RIVER MONITORING
In Real-Time

A GUIDE FOR CONFIGURING A RELIABLE AND HIGH-PERFORMANCE RIVER MONITORING SOLUTION

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Located in the Lower Great Lakes and Ohio River Valley region, Fondriest Environmental sells and services environmental monitoring products from industry leading suppliers such as YSI, Hach, Thermo Scientific, In-Situ, Turner Designs, SonTek, Vaisala, RM Young, NexSens, and many more...

The applications engineers and scientists at Fondriest Environmental specialize in designing and implementing real-time monitoring systems with data transmission via cellular, radio, landline phone, and satellite telemetry, as well as sharing data via the internet.

It is the company’s goal to supply equipment that provides high-quality data and years of service. Unlike many suppliers who carry every brand with every option, Fondriest seeks out vendors and products that meet stringent performance and quality standards. The company searches for advanced technologies that extend deployments and provide new methods of detection. The application engineers and scientists deploy many of the same products that they offer their customers.

Over the years, Fondriest Environmental has greatly expanded its product offering to provide environmental professionals with not only the finest measurement instrumentation, but also with a wide variety of equipment and accessories used extensively in day-to-day field work.

Fondriest’s commitment to customers and their projects ensure continued product support, resulting in long-lasting, value-added business relationships.

Fondriest Environmental, Inc.
1415 Research Park Drive
Beavercreek, OH 45432

☎ 888.426.2151
☎ 937.426.1125
☎ info@fondriest.com

WHY RIVER MONITORING MATTERS

Ensuring water quality in rivers is of paramount importance for sustaining their many uses. Rivers are invaluable sources of drinking water, as well as recreational and commercial opportunities. Society depends on river water for generating energy, growing crops, running machinery, washing and cleaning, cooking, gardening, and more.

Rivers sustain human and animal life in a multitude of ways, but they are also vulnerable to hazardous spills, combined sewer overflows, pollution from industrial sites, and other harmful contaminations.

WHAT’S INSIDE

3 Importance of River Monitoring
4 River Health Evaluation
5 Specific Uses
9 Real-Time Solutions
21 Short-Term Projects
23 Application
25 System Configuration Tool

Fondriest Environmental application engineers are available to assist in configuring an ideal solution for your project needs. They can also help with training and technical support. To reach them, please call (888) 426.2151 or email customercare@fondriest.com.

Fondriest offers both extensive field experience and a wide array of deployment hardware to facilitate seamless implementation of river monitoring systems. Moreover, if existing solutions are not suitable for a new project, Fondriest engineers can design custom platforms, sensors, and adaptations to suit a growing list of unique applications.
THE IMPORTANCE of River Monitoring

In the 1960s, water pollution was prevalent in many parts of the United States, with rivers, lakes, estuaries, and coastal waters rapidly degrading. There are many examples of industrialization impacting our waterways, but none are more notorious than the burning Cuyahoga River in northeast Ohio in 1969. The United States Environmental Protection Agency (USEPA) was formed in 1970 and the Clean Water Act (CWA) was introduced into law in 1972 to avoid such catastrophes in the future and begin healing America’s waters. According to the USEPA, the CWA eliminates an estimated 900 million pounds of sewage and over a billion pounds of toxic chemicals from entering U.S. waterways annually.

The CWA was extended with additional regulations and amendments, including: Storm Water Discharge, Industrial Pretreatment and Nonpoint Source Pollution.

Focus on estuaries, coastal waters, and wetlands, along with assessment and enforcement, have kept America’s water quality in check these past few decades. However, stresses on water resources continue to grow. Population growth and geographical redistribution, combined with increased demand for ecosystem services, climate change, water for energy, and an aging water supply infrastructure have been identified as significant trends.

Water quality oversight can only be actualized through reliable monitoring. River quality monitoring is essential to understanding the impact humans have on the environment. Clean water is important to the health of plants and animals and the quality of life for all people. River monitoring is the long-term, standardized measurement and observation of a river’s aquatic environment in order to determine its condition and quality trends. Only long-term monitoring can provide a sufficient amount of data to identify trends and implement predictive models.

River monitoring plays a crucial role in determining acceptable amounts of pollution discharge and sustainable abstraction levels, just to name a couple. It provides the basis for making rational management and regulatory choices, scientific conclusions, and any other decisions that require specific, quantifiable data regarding a river’s health. Moreover, river quality monitoring can provide insight into emerging problems so they may be addressed quickly.

COMPONENTS of River Health Evaluation

Comprehensive monitoring of any body of water requires assessment of chemical, physical, and biological characteristics. A river’s water quality cannot be understood fully without an assessment of all three.

Water’s physical characteristics consist of some of the oldest factors used to assess water quality. These properties include temperature, color, smell, stream width, depth, velocity, and turbidity. Physical quality measurements can serve as indicators for certain forms of pollution. Water’s temperature, for example, can indicate the presence of effluents, and dredging operations can cause changes in turbidity.

Water chemistry properties include any substance that dissolves into the water. This includes gases, such as oxygen and carbon dioxide, salts, nitrates, phosphorus, and other substances that are either naturally occurring or manmade. Common chemical parameters measured include conductivity (salinity), dissolved oxygen (DO), and pH.

