Lake Hicks
Integrated Phosphorus Management Plan

King County

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Table of Contents

INTRODUCTION **1**

PROBLEM STATEMENT **2**

HISTORY AND PAST MANAGEMENT EFFORTS **3**

LAKE HICKS HISTORY 3
PAST MANAGEMENT EFFORTS 3

MANAGEMENT GOALS **5**

WATERSHED AND LAKE CHARACTERISTICS **6**

WATERSHED CHARACTERISTICS 6
LAKE CHARACTERISTICS 8
CURRENT AND POTENTIAL BENEFICIAL USES 18

SOURCES OF PHOSPHORUS **22**

EXTERNAL LOADING 22
INTERNAL LOADING 23
SEDIMENT PHOSPHORUS SAMPLING METHODS 24

PHOSPHORUS CONTROL OPTIONS **26**

ALUM TREATMENT 26
DILUTION 27
STORMWATER DIVERSION, RETENTION, AND TREATMENT 27
ALGICIDES 28
SEDIMENT OXIDATION (RIPLOX) 28
AERATION 28
DREDGING 29
WATERSHED EDUCATION CAMPAIGN 29
NO ACTION 30

COMMUNITY INVOLVEMENT **31**

COMMUNITY COMMITMENT AND EDUCATION 31
PUBLIC PARTICIPATION 32

INTEGRATED PHOSPHORUS CONTROL PLAN **34**

IMPLEMENTATION 34

POST-TREATMENT MONITORING **37**

BUDGET **38**

REFERENCES **39**

APPENDICES **41**

List of Figures

FIGURE 1. LAKE HICKS WATERSHED 6
FIGURE 2. LAKE HICKS BATHYMETRY 8
FIGURE 3. PHOSPHORUS CONCENTRATIONS IN LAKE HICKS (UG/) 11
FIGURE 4. TSI VALUES FOR LAKE HICKS, 1996 - 1999 12
FIGURE 5. TSI VALUES FOR LAKE HICKS, 2004 13
FIGURE 6. MICROCYSTIN CONCENTRATIONS IN SUMMER 2004 17
FIGURE 7. BENEFICIAL USES AT LAKE HICKS 21

List of Tables

TABLE 1. MANAGEMENT STUDIES AND PLANS FOR LAKE HICK VICINITY 4
TABLE 2. MEAN PHOSPHORUS AND CHLOROPHYLL-A VALUES (MAY - OCT.) 11
TABLE 3. PHOSPHORUS AND DISSOLVED OXYGEN CONCENTRATIONS IN LAKE HICKS 14
TABLE 4. PHYTOPLANKTON PRESENT IN LAKE HICKS, 2004 15
TABLE 5. FISH STOCKING DATA.. 18
TABLE 6. ANNUAL PRECIPITATION AND PREDICTED PHOSPHORUS LOADS.............................. 23
TABLE 7. SEDIMENT PHOSPHORUS MONITORING RESULTS 24
TABLE 8. RECENT COMMUNITY ACTIVITY 32
TABLE 9. IMPLEMENTATION OF PHOSPHORUS MANAGEMENT PLAN 36
TABLE 10. ESTIMATED BUDGET... 38

INTRODUCTION

Lake Hicks is a four-acre lake in the White Center neighborhood of unincorporated King County just 0.9 miles south of Seattle city limits and 0.4 miles northeast of Burien, but within the area currently under scrutiny for annexation by Seattle and/or Burien in the near future. Lake Hicks is alternately known as Lake Garrett after a former owner of the property including the lake, L.E. Garrett. The lake is within King County's Lakewood Park, and is located in the Salmon Creek sub-basin within the Duwamish/Green River Watershed Resources Inventory Area 09 (WRIA 9).

Over the last 100 years, significant development and changes in land use in the watershed have resulted in changes to Lake Hicks. Though conditions at Lake Hicks have varied through time, the water quality in the lake is currently poor, which has resulted in the lake being designated as an impaired water body for both phosphorus and fecal coliform content on the Federal 303(d) list. Because of continuing degraded water quality, the lake has little appeal as a recreational destination for area residents, and does not provide suitable habitat for many fish species and other wildlife. Neighbors in the area agree that use of the lake has declined and that improving Lake Hicks will benefit the community.

Lake Hicks is in a highly urbanized watershed and has no natural outlet, so it is particularly susceptible to pollution and nutrients carried to the lake via surface water runoff. Although there is a pump operated seasonally that conveys water from the lake to Puget Sound, the lack of a natural outlet from Lake Hicks means that many of the nutrients and pollutants that reach the lake settle to the bottom rather than being transported downstream. Both recent and historical King County data show that Lake Hicks receives phosphorus from both internal and external sources (CH2M Hill, 1982, 1987; King County, 2004a). Surface water runoff draining to the lake each rainy season has been shown to contain high phosphorus concentrations (CH2M Hill, 1982, 1987). The lake also recycles phosphorus internally from sediment to the water when the deep waters of the lake become anoxic each summer.

Additions of phosphorus from external and internal sources contribute directly to increasingly frequent periods of dense cyanobacteria growth often referred to as "blue-green algae blooms". These blooms turn the lake unsightly colors, create foul odors, and have been shown to produce toxins that could endanger humans, pets, and wildlife (King County, 2004a).

Due to the high phosphorus concentrations, Lake Hicks is listed as "impaired" under section 303(d) of the Federal Clean Water Act of 1972. Because of this listing, King County has developed this *Integrated Phosphorus Management Plan* (IPMP), which includes a discussion of key sources of phosphorus to Lake Hicks, an outline of potential measures to reduce concentrations, and a suggested treatment plan that is likely to have the greatest benefit at the most reasonable cost. Lowering phosphorus concentrations in Lake Hicks should result in improved water quality and aquatic habitat, fewer algae blooms, and greater potential for recreational use of the lake. It is understood that other pollutants may be present, but that those will not be addressed in this plan.

The IPMP has been reviewed at a public meeting (Appendix B) and suggestions from community members have been incorporated into this IPMP. King County plans to implement suggested restoration measures beginning in April 2005.

PROBLEM STATEMENT

Lake Hicks has a documented history of water quality troubles and is currently experiencing frequent and severe cyanobacteria blooms, some of which have been shown to produce toxins. Although there have been no reports of humans, pets, or wildlife getting sick from contacting or ingesting cyanobacteria, it is likely that if left uncontrolled, problematic cyanobacteria blooms will continue to occur, and that some of them will be toxic.

The frequency and severity of cyanobacteria blooms at Lake Hicks have degraded the lake's value as a recreational destination for area residents, as well as rendering the lake much less suitable habitat for fish and wildlife. In addition, it is possible that the degraded water quality and resulting unsightliness of the lake create a public perception that the lake and park are neglected, increasing the likelihood of illegal activity. Area residents often mention gang activity in the park, and during a water quality sampling trip in July 2004, King County staff discovered three cars that had been stolen and rolled into the lake from the swimming beach.

Data suggest that phosphorus is the limiting nutrient in Lake Hicks, meaning that excessive phosphorus concentrations will likely facilitate continued cyanobacteria blooms (King County, 2004a). Available King County data show that average phosphorus concentrations in Lake Hicks far exceed water quality standards of 20µg/l as defined in Washington State Department of Ecology's *Water Quality Standards for Surface Waters of the State of Washington* (Chapter 173-201A WAC). These consistently high phosphorus concentrations required Lake Hicks to be listed as an "impaired water body" under section 303(d) of the Federal Clean Water Act of 1972.

Managing the lake and the surface inflows for phosphorus reduction should result in a dramatic water quality improvement in the lake. Hopefully improved water quality will be the first step toward revitalizing Lake Hicks and Lakewood Park as a safe and enjoyable natural escape in the middle of a heavily urbanized neighborhood.

HISTORY AND PAST MANAGEMENT EFFORTS

Lake Hicks History

The earliest Western settlers likely arrived in the area in the 1870s and found Lake Hicks surrounded by old growth timber, which provided their main source of income. Saw and shingle mills were built next to the lake in the 1880s, and it was during this time that the lake first became known as Lake Hicks, after an early resident in the area, Leonard Hicklin (CH2M Hill, 1982).

In the early 1900s, a railroad line to Lake Hicks was finished, and within several years most of the old growth timber had been removed from the watershed. After the land was cleared it was divided into small farm lots, then later into residential lots. Until the 1920s the watershed remained largely undeveloped, and the lake was used informally for swimming and fishing. L.B. Garrett then purchased a large block of land surrounding and including Lake Hicks (CH2M Hill, 1982). The lake is still known to some as Lake Garrett based this ownership. During the 1930s Garrett leased the land surrounding the lake to a group of Seattle businessmen who developed Lakewood Golf Course, dredging the lake to deepen it as an irrigation storage reservoir and using some of the sediments from the lake to landscape the golf course. Shortly after WWII, King County acquired 32 acres of the golf course, including Lake Hicks and adjacent wetlands, naming it Lakewood Park (King County, 2000).

Two schools are located just south of Lakewood Park; Evergreen High School opened in 1955 and Cascade Middle School opened in 1967.

Past Management Efforts

In the last several decades there have been numerous studies and plans focusing on Lake Hicks, Lakewood Park, and the Salmon Creek Basin, as shown in Table 1.

Each of these plans was carefully reviewed during development of this *Integrated Phosphorus Management Plan*. Topics of the past studies and plans vary, but two main themes are present: flood control and nutrient input reduction. Many of these plans mention that excessive phosphorus inputs to the lake are creating water quality problems, and several propose solutions that are consistent with the recommendations of this plan; none of the plans recommend against actions proposed in this IPMP. Relevant recommendations and citations from each of the plans are cited throughout the text of this document.

These plans are not appended to this report; although relevant water quality data from the plans is included in Appendix A. Copies referenced plans can be made available upon request.

Table 1. Management Studies and Plans for Lake Hick Vicinity

Title	**Author(s)**	**Date completed**
Salmon Creek Basin Plan	King County	2005
Lakewood Park Master Plan Update	King County	2000
Lake Hicks Hydrologic Modeling and Water Quality Summary,	KCM for King County	1999
Lakewood Park Wetlands Study Report	Adolfson Associates for Atelier, for King County	1999
Preliminary Hydrogeologic Assessment of Lakewood Park, Seattle, Washington	Udaloy Environmental Services for King County.	1998
Lake Hicks Post-Restoration Monitoring Study	CH2M Hill for King County	1987
Lake Hicks Restoration Study	CH2M Hill for King County	1982

MANAGEMENT GOALS

The goal for Lake Hicks' phosphorus reduction is to lower average ambient phosphorus concentrations in the lake below 20µg/l, which is the standard set for phosphorus concentrations in Puget lowlands lakes by Ecology (Ecology, 2003). Maintaining concentrations below 20µg/l would result in Lake Hicks being removed form the 303(d) list.

Lowering the phosphorus concentrations in the lake is the primary goal. However, it is possible that two secondary water quality improvement goals will be met as well: increasing average Secchi transparency to depths greater than 2 meters from June through September, and decreasing average chlorophyll *a* concentrations in the lake to less than 10µg/l for the same period. Chlorophyll *a* concentrations are an indicator of the density of phytoplankton populations, so achieving this secondary goal will signal that a reduction in phytoplankton blooms has been achieved.

