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Concurrent Session I, Track A
Nitrate monitoring, modeling, and mitigation in rural MN

Kura Clover and Winter Rye Covers in Irrigated Corn Cropping Systems to Mitigate Nitrate Leaching

Fabian Fernandez, Jessica Wayment, Eduardo Garay-Lagos, University of Minnesota

Cover crops can serve to mitigate nitrate leaching from corn (Zea mays L.) and soybean [Glycine max (L.) merr.] fields. Our objective was to determine the capacity of winter rye (Secale cereale) and kura clover (Trifolium ambiguum) in reducing nitrate leaching from a strip-still, irrigated, sandy soil with long-term (since 2011) continuous corn (CC) and corn-soybean rotations (CSb and SbC) in west-central Minnesota. Rye was planted in the fall and terminated the following spring and kura clover was inter-cropped as a living mulch and chemically suppressed in the spring. Agrotain (urea with a urease inhibitor) was applied at total rates of 0, 100, 200, 250, and 300 kg N/ha in three split-applications. Nitrate load was calculated as the product of concentrations in water leached below the root zone measured weekly with lysimeters and drainage estimated by water balance. Across 4 seasons for all cropping systems, kura clover reduced nitrate leaching by 74% whereas rye had no effect, possibly due to inconsistent establishment. Similar results were observed for average season-long nitrate concentrations. While corn yield at the economic optimum N rate (EONR) and soybean yield were similar between rye and no-rye, rye required additional N for corn to achieve the EONR. Compared to rye and no-rye, kura clover reduced yield by 36% in CC, 38% in CSb, and 19% in SbC. While kura clover can mitigate nitrate leaching, the large reduction in grain yield, likely caused by competition for N, represents a major issue deserving further research before these covers can be widely adopted in farmer fields.

Perennial grain crops mitigate nitrate leaching in the Central Sands region of Minnesota

Jacob Jungers, Jessica Gutknecht, University of Minnesota; *Dennis Fuchs,* Stearns County Soil and Water Conservation District; *Holly Kovarik,* Pope County Soil and Water Conservation District; *Matthew Leiphon, Riley Gordon*, Agricultural Utilization Research Institute

Unused nitrate-nitrogen (NO3-- N) from crop fertilizers can percolate through the soil and enter the groundwater. The vast majority of rural communities in MN rely on groundwater as their drinking water source, and NO3-- N leaching is contaminating this drinking water and threatening human health. One strategy to mitigate this environmental and public health issue is to plant high N use efficiency crops that require less fertilizers on cropland most vulnerable to leaching. One such crop is intermediate wheatgrass (IWG; Thinopyrum intermedium), a perennial grass being domesticated to serve as the world's first widely available perennial grain crop. Grain harvested from IWG is marketed as Kernza®. This presentation will summarize research showing the potential for IWG to mitigate NO3-- N leaching, describe a multi-stakeholder effort to demonstrate this potential in field-scale plantings, and highlight new research results from an ongoing study on the effects of irrigation on NO3-- N leaching beneath IWG and alfalfa (completion date June 2022). Outcomes from these projects have stimulated new markets and supply chains for Kernza, thus making this new sustainable crop an economically viable option for growers and municipalities across Minnesota.

The Minnesota Department of Agriculture's Use of Modeling to Reduce Nitrate Leaching in Vulnerable Groundwater Areas

Patrick Nash, Aicam Laacouri, Jeppe Kjaersgaard, Margaret Wagner, Minnesota Department of Agriculture

As part of the implementation of the Groundwater Protection Rule (GPR), the Minnesota Department of Agriculture is using computer modeling to estimate the impact of nitrogen fertilizer best management practices (BMPs) and Alternative Management Tools (AMTs) on nitrate leaching loss reduction from cropland. The modeling is focused on Drinking Water Supply Management Areas (DWSMAs) with elevated nitrate-nitrogen in the well water. Two models have been selected for the work based on a suitability analysis conducted by the University of Minnesota: The Environmental Policy Integrated Climate (EPIC) model is used for DWSMAs in central and southwest Minnesota, while the Soil and Water Assessment Tool (SWAT) is used in southeast Minnesota. Computer modeling of nitrate-N leaching below the root zone is an important tool the MDA will be using to provide farmers information on nitrate-N leaching based on current and alternative N management practices, as well a DWSMA wide estimate of annual reduction of nitrate-N leaching based on the adoption of BMPs and AMTs within the DWSMA. Substantial effort is expended on ensuring the input information for the models is accurate and reflects crop management practices in each DWSMA. This presentation will focus on providing information on the models being used, data requirements and sources, how the modeling tools fit into the overall GPR and inform local advisory teams (LATs), as well as provide examples of model output information that will be provided to LATs and farmers within the DWMSAs to help them select N management practices that will reduce nitrate-N leaching.

High Nitrate! The City of Fairmont's story

Becca Vermace, Michelle Stockness, Barr Engineering; *Troy Nemmers,* City of Fairmont

The City of Fairmont's drinking water comes from a chain of lakes fed by agricultural watersheds in southwest Minnesota. In 2016 the City of Fairmont (population 10,000) had unexpected and unprecedented high nitrate levels in their surface water source. In 2016, the City was forced to issue a public health notice that Fairmont's drinking water exceeded EPA's maximum contaminant level (10 mg/L). Dutch Creek is one of the largest tributaries to the Fairmont chain of lakes, with a watershed covering over 9,000 acres. Data collected since the year 2000 show periodic high nitrate occurrences in Dutch Creek, with peaks over three times the EPA maximum contaminant levels. In the history of Fairmont drinking water, nitrate had not been an issue in the past. The City had to scramble on solutions they could implement short term, while also planning out long term solutions to improve drinking water quality with much of the watershed out of their jurisdiction and no funding or staff time set aside for this issue.

Over the last 3 years, the City has collaborated with multiple stakeholders and agencies, including Martin Co SWD, MPCA, MDH, MDA, and the University of Minnesota to share data, develop long-term strategies, and secure grant funding for improvements. The City was awarded two grants to improve upstream water quality and habitat in 2019.
This presentation will discuss lessons learned by the City of Fairmont, steps they have taken so far, and what they plan to do, both short term and long-term, including the design of a nitrate bioreactor and habitat restoration upstream in the watershed, to maintain safe drinking water and improve water quality. The nitrate bioreactor, which includes innovative passive heating, is under construction and is expected to be online in the fall of 2021.

Concurrent Session I
Track B: Engaging Individuals and Communities

Maximizing Benefits of Diversity to Re-structure Green Infrastructure Projects

Katie Kowalczyk, Zachary Robinson, Minneapolis Public Works

Lacking a landscaping team to take care of your native vegetation installations?
Don't know how to reach people who are under-represented in your community?
Struggling to recruit the future workforce?
Want artistic elements to promote your capital projects?
These are some of the challenges we face in public works departments as we try to react to the urgent demands of climate change and racial equity with limited resources and expertise. The City of Minneapolis looks for ways to align our work with resources in the community to meet these pressing priorities.
The first project we piloted involved the retrofit of an existing stormwater basin to provide water quality treatment. The city crews do a lot of heavy construction; however, the equipment and skills are limited when it comes to restoration and enhancement of the vegetation. Concurrently, entities in the community focused on environmental skills development in local youth approach us looking for meaningful projects. Minneapolis is making a concerted effort to diversify the city's engagement. We know that our current methods of outreach do not always reach all affected by environmental issues and further do not engage these communities most affected by environmental injustice to develop skills that help them represent and connect their communities to contribute to decision making.
Re-evaluating how we structure our projects helped to identify a contract with a local non-profit. We looked at the parts of projects where we lack resources and set up an RFP to fill these gaps. The parts of the project we outsourced consisted of community outreach, engagement, installation of the native plants, and a two year maintenance period for the plants.
This presentation will briefly describe the retrofit project and focus on the contracted work. We will cover benefits of working with atypical organizations, the city's role, lessons learned, and how we plan to continue and expand more of this type of funded partnership

Tuesday October 19, 2021

Enhancing Community Engagement through GIS Story Maps

Nicole Krause, Roberta Cronquist, Anthony Adderley, Bolton & Menk, Inc.

The City of Shorewood had numerous stormwater projects throughout city, each in varying stages of planning, design, and construction. The city needed an effective way to communicate changing project details with community members and policy makers, as well as a user-friendly platform for the public to obtain additional project information. Bolton & Menk will demonstrate how we integrated a GIS Story Map as a community outreach and education tool to help the City of Shorewood inform the community about ongoing regional drainage improvement projects within their city.

Expanding water testing of private wells by owners-independent managers of Minnesota's hidden resource

Jeffrey Broberg, Paul Wotzka, Minnesota Well Owners Organization; *Bruce Olsen*, retired MDH; *Jeff Stoner*, Retired-USGS; *Mae Davenport, Amit Pradhananga*, University of Minnesota

The Minnesota Groundwater Association and the Minnesota Well Owner's Association cooperated on a project to expand testing of private water supply wells throughout Minnesota. Non-profit entities collaborated with government and academic efforts to increase private well owner knowledge and awareness of aquifers, wells, drinking-water health, and mitigating actions to improve water quality. We estimated that there are over 700,000 such wells in Minnesota. Private-well owners are the managers of the health of their drinking water. Key desired outcomes are to increase well owners' perception of the health risks of their drinking water and motivate them to take actions for improving and protecting water quality.

This effort included 29 volunteers (13 retirees) with over 700 years of collective experience in groundwater science, government, water wells, and drinking-water quality. In 2020, a steering committee developed a toolbox for expanding private well water testing focused on two pilot areas (collaboration with U of Minn. IonE Impact Grant) that exhibit geological and human-caused contamination. The toolbox used available resources-many of which are readily accessible from Minnesota and Wisconsin.

Key components for education and behavior success for the well owner are to 1) increase the convenience of private well water testing, 2) test for analytes that likely reflect geological or human-caused contamination, and 3) follow up promptly with technical and practical support to private-well owners-all critical for establishing a strong groundwater steward partnership between them, their neighbors, and local governments. Evaluated metrics must address the questions from well owners, volunteers, and potential grant funders of testing clinics.

Tuesday October 19, 2021

Changing the way we view Minnesota lawn watering practices

Shane Evans, Florence Sessoms, Maggie Reiter, Eric Watkins, University of Minnesota

Summer water use in the Twin Cities Metropolitan Area (TCMA) is nearly three times greater than winter water use. The Metropolitan Council attributes this seasonal increase to outdoor landscape watering. Human-driven water use has already reduced regional groundwater supplies, and future urbanization will continue to increase demands. The University of Minnesota turfgrass research group has focused on new approaches to improve lawn water use efficiency in order to address this growing issue. The objective of this presentation is to summarize a decade of lawn irrigation research conducted in the TCMA and discuss the ongoing research projects being conducted by the turfgrass research group. Studies to be highlighted include topics such as drought tolerance and appropriate species composition, the environmental impacts of mowing height, and the efficacy of smart irrigation controllers. This presentation will support stakeholders interested in improving landscape water use efficiency and protecting Minnesota's water resources.

Tuesday October 19, 2021

Concurrent Session I
Track C: Rainfall, Runoff and our Responses

Minnesota Evaluation of Hydrologic Change

Jason Carlson, Steve Kloiber, Minnesota Department of Natural Resources

The Minnesota Department of Natural Resources (DNR) developed a methodology called the Evaluation of Hydrologic Change (EHC), designed to characterize and quantify hydrologic change in major watersheds across Minnesota and identify historical changes to flood flows, channel-forming flows, and impacts to biological resources.

The EHC used long-term river discharge records, watershed averaged precipitation data, and USDA reported cropping data to assess 65 long-term river gages and their corresponding watersheds. A key objective was to identify breakpoints in each watershed's record, indicating altered hydrology, by using a preponderance of evidence involving 17 qualitative and quantitative tests.

We used the EHC to assess the degree of hydrologic alteration by analyzing 19 additional metrics to characterize changes before and after the breakpoint. Additionally, the relative influence of precipitation, temperature, and row cropping on watershed hydrology were assessed using random forest regression analysis.

Comparison of metrics between watersheds identified the range of hydrologic change within Minnesota and the relative influence of both land use and climate. These findings are informing current and future watershed planning efforts, and have the potential to be extrapolated to watersheds where discharge datasets are either unavailable or have a short period of record.

Representative Storm - Supplement or Substitution for the Standard Design Storm?

Nicholas Thomas,Michael McMahon, HDR

Storm events used to guide design and hydrologic and hydraulic evaluation of drainage and conveyance systems should be realistic and quantifiable in both space and time. Standardized methods for design storm development and application for use in stormwater, wastewater, and floodplain/watershed management is typically a synthetic exercise that can be overly conservative and disconnected from what occurs in nature.

HDR has developed a hybrid solution to this issue through advanced remote sensing and an understanding of storm behavior. This representative storm approach uses the high-resolution capabilities of gauge-adjusted radar rainfall analyses and focuses on the largest storms from the period of record. The product is a realistic, model-ready, moving storm which maintains the spatial and temporal characteristics of large storms, as they have occurred within a given region. These storms can be reasonably transposed within a region and scaled to represent storms of various recurrence intervals.

This representative storm approach has now been applied for a wide range of purposes including regional sewer planning, design/evaluation of flood infrastructure, and risk analysis. Are these representative storms a replacement for long-standing design storm standards? Maybe, but several challenges first need to be overcome. Uncertainties associated with a limited observed storm database, seasonal storm differences, appropriate spatial variability, associated hydrologic methods and runoff response to various temporal patterns (front end loaded for example), and the need to validate any pattern identified against a historic flow record to confirm that it provides a reasonable hydrologic response are very real and need to be addressed. Through several case studies, this presentation will characterize these uncertainties, discuss weighing the benefit-to-cost, and review quantifying risks associated with the use of representative storm events. Please join us!

Tuesday October 19, 2021

Updating Atlas-14 Precipitation Intensity Estimates with Dynamically Downscaled Climate Change Projections in MN

Ryan Noe, Jonathan Birkel, Tracy Twine, Christina Locke, Bonnie Keeler, University of Minnesota; *Leah Hall, Stephanie Pinkalla*, The Nature Conservancy

Municipalities, planners, and engineers in Minnesota rely on estimates of precipitation intensity from NOAA's Atlas-14 when designing stormwater infrastructure. Atlas-14 contains estimates of how much precipitation will occur in extreme precipitation events, and how frequently those events occur. For example, in the Minneapolis-St. Paul area, 7.5 inches of rain in a 24-hour period has a 1% chance of occurring in any year, sometimes referred to as a '100 year' storm. Estimates like these form the basis for building codes and help municipalities balance tradeoffs between the cost of stormwater infrastructure and ability to manage extreme events. However, these estimates use historical rainfall data dating back to the late 1800s and assume that climate and precipitation patterns are not changing. We applied the methods used in creating Atlas-14's precipitation depth, duration, and frequency estimates, to an ensemble of eight 10km dynamically downscaled climate change projects for Minnesota. In the process we explored the implication of assumptions of spatial aggregation, ensemble averaging, and time series selection. While still being analyzed, our work supports the conclusion that climate change will result in more frequent and extreme precipitation events in Minnesota. Because of the high resolution of our underlying projections, we will be able to provide projections specific to regions or counties throughout the state, without the interpolation and weighting required when using observational data. In addition to producing these datasets, we have partnered with The Nature Conservancy to engage with municipalities on the topic of climate resiliency planning. By working with the city planners and engineers developing the standards for climate resilient infrastructure, we will learn what climate and precipitation intensity datasets are most needed, and produce those for the state. "Sinkhole" covers a wide range of phenomena, ranging from potholes in the street to meteorite craters. Here it refers to collapse features in limestone or sandstone that result from natural or human undermining. Increased precipitation intensity has the potential to lead to more occurrences of undermining, raising sinkhole risk. In addition to being a direct threat to life, sinkholes can damage property, infrastructure, disrupt water and sewer infrastructure and obstruct roadways.

