BIG LAKE WATER QUALITY MONITORING REPORT

BIG LAKE, ALASKA

FINAL REPORT

Prepared for

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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

Big Lake is located approximately 15 miles west of Wasilla, Alaska. It covers an area of 2,500 acres and has a maximum depth of 90 feet. Both permanent residences and recreational cabins surround the lake, and two marinas and one restaurant currently operate along the shore of the lake. Because of its large size and close access to population centers, Big Lake is a popular year-round recreational area in Southcentral Alaska. This report summarizes the results of a water quality monitoring study of Big Lake, Alaska performed during the open water months in 2005.

Under contract with Alaska Department of Environmental Conservation (ADEC), OASIS Environmental, Inc. (OASIS) performed water quality monitoring for four separate groups of analytes: bacteria, hydrocarbons, nutrients, and physical parameters. OASIS, with support from personnel from Kinnetic Laboratories, Inc. (KLI), collected laboratory samples for the analysis of bacteria, hydrocarbons, and nutrients, while physical parameters were measured using in-situ water quality meters. Seven sampling events were conducted: May 12, May 28, July 3, July 23, August 20, September 4, and October 15. The first and last events were intended to occur before spring turnover and after fall turnover. The other events occurred on days with anticipated high recreational use. Field work was conducted according to the ADEC-approved Big Lake Sampling Plan and Quality Assurance Project Plan.

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

Measurement Date	Hydrocarbons	Nutrients	Bacteria	Field Parameters
May 12, 2005	X	X		X
May 28, 2005	X		X	X
July 3, 2005	X	X		X
July 23, 2005	X		X	X
August 20, 2005	X	X		X
September 4, 2005	X			X
October 15, 2005		X	X	X

Physical parameters met applicable AWQS and were generally consistent with values observed in previous studies. Continued monitoring of physical parameters is recommended so that the lake's physical characteristics and changes may be better understood through historical comparisons.

Fecal coliform bacteria analyses performed in 2005 indicated compliance with the drinking water supply AWQS (18AAC70) for 30-day geometric mean and for total coliform bacteria.

The trophic state index (TSI) was calculated for chlorophyll a and Secchi disk readings at Big Lake. The average chlorophyll a concentration at Big Lake for all sampling sites and dates was 1.6 µg/L, with a calculated TSI of 35. The average Secchi disk depth for all sites and dates at Big Lake was 4.5 m, with a corresponding TSI of 38. Both the chlorophyll a measurements and the Secchi disk readings classify Big Lake as oligotrophic.

Total phosphorous was detected in only 10 percent of samples, at concentrations just above the laboratory reporting limit; therefore, total phosphorous TSI cannot be accurately evaluated. However, for comparison purposes, the Carlson's TSI was calculated using the method reporting limit (31 µg/L) as the assumed phosphorous concentration. The resulting TSI of 54 would result in a eutrophic category for the lake. There was no evidence of a dominance of blue-green algae or algal scums at Big Lake; therefore, the assumption can be made that total phosphorous concentrations are generally well below the reporting limit used for this study. Long term monitoring for nutrients should be continued in Big Lake, albeit with lower detection limits if possible.

Several exceedances of the AWQS for TAH (10 µg/L) were reported at Big Lake in 2005. All exceedances occurred at either sampling site BL-8 or BL-10, with six of the nine exceedances occurring at sampling site BL-10. These sampling locations are in high-use boat launch areas. The elevated TAH concentrations appear to be commensurate with periods of higher lake usage, based on motorized user surveys conducted during each sampling event. OASIS recommends continuing to document hydrocarbon levels at these types of areas during high-use weekends. It may be particularly important to track TAH concentrations at BL-10. This location is immediately adjacent to the public swimming area, where consistently high hydrocarbon levels may pose a health risk.

Beyond the immediate water quality issues, a long-term plan for assessing water quality is advantageous as use and development increase at Big Lake. A full monitoring schedule could be performed every five years to ensure nutrient and bacteria levels remain stable.

1 INTODUCTION

This report summarizes the results of a water quality monitoring study of Big Lake, Alaska performed during the open water months in 2005. Big Lake is located approximately 15 miles west of Wasilla, Alaska. It covers an area of 2,500 acres and has a maximum depth of 90 feet. Both permanent residences and recreational cabins surround the lake, and two marinas and one restaurant currently operate along the shore of the lake. The 2000 census recorded the population of Big Lake as 2,635 residents with 2,122 housing units, of which 971 are occupied and the other 1,151 are vacant or seasonally vacant (ADCA 2005). Approximately 564 acres of land adjacent to the lake shore is residential, 35 acres are commercial, 652 acres are vacant, and 217 acres are public land. Because of its large size and close access to population centers, Big Lake is a popular year-round recreational area in Southcentral Alaska. Figure 1 provides a map of Big Lake.

1.1 Background

Under contract with Alaska Department of Environmental Conservation (ADEC), OASIS Environmental, Inc. (OASIS) performed water quality monitoring for four separate groups of analytes: bacteria, hydrocarbons, nutrients, and physical parameters. OASIS, with support from personnel from Kinnetic Laboratories, Inc. (KLI), collected laboratory samples for the analysis of bacteria, hydrocarbons, and nutrients, while physical parameters were measured using in-situ water quality meters. Seven sampling events were conducted: May 12, May 28, July 3, July 23, August 20, September 4, and October 15. 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. Other events occurred on weekends with high recreational use: Memorial Day weekend (May 28), Independence Day weekend (July 3), and Labor Day weekend (September 4). The remaining events occurred on dates (July 23 and August 20) when use was anticipated to be high.

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

1.2 Regulatory Overview

ADEC regulates water quality in the State. Current regulation specifies the degree of degradation that may not be exceeded in a water body 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.

As a non-groundwater, fresh water source, Big Lake is protected for the following water use classifications under 18 AAC 70.070:

- 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).

For Big Lake, the most appropriate sub-classification of water supply is drinking water and for water recreation it is primary contact. Table 1 presents the Alaska Water Quality Standards (AWQS) that apply to this study. For each analyte, the most stringent criterion is used as the applicable AWQS.

Table 1. Water Quality Criteria

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 more than 10 samples, may exceed 200 FC/100 ml.	Not Applicable
Dissolved Oxygen	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.	D.O. 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 the buffering capacity of the water.	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 In addition, weekly average temperature may not exceed site-specific requirements needed to preserve normal species diversity or to prevent appearance of nuisance organisms.
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

Figure 1. Map of Big Lake

2 METHODS

Water quality monitoring was conducted at Big Lake during seven sampling events in 2005. Field work was conducted according to the Big Lake Sampling Plan (OASIS 2005a). Table 2 presents the sample schedule and monitoring plan.

Table 2. 2005 Sample Plan and Schedule

Collection Date	Physical Parameters	Nutrients	Bacteria	Hydrocarbons
May 12, 2005	X	X		X
May 28, 2005	X		X	X
July 3, 2005	X	X		X
July 23, 2005	X		X	X
August 20, 2005	X	X		X
September 4, 2005	X			X
October 15, 2005	X	X	X	

For detailed descriptions of the sample methods and quality assurance procedures, refer to the Big Lake Sampling Plan (OASIS 2005a) in Attachment A and the Quality Assurance Project Plan (OASIS 2005b) in Attachment B. Table 3 below shows the list of sampling sites and parameters that were collected during each sampling event. Descriptions of each sampling site are also provided. Map 1, attached at the end of this report, shows the location of the sampling sites.

Table 3. Sampling Site Descriptions

Sampling Site	Nutrients	Bacteria	Hydrocarbons	Description
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.

Sampling Site	Nutrients	Bacteria	Hydrocarbons	Description
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.
BL-40		X		Semi-random sample location.
BL-50		X		Semi-random sample location.
BL-80		X		Semi-random sample location.
BL-90		X		Semi-random sample location.

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;
- oxygen 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 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 to determine 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.

2.2 Bacteria Sample Collection

Bacteria samples were collected for analysis of fecal coliform. Fecal coliform bacteria are naturally occurring microscopic organisms that live in the intestines of warm-blooded animals including birds. Although not necessarily disease-causing themselves, fecal coliform bacteria are used as an indicator species of possible human waste contamination. Human waste contamination can cause human illness at contact recreation areas, such as swimming beaches and shorelines at Big Lake.

Fecal coliform bacteria samples were collected at eight sample sites: four planned sites (BL-5, BL-10, BL-11, and BL-17) that were sampled during three separate events and four semi-random sites (BL-40, BL-50, BL-80, and BL-90) that were sampled only once. The semi-random samples were collected in areas that could potentially have higher bacteria levels e.g., adjacent to multi-family housing units and heavily vegetated areas. Semi-random sampling sites BL-50 and BL-60 were not sampled as discussed in Table 3. Table 4 shows when and where bacteria samples were collected.

Table 4. Bacteria Sample Summary

Sampling Site	Sample Dates	Location Description
BL-5	May 28, 2005 July 23, 2005 October 15, 2005	A condo development is present nearshore with no vegetative buffer between residences and lake.
BL-10	May 28, 2005 July 23, 2005 October 15, 2005	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	May 28, 2005 July 23, 2005 October 15, 2005	At the inlet of Meadow Creek; a large wetland area is associated with the creek and may be heavily used by waterfowl.
BL-17	May 28, 2005 July 23, 2005 October 15, 2005	The South State Recreation Area has a boat launch and camping.
BL-40	May 28, 2005	Semi-random sample location.
BL-50	May 28, 2005	Semi-random sample location.
BL-80	October 15, 2005	Semi-random sample location.
BL-90	October 15, 2005	Semi-random sample location.

At each sampling site, samples were collected at a primary sample location (e.g., BL-5) and at two secondary sample locations located approximately 50 meters north and south of the primary location (e.g., BL-5N and BL-5S). Sampling sites were located near swimming areas, dense residential development, other high use areas, or wildlife congregation areas where bacteria contamination from runoff and waste systems is possible. Map 1 at the end of this report displays the locations of the sampling sites.

Grab samples were collected by placing a sterile sample bottle in the water 0.30 meters below the surface, unscrewing the cap, allowing the bottle to fill and closing the bottle before returning to the surface. All fecal coliform samples were collected consecutively and transported to the laboratory before the 6-hour holding time expired for any of the samples.

2.3 Nutrient Sample Collection

Nutrient samples were collected at six sampling sites. These sampling locations were selected in areas with possible nutrient sources, such as lawns or other maintained areas where fertilizer would be applied and residential areas with septic systems, outhouses, and pet waste. At each location, samples for nutrient analyses were collected from a depth of one meter and seventy-five percent of the total lake depth. The exception to this method was sampling site BL-10 with a total water depth of less than two meters, in which case samples were collected at a depth of one meter only. Table 5 displays the sample summary for nutrient samples.

