

2013  
WESTERN SOUTH DAKOTA  
HYDROLOGY MEETING

Program and Abstracts

---

**April 18, 2013**  
**Rushmore Plaza Civic Center**  
**Rapid City, South Dakota**

## TABLE OF CONTENTS

About the Meeting .....	3
Acknowledgments .....	3
Program .....	5
Abstracts	
Session 1 – 2013 Themes: Climate and Resource Development.....	7
Session 2A – Surface-Water Issues (concurrent) .....	10
Session 2P – Groundwater (concurrent) .....	17
Luncheon – John T. Loucks Distinguished Lecture .....	24
Session 3A – Water Implications for Resource Development (concurrent).....	25
Session 3P – Remote Sensing and GIS (concurrent) .....	30
Session 4A – Climate (concurrent).....	35
Session 4P – Water Quality (concurrent) .....	39
Poster Session.....	43

# 2013 Western South Dakota Hydrology Meeting

This program and abstracts book has been produced in conjunction with the 2013 Western South Dakota Hydrology Meeting (11<sup>th</sup> annual), held at the Rushmore Plaza Civic Center on April 18, 2013. The purpose of this book is to provide summaries of the presentations made during the meeting.

The purpose of the 2013 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, the John T. Loucks Distinguished Lecture, and a poster session. The topics of the technical sessions include climate, water implications for resource development, surface-water issues, groundwater, remote sensing and GIS, 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, Chris Faulkner, is thanked for his time and perspectives. Registration help by Sheri Meier (USGS) is greatly appreciated. Josh Lee (USGS) provided computer support for the meeting.

The organizing agencies are thanked for support: National Weather Service, 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 Water & Natural Resources is thanked for being the Executive Sponsor. The many vendors are thanked for their support of the conference. Northwater Consulting and MidContinent Testing Laboratories, Inc. are thanked for helping to sponsor refreshments at the evening social. The chairpersons for this meeting were Melissa Smith (National Weather Service), Cheryl Chapman (RESPEC), Kelli McCormick (South Dakota Department of Environment and Natural Resources), Joanne Noyes (South Dakota Department of Environment and Natural Resources), Jenifer Sorensen (RESPEC), Bora Cetin (South Dakota School of Mines and Technology), Arden D. Davis (South Dakota School of Mines and Technology), Scott J. Kenner (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).

# RESPEC

CONSULTING & SERVICES

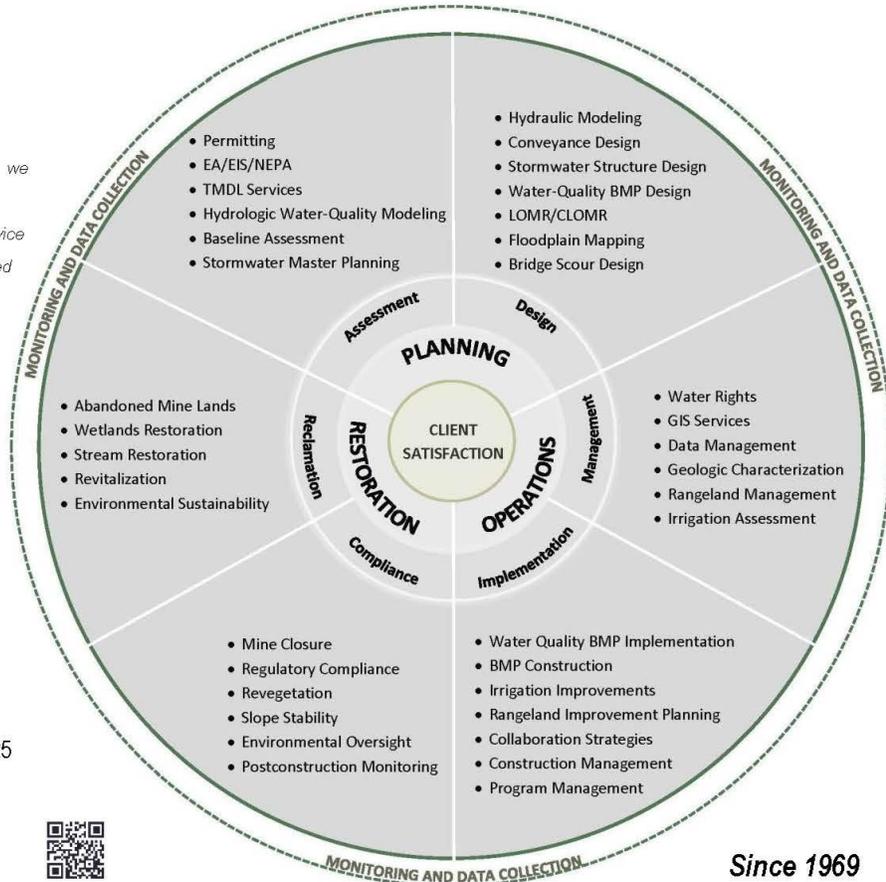
INNOVATION • COLLABORATION • INSPIRATION

MINING & ENERGY	WATER & NATURAL RESOURCES	INFORMATION TECHNOLOGIES
<p>Materials Testing Engineering Analysis Mine &amp; Field Services</p>	<p>Environmental Management Water Resources Watershed Management</p>	<p>Software Development Database Development Cloud Computing</p>

## Project Life Cycle Services Offered by RESPEC's Water & Natural Resources Division

*"Through recent acquisitions, we have greatly expanded our geographic footprint and service offerings, which has enhanced our ability to provide turnkey solutions to our clients."*

**Jason Love**  
Vice President WNR  
[Jason.Love@respec.com](mailto:Jason.Love@respec.com)



**To Find Out More:**  
3824 Jet Drive, P.O. Box 725  
Rapid City, SD 57709-0725  
Tel: 605.394.6400  
Fax: 605.394.6456  
[www.respec.com](http://www.respec.com)



Since 1969

# 2013 WESTERN SOUTH DAKOTA HYDROLOGY MEETING PROGRAM

Thursday, April 18, 2013  
Alpine/Ponderosa Rooms and Rushmore F and G  
Rushmore Plaza Civic Center

7:00 – 8:00 a.m.	<b>REGISTRATION</b>	
8:00 – 9:30 a.m.	<b>Plenary Session 1 in Alpine and Ponderosa Rooms – 2013 Themes: Climate and Resource Development (1.5 PDH)</b> <b>Moderator – Mark Anderson</b> , Director of the U.S. Geological Survey South Dakota Water Science Center, Rapid City, SD	
8:00 – 8:10 a.m.	Welcome, general information	<b>Mark Anderson</b> and <b>Daniel Driscoll</b> , U.S. Geological Survey
8:10 – 8:50 a.m.	Responding to extreme events in the Missouri River Basin	<b>Doug Kluck</b> , National Oceanic and Atmospheric Administration, Central Region Climate Services
8:50 – 9:30 a.m.	South Dakota's oil and gas potential and data availability through an interactive map	<b>Derric Iles</b> , South Dakota Department of Environment and Natural Resources
9:30 – 10:10 a.m.	<b>REFRESHMENT BREAK in Rushmore G</b>	
10:10 a.m. – 12:10 p.m.	<b>Concurrent Session 2A in Alpine Room – Surface-Water Issues (2.0 PDH)</b> <b>Moderator – Dan Driscoll</b> , U.S. Geological Survey	<b>Concurrent Session 2P in Ponderosa Room – Groundwater (2.0 PDH)</b> <b>Moderator – Joanne Noyes</b> , South Dakota Department of Environment and Natural Resources
10:10 – 10:30 a.m.	<i>Sediment transport in the Missouri River during the high-flow conditions of 2011 – <b>Joel Galloway</b>, <b>David Rus</b>, and <b>Jason Alexander</b></i> , U.S. Geological Survey	<i>A regional Black Hills groundwater-flow model of the Madison and Minnelusa aquifers: progress and plans – <b>Andrew Long</b></i> , U.S. Geological Survey, and <b>Jonathan McKaskey</b> , South Dakota School of Mines and Technology
10:30 – 10:50 a.m.	<i>Riverbank stability due to hydropower dam operations – <b>Soonkie Nam</b></i> , South Dakota School of Mines and Technology, <b>Marte Gutierrez</b> , Colorado School of Mines, <b>Panayiotis Diplas</b> , and <b>John Petrie</b> , Virginia Polytechnic Institute and State University	<i>Geophysical methods for characterization of karst features in the Madison aquifer – <b>Karl Koth</b>, <b>Andrew Long</b>, <b>Kyle Davis</b>, <b>Trevor Irons</b></i> , U.S. Geological Survey, <b>William Roggenthen</b> , <b>Kurt Katzenstein</b> , and <b>Jonathan McKaskey</b> , South Dakota School of Mines and Technology
10:50 – 11:10 a.m.	<i>Methods and challenges to wetland permitting in western South Dakota – <b>Cheryl Chapman</b>, <b>Mary Kenner</b>, and <b>Jenifer Sorensen</b></i> , RESPEC	<i>Pulling it together: integrating well data to generate elevation and depth-to-aquifer maps for major aquifers in the northern Black Hills – <b>Crystal Hocking</b></i> , RESPEC
11:10 – 11:30 a.m.	<i>Temperature total maximum daily load assessment for the Battle Creek watershed using the HSPF shade module – <b>Tyler French</b>, <b>Cory Foreman</b>, and <b>Robert Smith</b></i> , RESPEC	<i>Interaction of groundwater and surface water in the Williston and Power River structural basins – <b>Jennifer Bednar</b></i> , U.S. Geological Survey
11:30 – 11:50 a.m.	<i>Monitoring stormwater quality in two drainage basins in Rapid City, South Dakota, 2010-2012 – <b>Robert Prann</b></i> , South Dakota School of Mines and Technology, <b>Galen Hoogstraat</b> , U.S. Geological Survey, <b>Jennifer Benning</b> , and <b>Scott Kenner</b> , South Dakota School of Mines and Technology	<i>A comparison of groundwater recharge estimation methods in the Williston and Power River structural basins in the Northern Great Plains – <b>Katherine Aurand</b></i> , U.S. Geological Survey
11:50 a.m. – 12:10 p.m.	<i>Exceedance-based analysis of the central Big Sioux River watershed – <b>Jared Oswald</b>, <b>Peter Rausch</b></i> , RESPEC, and <b>Robert Kappel</b> , City of Sioux Falls	<i>Paleohydrology and the origin of Jewel Cave – <b>Mike Wiles</b></i> , Jewel Cave National Monument
12:10– 2:00 p.m.	<b>LUNCH in Rushmore F Room – with accompanying presentations (1.0 PDH)</b> RESPEC: "RESPEC – Yesterday, Today, and Tomorrow," <b>Todd Kenner</b> , President <b>John T. Loucks Distinguished Lecture: Chris Faulkner</b> , Breitling Oil and Gas – <i>Community Impact: Oil, Gas and Water – Water Recycling from Hydraulic Fracking</i>	
2:00 – 3:20 p.m.	<b>Concurrent Session 3A in Alpine Room – Water Implications for Resource Development (1.5 PDH)</b> <b>Moderator – J. Foster Sawyer</b> , South Dakota School of Mines and Technology	<b>Concurrent Session 3P in Ponderosa Room – Remote Sensing and GIS (1.5 PDH)</b> <b>Moderator – Jeppe Kjaersgaard</b> , South Dakota State University
2:00 – 2:20 p.m.	<i>Investigation of mercury and arsenic sediment concentrations within the Cheyenne River Basin of the Cheyenne River Sioux Tribe Reservation – <b>Maria Squillace</b> and <b>James Stone</b></i> , South Dakota School of Mines and Technology	<i>Education for the protection of water resources on the Pine Ridge Indian Reservation – <b>Nicholas Marnach</b>, <b>Jennifer Benning</b>, <b>Scott Kenner</b>, <b>Foster Sawyer</b></i> , South Dakota School of Mines and Technology, <b>Delinda Simmons</b> , and <b>Al Hancock</b> , Oglala Sioux Tribe Environmental Protection Program

