1.0 Introduction

St. John's University property is comprised of 2,400 acres of hardwood forest, prairie remnants, oak savanna, lakes and wetlands. The University's Strategic Plan specifically addresses the importance of maintaining and enhancing the quality of the property's natural environment. The natural features are considered an amenity to the community, and the University's lakes and wetlands are high profile resources serving many functions. This study was undertaken to characterize and help manage the campus watershed and water resources.

The study's purpose was to provide a detailed analysis of the watershed's hydrologic regime from a surface water quantity and quality perspective. Several areas of concern provided the impetus for this study: East Gemini Lake receives direct discharge from the University's wastewater treatment plant. Over time, nutrient loading has impacted the water quality. The quality of the wetland marsh located downstream of East Gemini Lake also has been affected. However, other upstream lakes within the University property reflect higher water quality, and the University recognizes the need and value in maintaining these lakes.

Overall goals of the study were to identify sources and amounts of phosphorus loading to the main water bodies on campus, to recommend management actions for priority water resources, and to create a framework for a water quality management plan.

2.0 Existing Conditions

2.1 Watershed Area and Geomorphology

St. John's University is located within the Platte-Spunk major watershed (USGS cataloging unit: 07010201). The existing minor watershed draining to and through the University is approximately 5,030 acres. Seven subwatersheds are identified within the study area. Maps 1A and 1B show the watershed and subwatersheds delineated for this study. Map 1A overlays the watershed onto existing topographic contours. Map 1B overlays the watershed onto a digital orthoquad aerial photograph.

Slope and profile of the terrain varies considerably. Much of the watershed's upper reaches are comprised of resistant knobs and winding ridges surrounding small, shallow kettle (or pothole) depressions. Slopes in the upper reaches of the watershed are moderate, typically about 10%. Slopes are steep (approximately 20%-25%) with pronounced ridges and escarpments dominating the landforms along the east portion of the study area. Middle and downstream reaches of the watershed reflect gradual changes in relief and a gentle topography with slopes ranging from 2%-7%. The highest ground elevation in the study area is 1,286 feet above sea level; the lowest elevation is 1,108 feet, a 178-foot differential.

2.2 Land Use

The study area is comprised of land uses differentiated on whether the land is within the University property boundary or outside University property. Agricultural functions dominate land use outside University property. Typical land use around the University is small dairy farms, according to the Stearns County Soil and Water Conservation District (SWCD). These dairy farms typically use a seven-year crop rotation during which alfalfa and small grain is grown for four years, followed by corn for three years. Inspections of aerial photos and contour data show areas too steep to farm have forested cover. The mix of forested land and farmed land is almost equal. No significant buildings, developments or structural facilities comprise land use outside of University property.

Within University property land use is dominated by forest cover. Forested areas are maintained in good condition. A small fraction of the overall University property is developed. The developed area consists of dormitories, lecture halls and other structural facilities. The developed area is concentrated in one primary location, referred to in this report as the campus. Within the property boundary are other land uses, principally recreational. These land uses range from athletic fields to walking trails or interpretive paths.

2.3 Drainage and Flows

Drainage and flow of surface water is northeasterly within the study area. The drainage system is a result of historic flows to the North Fork of the Watab River, which discharges into the Mississippi River. In the upper watershed of the study area, Pflueger Lake served as the headwaters for the historic stream that flowed through University property. The historic channel bed through the watershed remains defined; however it is inundated by standing water comprised of manmade lakes and wetlands. Pflueger Lake currently connects to Stumpf Lake by a creek approximately 15 feet wide.

The inundation of the historic channel bed illustrates how drainage in the study area was modestly altered as the University matured. This includes the creation of Stumpf Lake and East Gemini Lake by impoundment of the stream channel. Several lakes within the study area have road crossing structures at their outlets, a result of development. Finally, the constructed wetland complex at the watershed outlet has a control structure that can be operated to control water level and flows out of the study area.

Drainage patterns for the study area outside University property generally appear to be consistent with what may be expected before settlement. This is based on the large number of small wetlands seen in recent aerial photographs. A further review of aerial photographs indicates some artificial drainage and channeling in agricultural plots, as shown by the landscape's darkened patterns.

2.4 Depressional Storage and Wetlands

Within the study area many low spots collect runoff. These low spots resulted from glacial processes that formed today's landscape. Over time, these small, shallow depressions have become wetlands, many of which are listed on the National Wetland Inventory (NWI). Map 1B highlights these NWI depressions. These wetlands are commonly referred to as prairie pothole wetlands. From a hydrologic standpoint, they provide storage as well as attenuate and/or retain storm water runoff. Large ponds and lakes have formed where glacial processes have created deeper depressions. These ponds and lakes also provide storage and attenuate stormwater runoff.

The campus of St. John's University and the surrounding landscape has several lakes and wetlands. Table 1 provides an overview of the study area's major lakes and wetlands.

Table 1 – Major System Lakes

Name	**Surface Area[1] (Acres)**	**Outlet/Control Device**
Wetland Marsh	42[2]	Dual 42-inch culverts with adjustable stage weir
East Gemini Lake	37	24-inch primary pipe; 36-inch overflow
West Gemini Lake	12	30-inch equalizer to East Gemini
Stumpf Lake	68	36-inch culvert
Pflueger Lake	24	Overland flow, no structure found
Lake Sagatagan	176	18-inch pipe[3]

[1] Bonestroo determined all surface areas using aerial photos or 2-foot contours.
[2] Wimmer Pond (13 acres) is assumed to be hydrologically connected to the adjacent wetland marsh.
[3] The 18-inch outlet appears to be non-functional. No terminus was located, and the inlet invert appears to be above existing water level fluctuations.

2.5 Transportation Network and Waterway Crossings

The transportation network if formed by roads to and through the St. John's campus. The study area's northern boundary is Interstate 94. County Road 159 is aligned north-south and serves as a drainage divide. This road provides impoundment for West Gemini Lake as well as Stumpf Lake. County Road 51 is aligned east-west.

3.0 Water Quantity Modeling

3.1 Data Collection

The study area's water quantity model was constructed using a variety of sources. The USGS minor watershed boundary provided a reference to create subwatershed delineations. Two-foot contour intervals were studied to delineate subwatershed boundaries. Aerial photographs were used to interpret land use cover and determine curve numbers for runoff values. Surface area of existing lakes was determined in part from existing DNR information, but primarily through current aerial photos and contour data. St. John's staff field-checked the lakes' and wetlands' outlet structures for size, length and elevation relative to current water level.

