field inspection of zooplankton samples;
- Measurement of water transparency by Secchi disc; and
- *In-situ* measurement of dissolved oxygen and temperature profiles in the deepest areas of the waterbody.

3.2.1 Visual Appraisal

A visual assessment of the Main Lake was undertaken to inspect and assess a range of aspects on the physical and ecological condition of the lake and its surrounds. This included inspections of inflow and outflow points, accessibility, amenity use of the lake, presence of litter, visual water quality indicators and odour, bank and marginal edge condition, presence of aquatic plants and algal blooms, surrounding land use and presence of waterfowl. A photographic record was made during the visit.

3.2.2 Water Sample Collection and Analyses

A total of 4(no.) composite surface water samples were collected from the Main Lake. The waterbody was divided into 4 areas for the purposes of sample collection with 5(no) separate sub-samples collected from each area respectively. The locations used for each sub-sample collection point were recorded by GPS (accuracy during survey of 3 – 5m) and are shown in Figure 1 and summarised in Table 1.

The samples from each area were collected using a stainless-steel bailer and these sub-samples combined in a clean bucket to form a single composite sample for each area of the lake (Samples WS1 to WS4). This composite sample was then mixed in the bucket and sample bottles supplied by the laboratory filled from the bucket. Composite sampling was used as the results from the testing are more representative of conditions in the lake and overcomes the spatial variability in water quality typically seen in many lowland lakes.

Two discrete water samples (WS5 and WS6) were also collected from the lower water column. The deepest areas of the lake were identified using a Raymarine Dragonfly 4DV high resolution echo-sounder. The discrete water samples were recovered using a vertical water bottle sampler with a messenger weight to trigger closure of the device at a depth above any sediment accumulations shown on the echo-sounder. At each of these monitoring locations the water samples were recovered from a depth of 4.5m and decanted into the sample bottles.

The collected samples were stored in cool boxes with ice packs and delivered to a UKAS / MCerts accredited laboratory by same-day courier, and were received by the laboratory in the afternoon on the day of collection. The samples were analysed for the following range of chemical parameters on a standard 10-day analytical turn-around:

pH, suspended solids, biochemical oxygen demand (BOD), chloride, ammoniacal nitrogen*, nitrate, nitrite, total oxidised nitrogen, chlorophyll a, total phosphorus*, soluble reactive phosphorus (orthophosphate)*, total hardness and alkalinity.

*Ammoniacal nitrogen, total phosphorus and soluble reactive phosphorus were analysed using low detection level analytical methods.

As there is no principal point source inflow into the lake, no inflow sample was collected for analysis.

Table 1 - Water Quality and Phytoplankton (algae) Sampling Locations

Sample Code	Depth	Sub-sample	Location
WS1	Surface	a	TR 03312 43307
	Surface	b	TR 03337 43226
	Surface	c	TR 03310 43147
	Surface	d	TR 03342 43179
	Surface	e	TR 03216 43256
WS2	Surface	a	TR 03216 43415
	Surface	b	TR 03277 43436
	Surface	c	TR 03339 43467
	Surface	d	TR 03308 43483
	Surface	e	TR 03231 43473
WS3	Surface	a	TR 03237 43506
	Surface	b	TR 03296 43557
	Surface	c	TR 03263 43565
	Surface	d	TR 03202 43568
	Surface	e	TR 03138 43573
WS4	Surface	a	TR 03237 43647
	Surface	b	TR 03208 43705
	Surface	c	TR 03173 43710
	Surface	d	TR 03157 43672
	Surface	e	TR 03192 43647
WS5	4.5m		TR 03240 43555
WS6	4.5m		TR 03306 43469

3.2.3 Phytoplankton and Zooplankton Sampling

Phytoplankton (algae) samples were collected from the combined composite surface water samples (WS1 – WS4) as detailed above in section 3.2.2. The 1 litre samples were placed in a cool box with icepacks and delivered with the water samples to the laboratory. On arrival at the laboratory the samples were fixed and preserved with Lugol's iodine. In the laboratory, the samples were homogenised and sub-sampled and examined using a Sedgwick-Rafter counting slide under a light microscope. The samples were analysed to determine the following:

- Estimate of total algal cell density;
- Estimate of algal cell density by species; and
- Presence of potentially toxic blue-green algae (cyanobacteria).

Zooplankton samples were collected by trawling a plankton net (153 µm mesh) through the water column at four of the sampling stations used for *in-situ* dissolved oxygen and temperature profiling (see Table 3 in section 3.2.5). The recovered samples were informally inspected on site for the presence and relative composition of large and small-bodies zooplankton species.

3.2.4 Secchi Disc Depth

A Secchi disc is a method for measuring lake water turbidity, which is related to algae density and suspended solids concentrations, and was undertaken using a 20cm diameter black and white quadrant disc. The extinction depth (the depth at which the disc is no longer visible from the surface) was recorded to the nearest 10cms.

Secchi disc measurements were recorded at 12(no.) locations around the Main Lake which are shown in Figure 2 and Table 2.

Table 2 : Secchi Disc Monitoring Locations

Site No.	Location
1	TR 03268 43604
2	TR 03263 43633
3	TR 03238 43674
4	TR 03180 43652
5	TR 03192 43587
6	TR 03210 43512
7	TR 03335 43463
8	TR 03310 43265
9	TR 03336 43207
10	TR 03299 43168
11	TR 03218 43190
12	TR 03205 43263

3.2.5 Dissolved Oxygen and Temperature Profiling

The measurement of dissolved oxygen concentration and temperature at a lake surface is of little value as this can show wide daily variations when algae blooms are present. In addition, the majority of low oxygen concentrations problems tend to occur in the deeper water areas and towards the lake bed. Therefore, it is more useful to measure the temperature and dissolved oxygen concentrations through the water column in these deepest areas of the lake, which is a technique known as profiling. Deeper areas of the lake were identified with the echo-sounder to select the monitoring locations.

Dissolved oxygen and temperature profiles were measured at 0.5m depth intervals using a Hach Lange GHQ30D dissolved oxygen meter with 10m probe cable. Prior to measurements, the meter was calibrated on site using the manufacturer's recommended 100% air saturation method. Measurements were recorded to just above silt level.

The locations of the recorded profiles are shown in Figure 3 and Table 3.

Table 3: Dissolved Oxygen and Temperature Profiling Locations

Site No.	Location	Profile measured	Zooplankton Sampling Stations
1	TR 03276 43497	0-4.0m	Sampled
2	TR 03266 43551	0-4.0m	Sampled
3	TR 03216 43648	0-3.0m	Not sampled
4	TR 03214 43571	0-4.0m	Not sampled
5	TR 03203 43220	0-2.5m	Not sampled
6	TR 03262 43130	0-2.5m	Sampled
7	TR 03320 43233	0-3.5m	Sampled

4 RESULTS

4.1 Overview of Historical Information and Data

4.1.1 Formation of the Main Lake

The lakes in Conningbrook Country Park are a result of open-cast sand and gravel aggregate excavations undertaken from 1979 to the present day. The northern part of the main lake is reported to be a result of much older excavations than the area to the south of the island where mineral extraction was completed in approximately 2006. Further excavations were undertaken in 2015 where the causeway connecting the existing island to the eastern bank was removed.

The main lake has resulted from excavation undertaken into the superficial geological deposits which comprise of three types across the footprint of the lake. These are:

- Alluvium (majority of lake area);
- River Terrace Deposits (central western bank area); and
- Head Brickearth (south-western area of the lake).

4.1.2 Hydrogeology and Hydrology

The maintenance of water level in the Main Lake is reported to be a result of superficial groundwater inundation of the former aggregate excavations. Groundwater levels are recorded to be as shallow as 0.9m below ground level in areas across the site. The general flow of superficial groundwater is eastward across the site towards the Great Stour watercourse which forms the eastern boundary of the Country Park. It is reported that the lake water level is relatively constant and at an elevation of approximately 1.5m above the level in the Great Stour. This infers that the degree of hydraulic connectivity between the lake and the river is likely to be very limited with the Main Lake appearing to be effectively isolated from the watercourse to the east. (RMB Consulting 2012)

Some water quality data are available from the ground investigations works undertaken by Ecologia in 2012. These data demonstrated some contamination of near-surface groundwater across the site as a whole, with elevated concentrations of ammonia, BOD and some poly-aromatic hydrocarbons (PAHs) recorded.

In addition to the main lake, there are other surface water features associated with the site that include:

- Two smaller waterbodies to the north (known as the 'Eco Lake' and Northern Lake);
- The Great Stour river which bounds the southern and eastern boundary of the Country park and flows in a northerly direction.
- A series of drainage ditches in the northern part of the Country Park that direct surface water into the lake features and the Great Stour.

There is a piped surface drainage input into the north-west corner of the Main Lake which discharges surface drainage collected from the area around the Julie Rose Stadium and a lake outflow that enters an open ditch that discharges directly into the Great Stour.

The site is vulnerable to fluvial flood risk and a flood risk assessment of the site was undertaken in 2012 by RMB Consultants. The flood maps taken from the Environment Agency modelling data presented in this report report show inundation of the Main Lake by river flood water for 1 in 20 year and greater defended and undefended storm events.

Proposals were developed and presented to the Environment Agency in 2013 by Alconbury Environmental Consultants for a range of works on the Great Stour channel to improve its habitat quality. The reach of river channel adjacent to the Main Lake has historically suffered from habitat degradation as a result of dredging and straightening engineering works.

4.1.3 Ecology

The site is subject to an active ecological enhancement programme implemented by collaboration between Ashford Borough Council and the Kent Wildlife Trust. The Wildlife Trust is currently implementing a 5-year management agreement that commenced in November 2014. The Country Park site has no statutory ecological site designations, although the adjacent Great Stour is classified as a local wildlife site (LWS).

This work has included compartmentalising different areas of the Country Park and implementing different management regimes to maximise the ecological biodiversity and benefit to wildlife. A range of measures have been recommended for the Main Lake and its surrounds that include:

- Livestock grazing of surrounding grassland;
- Tree management including coppicing around the lake margins;
- Management of fish stocks;
- Creating shallow marginal areas for establishing additional stands of marginal aquatic vegetation; and
- Management of reed beds through seasonal cutting.

Waterfowl numbers tend to increase on the lake during the winter and a range of non-breeding duck species were recorded during the Bioscan ecological surveys undertaken in 2011-12 including Wigeon (120), Tufted duck (106), Pochard (31), Teal (5), Gadwall (149) and Shoveler (5). The values in brackets indicate the maximum number recorded during those winter surveys. The use of the lake by waterfowl is of importance due to the potential nutrient loading into the lake from waterfowl.

4.1.4 Historical Water Quality Monitoring Data

Water quality samples have been collected for microbiological quality and the presence of blue-green algae blooms from mid-2015 to the present. These are the key parameters that need to be monitored on the lake to ensure the safety of users participating in water sports activities on the Main Lake. There appears to be no historical monitoring data for chemical water quality which is of importance in terms of the ecological functioning of the lake. Further discussion on future water quality monitoring strategy and the interpretation of the data is discussed in Section 6.

Microbiological Water Quality

Microbiological water quality monitoring has been undertaken for three Bathing Water Indicators which are total coliforms, *E.coli* and intenstinal *enterococcus*. It should be noted that the revision of the Bathing Water Directive in 2006 (2006/7/EC) requires that only *E.coli* and intestinal *enterococcus* are monitored. The results for a series of monitoring visits are then combined to form percentile values for comparison against the quality standards. The data obtained is insufficient to calculate the status but the results of microbial contamination were found to be very low. One slightly elevated intestinal enterococcus value at 430 cfu / 100ml was recorded in July 2016.

Blue-green Algae (Cyanobacteria)

Blue green algae monitoring has shown the presence of the algae during the spring-summer period of 2015 and 2016. This has included elevated concentrations of *Anabaena* sp. reported above the WHO warning threshold value of 20000 cells / ml and causing formation of scums which resulted in closure of the lake during the summer and early autumn of 2016.

However, the reporting of data as presented in these previous monitoring samples does not provide enough information to allow risk to site users from blue-green algae to be adequately evaluated by the local authority and Ashford Leisure Trust. Further discussion of monitoring approach for blue-green algae is presented in Section 6.

4.1.5 Proposed Future Development

A future development of 300 residential properties is proposed for the area to the north of the Main Lake, together with commercial areas for the importation, packing, storage and distribution of aggregates. As part of this development a Water-Sports and Visitor hub will also be developed adjacent to the lake. The country park lakes will form key focal landscape and ecological features and recreational amenity facility within the locale of the new development.

It should be noted that the outline surface drainage strategy for the proposed development is that SUDS approaches are adopted. This includes drainage of 11.15 ha, of which 6.13 ha will be impermeable, towards the Main Lake. The drainage system will include a series of swales and detention ponds to attenuate flows and provide a degree of treatment before discharge into the lake. The key point here is that surface drainage entering the lake from residential and landscaped areas that have received fertiliser application has the potential to increase the nutrient loading to the waterbody. Increasing the nutrient loading to the lake may exacerbate the negative water quality and ecological effects that arise from the processes associated with nutrient enrichment.

4.2 Visual Appraisal and Lake Description

4.2.1 Physical and Landscape Features

The Main Lake in Conningbrook Lakes Country Park is a mature gravel pit formed from previous aggregate quarrying works. The lake is approximately 690m long, and 220 metres at its widest point and covers an area of approximately 13.96ha.

A water depth (bathymetric) plan of the lake was provided by Ashford Borough Council and is presented in Figure 4.

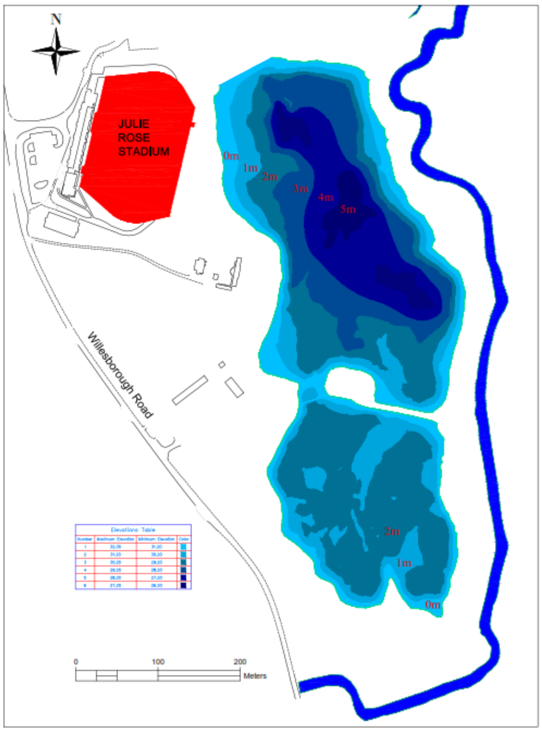


Figure 4: Bathymetric Plan of Conningbrook Main Lake (plan provided by Ashford Borough Council).

Working around the lake from a boat during the survey with a high resolution echo-sounder, indicated that the depth map to be relatively representative. Water depths of up to 5.5 metres to hard bed were recorded in the area of the lake to the north of the island. The lake bed appeared to be relatively uniform in profile and it was noted there were accumulations of suspended floc sediment present in the deeper areas and depressions on the lake bed. These accumulations appeared to be up to around 1 metre in depth. The bed profile in the southern area of the lake was found to be less uniform, showed greater variability and generally of shallower water depths. It was also found that the depth map of this area (see Figure 4) was less representative and water depths greater than 3 metres were found at several locations with the echo-sounder.

The lake is elongated in shape and orientated in a south to north direction. Originally the Main Lake was two waterbodies separated by a causeway. The causeway has been removed, the eastern part of the causeway excavated in 2015, to form a single waterbody with a small elongated island feature. The area to the north of the island was formed from earlier gravel extraction activities whilst excavation on the southern area was completed in around 2006. As a result, the southern end of the lake has a less mature appearance in terms of its bankside vegetation giving a more open visual aspect.

The lake is located within the southern part of a newly established country park setting which is bounded to the west by the A2070 and the Great Stour along the eastern perimeter. The Julie Rose Stadium is adjacent to the north-west bank of the main lake. To the north of the lake there are two additional smaller waterbodies together with ongoing aggregate extraction works.

The recently formed island feature is approximately 100m length and 40m in width. A floating pontoon bridge was installed from the east bank to the island but the central section of this has been removed to provide an access and launch point with a disabled access ramp on the western side of the island (see Photograph 1 in Appendix A). There are proposals being developed to construct a boat launch ramp immediately to the south of the floating platform on the west bank. A small car park with gravel surface car is located to west of this launch area (see Photograph 2 in Appendix A). Between the car park and launch area is an area of short grassland designated as an amenity area and includes a wooden shelter and litter bins. No litter was observed on the lake surrounds or water surface.

Public footpath access is only available at present around south-western, southern and eastern banks of the main lake. The northern and north-west banks currently have no public access due to on-going quarrying activities in this area. Footpaths are informal and comprise of mown strips through the rough grassland areas that surrounds the lake in these public access areas (see Photograph 3 in Appendix A).

Access to the water edge is generally restricted to informal fishing pegs located at various points around the lake and comprise of mown areas with accompanying thinning of bankside trees. It was noted that fishing pegs had been used for depositing aquatic plants from previous cutting works and the plant material had been left to decompose on the lake bank. (See Photograph 4 in Appendix A). It was further noted that the trees located adjacent to some of the fishing positions were overgrown in places and require some pruning to facilitate ease of angling activities (see Photograph 5 in Appendix A).

A gravel access area to the lake has been constructed on the western bank. This has been placed to aid and provide safe exit point from the lake for competitors in triathlon events (see Photograph 6 in Appendix A). There was little evidence of bank erosion around the lake margins which are well consolidated with established terrestrial and semi-aquatic marginal vegetation. The only area where some bank erosion was noted was on the small peninsula on the southern bank where grazing livestock visit the lake to drink (see Photograph 7 in Appendix A).

The principal water input into the lake is from near surface groundwater inundation from the local superficial geology. A discharge point that collects surface drainage from the area around the Julie Rose Stadium discharges into the north-west corner of the Main Lake. An outflow for the lake is located on the northern bank and discharges into an open ditch that flows eastward to the Great Stour. A further drainage channel flows, containing establish emergent aquatic vegetation, flows into the ditch from the north (see Photograph 8 in Appendix A). The lake outflow was not operating at the time of visit and reported to rarely discharge.