Table 5. Nutrient Sample Summary

Sampling Site	Sample Dates	Sampling Depths
BL-1	May 12, 2005	1 meter and 16 meters
	July 3, 2005	1 meter and 10 meters
	August 20, 2005	1 meter and 10 meters
	October 15, 2005	1 meter and 10 meters
BL-2	May 12, 2005	1 meter and 4 meters
	July 3, 2005	1 meter and 4.5 meters
	August 20, 2005	1 meter and 4.5 meters
	October 15, 2005	1 meter and 4.5 meters
BL-3	May 12, 2005	1 meter and 10.5 meters
	July 3, 2005	1 meter and 10.5 meters
	August 20, 2005	1 meter and 10.5 meters
	October 15, 2005	1 meter and 11.5 meters
BL-5	May 12, 2005	1 meter and 5.5 meters
	July 3, 2005	1 meter and 2.5 meters
	August 20, 2005	1 meter and 2.5 meters
	October 15, 2005	1 meter and 2.5 meters
BL-10	May 12, 2005	1 meter
	July 3, 2005	1 meter
	August 20, 2005	1 meter
	October 15, 2005	1 meter
BL-20	May 12, 2005	1 meter
	July 3, 2005	1 meter and 2 meters
	August 20, 2005	1 meter and 2 meters
	October 15, 2005	1 meter and 2 meters

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.

2.3.1 Chlorophyll a

Chlorophyll a samples were collected by 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 aluminum foil and placed between gel ice packs for transport to the laboratory for analysis.

2.3.2 Other Nutrients

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

- Ammonia-as nitrogen (N),
- Total Kjeldahl Nitrogen (TKN),
- Nitrate/Nitrite,

- Ortho-phosphate, and
- Total phosphorus.

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 during sample collection.

2.4 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.

There are five hydrocarbon sampling sites on Big Lake: BL-1, BL-6, BL-7, BL-8, and BL-10. 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 20 sampling event. TAH samples were collected at the correct depth of 1.5 meters for the September 4, 2005 sampling event. In addition, during the September 4, 2005 sampling event, sampling site BL-10 did not have the desired extra sample depth of 3 meters; therefore, the field team moved site BL-10 approximately 5 meters in order to reach a depth of 3 meters. This new location was called BL-10B. Map 1 shows the sampling sites. 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.

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 BL-1, which is considered an open water background location. Samples were collected from multiple shallow depths in order to determine whether dissolved phase hydrocarbons were mixing in the water column.

Table 6. TAH Sample Summary

Sampling Site	Sample Dates	Sampling Depths
BL-1	May 12, 2005	0.15 meter and 0.50 meter
	May 28, 2005	0.15 meter and 0.50 meter
	July 3, 2005	0.15 meter and 0.50 meter
	July 23, 2005	0.15 meter and 0.50 meter
	August 20, 2005	0.15 meter and 0.50 meter
BL-6	May 12, 2005	0.15 meter and 0.50 meter
	May 28, 2005	0.15 meter and 0.50 meter
	July 3, 2005	0.15 meter and 0.50 meter
	July 23, 2005	0.15 meter and 0.50 meter
	August 20, 2005	0.15 meter and 0.50 meter
BL-7	May 12, 2005	0.15 meter and 0.50 meter
	May 28, 2005	0.15 meter and 0.50 meter
	July 3, 2005	0.15 meter and 0.50 meter
	July 23, 2005	0.15 meter and 0.50 meter
	August 20, 2005	0.15 meter and 0.50 meter

Sampling Site	Sample Dates	Sampling Depths
BL-8	May 12, 2005	0.15 meter and 0.50 meter
	May 28, 2005	0.15 meter and 0.50 meter
	July 3, 2005	0.15 meter and 0.50 meter
	July 23, 2005	0.15 meter and 0.50 meter
	August 20, 2005	0.15 meter and 0.50 meter
	September 4, 2005	0.15 meter and 1.5 meters
BL-10	May 12, 2005	0.15 meter and 0.50 meter
	May 28, 2005	0.15 meter and 0.50 meter
	July 3, 2005	0.15 meter and 0.50 meter
	July 23, 2005	0.15 meter and 0.50 meter
	August 20, 2005	0.15 meter and 0.50 meter
	September 4, 2005	0.15 meter and 1.5 meters
BL-10B	September 4, 2005	0.15 meter, 1.5 meters, and 3.0 meters

3 RESULTS

Project analytical data were validated according to the QAPP (OASIS 2005b). Completeness for 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. Photographs taken during the sampling events are presented in the photograph log in Attachment D.

3.1 Weather Conditions

The following table shows weather conditions for each sampling event at Big Lake.

Table 7. Climatic Summary

Sample Day	Mean Daily Temperature	Net Precipitation	Wind Speed	Historical Mean Daily Temperature
May 12, 2005	56°F	0.00 in	4 mph	47°F
May 28, 2005	52°F	0.00 in	7 mph	49°F
July 3, 2005	60°F	0.00 in	1 mph	58°F
July 23, 2005	61°F	0.00 in	1 mph	58°F
August 20, 2005	60°F	0.00 in	5 mph	56°F
September 4, 2005	50°F	0.19 in	8 mph	51°F
October 15, 2005	34°F	0.00 in	4 mph	36°F

Source: Field Notes and www.weatherunderground.com

The above data show that the mean daily temperatures generally were above average for sample events, especially the initial event on May 12, 2005. The higher temperatures, especially in May, may contribute to the warmer water temperatures that are discussed under "Temperature" in Section 3.2.1. Otherwise, weather conditions do not indicate that any unusual atmospheric event would cause the observation of unusual or unexpected data.

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 lake bottom. Field and analytical results are presented in the data tables in Attachment E and discussed below. Sample field data sheets for all sampling events are presented in Attachment F. Absent or suspect measurements of field parameters are discussed in Section 5 as necessary.

Temperature

Temperature measurements ranged from 3.20 to 23.87°C during 2005 monitoring events at Big Lake. Charts showing the temperature change with depth at the open water, deep sampling sites, BL-3 and BL-1, in the east (BL-3) basin and west basins, respectively, are presented in Figure 2.

The May 12 and October 15 observations were very similar in temperature readings except that the May readings showed more variation between various depths. Based on the temperature profiles seen during the May 12 sampling event, it appears that the spring turnover of the lake may have already occurred, as the summer thermocline had started to develop. Prior to the spring turnover, it is expected that the deeper bottom waters would be approximately 4°C, which is the freshwater temperature of maximum density, and the surface waters would be in the range of 0 to 4°C following breakup. July and August readings appear to correlate well for both temperature and rate of change except that August temperatures indicate a deeper thermocline than that seen in July. The depth of the epilimnion (upper warm layer) at sampling sites BL-1 and BL-3 varied as shown:

- one meter deep on May 12, 2005,
- five meters deep on July 3, 2005,
- six to seven meters deep on August 20, 2005, and
- non-existent on October 15, 2005.

The thermocline (1°C change per meter) for both deep water sampling sites ranged as follows:

- one to three meters deep for both sites on May 12, 2005,
- three to five meters for BL-1 on May 28, 2005,
- five to six meters for both sites on July 3, 2005,
- seven to eight meters for BL-1 on July 23, 2005,
- seven to nine meters for BL-1 and six to seven meters and nine to eleven meters for BL-3 on August 20, 2005, and
- no thermocline observed at either sampling site on October 15, 2005.

Based on the thermocline observations, the hypolimnion (cold bottom layer) existed as shallow as 3 meters on May 12, 2005, to as deep as nine meters at BL-1 on August 20, 2005, and was non-existent on October 15, 2005. Uniform vertical profiles of temperature in the range of 7 to 8°C seen during the October 15 sampling event indicate that the fall turnover was in progress but not yet complete, as the bottom water was still substantially higher than 4°C. Eventually, the entire water column would cool to this uniform temperature (4°C) prior to the surface water cooling further and ice forming later in the fall.

The epilimnion is the upper layer heated by solar radiation and mixed by wind where most primary productivity occurs. The hypolimnion is the unmixed lower layer which is colder and darker than the epilimnion. This area is where organic matter settles and decomposes. The epilimnion at sampling sites BL-1 and BL-3 was above the AWQS of 15°C (water supply use) for all readings in July and August.

In comparison, Woods (1992) reported epilimnion water temperatures at 18°C (above the AWQS) in June and thermocline development at 5 m for May and June. Peak temperatures in the epilimnion were recorded as late as August and September in Woods' study. When compared to 2004 data from Big Lake monitoring, the 2005 data appears to be uniformly one to three degrees warmer per each meter of depth for both BL-1 and BL-3 for readings taken in May. The 2004 monitoring dates at Big Lake were May 16, May 31, and June 13, so only the May readings are comparable between 2004 and 2005 data.

Turbidity

Turbidity measurements ranged from 0.27 to 3.02 nepholemetric turbidity units (NTU) across all sampling sites and sampling events at Big Lake. The AWQS is 5 NTU above background conditions for all water uses. Given that the maximum reading during 2005 was 3.02 NTU, it is obvious that no reading exceeded background by more than 5 NTU. The mean of all turbidity readings collected in 2005 is 0.69 NTU, and the median is 0.61 NTU.

For 2004 data, the mean turbidity reading for all three sample events was 1.1 NTU; therefore, 2005 turbidity data showed a decrease in average turbidity for Big Lake.

pH

Results for pH during 2005 monitoring ranged from 6.15 to 8.32, with a median of 7.88. The AWQS for pH is 6.5 to 8.5 for recreational contact. The two readings that were less than 6.5 were measurements from one and two meters at BL-20 on October 15. These readings may have been biased by recent calibration with pH 4.0 solution. All prior readings at this location were within AWQS; therefore, the two measurements less than 6.5 likely are not true exceedances of water quality criteria.

There was little difference between 2004 and 2005 pH data at Big Lake.

Conductivity

Conductivity values ranged from 90 to 490 micro Siemens per centimeter (µS/cm) for all sampling sites and dates. The overall mean conductivity reading for all monitoring events was 130 µS/cm, and the median was 130 µS/cm. However, the October 15 sampling event had a mean conductivity reading of 96 µS/cm, with a median also of 96 µS/cm, below the overall average.

Edmundson (2002) reported conductivity measurements for Big Lake in 2001 from 126 to 144 umhos/cm (umhos=µS), which is comparable to measurements for 2005. Also, the mean conductivity reading from 2004 was 145 µS/cm, which is a 12% annual difference.

DO

DO measurements ranged from 6.70 to 15.58 milligrams per liter (mg/L) for all 2005 monitoring events with a mean of 9.68 mg/L and a median of 9.03 mg/L. Figure 3 presents two charts that show the relationship between DO and water depth at the two deep sampling sites, BL-3 and BL-1, in the east basin and west basins, respectively.

October 15 observations had highest DO readings, which showed very little variation with depth. July and August readings show a similar trend of increasing DO concentrations at a depth of 5 to 7 meters.

The AWQS for DO ranges from 4 mg/L to 17 mg/L. Monitoring results from Big Lake did not exceed the AWQS.

The mean DO reading for all three sample events from 2004 was 10.0 mg/L; therefore, there was little measured difference in DO readings from 2004 to 2005.

ORP

ORP measurements ranged from -21.9 to 360.1 millivolts (mV) for all 2005 monitoring events with a mean of 155 mV and a median of 94.1. These average statistics demonstrate that Big Lake's aquatic environment has oxygen available for chemical reactions. This fact is supported by measured DO concentrations.

No ORP measurements were taken in 2004, so 2005 represents the baseline year for ORP data.

Secchi Depth

Secchi depths generally ranged from 4.5-6.5 meters at the deeper sampling sites. At sampling sites BL-5, BL-7, BL-10, BL-11, BL-17, BL-20, BL-40, and BL-50, the Secchi disk was visible to the total lake depth during some or all of the sampling events. Results are presented in Table 8.

