

# LAKE PARRAMATTA WATER QUALITY MANAGEMENT PLAN

July 1998

**Prepared by:**

**Lyll & Macoun Consulting  
Engineers**

Level 6, 2 Help Street  
Chatswood NSW 2067

**Tel: (02) 9413 3411**

Fax: (02) 9413 3471

Email: [lmce@netro.com.au](mailto:lmce@netro.com.au)

**Robyn Tuft & Associates**

6 The Comenara Parkway  
West Pymble NSW 2073

**Tel: (02) 9983 1511**

Fax: (02) 9983 1993

**Lawson & Treloar**

Ground Floor  
14-16 Suakin Street  
Pymble NSW 2073

**Tel: (02) 9983 1000**

Fax: (02) 9983 1055

Job No: NZ489 File: j:\nz489\reports\mgtrep1.doc	Date: 17 March, 1999 Rev: 2.0	Principal: SJP Author: SJP/LCH
---	----------------------------------	-----------------------------------

## TABLE OF CONTENTS

	Page
<b>1. PURPOSE AND OBJECTIVES .....</b>	<b>1</b>
1.1 Purpose of the Plan .....	1
1.2 Objectives of the Plan.....	1
1.2.1 Ecosystem Protection .....	1
1.2.2 Visual Amenity .....	1
1.2.3 Primary Contact Recreation .....	2
1.2.4 Secondary Contact Recreation .....	2
1.3 Background and Outline of the Plan.....	2
<b>2. LAKE MONITORING AND CATCHMENT INPUTS .....</b>	<b>3</b>
2.1 Physical Setting .....	3
2.2 Nutrient and Ecological Status .....	3
2.3 Pathogens.....	4
<b>3. MODELLING OF LAKE BEHAVIOUR .....</b>	<b>5</b>
3.1 Lake Characteristics and Inflows.....	5
3.2 Water Quality Criteria .....	5
3.3 Pollutant Inflow Sources.....	5
3.4 Modelling Methodology .....	6
3.5 Storm Events.....	6
3.6 Coliform Levels in Lake Parramatta .....	6
3.7 Nutrients and Eutrophication .....	8
3.8 Sediment and Nutrient Retention .....	9
<b>4. MANAGEMENT OPTIONS.....</b>	<b>11</b>
4.1 Water Quality Targets.....	11
4.2 Principles.....	12
4.2.1 Non-Structural Controls.....	12
4.2.2 Structural Controls.....	14
4.3 Community Monitoring and Awareness .....	14
4.4 Pathogen Control.....	16
4.4.1 Sewer Overflow .....	16
4.4.2 Diffuse Runoff .....	17
4.4.3 Sewer Leaks.....	18
4.4.4 Manage the Waterfowl .....	19
4.5 Eutrophication Control.....	20
4.5.1 Stabilising or Removing the Lake Sediments .....	20
4.5.2 Lake De-stratification.....	21
4.5.3 Sewer Leaks and Overflows .....	22
4.5.4 Parks, Sports fields and Recreation Areas .....	22
4.5.5 Drainage System Maintenance .....	22
4.5.6 Street Sweeping .....	23
4.5.7 Waste Collection .....	23
4.5.8 Upgrading of Stormwater Drainage System .....	24
4.5.9 Other Source Controls .....	24
4.5.10 Floating Wetland .....	25
4.5.11 Stormwater Inlet near the Kiosk.....	25
<b>5. PROPOSED STRATEGY AND SCHEDULE .....</b>	<b>27</b>
<b>6. REFERENCES AND BIBLIOGRAPHY.....</b>	<b>30</b>

## FIGURE

Figure 1 Water Quality Reference Locations

## APPENDICES

- A Pre-feasibility Assessment: "Limnofix" In-situ Sediment Treatment
- B "HealthGuard" High Rate Filtration and Disinfection

# 1. PURPOSE AND OBJECTIVES

## 1.1 Purpose of the Plan

The purpose of this plan is to promote coordinated action by Parramatta City Council, Baulkham Hills Shire Council and landholders to significantly improve the water quality in Lake Parramatta

## 1.2 Objectives of the Plan

The "Streamly Clean" project undertaken by the Upper Parramatta River Catchment Trust (UPRCT) utilised the approach recommended by the National Water Quality Management Strategy (NWQMS) (ANZECC, 1992) to establish community endorsed water quality goals and to identify strategies for these goals for creeks and waterbodies in the Trust's area of responsibility. That process led to setting the water quality goal for Lake Parramatta as meeting the following NWQMS targets during dry weather (less than 10 mm of rainfall in a day):

- Ecosystem and associated wildlife protection;
- Visual amenity
- Primary contact recreation.

The applicable specific or measurable targets relevant to meet these goals for Lake Parramatta are:

### 1.2.1 Ecosystem Protection

The NWQMS Guidelines do not recommend general nutrient concentration levels which would prevent algal problems in lakes throughout Australia but suggest the following indicative concentrations ranges:

- Total phosphorus            5-50 µg/L
- Total nitrogen                100-500 µg/L
- Chlorophyll-a                2-10 µg/L.

Since chlorophyll-a is an indicator of available nitrogen and phosphorus, it may be taken as the key target parameter for ecosystem protection. For Lake Parramatta, the suggested target is 10 µg/L.

The guidelines for wildlife protection suggest that the guidelines for aquatic ecosystem protection will be sufficient to protect wildlife from detrimental effects of contacting contaminated water.

### 1.2.2 Visual Amenity

Many factors contribute to the visual amenity of a waterbody including:

- Absence of litter and oil;
- Absence of aquatic weeds,
- Clarity and colour of the water (absence of excessive turbidity).

Because of the subjective nature of aspects visual amenity, there is no single quantifiable guideline. The most appropriate simple indicator would be a minimum Secchi depth of 1.6 m.

### **1.2.3 Primary Contact Recreation**

This relates to direct contact with the water body where immersion or submersion is likely. Typical activities include swimming, diving, water skiing and surfing. The faecal coliform density guideline for primary contact recreation is median of 150 cfu/100 mL (based on a minimum of five samples taken within one month). Above this level swimming related activity is considered unacceptable due to the potential risk to human health.

### **1.2.4 Secondary Contact Recreation**

This includes activities that have less direct contact with the water body such as wading, boating and fishing. The probability of bodily immersion or the intake of significant amounts of water is minimal for this type of activity, which is reflected in the higher faecal coliform guideline set at median of 1,000 cfu/100 mL.

## **1.3 Background and Outline of the Plan**

As a means to achieve these goals, the Upper Parramatta River Catchment Trust commissioned a study to develop a cost effective, community endorsed, strategy to manage the lake and its catchment. This Plan, which is the outcome of the study, sets out an integrated strategy to improve water quality in the lake so that it satisfies the NWQMS criteria for the water quality goals during dry weather.

This plan has been developed from an assessment of a range of management options set in the context of current understanding of the inflows to, and the processes within, the lake. This plan builds upon three previous reports prepared as part of this project:

- Monitoring and Data Collection (February 1997)
- Water Quality Modelling (September 1997)
- Management Options (October 1997)

The detailed material presented in those reports will not be repeated here. However, in order to set the scene, Chapters 2 and 3 summarise the findings of the previous studies. Chapter 4 then outlines a range of options considered and assesses their likely effectiveness in achieving the stated goals. These options have been considered and endorsed by the Lake Parramatta Community Consultative Committee in formulating the overall Water Quality Management Plan set out in Chapter 5.

## 2. LAKE MONITORING AND CATCHMENT INPUTS

### 2.1 Physical Setting

Lake Parramatta is formed by a masonry dam which was originally built in 1855 to a height of 11 m and was raised to 14.5 m in 1898. The reported storage capacity at the time of enlargement was 590 ML.

The catchment of 760 ha has about 55% of the area in low density residential housing and the remainder almost evenly divided between public open space and special uses such as schools. Only about 1% of the catchment is used for commercial purposes and there is no industrially zoned land.

The lake itself has a surface area of about 10.5 ha and a current storage volume of about 485 ML. The loss of storage since it was originally constructed is partly due to sediment accumulation and partly due to the lowering of the normal operating level by about 1 m in 1991.

### 2.2 Nutrient and Ecological Status

The analyses undertaken for this project confirmed earlier water quality testing that showed that the Lake is nutrient enriched, contains consistent high levels of faecal coliforms and is strongly stratified. Eutrophication in the lake was evident in excessive macrophyte and algal growth, which included blue-green algae. The monitoring also revealed the high nutrient loads enter the lake via major inflows, especially in the early stages of storm events. Results suggest that sources such as fertilisers or animal faeces are washed into the tributaries and provide a readily available form of nitrogen and phosphorus.

