Water Quality Sampling of Lake Wabby, K'gari (Fraser Island) 2021

Nutrients, microbial contaminants, sunscreen and insect repellents

Queensland Government

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Contents

Introduction

The Queensland Parks and Wildlife Service are reviewing the management plan for Lake Wabby on K'gari (Fraser Island). Lake Wabby is a non-humic, water table window lake adjacent to the Hammerstone Sandblow, which is moving into the lake. The pH of Lake Wabby is higher than the humic perched lakes of the island, making it a more favourable environment for fish. Arthington et al. (1986) found that Lake Wabby supported eleven species of fish, compared to only one or two for perched lakes. An ongoing issue of concern for the lake is water quality to support the environmental values of the lake and the potential impact on this from tourist visitation. This often includes recreational swimming which is a particular risk as it can deliver nutrients and microbial contaminants from wastes and shedding, and a range of personal care chemical contaminants including sunscreen and insect repellent compounds, which are commonly applied before swimming and outdoor activities.

Environmental Monitoring and Assessment Sciences (EMAS) have undertaken a water quality sampling program from February to April 2021 to update the available data for Lake Wabby, determine if significant change in water quality has occurred, and assess the risk of sunscreen and insect repellent compounds as contaminants of concern for the lake.

Historic water quality data available for Lake Wabby was collated to provide background conditions to assess any potential changes in water quality conditions over time. Only a limited amount of data was available, so results from current monitoring are compared to the historic range of data, but formal statistical analysis was not possible. The available historic data is sourced from the literature and past government monitoring. This data spans from as early as 1963 for some parameters, and up to 2012 when the department last conducted water quality monitoring at Lake Wabby.

Monitoring Program

Sample locations

Water quality sampling was conducted three times at Lake Wabby from February to April 2021. For each sampling occasion there were 5 sites sampled for a range of parameters (Figure 1, Table 1). Sites 1 and 2 were sampled from boat for physical-chemical parameters, nutrients, and chlorophyll-a in the water column. Site 2 was also sampled for sunscreen and insect repellent compounds in the water column and sediment. A sample for standard water analysis was also taken at Site 2. Sites 3, 4 and 5 were shore-based sites sampled for microbial contamination (*Escherichia coli*).

Table 1 Sample design for 2021 sampling program

Site	Phys-Chem	Nutrients	Chlorophyll-a	Standard Water Analysis (see text for details)	Sunscreen and Insect Repellent – water and sediment	*E. coli*
1	*	*	*			
2	*	*	*	*	*	
3						*
4						*
5						*

Figure 1 Monitoring sites in Lake Wabby. Sites 1 and 2 are water and sediment sample sites. Sites 3-5 are shore-based sites for microbial samples. (Image from ArcGIS online).

Physical-chemical parameters, nutrients, and chlorophyll-a

Physical-chemical measurements, and samples for nutrient and chlorophyll-a analysis were collected at sites 1 and 2 (Figure 1).

In-situ measurements for temperature, conductivity, pH, and dissolved oxygen were taken with a YSI EXO sonde, at depths of 0.2m (surface) and each 1m thereafter of the water column. There was no stratification of the water column at the times of sampling and only the surface readings are reported for discussion.

Samples for total and dissolved nutrients were collected at 0.2m depth in laboratory supplied bottles. Total nutrients samples were collected directly into the sample container. Samples for dissolved nutrients were filtered in the field with an 0.45µm PES (Sartorius) syringe filter. Nutrient samples were placed on ice in the field and frozen until delivered to Queensland Health laboratory for analysis.

Samples for chlorophyll-a analysis were filtered in the field using glass fibre filters with 1.2µm particle size retention (ThermoFisher). The volume of water filtered was recorded, and filters were placed in plastic tubes and stored on ice in the dark, then frozen until analysed. Chlorophyll-a analysis was performed by EMAS staff.

Standard water analysis

Standard water analysis includes analysis for major ions (calcium, magnesium, sodium, potassium, chloride, sulfate, alkalinity) and laboratory measurement of some physical-chemical parameters. Each sample for standard water analysis was collected directly into a 1L HDPE (high density polyethylene) laboratory supplied bottle and placed on ice in the field and refrigerated until delivered to the Queensland Health laboratory for analysis.

Sunscreen and Insect Repellents

Samples for sunscreen and insect repellent measurement were collected at Site 2. Each sample was collected at approximately 0.2 m depth, directly into a 1L solvent (ethanol and acetone) washed, amber glass bottle supplied from the laboratory. Sediment samples were collected using a stainless steel sediment grab sampler. Three sediment grabs were collected at the site and combined in a stainless steel bowl. A composite sample was then collected in a solvent (ethanol and acetone) washed glass container. Samples were placed on ice in the field and refrigerated until delivered to the Queensland Health laboratory for analysis.

Microbial contaminants

E.coli is used as an indicator of definitive evidence of faecal pollution, being present in faeces of humans and other warm-blooded animals. *E.coli* is the most common thermotolerant coliform present in faeces but is generally not capable of growth under environmental condition, therefore its presence indicates recent faecal contamination (NHMRC 2011).

Sampling for *E.coli* occurred at 3 sites along the east shore of the lake; Site 3, 4 and 5 (Figure 1). The east shore was sampled as it is the focus for swimming activities of the lake as waterside access is possible via the sand blow.

Samples were collected in sterile jars, placed on ice in the field and refrigerated until delivered to laboratory for analysis within 24 hours of collection. *E.coli* samples were analysed by WaterOne laboratory in Hervey Bay.

Historic Data

A range of historic data for Lake Wabby water quality was sourced from the literature and previous department sampling efforts. Although only a small amount of historic data was found, it spans a period of 1963 to 2012 for some parameters. The historic data available for Lake Wabby water quality includes an 8-month sampling program which occurred in 1989-1990 (Arthington et al. 1990), a single sampling occasion in February 1999 (Hadwen et al. 2003), and sampling in October, November and December 2012 (Moss 2016). Four sampling occasions with a limited range of parameters were also found in the literature from between 1963 and 1987 (Bayly 1964, Bayly et al. 1975, Cosstick 1977, Bowling 1988). The historic data has been used as available, though early data may not be as accurate as more recent data collected with modern monitoring equipment. The historic data is shown in the results plots for physical-chemical parameters, nutrients and major ions for comparison to data collected in the current sampling program.

