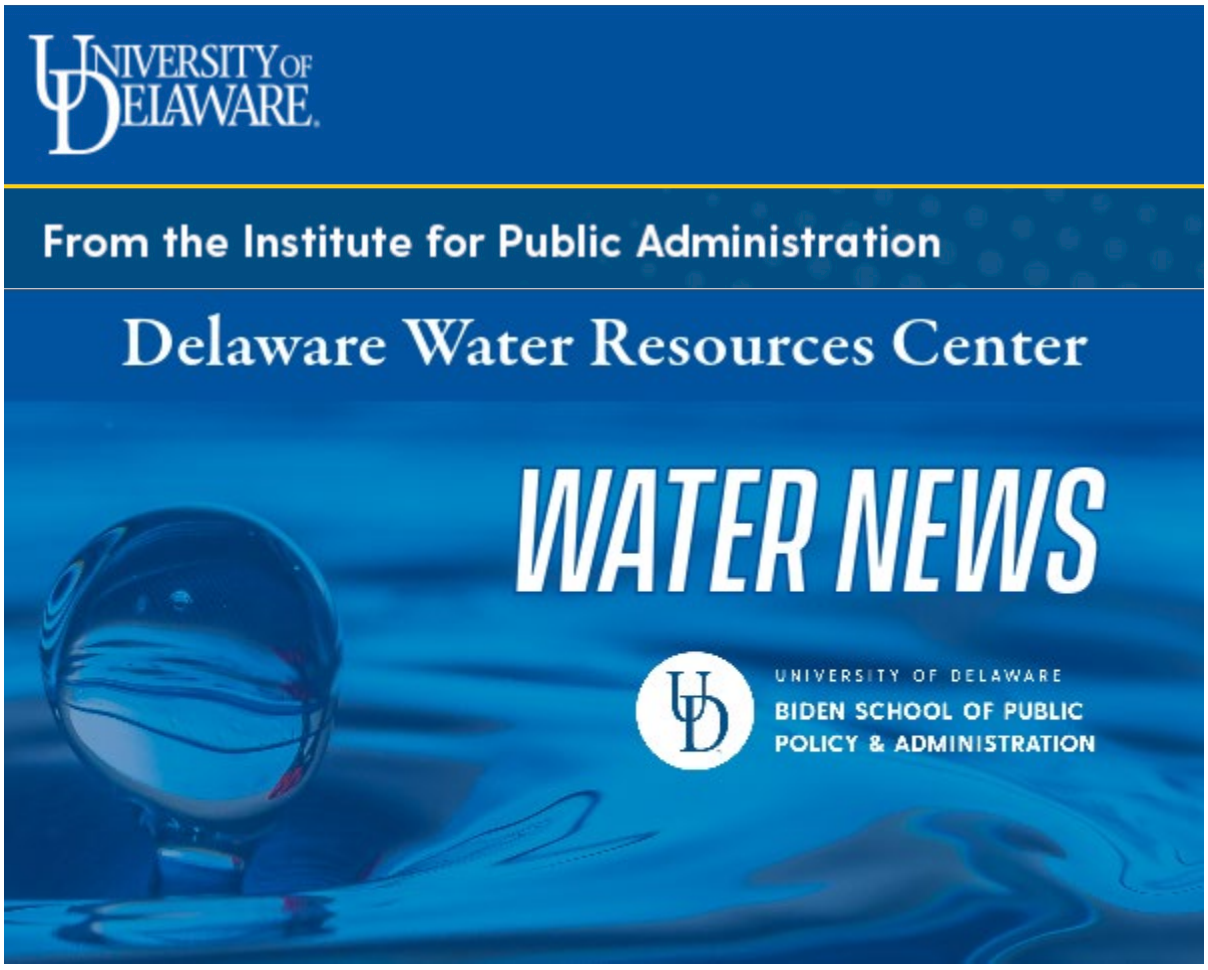

October 2023, Volume 21 No. 1

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UDWRC Director's Message

The UDWRC, Presidentially Speaking...

Dr. Gerald Joseph McAdams Kauffman, Jr., Director
University of Delaware Water Resources Center

Newly inducted President Gerald Kauffman at the UCOWR Annual Conference on June 14, 2023, at Colorado State University in Ft. Collins, CO.

Delaware is the First State and has had a prominent presidential role in leadership lately. After all, a Delaware resident leads the nation and indeed the free world. As one of the million residents in our small state, I am even more aware now of our standing in the nation and worldwide. You could also say that the UDWRC is “presidential” and indeed we are noted as a national leader in water resources research, education, and public service.

UDWRC is a Congressionally chartered water research institute: Established on-campus in 1965 in the year after Lyndon Baines Johnson signed the Water Resources Research Act (WRRA) of 1964, the UDWRC is one of the 54 Congressionally chartered National Institutes for Water Resources (NIWR) supported by the Department of Interior and U.S Geological Survey at land grant universities in the 50 states, D.C., and three island territories of Guan, Puerto Rico, and U.S. Virgin Islands.

UDWRC top ranked in the nation by USGS: The UDWRC is recognized as "exceptional" in support of our students at Delaware universities. Per the Water Resources Research Act of 1984, the Secretary of Interior and Director of the U.S. Geological Survey informed the President of the University of Delaware by letter that the UDWRC is “unique nationally” and its collaborations are “impressive” amounting to a “high” rating and top 12 ranking nationwide among the 54 land grant universities. The five-year evaluation of the 54 National Institutes for Water Resources (NIWR) at land grant universities that stretch from Maine to Micronesia noted that our institute: (1) Engages with universities/colleges around the state, (2) Has strong leadership on the part of the Institute Director, and (3) Facilitates research and information transfer closely tied to the water resources needs/issues of Delaware.

UD AWRA voted national student chapter of the year: Our national prominence in water is further cemented with news that the University of Delaware student section of the American Water Resources Association (UDAWRA) was voted for the 4th time as the national chapter of the year, a feat matched only by the University of Wisconsin and the University of Florida. Martha C. Narvaez is the faculty advisor of the nationally prominent UD student section of the AWRA.

American Water Resources Association (AWRA) 51st President: In 2015, Martha C. Narvaez was elected as the 51st President of the American Water Resources Association (AWRA). The AWRA was established in 1964 and with 25,000 members is the world's largest water resources professional organization.

Brandywine Red Clay Alliance (BRC) 77th President: In 2021, Andrew R. Homsey was elected as the 77th President of the Brandywine Red Clay Alliance of West Chester, Pennsylvania which was established in 1945 as the oldest small watershed association in the United States.

Universities Council on Water Resources (UCOWR) 59th President: In June 2023 at the national conference at Colorado State University, DWRC director Gerald J. Kauffman was elected as the 59th President of the Universities Council on Water Resources (UCOWR) which represents the 80 water resources research and degree-granting institutions of higher learning in America. Established in 1964, the UCOWR board is composed of faculty from the University of Delaware, Texas A&M, Minnesota, Oklahoma State, Mississippi State, Penn State, Purdue, Virginia Tech, Kansas State, University of Hawaii, University of California Berkeley, Washington State, and Southern Illinois University.

About the UDWRC

Mission: Established in 1965 as one of the 54 National Institutes for Water Resources (NIWR) at land grant universities in the 50 states, the District of Columbia, and three island territories of Guam, Puerto Rico, and the U.S. Virgin Islands. The UDWRC is Congressionally-mandated by Section 104 of the Water Resources Research Act of 1984 and 1964 administered by the U.S. Department of the Interior and U.S. Geological Survey. As part of the NIWR network, the mission of the UDWRC is to: (1) support research, education, and public outreach programs that focus on water supply, water management, and water quality—issues important to Delaware citizens and (2) foster/support training and education programs for future water scientists, engineers, managers, and policy-makers who will lead the water resources research, planning, and management efforts in our state.

Staffing: The UDWRC hosts the following faculty, scientists, and students to fulfill our mission:

Gerald J. Kauffman - Director/Associate Professor
Martha C. Narvaez - Policy Scientist/Associate Director
Nicole M. Minni - Associate Policy Scientist/GIS Laboratory, Lewes Campus
Andrew R. Homsey - Policy Scientist/GIS Manager
Marta Driscoll - Grant Analyst
Liz Shields - Post-Graduate Research Fellow (Master of Public Policy)
Lydia Franks - Graduate Research Fellow (Master of Water Science & Policy)
Jhaney Hamlett - Graduate Research Fellow (Master of Public Administration)
Alex Makowski - Graduate Research Fellow (Master of Public Administration)
Megan Wassil - Graduate Research Fellow (Master of Water Science & Policy)

UDWRC Advisory Panel

Stefanie Baxter
Delaware Geological Survey
University of Delaware, Newark, DE

Dr. Asia Dowtin
Department of Forestry
Michigan State University, East Lansing, MI

Dr. Dewayne Fox
College of Agriculture and Related Sciences
Delaware State University, Dover, DE

Christian Hauser
Delaware Sea Grant
Newark, DE

Dr. Miling Li
School of Marine Science & Policy
University of Delaware, Newark, DE

Stacy McNatt
Department of Special Services
New Castle County, New Castle, DE

Shane Morgan
White Clay Creek Wild and Scenic Management Program
Landenberg, PA

Chris Oh
Department of Public Works
City of Wilmington, Wilmington, DE

Erica Rossetti
Partnership for the Delaware Estuary
Wilmington, DE

Betzaida (Betzy) Reyes
U.S. Geological Survey
Dover, DE

Ethan Robinson
Department of Public Works
City of Newark, Newark, DE

Kash Srinivasan
Kash Srinivasan Group
Wilmington, DE

Kristen Travers
Delaware Nature Society
Hockessin, DE

Dr. Caroline Voter
Civil and Environmental Engineering
University of Delaware, Newark, DE

Steve Williams
DE DNREC Division of Watershed Stewardship
Dover, DE

Meet the 2023-2024 UDWRC Graduate Research Fellows

Lydia Franks

Lydia is a second-year Master's student in the Water Science and Policy Program and Co-Chair for the University of Delaware Student Chapter of the American Water Resources Association (AWRA). She is from Northeast Ohio and completed her Bachelor's degree in Environmental Science at the University of Akron. Prior to joining the University of Delaware community, Lydia worked in county parks systems and environmental consulting. Currently, at the Water Resources Center, she conducts water quality monitoring for the White Clay Creek National Wild and Scenic River Program, works with the City of Wilmington to locate and inventory water service lines according to the EPA's Lead and Copper Rule, assists with GIS projects on shoreline conditions and stormwater management, and is assisting with an economic valuation report of the upper Delaware River watershed in New Jersey. Lydia's primary research interests include human impacts on water quality and watershed restoration.

Jhaney Hamlett

Jhaney is a 2019 graduate of Delaware State University where she received her bachelor’s degree in Mass Communications with a specialization in Public Relations. After graduation, Jhaney’s background of connecting with communities and personal affinity for protecting the environment led her to work at Delaware Nature Society as a Communications and Outreach Coordinator. In this position, Jhaney found an appreciation for nonprofit work to service and improve the community. Jhaney’s work experience, mentorship, and encouragement from colleagues have brought her to the University of Delaware to continue her studies at the Biden School’s Institute for Public Administration to pursue a Master of Public Administration (MPA) degree, where she will specialize in Nonprofit Management. During Jhaney’s time in the MPA program, she will be working as a fellow with the University of Delaware’s Water Resources Center. Jhaney hopes that specializing in nonprofit work will give her the skills to be an advocate and do work that can bring social justice.

Alex Makowski

Alex is in his final semester of the Master's in Public Administration (MPA) program. He is a Delaware native and obtained his Bachelor's in Agriculture and Natural Resources from the University of Delaware. He was selected as a Legislative Fellow for the House Majority Caucus for the 2022 legislative session. He was then selected as a Graduate Research Assistant for the Water Resources Center where he has worked on projects for the White Clay Creek National Wild and Scenic River Program, the Center for the Inland Bays, and the City of Wilmington's lead pipe inventory program in conjunction with the EPA's Lead and Copper Rule.

Elizabeth Shields

Liz is a Delaware native and recent graduate of the Biden School’s Master of Public Policy program where she concentrated in environmental policy and climate change studies. She also earned her Bachelor’s in Environmental Studies from the University of Delaware’s College of Earth, Ocean, and Environment in 2020. Her research involves various activities throughout the Delaware River Watershed and projects related to community engagement around water, climate, and Environmental Justice topics. Liz volunteers on the Executive Committee of the Delaware Chapter for the Sierra Club where she is Co-Chair of the Climate & Energy Committee. She currently lives in Pike Creek with her family and dog, Myla.

Megan Wassil

Megan is a first-year Master's student in the Water Science and Policy program. She is from Lincoln University, Pennsylvania, and received her Bachelor's degree from the University of Delaware in Environmental Engineering. Megan has worked on various projects with the Delaware Water Resources Center in her undergraduate career which included water quality testing of the White Clay Creek, sampling of the tidal Christina River, and PFAS testing in various locations. This past summer Megan reviewed work orders of public water lines in the City of Wilmington to track lead pipes in Wilmington’s drinking water system.

Meet the 2023-2024 UDWRC Undergraduate Research Interns

FY24 Student Support

Beginning in June 2023, the UDWRC is supporting seventeen students, thirteen undergraduate, and four graduate water research internships, during FY24 through the annual base (104b) grants. The UDWRC research students are scheduled to present their research findings at the 59th annual meeting of the UDWRC Advisory Panel next May at the University of Delaware

Student Research Projects

Aaron Balmer, Wildlife Ecology
City of Wilmington Lead Inventory

Sasha Altman, Environmental Studies & Public Policy
Assessment of PFAS in the Drinking Water Streams in Delaware

Ambre Crawford, Marine Science
Water Quality and Quantity Trends along the Nanticoke River in Delaware and Maryland

Cooper Feeny, Economics & Public Policy
Taste, Odor, Water Quality and Public Perception of Drinking Water Supplies in Delaware

Caroline Gilliard, Environmental Engineering
Hydraulic Analysis of Floods along the Brandywine River in Delaware

Catherine Gilman, Energy & Environmental Policy
Evaluating the Effectiveness of Reimplementing a Bottle Bill for Cleaner Waterways in Delaware

Nicole Gutkowski, Marine Science
Identification and monitoring of PFAS in ground and surface water supplies in Delaware

Elizabeth Manning, Environmental Engineering
Watershed Characterization of the Tributaries Along the Red Clay Creek

Summer Moals, Agriculture (DSU)
The Effectiveness of Artificial Floating Wetlands with Different Aquatic Plants to Remove Water Nutrients: A Case Study at Delaware State University Aquaponics Research Facility

Cole Palmer, Fisheries Management (DSU)
Consolidation of Delaware's Insects of Greatest Conservation Need and Associations With Nontidal Freshwater Wetlands

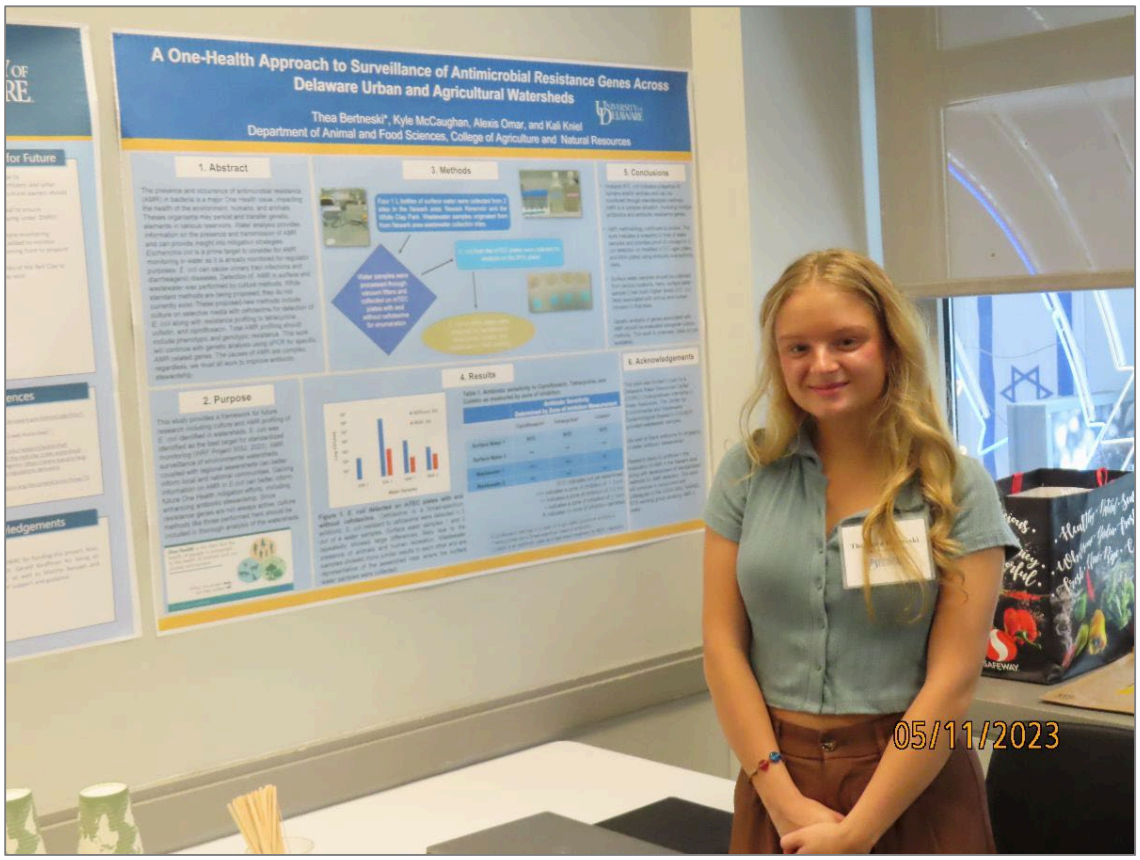
Brayden Rochester, Environmental Engineering
Soil Remediation Through Advanced Evaporative Treatment Technologies