Biological quality is determined by the presence or absence of biological indicators. The concept of these bioindicators is that the presence, condition, and abundance of different types of biota (e.g., fish, macroinvertebrates, algae and plants) correspond directly to the health of the water. The most common application of bioindicators has been the use of benthic macroinvertebrates to assess the water quality of streams and rivers.

Because they can measure a multitude of water quality parameters and transmit this data as it is collected, continuous, real-time monitoring systems have become popular means to help examine a river’s water quality. A real-time system can utilize a wide array of in-situ sensors to measure many water quality parameters and, using telemetry options such as radio, cellular, or satellite, can transmit this data instantly to a base computer running appropriate software. This continuous data about a river’s properties can give insight into how healthy the water is and what kind of contaminants it may contain.

Although they can only serve as one component to a complete monitoring solution, real-time monitoring systems can be crucial in many monitoring applications, especially when human health depends on the water quality. The most rapid responses are achievable with this real-time data.
The purpose of river monitoring is commonly related to water quality management, which aims to control the physical, chemical, and biological characteristics of the water through assessment and regulation. Real-time river monitoring can often act as an augmentation of other evaluation methods, such as use of bioindicators or manual sampling. Possible uses for a real-time monitoring system include assessment, regulatory monitoring (such as for TMDLs), early warning detection, restoration operations, and research projects.

**SPECIFIC USES of River Monitoring**

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**Assessment**

Real-time monitoring provides greater insight during a river quality assessment than incremental sampling alone.

Continuous monitoring can be used to graph time series data that display the scale and frequency of water-quality trends and allow for the evaluation of the water's changes over time. Daily, seasonal, or event-driven variations that conventional sampling would miss can be identified with a real-time monitoring solution. The ability to recognize changes in water quality conditions immediately also allows for effective scheduling of sample collection in order to reduce monitoring costs. Continuous, real-time monitoring can assist in generating more accurate total maximum daily loads (TMDLs) as well as augment other water-quality management plans.

Periodic sampling, however, must still be a part of any real-time monitoring system. Water quality sensors often cannot measure contaminant levels directly; instead, they measure water parameters that might indicate the presence of contaminants. Thus, equations must be developed relating sensor data to sampled data from the same sites that directly measures contaminant levels. Correlations between water quality parameter levels and actual contaminant amounts can then be generated.

**Regulatory Monitoring and TMDLs**

Before the Clean Water Act, pollution control was not a major priority for federal or state governments. As the U.S. progressed into the Industrial Age, factory work boomed. Industries met immense production demands, without regulations on how to handle waste. Although states began adopting limits on what could be dumped into natural waters in the 1960s, these rules were often loosely enforced. The fire that sparked the Clean Water Act didn’t come until June 22, 1969; it was the fire on the Cuyahoga River in Cleveland, Ohio. Reports and images of a river that had literally burst into flames due to pollution ignited public outrage for the poor state of America’s waterways. How did it happen? Riverside industries, city sewage systems, and even residents had been dumping chemicals, garbage, and other waste into the river for more than a century.

The river was so saturated with pollutants that some hypothesize sparks from a railroad bridge lit a pile of debris below and cascaded into the river fire. The fire cost Cleveland about $50,000 in damages, and many speculate it was this incident and the resulting outcry that prompted President Richard Nixon to sign the Act into law and create the EPA.

The Cuyahoga wasn’t the only river plagued with toxins, though. Before the Clean Water Act, many of the nation’s waterways were heavily contaminated. The Hudson River contained bacteria levels 170 times the safe limit, and the Mississippi was in serious decline, to name a few. In fact, river fires weren’t entirely uncommon before the 1970s, as water pollution was out of control across the nation.

In the roughly four decades of the CWA’s existence, the condition of surface waters has improved dramatically. People can now swim and fish in waters where it previously had not been safe to do so.

One of the CWA’s most notable requirements was the establishment of Total Maximum Daily Loads (TMDLs), which place limits on the amount of particular pollutants that can be present in water. As mandated in section 303(d), waters too polluted or otherwise diminished to meet water quality standards for their intended beneficial uses must have TMDLs established to protect them. If an assessment reveals a river is either impaired or threatened, water quality targets are established for certain pollutants that are already at high levels in the water. These levels are enforced through discharge permits. All organizations that dump pollution into waterways must possess a permit, which specifies the company’s discharge limitations.

It is important to survey bodies of water that may be impacted by industrial operations. Incorporating a real-time water quality monitoring system can build the framework for determining the environmental impact and find ways to reduce the negative effects. Moreover, a real-time monitoring system can ensure organizations with permits to discharge meet the requirements of their water quality-based effluent limitations (WQBELs).

Continuous monitoring, coupled with periodic sampling at monitoring sites, provides valuable information that can help indicate the presence of chemicals of concern. Regulatory agencies, discharge permit holders, and other stakeholders can all benefit from real-time monitoring.
Early Warning, Spill Detection, and Hazardous Response

A river early warning system’s primary function is to alert the appropriate officials of a change in water quality or level that could cause health risks, death, injury, damage, or irrevocable harm to the surrounding ecosystem. Possible causes of contamination include accidental spills, combined sewer overflows, and both point and non-point source pollution.