Results

Physical-Chemical Parameters

All turbidity values measured during the current sampling program were below 2NTU (Figure 2). Historic data ranged from zero to 1NTU. At these very low values there is lower confidence in the precision of results and a difference of 1NTU should not be viewed as significantly different.

During the current sampling program Secchi depth ranged from 1.15 to 1.8m (Figure 3). Historic data from 1989-1990 showed a range of 0.95 to 3.8m, showing that Secchi depth may be variable over short time periods of weeks to months. Two much earlier data points from 1972 and 1975 have values much higher than recent data at 5.1 and 7.2m. These early results may indicate a change in the system condition has occurred to relatively more turbid conditions in recent decades, possibly linked to the gradual infilling of the lake.

Conductivity is stable over time (Figure 4). All measures in this sampling program were 180µS/cm and within the range of historic data. Historic data shows a small range of 147 to 213µS/cm.

pH ranged between 5.5 and 6.4 for this sampling program (Figure 5). This is within the range of historic data. The observed range in historic data for pH is 4.7 to 7.4, though most samples are close to a value of 6.

Dissolved oxygen ranged from 98 to 113% in the current sampling program (Figure 6). This is within the range of historic data and shows a low risk of oxygen stress for biota. Although only surface readings are shown here, high dissolved oxygen levels were measured at all depths of the water column showing no stratification occurring.

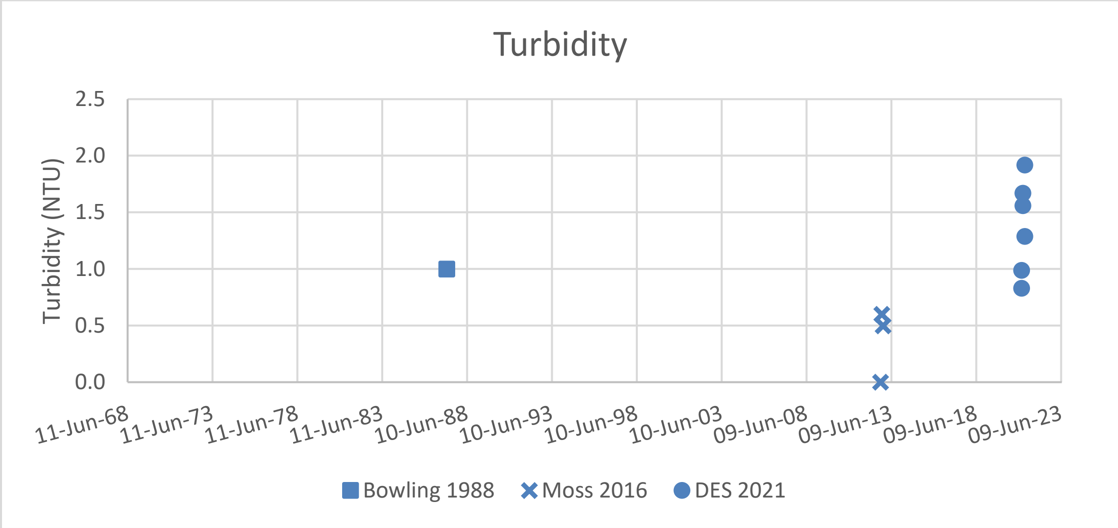

Figure 2 Turbidity (NTU) for Lake Wabby from historic data and current sampling program. Historic data is identified by source references, and current data is identified as DES 2021.

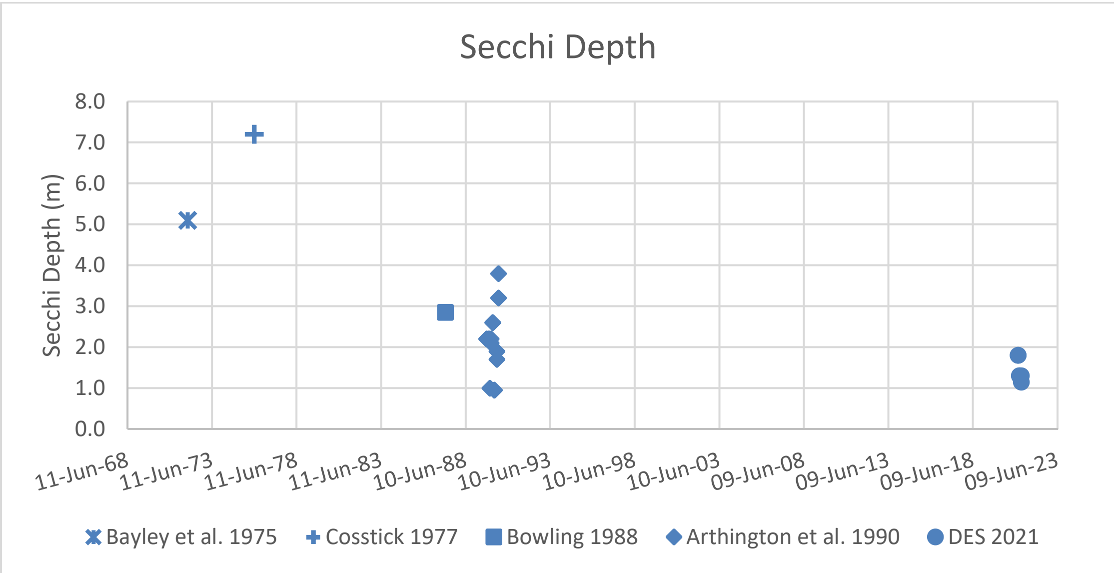

Figure 3 Secchi Depth (m) for Lake Wabby from historic data and current sampling program. Historic data is identified by source references, current data is identified as DES 2021.

