

# INLAND LAKE MONITORING

A GUIDE TO UNDERSTANDING AND ESTABLISHING HYDROLOGICAL PARAMETERS IN LAKES AND PONDS



**FONDRIEST**  
ENVIRONMENTAL

## WHAT'S INSIDE

- 01 Lake Management
- 02 Types of Lakes
- 04 Limnological Concerns
- 06 A Real-Time Solution
- 08 Typical Temperature Profiling System
- 10 Points of Compliance
- 12 Data Management
- 14 Quality Assurance
- 16 Recommended Equipment
- 18 Purchase or Rent?
- 19 About Fondriest Environmental
- 20 System Configuration Tool

# WHY MONITORING MATTERS

Lakes and ponds of any size are complex ecosystems with numerous inputs and outputs that can impact water quality in subtle or drastic ways. Whether the lake is man-made, with a focus on recreational fishing and watersport, or a habitat naturally formed from ancient glacial or tectonic activity, understanding the hydrological parameters that contribute to a lake's health is important for proper management.

A real-time monitoring system enables lake management professionals to stay abreast of constantly changing water quality, and address potential issues before they develop into larger problems. These issues may be related to sediment and turbidity, thermal stratification, excess nutrient loading and algal blooms, among others. Fondriest Environmental offers specific guides addressing many of these conditions; this guide will focus on limnology and lake management from a broader perspective.

A number of federal and private organizations offer guidelines for ideal lake conditions, including the U.S. Environmental Protection Agency, the U.S. Geological Survey, the North American Lake Management Society and more. Whether you're a resource manager overseeing a pond, lake or basin, or a member of a civil or commercial project that could impact lake health, be sure to check with your local Department of Natural Resources to ensure hydrological standards are being met.

# LAKE MANAGEMENT

## Definition & Approaches

"Lake management" is a broad term that can apply incorporate many disciplines and applications. Management of a single lake can include conservation, improvement, restoration and rehabilitation projects, as well as studies of the local watershed and other waterbodies in the system.

The North American Lake Management Society recommends "iterative steps" when managing lakes and watersheds. Small efforts toward an established goal cost less than major improvements, and are less likely to negatively impact non-targeted organisms and other aspects of the lake. It warns, however, that certain techniques are only effective when performed at a larger scale, potentially raising the cost and impact of lake management. Compromises may be necessary to achieve a desired effect under constrictions of time and funding, but local regulations should be consulted to determine whether any action to a lake or watershed is appropriately justified.

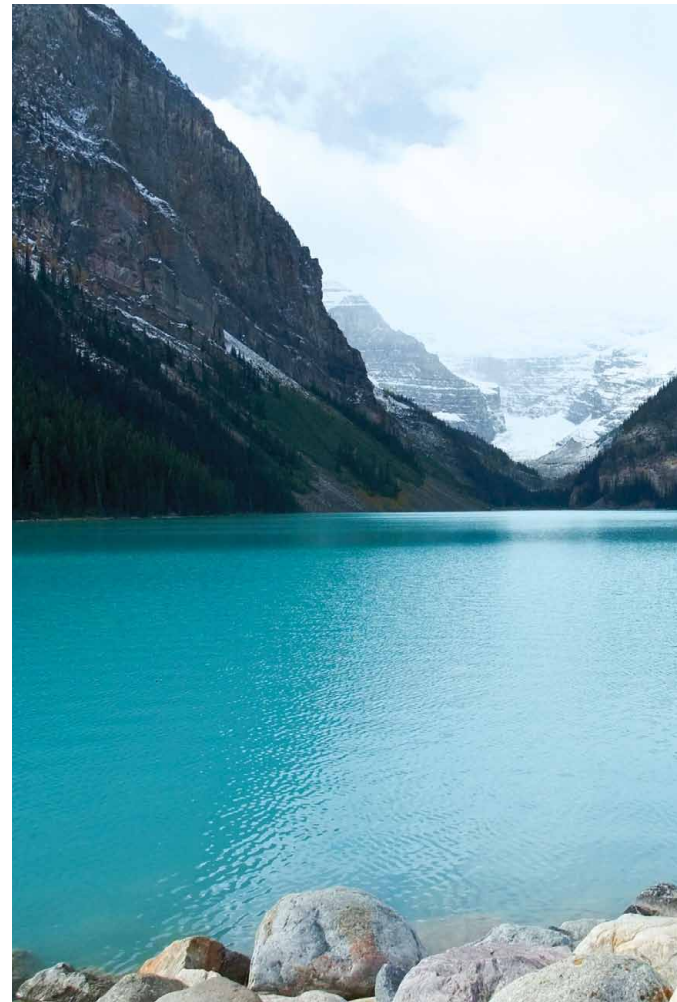
There are a variety of approaches to lake management, and many techniques capable of altering a lake's nutrient content, oxygen levels, biotic distributions and sediment composition. These can be as "simple" as harvesting plants, adding bacteria and removing certain fish species, or can include more complicated measures, such as lowering water levels, dredging sediment or controlling various hydraulic factors. Any of these operations can interfere with a lake's thermal profile, so it is advisable to maintain a hydrological monitoring system before, during and after a project.



# TYPES OF LAKES

The means by which a waterbody was created can have a lasting impact on its hydrological properties. Depth, area, volume and flow are all important characteristics that are at least partially determined by a lake's formation. Because lakes are formed by major events on or below the Earth's surface, lakes tend to be concentrated in areas with other waterbodies. An understanding of a lake's origins can provide a useful profile of the physical, chemical and biological events to which the lake may be prone, and also help you decide which types of monitoring are most appropriate for the circumstances.

## Glacial Lakes



Easily the most common of all lake basin formations, glacial lakes were created by the movements of massive sheets of ice 10,000 to 12,000 years ago. Glaciers were most common in the northern hemisphere during this period, therefore most of the world's lakes occur there as well. Remnants of the glaciers that formed most of North America's lakes can still be found today in certain mountainous regions of the U.S. and Canada.

When glaciers move across a landscape, they scrape off the tops of hills and relocate sediment of all sizes. Lakes formed from glacial movement can be a result of moraines, or dams created when deposited glacial sediment blocks a river. Other glacial lakes are formed from the glacier's back and forth scraping motion after many years. Glaciers covered by sand and gravel can form marshes when the ice melts and a depression is left behind. Slowly melting glaciers can also form rivers below the ice sheet.

## Solution Lakes



Sometimes, underground deposits of rock can dissolve as water flows through them, leaving behind a depression in the ground above. When these round depressions fill with water, they're known as solution lakes. Sodium chloride and calcium carbonate deposits are most soluble in water, and therefore most likely to dissolve and form solution lakes. These types of lakes are particularly common in Michigan, Indiana, Kentucky, and Florida.

## Volcanic Lakes



Volcanic activity can form lakes in a number of ways. When magma erupts from a volcano, the empty cavities that remain can collapse, leaving depressions on the volcano's surface in which lakes can form from rainfall and runoff. Lakes formed this way are known as calderas, and tend to appear unusually round. An inactive volcano can also collect water in its crater, forming a crater lake. Additionally, lava flowing from volcanoes can result in the formation of lakes as it cools more quickly on the surface than below. The hardened lava on top will often collapse on the molten lava below, creating depressions that can turn into lakes.

## Tectonic Lakes



As the Earth's crust moves deep below ground, depressions can result from tectonic faulting. During an earthquake, for instance, weak spots in the Earth's crust may cave in, forming a depression in which rain and ground-water can collect. Known as grabens, these sorts of lakes are often very old and deep, and exhibit highly diverse ecosystems. Lake Tahoe in the U.S. is a result of tectonic activity. The world's deepest lake, Lake Baikal in Siberia, is also a graben.

