



Grayson County, Texas



**Blue-Green Algae in Lake Texoma
An Assessment of the Health Effects of Cyanobacteria in
Lake Texoma
Based on Water Sampling Over a 16-Month Period
May 17, 2013**

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Executive Summary

The Grayson County Health Department (GCHD) has been actively studying the issue of blue-green algae (BGA – also referred to as cyanobacteria) in Lake Texoma since July, 2011. In the spring of 2012, the GCHD:

- 1) Wrote a County Order (county law) addressing BGA in Grayson County water bodies;
- 2) Wrote a detailed Blue-Green Algae Response Plan, adopted by reference in the County Order; and
- 3) Wrote an official Position Paper on the public relations issue represented by BGA in Lake Texoma.

The Health Department now possesses 16 months of water testing data and epidemiologic data related to BGA. In addition, the department has official responses from the Texas Department of State Health Services and the Texas Commission on Environmental Quality regarding each agency's position and level of concern regarding the human health risks posed by the presence of BGA in Texas' lakes and rivers. This comprehensive BGA study found that cyanobacteria in Lake Texoma vary in cell densities (cell counts) from a few thousand cells per milliliter of water to 800,000 cells/ml. Of the estimated 2000 known species of BGA worldwide, there are typically from 75 to 125 species inhabiting Lake Texoma. The majority of cyanobacteria species present, year round, is composed of species thought to be harmless. Testing for the four common BGA toxins revealed that three are essentially absent (anatoxin-a, microcystins, and saxitoxin), but the toxin cylindrospermopsin is present in each sample collected, averaging 0.2 parts per billion (**near the limit of detection, and of no public health significance**). Benchmark water sampling in Lake Ray Roberts and in Lake Lavon in August, 2012 revealed cell counts and toxin levels similar to those routinely found in Lake Texoma. Statistical analyses of Lake Texoma data revealed that the Total BGA, PTOX, and *Cylindrospermopsis raciborskii* cell counts showed a statistically-significant, positive correlation with the amount of cylindrospermopsin toxin in the lake water (though the amount of toxin was of no public health significance). Review of recent BGA studies from Florida reveal that strains of the species *Cylindrospermopsis raciborskii* that inhabit United States lakes and rivers are not capable of producing the toxin cylindrospermopsin, though strains of this alga from Australia do sometimes produce the toxin.

An extensive surveillance effort by the GCHD to seek reports of human illness and/or dog illnesses/deaths after exposure to Lake Texoma water resulted in two reports of digestive system illnesses in the summer of 2012. Epidemiologic investigations of both families' reports revealed symptoms consistent with a viral (contagious) gastrointestinal infection. The Health Department enlisted the help of hospital emergency departments in a five county Texas and Oklahoma region (the Texoma region), veterinarians, Texas Parks and Wildlife, the US Fish and Wildlife Service (Hagerman Wildlife Management

Area), local physicians, and the US Army Corps of Engineers (Lake Texoma office). Between January, 2011 and May, 2013, this surveillance resulted in the following:

- No reports of human illness from hospital Emergency Departments related to exposure to Lake Texoma
- No reports of human illness from local physicians or dermatologists (reports of suspicious skin rashes) related to exposure to Lake Texoma
- No reports from veterinarians in the five-county region of suspicious poisonings in dogs related to exposure to Lake Texoma or to local stock ponds
- No reports of fish kills (or suspicious bird or mammal deaths near lake shores) in Lake Texoma from the TD-USACE, Texas Parks & Wildlife, the US Fish & Wildlife Service, or TCEQ

The GCHD found that the amount of the toxin cylindrospermopsin generally present in Lake Texoma (ranging from not-detected to a high of six-tenths of one part per billion) has the following toxicological significance:

- The amount of toxin present is eight times below the GCHD's first level of concern (level Yellow at 5 ppb)
- The amount of toxin present is 31 times below the GCHD's high risk threshold for people and pets (20 ppb)
- A 40 pound child would have to accidentally ingest (drink) 33,000 gallons of Lake Texoma water to receive a fatal dose
- A 150 pound adult could drink about one gallon of Lake Texoma water, every day for a lifetime, without any health effects from the toxin cylindrospermopsin

The report includes 10 detailed recommendations, concluding with the following concepts:

1. The public relations issue of BGA in Lake Texoma (and other Texas and Oklahoma lakes) should be thoroughly reassessed by elected and appointed policy makers;
2. Data obtained in 2011, 2012, and 2013 in Lake Texoma support the position that these microscopic plants **do not represent a current hazard to lake patrons, or to their dogs;**
3. When compared to other health and safety risks involving outdoor lake recreation [e.g. drowning (4 drowning deaths in Lake Texoma in 2012), boating accidents, sunburn, slip/fall accidents, and digestive illnesses caused by accidental ingestion of lake water containing pathogenic bacteria or viruses], exposure to BGA cells becomes insignificant (except in rare ecological circumstances not previously found in Lake Texoma);
4. Cyanobacteria in Lake Texoma (and other Oklahoma and Texas lakes and rivers) are worthy of vigilance and study by health and environmental protection officials, **but not worthy of worry;**
5. Any blue-green algae risk communication releases to the public for Lake Texoma not provided by the Grayson County Health Department or the Oklahoma Tourism and Recreation Department should be viewed with caution, and generally ignored by the recreating public.

Introduction

This report serves as a situation update on the status of a group of microscopic plants (phytoplankton) commonly referred to as blue-green algae (BGA), also known to scientists as cyanobacteria, which are a component of the natural lake ecosystem in Lake Texoma. The information and data in the document should be considered as companion documents to reports published by the Grayson County Health Department (GCHD) in 2012 (i.e. a. Grayson County Blue-Green Algae Response Plan and b. Blue-Green Algae Position Paper). The purposes of the report are to 1) describe the state of knowledge of the seasonal variations in the amount and types of BGA in Lake Texoma, 2) discuss the results of testing for the four common BGA toxins, 3) present conclusions related to the relative risk to human and animal health posed by recreating in Lake Texoma, and 4) provide recommendations to elected and appointed policy-making officials in Texas and Oklahoma.

Recap of the Public Policy Issues Surrounding BGA in Lake Texoma

The GCHD became aware of the topic of BGA in Lake Texoma in the late summer of 2011. A few stories in the electronic and print media described a high level of concern on the part of the Tulsa District of the US Army Corps of Engineers' (TD-USACE) recent discovery of what the Corps thought were high amounts of BGA in the lake during the summer of 2011. GCHD employees began receiving telephone and e-mail inquiries from concerned citizens in August, asking the department whether it was safe to use Lake Texoma for swimming, fishing, boating, and lakeside camping. The GCHD's management team, led by its Environmental Health Division (EHD) officed in Denison, initiated an intensive research effort to ascertain the following:

- What public risk communication was TD-USACE releasing to the public?
- What scientific data was TD-USACE using on which to base its decisions?
- What legal authority did TD-USACE possess to establish water quality standards for cyanobacteria in any of the lake projects it manages in Kansas, Oklahoma, and Texas?
- What local, state, and federal recommendations or limits existed for cyanobacteria and/or their common toxins?
- What level of risk to human and animal health do BGA pose, as described in the worldwide scientific literature?

In essence, the GCHD was charged by the Grayson County Commissioners Court to study and understand the decisions being made by TD-USACE scientists and managers (i.e. the Corp's decision to suddenly begin looking at BGA in Lake Texoma and immediately begin warning Texoma-region citizens about allegedly hazardous conditions to lake patrons) and to assess whether the GCHD concurred with the Corps' relatively dire message to the public. The EHD's efforts included extensive phone interviews of TD-USACE managers and scientists, as well as discussions with public

health, environmental protection, and fish & wildlife agencies at the state and federal government levels. In addition, the EHD began a systematic review of the worldwide literature related to BGA in freshwater lakes and rivers. Before the Health Department could complete its comprehensive assessment of the prudence and appropriateness of the TD-USACE's public education campaign, the agency (just days prior to Labor Day weekend 2011) elevated its relatively new BGA threat communication system to its highest possible level (referred to as a BGA "Warning"). The Corps provided very specific cautionary advice to Lake Texoma patrons, inclusive of language recommending that "contact with the water should be avoided." These risk communication actions by the TD-USACE were taken in the near absence of communication and/or coordination with state and local health and environmental officials in Oklahoma and Texas. Public reaction to the Corps' public education campaign was swift and dramatic. Use of Lake Texoma on Labor Day weekend (2011) was greatly diminished. Reservations at resorts and campgrounds were cancelled in large volumes. The Lake Texoma Association (a non-profit lake-area business promotion organization) estimates that the loss in retail sales between September 1, 2011 and December 31, 2011 exceeded \$45 million. Approximately a half-dozen Grayson County food retailers near the lake went out of business.

