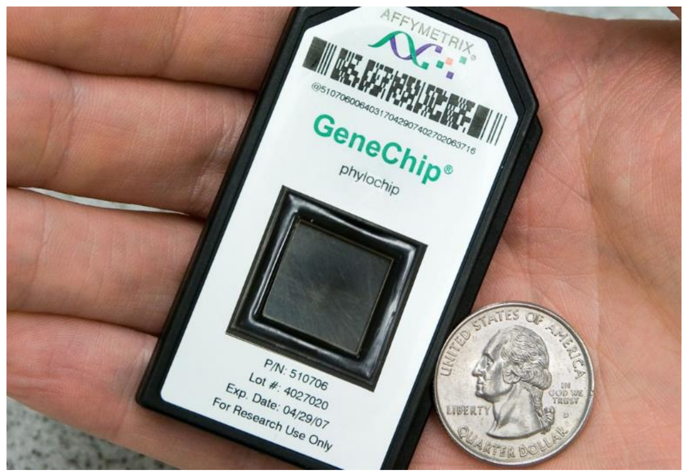
US Environmental Protection Agency
Office of Enforcement and Compliance Assurance

Next Generation Compliance
ADVANCED MONITORING

PhyloChip
Lawrence Berkeley Laboratory



Summary: The Lawrence Berkeley Lab's PhyloChip is a forensics tool that identifies all human, animal and environmental sources of bacteria with a single test. It can provide a source-specific DNA fingerprint of contaminant sources by measuring the composition of the entire microbial community.

Animal feces and environmental sources contain unique combinations of thousands of distinct microbial species—highly specific "fingerprints." PhyloChip can detect this microbial fingerprint. PhyloChip is a DNA microarray that contains over 1 million DNA probes that target nearly all types of bacteria and archaea found in any environment (feces, soil, water, air).

Older methods of sampling and growing cultures in the lab took days to weeks and could miss species that cannot grow on the culture medium. The Phylochip provides faster and possibly more accurate assessments of ambient microbes. In validation studies the PhyloChip has a high degree of sensitivity and specificity for human sources, cattle, swine, house pets, birds, and diverse wildlife. PhyloChip also has the unique capability to identify non-fecal sources such as sediments, soils, and decaying vegetation.

PhyloChip analysis can be customized to detect site-specific fingerprints for more precise forensic identification of local sources – such as a particular septic system or dairy farm. PhyloChip has the ability to measure thousands of source-specific microbes at very high or low quantities, and has many built in statistical controls and quantitative standards

The PhyloChip contains a unique microarray that can simultaneously detect most known microorganisms—testing for over 58,000 bacterial taxa. PhyloChip's glass microarray holds 1.1 million separate tests, each measuring a specific nucleic acid sequence. When each DNA molecule from the sample contact the short pieces of DNA bound to the glass surface, it adheres only to the appropriate location and microbes are identified by how well their DNA anneals, or "sticks," to the test sites.

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In the lab, the exposed PhyloChip is inserted into a scanner that detects which tests on the microarray are positive by the emission of fluorescent light from sites bound to nucleic acids from the sample. The intensity of the fluorescence corresponds to the quantity of organisms in the sample. Small sequence differences within ribosomal genes distinguish different taxa. PhyloChip has divided all known sequence variations from bacterial and archaeal ribosomal genes into over 58,000 distinctive groupings, each representing a specific microbial genus or species using ribosomal sequence data available in public databases.

PhyloChip does not require customization for different types of samples, eliminating guesswork as to what bacteria exist in a sample. Updated versions of the PhyloChip can incorporate new gene data as it becomes available.

In using the PhyloChip, researchers would need to put the sample on ice immediately and filter the sample within six hours. The sample can be stored in a traditional freezer for about a week, or longer in a -80 degree C freezer.

The costs of using the PhyloChip are the device itself (about $250 each) and analytical costs. Currently, the analytical test for each chip costs $500 with labor and results are usually obtained within a week (batches of at least 10 chips). Analytical testing is done by the University of California Berkeley.

EPA is testing the use of the PhyloChip in several regions under varied circumstances in urban and rural settings. Some projects will be done in cooperation with states and tribes. The uses are expected to include waste profiling, pollutant source bracketing (upstream and downstream), emerging contaminants, sewage effluent, groundwater contamination, and harmful algal bloom research. EPA will be seeking to see how effective PhyloChip may be in each of these circumstances and how future work can be done most efficiently.

For more information, see http://esd1.lbl.gov/research/facilities/andersenlab/phylochip.html.