3.2 Modeling Process

Hydrologic modeling was based on a 100-year recurrence interval rainfall, the equivalent of 5.8 inches of precipitation in 24 hours for the Stearns County area. The study area was divided into seven subwatersheds. Basic characteristics of subwatersheds are shown in Table 2.

Table 2 – Basic Subwatershed Characteristics

Subwatershed ID	**Subwatershed Area (Acres)**	**Weighted CN**
1	755	62
2	1,317	61
3	507	73
4	1,017	59
5	818	68
6	182	65
7	437	69

Time of concentration for each subwatershed was determined by the SCS lag method. For the water quantity modeling process, it was assumed that:

- Lake Igantius and Lake Sagatagan behave as one hydrologically connected lake. This assumption was made because aerial photos and DNR figures show an open channel between the two lakes.
- Wimmer Pond and the adjacent wetland behave as one hydrologically connected system. This assumption was made because Wimmer Pond has very little direct drainage to it, so modeling it separately has no benefit. Examination of contour data also shows normal water levels are likely equal, as are flows beneath the road.
- East and West Gemini behave as one hydrologically connected lake. This assumption was made because the equalizing structure beneath the road divides the lakes.
- Cichy Pond did not provide significant storage or attenuation. This assumption was made because it is relatively small in surface area, has a relatively small drainage area, and has no discernable connection, i.e. overland flow or piped, to other major system ponds.

The following factors were neglected in the modeling of the 100-year storm event:

- Direct conveyance of storm water runoff through existing storm sewers
- Discharge volume by the wastewater treatment plant (WWTP)
- Installation of an artificial turf system at the Athletic Field (underground drainage system conveys runoff to East Gemini Lake)

3.3 Modeling Results

Water quantity modeling analyzed discharges generated from a 100-year rainfall. For this region of Stearns County, the 100-year rainfall event equates to 5.8 inches of rainfall in 24 hours. Modeled discharges of the study area's surface water system are shown in Table 3.

Table 3 – 100-Year Storm Modeled Discharges

Waterbody	Outlet Structure	Peak Discharge	Estimated Elevation	Bounce
Wetland Marsh	Stage weir	90 cfs	1,110.4	2 feet
East Gemini Lake	24-inch culvert (primary); 36-inch (overflow)	32 cfs	1,124.1	2.5 feet
Stumpf Lake	36-inch culvert	27 cfs	1,135.6	3.5 feet
Pflueger Lake	Overland flow	298 cfs	1,139.7	1.75
Lake Sagatagan	18-inch pipe	None	1,166.3[1]	1 foot
Long Lake	Overland flow	37 cfs	1,198.4	0.5 feet
Island Lake	Overland flow	2 cfs	1,190.9	0.75 feet

[1] The DNR established an Ordinary High Water level of 1,168.9 feet for Lake Sagatagan

One result of the model is that "run time" had to be substantially increased. Typically a window of 24 hours is sufficient to capture the storm event, and associated runoff and discharge. However, this model reflected a run time of 60 hours to capture the system's full dynamics. Water levels rose in certain ponds well after the modeled storm event's peak, which occurred after only 12 hours. This signifies a great deal of attenuation in the existing system. Ponds and wetlands can store the runoff's peak and slowly release it downstream over time.

A notable result of the modeling is that no pond flooded, i.e. exceeded storage capacity, as a result of the modeled storm. This is particularly significant for manmade waterbodies such as Stumpf and Gemini Lakes because County Road 159 is an impoundment. Thus, the modeling showed no road overtopping for any pond. No flooding also indicates waterbodies can accommodate an increased volume of runoff should impervious drainage areas increase.

Very high discharges were reflected at the outlet of Pflueger Lake, a result of the lake having a small amount of storage above its normal water level. This high discharge supports the fact that this lake is the headwaters for the Watab tributary. It appears the channel width and floodplain can accommodate higher peak flows without adverse effects such as erosion or unnatural migration. However, it is important to keep in mind that although a discharge of approximately 300 cfs is very high, channel-forming flows typically result from smaller, more frequently occurring discharges.

No discharges were observed for Lake Sagatagan during the 100-year storm event. This modeled outcome was supported by field observations. Only one outlet structure was noted for Lake Sagatagan, an 18-inch reinforced concrete pipe. The pipe's inlet invert was approximately 2 feet above the current water level at the time of observation. This 2-foot differential is above the modeled lake level fluctuation for a 100-year storm. Further, this outlet pipe discharges to a shallow swale. The swale had no evidence of recent or historic flows, although earthen check dams were in place. Presumably Lake Sagatagan is a groundwater seepage lake. The difference in water profile elevation (approximately 35 feet) between Lake Sagatagan and Stumpf Lake suggests that Sagatagan feeds Stumpf via groundwater seepage.

It also is noteworthy that in 1987 the DNR set an Ordinary High Water (OHW) level for Lake Sagatagan at an elevation of 1,168.9 feet. According to regulations, the lake's level may be lowered a maximum of 1.5 feet below the OHW. The modeling assumed the existing outlet was constructed at an elevation of 1,167.4 feet. Field observations noted the lake level was approximately 2 feet below this control structure, likely due to evapotranspiration or groundwater seepage. Precipitation records (see 4.2.1) show rainfall was not a factor in low water levels.

3.4 Discussion of Modeling Results

Results of water quantity modeling indicate regional flood control within the study area is not an issue for St. John's University. However, this does not speak to localized flooding that may occur within the campus serviced by the storm sewer system. Previously documented high water levels in Lake Sagatagan in the 1980s, which resulted in washing out of footpaths and tree die-off, appear to no longer be a problem.

Generally, campus buildings and facilities are on high ground. Flow within the drainage system has no restrictions. Ample storage for high volumes exists both within the upland areas in small, natural depressions as well as within lakes and ponds. The relative lack of impervious surface and prevalence of natural landscape increases time of concentration, allowing for a lower peak volume.

Water quantity modeling also shows no significant problem in rate control. Pflueger Lake's very high rates of discharge for the 100-year storm may not be problematic if discharge flows are diffuse. However, field inspection by St. John's staff revealed Pflueger Lake discharging into a creek approximately 15 feet wide leading to Stumpf Lake. It is recommended that Pflueger Lake's outlet area and the downstream creek undergo a cursory inspection for potential problems relating to erosion, scour and incising. However, no problems are anticipated because of the region's lack of development.