Official Positions of the Texas Department of State Health Services and the Texas Commission on Environmental Quality

As a component of the GCHD's comprehensive assessment of the relative human (and animal) health risks posed by the presence of cyanobacteria in fresh water lakes and rivers, the Grayson County Commissioners Court was enlisted for assistance. In August, 2012, Grayson County Judge Drue Bynum sent letters to executives with the Texas Department of State Health Services (DSHS) and with the Texas Commission on Environmental Quality (TCEQ). Each letter requested a formal, written, official position each agency possessed with respect to the relative public health and environmental protection risk posed by BGA blooms in Texas' extensive inventory of lakes and rivers. The official responses of DSHS and TCEQ are included as Appendix 1. A summary of each agency's official response is as follows:

Texas Department of State Health Services

- The state health department does not sample bodies of water in Texas for BGA or the toxins they can produce.
- In 2012, the state health department fielded two calls at the Texas Poison Control Network in which callers stated they had illness symptoms after potential contact with BGA. One caller lived in Grayson County and one lived in Denton County. The state health department could not determine causality for their symptoms.
- The state health department has no plans to study the topic of BGA in Texas waters.
- No collaborative projects with the TCEQ regarding BGA are planned.

- DSHS has no authority to set water quality standards for BGA or their toxins: Only TCEQ has that authority.
- DSHS is not aware of any large-scale illness outbreaks associated with cyanobacteria in Texas lakes.
- DSHS does not have a position on whether cyanobacteria in recreational waters pose a health risk.
- DSHS has communicated a concern to the Association of State and Territorial Health Officials (ASTHO) regarding the issue of inconsistent standards used by the US Army Corps of Engineers.

Texas Commission on Environmental Quality (TCEQ)

- TCEQ is collaborating with several entities in efforts to sample certain Texas lakes and river systems for BGA and their toxins
- TCEQ is teaming with the US Geological Survey to monitor 19 Texas lakes for multiple parameters (inclusive of BGA) in the summers of 2012, 2013, and 2014
- TCEQ is cooperating with Auburn University in the sampling of selected US lakes
- The agency worked with the US EPA for the Texas portion of the 2012 National Lakes Assessment. This EPA study included 47 Texas lakes during the summer of 2012, and included tests for microcystin and BGA cell counts
- In recent years, TCEQ has received only one call about an illness in a citizen following swimming in a reservoir that the caller suspected could be related to BGA. An investigation by TCEQ staff did not identify visible algal blooms in the reservoir in question
- TCEQ often assists the Texas Parks & Wildlife Department (TPWD) in the investigation of fish kills. BGA are sometimes thought to contribute to fish kills when a bloom dies, thereby lowering dissolved oxygen in the water; however, these fish kills are not directly tied to BGA toxins in the water
- TCEQ considers blue-green algal toxicity as a potential water quality concern and is studying the topic
- The agency does not currently have any collaborative BGA studies occurring with DSHS or TPWD, nor are any such studies planned at this time
- In the near future, TCEQ will develop proposals for their triennial revisions to the Texas water quality standards; however, the agency does not have plans to include standards that address BGA
- TCEQ is unaware of specific documented instances of blue-green algal toxicity due to recreational exposure in Texas reservoirs
- Due to documented cases of adverse effects in other regions of the US, further evaluation of BGA is warranted

Blue-Green Algae Philosophies of the Fort Worth Office of the US Army Corps of Engineers

GCHD officials interviewed, by telephone, members of the field biology team for the Fort Worth District of the US Army Corps of Engineers (FWD-USACE) in the spring of 2012 and again in May, 2013. The purpose of the phone interview was to determine the level of importance that the FWD-USACE placed on the relative human health and environmental hazards posed by the presence of cyanobacteria in the 25 lakes in Texas managed by their district office. The position of the FWD-USACE remains consistent. The field biologists for this agency do not consider cyanobacteria to be a significant human health threat or risk for fish or wildlife. Consequently, the FWD-USACE does not test water in its 25 Texas lakes for BGA cell count or for BGA toxins. This district of the Corps indicates that, with respect to Lakes Lavon and Ray Roberts, no fish kills have been observed in 2012 or 2013, and no reports of human illness or pet or wildlife deaths potentially consistent with exposure to BGA toxins have been reported to the Fort Worth office.

Sampling and Testing Activities

Beginning in February, 2012 the GCHD initiated a regular water sampling and testing effort in Lake Texoma. Public Health Sanitarians, working as a team with Grayson County Deputy Sheriffs, use the Sheriff's Office patrol boat to collect water samples for cyanobacterial testing. To allow direct comparisons with historic and future water sampling conducted by TD-USACE and other agencies (e.g. University of Oklahoma), the GCHD utilizes the eight (8) official Texoma sampling sites* chosen by the Corps. These eight official water sampling sites are:

1. Burns Run East
2. Johnson Creek
3. Little Glasses Creek
4. Little Mineral Arm
5. Sheppard Annex
6. Lakeside PUA
7. Treasure Island
8. Highway 377/Highway 99 Bridge

*Note: Eisenhower State Park – UNT -17 is another site that has been sampled by both the USACE and the GCHD in the past.

To reduce the overall cost of laboratory testing, the GCHD chooses four of the eight sites during a specific month, then alternates to the other four official sites the following month. Sanitarians use a Wildco Brand Vertical Van Dorn Style Alpha Bottle sampling device, and collect water samples from a depth of three feet. Water samples from each of the four sites are placed on ice, then shipped to two different facilities for BGA analysis. All samples are shipped by air freight companies overnight. Water samples

shipped to the Institute for Environmental and Human Health (IEHH) at Texas Tech in Lubbock are analyzed for the four common cyanotoxins (i.e. cylindrospermopsin, anatoxin-a, microcystins, and saxitoxin). The IEHH has swift turnaround times, generally providing toxin results to the Health Department in 24 to 48 hours. Water samples from each of the four locations are also shipped to a private, for-profit environmental testing laboratory in Florida (GreenWater Laboratories in Palatka, FL). GreenWater phycologists (algae biologists) examine each water sample under microscopes to identify each type (species) of BGA present and to count each type of algae present. Numerical totals are reported as cells per milliliter of water (also called cell densities).

The GCHD's BGA Response Plan (adopted as County Law in May, 2012) requires the health department to collect samples once per month from October through April, and twice each month from May through September (boating season).

Relevant Water Quality Standards for Cyanobacteria in Recreational Lakes

Because cyanobacteria are normal components of the natural ecosystems in lakes and rivers throughout the world, and arguably due to the fact that cyanobacteria are not widely accepted in the public health, environmental protection, and medical communities as bona fide threats to human health (except in extremely rare instances), there are not a large number of state and federal agencies (or local jurisdictions) which have adopted quantitative (numerical) standards for these microscopic plants or for the four common toxins that some BGA species can produce. A partial summary of regulatory standards for BGA in the United States is as follows:

US Environmental Protection Agency

Currently, the EPA has no standards for cell counts or toxins in recreational waters. In addition, the EPA has no standards for cyanotoxins in tap water.

US Centers for Disease Control

Currently, the CDC has no standards for cell counts or toxins in recreational waters. In addition, the CDC has no standards for cyanotoxins in tap water.

State of Oklahoma

Senate Bill 259, enacted in May, 2012, prohibits any Oklahoma state agency or any county in Oklahoma from posting BGA advisories or warnings unless both of the following criteria are met:

- a) Total BGA cell counts exceed 100,000 cells/ml, and
- b) The concentration of microcystin is equal to or greater than 20 parts per billion.

State of Texas

Currently, the State of Texas has no standards for cell counts or toxins in recreational waters. In addition, the State of Texas has no standards for cyanotoxins in tap water.

Grayson County Health Department

Comprehensive epidemiologic and water testing-based risk communication tool. Green-Yellow-Red public information system based on concentrations of four toxins in lake water, and confirmation of sentinel events, such as adverse health effects in fish, wildlife, domestic pets, or people. BGA cell counts are not generally considered in the risk assessment protocol used to declare the level of advisory (green-yellow-red).

State of Ohio

For recreational waters, microcystin is the regulated toxin. State health department issues a “Health Advisory” if microcystins reach 6 ppb, and a “No Contact Advisory” if microcystins reach 20 ppb. No standards for BGA cell counts are used.

State of Vermont

For recreational waters, if microcystins reach 6 ppb, the state issues a “Health advisory/closure”.

State of Oregon

For recreational waters:

- Health Advisory if Total BGA cell count exceeds 100,000 cells/ml
- Health Advisory if Microcystis or Planktothrix cell counts exceeds 40,000 cells/ml
- Health Advisory if anatoxin-a reaches 20 ppb
- Health Advisory if cylindrospermopsin reaches 6 ppb
- Health Advisory if microcystins reach 8 ppb
- Health Advisory if saxitoxin reaches 100 ppb

State of California

For recreational waters, issue Health Advisory if:

- Microcystins exceed 0.8 ppb
- Cylindrospermopsin exceeds 4 ppb
- Anatoxin-a exceeds 90 ppb

Test Results for the Period February 2012 to May 2013

Date	Total BGA Cell Count-cells/mL	PTOX cell count-cells/mL	Cylindrospermopsin Toxin parts per billion (ppb)
2/22/2012	22,238	8,467	0.07
3/28/2012	27,290	719	0.15
4/16/2012	1,888	37	0.21
5/9/2012	34,460	493	0.04
5/16/2012	96,113	8,154	0.03
6/13/2012	205,747	12,418	0.08
6/26/2012	166,435	13,790	0.05
7/17/2012	564,374	79,992	0.28
7/26/2012	417,333	122,735	0.46
8/20/2012	337,160	40,595	0.43
9/20/2012	286,866	13,936	0.45
10/24/2012	534,911	15,290	0.22
11/26/2012	89,282	18,739	0.31
1/31/2013	34,054	3,423	0.03
3/27/2013	4,272	182	0.10
4/15/2013	77,233	6,450	0.22
5/13/2013	49,990	14,608	0.10
5/15/2013	195,570	17,425	<0.10 (not detected)

Total blue-green algae cell counts ranged from a low of 1888 cells/ml to a single site high of almost 800,000 cells/ml, with an average for calendar year 2012 of 214,000 cells/ml. The only BGA toxin found above detection limits was cylindrospermopsin, ranging from not-detected to a single site maximum of 0.63 parts per billion (July 2012-Little Mineral Arm). This toxin averaged 0.2 parts per billion over calendar year 2012.

