CleanWaterWorks

A Technical Journal of the Northeast Ohio Regional Sewer District

Volume 1 / 2024 edition

A Day at the Beaches

Testing water quality and safety along Cleveland's North Shore

Northeast Ohio Regional Sewer District

FROM THE MANAGER OF

Analytical Services

You are reading an updated version of the very first issue of *Clean Water Works*, published back in 2013 by the Northeast Ohio Regional Sewer District. Quite a bit has changed since then, including *Clean Water Works* itself, which now is produced as a podcast, encompassing the subjects explored in the print magazine and many other interesting topics as well.

A lot has changed in Analytical Services, too, and we've made some changes to the original articles to reflect the new methodologies, equipment, and friendly faces in our laboratory.

But unchanged is our pledge to continually improve our processes and analytical techniques to ensure we produce data of the highest quality. This issue of *Clean Water Works* focuses on the Sewer District's dedication to Cleveland's beaches and our steadfast commitment to preserving the environment and public health in Northeast Ohio.

Lake Erie is the most valuable asset to Northeast Ohio, and access to this natural resource is a large part of what makes us unique. Our regional economy is tied to Lake Erie, the lakefront, and the entire Lake Erie watershed. We all have a role in keeping our Great Lake great.

I am incredibly proud of our environmental leadership and the technical expertise of our staff. Without fail, and with quality as our cornerstone, our knowledgeable team collects and tests water samples every day throughout the beach season, and our substantial investment in this area demonstrates our purpose in protecting our waterways.

We hope you enjoy revisiting these topics in this *Clean Water Works* update.

A certified State of Ohio Class IV Wastewater Analyst, Cheryl Soltis-Muth has served as Manager of the Sewer District's Analytical Services department since 2018, having previously served as Supervising Chemist since 2003. Prior to coming to the Sewer District, Soltis-Muth worked in environmental laboratories in a variety of roles, from chemist to lab manager. She graduated summa cum laude *from Baldwin-Wallace University with a degree in Chemistry.*

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The Sewer District maintains a rigorous schedule for testing the water quality at Cleveland's beaches. Testing methods are getting quicker and better—much to beachgoers' benefit.

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Our Mission

Provide progressive regional management of sewage and stormwater that protects the environment and serves our community.

Our Vision

Be the environmental leader in enhancing quality of life in the region and protecting its water resources.

ON THE COVER: A view from the beach at Cleveland's Edgewater Park. Photo by Nicole Harvel.

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IN MEMORIAM

*Watersheds Manager **Lester Stumpe** worked at the Northeast Ohio Regional Sewer District for nearly three decades, dedicating his professional life to the restoration of urban watersheds. Beginning in 2003, Lester took an active role in beach monitoring—including watching the weather forecasts and monitoring current, wind, and wave data on a daily basis—and made the development of a predictive model a priority for the Sewer District. Lester passed away in 2010.*

by Eric Soehnlen

Testing the waters

Beach sampling and lab work help track water quality

When you think of Cleveland's beaches, do you think of the Northeast Ohio Regional Sewer District? If you don't, consider this: the Sewer District is now celebrating over 30 years of testing the waters at our local beaches.

We began conducting bacteriological monitoring at Lake Erie beaches in 1992, collecting daily samples during the recreation season at Edgewater Park, Euclid Beach, and Villa Angela. In 2005, sampling began at Euclid Creek, an urban stream which discharges to Lake Erie on the east side of Villa Angela Beach, to monitor the Creek's impact on water quality at the beach.

The Sewer District continues to administer one of the most rigorous beach-sampling programs in Ohio, and over the last three decades our beach program has continued to evolve. New technologies have been adopted to rapidly assess water quality and provide information to beach visitors here in Greater Cleveland. We perform this work to ensure that the public has advanced warning if water-quality conditions are not good for recreation.

The Sewer District works with several partners to ensure that the results of our beach-monitoring program are made rapidly available to the public. In 2008, we began submitting data to the Ohio Department of Health's BeachGuard website. Beyond providing a portal to the public for sampling results, this partnership has had additional benefits. The District has become an annual beneficiary of ODH's beach-monitoring grant program, which provides funds for water-quality monitoring. This has lessened the financial burden on our ratepayers for this work.

The Sewer District also partners with the United States Geological Survey, which publishes our sampling results on the Great Lakes NowCast Status website. (Those results can also be found on the Sewer District's website.) We also partner with Cleveland Metroparks, iHeart Radio, and News 5 Cleveland to ensure that the public has several outlets to keep tabs on water quality at our beaches.

Of the 85 Lake Erie beaches that are monitored through the ODH BeachGuard program, our three local beaches (along with the westside Huntington Beach, which lies outside the Sewer District's service area) are the most-surveyed, with an average of 110 sampling surveys conducted at each beach annually to provide results to the public every day from Memorial Day through Labor Day. This is in addition to samples collected outside of beach season to improve our water-quality predictive models. This makes our program one of the most rigorous in Ohio.

Environmental Compliance Inspector Jeff Harrison collects a water sample at Villa Angela Beach on the east side of Cleveland.

Did you ever wonder how scientists determine if the water is safe for recreation? The Sewer District uses standards set by the United States and Ohio Environmental Protection Agencies (U.S. EPA and OEPA) to determine if the waters at our beaches are safe for swimming. These standards require testing for fecal indicator bacteria (FIB) and harmful algal blooms (HAB).

Well-established tests exist for FIB to assess whether or not water is safe for swimming. High levels of bacteria indicate that harmful pathogens could be present in the water. *Escherichia coli* is the most commonly-used FIB for water-quality monitoring, but this method has its downside: the laboratory test for *E. coli* requires 18 to 24 hours to complete. Rather than waiting a whole day for results to advise the public if it is safe to swim, the Sewer District performs advanced mathematical modeling using VirtualBeach software developed by U.S. EPA to make daily predictions of how much *E. coli* is present in the water. We use data collected during our surveys along with historical *E. coli* data to make a water-quality forecast, similar to a weather forecast! These predictions are accurate over 80% of the time, and we are working to improve our predictive models to provide our communities with the most accurate water-quality information.