Table 8. Secchi Depths

Sample Site	Date	Secchi Depth (meters)	Total Depth
BL-1	5/12/2005	6	
	5/28/2005	6.5	
	7/3/2005	5.5	
	7/23/2005	9	
	8/20/2005	4.5	
	10/15/2005	4.5	
BL-2	5/12/2005	5.5	
	7/3/2005	5	
	8/20/2005	4	
	10/15/2005	4.5	
BL-3	5/12/2005	4	
	7/3/2005	5	
	8/20/2005	6.5	
	10/15/2005	4.5	
BL-5	5/12/2005	5	
	5/28/2005	3.5	X
	7/3/2005	3.5	X
	7/23/2005	3	X
	8/20/2005	3.5	X
	10/15/2005	3.5	
BL-6	5/12/2005	4.5	
	5/28/2005	5	
	7/3/2005	5.5	
	7/23/2005	7	
	8/20/2005	4.5	
BL-7	5/12/2005	2	X
	5/28/2005	2	X
	7/3/2005	2	X
	7/23/2005	2	X
	8/20/2005	2	X
BL-8	5/12/2005	3.5	
	5/28/2005	4.5	
	7/3/2005	5	
	7/23/2005	5	
	8/20/2005	5	
	9/4/2005	4.5	
BL-10	5/12/2005	1.5	X
	5/28/2005	<1.5	X
	7/3/2005	<1.5	X
	7/23/2005	<1.5	X
	8/20/2005	<2	X
	9/4/2005	<2	X
BL-10B	9/4/2005	3.5	X
BL-11	5/28/2005	<2	X
	7/23/2005	<2	X
BL-17	5/28/2005	2	X
	7/23/2005	2	X
BL-20	5/12/2005	2.75	X
	5/12/2005	2.75	X
	7/3/2005	7.5	
	10/15/2005	4.5	
BL - 40	5/28/2005	4.5	X
BL - 50	5/28/2005	3.5	X
BL - 80	10/15/2005	3.5	
BL - 90	10/15/2005	3.5	

3.2.2 Parameter Comparisons

Comparison of the results of some of the parameters lends useful information regarding the interaction of physical properties of Big Lake. In particular, a correlation was performed between DO/ORP and DO/temperature to determine how changes in ORP and temperature affect the amount of DO available in Big Lake.

DO/ORP Comparison

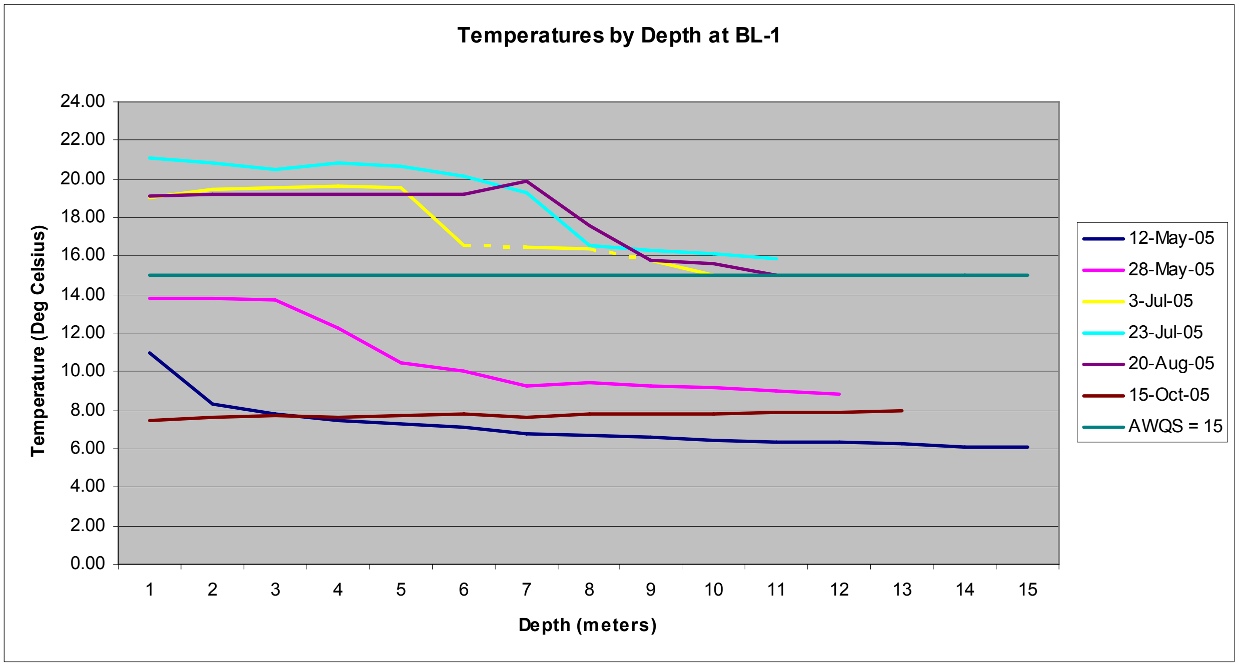
It is expected that the data should show a relationship between DO and ORP given that both are measuring a characteristic of oxygen in water. Figure 4 presents a scatterplot of DO and ORP readings from 2005 monitoring at Big Lake. The scatterplot includes a line of best fit for expected results. Review of the graph shows strong positive correlation (r^2 = 0.812) between DO and ORP.

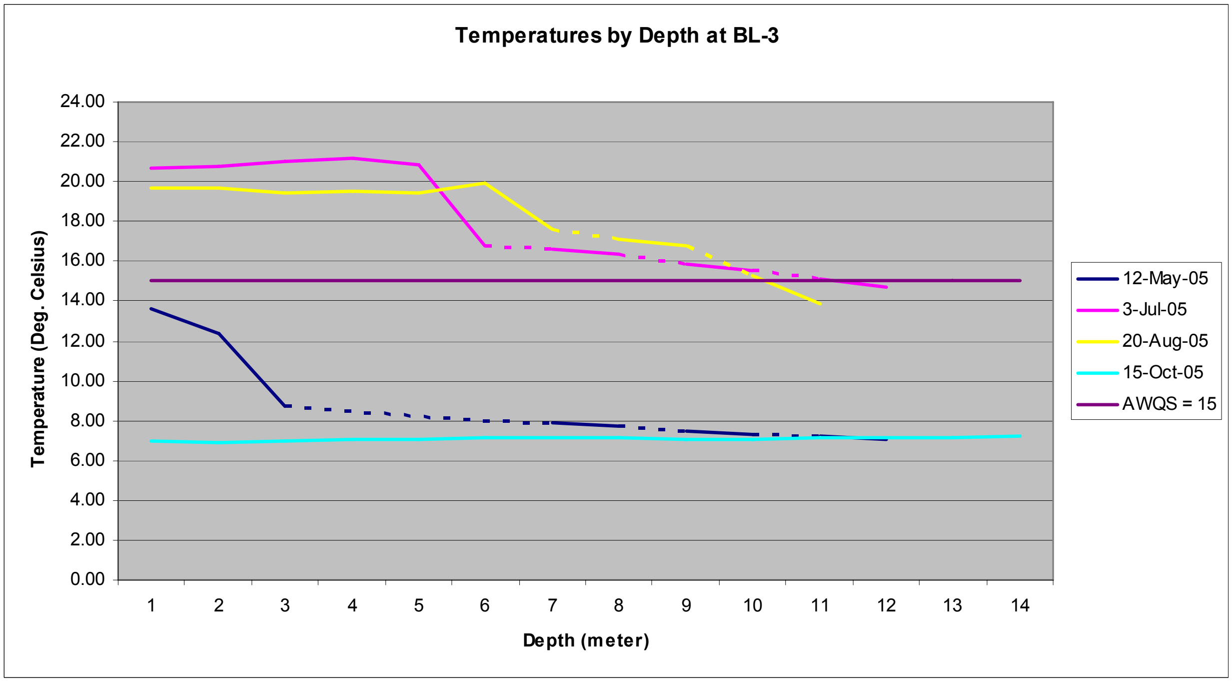
DO/Temperature Comparison

Similar to DO and ORP, DO and temperature are expected to exhibit a relationship, albeit negative instead of positive. Because the solubility of oxygen decreases with increasing temperatures, water is retains less dissolved oxygen as its temperature increases. Water temperatures within the hypolimnetic zone at Big Lake generally decreased with depth; therefore, DO readings generally increased and hypolimnetic oxygen depletion was not observed.

Figure 5 presents a scatterplot of DO and temperature from 2005 monitoring at Big Lake. The scatterplot includes a line of best fit for expected results. Review of the graph shows the expected strong negative correlation (r^2 = 0.826) between DO and temperature.

