Final Program and Abstracts

Minnesota Water Resources Conference

October 16–17, 2018
Saint Paul RiverCentre
ccaps.umn.edu/water
Mniówe / Water Bar
Mniówe is a place for gathering water. At Mniówe / Water Bar, you can sample drinking waters from around Mnísota (Minnesota) and connect conference themes to conversations about ways we use and interact with water in our daily lives. You can also learn about indigenous philosophies, relationships and practices relating to Mní (water) that have allowed Dakota people to thrive in this area for millennia. Mniówe is also the indigenized rendition of Water Bar, created in collaboration by Water Bar & Public Studio, Healing Place Collaborative, and Dakhóta Iápí Okhódakichiye (Dakota Language Society).

This session uses Pigeonhole Live for interactive Q&A
Pigeonhole Live is a simple, interactive mobile website where you can submit questions to speakers via your mobile web device. You can also vote for questions that interest you. Everyone gets to take part in Q&A sessions without running to the microphones. Yes, even if you are a little shy.

Go to www.pigeonhole.at
Enter event passcode: MNWRC18

Wetlands Conference Special Session
Wetlands in Minnesota's landscapes provide important functions and value to the public: water quality improvements, floodwater attenuation, wildlife habitat, groundwater recharge, recreational opportunities, and commercial uses, among others. The complex roles of wetlands in the changing landscape continue to be studied and documented. In joining with the Minnesota Water Resources Conference, this special session provides an excellent forum to focus on wetlands subject matter to improve collective wetlands knowledge and increase understanding of how wetlands integrate with water resources management throughout the state.
2018 Water Resources Planning Committee

Alicia Anderson, College of Continuing and Professional Studies, University of Minnesota
John Baker, US Department of Agriculture, and Department of Soil, Water, and Climate, University of Minnesota
Ann Banitt, US Army Corps of Engineers
Will Bartsch, Natural Resources Research Institute, University of Minnesota Duluth
Jeff Berg, Minnesota Department of Agriculture
John Bilotta, MN Sea Grant, University of Minnesota Extension
Mark Brigham, US Geological Survey
*Tina Carstens, Ramsey-Washington Metro Watershed District
Bill Douglass, Bolton & Menk, Inc.
Kristi Fischer, College of Continuing and Professional Studies, University of Minnesota
Katherine Hagberg, College of Continuing and Professional Studies, University of Minnesota
Lorin K. Hatch, RMB Environmental Laboratories
Andrea Hendrickson, Minnesota Department of Transportation
Kimberly Hill, St. Anthony Falls Laboratory, University of Minnesota
Karen Jensen, Metropolitan Council
Stephanie Johnson, Mississippi Watershed Management Organization
Cheryl Konate, Water Resources Center, University of Minnesota
Ron Leaf, Kimley-Horn and Associates, Inc.
* Joel Larson, Water Resources Center, University of Minnesota
Dendy Lofton, LimnoTech
Salam Murtada, Department of Natural Resources, Division of Waters
Randy Neprash, Minnesota Cities Stormwater Coalition & Stantec
* Jeffrey Peterson, Water Resources Center, University of Minnesota
Amit Pradhananga, Department of Forest Resources, University of Minnesota
Shawn Schottler, St. Croix Watershed Research Station
Wayne Sicora, Natural Resource Group
Gene Soderbeck, Minnesota Pollution Control Agency
James Stark, Minnesota Legislative Water Commission
Katy Thompson, ASCE Representative and RESPEC
Stew Thornley, Minnesota Department of Health
Rick Voigt, Voigt Consultants, LLC
Marcey Westrick, Board of Water and Soil Resources
Greg Wilson, Barr Engineering Company

*Committee Co-Chairs

Dave Ford Award

Originally known as the Kuehnast Award, the Dave Ford Water Resources Award was created in 2003, renamed for esteemed Department of Natural Resources hydrologist Dave Ford, who died prematurely from cancer in January 2003. Ford was highly regarded by his water resources colleagues, who sought to honor him with an award to be presented to others in the field who also have made an indelible impact on Minnesota’s environmental landscape. Ford had an excellent theoretical understanding of various computer simulation models, along with the practical knowledge to effectively use those models to address a variety of water resource management issues. But more importantly, he was a teacher, a mentor, a cooperator, and a friend.

Past Award recipients of the Earl Kuehnast Award

<table>
<thead>
<tr>
<th>Year</th>
<th>Recipient</th>
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<tbody>
<tr>
<td>1986</td>
<td>Earl Kuehnast</td>
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<tr>
<td>1987</td>
<td>Ed Bowers</td>
</tr>
<tr>
<td>1991</td>
<td>Peter Fischer</td>
</tr>
<tr>
<td>1992</td>
<td>Howard Midje</td>
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<tr>
<td>1999</td>
<td>Ron Nargang</td>
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Past award recipients of the renamed Dave Ford Water Resources Award

<table>
<thead>
<tr>
<th>Year</th>
<th>Recipient</th>
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<tbody>
<tr>
<td>2003</td>
<td>Heinz G. Stefan</td>
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<tr>
<td>2005</td>
<td>Marcel Jouseau</td>
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<tr>
<td>2006</td>
<td>Ron Harnack</td>
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<td>2007</td>
<td>Patrick Brezonik</td>
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<td>2008</td>
<td>Steve Heiskary</td>
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<td>2009</td>
<td>James L. Anderson</td>
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<td>2010</td>
<td>Nels Nelson</td>
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<tr>
<td>2011</td>
<td>Timothy Scherkenbach</td>
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<td>2012</td>
<td>Barbara Liukkonen</td>
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<td>2013</td>
<td>John Gulliver</td>
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<td>2014</td>
<td>Roland Sigurdson</td>
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<td>2015</td>
<td>Bruce Wilson (RESPEC)</td>
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<td>2016</td>
<td>Cliff Aichinger</td>
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<tr>
<td>2017</td>
<td>Dan R. Engstrom, Kent Johnson</td>
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</tbody>
</table>
### Program Schedule – Tuesday, October 16, 2018

**8:00–8:10 a.m.** Welcome, Jeff Peterson, Water Resources Center, University of Minnesota

**8:10–8:20** Dave Ford Water Resources Award

**8:20–9:30** Healing the Land: one heart and mind at a time, Ray Archuleta, Soil Health Consultants

**9:30–10:00** Poster and Vendor Refreshment Break

#### Concurrent Sessions

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<tr>
<th>Time</th>
<th>Track A</th>
<th>Track B</th>
<th>Track C</th>
<th>Track D</th>
<th>Wetlands Rooms 4-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:00–11:30 a.m.</td>
<td>Stormwater Innovative Science and Practices</td>
<td>Erosion and Sedimentation</td>
<td>Collaborative Watershed Management and Agricultural Decision Making</td>
<td>Chloride and Bacteria Monitoring and Management</td>
<td>Performance Standards and FQA</td>
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<tr>
<td></td>
<td>Moderator: John Bilotta, Minnesota Sea Grant and Water Resources Center, University of Minnesota</td>
<td>Moderator: Gene Soderbeck, Minnesota Pollution Control Agency</td>
<td>Moderator: Joel Larson, Water Resources Center, University of Minnesota</td>
<td>Moderator: Karen Jensen, Metropolitan Council</td>
<td>Moderator: Shawn Schottler, St. Croix Watershed Research Station</td>
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<tr>
<td>10:00–10:20</td>
<td>Sediment and Gross Solids Removal by Pretreatment Practices for Bioretention</td>
<td>From Skid Trails to Landscapes: Revegetation Is the Dominant Factor Influencing Erosion After Forest Harvest in Minnesota</td>
<td>Developing Watershed Solutions Strategies with Residents of the Watawman River Watershed</td>
<td>Chloride Contributions from Water Softeners and Other Domestic, Industrial, and Agricultural Sources to Minnesota Waters</td>
<td>10:00–11:00 Performance Standards for Wetland Mitigation</td>
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<td></td>
<td>Andy Erickson, Matt Hennick, St. Anthony Falls Laboratory; Chris Lord, Anoka Conservation District</td>
<td>Zachary McEachan, Diana Karwan, University of Minnesota; Rob Slesak, Minnesota Forest Resources Council and University of Minnesota</td>
<td>Kimberly Musser, Water Resources Center; Tyler Groza, Water Resources Center; MSU Mankato: Dustin Anderson, GBERBA; Paul Davis, MPCA</td>
<td>Alycia Overbo, Sara Hegel, University of Minnesota</td>
<td>Steve Eggers, US Army Corps of Engineers</td>
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<tr>
<td></td>
<td>Jen Keville, Brian Jastram, Udai Singh, Stephanie Johnson, Mississippi Watershed Management Organization</td>
<td>Joel Groten, US Geological Survey; Gregory Johnson, Minnesota Pollution Control Agency</td>
<td>Lawrence Baker, Doug Kimball, Bruce Wilson, University of Minnesota</td>
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<td></td>
<td>Greg Wilson, Barr Engineering Company</td>
<td>Carrie Jennings, Freshwater Society; Vania Stefanova, Mark Shapley, University of Minnesota</td>
<td>Lucia Levers, Amit Pradhananga, University of Minnesota</td>
<td>Steve Groeger, Burns &amp; McDonnell Engineering; Brian Corcoran, Vadnais Lake Area Water Management Organization</td>
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<td></td>
<td>Vinicio Teague, John Guiller, Ben Janke, Poornima Natarajan, St. Anthony Falls Laboratory, University of Minnesota; Tyler Olsen, Barr Engineering Company; Jacques Finlay, University of Minnesota</td>
<td>Jeff Powell, MSA Professional Services</td>
<td>Heather Johnson, Minnesota Department of Agriculture; Dustin Goering, National Weather Service</td>
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### Program Schedule – Tuesday, October 16, 2018 (continued)

<table>
<thead>
<tr>
<th>Time</th>
<th>Track A</th>
<th>Ballroom E</th>
<th>Track B</th>
<th>Ballroom F</th>
<th>Track C</th>
<th>Rooms 1-3</th>
<th>Track D</th>
<th>Rooms 7-9</th>
<th>Wetlands Rooms 4-6</th>
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<tbody>
<tr>
<td>11:20–11:30</td>
<td>Pop-up Poster Presentations</td>
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<tr>
<td>11:30–12:15</td>
<td>Lunch</td>
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<tr>
<td>1:15–2:45 p.m.</td>
<td>Green Infrastructure</td>
<td>Minnesota’s Water Quality Trends and Spatial Changes</td>
<td>Watershed Effects of Farm Scale Land Management</td>
<td>Groundwater: Minnesota’s Unseen Water Source</td>
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<td>Wetlands in Landscapes</td>
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<td>Minnesota’s Water Quality Project Over Time: Lessons Learned</td>
<td>Metro River Water Quality: Recent Conditions and Spatial Changes</td>
<td>Tillage and Fertilizer Management Effects On Phosphorus Runoff From “Flat” Fields</td>
<td>Spatial Variability in the Vertical Connectivity of Till Confining Units: Implications for Glacial Aquifers in Minnesota</td>
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<td></td>
<td></td>
<td>Rocky Keehn, Common Sense Water Resources Engineering, LLC</td>
<td>Erik Herberg, Hong Wang, Kent Johnson, Jack Barland, Judy Sventek, Metropolitan Council</td>
<td>Fabian Fernandez, University of Minnesota</td>
<td>William Simpkins, Iowa State University; Ayssa Witt, Golder Associates; Justin Blum, Minnesota Department of Health; Jared Tros, Andrew Berg, James Stark, United States Geological Survey Upper Midwest Water Science Center</td>
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<tr>
<td>1:35–1:55</td>
<td>Green Infrastructure Project Over Time: Lessons Learned</td>
<td>Metro River Water Quality: Long-Term Trends</td>
<td>Evaluating Effects of Crop Cover Applications and Perennial Cropland Conversion on Shakopee Creek Watershed Using a Physically Based Distributive Model</td>
<td>Evaluating the Source of Water to Wells Completed in Confined Glacial Aquifers</td>
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<td></td>
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<td>Hong Wang, Erik Herberg, Jack Barland, Kent Johnson, Judy Sventek, Metropolitan Council</td>
<td>Sajam Myrata, Daniel Reinartz, Minnesota Department of Natural Resources</td>
<td>Jared Tros, Daniel Feinstein, US Geological Survey; William Simpkins, Iowa State University; Ayssa Witt, Golder Associates, James Stark, Legislative Water Commission</td>
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<td>Brett Emmons, Olivia Sparrow Emmons &amp; Olivier Resources, Inc., Eric Bill, Impact Infrastructure</td>
<td>Lee Ganske, James Jahng, Minnesota Pollution Control Agency</td>
<td>Jessica Nelson, Kimberly Musser, Water Resources Center, Minnesota State University Mankato</td>
<td>Vanessa Demuth, Stephan Scott, Jill V. Trecott, Dakota County Environmental Resources</td>
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<td>2:15–2:35</td>
<td>Grand Rapids Stormwater Wetland</td>
<td>Using the Watershed Pollutant Load Monitoring Network Data Viewer to Determine Pollutant Sources and Source Contributions from Select Watersheds throughout Minnesota</td>
<td>Linking Watershed-Scale Hydrologic Response to Farm-Level Changes in Water Management</td>
<td>Minnesota Groundwater Tracing Database (MGTGD)</td>
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<td>Shawn Tracy, HR Green</td>
<td>Patrick Baskfield, Minnesota Pollution Control Agency</td>
<td>Brent Dalzell, Lu Zhang, Joe Magner, Jeff Strock, University of Minnesota</td>
<td>Wes Rutelonis, John Barry, Jeffrey Green, Holly Johnson, Ruth MacDonald, Bart Richardson, Calvin Alexander, Minnesota Department of Natural Resources</td>
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</thead>
<tbody>
<tr>
<td>3:15−4:45</td>
<td>Stormwater Management and Green Infrastructure</td>
<td>Form-ing Fluvial Linkages</td>
<td>Agriculture and Groundwater</td>
<td>Facets of Groundwater</td>
<td>Understanding Wetland Processes</td>
</tr>
<tr>
<td>Moderator: Bill Douglass, Bolton &amp; Menk, Inc.</td>
<td>Moderator: Salam Murtada, Minnesota Department of Natural Resources</td>
<td>Moderator: Jeff Berg, Minnesota Department of Agriculture</td>
<td>Moderator: Marcey Westrick, Board of Water and Soil Resources</td>
<td>Moderator: Beth Brown</td>
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<td>Co-Moderator: Dendy Lofton, LimnoTech</td>
<td>Co-Moderator: Andrea Hendrickson, Minnesota Department of Transportation</td>
<td>Co-Moderator: Gene Soderback, Minnesota Pollution Control Agency</td>
<td>Co-Moderator: Joel Lanson, Water Resources Center, University of Minnesota</td>
<td>Co-Moderator: Kristine Maurer</td>
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<td>Ron Leaf, Beth Kunkel, Kimley-Horn &amp; Associates, Inc.</td>
<td>Wade Johnson, Gina Quiram, Minnesota Department of Natural Resources</td>
<td>Steve Gaffield, Nick Hayden, Rob Montgomery, Montgomery Associates: Resource Solutions, LLC; Dan Mahoney, Village of Plover, WI</td>
<td>Jeff Paddock, Brennan Schaefer, Minnesota Department of Agriculture</td>
<td>Kate Kleiter, Geologist</td>
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<td>Kyle Johnson, Derek Anees, Lanol Leichty, Bolton &amp; Menk</td>
<td>Olivia Sparrow, University of Minnesota and Emmons &amp; Olivier Resources, Inc.; William Herb, St. Anthony Falls Laboratory; Bruce Wilson, John Gulliver, University of Minnesota</td>
<td>Hilary Pierce, Joe Magner, University of Minnesota</td>
<td>Sarah Fellows, Amit Pradhananga; Mae Davenport, University of Minnesota</td>
<td>Jennifer Gruetzman, US Fish and Wildlife Service</td>
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<td>Stephanie Hatten, Jake Newhall, WSB &amp; Associates; Pete Young, City of Prior Lake; Maggie Karschner, Prior-Lake Spring Lake Watershed District</td>
<td>Will Wilhelm, Kimley-Horn</td>
<td>Brian Bohman, Freshwater Society and University of Minnesota</td>
<td>Anna Arkin, Tannie Eshenaur, Katie Nyquist, Minnesota Department of Health</td>
<td>Laura Messman, WSB &amp; Associates, Inc. 2016−2017 Pesticide Results From the Private Well Pesticide Sampling Project</td>
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<td>Kyle Axtell, Rice Creek Watershed District;</td>
<td>Neel Haugarud, Kevin Zytkovicz, Minnesota Department of Natural Resources</td>
<td>Jacob Jungers, Don Wyse, David Muil, University of Minnesota; Lee DeHaan, The Land Institute; Craig Sheafer, University of Minnesota</td>
<td>Emmy Waldhart, Kara Dennis, Minnesota Department of Agriculture</td>
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<td>Dennis McAlpine, Houston Engineering, Inc.</td>
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<td>4:35−4:45</td>
<td>Pop-up Poster Presentations</td>
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<td>4:45−5:45</td>
<td>Reception, Vendor, and Poster Session</td>
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</table>
### Program Schedule – Wednesday, October 17, 2018

**8:00–8:10 a.m.** Welcome, Tina Carstens, Ramsey-Washington Metro Watershed District

**8:10–9:30 a.m.** Achieving Clean Water Through Relationship Building: A Social Scientist’s Water Restoration and Protection Strategy

Amit Pradhananga, University of Minnesota, joined by Paul Nelson, Scott County Environmental Services, and Kimberly Musser, Water Resources Center, MSU-Mankato

**9:30–10:00 a.m.** Poster and Vendor Refreshment Break

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</tr>
</thead>
</table>
| **10:00–11:30 a.m.** Protecting Lakes from Harmful Algal Blooms and Aquatic Invasive Species  
Moderator: Greg Wilson, Barr Engineering Company  
Co-Moderator: Gene Soderbeck, Minnesota Pollution Control Agency | Nutrient Removal Methods  
Moderator: Rick Voigt, Voigt Consultants, LLC  
Co-Moderator: John Baker, US Department of Agriculture/University of Minnesota | Advances in Water Monitoring Technology  
Moderator: Jim Stark, Water Commission, Minnesota State Legislature  
Co-Moderator: Mark Brightman, US Geological Survey | Watershed Planning and Education  
Moderator: Joel Larson, Water Resources Center, University of Minnesota  
Co-Moderator: Lorin Hatch, RMB Environmental Laboratories |
| **10:00–10:20** Proliferating Blue-Green Algae in Minnesota Lakes  
Shahram Missaghi, University of Minnesota Extension; Richard Kiesling, United State Geological Survey; Adam Heathcote, Science Museum of Minnesota | 2-Phase Modular Bioreactor Under Spring High Flow and Cold Conditions  
Andy Ranaivoson, Jeffrey Strock, University of Minnesota; Gary Feyereisen, Kurt Speaks, ARS-USDA; David Mulla, University of Minnesota | EnviroDIY Open-Source Technologies for Cost-Effective Water Quality Monitoring and Automated Sampling  
Anthony Audrenkangne, LimnoTech; Beth Fisher, University of Minnesota; Craig Taylor, LimnoTech; Bobby Schulz, University of Minnesota; Sara Damiano, Stroud Water Research Center | Cedar River Watershed—Multiple Scales for Cooperative Management  
Bill Thompson, State of Minnesota, Minnesota Pollution Control Agency |
| **10:20–10:40** Predicting Harmful Algal Blooms in Minnesota Lakes with a Three-Dimensional Coupled Hydrodynamic-Ecological Numerical Model  
Jackie Taylor, University of Minnesota; Shahram Missaghi, St. Anthony Falls Laboratory; Vaughan Voller, Miki Hondzo, University of Minnesota | Can Woodchip Bioreactors Meet WQ Goals by Denitrifier Enhancement or Carbon Dosing?  
Gary Feyereisen, USDA-ARS; Satoshi Ishii, Ping Wang, Emily Anderson, Jeonghwan Jang, University of Minnesota; Ehsan Ghane, Michigan State University; Scott Schumacher, Ed Dorsey, Carl Rosen, Michael Sadowsky, University of Minnesota | Monitoring Program Evolution: Improving Efficiency, Accuracy, and Consistency  
Joe Selinger, Britta Belden, Capitol Region Watershed District | Creating Watershed Plans that Build Capacity in the Long Term  
Melissa Bakman, Scott County |
| **10:40–11:00** Building a Carp Management Program in the Rice Creek Watershed  
Matt Kocian, Rice Creek Watershed District; Przemyslaw Bajer, University of Minnesota | Removing Nitrogen, Phosphorus, and Sediment From Runoff Using Low Cost Taconite Tailings and Wood Chip Bio-Reactors  
Bruce Miller, McGregor Mayor, Mike Nelson, Jeff Cheng, Pete Wilkening, WSB and Associates | Pesticide Monitoring in Minnesota Lakes  
Matt Ribikawskis, David Tollefson, Bill VanRyswyk, Minnesota Department of Agriculture | No Smoking Gun? The Challenge of Prioritization in a Protection Watershed  
Julie Blackburn, RESPEC; Shawn Tracy, HR Green |
| **11:00–11:20** A Watershed’s Role in AIS: From Committee Concepts to Rapid Response  
Laura Jester, Bassett Creek Watershed Management Commission; Margaret Rattei, Karen Chandler, Barr Engineering Company | Sulfide Capture by Iron-Bearing Mining Byproducts in Northern Minnesota  
Jeanette Voelz, University of Minnesota; Jacob Daire, University of Minnesota Duluth; William Arnold, University of Minnesota; Nathan Johnson, Chan Lan Chun, University of Minnesota Duluth; Lee Penn, University of Minnesota | Advancing Satellite-Based Remote Sensing Methods for Lake Water Quality and Ice Phenology  
Benjamin Page, University of Minnesota Water Resources Center; Leif Olmanson, Remote Sensing and Geospatial Analysis Laboratory | Interactive Water Resources Programs for Planetariums in Minnesota  
Sally Brummel, Bell Museum; Claire Halloran, University of Minnesota |