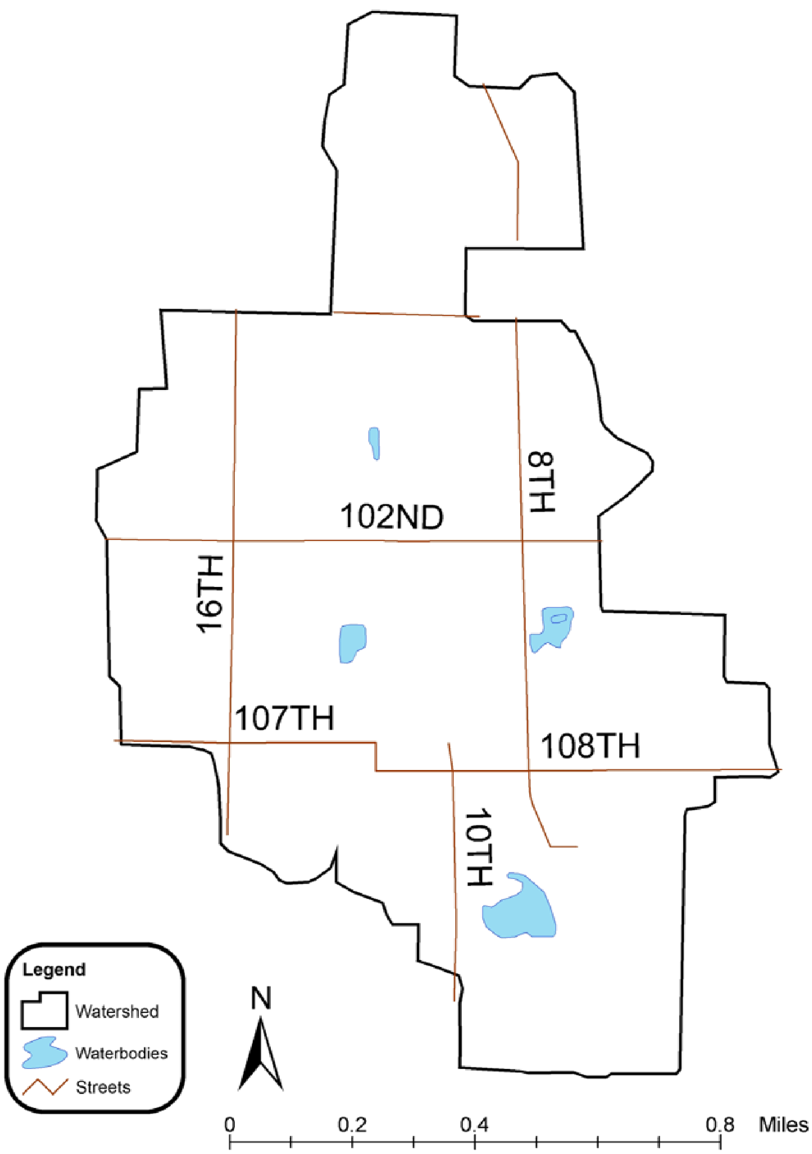
Ideally the effort to achieve de-listing will also result in a lake that provides safe and enjoyable recreational opportunities for area residents and sustains native plants and wildlife. These goals will be met through a combination of restoration, remediation, and capital improvement projects that will, to the extent possible, sustain desired conditions in the long term. Each element of the management effort should be designed to require minimal maintenance, because the urbanized nature of the watershed and the lake's hydrology make it less likely that the maintenance of the desired concentrations will ever be totally without management activities.

WATERSHED AND LAKE CHARACTERISTICS

Watershed Characteristics

Lake Hicks' watershed (Figure 1) is located in the White Center neighborhood of unincorporated King County between the cities of Burien and Seattle. The Lake Hicks watershed constitutes roughly 678 acres within the 1200-acre Salmon Creek sub-basin (Whiting, 2005. Pers. comm.). The lake and its watershed lie within the Salmon Creek basin in the Duwamish/Green River WRIA 9 as defined by the Washington State Department of Ecology (Ecology).

Figure 1. Lake Hicks Watershed



The Lake Hicks watershed is heavily developed. Approximately 39% of the land in the watershed is classified as impervious surface, and much of the development took place before implementation of surface water runoff control regulations (King County, 2000). Further, much of the open space in the watershed is comprised of grassy ball fields and open spaces near ponds or wetlands – attractive habitat for Canada geese and other waterfowl that can contribute significant nutrients, in particular phosphorus, to the lake. One report states that waterfowl are the main source of fecal coliform bacteria to Lake Hicks (King County, 2000)

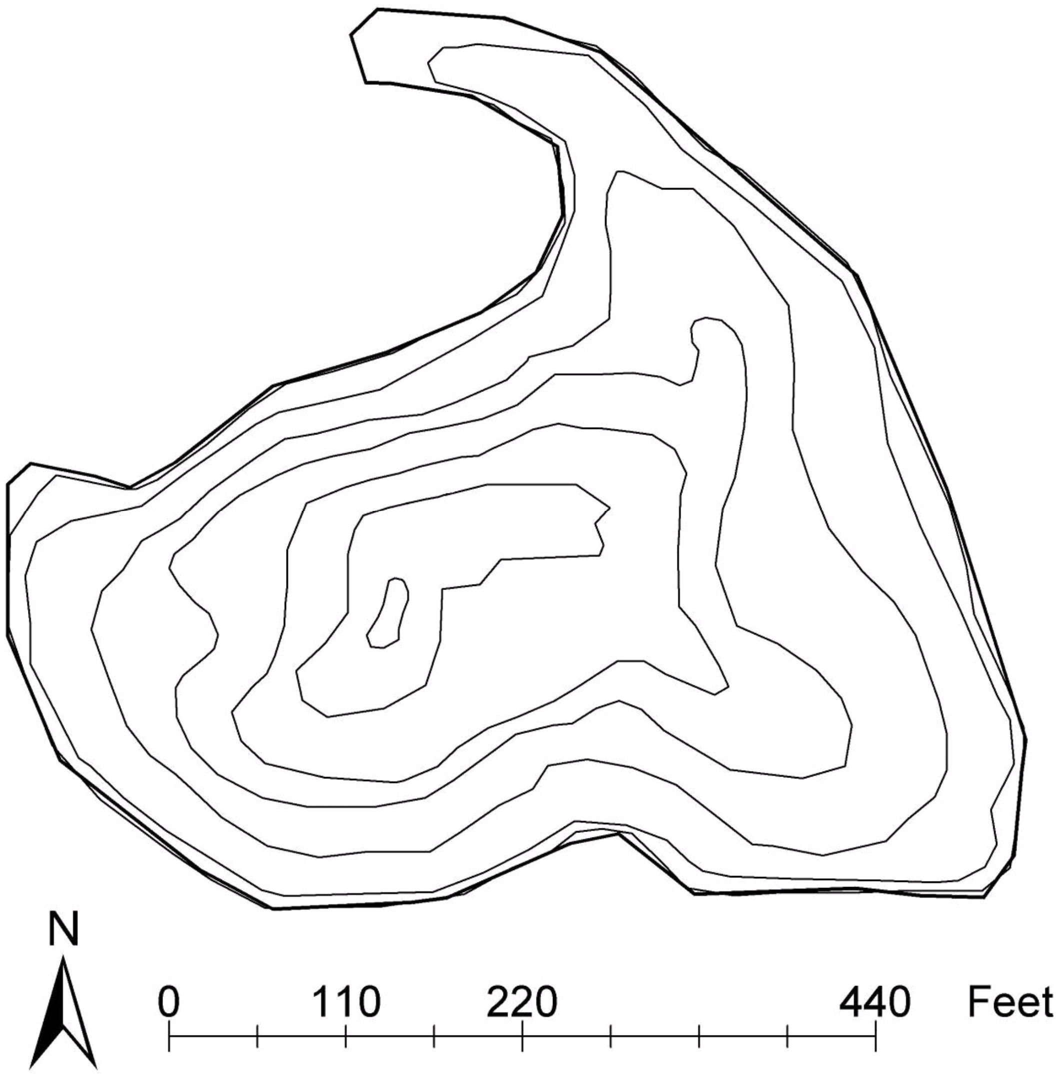
There are also some engineered changes that have affected the size of the watershed draining to the lake. "The size of the basin has changed over time due to development. A 1909 topographic map (USGS, 1909) shows that part of the basin, roughly 600 acres, used to drain into Longfellow Creek, which flowed to the north and discharged into Elliott Bay. This drainage pattern was modified at some point during the period of rapid development in the basin that occurred during the 1940s and 1950s. During that period, storm water flows were diverted to the south and contributed to the flows in Salmon Creek. At some point in the early 1980s, the storm water from most of the upper basin and from areas along Ambaum Boulevard was diverted to an abandoned sewer line that discharged directly to Puget Sound." (King County, 2004b).

Native soils in Lakewood Park consist of sands and gravels (from the Vashon recessional outwash) that have incised gravelly silt (Vashon till). The till is underlain by sand and gravel from the Vashon advance outwash (Udaloy, 1998).

Lake Characteristics

Lake Hicks has a surface area of approximately 4-acres, and a maximum depth of approximately 5-meters, although depth and surface area vary widely depending on the water level, which is highly influenced by surface runoff, particularly in fall and winter. Figure 2 shows the bathymetry. The lake is located within King County's 32-acre Lakewood Park, which serves the highly urbanized area of White Center, south of the Seattle city limits.

Figure 2. Lake Hicks Bathymetry



The lake has a history of varied usage. There is no natural outlet to the depression filled by the lake, and it is likely to have been an open water wetland before the area was logged in the late 1800s, similar to other closed depressions in the local area. At first, it apparently served as mill pond and gradually developed into an informal recreation site as the surrounding land turned into small farm holdings, followed by the creation of a golf course in the 1930s. There is ample evidence that the lake was dredged at this time to increase its capacity as a holding tank for irrigation water, with dredge spoils used as fill to create golf course contours (CH2M Hill, 1982). However, it is not known how much of the lake's current depth was created by the dredging. Residential and commercial developments in the 1960s began using the lake as a receiving pond for surface water runoff from projects, without substantial upstream detention or treatment facilities built into the system. It is apparent that the current engineering of the drainage system has caused water quality and quantity problems in the lake, leading to reduced recreational and aesthetic benefits to the community.

The Lakewood Park Master Plan Update (2000), reports that the average summer water level of Lake Hicks is 342-feet above mean sea level. Recreational uses of the lake and the park are significantly affected when the lake reaches a level of 353-feet above mean sea level. The parking lot floods at 354-feet, and the restroom begins to flood at 359-feet (King County, 2000).

Because the lake has no natural outlet, and water can leave naturally only through infiltration into inundated soils or by evaporation, pumps are used to lower winter high stands when water reaches 344-feet above mean sea level. The pump uptake pipe is located 100' off shore from the pump-house and draws from the bottom of the lake, which may be an important factor to take into consideration when designing restoration methods. Pumped water bypasses Salmon Creek, which is the natural drainage of the area adjacent to the Lake Hicks watershed, and empties directly to Puget Sound via a pipe system called the "Old Government Line," which has a limited carrying capacity. In very large storm events, some water may go into Salmon Creek when the capacity of the Old Government Line is exceeded.