## Other Types of Lakes

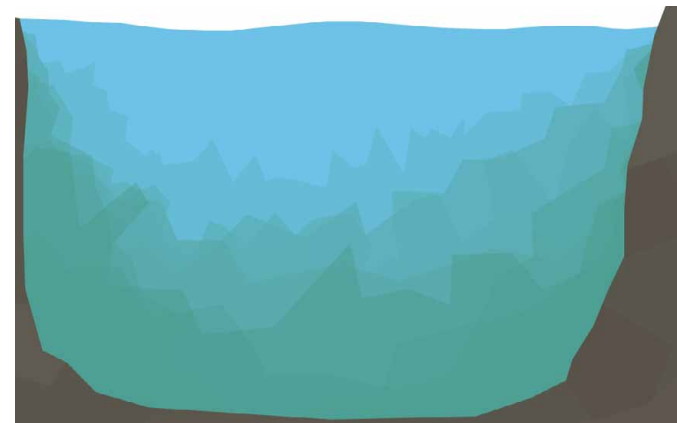
There are several other fairly common types of lake morphology that you may encounter during a monitoring project. Oxbow lakes are formed from erosion caused by river flow. The outer bend of the river exhibits the fastest flow, and therefore the highest rate of erosion. While the outer bend continues to expand, the river leaves sediment and other materials closer to the inner bend, eventually forming a separate, C-shaped area of limited flow known as an oxbow.

In North America, beavers are responsible for the creation of many small lakes and ponds, as their dams can divert river flow and leave behind shallow, nutrient-rich waterbodies. Humans, of course, also create artificial lakes for purposes including drinking water supply, power, recreation, and flood control. Disastrous events such as landslides can dam rivers and form lakes, though these are usually temporary, due to the instability of the damming materials.

# LIMNOLOGICAL CONCERNS

A wide array of hydrological phenomena can manifest in lakes, each as complex as the last, and, in many cases, are intertwined with one another. Natural resource managers responsible for lake upkeep may need to keep a close eye on some or all of these phenomena, while specific monitoring projects may only aim to observe a particular effect of one. Even if your application only calls for monitoring of one parameter or process, understanding how that process affects others and fits into the overall health of the lake will improve your ability to analyze data and respond appropriately.

## Eutrophication



When overgrown blooms of algae die and decompose, the increased loads of organic matter — and the organisms responsible for decomposition — consume available oxygen in the water, causing hypoxic “dead zones” to form. These dead zones reduce the liveable space in a lake, and can increase competition and kill off other organisms, such as fish. The process is natural in most water bodies, but anthropogenic activity, such as agricultural fertilization, can speed it up.

While eutrophication is mostly a function of nutrient loads, temperature can have a major impact on the phenomenon. Higher temperature can increase biomass production, therefore contributing to the overall rate of oxygen depletion. Furthermore, highly stratified lakes are more vulnerable than well-mixed lakes, as the thermocline prevents exchange between any anoxic zones and oxygenated waters.

## Thermal Stratification

Lake stratification is a product of the relationship between water density and temperature. Unlike other compounds, water is more dense as a liquid than a solid — that’s why ice floats. Water is most dense at 4 degrees Celsius, and becomes less dense as it warms or cools. At that point, of course, there is a lot more room for water to warm rather than cool, as it freezes at 0 degrees Celsius.

In the summer, solar radiation heats the epilimnion, or top layer of a lake, causing the water there to become less dense. The hypolimnion receives less light, if any, and remains cold and dense. Differences in density cause the epilimnion to float atop the hypolimnion without mixing, forming a dividing layer known as the thermocline. Algae and zooplankton live in the epilimnion during the summer, but when they die, invertebrates and microorganisms living in the benthic sediment decompose the remains, using up

oxygen in the process. Because the lake does not mix during the summer, the hypolimnion can become anoxic under certain conditions.

As the weather cools and sunlight grows less intense in the fall, the epilimnion begins to cool, reducing the difference in density between it and the hypolimnion. A combination of wind and shifting water density helps mix the layers, distributing oxygen and nutrients throughout the water column.

Some lakes ice over in the winter, preventing the wind from mixing the water. A thin layer of cool water forms beneath the ice, while warmer, denser water sits at the bottom of the lake, resulting in a phenomenon called inverse stratification. Just as in the summer, the hypolimnion receives no new oxygen. Lake hypoxia in the winter often produces a “winter kill,” in which oxygen-dependent fish and other organisms die en masse. The same chemical processes that lead to anoxic conditions can cause phosphorous release, leading to increased algae growth in the warmer months.

Lakes that mix twice a year are known as dimictic lakes. Shallow lakes exhibit different hydrological qualities, and can mix more often than deeper lakes.

## Turbidity and Sediment



Turbidity is a measurement of water clarity. Turbidity can be influenced by a number of factors present in waterbodies, including the presence of mud, silt, algae, or chemicals in the water. Industrial activities, such as mining, logging, and — perhaps most commonly — dredging often contribute to turbidity levels in lakes and rivers.

Turbidity often varies with the seasons, as ice and snow drastically affect flow and the presence of sediment that can cloud the water. Lakes covered in ice during the winter usually exhibit very low turbidity, but will develop high levels of turbidity following spring snowmelt as mud and dirt are washed into the water. The growth of algae and other organisms in the summer can also cause a boost in turbidity.

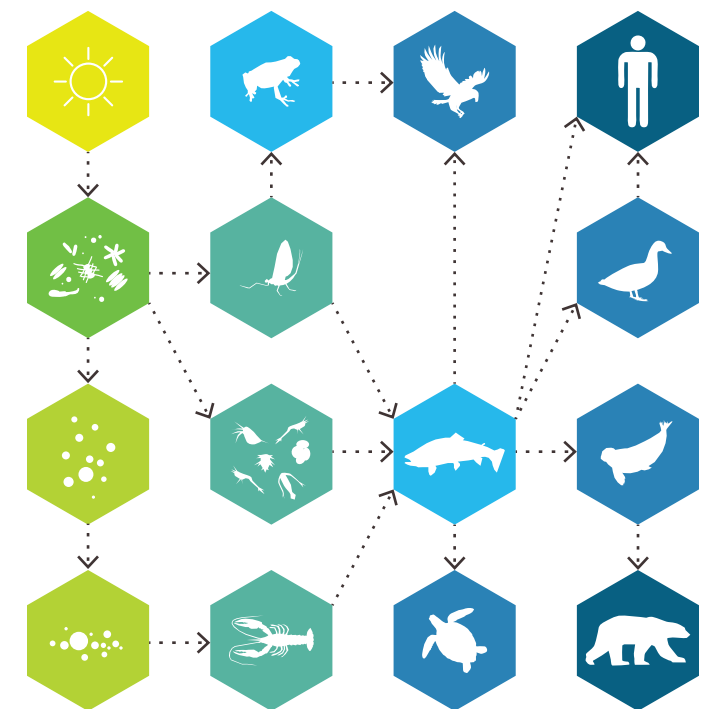
The significance of turbidity in a lake depends on the season, the lake’s morphology, and the ecosystem within. Highly turbid waters prevent the passage of light necessary for plant growth, which can also diminish the survivability of other organisms that rely on plants for food. Algae-related turbidity is often associated with eutrophication and hypoxia at the bottom of

lakes, particularly those that are highly stratified or suffer from poor mixing. Very high turbidity can actually cause fish and other organisms to suffocate, impact their ability to catch prey, and even bury fish eggs on the lake’s bottom. Particles responsible for turbidity may carry bacteria or other contaminants that can harm a lake’s water quality.

## Algal Blooms

Algae and algal blooms should not be regarded as inherently harmful to water quality in a lake. In fact, algae are an important part of lake ecosystems. Algae oxygenate water, convert inorganic matter into organic matter, and act as the base of a lake’s food chain.

Nutrient loads are the primary determinant of algae growth in lakes, and therefore it is vital to monitor nutrient levels — especially phosphorus and nitrates — in lakes that exhibit an overabundance or lack of algae. Water temperature, turbidity, and competition from other plants and animals can also influence the growth of algae. As mentioned above, high levels of algae can contribute to eutrophication, turbidity, and hypoxia in lakes. Because many algal blooms form on the surface of a lake, most monitoring can be done by sight alone, though aerial observation, or even satellite imaging may be necessary for especially large lakes.



# A REAL-TIME SOLUTION

An effective limnological monitoring system should be built upon real-time or interval-based measurements. The addition of data logging and telemetry instruments enables researchers and managers to study limnological readings remotely at their convenience. Depending on the conditions being examined, a limnological monitoring system can consist of one or many instruments.