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**Program Schedule – Wednesday, October 17, 2018 (continued)**

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<tr>
<td>11:20–11:30</td>
<td>Open Discussion</td>
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<td>11:30–12:15</td>
<td>Lunch</td>
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<td>12:15–1:00</td>
<td>Traditional Ecological Knowledge</td>
<td>Rosalyn LaPier (Blackfoot/MEHS), University of Montana</td>
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<td>1:15–2:45</td>
<td>TMDL Innovations</td>
<td>Innovations in Engineering</td>
<td>Modeling in Multiple Dimensions</td>
<td>Social Assessment and Community Engagement</td>
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<td>Moderator: Randy Neprash, Minnesota Cities Stormwater Coalition/Stantec</td>
<td>Moderator: Stew Thornley, Minnesota Department of Health</td>
<td>Moderator: Bill Douglass, Bolton &amp; Menk, Inc.</td>
<td>Moderator: Amit Pradhananga, University of Minnesota</td>
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<tr>
<td>1:15–1:35</td>
<td>Connecting Fisheries to Water Quality: A Biological Aspect to TMDLs?</td>
<td>Overview of Improved Countermeasures in Minnesota</td>
<td>1D/2D Urban Flood Modeling with XP-SWMM and PCSWMM</td>
<td>Cities + Citizens/Water Management = Strategies for Working Together</td>
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<td></td>
<td>Tom Langer, Jeff Strom, Wenck Associates</td>
<td>Solomon Woldeamlak, Aislyn Ryan, Minnesota Department of Transportation</td>
<td>Heather Hlavaty, Kim Baker, Barr Engineering; Paul Hydahl, City of Minneapolis</td>
<td>Leslie Yetka, Freshwater Society</td>
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<td>1:35–1:55</td>
<td>Restoring Streambank Stability to Achieve MS4 Water Quality Objectives—An Overview of Chesapeake Bay TMDL Experiences &amp; Applications in Minnesota</td>
<td>West River Parkway Slope Failure and Repair</td>
<td>Computational Fluid Dynamics (CFD) as a Tool to Predict Storm Water Geysers: The Como Tunnel Case</td>
<td>A Resident Survey of Minnesota Water Values</td>
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<td>Josh Running, Stantec Consulting, Inc.</td>
<td>Jim Herbert, Michael Haggerty, Barr Engineering Company, Cliff Swenson, Minneapolis Parks and Rec Board</td>
<td>Christian Frias, Brandon Barnes, Omid Mohseni, Barr Engineering Company</td>
<td>Amelia Kreiter, Jaren Poplinski, Mae Davenport, Bonnie Keeler, University of Minnesota</td>
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<td>Julie Blackburn, RESPEC, Cary Hernandez, Minnesota Pollution Control Agency, Mike Hirst, Lake of the Woods SWCD, Jesse Anderson, Minnesota Pollution Control Agency, Geoff Kramer, RESPEC</td>
<td>Michelle Larson, US Army Corps of Engineers</td>
<td>Roberta Cronquist, Jordan Thole, Bolton &amp; Menk, Inc.</td>
<td>Gael Zembal, Nine Mile Creek Watershed District/ Education and Outreach Coordinator; Erica Sniegowski, Nine Mile Creek Watershed District/ Project and Program Manager; Steve Gumney, City of Bloomington/Water Resources Specialist</td>
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<td>2:15–2:35</td>
<td>Benefit Metrics for Water Quality Regulation in Minnesota</td>
<td>Urban Drainage Pollution Loading Modeling and Results</td>
<td>Modeling Mississippi River Dredging Strategies after the Lock Closure at Upper St. Anthony Falls</td>
<td>Engaging with Communities to Develop Priorities for Cooperative Watershed Management: The Duluth Urban Watershed Advisory Committee</td>
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<td>Baishali Bakshi, Minnesota Pollution Control Agency</td>
<td>Lisa Veilleux, City of St. Cloud; April Ryan, Short Elliott Hendrickson, Inc.</td>
<td>Alex Nelson, US Army Corps of Engineers</td>
<td>Jesse Schonberg, University of Minnesota Sea Grant; Tiffany Sprague, Rich Axler, Natural Resources Research Institute; Brian Fredrickson, Minnesota Pollution Control Authority</td>
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<td>2:35–2:45</td>
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<td>2:45−3:15</td>
<td>Poster and Vendor Refreshment Break</td>
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<td>3:15−3:35</td>
<td>Quality in Bald Eagle Lake, MN&lt;br&gt;Joe Bischoff, Wenck Associates, Inc.; William James, University of Wisconsin-Stout; Brian Beck, Wenck Associates, Inc.; Matt Kocian, Rice Creek Watershed District</td>
<td>Improving Water Quality, Flood Storage, and Habitat Diversity in New Brighton’s Hansen Park&lt;br&gt;Kyle Axtell, Rice Creek Watershed District; Dennis McAlpine, Houston Engineering, Inc.</td>
<td>Localized Flood Map Tool for Climate Vulnerability Screening&lt;br&gt;Emily Resseger, Eric Wojchik, Metropolitan Council</td>
<td>White Bear Lake Court Case&lt;br&gt;Dan Miller, Minnesota Department of Natural Resources</td>
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<td>3:35−3:55</td>
<td>Spatial Distribution and Interrelationships Among Optical Water Quality Properties (Chlorophyll A, Suspended Solids, CDOM, and Secchi Depth) in Minnesota Lakes&lt;br&gt;Jacques Finlay, Patrick Brezonik, Leif Olmanson, Claire Griffin, Marvin Bauer, Raymond Hoaalski, William Arnold, University of Minnesota</td>
<td>Alternate Side Inlet Calculator: A Conservation Tool for Sizing Side Inlets on agricultural Drainage Systems for Temporary Storage and Sediment Removal&lt;br&gt;Baylee Griffin, Chuck Brandel, Mark Origer, ISG</td>
<td>Utilizing Forecast Technology for Flood Prevention in the Time of Climate Change&lt;br&gt;Tiffany Schauder, Minnehaha Creek Watershed District; Scott Stockhaus, National Weather Service</td>
<td>Advancing Safe and Sustainable Water Reuse in Minnesota&lt;br&gt;Anita Anderson, Minnesota Department of Health; Suzanne Rhees, Board of Water and Soil Resources</td>
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<td>3:55−4:15</td>
<td>Water Quality and Aquatic Ecosystem Responses to Changes in Water-Level Management for International Border Lakes&lt;br&gt;Jeffrey Ziegweid, Victoria Christensen, United States Geological Survey, Ryan Maki, National Park Service</td>
<td>In-Stream Nitrate Dynamics in the Cottonwood River Watershed, Minnesota&lt;br&gt;Katherine McLellan, Joe Magner, Diana Karwan, Gene-Hua Crystal Ng, John Nieber, University of Minnesota</td>
<td>Streamlined Analysis Demonstrates Stormwater Detention Benefits to Obtain HMGP Funding&lt;br&gt;Justin Klabo, Zach Magdol, Addie Braven AE2S, Inc.</td>
<td>Future State of Water in the Land of 10,000 Lakes&lt;br&gt;James Stark, Legislative Water Commission</td>
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<td>4:15−4:35</td>
<td>Landscape Controls on Colored Dissolved Organic Matter Distribution in 10,000 Minnesota Lakes&lt;br&gt;Claire Griffin, Jacques Finlay, Patrick Brezonik, Leif Olmanson, Marvin Bauer, Raymond Hoaalski, University of Minnesota</td>
<td>Innovative HSPF Modeling Frameworks for Simulating Hydrologically Important Features in Minnesota Watersheds&lt;br&gt;Michelle Schmidt, Jonathan Butcher, Jennifer Olson, Saumya Sarkar, Tetra Tech</td>
<td>A New Look at a Timeworn Problem: Southwest Harriet Feasibility Study&lt;br&gt;Lisa Goddard, City of Minneapolis; Bridget Osthorn, HR Green, Inc.</td>
<td>National MS4 Stormwater Permitting Program Assessments&lt;br&gt;Randy Neprash, Minnesota Cities Stormwater Coalition, Stantec, National Municipal Stormwater Alliance</td>
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<td>4:35−4:45</td>
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The following posters will be displayed during the breaks each day. The poster session with poster presenters will be held on Tuesday evening, during the reception. Please note, the posters listed below were submitted and accepted as poster presentations.

**Characterization of antibiotic Resistant Genes in Cities’ Sewer System in Western Lake Superior**  
Adelle Schumann, Sara Constantine, Adrian Hanson, and Chan Lan Chun, University of Minnesota - Duluth

**Pipestone National Monument Water-Quality Assessment**  
Alesha Krall and Victoria Glenn Christensen, United States Geological Survey

**Drivers of Stable, Turbid, Phytoplankton-Dominated State in Lake Winnebago, Wisconsin**  
Andrea Plevan and Jennifer Olson, Tetra Tech, Inc.; Brian Austin, Wisconsin Department of Natural Resources

**Assessing Past and Future Impacts of Mining on Hydrology in the St. Louis River Basin**  

**Understanding the Vertical Heterogeneity of Cyanobacteria and Microcystin in Lakes Using Local Physical Lake Conditions**  
Anne Wilkinson, Wenck Associates

**Which Iron Minerals and Chemical Conditions are Optimal for Iron Enhanced Sand Filter Effectiveness and Longevity?**  
Beth Fisher, Joshua Feinberg, and John Gulliver, University of Minnesota

**Predicting Nutrient & Sediment Reductions in Minnesota Watersheds Using HSPF-SAM**  
Dave Wall, Minnesota Pollution Control Agency; Seth Kenner, RESPEC

**Geochemical Augmentation with Aluminum Salts for Phosphorus Management: Principles and Case Studies**  
David Austin, Jacobs Engineering

**Cold Climate Nitrification in a Super-Oxygenated, Surface Flow Wetland**  
David Austin and Rafael Vazquez-Burney, Jacobs Engineering

**Quantifying Total Water Storage in the Minnesota River Combining Remote Sensing and Land Use Models**  
Francisco Lahoud and John Nieber, University of Minnesota

**Sulfide Capture Capacity of Iron Mining Process Byproducts**  
Jacob Daire, University of Minnesota - Duluth; Jeanette Voelz and R. Lee Penn, University of Minnesota; Nathan Johnson, and Chan Lan Chun, University of Minnesota - Duluth

**Crude Oil Metabolites in Groundwater**  
Jared Trost, U.S. Geological Survey; Barbara Bekins, USGS Menlo Park, CA; Isabelle Cozzarelli, USGS Reston, VA

**Social Science & Water Resources Relationship Mapping for Informed Planning and Management in Minnesota**  
Jennifer Moeller, Center for Changing Landscapes

**Bathymetry Mapping for Edina Lake and Ponds**  
Jessica Wilson, City of Edina; Rachel Pierstorff, City of Edina Engineering Intern

**Aqua Chautauqua: Using a STEAM Approach with Adult Audiences**  
Karen Terry, University of Minnesota Extension

**Stormwater biogeochemistry in an ephemeral, urban stream**  
Kathrine Kemmitt, Arizona State University; Steven Earl, Pennsylvania State University; Lauren McPhillips, Pennsylvania State University; Rebecca Hale, Idaho State University; Nancy Grimm, Arizona State University

**Isotopic Signatures of Precipitation Along Lake Superior**  
Kinsey Stoll, Salli Dymond, and John Swenson, University of Minnesota, Duluth; Jenny Jasperson, Minnesota Pollution Control Agency

**Ecosystem Services of Earth’s Largest Lakes**  
Kirsten Rhude, University of Minnesota Duluth Large Lakes Observatory; Bonnie Keeler and Stephen Polasky, University of Minnesota; Rajendra Poudel, National Oceanic and Atmospheric Association; Robert Sterner, Large Lakes Observatory, University of Minnesota

**Storm Water Bio-Filtration for Duluth Industrial Site**  
Kristofer Isaacson, Steve Sternberg, and Chan Lan Chun, University of Minnesota - Duluth

**Managing Nitrogen From Manure with a Winter Rye Cover Crop: Results of On-Farm Trials in Minnesota**  
Leslie Everett, University of Minnesota Water Resources Center; Randy Pepin, University of Minnesota Extension; Melissa Wilson, and Jeffrey Coulter, University of Minnesota

**Evaluating the Effects of Matrix Conditions and Transformation Processes On the Nitrogen and Carbon Isotope Fractionation of 2,4-Dinitroanisole**  
Matthew Berens, University of Minnesota; Bridget Ulrich, Eawag; Jennifer Streblau, University of Minnesota; Thomas Hofstetter, Eawag; William Arnold, University of Minnesota
**Photo-Degradation and Sorption of Strobin Fungicides in Aquatic Environments**  
Meghan O'Connor and William A. Arnold, University of Minnesota

**ASTM D6270 Type B TDA - Many Benefits**  
Monte Niemi, First State Tire Recycling

**Hidden in Plain Sight: Using Civil Engineering as a Gateway to STEM Outreach**  
Nicole Bartelt, Minnesota Department of Transportation

**Iron Has Minor Influence on Dissolved Color in Lakes of the Upper Great Lakes States**  
Patrick Brezonik, Jacques Finlay, and Claire Griffin, University of Minnesota

**Improved Detention Design Using Hydro-Brake Vortex Control Valves**  
Phillip Taylor, Hydro International

**The Lake Superior Collaborative - a DNR Initiative for Collaborative Water Governance and Integrated Management**  
Pooja Kanwar, Minnesota Department of Natural Resources

**The New Stormwater Core Curriculum Online Course**  
Shahram Missaghi, University of Minnesota Extension

**Sediment Nutrients and Microbial Communities Associated with Wild Rice and Competing Plants in Minnesota**  
Tyler Untiedt, Adelle Schumann, Carol Rescheke, George Host, Randall Hicks, and Chan Lan Chun, Natural Resources Research Institute, University of Minnesota Duluth

**Storm Pond Rehabilitation and Management**  
Wayne Jacobson, Jacobson Environmental, PLLC

**Natural Resource Atlas for Northeastern Minnesota**  
Will Bartsch, Lucinda Johnson, George Host, Dean Peterson, George Hudak, and Richard Axler, Natural Resources Research Institute, University of Minnesota Duluth; Mae Davenport, University Minnesota; Cynthia Hagley, Minnesota Sea Grant

**Impact of Colored Dissolved Organic Matter (CDOM) On Water Treatment**  
Yiling Chen, Raymond Hozalski, William Arnold, Leif Olmanson, and Claire Griffin, University of Minnesota

**The Kinetics of abiotic Reduction of RDX and HMX By Synthetic and Natural Iron-Bearing Minerals**  
Yiran Tong, Jennifer Strehlau, Matthew Berens, and William Arnold, University of Minnesota

The University of Minnesota shall provide equal access to and opportunity in its programs, facilities, and employment without regard to race, color, creed, religion, national origin, gender, age, marital status, disability, public assistance status, veteran status, sexual orientation, gender identity, or gender expression.

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Concurrent Session I, Track A

Sediment and Gross Solids Removal By Pretreatment Practices for Bioretention

Andy Erickson and Matt Hernick, St. Anthony Falls Laboratory; Chris Lord, Anoka Conservation District

Bioretention, often called a rain garden, has become an increasingly common low impact development option for treating stormwater runoff. Beyond stormwater treatment, bioretention areas have aesthetic and other benefits, and may be designed in a variety of ways to fit the characteristics of a given site. Pretreatment prior to bioretention is critical for minimizing the potential clogging that occurs with the accumulation of sediment and large solids. Actual data on the effectiveness of pretreatment practices, whether from field studies or laboratory or field testing, is limited or varies widely in method and results. This is of limited value to designers tasked with striking the right balance of effectiveness, initial construction costs, and long-term maintenance costs for the pretreatment and treatment practice system. This study used field-based performance testing of several pretreatment practices, both proprietary and non-proprietary, commonly used in Minnesota. The performance data generated for these pretreatment practices will assist project designers, local government maintenance staff, and others by providing a quantitative measurement of effectiveness of several pretreatment practices, informing assumptions about maintenance frequency, prompting innovations or design improvements based on measured data, and demonstrating a test method that can be applied in other locations and to other pretreatment practices.

St. Anthony Regional Stormwater Treatment and Research Facility: Monitoring and Operations and Maintenance Overview

Jen Keville, Brian Jastram, Udai Singh, and Stephanie Johnson, Mississippi Watershed Management Organization

The St. Anthony Regional Stormwater Treatment and Research Facility (SARTF) treats runoff from approximately 600 urban acres that drain to the Mississippi River. Completed in 2016, this project is the result of a partnership between the MWMO, City of St. Anthony Village, City of Minneapolis and Hennepin County. The facility arose from the vision of a large-scale treatment system that would reduce pollutant loading from a pipeshed with limited space for stormwater BMPs. SARTF was designed with a strong research objective, prioritizing treatment approaches that target the removal of dissolved nutrients and providing the flexibility of modifying treatment to test alternative methods in the future. The SARTF is constructed entirely below ground, diverting water from the stormsewer system into primary (swirl chamber) and secondary treatment cells (an iron enhanced sand filter and a cartridge filtration system). The system is outfitted with water quality and quantity monitoring equipment. Flow (base and event) and quality of stormwater entering and exiting each chamber within the system is monitored to assess the effectiveness of the treatment methods. Gross solids removed from the system during maintenance are also measured and analyzed. A previous presentation at this conference focused on the design and construction of the SARTF. This presentation will center around results from the first full year of monitoring data collected at the system as well as facility operations and maintenance. Lessons learned from instrumenting and collecting monitoring data in this multi-treatment BMP as well as observations from initial maintenance activities will be shared.
Concurrent Session I, Track A (continued)

Strategies for Identifying and Prioritizing Corrective Actions for Ineffective Water Quality Ponds and Wetlands

Greg Wilson, Barr Engineering Company

Detailed watershed monitoring data, combined with bathymetry, modeling assessments and fisheries surveys and have recently revealed that stormwater ponds and wetlands are increasingly subject to several factors that are compromising water quality treatment effectiveness. Bioturbation, sediment phosphorus release and resuspension/scour, as well as short-circuiting are common reasons why stormwater ponds and wetlands are not functioning as intended. In addition, increasing demands for resources to fund the implementation of new management practices and maintain existing treatment systems places greater importance on diagnosing problems and prioritizing/scheduling maintenance or retrofits regional ponds and wetland. Barr has completed several recent studies that have advanced the understanding of the factors that can compromise water quality treatment effectiveness in stormwater ponds and wetlands and implemented projects to mitigate the various sources of the problem. This presentation will discuss monitoring and survey techniques to diagnose each problem source, including the use of modeling and mapping to target the highest priorities (i.e., basins that combine higher effective pollutant removal and higher sedimentation filling rates) at a watershed scale. This presentation will also discuss examples of the cost and treatment effectiveness implications of dredging, chemical addition and structural retrofits, including implications of stormwater pond sediment contamination.

When Urban Stormwater Ponds Release Phosphorus

Vinicius Taguchi, St. Anthony Falls Laboratory - University of Minnesota; Tyler Olsen, Barr Engineering Company; John Gulliver, Ben Janke, and Poornima Natarajan, St. Anthony Falls Laboratory - University of Minnesota; Jacques Finlay, University of Minnesota

Stormwater retention ponds are ubiquitous in many urban landscapes, but are not given much consideration post-construction. High total phosphorus (TP) concentrations from pond grab sample data in Minnesota suggest that urban stormwater ponds may be releasing phosphorus (P) to receiving water bodies due to high internal loading. Laboratory incubations of intact sediment and water cores suggest that mobile-P concentrations (iron-bound P, loosely-bound P, and labile organic P) in pond sediments and sediment oxygen demand (Smax) are indicators of P release potential. Actual P release was measured under anoxic (DO above a concentration of 1 mg/L) conditions and was observed to be negligible under oxic conditions. However, field monitoring revealed that several shallow stormwater ponds in the Twin Cities Metro Area are so strongly stratified during the spring and summer months as to prevent diurnal mixing and reoxygenation of the water column from periodic storm events. This resulted in anoxic conditions at the sediment-water interface throughout much of the year, which would facilitate P release into the water column and downstream receiving water bodies.
Concurrent Session I, Track B

From Skid Trails to Landscapes: Revegetation is the Dominant Factor Influencing Erosion After Forest Harvest in Minnesota

Zachary McEachran, University of Minnesota; Rob Slesak, Minnesota Forest Resources Council and University of Minnesota; Diana Karwan, University of Minnesota

Water quality in working forested watersheds is generally high, but forestry activities may cause sedimentation of surface water if Best Management Practices (BMP’s) are not implemented during harvesting. There are several drivers of erosion: slope and slope length, soil characteristics, rainfall intensity, and vegetation; however, which of these dominate at different spatial scales in low-relief landscapes common in Minnesota are unknown. As water resources are often managed at different scales than the scales at which BMP’s are implemented, it is imperative to understand how these factors behave at multiple scales. Our objective was to identify which factors determine whether erosion occurs after forest harvesting in Minnesota at the plot, harvest site, and landscape scales in order to aid in BMP optimization and ecological assessment of erosion dynamics in working forested watersheds. We analyzed monitoring data collected on forest roads, skid trails, and forest landings on spatially referenced harvest sites in Minnesota (nsites = 183) collected between 2004 and 2009 at the plot, site, and landscape scales to identify major erosion risk factors. Revegetation levels dominate in importance over slope, soils, and climate factors at all scales for explaining the occurrence of erosion. At the landscape scale, we identified a strong relationship between mean erosion and revegetation levels on sites located on different glacial landforms (r2 = 0.90). This leads us to conclude that erosion is highly influenced by revegetation levels after forest harvesting, and that both erosion and revegetation are heavily influenced by the glacial history of Minnesota.