The watershed has a high percentage of impervious surfaces, so there is less infiltration, and pulses of surface water runoff carrying nutrients and pollutants reach the lake during rainstorms. Since there is no natural outlet, and the pump is only operated when water rises above 344-feet, much of these nutrients and pollutants stay in the lake. The nutrient rich water and sediment both contribute to frequent, dense cyanobacteria blooms, especially when water levels drop from lack of rain in the summer months and water in the lake becomes stagnant. Although the lake is not very deep, there is evidence that thermal stratification is semi-stable through summer, and oxygen depletion occurs beneath the thermocline as early as late spring. This leads to phosphorus release from the sediments, which further contributes to cyanobacteria blooms.

Water Quality

Evidence from past monitoring, combined with the history of recent uses of the lake, points out two main problems with summer water quality conditions in the lake: high fecal coliform counts and nutrient concentrations. Consistently high fecal counts through the 1960s and 1970s resulted in the closure of the constructed beach area to swimmers in 1975. The lake re-opened for the summer swimming season in 1986, but closed again because of poor water quality and high fecal coliform counts at the end of the 1991 season, and it has remained closed since then (Chavey, 2004. Email communication). High nutrient concentrations, particularly phosphorus, have contributed to large phytoplankton populations present through summer that have reduced water clarity and occasionally caused unpleasant conditions. In the 1990s these populations were dominated by nuisance cyanobacteria (commonly referred to as bluegreen algae) known to produce toxic blooms on occasion, although apparently none were investigated for toxicity in Lake Hicks during that time. Recent studies of toxicity of cyanobacteria blooms at the lake are discussed below.

Water quality of Lake Hicks has been monitored sporadically through the last several decades. Recent water quality data exist for the following periods

- Lake Garrett (Hicks) total Coliform counts 1961 – 1978. (CH2M Hill, 1982) Data shown in Appendix A.

- Two Storm Events in October and November 1978. (CH2M Hill, 1982) Data shown in Appendix A.

- March 1981 through February 1982 for the Lake Hicks Restoration Study (CH2M Hill, 1982). Data shown in Appendix A.

- February through December 1986 for the Lake Hicks Post-Restoration Monitoring Study (CH2M Hill, 1987). Data shown in Appendix A.

- 1996 through 1998 – King County Lake Stewardship program, Dick Thurnau, volunteer. Data shown in Appendix A.

- July 1998 for the Lakewood Park Master Plan Update (King County, 2000). Data shown in Appendix A.

- May through October 2004, collected by King County staff (King County, 2004a). Data shown in Appendix A

Recent data collected by the volunteer participating in King County's Volunteer Monitoring program and data collected by King County staff in 2004 are representative of current conditions in the lake. Several of these parameters are particularly important to consider when determining phosphorus control measures.

Figure 3 shows phosphorus concentrations in water samples taken at a depth of one meter below the surface above the deepest point of the lake. The target P concentration for eutrophic lakes of the Puget lowlands is 20μg/l, as defined by Ecology (Ecology, 2003). Every sample analyzed since 1996 has exceeded this value.

Figure 3. Phosphorus concentrations in Lake Hicks (µg/L)

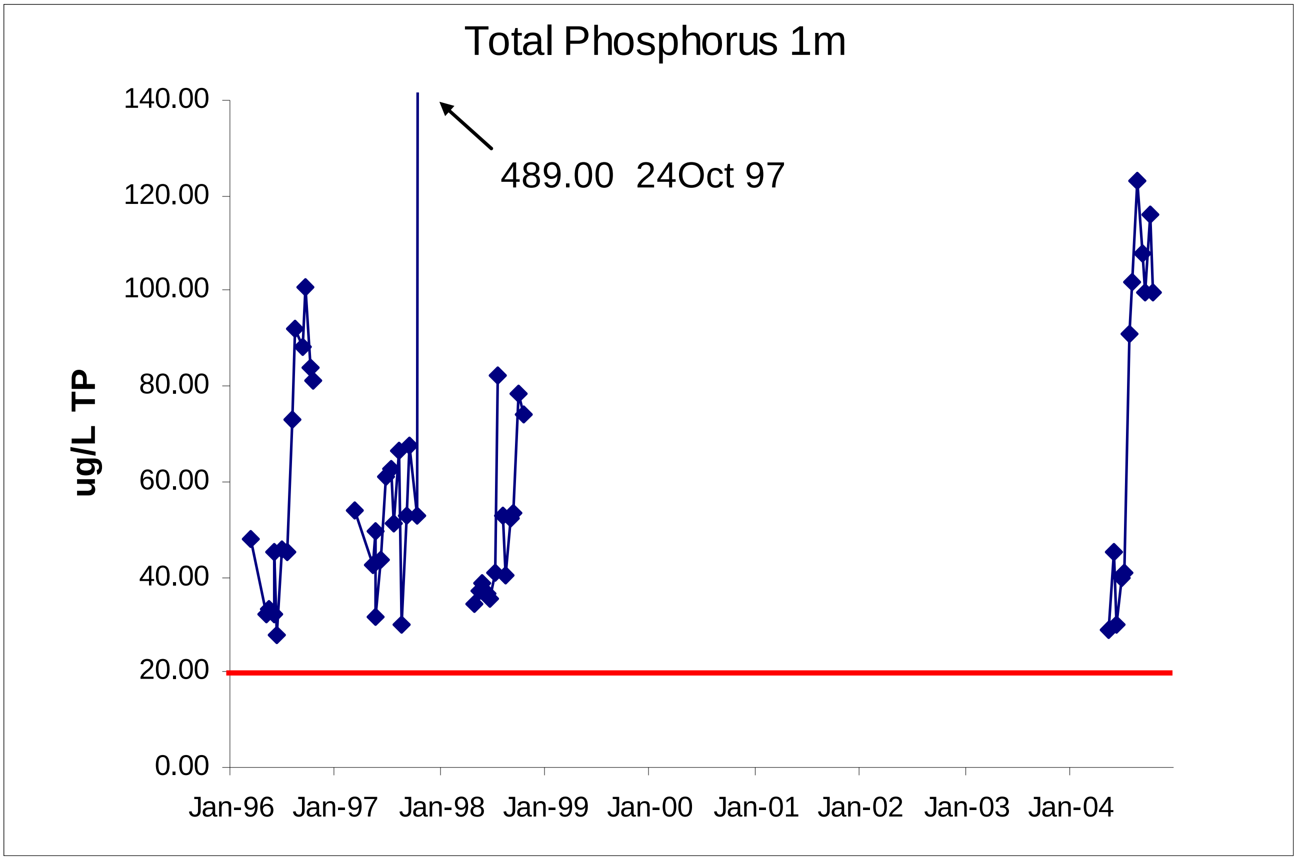


Table 2 shows the mean phosphorus and chlorophyll *a* values (May – October) for each of the years shown. Phosphorus exceeds the target value, and chlorophyll *a* exceeds the secondary management goal defined in this plan of 10µg/l.

Table 2. Mean Phosphorus and Chlorophyll-a Values (May - Oct.)

Year	Chlorophyll *a* (µg/l)	Total phosphorus (µg/L)
1996	21.8	60.0
1997	25.5	51.0
1998	26.6	49.6
2004	57.0	77.0

A common method of tracking water quality in lakes is by calculating the Trophic State Index (TSI), which converts each of three commonly measured water quality parameters – Secchi transparency, chlorophyll *a* concentrations, and total phosphorus concentrations – to a number between 0 and 100 for categorization and comparison (Carlson, 1977). In theory, the resulting numbers will predict the biological productivity or *trophic state*, of the lake. Lakes with values below 40 are considered to be oligotrophic – low productivity or nutrient poor; between 40 and 50 mesotrophic, or moderately productive; and lakes with values above 50 are predicted to be eutrophic – nutrient rich, or highly productive.

Excessive nutrient input to a lake resulting from urban development and corresponding human activities usually causes an increase in the TSI values. There is no water quality data to predict TSI values for Lake Hicks prior to development in the watershed for comparison, so the effects of development cannot be known for sure, but TSI values for Lake Hicks place the lake solidly in the eutrophic category. Figure 4 and Figure 5 show TSI values based on recent data collected through King County's Volunteer Monitoring Program and by King County staff.