Several spills in recent years have raised awareness for the need of such systems. On Super Bowl Sunday in 2004, about 42,000 gallons of two toxic solvents — methyl ethyl ketone and methyl isobutyl ketone — poured into the St. Clair River, forcing the closure of intakes for water plants serving tens of thousands of people in the Detroit area.

In February 2007, roughly 8,000 gallons of a petroleum-based substance called cumene spilled into the Ohio River between Illinois and Kentucky after a barge collided with a lock wall. The Ohio was contaminated yet again in 2009 when eight million gallons of raw sewage gushed from a wastewater treatment plant in Louisville, Kentucky, leaving a visible brown streak in the river.

Early warning systems are a crucial component to disaster readiness in such circumstances, and they are increasingly necessary for rivers near urban areas. Many major rivers now possess early warning systems, including the St. Clair, Ohio, Potomac, Alleghany, and Monongahela rivers. Many of these river monitoring systems incorporate NexSens data logging technology with real-time telemetry and multi-parameter sondes to monitor the water quality.

An early warning system must be capable of notifying officials and providing them with enough advanced notice to take necessary precautions. For this to happen, water conditions must be monitored, danger must be predicted, and this information must be communicated to necessary persons.

A minimal early warning system could consist of station operators using simple monitoring equipment and reporting this information via radio to a central location where the data can be combined and analyzed to assess possible problems. Real-time monitoring systems, however, can enhance or in some cases replace manual sampling. A continuous monitoring system can utilize electronic sensing, real-time telemetry, and software-generated alerts based on parameter limits to warn of impending problems as soon as they are detected. Real-time data makes it possible to respond to water quality impairments and identify contamination sources as quickly as possible.

Restorations (Dredging Operations, Dam Removals)

If performed with caution, restoration efforts such as dredging and dam removals can yield positive environmental or navigational results without jeopardizing a river’s health. The risk such operations often pose is that the sediment and debris stirred up or released from operations can become suspended in the water column, endangering humans and animals. Moreover, if the sediment is contaminated it can release toxins into the water and air.

Restoration projects should aim to remove material as efficiently as possible while diminishing short-term environmental impacts, most notably the re-suspension of potentially contaminated sediments. Effective monitoring of the nearby water quality, particularly with respect to re-suspended sediments, for the duration of operations allows supervisors to respond quickly to excess levels of debris or contamination.

For example, when work began on a restoration effort that involved removing low-head dams in southwest Ohio’s Buck Creek, many precautions were taken regarding flood hazards, wetland soils, endangered species, historic properties and sites, combined sewer overflows, and stream integrity. Fondriest Environmental was contracted to set up weather monitoring, water quality and stream gauge stations to help automate sampling efforts. These tools allow researchers at nearby Wittenberg University to monitor weather, stream flow, and water quality data as it occurs, helping to facilitate safe dam removal and assess the impact of stream restoration.

Real-time monitoring systems can immediately notify project managers of dangerous water quality levels by using telemetry, intelligent software, and automatic alerts sent via SMS text messages or email. This can complement other methods for monitoring restoration impact.

Research

Real-time monitoring systems can accommodate a wide array of research projects, from small stream research to major rivers. For instance, Dr. Eric Henry and his students at the University of North Carolina Wilmington are using NexSens temperature loggers to examine groundwater-surface water interactions in an urbanized creek near the campus. They have installed temperature logging chains consisting of multiple temperature loggers at several locations within the stream channel.

In Columbus, Ohio State University’s Olentangy River Wetland Research Park uses real-time river monitoring to feed the research park with constant data about the river and constructed wetlands. Researchers at the center seek to understand how the wetlands function and how to restore wetlands.

Director of the ORWRP Dr. William Mitsch mentioned why he preferred a real-time monitoring system: “It is the ecological analogy of seeing the score of a game as it is happening as opposed to reading about it the next day.”

Beyond the instant feedback, access to continuous, long-term data sets is often advantageous for assessing trends over time that might be missed by manual sampling efforts. As stated earlier, continuous data monitoring makes the identification of daily, seasonal, or event-driven variations in water quality possible, which is not always the case with periodic sampling methods. It also allows for more efficient scheduling of sampling. Furthermore, an automated sensing system with remote telemetry can reduce the amount of hours required in the field and simplify the process of collecting and analyzing data from many locations; researchers can simply access the data from the comfort of their office.
REAL-TIME RIVER MONITORING SOLUTIONS
Introduction

NexSens monitoring systems and data loggers have been refined over the years to accommodate the specific needs of river monitoring systems. In many cases, a PVC pipe-mounted system offers the greatest safety and stability. Deployments can house multi-parameter sondes, which are field rugged and can measure several water parameters. With analog and digital ports, NexSens data loggers can also support many other sensors and devices.

Offering a wide array of sensor, data logging, telemetry, and data management options and features, NexSens river-monitoring systems can address an extensive range of project needs.