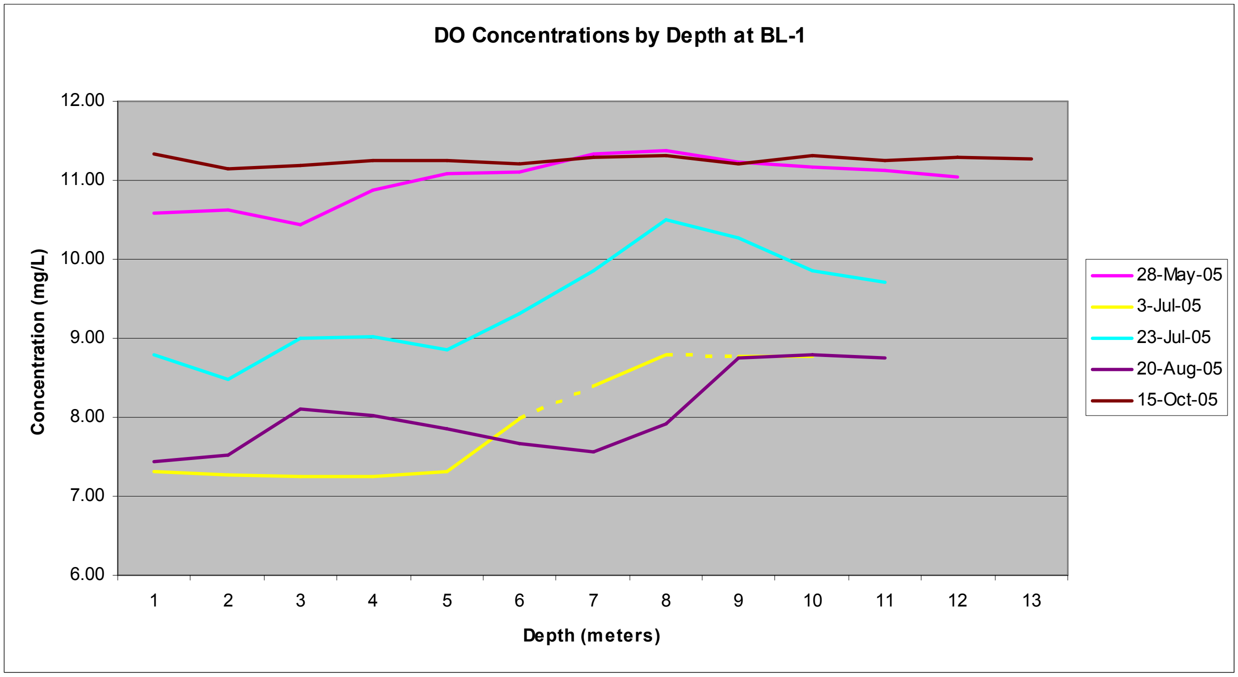
Figure 2. Temperature Measurements

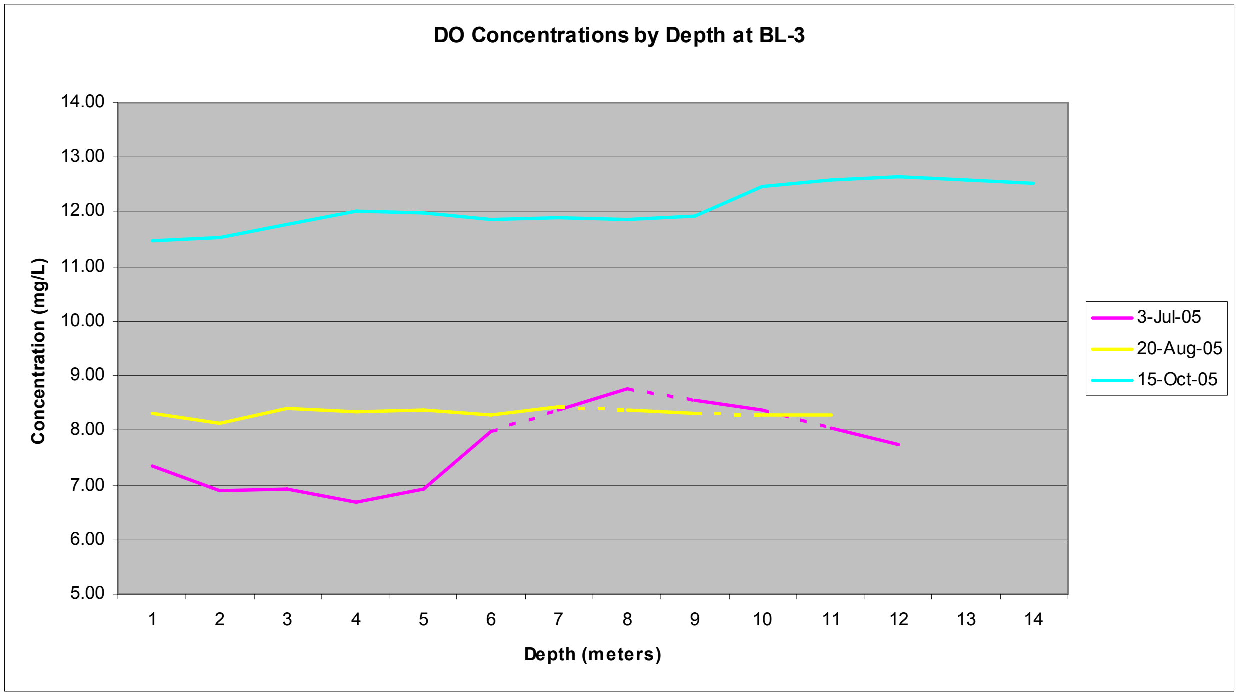




Note: Dashed lines indicate interpolated temperatures between observed readings.

Figure 3. DO Measurements





Notes:
1. Dashed lines indicate interpolated temperatures between observed readings.
2. May 12 DO data are not included on charts; see the data quality assurance review in Attachment C.

Figure 4. Big Lake DO/ORP Comparison

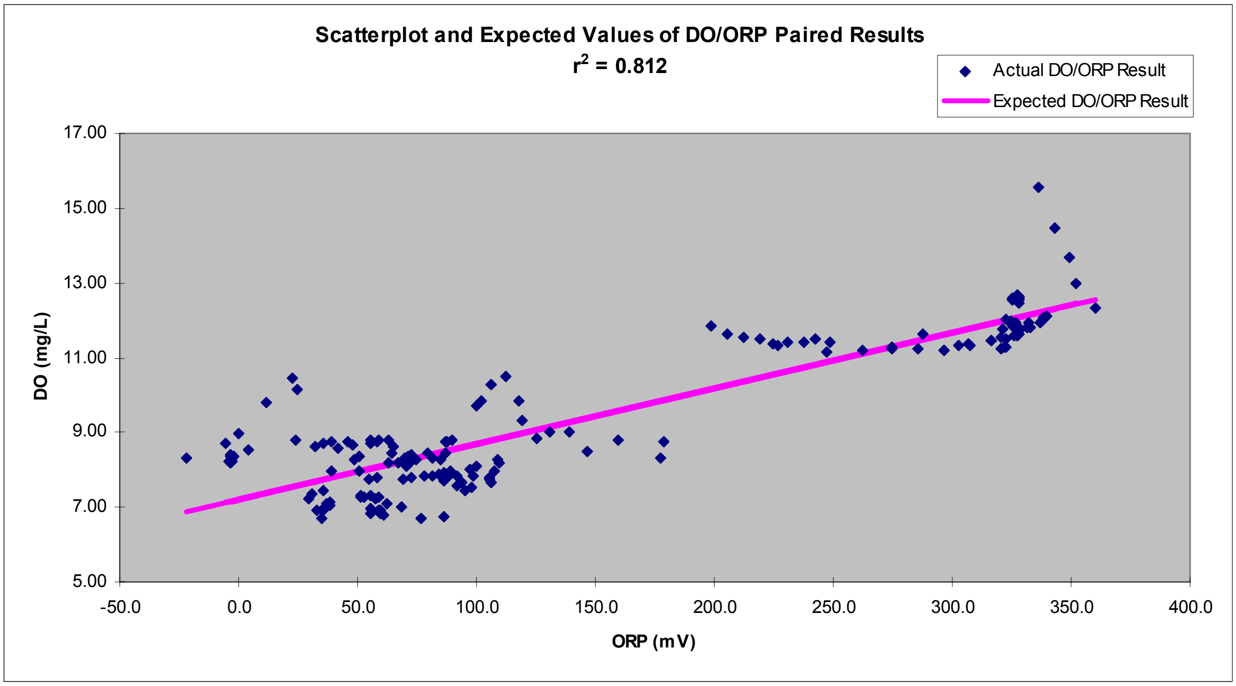
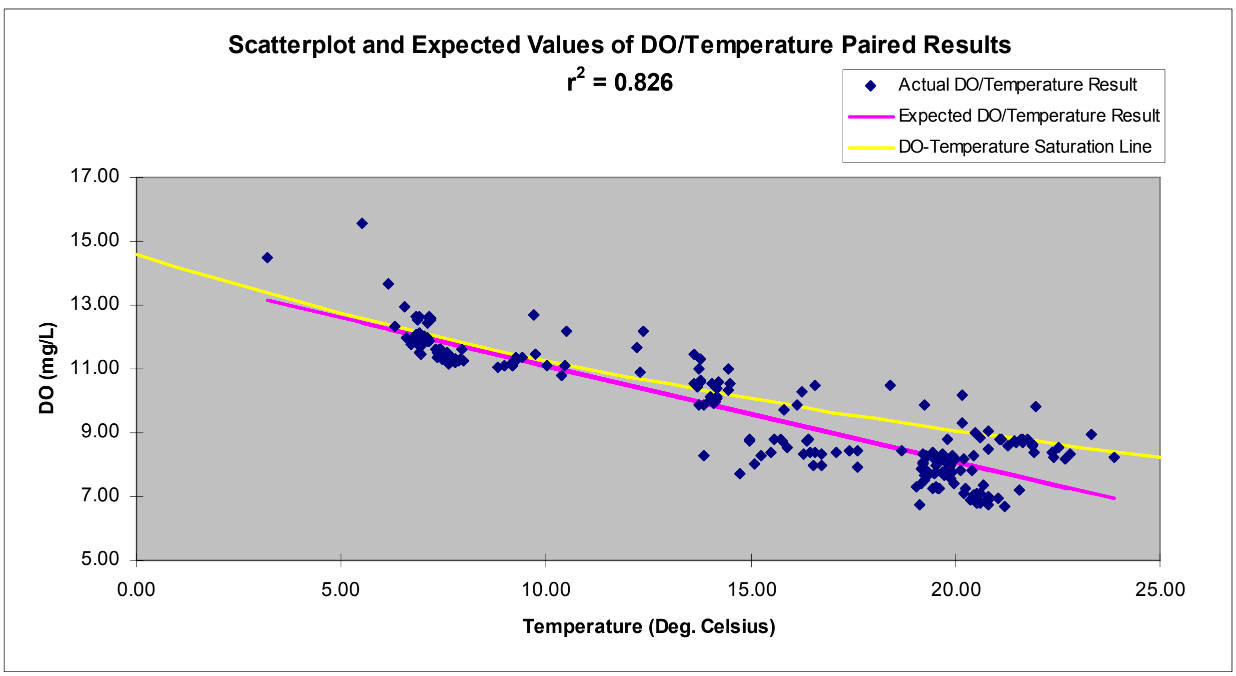


Figure 5. Big Lake DO/Temperature Comparison

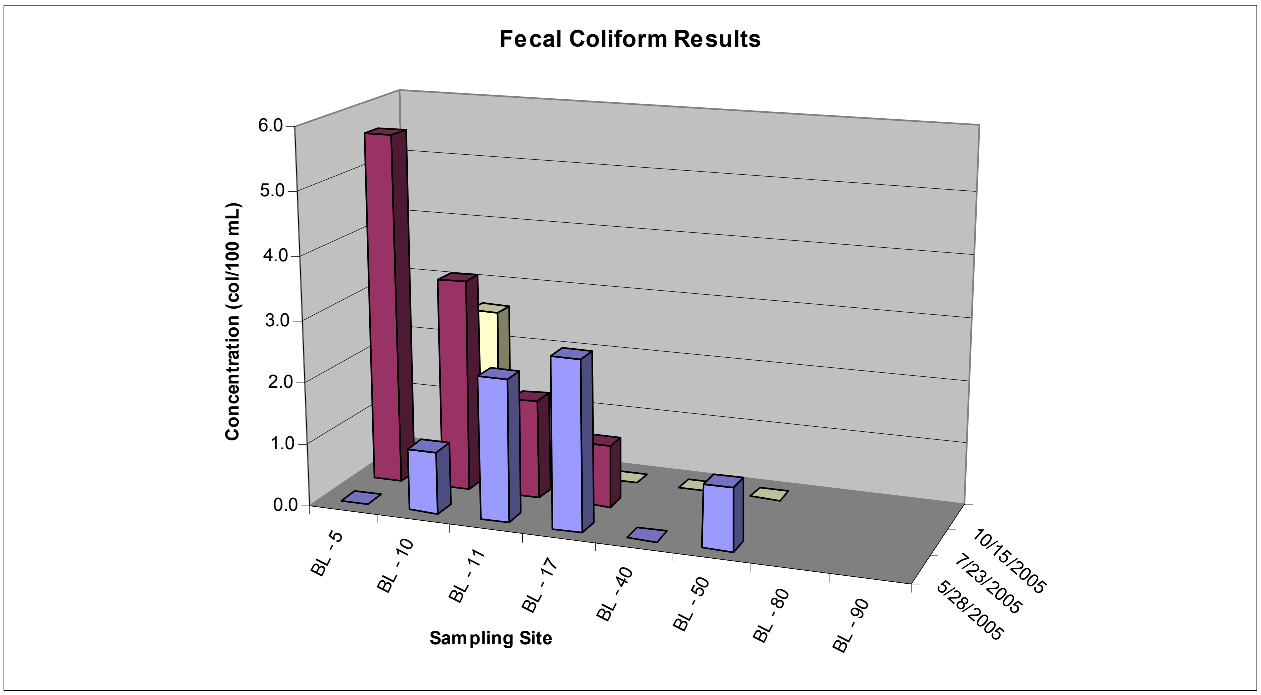


3.3 Bacteria

The drinking water supply AWQS (18AAC70) for fecal coliform bacteria states that the geometric mean of fecal coliform samples collected within a 30-day period may not exceed 20 colonies/100 milliliter (col/100 mL), and not more than 10% of samples may exceed 40 col/100 mL. Of all the fecal coliform samples collected at Big Lake in 2005, the maximum detected value was 9 col/100 ml at sampling site BL-10N on July 23. The greatest geometric mean for any sampling site was 5.6 col/100 mL at sampling site BL-10 for samples collected on July 23, 2005. BL-30 is a duplicate sample of sampling site BL-10, which had the second greatest geometric mean (4.3 col/100 mL on July 23, 2005). Figure 6 presents the geometric mean for the three samples collected from each sampling site during bacteria sampling. Results also are summarized in the data tables in Attachment E.