Figure 4. TSI values for Lake Hicks, 1996 - 1999

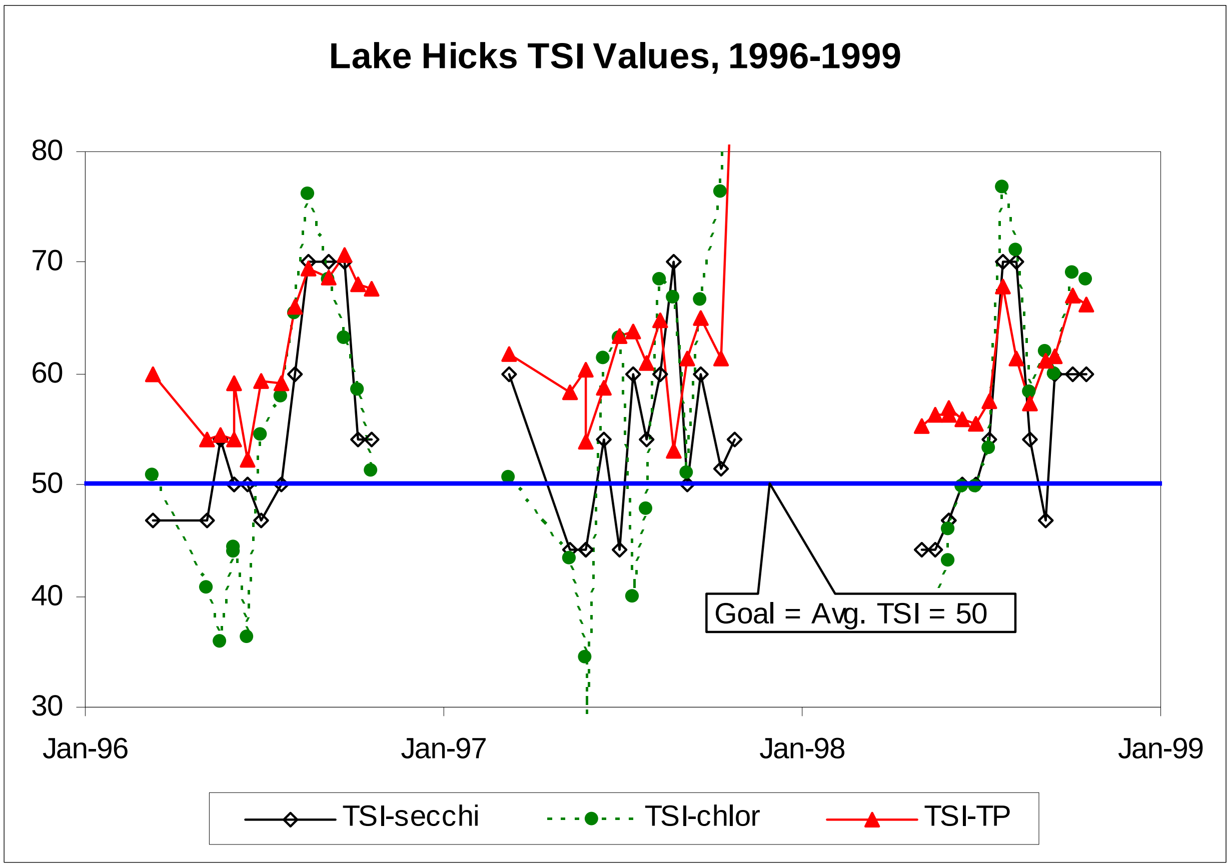
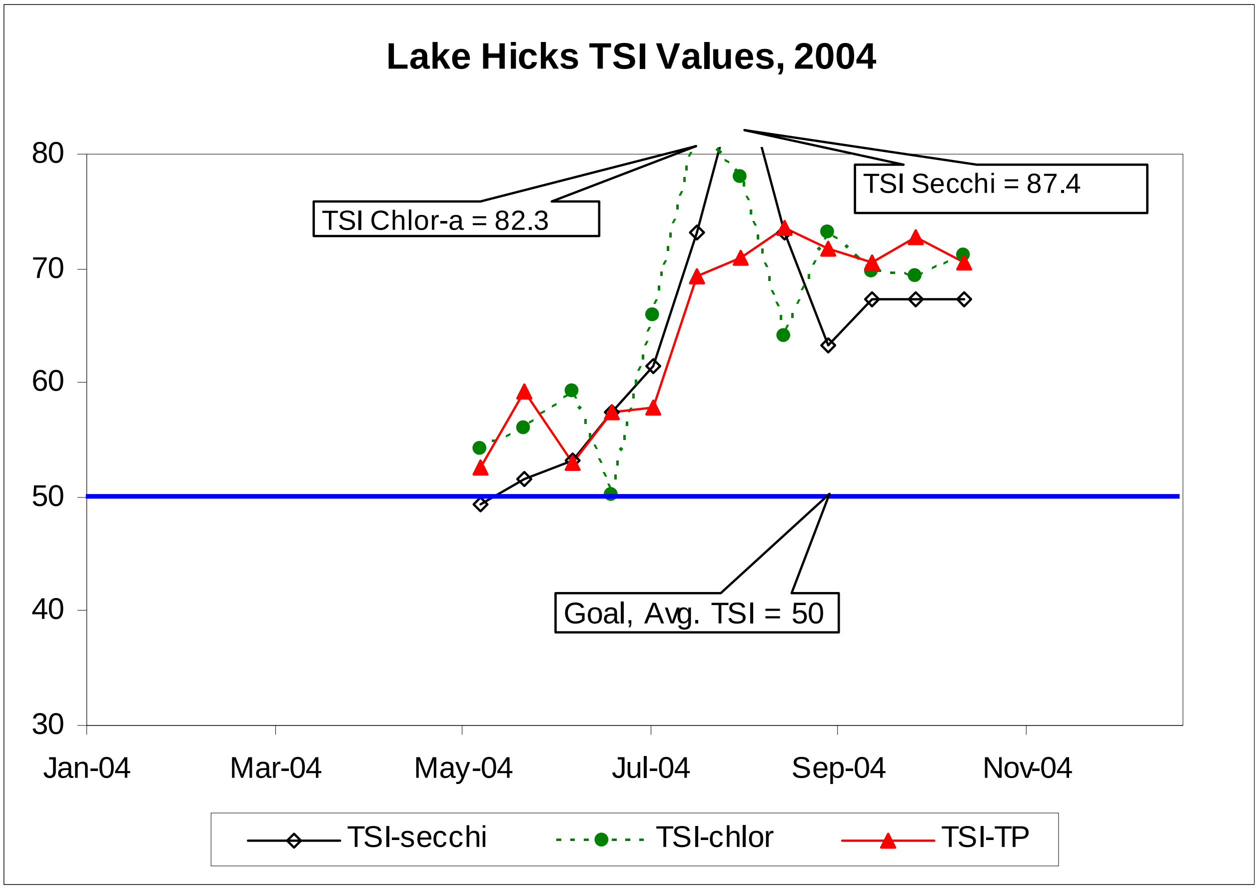


Figure 5. TSI values for Lake Hicks, 2004



Another important water quality measure related to internal phosphorus loading is the amount of dissolved oxygen in the hypolimnion. Table 3 shows dissolved oxygen and phosphorus concentrations measured in the hypolimnion of Lake Hicks in 2004.

Table 3. Phosphorus and Dissolved Oxygen Concentrations in Lake Hicks

Date	Depth (m)	SRP	TP	DO
5/19/2004	1	3.8	28.8	8.1
	5	14.1	72.5	0.85
6/2/2004	1	5.25	45	10.23
	5	4.4		0.35
6/17/2004	1	2.3	29.7	9.26
	5	7.62	NA	0.51
6/30/2004	1		40	7.38
	5	462		0.05
7/13/2004	1		41	9.42
	5	183	NA	0.04
7/27/2004	1	3.6	91	8.57
	5	272		0.04
8/10/2004	1		102	5.58
	5	335	294	0
8/24/2004	1	8.08	123	2.26
	5	44.1		0.19
9/7/2004	1	6.82	108	5.25
	5	76.2	NA	0
9/21/2004	1	4.8	99.5	5.99
	5	6.24	NA	6.11
10/5/2004	1	5.07	116	6.2
	5	5.71	NA	6
10/20/2004	1	3.3	99.8	6.85
	5	3.7		6.78

SRP Soluble Reactive Phosphorus
NA Not available
DO Dissolved oxygen
Source: King County water quality monitoring (King County, 2004a)

The low dissolved oxygen values on August 24, 2004 are likely the result of a summer storm in the days prior to the sample. Water flowing into the lake mixed deeper anoxic water with surface waters, in effect lowering dissolved oxygen of the surface layers.

Phytoplankton

There are several sources of information about the phytoplankton species present in Lake Hicks. Most recently, King County staff collected water samples several times in 2004 and identified several species phytoplankton from fine mesh net hauls and dipped samples. However, quantitative counts will eventually be analyzed from a subcontractor for the period between May and October 2004.

Data from collected from May 1981 through February 1982 (CH2M Hill, 1982) show that cyanobacteria made up a very small percentage of the algal volume, unlike samples collected and assessed more recently. Instead, the lake was dominated by a combination of various chlorophyte and euglenophyte species through most of the year.

Qualitative data collected through the Lake Stewardship Program in the mid 1990s suggested that cyanobacteria (blue-green algae) comprised a much greater percentage of the algal biovolume in Lake Hicks more recently (King County, unpublished data). Bluegreens dominated the assemblages about 55% of the time, with the most commonly occurring forms including species of *Anabaena*, *Anacystis*, *Aphanizomenon*, and *Coelosphaerium*. The dinoflagellate *Ceratium* was also a dominant form on several sampling dates. This agrees with the recent 2004 observations that early in the season the phytoplankton are dominated by chrysophytes and dinoflagellates (Table 4). The bluegreens became important in late spring of 2004 and persisted for the rest of the year. Filamentous genera such as *Aphanizomenon*, and *Anabaena* were important through August, followed by the colonial *Coelosphaerium*, which remained dominant through the end of the year.

Table 4. Phytoplankton present in Lake Hicks, 2004

Date	Species	Algal category	Abundance
19-May-04	Dinobryon sp.	Chrysophyte	****
19-May-04	Microcystis aeruginosa	Bluegreen	***
19-May-04	Peridineum sp.	Dinoflagellate	**
19-May-04	Synura sp.	Chrysophyte	**
19-May-04	Ceratium hirundinella	Dinoflagellate	**
19-May-04	Botryococcus braunii	Chlorophyte	*
19-May-04	Closterium sp.	Chlorophyte	*
19-May-04	Sphaerocystis schroeteri	Chlorophyte	*
19-May-04	Spirogyra sp.	Chlorophyte	*
19-May-04	Staurastrum paradoxum	Chlorophyte	*
2-Jun-04	Synura sp.	Chrysophyte	****
2-Jun-04	Microcystis aeruginosa	Bluegreen	**
2-Jun-04	Ceratium hirundinella	Dinoflagellate	**
2-Jun-04	Peridineum sp.	Dinoflagellate	*
2-Jun-04	Staurastrum paradoxum	Chlorophyte	*
17-Jun-04	Ceratium hirundinella	Dinoflagellate	****
17-Jun-04	Peridineum sp.	Dinoflagellate	***
17-Jun-04	Anabaena sp.	Bluegreen	**
17-Jun-04	Aphanizomenon flos aquae	Bluegreen	*
17-Jun-04	Coelosphaerium naegilianum	Bluegreen	*
17-Jun-04	Dictyosphaerium erhenbergianium	Chlorophyte	*
17-Jun-04	Staurastrum paradoxum	Chlorophyte	*
30-Jun-04	Aphanizomenon flos aquae	Bluegreen	***
30-Jun-04	Coelosphaerium naegilianum	Bluegreen	**
30-Jun-04	Anabaena sp.	Bluegreen	*
30-Jun-04	Coelastrum sp.	Chlorophyte	*
30-Jun-04	Staurastrum paradoxum	Chlorophyte	*
30-Jun-04	Ceratium hirundinella	Dinoflagellate	*
30-Jun-04	Pinnularia sp.	Dinoflagellate	*
12-Jul-04	Anabaena circinalis	Bluegreen	***
12-Jul-04	Anabaena flos aquae	Bluegreen	***
12-Jul-04	Aphanizomenon flos aquae	Bluegreen	**
12-Jul-04	Coelosphaerium naegilianum	Bluegreen	**
12-Jul-04	Ceratium hirundinella	Dinoflagellate	*