Once nutrients enter the lake the sediment and macrophytes provide a store which under specific conditions can release nitrogen and phosphorus to the water column. Water lilies, as an herbaceous succulent plant, proved to be a highly effective nutrient sink and potential recycler.

Ecological assessment indicated that the Lake is under stress. There are very few aquatic animals from higher trophic levels with most organisms being pollutant tolerant. This may be a result of bio-accumulation of toxicants concentrating up the food chain. Predation from exotic introduced fish such as *Gambusia* and Carp may also have contributed.

The Lake is well stratified in the deeper sections towards the dam wall allowing nutrients to enter the bottom waters under anoxic conditions. The annual lake overturn brings these nutrients to the surface where they become available for plant and algal growth. The anaerobic conditions in the sediments also produced sulphides and methane when disturbed.

Analysis of the catchment runoff and water quality indicates that the average annual loads of pollutants entering the lake are likely to be of the order of:

- Sediments 230 tonnes
- Total nitrogen 4,400 kg
- Total phosphorus 460 kg

## 2.3 Pathogens

Monitoring of Lake Parramatta indicates that its suitability for recreation is poor for activities such as swimming (due to high levels of pathogens, algal slimes and water clarity). Secondary contact activities such as boating are also impaired by obstruction from macrophytes. Storm flows were found to contribute substantial levels of faecal organisms (which may include human pathogens). Within the Lake, waterfowl are probably a major contributor of faecal coliforms and may also be adding to nutrient concentrations. The presence of litter also detracts from the aesthetic appeal of the Lake.

Sydney Water has undertaken both dry and wet weather sampling for coliforms as part of the Stormwater Monitoring Project. There is only one sewer overflow point upstream of Lake Parramatta that drains into Hunts Creek just upstream of the lake (via Manhole No 820631). Sewer overflow volumes and rates for this overflow have been estimated by Sydney Water (1995) and are summarised in Table 1. Sydney Water also estimated overflows that would occur in the year 2021, but these flows are very little different from those in Table 1. For purposes of estimating pathogen loads resulting from sewer overflows, the concentration may be assumed to be 2 million cfu/100 mL.

**Table 1**  
**Estimated Sewer Overflows in the Lake Parramatta Catchment**

Parameter	Average Recurrence Interval				
	10 years	2 years	1 year	6 months	3 months
Overflow Volume (m <sup>3</sup> )	11,000	460	90	20	0
Peak overflow rate (L/s)	390	35	12	4	0

## 3. MODELLING OF LAKE BEHAVIOUR

### 3.1 Lake Characteristics and Inflows

The dynamics of the lake are determined by the inflows, the topography of the lake bed and the dam wall that forms the downstream boundary. For this study the topography of the lake bed was derived from a recent detailed hydrographic survey of the lake.

Figure 1 shows the lake bathymetry, the location of the main inflow points and reference locations for assessing the water quality of the lake (see Section 2.6 below). The main inflow from Hunts Creek enters the top end and a smaller local creek lake, referred to as Kings School Creek, enters from the east. Hunts Creek accounts for about 87% of the total inflow, while Kings School Creek only contributes 6%. The remaining 7% of the total inflow occurs as runoff from the immediate catchment draining directly into the lake itself by means of a number of diffuse locations. For modelling purposes, creek flows were characterised by a series of runoff storm events as well as daily flow estimates over 17 years derived from modelling undertaken by the Upper Parramatta River Catchment Trust (UPRCT).

### 3.2 Water Quality Criteria

The water quality in Lake Parramatta can be assessed in terms of two key environmental indicators: nutrients and coliform bacteria. The nutrients are responsible for the eutrophication of the lake, whereas the coliform bacteria are indicators for the human health risk associated with using the lake for recreational purposes. The various NWQMS criteria for assessing the water quality of the lake are set out in Chapter 1 above and are:

- Primary contact recreation <150 cfu/100 mL.
- Secondary contact recreation <1,000 cfu/100mL
- Chlorophyl-a 2-10 µg/L.
- Secchi depth 1.6 m.

### 3.3. Pollutant Inflow Sources

The hydraulic modelling of Lake Parramatta took account of four primary sources of runoff and pollutant loads, three of these being treated as point source inputs to the lake.

1. A sewer overflow structure, located near the top end of the lake, which discharges diluted sewage during wet weather events into the relatively shallow upper end of the lake.
2. Hunts Creek, which is the primary source of urban runoff that has lower concentrations of coliforms than the discharged overflow but because the volume of runoff is much larger, the urban runoff can be the major source of nutrients and toxicants.
3. Inflow from Kings School Creek.
4. Runoff from the lake catchment itself which is directed into the lake through an unknown number of smaller inflows around the lake.

### 3.4 Modelling Methodology

Different modelling approaches have been used to analyse the impacts of nutrients and coliform bacteria.

- Faecal Coliform levels in Lake Parramatta have been examined in terms of the impacts of storms of different sizes. This approach accounts for the lake processes following heavy storms that provide episodic inputs such as sewage overflows and flood flows from the catchment. These inputs provide infrequent loads to the Lake which can be assigned frequencies of occurrence.
- The eutrophication of the lake was analysed using 17 years of mean daily flows and nutrient concentrations entering the lake.

### 3.5 Storm Events

For coliform modelling purposes it is necessary to provide an inflow hydrograph and pollutant loading which reflects the contributions of both the urban catchment and any sewer overflows.

The daily time series of runoff from the catchment generated by the RAFTS model developed by UPRCT was analysed to identify the daily peak flows corresponding to the storm events chosen for analysis of coliform loading and decay. The observed concentration of coliforms in Hunts Creek were assumed to be representative of runoff from the catchment. The sewer overflow volumes and quality were taken from Sydney Water (1995) which was the source of the data presented in Table 1. Table 2 below summarises the inflows to the lake from these two sources for five different storm events with average recurrence intervals (ARI) ranging from 3 months to 10 years.

**Table 2**  
**Characteristics of Selected Storm Events**

ARI	Mean Daily Runoff (m <sup>3</sup> /s)	Sewer Overflow Volume (m <sup>3</sup> )
3 months	1.4	0
6 months	2.4	20
1 year	4.2	90
2 years	7.7	460
10 years	20.1	11,000

### 3.6 Coliform Levels in Lake Parramatta

The impact of coliform bacteria loads on the lake was assessed using the computer based MIKE21 hydraulic and water quality program. The model of the lake is a two dimensional model which takes account of the surveyed bathymetry, wind stress and the boundary formed by the dam wall. The model assesses the effect of flow patterns and mixing on the redistribution of coliforms within the lake and the subsequent die-off.

The coliform levels were assessed by modelling the distribution and die-off of coliforms throughout the lake for the five selected storms. This analysis assumed that the observed levels of coliforms in Hunts Creek are representative of urban runoff entering the lake. Model results from three representative sites (locations shown on Figure 1) have been extracted to illustrate the water quality effects on the lake:

1. The "Upper" location represents the upper, northern part of the lake. The area is located south of the inflow from Hunts Creek and the sewer overflow, where the depth begins to increase as shown on Figure 1. This part of the lake is very shallow and, because there will be minimal dilution at this point, the water quality will be most directly affected by the inflows.
2. The "Southern" location at the southern end of the lake, which is not expected to be the main recreational area, but which is nevertheless likely to attract some people.
3. The "Main" location is close the dam wall and is expected to be the main area for recreational activities.

The impact of coliform levels can be described by the number of hours per year that the recreational guideline criteria (described in Section 3.2 above) are not met. The data shows that a storm which could occur once in three months could lead to coliform levels above the safe level for primary contact recreation for about three days near the dam wall. A storm occurring once in two years on average would cause coliform levels to reach a peak of about 50,000 cfu/100 mL and would be above the safe level for primary contact recreation for over five days.

Table 3 summarises the hours that coliform levels would be above the safe levels for primary and secondary contact recreation as a result of each of the five storms considered. The final column shows the hours per year, expressed as a long term average annual value, from all storms. It can be seen that the total time for which each criterion will not be met is lower towards the dam wall.

The modelling shows that the upper reaches of Lake Parramatta are significantly affected by the inflow from Hunts Creek and the sewer overflow. This area of the lake is likely to be unsuitable for swimming for up to nine days following rain. The southern area of the lake is equally affected and swimming cannot be recommended for up to seven days following rain. On the other hand, the main part of the lake is unsuitable for swimming for up to six days following heavy rain and for up to three days following a moderate storm which could be expected to occur once in three months on average.