Jordan Rosales, Geological Sciences
Introduction of Heavy Metals in the Christina

Dmitriy Rybin, Civil Engineering
City of Wilmington Lead Inventory

FY23 UDWRC Undergraduate Intern Research Projects

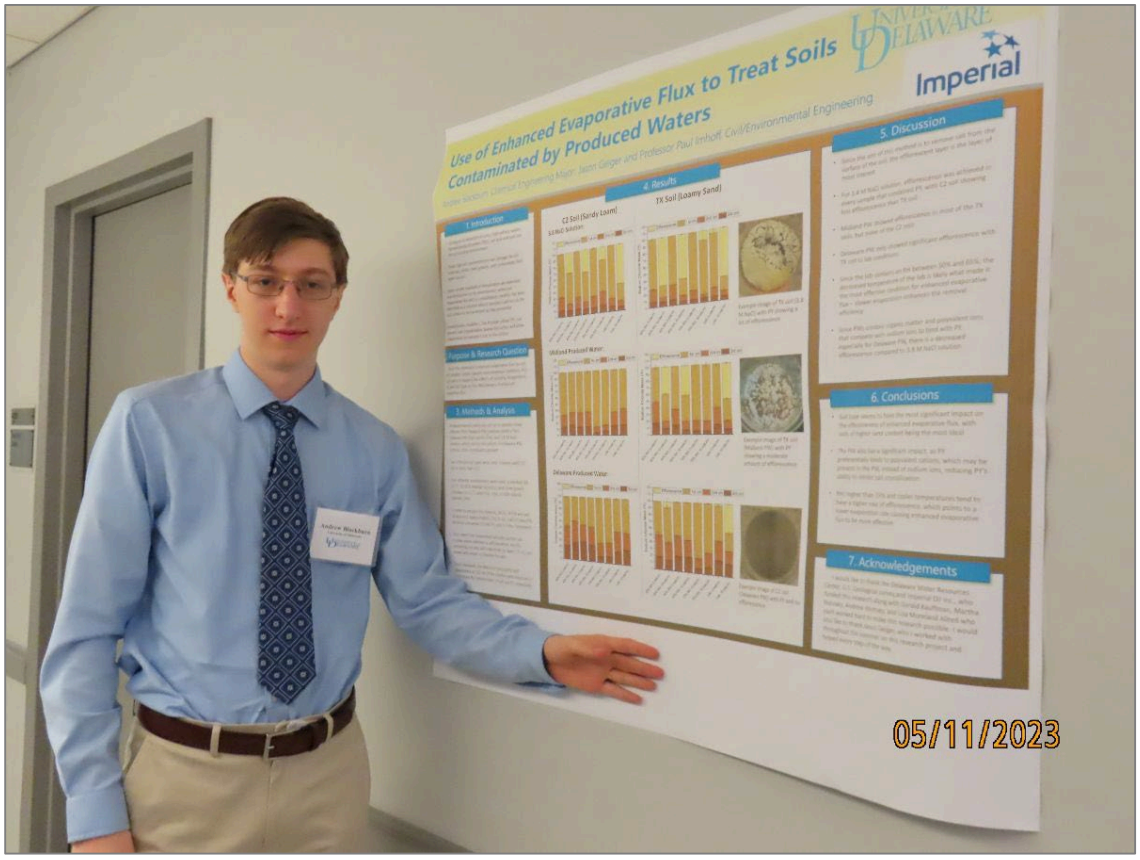
Surveillance of Antimicrobial Resistance Genes Across Delaware Watersheds
Theodora Bertnesk
Major: *Food Science*



The presence and occurrence of antimicrobial resistance (AMR) in bacteria is a major One Health issue, impacting the health of the environment, humans, and animals. These organisms may persist and transfer genetic elements in various reservoirs. Water analysis provides information on the presence and transmission of AMR and can provide insight into mitigation strategies. Escherichia coli is a prime target to consider for AMR monitoring in water as it is already monitored for regulator purposes. E. coli can cause urinary tract infections and diarrheagenic diseases.

Detection of AMR in surface and wastewater was performed by culture methods. While standard methods are being proposed, they do not currently exist. These proposed new methods include culture on selective media with cefotaxime for detection of E.coli along with resistance profiling to tetracycline, colistin, and ciprofloxacin. Total AMR profiling should include phenotypic and genotypic resistance. This work will continue with genetic analysis using qPCR for specific AMR-related genes. The causes of AMR are complex; regardless, we must all work to improve antibiotic stewardship.

Use of Enhanced Evaporative Flux to Treat Soils Contaminated by Produced Waters
Andrew Blackburn
Major: *Chemical Engineering*



During oil extraction, high-salinity waters are produced that can spill and contaminate the surrounding soil and groundwater. These high salt concentrations prevent plant life, modify hydraulic soil properties, and can pollute the local watershed enough to harm aquatic life. Currently, spills are most remediated using excavation and backfill, a process that is expensive and disruptive to the environment. In a less disruptive method, enhanced evaporative flux can be used to remove the salt from the soils using a crystallization modifier, potassium ferrocyanide, also known as Prussian yellow. More specifically, the Prussian yellow inhibits salt crystallization, which allows the water evaporation to carry the salt ions to the surface, where they can precipitate and be harvested. However, this method has not been properly studied under relevant environmental conditions. To explore the influence of atmospheric conditions, four different environments were used covering a range of temperatures and humidities. Two types of

soil were used, sandy loam and loamy sand, as well as three produced waters: two actual produced waters from the Permian Basin and a 3.8 M sodium chloride solution. Other studies involving this method of soil remediation claim that ferrocyanide can provide 60-90% efflorescence. However, the results in this study suggest that these removal rates depend on both the produced water composition and the environment since an increase in polyvalent ion concentrations and evaporation rates can decrease the removal efficiency. Soil structure has the most significant impact on the effectiveness of enhanced evaporative flux, with a preference for higher sand concentration. As for humidity, having a higher than 15% relative humidity and a cooler temperature result in a higher amount of efflorescence, which suggests that a lower evaporation rate will allow the enhanced evaporative flux process to remove more salt contaminants.

Water Quality Monitoring Along the Red Clay Creek and Tributaries in Delaware and Pennsylvania
Francesca Discenza
Major: *Environmental Engineering*

Jake Marren
Major: *Environmental Engineering*

The University of Delaware Water Resources Center (UDWRC) conducted water quality monitoring and trends analysis along the Red Clay Creek in Delaware and Pennsylvania. Water quality samples were collected at eleven stations, in Pennsylvania and Delaware for water quality criteria parameters. Appendix A contains a site map of all the locations sampled. Most of the location's samples contained concentrations below DNREC (Delaware Natural Resources and Environmental Control) and EPA (U.S. Environmental Protection Agency) standards. The only elements that contained traces above standards were nitrogen and phosphorus.

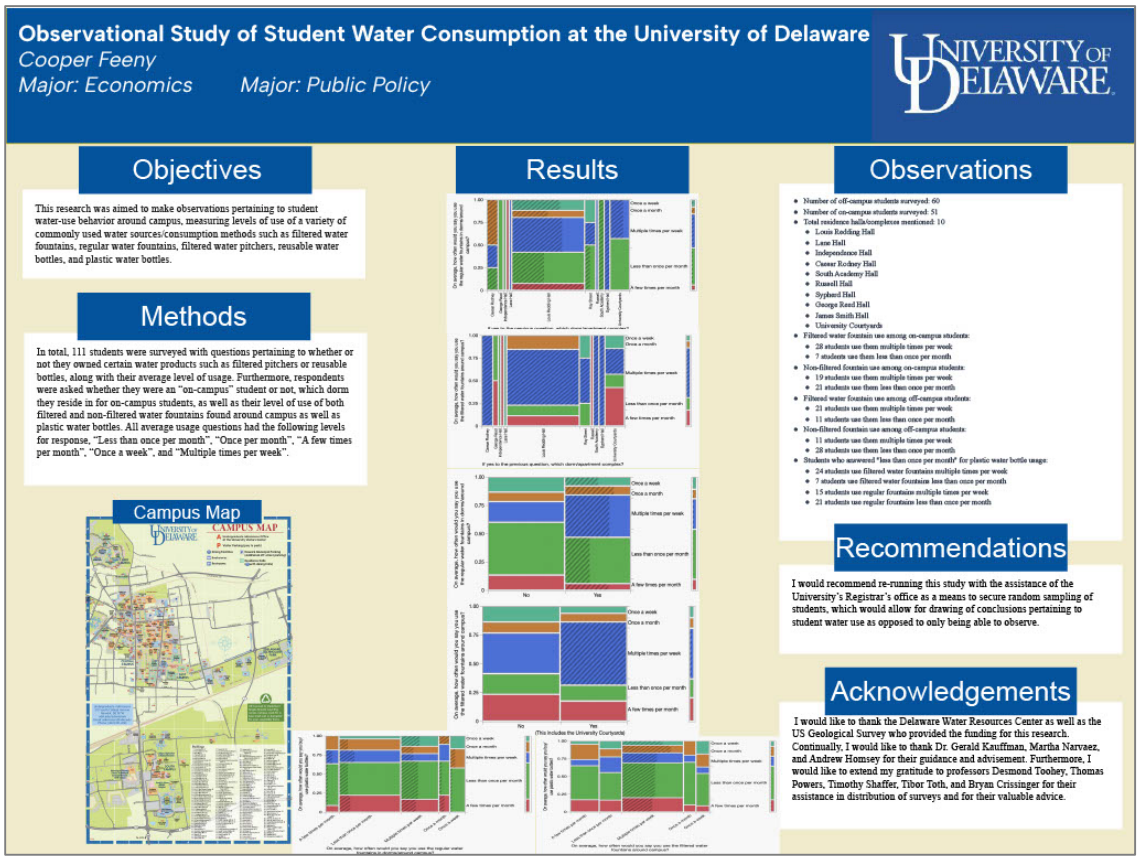
Vibrio parahaemolyticus bacteriophage VPMS1 DNA Polymerase I is active at a diverse range of temperatures

Owen Donnelly
Major: *Biology*

The removal of marine pathogenic bacteria via viral bacteriophage infection is a prominent way to control microbial communities and ensure safe drinking water availability. DNA polymerase I (polA), is present in 25% of dsDNA viruses that infect bacteria (phages) and is the sole replication enzyme for these phages. The 762 residue (E. coli numbering) is responsible for dNTP incorporation and amino acid substitutions at this single position can have profound effects on enzyme replication speed and accuracy. Tyrosine substitutions increase enzyme speed, compared to wild-type phenylalanine, and are associated with lytic viral life cycles, while leucine substitutions greatly increase fidelity at the expense of speed and are associated with temperate life cycles. The lytic Vibrio parahaemolyticus phage VPMS1 carries a polA with the wild-type phenylalanine 762 residue. Strengthening the connection between the 762 residue and the biochemical characteristics of polA can improve life-cycle predictions of unknown phages. This study sought to investigate whether the biochemistry of a viral polA under optimal conditions is predictive of the known lifestyle of the reference phage VPMS1. After producing and purifying a VPMS1 polA stock, contaminating nucleases such as DNase and RNase were found to be below the limit of detection. Primer extension and specific activity assays were performed within the VPMS1 isolation location's environmental temperature range (19℃ to 30°C). The VPMS1 polA strong primer extension throughout and beyond the range (19°C to 37°C), with peak performance observed at 28°C. The diverse range of successful primer extension temperatures was notable in this study due to the enzyme's tolerance of high temperatures ranging to

37°C. Specific activity assays found VPMS1 PolA to be slower than that of a Tyrosine 762 residue, thus supporting the 762 residue hypothesis.

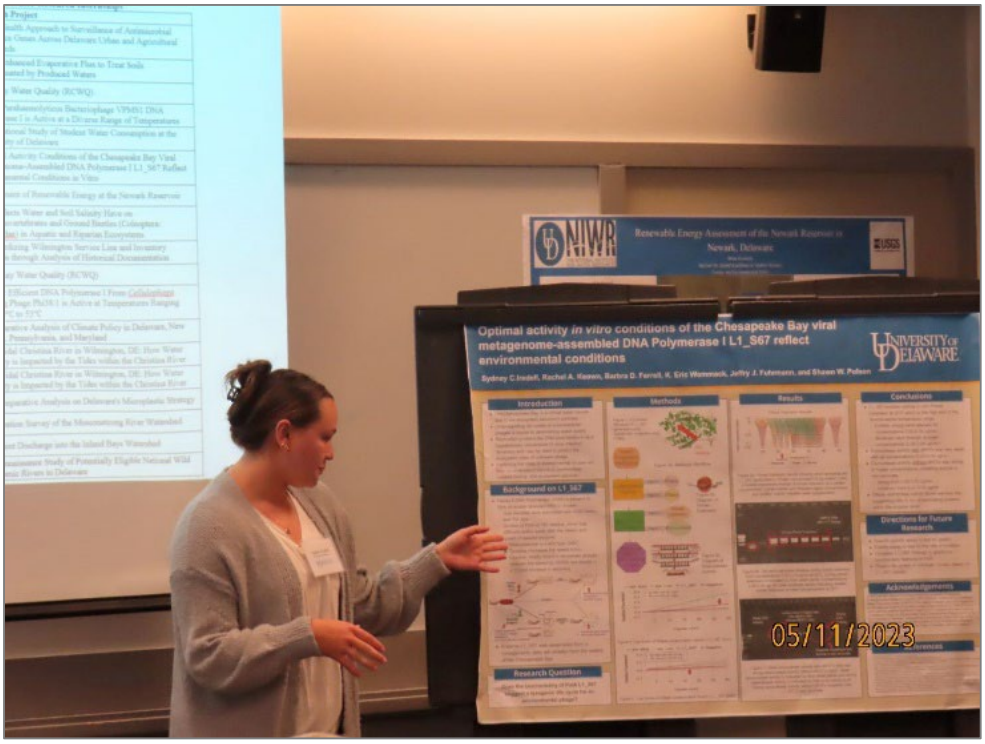
Observational Study of Student Water Consumption at the University of Delaware
Cooper Feeny
Major: *Economics and Public Policy*



The University of Delaware, throughout the school year, provides education to 23,613 students (University of Delaware), these students being a mix of undergraduates, graduate, and professional/continuing studies students, with the vast majority of them being undergraduates with a total of 18,618. These students are split, each year, into students living in university-provided living spaces (on-campus students), as well as students living in nearby apartments, and those who commute to campus for classes (off-campus students). Each year, according to the University, at least 7500 of the total students are considered “on campus” students, with their housing being provided to them by the University in one of “22 buildings on 4 areas of campus: Central, East, Laird, and Apartment-style living” (University of Delaware). As divided by the aforementioned regions of campus, the dorms and their respective date of construction, as marked on the cornerstones of each respective building, are as follows: Central: Brown (1941), Caesar Rodney (1966), Cannon (1952), Harter (1917), Kent (1956), New Castle (1925), Sharp (1951), Smyth (1952), South Academy (2017), Sussex (1917), Squire (1957), and Sypherd (1957); East: Gilbert (2013), Harrington (1960), Lane (1969), Thompson (1957), Redding (2013), and Russell (1963); Laird: George Read (2005), Independence (2004), James Smith (2005), Thomas McKean (2005), and Ray Street (2004); Apartment Style Living: University Courtyards (1999, later redeveloped in 2019 after being acquired by the University). As shown, students living on campus are subject to living in buildings built across an almost century-long span, leading to these students experiencing strikingly different living conditions when it comes to utilities