We prioritized shallow bedrock areas (less than 100') and areas near bedrock valleys, because they are more susceptible to cave- and sinkhole-forming processes. Downtown Minneapolis, Nicollet Island, W. River Parkway, and MSP International Airport were priority areas; additional areas were investigated as a result of community reporting and other data. A "new" source of information, namely, construction records for sanitary sewers and storm drains in Minneapolis contained valuable geological details that were used to further refine risk areas.

Hennepin County Emergency Manager, Eric Waage will use results of this investigation to highlight risk to the public in a way similar to the landslide atlas that they developed. It will allow stakeholders including cities in their county to take appropriate action to mitigate risk.

Tuesday October 19, 2021

Solving Flood Problems in Minneapolis: Using the Power of Cloud Computing and Intelligent Automation to Identify and Prioritize Flood Mitigation Projects

Paul Hudalla, City of Minneapolis Public Works, Surface Water & Sewers; *Juan Delgado*, City of Minneapolis

The impacts of urban flooding are significant and, as rainfall intensities increase due to climate change, the frequency and area of flooding is expected become worse. At the same time, aging infrastructure is a great problem that cities across the United States are facing. Many drainage systems are aging beyond their useful life and will soon need to be replaced. With limited resources to address these problems, a strategic approach is needed to identify and construct cost-effective projects.

The City of Minneapolis Public Works Department has initiated a program to identify and construct flood mitigation projects throughout the City. As a part of this work, the City has begun to use Optimatics software in conjunction with the City's SWMM models to rapidly identify the ideal combination of projects to reduce flooding. The application is also used to determine the order that the projects should be built and to compare cost / benefit of one project versus another.

This presentation will highlight a flood mitigation study recently completed for a north Minneapolis neighborhood. An overview of Optimatics software will be presented followed by a description of how City Staff are currently using Optimatics, including custom inputs developed in GIS. Finally, the results and outcomes of the study, benefits of using this type of software, and lessons learned will be discussed.

Concurrent Session I
Track D: The Challenge of Chloride: Trends, Indicators, and Alternative Deicers

A bottom up perspective: Salt-loving bacteria as indicators of chronic road salt pollution in a Lake Michigan Basin

Elexius Passante, Sandra McLellan, University of Wisconsin-Milwaukee School of Freshwater Science

Current research on road salt pollution focuses on transient measures of chloride levels in surface and some groundwaters and its toxicity to aquatic life. However, there is still much to learn when determining how these aquatic ecosystems are impacted by seasonal pollution during the winter. Currently, there is no ecological indicator that can be observed to pinpoint areas being over-salted. This project aims to quantify select salt-loving bacteria (i.e., halophilic and halotolerant microbes) in sediment that have been isolated out of multiple study sites in the Milwaukee River Basin. True halophiles, like Halomonas, have been found in some study sites and could serve as a suitable candidate indicator for assessing chronic chloride impaired areas. To make the indicator feasible for others to use as a tool, a direct plating technique is being explored by suspending the bacteria present in the sediment in deionized water. The bacteria are directly plated onto a 6% NaCl media where bacterial colonies are counted to estimate the concentration of salt-loving bacteria within the sample. Alternatively, quantitative polymerase chain reaction (qPCR) detection is also being developed to target Halomonas. DNA was extracted from sediment sampled at the study sites during winter and spring runoff of 2021 (a total of four sampling events) and is being analyzed utilizing qPCR. The end results of this project could provide insight to municipalities of areas that are impacted by road salt by using the presence of salt-loving bacteria as a measure of ecosystem health and water quality.

Environmental impacts of the application of potassium acetate as a deicer

Katie Cassidy,Chan Lan Chun, University of Minnesota Duluth; *Jerry Henneck*, Natural Resources Research Institute; *John Gulliver,* University of Minnesota

The adverse effects of the use of chloride-based salt as a deicer in winter road maintenance to water quality, soil, and infrastructure are driving a search for effective alternatives to chloride-based salt. Potassium acetate (KAc) is a biodegradable liquid deicer shown to be effective at lower temperatures than NaCl and less corrosive than chloride deicers. However, the environmental impacts of KAc are not fully understood. Due to the organic nature, KAc may result in a high biological oxygen demand in water bodies receiving stormwater carrying KAc. This study aims to determine KAc levels in the water and the impact of KAc on water quality by conducting an environmental field evaluation of winter stormwater and receiving lake water samples. Water samples were collected with a combination of automated samplers and grab sampling following snow events during the winters of 2019-2020 and 2020-2021. Major ions, dissolved organic carbon, metals, BOD5, and E. coli. were analyzed to evaluate the persistence and impact of KAc. The potential toxicity of the deicer to roadside vegetation will be determined by germinating grass seeds in varying concentrations of KAc and NaCl salt solutions. The field evaluation and toxicity work will be complete by Fall of 2021, and the results will be used in watershed modeling for assessment of the fate, transport, and degradation of KAc to receiving water. The findings from this research will inform best salting practices while protecting water resources.

Tuesday October 19, 2021

Chloride in Twin Cities Metropolitan Area Rivers and Streams: 147,947 data points initiating a dialog about regional chloride dynamics and inspiring action to alleviate chloride pollution

Casandra Champion, Hong Wang, Jennifer Kostrzewski, Joe Mulcahy, Emily Resseger, John Barland, Daniel Henely, Judy Sventek, Metropolitan Council Environmental Services

Chloride is rising in many Twin Cities Metropolitan Area (metro area) waterbodies and concern about chloride pollution has increased for watershed managers and the general public. In 2020, Metropolitan Council Environmental Services (MCES) calculated long-term chloride concentration trends, annual and seasonal chloride loads and annual and seasonal median chloride concentrations for 18 metro area rivers and streams.

The long-term chloride trend analysis was conducted using the advanced USGS statistical tool, QWTREND, to estimate non-monotonic and flow-adjusted concentration trends. Annual and seasonal chloride loads were calculated using Flux32.

This presentation will provide an overview of the project as well as describe how we communicated results to our partners. It will also provide an in depth look at chloride dynamics for select metro area rivers and streams. MCES is using these analyses to initiate a dialog about regional chloride dynamics and inspire action to alleviate chloride pollution.

Regional Assessment of Long-Term Chloride Trends in Select Twin Cities Metro Streams (1999 - 2019)

Hong Wang, Casandra Champion, Jennifer Kostrzewski, Joe Mulcahy, Emily Resseger, Jack Barland, Daniel Henely, Judy Sventek, Metropolitan Council

Chloride concentrations have been rapidly rising in many Twin Cities Metropolitan Area (metro area) waterbodies over the past two decades. Meanwhile, concern about chloride pollution has greatly increased in the region. To address chloride pollution, Metropolitan Council Environmental Services (MCES) included chloride as a pollutant of concern to collect information on as part of their stream monitoring program in 1999. Currently MCES and its partners collect chloride samples in 18 of the 20 monitored streams in the metro area.

To understand impacts of chloride in runoff on regional stream water quality and to understand more about the chloride sources contributing to the regional rivers, MCES recently completed a comprehensive assessment of stream chloride including long-term trends, annual and seasonal variations. This presentation focuses on the regional assessment of recent chloride conditions, yields and long-term trends in the 18 metro streams. Long-term chloride trends were analyzed using the USGS statistical model QWTREND, which estimates non-monotonic trends based on flow-adjusted concentrations. The chloride concentrations and yields for the recent ten-year period are estimated using median concentrations and the Flux32 model, respectively.

The results show that 16 of 18 assessed streams had an increasing chloride trend, ranging from 6% to 175%, over the 1999 to 2019 period. Higher chloride concentrations are generally observed in the streams located in the more urbanized part of the metro area. Recommendations to address elevated chloride pollution and mitigation are also discussed in this presentation.

Tuesday October 19, 2021

Concurrent Session I
Track E: Quantifying Benefits in Stream Restorations

Quantifying Benefits in Stream Restorations

Will Harman, Stream Mechanics, *April Marcangeli*, US Army Corps of Engineers, *Ken Powell,* MN Board of Water and Soil Resources, *Lucius Jonett*, Midwest Wetland Improvements, LLC, *Mark Pranckus,* Cardno

Over time many tools have been developed to help practitioners measure the benefits of stream restorations. In 2019 the MN Stream Quantification Tool (MNSQT) was released. This tool was developed through a collaboration of agency representatives and other experts in stream restoration. This session will bring together experts to explain the science behind the MNSQT, describe how the tool was developed, discuss the future regulatory role of the tool, and share experiences applying the MNSQT

Agricultural Climate Markets in Minnesota: Analysis and Assistance for Growers and Stakeholders

Brad Jordahl Redlin, Danielle Isaacson, Minnesota Department of Agriculture - MN Agricultural Water Quality Certification Program

According to the US Environmental Protection Agency, one approach to safeguarding ecosystem services is through incentive mechanisms for conservation, including markets. With ecosystem services markets, companies, communities, and other beneficiaries pay landowners and managers to protect, restore, or mitigate for impacts to ecosystems. In many of these markets, agricultural conservation can be a source of offsets. These markets can help incentivize carbon sequestration and GHG mitigation in the agricultural sector while providing farmers compensation for environmental benefits.

In implementing Governor Walz's Executive Order 19-37, the State of Minnesota determined a need for analyzing and assessing the more than ten climate markets available to Minnesota farmers. The Minnesota Agricultural Water Quality Certification Program (MAWQCP), in addition to tracking GHG emission reductions of adopted practices, has produced a comprehensive comparison of each climate market that concisely details their characteristics to assist policy analysts, public agencies, and agricultural producers.

Further, the MAWQCP has launched a Climate Smart Farms Project designed to function as a bridge to these marketplaces by serving as an opportunity for producers to explore the existing climate benefits they are producing and the potential for additional actions specific to their agricultural land and management. The MAWQCP is uniquely positioned to assist in this effort due to the whole farm risk mitigation that occurs during the initial water quality certification process. Participation in the MAWQCP Climate Smart Farms Project gives growers the space to explore and prepare for evolving climate marketplaces, with the explicit goal of helping growers realize a new and reliable earned income stream for the ecosystem benefits they are providing.

Concurrent Session II
Track A: Agriculture: Water and Climate

Agricultural Water Efficiency Measures in Minnesota

Carmelita Nelson, MN Department of Natural Recourses, Ecological & Water Resources Division

Minnesota has over a half million irrigated acres of farmland. About 81.5 billion gallons of water are applied annually. This year the Department of Natural Resources (DNR) asked irrigators to begin reporting their water conservation and efficiency efforts in a simple survey/reporting system. The Water Conservation Reporting System measures water conservation progress and tracks trends statewide. Results from the first agricultural Water Conservation Report will be presented. In addition to collecting data on water saving practices and technologies, the Water Conservation Report identified barriers and benefits to water conservation. The report also collected data from golf courses, nurseries, and livestock operations.

The survey questions asked in the Water Conservation Reporting System are designed to highlight best practices and were developed with the UMN Irrigation Specialist, the Department of Agriculture, local SWCDs and the Irrigation Association of Minnesota. The reporting system benefits agriculture by encouraging best practices that reduce operating cost, reduce energy costs associated with water production, increase crop productivity reduce runoff and soil erosion, improve their stewardship and sustainability image, and meet or exceed agricultural standards.

Completing the new annual Water Conservation Report is voluntary for irrigators. However, all crop irrigation water use permits have language that states, "All practical and feasible water conservation methods and practices must be employed to promote sound water management and use the least amount of water necessary." Minnesota cities, commercial, industrial, and institutional permit holders have been reporting their water conservation efforts for 1-3 years.

It's all connected: Pumping deeper aquifers lowers water levels in shallower aquifers

Jennifer Rose, Michele Walker, Rosalyn Krog, Amanda Yourd, MN Department of Natural Resources

Groundwater use for agricultural irrigation has expanded in recent years in southern Red Lake County and central Polk County. The number of groundwater appropriation permits increased from 10 in 2010 to 45 in 2020. This increase in high capacity pumping has led to domestic well water supply problems for at least 13 rural residences. The aquifer system in this area consists of water table aquifers along former Glacial Lake Agassiz beach ridges and multiple unconsolidated buried aquifers that are typically confined by glacial till. The aquifer system is not fully characterized due to the nature of the glacial deposits. Expansion has occurred in areas that have not been studied. The DNR has been requiring aquifer tests as part of permit requirements and monitoring groundwater levels to study the aquifer system.

Results show that the buried aquifers are leaky confined and strongly interconnected when pumped. High capacity pumping from the deep buried aquifers lowers water levels in the shallower buried aquifers where many domestic wells are screened. Shallow buried aquifers can take months to recover after the deep buried aquifers are pumped which has led to water supply problems even after pumping has stopped. The interconnection of the buried aquifers demonstrates the leaky nature of the confining units, and highlights the need to manage these multilayered aquifers as a system rather than individually in order to ensure water supply for all groundwater users.

Sustainable aquaculture in Minnesota and the Great Lakes region

Amy Schrank, Donald Schreiner, University of Minnesota Sea Grant

Interest in aquaculture is growing in Minnesota and the Great Lakes region because of the emphasis on local food sources, food security, worldwide demand for increased protein, and continued decline in wild-capture fisheries. However, aquaculture in the Great Lakes region is a small and relatively new industry. To address barriers and opportunities for sustainable aquaculture, University of Minnesota Sea Grant (MNSG) has two statewide projects addressing aquaculture market potential and the supply chain, and is leading the regional Great Lakes Aquaculture Collaborative (GLAC). GLAC is composed of Sea Grant extension educators and university researchers from eight Great Lakes states with the primary goal to provide relevant, science-based initiatives that support an environmentally responsible, competitive, and sustainable aquaculture industry. This regional collaboration, especially our strong emphasis on building connections among GLAC partners and regional producers through state advisory groups, has already filled in basic data gaps about the industry. Minnesota's statewide projects are contributing information to ongoing, regional GLAC research including understanding consumers' willingness to pay for aquaculture products, identifying what producers perceive as barriers to expanding and diversifying their businesses, and identifying policy and regulatory hurdles for aquaculture producers in the region. In addition to GLAC deliverables that include a website, annual events, and webinar series, a number of other collaborative projects have grown out of the GLAC. These include a website to directly connect fish producers to consumers and a project to engage the public in aquaculture through links to the cultural importance of seafood and healthy food preparation.

Concurrent Session II
Track B: Community Engagement in Education and Policy

American Institute of Hydrology: Certifying the Practice of Hydrology

Salam Murtada, Brennon Schaefer, American Institute of Hydrology & Minnesota Department of Agriculture; *John L. Nieber*, American Institute of Hydrology and University of Minnesota

Our growing environmental challenges related to climate change, conservation efforts, flood management, water quality, urban growth and related impacts to natural resources underscores the need to adopt a national standard for practicing hydrology. As a result, the American Institute of Hydrology (AIH) was established in Minnesota on March 3, 1981, to promote hydrology scientifically and professionally and to protect it from non-professional and irresponsible practices. Forty years later, AIH includes more than 400 mostly fully certified professional hydrologist, hailing from the U.S., Canada, Mexico, and the U.K.

In addition to establishing standards and procedures for certifying professional hydrologists in surface water, groundwater, and water quality, AIH certifies hydrologic technicians practicing in the field. AIH was also established to uphold ethical standards to protect the public, to deliver education and training, and to provide related advice and guidance to the public and government. However, there is more work to do and big challenges to meet.

In this presentation, we will provide an overview of AIH: its mission, history and accomplishments. We will also discuss the results of our efforts to reach out to various professional organizations, academic institutions, and water resources professionals throughout the U.S. and beyond.

