ZAPS TECHNOLOGIES

LiquID™ for Water Treatment – January 2012

Raw Water Monitoring and Event Detection

Source Water Monitoring

As a dynamic resource, the composition of water can change. This is true for any water source – creeks, rivers, lakes, oceans or underground aquifers – in fact, any source used as an input for water treatment plants. Change can occur slowly due to seasonal factors or other long-term trends, or quickly, when an "event," such as a spill or a storm in the catchment occurs. The general quality of the raw water and the occurrence of events can determine whether a plant manager has a good day or a bad day – and whether a water utility provides water that is not fit for purpose. One way to help prevent or mitigate those bad days is through input water monitoring. Raw water monitoring means committing to collecting frequent, comprehensive information about the water coming into the plant – to know when changes occur and to be ready to manage them.

Why We Monitor – Event Detection and Understanding

The primary rationale for raw water monitoring is for event detection. Event detection is the process of identifying when a change in water quality has occurred and characterizing that change in terms of source, impact on water quality, and the consequent requirements for manipulating the water treatment barriers in place.

Events can have profound effects both on plant operations and the outgoing potable water, so it is important in an immediate sense to monitor source water:

- **To ensure the safety of drinking water customers and the consistent quality of the water they receive.**
- **To optimize plant operations for changing conditions, either through responsive process control or through experimentation with different treatment processes.**
- **To avoid adverse and potentially damaging public relations as "the utility that got it wrong."**

There are also longer-term benefits to raw water monitoring. In a direct sense, monitoring for contamination events enables source water protection; informing efforts to mitigate or eliminate upstream contaminant sources and providing a validated risk-basis for source management. In the big picture, by collecting and keeping data over a long time period, the monitoring regimen provides a greater level of understanding of water quality and the factors that affect the water system, providing important information for planning and capital investment decisions.

Challenges in Event Detection

Water quality events may be fast, acute, and often have done their damage before anyone knows they even happened. A monitoring regimen should help to identify and characterize events as they occur, ideally providing an advance warning to allow for preventive operational changes to be made. However, this task is made difficult by a few major challenges:

- ***Events happen quickly*.** Test information for event detection is not useful if information becomes available only after the time for response has passed, so effective monitoring must provide data that is both frequent and rapid. An ideal system will allow for continuous real-time monitoring, reporting, and operational action – the essence of a "critical control point."
- ***Events are diverse*.** Different event types can occur in any given system, and no single parameter is sufficient to identify and characterize this diversity. The table to the right provides a comprehensive list of potential contaminant sources (from the Water Resource Foundation's swptool.org). Multiple parameters are required for the monitoring regimen to be adequate to the task.
- ***Each water system is unique*.** Every treatment plant faces unique operational challenges due to different raw water risks, and water plant designs and capabilities.

CONTAMINANT SOURCES
Agriculture: Fertilizer
Agriculture: Land Use Practices
Agriculture: Livestock
Agriculture: Pesticides
Concentrated Animal Feeding Operations
Construction
Contaminated Sites
De-icing Practices
Development
Forestry
Gas Stations
Industrial Discharges
Landscaping
Marinas and Boating
Mining activities
Naturally Occuring
Oil/Gas Wells
Pet waste
Recreation
Septic Systems
Soil Erosion
Solid Waste
Spills
Storage tanks
Stormwater runoff
Waste Disposal Practices
Wastewater Treatment Plants
Wildlife

***Table 1** - Potential Sources of Water Resource Contamination*

Given these challenges, it is clear that the traditional method of grab sampling and lab analysis is simply unable to keep up with the speed and diversity of events – being of use only as a verification rather than operational monitoring tool. Choosing an adequate range of monitoring parameters for lab testing is prohibitively expensive, often only within the budgetary reach of larger utilities, leaving most utilities open to product quality risk. Further, even at their best, some tests fail to provide results in sufficient time to be actionable.

Online monitoring systems, which automatically sample and interrogate raw water quality at a high frequency, help to address this raw-water risk exposure for the utility. Most online equipment is designed to monitor and report on only a single parameter, however, and the wide diversity of events means that no one parameter is sufficiently indicative to provide comprehensive information. The wider the range of possible events in a system, the more parameters are required to detect and distinguish them.

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Advanced, multi-parameter online systems have become available to overcome the challenge of event diversity by using sensor arrays – these consisting of a cluster of online instruments, in a cabinet with a single sample feed, that test a variety of parameters and report through a combined

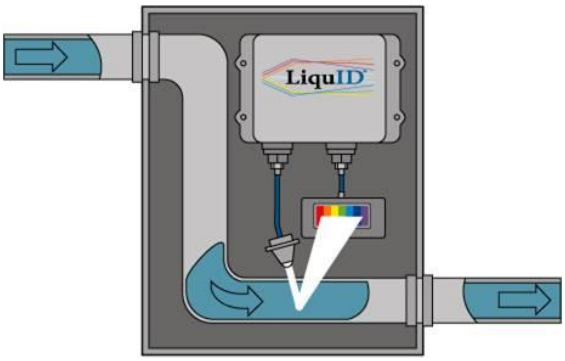
software interface. These systems provide a broad range of useful water quality data for effective event detection. However, these new instruments also create new challenges: including the capital cost of all the equipment, maintenance requirements for all the pieces, appropriately trained personnel for their operation, and interpreting vast amounts of conflicting data with the noise of multi-probe drift.