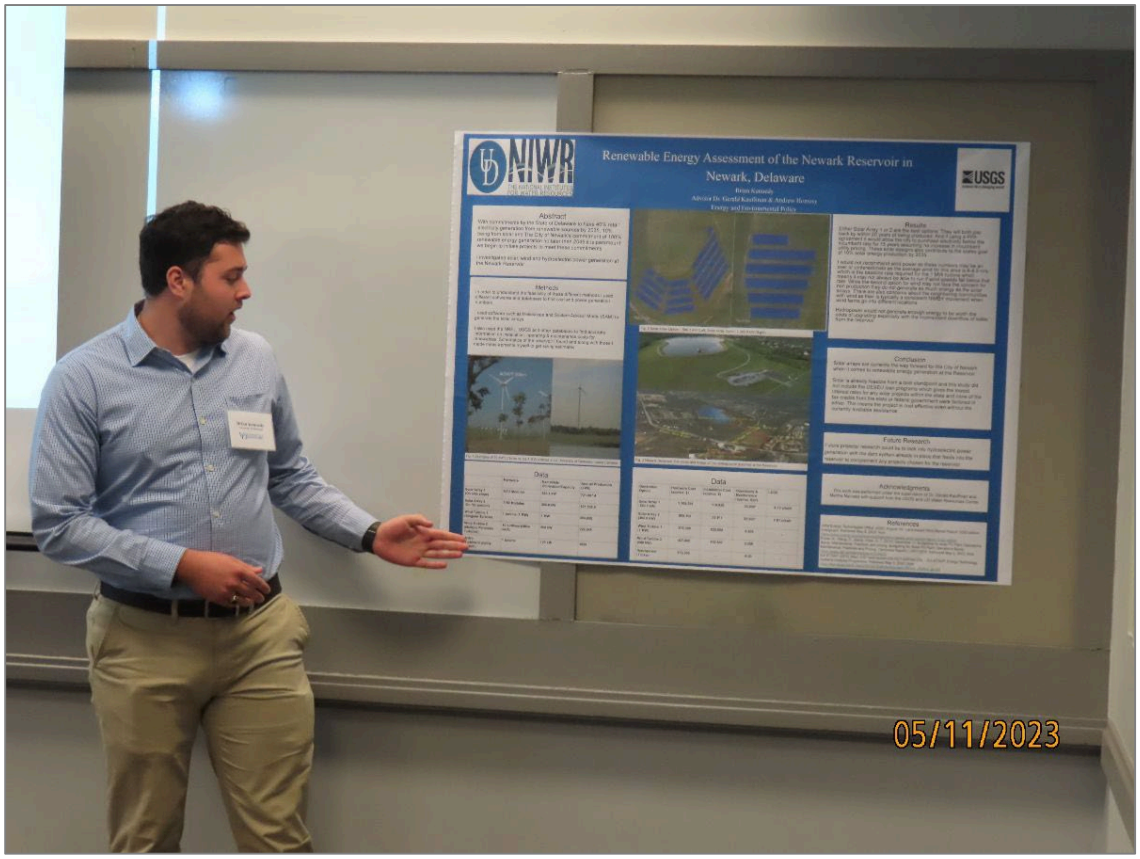
across campus. As the main focus of this study, older residence halls tend to have non-filtered water fountains with newer dorms having filtered fountains. This study aims to observe differences in water consumption among both on and off-campus students when it comes to their level of usage of different sources of water around campus.

Optimal Activity in vitro conditions of the Chesapeake Bay viral metagenome-assembled DNA Polymerase I L1_S67 reflect environmental conditions
Sydney Iredell
Major: *Biology*



Viruses are the most abundant and diverse biological entities on the planet. Family A DNA Polymerase I (polA) is present in 25% of dsDNA phage with the sole function of genome replication. The 762 residue (E. coli numbering) within the polA is our area of interest, as prior studies have suggested the amino acid identity at this position will indicate the phage life cycle. Position 762 is responsible for dNTP incorporation, and substitutions at this site have been shown to alter the fidelity, speed, and accuracy of polA. A leucine substitution has been shown to slow down the enzyme by 1000 fold, but increase its accuracy by 10 fold as compared to the wild-type phenylalanine residue. A virome polA, L1_S67, contains a leucine amino acid at the 762 residue and is the highlight of this study. L1_S67 was assembled from a virome collected in the Chesapeake Bay where environmental water temperatures range from 6.3℃–25.6℃. We hypothesized that optimal conditions for L1_S67 activity should fall in the environmental range of temperatures. This work assessed several biochemical characteristics of L1_S67 as a potential link to lysogenic life cycles of the environmental phage populations represented by this assembled contig. A variety of tests were run to help determine if the phage life cycle is determined by the amino acid at the 762 residue. Tests ran included DNase and RNAse contamination tests, primer extensions, and exonuclease assays. Results suggest that the optimal conditions in vitro match the maximum temperatures of the environment.

Feasibility Analysis of Renewable Energy Generation at the Newark Reservoir
Brian Kennedy
Major: *Environmental Engineering*



The Newark Reservoir provides a superb opportunity for the City of Newark to engage in renewable energy generation for the local community. The Reservoir provides many renewable energy generation options for the city to engage in, three will be discussed in this research: solar, wind, and hydroelectric. Solar is a primary method to research due to the decrease in the cost of arrays over the past decade and the face of the reservoir hill facing southward along with the lack of tree cover provides the optimal conditions for a solar array. Solar arrays are also modular and can be incorporated in many ways including ground mounts and carports where the panels provide shade for parked cars underneath.

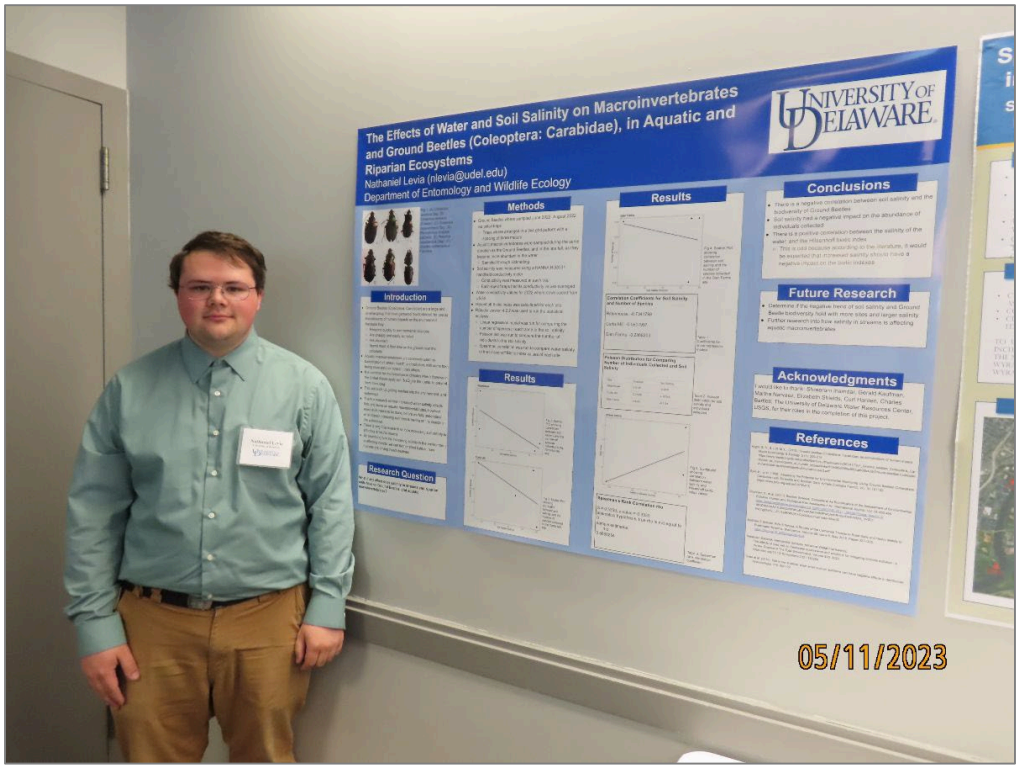
Wind is another option to consider due to the reservoir's elevation. Different sized turbines are explored and by doing power calculations we can determine the cost effectiveness of different turbines. Challenges to wind will be the sound and view disruption of the community members living around the reservoir. Along with average wind speeds in New Castle County potentially not meeting the requisite speed for certain turbines to be operational.

Hydropower can be implemented at this location through the incorporation of turbines into the pipes, the water flows down when the reservoir is drained to provide drinking water to the residents of Newark. By finding out how much head the water has we can then calculate the power a turbine installed in the pipe could generate annually.

These options can all be explored in order to demonstrate the feasibility and cost-effectiveness of each method in generating renewable electricity for the City of Newark. Each renewable energy type does not have to be used in isolation and there can be benefits to combining multiple types of renewable energy to work in tandem with one another if cost-effective.

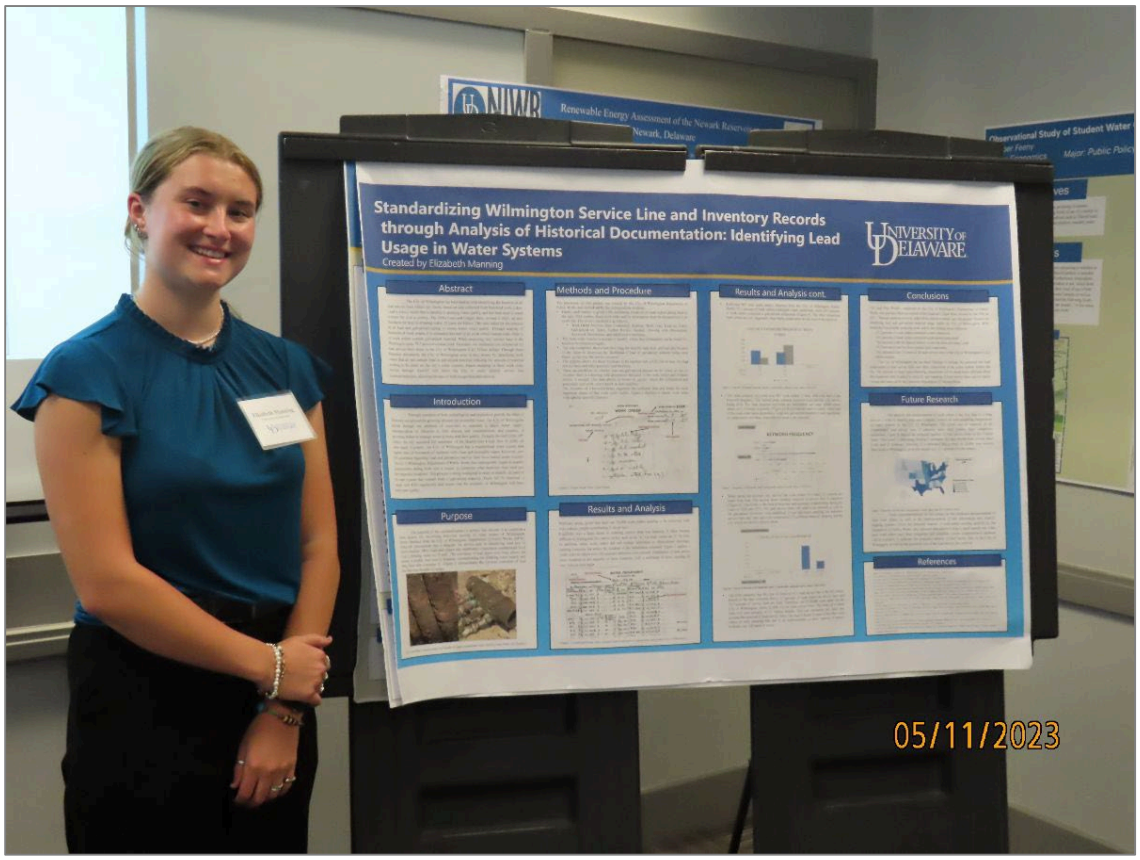
The Effects of Water and Soil Salinity on Macroinvertebrates and Ground Beetles (Coleoptera: Carabidae), in Aquatic and Riparian Ecosystems

Nathaniel Levia
Major: *Insect Ecology and Conservation*



A common way to de-ice roads in the United States is to apply salt to them, but there is little understanding of how this salt affects insects once it gets washed into the environment. Ground Beetles (Coleoptera: Carabidae) are a large and diverse group of insects that are frequently used to examine human impacts on the environment. This is due to the fact that they respond to environmental changes quickly, and can be easily and cost-effectively sampled. While many studies have examined the effects of various pollutants on Ground Beetles, few studies have examined how soil salinity due to human activities is affecting Ground Beetle communities. Ground Beetles were sampled across three sites, via pitfall traps. Aquatic macroinvertebrates are frequently used as a metric of steam health, but little is known about how salt pollutants from road deicing are affecting them. We found that soil salinity has a negative impact on the species richness and number of individuals present in Ground Beetle Populations. Our result on aquatic macroinvertebrates should be ignored, as it does not align with the findings of the majority of the literature.

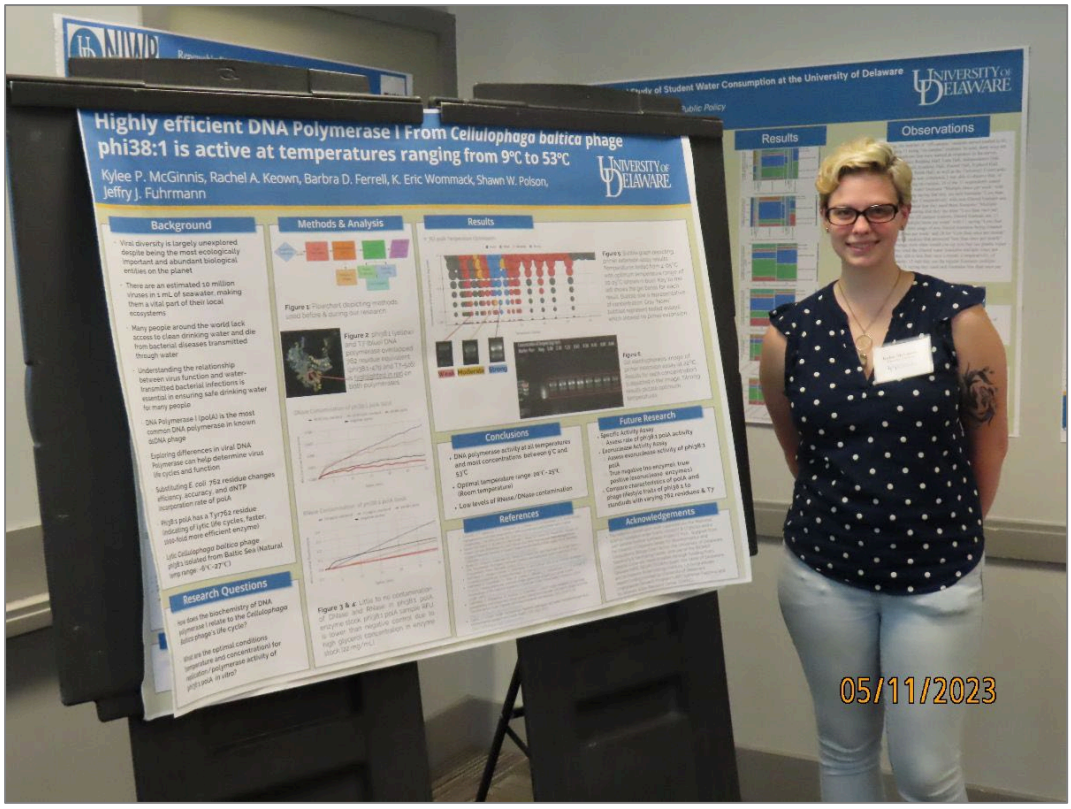
Standardizing Wilmington Service Line and Inventory Records through Analysis of Historical Documentation: Identifying Lead Usage in Water Systems
Elizabeth Manning
Major: *Environmental Engineering*



The City of Wilmington has been tasked with identifying the location of all lead service lines within city limits, based on data collected from historical work orders. Lead is a toxic metal that is harmful to drinking water quality and has been used in water systems for over a century. The EPA's Lead and Copper Rule, revised in 2021, set new standards for lead in drinking water: 15 parts per billion. This rule called for the removal of all lead and galvanized piping to ensure better water quality. Through analysis of hundreds of work orders, it is estimated that half of all work orders contain lead, while ¼ of work orders contain galvanized material. When analyzing only service lines in the Wilmington area, 72.7 percent contain lead. Therefore, the estimated cost of removal for lead service lines alone in the City of Wilmington is 2.2 billion dollars. Through the analysis of these historical documents, the City of Wilmington aims to save money by identifying work orders that do not contain lead or galvanized material, to reduce the amount of removal needing to be done on the city's water systems. Future mapping of these work order records through ArcGIS will allow the city to easily identify service line locations/materials, allowing for ease of both recognition and removal.