**Table 3**  
**Time for which of Coliform Levels Exceed Criteria**

### Assuming Urban Runoff and Sewer Overflows

(P-primary contact criteria, S-secondary contact criteria)

Storm Frequency (ARI)	Hours per storm when criteria are not met										Average	
	10 Year		2 Year		1 Year		6 Month		3 Month		Annual Total	
	P	S	P	S	P	S	P	S	P	S	P	S
Upper	205	164	202	161	156	115	187	145	170	129	4,800	3,700
Southern	179	132	172	127	134	90	147	94	142	87	4,000	2,500
Main	144	93	130	81	107	58	107	45	78	-	2,300	180

Table 4 presents results for a similar analysis assuming no sewer overflow occurs. The analysis shows that while the peak concentrations of coliforms are reduced, the total hours for which the two recreational criteria will not be met is much the same as the first case.

**Table 4**  
**Time for which of Coliform Levels Exceed Criteria**  
**Assuming Urban Runoff Only**

(P-primary contact criteria, S-secondary contact criteria)

Storm Frequency (ARI)	Hours per storm event when criteria are not met									
	10 Year		2 Year		1 Year		6 Month		3 Month	
	P	S	P	S	P	S	P	S	P	S
Upper	203	163	202	162	154	113	181	140	170	129
Southern	177	133	172	126	126	83	143	94	142	87
Main	143	93	124	75	98	48	93	44	78	-

The results in Table 4 are based on the assumption that the coliform concentrations monitored in Hunts Creek as part of this study represent the concentration in catchment runoff and were not affected by sewer overflow on those occasions. This appears to be likely because high coliform levels were also monitored in Kings School Creek which has no sewer overflow point in its catchment.

The data in Table 3 indicates that the criteria for primary contact recreation will not be met for 26% of the year (95 days) in the main part of the lake near the kiosk, 47% of the year (170 days) in the southern part and 55% of the year (200 days) in the upper area near the inlet from Hunts Creek. The secondary recreation contact criteria will not be met 2% of the year (8 days) in the main part of the lake, 29% (105 days) in the southern part and 42% of the year (155 days) in the upper part of the lake.

### 3.7 Nutrients and Eutrophication

Since the time scales for nutrient buildup in the lake and potential algal blooms is much longer than for coliform levels, a simpler model can be used for eutrophication analysis. A simple MIKE11 model was set up to simulate the lake hydraulics and eutrophication based on analysis of daily inflow to the for a 17 year period. This model takes into account the flushing behaviour of the lake due to inflows, but does not account for variability in concentrations of nutrients along the length of the lake.

Because no algal dynamics studies have been undertaken to allow calibration of the model, the parameters were chosen based on experience in other Sydney waterways. Predicted loads of

total nitrogen, inorganic nitrogen, total phosphorus and suspended solids were available, which were suitable for undertaking a broad assessment of the potential for algal growth over the 17 year period of inflow data.

The results of the eutrophication analysis may be summarised in terms of the proportion of time when the chlorophyll-a levels are above 10 µg/L (a typical indicator of bloom conditions). The results show that these levels can be expected to occur about 40% of the year (150 days) on average and to occur most of the time in summer. The occurrence of conditions in which chlorophyll-a levels would be above 10 µg/L can vary depending on seasonal conditions and, for the 17 years analysed, it ranges from 20% to 70% of the time (75 – 250 days).

### 3.8 Sediment and Nutrient Retention

Much of the water quality problem with the lake occurs because it acts as an efficient nutrient and sediment trap. No long term detailed studies have been undertaken into the overall trapping efficiency of the lake, but the modelling of chlorophyll-a levels indicates that current nutrient inputs are likely to sustain high algal growth for a significant proportion of the year. A further indication may be gained from recent studies into the effectiveness of other waterbodies at trapping sediments and nutrients.

The NSW EPA (1996) presented a summary of data derived from studies of water quality control ponds and lakes in NSW and the ACT including work by Lawrence (1986), Constandanopoulos and Clark (1996), and unpublished data from the Department of Land and Water Conservation. The results of that analysis were presented in the form of relationships between the mean hydraulic residence time (HRT) of the lake and the percentage of the pollutant retained.

Duncan (1997) carried out a statistical analysis of published performance of wet retention basins and small lakes from throughout the world. His analysis indicated that the ratio of water area to total catchment area is the best measure of basin size for predicting water quality change in a storage. The analysis also indicated that the second most important predictor of water quality change is the average input concentration of the pollutant concerned.

Table 5 summarises the predicted performance of Lake Parramatta based on these two generalised sets of data using the catchment and lake data set out in Section 2.1. An analysis of the sequence of daily inflows into the lake (as used for the modelling described in Section 3.5) indicates that the long term flow weighted average hydraulic residence time of water in the lake is about 50 days.

The data presented in Table 5 indicates significant differences in the estimated retention in the lake, depending on the method used. Nevertheless, the estimated mass of sediments and nutrients are substantial and are indicative of the available supply of nutrients for algal and macrophyte growth. To put these quantities into perspective, the same area (10.5 ha) of a well farmed irrigated crop of maize receiving the optimal amount of fertiliser would produce about 150 tonnes of dry matter and take up about 1,700 kg of nitrogen and about 370 kg of phosphorus. The estimated annual quantities on nutrients entering the lake are comparable to the nutrient utilisation by such a highly productive agricultural crop. This indicates that the nutrient inputs are sufficient to maintain a high level of algal and plant production in the lake.

**Table 5**  
**Indicative Pollutant Loads Retained in Lake Parramatta**

Parameter	Analysis Based on EPA Data		Analysis Based on Duncan's Data	
	% Captured	Mass Retained (kg/y)	% Captured	Mass Retained (kg/y)
Suspended Solids	98%	248,000	67%	171,000
Total Phosphorus	70%	360	40%	200
Total Nitrogen	59%	2,900	22%	1,100

## 4. MANAGEMENT OPTIONS

### 4.1 Water Quality Targets

The data summarised in Chapters 2 and 3 indicates that the water quality status of the lake may be summarised as:

- Near the dam wall, bacteria levels that would make the water unsuitable for swimming are likely to occur on about 95 days per year. The occasions on which the water is unsuitable for swimming are likely to be spread throughout the year, not just the summer months. The main sources of bacterial inputs appear to be:
  - Sewer overflows,
  - General catchment runoff.
  
- Sufficiently high nutrient loads enter the lake to give unacceptable chlorophyll-a levels for about 150 days per year. These conditions are most likely to occur in summer. In addition to the water quality problems associated with inflows from the catchment, the lake sediments provide an additional source of nutrients that, at certain times of the year, could contribute to algal bloom conditions. Any attempt to reduce the occurrence of potential algal bloom conditions would need to address both of the main sources:
  - Catchment runoff,
  - Lake sediments.
  
- The main aesthetic problems appear to be associated with poor water clarity and the occurrence of floating weeds. These problems are largely a function of the nutrient status of the lake and would improve if the nutrient inputs could be reduced. Litter and floating oil do not appear to be significant issues except in the immediate area of the kiosk.

The stated water quality objective for Lake Parramatta is that it should meet the NWQMS criteria for primary contact recreation, environmental protection and visual amenity during dry weather (defined as less than 10 mm of rainfall during 24 hours). This objective will require that all water quality objectives are met on about 340 days per year which are defined as “dry weather” (on average, 27 days per year have in excess of 10 mm of rainfall). The required reduction in the number of days per year when water quality objectives are exceeded are summarised in Table 6.

**Table 6**  
**Estimated Current and Proposed Targets for Water Quality**

	<b>Current Exceedance (days/year)</b>	<b>Proposed Exceedance (days/year)</b>	<b>Required Reduction (days/year)</b>
Primary contact recreation	95	27	68
Ecosystem protection	150	27	123

**These indicative reductions in the time when water quality criteria are exceeded are not trivial, and will only be achieved with substantial and sustained changes within the catchment.**

There is a wide range of possible actions that could be taken to improve water quality in Lake Parramatta. Because the poor water quality occurs as a result of a number of causes, it is likely that a multi-faceted approach will be required. It also appears that any strategy to achieve the stated water quality goals will need to be implemented in stages over a number of years. The sections below outline a range of measures that might be employed to tackle particular issues. Chapter 5 sets out a plan and timetable for implementing an integrated overall strategy.

## 4.2 Principles

With the exception of the lake sediments and sewer overflows and leakage, the causes of poor water quality lie in diffuse sources throughout the catchment rather than clearly identifiable “point” sources of pollution. Such diffuse sources are much more difficult to control and will require a long sustained campaign to achieve the stated goals.

