2018 ANNUAL MARYLAND GROUNDWATER SYMPOSIUM

Sponsored by the Water Supply Program
Maryland Department of the Environment

Maryland
Department of
the Environment

Welcome to the 27th Annual Maryland Groundwater Symposium. It is our pleasure to provide this excellent educational and networking opportunity for groundwater professionals. We are honored to have well-respected and renowned professionals speaking to us about their fields of expertise.

This Symposium is made possible by the generous contribution of the presenters who are willing to share their knowledge with us today. For that, we are all grateful.

We are also appreciative of the Environmental Protection Agency Region III. Their financial support allows us to keep registration costs affordable for all participants.

Many challenges arise in the protection and use of groundwater every year. Contaminants are discovered at new locations, water levels may decline in some of our major aquifers, accidental spills may occur, and conflicts may develop among competing water users. This symposium provides a forum to learn from each other to better be prepared for facing these challenges.

Whether we are employed in Federal or State agencies, local governments, water utilities, as consultants, in private industry or academia, we all share a common goal of protecting and conserving this most valued resource. The annual Groundwater Symposium is an enduring example of the State's coordinated effort to collaborate on water resource management issues.

We sincerely hope you enjoy the Symposium today, and that you learn something new which you are able to apply in your career. Thank you for all the wonderful work you do throughout the year. We hope you realize the positive impact you are making as public health and environmental professionals!

Sincerely,

Saeid Kasraei
Administrator
Water Supply Program

Morning Plenary: Embassy Room

9:00 – 9:15 a.m.	**Welcome and Opening Remarks**
9:15 – 10 a.m.	**Keynote Address** **The Importance of Groundwater Science to a Sustainable Future in Maryland** *Robert J. Shedlock, Scientist Emeritus, U.S. Geological Survey*
10 – 10:45 a.m.	**Impacts of Air Emissions and Wastewater Discharges from a Fluorochemical Manufacturing Plant on Nearby and Distant Communities** *Detlef Knappe, Ph.D., NC State University*

Break | 10:45 – 11:05 a.m.

Morning Session One | 11:05 – 11:35 a.m.

Canal Creek Aquifer: Contamination, Evolving Treatment, Beneficial Reuse
Jeff Aichroth and Rurik Loder, Aberdeen Proving Ground, Garrison Environmental Division
Maryland Room

Groundwater Level Decline in the Piney Point Aquifer of Delmarva and Western New Jersey
Scott Andres and Rachel McQuiggan, Delaware Geological Survey
Regency Room

Association Between Private Drinking Water Wells and the Incidence of Campylobacteriosis in Maryland: An Ecological Analysis Using Data from the Foodborne Diseases Active Surveillance Network (FoodNet)
Rianna Murray, MPH, University of Maryland College Park
Embassy Room

Disinfection Byproducts in Ground Water Systems
Chris Watling, MDE-Water and Science Administration
Wayne Room

Morning Session Two | 11:45 a.m. – 12:15 p.m.

A Reactive Biobarrier for in situ Remediation of Chlorobenzenes in Contaminated Groundwater at Anaerobic-Aerobic Interfaces
Steven J. Chow, Department of Environmental Health and Engineering, Johns Hopkins University
Maryland Room

Effects of Increased Withdrawals from the Aquia Aquifer on the Mayo Peninsula, Anne Arundel County, Maryland with an Evaluation of Water Quality
Tiffany VanDerwerker, P.G., Maryland Geological Survey
Regency Room

Enhancing Multi-Objective Management of Municipal Wastewater, Groundwater Use and Agricultural Irrigation via a Water Reuse GIS Decision Support System
James George, Ph.D., MDE-Water and Science Administration
Masoud Negahban-Azar, Ph.D., University of Maryland
Embassy Room

Challenges and Successes in Compliance with H.B. 270 Lead in Drinking Water
Terry L. Norman, Maryland Environmental Services
Robert Souza, Wicomico County Board of Education
Wayne Room

Lunch | 12:15 – 1:30 p.m.

CERTIFICATES FOR THE 27TH ANNUAL MARYLAND GROUNDWATER SYMPOSIUM

Thank you for attending the 27th Annual Groundwater Symposium. You will receive an e-mail from gws@mcet.org within two weeks of this event with a link to MDE's Program Evaluation Survey.

Once you complete the evaluation you will be able to download a certificate of attendance for this program. **The link will be available for three weeks and certificates will ONLY be available after completion of the survey and during this timeframe.** Please add gws@mcet.org to your e-mail address book to ensure receipt of this e-mail.

Afternoon Session One | 1:30 – 2 p.m.

Temporal and Spatial Variability of Groundwater Quality in the Mid-Atlantic
Brandon Fleming and Bruce Lindsey, P.G., U.S. Geological Survey
Maryland Room

Using Three-Dimensional Coupled Surface-Subsurface Models to Assess Urban Water Balances from Site to Regional Scales
Claire Welty, Ph.D., University of Maryland, Baltimore County
Regency Room

Conserving Groundwater Through Water Recycling for Food Crop Irrigation: A Focus on CONSERVE – A Center of Excellence at the Nexus of Sustainable Water Reuse, Food, and Health (Part 1)
Rachel Rosenberg Goldstein, Ph.D., Shirley Micallef, Ph.D., Masoud Negahban-Azar, Ph.D., University of Maryland, College Park
Embassy Room

The Incidence and Causes of Elevated Lead and Copper in Private Water Wells and Springs in Pennsylvania
Bryan Swistock, Penn State University
Wayne Room

Afternoon Session Two | 2:05 – 2:35 p.m.

Installing an Appropriate Monitoring Well Network for a Landfill that is Located on Top of a Reclaimed Strip Mine: Lessons Learned
John Agnoli and Carly Cushing, Maryland Environmental Service
Maryland Room

Determining Factors Detrimental to Well Yield: a Garrett County Case Study
John Boris, LEHS and Sara Albrecht, Maryland Department of the Environment
Regency Room

Conserving Groundwater Through Water Recycling for Food Crop Irrigation: A Focus on CONSERVE – (Part 2)
Rachel Rosenberg Goldstein, Ph.D., Shirley Micallef, Ph.D., Masoud Negahban-Azar, Ph.D., University of Maryland, College Park
Embassy Room

Sanitary Survey Basics: Identifying Contamination Risks of Well Systems
Alex McNamee, P.E., MDE-Water and Science Administration
Wayne Room

Break | 2:35 – 2:50 p.m.

Afternoon Session Three | 2:50 – 3:20 p.m.

Tree Trade-Offs in Stream Restoration Projects: Impact on Riparian Groundwater Quality
Kelsey Lynn Wood and Joseph George Galella, University of Maryland, ESSIC
Maryland Room

Estimated Use of Water in the United States for 2015 - A Closer Look at Groundwater Withdrawals
Cheryl A. Dieter, U.S. Geological Survey
Regency Room

Conserving Groundwater Through Water Recycling for Food Crop Irrigation: A Focus on CONSERVE – (Part 3)
Rachel Rosenberg Goldstein, Ph.D., Shirley Micallef, Ph.D., Masoud Negahban-Azar, Ph.D., University of Maryland, College Park
Embassy Room

Unique Process Control Strategy for Optimum Nitrogen Removal in Small Flow Wastewater Treatment Plants
Gary Lucas and Brandon Friedland, Innovative Treatment Products, LLC
Wayne Room

Afternoon Session Four | 3:25 – 3:55 p.m.