The Great Stour flows parallel to the south and eastern bank of the main lake. The river channel appears that it has been subject to historical engineering works in these areas resulting in a straightening and uniformity of the channel. The water level in the river appeared to be approximately 1.5m below the level in the lake at the time of the visit suggesting that hydraulic connectivity between these two surface water features is very limited (see Photograph 9 in Appendix A).

The lake surrounds consist of rough grassland areas that are managed through grazing by sheep and cattle to enhance ecological biodiversity. Established bankside trees, together with scrub, are present around most of the northern area of the lake and in the south-western corner (see Photograph 10 in Appendix A). The south-east corner of the lake has fewer trees and a more open aspect. The stands of trees are dominated by a variety of willow species (*Salix* sp.) and Alder (*Alnus* sp.)

4.2.2 Water Quality and Aquatic Ecological Features

At the time of the site visit, the water within the lake displayed a moderate transparency and bloom of blue-green algae (cyanobacteria). The blue-green algae were showing signs of scum formation in marginal areas but most notably where the algae had been trapped within filamentous algae growth that had developed on the surface growth of submerged aquatic plant beds (see Photograph 11 in Appendix A). Where blue-green algae form such scums they present the greatest potential health risk to site users due to the concentration of the algae and their toxins. At the time of the visit, the site was closed to water-based activity due to the blue-green algae bloom and warning signs about the potential health effects posted by the local authority in areas of public access.

There was no detectable odour around the lake at the time of the visit. No surface foams or visible pollution by hydrocarbons were present.

The lake shows extensive growth of Canadian Pondweed (*Elodea canadensis*). It was not possible to assess the extent of these submerged aquatic plants on the lake bed but across approximately 20 to 30% of the lake area the plants had grown to the surface. The majority of this surface growth was present in the north-western part of the lake, along the north-eastern bank in the area around the island and along the southern bank (see Photograph 12 in Appendix A). Where the Elodea had reached the surface, filamentous algae had developed around the plants, which as previously indicated, were causing aggregations of blue-green algae.

Established beds of emergent aquatic plants are present in areas around the lake and island margins. These stands of emergent plants were generally more established within the older northern part of the lake. The development of these beds was typically limited to a narrow vegetated fringe of up to 5m in width. This will be a result of the apparent relatively step gradient of the lake margins limiting the availability of suitable shallow water depths. The diversity of marginal species was relatively moderate with the dominant species being Reedmace (*Typha maxima*) (see Photograph 13 in Appendix A). Other species present include Reed Canary Grass (*Phalaris arundinacea*), Common Spike Rush (*Eleocharis palustre*), Soft Rush (*Juncus effusus*), Hard Rush (*Juncus inflexus*), Water Mint (*Mentha aquatica*), Yellow flag (*Iris pseudocorus*) and Water Plantain (*Alisma plantago-aquatica*). The latter is shown in Photograph 14 in Appendix A. Some of these plants are only present with limited abundance and distribution around the lake.

Fish populations in the lake are reported to be at relatively low abundance (Mid Kent Fisheries pers comm.) with the lake managed as a specimen fishery with a limited syndicate membership of anglers. However, the actual status of the fish populations is relatively unknown as angling on the lake has always tended to target specimen carp on this renowned fishery. The carp stock is believed to be around 30 fish ranging in size from around 5 – 22kg. Tench, pike, perch and eels are thought to be present at a relatively low abundance. There were no swarms of non-biting midges (*chironomid* sp.) observed around the lake margins which can occasionally develop when fish population abundance is low.

Number of waterfowl on the lake at the time of the visit were relatively low with 3(no.) Mute swan, 15 (no.) Mallard and 25(no.) Coot. No geese were observed to be present and it is reported that they rarely use the lake. This is a benefit in terms of management of lake water quality as overwintering flocks of geese can significantly contribute to phosphorus loading and nutrient enrichment in a lake. This is likely to result from the limited access available from the lake to areas of short grassland which these birds use for grazing. The steep margins of the island combined with dense vegetation will also discourage its use by geese.

During the visit a flock of approximately Herring gulls (see Photograph 15 in Appendix A) alighted on the lake for a short period to bathe and preen.

4.3 Water Quality Results

Results of the chemical analysis of the water samples collected from the lake and potable mains supply are presented in Table 4. Certificates of analysis are presented in Appendix B.

Table 4: Results of Chemical Analyses of Collected Water Samples

		Sample Number					
Determinand	**LOD (mg/l)**	**WS1 (0m)**	**WS2 (0m)**	**WS3 (0m)**	**WS4 (0m)**	**WS5 (4.5m)**	**WS6 (4.5m)**
Total Phosphorous (as P)	*0.026*	0.046	0.043	0.047	0.043	0.168	0.361
Soluble Reactive Phosphorous (as P)	*0.02*	<0.02	<0.02	0.06	<0.02	0.04	0.07
Nitrite (as N)	*0.08*	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Nitrate (as N)	*0.7*	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Ammoniacal Nitrogen (as N)	*0.06*	0.20	0.09	0.07	0.11	0.57	0.87
Total oxidised Nitrogen (as N)	*0.7*	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Alkalinity (as $CaCO_3$)	*2.8*	61.6	59.1	59.8	59.6	68.7	85.3
Total Hardness (as $CaCO_3$)	*3.2*	83.1	80.9	82.9	81.8	86.0	96.1
pH *	*1*	8.1	8.1	8.1	8.0	7.8	7.7
Total Suspended Solids	*1.0*	4	8	2	1	21	28
Chloride (as Cl)	*3.7*	36.5	35.8	35.5	35.2	35.4	35.0
Biochemical Oxygen Demand + ATU (5 day)	*1*	1	1	2	<1	4	5
Chlorophyll 'a'	*0.00005*	0.0116	0.0125	0.0277	0.0141	-	-

Table Notes:

Values in brackets after sample code indicates sampling depth.

LOD = Limit of detection

*As pH units

Value denotes elevated value

Care needs to be adopted when interpreting these data, that represent a 'snapshot' of conditions, against water quality environmental quality standards which are typical based on annual average or percentile values derived from a series of routine samples collected over an extended period.

It is not appropriate to use values developed under the Water Framework Directive (WFD) for comparative purposes for this reason and also due to the fact that the Main Lake falls outside the minimum area criteria of 50ha to be classified as a WFD waterbody.

For ease of interpretation, the results are compared to water quality guideline values presented in Table 5 that are derived from pre-WFD UK EQS and EC values for protection of coarse fish. Table 6 shows the OECD guidelines (1992) which are used to determine the trophic status (degree of nutrient enrichment or eutrophication) of lakes.

Table 5: Guideline Values for Water Quality

Determinand	Units	Normal range	Threshold value for protection of coarse fish
pH	pH units	6 - 9	6 - 9
Biochemical Oxygen Demand (BOD)	mg/l	4	6
Ammoniacal nitrogen as N	mg/l	0.6	0.78
Suspended solids	mg/l	15	25
Dissolved oxygen	mg/l	>5	4

Table 6: Trophic Status of Lakes under the OECD Classification Scheme (1992)

Trophic Status	Total Phosphorous (mg/l)	Chlorophyll a (mg/l)	Secchi Disk Depth (m)
Ultra Oligotrophic *(very low nutrient status)*	<0.004	<0.001	>12.0
Oligotrophic *(low nutrient status)*	<0.01	<0.0025	>6.0
Mesotrophic *(moderate nutrient status)*	0.01 - 0.035	0.0025 - 0.008	6.0 - 3.0
Eutrophic *(nutrient enriched status)*	0.035 - 0.1	0.008 - 0.025	3.0 - 1.5
Hypereutrophic *(highly nutrient enriched status)*	>0.1	>0.025	<1.5

4.3.1 Lake Water Quality Status

The chemical water quality status of the Main Lake is generally good but it shows a number of elevated values which are commonly associated with the process of nutrient enrichment or eutrophication.

pH, Hardness and Alkalinity

The lake displayed a relatively high water hardness and alkalinity and a pH that was slightly alkaline (i.e greater than pH 7). The slightly alkaline pH may be further associated with the photosynthetic activities of algae and submerged aquatic plants that are present in the lake that tends to cause daytime increase in alkalinity as carbon dioxide is utilised. It is expected that there will be some diel fluctuations in pH levels as algae and aquatic plants switch from daytime photosynthesis (carbon dioxide utilised) to night-time respiration (carbon dioxide generated).

However, such fluctuations are likely to be limited as the water will be well buffered by its high alkalinity.

Phosphorus and Soluble Reactive Phosphate

Elevated results were recorded for total phosphorus concentrations which is a indicator of lake nutrient enrichment. Typically in freshwater systems, phosphorus is the limiting nutrient to algae and aquatic plant growth. Nutrient enriched lakes are characterised by a number of management issues that include potential for the development of poor water quality conditions (particularly for dissolved oxygen), development of algal blooms or excessive aquatic plant growth, odour generation and a reduction in ecological diversity.

Comparison of the total phosphorus data with the OECD classification of trophic status (see Table 6) indicate that a geometric mean total phosphorus results of 0.044 mg/l for the surface water samples would classify the lake as being having a eutrophic or nutrient enriched status. Highly elevated concentrations of total phosphorus were recorded for water samples WS5 (0.168 mg/l) and WS6 (0.361 mg/l) which is likely to be associated with release of phosphorus from sediments on the lake bed under low oxygen conditions in the lower water column (see section 4.6). These results therefore reflect an internal loading of phosphorus from accumulated sediments that will contribute towards promoting the development of excessive aquatic plant and algae growth.

Soluble reactive phosphorus is the form of phosphorus that is biologically available for use by aquatic plants and algae. At all but one surface sampling location this was found to be very low and below the limit of analytical detection. These results reflect the fact that the majority of available phosphorus is likely to have been incorporated into existing aquatic plant and algae growth. However, as these plants show seasonal dieback then an increase in available phosphate concentrations may be expected.

Nitrogen Compounds

Nitrogen based compounds, such as nitrate, also contribute to aquatic plant and algae growth but are not generally a limiting factor in freshwater systems. However, in some waterbodies, nitrogen can become limited and such systems have a tendency for increased potential to develop of blue-green algae (cyanobacteria) blooms, which can be potentially toxic and harmful. This results from blue-green algae having the ability to fix nitrogen directly from the atmosphere and gain a competitive advantage over other phytoplankton (algae) in such nitrogen limited situations. Lakes that have a total nitrogen to total phosphorus ratio of less than 10 : 1 are usually considered to be nitrogen limited in the UK and have an increased tendency for blue-green algae development.

It is not possible to calculate an accurate Total N : Total P ratio from the data as total oxidised nitrogen concentrations were below the limit of analytical detection. However, was it obvious from these data is that nitrogen was present at low concentrations and the likelihood is that the system does show some nitrogen limitations. As with phosphate, it is likely that nitrogen becomes more limited as the growth season progresses and these nutrients become ‘locked up’ in aquatic plant growth which may increase the potential for blue-green algae blooms in the mid to late summer period.

It should be highlighted that care needs to be adopted with placing too much emphasis on the use of N : P ratios as there are many factors that influence and contribute to the development of blue-green algae blooms.

Ammoniacal nitrogen values were generally found to be within the normal range for a lowland freshwater lake. Elevated ammoniacal nitrogen concentrations were recorded in the discrete water samples (WS5 and WS6) collected from the lower water column.

Ammoniacal nitrogen is a by-product of these biological breakdown processes and build-up of ammonia concentrations, which can be toxic to aquatic life, can occur where oxygen concentrations are depressed (see section 4.6). The elevated concentrations will be associated with biological degradation processes occurring in the lower water column which was also reflected in the elevation of biochemical oxygen demand (BOD) concentrations recorded for these samples.

Suspended Solids, BOD and Chloride

Suspended solids were found to be low in the lake and this is reflected in the relatively good water transparency displayed by the lake. An increase in suspended solids was noted in the lower water column. During the sampling visit, it was noted that there appears to be a layer of unconsolidated 'floc' sediment that has accumulated in the deeper areas of the lake bed. This was evident from the echo-sounder display, during sampling of the lower water column and in places this appeared to be up to 1 metre deep.

Biochemical oxygen demand (BOD) is a measure of oxygen demand created by biological degradation processes within water, such as the breakdown of organic matter by bacteria. BOD was found to be at low concentrations at the time of a visit with an increase in samples collected from the lower water column. It may be expected that BOD concentrations will increase as seasonal die back of aquatic flora and fauna occurs with the onset of colder weather.

Chloride concentrations, which are used to assess salinity, were within the normal range for a freshwater system.

Chlorophyll a

Chlorophyll 'a' is the pigment present in algae and therefore is generally reflective of the density of algae cells in the water. Comparison of the chlorophyll 'a' data with a mean value of 0.016mg/l with the OECD classification in Table 6 would also classify the lake as being eutrophic (nutrient enriched). The eutrophic status was further confirmed by the recorded Secchi disc measurements being in the eutrophic status range (see section 4.5). The elevated chlorophyll 'a' concentrations will be associated with the bloom of algae present in the lake at the time of the visit.

4.4 Phytoplankton and Zooplankton Results

4.4.1 Phytoplankton (algae)

Results of the analysis of the four composite algae samples are presented in Table 7. The algae present in the samples are common species to lowland lakes and at a relatively moderate density for a nutrient enriched system. Three species dominated the phytoplankton community composition which were:

- *Melosira* (diatom)
- *Actinastrum* (green algae)
- *Microcystis* (blue-green algae)

Total overall cell density ranged between 7395 to 9253 cells / ml. The density of algae present will be supressed by the extensive growth of Canadian Pond weed in the lake and also due to grazing pressure by zooplankton which are afforded refuge from fish predation by the higher aquatic plants.

In terms of the recreational use of the lake, the key consideration is the presence of blue-green algae that can form potentially harmful toxic scums. *Microcystis* is noted as toxic and scum forming species. Scums of *Microcystis* were observed in some of the marginal areas and had also accumulated in filamentous algae which had developed on the surface growth of Canadian Pondweed. *Microcystis* density ranged from 1786 (WS4) to 6431 (WS3) cells/ml with the highest density being recorded in the central area of the northern part of the lake. This demonstrates that blue-green algae concentrations can vary widely across a lake which is mainly due to the algae tending to be moved easily in the surface layers by the prevailing winds. It also shows the importance of taking multiple samples across a lake to allow a representative density to be ascertained and determine exposure risk for site users.

Typically, blue-green algae investigations by the statutory authorities will collect a sample of marginal scum. This provides the worst-case scenario but is often associated with the margins and not always representative of the potential exposure of recreational users out in the main body of the lake.

The concentrations of *Microcystis* were below the WHO lower risk threshold of 20,000 cells / ml, although the 10µg/l (0.01mg/l) chlorophyll 'a' concentrations were exceeded (see Table 4). However, care needs to be adopted when interpreting blue-green algae data and ideally where filamentous, flake or colonial forms are present, additional measurements of algae should be recorded in the laboratory. For example, *Microcystis* tends to be present as two distinct colony sizes of 90 µm and 200 µm. Within the Environment Agency Guidance (2000) a density of 40(no). 90µm colonies / ml is the equivalent of the WHO lower 20,000 cells / ml threshold as is 4(no.) of the 200µm colonies. Recommendations on sampling and analysis for blue-green algae blooms will be described in the monitoring section in the discussion part of this report (see Section 6).

Table 7: Results of Analysis of Collected Phytoplankton Samples

	WS1	WS2	WS3	WS4
Diatoms				
Stephanodiscus	36			71
Cyclotella		572	250	179
Melosira	71	1608	1143	893
Navicula		71		
Nitzschia		107		
Synedra				71
Total	**107**	**2358**	**1393**	**1215**
Green Algae				
Actinastrum	5609	1786	1000	2072
Ankistrodesmus	36		36	
Crucigenia	250			
Cosmarium			107	71
Scenedesmus	572	429		715
Coelastrum				286
Total	**6466**	**2251**	**1143**	**3144**
Blue-green Algae				
Microcystis	2322	2179	6431	1786
Total	**2322**	**2179**	**6431**	**1786**
Others				
Ceratium	36			107
Euglena	36			
Rhodomonas	71	214	143	500
Cryptomonas		286	143	214
Gymnodinium		36		
Mallomonas		71		
Total	**143**	**607**	**286**	**822**
Total cell density	**9038**	**7395**	**9253**	**6966**

4.4.2 Zooplankton

Collected zooplankton samples were inspected on an informal basis in the field. Formal counting and identification of samples was not undertaken as zooplankton populations can show rapid fluctuations in abundance and compositions in response to algal blooms. Therefore, there is often little value from a single sampling visit.

Zooplankton graze on phytoplankton and this is undertaken more efficiently by larger species such as *Daphnia*. Therefore, a high density of large zooplankton species in a lake can help reduce phytoplankton density and therefore contribute towards improved water transparency.

Three types of zooplankton were present in the samples which included *Cyclops*, *Bosmids* and *Daphnia* species. *Daphnia* made up a moderate proportion of the zooplankton community. The presence of *Daphnia* at moderate densities is indicative that the abundance of small cyprinids (carp family i.e juvenile roach and bream) is probably relatively low in the lake and that the established beds of Canadian Pondweed also act to provide refuge for the zooplankton from predation. The larger zooplankton tend to be selectively predated by juvenile cyprinid fish and in lakes where a high abundance of these fish are present, then the zooplankton community will tend to be dominated by small species such as cyclops and bosmids. These small zooplankton species being less efficient grazers of algae tends to result in an increase in algal density and associated reduction in water transparency where there is a high levels of fish predation pressure.

It should be noted that zooplankton do not generally consume blue-green algae. Many blue-green algae, being colonial or filamentous in form, are too large for the zooplankton to graze.

4.5 Secchi Disc Depth

The results of Secchi Disc measurements are present in Table 8.

Table 8: Secchi Disc Measurements

Site No.	Extinction Depth (m)
1	1.6
2	1.5
3	1.6
4	1.4
5	1.8
6	1.7
7	1.6
8	1.6
9	1.5
10	1.5
11	1.5
12	1.4

Secchi Disc extinction depths ranged from 1.4 to 1.8m with an average depth of 1.56m. These results can be compared to the OCED Guidelines (1992) presented in Table 6 which would again classify the nutrient status of the lake as being of eutrophic (nutrient enriched) status.

4.6 Dissolved oxygen and Temperature Profiles

Results of the measured dissolved oxygen and temperature through the water column are presented in Appendix C.

Water temperature was found to be within the normal range for the time of the site visit with an average temperature of 18.8ºC. Water temperature ranged from a maximum of 19.6ºC at the surface to a minimum of 17.4ºC at the bed. Water temperatures were found to be relatively uniform through the water column with a slight decline with increasing water depth. There was no evidence of thermal stratification (the water column dividing into distinct warm and cold water layers). Thermal stratification is generally seen on deeper water bodies where water depths are greater than 7 to 8 metres.