Comparability of River Suspended-Sediment Sampling and Laboratory Analysis Methods

Joel Groten, U.S. Geological Survey; Gregory Johnson, Minnesota Pollution Control Agency

Accurate measurements of suspended sediment, a leading water-quality impairment in many Minnesota rivers, are important for managing and protecting water resources; however, water-quality standards for suspended sediment are based on grab field sampling and total suspended solids (TSS) laboratory analysis methods that have underrepresented concentrations of suspended sediment in rivers compared to equal-width-increment or equal-discharge-increment (EWDI) field sampling and suspended sediment concentration (SSC) laboratory analysis methods. Because of this underrepresentation, we collected concurrent grab and EWDI samples at eight sites to compare results obtained using different combinations of field sampling and laboratory analysis methods. Study results determined that grab field sampling and TSS laboratory analysis results were biased substantially low compared to EWDI sampling and SSC laboratory analysis results, respectively. The difference in laboratory analysis methods was slightly greater than field sampling methods. Sand-sized particles had a strong effect on the comparability of the field sampling and laboratory analysis methods. These results indicated that grab field sampling and TSS laboratory analysis methods fail to capture most of the sand being transported by the stream. The results indicate there is less of a difference among samples collected with grab field sampling and analyzed for TSS and concentration of fines in SSC. Even though differences are present, the presence of strong correlations between SSC and TSS concentrations provides the opportunity to develop site specific relations to address transport processes not captured by grab field sampling and TSS laboratory analysis methods.
Concurrent Session I, Track B (continued)

Sediment Accumulation Rates in the Lower Minnesota River Watershed Have Changed

Carrie Jennings, Freshwater Society; Vania Stefanova and Mark Shapley, University of Minnesota

Ever since glacial Lake Agassiz formed the glacial River Warren spillway, the modern river occupying the valley, the Minnesota and its tributaries have been filling it in. The rate of sediment accumulation varies spatially, with climate, and other factors that affect watershed hydrologynamely, ground cover and artificial drainage. Peak flows and in-channel sediment loads have increased, rivers widened, and nick points retreated more rapidly since the intensification of agriculture. A riverine lake on the Mississippi River downstream of the Minnesota confluence, Lake Pepin, is filling in almost ten times faster than pre-settlement rates. The watershed district charged with maintaining a navigation channel in the lower Minnesota River between Chaska and Minneapolis would like to document how sediment accumulation rates have changed in the reach that they manage. We chose two floodplain lakes that are in stable locations behind the levee. A transect of 6 cores from each allowed for a complete record of sediment and vegetation change using fossil pollen and non-pollen palynomorphs (stomata, algal cenobia, fungal spores and charcoal particles). Pollen stratigraphy from dated cores in non-floodplain locations were correlated to these floodplain-lake cores leading to estimates of changes in accumulation rates of sediment deposited in overbank settings along the lower Minnesota River.

Distinctive layers in the core that are used to quantify sedimentation rates are the Ambrosia rise dated at 1850, the oak rise in the 1950s and peaks in the magnetic minerals interpreted to be indicative of flooding in the late 1900’s to early 2000’s. Sedimentation rates change with land-use change in the watershed.

Large Scale Erosion Vulnerability Assessment for Agricultural Lands (EVAAL) Analysis in Support of Phosphorus Compliance: Cloud Data to Field Application

Jeff Powell, MSA Professional Services

Purpose:

The City of New Richmond, WI is anticipating a potential decrease in the WPDES Permit for phosphorus limits from 1.0 mg/L to 0.075 mg/L at their wastewater treatment plant (WWTP). In preparation of this regulatory change, the City is examining three compliance options - an upgrade to the WWTP, adaptive management, or water quality trading. The Highway 64 Coalition, made up of municipalities, counties, and regulatory representatives, provided grant funding to perform an Erosion Vulnerability Assessment for Agricultural Lands (EVAAL) using GIS. This tool delivers a GIS output showing areas with the highest potential risk for erosion on agricultural lands. While the ignition for the EVAAL analyses was provided by a need to examine all compliance options regarding WPDES Permit limits for phosphorus, the resulting model would benefit and need to be accessible to county land conservation staff, the city, and other stakeholders of the Highway 64 Coalition. The area upstream of the WWTP in New Richmond covered 6 HUC 12 subwatersheds, all of which were in consideration for water quality trading and adaptive management compliance options to implement best management practices on agricultural fields. The primary challenges of the EVAAL project consisted of analyzing a large area (228 sq. miles) and providing digestible, user friendly deliverables to a wide range of stakeholders varying in disciplines.

Methodology:

MSA Professional Services (MSA) worked with developers of the EVAAL toolset to determine the mechanics and limitations of the GIS tool when working across large subwatersheds (HUC12). After testing, MSA and St. Croix County developed a robust culvert dataset through aerial photography review, GIS analysis, and field verification. After modeling was completed, MSA published all of the EVAAL outputs to ArcGIS Online, enabling users on any device to access the information through an app.
Concurrent Session I, Track C

Developing Watershed Solution Strategies with Residents of the Watonwan River Watershed

**Kimberly Musser**, Water Resources Center, MSU - Mankato

The Minnesota Pollution Control Agency is developing Watershed Restoration and Protection Strategies (WRAPS) for the agriculturally-dominated Watonwan River Watershed located in south-central Minnesota. As part of the WRAPs process, one-on-one interviews and focus groups with watershed residents were conducted across the watershed to understand perspectives and concerns about water quality and quantity and to identify the barriers to implementing agriculture best management practices (BMPs) on the landscape. A group of citizens and conservation professionals met over a series of meetings, poured over the information gleaned from watershed residents and the latest watershed data collected from scientists and explored the question: Are there some leverage points that might lead to more conservation adoption across the watershed? The group came up with a long list of insightful strategies and prioritized actions for next steps that include: revamping conservation delivery with a dedicated staff for outreach, traveling conservation trailer, and targeting conservation with GIS mapping, creating a soil health team, promoting more water storage on ditch improvement projects, clarifying the economics of BMPs for landowners and bankers, among others. Project results are summarized in an interactive GIS Story map. Watershed residents can explore drone imagery, interactive maps, animations and videos that depict watershed conditions. They can also learn from their watershed neighbors and peers about local water stewardship on the farm and in the city with many landowner video profiles.

Collaborative Geodesign Technology for Multifunctional Watershed Management Planning

**Bryan Runck**, David Pitt, Carissa Slotterback, Len Kne, and Nicholas Jordan, University of Minnesota; **Madeline Goldkamp**, Stantec Corporation; **Jonathan Fillmore**, SRF Consulting Group; **David Mulla**, University of Minnesota; **Michael Reichenbach**, University of Minnesota

Multifunctional watershed management employs diverse management practices to provide multiple ecosystem services. Diverse patterns of land ownership and management jurisdiction require collaborative and iterative stakeholder engagement to create a multifunctional management plan. This paper introduces the use of collaborative geodesign technology to develop multifunctional agricultural landscape plans in the Seven Mile Creek watershed in Nicollet County, Minnesota. The paper examines the efficacy of the technology in allowing multiple stakeholder groups to create plans that optimize commodity production and provision of ecosystem services. The technology helps bridge diverse knowledge and experience among stakeholders, increase plan multifunctionality, and coordinate people to implement multifunctional plans that are specific to the idiosyncrasies of place. Collaborative geodesign technology allows people to discover and evaluate potential designs for multifunctional landscapes through iterative and adaptive planning. The technology allows stakeholders to try-on alternative landscape management scenarios to see if they provide a desired mix of multifunctional outcomes. A group of University of Minnesota researchers engaged 25 rural stakeholders in the co-design of watershed management plans to generate multifunctional landscapes. Participants used 52-inch touch-screen displays to integrate spatial information relating to soils, topography, hydrography, and land cover in collaboratively generating and evaluating alternative multifunctional design proposals on six criteria relating to enhancements of habitat and water quality, carbon sequestration, and profitability. The presentation examines the plans produced by stakeholders using the technology, the participants and their roles in the design process, and the places themselves.
Reducing the Environmental Impact of Corn Monoculture: Farmer Willingness to Accept for Alternative Cropping Systems

Lucia Levers and Amit Pradhananga, University of Minnesota

The American agronomic practice of growing row crops (i.e. corn) and leaving fields bare in winter contributes to multiple environmental concerns. Corn is grown with substantial nitrogen additions, and bare fields contribute to nitrogen leaching, which has well-studied water quality impacts, including the Dead Zone in the Gulf of Mexico. Uncovered fields also lead to erosion and downstream sedimentation, and result in lower soil organic matter, biodiversity, and biological activity than when plants are present. Two alternative practices to address these concerns are 1) replacing corn with certain perennial crop species, and 2) introducing winter cover crops. Both of these alternatives reduce nitrogen pollution, decrease sedimentation, and increase soil health metrics. However, adopting these practices may lead to less profit for farmers. Ergo, programs have been proposed to encourage farm adoption of perennial species and/or cover crops by paying farmers to participate in payment for ecosystem services contracts, in which the governing agency becomes the principle and the farmer becomes the agent, resulting in a number of typical principle-agent framework issues, leading to inefficiencies. One such source is the lack of information regarding the agents’ willingness to accept. Clearly, different farmers will have differing levels of willingness to accept, but this ambiguity need not be a total fog. In order to estimate factors that affect potential program participation, the relative importance of such factors, and the farmers’ willingness to accept to participate, we developed a self-administered survey, which was sent to a sample of Minnesotan farmers across six watersheds. The survey collected data on socio-economic factors, current and potential crop species, and willingness to participate in hypothetical programs of specified contract length and payment value. Overall, 430 respondents completed and returned the questionnaire for a response rate of 17.4 percent.

Minnesota’s Runoff Risk Advisory forecast

Heather Johnson, Minnesota Department of Agriculture; Dustin Goering, National Weather Service

The Minnesota Runoff Risk Advisory Forecast (RRAF) system is a tool developed by the Minnesota Department of Agriculture and the National Weather Service. It is designed to help farmers and commercial applicators determine the best time to apply manure to reduce the probability of off target movement of valuable nutrients and protect water resources. The RRAF takes into account estimated soil moisture content, forecast precipitation and temperatures, snow accumulation and melt to predict the likelihood of current day, next day, and 72 hour runoff events. Farmers and commercial applicators use an interactive map to locate their field and find the forecasted risk. Users can also sign up for email or text messages for their county that alert them to a severe runoff risk for that day. The home page for the project is at www.mda.state.mn.us/rraf. Runoff risk is grouped into four categories: No event, Low, Moderate and Severe. When the risk is Moderate or Severe, it is recommended that the applicator evaluate the situation to determine if there are other locations or later dates when the application could take place.

The RRAF website also provides statewide estimated 2 soil depth temperatures which can be useful at planting time, 6 soil depth temperatures which are helpful when determining fall fertilizer application in appropriate areas and daily precipitation forecasts. Results will be shared on website use, survey response data from potential users, and model performance at predicting runoff compared to Minnesota Discovery Farms data.
Concurrent Session I, Track D

**Chloride Contributions From Water Softeners and Other Domestic, Industrial, and Agricultural Sources to Minnesota Waters**

*Alycia Overbo and Sara Heger, University of Minnesota*

Chloride is an emerging environmental concern, as long-term increases in chloride levels have been observed in surf ace waters and groundwater resources across North America. Chloride is also an issue in many municipalities where wastewater treatment plant discharge exceeds water quality standards for chloride. While use of deicing salt for winter road maintenance is known to be a major source of chloride, previous research has not quantified chloride discharged from water softener use. A chloride budget was developed for the state of Minnesota to estimate the amount of chloride discharged from household water softeners as well as other domestic, environmental, and industrial sources. The analysis employed multiple types of data, including sales records and effluent monitoring data, and utilized statistical, spatial, and survey methods. Annual chloride mass contributions were estimated for the following sources: household water softener use; human excretions; household appliance use; chloride concentrations in drinking water; atmospheric deposition; deicing salt use; dust suppressant use; fertilizer application; industrial discharge; and livestock excretions. The results of the statewide chloride budget will be finalized in summer 2018 and research findings will be presented at the conference, which show that household water softener use is a major chloride point source. Chloride contributions from all sources included in the analysis will be discussed along with their potential impacts on chloride levels in surface water and groundwater. Potential solutions for reducing chloride discharge at the household and municipal scale will also be discussed, as well as implications for wastewater treatment plants.

**Adaptive Management to Improve De-Icing Operations**

*Lawrence Baker, Doug Klimbal and Bruce Wilson, University of Minnesota*

Road salting has caused increased chloride concentrations in both surface waters and shallow groundwater in the Twin Cities Metropolitan Area (TCMA). The goal of our study is to learn about the dynamics of road salt movement and to provide practical guidance to city managers on the proper application rates of road salt.

To do this we have developed a novel meltwater sampler which has been designed to continuously measure the flow, temperature, and conductivity of meltwater passing into a catch basin. Data from the winter of 2017-2018 from a residential watershed in Edina shows that chloride loading is highly disproportional, with 54% of the total winter chloride loading occurring in just two days, and 72% occurs in just 10 days. We also developed an approach to measure the distribution and water content throughout roadside snowpiles, enabling calculation of total chloride mass. Finally, salt input to the drainage area will be calculated from calibrated Precise-equipped plow trucks. We will present a salt balance, showing inputs, drainage outputs, and input to pervious surface.

We will also present a retrospective analysis of data from the main stormwater drain in the Nine-mile creek watershed (which includes our case study drainage). This analysis also reveals temporally disproportionate chloride loadings, with 25% of total chloride over 142 measurement events over 10 years occurring in just 3 days and 50% occurring in 19 samples. Finally a summary of an end-of-season workshop held with Edina’s Streets Department will be presented. These workshops will be used to improve the efficiency of road salt application using the results obtained at the street and watershed scales.
Concurrent Session I, Track D (continued)

**Bacterial Source Tracking in the Lambert Creek Watershed - An Integrated Approach to Identifying and Reducing Bacterial Loads to Meet Regulatory Requirements**

*Steve Gruber, Burns & McDonnell Engineering; Brian Corcoran, Vadnais Lake Area Water Management Organization*

Lambert Creek is located in the northeast Twin Cities Metropolitan Area of Minnesota in the Upper Mississippi River Basin and covers an area of approximately 25 square miles. The watershed falls within the jurisdiction of the Vadnais Lake Area Water Management Organization (VLAWMO) and consists of a mix of urban, open space, parks, and agricultural land uses. Lambert Creek does not currently meet state standards for (Escherichia coli) and in August 2013, a total maximum daily load (TMDL) for E. coli in Lambert Creek was developed. In response to the TMDL, VLAWMO conducted a bacterial source identification study to identify the sources of E. coli in the Lambert Creek Watershed and recommend best management practices (BMPs) that can be implemented to meet the load reduction requirements of the TMDL. The study design broke the watershed into four drainages and assessed bacterial sources during both dry and wet weather conditions. The results indicate that bacteria from human origin (e.g., leaking sewer lines, septic systems, homeless encampments, etc.) were negligible in all drainages of the watershed during both dry and wet weather conditions; however, birds were determined to be a likely source based on visual observations and species-specific molecular markers. During dry weather, E. coli levels were relatively low; however during wet weather pollutograph monitoring, concentrations were high throughout the watershed. Evidence of naturalized E. coli was evident from samples collected from both terrestrial soil and wetland sediment and is considered to be a likely source of E. coli in the receiving waters during wet weather events. Limited groundwater samples collected from wells in the upper portion of the watershed (Whitaker Drainage) were all below the detection limit for E. coli, indicating a lack of groundwater contamination. BMP recommendations were site-specific and are currently being considered throughout the watershed.

**What Can You Do about Bacteria in Stormwater Runoff?**

*Diane Spector and Ed Matthiesen, Wenck Associates*

Stormwater conveys bacteria such as E. coli to receiving waters, where contact can be a human health risk. In urban areas bacteria sources are diffuse pet and wildlife waste, sanitary overflows and leakages - and options for reducing loads are limited. How do you effectively address bacteria being conveyed to your impaired waters? The Shingle Creek Watershed Management Commission is field-testing three applications of a new promising yet simple technology. Iron-enhanced sand filters have proven to be effective at removing dissolved phosphorus from urban runoff. Biochar - a specially engineered type of charcoal added to iron-enhanced sand filters has been effective in lab experiments at removing bacteria in synthetic stormwater. The three field trials in suburban Hennepin County are testing the effectiveness of these filters at treating real-world stormwater runoff in pond filter benches, storm sewer catch basin inserts, and a filter box to directly treat flow in Shingle Creek. Initial results are promising, showing a 72% to 93% removal of bacteria and significant removal of dissolved phosphorus. Inflow and outflow from the catch basin inserts and filter box are being monitored for removal effectiveness. Pond inflow, ambient, and outflow water quality is monitored by grab samples. Additional probes log and display online real-time DO, conductivity, and oxidation-reduction potential in the pond filters as well as DO and conductivity of ambient pond flow. Cores from the filters are also being analyzed to characterize the initial binding capacity of the filter media and to characterize the iron mineral makeup within filter media to determine which iron minerals are bonding with phosphorus. This testing will explore the potential mechanisms for removals, and help to predict long-term effectiveness. Full results from two years of monitoring will be presented. A third year of monitoring will be completed in 2019.
Creating a Native Prairie Landscape within a Concrete Jungle
Abbie Browen and Justin Klabo, AE2S, Inc

In 2008, the Fargo Park District constructed a regional stormwater pond treatment system to treat urban runoff from the neighboring Scheels arena and surrounding development areas. The system included two moderately sized stormwater ponds, one filtration basin, a stormwater lift station, a waterfall, and two large detention basins over 10 acres of land. Over time, the detention basins have degraded in quality, which led to the Park District’s exploration of options to revitalize the area. During a charrette meeting, the concept of turning the stormwater ponds into a native prairie with a meandering stream was born. The main feature of the stream is that it includes a base flow during dry weather conditions. Similar to most developable land in Fargo, the site was once a native prairie that was converted to farmland during the late nineteenth century. Restoring the land to a native prairie will create an educational area for residents, students, and children. The project has turned the detention basins into four smaller ponds connected through the meandering stream. In addition, the project has added a lift station to the downstream end of the pond-channel system which allows the system to recirculate. This has created a base flow condition (5 cfs) within the meandering stream. Native vegetation, pedestrian trials, and bridges are integrated within the original pond footprint. The system still serves its primary purposes of providing water quality and flood control benefits but enables the local residents an appealing site to enjoy. Our presentation will focus on the key aspects of project from conception, design, construction and go over the operation of the facility since its construction in 2017.

Green Infrastructure Project Over Time: Lessons Learned
Rocky Keehn, Common Sense Water Resources Engineering, LLC

One of the challenges when doing Green Infrastructure projects is to try an imagine what they will look like in the future. The presentation will look back in time using construction photos from green infrastructure projects completed 15 to 30 years ago and then look at what they looked liked in the summer of 2017. The projects used prairie grass restoration, wetland construction techniques, treatment trains, special flow splitting structures and what may have been considered new or unique techniques when first designed and built. These projects were completed in Maplewood (Footprint Lake, 1991), Mounds View (Woodcrest Park, 2000), North St. Paul (Cowern School, 1998), Brooklyn Center (Centerbrook Golf Course, 2000) and Roseville (McCarren’s Ditch, 1988). As the main engineer for these projects, can provide insight into what the thought process was at the time they were designed. Some sites have worked as designed, some have worked better and other have seen drastic changes that could not have been anticipated. For each site there is a lesson learned which will be presented. We can’t always predict the future, but by looking at the past we can have a much better idea of what it might look like.
Concurrent Session II, Track A (continued)

Evaluating the Net Present Value of LID Retros in Edmonton

Brett Emmons and Olivia Sparrow, EOR; Eric Bill, Impact Infrastructure

Low Impact Development (LID) is a sustainable approach to land development and stormwater management (SWM) that aims to mimic natural runoff conditions. The City of Edmonton has identified LID as a strategy to achieve their water quality target of no net increase in pollutants discharged to the North Saskatchewan River. Flood reduction is also a top priority for the City to limit nuisance flooding and to build long term resiliency into the drainage system. Retrofitting the system is essential in mature neighborhoods built without SWM controls and storm sewers sized for small events. EOR and Impact Infrastructure teamed to evaluate the sustainable net present value (S-NPV) of LID retrofit opportunities on public land in Edmonton. The cloud-based automated triple bottom line cost benefit analysis software Autocase was used to estimate the incremental lifecycle costs and monetary value of the broader social and environmental impacts of LID retrofits. The team assessed over 33,000 LID retrofit opportunities using batch runs to prioritize the most cost-effective investments and estimate the holistic value of broad LID implementation across the city. Overall, the cumulative S-NPV of the LID retrofits is greater than CA $420 million over a 60+ year time frame. The greatest monetary benefits are provided by avoided grey infrastructure costs, followed by social benefits such as flood risk mitigation and property value uplift. Environmental benefits, such as air pollution reduction, generate the lowest monetary value. Environmental benefits are still the most challenging to quantify monetarily.

