2016
WESTERN SOUTH DAKOTA HYDROLOGY MEETING

Program and Abstracts

April 7, 2016
Rushmore Plaza Civic Center
Rapid City, South Dakota

With optional field seminars/trips
April 8, 2016

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2016 Western South Dakota Hydrology Meeting

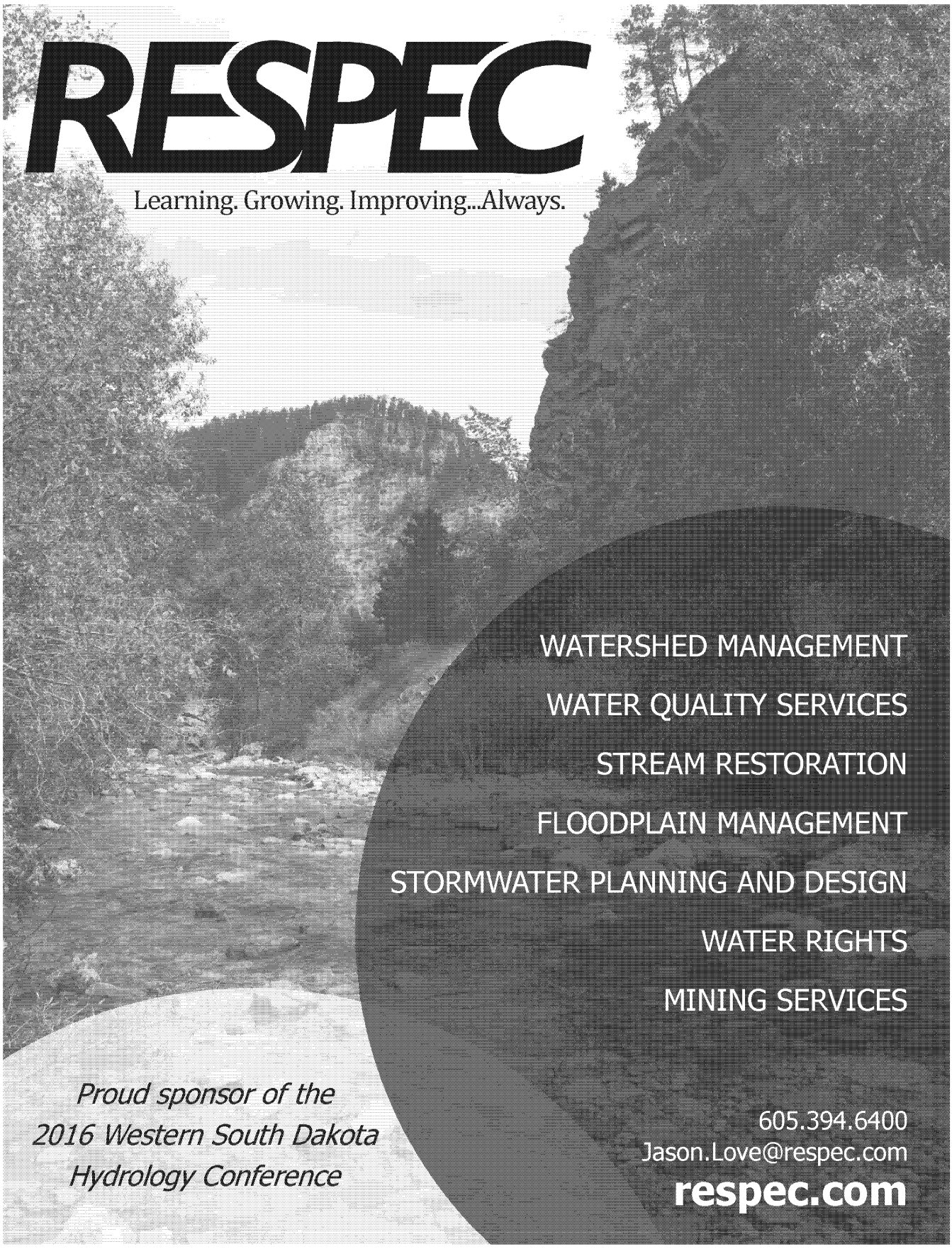
This program and abstracts book has been produced in conjunction with the 2016 Western South Dakota Hydrology Meeting (14th annual), held at the Rushmore Plaza Civic Center on April 7, 2016. The purpose of this book is to provide summaries of the presentations made during the meeting.

The purpose of the 2016 Western South Dakota Hydrology Meeting is to bring together researchers from Federal, State, University, local government, and private organizations and provide a forum to discuss topics dealing with hydrology in western South Dakota. This meeting provides an opportunity for hydrologists, geologists, engineers, scientists, geographers, students, and other interested individuals to meet and exchange ideas, discuss mutual problems, and summarize results of studies. The meeting consists of four technical sessions, several keynote speakers, the John T. Loucks Distinguished Lecture, and a poster session. The topics of the technical sessions include water, food, and energy—connections, challenges, and solutions; engineering solutions; groundwater modeling; land-use change; Williston Basin development and effects; hydrologic extremes and management; management strategies, and water quality.

ACKNOWLEDGMENTS

Many people have contributed to this meeting. The many presenters are thanked for their contributions. The moderators are thanked for their help in streamlining the technical sessions. The help by many students from the South Dakota School of Mines and Technology with presentations and lights is greatly appreciated. The distinguished lecturer, Mr. James Stone, is thanked for his time and perspectives. Keynote speakers Don Blankenau, William Alley, and Jay Gilbertson are thanked for their time and perspectives. Registration help by Sheri Meier and Misty Mandas (USGS) is greatly appreciated. Josh Lee (USGS) provided computer support for the meeting.

The organizing agencies are thanked for support: National Weather Service, RESPEC, South Dakota Department of Environment and Natural Resources, South Dakota School of Mines and Technology, U.S. Geological Survey, and West Dakota Water Development District. The West Dakota Water Development District is thanked for sponsoring the John T. Loucks Distinguished Lecture. RESPEC is thanked for being the Executive Sponsor. The many vendors are thanked for their support of the conference. Mid Continent Testing Labs, Inc., is thanked for sponsoring the morning break. The chairpersons for this meeting were Cheryl Chapman (Louis Berger), Melissa Smith (National Weather Service), Lacy Pomarleau (RESPEC), Joanne Noyes (South Dakota Department of Environment and Natural Resources), Arden D. Davis (South Dakota School of Mines and Technology), Scott J. Kenner (South Dakota School of Mines and Technology), Kelli McCormick (South Dakota School of Mines and Technology), J. Foster Sawyer (South Dakota School of Mines and Technology), Mark T. Anderson (U.S. Geological Survey), Janet M. Carter (U.S. Geological Survey), and Daniel G. Driscoll (U.S. Geological Survey).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2016 WESTERN SOUTH DAKOTA HYDROLOGY CONFERENCE PROGRAM

Thursday, April 7, 2016
Alpine/Ponderosa Rooms and Rushmore F, G, and H
Rushmore Plaza Civic Center

7:00 – 8:00 a.m.	**REGISTRATION**		
8:00 – 10:20 a.m.	**Plenary Session 1 in Alpine and Ponderosa Rooms – Water, Food, and Energy—Connections, Challenges, and Solutions (2.0 PDH)** **Moderator – Mark Anderson**, U.S. Geological Survey		
8:00 – 8:10 a.m.	Welcome, general information		**Mark Anderson** and **Daniel Driscoll**, U.S. Geological Survey
8:10 – 8:50 a.m.	Keynote: Interstate Water Litigation: Challenges and Solutions through Present Cases		**Don Blankenau**, Blankenau Wilmoth Jarecke LLP
8:50 – 9:30 a.m.	Keynote: Challenges in Groundwater Assessment for Agriculture and Energy Development		**Dr. William Alley,** National Groundwater Association
9:30 – 10:00 a.m.	Invited: South Dakota's River Basin Natural Resource Districts—Experiment at Water Resource Management		**Jay Gilbertson**, East Dakota Water Development District
10:00 – 10:40 a.m.	**REFRESHMENT BREAK in Rushmore G**		
10:40 a.m. – 12:00 p.m.	**Concurrent Session 2A in Alpine Room – Engineering Solutions (1.0 PDH)** **Moderator – Scott Kenner**, South Dakota School of Mines and Technology	**Concurrent Session 2P in Ponderosa Room – Groundwater Modeling (1.0 PDH)** **Moderator – Foster Sawyer**, South Dakota School of Mines and Technology	**Concurrent Session 2H in Rushmore H Room – Land-Use Change (1.0 PDH)** **Moderator – Dan Driscoll**, U.S. Geological Survey
10:40 – 11:00 a.m.	*Using 1972 flood memories to protect Rapid Creek greenway for the future* **– Suzanne Martley**, Friends of Rapid City Parks	*Comparison of recharge estimates for the High Plains aquifer in South Dakota* – **Jennifer Bednar** and **Kyle Davis**, U.S. Geological Survey	*Impacts of land use and climate change on hydrological processes in James River watershed* **– Manashi Paul, Laurent Ahiablame**, South Dakota State University, and **Mohammad Adnan Rajib**, Purdue University
11:00 – 11:20 a.m.	*Hydrologic methods for a flood hazard re-study of the Saltese Flats in Spokane County, WA* **– Michael Rotar** and **Tyler French**, RESPEC	*Use of an airborne electromagnetic survey to assess the Big Sioux aquifer to determine sustainable yield for City of Sioux Falls, South Dakota* – **Jeff Dunn**, City of Sioux Falls, **David Smith**, and **Gregory Delzer**, U.S. Geological Survey,	*Sensitivity of Black Hills hydrology to land-use change using WRF-Hydro* **– Lucas Barrett** and **William Capehart**, South Dakota School of Mines and Technology
11:20 – 11:40 a.m.	*Restoring Spearfish Creek to a more natural setting* **– Jonathan Lefers**, Advanced Engineering and Environmental Services, Inc. (AE2S)	*Groundwater-flow model of the Madison and Minnelusa aquifers in the Black Hills, South Dakota and Wyoming—Development progress* – **Bill Eldridge** and **Andrew Long**, U.S. Geological Survey	*Simulation of the effects of deforestation on headwater streams in the Black Hills, western South Dakota* **– Brian Freed,** South Dakota School of Mines and Technology, **Galen Hoogestraat**, U.S. Geological Survey, and **Scott Kenner**, South Dakota School of Mines and Technology