Social influences on residents' conservation actions to address stormwater runoff

Amit Pradhananga, Sarah Roth, Mae Davenport, University of Minnesota

Stormwater management, a concern to water managers in urban areas, requires not only technical solutions such as improved stormwater infrastructure, but also the support and actions of diverse stakeholders. Pro-environmental behaviors such as adoption of conservation practices (e.g., rain gardens) and community engagement in stormwater management are needed. Urban residents are key stakeholders in stormwater management because they are affected by, implement, and benefit from urban stormwater planning. However, the drivers of and constraints to residents' stormwater related conservation actions are not well understood. To be successful, strategies and programs aimed at engaging residents in stormwater management must be based on an understanding of residents' values and beliefs.

This study examines social factors that influence residents' conservation decision making. We developed and applied an integrated social-psychological framework to examine residents' conservation actions (e.g., use of rain gardens). We conducted a survey of 2000 residents in Duluth and Saint Cloud, Minnesota and analyzed data using structural equation modeling. Study findings show that beliefs about water pollution, and conservation norms are important predictors of practice use among residents. The study offers strategies for resource managers to design programs based on an understanding of residents' motivations to engage in conservation.

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The impacts of watershed governance on some costs and benefits of water resource management: plausibly causal estimates from the Twin Cities, MN

Terin Mayer, Humphrey School of Public Affairs, University of Minnesota

Which government(s) should manage water resources in the U.S.? Intergovernmental collaboration at the watershed scale has typified the answer this last half-century. Despite this, the causal effects on the costs and benefits of water resource management from such watershed governance are relatively understudied. This paper contributes by investigating a natural experiment in Minnesota's Twin-Cities metropolitan area, estimating the impact of watershed governance on water quality, flood damages, and local budget outcomes. In 1982 a state statute required all metro watersheds to be managed at the watershed scale. Since some watersheds were already managed this way, two comparison groups were naturally formed: a set of watersheds "treated" with watershed-scale management in both a pre- and post-law-change period; and a set of watersheds whose "treatment" status changes. I assemble a year-by-city panel data-set that tracks local budget data (revenues, expenditures, debts). An associated panel tracks a set of water quality indicators (dissolved oxygen, total suspended solids, fecal coliform). Flood damage claims from the National Flood Insurance Program (NFIP) are also arranged in a similar panel structure. This data is analyzed with an event study design to identify the impact of watershed governance. Because "treatment" stems from a state-level law and not local factors, this estimate identifies a plausibly causal effect.

Supporting Community-Centered Planning & Policy for Urban Water

Sarah Roth, Amit Pradhananga, Emily Green, Mae Davenport, University of Minnesota

Access to clean water is a human right. Healthy lakes, wetlands, and streams provide a host of benefits to people including purifying water for drinking, buffering floods, & cultural well-bring. Water can also become a liability when natural systems are degraded or impaired. The benefits and burdens of water are not distributed equally across landscapes or human communities. Urban infrastructure is more or less vulnerable to water impairments because of its location or sensitivity. Likewise, human communities can be more or less vulnerable to water impacts due to having, or lacking, the capacity and resources to influence management.

This study seeks to support community-centered urban water planning & policy by documenting the diverse water narratives through inclusive research methodology and by engaging urban communities that have been historically excluded from water resource management. We ask, "How can urban water science and management be more inclusive of the diverse water values and needs of urban residents?"

Quantitative and qualitative data were collected through participatory research methods. We conducted onsite surveys at 15 Twin Cities cultural and community events in 2019 resulting in nearly 500 respondents of whom 75% identified as black, indigenous, or a person of color (BIPOC). Results reveal strong values for clean drinking water for all, but differing water values, perceived water issues, and civic action behaviors between BIPOC respondents and white respondents. Following the surveys, we conducted focus groups with Twin Cities community members, in particular BIPOC residents, to collaboratively analyze the onsite survey data and discuss constraints and opportunities around taking water actions in their community. Key themes emerged related to constraints to water engagement and access, as well as water justice action opportunities. This study offers strategies for collaborative, community-centered science, planning and policy for urban water.

Concurrent Session II
Track C: Proactive Engineering Solutions

Nine Mile Creek Flood Readiness and Risk Assessment

Janna Kieffer, Barr Engineering Co.; *Randy Anhorn,* Nine Mile Creek Watershed District

An important part of risk management is understanding potential hazards and what can happen if a hazard occurs. When considering flood risk along a stream corridor, we often focus on 100-year frequency flood management elevations, which typically assume the existing infrastructure is in good working condition and flowing at full capacity during a modeled rainfall event. But what happens when a storm larger than a "100-year" event occurs? Or when a culvert crossing becomes clogged with debris or fails entirely during a large storm event? The Nine Mile Creek Watershed District (NMCWD) conducted a risk assessment of the Nine Mile Creek corridor to better understand the impacts of these potential hazards and identify creek crossings that pose the greatest risk.

Nine Mile Creek flows through a 50 square mile suburban watershed in the west metro, with approximately 70 unique roadway or railroad crossings along the creek system. The NMCWD used their watershed-wide model and GIS mapping techniques to identify the locations along the creek that pose the greatest risk for property damage or public safety resulting from extreme rainfall events or blocked or failing infrastructure. Locations that result in overtopping of roadways under large storm events (100-year and 500-year) were identified and mapped to improve flood preparedness. Creek crossings with the potential for significant upstream property damage due to back-up of water from a clogged or failed culvert were also identified to help target preventative inspection and maintenance efforts.

Critical Source Area and Priority Management Zone Determinations Result in Prescriptive BMP Implementation Planning

Greg Wilson, Barr Engineering Company

Modeling and terrain analysis refinements have been made possible by the recent release of high-resolution Light Detection and Ranging (LiDAR) topographic mapping for a portion of the Lake Superior region from two separate time periods. Work completed for the Deer Creek Watershed TMDL (Total Maximum Daily Load) Report and Implementation Plan project enabled us to make detailed determinations of critical source areas and prioritization of the associated management practices. Deer Creek is a small perennial tributary to the Nemadji River. The combined presence of sediment volcanoes and slumping streambanks with cohesive clay soils represent one of the highest unit area loading sources of turbidity to Lake Superior. This presentation will show how a combination of GIS terrain analysis and watershed monitoring and modeling results have been used to identify and prioritize areas of the landscape that have a high propensity to deliver excess runoff and/or sediment load to surface waters, either by an overland flow path or by an increased risk for mass wasting and streambed erosion.

Tuesday October 19, 2021

Strong partnerships create watershed-scale solutions in Lilydale Regional Park

Nathan Campeau, Barr Engineering Co., *Joe Barten,* Lower Mississippi River Watershed Management Organization

In 2013 and 2014, large landslides occurred in Lilydale Regional Park in Saint Paul. This park along Pickerel Lake and the Mississippi River contains steep bluffs and ravines and was the site of historic mining activity. As a result of the landslides, the City of Saint Paul, the Lower Mississippi River Watershed Management Organization (LMRWMO), and Ramsey County led a series of studies to identify unsafe slopes and construction projects to stabilize slopes and ravines to improve safety in the park and improve the water quality of downstream impaired waters. The work required partnerships with upstream municipalities, Ramsey County, and State and Federal agencies. Construction activities concluded in late 2019.

This presentation will share the opportunities and challenges of providing a watershed-scale set of solutions to address slope stability and water quality concerns in an area with complex geology. The presentation will highlight the hydrologic and geotechnical complexities and include a discussion of alternatives considered, as well as a short overview of the preferred alternatives that were ultimately constructed. This project highlighted the necessity for further study of bluff erosion throughout the larger watershed, which LMRWMO plans to investigate to identify additional areas for future stabilization.

What Goes Up Must Come Down ... the Bluff

Adam Tjaden, Ron Leaf, Kimley-Horn

A four-lane divided highway goes up the bluff with trail facilities that connect to the Minnesota River Bluffs Regional Trail. The project goes "up the bluff" through a steep and winding corridor that required significant planning to keep proposed grades at 8 percent and incorporated many unique design elements to meet the roadway and stormwater related design criteria and standards. The vast majority of stormwater runoff must flow down the bluff through the corridor and into Bluff Creek, with only a small amount continuing down adjacent ravines. The City of Chanhassen, Carver County and MnDOT partnered to design and implement these improvements to Highway 101 as the last leg of the TH 101 improvements that included the Minnesota River crossing a few years prior.

Stormwater management played a critical role in the project planning, design, and permitting. An eroded ravine to the east required a unique split flow system for the upper half of the project, while the lower half required oversized pipes to manage the peak flows form the entire corridor. Stormwater design challenges included managing ditch flows through large cut sections along steep grades, managing discharges to Bluff Creek, designing a filtration BMP to work with high ground water conditions and another with a liner to maintain the integrity of the bluff conditions, and managing velocities and pipe sizes through the trunk sewer down the bluff. With cooperation and flexibility between all the project partners, the design was completed in 2019, Phase 1 of construction on the lower half was completed in 2020 and Phase 2 is being completed in 2021.

Concurrent Session II
Track D: Remote Sensing, Telemetry, and GIS

Improving water resource management by automating data collection and data management workflows

Marissa Castro, Jill Sweet, Brian Beck, Kailey Cermak, Minnehaha Creek Watershed District

The introduction of telemetry devices coupled with environmental sensors in the late 1990s seemingly should have enabled all water resource scientists to implement an internet of things (IoT) water monitoring network to streamline data collection. However, the adoption of telemetry devices has been limited since most organizations cannot afford the equipment or lack specialized knowledge of telemetry equipment. Therefore, the collection of remote time series data continues to be labor-intensive and costly, which has limited the advancements in data analysis, empirical modeling, and mechanistic modeling in the field of water resources. Most importantly, these limitations have constrained water resource scientist's ability to inform management decisions due to the lack of system-wide quantitative data.

In recent years, the Minnehaha Creek Watershed District (MCWD) has made a concerted effort to reassess how data was collected to inform organizational priorities. MCWD staff identified the need to automate the transmission, storage, and visualization of hydrologic and water quality data. Staff are in the midst of installing telemetry devices coupled with continuous level sensors and automatic water samplers across the watershed. Concurrently, the incorporation of ArcGIS, R, Python, and JavaScript into the data workflow has allowed MCWD staff to automate subsequent data pipelines. The overhaul to MCWD data workflows has also provided an opportunity to modernize our discrete monitoring initiatives including fish surveys, aquatic vegetation surveys and routine water quality monitoring.

These updated processes have enabled MCWD staff to develop new insights on how water moves through the watershed, visualize data with web dashboards, publish MCWD's data with web APIs, and inform infrastructure management in real time.

Development of a GIS-Based Water Quality Model for the City of Richfield

Michael McKinney, Timothy Anderson, Heather Hlavaty, Barr Engineering Co.; *Mike Petersen,* City of Richfield

The City of Richfield needed a decision-support tool to evaluate pollutant loading, the performance of existing water quality treatment best management practices (BMPs), and impacts of future development to inform a variety of City initiatives. In addition to evaluating compliance with regulatory requirements and future development, the City desired a tool that is capable of evaluating citywide performance of storm water BMPs, and rapid evaluations of BMP implementation alternatives.

To meet the City's goals, Barr Engineering Co. developed a citywide geographic-information-system-based water quality model (GIS WQM) to (1) quantify runoff and associated pollutant loading (i.e., total phosphorus (TP) and total suspended solids (TSS)) generated from various land uses (roadways, housing areas, industrial areas), (2) estimate the runoff and pollutant removal that occurs at storm water best management practices (BMPs) such as ponds, swales, and rain gardens, and (3) account for water quality performance and interaction of BMPs in series. Results for the GIS WQM were compared to results from citywide P8 models (a continuous, physically based water quality model) to validate results and performance.

The project was completed in December of 2020. Water quality results will be presented and compared to results of the P8 models on a citywide and on an individual BMP-basis. Additionally, examples will be provided highlighting how the model can be used for rapid evaluation and scenario testing (e.g., future conditions, "what-if" scenarios, BMP implementation scenarios, etc.). As a planning-level tool, the model is being used by City staff for identifying loading "hotspots" and for rapidly evaluating opportunities to improve the quality of storm water entering City-monitored waterbodies.

Effects of forest disturbance on streamflow for Minnesota catchments using remotely sensed datasets and the case study approach

Zac McEachran, Moriya Rufer, Houston Engineering, Inc.; *Diana Karwan*, University of Minnesota Department of Forest Resources; *Jody Vogeler,* Colorado State Natural Resource Ecology Laboratory; *Rob Slesak, Brian Sturtevant, Gordon Reese, Brian Miranda, Kathleen Quigley, Jeffrey Suvada,* US Forest Service Northern Research Station;

Changes in forest cover, climate, and their interaction can alter how streamflow is generated and subsequent water quality. Catchments in northern Minnesota, characterized by low relief and widespread surface-groundwater connection, may be especially vulnerable to these factors. Small experimental catchment studies in western North America often influence our understanding of forest hydrology, but unique hydrological processes in Minnesota mean that historic studies in other regions may not be directly applicable. However, with new remote sensing data, we now can perform these analyses on a large scale. We utilize multiple case studies to quantify how climate and forest cover change affect water yield and peak streamflow across two spatial orders of magnitude in Minnesota. Case studies include the Upper Kawishiwi Basin within the Boundary Waters Wilderness, in which a fire burned 1/3 of the catchment area, and the St. Louis Basin, in which forest management is active but dispersed in space. We utilized Bayesian statistical models and remotely sensed data to quantify drivers of streamflow for small to large catchments. Results indicate a decreasing effect of forest cover disturbance as spatial area increases, with clearer effects on annual water yield than for peak streamflow. Climate was a primary driver of streamflow. To apply this research to land management, we used our findings to inform prioritization of protection areas in Minnesota's One Watershed, One Plan planning framework. This presentation will help attendees understand some emerging research in the field of Minnesota forest hydrology and how to apply it to future watershed management and planning efforts on a local scale.

Advanced Remote Sensing Methods for Automated Lake Water Quality Mapping

Leif Olmanson, David Porter, University of Minnesota

Using satellite imagery, we have been assessing lake water quality in Minnesota, USA for over 20 years. These assessments at around five year intervals were used for spatial and temporal trends and causative factors. Recent advances in satellite technology (improved spectral, spatial, radiometric and temporal resolution) and atmospheric correction, along with cloud and supercomputing capabilities have enabled the use of satellite data for automated regional scale measurements of water resource characteristics. These new capabilities provide opportunities to improve lake and fisheries management by measuring more variables (chlorophyll, colored dissolved organic matter (CDOM) and total suspended matter, the main determinants of water clarity) more often.

To utilize these capabilities we have develop field-validated methods and implemented them in an automated water quality monitoring system on University supercomputers. This system enables near real-time monitoring of water quality variables at regional scales, which will enhance our understanding of spatial and temporal variability and responses of surface waters to environmental change. Examples from Minnesota will be presented.

Concurrent Session II
Track E: Urban Stream and River Restoration

Urban Stream and River Restoration – How to restore dynamic streams in static spaces

Olivia Dorothy, American Rivers, *Laura Domyancich-Lee*, Minnehaha Creek Watershed District, *Beth Wentzel*, Milwaukee Metropolitan Sewerage District, *Adam Arvidson*, Minneapolis Park and Recreation Board, Marty *Melchior,* Inter-Fluve, *Will Lund*, USGS / University of Minnesota

Stream and river systems are naturally dynamic elements of the landscape. Prior to human intervention, Midwest streams frequently altered course, utilized floodplains, and meandered across valley bottoms. However, in the urban environment, the limits imposed by human interaction severely curtail natural stream processes. This panel provides an overview of when and how practitioners can integrate dynamic stream process, academic investigations that inform those designs, and planners that support this more ecologically-informed vision of the future.