The 2005 results for fecal coliform show little variation from the 2004 data. For 2004 data, sampling site BL-11 had much greater geometric means (13.2 and 14.2 col/100 mL) than any geometric means from 2005, but overall nearly all geometric means were less than 5 col/100 mL for both 2004 and 2005 data. Laboratory analytical data reports for fecal coliform analyses are included in Attachment G.

Figure 6. Fecal Coliform Results



3.4 Nutrients

Nutrient samples were collected from six sampling sites during four sampling events. All six sites had a sample collected from a depth of one meter. Five of the six sites also had a second, deeper, sample collected. Nutrient results are summarized in the data tables in Attachment E and are discussed below. Laboratory analytical data reports for nutrient analyses are included in Attachment G.

Phosphorus

Detections above laboratory reporting limits were infrequent. Only ortho-phosphate at sampling site BL-1 had any consistent detection, albeit at estimated concentrations near the reporting limit. Table 9 shows results for ortho-phosphate and total phosphorous that were above laboratory reporting limits. Neither dissolved ortho-phosphate nor total phosphorus has an AWQS.

Edmundson et. al. (2000) reported concentrations of total phosphorus (inclusive of the dissolved phosphorus fractions) in the range of 2.2-44.2 µg/L for Mat-Su lakes. Woods (1992) reported concentrations of total phosphorus at Big Lake in May and June at 8-20 µg/L and ortho-phosphate at 1-8 µg/L. For 2004 data, the reporting limits for total phosphorous and ortho-phosphate were 100 µg/L and 400 µg/L, respectively. Almost no detections above the reporting limit occurred in 2004. Lower reporting limits were requested and the laboratory was able to decrease reporting limits by approximately 70% for 2005. The reporting limit for total phosphorous decreased from 100 µg/L to 31 µg/L, and the reporting limit for ortho-phosphate decreased from 400 µg/L to 120 µg/L. Nonetheless, the change was still insufficient to adequately monitor phosphorous levels in Big Lake.

Table 9. Phosphorus Analytical Results

Sample Site	Depth (meters)	Date	Ortho-Phosphate (mg/L)	Data Flag	Total Phosphorus (mg/L)	Data Flag
BL-1	1	8/20/2005	0.176	J	ND(0.031)	
BL-1	1	10/15/2005	0.21	J	ND(0.031)	
BL-1	10	8/20/2005	0.29	J	ND(0.031)	
BL-1	10	10/15/2005	0.265	J	ND(0.031)	
BL-2	1	7/3/2005	ND(0.12)		0.05	J
BL-2	1	8/20/2005	0.123	J	ND(0.031)	
BL-2	1	10/15/2005	0.121	J	ND(0.031)	
BL-3	10.5	7/3/2005	ND(0.12)		0.05	J
BL-5	1	10/15/2005	0.133	J	ND(0.031)	
BL-10	1	7/3/2005	ND(0.12)		0.2	
BL-20	1	7/3/2005	ND(0.12)		0.04	J
BL-20	2	8/20/2005	0.275	J	ND(0.031)	
BL-30*	1	8/20/2005	ND(0.12)		0.04	J
BL-30*	1	10/15/2005	0.239	J	ND(0.031)	

*Duplicate of BL-10

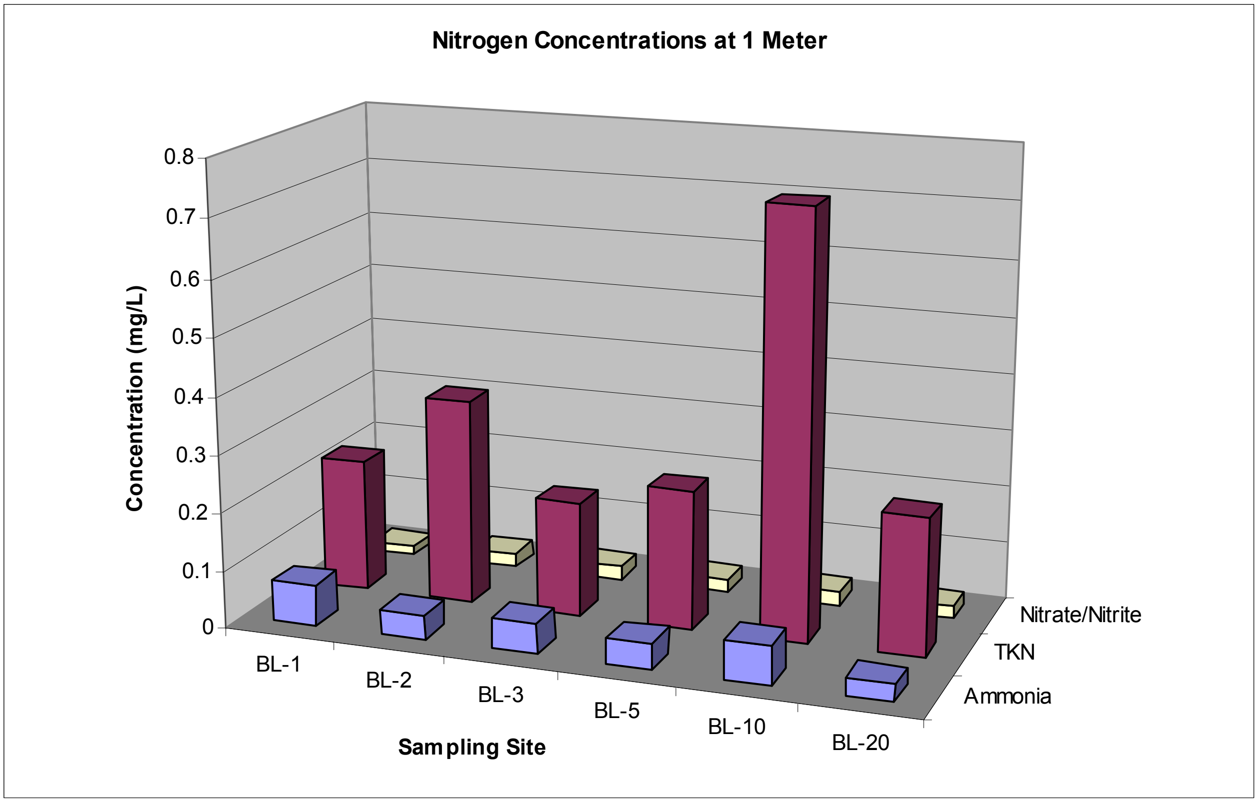
J = Estimate concentration.

Nitrogen

Samples collected for nitrogen analysis were analyzed for ammonia, TKN, and nitrate/nitrite. TKN was most frequently detected with 76.6% of analyses yielding a result above the reporting limit. Ammonia was next with a detection rate of 51.1%, and nitrate/nitrite was last with a detection rate of only 29.8%. TKN and nitrate/nitrite do not have AWQS. Ammonia does have an AWQS, but it is pH dependent and must be calculated for each result.

Figure 7 shows the mean concentration for all sampling events from a depth of one meter for each nitrogen analyte. For results not detected above the reporting limit, one-half the reporting limit was assumed to calculate the mean. Given the consistently low mean concentrations that are shown in Figure 7, ammonia AWQS were not calculated.

Figure 7. Nitrogen Results



The average concentrations of the three analytes resemble their frequencies of detection. TKN had the highest average concentration at a depth of one meter; ammonia and nitrate/nitrite followed, respectively. BL-10 had the highest concentration of TKN.

Ammonia, TKN, and nitrate/nitrite concentrations from the deeper depths at each sampling site are listed in Table 10. Only sampling events for which at least one analyte was detected above the reporting limit are listed.

Table 10. Nitrogen Results for Deep Sample Depths

Sample Site	Depth (meters)	Date	Ammonia-N (mg/L)	Data Flag	TKN (mg/L)	Data Flag	Nitrate/Nitrite (mg/L)	Data Flag
BL-1	10	7/3/2005	ND(0.031)		0.297	J	ND(0.031)	
BL-1	10	8/20/2005	0.043	J	0.314	J	ND(0.031)	
BL-1	10	10/15/2005	0.11		0.309	J	0.0405	J
BL-2	4	5/12/2005	ND(0.031)		ND(0.15)		2.79	
BL-2	4.5	7/3/2005	ND(0.031)		0.241	J	0.045	J
BL-2	4.5	8/20/2005	0.043	J	0.315	J	ND(0.031)	
BL-2	4.5	10/15/2005	0.0978	J	0.265	J	0.033	J
BL-3	10.5	7/3/2005	ND(0.031)		0.36	J	ND(0.031)	
BL-3	10.5	8/20/2005	ND(0.031)		0.278	J	ND(0.031)	
BL-3	11.5	10/15/2005	0.091	J	0.299	J	0.066	J
BL-5	2.5	7/3/2005	ND(0.031)		0.441	J	ND(0.031)	
BL-5	2.5	8/20/2005	0.033	J	0.349	J	ND(0.031)	
BL=5	2.5	10/15/2005	0.0809	J	0.323	J	0.0365	J
BL-20	2	7/3/2005	ND(0.031)		0.268	J	ND(0.031)	
BL-20	2	8/20/2005	ND(0.031)		0.278	J	ND(0.031)	
BL-20	2	10/15/2005	0.101		0.296	J	0.035	J

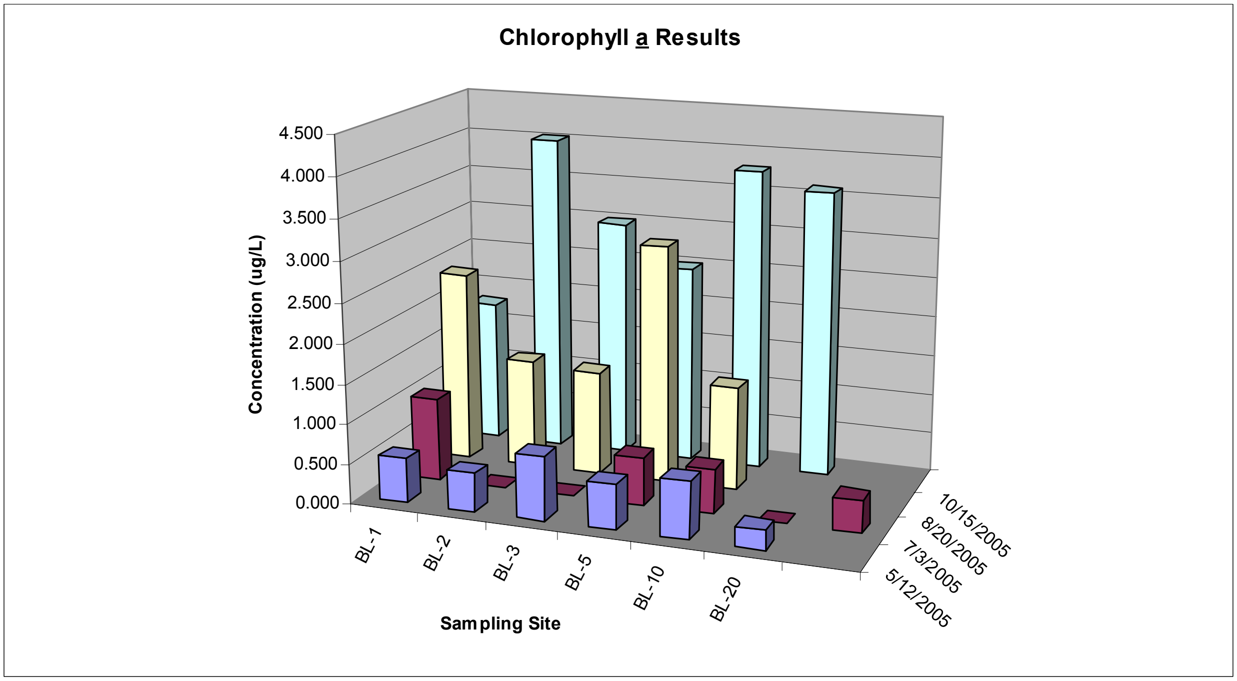
J = Estimated concentration.