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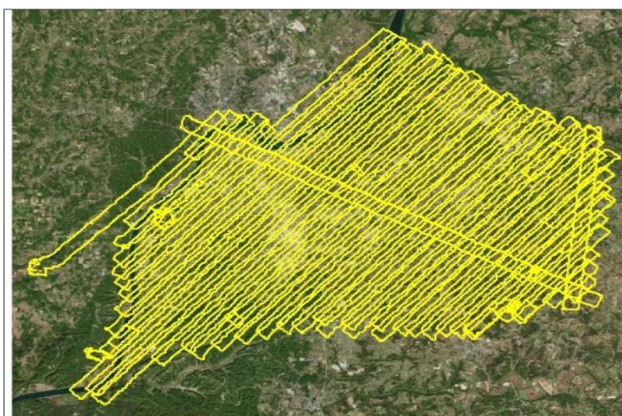
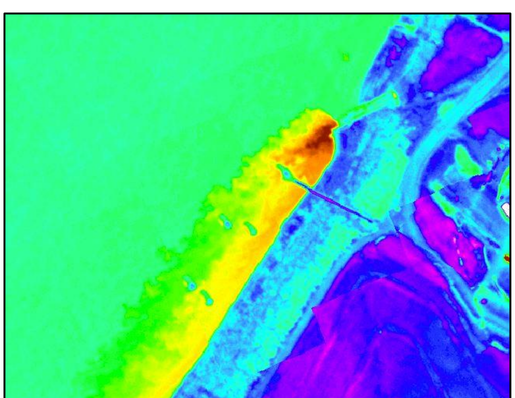
Using Aerial Infrared Images to Detect Illicit Discharges
Louisville, KY Metropolitan Sewer District

Summary: Louisville, KY Metropolitan Sewer District (MSD) has been using aerial photos along with infrared and thermal images to identify MS4 illicit discharges and other issues. MSD has found that these images help save money and find problems sooner so they can be fixed sooner. There is some expertise and data analysis needed to best interpret the images and identify issues. The issues are then verified with field observations.

Infrared cameras, especially gas-imaging cameras, have revolutionized air inspections and enforcement. Now Louisville, KY is using this same type of technology to help them find and investigate illicit discharges and septic issues. How this is done:

1. Contract for flight and imaging above the local stream network. (See image at right.) Flight is done during dry periods (at least 72 hours after a storm of > 0.1") and when there is a larger temperature difference between the conveyance system and illicit connections (winter).
2. Sensor data must be calibrated and converted into image files, then adjusted if needed to yield the best image differentiation.
3. Anomalies found on images are investigated by field personnel.
4. Enforcement or corrective action is taken as appropriate.



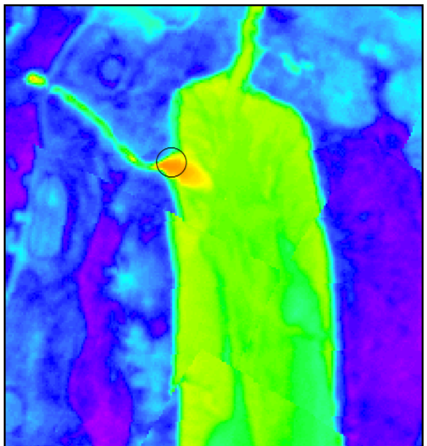


Infrared image shows permitted discharge (red) into Ohio River.

Infrared and thermal imaging detects wavelengths outside the visible range. Louisville MSD conducted these imaging flights in 2013 and 2015.

Infrared and thermal imaging and analysis saves money—it is an alternative to traditional, labor-intensive field exercises that can take months or years to complete with high costs and limited results. This method allows field investigations to be focused on areas where anomalies are detected, leading to much more efficient investigations and faster resolution of issues. In 2013, Louisville found that it spent $105 K on imaging and about $50 K on follow-up analysis. Compared with the traditional approach of walking the lines at a cost of about $450 K, the infrared and thermal imaging approach saved almost $300 K and found issues faster so they could be fixed faster.

Louisville MSD developed standard operating procedures for evaluating thermal images. This, together with field investigation, is important because some anomalies can be due to shallow water or slopes that can show on images as warmer water.



Orange in this image shows leakage from a valve and drainage pipe into a pond. This is a repeat offender. Imaging also allows better tracking of conditions over time.

This image shows the lines of a septic field.

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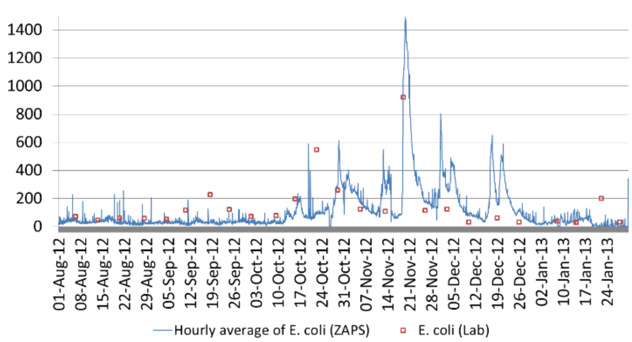
LiquID™ Station: Real Time Water Quality Monitoring
ZAPS Technologies

Summary: ZAPS LiquID pumps water from a stream and continuously measures up to six parameters at a time from approximately 25 possible parameters. The ZAPS LiquID measures by injecting light through the sample and measuring the reactions. It measures each parameter every two minutes, and can transmit data and alerts to the web or your mobile device.