In general, the reduction in pollutants is best achieved by controlling the source of pollutants and developing processes to trap these at the times of highest concentrations. Any overall stormwater quality management strategy should be based on these principles:

1. Keep pollutants out at the start. Even in cases of diffuse inputs from a catchment, there will be a few sources which are likely to give higher pollutant loads than other areas. It is much easier to deal with pollutants in a small volume of water at their source rather than to try to separate them from a large volume of water later.
2. It is often not practical to treat the entire volume of runoff from a storm. Under these circumstances it is preferable to capture and treat a “first flush” of runoff, particularly from sealed surfaces such as roads and roofs.
3. Use a “treatment train” approach to reducing pollutant loads rather than expecting a single treatment system to reduce all forms of pollution.

Control methods that can be implemented to reduce pollutants entering or discharging from the drainage system may be conveniently grouped as “structural” and “non-structural”. Best practice indicates that prevention (non-structural) is the most cost effective control but, in reality, a combination of non-structural and structural control methods are required to achieve the necessary improvement in stormwater quality.

### 4.2.1 Non-Structural Controls

Non-structural controls are based on prevention and reduction of pollution and stormwater flows at or near the source. These controls are the “first line of defence” and include such practices as:

- **Land use planning and management,**

These measures are generally most applicable at the development stage within the catchment, but are equally applicable during re-development. Such measures involve the imposition of appropriate conditions of development to ensure that the appropriate water quality targets are achieved. In the case of the catchment draining to Lake Parramatta, this might include the requirement that any new development is at least “nutrient neutral”. In cases where space is available, it might be possible to offer a rebate on S94 contributions in exchange for a reduction in pollutant loads leaving a development site. Even where the existing development remains,

there are opportunities for Council to encourage landholders to reduce nutrient loads by offering a rebate on Council rates.

- **Floodplain and riparian zone management**

The floodplain and riparian zones are in direct contact with the creek system and represent the area, which most directly affects water quality. These areas are, therefore, ones, which should be given greatest attention in terms of ensuring that pollutant sources are limited. Conversely, they also provide an area, which can be used to provide a buffer zone between the main land uses in the catchment and the creek system. In order to facilitate the functioning as a buffer, the riparian zone and floodplain should be subject to minimal disturbance compared to the natural state.

- **Public education**

The community at large is generally ignorant of the fate of nutrients and sediments entering the stormwater system or the impacts of those pollutants on the creek or lake receiving waters. In recent years Councils in NSW have developed a variety of approaches to making the public better informed including:

- "Phosphorus awareness" and "sediment awareness" brochures issued with rates notices (eg Albury-Wodonga and Tuggerah Lakes phosphorus action campaigns).
- Signposts at creek crossings identifying the water body to which the creek drains.
- Labelling of roadside stormwater inlet pits to identify where the stormwater is discharged.
- More stringent controls requiring pet owners to clean up and dispose of "pet poo".

- **Control of application of fertiliser and pesticides**

This measure can be implemented both through a public education campaign as well as through Council's own actions on its own lands. In particular, it is common to have sports fields and golf courses located on flood prone land or land adjacent to a creek. A detailed audit and review of Council's fertiliser application rates on sports fields will help focus attention on whether application rates exceed the requirements for plant growth.

- **Control of solid waste collection and disposal**

Poor housekeeping during collection of refuse from domestic and commercial premises is a common source of stormwater pollution. Minimising the spillage of refuse is relatively easy to achieve and extremely cost effective.

- **Street cleaning**

Much of the general diffuse urban pollution finds its way into the stormwater system via runoff from street surfaces. These pollutants may be due to poor refuse handling, vehicle deposits on the road and careless disposal of rubbish by residents. The problem can be alleviated by more regular street cleaning (further defined in Section 4.5.6) which aims to remove any accumulated refuse before it is washed into the stormwater system. Particular types of street sweeping also have the potential to remove particulates that can carry a high load of nutrients.

- **General good house keeping on construction sites and other operational activities**

Council can contribute to minimising pollutants loads reaching the stormwater system by good management of its own operations and control of all construction activities. These measures include adequate control of sediments from construction sites by means of silt barriers, diversion banks and sedimentation dams. Such good housekeeping extends to road and footpath repairs, mowing and vegetation management.

- **Enforcement of Council regulations**

Although Councils usually have an array of by-laws dealing with a wide range of activities which lead to stormwater pollution, the policing and enforcement of these by-laws is not usually sufficiently thorough to provide a powerful deterrent.

#### **4.2.2 Structural Controls**

Structural control methods, which support non-structural controls, can be very effective at preventing pollutants being carried further into the drainage system. However, these methods are generally more costly to construct and require regular maintenance to ensure they function satisfactorily. Structural control methods fall into two broad groups:

- Methods to reduce the volume of runoff and thereby reduce the pollutant loads.
- Methods to trap and retain particular pollutant types.

Table 7 (adapted from EPA, 1996) summarises the main water quality control features of a range of treatment methods. It can be seen that the range of methods to treat both nutrients and pathogens is limited, and that such methods usually require pre-treatment (removal of litter and sediments) to be effective. For Lake Parramatta there are also a range of possible management activities which deal with the symptoms rather than the causes. Such activities include control of aquatic weeds by harvesting or spraying, control of algae by chemical means and stabilising or removing the lake sediments.

In the sections below, a range of structural and non structural control measures are reviewed in the context of the two main issues facing Lake Parramatta, namely pathogen and nutrient control.

### **4.3 Community Monitoring and Awareness**

One of the key issues underlying any stormwater management plan is the need to gain community understanding and support. Without such support and the necessary changes in day to day behaviour, no amount of action by Councils can hope to adequately tackle the issues of pollution reduction on the scale that needs to be achieved for Lake Parramatta. In other catchments in Sydney a successful strategy for better defining the pollution sources in the catchment as well as increasing awareness in the community has been the development of a "Community Monitoring Program". Based on a currently operating program in the Berowra Creek catchment to the west of Hornsby, such a program for the Lake Parramatta catchment would have the following aims:

- identify sources of nutrients, pathogens and other pollutants impacting on Lake Parramatta.
- identify relationships to rainfall and seasonal factors
- involve the local community in encouraging ownership and control of pollutants at source.
- provide information that will increase awareness and values of natural local environments.
- provide information to assist land managers (including both Councils and Trust) in catchment management.

**Table 7**  
**Selection Guide Matrix for Stormwater Treatment Measures**

Treatment measure	Pre-treatment Required	Primary treatment function(s)						
		Litter	Coarse Sediment	Fine Sediment	Nutrients	Oxygen Demand	Hydro-carbons	Pathogen s
Litter basket		◆						
Litter rack		◆						
Litter boom		◆						
Continuous deflective separator		◆	◆					
Catch basin			◆					
Water quality inlet			◆				◆	
Buffer strip			◆					
Sediment trap			◆					
Gross pollutant trap		◆	◆					
Extended detention basin	◆		◆					
Wet basin	◆			◆	◆	◆		◆
Extended detention wet basin	◆			◆	◆	◆		◆
Constructed wetland	◆			◆	◆	◆		◆
Infiltration trench	◆			◆	◆			
Infiltration basin	◆			◆	◆			
Porous pavement	◆			◆	◆			
Sand filter	◆			◆	◆			

(Source: EPA, 1996)

The program would use community volunteers to collect samples and data from the Hunts Creek system. Water samples would be collected and analysed for nutrients, suspended solids and pathogen indicators in a NATA registered laboratory. Field measurements using a portable probe meter would be used to monitor dissolved oxygen, conductivity, temperature, turbidity and pH. Macroinvertebrates and algae would be collected and identified. Volunteers would also record observations of water clarity, foams, rubbish etc. The analyses would be undertaken using more sophisticated methods than those used in the "Streamwatch" program but would be complementary to it. The project would include a regular newsletter and a final report. Display material would be developed for use in schools, at shopping centres and at Council library.

An indicative budget for an intensive 10 month program on Hunts Creek, including a part time co-ordinator, a technical consultant, the required analyses at an NATA registered laboratory and the publication of a newsletter would be of the order of \$45,000. The expected outcome from such a program would be:

- Increased community awareness of the source and fate of pollutants in stormwater drainage.
- A much better picture of the location and nature of diffuse sources of pollution within the catchment.

## **4.4 Pathogen Control**

### **4.4.1 Sewer Overflow**

On the basis of the available data it is difficult to determine the precise contributions to pathogen levels in the Lake made by sewer overflows or diffuse urban runoff. The modelling analysis suggests that, with current pathogen inputs from the catchment, the main effect of sewer overflows will be to increase the maximum coliform levels in the lake, but have only a minor effect on the total time for which conditions are unsuitable for primary contact recreation. On the other hand, any attempt to reduce inputs from the catchment would not produce the required benefit unless the sewer overflow was significantly reduced in frequency, or preferably eliminated completely.

