2005 LAKE LUCILLE WATER QUALITY MONITORING REPORT

WASILLA, ALASKA

FINAL REPORT

Prepared for

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Division of Water
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GLOSSARY

Algal Bloom	Rapid growth of algae on the surface of lakes, streams, or ponds; stimulated by nutrient enrichment (or due to an increase in plant nutrients such as nitrates and phosphates). It is associated with eutrophication and results in deterioration in water quality (Vennie, 2004).
Convection Currents	Air or water movement caused by changes in density or thermal (temperature) gradients (Munson et al., 2004).
Cultural Eutrophication	Eutrophication due to anthropogenic influence
Epilimnion	The upper, wind-mixed layer of a thermally stratified lake. This water is turbulently mixed throughout at least some portion of the day and because of its exposure, can freely exchange dissolved gases (such as oxygen and carbon dioxide) with the atmosphere (Munson et al., 2004).
Euphotic Zone	Layer of water where sunlight is sufficient for photosynthesis to occur (Munson et al., 2004).
Eutrophic	Very productive and fertile; lake is seasonally deficient in dissolved oxygen.
Heterotroph	An organism that cannot synthesize its own food and is instead dependent on organic material for energy (Houghton Mifflin, 2004).
Heterotrophic Decomposition	In the context of lake ecology, it refers to the decomposition of plant material by heterotrophic bacteria
Hypolimnion	The bottom and most dense layer of a stratified lake. It is typically the coldest layer in the summer and the warmest in the winter. It is isolated from wind mixing and typically too dark for much plant photosynthesis to occur (Munson et al., 2004).
Isothermal	Meaning of constant in temperature (Munson et al., 2004).
Limnology	The study of fresh or saline waters within continental boundaries (Munson et al., 2004).
Mesotrophic	Moderately productive; relating to the moderate fertility of a lake in terms of its algal biomass.
Oligotrophic	Very unproductive; lakes low in nutrients and algae, usually very transparent with abundant hypolimnetic oxygen if stratified.
Photodegradation	The degradation of molecules by absorption of photons, which are found in sunlight or other forms of radiation.
Spring Turnover	Period of complete or nearly complete vertical mixing in the spring after a lake thaws and prior to its thermal stratification (Munson et al., 2004).
Trophic	Refers to the degree of nutrient enrichment in a lake. Three trophic classifications are typically used: eutrophic (nutrient-rich, highly productive), mesotrophic (moderately productive), and oligotrophic (nutrient-poor).

EXECUTIVE SUMMARY

Lake Lucille is a small (360 acres), moderately developed lake located in Wasilla, Alaska. In 1998, the lake was listed on the Alaska Department of Environmental Conservation (ADEC) Section 303(d) list of impaired waters for failure to meet ADEC 18 AAC 70 Water Quality Standards (AWQS) for dissolved oxygen. A Total Maximum Daily Load (TMDL) study was completed for the lake in 2001 to identify ways to increase dissolved oxygen concentrations by reducing anthropogenic lake inputs (e.g., phosphorus). The City of Wasilla has taken steps in recent years to reduce anthropogenic influence on the lake. To document the effects of the reduction efforts, ADEC Division of Water contracted OASIS Environmental, Inc. (OASIS) to perform water quality monitoring during open-water months in 2004 and 2005, and early winter 2006. This report summarizes the results of 2005-2006 monitoring at Lake Lucille.

Under contract with the ADEC, OASIS, with support from personnel from Kinnetic Laboratories, Inc. (KLI), collected laboratory samples from Lake Lucille for the analysis of hydrocarbons and nutrients. Physical parameters were measured using in-situ water quality meters (see table below). Open-water sampling events were conducted on May 7, July 4, August 21, and October 15, 2005. The first and last events were intended to occur before spring turnover and after fall turnover. The other events occurred on weekends with anticipated high recreational use. In addition, under-ice dissolved oxygen (DO) and temperature measurements were collected once in January and once in February 2006. Field work was conducted according to the ADEC-approved Lake Lucille Sampling Plan and Quality Assurance Project Plan.

Measurement Date	Hydro-carbons	Nutrients	pH	Dissolved Oxygen (mg/L)	Cond-uctivity (µS/cm)	Turbidity (NTU)	Temp-erature (ºC)	Secchi Depth (m)	Redox Potential (mV)
May 7, 2005	X	X	X	X	X	X	X	X	X
July 4, 2005	X	X	X	X	X	X	X	X	X
August 21, 2005	X	X	X	X	X	X	X	X	X
October 16, 2005	X	X	X	X	X	X	X	X	X
January 15, 2006			X	X	X		X		X
February 20, 2006			X	X	X		X		X

With the exception of pH, physical parameters met applicable AWQS and were generally consistent with values observed in previous studies. Most pH readings at Lake Lucille in 2005 were slightly above the AWQS of 8.5 and may result from aquatic plants photosynthesizing and fixing CO_2 in the lake water or from the lake's calcium carbonate substrate. Continued monitoring of physical parameters is recommended so that the lake's physical characteristics and changes may be better understood through historical comparisons.

Nutrient supply is one of the major factors in determining a lake's trophic status and understanding the effects of cultural eutrophication upon the lake. Clorophyll *a*, nitrogen (ammonia, nitrate, nitrite, and total Kjeldahl nitrogen), and phosphorous (total and dissolved) concentrations levels measured in 2005 at Lake Lucille indicate the lake is mesotrophic or moderately productive. Results for several of the nutrient parameters sampled for laboratory analyses were below the method reporting limits; however, the concentrations that were detected were relatively low and are consistent with previous sampling events. Based on the stable trophic state index indicting a mesotrophic status, continuing nutrient analyses in the sampling scheme at Lake Lucille is recommended, albeit with lower laboratory method detection limits.

Two exceedances of the AWQS for total aromatic hydrocarbons (TAHs) (0.010 mg/L) were reported at a single location (LL-4; 0.15 and 0.5 meters depth) on May 7, 2005. This sampling location is in a relatively high-use boat launch area. OASIS recommends continuing to document hydrocarbon levels at these types of areas during high-use weekends. Future monitoring activities should concentrate on the identified issue of TAH loading near sampling site LL-4, the public beach area, and any newly identified high-use areas.

The City of Wasilla should continue to implement the plan to reduce human impact to Lake Lucille (e.g., through boat launch fees, public education, storm water diversion program), with the goal of meeting the TMDL phosphorus target level.

1 INTRODUCTION

This report summarizes the results of a water quality monitoring study of Lake Lucille in Wasilla, Alaska. The monitoring was performed during the open water months of 2005 and early winter 2006. Lake Lucille is a small lake (360 acres) located in Wasilla with a maximum depth of 20 feet and a mean depth of 5.5 feet. The north and east shores are developed residential areas. There is a large lodge, restaurant and flight service on the north shore. The south and west shores are less developed, but include recreational areas. The entire lake shore is private land except for a park on the south shore, which owned by the Mat-Su Borough. Figure 1 provides a map of Lake Lucille.

The Lake Lucille watershed receives approximately 16 inches of rain and 55 inches of snow per year. Roughly 20 percent of Lake Lucille's input is derived from precipitation (ADEC, 2002). Groundwater flow is believed to contribute the other 80 percent, although this percentage may have decreased in recent years due to a reduction in septic system water (the city sewer system has been expanded to include Lake Lucille residents) and diversion from two drinking water wells that were installed in 1983 and 1985. Two storm drains on the north shore of the lake also contribute to lake input by draining storm water from the Parks Highway. A single outflow exits Lake Lucille. Lucille Creek flows west into Meadow Creek, which then moves west-southwest into Big Lake.

The watershed's predominant soils consist of silt loam in upland areas and peat in the low-lying areas. Two main types of vegetation, forest and sphagnum bog, exist in the watershed. The forest consists of white spruce, aspen, willow, and birch, while the sphagnum bog is dominated by black spruce (ADEC, 2002). The lake's vegetation includes four species of macrophytes. The dominant species is a type of macro-algae. It grows across most of the lake, while the other three occur near the developed north and east shores. Wildlife of the lake includes migrating birds such as mallards, nesting grebes, and occasionally loons. Fish species consist of stickleback, silver salmon, and rainbow trout. The watershed-to-lake ratio of Lake Lucille is 4 to 1. Other than the lake itself, the land use of the watershed is mainly (61%) residential, followed by commercial (22%), forest (14%) and wetland (2.5%) areas. Land use impacts were first seen between the 1950s and 1970s, when natural eutrophication processes were slightly accelerated. Cultural eutrophication then began due to the population increase of the 1970s (ADEC, 2002).

Lake Lucille was listed on the Alaska Department of Environmental Conservation (ADEC) 1998 Section 303(d) list of impaired waters for failure to meet dissolved oxygen criteria, as defined in 18 AAC 70 Alaska Water Quality Standards (AWQS). A Total Maximum Daily Load (TMDL) study was completed in 2001 to identify ways to reduce anthropogenic lake inputs to levels that fully support the water body's uses. At Lake Lucille, the goal was to reduce phosphorus levels to support its recreational uses (e.g., swimming and boating), with the assumption that a decrease in phosphorus leads to an increase in dissolved oxygen levels. Additionally, decreased BOD loading as a result of reductions in septic system inputs leads to increases in dissolved oxygen levels. The TMDL recognizes that anthropogenic sources of phosphorus and BOD have been reduced to help meet AWQS. Part of TMDL implementation is to continue this reduction.

The City of Wasilla recently has taken steps to reduce anthropogenic influence on the lake. For example, a boat launch fee of $10 has been charged since 2004 and a kiosk was placed in the boat launch parking lot aimed at educating the public on how to reduce impacts to the lake's water quality. One of the most significant accomplishments was the recent (2005) completion of a storm water diversion program. This program was designed to route runoff from downtown streets away from the lake. The water is directed through an underground treatment system to

a park. There are three ponds at the park, which act as a final filter for the water before it infiltrates through topsoil and gravel and returns to the water table.

1.1 Background

Under contract with the ADEC Division of Water, OASIS Environmental, Inc. (OASIS), with support from personnel from Kinnetic Laboratories, Inc. (KLI), collected laboratory samples for the analysis of hydrocarbons and nutrients, and measured physical parameters using in-situ water quality meters. Open-water sampling events were conducted on May 7, July 4, August 21, and October 15, 2005. The first event was intended to occur before spring turnover, which is when the water column is nearly isothermal and wind energy has yet to cause the lake to circulate. The last event was intended to occur after fall turnover when the epilimnion cools, becomes more dense, and is mixed with deeper strata by wind and convection currents. The other two events occurred on weekends with anticipated high recreational use (e.g., Independence Day weekend). In addition to these four open-water sampling events, under-ice dissolved oxygen (DO) and temperature measurements were collected once in January and once in February 2006. Table 1 lists the physical parameters that were measured during each monitoring event.

Table 1. 2005 Physical Parameter Measurements

Measurement Date	pH	Dissolved Oxygen (mg/L)	Cond-uctivity (µS/cm)	Turbidity (NTU)	Temp-erature (ºC)	Secchi Depth (m)	Redox Potential (mV)
May 7, 2005	X	X	X	X	X	X	X
July 4, 2005	X	X	X	X	X	X	X
August 21, 2005	X	X	X	X	X	X	X
October 16, 2005	X	X	X	X	X	X	X
January 15, 2006	X	X	X		X		X
February 20, 2006	X	X	X		X		X

This report describes the methods used to conduct water quality monitoring, presents the results of the monitoring, and draws conclusions regarding Lake Lucille's water quality. Recommendations for future monitoring are also presented.

1.2 Regulatory Overview

ADEC regulates water quality in the State of Alaska. Current regulation specifies the degree of degradation that may not be exceeded in a waterbody as the result of human actions. Complete water quality criteria are presented in 18 Alaska Administrative Code (AAC) 70 *Water Quality Standards*, dated June 26, 2003, and *Alaska Water Quality Criteria Manual for Toxic and Other Deleterious Organic and Inorganic Substances*, dated May 15, 2003 and available on the DEC website www.dec.state.ak.us/regulations/index.htm.

As a non-groundwater, fresh water source, Lake Lucille is protected for the following water use classifications under 18 AAC 70.020:

- Water supply,
- Water recreation, and
- Growth and propagation of fish, shellfish, other aquatic life, and wildlife.

Water supply and water recreation both have multiple sub-classifications. The sub-classifications of water supply are listed below:

- Drinking, culinary, and food processing;
- Agriculture, including irrigation and stock watering;
- Aquaculture; and
- Industrial.

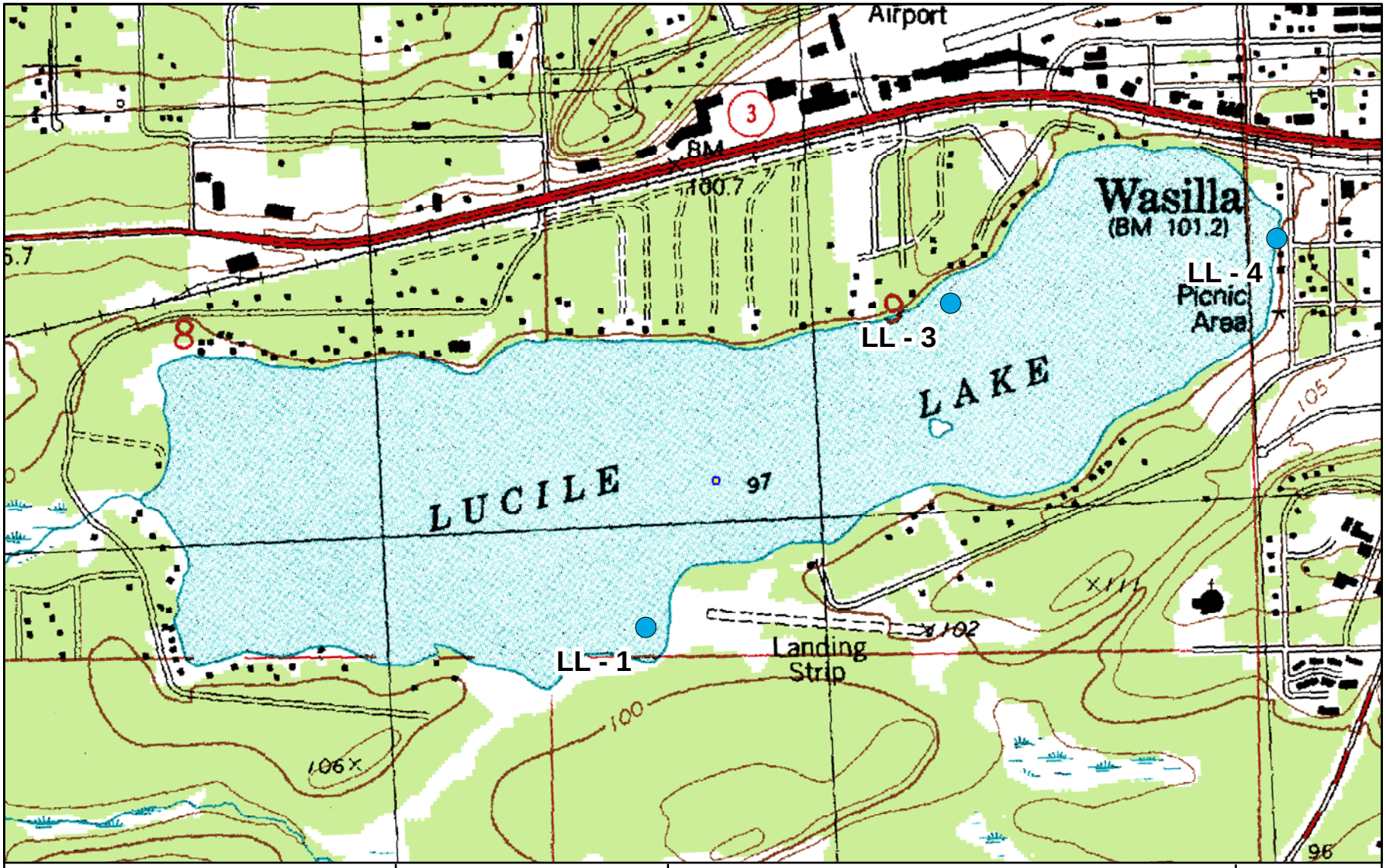
There are two sub-classifications of water recreation:

- Primary Contact (such as swimming and wading), and
- Secondary Contact (such as incidental contact while boating or fishing).

Table 2 presents the AWQS that apply to Lake Lucille. For each analyte, the most stringent criterion is used as the applicable AWQS.

Table 2. Applicable Water Quality Standards (18 AAC 70)

Analyte	Water Supply	Water Recreation	Growth and Propagation
Fecal Coliform	In a 30-day period, the geometric mean may not exceed 20 FC/100 ml, and not more than 10% of the samples may exceed 40 FC/100 ml.	In a 30-day period, the geometric mean of samples may not exceed 100 FC/100 ml, and not more than one sample, or more than 10% of the samples if there are > 10 samples, may exceed 200 FC/100 ml.	Not Applicable
Dissolved Oxygen (DO)	DO must be greater than or equal to 4 mg/l (this does not apply to lakes or reservoirs in which supplies are taken from below the thermocline, or to groundwater).	DO must be greater than or equal to 4 mg/l.	DO must be greater than 7 mg/l in waters used by anadromous or resident fish. In no case may D.O. be greater than 17 mg/l. The concentration of total dissolved gas may not exceed 110% of saturation at any point of sample collection.
Total Aromatic Hydrocarbons	May not cause a visible sheen upon the surface of the water. May not exceed concentrations that individually or in combination impart odor or taste as determined by organoleptic tests.	May not cause a film, sheen, or discoloration on the surface or floor of the waterbody or adjoining shorelines. Surface waters must be virtually free from floating oils.	TAH in the water column may not exceed 10 µg/L. There may be no concentrations of petroleum hydrocarbons, animal fats, or vegetable oils in shoreline or bottom sediments that cause deleterious effects to aquatic life. Surface waters and adjoining shorelines must be virtually free from floating oil, film, sheen, or discoloration.
pH	May not be less than 6.0 or greater than 8.5.	May not be less than 6.5 or greater than 8.5. If the natural condition pH is outside this range, substances may not be added that cause an increase in water buffering capacity.	May not be less than 6.5 or greater than 8.5. May not vary more than 0.5 pH unit from natural conditions.
Temperature	May not exceed 15° C.	May not exceed 30° C.	May not exceed 20° C at any time. The following temperatures may not be exceeded: Migration Routes (15°C); Spawning Areas (13°C); Rearing Areas (15°C); Egg and Fry Incubation (13°C)
Turbidity	May not exceed 5 NTU above natural conditions	May not exceed 5 NTU above natural conditions.	May not exceed 5 NTU above natural conditions.
Benzene	0.005 mg/L	Not Applicable	Not Applicable
Ethylbenzene	0.7 mg/L	Not Applicable	Not Applicable
Toluene	1 mg/L	Not Applicable	Not Applicable
Xylenes	10 mg/L	Not Applicable	Not Applicable



LAKE LUCILLE AND BIG LAKE WATER QUALITY MONITORING

LAKE LUCILLE SAMPLING SITES
Wasilla, Alaska

oasis ENVIRONMENTAL

N

0 0.15 0.3 Miles

Map 1

2 METHODS

Water quality monitoring was conducted at Lake Lucille during four open-water events in 2005 and two under-ice events in 2006. Field work was conducted according to the Lake Lucille Sampling Plan (OASIS, 2005a). Table 3 presents the sample schedule and monitoring plan.

Table 3. 2005 Sample Plan and Schedule

Collection Date	Physical Parameters	Nutrients	Hydrocarbons
May 7, 2005	X	X	X
July 4, 2005	X	X	X
August 21, 2005	X	X	X
October 16, 2005	X	X	X
January 15, 2006*	X		
February 20, 2006*	X		

*Field parameter measurements taken under ice.

For detailed descriptions of the sample methods and quality assurance procedures, refer to the Lake Lucille Sampling Plan (OASIS, 2005a) in Attachment A and the Quality Assurance Project Plan (OASIS, 2005b) in Attachment B. Table 4 below shows the list of sampling sites and parameters that were collected during each sampling event. Descriptions of each sampling site are also provided. Figure 1 shows the location of the sampling sites.

Table 4. Sampling Site Descriptions

Sampling Location	Nutrients	Hydrocarbons	Description
LL-1	X	X	A public campground is near this site as well as a large wetland area.
LL-3	X	X	This historic USGS sampling site is located in the deepest section of the lake, with an island to the south and waterfowl activity and residences to the north.
LL-4	X	X	This public boat launch on the east end of lake is heavily used. A public park is located approximately 0.25 miles to the south and there are residences in the area.

2.1 Field Parameters

The following field parameters were collected using a YSI® 556 multi-parameter water quality meter with a flow-through cell:

- pH – a measure on a scale of 0 to 14 of water's acidity or alkalinity;
- temperature – a measure of the hotness or coldness of water;
- dissolved oxygen (DO) – the amount of free oxygen available in water;
- oxidation-reduction potential (ORP) – a measure of water's ability to oxidize contaminants; and
- conductivity – a measure of water's ability to carry an electric current.

Turbidity, a measure of water clarity, also was measured using a Hach 2100P turbidity meter. Measurements generally were taken at 1 meter depth intervals from the surface to the lake

bottom. Some variations occurred, such as a missed interval or sensor malfunction for a parameter at a sampling site, but no deviation occurred that seriously impacted the data set.

A Secchi disk was used as another measure of water clarity. The disk is divided into quarters of alternating black and white. Measurements are obtained by lowering the disk on a graduated rope and recording the depth at which the disk is no longer visible. Secchi depth was measured at each sampling site for each sampling event.

In the winter of 2006, under-ice measurements were taken at all sampling locations at one-meter intervals. Parameters measured included pH, DO, ORP, temperature, and conductivity.