Harmful algal blooms are toxin-producing cyanobacteria that can photosynthesize like plants, and HABs have become a major environmental issue on Lake Erie. Over the past several decades, increased nutrient inputs in the

Field Biologist Eric Soehnlen demonstrates a data sonde used to take the field parameters. "These are essentially little arrays of portable laboratory instruments that we can take in the field to measure oxygen, conductivity, pH, temperature, and harmful algal bloom pigment concentrations."

lake have led to excessive HAB growth. This can result in elevated toxin concentrations in beach water and drinking-water sources, which can be harmful to people and animals. The Sewer District has invested in advanced equipment to monitor HABs in the field and test for HAB toxins in our laboratory.

Water samples from the beaches are analyzed daily using a YSI Total Algae Sensor, which can detect HAB species in real time. These sensors are deployed as long-term remote monitoring stations that allow our scientists to check the water quality from a cell phone app. The sensors can also be taken around to investigate any area of a beach that is showing signs of a potential HAB. If our field scientists identify a potential HAB with these sensors, additional water-quality samples are collected and brought to our Analytical Services laboratory, where an Enzyme Linked Immunosorbent Assay (ELISA) test for HAB toxins is performed.

These technologies allow the Sewer District to rapidly provide information to Cleveland Metroparks beach managers so that the public can be notified of poor water-quality conditions.

We are very proud of the Sewer District's beach-monitoring program. It is our great pleasure and privilege to serve our member communities, and working together we are able to provide the public with up-to-date and accurate water-quality information. We hope you will visit one of our beaches and feel confident the Sewer District is working to keep you safe and healthy. ◆

Eric Soehnlen, PhD is a Field Biologist with the Northeast Ohio Regional Sewer District.

Clean Water Works

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From the Northeast Ohio Regional Sewer District, an in-depth and fun conversation led by Mike Uva and Donna Friedman on any and all topics related to clean water, wastewater treatment, stormwater management, and the people, projects, and programs serving Lake Erie and our local waterways and communities.

Clean Water Works

Northeast Ohio Regional Sewer District

Q&A

Brian Zimmerman

CEO, Cleveland Metroparks

In 2013, the State of Ohio transferred control of Cleveland's lakefront parks to Cleveland Metroparks. But your organization wasn't new to beach management.

Cleveland Metroparks had long-standing beach management experience with Huntington Reservation [in Bay Village, Ohio] and the challenges with rainfall producing poor water quality along Porter Creek. In 2011, Huntington Beach earned its Blue Wave Certification, a national environmental certification for clean beaches, which sets the bar very high in terms of accountability, signage, beach nutrition, and all the components that provide a high-quality beach experience.

Do Cleveland's beaches present unique challenges?

The true challenge is changing the culture so people come down and use Lake Erie, one of Northeast Ohio's greatest assets. We're working on water quality and amenities and getting the beach clean. All of those have end solutions, but we have to make sure the public knows that we have welcoming assets on our lakefront. Our core focus now is getting the beaches clean and safe, while considering the right programming and special events that will bring people to the lakefront.

The Northeast Ohio Regional Sewer District purchased beach cleaning machines for the lakefronts. Can you talk about the Metroparks's partnership with the Sewer District?

In Milwaukee, I learned the value of partnering with a regional sewer agency. With the transfer of the lakefront parks to Cleveland Metroparks, we really wanted to show the public what our standard of care was by partnering with the Sewer District to address problems at our beaches. Certainly, the District's handling of upstream pollution before it even gets to Lake Erie is extremely important. And the beach cleaners are important for the overall quality and visitor experience. The equipment runs almost every day at Euclid Beach and Edgewater Park.

What the Sewer District brings to the table is vital to the overall health of our water quality in Northeast Ohio. It's a really nice partnership to move things forward for the community.

Brian Zimmerman is the Executive Director of Cleveland Metroparks.

by Cheryl Soltis-Muth

A day at the beaches

Monitoring water quality at Cleveland's lakefront parks

By now, the way the Northeast Ohio Regional Sewer District monitors the beaches is considered a Standard Operating Procedure.

We can generally discuss the procedure in two phases—*sampling* and *analysis*. The Sewer District samples and tests for *E. coli,* since it has been identified as one of the best indicator organisms at freshwater beaches and its presence has been correlated to other pathogenic microorganisms that can all cause illness. The data obtained from this sampling and analysis is reported to the Ohio Department of Health (ODH) and used for public notification of water quality advisories.

The driving force in both sampling and analysis is quality. District personnel strive to provide the highest quality beach data. From the moment the sample is collected to when data is reported, many quality control measures are in place.

SAMPLING SAFELY

During the "recreation season" (typically Memorial Day to Labor Day), the Sewer District samples and tests seven days a week to monitor Lake Erie water quality at the Edgewater, Euclid, and Villa Angela beaches, for communicating beach conditions to the public and evaluating water-quality standards attainment. Outside of the recreation season, we continue to monitor these beaches, but on a limited schedule: four days a week (Monday through Thursday) from May 1 through Memorial Day and from Labor Day through September 30.

The Sewer District has several Level 3 Qualified Data Collectors, Level 3 being the highest achievable level. This certification is given by the Ohio EPA, which oversees all sampling activities.

GPS and landmarks are used to guide our team in obtaining samples from clearly-defined locations at each of the beaches.

Sterilized 250-mL polypropylene containers are used for sampling. Additionally, as a quality control measure,

From Memorial Day to Labor Day, the Sewer District collects and analyzes samples daily to monitor water quality at Lake Erie beaches and assist other local organizations like the Cuyahoga County Board of Health with public notification.

bacteriological field duplicate samples are collected from a randomly chosen site at a frequency of not less than 5% of the total samples collected each day. All samples are collected as grab samples in a spot where the total depth of water is approximately three feet. Samples are collected approximately six to twelve inches below the water surface.

If weather conditions prevent the sampler from safely wading out to a depth of three feet, a sampling pole is used. If weather conditions do not permit the use of a sampling pole, no samples are collected that day.