Even though works to reduce or eliminate sewer overflows would not necessarily solve the problem, such works would be an important signal to the wider community that a serious attempt is to be made to achieve the community's goals for Lake Parramatta. Without that signal, the community are likely to regard efforts to reduce catchment inputs cynically.

The costs of reducing or eliminating sewer overflows are unknown. Any costs associated with such a program should be attributable to Sydney Water not the Council or local community. The main difficulty is likely to be that, for Sydney Water, the overflow near Lake Parramatta is of lower priority than a number of other larger overflows. Sydney Water should be approached to make this a priority in their current overall program to reduce sewer overflows throughout Sydney.

An alternative approach would be to utilise a high rate filtration and disinfection system to treat both dry weather flows in the creek and a large proportion of any sewer overflow. A number of technologies have been developed in Europe and North America for the removal of solids and faecal contaminations from stormwater and sewage overflows.

The dominant feature of these technologies is their capacity to treat high instantaneous flow rates in a compact, cost effective plant. Typically this system comprises a 3-phase treatment, the first being litter and coarse solids removal, followed by high rate, fine filtration and finally disinfection. All this is achieved in a very compact plant because of the high rate at which the water is treated. Normally the plant will be located underground to maximise visual amenity.

One such system, which is representative of the system proposed for Hunts Creek downstream of Bettington Road, is the HealthGuard® system which has been operating as a demonstration facility for nearly 2 years at Columbus, Georgia, USA. The demonstration facility at that site has been largely funded by the US EPA to demonstrate the effectiveness of treating combined storm flows as an alternative to transporting or storage options. The components of the Columbus plant include a vortex separator, a compressible fibre media filter, and UV disinfection. Test results have indicated very high levels of solids removal and disinfection achieved over the extended operating trials.

The system is readily scalable to treat any flow. Many areas suffer from dry weather flows in storm drains, which are highly contaminated with faecal matter from sewer exfiltration. The system can effectively treat this dry weather flow to remove faecal contamination, and capture and treat the usually highly contaminated first flush of any storm flow.

An indicative cost for a high rate filtration and disinfection system to treat dry weather flow and sewer overflow is \$1.5 million capital cost plus an annual operating and maintenance cost of \$30,000.

#### 4.4.2 Diffuse Runoff

The monitoring of inputs to the lake and of bacteria within the lake have indicated that there are significant sources of pathogens within the catchment. At this stage it is not clear whether the sources are primarily human (from leaks in sewers) or animal (pets and livestock).

None of the routine bacterial indicators can, on their own, effectively distinguish different sources of warm blooded faecal pollution. Studies using the biochemical markers, coprostanol, have been able to reveal sources of faecal contamination. Catchments with little human influence have shown that up to 90% of contamination in a waterway can come from birds (Bate et al 1996). In the Hunts Creek system there would also be inputs from pets and livestock as well as possible sewer leaks.

Further sampling and analysis of bacteriological quality in both dry and wet weather should be undertaken to:

- Distinguish the relative importance of human and animal sources.
- Locate the general area where these inputs are occurring.

If the origin is found to be primarily human, then the presumed source is likely to be sewer leakage or unrecorded sewer overflows. In either case, Sydney Water should be requested to investigate and rectify the problem.

If the problem is found to be primarily animal, then the testing should indicate the general area of the catchment where major inputs occur. Such information could then be used to target a program to reduce particular animal inputs. Regardless of the need to target any particular location or land use class, there are a number of actions that should be taken immediately:

- Community education about the pathogen problems in Lake Parramatta and encouragement to clean up "pet poo". This campaign could be run by Council and involve the preparation of

a simple brochure for distribution to residents throughout the catchment. Signs in local parks where pets are exercised should also be considered. These signs could simply remind users of the park where the stormwater ends up and invite residents to drop in for a swim on a summer's evening!

- Promotion of stringent controls on food and putrescible wastes spillage, particularly at commercial outlets including the kiosk adjacent to the lake. There is no specific evidence which points to this source in the catchment but investigations in other catchments indicate that very high bacterial levels are found in stormwater systems:
  - At the front of fast food outlets (presumably from discarded food scraps and the birds attracted to them).
  - At the rear of food establishments where spillage of wastes has occurred in uncovered or unprotected areas.

A visual audit by Council of the area around major food outlet locations followed by guidance to the shop owners could be achieved at very little cost. Council could consider a code of best practice for food retail outlets which would set out a range of measures to control food wastes on the footpath or carpark, discourage bird scavengers and ensure that putrescible waste spillage cannot enter the stormwater system. Auditing by Councils has been successfully attempted by Warringah Council in an industrial area (Anthony, 1995). A methodology for the undertaking of catchment audits is outlined in Sydney Coastal Councils (1992).

- Encourage and assist The Kings School to develop an integrated stormwater management strategy for their land, with a view to minimising both pathogen and nutrient runoff. Special precautions should be taken to manage runoff from those areas where livestock are kept. The most cost effective strategy would probably be to capture and store runoff to use for irrigating the grounds and sports fields.
- Alternatively, the school sports fields could be equipped with an intensive network of sub-soil drainage. The sports fields could then be used as a large filter system to treat irrigation water pumped from Lake Parramatta. Such a scheme would, however, need to be thoroughly researched in terms of the overall water balance to ensure that in the process of improving water quality it did not significantly reduce Lake levels.

Indicative initial costs for the activities outlined above are:

- |  |          |
|--|----------|
| • Community education and "pet poo" control campaign                                   | \$5,000  |
| • Further sampling and analysis for pathogens (10 months)                              | \$45,000 |
| • Audit of retail food outlets and preparation of 'good practice' guidelines           | \$2,000  |
| • Assistance to Kings School for development of a stormwater management strategy (say) | \$5,000  |
| • Investigation of applicability of sports field irrigation and drainage scheme        | \$10,000 |

Ongoing costs for maintaining public awareness would need to be carried by Council as part of its normal activities. Any capital and operating costs for stormwater management or irrigation systems installed at the Kings School would need to be financed by the School itself.

#### 4.4.3 Sewer Leaks

The currently available monitoring data indicates that there are substantial bacterial inputs from the catchment. The relative contributions from various possible sources are unknown and can only be determined by further monitoring and analysis (as outlined in Section 4.4.2 above). Nevertheless, based on other investigations in catchments around Sydney, it is likely that leaks in the trunk sewers, illegal cross connections or blocked household sewer connections occur within the catchment (Sydney Water, 1994). An ongoing campaign over several years will be required to track down and rectify such problems.

Sydney Water should be encouraged to undertake a catchment wide program of inspections and checking of the sewer network as well as assisting in ongoing monitoring to identify the sources of bacteriological inputs. This work could further reinforce any checking that Sydney Water has undertaken to eliminate illegal connection of stormwater to the sewer system.

In the meantime, the high rate filtration system proposed for Hunts Creek would provide a significant reduction in pathogen levels from these sources reaching Lake Parramatta.

#### **4.4.4 Manage the Waterfowl**

Modelling results for faecal coliforms in Lake Parramatta show an underestimate for values predicted near the dam wall. As the program modelled decay of faecal coliforms derived from the major inflows, this implies that another source of faecal bacteria is influencing measured results. The discrepancy is particularly evident in dry weather. A likely source of these bacteria is faeces from the large number of ducks and geese that frequent the water near the dam wall.

It is not known whether faecal material from these birds poses a health hazard to humans. The fact that dry weather concentrations of faecal coliforms exceed guidelines for primary recreation, indicate that the water cannot be recommended for primary contact recreation, particularly in the shallow area most likely to be used by small children.

In order to meet the goal of providing quality suitable for swimming, it would be highly desirable to develop a strategy to remove the waterfowl from the foreshores area near the kiosk, and to discourage their return. A key part of such a strategy would be a campaign to:

- strongly discourage the public from deliberately offering food to the birds (reminder signs).
- provide adequate size rubbish receptacles with suitable lids to discourage foraging by birds.
- encourage the public to discard rubbish into the bins provided (appropriate signage)

The costs of such measures are difficult to estimate and should be largely taken up as part of the future management of the reserve.