Measurement of dissolved oxygen found concentrations to be depressed on what would typically be expected at the time of the visit given the presence of an algae bloom and extensive beds of aquatic vegetation. Typically, in these conditions it would be expected that higher concentrations of dissolved oxygen would be present in the surface layers of the lake due to oxygen produced by plant photosynthesis. Dissolved oxygen concentrations at the lake surface were recorded to be between 5.54 – 7.05 mg / l (59.1 – 76.1% saturation). Across the lake a decline in dissolved oxygen concentrations was observed with increasing water depth and in some deeper areas was below the 4mg/l threshold EQS for the protection of coarse fish.

At sampling site 4 (see Graph 4 in Appendix C), the dissolved oxygen probe was allowed to enter the 'cloud' of floc silt that appears to have accumulated in the deeper areas of the lake. A rapid decline of dissolved oxygen was recorded within this 'cloud' of silt. The lack of oxygen in this 'cloud' will be associated with oxygen demand created by microbial activity breaking down organic material. This has implications in terms of the water quality within the lake, as under such conditions the key plant nutrient phosphorus tends to be readily mobilised back into the water column as observed in water samples WS5 and WS6. This release of phosphorus from the sediment, a process known as internal nutrient loading, can further contribute towards the development algal blooms and excessive plant growth. The lack of oxygen also reduces the rate of breakdown of the organic material in the silt and leads to release of other degradation chemicals such as ammonia which is potentially harmful to aquatic life. This effect is shown diagrammatically in Figure 5.

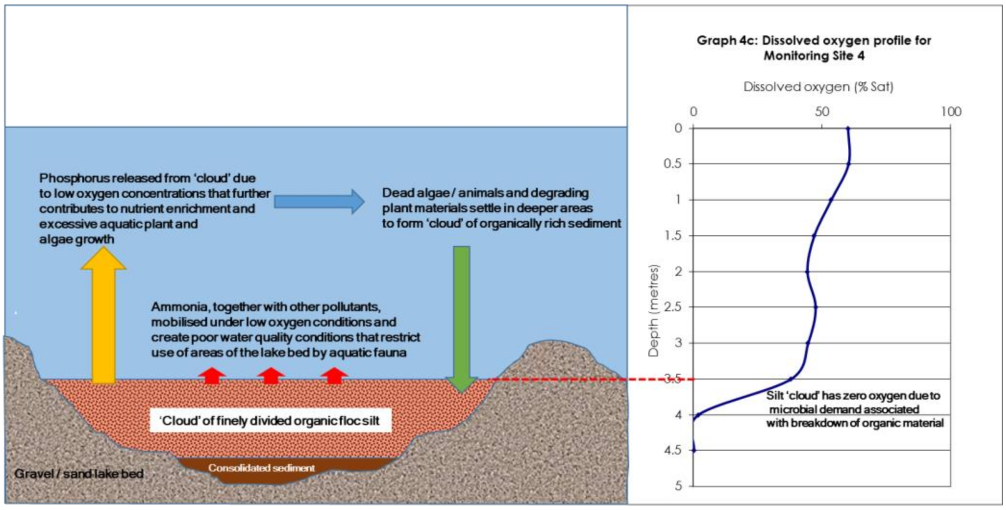


Figure 5: Diagram showing effects of 'cloud' floc silt on Dissolved Oxygen and Water Quality.

The accumulation of the 'cloud' of sediment in the deeper areas of the lake will create areas that present hostile conditions for both aquatic invertebrate fauna and use by fish.

5 DISCUSSION

The baseline assessment of the Main Lake in Conningbrook Lakes Country Park has identified a range of management issues that are impacting on the aesthetic quality, water quality status, ecological functioning and amenity use of the waterbody.

Key management issues are:

- Nutrient enrichment;
- Accumulations of 'floc' sediment;
- Excessive growth of submerged aquatic plants; and
- Blue-green algae blooms.

These issues are interrelated and result from the process of nutrient enrichment of the waterbody the affects the ecology of the lake with associated impacts on water quality.

There is no single action that will fix the management issues within the lake and a combination of measures and a pro-active maintenance strategy will need to be implemented to achieved the desired objectives for the waterbody. Where waterbodies are required to serve a wide range of amenity functions there is inevitably conflict in terms of amenity requirements and management. For example, fish populations required to support a recreational fishery can have a direct impact on water quality status and therefore the performance of the waterbody for other water-based activities. As such, there is often a need for comprises to be established to allow all activities to be supported across a single waterbody. The segregation of various activities into specific parts of the lake is sometimes adopted with different management regimes applied to these areas. It is assumed for the Main Lake that the management will be for all activity to be undertaken across the entire lake area.

5.1 Nutrient Management

The Main Lake is currently in a eutrophic or nutrient enriched state. This is a common feature of lowland lakes and impacts on a range of aspects of lake performance. The nutrient enrichment of the waterbody is likely to have arisen due to loadings of phosphorus, and to a lesser degree nitrogen, from a range of sources that include:

- Elevated phosphorus concentrations with groundwater;
- Periodic flood inundation of the lake;
- Phosphorus mobilisation from local soil excavations;
- Use of the lake by waterfowl and gulls;
- Inputs of angling bait; and
- Leaf litter entry from surrounding trees.

The primary objective of the long-term lake management strategy should be to implement measures to reduce the availability of nutrients which increase the potential for excessive submerged aquatic plant growth and algal bloom development. Nutrient loading into the lake may be divided into internal and external sources of loading.

5.1.1 Reducing external nutrient inputs

There is only limited potential for reducing external nutrient inputs into the Main Lake as the principal water supply is from groundwater inundation for which it will not be possible to implement any measures to reduce its nutrient status. In addition, the Great Stour periodically inundates the lake during flood events and again it will not be possible to control loadings of phosphorus from this source.

Surface Drainage Inputs

There is currently a drainage pipe input into the north-west corner of the lake that discharges surface drainage into the lake during rainfall events. The catchment of this drainage system should be established to ensure that it not discharging drainage from the grassed sports areas in the Julie Rose Stadium, that are likely to receive high rates of fertiliser application into the lake. The use of any fertiliser within the surface drainage catchment of the lake should be avoided.

Within the outline drainage strategy for the new development area to the north of the Main lake, it is proposed that some surface drainage is directed towards the lake. This surface drainage may include elevated concentration of phosphorus from fertiliser applied to landscaped and garden areas, together with detergent run-off from car washing on driveways. This is also the case for the construction phase of the development, where soil disturbance may lead to mobilisation of phosphorus from soils and elevated concentrations being present in surface drainage. The implementation of both construction and operational drainage systems should be based on a designs and approaches that minimises the potential for increasing nutrient loading into the lake. The outline operational drainage proposals include the use of swales and detention basins. These will assist to a degree in reducing nutrient inputs by allowing the settlement of sediment, to which phosphorus often adheres. It should be noted that the use of constructed wetlands for water treatment of the drainage water, is usually only of limited success for the reducing phosphorus concentrations.

Livestock

Areas surrounding the lake are grazed by cattle and sheep for ecological management purposes. As there are no drinking water facilities for the animals, they are allowed free access to the lake and its margins. This is evident at the southern end of the lake where some bank erosion has occurred due to the activities of livestock. Excrement from the animals entering the water will contribute to nutrient enrichment and potential for microbiological contamination.

Ideally livestock would be prevented from entering the lake and this would require drinking facilities to be provided. An approach for this would be erect stock fencing between the grazing areas and lake margin. The fence would require occasional gateways to allow access to the lake edge for site users. The use of fencing would have further benefit in that it would allow a buffer strip of vegetation to be created around the lake margin.

Approaches for providing drinking water for the animals may include excavation of a small groundwater supplied pool in the grazing area or excavating a channel back from the lake margin into the grazing area. The lake end of the channel could be planted with Reedmace to assist in ameliorating the effects of any nutrient or bacteria inputs into the channel.

The use of fencing and creation of a lake buffer zone should be discussed with Kent Wildlife Trust (KWT).

Waterfowl and their feeding

Waterfowl can contribute high nutrient loadings to lakes through their droppings both directly into the water and from wash-off from deposits on surrounding areas. The main species associated with problems are geese. The presence of large over wintering flocks of geese on lake can significantly contribute to nutrient enrichment. However, currently the lake is not used by geese and this is most likely to result from the limited accessibility between the lake and areas of short grassland suitable for grazing and roosting. The steep margins of the island combined with its established marginal reed growth forming a barrier and dense vegetation is also likely to be unattractive to geese flocks.

The lake supports a moderate density of a range of duck species during the winter months and probably provides a site of good winter habitat for the birds. These birds will be contributing to external nutrient loading but there are no effective measures available to control the use of the lake by these birds. The nutrient loading from these birds is like to be relatively low in comparison to inputs from groundwater or flood inundation.

It is recommended that the surrounding grassland areas are maintained at longer lengths to discourage the attractiveness of the lake to geese. It is not evident that there is currently much feeding of the waterfowl by visitors. However, this could change with the future planned nearby residential development. If this were to be the case, then it is recommended that information boards are erected to discourage the feeding of waterfowl by the public.

Collection and removal of Leaf Litter

Leaf litter inputs into a lake contribute to siltation and organic matter and nutrient loading. Ideally collection of leaves from the lake surrounds and any accumulations in marginal areas that occur during the autumn should be collected and removed.

There are large numbers of trees surrounding the lake perimeter and so control of leave litter input is likely to prove challenging. However, where possible collection of large deposits of leaves and their disposal away from the lake would be of benefit.

Angling Bait

Bait used by anglers provides a further source of nutrient input. Currently angling on the lake is only available to a limited syndicate of anglers and therefore the overall bait inputs into the waterbody are relatively low in relation to its area. If the fishery is further developed in the future and increased number of anglers start to use the fishery, then it is recommended that consideration is given to restrictions on the quantities of bait used during a fishing session.

5.1.2 Reducing internal nutrient availability

The Main Lake was shown to have a eutrophic status at the time of the visit with elevated concentrations phosphorus recorded. Additional phosphorus will be seasonally ‘locked’ into existing algae, plant and invertebrates which is released back into the water as these undergo seasonal dieback of algae in the autumn and winter. Therefore, phosphorus concentrations are often reach peak concentrations during the winter months.

A further important phosphorus source is found in accumulations of organic sediment which will tend to be released into the water under low oxygen conditions (see Figure 5). Therefore, there is a need to take steps to reduce these internal sources of phosphorus for which a range of approaches may be adopted.

Chemical Treatment

The waterbody may be subject to chemical treatment to make the phosphorus biologically unavailable. Within the UK the only approved treatment for reducing phosphorus concentrations in lakes is a product called ‘Phoslock’. This is a lanthanum clay based compound that when added to the lake and forms a permanent chemical bond with the phosphorus. The ‘Phoslock’ is mixed with the lake water and added as a slurry which sinks through the water and binds with the phosphorus before settling on the bed where it also tends to forms a sealing cap on any sediment deposits.

It should be noted that ‘Phoslock’ has a limited chemical capacity to bind phosphorus. Therefore, the benefits of this treatment in lake systems for which groundwater is the principal water source and that are also subject to periodic flood inundation is likely to be short term and necessitate the requirement for frequent repeat applications. ‘Phoslock’ is an expensive product at around £2500

/ tonne and at an application rates of around 1-2 tonnes / 0.4 ha then the cost per treatment for the Main Lake is likely to be in the region of £87000 - £174000 per dosing without application labour costs.

Given the high costs and expected short-term benefits of any treatment it is not recommended that this would be a cost-effective method of controlling internal nutrient loading within the Main Lake.

Aquatic Plant Harvesting

The harvesting of aquatic plants at the end of the growth season can be used as an approach for reducing phosphorus availability in a lake. The removal of plant growth effectively removes phosphorus from the lake system. Weed cutting has previously been undertaken on the lake but the removed weed was left to decompose on the lake margins and therefore the nutrients are likely to have leached back into waterbody.

Aquatic plant harvesting should be undertaken during the early autumn before seasonal dieback commences. During harvesting works only a proportion of the submerged plants should be removed with 70% removal being the maximum. Complete clearance of the submerged plants creates a potential risk of the lake switching to a system dominated by phytoplankton (algae) blooms given its nutrient enriched status. Harvesting should also include the top growth of beds of emergent marginal plants such as reedmace. Cutting of these plants is a beneficial action as it will encourage further growth of the marginal plants the following year and aid in establishment of a more widespread vegetated fringe.

All removed plant material should be disposed of at distance from the lake and it is recommended that it is ideally taken to a local authority composting facility if available.

Aeration

The installation of an aeration / mixing system into the lake will prevent the development of low oxygen conditions in the lower water column. Low oxygen conditions promote the remobilisation of phosphorus from sediments in the lake. By raising dissolved oxygen concentrations, an oxidised layer (known as the oxidised microzone) forms at the sediment / interface and prevents release of the nutrients into the water. There are further advantages on using an aeration system are discussed in more detail in section 5.4.3.

Fish Stock Management

Large bottom feeding species of fish such as carp and bream, through their feeding activities and excretions can promote the release of phosphorus from lake bed sediments. It is recommended that the fishery is managed in line with its heritage as an important carp fishery and maintained as a specialist specimen fishery with a relatively low stock density of large fish. No stocking of other fish species should be undertaken.

5.2 Sediment Conditioning

Accumulations of finely divided organic sediment have accumulated within the deeper areas of the lake. These have formed a 'cloud' of organic material which has a very low dissolved oxygen concentration and contributing to internal nutrient loading within the lake. The low oxygen concentrations within the 'cloud' are also likely to be slowing down decomposition processes on this organic material.

The depth of sediment does not appear to be significant in relation to the retained water depth of the lake, which would warrant consideration of dredging, however it is likely that it is impacting on nutrient status of the lake and resultant water quality conditions.

It would be beneficial to cause consolidation of the sediment ‘cloud’ and also increase dissolved oxygen concentrations in the lower water column to reduce internal nutrient loading. Therefore, it is recommended that treatment of the sediment is undertaken using a combination of finely powered chalk, such as ‘Siltex’, and the deployment of a diffuser based aeration system. This combination approach has been shown to help breakdown organic matter and cause consolidation of sediments. In addition, there is potential for some limited binding of phosphorus to chalk’s calcium that would be maintained by increasing dissolved oxygen concentrations.

It is recommended that the chalk application is undertaken in advance of any aeration system installation so that the silt has become more consolidated prior to any aeration system operation. This will aid in reducing nutrient mobilisation from the sediment layer in the lake. It is likely that there may be some initial short-term increases in nutrient concentrations in the lake due to mixing by the expectation would be that this approach in cause a reduction in loadings in the longer term.

The chalk is a relatively low cost treatment and is usually applied as an initial dose of 1 tonne / 0.4 hectares and a follow-up dose after 6 months of 800kg / 0.4 ha. Therefore, the initial dose would be 35 tonnes with a subsequent dose of 28 tonnes distributed across the lake from a boat. The cost for both doses of finely powered chalk would be approximately £8200 (ex VAT) excluding labour application costs.

It should be noted there are chalk products available which are combined with bacteria which are claimed to have an enhanced effect on sediment degradation and a charge at a highly elevated cost. It should be noted that these bacteria are already present in the lake and it is a better approach to simply creating the correct conditions in the lake for them to flourish naturally. This is generally the case for bacteria based lake products that offer a wide range of improvement claims.

5.3 Aquatic Plant Management

Excessive growth of Canadian Pondweed is causing interference to amenity use of the lake for both angling and recreational water sports. Growth of submerged plants in nutrient enriched systems is becoming an increasing issue in lowland activity lakes as there is currently no permitted aquatic herbicides that are permitted for use within the UK. Therefore, a combination of other control measures now need to be employed.

To date management of the lake has been restricted to periodic weed cutting operations using ‘Truxor’ weed cutters. However, this has only shown limited success in managing the submerged aquatic plant issues.

In terms of management of the submerged aquatic plants it is important that complete clearance is not undertaken as this would create a potential risk of the lake switching to an algae dominated system due to its nutrient enriched status. The presence of aquatic plants inhibits the development of phytoplankton algae blooms through various mechanism that include utilisation of available plant nutrients, shading, providing a predation refuge for zooplankton which graze on phytoplankton and release of algicidal chemicals. A coverage of around 30% coverage of the lake area with submerged plants should be maintained.

Plant management within the lake is likely to be an on-going process over several years to achieve the desired results and balance between plant presence and amenity use.

5.3.1 Cutting

Given the amenity use of the lake, it is recommended that submerged plant growth is allowed to develop around shallow marginal areas with the deeper central area of the lake maintained free of plants for activities to pursued. Access and egress points to the lake together with the channels in front of angling pegs should also be maintained free of submerged plants.

Where weed cutting is undertaken, as much cut plant material should be removed as practically possible, as fragments of Canadian Pondweed can form new plants. Recovered plant material should be disposed of at a site remote from the lake, as previously discussed, to prevent nutrient-rich leachate draining back into the lake.

It would be advantageous to maintain the submerged plants with limited surface growth, to prevent the issue observed during the site visit, of accumulations of blue-green algae becoming trapped and effectively forming a scum. Such scums would present an increase potential health risk to site users undertaking water-based activites.

5.3.2 Harrowing

Harrowing is the use of trawled chain or rake behind a powered boat and is generally undertaken in the early spring when the submerged plants are starting to grow. The technique works by disrupting emerging plant shoots, burying seeds and increasing lower water turbidity and light availability. This technique has been successfully used on a number of lakes used for sailing to successfully manage submerged plant issues.

Usually repeat harrowing needs to be undertaken at 6 – 8 week intervals through the plant growth season. Harrowing undertaken over several years tends to reduce the plants ability to reproduce successfully resulting in a reduction in overall plant growth. As with weed cutting, harrowing works are labour intensive activities.

A downside of harrowing is that it is causing disturbance of bed substrates and where low dissolved oxygen levels are present may cause increased potential for mobilisation of nutrients. Ideally harrowing would be undertaken where adequate concentrations of dissolved oxygen are maintained in the lower water column.

Harrowing may be applied as a technique for managing the submerged plants in the central area of the Main Lake to try and achieve an area clear of plants. In terms of the areas to be harrowed then it would need to take account of any installed aeration system to prevent snagging and potential damage to the installed system. Therefore harrowing could be undertaken between lines of any diffusers placed on the lake bed (see Figure 6 in section 5.4). The layout of any aeration system should be optimised to facilitate harrowing activities.