Selecting a System Type

PVC Pipe Deployment

PVC deployment pipes can mount along bridges, piers, dams, railroad trestles, other structures in the river, or river banks. A solar panel for charging the data logger can also be mounted to the structure.

The PVC pipe houses the monitoring instruments and has perforations at the bottom to allow fresh sample water to pass over the sensors. Deployment pipes are manufactured from rugged schedule 80 PVC to ensure durability and reliability in the harshest field applications. A stainless-steel pin is installed at the bottom of the pipe to keep the sensors in a fixed position.

Locking well caps cover the deployment pipes and secure valuable instruments housed inside. Furthermore, data loggers can be placed within stainless steel enclosures to protect them from harsh weather and vandalism.

For outdoor river monitoring, a PVC pipe deployment is often the best technique, as the equipment is held firmly in place and is safe inside the pipe from debris and ice floating downstream.

Buoy Platforms

If site conditions make it difficult or impossible to mount monitoring equipment in a PVC pipe along a structure or shore, a buoy-based system might be a better solution.

NexSens data buoys consist of a cross-linked polyethylene foam hull with a tough polymer skin coating. A round center housing accommodates an SDL500 submersible data logger. Three five-watt solar power packs are designed to mount to the top of the buoy to provide continuous power to the data logger and communications module. Top and bottom mounted stainless steel eye-nuts accommodate moorings and lifting rigs for quick and easy deployment. The buoy is moored to the river bottom via anchors, chains, and shackles.

Data buoy systems, however, are difficult to maintain for permanent placement within rivers. The buoys are vulnerable to debris, ice, and high water. If at all possible, outdoor systems in rivers and streams should utilize a fixed river bank or structure mounting solution.

In-Facility Systems

Monitoring systems can also be placed inside drinking water facilities, power utilities, and other industrial complexes that use raw water from a river or stream.

This in-facility option has several advantages. AC power allows not only for more powerful sensors, but other more sophisticated lab systems such as gas chromatography-mass spectrometers (GC-MS) and hydro carbon detectors.

The additional sensor options available for an indoor monitoring station are not covered in this guide. For more information about in-facility systems, contact a Fondriest application engineer.
Water Parameter Options

A vast selection of in-situ sensors and monitoring options exists, allowing the measurement of numerous water quality and hydrology parameters. The following are the most common and popular parameters measured in river-monitoring applications.

Water Quality

Multi-parameter sondes make it possible to measure a wide array of water parameters. These sondes are used to house and protect several underwater sensors, store sensor calibration information, and provide a single connection to a data logger. Sondes vary in size and price depending on the number and type of sensors included. The simplest sonde measures temperature and conductivity, while the largest model houses up to six sensors simultaneously, four of which can be optical sensors. Sensor parameter options include temperature, conductivity, dissolved oxygen pH, turbidity, chlorophyll, and more.

Temperature

Water temperature is one of water’s most basic properties, and many other parameters depend on temperature for sensor compensation and parameter calculation. Furthermore, water’s temperature has many important effects on the biological, chemical, and physical aspects of aquatic environments. It affects the growth, reproduction, and migration of living organisms. Warmer water also decreases the solubility of oxygen, thus limiting oxygen supply.

Temperature data is one of the most commonly reported river measurements. Not only is it extremely important in a number of aquatic processes, but it is relatively inexpensive and easy to measure. These readings can help track thermal pollution generated by factories and power plants, which can endanger aquatic life.

In-situ monitoring systems commonly measure water temperature with a thermistor, which is a device that undergoes a predictable change in resistance in response to temperature changes. This resistance is measured and converted to a temperature reading in Celsius, Fahrenheit, or Kelvin.

Dissolved Oxygen (DO)

Dissolved oxygen, or how much oxygen is dissolved within the water, is vital for underwater life. It is what aquatic creatures, such as fish, breathe. The DO concentration is often expressed in milligrams of oxygen per liter (mg/L) of water, parts per million (ppm), or percent air saturation (% air sat).

Dr. Leland Clark offered the first practical in-situ measurements with his patented membrane-covered electrochemical sensor. Over the years, the technology has evolved into three common electrochemical sensors technologies: galvanic, polarographic and pulsed polarographic.

Galvanic and polarographic DO sensors both use a thin semi-permeable membrane that wraps over an electrolyte solution and two metal electrodes. Oxygen in the water diffuses through the membrane at a rate proportional to its partial pressure. These probes measure the current as oxygen is reduced at the cathode and more oxygen diffuses through the membrane. Membrane-based DO sensors, however, have a number of deficiencies making them difficult to use in extended deployments. The membrane is fragile, requires frequent replacement, and these sensors require frequent calibration and stirring or flowing water.

Manufacturers have now also developed dissolved oxygen sensors with optical sensing technology. These units have more durable sensing elements than membrane-based DO sensors. They utilize a fluorescent element that reacts to different levels of oxygen in the water, which is measurable by the color of light that reflects off the fluorescent element and into a light detector inside the sensor. This technology has changed DO sensors from having the shortest deployment endurance to one of the longest and is far more feasible for long-term river monitoring applications.