## 4.5 Eutrophication Control

Any attempt at controlling eutrophication in Lake Parramatta will need to address both the store of phosphorus within the lake sediments as well as the diffuse sources contributing to the load entering the lake. Neither action will be successful without the other. In practice, the elimination of all significant diffuse sources of nutrients in the catchment is likely to require an ongoing program over a number of years. On the other hand, the treatment of lake sediments to remove or immobilise the phosphorus in the lake sediments could be achieved with a "one off" set of actions. Such a "one off" set of actions would have the added advantage of providing a strong signal to the community of the resolve of the Councils and UPRCT to achieve some significant improvements in water quality. Without such a signal any efforts to significantly reduce diffuse catchment sources might be treated with a degree of cynicism by the community.

A range of possible measures to address both the lake sediments and diffuse catchment sources of nutrients is outlined below.

### 4.5.1 Stabilising or Removing the Lake Sediments

Sediment analysis of the lake during this study showed that sediments are a significant storage location for phosphorus and nitrogen. This was also reflected in Dolman's analyses (Dolman 1987). While the analysis also showed that stormwater inputs are sufficient to maintain unacceptable levels of algal growth, any long term strategy to control water quality would also need to remove or immobilise the nutrients in the sediments.

A number of ways of achieving this have been canvassed and a scoping study has been undertaken into a proprietary method of immobilising the nutrients (see Appendix A). The options and some of the considerations associated with each are:

#### ***Dredge Sediments***

It is difficult to estimate the total volume of sediments that would need to be dredged from the lake. Based on the originally stated storage volume (590 ML) and that measured by a recent survey (485 ML), the lake appears to have lost about 105 ML of storage which would equate to about 130,000 tonnes of wet sediment which would need to be removed. The removal of such a quantity would give rise to a number of practical difficulties:

- The presence of heavy metal contaminants in the sediments mean that there are likely to be problems in disposal of the dredged material unless the contaminants are chemically immobilised.
- Any proposal to drain the lake for the purposes of sediment removal is likely to require careful consideration to the effect of the discharged water on the downstream environments in Parramatta River and Sydney Harbour (Port Jackson). It is likely that draining the lake would convey a substantial quantity of sediments, from the bottom as the water was drained. Because of these threats it might require some kind of environmental assessment (Environmental Impact Statement or a Statement of Environmental Effects) to be undertaken in order to allow draining to occur.
- There is no alternative route for stormwater runoff to bypass the lake if it was drained. This would mean that the sediment removal operation would have to occur with the constant threat of the lake refilling.

- It would probably be impractical to allow the sediments to dry out before being transported off site (as has been done with sediment removal from Tuggerah Lake). This would make transport and disposal of the sediments difficult and expensive.
- If the operation was carried out from a barge, it is likely that a significant quantity of sediment would be disturbed in the process and this could, itself, remobilise both nutrients and heavy metals.

Given the unique constraints and conditions associated with removal of sediments from Lake Parramatta, such an operation is unlikely to be achieved at a cost (including disposal) of less than \$100 per tonne. At this rate, sediment removal would cost of the order of \$1.3 – 1.5 million.

***Fixing of Nutrients in the Surface Sediments***

The option of chemical fixing of the sediments in-situ has merit because it would overcome the problems associated with draining the lake. It may be possible to use gypsum or lime to fix phosphorus in a more stable form, but further work would be required to determine the most effective chemical to use and the mode and quantity of application.

***In-situ Treatment by “Limnofix” Process***

The “Limnofix” process involves injection of calcium nitrate at a concentration of 1-2 mg/L into the top 200 mm of sediments. A preliminary appraisal of the applicability of this technology to Lake Parramatta has been undertaken by McConnell Consulting (see Appendix A). That appraisal indicated that there did not appear to be any significant physical or chemical constraints to the use of the process at Lake Parramatta. The process would probably achieve a reduction of nutrients by 80% and is claimed to reduce phosphorus levels to such a degree that algae would not grow. One of the claimed advantages of the process is that it is completely benign to the lake environment and would not affect animals or plants.

The preliminary appraisal suggested the following timetable and indicative budgets for pursuing this option:

- |   |               |
|---|---------------|
| • Sediment sampling and bench testing (6-8 weeks) | \$28,000      |
| • Visit by Canadian expert (early 1998)           | \$15-20,000   |
| • In-situ treatment (mid 1998)                    | \$130-180,000 |

**4.5.2 Lake De-stratification**

Lake Parramatta is a thermally stratified reservoir that is thought to overturn once a year. When it is stratified, little mixing occurs between the surface and bottom layers. This causes low oxygen conditions to develop in the lower layers and facilitates the release of phosphorus from sediment stores into the water column. When the reservoir overturns, usually in autumn, there is a mixing of layers and nutrient rich bottom waters are brought to the surface with the potential for algal blooms or stimulation of floating aquatic plants.

To overcome the effects of ‘overturn’ many reservoirs and lakes are artificially destratified (eg Myponga Reservoir in South Australia, Chaffey Dam in NSW) continuously or during problem periods. The two main means of destratification used in Australia are mechanical means (a

large propeller mixer) or pneumatic means (a bubble aerator). Mechanical means breaks the stratification by stirring (Stephens and Imberger, 1993) and pneumatic means breaks the stratification by releasing air into the water column, the bubbles then entrain waters from depth to the surface (Asaeda and Imberger, 1993).

Australian Water Technologies (AWT) provided indicative costs for installation of a de-stratification system in Lake Parramatta (I. Fisher pers comm). AWT recommended that a propeller system would be more cost effective in a small reservoir the size of Lake Parramatta. A similar system is used in Manly Dam, a small recreational impoundment on the northern beaches of Sydney.

A bubble plume system is considered more cost effective on larger reservoirs.

Indicative cost estimates for a propeller system suitable for Lake Parramatta are:

- |  |          |
|--|----------|
| • Installation including power supply and controls | \$35,000 |
| • Annual power costs                               | \$1,000  |
| • Annual removal for inspection and maintenance    | \$3,000  |

#### 4.5.3 Sewer Leaks and Overflows

The question of dealing with possible sewer leaks and the overflow, has been dealt with in Section 4.3 above. Although the reduction or elimination of such inputs is likely to have most benefit in terms of the bacteriological quality of the lake, they would also have a secondary benefit in reducing nutrient inputs.

#### 4.5.4 Parks, Sports fields and Recreation Areas

The Lake Parramatta catchment is less urbanised than many other catchments in Sydney because it has almost 45% that is not developed for residential purposes. Whilst some of this land is devoted to schools there remains a substantial area of open space, including the foreshore reserve around the lake and the riparian zone along Hunts Creek between Bettington Road and Jenkins Road. Because of the sensitivity of Lake Parramatta to nutrient inputs, Council should include in the management plan for these areas a strategy to:

- Minimise fertiliser usage on reserves.
- Give priority to removal of grass clippings and vegetation wastes from areas close to the creek.
- Provide signage to encourage responsible behaviour by the community including placement of rubbish in receptacles and not dumping rubbish in the creek.
- Replace high maintenance grass areas with low ground cover, particularly adjacent to the creek.
- Use of indigenous vegetation adjacent to the creek.

The main costs associated with this would be:

- |   |           |
|---|-----------|
| • Council administrative costs to review fertiliser usage and if necessary, develop an alternative fertiliser use program | \$1,000   |
| • Council costs for removal and disposal of grass clippings and vegetative waste  | \$unknown |
| • Provisions of signage within parks (allow)  | \$10,000  |
| • Replanting and bush regeneration along creek lines  | \$unknown |

#### 4.5.5 Drainage System Maintenance

The existing stormwater drainage infrastructure often provides a temporary storage of various pollutants, particularly sediments and litter. Whilst these pollutants might not be of critical

importance to Lake Parramatta, a program to maintain the facilities to a high standard will also assist in controlling nutrients and pathogens. Typical "good practice" activities would include:

- Determination of the accumulation rates of litter, silt, debris, leaves etc in the drainage system.
- Identify stormwater drain inlets/pits that require cleaning more frequently than usual. Undertake additional cleaning or change the design.
- Determine "hot spots" and frequency of cleaning required.
- Use appropriate machinery to collect material and cart away for disposal at a suitable site.

The costs of such activities are not possible to quantify at this stage and should be part of Council's stormwater management system.

#### **4.5.6 Street Sweeping**

Street sweeping is a practical and cost-effective way of reducing the quantity of pollutants entering the drainage system. In particular, it has the potential to provide a "back up" defence against pollutants entering the stormwater system in the vicinity of heavily used areas such as shopping centres, community facilities and sports fields. The effectiveness of street sweeping on pollutant removal however has not been proven by any research. Discussion of water quality improvement in the USA (American Sweeper, 1998) indicate that 'although sweeping is listed by the USEPA as a best management practice (BMP) in the reduction of pollutants in stormwater runoff, there is still no documented testing showing street sweeping to be effective in improving water quality'.