The LiquID Station™ - Multi-Parameter Detection in a Single Instrument

The LiquID Station, from ZAPS Technologies, is an automated, optical instrument for online water-quality monitoring. The system includes a number of key features to meet the challenges of event detection.

Automated Monitoring with Continuous Real-Time Results

LiquID is a true self-cleaning and self-calibrating automated flow-through device that uses just spectral light data for water quality analysis (see graphic below). The system views the fluid sample with many different frequencies in rapid succession and processes the readings through an onboard computer for effectively real-time results. This speed informs plant operators immediately when an event has occurred, providing the maximum possible time for response.



Above: Stylized view of LiquID flow-through water monitoring

Right: Photograph of a LiquID Station configured for source water monitoring

Multiple Parameters and Indicators in One System

The LiquID Station features a unique hybrid spectrophotometer design – combining UV-Visible absorbance and fluorescent light measurement capability in a single platform. This produces an unprecedented broad range of spectral data. The system uses these data to produce multiple matrix-corrected parametric measurements (see parameter lists, right and upper right). These measurements compose a broad set of important quantitative data related to a diverse range of water quality events.

The system also features ZAPS own proprietary Contaminant Indicator Series™ - powerful event detection tools that utilize intrinsic fluorescence or a combination of techniques to provide reactive and sensitive semi-quantitative measurements that are specific to certain classes of compounds (See list, lower right).

LiquID combines all these parameters and indicators in a single optical platform. That means only one instrument to purchase and maintain, no need to worry about multi-probe drift, and no need to deal with expensive reagents. The LiquID Station, using two distinctive optical techniques, provides event detection alarms that are both sensitive and selective, to alert operators of events as they occur and provide the necessary information to distinguish the type of event as it happens.

KEY PARAMETERS For DRINKING WATER & ENVIRONMENTAL MONITORING	
TOC	Total Organic Carbon
UVT/UVA	Ultraviolet Transmission / Absorbance
FDOM	Fluorescent Dissolved Organic Matter
Chlorophyll	Chlorophyll *a* Fluorescence
Nitrate	Combined Nitrate + Nitrite
Turbidity	Transmission Turbidity

OPTIONAL PARAMETERS *Available for Specific Applications*	
Ammonia	NH3
Chlorine	Free Chlorine
Color	Color @ 440 nanometers
TOX	Disinfection Byproducts

ZAPS INDICATOR SERIES *Powerful Event Detection & Event Characterization Capability*	
ECOLI	Fecal Contaminants
OIL	Refined Hydrocarbon Fluorescence
FTOC	Specific Humic Fluorescence
SUVA	Specific UV Absorbance

Table 2 *- List of Parameters and Indicators available with LiquID*

The ZAPS Approach – Man and Machine

Because every water system is different, an approach to event detection that utilizes just a few measurements and an out-of-the-box software package will tend to fail without adaptation to specific use requirements. Different event risks require different measurements, and the observed patterns in the data tend to vary in ways that confound a “one size fits all” solution.

In short, no combination of instrument and software can match the judgment of a water system operator or plant manager. Based on this observation, ZAPS takes a systemic “Man and Machine” approach to event risk management – whereby LiquID does the work of sampling and testing, providing data in the right way to inform judgment and operational decisions of the system operator.

The set up process begins with a risk analysis of your unique water supply system by ZAPS and its expert partners. The first step is to identify potential hazardous events that can plausibly occur and are likely to cause an impact on the system. These determinations are made based on a range of factors, including raw water source, land-use types, hazard sources and any particular needs of water customers and

regulators. The events are then prioritized, based on a risk assessment process, to allow the most likely hazards (*i.e.* water quality contaminants) to be distilled from the overall list. This process is undertaken in collaboration with ZAPS and its partners, who bring public health and environmental risk assessment as well as management and regulatory knowledge to the table, and treatment plant personnel, who possess specialized knowledge of their system and their community. We encourage all Water professionals to provide their unique knowledge within the boundaries of the source water understanding.

