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Monitoring and Evaluation of Cyanobacteria in Burlington Bay, Lake Champlain 2001

Lake Champlain Basin Program

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MONITORING AND EVALUATION OF CYANOBACTERIA IN BURLINGTON BAY, LAKE CHAMPLAIN

Summer 2001

Report to

Lake Champlain Basin Program

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EXECUTIVE SUMMARY

Cyanobacteria toxins were first documented in Lake Champlain in 1999, when two dogs died as a result of consuming water containing large amounts of Cyanobacteria, also called blue-green algae (BGA). In 2000, we documented the regular presence of toxin-producing BGA in Lake Champlain and trace amounts of toxin on several occasions. In the summer of 2001, we assessed the potential for human exposure to BGA by evaluating the occurrence and toxicity of algae in the vicinity of 2 municipal water intakes, two swimming beaches and several offshore sites in the Burlington Bay area, one of the most populated sections of Lake Champlain.

BGA were again a common component of the plankton in Burlington Bay during the summer of 2001, but visible BGA surface blooms were not noted at any of our sampling sites. The only exception to this occurred in the boat slip adjacent to the UVM Rubenstein Ecosystem Science Laboratory in Burlington, where a dense surface scum was present for several days in July. BGA blooms were documented by NY and VT State field personnel in northern Lake Champlain, specifically in Missisquoi Bay, the Northeast Arm and Maquam Bay.

Both potential toxin-producing and non-producing BGA taxa were observed in the plankton. Potential toxin-producers were the same species identified in 2000 including *Anabaena spp., Aphanizomenon flos-aquae, Microcystis aeruginosa, and Gloeotrichia spp.*. The bloom noted in the Melosira slip was primarily *Anabaena flos-aquae* with some *Microcystis*. The blooms documented in the northern portions of the lake were composed of *Gloeotrichia* and *Aphanizomenon flos-aquae.*

The open waters of Burlington Bay do not appear to be conducive to the development of algal surface blooms under typical environmental conditions. While the warm weather and drought conditions did lead to large populations of BGA, there were no extended periods of calm water during 2001 and no surface accumulations of BGA in the open waters or near the beaches. In the more protected environments of the Rubenstein boat slip and the northern portions of Lake Champlain, potential toxin-producers did accumulate in dense surface scums. Had Burlington Bay experienced an extended wind-free period, it is likely that BGA would have accumulated visibly at the surface in some areas of the bay.

Microcystins were detected all summer at the beaches and in offshore surface waters. Anatoxin was detected at low levels in several samples collected around Burlington Bay in September. Ambient microcystin concentrations in Burlington Bay plankton did not exceed the World Health Organization guideline of 1 μg/L, probably because environmental conditions prevented the accumulation of BGA at the surface in scums.

Low levels of microcystins were detected in raw water samples collected from both water treatment facilities and microscopic analysis confirmed the presence of BGA at very low densities in raw water. Because the intake structures for both facilities are located in more than 50 feet of water and BGA tend to accumulate in the upper water column, the likelihood that large quantities of BGA would enter these facilities seems low. Water treatment facilities with intakes located in shallow waters appear to be at the greatest risk of drawing significant accumulations of BGA into the plant when environmental conditions favor higher BGA densities.

At the Burlington Bay beaches, microcystin was frequently detected in the plankton at ambient concentrations below the WHO guideline of 1 μg/L, and anatoxin was also detected on one date. Under environmental conditions leading to surface accumulations near shore, toxin concentrations may reach or exceed this guideline. Swimmers and pets should avoid the water when visible scums are present to minimize or avoid exposure.

Because environmental conditions influence the distribution and accumulation of potential toxin-producing BGA, it is difficult to predict blooms. A tiered monitoring and alert system framework to inform health officials and the general public about the occurrence of and potential risks associated with the development of BGA blooms would be beneficial. The users of this information would include the VT and NY Departments of Health, operators of drinking water facilities drawing from the lake, beach managers, recreational users, and home or camp owners who draw their water directly from Lake Champlain. A prototype of such a system will be tested during the summer of 2001.

INTRODUCTION

During the summer of 1999 and again in 2000, several dogs died after ingesting water from Lake Champlain containing large amounts of Cyanobacteria, also called blue-green algae (BGA). In 2000, a collaborative effort involving the University of Vermont (UVM), the NRCS Watershed Science Institute, the Vermont Department of Health (VT DOH), the Vermont Department of Environmental Conservation (VT DEC), SUNY – Syracuse, Wright State University, the Florida Department of Health and the Maine Department of Marine Resources documented the regular presence of toxin-producing BGA in the lake and presence of trace amounts of toxin on several occasions (Rosen et al. 2000).

These toxins are potentially harmful to human health. Human exposure is likely to occur in one of two ways: contact with or ingestion of water containing BGA or cyanotoxins, either through recreational activities or a drinking water source. In 2001, this project assessed the potential for human exposure to BGA by evaluating the occurrence and toxicity of algae in the vicinity of 2 municipal water intakes, two swimming beaches and several offshore sites in the Burlington Bay area, one of the most populated sections of Lake Champlain.

Specifically, we focused on the following three objectives:

1. To identify the BGA present in the Burlington Bay area;
2. To screen for toxin production when known toxin-producing taxa were present; and
3. To evaluate potential human exposure through drinking water sources and recreational activities on Lake Champlain.

METHODS

Field Collection

Location

Samples were collected from nine sites in the Burlington Bay area: 5 locations routinely monitored for water quality and plankton populations by the University of Vermont's Burlington Bay Project (Appletree Bay, Inner Harbor North, Outer Harbor South, Lakeside South, and Juniper Island) , North Beach in Burlington, the surface waters above the Burlington Municipal Water Facility intake, Red Rocks Beach in South Burlington, and the surface waters above the Champlain Water District intake in Shelburne Bay (Figure 1). Water was also collected inside the drinking water facilities on several occasions. Both pre-treatment ("raw") water and treated ("finish") water were examined. Occasional samples brought in from other sections of Lake Champlain by other persons were also examined.

Frequency

Monitoring for the presence of BGA began in June 2001 and continued through October 2001. Samples were collected twice a month from the 5 routine monitoring sites, the beaches and the surface waters above the treatment facility intakes. Additional samples were collected from areas where algae appeared to be accumulating or when weather conditions seemed conducive to the accumulation of BGA in the surface waters of the Bay. No evidence of a BGA bloom, defined as a dense accumulation of BGA in near-surface waters, was observed in Burlington Bay during the summer of 2001. As a result, sampling frequency remained constant over the summer.

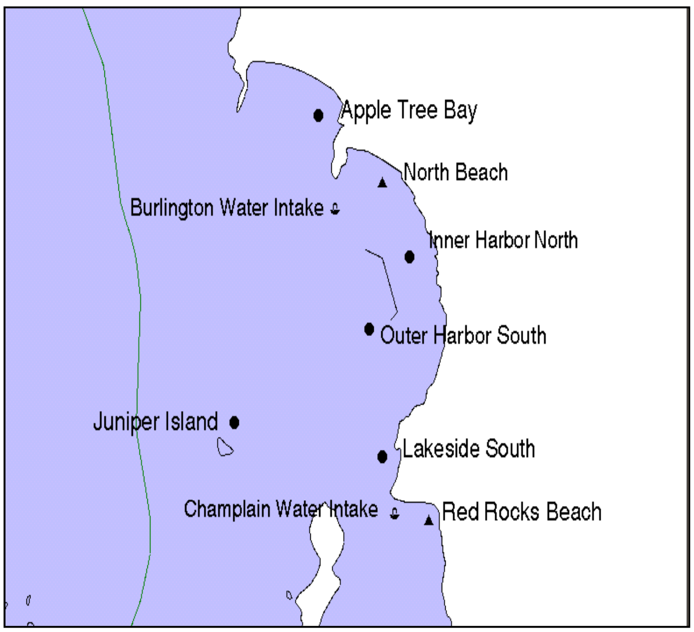

Figure 1. Sampling locations in Burlington Bay, 2001.

Analytical Parameters

Samples were collected for the following during 2001:

- taxonomic identification of BGA (whole water and net plankton)
- when densities were high, quantitative enumeration of BGA
- chlorophyll analysis
- toxin analysis (analysis of this parameter began on selected samples when microscopic analysis indicated potential toxin-producing taxa were present)

Secchi depth was also measured and conductivity, temperature, oxygen concentration, and depth were recorded using a Seabird Profiler from 0.5 m below the surface to 0.5 m above the bottom.

Sample Collection

Whole water plankton samples from lake sites consisted of whole water collected in duplicate using a 1L Niskin water sampler at 1 m depth. Net plankton, chlorophyll and toxin samples were obtained in duplicate using a 63 µm Wisconsin net. Multiple tows were made with the net and combined into a single acid-washed container. This composite was taken to the lab and subdivided for algal enumeration, chlorophyll and toxin analyses as needed. The total volume of water sampled for each composite was recorded. Samples were placed in coolers on ice for transport to the lab.

At the water treatment facilities, samples were collected directly from the raw and finish water lines after allowing them to flow freely for several minutes. Twenty liters of raw and finish water were collected in large acid-cleaned carboys for toxin analysis. Plankton samples were collected with a 63 µm plankton net by allowing the raw water to flow through the 63 µm Wisconsin net. Finish water was unlikely to contain plankton after passing through the facility, and, therefore, was not sampled for this purpose. Two replicates were collected for each parameter, except toxins where only a single 20L sample was obtained. The small sample bottles were placed on ice in a cooler for transport to the lab. The carboys were shaded from direct sun, transported immediately to the lab, and refrigerated.

Preservation and storage

Pre-cleaned polyethylene bottles were used for all field samples. Toxin containers were cleaned with 20% hydrochloric acid solution prior to use. Plankton samples were preserved with 1% Lugols iodine solution or 0.5% glutaraldehyde and stored in the dark until analysis. Chlorophyll extractions began within 12 hours of collection. Lake water samples for toxin analysis were preserved in one of three ways: filtered and frozen at -40° C upon return to the lab, filtered and shipped for analysis within 48 hours, or shipped as whole water samples within 48 hours for analysis. Water treatment facility raw and finish water was extracted using solid phase cartridges within 48 hours and shipped for analysis. All samples were shipped on ice by overnight carrier.

Analysis

Chlorophyll

Composite material collected with the 63 µm net was thoroughly mixed and a subsample removed for chlorophyll analysis. Algae were filtered onto a Whatman GF/F glass fiber filter under low pressure. Sufficient material was filtered to leave a visible green layer. Filters were placed in clean 15 mL plastic centrifuge tubes and 8 mL of 95% ethanol was added. Test tubes were placed in an 80° C water bath for 8 minutes. Tubes were covered with foil and placed in a refrigerator overnight to extract. After the extraction, samples were brought back to room temperature, shaken to homogenize the extract and centrifuged at 3000 rpm for 10 minutes. Absorbance was measured at 665 and 750 in non-acidified and acidified extract. Chlorophyll concentrations in the extract were extrapolated to reflect actual chlorophyll concentrations in the original lake water. Approximately 10% of the samples were run in duplicate.

Net Plankton

Net plankton were analyzed either as qualitative or quantitative samples. Initial samples collected in June were evaluated qualitatively, noting the taxa present and whether they were abundant. Once BGA were identified in the samples and observed routinely, evaluation became quantitative. Individual alga in the samples were identified and enumerated, and densities calculated for each taxon.