5.3.3 Lake Mats

Another effective method of preventing submerged aquatic plant development is using self-sinking frame-mounted geotextile to cover areas of the lake bed.

(Image courtesy of Lake Mats)

This approach prevents plant growth by stopping light and also the chemistry changes that occur in the sediment below the cover can cause the roots of the plants to die back. This approach is commonly used in the USA to keep areas of the lake weed free. It is recommended that a lake mat is deployed in front of access and egress points of the western bank of the Main lake to maintain submerged plant free areas. These mats are available commercially in the USA and sold as 'Lake Mat-Pro™'. Another type of mat is also available which is sold as a Muck-Mat ™. This is similar to a lake mat but is reinforced with an underlying geogrid and design to prevent lake users from sinking into lake silt. This may provide a more robust solution if there is expected to be a lot of user traffic at access and egress points.

It is recommended that the mats could be installed in front of the launching area and triathlon exit point. The mats can be periodically removed to dislodge any settled sediment on top of them.

5.3.4 Lake Dye Application

Lake dyes have been developed to absorb the red-yellow wavelengths plants use for photosynthesis and successfully inhibit plant and filamentous algae growth. The dyes are not so successful in controlling phytoplankton (algae) which tend to accumulate at the lake surface. Previously these dyes have only been available in blue or black but a relatively new dye product 'Lake Shadow™' has been developed for Grade 1 list waterbodies which combines the blue dye with red and yellow pigment so the dye is effectively nearly colourless. However, this 'colourless' dye requires an increased application rate to achieve the same effect as the blue dye in terms of plant control. These dyes provide a relatively low cost and effective approach for inhibiting plant and filamentous algae growth within waterbodies.

The dye is applied in the spring and periodic top-ups are required through the year to maintain the dye intensity. Based on the estimated lake volume of approximately 420 million litres, 15 x 5 kg bottles of blue type dye would be required for an initial dose combined with12 x 5kg bottle for a monthly top up to maintain dye intensity through the year. The total annual cost for applications on the Main Lake of 27 x 5kg bottles of liquid dye concentrate would be in the region of £3375 (ex VAT) without labour costs for application.

The main issue with dye application is preventing its entry into controlled watercourses as it can be classed as a pollutant. The Environment Agency have already raised concerns about use of lake dye on the Main Lake due to it being a groundwater fed waterbody and the proximity to the Great Stour including periodic flood inundation. It would be appear from previous studies that the lake is relatively hydraulically isolated from the river due to difference in water level. Therefore, the concerns from the Environment Agency would centre on dye entering the watercourse from the lake outflow (which is reported to rarely operate) or during flooding events (when the dye would be significantly diluted). Further discussions should be held with the Environment Agency on seeking consent for use of lake dye.

5.3.5 Aquatic Plant Introductions

Further introductions of aquatic plants may be made into the lake to assist in managing the issues associated with excessive growth of Canadian Pondweed. The purposes of these introductions are:

- To direct nutrients into other aquatic plant growth beyond Canadian Pondweed, phytoplankton and filamentous algae;
- To establish lily beds to provide shading to reduce algae and submerged plant growth;
- To enhance the visual appearance of the lake and diversity of marginal vegetation; and
- To further stabilise the banks to reduce erosion.

It is recommended that both lilies and emergent marginal plants are introduced as these should be unaffected by any lake dye applications, if its use is permitted. The introduced plants should be native species and ideally sourced locally and may be planted into areas of suitable water depths directly into the lake bed substrate

Emergent marginal plants can be used to further extend the marginal vegetation fringing around the lake and also enhance species diversity. Species that may be considered for introduction include:

Water Mint - *Mentha aquatica*

Marsh Marigold – *Caltha pulstris*

Sedges -*Carex rostrata, C. riparia, C. acutiformis*

Water Plantain – *Alisma plantago*

Arrowhead - *Sagittaria latifolia*

Lesser Reedmace - *Typha angustifolia*

Yellow Flag - *Iris pseudacorus*

Sweet Flag- *Acorus calamus*

Reedmace – *Typha latifolia*

Common Reed – *Phragmites australis*

For marginal plant species, it is also important that there is sufficient light falling on the lake margins and some thinning of bankside trees may be required to ensure suitable planting conditions are developed. Aquatic plant introductions should be made in April such that the plants have a full growth season to establish before seasonal die-back. Introduced plants, once established, should be subject to the recommended seasonal harvesting as described in section 5.1.2. If large numbers of waterfowl, particularly geese, take up residence on the lake after plant introductions then there may be a requirement to provide the plants with temporary protection until establishment to prevent loses to grazing.

There are only two common native lily species in the UK. These are the White Lily (*Nymphaea alba)* and the Yellow Lily (*Nuphar lutea*). The yellow species can demonstrate vigorous excessive growth which can have maintenance implications. Therefore, consideration should be made to the use of white lily only. Given the shallower water depths the southern end of the lake is likely to provide more suitable planting depths for lily introductions.

5.4 Algae Bloom Control

The development of phytoplankton (algae) blooms is a common feature of nutrient enriched lakes particularly where there is an absence or low abundance of aquatic plants. Algae blooms can have a direct impact on water quality through changes in pH and dissolved oxygen concentrations associated with day-time photosynthesis and night-time respiration.

In terms of amenity lakes there are two algae types that cause significant issues which are:

- Filamentous algae- unsightly mats of algae that develop across the bed and often rise to the surface which can interfere with boating and angling; and
- Blue-green algae (cyanobacteria) – these algae can form potentially toxic scums which present health risks and can cause closure of a lake.

Minimising nutrient availability and establishing and maintaining beds of submerged aquatic plants will both contribute to reducing the potential for algae bloom development. On many nutrient enriched waterbodies, supplementary measures are often implemented to assist in algal bloom control.

5.4.1 Barley straw

Decomposing barley straw has well documented algicidal properties. However, its deployment on lakes tends to show variable success that often results from incorrect application. For barley straw to be successful it needs to be introduced into the lake at the correct time, requires a top application during the summer and needs to be widely distributed around the lake. Most failures of barley straw applications result from the need to adequately distribute the straw around the lake. The chemicals released by the straw as it decomposes includes high reactive hydrogen peroxides that only have a short effective distance from the straw. Therefore, if straw is just placed in one corner of the lake any algicidal effect will be very localised. The needs for the extensive distribution of straw, which is introduced as floating loosely packed netting booms, is usually not compatible with lakes that are used for recreational activities. The costs for deployment and maintenance of sufficient straw across the lake to provide a positive outcome in terms of algae control is also likely to be prohibitive.

Given the above constraints imposed by use of barley straw its deployment is not recommended on the Main Lake.

Extract of barley straw is commercially available as an alternative to deployment of barley straw however, the effectiveness of this type of product in controlling algal blooms on large waterbodies has yet to be adequately demonstrated.

5.4.2 Ultrasonic Devices

Ultrasonic devices have been developed to control algae. However, there is little scientific evidence of the effectiveness of these devices on reducing algae density, especially on larger bodies of water. The devices are reported to work by causing disruption of gas vacuoles which provide the algae with buoyancy, causing them to sink to the bed and die. However, it is unlikely on larger lakes that the devices can generate sufficient energy to cause gas vacuole collapse over any distance and any localised algae mortality is overcome by the rapid reproduction rates. Given the unproven performance of these devices on large waterbodies, their deployment into the Main Lake is not recommended.

5.4.3 Water Mixing

Water mixing, through use of propeller mixers or aeration diffusers driven by compressed air, has been proven as a technique for ameliorating the development of blue-green algae blooms. Most of the scientific studies on this technique for control of blue-green algae have focused on deep water supply reservoirs where depths are greater than 10m where successful result have been achieved. However, there is an increasing body of anecdotal and monitoring evidence suggesting that positive benefits in blue-green algae control can be achieved in shallower lakes if a relatively vigorous mixing regime is pursued. This is a technique that is now called Vigorous Eplimnetic Mixing (VEM)in the USA. The mixing of a lake does not necessarily prevent blue-green algae blooms from developing, however it tends to shift the blue-green algae community towards non-scumming species such as Planktothrix (formerly *Oscillatoria*) that present a lower risk to site users than scum forming species such as *Anabaena* and *Microcystis*. Mixing of a lake tends to impact on blue-green algae bloom development in three key ways:

- Increasing dissolved oxygen concentrations in the lower water column helping with reducing internal nutrient loadings;
- Mixes the algae down to depth on deeper lakes where they become light limited. A similar effect may be achieved on a shallower lake through combining mixing with the use of lake dye.
- A vigorous mixing regime disrupts the development of a bloom which seem to favour still water conditions.

There are further benefits to be gained from lake mixing that include oxidation of organic material leading to consolidation of sediments, increase habitat availability by raising dissolved oxygen concentrations in areas of the lake bed where there are depressed oxygen levels, reducing the concentration of bathing water bacteria by increasing exposure to UV radiation, preventing odour and ice formation.

On amenity lakes, the approach for mixing is to usually use an array of fine bubble diffusers across the lake bed which are supplied with compressed air through self-sinking airlines from a bankside compressor station. Therefore, all the equipment on this type of system sits on the lake bed and prevents no interference to either boating or angling activities. The systems are robust with a low maintenance requirement but do have an operational cost in terms of electricity supply and on-going periodic maintenance. The use of propeller mixers are generally avoided on activity lakes due to the potential health and safety risks. Diffuser based systems operate by creating columns of air rising from the diffusers to the lake surface which act as air lifts drawing poor quality water from the bed and exposing it to the atmosphere where it is oxygenated. Circulations cells develop around each diffuser which is known as primary mixing sphere and is a function of water depth. The primary mixing cell is a radial distance of 5 to 7 times the water so deeper waterbodies require less diffusers to mix the waterbody. Secondary circulation currents develop between the primary mixing areas such that the entire water is mixed.

The appearance of an operating diffuser is shown in the following photograph.

To create a vigorously mixed regime to assist in the amelioration of blue-green algae blooms, it important that there are sufficient numbers of diffusers deployed at the correct spacing within a lake. This usually is achieved by ensuring the primary mixing spheres from each diffuser are close or overlapping.

An example of a diffuser based mixing approach that could be adopted is shown in Figure 6 for the northern part of the Main Lake. No layout has been shown on the southern lake area due to uncertainties over the water depth profile. The system shown is based on mixing the central amenity area of the lake in water depths below the 3m contour. The coloured circles represent the primary sphere of mixing influence from each diffuser. It should be noted that the system layout is based on the ISS-Flowthrough aeration system design which is different to traditional diffuser based aeration systems which require an individual airline to each diffuser.

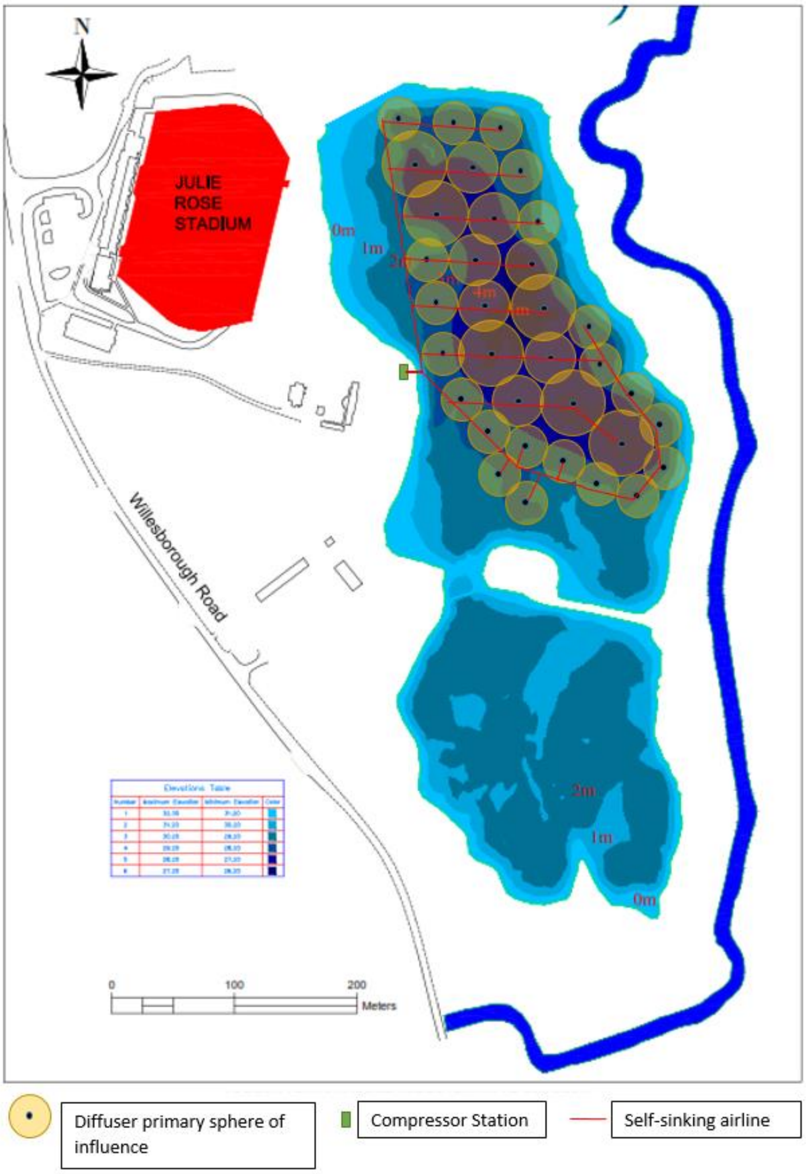


Figure 6: Example Diffuser and Airline Layout (based figure supplied by Ashford Borough Council)

The costs for installation of the example system shown in Figure 5 would is likely to be in the region of XXXXXXXXXXXX. The system would need to be operated on a 24 / 7 basis between April and the end of September and for 30 minutes each day between October and March. The example system would have a power requirement of around 7KW and so an approximate annual running cost of around £3500. Electrical costs for operating such a system could be offset by installing solar panels on the roof of the proposed Watersports Hub. It should be noted that lake mixing systems cannot be powered directly to generate sufficient reliable power to create the vigorously mixed regime necessary to assist in ameliorating blue-green algae blooms.

6 MONTIORING PROGRAMME

In addition to the management recommendations set out in section 5, it is recommended that an routine water quality monitoring programme is developed on the lake to monitor its performance and also provide relevant information to inform and assess risk to site users. Two key areas of water quality should be monitored which are microbiological water quality in accordance with the sampling protocols set out in the 2006/7/EC Bathing Water Directive and Blue-green algae monitoring.

In adopting a sampling regime care needs to be taken during both the sample collection to ensure that results are representative of likely user exposure. As such, composite samples collected from a number of fixed monitoring points across the lake area should ideally be sampled to provide adequate coverage of the lake. Care should be taken in both sample handing, storage and ensuring delivery to the testing laboratory is achieved within the window of sample viability. During sampling the sampler should also complete a standard sampling observation sheet to record conditions on the lake at the time of sampling i.e presence of waterfowl, visible pollution, algae blooms, foam or scum formation etc.

Interpretation of data also needs to be undertaken carefully as many of the standards are based not thresholds against which percentile values from a series of samples are compared. The development of a detailed monitoring protocol is outside the scope of this report and therefore the information below is provided as outline guidance.

6.1 Microbiological Monitoring

Microbiological monitoring should be undertaken in accordance with the sampling regime set out in the EC Bathing Water Directive 2006/7/EC. This requires a series samples to be taken on a minimum of monthly basis through the bathing period (suggest April – September). Samples should be analysed for *E.coli* and intestinal *enterococcus* only. The laboratory should be requested to undertake actual counts with dilutions where high concentrations are present rather than providing results as greater than values to aid with interpretation. Percentile values should be calculated to compare with the Directive standards.

Additional sampling may be required following a flood event into the lake to determine bathing water indicator bacteria concentrations as there may be potential for inflow of contaminated water, for example from storm overflows into the river.

Care needs to be adopted in the interpretation on intestinal *enterococcus* results. Elevated results may be the result of a large presence of waterfowl on a lake at the time of sampling, although these bacteria present a very low risk to human health. It is now possible for laboratories to undertake speciation of the intestinal *enterococcus* to determine if the source is avian, bovine, human etc at a low additional cost. This information provides an extra layer of useful information when interpreting monitoring results.

6.2 Blue-green Algae Monitoring

Blue-green algae monitoring should also be routinely undertaken on the lake between April or September or outside of this period if there are visible signs of suspected blue-green algae being present. A water sample should also be collected alongside the algae samples for testing for chlorophyll a.

For sampling of blue-green algae, the sample should be representative of likely user exposure. If a small patch of scum has accumulated in a corner of the lake, collecting a sample of this scum will provide the worst-case scenario but would not be representative. Prior to sampling it is often useful for the sampler to walk around the lake to make field notes on the distribution of algae at the time of sampling.

In terms of analysis of the analysis samples, they should be analysed for species composition and estimates of total cell density and density by species. For the blue-green species estimates of mean colony or filament size should also be recorded and ideally concentration recorded as number of filaments or colonies. This will then allow the data to be compared to the concentration of colonial and filamentous species that are equivalent to the lower WHO warning threshold of 20000 cells / ml.

7 SUMMARY RECOMMENDATIONS

A summary of recommendations is provided below:

1) **Reduce external nutrient loading.**
    - Measures include:
    - Examining current and future surface drainage inputs into the lake and minimising the nutrient loading;
    - Restricting livestock access to the lake and providing dedicated drink facility;
    - Discouraging feeding of waterfowl through signage;
    - Collection of leaf litter were practically possible and disposal remotely from the lake; and
    - Restrictions on the use of bait if increased numbers of anglers use the lake in the future.

2) **Reduce internal nutrient loading**
    - No 'Phoslock' treatment of lake to be undertaken;
    - Seasonal harvesting of submerged and emergent aquatic plants and disposal remotely from the lake;
    - Installation of a diffuser based aeration system; and
    - Management of fish stock at a low density with an emphasis on a specimen carp fishery.

3) **Sediment Conditioning and Consolidation**
    - Two applications of finely powered chalk to aid with settlement of silt 'floc' cloud and enhance breakdown or organic material (particularly when combined with aeration).

4) **Aquatic Plant Management**
    - Routine cutting of plants to maintain a 30% cover by area around marginal areas;
    - Harrowing of lake bed in central areas of lake;
    - Use of lake mats to prevent plant growth at access and egress points to the lake;
    - Use of lake dye to inhibit plant and filamentous algae growth (subject to EA consent); and
    - Introduction of additional marginal emergent aquatic plants and lilies.

