



MICHIGAN'S UNIVERSITY  
RESEARCH CORRIDOR

# Tackling Environmental Health Threats





Dear Readers,

The world has undergone dramatic change in the past two years. The pandemic has shone a light on systemic inequities in our healthcare system and our nation has experienced a reckoning with racial injustice. What has received less attention, but also has dire implications, are disparities related to environmental health risks.

The University Research Corridor (URC) and its member institutions—Michigan State University (MSU), the University of Michigan (U-M), and Wayne State University (WSU)—are dedicated to assembling their collective expertise and capabilities to produce tangible impacts that improve the lives and health of all Michiganders and help to ensure justice for all.

In this brief, we focus on how URC institutions work to understand and mitigate environmental impacts on human health. As the Great Lakes State, Michigan is endowed with incredible environmental assets that elevate the quality of life for residents and visitors alike. But these benefits are not universal. For many communities, pollution, climate change, and inadequate water infrastructure threaten public health.

Furthermore, these risks disproportionately affect exploited populations and individuals with low incomes. And in many cases, remediation of environmental threats requires significant investments of research, money, and time.

From 2016-2020, URC institutions conducted nearly \$494 million in environmental health research, including work in engineering, business, economics, and sociology. Over those five years, we awarded 52,709 undergraduate and graduate students with environmental health-related degrees. Our institutions have and continue to tackle environmental risks that threaten the health of Michiganders today and into the future.

One example is that all three URC universities conduct National Institute of Environmental Health Sciences (NIEHS) research. MSU is home to the long-funded Superfund Research Program (SRP), U-M features the Michigan Center on Lifestage Environmental Exposures and Disease (M-LEEaD), and WSU hosts the Center for Urban Responses to Environmental Stressors (CURES). All three programs support community engagement and connect research to communities across the state, providing local leaders with information they can use to benefit residents and economies.

Smarter, safer and more equitably distributed modern infrastructure is a means of better protecting the health of people and communities from environmental threats. Whether it's flooding from stormwater or broken dams, lead in drinking water or air pollution, URC researchers are at the forefront in discovering how to mitigate the impacts of these threats to protect residents' health. They are designing and testing new technologies for infrastructure systems and working with communities to implement them. And as states and communities begin to use the once-in-a-generation funding from the Infrastructure Investment and Jobs Act, URC university researchers can help to ensure communities have access to the most up-to-date knowledge and innovation to serve residents today and into the future.

Recent events have had a profound impact on our universities, economy, and the state—a trend that will likely continue for some time. We continue to deliver on our core activities of education, research, and service, and to fulfill our mission to serve Michigan and its residents by addressing the most enduring challenges facing our communities.

Sincerely,

**Samuel L. Stanley Jr.**  
President  
Michigan State University

**Mary Sue Coleman**  
President  
University of Michigan

**M. Roy Wilson**  
President  
Wayne State University





# What Is Environmental Health?

Every day, millions of Michigan residents interact with the environment, whether gardening at home, visiting the state's abundant network of trails, or fishing in the Great Lakes. These interactions affect quality of life, years of healthy life lived, and health disparities. However, across the state, news headlines feature a steady stream of environmental health challenges that threaten residents' well-being, such as per- and polyfluoroalkyl substances (PFAS), lead exposure, compromised air and water quality, and industrial pollution.

Poor environmental quality most greatly impacts people whose health statuses are already at risk, such as those with asthma or cancer. Therefore, **it is critical that the environmental health field address the societal and environmental factors that increase the likelihood of exposure and disease.** According to the World Health Organization (WHO) (2019), 23 percent of all deaths and 26 percent of deaths among children under age five in 2016 were due to preventable environmental factors. **In Michigan, children face higher rates of asthma and pediatric cancer than children across the entire nation, according to a 2019 report from the Children's Environmental Health Network.**

As one of the nation's top academic research clusters, the University Research Corridor—an alliance between Michigan State University, the University of Michigan, and Wayne State University—is dedicated to improving the quality of life for the Great Lakes region while advancing knowledge at a global level.

This brief serves as a resource for understanding the **vital research, programs, and value that URC institutions provide** on environmental health issues that affect Michiganders every day. Over time, environmental health has evolved into a complex, multidisciplinary field. Many of the key determinants and solutions to environmental health problems lie outside the direct realm of health. As a result, the research and programs presented in this brief are gleaned from the full suite of diverse disciplines in order to gain a more complete picture of the environmental health landscape. This brief provides a snapshot of the URC's work as it connects to current news headlines.

According to the National Environmental Health Association (n.d.), **environmental health is the science and practice of preventing human injury and illness and promoting well-being** by:

- Identifying and evaluating environmental sources and hazardous agents
- Limiting exposure to hazardous physical, chemical, and biological agents in the environment that may adversely affect human health

According to the WHO (2019), the environment impacts human health when people are exposed to the following risk factors in their homes, workplaces, and communities:

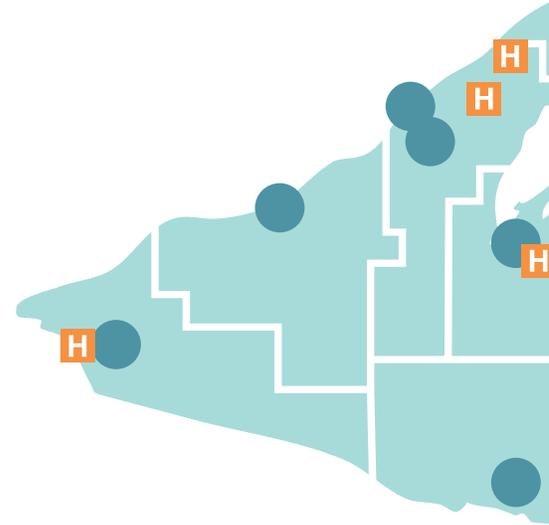
- Agricultural practices, including pesticide and wastewater reuse
- Air pollution, both indoors and outdoors
- Built environments, including housing and roads
- Chemicals and biological agents
- Climate change
- Community noise
- Inadequate water, sanitation, and hygiene
- Occupational risks
- Radiation, both ultraviolet and ionizing

**All of these risk factors are present in our Michigan communities.** This is why URC researchers, faculty, and students are engaged in on-the-ground projects with local and state partners to understand these risks, mitigate them, and eliminate them. The following pages quantify the impact of the URC's engagement in environmental health and the diverse nature of their work.