2.2 Nutrient Sample Collection

Nutrient samples were collected at all sampling locations. These sampling locations were selected in areas with possible nutrient sources, such as lawns or other maintained areas where fertilizer would be applied. At each location, samples for nutrient analyses were collected from a depth of one meter and seventy-five percent of the total lake depth. Samples were collected at a depth of one meter only at locations with a total water depth of less than two meters (LL-1 and LL-4). Table 5 displays the sample summary for nutrient samples.

Table 5. Nutrient Sample Summary

Sampling Site	Sample Dates	Sampling Depths
LL-1	May 7, 2005	1 meter
	July 4, 2005	1 meter
	August 21, 2005	1 meter
	October 16, 2005	1 meter
LL-3	May 7, 2005	1 meter and 4 meters
	July 4, 2005	1 meter and 4 meters
	August 21, 2005	1 meter and 4 meters
	October 16, 2005	1 meter and 4 meters
LL-4	May 7, 2005	1 meter
	July 4, 2005	1 meter
	August 21, 2005	1 meter
	October 16, 2005	1 meter

Samples were collected from a depth of one meter to determine the nutrients available in the euphotic zone (depth to which light penetrates), where algal blooms may result from nutrient loading. Samples collected from 75% of total lake depth indicate the degree of nutrient mixing throughout the lake. Whereas shallow areas may experience a mixing effect from wind and watercraft traffic, deeper areas may remain stratified between the spring and fall overturns. Although, Lake Lucille is relatively shallow throughout with a maximum depth of approximately 20 feet, and therefore it's expected that the water column would be periodically mixed during higher wind and wave events. Therefore, nutrient concentrations in deeper areas tend to be lower in winter than in summer. However, phosphorus levels do sometimes increase at depth in winter, but not because of mixing. If DO levels are low (i.e., below 1 mg/L), chemical processes at the water-sediment interface often cause release of phosphorus from the sediments (Munson et al., 2004). The phosphorus that would normally be sorbed to iron hydroxides is released as the lack of oxygen causes iron hydroxides to dissolve (ADEC, 2002).

2.2.1 Chlorophyll *a*

Chlorophyll *a* is a photosynthetic component of algae and aquatic vascular plants; consequently, it is a good indicator of algal biomass. Chlorophyll *a* samples were collected at

all sampling locations using a Kemmerer water sampling bottle to obtain one liter of sample water from depths of one meter and 75% of total depth. The liter of water was then passed through a sample filter using a hand pump. The liter of water and filtering process was shielded by an opaque cover to prevent photodegradation of chlorophyll. Sample filters were wrapped in tin foil and placed between gel ice packs for transport to the laboratory for analysis.

2.2.2 Other Nutrients

The remaining nutrient parameters collected at each sampling site are listed below:

- Ammonia-as nitrogen (N) – Ammonia is a form of nitrogen found in organic materials, sewage, and fertilizers. It is the first form of nitrogen released when organic matter decays. It is an important nutrient because it is readily available and can be used by most aquatic plants.
- Total Kjeldahl Nitrogen (TKN) – TKN is the total concentration of nitrogen in a sample, either present as ammonia or bound in organic material. Measuring levels of TKN and ammonia provide an estimate of how much organic nitrogen is in a water sample.
- Nitrate/Nitrite – Nitrate is a form of nitrogen used in fertilizers to promote plant growth. In the process of nitrification, ammonia is first oxidized to nitrite and then to nitrate. Addition of nitrate to surface water can lead to excessive plant growth (Vennie, 2004). Sources to water bodies include septic systems, agricultural fertilizers, manure, and landfills...
- Ortho-phosphate – Ortho-phosphate is a component of total phosphorus that is most readily available for use as a plant nutrient. It is a good indicator of a lake's trophic status (see section 4.2).
- Total phosphorus – Total phosphorus represents the phosphorus dissolved in solution and associated with colloidal material or particulate matter. Like ortho-phosphate, it is used to determine the trophic status of lakes.

These samples were collected at 1 m depth and 75% of total depth using a Kemmerer water sampling bottle. Sample bottles for ammonia-N, TKN, nitrate/nitrite, and total phosphorous were filled directly from the Kemmerer sample bottle. Ortho-phosphate samples were filtered in the field through an in-line 0.45 micron filter using a peristaltic pump after sample collection. The filtered samples were kept in a cooler on gel packs and transported to the laboratory for analysis (or similar language).

2.3 Hydrocarbon Sample Collection

Hydrocarbon samples were collected for total aromatic hydrocarbons (TAH). TAH includes the compounds benzene, toluene, ethylbenzene and xylenes, which are constituents of gasoline. Gasoline is the most commonly used fuel source for watercraft on the lake.

Samples were collected from multiple shallow depths in order to determine whether dissolved phase hydrocarbons were mixing in the water column. Sampling occurred at depths of 0.15 meter and 0.5 meter for each sample location through the August sampling event, although the project's Quality Assurance Project Plan (QAPP) stated that sample depths were to be 0.15 meter and 1.5 meter. The error was not identified until after the August 21 sampling event. TAH samples were collected at the correct depth of 1.5 meters for the October 16, 2005 sampling event. Figure 1 shows the sampling locations. Table 6 shows the dates and depths TAH samples were collected.

Hydrocarbon samples were collected using a volatile organic carbon sampler designed by the U.S. Geological Survey (USGS) and built by Wildco®. TAH samples were preserved with five drops of hydrochloric acid (HCl) after sample collection, kept in a cooler, and sent to laboratory for analysis.

Sampling sites were selected in areas with potential hydrocarbon sources. Suspect sources included boat traffic lanes, fueling and maintenance facilities, public boat launches and residential areas with small watercraft activity. The exception is LL-1, which is considered a near-shore background location for comparison.

Table 6. TAH Sample Summary

Sampling Site	Sample Dates	Sampling Depths
LL-1	May 7, 2005	0.15 and 0.5 meters
	July 4, 2005	0.15 and 0.5 meters
	August 21, 2005	0.15 and 0.5 meters
	October 16, 2005	0.15 and 1.5 meters
LL-3	May 7, 2005	0.15 and 0.5 meters
	July 4, 2005	0.15 and 0.5 meters
	August 21, 2005	0.15 and 0.5 meters
	October 16, 2005	0.15 and 1.5 meters
LL-4	May 7, 2005	0.15 and 0.5 meters
	July 4, 2005	0.15 and 0.5 meters
	August 21, 2005	0.15 and 0.5 meters
	October 16, 2005	0.15 and 1.5 meters

3 RESULTS

Project analytical data were validated according to the QAPP (OASIS, 2005b). Completeness of analytical sample collection met the project goal of 95% and the data are considered usable for this project. Details are presented in the project Quality Assurance Review (QAR) in Attachment C.

3.1 Weather Conditions

Table 7 shows the daily weather conditions for each sampling event at Lake Lucille.

Table 7. Climatic Summary

Sample Day	Mean Daily Temperature	Net Precipitation (24hrs)	Wind Speed	Historical Mean Daily Temperature
May 7, 2005	52°F	0.00 in	3 mph	47°F
July 4, 2005	60°F	0.00 in	1 mph	58°F
August 21, 2005	53°F	1.34 in	2 mph	56°F
October 16, 2005	32°F	0.00 in	5 mph	36°F
January 15, 2006	8°F	0.08 in	0 mph	13°F
February 20, 2006	30°F	0.00 in	7 mph	23°F

Source: Field notes and www.weatherunderground.com

The mean daily temperatures generally were on par with historical mean daily temperatures. Weather conditions do not indicate that any unusual atmospheric event would cause unusual or unexpected measurements.

3.2 Field Parameters

3.2.1 Individual Parameters

Field parameter results were recorded at each sampling site for each sampling event. Field parameters were generally measured at one meter intervals from surface to the lake bottom. Results are presented in the data tables in Attachment D and discussed below. Under-ice dissolved oxygen and temperature observations measured in January and February 2006 are discussed separately. Absent or suspect measurements of field parameters are discussed in the Quality Assurance Review (QAR) in Appendix A, as necessary.

Temperature

Temperature measurements ranged from 3.34 to 21.01°C, with a mean of 13.49°C and a median of 15.32°C during 2005 monitoring events at Lake Lucille. There is no developed thermocline or hypolimnion at Lake Lucille due to shallow lake depth (~4 meters). The temperature gradient at the deepest of the three sampling locations (LL-3) is presented in Figure 2.

Under-ice temperature measurements collected on January 15 and February 20, 2006 ranged from 2.44 to 5.38°C, with a mean of 4.19°C and a median of 4.24°C. Table 8 contains these temperature measurements.

Turbidity

Turbidity measurements ranged from 0.63 to 4.99 nepholemetric turbidity units (NTU) during 2005 monitoring events at Lake Lucille. The AWQS is 5 NTU above background conditions for all water uses. Given that the maximum reading during 2005 was 4.99 NTU, it is obvious that

no reading exceeded background by more than 5 NTU. The mean of all turbidity readings collected in 2005 was 1.63 NTU, and the median was 1.31 NTU.

pH

Results for pH during 2005 monitoring ranged from 7.87 to 9.42, with a median of 8.82. Most pH readings exceeded the AWQS for pH of 6.5 to 8.5 for recreational contact. The pH readings at Lake Lucille generally are higher as a result of the underlying limestone formation. As the limestone weathers and dissolves, the resulting calcium carbonate raises the lake's pH levels.

DO

Open-water DO measurements ranged from 7.71 to 16.79 milligrams per liter (mg/L) for all 2005 monitoring events, with a mean of 12.7 mg/L and a median of 14.03 mg/L. As expected, DO concentrations were highest in May and October when oxygen demand is lowest for the lake. The AWQS for DO ranges from 4 mg/L to 17 mg/L. Monitoring results from open-water measurements at Lake Lucille were within the AWQS range. Figure 3 presents a chart that shows the relationship between DO and water depth at the deepest sampling site (LL-3) in 2005.

Under-ice DO measurements collected on January 15 and February 20, 2006 ranged from 0.13 to 10.84 mg/L, with a mean of 3.08 mg/L and a median of 2.65 mg/L. Table 8 contains the 2006 under-ice DO readings as well as temperature measurements. Note the significant decrease with depth at the deepest sampling site, LL-3. These DO results are comparable to previous findings: a 1991-1993 study showed winter DO levels decreased with depth, with values ranging from 12 mg/L at the surface to zero at the bottom of the lake (ADEC, 2002).

Table 8. 2006 Under-Ice Dissolved Oxygen and Temperature Measurements

Date	Sample Site	Depth	Dissolved Oxygen	Temperature
		meters	mg/L	° C
1/15/2006	LL-1	1	3.11	3.50
1/15/2006	LL-1	2	3.08	3.80
2/20/2006	LL-1	1	1.17	3.60
2/20/2006	LL-1	2	3.16	4.78
1/15/2006	LL-3	1	4.13	3.59
1/15/2006	LL-3	2	2.38	4.12
1/15/2006	LL-3	3	0.38	4.96
1/15/2006	LL-3	4	0.26	5.07
1/15/2006	LL-3	5	0.13	5.38
2/20/2006	LL-3	1	10.84	3.61
2/20/2006	LL-3	2	1.69	4.52
2/20/2006	LL-3	3	0.26	4.73
2/20/2006	LL-3	4	0.45	4.81
2/20/2006	LL-3	5	0.37	4.93
1/15/2006	LL-4	1	5.34	2.44
1/15/2006	LL-4	2	2.65	3.59
2/20/2006	LL-4	1	5.96	3.60
2/20/2006	LL-4	2	6.51	4.24
2/20/2006	LL-4	2.5	6.64	4.28

Conductivity

Conductivity values ranged from 100 to 316 micro Siemens per centimeter (µS/cm) during 2005 monitoring. The mean conductivity reading for all 2005 monitoring events is 220 µS/cm and the median is 199 µS/cm.

ORP

ORP measurements ranged from -0.5 to 181 millivolts (mV) for all 2005 monitoring events, with a mean of 81.5 mV and a median of 84.1 mV.

Secchi Depth

Secchi depths generally ranged from 3 to 4.5 meters at the deeper sampling site (LL-3). At sampling sites LL-1 and LL-4, the Secchi disk was visible to the total lake depth during some or all of the sampling events.

3.2.2 Dissolved Oxygen/Temperature Comparison

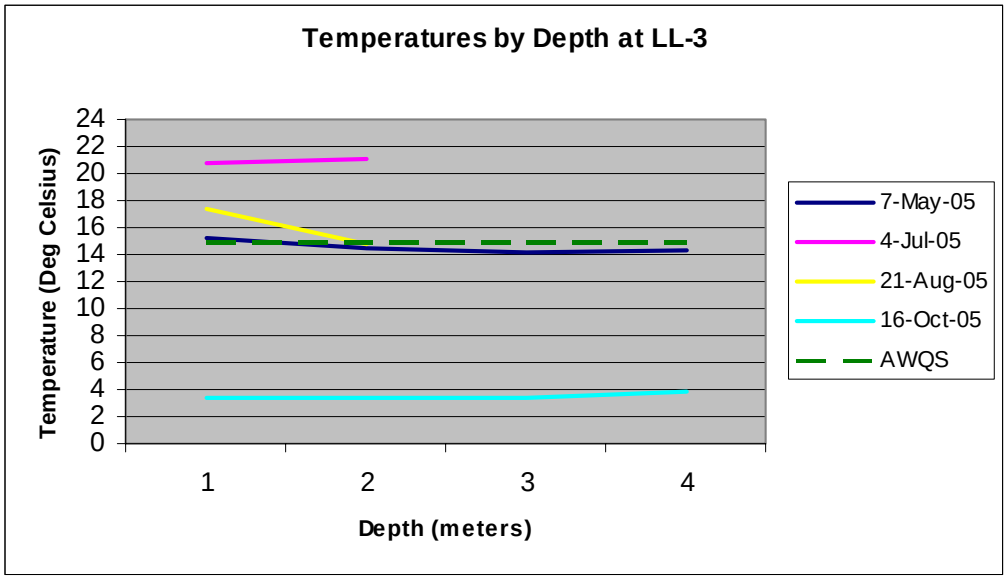
A correlation was performed between DO/temperature to determine how changes in temperature affect the amount of DO available in Lake Lucille.

Dissolved oxygen and temperature are expected to exhibit a negative relationship e.g., as temperatures decrease, the oxygen concentration increases. Because the solubility of oxygen decreases with increasing temperatures, water is generally unable to retain oxygen as its temperature increases.

Figure 4 presents a scatterplot of DO and temperature from 2005 monitoring at LL-3 at Lake Lucille. The scatterplot includes a line of best fit for expected results. Review of the graph shows the expected negative correlation between DO and temperature.

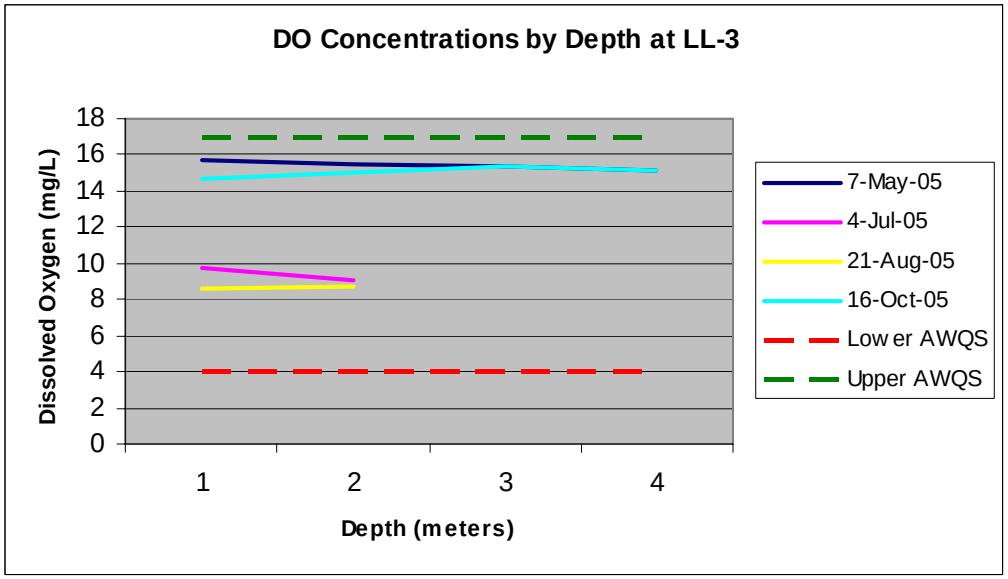
A scatterplot of DO and temperature from 2006 under-ice monitoring at LL-3 at Lake Lucille is presented as Figure 5. The scatterplot includes a line of best fit for expected results. Review of the graph also shows the expected negative correlation between DO and temperature, although the DO levels are depressed compared to those seen during the open-water period.

Figure 2. 2005 Temperature Measurements



Note: Field parameter measurements limited to 2-meters deep in July and August due to the presence of heavy aquatic vegetation.

Figure 3. 2005 Dissolved Oxygen Measurements



Note: Field parameter measurements limited to 2-meters deep in July and August due to the presence of heavy aquatic vegetation.

Figure 4. 2005 DO/Temperature Comparison

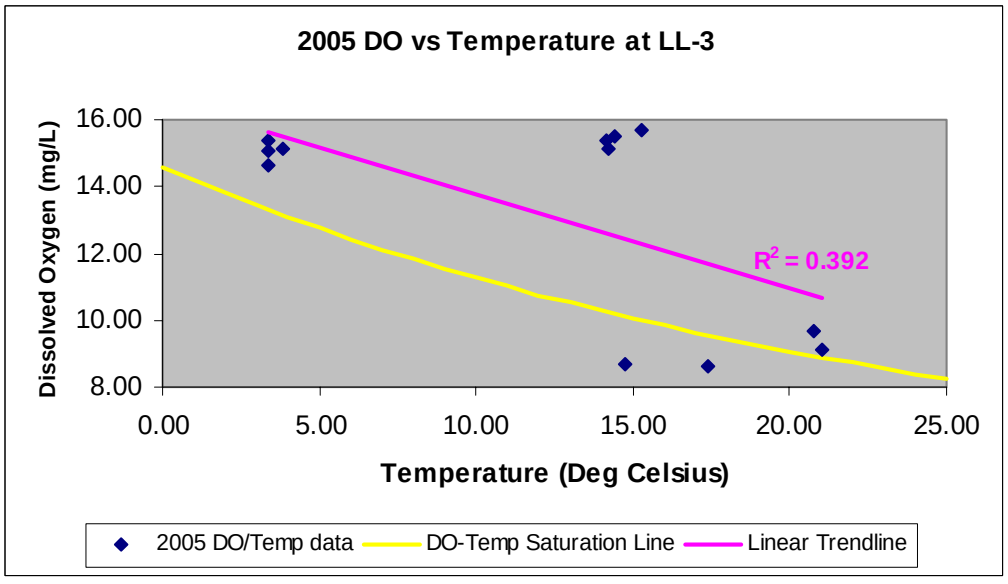
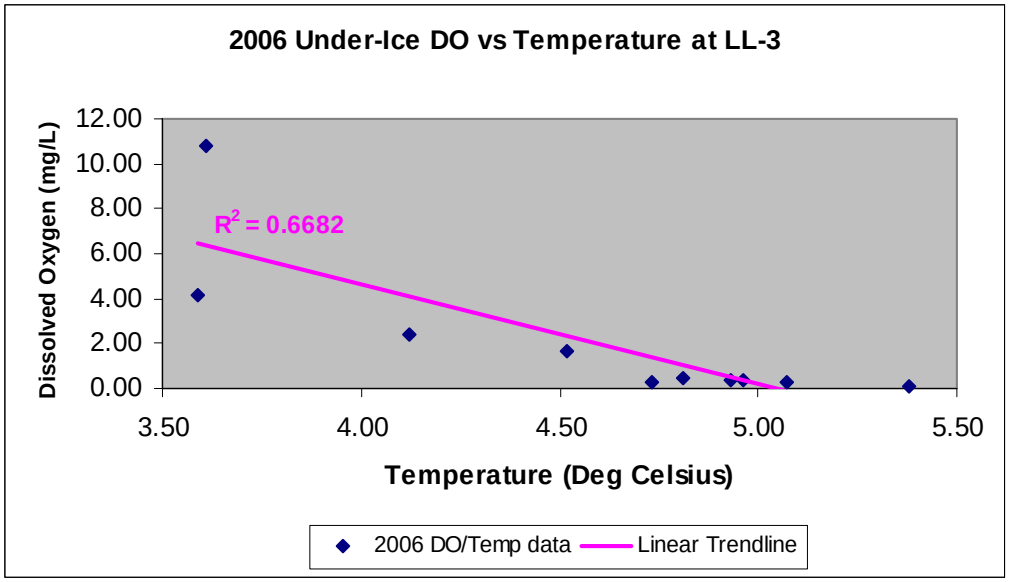


Figure 5. 2006 Under-Ice DO/Temperature Comparison



3.3 Nutrients

Nutrient samples were collected from all locations during the four sampling events of 2005. All three sites had a sample collected from a depth of one meter. LL-3 also had a second, deeper sample collected. Nutrient results are summarized in the data tables in Attachment D and are discussed below.