Before the start of any monitoring project, a series of objectives should be established so that the necessary equipment and personnel can be procured, and an appropriate schedule can be established. The U.S. EPA, for instance, lists these common objectives in their Great Lakes monitoring program:

- Assess the state of water quality in the open lake basins.
- Provide data to detect and evaluate trends and annual changes in chloride, nitrate nitrogen, silica, phytoplankton, total phosphorus, chlorophyll a, and secchi disc depth.
- Provide data sufficient to verify or modify water quality models.
- Provide data to calculate the trophic index of each lake.

While a program that covers all of the Great Lakes will almost certainly have a greater need for equipment, personnel, and coverage than a similar program on a smaller lake, the objectives of your project could include all or any combination of those in the EPA's list.

## Multi-Parameter Sondes

A limnological monitoring project can require the observation and measurement of a wide variety of hydrological parameters. For this reason, Fondriest Environmental recommends using a multi-parameter sonde as the foundation of your project.

Multi-parameter sondes differ from brand to brand and model to model, but they are unified by a few common traits. As would be expected, multi-parameter sondes usually feature an array of ports for attaching conductivity, temperature, depth, pH and level sensors and probes. Ideally, these sensors should be replaceable in the field for off-the-cuff maintenance and system modifications. Some sondes will feature built-in sensors, leaving more sensor ports free for additional measurements. Most sondes contain an internal battery and memory so they can be deployed for long periods without regular attendance. Data logger and external power connectivity allow for even longer deployments on certain sondes. For applications in lakes, it's common to mount multi-parameter sondes in a buoy along with a data logger.

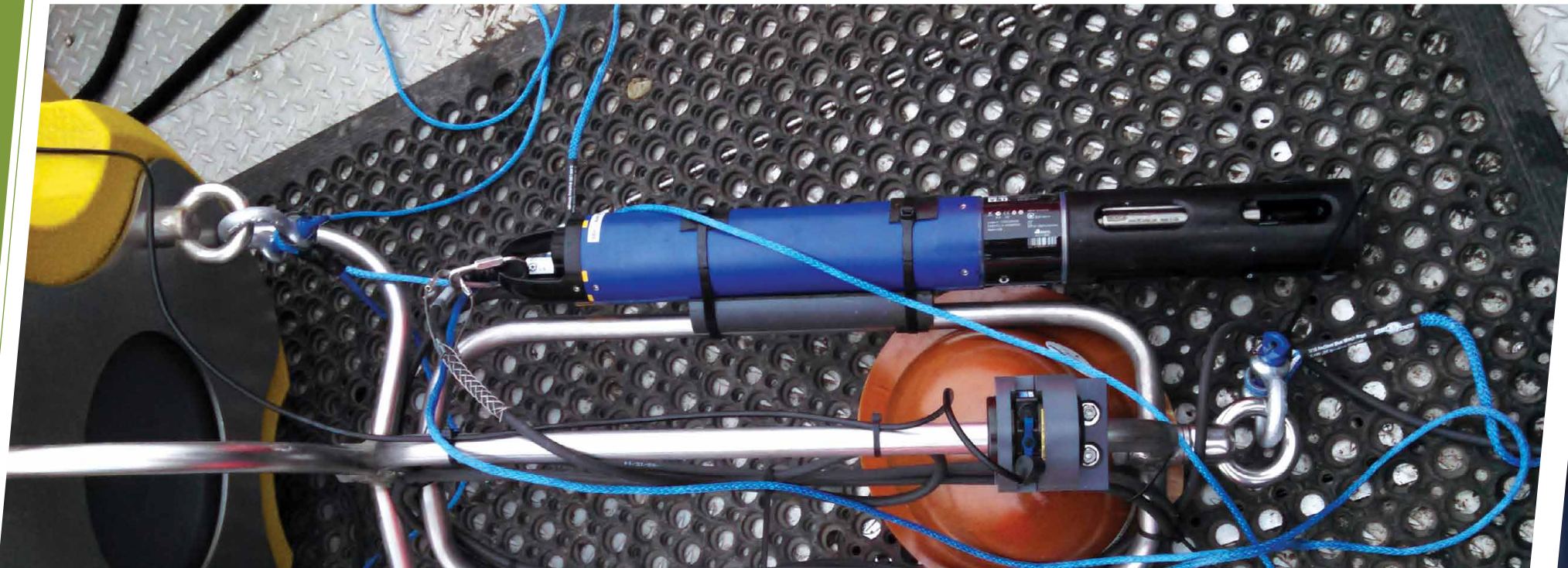
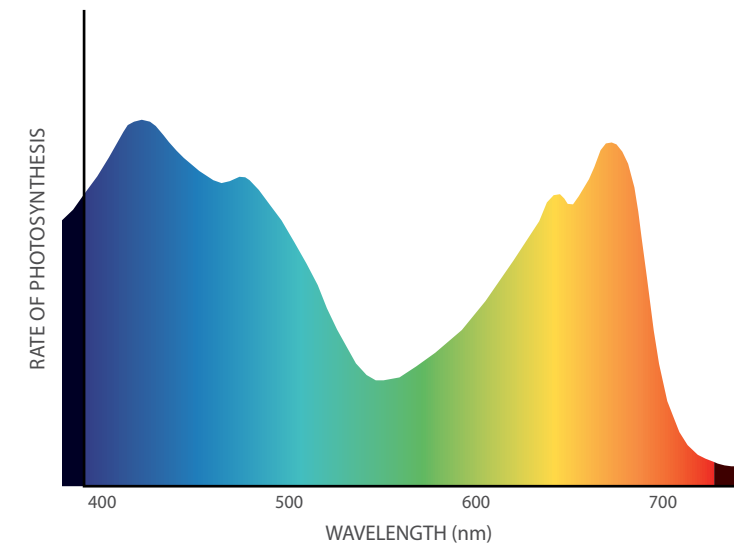
Lake water conditions can vary widely, sometimes even in the same lake. Sondes with built-in optical sensors may include anti-fouling wipers to ensure their lasting performance in the field. Even these sondes, however, should still be occasionally checked for accumulation of grime and organic matter around sensors, ports, and connections.

## Measuring PAR

Solar radiation falling between 400 and 700 nanometers is known as photosynthetically active radiation, or PAR. This parameter is of particular importance in freshwater lake environments, as it is a determining factor of aquatic productivity. Plants, of course, rely on PAR for growth, but a number of other vital organisms at the base of the food chain do as well.

Some PAR sensors are constructed to resist corrosion and minor jostling. Each PAR sensor is rated for use up to a certain depth or pressure. While some PAR sensors measure radiation in one direction, others can sense photon flux in all directions. This is especially useful when studying certain photosynthetic organisms such as phytoplankton, which acquire radiation from multiple directions.

Before deployment with a multi-parameter sonde or data buoy, make sure your PAR sensor is suited for the job: water depth and turbidity can affect the performance of some sensors. Highly turbid waters may require special PAR sensors for accurate readings.



# TYPICAL LAKE MONITORING SYSTEM

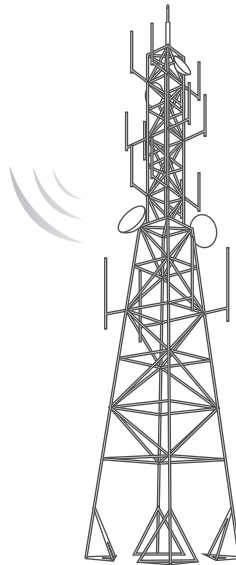
As mentioned before, there are many hydrological parameters that can be measured in any given lake, but the needs of one limnological project can differ widely from another. The number of monitoring sites, their locations, and the instruments used at each will vary from project to project, but there are a few qualities that most inland lake monitoring systems will share.

To be effective, measurement data should be provided in real time. The easiest and most efficient way to do this is with a buoy-based monitoring system. A data buoy can house sensors at multiple depths in the deepest part of the waterway, providing more comprehensive data than a shore-based system. This system can then securely transmit the data to the Internet in real time for access from any computer.