Use of Bacteria in Degradation of BTEX Contaminated Groundwater
Mahnaz Mazaheri-Assadi, Ph.D., Chesapeake Research Consortium
Maryland Room

Water Use Estimates in Maryland for 2015
Wendy S. McPherson, U.S. Geological Survey
Regency Room

Options for the Management of Food Processing Wastewater
Michael Eisner, MDE-Water Management Administration, Wastewater Permits Program
Embassy Room

Emerging Contaminants: Do They Eventually Emerge?
Simin Rezai, Ph.D., MDE-Water and Science Administration
Wayne Room

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ABSTRACTS OF PRESENTATIONS

Morning PLENARY | 9:15 – 10:45 a.m.

The Importance of Groundwater Science to a Sustainable Future in Maryland
Robert J. Shedlock, Scientist Emeritus, U.S. Geological Survey

The annual Maryland groundwater symposium is a testament to the enthusiasm of all the individuals and organizations that form the groundwater community of practice in the State of Maryland. All of us in this community know that groundwater is an essential and dynamic component of the entire hydrologic system and interacts with or is influenced by the other components. We know that groundwater is an important source of water supply and nearly a sole source in many areas of Maryland. We also know that groundwater is vulnerable to contamination and in many areas is a source of excess nutrients and toxic compounds to streams, wetlands, and estuaries. We recognize that groundwater is ubiquitous and find it hard to imagine many environmental challenges for which the underlying groundwater system is not a significant consideration. Unfortunately, the breadth and importance of groundwater science is not always well understood by policy makers and the general public. Public misconceptions about groundwater abound partly because people cannot see groundwater and do not understand the variability in groundwater flow systems and residence times.

This presentation will review some of the important water resource, environmental quality, and geotechnical issues for which an understanding of the underlying groundwater system is crucial to maintaining and promoting human health and welfare, viable agricultural systems, ecosystem health, and the sustainability of our towns and cities. The presentation will also emphasize how our groundwater community must explore how groundwater systems are affected by climate change, sea-level rise, the growth of urban and suburban areas, aging infrastructure, and changes in agricultural practices. With these emerging issues, groundwater availability will still be important, especially in suburban and rural areas, but new lines of inquiry will need to be explored such as monitoring and investigating groundwater in coastal zones susceptible to brackish water intrusion and investigating interactions between groundwater and wetlands in coastal zones. The groundwater community will also need to continue working on important water quality issues such as the loading of groundwater contaminants to urban streams, the effects of groundwater on surface water quality in agricultural areas, and the ever-growing effects of road salt on both groundwater and surface water quality.

Much more work needs to be done to educate policy makers and the public on the importance of groundwater and how it should be properly managed as a resource. Scientists need to be part of this education process, but the groundwater community also needs to figure out ways of partnering with and enlisting the support of politicians, business

leaders, and non-governmental organizations. Strong and effective advocates are needed for groundwater systems to be considered in plans and discussions of environmental issues of the future, especially those that relate to sustainability. Moreover, these plans ought to acknowledge that additional monitoring programs and new simulation studies need to be started.

Impacts of Air Emissions and Wastewater Discharges from a Fluorochemical Manufacturing Plant on Nearby and Distant Communities
Detlef Knappe, Ph.D., NC State University
Embassy Room

In the past, a common processing aid in the production of fluoropolymers was the ammonium salt of perfluorooctanoic acid (PFOA). Because PFOA is bioaccumulative, toxic, and persistent, its production and use in the United States (US) is being phased out. In 2009, the US Environmental Protection Agency stipulated conditions for the production and commercial use of GenX, a PFOA replacement. The acid form of GenX and other perfluoroalkyl ether acids (PFEAs) are also generated as by-products during the production of fluoromonomers, and the discharge of PFEAs to water and air is unregulated.

In this presentation, the chemistry of PFEAs is introduced, and pathways by which PFEAs enter the environment are described. In North Carolina, wastewater discharges from a fluorochemical manufacturer to the Cape Fear River impacted drinking water quality of several communities located ~150 km downstream of the fluorochemical plant. In these communities, more than 200,000 residents were likely exposed to high fluorochemical levels (tens of micrograms per liter) for almost four decades because public water systems employing conventional and advanced drinking water treatment processes were unable to remove PFEAs. Also, PFEAs and their acid fluoride precursors have been emitted to the air. Atmospheric transport and PFEA deposition to the soil has contaminated wells of private residences and public water systems within an area that extends several miles from the property line of the fluorochemical manufacturer. Apart from PFEA exposure via drinking water, residents are also concerned about additional exposure routes including inhalation and ingestion of locally grown food. For example, a recent analysis showed that honey from a nearby beekeeper contained 2,000 ng/L GenX. The audience will receive current information about PFEA occurrence in multiple environmental compartments in the vicinity of the fluorochemical manufacturer.

Morning Session One | 11:05 – 11:35 a.m.

Canal Creek Aquifer: Contamination, Evolving Treatment, Beneficial Reuse
Jeff Aichroth and Rurik Loder, Aberdeen Proving Ground, Garrison Environmental Division
Maryland Room

The Canal Creek aquifer located on the United States Army Garrison at Aberdeen Proving Ground (APG), Maryland has been the subject of study since the mid -1970s. The aquifer had not been used as a potable water source since 1968, and had begun undergoing investigation several years afterwards. Chlorinated Volatile Organic Compounds such as Tetrachloroethane and Trichorloethylene were verified as among the primary contaminants. To address the contaminated aquifer (in conjunction with other sites at APG) a Federal Facilities Agreement with EPA was signed in 1990 which provided a defined process to achieve remediation in a structured and documented approach via the CERCLA (Superfund) program.

In accordance with the Record of Decision in 2000, a groundwater treatment system was designed, installed, and became operational in 2004. The original water plant was converted to a pump and treat facility. A 3-phase treatment process was developed and consisted of metals removal, adsorptive resin, and later carbon polishing. The remedial goal being to achieve <100ug/l for the total VOCs as well as other water quality parameters that satisfied the NPDES requirements prior to surface discharge. Although originally designed to process 50 gallons per minute, to maintain the plume capture and containment, the system needed modification. The plant currently processes an average of 130 gallons per minute which is accomplished through redundant trains. Evolving optimizations also occurred over time including changing the adsorptive resin when the original material was no longer available, changing the direction of the process flow thru the resin vessels to reduce system pressures, adjusting the pH in the metals removal portion of the process which reduced waste generation as well as maintenance downtime. The plant continues to consistently meet parameters for regulatory compliance, as well as maintaining excellent process up-times often exceeding 95%. The contaminant plume is well delineated by an extensive monitoring well system. Currently, six strategically located extraction wells provide capture. Iso-contour maps continue to demonstrate decreasing areas with incremental values of greater than the 100ug/l target. While the plume shape has shown minor shifts over time, adjusting the pumping system to include extraction pulsing, allows us to respond to a specific area without major impacts to the rest of the system.

In the development of the Record of Decision, (which defines and documents the agreed upon path forward), the writers had the wisdom to include language allowing for Beneficial Reuse of the treated effluent. This came to fruition in 2016 with utilization of the effluent as boiler make-up water as part of the revitalization of the boiler plant which provides for the significant energy needs of the Edgewood portion of the Army installation. All of the treated groundwater can be used by this new Co-Generation facility and provides a $400,000

annual savings vs. the purchase of potable supply from off -post for the same purpose. Ultimately, groundwater monitoring, active / dedicated treatment operations, and creativity have led towards a positive outcome while addressing aquifer contamination.