An aliquot of well-mixed sample was placed into a phytoplankton counting chamber (Phycotech Inc, volume 0.06 mL) and allowed to settle for 5 minutes. Chamber bottoms were evaluated using an Olympus CK-2 or IX70 inverted microscope at 100x. For qualitative samples, the entire chamber was scanned and algal taxa present were recorded. For quantitative samples, individual algal cells and colonies were identified and counted. Counting continued until 100 individuals of the most abundant taxa had been identified, or 10 fields had been examined from each of 5 aliquots. Mean number of cells per natural unit was determined by counting cells in up to 10 colonies of each taxa observed. The number of natural units counted in a sample was multiplied by the mean number of cells per natural unit to estimate cell densities.

Whole water Plankton

Whole water plankton samples were enumerated using Ütermohl settling chambers, following APHA (1995). Aliquots of a well-mixed sample were allowed to settle for a minimum of 4 days and then counted using an Olympus CK-2 or IX-70 inverted microscope at 400x. Counting continued until 100 individuals of the most abundant taxa had been observed or 100 fields had been evaluated. Natural units and cell densities were determined as described above.

Toxins

Preparation of net plankton for analysis – A well-mixed aliquot of net plankton was filtered onto Whatman 934-AH filters using acid-cleaned glassware. In this way, all labs received material from the same composite samples. Filters were placed on ice and shipped by overnight carrier to SUNY Syracuse for analysis of toxins by enzyme-linked immunosorbant assay (ELISA), high pressure liquid chromatography (HPLC) and a protein phosphatase assay (PP1A). Filters for ELISA analysis by VT DOH were placed on ice and delivered within 24 hours. Filters for ELISA analysis by UVM were placed in 7 mL septa-topped glass vials with 4 mL of 50% methanol, shaken well and placed at -40° C.

Preparation of whole water for analysis – Whole water samples for toxin analysis by ELISA, HPLC and PP1A at SUNY Syracuse were kept cold and sent off for analysis within 24 hours. At UVM, whole water aliquots were placed in 7 mL septa-topped glass vials and frozen until analysis. Raw and finish waters were filtered through solid phase extraction cartridges (Baker Co.) using a Cole-Parmer peristaltic pump at a rate of 10 - 12 mL/minute. Filtering continued until a minimum of 8 L had been filtered or the cartridge appeared discolored. Cartridges were rolled into aluminum foil and placed in a ziplock bag for shipment to SUNY within 48 hours.

Microcystin by ELISA - At UVM and the VT DOH, toxin samples in 50% methanol were thawed, shaken and re-frozen three times before beginning analysis. Extracted samples were diluted with deionized water until methanol represented 5% or less of the total volume, following recommendations to improve assay accuracy (Metcalf et al. 2000). Microcystin plate kits were purchased from Envirologix Inc. UVM and VT DOH used kits from the same production lot. Samples were run in duplicate following manufacturer instructions on a KC Jr plate reader (Bio-tek Instruments), utilizing standards provided in the kit. Mean values were used to determine the toxin concentration of each pair of samples. Samples exceeding the range recommended by the kit were diluted and re-analyzed. Samples below the range were also re-analyzed, using manufacturer recommended dilution procedures for the standards. SUNY prepared their own microcystin standard in methanol and used this in addition to the manufacturer's standards when running ELISA assays. Laboratory blanks were run with each sample batch using Type I water, but otherwise following all sample processing steps.

Microcystin by PP1A – PP1A analysis followed a modification of An and Carmichael (1994). Microcystin LR standards (0.06 to 1000 µg/L) were prepared fresh from a 40 µg/ml stock in 50% acidified MeOH. The protein phosphatase 1, catalytic subunit (Roche), was used at a working concentration of 0.1 mU/200 µL. All assays were done in 96 well plates in a 37^{o}C incubator. Readings at 405 nm were taken every 5 minutes for 60 minutes using an E-max plate reader.

Anatoxin by HPLC – At SUNY, algal material was freeze-dried and then extracted with acidified methanol. Solid phase extraction cartridges were eluted with 100% methanol. Samples were analyzed in a Zorbax ACE C18 column with C-18 Phenomenex guard disk following James et al. (1997). Several duplicate samples were also analyzed by Dr. Wayne Carmichael at Wright State University using the same procedures.

RESULTS

Composition and Population Dynamics of Cyanobacteria

Environmental conditions in the Burlington Bay area did not support extensive BGA blooms during the summer of 2001, despite low water levels and drought conditions around the Northeast. Because of this, sampling continued at 2-week intervals throughout the summer to characterize the plankton population under non-bloom conditions in Burlington Bay.

A total of 36 qualitative plankton samples were collected in duplicate and analyzed from June 4 through July 3, 2001. Quantitative plankton samples, including replicates, were collected from July 20 through October 16, 2001. Of these, 61 quantitative net samples collected from July 20 to September 25 were analyzed as were 9 whole water samples collected on October 16.

Qualitative samples were dominated by diatoms, in particular *Asterionella formosa* and *Tabellaria spp*. (Table 1). In these samples, BGA were observed infrequently and in low densities.

Table 1. Results of qualitative plankton samples collected at surface locations during the summer of 2001 in Burlington Bay VT.

			BGA Taxa			
Collection Date	Location	BGA observed	*Anabaena*	*Aphanizomenon*	*Coelospherium*	Other Taxa
6/4/2001	Apple Tree Bay	no				*Asterionella*
6/4/2001	Burlington Water Intake	yes	x	x		*Asterionella*
6/4/2001	Champlain Water Intake	no				*Asterionella*
6/4/2001	Juniper Island	yes		x		*Asterionella*
6/4/2001	Lakeside S	no				*Asterionella*
6/4/2001	Outer Harbor S	yes		x		*Asterionella*
6/25/2001	Burlington Water Intake	no				Diatoms
6/25/2001	Champlain Water Intake	yes	x			Mostly diatoms
6/25/2001	Inner Harbor N	yes	x	x		Mostly diatoms
6/25/2001	Juniper Island	no				Mostly diatoms
6/25/2001	Lakeside S	yes		x	x	Mostly diatoms
6/25/2001	Outer Harbor S	yes			x	Mostly diatoms
6/26/2001	Apple Tree Bay	no				Mostly diatoms
7/3/2001	Apple Tree Bay	no				Mostly diatoms
7/3/2001	Champlain Water Intake	no				Mostly diatoms
7/3/2001	Inner Harbor N	yes			x	Mostly diatoms
7/3/2001	Juniper Island	yes	x	x	x	*Tabellaria* bloom
7/3/2001	Lakeside S	no				Mostly diatoms
7/3/2001	Outer Harbor S	yes	x	x		Mostly *Tabellaria*

Results of the quantitative net plankton analyses are summarized in Table 2. Total cell density remained low through July, generally less than 500 cells per mL, at both near-shore and offshore locations. The most abundant algae during this time were diatoms, although BGA were equally or more abundant at the Inner Harbor N site and in a sample collected offshore from our Lakeside site.

In August and September, cell densities increased at most locations and varied greatly from site to site. BGA represented the most abundant algal group, comprising 70 % or more of the algae

Table 2. Algal density and composition in plankton net tows collected at surface locations on Lake Champlain. * indicates estimated cells densities exceeded 1 million cells per mL.

				Percent of Total Cells by Algal Group				
Date	Sample Locations	N	Total Cells per mL	Cyanobacteria	Diatoms	Chrysophyta	Dino-flagellates	Green
7/20/01	Apple Tree Bay	1	310	7.50	91.87	0.14	0.00	0.49
7/20/01	Burlington Water Intake	1	288	38.30	61.34	0.32	0.04	0.00
7/20/01	Champlain Water Intake	1	271	43.30	56.66	0.00	0.04	0.00
7/20/01	Inner Harbor N	1	345	49.66	50.31	0.00	0.02	0.00
7/20/01	Juniper Island	1	133	34.11	64.25	0.00	0.02	1.62
7/20/01	Lakeside	1	269	41.00	58.78	0.20	0.02	0.00
7/20/01	Outer Harbor	1	364	23.42	76.50	0.00	0.02	0.05
7/31/01	.25 mile off Lakeside	1	797	63.72	35.38	0.00	0.02	0.88
8/1/01	Burlington Water Intake	1	2,405	50.67	48.81	0.48	0.05	0.00
8/1/01	Champlain Water Intake	1	753	77.10	21.22	0.47	0.03	1.19
8/1/01	North Beach	2	267,184	99.92	0.06	0.01	0.00	0.00
8/1/01	Offshore Red Rocks	3	87,863	98.23	1.36	0.24	0.01	0.16
8/1/01	Red Rocks Beach	2	87,678	99.85	0.14	0.00	0.00	0.01
8/9/01	Apple Tree Bay E	1	153,811	99.95	0.04	0.00	0.00	0.00
8/9/01	Burlington Water Intake	2	130,371	99.54	0.44	0.01	0.00	0.01
8/9/01	Champlain Water Intake	1	2,763	98.63	1.19	0.12	0.02	0.03
8/9/01	Inner Harbor	1	29,793	99.79	0.19	0.02	0.00	0.00
8/9/01	Juniper Island	2	2,147	89.27	7.26	1.46	0.17	1.84
8/9/01	North Beach	1	29,979	99.89	0.10	0.01	0.00	0.01
8/9/01	Outer Harbor	1	1,049	96.93	2.45	0.37	0.03	0.22
8/9/01	Red Rocks Beach	2	4,956	96.27	3.35	0.37	0.01	0.00
8/22/01	Blanchard Beach	1	212	92.03	7.84	0.00	0.06	0.06
8/22/01	North Beach	1	3,303	97.61	2.29	0.08	0.01	0.01
8/22/01	Red Rocks Beach	1	55	78.41	20.45	0.00	0.00	1.14
8/27/01	Burlington Water Intake	1	549	100.00	0.00	0.00	0.00	0.00
8/27/01	Champlain Water Iake	1	529	69.95	30.02	0.00	0.03	0.00
8/27/01	North Beach	1	1,698	99.35	0.54	0.00	0.00	0.11
8/27/01	Red Rocks Beach	1	759	96.56	2.10	1.30	0.02	0.01
9/4/01	Burlington Water Intake	2	887	93.19	5.00	1.53	0.07	0.21
9/4/01	Champlain Water Intake	2	464	53.22	46.62	0.14	0.02	0.00
9/4/01	North Beach	2	42,991	99.91	0.05	0.02	0.00	0.01
9/4/01	Red Rocks Beach	2	505	96.68	3.21	0.00	0.02	0.09
9/11/01	Missisquoi Bay	1	*	98.15	1.28	0.44	0.11	0.01
9/18/01	Northeast Arm	1	*	100.00	0.00	0.00	0.00	0.00
9/19/01	Missisquoi Bay	1	*	85.47	9.11	3.84	0.20	1.38
9/25/01	Burlington Water Intake	2	1,025	75.29	23.09	0.00	0.01	1.61
9/25/01	Champlain Water Intake	1	719	88.95	7.31	3.59	0.10	0.04
9/25/01	North Beach	2	3,435	97.47	1.40	0.02	0.02	1.08
9/25/01	Red Rocks Beach	2	868	96.35	2.58	0.64	0.08	0.35

observed. In the Burlington Bay area, cell densities ranged from less than 100 cells per mL to roughly 300,000 cells per mL. In contrast, samples collected on September 18 and 19 in Missisquoi Bay and the Northeast Arm from visible surface scums were estimated to have more than 1 million cells per mL.