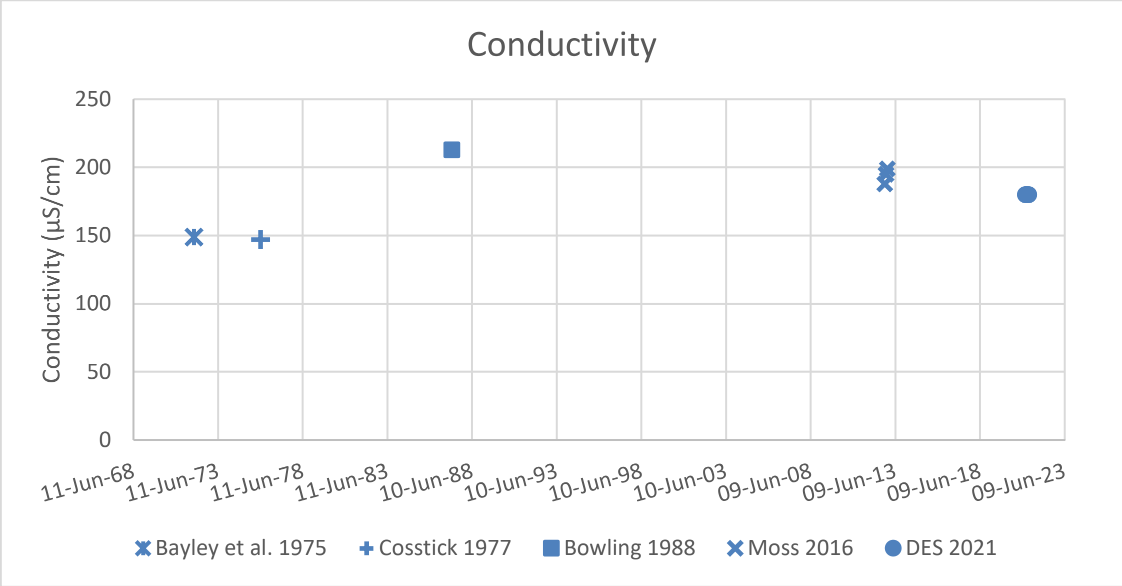

Figure 4 Conductivity (µS/cm) for Lake Wabby from historic data and current sampling program. Historic data is identified by source references, current data is identified as DES 2021.

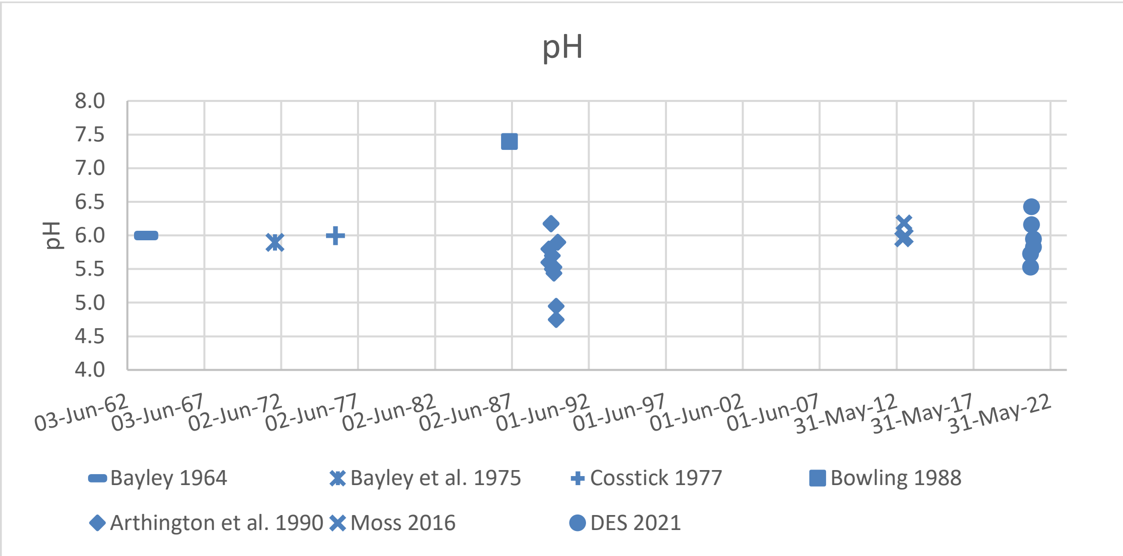

Figure 5 pH for Lake Wabby from historic data and current sampling program. Historic data is identified by source references, current data is identified as DES 2021.

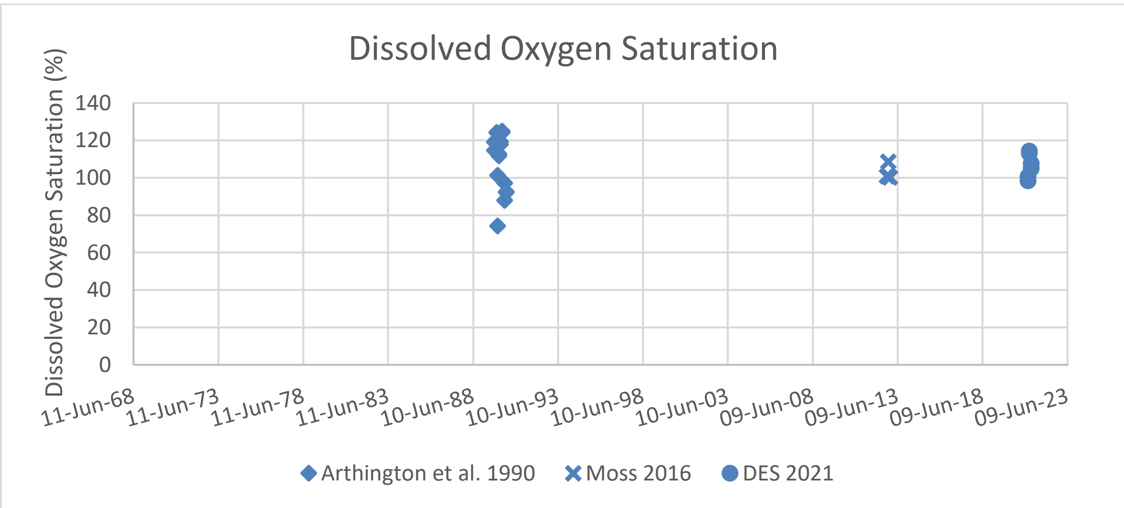

Figure 6 Dissolved Oxygen Saturation (%) for Lake Wabby from historic data and current sapling program. Historic data is identified by source references, current data is identified as DES 2021.