11:40 – 12:00 p.m.	*Hydraulic and sediment transport analysis of the Missouri River near Williston, North Dakota* **– Jonathan Lefers**, Advanced Engineering and Environmental Services, Inc. (AE2S)	*Hydrogeologic training and use of MODFLOW groundwater model for the Tuul River Basin, Mongolia – Phase 1 and 2*– **Kyle Davis, Joshua Valder**, **Mark Anderson,** and **Janet Carter**, U.S. Geological Survey	*Geochemical impacts of mountain pine beetles on Rapid Creek, SD* **– Jesse Punsal, Erik Vik, Heidi Sieverding, Scott Kenner, Lisa Kunza,** and **James Stone,** South Dakota School of Mines and Technology
12:00 – 1:30 p.m.	**LUNCH in Rushmore F Room (1.0 PDH) –** with accompanying presentations **RESPEC: Jason Love** **John T. Loucks Distinguished Lecture** – "Food/Energy/Water Nexus Challenges and Potential Solutions for the Northern Great Plains" by Dr. James Stone, South Dakota School of Mines and Technology		
1:40 – 3:20 p.m.	**Concurrent Session 3A in Alpine Room – Williston Basin Development and Effects (1.5 PDH)** **Moderator – Gregory Delzer**, U.S. Geological Survey	**Concurrent Session 3P in Ponderosa Room – Food, Water, Energy Solutions (and Caves!) (1.5 PDH)** **Moderator – James Stone**, South Dakota School of Mines and Technology	**Concurrent Session 3H in Rushmore H Room – 2015 Hydrologic Extremes and Management (1.5 PDH)** **Moderator – Melissa Smith**, National Weather Service
1:40 – 2:00 p.m.	*Development of a historical water-quality dataset for samples collected in the Williston Basin of North Dakota, Montana, and South Dakota* **– Robert Lundgren, David Bender, Rochelle Nustad**, and **Gregory Delzer,** U.S. Geological Survey	*Food-energy-water nexus: Critical sustainability thresholds for the Upper Great Plains* – **Heidi Sieverding** and **James Stone**, South Dakota School of Mines and Technology	*Feast or famine: What led to record-breaking rainfall in western South Dakota during the summer of 2015* **– Aaron Ward**, National Weather Service
2:00 – 2:20 p.m.	*Characterization of historical water-quality data within the Williston Basin of North Dakota, Montana, and South Dakota* **– Gregory Delzer, Robert Lundgren, Rochelle Nustad**, and **David Bender**, U.S. Geological Survey	*Biodiesel supply chain optimization in the Northern Great Plains region* – **Hyunju Jeong, Heidi Sieverding,** and **James Stone**, South Dakota School of Mines and Technology	*High-flow streamflow conditions during 2015 in western South Dakota* **– Joyce Williamson** and **Daniel Driscoll,** U.S. Geological Survey
2:20 – 2:40 p.m.	*Quality and age of shallow groundwater in the Bakken Formation production area* **– Joshua Valder** and **Peter McMahon**, U.S. Geological Survey	*Western water use management modeling—A decision support tool for the southern Nebraska panhandle* **– Thad Kuntz**, Adaptive Resources, Inc.	*Water year 2015 management and flood operations: record elevations and releases* **– Steven Schelske, Jeffrey Nettleton,** and **Ginger Wessels**, Bureau of Reclamation
2:40 – 3:00 p.m.	*Estimating water use associated with unconventional oil and gas development* **– Janet Carter, Gregory Delzer, Kathleen Rowland,** and **Joanna Thamke**, U.S. Geological Survey	*New observations on the origin of Jewel Cave* **– Michael Wiles**, Jewel Cave National Monument	*Technological advances in flash flood warning methods* **– Susan Sanders**, National Weather Service
3:00 – 3:20 p.m.	*Integrated science studies of effects of oil and gas development on ecosystems in the Williston Basin* **– Bruce Smith, Todd Preston, Aida Farag, Chauncey Anderson, Joanna Thamke, Brian Tangen, Max Post Van der Burg, David Naftz, David Harper,** and **Robert Gleason**, U.S. Geological Survey		*Public information, public warning, and emergency response related to high flow events in Pennington County during May and June 2015* **– Dustin Willett**, Pennington County Emergency Management
3:20 – 3:50 p.m.	**REFRESHMENT BREAK in Rushmore G**		
3:50 – 5:10 p.m.	**Concurrent Session 4A in Alpine Room – Management Strategies (1.0 PDH)** **Moderator – Jay Gilbertson**, East Dakota Water Development District	**Concurrent Session 4P in Ponderosa Room – Water Quality (1.0 PDH)** **Moderator – Joanne Noyes**, South Dakota Department of Natural Resources	
3:50 – 4:10 p.m.	*Helping Minnesota implement its nutrient reduction strategy and reduce its impact on downstream water supporting local, state, and international water quality efforts* **– Megan Burke, Julie Blackburn**, and **Chris Lupo**, RESPEC	*Perchlorate and selected metals associated with fireworks occurrence within Mount Rushmore National Memorial, South Dakota, 2011-2015* **– Galen Hoogestraat**, U.S. Geological Survey	

4:10 – 4:30 p.m.	*Hydrologic and water quality impacts of drainage management strategies in eastern South Dakota* **– Ashik Sahani, Laurent Ahiablame, and Christopher Hay,** South Dakota State University	*Does Didymosphenia geminate alter benthic resource availability and macroinvertebrate diet selection?* **– Lisa Kunza**, and **R.W. Marlow**, South Dakota School of Mines and Technology	
4:30 – 4:50 p.m.	*Developing a web-based irrigation decision support system for Benton County, Minnesota* **– Jared Oswald, Julie Blackburn**, RESPEC, and **Gerry Maciej,** Benton SWCD	*Tritium in groundwater in the southern Black Hills* **– Perry Rahn**, South Dakota School of Mines and Technology	
4:50 – 5:10 p.m.	*Life cycle assessment of low impact development technologies combined with conventional system for residential zones in the City of Atlanta, Georgia* **– Hyunju Jeong**, South Dakota School of Mines and Technology, **Osvaldeo Broesicke**, Georgia Institute of Technology, **Bob Drew**, Rainwater Collection Systems, **Dou Li,** Crittenden and Associates, **and John Crittenden**, Georgia Institute of Technology	*Perfluorochemicals (PFCs): An emerging contaminant class with far-reaching human health and environmental implications* **– Shalene Thomas**, Amec Foster Wheeler	
5:10 – 7:00 p.m.	**POSTER SESSION AND EVENING SOCIAL (with refreshments) in Rushmore G**		
	Drainage management practices to improve water quality in eastern South Dakota **– Laurent Ahiablame, Christopher Hay, and Ashik Sahani**, South Dakota State University		
	Comparison of reference evapotranspiration estimated by automated weather station and measured with an atmometer **– Arturo Reyes-Gonzalez, Todd Trooien, Christopher Hay**, South Dakota State University, and **Jeppe Kjaersgaard**, Minnesota Department of Agriculture		
	Vegetative best management practices for controlling roadway runoff **– Alex Boger, Laurent Ahiablame**, and **Dwayne Beck**, South Dakota State University		
	Steps toward building groundwater modeling capacity in Mongolia **– Janet Carter, Mark Anderson, Joshua Valder**, and **Kyle Davis**, U.S. Geological Survey		
	Applications of soil and vegetation data on bedrock identification **– Cori Christensen**, South Dakota School of Mines and Technology		
	*Optimizing Algal Composition May Influence Nutrient Removal Efficiency From Surface Water***– Taylor Clemmons** and **Lisa Kunza**, South Dakota School of Mines and Technology		
	Estimating water usage related to unconventional oil and gas development in the Williston Basin in North Dakota, Montana, and South Dakota **– Amy Gnoinsky, Christina Hargiss**, North Dakota State University, **Kathleen Rowland**, and **Janet Carter,** U.S. Geological Survey		
	Watershed decomposition: New GIS methods for watershed scale long valley profile analysis **– Kyle Hazelwood** and **Larry Stetler**, South Dakota School of Mines and Technology		
	Impacts of grassland conversion on hydrology and water quality in the Bad River watershed, South Dakota **– Jiyeong Hong, Laurent Ahiablame**, South Dakota State University, and **Kyoung Jae Lim**, Kangwon National University, Chuncheon, South Korea		
	Establishing gene fingerprints of pathogenic bacteria along selected reaches of Rapid Creek, Skunk Creek, and the Big Sioux River **– Kelsey Murray, Lisa Kunza,** and **Linda DeVeaux**, South Dakota School of Mines and Technology		
	Identifying bacterial genes encoding for antimicrobial resistance in selected areas of the Big Sioux River **– Ashley Preston, Lisa Kunza,** and **Linda DeVeaux**, South Dakota School of Mines and Technology		
	Modeling the hydrological impact with land cover change over time **– Patrick Shaw** and **Scott Kenner**, South Dakota School of Mines and Technology		

	Evaluation of integrated drainage water and agricultural management strategies for water quality protection **– Shailendra Singh, Laurent Ahiablame,** and **Christopher Hay**, South Dakota State University
	Using denitrification bioreactors and phosphate adsorption media to remove nutrients from agricultural subsurface drainage water **– Utsav Thapa, Laurent Ahiablame, Todd Trooien,** South Dakota State University, **Jeppe Kjaersgaard**, Minnesota Department of Agriculture, **Guanghui Hua**, and C**hristopher Hay**, South Dakota State University
	Assessing arsenic contamination in the Black Hills and new treatment technology for drinking water **– Arden Davis, David Dixon, Sam Papendick,** and **Mat Peabody**, South Dakota School of Mines and Technology
	Ionospheric plasma coupling to low-frequency electromagnetic radiation: A mechanism for monitoring earthquake precursors using the existing Global Navigation Satellite System **– Kelsey Kramer, Donna Kliche,** South Dakota School of Mines and Technology, **Al Meidinger and Jessica Clayton**, National Security Technologies

Optional Field Seminars/Trips
Friday, April 8, 2016

Times	Field Seminar/Trip
8:00 a.m. – 10:00 a.m.	Tour of new Rapid City water treatment facility and Cleghorn Springs Fish Hatchery (2.0 PDH)
8:00 a.m. – 10:00 a.m.	Walking tour of 1972 flood area (2.0 PDH)

THURSDAY, APRIL 7, 2016
SESSION 1
8:00 – 10:00 A.M.

2016 THEME: WATER, FOOD AND ENERGY – CONNECTIONS, CHALLENGES AND SOLUTIONS (ALPINE/PONDEROSA ROOMS)

SOUTH DAKOTA'S RIVER BASIN NATURAL RESOURCE DISTRICTS – A WATERSHED-SCALE EXPERIMENT AT WATER RESOURCE MANAGEMENT

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In 2012, the South Dakota Legislature created the Regional Watershed Advisory Task Force (Senate Bill 169). The Task Force was given many charges; perhaps chief among them was the consideration of "Potential alternative organizational structures, entities, and strategies appropriate to address statewide, regional, and local issues relating to water and natural resources conservation, protection, management, and use." The Task Force met numerous times during the following three years, both in Pierre and at various locations in eastern South Dakota, taking testimony on a range of water resource issues and concerns.

One legislative outcome of the Task Force was Senate Bill 2, An Act to provide for the establishment of river basin natural resource districts, considered by the 2015 Legislature. Although the version that was ultimately passed was greatly curtailed, the final version retained the core concept that water resource issues are best handled at the watershed scale. The Task Force recognized that rivers and streams span the political boundaries, and an effort should be made to address water management issues with a basin-wide perspective. The whole of the state was divided into nine river basin natural resource districts (RBNRDs), with each encompassing one or more related river basins. It also created a new Task Force, charged with developing formal boundaries and defining the governance, role and function of these entities. South Dakota Codified Law Chapter 46A-19 contains the details (to-date) of these entities.

Legislation is scheduled to be proposed during the 2016 Legislative Session which will further define the boundaries of the RBNRDs, as well as create sub-districts and a framework mechanism for electing persons to manage the entities. A more detailed history of the process that led to the creation of RBNRDs, and the outcome of the 2016 Legislative Session, will be presented.

THURSDAY, APRIL 7, 2016
SESSION 2A
10:40 A.M. – 12:00 P.M.

ENGINEERING SOLUTIONS
(ALPINE ROOM)

USING 1972 FLOOD MEMORIES TO PROTECT RAPID CREEK GREENWAY FOR THE FUTURE

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Planners and developers point to the attraction of Rapid City's parks, bike trails, and access to outdoor recreation as a draw to active millennials, young professionals and the kinds of companies that attract such a workforce. This cohort is a component of the citizens of Rapid City who have no recollection of the Black Hills Flood of 1972. Decision making about land and water planning and uses of the Rapid Creek greenway will increasingly be made by people who moved to Rapid City after 1972, or were born thereafter. The mission of Friends of Rapid City Parks is to protect the greenway and prevent construction and development in the flood plain, but that mission has become increasingly difficult as the people who experienced the flood and who advocate to preserve green space are fewer. In an effort to reach a younger generation, Friends of Rapid City Parks and the Rapid City Public Library collaborated on installation of QR codes that connect bike path users to mobile web content developed by the two organizations. Audio, video, photos, and links to the library's archive pop up on smart phone screens, as well as brief facts and figures about the site where the viewer is standing. The technology allows Friends and the Library to update audio, video, info graphics, and links to stories and resources. Users have access to 14 codes along the 8 miles of the system on signs that were installed as part of the 40th anniversary observance of the flood in 2012. Each year since then, Friends has sponsored a Memory Walk to introduce users to the function of the interpretive signs and codes and issues that pose a threat to the greenway. Presentation will provide data on usage, participation, and outcomes in planning documents that address the flood plain.

HYDROLOGIC METHODS FOR A FLOOD HAZARD RE-STUDY OF THE SALTESE FLATS IN SPOKANE COUNTY, WA

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Spokane County Utilities Division is working to restore wetlands at Saltese Flats, located directly southeast of Spokane Valley, Washington. Saltese Flats is a former lakebed that was drained in the early 1900s for agricultural purposes. The Saltese Creek watershed is also a closed basin with its terminus at Shelley Lake. The county is leading a flood hazard re-study of Saltese Creek in support of the restoration project and to correct known inaccuracies within the effective FEMA Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRMs).