A ZAPS LiquID Station stands about six feet tall. It constantly measures up to six parameters and can transmit data to your cell phone.

ZAPS is an acronym for Zero Angle PhotoSpectroscopy. ZAPS LiquID is a reagent-free spectrophotometer. It uses a beam of light that passes through the flowing sample, measures the absorbance, scattering, and fluorescence, then uses proprietary algorithms determine background water makeup, inorganic load (e.g. turbidity), known compounds (e.g. E. coli, BOD, NO3, NH3, TSS, VFA, etc.), and the signatures of unknown compounds. It measures every two minutes without using additional chemicals or destroying the sample stream. This measuring frequency, coupled with internet connectivity, can provide real time web updates and mobile device alerts.

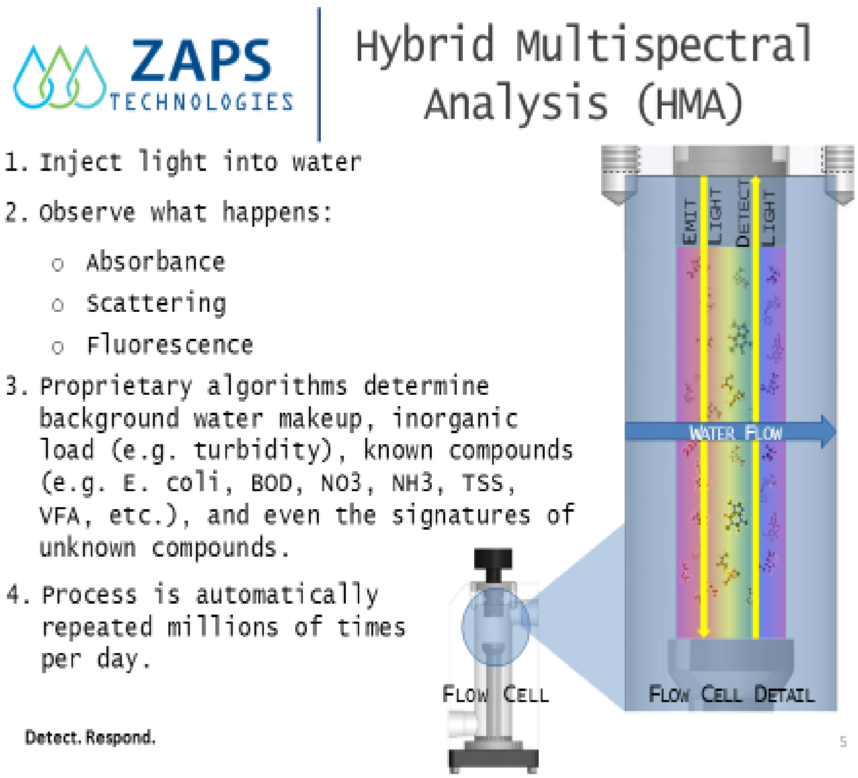
ZAPS LiquID is best used in a building or trailer adjacent to the stream to be tested. It can operate outdoors, but needs constant electricity and internet connection. It can operate for weeks at a time without intervention. While the machine will automatically clean and calibrate itself hundreds of times over the deployment, it will need a manual cleaning every few weeks using pressurized clean water, or more in challenging environments. An internet connection (e.g., possibly using cell phone technology) is needed to transmit data and receive alerts.



Example graph comparing ZAPS LiquID data with lab analysis of grab samples. Image from ZAPS Technologies.

ZAPS Technologies claims a high level of data reproducibility and has provided data on LiquID performance compared with lab analyses.

EPA is testing ZAPS LiquID water quality monitoring stations in two different environments, measuring some similar and some different parameters at each site, and comparing the data with a standard lab test of grab samples. Deployments began in January, 2016. EPA's Next Generation Compliance team within the Office of Enforcement and Compliance Assurance and EPA's Office of Research and Development are working with two EPA Regions to deploy and test these machines.



BOD	Biochemical Oxygen Demand
CBOD	Carbonaceous BOD
CHLa	Chlorophyll-a
CHLb	Chlorophyll-b
CHLORINE	Total Free Chlorine
COD	Chemical Oxygen Demand
COLOR	Color
ECOLI	Fecal Contamination
FDOM	Fluorescent Dissolved Organic Matter
NH3	Ammonia Gas
NO3	Nirate+Nitrite
OIL	Refined Hydrocarbons
PHYCO	Phycobilin Chromophore
RHO	Rhodamine
SIZE	Relative Particle Size
SUVA	Specific UV Absorption
T	Temperature
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TDFe	Total Dissolvable Iron
TOX	Disinfection Byproducts
TSS	Total Suspended Solids
TURB	Turbidity (ATU)
UVA	UV 254 Absorbance
UVT	UV 254 Transmission
VFA	Volatile Fatty Acids

This image shows the basic functioning of the ZAPS LiquID Station and the parameters it can be attuned to measure.