Benchmark Comparisons
From Two Nearby US Army Corps of Engineers Lakes

When lake patrons who normally use Lake Texoma are warned against contact with water in the lake by public service announcements issued by TD-USACE, many of these boaters use either Lake Ray Roberts (in Denton and Grayson Counties), or Lake Lavon (in Collin County). To ascertain whether Lakes Ray Roberts and Lavon contained BGA cell counts and/or BGA toxin levels similar to Lake Texoma during the boating season, the GCHD collected water samples from Lake Texoma on August 20, 2012, and Lake Ray Roberts and Lake Lavon on August 21, 2012. These samples were analyzed for BGA cell counts and for the four common BGA toxins. A comparison of the test results for Lakes Texoma, Ray Roberts, and Lavon in August, 2012 is shown below:

Location	Total BGA in cells/mL	PTOX in cells/mL	Cylindrospermopsin toxin in ppb
Lake Texoma	337,160	40,595	0.25
Lake Ray Roberts	188,234	51,777	0.10
Lake Lavon	1,665,849	146,284	Not Detected

The GCHD repeated this benchmark sampling in May, 2013. Public health sanitarians collected samples on May 15, 2013, with results shown below:

Location	Total BGA in cells/ml	PTOX in cells/ml	Cylindrospermopsin toxin in ppb
Lake Texoma	195,570	17,425	Not detected
Lake Ray Roberts	413,812	177,683	Not detected
Lake Lavon	97,485	1,046	Not detected

As can be seen from these data, total cyanobacterial cell counts are somewhat similar (except for PTOX in Ray Roberts in 2013) for each of these three lakes, with the cell densities (cell counts) for Lake Lavon being the highest in 2012, and Lake Ray Roberts having the highest cell counts in May, 2013. Consistent with toxin testing in Lake Texoma over the 16 months discussed in this report, only one of the four common BGA toxins (cylindrospermopsin) was found in the benchmarked lakes (Lake Ray Roberts), and the concentration was near the limit of detection in 2012. In May of 2013, no cylindrospermopsin toxin was detected in any of the three lakes. Using the official BGA risk communication tool adopted by Grayson County in 2012, the BGA risk level in all three lakes in August of 2012 and May of 2013 would have been Level Green (No Blue Green Algae Advisory).

It should be noted that the benchmark samples taken in Lakes Ray Roberts and Lavon on August 21, 2012 tested negative for the BGA toxins microcystin, anatoxin-a, and saxitoxin (paralytic shellfish poison), which is consistent with results obtained in 2012 and 2013 for Lake Texoma.

Fig. 1 - Monthly Variations in Cell Densities of Total BGA, PTOX Cell Count, and C. raciborskii Cell Count