Grand Rapids Stormwater Wetland

Shawn Tracy, HR Green

Grand Rapids, Itasca SWCD and the Mississippi Headwaters Board partnered to convert a ditch in Grand Rapids to a 1.25-acre wetland system in the fall of 2017. Minnesota’s Clean Water Funds were matched by the City for its construction. The project was designed to protect the Mississippi River and bluffland, improve habitat and enhance public open space. The system treats stormwater from 133 City acres and an additional 142 acres from outside the city. Modeling suggests potential for the wetland to remove and average of 20 tons of TSS and 62 pounds of TP per year through settling processes. Flow rates to the Mississippi River are estimated to be reduced by 48% for the 2-year rainfall event. The wetland was designed with 5 distinct zones: Deepwater, Low Marsh, High Marsh, Semi-wet and Upland. Sediment and associated pollutants are settled and stored in permanent pools as well as assimilated and filtered by emergent and transitional vegetation. The upland buffer filters overland flows to the wetland. Each zone provides a variety of habitat benefits. A diverse combination of seeding and live planting was used to vegetate each zone including rushes, sedges, grasses, forbs, shrubs and trees. Forebays at each inlet protect the wetland from scour and provide initial settling functions. The outlet controls ponding depth and duration of water as well as effluent velocity control. An interpretive sign was installed between the wetland and a walking trail.
Metro River Water Quality: Recent Conditions and Spatial Changes

Erik Herberg, Hong Wang, Kent Johnson, Jack Barland, and Judy Sventek, Metropolitan Council

Metropolitan Council Environmental Services (MCES) monitors more than 150 river miles in the Minneapolis-St. Paul metro area, covering the Mississippi, Minnesota, and St. Croix Rivers. MCES recently completed a comprehensive river assessment study and expects to publish the report in July 2018. This presentation focuses on recent (10-year) water quality conditions of the three rivers in the metro area and how those conditions changed as the rivers moved through the metro area. Median concentrations of 15 water quality parameters were calculated for the 10-year period 2006 to 2015 at 10 river monitoring sites. These medians represented the most typical concentrations recorded at each site in that 10-year period. The results were plotted on maps to visually compare the median concentrations between and along the rivers. For seven parameters (conductivity, BOD5, TSS, TP, Chl-a, TN, and NO3), the median concentrations were highest in the Minnesota River, lowest in the St. Croix River, and intermediate in the Mississippi River. For three parameters (NH3, fecal coliform, and E. coli), the highest median concentrations occurred in the core of the metro area. The medians of temperature, pH, and DO concentrations in the rivers were more even throughout the metro area. Median chloride concentrations were highest in the Minnesota River, lowest in the St. Croix River, and intermediate in the Mississippi River as the rivers entered the metro area and noticeably increased in the core of the metro area. Many factors such as land cover, geology, and pollution sources likely contributed to these patterns.

Metro River Water Quality: Long-Term Trends

Hong Wang, Erik Herberg, Jack Barland, Kent Johnson, and Judy Sventek, Metropolitan Council

Metropolitan Council Environmental Services (MCES) initiated a river monitoring program in 1930s. Currently, MCES monitors more than 150 river miles in the metro area, covering the Mississippi, Minnesota, and St. Croix Rivers. MCES recently completed a comprehensive river assessment study and expects to publish the report in July 2018. This presentation focuses on the statistical analysis of water quality trends in the metro area reaches of three rivers, aiming to understand historical changes in regional river water quality. Trends were analyzed using the USGS statistical model QWTREND, which estimates non-monotonic trends based on flow-adjusted concentrations to identify changes in water quality over time. The analysis was performed for nine parameters at ten river sites from 1976 to 2015. Results indicate that five of the nine parameters assessed (BOD5, TSS, TP, NH3, and fecal coliform) typically exhibited long-term decreasing trends in their flow-adjusted concentrations, indicating an improvement in regional river water quality as it relates to those parameters. Three parameters (TN, NO3, and Cl) generally showed increasing trends, while one parameter (Chl-a) exhibited mixed trends during the assessment period. As noted in previous studies, increasing nitrogen (TN and NO3) concentrations in metro area rivers are a significant regional concern. Chloride concentrations have significantly increased in metro area rivers during the last 31 years.
Concurrent Session II, Track B (continued)

**Water Quality Trends in Minnesota’s Rivers and Streams**

*Lee Ganske and James Jahnz, Minnesota Pollution Control Agency*

The Minnesota Pollution Control Agency’s (MPCA) Watershed Pollutant Load Monitoring Network (WPLMN) consists of 200 river and stream monitoring stations statewide and has been in operation since 2007. Water quality trend analysis is being conducted on the data collected at many of these stations, some of which have pre-2007 data. The purpose of the trend analysis is to assess general patterns of water quality change, as well as progress towards meeting Total Maximum Daily Load (TMDL) goals and targets for statewide nutrient and sediment reduction.

Multiple trend analysis methods and approaches are being utilized including Mann-Kendall and Seasonal Kendall tests, the USGS QWTREND model, differing periods of record, and controlling for streamflow variability. Comparisons of these will be presented, along with results. In general over the past 10-20 years, Minnesota’s rivers and streams show no trend or decreases in total phosphorus, no trend or increases in nitrate, and mixed results for total suspended solids.

**Using the Watershed Pollutant Load Monitoring Network Data Viewer to Determine Pollutant Sources and Source Contributions from Select Watersheds throughout Minnesota**

*Patrick Baskfield, Minnesota Pollution Control Agency*

The Minnesota Pollution Control Agency’s (MPCA) Watershed Pollutant Load Monitoring Network (WPLMN) is a long-term, statewide, river monitoring network designed to collect and analyze spatial and temporal pollutant load data from more than 200 river monitoring sites. The WPLMN Data Viewer is a publicly-available, interactive application that allows users to graphically review and download daily, annual, or average pollutant load, yield, or concentration data. This presentation demonstrates the recently-developed WPLMN Data Viewer and example uses, including developing pollutant source contribution estimates. Several examples from watersheds affected by both point and non-point source pollutants will be examined and discussed.
Concurrent Session II, Track C

Tillage and Fertilizer Management Effects On Phosphorus Runoff From “Flat” Fields

Fabian Fernandez, University of Minnesota

Phosphorus fertilization can increase P losses in surface runoff, but limited information is available for fields with slopes in the U.S. Midwest. The objectives were to determine the effects of tillage/fertilizer placement, strip-till/broadcast; strip-till/deep-placement 15 cm subsurface band, fertilizer rate applied in the fall (0, 52, 90 kg P2O5 ha-1 yr-1) on runoff P concentrations and loads in fields with slopes during fall and spring simulation runoff events, and to measure corn (Zea mays L.) and soybean [Glycine max (L.) Merr.] grain yield. Across four simulated runoff events, deep-placement reduced DRP loads by 69-72% compared to the broadcast treatments. A tillage/fertilizer placement by P rate interaction showed that DRP and TP concentrations remained low when P was deep-placed regardless of P rate, while concentrations increased with increasing P rate for the broadcast treatments, but no differences existed for bioavailable P. At one site, rainfall simulation in the spring compared to fall increased runoff volumes but sharply decreased BAP concentrations. During fall runoff simulations, deep-placement reduced TP loads and greater TP loads occurred with the 90- than the 52-kg P2O5 ha-1 yr-1 rate. Similarly, when P was broadcast in the fall, DRP and TP concentrations were greater relative to deep-placed P, but no treatment differences occurred in the spring. Deep-banding P and K did not reduce crop yield, but reduced runoff losses of P from flat fields compared to broadcast P applications, particularly at high rates of P application.

Evaluating Effects of Crop Cover Applications and Perennial Cropland Conversion on Shakopee Creek Watershed Using a Physically-Based Distributive Model

Salam Murtada and Daniel Reinartz, Minnesota Department of Natural Resources

Best management practices involving the use of cover crops and land use conversion of marginal agricultural areas to perennial crops provide economic and environmental benefits. These practices have been shown to reduce surface water runoff and erosion on the landscape due to enhanced infiltration and evapotranspiration, allowing nutrients to be more readily available for plant uptake. Consequently, due to the increase in organic matter within the soil matrix extending to the root system, soil compaction is reduced and water storativity is increased.

In this study, the Gridded Surface Subsurface Hydrological Analysis (GSSHA) model was used to simulate the effects of applying these best management practices on the 345 mi2 Shakopee Creek Watershed, where various spatially targeted scenarios were run continuously for a period of 12 years. The model responses were evaluated and compared for water surface runoff, infiltration, evapotranspiration and erosion in order to quantify and rank them. For example, based on the BWSR recommended scenario involving the 30% marginal land conversion to perennial and 40% application of cover crops, up to 20% of surface run-off reduction was computed during the non-growing season.

In this presentation:

- The model and related assumptions will be introduced.
- The methodology used to capture these benefits will be discussed.
- The various scenarios and their results will be summarized.

We hope that this study and future related ones will better inform best management decision making and practice.
Concurrent Session II, Track C (continued)

**Linking the Science with Local Land Management Decisions Using ACPF**

*Jessica Nelson and Kimberly Musser*, Water Resources Center, Minnesota State University Mankato

Le Sueur River Watershed hydrology is becoming flashier in part due to increased frequency of mega-rain events and in part due to historical land management decisions. Le Sueur River Watershed Network Steering Committee members are working within their communities to respond to these changes and create landscapes that are more resilient. The citizen-led watershed group developed Seven Recommendations towards Cleaner Water and River Health that includes experimenting with storm water management and in-ditch storage to increase temporary water storage. This will help to stabilize streambanks, reduce erosion from key sediment sources, and protect public infrastructure. Using the Agricultural Conservation Planning Framework (ACPF) GIS toolset and concepts, a menu of conservation opportunities has been identified and used to inform local partners about priority areas within Boot Creek Watershed to reduce flashiness and pollutant loads. During summer 2018 Waseca County field staff and Water Resources Center, Minnesota State University, Mankato staff met with watershed residents to learn from one another on operational needs of local farmers and ways we can work together. Feedback from meetings with farmers and residents and results from the GIS study were used to develop maps using field-reviewed ACPF outputs to illustrate feasible targeted BMP implementation strategies. These strategies include scenarios evaluating different combinations of BMPs and the estimated benefits of in field, edge-of-field and riparian best management practices to achieve water quantity and quality goals.

**Linking Watershed-Scale Hydrologic Response to Farm-Level Changes in Water Management**

*Brent Dalzell, Lu Zhang, Joe Magner, and Jeff Strock*, University of Minnesota

In agricultural landscapes, farm scale management decisions can play an important role in watershed scale hydrologic response to snowmelt and rainfall. However, the link between farm and watershed scale responses to management is difficult to quantify because of variability in watershed characteristics (e.g., soils, weather) as well as differences in the timing and nature of farm management. In an effort to understand which field scale processes are important for watershed scale hydrology, we conducted a field campaign to measure stable isotopes of water for different likely source water end-members and then used those data to determine contributions to river water. We coupled these results with field monitoring and watershed scale hydrologic modeling in order to generate a more comprehensive understanding of watershed hydrology across events and seasons. Preliminary results from the Cottonwood River Basin suggest that surface runoff makes an important contribution to peak flow following precipitation events but that flow from subsurface tile drainage comprises roughly two thirds of total water yield and tile flow is often the main component of stream flow. The result of the research will aid in drainage water management strategy selection in a way that both increases production and minimize environmental impact.
Concurrent Session II, Track D

Spatial Variability in the Vertical Connectivity of Till Confining Units: Implications for Glacial Aquifers in Minnesota

William Simpkins, Iowa State University; Alyssa Witt, Golder Associates; Justin Blum, Minnesota Department of Health; Jared Trost, Andrew Berg, and James Stark, United States Geological Survey Upper Midwest Water Science Center

Buried glacial aquifers of finite extent comprise an important water supply for Minnesota. Knowledge of their source of water and contamination susceptibility is essential to evaluating their sustainability. In 2014, the USGS Upper Midwest Water Science Center, Iowa State University, and three State of Minnesota agencies initiated an LCCMR-funded project (completion schedule for 2019) to characterize hydraulic properties of buried glacial aquifers and till confining units (aquitards). Phase I sites included Cromwell (Superior lobe) and Litchfield (Des Moines lobe). Phase II sites included the University of Minnesota Hydrogeology Field Camp near Akeley (Wadena lobe) and Olivia (Des Moines lobe). We present the Litchfield site as an example of our investigation. Eleven piezometers were installed at two nests, LFO1 and LFO2, 0.5 miles apart, at depths between 20 and 162 ft. Downward-directed hydraulic gradients occur in till at both sites; however, horizontal hydraulic conductivity (Kh) is two orders of magnitude lower at LFO2 (Kh=2E-09 m/s; 6E-04 ft/d) than at LFO1 (Kh=8E-07 m/s; 0.23 ft/d). Cl concentrations and Cl/Br ratios in the till suggest anthropogenic contamination at both nests. An enriched 3H value of 16.08 tritium units (TU) at 95 ft at LFO1 suggests young (1960s age) groundwater. Results of a pumping test in the underlying glacial aquifer showed till hydraulic heads at LFO2 to be unresponsive, but that they declined significantly at LFO1. Multiple lines of evidence suggest a higher degree of vertical connectivity at the LFO1 nest than the LFO2 nest, likely due to better-connected vertical fractures at the former nest. This finding has significant implications for assessing vertical leakage to and contamination susceptibility of glacial aquifers in Minnesota.

Evaluating the Source of Water to Wells Completed in Confined Glacial Aquifers

Jared Trost and Daniel Feinstein, U.S. Geological Survey; William Simpkins, Iowa State University; Alyssa Witt, Golder Associates; James Stark, Legislative Water Commission

Confined aquifers overlain by till confining units provide drinking water to thousands of people in Minnesota. Confined aquifers are thought to be protected from surface contamination, but may be slowly recharged and prone to unsustainable groundwater withdrawals. Evaluations of confined aquifer sustainability are challenging because till hydraulic properties, confined aquifer extents, and connections between confined aquifers are often unknown. In 2014, the USGS, Iowa State University, and three State of Minnesota agencies initiated an LCCMR-funded project (completion in 2019) to measure hydraulic properties and responses to high-capacity pumping in Des Moines, Superior, and Wadena Lobe tills overlying buried aquifers. These data were used to parameterize a series of steady-state interpretive MODFLOW models which were used to (1) investigate a range of surface-water and groundwater responses to pumping from confined aquifers and (2) complete a sensitivity analysis. Model results demonstrated that pumping induced hydraulic gradients through tills above confined aquifers. The resulting downward flow through 80 feet of low hydraulic conductivity tills (Kv = 0.001 feet per day) affected the groundwater flux to surface-water features. Model results also demonstrated that the relative amounts of water reaching a buried aquifer from above and laterally are highly dependent on the hydrogeologic setting. The proportion of water entering the aquifer from above was sensitive to 1) variations in till vertical hydraulic conductivity, 2) the confined aquifer’s lateral connectivity to adjacent aquifers, and 3) the areal extent of the confined aquifer. This proportion of water was less sensitive to the thickness of the upper till, the pumping rate, and the aquifer’s hydraulic conductivity. This interpretive modeling gives insight to the relative importance of hydrogeologic properties for evaluating the sustainability of pumping water from confined aquifers.
Dakota County Ambient Groundwater Quality Study Major Findings

Vanessa Demuth and Stephan Scott, Dakota County Environmental Resources

Dakota County began its multiyear Ambient Groundwater Quality Study in 1999 to measure baseline groundwater quality; assess the occurrence, distribution, and trends of non-point source pollutants; and investigate the influences of well construction and land-use on drinking water quality. A total of 76 domestic wells, representing the three principal water supply aquifers and various hydrogeologic and land use regimes, were sampled periodically, up to 13 sampling events. The water samples were analyzed for general chemistry and major ions. A majority of the wells were also analyzed for anthropogenic organic compounds including pesticides and their breakdown products, volatile organic compounds (VOCs), wastewater compounds, pharmaceuticals, and perfluorochemicals (PFCs).

Natural or anthropogenic chemicals were found at levels that exceeded the applicable drinking water guideline in 60% of the study wells. Notably, breakdown products of cyanazine, an herbicide banned in 1999, were found above health standards in 19% of the wells. The presence and concentrations of anthropogenic compounds are strongly correlated with well depth and land use. Herbicides commonly applied to corn and soybean crops were detected in 88% of the sampled wells. Statistically, nitrate and herbicide levels were highly correlated to each other and to the percent of nearby land in row crop agriculture. Additionally, the age of the water in a well can be estimated from knowing the year agricultural chemicals were introduced and chloride from road salt. Ion and herbicide concentrations and trends are used to estimate the time for water to infiltrate from the surface to various depths within the aquifer, providing a general age of the water. Future sampling will provide an ongoing assessment of the groundwater quality and trends. The study wells also provide Dakota County with a framework for measuring the prevalence of contaminants of emerging concern when identified.

Minnesota Groundwater Tracing Database (MGTD)

Wes Rutelonis, John Barry, Jeffrey Green, Holly Johnson, Ruth MacDonald, Bart Richardson, Calvin Alexander, Minnesota Department of Natural Resources

Scientists, both in academia and in the public sector, are faced with an increasing demand for useful online tools that make geospatial content available and easily accessible. An especially challenging task is integrating historical scientific content that may have been generated when GIS and online tools did not exist into these systems. We present a success story of data integration and accessibility with the Minnesota Groundwater Tracing Database (MGTD). This database, which includes a new, sustainable documentation structure and geospatial tracing data, integrates recent groundwater tracing with an eighty-year history of groundwater tracing into an online web application.

The Minnesota Spring Inventory (MSI), the Karst Feature Database (KFD), and the County Well Index (CWI) are included in the application as they are integral parts of groundwater tracing in the karst regions where the preponderance of the traces have been conducted. MSI, KFD, CWI and MGTD share a common primary key that is used to relate tracer input and sampling locations to each of the databases. Each trace also has a unique identifier that is used to identify inferred groundwater flow vectors, surface water springshed inputs, and sampling locations associated with that trace. These relationships as well as easy to use links to groundwater tracing reports are set up in the application and allow users to discover information about a trace without advanced GIS experience.

These resources are available at mndnr.gov/groundwatermapping.
Concurrent Session III, Track A

**Rice Creek Commons Green Infrastructure Public-Private Partnership**

The first approved Comprehensive Stormwater Management Plan (CSMP) under Rice Creek Watershed District rules was completed in 2015 for the 427-acre, mixed-use redevelopment site in Arden Hills formerly known as the Twin Cities Army Ammunitions Plant (TCAAP). The CSMP anticipated that projects would be phased in over a 15- to 20-year timeframe and as of May 2018 four projects have been completed or are under construction. As several of the more significant projects advance through design in 2018, the partners identified the need to update the CSMP to respond to planned changes in the development plan. The partners also recognized the opportunity to also look at what could be done to go above and beyond the baseline requirements and achieve additional pollutant load reductions. A second yet related Green Infrastructure and Stormwater Reuse Feasibility Study was completed to compliment the CSMP. The Green/Reuse Study identifies iron filters, tree trenches, reuse and educational features that can enhance this already unique development site. The site will have a centralized natural resources corridor with a combination of natural and created wetlands, wet ponds and infiltration features (in the areas where soils are suitable). The presentation will highlight the benefits of the CSMP approach, the key technical challenges and how they were addressed, and the lessons learned from the first few projects.

**Funneling Seven Stakeholders through One Pipe: CSAH 10 Stormwater Management**
*Kyle Johnson, Derek Arens, and Lanol Leichty, Bolton & Menk*

What do you get when seven parties with different stormwater needs come to the table and everything needs to drain to the same existing pipe?

This presentation will cover how a proposed 65 acre high school expansion escalated into an 850 acre joint stormwater management project that included a new 1.7 mile county highway, a new trunk highway roundabout, new city streets, new pedestrian box culverts, new developments, township drain tile improvements, and farmland all discharging to the same location.

The process included innovative design solutions and consensus building with seven different stakeholders with varying stormwater needs and requirements, resulting in a truly unique and interconnected final outcome that met the needs of all parties involved. Water reuse ponds, water quality ponds, a biofiltration basin, tree box filters, a drain tile bypass system, an EOF diversion pipe, and a wetland were used to address water quality, volume and rate control requirements. We will discuss how a complex project, with limited on-site ponding options, was managed and designed using a variety of methods to meet the project goals.

The project was initiated summer 2017, with estimated completion in fall of 2018.
Sand Point Beach Park Pond Improvements and Iron-Enhanced Sand Filter Retrofit

Stephanie Hatten and Lake Newhall, WSB & Associates; Pete Young, City of Prior Lake; Maggie Karschnia, Prior-Lake Spring Lake Watershed District

The Sand Point Beach Park Pond Improvement Project provided a partnership opportunity for the City of Prior Lake and the Prior Lake-Spring Lake Watershed District to complete the following activities:

- Provide water quality treatment for approximately 15 acres of untreated drainage that previously drained directly into Lower Prior Lake
- Utilize currently unusable land to construct an iron-enhanced sand filter that removes an additional 24 pounds/year of total phosphorus
- Providing a high-profile water resource/stormwater educational opportunity in the frequently visited Sand Point Beach Park
- Perform maintenance and add additional storage to existing stormwater ponds

The existing stormwater ponds received 63 acres of drainage and were currently undersized. Pond maintenance projects were completed to remove contaminated material at the bottom of the ponds and to enlarge the ponds for additional storage. The existing storm sewer system was diverted into the modified stormwater ponds, providing water quality treatment to an additional 15 acres of previously untreated stormwater.

The existing discharge from the stormwater ponds went directly into Lower Prior Lake. A new outlet was constructed from the second pond to direct most of the discharge to an iron-enhanced sand filter. The constructed iron-enhanced sand filter was the final leg of the treatment train to remove additional phosphorus that wasn't being removed from the stormwater ponds. This iron-enhanced sand filter is approximately 6500 square feet in size and is designed to remove an additional 24 pounds/year of total phosphorus.

Construction challenges will be discussed including: contaminated sediment testing and removal and contractor lessons learned.