# Where We Work

## Projects Addressing Environmental Health



### Guiding National Research in Environmental Health

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#### SAGINAW, MIDLAND, AND BAY CITY

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### Fighting Lead Exposure

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### Leading the Charge in PFAS

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### Protecting Michigan's Air and Water

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### Collaborating on Freshwater Innovation

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#### DETROIT/DEARBORN

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## URC LOCATIONS

-  NIEHS Centers
-  AgBioResearch Centers and Field Stations
-  Campus Locations
-  MSU Extension District Offices
-  MSU Extension
-  Partner and Affiliate Hospitals

*Map adapted from 2020 URC Benchmark Report from Anderson Economic Group*

# 72

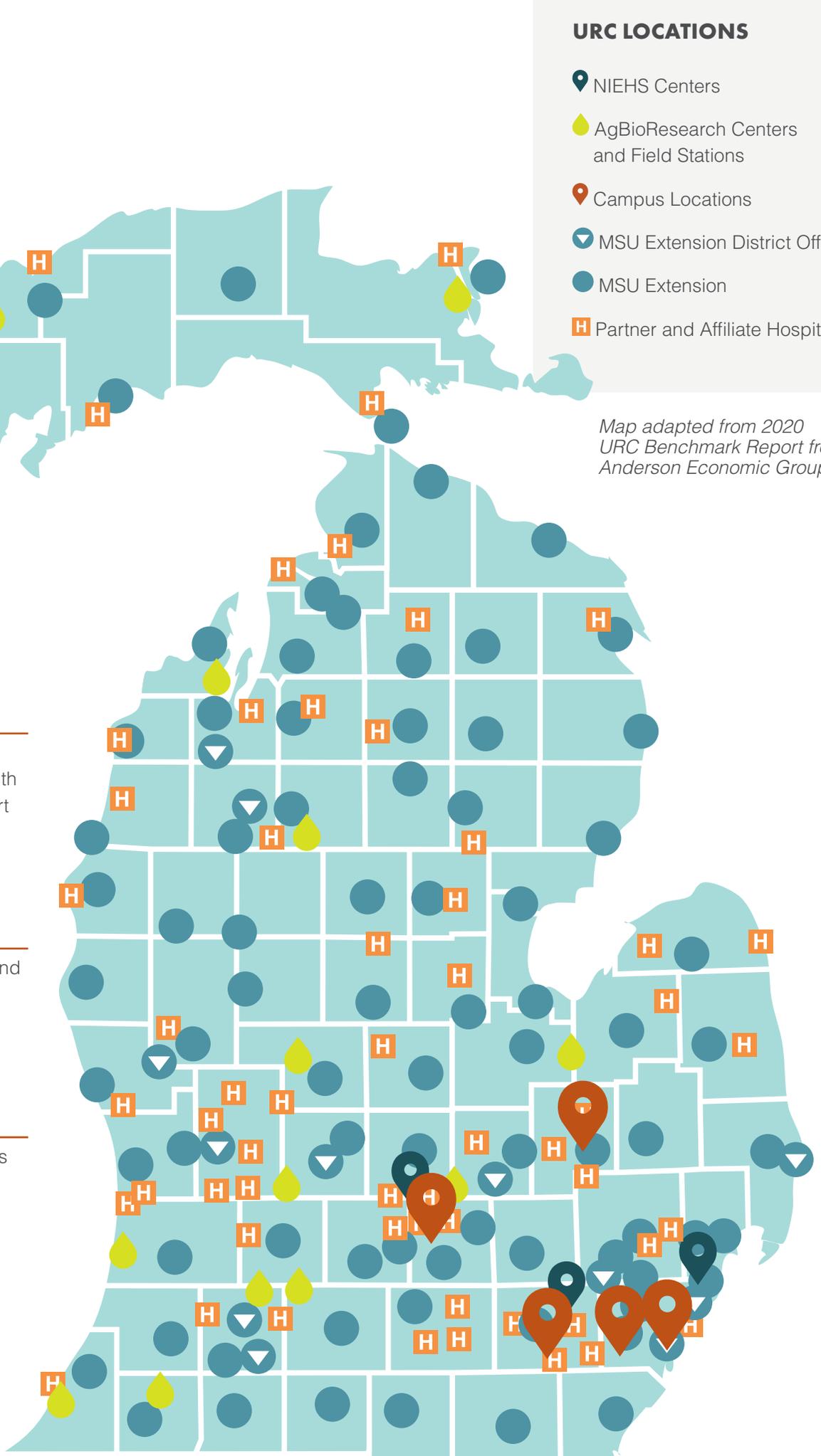
Counties with MSU Extension and health department support

# 71

Affiliate hospitals and healthcare centers

# 3

NIEHS partnerships and Core Centers



# Making A Difference

## Our Investment

**\$493.8 million**

The amount of funding URC universities were awarded to conduct environmental health research between 2016 and 2020. This research includes clinical trials, private-sector partnerships, public service projects, and talent development throughout Michigan across 1,486 projects.

## Our Reach

The URC produces researchers and professionals who are on the frontlines of environmental health work, providing skills and training to better meet Michigan's needs.

**52,709 students**

The number of URC students who graduated from 2016 to 2020 with environmental health-related degrees.



**29,542**

The number of bachelor's degrees awarded.

**13,855**

The number of master's degrees awarded.

**9,312**

The number of doctoral degrees awarded.

Complex, multidisciplinary fields such as environmental health draw graduates with majors across diverse disciplines, including public health, communications, plant and soil sciences, environmental health engineering, law, economics, and biochemistry. URC alumni are engaged in environmental health fieldwork across a range of roles, including journalists, researchers, and directors of medical facilities, nongovernmental organizations, and state and federal agencies.