The methods selected for hydrologic evaluation of a watershed are typically based on characteristics of the basin, the availability of data, and specific study requirements. Hydrologic analyses establish discharge-frequency and stage-frequency relationships along channel reaches and in storage areas, respectively. Engineering hydrology is typically determined by applying a statistical analysis of recorded flow data, or through development of hydrologic models that apply either stochastic or deterministic methods to generate model output. Deterministic models are further classified as single-event or continuous simulations. Selection of the most appropriate method based on study purpose and data availability is critical, with significant effect on the final results.

Several event-based hydrologic methods, including regression analysis and precipitation-runoff modeling using mixed precipitation (rain-on-snow) and multi-frequency/multi-day duration regimes, were evaluated for use in the flood study. The HEC-HMS modeling platform was selected for use in these analyses. Due to the inherent difficulty with assigning occurrence probability to snowmelt-driven hydrologic events, it was ultimately decided to develop a continuous simulation, also using the HEC-HMS model.

Precipitation data is a key input for continuous watershed modeling. There are no precipitation stations located within the Saltese Creek watershed, therefore, a spatially-derived precipitation dataset termed Parameter-elevation Relationships on Independent Slopes Model (PRISM) containing daily precipitation depth values was utilized. In order to develop an hourly time series for adequate simulation, the PRISM dataset was disaggregated to hourly intervals utilizing surrounding precipitation gages.

Hydrologic calibration is an iterative process intended to match simulated flow to observed flow by methodically adjusting model parameters. Given the complex nature of simulating snowmelt and the effect snowmelt plays in the local hydrology, a sensitivity analysis was performed on a series of snowmelt parameters to measure the effect each of the parameters has on the resultant discharges and SWE of the snowpack within the watershed.

Once representative flows were calibrated and validated using observed flow and water surface elevation data, statistical frequency analyses were ran under the guidelines of USGS's Bulletin 17B. Through this analysis, 10-percent, 2-percent, 1-percent, and 0.2-percent annual chance discharges and water surface elevations of storage features were calculated, these flows and water surface elevations were ultimately used as inputs for hydraulics modeling within HEC-RAS.

RESTORING SPEARFISH CREEK TO A MORE NATURAL SETTING

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Spearfish Creek is a highly valuable trout stream flowing through the City of Spearfish, SD. On the north end of the City, the creek splits into two separate channels that are created by a large, flow control structure. One channel is the old, original creek bed, and the second is a straight, man-made channel that serves as a bypass channel for high flows.

Because of the large drop at the structure, the structure creates challenges with fish passage, sedimentation, and icing issues along both channels. Further, irrigation water rights combined with low summertime flows can dry up one of the channels depending on how the structure is configured, leading to fish kills and degradation of fish habitat.

AE2S was hired by the City and South Dakota Department of Transportation (DOT) to develop alternatives and conceptual plans for restoring the Creek to a more natural system including the following design objectives:

- Reduce ice jams under Old US 14;
- Reduce ice jams along the old channel;
- Reduce sedimentation problems upstream of flow control structure and along old channel; and
- Reduce operation and maintenance associated with the flow control structure.

In addition to these project objectives, AE2S had to balance the project objectives with several considerations and constraints, such as:

- 100-year floodplain elevations;
- Fish passage issues associated with the current flow control structure;
- Fish habitat along the old channel;
- Water rights along the old channel;
- Landowner preferences and needs;
- Potential for overtopping the Interstate highway during extreme floods; and
- Permitting requirements from the US Army Corps of Engineers.

AE2S developed nine different alternatives that had varying success meeting the four project objectives and balancing the considerations and constraints. The project is currently in the concept plan phase.

HYDRAULIC AND SEDIMENT TRANSPORT ANALYSIS OF THE MISSOURI RIVER NEAR WILLISTON, NORTH DAKOTA

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The City of Williston, in conjunction with the Western Area Water Supply Authority (WAWSA), draws their potable water from the Missouri River. Historically, the treatment plant had three intakes on the river immediately downstream of the US Highway 85 bridge; however, two of these intakes have become buried with sediment, leaving a single intake as the sole source of potable water for the City and the surrounding region.

The NDDOT designed a new bridge upstream of the existing bridge, which will be demolished. The relocation of the US Highway 85 bridge could alter flow characteristics near the water intake structure and cause for additional sedimentation to occur in the area, thereby potentially reducing the operational lifespan of the existing intake. A combined one-dimensional (1D) and two-dimensional (2D) hydraulic and sediment transport analysis of the Missouri River was developed and concluded that the proposed NDDOT bridge project would not increase the sedimentation potential at the remaining intake compared to existing conditions.

The 1D analysis covered approximately 90 miles of the Missouri River that stretched from the North Dakota / Montana border to Lake Sakakawea. The 1D analysis was calibrated to more than 50 years of historic data, including the 2011 Missouri River flood. Following the 1D model calibration, a current-to-future conditions scenario was developed to determine if ongoing reach-wide Missouri River sedimentation would create additional sedimentation in the vicinity of the intake during the operational lifespan of the intake.

A separate 2D analysis was completed for a 7.5 mile reach of the Missouri River in the vicinity of the intake. The purpose of the 2D sediment transport analysis was to evaluate the scour potential near the existing / proposed bridge piers and intake under a range of flow conditions under both current and future Missouri River channel conditions.

THURSDAY, APRIL 7, 2016
SESSION 2P
10:40 A.M. – 12:00 P.M.

GROUNDWATER MODELING
(PONDEROSA ROOM)

COMPARISON OF RECHARGE ESTIMATES FOR THE HIGH PLAINS AQUIFER IN SOUTH DAKOTA

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Recharge to aquifer systems occurs in a variety of ways, with most of the recharge occurring from infiltration from stream systems or precipitation. For the High Plains aquifer in southern South Dakota, most of the recharge occurs from infiltration of precipitation on the land surface. Recharge from precipitation is commonly estimated using methods that can produce spatially varied gridded outputs. These methods have limitations due to underlying assumptions and the limited availability of necessary spatial and temporal data; therefore, point recharge estimates can be used to validate results of spatially varied gridded recharge estimates. Spatially varied recharge estimates are often important data used in groundwater-flow models, and validation should be used to ensure the appropriate use of the recharge estimates in these models.

Recharge estimation methods used in this study of the High Plains aquifer include a modified Thornthwaite-Mather Soil-Water-Balance code (SWB), Water-Table Fluctuation (WTF) method, and a chemical-mass balance (CMB) method using a chloride-tracer. The SWB method uses tabular or spatially distributed climate, soil, and land-use data, resulting in a gridded estimate of recharge for the study area. The WTF and CMB methods are point (localized) recharge estimates that will be used to increase confidence in the SWB estimates for model use.

This research on recharge estimation methods is part of a study by the U.S. Geological Survey (USGS) in cooperation with the Oglala Sioux Tribe and Rosebud Sioux Tribe to model groundwater flow in the High Plains aquifer in southern South Dakota. The study area consists of an area bounded by the White River in southwestern South Dakota to the north and west, the Niobrara River in northern Nebraska to the south, and the Missouri River to the east.

USE OF AN AIRBORNE ELECTROMAGNETIC SURVEY TO ASSESS THE BIG SIOUX AQUIFER TO DETERMINE SUSTAINABLE YIELD FOR THE CITY OF SIOUX FALLS, SOUTH DAKOTA

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The City of Sioux Falls (City) requires a sustainable supply of municipal water to meet demands to support economic development and population growth into the second half of the 21st century. Some wells operated by the City are located within the regional airport (Joe Foss Field) and are planned to be abandoned and (or) relocated as they interfere with flight operations. The City also has a vested interest in maintaining current water rights. Groundwater, primarily from the Big Sioux aquifer, is an important component of the City's supply, comprising almost 52% (2015) of the potable water that is delivered to its citizens. Management of sustainable groundwater supplies is contingent upon detailed characterization of groundwater availability.

In an effort to characterize potential areas of high specific yield necessary for new or relocated wells in the aquifer, the City and U.S. Geological Survey are cooperating on a study to develop a calibrated groundwater model for the Big Sioux aquifer. A calibrated groundwater model would provide a unique opportunity to evaluate various scenarios for well development. Traditionally, observation wells are drilled into aquifer formations to monitor the potentiometric surface, and to perform aquifer tests to extract formation characteristics such as depth to bedrock, transmissivity, and specific yield. These data are often utilized by groundwater models. Modeling areas affected by glaciation often pose several challenges. One such challenge includes modeling buried channels that are not identifiable from surface geology because they are often covered by glacial drift. Ground-based geophysical methods can be used to characterize buried channels, depth-to-bedrock, and aquifer properties necessary for groundwater model development. However, the spatial scale specific to the Big Sioux aquifer is large, approximately 24 by 6 kilometers, which hinders the use of ground-based methods. As such, limited surface electrical resistivity transects were run only to obtain ground-truth data in advance of an airborne electromagnetic (AEM) survey of the aquifer. The AEM method is very efficient and cost effective, mainly due to the timely collection of three-dimensional data needed for aquifer characterization with a high degree of accuracy and detail. This presentation will introduce the overall study, discuss public outreach efforts, and highlight preliminary resistivity results for the Big Sioux aquifer.

GROUNDWATER-FLOW MODEL OF THE MADISON AND MINNELUSA AQUIFERS IN THE BLACK HILLS, SOUTH DAKOTA AND WYOMING – DEVELOPMENT PROGRESS

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The U.S. Geological Survey (USGS), in cooperation with the National Park Service, the city of Rapid City, and the West Dakota Water Development District, is constructing a regional numerical groundwater-flow model of the Madison and Minnelusa aquifers with a focus on the Black Hills region. The model's purpose is to facilitate a better understanding of the effects of increased groundwater use and potential climatic changes on groundwater availability. The Madison and Minnelusa aquifers in the Black Hills of South Dakota and Wyoming are vitally important water resources providing groundwater for agricultural, industrial, commercial, public, and domestic use. From 1985 to 2010 in the 21 counties surrounding the Black Hills, total groundwater use increased by greater than 35 percent while population increased by more than 20 percent. The model area includes about 60,000 square miles located primarily in western South Dakota and northeastern Wyoming. The model also integrates data from a previously published groundwater model of the Rapid City area. Groundwater, streamflow, springflow, and precipitation data from 1980 through 2010 were used for model construction and calibration. MODFLOW 2005-NWT (structured grid) groundwater modeling software and PEST parameter estimation and uncertainty analysis software were used for model development and preliminary calibrations. Preliminary modeled water budget results showed recharge to the aquifers exceeded withdrawals. The estimated average annual recharge from precipitation on Madison and Minnelusa outcrop areas was 205 ft^3/s with a maximum annual average value of 481 ft^3/s and a minimum of 5 ft^3/s. Average annual groundwater recharge from sinking streams to both aquifers was estimated as 113 ft^3/s with an maximum average annual value of 184 ft^3/s and a minimum of 71 ft^3/s. Spring outflow average annual estimates were 143 ft3/s with a maximum annual average of 159 ft^3/s and a minimum of 133 ft^3/s. Total average annual groundwater withdrawal estimates were 27 ft^3/s with a maximum average annual value of 36 ft^3/s and a minimum of 18 ft^3/s. Groundwater withdrawal estimates were based on previous USGS publications, State water-well databases, and withdrawal records provided by the city of Rapid City. Scenarios focused on water-level changes in underground springs in Wind Cave National Park and in wells in the Rapid City area are in development.

HYDROGEOLOGIC TRAINING AND USE OF MODFLOW GROUNDWATER MODEL FOR THE TUUL RIVER BASIN, MONGOLIA – PHASE 1 AND 2

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Ulaanbaatar, the capital city of Mongolia, is dependent on groundwater for its municipal and industrial water supply. Water is drawn from a network of shallow wells in an alluvial aquifer along the Tuul River. Evidence, however, suggests that current water use and especially the projected water demand from a rapidly growing urban population, is not sustainable from existing water sources. In response, the Mongolia Ministry of Environment and the Mongolian Fresh Water Institute requested technical assistance on groundwater modeling through the U.S. Army Corps of Engineers to the U.S. Geological Survey (USGS). The Mongolia Ministry of Environment, Green Development, and Tourism (MEGDT), in collaboration with United Nations Educational, Scientific and Cultural Organization (UNESCO), invited participants to attend Phase 1 training in Ulaanbaatar on principles of geohydrology and the use of MODFLOW for groundwater modeling and Phase 2 training on advanced groundwater modeling and monitoring.