Design and Deployment of Automated (Pump-Controlled) Iron-Enhanced Sand Filter Systems in the Rice Creek Watershed

Kyle Axtell, Rice Creek Watershed District; Dennis McAlpine, P.E., Houston Engineering, Inc.

In recent years, the Rice Creek Watershed District has partnered on installation of passively-operated Iron-Enhanced Sand Filter (IESF) systems of assorted designs. During development of an IESF design for the Hansen Park Comprehensive Water Management Project the District sought improved operational control and round-the-clock functionality. This would allow for treatment of baseflow conditions in addition to treatment of rain events, increasing the system’s annual phosphorus removal capacity.

Work with Houston Engineering, Inc., the project engineer, resulted in development of an all-new IESF system design using components and automation logic developed in cooperation with EPG Companies, Inc. that married technology and equipment used in the water resources and solid waste industries. Through the use of multiple filter beds, automated valve controls, real-time water level monitoring, customizable user interface logic and remote real-time cellular control, the IESF system was designed to provide unrivaled operational and maintenance efficiency. After achieving proof-of-concept in late 2017 at Hansen Park, a second similar system was designed for installation at Oasis Pond in Roseville, MN. Both systems will be fully operational in 2018.

This presentation will detail the site constraints and project goals that led to the chosen design while diving into the functional design and unique operation of the system. Attendees may also look forward to a live demonstration of the IESF’s remote function capability.
Concurrent Session III, Track B

Restoration Evaluation Program for Legacy Fund Projects

Wade Johnson and Gina Quiram, Minnesota Department of Natural Resources

In 2011 a legislative requirement was enacted to evaluate habitat restoration projects funded by the Clean Water, Land and Legacy Amendment. The goal of the Restoration Evaluation Program is to improve the quality of restorations throughout the State. State Agencies charged with implementing this evaluation program, the Minnesota Board of Water and Soil Resources and Department of Natural Resources facilitate third party reviews of restorations relative to the law, current science and stated goals of the projects. They have also seated a panel of restoration experts to review project plans and field assessment reports. More than 120 site evaluations have been conducted throughout the State in a variety of habitat types, including wetlands, prairies, forests, rivers, streams and lakeshores. Based on findings from the first five years of project evaluations, the panel has made five recommendations for improving restoration practice. These recommendations include improved restoration training, improved project documentation and multidisciplinary project teams. Efforts are underway to support adoption and implementation of these recommendations as well as track the impact of the Restoration Evaluation Program on work done throughout the State. Moving forward it is anticipated that at least 30 restoration evaluations will be conducted annually. Program staff will continue to work to use the results of the evaluations to promote the science and practice of high quality ecological restoration.

Grassy and Woody Riparian Shade Analysis and Implications for Restoring Biotic Health in an Urbanizing Coldwater Stream

Olivia Sparrow, University of Minnesota; Emmons & Olivier Resources, Inc.; William Herb, St. Anthony Falls Laboratory; Bruce Wilson and John Gulliver, University of Minnesota

Rising water temperatures in urban and intensively farmed areas threaten the health and survival of coldwater biota. Strategies to control stream temperature during dry and warm summer days include managing baseflow, channel morphology, and riparian vegetation, however there is limited research quantifying shade provided by grassy vegetation in narrow streams. Shade provided by both grassy and woody riparian vegetation on Brown's Creek was assessed using the novel technique of hemispherical photographs. The creek is a small designated trout stream in Stillwater, Minnesota impaired by both high temperatures and turbidity. Shade was estimated using the program WinSCANOPY by simulating the solar path across each monitoring location relative to the detailed canopy structure from the hemispherical photographs. The results of the hemispherical photograph analysis were extrapolated to the entire main branch of the creek using a correlation with relative shade estimated by LiDAR analysis. The direct use of LiDAR data would have underestimated existing shade and over-estimated the potential stream temperature benefits of shade restoration. Solitary trees in meadow riparian buffers were found to increase riparian shade above 80%. Shade at locations with no riparian trees ranged from 10% to 61% with an average of 34%. The riparian shade analysis was used to develop a targeted shade restoration plan for the Brown's Creek Watershed District while balancing other objectives, such as limiting detrimental impacts of dense forest canopy on bank stability. The potential benefits of the restoration plan were estimated using the CE-QUAL-W2 modeling platform which indicated shade restoration could decrease monthly mean stream temperatures in the summer by 0.16 to 0.52°C. Hemispherical photography was found to be useful in assessing shade in this narrow stream with grassy vegetation. Shade restoration alone will not fully address the high stream temperature in Brown's Creek.
Concurrent Session III, Track B (continued)

Making the Connection: Linking Urban Streams and People
Will Wilhelm, Kimley-Horn

Past stream and floodplain management practices have left many stream and floodplain corridors disconnected from our communities. The historical practice of managing streams and floodplains with a sole focus on storm conveyance created a cultural mindset of streams as a liability (i.e., a cause of floods) rather than assets to neighborhoods and cities. Throughout the past few decades, stream restoration and urban greenways construction has reintroduced people to streams and floodplains as green assets. Mecklenburg County has benefitted from this first-hand by combining stream rehabilitation projects with multi-use path projects and viewing restoration in the context of adjacent existing or planned neighborhoods, commercial developments, and open spaces and parks.

In addition to a technical focus on urban stream hydraulics and geomorphology, this presentation concentrates on the design considerations needed to make this connection a success. Case studies will include multiple projects during the past decade including the Little Sugar Creek Stream Restoration and Greenway—one of the largest urban restoration projects in the Southeast in its final year of construction. The Little Sugar Creek project involves restoring over three miles of a 50-square-mile urban channel with a bankfull width of more than 100 feet, in addition to five miles of greenway with multiple bridges and overlooks.

Establishment of a Statewide (Minnesota) Channel Morphology Dataset
Neil Haugerud and Kevin Zytkovicz, Minnesota Department of Natural Resources

The establishment of a statewide channel morphology dataset and web interface to gather, organize and distribute morphological data is necessary for water resource professionals. Channel morphology is field collected data that describes a channel's shape, profile and bed composition. This information is required prior to any stream project or assessment for proper management decisions.

The MNDNR River Ecology Unit (REU) has used channel morphology data from reference channels for over 100 successful restoration projects statewide. This dataset will serve to provide access to this information and allow users to see geographically where data exists not only for areas that provide references for restoration, but for all stream sites that have had data collected.

Over the past 20+ years, the REU has trained water resource professionals on proper channel morphology data collection techniques. In the fall of 2017, a statewide solicitation of channel morphology data was sent to those professionals. The provided data was organized and reviewed to create the current dataset. Summaries of basic channel morphology information and links to detailed data through a geospatial web interface will be the initial product. Once established it will serve to:

- Raise awareness of previous morphology data collected
- Establish baseline channel and floodplain conditions
- Quantify temporal changes in stream channels
- Facilitate systems management of streams
- Improve regional hydraulic geometry relationships
- Provide information for channel and floodplain management decisions
- Standardize data collection procedures
- Provide long term data storage of this information

As this dataset grows, through user support, we plan to expand this interface to offer improved tools and more advanced channel morphology assessments and metrics. This presentation will include overview of the platform, types of data, analysis and examples of how it can be utilized.

#mnwrc18
Concurrent Session III, Track C

Restoring the Little Plover River in Wisconsin: A Collaboration to Manage a Trout Stream in an Agricultural Landscape

Steve Gaffield, Nick Hayden, and Rob Montgomery, Montgomery Associates: Resource Solutions, LLC; Dan Mahoney, Village of Plover, WI

Conflicts between groundwater withdrawals and trout stream management are widespread in the upper Midwest, especially in areas of intensive irrigated agriculture. The impacts of groundwater pumping in Wisconsin's Central Sands on flow in the Little Plover River have been studied for decades, and partial dry ups starting in 2005 generated significant publicity and debate among interest groups. Recently, the Village of Plover initiated the Little Plover River Watershed Enhancement Project to improve conditions in the Little Plover River, working with local and state government, agricultural producers and nonprofits. The project is using past studies, a recent MODFLOW groundwater model and other tools to prioritize and implement voluntary actions to work toward restoring baseflow and enhancing habitat. Projects underway now include optimizing Village of Plover water supply well pumping to reduce low flow impacts, transitioning irrigated agricultural land near the river to other uses, and restoring wetlands and prairies for hydrologic and habitat benefits. Additional actions being evaluated to enhance streamflow include municipal water conservation, agricultural irrigation practices to reduce water use, and infiltration of stormwater runoff. Additional habitat improvements to complement flow restoration will include management of woody riparian vegetation to stabilize streambanks and restore a narrower and deeper river channel, which could reduce stream temperature and increase cover for fish. A network of stream gauges and monitoring wells already present in the watershed will provide data on the success of restoration measures and guide efforts in coming years to manage this river and other agricultural watersheds.

Effect of Stream Channel Incision On the Depth to Groundwater in Riparian Corridors across Southwestern Minnesota

Hilary Pierce and Joe Magner, University of Minnesota

Riparian buffers have the potential to remove nitrogen from shallow groundwater in the riparian corridor, but this function depends on the saturation of the riparian zone near the ground surface and interactions between the shallow groundwater table and riparian vegetation. By determining if there is a relationship between channel type, degree of incision and the depth to the shallow groundwater table in the riparian corridor, it may be possible to better guide riparian buffer planning in order to maximize efficiency. Streams with a higher degree of incision may be less likely to have elevated groundwater tables, making them more effective at removing sediment and particulate phosphorus from overland flow, than removing nitrogen from groundwater. Southwestern Minnesota, the home of the Minnesota River Valley, is a largely agricultural part of the state, where there are issues with excess nutrients and sediment entering water bodies and travelling to the Minnesota River, which has impairments for nitrogen, phosphorus and total suspended solids. This study analyzes six sites on tributaries of the Minnesota River, characterizing them by their Rosgen stream channel type, degree of incision, soil type and dominant vegetation and monitoring the depth to the shallow riparian groundwater table during several seasons. The monitored groundwater depth was used to confirm a water balance model of the depth to the water table in the riparian corridors.
**Groundwater and Agriculture: What’s Working and What’s Missing?**

*Brian Bohman, Freshwater Society and University of Minnesota*

Despite the effort of farmers, researchers, regulators, and environmental advocates, Minnesota has not yet been able to meaningfully move the needle towards clean water when it comes to groundwater and agriculture. Nitrate contamination in groundwater has become one of the most important and expensive environmental issues for public water suppliers, their rate payers, and private well owners.

A report released by the Freshwater Society *The Water Underground: Implications for Agriculture and Opportunities for Change* finds that while the current suite of agriculture best management practices have been widely adopted, they haven’t done enough to fix the problem altogether. New precision agriculture management practices are showing potential to improve the nitrogen and water use efficiency of producers, which should also have positive environmental benefits. However, the consensus of available evidence points towards the need for wholesale changes to cropping systems to achieve our non-degradation goal and have groundwater that is safe to drink.

These system changes are impeded by structural barriers which make it difficult for farmers to voluntarily adopt additional groundwater friendly practices. Through a series of workshops hosted in partnership with the East Otter Tail SWCD, a group nearly 100 farmers and agricultural professionals expressed that strategies such as shifting the public narrative, facilitating local information exchange, and providing technical assistance would make a positive impact on their existing work to protect groundwater. These insights from farmers as well the best available science provide a sense of what’s working and what’s missing when it comes to groundwater and agriculture.

**Nitrate Leaching Reductions to Groundwater Beneath a New Perennial Grain Crop**

*Jacob Jungers, Don Wyse, David Mulla, University of Minnesota; Lee DeHaan, The Land Institute; Craig Sheaffer, University of Minnesota*

Nitrate nitrogen (NO3-N) leaching from fertilized annual crops can contaminate groundwater and pollute natural aquatic ecosystems and rural drinking water sources. Intermediate wheatgrass (IWG; Thinopyrum intermedium) is a perennial grass that is being domesticated to serve as the world’s first widely available perennial grain crop. Our objective was to measure water quality variables and crop yields to model NO3-N leaching beneath IWG, maize, and switchgrass under three N fertilizer treatments; low N (0 kg N ha⁻¹), medium N (maize = 80, switchgrass and IWG = 40 kg N ha⁻¹), and high N (maize = 160, switchgrass and IWG = 120 or 160 kg N ha⁻¹). The NO3-N concentration in soil solution 50 cm below the surface was one and two orders of magnitude lower in high N fertilized IWG compared to switchgrass and maize, respectively. Soil solution NO3-N increased with N fertilizer in all crops. Soil water content was less at 50 and 100 cm depths in IWG compared to switchgrass and maize; but was unaffected by N fertilizer treatment. Using the Denitrification and Decomposition (DNDC) model, average annual NO3-N leaching estimates in the high N treatments were 33.6 kg N ha⁻¹ for maize and 3.0 and 0.2 kg N ha⁻¹ for switchgrass and IWG, respectively. Intermediate wheatgrass has great potential to provide food-quality grain and biomass while preventing NO3-N leaching.
Concurrent Session III, Track D

2016-2017 Pesticide Results From the Private Well Pesticide Sampling Project

Jeff Paddock and Brennon Schaefer, Minnesota Department of Agriculture

In 2014 the Minnesota Department of Agriculture (MDA) began an ambitious project to sample private drinking water wells that had previously tested positive for the presence of nitrate. The primary purpose of the Private Well Pesticide Sampling (PWPS) Project is to provide information to homeowners about the presence of pesticides in their private wells. The PWPS data also helps fill data gaps in areas of the state where limited groundwater pesticide data information is available. PWPS sampling occurs as a follow-up to the Township Testing Program which targets private wells in townships with row-crop agriculture and vulnerable groundwater, offering free well testing for nitrate. The Township Testing Program and PWPS Project are funded primarily by the Clean Water, Land and Legacy Amendment.

Pesticide samples were collected by MDA staff and analyzed for approximately 125 pesticides and pesticide degradates. From 2014 through 2017 the MDA sampled approximately 3,750 wells in nineteen counties. Pesticides and/or pesticide degradates were detected in 70% of wells sampled in 2016-2017. During this same period, 63 different pesticides and pesticide degradates were detected in the private wells. The most frequently detected compound was metolachlor ESA, a degradate of the herbicide metolachlor. Pesticide concentrations were generally very low, although concentrations exceeded the health reference values in three wells. Confirmation samples collected later from the three wells indicated the previously elevated compounds were all non-detect. The MDA anticipates that approximately 7,000 wells will be sampled by the time the PWPS Project is complete in 2020.

Managing an Invisible Resource: an Assessment of Local Needs for Groundwater Protection

Sarah Fellows, Amit Pradhananga, and Mae Davenport, University of Minnesota

Groundwater protection requires coordinated action from multiple stakeholders across jurisdictional boundaries including at the state (e.g., state agencies) and local levels (e.g., soil and water conservation districts, counties, cities). The success of state-level initiatives depends on the participation of local government units (LGUs). Therefore, it is critical to understand capacities and constraints associated with groundwater protection at the local level. This purpose of this study was to identify and prioritize critical capacity-building needs of LGU and SWCD staff in groundwater and drinking water protection. Data were gathered using a statewide survey of SWCD and LGU staff in 2015 and 2017, respectively (n=671). The survey was administered online using Qualtrics. The survey inquired about respondents’ technical expertise in groundwater issues, their perspectives on groundwater protection, and importance and effectiveness of various groundwater related roles (e.g., conservation practice implementation, community engagement). Study findings suggest that while SWCD and LGU staff were aware of groundwater issues, and believed that groundwater issues are important to their organization, they lack the resources and technical expertise needed to protect groundwater. Additionally, data were analyzed using importance-performance analysis to identify areas of need for groundwater protection. While respondents believed that local community member engagement and education and outreach are important to address groundwater issues, they were unsure or disagree that their organization is effective in these roles. Findings suggest that enhancing staff capacity to engage local community members in groundwater protection is a critical need. Further implications for groundwater planning and programming will be discussed.
Concurrent Session III, Track D (continued)

Risk Communication in the 21st Century
Anna Arkin, Tannie Eshenaur, and Katie Nyquist, Minnesota Department of Health

Contaminants of emerging concern present a new communication challenge. Why is risk communication important and how is it different from emergency communication? How do we communicate with customers so that they are aware of contaminant risks but continue to maintain confidence in public water supplies?

The Minnesota Department of Health (MDH) is creating a risk communication toolkit to help public water systems across Minnesota communicate about drinking water contaminants. MDH staff will present on the importance of risk communication, our new risk communication toolkit, and some strategies for communicating about drinking water contaminants with your customers so that they are aware of risk but still have confidence in their tap water.

As part of this project, MDH also interviewed several drinking water systems across the state. We will touch on findings from these interviews, including what has and hasn't worked for MDH and these systems when communicating with customers about contaminants in drinking water.

Flooding and Private Wells: A New Approach to Anticipating Future Impacts and Reducing Public Health Risks
Emmy Waldhart and Kara Dennis, Minnesota Department of Health

Minnesota private well users are vulnerable to climate change impacts on source waters. However, climate projection data are often not available in the form needed for adaptation planning. We present an approach utilizing projection data to characterize future flood impacts on private wells and potential exposures to nitrate contamination.

A GIS-based model was developed based on precipitation projections, well locations, floodplains, land use, and demographics to derive a composite index of future vulnerability. We describe the process of adjusting projection data to reflect precipitation extremes using available data and basic measures of statistical distribution. Results were cast in a qualitative frame of flood risk by comparing to past rainfall events that led to federal flood disaster declarations at the county level.

Our approach for estimating precipitation extremes produced values similar to those at the 95th percentile using historical data, demonstrating that this method is reliable for estimating future extremes using projection data. Counties with the highest projected extremes also have a majority of susceptible wells. Our composite index suggests that even where nitrate applications are high, overall vulnerability can be low if wells are not within a floodplain and population growth will be minimal.

Our approach for estimating future flood risk to private wells is accessible, transparent, and therefore transferable to other jurisdictions. As a case study of scenario-planning, this approach is an example of how professionals outside of climatology can and should apply climate projection data to support the design and implementation of adaptation strategies within their own sectors.
Concurrent Session IV, Track A

Proliferating Blue-Green Algae in Minnesota Lakes

Shahram Missaghi, University of Minnesota Extension; Richard Kiesling, United State Geological Survey; Adam Heathcote, Science Museum of Minnesota

Minnesota communities are facing potential negative environmental, health, and economic consequences of harmful and toxic algae. Freshwater Harmful Algal Blooms (HABs), formed primarily by toxin-producing strains of blue-green algae, pose specific and serious health risks to animals and people through contact with affected waters and through ingestion of algae and toxins in water, particularly when communities depend on lakes for swimming beaches or drinking water, as is the case for approximately 20% of the residents of Minnesota. Over the past three years, the MN HAB Group, a collaborative research team and funded in parts from the Environment and Natural Resource Trust Fund, has worked to develop an understanding on how to detect, track and predict the development and persistence of freshwater harmful algal blooms in Minnesota lakes. The Group has also facilitated collaboration and communication in research, education, training, and statewide outreach through an annual MN HAB Workshop sponsored by the University of Minnesota. To date, the Workshop has provided training to over 100 water resources students, professionals, and practitioners.

As part of our presentation, we will also share information on algae bloom terminology, with a focus on blue-green algae in Minnesota lakes, while sharing our updates on advanced monitoring and modeling research. The session participants will be invited to join in a conversation on how to better increase our understanding of blue-green algae in Minnesota lakes and discuss how we can work together to increase the resiliency of Minnesota communities to the potential for toxic algae breakouts.

Predicting Harmful Algal Blooms in Minnesota Lakes with a Three-Dimensional Coupled Hydrodynamic-Ecological Numerical Model

Jackie Taylor, University of Minnesota; Shahram Missaghi, St. Anthony Falls Laboratory; Vaughan Voller and Miki Hondzo, University of Minnesota, Twin Cities

Harmful algal blooms (HABs) are the most imminent threat to freshwater quality across the globe (Bryan W. Brooks; R. S. Hans W. Paerl). As anthropogenic activities accelerate lake eutrophication, HABs are expected to increase in magnitude and duration; yet, our ability to predict and properly characterize HABs is lacking. Our project aims are to improve a three-dimensional water quality model to accurately forecast HABs using a high-frequency data collection station for improved analysis.

The University of Western Australia developed the hydrodynamic Estuary, Lake, Coastal Ocean Model (ELCOM) and the ecological Computational Aquatic Ecosystem Dynamics Model (CAEDYM). When coupled together, ELCOM-CAEDYM has been used to model three-dimensional HAB formation in lakes (Shahram Missaghi; S. W. Chung; Clelia Luisa Marti); however, most studies rely on infrequent grab samples or short duration monitoring for calibration. Our group used ELCOM-CAEDYM to simulate HAB evolution in South Center Lake, located in Chisago County, MN, during the 2017 summer season (May - October). To improve calibration and strengthen verification, an Eulerian research station was anchored in South Center Lake for the duration of the study. Meteorological measurements were recorded every five minutes, and water quality parameters were measured throughout the water column every even hour. Results demonstrate strong temporal and spatial prediction of lake thermodynamics and chemical composition and adequate temporal prediction of phytoplankton biomass. By the end of the 2018 summer season, our group will have improved simulations of vertical distribution of HAB biomass by implementing temperature- and light-dependent buoyant velocities of cyanobacteria into ELCOM-CAEDYM.
Concurrent Session IV, Track A (continued)

Building a Carp Management Program in the Rice Creek Watershed

Matt Kocian, Rice Creek Watershed District; Przemyslaw Bajer, University of Minnesota

When sufficiently dense, common carp negatively impact clarity by their feeding behavior. Management of carp will be needed to meet water clarity goals on some lakes. Such is the case with Long Lake in New Brighton, MN, where algae blooms are frequent and carp densities are exceptionally high (800 kg/ha!). The Rice Creek Watershed District (RCWD) has initiated a carp management program to reduce carp density and improve water clarity in the Long Lake system. Beginning in 2014, the University of Minnesota and the RCWD have been tracking, aging, and modeling the carp population. Implanted radio- and PIT-tags indicate complex migratory patterns, with carp traveling long distances between their winter habitat (Long Lake) and their spawning habitat. Aging data show that recruitment is occurring almost annually, with fish aged 3-30. Models suggest that significant adult removal and effective recruitment suppression will be needed to reduce the population and improve water clarity. Recently, several new and innovative management strategies have been tested, including box netting, a low-voltage electric barrier, and a Whooshh transport system. Box netting may be an effective means for removing adult carp, but labor costs are relatively high. A portable, low-voltage, bed-mounted electric barrier is being tested to block migration or direct migrating fish into a pen for removal. Initial test results are positive, with greater than 90% efficacy. The Whooshh, a volitional-entry transport system, is being tested with the electric barrier as an economical means for removing trapped fish.

