FINAL REPORT ON THE

EMPACT/TECHNOLOGY TRANSFER: NEW YORK LAKE ACCESS PROJECT

Lake George Component

EPA CONTRACT # X-982576-00

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Introduction

The Environmental Protection Agency (EPA) created the Environmental Monitoring for Public Access and Community Tracking (EMPACT) program to provide local, time relevant environmental information to communities via the Internet. Increasing the accessibility of environmental information will serve to better educate the public about their surrounding environment and allow them to make informed choices about their lives. As part of the EMPACT project, EPA, state, university and community groups collected and recorded water quality information. By using common data elements, the ability to share and use the collected information was enhanced. To accomplish the EMPACT goals, the EPA instituted a program that coordinated EPA-sponsored projects with community initiated projects to produce a national network of local environmental information. The goal of this new program was to increase the accessibility of "up-to-date environmental information that the public can understand and use in day-to-day decision making about their health and the environment."

The New York Lake Access Project was created in 2001 from an USEPA EMPACT Metro Grant. The network originally involved robotic buoys on Onondaga Lake and the Seneca River and a webpage to provide access to the database being developed. In 2002, the network was extended with an USEPA EMPACT Technology Transfer Grant adding robotic buoys on Lake George, Otisco and Skaneateles Lakes. Upstate Freshwater Institute (UFI) maintained the buoys on Otisco and Skaneateles Lakes while the Darrin Fresh Water Institute (DFWI) maintained the Lake George buoy. UFI also maintained a webpage (http://NYWaterNet.org/) to facilitate near real time information transfer. A third co-operator in the project, the Lake George Association (LGA), developed curricula for secondary school education programs.

The goals of the Technology Transfer Program in general and the Lake George component in particular are to:

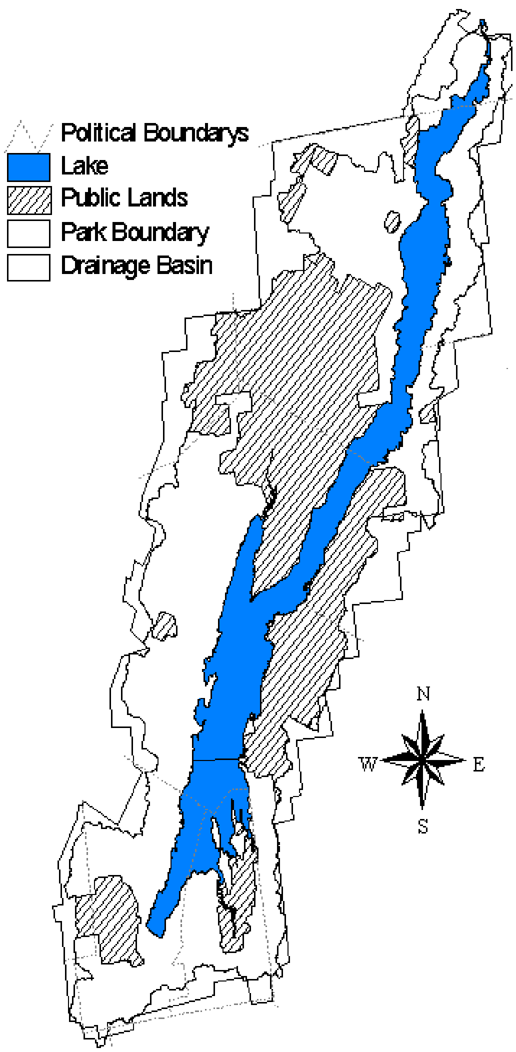
1. apply and advance innovative techniques to meet present and future monitoring needs for the aquatic systems within the network
2. demonstrate the temporal and spatial patterns found in diverse freshwater systems
3. evaluate the utility of this technology for integration into long-term monitoring and management programs for these, and other, New York State surface water systems
4. facilitate the community's understanding of the lakes and their surrounding watersheds
5. develop curricula for students to increase awareness of environmental issues and encourage stewardship.

Background

Study Site

Lake George is located in Warren, Washington and Essex Counties of New York State, with the majority of the lake lying within Warren County. The lake's watershed is located in the foothills of the Adirondack Mountains in the Lake Champlain drainage system. The lake serves as a recreational resource for the entire region.

Figure 1. Map of Lake George.