The Tuul River Basin in Mongolia was used for a groundwater model case study during two workshops. The Phase 1 workshop gathered water resource experts in Mongolia to further collaborate on integrated water resource management (IWRM) using MODFLOW. The purpose of the training was to bring together representatives from the Government of Mongolia, local universities, technical experts, and other key stakeholders to deliver a groundwater modeling and monitoring training workshop. The workshop provided understanding of groundwater principles; aquifer characterization; and data acquisition needed to design, construct, and evaluate groundwater model results. Highlights of the training include: 39 Mongolian professional hydrogeologists participated in a 4-day groundwater modeling workshop, and exercises were facilitated with USGS-supported groundwater modeling software.

For Phase 2 training, interim products for a steady-state groundwater model of the Tuul River Basin were presented to decision-makers for consideration in future water-related planning activities. The purpose of the workshop was to deliver advanced groundwater modeling and monitoring training and to provide a better understanding of groundwater principles; aquifer characterization; and data acquisition needed to design, construct, and evaluate groundwater model results. Highlights of the training include: 27 Mongolian professional hydrogeologists participated in the two-day groundwater modeling workshop, and 20 government officials, primarily from MEGDT, participated in a session in which USGS presented alternative methods to achieve sustainable groundwater use.

THURSDAY, APRIL 7, 2016
SESSION 2H
10:40 A.M. – 12:00 P.M.

LAND-USE CHANGES
(RUSHMORE H ROOM)

IMPACTS OF LAND USE AND CLIMATE CHANGE ON HYDROLOGICAL PROCESSES IN JAMES RIVER WATERSHED

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Climate and land use are both major contributors to hydrological changes in a watershed. Recent research revealed that 1 to 5% of grassland is being converted to cropland annually in the Western Corn Belt, which includes South and North Dakotas. Concurrently, climate change impacts on water resources have been a concern in this region. A thorough understanding of hydrological processes under land use change and an increasing variable and changing climate is, therefore, needed for development of sustainable water management strategies in South Dakota and neighboring states. In this study, the Soil and Water Assessment Tool (SWAT) will be used to quantify changes in watershed hydrology under 18 combinations of climate and land use scenarios in the James River Watershed located in South and North Dakotas. The scenarios will be designed in a way that land use will be changed while climate conditions remains constant, land use will remain constant under a changing climate, and both land use and climate will be changed based on future projections. This study will provide science-based information for understanding of the environmental implications of climate and land use changes in the region.

SENSITIVITY OF BLACK HILLS HYDROLOGY TO LAND-USE CHANGE USING WRF-HYDRO

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As time passes, environments begin to change due to varying factors from climate change to species migration. The Black Hills region is one that could be on the verge of such change, due to the mountain pine beetle and human activity, and it's important to know the effects this may cause around the region, particularly related to hydrology.

The National Center for Atmospheric Research (NCAR) has released a new version of WRF that integrates terrestrial and stream hydrology into its predictive framework called WRF-Hydro. It was developed to be coupled to a dynamic atmospheric model or run uncoupled. It provides the ability to examine hydrologic impacts from events in a distributed (rasterized) framework at the same or higher resolution as the overlying atmospheric model or forcing dataset. WRF-Hydro also has the ability to analyze and model a variety of processes such as land-atmosphere energy budgets, evapotranspiration, soil moisture, subsurface flow, and surface runoff.

The objective of this study is to use WRF-Hydro to perform offline simulations, using National Weather Service (NWS) precipitation analyses and National Land Data Assimilation System (NLDAS) forcings, to test the hydrologic changes with land-use change in the Black Hills region. This will be enacted by analyzing scenarios that use the existing land cover and alternative regimes that incorporate potential long-term pine beetle damage, fire damage, and land-use change on hydrologic processes.

An analysis between the WRF-Hydro output from the 2013-2014 water year (not including a one year spin-up, to get the system into equilibrium) to actual observations will be used to assess whether WRF-Hydro can be used to evaluate the sensitivity of hydrologic parameters caused by land cover change within the Black Hills region. From there, an analysis will be done on the alterations of the land cover to simulate different scenarios in the Black Hills.

SIMULATION OF THE EFFECTS OF DEFORESTATION ON HEADWATER STREAMS IN THE BLACK HILLS, WESTERN SOUTH DAKOTA

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Similar to elsewhere in the Rocky Mountains, mountain pine beetle (Dendroctonus ponderosae) infestation has affected large areas of the central and southern Black Hills of western South Dakota. The hydrologic response of watersheds to pine beetle infestation has been studied by other researchers, but typically for sub-alpine settings where runoff is dominantly derived from snowpack. There is a need for studies of the hydrologic response of ponderosa pine (Pinus ponderosa) forests, which are not a snow-dominated system, but are rather semi-arid settings where evapotranspiration potentially plays a greater role in the hydrologic budget.

The Rainfall-Response Aquifer and Watershed Flow (RRAWFLOW) model has been successfully used to model springflow in the Black Hills, including Rhoads Fork Spring in the headwaters of Rapid Creek. This presentation will describe RRAWFLOW models that simulate changes in the hydrologic response since 2008 of Black Hills watersheds to the cycle of beetle infestation, tree mortality, and regrowth. Projected response from the year 2015 to 2030 was simulated by RRAWFLOW on the basis of climate model simulations and various synthetic climate scenarios. Each climate scenario was run with and without the tree mortality from the mountain pine beetle to determine the potential effects caused by the infestation. Results show a maximum increase in mean annual streamflow of 7 percent in the Upper Rapid Creek watershed during the wettest climate scenario, with other basins showing similar results. The changes to streamflow from the mountain pine beetle infestation during normal or dry climatic conditions are perceived to be negligible compared to the annual variability of the watersheds examined. This study is a cooperative effort between the U.S. Geological Survey, South Dakota School of Mines and Technology, and the City of Rapid City.

GEOCHEMICAL IMPACTS OF MOUNTAIN PINE BEETLES ON RAPID CREEK, SD

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Mountain pine beetle (MPB) (Dendroctonus ponderosae) infestations in pine forest (Pinus spp.) dominated watersheds may affect drinking water supplies through increased loading of organic carbon, due to increased tree mortality and decomposition. Both total organic carbon (TOC) and dissolved organic carbon (DOC) are precursors to the formation of toxic disinfection by-products (DBP) in municipal water supplies. Soil and water quality sample site selection was based on remotely sensed EROS Landsat algorithms, USFS management records, and historic land use data. Characterization of the organic carbons from these sites was preformed to develop a better understanding of possible impacts and remediation. Preliminary results from the upper reaches of Rapid Creek and Castle Creek indicate that MPB infestation impacts stream DOC and water quality. Historic land use, forest management, and current stream flow affect the degree of impact of MPB. The Black Hills MPB outbreak may necessitate long-term changes to watershed management as both the quantity and quality of local and regional surface water and groundwater resources may be impacted due to the MPB outbreak.

THURSDAY, APRIL 7, 2016
LUNCHEON
12:00– 1:30 P.M.

JOHN T. LOUCKS DISTINGUISHED LECTURE:
JAMES J. STONE
"FOOD/ENERGY/WATER NEXUS CHALLENGES AND POTENTIAL SOLUTIONS FOR THE NORTHERN GREAT PLAINS"
(RUSHMORE F ROOM)

THURSDAY, APRIL 7, 2016
SESSION 3A
1:40 – 3:20 P.M.

WILLISTON BASIN DEVELOPMENT AND EFFECTS
(ALPINE ROOM)

DEVELOPMENT OF A HISTORICAL WATER-QUALITY DATASET FOR SAMPLES COLLECTED IN THE WILLISTON BASIN OF NORTH DAKOTA, MONTANA, AND SOUTH DAKOTA

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A water-quality database used to characterize available data and describe conditions across the Williston Basin was developed using the Water-Quality Portal and the U.S. Geological Survey's Western States Data Aggregation. The database was developed in cooperation with the Bureau of Land Management and will be available as part of the Bakken Environmental Status and Trends (BEST) Report, when completed. The database is intended to synthesize current information and identify data gaps concerning the status of natural resources within the Williston Basin. Water-quality data were compiled from numerous Federal, State and local agencies. Data were selected for inclusion with an emphasis on three matrices: groundwater, streams and rivers, and lakes and wetlands. Although water-quality data were available since early 1900 and data existed for about 300 individual constituents, emphasis was placed on samples collected during 1970 through 2014 for five primary constituents (specific conductance, total dissolved solids, pH, sulfate, and chloride) and ten secondary constituents (select trace metals). The large dataset presented challenges that included removing known quality-control samples and duplicate sites from multiple agencies, as well as standardizing multiple constituent naming conventions. Because of various study objectives, sample collection protocols, and reporting processes among different agencies and states, the availability of consistently collected, systematically processed and reported data over large portions of the Williston Basin is limited. The dataset does, however, serve as a tool to complement current and future water-quality monitoring programs.

CHARACTERIZATION OF HISTORICAL WATER-QUALITY DATA WITHIN THE WILLISTON BASIN OF NORTH DAKOTA, MONTANA, AND SOUTH DAKOTA

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Select groundwater and surface-water quality data were characterized for the Williston Basin in North Dakota, Montana, and South Dakota during 1970 through 2014 in cooperation with the Bureau of Land Management as part of the Bakken Environmental Status and Trends (BEST) Report. Water-quality data were compiled from numerous Federal, State and local agencies for three matrices: groundwater, streams and rivers, and lakes and wetlands. Five primary constituents (specific conductance, total dissolved solids, pH, sulfate, and chloride) and ten secondary constituents (select trace metals) were characterized. Concentrations across the Williston Basin vary widely, both spatially and temporally for each matrix. These differences in concentrations may be due to, in part, varying study objectives, analytical methods, sample collection protocols, and reporting processes. Characterization of the data was used to identify gaps in spatial and temporal representation of water quality in the context of unconventional oil and gas development. In addition, potential enhancements of the current water-quality dataset were identified. Lastly, considerations were presented highlighting a need for a coordinated and collaborative water-quality sampling program within the Williston Basin.

QUALITY AND AGE OF SHALLOW GROUNDWATER IN THE BAKKEN FORMATION PRODUCTION AREA, WILLISTON BASIN, MONTANA AND NORTH DAKOTA

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The quality and age of shallow groundwater in the Bakken Formation production area were characterized using data from 30 randomly distributed domestic wells screened in the upper Fort Union Formation. Comparison of inorganic and organic chemical concentrations to health-based drinking-water standards, correlation analysis of concentrations with oil and gas well locations, and isotopic data give no indication that energy development activities affected groundwater quality. It is important, however, to consider these results in the context of groundwater age. Most samples were recharged before the early 1950s and had 14C ages ranging from <1000 to >30,000 years. Thus, domestic wells, which have a median depth of at least 23 meters, may not be as well suited for detecting contamination associated with recent surface spills compared to shallower wells screened near the water table. Old groundwater could be contaminated directly by recent subsurface leaks from imperfectly cemented oil and gas wells, but horizontal groundwater velocities calculated from 14C ages imply that the contaminants would still be less than 0.5 km from their source. For the wells sampled in this study, the median distance to the nearest oil and gas well was 4.6 km. Because of the slow velocities, a long-term commitment to groundwater monitoring in the upper Fort Union Formation is needed to assess the effects of energy development on groundwater quality. In conjunction with that effort, monitoring could be done closer to energy development activities to enhance early detection of groundwater contamination if it did occur.

ESTIMATING WATER USE ASSOCIATED WITH UNCONVENTIONAL OIL AND GAS DEVELOPMENT

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The relatively recent technological advances have rapidly expanded oil and gas production from continuous formations in the Northern Great Plains, most notably the Bakken and Three Forks Formations in North Dakota and Montana. The recent (since 2005) and rapid unconventional oil and gas (UOG) development in the Williston Basin provides a unique opportunity to characterize water use associated with UOG development. That is, water use in the Williston Basin was relatively similar from year to year prior to 2005 and, thus, any substantive change in water use since then can be attributed to water-use needs to support UOG development. As such, this provides the unique ability to better characterize water use associated with UOG development in the Basin and, subsequently, water use in other UOG plays in North America.