The cost of a ZAPS LiquID station is about $80,000 to $100,000 each. The Station must be configured by ZAPS Technology to be tuned to the parameters you want to measure. Some servicing by ZAPS personnel may also be needed to make adjustments during deployment.

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MoteStack Sensor Connection and Data Transmission/Management Platform
Clemson University

Summary: Real-time in situ measurements and data transmission known as the Intelligent River® enables fine grained, long lived, low cost, in situ monitoring at the landscape scale and supports meaningful analyses of data. Clemson University's MoteStack is a technology platform for connecting in situ sensors to create a data network over a large geographic area. It includes telemetry platforms, wireless transmission technology, data processing and storage systems, visualization and analytics tools, and presentation tools. MoteStack supports most sensor interface standards, with communication options including Bluetooth Low Energy, Wi-Fi, 900MHz and 400MHz XBee, GSM/GPRS cellular, and most types of sensors, even in extreme environments. The resulting sensing is connected to a cloud based data management system for data aggregation and interoperability across data sources.

MoteStack is a "highly configurable" data storage and transmission platform for connecting various air and water sensors to create a broader environmental data network. Clemson is working with an interdisciplinary team of experts using MoteStack for the Intelligent River®, the Intelligent Forest, the Intelligent City, and the Intelligent Farm.

Gene Eidson and Jason Hallstrom of Clemson University explain the MoteStack.

MoteStack is the cyber/communications backbone for their sensor systems. Using this sensor and communications system, Clemson built models to show what flows into a river or farm and to find the root causes of what affects environmental conditions there. MoteStack connects the sensors and data transmission and management so researchers can better see what factors affect water quality and so environmental issues can be better understood.

Clemson found that commercial instruments were expensive and battery life was shorter than they wanted, allowing them to deploy sensors for only 15 to 20 days at a time. To meet their needs, they customized the hardware and software to provide low-cost, customizable connections. Each board layer in the stack has a different function for communication or connections to sensors allowing the user to use different board layers to get the needed service. Sensors are attached to sensor board layers. For example, 26 attached devices that measure 26 different parameters can be used. Different types of boards could be used for sensors with different connection protocol requirements (SDI12, onewire, etc.). Other boards, or layers, can be added to the stack to handle different communication technologies (wifi, Bluetooth, cellular, satellite, etc.). There are also data storage layers.

Jason Hallstrom shows how the different layers of the MoteStack fit together.

Clemson has installed a wireless data communication infrastructure designed to interface directly with the MoteStack. With this infrastructure, one can transmit data from the field environment through an internet connection. There is no need for a separate wifi or satellite connection for each MoteStack and connected sensors. Instead, the MoteStack connects wirelessly with cellular chip sets, which establish cellular internet connections to their cloud infrastructure. In another network, a mobile hop wireless mesh network, the signal jumps from the MoteStack to a base station then to another device or series of devices until it reaches their internet uplink. The mesh network is more "tolerant" of differing conditions, so that if one device is overloaded or goes down, the signal will jump to a different device in the network.

The MoteStack collects and sends the sensor information to a higher lever network that integrates the information into a broader scale image of the study area. The data can be sent to an interactive web portal to display the data. Researchers can use the data to predict what the environment will look like in five, ten, or fifteen years.

Clemson received about $6 M from Federal and state sources to support the technology development and demonstration. An associated grant from the National Science Foundation brought total development and demonstration expenses to about $14 M. Everything is designed to be low cost, however, so deploying a similar network would not include these development costs. MoteStack layers cost about $80 to $160 each depending on how they are configured (one telemetry point). The mesh network devices are also designed to be low cost. The sensors would be a separate cost. Clemson would configure the stacks in the lab, test them, then ship them. A deployment team sets up the devices in the field.

MoteStack can handle data from inexpensive or sophisticated sensors—the user can decide what costs and accuracy of sensors are needed for their application. All the metadata about the sensor will be captured by the MoteStack technology so it can be matched with the observation data.