5) **Algal Bloom Control**
    - No use of barley straw or extract due to interference with activities, costs and inconsistency in effectiveness;
    - No use of ultrasonic equipment due to unproven performance on large lakes;
    - Application of vigorous mixing regime using a diffuser based aeration system;

6) **Monitoring**
    - Establish routine monitoring programme for microbiology water quality and blue-green algae testing.

Following issue of the draft report (version 1.1), a series of questions were provided by Ashford Council. These questions and response to them are provided in Appendix D.

8 PROGRAMME OF WORKS

A proposed sequence of rehabilitation / maintenance works is presented in Table 9. This sequence assumes that works would start immediately and would be undertaken as a 2-year programme. The speed of implementation will be dependent on resource availability. The works detailed in 2018 may be considered, apart from the fish introductions, as the basis of long-term routine maintenance works.

Table 9: Sequencing and timing of Rehabilitation and Maintenance Works

	2016			2017												2018											
WORKS	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Aquatic plant harvesting	■											■												■			
Submerged plant harrowing						■			■									■			■						
Submerged plant cutting*								■	■	■										■	■	■					
Powdered chalk application**						■						■															
Lake dye initial dose***						■												■									
Lake dye maintenance dosing***							■	■	■	■	■	■	■						■	■	■	■	■	■	■		
Aquatic plant introductions (Phase 1) - Lilies							■																				
Aquatic plant introductions (Phase 2) - Marginal Plants																			■								
Aeration system installation							■																				
Aeration system full time operation							■	■	■	■	■	■							■	■	■	■	■	■			
Aeration system annual maintenance																		■									
Stock fencing of margins					■																						
Creation of livestock drinking facility					■																						
Fish stock management****																	■	■									
Routine microbiology WQ monitoring							■	■	■	■	■	■							■	■	■	■	■	■			
Routine blue-green algae monitoring							■	■	■	■	■	■							■	■	■	■	■	■			

*As required. **Further applications can be made as required in future years.

*** Subject to approval from statutory regulators. **** One off introduction of specimen carp. Maximum number to be introduced 70 fish.

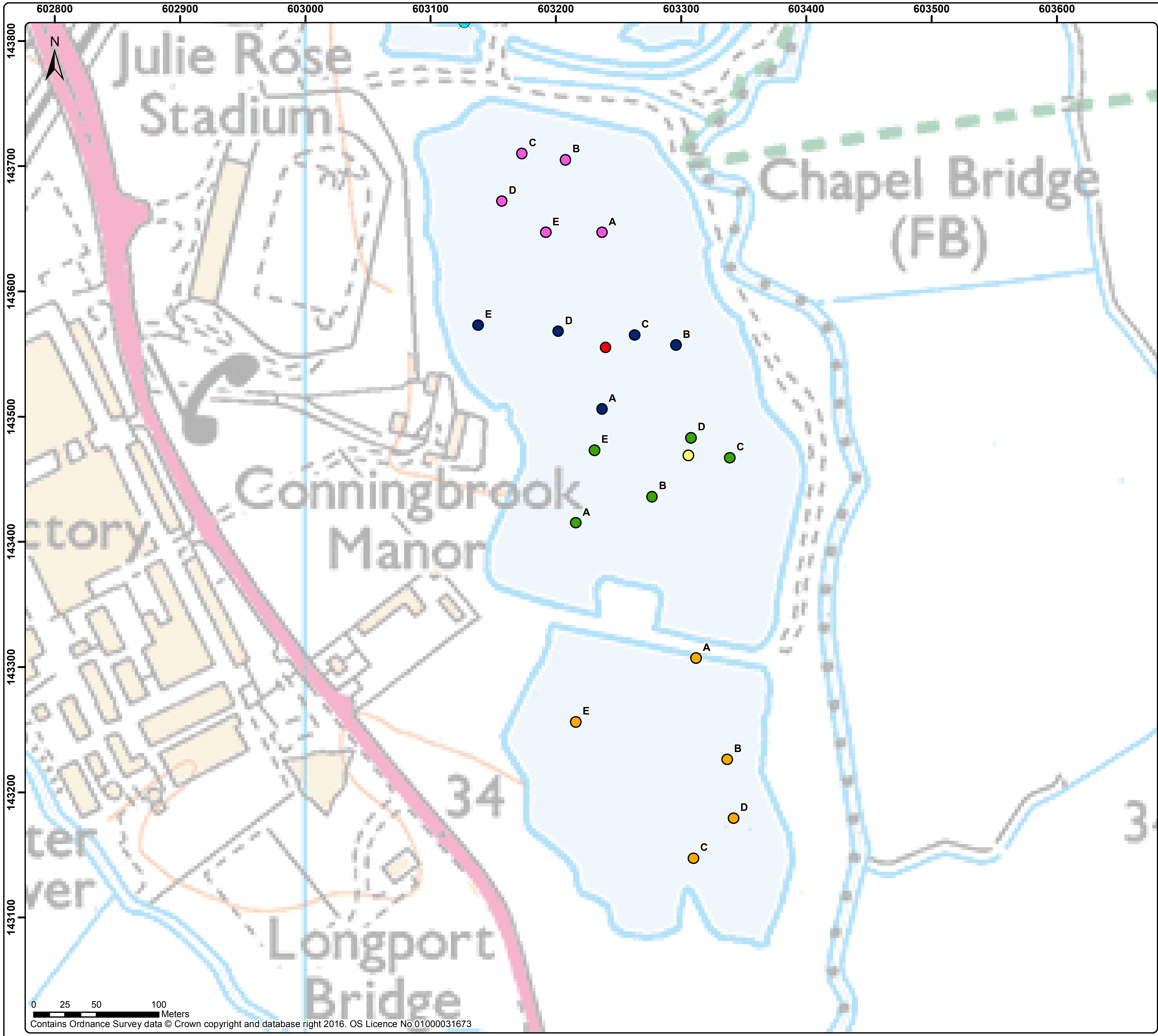
9 BUDGET COSTINGS

The costings for rehabilitation and management of the Main Lake are presented in Table 10. These costings should only be viewed as indicative. If a particular option is pursued, then it is recommended that full detailed costing should be prepared.

Table 10: Indicative Costing for Management Actions

Work Element		Cost Estimate
Aquatic plant harvesting	Removal and disposal of aquatic plants.	£8,000 per annum
Submerged plant harrowing	Harrowing of central activity areas of the lake	£4,000 per annum
Submerged plant cutting	Annual plant cut (mid-summer)	£6,000 per annum
Powdered chalk application	Supply and application of chalk	£8200 for supply of chalk £6000 for application
Lake dye application	Supply and application of Lake Dye (Blue type)	£4000 supply of dye per annum £1500 application of dye per annum
Aquatic plant introductions (Phase 1) - Lilies	Supply and introduction of aquatic plants	£10,000
Aquatic plant introductions (Phase 2) - Marginal Plants	Supply and introduction of aquatic plants	£10,000
Aeration system installation	Planted directly into overburden	xxxxxxxxxxxxxx for supply and installation (subject to detailed quote from supplier
Aeration system full time operation	Electrical costs	£3500 per annum
Aeration system annual maintenance	Maintenance of compressors and annual cleaning of diffusers	£1500 per annum
Stock fencing of margins	Stock fencing of area of lake margin to create buffer zone and prevent livestock access to lake. Require agreement with KWT.	£15,000 (depends on area to be fenced.
Creation of livestock drinking facility	Creation of shallow channel or pond	£5000
Fish stock management	Introduction of additional specimen carp to support recreational fishery	To be arranged by Mid-Kent Fisheries.
Routine microbiology WQ monitoring	6 months of monitoring (assumed to be undertaken by local authority personnel).	£1000
Routine blue-green algae monitoring	6 months of monitoring (assumed to be undertaken by local authority personnel).	£1000

Figures



Key

Water Quality and Phytoplankton Sampling Locations

Sample Code

- WS1
- WS2
- WS3
- WS4
- WS5
- WS6

LAGUNA SCIENCE

Project:
Conningbrook Lake

Title: **Figure 1: Water Quality and Phytoplankton Sampling Locations**

Status:	Revision:	Page Size:
Draft	0	A3
Drawn by:	Reviewed by:	Date:
AS	RS	10.10.2016

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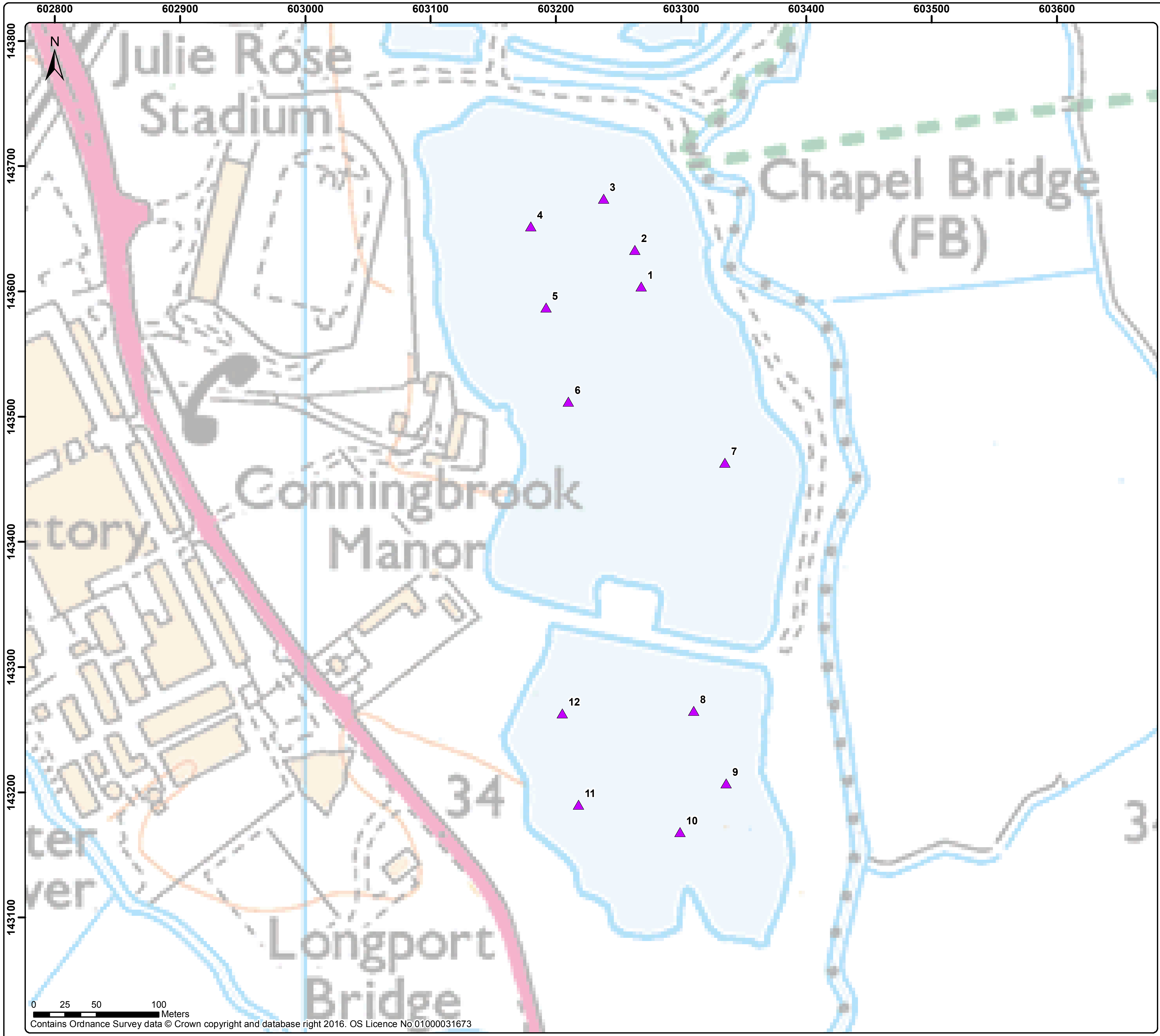

Key

▲ Secchi Disc Measurement Locations

LAGUNA SCIENCE

Project:
Conningbrook Lake

Title:
Figure 2:
Secchi Disc Measurement Locations

Status:	Revision:	Page Size:
Draft	0	A3
Drawn by:	Reviewed by:	Date:
AS	RS	11.10.2016

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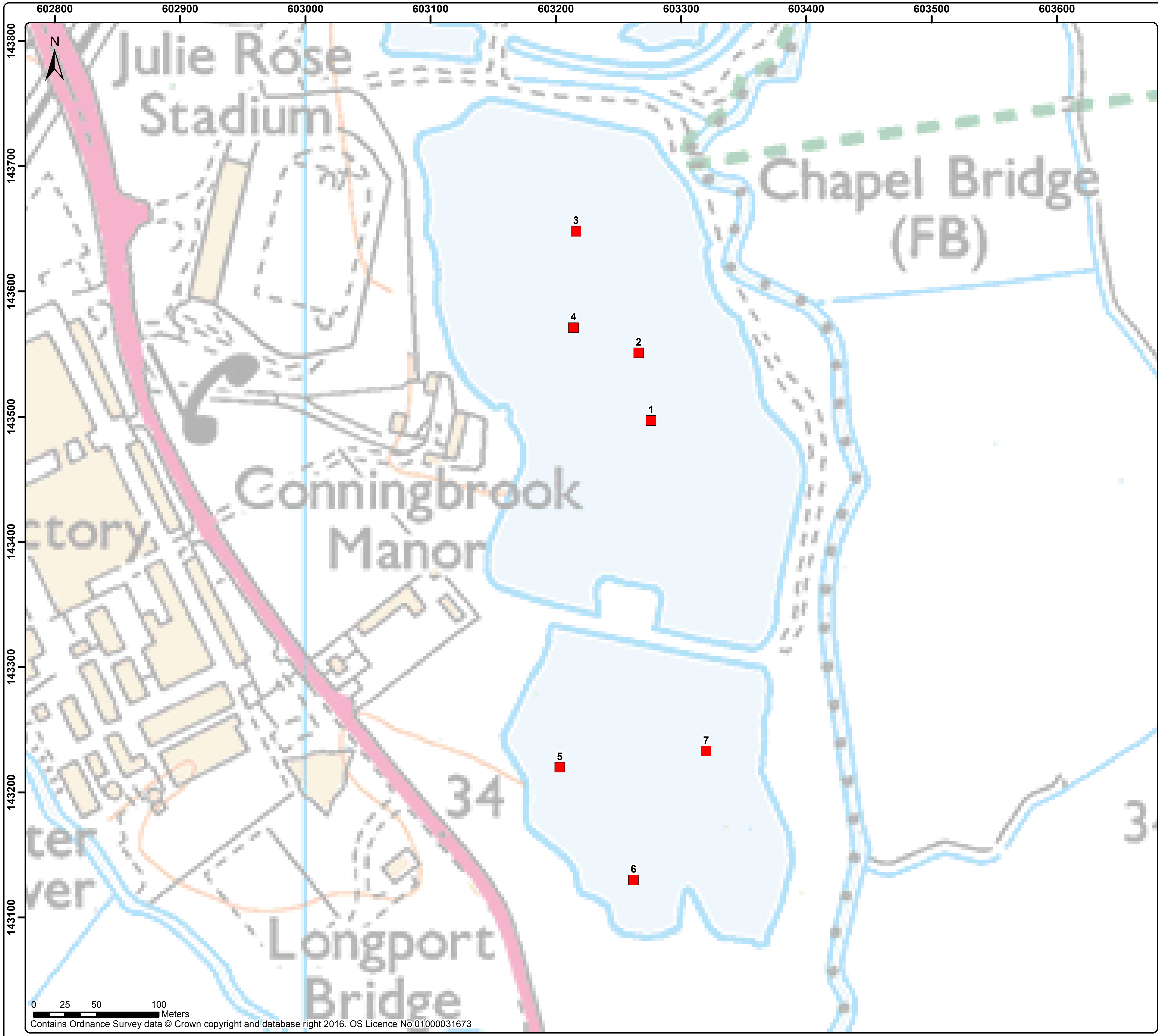

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Key

■ Dissolved Oxygen and Temperature Profiles

LAGUNA SCIENCE

Project: **Conningbrook Lake**

Title: **Figure 3: Dissolved Oxygen and Temperature Profiling Locations**

Status:	Revision:	Page Size:
Draft	0	A3
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AS	RS	11.10.2016

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Appendix A. Site Photographs

Photograph 1: Pontoon access point to the lake.

Photograph 2: Car park with leisure area.

Photograph 3: Mown informal access footpath in south-west corner of the main lake.

Photograph 4: Angling peg showing decomposing cut aquatic plant deposits.

Photograph 5: Angling peg showing bankside trees requiring some pruning.

Photograph 6: Gravel ‘beach’ used as an exit point for triathlon swimming events.

Photograph 7: Eroded area on the southern bank due to livestock.

Photograph 8: Vegetated ditch drainage channel in the north-west corner of the main lake.

Photograph 9: Great Stour along the eastern bank of the Main Lake.

Photograph 10: View to northern end of the Main Lake showing established bankside trees.

Photograph 11: Blue-green algae and associated scum formation with filamentous algae.

Photograph 12: Surface growth of Elodea and filamentous algae in the north-west corner of the lake.

Photograph 13: Established bed of marginal Reedmace (*Typha maxima*)

Photograph 14: Hard Rush, Water Mint and Water Plantain on the western bank.

Photograph 15: Flock of Herring Gull on the Main Lake.