Buoy systems are flexible and customizable based on the limnological project requirements. They can house as many sensors as needed, and all equipment is powered via a marine battery and recharging solar panel system. With multiple telemetry options to choose from, continuous real-time data are available from any computer. This ensures that the project runs smoothly, and any control measures can be implemented immediately if parameter limits are exceeded.

## Telemetry

Telemetry provides access to data in real time. The wireless communication can be radio-to-shore, cellular, or satellite based.



## Live Data

Instant access to project data is available 24/7 through a cloud-based data center. Monitoring data can be viewed in real time, or as a graph to identify trends. Real-time automated alerts can be sent via text or email when specified parameters exceed pre-defined limits.

## Data Buoy

A data buoy is a floating platform that supports real-time monitoring instruments such as sensors and data loggers. In addition to housing the monitoring equipment the buoy supplies all power and can transmit sensor data in real time.

## Multi-Parameter Sonde

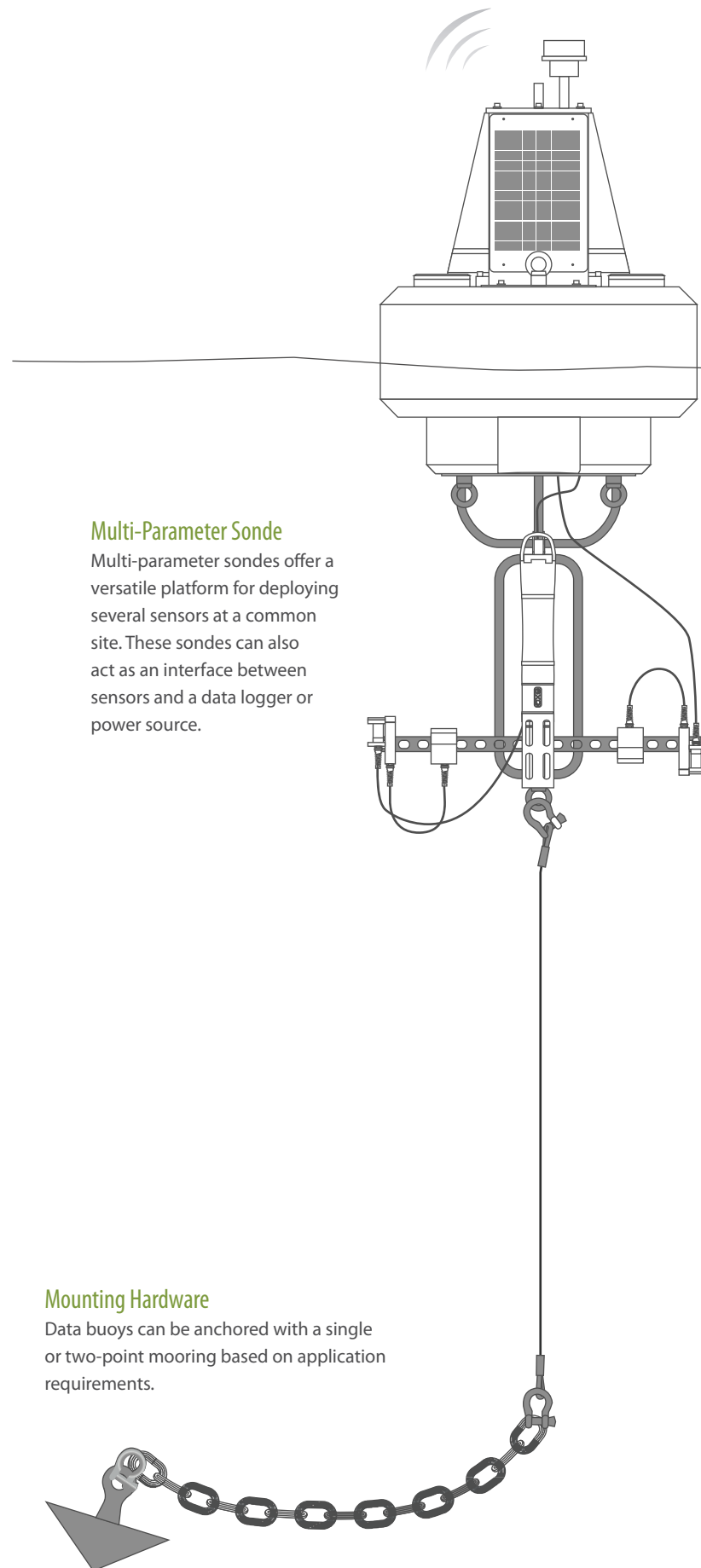
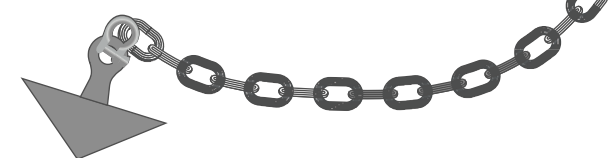
Multi-parameter sondes offer a versatile platform for deploying several sensors at a common site. These sondes can also act as an interface between sensors and a data logger or power source.

## PAR Sensor

The PAR sensor uses a silicon photodiode and glass optical filters to create uniform sensitivity to light between 400 nm to 700 nm, which closely corresponds to light used by most aquatic plants and algae. Sensors can be oriented to measure both downwelling and upwelling radiation.

## Mounting Hardware

Data buoys can be anchored with a single or two-point mooring based on application requirements.



# MONITORING LOCATION

Where an inland lake monitoring system should be located will depend largely on the site conditions. Careful planning is needed to select the location, determine depth and water level fluctuation, and design a mooring solution that will effectively hold the system in place without damaging the instruments.

## Selecting the Location

As suggested by the name, stationary systems are set at fixed locations. These systems can be placed on structure or on an anchored buoy in the water. However, site conditions often make it difficult or impractical to mount the monitoring equipment along the shore. In addition, relying solely on shoreline solutions may not accurately represent water quality conditions. For these reasons, buoy-based systems offer the most comprehensive and cost-effective solution. Data buoys provide a stable platform for temperature profiling, with the ability to house multiple sensors at different depths in the water column. In addition, they can carry a data logger, solar-powered battery pack, and telemetry (wireless communications) systems for extended deployments.

These buoys can come in different sizes based on the environmental conditions and the number of sensors suspended from the buoy. Data buoys with 150- to 450-lb. net buoyancy are generally adequate for monitoring projects on rivers, inland lakes and protected waters. Larger platforms may be required in coastal and Great Lakes deployments that are subject to more extreme conditions and wave action.



## Pre-Deployment

For accurate data, all sensors should be calibrated shortly before the project begins. If using a buoy-based system, the platforms should be fully assembled on shore prior to deployment. This includes attaching any sensors, towers, solar panels and additional ballast weights if needed. Furthermore, the complete monitoring system (sensors, data logger, telemetry, software) should be tested before the buoy is put in the water. While this process ensures that all equipment is functioning within specifications, it also gives everyone the chance to familiarize themselves with the system prior to deployment. Issues are always easier to deal with before the buoy platform is deployed in the water.

## Buoy Mooring

A buoy-based system must be moored to ensure that it remains stationary. The buoy is usually moored via a stainless steel mooring line, bottom chain and anchor. It is recommended to moor the buoy in the deepest part of the waterway to ensure the most inclusive measurements. This allows for multiple measurement depths and will best reflect the characteristics of the water body as a whole.

Buoy-based systems are typically moored as either a single-point or two-point mooring, based on environmental and application-specific factors.