4.0 Water Quality Modeling

4.1 Description of Lakes

Water quality modeling focused on Lake Sagatagan, Stumpf Lake and East Gemini Lake due to their visibility within the campus, current quality and aesthetics, and utilization by the University.

4.1.1 Lake Sagatagan

This 176-acre lake is the largest waterbody within University property and within the watershed. Maximum depth is 40 feet; mean depth is about 9 feet. Much of the lake area is comprised of littoral zone. The high littoral acreage (114 acres as noted by the Department of Natural Resources) supports an abundant and diverse aquatic plant community. Lake Sagatagan has excellent water clarity and supports a variety of recreational activities such as canoeing, swimming and fishing. The overall watershed draining to Lake Sagatagan is about 640 acres and is predominantly undeveloped land with somewhat steep slopes. The relatively small drainage area in combination with the large surface area helps promote the lake's high quality.

4.1.2 Stumpf Lake

As noted in Section 2.3, Stumpf Lake is a manmade lake created by the impoundment of a channel draining Pflueger Lake. Today, Stumpf Lake has a surface area of about 68 acres. Maximum depth of this lake is about 36 feet; mean depth is about 10 feet, making it similar to Lake Sagatagan. However, the total watershed (direct runoff as well as upstream discharges) draining to Stumpf Lake is about 2,560 acres. Approximately 75 acres are classified as impervious and contributes runoff directly to the lake. Stumpf Lake has fair water clarity.

4.1.3 East Gemini Lake

The name Gemini is appropriate because there is an East Gemini and a West Gemini, split by the main entrance road (County Road 159) to the University. Similar to Stumpf Lake, the Gemini Lakes are artificial impoundments. While these two lakes are hydraulically connected by an equalizing culvert structure, water quality dynamics are considered independent because flows from West Gemini must pass into and through East Gemini to reach the outlet. A second reason for independent consideration is because East Gemini receives direct discharge from the University's wastewater treatment plant (WWTP).

East Gemini is the smallest of the study's three focus lakes. It has a surface area of about 37 acres, with a mean depth of about 5.5 feet. Maximum depth is approximately 11 feet. East Gemini is at the downstream end of the University watershed and therefore has an overall drainage of about 2,930 acres. The large area draining to this small lake is one factor for the poor water quality. However, the key factor causing East Gemini's poor water quality is direct discharge from the WWTP.

4.2 Data Collection

4.2.1 Precipitation

Precipitation data was gathered using the internet from the Midwest Regional Climate Center (http://mcc.sws.uiuc.edu). Precipitation values were from Station No. 211691 maintained by the National Weather Service for Collegeville. The study area's precipitation for the 2002 hydrologic water year (October 2001 through September 2002) was utilized for water quality modeling. Table 4 shows the values.

Table 4 – 2002 Hydrologic Water Year Precipitation Values

	Oct.	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	
Inches	1.31	4.42	0.38	0.23	1.77	1.96	
	Apr.	**May**	**June**	**July**	**Aug.**	**Sept**	**Total**
Inches	3.98	2.29	5.03	11.46	7.88	2.81	43.52

It should be noted that average precipitation for all of Stearns County for the 2002 hydrologic water year was 36.75 inches. Historic annual precipitation (January through December, 1971-2000) for Collegeville is 29.33 inches.

4.2.2 Wastewater Treatment Plant

Current and historic data were obtained regarding discharge from the University's wastewater treatment plant (WWTP). Appendix A shows information gathered on WWTP contributions to East Gemini Lake in water volume and phosphorus loading. Discharge and loading data for the 2002 hydrologic water year were evaluated for water quality modeling, and this information is shown in Table 1, Appendix A. Overall discharge for the 2002 hydrologic water year was calculated at approximately 107.7 million gallons (206,109 m^3); load of total phosphorus to East Gemini Lake was estimated at approximately 2,370 pounds. These values equate to an estimated mean total phosphorus discharge concentration of 5.2 ppm.

Historical data shows a general downward trend in mean monthly effluent concentration as shown in Appendix A, Figure 3. Trends for yearly loads are shown in Figure 4; however incomplete data limits interpretation. Figure 5 shows how mean monthly phosphorus loadings to East Gemini fluctuate with the academic season.

4.2.3 Sediment Sampling

Sediment samples were manually collected on March 7, 2002. Sediment sampling was performed to determine concentrations of phosphorus on the lake bottom, at the sediment/water interface. Sample site locations are shown in Map 2. Laboratory analyses determined levels of loosely-sorbed phosphorus and iron-bound phosphorus. Results of sediment sampling and associated water quality data are in Appendix B, Table 1. Appendix B, Table 2 shows a depth/dissolved oxygen profile for East Gemini at sediment sample points.

Appendix B, Figures 1 and 2 show East Gemini Lake sediment phosphorus dynamics, while Figures 3 and 4 illustrate Stumpf Lake sediment phosphorus dynamics. These dynamics show the various relationships and results of sediment phosphorus analysis. This information can be used to develop an understanding of the potential internal loading, or recycling, of phosphorus due to anoxic conditions during summer stratification. There were several notable points regarding sediment phosphorus level. Sample site ST1 showed a much higher level of loosely-sorbed phosphorus than other samples from Stumpf Lake. All samples from Stumpf Lake and East Gemini Lake showed very elevated levels of iron-bound phosphorus. This was expected for East Gemini Lake due to loading from the wastewater treatment plant, but was unexpected for Stumpf Lake.

4.2.4 Water Quality Sampling

Water quality sampling was performed monthly starting in May and continuing into early October. Map 3 shows locations of water quality sample sites for the three lakes. Appendix C contains graphs and tables reflecting water quality sampling data. In-lake sampling was performed in Lake Sagatagan, Stumpf Lake, East Gemini Lake and a grab sample was taken at the campus wetland's outlet downstream of East Gemini. In-lake samples were taken at the water's surface and in the lake's deep zone, slightly above bottom sediments. Care was taken to obtain "deep" samples without disturbing bottom sediments, which could alter water quality readings.

All samples (surface and deep water) were laboratory analyzed for orthophosphate and total phosphorus (TP). Surface samples were analyzed for other parameters, including Total Kjeldahl Nitrogen, nitrate-nitrogen, ammonia and total alkalinity. Full results of laboratory analyses are shown in Appendix C, Tables 1a and 1b, while Figures 1 to 5 summarize phosphorus data. Temperature and dissolved oxygen profiles, as well as secchi depth, were recorded for each lake at each sample event. Data for each lake are in Figures 6 to 8.