No new toxin producers were found in samples collected from Lake Champlain in the summer of 2001. All five potentially toxic taxa observed in the summer of 2000 were also common members of the phytoplankton in 2001. As in the summer of 2000, *Gloeotrichia* and *Coelospherium*, potential gastrointestinal and skin irritants, were occasionally observed. The frequency at which these taxa were observed is summarized in Table 3.

Table 3. Occurrence of potential toxin-producing Cyanobacteria in plankton samples collected during 2001.

Potentially Toxic BGA Taxa	Frequency of Occurrence in Samples (%)
Microcystis aeruginosa	48
Aphanizomenon flos-aquae	68
Anabaena flos-aquae	76
Anabaena circinalis	32
Anabaena planktonica	45
Coelospherium	66
Gloeotrichia	15

Toxin Production

Thirty-two samples, collected between July 17 and October 15, were analyzed for the presence of microcystin and anatoxin. These included samples from the surface waters at the beaches, near the water facility intakes, nearshore locations around Burlington Bay, and the water treatment facilities. Three additional samples, collected in September from algal blooms by NY field personnel in Missisquoi and Maquam Bays at the north end of the lake, were also analyzed. Microcystin and anatoxin results are discussed below.

Beaches

Four plankton samples from the beaches were collected for toxin analyses during August and September (Figure 2). Microcystin was not detected at North Beach on August 27. All other samples tested had detectable levels of microcystin in the plankton. Although the concentration varied among the methods used, ambient microcystin concentrations in the beach plankton were below the World Health Organization (WHO) human health protection guideline of 1 µg/L on the dates tested. Anatoxin was detected in samples collected from both beaches on September 4. Essentially all the algae observed in the net samples on this date were BGA. Ambient concentrations of 0.003 µg/L were found at Red Rocks and 0.011 µg/L at North Beach. There currently are no guidelines available for anatoxin, but both these concentrations were low.

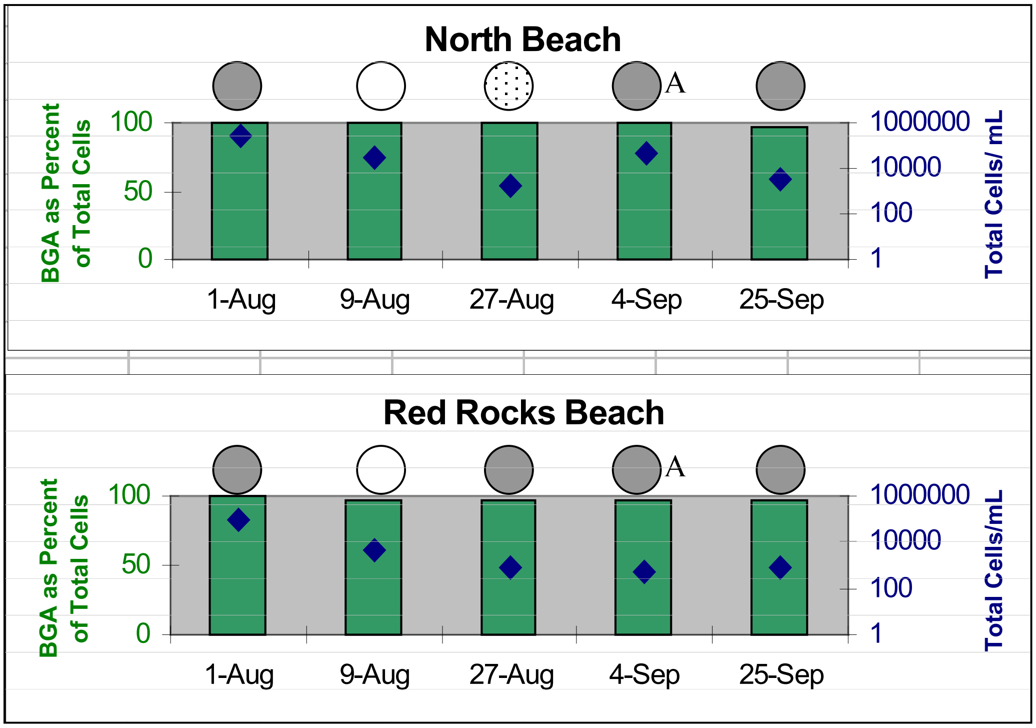

Figure 2. Toxin results at Burlington Bay beaches, 2001. Bars indicate the percent of total cells represented by BGA. Diamonds indicate total cell densities. Circles represent microcystin concentration: white – not tested stippled – below detection gray – below 1 µg/L black – greater than 1 µg/L. "A" indicates that anatoxin was detected.

Water Facilities

Because no BGA blooms were observed in Burlington Bay during 2001, limited sampling was conducted at the water treatment facilities. When quantitative plankton analysis indicated that BGA were present in relatively high densities in early August, samples were obtained from both facilities. Additional samples were collected on September 9 while BGA densities remained high. A final sample was collected in October after isothermal conditions had developed on the bay to determine if residual toxin or plankton material was reaching the facilities. Raw and finish waters were concentrated using solid phase extraction cartridges. Plankton densities in raw water were very low and, therefore, plankton were not analyzed for toxin content.

Microcystin was not detected in the surface waters above the water treatment facilities on August 27 (Figure 3). On August 1, August 4 and September 25, ambient concentrations of microcystin in the plankton were below 1µg/L. Anatoxin was detected in the plankton above both intakes on September 4 (0.002 – 0.005 µg/L). BGA represented between 50 and 100% of the cells observed on these dates.

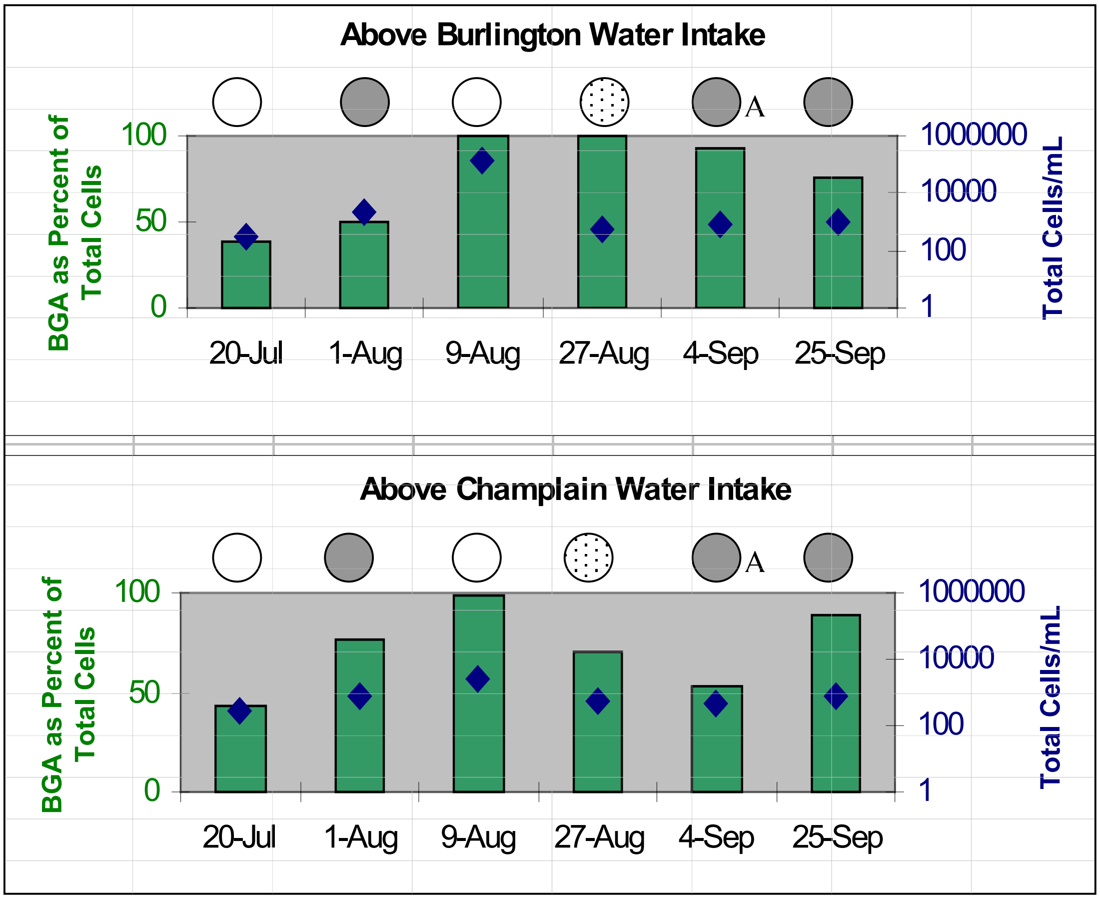

Figure 3. Toxin results in surface waters above Burlington Bay water facility intake structures, 2001. Bars indicate the percent of total cells represented by BGA. Diamonds indicate total cell densities. Circles represent microcystin concentration: white – not tested stippled – below detection gray – below 1 µg/L black – greater than 1 µg/L. "A" indicates that anatoxin was detected.

Microcystins were detected in raw water collected at both facilities on all the dates sampled using at least one analytical technique (0.001 to 0.157 µg/L, Table 4). The PP1A technique works differently than the ELISA method and seemed to be more sensitive. Microcystins were detected in reduced concentrations in the finish water at both facilities in August, and at the Burlington facility on September 5. Raw and finish water at the Champlain Water facility had similar concentrations of microcystin on September 5.

In October, raw water concentrations at the Burlington facility decreased compared to earlier in the season. Raw water concentrations at the Champlain facility remained low, as seen in August and September. Although not detected in the raw water, anatoxin was detected at low concentrations in finish water at both facilities on September 5 (0.001 – 0.003 µg/L); at the same time that anatoxin was detected in the surface plankton above the intake structures.

Table 4. Toxin concentrations in water collected from Burlington Bay water treatment facilities in 2001. Raw water samples represent untreated incoming water. Finish water represents treated water leaving the facility for distribution. nd = not detected.

		Microcystin Concentration (µg/L)					Anatoxin-a
Collection Dates	Sample Locations	SUNY ELISA	UVM ELISA	VTDOH ELISA	ELISA w/SUNY std	PPIA	HPLC-FD
8/1/01	Burl. Water - Finish	0.000	--	--	--	0.001	0.000
8/1/01	Burl. Water - Raw	--	0.000	--	0.078	0.157	0.000
8/1/01	Champ. Water - Finish	0.000	--	--	--	0.001	0.000
8/1/01	Champ. Water - Raw	0.006	0.000	--	0.076	0.094	0.000
9/5/01	Burl. Water - Finish	--	--	--	0.002	0.003	0.001
9/5/01	Burlington Water - Raw	--	0.000	0.000	0.007	0.126	0.000
9/5/01	Champ. Water - Finish	--	--	--	0.004	0.008	0.003
9/5/01	Champ. Water - Raw	--	0.000	--	0.001	0.001	0.000
10/9/01	Champlain Water - Finish	--	--	--	0.001	0.001	0.000
10/9/01	Champlain Water - Raw	--	--	--	>0.008	0.102	0.000
10/15/01	Burlington Water - Finish	--	--	--	0.003	0.005	0.000
10/15/01	Burlington Water - Raw	--	--	--	0.006	0.008	0.000

Northern Lake Champlain

The bloom samples collected by NY and VT state field personnel in Missisquoi Bay and the Northeast Arm were tested for toxins. In all cases, microcystin exceeded, and at times significantly exceeded, the WHO guideline of 1 µg/L (Table 5). Anatoxin was not detected.