Major Ions

Major ions were consistent between the three sampling occasions of the current monitoring period (Figure 7). Major ions are also remarkably consistent over time, with very similar results to literature values reported by Arthington et al. (1990) from 1989-1990. This shows consistency in the source and condition of water to the lake over time and no significant impacts on ionic composition.

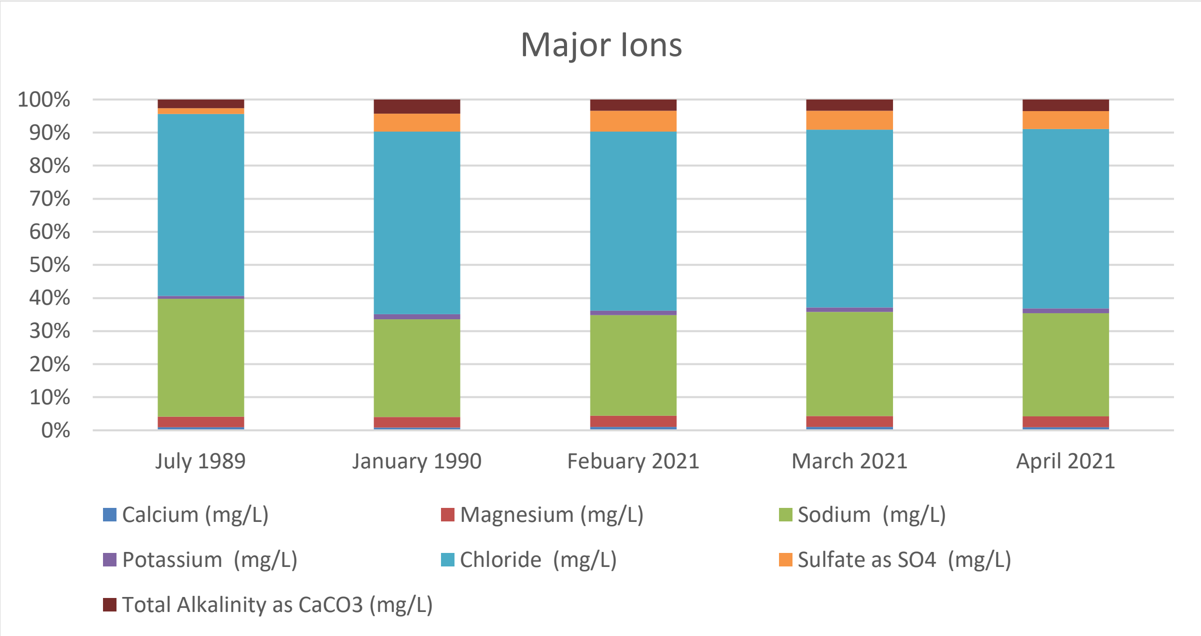

Figure 7 Composition of major ions for Lake Wabby from historic and current sampling program. Historic data for July 1989 and January 1990 is sourced from Arthington et al. (1990).

Nutrients and Chlorophyll-a

Nutrient and chlorophyll-a values from the current sampling program and the available historic data are shown below in Figures 8 to 12.

Total nutrient values are low and within the range of the small amount of historic data available. Total P ranged from 0.007 to 0.014mg/L in the current sampling program, and the maximum value in historic data is also 0.014 mg/L (Figure 8). Total N ranged from 0.310 to 0.380mg/L in the current sampling program, which is similar to the result from Hadwen et al. (2003) of 0.370mg/L, though higher than other available data which was 0.110 to 0.180mg/L (Figure 10).

Inorganic nutrients (filterable reactive phosphorus, oxidised nitrogen and ammonia nitrogen) were very low in the current sampling program being near or below the level of detection, with a maximum concentration of 0.003mg/L. This is within the range of the small amount of historic data available (Figures 9, 11 and 12).

Chlorophyll-a values were generally within the range of the 1989-90 sampling, at less than 14µg/L, though higher than the few data available from other times. Only one sample exceeded previous recorded values from historic data at 19µg/L (Figure 13).

Overall, these results show data from the current monitoring program is similar to the available historic data, and does not indicate changes in condition over the span of data availability.