Lake George is a magnificent 28,000-acre body of water located in the southeastern Adirondack mountain region of New York State. Elevations within the watershed range from 319 feet at the surface of the lake to 2600 feet above sea level. The lake has a surface area of 42 square miles and a steeply sloping watershed of 238 square miles. Lake George has a maximum depth of 196 feet off the eastern side of Dome Island and a mean depth of approximately 70 feet. The hydraulic retention time is calculated as 8.7 years. Located at the northern end is the only outlet, which is dammed and used to maintain the level of the lake. The lake bottom slopes rapidly away from the shoreline in most places, with limited areas for the growth of aquatic plants.

The lake is separated into two distinct basins (North and South) by a shallow, narrow region (the Narrows). Most of the lake's 172 islands lie within the Narrows. Lake George is a soft water, low alkalinity water body typical of many lakes in the Adirondack region of New York. It is dimictic, exhibiting both summer and winter thermal stratification. The lake is best classified as oligotrophic which indicates that nutrients necessary to support growth of algae are low and, subsequently, the myriad of organisms that feed on these microscopic plants, are low as well.

Table 1. Physical features of Lake George, New York.

Lake Basin		
Length	32 miles	51.5 kilometers
Max Width	2.05 miles	3.3 kilometers
Average Width	1.33 miles	2.15 kilometers
Area	42.45 square miles	110 square kilometers
Average Depth	69.7 feet	21.25 meters
Maximum Depth	196 feet	60 meters
Elevation	320 feet	97.5 meters
Drainage Basin		
Area	238.4 square miles	618 square kilometers
Maximum Elevation	2646 feet	806.7 meters

Lake George is a residential/recreational lake with boating, fishing and swimming as the primary uses. The fishery is classified as two-story, indicating the presence of both cold and warm water species. Several communities and numerous private users draw their drinking water from Lake George, frequently with minimal treatment. Public access is extensive, via numerous state, local and private launch ramps, marinas and bathing beaches. An annual boat census by the Lake George Park Commission has recorded in excess of 10,000 boats registered on the lake. The New York State Department of Environmental Conservation ranks Lake George as Class AA(special) indicating the highest use of the lake is as a potable water supply.

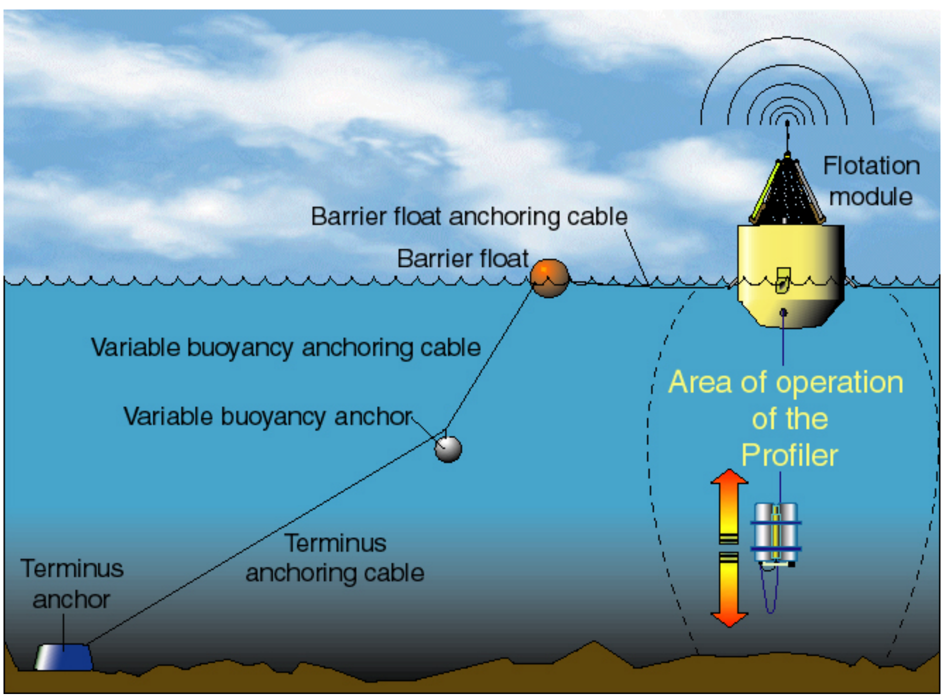
Figure 2. Lake George vista in the region of RUSS buoy.