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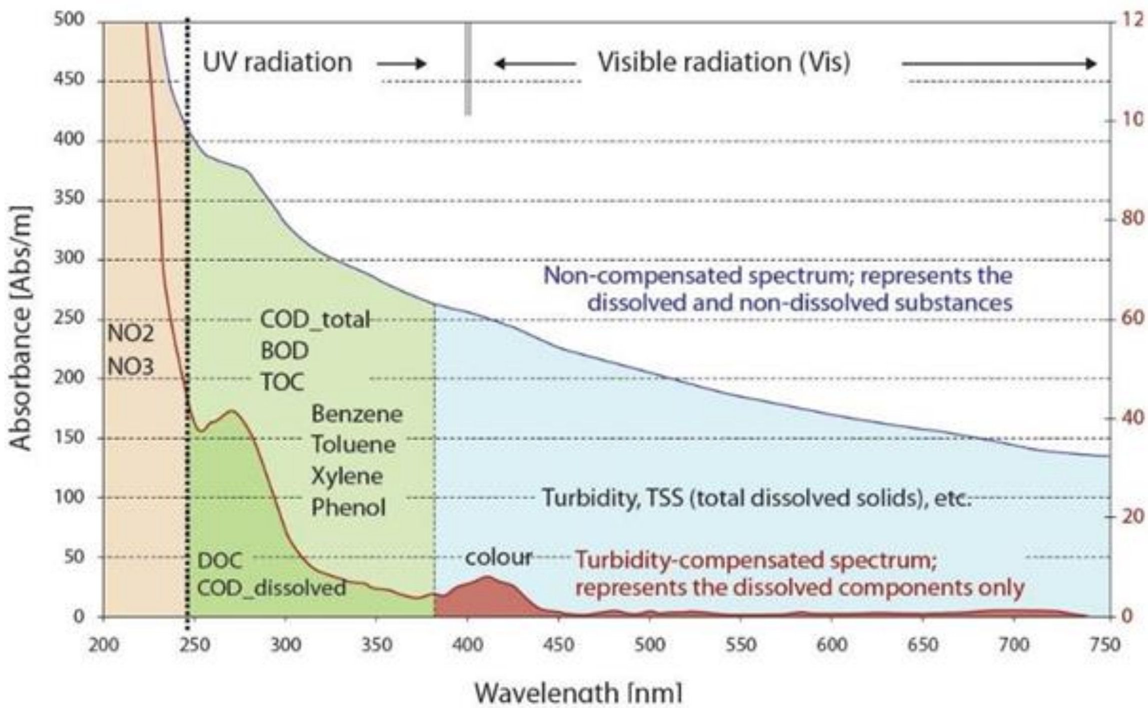
Submersible UV-Vis Spectro::lyser by S::CAN

Summary: The S::CAN Spectro::lyser is a submersible UV-Vis spectrometer probe that can be deployed for extended periods (limits are battery life and biofouling). It runs on AC or battery power. It can be programmed to scan every few seconds to minutes and can scan for equivalent concentrations of multiple pollutants, depending on pathway, calibration selected and source water characteristics.

The S::CAN submersible UV-Vis Spectro::lyser probe operates *in situ* as a spectrometer by shining UV and visible light through the sample water as it flows over the submersible probe. The different wavelengths of light allow for the detection of different pollutants.

The Spectro::lyser probe



The S::CAN UV-Vis Spectro::lyser is being tested by EPA in two Regions for in-stream monitoring. The probes can test for multiple pollutants simultaneously. The probes can test for TSS, turbidity, NO3-N, COD, BOD, TOC, DOC, UV254, color, BTX, O3, H2S, AOC, temperature and pressure. The pollutants being monitored by the Regions are nitrate (NO3-N), TOC, DOC, temperature, and turbidity (NTU/FTU), in one probe. The regions are testing the accuracy of the spectrometer by comparing the readings with other known equipment and grab samples that are analyzed in the lab.

Spectro::lyser is purchased with a specific calibration algorithm for your scenario, with local multi-point calibration possible. It is intended to operate on AC power but can be adapted to operate on battery power. EPA Regions are running the probe on upgraded long-life batteries in a waterproof case that allows *in situ* monitoring every 15 minutes for a week. Data can be stored on-site and later transferred to a computer (as the Regions are doing) or, with additional software and equipment, transmitted electronically via cell connection. Some challenges in deployment included finding a secure location with ease of access for maintenance. The Regions are also evaluating the short and long term durability of the Spectro::lyser. It can become contaminated by sediments and biofouling and will need to be cleaned. Storm events during in-stream monitoring can lead to increased sediment contamination.

Batteries and S::CAN electronics in waterproof case with marine grade connectors.

Probe contaminated by sediments and biofouling.

The cost of one probe, calibration, and software is approximately $23,000 and an additional $325 to upgrade the batteries and enclose in a waterproof case.

Regional staff are handling the deployment. The Regions are working on a method to translate the data to be analyzed and graphed to provide near real-time information on stream conditions.

More information:
http://www.s-can.at/text.php?kat=5&id=21&langcode.

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QR code for Next Generation Compliance website.

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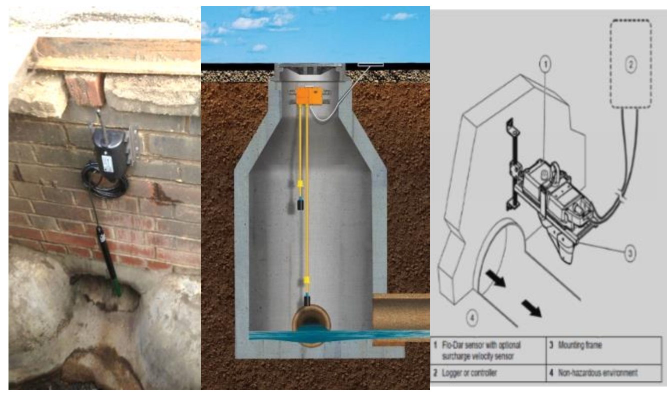
Flow Sensors Connected to Communications Can Improve Operations, Notify the Public to Lower Exposure, Build Public Support for Infrastructure