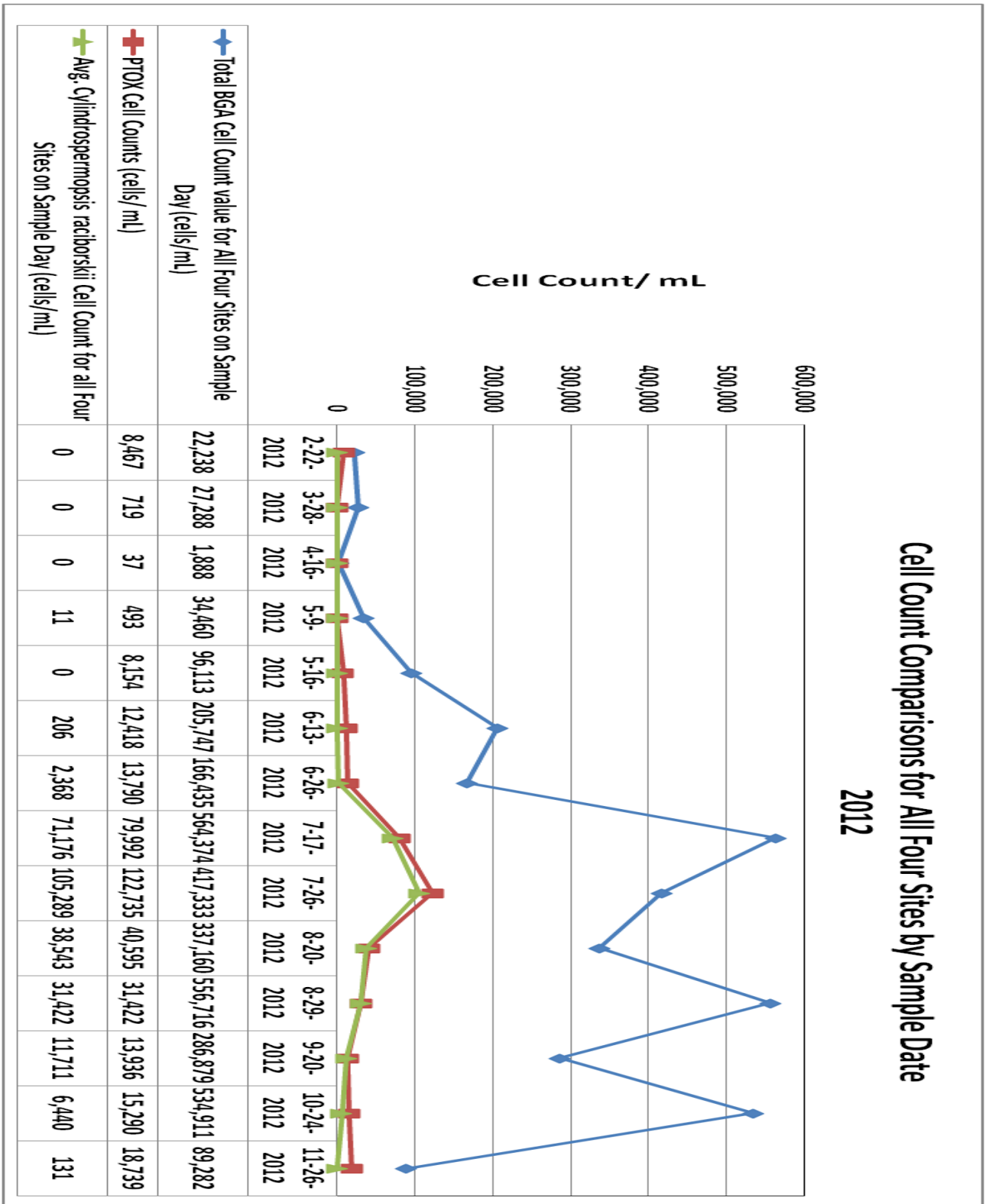


Fig. 2 - Cell Count History by Sample Site

Fig. 2 Total BGA Cell Counts by Date and Sample Location - 2012

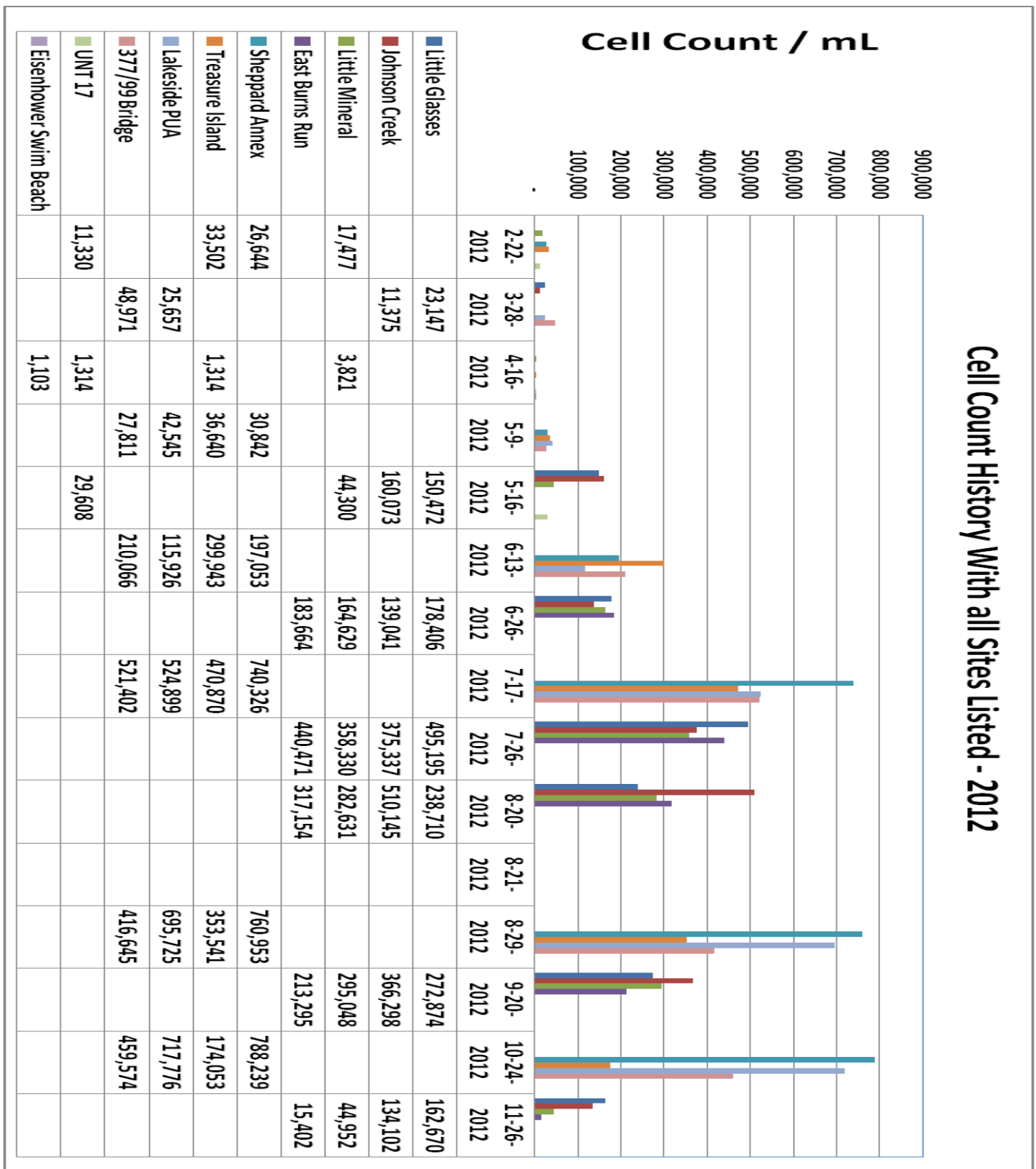


Fig. 3 - Total BGA Cell Count versus Cylindrospermopsin Toxin Levels

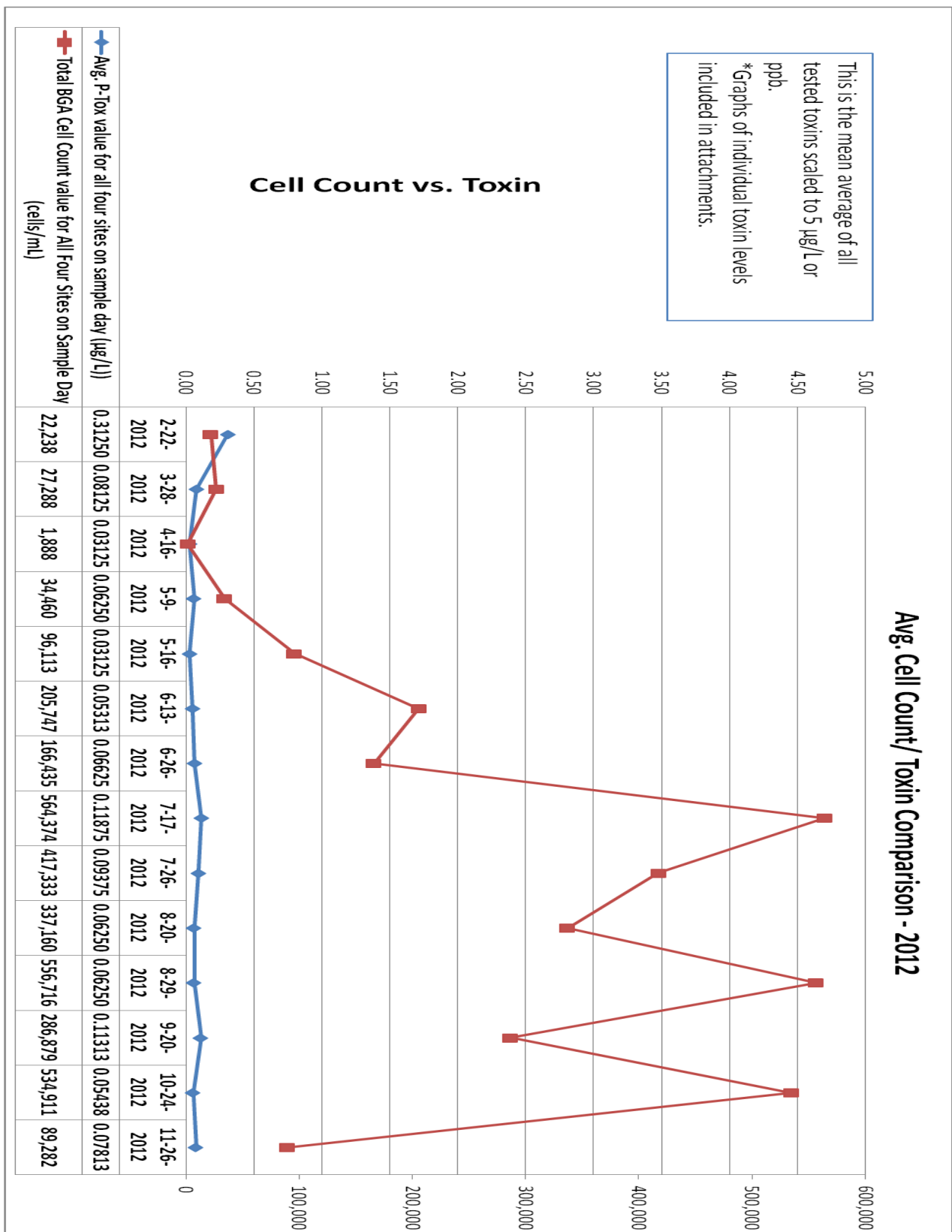
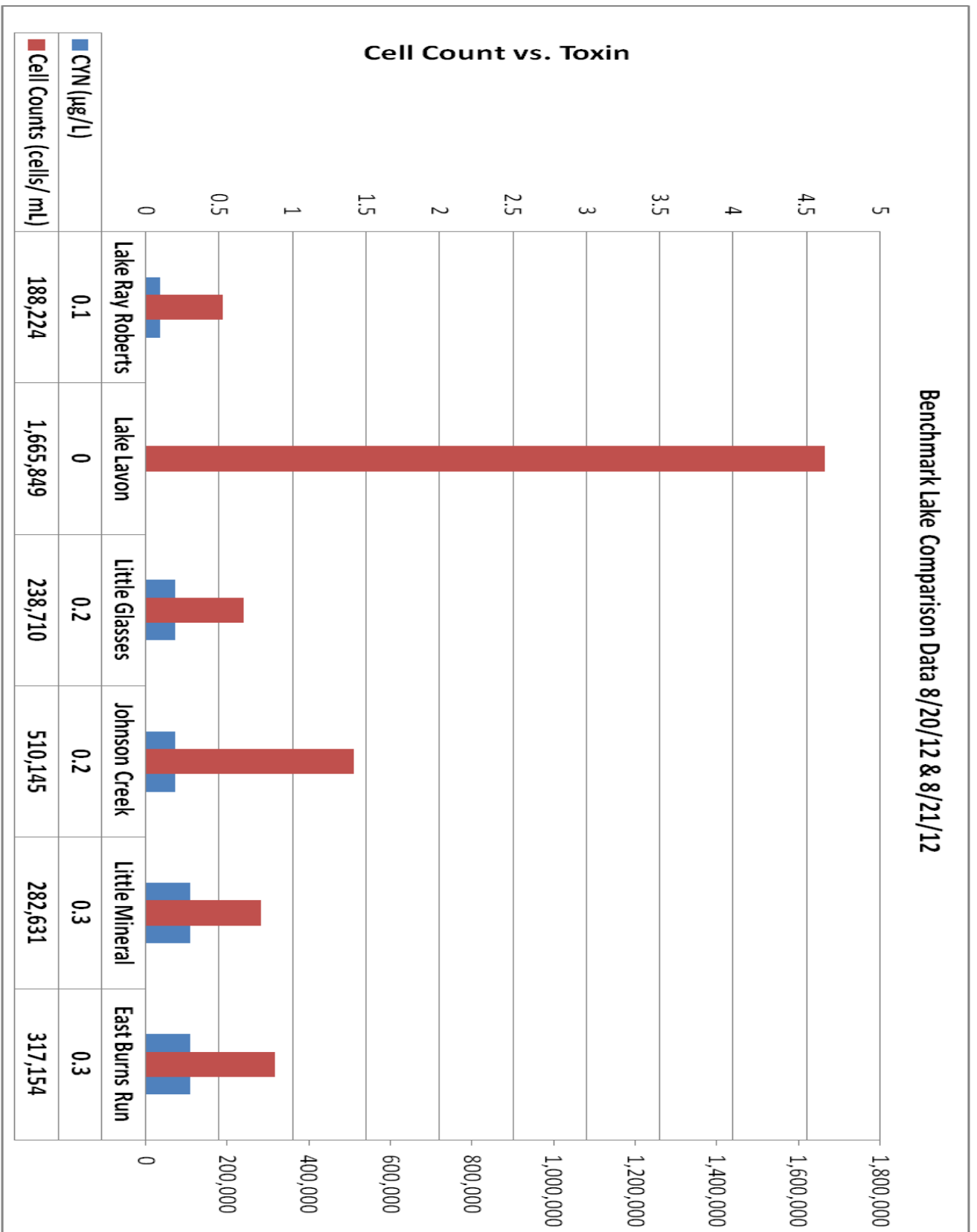


Fig. 4 – Benchmark Lake Texoma Comparison Data



amount of CYN was always near the absolute limit of detection using the most modern scientific methods available).