Concurrent Session III
Track A: Estimating Changes to Carbon, Soil Health and Nutrient Loss

Carbon Benefits Calculations for Agricultural and Stormwater Practices

Anthony Aufdenkampe, Ben Crary, Chelsie Boles, Pranesh Selvendiran, Laura Weintraub, Nick Grewe, LimnoTech

Climate change mitigation has emerged as a priority issue across the nation in the last two years. Many organizations - from private corporations, municipalities, federal and state agencies, and non-profit organizations - have initiated active efforts to assess their risks from climate change, their potential impacts to greenhouse gas emissions, and opportunities to improve both. A critical need for these organizations are scientifically defensible yet easy-to-implement approaches to quantify their risks, impacts, and opportunities. Fortunately, the datasets required for these calculations are typically the same datasets required as inputs to water risk/impact/opportunity analysis, even if the models themselves are very different.

LimnoTech has developed a number of practical approaches to calculating carbon impacts and benefits for typical agricultural and stormwater practices for a diversity of organizations. We will present these approaches to calculating carbon benefits alongside water benefits, along with case studies of each. These approaches leverage public, national-level data resources and tools, enabling their broad transfer to a wide range of locations and practices. We will conclude with a vision for how these approaches could be used within Minnesota.

Investigation of Activated Carbon/Ultrafiltration Performance for Agricultural Surface Drainage Runoff Treatment

Nazli Wodzinski, Minnesota State University, Mankato

Historic data shows that the suspended sediment and phosphorus levels in agricultural surface drainage systems (ditches) peak during early spring rainfall events. The suspended sediment and excess nutrient decreases the quality of the receiving waters. Previously, nutrient and sediment removal capacity of granular activated carbon (GAC) was tested in laboratory environment. Results of column experiment showed that GAC has a high ability to remove nutrients, but only in long term. The long period of the treatment makes it impractical for field applications. In this study, we investigated the physical conditions of the treatment via a series of laboratory experiments to decrease its duration. By varying pressure, discharge and filter properties we aimed to accomplish remarkable treatment for the average volumetric flow rate of the influent. The generated data will be used to check the possibility of a smart filter that will perform this treatment method on-site without delaying the flow and causing accumulation on site.

Minnesota Phosphorus Loss: How Soil Quality Is Only Part of the Story and Why Modeling Can Be Improved by Considering Subsurface Phosphorus Losses

Heidi Reitmeier, Lindsay Pease, Melissa Wilson, Paulo Pagliari, University of Minnesota; *Heidi Peterson,* Sand County Foundation

This study explores 20 years of nutrient management data to identify how changing trends in cropping and fertilizer applications have affected phosphorus (P) loss risk across the state of Minnesota. Nutrient-loading and farm management records from 1999 to 2019 were compiled across 17 different Minnesota counties representing 5 different state regions, including sites from Discovery Farms of Minnesota, Minnesota Department of Agriculture, Minnesota Agricultural Water Resource Center, and the University of Minnesota. The consolidated data cover two critical watersheds in nutrient management, one flowing north to Canada's Lake Winnipeg, the other flowing south through the Mississippi River ultimately to the Gulf of Mexico. Best management practices are needed for P loss within these watershed basins due to rising concerns about recurrent harmful algal blooms in both watersheds. This study combines historical nutrient-loading data and farm management data to see how soil quality impacts P losses.

Concurrent Session III
Track B: Taking it to the Streets, Urban BMPs

Adopt-a-Drain in a Post Pandemic World

Lane Christianson, City of Minneapolis

Minnesota communities face negative environmental impacts of excessive stormwater runoff. Health and economic consequences of too much TP and algae in our waters pose serious health risks to people. Since the 90's, the City of Minneapolis has advocated community outreach and education for residents and businesses on how they can improve the City's water resources.

Two grass-roots volunteer programs in Minneapolis have shown significant educational and water quality impacts. Both empower people to protect and manage their local water by keeping trash, leaves and sediment out of the streets, resulting in measurable TP reductions.

The Minneapolis Adopt-a-Drain Program started in 2016 before joining the metro-wide program in 2019. The metro-wide program was created and is administered by the Center for Global Environmental Education (CGEE) at Hamline University. Adopt-a-Drain provides direction and tools to adopt storm drains, keeping them clean by removing debris, trash and sediment.

The 'sister' Minneapolis program is the Storm Drain Stenciling Program, providing volunteers with equipment to clean up and stencil storm drains. All equipment is supplied free to volunteers.

During our presentation, we will share GIS mapping efforts; door hanging results; lessons learned about outreach initiatives; a new teaching module for K-12 Minneapolis classrooms; efforts to include social equity and environmental Justice components; before finishing with highlighting the efficacy of these two programs.

In 2019, Minneapolis had 810 new adopters, who spent 2,100 hours cleaning 1,545 drains, collecting 27,000 pounds of debris and removing 24 pounds of TP. Minneapolis reporting of collection data rose from 32% in 2019 to 50 % in 2021. Actual debris collected and TP removed is certainly higher than reported data.

Session participants will understand the importance of adopting storm drains, and the different strategies that can be successfully employed in their organizations.

Tuesday October 19, 2021

Incorporating Green Stormwater Infrastructure Guidance into the Minneapolis Street Design Guide
Allison Bell, Paul Hudalla, City of Minneapolis Public Works

The City of Minneapolis recently incorporated a Green Stormwater Infrastructure (GSI) section into the City's new Street Design Guide. The Street Design Guide (SDG) was developed to provide detailed guidance to planners and designers to meet the goals outlined in The Transportation Action Plan (TAP). The TAP promotes city goals to enhance pedestrian safety, address climate change, enhance mobility throughout the city, among others, which the City recently adopted to guide future planning, design, and implementation of transportation projects. The GSI section of the SDG provides transportation planners and engineers guidance to successfully incorporate GI into transportation projects meeting relevant local requirements and aligning with local safety, traffic, and maintenance needs.

At the time of the SDG development, transportation projects were exempt from meeting the stormwater ordinance. Therefore, the city established a voluntary initiative to incorporate green infrastructure in transportation projects to incorporate city goals including climate change, safety, water quality, and user experience, with the expectation that future ordinance development would no longer exempt transportation projects. Without an explicit regulation, a concerted effort was launched to formally include GSI into the Street Design Guide.

In this presentation, we will provide an overview of the process to get the GSI section into the Street Design Guide as well as an overview of the GSI section in the guide. We will also discuss upcoming updates and examples of successful implementation where designers used the section to guide a project.

Putting down roots: using tree trenches to infiltrate stormwater in downtown Minneapolis
Alicia Beattie, Brittany Faust, Mississippi Watershed Management Organization, *Matt Kumka*, Barr Engineering

Identifying, constructing and maintaining infiltrative stormwater practices with native vegetation in ultra-urban corridors poses unique challenges. In downtown Minneapolis, the Mississippi Watershed Management Organization (MWMO) worked with the City and Downtown Improvement District to evaluate stormwater treatment opportunities and selected a project to install tree trenches with sedges to treat an approximately 1-acre drainage area as part of the 8th Street South reconstruction project. Learn how partners worked with Barr Engineering and Alliant Engineering to design the practice to withstand the stressors of a downtown environment, establish clear roles and responsibilities for operation and maintenance to ensure its long-term function, and communicate the benefits of this high-profile project with the public. The MWMO will also share information about its monitoring set-up and initial findings, including captured stormwater volume, infiltration rates and vegetation health, which will help guide decisions about whether and how to replicate this type of stormwater practice in other places.

Successes and Lessons Learned from a Joint City-Watershed District Enhanced Street Sweeping Program

Paula Kalinosky, Emmons and Olivier Resources, Inc., *Mike Kinney*, Comfort Lake Forest Lake Watershed District

In 2017, the Comfort Lake-Forest Lake Watershed District (CLFLWD), Rice Creek Watershed District, and the City of Forest Lake partnered on funding and implementation of an enhanced street sweeping program in the City of Forest Lake to reduce storm water pollutant loads and protect water quality in several important recreational lakes in the area. In 2019, after purchase of a new regenerative air sweeper, the city and CLFLWD partnered with the University of Minnesota and MPCA to collect data for development of the MPCA Street Sweeping Credit Calculator, a spreadsheet tool used to calculate the total phosphorus (TP) reduction achieved through street sweeping. Samples of swept material were collected from 14 sweeping routes for 107 sweepings conducted with the new regenerative air sweeper during the 2019 sweeping season. Samples were analyzed for total solids and total phosphorus and the data were incorporated into the larger U of MN street sweeping data set. With lab results in hand, the CLFLWD compared the 2019 observed TP recovery to TP recovery predictions from the U of MN Street Sweeping Planning Calculator (2013). Overall, observed TP recovery exceeded predicted recovery by 2.5 X for total solids and 1.3 X for total phosphorus. The city and CLFLWD continued monitoring at a reduced scope during the 2020 sweeping season. During this talk we will review the goals of the Forest Lake Street Sweeping Management Plan; compare monitoring results for 2019-2020 year-to-year, to predictions from the U of MN Street Sweeping Planning Calculator, and to TP the reduction credit calculated using the new MPCA Street Sweeping Credit Calculator. In addition, we will share successes and lessons learned from implementation of the first three years of this program, including the creation of a strong partnership between the City and Watershed Districts, a robust education program, and strategic use of grant and cost-share dollars to fund storm water management at a City-wide scale.

Concurrent Session III
Track C: Supporting Sustainable Use of Groundwater in the Little Rock Creek Area

Little Rock Sustainable Groundwater Use: The Intersection of Science and Stakeholder Engagement
Jason Moeckel, Minnesota Department of Natural Resources

Minnesota law requires that permitted groundwater use be sustainable and defines it as "use [that] does not negatively impact ecosystems, water quality and does not reduce water levels beyond the reach of public water supply and private domestic wells...". Little Rock Creek is impaired for high nitrates, low dissolved oxygen, high temperature and lack of a coldwater assemblage. Use of groundwater for agricultural irrigation was identified as one of the contributing factors.

In 2016 the DNR invited community members to help the DNR develop a DNR action plan for Little Rock Creek Area. A centerpiece of this plan states "[DNR] will be collecting and analyzing additional information to determine whether total permitted groundwater use is or is not having a negative impact on Little Rock Creek."
The groundwater flow analyses completed in March 2021 by the DNR shows that groundwater use in the Little Rock Creek area is reducing some of the seasonal low flows by more than 20% in four of twelve years analyzed. The associated fish habitat analysis showed that this amount of change in streamflow results in a loss of fish habitat during those periods. The use of groundwater flow analysis to quantify habitat reduction as a function of base flow diversion is a new approach in Minnesota.

This presentation (1 of 4) will focus on the integration of hydrologic models, stream temperature analysis, fish habitat analysis, and stakeholder engagement processes to ensure that water use meets the requirements of Minnesota law.

Assessment of instream temperatures in Little Rock Creek near Sartell Wildlife Management Area
Jeremy Rivord, Minnesota Department of Natural Resources

Little Rock Creek is a designated trout stream located in Central Minnesota. In 2013, the Minnesota Pollution Control Agency (MPCA) listed Little Rock Creek as impaired for dissolved oxygen, nitrate, and temperature. The Minnesota Department of Natural Resources has studied baseflow and stream temperatures in the creek to understand the relationship between climate, streamflow, run of river impoundments, and fish habitats. The two models used to analyze baseflow were the WHAT model and the paired watershed method. The WHAT model showed an increase in median August baseflow from 2012 to 2018. The paired watershed method showed baseflow could be higher without intensive land use.
As expected, climate greatly influences the hydrology and water temperatures in Little Rock Creek and this area experienced winter warming and some of the wettest years on record during our study period. Stream temperatures were investigated at an impoundment near the middle of the watershed. Our analysis found that summertime water temperatures (a time of year critical to trout survival) were higher downstream of the impoundment than upstream and that the impoundment increases water temperatures by at least 2 degrees C during summer.

Tuesday October 19, 2021

Groundwater Flow and Groundwater / Stream Interaction in the Little Rock Creek Area

Glen Champion, Minnesota Department of Natural Resources

Groundwater use has increased in the Little Rock Creek Area (LRCA) in Benton and Morrison counties over the last several decades. The Minnesota Department of Natural Resources (DNR) is responsible for issuing permits for reasonable appropriation and use of water. DNR is concerned that permitted groundwater use in the LRCA might have a negative impact on Little Rock Creek, a designated trout stream, by reducing base flows. In September 2018, the DNR adopted a five-year action plan to ensure that groundwater use in the LRCA is sustainable. Groundwater is the primary water source in the area with more than 95 percent of the permitted uses for crop irrigation. A key component of the DNR's work was the development and application of the LRCA hydrological model. The model computes groundwater levels and stream base flows for water years 2006 through 2018. DNR computed the monthly rates of streamflow diversions due to groundwater use and estimated base flow for a no-use, reference condition. The DNR has recommended setting diversion limits relative to the median August base flow. DNR evaluated the range of possible groundwater diversions and reference August base flow considering data and model uncertainties and limitations. An important source of uncertainty is the reported monthly pumping volumes. The computed diversions are also sensitive to the choice of land cover replacing irrigated crops in the no-use scenario. It is likely that monthly diversions exceeded 15 percent of the August median base flow in some months for the selected reference condition. DNR also calculated reference total streamflow to compare against recorded streamflow in a stream habitat analysis. Finally, the DNR will use the model to support evaluations of several alternative management actions identified in the action plan.

Instream Flow Incremental Methodology (IFIM) Study for Little Rock Creek, Mississippi River - Sartell Watershed, Minnesota

Ian Chisholm, Daniel O'Shea, Lecia Babeu, Minnesota Department of Natural Resources

This study and analysis of the aquatic habitats and potential impacts of groundwater pumping is part of a comprehensive effort to examine water use and associated resource impacts in the Little Rock Creek area with the aim of ensuring sustainable water management. We used the Instream Flow Incremental Methodology (IFIM), which is a modular decision support system for assessing potential flow management proposals. Its unique feature is the simultaneous analysis of stream habitat variability over time and space.

Using the IFIM, we assessed the impact of the estimated hydrologic change caused by groundwater pumping on the habitat and ecology of Little Rock Creek. A series of alternative streamflow depletion level scenarios were generated using incremental percentages of the August median base flow (ABF) to assess the impacts of groundwater depletion relative to the threshold of ecological harm (>20% change in habitat), and identify viable management levels.

Based on this study, we found that low flows are significantly reduced by the currently authorized groundwater pumping. The reduction in flows below 75% exceedance is significant and increases as flows decrease. The percent change between reference (without groundwater pumping) and baseline (with groundwater pumping) conditions was greater than 35% in low flow magnitude, frequency, duration, and recurrence. The impact of these low flow reductions in Little Rock Creek corresponds to a significant loss of fish habitat. Reductions in streamflow depletion are needed to avoid ecosystem harm. We provide specific recommendations for managing groundwater depletion to minimize ecological harm in Little Rock Creek and work towards water management sustainability for this system.