However, it is important to note that these concentrations were observed in extracted plankton material. No water samples were available and so no estimate can be made of ambient water concentrations within the blooms, however. These concentrations were undoubtedly significantly lower.

Table 5. Toxin concentrations in plankton blooms from northern Lake Champlain, 2001.

		Microcystin Concentration (µg/L)				Anatoxin-a
			ELISA Results			(µg/L)
Collection Dates	Sample Locations	PPIA	Average	n	SE	HPLC-FD
9/11/01	Miss. Bay	--	5.481	2	5.470	--
9/18/01	NE Arm St.Albans	5.815	59.730	2	53.870	0.000
9/19/01	Miss. Bay Sta.50	70.022	235.550	2	175.126	0.000
9/19/01	Miss. Bay-Boat Launch	114.570	285.849	3	183.238	0.000

DISCUSSION AND CONCLUSIONS

The Occurrence of Potential Toxin-Producing BGA

BGA were documented in Burlington Bay during the summer of 2001. Several different taxa were identified at low densities in the qualitative samples collected during June. This is consistent with historical data from Lake Champlain (Brown et al. 1991, 1992) and with the ecology of these organisms. BGA prefer warmer water temperatures and are prevalent later in the summer. Quantitative samples collected in 2001 confirmed this.

Visible BGA surface blooms were not noted in the open waters of Burlington Bay during the summer of 2001. While densities of BGA greater than 10,000 cells per mL were noted in several net plankton samples collected in the bay, cells did not accumulate in surface scums. The only known exception to this occurred in the boat slip adjacent to the UVM Rubenstein Ecosystem Science Laboratory in Burlington, where a dense surface scum was present for several days in July. BGA blooms were documented by NY and VT State field personnel in northern Lake Champlain, specifically Missisquoi Bay, the Northeast Arm and Maquam Bay.

Both potential toxin-producing and non-producing BGA taxa were observed in the plankton. Potential toxin-producers were the same species identified in 2000 (Rosen et al.): several *Anabaena spp., Aphanizomenon flos-aquae, Microcystis aeruginosa, and Gloeotrichia spp.*. No new taxa were documented. *Anabaena flos-aquae* and *Aphanizomenon flos-aquae* were ubiquitous in Burlington Bay, occurring in approximately 70% of the samples analyzed. The bloom noted in the Melosira slip was primarily *Anabaena flos-aquae* with some *Microcystis*. The blooms documented in the northern portions of the lake were composed of *Gloeotrichia* and *Aphanizomenon flos-aquae.*

The open waters of Burlington Bay do not appear to be conducive to the development of algal surface blooms under typical environmental conditions. While the warm weather and drought conditions did lead to large populations of BGA, there were no extended periods of calm water during 2001 and no surface accumulations of BGA were noted in the open waters or near the beaches. In the more protected environments of the Rubenstein boat slip and northern portions of Lake Champlain, potential toxin-producers did accumulate in dense surface scums. Had Burlington Bay experienced an extended wind-free period, it is likely that BGA would have accumulated visibly at the surface in some areas of the bay.

Toxin Production in Burlington Bay

Anatoxin was detected at low levels in several samples collected around Burlington Bay on September 4 and in finish water at the water treatment facilities. Anatoxin was also detected in the boat slip bloom. Microcystin was detected all summer at beaches, offshore surface waters, and in raw and finish water from both treatment plants. Ambient microcystin concentrations in Burlington Bay plankton did not exceed the World Health Organization guideline of 1 µg/L.

Microcystin concentrations in the plankton samples collected from Missisquoi Bay and the Northeast Arm also exceeded the WHO guideline, but because sample volumes were not known and whole water samples were not available, ambient concentrations could not be calculated.

The environmental conditions that prevented the accumulation of BGA at the surface in Burlington Bay also prevented toxin concentrations from reaching levels of concern. Accumulations of BGA in scums in the surface waters of Burlington Bay during 2001 would likely have resulted in significant ambient concentrations of toxins similar to those noted in the Rubenstein boat slip and northern portions of Lake Champlain.

Assessing Potential Human Exposure

Drinking Water Facilities

Low levels of microcystin were detected in raw water samples collected from both water treatment facilities and microscopic analysis confirmed the presence of BGA at very low densities in raw water. Because the intake structures for both facilities are located in more than 50 feet of water and BGA tend to accumulate in the upper water column, the likelihood that large quantities of BGA would enter these facilities seems low. Large amounts of water are processed by such facilities however, and it is possible to artificially concentrate BGA in the pre-filtering process, resulting in detectable toxin concentrations (Chorus and Bartram 1999, Lahti et al. 2001). In these analyses, however, the concentrations measured in finished water were 10 to 100 times lower than the WHO recommended guideline for protection of human health. If BGA densities remain high during fall turnover, it is also possible that algae and toxins would be carried down to the intake pipe at this time.

On Lake Champlain, there are many water treatment facilities with intakes located in shallow waters. These facilities appear to be at the greatest risk of drawing significant accumulations of BGA into the plant when environmental conditions favor higher BGA densities.

In the future, BGA toxins will be regulated under the Federal Safe Drinking Water Act as a contaminant of concern. The USEPA is currently developing recommendations on methods of analysis and public notification for these toxins.

Recreational Activities

Swimming is the recreational activity mostly likely to result in contact with or ingestion of water containing BGA or cyanotoxins. At the Burlington Bay beaches, microcystin was frequently detected in the plankton at ambient concentrations below the WHO guideline of 1 µg/L, and anatoxin was also detected on one date. Under environmental conditions leading to surface accumulations near shore, toxin concentrations may reach or exceed this guideline. Adult swimmers will generally avoid water where there is visible accumulating plant material, however, and therefore, minimize or avoid exposure. Children and pets are more likely to ignore accumulating algae and, because of their smaller size, may be more sensitive to the toxins present. Dogs are particularly at risk here because they may consume algal material directly as well as ingest it while drinking.

While toxins are contained within intact cells, exposure risk is reduced by avoidance. Once a bloom begins to decay and cells lyse, more toxins are released into the water and these toxins, especially microcystin, may persist for several weeks (Chorus and Bartram 1999). There may be no visible indication of a bloom, yet toxin concentrations may be high. Ingestion would pose a significant risk to swimmers, especially younger or less skilled swimmers who may be more likely to swallow water.

Future Needs

Monitoring Cyanobacteria

Because environmental conditions influence the distribution and accumulation of potential toxin-producing BGA, it is difficult to predict blooms. A tiered monitoring and alert system framework to inform health officials and the general public about the occurrence of and potential risks associated with the development of BGA blooms would be beneficial. The users of this information would include the VT and NY Departments of Health, operators of drinking water facilities drawing from the lake, beach managers, recreational users, and home or camp owners who draw their water directly from Lake Champlain. Such an alert system must be comparatively simple to implement, economically feasible and provide needed information in a timely manner.

We suggest the following prototype for a tiered BGA monitoring system:

Initial Screening: The first stage of monitoring is designed to locate developing BGA populations. Samples would be collected once a month in spring and early summer and twice a month from mid-summer through the fall. A vertical plankton net tow will be used to concentrate surface waters for microscopic analysis of the BGA present. Samples will be screened within 48 hours for the presence of potential toxin-producing BGA. Once potential toxin-producing species are found, quantitative sampling would begin.

Quantitative Monitoring: At this level, phytoplankton collections will be made with a plankton net twice each month. The BGA in these samples will be enumerated within 48 hours. Detection of BGA at densities of 2000 cells per mL in the upper 3 m of the water column will trigger the progression to the next level.

Vigilance Level: Quantitative net samples for phytoplankton and chlorophyll a will be collected once a week at mid-day at this level. Because warm calm conditions can result in rapid accumulation of BGA at the surface, weather conditions will influence the specific sampling days. Public health officials will be notified that BGA are abundant and under certain conditions could accumulate at the surface. Should the density fall below the threshold, sampling will return to the biweekly quantitative monitoring frequency. BGA densities of more than 4000 cells per mL or 1 µg chlorophyll a per L with greater than 80% of the cells represented by BGA will trigger the progression to the next level.

Alert Level 1: At this level, there is accumulating algal biomass in the upper water column. Toxins in this accumulated material could potentially reach concentrations that pose a risk to humans and animals. Public health officials will be notified of the increased biomass and the need for caution. Whole water samples will be collected on a weekly basis at mid-day to determine algal density, chlorophyll concentration and toxin concentration, more frequently if conditions warrant. Whole water samples will be collected at this point to reduce loss of colony fragments through the net. Subsamples for toxin analysis will be screened primarily by enzyme-linked immunosorbant assays (ELISA) for microcystin. ELISA analytical capability exists at UVM and the VT DOH laboratory in Burlington, and the analyses can be completed rapidly (within several hours). Anatoxin analysis requires significantly more time (several days) and is currently not available in Vermont. ELISA results will be communicated to public health officials, along with appropriate level of concern.

Ambient toxin concentrations above the World Health Organization's guideline of 1 μg per L microcystin represent a potential threat to human health and will trigger progression to the next level. By relying on the results of the ELISA for action, anatoxin-producing blooms may be missed, but technology offers no rapid screening method for anatoxin at this time. If anatoxin-producing species predominate in a bloom, then anatoxin analyses will be conducted and the results will be communicated to public health officials as soon they are available.

Alert Level 2: Significant toxin concentrations have been documented in the water at this level. Public health officials will be notified of the toxin concentrations and advisories may be issued concerning recreational activities and consumption of water. Frequent sampling to track toxin and chlorophyll concentrations should continue until the bloom subsides and toxin concentrations fall below 1 μg per L microcystin.

<u>Public Education</u>

The occurrence of toxic algal blooms on Lake Champlain is recent and there is relatively little information available to the public. As a result, there is likely to be considerable amount of misleading information regarding algal blooms. In conjunction with the implementation of a tiered monitoring framework, a public education campaign should be initiated to provide lake users with the skills/information they need to make decisions regarding water withdrawal and recreational activities on Lake Champlain. Goals of such a program would be to:

1) introduce the concept of the monitoring framework and the advisory information that would be issued under the framework;
2) provide basic information about bloom occurrence and avoidance;
3) provide basic information about effects of toxin exposures; and
4) provide regulatory contacts for reporting blooms and seeking additional information.