Table 4. Phytoplankton in Lake Hicks, 2004 - Continued

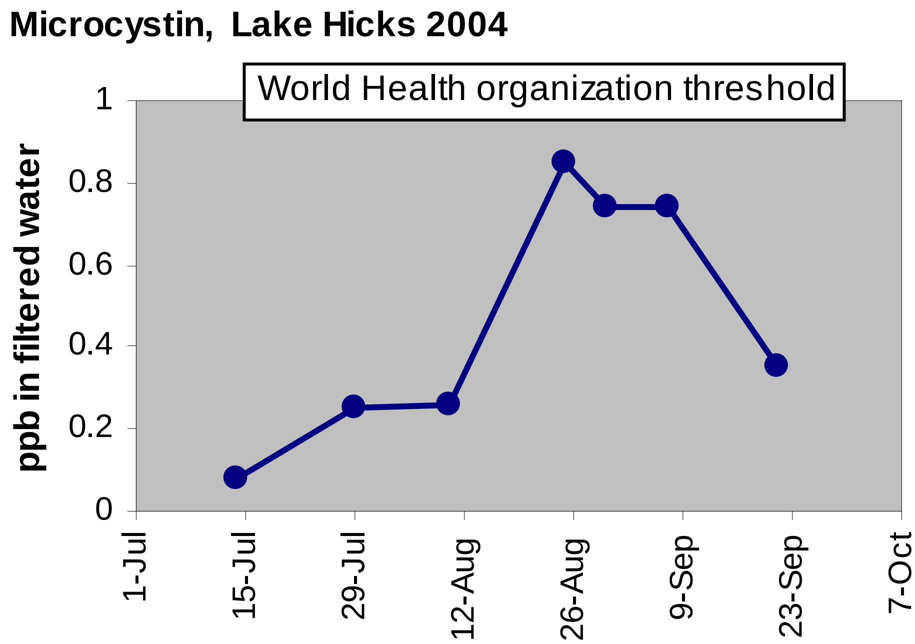
Date	Species	Algal category	Abundance
12-Jul-04	Microcystis aeruginosa	Bluegreen	*
12-Jul-04	Peridineum sp.	Dinoflagellate	*
28-Jul-04	Anabaena spiroides	Bluegreen	****
28-Jul-04	Aphanizomenon flos aquae	Bluegreen	*
28-Jul-04	Microcystis aeruginosa	Bluegreen	*
10-Aug-04	Anabaena spiroides	Bluegreen	****
10-Aug-04	Aphanizomenon flos aquae	Bluegreen	**
10-Aug-04	Coelosphaerium naegilianum	Bluegreen	**
10-Aug-04	Microcystis aeruginosa	Bluegreen	*
24-Aug-04	Aphanizomenon flos aquae	Bluegreen	****
24-Aug-04	Anabaena spiroides	Bluegreen	**
24-Aug-04	Coelosphaerium naegilianum	Bluegreen	*
24-Aug-04	Volvox sp.	Chlorophyte	*
7-Sep-04	Coelosphaerium naegilianum	Bluegreen	****
7-Sep-04	Aphanizomenon flos aquae	Bluegreen	**
7-Sep-04	Volvox sp.	Chlorophyte	**
21-Sep-04	Coelosphaerium naegilianum	Bluegreen	****
21-Sep-04	Aphanizomenon flos aquae	Bluegreen	**
21-Sep-04	Anabaena sp.	Bluegreen	*
5-Oct-04	Coelosphaerium naegilianum	Bluegreen	****
5-Oct-04	Aphanizomenon flos aquae	Bluegreen	*
5-Oct-04	Mallomonas sp.	Chrysophyte	*
5-Oct-04	Microcystis aeruginosa	Bluegreen	*
5-Oct-04	Trachelomonas sp.	Euglenophyte	*
20-Oct-04	Coelosphaerium naegilianum	Bluegreen	****
20-Oct-04	Aphanizomenon flos aquae	Bluegreen	*
20-Oct-04	Microcystis aeruginosa	Bluegreen	*
7-Dec-04	Coelosphaerium naegilianum	Bluegreen	*
7-Dec-04	Anabaena sp.	Bluegreen	*
7-Dec-04	Aphanizomenon flos aquae	Bluegreen	*

**** = predominant
*** = abundant
** = common
* = rare or present

Toxic Cyanobacteria blooms

During much of the summer, King County staff and community residents have noticed dense cyanobacteria blooms (B. Cullen, pers. comm.). In summer 2004, seven water samples tested positive for the presence of microcystin, a hepatotoxin found in certain species of cyanobacteria. Although toxin levels did not exceed safety standards of 1µg/L set by the World Health Organization, toxins were detected in each of the samples as shown in Figure 6. Different methods were used to evaluate toxin amounts in each of the samples, so actual amounts of some samples may be under-reported (Abella, 2004. pers. comm.).

Figure 6. Microcystin concentrations in summer 2004



Fish and Wildlife Communities

The fish populating Lake Hicks are not known. However, extremely low dissolved oxygen levels in the hypolimnion (King County, 2004a; Table 2) make conditions unfavorable for some desirable fish, especially salmonids.

Lake Hicks is not listed currently on the Washington Department of Fish and Wildlife (WDFW) website as a fishing area. The WDFW (or its predecessor agencies) stocked the lake each April from 1976 through 1992, with the exception of 1983 (Table 5). It is uncertain why the lake was not stocked after 1992, although it is likely due to high levels of fecal coliform bacteria detected through monitoring by King County Public Health.

Table 5. Fish Stocking Data

Date	Species	# fish/lb	Number stocked
Apr-76	Rainbow trout	4.5	500
4-Apr-77	Rainbow trout	4.5	800
28-Mar-78	Rainbow trout	4.0	1,000
20-Apr-79	Rainbow trout	6.4	1,000
18-Apr-80	Rainbow trout	6.5	900
23-Apr-81	Rainbow trout	6.0	900
16-Apr-82	Rainbow trout	5.0	700
13-Apr-84	Rainbow trout	3.9	355
16-Apr-86	Rainbow trout	6.3	350
22-Apr-88	Rainbow trout	3.7	300
20-Apr-89	Rainbow trout	2.4	400
19-Apr-90	Rainbow trout	3.6	300
Apr-91	Rainbow trout	4.2	300
21-Apr-92	Rainbow trout	3.6	310

(Tsunoda, 2004)

Aquatic Plants

There has not been a comprehensive aquatic plant survey completed at Lake Hicks in the recent past. During water quality monitoring trips in summer 2004, King County staff noticed *Chara spp.* (plant-like algae) and *Elodea canadensis* in the lake (Murphy, 2004. Personal observation).

Although aquatic plant density and distribution in Lake Hicks has not been surveyed recently, lowering phosphorus concentrations will likely improve conditions in the lake for aquatic plant growth. Lower phosphorus concentrations are intended to reduce the frequency and severity of algae and cyanobacteria blooms, resulting in increased water clarity for a greater portion of the growing season. Additional light penetration may result in increased plant density throughout the lake. After the Alum treatment in Green Lake in 1991, average Secchi transparencies went from 1.9 to 6.1 meters (Herrera, 2003).The increased water clarity is believed to be a contributing factor in subsequent dense milfoil growth.

Although a similar problem is possible at Lake Hicks, there is no evidence of milfoil or other submersed aquatic noxious weeds in the lake as of September 2004.

Current and Potential Beneficial Uses

Aesthetics

Neighborhood residents reminisce about the beauty of Lake Hicks in decades past, recalling the days when “the entire lake shore would be filled with families having picnics and people swimming” (Thurnau, 2004. Pers. comm.). The lake is often bright green with scums formed by algae blooms in the summer, and there is very little recreational use of the lake by the surrounding community.

Fishing

The extent to which people currently fish at the lake is unknown, although the lake has been a popular fishing destination in the past (King County, 2000).The deeper, colder waters of the lake are anoxic through much of the summer (King County, 2004a; Table 2), so it is unlikely that the lake supports a fish population that would make it a worthwhile fishing destination.

Swimming

By the 1970s Lakewood Park and Lake Hicks had become a popular swimming and fishing destination for residents in the White Center area. According to long-time residents of the community there was a time that the entire shore of the lake was crowded with community residents picnicking, fishing, and swimming in the lake (D. Thurnau, pers. comm.).

By 1974 many facilities at the park had been upgraded or created, including a restroom, parking lot for 90 cars, swimming/fishing dock, sandy swimming beach, and a lifeguard station. The King County Health Department recommended closing the lake for swimming after samples collected during the summer 1974 showed a dramatic increase in fecal coliform bacteria. King County Parks closed Lake Hicks for swimming in 1975 (King County, 2000).

In 1982 King County Division of Parks and Recreation contracted with CH2M Hill to develop the Lake Hicks Restoration Study. In 1986, King County constructed a detention basin upstream to divert high flows around the lake and extended the pump intake pipe to the deepest point of the lake (King County, 2000). As a result, fecal coliform counts dropped and water clarity improved, prompting King county to re-open the lake for swimming during the summer of 1986 (CH2M Hill, 1987). However, the lake was closed again at the end of the summer in 1991, following testing by the King County Public Health Department that showed high levels of “contaminants, severe algae and very high fecal coliform counts” (Chavey, 2004. Email communication). Lake Hicks remains closed to swimming.

The Friends of Hicks Lake would like to have “water quality to be restored so that swimming could again take place at the lake. This is (their) primary goal” (Droege, 2005. Email communication).

Education

Three area schools have students that use the lake as an outdoor classroom. Science classes from Evergreen High School visit the lake on a regular basis to study the lake. In partnership with King County’s Lake Stewardship Program between 2003 and 2004, students at Cascade Middle School and White Center Heights Elementary School measured lake level, water temperature, Secchi transparency, and precipitation amounts, and submitted the data they collected to King County.

Disc Golf/Play Ground

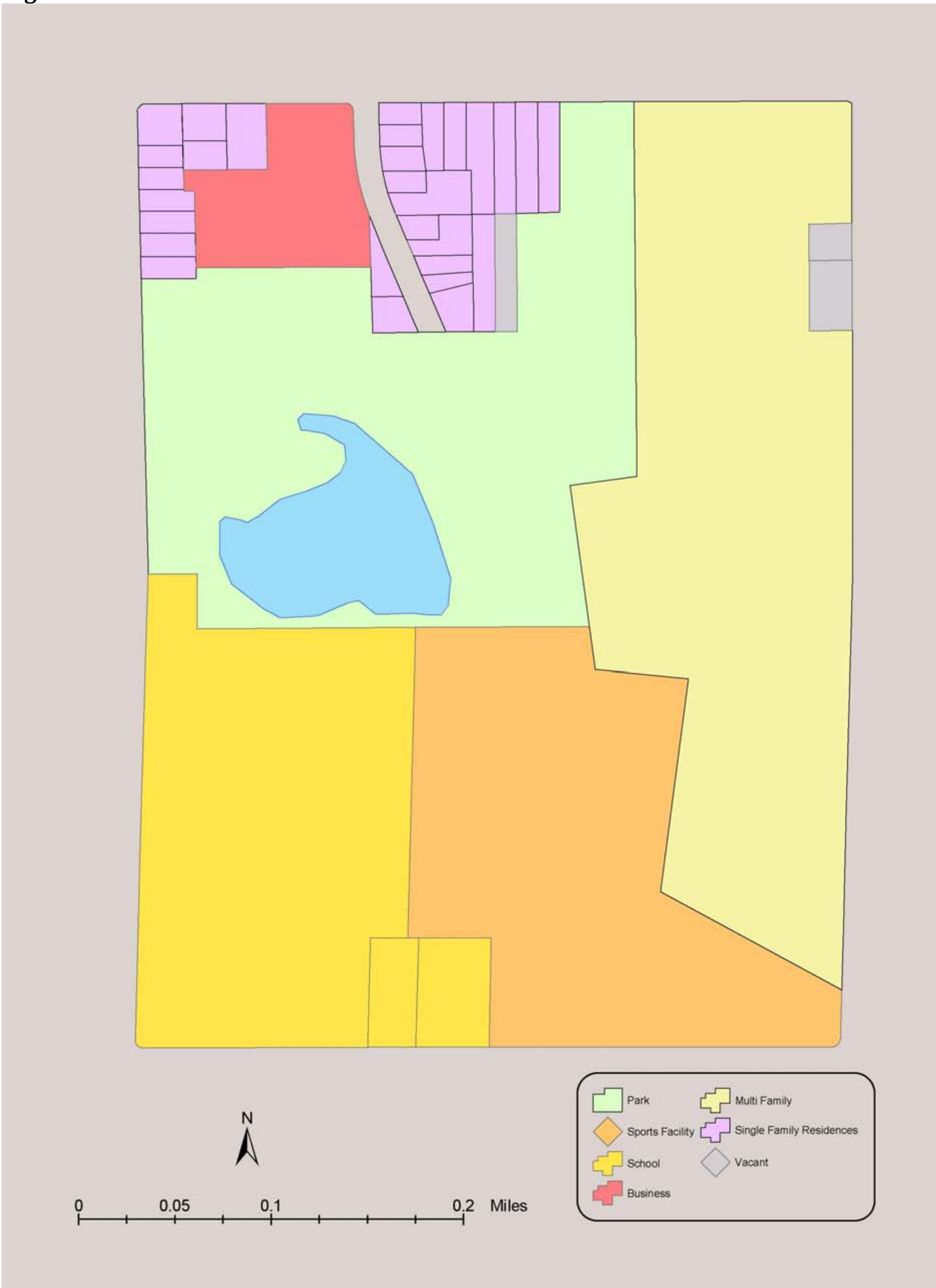
The Lakewood King County Park has one of very few disc golf courses in the region. The course is similar to a traditional golf course with 18 "holes" forming a continuous loop through the park. Although errant flying discs can end up in natural areas, including the lake and habitat restoration areas, there is likely negligible environmental impact from the course or the additional visitors to the park. Information about projects in Lakewood Park should be posted at several tee-off areas, as if approached, the disc golfers could be an additional network of volunteers and stewards.