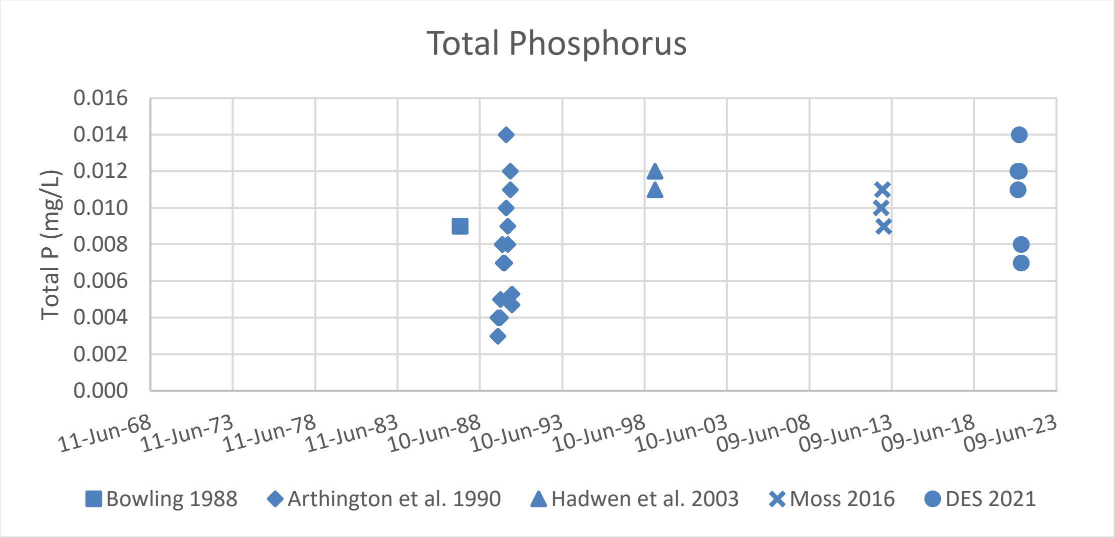

Figure 8 Total Phosphorus (mg/L) for Lake Wabby from historic data and current sampling program. Historic data is identified by source references, current data is identified as DES 2021.

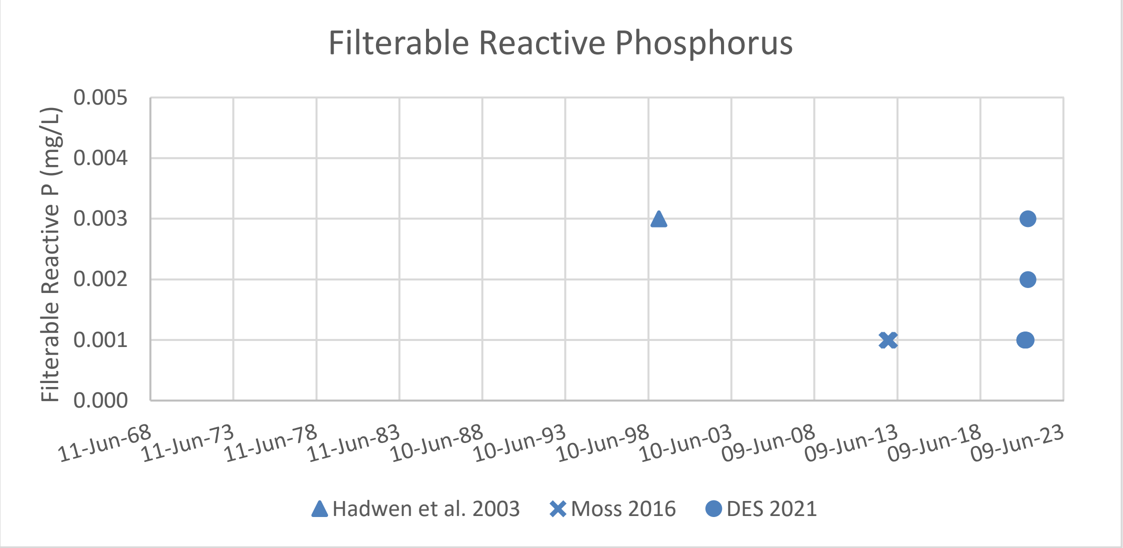

Figure 9 Filterable Reactive Phosphorus (mg/L) for Lake Wabby from historic data and current sampling program. Historic data is identified by source references, current data is identified as DES 2021.

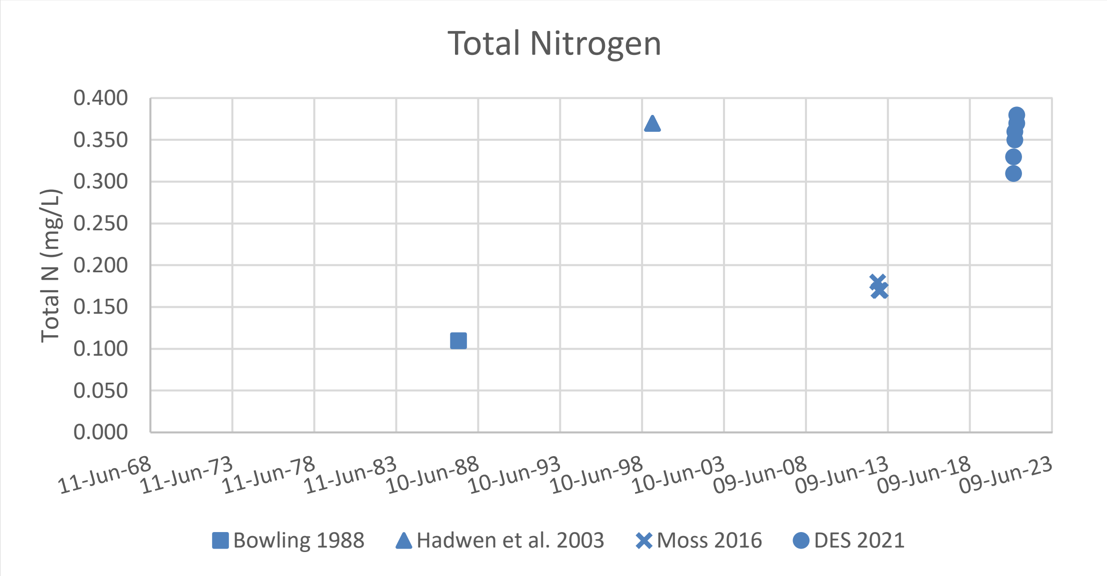

Figure 10 Total Nitrogen (mg/L) for Lake Wabby from historic data and current sampling program. Historic data is identified by source references, current data is identified as DES 2021.