Cylindrospermopsis raciborskii – A Single BGA Species Discussion

The blue-green algae species known as Cylindrospermopsis raciborskii (or C.r.) seems to be the one species that is of the utmost concern to biologists assigned to the Tulsa District of the US Army Corps of Engineers. This species of potentially-toxigenic BGA appears to be of major concern to TD-USACE officials because 1) it is a common component of the mix of BGA species during warm water months; 2) the scientific literature often includes C.r. on lists of species capable of producing the toxin called cylindrospermopsin; and 3) this particular alga, during major blooms, does not generally float to the surface and form floating mats of algae, known as scum. In other words, unlike many other BGA species, persons recreating in lakes with major blooms of C.r. are not warned of its presence by visible scum. TD-USACE biologists indicate that in Lake Texoma and other Oklahoma and Kansas lakes, the biologists have found blooms occurring in long, ribbon-like bands suspended from one foot to a few feet below the surface (i.e. not easily visible to boaters and swimmers, but accessible to people who are submersed in the lake while swimming and recreating).

Data obtained during this study indicate the following trends related to C.r.:

- This alga appears to favor warmer water temperatures
- C.r. is generally not detectable in January, February, March, and April
- C.r. begins to appear in water samples in very low numbers in May (under 100 cells/ml)
- This alga begins to increase in densities in June to a few hundred cells/ml
- C.r. appears to reach annual maximum densities in July and August, with cell counts ranging from 30,000 to approaching 100,000 cells/ml
- C.r. begins to drop in cell counts to under 15,000 cells/ml in September and October
- When water temperatures cool in November, cell counts for C.r. drop to below 500 cells/ml

As an overall field observation, GCHD officials have not been able to observe the colored bands (just below the water's surface) previously described by TD-USACE biologists in Lake Texoma. If these bands are present during warm months (e.g. July/August), they may be more visible from high vantage points or from an aircraft, than from the deck of a sampling boat.

With respect to the relationship between the presence of, and cell counts of Cylindrospermopsis raciborskii and the presence of its namesake toxin (cylindrospermopsin), it should be noted that during cold water months, the toxin is present in almost every water sample collected, even when no C.r. is present. Conversely, statistical analysis of test data from 2012 shows a weak, but statistically-significant correlation between the amount of 1) Total BGA cell count, 2) PTOX cell count, and 3) C.r. cells in the water column, and the concentration of the toxin

cylindrospermopsin. This correlation is suggestive (but does not prove) that, as the cell count of Total BGA, and potentially-toxigenic BGA, and C.r. in Lake Texoma increases, so does the amount of this toxin (though the toxin never reaches amounts that concern health officials). Correlation data for data pairs are shown in Appendix 2.

Finally, a very important scientific trend is emerging regarding this algal species that bears noting in this report. Scientists in Florida have found that only one species of BGA in the United States is capable of producing the toxin cylindrospermopsin. That species is called Aphanizomenon ovalisporum, and this particular alga is often found by the GCHD during sampling efforts. The Florida scientists mentioned above have discovered that Cylindrospermopsis raciborskii in lakes and rivers in the United States **does not produce the toxin cylindrospermopsin** (Yilmaz and Philips, 2011).* A major testing laboratory in Florida, which tests water from around the world for BGA cells and toxins, has never found any United States C.r. which is capable of producing toxin. In fact, the laboratory in question has to purchase Cylindrospermopsis raciborskii from Australia in order to culture large amounts of this alga, and to recover the toxin for later sales to other testing labs. These recent studies appear to explain the reason why water samples which are devoid of any C.r. in Lake Texoma still have tiny amounts of toxin. The insignificant amounts of CYN toxin are apparently being produced by a different alga altogether (i.e. A. ovalisporum). Based on the strengths of this recent scientific evidence, it appears that the presence of Cylindrospermopsis raciborskii blooms in Lake Texoma and other US lakes and rivers may not represent a health risk in any form, though more study is warranted.

*Yilmaz,M and E. Philips. 2011. Diversity of and Selection Acting on Cylindrospermopsin *cyrB* Gene Adenylation Domain Sequences in Florida. Applied and Environmental Microbiology. April, 2011. Vol. 77, No. 7

Cylindrospermopsis



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Photomicrograph of the BGA Cylindrospermopsis



Photomicrograph of the Genus Aphanizomenon – a theoretical source of the trace amounts of the toxin cylindrospermopsin in Lake Texoma water samples

Disease Surveillance Efforts Instituted by the Grayson County Health Department

To facilitate the probability of rapid reporting of morbidity (illness) or mortality (death) potentially related to exposure to lake water containing cyanobacteria, the GCHD initiated a public outreach program to the medical community and the veterinary medical community in the Texoma region. In June, 2012, official CDC information documents regarding cyanobacteria exposure symptomology were mailed to emergency departments at each hospital within the Texoma region. These hospitals included:

Grayson County, Texas – Texoma Medical Center in Denison; Presbyterian Wilson N Jones Hospital in Sherman; Heritage Park Hospital in Sherman

Cooke County, Texas – North Texas Regional Medical Center in Gainesville; Muenster Hospital in Muenster

Fannin County, Texas – Red River Regional Hospital in Bonham

Bryan County, Oklahoma – Southeastern Oklahoma Medical Center in Durant

Marshall County, Oklahoma – Integris Marshall County Medical Center

To provide outreach to and request reporting assistance from veterinarians, the Health Department mailed CDC-generated cyanobacteria exposure symptom charts to all veterinarians in Cooke, Grayson, Fannin, Bryan, and Marshall counties. The cover letter requested that any veterinarian who examined dogs (or livestock) with intoxication symptoms consistent with ingestion of cyanotoxins call the GCHD immediately. Veterinarians were encouraged to perform necropsies on any dogs who had died of apparent liver toxicity, and which had been exposed to lake or pond water in the hours before onset of symptoms.

To assist the GCHD with awareness of sentinel events related to suspicious bird and mammal deaths (near the shoreline areas of Lake Texoma), the department requested that officials with the Hagerman Wildlife Refuge (in Pottsboro) institute an increased awareness for the presence of mortality in birds and/or mammals within the Refuge.

During the period of February, 2012 through the date of this report (May, 2013), this increased disease surveillance for possible BGA exposure has resulted in the following:

- No reports of human illness from hospital Emergency Departments in the five counties,
- No reports of human illness from primary care physicians or dermatologists (skin rash) in Grayson County or any other county,
- One report of a possible case of human illness in Spring 2012 (gastroenteritis) from a southeastern Oklahoma resident (reported to a state BGA hotline) – patient refused to communicate with the GCHD,
- Two separate reports of gastroenteritis (vomiting and diarrhea) from North Texas residents who used Texoma for swimming in early summer, 2012. Epidemiologic investigations by GCHD revealed that within 48 hours of the index case becoming ill, other family members developed fever, vomiting, and diarrhea, indicative of a viral gastroenteritis (not related to BGA),
- No reports of possible poisonings in dogs related to exposure to lake water or pond water from veterinarians in the five counties,
- No reports of suspicious bird or mammal deaths near the shorelines within Hagerman Wildlife Refuge,
- No reports of fish kills from the TD-USACE, and
- No reports of fish kills from Texas Parks & Wildlife.