## Alumni Research Leadership



**Dr. Mona Hanna-Attisha** earned her bachelor's and master's degrees in public health from U-M and her doctorate in medicine from the MSU College of Human Medicine. A pediatrician, scientist, activist, and author, Dr. Hanna-Attisha is the founder and director of the MSU-Hurley Children's Hospital Pediatric Public Health Initiative in Flint, C.S. Mott Endowed Professor of Public Health and author of the bestselling book *What the Eyes Don't See: A Story of Crisis, Resistance, and Hope in an American City*. For her role in uncovering the Flint water crisis and leading recovery efforts, Dr. Hanna-Attisha received the Freedom of Expression Courage Award by PEN America and the 2020 CDC Foundation's Fries Prize for Improving Health and was named one of *Time* magazine's 100 Most Influential People in the World, recognized as one of *USA Today's* Women of the Century. She continues to care and advocate for children and families in the city.



**Dr. Christine Joseph** is a senior epidemiologist for Henry Ford Health (HFH), earning her master's and doctorate degrees in epidemiology from U-M. Dr. Joseph is director of the HFH Health Disparities Research Collaborative, a platform for the support and collaboration of Henry Ford Health investigators working to understand these issues. She has served as principal and coinvestigator on several studies funded by the National Institutes of Health (NIH) and is an adjunct associate research scientist at U-M, on state committees focused on the elimination of racial disparities in asthma care and chaired the Committee on the Underserved for the American Academy of Allergy, Asthma & Immunology.



**Dr. Larry Brilliant** received his bachelor's degree as well as a master's degree in public health from U-M and his doctorate in medicine from WSU. An American epidemiologist, technologist, philanthropist, and author, Dr. Brilliant is the CEO of Pandefense Advisors, an interdisciplinary network of world-class experts and professionals urgently engaged in pandemic response. He is also a medical analyst for CNN and author of *Sometimes Brilliant: The Impossible Adventure of a Spiritual Seeker and Visionary Physician Who Helped Conquer the Worst Disease in History*, which is based on his experience as a United Nations medical officer in India, where he played a key role in the World Health Organization's smallpox eradication program. He also serves on the board for Ending Pandemics, a philanthropy working to prevent pandemics, and has served as a board member for the Skoll Foundation and Salesforce. Dr. Brilliant is cofounder, past chairman, and executive director of the Seva Foundation; past president of the Skoll Global Threats Fund; and former executive director and vice president of Google.org, the charitable arm of Google.



# URC Impact

## Collaborating for a Cause: Keeping Michigan's Kids Healthy

Environmental exposures greatly impact Michiganders' health and quality of life. This is why URC institutions collaborate with statewide partners to mitigate the potentially dangerous effects of these exposures.

As part of a network of more than 80 partner hospitals, URC institutions work with the Michigan Department of Health and Human Services (MDHHS) and county health departments to collect information and disseminate research to serve families across the state's 83 counties. The following research projects showcase how research with birth parents and infants advances the health of Michigan's children.

### Prenatal Exposures Linked to Childhood Health Outcomes

Many problems in child health and development may result from prenatal exposure to dietary deficiencies, infections, and environmental toxins. The impact of these exposures, particularly when they occur in utero, are not well understood.

**With NIH funding through 2023, an alliance of scientists and providers from five Michigan organizations are aiming to improve the health of mothers and children in the state.** Built on data collected by the Archive for Research on Child Health in 2008, the Environmental influences on Child Health Outcomes (ECHO) program is a seven-year initiative that includes Henry Ford Health System, MDHHS, MSU, U-M, and WSU. Researchers are studying approximately 2,000 mothers and their infants to measure the impact of environmental contaminants, nutritional factors, infections, and stress during pregnancy and early life. They use this information to learn what changes could be made during pregnancy that could prevent future health issues for the child.

### Prenatal Lead Exposure Can Affect Future Generations

Prenatal lead exposure can affect fetal brain development and cause other adverse effects, including low birth weights and gestational hypertension. **A team of URC researchers found**

**that birthing parents with high levels of lead in their blood can affect fetal blood cells across generations.**

Dr. Douglas Ruden—professor for WSU's Department of Obstetrics and Gynecology, director of epigenomics for WSU's Institute of Environmental Health Sciences, and program leader for Center for Urban Responses to Environmental Stressors (CURES)—found that prenatal lead exposure can even change DNA across generations.

Dr. Ruden and his research team obtained neonatal bloodspots from the Michigan Neonatal Biobank, a unique resource that includes more than five million residual bloodspot specimens that represent nearly every Michigan birth since October 1987.

"This is the first demonstration that an environmental exposure in pregnant mothers can have an epigenetic effect on their grandchildren's genes," said Dr. Ruden.

*"Epigenetic effects of environmental exposures beyond one generation have not yet been demonstrated in humans prior to this study."*

#### **Dr. Douglas Ruden**

WSU Department of Obstetrics and Gynecology Professor, WSU Institute of Environmental Health Sciences Director of Epigenomics, program leader for CURES



*“Because we recruit our participants in early pregnancy and follow their children from infancy and childhood, we can examine the earliest influences of the environment, infection, and nutrition on child health and development. Pregnancy and the perinatal period are times of special vulnerability and also times when interventions can perhaps do the most good.”*

**Dr. Nigel Paneth, MD, MPH**  
Emeritus University Distinguished Professor of  
Epidemiology and Biostatistics and Pediatrics, MSU



## Michigan Bloodspot Environmental Epidemiology Project

To generate insights into the impact of prenatal environmental exposure on adverse health outcomes, the Michigan Bloodspot Environmental Epidemiology Project funded early-stage epidemiological research using the Michigan Neonatal Biobank to investigate whether researchers can obtain environmental exposure and genetic information from available bloodspots.

The \$450,000 award from the URC was distributed to 12 early-stage epidemiological research projects through two competitive rounds of funding to collaborative teams across the URC. Preliminary results from a number of these projects have yielded academic publications and external funding, like the examples included in this section.

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**33**

Years of neonatal bloodspot bank collection

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**9,000+**

Michigan pregnancies analyzed for McKinsey, Boston Consulting Group, and Bain & Company studies and utilized by projects referenced in this brief



## Guiding National Research in Environmental Health

Scientific collaboration across national universities and cutting-edge technologies can advance environmental health sciences. The National Institute of Environmental Health Sciences Core Centers Program facilitates these collaborations by funding institutional infrastructure to support scientific equipment, facilities, and other resources that can be shared among environmental health researchers. Michigan is one of six states with two or more of these centers, with one located at WSU and the other at U-M. Additionally, MSU has been home to a long-established NIEHS-funded Superfund Research Program.