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Appendix – Data Summary

dashes indicate sample was not collected; blanks indicate sample was collected, but analysis is not complete

					Microcystin Concentration (ug/L)				Anatoxin-a (ug/L)
Collection Dates	Sample Locations	Rep	Time Sampled	Approx. Total Depth (ft)	Analyzed for Toxins	ELISA w/Envirologix Std	ELISA w/SUNY std	PPIA	HPLC-FD
4-Jun-01	Apple Tree E	1	9:27	25	---	---	---	---	---
4-Jun-01	Apple Tree E	2	9:27	25	---	---	---	---	---
4-Jun-01	Burl. Water- Bay	1	9:10	58	---	---	---	---	---
4-Jun-01	Burl. Water- Bay	2	9:10	58	---	---	---	---	---
4-Jun-01	Champlain Water- Bay	1	10:33	76	---	---	---	---	---
4-Jun-01	Champlain Water- Bay	2	10:33	76	---	---	---	---	---
4-Jun-01	Inner Harbor N	1	8:47	23	---	---	---	---	---
4-Jun-01	Inner Harbor N	2	8:47	23	---	---	---	---	---
4-Jun-01	Juniper Island	1	9:57	80	---	---	---	---	---
4-Jun-01	Juniper Island	2	9:57	80	---	---	---	---	---
4-Jun-01	Lakeside S	1	10:49	15	---	---	---	---	---
4-Jun-01	Lakeside S	2	10:49	15	---	---	---	---	---
4-Jun-01	Outer Harbor S	1	11:07	60	---	---	---	---	---
4-Jun-01	Outer Harbor S	2	11:07	60	---	---	---	---	---
25-Jun-01	Apple Tree E	1	11:11	25	---	---	---	---	---
25-Jun-01	Apple Tree E	2	11:11	25	---	---	---	---	---
25-Jun-01	Burl. Water- Bay	1	10:57	58	---	---	---	---	---
25-Jun-01	Burl. Water- Bay	2	10:57	58	---	---	---	---	---
25-Jun-01	Champlain Water- Bay	1	12:09	76	---	---	---	---	---
25-Jun-01	Champlain Water- Bay	2	12:09	76	---	---	---	---	---
25-Jun-01	Inner Harbor N	1	10:35	25	---	---	---	---	---
25-Jun-01	Inner Harbor N	2	10:35	25	---	---	---	---	---
25-Jun-01	Juniper Island	1	11:38	80	---	---	---	---	---
25-Jun-01	Juniper Island	2	11:38	80	---	---	---	---	---
25-Jun-01	Lakeside S	1	12:24	15	---	---	---	---	---

25-Jun-01	Lakeside S	2	12:24	15	---	---	---	---	---
25-Jun-01	Outer Harbor S	1	12:38	60	---	---	---	---	---
25-Jun-01	Outer Harbor S	2	12:38	60	---	---	---	---	---
3-Jul-01	Apple Tree E	1	9:22	25	---	---	---	---	---
3-Jul-01	Apple Tree E	2	9:22	25	---	---	---	---	---
3-Jul-01	Burl. Water- Bay	1	9:12	58	---	---	---	---	---
3-Jul-01	Burl. Water- Bay	2	9:12	58	---	---	---	---	---
3-Jul-01	Champlain Water- Bay	1	10:19	56	---	---	---	---	---
3-Jul-01	Champlain Water- Bay	2	10:19	56	---	---	---	---	---
3-Jul-01	Inner Harbor N	1	8:53	23	---	---	---	---	---
3-Jul-01	Inner Harbor N	2	8:53	23	---	---	---	---	---
3-Jul-01	Juniper Island	1	9:50	80	---	---	---	---	---
3-Jul-01	Juniper Island	2	9:50	80	---	---	---	---	---
3-Jul-01	Lakeside S	1	10:34	15	---	---	---	---	---
3-Jul-01	Lakeside S	2	10:34	15	---	---	---	---	---
3-Jul-01	Outer Harbor S	1	10:57	60	---	---	---	---	---
3-Jul-01	Outer Harbor S	2	10:57	60	---	---	---	---	---
17-Jul-01	Melosira Boat Slip	1	unknown	8	---	---	---	---	---
17-Jul-01	Melosira Boat Slip	2	unknown	8	---	---	---	---	---
17-Jul-01	Melosira Boat Slip	3	unknown	8	SUNY	0.009	0.037	0.076	0.026
19-Jul-01	Melosira Boat Slip	1	unknown	8	SUNY	0.459	0.242	2.192	0
19-Jul-01	Melosira Boat Slip	2	unknown	8	x	below detection	---	---	---
19-Jul-01	Melosira Boat Slip	3	unknown	8	---	---	---	---	---
19-Jul-01	Melosira Boat Slip	ww	unknown	8	SUNY	1.15	0.174	0.483	0
20-Jul-01	Apple Tree E	1	9:47	25	---	---	---	---	---
20-Jul-01	Apple Tree E	2	9:47	25	---	---	---	---	---
20-Jul-01	Burl. Water- Bay	1	9:20	50	---	---	---	---	---
20-Jul-01	Burl. Water- Bay	2	9:20	50	---	---	---	---	---
20-Jul-01	Champlain Water- Bay	1	11:00	76	---	---	---	---	---
20-Jul-01	Champlain Water- Bay	2	11:00	76	---	---	---	---	---
20-Jul-01	Inner Harbor N	1	9:00	23	---	---	---	---	---
20-Jul-01	Inner Harbor N	2	9:00	23	---	---	---	---	---
20-Jul-01	Juniper Island	1	10:13	80	---	---	---	---	---
20-Jul-01	Juniper Island	2	10:13	80	---	---	---	---	---
20-Jul-01	Lakeside S	1	11:16	15	---	---	---	---	---
20-Jul-01	Lakeside S	2	11:16	15	---	---	---	---	---
20-Jul-01	Outer Harbor S	1	11:31	60	---	---	---	---	---

20-Jul-01	Outer Harbor S	2	11:31	60	---	---	---	---	---
31-Jul-01	.25 mile off Lakeside	0			---	---	---	---	---
1-Aug-01	Burl. Water- Bay	1			x	0.002	--	--	--
1-Aug-01	Burl. Water- Bay	2			SUNY	--	0.075	0.104	0
1-Aug-01	Burl. Water- Finish	1			SUNY	0	--	0.001	0
1-Aug-01	Burl. Water- Raw	1			x	out of range	--	--	--
1-Aug-01	Burl. Water- Raw	2			SUNY	--	0.078	0.157	0
1-Aug-01	Champ. Water- Bay	1			x	out of range	--	--	--
1-Aug-01	Champ. Water- Bay	2			SUNY	0.007	0.075	0.107	0
1-Aug-01	Champ. Water- Finish	1			SUNY	0	--	0.001	0
1-Aug-01	Champ. Water Raw	2			SUNY	0.006	0.076	0.094	0
1-Aug-01	Champ. Water- Raw	1			x	out of range	--	--	--
1-Aug-01	North Beach	1			x	0.00287850	--	--	--
1-Aug-01	North Beach	2			SUNY	--	0.003	0.11	0
1-Aug-01	NorthB-whole water on filter	1			x		--	--	--
1-Aug-01	Offshore Red Rocks	1			x	out of range	--	--	--
1-Aug-01	Offshore Red Rocks	2			SUNY	0.007	0.002	0.093	0
1-Aug-01	Offshore Red Rocks	3			---	--	--	--	--
1-Aug-01	Red Rocks Beach	1			x	0.00218867	--	--	--
1-Aug-01	Red Rocks Beach	2			SUNY	0.008	0.076	0.097	0
9-Aug-01	Apple Tree Bay E	1	9:30	25	--	--	--	--	--
9-Aug-01	Apple Tree Bay E	2	9:30	25	--	--	--	--	--
9-Aug-01	Burl. Water- Bay	1	9:12	58	--	--	--	--	--
9-Aug-01	Burl. Water- Bay	2	9:12	58	--	--	--	--	--
9-Aug-01	Champ. Water- Bay	1	10:26	76	--	--	--	--	--
9-Aug-01	Champ. Water- Bay	1	10:26	76	--	--	--	--	--
9-Aug-01	Champ. Water- Bay	2	10:26	76	--	--	--	--	--
9-Aug-01	Inner Harbor N	1	8:53	23	--	--	--	--	--
9-Aug-01	Inner Harbor N	2	8:53	23	--	--	--	--	--
9-Aug-01	Juniper Island	1	9:56	80	--	--	--	--	--
9-Aug-01	Juniper Island	2	9:56	80	--	--	--	--	--
9-Aug-01	Lakeside	1	10:48	15	--	--	--	--	--
9-Aug-01	Lakeside	2	10:48	15	--	--	--	--	--
9-Aug-01	North Beach	1			--	--	--	--	--
9-Aug-01	North Beach	2			--	--	--	--	--
9-Aug-01	Outer Harbor S	1	11:05	60	--	--	--	--	--
9-Aug-01	Outer Harbor S	2	11:05	60	--	--	--	--	--

9-Aug-01	Red Rocks Beach	1			--	--	--	--	--
9-Aug-01	Red Rocks Beach	2			--	--	--	--	--
14-Aug-01	Blanchard Beach	1	10:30		--	--	--	--	--
14-Aug-01	North Beach	1	9:45		--	--	--	--	--
14-Aug-01	Red Rocks Beach	1	10:15		--	--	--	--	--
22-Aug-01	Blanchard Beach	1			--	--	--	--	--
22-Aug-01	North Beach	1			--	--	--	--	--
22-Aug-01	Red Rocks Beach	1			--	--	--	--	--
27-Aug-01	Apple Tree Bay E	1	9:13	23	---	--	--	--	--
27-Aug-01	Apple Tree Bay E	2	9:13	23	---	--	--	--	--
27-Aug-01	Burl. Water- Bay	1	8:52	58	x	0.00847407	--	--	--
27-Aug-01	Burl. Water- Bay	2	8:52	58	x	out of range	--	--	--
27-Aug-01	Champ. Water- Bay	1	10:21	76	x	0.00661784	--	--	--
27-Aug-01	Champ. Water- Bay	2	10:21	76	x	0.00366782	--	--	--
27-Aug-01	Inner Harbor N	1	8:34	23	---	--	--	--	--
27-Aug-01	Inner Harbor N	2	8:34	23	---	--	--	--	--
27-Aug-01	Juniper Island	1	9:38	80	---	--	--	--	--
27-Aug-01	Juniper Island	2	9:38	80	---	--	--	--	--
27-Aug-01	Lakeside S	1	10:35	15	---	--	--	--	--
27-Aug-01	Lakeside S	2	10:35	15	---	--	--	--	--
27-Aug-01	North Beach	1			x	out of range	--	--	--
27-Aug-01	North Beach	2			x	out of range	--	--	--
27-Aug-01	Outer Harbor S	1	10:48	60	---	--	--	--	--
27-Aug-01	Outer Harbor S	2	10:48	60	---	--	--	--	--
27-Aug-01	Red Rocks Beach	1			x	0.00460756	--	--	--
27-Aug-01	Red Rocks Beach	2			x	0.00503703	--	--	--
4-Sep-01	Apple Tree East	1	9:11	23	--	--	--	--	--
4-Sep-01	Apple Tree East	2	9:11	23	--	--	--	--	--
4-Sep-01	Burlington Water Bay	1	?	58	SUNY	--	0.024	0.017	0.014
4-Sep-01	Burlington Water Bay	2	?	58	x	0.01837398	--	--	--
4-Sep-01	Burlington Water Bay	3	?	58	VT DOH	0.022	--	--	--
4-Sep-01	Champ. Water Bay	1	11:18	76	SUNY	--	0.028	0.013	0.005
4-Sep-01	Champ. Water Bay	2	11:18	76	x	0.01252715	--	--	--
4-Sep-01	Champ. Water Bay	3	11:18	76	VT DOH	0.017	--	--	--
4-Sep-01	Inner Harbor North	1	?	25	--	--	--	--	--
4-Sep-01	Inner Harbor North	2	?	25	--	--	--	--	--
4-Sep-01	Juniper	1	9:38	80	--	--	--	--	--
4-Sep-01	Juniper	2	9:38	80	--	--	--	--	--