Summary: Current technologies allow a facility to remotely identify when it is having a discharge, such as for Combined Sewer Overflow (CSO) and illicit Sanitary Sewer Overflow (SSO) outfalls, chronic sewage overflow points such as manholes, and stormwater outfalls. Sensors that detect overflows can be connected to information communication technology that transmits information to facility operators, local and state officials, public websites and cell phones at about $4,000 per installation (including telemetry capabilities). Real-time notices help facilities improve their operations, and transparency motivates facilities to improve their performance. Combine with public notification to ensure that residents know about CSO occurrences and CSO impacts to meet one of the nine minimum controls and allow the public to lower their exposure to waterbodies contaminated with untreated sewage. Improved public information about overflows also helps build long-term support for infrastructure improvements to eliminate overflows.

Sensors that detect overflows and provide real-time notices help facilities understand and improve their operations while transparency provides the motivation to do so. Telling members of the public avoid contact with contaminated water will improve human health. This is easily done by using advanced monitoring sensors to detect when a CSO or SSO is occurring. Many municipalities are already using these technologies. Connecting flow sensors to communication technology allows it to transmit this information so facility operators can monitor overflows from a central location, send information to public officials or oversight agencies, post it to a public website, and transmit it to citizens who sign up to receive the information via email or cell phone.

This red light on the bank of the Potomac indicates a CSO is occurring.

One of the first examples is from **Washington, DC**: DC Water installed two CSO Event Indicator Lights to notify river users of CSO events. A red light is illuminated during a CSO occurrence and a yellow light is illuminated for 24 hours after the CSO has stopped.

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A 2013 **New York State** law requires that "no later than four hours from discovery of the discharge, the [POTW] shall notify the local health department ... [and] the general public ... through appropriate electronic media, including, but not limited to, electronic mail or voice communication as determined by the department." Recent CSOs are also posted online. The law protects human health by allowing citizens to make smart swimming and fishing decisions, prompt pollution reductions through the power of transparency, and raise public awareness and support for water infrastructure funding.

Illinois requires **Chicago** to provide text message or email alerts of sewer overflows to interested members of the public as a special condition to the City's NPDES permit. The public can receive e-mail notification of CSO events. On-line maps of CSOs are updated as information becomes available and certified the following day. The website provides a 7-day record of CSO/floodwater discharge events.

Washington State requires **Seattle** to implement web-based public notification system to inform the citizens of when and where combined sewer overflows occur.

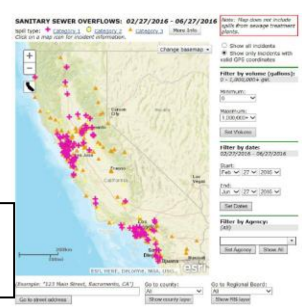
Milwaukee, WI has a robust monitoring network that shows rainfall and CSO status throughout system at a central location, updates automatically every 3-5 minutes, and transmits this data to public website. They use green infrastructure, managed automatically, to lower stormwater quantity and CSOs.

Connecticut, Vermont, New York (requires Google Earth software), and **California** post reports or maps online of sewer overflows.

Harrisburg, PA is evaluating flow activation technologies to send an alert each time a monitored CSO outfall begins discharging.

For more information:
Washington, DC: http://www2.epa.gov/enforcement/consent-decree-washington-suburban-sanitary-commission-clean-water-settlement
New York State: http://www.dec.ny.gov/chemical/90315.html
Connecticut: http://www.ct.gov/deep/cwp/view.asp?a=2719&q=525758&deepNav_GID=1654
Vermont: https://anrweb.vt.gov/DEC/WWInventory/SewageOverflows.aspx
California: http://www.waterboards.ca.gov/water_issues/programs/sso/sso_map/sso_pub.shtml
Chicago: http://www.mwrd.org/irj/portal/anonymous/overview Map page:
http://www.mwrd.org/irj/portal/anonymous?NavigationTarget=navurl://eec9b2f677d42e0dea742ba5e2b45713
Milwaukee: http://www.mmsd.com/weather/weather-center

Flow meter with communication technology.



California online SSO map with interactive web tools.

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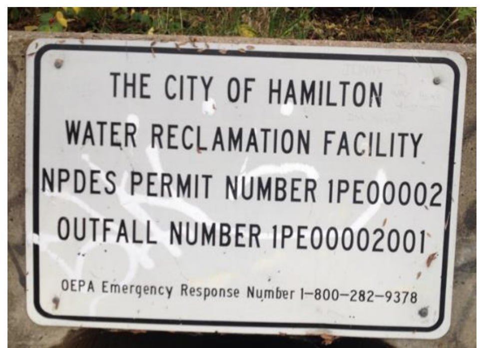
Use Transparency and Citizen Reporting to Improve Waterways

Summary: Transparency allows regulators and the public to have more information about the environmental performance of regulated entities. Most facilities want to be good neighbors and will be inspired to improve performance when they know that others are watching them. Transparency can take several forms, from the regulatory agency posting information on facility performance online to requiring the facility to post information online or on signs at the facility itself. Citizen reports of observations can also help regulatory agencies identify violations and the status of waterbodies.