### **WSU Center for Urban Responses to Environmental Stressors**

Headquartered at WSU in the heart of Detroit, CURES works with community partners to understand how complex exposures to chemical and nonchemical stressors in the urban environment can influence the development of environmentally linked disease. CURES places special focus on life windows of heightened susceptibility to environmental exposure and vulnerable persons at risk for related diseases, including children and adults from low socioeconomic backgrounds, older adults, immigrants, refugees, and first responders.

### **U-M Michigan Center on Lifestage Environmental Exposures and Disease**

The M-LEEaD works to improve understanding of the connections between environmental exposure and its impact on chronic illness and disease, including asthma and metabolic syndrome. The center also supports research in environmental health sciences with three science facility cores: The Integrated Health Sciences Core, the Exposure Assessment Core, and the Omics and BioInformatics Core. It has a strong commitment to engaging communities affected by environmental exposures through the activities of its fourth facility core: The Community Engagement Core, with priorities driven by its Stakeholder Advocacy Board.

*“The Community Engagement Core at M-LEEd is strongly committed to bringing environmental health science to bear on environmental priorities experienced by residents of Southeast Michigan, with a focus on communities that experience a disproportionate burden of environmental challenges. The M-LEEd Stakeholder Advocacy Board has identified priorities including environmental exposure and birth outcomes, air pollution and access to clean water, as reflected in the Flint water crisis and water shut-offs in Detroit. We have worked closely with CURES at WSU to bring environmental science on community-prioritized issues to community members and decision makers, for example, through our legislative events. Recent events have focused on water quality and infrastructure, air quality and health, and large scale chemical contaminations, such as PBB and PFAS, in Michigan.”*

**Amy J. Schulz, PhD**

University Professor of Health Behavior & Health Education, Associate Director for the Center for Research on Ethnicity, Culture and Health (CRECH) and Leader of M-LEEd Community Engagement Core at U-M

## **MSU Superfund Research Program**

First awarded NIEHS funding in 1988, the MSU SRP conducts research on understanding and alleviating the adverse impacts on human health from exposure to chemicals commonly found at Superfund sites. This long-term program operates a Community Engagement Core (CEC) that partners with MSU Extension in the Michigan Tri-Cities area (Saginaw, Midland, and Bay City). The CEC builds upon MSU Extension's established trust in the region to enable communication and engagement between the MSU SRP and the Tri-Cities community. In addition to the CEC, the NIEHS has provided continued support to the MSU toxicology graduate program in East Lansing since 1989.



## **LEADERSHIP SPOTLIGHT: DR. ELANA ELKIN**

Dr. Elana Elkin is the recipient of the NIEHS 2019 Karen Wetterhahn Memorial Award, which honors a graduate or postdoctoral researcher who demonstrates scientific excellence. Dr. Elkin's research examines how exposure to environmental contaminants may affect placental development and function, a common precursor to adverse birth outcomes, such as preterm birth.

Dr. Elkin is a postdoctoral researcher at U-M and a trainee at Northeastern University's Puerto Rico Testsite for Exploring Contamination Threats (PROTECT) SRP Center, a multi-institution collaboration that includes U-M. In addition to her postdoctoral research, Dr. Elkin works for a WSU startup that isolates placental cells for use in research and prenatal testing services. In the future, she hopes to work as a toxicologist for a government agency to gain experience in environmental health policy and—ultimately—return to academia to mentor and educate the next generation of toxicologists and placental biologists.

“Through her many accomplishments and activities so early in her career, Elana is a model for all of our trainees,” said PROTECT SRP Center director Dr. Akram Alshwabkeh. “She holds tremendous potential to be an outstanding environmental health leader.”



# Fighting Lead Exposure

## Helping Residents Navigate the Flint Water Crisis

From 2014 to 2016, between 6,000 and 12,000 children in Flint were exposed to high levels of lead through the city's drinking water (Keller and Chapman 2016). URC institutions quickly assembled to help affected families, discovering lead exposure sources, creating children and family health initiatives, continuing longtime medical education programs in area hospitals, and fostering economic growth.

At WSU, researchers are investigating the connection between the Legionella outbreak and the water supply, and those at U-M are collaborating with the Genesee County Health Department to collect data on water quality. At MSU, researchers have been developing a registry to help track those affected by the crisis. The URC's work continues today—in partnership with community leaders—through ongoing research, monitoring, innovative program development, and startup creation to ensure a safer, healthier future for all Flint residents.

## Discovery: Researching How Lead Exposure Impacts Behavior

Researchers from WSU and MSU are investigating how children born in areas with high levels of pollutants suffer from notably higher rates of adverse health outcomes, including behavioral problems such as aggression, antisocial behavior, and hyperactivity. Their study examines the connection among prenatal exposure to three common toxicants (tobacco smoke, lead, and mercury), fetal resting-state functional connectivity at 35 weeks, and the long-term effects these have on child behavior.

## Making Flint Lead Free

Flint Lead Free is a multidisciplinary group of partners—including MSU researchers, Flint residents, nonprofits, landlords, and governmental agencies—all striving to make Flint a lead-free city. [\*The Flint Lead Free 2021 report\*](#) shares lead-related trends up to the end of 2019, emphasizing primary prevention efforts currently underway in the city of Flint, and the trends show significant decreases in lead risks year over year.



The report shares the economic benefits of lead elimination as well as the benefits of increasing health and community development. Analysis of Flint's lead elimination efforts estimates that lead prevention activities will generate \$53.3 million in future economic benefits for children when considering the number of pipes replaced and homes abated from 2016 to 2019.

*“From pipe replacements to home abatements, Flint is leading the nation in efforts to remove lead from homes before kids are poisoned. We have more work to do to eliminate this systemic inequity, but we are definitely moving in the right direction.”*

**Dr. Mona Hanna-Attisha**

C.S. Mott Endowed Professor of Public Health and Assistant Professor of Pediatrics at MSU's College of Human Medicine and Director of MSU-Hurley Children's Hospital Pediatric Public Health Initiative, and Director of Pediatric Residency Program at Hurley Medical Center

## **Market Solutions: Using Artificial Intelligence to Detect Lead Lines and Save Money**

U-M startup BlueConduit, a water infrastructure analytics consulting company, uses data and machine learning—the study of computer algorithms to find data patterns—to help cities conduct more efficient lead service line removal and material inventories. Their data, powered by artificial intelligence and statistics, can estimate how many lead service lines are in a system, where they are located, and how much it would cost to replace them. This allows cities to determine their inventory and replacement projects while reducing labor expenses to combat public health risks.