4-Sep-01	Lakeside South	1	11:33	15	--	--	--	--	--
4-Sep-01	Lakeside South	2	11:33	15	--	--	--	--	--
4-Sep-01	North Beach	1			SUNY	--	0.023	0.014	0.011
4-Sep-01	North Beach	2			x	0.01497971	--	--	--
4-Sep-01	North Beach	3			VT DOH	0.016	--	--	--
4-Sep-01	Outer Harbor South	1	11:44	60	--	--	--	--	--
4-Sep-01	Outer Harbor South	2	11:44	60	--	--	--	--	--
4-Sep-01	Red Rocks	1			SUNY	--	0.023	0.008	0.003
4-Sep-01	Red Rocks	2			x	0.00938773	--	--	--
4-Sep-01	Red Rocks	3			VT DOH	0.009	--	--	--
5-Sep-01	Burl. Water Finish	1			SUNY	--	0.002	0.003	0.001
5-Sep-01	Burl. Water Finish	2			---	--	--	--	--
5-Sep-01	Burlington Water Raw	1			SUNY	--	0.007	0.126	0
5-Sep-01	Burlington Water Raw	2			x	-7.64167E-0	--	--	--
5-Sep-01	Burlington Water Raw	3			VT DOH	0.0001	--	--	--
5-Sep-01	Champ. Water Finish	1			SUNY	--	0.004	0.008	0.003
5-Sep-01	Champ. Water Finish	2			---	--	--	--	--
5-Sep-01	Champ. Water Raw	1			x	1.01655E-0	--	--	--
5-Sep-01	Champ. Water Raw	2			SUNY	--	0.001	0.001	0
11-Sep-01	Miss. Bay	1			x	10.95	--	--	--
11-Sep-01	Miss. Bay	2			VT DOH	0.011	--	--	--
11-Sep-01	Miss. Bay	3			x		--	--	--
12-Sep-01	North Beach Inshore	1			x	-0.41	--	--	--
12-Sep-01	North Beach Inshore	2			x		--	--	--
12-Sep-01	North Beach Offshore	1			x		--	--	--
12-Sep-01	North Beach Offshore	2			x		--	--	--
12-Sep-01	North Beach Offshore	3			x	-0.45	--	--	--
12-Sep-01	Outer Harbor N	1			x		--	--	--
12-Sep-01	Outer Harbor N	2			x		--	--	--
18-Sep-01	NE Arm St.Albans	1			---	--	--	--	--
18-Sep-01	NE Arm St.Albans	2			---	--	--	--	--
18-Sep-01	NE Arm St.Albans	3			---	--	--	--	--
18-Sep-01	NE Arm St.Albans	4			x	?	--	--	--
18-Sep-01	NE Arm St.Albans	5			SUNY	113.599	5.86	5.815	0
18-Sep-01	NE Arm St.Albans	6			---	--	--	--	--
19-Sep-01	Miss. Bay Sta.50	1			---	--	--	--	--
19-Sep-01	Miss. Bay Sta.50	2			---	--	--	--	--
19-Sep-01	Miss. Bay Sta.50	3			---	--	--	--	--

19-Sep-01	Miss. Bay Sta.50	4			x	?	--	--	--
19-Sep-01	Miss. Bay Sta.50	5			SUNY	410.676	60.424	70.022	0
19-Sep-01	Miss. Bay Sta.50	6			---	--	--	--	--
19-Sep-01	Miss. Bay-Boat Launch	1			---	--	--	--	--
19-Sep-01	Miss. Bay-Boat Launch	2			---	--	--	--	--
19-Sep-01	Miss. Bay-Boat Launch	3			---	--	--	--	--
19-Sep-01	Miss. Bay-Boat Launch	4			x	58.45	--	--	--
19-Sep-01	Miss. Bay-Boat Launch	5			SUNY	648.438	150.659	114.57	0
19-Sep-01	Miss. Bay-Boat Launch	6			---	--	--	--	--
25-Sep-01	Apple Tree E	1	9:30	25	---	--	--	--	--
25-Sep-01	Apple Tree E	2	9:30	25	---	--	--	--	--
25-Sep-01	Burlington Water Bay	1	9:16	58	SUNY	--	0.023	0.012	0
25-Sep-01	Burlington Water Bay	2	9:16	58	x	lost?	--	--	--
25-Sep-01	Burlington Water Bay	3	9:16	58	x	lost?	--	--	--
25-Sep-01	Champ. Water Bay	1	10:38	76	x	0.01696782	--	--	--
25-Sep-01	Champ. Water Bay	2	10:38	76	x	0.01787460	--	--	--
25-Sep-01	Champ. Water Bay	3	10:38	76	SUNY	--	0.022	0.017	0
25-Sep-01	Inner Harbor N	1	8:51	25	---	--	--	--	--
25-Sep-01	Inner Harbor N	2	8:51	25	---	--	--	--	--
25-Sep-01	Juniper Island	1	9:55	80	---	--	--	--	--
25-Sep-01	Juniper Island	2	9:55	80	---	--	--	--	--
25-Sep-01	Lakeside S	1	10:53	15	---	--	--	--	--
25-Sep-01	Lakeside S	2	10:53	15	---	--	--	--	--
25-Sep-01	North Beach	1			SUNY	--	0.034	0.012	0
25-Sep-01	North Beach	2			x		--	--	--
25-Sep-01	North Beach	3			x		--	--	--
25-Sep-01	Outer Harbor S	1	11:05	60	---	--	--	--	--
25-Sep-01	Outer Harbor S	2	11:05	60	---	--	--	--	--
25-Sep-01	Red Rocks	1			x	0.00537455	--	--	--
25-Sep-01	Red Rocks	2			x	0.00556729	--	--	--
25-Sep-01	Red Rocks	3			SUNY	--	0.023	0.006	0
9-Oct-01	Champlain Water Finish	1			SUNY	--	0.001	0.001	0
9-Oct-01	Champlain Water Raw	1			SUNY	--	>0.008	0.102	0
15-Oct-01	Burlington Water Finish	1			SUNY	--	0.003	0.005	0
15-Oct-01	Burlington Water Finish	2			---	--	--	--	--
15-Oct-01	Burlington Water Raw	1			SUNY	--	0.006	0.008	0
15-Oct-01	Burlington Water Raw	2			---	--	--	--	--

16-Oct-01	Apple Tree E	1	9:21	25	--	--	--	--	--
16-Oct-01	Apple Tree E	2	9:21	25	--	--	--	--	--
16-Oct-01	Burlington Water Bay	1	9:11	58	--	--	--	--	--
16-Oct-01	Burlington Water Bay	2	9:11	58	--	--	--	--	--
16-Oct-01	Champ. Water Bay	1	10:20	76	--	--	--	--	--
16-Oct-01	Champ. Water Bay	2	10:20	76	--	--	--	--	--
16-Oct-01	Inner Harbor N	1	8:44	23	--	--	--	--	--
16-Oct-01	Inner Harbor N	2	8:44	23	--	--	--	--	--
16-Oct-01	Juniper Island	1	9:45	80	--	--	--	--	--
16-Oct-01	Juniper Island	2	9:45	80	--	--	--	--	--
16-Oct-01	Lakeside S	1	10:34	15	--	--	--	--	--
16-Oct-01	Lakeside S	2	10:34	15	--	--	--	--	--
16-Oct-01	North Beach	1			--	--	--	--	--
16-Oct-01	North Beach	2			--	--	--	--	--
16-Oct-01	Outer Harbor S	1	10:47	60	--	--	--	--	--
16-Oct-01	Outer Harbor S	2	10:47	60	--	--	--	--	--
16-Oct-01	Red Rocks	1			--	--	--	--	--
16-Oct-01	Red Rocks	2			--	--	--	--	--

Collection Dates	Sample Locations	Rep	Time Sampled	Approx. Total Depth (ft)	TN (mg/L)	TP (ug/L)	Chl a Conc., ug/L	Secchi Depth (m)	Avg.T in top 3m (°C)	Quant. Net	Quali-tative	Total Cells per ml	Blue-greens as % Total Cells/ml
4-Jun-01	Apple Tree E	1	9:27	25	0.42	8.3	---	4	10.22	---	ekb	---	---
4-Jun-01	Apple Tree E	2	9:27	25	0.42	8.7	---	4	10.22	---	---	---	---
4-Jun-01	Burl. Water- Bay	1	9:10	58	0.50	12.1	---	4.5	10.32	---	ekb	---	---
4-Jun-01	Burl. Water- Bay	2	9:10	58	0.45	10.5	---	4.5	10.32	---	---	---	---
4-Jun-01	Champlain Water- Bay	1	10:33	76	0.44	7.7	---	3.5	10.25	---	ekb	---	---
4-Jun-01	Champlain Water- Bay	2	10:33	76	0.44	10.1	---	3.5	10.25	---	---	---	---
4-Jun-01	Inner Harbor N	1	8:47	23	0.42	8.8	---	5	10.45	---	not coll.	---	---
4-Jun-01	Inner Harbor N	2	8:47	23	0.44	12.9	---	5	10.45	---	---	---	---
4-Jun-01	Juniper Island	1	9:57	80	0.44	10.6	---	4	10.84	---	ekb	---	---
4-Jun-01	Juniper Island	2	9:57	80	0.41	10.6	---	4	10.84	---	---	---	---
4-Jun-01	Lakeside S	1	10:49	15	0.42	10.0	---	3	10.47	---	ekb	---	---
4-Jun-01	Lakeside S	2	10:49	15	0.41	10.5	---	3	10.47	---	---	---	---
4-Jun-01	Outer Harbor S	1	11:07	60	0.44	7.8	---	3.5	10.31	---	ekb	---	---
4-Jun-01	Outer Harbor S	2	11:07	60	0.43	6.9	---	3.5	10.31	---	---	---	---
25-Jun-01	Apple Tree E	1	11:11	25	0.37	n/a	---	4.5	17.00	---	ekb	---	---
25-Jun-01	Apple Tree E	2	11:11	25	0.36	n/a	---	4.5	17.00	---	---	---	---
25-Jun-01	Burl. Water- Bay	1	10:57	58	0.40	2.8	---	5.5	16.62	---	ekb	---	---
25-Jun-01	Burl. Water- Bay	2	10:57	58	0.37	n/a	---	5.5	16.62	---	---	---	---
25-Jun-01	Champlain Water- Bay	1	12:09	76	0.37	8.8	---	6	17.63	---	ekb	---	---
25-Jun-01	Champlain Water- Bay	2	12:09	76	0.37	2.9	---	6	17.63	---	---	---	---
25-Jun-01	Inner Harbor N	1	10:35	25	0.39	8.0	---	5	17.00	---	ekb	---	---
25-Jun-01	Inner Harbor N	2	10:35	25	0.37	6.6	---	5	17.00	---	---	---	---
25-Jun-01	Juniper Island	1	11:38	80	0.43	4.5	---	5	17.63	---	ekb	---	---
25-Jun-01	Juniper Island	2	11:38	80	0.40	4.2	---	5	17.63	---	---	---	---
25-Jun-01	Lakeside S	1	12:24	15	0.40	n/a	---	5.5	17.66	---	ekb	---	---
25-Jun-01	Lakeside S	2	12:24	15	0.39	5.8	---	5.5	17.66	---	---	---	---
25-Jun-01	Outer Harbor S	1	12:38	60	0.34	2.2	---	6.5	17.42	---	ekb	---	---
25-Jun-01	Outer Harbor S	2	12:38	60	0.39	10.5	---	6.5	17.42	---	---	---	---
3-Jul-01	Apple Tree E	1	9:22	25	0.44	11.1	---	4.75	17.95	---	ekb	---	---
3-Jul-01	Apple Tree E	2	9:22	25	0.41	10.1	---	4.75	17.95	---	---	---	---
3-Jul-01	Burl. Water- Bay	1	9:12	58	0.44	10.6	---	4.25	18.38	---	ekb	---	---
3-Jul-01	Burl. Water- Bay	2	9:12	58	0.41	10.8	---	4.25	18.38	---	---	---	---