2:20 – 2:40 p.m.	<i>Groundwater availability and flow processes in the Williston and Powder River Basins in the Northern Great Plains – Kyle Davis, Andrew Long, Joanna Thamke, Katherine Aurand, Timothy Bartos, Jennifer Bednar, Gary LeCain, Derek Ryter, and Roy Sando, U.S. Geological Survey</i>	<i>Remote-sensing-based evapotranspiration from fields with and without cover crops – Jeppe Kjaersgaard, Brett Hankerson, and Christopher Hay, South Dakota State University</i>
2:40 – 3:00 p.m.	<i>Water for oil country: the Western Area Water Supply Project – Cory Chorne, AE2S</i>	<i>Building digital elevation models (DEMs) for hydrologic modeling from LAS datasets – Janet Gritzner and Bruce Millett, South Dakota State University</i>
3:00 – 3:20 p.m.	<i>Comparison of water quantity impacts and economic benefits of the Dewey-Burdock in-situ uranium recovery project (DBP) – Mark Hollenbeck, Powertech (USA) Inc.</i>	<i>GIS based pollution load water quality model – Jeff Boeckler, Northwater Consulting</i>
<b>3:20 – 4:00 p.m.</b>	<b>REFRESHMENT BREAK in Rushmore G</b>	
<b>4:00 – 5:00 p.m.</b>	<b>Concurrent Session 4A in Alpine Room – Climate (1.0 PDH)</b> <b>Moderator – Melissa Smith, National Weather Service</b>	<b>Concurrent Session 4P in Ponderosa Room – Water Quality (1.0 PDH)</b> <b>Moderator – Jenifer Sorensen, RESPEC</b>
4:00 – 4:20 p.m.	<i>The 2012 South Dakota drought: perspectives of the State Fire Meteorologist – Darren Clabo, South Dakota School of Mines and Technology</i>	<i>Water-quality sampling of Precambrian crystalline aquifers in the central Black Hills – Arden Davis, Alvis Lisenbee, Maribeth Price, Katherine Aurand, Jennifer Bednar, and Micheal Tekle, South Dakota School of Mines and Technology</i>
4:20 – 4:40 p.m.	<i>Dual-polarization radar applications for hydrology – Matthew Bunkers, NOAA/National Weather Service</i>	<i>Groundwater impacts of highways stabilized with waste materials – Bora Cetin, South Dakota School of Mines and Technology</i>
4:40 – 5:00 p.m.	<i>Severe weather associated with mergers between squall lines and isolated supercell thunderstorms – Adam French, South Dakota School of Mines and Technology</i>	<i>Evaluation of water-quality characteristics and sampling design for streams in North Dakota, 1970-2008 – Joel Galloway, Aldo Vecchia, Kevin Vining, and Robert Lundgren, U.S. Geological Survey</i>
5:00 – 7:00 p.m.	<b>POSTER SESSION AND EVENING SOCIAL (with refreshments) in Rushmore G</b> <b>Moderator – Janet Carter, U.S. Geological Survey</b>	
	Developing BMPs to minimize the water quality impacts of winter manure spreading	<b>Nathan Brandenburg, Jeppe Kjaersgaard, Ronald Gelderman, and Todd Trooien, South Dakota State University</b>
	Evaluating spatial and temporal scale issues with hydrologic models	<b>Dolraj Chalise, Thomas Fontaine, South Dakota School of Mines and Technology, and Adel Haj, U.S. Geological Survey</b>
	Improving reclamation design through runoff and erosion modeling of high-intensity precipitation events at the Riley Pass CERCLA Site, Custer National Forest, Harding County, South Dakota	<b>James Efta and Dan Seifert, USDA Forest Service</b>
	Geomorphic assessment of the Missouri River from Lake Sakakawea to Lake Oahe, North Dakota, 2012-2015 (LiDAR)	<b>Joel Galloway, Katherine Skalak, Edward Schenk, Rochelle Nustad, Adam Benthem, and Clifford Hupp, U.S. Geological Survey</b>
	A study on the effect of flow variation on the existing stability condition at the lower mouth of the Plum Creek, Stanley County, South Dakota	<b>Govinda Karki and Suzette Burckhard, South Dakota State University</b>
	A groundwater-flow model of the Black Hills area: Madison and Minnelusa aquifers	<b>Jonathan McKaskey, South Dakota School of Mines and Technology, and Andrew Long, U.S. Geological Survey</b>
	Demonstrating the nitrogen-removal effectiveness of denitrifying bioreactors for improved drainage water management	<b>Cynthuja Partheeban, Jeppe Kjaersgaard, Christopher Hay, and Todd Trooien, South Dakota State University</b>
	Detecting earth surface changes using archived 1954 photography for historic surface and 2012 lidar for current surface—Riley Pass CERCLA Site, Custer National Forest, Harding County, South Dakota	<b>Dan Seifert, USDA Forest Service, James Monty, Jeremy Webb, RedCastle Resources, Inc., and Haans Fisk, USDA Forest Service</b>
	Ground-water quality and relationships to fault zones and mining districts in Precambrian crystalline rocks of the central Black Hills	<b>Micheal Tekle, Arden Davis, Alvis Lisenbee, Maribeth Price, Katherine Aurand, and Jennifer Bednar, South Dakota School of Mines and Technology</b>
	A comparison of groundwater recharge estimation methods in the Williston and Powder River structural basins in the Northern Great Plains	<b>Katherine Aurand, South Dakota School of Mines and Technology</b>
	Using light detection and ranging (LiDAR) to monitor bank erosion along Big Bend on the Missouri River (Mnisosa Wakpa)	<b>Willis Zephier and James Sanovia, Oglala Lakota College</b>
	A resource inventory of selected sites along the White Clay fault in southwest South Dakota	<b>Lilly Jones, Oglala Lakota College</b>

---

**THURSDAY, APRIL 18, 2013**  
**SESSION 1**  
**8:00 – 9:30 A.M.**

**2013 THEMES: CLIMATE AND RESOURCE DEVELOPMENT**  
**(ALPINE/PONDEROSA ROOMS)**

---

# Responding to Extreme Events in the Missouri River Basin

## **Doug Kluck**

National Oceanic and Atmospheric Administration, Central Region Climate Services, 7220 NW 101<sup>st</sup> Terrace, Kansas City, MO, 64158, email: *doug.kluck@noaa.gov*

Over the past two years the Missouri River Basin has seen its share of extreme events at both ends of the hydrologic spectrum. Interest in the basin has never been higher with many sectors and groups. Of the many concerns, there is a need to better understand the climate in the context of current and future conditions. Many decision makers in the basin have related their desire to have better information for planning, monitoring and mitigation. A number of federal agencies, state officials, tribes, academic institutions and many others have been working collaboratively to provide some of these answers and aid efforts to prepare for the next extreme event. This presentation will highlight some of those efforts that are in progress and those yet to be started.

# South Dakota's Oil and Gas Potential and Data Availability through an Interactive Map

**Derric Iles**

Geological Survey Program, South Dakota Department of Environment and Natural Resources, USD Science Center, 414 East Clark Street, Vermillion, SD 57069, email: *Derric.Iles@usd.edu*

Examples of South Dakota's under-explored potential are the Red River Formation, which has been producing oil in South Dakota since 1954, and the basal Minnelusa Formation. The basal Minnelusa is an oil producer in southwestern South Dakota and is equivalent to a producing unit in North Dakota named the Tyler Formation. The Minnelusa Formation has been drilled through many times in South Dakota but with perhaps no intent to assess hydrocarbon potential as this unit may simply have been a rock unit that had to be drilled through to reach a deeper target, the Red River Formation. Most of the drilling through the Minnelusa Formation was performed prior to the concept of producing oil from tight formations such as the Bakken in North Dakota. It is difficult to find a resource if there is no exploration for it and if the exploration program is not designed to perform the necessary tests in the appropriate stratigraphic intervals.

The South Dakota Department of Environment and Natural Resources (DENR) is promoting exploration and development of South Dakota's oil and gas resources through its Oil and Gas Initiative. One aspect of the initiative is to make state-held information, which is pertinent to the exploration and development of South Dakota's oil and gas resources, searchable and readily available online. Therefore, DENR has developed, and continues to improve, an online, "one-stop shop" for oil and gas information. The initiative has resulted in an online, searchable, and interactive map containing several data layers drawing information from DENR's Minerals and Mining, Geological Survey, and Water Rights programs.