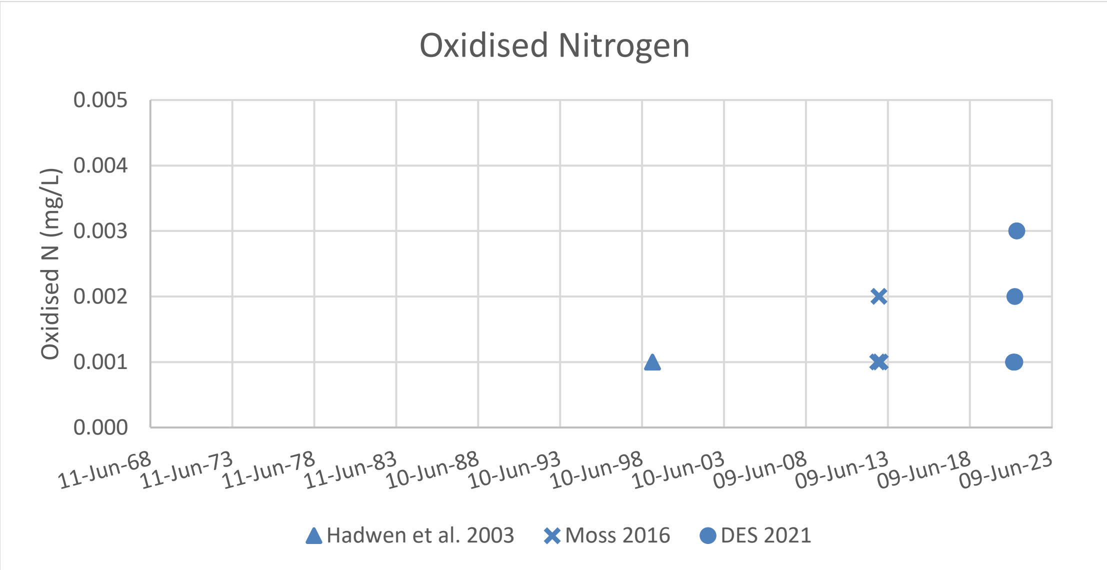

Figure 11 Oxidised Nitrogen (mg/L) for Lake Wabby from historic data and current sampling program. Historic data is identified by source references, current data is identified as DES 2021.

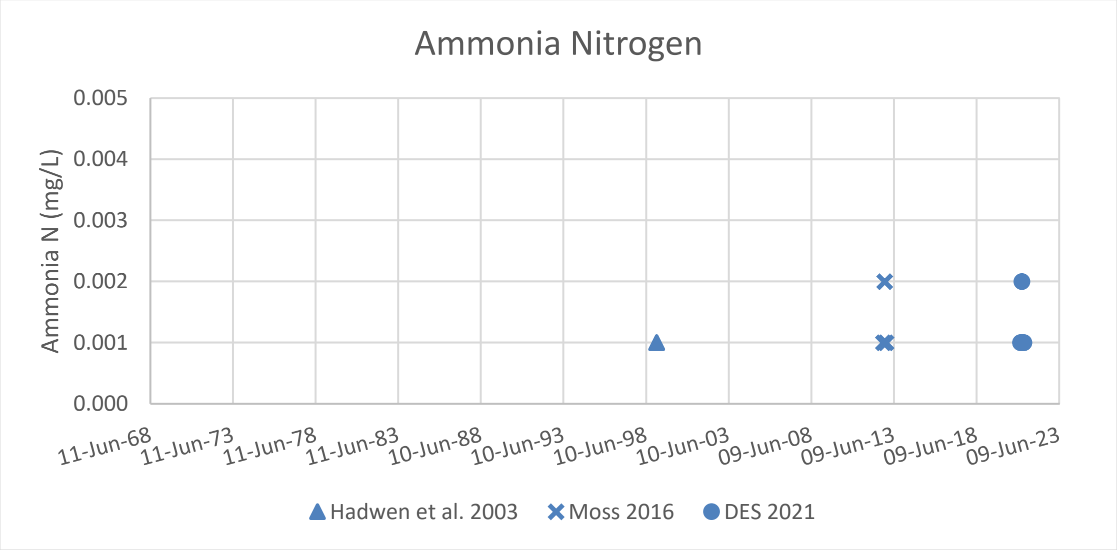

Figure 13 Ammonia Nitrogen (mg/L) for Lake Wabby from historic data and current sampling program. Historic data is identified by source references, current data is identified as DES 2021.

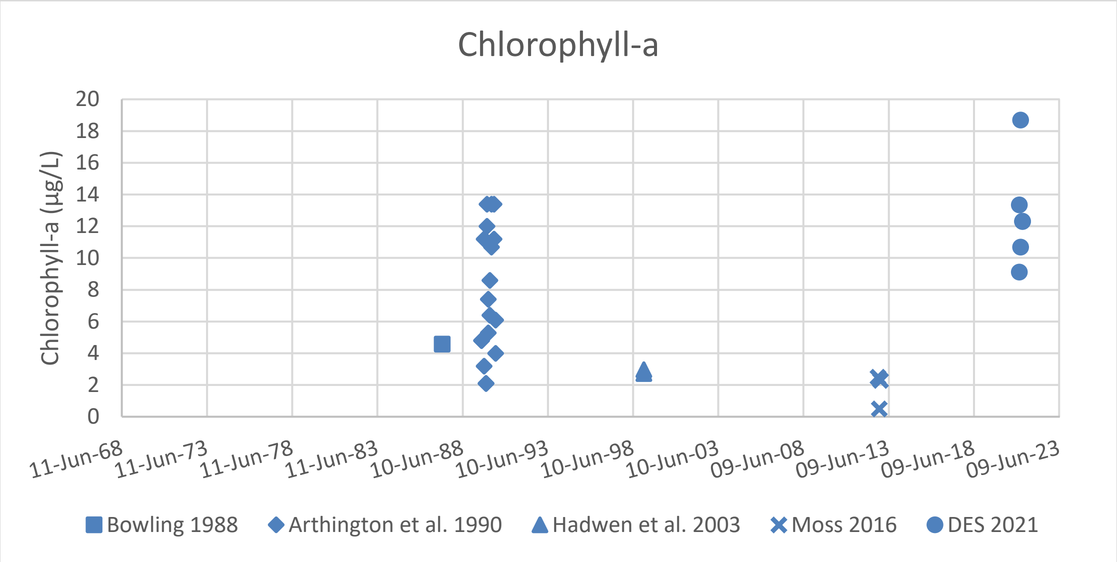

Figure 12 Chlorophyll-a (µg/L) for Lake Wabby from histroic data and current monitroing program. Historic data is identified by source references, current data is identified as DES 2021.