Groundwater Level Decline in the Piney Point Aquifer of Delmarva and Western New Jersey

Scott Andres and Rachel McQuiggan, Delaware Geological Survey

Regency Room

The Piney Point aquifer extends beneath the mid-Atlantic coastal states and is a significant groundwater resource for parts of Maryland, Delaware and New Jersey. Those familiar with the Piney Point story probably recall a period during the 1970s when increases in rates of annual drawdown on Delmarva were accelerating. A flurry of monitoring and modeling activities by the USGS and MGS tied the water level declines to increased water use and raised the specter of a dewatered aquifer within a few decades. A combination of water management initiatives and economic changes slowed the increase in water use and, as a result, water level declines dropped to rates that were of limited concern or even recovering in some key Maryland observation wells.

After about twenty years of relative stability, water level declines observed in the Piney Point aquifer are again occurring at rates causing concern for the area around Dover, Delaware. This aquifer receives recharge only through diffuse leakage, and as a result, there is a greater potential for increased usage to impact the sustainability of the Piney Point. Beginning about 2010, water level decline rates in the Dover area are now approaching five feet per year. At this rate of decline, water levels are projected to reach the top of the aquifer in the Dover area in about 20 to 30 years. Dewatering can reduce the yield of any aquifer; however, the Piney Point is largely composed of the clay mineral glauconite that is susceptible to compaction and pore -space rearrangement when pore pressure declines and lithostatic stresses increase.

New hydraulic, geophysical, and hydrologic data is now being collected to enhance our ability to more precisely determine when and where drawdown will be an issue. The goal is to make predictions of sustainable pumping rates from the aquifer.

Association Between Private Drinking Water Wells and the Incidence of Campylobacteriosis in Maryland: An Ecological Analysis Using Data from the Foodborne Diseases Active Surveillance Network (FoodNet)

Rianna Murray, MPH, University of Maryland College Park

Embassy Room

Campylobacter is a leading cause of foodborne illness in the United States. *Campylobacter* infections have most often been associated with food-related risk factors, such as the consumption of poultry and raw milk. Recent studies, including one in Maryland, have indicated that beyond food-related risk factors there are socioeconomic, agricultural and environmental risk factors for campylobacteriosis, including living in close contact with livestock and consumption of contaminated water. Approximately 19% of Maryland residents rely on private wells as their sole source of water, particularly in Southern Maryland and along the Eastern Shore. However, no previous studies have evaluated the association between consumption of water from a private well and campylobacteriosis rates in Maryland. Given that the Safe Drinking Water Act does not regulate the water quality of private wells, these could be an important non-foodborne transmission pathway for *Campylobacter*.

Therefore, using an ecological approach, we examined the association between the prevalence of private drinking water wells and the incidence of campylobacteriosis at the zip code level. In addition, we assessed whether proximity to animal feeding operations influenced this association. FoodNet data on culture-confirmed cases of *Campylobacter* infection in Maryland between 2007-2016 were linked by zip code with data from the Maryland well permits registry, the 2010 US Census, the 2016 American Community Survey, and the USDA Agricultural Census. Campylobacteriosis incidence rates were calculated by zip code and the prevalence of wells was also calculated by zip code. A negative binomial regression model was then used to evaluate the association between the prevalence of private wells, proximity to animal feeding operations and the incidence of campylobacteriosis. These relationships were examined across the different physiographic provinces in Maryland.

From 2007-2016, a total of 5,746 cases of campylobacteriosis were reported in Maryland, and annual incidence rates ranged from 6.65 to 11.59 per 100,000 people. A significant positive association was detected between the prevalence of private wells in a zip code and the risk of campylobacteriosis in the Piedmont province of Maryland (Incidence rate ratio = 1.1609; 95% CI = 1.0188, 1.3229). The presence of broiler chicken operations, cattle operations, dairy operations and turkey operations in zip codes were also significantly associated with campylobacteriosis incidence in some physiographic provinces in Maryland. These findings suggest that private drinking water wells may be a risk factor for campylobacteriosis in the State of Maryland. Additionally, certain geologic features may also influence the incidence of campylobacteriosis in the state.

Disinfection Byproducts in Ground Water Systems

Chris Watling, MDE-Water and Science Administration

Wayne Room

It is not surprising that Disinfection byproducts (DBPs) are of concern in the distribution systems of surface water systems. However, in Maryland, there have been many ground water systems, mostly on the Eastern Shore, that have had unexpectedly high DBP results. DBPs can form in drinking water distribution systems when naturally occurring organic materials react with disinfectants (other than ultra-violet treatment). The Stage 1 and Stage 2 Disinfectants and Disinfection Byproducts Rules (DBPRs) established monitoring requirements and Maximum Contaminant Levels (MCLs) for Total Trihalomethanes (TTHM), 5 Haloacetic Acids (HAA5), Chlorite, and Bromate, for all Community and Non-Transient Non-Community drinking water systems. When organic materials are not removed from source water, it is likely that disinfection byproducts, to some extent, will form in the distribution system.

Surface water sources are more likely than ground water sources to have significant organic materials in the raw water. Thus, under the Stage 1 DBPR, surface water systems were required to remove specific percentages of disinfection byproduct precursors (i.e., organic materials measured as Total Organic Carbon (TOC)) from raw water at the treatment plant. Surface water treatment plants typically utilize coagulation, flocculation, sedimentation, and filtration to remove TOC from raw water before these disinfection byproduct precursors can enter the distribution system. Ground water systems, however, do not typically monitor TOC in their source water, nor do they filter or treat the water to reduce the level of TOC that enters the distribution system. Thus, ground water sources that are susceptible to higher levels of TOC in the source water are likely to have significant problems with the formation of DBPs in the distribution system. This presentation will examine several factors that contribute to elevated levels of DBPs in ground water distribution systems, and the possible ways to reduce the formation of DBPs by examining source water characteristics, treatment options, and distribution system management practices.

Morning Session Two | 11:45 a.m. – 12:15 p.m.

A Reactive Biobarrier for in situ Remediation of Chlorobenzenes in Contaminated Groundwater at Anaerobic-Aerobic Interfaces

Steven J. Chow, Department of Environmental Health and Engineering, Johns Hopkins University

Maryland Room

Halogenated organic chemicals have been produced and improperly released into the environment for over a century, leaving thousands of contaminated sites around the world at risk and in need of remediation. At the Standard Chlorine of Delaware (SCD) EPA Superfund Site (New Castle, Delaware), groundwater is contaminated with a persistent source of chlorobenzenes (CBs) and is discharged into an extensive wetland surface water system. Natural anaerobic-aerobic gradients in contaminated wetlands similar to the SCD site may potentially be leveraged to facilitate bioremediation of these contaminants. Reductive dechlorination of higher chlorinated CBs under anaerobic conditions can lead to the accumulation of daughter products such as monochlorobenzene and benzene, which are more toxic and bioavailable than their parent compounds. Aerobic biodegradation can readily mineralize less chlorinated daughter compounds to harmless end-products, however, oxygen availability often limits this degradation pathway in anaerobic sediments. Deploying microorganisms capable of both degradation pathways in a permeable barrier at a wetland surface represents a low-cost and novel strategy to treat persistent sources of CB contamination.