4.3 Discussion of Sampling Results

4.3.1 Lake Sagatagan

Total amount of phosphorus measured in the sediment was quite low at 99 ppm. The iron-bound fraction of phosphorus in sediment also was very low. This indicates an overall low amount of phosphorus loading. While this interpretation is consistent with other data and observations, it should be noted that only one sediment sample was taken.

The mean orthophosphate value from summer sampling was at or below detectable limits, both in surface and deep samples. This indicates phosphorus as a nutrient continues to limit growth of phytoplankton in Lake Sagatagan. The mean TP value from summer sampling was slightly higher in the deep zone than in the surface zone. This could be caused by zooplankton predation on algae in the surface zone.

Sampling results supported what was expected from the watershed with the associated lake characteristics. Specifically, a high lake volume, a low watershed-to-surface area ratio, and minimal land use activities will preclude eutrophic circumstances.

4.3.2 Stumpf Lake

Sediment sampling in Stumpf Lake revealed a fairly low average sediment phosphorus concentration. However, the ratio of loosely sorbed phosphorus to iron-bound phosphorus was relatively high. This indicates some potential for release of phosphorus from the sediment to the water column during anoxic conditions. The lowest value of total sediment phosphorus was at sample site ST5, near the lake's outlet. In contrast, the highest value of total sediment phosphorus was at site ST1, a relatively protected location from overall flow direction. Noteworthy is that ST1 is adjacent to a storm sewer outfall. Between ST1 and ST5 is an approximate gradation of phosphorus concentrations. It may be high phosphorus content from the storm sewer outfall, combined with a quiescent mixing area facilitating settling, contributing to ST1's high values. For other sample sites the historic channel, along with increased turbulence and mixing towards the lake's outlet, may prevent settling and accumulation of phosphorus.

Mean orthophosphate and mean total phosphorus levels in Stumpf's deep zone were much greater than for surface samples. In part this is due to anomalously high deep values recorded in June and August. It is possible sediment was inadvertently stirred up for these deep sample events, skewing the values. Another explanation could be sediments releasing phosphorus due to stratification. However, although the lake is stratified and very low dissolved oxygen concentrations exist in the deep zone, this does not explain why July did not have a similar high reading. More research into this phenomenon is needed.

Orthophosphate was below detectable limits in Stumpf's surface waters in June, July and August. This would indicate phosphorus as a nutrient is limiting algal growth, but the potential exists for algal blooms during turnover or other mixing events to bring reserves up from the deep to the surface.

4.3.3 East Gemini Lake

East Gemini showed the highest amounts of total sediment phosphorus concentrations, both in mean value (1,085 ppm) and in maximum value (1,677 ppm). However, these values displayed a greater range (1,225 ppm) between minimum and maximum values than Stumpf (248 ppm). Nonetheless, the lowest value for East Gemini was above the maximum value for Stumpf. High ratios of loose-to-bound phosphorus can be found, especially in close proximity to the wastewater treatment plant's outfall.

Water quality data from both surface and deep areas shows extremely elevated levels of orthophosphate and total phosphorus. Observed values were highest in June. The wastewater treatment plant's discharge was roughly equal for May and June, so this is an unlikely factor for the spike. Overall, ratios and concentrations of orthophosphate and total phosphorus are typical of hypereutrophic lakes.

4.3.4 Summary of Lake Quality

A lake water quality report card has been developed by Metropolitan Council staff to grade water quality in lakes in the Twin Cities area based on summertime (May-

September) average values for several key parameters, including total phosphorus. Table 5 illustrates grades and the total phosphorus ranges to which they apply.

Table 5 – Lake Water Quality Report Card Grade Ranges[1]

Grade	**Total Phosphorus**[2] (ug/l)	**Chlorophyll "a"**[2] (ug/l)	**Water Clarity**[2] (meters)	**Comment/Explanation**
A	< 23	< 10	> 3.0	Exceptional quality; no recreational use impairment
B	23-32	20-30	2.2-3.0	Very good quality; minor recreational impairment, often in late summer
C	33-68	30-48	1.2-2.2	Average quality for this region; moderate impairment for recreational use, often in the later half of the summer
D	69-152	48-87	0.7-1.2	Poor quality; recreational use severely impaired
F	> 152	> 87	< 0.7	Extremely poor quality; no recreational use possible

[1] Grades characterize open-water quality of lakes. Other nuisances, such as abundance of aquatic plant growth, are not accounted for.
[2] Mean values for May-September.

Grades based on recent data for each of the three lakes are shown in Table 6 on the following page.

Table 6 – Water Quality Grades for St. John's University Lakes (based on mean values from May-October)

Lake	Data Year	*Total Phosphorus* Value (ug/l)	Grade	*Water Clarity* Depth (meters)	Grade
Lake Sagatagan	2002	21	A	5.0	A
Stumpf Lake	2002	40	C	2.5	B
East Gemini Lake	2002	355	F	1.0	D

4.4 Modeling Process

Two water quality models were constructed for St. John's University. One model captured Lake Sagatagan and the other captured Stumpf Lake and East Gemini Lake. Lake Sagatagan was developed separately because modeling showed it is hydraulically isolated from downstream water resources. Therefore, land use parameters for modeling Lake Sagatagan's water quality were developed independently from those for Stumpf and East Gemini.

Two software packages to predict in-lake TP concentrations were used in the water quality modeling process. William Walker's Pondnet model was used to determine water budgets and non-point source phosphorus loading based on watershed land use parameters. Non-point source outputs from Pondnet, as well as point source loading estimated from the wastewater treatment plant (WWTP), were entered as inputs into the Wisconsin Lake Modeling Suite (WiLMS). This model allows us to predict in-lake phosphorus concentrations based on a variety of predictive tools.

Empirical water quality data allowed the calibration of the water quality model. The calibration was performed by refining the modeled land use parameters so predicted and observed in-lake TP concentrations were approximately equal.

4.5 Modeling Results

Lake Sagatagan and Stumpf Lake were both modeled to within 5% of observed total phosphorus values. However, the modeling process under-predicted East Gemini by about 22%. Table 7a shows results of the modeling in terms of overall inputs.