Overall, results for nitrogen in 2005 appear to be similar to previous studies. Edmundson (2002) showed that ammonia concentrations in 2001 were in the range of 0.001 to 0.022 mg/L. Woods (1992) reported TKN concentrations at Big Lake in the east basin in 1983 and 1984 in the range of 0.160 to 0.370 mg/L, and Woods (1992) also showed nitrate/nitrite concentrations ranged from 0.001 to 0.060 mg/L. The 2004 nitrogen data had so few detections above reporting limits that no useful comparison could be made between 2004 and 2005 data. Similar to phosphorous, the analytical reporting limits for nitrogen samples were significantly lowered for 2005. The reporting limits for ammonia, nitrate/nitrite, and TKN all decreased by approximately 70%: ammonia from 0.1 mg/L to 0.031 mg/L, nitrate/nitrite from 1.0 mg/L to 0.31 mg/L, and TKN from 0.5 mg/L to 0.15 mg/L. However, these changes were still insufficient to quantify nitrogen levels in Big Lake adequately.

Chlorophyll a

Chlorophyll a is an indicator of algal productivity within a water body. Chlorophyll a concentrations at Big Lake ranged from 0.24 to 5.7 µg/L. The average concentration for each sampling event was 0.48, 0.59, 1.3 and 3.1 µg/L for May 12, July 3, August 20 and October 10, respectively. Chlorophyll a results are presented in Figure 8. These data are consistent with those recorded in 2004 for similar timeframes. Woods (1992) reported chlorophyll a concentrations in the east basin as high as 46.5 µg/L at 10 m depth in August of 1983. Such levels were not observed in 2004 and 2005, perhaps due to different sampling and analysis techniques.

Figure 8. Chlorophyll a Results



3.5 Hydrocarbons

Total aromatic hydrocarbon (TAH; the sum of benzene, toluene, ethylbenzene, and xylene concentrations) samples were collected at five sampling sites on all dates except October 15, 2005. Sampling depths were 0.15 meter and 0.5 meter for all five sites. An additional abbreviated round of sampling occurred on September 4, 2005, when sampling sites BL-8 and BL-10 were sampled at greater depths. Results are summarized in the data tables in Attachment E and are discussed below. Laboratory analytical data reports for hydrocarbon analyses are included in Attachment G.

Benzene exceeded its AWQS a total of five times at BL-10: May 28, July 3, and July 23 at a depth of 0.5 meter, and July 3 and July 23 at depths of 0.15 meter. The highest benzene reading was 0.0105 mg/L on July 3 at 0.15 meter, which is more than twice the AWQS of 0.005 mg/L.

Figure 9 shows TAH concentrations at the depth of 0.15 meter for all sample events. For instances when no TAH parameters were detected above the reporting limit for a particular sample, the reporting limit for benzene was used to represent that sample's value in the graph. As seen in Figure 9, BL-10 had the greatest TAH concentrations of the six sampling sites. The TAH AWQS of 0.010 mg/L was exceeded during four of the six sampling events at BL-10: May 28, July 3, July 23, and September 4. The TAH AWQS was also exceeded during two sampling events at BL-8: July 23 and August 20.

Figure 9 also shows TAH concentrations at the depth of 0.5 meter (except for September 4 values which were collected from a depth of 1.5 meters). For instances when no TAH parameters were detected above the reporting limit for a particular sample, the reporting limit for benzene was used to represent that sample's value in the graph. As seen in the second graph of Figure 9, sampling site BL-10 again had the greatest concentrations of TAH for the six sampling sites. TAH concentrations exceeded the AWQS of 0.010 mg/L for three of the five sampling events at BL-10: May 28, July 3, and July 23. TAH also exceeded the TAH AWQS at BL-8 for the July 23 and August 20 events.

The best comparison to make is between the late May sample events: May 29, 2004 and May 28, 2005. For May 29, 2004, six exceedences of the TAH AWQS occurred at 0.15 meter for 14 total samples collected, while for May 28, 2005, only one exceedence occurred at 0.15 meter for 5 total samples collected. Sampling site BL-10 was the exceedence that occurred both years. Based on this comparison, it appears that water quality for TAH was probably better for late May 2005 than late May 2004.

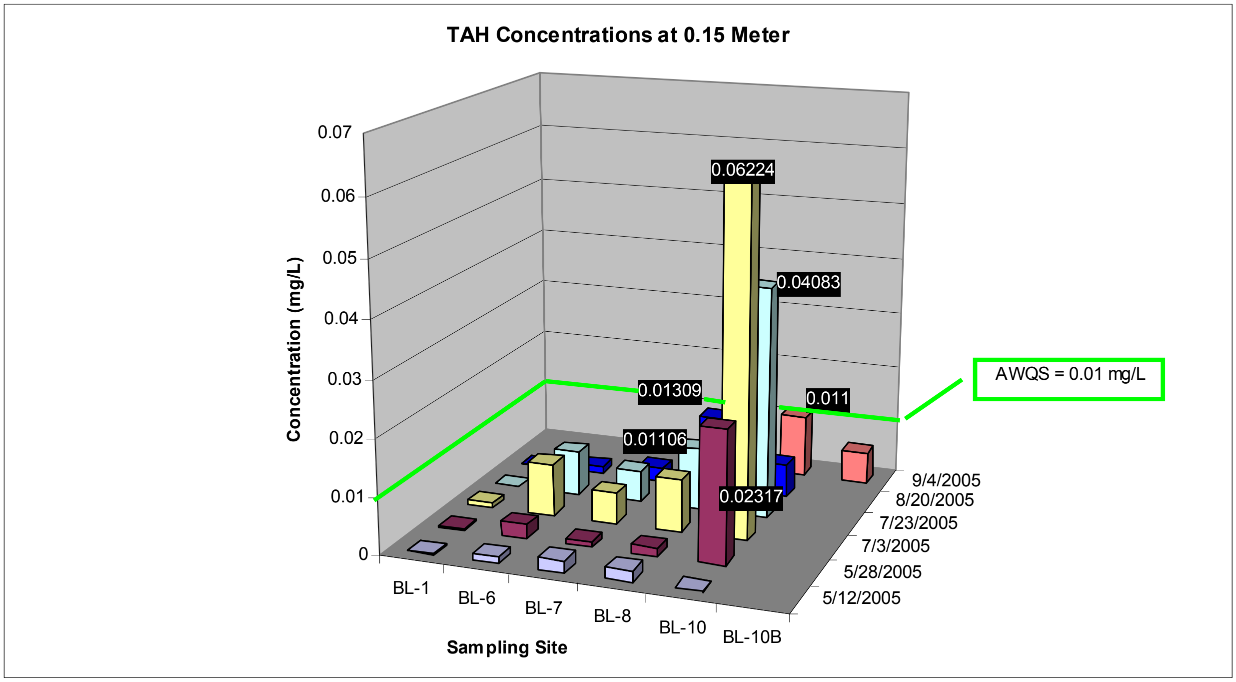
Table 11 shows the sample event that the highest TAH concentration was detected at each sampling site for each sample depth.

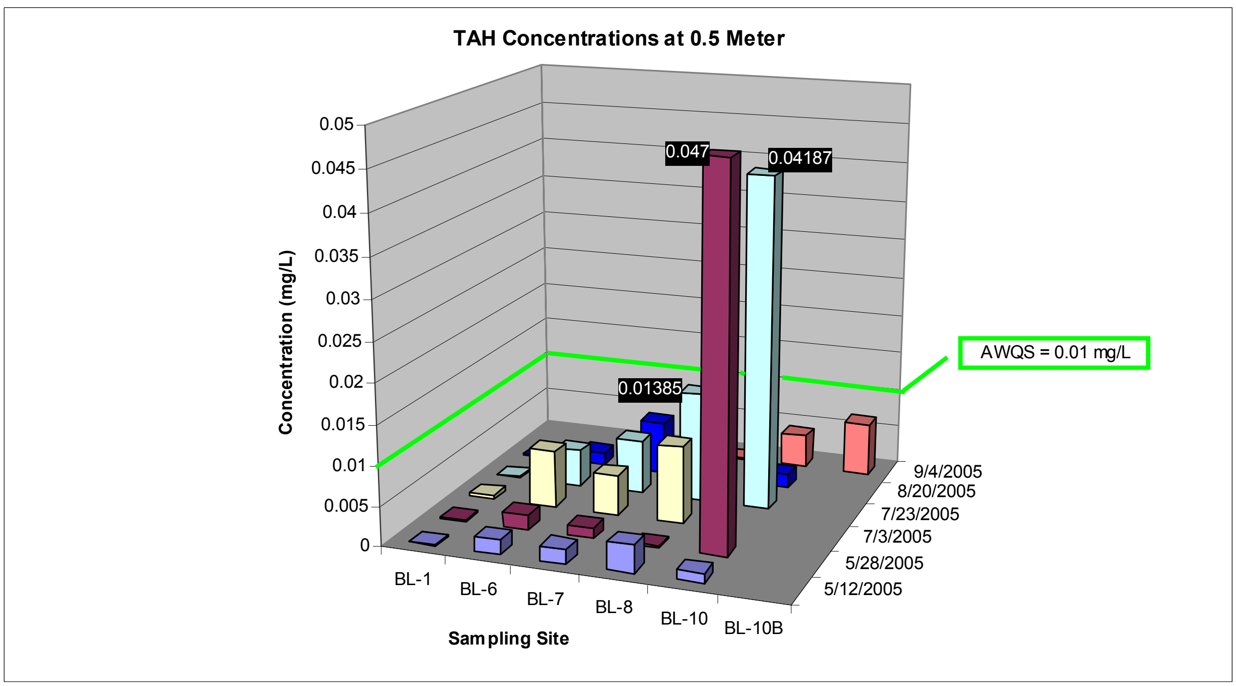
Table 11. Sample Event of Highest TAH Concentrations for Sampling Site

Sample Site	0.15 Meter	0.5 Meter
BL-1	July 3, 2005	July 3, 2005
BL-6	July 3, 2005	July 3, 2005
BL-7	July 23, 2005	July 23, 2005
BL-8	August 20, 2005	July 23, 2005
BL-10	July 3, 2005	July 3, 2005

As seen in Table 11, the July 3 sample event had the highest TAH concentrations at three of the five sampling sites for both sample depths. The July 23 sample event had three of the remaining four possible maximum TAH concentrations, and the August 20 sample event had a single highest TAH concentration. This comparison demonstrates that TAH concentrations are likely influenced by a combination of good weather and time of season. The three sample events identified in Table 11 had the three highest mean temperatures of the six main sample events, and those three sample events also are likely prime recreational dates based on their peak timeframe.