Salinity / Conductivity

Aquatic animals and plants are adapted for a certain range of salinity. Spikes outside of this range may indicate a pollution event, negatively affecting and possibly killing aquatic life. Industries may release chemicals that drastically raise the salinity in a particular body of water. It is important to monitor salinity to ensure its level remains stable.

The most comprehensive method to determine salinity is to perform a chemical analysis of the concentrations of different ions in water, such as calcium, sodium, chloride, and carbonate. However, since this method is time-consuming, tedious, expensive, and infeasible for real-time monitoring, salinity is estimated from conductivity.

Salts in water conduct current, thus conductivity is proportional to the salt concentration. The equation used to derive salt concentration from conductivity levels also accounts for the temperature dependence of conductivity.

Conductivity is reported using a unit called a Siemen, often reported in milli Siemens per centimeter (mS/cm) or micro Siemens per centimeter (uS/cm). Since conductivity increases as water temperature increases, a temperature independent reading called specific conductance is often used. Specific conductance adjusts readings to what conductivity would be if the water were 25°C. This allows the conductivity of water at different temperatures to be compared.

Conductivity is measured by a sensor that determines how easily an electrical current flows between two electrodes. The electrical current has a direct relationship with the conductivity of the solution.

Salinity can be measured using in-situ probes that either consume a specific amount of oxygen or measure the amount of electrical current consumed. The former method is based on the known relationship between the temperature and salinity of seawater. The latter method, called specific conductance, is widely used and is often used as a proxy for salinity. It is easier to measure and less expensive than salinity, but it is not as accurate. Specific conductance is often reported in milliSiemens per centimeter (mS/cm) or microSiemens per centimeter (uS/cm).

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**Water Parameter Options**

**pH**
A river’s pH level can indicate the presence of pollution from accidental spills, agricultural runoff, sewer overflows, and both point and non-point sources. While young fish and insect larvae are highly sensitive to low pH values, extreme values at either end of the scale can be lethal to most organisms.

Electronic pH sensors typically use a specially-prepared electrode with an ion-selective barrier that measure the hydrogen ion concentration in the water. A measurable potential is generated between this electrode and second electrode, which serves as the reference and is surrounded with a neutral pH buffer. The voltage generated is directly proportional to the water’s pH level.

YSI’s sonde-based pH sensors utilize this technique and contain a “long-life” sealed gel reference, eliminating the need to refill. These pH sensors have been carefully designed to perform under all ionic strength conditions, from seawater with a conductivity of 53,000 uS/cm, to “average” freshwater lakes and rivers with conductivities of 200 to 1500 uS/cm, and even pure mountain streams with conductivities as low as 15 uS/cm, which has historically been the most difficult medium with respect to accuracy, quick response to pH changes, and minimal flow dependence.

**Chlorophyll**
Chlorophyll is the key biochemical component in photosynthesis. In its many forms, it is present within all photosynthetic organisms, such as phytoplankton and cyanobacteria (blue-green algae). Chlorophyll levels can serve as a measurement of the concentration of phytoplankton, which is an indicator of the general biological “health” of a river. The data is also useful for predicting detrimental algal blooms and, indirectly, determining nutrient loading.

Chlorophyll fluoresces when irradiated with light of a particular wavelength (435-470 nm), emitting light of a higher wavelength. In-situ fluorometers, such as the YSI model 6025 chlorophyll sensor, shine a beam of light of the proper wavelength into the water and then measure the higher wavelength light which is emitted. Since these sensors only scan a narrow range of possible wavelengths, ambient light within the water does not drastically interfere with readings. These real-time chlorophyll measurements can complement extractive lab analysis.

**Total Suspended Solids / Turbidity**
Suspended sediments in water, such as clay, silt, and algae, can have many negative effects on aquatic life. Suspended materials reduce water clarity and can block light to aquatic plants, smother aquatic organisms, and carry contaminants and pathogens, such as lead, mercury, and bacteria. Suspended sediments can be caused by runoff from construction sites, agriculture, and logging sites; runoff from urban areas with paved and impermeable surfaces; eroding stream banks; bottom-dwelling fish and burrowing animals; excessive algae growth; high-velocity water; including storm water; and windy conditions in shallow-water areas.

While measuring total suspended solids (TSS) directly is the ideal method to evaluate sediment suspension, it is not feasible for real-time applications. TSS can presently only be evaluated by collecting water samples and performing laboratory tests, which involve separating the sediment from the water and weighing it. Thus, turbidity, a measurement of water cloudiness, is typically used to provide real-time data that represents approximate levels of suspension.

**Other Parameter Needs**
YSI multi-parameter sondes are capable of housing a number of other sensors, including a selection of ion-selective electrodes (for ammonium, nitrate, and chloride) and additional optical sensors. Furthermore, NexSens data loggers are configured with five sensor ports for connection to any sensors that provide industry-standard digital or analog interfaces, including RS-485, SDI-12, 1-wire temp string, 0-2.5 VDC, pulse count, and more. Finally, if desired sensors utilize a different or proprietary interface, custom-built connections and control software can be developed.