Phosphorus

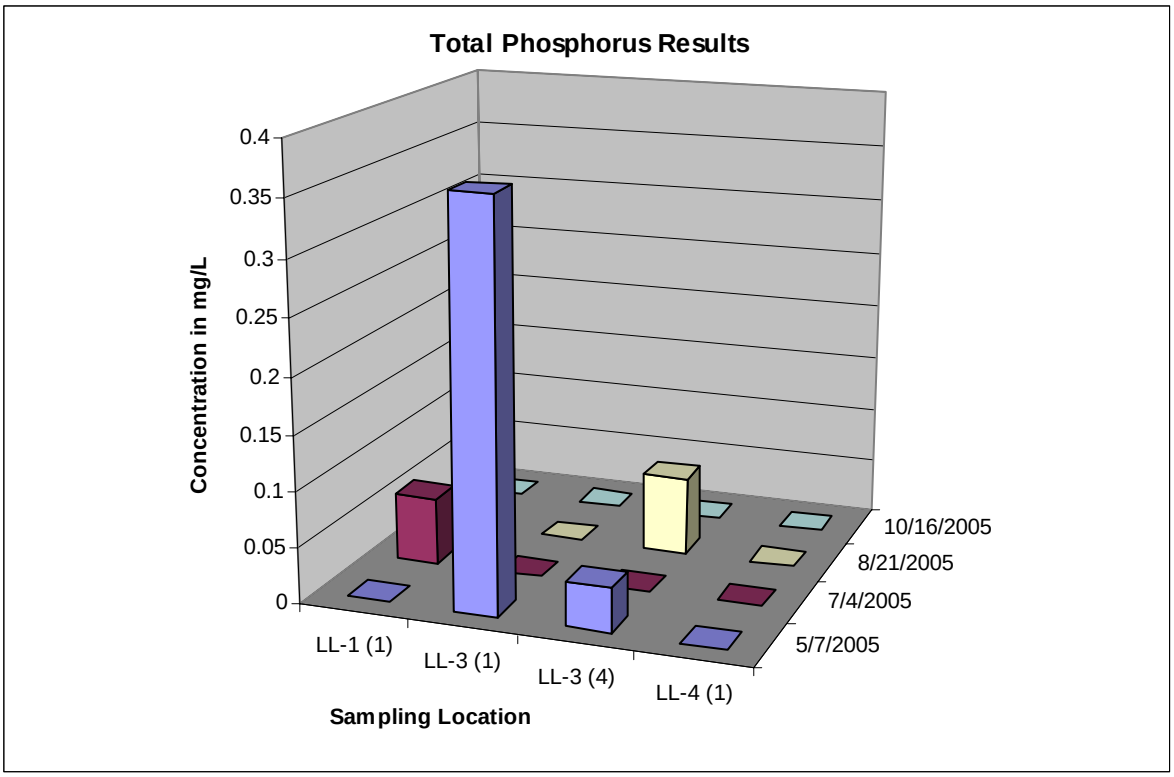
Total phosphorus and ortho-phosphate detections above laboratory reporting limits (100 mg/L and 400 mg/L, respectively) were infrequent and most detected concentrations were flagged by the laboratory as estimates. Detected total phosphorus concentrations ranged from 0.04 to 0.36 mg/L. Detected ortho-phosphate concentrations ranged from 0.13 to 0.25 mg/L. Table 9 and Figure 6 show results for ortho-phosphate and total phosphorous. Neither dissolved ortho-phosphate nor total phosphorus has an AWQS.

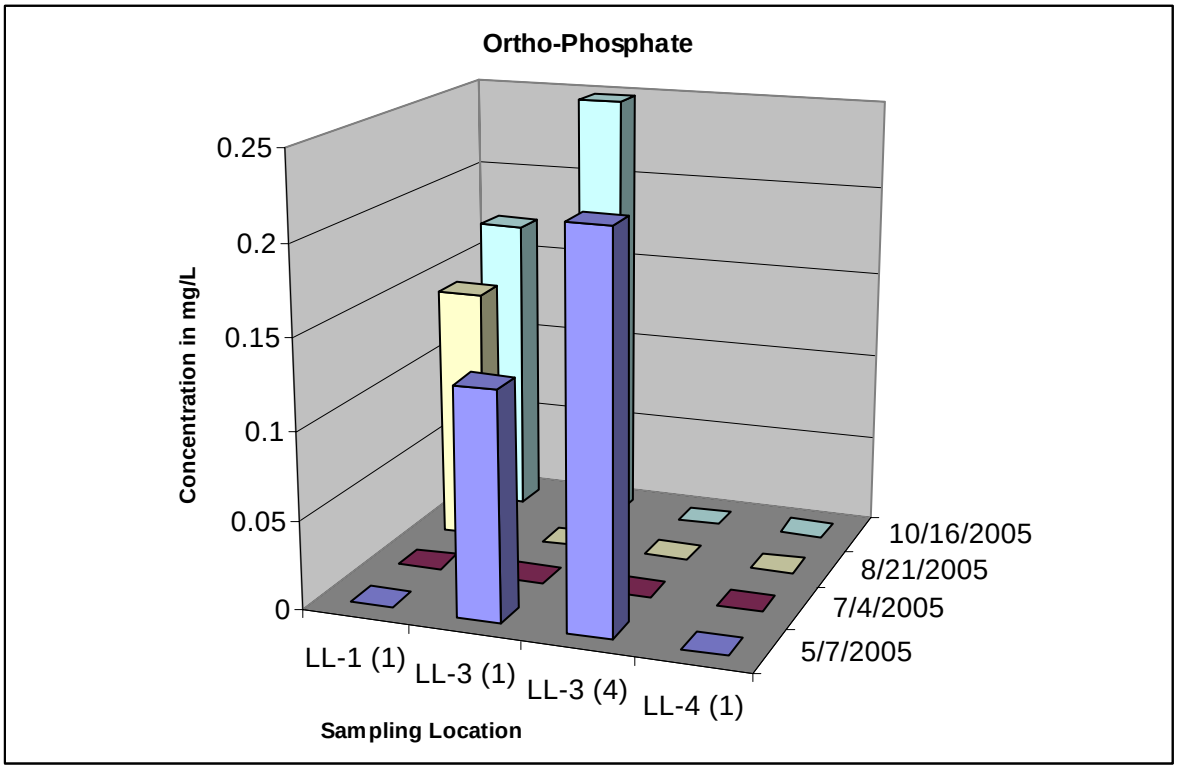
Historical levels of total phosphorus at Lake Lucille fall well below the laboratory's detection limits: previous studies report levels averaging between 19.5 and 21 µg/L (ADEC, 2002). Due to such low levels, requesting a lower detection limit may benefit future monitoring. However, attaining detection limits within the range of historical levels can be difficult. For instance, in a similar water-quality monitoring study at Big Lake (OASIS, 2006), lower detection limits were requested because they were also well above the lakes historic levels (8-20 µg/L for total phosphorus, 1-8 µg/L for ortho-phosphate; Woods, 1992). The lab was able to lower the limits by approximately 70%. The resulting detection limits were 31 µg/L for total phosphorus and 120 µg/L for ortho-phosphate, which unfortunately were still too high to adequately monitor phosphorus levels in Big Lake.

Table 9. Phosphorus Analytical Results

Sample Site	Depth (meters)	Date	PHOSPHORUS					
			Ortho-Phosphate	Data Flag	Units	Total Phosphorus	Data Flag	Units
LL-1	1	5/7/2005	ND(<0.12)		mg/L	ND(<0.031)		mg/L
LL-1	1	7/4/2005	ND(<0.12)		mg/L	0.06	J	mg/L
LL-1	1	8/21/2005	0.144	J	mg/L	ND(<0.031)		mg/L
LL-1	1	10/16/2005	0.171	J	mg/L	ND(<0.031)		mg/L
LL-3	1	5/7/2005	0.128	J	mg/L	0.36		mg/L
LL-3	1	7/4/2005	ND(<0.12)		mg/L	ND(<0.031)		mg/L
LL-3	1	8/21/2005	ND(<0.12)		mg/L	ND(<0.031)		mg/L
LL-3	1	10/16/2005	0.249	J	mg/L	ND(<0.031)		mg/L
LL-3	4	5/7/2005	0.218	J	mg/L	0.04	J	mg/L
LL-3	4	7/4/2005	ND(<0.12)		mg/L	ND(<0.031)		mg/L
LL-3	4	8/21/2005	ND(<0.12)		mg/L	0.07	J	mg/L
LL-3	4	10/16/2005	ND(<0.12)		mg/L	ND(<0.031)		mg/L
LL-4	1	5/7/2005	ND(<0.12)		mg/L	ND(<0.031)		mg/L
LL-4	1	7/4/2005	ND(<0.12)		mg/L	ND(<0.031)		mg/L
LL-4	1	8/21/2005	ND(<0.12)		mg/L	ND(<0.031)		mg/L
LL-4	1	10/16/2005	ND(<0.12)		mg/L	ND(<0.031)		mg/L

Figure 6. Phosphorus Results





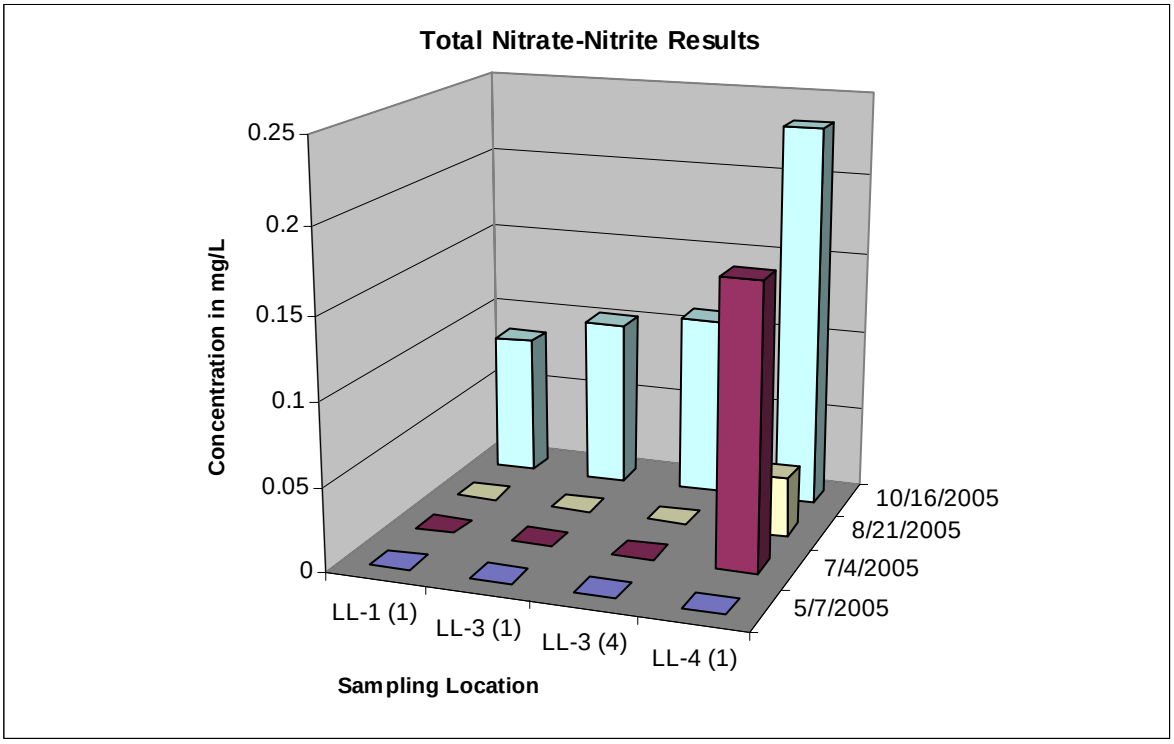
Nitrogen

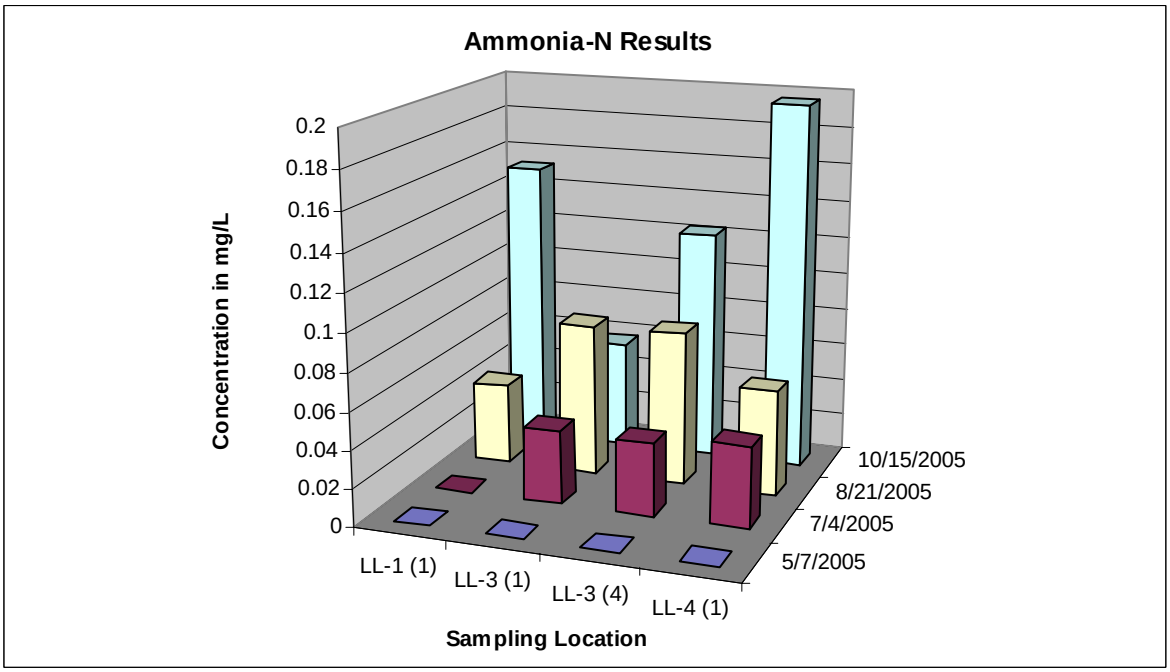
Nitrogen samples were analyzed for ammonia, TKN, and nitrate/nitrite. TKN was most frequently detected with 100% of analyses yielding a result above the reporting limit. Ammonia was next with a detection rate of 68.8% and nitrate/nitrite followed with a detection rate of 37.5%. Table 10 and Figure 7 show results for ammonia, TKN, and nitrate/nitrite.

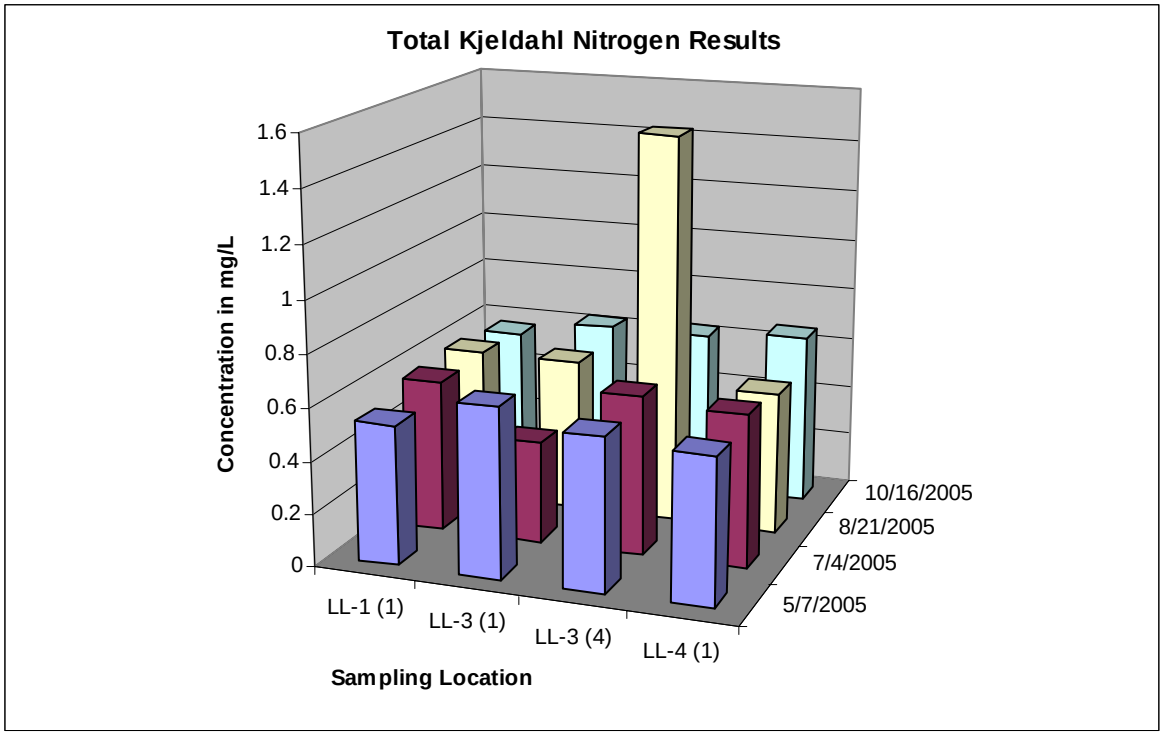
Table 10. Nitrogen Results

Sample Site	Depth (meters)	Date	NITROGEN								
			Ammonia-N	Data Flag	Units	Total Kjeldahl Nitrogen	Data Flag	Units	Total Nitrate/Nitrite	Data Flag	Units
LL-1	1	5/7/2005	ND		mg/L	0.534		mg/L	ND		mg/L
LL-1	1	7/4/2005	ND		mg/L	0.585		mg/L	ND		mg/L
LL-1	1	8/21/2005	0.043	J	mg/L	0.591		mg/L	ND		mg/L
LL-1	1	10/16/2005	0.152		mg/L	0.564		mg/L	0.086	J	mg/L
LL-3	1	5/7/2005	ND		mg/L	0.645		mg/L	ND		mg/L
LL-3	1	7/4/2005	0.039	J	mg/L	0.389	J	mg/L	ND		mg/L
LL-3	1	8/21/2005	0.081	J	mg/L	0.59		mg/L	ND		mg/L
LL-3	1	10/16/2005	0.0572	J	mg/L	0.63		mg/L	0.102		mg/L
LL-3	4	5/7/2005	ND		mg/L	0.583		mg/L	ND		mg/L
LL-3	4	7/4/2005	0.039	J	mg/L	0.61		mg/L	ND		mg/L
LL-3	4	8/21/2005	0.082	J	mg/L	1.5		mg/L	ND		mg/L
LL-3	4	10/16/2005	0.123		mg/L	0.63		mg/L	0.11		mg/L
LL-4	1	5/7/2005	ND		mg/L	0.56		mg/L	ND		mg/L
LL-4	1	7/4/2005	0.043	J	mg/L	0.585		mg/L	0.171		mg/L
LL-4	1	8/21/2005	0.056	J	mg/L	0.546		mg/L	0.036	J	mg/L
LL-4	1	10/16/2005	0.196		mg/L	0.66		mg/L	0.234		mg/L

Figure 7. Nitrogen Results







Detected total nitrate/nitrite results for all samples collected at Lake Lucille ranged from 0.04 to 0.23 mg/L. These concentrations were well below the drinking-water primary maximum contaminant level (MCL) of 10 mg/L (ADEC, 2003). Similarly, nitrate concentrations during a 1991-1992 study were far below the MCL: almost all concentrations were below 0.20 mg/L. Only one result, a January 1992 sample concentration of 0.39 mg/L, was above 0.20 mg/L (ADEC, 2002).

Detected ammonia results for all samples collected at Lake Lucille in 2005 ranged from 0.04 to 0.2 mg/L, with a mean of 0.08 mg/L and a median of 0.06 mg/L. Ammonia has an AWQS that is pH-dependent and must be calculated using the equation in the *Alaska Water Quality Criteria Manual for Toxic and Other Deleterious Organic and Inorganic Substances*, incorporated by reference in 18 AAC 70.020(b)(11) (ADEC, 2003). Using the median pH of 8.82 and the average temperature of 13.49°C, an ammonia AWQS of 0.640 mg/L was calculated using the equation for aquatic life fresh water chronic criteria when early life stages of fish are present (ADEC, 2003). All sample results were below the calculated ammonia AWQS. Results from a 1991-1992 study found similar levels, where the average ammonia concentration was 0.022 mg/L (ADEC, 2002).

TKN concentrations at Lake Lucille ranged from 0.39 to 1.5 mg/L, with a mean concentration of 0.64 mg/L and a median of 0.59 mg/L. TKN does not have an AWQS. A previous study (ADEC, 2002) noted a possible slight increase in TKN levels from 1991 to 1993. Concentrations averaged 0.30 mg/L in 1991, 0.72 mg/L in 1992, and 1.2 mg/L in the first three months of 1993. The study also showed hypolimnetic concentrations to be higher than those of the epilimnetic zone. The highest concentration of our results, 1.5 mg/L, was from the deepest sampling location (4 meters at LL-3), and was well above the shallower concentrations. However, our deep samples were limited (only 4 of 20 samples), and so it is difficult to decipher a pattern from the results.

Chlorophyll *a*

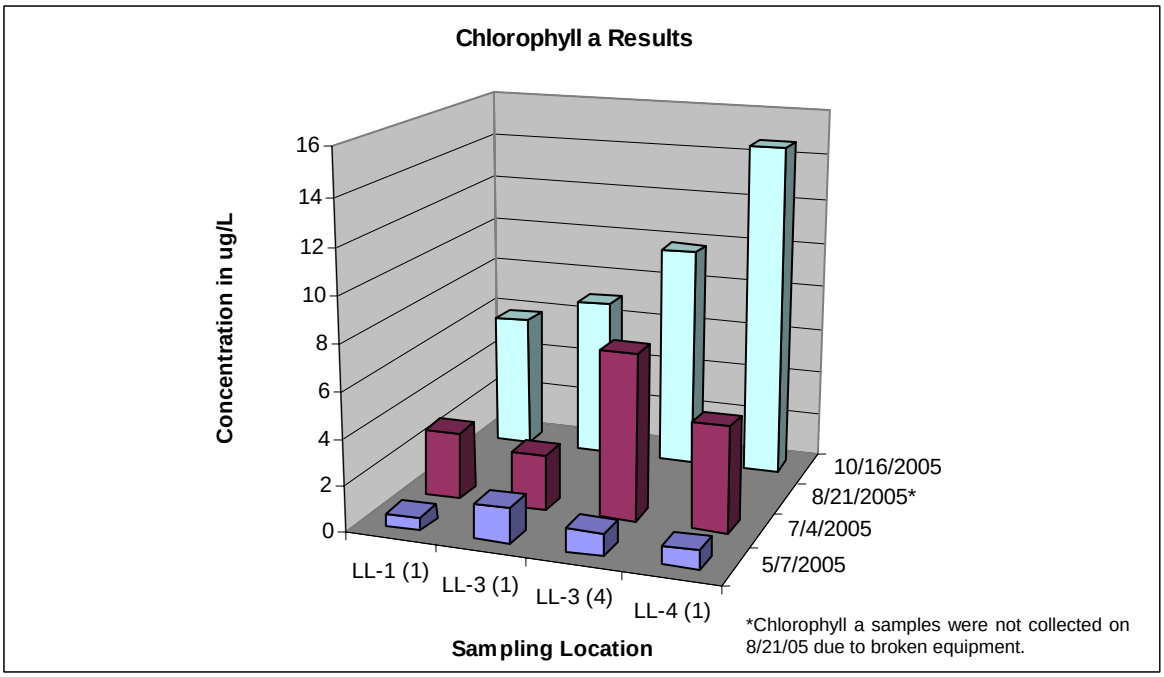
Chlorophyll *a* concentrations at Lake Lucille ranged from 0.56 to 14.7 µg/L. The average concentration for each sampling event was 0.96, 4.3 and 9.3 µg/L for May 7, July 4, and October 16, respectively. Chlorophyll *a* samples were not collected on August 21 because the hand pump used to filter the samples was broken (see the quality assurance review in Appendix A for additional information). Chlorophyll *a* results are presented in Table 11 and Figure 8. Concentrations from previous studies ranged from 1.6 to 4.7 µg/L (ADEC, 2002). These levels indicate low algal growth and are typical of lakes such as Lake Lucille, which is dominated by rooted aquatic weeds (ADEC, 2002).