Concurrent Session III
Track D: Lake and Pond Management

Why shouldn't you give Elsa a goldfish for a pet? Field studies and management of invasive goldfish

Jordan Wein, WSB; *Randy Anhorn*, Nine Mile Creek Watershed District; *Tim Sundby,* Carver County Water Management Organization

Goldfish have likely been released from aquariums into lakes and ponds for decades. Only recently have they been viewed as a priority invasive species by the Minnesota Aquatic Invasive Species Research Center. So, while it is assumed that goldfish infestations may largely be an be urban issue (and have recently made headlines as such in the Twin Cities metro area), once engrained and allowed to migrate downstream, their ecological influence could match or exceed that of the common carp (their close relative).Carp and goldfish share the same characteristic for feeding; bottom feeders that resuspend nutrients feeding algae blooms and decrease water clarity. This decreases aquatic vegetation needed as habitat for other native fish. Although goldfish have been studied in a laboratory setting, relatively little is known about behavior, population dynamics, and management options outside of the lab. Chemical removal, water level drawdowns, and fyke netting have been used in attempts to reduce goldfish numbers. But these options are not always plausible. Using similar techniques to survey and manage common carp, we are evaluating if these are affective enough to invest in to manage goldfish. Following integrated pest management methods, they include electrofishing surveys, PIT tagging, ageing analysis, box net trapping, open water seining, and targeted trapping corresponding to migration patterns following integrated pest management methods. Two lake chains in Minnesota were tested: Grace Chain of Lakes in Chaska and Lake Cornelia in Edina. Results show migration routes can be targeted to remove sexually mature adults, movement patterns show similarities to common carp, and electrofishing surveys may be used to estimate goldfish biomass. Like carp, it appears that connected winter kill prone water bodies with low native fish diversity are functioning as goldfish nurseries and ageing analysis suggests recruitment spikes follow winterkills in these nurseries.

Extent of Under-Reported Aquatic Invasive Species Sightings in Northeast Minnesota

Douglas Jensen, Alyssa Hagemeyer, University of Minnesota Sea Grant Program; *Josh Dumke,* UMD Natural Resources Research Institute

Management of aquatic invasive species (AIS) depends strongly on understanding their location and distribution. Across Northeast Minnesota entities such as federal agencies, counties, and lake associations conducted independent fieldwork for early detection and monitoring for AIS. Some fieldwork was non-AIS in nature, so AIS sightings may have become buried in field notes and never formally reported. Particular species of interest include: banded mystery snail (Viviparus georgianus), Chinese mystery snail (Cipangopaludina chinensis), curly-leaf pondweed (Potamogeton crispus), and rusty crayfish (Faxonius rusticus). Our objective was to request citing locations for these AIS from entities in five Northeast Minnesota counties to improve our understanding of the extent of the infestations. Spread was far greater than expected with a total of 451 sightings reported, mainly rusty crayfish, Chinese mystery snails, curly-leaf pondweed and banded mystery snails, plus sightings for six other AIS. Sightings were uploaded into the St. Louis County AIS Risk Assessment Tool (https://data.nrri.umn.edu/ais/) at the UMD Natural Resources Research Institute and reported to NOAA/GLERL's Great Lakes Aquatic Nonindigenous Species Information System. Understanding the extent of infestations helps inform outreach to prevent spread, detection and monitoring, research, and control to minimize potential impacts on the environment, recreation and economy of the region.

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Recognizing and Quantifying the Role of Aquatic Plants in Shallow Lake Nutrient Management

Keith Pilgrim, Barr Engineering CO.

The importance of aquatic plants in supporting healthy shallow lakes is generally understood but the nutrient phytoplankton control benefits of aquatic plants is not often quantified. The role of these plants in the nutrient cycling of a lake is not as well understood and often overlooked when modeling lakes and evaluating potential management activities. Not only can aquatic plants uptake nutrients throughout the growing season, they can also cause shading and inhibit phytoplankton growth.

The Nine Mile Creek Watershed District has been evaluating the health of several shallow lakes within the watershed in recent years to better understand the nutrient cycling and identify effective management techniques. An important part of this work has been to quantify the impacts of aquatic plants on nutrient cycling and overall lake dynamics and to use this information to target management actions.

This presentation will include a discussion of a new lake model being used to account for the important role of aquatic plants in these shallow lake systems and general observations and conclusions regarding the role of aquatic plants from recent studies of Lake Smetana, Lake Cornelia, and others.

Are Stormwater Ponds Incubators for Harmful Algal Blooms?

Tyler Olsen, Katie Turpin-Nagel, Joe Bischoff, Barr Engineering Co.; Josh Maxwell, Riley Purgatory Bluff Creek Watershed District

Stormwater ponds are one of the most common practices in Minnesota used to reduce pollutant loading by settling and storing sediment and nutrients in watershed runoff. Many of these ponds are in well protected areas of the watershed resulting in calm, warm, and high nutrient water creating ideal conditions for harmful cyanobacterial algal blooms. Many of these stormwater ponds are viewed as assets to surrounding residents with intensively used shoreline areas including patios close to the pond and sometimes docks. While residents may not come in direct contact with pond water, pets are certainly at risk. More concerning are recent studies that suggest cyanobacteria may represent a threat to public health through aerosolization. Because current stormwater pond design standards focus on modeling sediment and phosphorus settling and not on measured pond water quality, the Riley Purgatory Bluff Creek Watershed District (RPBCWD) monitored water quality in 9 stormwater ponds. Conditions in all 9 of the ponds were ideal for cyanobacteria blooms with high nutrients, warm temperatures, and low dissolved oxygen that can lead to sediment phosphorus release. Measured phycocyanin, a photosynthetic pigment specific to cyanobacteria, was high in many of the ponds suggesting that harmful algal blooms were occurring. Other monitored ponds were dominated by duckweed on the pond surface, likely limiting light availability for cyanobacteria production. This presentation will discuss the factors that make stormwater ponds vulnerable to harmful algal blooms and considerations for stormwater managers to prevent public health risks from harmful algal blooms in stormwater ponds.

Concurrent Session IV
Track A: 2D H&H Modeling Applications

Integrated 1D-2D Modeling for Flood Hazard Delineation

Dustin West, Christopher Reichle, Hazen and Sawyer; *MaryLynn Lodor,* Metropolitan Sewer District of Greater Cincinnati

Muddy Creek Road, located in Cincinnati, Ohio, follows a natural channel which was filled in the 1950's. A large diameter combined sewer was installed to drain the area, but residents living along the road experience chronic flooding and property damage during extreme rain events. A Flood Insurance Rate Map (FIRM) has not been previously developed in this area. As a response to the flooding issues, the Metropolitan Sewer District of Greater Cincinnati (MSDGC) is pursuing grant funding from the Ohio Emergency Management Agency (OEMA) Mitigation Branch. The intent of the funding is to purchase and demolish houses prone to chronic flooding. With enough participants, MSDGC will be able to develop flood mitigation measures for the entire study area.

MSDGC's current calibrated PCSWMM model was enhanced with state of the art 1D and 2D modeling techniques to characterize the cause and extents of flooding, delineate the flood hazard boundary, and quantify flooding impacts on finished first floor elevations of structures along Muddy Creek Road during extreme events. This flood hazard modeling approach leverages newly available technologies and best practices for these type of complex urban flooding conditions and resulted in a highly credible delineation, while also providing keen insights into the root causes of the flooding. The integrated 1D/2D model was useful for predicting the depth, extent, and duration of flooding at high-risk areas. With this information, more appropriate remedial measures can be taken than would be permitted using only a traditional 1D analysis.

Development of Sustainable Solar Farms through 2D Hydrodynamic Modelling

Mathew Cox, Melissa Duyar, Kimley-Horn and Associates

In the U.S. today, power is a basic commodity. However, traditional power sources contribute to climate change and have fueled the development of solar power and other renewables. The Fourth National Climate Assessment predicted and warned the world: "more frequent and intense extreme weather and climate-related events" will place even more stress on our current and future infrastructure.

While there is no preference to site solar fields near water like traditional power plants, precipitation and increased intensity of storms directly affects the risk taken by developers and owners when building a solar site. Mitigating this risk is at the forefront of design. Hydrologic and hydraulic modeling can play an integral role in managing risk for these sites.

FEMA Flood Insurance Rate Maps are widely used as a way to ensure that proposed infrastructure is not within a 100-year floodplain or floodway. However, there is little known of the flood risks outside of these mapped areas. Solar sites have panels and inverters that must stay dry to ensure reliable power generation. Kimley-Horn has been using HEC-RAS 2-D to quantify inundation depths outside of the FEMA floodplain. The 2-D flow model is able to estimate the depth of flow at a given location (i.e. at a solar panel or inverter). The HEC-RAS model also quantifies the velocity of flow at locations within the project area. Recently, many stakeholders have asked if their equipment is adequately protected from scour and as a result, scour analyses and recommendations on how to mitigate scour have become more frequent in designing solar panel sites.

With solar energy and other renewables becoming more prevalent to combat climate change, the presentation will highlight the importance of performing hydrologic and hydraulic analysis to design resilient solar farms in the face of more frequent extreme weather.

Wednesday October 20, 2021

Sauk River 2D Floodplain Analysis

Madison Rogers, Earth Evans, WSB; *Salam Murtada,* DNR

The complex goals of the CSAH 13 bridge replacement and channel realignment project provided an opportunity to utilize 2D floodplain analysis and coordinate with the DNR. This is the first project the DNR has reviewed that converts an existing 1D to 2D model to comply with FEMA's recent issuance of guidelines on 2D modeling (December 2020).

The project is located downstream of the Sauk River Dam in Melrose, MN. The Sauk River is a major stream in Central Minnesota, and the project area is within a designated FEMA floodplain. The project involves the realignment of 1,000 feet of the Sauk River to reduce the erosion and scour that is occurring downstream of an existing dam, reconnect the floodplain, restore ecological integrity, and reduce sediment loads from bank erosion. During this presentation we will describe the reasons for utilizing SRH-2D hydraulic analysis, discuss the new regulatory guidelines, and outline lessons learned from this process. The 2D modeling includes:

-Existing and proposed bridge over realigned channel

-Scour analysis to provide protection for the proposed bridge piers

-Complexities within the project area including a levee adjacent to the project, a dam upstream of the project and a new channel alignment for the proposed condition.

-2D analysis was selected due to the wide floodplain, complexities of the terrain, scour evaluation, and ability to clearly show velocity vectors for known erosion issues

-Partnerships with DNR floodplain and fisheries staff, USACE, and City staff to produce an innovative design that meets various agency requirements.

The proposed channel design also utilizes habitat restoration, bioengineering to improve water quality, and long-term vegetative restoration to minimize bank failures. The 2D hydraulic analysis is used to perform the LOMR analysis for the proposed project. Construction begins in 2022. The design, hydraulic analysis, floodplain analysis and permits are complete.

Hydrologic and Hydraulic Design at Large Solar Energy Developments

Roger Clay, Rick Archer, Cassie Borden, Ulteig Engineers

At locations across the United States there are large, greater than 1000 acre, solar energy facilities being planned, designed and constructed. An interesting aspect of these projects is the hydrologic and hydraulic design needed for them. Given the size of the facilities alone, there is a large area to plan and design surface water management facilities for. Another level of complexity is quite often off-site areas drain into and through the site, some of which have substantial watershed areas (10s of square miles). There may be a FEMA Flood Insurance Rate Map covering the area or floodplain mapping may be necessary. As is typical for new development, there is a relatively short time period to complete the analysis, which must be coordinated with other site needs such as roads, power lines and the solar arrays. For these renewable developments the owner desires water resources information that differs from other types of development, such as overland flow velocities and depths, and scour potential at the foundations of the arrays.

There is typically limited ground survey data available for the hydrologic and hydraulic design for solar developments. As a result, the designs often are largely based on digital elevation model (DEM) data, with this data sometimes specifically collected for the project, or obtained from public sources. A hydrologic and hydraulic model is implemented that can use DEM data to rapidly complete the design. For this presentation we will describe using the Flo2D model to generate hydrographs for design storms and then the routing of runoff through the site to obtain design data needed. Typical sources of input data and how they are used will be described, including limitations and potential problems. Selection of model parameters such as grid size selection and implications, and post processing of model output will be reviewed. To end the presentation we will discuss how solar developers use the data and summarize key regulatory issues.

Concurrent Session IV
Track B: Agricultural Drainage Systems: Storage and Water Quality

Water Storage Virtual Tour

Kimberly Musser, Minnesota State University, Mankato

Research shows the long-term solution to improve Minnesota River water quality is to reduce peak flows and store more water on the land. There's a critical need to raise awareness about water quality and community resilience benefits of water storage along with garnering support to implement and fund more water storage practices across the Minnesota River Basin. This project helps to clarify diverse approaches to water storage by highlighting existing case studies.

A water storage virtual tour was created to illustrate diverse examples of existing water storage practices that slow the flow of water to the Minnesota River for landowners, conservation partners, and elected officials. A GIS Story Map format highlights effective storage practices in Southern Minnesota, focusing in the highly-impaired Greater Blue Earth River Basin (Le Sueur, Blue Earth, and Watonwan River Major Watersheds). Case studies range from wetland restorations and multi-purpose drainage management to soil health practices and urban rain gardens. Part of this project's goal is to expand the vision of water storage beyond large structural practices to include soil health (tillage and cover crops) and smaller, less costly approaches like alternative tile inlets.

The tour helps to make the case that there are already many successful water storage examples in place that could be emulated and replicated. The project is a collaboration among Water Resources Center at Minnesota State University, Mankato, University of Minnesota Regional Sustainable Development Partnerships, and a diverse Advisory Committee. This tour was designed as a follow up to the Water Storage Forum

Water dynamics of managed and unmanaged agricultural drainage ditches

Jeffrey Strock, Andry Ranaivoson, Satoshi Ishii, Hao Wang, University of Minnesota; *Anna Baker, Jared Trost*, US Geological Survey

In order to improve productivity, extensive agricultural areas in the Midwest require drainage systems consisting of subsurface drainage (tile) and open ditches. These drainage systems are known to transport nutrients and sediment to streams and rivers. The objectives of this research were characterize annual and seasonal ditch flow, measure hydraulic residence time for ditch systems with and without low-grade-weirs, and measure whether there was evidence of surface water-groundwater interactions occurring within managed ditch channels. The site included a pair of 180 m long drainage ditch channels, one unmanaged the other managed near the outlet with a low-grade weir. During July 2020, a ditch bank temperature profiling survey was conduct within each ditch channel. Results from a temperature survey suggested that there were reaches within each channel that behaved as though the channels were gaining water from shallow groundwater and reaches where the channels were either stable or losing water to shallow groundwater. Results from conservative tracer tests under moderate-flow conditions indicated that the residence time of water in the unmanaged channel was less than one hour whereas it was about five hours in the channel managed with a low-grade weir. Results indicated that ditch flow is highly variable and dependent on soil moisture along with snowmelt and precipitation runoff. Minimally invasive ditch management has the potential to increase temporary water storage on the landscape without impacting drainage system performance.

Seasonal and annual nutrient removal from agricultural drainage ditches using low-grade weirs

Andry Ranaivoson, Jeffrey Strock, Satoshi Ishii, Hao Wang, University of Minnesota; *Anna Baker, Jared Trost,* US Geological Survey

In order to improve productivity, extensive agricultural areas in the Midwest require artificial drainage systems consisting of subsurface drainage (tile) and open ditches. These drainage systems are known to transport particulate and dissolved phosphorus, nitrate-nitrogen, and sediment to streams and rivers. The objective of this research was to measure the seasonal variability of nitrogen and phosphorus removal from experimental drainage ditches with and without low-grade-weirs in a cold climate. This field research took place in the Cottonwood River Watershed at the University of Minnesota, Southwest Research and Outreach Center near Lamberton, MN. The site included a paired drainage ditches equipped with H-flumes and water level sensors for determination of discharge and flow rates along with automated samplers for collecting water to quantify water quality parameters. Monthly and annual precipitation influenced ditch discharge and nutrients loads. On average, ditch management between 2017 and 2020 resulted in a 55% reduction in discharge from the ditch with the low-grade weir compared to the ditch without the low-grade weir. The ditch containing the low-grade weir resulted in nitrate-nitrogen and dissolved reactive phosphorus load reductions of 62% and 63%, respectively, over the four years. Flow weighted nitrate-nitrogen concentration was reduced by 51% whereas flow weighted dissolved reactive phosphorus concentration was reduced by only 6%. Minimally invasive ditch management has the potential to mitigate nutrient fluxes from agricultural drainage and runoff without impacting drainage system operation.