Field parameters measured during sampling include pH, water temperature, conductivity, and turbidity. Conductivity, pH, and temperature are measured directly in the lake using the Hanna HI 98129 direct measurement probe or an equivalent model. At each site, a 500-mL plastic bottle is filled and analyzed for turbidity using a Hach 2100Q or 2100P portable field turbidity meter. This measurement yields information about the clarity of the water.

A field assessment of the beach is conducted as well. Observations such as number of swimmers and birds, wave height, average and maximum wind speed, wind direction, color, clarity, odor, and surface coating of the water, lake surface conditions, and weather conditions are recorded on a Beach Sampling Field Data Form. These observations are factors that influence beach water quality and are used by the Sewer District in models used to predict water quality at these beaches. Pictures are also taken during each sampling event to document the conditions at each of the beaches.

Additional guidelines for sampling include:

- Ensuring sampling bottles are sterile with custody seals intact
- Ensuring all proper sampling and safety equipment are present and in good working order
- Using proper sampling techniques:
    - Not touching inside of bottles or caps as this may contaminate the sample

Lab Analyst Matt Lauren prepares a water sample using an auto pipettor. Auto pipettors are designed to deliver very small volumes of liquid and are checked for proper operation daily.

- Not sampling too close to the shoreline as this may cause elevated bacteria counts
- Not sampling near sediment, bird feces, trash, or other floating debris
- Avoiding disturbing and kicking up bottom material at the sampling location

Samples are collected, labeled, and immediately placed on ice inside of a sample cooler. The cooler is stored inside the field truck, which always remains locked when not occupied or visible, to ensure integrity and security of the samples. Sampling activities, including the sample time and condition of surface water sampled, are entered in a logbook and on the Beach Sampling Field Data Form. A Chain of Custody form is also filled out, with collection times of each sample noted. The samples are delivered immediately to Analytical Services where custody is transferred.

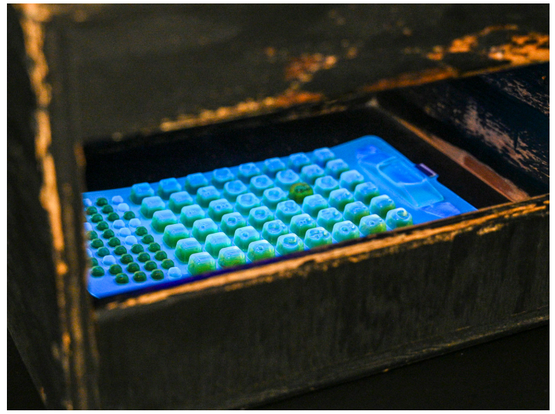
ANALYSIS AND ACCURACY

When it comes to bacteriological analysis, cleanliness and quality are key. The Sewer District's Analytical Services Quality Assurance Manual and associated Standard Operating Procedures (SOPs) are on file with Ohio EPA. The Quality Assurance team at the Sewer District sends updates, revisions, and any information on document control to Ohio EPA as needed.

To collect samples that are free of any contamination and to perform analyses that are accurate, the NEORSD staff needs to have bottles, equipment, and reagents that are free from any kind of bacteria. Using an autoclave, a piece of equipment that uses high temperatures and high pressure to completely sterilize all equipment and reagents, the staff can ensure that all are contaminant-free.

For autoclaving, the Analytical Services staff has in place SOPs that are required by the National Environmental Laboratory Accrediting Program, through which Analytical Services is accredited. These SOPs ensure that the sample containers, equipment, and solutions are sterile and usable. If a sterility check comes back positive, all equipment must be re-sterilized.

Supervisor of Sample Control Leslie Vankuren receives a sample in the drop-off zone at EMSC. Beach samples are placed on ice and placed in a cooler after collection to slow bacterial growth in order to get an accurate bacteria result.



After 24 hours in an incubator, the water sample Matt was working with is viewed under a UV light to measure E. coli *levels.*

When determining the number of microbes in a sample, the sample must be "pure" and all equipment must be sterile. Working in the real world, keeping things sterile is difficult, as microorganisms abound around us. To protect sterile equipment, reagents, and pure cultures needed to perform the analysis of *E. coli,* the lab staff practices *aseptic technique*. This simply means that sterile surfaces or sterile media must be protected from contamination from microbes present in the laboratory environment. With aseptic technique, only sterile surfaces touch other sterile surfaces, and exposure to the air is kept to a minimum.

Analytical Services performs Colilert® Quanti-Tray testing exclusively on all beach samples. This method utilizes a special reagent that is added to the sample, then the sample is poured into a tray with wells and sealed, incubated for either 18 or 24 hours (depending on the type of reagent added), and placed under a black light to see which, if any, wells fluoresce. The fluorescence and color of the wells is then compared to a table, and the concentration of *E. coli* is determined. Analytical Services staff uses Quanti-Tray following Method 9223B in *Standard Methods for the Examination of Water and Wastewater*.

To ensure the most accurate data, many quality control (QC) procedures are practiced. The QC for *E. coli* analysis includes:

- *Demonstration of capability* (DOC) is performed by all analysts performing Colilert® and each analyst must pass the DOC before analyzing samples.
- *Aseptic technique* is used to ensure sterility throughout the process.
- Batch *quality control samples* (QCS) are performed.
  - Method blanks confirm the effectiveness of sterilization and that analyses are free from contamination.
  - Laboratory control standards (sterile water inoculated with a colony of *E. coli* pure culture) confirms test-reagent efficacy.
  - Duplicate analyses confirm precision of the method.
- Documentation
  - Logbooks and Forms are used to ensure traceability and data integrity. These include:
    - Equipment calibration verification (balances, pH meters, desiccators, autoclaves)
    - Equipment and reagent validation (pure cul-

Bottles of environmental samples await analysis for nutrients. In high levels, nutrients (most notably nitrogen and phosphorus) are major contributors that fuel algal blooms in Lake Erie.

ture tracking; Colilert® reagent, bottle, tray, and serological pipette sterility)

- Data collection (Laboratory Information Management System (LIMS) batch worklist and data report, data validation and QC checklist, analysis logs)