The U.S. Geological Survey (USGS) initiated a study in 2015 to better estimate water use associated with direct, indirect, and ancillary processes for UOG development. Both economic factors and technological advances in extraction methods (including horizontal drilling and hydraulic fracturing) have intensified UOG development in the United States in recent years. Understanding the relation between production of energy and the water used to produce the energy is a key component of the USGS Water Availability and Use Science Program's characterization of the water-use cycle for the Nation. This relation applies to the entire life-cycle of both renewable and nonrenewable forms of energy and includes extraction, production, refinement, delivery, and disposal of waste byproducts as well as the water used to support the related infrastructures and industries to oil and gas development. The study is multi-phased. Phase I will quantify water use associated with UOG development in the Williston Basin, develop an estimation model, and determine associated uncertainty. Analyses for Phase I include water use, sources, reuse, and disposal data for direct processes (for example, hydraulic fracturing and borehole maintenance), indirect processes (for example, crew camps, well pad upkeep, and road dust abatement), and ancillary processes (for example, recreation) related to UOG development in the Williston Basin from 2005–2015. Phase II will test the estimation model in two or three additional plays to evaluate model capabilities for estimating water use associated with UOG development. Phase III will finalize estimation model and prepare for national assessment.

INTEGRATED SCIENCE STUDIES OF EFFECTS OF OIL AND GAS DEVELOPMENT ON ECOSYSTEMS IN THE WILLISTON BASIN

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USGS integrated science projects are collecting data on the cumulative effects of energy development in the Williston Basin on terrestrial and aquatic ecosystems. Specifically, these projects address data compilation and access needs, land use change, produced water toxicity, and potential contamination of aquatic resources. These studies not only provide datasets that are useful to stakeholders, but are also useful in designing new studies and assigning priority areas for collection of new data. Examples of new data would be from geological, geochemical, and geophysical surveys. For studies examining energy development in the Williston Basin, researchers need to have access to ancillary datasets that include oil and gas infrastructure, aquatic and terrestrial resources, and ecosystem layers. As a step in this direction, we are creating a one-stop location where internal and external partners can obtain consistent datasets. We will then demonstrate the use of these databases in a series of assessments targeting landscape change and biological resources. We are currently quantifying the amount of agricultural land and native habitat that has been converted within the Williston Basin due to well pad construction. Likewise, we are developing spatial statistical models to investigate the cumulative effects of oil and gas development on population trends in breeding birds. These data can be used to extrapolate the land use and bird modeling results across a range of future development scenarios that will help inform land and wildlife managers. Results from the preliminary studies suggest the importance of improving our understanding of the possible effects of salts from produced water on aquatic resources. The databases can also be used to identify and prioritize areas where subsurface information on hydrology and water quality is needed. This information can be obtained from ground and airborne geophysics and hydrogeologic framework studies. The project databases and their interpretation can be used in landscape scale assessments of the vulnerability of wetlands to possible contamination from oil and gas development.

THURSDAY, APRIL 7, 2016
SESSION 3P
1:40 – 3:20 P.M.

FOOD, WATER, ENERGY SOLUTIONS (AND CAVES!)
(PONDEROSA ROOM)

FOOD-ENERGY-WATER NEXUS: CRITICAL SUSTAINABILITY THRESHOLDS FOR THE UPPER GREAT PLAINS

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Across the globe, resource mining and agriculture compete for human, land, transportation, and fresh water resources. This competition is exemplified in the upper Great Plains. An imbalanced system causes harm to the environment, changing once renewable and recyclable resources such as water into waste. Rural areas provide food, resources, and energy. They are the foundation of our supply chain. As we cope with resources constraints and anthropogenic change, we will encounter thresholds or 'tipping points' after which the ability to recover will be lost. Critical vulnerabilities create difficult questions which if unaddressed may tear the fabric of our economy and society. In order to achieve sustainability, critical vulnerabilities need to be addressed while maintaining existing strengths and expanding opportunities. This presentation will discuss the key vulnerabilities identified during the 2015 NSF food-energy-water nexus workshop for the upper Great Plains.

BIODIESEL SUPPLY CHAIN OPTIMIZATION IN THE NORTHERN GREAT PLAINS REGION

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Camelina has been remarked as a non-food oilseed crop feasible for biodiesel production. The crop can be cultivated with low water demand. Cultivating it on wheat fallow also enhances soil carbon content. A biodiesel supply chain optimization model was built as one of efforts to develop biodiesel from camelina oilseed in the Northern Great Plains (NGP) region. The model is used to determine biodiesel supply chains to process and transport oilseed, biodiesel, and livestock meal at minimum cost. Oilseed supply, existing biodiesel plant usage, and new biodiesel plant location and capacity are designed on the basis of a regional transportation network. The transportation network includes rail, roads, and intermodal facility (i.e., shuttle elevators) of the NGP region. Minimum cost routes among oilseed cropland, plant sites, and biodiesel and meal demand sites are simulated using an ArcGIS network analysis function. A mixed integer linear programming (MILP) was built to optimize oilseed, biodiesel, and meal flows on the route at minimum processing and transportation cost. The MILP was scripted and solved using PuLP, a linear programming modeler written in python. The model was tested for the NGP region under the condition of supplying biodiesel demands estimated for eight cities.

Building three plants of small-scale biodiesel production (~ 20,000,000 kg/yr) in addition to using the existing biodiesel plant in Velva, ND, costs 29% less than using the existing plant only. In other words, investing $6.20 million/yr on building new plants could save the transportation cost of $39.4 million/yr.

WESTERN WATER USE MANAGEMENT MODELING—A DECISION SUPPORT TOOL FOR THE SOUTHERN NEBRASKA PANHANDLE

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The Western Water Use Management Modeling is a cooperative effort between North Platte Natural Resources District (NRD), South Platte NRD, and Nebraska Department of Natural Resources to create a robust modeling tool for water resource management decisions. The NRDs are local governmental entities responsible for regulating and managing ground water pumping over several counties. The modeling extends from the Wyoming-Nebraska border in the west to Ogallala, NE in the east and from Alliance, NE (in the middle of the Nebraska Panhandle) in the north to the Nebraska-Colorado border in the south. The primary surface water bodies within the model are the North Platte River, South Platte River, and Lodgepole Creek. The principal ground water aquifers in the area are the alluvial and High Plains (Ogallala Formation and others) systems. The modeling consists of a surface water operations model of the North Platte River system that provides estimated pumping, canal operations and recharge, and river operations; a regionalized soil water balance model to estimate crop consumptive use, ground water pumping, and recharge; and a ground water model to provide storage and movement of water through the alluvial and High Plains aquifers. The three models are partially integrated and share datasets, with each model providing outputs and feedback for use in calibration. Extensive climate, land use, hydrologic, hydrogeologic, and metered agricultural, municipal, and industrial pumping information was utilized to create models that simulate hydrologic and hydrogeological conditions from 1953 through 2013. These models are being utilized by the NRDs for day to day operations and regional to sub-regional management decisions. Recent studies have included aquifer life analyses of the High Plains Aquifer that provides future estimates of drawdown and percent saturated thickness used to aid the NRDs in management decisions of determining the next increment of ground water pumping allocations.

NEW OBSERVATIONS ON THE ORIGIN OF JEWEL CAVE

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Purpose

With over 180 miles (290 km) of mapped passages, Jewel Cave is the third longest cave in the world. Previous work has demonstrated an intimate relationship between the cave and the geologic structure, contacts, and topography as they exist today. This is the latest iteration of a paper that explores the possibilities of how and when the cave might have formed.

Results

The distribution of ellipsoidal quartzite clasts – scattered across 1,500 square miles (3,885 km^2) of the western and southern flanks of the Black Hills – cross-cuts sedimentary rocks from the Pahasapa Limestone through upper Lakota Formation. It provides a timing element for a Hills-wide event that can be correlated with the cave, particularly because one clast within Jewel Cave was emplaced before the deposition of calcite spar. A single U-Pb date places the spar at 14.7Ma, the presumed end of dissolutional flow. A rough estimate of hydrologic properties shows that, under optimal abiotic conditions, there would have been sufficient flow to remove the entire volume of cave in less than one million years. The carbon dioxide needed for dissolution may have been produced by the interaction of microbes and the organic carbon of shale layers within the confined aquifer.

Conclusions

These observations continue to define a framework consistent with geologically recent cave development. More work is needed to determine the source, transport method, and timing of the quartzite clasts. The U-Pb dating of the calcite spar is inconclusive, and must be validated or rejected. Initial fracture sizes should be estimated. Once the hydrologic parameters of a crucial sandstone unit have been determined, there will be sufficient information to begin computer modeling, to provide valuable insight on how all the observations fit together. Finally, more work is needed on the role of microbes in hydrogeological processes.

THURSDAY, APRIL 7, 2016
SESSION 3H
1:40 – 3:20 P.M.

2015 HYDROLOGIC EXTREMES AND MANAGEMENT
(RUSHMORE H ROOM)

FEAST OR FAMINE: WHAT LED TO RECORD-BREAKING RAINFALL IN WESTERN SOUTH DAKOTA DURING THE SUMMER OF 2015

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Up until May 2015, most of western South Dakota and northeastern Wyoming had seen some of the driest months on record during the winter and early spring. March and April are typically the months of greatest snowfall for the area, but very little to no precipitation was recorded during that time. All initial indications suggested that the fire season was going to be long and that drought was setting in. However, some long-range climatological models and a strengthening El Niño hinted at a major change in the general upper-level pattern that would be more favorable for above-average precipitation over the summer.

Precipitation trends made a remarkable reversal during May and June 2015. Instead of fires and drought, high stream flows and flooding were the major concerns throughout the summer as soils became saturated and excessive runoff occurred with each rainfall event. The two-month period of May and June ended up being the wettest on record at the Rapid City Regional Airport, Cottonwood, Hot Springs, Interior, and Mount Rushmore; these stations received 75 to 85% of their normal yearly precipitation during that time. The meteorological conditions that led to the record-breaking precipitation will be discussed, along with some of the impacts it had on the local area.

HIGH-STREAMFLOW CONDITIONS DURING 2015 IN WESTERN SOUTH DAKOTA

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Streamflow in South Dakota has varied through the years, responding primarily to climatic effects and land-use changes. Some years are noted for being very dry (for example, the late 1980s, 2004, 2007, and 2012), whereas others are noted for being very wet (for example, 1997, 1999, 2009, 2011, and 2014). During water year (WY; October 1 through September 30 and designated by the calendar year in which it ends) 2015, U.S. Geological Survey (USGS) streamgages in western South Dakota recorded annual runoff greater than long-term medians as well as a few high instantaneous peak flows. During May and June, which followed low flows in April, provisional data indicate flows substantially greater than long-term medians for all of the major river systems in western South Dakota (Grand, Moreau, Bad, Cheyenne, Little White, and White Rivers) for the WY 2015.

The most noteworthy high-flow conditions during WY 2015 generally occurred within the Cheyenne and White River Basins in southwestern South Dakota, where streamflow rates of about an order of magnitude larger than the long-term medians were sustained for most of May and June. As an example, the cumulative flow at the White River near Oglala (streamgage 06446000), which has 71 years of record, was almost double the previous record set in WY 1997. Within the Cheyenne River Basin, cumulative runoff for the Cheyenne River near Wasta (streamgage 06423500) was just slighter larger than in WY 1997, and cumulative runoff for the Cheyenne River near Plainview (streamgage 06438500) was slightly less than WY 1997. For the Cheyenne River at Wasta and the upper basin tributary Hat Creek near Edgemont (streamgage 06400000), instantaneous peaks in May and June were the largest recorded since the mid-1960s. Cumulative runoff for Rapid Creek at Rapid City (streamgage 06414000) was the highest on record, exceeding WY 1999 by more than 3,400 acre-feet, and the highest releases on record (since 1954) from Pactola Dam took place in 2015. The third largest release (since 1946) from Angostura Reservoir also took place in 2015.

WATER YEAR 2015 MANAGEMENT OF FLOOD OPERATIONS; RECORD ELEVATIONS AND RELEASES

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The U.S. Bureau of Reclamation manages area dams using Standing Operating Procedures (SOP), which are structure-oriented operating instructions for each dam and reservoir. These instructions include filling schedule and release procedures, inflow forecasting, flood operating criteria, special reporting during flood or high water conditions, and filling and drawdown limits. Monitoring specific criteria Reclamation determines when to notify the local media and cooperating agencies that provide public warnings.

During Water Year 2015 (October 1, 2014 to September 30, 2015) the dams and reservoirs at Angostura and Pactola experienced record elevations and flows which triggered emergency events. Emergency events are classified into five unique emergency classifications starting at Internal Alert and upgrading from Response Level 1 through Response Level 4.

Pactola Dam was upgraded to Response Level 2 on May 28, 2015 based on reaching first fill elevation (the highest previously recorded reservoir elevation) of 4,585.87 feet, precipitation forecasts for more rain, and the outlet release increased to 500 cfs. The reservoir reached a new historic high elevation of 4,589.43 on June 29, 2015.