Table 11. Clorophyll a Results

Sample Site	Depth (meters)	Date	CHLOROPHYLL A		
			Chlorophyll a	Data Flag	Units
LL-1	1	5/7/2005	0.561		µg/L
LL-1	1	7/4/2005	2.92		µg/L
LL-1	1	8/21/2005	--		µg/L
LL-1	1	10/16/2005	5.90		µg/L
LL-3	1	5/7/2005	1.52		µg/L
LL-3	1	7/4/2005	2.40		µg/L
LL-3	1	8/21/2005	--		µg/L
LL-3	1	10/16/2005	7.01		µg/L
LL-3	4	5/7/2005	0.961		µg/L
LL-3	4	7/4/2005	7.26		µg/L
LL-3	4	8/21/2005	--		µg/L
LL-3	4	10/16/2005	9.76		µg/L
LL-4	1	5/7/2005	0.801		µg/L
LL-4	1	7/4/2005	4.61		µg/L
LL-4	1	8/21/2005	--		µg/L
LL-4	1	10/16/2005	14.70		µg/L

-- = chlorophyll a samples not collected on 8/21/05 due to broken hand pump.

Figure 8. Chlorophyll a Results



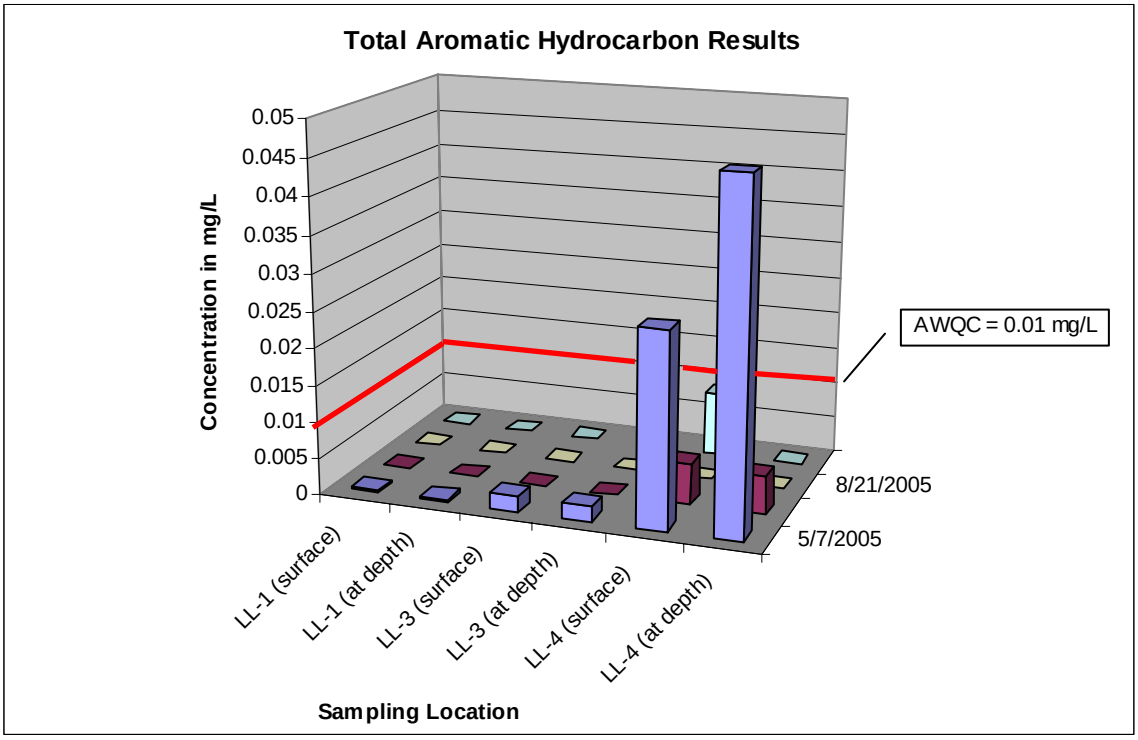
3.4 Hydrocarbons

Total aromatic hydrocarbons (TAH; the sum of benzene, toluene, ethylbenzene, and xylene concentrations) samples were collected at all sampling locations on all dates. Sampling depths were 0.15 meter and 0.5 meter, except on October 16, when samples were collected at 0.15 and 1.5 meters. Results are summarized in the data tables in Attachment D and are discussed below.

The benzene concentration in one sample exceeded the AWQS of 0.005 mg/L for drinking water supply. The sample had a concentration of 0.006 mg/L and was taken on May 7 at LL-4, at a depth of 0.5 meters.

Figure 9 shows TAH concentrations for all sample events. As seen in Figure 9, sampling site at the public boat launch (LL-4) had the greatest concentrations of TAH of the three sampling locations. TAH concentrations exceeded the AWQS of 0.010 mg/L at both depths at LL-4 (0.15 and 0.5 meters) on May 7. There were no other AWQS exceedances.

Figure 9. TAH Results



4 DISCUSSION & CONCLUSIONS

4.1 Field Parameters

The most stringent AWQS for temperature is 15°C for drinking water supplies. Nearly every temperature reading from May 7, July 4, and August 21 exceeded this standard. Given that Lake Lucille is mainly used as a recreational waterbody, the AWQS for water recreation (30°C) may be a more appropriate standard for comparison even though it is less stringent. All temperature measurements recorded during 2005 were less than 30°C.

Similar temperature readings were observed in 2004 at Lake Lucille. Lake Lucille is a shallow lake heated by solar radiation to depth. A hypolimnion did not develop in the lake and readings were similar at all depths. Edmundson (2002) reported similar readings for Threemile Lake, also only 4 meters deep, in May 2001.

The most stringent AWQS for pH is a pH greater than 6.5 and less than 8.5 (water recreation). Most pH readings at Lake Lucille in 2005 were slightly above the AWQS of 8.5 and ranged from 7.87 to 9.42 pH units. High pH readings may result from aquatic plants photosynthesizing and fixing CO_2 in the lake water. Lake Lucille has a calcium carbonate substrate in some areas, which also may contribute to high pH concentrations. The pH values observed during the 2005 study are consistent with those observed in 2004.

The most stringent AWQS for DO that pertains to Lake Lucille is a DO concentration greater than 4 mg/L (water supply), but less than 17 mg/L (growth and propagation). There were no AWQS exceedances for DO during open-water measurements in 2005. The DO mean for 2005 was 12.49 mg/L. The mean DO reading for all sample events from 2004 was 12 mg/L; therefore, there is little measured difference in DO readings from 2004 to 2005.

The 2006 under-ice DO measurements were significantly lower than the open-water levels of 2005, with an average of only 3.08 mg/L compared to 12.49 mg/L. Such a decrease is expected due to the lack of exposure to the atmosphere, which prohibits near-surface diffusion. Additionally, if snow covers the ice, it becomes too dark for photosynthesis. Lack of air exposure also prevents wind-induced mixing, resulting in the distinct stratification observed during under-ice measurements.

Under-ice DO concentrations measured in 2006 ranged from 0.13 mg/L [LL-3(5) on January 15] to 10.84 mg/L [LL-3(1) on February 20]. The higher reading likely is the result of localized mixing near the surface while augering the ice hole.

Turbidity measurements had no readings that exceeded the AWQS of 5 NTU above natural conditions. A single anomalous turbidity reading above 5 NTU (25.5 NTU at LL-3 on July 4) is attributed to the presence of high concentrations of sediment and other organic material in the instrument sampling container. This reading does not reflect an impairment of lake water quality for turbidity. Compared to 2004 data, where the mean turbidity reading for all sample events was 1.2 NTU, there was a slight increase in average turbidity in 2005 (1.63 NTU).

The average statistics for the 2005 ORP measurements (mean of 81.5 mV and a median of 84.1 mV) demonstrate that Lake Lucille's aquatic environment has oxygen available for chemical reactions. This fact is supported by measured DO concentrations. No ORP measurements were taken in 2004, making 2005 the baseline for ORP data.

Conductivity values varied within a small range (100 to 316 µS/cm) for 2005. The mean reading for 2005 was 230 µS/cm. These results are slightly lower than the 2004 data set, which ranged from 210 to 362 µS/cm (OASIS, 2004).

4.2 Nutrients

Nutrient supply is one of the major factors in determining a lake's trophic status. Trophic status refers to the productivity of a lake. Lakes can be classified as oligotrophic, mesotrophic, and eutrophic. Oligotrophic describes a lake with low productivity, deficient in plant nutrients, rich in oxygen throughout its depth, and with good water clarity. Eutrophic describes a lake with high productivity and biomass. It is rich in dissolved nutrients and seasonally deficient in oxygen. A mesotrophic lake lies between the two extremes; that is, it exhibits moderate productivity.

Nutrients are important for understanding the effects of cultural eutrophication upon Lake Lucille. As discussed in the Introduction, residential development on the lake's shorelines has the potential to affect water quality. Development contributes nutrients from failing waste systems, fertilizers, detergents, pet waste and other sources. Increased nutrient inputs increase the natural rate at which lakes change from oligotrophic to eutrophic classifications.

The parameters most commonly used to calculate the trophic state are total phosphorus, chlorophyll a, and Secchi disk depth. Multiple limnology studies reference Carlson's Trophic State Index, which is summarized in Table 12 below.

Table 12. Carlson's Trophic State Index (MPCA 2004)

TSI Range	Total Phosphorus (µg/L)	Chlorophyll a (µg/L)	Secchi Disk (m)	Description
<30	<6	<0.94	>8	Classic Oligotrophy; Clear water, oxygen through the year in the hypolimnion
30-40	6-12	0.94-2.6	4-8	Deeper lakes still exhibit classical oligotrophy, but some shallower lakes will become anoxic in the hypolimnion during the summer.
40-50	12-24	2.6-6.4	2-4	Water moderately clear, but increasing probability of anoxia in hypolimnion during summer.
50-60	24-48	0.4-20	1-2	Lower boundary of classical eutrophy: Decreased transparency, anoxic hypolimnion during the summer, macrophyte problems evident, warm-water fisheries only.
60-70	48-96	20-56	0.5-1	Dominance of blue-green algae, algal scums probable, extensive macrophyte problems.
70-80	96-192	56-164	0.25-0.5	Heavy algal blooms possible throughout the summer, dense macrophyte beds, but extent limited by light penetration. Often would be classified as hypereutrophic.
> 80	>192	>154	<0.25	Algal scums, summer fish kills, few macrophytes, dominance of rough fish.

Clorophyll a

Chlorophyll a is an indicator of algal productivity within a water body. Chlorophyll a concentrations at Lake Lucille ranged from 0.56 to 14.7 µg/L with the lowest levels seen in the spring and the highest concentrations seen during the fall sampling event in October. With the

exception of the October sampling event, values are consistent with those reported in 2004 (1 to 7.2 µg/L; OASIS 2004) and 2002 (1.6 to 4.7 µg/L; ADEC 2002).

Nitrogen

Nitrogen parameters are also important for evaluating nutrient availability or nutrient overload for aquatic organisms. Ammonia is a common ingredient in fertilizers, septic system effluent, and animal waste. Nitrate and nitrite also are associated with fertilizers because they are degradation compounds of ammonia. Total Kjeldahl nitrogen (TKN) is the sum of organic nitrogen and ammonia, and high levels often indicate the presence of contaminant loading from sewage. Total nitrogen to total phosphorus ratios can determine which nutrient is limiting algal growth (Edmundson 2002). Inorganic nitrogen is measured by the ammonia and nitrate/nitrite components. Organic nitrogen is measured by subtracting ammonia from TKN.

TKN was detected in every sample collected in 2005 at consistent concentrations throughout the year. The frequency of ammonia and nitrate/nitrite detections in samples increased throughout the 2005 sampling year, from a 0% detection frequency in May to 100% in October. Increased heterotrophic decomposition in the lake may contribute to these increasing concentrations. In addition to potential sewage and other pollutant inputs, decomposition of organic matter by heterotrophic bacteria releases ammonia into the surrounding water column, thereby increasing lake nitrogen levels. These processes would be expected to increase over the course of the summer as the water temperatures increase allowing for increased production. As the nutrient levels increase over the course of the open-water period, algal growth would also be expected to increase as was evidenced by the increases in chlorophyll *a* over that same time period.

Overall, results for nitrogen in 2005 appear to be similar to previous studies. Ammonia was reported in two samples in 2004 (0.273 and 0.134 mg/L) at concentrations similar to those reported in October 2005. TKN concentrations ranging from 0.50 to 0.76 mg/L are similar to those observed in 2005. Nitrate/nitrite was not detected in samples collected at Lake Lucille in 2004; however, the reporting limit (1 mg/L) was elevated compared to the reporting limit for most 2005 samples (0.1 mg/L).

Phosphorus

Phosphorus parameters are important for evaluating the availability of this nutrient for aquatic plant growth. Total phosphorus represents the phosphorus dissolved in solution and associated with colloidal material or particulate matter. Colloidal material is defined as particles dispersed in a medium that are not filtered or settled easily. Dissolved phosphorus includes all phosphorus that passes through a 0.45 um filter and ortho-phosphate is the dissolved form of phosphorus available for plant uptake. Total phosphorus is most commonly used to evaluate the trophic state of a lake.

Similar to last year, the method reporting limits for phosphorus parameters in this study were not low enough to detect phosphorous parameters for most samples. The 2005 reporting limit for total phosphorus and ortho-phosphate were 0.1 mg/L and 0.4 mg/L, respectively. None of the ortho-phosphate results were above the method reporting limit, although 25% were estimated below the limit (flagged with a 'J'). Likewise, all but one of the total phosphorus results were below the reporting limit of 0.1 mg/L, and 25% were estimated below the limit; the one sample concentration above the reporting limit was 0.36 mg/L, and was sampled at LL-3 on May 7. Such a limited data set is inadequate for proper analysis of phosphorus parameters in Lake Lucille.

Trophic State Index

The trophic state index (TSI) was calculated for chlorophyll a and Secchi disk readings at Lake Lucille. The average chlorophyll a concentration at Lake Lucille for all sampling sites and dates was 4.87 µg/L, with a calculated TSI of 46.1. The average Secchi disk depth for LL-3, the deepest location, was 3.5 m, with a corresponding TSI of 42.0. Due to the limited total phosphorus results, a total phosphorous TSI could not be accurately evaluated. However, for comparison purposes, the Carlson's TSI was calculated using the method reporting limit (100 µg/L) as the assumed total phosphorous concentration. The resulting TSI of 71 would classify the lake as hypereutrophic. Because there was no evidence of a dominance of blue-green algae or algal scums at Lucille Lake, the assumption can be made that total phosphorous concentrations are significantly lower than the method reporting limit.

Both the chlorophyll a and Secchi disk TSI scores fall in the 40-50 range, which classifies Lake Lucille as mesotrophic. Mesotrophic lakes are more nutrient rich than oligotrophic lakes but are not considered eutrophic.

4.3 Hydrocarbons

Two exceedances of the TAH AWQS (0.010 mg/L) were reported at sampling site LL-4 at both depths (0.15 and 0.5 meters) on May 7. TAH was 0.026 mg/L at 0.15 meters and 0.046 at 0.5 meters. The benzene concentration also exceeded the AWQS at LL-4 (0.5 meter depth) on May 7. The concentration of 0.006 mg/L exceeded the AWQS of 0.005 mg/L.

Sampling site LL-4 is located at the public boat launch on the eastern shore of the lake. Activities observed here include boating and launching. All AWQS exceedances during 2004 sampling also were at sampling site LL-4 at both depths. A public swim beach and associated park and picnic area is located at the southeast corner of Lake Lucille (Figure 1).

4.4 Sampling Sites

The previous subsections reviewed results by analyte. This subsection presents a summary by sampling site. Table 13 presents pertinent information and data for each sampling site.

Table 13. Sampling Site Analytical Summary

Sampling Site	Summary of Results
LL-1	This location exhibited the lowest concentration of hydrocarbons and nutrients; this is expected due to its relative location (farthest from boat launch, stormwater drains, roads, and residential/commercial developments).
LL-3	The highest TKN, total phosphorous, and ortho-phosphate concentrations were detected at this location. Also, it is the only location where a total phosphorous concentration was above the MDL. Hydrocarbon results were unremarkable/average (higher than LL-1, lower than LL-4)
LL-4	This location is in the most developed area. It is the only site with sample TAH concentrations exceeding the AWQS (46.4 µg/L @ 0.5m, 26.4 µg/L @ 0.15m); also a benzene exceedance in one of these two samples (0.5m); The highest chlorophyll a, nitrate/nitrite, and ammonia concentrations were found here as well.

4.5 Recommendations

Results for several of the nutrient parameters sampled for laboratory analyses were below the method reporting limits. The concentrations that were detected were relatively low and are consistent with data from sampling conducted in 2004. Based on the stable trophic state index indicting a mesotrophic status, OASIS recommends continuing nutrient analyses in the sampling scheme at Lake Lucille. In particular, it is recommended that the laboratory's method detection limit be lowered to below the TMDL target of 17 µg/L if at all possible. A better estimate of phosphorus concentrations can help in determining the trophic status of the lake and the implications for measured DO levels.

Two exceedances of the AWQS for TAH (0.010 mg/L) were reported at a single location (LL-4; 0.15 and 0.5 meters depth) on May 7, 2005. This sampling location is in a relatively high-use boat launch area. OASIS recommends continuing to document hydrocarbon levels at these types of areas during high-use weekends. It also may be important to monitor TAH concentrations at the public beach area, located approximately 1/10-mile south of the public boat launch. Future monitoring activities should concentrate on the identified issue of TAH loading near sampling site LL-4, the public beach area, and any newly identified high-use areas.

The long-term plan should also include monitoring of physical parameters so that the lake's physical characteristics and changes may be better understood through historical comparisons. Future monitoring should include early-spring and late-fall monitoring of physical parameters. An effort should be made to measure physical parameters throughout the lake's depth (e.g., to a full 5 meters at LL-3) during every monitoring event to better understand the DO-temperature relationship and the lake's trophic status.

Another long-term goal involves continuing to implement the City's plan to reduce human impact (e.g., boat launch fee, public education, storm water diversion program), with the goal of meeting the TMDL phosphorus target level (assuming low enough detection limit can be obtained in lab analyses). The TMDL report states that this goal "can be achieved only by reducing almost all anthropogenic sources of P [phosphorous] to the lake."

5 REFERENCES

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ATTACHMENT A
PROJECT SAMPLING PLAN

Lake Lucille and Big Lake Water Quality Monitoring

Lake Lucille Sampling Plan

April 13, 2005

Prepared for:

Alaska Department of Environmental Conservation

555 Cordova Street

Anchorage, AK 99501

Prepared by:

OASIS Environmental, Inc.

807 G Street, Suite 250

Anchorage, AK 99501

Table of Contents

1 Introduction

Lake Lucille is a small, shallow lake of 360 acres with a maximum depth of 20 feet. Located in Wasilla, the north and east shores are developed residential areas; a large lodge, restaurant, and flight service are located on the north shore. The south and west shores are less developed, but there are extensive recreational activities throughout the lake. The entire lake shore is private land except for a park on the south shore owned by the Matanuska-Susitna Borough.

Lake Lucille was listed on the Alaska Department of Environmental Conservation (ADEC) 1998 Section 303(d) list of impaired waters for failure to meet the dissolved oxygen criteria. A Ttoal Maximum Daily Load (TMDL) was completed in 2001 to determine the maximum dissolved oxugen levels that meet the 18 AAC 70 Alaska Water Quality Standards (AWQS). The TMDL recognized that anthropogenic sources of phosphorus have been reduced to help meet AWQS and part of the TMDL implementation is to continue this reduction.

The 2005 water quality monitoring at Lake Lucille is being performed for ADEC. Parameters that will be included in the monitoring are nutrients, dissolved oxygen, bacteria and hydrocarbons.

2 Sampling Design

2.1 Schedule

Samples will be collected at Lake Lucille over four sampling events; specific dates and corresponding analytes are presented in Table 1. All sampling events will take place on weekends, including Independence Day weekend. This sampling schedule will allow sample collection on dates with high recreational use as well as dates with less recreational use for comparison.