Require facilities to be transparent: New York and Ohio require signs to be posted at NPDES outfalls. Ohio requirements are to post a sign at each permitted outfall accessible to the public by land or water, including discharges of process wastewater, non-contact cooling water, sewage or discharges from remediation sites, and bypass or combined sewer overflow discharges. The sign is required to include the name of the permittee, the permit number, and the outfall number identified in the permit. The sign must be a minimum of two feet by two feet with the bottom of the sign at least three feet above the ground, printed in letters not less than two inches high. The University of Virginia is examining the impact of this requirement on effluent discharges in Ohio. Preliminary findings are that both violations and pollutant levels for conventional water pollutants fell after the signage requirement went into effect.



Outfall sign in Ohio.

New York State requires SPDES permittees to post a legible sign at all wastewater outfalls including the SPDES permit number and contact information for the permittee and NY DEC regional office.

Consider requiring a QR (quick response) code on signs posted at permitted outfalls. Citizens can read the code with a smartphone—this can take them to a website with regulatory or permit requirements and how to report a violation. QR codes can be generated for free online and the QR code reader is a free app.

QR code for Next Generation Compliance website.

Post permits and violations: NY posts online State Pollutant Discharge Elimination System (SPDES) Individual and Multi-Sector General (MSGP)

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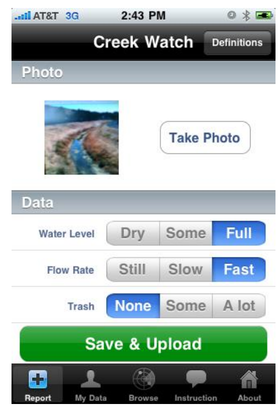
Permits and other facility documents organized geographically according to the DEC Regions. See https://www.dropbox.com/sh/hz3spt98h4d88ue/AADmNLcYxcpZQFeWUNAxGMi9a?dl=0.

Vermont reports unpermitted discharges online at http://dec.vermont.gov/watershed/wastewater/discharge-notifications.

Allow citizens to report problems: Alabama's online electronic compliance system allows the public to electronically submit detailed information, including pictures, have the complaints quickly routed, and see what actions have been taken. See http://app.adem.alabama.gov/complaints/submission.aspx.

Arkansas has a mobile app that allows users to report environmental hazards in real time and provide feedback directly to state inspectors, such as location, driving directions, and GPS-tagged photos. The app is available from app stores or at https://www.adeq.state.ar.us/home/about/website/apps.aspx. People in areas without cell service can save a complaint and submit it when they regain cell service. If users provide contact information, ADEQ sends a confirmation email. Inspectors follow up on all complaints, which also can be submitted online at www.adeq.state.ar.us, in person, or by calling 501-682-0744.

The California Water Quality Control Board partnered with IBM to create the California Creek Watch smartphone app. It allows iPhone users to help monitor water quality and alert authorities to problems. It enables citizens to send a picture and report on water levels, flow, and trash seen. The data is sent to Water Control Boards to help track pollution and manage water resources.



More information:
Arkansas mobile app presentation: http://www.exchangenetwork.net/EN2015_files/2_1205.pdf.
California Creek Watch video: http://www.waterboards.ca.gov/videos/video_pages/creekwatch.shtml.
A Picture Saves 1,000 Streams – Water Quality Monitoring on Your Smartphone: http://scistarter.com/blog/2013/09/picture-saves-thousand-streams-water-quality-monitoring-smartphone/
New York State public notification of discharges law: https://govt.westlaw.com/nycrr/Document/I4ed9a055cd1711dda432a117e6e0f345?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default)
Ohio permit requirements to post signs at outfalls: Generic Permit Conditions at http://codes.ohio.gov/oac/3745-33-08v1, A 12.

Next Generation Compliance

https://www.epa.gov/compliance/next-generation-compliance

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ACWA Water Monitoring Fact Sheet

ACWA Annual Meeting – August 15-17, 2016

1. Clean Water Act (CWA) Monitoring Objectives

Monitoring is a core water program. Congress recognized monitoring as the foundation for CWA implementation by making it and enforcement authority as the two eligibility requirements for states receiving 106 grants.

CWA Monitoring Objectives include:

- Establishing, reviewing, and revising water quality standards (Section 303(c)).
- Reporting on the extent of waters that support the goals of the Act, and determining water quality standards attainment (Section 305(b), 314, 205).
- Identifying impaired waters (Section 303(d)).
- Identifying causes and sources of water quality impairments (Sections 303(d), 305(b), 319, 205, 604).
- Supporting the implementation of water management programs
    - Water quality based permits reflecting receiving water characteristics and assimilative capacity (Section 402).
    - TMDL models using ambient data to develop and validate load estimates (Section 303(d))
    - Watershed Plans, including source water protection plans
- Supporting the evaluation of program effectiveness (Sections 303, 305, 402, 314, 319, etc.).