Appendix B. Analysis Certificates

Certificate of Analysis

ANALYSED BY

UKAS TESTING
1314
0897
4409

ALS

Report Number:	**COV/1320983/2016**	Issue	**1**
Laboratory Number:	**15577378**	Sample	**1** of **10**

Sample Source: **Laguna Science**
Sample Point Description:
Sample Description: **WS 1 0m**
Sample Matrix: **Surface Water**
Sample Date/Time: **23 September 2016** **09:00**
Sample Received: **23 September 2016**
Analysis Complete: **07 October 2016**

Test Description	Result	Units	Analysis Date	Accreditation		Method
Phosphate, Ortho as P LL	<0.02	mg/l	29/09/2016	N	Cov	WAS067
Phosphorus UL Total as P	46	ug/l	06/10/2016	N	Cov	WAS060
pH	8.1	pH units	27/09/2016	N	Cov	WAS039
Alkalinity as CaCO3	61.6	mg/l	06/10/2016	N	Cov	WAS025
Total Hardness as CaCO3	83.1	mg/l	28/09/2016	N	Cov	WAS049
Ammoniacal Nitrogen as N (LL)	0.20	mg/l	29/09/2016	N	Cov	WAS067
Chloride as Cl	36.5	mg/l	26/09/2016	Y	Cov	WAS036
Nitrite as N	<0.08	mg/l	26/09/2016	Y	Cov	WAS036
Nitrate as N	<0.7	mg/l	26/09/2016	Y	Cov	WAS036
Nitrogen, Total Oxidised as N	<0.7	mg/l	26/09/2016	Y	Cov	WAS036
Total Suspended Solids	4.00	mg/l	30/09/2016	N	Cov	WAS006
BOD + ATU (5 day)	1	mg/l	05/10/2016	Y	Cov	WAS001

Analyst Comments for 15577378: No Analyst Comment

Accreditation Codes: Y = UKAS / ISO17025 Accredited, N = Not UKAS / ISO17025 Accredited, M = MCERTS.
Analysed at: Cov = Coventry(CV4 9GU), Che = Chester(CH4 9EP), Ott = Otterbourne(SO21 2SW), S = Subcontracted, Trb = Subcontracted to Trowbridge(BA14 0XD), Wak = Wakefield(WF5 9TG).
For Microbiological determinands 0 or ND=Not Detected, For Legionella ND=Not Detected in volume of sample filtered. The LOD for the Legionella analysis will increase where the volume analysed is <1000g (1g is approximately equivalent to 1ml for sample volume analysed).
I/S=Insufficient sample For soil/sludge samples: AR=As received, DW=Dry weight.

Signed:

Name: **R. Stocks** Date: **07 October 2016**
Title: **Inorganic Team Leader**

Certificate of Analysis

ANALYSED BY

UKAS TESTING
1314
0897
4409

Report Number:	**COV/1320983/2016**	Issue	**1**
Laboratory Number:	**15577379**	Sample	**2** of **10**

Sample Source: **Laguna Science**
Sample Point Description:
Sample Description: **WS 2 0m**
Sample Matrix: **Surface Water**
Sample Date/Time: **23 September 2016** **09:15**
Sample Received: **23 September 2016**
Analysis Complete: **07 October 2016**

Test Description	Result	Units	Analysis Date	Accreditation		Method
Phosphate, Ortho as P LL	<0.02	mg/l	29/09/2016	N	Cov	WAS067
Phosphorus UL Total as P	43	ug/l	06/10/2016	N	Cov	WAS060
pH	8.1	pH units	27/09/2016	N	Cov	WAS039
Alkalinity as CaCO3	59.1	mg/l	06/10/2016	N	Cov	WAS025
Total Hardness as CaCO3	80.9	mg/l	28/09/2016	N	Cov	WAS049
Ammoniacal Nitrogen as N (LL)	0.09	mg/l	29/09/2016	N	Cov	WAS067
Chloride as Cl	35.8	mg/l	26/09/2016	Y	Cov	WAS036
Nitrite as N	<0.08	mg/l	26/09/2016	Y	Cov	WAS036
Nitrate as N	<0.7	mg/l	26/09/2016	Y	Cov	WAS036
Nitrogen, Total Oxidised as N	<0.7	mg/l	26/09/2016	Y	Cov	WAS036
Total Suspended Solids	8.00	mg/l	04/10/2016	N	Cov	WAS006
BOD + ATU (5 day)	1	mg/l	05/10/2016	Y	Cov	WAS001

Analyst Comments for 15577379: No Analyst Comment

Accreditation Codes: Y = UKAS / ISO17025 Accredited, N = Not UKAS / ISO17025 Accredited, M = MCERTS.
Analysed at: Cov = Coventry(CV4 9GU), Che = Chester(CH4 9EP), Ott = Otterbourne(SO21 2SW), S = Subcontracted, Trb = Subcontracted to Trowbridge(BA14 0XD), Wak = Wakefield(WF5 9TG).
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I/S=Insufficient sample For soil/sludge samples: AR=As received, DW=Dry weight.

Signed:	Name: **R. Stocks**	Date: **07 October 2016**
	Title: **Inorganic Team Leader**	

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Report Number:	**COV/1320983/2016**	Issue	**1**
Laboratory Number:	**15577380**	Sample	**3** of **10**

Sample Source: **Laguna Science**
Sample Point Description:
Sample Description: **WS 3 0m**
Sample Matrix: **Surface Water**
Sample Date/Time: **23 September 2016** **09:30**
Sample Received: **23 September 2016**
Analysis Complete: **07 October 2016**

Test Description	Result	Units	Analysis Date	Accreditation		Method
Phosphate, Ortho as P LL	0.06	mg/l	29/09/2016	N	Cov	WAS067
Phosphorus UL Total as P	47	ug/l	06/10/2016	N	Cov	WAS060
pH	8.1	pH units	27/09/2016	N	Cov	WAS039
Alkalinity as CaCO3	59.8	mg/l	06/10/2016	N	Cov	WAS025
Total Hardness as CaCO3	82.9	mg/l	28/09/2016	N	Cov	WAS049
Ammoniacal Nitrogen as N (LL)	0.07	mg/l	29/09/2016	N	Cov	WAS067
Chloride as Cl	35.5	mg/l	26/09/2016	Y	Cov	WAS036
Nitrite as N	<0.08	mg/l	26/09/2016	Y	Cov	WAS036
Nitrate as N	<0.7	mg/l	26/09/2016	Y	Cov	WAS036
Nitrogen, Total Oxidised as N	<0.7	mg/l	26/09/2016	Y	Cov	WAS036
Total Suspended Solids	2.00	mg/l	30/09/2016	N	Cov	WAS006
BOD + ATU (5 day)	2	mg/l	05/10/2016	Y	Cov	WAS001

Analyst Comments for 15577380: No Analyst Comment

Accreditation Codes: Y = UKAS / ISO17025 Accredited, N = Not UKAS / ISO17025 Accredited, M = MCERTS.
Analysed at: Cov = Coventry(CV4 9GU), Che = Chester(CH4 9EP), Ott = Otterbourne(SO21 2SW), S = Subcontracted, Trb = Subcontracted to Trowbridge(BA14 0XD), Wak = Wakefield(WF5 9TG).
For Microbiological determinands 0 or ND=Not Detected, For Legionella ND=Not Detected in volume of sample filtered. The LOD for the Legionella analysis will increase where the volume analysed is <1000g (1g is approximately equivalent to 1ml for sample volume analysed).
I/S=Insufficient sample For soil/sludge samples: AR=As received, DW=Dry weight.

Signed:	Name:	**R. Stocks**	Date:	**07 October 2016**
	Title:	**Inorganic Team Leader**		

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Report Number: **COV/1320983/2016** | Issue **1**
Laboratory Number: **15577381** | Sample **4** of **10**

Sample Source: **Laguna Science**
Sample Point Description:
Sample Description: **WS 4 0m**
Sample Matrix: **Surface Water**
Sample Date/Time: **23 September 2016** **09:45**
Sample Received: **23 September 2016**
Analysis Complete: **07 October 2016**

Test Description	Result	Units	Analysis Date	Accreditation		Method
Phosphate, Ortho as P LL	<0.02	mg/l	29/09/2016	N	Cov	WAS067
Phosphorus UL Total as P	43	ug/l	06/10/2016	N	Cov	WAS060
pH	8.0	pH units	27/09/2016	N	Cov	WAS039
Alkalinity as CaCO3	59.6	mg/l	06/10/2016	N	Cov	WAS025
Total Hardness as CaCO3	81.8	mg/l	28/09/2016	N	Cov	WAS049
Ammoniacal Nitrogen as N (LL)	0.11	mg/l	29/09/2016	N	Cov	WAS067
Chloride as Cl	35.2	mg/l	26/09/2016	Y	Cov	WAS036
Nitrite as N	<0.08	mg/l	26/09/2016	Y	Cov	WAS036
Nitrate as N	<0.7	mg/l	26/09/2016	Y	Cov	WAS036
Nitrogen, Total Oxidised as N	<0.7	mg/l	26/09/2016	Y	Cov	WAS036
Total Suspended Solids	1.00	mg/l	30/09/2016	N	Cov	WAS006
BOD + ATU (5 day)	<1	mg/l	05/10/2016	Y	Cov	WAS001

Analyst Comments for 15577381: No Analyst Comment

Accreditation Codes: Y = UKAS / ISO17025 Accredited, N = Not UKAS / ISO17025 Accredited, M = MCERTS.
Analysed at: Cov = Coventry(CV4 9GU), Che = Chester(CH4 9EP), Ott = Otterbourne(SO21 2SW), S = Subcontracted, Trb = Subcontracted to Trowbridge(BA14 0XD), Wak = Wakefield(WF5 9TG).
For Microbiological determinands 0 or ND=Not Detected, For Legionella ND=Not Detected in volume of sample filtered. The LOD for the Legionella analysis will increase where the volume analysed is <1000g (1g is approximately equivalent to 1ml for sample volume analysed).
I/S=Insufficient sample For soil/sludge samples: AR=As received, DW=Dry weight.

Signed:	Name: **R. Stocks**	Date: **07 October 2016**
	Title: **Inorganic Team Leader**	

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Report Number:	**COV/1320983/2016**		Issue	**1**
Laboratory Number:	**15577382**		Sample	**5** of **10**

Sample Source: **Laguna Science**
Sample Point Description:
Sample Description: **WS 5 4.5m**
Sample Matrix: **Surface Water**
Sample Date/Time: **23 September 2016** **10:00**
Sample Received: **23 September 2016**
Analysis Complete: **07 October 2016**

Test Description	Result	Units	Analysis Date	Accreditation		Method
Phosphate, Ortho as P LL	0.04	mg/l	29/09/2016	N	Cov	WAS067
Phosphorus UL Total as P	168	ug/l	06/10/2016	N	Cov	WAS060
pH	7.8	pH units	27/09/2016	N	Cov	WAS039
Alkalinity as CaCO3	68.7	mg/l	06/10/2016	N	Cov	WAS025
Total Hardness as CaCO3	86.0	mg/l	28/09/2016	N	Cov	WAS049
Ammoniacal Nitrogen as N (LL)	0.57	mg/l	29/09/2016	N	Cov	WAS067
Chloride as Cl	35.4	mg/l	26/09/2016	Y	Cov	WAS036
Nitrite as N	<0.08	mg/l	26/09/2016	Y	Cov	WAS036
Nitrate as N	<0.7	mg/l	26/09/2016	Y	Cov	WAS036
Nitrogen, Total Oxidised as N	<0.7	mg/l	26/09/2016	Y	Cov	WAS036
Total Suspended Solids	21.0	mg/l	04/10/2016	N	Cov	WAS006
BOD + ATU (5 day)	4	mg/l	05/10/2016	Y	Cov	WAS001

Analyst Comments for 15577382: No Analyst Comment

Accreditation Codes: Y = UKAS / ISO17025 Accredited, N = Not UKAS / ISO17025 Accredited, M = MCERTS.
Analysed at: Cov = Coventry(CV4 9GU), Che = Chester(CH4 9EP), Ott = Otterbourne(SO21 2SW), S = Subcontracted, Trb = Subcontracted to Trowbridge(BA14 0XD), Wak = Wakefield(WF5 9TG).
For Microbiological determinands 0 or ND=Not Detected, For Legionella ND=Not Detected in volume of sample filtered. The LOD for the Legionella analysis will increase where the volume analysed is <1000g (1g is approximately equivalent to 1ml for sample volume analysed).
I/S=Insufficient sample For soil/sludge samples: AR=As received, DW=Dry weight.

Signed:	Name:	**R. Stocks**	Date:	**07 October 2016**
	Title:	**Inorganic Team Leader**		

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Report Number:	**COV/1320983/2016**		Issue	**1**
Laboratory Number:	**15577383**		Sample	**6** of **10**

Sample Source: **Laguna Science**
Sample Point Description:
Sample Description: **WS 6 4.5m**
Sample Matrix: **Surface Water**
Sample Date/Time: **23 September 2016** **10:15**
Sample Received: **23 September 2016**
Analysis Complete: **07 October 2016**

Test Description	Result	Units	Analysis Date	Accreditation		Method
Phosphate, Ortho as P LL	0.07	mg/l	29/09/2016	N	Cov	WAS067
Phosphorus UL Total as P	361	ug/l	06/10/2016	N	Cov	WAS060
pH	7.7	pH units	27/09/2016	N	Cov	WAS039
Alkalinity as CaCO3	85.3	mg/l	06/10/2016	N	Cov	WAS025
Total Hardness as CaCO3	96.1	mg/l	28/09/2016	N	Cov	WAS049
Ammoniacal Nitrogen as N (LL)	0.87	mg/l	29/09/2016	N	Cov	WAS067
Chloride as Cl	35.0	mg/l	26/09/2016	Y	Cov	WAS036
Nitrite as N	<0.08	mg/l	26/09/2016	Y	Cov	WAS036
Nitrate as N	<0.7	mg/l	26/09/2016	Y	Cov	WAS036
Nitrogen, Total Oxidised as N	<0.7	mg/l	26/09/2016	Y	Cov	WAS036
Total Suspended Solids	28.0	mg/l	04/10/2016	N	Cov	WAS006
BOD + ATU (5 day)	5	mg/l	05/10/2016	Y	Cov	WAS001

Analyst Comments for 15577383: No Analyst Comment

Accreditation Codes: Y = UKAS / ISO17025 Accredited, N = Not UKAS / ISO17025 Accredited, M = MCERTS.
Analysed at: Cov = Coventry(CV4 9GU), Che = Chester(CH4 9EP), Ott = Otterbourne(SO21 2SW), S = Subcontracted, Trb = Subcontracted to Trowbridge(BA14 0XD), Wak = Wakefield(WF5 9TG).
For Microbiological determinands 0 or ND=Not Detected, For Legionella ND=Not Detected in volume of sample filtered. The LOD for the Legionella analysis will increase where the volume analysed is <1000g (1g is approximately equivalent to 1ml for sample volume analysed).
I/S=Insufficient sample For soil/sludge samples: AR=As received, DW=Dry weight.

Signed:	Name:	**R. Stocks**	Date:	**07 October 2016**
	Title:	**Inorganic Team Leader**		

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Report Number:	**COV/1320983/2016**	Issue	**1**
Laboratory Number:	**15577384**	Sample	**7** of **10**

Sample Source: **Laguna Science**
Sample Point Description:
Sample Description: **Algae 1 0m**
Sample Matrix: **Surface Water**
Sample Date/Time: **23 September 2016** **10:30**
Sample Received: **23 September 2016**
Analysis Complete: **07 October 2016**

Test Description	Result	Units	Analysis Date	Accreditation		Method
Algae, Total	9038	cells/1ml	07/10/2016	Y	Cov	W44
Chlorophyll "a" COLD	11.56	ug/l	30/09/2016	Y	Cov	W45

Analyst Comments for 15577384: No Analyst Comment

Accreditation Codes: Y = UKAS / ISO17025 Accredited, N = Not UKAS / ISO17025 Accredited, M = MCERTS.
Analysed at: Cov = Coventry(CV4 9GU), Che = Chester(CH4 9EP), Ott = Otterbourne(SO21 2SW), S = Subcontracted, Trb = Subcontracted to Trowbridge(BA14 0XD), Wak = Wakefield(WF5 9TG).
For Microbiological determinands 0 or ND=Not Detected, For Legionella ND=Not Detected in volume of sample filtered. The LOD for the Legionella analysis will increase where the volume analysed is <1000g (1g is approximately equivalent to 1ml for sample volume analysed).
I/S=Insufficient sample For soil/sludge samples: AR=As received, DW=Dry weight.

Signed:	Name:	**R. Stocks**	Date:	**07 October 2016**
	Title:	**Inorganic Team Leader**		

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Report Number:	**COV/1320983/2016**	Issue	**1**
Laboratory Number:	**15577385**	Sample	**8** of **10**

Sample Source: **Laguna Science**
Sample Point Description:
Sample Description: **Algae 2 0m**
Sample Matrix: **Surface Water**
Sample Date/Time: **23 September 2016** **10:45**
Sample Received: **23 September 2016**
Analysis Complete: **07 October 2016**

Test Description	Result	Units	Analysis Date	Accreditation		Method
Algae, Total	7395	cells/1ml	07/10/2016	Y	Cov	W44
Chlorophyll "a" COLD	12.51	ug/l	30/09/2016	Y	Cov	W45

Analyst Comments for 15577385: No Analyst Comment

Accreditation Codes: Y = UKAS / ISO17025 Accredited, N = Not UKAS / ISO17025 Accredited, M = MCERTS.
Analysed at: Cov = Coventry(CV4 9GU), Che = Chester(CH4 9EP), Ott = Otterbourne(SO21 2SW), S = Subcontracted, Trb = Subcontracted to Trowbridge(BA14 0XD), Wak = Wakefield(WF5 9TG).
For Microbiological determinands 0 or ND=Not Detected, For Legionella ND=Not Detected in volume of sample filtered. The LOD for the Legionella analysis will increase where the volume analysed is <1000g (1g is approximately equivalent to 1ml for sample volume analysed).
I/S=Insufficient sample For soil/sludge samples: AR=As received, DW=Dry weight.

Signed:	Name:	**R. Stocks**	Date:	**07 October 2016**
	Title:	**Inorganic Team Leader**		

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Report Number:	**COV/1320983/2016**	Issue	**1**	
Laboratory Number:	**15577386**	Sample	**9**	of **10**

Sample Source: **Laguna Science**
Sample Point Description:
Sample Description: **Algae 3 0m**
Sample Matrix: **Surface Water**
Sample Date/Time: **23 September 2016** **11:00**
Sample Received: **23 September 2016**
Analysis Complete: **07 October 2016**

Test Description	Result	Units	Analysis Date	Accreditation		Method
Algae, Total	9253	cells/1ml	07/10/2016	Y	Cov	W44
Chlorophyll "a" COLD	27.68	ug/l	30/09/2016	Y	Cov	W45

Analyst Comments for 15577386: No Analyst Comment

Accreditation Codes: Y = UKAS / ISO17025 Accredited, N = Not UKAS / ISO17025 Accredited, M = MCERTS.
Analysed at: Cov = Coventry(CV4 9GU), Che = Chester(CH4 9EP), Ott = Otterbourne(SO21 2SW), S = Subcontracted, Trb = Subcontracted to Trowbridge(BA14 0XD), Wak = Wakefield(WF5 9TG).
For Microbiological determinands 0 or ND=Not Detected, For Legionella ND=Not Detected in volume of sample filtered. The LOD for the Legionella analysis will increase where the volume analysed is <1000g (1g is approximately equivalent to 1ml for sample volume analysed).
I/S=Insufficient sample For soil/sludge samples: AR=As received, DW=Dry weight.