3-Jul-01	Champlain Water- Bay	1	10:19	56	0.44	12.0	---	4	18.40	---	ekb	---	---
3-Jul-01	Champlain Water- Bay	2	10:19	56	0.41	21.6	---	4	18.40	---	---	---	---
3-Jul-01	Inner Harbor N	1	8:53	23	0.43	11.3	---	4.25	18.23	---	ekb	---	---
3-Jul-01	Inner Harbor N	2	8:53	23	0.44	12.6	---	4.25	18.23	---	---	---	---
3-Jul-01	Juniper Island	1	9:50	80	0.43	8.5	---	5	16.29	---	ekb	---	---
3-Jul-01	Juniper Island	2	9:50	80	0.41	6.8	---	5	16.29	---	---	---	---
3-Jul-01	Lakeside S	1	10:34	15	0.43	10.5	---	4.5	18.18	---	ekb	---	---
3-Jul-01	Lakeside S	2	10:34	15	0.42	10.5	---	4.5	18.18	---	---	---	---
3-Jul-01	Outer Harbor S	1	10:57	60	0.37	11.5	---	5	18.42	---	ekb	---	---
3-Jul-01	Outer Harbor S	2	10:57	60	0.37	9.5	---	5	18.42	---	---	---	---
17-Jul-01	Melosira Boat Slip	1	unknown	8	---	---	20.6025	bottom	---	---	---		
17-Jul-01	Melosira Boat Slip	2	unknown	8	---	---	3.37917	bottom	---	---	---	---	---
17-Jul-01	Melosira Boat Slip	3	unknown	8	---	---	16.53	bottom	---	---	---	---	---
19-Jul-01	Melosira Boat Slip	1	unknown	8	---	---	725.072	bottom	---	ekb	---	1999393.76	100
19-Jul-01	Melosira Boat Slip	2	unknown	8	---	---	27.498	bottom	---	---	---	---	---
19-Jul-01	Melosira Boat Slip	3	unknown	8	---	---	623.13	bottom	---	---	---	---	---
19-Jul-01	Melosira Boat Slip	ww	unknown	8	---	---	below detection	bottom	---	---	---	---	---
20-Jul-01	Apple Tree E	1	9:47	25	0.37	4.1	---	4.25	20.99	ekb	---	309.96	7.50
20-Jul-01	Apple Tree E	2	9:47	25	0.36	lost	---	4.25	20.99	---	---	---	---
20-Jul-01	Burl. Water- Bay	1	9:20	50	0.37	lost	---	4.25	21.03	ekb	---	288.00	38.30
20-Jul-01	Burl. Water- Bay	2	9:20	50	0.39	4.9	---	4.25	21.03	ekb	---		
20-Jul-01	Champlain Water- Bay	1	11:00	76	0.37	7.1	---	4.5	21.18	ekb	---	271.39	43.30
20-Jul-01	Champlain Water- Bay	2	11:00	76	0.38	5.4	---	4.5	21.18	---	---	---	---
20-Jul-01	Inner Harbor N	1	9:00	23	0.40	10.6	---	4	21.20	ekb	---	344.83	49.66
20-Jul-01	Inner Harbor N	2	9:00	23	0.42	7.1	---	4	21.20	---	---	---	---
20-Jul-01	Juniper Island	1	10:13	80	0.36	n/a	---	6.25	20.90	ekb	---	133.26	34.11
20-Jul-01	Juniper Island	2	10:13	80	0.38	3.2	---	6.25	20.90	---	---	---	---
20-Jul-01	Lakeside S	1	11:16	15	0.37	4.8	---	4.5	21.50	ekb	---	269.14	41.00
20-Jul-01	Lakeside S	2	11:16	15	0.38	6.6	---	4.5	21.50	---	---	---	---
20-Jul-01	Outer Harbor S	1	11:31	60	0.36	3.6	---	4.75	20.91	ekb	---	364.43	23.42
20-Jul-01	Outer Harbor S	2	11:31	60	0.36	n/a	---	4.75	20.91	---	---	---	---
31-Jul-01	.25 mile off Lakeside	0			--	--	---	--	--	ekb	---	797.39	63.72
1-Aug-01	Burl. Water- Bay	1			0.35	5.4	--			ekb	---	2405.13	50.666250
1-Aug-01	Burl. Water- Bay	2			0.34	8.7	0.881346			ekb	---		
1-Aug-01	Burl. Water- Finish	1			---	---	1.153992	--		---	---	---	---
1-Aug-01	Burl. Water- Raw	1			0.35	7.3	---	--	--	ekb	---		
1-Aug-01	Burl. Water- Raw	2			0.39	4.7	0.149771	--	--	ekb	---		

1-Aug-01	Champ. Water- Bay	1			0.34	6.6	0.1		--	ekb	---	752.56	77.096985
1-Aug-01	Champ. Water- Bay	2			0.31	10.5	0.916600		--		---		
1-Aug-01	Champ. Water- Finish	1			---	---	0.8	--	--	---	---	---	---
1-Aug-01	Champ. Water Raw	2			0.48	7.4	---	--	--	ekb	---	64.02	0
1-Aug-01	Champ. Water- Raw	1			0.48	11.9	0.4	--	--	ekb	---	475.55	61.455414
1-Aug-01	North Beach	1			0.33	4.7	0.301513			ekb	---	1081.63	72.234941
1-Aug-01	North Beach	2			0.32	9.2	0.870189			ekb	---	533287.25	99.978802
1-Aug-01	NorthB-whole water on filter	1			x		0.916600			ekb	---	591.40	80.672979
1-Aug-01	Offshore Red Rocks	1			0.51	15.3	x	--		ekb	---	240541.44	99.939655
1-Aug-01	Offshore Red Rocks	2			0.50	12.4	28.59119	--		ekb	---	8583.54	53.633310
1-Aug-01	Offshore Red Rocks	3			---	---	5.416273	--		---	---	14464.99	96.186961
1-Aug-01	Red Rocks Beach	1			0.36	8.9	5.7			ekb	---	174571.44	99.944418
1-Aug-01	Red Rocks Beach	2			lost		0.607019			ekb	---	784.27	79.394240
9-Aug-01	Apple Tree Bay E	1	9:30	25	0.35	9.7	0.711646	4	25.04	ekb	---	153811.19	99.95
9-Aug-01	Apple Tree Bay E	2	9:30	25	0.32	9.7	---	4	25.04	---	---	---	---
9-Aug-01	Burl. Water- Bay	1	9:12	58	?	?		5	24.67	ekb	---	1054.23	0.4743083
9-Aug-01	Burl. Water- Bay	2	9:12	58	?	?	---	5	24.67	---	---	259687.52	99.940130
9-Aug-01	Champ. Water- Bay	1	10:26	76	?	?	---	4	25.01	ekb	---	2763.15	98.632965
9-Aug-01	Champ. Water- Bay	1	10:26	76	---	---	---	4	25.01	---	---	---	---
9-Aug-01	Champ. Water- Bay	2	10:26	76	?	?	---	4	25.01	---	---	---	---
9-Aug-01	Inner Harbor N	1	8:53	23	0.35	13.2	---	4.5	24.93	ekb	---	29792.73	99.786178
9-Aug-01	Inner Harbor N	2	8:53	23	0.34	12.9	---	4.5	24.93	---	---	---	---
9-Aug-01	Juniper Island	1	9:56	80	0.38	11.0	--	3.5	24.04	ekb	---	449.43	45.440729
9-Aug-01	Juniper Island	2	9:56	80	0.32	9.7	---	3.5	24.04	---	---	3844.79	94.398245
9-Aug-01	Lakeside	1	10:48	15	0.39	14.8	---	4	25.07		---		
9-Aug-01	Lakeside	2	10:48	15	0.37	13.3	---	4	25.07	---	---	---	---
9-Aug-01	North Beach	1			?	?	---	5		ekb	---	29979.03	99.891751
9-Aug-01	North Beach	2			?	?	---	5		---	---	---	---
9-Aug-01	Outer Harbor S	1	11:05	60	0.32	10.6	---	4	24.72	ekb	---	1048.77	96.934144
9-Aug-01	Outer Harbor S	2	11:05	60	0.37	12.1	---	4	24.72	---	---	---	---
9-Aug-01	Red Rocks Beach	1			?	?	---	3.5		ekb	---	1839.95	86.902730
9-Aug-01	Red Rocks Beach	2			?	?	---	3.5		---	---	8072.14	98.409290
14-Aug-01	Blanchard Beach	1	10:30		---	---	---	--		---	---	211.65	92.028903
14-Aug-01	North Beach	1	9:45		---	---	---			---	---	3302.96	97.611570
14-Aug-01	Red Rocks Beach	1	10:15		---	---	---			---	---	55.35	78.409071
22-Aug-01	Blanchard Beach	1			---	---	---	--		ekb	---		
22-Aug-01	North Beach	1			---	---	---			ekb	---		