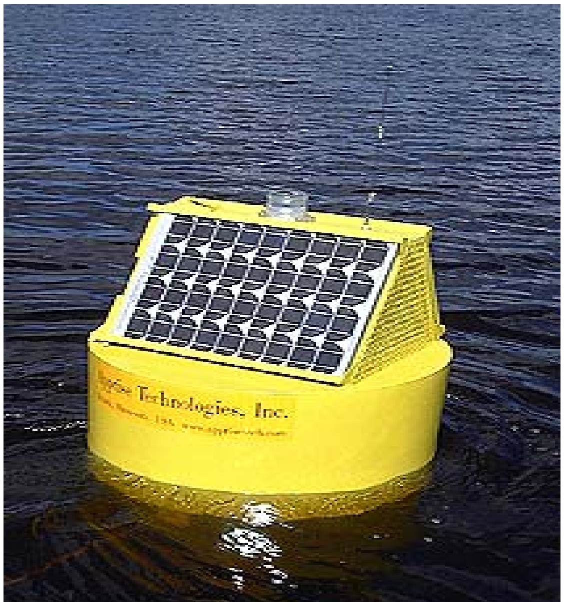
Human activity and changing land use around the lake (perturbation of the watershed) in the last 15 to 20 years is suspected of increasing the rate at which nutrients and other pollutants are coming into the lake. Lake George is currently listed on New York's Priority Waterbody List due to nutrients levels. Additional concerns include the invasion of exotic species (e.g., Eurasian watermilfoil and zebra mussels).

Methods

The Lake George EMPACT Program was based on data collection by a Remote Underwater Sampling Station (RUSS) unit manufactured by Apprise (Apprise Technologies, Inc., Duluth, MN). The near real time data collection system employs a buoy mounted robotic profiler and a sonde mounted probe system. The RUSS unit consists of a floating platform containing solar panels, a series of deep-cycle batteries, and an on-board computer and communications package (Figure 3). A data cable connects the computer to a combination leveling device and sensor package that floats freely below the platform. A buoyancy compensation unit within the profiler is used to move the sensor system up and down in the water column; the profiler can sample at user-specified intervals to depths of 20 m with a precision of 0.2 m of a target depth. The profiler accommodates a Yellow Springs Instruments, Model 6600 (Yellow Springs, OH) water quality sensor package, equipped with probes to measure depth, temperature, pH, specific conductance, dissolved oxygen, turbidity and chlorophyll. The sensors transmit data via the communication cable into a memory buffer within the on-board computer, where it can be downloaded on demand via a combination modem/cell phone. RUSS units are thus able to provide near real-time water quality data at user-specified sampling intervals, virtually independent of lake conditions.

Figure 3. Schematic of the RUSS robotic buoy and profiler system, courtesy of Apprise Technologies, Inc.





Lake George RUSS Unit

The principal limitations to sampling frequency are the periods required for the sensor unit to descend to a specified depth and for the individual sensors to equilibrate. Data collection was limited primarily by available power, with the largest drain being the power required to operate the cell phone connection. Cell phone communication was limited to 2 hours per day in order to maximize buoy operations. Another limitation to data collection was the parking of the profiler near the lake surface during data collection, exposing it to the intense recreational boat traffic on Lake George. With these limitations in mind, the profiler and sensor were programmed to collect 1 m interval profiles at midnight daily. The units were active during open water periods, and removed from the lake during freezing and thawing conditions. The Lake George RUSS unit data is currently available as part of the Water on the Web and *Lake Access* projects.

Parameters for Lake George
Dissolved Oxygen (mg O_2/l)
Temperature (^oC)
pH (Std Units)
Specific Conductance (μS/cm)
Turbidity (NTU)
Chlorophyll (μg/l)

The Lake George RUSS unit was configured to sample six critical water quality parameters: pH, specific conductance (conductivity), turbidity, chlorophyll, dissolved oxygen and temperature. The data is stored in a variety of ways. The data can be accessed with a variety of tools, from simple visual inspection of the raw data, to analysis by standard spreadsheet and statistical software, to advanced analytical and visualization tools.