We have demonstrated that this treatment paradigm is viable using a model barrier in laboratory column experiments. Both anaerobic and aerobic degradation pathways were maintained for 1 year under various organic carbon dosage levels, with up to 72% mineralization (3.5 mg/L) of initial 1,2 4-trichlorobenzene contaminant achieved. Through sacrificial sampling, we are able to probe the spatial distribution of microbial biofilm and identify trends and characteristics of a well-functioning degradative community. Additionally, biodegradation processes can be confounded by a wide range of alternative electron acceptors such as nitrate, ferric iron, and sulfate. They create overlapping redox conditions that may favor competing non-biodegradative microbial pathways limiting the effectiveness of engineered treatment systems. In our ongoing work, we utilize parallel model barriers to determine the performance of both dual- and single- pathway degradation under alternative redox conditions. Here, we evaluate the influence of varying concentrations of electron acceptors nitrate and sulfate on individual biodegradation pathways, overall bioremediation outcomes, and the underlying microbial biofilm communities. Utilizing the results of these experiments, we will better understand the functionality and limitations of implementing this biobarrier system at scale in the field for sites such as SCD.

Effects of Increased Withdrawals from the Aquia Aquifer on the Mayo Peninsula, Anne Arundel County, Maryland with an Evaluation of Water Quality

Tiffany VanDerwerker, P.G., Maryland Geological Survey

Regency Room

The Mayo Peninsula in east-central Anne Arundel County, Maryland relies primarily on the Aquia aquifer for drinking-water supply. The deeper Magothy aquifer is also utilized but to a much lesser extent. The lifting of a building moratorium in 2017 on the peninsula associated with increased capacity for treating sewage effluent may result in the construction of up to approximately 630 homes. The potential effects of increased domestic water withdrawals to support the possible growth on water levels and on the brackish-water interface in the Aquia aquifer were evaluated. In addition, water quality of the Aquia aquifer, both natural and affected by anthropogenic contaminants that might constrain the use of the Aquia aquifer for domestic potable supply was also evaluated.

To characterize water quality of the Aquia aquifer, 24 wells were sampled during this study. Three wells with chloride concentrations between 284 and 386 milligrams per liter (mg/L) and a Cl:Br ratio between 249 and 392 were determined to be affected by brackish-water intrusion, located near the shoreline (less than 600 feet); Eight wells with chloride concentrations between 81 and 221 mg/L and a Cl:Br ratio greater than 529 were determined to be affected by road salt and; 13 wells were determined to be freshwater. The uppermost portion of the Aquia aquifer is weathered (maximum depth of approximately 60 feet below land surface) and produces water that may be acidic (pH less than 6.5). Cadmium and chloride concentrations tend to be greatest in that portion of the aquifer. The deeper Magothy aquifer, an alternative drinking water supply on the peninsula, is less susceptible to surface contamination and brackish-water intrusion; however, iron concentrations can range from 14.0 – 26.0 mg/L, requiring treatment for domestic supply.

The potential increase of between 0.093 and 0.158 million gallons per day resulting from the possible new development on the Mayo Peninsula was evaluated using a one-layer numerical groundwater-flow model (MODFLOW) to estimate the effects on water levels in the Aquia aquifer and on the brackish-water/freshwater interface. Additional withdrawal from the Aquia aquifer resulting from new development will likely result in drawdown (lowering of the water-table) of less than 0.25 feet for most of the peninsula. Potential drawdown from new development on the peninsula is greatest near Glebe Bay, where drawdown could reach approximately 2 feet. Where potential drawdown is greatest, the brackish-water/freshwater interface could rise by approximately 55 feet to more than 65 feet and pose a risk for existing wells near the shoreline. The effects of the potential increased withdrawals on the Aquia aquifer could be reduced by shifting pumpage to the deeper Magothy aquifer in areas of greatest drawdown.

Enhancing Multi-Objective Management of Municipal Wastewater, Groundwater Use and Agricultural Irrigation via a Water Reuse GIS Decision Support System

James George, Ph.D., MDE-Water and Science Administration
Masoud Negahban-Azar, Ph.D., University of Maryland
Embassy Room

In this joint presentation Dr. George, from the Maryland Department of Environment, will provide a brief orientation to the topic of water reuse. He will outline MDE's water reuse initiative and motivations for collaborating with the University of Maryland on water reuse GIS decision support platform. The GIS Tool will assemble information on reclaimed water source locations, reclaimed source quantity and quality, ground water availability and quality, surface water discharge constraints, potential user information, ease of access, relative costs among competing reuse and non-reuse water supply alternatives. Dr. George will describe how this tool could help water appropriations permit writers, wastewater discharge permit writers and others facilitate more reuse of reclaimed municipal wastewater for agricultural irrigation.

Dr. Azar, from the University of Maryland, will briefly describe the CONSERVE: the Center of Excellence for Sustainable Water Reuse in Agriculture Center, in which the water reuse GIS platform is being developed. Dr. Azar will outline how the GIS Tool has been developed and applied in the Mid-Atlantic and Southwest U.S. to date. The GIS Tool is envisioned to enable the comprehensive characterization of nontraditional irrigation water sources with respect to their quality and quantity. The pilot application on Maryland's Eastern Shore is focusing on data and decision needs, which should be widely applicable to coastal plain physiographic regions. The presentation will showcase examples of creative combinations of readily available data, which enable reliable inferences without the need for labor-intensive data collection. Case studies will be presented that demonstrate the logic of the GIS Tool's application.

Challenges and Successes in Compliance with H.B. 270 Lead in Drinking Water

Terry L. Norman, Maryland Environmental Services
Robert Souza, Wicomico County Board of Education
Wayne Room

Events in Flint, Michigan in 2015, thrust concerns over the health threat of lead in schools' water into the national spotlight. It has been long known that lead is highly toxic and especially damaging to children – affecting their ability to learn, their physical development and behavior. During the 2017 legislative session, the State of Maryland passed House Bill 270 and COMAR 26.16.07 Lead in Drinking Water – Public and Nonpublic Schools which became effective on April 9, 2018. All public and nonpublic schools are required to test their drinking water outlets for lead contamination while school is in session, during the regular school year but no later than July 1, 2018, unless a waiver or deferral is requested.

The purpose of the Lead in Drinking Water regulations complements the requirements of the Lead and Copper Rule (LCR) of 1991 which was primarily designed to get utilities to identify problems that require system-wide action, such as adjusting corrosion control at water treatment plants. Approximately 10% of schools and pre-schools use private or well water for drinking. The result is that the LCR does not apply to roughly 90 percent of schools and daycares. The goal of the sampling specified under COMAR 26.16.07 seeks to gather data by reproducing the potential lead exposure level of students when using drinking water outlets in schools by requiring first-draw samples of 250 ml – a volume roughly equivalent to a child's water bottle.

Maryland Environmental Service collaborated with a partner public school system to sample 13 schools in May and June of 2018 as Phase 1 of the System's effort to comply with this regulation. Our partner elected to seek deferrals for some of their schools and focused their efforts on elementary schools in the first phase of work. This recently completed Phase 1 provided lessons learned about the communication and community response to the mandatory reporting requirements contained in this regulation. The performance of the work revealed efficiencies that will inform the future work of our partner system and the planning of those systems that sought deferrals and will undertake their sampling during the 2018-2019 school year. The careful selection of priority schools coupled with planning with school staff and maintenance staff optimizes the collection of representative samples in first round sampling efforts. Sample collection can be highly efficient if stakeholders are consulted as to scheduling multiple school visits in a given day. Preparation of documentation that is a collaboration between the samplers and laboratories reduces the paperwork burden on the school system.