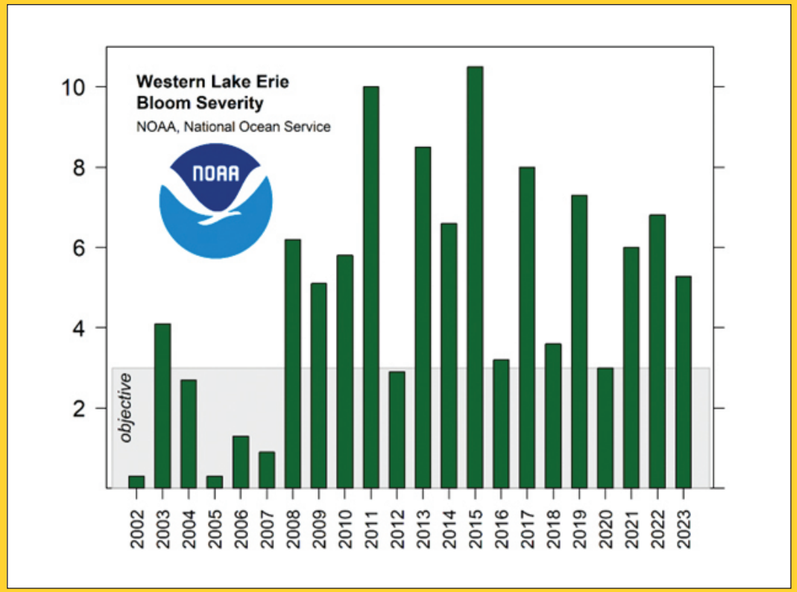
o Data review that includes at least two rounds of data verification from the analyst and supervisor.

- Participation in performance evaluation (PE) studies relating to surface (beach) waters at least twice per year in which blind samples containing *E. coli* are analyzed to demonstrate continued proficiency.
- Tray well counting: Each month, all analysts performing Colilert® must count the positive (yellow) and fluorescing wells on the same tray to validate counting procedures. Counts must be within 10% between analysts to be acceptable.
- Environmental conditions testing: Twice a year, evaluation of the laboratory environmental conditions is performed to ensure the area's suitability for *E. coli* testing.

Bacteriological sample results are compared to the State of Ohio water-quality standards to determine whether any exceedances of the applicable water quality criteria have occurred. District staff works with other agencies to communicate to the public beach water-quality conditions at the beaches.

Monday through Friday during the recreation season, Analytical Services prepares a summary report and sends it to the ODH. A second internal report and the field observation sheets are sent to personnel from the Sewer District and the United States Geological Survey (USGS). The internal report contains data from all samples collected and the various parameters analyzed from the previous day.

At the end of each sampling season, a summary report that includes all the data collected during the season is prepared. This report, along with the field observation sheets, laboratory bench sheets, and chain of custody information, is sent to the ODH. Additionally, reports summarizing, interpreting, graphically presenting, and discussing data and any excursions from water quality standards may be prepared by the Sewer District as well. ◆



https://coastalscience.noaa.gov/news/2023-lake-erie-algal-bloom-more-severe-than-predicted-by-seasonal-forecast/

Western Lake Erie Bloom severity index (SI) for 2002-23. The SI is based on the amount of algal biomass over the peak 30 days. The 2023 bloom had a severity of 5.3. A severity below 3 is the goal of the Great Lakes Water Quality Agreement (GLWQA).

The National Oceanic and Atmospheric Administration (NOAA) uses satellites and state-of-the-art sensors as well as predictive modeling to provide early warning and real-time bloom location and density.

About algal blooms

SINCE THE FIRST PUBLICATION of this magazine in 2013, Lake Erie has had annual algal blooms that have threatened the water quality at our local beaches. Consisting of blue-green algae (a.k.a. cyanobacteria, or *microcystins*), the blooms produce toxins that are detrimental to humans and other animals, most notably dogs. They cost big money as they contaminate water, hurt tourism, damage the environment, and kill fish. These "harmful" algal blooms (HABs) threaten not only the recreation on Lake Erie, but the drinking water for approximately 11 million people in the United States and Canada.

These blooms prompted environmental agencies such as the U.S. EPA and Ohio EPA to act. The Sewer District acted as well. Concerned with the threat of HABs and their impact to the water quality and public health of Northeast Ohio, the Sewer District invested in equipment, time, and energy to develop and validate methods to analyze for microcystin toxins in the event of an algal bloom. Because of this investment, our Analytical Services team is in the position to perform analyses when our beach-sampling crews detect blooms, and serve as a resource for other boards of health and park districts when they are faced with algal blooms in their service areas. And, as with bacteria levels, the Sewer District works with other organizations to communicate to the public the presence of these harmful organisms and their impact on beach water quality and public health.

Here at the Sewer District, we take any threat to Northeast Ohio's water quality seriously. We endeavor to protect our clean-water environment by staying up to date with contaminants of emerging concern and enacting ways to analyze for and address them.

—Cheryl Soltis-Muth

by Jennifer Elting

Dirty birds

Lakeside waterfowl are a pretty picture—but they pollute, too

Picture yourself enjoying a relaxing day at the beach. You might imagine kids building sand castles, a couple holding hands as they stroll along the shoreline, or gulls at the water's edge looking for a quick lunch. Unfortunately, those picturesque birds—and the bacteria they leave behind—contribute to high pollution levels at Northeast Ohio's lakefront beaches.

Bird droppings can contain bacteria such as *E. coli* and *enterococci,* both of which cause a variety of human illnesses and are among the top culprits for triggering beach warnings.

Waterfowl waste is just one of many factors that can impact the beaches in a negative way. Others include combined (and sanitary) sewer overflows, treated wastewater effluent, effluent from private sources, fecal pollution from other wildlife, and stormwater runoff. Add in variable factors such as lake currents and weather conditions, and the study of these relationships becomes very complex.

The Northeast Ohio Regional Sewer District has been researching the impact of waterfowl for many years, using new techniques such as spatial sampling at Edgewater Beach on Cleveland's west side and Villa Angela Beach and Euclid Beach on the east side. During the peak of recreation season, the Sewer District samples these beaches daily. (Very few agencies test this often.)