Sunscreen and Insect Repellents

There is growing awareness of the extent of contamination, and concern about the ecological effects of sunscreen and insect repellent compounds in the environment. Many sunscreen compounds (organic UV filters) have the potential to act as endocrine disrupters, however, there is little data of their concentration in the environment and their effects on aquatic biota. This field of research is continuing to grow, but as yet there are no guideline values available to apply to monitoring data of these compounds. During the current sampling program a total of five sunscreen and two insect repellent compounds were detected in the water of Lake Wabby, and four sunscreen compounds and no insect repellents were detected in the sediments (Tables 2 and 3).

The sunscreen compound homosalate was detected in the water column in all three months, with concentrations increasing across the three months. Octocrylene was detected in the water column in both March and April sampling rounds. A further three sunscreen compounds were also detected in the water column during the April sampling round. The April sampling round occurred in the week following the Easter school holiday period, which is a peak tourist period on Fraser Island and visitation to the lake would be expected to peak. Other studies have found that sunscreen compounds peak in concentration during summer when visitation and swimming activity is highest (Kaiser et al. 2012).

The sunscreen compounds octocrylene and 4-methylbenzylidene camphor were detected in the sediment in all three sampling occasions. Butyl methoxydibenzoylmethane was also detected in March and April. Homosalate was detected in the sediment in April, when it was at its highest concentration in the water column.

The common insect repellent diethyltoluamide (DEET) was detected in the water column in February and April, and picaradin was detected in the water column in April only. No insect repellent compounds were detected in the sediments.

Previous reported results for sunscreen and insect repellents in waters of lakes Mackenzie, Birrabeen, Boomanjin and Allom, sampled December 2013, showed no detection of these compounds (Moss 2015). However, in that study the level-of-reporting (LOR) was 1µg/L, which is much higher than that of the current sampling program and would not be sensitive enough to detect the concentrations of compounds detected in Lake Wabby or reported in the literature cited below. The LOR of analysis used in the current monitoring for various sunscreen and insect repellent compounds ranged from 0.05 to 0.1µg/L for water and 40 to 100µg/kg for sediments (Tables 2 and 3).

Fent et al. (2008) provides a brief review of environmental data of some sunscreen compounds. Of the six compounds detected in Lake Wabby, three are reported by Fent et al. (2008) as being detected in lakes used for recreation in Switzerland and Slovenia, with maximum concentrations for 4-methylbenzylidene camphor of 0.08µg/L, oxybenzone of 0.125µg/L, octocrylene of 0.031µg/L. The current sampling showed that concentration of octocrylene found in Lake Wabby is much higher, with a maximum concentration of 0.25µg/L. Homosalate is reported in Fent et al. (2008) to be up to 0.345µg/L in recreational use river water, while concentration in Lake Wabby was up to 0.410µg/L. Kaiser et al. (2012) measured a range of sunscreen compounds in river and lake sediments of Germany. Octocrylene was found at up to 642µg/kg, similar to the maximum concentration found in Lake Wabby sediments of 610µg/kg. 4-methylbenzylidene camphor was found at only 2µg/kg, but in Lake Wabby was detected on all three occasions and at a concentration up to 130µg/kg. Butyl methoxydibenzoylmethane was found by Kaiser et al. up to 62µg/kg, but in sediments of Lake Wabby it was measured at up to 150µg/kg.

The insect repellent diethyltoluamide (DEET) has been reported in surface waters of south-east Queensland at concentrations up to 0.49µg/L (Costanzo et al. 2007). Costanzo et al. (2007) also provide a review of worldwide observations of DEET in surface waters, which had a maximum concentration of 1.13µg/L. DEET was detected in two of the three sampling occasions in Lake Wabby with concentrations of 0.6 and 1.62µg/L, showing high concentrations compared to other waters of south-east Queensland and globally.

Comparison to literature sources shows that the sunscreen and insect repellent compounds detected in Lake Wabby waters and sediments are similar to, and in some cases higher than, concentrations reported from other recreational waters worldwide. Further sampling would be required to determine seasonal variations and links to rates of tourist visitation and swimming.

*Table 2 Sunscreens and Insect Repellents in the water column of Lake Wabby. Compounds detected above the LOR (limit of reporting) are in **bold**.*