Highly efficient DNA Polymerase I From Cellulophaga baltica phage phi38:1 is active at temperatures ranging from 9℃ to 53℃

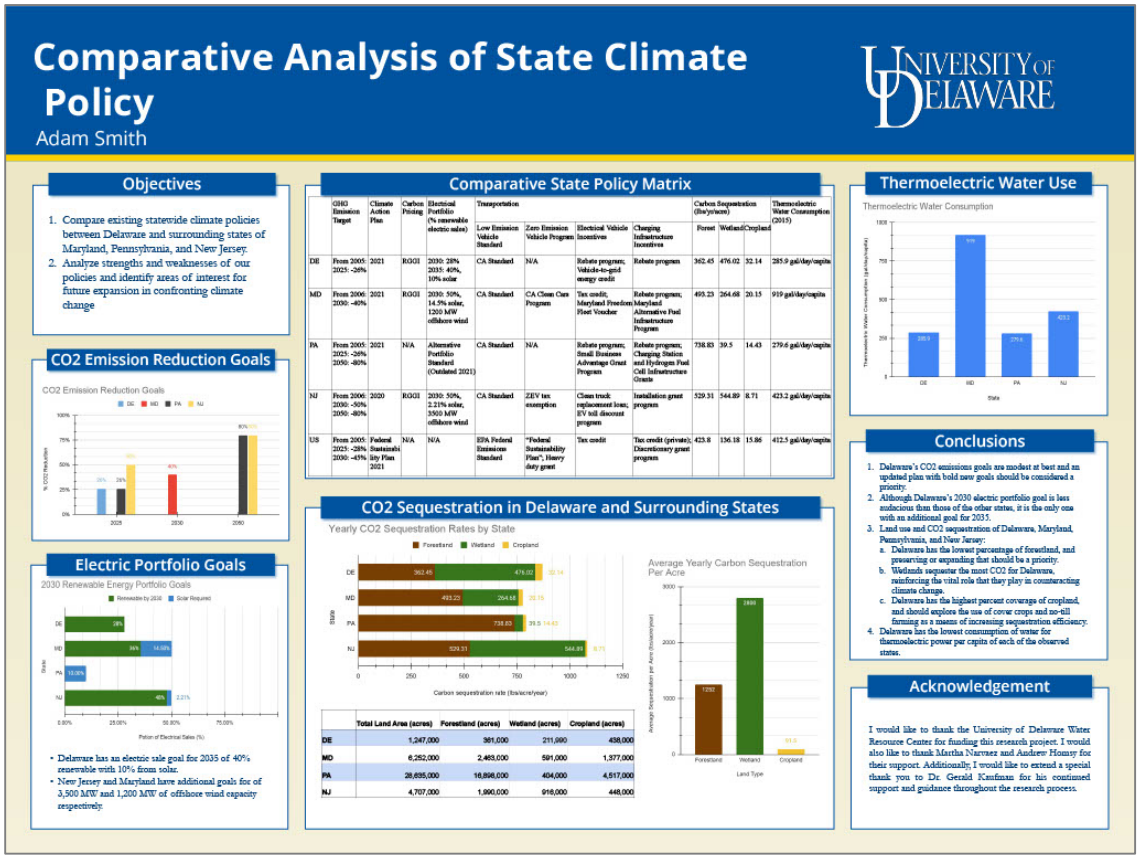
Kylee McGinness
Major: *Biology*



Viruses are the most abundant and ecologically important biological entities on Earth. DNA Polymerase I (polA) is the most common DNA polymerase in dsDNA phage, present in approximately 25% of environmental dsDNA phage populations. The main function of a phage is replication, so evaluating sequence differences between phage polA enzymes can help elucidate differences in biochemical characteristics across known polA diversity. An amino acid substitution at the polA 762 residue (E. coli numbering) has been shown to alter the replication efficiency and fidelity of the enzyme and is hypothesized to be predictive of the phage life cycle. The focus of this research, Cellulophaga baltica phage phi38:1 polA, contains a Tyrosine (Tyr) amino acid at the 762 residues. Tyr762 has been associated with highly lytic phages and mutagenesis has shown this residue to be present in faster, 1000-fold more efficient enzymes as compared to enzymes with the wild-type phenylalanine residue. This work investigates the relationship between the biochemistry of a Tyr762 polA and the known lifestyle of Cellulophaga baltica phage phi38:1 by characterizing polymerase activities over temperature and concentration gradients. The synthesized phi38:1 polA protein sequence was cloned into and produced by E. coli, and the resulting enzyme stock was relatively pure showing minimal DNase and RNase contamination levels. In vitro primer extension was observed at a range of temperatures (9°C–53°C), with the strongest activity at 20°C–25°C. Strong activity for primer extension at both high (5ug/rxn) and low (0.04ug/rxn) concentrations at every temperature tested confirms the high efficiency of phi38:1 polA.

Comparative Analysis of State Climate Policy in Delaware and Surrounding States

Adam Smith
Major: *Political Science and Criminal Justice*



The threat of climate change is more apparent than ever, and a challenge of such a magnitude requires bold, coordinated responses at every level of government. While individual state policy may seem insignificant, in an era of hyperpartisanship, state governments in the United States can act as laboratories of democracy, combating climate change in their own individualized ways.

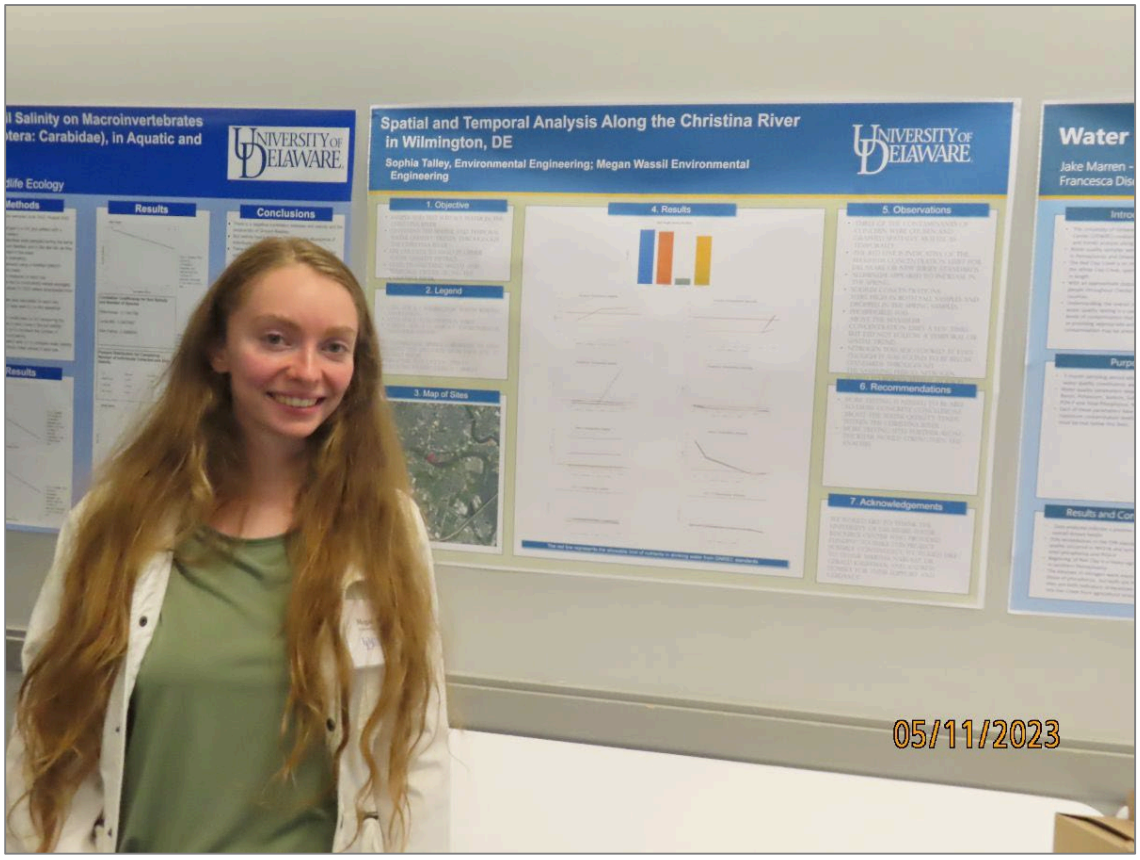
This research aims to compare and evaluate the climate policies of Delaware with those of the surrounding states of New Jersey, Pennsylvania, and Maryland. In doing so, I hope to provide recommendations to strengthen Delaware's climate policies going forward so as to more effectively confront the climate crisis. Additionally, I will provide grounds for future research on the subject of state climate action.

To evaluate the climate policies of Delaware, New Jersey, Pennsylvania, and Maryland, I have created a policy matrix comprising topics of greenhouse gas emissions plans, climate action plans, carbon pricing programs, electric portfolio goals, transportation, carbon sequestration, and thermoelectric water consumption. Upon comparison with the surrounding states, I have found that although Delaware's current climate policies are adequate, bold steps can and must be taken moving forward in order to rise to such a monumental challenge as climate change.

Temporal and Spatial Analysis of the Christina River in Wilmington, Delaware

Sophia Talley
Major: *Environmental Engineering*

Megan Wassil
Major: *Environmental Engineering*



The Christina River is a cornerstone for local recreation and businesses as well as supporting an expansive ecosystem. Due to its importance, it is vital that the water quality is closely monitored and that water quality trends can be identified to help protect and ensure the health of the river. This research set out to analyze the temporal and spatial trends within the Christina River.

Three sampling locations were chosen in the fall of 2022 and samples were taken from the fall of 2022 throughout the spring of 2023. These sites were visited on 2 occasions each semester. These dates include 10/28/2022, 11/29/2022, 03/14/2023, and 04/18/2023. On these dates, field measurements were collected as well as water samples to then be tested in a laboratory. These samples tested for potential contamination in the forms of nutrients as well as metals and other elements. It was found that Aluminum (Al), Nitrate-Nitrogen (NO3-N), Phosphorus (P), and Sodium (Na) reached concentrations above the water quality standard for either Delaware or New Jersey. These four contaminants were then graphed spatially and temporally to understand the trends in the results. Aluminum concentrations increased in the spring. Nitrate-nitrogen levels remained steady throughout the study but were consistently above the standard of 1.0 mg/L. Phosphorus had elevated levels in the spring but this may have

been an outlier in the dataset. Sodium appeared to follow a temporal trend of high concentrations in the fall and decreasing concentrations in the spring.

Additional sampling locations are recommended as these locations only spanned three sites. This would allow for a larger, more comprehensive understanding of the spatial distribution of the data. It is also recommended that more samples are collected at low tide. The Christina River of Wilmington, Delaware is tidal and these tidal fluctuations could potentially affect the results. Many of the samples were collected at high tide but collecting at low tide would also be advised for future research on this river.

A Comparative Analysis To Improve Delaware's Statewide Microplastic Strategy
Alyssa Wentzel
Major: *Energy and Environmental Policy*

Microplastics are so small in size that they easily spread through the air and accumulate in the environment. They are extremely persistent and it is almost impossible to remove them from the environment where they accumulate. Plastics are not biodegradable, instead, they break into fragments and form microplastics over time. Microplastics are ingested by people and animals. They are often mistaken as food by small organisms like plankton or even large animals like
sharks. The biggest problem that can be seen is how microplastics affect fish as well as other marine and aquatic animals. These animals will ingest the plastics which can cause these animals to reduce food intake and impede on development stages.

Many issues of microplastics revolve around uncertainty and a lack of consistent and viable methods, standards, and consistency of observed exposures. Addressing microplastics is difficult because it requires a global approach, linking industry, and academia in order to solve problems and offer solutions. Right now, minimal action is being taken on a legislative scale, causing microplastics to still be produced all over the United States. California is the only state that has a state-wide microplastics policy initiative plan. In Delaware, research has been taking place to discuss how microplastics are affecting organisms' health, such as mud crabs and blue crabs.
However, Delaware does not focus on the policy side of microplastics and what can be done to reduce microplastics.

Some of the big problems and questions that will be addressed are:

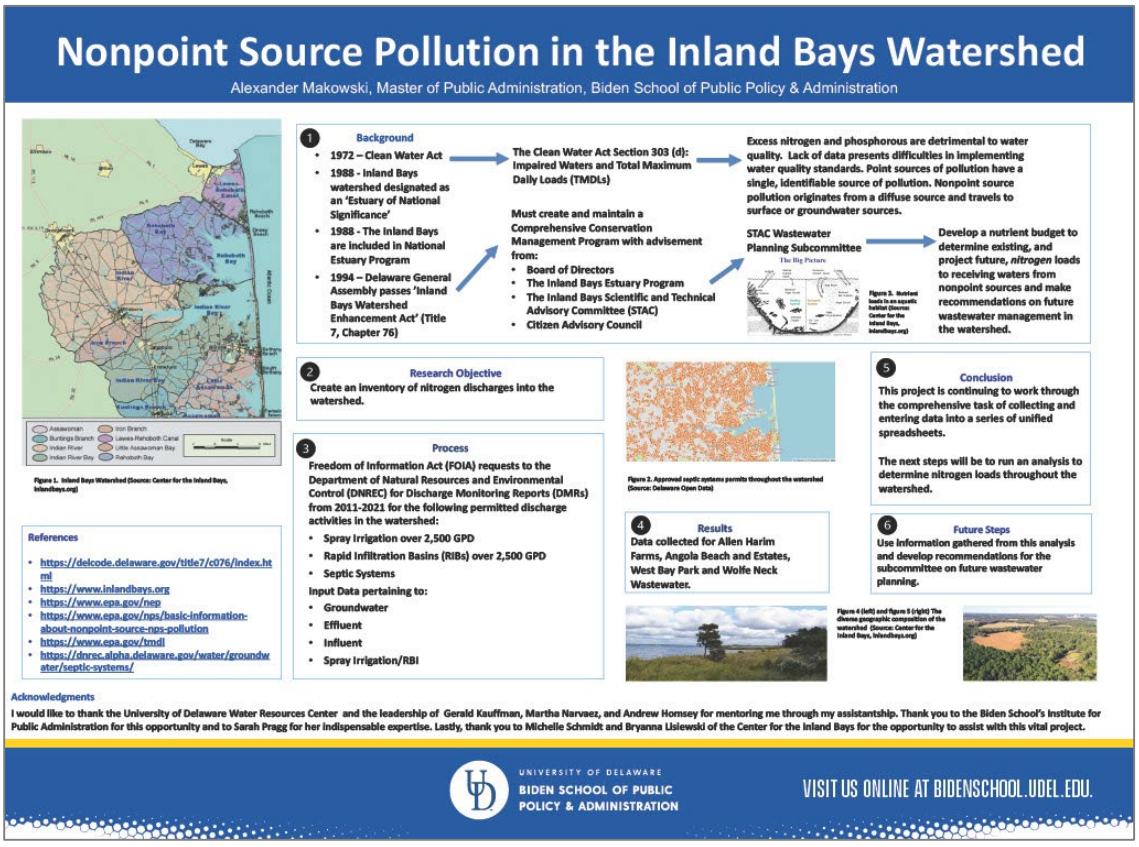
- What implementation strategies are taking place in other states and are they effective?
- How can science and research about microplastics be communicated clearly to the public?
- How can we encourage and incentivize more microplastic clean-up within the community?
- How can the reintroduction of certain bills improve the statewide initiative of reducing microplastics?
- What are some possible implementations or policies Delaware could adopt for microplastic prevention?
- What is a Microplastic Statewide Initiative and should Delaware adopt it?

FY23 UDWRC Graduate Assistant Research Projects

Economic Recreation Survey of the Musconetcong River Watershed
Lydia Franks
Master of Water Science & Policy

The New Jersey tributary watersheds of the Delaware River span five counties throughout the northwestern part of the state and provide significant economic benefits to local communities and the regional economy. Within this area is the Musconetcong River watershed, which is situated in northern New Jersey and reaches across Hunterdon, Morris, Sussex, and Warren counties. The Musconetcong River is a Partnership Wild and Scenic River and National Water Trail, supporting extensive outdoor recreational opportunities and attracting visitors from across the region to its 157-square-mile watershed. Examining how residents and non-residents spend time and money in this watershed, as well as in other New Jersey tributary watersheds of the Delaware River, is essential in demonstrating their economic value and providing information for management decisions. This survey-based study, as a collaboration between the University of Delaware Water Resources Center, Musconetcong Watershed Association, and Environment New Jersey, analyzes recreational use and spending in the Musconetcong River watershed and uses these dollar values to estimate the economic value of recreation in the larger study area of northwest New Jersey tributaries to the Delaware River (Figure 2). Using these values and existing research, the total expenditure range for recreation in the northwest New Jersey tributaries of the Delaware River was estimated as a low of nearly $133 million to a high of almost $353 million annually.