The project is primarily a technology transfer effort, though elements of information management and communication and outreach developed in the parent project will also be transferred. The principal technological features of the transfer are: 1) the use of computer driven remote (robotic) measurement platforms to conduct vertical profiling of important water quality/limnological parameters, and 2) the use of innovative data visualization software that enhances communication of important features of the observations to all stakeholders.

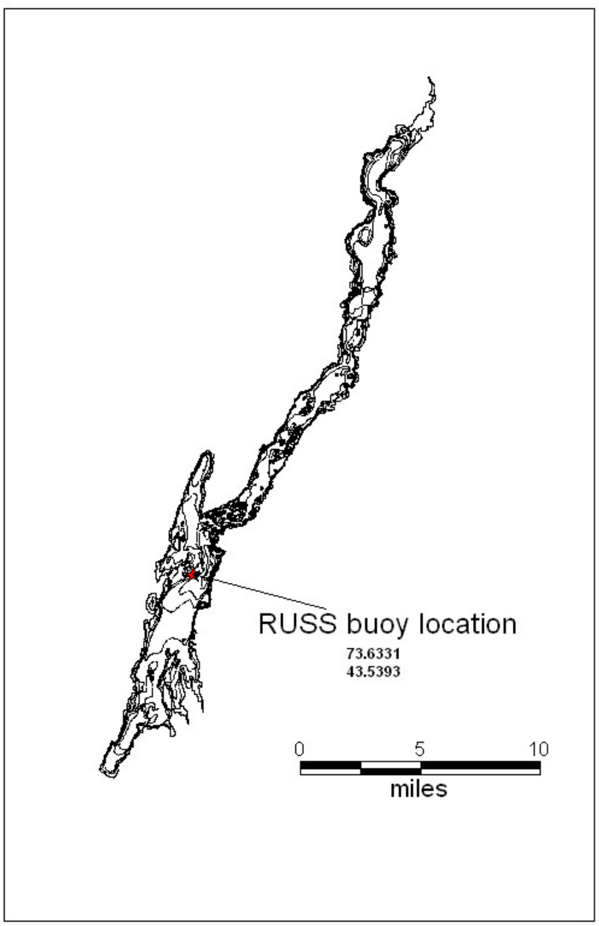
Results

The results of the Lake George EMPACT Program are described below and were keyed to meeting specific objectives including:

(a) deploying a computer-driven robotic underwater sampling platform (RUSS unit), equipped with an array of sensors/probes in Lake George,
(b) implementimg and maintaining an appropriate data management/delivery/QA program, for measurements made with the RUSS units on Lake George,
(c) operating and maintaining the RUSS hardware on Lake George,
(d) conducting ground-truth measurements to support QA on Lake George, and
(e) contributing to the design of the web sites that will report the remotely collected data in near-real-time (NRT) from these systems,
(f) supporting environmental education and outreach programs.

Results are summarized in relation to the alphabetical listing of objectives.