Discussion

The first two official government documents written about BGA by the GCHD in 2012 were based on a rather small amount (limited body of knowledge) of BGA testing data from Lake Texoma and area lakes. The increased quantity of data on the types and quantities of cyanobacteria which comprise the normal phytoplankton in Lake Texoma, their seasonal variations, and the quantity and types of BGA toxins present in surface waters of this lake allows for greater confidence in assessments of the relative risk posed by these microscopic plants to people and pets. The following observations can now be made about blue-green algae in Lake Texoma:

1. Out of the approximately 2000 known species of BGA worldwide, there are typically from 75 to 125 species present here, and most are harmless;
2. During winter and early spring months (through April), Total BGA cell counts are generally below 30,000 cells/ml;
3. During winter and early spring months, the portion of Total BGA that is known to be capable of making toxins (called Potentially-Toxigenic or PTOX) is generally below 10,000 cells/ml (often below 1000);
4. The species of BGA which often concerns the TD-USACE (a member of the PTOX group called Cylindrospermopsis raciborskii, or C.r.) is generally not detectable in winter and early spring months, even though the toxin called cylindrospermopsin is always present in at least one of the four sample sites (at ultra-trace levels);

5. Cylindrospermopsis raciborskii generally appears in small numbers in June, increasing steadily throughout the summer months;
6. C.r. cell counts begin increasing by June, and remain elevated throughout the summer months (sometimes reaching 100,000 cells/ml). By October, C.r. cell counts decrease rapidly;
7. Three of the four common BGA toxins (anatoxin-a, microcystins, and saxitoxin) are essentially missing from Lake Texoma, though on one occasion each, microcystin and saxitoxin were possibly present in parts-per-trillion levels (at or below the limit of detection of the test method). Consequently, except in cases where a sentinel event (like a fish kill, massive algae bloom, dog death, or report of human illness) has or may have occurred, testing for these toxins may not be cost-effective;
8. In the five-county Texoma region, no reports of human illness linked to lake exposure have been reported by hospital emergency rooms between January, 2011 and May, 2013;
9. In the five-county Texoma region, no reports of human illness linked to lake exposure have been reported by family medicine physicians or dermatologists between January, 2011 and May, 2013;
10. In the five-county Texoma region, no reports of dog poisonings linked to lake or stock pond exposure have been reported by veterinarians between January, 2011 and May, 2013;
11. Between January, 2011 and May, 2013 neither the TD-USACE nor the Fort Worth District USACE has reported fish kills to the GCHD;
12. Between January, 2011 and May, 2013, neither Texas Parks & Wildlife nor the Texas Commission on Environmental Quality has reported a fish kill to the GCHD;
13. Between January, 2011 and May, 2013 the US Fish & Wildlife Service (managers of the Hagerman Wildlife Refuge on Lake Texoma) reported no fish kills or suspicious bird or mammal deaths to the GCHD;
14. The great majority of BGA found in Lake Texoma appears to be harmless species. The fraction of Total BGA that includes species known to be capable of making toxins ranged from a low of one percent to a high of 29 percent, averaging 13 percent;
15. The maximum amount of the toxin cylindrospermopsin found in Lake Texoma during this study period was six tenths of one part per billion (six tenths of one microgram per liter). This maximum amount found is eight times below Grayson County's first level of concern (Level Yellow which is 5 parts per billion) and 31 times below Grayson County's high risk threshold for people and pets (Level Red which is 20 parts per billion);
16. Using the highest single value of the toxin cylindrospermopsin found during the 16-month study (0.63 parts per billion), and using toxicity data from mouse studies, a 40 pound child would have to drink 33,000 gallons of Texoma lake water to receive a fatal dose of this BGA toxin;
17. Using the highest single value of the toxin cylindrospermopsin found during the study (and using an unpublished EPA "Reference Dose" or RfD of 0.00003

mg/kg/day), a 150 pound man could drink about one gallon of Lake Texoma water each day for a lifetime without any adverse health effects from the toxin.

Conclusions

The Grayson County Health Department, after reviewing current scientific literature on cyanobacteria, analyzing water testing data over the past sixteen months, assessing epidemiologic data for human and dog illness, and holding discussions with public health and environmental protection officials at state and federal levels, has formulated the following conclusions to date:

- A. BGA are normal, generally harmless flora in Lake Texoma and almost all other fresh water and salt water habitats in the world;
- B. The amount and types of BGA in Lake Texoma are probably similar to other reservoirs in Texas and Oklahoma;
- C. The amount of the toxin cylindrospermopsin in Lake Texoma is probably similar to the amounts of this toxin in other Oklahoma and Texas lakes;
- D. Three of the four common BGA toxins (anatoxin-a; microcystins; and saxitoxin) do not appear to exist in Lake Texoma;
- E. The amount of the toxin cylindrospermopsin present in Lake Texoma is very near the scientific limit of detection (using the world's most sophisticated detection instruments), **and has no public health significance;**
- F. "The Morbidity is Missing" – there appears to be no human illness caused by recreating in Lake Texoma due to the presence of BGA;
- G. "The Mortality is Missing" – there are no reports of human deaths from contact with BGA present in Lake Texoma, or in any other body of water in the United States;
- H. BGA did not cause fish kills in Texoma during the study period;
- I. BGA did not cause dog deaths related to Texoma (or from stock ponds) during the study period;
- J. BGA did not cause bird or mammal deaths within the Hagerman Wildlife Refuge during the study period;
- K. The vast majority of the blue-green algae cells that inhabit Lake Texoma (more than 70 percent of every water sample) is harmless, rendering any public policy decisions based on Total BGA cell counts misleading, critically-flawed, and bad public policy;
- L. The presence of BGA in Texas lakes does not constitute a significant concern to either the Texas Department of State Health Services or to the Texas Commission on Environmental Quality, and neither agency has any plans to recommend water quality standards for BGA or their toxins.

Recommendations

Based on a careful analysis of the data utilized for this report, the Grayson County Health Department makes the following recommendations:

1. To reduce overall water testing costs, and labor costs associated with water sampling efforts, the GCHD's BGA response plan should be modified to eliminate BGA testing during the months of December, January, February, March, and April (unless a sentinel event occurs during these months);
2. To reduce testing costs, testing for the toxins anatoxin-a, microcystins, and saxitoxin should be eliminated (except for sentinel events in which BGA species are found which are known to produce one or more of these toxins);
3. To increase the body of knowledge on the potential (or lack thereof) of BGA toxins to represent current or future health threats to Lake Texoma lake patrons, fish samples should be tested for the presence of BGA toxins;
4. The use of total blue-green algae cell counts for public policy decisions in the State of Oklahoma should cease. SB 259 in Oklahoma should be modified to remove the criterion for a 100,000 total BGA cell count;
5. No local, state or federal agency should issue risk communication advisories based solely on BGA cell counts;
6. All risk communication advisories should be holistic in nature, based on current (very recent) water tests for BGA toxins and situational awareness related to sentinel events (sick people, sick or dead dogs, fish kills, wildlife kills, etc.);
7. Public policy makers (elected and appointed) should remain cognizant of the potential motives for some academicians and some regulatory officials to possibly overstate the human health risks of BGA in recreational waters, potentially to obtain increased funding for testing and research;
8. Lake Managers and limnologists/phytologists should be prevented by statute from establishing and enforcing quantitative standards regarding BGA (cell counts or toxin concentrations). Public Health standards for cyanobacteria should be recommended by public health and environmental protection subject matter experts and should be fully vetted by elected policy makers prior to adoption;
9. No state or federal agency in the United States should use or adopt BGA cell count or toxin standards adopted by the World Health Organization (WHO) until and unless such standards have been vetted by US public health and environmental protection subject matter experts;
10. Local and state elected officials in Oklahoma and Texas should consider asking the US Congress to direct the Secretary of the Army to prohibit the US Army Corps of Engineers from establishing and enforcing BGA public health standards on any Corps'-managed projects. The authority and responsibility for the setting of such standards should be assigned to either the US Environmental Protection Agency or to the US Centers for Disease Control. Alternatively, the setting of BGA standards should be left to the individual states.

Summary

The public relations issue of blue-green algae in Oklahoma and Texas lakes should be thoroughly reassessed by elected and appointed policy makers. Data obtained by the Grayson County Health Department in 2011, 2012, and early 2013 indicate that these microscopic plants **do not represent a current hazard to lake patrons, or to their dogs**. When various risks posed by lake recreation are considered [e.g. drowning (4 drowning deaths in Texoma in 2012), injuries from boating accidents, skin damage from sun exposure, slip/fall accidents, and possible digestive system disorders caused by accidental exposure to bacteria or viruses in untreated lake water), the extremely low risk of accidental swallowing of water containing BGA toxins and the equally low risk of skin rashes related to exposure to BGA cells becomes insignificant.

BGA in Lake Texoma (and other Oklahoma and Texas lakes) are worthy of vigilance and study by health and environmental protection officials, but not worthy of worry (except in the rarest of ecological circumstances). The well-intentioned, but scientifically-questionable actions by the Tulsa District of the US Army Corps of Engineers in 2011 and 2012 represent a major public health risk communication failure. This division of the Corps has declared something that is normal and harmless (the vast majority of the time) to be something abnormal and harmful.

The GCHD will continue its routine testing of cyanobacteria and their potential toxins in Lake Texoma, and will continue to provide timely, accurate, common sense-based risk communication information to Texoma-region citizens. Any risk communication information regarding blue-green algae in Lake Texoma from sources other than the Grayson County Health Department or the Oklahoma Tourism and Recreation Department should be viewed with significant caution, and generally ignored.