**A Note on Self-Cleaning Sensors**
The most common problem for in-situ measurement of any kind, especially for extended deployments, is fouling. Either biological (active) or non-biological (passive) fouling can occur. Active fouling refers to biological growth over the optics of a measuring instrument, whereas passive fouling results from substances such as silt, clay, and organic residue accumulating on sensor lenses. Fouling can have a substantial effect on sensor readings. For example, for many optical sensors, such as dissolved oxygen, chlorophyll, CDOM, or turbidity sensors, fouling material can block the passage of light from the source beam to the light detector. In the interest of long-term deployments, particularly those in high-fouling waters, many sensors have the option of mechanical wiping devices that sweep fouling from the sensor surfaces prior to measurement.

YSI multi-parameter sondes have become the preferred choice for use in many environments with high fouling. Before taking a reading, a mechanical wiper cleans the sensing optics to ensure that the measurement is not affected by fouling sediment debris. The YSI 6136 sensor measures turbidity using the ISO 7027 method. Extended deployments with this sensor, a component of YSI’s multi-parameter water quality monitoring sondes, have exhibited stable and accurate results for long deployment periods.
River monitoring stations can be equipped to measure both water level and velocity. Each of these readings can be used with a water flow rating curve to estimate flow continuously. Level is measurable either with a pressure or non-contact radar sensor, and a SonTek Argonaut acoustic Doppler system can record water velocity.

Level Sensors
Pressure
There are two basic kinds of pressure sensors: absolute and vented.

An absolute pressure sensor measures the combined pressure exerted on it by the atmosphere and the head of water above it. In order to determine only the water’s pressure, absolute sensors must be paired with a nearby barometric sensor. The barometric pressure is then subtracted from the absolute sensor reading to obtain accurate water pressure information.

A vented pressure sensor, on the other hand, automatically corrects for changes in barometric pressure and does not need a barometer.

For each of these types, the sensor is fixed below the minimum expected water level, and a cable containing the sensor signals connects to a data logger. Cables for vented sensors also carry a vent tube. The pressure sensor is the most common type of stream gauge sensor because it is relatively cost-effective to install and maintain.

Radar
Radar sensors mount above the water and measure the time of travel for a radar pulse to reflect and return to the sensor. Antennas transmit and receive pulses to and from the water surface. The transmitting antenna transmits short radar pulses, and the receiving antenna receives the pulses reflected from the water surface. The time delay from transmission to receipt is proportional to the distance between sensor and water surface. Radar sensors can mount to a bridge, frame, pipeline, or extension arm and determine level based on its distance from the water surface.

Historically, radar level sensors have not delivered the same accuracy as bubbler sensors or pressure transducers. The OTT RLS Radar Level Sensor, however, uses an advanced non-contact level measurement technology, which provides the USGS accuracy requirement of +/-0.01 feet. With a non-contact measurement distance range of 115 feet to water, the OTT RLS is an ideal choice when a bridge or above-water structure is available for mounting. Since the entire radar system is far above the water, it is safe from any debris.

Velocity Sensors
Doppler
SonTek Argonaut acoustic Doppler current meters use sonar for precise water velocity measurements in streams and rivers. Doppler current meters are mounted in a fixed spot, typically on a riverbank, bridge abutment, or other vertical structure. These devices can provide significantly more information than water level sensors because they directly measure both water level and horizontal water velocity. They are also widely used in streams and rivers that may experience bi-directional water flow, such as an estuary. Three models of the Argonaut system are available to accommodate narrow streams to very wide rivers.

Hydrology

Volumetric flow rate measures the speed at which a volume of water in a river is travelling downstream (often reported in cubic feet per second). When flow rate increases, water has a greater ability to erode its channel and banks. More and heavier sediment can be carried by the river, which increases the river’s turbidity.

The volumetric flow rate of water (discharge) is commonly estimated from the measured water-surface elevation (stage) using an empirical fit to measurements of stage and concurrent discharge. This is referred to as the stage-discharge relationship, or stream rating.

Measuring the changes in water level over time is only one component to developing a stage discharge relationship. In order to obtain a good estimate of water flow, point discharge measurements should be taken periodically to establish and maintain a good rating curve. Each discharge measurement is correlated to the water level at the time the measurement was taken. With this information, discharge data can be interpolated and applied to the full range of water level measurements.

Point discharge measurements in wadeable streams can be obtained using a handheld velocity meter mounted to a wading rod. The SonTek FlowTracker is one such instrument commonly used by government organizations such as the U.S. Geological Survey. In non-wadeable stream environments, a more sophisticated stream discharge measurement system is often required. Towable Doppler velocity systems mounted on either a boat or Trimaran are commonly used to measure discharge in these situations.

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NexSens data loggers can connect to virtually any sensor via analog and digital interfaces. Specifically designed for remote environmental monitoring applications, these data loggers offer superior data acquisition performance in extreme conditions. There are options for landline phone, cellular, radio, Ethernet, WiFi, and satellite telemetry. A NexSens data logger simultaneously supports eight analog inputs and four digital inputs for multi-sensor data logging capability. All electronics are housed in a rugged, NEMA 4X enclosure constructed of heavy-duty fiberglass. The built-in 8.5 amp-hour sealed lead acid battery provides 12-volt power to the system, and the battery can continuously charge using AC or solar power. Polymer-coated circuit boards, sealed connectors, corrosion-resistant stainless steel hardware, and built-in lightning protection ensure reliable performance in even the harshest conditions. All sensor cables run through Sealcon gland fittings to ensure protection from the elements.