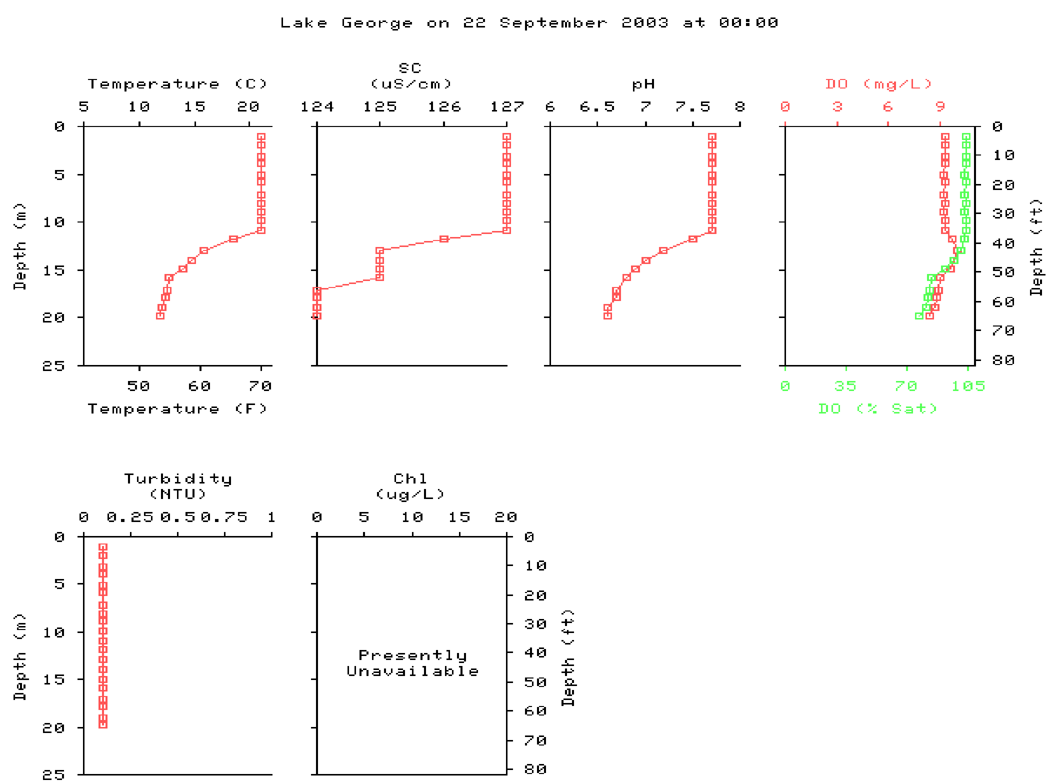
(a) Deployment of the Lake George RUSS unit was originally planned for the spring of 2002, however a delay in the receipt of the buoy and all of its components pushed back deployment to mid-summer. A further delay was caused by local regulatory authorities, with the requirement of a floating object permit prior to installation of the RUSS unit in Lake George. The Lake George RUSS unit was deployed on September 2, 2002 at the approximate mid-point of Lake George. This location was chosen not only as a central location but also because it represents a long-term monitoring location for Lake George. Contact with the RUSS unit via the cellular modem was not possible at the time of deployment due to a manufacturers programming issue. The modem was returned to Apprise on September 16, the programming corrected and the modem installed on October 8, 2002. On October 11, battery voltage had declined to below acceptable ranges and the RUSS unit ceased data collection. An anchor line failure caused the buoy to change orientation resulting in the solar panel not generating adequate voltage to recharge the batteries. The factory supplied dacron anchor line was replaced with coated steel cable to



prevent future failures. Even after re-orienting the buoy and recharging the battery, the voltage was insufficient to operate the profiler. An investigation of the possible causes revealed an excessive voltage draw by the cellular modem. The modem “on” time was reduced by 4 hour increments over the next several days, however the daily power drain continued to exceed the capacity of the solar panel to recharge batteries. Contact with the RUSS modem was established, however data downloads were somewhat irregular due to uneven cellular network coverage in the region. This deployment lasted until November 15, 2002 when the solar panel was unable to maintain voltage for operation of the profiler, even without the cellular modem operating. The RUSS unit and its anchoring system were retrieved and the YSI probes and RUSS unit were prepared for winter storage as per manufacturers recommendations.

The Lake George RUSS unit was prepared for deployment in May of 2003 with an additional battery installed to address voltage issues encountered in the Fall of 2002. The profiler failed to regulate depth properly and after numerous discussions with Apprise, the profiler was returned to Apprise for servicing in June of 2003. Apprise located a solenoid failure that caused the pump and motor cards to fail, requiring replacement of all

Example of a “NYWaterNet” page displaying data
from the Lake George RUSS unit.



components. Apprise provided no warranty coverage on this one-year-old instrument, resulting in several thousand dollars in cost to the grant. The repaired RUSS unit was received from Apprise on July 25, in-lake tested on July 29 and deployed on August 4, 2003. The cellular modem was “on” for 2 hours daily to conserve power and only a single daily profile was recorded. Daily downloads of data were conducted via the cellular link and provided to the Upstate Freshwater Institute for incorporation into the New York Water Network Webpage through October 9, 2003. Manual downloads from the RUSS unit were continued through October 22, 2003 at which time voltage was too low to continue profiles. The RUSS unit was retrieved November 17, 2003 and the YSI probes and RUSS unit were prepared for winter storage as per manufacturers recommendations. The DFWI applied for and was granted a ‘no cost’ extension to the EMPACT/Technology Transfer Program through 2004, to continue to employ the RUSS unit.