APPENDIX 1
OFFICIAL LETTERS FROM TEXAS DEPARTMENT OF STATE HEALTH
SERVICES AND THE TEXAS COMMISSION ON ENVIRONMENTAL QUALITY



TEXAS DEPARTMENT OF STATE HEALTH SERVICES

DAVID L. LAKEY, M.D.
COMMISSIONER

P.O. Box 149347
Austin, Texas 78714-9347
1-888-963-7111
TTY: 1-800-735-2989
www.dshs.state.tx.us

October 22, 2012

The Honorable Drue Bynum
Grayson County Judge
100 W. Houston, Suite 15
Sherman, TX 75090

Dear Judge Bynum:

I received your letter dated October 1, 2012, related to the blue green algae issues in Lake Texoma and Grayson County. DSHS has not issued any contact recreational advisories for blue green algae (BGA) in Texas. Please note the following in response to the questions posed in your letter:

- **Does DSHS sample any water bodies in Texas for either the presence of BGA or the presence of cyanobacteria?** DSHS does not routinely sample water bodies in Texas for BGA, cyanobacteria, or the cyanotoxins they may produce.
- **Has DSHS received reports of any human morbidity or mortality allegedly caused by exposure to recreational water containing BGA?** Since this is not a reportable condition in Texas we do not actively collect such reports. However, in response to your request, we did review 2012 call data from the Texas Poison Control Network and located two calls, one from Grayson County and one from Denton County, involving illnesses reported by callers to have occurred after contact with BGA. While contact with BGA was mentioned in these reports, actual causality cannot be determined based on the documented information.
- **Is DSHS studying the topic of cyanobacteria in Texas' recreational waters as a potential disease or injury threat?** Beyond the preliminary review of data regarding cyanobacteria and cyanotoxins conducted in response to your inquiries, DSHS has not studied the topic of cyanobacteria in Texas's recreational waters.
- **Are there current or planned collaborative studies or actions between DSHS and TCEQ related to cyanobacteria in Texas' recreational waters?** At present, our communications with the TCEQ regarding this issue have been limited and no collaborative studies are underway or being planned at this time.

- **Does DSHS have plans to establish water quality standards for cyanobacteria (cell counts or toxin concentrations) in recreational waters, raw water supplies or finished drinking water?** DSHS does not have jurisdiction to set water quality standards in Texas; TCEQ is responsible for setting these standards. TCEQ is also responsible for public drinking water supplies in Texas.
- **What is DSHS's official position on whether the presence of cyanobacteria in Texas' recreational waters poses a public health risk?** The presence of cyanobacteria can pose a health risk if toxins are being produced at a level that affects humans or animal life. We are not aware of any large scale illness outbreaks associated with cyanobacteria from Texas water bodies. At this point, DSHS does not have adequate information to establish a position on the risk that cyanobacteria poses in Texas waters. To date, DSHS has not issued any advisories related to cyanobacteria. As a result of your inquiries, DSHS has raised the issue of inconsistent federal standards by the Army Corps of Engineers with the Association of State and Territorial Health Officials and other state environmental public health directors.

I hope you will find the answers to your questions useful. If you have additional questions, please contact me at (903) 533-5264 or Paul.McGaha@dshs.state.tx.us.

Respectfully,



Paul McGaha, D.O., M.P.H
Health Service Region 4/5 Medical Director

Bryan W. Shaw, Ph.D., *Chairman*
Carlos Rubinstein, *Commissioner*
Toby Baker, *Commissioner*
Zak Covar, *Executive Director*



TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

December 7, 2012

The Honorable Drue Bynum
Grayson County Judge
100 W. Houston, Suite 15
Sherman, Texas 75790

Re: Cyanobacteria in Texas' Lakes

Dear Judge Bynum:

Thank you for your letter dated October 10, 2012 concerning blue-green algae in Texas reservoirs. In that letter, you requested responses to specific questions about the perspectives and activities of the Texas Commission on Environmental Quality (TCEQ) with respect to blue-green algae. Our responses to these questions are provided below.

A. Does TCEQ sample any water bodies in Texas for either the presence of BGA [blue-green algae] or the presence of cyanotoxins?

TCEQ has an extensive long-term monitoring program in the larger reservoirs, lakes, and streams in Texas. Historically, this monitoring effort has included periodic sampling of chlorophyll *a* in water, which is a common measure of overall algal abundance. Blue-green algae (including numerous non-toxic forms) are often a substantial part of the algal community, but sampling data on chlorophyll *a* does not distinguish between the major types of algae.

TCEQ is coordinating with other entities on several monitoring projects in selected Texas reservoirs that include specific sampling for blue-green algae and some of the associated toxins. These projects are as follows:

- A project funded by the U.S. Geological Survey involves participation and sample collection by several Texas river authorities. The project includes sampling in the summers of 2012, 2013, and 2014. Approximately 19 selected reservoirs will be sampled once during each summer.
- Researchers at Auburn University are conducting a project on the identification of blue-green algae and analysis of selected blue-green toxins. The overall project includes a variety of reservoirs in the Southeastern United States.
- TCEQ participated for the Texas portion of the 2012 National Lakes Assessment conducted by the U.S. Environmental Protection Agency (EPA). This study included measurements of the blue-green algal toxin microcystin and algal cell counts for 47 Texas lakes in the summer of 2012. Processing of samples and data is in progress. For the previous National Lakes Assessment in 2007, EPA had sponsored similar sampling; and blue-green algae cell counts and microcystin

Re: Cyanobacteria in Texas' Lakes

concentrations were sampled for 43 Texas reservoirs (including a variety of smaller reservoirs).

- TCEQ staff has also reviewed results of blue-green algae sampling by the U.S. Army Corps of Engineers in Lake Texoma, and we would be interested in any additional sampling for blue-green algal cell counts and specific toxins that are conducted by the Grayson County Health Department.

B. Has TCEQ received reports of any human morbidity or mortality allegedly caused by exposure to recreational water containing BGA?

TCEQ has received at least one call about an illness following swimming in a Texas reservoir that might be related to blue-green algae, but an investigation by TCEQ regional staff did not identify visible algal blooms. Medical confirmation of blue-green toxicity would be the purview of the Texas Department of State Health Services [DSHS]. It is our understanding that you have been in contact with Dr. Paul McGaha, Medical Director of Health Service Region 4/5 for TDSHS, regarding reports of human illness due to blue-green algae. Dr. McGaha, [telephone: (903) 533-5264, email: Paul.McGaha@dshs.state.tx.us] is the appropriate contact regarding this matter.

C. Has TCEQ received reports of any fish kills or mortality to other fresh water species allegedly caused by exposure to recreational water containing BGA?

Fish kill reports are often developed by the Texas Parks and Wildlife Department (TPWD), and the results and follow-up actions are coordinated with TCEQ. There have been instances where algal blooms (sometimes including blue-green algae) have been suspected of causing or contributing to a fish kill by lowering dissolved oxygen in the water; but this is not directly related to impacts of blue-green algae toxins. The regional contacts for TPWD concerning fish kills in North and Northeast Texas are Greg Conley [telephone: (903) 566-2518, email: Greg.Conley@tpwd.state.tx.us] and Adam Whisenant [telephone: (903) 566-8387, email: Adam.Whisenant@tpwd.state.tx.us].

D. Is TCEQ studying the topic of cyanobacteria [blue-green algae] in Texas' recreational waters as a potential disease or injury threat to people or to wildlife?

Yes, the TCEQ considers blue-green algal toxicity as a potential water quality concern and is studying the topic. TCEQ staff review (1) information on scientific studies and evaluations of potential blue-green algal toxicity, and (2) the monitored occurrence of blue-green algae and specific toxins in Texas, as discussed above. As more information and data are accumulated, TCEQ will assess the possibility of conducting more

Re: Cyanobacteria in Texas' Lakes

widespread, targeted sampling of blue-green algae and further consider the use of scientifically appropriate screening levels of concern.

E. Are there current or planned collaborative studies or actions between the DSHS [Department of State Health Services] and TCEQ, with or without participation by TPWD [Texas Parks and Wildlife Department], related to cyanobacteria in Texas' recreational waters?

No, the TCEQ does not currently have collaborative studies or actions with other Texas agencies related to cyanobacteria in Texas' recreational waters, nor are there immediate activities planned. While TCEQ and other Texas agencies have long been concerned about harmful algal blooms, the focus of these concerns has been on algae other than blue-greens. Primary problems have been (1) algal blooms that cause red and brown tides in coastal waters (causing fish kills, shellfish toxicity), and (2) blooms of golden algae in inland waters (causing fish kills).

The following programs and actions have been established to address harmful algal blooms: (1) TPWD investigates and evaluates harmful algal blooms and has rapid response capability through their fish kill investigation program. TPWD reports on the current status of ongoing blooms on their website; (2) DSHS has authority to post advisories for fish and shellfish consumption, including cases of contamination by algal toxins; (3) TCEQ regional offices investigate reported water quality problems, and TCEQ coordinates long-term water quality monitoring for Texas; (4) TPWD, TCEQ, DSHS and others coordinate in the Harmful Algal Blooms Subcommittee of the State Toxic Substances Coordinating Committee. The committee was established by the Texas Legislature in 1987, with participation by DSHS (chair), TPWD, TCEQ, Texas Department of Agriculture, Texas Railroad Commission, and the Department of Public Safety.

The above framework for addressing harmful algal blooms is available to help address the issue of blue-green algal blooms as needed.

F. Does TCEQ have current plans to establish water quality standards for cyanobacteria (cell counts or toxin concentrations) in recreational waters, raw water supplies, or finished drinking water?

TCEQ staff are developing proposals for the upcoming triennial revisions of the Texas water quality standards, and there are no specific provisions that address blue-green algae. In 2010, TCEQ adopted water quality standards for overall algal abundance (as chlorophyll *a* concentrations) for 75 reservoirs. These standards are intended to protect reservoirs from aesthetic and ecological impacts of excessive algal growth, but they are not focused on blue-green algal densities or toxin concentrations.