Table 1: 2005 Lake Lucille Sampling Events

Collection Date	Nutrients	Hydrocarbons
May 8, 2005	X	X
July 4, 2005	X	X
August 21, 2005	X	X
October 16, 2005	X	X

The first event intends to sample the lake prior to spring turnover. When ice cover melts, the water column is nearly isothermal. Sufficient wind energy then causes the lake to circulate completely, which is known as spring turnover. The last event intends to sample the lake following fall turnover when the epilimnion cools, becomes more dense, and is mixed with deeper strata by wind and convection currents. As the exact dates for turnover will depend on weather conditions, the scheduled dates of May 8 and October 16 are tentative and subject to change.

The remaining sampling events are scheduled to occur on weekends, when recreational use is highest. Sampling is scheduled for Independence Day weekend (July 2-4) when recreational use is expected to be at its peak for the season.

In addition to these analytical sampling events, under ice dissolved oxygen (DO) and temperature measurements will be collected once in January and once in February.

2.2 Site Selection

Sampling sites on Lake Lucille will be selected for nutrients and hydrocarbons based on the results of the 2004 water quality monitoring conducted at Lake Lucille. Proposed sampling locations for 2005 are presented in Table 2.

Table 2: 2005 Lake Lucille Sampling Locations

Sampling Site	Nutrients	Hydrocarbons	Description
LL-1	X	X	A public camp ground is near to this site as well as a large wetland area.
LL-3	X	X	This historic USGS sampling site is located in the deepest section of the lake, with an island to the south and waterfowl activity and residences to the north.
LL-4	X	X	This public boat launch on the east end of lake is heavily used. A public park is located approximately 0.25 miles to the south and there are residences in the area.

Nutrient sampling sites are located near areas of high density housing where inputs such as fertilizers, septic systems, outhouses, pet waste, etc. may contribute to nutrient loading. At each location, samples for nutrient analyses will be collected from a depth of one meter and seventy-five percent of the total depth. The exception to this is sampling locations with a total depth of less than two meters (seven feet), in which case samples will be collected at a depth of one meter only.

Hydrocarbon sampling sites are located in areas where TAH was detected during the 2004 water quality monitoring program (LL-1, LL-3, and LL-4). At each sampling location, hydrocarbon samples will be collected at two depths: 0.15 and 1.5 meters.

3 Methods

A small (15') aluminum skiff with a 25 hp outboard motor will be launched at the public boat launch on the east end of Lake Lucille. A handheld Garmin® GPS unit will be used to locate the sampling locations using the latitude and longitude data from the 2004 water quality monitoring program. The motor will be turned off prior to reaching the sample site and the boat will drift to the location. If necessary, an anchor will be dropped to keep the boat in place while sampling. Samplers will wear nitrile gloves at all times during sampling and new gloves will be used for collecting each set of samples. Observations and photographs will be taken at each sampling location and recorded in a field notebook. Observations will include algal presence on the lake surface; motorboat, plane and small motorcraft traffic near to the sampling site; approximate wind direction and speed; presence of surface sheen; and weather conditions. As Lake Lucille is a relatively small lake, observations of the entire lake will be recorded.

3.1 Analytical Sample Collection

Hydrocarbon samples will be collected using a Wildco® sampler specifically designed by the USGS for the collection of VOC samples from surface water. This VOC sampler is

designed to collect samples at depth without any loss to volatilization. For a complete description of the sampler, see Attachment A.

A Wildco® Kemmerer bottle will be used to collect water from the appropriate depth interval for nutrient samples. Containers will either be filled directly from the Kemmerer bottle or field filtered, as necessary. For the collection of chlorophyll a samples water will immediately be poured from the Kemmerer bottle to a graduated cylinder, which will be shielded from daylight during the sample collection process.

Sample collection equipment will be decontaminated at each location using an Alconox® and distilled water solution and rinsed with distilled water. After decontamination, the equipment will be flushed with lake water prior to collecting samples at each location. For samples collected at the same location but at different depths, the equipment will be flushed once with lake water at each depth interval prior to collection.

TAH samples will be collected prior to nutrient samples as they are more sensitive to loss or contamination. The nutrient samples can be collected in any order and include chlorophyll a, total phosphorus, filterable reactive phosphorus, Kjeldahl nitrogen, ammonia, and nitrate/nitrite.

When collecting samples for dissolved analyses (filterable reactive phosphorus), a 0.45-micron, high-capacity, disposable filter will be attached to flexible Teflon® tubing that has been threaded through a peristaltic pump. Prior to filling sample bottles, the tubing and filter will be flushed with approximately 500-mL of lake water from the Kemmerer water sampling bottle. A new filter and associated tubing will be used for each sample location.

Samples will be kept in a cooler with gel ice at 4°C (±2°C) for transport to the laboratory. Samples will be transported to the laboratory in Anchorage after collection for analysis to be completed within their holding times. Specific methods for collecting analytical samples and field parameters are provided in the QAPP.

3.2 Field Parameters

Field parameters will be measured after collection of analytical samples using a YSI® 556 multi-parameter water quality meter with a flow-through cell. Water quality parameters to be measured in the field include temperature, pH, dissolved oxygen, conductivity and turbidity. Measurements will be recorded every meter until the thermocline is reached, and then at one, three, and five meters from the lake bottom. Transparency will be measured with a Secchi disk at each sampling location. Specific methods for measuring Secchi depth transparency are included in the QAPP. Information on field instrument calibration and maintenance is also detailed in the QAPP.

ATTACHMENT B
QUALITY ASSURANCE PROJECT PLAN (QAPP)

OASIS ENVIRONMENTAL, INC.
LAKE LUCILLE AND BIG LAKE
WATER QUALITY MONITORING

Quality Assurance Project Plan

April 2005

A. Project Management Elements

A1. Title Page and Approvals

Project Manager	**Date**
Quality Assurance Officer	**Date**
ADEC Project Manager	**Date**
ADEC Water Quality Assurance Officer	**Date**

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A2. Table of Contents

Tables

Figures

Attachments

A3. Distribution List

This list includes the names and addresses of those who receive copies of this approved QAPP and subsequent revisions. It is not the list of those who receive data reports.

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A4. Project/Task Organization

OASIS Environmental, Inc. (OASIS) has been contracted to monitor lake water quality for Big Lake and Lake Lucille in the Matanuska Susitna Borough. Nutrients, bacteria, hydrocarbons and additional field parameters will be monitored throughout the project. Tasks to be performed include six sampling events on Big Lake and four sampling events on Lake Lucille, scheduled to occur between March and October 2005. Additionally under-ice dissolved oxygen and temperature profiles will be measured at Lake Lucille once during January and once during February 2006. Separate final reports will be submitted for Big Lake and Lake Lucille on February 1, 2006 and June 30, 2006, respectively. Staff duties and responsibilities for completing these tasks are described below.

OASIS staff

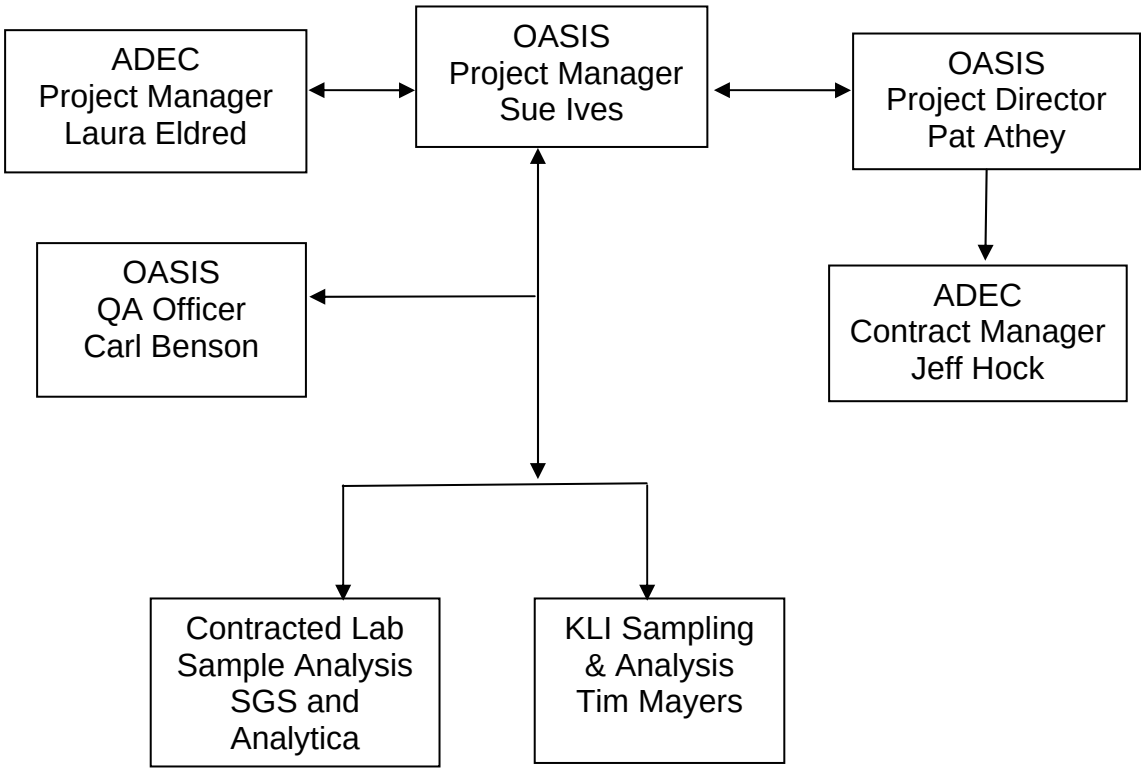
- Pat Athey is the Project Director. He will provide overall senior review and direction for the project.
- Sue Ives is the Project Manager for OASIS. She will coordinate tasks and deliverables for the project and serve as the primary point of contact for communications with ADEC project staff. She will contribute to sampling throughout the summer and interpretation and reporting of data.
- Carl Benson is the Quality Assurance Officer. He will be responsible for QA/QC of all data.
- Tim Mayers will provide support as an Environmental Scientist. He will assist in collecting samples throughout the summer and help in reporting responsibilities.

Two laboratories will be used for this project. The main project laboratory will be SGS Environmental Services (SGS). Shane Poston will be the SGS contact for this project; SGS will perform all analyses with the exception of chlorophyll a. Analytica Alaska, Inc. (Analytica) will analyze the chlorophyll a samples. Wendy Mitchell will be the Analytica contact for these samples.

ADEC Staff

- ADEC Project Manager is Laura Eldred. Laura will be the primary contact for technical questions or other questions related to the project.
- ADEC Contract Manager is Jeff Hock.
- ADEC Quality Assurance Officer is Jim Gendron. He will assist in development of the QAPP, if necessary, and approve it for ADEC along with the ADEC Project Manager. He may also review data and/or audit monitoring activities.

Organization Chart



A5. Problem Definition/Background

The purpose of this project is to continue water quality assessments of Lake Lucille and Big Lake for nutrients, dissolved oxygen, bacteria, hydrocarbons, and other field parameters.

A Total Maximum Daily Load (TMDL) for Lake Lucille was completed in 2002[1] for dissolved oxygen (DO). Phosphorous is the limiting nutrient for plant growth in Lake Lucille; increased phosphorus concentrations in the lake lead to an increased growth of aquatic vegetation. Oxygen is consumed during decomposition when the vegetation dies, depressing DO levels in the lake. Anthropogenic sources of phosphorus include historical septic systems, wildlife and pet waste, and urban runoff from lawn fertilizers. Additional contaminants of concern at Lake Lucille are hydrocarbons from motorized recreation.

[1] ADEC. 2002. Total Maximum Daily Load (TMDL) for Dissolved Oxygen in the Waters of Lake Lucille in Wasilla, Alaska. Alaska Department of Environmental Conservation. February 11.

A detailed study on the limnology of Big Lake was conducted in 1983-84[2], prompted by concerns over potential cultural eutrophication of the lake. Nutrient results indicated that the lake was oligotrophic. However, DO levels were uncharacteristic for an oligotrophic lake with a deficit in the hypolimnion during summer stratification and also under winter ice cover. Shoreline development at Big Lake may be contributing nutrients that are increasing aquatic growth and thereby lowering DO levels. Additional contaminants of concern include hydrocarbons from motorized recreation and bacteria from human and animal waste.

This sampling program includes sites selected based on results from the 2004 water quality monitoring at both lakes. Activities that may contribute to the parameters of concern include boat, plane, and small watercraft traffic; maintenance and fueling areas; boat launches; marinas; docks; septic systems; animal waste; waterfowl waste; subdivisions; and fertilizers.

Six sampling events are scheduled for Big Lake and four for Lake Lucille. Specific dates for all sampling events are presented in the sampling plans for each lake.[3] The first event intends to sample the lake prior to spring turnover. When ice cover melts, the water column is nearly isothermal. Sufficient wind energy then causes the lake to circulate completely, which is known as spring turnover. The last event intends to sample the lake following fall turnover when the epilimnion cools, becomes more dense, and is mixed with deeper strata by wind and convection currents. As the exact dates for turnover will depend on weather conditions, the scheduled dates in early May and mid-October are tentative and subject to change. The remaining sampling events are scheduled to occur on weekends, when recreational use is highest.

In addition to these analytical sampling events, under ice DO and temperature measurements will be collected once in January and once in February at Lake Lucille.

Final data results will be analyzed by comparing water quality parameters with Alaska Water Quality Standards (AWQS) and evaluating the temporal and spatial extent of their impact.

A6. Project/Task Description

The proposed work elements to meet the project objective are summarized below by task. Each task summary includes the task's deliverables and schedule.

Develop Sampling Plans

Sampling plans for each lake will be developed in draft form and finalized upon receipt of comments from ADEC.

Deliverable: Big Lake Sampling Plan and Lake Lucille Sampling Plan

[2] Woods, P.F. 1992. Limnology of Big Lake, South-Central Alaska, 1983-84. U.S. Geological Survey Water-Supply Paper 2382.

[3] OASIS. 2005. Lake Lucille and Big Lake Water Quality Monitoring: Big Lake Sampling Plan. OASIS Environmental, Inc. March.
OASIS. 2005. Lake Lucille and Big Lake Water Quality Monitoring: Lake Lucille Sampling Plan. OASIS Environmental, Inc. March.

Schedule: completed by April 15, 2005

Quality Assurance Project Plan

This QAPP will be submitted for approval by ADEC prior to collection of samples.

Deliverable: QAPP

Schedule: completed by April 15, 2005

Field Data Collection

Field parameters, nutrient, hydrocarbon, and bacterial samples will be collected May through October 2005. Additionally, under-ice DO and temperature profiles will be measured at Lake Lucille once per month during January and February 2006. Table 1 in Section A.7 presents a complete list of analytes; a detailed description of the sampling program is provided in Section B1, Sampling Process Design. Table 2 in Section B1 describes the individual sampling locations.

Sampling staff are trained in general water sampling procedures and specifically for the water sampling equipment to be used for this project. Training includes proper sampling procedures to avoid sample contamination or cross-contamination between samples, methods for collecting samples using the Wildco® VOC sampler and Kemmerer water sampling bottle, and procedures for measuring depth transparency using a Secchi disk. Sampling staff assigned to this project are also trained in the use of motorboats, including safety while driving with the trailer and while operating the motorboat.

Samples will be submitted to the contracted laboratories, SGS and Analytica. Laboratories will provide the sampling containers, coolers, gel ice, trip blanks and temperature blanks for each sampling event. Upon receipt of the samples, the laboratories will analyze them for the analytical parameters listed in Table 1 and report results both in hard-copy format and in electronic form (Access database) by normal turn around times.

Data obtained over the course of the program, including weather data described below, will be entered into a Microsoft Access database following ADEC guidelines as referenced in the project scope of work. Numeric or other abbreviated coding schemes will be avoided, and departmental data management guidance such as that described at http://www.state.ak.us/dec/water/wqsar/storetdocumentation.htm will be applied as appropriate.

Appropriate data validation reporting requirements as detailed in Section D will be included in the Final Report.

Deliverable: Results for laboratory analyses and field parameters will be included in the database delivered with the Final Report.

Schedule: Sampling will be conducted on May 7, 8, and 28; July 3, 4, and 23; August 20 and 21; and October 15 and 16. The final report for Big Lake water quality monitoring will be completed February 1, 2006 and the final report for Lake Lucille water quality monitoring will be completed June 30, 2006.

Weather Conditions

During the sampling season, weather conditions will be obtained from the NOAA National Weather Service website (http://www.arh.noaa.gov/obs.php) for weather observations at the Wasilla Airport. Precipitation data will also be obtained from NOAA's National Climatic Data Center (NCDC) for inclusion in the final Access database. Data collected will include weather observations for the week and month prior to sampling events. Parameters that will be reported include total precipitation, precipitation duration, average temperature and dew point. These data will be compared to annual or seasonal data for the sampling locations to help determine if representative weather conditions have been met for each sampling event.

Deliverable: Database of weather conditions during the sampling events.

Schedule: Weather conditions will be included in the Big Lake final report due February 1, 2006, and the Lake Lucille final report due June 30, 2006.

Draft Report

Draft reports for each lake will include the complete sampling results for the respective lake's water quality monitoring. Samples will be analyzed and compared to state water quality standards in 18 AAC 70. The draft report for Big Lake water quality monitoring will be submitted on January 15, 2006 and the draft report for Lake Lucille water quality monitoring will be submitted on June 19, 2006 for ADEC review.

Results will be used by ADEC staff and other agencies to make management decisions to protect Big Lake and Lake Lucille for all of its uses.

Deliverable: Draft Report

Schedule: Draft reports for Big Lake and Lake Lucille will be completed by January 16 and June 19, 2006, respectively.

Final Report

Final reports will be prepared following ADEC review of the draft reports, incorporating comments from that review. Photographic records and the project database will be submitted with final reports.

Deliverable: Final Report with database

Schedule: Final reports for Big Lake and Lake Lucille will be completed by February 1 and June 30, 2006, respectively.

A7. Data Quality Objectives and Criteria for Measurement of Data

Project Data Quality Objectives

The overall quality objective of this QAPP is to ensure that the state water quality criteria for the contaminants of concern are accurately monitored at Big Lake and Lake Lucille.

Detection limits for the analytical methods must be comparable to the levels of concern in order to meet data quality objectives. Hydrocarbon levels of concern for this project

are the water quality criteria in 18 AAC 70; nutrient levels of concern for this project have been developed by ADEC after review of prior water quality studies[4]. A summary of the parameters, their associated analytical methods with practical quantitation limits (PQLs), and the levels of concern are provided in the following table. PQLs are defined by the EPA as "the lowest concentration of an analyte that can be reliably measured within specified limits of precision and accuracy during routine laboratory operating conditions."

[4] ADEC. 2005. Project Scope of Work for Water Quality Technical Assistance: Lake Lucille and Big Lake Water Quality Monitoring. February 18.

Table 1. Parameter PQLs and Levels of Concern

Analyte	Method	Practical Quantitation Limit[1]	Levels of Concern[1]
Total Phosphorus	EPA 365.2	0.005 mg/L	NA
O-Phosphorus, dissolved	EPA 365.2	0.005 mg/L	NA
Kjeldahl Nitrogen	SM 4500-N D	0.5 mg/L	NA
Ammonia	SM 4500-NH3 F	0.1 mg/L	*pH dependent*
Nitrate + Nitrite	EPA 300.0	0.1 mg/L	10 mg/L
Fecal Coliform	SM 9222D	0 colonies/100 mL	20 FC/100mL
Chlorophyll a	SM 10200H	3.0 mg/m3	NA
Benzene	EPA 602	0.4 ug/L	TAH 10 ug/L
Toluene	EPA 602	1.0 ug/L	TAH 10 ug/L
Ethylbenzene	EPA 602	1.0 ug/L	TAH 10 ug/L
Xylene	EPA 602	2.0 ug/L	TAH 10 ug/L
pH	In situ (electronic probe)	+/- 0.01 pH units	<6.5 and <8.5 pH units
Dissolved oxygen	In situ (electronic probe)	+/- 0.01 mg/L	<7 and <17 mg/L
Temperature	In situ (electronic probe)	+/- 1°C	13 °C
Conductivity	In situ (electronic probe)	0-1: 0.001 1-10: 0.01 10-100: 0.1 (mS/cm)	NA
Salinity	In situ (electronic probe)	+/- 0.01%	NA
Turbidity	In situ (electronic probe)	+/- 1 NTU	5 NTU above natural conditions

NA - Not applicable
[1] For a discussion of PQLs and Levels of Concern, see Section A7 above.

Criteria for Measurement of Data

Criteria for measurements of data are the performance criteria: accuracy, precision, comparability, representativeness and completeness of the tests. These criteria must be met to ensure that the data are verifiable and that project quality objectives are met.

OASIS' objectives for accuracy, precision, comparability, representativeness and completeness are summarized in this section. OASIS' contracted laboratories, SGS and Analytica, are ADEC-certified for drinking water analyses. A copy of their Quality Management Plan (QMP) is on file with the ADEC Water Quality Assurance Officer, which includes the laboratory measurement criteria. The QA/QC measures included in the SGS and Analytica QMPs are not repeated in this document.

Accuracy

Accuracy is a measure of confidence that describes how close a measurement is to its "true" value. Methods to ensure accuracy of field measurements include instrument calibration and maintenance procedures discussed in Section B of this QAPP. Sample handling procedures are also discussed in Section B and review of these procedures for verification of data is included in Section D.

Laboratory accuracy is normally determined by the percent recovery of the target analyte in spiked samples and also by the recoveries of the surrogates in all samples and QC samples. Laboratory accuracy ranges are specified in SGS' Quality Management Plan (kept on file at ADEC) and depend on the parameter being measured. Accuracy is calculated as follows:

$$\%R = \frac{\text{Analyzed value}}{\text{true value}} \times 100$$

OASIS will ensure laboratory accuracy by meeting %R values specified by EPA methods listed in Table 4 in Section B4.

Precision

Precision is the degree of agreement among repeated measurements of the same characteristic, or parameter, and gives information about the consistency of methods. Precision is expressed in terms of the relative percent difference (RPD) between two measurements (A and B), and is computed as follows:

$$RPD = \frac{A - B \times 100}{(A+B)/2}$$

Field and lab precision is measured by collecting blind (to the laboratory) field duplicate samples. One duplicate QC sample will be collected on each sample event date.