The Lake George RUSS unit was prepared for deployment in April of 2004, however feedback from the turbidity probe was causing erratic response in the chlorophyll probe. The turbidity probe was removed for repair prior to deployment. The unit was deployed on April 22. Cellular communication to the RUSS unit was erratic so manual downloads were conducted successfully on May 6, May 24, and June 4, 2004. The profiler was found entangled in the anchor lines on the June 4 site visit with apparent damage to the data cables. The profiler did not respond to manual commands at this time so the unit was returned to the laboratory for inspection and possible repair. It was determined that the profiler pump had failed, and with Apprise no longer supporting the RUSS instruments, no repair was possible. The entire buoy system was removed from Lake George on July 7, 2004.

b) Near real time data delivery to the Upstate Freshwater Institute for incorporation into the New York Water Network Webpage was accomplished from August 4 through through October 9, 2003. All other data reports required manual download from the RUSS unit with delays of from 1 to 10 days from the time of recording. Quality Assurance goals were accomplished by semi-monthly removal of the YSI Model 6600 sonde from the profiler and return to the laboratory for calibration of all probes. Profile data was reviewed by the staff for the DFWI for consistency and compared to routine monitoring data collected by other programs. Once the original programming of the cellular modem was corrected by Apprise, cellular communication with the RUSS unit was routinely possible. However, frequently inconsistent and erratic cellular signals often confounded cellular communication. This is a common problem with cellular telephone usage in our rural region, with very limited numbers of cellular towers and mountainous topography interfering with ‘light of sight’ signal transmission. Consideration of satellite communication for future programs should yield better results for remote locations.

c) Operation and maintenance of the RUSS unit hardware on Lake George posed a number of problems. Intense recreational use of Lake George may have been responsible for a number of failures of the anchoring system. The investigators suspect that the dacron anchor lines recommended by the manufacturer were cut by fishermen who became entangled. The substitution of braided steel cables solved the line failure problem, however even the steel cables were found entangled with numerous fishing lines when they were retrieved at the end of each season. The operation of the complex RUSS profiler was erratic in function and expensive to repair. Turn-around time for repairs, even prior to Apprise abandoning the RUSS program were excessive, with no 'loaner' equipment available. The recommended battery configuration and solar panel were undersized for the planned deployment needs of the RUSS unit. Adding a second large battery and removal of ballast from the buoy to compensate improved performance. The available voltage was still very limited if multiple daily profiles to 20m were desired or if early Spring or late Fall data collection and cellular communication was important. The YSI Model 6600 sonde and probe array functioned well, with the exception of the turbidity and chlorophyll probe sharing a power supply. Irregular voltage across the turbidity probe impacted the chlorophyll probe, and rendered both results questionable at times. Failure of the turbidity probe in 2003 actually solved the problems with the chlorophyll probe. Occasional problems with the DO probe were attributable to rapid depletion of the electrode filling solution. This problem was resolved by changing the filling solution with each calibration or approximately semi-monthly.

d) Ground truth measurements were conducted according to the proposal QAPP.

e) Near real time data was delivered to the Upstate Freshwater Institute (UFI) for incorporation into the New York Water Network page (http://www.NYWaterNet.org/) to facilitate technology transfer. Data was also provided to the University of Minnesota to be posted on their Water On The Web page (http://waterontheweb.org/) to reach a broader audience.

f) The DFWI submitted required progress (quarterly) reports and participated in progress meetings (conference calls) with project partners and EPA staff.

g) The Lake George RUSS unit has been transferred to the Upstate Freshwater Institute (UFI) in Syracuse, NY. Apprise Technologies abandoned the RUSS program in 2004, thus ending the general availability of parts, supplies and service for these units. In 2005, the Darrin Fresh Water Institute donated the Lake George RUSS unit and profiler system to UFI, to use for parts to keep their systems operating for a while longer.

Summary & Conclusions

The value of a RUSS type near-real-time robotic monitoring system has been proven by the EMPACT Program, particularly for more remote locations. Continuous temporal (daily) and spatial (profile) data has proven a valuable addition to the Lake George limnological database. The complexity of the RUSS unit required more maintenance and support than anticipated, however the concept remains valid. Sadly, Apprise Technologies ceased to manufacture and support the RUSS units in 2004, limiting the future utility of these systems. Data gathered on Lake George in 2002, 2003 and 2004 has been incorporated into the limnological water quality database for the lake, where it supports conventional monitoring and assessment programs. The Lake George data is also available on the University of Minnesota's Water on the Web page where it can be used for educational and outreach purposes.