Table 7a – Results of Water Quality Modeling for 2001-2002

	Lake Sagatagan	Stumpf Lake	E. Gemini Lake
Observed Mean TP (ppb)	21	40	355
Predicted Mean TP (ppb)	22	41	276
Lake Area (acres)	176.2	67.7	37
Total Drainage Area (acres)	641.2	1591.75	2,933.6
Lake Flushing Time (days)	2,607	408	58
Total Estimated "P" Load (lbs/yr)	147.4	385.6	2,736.8

Modeling results also can be viewed in terms of relative pollutant contributions by source. Table 7b illustrates main sources of phosphorus loading to each lake.

Table 7b – Results of Water Quality Modeling for 2001-2002

Relative Phosphorus Contribution (Percent of Loading by Source)	**Lake Sagatagan**	**Stumpf Lake**	**E. Gemini Lake**
Non-Point Source (Runoff)			
Campus (impervious)	5	41	0
Non-campus	95	59	10
Point Source (WWTP)	0	0	90

Results of water quality modeling are based on particular parameters entered into the model. These parameters are runoff phosphorus concentrations and runoff coefficients for each land use. Parameters, and their associated unit loading value, are found in Appendix D, Table 1.

4.6 Discussion of Modeling Results

4.6.1 Lake Sagatagan

Modeling of Lake Sagatagan's watershed shows a very low amount of phosphorus being mobilized. An estimated 150 pounds of phosphorus were delivered to the lake via surface runoff during the modeled period of October 2001 through September 2002. Appendix D, Figures 1 and 2 identify sources and relative contributions of phosphorus to Lake Sagatagan. The large volume within the lake and the high amount of surface area minimize the impact of this loading. However, about 5% (close to 7.5 pounds) of the total amount of phosphorus was attributed to urban runoff from the University. This is significant for two reasons. First, 5% of the nutrient load is being modeled from only 1% of the total drainage area. This is a disproportionate contribution of phosphorus loading.

Second, the high phosphorus load generated by the impervious (campus) runoff is significant because of its intensity. This impervious stormwater runoff occurs within a consolidated area draining to the lake. Loading of phosphorus is occurring intensely in the north area of the lake in contrast to other nonpoint source loads entering the lake diffusely around its perimeter. It should be noted that it appears up to four storm sewer outfalls are discharging to the lake's northwest bay behind the student bathhouse. Although not specifically modeled, it is likely most of the urban runoff to Lake Sagatagan ends up in this part of the lake. Concentrated delivery of stormwater and phosphorus to this localized area could have a site-specific adverse impact.

Worth noting is that water quality modeling indicated Lake Sagatagan's flushing time was more than seven years (2,607 days). Further, water quantity modeling indicated no discharge under extreme storm event conditions. The data signifies that any pollutants entering the lake will remain in the aquatic system for an extremely long time.

4.6.2 Stumpf Lake

Stumpf Lake receives both direct input and indirect input of stormwater runoff. Direct input comes from runoff immediately surrounding the lake. Indirect runoff comes from upstream drainage areas flowing through Pflueger Lake, which discharges to Stumpf. Only 20% of the overall yearly phosphorus load to Stumpf came from indirect drainage. Eighty percent of the phosphorus load to Stumpf Lake came from direct drainage. Appendix D, Figures 3 and 4 identify sources and relative contributions of phosphorus to Stumpf Lake.

Noteworthy is that of the 80% of directly incoming phosphorus, more than 50% (156 pounds per year) was modeled from impervious areas of the campus. This impervious area comprises less than one-fifth of the direct drainage area. More significantly, when considered in the context of total drainage and loading, i.e. direct and indirect/upstream sources, just 5% of the total drainage area contributes more than 40% of the phosphorus load to Stumpf Lake. This is more than the total yearly phosphorus load to Lake Sagatagan. This highly disproportionate amount of loading is substantiated by the number of storm sewer outfalls (approximately eight) located on Stumpf Lake's west bank.

Agricultural practices also contributed a substantial amount of phosphorus to direct loading to Stumpf Lake. About half the direct drainage to Stumpf is outside the St. John's University property. Much of this is agricultural land use.

The phosphorus loading to Stumpf Lake is somewhat ameliorated by the system's flushing time, modeled at a little more than one year (408 days). Phosphorus or other pollutants can accumulate but the lake has a fair degree of resilience in the long run because pollutants are flushed out relatively quickly.

4.6.3 East Gemini Lake

Wastewater treatment plant (WWTP) discharge was by far the most significant factor in East Gemini Lake's water quality modeling. Estimated phosphorus loading to East Gemini from October 2001 through September 2002 was about 2,369 pounds. The WWTP was responsible for 90% of the total loading to East Gemini. Remaining loads were from upwatershed sources draining through West Gemini Lake and from phosphorus exported from Stumpf. Appendix D, Figures 5 and 6 identify sources and relative contributions of phosphorus to East Gemini Lake.

Of the direct acreage draining to East Gemini, local runoff contributions of phosphorus were negligible. No direct impervious drainage was captured in the modeling for runoff to East Gemini.

Modeled flushing time is approximately two months (58 days with WWTP discharge and 67 days without WWTP discharge), giving the lake system a strong ability to purge pollutant loadings.

Note again the water quality modeling process under-predicted TP values for East Gemini. This indicates the need to consider other dynamics for pollutant loading. Dynamics that are possible factors in under-prediction are:

- Precipitation – The yearly precipitation value used was abnormally high compared to annual average rainfall. It is possible this affected the modeling process. Thus the model was also performed using the average annual rainfall amount (all other factors remained the same). In this scenario, the predicted value of in-lake TP for East Gemini was 334 ppb, which is within 6% of observed values. However, under this scenario the model under-predicted TP values in Stumpf Lake with a concentration of 29 ppb, a discrepancy of more than 25%. Accounting for the abnormally high precipitation did not result in a net improvement in accuracy.
- Wastewater Treatment Plant – Loading values calculated for the WWTP were based on an average TP effluent concentration and overall monthly volume discharge. Average TP effluent concentration was determined from only two grab samples per month. It is possible the grab sample averages did not reflect the actual mean values for phosphorus discharge. Thus the model was also performed assuming a higher loading from the WWTP. Point source loading had to be increased by approximately 45% to account for the under-prediction of East Gemini. Although this increase may seem dramatic, it only increases the WWTP relative contribution to East Gemini by about 3% (from 90% to 93%). The increase in loading equals an average TP of 7.6 ppm, while the original average TP was calculated at 5.2 ppm.
- Internal Loading – Another factor in the under-prediction of the water quality model for East Gemini may be not explicitly accounting for what is likely very high internal recycling of phosphorus. The extremely high concentration of phosphorus measured in East Gemini's sediment supports the supposition of large internal loading. Phosphorus could have been released either from anoxic (reducing) conditions at the sediment-water interface, from resuspension of fine particles on the lake bottom by storm events or high discharges, or from both conditions.