A Watershed’s Role in AIS: From Committee Concepts to Rapid Response

Laura Jester, Bassett Creek Watershed Management Commission; Margaret Rattei and Karen Chandler, Barr Engineering Company

Like many watershed organizations, the Bassett Creek Watershed Management Commission (BCWMC) found it difficult to define what their role should be in aquatic invasive species (AIS) management. The BCWMC knew AIS was a significant concern among some watershed residents and realized that many entities had varying levels of involvement in AIS issues. The BCWMC set out to determine what was already being done and how they could fill gaps.

The BCWMC convened an Aquatic Plant Management/Aquatic Invasive Species (APM/AIS) Committee in 2016 to discuss and consider the BCWMC’s possible role in these issues. The committee included BCWMC and city staff, and multiple partners including representatives from lake groups, Three Rivers Park District, Minneapolis Park and Rec Board, Hennepin County, Met Council, and the MnDNR. First, the committee identified activities needed to address AIS early detection, monitoring, vulnerability assessments, rapid response needs, boat launch management, education, AIS treatments. Then, the committee identified the entities already filling all or parts of these roles and determined how the BCWMC could assist with and augment these activities.

The BCWMC approved the committee’s recommendations, including a new APM/AIS budget, and development of an AIS rapid response plan. The rapid response plan was completed in early 2018 for key AIS species (starry stonewart, Eurasian watermilfoil and zebra mussels) in priority lakes. It was developed after in-depth discussions with the BCWMC partner organizations and is the first of its kind to involve multiple partners. The plan outlines the actions required to address new AIS infestations including communication, surveys, containment, and treatments, and it defines the roles of the BCWMC and partnering entities so they can efficiently and effectively respond to new infestations. The BCWMC is already implementing the rapid response plan to address a new zebra mussel infestation in Medicine Lake.
Concurrent Session IV, Track B

2-Phase Modular Bioreactor Under Spring High Flow and Cold Conditions
Andry Ranaivoson and Jeffrey Strock, University of Minnesota; Gary Feyereisen and Kurt Spokas, ARS-USDA; David Mulla, University of Minnesota

New strategies are needed in order to meet water quality goals outlined in the Minnesota Nutrient Reduction Strategy. Our objective was to design a novel bioreactor with the capacity of removing both nitrogen (N) and phosphorus (P) from agricultural drainage water. An experiment was conducted at the University of Minnesota Southwest Research and Outreach Center near Lamberton during 2016 and 2017. A bioreactor was designed which consisted of a cube-shaped reinforced tank, porous lava rock, a sheet of Brotex, a honeycomb shaped geotextile cellular containment material, a layer of wood chips and a layer of corn cobs. Three materials were selected for the P removal media including sieved steel slag, crushed, recycled concrete or limestone. The concept for the bioreactor system was a modular system that could be installed at the edge of a field for drainage water treatment and removed when necessary for maintenance and replaced.

Between April and May 2017 the cubes underwent a period with a high rate of discharge. During this period, P load was observed to increase in the bioreactor outflow. This led to the conclusion that P desorption rather than sorption occurred during those two months. In general, nitrate load reduction was lower in 2017 compared to 2016 due to a reduction in the concentration of supplemental carbon delivered to the cubes. Additionally, it was observed that the redox conditions, which influence denitrification, were strongly impacted by temperature. The reduction in denitrification rate was planned a priori in an attempt to reduce the production of excess extracellular polymeric substances (EPS). Each cube showed unique behavior with respect to N and P load reduction. The crushed concrete cubes performed at a satisfactory level with respect to recovery rate of N and P load reduction following the months of April and May compared to steel slag and limestone.

Can Woodchip Bioreactors Meet WQ Goals By Denitrifier Enhancement Or Carbon Dosing?
Gary Feyereisen, USDA-ARS; Satoshi Ishii, Ping Wang, Emily Anderson, and Jeonghwan Jang, University of Minnesota; Ehsan Ghane, Michigan State University; Scott Schumacher, Ed Dorsey, Carl Rosen and Michael Sadowsky, University of Minnesota

By-pass flow and cold temperatures limit nitrate load reductions in woodchip bioreactors in northern climates. For example, in Minnesota, on average one half of annual tile drainage losses occur by the middle of May. This field study was conducted to improve bioreactor performance during cool, springtime temperatures by additions of either cold-adapted denitrifier strains (bioaugmentation) or a readily available carbon source (biostimulation). These effects were investigated at a replicated bioreactor site on a private farm near Willmar, Minnesota. Results from 2017 show that biostimulation dramatically reduces nitrate outlet concentrations, but stimulates biofouling of the bed, which restricts flow. The nutrient removal corresponds to an increase in nosZ gene abundance for the biostimulation treatment. Two denitrifier strains were introduced in 2016 and 2017 with mixed results. Laboratory selection continues and a fourth inoculation and biostimulation campaign is being conducted in spring of 2018. The anticipated outcome of this research is a technology that substantially improves the nitrate removal effectiveness of woodchip bioreactors under springtime conditions.
Concurrent Session IV, Track B (continued)


*Mike Nielson, Jeff Cheng, and Pete Willenbring, WSB and Associates*

For many years, the City of McGregor has been experiencing significant flooding problems in a drainage system served by Judicial Ditch 5. Since 2005, the City has been trying to implement a standard repair project to improve the capacity of the Ditch and alleviate this flooding, but had been unable to proceed based on MPCA findings that such a project would result in the loss of nitrogen, phosphorous and sediment retention within the drainage system, and increase the loading of these pollutants downstream to the Sandy River, Steamboat and Davis Lakes, and ultimately to Big Sandy Lake.

To respond to this concern, the City of McGregor partnered with WSB & Associates and St. Cloud State University to study this issue, and developed a design approach that would not only allow the needed drainage system capacity improvements to be implemented, but also implement other improvements that would reduce the phosphorous, nitrogen and sediment loadings from the system to the extent needed for the project to meet Section 401 water quality requirements.

This presentation reviews the findings of this study, and provides specific information on a design approach that removes phosphorus, nitrogen and sediment from storm water runoff using 1) taconite tailings as the source of iron to bind with phosphorus, and 2) bio-reactors that use wood chips to facilitate the reaction.

Sulfide Capture By Iron-Bearing Mining Byproducts in Northern Minnesota

*Jeanette Voelz, University of Minnesota; Jacob Daire, University of Minnesota - Duluth; William Arnold, University of Minnesota; Nathan Johnson and Chan Lan Chun, University of Minnesota - Duluth; Lee Penn, University of Minnesota*

Sulfide contamination of freshwater resources from industrial activities such as mining and manufacturing is a major concern due to its adverse impact on aquatic ecosystem. One known sink for sulfide is iron. Solid byproducts from iron mines contain iron-bearing minerals such as goethite, hematite, magnetite, siderite, ilmenite, and olivine. Depending on the mineralogy of the iron-rich mining waste rocks, these materials may have use in sulfur-capture systems within mining discharge streams. We investigated the relative sulfide removal capacities of well-characterized iron-rich mining waste materials from several mines in northern Minnesota and compared the results with pure iron-bearing minerals. Parallel to abiotic studies, microbial iron liberation experiments were also performed. Mining materials containing siderite were most effective at sequestering sulfur in abiotic reaction conditions.
Concurrent Session IV, Track C

EnviroDIY Open-Source Technologies for Cost-Effective Water Quality Monitoring and Automated Sampling

Anthony Aufdenkampe, LimnoTech; Beth Fisher, University of Minnesota; Craig Taylor, LimnoTech; Bobby Schulz, University of Minnesota; Sara Damiano, Stroud Water Research Center

The last several years have seen a revolution in extremely low-cost and often open-source wireless sensing devices that share real-time data via the internet. Here we present two projects to develop sophisticated, solar-powered wireless water quality monitoring stations by building on open-source electronics hardware and software at a fraction of the cost of commercial, black-box systems. The brain of our stations is the Arduino-compatible Mayfly data logger board, developed by the EnviroDIY community for sharing do-it-yourself (DIY) ideas for environmental science and monitoring.

For Riley Purgatory Bluff Creek Watershed District, we developed stations that measured water depth, conductivity, turbidity and temperature for $1500 per station. For Winona State University, we developed stations that measured water depth, conductivity, turbidity, dissolved oxygen, pH and water temperature, in addition to rainfall, barometric pressure, humidity and air temperature. In addition, these stations trigger an automated sampler based on turbidity values that exceed a threshold. All of these stations were completed in Spring 2018 for deployment in 2018.

Monitoring Program Evolution: Improving Efficiency, Accuracy, and Consistency

Joe Sellner and Britta Belden, Capitol Region Watershed District

Capitol Region Watershed District (CRWD) established a monitoring program in 2004 to collect data on the water resources of the District, including stormwater, lakes, wetlands, and BMP performance. The goals of the program are to identify water quality problem areas, quantify the runoff and pollutant loading of the watershed to the Mississippi River, and promote understanding of District water resources. As the monitoring program expanded and the dataset grew, the ability to effectively and accurately collect, and more importantly analyze and use, data was hampered by inefficient methods and limited staff time. These constraints were a result of manual activities such as station maintenance, data retrieval, sample collection, data QA/QC, data calculations and report generation. CRWD has been able to optimize efficiency and accuracy by automating manual tasks, where possible, reducing time spent in the field by implementing remote access, and developing a web data portal for user-generated reports. The monitoring program has been further optimized by ensuring that monitoring site selection, equipment selection and sampling frequency are tailored to specific end goals. These increases in efficiency have allowed CRWD’s monitoring program to continue to expand without increasing staffing or compromising data quality. More staff time can be devoted to putting data to use instead of simply collecting it. Similar opportunities exist within other organizations and monitoring programs and CRWD hopes to share their solutions to some common inefficiencies.
Concurrent Session IV, Track C (continued)

Pesticide Monitoring in Minnesota Lakes
Matt Ribikawskis, David Tollefson, and Bill VanRyswyk, Minnesota Department of Agriculture

The Minnesota Department of Agriculture (MDA) analyzed pesticide water quality samples collected from Minnesota lakes during the 2017 National Lakes Assessment (NLA). The NLA is a statistical survey of the condition of our nation's lakes, ponds, and reservoirs coordinated by the US Environmental Protection Agency. It is designed to provide information on the extent of lakes that support healthy biological condition and recreation, estimate how widespread major stressors are that impact lake quality, and provide insight into whether lakes nationwide are getting cleaner. The lakes in Minnesota were randomly selected and samples were collected by the Minnesota Pollution Control Agency as surface grabs over the deepest portion of the lake. Samples from 50 lakes were analyzed for 150 pesticide compounds including glyphosate with an additional 101 lakes targeted specifically for glyphosate analysis. Seventeen different pesticide related compounds were detected at least once and a total of 147 pesticide detections were measured. Of the 147 pesticide detections, 97 detections were herbicide degradates, 47 detections were herbicides, two detections were insecticides and there was one fungicide detected. With the exception of the two insecticide detections, all pesticide concentrations were well below the applicable water quality benchmarks. Hydroxyatrazine and 2,4-D were the most frequently detected pesticide compounds; both were detected in 46% of the lakes sampled. Total pesticide concentrations were generally higher in western and south-central Minnesota lakes and lower in north and northeast Minnesota lakes. The 2017 pesticide data will also be compared to NLA pesticide surveys completed in 2007 and 2012.

Advancing Satellite-Based Remote Sensing Methods for Lake Water Quality and Ice Phenology
Benjamin Page, University of Minnesota Water Resources Center; Leif Olmanson, Remote Sensing and Geospatial Analysis Laboratory

To understand and ensure the sustainability of inland aquatic ecosystems on a regional scale, alternative monitoring techniques will be imminent for effective management. With the expanding constellations of low Earth-orbiting satellites, advances in water quality and ice-phenology mapping products from remote sensing systems have excellent potential to improve the reporting abilities of state agencies and assist day-to-day management. The increased spectral, radiometric, spatial and temporal resolution of satellites such as NASA's Landsat-8 and ESA's Sentinel-1/2 enables more frequent monitoring of Earth's inland water bodies, and will permit more automated image processing applications for lake resource managements. This project advances remote sensing techniques in optically variable inland lakes by generating regional bio-physical models of surface waters from calibrated, multi-spectral imagery and synthetic aperture radar data across 12,000 lakes at high frequency and low cost. Due to the large data volume and processing requirements, Google's Earth Engine was used to facilitate the pre-processing and analysis phases for this study in preparation for the eventual migration of the validated models into the University of Minnesota's Supercomputing Institute. The production of frequent, near-real time maps on water clarity (measured in terms of secchi disk transparency), chlorophyll-a, colored dissolved organic matter, non-algal suspended solids, and ice phenology indicators for lakes across Minnesota will not only enable water quality and fisheries managers to understand the dynamics of lake ecosystems over time, but also mitigate potential aquatic hazards, thus yielding positive societal and economic benefits. Time series of water quality and ice phenology products will be discussed.
Concurrent Session IV, Track D

Cedar River Watershed - Multiple Scales for Cooperative Management

*Bill Thompson*, State of Minnesota, Minnesota Pollution Control Agency

The Cedar River Watershed in Minnesota covers about 600 square miles of land in Mower, Freeborn and Dodge Counties, of southern Minnesota. The main stem of the Cedar River encompasses 54 river miles, before entering Iowa. Like many watersheds in southern Minnesota, water resources are affected by land use and land management practices, including both rural/agricultural and urban areas. The Cedar River watershed is addressing land and water challenges with people and institutions working cooperatively, at multiple scales. This presentation will cover water quality, water quantity, BMP implementation, the application of numerous predictive models and tools, institutional arrangements, watershed planning, public sector/private sector collaborations, and what lessons we have learned over the last 15 years. With an increase in the public's interest and use of the Cedar River, an assessment of our joint work and the development of common plans and strategies for improvement, will be reported.

Creating Watershed Plans that Build Capacity in the Long Term

*Melissa Bokman*, Scott County

The Scott Watershed Management Organization (Scott WMO) has been experimenting with various methods of changing behavior of individuals to want to do conservation and stewardship since 2011. We learned quickly that we needed to better understand what landowner’s beliefs, attitudes and motivations associated with water resources and conservation were. In 2017, the Scott WMO embarked on updating its Comprehensive Water Resources Management Plan and intentionally considered these elements of capacity building as a framework for the Plan versus project identification. Building capacity is a management philosophy that guides operating our programs and how we will approach implementation of various priorities and strategies, with specific details woven into the descriptions of the various implementation programs in our new Plan. The Plan was designed around building capacity to incorporate the preference for achieving long-term sustainable solutions in our watershed. The presentation will focus on what our guiding principles are for building capacity with individuals, communities, organizations and programs, with examples of how they now have been integrated into our programs. This focus and deliberate intention with respect to building capacity is a new concept in water planning.
Concurrent Session IV, Track D (continued)

No Smoking Gun? The Challenge of Prioritization in a Protection Watershed

Julie Blackburn, RESPEC; Shawn Tracy, HR Green

The Leech Lake River watershed is one of the most pristine in the state with an abundance of high quality forests, wildlife, surface water, and groundwater. The richness of its high-quality resources presents unique challenges in prioritized and measurable outcome-based planning. There is no smoking gun in this watershed that drives issues or to base restoration targets on. This 1W1P process employed a hierarchy of resource values focused on sustainability to build a 10-year management plan. Analytics of key words from current plan goals and stakeholder surveys formed a hierarchical set of priority values. Elements from the Envision planning process where adapted to provide a holistic framework for evaluating and prioritizing the community, environmental, and economic benefits of where and how management activities will be implemented. An assessment of current implementation actions was completed identifying resource vulnerability and protection needs. Next, an iterative assessment and prioritization process considered future threats related to priority values related to natural resources, climate and risk, quality of life, and leadership. Three increasing levels of goal attainment were developed for each: 'Maintain, Enhance, and Protect' and metrics were established for each management level. Stakeholders then selected 10-year management levels for each value. Subwatersheds were targeted and prioritized by screening by their degree of opportunity to meet each resource value goal. As opposed to typical natural resource planning solely focused on water quality treatment, implementation actions were prioritized by their ability to meet a comprehensive set of values that work together to help ensure sustainability. The creative adaption of Envision and a value-based prioritization process, as the foundation of implementation action selection, will be discussed. The draft 1W1P will begin the review process in fall 2018.

Interactive Water Resources Programs for Planetariums in Minnesota

Sally Brummel, Bell Museum; Claire Halloran, University of Minnesota

Water flows out of Minnesota in three directions and our personal and public choices have impacts far beyond our borders. Understanding these impacts from a local to global perspective is necessary in order to address Minnesota’s water challenges of the present and future. The Bell Museum and statewide partners are creating planetarium programs on water resources to be featured at eight planetariums throughout Minnesota and via the two portable planetariums in the University of Minnesota system. Minnesota Water Stories is uniquely designed as an interactive and audience participatory experience tailored to the water stories relevant to each region. The production team will combine media, satellite data, and science results in these live presentations to support a statewide dialogue around water. Using compelling original stories, presenters will guide citizens through a visual experience that transports them from outer space to inside a water molecule and all scales in between. The objectives are to have audience members and planetarium professionals develop an understanding of relationships of water-related ecological issues to larger systems (e.g., the cosmic, global, regional, and local impacts), and build relationships with community partners around solutions to these challenges. In spring 2018, the Bell Museum presented pilot programs in coordination with planetariums in Duluth and Moorhead, as well as in their portable planetarium at a school in Bloomington. The University of Minnesota Center for Applied Research and Educational Improvement (CAREI) performed a formative evaluation on the pilot presentations, to determine whether they met the objectives. The formative evaluation will inform production of a final program which will debut in the Bell Museum's Whitney and Elizabeth MacMillan Planetarium 2018 and be delivered in planetariums across the state in 2020. Funding is provided by the Minnesota Environment and Natural Resources Trust Fund.
Concurrent Session V, Track A

Connecting Fisheries to Water Quality: A Biological Aspect to TMDLs?

Tom Langer and Jeff Strom, Wenck Associates

Shallow lake ecosystems are prevalent throughout the Western Corn Belt and Central Hardwood Forest ecoregions of Minnesota. Located in urbanized or agricultural landscapes, the State of Minnesota’s Total Maximum Daily Load (TMDL) approach for these systems has focused on quantifying the watershed nutrient inputs/sources first, and then uses literature rates and/or model residual to estimate and explain internal nutrient sources. As more and more watershed TMDLs are being completed, we are finding this approach problematic as the TMDL modeling is suggesting internal sources are a larger source of nutrients than watershed sources. We present case studies for impaired shallow lakes in both urban and rural settings that investigated internal and external nutrient loading and found evidence supporting the deleterious impacts of fisheries on water quality. Specifically, we discuss the need for fisheries management as a best management practice (BMP) to address required nutrient reduction targets. The degradation of water quality due to certain fish species is well documented in scientific literature, yet, over the past decade management groups are focusing almost exclusively on common carp management to improve water quality condition. However, high densities of native species (i.e. black bullhead, fathead minnow) or an imbalanced fishery can also have deleterious effects on water quality and alter habitat conditions within shallow lake ecosystems. We show the importance of assessing/evaluating the entire fish community during the shallow lake TMDL process and the need for fisheries management as a BMP to meet required nutrient reduction targets. This topic also has implications for aquatic invasive species management and protection efforts/strategies for shallow lakes that are currently meeting state water quality standards.

Restoring Streambank Stability to Achieve MS4 Water Quality Objectives - An Overview of Chesapeake Bay TMDL Experiences & Applications in Minnesota

Josh Running, Stantec Consulting, Inc

Legislative and regulatory changes in 2013 led to significantly increased compliance challenges for all MS4 localities (6 states and DC) within the Chesapeake Bay watershed. These localities are now responsible for sediment and nutrient load reductions from existing sources, or retrofits. Upland BMP retrofits are commonly considered one of the more costly interventions on a dollar per pound of nutrients removed basis, while stream restoration, has recently shown to be one of the most cost-effective practices available to MS4 permittees. The EPA Chesapeake Bay Program Office (CBPO) currently estimates that 418 miles of urban stream restoration will be implemented by 2025 in Virginia and Maryland alone, because of these new water quality requirements.

To quantify nutrient reductions, the CBPO developed a practical guidance document outlining acceptable methodologies in a document titled Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects (approved May 13th 2013). Within this document, four protocols are described as acceptable to quantify these reductions for proposed WQ improvement projects. Over the past five years, Stantec has tested the relevant protocols, evaluated case studies, and provided our clients with direction on the most cost-efficient practices for sediment and nutrient crediting towards TMDL requirements, including stream restoration.