The Honorable Drue Bynum
Page 4
December 7, 2012

Re: Cyanobacteria in Texas' Lakes

At the present time no national guidance criteria for blue-green algae have been established by EPA. There are also no federal drinking water standards for blue-green algae that might be adopted by the TCEQ drinking water protection program. TCEQ will continue to evaluate available information and consider the potential use of preliminary screening levels to identify areas where blue-green algae or specific toxins tend to occur at relatively high concentrations and the need for further investigation.

G. What is TCEQ's official position on whether the presence of cyanobacteria in Texas' recreational waters poses a public health risk?

As indicated above, TCEQ is unaware of specific documented instances of blue-green algal toxicity due to recreational exposure in Texas reservoirs. However, at sufficiently high levels blue-green algae and the resulting toxins can be a potential health risk. Adverse effects have been reported in other regions, and toxicity studies have demonstrated the adverse effects of blue-green algal toxins in animal studies. The limited available data in Texas show that relatively elevated blue-green algae levels can occasionally occur. Therefore, in order to better characterize and address potential risk in Texas reservoirs, further evaluation of the occurrence and toxicity of blue-green algae is warranted. While there are no specific studies or actions planned with other Texas agencies, TCEQ staff continues to review information, scientific studies and evaluations regarding blue-green algal toxicity to increase their understanding of this issue.

I hope that these responses are helpful to your efforts to evaluate blue-green algae and to understand current programs and activities of state agencies. Please let me know if you need additional information or would like to further discuss these issues.

Sincerely,



L'Oreal W. Stepney, P.E., Deputy
Office of Water
Texas Commission on Environmental Quality

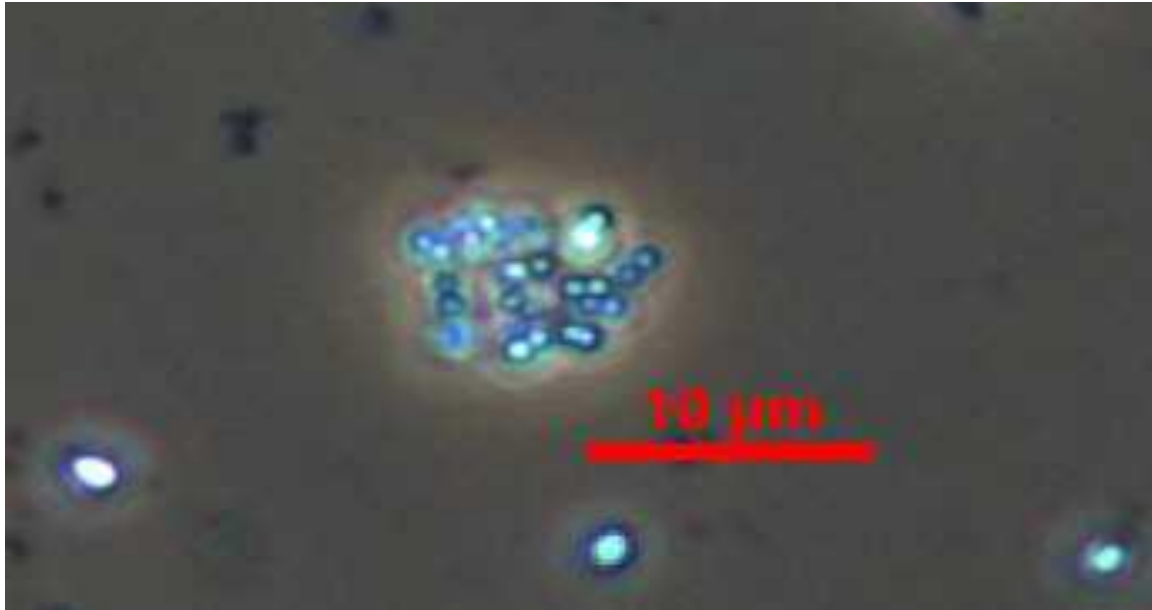
APPENDIX 2
 STATISTICAL ANALYSES OF LAKE TEXOMA BGA DATA FROM 2012
 Cell Counts versus Concentration of the Toxin Cylindrospermopsin

Variable Compared	Pearson's Coefficient	At What Level is P-Value Significant?	r-square value	At What Level is r-square Significant?
Total BGA cell count	0.54870	0.0522	0.3011	0.0522
PTOX cell count	0.61127	0.0264	0.3737	0.0264
C. raciborskii cell count	0.63800	0.0190	0.4070	0.0190

The Grayson County Health Department wishes to thank and acknowledge the University of North Texas Department of Biological Science for performing these statistical analyses on data provided by Grayson County



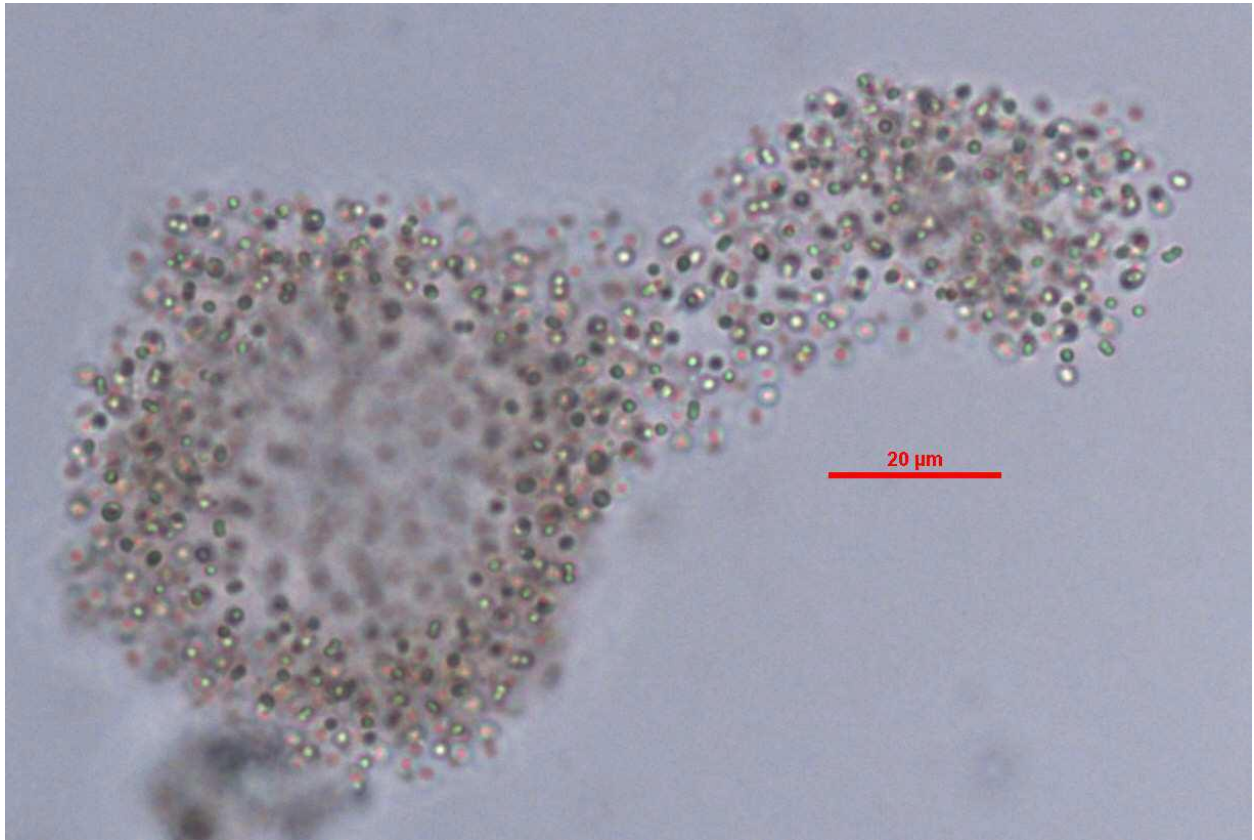
Cylindrospermopsis raciborskii with akinete 400X (scale bar = 10 μm)
Picture provided by GreenWater Laboratories from samples collected on 08/29/12, report dated 09/20/12



Cyanodictyon/Aphanocapsa sp. 400X (scale bar = 10 µm)
Picture provided by GreenWater Laboratories from samples collected on 10/24/12, report dated 12/13/12



Planktothrix agardhii 400X (scale bar = 50 µm)
Picture provided by GreenWater Laboratories from samples collected on 10/24/12, report dated 12/13/12



Aphanocapsa holsatica 400X (scale bar = 20μm)

Picture provided by GreenWater Laboratories from samples collected on 11/26/12, report dated 12/14/12



Planktothrix agardhii 400X (scale bar = 50 μm)

Picture provided by GreenWater Laboratories from samples collected on 01/31/13, report dated 02/18/13



Anabaena cf. circinalis 400X (scale bar = 10µm)

Picture provided by GreenWater Laboratories from samples collected on 03/27/13, report dated 04/29/13



Cyanodictyon sp. 400X (scale bar = 10 μ m)

Picture provided by GreenWater Laboratories from samples collected on 03/27/13, report dated 04/29/13