**Since 2016, the BlueConduit team has collaborated with the City of Flint on replacement projects that have saved tens of millions of dollars and hundreds of labor hours.** Projects achieved a 95 percent accuracy rate (compared to a national firm's 15 percent accuracy rate with digging alone),



revealing 300 percent more homes in need of service line replacement. More efficient risk prioritization allowed officials to send crews sooner to homes with the highest risk of lead pipes, reducing the total number of days that residents lived with a lead-tainted water supply and minimizing public health consequences. As part of this work, the City of Flint established new data collection procedures to ensure outdated historical records are regularly updated.



## Michigan Universities Collaborate to Study Flint Water Filters and Build Community Confidence

In response to water contamination in Flint, Michigan, researchers from U-M, WSU and MSU initiated studies to determine the best ways to manage the type of point-of-use water filters Flint residents were using. The studies were supported by grants from the National Science Foundation and the University of Michigan.

“All water, including drinking water, contains some bacteria. The question is whether the bacteria are harmful,” said Dr. Nancy G. Love, professor of civil and environmental engineering at U-M. “Our research is focused on helping to determine how filters designed to remove lead can be used in a way that also reduces or prevents passage of harmful bacteria.” The research team coordinated closely with MDHHS and Genesee County Health Department during the crisis, and continue to work with the Flint Mayor’s Office and Flint Community Schools on ensuring best practices with building-scale drinking

water filters. The research team is coordinating closely with MDHHS, the Genesee County Health Department, and the Flint Mayor’s Office.

Manufacturers typically recommend replacing filters after processing approximately 100 gallons of water. Dr. Susan Masten, professor of civil and environmental engineering at MSU, noted that the team is examined if this point-of-use replacement schedule is best for the Flint water distribution system.

“Based on the results we have gathered thus far, the filters are doing a good job removing lead and disinfection byproducts,” Dr. Masten said. “These byproducts are the chemical compounds that occur after water has been disinfected and are measured as total trihalomethanes. So far, after filtration, these chemicals are typically at concentrations below what we can measure.”

Dr. Love and Dr. Shawn McElmurry, professor of civil and environmental engineering at WSU, also worked with community partners to develop a training program to share the latest scientific information with



Flint residents and [provide training](#) on how to maintain water quality using these devices.

Team members say they appreciate the cooperation of Flint residents, which makes the study possible. Residents have been providing access into their homes and supplying the filters used in the study.

### **Community Engagement in Action**

During the Flint crisis, MSU Extension responded to stakeholder needs for information about combating the effects of lead exposure to Michigan communities. They developed an exceptional emergency response with limited staff, time, and budget. In 2016, the United States Department of Agriculture (USDA) awarded MSU Extension with the Abraham Lincoln Award for External Partnership, which recognized the exceptional contributions of the USDA's external partners in innovation, productivity, and efficiency in program delivery.

### **RESEARCHER SPOTLIGHT: DR. JENNIFER CARRERA**

MSU assistant professor Dr. Jennifer Carrera uses an environmental justice perspective to focus on access to environmental resources and how this affects the well-being of underserved communities. Using water as a lens, Dr. Carrera examines mechanisms of exclusion that contribute to environmental injustices for those with few socioeconomic resources. She employs a method called community-based participatory research (CBPR) to study health inequities. CBPR engages the community in the research process by allowing representatives to participate in and contribute to each stage of the work. Dr. Carrera has used this method to investigate the role that low-cost, coproduced technologies play in a community's health literacy. For example, the citywide lead exposure crisis in Flint highlighted a national crisis regarding outdated water infrastructure in the U.S. Her prior water quality work in Detroit—using CBPR and citizen science—guides her current research in the Flint community.

Dr. Carrera is focused on characterizing the factors that affect the utility of publicly available tools for environmental monitoring to improve environmental health literacy and protect personal health. She is also examining how the use of these technologies affects trust in science and scientists.

# Leading the Charge in PFAS

## Researchers Fight PFAS Together

PFAS are a large group of synthetic chemicals that include perfluorooctanoic and perfluorooctanesulfonic acids. PFAS are commonly referred to as “forever chemicals” because they persist in the environment and human body, accumulating over time and never breaking down. Since the 1940s, these substances have been used globally across various industries, including manufacturing and firefighting, and are also present in thousands of common household products. PFAS can be absorbed through direct contact, such as drinking, bathing, and swimming, or indirectly, such as eating meat or vegetables exposed to these substances.

In recent years, experts have become increasingly concerned about the potential effects of high concentrations of PFAS on human health. These chemicals are potential carcinogens, disrupt the endocrine system, have caused birth defects and obesity, and are difficult to destroy (Michigan PFAS Science Advisory Panel 2018).

According to the Michigan Department of Environment, Great Lakes, and Energy (EGLE), PFAS contamination from firefighting foam, nonstick surfaces, stain guards, and other commercial and industrial applications may be present in more than 11,300 locations. Additionally, regulators have identified more than 160 locations across Michigan with levels above the Environmental Protection Agency’s health limit for groundwater. One particular site of concern is Wurtsmith Air Force Base in Oscoda, where the long-term use of aqueous film-forming foams have resulted in groundwater contamination.

URC institutions are working to both test and track PFAS contamination and exposure as well as research scalable methods to eliminate and remediate these chemicals out of the environment. They are also

developing methods to trap and remove PFAS and, in so doing, positioning Michigan as a leader in detecting and remediating this family of pollutants.

## Infrastructure Innovation Tour: PFAS Roundtable in Kalamazoo

In March 2019, the URC convened legislators, business leaders, and researchers to discuss emerging PFAS challenges, review ongoing research, and build new pathways for collaboration as part of their Infrastructure Innovation Tour. The conversation took place in Kalamazoo near the City of Parchment and Cooper Township, both of which are early hotspots of PFAS contamination.