There has been some indirect work on the effectiveness of street sweeping by students at the University of New South Wales. Investigations into pollutant build up and washoff from roads (particulates only, not litter) indicate that of the three cleansing processes (rainfall > 7mm/hr, wind > 21 km/hr and conventional street sweeping), conventional street sweeping was the least effective in particulate removal (J. Ball, UNSW, pers comm).

Recommendations for effective street sweeping to remove fine particles that carry a substantial pollutant load include the following list derived from observations in the USA (Woodward Clyde Consultants, undated):

- Use of a sweeper designed to pick up fines (eg broom sweeper in conjunction with a regenerative air machine)
- Sweeping just before a storm event (would require a crew to be on standby and real time meteorological analysis to be available)
- Maximise travel along street edges where dirt tends to collect (possibly requiring parking controls)
- Increase street sweeping during months of greater rainfall.

The additional costs associated with any increased frequency of sweeping or change in sweeping plant would need to be assessed by Council.

#### **4.5.7 Waste Collection**

Kerb side waste collection and recycling collections generate considerable amounts of pollutants through spillage from the refuse receptacles and within the collection and emptying processes.

The amount of spillage will be a function of the degree of care by garbage operators and householders, the type of collection systems used, problems associated with scavenging dogs and the frequency of collection.

With the advent of green waste recycling, precautions will need to be taken to keep these wastes in a controlled manner, rather than having them stockpiled loose on the footpath.

#### **4.5.8 Upgrading of Stormwater Drainage System**

All stormwater drainage systems contain opportunities for the installation of additional facilities to capture various pollutants. In order of ease of installation these typically comprise three classes of facilities:

- Litter baskets and sediment sumps installed in modified stormwater inlet pits within the road drainage system. Such systems are easiest to install when a road is being newly constructed or reconstructed as part of a major upgrade. Other systems are available to retrofit the existing system including the Amyroo Kerbside 'Litta Bin'. These devices have been installed in a major shopping area in the western suburbs of Sydney.
- Gross pollutant traps installed at strategic locations within the trunk drainage system. Such traps are designed to primarily remove coarse litter and sediments and have little effect on fine sediments and nutrients.
- Wet retarding basins and wetlands that can be effective at removing finer sediments and nutrients. To be most effective a wetland should be located downstream of a gross pollutant trap. While such systems can be moderately effective in reducing nutrient loads, they have large space requirements and also require ongoing maintenance.

No specific sites have been identified for litter baskets and gross pollutant traps. Earlier proposals for a flood retarding basin on Kings School land are worthy of reassessment with a view to creating a wet retarding basin that fulfils a pollution control function. Such a facility, depending on its size, could cost of the order of \$100,000 - \$400,000.

#### **4.5.9 Other Source Controls**

Community awareness of the implications of where stormwater goes and the consequences of allowing pollutants into the drainage system is considered one of the most cost effective ways of reducing the pollutant load on the stormwater system. Leaflets (such as those used by the EPA for their H<sub>2</sub>Oonly campaign) should be prepared to discourage such common practices as:

- Washing cars in the street.
- Hosing down of driveways.
- Hosing of street gutters by householders.

Residents should also receive advice on appropriate maximum fertiliser requirements for gardens and lawns. It is unlikely to be appreciated that, per household, the quantities of nitrogen and phosphorus that cause problems in Lake Parramatta are relatively trivial. The estimated annual loads reaching Lake Parramatta per household amount to about 750 g of nitrogen and 80 g of phosphorus (total value of fertiliser purchase of less than \$2.00 per household).

Publicity and community education material advising residents of simple “good practice” steps could be prepared by Council for distribution to the community and through retail outlets such as garden shops. Community education has been found to be effective in reducing these sources (eg the Albury-Wodonga, and Tuggerah Lakes phosphorus action campaigns).

A program to increase community awareness could be linked to the proposed Community Monitoring Program outlined in Section 4.3.

Further reinforcement could be provided by the appointment of an enforcement officer/increased number of ordinance inspectors with powers to impose penalties for illegal dumping of rubbish and other negligent acts.

#### 4.5.10 Floating Wetland

The nutrient budget of Lake Parramatta shows that a substantial proportion of both nitrogen and phosphorus can be stored in aquatic plants, particularly floating succulent plants such as water lilies. One suggestion for nutrient load reduction to the Lake is to provide an artificial wetland near the inflow from Hunts Creek to remove a major source of nutrients flowing into the Lake.

Due to constraints of shade from the tree canopy and the incised nature of the creeks, a conventional reed type wetland is unlikely to be practical. A wetland utilising floating plants is suggested in the upper sections of the lake. The wetland would consist of floating macrophytes (not *Salvinia* or Water Hyacinth) contained by a purpose made boom structure. Regular harvesting of the plant material would be needed to remove nutrient stores. Such harvested material could be composted for fertiliser.

Floating plants have been used for nutrient removal for wastewaters and stormwater polishing (Reddy & Debusk, 1987). For example, water hyacinths were used for improvement of water quality of a eutrophic lake in Florida, USA. Trials were undertaken on the nutrient removal efficiency of harvested and non-harvested artificial channels built into the lake. The studies showed that an average removal of 54% nitrogen and 63% phosphorus could be achieved, compared to 36% nitrogen and 42% phosphorus from a channel with no plants.

One of the main issues to be considered for this proposal is that of providing vehicle access to the headwaters of the lake. A vehicle access track capable of taking trucks and tractors would be needed for maintenance purposes. Such a track might require further disturbance of some of the foreshore bushland.

The costs of such a system are hard to determine because of its unusual nature. For budgeting purposes the following costs are suggested:

- |  |          |
|--|----------|
| • Capital cost of boom and access track                          | \$50,000 |
| • Wetland plants   | \$10,000 |
| • Annual maintenance including harvesting and disposal of plants | \$15,000 |

#### 4.5.11 Stormwater Inlet near the Kiosk

A stormwater drainage pipe enters Lake Parramatta between the kiosk and James Ruse Drive. This inlet discharges adjacent to the shallow area is popular with children (and also the waterfowl). This location lends itself to a small treatment system. Two alternative systems have been proposed:

- A “pocket” wetland that could provide some visual interest as well as water quality benefits from treating the stormwater inlet. Anticipated costs for such a wetland (200 m<sup>2</sup>), including the inlet and outlet structures for water level control and bypass of high flows would be of the order of \$10,000.
- A sub-surface sand filtration system similar in concept to the infiltration systems installed on the beach front at Bondi by Atlantis Corporation Pty Ltd for Waverley Council (P. Davies, Waverley Council, pers comm). Such a system has the advantage that it could be constructed underground and would not take up space in an area where space is at a premium. Capital costs and operating costs are likely to be no more than would be required for a “pocket” wetland.

## 5. PROPOSED STRATEGY AND SCHEDULE

The management options outlined in Chapter 4 represent a suite of activities that could be undertaken on a range of timescales. This range of options has been reviewed by the Lake Parramatta Community Consultative Committee and a recommended plan has been developed which recognises that:

- There is no single simple action that will achieve the required water quality goals.
- To achieve the stated water quality goals will require most of the possible actions outlined in Chapter 4 be undertaken at some stage.
- The stated goals will take several years to achieve and will require sustained efforts by all parties to reduce the sources of nutrients and pathogens entering the lake.
- For both nutrients and pathogens, there will need to be concerted action on a catchment wide basis as well as action on identifiable projects:
  - Reduction or elimination of sewer overflows.
  - Immobilisation or removal of lake sediments.

Catchment controls will be ineffective without these actions and vice versa. The dilemma is which action should come first.

The various actions outlined in Chapter 4 are likely to take at least 10 years to achieve the stated water quality goals for Lake Parramatta. In the interim, it is likely that preventative and remedial actions will continue to be necessary. These actions might include:

- Periodic harvesting and removal of excess weed growth.
- Chemical sprays to control algal blooms.
- Signage to advise the public of when it is unsafe to swim.

Parramatta City Council will also need to address the question of where, and under what conditions, it will permit swimming to occur. Whilst the achieving of water quality suitable for swimming is a stated community goal for the lake, it would be pointless to strive to achieve this if Council is not prepared to allow swimming because of its perceived public liability in case of accidents.

Table 8 summarises the recommended suite of management actions and attempts to summarise the following considerations with each:

- The indicative cost of implementation including initial and annual costs.
- Suggested responsibility for funding and action.
- The timeframe for starting
- The timeframe for achieving an effective outcome from each action.
- The likely contribution of the action towards achieving the stated water quality goals.