SGS and Analytica (per their QMPs) and OASIS ensure laboratory precision by measuring Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples and by the analysis of laboratory duplicate samples. One set of MS/MSD and duplicate samples will be analyzed per batch of samples. OASIS will use RPDs specific to the EPA method listed in Table 4 in Section B4 for each sample parameter.

Representativeness

Representativeness is the extent to which measurements actually represent the true environmental condition. Representativeness of data collected is part of the sampling program developed by ADEC and outlined in the scope of work. The locations of the sampling sites are based on the possible sources for nutrient, bacteria and hydrocarbon contamination to Big Lake and Lake Lucille. Sampling sites for nutrients were chosen where there are high densities of houses where fertilizers, septic systems and pet waste exist and also areas where wildlife populations are high or fish carcasses accumulate. Bacteria sampling sites were chosen also in high density housing areas to target human and animal waste and also wildlife concentration areas. Hydrocarbon sites were chosen based on proximity to boat launches, maintenance and fueling areas, traffic lanes, and

areas of high density housing. Additionally, sites were chosen for their ability to provide information on the background conditions present.

The timing of sample collection is based on the high density of users experienced at both lakes on weekends during the summer months. High use weekends (Memorial Day and Independence Day weekends) are included in the schedule.

OASIS will ensure the representativeness of the data by recording weather conditions throughout the sampling season (see discussion of task in Section A6), using consistent sampling methods and ensuring quality during sample collection, handling and transport (see Sections B2 and B3).

Comparability

Comparability is the degree to which data can be compared directly to similar studies. Standardized sampling, analytical methods, and units of reporting with comparable sensitivity will be used to ensure comparability. Analytical sample analysis will be performed following EPA-approved procedures by the ADEC-certified laboratories SGS and Analytica.

Completeness

Completeness is a comparison of the amount of usable data versus the amount of data called for in the scope of work. OASIS will determine completeness by comparing sampling and analyses completed with the requirements in the scope of work. OASIS' goal is to complete 95%+ of required monitoring. The following equation is used to calculate completeness:

$$\frac{T - (I+NC)}{T} \times (100\%) = \text{Completeness}$$

Where T = Total number of expected measurements.
I= Number of invalid results.
NC = Number of results not produced (e.g. spilled sample, etc.).

A8. Training and Certifications

Sampling personnel are trained in sampling methods, sample handling, chain-of-custody, sample transport, and field laboratory measurements. Personnel analyzing and reporting data are qualified to conduct these tasks per their experience with surface water sampling at various sites in the state and with 18 AAC 70 water quality criteria. Resumes of all project personnel are on file with ADEC as part of the Water Quality Term Contract. The contracted laboratories, SGS and Analytica, are ADEC-certified for drinking water analyses. Other certifications held by the laboratories and their staff are on file at SGS and Analytica and may be requested by ADEC.

A9. Documents and Records

Field notebooks will be filled out using *Write in the Rain* ink or pencil, and should not be erased. Changes are made by crossing out errors, initialing, and adding correct information. Field notebooks will be bound with numbered pages.

Laboratory data results are recorded on laboratory data sheets, bench sheets and/or in laboratory logbooks for each sampling event. These records as well as control charts, logbook records of equipment maintenance records, calibration and quality control checks, such as preparation and use of standard solutions, inventory of supplies and consumables, check in of equipment, equipment parts and chemicals are kept on file at the laboratory.

Any procedural or equipment problems are recorded in the field notebooks. Any deviation from this Quality Assurance Project Plan will also be noted in the field notebooks. Data results returned to ADEC will include information on field and/or laboratory QA/QC problems and corrective actions.

Standard turnaround time for the analytical samples taken to SGS will be seven to ten working days. Analytica will be performing the chlorophyll a analysis which will have a standard turnaround time of ten working days.

Chain-of-Custody and/or Transmission forms will be kept with the sample during transport and will accompany data results back to ADEC. Training records and data review records will be kept on file at OASIS, SGS and Analytica and will be available on request by ADEC. All sample analysis records and documents are kept at SGS and Analytica and are available to EPA and ADEC for inspection at any time.

In addition to any written report, data collected for the project will be provided electronically to ADEC via a CD-ROM or Email ZIP file in a STORET compatible format, as detailed in the following web address:

https://www.state.ak.us/dec/water/wqsar/storetdocumentation.htm.

All records will be retained by SGS and Analytica for five years. All project records at OASIS are retained permanently.

B. Data Generation and Acquisition

B1. Sampling Process Design

This project will include sampling events for water quality parameters at Big Lake and Lake Lucille in order to evaluate the extent of possible nutrient, bacteria and hydrocarbon contamination in these lakes during the summer. Multiple sites will be sampled on each lake for each group of parameters. At Lake Lucille, there will be three sampling sites each for nutrients and hydrocarbons. At Big Lake, there will be six sampling sites for nutrients, six sampling sites for bacteria, and five sampling sites for hydrocarbons. The locations of the sampling sites will be based on source inputs in the immediate area (boat launches, parks, septic systems, lawns, animal concentration areas). Locations will overlap for many of the sampling sites between parameter groups. For example, both nutrients and bacteria may be sampled from many of the same sites near to houses where fertilizers, septic systems and animal waste may all contribute to contamination. On each lake, one of the sites for each of the parameter groups will be used as a background site, away from source inputs where contamination is not expected.

The sample events will be conducted using a 15' aluminum skiff with a 25 horsepower outboard motor. The boat will be launched at Lake Lucille at the undeveloped boat launch at the east end of the lake accessible off of Park Avenue. The boat will be launched at Big Lake at the North Shore State Recreation Area accessible off of North Shore Drive. If wind or wave action on either of the lakes creates enough force to move the boat, an anchor will be dropped to hold the boat at each sampling location. The motor will be turned off to avoid contaminating the samples during collection. All sample site locations will be identified using a GPS receiver and through landmarks logged in the field notebook.

Sampling locations marked on the maps in Figures 1 and 2 were determined during the 2004 water quality monitoring for Lake Lucille and Big Lake. Sampling will continue through 2005 at these locations to provide comparability. Site locations were recorded in 2004 using a GPS receiver, photographed and marked on the map. Table 2 includes a description of each numbered sample site as well as parameters to be monitored. The locations of two additional bacterial samples at Big Lake will be determined during the first sampling event in May.

Table 3 details the dates and parameters for each sampling event. One duplicate will be collected for all analyses will be collected at each lake per sampling event. During two sampling events at each lake, two rinsate blanks will be collected: one each from the VOC sampler and the Kemmerer sampler.

Conditions on the lake may exist during a sampling event which will affect accessibility to the sampling locations or sample integrity. If a sampling site is inaccessible due to other lake users occupying the area, samplers will move on to other locations and return later. If necessary, OASIS staff will request permission to access a sampling location temporarily to collect water for analyses. Weather conditions may affect sample integrity

such as rain, wind or sunshine (for chlorophyll a samples). A tarp or other cover will be used while filtering chlorophyll a samples. Chlorophyll a can degrade when exposed to light and filtration will be performed under a shield immediately upon collecting the water sample. On windy days or when other motorized traffic causes extensive wave action or spray, sampling equipment will be stored on the boat floor and samplers will use caution while sampling to ensure all sampling equipment is protected from cross-contamination. Any modifications to methods due to unforeseen conditions will be documented thoroughly in the field notebook and reported to ADEC. For information on possible failure of field equipment or instruments, see Sections B2 and B6 respectively.

Table 2. Sampling Site Descriptions

	Sampling Site	Nutrients	Bacteria	Hydrocarbons	Description
Lake Lucille	LL-1	X		X	A public camp ground is near to this site as well as a large wetland area.
	LL-3	X		X	This historic USGS sampling site is located in the deepest section of the lake, with an island to the south and waterfowl activity and residences to the north.
	LL-4	X		X	This public boat launch on the east end of lake is heavily used. A public park is located approximately 0.25 miles to the south and there are residences in the area.
Big Lake	BL-1	X		X	This historic USGS sampling site at the deepest area of the west basin will serve as a background sampling location for TAH. No TAH compounds were detected in the 2004 sampling. An island with a residence is near this sampling location.
	BL-2	X			This narrow area between the two basins is a major traffic lane with residences on both banks.
	BL-3	X			Historic USGS sampling site at the deepest area of the east basin.
	BL-5	X	X		A condo development is present nearshore with no vegetative buffer between residences and lake.
	BL-6			X	The Southport Marina and several residences are nearshore.
	BL-7			X	The outlet at Fish Creek is a popular fishing area as well as a high traffic lane.
	BL-8			X	The nearshore area contains the Burkeshore Marina and extensive residential development.
	BL-10	X	X	X	The North Shore State Recreation Area is heavily used for launching boats, swimming, camping, and small watercraft operation. The highest TAH concentration detected during the 2004 sampling was collected from this swimming area.
	BL-11		X		At the inlet of Meadow Creek; a large wetland area is associated with the creek and may be heavily used by waterfowl.
	BL-17		X		The South State Recreation Area has a boat launch and camping.
	BL-20	X			A residential area in the east basin of the lake.

Table 3. Sample Dates and Parameters

	Collection Date	Nutrients	Bacteria	Hydrocarbons
Lake Lucille	May 8, 2005	X		X
	July 4, 2005	X		X
	August 21, 2005	X		X
	October 16, 2005	X		X
Big Lake	May 7, 2005	X		X
	May 28, 2005		X	X
	July 3, 2005	X		X
	July 23, 2005		X	X
	August 20, 2005	X		X
	October 15, 2005	X	X	

B2. Sampling Methods

Sample sites will be accessed using a 15' aluminum skiff with a 25 hp outboard, which will be anchored if necessary to remain at the sampling locations. A minimum of two people will man the boat during all sample events. Sampling sites will be located using a GPS receiver.

Nutrient samples will be collected using a Kemmerer water sampling bottle. Samples will be collected from two depths at each location: one meter and seventy-five percent of the total depth. In the event that a specific sampling location is less than two meters in depth, nutrient samples will be collected at a depth of one meter only.

Chlorophyll a samples require a specific procedure as outlined below:

1. The Kemmerer bottle will be filled at the required depth and raised to the surface for filtration. One liter of sample water is immediately poured into a graduated cylinder and shielded from sunlight to prevent photodecomposition. All following steps will be performed while shielded from sunlight.
2. A new filter for each sample will be placed inside the porcelain funnel. The funnel will be placed in a stopper on top of the beaker to which the vacuum pressure will be applied.
3. 1 liter of sample volume will be measured in a graduated cylinder and added to the porcelain funnel for filtration.
4. The peristaltic pump will be used to apply a vacuum onto the beaker and suck the sample from the funnel through the filter. Pressure will be monitored and shall not exceed 12 pounds per square inch (psi).
5. The filter will be removed by a sampler wearing nitrile gloves and folded in half twice with the chlorophyll a on the inside. The filter will be placed in a Ziploc bag and sealed. The sample number will be written on the outside of the bag.
6. The Ziploc bag will be wrapped in aluminum foil, placed between two frozen packs of gel ice and stored in a cooler for transport to the laboratory.

Bacteria samples will be collected as grab samples at approximately one foot below the surface using the following procedure:

1. Sampler will put on nitrile gloves.
2. The labeled sample bottle will be lowered, while closed, to one foot below the water surface.
3. The bottle will be uncapped, allowed to fill, and recapped while at one foot below the surface.

Protocols for grab sampling will follow the USGS report, National Field Manual for the Collection of Water Quality Data.[5]

Hydrocarbon samples will be collected in accordance with the USGS report "Field guide for collecting samples for analysis of volatile organic compounds in stream water for the National Water Quality Assessment Program (USGS Open File Report 97-401)."[6] This report contains detailed instructions on sample collection procedures using the USGS-designed VOC sampler distributed by Wildco®.

One sample to be analyzed for TAH will be collected (3 vials) from each lowering of the VOC sampler. A 1:1 HCL solution will be added to each vial after sample collection for preservation and capped (~5 drops). The samples will be checked to ensure that there are no air bubbles after capping. A duplicate sample will be obtained by lowering the sampler in the same spot immediately after collecting the project sample. Hydrocarbon samples will be collected at two depth intervals at each site: 15 cm and 1.5 m.

Prior to collecting a sample from a site, the water sampling equipment will be decontaminated in Alconox and deionized water, rinsed with deionized water, submerged in the lake at the new collection site, and allowed to flush completely. The VOC sampler will be submerged for approximately four minutes so that the copper tubes can allow enough volume into the sampler for a complete flushing. Four rinsate blanks will be collected for both the VOC sampler and the Kemmerer bottle (two at each lake) on separate dates to ensure that cross-contamination is not occurring between sample sites.

The rinsate blank will be collected using the following procedure. Both pieces of water sampling equipment will be used to sample at a site near to a possible contamination source. The sampling equipment will be decontaminated following the procedure described above. Both pieces of equipment will be submerged twice in a clean bucket with DI water, once to simulate the flushing at the new site and a second time to collect the rinsate blank. Rinsate blanks will be analyzed for all analyses to ensure the decontamination procedure is adequate. This process will be used to collect one rinsate blank per sampler and will occur twice at each lake on separate dates.

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[5] U.S. Geological Survey, variously dated, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A1-A9, available online at http://pubs.water.usgs.gov/twri9A.

[6] U.S. Geological Survey, 1997, Field guide for collecting samples for analysis of volatile organic compounds in stream water for the national Water Quality Assessment Program.

Should any of the sampling equipment fail during sampling and require maintenance, the project manager will contact the appropriate technical support for repair. Parts for both of the water sampling devices can be ordered and received via 2-day shipment. Due to the expense of many of the sampling supplies, duplicates could not be purchased for backup during sampling events. If a critical sampling device were to fail during a sampling event, all efforts will be made to conduct on-site repair in order to complete sample collection.

To ensure sample integrity, specific sampling and documentation procedures will be followed. This process will include labeling containers prior to sampling, extensive sample and site information recording, appropriate sample handling and comprehensive chain-of-custody procedures. All samples will be immediately placed on gel ice after sampling and will remain chilled to 4°C (±2°C) during transportation to the laboratory. Holding times for each sample analysis are provided in Table 4. Two analyses have short hold times: fecal coliform and dissolved ortho-phosphate. All bacteria and nutrient samples will be rushed to SGS in Anchorage immediately after sampling in order to meet the short hold times. Sample documentation procedures will include field notebooks, chain-of-custody forms and sample labels. Specific information such as site identification, sample identification numbers, sampling observations and sample collection time and date will be recorded in field notebooks. Additionally, photo documentation will be collected during each sampling event.

Standard chemistry parameters (pH, temperature, conductivity, dissolved oxygen and turbidity) will be measured at all sampling sites using a multi-parameter water quality meter and recorded in the field notebook. Parameters will be measured at one meter intervals until the thermocline is reached and then at one, three, and five meters from the bottom depth. Prior to and after each sampling event, all field meter probes will be rinsed with de-ionized water. A Secchi depth transparency test will also be performed at each sampling site following the procedure below.

1. The Secchi disk will be lowered off of the side of the boat using a graduated line.
2. When the black and white partitions on the Secchi disk are no longer discernible, the lowering depth transparency measurement will be recorded in the field notebook.
3. The disk will be lowered until it is no longer visible and raised. When the black and white partitions are visible again, a second depth will be recorded for comparison with the first measurement.
4. If the two measurements vary by >20%, repeat the process, collect two additional measurements and average the four.

Unique sample IDs will be based on the following format:

- *WW-X(Y)*
- WW = Lake ID, BL for Big Lake and LL for Lake Lucille.
- X = sample site. See Appendix 1 for a map of the sampling locations and specific sampling site numbers.

- Y = sample depth in meters. No depth suffix will be appended to bacterial sample identifications.
-

The duplicate sample on each date will be labeled with a fictitious sample site number that will be recorded in the field notebook.

Sample labels will include the sample ID, date sampled, time sampled, sampler initials, analysis and any special instructions to the laboratory.

B3. Sample Handling and Custody

Individual samples for analysis will be placed in the appropriate pre-cleaned sample containers as shown in Table 4. To ensure sample integrity specific sampling and documentation procedures will be followed. These procedures will include labeling containers prior to sampling, extensive sample and site information recording, appropriate sample handling and comprehensive chain-of-custody procedures. Sample and site information will be recorded in the field notebooks. Quality control samples or additional sample volume for laboratory QC will be collected as appropriate and are discussed in more detail in B5. All samples will be immediately placed in coolers and packed with gel ice after sampling and will remain chilled to 4°C (±2°C) during transportation to SGS in Anchorage, Alaska. All samples shipped will be accompanied with completed chain-of-custody forms and coolers will be sealed with signed and dated fiber tape for shipment. Holding times and sample preservation requirements are described in Table 4. Holding times for each sample analysis type will be met.

Table 4. Preservation and Holding Times for the Analysis of Samples

Analyte	Matrix	Container	Preservative and Filtration	Holding Time
Total Phosphorus	water	1 x 1 L HDPE	H_2SO_4, 4° C	28 days
O-Phosphorus, dissolved	water	1 x 1 L HDPE	Field filter, 4° C	48 hours
Kjeldahl Nitrogen	water	1 x 1 L HDPE	H_2SO_4, 4° C	28 days
Ammonia	water	1 x 1 L HDPE	H_2SO_4, 4° C	28 days
Nitrate + Nitrite	water	1 x 60 mL nalgene	H_2SO_4, 4° C	28 days
Fecal Coliform	water	120 mL sterile plastic	4° C	6 hours
Chlorophyll a	water	1000 mL of sample on filter	See methods in B2, 4° C	30 days
TAH	water	3 x 40-mL vials	HCL to <2 pH, 4 °C	14 days

Sample documentation procedures will include project field notebooks, chain-of-custody forms and sample labels. Specific information such as site identification, sample identification numbers, sampling observations and sample collection time and date will

be recorded in field notebooks. Additionally, photographic documentation will be collected during each sampling event.

B4. Analytical Methods

Water quality analytical methods that will be used throughout this project are outlined below. All analysis methods used for this program are EPA-approved. The contracted laboratories, SGS and Analytica, are ADEC-certified for drinking-water analyses. SGS and Analytica have Quality Management Plans (QMP) on file with ADEC detailing their quality assurance procedures. Laboratory turnaround times are 7-10 working days for SGS and 10 working days for Analytica. Any issues regarding analytical data quality will be resolved by the OASIS project manager through discussions with the laboratory project managers.

Table 5. Analytical Methods Precision and Accuracy

Analyte	Method	Precision (RPD)[1]	Accuracy (%R)[1]
Benzene	EPA 602	20%	88-117%
Toluene	EPA 602	20%	87-115%
Ethylbenzene	EPA 602	20%	80-120%
Xylene	EPA 602	20%	75-125%
Total Phosphorus	EPA 365.2	25%	75-125%
O-Phosphorus, dissolved	EPA 365.2	25%	75-125%
Kjeldahl Nitrogen	SM 4500-N D	25%	75-125%
Ammonia	SM 4500-NH3 F	25%	75-125%
Nitrate + Nitrite	EPA 300.0	20%	75-125%
Fecal Coliform	SM 9222D	25%	75-125%
Chlorophyll a	SM 10200H	25%	75-125%

[1] For a discussion of precision (RPD) and accuracy (%R) see Section A7.

B5. Quality Control

Quality control activities in the field will include adherence to documented procedures and the comprehensive documentation of sample collection information included in the field notebooks. A rigidly enforced chain-of-custody program will ensure sample integrity and identification. The chain-of-custody procedure documents the handling of each sample from the time the sample was collected to the arrival of the sample at the laboratory.

Analytical methods in use on the program have been approved and documented by EPA. These methods will be used as project-specific protocols to document and guide analytical procedures. Adherence to these documented procedures will ensure that analytical results are properly obtained and reported.

Quality control activities in the field will consist of the following items:

- Adherence to documented procedures in this QAPP;

- Cross-checking of field measurements and recording to ensure consistency and accuracy; and
- Comprehensive documentation of field observations, sample collection and sample identification information.

Internal laboratory quality control checks will include the use of surrogate solutions and quality control samples such as procedural (or method) blanks, laboratory control blanks, matrix spike/spike duplicates, standard reference materials (SRMs) or EPA QC check samples and duplicates as specified in the EPA approved analytical procedures. Surrogate compounds will be spiked into the samples as appropriate to measure individual sample matrix effects that are associated with sample preparation and analysis.

In addition to laboratory QC samples, multiple field quality control samples will also be collected. One field duplicate sample will be collected during each sampling date and sent to the lab blind to test for precision of analytical procedures. A trip blank will be submitted to the lab during each sampling event to ensure that equipment handling and transport procedures do not introduce contamination. Rinsate blanks will be collected at different periods throughout the program to assure that cross-contamination between samples is not occurring (see Section B2, Sampling Methods). A list of the quality control samples and their frequency is included in the table below.

Table 6. Quality Control Samples

Quality Control Sample	Frequency
Method Blanks	1/batch
Matrix Spike/Matrix Spike Duplicates	1/batch
Laboratory Control Sample/Laboratory Control Sample Duplicate	1/batch
Surrogate Compounds	3/EPA 602 1/EPA 610
Field Duplicate	1/sampling date
Trip Blank	1/sampling date
Rinsate Blank	4 total for each sampling device

Laboratory duplicates and the blind field duplicate will be compared to the RPD criteria for the methods provided in Table 4. Spiked QC samples including surrogates, matrix spikes and laboratory control samples will be compared to the %R values in Table 4. Concentrations of contaminants of concern reported in method blanks will be compared to reported values in the analytical samples. If analytical sample results are less than five times the concentration reported in the method blank, then results will be reported as a laboratory contaminant.

Results from quality control samples allow the assessment of quality assurance parameters such as accuracy and precision of the data. Any data falling outside the acceptable criteria as defined in the methods will be appropriately investigated and qualified as described in Section D2.