Data layers in the interactive map that are that are most relevant to the oil and gas industry contain (1) the complete oil and gas permit file in bookmarked, PDF format, (2) scanned geophysical logs in TIFF format, (3) database records of oil and gas drilling, (4) boundaries of oil and gas fields, (5) boundaries of enhanced recovery units, and (6) Board Orders in PDF format that establish legal and operational constraints on geographic areas and wells. Other data layers in the interactive map contain (1) non-oil-and-gas geophysical logs, (2) water well completion reports, (3) other descriptive logs of non-oil-and-gas drilling, and (4) records of water-level measurement and water quality from a network of regulatory observation wells. Data on oil and gas production are also available.

Although this online availability of information was developed to promote further exploration and development of South Dakota's hydrocarbon resources, the information is relevant to more than oil and gas. For example, the information is important to the topics of public and private ground-water supplies, ground-water quality and contamination events, confined animal feeding operations, and county zoning issues.

---

**THURSDAY, APRIL 18, 2013**  
**SESSION 2A**  
**10:10 A.M. – 12:10 P.M.**

**SURFACE-WATER ISSUES**  
**(ALPINE ROOM)**

---

## **Sediment Transport in the Missouri River during the High-Flow Conditions of 2011**

### **Joel M. Galloway**

U.S. Geological Survey, North Dakota Water Science Center, 821 E. Interstate Ave, Bismarck, ND 58503, email: [jgallowa@usgs.gov](mailto:jgallowa@usgs.gov)

### **David L. Rus**

U.S. Geological Survey, 5231 South 19th Street, Lincoln, NE 68512-1271, email: [dllrus@usgs.gov](mailto:dllrus@usgs.gov)

### **Jason S. Alexander**

U.S. Geological Survey, 5231 South 19th Street, Lincoln, NE 68512-1271, email: [jalexand@usgs.gov](mailto:jalexand@usgs.gov)

During 2011, many tributaries in the Missouri River Basin experienced near record peak streamflow and caused flood damage to many communities along much of the Missouri River. The large runoff event in 2011 provided an opportunity to examine characteristics of sediment transport in the Missouri River at high-magnitude streamflow and for a long duration. Sediment characteristics were examined during the 2011 high-flow conditions at six sites on the Missouri River, two in the middle segment of the basin between Lake Sakakawea and Lake Oahe in North Dakota, and four downstream from Gavins Point Dam along the Nebraska-South Dakota and Nebraska-Iowa borders.

Measured bedload transport rates in the lower segment of the Missouri River were consistently higher than those in the middle segment during the high-flow conditions in 2011. At the two sites in the middle segment of the Missouri River, the greatest bedload was measured during the recession of the streamflow hydrograph. A similar pattern was observed at some of the sites in the lower segment of the Missouri River, although the increase in bedload during the recession of the streamflow hydrograph was not as dramatic as observed at the sites in the middle segment of the Missouri River.

In general, the total-sediment load on the Missouri River was highest at the beginning of the high-flow event and decreased as streamflow decreased. The suspended-sediment load comprised an average of 93 percent of the total-sediment load, with the exception of site 3, where the suspended-sediment load comprised only 72 percent of the total-sediment load. A significant portion of that suspended-sediment load was comprised of streambed material that had been put into suspension by the high streamflows.

A description of the sediment characteristics for the Missouri River during the high-flow conditions in 2011 will be presented. The results from 2011 also will be compared to preliminary results from data collected in 2012 during relatively low to average flow conditions in the Missouri River.

# Riverbank Stability Due to Hydropower Dam Operations

## **Soonkie Nam**

Department of Civil and Environmental Engineering, South Dakota School of Mines and Technology, 501 E. St. Joseph Street, Rapid City, SD 57701, email: *Soonkie.Nam@sdsmt.edu*

## **Marte S. Gutierrez**

Division of Engineering, Colorado School of Mines, 1610 Illinois St., BB 269, Golden, CO 80401, email: *mgutierr@mines.edu*

## **Panayiotis Diplas**

Baker Environmental Hydraulics Laboratory, Department of Civil and Environmental Engineering, Virginia Polytechnic Institute and State University, Patton Hall 220-B, Blacksburg, VA 24061, email: *pdiplas@vt.edu*

## **John Petrie**

Baker Environmental Hydraulics Laboratory, Department of Civil and Environmental Engineering, Virginia Polytechnic Institute and State University, Patton Hall 220-B, Blacksburg, VA 24061, email: *jpetrie@vt.edu*

Several factors influence the water surface elevation in a river. Most are due to factors outside our control such as seasonal climate changes or unexpected heavy rainfall, but in some cases, human activity also affects these fluctuations. A hydropower dam is one such case, artificially dominating fluctuations in the river water elevation depending on its different operational modes based on considerations such as electricity generation, nature conservation, and/or natural hazard mitigation. Downstream water elevation inevitably fluctuates due to the different discharge rates of an upstream dam and, as a result, the water table in the riverbanks is also affected, ultimately affecting the stability of the riverbanks themselves. In this study, transient seepage and slope stability analyses are performed for representative riverbanks on the Lower Roanoke River under typical and extreme flow conditions experienced as a result of the operational and emergency modes of a hydropower dam. Variations in the riverbank stability due to different flow and soil conditions are explored taking into account unsaturated soil properties. The results illustrate that regular dam operations such as steady state, drawdown, and peaking do not affect the slope stability significantly. The factor of safety decreases as the WSE decreases. Drawdown and fluctuation also decrease the safety factor, though the rate of the decrease depends on the hydraulic conductivity of the soils rather than the discharge pattern. Geotechnical factors such as bank geometry, soil type, and hydraulic conductivity appear to make riverbanks more susceptible to stability issues rather than hydraulic characteristics such as discharge rate, frequency, and duration.

## **Methods and Challenges to Wetland Permitting in Western South Dakota**

### **Cheryl K. Chapman**

Vice President, RESPEC, P.O. Box 725, Rapid City, SD 57709,  
email: *Cheryl.Chapman@respec.com*

### **Mary A. Kenner**

Project Analyst, RESPEC, P.O. Box 725, Rapid City, SD 57709,  
email: *Mary.Kenner@respec.com*

### **Jenifer L. Sorensen**

Project Engineer, RESPEC, P.O. Box 725, Rapid City, SD 57709,  
email: *Jenifer.Sorensen@respec.com*

The U.S. Army Corps of Engineers evaluates permit applications for construction activities that affect navigable surface waters and wetlands as part of its regulatory role in protecting aquatic resources. The wetland permitting process has multiple steps that include delineating the wetland area(s), providing an alternative analysis, developing mitigation and monitoring plans, and conducting a minimum of five years of site monitoring.

A mitigation work plan describes how compensatory wetland mitigation will be completed on the site. Compensatory mitigation is required at a wetland site to offset impacts that cannot be avoided. Site monitoring follows wetland construction. Monitoring includes collecting data for quantifying open water and evaluating wildlife habitat and vegetative response on the site. Mitigation metrics used during monitoring ensures that quality habitat is replaced.

One of the challenges to wetland mitigation in western South Dakota is the impact droughts have on wetland development. As the frequency and longevity of droughts increase, wetland mitigation will become more challenging. Mitigation banking is one way to ensure that quality wetland habitat is available and maintained, while still allowing for economic development.

## Temperature Total Maximum Daily Load Assessment for the Battle Creek Watershed Using the HSPF Shade Module

### **Tyler O, French**

Engineer, RESPEC Water & Natural Resources, P.O. Box 725, Rapid City, SD 57709,  
email: *Tyler.French@respec.com*

### **Cory S. Foreman**

Manager, RESPEC Water & Natural Resources, P.O. Box 725, Rapid City, SD 57709,  
email: *Cory.Foreman@respec.com*

### **Robert L. Smith**

Engineer, South Dakota Department of Environment and Natural Resources, 2050 West Main Street, Rapid City, SD 57702, email: *Robert.Smith@state.sd.us*

The Battle Creek Watershed contains four assessment stream reaches that are listed on South Dakota's 2012 303(d) list of impaired waterbodies for exceeding water-quality criteria for temperature based on beneficial uses of cold-water permanent and cold-water marginal fish life propagation. The U.S. Environmental Protection Agency (EPA) requires Total Maximum Daily Load (TMDL) assessments be developed for all waterbodies listed as impaired. The objective of this project is to determine TMDLs for the reaches in the Battle Creek Watershed that fail to meet the water temperature criteria.

An **HSPF** model application was used to simulate continuous flow and water-temperature data throughout the watershed using available historical data for calibration and validation. In addition to historical data, 24 new sites were established during the summer of 2012 for physical habitat assessment and collection of continuous water-temperature and flow data. Physical habitat assessment data; more specifically, bank vegetation and canopy cover densities, in addition to stream orientation, topographic features, and sun position, were entered into **HSPF** using the **SHADE** module to determine the amount of solar radiation absorbed by the stream each hour. Vegetation and topographic shading characteristics were calculated for each reach using combined characteristics from several cross sections along each reach. These characteristics were found using **ArcGIS** and validated using **Solar Pathfinder** data that were collected at each of the physical habitat assessment sites.

Based on the temperature criteria for each impaired reach, allowable thermal loads will be calculated and allocated using a load duration curve (LDC) approach that expresses thermal loads as heat energy per day (kCal/day). Nonpoint sources, including solar radiation, air convection, conduction of the stream bed and evaporation/condensation, and point sources will be a part of the TMDL calculations. The model application will then be used to predict the flows and loads associated with alternative or future management conditions resulting from implementing Best Management Practices (BMPs) to understand the type and quantity of BMPs that are required to meet the water-quality criteria.