It is critical for Northeast Ohioans to know whether or not it is safe to swim at their favorite local beach. For more than a decade, the Sewer District has partnered with the Cuyahoga County Board of Health and local television station WKYC TV-3 to educate weekend viewers about conditions at all area beaches. Beach reports are also available at **neorsd.org/beaches.** ◆

Jennifer Elting is Senior Manager of Community & Media Relations at the Northeast Ohio Regional Sewer District.

Tracking pollution sources at Cleveland's beaches

VILLA ANGELA BEACH (VAB) AND Euclid Beach (EB) are two adjacent Lake Erie beaches located in a highly urbanized area in Cuyahoga County on Cleveland's east side. As VAB and EB are in close proximity to one another, they exhibit similar water-quality responses to environmental conditions. Both have been listed on the "Repeat Offenders" list of the National Resources Defense Council (NRDC). The list compiles all the beaches that have exceeded the Single Sample Maximum (SSM) standard on more than 25% of the samples collected over consecutive years. Because of this and the inability to create an accurate predictive model, a multi-year research project was started using grant funding available through the Great Lake Restoration Initiative. The purpose of this research was to better understand beach-specific processes governing the movement of pollutants into bathing beach waters of the VAB/EB unit.

The VAB/EB unit has several large breakwalls that run parallel to the shoreline (see photo below). Additionally, there is a large tributary, Euclid Creek, located on the eastern side of the beach unit. The mouth of Euclid Creek is separated from the shore by a breakwall that extends past the beach's bathing area.

Euclid Creek is a highly urbanized creek and receives impacts from stormwater runoff, illicit discharges, and combined sewer overflow (CSO). One of the larger CSO structures is the Euclid Creek Pump Station (ECPS) on Lakeshore Boulevard, approximately one half mile upstream from the mouth of Euclid Creek. Data regarding CSO events occurring at the ECPS is readily available and includes volume and duration. Information regarding CSO occurrences from ECPS (and information on how the flow from Euclid Creek interacts with currents along the shoreline and around the various breakwalls) is critical to understanding processes surrounding the VAB/EB unit. Due to the complexity of these interactions, creating a predictive model for VAB/EB has proven difficult.

The approach taken to develop a predictive model for VAB/EB was to continue collecting data for parameters normally used in predictive models along with data from the NEORSD collection system and rain gauges and operational data from the Sewer District's three wastewater treatment plants.

Additional on-shore data was collected to quantify the fecal matter and debris present on the beach sand, wave action, sand erosion, re-suspension of sediments, and flow interactions along the shore. Off-shore data collection included mapping the flow patterns parallel to the beach and breakwalls, along with the interaction of lake water with Euclid Creek flow.

The scope of work for this project at VAB/EB included the investigation of potential pollution sources, identifying how these pollution sources interact with various beach processes, and understanding the impact of Euclid Creek on the bathing waters of VAB/EB. Understanding the sources and processes will help in developing a predictive model.

Fecal contamination at VAB/EB was determined to be the result of waterfowl on the beach sands and in the water, contaminated sands and sediments, shore debris or detritus, stormwater runoff, and CSO and illicit discharges from along Euclid Creek. Each of these sources of pollution interacts with the various beach processes to eventually contaminate the bathing beach water. The chart below shows the interaction of these different processes and pollution sources.

WATERFOWL AT THE BEACH

The VAB/EB unit has a very large population of waterfowl that reside on the beach. The majority are gulls and Canada geese. The gulls are present at the beach throughout the year while geese are seen mainly during late spring and summer. The bird population tends to increase during the recreation season and peak in June and July. However, when looking at the total number of days exceeding the Single Sample Maximum (SSM) during each of these months, the numbers are consistent from month to month and do not follow the same pattern as the number of birds on the beach.

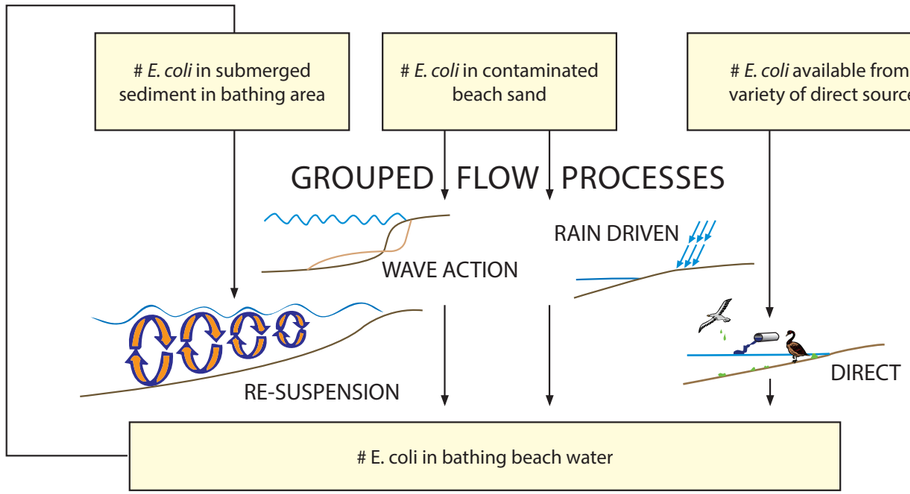
Waterfowl at the beach present a problem, as fecal matter is deposited on the beach sands and in the water. The amount of fecal matter was categorized by the sampling crew on a daily basis, using a scale of 1 to 5:

1: *No fecal matter present.*
2: *Sparse fecal material.*
3: *Some fecal material in one area of the beach.*
4: *Some fecal material in several areas of the beach.*
5: *Fecal material all along shoreline, requiring vigilance to avoid stepping on it.*

There was no direct correlation between fecal matter on the beach sand with the beach waters exceeding the SSM for *E. coli* of 235 cfu/100mL. However, a correlation (R2 of 0.1792) exists with wave height at the time of sampling. When wave height is combined with the amount of fecal matter, the correlation becomes stronger and increases (R2 of 0.2476), indicating a correlation between the *E. coli* concentration in beach waters and the amount of fecal matter on the sand and the wave action present, and confirming that waterfowl fecal matter is a source of pollution at the VAB/EB unit.

It's difficult to quantify the percentage of *E. coli* in the water from waterfowl, but molecular methods can be used to differentiate waterfowl and human *E. coli.* Most of these methods are still being researched and perfected.