These lessons learned will be shared with conference participants so that the conversation can continue about best practices to manage the compliance of this new legislation.

Afternoon Session One | 1:30 – 2 p.m.

Temporal and Spatial Variability of Groundwater Quality in the Mid-Atlantic
Brandon Fleming and Bruce Lindsey, P.G., U.S. Geological Survey
Maryland Room

Timescales of change in groundwater quality are not well understood in the mid-Atlantic region. Improved understanding of the timing and factors affecting groundwater quality change is needed to inform decisions of water resource managers. To address this need, the U.S. Geological Survey, National Water Quality Assessment (NAWQA) project is monitoring groundwater quality at timescales from days to decades. High frequency groundwater chemistry data collected from wells in the surficial aquifer of the Northern Atlantic Coastal Plain from 2014 to 2018 provide insight into the timing and drivers of groundwater quality change. Understanding how recharge, land use, well construction, and aquifer position affect groundwater quality on daily to annual time scales motivates an analysis of long-term decadal groundwater-quality networks in the Mid-Atlantic. Hydrologic conditions prior to the collection of groundwater quality samples appear to be important in determining changes in nitrate, chloride, and total dissolved solids (TDS) concentrations. Examples include 1) higher TDS concentrations with samples collected during drought antecedent conditions in the Great Valley carbonate system, 2) higher nitrate concentrations during wet antecedent conditions on the Delmarva Peninsula. Improved understanding of the timescales of change in groundwater quality will help resource managers protect drinking water resources across the mid-Atlantic region.

Using Three-Dimensional Coupled Surface-Subsurface Models to Assess Urban Water Balances from Site to Regional Scales
Claire Welty, Ph.D., University of Maryland, Baltimore County
Regency Room

We have applied the three-dimensional, coupled groundwater-surface water-land surface model ParFlow.CLM at scales ranging from the metropolitan region to small watersheds to quantify the impacts of urbanization on groundwater-surface water interactions and groundwater storage.

At the Baltimore metropolitan scale, we investigated effects of four features that impact subsurface storage in urban landscapes. These include reduced vegetative cover, impervious surface cover, infiltration and inflow of groundwater and storm water into wastewater pipes, and other anthropogenic recharge and discharge fluxes including water supply pipe leakage and well and reservoir withdrawals. We found that the change in subsurface storage due to infiltration of groundwater into wastewater pipes had the greatest effect on subsurface storage, compared to other features examined.

At the small watershed scale (0.2 - 2 sq km), we compared the effects of urban development type and spatial pattern on the hydrology of six small headwater catchments

near Baltimore, Maryland. Catchments with the lowest amounts of impervious cover showed the greatest variability in total storage response to climatic variation, whereas those with the greatest amount of impervious cover show less variability in response of subsurface storage to annual and seasonal variability in precipitation input. The storage response among catchments was pronounced during prolonged dry and wet periods, with the variability in response being less pronounced over short-term events. A negative correlation was observed across catchments between impervious cover and net subsurface storage variability. Temporal variability in subsurface storage was most responsive to development pattern in near-surface layers, but transitioned to topographic control at depth. Spatially, the development footprint appeared to control where recharge and evapotranspiration occurred in the unsaturated zone.

We have recently extended this approach to quantifying the hydrologic budget at site scale at green infrastructure installations. For a permeable pavement GI site in Philadelphia, we quantified the temporally-variable nature of the infiltration process as affected by precipitation and evapotranspiration. Simulation and groundwater monitoring results for 2016 indicate that during winter months, snow and snowmelt play an important role in the water balance. Snowmelt can be significant on an inter-monthly time scale, with infiltration from snowmelt contributing to the peak winter infiltration rates. During summer months when evapotranspiration exceeds precipitation, water captured by the GI contributing area during precipitation events enhances recharge to groundwater. This is a deviation from expected seasonal behavior at the site scale, when summer months would typically see reductions from storage resulting from evapotranspiration. Model results indicate that the site discharges to regional groundwater throughout the year.

Conserving Groundwater Through Water Recycling for Food Crop Irrigation: A Focus on CONSERVE – A Center of Excellence at the Nexus of Sustainable Water Reuse, Food, and Health (Part 1)

Rachel Rosenberg Goldstein, Ph.D., Shirley Micallef, Ph.D., Masoud Negahban-Azar, Ph.D.
University of Maryland, College Park
Embassy Room

Ongoing climate variability and growing water demand continue to place severe stress on high-quality agricultural irrigation water sources such as groundwater. As a result, the exploration of alternative irrigation water sources (e.g. recycled water, return flows, brackish water) has become a national priority with regard to agricultural water security and the sustainable production of our food supply. Successful implementation of water reuse strategies will depend not only upon scientific advances in technology to assure the safety of recycled water, but also upon acceptance and support from growers, consumers, and regulatory agencies.

This panel will bring together speakers from CONSERVE: A Center of Excellence at the Nexus of Sustainable Water Reuse, Food, and Health funded by USDA. They will describe a complex picture of the potential for recycled water to become a more commonly accepted

and used source for irrigation of food crops. Talks in this panel will focus on: (1) the potential public health impacts of reusing water on food crops that are eaten raw; (2) identification, location, and classification of alternative water sources; (3) microbial quality of irrigation water and relevance to crop safety; (4) growers' knowledge and concerns regarding alternative water source use for irrigation and a discussion of some relevant laws and legal issues on water reuse in food production.

The Incidence and Causes of Elevated Lead and Copper in Private Water Wells and Springs in Pennsylvania

Bryan Swistock, Penn State University
Wayne Room

Penn State conducted numerous studies of lead and copper in private groundwater wells and springs between 1987 and 2017. These studies of thousands of wells and springs have consistently found that corrosive water is one of the most common water quality problems affecting more than 50% of these water supplies. Corrosive water can cause damage to metal components of the plumbing system and can cause dangerous levels of copper, lead and other metals to be dissolved in drinking water. A study in the late 1980's found that lead in first-draw water exceeded the action level in 20% of 1,600 homes served by groundwater wells and springs. Particulate lead was found to be a significant contributor to the overall lead burden suggesting that testing for total lead as opposed to just dissolved lead was necessary to accurately determine lead exposure. A 2007 study of 701 groundwater wells found that lead contamination had dropped to 12% presumably in response to federal lead and copper in the 1990's.

This same study found that lead was strongly correlated to corrosive water and the presence of older metal plumbing. Awareness of lead in drinking water by homeowners was nonexistent because lead testing was rarely conducted outside of research projects. A current project of 365 groundwater well and spring supplies in nine underserved counties of Pennsylvania found that 11% exceeded the first draw action level for lead but 92% of these high lead levels were reduced below the action level after flushing the plumbing. Nearly all (96%) of the water supplies with high first draw lead had LSI corrosivity indices below -0.5. This study also found similar results for the occurrence and causes of elevated copper in drinking water. Follow up surveys of homeowners with elevated lead in drinking water have found that the majority address the problem quickly after receiving water testing results by installing water treatment, replacing metal plumbing components or flushing plumbing before consuming water. These results demonstrate that educational efforts to incentivize water testing for symptomless contaminants like lead can result in significant drinking water improvements for homeowners using private wells and springs.