Dr. David Hyndman, MSU hydrogeology professor and chair of MSU’s Department of Earth and Environmental Sciences, is a member of the Michigan PFAS Action Response Team, a group that leads coordination among all levels of government and



directs implementation of the state's action strategy. At the roundtable, Dr. Hyndman shared models for understanding the movement of contaminants in groundwater over time and discussed the highly variable characteristics of solute transport.

Dr. Rodrigo Fernandez-Valdivia, WSU assistant professor of medicine, discussed studies that help inform the current understanding of the health effects of PFAS on humans. He noted that PFAS exist in a variety of products, including some pharmaceuticals that use short-chain PFAS compounds—the next iteration of PFAS chemicals.

It can be difficult for consumers to track and understand PFAS in everyday products, as this group of chemicals is not characterized as a hazardous material. However, monitoring and testing are critical activities at this stage, according to Dr. Terese Olson, U-M associate professor of civil and environmental engineering and associate department chair of undergraduate programs. Her work informs Michigan's remediation efforts by gaining a greater understanding of where PFAS are and their effects.

*“Sound water infrastructure is fundamental to quality of life. Cooperation like this helps. While much anxiety remains about PFAS and their unknown health effects on humans, the more collaboration we have between researchers and community leaders, the better served our public will be.”*

**Robert D. Britigan III**  
Mayor of Parchment, Michigan



## USING INNOVATIVE BIOCHAR TECHNOLOGY TO FILTER PFAS

While biochar—a porous carbon material—is typically used for improving soil conditions, it also has multiple advanced applications. Dr. Qi Hua Fan, Associate Professor in the Department of Electrical and Computer Engineering and the Department of Chemical Engineering and Materials Science, developed an innovative biochar technology with a polarized active surface designed to trap PFAS chains. The technology allows these chemicals to be treated in a plasma chamber to break them down and destroy their structural chains. Dr. Fan's Plasma Sources and Processing Lab at MSU is scaling up testing and production of this filtration system to commercialize the technology.





## New Technology Decontaminates Wastewater in Grand Rapids

MSU and Fraunhofer USA Center Midwest (Fraunhofer) have made strong progress on a viable solution to destroy PFAS in wastewater using electrochemical oxidation (EO) with boron-doped diamond (BDD) electrodes. Their work with the Grand Rapids Water Resource Recovery Facility has shown promising results. Electrochemical treatment approaches to remediation have shown exceptional potential over the last decade for breaking down contaminants.

*“We found that electrochemical oxidation using BDD electrodes was effective at breaking down more than 70 percent of total PFAS contamination in landfill leachate (liquid that drains from a landfill) wastewater over six hours of treatment time. Now in scale-up, this new method may be a viable way to effectively treat thousands of gallons of wastewater for cities in Michigan and around the world.”*

**Dr. Suzanne Witt**

Electrochemist with the Fraunhofer USA Center Midwest at MSU

Wastewater treatment is a multistep process used to remove contaminants or additives in order to create water clean enough for discharge. MSU and Fraunhofer developed a laboratory-scale EO system that destroys PFAS in contaminated wastewater. The process itself transforms PFAS into carbon dioxide, fluoride, and water. As an industry leader in diamond technology, MSU and Fraunhofer’s BDD electrodes prove their worth after hundreds of treatment rounds with little to no wear. Their combined expertise in diamond fabrication, electrochemistry, and reactor design creates a diverse team of professors, scientists, and students capable of solving an emerging, yet significant, issue in water-based PFAS contamination.

Ongoing efforts focus on exploring treatment train scenarios that have the potential to reduce the energy consumption of PFAS removal and degradation, as well as mitigate the formation of unwanted byproducts such as perchlorate. Fraunhofer’s testing of these treatment strategies at lab- and pilot-scale will further understanding of optimizing permanent destruction approaches of PFAS in leachate wastewater.

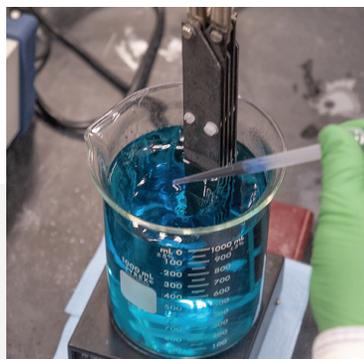
## U-M Urban Collaboratory Unites Campus and City Hall to Fight PFAS

The U-M Urban Collaboratory is a community of scholars that works directly with communities to address targeted challenges that impact the health and livability of urban centers. With respect to PFAS, the Urban Collaboratory has dedicated time and expertise to addressing this complicated issue with key stakeholders, including work with the State of Michigan to match state priorities with U-M research teams. Two such teams are working on a rapid, field-deployed PFAS detection sensor and a true destruction technology involving a patented plasma treatment process.

The Urban Collaboratory, established in 2017, starts with stakeholder engagement to understand a community's needs and priorities, and then gathers research faculty across U-M's Ann Arbor campus and disciplinary spectrum. The resulting interdisciplinary teams are poised to address complex challenges from a multitude of expertise, including engineering, urban planning and design, computing and analytics, spatial informatics, social science, public health, policy, and education.

*“It’s exciting to work with communities and stakeholders throughout the state to address complex challenges. PFAS are a great example where we first listened to community needs and research priorities and then networked across campus to find technologies and researchers that could address specific issues. In some cases, researchers weren’t working on PFAS specifically, but their research was relevant to solving some of the many complex problems associated with this emerging contaminant.”*

**Charles C. (Curt) Wolf**, MBA, P.E.  
Managing Director of the Urban Collaboratory,  
U-M College of Engineering



### USING BUBBLES TO COLLECT PFAS

Dr. Long Luo, WSU assistant chemistry professor, developed a simple and efficient method for preconcentrating PFAS in water, crediting this innovation to sea spray. As bubbles in the ocean burst, they form a sea-spray aerosol, and the resulting particles are then enriched in active organic compounds on the surface.

In the lab, Dr. Luo and his team generated bubbles that gather PFAS molecules as they rise through the water. When these bubbles reach the surface, they burst and produce aerosol droplets enriched in PFAS, which are then collected on a glass slide. According to Dr. Luo, these droplets “contain roughly a thousand times more PFAS than the initial sample.”