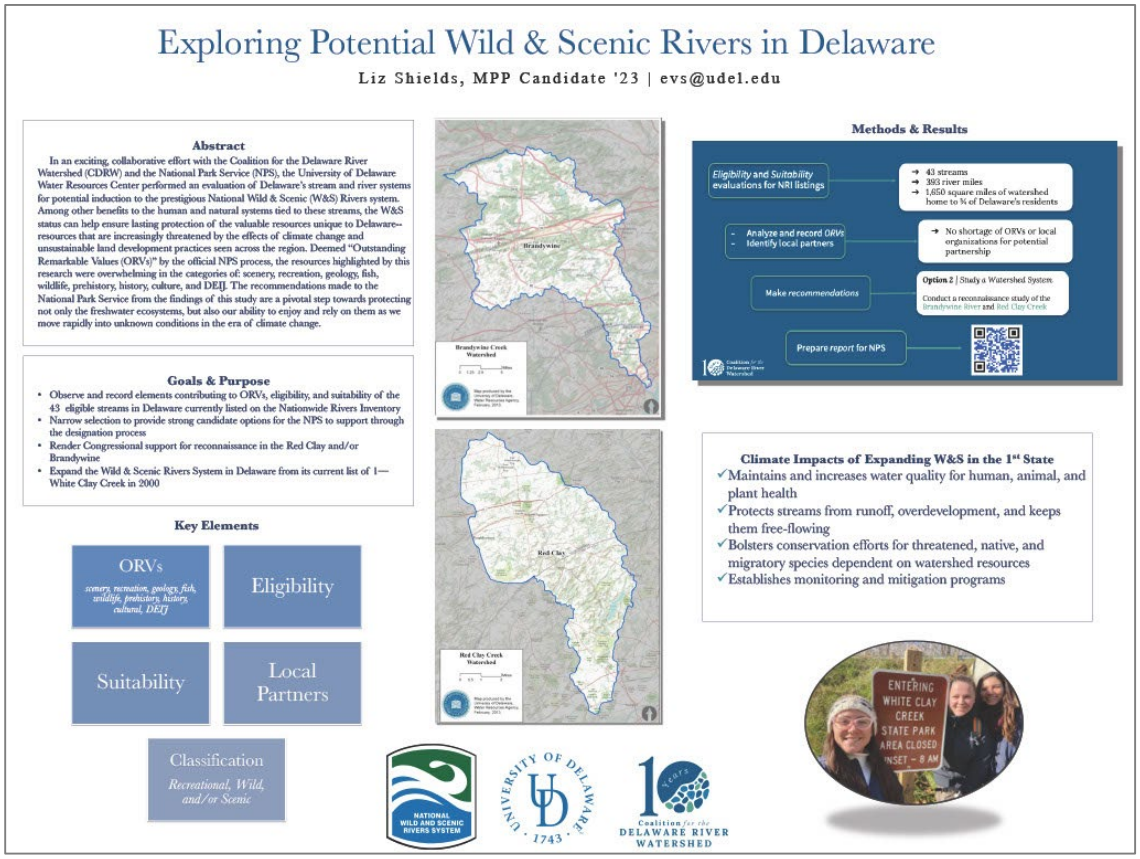
Center for the Inland Bays Nutrient Budget
Alex Makowski
Master of Public Administration



The Clean Water Act of 1972 identified the Delaware Inland Bays as an "Estuary of National Significance" in addition to their inclusion in the National Estuary Program. In 1994, the Delaware General Assembly passed the Inland Bays Watershed Enhancement Act to create and maintain a Comprehensive Conservation Management

Program with advisement from a Board of Directors, the Inland Bays Estuary Program, the Inland Bays Scientific and Technical Advisory Committee (STAC), and a Citizen Advisory Council. The STAC oversees the Wastewater Planning Subcommittee which is developing a comprehensive nutrient budget to determine existing and projected nitrogen loads to receive water from nonpoint sources. Information garnered from these efforts will be considered in making recommendations on future wastewater management decisions within the watershed. Freedom of Information Act (FOIA) requests were filed with the Delaware Department of Natural Resources and Environmental Control (DNREC) to obtain information related to monitoring for facilities within the watershed with discharge permits for 2,500 gallons or more per day. Data was collected for information in relation to groundwater monitoring, effluent, influent, spray irrigation, and rapid infiltration basins. The project is extensive and ongoing.

Exploring Potential Wild & Scenic Rivers in Delaware
Elizabeth Shields
Master of Public Policy



In collaboration with the Coalition for the Delaware River Watershed and the National Park Service, the University of Delaware Water Resources Center (UDWRC) continues to advance on the process of evaluating potential National Wild and Scenic Rivers both in the state and across shared watersheds with neighboring states. This project will involve extensive research to explore the eligibility and suitability aspects of the Brandywine River and Red Clay Creek watersheds. The intended outcome is the construction of a robust profile for the consideration of these identified segments as additions to the Wild and Scenic River system in the United States.

UD Master of Public Policy Grad Liz Shields Awarded 2023 University of Delaware Water Resources Center's Excellence in Water Resources Scholarship Medal

Martha Narvaez

On May 27, 2023, Elizabeth Shields graduated from the University of Delaware with a Master's in Public Policy. During the spring semester, Shields was also awarded the 2023 Biden School of Public Policy and Administration Excellence in Water Resources Scholarship Award for her dedication and innovation. Shields began working at the University of Delaware's Water Resources Center (UDWRC) in August 2021 and since then she has consistently demonstrated that she is a motivated and responsible individual deserving of this distinguished award. During her time at UDWRC, Shields consistently and efficiently completed all assigned projects. In addition, she brought innovative ideas to the wide range of projects that she took on. A few of her most notable research projects include the (1) Reconnaissance Study of Potentially Eligible National Wild and Scenic Rivers in Delaware, (2) Study of The Economic Value of the Tributaries of The Upper Delaware River, and (3) Administration and Oversight of the City of Wilmington Green Jobs Program.

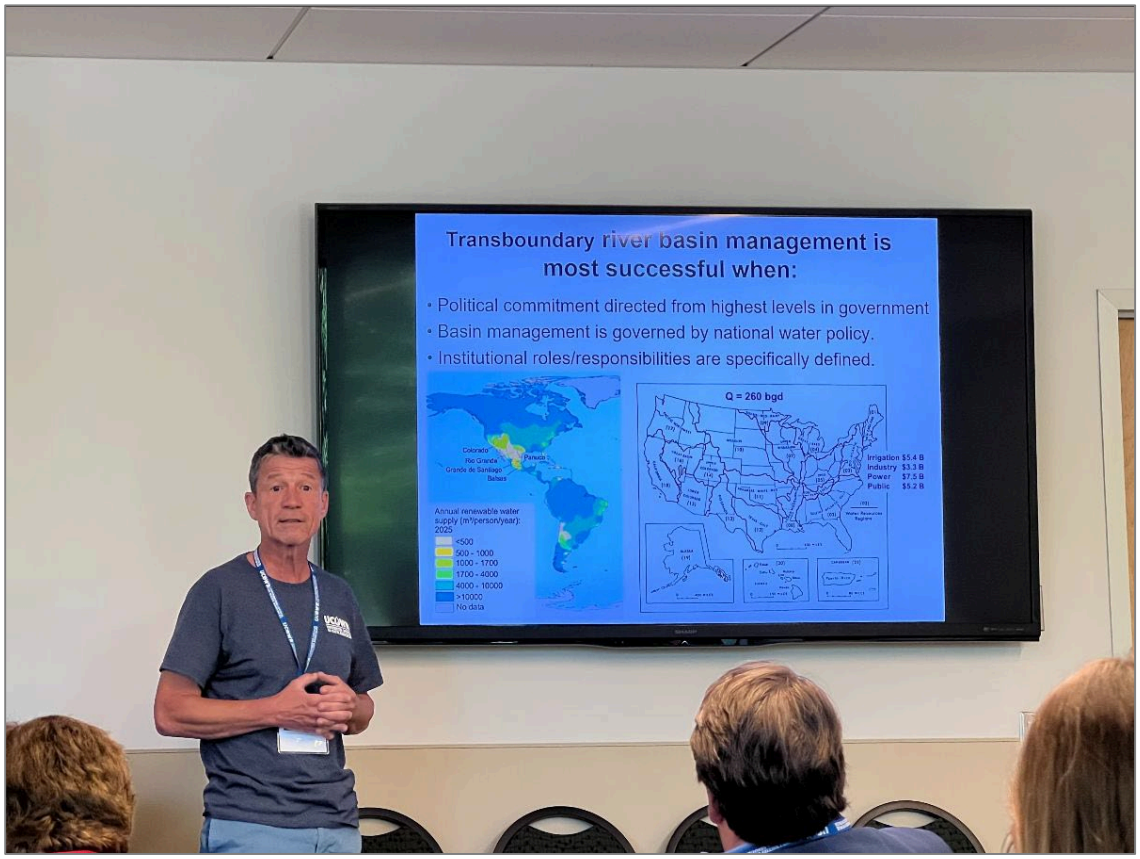
Shields has also shown interest in learning more about the multitude of ongoing projects at UDWRC and has taken on extra work to further her knowledge of the water resources field in areas such as field work, advocacy and education, and outreach. She is committed to expanding her professional network and expertise in the water resources field which has been demonstrated by attending conferences and meetings related to the field. By frequently participating in these events, Shields furthers her own professional development and represents the Water Resources Center. These activities, while outside of her academic and research assignments, are truly motivated by her desire to gain experience and a better understanding of the water resources field.

Image (from left to right) of Jerry Kauffman, Jerome Lewis, Liz Shields, Martha Narvaez, and Andrew Homsey.

Peers like Lydia Franks, MSP ’24, and Alex Makowski, MPA ’24, often collaborate with Shields on projects, benefiting from her commendable mentorship and leadership experience at the Water Resources Center. Over the past two years, Shields has been an asset to the Water Resources Center staff and students. She has demonstrated that she is a mature, responsible, and self-motivated individual who has a true interest in helping to sustain and improve our nation's water resources. Congratulations to Liz and we look forward to working with her wherever her future takes her!

UDWRC Director, Gerald Kauffman, Jr. Officially Installed as the 59th President of UCOWR

Gerald Kauffman, Jr.



Jerry Kauffman leads the session *East is East and West is West* at the UCOWR conference in June 2023.

Water research universities throughout North America gathered at the 2023 Universities Council on Water Resources and National Institutes for Water Resources (UCOWR/NIWR) Annual Water Resources Conference. The event was held on June 13-15, 2023, at Colorado State University in Fort Collins, Colorado. At the conference awards luncheon, Gerald Kauffman, Jr. director of the UDWRC and associate professor with the Joseph R. Biden, Jr. School of Public Policy and Administration was installed as the 59th president of UCOWR to serve a one-year term. Kauffman also presented on interstate river basin governance of drought and flood in the U.S. Four additional papers on water resources research in Delaware were presented by UDWRC staff and graduate students.

UCOWR was founded in 1964 as a consortium of 80 academic institutions and affiliates invested in water resources research, education, and outreach with membership from research universities, undergraduate institutions, tribal colleges, historically black colleges and universities, and Hispanic-serving institutions.

UDWRC Director Gerald Kauffman accepting the gavel from outgoing UCOWR Board President Dr. Bridgette Guerrero at the UCOWR Annual Conference Awards Luncheon on June 14, 2023 at Colorado State University in Ft. Collins, CO.

UD Water Resources Center Represents at the 2023 UCOWR/NIWR Annual Water Resources Conference at Colorado State University in Fort Collins, Colorado

Gerald Kauffman, Jr.

The UD Water Resources Center was well represented among the 360 attendees from water research universities throughout North America at the 2023 UCOWR/NIWR Annual Water Resources Conference on June 13-15, 2023, at Colorado State University in Ft. Collins, Colorado. UDWRC staff and students presented the following water resources research in Delaware and the region.

East is East and West is West: Interstate River Basin Governance of Drought and Flood in the USA.

- Dr. Gerald Kauffman, Director, Delaware Water Resources Center, University of Delaware, Newark, Del.
- Dr. Sharon Megdal, Director, Arizona Water Resources Research Center, University of Arizona, Tucson, AZ
- Dr. John Tracy, Director, Colorado Water Center, Colorado State University, Ft. Collins, CO

UD Water Resources Center represents at the UCOWR Annual Conference on June 14, 2023, at Colorado State University in Ft. Collins, CO.

City of Wilmington Green Jobs Program

Martha Narvaez, UDWRC Associate Director and Policy Scientist

The Watersheds and Landscapes of the Delaware Basin and Estuary: 2023 Status and Trends

Andrew Homsey, Policy Scientist

Indigenous and European Place Names Along Streams and Waterways in Delaware (Lenapehocking)

Elizabeth Shields, Master of Public Policy Graduate Student

Economic Value of New Jersey Tributaries to the Delaware River

Lydia Franks, Water Science & Policy Graduate Student

UDWRC's Gerald Kauffman, Andrew Homsey, and Martha Narvaez at the UCOWR Annual Conference on June 14, 2023, at Colorado State University in Ft. Collins, CO.

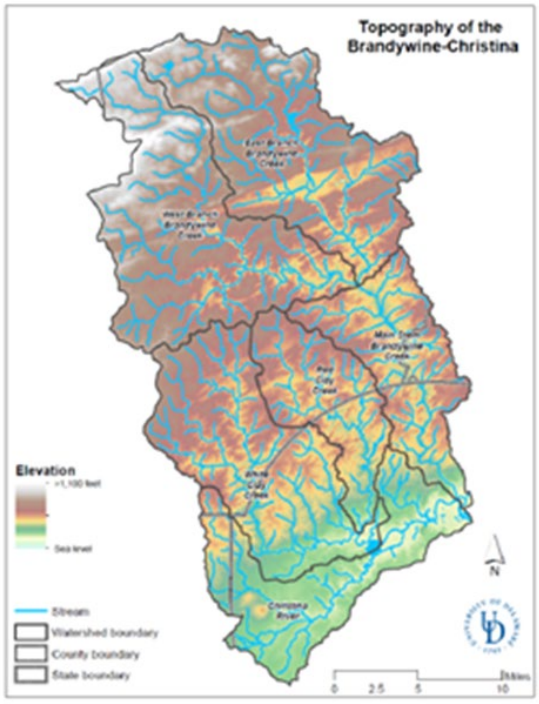
Master of Public Policy graduate student Elizabeth Shields and Water Science and Policy graduate student Lydia Franks at the UCOWR Annual Conference on June 14, 2023 at Colorado State University in Ft. Collins, CO.

Brandywine Flood Study

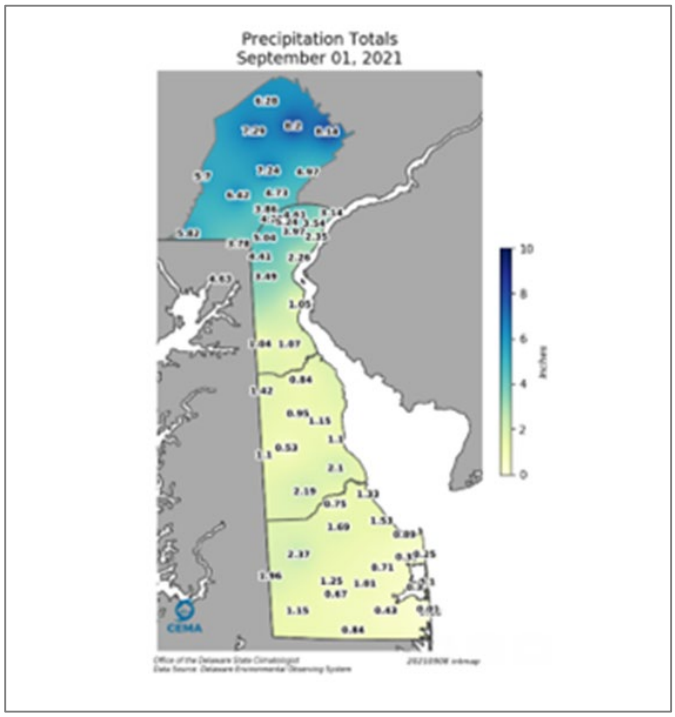
Gerald Kauffman, Jr.

In 2021, Hurricane Ida sideswiped the area and caused the biggest flood in 200 years along the historic Brandywine Creek. The University of Delaware Water Resources Center looks forward to working with upstream partners in this bistate and intergovernmental Brandywine Flood Study to identify the root causes of the flooding, as well as recommend and hopefully implement real flood solutions for the people who live and work in the watershed in Delaware and Pennsylvania," said Gerald Kauffman Jr., Director of the University of Delaware Water Resources Center.