# **Monitoring Stormwater Quality in Two Drainage Basins in Rapid City, South Dakota, 2010–2012**

## **Robert A. Prann**

South Dakota School of Mines and Technology, 501 East St. Joseph, Rapid City, SD 57701,  
email: *robert.prann@mines.sdsmt.edu*

## **Galen K. Hoogestraat**

U.S. Geological Survey, South Dakota Water Science Center, 1608 Mountain View Road, Rapid City, SD 57702, email: *ghoogest@usgs.gov*

## **Jennifer L. Benning**

South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57701, email: *jennifer.benning@sdsmt.edu*

## **Scott J. Kenner**

South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57701, email: *Scott.Kenner@sdsmt.edu*

The city of Rapid City, South Dakota has implemented programs to improve stormwater quality in acknowledgement of the Phase II stormwater permitting requirements as defined by the U.S. Environmental Protection Agency. The U.S. Geological Survey, City of Rapid City, and South Dakota School of Mines and Technology began a cooperative stormwater monitoring program in 2008 within the Arrowhead drainage basin to evaluate runoff characteristics. Results from 2008–09 sampling efforts indicated high concentrations of fecal coliform bacteria. In 2010 the monitoring efforts were expanded to include the Meade/Hawthorne drainage basin in an effort to provide comparisons of water quality between different land uses and drainage types. The Arrowhead drainage basin is less developed (about 10 percent impervious area) and has a lower bacterial contribution to the Rapid Creek system than does the Meade/Hawthorne drainage basin (about 38 percent impervious area).

The focus of this presentation will be the development and discussion of detailed Storm Water Management Models (SWMM) to simulate runoff and pollutant concentrations in each basin to evaluate the effects of differing land uses, channel types, and best management practices (BMPs) for control of stormwater runoff quality. A parameter estimation and optimization program, PEST, was used to calibrate the models using flow and water quality data collected in 2010–11. Estimates of connected impervious area in these basins were obtained, in part, through the use of the PEST calibration routine. On an area-normalized basis, model results show that peak flows at the Meade/Hawthorne outlet were about 6 times greater than peak flows at the Arrowhead outlet in 2011 and annual fecal coliform loads were about 4 times greater, demonstrating the detrimental effects of increased urbanization. These models begin to characterize the level of additional BMP development needed to reach desired flow and pollutant load goals. Disconnecting impervious surfaces improves stormwater quality and volume, and can be an effective BMP strategy for future development.

# Exceedance-Based Analysis of the Central Big Sioux River Watershed

## **Jared K. Oswald**

Manager, RESPEC Water & Natural Resources, P.O. Box 725, Rapid City, SD 57709,  
email: [jared.oswald@respec.com](mailto:jared.oswald@respec.com)

## **Peter P. Rausch**

Engineer, RESPEC Water & Natural Resources, P.O. Box 725, Rapid City, SD 57709,  
email: [peter.rausch@respec.com](mailto:peter.rausch@respec.com)

## **Robert J. Kappel**

Environmental Engineer, City of Sioux Falls Public Works-Environmental Office, 1017 East  
Chambers Street, Sioux Falls, SD 57104, email: [bkappel@siouxfalls.org](mailto:bkappel@siouxfalls.org)

The Central Big Sioux River Watershed in eastern South Dakota has multiple stream reaches with beneficial uses impaired by sediment, bacteria, or both. Respec Consulting & Services developed an **HSPF** model to simulate the fate and transport of these pollutants within the watershed, so that sources can be identified and a Best Management Practice (BMP) Implementation Plan can be recommended. The characteristics of the watershed and its impaired reaches presented a difficult question: Is it more effective to implement BMPs within a large-scale urban Municipal Separate Storm Sewer System (MS4) or throughout agricultural areas? Large loads of pollutants are contributed by urban areas during storms, but these storms are relatively infrequent. Agricultural areas contribute smaller loads per acre during storms, yet these areas continue to contribute direct stream loads daily without the presence of rainfall.

The goal of every implementation project is to ultimately protect the health of streams every day, not just during storm events. To better understand the drivers of daily contributions to sediment and bacteria levels in the watershed, a unique exceedance-based analysis was developed. It tracks and quantifies the contributions from different areas of the watershed to water-quality exceedances at a specified point of the river. The same exceedance-based analysis was used to determine whether or not pollutants from areas throughout the watershed were contributed more by direct-stream loading or by rainfall runoff. Additionally, BMP scenarios were priced and applied throughout the watershed. The estimated cost for implementation within each area was normalized by the subsequent reductions in exceedances of water-quality standards to develop a Reduction Efficiency Index for those areas. The combination of this information resulted in a multi-tiered, source-targeted BMP Implementation Plan for the Central Big Sioux River Watershed.

---

**THURSDAY, APRIL 18, 2013**  
**SESSION 2P**  
**10:10 A.M. – 12:10 P.M.**

**GROUNDWATER**  
**(PONDEROSA ROOM)**

---

# **A Regional Black Hills Groundwater-Flow Model of the Madison and Minnelusa Aquifers: Progress and Plans**

**Andrew J. Long**

U.S. Geological Survey South Dakota Water Science Center, 1608 Mt. View Road, Rapid City, SD 57702, email: [ajlong@usgs.gov](mailto:ajlong@usgs.gov)

**Jonathan D.R.G. McKaskey**

South Dakota School of Mines and Technology and U.S. Geological Survey, 1608 Mt. View Road, Rapid City, SD 57702, email: [jmckaskey@usgs.gov](mailto:jmckaskey@usgs.gov)

The Madison and Minnelusa aquifers are critically important water resources in the Northern Great Plains and, in particular, the Black Hills area. These aquifers can substantially affect surface-water systems and provide the most important source of groundwater in this area for municipal, domestic, agricultural, and industrial use. Rapidly increasing demand from these aquifers may affect long-term groundwater and surface-water availability. Therefore, a regional numerical groundwater-flow model of the Madison and Minnelusa aquifers, with a primary focus on the Black Hills area, is in progress. The modeled area includes much of western South Dakota and northeastern Wyoming. Previous groundwater-flow models of these aquifers are limited to local extents in the Rapid City area and northern Black Hills. Future modeling needs are likely to include simulations of other areas of the Black Hills and also updated simulations in previously modeled areas. These needs could be met with a regional model, which has several additional advantages over individual local models. First, developing a single regional model is more cost effective than developing multiple smaller models. Second, simulation of site-specific areas is most accurate within a regional flow model because artificial model boundaries are not necessary. Third, artesian springs are critical water sources that capture groundwater from regional areas and thus are best simulated with a regional model. Fourth, the model grid can be refined for high-resolution simulations in any area of special interest or to answer specific hydrologic questions, such as local-scale effects of pumping. This regional model will answer three primary questions of broad scope: (1) How do the regional aquifers affect local groundwater flow? (2) What is the aquifer sensitivity to pumping and drought? (3) How might future data-collection efforts be planned most effectively? The three-dimensional model framework and potentiometric surfaces have been constructed, and estimation of recharge using a soil-water-balance model currently is in progress.

# Geophysical Methods for Characterization of Karst Features in the Madison Aquifer

**Karl R. Koth, Andrew Long, Kyle Davis**

U.S. Geological Survey South Dakota Water Science Center, 1608 Mountain View Road, Rapid City, SD 57702, email: *kkoth@usgs.gov, ajlong@usgs.gov, kyledavis@usgs.gov*

**Trevor Irons**

U.S. Geological Survey Crustal Geophysics and Geochemistry Science Center, Box 25046, Denver Federal Center, Denver, CO 80225-0046, email: *tirons@usgs.gov*

**William Roggenthen, Kurt Katzenstein, Jonathan McKaskey**

South Dakota School of Mines and Technology 501 E. Saint Joseph Street, Rapid City, SD 57701, email: *William.Roggenthen@sdsmt.edu, Kurt.Katzenstein@sdsmt.edu, jmckaskey@usgs.gov*

An integrated, non-invasive geophysical approach was developed to characterize karst features for a spring and stream sink complex in the Madison aquifer near Doty and Gravel Springs, about 9 miles northeast of Rapid City, SD. The Madison aquifer is a carbonate aquifer containing caves, conduits, and other dissolution cavities. The electrical resistivity tomography (ERT) method was used to image these features. The ERT data also were used to determine the resistivity of the subsurface limestone to constrain surface nuclear magnetic resonance (sNMR) data inversions (completed analyses will provide porosity estimates). High resistivity features were observed (between 2 and 5 meters) below the land surface in the ERT inversion. These features were investigated further, with cooperation from the South Dakota School of Mines and Technology, using ground-penetrating radar (GPR) to confirm the presence and location of dissolution cavities in the Madison Limestone.

Surface nuclear magnetic resonance is sensitive to water molecules residing in the pore spaces of aquifer materials. An sNMR loop acts as both a transmitting and receiving antenna; in transmit mode the antenna sends an electromagnetic pulse into the subsurface that excites the water molecules. This excitation creates an electromagnetic resonance signal that induces a current in the sNMR receiver loop. The magnitude of the induced current is proportional to the total sum of magnetic moments of the water molecules in the pore spaces underneath the sNMR loop.

GPR uses high-frequency radar pulses to image shallow subsurface features. Subsurface boundaries between materials with different dielectric constants cause variations in the reflections of the radio waves, which are recorded by the receiving antenna. The dissolution features in the Madison Limestone provided a favorable scenario for reflection of GPR radio waves and detection of cavities.

In an ERT survey, electrodes are used to induce a current into the ground and simultaneously measure the voltage at grounded electrodes along the survey line; the result is an estimate of the electrical resistivity of the subsurface. Preliminary results for a dipole-dipole survey with 2-meter electrode spacing show very high resistivity features 2-3 meters below the land surface. These highly resistive features have low resistivity bottoms that might indicate an air-filled void space (cave/conduit) with perched water or subsurface channels partially filled with insoluble high-conductivity sediments. Several other high-resistivity features about 2-5 meters below the surface might be deeper caves (signal attenuation is related to the size and depth of the feature) or areas containing many smaller solution openings.