Information about the disc golf course is available on this website:
http://www.pdga.com/course/courses_by_city.php?id=894

The playground is open to residents and often small children are found playing there. There is a picnic shelter at the playground with restrooms. Picnic tables are scattered throughout the park for passive recreation.

A map showing the beneficial uses of Lake Hicks is shown in Figure 7.

Figure 7. Beneficial Uses at Lake Hicks



SOURCES OF PHOSPHORUS

Data suggest that Lake Hicks receives phosphorus from both external and internal sources (King County, 2004; CH2M Hill, 1982). Likely external sources of phosphorus to Lake Hicks include natural organic matter in the watershed, soil erosion, pet and waterfowl wastes, and playfield, lawn, and garden fertilizers. However, it is likely that an equally significant source of phosphorus to Lake Hicks is internal recycling to the water from phosphorus rich sediments. Improving conditions at Lake Hicks will require understanding and controlling both external and internal phosphorus loading.

External loading

In a highly developed watershed such as that of Lake Hicks, both impervious surfaces and non-impervious surfaces can be sources of pollution, including nutrients from anthropogenic sources (King County, 1998). When a watershed is developed, nutrient enrichment of lakes from anthropogenic non-point sources of phosphorus generally increase. Although a variety of nutrients may reach the lake from non-point sources, phosphorus is generally the substance with lowest availability for phytoplankton (the "limiting nutrient") in the majority of lakes in the Puget Sound region (Gilliom and Patmont, 1982). Likely sources of non-point phosphorus loading in urbanized areas include atmospheric deposition, erosion or soil and other organic matter from construction sites, fertilizers used on residential lawns and gardens, and at playfields at nearby schools and parks (Garman, Good, and Hinsman, 1986). Animal wastes (both domesticated pets and wild animals) are another likely non-point source of nutrients (http://stormwatercenter.net/pollution_prevention_factsheets/animalwastecollection.htm, 2004).

Because there is no natural outlet from Lake Hicks, nutrients entering the lake do not leave unless they are contained in water pumped from the lake. The King County Department of Natural Resources and Parks replaced the outlet pump in November 2004.

Previous planning and modeling efforts determined that the primary source of water inflow and associated phosphorus loading to Lake Hicks is surface water coming in from the surrounding watershed (CH2M Hill, 1987; KCM, 1999; King County, 2004b). In a CH2M Hill study in 1982, a model was used to calculate phosphorus inputs to the lake based on rainfall amounts. Table 6 shows annual rainfall amounts from 1994 to 2003. Model outputs in the CH2M Hill predict that 77.3 pounds of phosphorus enter the lake in a "Seattle typical year" (35-inches of rainfall) and 92.6 pounds of phosphorus would enter the lake in a "Kent typical year" (40-inches). A regression analysis was performed using these two values. The actual precipitation amounts from 1994 to 2003 were inserted into the slope equation given by the trend line between the two values (intercept = zero, R^2=.93) to calculate approximate phosphorus loads to the lake for those years.

Table 6. Annual precipitation and predicted phosphorus loads

Year	Precipitation (inches)*	Predicted P load (lbs)**
1994	34.82	79.0
1995	42.6	96.7
1996	50.67	115.0
1997	43.26	98.1
1998	44.06	100.0
1999	42.11	95.5
2000	28.69	65.1
2001	37.03	84.0
2002	31.61	71.7
2003	41.94	95.2
Average	**39.7**	**90.0**
Min (2000)	**28.7**	**65.1**
Max (1996)	**50.7**	**115.0**

*Source for precipitation amounts: National Oceanic and Atmospheric Administration, National Climatic Data Center, Asheville, NC. Station: SeaTac Airport; Lat: 47°27'N Lon: 122°19'W
**P inputs calculated base on CH2M Hill predictive model (CH2M Hill, 1982)

Internal Loading

Lake Hicks sediments are rich in phosphorus (Siebens, 2004. pers comm.). Lake Hicks also becomes thermally stratified in the summer, and the hypolimnion becomes anoxic and typically remains so until the lake mixes in the fall (CH2M Hill, 1982; King County, 2004a). Through a chain of chemical reactions, hypolimnetic anoxia accelerates the release of phosphorus from the sediment, which can account for a significant percentage of the phosphorus load to the lake (Cooke, et al. 1993).

There may be other internal sources of phosphorus to Lake Hicks. Green Lake was shown to recycle phosphorus from the sediment when phytoplankton take up phosphorus from the sediment and migrate upward through the water column. When aquatic plants senescence and decay they release phosphorus into the water contributing to internal loading (Herrera, 2003).

King County staff recently collected sediment samples from two locations in Lake Hicks which were analyzed for phosphorus content. Results are shown in Table 7, followed by sampling methods.

Table 7. Sediment Phosphorus Monitoring Results

Sample	Loc	Type	Sediment layer	Water Depth (m)	TP (mg/kg, wet weight basis)	pH	% Solids
1	A745	Sediment	Top	5	539	6.98	15.7
2	A745	Sediment	Bottom	5	575	6.9	16.9
3	A745E	Sediment	Top	3.5	354	6.7	14.2
4	A745E	Sediment	Bottom	3.5	645	6.81	26.1
5	A745W	Sediment	Top	2.5	359	7.35	13.8
6	A745W	Sediment	Bottom	2.5	626	6.98	24.3

Sediment Phosphorus Sampling Methods

Purpose: Sediment from Lake Hicks will be tested for levels of phosphorus to help determine the alum dose necessary to have the desired effect. To the extent possible sediment was collected from two distinct layers, the top 2cm of the sediment, and the layer of sediment 2cm above the depth reached by the Ekman dredge (9-14cm for these samples). Analyses of different layers will determine how uniform the sediment is with respect to phosphorus content.

Locations:

A745
Description: deepest point
Water depth: 5m
Depth of sample: 9cm
Lat/Lon: 47°30.187'N; 122°20.739W

A745W
Description: near western shore
Water depth: 2.5m
Depth of sample: 14cm
Lat/Lon: 47°30.187'N; 122°20.752W

A745E
Description: approximately 20m off swimming beach, half way between outlets from upstream retention ponds and ball field drainage
Water depth: 3.5m
Depth of sample: 11cm
Lat/Lon: 47°30.193'N; 122°20.679W

Methods:

1. Determined sites. Three sites were chosen for sediment analysis. Site A745 is the regular deepwater sampling site at the deepest point in the lake, which was initially determined using old bathymetric maps and a handheld depth meter. General location of sites A745W and A745E were predetermined based on proximity known surface stormwater inflows. The exact locations were determined in the field prior to sampling.

2. Positioned boat over each site. Coordinates recorded for each site. Water depth was determined using the handheld depth meter just prior to dropping the Ekman.

3. Set, dropped, triggered, and hauled the Ekman dredge. The Ekman was dropped straight down and allowed to accelerate through the final meter of water above the sediment to “set” it as deep as possible into the sediment. The Ekman grabbed samples 9cm, 14cm, and 11cm deep. The Ekman was then hauled to just above the surface and held there for ~10 seconds so excess water could drain. Finally, the Ekman was hauled into the boat and placed upright in a white plastic tub.

4. Collected sediment from top layer. The top flaps of the Ekman were held open and a ruler was inserted in the sediment to determine the overall depth of the sample. If any water was present above the sediment, the Ekman was tilted slightly to drain most of the water, and a syringe was used to suck the rest of the water off the top until the sediment was exposed. A clean spoon was used to scoop off the top 2cm of the sediment, using the ruler as a guide. The sample jar was filled to ~3/4 full.

5. Extracted sediment from the bottom of the sample. The distance from the new surface of the sediment to 2cm up from the bottom was determined by reading from the inserted ruler. Then the syringe was marked at that distance from the tip of the syringe. The syringe was inserted to the mark (so the tip was at a depth of 2cm up from the bottom of the sediment) and sediment was sucked into it. This was repeated 3 times, which yielded enough material to fill the jar ~3/4 full. If necessary the syringe was washed off in water to avoid sediment contamination – if this was the case the first few “squirts” were emptied into the water prior to putting the sample in the jar.

6. Cleaned the Ekman and bucket. Rinsed all equipment to not contaminate the next set.

PHOSPHORUS CONTROL OPTIONS

There are a variety of phosphorus reduction measures that might be effective at Lake Hicks, some of which involve treating the water and sediment in the lake directly, and others that create or restore conditions in the watershed that will reduce the amount of phosphorus entering the lake via surface water. To the extent possible through reviewing literature and case studies, benefits and drawbacks of each method are listed. It is likely that reduction of phosphorus concentrations will be achieved most effectively through implementation of two or more of the following alternatives. Ideally, the chosen method(s) will also reduce sources of fecal coliform bacteria as an added benefit.

Alum Treatment

High phosphorus concentrations in Lake Hicks could be lowered by treating the water and sediments in the lake with aluminum sulfate (alum). This treatment will decrease the nuisance bluegreen algae and address the 303(d) listing of the lake in 1996 for phosphorus concentrations.

Adding aluminum sulfate (alum) to a lake has become a common way to remove phosphorus from water and prevent internal recycling of sediment-bound phosphorus when high phosphorus concentrations contribute to eutrophication problems (Welch and Jacoby, 2004). For many lakes, this method provides a relatively safe, cost-effective way to limit excessive algae production and the associated problems. Alum acts by binding phosphorus in the water into an insoluble compound that makes it unavailable for uptake by algal cells. Upon contact with the water, it forms a flocculant that sinks to the bottom of the lake, forming a layer that limits the release of phosphorus from the sediments back into the water column. It is not a permanent solution, but case studies suggest that if the dose is calculated correctly, alum could effectively reduce internal phosphorus loading for more than ten years (Welch and Cooke, 1999).