B6. Instrument/Equipment Testing, Inspection and Maintenance

Field equipment used for collection, measurement and testing will be subject to a strict program of control, calibration, adjustment and maintenance. Samples for TAH analysis will be collected in the field using a Wildco® VOC sampler, described in Appendix 2. Routine maintenance of the VOC sampler will be conducted prior to each sampling event. Maintenance will include a visual inspection that all parts are present, attached correctly, and devoid of any obvious contamination. The sampler will be submerged in lake water for 10 seconds with bottles inside the sampler to check that all four copper tubes are not blocked and are sampling correctly. Parts for the VOC sampler and the Kemmerer bottle can be ordered directly from Wildco® and shipped within two working days. The project manager will coordinate ordering replacement parts and repairing samplers.

Water quality parameters including pH, conductivity, salinity, turbidity and temperature will be measured in the field during each sampling event using a YSI® 556 multi-parameter water quality meter. Routine maintenance on the meter will be conducted according to schedules described in the manual provided by the manufacturer and recorded in the maintenance log stored in its carrying case.

B7. Instrument/Equipment Calibration and Frequency

Care will be taken to ensure that the YSI® 556 used for field measurements is calibrated and adjusted prior to each sampling event using known buffer solutions that are included with the instrument. The YSI® 556 will be calibrated following the manufacturer's designated procedures.

All calibration measurements will be recorded on the appropriate field forms or in field logbooks and will be available for review by ADEC upon request.

B8. Inspection/Acceptance of Supplies and Consumables

All buffer solutions used for field instrument calibration will be checked for expiration date, sufficient quantity, and discoloration.

Qualified field staff will check all field equipment and supplies that are required for this project to ensure their technical specifications before use. Evaluation criteria that will be used are listed below:

- Ensuring that equipment and supplies have been cleaned if they are reusable or are sterile if they are packaged;
- Equipment is in serviceable condition;
- The appropriate chain-of-custody procedures have been taken if equipment or supplies were shipped.

Any deviances during inspection procedures will be remedied by the project manager and recorded in the field notebook. If necessary, replacements to shipped consumables will be made.

Coolers, gel ice, samples containers, and chain-of-custody forms will be provided by SGS prior to field mobilization. Extra sample containers will be available in the event re-sampling becomes necessary. All COC records will be kept at OASIS should ADEC request to see them.

B9. Non-Direct Measurements

Non-direct measurements collected for this project include:

- Matanuska-Susitna Borough GIS mapping layers,
- Weather data, and
- Topographic maps.

Matanuska-Susitna Borough GIS mapping layers will be used to overlay on maps to be included in the Draft and Final Reports. Weather data will be obtained from the National Weather Service website. Topographic maps are from All Topo Maps software.

Topographic maps and GIS layers are both limited in the accuracy of their information based on the date they were updated. All efforts will be made to obtain up-to-date mapping layers. The dates for mapping layers will be provided in final reports.

B10. Data Management

Data obtained during sampling activities will be entered into field notebooks.

The following is a list of possible data information that will be kept at OASIS or SGS for ADEC review upon request:

- Field equipment and chemicals maintenance, cleaning and calibration records;
- Field notebooks;
- Sample Data Sheets (included as Attachment 1);
- Photographs of sampling stations and events;
- Chain-of-Custody forms;
- Laboratory equipment maintenance, cleaning and calibration records;
- Laboratory bench sheets, control charts, and SOPs;
- Records of QA/QC problems and corrective actions (field and/or laboratory);
- Laboratory data QC records;
- Records of data review sheets;
- Duplicate, performance evaluation records and other QA/QC control records (field and laboratory); and

- Data review, verification and validation records.

Data handling equipment will include computer software applications Microsoft Excel and Access. Data will be entered into the Access database in a form compatible with requirements of the statewide database entry into STORET. Requirements for data entry can be found in Section A9.

C. Assessment and Oversight

C1. Assessments and Response Actions

Should the sampling staff, laboratory personnel or Quality Assurance Officer find errors in sampling or analysis, the Quality Assurance Officer will notify the Project Manager and the party responsible for the error or deficiency and recommend methods of correcting the deficiency. The responsible party will then take action to correct the problem and will report corrections to the QA Officer and Project Manager.

The Quality Assurance Officer will review the QA/QC procedures used for the sampling and analytical program. Procedures for this review are included in Section D2 to meet the data quality criteria specified in A7. The Quality Assurance Officer will report these assessment records in the FY05 and FY06 Interim Reports and in the Draft and Final Reports.

C2. Reports to Management

Sampling results will be summarized in the draft and final reports completed for this project. These reports will include the results of project assessments listed above. Reports will be submitted to the ADEC Project Manager. Email updates will be submitted to the ADEC Project Manager after each sampling event providing notification of any issues or problems for which corrective actions will be taken. The results of all corrective actions or data quality assessments will be reported to the ADEC Project Manager upon completion.

D. Data Validation and Usability

D1. Data Review, Validation & Verification Requirements

Analytical results will be reviewed and validated in accordance with United States Environmental Protection Agency (USEPA) documents, including the *USEPA Environmental Data Verification and Validation* (EPA QA/G-8), August 1999; the *USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review* (EPA 540/R-94/012), 1994; and the *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA 540/R-94/013), 1994.

OASIS will conduct data review and validation using the following methods on 10% of the primary project samples, including their associated quality control duplicates and laboratory quality control samples.

- A review of sample handling and analytical and field data for completeness, accuracy, holding time compliance, and quality control (QC) sample frequency compliance.
- Evaluation of laboratory blank samples.
- Evaluation of the accuracy and precision of field duplicate samples, laboratory control samples (LCS), and matrix spike/spike duplicate (MS/MSD) samples.
- Assignment of data qualifiers, when necessary, to reflect limitations identified in the data assessment process.
- Estimation of completeness.

D2. Validation and Verification Methods

The following procedures will be used to determine if data meets the data quality objectives and criteria specified in Section A7. If data QA/QC procedures do not meet the specified criteria, the Quality Assurance Officer will review all field and laboratory records to determine the cause. If equipment failures are limiting the usability of the data, calibration and maintenance procedures will be reviewed and changed as needed. If sampling or analytical procedures are causing the failures, methods will be reviewed to resolve the errors. Any changes or modifications to quality control procedures will be approved by ADEC prior to inclusion in the QAPP.

Review of Sample Handling

Proper sample handling techniques are required to ensure sample integrity. During data review, the sample handling procedures identified below are evaluated to determine potential effects on data quality.

- Review of field sample collection and preservation procedures to determine whether they were completed in accordance with the requirements specified by the analytical methods.

- Review of chain-of-custody documentation to ensure control and custody of the samples was maintained.
- Review of sample holding times between sample collection, extraction, and analysis (see Table 3 in Section B3).
- Review of sample conditions upon receipt at the contract laboratory.
- Review of Quality Assurance/Quality Control (QA/QC) Samples. Specific procedures for review of QA/QC samples are included in the sections below.

Laboratory Blank Samples

Laboratory blank samples (method and instrument blanks) are laboratory-prepared, analyte-free samples used to detect the introduction of contamination or other artifacts into the laboratory sample handling and analytical process. These blanks play an especially important role in sampling programs involving trace-level analyses or analytes that are common solvents found in a laboratory. None of the analytes of concern for this project are common laboratory contaminants. If a contaminant is discovered in the analytical sample at less than five times the concentration it is found in the laboratory blank, it will be considered a laboratory contaminant. Otherwise, it will be reported as an environmental contaminant.

Laboratory Control Samples

Laboratory control samples are used to assess analytical performance under a given set of standard conditions. Synthetic samples, containing some or all of the analytes of interest at known concentrations, are prepared independently from calibration standards. The samples consist of laboratory control samples (LCS) and laboratory control sample duplicates (LCSD). Laboratory control samples will be analyzed with each analytical batch. LCS may be used to estimate analytical accuracy and precision by comparing measured results to actual concentrations. LCS/LCSD percent recoveries will be checked on laboratory reports to ensure they are within the limits set by the EPA methods listed in Table 4.

LCS are also duplicated in the laboratory and then analyzed in an identical manner by the laboratory to assess the laboratory's internal precision. The analytical precision is expressed by the RPD (see calculation in A7). Analytical precision and accuracy should meet the method criteria listed in Table 4 in Section B4.

Matrix Spike and Matrix Spike Duplicates

Matrix spike samples are actual field samples to which known amounts of select compounds (one, or more, of the analytes of interest) are added. Both spiked and unspiked aliquots are analyzed. The difference between the concentration of the spike compound(s) in the spiked and unspiked aliquots is compared to the amount of spike added before the extraction process. Since actual samples are used for the recovery determination, the matrix effects can be evaluated. Usually expressed as a percentage of the mass of the spiked amount, spike recovery is the measurement of accuracy

anticipated for the sample matrix. Percent recoveries will be compared to EPA method-specific recoveries listed in Table 4.

Matrix spike samples are also duplicated in the laboratory and then analyzed in an identical manner by the laboratory to assess sample reproducibility and the laboratory's internal precision. The analytical precision is expressed by the RPD between the measurement results of the two duplicate samples. Analytical precision and accuracy should meet the criteria provided in Table 4. MS/MSD samples will be run on each batch of samples.

Surrogates

Surrogate compounds will be added to all samples being analyzed for TAH to evaluate analytical accuracy for each individual sample. Surrogate compounds are chemically similar to the analytes of interest but are not expected to be present in the field samples. Recovery of these surrogate compounds gives an estimate of the effectiveness of the extraction and analysis for each individual sample. Surrogate recoveries (%R) should meet the criteria provided in Table 4 for each analyte.

Field Duplicate Samples

Field duplicate samples will be collected simultaneously with a primary project sample. Duplicates are treated in the same manner as the primary sample during all phases of sample collection, handling, and analysis. Duplicate sample results are used to assess precision, including variability associated with both the laboratory analysis and the sample collection process (i.e., QC purposes). At least one duplicate field sample will be collected and submitted blind to the laboratory during each sampling date for this program.

Analytical results will be reviewed for agreement with each other or their respective reporting limits and evaluated for comparability. Estimated results quantified below the reporting limit and qualified with a "J" flag are not considered significant for the purpose of data agreement. The comparison between project and field duplicate sample results should meet RPD criteria for each method listed in Table 4.

Reporting Limits

The reporting limits are the lowest concentration that can be reliably achieved within specified limits of precision and accuracy during routine laboratory conditions. For many analytes, the reporting limit analyte concentration is selected by the laboratory as the lowest non-zero standard in the calibration curve. Sample reporting limits vary based on sample matrix and dilution of the samples during analysis. Reporting limits should be equal to or below the PQLs provided in Table 1 for each method.

Data Qualification

Qualifiers will be applied to QC samples when acceptance criteria are not met and corrective action is not performed or is unsuccessful. These same qualifiers will be applied to the associated sample data, as defined in the following table.

Table 7. Data Qualifiers

Qualifier	Description
J	The analyte was positively identified, the quantitation is estimated.
U	The analyte was analyzed for, but not detected. The associated numerical value is at or below the method detection limit (MDL).
F	The analyte was positively identified but the associated numerical value is below the reporting limit (RL).
R	The data are unusable due to deficiencies in the ability to analyze the sample and meet QC criteria.
B	The analyte was found in an associated blank, as well as in the sample.
M	A matrix effect was present.
H	Analysis was performed outside of the recommended holding time.

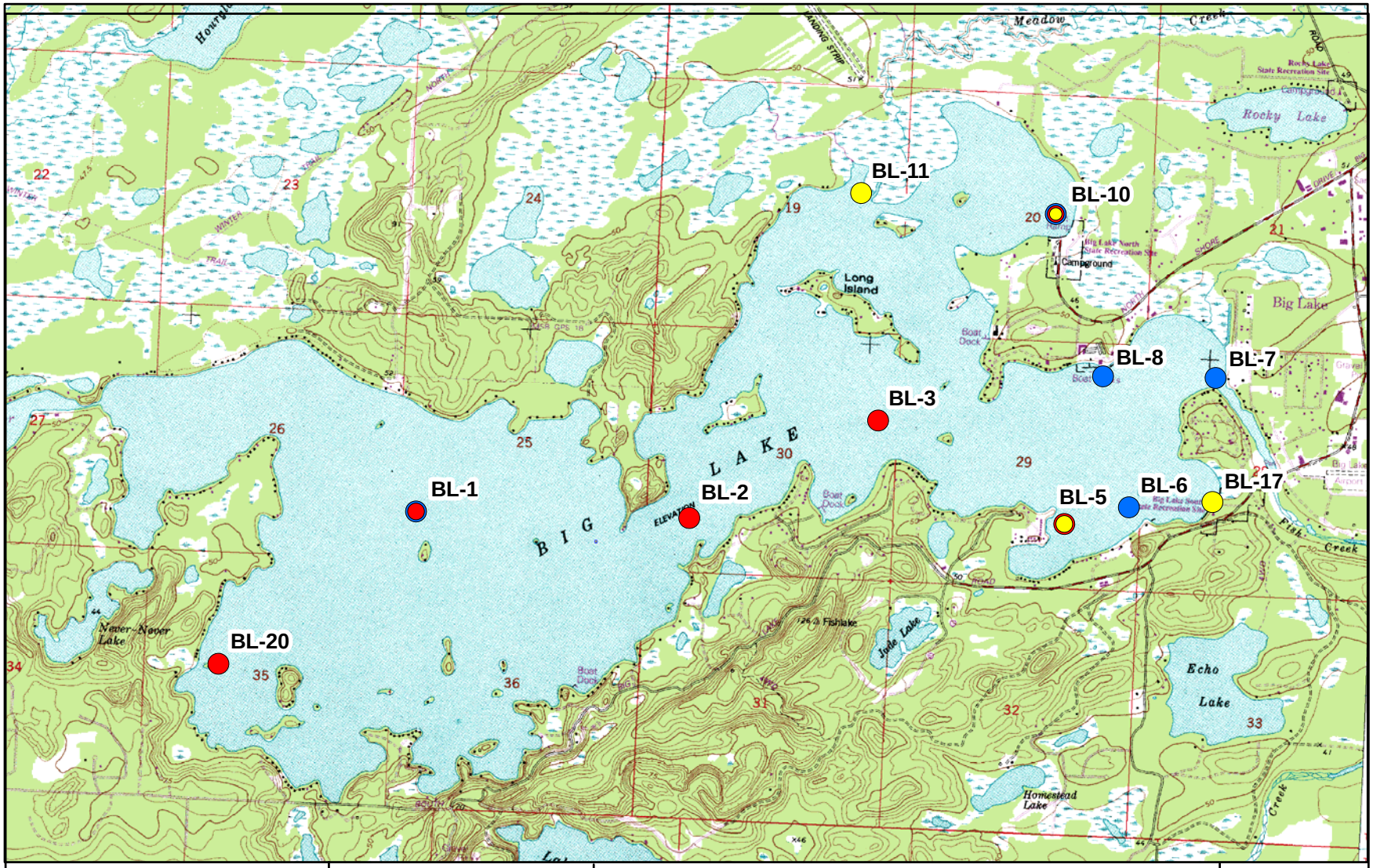
Completeness

Completeness is calculated after the QC data have been evaluated, and the qualifiers have been applied to the sample data. Invalid results, broken or spilled samples, and samples that are unable to be analyzed for other reasons are included in the assessment of completeness. The criteria and calculation to determine completeness are provided in Section A7. If data cannot be qualified to meet completeness goals, OASIS will consult with the ADEC Project Manager to determine if additional sampling should be performed to accomplish data quality objectives.

D3. Reconciliation with User Requirements

The Project Manager will review all data deliverables upon receipt from the lab. Laboratory results will be checked for data qualifiers entered by the lab to ensure that sample collection and preservation procedures were adequate and that laboratory analysis procedures met quality assurance objectives. Any outstanding issues will be addressed immediately with the lab and/or sampling staff to ensure that project quality assurance objectives are met.

The Project Manager and Quality Assurance Officer will review and validate the data during the three interim reporting and final reporting stages. If there are any problems with quality sampling and analysis, these issues will be addressed immediately and methods will be modified to ensure that data quality objectives are being met. Modifications to monitoring will require notification to ADEC and subsequent edits to the approved QAPP.



LAKE LUCILLE AND BIG LAKE WATER QUALITY MONITORING

BIG LAKE SAMPLING SITES
Big Lake, Alaska

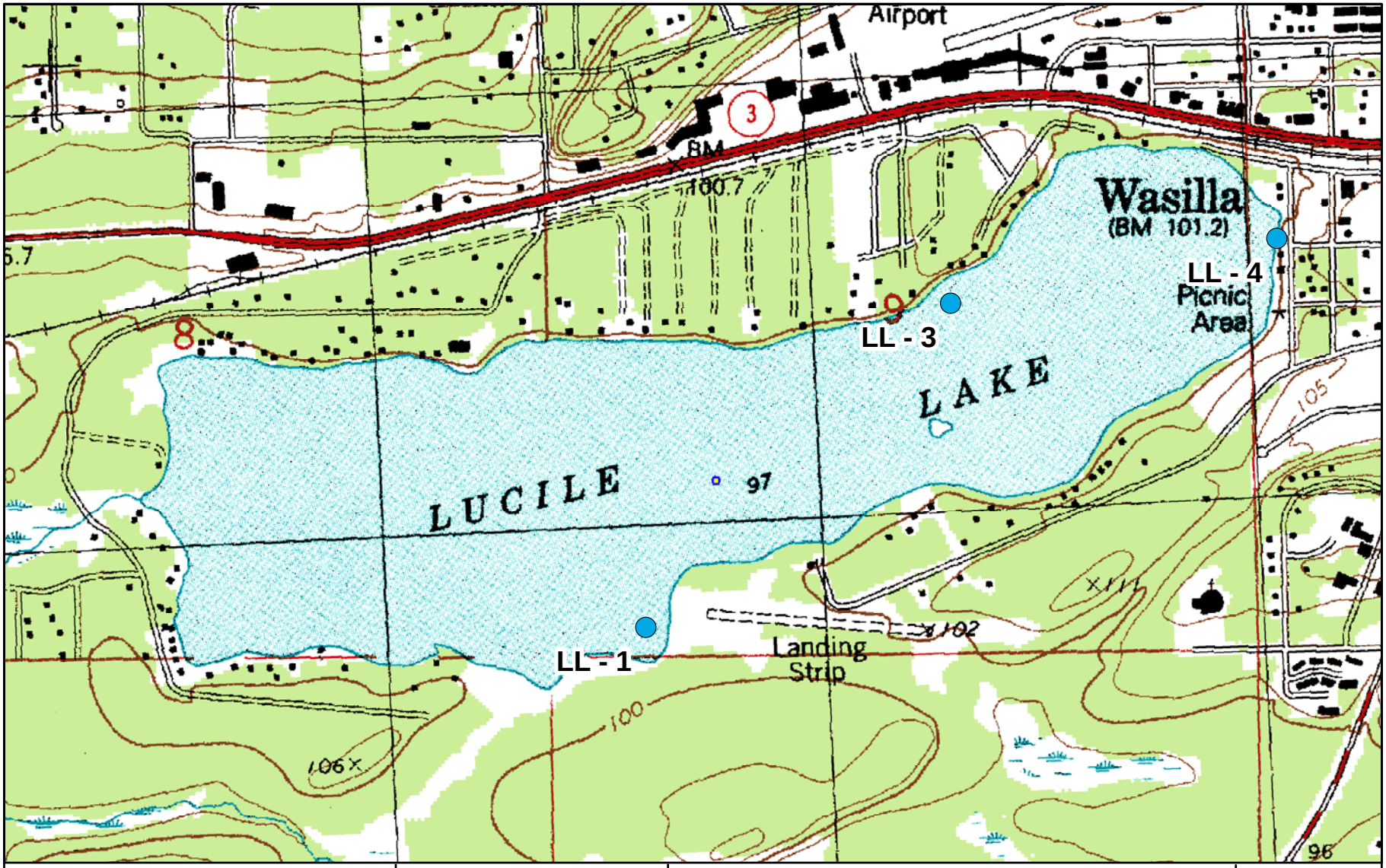
oasis ENVIRONMENTAL

N

0 0.4 0.8 Miles

- Hydrocarbon Sampling Location
- Nutrient Sampling Location
- Bacterial Sampling Location

Map 1



LAKE LUCILLE AND BIG LAKE WATER QUALITY MONITORING

LAKE LUCILLE SAMPLING SITES
Wasilla, Alaska

oasis ENVIRONMENTAL

N

0 0.15 0.3 Miles

Map 2

LAKE LUCILLE AND BIG LAKE WATER QUALITY MONITORING
SAMPLE DATA SHEET

SITE INFORMATION		
DATE: / /2005	**SAMPLERS:**	
SAMPLING LOCATION:		
CIRCLE TYPE:	**BACTERIA HYDROCARBONS NUTRIENTS**	
GPS COORDINATES:	N	W
PHOTO # AND DESCRIPTION:		

FIELD MEASUREMENTS: Horiba U-22		
1 METER	**2 METERS**	**3 METERS**
pH:	pH:	pH:
D.O.(Mg/L):	D.O.(Mg/L):	D.O.(Mg/L):
cond. (mS/cm)):	cond. (mS/cm)):	cond. (mS/cm)):
turb. (NTU):	turb. (NTU):	turb. (NTU):
salinity :	salinity :	salinity :
temp. (°C):	temp. (°C):	temp. (°C):
4 METERS	**5 METERS**	**6 METERS**
pH:	pH:	pH:
D.O.(Mg/L):	D.O.(Mg/L):	D.O.(Mg/L):
cond. (mS/cm)):	cond. (mS/cm)):	cond. (mS/cm)):
turb. (NTU):	turb. (NTU):	turb. (NTU):
salinity :	salinity :	salinity :
temp. (°C):	temp. (°C):	temp. (°C):
7 METERS	**8 METERS**	**9 METERS**
pH:	pH:	pH:
D.O.(Mg/L):	D.O.(Mg/L):	D.O.(Mg/L):
cond. (mS/cm)):	cond. (mS/cm)):	cond. (mS/cm)):
turb. (NTU):	turb. (NTU):	turb. (NTU):
salinity :	salinity :	salinity :
temp. (°C):	temp. (°C):	temp. (°C):
10 METERS	**11 METERS**	**12 METERS**
pH:	pH:	pH:
D.O.(Mg/L):	D.O.(Mg/L):	D.O.(Mg/L):
cond. (mS/cm)):	cond. (mS/cm)):	cond. (mS/cm)):
turb. (NTU):	turb. (NTU):	turb. (NTU):
salinity :	salinity :	salinity :
temp. (°C):	temp. (°C):	temp. (°C):
13 METERS	**14 METERS**	**15 METERS**
pH:	pH:	pH:
D.O.(Mg/L):	D.O.(Mg/L):	D.O.(Mg/L):
cond. (mS/cm)):	cond. (mS/cm)):	cond. (mS/cm)):
turb. (NTU):	turb. (NTU):	turb. (NTU):
salinity :	salinity :	salinity :
temp. (°C):	temp. (°C):	temp. (°C):
16 METERS	**17 METERS**	**18 METERS**
pH:	pH:	pH:
D.O.(Mg/L):	D.O.(Mg/L):	D.O.(Mg/L):
cond. (mS/cm)):	cond. (mS/cm)):	cond. (mS/cm)):
turb. (NTU):	turb. (NTU):	turb. (NTU):
salinity :	salinity :	salinity :
temp. (°C):	temp. (°C):	temp. (°C):

LAKE LUCILLE AND BIG LAKE WATER QUALITY MONITORING
SAMPLE DATA SHEET

SECHHI DEPTH TRANSPARENCY	
READING 1:	**READING 3:**
READING 2:	**READING 4:**

SAMPLES COLLECTED

SAMPLE ID: **TIME:**

SAMPLE DEPTH(S):

USE:
Activity (fishing, skiing, at rest)

No. jetskis

No. 2-stroke boats

No. 4-stroke boats

No. ??-stroke boats

ATTACHMENT C
QUALITY ASSURANCE REVIEW

Quality Assurance Review
2005 Lake Lucille Water Quality Monitoring

Sampling Protocol

A deviation from QAPP sampling protocol occurred during the Lake Lucille study. The instance involved sampling depth for hydrocarbons. The QAPP stated that deep hydrocarbon samples were to be collected from a depth of 1.5 meters beneath water surface. However, an error occurred during the first sampling event when deep hydrocarbon samples were collected from 0.5 meter beneath water surface, and this error was perpetuated through the August 20 sampling event. Hydrocarbon samples were collected at the correct depth of 1.5 meters during the October 16 sampling event. Although the sample depth was incorrect, the data obtained is valid and useful for determining hydrocarbon concentrations in the water column.