## Single-Point Mooring

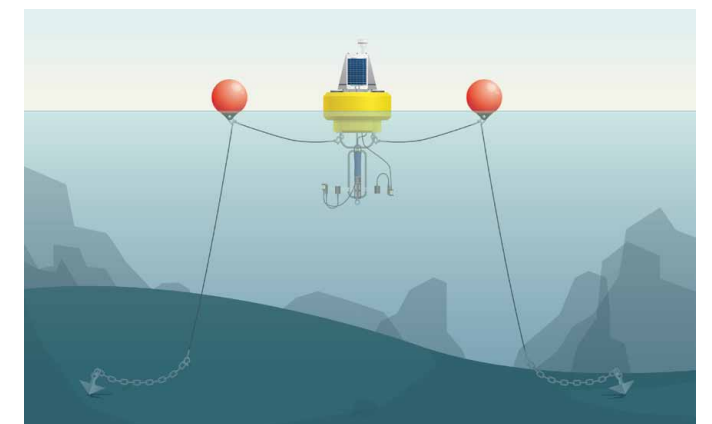
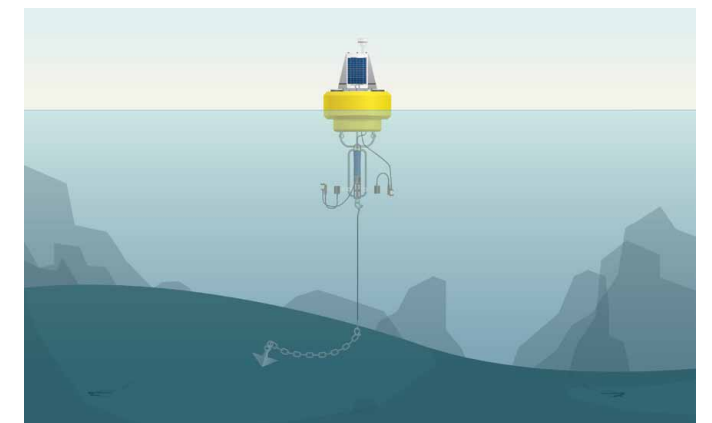
Single-point moorings are not common, but they require the least amount of mooring equipment. This setup can be deployed in very calm waters with minimal instruments. A single-point mooring should only be used when all sensors and equipment are housed within an instrument cage or deployment pipe. Hanging sensors risk getting damaged or entangled with the anchor line. A cage or pipe protects the instruments from entanglement, subsurface debris and currents without affecting sensor readings.

In a single-point configuration, a mooring line connects the buoy directly to a bottom chain and anchor. The sensors are typically housed within a central deployment pipe or attached to a rigid instrument cage. The anchor, bottom chain and mooring line are assembled and attached to the buoy prior to deploying the system.

## Two-Point Mooring

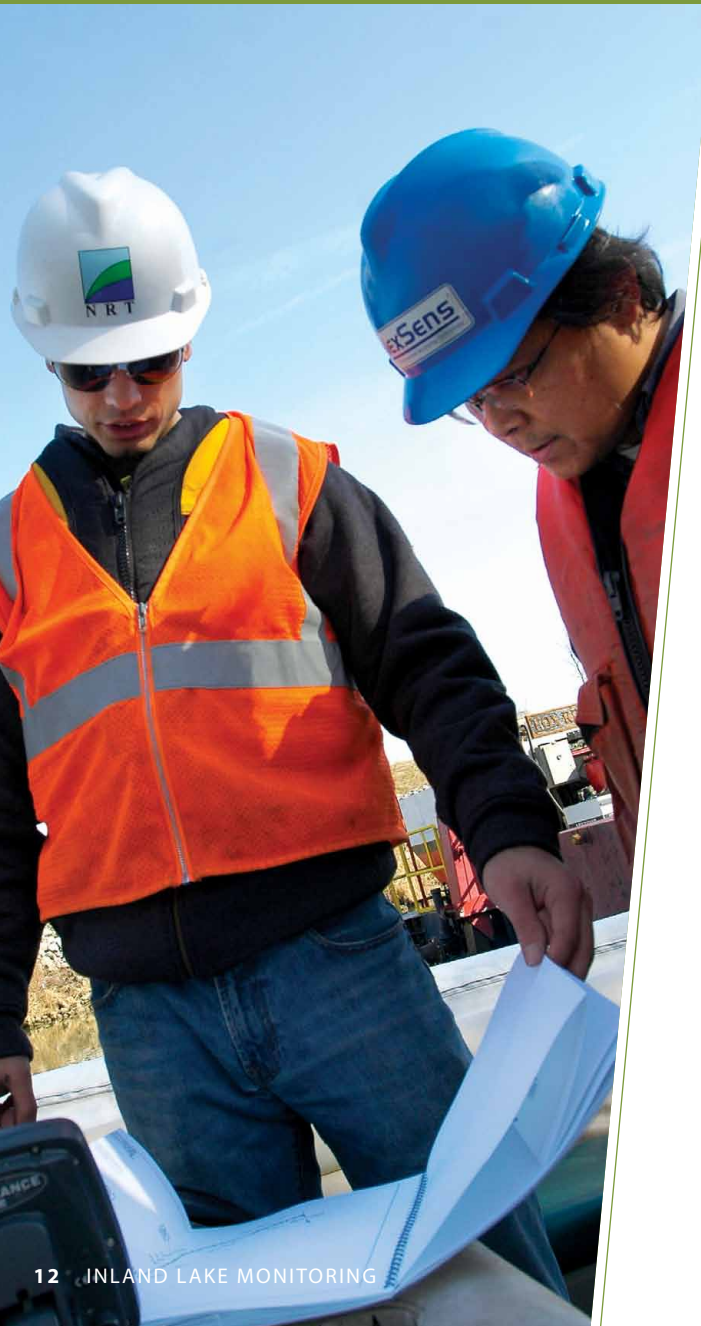
Two-point moorings are the most common deployment configuration. This is the recommended setup if sensors will be hanging at multiple depths in the water column. In a two-point setup, the mooring lines are pulled away from the data buoy by two smaller marker buoys. This configuration leaves the water column below the buoy available for sensors, without risk of entanglement with anchor lines. It also offers greater stability if there are currents or wave action at the location.

A two-point mooring requires a larger deployment area than a single-point mooring, as the marker buoys are typically set about ten feet away from the data buoy. Additional mooring lines run from the marker buoys to bottom chains and anchors at the seafloor. The increased system stability from the two anchor setup is well worth the extra equipment, as is the expanded area for hanging sensors. If there is significant subsurface debris or other risks present, deployment pipes or instrument cages can still be used.



# DATA MANAGEMENT

A major part of any monitoring project is collecting and accessing the data. While it is possible to simply record measurements onsite, the ability to log, send and view monitoring data in real time is far more efficient.



## Data Logger

As the name implies, a data logger is an instrument that stores data. In environmental monitoring applications, data loggers can be used not only to collect data from sensors and sondes, but to control sampling rates and transmit data to a central location in real time.

While some water monitoring instruments have the ability to log their own data, a separate, dedicated data logger can gather all data from any and all attached sensors ensuring that no data are lost. If telemetry (wireless communication) is available, the logger can remotely control sensor sampling rates and transmit collected data to a central project computer. Data loggers with telemetry technology can provide real-time hydrological data and remote access via a cellular modem, radio transmission or satellite modem.

When housed in a data buoy, a data logger is charged by the buoy's solar power system. If a solar panel system or external battery is not available, the logger can be self-powered using alkaline batteries. Data loggers can be configured with a number of sensor ports for connection to industry-standard digital and analog interfaces, including RS-485, SDI-12 or 0-2.5 VDC. A data logger can also support water quality sensors and sondes, weather stations, and other instruments to complement the limnological profile data.

## Telemetry

Telemetry, or wireless communication, is a useful tool for monitoring inland lakes in real time. Common telemetry options are cellular and radio, though satellite telemetry can be used in more remote locations. The deciding factor when determining the most cost-effective telemetry option should be the local site conditions and proximity to a project computer. All three of these options permit real-time updates for local lake conditions.

Radio telemetry is recommended when all equipment is in close proximity. If equipped with a license-free spread-spectrum radio, a data logger can communicate with a shore-side or dam-mounted radio base station. This range may vary depending on the logger and base station used. Spread-spectrum radio technology may allow a range as far as five miles (line-of-sight) or a few hundred feet (non-line-of-sight). The radio base station serves as a central hub for any compatible data logger in range, with the ability to send the collected data to a project computer.

Cellular telemetry offers more geographic flexibility than radio, though it does require a cellular data plan. This small, additional cost permits data transmissions from anywhere that receives a cellular signal. With cellular telemetry, monitoring stations do not need to be in close proximity, nor is a

base station required. If multiple monitoring stations are required, each data logger can send information individually to a central database. All the data can then be accessed wirelessly from any computer via the Internet. Data loggers may be equipped with cellular modems from different providers, including AT&T, Verizon and Sprint.