Characterization and Identification of Microbial Communities in Agricultural Drainage Ditches

Hao Wang, Satoshi Ishii, Jeffrey Strock, Andry Ranaivoson, University of Minnesota; Anna Baker, Jared Trost, US Geological Survey

In order to improve productivity, extensive agricultural areas in the Midwest require artificial drainage systems consisting of subsurface drainage (tile) and open ditches. These drainage systems are known to transport particulate and dissolved phosphorus, nitrate-nitrogen, and sediment to streams and rivers. Low-grade weirs have been shown to increase hydraulic residence time (HRT), reduce nutrient load, and nutrient concentration. In this study, we investigated the microbial community composition and function in drainage ditches. The experiment was located in the Cottonwood River Watershed at the University of Minnesota, Southwest Research and Outreach Center near Lamberton, MN. The site included an unmanaged drainage ditch and a drainage ditch managed with a low-grade weir to increase HRT in the managed ditch. Sediment samples were collected from the drainage ditches throughout 2020 and 2021. Total DNA was extracted from ditch sediment and was used for downstream analysis. Bacterial communities were assessed by sequencing the amplicons of the 16S rRNA gene. Furthermore, various N cycle associated genes were quantified using the Nitrogen Cycle Evaluation (NiCE) chip on the Smartchip platform. Denitrifying bacteria were isolated from the ditch sediment and verified by 15-N labeled nitrate and Gas Spectrometry - Mass Chromatography (GC-MS). Isolated, cold adapted, denitrifying strains will be used for bioaugmentation in the ditch channels in order to measure whether bioaugmentation can facility nitrogen removal from agricultural ditch water.

Concurrent Session IV
Track C: Performance of Stormwater Filtration Media and BMP Planning and Assessment

Biofiltration Media: What to Choose and Why

Katie Kramarczuk, Andy Erickson, Jessica Kozarek, Laura Lewis, St. Anthony Falls Laboratory

Biofiltration is a common practice for stormwater treatment throughout the state of Minnesota, particularly in urban areas. However, professionals continue to face design challenges pertaining to media mixes, particularly those containing compost which have been shown to export of phosphorus, the main pollutant we are trying to treat. This study design consists of 30 outdoor biofiltration mesocosms comprising nine different media mixes compared to clean washed sand (three replicates of each mixture). Media components were mixed with clean washed sand to produce mixed media, including food residue compost (10% or 20%), leaf compost (10% or 20%), sphagnum or reed sedge peat (20%), 15% biochar mixed with 20% leaf compost, 5% spent lime mixed with 20% leaf compost, or 5% iron mixed with 20% leaf compost. Over two years, a series of 22 simulated runoff events were conducted approximately weekly and the effluent and influent phosphorus measurements were compared. Phase 1 and phase 2 of our research has shown that the filtration rate had little variation. Effluent phosphate concentration was significantly higher than the influent phosphate concentration (i.e., phosphate release) in the food compost, leaf compost, biochar and spent lime mixes . Mixes containing Iron, sphagnum peat and reed sedge-peat had the lowest concentration of phosphate in the effluent (i.e., phosphate capture). Mixes with food compost (20%), leaf compost (10% & 20%), biochar, and spent lime showed relatively high vegetation max height and above-ground biomass, while mixes with 10% food compost, sphagnum or reed sedge peat, iron, or 100% sand had relatively low vegetation max height and biomass. The next field seasons will include the application of road salt on our media and an indoor vegetation germination study to examine low organic content (<10% compost) media mixes. With the information from this study, stormwater practitioners will be able to design better biofiltration practices that capture phosphorus and support healthy vegetation while also maintaining adequate filtration rates.

Water Treatment By-Product used to Enhance Phosphorus Reductions

Joshua Maxwell, Riley Purgatory Bluff Creek Watershed District; *Brandon Barnes,* BARR Engineering

Lake Susan, an 88-acre lake within the City of Chanhassen, is considered impaired by the Minnesota Pollution Control Agency for excess nutrients. In 2016, an innovative stormwater management system using spent lime was constructed along a tributary stream to improve water quality entering the lake. Spent lime is calcium carbonate that comes from drinking-water treatment plants as a byproduct of treating water. Observation and monitoring data collected by District staff in 2016 - 2018 at the inlet and outlet of the system, indicated inconsistent system performance and periods of extended inundation. In 2019, RPBCWD and Barr Engineering collaborated on the design and column testing experiments for various mixtures of spent lime and types of sand. System modifications were implemented to replace the deteriorated spent lime with a mixture of plaster sand and spent lime, replace the underdrain, and install an automated water control structure. In 2020 and 2021, water samples were analyzed for total dissolved phosphorus (TDP), total phosphorus (TP), total suspended solids (TSS), ortho phosphorous (OP), and chlorophyll-a (Chl-a). In 2020, a total of 18 TP samples were collected over the summer yielding an average TP reduction of 62% with a maximum TP reduction of 91% occurring in July. For TDP, TSS, OP, Chl-a, reductions were around 50%. The spent lime treatment system was effective at removing phosphorus and other nutrients and will be monitored moving forward to ensure removal efficiencies are maintained.

Wednesday October 20, 2021

Stormwater Retrofit Assessments in Smaller Rural Minnesota Communities

Lorin Hatch, AECOM; *Shawn Tracy,* HR Green

Small rural Minnesota cities typically focus their efforts on road, water, and sewer programs, to name a few, while stormwater management may not receive as much attention (they are not typically subject to MS4 rules). However, there are small cities adjacent to lakes and streams where stormwater may cause water quality problems. Stormwater issues are typically looked at as a quantity issue with respect to flooding and water quality may be addressed in a piecemeal approach such that the entire city is not examined holistically to determine the best strategies and locations related to stormwater water quality BMPs. The net result can be a hodge-podge of localized spot treatments of stormwater that are not cost-effective in the long run, and do not directly address the water quality of the stormwater. Small communities also have small stormwater budgets, and highly intensive, costly analyses are typically not an option.

Here we present the process we took, and the tools used for evaluating the City of Warroad for cost-effective stormwater BMP retrofits. We will focus on our recently completed SRA for the City of Warroad but will draw upon experience from other studies as well. We'll lead the audience through the process, moving from issues analysis and goal setting through desktop analyses, field assessment, pre-post water quality analysis, alternatives analysis, and costing of recommended implementation projects. Though not as intensive as is typically employed for larger municipal analyses, the process and tools used for the Warroad study presents a simple, effective solution for smaller communities and budgets.

Columbia Golf Course BMPs - Multi-Partner Implementation of an Urban Stormwater Project

Erin Hunker, SRF Consulting Group, Inc.; *Nancy Stowe,* Mississippi Watershed Management Organization; *Lisa Goddard,* City of Minneapolis

The 1NE Watershed drains 2,150 acres of NE Minneapolis and Columbia Heights into the Mississippi River. The watershed is a mix of urban land uses, with a large park, golf course, and railyard lying in its center. The watershed faces several urban stormwater challenges: multiple residential flooding locations, combined sewer connections, and a lack of water quality treatment.

The Mississippi Watershed Management Organization (MWMO), City of Minneapolis (City), and Minneapolis Park and Recreation Board (MPRB), along with SRF, have been planning, prioritizing, and developing designs for capital projects that increase flood resiliency, reduce pollutant loading, and improve ecological function throughout the 1NE Watershed. The planning and design components were presented at the 2020 conference. For the 2021 conference, we will provide an update on construction of one of the projects and the on-going collaboration between the partners.

We will focus on the construction of three new BMPs and 4,000 linear feet of new storm sewer trunk system within Columbia Park and Golf Course. The project reduces flooding extents and duration and significantly reduces phosphorus and sediment loading from a 600-plus acre subwatershed. The presentation will provide an overview and aerial images of the $7M construction project. It will also dive deep into construction challenges, including obstructions found during tunneling of storm sewer beneath an active railroad, the discovery of debris and contaminated material during excavation, and the discovery of deep muck requiring mitigation to reduce risk of settlement of new storm sewer and an outlet control structure. The presentation will talk about collaborative solutions and decision making needed to resolve these issues from a technical perspective between design engineer and contractor, and from a funding perspective between the three partners. Construction began in November 2020 and will be substantially complete in August 2021.

Concurrent Session IV
Track D: Facilitating Challenging Conversations in the Context of Water Equity and Justice

Facilitating Challenging Conversations in the Context of Water Equity and Justice

Patricia Izek, Patrick Nunnally, University of Minnesota; *Wendy Smythe,* University of Minnesota-Duluth

Explore the intersecting urgencies of water resource challenges and environmental/ social justice. First, you will be introduced to skills on noticing and naming our own biases and developing empathy and active listening skills when we interact with others. Then, you will hear examples from peers working to address equity and social justice issues in their water resource work. Finally, in small groups, you will explore action steps to employ in your personal and professional work.

Wednesday October 20, 2021

Concurrent Session IV
Track E: Wetlands Workshop

Wetland Program Updates and Compensatory Planning Framework
Dennis Rodacker, Board of Water and Soil Resources

Discussion will include Wetland Program Updates and an introduction to the Compensatory Planning Framework (CPF). The talk will also include how the CPF can be used, the status of development, examples of completed CPFs, and what they show.

Fen Diversity in Minnesota
Scott Milburn, Midwest Natural Resources

Minnesota is home to millions of acres of peatlands, primarily within the Laurentian Mixed Forest province, but also in the other three ecological provinces. These peatlands, varying in terms of hydrology, species composition, and chemistry, add to the complexity of Minnesota's ecological landscape. Peatlands, often thought of as economic wastelands, have remained considerably intact and viable as time progresses and despite the pressure to convert them for profit.

This presentation will initially showcase the diversity of peatland systems from acid peatland communities to open rich peatlands. Open rich peatlands will be further explored, highlighting the various open rich peatland communities, alternatively referred to as fens. And we will dive further into defining fens and subsequently calcareous fens, including both prairie and spring communities found throughout Minnesota.

Engineering Nature: the structure of calcareous fens and the delicate balance of an ancient wetland
Keylor Andrews and Megan Benage, Minnesota Department of Natural Resources

The Minnesota DNR's mission includes balancing use and protection of the state's natural resources. This responsibility becomes especially challenging near calcareous fens. Since 1991, Minnesota Statute has prohibited degradation of calcareous fens by any activity. Minnesota is home to more than 200 calcareous fens, most of which are smaller than ten acres in size. Though small, calcareous fens have high species richness and are home to several rare plant species. The Kasota 7 calcareous fen is positioned in the Minnesota River Valley below a river terrace of Jordan Sandstone, and in proximity to a mining operation. As part of the water appropriation permitting process, the mine operation was required to develop a fen management plan that included installation of a mitigation system between the mine and the fen. The mitigation system maintains water levels by pumping water from the Jordan aquifer and conveying it to an infiltration gallery adjacent to Kasota7. The system is elaborate and expensive. To track the performance of the mitigation system, rigorous quantitative hydrological, geochemical and biological monitoring occurred in and around the fen and mine sites. The collection of these data provided an opportunity to assess the mechanics of one of the rarest wetlands in the world. Vegetative plots were established, water levels were monitored in the fen and surrounding aquifers, and geochemical samples were taken before and during the systems operation. This extensive data set has led to new insights into why calcareous fens occur where they do, a link between geochemistry and plant community and lessons learned in the monitoring of calcareous fens.

Wednesday October 20, 2021

Sprague Creek Scientific and Natural Area (SNA) Restoration Project
Torin McCormack, Roseau River Watershed District

Spring fens are wetlands fed by mineral-rich groundwater that feed into a network of open vegetative channels that branch through forests of black spruce, tamarack, and white cedar. The Sprague Creek Scientific and Natural Area (SNA) Restoration Project proposes to restore hydraulic connection to Sprague Creek Fen, a spring fen that is currently dissected by a jurisdictional ditch network. Sprague Creek Fen is one of only eight spring fens identified within the State of Minnesota and is likely the most impacted as a result of extensive public drainage ditches. The restoration project is required mitigation for the nearby Roseau Lake Rehabilitation Project and is being undertaken by the Roseau River Watershed District and the MN Department of Natural Resources.
The project goals are to partially restore and preserve the function and value of the SNA and the surrounding wetland complexes, reduce discharges that exacerbate peat oxidation/erosion and downstream flooding, and improve water quality. Restoration work will include: filling in jurisdictional ditches to maintain water tables and reverse the loss of peat, removing spoil to restore flow in the fen channels and monitoring of the site hydrology, soils and vegetation to ensure project success. Monitoring has been established and includes pre-project peat sampling, surface and groundwater level monitoring, and baseline vegetation analysis. The current baseline monitoring data will be presented along with the proposed restoration work that is to be completed by Fall 2022.

A New Approach for Wetland Functional Assessments in the Riley Purgatory Bluff Creek Watershed
Joseph Bischoff and Scott Sobiech, Barr Engineering Co., *Terry Jeffery and Zach Dickhausen*, Riley Purgatory Bluff Creek Watershed District

Wetland management in Minnesota is typically supported by a functional assessment of wetlands to make sound management decisions based on the quality and function of a wetland. The most commonly used tool in Minnesota is the Minnesota Rapid Assessment Methodology (MnRAM), a numeric model to rank each wetland function. This approach is now over a decade old and updates for this tool have waned. Additionally, new tools are being rapidly developed using recent scientific advancements in our understanding of wetlands and their role in watershed functioning. To advance its wetland program, RPBCWD is developing a wetland assessment methodology based on ecosystem services to prioritize wetland rehabilitation, protection, and creation across the watershed. While other ecosystem services may be addressed as the program evolves, the District chose to focus on five ecosystem services including nutrient cycling, community resilience, biodiversity, habitat, and recreation/cultural resources. To develop this methodology, the District reviewed numerous, recently developed wetland functional assessment approaches to determine applicability to the Riley Purgatory Bluff Creek watersheds. Ultimately, the functional assessment methodology developed by the District represents an amalgamation of other approaches including MnRAM, Wetlands by Design, the Hydrogeomorphic Approach, and EPA's National Wetland Condition Assessment. Metrics were developed for each of the ecosystem services using a stressor-response gradient leveraging existing data and models as much as possible. For example, wetland areal loads for nutrients and metals were estimated using the District's P8 model and then compared to reference conditions. This presentation will provide an overview of the RPBCWD wetland functional assessment approach.

Creating Dynamic Wetland Maps with Google Earth Engine

Audrey Lothspeich and Joe Knight, University of Minnesota Remote Sensing and Geospatial Analysis Laboratory

Wetland inventories like the National Wetlands Inventory are important tools for water resource management, but they are a snapshot in time of a dynamic system. We present new research to identify inter-annual change in Minnesota wetlands, which provides additional temporal information to wetland inventories and detailed information about hydrologic regime. Our method identifies changes in water and vegetation presence for Minnesota wetlands from 1984 to 2019, using the archive of Landsat and Sentinel satellite imagery, the LandTrendr algorithm for summarizing time-series of spectral data, and the cloud-computing platform for large-scale geospatial analysis Google Earth Engine. We illustrate the applicability of LandTrendr and Google Earth Engine for increasing the temporal information in wetland inventories, and highlight the information about wetland change and hydrology that this method can produce.