Signed:	Name:	**R. Stocks**	Date:	**07 October 2016**
	Title:	**Inorganic Team Leader**		

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Report Number:	**COV/1320983/2016**	Issue	**1**
Laboratory Number:	**15577387**	Sample	**10** of **10**

Sample Source: **Laguna Science**
Sample Point Description:
Sample Description: **Algae 4 0m**
Sample Matrix: **Surface Water**
Sample Date/Time: **23 September 2016** **11:15**
Sample Received: **23 September 2016**
Analysis Complete: **07 October 2016**

Test Description	Result	Units	Analysis Date	Accreditation		Method
Algae, Total	6966	cells/1ml	07/10/2016	Y	Cov	W44
Chlorophyll "a" COLD	14.09	ug/l	30/09/2016	Y	Cov	W45

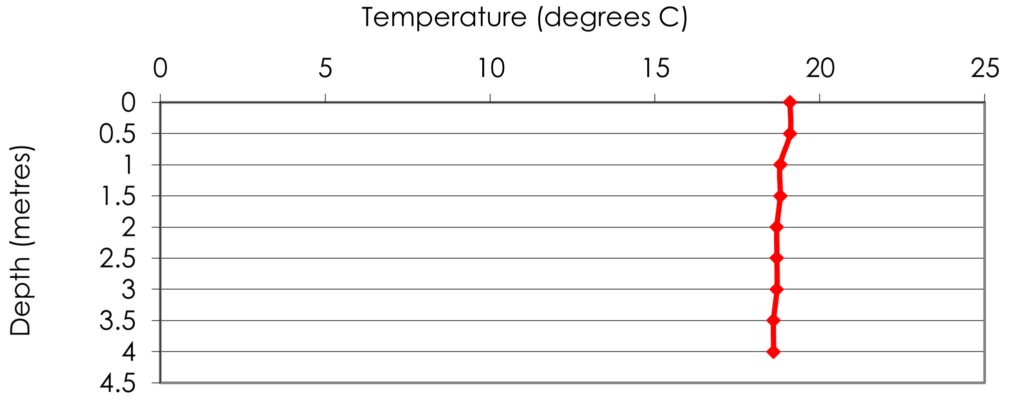
Analyst Comments for 15577387: No Analyst Comment

Accreditation Codes: Y = UKAS / ISO17025 Accredited, N = Not UKAS / ISO17025 Accredited, M = MCERTS.
Analysed at: Cov = Coventry(CV4 9GU), Che = Chester(CH4 9EP), Ott = Otterbourne(SO21 2SW), S = Subcontracted, Trb = Subcontracted to Trowbridge(BA14 0XD), Wak = Wakefield(WF5 9TG).
For Microbiological determinands 0 or ND=Not Detected, For Legionella ND=Not Detected in volume of sample filtered. The LOD for the Legionella analysis will increase where the volume analysed is <1000g (1g is approximately equivalent to 1ml for sample volume analysed).
I/S=Insufficient sample For soil/sludge samples: AR=As received, DW=Dry weight.

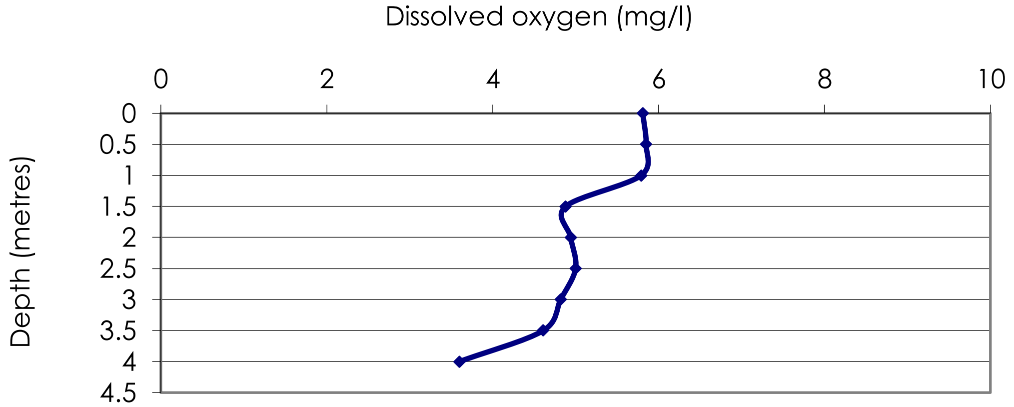
Signed:	Name: **R. Stocks**	Date: **07 October 2016**	
	Title: **Inorganic Team Leader**		

Appendix C. Oxygen and Temperature Profiles

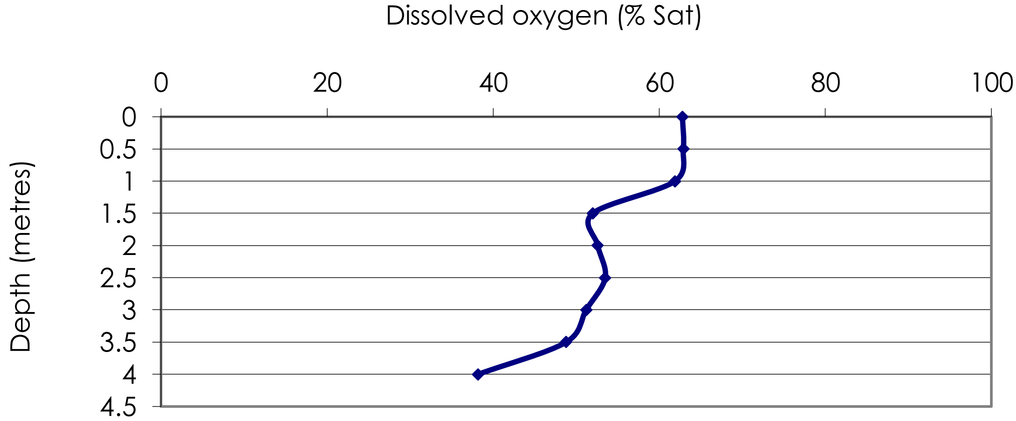
Graph 1a: Temperature profile for Monitoring Site 1



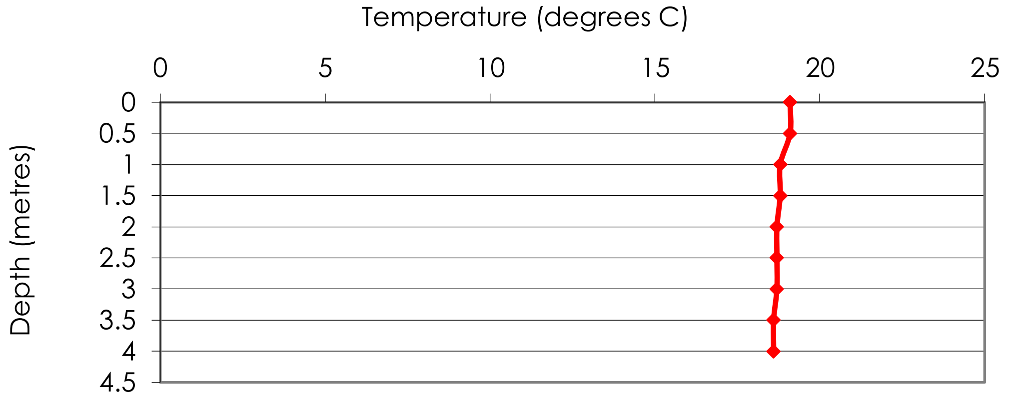
Graph 1b: Dissolved oxygen profile for Monitoring Site 1



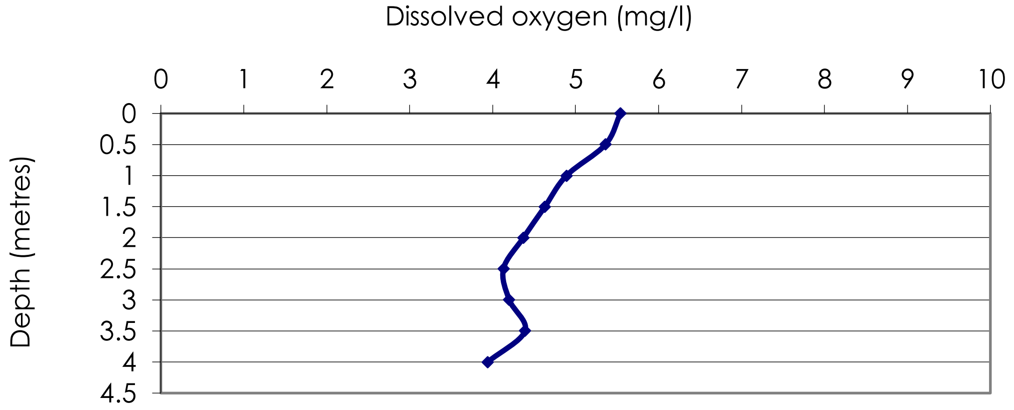
Graph 1c: Dissolved oxygen profile for Monitoring Site 1



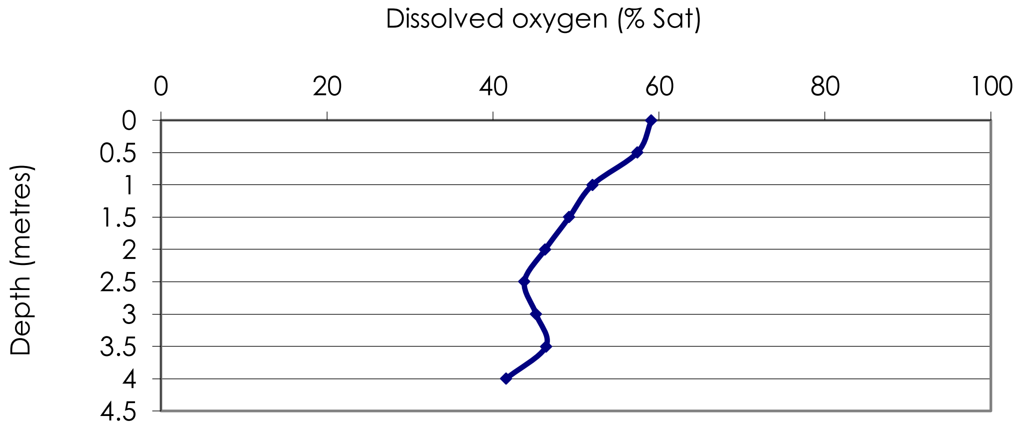
Graph 2a: Temperature profile for Monitoring Site 2



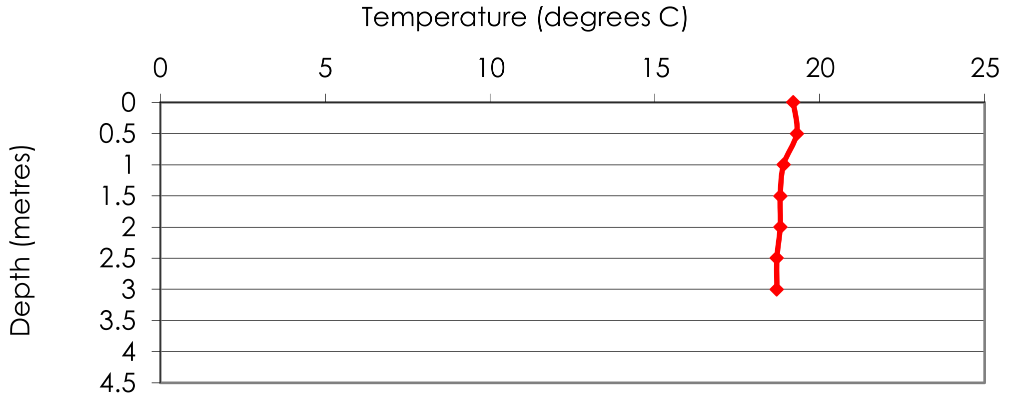
Graph 2b: Dissolved oxygen profile for Monitoring Site 2



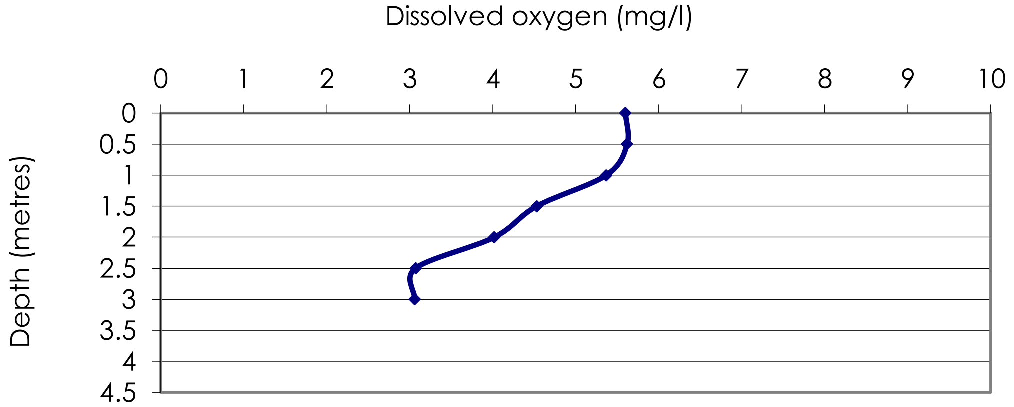
Graph 2c: Dissolved oxygen profile for Monitoring Site 2



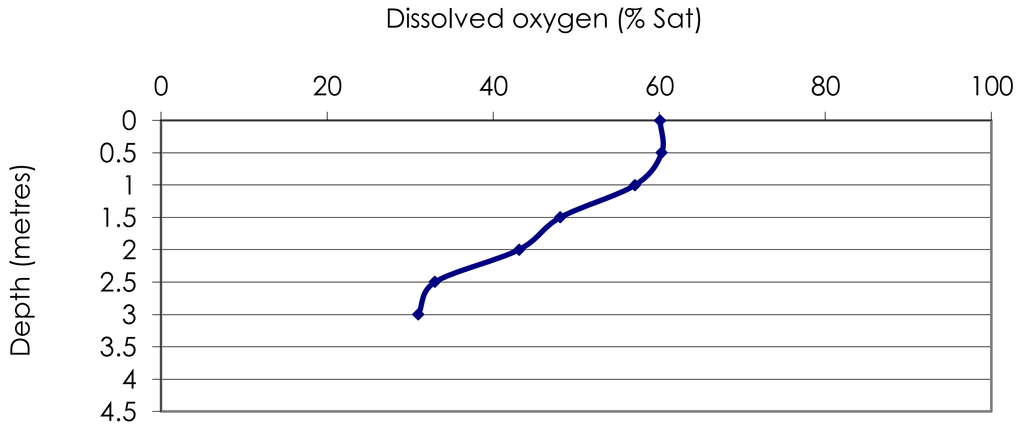
Graph 3a: Temperature profile for Monitoring Site 3



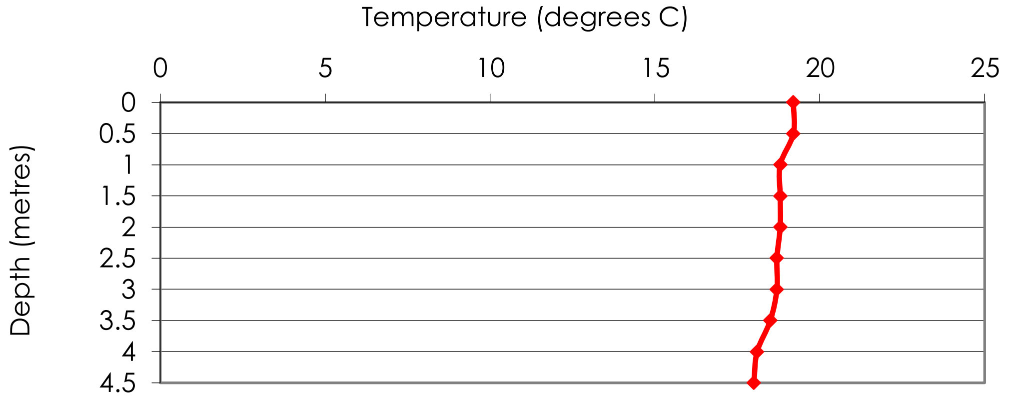
Graph 3b: Dissolved oxygen profile for Monitoring Site 3



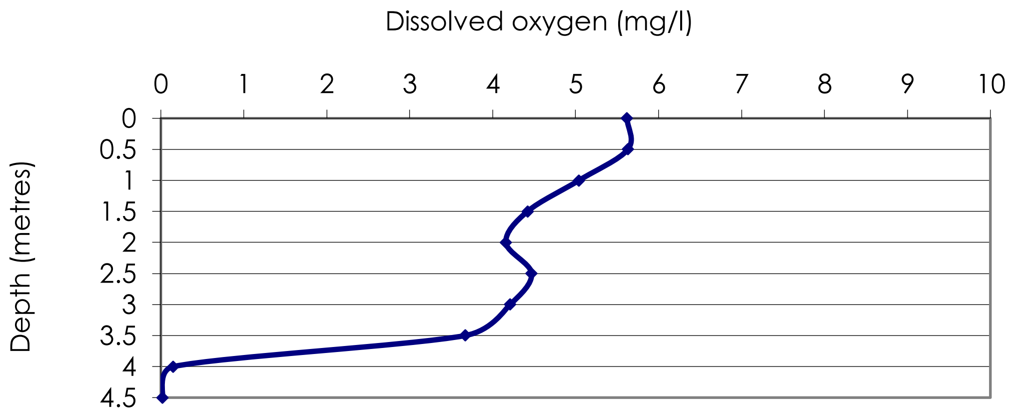
Graph 3c: Dissolved oxygen profile for Monitoring Site 3



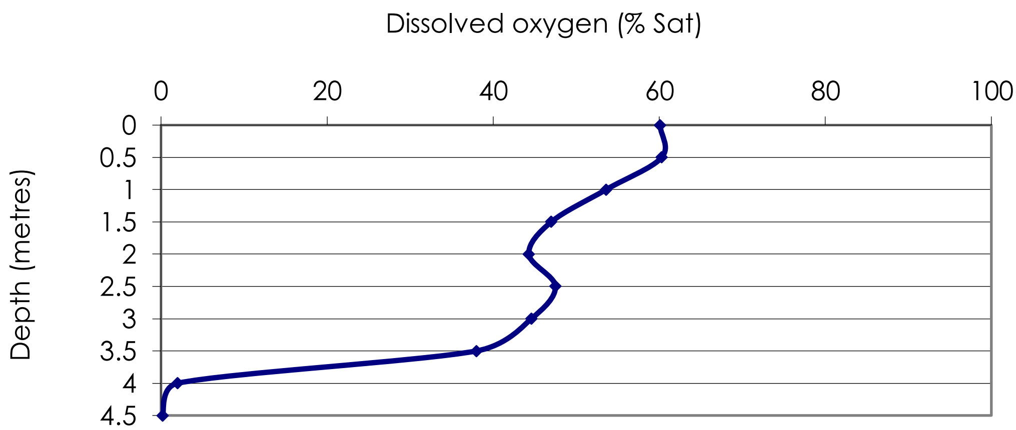
Graph 4a: Temperature profile for Monitoring Site 4