This presentation discusses the many of the findings and conclusions from the past five years on the East Coast and will be geared towards initiating an open dialog focused on stream restoration as potential treatment available for TMDL compliance in Minnesota. Data from two Stantec projects in Minnesota (Knowlton Creek in Duluth and Little Stuart near Two Harbors) will be presented to demonstrate how the quantified results from stream restoration can show positive water quality benefits to downstream receiving waters.
Concurrent Session V, Track A (continued)

Are TMDLs Enough? Risk and Uncertainty in the Lake of the Woods

Julie Blackburn, RESPEC; Cary Hernandez, Minnesota Pollution Control Agency; Mike Hirst, Lake of the Woods SWCD; Jesse Anderson, Minnesota Pollution Control Agency; Geoff Kramer, RESPEC

The Lake of the Woods TMDL is one of the most complex lake TMDLs ever undertaken in the state due to its size, history, and the relatively undeveloped nature of the watershed. These complexities are compounded by straddling an international border and a lack of long term water quality data. While the TMDL project may be wrapping up during the fall of 2018, the questions about the future of this lake continue to grow and these questions extend well beyond the equation of nutrient reductions to meet water quality standards. In the last 10 years an enormous effort has been underway to study and understand the Lake of the Woods. Studies have been conducted by governmental agencies, universities and research institutions, foundations, private companies, and citizen groups. Study results have shown that even with appreciable reductions in phosphorus concentrations, algal blooms have become more harmful and longer-lasting and occur later in the year and in more remote areas that are not directly impacted by historical loading. Other studies include forest change models aimed at predicting future conditions under disturbances such as climate change, while other studies have tried to predict future hydrologic patterns when considering forest change and increased temperatures that evapotranspiration. How will the lake respond to the impacts of these stressors? What are the appropriate adaptive management thresholds that will trigger a reevaluation of the restoration plan and possibly even the restoration target? The focus on this presentation is to provide a critique of risk and uncertainty of the LOW TMDL given environmental and climate stressors. A thorough review of recent studies that provide both answers and questions to future management scenarios will be provided as well as a draft framework for capturing uncertainty in adaptive management plans.

Benefit Metrics for Water Quality Regulation in Minnesota

Baishali Bakshi, Minnesota Pollution Control Agency

Water provides a variety of valuable ecosystem services or beneficial uses to Minnesotans such as recreation, drinking water, navigation, recreation and wildlife habitat. Water quality regulation such as the Clean Water Act helps protect, maintain, and restore lakes and streams so that water quality benefits can be realized. Water being a public good makes water quality benefits harder to measure compared to costs, disincentivizing water quality protection and valuation. Constructing metrics of water quality improvement due to regulation are the first step to measuring water quality benefits. We analyze Minnesota Pollution Control Agency’s data on water quality assessments, effluent discharges, water quality parameters, and best management practices to examine the relationship between water quality regulation and water quality change over time. We present analyses results as a set of usable metrics for measuring these water quality benefits due to regulation in Minnesota.
Overview of Improved Countermeasures in Minnesota

Solomon Woldeamlak and Aislyn Ryan, Minnesota Department of Transportation

Riprap is the most commonly used form of scour countermeasure for bridges. However, there are instances when Riprap application may not be suitable due to difficulty of placement or inability to keep in situ after installation. In order to combat those challenges, MnDOT has recently adapted two types of countermeasures: Matrix Riprap (partially grouted riprap) and Geotextile Containers (Geobags). Matrix Riprap is primarily used at MnDOT as a cost-effective alternative to more traditional armoring treatments to protect bridge abutments from scour during flood events, especially on abutments that experience high shear stresses. It consists of angular riprap that is glued together at rock contact points using a Portland cement based grout. Matrix riprap is used where riprap rock sources are of poor quality or in place of much larger standard riprap sizes. MnDOT has installed this countermeasure at a number of sites across the state. Geotextile Containers (Geobags) are primarily used at MnDOT as a method to install a filter layer in deep and/or moving water, generally to be placed prior to riprap installation. Geobags could also be used as standalone slope stabilization or scour countermeasures. A Geobag consists of a sewn geotextile filter bag filled with coarse filter aggregate. The finished dimension of each container is 4’ wide x 4’ long x 2’ thick. Each container is filled approximately 50% full, weighing about 1 ton each. We have installed this countermeasure at two sites in Minnesota: TH-43 bridge and I-90 bridge crossing the Mississippi River. In the case of TH-43 bridge, geobags were first installed as stand alone temporary pier scour protection during construction phase, while a system of geobags and riprap was installed after completion of the pier construction. Constant sonar monitoring has shown that the placement of the riprap-geobag system has stabilized the river bed from scour hole formation.

West River Parkway Slope Failure and Repair

Jim Herbert and Michael Haggerty, Barr Engineering Company; Cliff Swenson, Minneapolis Park and Recreation Board

On June 19, 2014, after historic sustained and heavy rains in Minnesota’s Twin Cities, an approximate 10,000 sq. ft. section of bluffs along the Mississippi River and adjacent to West River Parkway failed. The resulting mudslide covered the parkway with over 4,000 cubic yards of debris and soil and exposed several Fairview University of Minnesota Medical Center (UMMC) structures located near the bluff’s edge and a Minneapolis Park and Recreation Board (MPRB) property line. FEMA officially declared the site a disaster on July 21, 2014, and Hennepin County was added as an area eligible to receive reimbursement for disaster-related expenses.

Barr Engineering Co. was hired to implement monitoring of the slope and the adjacent infrastructure, perform field investigations necessary for final repairs, and engineer temporary and permanent repairs. An elevation change of 100 feet, 1:1 slopes, and seeping groundwater through soils and bedrock made the West River Parkway slope repair a challenging project. In addition, UMMC had several million dollars of business-critical infrastructure sitting at the edge of the failed slope. The slope repair design consisted of five retaining walls, soil nails, new stormwater and groundwater collection infrastructure, and erosion-control measures. The retaining walls consisted of micropile supported walls, drilled soldier pile walls one of which was constructed with limestone facing to emulate the adjacent limestone block wall built under the Works Progress Administration (WPA) - and modular block walls. Construction was challenging given the steepness and access of the slope as well as the seepage conditions and the environmentally impacted soils. The parkway opened to traffic August 2016. This presentation will provide an overview of the design and construction associated with this challenging project and include construction related photographs of backhoes, cranes and a spider excavator used for working on extreme slopes.
Concurrent Session V, Track B (continued)

**Reconnecting Fish Habitat On the Sand Hill River**
*Michelle Larson, US Army Corps of Engineers*

Fish passage and connectivity of fish habitat is an issue for streams that have grade control structures or dams. The upper reaches of many Red River of the North (RRN) tributaries have gravel channel bottoms where the river crosses through the beach ridge area left behind by the retreating glacial Lake Agassiz. The Sand Hill River in northern Minnesota had 4 drop structures for grade control due to a US Army Corps of Engineers 1950s channel straightening project near Beltrami, MN. Many times a rock rapids fishway can be constructed over the top and downstream of the dam. The narrow channel at the existing drop structures required modifications to lower velocities enough for fish passage at the rock rapids fishways. Construction of rock rapids fishways at each drop structure in 2017 has reconnected the substantial spawning and rearing habitat in the upstream Sand Hill River to the downstream reaches of the Sand Hill River and the RRN. The rock rapids fishways has also reduced erosion compared to the drop structures.

The construction of the fishways complements the Sand Hill River Grade Stabilization Project by the Sand Hill River Watershed District, which constructed about 16 rock riffles for stabilization of the channel grade and improved fish habitat. The synergy of the two projects together has greatly improved fish habitat connectivity and water quality in the river. This presentation will cover the pre-project conditions, design parameters, final design, construction phase with differing site conditions and current conditions of the fishways project.

**Urban Drainage Pollution Loading Modeling & Results**
*Lisa Vollbrecht, City of St. Cloud; April Ryan, Short Elliott Hendrickson, Inc.*

In an effort to protect and restore the region’s water resources, the City of St. Cloud analyzed urban pollutant loads and cost-effective improvements to manage and treat stormwater runoff. Efforts focused on two priority sub-watersheds. The Downtown sub-watershed consists of impervious surfaces with essentially no existing stormwater treatment before directly discharging into the Mississippi River, which is the City’s sole drinking water source. The Lake George sub-watershed includes residential and commercial land use from the Highway 23 corridor, which discharges to Lake George, an impaired water, before discharging to the Mississippi River. The presentation will focus on WinSLAMM modeling results, used to better understand the relationship between the sources of urban runoff and pollutant loadings. 140 minor catchments were modeled over a representative one year period and provide loading results on an annual basis for TSS, TP, and runoff volume. To prioritize city resources and funds, the City modeled BMPs ranging from street sweeping efforts, rainwater gardens, linear street BMPs, and grit chambers, to site specific and regional treatment BMPs. The presentation will include a summary of the BMP pollution reduction modeling results, cost estimates, and project prioritization recommendations. In addition to BMPs, recommendations include minimum design goals, enforcement efforts of ordinances, policies and design standards, and education and public involvement efforts. The presentation will touch on the City’s effective watershed focused, comprehensive approach to address urban stormwater pollution.
Concurrent Session V, Track C

1D/2D Urban Flood Modeling with XP-SWMM and PCSWMM

Heather Hlavaty and Kim Baker, Barr Engineering; Paul Hudalla, City of Minneapolis

The publication of NOAA's Atlas 14 has shed light on increased risk of flooding and brought about significant stormwater management challenges. Stormwater infrastructure often struggles to contain runoff, forcing flow onto the ground surface. Traditional methods for constructing dual-layer 1D hydraulic models are potentially becoming less representative of complex flow paths routing flow on the surface. With the increased availability of high resolution LiDAR data, and increase in computing power, two-dimensional (2D) hydraulic modeling is the future of complex urban modeling. The objective of this project was to compare model construction effort, hydraulic results, run time, data storage, and presentation capabilities of two modeling platforms: PCSWMM and XP-SWMM. A 288-acre urban study area was modeled with 1D/2D techniques in both XP-SWMM and PCSWMM. Watersheds were delineated to catchbasin clusters, each covering an area of one block or less. The storm sewer was modeled with 1D elements that passed water to the 2D grid at the surface. In general, flood inundation extents and elevations of the 2D models were similar to the detailed 1D benchmark model. Benefits using 2D modeling were: potential to save significant time capturing water, less reliance on engineering judgement of flow routing, and less potential for double-counting storage. Two-dimensional modeling also allows for the viewing of inundation results, flow velocity vectors, hazard classification, and animation options to clearly portray flood timing. The project indicates that 2D modeling in urban environments has the potential to replace 1D modeling in small study areas where high-resolution LiDAR data exists.

Computational Fluid Dynamics (CFD) as a Tool to Predict Storm Water Geysers: The Como Tunnel Case

Christian Frias, Brandon Barnes and Omid Mohseni, Barr Engineering Company

Over the past few decades, there have been efforts to predict geyser events and to design mitigation measures to prevent or control geysers. Current research indicates that the geysers are caused by a violent release of air-water mixture as a result of trapped air pockets in tunnel systems. Geyser events have been simulated via experimental and numerical models in the past. However, up to now, the simulations have been either too theoretical or conducted for simplified geometries and/or scenarios, with little or no practical use for control or prevention. Herein, two-phase flow computational fluid dynamics (CFD) models have been developed to simulate observed geyser events and to evaluate design alternatives for geyser mitigation measures on a tunnel segment in the City of Minneapolis, MN. The CFD models were validated using observed data such as pressure, geyser height and manhole maintenance records. The observed data was complemented with results from precursor hydrology models (i.e. velocities and pressure values for different locations in the tunnel). The model results allowed us to have an informed decision on geyser mitigation alternatives based on parameters such as geyser height, force on the manhole cover and volume of water expelled per geyser. Finally, three design alternatives were evaluated which intended either to contain the water expelled by the geyser (a surge chamber and an oversized manhole) or to avoid the violent release of air-water mixture (a modified tunnel connection).
Concurrent Session V, Track C (continued)

Leveraging 2-D Modeling for Stream Restoration

Roberta Cronquist and Jordan Thole, Bolton & Menk, Inc.

Leveraging new technologies and data resources creates an opportunity to better understand how our projects function in a real-world environment. Bolton & Menk will present case studies on the use of HEC-RAS 2-D flood modeling for stream restoration projects to aid in project development. Additionally we will discuss opportunities to use modeling results as a communication tool in illustrating and visualizing stream responses to changes resulting from restoration efforts. Projects to be presented will include: replacing an existing dam structure with a rock riffle; and, construction of bendway weirs to reduce stream bank erosion.

Modeling Mississippi River Dredging Strategies after the Lock Closure at Upper St. Anthony Falls

Alex Nelson, US Army Corps of Engineers

With the closure of the Upper St. Anthony Falls (USAF) lock in 2015, new opportunities have arisen to investigate eliminating channel maintenance in the upper navigation pools of the Mississippi River near Minneapolis and St. Paul, Minnesota. Since lockages through USAF have halted, the current dredging activities that are in place to ensure a nine-foot navigation draft in the pool may no longer be required. Additionally, due to reduced commercial boat traffic traveling to USAF through Lock & Dam No. 1 (LD1), elimination of channel dredging through this reach may also be warranted. The results of this sediment transport modeling study, using HEC-RAS hydraulic modeling software, show the relative differences in dredging quantities between the current channel maintenance practices and proposed alternatives. Modeled impacts for two alternatives, eliminating dredging above USAF and eliminating dredging above LD1, are quantified for the Mississippi River system through Lake Pepin in order to assess the viability of each strategy. In addition, future studies may utilize this model to analyze sediment trends through Lake Pepin and to investigate the feasibility of major operational changes (e.g. water level drawdowns) or physical changes (e.g. dam modification) at the structures in the navigation system.
Concurrent Session V, Track D

Cities + Citizens/Water Management = Strategies for Working Together

*Leslie Yetka, Freshwater Society*

Citizen involvement in municipal water resources management and decision-making has evolved over the past few decades, moving from general ‘raising awareness’ about policies, projects, and programs, to inclusion of perspectives in data collection and planning, to citizen participation as the norm in decision-making (albeit usually limited to the public hearing). We now find ourselves at a time where many citizens want to play a larger role in helping to identify problems as well as solutions to the complex issues communities are trying to address. And often, cities need them to be a part of the process (whether acknowledged or not). Effective engagement between cities and citizens leads to enhanced knowledge of problems and solutions, along with increased buy-in of decisions made. However, if this is the case, why can good engagement be so challenging to achieve? More importantly, how can cities and citizens work together more effectively to achieve a community’s clean water goals?

A qualitative research project was conducted in 2017 in the Twin Cities metro area to answer these very questions, leading to a better understanding of the attitudes and beliefs held by citizens, city staff, and local decision-makers regarding the role of both cities and citizens in municipal water management. Through interviews and a focus group, themes of trust, transparency, a balance of knowledge, and feeling empowered emerged as being critical on both sides. Through this understanding emerged strategies that both cities and citizens should be mindful of as they work together to achieve success in reaching our clean water goals.

A Resident Survey of Minnesota Water Values

*Amelia Kreiter, Jaren Peplinski, Mae Davenport and Bonnie Keeler, University of Minnesota*

In Minnesota, access to clean and safe water is essential to health, recreation, cultural identity and economic development. Yet water is continuously undervalued or disregarded in land use and water resource decisions. Undervaluing water results not only in water impairments but also in public health problems and social inequities through the disproportionate distribution of water’s myriad ecosystem services (and burdens). To blame, in part, are predominating perceptions of an abundant supply of clean and safe water in Minnesota, as well as the prioritization of economic values over ecosystem health. University of Minnesota researchers, with funding from the Clean Water, Land and Legacy funds, the Environment and Natural Resources Trust Fund, and the McKnight Foundation, seek to understand and articulate the value of water to Minnesotans through social science survey research. The research will provide decision makers science-based information on diverse water values as well as (1) how Minnesotans use water, 2) what strategies for protection and restoration Minnesotans support, and 3) how Minnesotans prioritize limited resources for reaching water quality objectives. The survey is administered through an 8-page, 25-item questionnaire mailed to a regionally representative sample of 6000 Minnesota residents. The questionnaire includes a discrete choice experiment to assess value tradeoffs in distinct water management goals. This study broadens the water policy and spending deliberations in Minnesota to include resident values. Project findings will inform water program funding, policy development, and project evaluation.
Concurrent Session V, Track D (continued)

Educating for Positive Behavior Change

*Gael Zembal,* Nine Mile Creek Watershed District/Education and Outreach Coordinator; *Erica Sniegowski,* Nine Mile Creek Watershed District/Project and Program Manager; *Steve Gurney,* City of Bloomington/Water Resources Specialist

In 2017, the City of Bloomington and Nine Mile Creek Watershed District partnered on two creative education programs to raise awareness of water resource issues and promote positive behavior change. The Adopt a Drain program promotes removing debris from storm drains. Residents claim a drain at adopt-a-drain.org, then they receive educational materials and a sign to place in their yard. Twice a year, participants report the number of bags of debris gathered. In our pilot season, 69 participants adopted 92 drains. 46% of adopters collectively removed 145.5 bags of material. We estimate that this is about 4 to 12 pounds of phosphorus diverted from city waters. By engaging the community in their front yards, we hope to create new social norms around keeping storm drains pollutant free. Our goal for 2018 is 200 additional participants. The second program is a Pop-up cart funded by a Hennepin County AIS Prevention Grant that educates the public about preventing the spread of Aquatic Invasive Species (AIS). Staff presented interactive activities on AIS at community events and popular locations in Bloomington. In 2017, the Pop-up Cart attended eight events, and reached over 670 people in the four-month pilot. In a survey of participants, 76% said they would teach others about AIS, 68% said they would clean their fishing gear before using it in a new lake, and 66% said they would dispose of unwanted fishing bait in the trash. The City and the District will continue to use the cart in 2018.

Engaging with Communities to Develop Priorities for Cooperative Watershed Management: the Duluth Urban Watershed Advisory Committee

*Jesse Schomberg,* University of Minnesota Sea Grant; *Tiffany Sprague and Rich Axler,* Natural Resources Research Institute; *Brian Fredrickson,* Minnesota Pollution Control Agency

The 10 communities around Duluth, MN have been working together since 2015 to develop a collective watershed management strategy for the urban watersheds in this area. An advisory committee consisting of representatives from all communities included within these watersheds (5 townships, 4 cities, 1 county), as well as other agencies and organizations, was created in 2015 to not only inform watershed assessment and development of the WRAPS (Watershed Restoration and Protection Strategies), but to also provide recommendations for how these communities can work together to manage these watersheds more holistically. During 2015 and 2016, representatives from these communities and organizations met to explore the benefits and drawbacks of different watershed management models for this area, including a watershed district, joint powers board, and voluntary cooperation. After in-depth consideration and individual community meetings, a voluntary cooperation model is under development. As part of the process, the communities identified 5 priority areas where they see the greatest need for cooperation: 1) Regulation, Ordinances & Policies, 2) Community Training & Capacity Building, 3) Project Identification, Tracking & Prioritization, 4) Restoration/Protection/Preservation, and 5) Agency Cooperation & Engagement. Formalization of this organization through a Memorandum of Understanding is expected to be complete by 2018. The effort is being coordinated by the Minnesota Pollution Control Agency, Minnesota Sea Grant, and the Natural Resources Research Institute.
Concurrent Session VI, Track A

Quality in Bald Eagle Lake, MN

Joe Bischoff, Wenck Associates, Inc.; William James, University of Wisconsin-Stout; Brian Beck, Wenck Associates, Inc.; Matt Kocian, Rice Creek Watershed District

Bald Eagle Lake is a highly used recreational lake in the northern suburbs of the Twin Cities Metropolitan Area that routinely experienced cyanobacteria blooms. The Rice Creek Watershed District (RCWD) has actively managed Bald Eagle Lake for over 30 years, but recently developed a targeted nutrient reduction program, including a TMDL, focused on achieving measurable improvements in lake water quality. One of the critical TMDL goals was to quantify the roles of watershed and internal phosphorus loading in driving lake water quality. Laboratory-derived sediment P release was high at 10.8 mg/m2d, representing 44% of the P load to the lake. The RCWD decided to pursue an aluminum sulfate (alum) treatment to reduce sediment phosphorus release in Bald Eagle Lake. The alum dose required to inactivate 90% of the redox-sensitive P in the top 0-10 cm of profundal sediments was approximately 100 g Al/m2 based on laboratory jar tests. However, application of this rate throughout the lake was cost prohibitive. So, the 100 g Al/m2 rate was used for areas greater than 20 feet in depth and a lower rate of 50 g Al/m2 was used to inactivate the top 5 cm in the 15 to 20-foot depth zone. An adaptive alum application approach was used to achieve sediment aluminum targets and achieve the desired reductions in sediment phosphorus release. Half of the prescribed alum dose was applied to Bald Eagle Lake in the Spring of 2014 followed by sediment coring to measure changes in aluminum-bound phosphorus and sediment phosphorus release. Application zones and rates for the second (2016) application were adjusted based on the interim monitoring results. Following the completion of the alum applications, implementation of watershed BMPs and curly-leaf pondweed management, Bald Eagle Lake is meeting State water quality standards for the first time in over 30 years.