Angostura Dam was placed in a Response Level 1 status on June 7th after rainstorms saturated the drainage basin and reached the peak reservoir elevation of 3187.65. Inflows peaked at 17,769 cfs, with a peak release of 14,397 cfs that same day.

The Standing Operating Procedures for these dams proved to be an effective method of monitoring the conditions, operating the reservoirs in flood conditions, and providing the local media and cooperating agencies the information necessary to provide the public with warnings in a timely manner.

TECHNOLOGICAL ADVANCES IN FLASH FLOOD WARNING METHODS

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Modern communications technologies have increased the opportunity for the National Weather Service and other emergency officials to reach many more people with hazardous weather and flood warnings and other emergency information. From traditional broadcast media to the Internet and wireless communications, they can notify people more quickly and in more locations. However, some of the warning systems require people to seek additional information, including crucial protective actions. Details of the flash flood warning process will help the audience to understand these methods and explain them to others, improving response to life-threatening situations.

PUBLIC INFORMATION, PUBLIC WARNING, AND EMERGENCY RESPONSE RELATED TO HIGH FLOW EVENTS IN PENNINGTON COUNTY DURING MAY AND JUNE 2015

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Spanning the period between May 1st, 2015 and June 30th, 2015 we will briefly discuss the techniques and results of both emergent and non-emergent hazard communication between Emergency Management and the public-at-large regarding high water flow events within Pennington County. Tools such as the Integrated Public Alert & Warning System, town hall-style meetings, and social media platforms will be presented and messaging challenges related to the speed at which flash flood events can develop, the geographically localized nature of these events, and public misconceptions will be addressed. We will also highlight some of the more noteworthy emergency responses during that timeframe to include the White River / Oglala swiftwater rescue and the flooding that occurred in Hill City.

THURSDAY, APRIL 7, 2016
SESSION 4A
3:50 – 5:10 P.M.

MANAGEMENT STRATEGIES
(ALPINE ROOM)

HELPING MINNESOTA IMPLEMENT ITS NUTRIENT REDUCTION STRATEGY AND REDUCE ITS IMPACT ON DOWNSTREAM WATERS SUPPORTING LOCAL, STATE, AND INTERNATIONAL WATER QUALITY EFFORTS

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Excessive nutrients pose a significant problem for Minnesota's lakes and rivers and downstream waters, including the Great Lakes, Lake Winnipeg, Hudson Bay, the Mississippi River, and the Gulf of Mexico. To ensure high quality water resources, Minnesota implemented the Water Management Framework, which outlines a process for assessing, restoring, and protecting surface waters. This approach is a four-step process repeated on a 10-year cycle that includes (1) monitoring, (2) data assessment, (3) developing restoration and protection strategies, and (4) implementing restoration and protection projects.

As part of this framework, the Minnesota Pollution Control Agency (MPCA) is developing watershed modeling applications across the state, including watersheds draining to Lake Winnipeg and the Mississippi River. Watershed scale modeling effort aims to develop holistic watershed-scale approaches for monitoring, assessing, and developing Total Maximum Daily Loads (TMDLs) and Watershed Restoration and Protection Strategies (WRAPS).

Lake Winnipeg and the Lake of the Woods: The International Joint Commission (IJC) developed nitrogen and phosphorus reduction targets for the Red River of the North, conforming with nutrient objectives for Lake Winnipeg (Canada). A watershed model application was developed for the U.S. and Canadian portions of the Lake of the Woods Basin (tributary to Lake Winnipeg). The Lake of the Woods TMDL study utilizes the watershed model application linked with the BATHTUB lake model to assess pollutant sources to determine the loading capacity of the lake, including internal loading.

Mississippi River and the Gulf of Mexico: Watershed model applications have been developed for the Upper Mississippi Basin watersheds. WRAPS are currently underway throughout these watersheds, including several projects that leverage watershed model applications to explore how frequency, duration, and magnitude of low and peak flows are influenced by changing land use, forest condition and composition, and climate/changing weather patterns and the implications of these changes for water users.

HYDROLOGIC AND WATER QUALITY IMPACTS OF DRAINAGE MANAGEMENT STRATEGIES IN EASTERN SOUTH DAKOTA

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Subsurface drainage is a common water management practice in the Midwest United States. Even though research on subsurface drainage systems and their management has been conducted for many years, continued understanding of their hydrologic and water quality impacts, based on field measurements is still needed to improve the practice of subsurface drainage, especially when combined with other conservation practices such as nutrient management and crop rotation. This research aims to determine the impacts of drainage and other management practices on hydrology and water quality using field measurements from research plots in eastern South Dakota over a period of two years (2014 -2015). Six research plots, of which three conventionally drained and the other three undrained, were planted with corn and soybean rotation. All the six plots are further subdivided in split-plots for conventional urea and super-urea (nitrogen inhibitors) treatments. Results showed that soil moisture in undrained plots was higher than that of drained plots at 45-cm and 76-cm depths while lower at 15-cm and 106-cm depths. Nitrate losses from drained plots with super-urea were lower compared to drained plots with urea application, whereas nitrate concentrations in the water from for super-urea application were higher compared to urea application in undrained plots. Nitrate losses were lower for drained plots than undrained plots. Shallow groundwater nitrate concentrations for drained plots were lower compared to undrained. This study would help the local community and decision makers to develop a better understanding of drainage impacts on field water balance in South Dakota.

DEVELOPING A WEB-BASED IRRIGATION DECISION SUPPORT SYSTEM FOR BENTON COUNTY, MINNESOTA

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Little Rock Creek is a trout stream located within Benton and Morrison Counties in Minnesota that is listed as impaired for temperature, low dissolved oxygen, and nitrates. A stressor identification report developed by Benton Soil and Water Conservation District (SWCD) found that altered flow (low flow) is the dominant stressor contributing to degraded surface water quality in Little Rock Creek. The report also identified a positive statistical correlation between increased groundwater pumping and decreased stream flow. The goal for this project, as set forth by the project sponsor Benton County SWCD, is to reduce groundwater use to sustainable levels and restore trout to Little Rock Creek through voluntary implementation of soil health best management practices and increased irrigation efficiency.

The Benton County SWCD is working with RESPEC to develop a conservation irrigation decision support system to help irrigators scientifically schedule their irrigation applications and also provide up-to-date information on pertinent surface and groundwater conditions. Research has documented how scientific irrigation water management (IWM) can improve water conservation and productivity. Scientific IWM considers factors, such as soil water-holding capacity, crop-water use, and allowable depletions, are necessary to apply the optimum amount of water needed for crop production. The mobile application that is being developed will consider all these factors while being simple to set up and intuitive to use.

LIFE CYCLE ASSESSMENT OF LOW IMPACT DEVELOPMENT TECHNOLOGIES COMBINED WITH CONVENTIONAL SYSTEM FOR RESIDENTIAL ZONES IN THE CITY OF ATLANTA, GEORGIA

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Bioretention area, rainwater harvesting, and xeriscaping are considered low impact development (LID) technologies that are decentralized alternatives to conventional systems (CS) such as stormwater collection, water supply, and lawns. The goal of this study is not only to compare the technologies to the conventional sub-systems, but also to evaluate how those alternatives together contribute toward improving the environmental sustainability of CS according to land use and population. Environmental impacts were evaluated using life cycle assessment (LCA) and freshwater ecosystem impact (FEI). Each LID technology reduces the major impacts of a respective sub-system while adversely affecting others. The feasibility of LID technologies as well as the synergistic effects between them are different according to land use and population in a zone. Bioretention, for instance, reduces eutrophication and acidification impacts of the stormwater collection system by more than 50%, whereas rainwater harvesting has 46% less carcinogenic effects than the current water supply system, and xeriscaping has 67% less non-carcinogenic effects than lawns. A hybrid system (HS), LID alternatives combined with CS, was compared with CS in five single-family home zones (SHZs) and four multi-family apartment building zones (MAZs). Implementation of HS resulted in the following results when compared to CS: an increase of 48% and 15 % for carcinogenic effects, 0% and -41% in ecotoxicity, and a decrease of 58% and 35% for non-carcinogenic effects, for SHZs and MAZs, respectively. FEI is 75% lower in HS as compared to CS in the zones.

THURSDAY, APRIL 7, 2016
SESSION 4P
3:50 – 5:10 P.M.

WATER QUALITY (PONDEROSA ROOM)

PERCHLORATE AND SELECTED METALS ASSOCIATED WITH FIREWORKS OCCURRENCE WITHIN MOUNT RUSHMORE NATIONAL MEMORIAL, SOUTH DAKOTA, 2011–2015

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Mount Rushmore National Memorial (NM) provides drinking water to about 3 million visitors and year-round park personnel annually. An environmental concern to water resources within Mount Rushmore NM has been associated with the annual aerial fireworks display at the monument around the July 4th holiday during 1998–2009. A major concern by park management is the contamination of groundwater and surface water by perchlorate, which is used as an oxidizing agent in firework displays. This presentation provides a characterization of water quality in groundwater and surface water within and adjacent to Mount Rushmore NM during 2011–2015. Concentrations of perchlorate and metals in 106 water samples and 11 soil samples from 6 groundwater sites, 14 surface-water sites, and 11 soil sites are presented.

Within the Mount Rushmore NM boundary, perchlorate concentrations were greatest east of the monument, in the Lafferty Gulch basin, ranging from less than 0.20 to 38 micrograms per liter (µg/L) in groundwater samples and 2.2 to 54 µg/L in surface-water samples. Starling Gulch basin, west of the monument, also showed some evidence of perchlorate contamination, with concentrations ranging from 0.61 to 19 µg/L. All groundwater and surface-water samples within the unnamed tributary to Grizzly Bear Creek and reference sites outside the park boundary had concentrations less than 0.20 µg/L.

The groundwater system within the Lafferty Gulch drainage basin is highly susceptible to contamination via recharge, and is isolated from downstream movement by an intrusive body acting as a dam, explaining how a contamination problem is not likely to quickly disappear. The observed deposition of firework debris within Lafferty Gulch basin coupled with the lack of alternative perchlorate sources may indicate that past firework displays are a probable source of perchlorate occurrences.

DOES DIDYMOSPHENIA GEMINATA ALTER BENTHIC RESOURCE AVAILABILITY AND MACROINVERTEBRATE DIET SELECTION?

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Benthic macroinvertebrates (BMI) are structured to process the resources present in fluvial ecosystems and can alter their foraging strategies dependent upon stress and availability of resources. *Didymosphenia geminata*, a nuisance freshwater diatom, forms mats of extracellular stalk material that can blanket stream/river substrates. In 2014, *D. geminata* mats in Rapid Creek, SD at times covered 80+% of the stream substrate with mat thickness up to 3.5 cm. Ultimately, *D. geminata* mats alter resource composition and availability for the BMI community. We examined BMI diet composition and resource availability shift in relation to the presence and growth of *D. geminata* mats. With variable *D. geminata* mat thickness and patchiness depending upon season and location in Rapid Creek, we structured our experimental design to examine seasonal and longitudinal trends. Our objectives were to examine the influence of *D. geminata* on the quantity and availability of benthic resources, and BMI diet selection. Due to flows 5 times the average daily discharge, flow regime altered *D. geminata* mat thickness throughout 2014 and lead to an observable decrease in BMI abundance and resource availability.

TRITIUM IN GROUNDWATER IN THE SOUTHERN BLACK HILLS

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Tritium fallout from H-bomb tests in the Pacific Ocean area fell on North America, peaking in 1963. Inadvertently, tritium-enriched rain has provided a way to establish the time of groundwater recharge because prior to 1952 practically no tritium existed in groundwater.

In 1967 the U. S. Geological Survey (Gott et al., 1974) took numerous groundwater samples in the Dewey/Burdock area of the southwestern Black Hills. They found tritium concentrations exceeding 200 TU (tritium units), and determined the groundwater velocity in the Inyan Kara aquifer, assuming the tritium originated from rainout on nearby outcrops.

In 2011 the U. S. Geological Survey (Johnson, 2012) took groundwater samples in the same general area as the 1965 study. Because the half-life of tritium is 12.26 years, only 7 % of the tritium would still be present by year 2011 (48 years after 1963). Tritium concentrations in the 2011 samples ranged from 0 to 15.4 TU, roughly the range to be expected due to radioactive decay. The great range of tritium values indicate great groundwater dispersion occurs in the Inyan Kara Group. This dispersion is not unexpected since there are numerous stratigraphic units of variable thickness and geometry in the Inyan Kara Group.