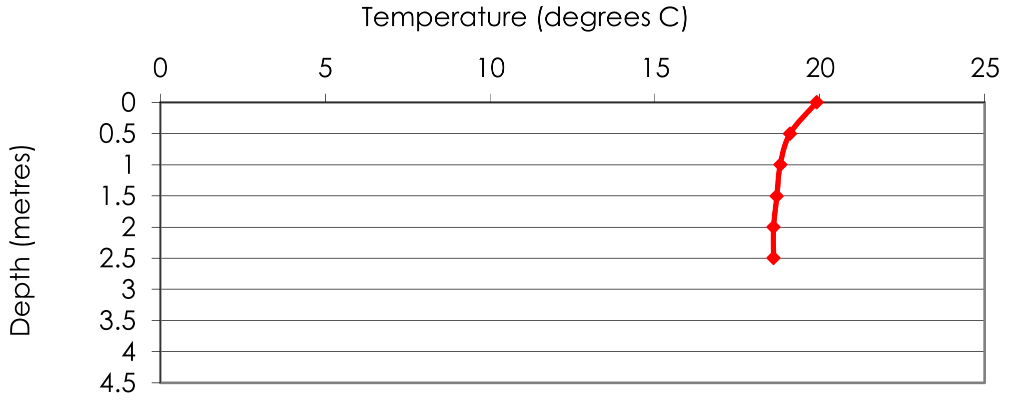
Graph 4b: Dissolved oxygen profile for Monitoring Site 4



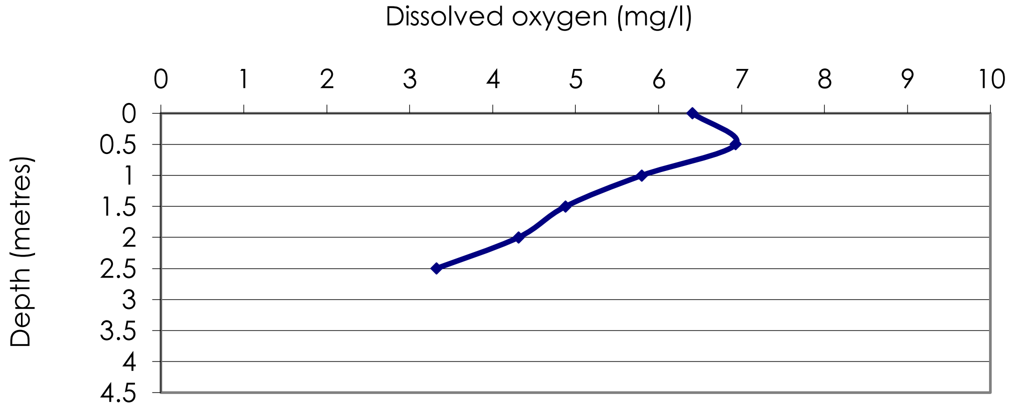
Graph 4c: Dissolved oxygen profile for Monitoring Site 4



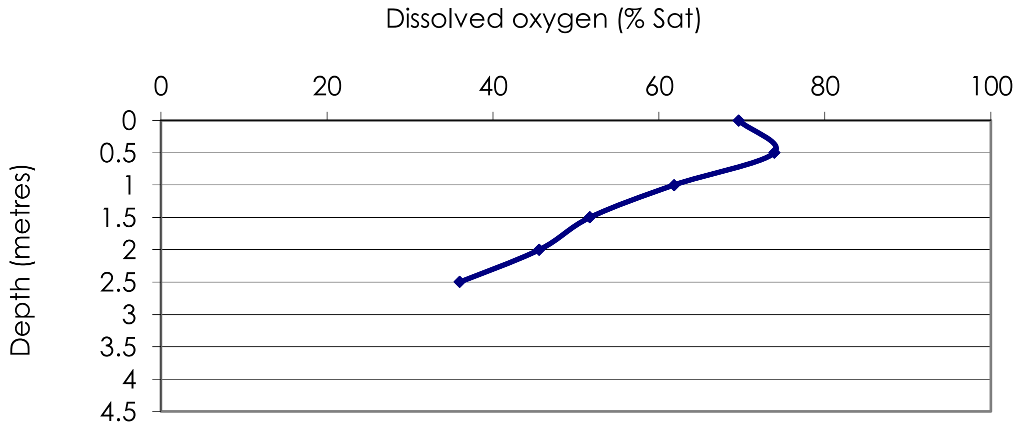
Graph 5a: Temperature profile for Monitoring Site 5



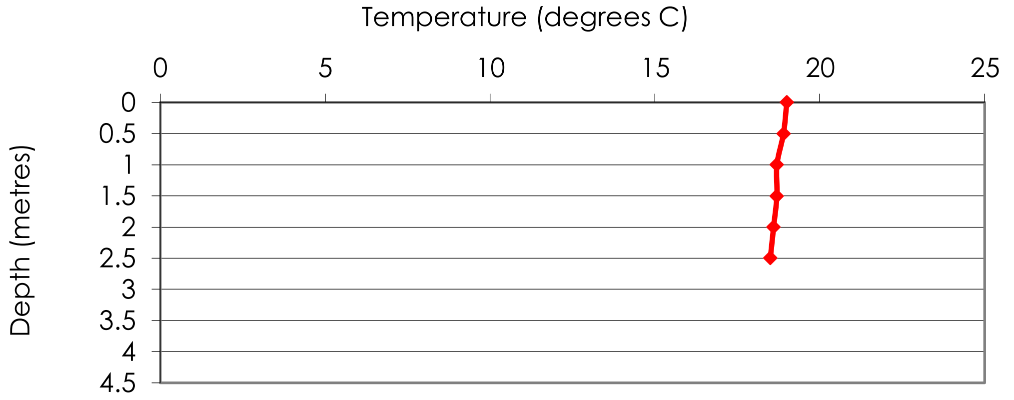
Graph 5b: Dissolved oxygen profile for Monitoring Site 5



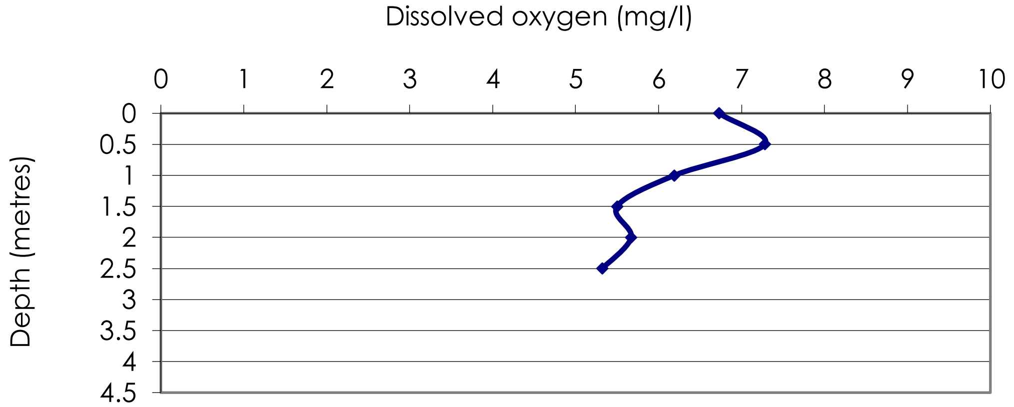
Graph 5c: Dissolved oxygen profile for Monitoring Site 5



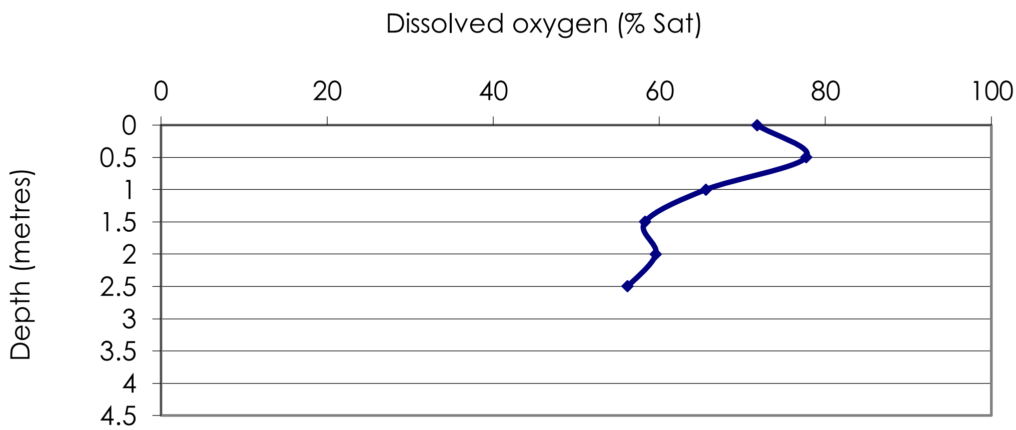
Graph 6a: Temperature profile for Monitoring Site 6



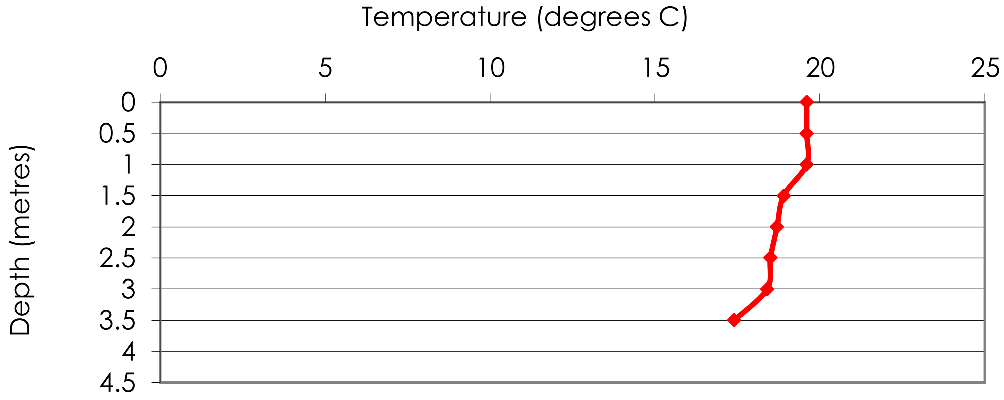
Graph 6b: Dissolved oxygen profile for Monitoring Site 6



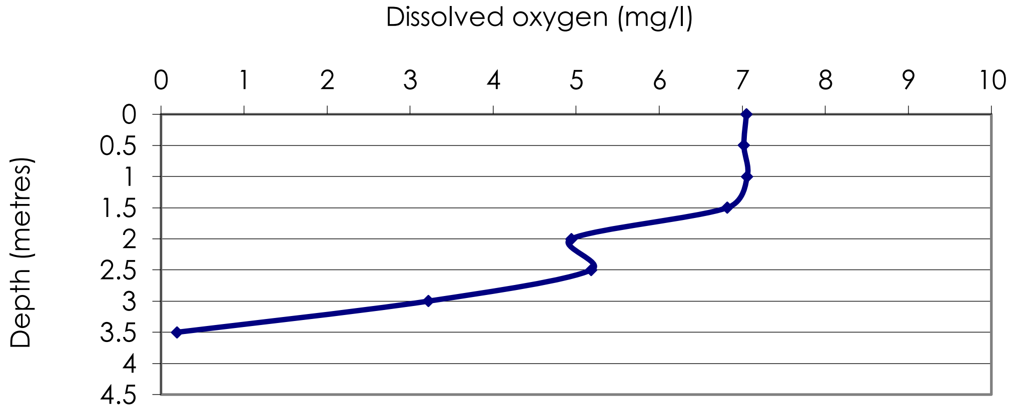
Graph 6c: Dissolved oxygen profile for Monitoring Site 6



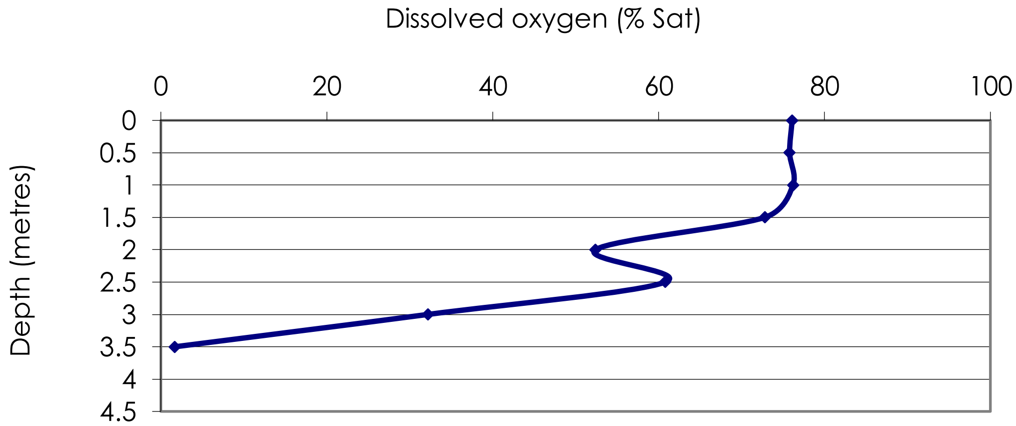
Graph 7a: Temperature profile for Monitoring Site 7



Graph 7b: Dissolved oxygen profile for Monitoring Site 7



Graph 7c: Dissolved oxygen profile for Monitoring Site 7



Appendix D. Questions and Responses from Draft Report

The following questions, following issue and review of the draft report (version 1.1), were received from Terry Jones of Ashford Borough Council. Responses to these questions are provided.

Question 1

I understand that the report recommends a package of measures that taken together will offer a good basis (even if not certainty) for maintaining a weed and toxic algae free lake in the long term. However – are there some measures that might be omitted – while still providing a reasonable chance of success?

The package of measures recommended should provide a good basis for the on-going management of aquatic weed and algae bloom issues in Conningbrook Lake. It is important to emphasise that there is no instant cure for the problems displayed for the waterbody and it will require an on-going pro-active management and maintenance programme to address the management issues associated with nutrient enrichment. The likelihood is that initial works will results in some instability in the lake ecosystem in the short-term before it settles to a new equilibrium.

The measures are recommended to be implemented as a complete package to address specific elements in management of the lake such as water quality, sediment accumulations, internal nutrient loading, limiting and reducing plant growth, re-directing nutrient into other plant growth and reducing the potential for harmful blue-green algae blooms developing. Implementing the full range of recommendations is likely to provide the greatest chance of achieving the desired objectives for the waterbody.

Question2

Assuming the recommended programme is implemented in full over 2016-2018 – will it still be necessary to harrow and harvest weed in subsequent years?

Aquatic plant growth can show significant variability between years depending on climatic conditions. For example, a mild winter and following warm summer may enhance the development of aquatic plant growth. It is likely there will be always be some requirement for weed cutting and particularly the autumn harvesting of both submerged and marginal plants as this provides a good approach for removing nutrients from the lake. The degree of plant cutting and harvesting required is likely to be variable and dependent on whether the use of lake dye is permitted by the Environment Agency. It is important that aquatic plants are maintained in the lake as discussed within the report to maintain the balance within the lake and stop the waterbody switching to a system dominated by phytoplankton blooms.

The expectation would be that gains would be made from repeated harrowing for maintaining a clear area for activities in the centre of the lake. Successful harrowing applied over several seasons, reduces the ability of the plants to regenerate leading typically leading to a reduction in aquatic weed management effort over time.

Question 3

Or will the continued use of blue dye and aeration be sufficient to maintain the lake in a relatively weed free condition?

As indicated above in the response to question 2, there will always be a requirement for some plant maintenance. If lake dye is permitted, then this should inhibit plant growth resulting in a reducing removal requirement. The main functions of the aeration system are to improve water quality conditions through the maintenance of dissolved oxygen concentrations and to create mixing in the lake to discourage the development of harmful blue-green algae species. Further beneficial effects from the use of aeration are likely to include:

- Reductions in sediment accumulations;
- Reducing the degree of internal nutrient loadings;
- Allowing fish and invertebrates to colonise areas of the lake were previously hostile low oxygen concentrations were present;
- Reduction of aquatic weed growth in the immediate vicinity of the diffusers;
- Reduction in bathing water indicator bacteria concentrations.

Question 4

The installation of the proposed aeration system is obviously the most costly element. Would it still be possible to control weed and algae growth If we omitted this recommendation but implemented all the other measures?

The aeration system is proposed as it should assist in the amelioration of potentially harmful blue-green blooms. Such blooms are likely to be the main cause for potential future closure of the lake. If an aeration system is not installed, then the likelihood is that there would be an increased maintenance requirement for aquatic plants and potential algae bloom development. Other algae control measures such as barley straw may need to be considered in the absence of aeration and mixing although these would be difficult to implement effectively given the amenity use of the lake and how the straw needs to be deployed.

It should be noted that the use of aeration and mixing, particularly on shallow waterbodies will not necessarily prevent the development of blue-green algae. The effect of mixing tends to shift the composition of the algae community towards less harmful non-scum forming blue green algae species that reduce the risk to site users.

Question 5

How do other recreational / water sports centres manage access onto water bodies where there is a presence of toxic algae blooms?

Other sites do permit continued use of the water for activities when blue-green algae are present. The main risk is presented by areas where scums form and the algae and their toxins are concentrated. For toxic algae blooms, it is important that risk to users is adequately assessed by use of an appropriate monitoring approach which is representative of likely user exposure and that provides the necessary data that allows to degree of risk to be properly determined. This was discussed in outline in the monitoring strategy of the report but it is recommended that a formal monitoring strategy and risk assessment approach is developed for activities on the lake to ensure the safety of users.

Where blooms are present other operating sites may also adopt additional measures to protect users that include:

- Closure of areas of the lake where the scums have accumulated. This requires active monitoring as the scums tend to be mobile with prevailing winds;
- Developing fringes of aquatic vegetation to reduce potential exposure to visitors around the lake from marginal scum accumulations;

- Temporary limiting full immersion activities and the use of wet suits (which can trap a layer of algae-laden water next to the skin); and
- Providing shower facilities and recommending users shower after immersion.