Afternoon Session Two | 2:05 – 2:35 p.m.

Installing an Appropriate Monitoring Well Network for a Landfill that is Located on Top of a Reclaimed Strip Mine: Lessons Learned
John Agnoli and Carly Cushing, Maryland Environmental Service
Maryland Room

Required under RCRA is the installation of an adequate monitoring network at a landfill site to ensure that there are no leaks from the operation into the surrounding groundwater. Constructing an appropriate monitoring network in a landscape that has been disturbed by previous subsurface operations makes for a difficult task. The purpose of the presentation is to discuss the trouble that we ran into while we were trying to make a robust monitoring network at a landfill site in the Appalachian plateau. We would like to go over how we ended up establishing the monitoring network at the site and the lessons that we learned once the network was finalized.

Determining Factors Detrimental to Well Yield: a Garrett County Case Study
John Boris, LEHS and Sara Albrecht, Maryland Department of the Environment
Regency Room

Since the majority of Garrett County resides in Hydrogeological Area 4, there is no regulatory requirement for mandatory yield testing. Due to basic knowledge of the hydrogeologic conditions of the site and no yield testing, it is not uncommon for multiple wells to be drilled at sites in order to meet State minimum requirements for yield and storage. This time consuming and costly process could be minimized if there were methods to determine whether a suggested well location is unsuitable prior to drilling. This presentation will focus on using statistical, topographical and geological reviews to help predict future sites where low yield wells may be drilled in Garrett County, Maryland.

Conserving Groundwater Through Water Recycling for Food Crop Irrigation: A Focus on CONSERVE – (Part 2)
Rachel Rosenberg Goldstein, Ph.D., Shirley Micallef, Ph.D., Masoud Negahban-Azar, Ph.D.
University of Maryland, College Park
Embassy Room

Sanitary Survey Basics: Identifying Contamination Risks of Well Systems
Alex McNamee, P.E., MDE-Water and Science Administration
Wayne Room

MDE performs sanitary surveys to help protect public health. As the saying goes, an ounce of prevention is worth a pound of cure. Most water systems that are constructed, maintained, and operated correctly supply safe drinking water, but each year hundreds of significant sanitary defects are observed across the country. If a sanitary survey is effective, it should identify any sanitary deficiency of the water system that may pose a public health threat. If sanitary defects are present, the survey could literally save lives. During this session, I will discuss a little history of public water systems, contamination events, survey basics, and some common things to watch out for. In responding to bacteria detections for decades, water sources have been the most common vulnerability, followed by storage tanks. I will give tips on how to recognize common vulnerabilities based on the source and design of a water system, and how to spot issues with maintenance and operations that could lead to water quality issues.

Afternoon Session Three | 2:50 – 3:20 p.m.

Tree Trade-Offs in Stream Restoration Projects: Impact on Riparian Groundwater Quality
Kelsey Wood and Joseph George Galella, University of Maryland, ESSIC
Maryland Room

Efforts to restore degraded river channels in urbanized areas often include alteration or manipulation of the riparian zone. Methods can include removing mature trees from riparian areas to reshape the topography or allow large equipment access. Our goal is to assess the impact of tree removal on riparian zone groundwater quality. With support from the Chesapeake Bay Trust we have started a project monitoring multiple restored sites in the Anacostia and Gwyn's falls watersheds. We have installed wells in transects perpendicular to the stream channel in hopes of deducing nutrient uptake along groundwater flow paths to the channel. The sites were chosen to encompass a range in restoration ages from current up to twenty years ago. Young trees are often planted after restoration so the gradient in stages of regrowth between sites should provide insight to the relationship between tree removal and maturity with nutrient and contaminant retention. Where possible we also install a control transect in an unrestored reach of the stream. All wells are sampled monthly and after major rain events. Water samples are then analyzed for carbon (organic and inorganic), nitrogen, salts, and metals. We plan to correlate these measurements with other site characteristics obtained through geospatial data and public national datasets in the modeling software RZ-TRADEOFF. Watershed area, soils, bedrock, land use, and leaf area index have been analyzed in ArcMap10.4 to characterize environmental variables, which may influence water quality at the study sites. Impervious surface cover ranges from 18.5 to over 40 percent for each watershed with developed open space being the dominant land use.

Bedrock is most often schist and gneiss based but is more variable, also including gravel and sand, gabbro, and marble. Fine loam was found to be the most dominant soil type, fine silts and fluvial sediment are also present. We will evaluate the accuracy of values predicted by the riparian groundwater model RZ-TRADEOFF for these sites and calibrate the model to our geographic region. The goals of this project are to gain a better understanding of riparian tree removal and restoration effects on groundwater quality, as well as to generate a model that can be used to more accurately predict nutrient cycling in Maryland's riparian ecosystems.

Estimated Use of Water in the United States for 2015 - A Closer Look at Groundwater Withdrawals

Cheryl A. Dieter, U.S. Geological Survey

Regency Room

Water use in the United States in 2015 was estimated to be about 322 billion gallons per day (Bgal/d), which was 9 percent less than in 2010. The 2015 estimates put total withdrawals at the lowest level since before 1970, following the same overall trend of decreasing total withdrawals observed from 2005 to 2010. Thermoelectric power and irrigation remained the two largest uses of water in 2015, and total withdrawals decreased for thermoelectric power, but increased for irrigation. Withdrawals in 2015 for thermoelectric power were 18 percent less and withdrawals for irrigation were 2 percent greater than in 2010.

In the United States in 2015, total groundwater withdrawals were 84.7 Bgal/d, of which 97 percent (82.3 Bgal/d) was freshwater. Of the total fresh groundwater withdrawals nationwide (82.3 Bgal/d), irrigation accounted for 70 percent, primarily in California, Arkansas, Nebraska, Idaho, and Texas. Fresh groundwater irrigation withdrawals in these five States (38.0 Bgal/d) cumulatively accounted for 46 percent of the total fresh groundwater withdrawals for all categories nationwide. Nearly all groundwater withdrawals (97 percent) were from freshwater, predominantly used for irrigation. Saline groundwater withdrawals (2.34 Bgal/d) were predominantly used for mining (80 percent) and occurred in Texas, California, and Oklahoma. Irrigation used greater than three times more fresh groundwater than public supply, which was the next largest use of fresh groundwater in the Nation.

Conserving Groundwater Through Water Recycling for Food Crop Irrigation: A Focus on CONSERVE – (Part 3)

Rachel Rosenberg Goldstein, Ph.D., Shirley Micallef, Ph.D., Masoud Negahban-Azar, Ph.D.
University of Maryland, College Park

Embassy Room

Unique Process Control Strategy for Optimum Nitrogen Removal in Small Flow Wastewater Treatment Plants

Gary Lucas and Brandon Friedland, Innovative Treatment Products, LLC
Wayne Room

Small decentralized wastewater treatment plants are often constructed for residential developments, commercial facilities, schools, parks, churches, campgrounds, rest stops etc. The flows from these sources generally do not exceed 20,000 GPD. Inherently, the flow patterns at these locations vary with the human occupancy which can fluctuate daily, monthly or seasonally. This fluctuation results in high instantaneous flow peaks and long, low flow periods. In the case of schools or campgrounds, a seasonal period of low flow could be up to 3-4 months long. In many cases, compounding the problems related to variable flow conditions, newer facilities have installed low-flow water fixtures which significantly concentrate the waste, making treatment to high levels of nutrient removal quite challenging.