Lake Hicks has relatively low alkalinity (King County, 2004a), so the alum treatment will need to be “buffered” by addition of sodium aluminate and/or calcium hydroxide to prevent the pH of the lake from dropping below 6.0, which could lead to the appearance of soluble aluminum forms with greater toxicity (Cooke et al., 1993). If alum and buffer doses are calculated and applied correctly, research suggests that there should be little or no negative effect to aquatic plants and animals in the lake (Cooke et al., 1993).

If alum treatment is chosen as a phosphorus reduction measure, King County must apply for a National Pollutant Discharge Elimination System (NPDES) permit through the Washington Department of Ecology. This IPMP and a public participation process are the two main steps required prior to approval. The IPMP is then reviewed and approved by Ecology before coverage can be granted under the NPDES permit. The benefits provided by the alum treatment are not expected to be permanent, but should give several years of relief from annual nuisance algae problems while watershed-wide solutions are put in place. In addition, post-treatment monitoring must be carried out as part of the permit, but this may be at least partially combined with the water quality monitoring for other purposes.

Dilution

Diluting the lake with municipal water very low in phosphorus could result in water quality improvements. The water levels in Lake Hicks are low in summer, and the lack of inflows or outflows contributes to stagnation and accumulation of nutrients, algae, and bacteria. This method would pipe high quality water into the lake during summer low-stands and pump out excess to maintain a desired water level. Information on this method suggests that meeting a goal of adding 10% of the total lake volume per day would offer significant water quality benefits.

Diluting the lake with municipal water to improve water quality would be prohibitively expensive. Based on a lake volume of 40 acre-feet (CH2M Hill, 1982) and applicable consumer rates for water, the cost to dilute Lake Hicks with 10% of its volume daily for 90 days would exceed $500,000 (Sally Abella, pers. comm.).

Not only would dilution cost too much, but it would also require millions of gallons of water, which would be wasteful of the resource, considering that there are other equally effective, less expensive options for phosphorus control. Furthermore, dilution would not address internal recycling of phosphorus from the sediments.

Stormwater Diversion, Retention, and Treatment

The 1982 restoration plan noted that "Storm events produce fairly instantaneous flows in the overall system and into Lake Hicks" (CH2M Hill, 1982). Because surface water runoff in an urban watershed usually carries nutrients and other pollutants, diverting stormwater flows away from the lake would be likely to reduce nutrient and pollutant inputs. However, re-routing all of the stormwater would be prohibitively expensive and is not considered a viable option.

Retention and Treatment

King County's Capital Projects, Open Space and Acquisitions (CPOSA) group is planning to complete a series of drainage improvements in the park in 2005. King County will install a "bioswale" in the existing drainage pathways upstream of Lake Hicks in Lakewood Park.

The existing drainage pathways to the Lake are filled only in high flow events, or when the lake level rises and the lake backwaters into the drainage pathways. The large swale just upstream from the lake has limited vegetation and substrate suitable for water quality treatment. Additionally, the swale does not provide water quality treatment with high flows. This swale currently provides a limited water quality function to Lake Hicks. Through natural design techniques, CPOSA will retrofit the existing high-flow swale to a bio-filtration swale with native vegetation that will reduce the quantity of water reaching Lake Hicks and filter and absorb pollutants. These enhancements shall use existing drainage flow-paths and not require additional Parks lands currently used for recreation. In addition, native plants in the swale will increase nutrient uptake and sediment retention. The project is designed to treat 60% of a 2-year storm, which is defined as a rain event of a given magnitude that has a 50% chance of occurring in any given year. However, the existing channel is not large enough to treat all water inputs, based on the size of the contributing basin, so the completed project will modify the channel to provide the maximum percentage of runoff treated; resulting in 63% of runoff treated.

The overall goal of this effort is to design a project for low maintenance and public safety, while achieving optimal improvements in water quality treatment in such a way that will not negatively impact existing flooding conditions and that will not reclaim or impact existing recreational areas.

The Friends of Lake Hicks “would like to see a series of ponds in the upper basin to help the water quality of the lake.” (Droege, 2005. Email communication)

Diversion and Outlet Pump

King County is also planning to install a stormwater diversion that re-routes runoff from the ball fields located to the southeast of the lake directly to the pumps moving water through the Old Government Sewer line to Puget Sound. This diversion will prevent nutrient-laden runoff from the ball fields from entering the lake, and should result in decreased nutrient inputs. Further details of the proposed project are not available at this time.

King County has installed new outlet pumps at the lake to help alleviate flooding in the park. Although the pump is meant to address water quantity issues rather than water quality issues, increased stormwater conveyance out of Lake Hicks may extend the period of effectiveness of the proposed alum treatment. The new pump should move water through the system more quickly, allowing less time for phosphorus-laden particulates in stormwater runoff to settle to the bottom of the lake. In addition, regulated water levels will reduce erosion of the banks around the lake, another potential source of phosphorus.

Algicides

The use of algicides would treat the symptom (cyanobacteria blooms), not the problem (high phosphorus concentrations), and is therefore not considered a viable treatment option. However, implementing measures that will decrease the phosphorus concentrations in the water are expected to significantly decrease the frequency and severity of cyanobacteria blooms.

Sediment oxidation (RIPLOX)

The “Riplox” technique involves oxidation of sediment by addition of $Ca(NO_3)_2$. The resulting denitrification and oxidation of the sediments prevents the conditions that allow release of phosphorus from sediments. Riplox is an unsuitable phosphorus removal technique for Lake Hicks due to the overall cost, and that to date its effectiveness is not well documented (Welch and Jacoby, 2004).

Aeration

Theoretically, a hypolimnetic aerator would provide enough dissolved oxygen to the hypolimnion of a stratified lake to reduce the sediment-bound phosphorus release that occurs during anoxic conditions in the hypolimnion. However, case studies have shown mixed

results in controlling internal phosphorus loading through hypolimnetic aeration (Welch and Jacoby, 2004).
Aeration would not be likely to solve the problem of sediment phosphorus release in Lake Hicks. Studies have determined that in shallow lakes higher temperatures can create micro-anaerobic zones that facilitate sediment phosphorus release in well aerated water and that sediment phosphorus release in an aerobic hypolimnion can be of the same magnitude as that of an anaerobic hypolimnion (Bostrom et al., 1982).

King County Senior Engineer, Sally Abella, researched the potential positive and negative effects of aerating Lake Hicks in response to a citizen inquiry and concluded that, "there is no strong evidence that aeration would provide the desired benefit in Hicks Lake of decreasing the algae blooms presently occurring in summer. There is even the possibility that blooms could worsen as a result of aeration. Other techniques, such as reduction of phosphorus and bacteria in water inflows or in-lake alum treatments at intervals are likely to have better and more predictable impacts on water quality both immediately and over time." (Abella, 2004b)

Dredging

Lakewood Park Master Plan Update states that dredging would not be likely to decrease stormwater retention. Given that the primary source of water inflow to the lake is urban stormwater runoff, it is very likely that sediments of the lake contain toxins, but this type of sediment data are as yet unavailable. If toxics are present, dredging could re-suspend particles and may cause further harm than if left undisturbed.

Whether toxic or not, removal and disposal of the dredge spoils would be very expensive. Further, a 1998 hydrogeological study of Lakewood Park determined that dredging might result increased circulation between the lake and groundwater, which could lower lake levels through loss of water in the lake to infiltration of the sediments beneath the lake basin (Udaloy Environmental Services, 1998).

Watershed Education Campaign

Studies have determined that surface water runoff from the watershed accounts for the majority of the dissolved phosphorus in Lake Hicks (CH2M Hill, 1982). If residents in the watershed changed their behaviors to reduce the majority of their phosphorus contributions to the environment, through time, it may help reduce the phosphorus concentrations in Lake Hicks, although it would be unlikely to result in stabilization at the lower target levels ($<20\mu g/l$).

Effective watershed education campaigns take many years, and getting residents to change their behaviors can be extremely difficult. Achieving significant reductions in phosphorus concentrations is not likely to stand alone as an effective solution. A neighborhood education campaign led by a local group, such as the Friends of Hicks Lake, should apply for grants to institute an education campaign that focuses on reducing three known contributors to phosphorus in surface runoff: lawn and garden fertilizers, waterfowl and pet wastes.

No action

Taking no action to control phosphorus is not recommended. Lowering phosphorus concentrations to meet requirements of the Total Maximum Daily Load (TMDL) would not be likely to occur if no action is taken. Also, there is potential for increasingly frequent toxic cyanobacteria blooms. Taking no action would allow the further degradation of the water quality in Lake Hicks and possibly subject humans, pets, and wildlife to potentially serious health risks.

COMMUNITY INVOLVEMENT

Community Commitment and Education

The White Center community has demonstrated a keen interest in the health of Lake Hicks through the years. In 1978, local residents formed the Lake Hicks Improvement Committee to study possibilities for lake restoration and park improvements. Since then, there have been area residents devoting time and energy to improving conditions at Lake Hicks and Lakewood Park. This group is now called the Friends of Hicks Lake, which currently has 15 active members.

One dedicated resident, Dick Thurnau has tirelessly shared with King County his thoughts and opinions about what would be best for Lake Hicks. In 1998, Mr. Thurnau distributed a survey to 500 homes in the Lake Hicks vicinity. The survey asked residents to rate 10 action statements related to Lakewood Park and Lake Hicks from "strongly agree" to "strongly disagree". The action statements ranged from "request Evergreen and Cascade schools to control student trash from blowing into the lake" (95% of respondents in agreement), to "limit disc golf club to nine baskets to control park environment" (54% of respondents in agreement). Although the statistical validity of the survey and results cannot be verified, the reported response rate of 16% and the general agreement with proposed restoration actions at the lake is evidence that the community cares about Lake Hicks. Mr. Thurnau is sure to remain in the conversation as restoration actions are implemented.

Recently, several other organizations have begun to participate in projects at the lake. The Friends of Lake Hicks has recently become more active. In 2004 the group had regular monthly meetings, sponsored a community barbeque and lake awareness day in June and a fall planting around the lake in October. Table 8 shows a list of recent projects and activities. Evergreen High School, Cascade Middle School and White Center Heights Elementary all use the lake as an outdoor science classroom.

Steven Reilly, a community activist, runs a youth service program that has received funding through King County-administered Natural Resources Stewardship Grants to work with area youth who are "at-risk" to improve the habitat conditions at the park. Grant-funded activities of the White Center Heights Summer Youth Crew have included removal of Scot's broom and Himalayan blackberry and planting native plants along the lake shore. Mr. Reilly is also a member of the Friends of Hicks Lake and has been involved in their activities as well.