5.0 Implications for Water Quality Management

5.1 Background

Lake Sagatagan, Stumpf Lake and East Gemini Lake have varying degrees of water quality. Different factors influence the health of these lakes. It is important to understand the nature and magnitude of these factors to properly begin managing the lakes and, more importantly, their watersheds. This is especially relevant in the context of developments and facility expansions the University plans to undertake in the next few years. As a goal, the University may wish to evaluate and control storm water runoff into any lake when a change in land use occurs. Also as a goal, the University may wish to evaluate the existing potential to treat storm water runoff prior to entering receiving waters. Prioritizing protection, establishing goals and developing a strategy for water quality management should focus on long-term efforts. Long-term efforts must be oriented towards appropriate high priority areas for results to occur.

5.2 Lake Sagatagan

The magnitude and localized nature of phosphorus loading to Lake Sagatagan is a critical factor in lake health. Although the lake is high quality, it will not take much degradation to cause noticeable declines in water clarity and aquatic diversity. Additionally, the system's extremely limited flushing dynamic means pollutants will remain sequestered within the lake. Once degraded, Lake Sagatagan will need a very long time to respond to any decreases in pollutant loading. It is well documented that the cost of modest efforts to prevent degradation will highly outweigh cost of restoration. This is especially true of high quality lakes, where complete restoration is almost never possible.

The northwest bay of the lake adjacent to the bathhouses appears to have several storm sewer inputs. This area of the lake should be monitored for water quality in addition to the area noted on Map 2. At minimum, secchi depth readings should be compared with lake averages to highlight potential degradation. It may be beneficial to perform a more detailed assessment of storm sewer drainage boundaries and land uses to provide an understanding of what campus areas are draining to Lake Sagatagan. Ultimately, more conservative land use practices can be employed in this area of the campus to help sustain the high water quality in the northwest area of the lake near the bathhouses.

Management of Lake Sagatagan should also incorporate control of sediment erosion and delivery. Sediments transport phosphorus. Increased sediment loads often compromise water clarity and aquatic diversity. Outfalls of storm sewers frequently are prone to erosion. The woodlands behind the Michael Hall Preparatory School has been identified as a site of erosion due to storm sewer discharge. (See Section 6.0 for more discussion on this issue.) Overall, water quality management for Lake Sagatagan should seek to decrease nutrient and sediment loadings as opportunities arise, and include a water quality monitoring program for the northern area of the lake.

5.3 Stumpf Lake

Stormwater runoff from the impervious areas around Stumpf Lake is clearly the largest factor in phosphorus loading to the lake. The "report card" grade for Stumpf was average and management of this resource should be geared to that level of water quality. Specific efforts should focus on preventing further degradation of the lake by phosphorus loading. Evaluating storm sewer system inputs, continued observation of land use around the lake, and monitoring inputs will serve to protect the lake. If specific "hot spots" to Stumpf are identified, implementing structural retrofits or Best Management Practices (BMPs) could provide substantial protection against degradation. An analysis of appropriate BMPs should be undertaken, especially in agriculturally important areas of the watershed.

Restorative measures could be undertaken for Stumpf Lake. However, although the lake quality is average, a substantial investment is needed to marginally improve quality. The lake's current quality may not be objectionable to the University and therefore may not warrant efforts to improve the quality. In total, Stumpf Lake has a lower visibility to the campus and has relatively good water quality. Again, the ideal water quality management strategy may be simply to prevent further degradation. The approaches need not be as stringent as those for Lake Sagatagan and its watershed, in part because Stumpf has a significantly faster flushing rate than Sagatagan. Also, Stumpf is already moderately eutrophic and therefore less sensitive to water quality changes.

5.4 East Gemini Lake

Effective water quality management must focus on the sources of pollutants. In this case, sources to address are the wastewater treatment plant (WWTP) and the sediment. The lake has become so saturated with phosphorus that lake sediment is a significant source of phosphorus loading. An effective management strategy must take into consideration these two factors.

Further, water quality management for East Gemini should take into account contributions from Stumpf Lake and West Gemini Lake. Clearly, contributions of phosphorus from these two sources are negligible in comparison to the WWTP. However, estimated yearly loadings from these two lakes are higher than yearly loading from East Gemini's direct watershed runoff. Yet the flushing time of East Gemini encourages restoration efforts, primarily because of contributions from Stumpf Lake and West Gemini Lake. It takes only about two months for the lake to displace all of the "old" water. Rapid flushing East Gemini means it is expected to respond positively to decreases in external loading. Ultimately, a delay in lake response will remain present between implementation of management strategies and improvement in lake quality. However, East Gemini's rapid flushing will minimize the delay.

Any water quality management objectives for East Gemini should consider possible ramifications to the downstream wetland. Management decisions made for the lake directly influence the wetland's hydrology and water quality.

The immediate goal for East Gemini improvement should focus on decreasing the severity and intensity of algal blooms. Other implications for management decisions include:

- Setting short-term and long-term in-lake phosphorus concentration goals
- Review the feasibility of removing point source inputs to East Gemini
- Plan for a substantial delay in lake response while the internal sediment load of phosphorus is exhausted
- Review alternatives for lake restoration
    - Install a fountain or mechanical aeration
    - Alum treatment
    - Iron treatment
    - Excavation of sediment
    - Isolate WWTP inputs from the rest of the lake system

5.5 Wetlands

There is an abundance of wetlands within and around the University. These wetlands provide valuable water quality and quantity functions, as well as habitat functions. Increased pollutant loads to wetlands, especially nutrients and sediment, are a significant factor to the degradation of diverse wetland communities. For example, phosphorus is a pollutant of high concern because of its role in enriching aquatic systems. Nutrient enrichment of a wetland usually favors aggressive species and thereby decreases vegetative and habitat diversity. The magnitude and duration of water level increases due to runoff events also can negatively impact wetland quality. Frequent, high-water-level bounces and long periods of inundation of the wetland fringe flood out sensitive plant species often characterizing a high quality wetland community. Wetlands with a high occurrence of sensitive species (such as sedges) are usually among the highest quality wetlands from an ecologic perspective, but generally are most susceptible to stormwater impacts associated with water level bounce and contaminant inputs. Other types of wetlands (such as floodplain forests) have species better adapted to handle these inputs.