For remote applications where radio and cellular telemetry are not feasible, satellite telemetry can be used. The Iridium communications network maintains a dynamic, cross-linked constellation of Low Earth Orbiting (LEO) satellites, providing coverage all over the world. This means that data loggers with an Iridium satellite modem can transmit data in real time from anywhere on Earth. As with cellular networks, the data are sent to a central gateway, which then transfers the data over the Internet to any project computer or cell phone.

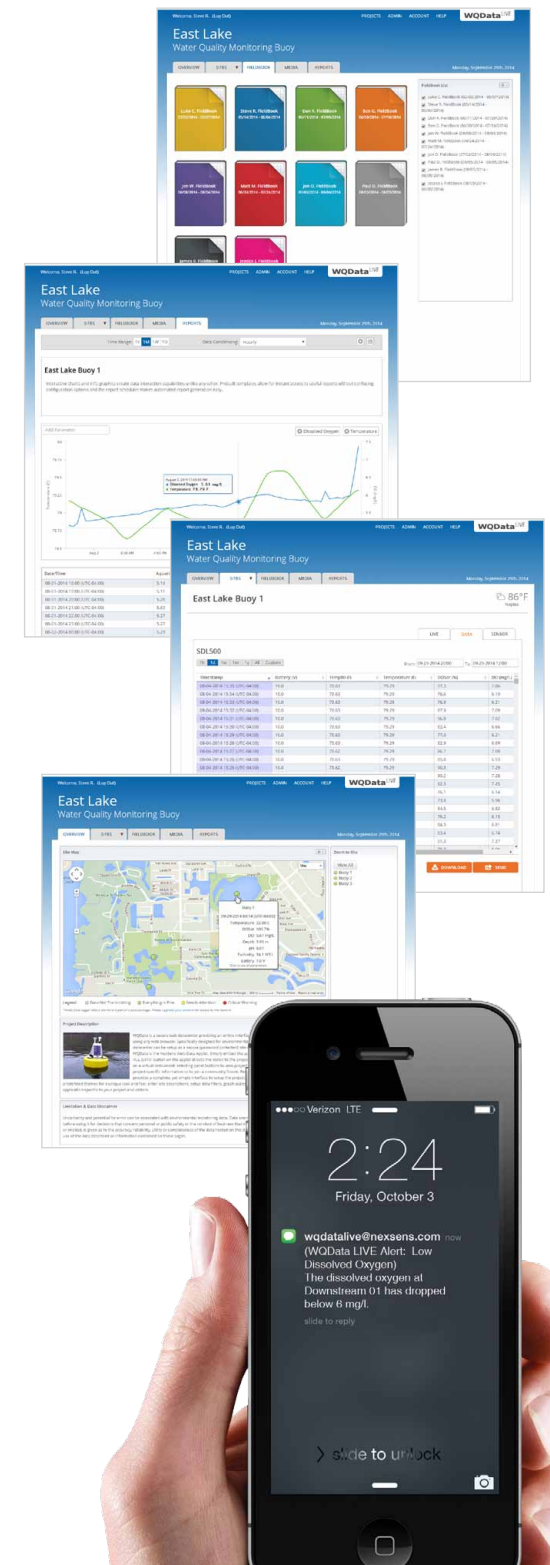
## Real-Time Online Datacenter

The easiest way to share and view limnological monitoring data is through a web-based datacenter. An online datacenter offers 24/7 instant access to project data via any web browser. Temperature and other data can be exported into the datacenter directly from the data logger, or through the project software.

This project management service can be password protected or public, and allows users access to the collected data in real time. In addition to any profile-specific information, the online interface can provide dynamic area maps, overlaid with weather information, recent and historical data, time series graphs and statistical summaries. Visitors can interact with the project maps and view real-time monitoring data or hydrological trends over time.

But these cloud-based datacenters are more than just a pretty face. Many can be programmed to send out automated alarm notifications when parameters exceed pre-defined limits. Once an allowable range has been set, the data are entered into the online database. If levels exceed or fall below these recommended ranges, the datacenter will immediately issue an alert (text and/or email) to the appropriate project manager or interested party.

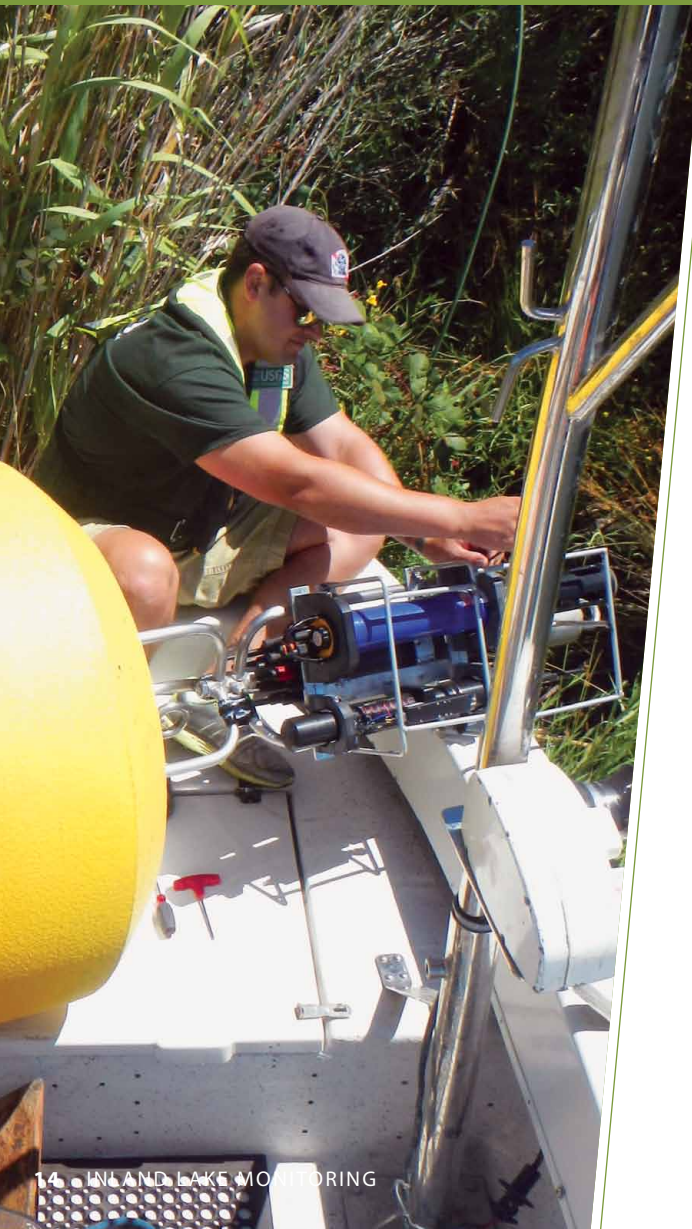
With the availability of real-time data and the datacenter's auto-alert system, lake managers can be notified immediately when interesting or action-oriented events may exist. This can be thermal pollution, eutrophication, stratification, etc. The online datacenter can also transmit this alert back to the data logger in order to respond to the exceeded temperature, conductivity, pH or any other range. Automated responses may include taking more frequent readings during high or low temperature periods, then resuming regular log intervals when levels return to normal.





# QUALITY ASSURANCE

To maintain accuracy and keep equipment functioning within specifications, best practice recommends cleaning and calibrating the instruments at regular intervals. It is also recommended to cross-check sensor accuracy against a separate instrument. Projects may even require the use of a Quality Assurance Plan (QAP) that provides a detailed outline of maintenance, calibration, and QA/QC requirements.



## System Maintenance

Regardless of the water quality instrument(s) deployed, periodic maintenance and calibration is essential. Instrument maintenance includes cleaning the instruments (especially if a sensor is not self-wiping), and replacing any deteriorating O-rings to prevent water ingress. Maintenance intervals are largely dependent on site conditions and other variables, such as the potential for biofouling. Common calibration and maintenance intervals are on a bi-weekly or monthly basis.