In the Chesapeake Bay watershed, tight effluent nitrogen limits are paramount to meeting today's nutrient removal goals. So how does an operator run a biological wastewater treatment process under these extremely variable conditions and reliably achieve high levels of total nitrogen removal? When sizing a system using standard treatment plant design protocol, engineers use published flow and loading parameters that may not be present once the facility is up and running. Turn-down of the process pumps, chemical feed systems and aeration systems are often a challenge with these types of plants. Control of dissolved oxygen in the aeration and anoxic zones is critical to meeting low levels of effluent nitrogen but is often difficult at best in this type of small wastewater treatment plant.

This presentation will discuss the innovative process strategies of design and controls used by ITP's engineering team to accomplish the goals of meeting high quality treated effluent with an emphasis on low levels of total nitrogen to satisfy the needs of the Chesapeake Bay watershed.

Afternoon Session Four | 3:25 – 3:55 p.m.

Use of Bacteria in Degradation of BTEX Contaminated Groundwater
Mahnaz Mazaheri-Assadi, Ph.D., Chesapeake Research Consortium
Maryland Room

It has been known for years, BTEX (benzene, toluene, ethylbenzene and xylenes) compounds are found in groundwater of the numerous sites used for fuel operations, refineries, gasoline stations, and gasification. Releases of BTEX compounds to the environment occur through the accidental spill of diesel fuel, gasoline during transportation, leakages from underground storage tanks and pipelines. During the past few decades, a number of remediation techniques including biological (e.g., bioventing, phytoremediation), chemical (e.g., chemical oxidation, soil flushing), and physical (e.g., soil vapor extraction, thermal treatment) methods has been developed for the reuse of BTEX-contaminated groundwater. One of most important technology in Water Reuse is bioremediation technologies. In this study, a new strain degrading BTEX compounds was isolated from oil contaminated groundwater. We first optimized the effective parameters (e.g., pH, temperature, and inorganic nutrients as percent of BTEX concentration) on the degradation of BTEX compounds. Results showed the optimum pH, temperature and, nutrient are 7.4, 34.3, and 200%, respectively. We found that the strain is able to completely degrade benzene, toluene, and ethylbenzene in the single substrate batch experiments while m-xylene remains non-degradable if it is an only carbon source in the ambient temperature. Toluene was degraded faster, followed by benzene and ethylbenzene in the single substrate batch experiments. Results showed that all BTEX compounds can be degraded within the mixed substrate batch experiments. We also found that benzene was first degraded followed by toluene, ethylbenzene, and m-xylene. An increase in the production of enzyme as a result of cell growth due to the degradation of benzene and toluene accelerated the degradation process of m-xylene. Result revealed that the biodegradation of ethylbenzene and m-xylene was initiated when a considerable amount of benzene and toluene was degraded.

Water Use Estimates in Maryland for 2015
Wendy S. McPherson, U.S. Geological Survey
Regency Room

The U.S. Geological Survey (USGS) estimates water use by state, source of water, and category of use nationally every 5 years. As part of this effort, water use was estimated for Maryland for 2015. Water withdrawals were estimated for groundwater and surface water, fresh and saline water, and by the following categories: public supply, self-supplied domestic, industrial, irrigation, aquaculture, livestock, mining, and thermoelectric power. Consumptive water use was estimated for irrigation and thermoelectric water use. The USGS uses withdrawal data reported to the Maryland Department of the Environment for permitted users withdrawing more than 10,000 gallons per day. In Maryland, 81 percent of

total water withdrawals, 6,530 Mgal/d, are from saline water sources, mostly for thermoelectric power generation and cooling. Freshwater withdrawals constitute the remaining 19 percent in Maryland and were estimated to be 1,230 Mgal/d, of which 24 percent (295 Mgal/d) was from groundwater, and 76 percent (935 Mgal/d) from surface water sources.

By water use category, in 2015, the largest water withdrawals in Maryland were for thermoelectric power generation and cooling with a total of 5,520 million gallons per day (Mgal/d). Groundwater withdrawals for thermoelectric power generation were 2.30 Mgal/d and fresh surface water withdrawals were 218 Mgal/d. Saline withdrawals for thermoelectric were 5,300 Mgal/d. Public supply had the second largest water withdrawals, serving about 4,580,000 people (20 percent of the population from groundwater and 80 percent from surface water). A total of 656 Mgal/d was withdrawn from surface water sources for public supply for Maryland, primarily from the Baltimore Reservoirs and the Potomac River. Groundwater withdrawals for public supply were 93.9 Mgal/d. Groundwater withdrawn for self-supplied domestic users was 114 Mgal/d, serving about 1,420,000 people. Irrigation had the fourth largest withdrawals in Maryland in 2015. A total of 64.1 Mgal/d was withdrawn for irrigation, of which 90 percent was for crop and 10 percent was for golf. Seventy-five percent of the irrigation withdrawals were from groundwater, and 25 percent were from surface water. Industrial withdrawals were 50.8 Mgal/d. Aquaculture, livestock, and mining withdrawals combined were 32.7 Mgal/d in 2015.

Options for the Management of Food Processing Wastewater

Michael Eisner, MDE-Water Management Administration, Wastewater Permits Program
Embassy Room

Small-scale food processing operations are becoming increasingly popular as a value added activity at small farms around the state of Maryland. These food processing operations include on-farm small scale poultry raising and slaughtering, beer and winemaking, milk processing to produce ice cream and cheese, and other miscellaneous food processing operations. While the food product created is different, these operations share a common need to manage wastewater generated from producing these products in an economical viable and environmentally protective manner. This talk will look at wastewater management options for these types of small-scale food processing operations. Wastewater management options to be discussed include beneficial reuse via land application, storage in a holding tank for later offsite transport, treatment and disposal, permitting the discharge to surface waters, and permitting the discharge to an onsite subsurface disposal system. In this presentation, the challenges and potential benefits of these different wastewater management options will be discussed.

Emerging Contaminants: Do They Eventually Emerge?

Simin Rezai, Ph.D., MDE-Water and Science Administration
Wayne Room

Societal demand for new products results in production and release of new chemicals. Emerging contaminants originating from thousands of chemical used for decades are being detected by increasingly sensitive analytical techniques.

The surface and ground waters are the ultimate recipient of tens of thousands of chemicals consumed in the United States. Some toxic chemicals accumulate in animal tissue and become more concentrated further up the food chain.

No single treatment process can provide an absolute barrier to these contaminants in water. Additionally, as the result of population growth direct and indirect water reuse is becoming more common.

Kavanaugh et al. NRC report, 2013, gave the following list of emerging contaminants (Alvarez-Cohen L., 2018):

- 1,4 Dioxane
- Naphthalene
- N-nitrosodemethylamine
- Perchlorate
- PFASs
- PPCP
- Nanomaterials
- Siloxanes

The list is growing continuously.

U.S. Department of Defense (DoD) may have thousands of sites contaminated with PFASs, 1,4-dioxane, 1,2,3-TCP, and NDMA., with a current estimated cost for managing these sites of approximately $2 billion (Stroo et al. September 2017).