**Pulling It Together:  
Integrating Well Data to Generate Elevation and Depth-to-Aquifer  
Maps for Major Aquifers in the Northern Black Hills**

**Crystal M. Hocking, P.G.**

RESPEC, 3824 Jet Drive, P.O. Box 725, Rapid City, SD 57709,  
email: *Crystal.Hocking@respec.com*

Increases in groundwater development and use within the Northern Black Hills have created a rising concern about the sustainable yield and overuse of the underlying aquifers. This concern creates the need for accurate and accessible aquifer information. Having access to various information, including well locations, aquifer properties, and withdrawal impacts, is becoming crucial for the agriculture community, government officials, and urban development planners. Currently, no central data repository exists for groundwater information within the watershed.

The goal of this project initiative was to more fully characterize the groundwater sources within the watershed by generating a suite of elevation (structure contour) and depth-to-aquifer maps. The project area includes all of Butte, Meade, and Lawrence Counties of the Northern Black Hills, South Dakota. The study focused on the four major aquifers in the region: Deadwood Formation, Madison Limestone, Minnelusa Formation, and the Inyan Kara Group.

The elevation maps are presented as contours on the top of the formation relative to sea level. The depth-to-aquifer maps are presented as a color gradient to indicate the approximate depths to the top of the aquifer for drilling. The maps were constructed by compiling numerous data sources including structural contour maps, oil and gas wells, and water wells logs. Much of this data, including historic maps and water well logs, were not available in a digital format. Historic maps were georeferenced and digitized. Approximately 4,000 water well logs (available only in a pdf format), were interpreted and transcribed into a geodatabase.

This project was prepared for the Belle Fourche River Watershed Partnership with funding from the South Dakota Conservation Commission, Butte County Conservation District, Butte County Commissioners, Meade County Commissioners, and the City of Spearfish.

# **Interaction of Groundwater and Surface Water in the Williston and Powder River Structural Basins**

**Jennifer M. Bednar**

U.S. Geological Survey, South Dakota Water Science Center, 1608 Mountain View Road, Rapid City, SD 57702, email: [jbednar@usgs.gov](mailto:jbednar@usgs.gov)

Groundwater availability in the Lower Tertiary and Upper Cretaceous aquifer systems in the Williston and Powder River structural basins is currently being assessed by the U.S. Geological Survey (USGS). The Williston basin is located in parts of North Dakota, South Dakota, and Montana in the United States and Manitoba and Saskatchewan in Canada. The Powder River basin is located in parts of Montana and Wyoming. Both structural basins are in the forefront of energy development, with an increased demand for both surface water and groundwater uses. As part of this study, the interaction between groundwater and surface water is being quantified. Estimates of base flow, gaining streams, sinking streams, and reservoir interactions have all been computed. Streamflow records from more than 300 streamgages available in the USGS National Water Information System database were used in conjunction with the hydrograph separation software, PART, developed by the USGS. To eliminate interference from natural and anthropogenic processes associated with measuring streamflow, only fall estimates of base flow were used in the study. A net balance approach was used along stream reaches where streamgages were located. Base-flow estimates from PART were compared to actual streamflow measurements. The streamflow estimates were used in the final quantification of the interactions. A water budget for each mainstem reservoir along the Missouri River was completed using data from the U.S. Army Corps of Engineers. Most of the streams in the study area are gaining flow from the aquifers, whereas the main-stem reservoirs are recharging or contributing water to the underlying aquifers.

# **A Comparison of Groundwater Recharge Estimation Methods in the Williston and Powder River Structural Basins in the Northern Great Plains**

**Katherine R. Aurand**

U.S. Geological Survey, South Dakota Water Science Center, 1608 Mountain View Road, Rapid City, SD 57702, email: [kaurand@usgs.gov](mailto:kaurand@usgs.gov)

The water-table fluctuation (WTF) and chloride mass-balance (CMB) methods were used as a comparison to a numerical soil-water-balance (SWB) model to estimate groundwater recharge in the Williston and Powder River structural basins in the Northern Great Plains. Recharge was estimated for glacial deposits and exposed areas of the Lower Tertiary and Upper Cretaceous aquifer systems in the Dakotas, Montana, Wyoming, Saskatchewan, and Manitoba. The WTF and CMB methods were applied to local areas with available groundwater-level and chloride data. The SWB model consisted of 1 km<sup>2</sup> grid cells across the entire study area.

The WTF method uses easily accessible groundwater-level data to estimate groundwater recharge under the assumption that rises in unconfined groundwater levels are a result of recharge from precipitation. For this assumption to be valid, only recharge to unconfined aquifers can be estimated by this method. Recharge is then calculated by multiplying the specific yield of the aquifer by the change in water level. The CMB method determines the rate of recharge to an aquifer based on the chloride concentration in the groundwater and the rate of atmospheric chloride deposition. An assumption with this method is that all chloride in the aquifer is derived from atmospheric deposition, although other sources of chloride can be accounted for if known. Both the WTF and CMB methods inherently take into account mechanisms of flow through the unsaturated zone and are simple to apply. The SWB model is based on a modified Thornthwaite-Mather approach and is used to estimate recharge as infiltration below the root zone to each model cell on a daily time step. Inputs for the SWB model include daily precipitation and air temperature data, land-use classification, soil type, and surface-water flow direction for each model cell. The sources and sinks of water within each grid cell are determined by the SWB model on the basis of input data. Recharge is then calculated as the difference between the change in soil moisture and the flow rates of sources and sinks.

# Paleohydrology and the Origin of Jewel Cave

**Michael E. Wiles**

Jewel Cave National Monument, 11149 U.S. Highway 16, Custer, SD 57730,  
email: *Mike\_Wiles@nps.gov*

## **Purpose**

With 165 miles of mapped cave passages, Jewel Cave is the third longest cave in the world. Ongoing exploration and geological mapping continue to refine our understanding of the cave and the surrounding area. Previous work has demonstrated an intimate relationship between the cave and the geologic structure, contacts, and topography, as they exist today. This paper proposes a hydrological model that 1) identifies likely recharge and discharge areas, and 2) describes a progression of hydrologic flow that accounts for the unique characteristics of the cave system.

## **Results**

Hell Canyon is in the bottom of a south-plunging syncline. The east limb, where most of the cave passages have been found, has an average dip of about 1.5 degrees from east to west. A down-dip cross section illustrates how the cave passages assume the shape of an elongate lens, located just below the Pahasapa/Minnelusa contact. The lower boundary is a maximum of 250 feet below the contact, but thins at each end, where the permeable, basal Minnelusa sandstone is exposed. These exposures occur in the Pass Creek drainage, Lithograph Canyon, and Hell Canyon.

## **Conclusions**

The relationship between cave passages, geology, and surface morphology support a hydrological model that portrays cave development as the result of local groundwater movement in geologically recent time. The apparent recharge was in the Pass Creek and Lithograph Canyon areas, and the discharge was in Hell Canyon. Groundwater initially moved through a shallow confined aquifer comprised of the basal Minnelusa sandstone, which was initially confined by the underlying Pahasapa Limestone and an overlying Minnelusa limestone. Although Laramide fractures provided secondary porosity, they weren't necessarily continuous enough to provide landscape-scale permeability. As water from the sandstone circulated into the discontinuous fractures of the Pahasapa, dissolutional enlargement integrated them to form the system of interconnected cave passages known today.

---

**THURSDAY, APRIL 18, 2013**

**LUNCHEON**

**12:10– 2:00 P.M.**

**JOHN T. LOUCKS DISTINGUISHED LECTURE:**

**CHRIS FAULKNER, CEO BREITLING OIL AND GAS**

**“COMMUNITY IMPACT: OIL, GAS AND WATER – WATER RECYCLING FROM  
HYDRAULIC FRACKING”**

**(RUSHMORE F ROOM)**

---

---

**THURSDAY, APRIL 18, 2013**  
**SESSION 3A**  
**2:00 – 3:20 P.M.**

**WATER IMPLICATIONS FOR RESOURCE DEVELOPMENT**  
**(ALPINE ROOM)**

---

# **Investigation of Mercury and Arsenic Sediment Concentrations within the Cheyenne River Basin of the Cheyenne River Sioux Tribe Reservation**

## **Maria Squillace**

South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57701, email: *Maria.K.Squillace@mines.sdsmt.edu*

## **James Stone**

Department of Civil and Environmental Engineering, South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57701, email: *James.Stone@sdsmt.edu*

The goal of this study was to determine the extent of arsenic and mercury sediment impacts due to historical Black Hills mining operations within the Cheyenne River basin of the Cheyenne River Sioux Tribe (CRST) Reservation. Fifteen sediment cores were collected within the floodplain using a sleeved split core sampler. Eleven of the recovered sediment cores were divided to represent surface and subsurface conditions, while the remaining four samples were individually homogenized due to poor recovery. Samples were subject to the following analyses: mineralogy (XRD), elemental analysis (XRF), carbon content (loss on ignition), total mercury, and sediment-bound microbial activity (Biolog). Further, a preliminary human health risk assessment is being completed following the EPA Region 8 guidelines. Sediment arsenic and mercury concentrations ranged from 40.8-160.5 ppb and 26-302 ppm, respectively, with concentrations generally decreasing downstream towards Lake Oahe. Mercury significantly correlated with arsenic and iron sediment concentrations, suggesting the source and mechanism of transport within the watershed may be similar. Quartz was the predominant mineralogy, with varying quantities of albite, calcite, illite, kaolinite, microcline, and muscovite also existing within the samples. Mercury concentrations significantly correlated with calcite and kaolinite, while arsenic negatively correlated with illite. These findings provide insight into the risk, fate, and transport of mercury and arsenic within the lower Cheyenne River system.