The recommended actions set out in Table 8 are grouped into four classes of actions that deal primarily with:

- control of pathogen levels,
- control of plant nutrients and
- interim management actions.
- personnel to initiate remedial actions

These latter actions could be undertaken to allow the water quality goals to be met more often than currently occurs, while the longer term actions become effective.

As noted earlier, an integrated plan which includes most, if not all, the options outlined in Chapter 4 is likely to be required to achieve the stated goals for Lake Parramatta. Some of these actions could be started immediately and require comparatively little funding, whilst others will require further investigations and the commitment of substantial funds, which may take several years to put into effect.

Table 8  
Lake Parramatta Water Quality Plan

Option	Suggested Responsibility	Initial Cost (\$)	Annual Cost (\$)	Prior Actions (option no.)	Associated Actions (option no.)	Effectiveness*		Implementation		
						Pathogens	Nutrients	Start (years)	Effective (years)	
<b>I</b>										
<b>Pathogen Control</b>										
1 High rate filtration and disinfection	BHSC/Government	\$1,500,000	\$30,000	-	2-8	40	7	1	1	
2 Identify other pathogen sources	UPRCT/BHSC	\$15,000	\$0	-	1	0	0	0	1	
3 Community education campaign	UPRCT/BHSC	\$5,000	\$2,000	2	1 + 4-8	10	10	0	10	
4 Waste controls near food outlets	BHSC	\$2,000	\$1,000	2	1 + 3	5	2	0	5	
5 Stormwater management plan for Kings School	UPRCT/School	\$15,000	\$0	2	1 + 6-7	0	0	0	1	
6 Sportsfield irrigation and drainage for Kings School	UPRCT/School	\$75,000	\$5,000	2	1 + 5 + 7	5	5	0	2	
7 Implement stormwater management for Kings School	School	\$40,000	\$5,000	5	1+5-6	5	5	1	3	
8 Prevent/fix sewer leakage	SW	?	\$0	2	1	12	2	1	10	
9 Manage the ducks	PCC	\$2,000	\$1,000	-	1-8	10	2	0	1	
<b>Nutrient Control</b>										
10 Investigation of sediment management options	UPRCT/PCC/Government	\$45,000	\$0	-	11 a - 11 c	0	0	0	1	
11 a Dredge the sediments	UPRCT/PCC/Government	\$1,300,000	\$0	10	13-19	0	25	1	2	
11 b Chemically fix surface sediments	UPRCT/PCC/Government	\$100,000	\$0	10	13-19	0	"	1	2	
11 c In-situ treatment using "Limnofix" process	PCC	\$180,000	\$0	10	13-19	0	"	1	2	
12 Destatification of the lake	PCC	\$35,000	\$4,000	-	10-11 + 13-19	0	8	1	2	
13 Parks management	BHSC	\$1,000	\$1,000	-	10-12 + 14-19	2	5	0	5	
14 Drainage system maintenance	BHSC	\$2,000	\$15,000	-	10-13 + 15-19	2	7	0	2	
15 Street sweeping	BHSC	\$0	\$15,000	-	10-14 + 16-19	2	3	0	5	
16 Waste collection	BHSC	\$2,000	\$0	-	10-15 + 17-20	5	7	0	5	
17 Drainage system litter traps and GPT	BHSC	\$400,000	\$15,000	-	10-16 + 18-20	10-16 + 18-20	2	7	0	10
18 Other source controls	PCC	\$10,000	\$2,000	-	10-17 + 19-20	2	7	0	10	
19 Floating wetland	PCC	\$50,000	\$25,000	-	10-18 + 20	0	3	0	3	
20 Pocket wetland or sand filter	PCC	\$10,000	\$2,000	-	10-19	0	2	0	2	
Interim Management	PCC	\$10,000	\$10,000	-	-	0	0	0	0	
20 Harvest excess aquatic weed growth	PCC	\$10,000	\$10,000	-	-	0	0	0	0	
21 Chemical addition for algal control	PCC	\$2,000	\$1,000	-	-	0	0	0	0	
22 Advisory signs for swimmers	PCC	\$10,000	\$10,000	-	-	0	0	0	0	
<b>Personnel</b>										
23 Catchment Officer (2 years)	PCC	\$10,000	\$10,000	-	-	0	0	0	0	
24 Project Manager (1 year)	PCC	\$10,000	\$10,000	-	-	0	0	0	0	
(high rate filtration and sediments)	BHSC	\$100,000	-	-	-	0	0	0	0	
	PCC/BHSC	\$70,000	-	-	-	0	0	0	0	
Total (lower range)		\$2,309,000	\$123,000			100	100			
Total (upper range)		\$3,509,000	\$123,000							

Note: Effectiveness based on subjective assessment of the overall contribution of an option to achieving required targets

BHSC                      Baulkham Hills Shire Council                      SW                      Sydney Water  
PCC                        Parramatta City Council                                      UPRCT                      Upper Parramatta River Catchment Trust

## 6. REFERENCES AND BIBLIOGRAPHY

- American Sweeper (1998) *Stormwater Runoff: Obstacle or Opportunity?* Volume 5, No 1, <http://www.schwarze.com/~asforum/secure/v5n1/v5n1stormwater.html>.
- Anthony, L. (1995) Achieving effective urban stormwater pollution control – A catchment-wide community approach, *Proceedings, Planning for Creative Stormwater Management, 3<sup>rd</sup> Annual Conference, Soil and Water Management for Urban Development*, Sydney 12 – 15 September.
- ANZECC (1992) *Australian Water Quality Guidelines for Fresh and Marine Waters*, National Water Quality Management Strategy, Australian & New Zealand Environment & Conservation Council.
- Asaeda, T. and Imberger, J. (1993) Structure of bubble plumes in linearly stratified environments, *J. Fluid Mech.*, Vol 249, pp 35-57.
- Bate, N., Hewlett, R., Leeming, R. and Reed, R., (1996) The origin of faecal contamination in the lower Yarra River – an investigation using faecal sterols and bacteria, *Australian Society for Limnology: 35<sup>th</sup> Congress*, Berri, South Australia.
- Constandanopoulos J and Clark P, (1996), Pollutant Load Reduction Curves for a Sydney Stormwater Pollution Control Pond at Mt Annan, *Proceedings 4th Annual Conference: Soil and Water Management for Urban Development*, Sydney, 9-13 September 1996, pp 145-155.
- Department of Housing, NSW, (1993), *Soil and Water Management for Urban Development*, prepared by Morse McVey & Associates, Sydney, 171 pp.
- Department of Land & Water Conservation, 1996, *The Manager's Guide to Sediment, Nutrient and Gross Pollutant Control*, First Edition (draft), DLWC, Sydney, 104 pp + Figs.
- Dolman G.S., (1987), *Dynamics of Sydney's Urban Bushland from Fine Resolution Pollen Analysis*, PhD Thesis, Australian National University, Canberra.
- Duncan H P, (1997), *Urban Stormwater Treatment by Storage: A Statistical Overview*, Report 97/1, CRC for Catchment Hydrology, Melbourne.
- Environmental Protection Authority, (1996), *Managing Urban Stormwater*, Draft for comment, 3 Vols, EPA, Sydney.
- Environmental Protection Authority, (1996), *Managing Urban Stormwater: Treatment Techniques*, EPA, Sydney, 104 pp.
- Lawrence, I A, (1986), *Source and Fate of Urban Runoff Constituents and their Management*, Proceedings of Symposium on Stormwater Quality in Urban Areas, Water Research Foundation, Illawarra Region, Wollongong.
- Reddy K.R. & DeBusk T.A., (1987), *State-of-the-Art Utilization of Aquatic Plants in Water Pollution Control*, *Water Science & Technology*, 19 (10), 61-79.
- Stephens, R. and Imberger, J. (1993) Reservoir Destratification via Mechanical Mixers, *Journal of Hydraulic Engineering*, Vol 119, No 4, April, pp438-457.
- Sydney Coastal Councils Group (1992) *Stormwater Pollution Control Code for Local Government*, Sydney.
- Sydney Water (1994) *Managing Sewerage Overflows in the Sydney Region*.
- Sydney Water, (1995), *Existing System Performance Report, Northern Suburbs Ocean Sewerage System*, prepared by Sydney Water, June 1995.

Sydney Water, (1995), *Strategic Options for Overflow Abatement - Northern Suburbs Ocean Outfall Sewerage System*, Sydney Water Utilities Planning Services, November 1995.

Woodward Clyde Consultants (undated) Street Sweeping/Storm Inlet Modification Literature Review, in American Sweeper, *Sweeping for Water Quality*  
<http://www.schwarze.com/~asforum/secure/v4n2/v4n2alameda.html>.