Field Parameters

All field water quality meters were calibrated according to manufacturer's specifications the morning of each sampling date using Autocal® solution. After calibrating, measurements were taken of the calibration solution to ensure accuracy within 5%. If accuracy was outside 5%, meters were recalibrated and checked again.

During the July 4 sampling event, an anomalous turbidity reading of 25.5 NTU was recorded at LL-3 at a depth of 2 meters. This reading was attributed to a significant amount of organic matter and debris that was pumped into the flow-through cell from the surrounding aquatic vegetation. Lake vegetation was thick during the July and August sampling events and grew to within 2 meters of the lake's surface.

During the final sampling event at Lake Lucille on October 16, while taking field parameters measurements at location LL-1, pH measurements notably increased. The field sampler indicated that the cause of this anomaly was apparent cold-temperature effects on the pH probe. Field parameter pH measurements for LL-1 on October 16 were not included in summary statistical calculations.

Analytical Results

The analytical results for the surface water and associated laboratory quality assurance and quality control (QA/QC) samples were reviewed to determine the integrity of the reported analytical results and ensure they met the established data quality objectives. Laboratory data may include a laboratory "J" qualifier when the reported sample result was above the method detection limit, but below the method reporting limit. This laboratory qualifier indicates an estimated concentration below the lower limit of calibration. Data qualifiers added during the data validation process are preceded by a "V" to indicate a validation qualification. All "V" qualified data are discussed herein.

Surface water samples were collected on four separate occasions from Lake Lucille during 2005. These sampling events were conducted on May 7, July 4, August 21, and October 16, 2005. The associated SGS Environmental Services, Inc. (SGS) work orders for these sampling events were 1052448, 1053969, 1055402, and 1056891. Surface water samples collected for the analysis of chlorophyll A were submitted to Analytica Environmental Laboratories (Analytica). Surface water samples were collected for the analysis of chlorophyll A from sampling stations on Lake Lucille on May 7, July 4, and October 16, 2005. The associated Analytica work orders for these sampling events were A0507023, A0505105, and A0510174. Surface water samples were not collected from Lake Lucille for the analysis of chlorophyll A during the August 21 sampling event due to a malfunction of the collection pump. One rinse

blank sample was collected to evaluate the decontamination procedure used between sampling stations. This sample was collected during surface water sampling activities on July 4, 2005 and is reported in SGS work order number 1053969.

Documentation associated with the surface water samples was reviewed to determine compliance with recommended holding times and sample preservation techniques. All samples were received under chain of custody with proper preservation and were analyzed within their respective holding times. Due to a laboratory error, holding times were not met for total nitrogen as nitrite/nitrate using EPA Method 353.2 and the samples were run using EPA Method 300.0 in work orders 1052448, and 1055402, for the May 7, 2005, and August 21, 2005 sampling events, respectively. The change in methodology resulted in a ten-fold increase in method reporting limit in work order 1052448, to accommodate sample dilution, as noted in the analytical results table. The lowest documented level of concern for nitrogen as nitrite and nitrate was for nitrite at 1 milligram per liter (mg/L) per 18 AAC 80.300(b) Drinking Water Primary Maximum Contaminant Levels. Therefore, the total nitrogen data as nitrate/nitrite obtained using EPA Method 300.0 are useable for project objectives.

Trip blanks accompanied the samples and were submitted for analysis of BTEX compounds. BTEX compounds were not detected in any of the four trip blanks submitted with surface water samples collected from Lake Lucille in 2005.

One decontamination blank was collected with distilled water after decontaminating the water sampling equipment to evaluate the possibility of cross-contamination between sampling sites. The rinse blank was collected during sampling activities on Lake Lucille on July 4, 2005 (SGS work order 1053969). No detections of nutrients were reported above the detection limit in the decontamination blank collected from the Kemmerer water sampling bottle. One decontamination sample was also collected from the VOC water sampling bottle. Toluene was detected above the reporting limit at a concentration of 0.0048 mg/L. This detection was deemed anomalous, likely the result of contaminated rinse water, because it was nearly four times the highest toluene result obtained from samples collected from Lake Lucille that day. No qualifications to Lake Lucille water sample data have been made based on the toluene result in the rinse blank sample.

Method blanks were analyzed in the laboratory to detect instrument and sample cross-contamination. Ortho-phosphate was detected at a concentration greater than the method detection limit, but less than the reporting limit in the method blank associated with samples collected during the October 16, 2005 sampling event (SGS work order 1056891). Ortho-phosphate was below the method reporting limit in all associated project samples and no data qualification was performed.

Laboratory control samples and laboratory control sample duplicates (LCS/LCSD) were analyzed to confirm acceptable recovery of target analytes. Multiple analytes in the LCS and LCSD samples were slightly outside the method control limits. All analytes outside of method limits were not present in the project samples and were not contaminants of concern.

Matrix spikes and matrix spike duplicate (MS/MSD) samples are analyzed to evaluate possible matrix interference with analyte detection. Separate sample volumes for MS and MSD analysis were not collected during the 2005 season. The laboratory spiked remaining sample volume from the primary sample container to develop MS information. Sample volume limitations prevented the analysis of MSD samples. Percent recoveries for project samples matrix spikes were above the upper control limit, biased high, for ortho-phosphate and total nitrogen as nitrite/nitrate in SGS work order 1055402, for samples collected on August 21, 2005. None of the associated analytical results were above the respective method reporting limits and no data were qualified. Percent recoveries for project sample matrix spikes were below the lower control limit for two of the four sampling events at Lake Lucille in 2005. Matrix interference may

indicate that the spiked sample has been broken down by other compounds in the matrix or adsorbed onto compounds reducing the final result. Laboratory LCS samples of deionized water spiked with target compounds were within QC limits; therefore, due to systematically low MS recoveries in representative project samples, total nitrogen as nitrite/nitrate data from SGS work orders 1053969 and 1056891 for sample events, on July 4, 2005 and October 16, 2005, have been qualified "VM" to indicate a potential matrix interference.

Surrogate compounds are added by the laboratory to evaluate the accuracy of individual sample analyses. Surrogate compound recoveries were within established control limits in all samples analyzed for volatile hydrocarbons.

Field duplicates were collected for each analysis during each sampling event. Four duplicates were collected for TAH and nutrients. Two duplicate sample pairs were collected for chlorophyll a. Relative percent differences (RPDs) between primary and duplicate results are calculated for analytes with concentrations greater than ten times the reporting limit. Excluding chlorophyll a, target analytes were not detected at concentrations greater than ten times the reporting limit so RPDs were not calculated. The field duplicate and primary sample for chlorophyll a collected at Lake Lucille on July 4, 2005 was > 20% RPD at 62%. The differences between the primary and duplicate samples could result from actual differences in the sample as they were collected from separate deployments of the Kemmerer sampling bottle.

Project completeness for analytical sample collection is 97.9%. This meets OASIS' goal of 95% established for the project in the QAPP. The only data not included in the project total were points not collected for chlorophyll a on August 21. Project completeness measures the number of samples collected divided by the number called for in the original sampling design.

ATTACHMENT D
FIELD AND ANALYTICAL DATA TABLES

Lake Lucille: Field Parameter Results

Sampling Device:			YSI 556 Meter												Secchi Disk[1]	
Date	Sample Site	Depth	pH	Data Flag	Dissolved Oxygen	Data Flag	Conductivity	Data Flag	Turbidity (measured with Hawk meter)	Data Flag	Redox Potential	Data Flag	Temperature	Data Flag	Secchi Depth	Data Flag
		meters	pH unit		mg/L		mS/cm		NTU		mV		° C		meters	
5/7/2005	LL-1	1	8.66		13.68		0.300		--		181.0		15.38		2.5	bottom
5/7/2005	LL-1	2	8.74		13.78		0.299		--		173.5		15.36		2.5	bottom
7/4/2005	LL-1	1	9.27		9.91		0.208		1.42		19.0		20.04		2.5	bottom
8/21/2005	LL-1	1	9.07		8.88		0.174		0.85		96.2		17.4		2.5	bottom
10/16/2005	LL-1	1	*13.30*		*17.04*		*0.090*		*1.76*		*-88.3*		*2.27*		2.5	bottom
5/7/2005	LL-3	1	8.83		15.69		0.311		--		162.2		15.28		3	
5/7/2005	LL-3	2	8.87		15.48		0.309		--		143.0		14.40		3	
5/7/2005	LL-3	3	8.80		15.39		0.307		--		141.1		14.17		3	
5/7/2005	LL-3	4	8.73		15.15		0.310		--		139.3		14.25		3	
7/4/2005	LL-3	1	9.40		9.70		0.199		4.99		2.8		20.80		3.5	
7/4/2005	LL-3	2	9.42		9.11		0.198		*25.5*		-0.5		21.01		3.5	
8/21/2005	LL-3	1	9.03		8.62		0.100		1.35		85.8		17.40		3.5	
8/21/2005	LL-3	2	9.14		8.69		0.175		1.27		82.4		14.72		3.5	
10/16/2005	LL-3	1	8.49		14.64		0.158		1.65		32.5		3.40		4.5	
10/16/2005	LL-3	2	8.56		15.04		0.158		0.82		34.5		3.35		4.5	
10/16/2005	LL-3	3	8.64		15.37		0.158		0.74		36.9		3.34		4.5	
10/16/2005	LL-3	4	8.69		15.11		0.159		0.63		38.4		3.81		4.5	
5/7/2005	LL-4	1	8.87		14.28		0.316		--		162.7		15.56		1.5	bottom
7/4/2005	LL-4	1	9.38		11.04		0.211		2.23		5.9		19.59		1.5	bottom
8/21/2005	LL-4	1	8.70		7.71		0.181		2.4		90.9		16.96		1.5	bottom
10/16/2005	LL-4	1	7.87		16.79		0.169		1.16		3.0		3.56		1.5	bottom
Under Ice Measurements (2006)																
1/15/2006	LL-1	1	7.05		3.11		0.249		--		139.2		3.50		--	
1/15/2006	LL-1	2	7.02		3.08		0.252		--		140.3		3.80		--	
2/20/2006	LL-1	1	6.83		1.17		0.280		--		173.5		3.60		--	
2/20/2006	LL-1	2	6.76		3.16		0.307		--		-35.2		4.78		--	
1/15/2006	LL-3	1	6.92		4.13		0.247		--		202.5		3.59		--	
1/15/2006	LL-3	2	6.91		2.38		0.250		--		201.5		4.12		--	
1/15/2006	LL-3	3	6.87		0.38		0.268		--		202.4		4.96		--	
1/15/2006	LL-3	4	6.76		0.26		0.278		--		-101.5		5.07		--	
1/15/2006	LL-3	5	6.67		0.13		0.302		--		-116.4		5.38		--	
2/20/2006	LL-3	1	7.04		10.84		0.242		--		356.7		3.61		--	
2/20/2006	LL-3	2	6.88		1.69		0.281		--		257.5		4.52		--	
2/20/2006	LL-3	3	6.79		0.26		0.301		--		261.7		4.73		--	
2/20/2006	LL-3	4	6.67		0.45		0.326		--		-121.6		4.81		--	
2/20/2006	LL-3	5	6.52		0.37		0.347		--		-136.7		4.93		--	
1/15/2006	LL-4	1	6.89		5.34		0.267		--		129.2		2.44		--	
1/15/2006	LL-4	2	6.72		2.65		0.303		--		131.3		3.59		--	
2/20/2006	LL-4	1	6.62		5.96		0.258		--		88.0		3.60		--	
2/20/2006	LL-4	2	6.57		6.51		0.298		--		93.9		4.24		--	
2/20/2006	LL-4	2.5	6.58		6.64		0.299		--		99.9		4.28		--	
Italicized values were erroneous and were not use in summar					3.08		0.267									

Lake Lucille: Nutrient Results

Sample Site	Depth (meters)	Date	CHLOROPHYLL A			NITROGEN									PHOSPHORUS					
			Chlorophyll a	Data Flag	Units	Ammonia-N	Data Flag	Units	Total Kjeldahl Nitrogen	Data Flag	Units	Total Nitrate/Nitrite	Data Flag	Units	Ortho-Phosphate	Data Flag	Units	Total Phosphorus	Data Flag	Units
LL-1	1	5/7/2005	0.561		µg/L	ND(<0.10)		mg/L	0.534		mg/L	ND(<1.0)		mg/L	ND(<0.40)		mg/L	ND(<0.10)		mg/L
LL-1	1	7/4/2005	2.92		µg/L	ND(<0.10)		mg/L	0.585		mg/L	ND(<0.10)	VM	mg/L	ND(<0.40)		mg/L	0.06	J	mg/L
LL-1	1	8/21/2005	--		µg/L	0.043	J	mg/L	0.591		mg/L	ND(<0.10)		mg/L	0.144	J	mg/L	ND(<0.10)		mg/L
LL-1	1	10/16/2005	5.90		µg/L	0.152		mg/L	0.564		mg/L	0.086	J, VM	mg/L	0.171	J	mg/L	ND(<0.10)		mg/L
LL-3	1	5/7/2005	1.52		µg/L	ND(<0.10)		mg/L	0.645		mg/L	ND(<1.0)		mg/L	0.128	J	mg/L	0.36		mg/L
LL-3	1	7/4/2005	2.40		µg/L	0.039	J	mg/L	0.389	J	mg/L	ND(<0.10)	VM	mg/L	ND(<0.40)		mg/L	ND(<0.10)		mg/L
LL-3	1	8/21/2005	--		µg/L	0.081	J	mg/L	0.59		mg/L	ND(<0.10)		mg/L	ND(<0.40)		mg/L	ND(<0.10)		mg/L
LL-3	1	10/16/2005	7.01		µg/L	0.0572	J	mg/L	0.63		mg/L	0.102	VM	mg/L	0.249	J	mg/L	ND(<0.10)		mg/L
LL-3	4	5/7/2005	0.961		µg/L	ND(<0.10)		mg/L	0.583		mg/L	ND(<1.0)		mg/L	0.218	J	mg/L	0.04	J	mg/L
LL-3	4	7/4/2005	7.26		µg/L	0.039	J	mg/L	0.61		mg/L	ND(<0.10)	VM	mg/L	ND(<0.40)		mg/L	ND(<0.10)		mg/L
LL-3	4	8/21/2005	--		µg/L	0.082	J	mg/L	1.5		mg/L	ND(<0.10)		mg/L	ND(<0.40)		mg/L	0.07	J	mg/L
LL-3	4	10/16/2005	9.76		µg/L	0.123		mg/L	0.63		mg/L	0.11	VM	mg/L	ND(<0.40)		mg/L	ND(<0.10)		mg/L
LL-4	1	5/7/2005	0.801		µg/L	ND(<0.10)		mg/L	0.56		mg/L	ND(<1.0)		mg/L	ND(<0.40)		mg/L	ND(<0.10)		mg/L
LL-4	1	7/4/2005	4.61		µg/L	0.043	J	mg/L	0.585		mg/L	0.171	VM	mg/L	ND(<0.40)		mg/L	ND(<0.10)		mg/L
LL-4	1	8/21/2005	--		µg/L	0.056	J	mg/L	0.546		mg/L	0.036	J	mg/L	ND(<0.40)		mg/L	ND(<0.10)		mg/L
LL-4	1	10/16/2005	14.70		µg/L	0.196		mg/L	0.66		mg/L	0.234	VM	mg/L	ND(<0.40)		mg/L	ND(<0.10)		mg/L
LL-30*	3	5/7/2005	--		µg/L	ND(<0.10)		mg/L	0.544		mg/L	ND(<1.0)		mg/L	ND(<0.40)		mg/L	0.06	J	mg/L
LL-30*	1	7/4/2005	4.55		µg/L	ND(<0.10)		mg/L	0.512		mg/L	0.056	J, VM	mg/L	ND(<0.40)		mg/L	0.04	J	mg/L
LL-30*	1	8/21/2005	--		µg/L	0.082	J	mg/L	0.524		mg/L	0.04	J	mg/L	ND(<0.40)		mg/L	ND(<0.10)		mg/L
LL-30*	1	10/16/2005	8.41		µg/L	0.147		mg/L	0.903		mg/L	0.322	VM	mg/L	ND(<0.40)		mg/L	ND(<0.10)		mg/L

*Duplicate of LL-3

Lake Lucille: Total Aromatic Hydrocarbon Results

Sample Site	Depth (meters)	Date	Units	Benzene	Data Flag	Ethylbenzene	Data Flag	o-Xylene	Data Flag	P & M -Xylene	Data Flag	Toluene	Data Flag	Total Aromatic Hydrocarbons
LL-1	0.15	5/7/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		0.00039	J	0.00039
LL-1	0.15	7/4/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
LL-1	0.15	8/21/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
LL-1	0.15	10/16/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
LL-1	0.5	5/7/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		0.00037	J	0.00037
LL-1	0.5	7/4/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
LL-1	0.5	8/21/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
LL-1	1.5	10/16/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
LL-3	0.15	5/7/2005	mg/L	0.00042		ND(<0.001)		ND(<0.001)		0.00072	J	0.00095	J	0.00209
LL-3	0.15	7/4/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
LL-3	0.15	8/21/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
LL-3	0.15	10/16/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
LL-3	0.5	5/7/2005	mg/L	0.00041		ND(<0.001)		ND(<0.001)		0.00069	J	0.00093	J	0.00203
LL-3	0.5	7/4/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
LL-3	0.5	8/21/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
LL-3	1.5	10/16/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
LL-4	0.15	5/7/2005	mg/L	0.00342		0.00169		0.00243		0.00685		0.012		**0.02639**
LL-4	0.15	7/4/2005	mg/L	0.00054		ND(<0.001)		0.00132		0.00257		0.00127		0.0057
LL-4	0.15	8/21/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
LL-4	0.15	10/16/2005	mg/L	0.00135		0.00049	J	0.00063	J	0.00215		0.00414		0.00876
LL-4	0.5	5/7/2005	mg/L	**0.00599**		0.00302		0.00442		0.0124		0.0206		**0.04643**
LL-4	0.5	7/4/2005	mg/L	0.00049		ND(<0.001)		0.00128		0.0024		0.00109		0.00526
LL-4	0.5	8/21/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
LL-4	1.5	10/16/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
LL-30	0.15	5/7/2005	mg/L	0.00044		ND(<0.001)		ND(<0.001)		0.00074	J	0.00087	J	0.00205
LL-30	0.15	7/4/2005	mg/L	0.00053		ND(<0.001)		0.0013		0.00248		0.00117		0.00548
LL-30	0.15	8/21/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
LL-30	0.15	10/16/2005	mg/L	0.00095		0.00041	J	0.00051	J	0.00156	J	0.00327		0.0067
Trip Blank	--	5/7/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
Trip Blank	--	7/4/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
Trip Blank	--	8/21/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
Trip Blank	--	10/16/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		ND(<0.001)		ND
RB-1	--	7/4/2005	mg/L	ND(<0.0004)		ND(<0.001)		ND(<0.001)		ND(<0.002)		0.0048		ND

J - estimated value
RB - Rinsate Blank
*Duplicate of LL-3
Bolded values exceed 18 AAC 70 Water Quality Standard

ATTACHMENT E
SAMPLE FIELD DATA SHEETS

ATTACHMENT F

CD OF REPORT, SITE PHOTOGRAPHS, AND ANALYTICAL DATA REPORTS