5.5.1 Vincent Court Wetland

We have reviewed the wetland area just south of West Gemini Lake and west of East Gemini Lake. Currently this wetland receives runoff from a parking lot to the north of Vincent Court Apartments. The analysis was done to determine potential impact of runoff from the parking lot on the wetland's quality and recommend specific enhancement (restoration) opportunities.

The National Wetland Inventory (NWI) map for this area was reviewed to help analyze the wetland. The NWI map was created in the late 1970s, prior to the development of this portion of the campus. It indicates the wetland is a PEMC (palustrine emergent seasonally flooded) basin. These types of wetlands are commonly referred to as shallow marshes and typically have waterlogged soil early during the growing season and may often be covered with as much as 6 inches or more of water. Vegetation often includes grass, bulrush, spikerush and other marsh plants such as cattail, arrowhead, pickerelweed and smartweed.

As part of our review we analyzed a 1991 aerial photograph of the wetland. This photograph indicates the wetland has lost some of its original hydrology and may have been partially filled as this portion of the campus was developed. Aerial photographs indicate vegetation is predominately grass, likely reed canary grass, and has taken on characteristics of a wet meadow rather than a shallow marsh. Wet meadows typically are without standing water during most of the growing season but are waterlogged within at least a few inches of the surface. Reed canary grass is an invasive plant species common in wetlands that have been disturbed.

5.4.2 Potential Impact of Runoff on Wetland Quality

The parking lot north of Vincent Creek apartments is the main impervious surface contributing flows to this basin. Currently there is a drainage swale/ditch that outlets at the north end of this basin and flows to West Gemini Lake. Loss of hydrology to the wetland basin could be from accumulated sediments or the outlet being lowered due to natural, or unnatural, down cutting from increased runoff. Most sedimentation to a wetland occurs during grading operations when adjacent upland areas are void of vegetation and prone to erosion. Runoff rates likely increased to the wetland after construction of the campus facilities and parking lot. As a result, impacts to the basin have already occurred and reduced the basin's quality. In its current condition the wetland has a high threshold for bounce and nutrients, and thus the wetland is likely not going to be further impacted by continued parking lot runoff.

5.4.3 Restoration Opportunity

A defined outlet for this basin makes restoration to a shallow marsh economical. A berm and spillway constructed with an outlet elevation of 1,126 or 1,128 feet would restore this wetland basin to shallow marsh. Raising water levels would improve the wetland plant community because reed canary grass does not tolerate permanent inundation. Reed canary grass is a species that can become extremely abundant in a wetland and typically shades out other species. Removal by inundation would allow other plants to colonize the wetland. Planting some species listed in the first paragraph ("Existing and historic conditions") under the description for the shallow marsh would accelerate vegetative restoration.

Restoring this basin's hydrology also would enhance its function for treatment of nutrients before discharge to West Gemini Lake. Permanent inundation and establishing emergent vegetation resulting from a berm would be more efficient in small sediment removal than it is in its current relatively dry vegetative condition.

6.0 Preparatory School Ravine

6.1 Background

The Michael Hall Preparatory School Residence is located on the campus' southeast portion. The Preparatory School is above Lake Sagatagan's north shoreline. The Preparatory School is within a drainage area of approximately 4.30 acres of which approximately 1.75 acres is impervious surface (pavement and rooftop). Impervious surfaces account for approximately 40% of overall land use in this micro-watershed.

The Preparatory School's stormwater runoff and storm sewer discharges generally are directed toward Lake Sagatagan. Specifically, flows are concentrated at an undeveloped area between the dormitory and the lake. This undeveloped area is predominantly wooded with poorly established ground cover, and the slope is significant at approximately 11%. Stormwater flows in this area have caused erosion of the slope and ravine. Incising is noticeable at the outfall of the storm sewer, with an approximate 2-foot drop between the outlet invert and existing grade. Evidence exists of failed hard armoring efforts with cobble and other stone debris.

6.2 Discussion

Erosion at storm sewer outfalls is a common concern. However, the Preparatory School ravine is of particular concern because Lake Sagatagan is downstream. This high quality lake is susceptible to adverse impacts caused by sediments and pollutants (such as nutrients and/or hydrocarbons) transported by storm water runoff.

Due to the wooded condition of the undeveloped area, creating a settling pond for rate control and water quality improvement is an unattractive alternative. A more feasible approach may be to control overland flow from the storm sewer outlet. Ravine restoration strategies could be employed to stabilize slopes and address stormwater quality. A combination of bioengineering techniques and terraced rock-weir structures would provide erosion protection and control the flow rate while allowing fine particles to settle and potential filtration by vegetation. Examples of this type of ravine restoration approach are shown in Appendix E, Figure 1. Also, Appendix E, Figure 2 shows an example of a grading plan for a meandering wetland, which could be located at the ravine's downstream end. This approach would be aesthetically pleasing, could be built and maintained by staff, and would not require significantly altering the existing landscape.

7.0 Conclusions

7.1 Status of Water Resources

The water resources of the campus are important to the Benedictine Community, and University students, staff, alumni and benefactors. Currently, the need for managing water resources for flood control appears not to exist. Even under extreme circumstances, watershed runoff does not overwhelm the existing lakes' storage capacity. However, the rate and volume of stormwater runoff from the campus should be observed for potential erosion and related damages.

The water quality varies for the three lakes focused on in this report. Classification of the lakes based on water quality falls within what University leadership and constituents would expect. Specifically, Lake Sagatagan is in good condition, Stumpf Lake is in fair condition and East Gemini is in poor condition. The poor condition of East Gemini also is affecting the restored wetland downstream.

It should be noted that a fish consumption advisory was posted for Lake Sagatagan on the Minnesota DNR's Lake-Finder Web site. The advisory was for mercury in northern pike, and offered advice on how often certain-size pike should be consumed. This advisory is similar to other pristine lakes in the state since mercury is largely an airborne contaminant and therefore is an "equal opportunity polluter." Mercury is emitted into the air largely as a result of coal-fired power plants. This is particularly important because the University operates a coal-fired power plant on campus, adjacent to Stumpf Lake.