Additional Monitoring Objectives include:

- BMP effectiveness monitoring
- Emergency response needs baseline data, quick response hazard assessment, and long- term impact assessment (e.g., BP spill, TVA coal ash, Hurricane Sandy, Harmful Algal Bloom response)
- Determining whether permittees and others are complying with standards

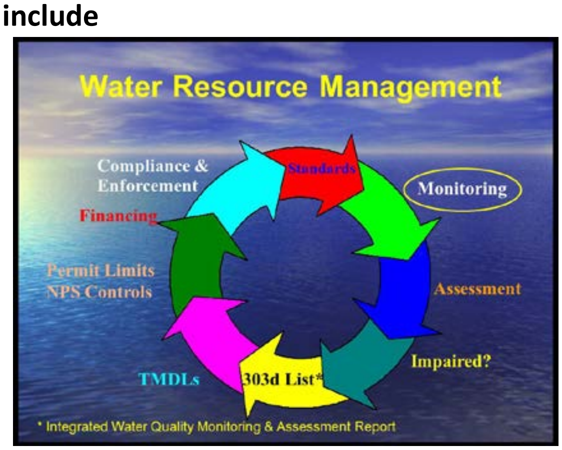
2. Key Questions Answered by Monitoring

- A State monitoring program that meets CWA objectives should be able to answer the questions below for the different water types (e.g., rivers, lakes, estuaries) and water uses (e.g., recreational, aquatic life). Monitoring designs may vary to answer different questions, or to assess various types of criteria.

- What is the overall quality of waters in the State?
- To what extent is water quality changing over time?
- What are the problem areas and areas needing protection?
- What protection level is needed and how do we achieve through point and nonpoint controls?
- What are the most effective monitoring and assessment indicators to track progress?
- How effective are permits, projects, and programs at protecting and restoring water quality?

3. Programs and Functions Which Depend on Monitoring, include

- Assessment & Listing - CWA 303(d) and 305(b)
- Water Quality Standards
- NPDES Permits
- TMDLs and Modeling
- Watershed Protection/Restoration
- BMP Effectiveness
- Source Water Protection
- Fish and Shellfish Consumption Advisories
- Compliance & Enforcement
- Emergency Response



4. State Long-term Water Monitoring Strategies

All states develop and maintain a monitoring strategy that describes how monitoring objectives are or would be met, and the resources needed for implementation (*Elements of a State Monitoring and Reporting Program, EPA, 2003).* For each water type, these plans include: objectives, designs, indicators, quality assurance, data management, analysis and assessment, reporting, resources and infrastructure, and programmatic evaluation.

The State strategies identify monitoring gaps, help States set monitoring priorities, and guide program enhancement funding from the 106 Monitoring Initiative Grant. Examples of funded enhancements include new State lab capacities, fish tissue monitoring, data management, new biological monitoring protocols and index development. Some states have used the strategies, and the identification of monitoring gaps, to secure additional monitoring funding through State legislative mandates.

5. Potential Funding Sources for State monitoring programs include:

- CWA 106 base grant – Water Pollution Control Programs
- CWA 319 grant – Non–point source program
- CWA 604 grant – Water Quality Management Planning
- BEACH grant
- CWA 106 Monitoring Initiative – For monitoring gaps/enhancements
- State General Funds
- State Permitting Fees
- State Dedicated Funds (e.g., Watershed, Water Monitoring)
- Leverage Partner Resources - government (federal, interstate, local), private, nonprofit & volunteer

6. Water Monitoring Councils Assist with Monitoring Challenges

- Through communication, collaboration & coordination, Councils improve water quality through development of partnerships, sharing data and promoting the efficient use of resources
- The National Water Quality Monitoring Council (NWQMC), co-chaired by EPA and USGS, includes 10 state representatives and > 40 members from many types of organizations
- Water resource management in 18 States/Regions is benefitting from the partnerships and data exchange developed through their Water Monitoring Councils
- State Water Monitoring Councils include: CA, CO, FL, IN, MD, MI, NJ, ND, OH, OK, UT, VA, WI

7. Advanced Water Monitoring Methods

Categories include:

- Sensor monitoring – continuous, real-time, and/or using probes for newer parameters like nutrients, pathogen indicators, or cyanobacterial pigment (phycocyanin)
- Remote sensing - both satellite and fly-over
- Unmanned aerial vehicles (e.g. drones) and unmanned underwater vehicles (e.g., gliders)
- Faster analyses for acute exposure parameters (e.g., pathogen indicators, algal toxins)

CWA Program Applications (now or potential) include:

- Assessing Water Quality Standards (WQS) and recreational use
- Reasonable potential analyses and background concentrations for NPDES
- Reduced pollution through improved compliance assurance
- Real time or close to real time public transparency on water quality and compliance

Challenges and Progress include:

- Equipment and operational costs, and availability of technical expertise
- Data storage, management and sharing
- Interpretation in context of WQS and discharge limits
- New sensor quality for approved regulatory and non-regulatory applications