# **Groundwater Availability and Flow Processes in the Williston and Powder River Basins in the Northern Great Plains**

## **Kyle Davis, Andrew J. Long**

U.S. Geological Survey, South Dakota Water Science Center, 1608 Mountain View Road, Rapid City, SD 57702, email: [kyledavis@usgs.gov](mailto:kyledavis@usgs.gov), [ajlong@usgs.gov](mailto:ajlong@usgs.gov)

## **Joanna Thamke**

U.S. Geological Survey, Montana Water Science Center, 3162 Bozeman, Helena, MT 59601, email: [jothamke@usgs.gov](mailto:jothamke@usgs.gov)

## **Katherine R. Aurand**

U.S. Geological Survey, South Dakota Water Science Center, 1608 Mountain View Road, Rapid City, SD 57702, email: [kaurand@usgs.gov](mailto:kaurand@usgs.gov)

## **Timothy T. Bartos**

U.S. Geological Survey, Wyoming Water Science Center, 521 Progress Circle, Ste 6, Cheyenne, WY 82007, email: [ttbartos@usgs.gov](mailto:ttbartos@usgs.gov)

## **Jennifer M. Bednar**

U.S. Geological Survey, South Dakota Water Science Center, 1608 Mountain View Road, Rapid City, SD 57702, email: [jbednar@usgs.gov](mailto:jbednar@usgs.gov)

## **Gary D. LeCain**

U.S. Geological Survey, Office of Groundwater, West 6th Ave. & Kipling St., Lakewood, CO 80225

## **Derek Ryter**

U.S. Geological Survey, Oklahoma Water Science Center, 202 NW 66th Street, Oklahoma City, OK

## **Roy Sando**

U.S. Geological Survey, Montana Water Science Center, 3162 Bozeman, Helena, MT 59601

The recent oil and gas development in the Williston structural basin (containing the Bakken Formation) in the Dakotas, Montana, Saskatchewan, and Manitoba, and in the Powder River structural basin in Montana and Wyoming, provides an opportunity to study the water-energy nexus within a groundwater context. A large amount of water is needed for energy development in these basins, and the primary accessible aquifers are glacial sand and gravel aquifers and the Lower Tertiary and Upper Cretaceous aquifer systems. The U.S. Geological Survey currently is conducting a 4-year groundwater availability study of these regional aquifer systems, which will include conceptual and numerical models of groundwater flow.

The conceptual model includes a three-dimensional hydrogeologic framework, potentiometric surfaces, a description of groundwater-flow processes, and quantification of recharge and discharge components. The quantity and spatial variability of recharge within the study area is being assessed by using soil-water balance, water-table fluctuation, and chloride mass-balance methods. The interaction between groundwater and surface water is being quantified by analyzing streamflow records, using hydrograph separation methods, and implementing water-budget analyses for major reservoirs in the study area. Groundwater withdrawals are being quantified by analyzing Federal and State well databases and assessing previously published information. Future water-use projections will be made as part of the regional aquifer assessment.

The results of the conceptual model will be used to develop inputs to a numerical model of groundwater flow in the Williston structural basin. This model will provide an improved method for assessing how the groundwater resources have changed over time, determining groundwater-flow directions and inter-aquifer connection, and estimating the effects of potential future environmental stresses and anthropogenic demands.

# **Water for Oil Country: The Western Area Water Supply Project**

## **Cory Chorne**

Project Manager, AE2S, 1815 Schafer Street Suite 301, Bismarck, ND 58501,  
email: *Cory.Chorne@ae2s.com*

Regional aquifers in the western area of the state of North Dakota cannot handle the amounts of water needed to supply the oil industry and the growth in the region. In addition, some systems in the region are faced with poor water quality and insufficient quantity.

The Western Area Water Supply Project (WAWSP) is a domestic water project utilizing Missouri River water to meet the municipal, rural, and industrial water needs. The primary focus of the project is to supply drinking water for estimated 48,000 (peak pop.) expected in 2032. WAWSP is on track to be the fastest built regional/rural water system constructed in North Dakota out of necessity to serve the rapidly expanding regional population. This feat is achievable due to local stakeholder participation and local governance over the system.

One of the major benefits of the project is that the system will utilize its unused capacity during the growth period to sell water to the oil industry, which is projected to pay for 80 percent of the initial project cost. The project maximizes infrastructure already in place and combines the efforts of many entities for the good of region.

The WAWSP is an incredible success story. In just one biennium, stakeholders were able to come together - through multiple team meetings - to sign agreements and contracts, organize and contract their own infrastructure for WAWSA use, and design, bid, and build the trunk infrastructure to the major growth areas in the region.

This presentation will educate the audience on the demand and success of the WAWSP.

## **Comparison of Water Quantity Impacts and Economic Benefits of the Dewey-Burdock *In-Situ* Uranium Recovery Project (DBP)**

### **Mark Hollenbeck**

Project Manager, Powertech (USA) Inc., Edgemont, SD, email:  
*mhollenbeck@powertechuranium.com*

The US Nuclear Regulatory Commission (NRC) issued a positive Draft Supplemental Environmental Impact Statement (DSEIS) for public comment on November 23, 2012. Likewise, the State Department of Water and Natural Resources (DENR) Water Rights staff and Chief Engineer issued their respective optimistic reviews and recommendations to the Water Rights Board last fall.

Of the 52 potential impacts analyzed by NRC, the vast majority are considered SMALL, a few SMALL to MODERATE with only one (involving cultural resources) rated SMALL to LARGE. Similarly, DENR recommended issuance of the permit as abundant unallocated water resides in the aquifers. Consequently, NRC's Final SEIS and the Board's water right permit decisions are imminent.

While not all will be operating at the same time, multiple wellfields are anticipated at the DBP. Each wellfield will experience four distinct phases – construction, operation, restoration and decommissioning. Each phase will have its own inherent impact on water quantity from both the Inyan Kara and Madison Aquifers.

This presentation addresses the impacts to water quantity by comparing annual recharge and existing allocated quantities to estimated water consumption during construction, operation, restoration and decommissioning.

It will also highlight the economic benefits to resource owners from removing the uranium compared to utilizing the land in its usual and customary purpose of raising cattle. Quantitative analysis indicates that using ground water to recover uranium vs raising cattle results in a significant net positive gain for the resource owners. Additionally, direct economic impacts encompassing nearly a hundred decent paying jobs and severance taxes paid to the host counties and state overwhelm the few potential negative impacts identified in the DSEIS.

---

**THURSDAY, APRIL 18, 2013**  
**SESSION 3P**  
**2:00 – 3:20 P.M.**

**REMOTE SENSING AND GIS**  
**(PONDEROSA ROOM)**

---

## **Education for the Protection of Water Resources on the Pine Ridge Indian Reservation**

**Nicholas M. Marnach, Jennifer L. Benning, Scott Kenner, and J. Foster Sawyer**  
South Dakota School of Mines and Technology (SDSMT), 501 E. Saint Joseph Street, Rapid  
City, SD 57701, emails: *nicholas.marnach@mines.sdsmt.edu*, *jennifer.benning@sdsmt.edu*,  
*scott.kenner@sdsmt.edu*, *foster.sawyer@sdsmt.edu*

### **Delinda Simmons and Al Hancock**

Oglala Sioux Tribe Environmental Protection Program (OSTEPP), P.O. Box 2008, Pine Ridge,  
SD 57770, email: *ostwpdls@gwtc.net*

To promote sustainable water resource management, on the Pine Ridge Indian Reservation, the SDSMT and OSTEPP have partnered together beneath a U.S. Environmental Protection Agency education grant focused upon the protection of water resources on the Pine Ridge Reservation.

This partnership fostered the creation of a multi-tiered environmental education project with the aim of advancing critical watershed management components on the reservation. Collaborative participation within watershed management activities has added resilience to watershed management on the reservation and has the potential to positively affect Lakota culture and socioeconomic conditions on the reservation. Solutions were met through sustainable localized adaptation strategy and provided for the integration of numerous organizations' resources while facilitating the mission accomplishment of each.

Project members and organizations included: over 250 students of the Gaining Early Awareness and Readiness for Undergraduates Program (GEAR UP), Pre-Engineering Educational Collaborative (PEEC) students, Oglala Lakota College staff and students, OSTEPP staff, and SDSMT staff and students. Collaborative efforts coalesced with the assembling of data and implementation of practice required for effective watershed management.

Two automated stream monitoring locations installed as part of this project provided a spring board with which to launch and integrate project components. As a result of this project the cooperative development and delivery of higher order technical watershed management processes relative to the TMDL approach have been integrated to fill needs within the Oglala Sioux Tribe Non-Point Source Management Plan.

# Remote-Sensing-based Evapotranspiration from Fields with and without Cover Crops

## **Jeppe Kjaersgaard**

South Dakota Water Resources Institute, South Dakota State University, Box 2120, Brookings, SD 57007, email: [jeppe.kjaersgaard@sdstate.edu](mailto:jeppe.kjaersgaard@sdstate.edu)

## **Brett Hankerson**

Department of Agricultural and Biosystems Engineering, South Dakota State University, Box 2120, Brookings, SD 57007

## **Christopher Hay**

Department of Agricultural and Biosystems Engineering, South Dakota State University, Brookings, SD 57007, email: [christopher.hay@sdstate.edu](mailto:christopher.hay@sdstate.edu)

Considerable uncertainty exists regarding the spatial and temporal variability and distribution of the crop consumptive water use. The variability is caused by local and regional differences in weather, variations in precipitation distribution and quantity across a region, and differences in soil types, land form and land use, vegetation type, cultivar and cropping system, irrigation application method and land management. Normally the vast majority of the consumptive water use is made up by evapotranspiration, ET. The use of cover crops in agricultural production systems is a practice that is gaining popularity. Estimates of the consumptive water use by the cover crops are largely unavailable, though, and with the vast number of individualized seed mixtures, variations in planting densities and differences in planting methods, cover crops do not lend themselves well to universal crop coefficients. There is a need, therefore, to estimate and assess the water use by cover crops in order to determine the impact on the soil water balance and moisture availability. Suitable models and algorithms applied to high resolution (30 m) satellite imagery provide a cost effective and time efficient method to obtain evapotranspiration estimations from bare soil and vegetation. METRIC (Mapping Evapotranspiration at high Resolution with Internalized Calibration) is a model utilizing satellite imagery that can be used to estimate water use with high resolution (30 m) over a large area, thereby enabling the evaluation of the water consumption on a field-by-field basis. This is advantageous because of the ability to compare fields with different crop rotations side-by-side as well as fields with non-traditional crops, such as cover crops which are both late season and short season crops. The objective of this research is to examine the utility of using METRIC to estimate cover crop water use and compare the ET estimates produced by METRIC to ground-based vapor flux point measurements.