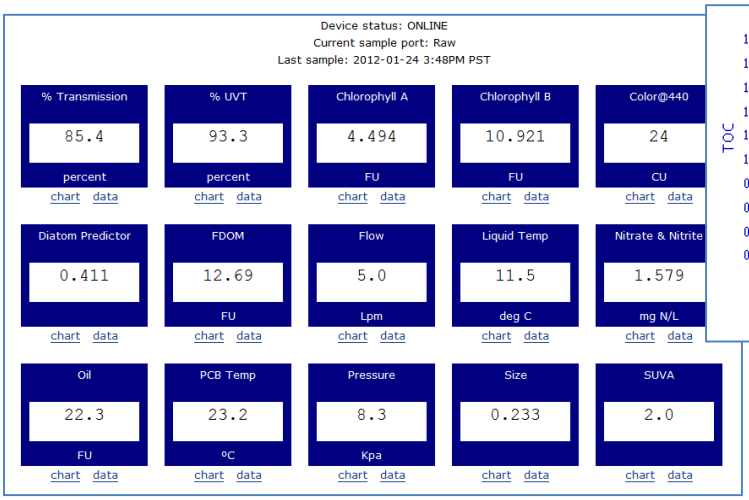
After identifying risks, the next step is to establish the configuration of parameters and indicators to match the priority event types. In this process, ZAPS aims to educate users in a few steps:

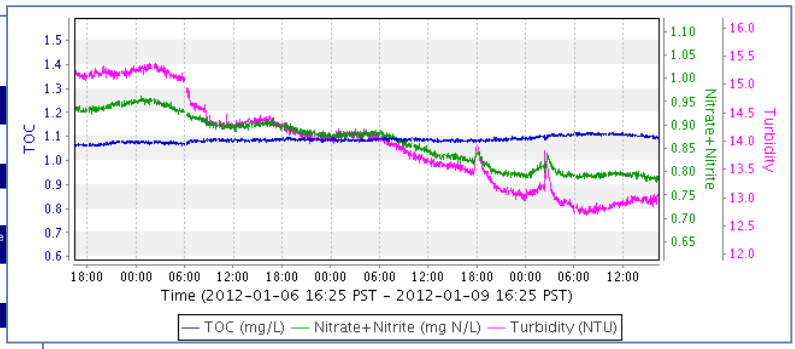
Comprehensive Risk Management

The ZAPS LiquID technology has been designed to help provide utilities with a "source to customer" quality assurance focus, helping to minimize risk. The conceptual approach of LiquID fits with the risk-based requirements of contemporary water cycle management frameworks (e.g. ISO 22000, HACCP and statutory risk management plans). Implementing such technology, for instance at critical control points as part of an overarching risk management plan, would allow a water utility to demonstrate due diligence and increase confidence in its consistent production of safe, quality water to the customer.

- First, in the meaning of different parameters and indicators available with your LiquID Station.
- Second, in how to quickly access and view multi-parameter data on ZAPS own intuitive web-user interface (see below).
- Third, in how different parameters and indicators match up to key water quality events (see Table 3, following page).

This education process takes some time, but with continuous real-time data, some background knowledge and a well-constructed event detection matrix, the operator and the instrument together become a powerful water quality analyst and effective event detection system.





Screen captures of data presented on the LiquID web user interface. On the left are live, up-to-the-minute readings on the Quick Glance view, while the image above is a 3-day graph using the program's intuitive graphing feature.

Key Groundwater Contaminants	PARAMETERS						INDICATORS			
	TOC	*FDOM*	*UVA*	*NO3*	*Colour*	*NTU*	*SUVA*	*FTOC*	*ECOLI*	*OIL*
Agricultural Runoff										
Livestock Waste		●		●			●	●	●	
Fertilizer				●						
Pesticides		●	●				●	●		
Urban Runoff										
Fuels and Oils		●						●		●
Road Salts										
Other Organic Chemicals	●	●	●				●	●		
Septic System Leakage	●	●	●	●	●		●	●	●	
Landfill Leachate Seepage	●	●	●	●	●		●	●	●	
Sediment Intrusion						●				

Table 3 *- Example matrix for event detection in a groundwater source, listing contaminant sources and types and key parameter and indicators for detection and characterization of events.*

Once the event detection matrix is complete, the system is further refined through the addition of parameter and indicator alarms. These alarms fall into three general categories – shift, drift and threshold alarms – and are customized for each parameter for each customer to match key events and the customer's own requirements for sensitivity. The alarms provide an alert to issues that deserve further attention to operators, who then decide whether to act, ignore or seek further information.

Finally, the last part in the process is ongoing collaboration following installation. A good event detection system must be well-maintained and incorporates new information as it becomes available. In this spirit ZAPS provides ongoing support, keeping the instrument healthy, making sure alarm systems are optimally tuned, and ensuring that both man and machine are able to see new priority events as they become known. ZAPS and its distribution partners take pride in the support provided to customers after the sale and share an interest in building success stories.

Event Detection Steps to Success

1. ***Event Risk Analysis***
2. ***Configure Parameters for Event Detection***
3. ***Establish Alarms***
4. ***Ongoing Collaboration and Support***

Conclusion

Two major principles guide ZAPS in its quest to build and deliver the world's best water quality event detection system for source water monitoring.

The first is that the safety of water consumers – which includes us all – is paramount. No person should be without assurance and access to reliably safe drinking water. The second is that information is power. Safety can be assured at the same time that efficiencies are achieved and costs are saved through access to both broader and more usable information.

We invite you to learn more about the benefits and process of event detection by contacting ZAPS, through email or phone, or visiting our website.

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