22-Aug-01	Red Rocks Beach	1			---	---	---			ekb	---		
27-Aug-01	Apple Tree Bay E	1	9:13	23	0.38	4.1	---	4.5	21.68		---		
27-Aug-01	Apple Tree Bay E	2	9:13	23	0.37	5.1	---	4.5	21.68		---		
27-Aug-01	Burl. Water- Bay	1	8:52	58	0.33	6.3	---	4	21.87	ekb	---	549.30	100
27-Aug-01	Burl. Water- Bay	2	8:52	58	0.33	4.5	0.537266	4	21.87		---		
27-Aug-01	Champ. Water- Bay	1	10:21	76	0.34	5.3	0.537266	4.5	21.29	ekb	---	529.34	69.952406
27-Aug-01	Champ. Water- Bay	2	10:21	76	0.33	5.0	0.579101	4.5	21.29		---		
27-Aug-01	Inner Harbor N	1	8:34	23	0.35	6.8	0.541740	4.75	21.74		---		
27-Aug-01	Inner Harbor N	2	8:34	23	0.37	6.6	---	4.75	21.74		---		
27-Aug-01	Juniper Island	1	9:38	80	0.36	6.9	---	4	21.38		---		
27-Aug-01	Juniper Island	2	9:38	80	0.35	7.1	---	4	21.38		---		
27-Aug-01	Lakeside S	1	10:35	15	0.36	4.4	---	5.25	21.73		---		
27-Aug-01	Lakeside S	2	10:35	15	0.40	6.0	---	5.25	21.73		---		
27-Aug-01	North Beach	1			0.36	4.8	---	4		ekb	---	1697.55	99.353703
27-Aug-01	North Beach	2			0.44	5.5	0.273983	4			---		
27-Aug-01	Outer Harbor S	1	10:48	60	0.38	6.0	0.296815	4	21.63		---		
27-Aug-01	Outer Harbor S	2	10:48	60	0.40		---	4	21.63		---		
27-Aug-01	Red Rocks Beach	1			0.35	4.8	---	4		ekb	---	758.84	96.559300
27-Aug-01	Red Rocks Beach	2			0.37	5.1	0.407516	4			---		
4-Sep-01	Apple Tree East	1	9:11	23	0.40751	6.4	0.407516		19.43	---	---	---	---
4-Sep-01	Apple Tree East	2	9:11	23		5.4	---		19.43	---	---	---	---
4-Sep-01	Burlington Water Bay	1	?	58	0.33	6.9	---	3	20.88	ekb	---	842.49	93.246131
4-Sep-01	Burlington Water Bay	2	?	58	0.39	5.0	1.1	3	20.88	ekb	---	930.80	93.136487
4-Sep-01	Burlington Water Bay	3	?	58	---	---	1.023476	3	20.88	---	---	---	---
4-Sep-01	Champ. Water Bay	1	11:18	76	0.33	5.7	1.039722	3.5	19.67	ekb	---	474.81	64.935629
4-Sep-01	Champ. Water Bay	2	11:18	76	0.35	4.7	1	3.5	19.67	ekb	---	452.65	40.928625
4-Sep-01	Champ. Water Bay	3	11:18	76	---	---	0.922572	3.5	19.67	---	---	---	---
4-Sep-01	Inner Harbor North	1	?	25	0.34	9.3	0.920566		21.44	---	---	---	---
4-Sep-01	Inner Harbor North	2	?	25	0.33	5.72857	---		21.44	---	---	---	---
4-Sep-01	Juniper	1	9:38	80	0.36	4.58571	---		19.61	---	---	---	---
4-Sep-01	Juniper	2	9:38	80	0.34	8.01428	---		19.61	---	---	---	---
4-Sep-01	Lakeside South	1	11:33	15	0.36	8.44285	---		19.54	---	---	---	---
4-Sep-01	Lakeside South	2	11:33	15	0.34	5.3	---		19.54	---	---	---	---
4-Sep-01	North Beach	1			0.35	?	---	4.25		ekb	---	1041.66	96.384001
4-Sep-01	North Beach	2			0.35	5.4	0.5	4.25		ekb	---	84940.27	99.956481
4-Sep-01	North Beach	3			---	---	0.481076	4.25		---	---	---	---
4-Sep-01	Outer Harbor South	1	11:44	60	0.34		0.441694		19.43	---	---	---	---
4-Sep-01	Outer Harbor South	2	11:44	60	0.35				19.43	---	---	---	---

4-Sep-01	Red Rocks	1			0.33	9.5		4		ekb	---	605.41	96.853882
4-Sep-01	Red Rocks	2			0.35	6.7	0.5	4		ekb	---	404.52	96.426313
4-Sep-01	Red Rocks	3			---	---	0.528152	4		---	---	---	---
5-Sep-01	Burl. Water Finish	1			---	---	0.538308	--	--	---	---	---	---
5-Sep-01	Burl. Water Finish	2			---	---	---	--	--	---	---	---	---
5-Sep-01	Burlington Water Raw	1			0.40	6.3	---	--	--	ekb	---	635.45	80.321515
5-Sep-01	Burlington Water Raw	2			0.40	7.3	0.5	--	--	ekb	---	551.94	76.253402
5-Sep-01	Burlington Water Raw	3			---	---	0.257512	--	--	---	---	---	---
5-Sep-01	Champ. Water Finish	1			---	---	0.119392	--	--	---	---	---	---
5-Sep-01	Champ. Water Finish	2			---	---	---	--	--	---	---	---	---
5-Sep-01	Champ. Water Raw	1			0.48	9.7	---	--	--	?	---	420.13	80.694753
5-Sep-01	Champ. Water Raw	2			0.46	8.8	---	--	--	ekb	---	---	---
11-Sep-01	Miss. Bay	1			---	---	---	--	--	ekb	---	2.07E+08	98.152595
11-Sep-01	Miss. Bay	2			---	---	303.6237	--	--	---	---	---	---
11-Sep-01	Miss. Bay	3			---	---	569.0558	--	--	---	---	---	---
12-Sep-01	North Beach Inshore	1			---	---	---	--	--	---	---	---	---
12-Sep-01	North Beach Inshore	2			---	---	1.145750	--	--	---	---	---	---
12-Sep-01	North Beach Offshore	1			---	---	below detection	--	--	---	---	---	---
12-Sep-01	North Beach Offshore	2			---	---	0.859312	--	--	---	---	---	---
12-Sep-01	North Beach Offshore	3			---	---	2.291500	--	--	---	---	---	---
12-Sep-01	Outer Harbor N	1			---	---	---	--	--	---	---	---	---
12-Sep-01	Outer Harbor N	2			---	---	below detection	--	--	---	---	---	---
18-Sep-01	NE Arm St.Albans	1			---	---	1.636785	--	--	ekb	---	3.64E+12	99.997337
18-Sep-01	NE Arm St.Albans	2			---	---	---	--	--	---	---	---	---
18-Sep-01	NE Arm St.Albans	3			---	---	25168.30	--	--	---	---	---	---
18-Sep-01	NE Arm St.Albans	4			---	---	10388.13	--	--	---	---	---	---
18-Sep-01	NE Arm St.Albans	5			---	---	---	--	--	---	---	---	---
18-Sep-01	NE Arm St.Albans	6			---	---	---	--	--	---	---	---	---
19-Sep-01	Miss. Bay Sta.50	1			---	---	11961.7	--	--	ekb	---	3.53E+09	85.471530
19-Sep-01	Miss. Bay Sta.50	2			---	---	---	--	--	---	---	---	---
19-Sep-01	Miss. Bay Sta.50	3			---	---	7928.590	--	--	---	---	---	---
19-Sep-01	Miss. Bay Sta.50	4			---	---	10832.54	--	--	---	---	---	---
19-Sep-01	Miss. Bay Sta.50	5			---	---	---	--	--	---	---	---	---
19-Sep-01	Miss. Bay Sta.50	6			---	---	---	--	--	---	---	---	---
19-Sep-01	Miss. Bay-Boat Launch	1			---	---	9000.1	--	--	---	---	---	---
19-Sep-01	Miss. Bay-Boat Launch	2			---	---	---	--	--	---	---	---	---

19-Sep-01	Miss. Bay-Boat Launch	3			---	---	19798.56	--	--	---	---	---	---
19-Sep-01	Miss. Bay-Boat Launch	4			---	---	191976.7	--	--	---	---	---	---
19-Sep-01	Miss. Bay-Boat Launch	5			---	---	---	--	--	---	---	---	---
19-Sep-01	Miss. Bay-Boat Launch	6			---	---	---	--	--	---	---	---	---
25-Sep-01	Apple Tree E	1	9:30	25	0.37	11.7	22673.7	3	18.82		---		
25-Sep-01	Apple Tree E	2	9:30	25	0.36	9.9	---	3	18.82		---		
25-Sep-01	Burlington Water Bay	1	9:16	58	0.36	9.3	---	4.5	18.59	ekb	---	1126.70	74.679752
25-Sep-01	Burlington Water Bay	2	9:16	58	0.35	8.8	0.8	4.5	18.59	ekb	---	923.34	76.028026
25-Sep-01	Burlington Water Bay	3	9:16	58	---	---	0.711627	4.5	18.59	---	---		
25-Sep-01	Champ. Water Bay	1	10:38	76	0.33	9.4	0.733191	4	18.70	ekb	---	718.67	88.952699
25-Sep-01	Champ. Water Bay	2	10:38	76	0.33	8.4	1.353778	4	18.70	ekb	---		
25-Sep-01	Champ. Water Bay	3	10:38	76	---	---	0.963772	4	18.70	---	---		
25-Sep-01	Inner Harbor N	1	8:51	25	0.35	6.5	1.2	6	18.69		---		
25-Sep-01	Inner Harbor N	2	8:51	25	0.35	9.2	---	6	18.69		---		
25-Sep-01	Juniper Island	1	9:55	80	0.36	7.3	---	4.5	18.29		---		
25-Sep-01	Juniper Island	2	9:55	80	0.34	8.0	---	4.5	18.29		---		
25-Sep-01	Lakeside S	1	10:53	15	0.39	11.9	---	4	18.58		---		
25-Sep-01	Lakeside S	2	10:53	15	0.39	9.1	---	4	18.58		---		
25-Sep-01	North Beach	1			0.35	8	---	4.5		ekb	---	978.65	100
25-Sep-01	North Beach	2			0.33	8	0.4	4.5		ekb	---	5891.84	97.054323
25-Sep-01	North Beach	3			---	---	0.464942	4.5		---	---		
25-Sep-01	Outer Harbor S	1	11:05	60	0.37	11.6	0.434065	3.5	18.50		---		
25-Sep-01	Outer Harbor S	2	11:05	60	0.37	11.7	---	3.5	18.50		---		
25-Sep-01	Red Rocks	1			0.33	8.1	---	4.5		ekb	---	1061.25	95.293348
25-Sep-01	Red Rocks	2			0.35	7.7	0.489190	4.5		ekb	---	674.73	98.018381
25-Sep-01	Red Rocks	3			---	---	0.499382	4.5		---	---	---	---
9-Oct-01	Champlain Water Finish	1			---	---	0.5	--	--	---	---	---	---
9-Oct-01	Champlain Water Raw	1			---	---	---	--	--	---	---	---	---
15-Oct-01	Burlington Water Finish	1			---	---	---	--	--	---	---	---	---
15-Oct-01	Burlington Water Finish	2			---	---	---	--	--	---	---	---	---
15-Oct-01	Burlington Water Raw	1			---	---	---	--	--	---	---	---	---
15-Oct-01	Burlington Water Raw	2			---	---	---	--	--	---	---	---	---
16-Oct-01	Apple Tree E	1	9:21	25	0.34	2.5	---	6	15.25		---		
16-Oct-01	Apple Tree E	2	9:21	25	0.35	n/a	---	6	15.25		---		
16-Oct-01	Burlington Water Bay	1	9:11	58	0.34	2.4	---	4.25	15.00		---		
16-Oct-01	Burlington Water Bay	2	9:11	58	0.33	2.8	---	4.25	15.00		---		
16-Oct-01	Champ. Water Bay	1	10:20	76	0.31	4.9	---	5	15.03		---		

16-Oct-01	Champ. Water Bay	2	10:20	76	0.33	3.4	---	5	15.03		---		
16-Oct-01	Inner Harbor N	1	8:44	23	0.41	3.8	---	6	15.18		---		
16-Oct-01	Inner Harbor N	2	8:44	23	0.36	3.2	---	6	15.18		---		
16-Oct-01	Juniper Island	1	9:45	80	0.34	4.5	---	4.5	15.00		---		
16-Oct-01	Juniper Island	2	9:45	80	0.37	3.7	---	4.5	15.00		---		
16-Oct-01	Lakeside S	1	10:34	15	0.35	3.1	---	5.5	15.15		---		
16-Oct-01	Lakeside S	2	10:34	15	0.34	8.1	---	5.5	15.15		---		
16-Oct-01	North Beach	1			0.35	4.1	---	5.5			---		
16-Oct-01	North Beach	2			0.37	4.1	---	5.5			---		
16-Oct-01	Outer Harbor S	1	10:47	60	0.35	2.8	---	5.5	15.26		---		
16-Oct-01	Outer Harbor S	2	10:47	60	0.36	3.7	---	5.5	15.26		---		
16-Oct-01	Red Rocks	1			0.35	3.5	---	5.5			---		
16-Oct-01	Red Rocks	2			0.36	3.9	---	5.5			---		