Dr. Luo's method effectively concentrates ten common types of PFAS. Tests would preconcentrate these substances in tap water, indicating a potential use for quantitative analysis of PFAS in real-world water samples (Cao et al. 2019)





## Protecting Michigan's Air and Water

### U-M Graham Sustainability Institute Water Center

The Water Center at U-M's Graham Sustainability Institute tackles complex issues such as urban and agricultural discharges, climate change, and emerging contaminants of concern in the Great Lakes region and across the nation. All projects are grounded in a collaborative research approach that informs policy and management decisions affecting shared waters.

*"We have seen that engaging stakeholders early in the research process, such as when we're initially developing ideas, and being able to integrate their comments throughout the life of the project results in work more closely aligned with their needs. Stakeholders find our work responsive to their questions and specific concerns and, therefore, requires little to no adaptation before it can be integrated into their own work."*

#### Dr. Jennifer Read

Director of the Water Center at the Graham Sustainability Institute at U-M

One recent project by Water Center researchers has focused on harmful algal blooms (HABs), such as those common to the western basin of Lake Erie, which required the City of Toledo to close its drinking water plant. The species of cyanobacteria, *Microcystis*, found in these HABs produces toxins that pose serious threats to animal and human health. Agricultural lands that drain to Lake Erie contribute the high phosphorus loads necessary for the cyanobacteria to thrive (Water Center 2016).

Recent work has focused on lead in public water supplies across Michigan with the introduction of the revised state Lead and Copper Rule in 2018. The Water Center convened a multisector advisory group comprising state public health agency personnel, water utility managers, local public health officials, members of frontline community groups, and technical experts. The advisory group identified questions of concern from their extended networks, which a multidisciplinary team of public health, policy, technical, and communication experts addressed. The resulting package of frequently asked questions, financial policy briefs, and infographics is available for

use by communities across the state to communicate with consumers about understanding and mitigating the risk of lead in their drinking water.

## **WSU Healthy Urban Waters: Huron-to-Erie Real-time Drinking Water Protection Network**

HUW is a collaboration of WSU researchers—networked with the Detroit community—that focuses on water in urban settings and its relationship to residents, the ecosystem, health, and the economy. Recent activities include projects defining and mitigating microplastics pollution, PFAS, flooding, and emerging contaminants in regional waterways. These waterways provide drinking water to more than three million people in Southeast Michigan. Legacy contaminants from manufacturing, the global shipping industry, and combined sewer overflows provide a challenging situation requiring constant vigilance.

The Huron-to-Erie Real-time Drinking Water Protection Network was created in the 1990s to provide a monitoring system and communication strategy for the drinking water utilities within the network. More recently, WSU's HUW team provided expertise to expand the communication through a public portal that provides current and historical data regarding

water quality in this corridor. In 2017, WSU's HUW program joined the Michigan Office of the Great Lakes and the Southeast Michigan Council of Governments in assessing the status of the network in the international corridor. The report produced recommendations and action steps for improving and expanding the network to further protect drinking water for millions of Michiganders.

*“Healthy Urban Waters has evolved into an essential collaborator with community partners, along with state and local agencies, to better understand and mitigate environmental impacts from regional pollutants on the land and in the water. Expanding collaborations with WSU’s medical programs and local, nationally recognized hospital systems, have positively impacted the public health outcomes of environmentally related diseases and threats.”*

**Dr. Carol J. Miller**, PhD, PE  
WSU Professor of Civil and Environmental Engineering and Director of HUW, WSU Co-Director of One Health Initiative







## **MSU Supports the Next Generation of Environmental Leaders**

MSU's 4-H program and Microsoft are helping Alpena teens change behaviors in their community by educating neighbors and businesses about microplastics and how they pollute the Great Lakes. Alpena County 4-H received one of only eight grants nationwide from Microsoft's 4-H Tech Changemakers program, which provides the necessary tools and training to support communities. These Alpena teens are learning to advocate for their community's needs and broadening perceptions about the opportunities that digital skills can provide.

## **WSU Collaboration with Kids' Health Connections**

In the U.S., an estimated 5.5 million children have asthma (CDC 2019). A child with asthma may miss more school days and have more emergency room visits than a peer without the disease. WSU's School of Medicine and Kids' Health Connections are working to improve quality of life for this vulnerable population in the Detroit area—where air pollution greatly worsens asthma symptoms. The team seeks to provide cost-effective, evidence-based interventions to improve asthma control scores among underserved children by reducing barriers to optimal asthma management. The research is funded through a \$3.2 million award from the National Heart, Lung, and Blood Institute.

## **Smart Energy for Cleaner Great Lakes**

Researchers at WSU launched the Locational Emissions Estimation Methodology (LEEM) to track, control, and reduce emissions of mercury, carbon, and other pollutants resulting from electricity consumption. Currently, LEEM emission-intensity data are available in 18 states, but the team hopes to expand availability, especially given LEEM's power to support commercial needs and serve communities. The LEEM venture has also spurred a WSU startup business, Energy Emissions Intelligence, which provides data for energy managers, energy management system developers, and users.



# Collaborating on Freshwater Innovation

## Michigan's Freshwater Future

The human health risks associated with aging water and wastewater infrastructure are well documented, from emerging contaminants, lead, copper, PFAS, and pharmaceuticals, to waterborne pathogens, such as *Giardia*, *Legionella*, norovirus, *E. coli*, and the novel coronavirus (COVID-19). These risks disproportionately affect individuals living in resource-scarce communities and communities of color, creating multigenerational social justice issues.

Michigan utilities struggle with funding, inadequate staffing, and deferred maintenance. They need effective, cost-efficient solutions—the type of solutions that URC researchers are studying, developing, testing, and sharing with partners from utilities and industry. Working with industry and municipal partners, they are engaged in solving the major water and wastewater challenges in our state.

For example, the URC institutions are part of a sponsored research program run by the Great Lakes Water Authority (GLWA) that launched in 2018. GLWA is Michigan's largest water utility and serves four million customers across 125 Southeast Michigan communities, including Detroit. Recognizing the potential for technological innovations to mitigate health risks in their water and wastewater systems while saving money in the long term, GLWA allocates approximately \$2 million a year to contract researchers at URC institutions for conducting research and testing new innovations.

Dozens of freshwater projects are underway, including efforts that track COVID-19 in wastewater and epidemiological studies that examine threshold levels for PFAS in drinking water. The following examples of the URC institutions' work with GLWA highlight efforts across the URC and exemplify robust collaborations with industry and municipal partners.