Beneath the surface: what we've learned about wetland seeds in the past 20 years and why it matters to wetland restoration practice

Dr. Sue Galatowitsch, University of Minnesota, Department of Fisheries, Wildlife and Conservation Biology

The extent to which a wetland restoration supports biodiversity greatly depends on whether native vegetation or invasive species establish and claim the site. While specific wetland revegetation practices, including invasive species control during site preparation, native plant propagation, installation, and herbivore protection, have improved over the past few decades, choosing an optimal approach for a project requires a sound assessment of the wetland seedbank and propagule pressure in the surrounding landscape. In practice, generally it is not feasible to directly assess seedbanks and seed dispersal, which creates uncertainty for determining the intensity and time frames necessary for adequate invasive species control or the extent to which desirable native plants are likely to recolonize before invasive species do. Our research into the fate of seeds in wetland seedbanks and the ecology of wetland seed dispersal offers insights and guidance for wetland practice that has potential to make wetland revegetation more predictable.

Concurrent Session V
Track A: Addressing Urban Flood Risk

From Planning to Projects: Addressing a Chronic Urban Flooding Problem

Jennifer Koehler, Barr Engineering; *Eric Eckman,* City of Golden Valley; *Laura Jester,* Bassett Creek Watershed Management Commission

The Cities of Golden Valley and New Hope have experienced chronic flooding around Medicine Lake Road and the DeCola Ponds during intense storms, making the road impassible to emergency vehicles, flooding nearby structures, homes, and vehicles. Although not in a FEMA-mapped floodplain, several owners have flood insurance through the National Flood Insurance Program.

The Cities of Golden Valley, New Hope, and Crystal completed a long-term flood mitigation plan in 2016 that identified 39 structures as at-risk of flooding during the 1% chance event and the solution included six flood storage projects along with flood proofing remaining at-risk properties at an estimated cost of $22 million. The City of Golden Valley used this plan to successfully pursue state Flood Damage Reduction Grants as well as secure Bassett Creek Watershed Management Commission (BCWMC) support through its CIP program.

Several projects have been implemented, lowering flooding to allow for safe passage of emergency vehicles and protect structures and vehicles on adjacent properties. In 2017, the City of Golden Valley completed construction of an 8 acre-ft flood storage project in partnership with a private developer. In 2020, the City of Golden Valley and the BCWMC, with additional funding support Hennepin County and the MnDNR, completed construction of the DeCola Ponds B & C Improvement Project with 22 ac-ft of flood storage, additional water quality treatment, and restored wetland and upland habitat.

The City and BCWMC are in the process of developing the SEA School/Wildwood Park Flood Reduction Project. Public and stakeholder engagement has been a key component during planning and feasibility evaluations. Project design is anticipated later in 2021 with construction in 2022/2023.

This presentation demonstrates the value of good planning, modeling, public engagement, and partnerships among multiple stakeholders to successfully implement and achieve mutual flood mitigation goals

Wednesday October 20, 2021

Central Draw Overflow Phase V Construction - Making the Final Connection

Erin Hunker, SRF Consulting Group, Inc.; *Matt Moore*, South Washington Watershed District

The South Washington Watershed District led a two-decade long planning effort to identify the comprehensive, combined use system known as the Central Draw Storage and Overflow. The system provides storage and infiltration, flood protection, and public open space and leads water from the Central Draw Storage Facility (CDSF) in Woodbury and Cottage Grove to the Central Draw Overflow (CDO) outfall to the Mississippi River. The CDSF includes 1,800 acre feet of storage in 250 acres of publicly owned property near the outlet of Bailey Lake and provides residents with 250 acres of open space to explore native prairie and learn about pollinators, stormwater, groundwater and history of the land. Because of the recent trend of extreme precipitation events and safety during flooding situations, SWWD began the challenging process of planning and constructing an overflow out of the CDSF to the Mississippi River.

The CDO project was implemented in five phases, with the last phase of the project providing the critical pipe connection for an outlet for the 23 square mile drainage area. The project included 6,200 linear feet of 72-inch storm sewer at depths of 5 to 45 feet, which required use of the D-Load pipe design method. The project also constructed 1,400 feet of stabilized channel that ties the pipe into the downstream channel system in Cottage Grove Ravine Regional Park. With construction of the final segment of pipe, the resilient stormwater management system that SWWD and the project partners envisioned has been achieved. The completion of this regionally important project has eased fears of flooding within the watershed and provides a safe and effective way to manage high precipitation rate storm events while allowing development in the surrounding communities to occur in a sustainable matter. The presentation will focus on project planning, design and construction, which was completed in the fall of 2020.

Wednesday October 20, 2021

Morningside Flood Infrastructure Project, Part 1 Engagement and Decision

Jessica Wilson, Ross Bintner, City of Edina; *Sarah Stratton, Cory Anderson,* Barr Engineering Company

The City of Edina developed a Flood Risk Reduction Strategy which established a framework for addressing community flood risk through infrastructure, regulation, outreach and engagement, and emergency services. A pilot project to design flood infrastructure, guided by the new strategy, is underway. This session is an overview of the project. public engagement campaign, and decision-making process.

Reducing flood risk in established urban spaces is challenging - there is limited public space to work in, existing public infrastructure is obsolete due to climate change, and existing low homes were permitted based on a past understanding of risk. Design options iteratively balanced tradeoffs in cost, effectiveness, land use, and impact. This pilot project is further complicated by a FEMA floodplain designation, a historic judicial ditch, high groundwater, crossing political boundaries, limited room to store flood waters, and a beloved opportunity space flood storage expansion with mature trees.

We implemented a public participation plan to share flood information and iterate on concept designs using online and in-field engagement tools. Input from residents shaped our design goals, identified design considerations, and established opportunities to take advantage of. Detailed conversations with residents also led the design team to improve the system map and model accuracy as well as consider site-specific issues.

In addition to these direct effects on our design, City staff engaged directly with many residents on individual concerns and responded with phone conversations, conducted site visits, shared flood vulnerability reduction technical advice, interpreted and questioned model results, expanded on and shared ideas for flood risk and reduction techniques, attended on-site public open houses, and held online live virtual meetings with discussions.

Morningside Flood Infrastructure Project, Part 2 Design Challenges

Ross Bintner, Jessica Wilson, City of Edina; *Sarah Stratton, Cory Anderson,* Barr Engineering Company

This session expands on part 1.
This presentation will discuss how the project evolved our understanding of flood risk and details of bringing a large flood risk reduction project through concept and design.

Our concept design process included investigations on imperviousness, storage at various places in the neighborhood, and a novel neighborhood-scale flood damage estimate. The storage evaluations tested the value of storage of various sizes, configurations, and locations in the watershed.

Our design process included 2-dimensional modeling, refinement of the neighborhood-scale flood damage estimate, and an expert technical panel. The 2-dimensional modeling revealed a new dimension to how we view flood risk, and the damage model was useful for communicating neighborhood scale balance of benefits.
The design included lowering and expanding a pond using a pump station, predictive pumping, neighborhood scale trunk pipe expansion, and detailed grading for planned overflows.
This project was atypical from a permitting and capital spending perspective. We'll share our experience on both fronts. We expect to break ground spring 2022.

Concurrent Session V
Track B: Stream Restoration—from Design to Results

North Browns Lake Watershed and Channel Load Reduction Analysis

Shawn Tracy, HR Green; *Greg Berg,* Stearns SWCD; *Peter Rausch,* RESPEC

The Stearns SWCD and Sauk River Watershed District have completed an analysis of watershed and channel source loads to inform selection and optimization of implementation strategies towards restoration of North Browns Lake's water quality. This presentation will discuss the hydrologic and hydraulic analysis, geomorphic analysis, selection and performance of implementation strategies related to pollutant loads and fish habitat. The impaired North Browns Lake is part of the Sauk River Chain of Lakes & Eden Valley Creek Subwatershed, within the Sauk River Watershed, in central Minnesota. Altered hydrology, ineffective culverts and erodible soils has led to channel destabilization. The result is high sediment and phosphorus yields to and from the channels and to North Browns Lake, impacts to in-stream habitat and loss of habitat connectivity. This study identified options for upland BMPs and stream restoration strategies within the two subwatersheds. A base condition hydrologic and hydraulic model was developed followed a geomorphic assessment of the main channels. Upland BMPs were identified and screened for prioritization. Results of the geomorphic assessment informed selection of channel strategies. The published TMDL requires a 2,644 lb-TP/yr load reduction to the Lake. This study targets and prioritizes significant opportunities to meet or exceed these goals.

Pre- and Post-Stream Restoration Sediment Monitoring and Modeling of Rice Creek, Minnesota, 2010-2019

Joel Groten, U.S. Geological Survey; *Matthew Kocian,* Rice Creek Watershed District

The Rice Creek Watershed District (RCWD) cooperated with the U.S. Geological Survey to establish a 10-year sediment monitoring and modeling effort to evaluate the effects of two restored meander sections on middle Rice Creek, Minnesota. The RCWD's goals were to reduce water quality impairments and associated costs of dredging a sedimentation pond by completing this stream restoration. The results indicated there was a reduction in the post-stream restoration suspended fines transport curve even though higher streamflows were sampled during the post-stream restoration monitoring period. Two-dimensional flow and morphodynamic modeling results indicated the downstream restored section had less shear stress and could access the floodplain at a lower streamflow than the original channel. The results suggest the reduction in suspended fines at higher streamflows could be caused by less shear stress and erosion on the restored streambanks and deposition of fines in the floodplain. Another potential driver for reduction of fines was a dilution effect from the higher streamflows sampled during the post-stream restoration monitoring period. The suspended sands and bedload transport curves did not decrease during the post-stream restoration monitoring. Because transport of suspended sands and bedload are more dependent on the energy of moving water than suspended fines, the greater streamflows during the post-stream restoration monitoring period and the supply of sand in the study are likely reasons the sand and bedload transport curves were not significantly different than the pre-stream restoration transport curves. The results will be used by the RCWD to evaluate changes in water-quality criteria for aquatic life and the sedimentation pond. Overall, the uncertainty of the results indicates the complexity of sediment transport in a river, and suggests a need for multi-faceted, multi-year data, and tools to simulate those data, to effectively eval

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Natural Channel Design and the Middle Sand Creek Corridor Restoration Project

Ed Matthiesen, Seth Bossert, Wenck Associates; *Justine Dauphinais, Jon Janke,* Coon Creek Watershed District

Sand Creek is a tributary of Coon Creek in the city of Coon Creek, Minnesota. About 2.2 miles of the stream is Impaired for failing to meet federal standards for aquatic life due to excess sediment and phosphorus, poor habitat, and altered hydrology. The Middle Sand Creek Corridor Restoration Project was undertaken to reduce sediment and nutrient loading from bank erosion; enhance habitat to better support native fish and aquatic life; and lessen the impacts of altered hydrology while still providing adequate flood conveyance. The Coon Creek Watershed District and its consultant Wenck worked with the Minnesota DNR to incorporate Natural Channel Design principles into the project, including using materials harvested on site such as logs and root wads to limit the use of rock and other hard armoring. The project also re-introduced a more natural channel form and function by restoring some of the original meanders and creating opportunities for floodplain reconnection. Although the District has been doing stream bank restoration and slope stabilization projects for over 30 years this was the first time the District incorporated as much woody material and added significant channel length. The collaboration with the MnDNR achieved a happy outcome of a channel with more length, more carbon sources for macroinvertebrates, more refugia, a beneficial reuse for on-site trees, and a slightly increased flood storage using robust and resilient stabilization techniques. We will present project results, designs that worked, and lessons learned. Significant public engagement guided the project, including pre-project open houses, guided interactive "watershed walks," and interpretive signage. Planning started in Spring 2019 with construction and final site restoration complete by Summer 2020. Post construction monitoring will evaluate water quality and biotic impacts, but wood ducks have already moved into their new houses.

Willow River Rock Arch Rapids Dam Restoration - A Collaborative Design Approach

Jessica Olson, Barr Engineering; *Crystal Payment,* Minnesota Department of Natural Resources

In 2016, floodwaters overtopped a low-head dam on the Willow River, breaching the structure's right abutment. The dam failure drained an 86-acre reservoir and routed significant quantities of sediment downstream of the site.

The Minnesota Department of Natural Resources (DNR) developed a concept to replace the dam with rock arch rapids and hired Barr Engineering in Spring 2019 to take the project from concept through final design and construction. Goals of the project included eliminating the drowning hazard of the original weir, creating aquatic organism passage, and re-establishing the run-out elevation of Stanton Lake. The final structure design includes 22 compound arch rock weirs ranging from 70 to 160 feet in length, dropping 13 feet over 380 feet. The irregular shape of the weirs required development of a high-resolution 2-dimensional HEC-RAS model to evaluate the design surface. The model results were used to iteratively adjust the overall structure width and weir alignments to maintain acceptable shear stress and velocity throughout the rapids.

The project also included evaluation of the existing soils and intact embankment, and design of a new clay core for placement beneath the rock arch rapids to preserve the run-out elevation of the lake. Project constraints included a 3-cell box culvert immediately downstream; native mussel relocation; winter construction; and preserving flow to a seasonal wetland adjacent to the project. Collaboration between Barr and DNR engineers over the course of a year led to a project with 11 bids in October 2020, with construction substantially complete in February 2021.

Concurrent Session V
Track C: Multifarious Methods to Improve Water Quality

Reducing Plastic in Erosion Control

Peter Leete, Minnesota Department Natural Resources; *Ken Graeve,* Minnesota Department of Transportation

The problems of plastic waste and microplastic pollution have emerged as significant threats to water quality in Minnesota and around the world. The use of plastics in erosion and sediment control products contribute to this problem in spite of its inherent intent of protecting water quality. The MN DNR and MnDOT have collaboratively addressed this disconnect by reducing the use of plastic in erosion and sediment control products. This presentation will explain the problem and discuss the effort behind MnDOT's new 2020 construction specifications for temporary control blankets. We will also share the latest updates on the state's efforts to develop alternative biodegradable products along with national coordination efforts to reduce the use of plastic in erosion and sediment control practices.

Sediment Nutrient Hot Spots in Lakes and Ponds in Minnesota

Anne Wilkinson, Stantec

Internal loading studies in storm water ponds and lakes require sediment core analysis for sediment chemistry and phosphorous release. Stantec has conducted these studies in 20 storm water ponds and 30 lakes across Minnesota. This presentation will highlight trends in sediment chemistry and phosphorous release amongst different water bodies and watersheds. These trends can inform internal loading hot spots within Minnesota, similarities/differences between lakes and storm water ponds, diagnostics, and management.

A Tale of Two Models: A case study comparing PTMApp and ACPF

Alicia O'Hare, Wright SWCD

Best management practices (BMPs) on agricultural fields (structural and non-structural) reduce the nutrients and sediment leaving the landscape. Conservation professionals must determine the areas most in need of improvement. But how do we determine where the BMPs will do the most good? Many professionals are turning to computer models to identify critical areas of the watershed that most need work completed, provide a menu of BMPs and support funding applications. This begs the question of which model should be used? This study examined two rural watershed models: the Prioritize, Target, Measure Application (PTMApp) and the Agricultural Conservation Planning Framework (ACPF). Each model was run on the same HUC-12 watershed in Wright County Minnesota. We compared the needed preparations of each model, the limitations of model scale, critical areas each model identified, the variety of BMPs identified, the practicality of the practices identified and the benefits of other associated outputs. In general, ACPF was quicker and easier to run and more accurate in practice placement. PTMApp provides a wider menu of project options and has the benefit of calculating the reductions associated with each project. For PTMApp critical areas we identified based on which 40-acre catchments exported the most sediment and phosphorus. For ACPF we identified which agricultural field were had a "Very High" likelihood of runoff as critical areas. The models only had a 17% agreement on these critical areas but there were several examples in which the two models identified the same project

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Processes for targeting water storage and treatment

Drew Kessler, Jeremiah Jazdzewski, Joe Lewis, Houston Engineering, Inc.; *Justin Hanson,* Cedar River Watershed District; *Sarah Jo Boser*, Sauk River Watershed District

Across Minnesota, water storage goals are being set as part of local watershed plans like those developed through the One Watershed, One Plan Program. After setting these goals, many practitioners lack a tangible process for going from a goal in a local water plan to implemented water storage and treatment practices on the ground. There's a need for more information on the various approaches being used to target constructable water storage and treatment practices that will make progress towards resource management goals, while also holding the potential for additional environmental benefits such as wildlife habitat and water quality improvements. This presentation will highlight examples from Southeastern, Central, and Northwestern Minnesota where constructible projects are being targeted using a variety of tools and processes that address local water resource issues identified in comprehensive watershed management plans.