The NexSens SDL500 submersible data logger is also available for situations in which the data logger will be exposed to more severe environmental conditions. The SDL500 can withstand extreme wave action, drops, and floods. It consists of the data logger and communications module housed in a fully-submersible, five-inch-diameter round enclosure. It can be outfitted with either a spread-spectrum radio or cellular modem and antenna for real-time communication. It also offers five sensor ports for connection to industry-standard digital and analog sensors. Each sensor port offers a UW receptacle connection with double O-ring seals for waterproof sensor connections.

The SDL500 can be placed into a perforated PVC pipe. Alternatively, a NexSens data buoy can accommodate the data logger as well as three NexSens five-watt solar power packs to provide continuous power.

DATA LOGGING & TELEMETRY

Data Loggers

NexSens data loggers can transmit from almost anywhere on Earth. Real-time telemetry options include radio, cellular, Ethernet, WiFi, and satellite connections. Two factors, however, help determine the best and most cost-effective telemetry method — site conditions and distance to the project computer.

When the project computer can be located within a few miles (line-of-sight) or few hundred feet (non-line-of-sight), license-free, spread-spectrum radio telemetry is often the best choice. A radio telemetry data logger is able to communicate with a NexSens radio base station, which serves as a central hub for one or more remote data loggers and can connect directly to a base computer or relay data to a remote computer.

Cellular telemetry requires the additional cost of a cellular data plan, but it offers greater geographic flexibility. With this method, data transmissions from almost anywhere in the U.S. are possible. A cellular data logger does not need to be in proximity to a base station; instead, its data is accessible, with appropriate credentials, over the Internet. NexSens data loggers can use cellular data plans from many U.S. providers, such as AT&T, Verizon, or Sprint Nextel.

If sites have access to Ethernet ports or are in a WiFi network’s range, Ethernet and WiFi telemetry are ideal choices. With these options, the data logger is available directly on the local network. A landline connection is also available, but it does not provide real-time results as a computer must dial the data logger periodically for updates.

Lastly, for the remotest applications — where cellular telemetry is unfeasible — satellite telemetry may be required. Data loggers with this option communicate with Iridium satellites, allowing them to transmit data from anywhere on Earth.
MANAGING DATA

Data Acquisition Software

The computer at the receiving end of data logger transmissions requires software to acquire, process, analyze, and possibly publish water quality data. NexSens iChart software is a user-friendly package that can fulfill these needs, serving as the centralized interface and database for all incoming data. All data and sensor configuration settings are stored in a single iChart database. The software is designed with an open architecture and offers a straightforward interface, making it easy for individuals at any level of technical expertise to configure and customize a monitoring and data collection project.

The software offers a unique historical report creation tool that can generate customized reports with data from all sensors in an iChart database. When creating a report, users can include specific information about the monitoring site, location, sensors, and project. After creation, reports can be converted to PDF, exported to Microsoft Excel, sent to interested parties via email, uploaded to a web server, and more. The report template can also be saved and automatically generated, further automating the reporting process.

Real-Time Online Datacenter

iChart can export data directly into WQData, a secure web datacenter providing an online interface for viewing environmental data. It offers 24/7 instant access to project data using any web browser.

Project datacenter sites can be password-protected or publicly accessible. Using WQData, visitors can view dynamic project area maps overlaid with the most recent data, historical data, time series graphs, statistical summaries, and project-specific information.

An administrator login provides an intuitive interface for setting up the project, modifying data views, and adding relevant project information. Administrators can select from a library of predefined themes, enter site descriptions, set up data filters, and graph scales and other data attributes. Also included with WQData is the NexSens embeddable Web-Data Applet. This HTML code can be added to any web page to present visitors with a quick snapshot of project data that also links back to the complete project datacenter.
**Alarm Notifications**

iChart software can immediately transmit automated alarm notifications when certain pre-defined parameter limits are exceeded.

Software alarms can notify persons via SMS text messaging or email. If a voice message alarm is preferable, the NexSens system can be configured with an auto-dialer to call a designated individual (or list of individuals) with a pre-recorded message.

Additionally, NexSens data loggers can temporarily change their functionality as a response to exceeded parameter limits. For example, the data logger can change sample and log intervals based on a particular sensor reading. Data logger control outputs are also available to control external devices via 5 V DIO or 12 V switches.

**System Maintenance**

Regardless of the sensors used, periodic maintenance and calibration are required. Common maintenance intervals are weekly or bi-weekly, but maintenance intervals are largely dependent on site conditions and other variables. For example, waterways that contain highly productive algal content or experience higher levels of suspended sediment and debris are more susceptible to fouling and degradation of sensor data quality. Each sensor usually has its own recommended calibration frequency; consult instrument-specific literature for more details. Fondriest’s application engineers work with customers to recommend site-specific maintenance and calibration frequencies.