Table 8. Recent Community Activity

Date	Location	Volunteer	Project
3/21/2004	Lakewood Park	Lakewood Disc Golf	Cleanup
3/31/2004	Lakewood Park	White Center Ponds Project - WCH	Planting
4/30/2004	Lakewood Park	City Year	Cleanup
5/6/2004	Lakewood Park	City Year	Cleanup
10/2/2004	Lakewood Park	Friends of Hicks Lake	Flowerbed planting
11/19/2004	Lakewood Park	White Center Ponds Project - WCH	Planting
1/1-1/31/04	Lakewood Park	White Center Ponds Project -WCH	Water quality testing
1/1-1/31/04	Lakewood Park	White Center Ponds Project -CMS	Water quality testing
2/1-2/28/04	Lakewood Park	White Center Ponds Project -WCH	Water quality testing
2/1-2/28/04	Lakewood Park	White Center Ponds Project -CMS	Water quality testing
3/1/-3/31/04	Lakewood Park	White Center Ponds Project -CMS	Water quality testing
3/1-3/31/04	Lakewood Park	White Center Ponds Project -WCH	Water quality testing
4/1/-4/30/04	Lakewood Park	White Center Ponds Project -CMS	Water quality testing
4/1-4/30/04	Lakewood Park	White Center Ponds Project -WCH	Water quality testing
5/1/-5/31/04	Lakewood Park	White Center Ponds Project -CMS	Water quality testing
5/1-5/31/04	Lakewood Park	White Center Ponds Project -WCH	Water quality testing
7/1/-7/31/04	Lakewood Park	New Start Program	Maintenance assistance
8/1-8/31/04	Lakewood Park	White Center Ponds Summer Youth Crew	Maintenance assistance
8/26-8/31/04	Lakewood Park	Lakewood Disc Golf	Course improvements
9/1-9/30/04	Lakewood Park	Lakewood Disc Golf	Scotts Broom pull
2004	Lakewood Park	Earth Corps	Habitat construction

WCH = White Center Heights Elementary School
CMS = Cascade Middle School

Public Participation

Public participation and support in the planning and implementation process will be instrumental to the long term success of the efforts to improve Lake Hicks. Through the years there has been a core of dedicated local residents that acted to raise awareness about the deterioration of the lake and encouraged King County to initiate several studies and capital improvements at the lake. This group formed the Friends of Hicks Lake (FOHL) in 1976, and has been involved since in projects to improve the lake and park. A draft of this IPMP was presented to the FOHL and other community members at a public meeting on January 12th, 2005 at Cascade Middle School. An announcement flyer was distributed to community members by members of the Friends of Lake Hicks prior to the meeting. A copy of the announcement flyer is included in Appendix B. At the meeting, members of the FOHL were given hard copies and after the meeting King County staff sent an electronic copy to a representative of FOHL. Members of FOHL reviewed this plan and offered suggestions and edits that have been incorporated.

At the public meeting King County staff presented an outline of the plan and discussed the proposed phosphorus reduction measures with those in attendance. Copies of the plan were available at the meeting, and several people requested electronic copies for review. Community members and other interested parties submitted comments, which have been incorporated into this final plan. A meeting announcement, sign in sheets of attendees, an agenda, and a copy of the PowerPoint show are included in Appendix B.

FOHL has outlined their four priorities for improvements to Lake Hicks and its watershed (Droege, 2005. Email communication):

1. Carry out the planned alum treatment for spring 2005, including extensive community outreach to educate our community about the process. Friends of Hicks Lake is eager to assist in public and community outreach.
2. Construct a series of detention “cleansing” ponds, on public lands between White Center and Hicks Lake, along the main drainage path for water that ends up in Hicks Lake. This strategy, of using a series of settling ponds linked by streams, with the water finally arriving at the lake, has worked in Shoreline for the park system there. Shoreline residents have raved about the cleanliness of the water that has resulted from their effort. We feel strongly, that this strategy should be implemented at Hicks Lake.
3. Continue working with our group to continue habitat restoration along the shoreline and drainage areas in the park and throughout the 750-acre Hicks Lake drainage basin.
4. The dock is central to the quality of a visit to Hicks Lake. We want that dock to be preserved and re-built if necessary. If it is more cost effective, replace the dock with a new one.

A final draft of the IPMP will be reviewed at a second public meeting on March 24, 2005.

INTEGRATED PHOSPHORUS CONTROL PLAN

Based upon review of the possible phosphorus reduction measures, the most suitable phosphorus control plan will involve a combination of four elements:

1. Bioswale and retention ponds upstream,
2. Alum treatment to the lake in early spring, 2005,
3. Stormwater diversion measures, and
4. Ongoing public education

This is believed to be the best combination of restoration activities based on the best available science. As with any project in a natural system, it will be important to monitor the outcome of the projects and adjust future efforts accordingly.

Implementation

Bioswale and Retention ponds

King County Capital Projects, Open Space and Acquisitions (CPOSA) section in the Water and Land Resources Division plans to complete construction of the bioswale and retention pond before the autumn rains begin in 2005. Goals and objectives of this project are included in Appendix C.

Cost

Cost projections for this project are not available at this time.

Alum Treatment

Aluminum sulfate added to the water will reduce the phosphorus concentrations in the water column, and immobilize the phosphorus in the lake sediments, preventing release to the water through redox reactions during periods of hypolimnetic anoxia. Results from water quality and sediment monitoring were used to determine the proper dose of alum and buffering agent (sodium aluminate).

Pre-treatment Water Quality Monitoring

Determining conditions in the lake prior to treatment will be necessary to calculate the correct dose of alum. Key parameters include total phosphorus, alkalinity, and pH, which will help determine the required amount of buffer.

Determining sediment phosphorus content through sediment sampling will be an important determinant of how much alum will be required to immobilize sediment-bound phosphorus. Preliminary sediment phosphorus analysis was performed on samples collected by King County Staff on December 7, 2004. See Table 7 for analysis results.

Prior to the alum treatment a series of “jar tests” will be conducted using water from Lake Hicks. These jar tests will determine the amount of phosphorus dissolved in the water, which in conjunction with results from the sediment analysis will help to determine the amount of alum necessary to inactivate dissolved phosphorus and sediment-bound phosphorus. An additional set of jar tests will be completed in the week prior to treatment.

Treatment Methods

The alum and sodium aluminate (buffer) will be delivered to the site by tanker trucks and stored in the trucks or in stand-alone tanks rented from the supplier. A boat with two tanks (one for alum and one for buffer) will be used to apply the alum and buffer to the lake. The size of the tanks on the boat will be limited by the weight of the alum and buffer, so multiple trips will be necessary. A hose extending from each storage tank will be used to refill the tanks on the boat as many times as necessary.

The boat will slowly traverse the lake, going back and forth from one side to the other pumping each chemical into the water. The alum will be pumped through a manifold or set of hoses in the water at or near the front of the boat, and the buffer will be pumped through a manifold or set of hoses trailing from the rear of the boat. As the boat moves through the lake, the boat operator will make sure that chemicals are spread evenly over the surface of the lake. Since it will be easy to see the white “floc” that forms when the two chemicals combine in the water, the applicator will know which portions of the lake have been treated and which have not.

If necessary, reference points such as painted wood stakes, will be placed on the lake shore to guide the boat operator during chemical application.

Water Quality Monitoring During Treatment

During the alum application a King County staff member will be on the lake in canoe taking pH measurements at regular intervals to ensure that the pH stays between 6.0 and 8.5. Maintaining a pH within this range is a condition of the required National Pollution Discharge Elimination System permit. The KC staff member will also collect water samples that will be analyzed onsite by another staff member for alkalinity.

Several King County staff will be at the site during the treatment to offer assistance to the applicator and perform water quality monitoring as necessary.

Implementation Steps

Table 9 shows basic steps leading to project implementation.

Table 9. Implementation of Phosphorus Management Plan

October 2004 – January 2005	Research current and historical conditions at Lake Hicks and the drainage basin.
November 2004 – January 2005	Write *Integrated Phosphorus Management Plan*.
January 2005	Convene interested members of the public at a public meeting to discuss the proposed plans for water quality and drainage improvements.
January 2005	Incorporate public comments into IPMP.
February 2005	Submit IPMP to Ecology for review and approval.
February-March 2005	Finalize specifics of alum treatment and other restoration measures including: alum and buffer dose determination, application methods, pre and post-treatment monitoring plan. An outside consultant may be hired to assist in this planning.
February 2005	Complete SEPA checklist (Appendix D)
March 2005	Procure NPDES permit through Ecology
March 2005	Perform Jar Tests
March 2005	Present final IPMP and proposed restoration plan to community.
April 2005	Perform alum treatment
March – October 2005	Complete construction of bioswale and detention pond
April - October 2005	Post-treatment water quality monitoring

POST-TREATMENT MONITORING

Post-treatment water quality monitoring will be important to ensure that the alum treatment is having the desired effect, and that water quality in the lake is remaining stable. The first post-treatment monitoring will occur two days after treatment is completed, then monthly for six months (through October). Parameters measured at each sampling trip will include:

- pH
- Dissolved oxygen
- Conductivity
- Temperature
- Secchi transparency
- Alkalinity
- Total phosphorus
- Orthophosphate
- Fecal coliform

Results of the monitoring will be used to determine the effectiveness of the alum treatment and ensure that water quality remains stable and that that alum treatment did not create conditions that would pose a threat to humans or aquatic life in the lake.

BUDGET

Table 10 shows the estimated budget for the alum treatment, including pre-treatment planning, permits, all treatment related activities, and post-treatment monitoring. Actual costs may vary from estimated amounts, but total project cost will not exceed the budgeted amount of $50,000.

Table 10. Estimated Budget

STAFF	Burdened Hourly	Hours	Total	Notes
Sally	$83.94	90	$7,554.33	Project oversight
Murph	$60.48	150	$9,072.05	Project management, field work
Beth	$56.35	110	$6,198.09	Field work
Intern	$31.28	30	$938.40	Field work (summer monitoring)
Tom Smayda			$2,500.00	Lump sum consultant contract.
Staff costs			$26,262.87	
Contingency		7.5%	$1,969.72	
			$28,232.58	**Staff Total**

TREATMENT	Unit Cost	Units	Total	Notes
Applicator	$1,300	2	$2,600.00	two days estimated
Materials:			$0.00	
Alum	$0.10	30816	$3,204.86	$/lb. from Cascade Columbia Distributors
Buffer	$0.48	14212	$6,878.61	$/lb. from Cascade Columbia Distributors
Alum and Buffer Delivery:				
Hourly Charge	$50.00	16	$800.00	
Treatment costs			$13,483.47	
Contingency		20%	$2,696.69	higher contingency to cover estimates
			$16,180.17	**Treatment Total**

MONITORING	Cost	Units	Total	
Lab costs per trip	$149.00	7	$1,043.00	7 trips/mo. Apr - Oct. (TPx2, PO4, Chl-a, Alk, Fecs)
Phytoplankton assessment	$80.00	$7.00	$560.00	Consultant contract
Monitoring costs			$1,603.00	Staff time included in staff costs above
Contingency		7.5%	$120.23	
			$1,723.23	**Monitoring Total**

PUBLIC OUTREACH	Cost	Units	Total	
Signs	$20.00	3	$60.00	
Printing and postage	$0.45	100	$45.00	
Public announcement	$70.00	3	$210.00	
IPMP printing	$100.00	1	$100.00	
Public Outreach costs			$415.00	
Contingency		7.5%	$31.13	
			$446.13	**Public Outreach Total**

$ 46,582.10	**TOTAL PROJECT COSTS**

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APPENDICES

Appendix A:	Water Quality Data
Appendix B:	Public Participation
Appendix C:	Lakewood Park Stormwater Management
Appendix D:	SEPA Environmental Checklist
Appendix E:	Lake Hicks Photos