Prior to calibration, it is important to thoroughly rinse the calibration cup with water and then rinse with a small amount of the calibration standard for the sensor being calibrated. Two to three rinses are recommended. Discard the rinse standard, then refill the calibration cup with fresh calibration standard. Fill the cup with adequate calibration standard to fully submerge the sensor. Volumes will vary, just make certain that the sensor is submerged. Be careful to avoid cross-contamination with other standards. For greater details regarding sensor calibration, the manufacturer's user manual should be referenced.

In case of sensor failure or damage, it is useful to have spare sensors or sondes on hand. These can be field swapped during calibration or routine maintenance checks. Having spare equipment available will reduce downtime due to unforeseen sensor failure, which could cause critical and costly interruptions to long-term datasets.



## Performance Verification

In addition to keeping equipment calibrated, it's important to periodically verify that the sensors are providing accurate data. The best way to achieve this is by checking water quality values in the same area using a separate, portable monitoring system. This is also known as spot sampling.

In many cases, the same water quality instruments deployed on the buoy can be outfitted with a cable and handheld display for spot sampling. For example, if a buoy is deployed with an YSI EXO2 water quality sonde, then a separate EXO2 sonde with cable and handheld display can be used for performance verification. It is important to use the similar and consistent sensors when verifying data, as values tend to have variability across dif-

ferent sensing instruments. The sonde or sensor can be lowered into the water column to a depth that matches the in-place sensors. While it is at that depth, a water quality measurement can be taken. The data from this portable system can then be compared to the in-place monitoring system and checked for discrepancies.

Another way to verify sensor performance is to pull the water quality instrument and check the sensor values in known standards prior to recalibration. This is sometimes referred to as a post calibration check. By checking the measured values against a known standard, it is possible to observe and document the amount of sensor drift that occurred since the last calibration. The difference in value can be compared to pre-determined criteria. If the difference is outside the criteria, then the measurement data may need to be qualified.



# RECOMMENDED EQUIPMENT

While there are plenty of limnological and hydrological monitoring instruments on the market, some stand out about the rest. Fondriest Environmental has selected these products as the best in their field for their quality, reliability and value. Together, they provide an advanced and powerful real-time temperature profiling system. YSI's EXO2 Multi-Parameter Water Quality Sonde provides six sensor ports, making it the perfect foundation for water quality monitoring in any setting. The LI-COR LI-192 Underwater PAR Sensor Quantum sensor, coupled with Zebra-Tech Hydro-Wiper, is an accurate way to measure photosynthetically active radiation (PAR) in freshwater environments. The rugged NexSens CB-450 offers long-term durability with 30 watts of solar power, 450 pounds of buoyancy and a choice of instrument mounts for multiple sensors. Additionally, the WQData LIVE web datacenter allows 24/7 remote access to collected data from any computer or mobile device, while incorporating instant alarm notifications and trend tracking.

## YSI EXO2 Multi-Parameter Sonde

The YSI EXO represents the next generation of water quality instruments from YSI. The advanced sonde platform offers a wide range of capabilities to those dedicated to monitoring natural aquatic environments such as oceans, estuaries, rivers, lakes, and groundwater. With a highly efficient power management platform, robust construction, and chemistry-free anti-fouling system, EXO allows accurate data collection for up to 90 days between service intervals.

The EXO2 sonde includes six sensor ports and a central anti-fouling wiper option. Sensor parameters include temperature, conductivity, depth, dissolved oxygen, pH, ORP, total algae (phycocyanin and chlorophyll), turbidity, and fluorescent dissolved organic matter (fDOM). The sonde can also output 4 calculated parameters including salinity, specific conductance, total dissolved solids (TDS) and total suspended solids (TSS).

All EXO sensors are digital sensors with on-board signal processing and memory. Built-in sensor diagnostic and calibration data allows users to calibrate multiple sensors in one sonde and distribute to various other sondes in the field. Wet-mateable connectors allow for swaps in wet conditions, while active port monitoring automatically detects each sensor and verifies operation.



## LI-COR LI-192 Underwater PAR Sensor

The LI-COR LI-192 Underwater PAR Sensor accurately measures photosynthetically active radiation (PAR) in freshwater or saltwater environments. Limnologists, oceanographers and biologists conducting aquatic productivity studies and vertical profiling have used these sensors extensively. The LI-192 is cosine corrected and features corrosion resistant, rugged construction for use in freshwater or saltwater and pressures up to 800 psi or 560 meter depths.



## Zebra-Tech LI-COR LI-192 Hydro-Wiper

The Zebra-Tech LI-COR LI-192 Hydro-Wiper is a mechanical wiper system designed to fit easily to the LI-COR LI-192. Using a regular gentle brushing action, the Hydro-Wiper keeps the optical window of the LI-COR LI-192 clean from bio-fouling and other unwanted deposits such as mud. The Hydro-Wiper reduces the need for costly site visits to manually clean the instrument, maintaining data integrity throughout long deployments.

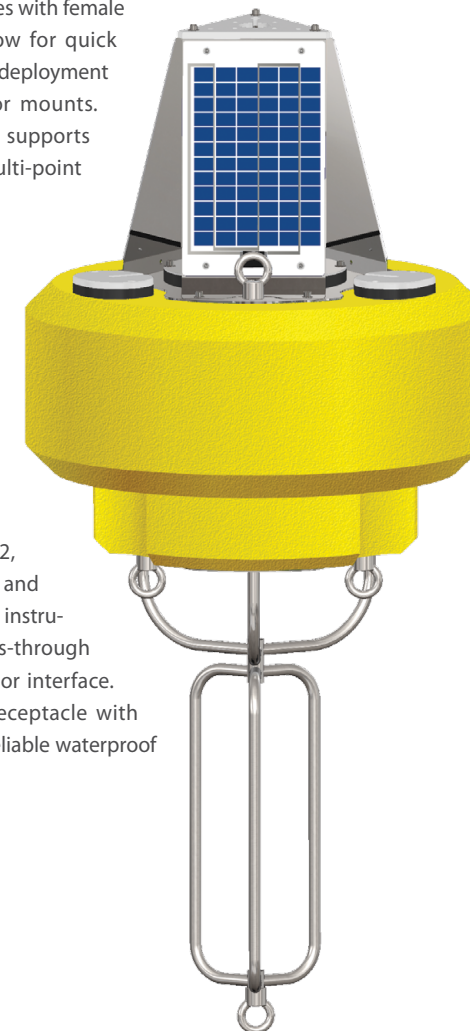


## NexSens CB-450 Data Buoy

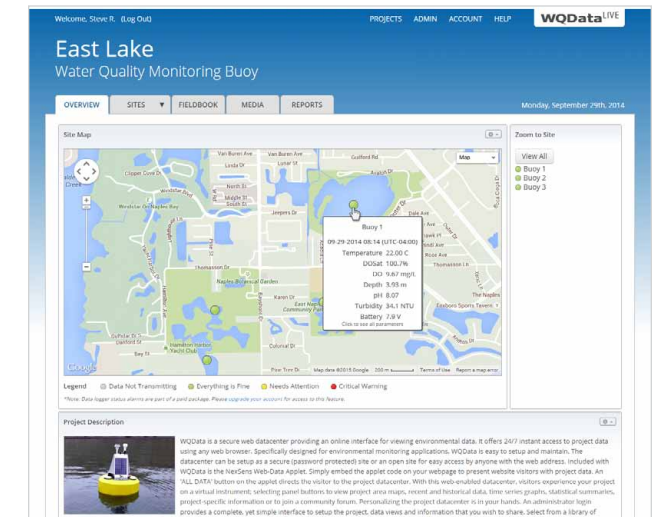
The NexSens CB-450 Data Buoy is designed for deployment in lakes, rivers, coastal waters, harbors, estuaries and other freshwater or marine environments. The floating platform supports both topside and subsurface environmental monitoring sensors including weather stations, wave sensors, thermistor strings, multi-parameter sondes, Doppler current profilers and other monitoring instruments.