It is common to have a spare sensor on hand both to swap sensors in the field during calibration and to reduce downtime resulting from unforeseen sensor failure, which could cause critical and costly interruptions to monitoring and projects dependent on the real-time data.

iChart will automatically issue the alert via text message or email.

**SHORT-TERM PROJECTS**

**Rental vs. Purchase**

While it often makes sense to purchase systems outright, many short-term river monitoring projects make it cost-prohibitive. Fondriest offers real-time river monitoring systems with weekly and monthly rental rates to meet project requirements. Fondriest leases a wide array of monitoring equipment as well as field supplies needed to set up and use a real-time river monitoring system.

Fondriest Environmental application engineers are available to assist in configuring an ideal solution for project needs. They can also help with training and technical support. To reach them, please call (888) 426.2151 or email customercare@fondriest.com. Fondriest offers both extensive field experience and a wide array of deployment hardware to facilitate seamless implementation of river monitoring systems. Moreover, if existing solution options are not suitable for a new project, Fondriest engineers can design custom platforms, sensors, and adaptations to suit a growing list of unique applications.
Fondriest Environmental was contacted to provide the water quality data telemetry system. Students and staff from Bucknell University and Bloomsburg University maintain the instruments and equipment. This system collects water quality and flow data from the Susquehanna River on the North Branch at Danville, the West Branch at Milton, and the Susquehanna River Confluence near Selinsgrove, Pennsylvania.

YSI 6600 V2-4 multi-parameter sondes measure water quality at three river locations. The sondes are connected to NexSens 3100-iSIC data loggers equipped with cellular telemetry. Every five minutes, the sondes measure water temperature, pH, ORP, turbidity, specific conductance, chlorophyll, dissolved oxygen, depth, and battery voltage. This data is transmitted wirelessly to a remote computer at Bucknell University.

NexSens iChart software is used to communicate with the data loggers and sensors. The software automatically streams live data to an online web datacenter. WQData allows anyone to view real-time water quality data being transmitted from the Susquehanna. Visitors may also view statistics and plots of the data, as well as download Excel tables.

The Susquehanna River is the longest river on the American east coast. The river flows from near upstate New York and western Pennsylvania for over 440 miles before it channels into the Chesapeake Bay. It is widely believed to be one of the oldest river systems in the world.

Over the more recent years, the Susquehanna has been subject to various forms of pollution, including agricultural runoff, urban stormwater runoff, and raw sewage. The United States government has pushed for the cleanup of the river and proper monitoring of water quality.

The Heartland Coalition for Environmental Studies is endeavoring on a collaborative effort to collect data on water quality, ecological habitat, and geology of the river and selected tributaries in central Pennsylvania. The coalition is made up of faculty and students from Bloomsburg University, Bucknell University, King’s College, Lycoming College, Susquehanna University, and EcoAnalysts, Inc. Additional support is provided by Pennsylvania American Water and Danville Municipal Water Authority.

APPLICATION:
Susquehanna River

Project Overview

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SYSTEM CONFIGURATION TOOL

Fondriest Environmental application engineers will assist with configuration and equipment choices on a site-by-site basis to ensure reliability, safety, and proper data management. However, 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.

Contact Information

Name: 
Organization: 
Telephone: 
Email: 

Site Location

The location of a monitoring system can affect what platform options are available, primarily whether a monitoring system can be mounted along a structure in a PVC pipe or if a monitoring buoy is required. Is there an available structure at the site location on which to mount a PVC deployment pipe?

Yes  No

Site Conditions

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

Desired Water Quality Parameters

YSI multi-parameter sondes make it possible to measure a wide array of water parameters, including the following. Please select any necessary parameters.

Temperature  Conductivity  Dissolved Oxygen  pH
Turbidity  Chlorophyll  Others

Flow Measurements

River monitoring stations can be equipped to measure both water level and velocity. Each of these readings can be used with a water flow rating curve to estimate flow continuously. Level is measurable either with a pressure or non-contact radar sensor; and a SonTek Argonaut acoustic Doppler system can record water velocity.

Are flow measurements required?  Yes  No

If yes, is any measurement technology preferred?

Pressure level sensor  Non-contact radar level sensor
Acoustic Doppler water velocity system  No Preference

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. Ethernet or WiFi telemetry is often ideal if a site is close to an Ethernet port or within a WiFi network’s range. Landline telemetry or direct-to-PC options are also available for projects with a nearby phone line or Windows-based computer. Finally, for the remotest applications — where cellular telemetry is unfeasible — satellite telemetry may be required.

Cellular  Radio  Ethernet  Direct-to-PC
WiFi  Satellite  Landline  None

Data Management

While river monitoring systems can function with iChart software alone, WQData is a seamless extension and enhancement of the software. It is a secure web datacenter providing an online interface for viewing environmental data. It offers 24/7 instant access to project data using any web browser.

iChart  iChart & WQData

Project Length (Rental vs. Purchase)

Although it often makes sense to purchase systems outright, many short-term river monitoring projects make it cost-prohibitive. NexSens Technology offers real-time river monitoring systems with weekly and monthly rental rates to accommodate these operations. An application engineer can make recommendations on what choice is most cost-effective.

1-3 months  3-6 months  6-12 months  1 year