7.2 Recommendations

The following recommendations are offered as ways to help protect and restore water quality of the lakes on the St. John's campus. It is important to remember these recommendations are targeted toward the qualities and characteristics unique to each lake.

1. Continue the water quality monitoring program and coordinate with MPCA

   Long-term data will help understand the dynamics and trends of the lakes. Coordinating with the MPCA and its lake monitoring effort may be beneficial to enhance robustness of available data.

2. Adopt a non-degradation approach for Lake Sagatagan and Stumpf Lake

   The University should take steps to ensure the water quality of these two lakes does not decline. Pollution prevention will be the most effective and economical way to manage the lakes. Watershed-based approaches and sound land use decisions will help promote the lakes' integrity.

3. Perform soil sampling in campus areas

   Using fertilizers is important for turf grass maintenance. Often the nutrient level of the soils supporting turf grass can become saturated. It is important the proper amount of fertilizers be applied in relation to what exists in the soil. Over-application of fertilizers can be costly, both financially and environmentally. It is recommended the University perform soil sampling of turf grass areas within the campus to determine the phosphorus level of soils. Sampling can be a one-time approach, but ideally sampling activities would be incorporated into long-term grounds operations. Soil samples can be inexpensively analyzed at the University of Minnesota's soil testing laboratory.

4. Identify "hot spots" of loading sources within the impervious areas of the campus

   Areas should be identified from where high amounts of phosphorus and/or sediments are exported to the lakes. The entire campus can be analyzed at once or individual lakes and their impervious drainages can be analyzed incrementally. If an incremental approach is taken, recommendations are to start with Lake Sagatagan, followed by Stumpf Lake, and then East Gemini.

   "Hot spot" identification can be accomplished with a water quality model such as P8, which is geared towards urban runoff dynamics. Also, areas where concentrated inputs of stormwater runoff occur should be identified. This can be done by mapping the types and locations of storm sewer outfalls and detailing drainage areas served by each outfall. Understanding these "hot spots" will allow the University to target pollution prevention and management efforts, maximizing investments to its resources.

   Estimated possible cost range for this option: $7,500 – $15,000

5. Investigate power plant coal storage options and air emissions testing

   Runoff from the power plant facility is conveyed directly to Stumpf Lake. The listing of Lake Sagatagan for mercury concentrations suggests power plant emissions could be improved.

6. Address erosion and storm water discharge at the Prep School ravine

   Controlling the rate of stormwater discharge from the existing outfall will be critical. The ideal approach may involve incorporating a series of terraces, settling basins and bioengineering methods. This would slow the rate of overland flow, protect exposed soils, allow sediment and attached nutrients to settle out, be easily installed and maintained, and be aesthetically pleasing.

7. Review the wastewater treatment plant's (WWTP) upgrade approach and coordinate with East Gemini management

   Currently the University is discussing improvements to the WWTP facility in terms of capacity and efficiency. Any WWTP improvements will impact East Gemini and other downstream resources. It is critical to maximize the WWTP's investment and develop an approach that leverages benefits to East Gemini to the greatest extent possible. Several scenarios, listed on the next page, should be explored to fully understand ramifications of the potential improvement. Review and exploration will best prepare the University to select the most cost-effective and beneficial approach to managing the WWTP together with East Gemini Lake.

   Estimated possible cost range for this recommendation: $6,000 – $18,000

Scenario A – Limit WWTP phosphorus effluent concentration to 1 ppm

Modeling showed that even by reducing the WWTP effluent TP concentration to 1 ppm (under normal annual precipitation) the lowest predicted in-lake TP value was 100 ppm. This value equates to a report card "grade" of D (see Table 5). Thus, algal blooms will remain frequent and clarity will continue to be poor in East Gemini.

Scenario B – Limit WWTP phosphorus effluent concentration to 0.3 ppm

Modeling indicated that reducing WWTP effluent TP concentration to 0.3 ppm (which is considered the most aggressive "doable" concentration) resulted in setting East Gemini's water quality values at about 50 ppb. While this equates to a report card "grade" of C, direct loading to the lake will still occur. As a result, it will be difficult to allow initial lake improvement efforts to be fully successful.

Scenario C – Temporarily isolate discharge of WWTP effluent low in phosphorus (0.3 ppm)

East Gemini restoration efforts could be more successful if the low-concentration effluent were temporarily isolated from the rest of the lake system. Preventing mixing of effluent will allow natural flushing of the lake to purge previously sequestered pollutants without additional burden on the system. Isolation could be done by curtaining off a fraction of the east shoreline of East Gemini, or possibly by routing WWTP discharge by pipe to a dedicated polishing cell that is constructed.

Scenario D – Divert WWTP phosphorus laden effluent

Modeling indicated that eliminating WWTP discharge to East Gemini resulted in water quality values similar to Stumpf Lake (approximately 40 ppb). It is recommended to develop a solution that isolates WWTP discharge from East Gemini. This recommendation could be accomplished by diversion of the effluent to a treatment cell. However, this may be size and cost prohibitive. Instead, it may be possible to infiltrate all, or a portion of, WWTP discharge to the local groundwater system. This option depends primarily on existing soils but also other considerations. However, the benefit of this option is that the infiltration process would naturally treat the phosphorus-laden effluent. Also, minimal space would be sacrificed to employ this method. Lastly, because discharge would be from the WWTP, it would be low in suspended solids or other particulates that typically shorten the operational life of infiltration facilities.

8. Install a mechanical mixing device in East Gemini

Even if point source contributions to East Gemini are isolated or diverted, there is still a considerable pool of phosphorus in the lake's sediment. Over time, the natural flushing of the lake is expected decrease this phosphorus load. However, a mechanical mixing device such as a fountain, bubbler or other agitator could help expedite the exhaustion of the

lake's internal load of phosphorus. This also will serve as an aesthetic focus for a very visible lake.
Estimated possible cost range for this option: $30,000 – $75,000

Overall, a long-term water quality management strategy should be developed for the lakes on campus. In order to maximize the full potential of the above recommendations, the best approach will focus on integrating the water quality strategy into many aspects of University operations. Land use decisions, capital improvements, lawn and garden maintenance, and many other facets all have some bearing on water quality. By integrating lake management, water quality and stormwater runoff issues with broader University operations, the health and integrity of the lakes will be sustained or improved for generations to come.