The buoy is constructed of an inner core of cross-linked polyethylene foam with a tough polyurea skin. A topside 20" tall stainless steel tower includes three 10-watt 12VDC unbreakable solar panels, and a center 10" ID x 18" tall instrument well accommodates batteries, data loggers, sensors and more. Three 4" pass-through holes with female NPT bottom threads allow for quick connection of instrument deployment pipes and custom sensor mounts. The stainless steel frame supports both single-point and multi-point moorings.

The CB-450 Data Buoy is optimized for use with NexSens data loggers. Wireless telemetry options include Wi-Fi, spread spectrum radio, cellular and Iridium satellite. Compatible digital and analog sensor interfaces include RS-232, RS-485, SDI-12, VDC, mA and pulse count. The top of the instrument well includes 8 pass-through ports for power and sensor interface. Each port offers a UW receptacle with double O-ring seal for a reliable waterproof connection.



## NexSens WQData LIVE Web Datacenter



WQData LIVE is a web-based project management service that allows users 24/7 instant access to data collected from NexSens remote environmental data logging & telemetry systems. More than just an online database, WQData LIVE offers the ability to generate automated reports, configure alarms to notify project personnel when data values exceed threshold limits, create FieldBooks to store calibration forms, notes and media and much more. Projects are password protected with the ability to configure a public portal or presentation view to share data with the general public. Project Administrators have the ability to edit project descriptions and information, while users given Collaborator access are limited to data viewing and form entry.

The Google Maps view shows all project sites on a map with zoom, scroll and drag capability. Mousing over a site on the map displays the most recent data values, and clicking on the site navigates to a display showing the last reading or tabular data that can be downloaded to Excel and sent via email or FTP. FieldBooks can be created to store notes recorded during field visits, including forms to store calibration data, which can be submitted from the WQData LIVE mobile app. This eliminates the need for conventional fieldbooks while keeping critical project information in a single, easy-to-access location. Site photos can even be placed onto FieldBook pages or uploaded into the project's Media page.

The WQData LIVE report feature allows data to be shown both graphically and in a tabular format. Report templates can be saved so that specific information can quickly be referenced. Project alarms send email or text messages to project staff for immediate notification of critical conditions. With this unique set of features, WQData LIVE provides everything needed to effectively manage an environmental monitoring application.

# PURCHASE OR RENT?

When managing a large or long-term lake monitoring project, purchasing several systems is often the most economical option. However, for short-term monitoring projects on a tight budget, it may not be practical to purchase the necessary hydrological equipment. In these situations, it is much more prudent to rent real-time monitoring systems. With several lease duration and extension options available, the flexibility of renting monitoring systems may still be cost-effective for the larger limnological applications as well.

Lake monitoring equipment can be rented instrument by instrument, or as an entire system, calibrated and ready to deploy on arrival. Rental equipment can include multi-parameter sondes, PAR sensors, data buoys, and web-based datacenter access. Real-time telemetry via radio-to-shore, cellular, and satellite can also be incorporated. A large rental pool also means that most monitoring equipment can be shipped same-day for quick deployment and emergency situations.

Just as with Fondriest purchases, rental projects have access to a knowledgeable support staff who will provide personalized service before, during and after the project.

Fondriest Environmental, Inc.  
2091 Exchange Court  
Fairborn, OH 45324

tel: 888.426.2151  
fax: 937.426.1125  
customer@fondriest.com

# ABOUT FONDRIEST

## Company

Located in the Lower Great Lakes and Ohio River Valley region, Fondriest Environmental is a leading distributor and integrator of equipment for natural resource professionals and outdoor enthusiasts. Our team of specialists can help customers understand the products they are buying and make the correct decisions out in the field. We seek to understand project needs, devise a comprehensive solution, provide the equipment and know-how to implement it and then offer long-term project support for whatever needs arise.

## Capabilities

We work closely with NexSens Technology, a company that specializes in the design and manufacture of real-time environmental measurement systems. A variety of sensor, platform and telemetry options are available to fit the unique needs of each project. We can provide complete integrated solutions and support projects from conception to completion. An extensive fleet of rental equipment is also available for short-term project needs.

## Certifications

Fondriest Environmental is a Certified Repair Center for YSI, NexSens & FishSens, offering quick turnaround, affordable labor rates and personalized service. Our knowledgeable technicians are available for phone, email and onsite support when the need arises.

## Publications

We cover many customer projects in our Environmental Monitor magazine, which is updated daily online and printed quarterly. We also produce Lake Scientist, an interactive online resource providing research articles and news on lake ecology. Informational pages on environmental parameters and applications are available in the Measurement Sciences section of our website. And FishSens Magazine, available online, provides anglers, boaters and fisheries professionals with the latest fish science news.

## Commitment

A commitment to integrity and longstanding customer relations are the standard, rather than the exception, at Fondriest Environmental. We support professionals, educators and researchers who continuously work to monitor and protect our global resources by providing them with the products and services needed to face today's environmental challenges. Our team of solution-driven experts has years of field experience and a keen eye for finding the best equipment for each application.

## Contact Information

To reach an application specialist, please call (888) 426.2151 or email [customer@fondriest.com](mailto:customer@fondriest.com)



**SYSTEM CONFIGURATION TOOL**

Fondriest application specialists will assist with tailoring buoy configuration and equipment choices on a site-by-site basis to ensure reliability and proper data management. The questionnaire below can help you get started. Once completed, this form can be faxed to (937) 426.1125 or, if completed digitally, emailed to [customercare@fondriest.com](mailto:customercare@fondriest.com).

Contact Information

Name: \_\_\_\_\_

Organization: \_\_\_\_\_

Telephone: \_\_\_\_\_

Email: \_\_\_\_\_

Site Conditions

Describe the site conditions in a paragraph or two. Please include details regarding levels of wind, waves and boat traffic experienced in the area.

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Site Location

The location of a monitoring system can affect what buoy configuration best suits the conditions. Please select in what type of water body the system will reside.

Lake  River  Coastal  Other Please Specify \_\_\_\_\_

Approximate Depth

The mooring hardware and cable lengths used for a deployment depends on the distance to the sea floor. An application specialist can develop the best mooring plan to accomodate the approximate water depth.

< 5 ft.  Between 5 and 25 ft.  Between 25 and 50 ft.  Between 50 and 100 ft.  > 100 ft.

Water Column Measurements

Measuring water quality at a single depth near the surface is the most common configuration. In some cases, readings may be desired at multiple depths.

Single Depth  Multiple Depths Please Specify \_\_\_\_\_

Telemetry

License-free spread-spectrum radio telemetry allows communication with a shore-side NexSens radio base station as far as five miles line-of-sight from the monitoring site. Cellular telemetry allows greater geographic flexibility and is able to transmit from almost anywhere in the U.S., but it includes the cost of a cellular data plan. Satellite telemetry can be used nearly anywhere in the world, but it tends to have the highest data cost compared with cellular telemetry.

Cellular  Radio  Satellite  None

Quality Assurance

A spare multi-parameter sonde connected to a handheld display is an ideal way to verify the accuracy of a monitoring system. Additionally, it offers a back-up replacement in the case of a sensor or instrument failure.

Multi-parameter sonde & handheld display  None

Project Length (Rental vs. Purchase)

Although it often makes sense to purchase systems outright, many short-term water quality projects make it cost-prohibitive. Fondriest Environmental offers real-time buoy-based monitoring systems with weekly and monthly rental rates to accommodate short-term needs. An application specialist can make recommendations on what choice is most cost-effective.

1-3 Months  3-6 Months  6-12 Months  >1 Year Please Specify \_\_\_\_\_

# FONDRIEST ENVIRONMENTAL

Fondriest Environmental, Inc.  
2091 Exchange Court  
Fairborn, OH 45324

**P** 888.426.2151

**F** 937.426.1125

**E** [customercare@fondriest.com](mailto:customercare@fondriest.com)



when your  
**research**  
demands  
**quality data**

PRSR STD  
US POSTAGE  
**PAID**  
DAYTON, OH  
PERMIT# 860

**TAKE YOUR PROJECT TO THE NEXT LEVEL.**  
CONTACT A FONDRIEST APPLICATION SPECIALIST  
888.426.2151