# **Building Digital Elevation Models (DEMs) for Hydrologic Modeling from LAS Datasets**

**Janet H. Gritzner**

Department of Geography, South Dakota State University, Box 504, Brookings, SD 57007,  
email: *janet.gritzner@sdstate.edu*

**Bruce V. Millett**

Department of Geography, South Dakota State University, Box 504, Brookings, SD 57007,  
email: *Bruce.Millett@sdstate.edu*

The Prairie Pothole Region (PPR) of the US and Canada is characterized by thousands of shallow, water-filled depressions with sizes ranging from a fraction of a hectare to several square kilometers. The purpose of this work is to apply GIS hydrologic modeling techniques to further understanding of the surface flow characteristics in the glacially disturbed landscapes of the PPR. Hydrologic modeling begins with accurate, appropriately scaled elevation data. LIDAR LAS elevation datasets at 0.9 m point spacing show real potential for resolving subtle landscape features and is used in this work for constructing hydrologically-correct DEMs. This research uses LAS Dataset evaluation tools in ArcGIS10.1 to guide the processing of LAS data. It tests various interpolation methods to determine which will produce the best hydrologically-correct digital product. Hydrologic modeling part of study is accomplished using ArcGIS 10.1 ArcHydro beta tools. Derivative products of this processing include flow direction grids with sink features, flow accumulation grids, vector datasets of streams, catchments and adjoint catchments, elevation contours, and drainage connectivity characterization data. Other results include calculations for depression area, depth, volume, and drainage area as well as comparisons of size and extent with known wetland features.

## **GIS Based Pollution Load Water Quality Model**

**Jeff H. Boeckler**

Northwater Consulting, 624 6th Street, Suite 212, Rapid City, SD 57701, email:

*jeff@northwaterco.com*

Northwater Consulting has developed and applied a GIS, spatially based and customized method for calculating upland non-point source pollution loading. This GIS model is unique in that it is spatially based, fully customizable, easy to understand and visualize and it has the ability to quantify pollution loads and water volumes down to the field/parcel level. This model can accommodate a variety of water quality constituents and provide total loading and load reduction calculations from the implementation of Best Management Practices. It can identify loading hot spots at the field level and results can be visualized in high quality map format.

This model forms the basis for conducting subwatershed analysis and BMP load reduction estimates as well as determining the appropriate linkage with pollution sources. The foundation of this model relies on soils data and land use and therefore annual loading and runoff outputs are generated for each land use and soils polygon. Results can be tabulated at the field level and the model is fully customizable to include local weather, site conditions and known watershed data. In urban and developing watersheds, the model can evaluate stormwater runoff and water quality impacts from future development forecasts, comparing results to existing conditions.

What is different with this modeling process compared to virtually all other efforts to quantify and allocate pollution loads, is this model can tie loading to a location on the ground and provide real estimates based on actual locations rather than estimates based on a group of individual land use/land cover categories; it can help to pinpoint treatment practices. Once established, users with GIS can utilize it to evaluate future project scenario(s). Furthermore, the model simplifies the ability to identify site specific project locations and can be presented to stakeholders in a format that is visually appealing and easy to understand.

---

**THURSDAY, APRIL 18, 2013**  
**SESSION 4A**  
**4:00 – 5:00 P.M.**

**CLIMATE**  
**(ALPINE ROOM)**

---

# **The 2012 South Dakota Drought: Perspective of the State Fire Meteorologist**

**Darren R. Clabo**

South Dakota State Fire Meteorologist, South Dakota School of Mines and Technology, 501 East Saint Joseph Street, Rapid City, SD 57701, email: *Darren.clabo@sdsmt.edu*

Numerous large wildland fires occurred during 2012 that undoubtedly owe at least some of their growth to the extensive drought. As 2012 was a year of above average temperatures and below average precipitation state-wide, all time-lag fuel categories were substantially drier than in previous years and evidence suggests that the wildland fuels were the driest they have been in decades.

This presentation will elaborate on fuel dryness and fire behavior within the context of the drought of 2012. Focus will be given to exploring the recent wildland fires within South Dakota and the surrounding region, including the Longhorn Fire Complex and the Region 23 Fire Complex, from the eyes of an Incident Meteorologist. These fires exhibited extreme fire behavior such as unprecedented fire runs, explosive fire growth, and plume-dominated smoke columns. Information will also be presented on how fire managers quantify fire danger, potential for fire growth, and fuel dryness, as well as how these concepts are communicated to wildland firefighters and the public.

## **Dual-Polarization Radar Applications for Hydrology**

**Matthew J. Bunkers**

NOAA/National Weather Service, 300 East Signal Drive, Rapid City, SD 57701, email:  
*matthew.bunkers@noaa.gov*

In October 2012 the National Weather Service upgraded its radar, located just north of New Underwood, South Dakota, to include dual-polarization capability. This allows information on horizontal and vertical properties of atmospheric targets—both meteorological and non-meteorological—to be ascertained and compared. The ratio of the horizontal component versus the vertical component of the radar returned power provides information on average size and orientation of targets; the differential phase shift of the two electromagnetic radar components is related to precipitation intensity; and the variability of the phase of the horizontal and vertical components can indicate precipitation type, as well as distinguish between precipitation and non-precipitation.

The dual-polarization radar will be helpful in determining areas of heavy rain, rain mixed with hail, very large hail, and non-meteorological targets. Examples from across the United States will be presented to illustrate these improvements, with an emphasis on how this information will be helpful for short-term hydro-meteorological forecasts for the Black Hills area.

# Severe Weather Associated with Mergers between Squall Lines and Isolated Supercell Thunderstorms

**Adam J. French**

Department of Atmospheric Sciences, South Dakota School of Mines and Technology, 501 East Saint Joseph Street, Rapid City, South Dakota 57701, email: *adam.french@sdsmt.edu*

Severe thunderstorms, those that produce large hail ( $>2.54$  cm), damaging straight line winds ( $>25$   $\text{ms}^{-1}$ ) or tornadoes, pose a significant threat to life and property across the United States, including the Northern Plains region. Recent work has used idealized numerical model simulations to investigate how mergers between two thunderstorm organizations, squall lines and supercells, affect storm organization and severe weather production. This presentation will present a sub-set of the results from this study focused on 1) severe weather production in simulations with a merger compared to those without a merger, and 2) how this changes as the merger location is varied along the squall line. The goal of this project is to develop a conceptual model to help forecasters anticipate how the severe weather threat may evolve in similar storm merger scenarios.

Analysis of the model simulations has indicated that when a supercell merges with a squall line, the resultant system produces a localized area of strong near-surface winds, increased rainfall and low-level storm rotation, indicating the potential for tornadoes. These features are diminished or absent in simulations of the squall line without the merger. Sensitivity tests varying the location of the merger along the squall line suggest that the merger location may represent a region of enhanced severe weather potential compared to the remainder of the squall line. Additionally, mergers that occur near the north end of the squall line appear to have the most dramatic impact in terms of generating long-lived severe weather episodes. These model results compare well with recent observations of severe weather reports associated with squall line-supercell mergers, and provide more conclusive proof that the merger location represents a localized area of enhanced severe weather potential compared to other locations along the squall line.

---

**THURSDAY, APRIL 18, 2013**  
**SESSION 4P**  
**4:00 – 5:00 P.M.**

**WATER QUALITY**  
**(PONDEROSA ROOM)**

---

# **Water-Quality Sampling of Precambrian Crystalline Aquifers in the Central Black Hills**

## **Arden D. Davis**

Department of Geology and Geological Engineering, South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57701,  
email: *Arden.Davis@mines.sdsmt.edu*

## **Alvis L. Lisenbee**

Department of Geology and Geological Engineering, South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57701,  
email: *Alvis.Lisenbee@sdsmt.edu*

## **Maribeth H. Price**

Department of Geology and Geological Engineering, South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57701,  
email: *Maribeth.Price@sdsmt.edu*

## **Katherine Aurand**

Department of Geology and Geological Engineering, South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57701,  
email: *katherine.aurand@mines.sdsmt.edu*

## **Jennifer Bednar**

Department of Geology and Geological Engineering, South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57701,  
email: *jennifer.bednar@mines.sdsmt.edu*

## **Micheal Tekle**

Department of Geology and Geological Engineering, South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57701,  
email: *micheal.tekle@mines.sdsmt.edu*

This work examines the water quality of Precambrian crystalline aquifers in the central Black Hills. During a pilot study in the early phases of this project, existing water-quality information was compiled from available records of public water systems and wells, as reported to the South Dakota Department of Environment and Natural Resources. Information also was collected from the National Water Information System of the U.S. Geological Survey, as well as other data bases and sources. Special emphasis was given to arsenic, iron, hardness, nitrate, and bacterial data. Preliminary results indicate an area of elevated arsenic concentrations in the Keystone and Mount Rushmore area, which appears to be associated with arsenopyrite in Precambrian metagraywacke and within mineralized zones of the Keystone mining district. Because existing water-quality information is incomplete in areal extent and is scattered across decades of time, a sampling program is planned for 2013. One hundred well-water samples will be collected and analyzed for As, Ca<sup>2+</sup>, Mg<sup>2+</sup>, SO<sub>4</sub><sup>2-</sup>, Fe<sup>2+</sup>, and coliform bacteria. The help of well owners is sought for this sampling program.

# Groundwater Impacts of Highways Stabilized with Waste Materials

**Bora Cetin**

Assistant Professor, Department of Civil and Environmental Engineering, 501 East Saint Joseph Street, Rapid City, SD 57701, email: *bora.cetin@sdsmt.edu*

Use of waste materials such as fly ash and recycled concrete in highway constructions are very popular due to their low cost and satisfactory mechanical properties. These applications have the potential to generate millions of dollars in savings to taxpayers. In addition, reuse of materials in construction has several benefits, including reduction of solid waste disposal costs incurred by industry, reduction in landfill space requirements, minimization of damage to natural resources caused by the excavation of earthen materials for construction, obtaining added value from waste materials, conservation of production energy, and ultimately providing sustainable construction and economic growth.