PFASs, e.g. PFOA and PFOS, have been used in manufacturing processes and were released into the environment beginning in the 1950's. Once PFOS and PFOA are released into the aquatic environment, they can easily be transferred into different environmental compartments, reaching groundwater (Houtz et al., 2013), soils (Houtz et al., 2013), sediments (Gao et al., 2015) and biota (Campo et al., 2016). Hu et. al. (2016) found drinking water supplies for 6 million U.S. residents exceeded EPA's lifetime health advisory (70 ng/L) for PFOS and PFOA. A new study showed that PFASs are unsafe for human health at a lower level than current EPA standards. Nelson et al. (2009) found a positive association between concentrations of PFOS, PFOA, and PFNA and bad cholesterol (non-HDL).

This presentation focuses on the fate, transport, and treatment of emerging contaminants, such as PFOA, PFOS, perchlorate, NDMA, 1,4-dioxane, and microplastics, among others.

Poster Presentations

The Agricultural Water Footprint of the Choptank River

Mary Wakefield, University of Maryland

In the Chesapeake Bay Watershed, the annual rainfall is high enough to support crop growth without irrigation. As rain patterns shift with climate, however, the rain is beginning earlier and heavier in the growing season, with more short, intense rain events, leaving the late summer crops without enough soil water to survive. Irrigation is thus on the rise: between 1985 and 2006, Mid-Atlantic irrigated acres increased by 33% from 2003 to 2009, despite only a 6% increase in farmland acreage, and water use in agriculture increased by 100% to 250% (except in New Jersey) from 1985 to 2010.

Observing other parts of the country and world experiencing water scarcity, it becomes evident that water should be considered a valuable commodity. To this end, this project seeks to trace its use, from origin through either direct use for crop irrigation, or indirect use in the agricultural production chain, to production endpoint, in order calculate the virtual water content and cost of Mid-Atlantic agricultural commodities.

Water "origin" comes in three forms, known as blue, green, or grey water. Blue water is irrigation water, sourced from either surface or groundwater, making this a straightforward calculation on recorded water use. Green water is precipitation that is stored in the root zone of the soil and evaporated, transpired or incorporated by plants. To determine accurate green water it is necessary to do evapotranspiration calculations, to determine how much water a plant uses in a given climate, soil, and growing cycle, as compared with known monthly rainfall averages. These calculations produce three significant numbers: the average effective rainfall, efficient irrigation needs (which can be used to refine blue water), and rainfall excesses, which can in turn be used to calculate either storage or groundwater recharge potentials for both water budget and environmental impact purposes. Initially, this project looks at corn, wheat, and soybeans, which account for 79% of Chesapeake Bay Watershed crops, and also incorporates two water-thirsty crops (corn and wheat). Grey water is the theoretical amount of fresh water required to assimilate agricultural pollutants in order to meet specific water quality standards. This varies by legislative standard, and is the most ambiguous calculation among the three.

The sum of these water origins can be used to calculate overall water use by area, and then cross-referenced with rainfall to see what optimal irrigation should be, and when, as compared to current trends. This research should provide a pathway to more responsible water use, as well as the foundation of information for East Coast water markets, should they become necessary. This project begins by looking specifically at the Choptank as a way to verify the water footprint calculations and the resulting water modeling.

Conserving Groundwater Through Water Recycling for Food Crop Irrigation: A Focus on CONSERVE – A Center of Excellence at the Nexus of Sustainable Water Reuse, Food, and Health

Rachel Rosenberg Goldstein, Ph.D., Shirley Micallef, Ph.D., Masoud Negahban-Azar, Ph.D.
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Ongoing climate variability and growing water demand continue to place severe stress on high-quality agricultural irrigation water sources such as groundwater. As a result, the exploration of alternative irrigation water sources (e.g. recycled water, return flows, brackish water) has become a national priority with regard to agricultural water security and the sustainable production of our food supply. Successful implementation of water reuse strategies will depend not only upon scientific advances in technology to assure the safety of recycled water, but also upon acceptance and support from growers, consumers, and regulatory agencies.

PRESENTER BIOGRAPHIES

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Sara E. Albrecht is a Natural Resource Planner with the Maryland Department of the Environment. She graduated from the University of Delaware with a Bachelor's degree in Natural Resource Management and a Master's degree in Agricultural and Resource Economics. For her Master's thesis, Sara designed and conducted economic field experiments across three states to determine consumer demand for produce grown under the farmland preservation program. This was funded through a United States Department of Agriculture grant. Prior to her graduate research, Sara worked as a chemist and a process engineering intern at Cristal, where her research focused on reducing total dissolved solids in waste effluent being discharged into Lake Erie, in compliance with the Clean Water Act. Prior to Cristal, she worked as a laboratory assistant at the University of Maryland, Baltimore County conducting research on the structural properties of the HIV virus, resulting in co-authorship on an article published in *Science* magazine.
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Scott Andres has been a hydrogeologist with the Delaware Geological Survey since 1984. During this time he worked, published, and presented on a variety of ground and surface water projects and issues. Scott began his career in hydrogeology in 1980 with the New Jersey Department of Environmental Protection, where he was responsible for investigating ground-water pollution incidents. Scott's recent research efforts, related to water resources, have focused on effects of agriculture and land based disposal of wastewater on soils, rocks, and ground and surface waters, use of automated sensors for high-frequency monitoring of groundwater and watershed-scale water quality, ground-water modeling, submarine groundwater discharge, and large scale mapping and characterization of aquifer hydrology, geometries, and hydraulics.
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John Boris, LEHS started his career as a Senior Field Technician/Staff Geologist for a geotechnical firm that provided mobile lab and direct push technique sampling, based in Golden, Colorado. After graduating from the Clarion University of Pennsylvania with a bachelor's degree in Earth Science in 1995, John moved to Maryland and began his professional career as a sanitarian with the Anne Arundel County Health Department in their Sanitary Engineering Division. In 2002, he transferred to the Howard County Health Department where he served as the Well & Septic Program Supervisor until his departure. In the summer of 2005, John was hired by the Maryland Department of the Environment (MDE) as a Project Manager within the Wastewater Permits Program, in the Bay Restoration Fund Onsite Sewage Disposal System Upgrade Program. In the fall of 2009, John became the Geologist Program Consultant for the State of Maryland's Onsite Systems Division at MDE. In this capacity he provides oversight to both local governments and the well drilling industry as it pertains to the enforcement of regulations and techniques related to the practice of well drilling and construction in the State of Maryland. Other duties currently include being a Regional Consultant to Counties as assigned.
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Steven Chow, is a Maryland native from Calvert County. He graduated from Clemson University in 2012 with his Bachelor's in Biosystems Engineering and an M.S.E. in Geography and Environmental Engineering from Johns Hopkins University. Steven is currently a Ph.D. Candidate in the Department of Environmental Health and Engineering at Johns Hopkins University and has an anticipated Ph.D. defense in May 2019. His research focuses on the factors affecting microbial degradation of chlorobenzenes occurring at anaerobic-aerobic groundwater interfaces. Steven uses analytical chemistry and molecular biology tools to investigate how physical and chemical factors can affect remediation of contaminated sites. His interests include environmental policy, water treatment technology, and sustainable development.
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Cheryl Dieter is a hydrologist with the U.S. Geological Survey, Maryland-Delaware-DC Water Science Center. She is the USGS Water-Use Specialist for the northeast U.S., and the MD-DE-DC Water Science Center. She is also the coordinator for the USGS Water Use Data and Research Financial Assistance Program. Cheryl's current focus is on water-use data and research in the United States, but interests also include recharge and water-supply issues in regional aquifers, ground-water flow modeling, geochemistry in aquifers, and ground and surface-water interaction.
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