Concurrent Session V
Track D: PFAS Across Minnesota

PFAs Across Minnesota

Katrina Kessler, Rebecca Higgins, MPCA; *Helen Goeden,* Minnesota Department of Health; *Lawrence Burkhart*, EPA Duluth; *Andy McCabe,* Barr Engineering, *Matt Simcik, Madison Bygd, William Longo, Jiwei Zhang*, University of Minnesota; *Michelle Crimi*, Clarkson University; *Gerald Ankley*, EPA

"PFAS Across Minnesota", hosted by MnDRIVE Environment (UMN) and MPCA, will highlight "Minnesota's PFAS Blueprint". Session 1 will look at short-term PFAS priorities and challenges related to decision-making with incomplete information. Participants will hear from invited panelists and have ample opportunity to ask questions and explore the Blueprint. Session 2 will focus on treatment and remediation approaches. University and industry experts will share research vignettes and lead working group discussions to identify research gaps.

Concurrent Session VI
Track A: Where Will the Water Go?

Alternatives to mitigate flooding in the landlocked basin of Lake Barney in southern Wisconsin

Nick Hayden, Steve Gaffield, Emmons & Olivier Resources (EOR)

Flooding of landlocked basins is a widespread problem in the upper Midwest after a series of wet years. Lake Barney in the City of Fitchburg, Wisconsin is a dramatic example, swelling from 42 acres in 2017 to nearly 400 acres in 2020. The lake now threatens residences, floods agricultural land, and overflows through the downstream community. The City of Fitchburg commissioned this study, completed in March 2021, to evaluate the feasibility, costs, and benefits of constructing a gravity outlet for the lake to lower its stage and control overflows. Statistical analysis of precipitation and lake levels illustrated that both high groundwater and surface water runoff have caused the flooding and estimated 5-10 years for the lake level to fall naturally if no outlet is constructed. We refined a regional groundwater model and created a SWMM model of the 5200-acre watershed to estimate seepage, the extent of groundwater drawdown, and to evaluate the overall performance of a constructed outlet. Outlet alternatives could lower the lake to its typical historical stage or 2-3 feet higher over approximately 2 months, at a cost of half to one million dollars. Financial benefits to the City are estimated to be lower than these costs, but flood storage protection for the downstream community and other qualitative benefits are being considered. However, significant permitting challenges exist related to wetland impacts and a downstream TMDL.

Statistical Comparison of the National Water Model Streamflow Guidance with non-USGS Stream Gages on the Cottonwood River in Minnesota

Deborah Nykanen, Minnesota State University, Mankato; *Steve Buan,* North Central River Forecast Center, NOAA National Weather Service; *Craig Schmidt,* Minneapolis Weather Forecast Office, NOAA National Weather Service

The National Water Model (NWM) provides streamflow guidance to forecasters at the National Weather Service (NWS) River Forecast Centers (RFC) and Weather Forecast Offices (WFO). It produces forecasts for 2.7 million river reaches within the continental United States. There are just over 10,000 United States Geological Service (USGS) river gages in service across the country, of which a subset was used to calibrate the NWM. However, millions of reaches do not have a USGS river gage for model calibration. To assess how accurate the NWM may or may not be at any given location, NWS forecasters will need to compare it with additional data sources. The state of Minnesota has strategically invested in ecological and water resource monitoring equipment over the past several decades. The Minnesota Department of Natural Resources (DNR) and Minnesota Pollution Control Agency (MPCA) have installed stream gages and water quality gages on streams throughout the state to supplement the USGS network and provide localized data on rivers and streams. The focus of this presentation will be on the Cottonwood River in southcentral Minnesota. This river regularly poses forecasting challenges for the NWS North Central River Forecast (NCRFC) office with ice jams and prolonged spring flooding. The growing agricultural drainage infrastructure has amplified forecasting challenges on the Cottonwood River and many other rivers in the NCRFC region. The Cottonwood River has seen several major floods in the past decade. Three of the top four Historical Crests for this river occurred in 2018 and 2019. The variety of local, state, and federal stream gaging sites on the Cottonwood River will be used to compare and statistically quantify performance of the National Water Model (NWM) for these recent flood events.

Using the Simplified Stochastic Event Flood Modeling Approach to Support the Risk Informed Decision Making Method to Evaluate Dam Safety

Omid Mohseni, Cory Anderson, Katie Turpin-Nagel, David Bowles, RAC; *Mel Schaefer, Bruce Baker,* MSG Engineers; *Tye Parzybok,* DTN; *Michael Thelen,* Consumers Energy Company

One of the objectives and supporting strategies in FERC's Strategic Plan for fiscal years 2014-2018 is to minimize risk to the public by using Risk-Informed Decision-Making (RIDM) for evaluating dam safety in parallel to traditional dam safety methods. Resulting risk estimates can be used, along with standards-based analyses, to decide if dam safety investments are justified. Consumers Energy Company (CEC) identified a concern at their Alcona Dam in Michigan regarding potential erosion of the unlined, earthen auxiliary spillway, and the potential subsequent failure of the dam during flood events more frequent than the inflow design flood (the PMF). However, given the possible consequences downstream, the estimated dam fragility, and the proposed and completed risk reduction measures, the risk may be low enough such that modifications to the auxiliary spillway are not warranted. Therefore, in 2017 CEC began a RIDM study of the Alcona Dam auxiliary spillway for submission to FERC.

RIDM requires a set of hydrologic hazard curves (HHCs) to estimate the overall risk. A Simplified Stochastic Event Flood Modeling (SSEFM) approach was used to develop the HHCs for Alcona Dam. The SSEFM method is a compromise between a purely deterministic approach which tends to be conservative and a fully stochastic, Monte-Carlo approach. The resulting HHCs are estimates of peak inflow rates for a range of annual exceedance probabilities (AEPs) from 0.01 to less than 1x10 7 for both cool-season (rain on snow) and warm-season (rain only) events. The SSEFM approach is the cornerstone of this RIDM study, allowing all other aspects of the study to relate important loading characteristics (peak water level, hydrostatic pressure, auxiliary spillway flow duration, etc.) to AEPs and therefore, a proper estimate of the risk. We will present the steps of the approach, data sources, the results of the SSEFM, subsequent RIDM steps using these results, and the lessons learned throughout the process.

Downscaling Water Storage: Training Long Short-Term Memory (LSTM) model to Downscale Nonlinear Storage-Discharge Relation in Rum River Watershed, MN

Pai-Feng Teng, John Nieber, University of Minnesota

Flooding is one of the most financially devastating natural hazards in the world. When current hydrological models emphasize rainfall-runoff models, studying storage-discharge relation can potentially improve existing flood forecast. This presentation will assess the relation between daily water storage (S) and discharge (Q) by utilizing physical-based hydrological modeling and long short-term memory (LSTM) network; and evaluate the improvement of predicting discharge by downscaling total water storage. Currently, linear regression models do not represent the relationship between the total S and total Q at the HUC-8 watershed (R2 = 0.3667). Machine learning (ML) algorithms have been used for predicting the outputs that represent arbitrary non-linear functions between predictors and predictands. LSTM, the time-series deep learning neural network that has been used for improving the accuracy of non-linear rainfall-runoff prediction, will be applied to improve non-linear predictions between S and Q. This experiment will first train LSTM networks with two sets of storage-discharge relationships with unbiased hydrological variables simulated by the semi-distributed Hydrological Simulated Program-Fortran (HSPF). First, LSTM will be trained with both total discharge and 7 input variables, including air temperature, cloud cover, dew point, potential evapotranspiration, precipitation, solar radiation, and wind speed. Then, LSTM will be trained with total discharges and 8 input variables that include total water storage at Rum River Watershed, a HUC8 watershed at Minnesota, between 1995-2015. 7670 samples are used. 90% of the inputs were used for training the HSPF network and 10% were used for testing the prediction. In the second part, improvement of prediction was evaluated by comparing prediction with hydrological inputs with total water storage and water storage downscaled into 133 sub-watersheds. The result showed that including total water storage LSTM networks improve

Concurrent Session VI
Track B: Assessing and Treating Chemical Contaminants

Assessment of Pesticides across Three Small Watersheds in Southeast Minnesota

Katie Rassmussen, Matt Ribikawskis, Heather Johnson, Minnesota Department of Agriculture

In 2012, the Minnesota Department of Agriculture (MDA) added pesticide water quality monitoring to the Root River Field to Stream Partnership (RRFSP) stream outlet sites. The goal was to better characterize pesticide fate and transport in southeastern Minnesota agricultural watersheds and to develop a better understanding of the conditions that can potentially lead to an elevated pesticide concentration in southeast Minnesota streams. Pesticide application information was collected from 2012 through 2017 in the Headwaters, Crystal Creek and Bridge Creek watersheds and were compared against the water quality results for each stream. From 2012 through 2019, the three RRFSP watersheds had 11 pesticides or pesticide degradates detected and indicated that herbicides comprised 95, 98 and 92% of the total pesticide load at the Headwaters, Crystal Creek and Bridge Creek watersheds, respectively. On average, pesticide loading was greatest in June (75%), followed by May (14%) and July (5%) with the remaining five percent coming from August through April. Results will be shared that analyze both monthly and yearly pesticide loads and flow-weighted mean concentrations.

Low concentration sulfate treatment by chemical precipitation technology

Mei Cai, Shashi Rao, Lucinda Johnson, Adrian Hanson, Chan Lan Chun, George Hudak, UMD-NRRI

In 1973, Minnesota adopted a sulfate standard of 10 mg/L to protect wild rice. Membrane technologies such as reverse osmosis and nanofiltration are well-developed alternatives that can reduce concentrations to 10 mg/L or lower. However, these technologies generate waste brine solutions that are technically challenging and costly to manage. Industries and municipalities faced with the need for compliance options for meeting a sulfate limit are seeking cost-effective sulfate treatment technologies. NRRI's barite precipitation technology offers a cost-effective and less technically complex alternative to remove sulfate from municipal wastewater and groundwater. The sulfate in the wastewater readily precipitates with barium salts as insoluble barium sulfate (barite). The bench-scale testing identified an acceptable treatment train and an operational range for chemical dosing. The batch and continuous tests demonstrated barite precipitation technology's ability to reduce sulfate concentrations from 50-200 mg/L to below 10 mg/L from municipal wastewater and groundwater.

Based on the batch lab data, NRRI designed and constructed a trailer-based pilot demonstration system. With this pilot system, NRRI performed an indoor pilot trial to treat groundwater and municipal wastewater at 2 gallons per minute. The sulfate concentrations were successfully reduced from 120 mg/L to below 10 mg/L and the effluent turbidity was below 5 NTU. This mobile treatment system will be deployed at two municipal wastewater treatment plants this summer to test and refine the chemical treatment system on-site. Each will run for a duration of 1-3 months for two seasons (summer and cold season). This study highlights the potential of barite precipitation technology for achieving low concentrations (<10 mg/L) of sulfate in municipal and industrial wastewater (SO4 concentration below 200 mg/L).

Wastewater Nitrogen Monitoring and Reduction

Marco Graziani, Casey Scott, David Wall, Minnesota Pollution Control Agency

Reducing wastewater nitrogen discharges is part of Minnesota's Nutrient Reduction Strategy (NRS) to reduce nitrogen loads leaving the state and affecting the Gulf of Mexico, Lake Winnipeg and Lake Superior. The NRS's first step was to increase the frequency wastewater nitrogen monitoring. In 2021, more than 600 wastewater treatment facilities (WWTFs) are monitoring 93% of the state's domestic wastewater (by volume) for nitrogenous constituents. Effluent Total Nitrogen (TN) concentrations average 21 mg/L for large and medium mechanical WWTFs and 6 mg/L for stabilization pond WWTFs. Discharges from domestic facilities represent 96% of wastewater TN loads, while 4% is from industrial sources. Monitoring data show that Minnesota wastewater TN loads to the Mississippi River Basin are 7% higher than estimated in the 2014 Minnesota Nutrient Reduction Strategy (NRS), while TN discharged to the Red River Basin and Lake Superior Basin are 4% and 33% lower, respectively. Statewide wastewater nitrogen loads have generally remained steady or increased slightly with population growth and increased precipitation. Minnesota's ongoing efforts to advance wastewater nitrogen reduction include modeling WWTF nutrient reduction alternatives and identifying facilities that could provide the greatest nitrogen reduction benefits. The NRS' 2025 wastewater reduction goals for the Mississippi River Basin could theoretically be achieved by reducing nitrogen concentrations to 15 mg/l by as few as 20 WWTFs.

Biological sulfate treatment coupled with iron-based sulfide immobilization for industrial water

Susma Bhattarai Gautam, Susma Bhattarai, Maxwell Brubaker, Nathan Johnson, Chan Lan Chun, UMD-NRRI

Biological sulfate removal is often limited due to challenges associated with providing an effective carbon source, a rigorous engineering system to support the growth of sulfate reducing bacteria and managing toxic sulfide in effluent water. To reduce these limitations, this study aims to enhance and sustain biological sulfate removal by optimizing the bioreactor design and operation conditions and sulfide removal with the use of iron bearing materials. A 5 L perfusion bioreactor system with an ultra filtration hollow fiber membrane module was operated at ambient pressure and 35oC for over 150 days. The bioreactor was inoculated with the anaerobic sulfate reducing bacteria enrichment from sulfate-impacted creek and was operated with 6.5 days hydraulic retention time (HRT) in the beginning. HRT was gradually decreased to 3 days with the biomass growth and biofilm development. Effluent sulfide water was removed by pumping water through packed bed columns with natural iron-bearing minerals containing iron oxide and siderite from the Iron Range in Minnesota. Around 6 mM of sulfide was produced - with almost equimolar sulfate removal - when the bioreactor was operated at 6.5 days HRT. The fraction of sulfate removed decreased with a decrease in the HRT (increase of flow rate) but the overall rate of sulfate removal was similar at the higher flow rate. Consistent sulfate reduction was achieved with 90% sulfur recovery. Bioreactor effluent with 3 mM sulfide was pumped into columns with iron-bearing minerals and complete sulfide removal was achieved until the material became saturated with sulfide. Sulfide removal capacity was similar among the iron oxide and the siderite material. Scanning electron microscopy of the membrane has shown the growth of rod-shaped sulfate reducing bacteria on the membrane surface. A detailed microbial analysis of the enriched biomass is being carried out to understand the process and its potential application in treating industrial wastewater.

Concurrent Session VI
Track C: Biochar and Water Quality: From Microscale Interactions to Field-scale Applications

Biochar and Water Quality: From Microscale Interactions to Field-scale Applications

Brian Barry, Bridget Ulrich, NRRI; *Kurt Spokas,* CFANS/USDA; *Sebastion Behens,* CEGE; *Ed Matthiessen,* Wenck; *Jim Doten,* Minneapolis Health Department

Biochar is a charcoal-like substance that has shown promise as a sustainable filtration material. However, varying biochar production practices have presented challenges in transitioning from laboratory-scale to field-scale. In this special session we will bring together a panel of experts to explore the utility of biochar for water quality applications by considering processes across various scales. Through interactive Q&A and audience surveys, we seek to stimulate discussions between state agencies, researchers, and practitioners.