“The purpose of these partnerships is to continue improving GLWA's water treatment processes, discover solutions for unanticipated risks, and reduce energy consumption, thereby reducing polluting emissions, among other things,” said Cheryl Porter, GLWA's chief operating officer. “This innovative, new approach to water and sewerage treatment is also anticipated to help GLWA attract and retain top talent in the state of Michigan and provide a hands-on learning experience to students” (King 2018).

## Sensor Technology Helps Extend the Life of Aging Pipelines

Like most major U.S. cities, Detroit has a problem hiding beneath the streets—outdated water and sewer pipeline systems. The American Society of Civil Engineers estimates the U.S. experiences 240,000 water main breaks per year, wasting more than two trillion gallons of treated drinking water.

U-M researchers are collaborating with GLWA and Structural Technologies, an engineering firm, on a pilot project in Detroit that combines the power of smart infrastructure sensors and innovative lining technologies. Together, they bolster pipeline strength and alert the utility about possible line ruptures that may leave residents without service and cost municipalities millions to repair.

In August 2020, GLWA crews installed a liner inside a pipeline a few miles east of Detroit's main downtown area. Created by Structural Technologies, the liner is made of both mortar composites and steel-reinforced polymer, increasing pipeline durability and adding structural capacity.

“Our research focuses on finding cost-effective ways to identify when aging infrastructure systems are showing signs of breakdown,” said Dr. Jerome Lynch, former chair of U-M's Department of Civil



and Environmental Engineering and director of the Laboratory of Intelligent Systems Technology and current dean of Engineering at Duke University. “If we can do that successfully, we’re able to identify distress before failure occurs. That way, the data can lead us to more cost-effective intervention strategies.”

Existing cast iron piping in the repaired area was from 1913—more than 100 years old. Detroit announced a five-year, \$500 million replacement program for water and sewer pipes throughout the city in 2019, the first major upgrade to the system in roughly 90 years. Detroit is not alone: Over the next 25 years, as much as \$1 trillion in funding for drinking water will be needed to maintain current services, according to the American Water Works Association.

With the help of URC research partnerships, utilities and municipalities can leverage new methods and technologies to mitigate costs and keep clean water flowing safely and affordably.

## **PFAS Insights Found through Water Models**

Led by the HUW Initiative at WSU, the PFAS study focuses on contaminants of emerging concern through the drinking water treatment process. The study will improve an existing water system that captures data on water quality from Lake Huron to

Lake Erie. There are 15 utility systems, including GLWA, that draw source water from the 80-mile stretch of these connected waterways to serve people in various communities.

Many wastewater treatment plants are not designed to filter out PFAS chemicals, and there are several possible points within the Huron-to-Erie Corridor that contribute to the accumulation within waterways.

Dr. Carol Miller, director of HUW and professor of civil and environmental engineering at WSU, will compile findings into one central database. This information will be broadly available to researchers and the public for both simple status checkups as well as complex environmental analyses.

“Monitoring water quality is a major challenge due to the large numbers of chemicals that can make their way into our waters,” said Dr. Miller. “Our research with the GLWA will allow us to quickly identify and share water quality concerns and determine the most effective treatment technologies to target the wide range of chemicals that may be present.”

The results will help better locate where water quality may shift along the route and serve as an early warning system. Research-related enhancements further leverage a State of Michigan investment to provide updated equipment for monitoring.





## MSU Tests Wastewater Statewide for Early COVID-19 Detection

All three URC institutions are active in wastewater monitoring and research for pathogen detection to provide early warning of possible illness. In December 2020, MSU researchers received \$2.1 million in grant funding to conduct COVID-19 testing statewide. Funded by EGLE, MDHHS, and a portion of Michigan's federal Coronavirus Aid, Relief, and Economic Security Act, existing wastewater surveillance programs were further supported to quickly establish a standardized, coordinated network of monitoring systems across Michigan.

MSU researcher Dr. Joan Rose, the Homer Nowlin Chair in Water Research, was awarded \$1.3 million of the total funding to train and assist labs with analytical methods. Dr. Rose works with 20 advanced polymerase chain reaction (PCR) laboratories around the state. PCR is a valuable DNA-based technology tool that helps detect viruses.

More than 100 wastewater locations are monitored to provide early warning and to assist health departments with implementing public health measures to prevent the spread of the severe acute respiratory syndrome coronavirus 2 (SARS-COV-2), particularly among vulnerable populations.

“Early in the infection—from both people with and without symptoms—the virus is excreted in feces and ends up in wastewater,” said Dr. Rose. “Working with wastewater utilities, we can provide an early look at what is happening in the community, maybe up to a week in advance.”

Dr. Irene Xagorarakis, professor of civil and environmental engineering at MSU, was awarded \$800,000 to expand an ongoing COVID-19 detection program to test untreated sewage in the Detroit area. In 2017, she received funding from the National Science Foundation to begin a wastewater-based epidemiology project in collaboration with GLWA and the Detroit Water and Sewerage Department. In April 2020 and June 2021, Dr. Xagorarakis received additional funding to focus on COVID-19 and develop an early warning system for the metro Detroit area.

*“Our early work confirmed the validity of the method to provide early warning of multiple viral diseases, including COVID-19. The Detroit project goes above and beyond simple testing of wastewater. We include multiple other data, measurements, and processes to provide a tool that can be used by public health officials.”*

**Dr. Irene Xagorarakis**

Professor of Civil and Environmental Engineering, MSU

# Conclusion: Making an Impact

URC institutions have been at the forefront of tackling environmental health threats to people and communities through research conducted in communities and at university-based centers. This includes issues like air and water quality in urban, industrial, and agricultural areas; lead exposure; and PFAS levels in drinking water. These centers coordinate with local, state, and national partners to also study environmental threats related to aging infrastructure and emerging issues, like microplastics and invasive species in our lakes and rivers.

Researchers have led the way to identifying solutions that have tangible impacts on the quality of health and life for Michiganders, including those who are most vulnerable to environmental threats. These solutions stem from URC research efforts to discover and develop innovations in technology, policy, and practice. The COVID-19 pandemic has only heightened the urgency of these issues. The URC institutions are committed to continuing high-impact work that helps move Michigan forward.



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