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Johnson, R.H., 2012, Presentation of EPA, February 22, 2012: accessed May 5, 2014, at http://crustal.usgs.gov/projects/UREP/2-Groundwater-geochemistry-Dewey-Burdock-Johnson-final.pdf

PERFLUOROCHEMICALS (PFCS): AN EMERGING CONTAMINANT CLASS WITH FAR-REACHING HUMAN HEALTH AND ENVIRONMENTAL IMPLICATIONS

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Perfluorochemicals (PFCs), a sub-class of per- and polyfluorinated alkylated substances (PFAS), were used in a wide range of industrial applications from water proofing and protective coatings for textiles, preservatives, food packaging, hydraulic oils, cosmetics, floor wax, polish, paint, and lacquer as well as fire-fighting foams (aqueous film-forming foam [AFFF]) and are ubiquitous in the environment. The threat to public health and the environment is of increasing concern; the toxicology and regulatory framework is unfolding.

The presentation will discuss this emerging contaminant class and associated progress and challenges in the disciplines of analytical chemistry, fate and transport, remediation, regulatory policy, and toxicology over recent history and looking forward.

THURSDAY, APRIL 7, 2016
POSTER SESSION AND EVENING SOCIAL
5:10 – 7:00 P.M.

(RUSHMORE G ROOM)

DRAINAGE MANAGEMENT PRACTICES TO IMPROVE WATER QUALITY IN EASTERN SOUTH DAKOTA

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Subsurface drainage has increased dramatically in eastern South Dakota in the last several years driven by increases in precipitation and commodity and land prices. However, expansion of tile drainage may lead to downstream water quality problems. This study is conducted to evaluate how field water table management through controlled drainage can be used to secure water for crop production and protect water quality from drained lands. Two adjacent experimental plots, 4 acres for conventional drainage and 5.3 acres for drainage water management, were installed and instrumented at South Dakota State University Southeast Research Farm (SERF) near Beresford, South Dakota. Various field data on water balance components, soil hydrology, crop production, drainage flow, and water quality are continuously being collected to develop a better understanding of controlled drainage. Preliminary results showed that raising or lowering the water table in controlled drainage plots did not seem to have much impact on soil moisture compared to conventional drainage treatment. This study would increase understanding of subsurface drainage impacts on hydrology, water quality, and crop yields in South Dakota.

COMPARISON OF REFERENCE EVAPOTRANSPIRATION ESTIMATED BY AUTOMATED WEATHER STATION AND MEASURED WITH AN ATMOMETER

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Irrigation scheduling requires accurate estimations of reference evapotranspiration. The Atmometer is a simple and economical device that provides estimates of reference evapotranspiration in situ. The objective of this study was to compare the reference evapotranspiration estimated with the short-crop FAO-56 Penman-Monteith equation (ET_o) to measurements with an atmometer with the number 30 green canvas cover designed to simulate the short-crop reference ET (ET_{atm}). The atmometer readings were recorded every day at 8:30 a.m. for 28 days and the weather data were retrieved from automatic Brookings weather station for September 2015 in Brookings, SD. Results showed that ETatm tended to overestimate the ETo by approximately 12 percent. However, a good correlation between daily values of ETatm and ETo was observed (R^2=0.89). Among linear regressions for daily, three-day, and weekly values of ET_{atm} and ET_o, the weekly values demonstrated the best correlation (R^2=0.97). Therefore, the accuracy of reference ET estimated by atmometer is improved using weekly average, as compared to daily values. Finally, we concluded that the atmometer is a device that can be used to estimate reference evapotranspiration for irrigation scheduling where weather data are not available.

VEGETATIVE BEST MANAGEMENT PRACTICES FOR CONTROLLING ROADWAY RUNOFF

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Roadside ditches are an integral part of the drainage network in many locations of the United States; as such the quality of water leaving these ditches would necessarily affect downstream waters. Vegetative best management practices (BMPs) such as vegetative filter strips and grassed swales are often used to manage roadside ditches and conserve water quality. The objective of this study is to (1) summarize the current state literature and determine future research needs; and (2) provide recommendations for vegetative BMP implementation. Data on pollutant levels and removal rates is being compiled in order to gain insight on the effectiveness of roadway vegetative BMPs. This information is used in this study to make inferences and explore factors that affect pollutant removal in roadside ditches.

STEPS TOWARD BUILDING GROUNDWATER MODELING CAPACITY IN MONGOLIA

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Ulaanbaatar, the capital city of Mongolia, is dependent on groundwater for its municipal and industrial water supply. The population of Mongolia is about 3 million people, with about one-half the population residing in or near Ulaanbaatar. Groundwater is drawn from a network of shallow wells in an alluvial aquifer along the Tuul River. Evidence suggests that current water use and especially the projected water demand from a rapidly growing urban population, is not sustainable from existing water sources. In response, the Mongolia Ministry of Environment and the Mongolian Fresh Water Institute requested technical assistance on groundwater modeling through the U.S. Army Corps of Engineers to the U.S. Geological Survey (USGS). Scientists from the USGS-South Dakota Water Science Center provided two workshops in 2015 to Mongolian hydrology experts on basic principles of groundwater modeling using MODFLOW. The purpose of the workshops was to bring together representatives from the Government of Mongolia, local universities, technical experts, and other key stakeholders to build in-country capacity in hydrogeology and groundwater modeling. A preliminary steady-state groundwater-flow model was developed to simulate groundwater conditions in the Tuul River Basin and to utilize in water management decision-making. The model consisted of 2 layers, 226 rows, and 260 columns with uniform 500 meter grid spacing. The upper model layer represented the alluvial aquifer and the lower layer represented the underlying bedrock, which includes areas characterized by permafrost. Groundwater withdrawal was estimated at 180 m^3/d. Recharge was estimated for the Tuul River Basin at 114 mm/yr. The model is being modified and updated by Mongolian scientists as more data become available. Ultimately the model will be used to assist managers in developing a sustainable water supply, for current use and changing climate scenarios. Alternative water management methods, such as artificial recharge, injection wells, and high-flow diversions are under consideration. A key to success was developing in-country technical capacity and partnerships with the Mongolian University of Science and Technology; Mongolian Freshwater Institute, a non-profit organization; United Nations Educational, Scientific and Cultural Organization (UNESCO); the Government of Mongolia; and the U.S. Army Corps of Engineers.

APPLICATIONS OF SOIL AND VEGETATION DATA ON BEDROCK IDENTIFICATION

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The evaluation of correlations between soil and vegetation in relation to bedrock, is utilized to determine the validity of soil and vegetation data in identifying lithology in areas where bedrock is not visible or difficult to map by formation. The evaluation of soil, vegetation, and bedrock relationships is based upon data collected in the Hermosa Quadrangle, South Dakota. Geospatial analysis has been conducted through mapping of soil and vegetation data to bedrock boundaries in ArcGIS for the purpose of correlation. Following the geospatial analysis, field soil and bedrock sampling were used to evaluate the relationship between soil and bedrock based on chemical and physical properties. The chemical properties of soil and bedrock were determined using multi element x-ray fluorescence. Physical properties were described for both bedrock and soil, and compared to identify bedrock parent material traits present in the soil. This research is ongoing, however, upon completing research it is expected that an association of bedrock, soil type, and vegetation patterns will be identified. A correlation, or lack thereof, between bedrock, soil, and vegetation will be utilized to access the validity of bedrock identification through soil and vegetation analysis.

OPTIMIZING ALGAL COMPOSITION MAY INFLUENCE NUTRIENT REMOVAL EFFICIENCY FROM SURFACE WATER

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Nutrient loading has been a problem in Lake Kampeska near Watertown, SD for more than a decade. Lake Kampeska receives nutrients and sediment, from the Big Sioux River watershed, and the elevated nutrient loads can alter the ecosystem of the lake. Increased N and P loading leads to eutrophic and anoxic conditions which may lead to fish kills. To manage the nutrient input into Lake Kampeska, a retired water treatment facility was re-purposed in Watertown, SD into an algal growth facility. The goal of this facility is to remove nutrients biologically through the use of algae from the lake. We are examining the proportion of blue green algae cyanobacteria), green algae, and diatoms with in both the lake and the growth chamber within the facility. Diatoms and green algae dominated in the lake and the nutrient removal facility phytoplankton year round, while cyanobacteria were observed in the lake and nutrient removal facility, only in late summer and early fall. The increase in temperature also led to an increase in algal cells per mL. Total phosphorous decreased when there were more algae present. Understanding the seasonal distribution of algae in the lake and how that compares to the facility will provide the data needed for management of the nutrient removal facility as they strive to become more efficient. Average removal of nutrients from the facility throughout 2015 was 3.13% P and 18.15% N, however adjustments to the facility may increase efficiency of nutrient removal in the future.

ESTIMATING WATER USAGE RELATED TO UNCONVENTIONAL OIL AND GAS DEVELOPMENT IN THE WILLISTON BASIN IN NORTH DAKOTA, MONTANA, AND SOUTH DAKOTA

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The U.S. Geological Survey (USGS) has initiated two studies to better estimate water use associated with oil and gas development. These studies will fill knowledge gaps and inform water-use managers in North Dakota, Montana, and South Dakota. The first study is through North Dakota State University to assess available municipal water-use data and to define urban water-use categories to more effectively develop a municipal water-use profile. The development of an urban water-use profile will help determine trends in statewide municipal water use in light of oil and gas development and supplement information to water-use managers. The second study aims to develop methods to estimate water use associated with unconventional oil and gas (UOG) development in the United States, including a pilot study of water use associated with UOG development in the Williston Basin in North Dakota, Montana, and South Dakota. Technological advances in horizontal drilling, limited access to conventional oil and gas fields, and increased oil and gas prices have intensified development of UOG in the United States since 2005. The pilot study will include analyses of water use, sources, reuse, and disposal data for direct processes (for example, hydraulic fracturing and borehole maintenance), indirect processes (for example, crew camps, well pad upkeep, and road dust abatement), and ancillary processes (for example, recreation) related to UOG development in the Williston Basin from 2005–2015. This pilot study provides a unique ability to better characterize water use associated with UOG development in the Williston Basin and, subsequently, water use in other UOG plays in North America.

WATERSHED DECOMPOSITION: NEW GIS METHODS FOR WATERSHED SCALE LONG VALLEY PROFILE ANALYSIS

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30 meter digital elevation model data of the Rapid Creek watershed in the Black Hills was used to develop a new technique to accurately plot any topographic data on a longitudinal profile of a channel of interest. This method replaces the geographic coordinates of each DEM pixel with its corresponding flow length to the channel of interest. This was accomplished using swath profiles generated for the length of Rapid Creek. Once the geographic coordinates were replaced with flow length values, the basal elevations of fluvial deposits, terrace elevation profiles, and watershed boundary profiles were accurately and efficiently plotted on the long valley profile of Rapid Creek. We also used a swath profile of the channel elevation to subtract the elevation profile of Rapid Creek from the topography of the watershed. This allowed for automated extraction of continuous flood plain width for the entire length of Rapid Creek. Long valley profiles are a long-standing powerful tool used by geomorphologists to extract geologic information from fluvial systems. Although significant geomorphic information can be determined from channel profiles alone, the addition of other data such as terrace elevations, flood plain widths, or watershed boundaries can increase the power of long valley profile analysis significantly. However, to date, inclusion of any data other than the direct channel of interest has not been possible. The new techniques developed in this study have provided a more detailed geomorphic analysis of the Rapid Creek watershed leading to many new insights on the geomorphic evolution of the Black Hills. These new techniques have collectively been referred to as watershed decomposition and are applicable to any fluvial analyses projects across the field of geomorphology.

IMPACTS OF GRASSLAND CONVERSION ON HYDROLOGY AND WATER QUALITY IN THE BAD RIVER WATERSHED, SOUTH DAKOTA

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Grassland is a valuable natural resource with many environmental benefits such as reducing soil erosion, increasing carbon sequestration, providing wildlife habitat, and improving water quality. Grassland management is necessary for environmental preservation. This study aims to evaluate the effects of grassland conversion on water quality. The Soil and Water Assessment Tool (SWAT) will be used to evaluate scenarios for sediments, NO_3, and TP, as well as hydrology (e.g. runoff, ET, soil moisture, and water yield), in the Bad River watershed near Fort Pierre, South Dakota. This watershed has more than 80% of grassland and 14% of agricultural land use.