Figure 9. TAH Results





4 CONCLUSIONS

4.1 Field Parameters

The most stringent AWQS for pH and DO that pertain to Big Lake are:

- pH – greater than 6.5 and less than 8.5 (water recreation) and;
- DO – greater than 4 mg/L (water supply) but less than 17 mg/L (growth and propagation).

There were no AWQS exceedences for DO. Two pH readings on October 15, 2005 were below 6.5, but these readings were likely biased low as discussed in Section 3.2.1.

The most stringent AWQS for temperature is 15°C for water supply. Nearly every temperature reading from July 3, July 23, and August 23 exceeds this standard. Given that Big Lake 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.

The depth of the epilimnion varied with the time of year. It ranged from approximately one meter on May 12 to near seven meters on August 20. No epilimnion was observed on October 15 as the surface and bottom of the lake differed by less than 0.5°C. The thermocline began as shallow as one meter deep on May 12, but for each successive sampling event it became deeper through the August 20 sampling event when it began at six to seven meters beneath the water surface. No thermocline was observed during the October 15 sampling event. Lake stratification was apparent for all sampling events except for sampling conducted on October 15. Table 12 below shows the approximate development of stratified layers during 2005 in Big Lake.

Table 12. Stratification at Sampling Sites BL-1 and BL-3

BL-1			
Sample Event	**Depth of Epilimnion**	**Depth of Thermocline**	**Depth of Hyperlimnion**
May 12, 2005	0 - 1 meter	1 - 3 meters	3 - 15 meters
May 28, 2005	0 - 3 meters	3 - 7 meters	7 - 12 meters
July 3, 2005	0 - 5 meters	5 - 6 meters	6 - 10 meters
July 23, 2005	0 - 6 meters	6 - 8 meters	8 - 11 meters
August 20, 2005	0 - 7 meters	7 - 9 meters	9 -11 meters
October 15, 2005	NM	NM	NM

BL-3			
Sample Event	**Depth of Epilimnion**	**Depth of Thermocline**	**Depth of Hyperlimnion**
May 12, 2005	0 - 1 meter	1 - 3 meters	3 - 12 meters
July 3, 2005	0 - 5 meters	5 - 6 meters	6 - 12 meters
August 20, 2005	0 - 7 meters	6 - 7 meters and 9 - 11 meters	NM
October 15, 2005	NM	NM	NM

NM = Not measured - layer not present in data

DO concentrations were found to be highly correlated with temperature and near saturation throughout the water column for all sampling events. The data did not indicate a hypolimnion zone that was depleted in oxygen, in fact the bottom waters were found to generally have higher DO concentrations than the surface waters as a result of the colder temperatures at depth. It appears that following the spring turnover, the bottom waters are high in oxygen and the oxygen uptake rates of the bottom sediments from decaying organic matter are relatively low thus allowing the hypolimnion to remain high in DO throughout the summer. Also, Big Lake is relatively large in surface area that may allow wind and wave action to effectively mix the surface waters during the summer months. Since the first sampling event in May took place after the spring turnover, it is not know if the bottom waters become oxygen depleted during the winter months.

Turbidity measurements had no readings that exceeded the AWQS of 5 NTU above natural conditions. Conductivity values varied within a small range for 2005. The mean reading for 2005 was 0.129 µS/cm, although the mean for the October 15 sampling event, 0.96 µS/cm, was lower than readings from all other events.

4.2 Bacteria

Fecal coliform bacteria concentrations at Big Lake in 2005 were all less than the AWQS of 20 col/100 mL. The highest reading of 2005 was 9 col/100 mL, recorded at BL-10 on July 23, 2005. The sampling site with the highest geometric mean concentration during 2005 was BL-11. BL-11 is a shallow, reedy sampling site where a beaver was observed swimming on October 15. Sampling site BL-10 had the next highest mean reading of 1.8 col/100 mL.

4.3 Nutrients

Nutrients are important for understanding the effects of cultural eutrophication upon Big Lake. As discussed in the Introduction, residential development on Big 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. 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.

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 (TSI), which is summarized in Table 13 below. Ranges provided for Carlson's TSI indices were entered into his calculations to obtain the relative total phosphorus, chlorophyll a and Secchi disk ranges for the trophic state of Big Lake.

Table 13. 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

TSI Range	Total Phosphorus (µg/L)	Chlorophyll a (µg/L)	Secchi Disk (m)	Description
				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.

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/nitrite also are associated with fertilizers because they are degradation compounds of ammonia; and TKN is a 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 and also the composition of the plant community (Edmundson 2002). Inorganic nitrogen is measured by the ammonia and nitrate/nitrite components. Organic nitrogen is measured by subtracting ammonia from the TKN value.

The frequency of ammonia detections in samples increased throughout the 2005 sampling season, from a 9% detection frequency in May to 100% in October. The average ammonia level in the lake in October was 90 µg/L. Ammonia was detected in only a single sample in 2004 (186 µg/L on May 16, 2004) and ammonia concentrations from two previous studies never peaked above 30 µg/L in the epilimnion (Woods 1992 and Edmundson 2002). Samples taken during the 2004 study were collected prior to mid-June. The higher ammonia detection frequency noted later in the summer in 2005 can be attributed to lower dissolved oxygen levels and increasing heterotrophic decomposition of organic matter (Woods 1992). The higher ammonia concentrations in 2005, compared to maximums reported by Woods (1992) and Edmundson (2002), may be attributed to an increase in average atmospheric temperatures in 2005.

TKN was detected in a single sample during the May 12 sampling event (9% of samples) and in almost every sample during remaining events. Average TKN for the lake peaked in July at 0.47 mg/L and decreased slightly over the course of the sampling season to an average of 0.30 mg/L in October. Organic matter produced by plankton in the epilimnion (upper lake thermal stratum) may contribute to higher TKN values in mid-summer.

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 0.031 mg/L and 0.120 mg/L, respectively. Only 19.1% of ortho-phosphate samples were detected above the reporting limit, and even less (10.6%) of total phosphorus samples. This means that an analysis of phosphorus-associated parameters cannot be performed given the data set that exists for Big Lake.

Trophic State Index

The trophic state index (TSI) was calculated for chlorophyll a and Secchi disk readings at Big Lake. The average chlorophyll a concentration at Big Lake for all sampling sites and dates was 1.6 µg/L, with a calculated TSI of 35. The average Secchi disk depth for all sites and dates at Big Lake was 4.5 m, with a corresponding TSI of 38. Both the chlorophyll a measurements and the Secchi disk readings classify Big Lake as oligotrophic.

Total phosphorous was detected in only 10 percent of samples, at concentrations just above the laboratory reporting limit; therefore, the total phosphorous TSI cannot be evaluated with accuracy. However, for comparison purposes, the Carlson's TSI was calculated using the method reporting limit (31 µg/L) as the assumed phosphorous concentration. The resulting TSI of 54 would result in a eutrophic category for the lake. There was no evidence of a dominance of blue-green algae or algal scums synonymous with eutrophic conditions at Big Lake; therefore, the assumption can be made that total phosphorous concentrations are generally low.

4.4 Hydrocarbons

Eleven exceedences of the AWQS for TAH (10 µg/L) were reported at Big Lake. All exceedences occurred at either sampling site BL-8 or BL-10, with seven of the eleven exceedences occurring at sampling site BL-10. Sampling site BL-10 had the highest concentrations of TAH with a maximum of 62 µg/L. The majority of exceedences occurred at the shallow depth of 0.15 meter although at BL-1 on May 28 and July 23, the deeper sample (0.5 meter) had a higher concentration than the corresponding shallow sample. This indicates that lake activity, whether boats or wind or other factors, is mixing the lighter-than-water hydrocarbons into the water column.

Sampling site BL-8 is in front of Berkshore Marina, and sampling site BL-10 is at the North Shore State Recreation Area public boat launch. It is likely that fuel handling practices and the mixing of cooling water with exhaust emitted from recreational outboard motors have resulted in the TAH contributions noted near the boat launch areas. Therefore, it is not surprising that the highest TAH readings came from these sampling sites where boat traffic would be expected to be most frequent.

4.5 Sampling Sites

The previous four subsections reviewed results by analyte. This subsection presents a summary by sampling site. Table 14 presents pertinent information and data for each sampling site.

Table 14. Sampling Site Analytical Summary

Sampling Site	Summary of Results
BL-1	The deep water, west basin location was the only location with consistent detections of ortho-phosphate. Both shallow and deep samples on August 20 and October 15 had detected concentrations. The lowest concentrations of TAH were observed at this location.
BL-2	This location between the two basins had TKN concentrations that appear to be above average at the depth of 1 meter. The greatest detection of TKN for all of 2005 was recorded from a deep sample (4 meters) at this location.
BL-3	This deep water, east basin location appears to have average concentrations of nutrients.
BL-5	This location near a condo development appears to have average concentrations of nutrients and bacteria.
BL-6	A slight spike in TAH concentrations occurred during the July sampling events at this location near the Southport Marina.
BL-7	A slight spike in TAH concentrations occurred during the July and August sampling events at this location.
BL-8	This location had TAH concentrations that exceeded AWQS on July 23 and August 20 from both the shallow and deep samples. This location is near the Burkeshore Marina.
BL-10	This location at the North Shore State Recreation Area public boat launch had the following maximums during 2005: greatest geometric mean of fecal coliform recorded in 2005 during the July 23 sample event; greatest mean concentration of TKN for all of 2005; greatest TAH concentrations for Mat 28, July 3, July 23, and September 4.
BL-11	Located in a wetland area at the inlet of Meadow Creek, this location had the greatest geometric mean of fecal coliform of all sampling sites. Given the shallow wetland environment and the presence of a beaver during the October 15 sampling event, this fecal coliform result is not unexpected.
BL-17	The sampling site is near the South State Recreation Area boat launch and camping area. It had the greatest geometric mean of fecal coliform for the May 28 sample event, but concentrations decreased with each sample event.
BL-20	This sample location is in a residential area in the east basin of the lake. Nutrient results were unremarkable at this location.
BL-40	Semi-random sample location for May 28. Fecal coliform results were non-detect.
BL-50	Semi-random sample location for May 28. Fecal coliform results were non-detect.
BL-80	Semi-random sample location for October 15. Fecal coliform results were non-detect.
BL-90	Semi-random sample location for October 15. Fecal coliform results were non-detect.