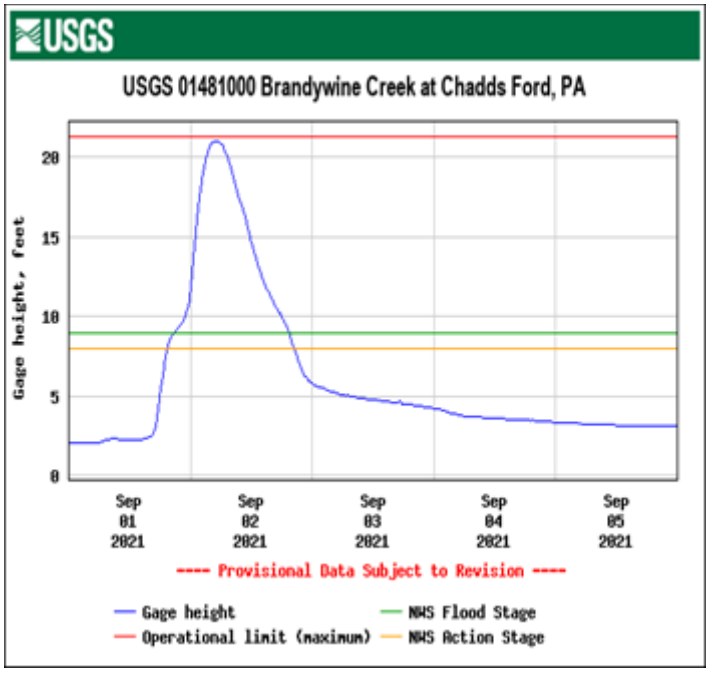
In the aftermath of the once-in-two-century flooding from the remnants of Tropical Storm Ida on Sep 1-2, 2021, the Brandywine Conservancy (BC), Chester County Water Resources Authority (CCWRA), and University of Delaware Water Resources Center (UDWRC) are conducting a Brandywine Flood Study in Delaware and Pennsylvania. The flood study is designed to (1) identify chronic flood sites, (2) conduct hydrologic/hydraulic watershed modeling, and (3) recommend structural/nonstructural flood solutions in this bi-state watershed. The flood study will examine flooding in the 320 sq. mi. watershed that stretches 30 miles from Wilmington, Del. through West Chester, Downingtown, and Coatesville to Honeybrook, Pa., and covers two states, 5 counties, 40 municipalities and 19 subwatersheds in the east and west branches and main stem of the Brandywine River. Of the close to a quarter million people who live in the Brandywine watershed, 4/5 live in Pennsylvania and 1/5 live in Delaware although 90% of the watershed lies in the commonwealth.



Topography of the Brandywine watershed



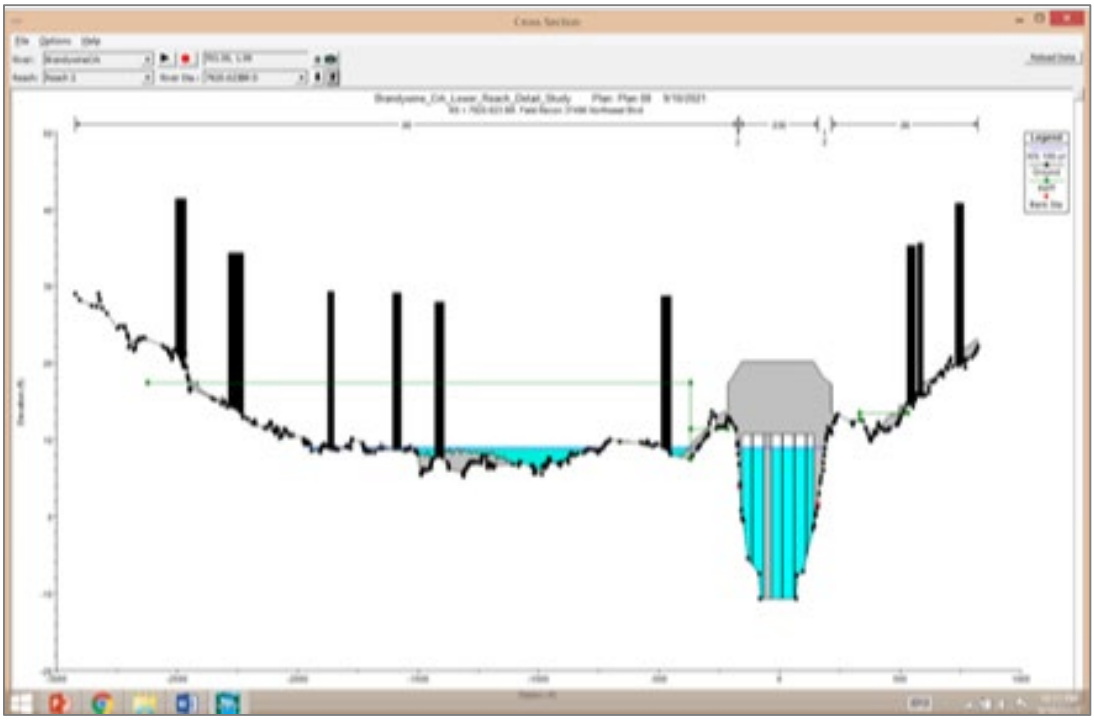
Precipitation on Sept. 1, 2021



Stream flow at Chadds Ford, PA during Ida

The remnants of Tropical Storm Ida left 7.29 inches of rain at Coatesville and 8.2 inches at Downingtown in Chester County, Pa. which is close to the 100-yr, 24-hour storm of 8.0 inches as per NOAA Atlas 14. Ida's peak flood of 33,700 cfs (cubic feet per second) (>100-yr) on Sep 2, 2021, is the highest on record along Brandywine Creek at Wilmington dating to 1946 surpassing Hurricane Agnes of 29,000 cfs on Jun 23, 1972. Ida's peak discharge in the Brandywine Creek at Chadds Ford, PA was greater than 33,000 cfs at 2 a.m. on September 2, 2021. Ida's flood wave was accentuated by the inherently steep Piedmont topography in the funnel-shaped Brandywine River watershed. Peak rainfall (>8 inches) above Coatesville and Downingtown, PA caused runoff that flowed down from 1,000 ft above sea level in the Welsh mountains (foothills of the Appalachians) and the flow siphoned down to Chadds Ford, Pa then to Delaware at William Penn's 1682 arc boundary that separates the once co-joined states.

Flooding from the remnants of Tropical Storm Ida at Wilmington, DE, Sept. 1-2, 2021

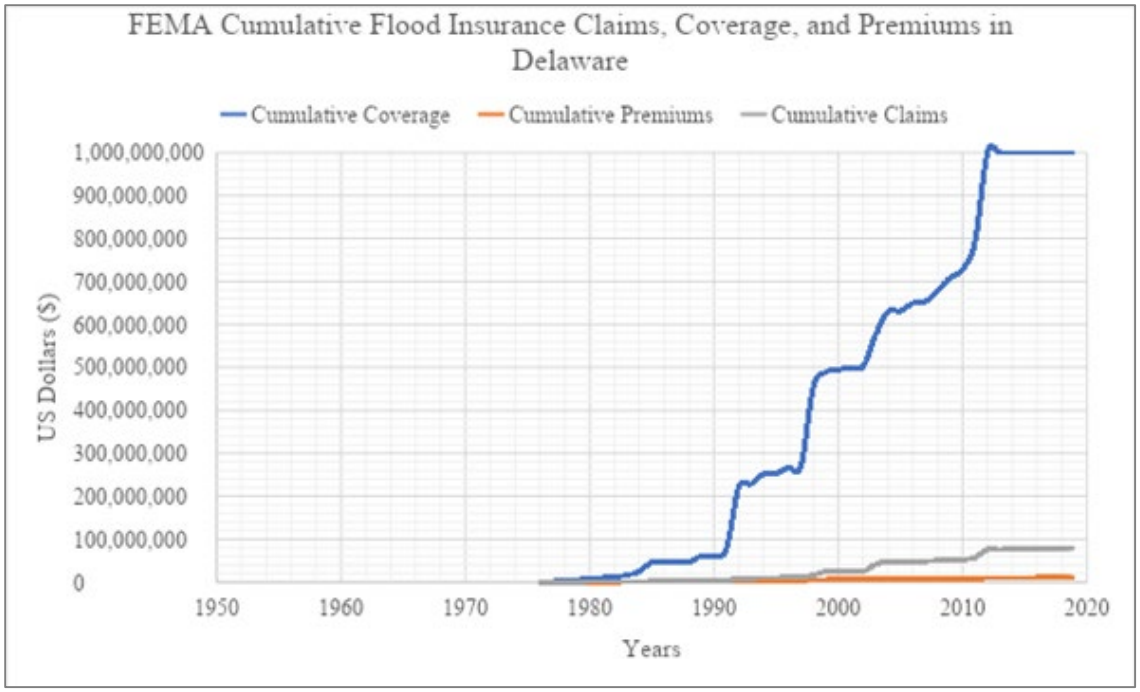


Flood cross-section during TS Ida at Wilmington, Del. Sep 1-2, 2021

Flood Insurance Policies in the Coastal Floodplain of Delaware

Gerald Kauffman, Jr.

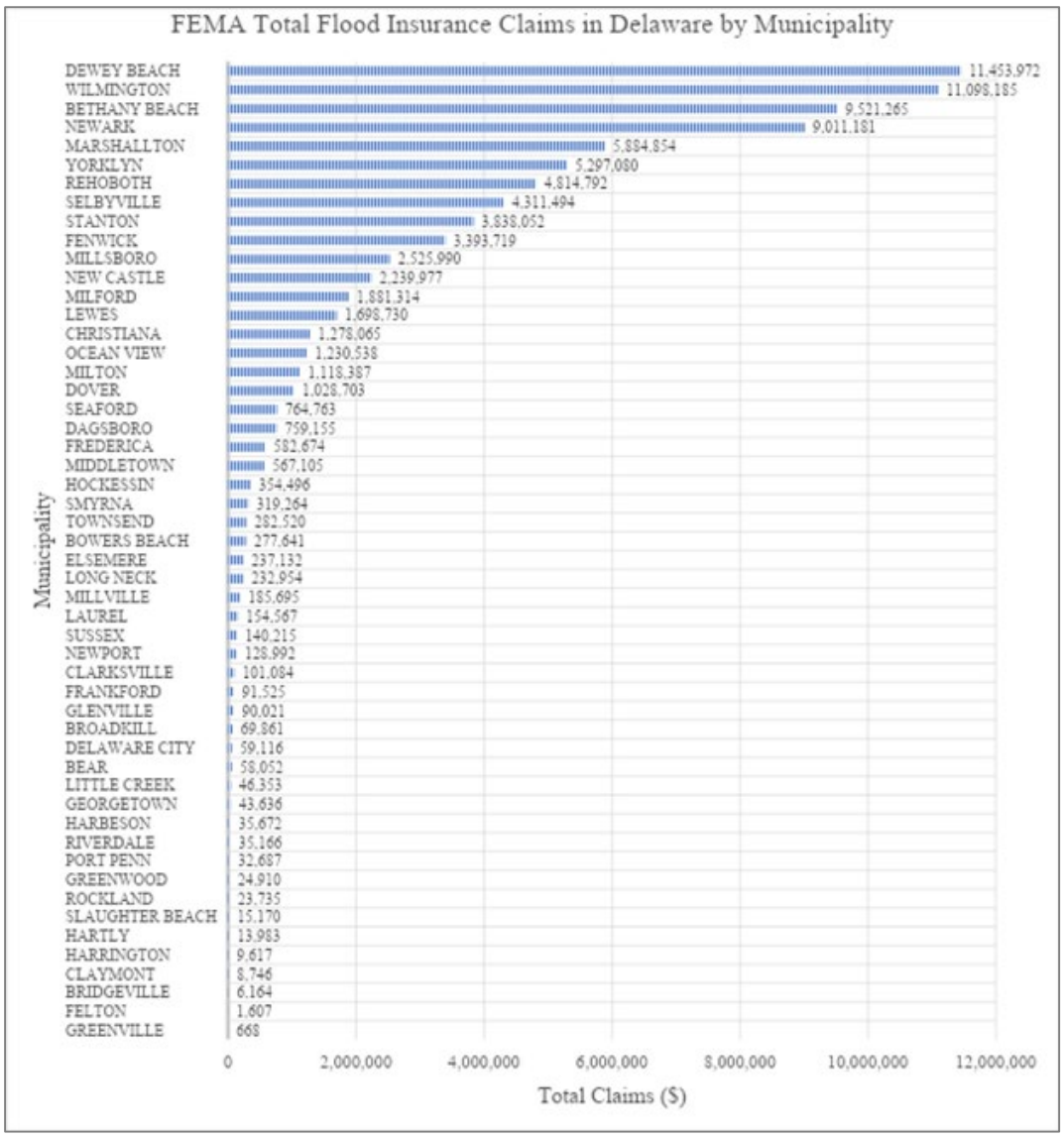
Climate change is a rising environmental crisis that threatens the United States with unpredictable storms, flooding, and natural disasters imposing menace on many structures and homes. This research into the economic value of properties in the coastal and riverine floodplain in Delaware seeks to assess the real estate value of properties in Delaware and how it has changed since 1975 in relation to sea level rise and flooding. UDWRC analyzes flood insurance premiums, claims, and coverage in Delaware to find high-flood risk areas and determine whether the flood insurance program is adequately funded or subsidized by the Federal Emergency Management Agency (FEMA). Through ArcGIS, FEMA and NOAA flood inundation maps are overlayed with parcel and property value maps to estimate the value of real estate at risk for flooding given that nearly 1/5 of Delaware rests in the 100-year floodplain. UDWRC research indicates that the floodplain in Delaware affects a large portion of the First State's population and that flood damage claims are not adequately funded by flood insurance premiums meaning that the market is subsidized by FEMA and/or the U.S. Treasury.



FEMA cumulative flood insurance claims, coverage, and premiums in Delaware.

Over the last half-century climate change and sea level rise have caused a significantly increased risk of flooding, hurricanes, and natural disasters in the United States. Flood insurance allows residents, homeowners, and business owners to protect against these risks. In theory, flood insurance establishes a relationship between homeowners and insurance companies, where the insurance industry provides well-needed protection against property damage and the property owners supply businesses keeping the insurance corporations afloat. This relationship has many complications, and some of the largest issues nationally occur in the state of Delaware. The research conducted by the University of Delaware Water Resources Center seeks to evaluate the insurance company and property owner relationship in the three counties of Delaware where homes face a large risk of flood damage and flood insurance companies are confronted with liabilities due to low insurance premiums and increasing risk and frequency of flooding.

The average ratio in Delaware of claims/premiums is 12 which indicates that to create a profitable margin for the flood insurance industry the average premium would have to be raised by 12 times roughly $6,000 - $30,000 annually. The current state of the industry is entirely unsustainable, especially for flood insurance agencies, premiums do not properly reflect the damages caused to property or the risk. Mitigation measures and raised deductibles are considerable anti-risk strategies that should be enacted to prevent large claims totaling anywhere from two to twenty times that of the premiums paid. The delineation of economic properties that lie in Delaware's floodplain is not only an astounding record of which municipalities are greatly affecting the flood insurance industry's profitability, but also a transcript of the unsustainable climate and market that currently threatens Delaware's housing and insurance market.



FEMA total flood insurance claims, coverage, and premiums in Delaware

Identifying Diadromous Fish Abundance, Habit Utilization and Fish Passage Feasibility in the Red Clay, White Clay and Christina Watersheds in New Castle County, Delaware

Gerald Kauffman, Jr.

Delaware Sea Grant (DESG) and the University of Delaware Water Resources Center (UDWRC) are working with the Brandywine Red Clay Alliance (BRC) and Inter-Fluve to restore diadromous fish abundance and habitat utilization at three tributaries of the Delaware River, as well as explore the feasibility of providing fish passage at 11 dams along the Red Clay Creek. Our effort is the first step to restoring diadromous and resident fish passage to 13 miles and 153 acres of spawning habitat from tidewater to 180 ft above sea level in the Piedmont plateau at the Delaware/Pennsylvania arc boundary. This initiative is designed to address the restoration of diadromous fish such as American Shad and Striped Bass to the Red Clay Creek and will provide high-quality fishing and outdoor recreational opportunities for the urban residents in Stanton in New Castle County, Delaware. Further, by examining how these fish use the Christina River and White Clay Creek tributaries, there can be a better understanding of the aquatic community at large, documenting variability in spatial utilization of these systems across a broader spatial scale as impediments are removed.

Sharpless Road dam failure along Red Clay Creek in Delaware

UDWRC and project partners seek to collaborate with river partners to conduct a feasibility analysis and initiate discussions with the permitting/regulatory agencies about restoring fish passage of American Shad, Hickory Shad, River Herring, Striped Bass, and other diadromous fish like American Eel to the Red Clay Creek in New Castle County, Delaware. The long-term conservation outcome of this proposal is to restore fish passage and habitat to the Red Clay Creek watershed by removing in-stream dams and/or installing fish ladders, fish notches, rock ramps, or

bypass channels. Currently, there are 11 low-head (2 feet to 10 feet high) dams along 13 miles of the Delaware portion of the Red Clay Creek from tidewater upstream into the Piedmont to 180 feet above sea level (Figure 3 and Table 1). However, critical parameters for understanding the feasibility of removal including land ownership, whether or not the dam serves as a mill race, historic value, and potential American Shad production values are presently unknown for each of these dams. In addition to the identification of dam feasibility, the project partners aim to better understand the spatial scale variability in alosine abundance between the Red Clay Creek, White Clay Creek, and Christina Rivers, as well as to determine how adult American Shad use these habitats using a newly established array of acoustic receivers, paired with an existing array in the Brandywine River and Delaware River estuary that will elucidate fine-scale movements within each tributary and beyond.