SOURCES OF *E. COLI* CONTAMINATION AND PROCESSES FOR DISTRIBUTION TO BEACH WATERS



Wading, not waiting

Water quality predictions help keep beachgoers safer sooner

Swim advisories issued at local beaches are based on the concentration of specific bacterial indicators. For fresh water beaches, the indicator bacteria are *E. coli* or *enterococci,* while marine beaches use *enterococci.*

The State of Ohio uses *E. coli* as the indicator bacteria to issue advisories at local beaches. The analytical methods used to quantify the density of bacteria in bathing waters takes at least 18 to 24 hours. Therefore, by the time the results are ready, the water quality at the beaches may have already changed. Because of this, agencies have turned to the development of *predictive models* to obtain near real-time predictions of water quality.

There are two approaches to creating a predictive model for recreational water. The first is to use a statistical-based model that uses a multiple-linear regression (MLR) analysis to identify relationships between *E. coli* concentrations and known variables that affect their concentration. This type of model has been used by the Ohio Nowcast system for Huntington and Edgewater Beaches. The second approach to modeling is to make a deterministic, or mechanics-based, model based on the mixing and transport of pollution sources through various processes.

The use of a statistical approach for real-time forecasting resolves the delayed notification of fecal contamination in recreational waters. Predictive modeling is an instrumental tool in predicting the water quality of several beaches within the United States. The United States Geological Survey (USGS) is one of the leading advocates for its success, and has continued to strive for its improvements and accuracy.

The USGS has developed real-time mathematical models to predict the probability of a swim advisory or

It is essential to compile several years' worth of quality data to know what environmental factors contribute to E. coli exceedances.

closing based on water-quality. Water-quality advisories are issued based on state standards for concentrations of fecal-indicator bacteria such as *E. coli.* These models are developed using several environmental factors that have significant correlations to the increase in *E. coli* concentration. The USGS has been using predictive models for several beaches for nearly a decade, including local beaches Edgewater and Villa Angela. Donna Francy, a USGS Water Quality Specialist, said, "We have worked at 42 Great Lakes beaches to develop models with local agencies. We're hoping to add more Ohio beaches to the Ohio Nowcast, working with Erie and Lake Counties." Through the Great Lakes Restoration Initiative and the USGS Coastal and Marine Program, the USGS receives funding to help local agencies develop predictive models at their beaches. These calculated predictions can be more accurate than the methods used in the past; such as using the results from the previous day's data.

The first Ohio beach—the first in the country, in fact—to have a valid and accurate predictive model was Huntington Beach, and this led to the implementation of the Ohio Nowcast system in 2006. "It first happened in Ohio due to cooperative projects between the USGS, Cuyahoga County Board of Health, and the Northeast Ohio Regional Sewer District, with seed funding from the Ohio Water Development Authority in the late 1990s," said Francy.

In 2008, Edgewater Beach was added to the Ohio Nowcast site. Attempts were made to create a predictive model for Villa Angela Beach. However, due to the complex processes at this beach, these attempts failed to create an accurate model.

In 2010, the Sewer District partnered with the USGS to develop a predictive model for Villa Angela Beach that incorporated the use of a new rapid-method technology, qPCR (see page 22). This model was very successful and was incorporated into the Ohio Nowcast in 2012. Due to this cooperative working relationship, the Sewer District now has the knowledgeable and competent staff to assume the responsibility of creating, maintaining, and managing the predictive model for both Villa Angela and Edgewater beaches.

Sewer District employees learn about predictive models from Analytical Services staff at Euclid Beach.

In order to develop a predictive model for a beach, substantial environmental data (which may include turbidity, wind speed and direction, wave height, and rainfall) must be collected for several years. This data is used to develop *multiple linear regression* (MLR) models in a statistical program called Virtual Beach. These models calculate an expected *E. coli* concentration and also the exceedance of the bathing-water standard based on selected environmental variables. Its accuracy will be tested against a selected threshold probability of exceedance for *E. coli*. After examining and evaluating each MLR equation that Virtual Beach provides, a model will be selected based on its correlation, specificity, sensitivity, and accuracy.

With the use of qPCR, the new real-time method of quantifying *E. coli,* the Sewer District is able to develop models for Villa Angela and Edgewater that have higher prediction accuracy than using environmental factors alone.

It is essential to compile several years' worth of quality data to know what environmental factors contribute to *E. coli* exceedances. This year's model for Edgewater Beach includes water temperature, accumulation of rain within the past 72 hours, turbidity, and qPCR. The predictive model for Villa Angela Beach includes turbidity, air temperature, wave height, daily rain, pH, and qPCR. With the completion of these models, the Sewer District is confident in its ability to inform the public of any water-quality advisories. ◆

The basics of DNA and quantitative PCR

DEOXYRIBONUCLEIC ACID, OR DNA, is the fundamental genetic material found in all living organisms. Discovered in 1953 by James Watson and Francis Crick, DNA is a double-stranded helical molecule that carries the genetic instructions for life.

Quantitative polymerase chain reaction, or qPCR, is a molecular biology technique used to amplify and quantify specific DNA sequences. It builds upon the foundational *polymerase chain reaction* (PCR) technology developed by Kary Mullis in the 1980s, for which he was awarded a Nobel Prize. Over the past few decades, qPCR has evolved into a versatile tool employed not only in research and healthcare but also in various fields, including environmental monitoring and water-quality surveillance.

The qPCR process begins by identifying a specific target DNA sequence. Next, a specialized reaction mixture is prepared, comprising DNA templates, gene-specific primers, and a fluorescent probe. This mixture undergoes temperature cycling in a thermocycler equipped with a fluorescence detector. During these cycles of heating and cooling, DNA amplification occurs in real time. This entire process can be completed in a few hours, rendering qPCR an invaluable tool for real-time water-quality monitoring and timely public notifications.