ESTABLISHING GENE FINGERPRINTS OF PATHOGENIC BACTERIA ALONG SELECTED REACHES OF RAPID CREEK, SKUNK CREEK, AND THE BIG SIOUX RIVER

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Bacterial levels, particularly fecal coliforms such as *E. coli*, are standard water quality indicators of fecal contamination. According to the 2014 South Dakota Integrated Report for Surface Water Quality Assessment, sections of Rapid Creek, Skunk Creek, and the Big Sioux River are affected by unacceptably high levels of indicator bacteria. Routine coliform testing provides a snapshot of microbial abundance and content; however, such sampling does not take into account the pathogenic profile of the bacteria.

Genes conferring harmful and invasive traits can be acquired by normally innocuous bacteria through “horizontal gene transfer,” which has been observed in environments with high bacterial levels, especially where sewage or other waste is concentrated. Since the ability of a microbe to cause disease in humans is directly related to its genetic make-up, the more virulence genes a bacterium acquires, the higher the chance it will cause disease. For example, shiga-toxigenic *E. coli* variants possess a gene that allows for production of a toxin that increases pathogenicity. Both municipal drinking water and water used recreationally have been shown to harbor Shiga-toxin producing bacteria, which have the potential to transfer these genes to otherwise harmless bacteria, creating new pathogens.

We have developed and applied a new pathogenicity PCR metric to assay the disease-causing potential of organisms in impaired surface water. From total DNA isolates obtained from Rapid Creek, Spring Creek, and the Big Sioux River, virulence genes including *stx1* (Shiga toxin 1), *stx2*, *ehxA*, *malB*, and *VT1* have been detected, indicating that the stream water may be harmful when ingested. Bacteria containing the virulence genes are a higher health risk than presence of fecal coliforms or *E. coli* alone. Thus, our work could lead to the implementation of new monitoring metrics, which include human health risk, as best management practices are developed for watersheds across the country.

IDENTIFYING BACTERIAL GENES ENCODING FOR ANTIMICROBIAL RESISTANCE IN SELECTED AREAS OF THE BIG SIOUX RIVER

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Bacteria have many innate as well as acquired mechanisms that enable survival to antimicrobials. Selective pressures, such as antimicrobial use in human health treatment and animal production, lead to increased levels of resistance in bacterial communities. This raises particular concern in environments with high levels of bacteria where ingestion by humans is a possibility, such as in recreational waters.

Many waterways across the U.S. are listed as impaired for fecal coliform and E. coli; it is important to understand the risk to human health from exposure to these waters. Bacteria are the cause of this public health concern as some harbor genes for human disease. The more “virulence factors” a single bacterium contains, the higher the potential for causing severe illness. Adding to this concern is the ability of bacteria to share genes across species through “horizontal gene transfer”. Pathogenic bacteria also expressing antimicrobial resistance are an even greater threat, as infections are harder to treat with commonly used antibiotics.

Many sections of the Big Sioux River, in eastern SD, are listed as “impaired” for fecal coliforms and E. coli. We have developed a method to screen the entire bacterial population present in water for potentially harmful genes, and have found that many genes common to enterohemorraghic E. coli are present in these waters (see Murray, Kunza and DeVeaux, this conference). The presence of antibacterial resistance genes in these same populations would increase the potential for creating a “superbug” resistant to eradication efforts. We will be extending our current panel to include families of antibiotic-resistance genes to further examine the human health risk associated with the entire bacteria community in this particular body of water. Understanding the source of antimicrobial resistant bacteria and associated health risks may lead to improved monitoring and remediation efforts for bacteria in the future.

MODELING THE HYDROLOGICAL IMPACT WITH LAND COVER CHANGE OVER TIME

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With the mountain pine beetle infestation spreading across the Black Hills in western South Dakota, the response of streamflow characteristics to the constantly changing land cover is being studied. The United States Geological Survey Earth Resources Observation Systems Data Center published land cover change over time for the Black Hills. The upper Rapid Creek basin in the Black Hills, a sub-basin of the Cheyenne River basin, is the study area using the land cover change database. The upper Rapid Creek watershed experiences rainfall dominated precipitation and changing land uses of mountain pine beetle infestation, burned vegetation, and managed forest. Upper Rapid Creek watershed includes three United States Geological Survey stream gage stations with data for the past forty years. This study examines streamflow variation with precipitation and land cover variation in upper Rapid Creek watershed in both wet and dry years. Converting the continuous land cover change characterization into dynamic parameters for input into the Hydrological Simulation Program – Fortran (HSPF) will result in a hydrologic simulation for the land-use change over an extended time period. The result provides a modeling tool to aide in time-variable hydrologic parameterization of land cover change for input into HSPF as well as determining the influence of land cover change on stream flow characteristics.

EVALUATION OF INTEGRATED DRAINAGE WATER AND AGRICULTURAL MANAGEMENT STRATEGIES FOR WATER QUALITY PROTECTION

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Subsurface drainage received considerable attention the recent few years in South Dakota. However, research showed that tile drainage contributes to off-site water quality problems. Agricultural drainage water management practices supplemented with conservation practices such as crop rotation, winter forage, limited fertilizer application, and controlled drainage may decrease tile flows and nutrient loads from tile drained lands. A two-year (2014-2015) study on agricultural subsurface drainage was conducted at South Dakota State University Southeast Research Farm (SERF) near Beresford, South Dakota to evaluate the effectiveness of selected conservation practices in reducing subsurface drainage volume and nitrate losses at plot scales. Six experimental plots, under corn-soybean rotation, divided into drained and undrained plots and subjected to two different fertilizer treatments, were monitored for baseline data collection. DRAINMOD was used with the baseline data to quantify the long-term hydrologic and water quality impacts of subsurface tile drainage. Various subsurface drainage scenarios- conventional drainage, no-drainage, controlled drainage, and sub-irrigation- are being evaluated in combination of conservation practices (e.g. winter forage, crop rotation, and fertilizer treatments) for managing water and nutrients in South Dakota soil and climatic conditions.

USING DENITRIFICATION BIOREACTORS AND PHOSPHATE ADSORPTION MEDIA TO REMOVE NUTRIENTS FROM AGRICULTURAL SUBSURFACE DRAINAGE WATER

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Increased loading of nutrients in subsurface water accelerate eutrophication of receiving waters, causing hypoxic conditions such as the case in the Gulf of Mexico. Research showed that nitrogen and phosphorus losses from agricultural streams in the Midwest, especially from subsurface drainage systems, are major contributors to the hypoxia problem in the Gulf of Mexico. Therefore, there is a critical need for low-cost and simple technologies to reduce exports of excess nutrients from subsurface drainage systems to sensitive aquatic ecosystems. Phosphorus can be removed from subsurface drainage waters via adsorption media using various low-cost industrial by-products, while nitrogen can be removed with denitrifying woodchip bioreactors. The objective of this project is to evaluate the performance of nitrogen and phosphorus removal reactors at field scales. Four woodchip bioreactors were installed between 2012 and 2014 near Baltic, Montrose, Arlington and Hartford in South Dakota. A phosphorus removal bed was designed and installed downstream of the woodchip bioreactor near Baltic early this year. The phosphorus removal bed was designed with large carbon steel turnings as the adsorption material. We are collecting and analyzing water samples before and after the reactors to evaluate their efficiency in removing nitrogen and phosphorus from the drainage water. Removal rates are also being calculated for each sample event to estimate the cost per pound of nitrogen and phosphorus removed. This study will benefit producers and policy makers by providing recommendations for conservation drainage practices.

ASSESSING ARSENIC CONTAMINATION IN THE BLACK HILLS AND NEW TREATMENT TECHNOLOGY FOR DRINKING WATER

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Arsenic (As) contamination in drinking water is a global problem and the Black Hills is no exception. Public water systems have been required by law to comply with the U.S. EPA maximum contaminant level (MCL) of 10 ppb. Private wells pull water from the same aquifers but are not required to treat their water. More than 300 private wells in the Black Hills, SD area were sampled for Arsenic contamination during 2013, 2014, and 2015 and analyzed for As and certain other constituents. Results show that in some areas more than 20% of private well samples exceeded the MCL. Well owners rarely treat the water either because they are unaware of the problem or because of the expenses involved.

CalxAqua, LLC in collaboration with South Dakota School of Mines and Technology has developed an affordable and environmentally friendly media for removing As and other heavy metals from water. It is a proprietary iron coated limestone that competes well with other adsorption media. The technology currently is being scaled-up and commercialized to bring an affordable remediation solution to private wells and small system operators. Bench top burette experiments were conducted using defined As concentrations (100 ppb) and show a reduction in As concentrations below the MCL for ~2,500 bed volumes. Pilot scale tests are being conducted to determine the media performance on real systems with pending results. The media has also shown the removal of Lead, Radium and Selenium. Preliminary point of use tests are assessing the viability of using this media in more remote drinking water wells. Beyond drinking water, the media can also be used in mining remediation projects.

IONOSPHERIC PLASMA COUPLING TO LOW-FREQUENCY ELECTROMAGNETIC RADIATION: A MECHANISM FOR MONITORING EARTHQUAKE PRECURSORS USING THE EXISTING GLOBAL NAVIGATION SATELLITE SYSTEM

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It is fairly well established in scientific literature that the ionosphere responds to a variety of geophysical activity and that a connection exists between processes in the Earth's lithosphere and subsequent disturbances observed in the upper atmosphere and ionosphere. Additionally, published analyses of geomagnetic field fluctuations reveal a correlation to future seismic events. Various techniques have been applied to monitor ionospheric changes; however, a new detection method for identifying earthquake precursors is possible through identification of low-frequency electromagnetic signatures in continuously monitored and corrected Global Navigation Satellite and GPS signals. The method applies statistical analysis of geomagnetic field fluctuations at the earth's surface and ionospheric total electron content (TEC) to identify precursive geomagnetic field fluctuations and corresponding ionospheric response that signify impending earthquake activity.

The present study involved the simultaneous monitoring of collocated seismic, geomagnetic, and ionospheric activity for the 2008 Wenchuan earthquake. An anomalous enhancement of TEC in southern China was found three days prior to the earthquake. Because the solar-terrestrial condition was quiet that day, it was improbable that the elevated TEC was caused by a geomagnetic storm. The spatial distribution was very local, which is likely associated with the seismo-ionospheric coupling process. Our subsequent analysis of vertical geomagnetic field data in the same region showed a corresponding geomagnetic field deviation from the four-week average preceding the earthquake. The data suggest anomalous changes in ionospheric TEC occur as a result of changes in the magnitude of geomagnetic fields. The data indicate a strong correlation from both the spatial and temporal perspective.

This work was done by National Security Technologies, LLC, under Contract No. DE-AC52-06NA25946 with the U.S. Department of Energy and supported by the Site-Directed Research and Development Program.

FRIDAY, APRIL 8, 2016
FIELD SEMINARS/TRIPS
PRE-REGISTRATION REQUIRED

TOUR OF NEW RAPID CITY WATER TREATMENT FACILITY AND CLEGHORN SPRINGS FISH HATCHERY

Brief description: Tour will start at the new Rapid City Water Treatment facility, which is accessed by taking the first right as you start up Cleghorn Canyon (about 1/4 mile west of Canyon Lake). From there we will walk down to the Raw Water facility that is located just downstream from the mouth of Cleghorn Canyon and just south of SD44. From there we will walk down to the Cleghorn Springs Fish Hatchery.

Leader(s): John Wagner, Rapid City Water Department, 605-209-2137 (cell) and
Brian Fletcher, Cleghorn Springs Hatchery Manager, 605-394-4100 (office)
Also feel free to call Dan Driscoll (USGS, 605-209-2137 (cell) if necessary)

Meeting time: Begin gathering (and any shuffling of people and vehicles) at 0800 and tour starts at 0815.

Meeting location: new Rapid City Water Treatment facility

Duration: 2 to 3 hours (2.0 PDH)

Special instructions: Parking is available at the Water Treatment Plant, the Raw Water, and at the Fish Hatchery. All three locations are within easy walking distance, especially if weather is nice.

WALKING TOUR OF 1972 FLOOD AREA

Brief description: Tour will start at the front entry of the Journey Museum, heads south to the Bike Path along Rapid Creek, follows the Bike Path westerly to Memorial Park, and returns easterly along New York Street. Points of interest are discussed at six stops identified on the tour map that will be provided to participants.

Leader(s): Perry H. Rahn

Meeting time: 0800

Meeting location: Journey Museum

Duration: 2 hours (2.0 PDH)