Dams along the Red Clay Creek in Delaware

American shad fish abundance survey conducted by Delaware Sea Grant

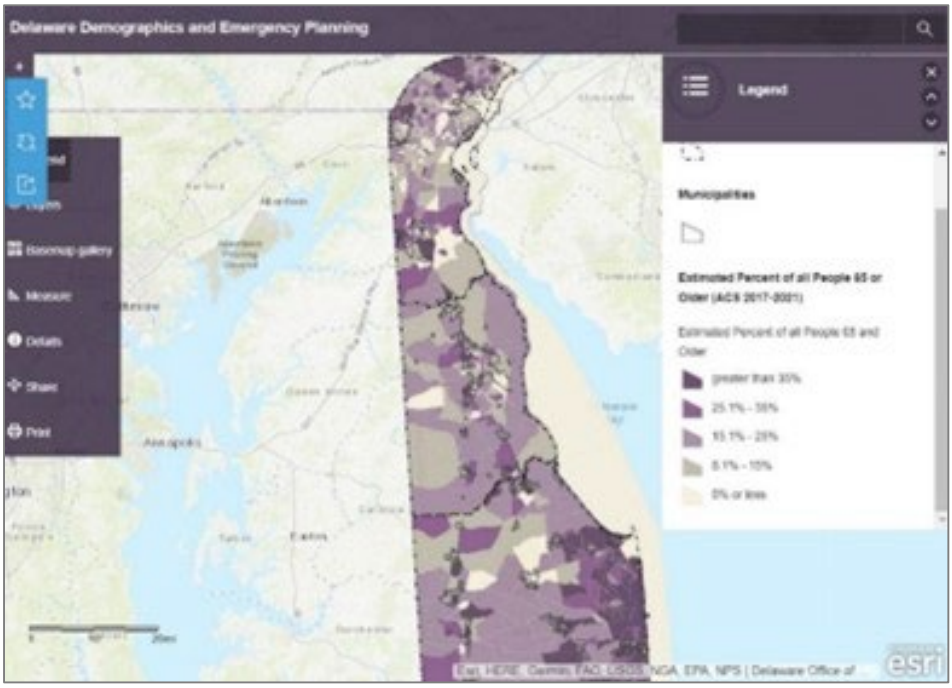
Connecting Aging in Place and Emergency Preparedness: Data Visualization to Support Community Leaders, Service Providers, and Hazard Mitigation Planners

Nicole Minni and Julia O'Hanlon

Overview

The percentage increase in Delaware's older adult population continues to be relatively high compared to other states. According to the U.S. Administration on Community Living's 2020 Profile of Older Americans, between 2009 and 2019, the first state experienced a 49 percent increase in its 65 and older population (65+) (Administration for Community Living, 2021). Growth in the state's older adult population underscores the need for thoughtful planning to support the ability of older adults to live in their homes and communities comfortably and safely for as long as they are able.

Delaware Equitable Planning for Local Adaptation Needs (DE-PLANs) is a hub site that compiles social vulnerability data, U.S. Census demographic data, social services, infrastructure, and hazard information to assist state, county, and local entities with hazard risk assessment, mitigation, grant writing, and emergency services such as preparedness, response, and recovery efforts related to older adults. DE-PLANs is funded by the Delaware Emergency Management Agency (DEMA) and is developed by the Delaware Sea Grant and the University of Delaware's Institute for Public Administration (IPA). Since 2020, Delaware Sea Grant and IPA have worked collaboratively to bridge areas of expertise and work on hazard mitigation, aging in place, flooding, and planning.



GIS Map showing the estimated percent of all people aged 65 and older in Delaware. Policy Map, Census, ACS 2017-2021

The figure above shows census block groups where the 65+ is greater than 35 percent. As seen during the COVID-19 pandemic, older adults experience higher rates of social isolation, are less connected to resources and

the internet, have health care and mobility needs, are distant from family, and tend to live on fixed incomes. These factors can make older adults especially vulnerable to disasters.

Featured Themes of DE-PLANS

Three themes are featured on the hub site: *Aging in Place, Hazards, and Connectivity*. Each theme presents information and resources relevant to end users. In addition to individual descriptions of these themes, other resources—including community and population profiles—connect the three areas and offer important data designed to aid in appropriate planning.

At Risk Community Profile for the Town of Bethany Beach

Joe Thomas from Sussex County at the Ready or Not Workshop, held in Lewes, DE

Looking Ahead

As the current state's 65+ population ages, community leaders, service providers, and hazard mitigation planners are presented with challenges around infrastructure, and services to support individuals in the community. Planning for this population requires comprehensive intergovernmental and multi-sectoral collaboration. DE-Plans is one resource that can provide continual support for local officials and policymakers to use in this process. By offering a variety of data visualization tools and resources, end users are better equipped to understand current and future vulnerabilities in their communities.

What is a Watershed Worth?

Andrew Homsey

We all value water. Without clean and sufficient water, life cannot be sustained. We want to live near water, and we want to vacation near water. Water sustains our industries, our cities, and our lives.

However, the value of water should not be taken for granted. Threats to water quality and the habitats that are sustained by it can be degraded through overdevelopment, pollution, or other types of mismanagement. To help protect these resources it is helpful to assign a dollar value to quantify their worth so that the true costs of not protecting them can be put in context. Doing so allows managers, decision-makers, and politicians to allocate resources to their protection, and gives the public a sense of the true economic impact of water resources.

In 2022 UDWRC studied the economic value of the tributaries to the upper Delaware River above Trenton in New Jersey (see map), and determined that overall, they contribute over **$6 billion** annually to the state's economy. Protecting and enhancing those resources is not a luxury, but rather a vital economic necessity.

Looking at economic value from several points of view allows a full assessment of all the various "values" that the watershed's resources provide. The usage of this region's water resources can be attributed to direct economic impacts such as revenue generation and economic activity. These can include the provision of clean drinking water, hydropower, agricultural irrigation, recreational activities, and revenue generated by businesses related to or dependent on clean water. Studies have also shown that these factors account for over **$1.6 billion** annually.

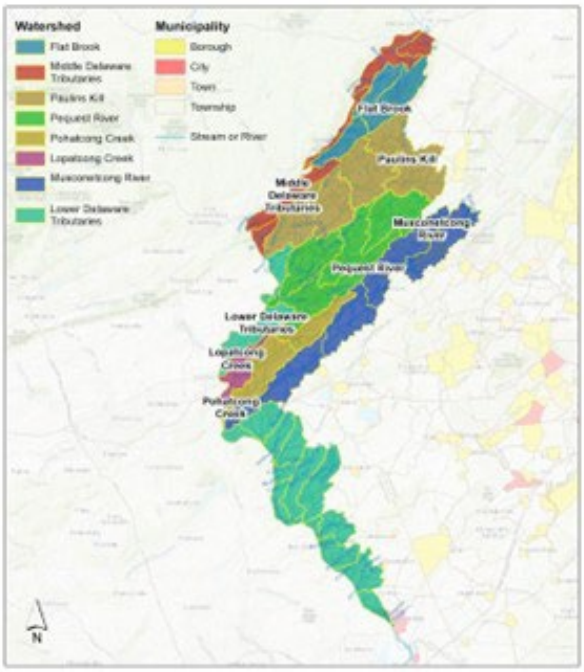
The Delaware Water Gap National Recreation Area is one of the most popular National Parks in the nation, drawing over 4.3 million visitors annually.

Ecosystem services are those services that natural environments provide to humans. These can include carbon sequestration, water filtration, pollination, soil health, flood, and stormwater control, and increased property values, among others. By estimating the dollar values of those services, we can determine their economic impact (or the negative impact should the resources be degraded). We found that ecosystem services provided by the New Jersey tributaries have a value of nearly **$2.3 billion** per year.

A final way employed to quantify the value of watersheds is by looking at jobs and wages associated with water resources. Jobs related to clean water can include those related to marinas, fishing, navigation, agriculture, and recreation. Those jobs are highly dependent on a healthy watershed and clean water. Overall, it was found that the watershed helps sustain over 40,000 local jobs, which generates over **$2 billion** in annual wages.

To enhance and refine the quantification of the direct value (willingness to pay) for recreation, UDWRC, in concert with the Musconetcong Watershed Association (MWA) and Environment NJ, conducted a series of field surveys of recreational users of the streams and lakes of the region. By surveying anglers, hikers, boaters, and hunters over a period of eight months, it was found that the recreational value of the NJ tributaries of the Upper Delaware River adds between $130 million and $350 million annually to the state’s economy.

From this perspective and many others, water is vital and precious to our society. Quantifying its monetary value can have an important impact on how it is managed for the future.



Delaware River Watersheds in New Jersey Above Trenton

Grad student Haley Rost surveying boaters at Lake Musconetcong

White Clay Creek State of the Watershed

Martha Narvaez and Andrew Homsey

The nationally designated Wild & Scenic White Clay Creek spans 108 square miles in southeastern Pennsylvania, northeastern Delaware, and a small segment of Maryland. Within Delaware and Pennsylvania, the White Clay Creek watershed includes two counties and thirteen towns and municipalities. The White Clay Creek consists of three main branches (West, Middle, and East). The rolling hills of the headwaters are agriculturally prevalent and flow through to the more urbanized Coastal Plain downstream. The White Clay Creek State of the Watershed Report, an update to the State of the Watershed Report, 2016, and State of the Watershed Report, 2008 was completed by the DWRC in the summer of 2023.

This report provides an overview of the White Clay Creek watershed and an assessment of the health of the watershed based on five key categories and 20 indicators within each of the five categories. The report provides technical analysis for each indicator, data analysis, and grades summarizing the data in color-coded wheels for the White Clay Creek watershed and each 12-digit Hydrologic Unit Code (HUC 12). The color-coded wheels provide a snapshot of the health of the entire White Clay Creek watershed and the five HUC 12 sub-watersheds

by indicator and category. DWRC worked in partnership with the Stroud Water Research Center, Brandywine Conservancy, and multiple organizations that have contributed to the data, content, and review of this report. This project, led by the University of Delaware Water Resources Center, is funded through the William Penn Foundation, the National Park Service, and the Stroud Endowment for Environmental Research and developed in partnership with the Brandywine-Christina cluster partners and the White Clay Wild and Scenic Management Committee

White Clay Creek watershed scoring for each category and indicator

Based on the data and analysis summarized in the report, White Clay Creek receives a B- for the overall watershed health. The sub-watersheds score similarly in the B to B- range for watershed health with the West Branch and Upper Main Stem scoring a B and the Middle and East Branches and Lower Main Stem scoring a B-. Of the five watershed health categories, Water Quality ranks the lowest in the White Clay watershed and four of the five sub-watersheds, excluding the West Branch where water quality is ranked in good health. The indicators with the prevailing low scores in the watershed and sub-watersheds are macroinvertebrates, flooding, and Nitrate. The indicator with the highest ranking in the White Clay Creek watershed and all five sub-watersheds is Dissolved Oxygen (DO) and chloride. The Scenic Quality indicator was measured in three of the five sub-watersheds and all three sub-watersheds (Upper Main Stem, East Branch, and Middle Branch) achieved a high value for scenic quality.

The Delmarva GIS Conference

Andrew Homsey and Nicole Minni

The 2022 Delmarva GIS conference was held at the Hyatt Place in Dewey Beach, Delaware, on May 12th and 13th. Coming off over two years of COVID shutdowns, it was refreshing to convene in person, especially at a beautiful venue overlooking scenic Rehoboth Bay. More than 175 professionals, academics, and students from the region, united by their interest in geospatial science and application came together to enjoy this two-day event.

Nicole Minni (center) prepares for DEGIS 2022 with Miriam Pomilio (L) and Laurel Sullivan (R).

Highlights from the first day included popular workshops, where participants learned about field mapping techniques, open-source GIS options, database processing with GIS, and promoting GIS programs within organizations. The second day of the conference saw many presentations, posters, and lightning talks, highlighted by a plenary featuring John Nelson of Esri, the global leader in GIS, and a lunchtime presentation on the history of GIS and the WRC's role in it by UDWRC director Dr. Jerry Kauffman.

Nicole Minni (L) poses with Kymberlie Kelly as they set up for DEGIS 2022 at the Dewey Beach Hyatt.

Attendees enjoyed the stunning setting (though the weather was unseasonably chilly), and were able to network, exchanging ideas (and business cards). Students could talk to potential future employers, and everyone took the opportunity to connect with old friends and colleagues as well as forge new relationships. Thursday night's Mappy Hour proved to be a crowd favorite and featured delicious hors d'oeuvres, a cash bar, and a lively trivia game complete with donated prizes.

This bi-annual event proved to be a wonderful opportunity to grow and learn from each other in support of this important discipline that benefits all of us. We look forward to our 25th-anniversary conference coming in 2024.

Attendees enjoying a relaxing moment at the 2022 Delmarva GIS Conference

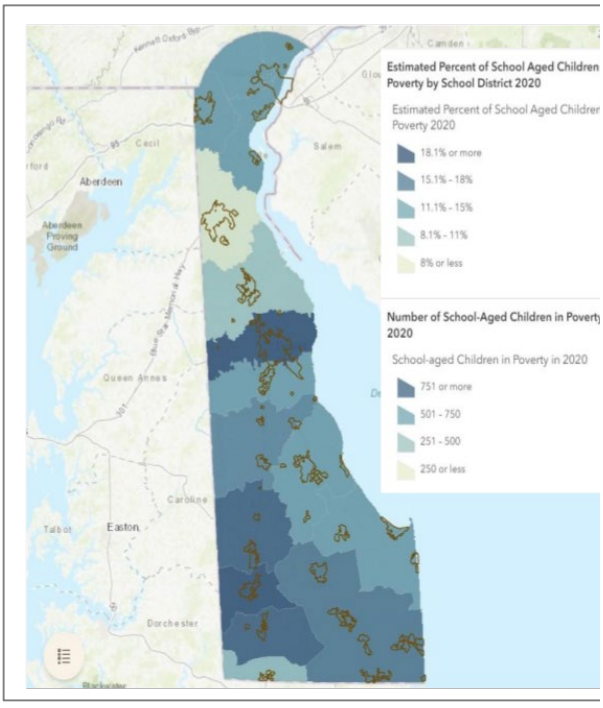
Save the Date: *Coming in 2024!*

On May 1 – 2, 2024 Delmarva GIS Professionals will come together to celebrate the 25th Anniversary of our Delaware GIS conference. The theme for this year is The Delmarva GIS Conference 2024: Celebrating 25 Years! The conference will once again be held at the Hyatt Place Dewey Beach in Dewey Beach, Delaware. Workshops and Mappy Hour will be held on Wednesday, May 1st, and the main conference event will be held on Thursday, May 2, 2024. Visit www.degis.org to stay up to date on all the conference details, which is sure to be quite a celebration. We hope to see you there

The Food Resources Connection

Nicole Minni and Julia O'Hanlon

As we approach the three-year mark since the pandemic's onset, the dynamic efforts of the Delaware Council on Farm and Food Policy and its partners have been busy coordinating and collaborating on a statewide approach to feeding Delaware communities. Working collaboratively with the Delaware Department of Agriculture and the Council, the Institute for Public Administration (IPA) at the University of Delaware (UD), and other partners continue to expand work on food resource mapping and data collection in the first state. The initiative is designed to use information and analyses to guide decision-making on statewide food resource opportunities supporting the coordination of food distribution efforts addressing food insecurity issues and aiding long-term recovery and strategic planning efforts throughout the state.



Estimated Percent of School-Aged Children in Poverty in 2020 (Census: Policy Map 2020).