4.6 Recommendations

Results for several of the nutrient parameters were below the method reporting limits. Detected nutrient concentrations were relatively low and consistent with data from sampling conducted in 2004. Based on the apparent consistency in nutrient data from year to year, and a stable Carlson's TSI indicting oligotrophic conditions, OASIS recommends eliminating nutrient analyses from the annual sampling scheme at Big Lake.

Similarly, fecal coliform levels for 2004 and 2005 have been consistent and below applicable AWQS. OASIS recommends eliminating fecal coliform from the list of annual sampling parameters.

Several exceedences of the AWQS for TAH (10 µg/L) were reported at Big Lake in 2005. All exceedences occurred at either sampling site BL-8 or BL-10, with six of the nine exceedences occurring at sampling site BL-10. These sampling locations were located in high-use boat launch areas. Based on motorized user surveys conducted during each sampling event, the elevated TAH concentrations appear to be associated with periods of higher lake usage. OASIS recommends continuing to document hydrocarbon levels at these types of areas during high-use weekends. It may be particularly important to track TAH concentrations at BL-10. This location is immediately adjacent to the public swimming area, where consistently high hydrocarbon levels may pose a health risk.

Future monitoring activities should concentrate on the identified issue of TAH loading near sampling sites BL-8 and BL-10. BL-8 is located in front of Berkshore Marina, and sampling site BL-10 is located at the North Shore State Recreation Area public boat launch. Further study in these areas should be designed to assess the usage level that causes TAH concentrations to exceed the AWQS. The sampling periods should compare the popular holiday weekends of Memorial Day, Independence Day, and Labor Day, which are likely the peak boat usage weekends, with lower-use days exhibiting average watercraft activity. With a suitably robust sampling plan, such a study would characterize the use-level that causes TAH exceedances i.e., a threshold use-level. The estimated threshold use-level could then be compared to historic state Park Service boat launch area use data to estimate the number of days per year that TAH levels are likely exceeded.

The conclusions from this study would allow local authorities to decide whether available management options for the boat launch areas should be evaluated to minimize human health concerns over the elevated TAH concentrations. Best management practices (BMPs) used in high-use aquatic recreation areas elsewhere could be researched based on the study findings.

The long-term plan should also include monitoring of physical parameters at deep water sites BL-1 and BL-3 so that the lake's physical characteristics and changes may be better understood through year-over-year comparisons. The 2006 monitoring should include early spring monitoring of physical parameters to examine DO levels, etc. following the winter season, as well as late September monitoring to better understand when the lake stratification terminates, as was observed in data from October 15, 2005.

Beyond the immediate water quality issues, a long-term plan for assessing water quality is advantageous as levels of use and development increase at Big Lake. A full monitoring schedule could be performed every five years to track nutrient and bacteria levels.

5 REFERENCES

ADEC, 2002. *Total Maximum Daily Load for Dissolved Oxygen in the Waters of Lake Lucille, Alaska.* February 11, 2002.

Edmundson, J.A., V.P. Litchfield and D.M. Cialek, 2000. *An Assessment of Trophic Status of 25 Lakes in the Matanuska-Susitna Borough, Alaska.* ADF&G, Commercial Fisheries Division, Regional Information Report No. 2A00-26:41p.

Edmundson, J.A., 2002. *Limnological Information Supporting the Development of Nutrient Criteria for Alaskan Lakes: Water-Quality Monitoring and Trophic Assessment of Seven Lakes in the Matanuska-Susitna Borough.* ADF&G, Division of Commercial Fisheries, Regional Information Report No. 2A02-24:72p.

Eilers, J.M. and J.A. Bernert, August 31, 1993. *Final Report, Lake Lucille, Alaska, A Phase-I Diagnostic & Feasibility Study.* Prepared for City of Wasilla, Alaska by E&S Environmental Chemistry, Inc.

Minnesota Pollution Control Agency (MPCA), 2004. *Assessments of Lake Conditions in Minnesota's Major River Basins.* Accessed on the web on July 14, 2004 http://www.pca.state.mn.us/water/basins/305blake.html#process. July 14, 2004.

OASIS, 2004. *Big Lake and Lake Lucille Water Quality Monitoring, Final Report (2004).* September 6, 2004.

OASIS, 2005a. *Lake Lucille and Big Lake Water Quality Monitoring, Big Lake Sampling Plan.* April 13, 2005.

OASIS, 2005b. *Lake Lucille and Big Lake Water Quality Monitoring, Quality Assurance Project Plan.* April 2005.

Woods, Paul F. 1992. *Limnology of Big Lake, South-central Alaska,* 1983-84. USGS Water Supply Paper 2382.

ATTACHMENT A
PROJECT SAMPLING PLAN

ATTACHMENT B
QUALITY ASSURANCE PROJECT PLAN

ATTACHMENT C
QUALITY ASSURANCE REVIEW

Quality Assurance Review
2005 Big Lake Water Quality Monitoring

Sampling Protocol

A deviation from QAPP sampling protocol occurred during the Big Lake 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. The added, abbreviated sampling event on September 4 amended the error by collecting the deep hydrocarbon samples from 1.5 meters. 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 first sampling event at Big Lake on May 12, while taking field parameters measurements at location BL-2, pH measurements notably started to increase. The cause of this anomaly was an apparently faulty YSI meter cable, as confirmed by the manufacturer's representative following the sampling event. Dissolved oxygen measurements also were anomalous and may be contributed to the faulty cable. Field parameter measurements from the May 12 sampling event 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 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 seven separate occasions from Big Lake during 2005. These sampling events were conducted on May 12, May 28, July 3, July 23, August 20, September 4, and October 15, 2005. The associated SGS Environmental Services, Inc. (SGS) work orders for these sampling events were 1052584, 1053002, 1053957, 1054531, 1055346, 1055782, and 1056889. Surface water samples collected for the analysis of chlorophyll A were submitted to Analytica Environmental Laboratories (Analytica). Surface water samples were collected from sampling stations on Big Lake on May 12, July 3, August 20, and October 15, 2005. The associated Analytica work orders for these sampling events were A0505181, A0507023, A0508252, and A0510174. 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 Lake Lucille and is reported in SGS work order number 1053969. The rinse blank is applicable to activities at Big Lake because the sampling equipment and decontamination procedures used at both lakes were identical. Sampling events at these lakes were conducted concurrently within the same weekend.

Documentation associated with the surface water samples was reviewed to determine compliance with recommended holding times and sample preservation techniques. All samples were analyzed within their respective holding times except for the ortho-phosphate samples collected at Big Lake on May 12, 2005. The holding time for ortho-phosphate is 48 hours (2 days). Samples were analyzed on June 2, 17 days after sample collection. All of the results were below the reporting limit and have been qualified “VR” to indicate potential degradation of the analyte in the sample matrix prior to analysis due to the 8.5-fold hold time exceedence. Samples collected for total phosphorous in this work order were preserved properly and analyzed within hold time. Analytical results in SGS work order 1052584 for total phosphorus were all non-detect at the 0.1 mg/L reporting limit. The reporting limit for the total phosphorous method, after correcting for molecular weight differences, is lower than the ortho-phosphate method; therefore, the total phosphorous data may be used in lieu of ortho-phosphate data in SGS work order 1052584 to assess for the presence of phosphorous contributed by the presence of ortho-phosphate at the ortho-phosphate reporting limit of 0.4 mg/L.

The cooler submitted on the October 15, 2005 sampling event (SGS work order 1056889) was received at the lab with temperature blank and cooler temperatures below the method requirements of 4.0°C (+/- 2.0°C). Although some ice was noted in five of the samples submitted, sample container integrity in this cooler was not compromised due to freezing and associated laboratory data were not qualified.

The laboratory noted a sample labeling transposition that did not agree with field labeling during the sample receipt process for two samples collected on July 3, 2005 (SGS work order 1053957). The laboratory contacted OASIS field personnel and corrected the labeling error prior to sample analysis. Laboratory records did not indicate any other inconsistencies with the sample handling process.

Trip blanks accompanied the samples and were submitted for analysis of BTEX compounds. The BTEX compounds toluene, ethylbenzene, and o-xylene were detected at concentrations of 0.000610 mg/L, 0.000630 mg/L, and 0.000440 mg/L, respectively in the trip blank submitted during the July 3, 2005 sampling event (SGS work order 1053957). These concentrations were below the method reporting limit (MRL) for the respective analytes and no data qualification was performed. The compounds p&m-xylene were detected at a concentration of 2.24 mg/L, exceeding the MRL of 2 mg/L. Results for p&m-xylene in work order 1053957 that were within five times the concentration observed in the trip blank were qualified “VB” to indicate potential contamination.

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 more than three times the highest toluene result obtained from samples collected from Lake Lucille that day. No qualifications to Big Lake 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 15, 2005 sampling event (SGS work order 1056889). Orthophosphate was non-detect in all associated project samples and no data qualification was performed. One volatile organic compound (VOC) method blank analyzed with samples collected during the July 3, 2005 sampling event (SGS work order 1053957) contained naphthalene. This compound was not a target analyte 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 are 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. Matrix volume limitations prevented the analysis of MSD samples. Percent recoveries for project sample matrix spikes were below the lower control limit for the four events during which nutrient samples were collected from Big Lake 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, all total nitrite/nitrate data from the 2005 sampling season 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 with the following exceptions. The bromofluorobenzene (BFB) surrogate in the method blank for the July 3 2005 sampling event (SGS work order 1053957) exceeded the upper control limit. Associated target analytes were not detected in this method blank and no data qualification was required. The BFB surrogate results for samples collected for the August 20, 2005 sampling event (SGS work order 1055346) exceeded upper control limits. Associated target analytes were not detected above the MRL and no data qualification was required.

Field duplicates were collected for each analysis during each sampling event. Six duplicates were collected for TAH, fifteen duplicates were collected for fecal coliform, and four duplicates were collected for nutrients. One duplicate sample pair was 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, benzene, and toluene, 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 Big Lake on October 15 was > 20% RPD at 34%. 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. Primary and duplicate sample results for benzene and toluene were greater than 10 times their respective reporting limits of 0.4 mg/L and 1.0 mg/L on July 3, 2005 and July 23, 2005. Primary and duplicate results for benzene and toluene for samples collected on July 23 were within the 20% RPD precision criterion. Primary and duplicate results for benzene and toluene for samples collected on July 3 exceeded the 20% RPD precision criterion at 25.6%, and 28.3%, respectively. Associated benzene and toluene data that exceed the method reporting limit in SGS work order 1053957 have been qualified “VJ” to indicate estimated values.

Project completeness for analytical sample collection is 98%. This meets OASIS’ goal of 95% established for the project in the QAPP. Chlorophyll a samples were not collected at BL-5(1) and BL-10(1) on 8/20/05 because the hand pump used to filter the samples broke during sampling. Rejected ortho-phosphate data from SGS work order 1052584 is supplemented by the total phosphorus data with passing QC. Project completeness measures the number of samples collected divided by the number called for in the original sampling design. The original sampling design called for collection of nutrient and hydrocarbon samples at specific lake depths that were not collected at all sites due to shallow water. Completeness was calculated using the number of sampling sites and depths established after the first sampling event at both lakes.

ATTACHMENT D
PHOTOGRAPH LOG

ATTACHMENT E
FIELD AND ANALYTICAL DATA TABLES

ATTACHMENT F
SAMPLE FIELD DATA SHEETS

ATTACHMENT G

CD of REPORT, LABORATORY DATA REPORTS, AND ANALYTICAL RESULTS DATABASE