The lab's DNA-extraction workstation. The Qiacube (right) can automate DNA extraction, and its centrifuge feature makes the manual extraction process easier. A refrigerated centrifuge (left) keeps samples cool during the initial steps of extraction.

qPCR FUNDAMENTALS

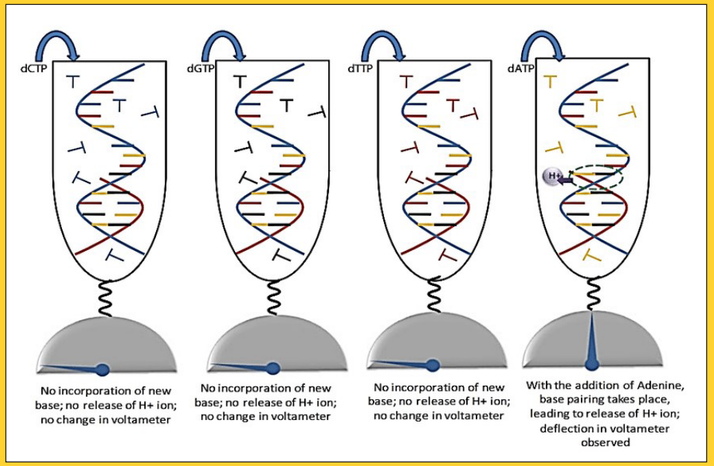
The biochemistry underlying qPCR is intricate and highly specific. This method relies on a DNA-based probe equipped with a fluorescent reporter (fluorophore) at one end and a quencher of fluorescence at the opposite end. The proximity of the reporter to the quencher inhibits fluorescence detection.

The qPCR process begins by raising the temperature to denature the double-stranded DNA into two single strands. Subsequently, the temperature is lowered, allowing gene-specific primers and the probe to anneal to the single-stranded DNA. As DNA synthesis (polymerization) proceeds, the DNA polymerase replicates the target DNA and concurrently degrades the probe, separating the reporter from the quencher. This separation leads to the emission of fluorescence, which is detected by the thermocycler platform. The temperature cycling typically occurs 40 times, resulting in exponential DNA replication. The degree of fluorescence is quantified as the cycle threshold (CT) value, with a lower CT value indicating a higher initial concentration of the target of interest.

SEQUENCING AND NGS

DNA sequencing is a process that involves determining the precise order of nucleotides (adenine, cytosine, guanine, and thymine) in a DNA molecule. Understanding the sequence of DNA is crucial for various scientific applications, as it provides insights into the genetic code and can help researchers identify genes, mutations, and variations associated with specific traits, diseases, or organisms. Next-generation sequencing (NGS), also known as high-throughput sequencing, is a revolutionary advancement in DNA sequencing technology that has significantly increased the speed and efficiency of the sequencing process.

The origins of DNA sequencing trace back to the pioneering work of Frederick Sanger in the 1970s, who developed the first-generation sequencing method.



A sequencing by synthesis graphic that illustrates what the instrument is doing. As the nucleotides are added, they are incorporated into the growing sequence strand and the meter detects the release of a proton ion when they bind. In this image, the next nucleotide in the sequence is the A since it produced a signal when added.

https://www.researchgate.net/figure/on-Torrent-semiconductor-sequencing-principle-Verma-et-al-2016_fig5_338830137

Although this approach laid the foundation for genetic analysis, it was characterized by labor-intensive procedures and limited scalability. Each sequencing reaction necessitated individual gel electrophoresis, rendering it impractical for large-scale genomic endeavors.

The turning point emerged in the early 2000s with the advent of NGS technologies, marking a transformative shift in the landscape of DNA sequencing. These innovations stemmed from novel methodologies and revolutionary concepts, enabling the sequencing of DNA with unprecedented speed and efficiency. Subsequent years witnessed a rapid evolution of NGS platforms, encompassing various techniques. The technique used at the Sewer District is called *sequencing by synthesis.*

SBS FOR PROTON SEQUENCING

Sequencing by synthesis (SBS) has emerged as a cornerstone of NGS methodologies due to its high-throughput capabilities and exceptional accuracy. This technique involves the cyclical incorporation of nucleotides into a growing DNA strand, with each added nucleotide emitting a detectable signal. The accumulation of these signals facilitates the precise determination of the DNA sequence.

A pivotal milestone in SBS technology was the integration of proton detection systems, also known as proton sequencing. This innovation produced advantages, including reduced costs, streamlined workflows, and the elimination of the necessity for fluorescent labels.

In a proton detection system, DNA sequencing relies on the release of hydrogen ions (protons) during nucleotide incorporation. Correct nucleotide incorporation results in the release of a proton as a byproduct. This proton release is subsequently detected as a pH change, which is transformed into an electrical signal. The amplitude of the signal corresponds to the nucleotide added, allowing for precise determination of the DNA sequence.

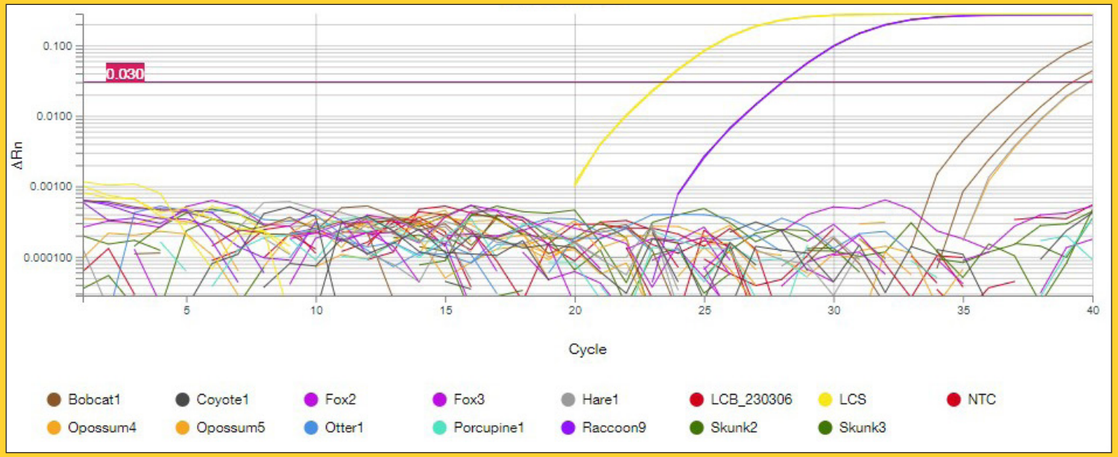
The introduction of proton-detection systems has significantly simplified the NGS workflow, rendering it more accessible to researchers.