Sunscreens and Insect Repellents in Water						
Sunscreens	**LOR**	**Unit**	**February 9/02/2021**	**March 9/03/2021**	**April 21/04/2021**	**Other names:**
4-Methylbenzylidene camphor	0.05	µg/L	<0.05	<0.05	**0.06**	Enzacamene
Butyl methoxydibenzoylmethane	0.1	µg/L	<0.1	<0.1	<0.1	Avobenzone, 4-tert-butyl-4'-methoxydibenzoyl methane.
Cinoxate	0.05	µg/L	<0.05	<0.05	<0.05	
Diethylamino hydroxybenzoyl hexyl benzoate	0.05	µg/L	<0.05	<0.05	<0.05	
Dioxybenzone	0.05	µg/L	<0.05	<0.05	<0.05	
Homosalate	0.05	µg/L	**0.12**	**0.22**	**0.41**	
Isoamyl methoxycinnamate	0.05	µg/L	<0.05	<0.05	<0.05	
Menthyl anthranilate	0.05	µg/L	<0.05	<0.05	<0.05	
Octocrylene	0.05	µg/L	<0.05	**0.1**	**0.25**	
Octyl methoxycinnamate	0.05	µg/L	<0.05	<0.05	<0.05	Octinoxate
Octyl salicylate	0.05	µg/L	<0.05	<0.05	**0.1**	Octisalate
Oxybenzone	0.05	µg/L	<0.05	<0.05	**0.06**	Benzophenone-3
Padimate O	0.05	µg/L	<0.05	<0.05	<0.05	
Sulisobenzone	0.1	µg/L	<0.1	<0.1	<0.1	
*4,4'-Dihydroxybenzophenone	0.05	µg/L	<0.05	<0.05	<0.05	
*Hydroxy methoxy methylbenzophenone	0.05	µg/L	<0.05	<0.05	<0.05	Mexenone
*Hydroxy octyloxy benzophenone	0.05	µg/L	<0.05	<0.05	<0.05	Octabenzone
Insect Repellents						
Diethyltoluamide	0.05	µg/L	**1.62**	<0.05	**0.6**	DEET
Ethyl butylacetylaminopropionate	0.05	µg/L	<0.05	<0.05	<0.05	IR3535
N-Octyl bicycloheptene dicarboximide	0.05	µg/L	<0.05	<0.05	<0.05	MGK-264
Picaridin	0.05	µg/L	<0.05	<0.05	**0.09**	
*Dipropyl isocinchomeronate (MGK-326)	0.05	µg/L	<0.05	<0.05	<0.05	MGK-326

***not approved for use in Australian products (TGA, APVMA), but approved elsewhere in the world.**

*Table 3 Sunscreens and Insect Repellents in sediments of Lake Wabby. Compounds detected above the LOR (limit of reporting) are in **bold**.*

Sunscreens and Insect Repellents in Sediment

Sunscreens	LOR	Unit	February 9/02/2021	March 9/03/2021	April 21/04/2021	Other names:
4-Methylbenzylidene camphor	40	µg/kg	**50**	**70**	**130**	Enzacamene
Butyl methoxydibenzoylmethane	40	µg/kg	<40	**50**	**150**	Avobenzone, 4-tert-butyl-4'-methoxydibenzoyl methane.
Cinoxate	100	µg/kg	<100	<100	<100	
Diethylamino hydroxybenzoyl hexyl benzoate	40	µg/kg	<40	<40	<40	
Dioxybenzone	100	µg/kg	<100	<100	<100	
Ensulizole	100	µg/kg	<100	<100	<100	
Homosalate	40	µg/kg	<40	<40	**40**	
Isoamyl methoxycinnamate	40	µg/kg	<40	<40	<40	
Menthyl anthranilate	40	µg/kg	<40	<40	<40	
Octocrylene	40	µg/kg	**330**	**470**	**610**	
Octyl methoxycinnamate	40	µg/kg	<40	<40	<40	Octinoxate
Octyl salicylate	40	µg/kg	<40	<40	<40	Octisalate
Oxybenzone	40	µg/kg	<40	<40	<40	Benzophenone-3
Padimate O	40	µg/kg	<40	<40	<40	
Sulisobenzone	40	µg/kg	<40	<40	<40	
*4,4'-Dihydroxybenzophenone	40	µg/kg	<40	<40	<40	
*Hydroxy methoxy methylbenzophenone	40	µg/kg	<40	<40	<40	Mexenone
*Hydroxy octyloxy benzophenone	40	µg/kg	<40	<40	<40	Octabenzone
Insect Repellents						
Diethyltoluamide	40	µg/kg	<40	<40	<40	DEET
Ethyl butylacetylaminopropionate	40	µg/kg	<40	<40	<40	IR3535
N-Octyl bicycloheptene dicarboximide (MGK-264)	40	µg/kg	<40	<40	<40	MGK-264
Picaridin	40	µg/kg	<40	<40	<40	
*Dipropyl isocinchomeronate (MGK-326)	40	µg/kg	<40	<40	<40	MGK-326

***not approved for use in Australian products (TGA, APVMA), but approved elsewhere in the world.**

Microbial contaminants

E. coli is used as an indicator of definitive evidence of faecal pollution, as it is present in faeces of humans and other warm-blooded animals, and generally is not capable of growth under environmental conditions (NHMRC 2011).

E. coli counts were very low in the samples collected (Table 4), and as such there is low confidence in the precision of the counts and these values should be regarded as estimations. The NHMRC Guidelines for Managing Risks in Recreational Water (2008) state that although suitable as an indicator for freshwater recreation, there is currently insufficient data to develop recreational water guideline values for *E. coli*. The Australian Drinking Water Guidelines (NHMRC 2011) state that *E. coli* should not be detected in any 100 mL sample of drinking water.

Given the very low values measured, there is expected to be a low risk of microbial contamination and associated health risk for recreational use of Lake Wabby.

Table 4 E.coli (cfu/100mL) results measured at shore based sites in Lake Wabby. Due to the low levels of organisms detected, the precision of the results is low and the counts should be considered approximations.

Site	**Date of Sample**		
	February 9/02/2021	March 9/03/2021	April 21/04/2021
3	1	7	<1
4	7	1	<1
5	2	2	2

Summary

Condition of water quality, as indicated by physical-chemical, nutrient and chlorophyll-a parameters, does not show apparent changes from historic data, with relatively consistent results recorded over time. Physical-chemical parameters and ionic composition of the water remains consistent over time showing no significant change to condition of the lake or contamination of water sources. Early secchi depth readings from 1972 and 1975 show that conditions of greater clarity may have occurred in the past, though current conditions would appear to be relatively stable from at least 1987 onwards. Low nutrient levels have persisted across the period of available data and do not indicate changes in condition. Microbial contamination for Lake Wabby is very low and remains a low risk for recreational use.

A number of sunscreen and insect repellent compounds were detected in water and sediment of Lake Wabby, however, there are currently no guideline values against which to assess their potential risk. The sunscreen and insect repellent compounds detected are at concentrations similar to or higher than those found from literature sources in Australia and worldwide. Future work may include continued monitoring of these compounds and investigate relation to seasonality, visitation rates and comparison with less visited lakes.

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