Spatial Distribution and Interrelationships Among Optical Water Quality Properties (Chlorophyll A, Suspended Solids, CDOM, and Secchi Depth) in Minnesota Lakes

Jacques Finlay, Patrick Brezonik, Leif Olmanson, Claire Griffin, Marvin Bauer, Raymond Hozalski, and William Arnold, University of Minnesota

Chlorophyll, suspended solids (SS), and colored dissolved organic matter (CDOM) are the main optical properties of lake water that influence water clarity (e.g., Secchi depth, SD) and also exert important controls on lake water quality and lake suitability for various intended uses. We explored relationships among these variables in Minnesota lakes using a database on >300 lakes sampled statewide from 2014 to 2017 as part of a long-term study to develop models based on satellite imagery for water quality indicators that affect lake optical properties. Distributions of chlorophyll and TSS were essentially orthogonal to distributions of CDOM; i.e., wide ranges found in the first two variables occurred over a narrow (and low) range of CDOM. In contrast, TSS, SD, and chlorophyll a values were highly correlated with each other, especially once the influence of high CDOM waters was removed. We used 2017 ground data to calibrate models to retrieve chlorophyll and SS concentrations from satellite imagery, and we used these models to map distributions of these water quality metrics in >10,000 lakes across the state based on surface reflectance values obtained from 2017 Sentinel 2 and Landsat 8 imagery. Preliminary analyses at the scale of aquatic ecoregions revealed stark differences in the distribution of these optical properties within and among the six major ecoregions of the state related to land-cover conditions of the lakes’ catchments. Rapidly improving remote sensing capacities will provide increasing ability to monitor and manage spatial and temporal changes in water quality across the state.
Concurrent Session III, Track A

Water Quality and Aquatic Ecosystem Responses to Changes in Water-Level Management for International Border Lakes

Jeffrey Ziegweid and Victoria Christensen, United States Geological Survey; Ryan Maki, National Park Service

Voyageurs National Park was established in 1975 to preserve the pristine scenery and remote system of interconnected waterways along the US-Canada border. The complexity of the waterways increased with the installation of dams in the early 1900s. The International Joint Commission set new rules governing dam operation for this system of lakes in 2000. Therefore the U.S. Geological Survey and National Park Service collaborated on several studies to evaluate water-level changes in these lakes and how they are related to various water-quality and ecological effects. Our research has shown a decrease in chlorophyll-a concentration and an increase in Secchi depth in two of the most eutrophic water bodies in the park. Substantial improvements were not seen for total phosphorus. A follow-up study suggested a possible link between frequent recirculation and internal recycling of phosphorus. Additional studies evaluated trophic state, flow direction, fish mercury concentrations, and cyanobacterial harmful algal blooms. These collaborative studies provided useful information for a Supplementary Order issued by the International Joint Commission in 2018, which prescribes a new method of regulating water levels of international border lakes.

Landscape Controls on Colored Dissolved Organic Matter Distribution in 10,000 Minnesota Lakes

Claire Griffin, Jacques Finlay, Patrick Brezonik, Leif Olmanson, Marvin Bauer, and Ray Hozalski, University of Minnesota

Colored dissolved organic matter (CDOM) in Minnesota lakes varies widely, with consequences for lake ecology, metals mobilization, drinking water treatment processes, and elemental cycling. High CDOM levels of some lakes in northern Minnesota decrease Secchi depths and can decrease primary productivity through light inhibition. Measured as absorptivity at 440 nm, CDOM can be measured by lab, field, and remote sensing techniques. Recent efforts have led to successful mapping of CDOM across the state using satellite remote sensing, in lakes ranging in size from 10 to 132,480 acres (Mille Lacs Lake). Using this extensive database of remotely sensed CDOM, we assessed watershed controls on lake organic matter distribution. Watershed land use, landscape position, lake morphology and area, and watershed area were included in both univariate and multivariate analyses to predict CDOM throughout Minnesota. Lakes in southern and central Minnesota, where agriculture and urbanization has led to drainage of wetlands, generally have low levels of CDOM. Preliminary results from northeast Minnesota show moderate, univariate relationships between CDOM and wetlands as a proportion of watershed land cover (R^2 = 0.35). Land cover variables alone do not strongly predict CDOM in the hydrologically complex northeast region of Minnesota, re-inforcing the use of remote sensing to map CDOM across broad spatial scales. Further investigation of such landscape controls is critical for improving our understanding of how watershed management practices will impact regional carbon cycling and CDOM export.
Concurrent Session VI, Track B

**Improving Water Quality, Flood Storage and Habitat Diversity in New Brighton’s Hansen Park**  
*Kyle Axtell, Rice Creek Watershed District; Dennis McAlpine, Houston Engineering, Inc.*

Originally constructed in 1969, the pond in New Brighton’s Hansen Park has since been filled by the accumulation of contaminated sediment from urban runoff and its fringes were engulfed by invasive monocultures of hybrid cattail and reed canary grass. Having long lost its ability to provide meaningful water quality treatment for runoff to Pike and Long Lakes, the pond was no longer providing adequate aquatic wildlife habitat. The design of the pond’s dam did very little to limit flood flows downstream or utilize available flood storage areas within the park. Seeking to remedy declining water quality in downstream Pike and Long Lakes and reduce the risk of severe flood damage in this area of the City, the Rice Creek Watershed District has completed the Hansen Park Comprehensive Water Management Project; the capstone in a series of projects funded in part by a 2014 BWSR Targeted Watershed Demonstration Program grant. Project components included a first-of-its-kind automated pump-controlled Iron-Enhanced Sand Filter (IESF) system, an adjustable-level outlet control structure, complete pond reconstruction including removal of contaminated sediment materials, native vegetation restoration and other ancillary park enhancements.

The $4,000,000 project is expected to reduce the annual phosphorus load to Pike and Long Lakes by 150-200 pounds per year, provide an additional 27.4 acre-feet of new flood storage within the park, and re-establish a high quality native plant community within and surrounding the pond. Operation of the automated pump-controlled IESF will began in earnest during the late summer of 2018 and early monitoring data from the entire project is anticipated to be available shortly thereafter. This presentation will detail the site history, regulatory challenges, engineering solutions and construction procedures that contributed to the project’s success, with a special focus on the operational functionality and beneficial outcomes of the project design.

**Alternate Side Inlet Calculator: a Conservation Tool for Sizing Side Inlets on Agricultural Drainage Systems for Temporary Storage and Sediment Removal**  
*Bailey Griffin, Chuck Brandel and Mark Origer, ISG*

The Alternate Side Inlet Calculator is a conservation tool for sizing side inlets on agricultural drainage systems for temporary storage and sediment removal.

The Greater Blue Earth River Basin Alliance (GBERBA) was awarded Clean Water Land and Legacy funds to develop this tool for landowners and agencies to calculate drainage figures in determining an effective strategy for sizing side inlets in conservation agricultural drainage improvement and repair projects. This tool was designed to be used by city and county officials, drainage authorities, SWCD’s, farmers, landowners, and other agencies like the Minnesota DNR. Now complete, the Alternative Side Inlet (ASI) Calculator is being used by organizations including the Heron Lake Watershed District to provide conservation solutions.

The excel spreadsheet incorporates a series of calculations that includes location, hydrologic conditions, topographic landscape, soil types. Outputs include recommended inlet size and type for maximum storage and sediment trapping while draining quickly enough to not damage crops. Methodologies used in developing this calculator include an Excel spreadsheet with macros, fluid mechanical equations, and calculations following the Natural Resources Conservation Service (NRCS) design guidelines. Once users input site conditions and make selections from a menu of options, an output is provided in a simple format that could then be emailed directly to the user in a printable format using a web-based platform. Efforts to share this calculator in a more public setting are underway. The ASI Calculator is being used by GBERBA members and stakeholders like Heron Lake Watershed District, to incorporate recommendations in conservation drainage projects to enhance water quality while providing production benefits to landowners and farmers.
Concurrent Session VI, Track B (continued)

In-Stream Nitrate Dynamics in the Cottonwood River Watershed, Minnesota
Katherine McLellan, Joe Magner, Diana Karwan, Gene-Hua Crystal Ng, and John Nieber, University of Minnesota

Nitrate is a common agricultural pollutant with severe ecological consequences. The Cottonwood River Watershed is an intensively managed agricultural setting within the Mississippi River Basin, which exports nitrate that contributes to the hypoxic zone in the Gulf of Mexico. Understanding nitrate sources, pathways, and processes within the Cottonwood River Watershed sheds light on the larger issue of nitrate loading to the Gulf. This study utilizes an end-member mixing analysis (EMMA) approach to identify water and nitrate sources to the Cottonwood River; performs a nitrate mass balance to find magnitudes of in-stream nitrate transformation over a range of discharges and dates; and assesses long-term concentration-discharge relationships in the watershed to elucidate nitrate transport patterns and processes. The three main sources of water that contribute to the Cottonwood River at Lamberton (approximately halfway up the watershed) are tile drainage, shallow groundwater, and Quaternary aquifer groundwater. In-stream nitrate removal is found to be highest at low discharge levels, which occur late in the crop growing season. Concentration-discharge relationships from long-term datasets confirm this finding, and demonstrate that intra-annual variability in stream nitrate concentration has decreased during the period of record. Nitrate removal within the stream channel is attributed to biogeochemical processes such as denitrification and dissimilatory nitrate reduction to ammonium, which disproportionately decrease in-stream nitrate concentrations at low discharges. Given the low in-stream nitrate removal at high discharges, management of nitrate in agricultural watersheds should strive to decrease peak discharges.

Innovative HSPF Modeling Frameworks for Simulating Hydrologically Important Features in Minnesota Watersheds
Michelle Schmidt, Jonathan Butcher, Jennifer Olson, and Saumya Sarkar, Tetra Tech

MPCA facilitates the development of Hydrologic Simulation Program Fortran (HSPF) watershed models to support a variety of activities including discharge permitting, pollutant loading analyses, and BMP scenarios. Traditional model design can misrepresent flow pathways and water quality processes in watersheds where unique features exist, rendering the models less suitable for application studies. For example, HSPF’s 1-dimensional, completely mixed segment design does not represent thermal stratification in deep lakes, which can produce hypoxic conditions in bottom water, and lead to nutrient pulses during the spring and fall mixing periods. To better represent vertical temperature and dissolved oxygen gradients in stratified lakes in the Otter Tail watershed model, we adapted HSPF segments to simulate interacting lake epilimnion and hypolimnion components. We’ve also modified the HSPF reach scheme to simulate surface and subsurface flow exchanges in karst areas. Using information about identified sinkholes, losing streams, springs, perennial and ephemeral stream classifications, and dye tracing studies, we defined karst flow pathways in the Root River HSPF model. Mine features, such as excavated and dewatered pits, can intercept both surface and groundwater flow and alter hydrology in the St. Louis River watershed, so we created an approach for representing mines in HSPF. We will discuss design features, implementation strategies, benefits and potential improvements for each unique framework. In addition, we will recommend analyses for determining if the HSPF model is suitable for the proposed application and address common misconceptions related to using HSPF for beneficial use impairment studies.
Localized Flood Map Tool for Climate Vulnerability Screening

Emily Resseger and Eric Wojchik, Metropolitan Council

Extreme rainfall is nothing new to Minnesotans, and the Minnesota State Climatology Office is highly confident that extreme rain events will increase in frequency and magnitude through the end of this century. It is paramount that agencies and communities understand their assets’ vulnerability to flooding. Traditionally flood vulnerability has been assessed using FEMA’s flood maps, which generally do not incorporate information about flood risks that may occur independent of a lake or river. This type of flooding, often exacerbated by undersized stormwater infrastructure, arises especially in urban areas due to short, intense rain events. As part of its regional Climate Vulnerability Assessment, the Metropolitan Council has created a suite of tools for community use in resilience planning. One of these tools, the Localized Flood Map for Climate Vulnerability Screening, is a GIS tool derived from state-wide high resolution elevation data. The tool can be used as a first pass for communities to understand the potential locations and severity of localized flooding without conducting sophisticated storm sewer modeling. This presentation will include an overview of the risks from localized flooding, a discussion of tool development, and examples of how the Council has used the localized flooding dataset to assess the vulnerability of its assets including transit routes and wastewater infrastructure.

Utilizing Forecast Technology for Flood Prevention in the Time of Climate Change

Tiffany Schaufler, Minnehaha Creek Watershed District; Craig Schmidt, National Weather Service

The Minnehaha Creek Watershed District (MCWD) has observed extreme rainfall events as a result of climate change, and through a strong partnership with the National Weather Service (NWS), is taking steps to proactively control dam operations to prevent flooding. MCWD operates a dam on Lake Minnetonka in accordance with an approved operating plan which controls Lake Minnetonka levels and discharge into Minnehaha Creek. The operating plan prescribes discharge zones based on the time of year, the existing lake level, downstream capacity in Minnehaha Creek, and forecasted precipitation. In 2014, MCWD experienced a record amount of precipitation in the first half of the year, resulting in flooding throughout the watershed. Lake Minnetonka reached an all-time high level in 2014 which caused the dam to become inundated and thus inoperable for 83 days, resulting in major flood damage along Lake Minnetonka and Minnehaha Creek. After the 2014 flooding, MCWD set a goal to identify ways to refine dam operations in an attempt to respond to the effects of climate change. The NWS has been a critical partner to assist MCWD with this goal and has developed two tools for MCWD to use to help inform dam operations. One tool is an automated precipitation forecast for the Lake Minnetonka drainage area which depicts expected precipitation in six-hour increments over a seven-day forecast period. This forecast feeds into the second tool, a reservoir inflow model for Lake Minnetonka. This model is included in the NWS Community Hydrologic Prediction System (CHPS) which allows the NWS to create inflow and lake level predictions for Lake Minnetonka. MCWD then uses the lake level predictions and local precipitation forecasts to inform the operations of the dam. In 2016 the value of this partnership was observed first hand as proactive dam management prevented flooding on both Lake Minnetonka and Minnehaha Creek during the wettest year on record.
Concurrent Session VI, Track C (continued)

Streamlined Analysis Demonstrates Stormwater Detention Benefits to Obtain HMGP Funding

Justin Klabo and Zach Magdol, AE2S, Inc

The City of Worthington has experienced routine localized flooding within the older, more affordable area of the community. This area is located along County Ditch 12, which serves as the primary surface water conveyance feature. The contributing drainage area to County Ditch 12 is over 9,900 acres of primary agricultural land use. During modest rainfall events, County Ditch 12 fills its banks with runoff which encroaches on the low openings of the residential structures located within the FEMA Zone AE floodplain. Within this reach of County Ditch 12 over 600 structures are located within the floodplain. The City applied for and received a Hazard Mitigation Grant from FEMA to determine if the conceptual improvements are beneficial to receive the full funding for construction. AE2S worked with the City & FEMA to develop a Benefit Cost Analysis approach that meets FEMA requirements while completing the analysis using GIS to streamline the process to develop the necessary data for over 600 structures. This was done without utilizing more traditional techniques such as survey which was cost prohibitive to the City. Through this approach, the project was able to determine the Benefit Cost Ratio (BCR) was greater than 1.0 leading the City to receive FEMA HMGP funding. The proposed improvements throughout the community include installation of a 10’x10’ box culvert on Oslo St., installation of 14’x10’ box culvert on Oxford St. and the construction of a 13 acre regional detention facility located on County Ditch 12. Our presentation will be a case study on how to effectively utilize FEMA HMGP funding for regional retention projects while utilizing GIS to cost effectively evaluate large floodplains to determine if a project is beneficial. The project will discuss how multiple improvements were used to achieve the floodplain reduction needed to meet the BCR requirements and the simultaneous construction of the improvements in three locations throughout the City.

A New Look at a Timeworn Problem: Southwest Harriet Feasibility Study

Lisa Goddard, City of Minneapolis; Bridget Osborn, HR Green, Inc.

Due to undersized infrastructure and fully developed communities, the City of Minneapolis has been working to resolve multiple flooding issues in the neighborhoods south and west of Lake Harriet for the past 40 years. Although many studies and proposed projects have been identified in the past, no major stormwater improvements have been made due to a number of communication, collaboration and constructability obstacles. Recent changes in how the City works with its project partners have given new life to the effort. Leveraging the City’s robust XPSWMM model, the engineering team engaged with Optimatics’ Optimizera, an infrastructure planning software. The software can evaluate thousands of possible solutions based on a set of decision factors, costs, and penalties specific for the project area. Solutions were held to strict flow constraints as to not adversely affect Lake Harriet or Minnehaha Creek. Potential solutions from Optimizer were then incorporated into the XPSWMM model to verify performance and were investigated for their constructability and cost impacts. The collaboration resulted in a program of potential projects that were prioritized based on community impact, phasing, cost, and compatibility with partner agency programs or funding requirements. Overall, the proposed improvements are expected to significantly reduce flooding issues without adverse effects to the adjacent water bodies.
Concurrent Session VI, Track D

White Bear Lake Court Case

Dan Miller, Minnesota Department of Natural Resources

The Minnesota Department of Natural Resources (DNR) was sued in 2012 by the White Bear Lake Homeowners Association and the White Bear Lake Restoration Association claiming the DNR allowed too much pumping of groundwater and that in turn reduced water levels of White Bear Lake. The parties settled in 2014 requiring the DNR to work with communities in and around White Bear Lake to reduce water use and improve water consumption efficiencies. The settlement was dependent on funding from the state legislature in 2016 that would have provided money for the communities in the area to move from a groundwater source to a surface water source for their public water supplies. The funding did not occur and the following year, in early 2017, the case went to trial. After many days of testimony and deliberations during the trial the Ramsey County District Court ordered in favor of the plaintiffs, the homeowners association and the restoration association, on August 30, 2017. The Court Order directed the DNR to evaluate the groundwater appropriation permits, cumulatively and individually, within 5 miles of White Bear Lake and it also prohibits the DNR from issuing new groundwater use permits or any new increases in groundwater use permits within the same area. Additionally, the Court Order states the DNR needs to implement the following:

- A residential irrigation ban when certain levels of the lake are reached,
- Require per capita water use plans from permittees,
- Require a source water shift plan from permittees, and
- Require permittees to report on collaborative efforts with other northeast metro communities

The DNR has appealed the decision and is waiting to hear from the appeals court. The DNR made changes to water appropriation permits within the 5-mile radius of White Bear Lake to comply with the Court Order on January 17 and March 1 of 2018. A number of permittees requested a contested case hearing on the permit changes made on March 1 which puts their permit condition

Advancing Safe and Sustainable Water Reuse in Minnesota

Anita Anderson, MN Department of Health; Suzanne Rhees, Board of Water and Soil Resources

The State of Minnesota needs a comprehensive approach to water reuse, because interest in it is growing and examples are cropping up all over the state. During the 2015 legislative session, the Legislature directed the Department of Health to prepare a comprehensive study of and recommendations for regulatory and non-regulatory approaches to water reuse for use in the development of state policy for water reuse in Minnesota.

The objective of this initiative was to develop recommendations for practices and policies to ensure that water reuse can be safely and sustainably implemented in Minnesota. An interagency team evaluated different policy, management, and design approaches for water reuse within a Minnesota context.

As part of the project the workgroup completed the following:

- Defined the scope of reuse and identified challenges and opportunities
- Analyzed existing regulatory and nonregulatory frameworks
- Evaluated existing and planned reuse projects
- Gathered input from stakeholders
- Collaborated with University of Minnesota to research water quality in two reuse systems.
- Completed an assessment of state models for water reuse management
- Incorporated results from national reports on public health guidance for water reuse systems
- Developed recommendations for water reuse practices and policies in Minnesota
- Released a final report in March 2018

This presentation will describe the recommendations outlined in the report and how they are being implemented.
Future State of Water in the Land of 10,000 Lakes

James Stark, Legislative Water Commission

In 2008, Minnesota’s citizens passed the Clean Water, Land and Legacy Amendment to the Constitution that dedicated a portion of the state sale's tax for water. These funds, in excess of 100 million dollars per year, created the Clean Water Fund which is managed by the Clean Water Council. These resources created significant opportunities to achieve a sustainable water future for our state. In 2009, the Legislature directed the University of Minnesota to prepare implementation guidelines. Those guidelines, and other plans, have helped the Clean Water Council’s planning over the past decade. Much has been accomplished, including research, monitoring, mapping, planning and implementation. However, recent analyses have suggested that improvements to our state’s water, when the amendment expires in 2034, may not meet citizen expectations. In response, the Governor asked citizens to describe what could be done to improve water quality. Residents of the state provided suggestions are grouped into priority areas. As the amendment period reaches a half-way point, there is need to reflect and refocus on a desired future state for water for 2034 and beyond. The citizens of Minnesota, local governments, the Clean Water Council, the Administration, and the Legislature each have important roles and responsibilities to work together in prioritizing, funding, implementing and evaluating environmental programs aimed at improving our water, increasing our return on investment, and reaching a desired future state for water in Minnesota.

National MS4 Stormwater Permitting Program Assessments

Randy Neprash, Minnesota Cities Stormwater Coalition, Stantec, National Municipal Stormwater Alliance

The MS4 stormwater program has been active since 1990. Currently, there are 7,550 MS4 permittees throughout the United States, including about 6,500 MS4 cities. In the nearly-30 years of the MS4 program’s existence, there has not been an overall evaluation focused on improving program implementation and MS4 permitting practices and approaches. Recently, there have been two national assessment initiatives to evaluate the state of and consider possible improvements for the MS4 program. In his role as the Vice-Chair of the National Municipal Stormwater Alliance, the author has been directly involved in both efforts. Products from both initiatives will be available before the Conference and this presentation will include results and reports from both projects. In the first initiative, the Water Environment Federation Stormwater Institute is implementing a first-of-its-kind national MS4 needs assessment survey to better understand both the challenges and possibilities the MS4 permittees are subject to. The national survey will determine where potential program theme gaps may occur, identify opportunities to share lessons among peers, and provide a catalyst for developing new programs to meet the stormwater challenges. The results of this survey will be available before the Conference. EPA Region 9, in partnership with the State of California and EPA Headquarters, convened a small group of stormwater professionals from across the country for two workshops designed to review and assess the state of the MS4 program. The workshops engaged 30 national experts from EPA, state CWA permitting agencies, local stormwater programs, national associations, consulting firms, and nonprofit organizations in facilitated discussions to identify tangible ways to enhance permit efficiency and effectiveness to help build state and local program capacity. The reports from these workshops will be complete before the Conference.