Background

In March 2020, a coalition of civic and community organizations in the Cape Henlopen region of Sussex County, Delaware, named the Cape Community Coordination for COVID-19 (CCC4COVID)—and since renamed the Cape

Community Coalition —united to coordinate the local response to the pandemic. As part of the coalition, IPA developed an interactive GIS emergency food resource mapping application (https://arcg.is/T0uKa) to provide a rapid response to the rising food insecurity needs of vulnerable populations in the Cape Henlopen region. It was designed to identify gaps and coordinate emergency food distribution services. In adding U.S. Census Data to the application, it was immediately apparent by the Estimated Percent of School-Aged Children in Poverty by School District in 2020 that there was a need in Western Sussex County. IPA then expanded the work to all of Sussex County, and eventually statewide, to include data and resources for Kent and New Castle Counties (https://arcg.is/1iCXqS). Between May and June 30, 3021, funding support from Healthy Communities Delaware (HCD) allowed providing ongoing updates to the existing statewide food resource data and maps, while setting the stage for more extensive mapping and analyses. During this time, food resource partners, DDA, the Delaware Department of Education, Food Bank of Delaware began publishing their data to Delaware FirstMap. This work extended COVID-19 response efforts and supported HCD-affiliated stakeholders, including the Council, in identifying statewide food resources and distribution efforts targeted at the needs of Delawareans aged 18 and younger (https://arcg.is/1nT9e90)

Connecting Food Resources to Communities in Delaware, developed by the University of Delaware, Institute for Public Administration, with funding from the Delaware Council on Farm and Food Policy and Healthy Community Delaware

Current Projects and Initiatives

Funding over the past several fiscal years (FY22-FY23), continued IPA's support to the Council and contributed to their broader and longer-range vision of a comprehensive food systems collaborative and will continue to support the Delaware Food Resource Connection.

IPA has continued to conduct food resource mapping, data collection, and geospatial analysis to ensure that food

distribution methods, modes, and locations are prioritized to meet the needs of Delaware's food-insecure and vulnerable populations. This work could not have been done without the project partners, DDA, DOE Nutrition Services, Delaware Food Bank, CCC, and other Community-Based Organizations. The primary goals of the project are to support and expand the primary elements of the *Delaware Food Resource Connection* through data collection, case studies, and policy briefs and to assist partner organizations and other statewide policymakers in decision-making on issues involving opportunities and barriers related to food insecurities in Delaware. Featured information includes specific community characteristics, such as "At Risk Communities" Infographics from Esri's Community Analyst, U.S. Census demographic information, school district data, existing food resources such as local pantries in Delaware that are not part of larger databases (for example, U.S. Census or Policy Map). In addition, capturing state-wide healthy food availability from retail resources and grocery stores is helping to inform access barriers to food resource sites such as walking and driving distances from these locations. Food insecurity is a major health and quality of life issue. Connecting our most vulnerable populations to food resources will help close the gap in our Delaware communities. Working with the Delaware Council on Farm and Food Policy and its partners on these projects has been a valuable experience.

To learn more visit - https://farm-and-food-delaware.hub.arcgis.com/pages/about-the-council.

City of Wilmington Lead Service Line Inventory

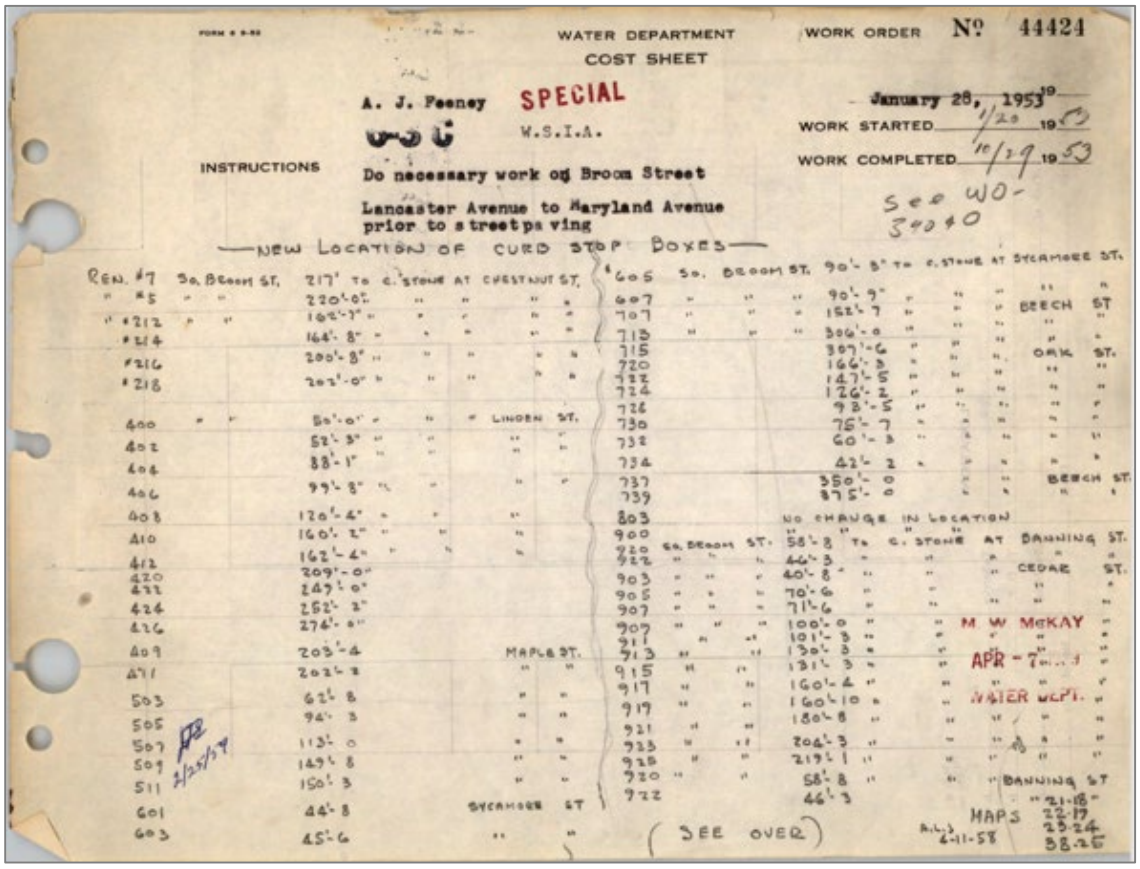
Martha Narvaez and Andrew Homsey

Lead is a toxic metal that is harmful to drinking water quality and has been used in water systems for over a century. The U.S. Environmental Protection Agency's (EPA) Lead and Copper Rule (LCR), established in 1991, protects public health by reducing lead and copper in drinking water systems. In 2021, based on the revised Lead and Copper Rule, the City of Wilmington, Delaware, like water systems throughout the nation, has been required to prepare and maintain a lead service line inventory by October 2024. As a result of these regulations, the City must identify the location of all lead service lines by 2024. The City of Wilmington has partnered with a private firm, Jacobs, to establish a procedure to develop an inventory of the City's lead pipes. In 2023, at the request of the City of Wilmington, UDWRC joined the project team to help lead the development of the City's lead inventory and analyze over 70,000 work orders to develop the inventory of the City's drinking water system.

The cost to the City to test for lead can be as much as $7,000 per address, and to replace each lead service line can run into the tens of thousands of dollars. With over 70,000 water service connections, this assessment will potentially save the City of Wilmington millions of dollars in avoided costs to meet the requirements of the LCR.

This inventory will be a cost-effective and critical tool to replace the City of Wilmington's lead pipes in the drinking water system and protect the residents' public health.

The Lead Project's data collection and inventory development is being led by the City of Wilmington Department of Public Works and Jacobs and is being implemented and adapted by UDWRC staff Martha Narvaez and Andrew Homsey and UDWRC Graduate and Undergraduate students. The project team has been working together to establish a uniform process for analysis and review of the drinking water system's historic work order records, dating back to the early 1900s. Obtained from the City of Wilmington, Department of Public Works (DPW), inputting this information into a singular file allows ease in identifying lead and its respective location. The City of Wilmington, through the work of Jacobs and UDWRC, aims to create an accurate inventory that will make future pipe replacement efficient and cost-effective. The process includes ArcGIS mapping the work order records with detailed data for each work order and pipe to allow the City to easily identify service line locations and materials and enable ease of both recognition and removal of the City's lead pipes. As data is entered and work orders are processed UDWRC students are providing project leads with input and feedback to modify and improve the process and final output for the inventory. UDWRC staff and students look forward to continuing this work with Jacobs and the City of Wilmington to ensure clean drinking water for the residents of Wilmington



WATER DEPARTMENT
COST SHEET

WORK ORDER Nº 44424

A. J. Feeney SPECIAL

W.S.I.A.

January 28, 1953

WORK STARTED 1/29 1953

WORK COMPLETED 10/29 1953

INSTRUCTIONS

Do necessary work on Broom Street

Lancaster Avenue to Maryland Avenue
prior to street paving

See WO-
34040

—NEW LOCATION OF CURB STOP BOXES—

REN. #7	So. Broom ST.	217'	To C. STONE	AT CHESTNUT ST.	605	So. BROOM ST.	90'-8"	To C. STONE	AT SYCAMORE ST.
" #5	" "	220'-0"	"	" "	607	" "	90'-9"	"	" "
" #212	" "	182'-7"	"	" "	707	" "	152'-7	"	" BEECH ST
#214		164'-8"	"	" "	713	" "	306'-0	"	" "
#216		200'-8"	"	" "	715		307'-6	"	" "
#218		202'-0"	"	" "	720		166'-3	"	" OAK ST.
					722		147'-5	"	" "
					724		126'-2	"	" "
400	" "	80'-0"	"	" LINDEN ST.	726		98'-5	"	" "
402		52'-3"	"	" "	730		75'-7	"	" "
404		88'-1"	"	" "	732		60'-3	"	" "
406		99'-8"	"	" "	734		42'-2	"	" "
408		120'-4"	"	" "	737		350'-0	"	" BEECH ST.
410		160'-2"	"	" "	739		875'-0	"	" "
412		162'-4"	"	" "	803		NO CHANGE IN LOCATION		
420		209'-0"			900		" " "		
422		249'-0"			920	So. BROOM ST.	58'-8	To C. STONE	AT BANNING ST.
424		252'-2"			922	" "	46'-3	"	" "
426		274'-8"			903	" "	40'-8	"	" CEDAR ST.
409		203'-4		MAPLE ST.	905	" "	70'-6	"	" "
411		202'-2		" "	907	" "	71'-6	"	" "
503		62'-8		" "	909	" "	100'-0	"	" M. W. McKAY
505		94'-3		" "	911	" "	101'-3	"	" "
507		113'-0		" "	913	" "	130'-3	"	" APR - 7
509		149'-8		" "	915	" "	131'-3	"	" "
511		150'-3		" "	917	" "	160'-4	"	" "
601		44'-8		SYCAMORE ST	919	" "	160'-10	"	" WATER DEPT.
603		45'-6		" "	921	" "	180'-8	"	" "
					923	" "	204'-3	"	" "
					928	" "	219'-1	"	" "
					720	" "	58'-8	"	" BANNING ST
					922		46'-3		" "

(SEE OVER)

MAPS 21-18
22-17
23-24
38-25

A.L.J. 4-11-58

City of Wilmington Water Department Work Order, January 28, 1953

Local Leadership in the Chesapeake Bay Watershed

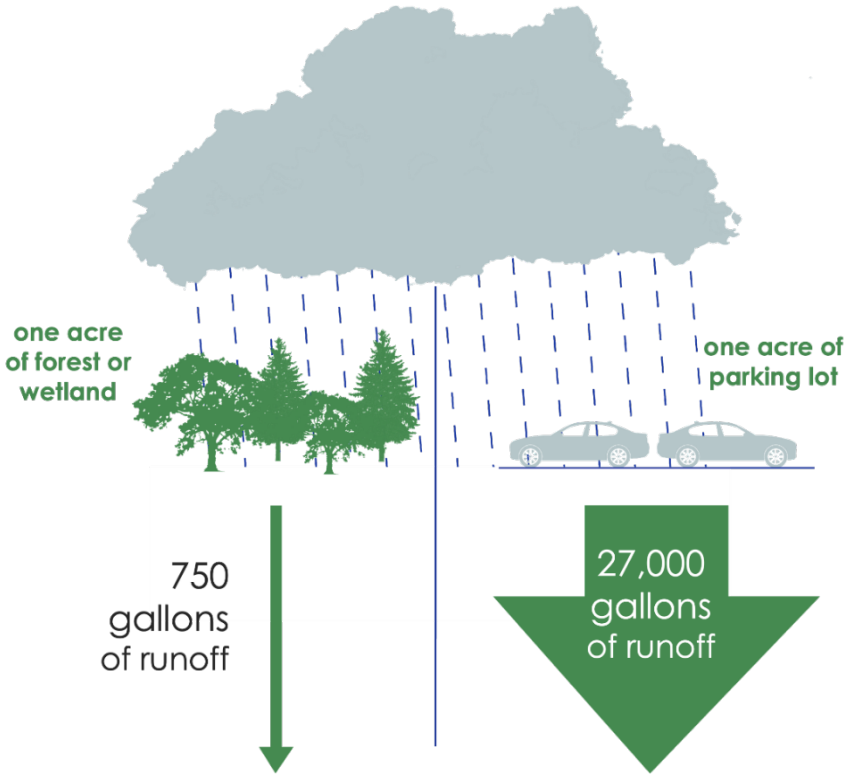
Martha Narvaez

The western portion of Delaware, with land in all three counties—New Castle, Kent, and Sussex—drains to the largest estuary in the United States, the Chesapeake Bay watershed. The Chesapeake Bay, an iconic watershed is home to 18 million people and 3,600 species of plants and animals. The watershed is 64,000 square miles and contains 11,684 miles of shoreline and 150 major rivers and streams that span six states – Delaware, Maryland, New York, Pennsylvania, Virginia, West Virginia, and the entire District of Columbia.

The Local Leadership Workgroup (LLWG) was established through the 2014 Chesapeake Watershed Agreement with the goal of increasing the knowledge and capacity of local officials on issues related to water resources and in the implementation of economic and policy incentives that support local conservation actions. To achieve these goals, the LLWG has developed a 2023 – 2025 Logic and Action Plan and Management Strategy that prioritizes outreach and engagement activities with the local officials in the Chesapeake Bay watershed.

Most recently, LLWG, with assistance from the Chesapeake Bay Program and Green Fin Studios, has developed educational modules and the ProtectLocalWaterways.org website. Eleven modules were developed by local elected officials for local elected officials, to support decision-making and achieve mutually beneficial outcomes for communities and the environment. The educational modules include fact sheets, presentations, and brief videos on topics relevant to the preservation and protection of local communities. These modules can be customized to align with the unique needs of the Chesapeake Bay communities and help to provide local leaders with outreach and educational resources. The modules include a variety of topics from over-arching water resource topics such as how your watershed works, foundations of clean water, and clean water for the economy and more specific topics such as:

- Capitalizing on the Benefits of Trees
- Preparing Your Community for Water Extremes
- Understanding and Supporting Your Agricultural Allies
- Keys to Building Community Buy-in for the Environment
- Your Health and the Environment



LLWG education module graphic that provides local leaders with education and outreach materials

These learning modules, videos, fact sheets, and case studies can be accessed on the new website, ProtectLocalWaterways.org.

The workgroup also coordinates and hosts activities to engage local leaders. In Delaware, LLWG coordinated the *Wandering Delaware's Waterways* tour in Fall 2022 in partnership with the Delaware League of Local Governments. Beyond Delaware, in the Bay watershed, LLWG has coordinated roundtable discussions in Lancaster County, PA, local magazine articles on prevalent topics such as green infrastructure, peer-to-peer tours in DC and the Delmarva region, and webinars with a focus on location-specific watershed topics.

UDWRC's Martha Narvaez serves as Vice Chair and will become Chair of the workgroup in 2024. The Vice Chair/Chair serves as a voice in engaging local elected officials, appointed officials, and senior staff in the restoration of the Chesapeake Bay and helps to lead the workgroup's efforts in meeting the Local Leadership Outcome of the 2014 Chesapeake Bay Watershed Agreement. Martha works with Chesapeake Bay Program staff and workgroup members to bring a local government perspective that balances local priorities with watershed restoration efforts.

Wandering Delaware’s Waterways tour with the Delaware League of Local Governments and LLWG, Fall 2022

UDWRC Photo Gallery

Jerry Kauffman speaks at the Brandywine Flood Study Press Event at the Brandywine Conservancy in August 2023.

DWRC students conduct water quality sampling and field work in the Wild & Scenic White Clay Creek. Pictured is Lydia Franks.

Lydia Franks, Liz Shields, Jerry Kauffman (left to right) participate in outreach at the White Clay Creek Fest.

City of Wilmington Mayor Purzycki, Deputy Director City of Wilmington Parks and Recreation Department, DWRC's Martha Narvaez and City of Wilmington Green Jobs Program interns attend the Program's closing ceremony on August 4th.

IPA Director, Jerome Lewis, and DWRC staff and graduate and undergraduate research interns gather at the DWRC Advisory Panel meeting in May 2023.

DWRC's annual Bratfest cookout brought out both students and other faithful friends.

Andrew Homsey, Jerry Kauffman and Martha Narvaez led a bike tour around Wilmington as part of the 11th Annual Delaware River Watershed Forum sponsored by the Coalition for the Delaware River Watershed.

Water Resources Information and Training

Delaware Section of the American Water Resources Association events information can be found here.

The University of Delaware Section of AWRA - activities can be found here.

Water News serves citizens interested in topics on Delaware water resources and is published by the Delaware Water Resources Center, University of Delaware.

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