UNMASKING THE CULPRITS OF CONTAMINATION

At our laboratory, our primary mission is to protect the health of our local waterways using precise molecular assays. Our primary focus revolves around the identification and mitigation of fecal contamination sources, a critical task for preserving the ecological balance and ensuring public health.

The core of our research utilizes the power of target-specific PCR assays. These assays have become indispensable tools in our arsenal, enabling us to determine the origins of contamination with exceptional accuracy. We have incorporated assays developed by the U.S. EPA, U.S. Geological Survey (USGS), and other research groups focused on the different sources of fecal contamination. These assays are instrumental in distinguishing the sources of contamination, whether they stem from human activity, domestic pets like dogs, or even the presence of wild animals like deer, geese, and gulls.

Our most recent research project involved designing and validating a raccoon-specific marker. Raccoons, commonly found in our local sewer systems, presented a unique challenge because there was no pre-existing qPCR assay for tracking them. Using NGS techniques, we identified a conserved sequence in our



An amplification plot from a raccoon-validation PCR run. The legend at the bottom shows all the different animal feces run. "The one raccoon sample provided was the only sample to be positive for our raccoon marker, as expected," said biologist Justin Seikel. With dozens of tests completed, every result has validated that Seikel's marker is specific to raccoon.

local raccoon populations and designed a qPCR assay around it. Validation results have been promising (see chart, above) and we are now transitioning to sample testing. Our goal is to use this new assay for tracking raccoon-related contamination and developing mitigation strategies.

COLLABORATIVE EFFORTS IN ENVIRONMENTAL STEWARDSHIP

Our work extends beyond the identification of contamination sources, and we take great pride in our close collaboration with our Water Quality and Industrial Surveillance (WQIS) department. Together, we share a common mission: assessing and preserving the health of aquatic ecosystems in our local waterways.

As an integral part of this partnership, we have developed a targeted metagenomic sequencing approach. This innovative technique complements the efforts of the WQIS team, who conduct electrofishing surveys in various water bodies, including Lake Erie and its tributaries. Electrofishing surveys play a crucial role in determining the health of these environments, focusing on the fish species present and conducting health assessments to evaluate the fish population's and the ecosystem's well-being.

To aid in these electrofishing efforts, we've designed a metagenomic sequencing analysis method using MiFish markers, a set of universal PCR primers for metabarcoding environmental DNA from fishes. We initiated our efforts by testing this newly developed metagenomic sequencing assay against samples taken from our in-house aquariums to gauge its accuracy. Subsequently, we shifted our focus to testing environmental samples, and the results show great potential.

The results obtained from the NGS assay aligned closely with what we observed during electrofishing surveys. This alignment not only validates the effectiveness of our metagenomic sequencing approach but also enhances the accuracy and depth of the data gathered through electrofishing. It's a synergy of traditional and cutting-edge methods, reinforcing our commitment to understanding and preserving the environmental health of our local waterways.

A COMMITMENT TO SAFETY AND PUBLIC HEALTH

The molecular techniques employed in our laboratory are essential in our mission of safeguarding the environment and public health. The combination of PCR and NGS technologies reinforces our efforts to investigate contamination sources, develop proactive mitigation strategies, and support water-quality assessments conducted by our dedicated colleagues in the WQIS department. We are committed to using these advanced scientific tests to keep our valued waterways clean and healthy, now, and for future generations.

—Justin Seikel

Justin Seikel is a Biologist in the Analytical Services department at the Northeast Ohio Regional Sewer District.

Q&A

Erin Huber Rosen

DRINK LOCAL DRINK TAP FOUNDER TALKS BEACH CLEANUPS

How many beach cleanups has Drink Local Drink Tap held?
Drink Local Drink Tap held 23 beach cleanups in 2023. We've held over 250 cleanups since our founding in 2010.

What is the most common trash item collected?
When you first asked our team this question in 2012, the overwhelming answer was plastic cigarillo tips, and this remains true today. These single-use plastic items still wreak havoc on our environment. We often encounter a few thousand of them in a single cleanup.

What is the typical reaction of a first-time volunteer?
Our volunteers are enthusiastic to get out to the beach to help clean up, but often are surprised a few minutes into the job because the pieces are often smaller than they expected. When trash breaks down from being blown around in the weather, it gets smaller and harder to clean up. This is a health risk to animals and humans, as fish and wildlife consume these microplastics. it affects our entire ecosystem.

What is the strangest thing you've ever uncovered at a beach cleanup?
Often we will find unique auto parts in grass and brush, or clothing. The surprising takeaway, though, is the sheer volume of mundane, everyday items, like bottle caps, straws, single-use plastic utensils, cigarillo tips, and soft plastic fragments from bags. These items aren't necessarily being left behind by beachgoers. Weather events move trash around our communities, and as the Sewer District

knows all too well, it can enter sewer grates and end up on our shores during CSO events. Or it can cause issues at the wastewater treatment plants. So if we pick up trash in our neighborhoods, we may make just as big of an impact as volunteering at a beach cleanup!

Do you know how much trash you've collected?
Since 2010, our volunteers have collected 607,241 individual pieces of trash—that's 17,262 pounds! Our cleanups this year alone collected 1,354 pounds.

What does it mean to you to be involved in this work?
I feel very lucky to be leading an incredible team that engages youth and our community in water stewardship. We know that we are changing minds and habits and having a hand in influencing future leaders to care about water and each other. When we have clean, affordable, accessible water and reliable sanitation services, we improve equity in our community. Our work and impact on the beach are just part of our story in creating ripples for lasting change for Lake Erie communities and beyond.

Erin Huber Rosen is the Executive Director and Founder of Drink Local Drink Tap, an international non-profit based in Cleveland and focused on solving water-equity and -quality issues. Drink Local Drink Tap staff and volunteers work to educate, advocate, and create affordable, safe clean-water sources and sanitation facilities.

*For more information, visit **drinklocaldrinktap.org***

Learn more about beach monitoring at
neorsd.org/beaches

CleanWaterWorks

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