This study specifically focused on the reuse of fly ash and recycled concrete materials in the base layer of the pavement structures. Fly ash is a coal combustion byproduct that is obtained during the coal combustion process in a coal power plant. The fly ashes used in the current study contain a large amount of unburned carbon contents (12% - 30%). Therefore, they are known as High Carbon Fly Ash (HCFA). Recycled concrete (RCs) is generated from the demolition of concrete structures; the concrete is crushed and used as aggregate in the construction of roadways.

Roadways have high potential for large volume use of HCFA and RCs. However, in such applications, the leaching of heavy metals from highway base layers that are built with these materials can cause significant groundwater contamination. In addition, these materials contain high amount of calcium present in cement, the release of Ca minerals to groundwater yields a high leachate pH ( $\text{pH} > 11$ ) which can be very detrimental for vegetation and environmental health. To check the environmental suitability of the use of these materials in such applications, a series of laboratory tests and numerical analysis were conducted to investigate the leaching potential of metals and the pH levels from the roadways built with the impact of these to the groundwater.

## **Evaluation of Water-Quality Characteristics and Sampling Design for Streams in North Dakota, 1970-2008**

### **Joel M. Galloway**

U.S. Geological Survey, North Dakota Water Science Center, 821 E. Interstate Ave, Bismarck, ND 58503, email: [jgallowa@usgs.gov](mailto:jgallowa@usgs.gov)

### **Aldo V. Vecchia**

U.S. Geological Survey, North Dakota Water Science Center, 821 E. Interstate Ave, Bismarck, ND 58503, email: [avecchia@usgs.gov](mailto:avecchia@usgs.gov)

### **Kevin C. Vining**

U.S. Geological Survey, North Dakota Water Science Center, 821 E. Interstate Ave, Bismarck, ND 58503, email: [kcvining@usgs.gov](mailto:kcvining@usgs.gov)

### **Robert F. Lundgren**

U.S. Geological Survey, North Dakota Water Science Center, 821 E. Interstate Ave, Bismarck, ND 58503, email: [rflundgr@usgs.gov](mailto:rflundgr@usgs.gov)

Various agencies have conducted water-quality sampling programs and projects for streams in North Dakota for a number of years for multiple purposes. The various programs and projects have used different sampling designs, different selected water-quality constituents, and different laboratories based on the program objectives. Although data collected for these projects and programs provide valuable information on the quality of water in streams of the State, the objectives vary among the programs and some of the programs overlap spatially and temporally. In addition, some of the sampling designs may not be the most efficient or relevant to the objectives of the individual programs as the programs have changed through time. In response to the need to examine the large amount of historic water-quality data across North Dakota and evaluate the efficiency of the state-wide sampling programs, a study was conducted by the U.S. Geological Survey (USGS) in cooperation with the North Dakota State Water Commission (NDSWC) and the North Dakota Department of Health (NDDH). The objective of the study was to describe the water-quality data collected for the various programs and determine an efficient state-wide sampling design for monitoring future water-quality conditions. All data from streams throughout North Dakota collected by NDDH, NDSWC, and USGS from 1970 to 2008 were evaluated. Statistical methods were used to analyze spatial and temporal variability, trends, and loads of selected major ions, nutrients, and trace metals to minimize redundancy in the collection of water-quality data in an effort to design an efficient sampling program for meeting future goals and objectives of the various agencies.

---

**THURSDAY, APRIL 18, 2013**  
**POSTER SESSION AND EVENING SOCIAL**  
**5:00 – 7:00 P.M.**

**(RUSHMORE F ROOM)**

---

## **Developing BMPs to Minimize the Water Quality Impacts of Winter Manure Spreading**

### **Nathan A. Brandenburg**

Graduate Research Assistant, Agricultural and Biosystems Engineering, South Dakota State University, email: *nathan.brandenburg@sdstate.edu*

### **Jeppe Kjaersgaard**

South Dakota Water Resources Institute, South Dakota State University, Box 2120, Brookings, SD 57007, email: *jeppe.kjaersgaard@sdstate.edu*

### **Ronald Gelderman**

South Dakota State University

### **Todd P. Trooien**

South Dakota State University, email: *Todd.Trooien@sdstate.edu*

There are very limited options when managing agricultural waste during the winter months. Currently the South Dakota Department of Environment and Natural Resources (SD DENR) discourages any manure spreading on frozen soils, and some of the Natural Resources Conservation Service (NRCS) farm benefit programs restrict winter spreading. As a result, the only option for winter manure management is to store it until the following spring and summer. Allowing some manure spreading during the winter on crop ground would decrease the amount of storage space needed and reduce the environmental risk associated with stockpiling manure.

Conducting research on this topic will provide detailed information on manure spreading on frozen soil. A three-year study was being conducted where three separate watersheds located on the same field are being used for two different manure treatments and a control. Runoff methodology techniques were redeveloped for monitoring runoff during winter months. Runoff volumes and nutrient/sediment concentration samples were measured to determine the manure treatment effect. Climatic and soil data were also collected to assess the environmental impact of spreading manure on frozen soil. The Water Erosion Prediction Project was also used to model runoff and sediment losses based on slope and soil type. Using the data collected and model results best management practices (BMPs) could be developed based on location, placement, and timing of manure applications. The results at this stage of the project indicate there is not a significant difference between the manure treatments and the control. BMPs are still being developed but current evidence shows soil type is more significant than slope. More data and results are still calculated so more information will be available for the conference.

# Evaluating Spatial and Temporal Scale Issues with Hydrologic Models

## **Dolraj Chalise**

Department of Civil and Environmental Engineering, South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57001,  
email: *dolraj.chalise@mines.sdsmt.edu*

## **Thomas A. Fontaine**

Department of Civil and Environmental Engineering, South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57001,  
email: *thomas.fontaine@sdsmt.edu*

## **Adel E. Haj**

U.S. Geological Survey South Dakota Water Science Center, 1608 Mt. View Road, Rapid City, SD 57002, email: *ahaj@usgs.gov*

Precipitation Runoff Modeling System (PRMS) and Hydrological Simulation Program Fortran (HSPF) are semi distributed, deterministic hydrological tools to simulate the impacts of precipitation, land use and climate on basin hydrology and stream flow. PRMS is primarily used by the U.S. Geological Survey to simulate basin hydrology across the United States. HSPF is used by a larger user base of public and government modelers to simulate basin hydrology, sediment processes, and water quality worldwide. The primary objective of this research is to evaluate the role of temporal and spatial scales in the accuracy of model output. Both models are applied in comparison studies on well instrumented catchments in Western South Dakota. The models are also evaluated for the effort required to acquire the data sets for simulations (e.g., time series, physical watershed characteristics, and calibration and validation data). The uncertainty in model results is measured, and sensitivity analyses are used to identify the most important parameters and identify common sources of error.

# **Improving Reclamation Design through Runoff and Erosion Modeling of High-Intensity Precipitation Events at the Riley Pass CERCLA Site, Custer National Forest, Harding County, South Dakota**

**James A. (Andy) Efta**

Hydrologist, USDA Forest Service--Custer National Forest, email: *jefta@fs.fed.us*

**Dan Seifert**

Geologist/On Scene Coordinator, USDA Forest Service--Custer National Forest, email: *dseifert@fs.fed.us*

Riley Pass is a CERCLA site under the jurisdiction of the USDA Forest Service in northwest South Dakota. Strip mining and onsite processing to remove uranium from lignite coal beds took place at Riley Pass during the 1950s and 1960s. Over 250 acres of bluffs were impacted when spoils and mine waste were pushed off the steep bluffs and deposited on the slopes and prairie below. Primary waste contaminants are arsenic and radium-226. Vegetation is not reestablishing on residual mine spoils and waste. Lack of vegetation, fine soil textures, contiguous over-steepened slopes, and a flashy runoff regime have combined to aggravate rill and gully erosion on hillslopes. Below the mined bluffs, runoff is forming deep gullies, impacting water quality, and transporting contaminated sediments onto adjacent private lands.

Intensive reclamation efforts have been ongoing since 2010 and have included consolidating, compacting, and capping waste on smaller bluffs with low angle slopes. As reclamation work continues, larger disturbed bluffs and steeper slopes will require more intensive and robust reclamation designs to accommodate runoff. To ensure that hazardous waste remains in constructed onsite repositories and waste removal areas are revegetated, reclaimed areas need to be able to withstand precipitation and runoff events in excess of 500- to 1000- year runoff events. The purpose of this project is to 1) identify the magnitude of runoff events through analysis of existing records and further statistical analysis, 2) model the effects of runoff and erosion events using process-based runoff and erosion modeling tools, 3) evaluate modeled effects against tolerable rates of surface erosion and mine waste transport, and 4) use those results in tandem with further modeling to evaluate the potential efficacy of candidate reclamation designs. As this work is ongoing, the poster presentation will convey the status of this work through April 2013.

## **Geomorphic Assessment of the Missouri River from Lake Sakakawea to Lake Oahe, North Dakota, 2012-2015**

### **Joel M. Galloway**

U.S. Geological Survey, North Dakota Water Science Center, 821 E. Interstate Ave, Bismarck, ND 58503, email: [jgallowa@usgs.gov](mailto:jgallowa@usgs.gov)

### **Katherine Skalak**

U.S. Geological Survey, National Research Program, 430 National Center, Reston, VA 20192, email: [kskalak@usgs.gov](mailto:kskalak@usgs.gov)

### **Edward R. Schenk**

U.S. Geological Survey, National Research Program, 430 National Center, Reston, VA 20192, email: [eschenk@usgs.gov](mailto:eschenk@usgs.gov)

### **Rochelle A. Nustad**

U.S. Geological Survey, North Dakota Water Science Center, 102 North 4th Street, Grand Forks, ND 58201, email: [ranustad@usgs.gov](mailto:ranustad@usgs.gov)

### **Adam Benthem**

U.S. Geological Survey, National Research Program, 430 National Center, Reston, VA 20192, email: [abenthem@usgs.gov](mailto:abenthem@usgs.gov)

### **Clifford R. Hupp**

U.S. Geological Survey, National Research Program, 430 National Center, Reston, VA 20192, email: [crhupp@usgs.gov](mailto:crhupp@usgs.gov)

The upper Missouri River regularly received annual peak flows above 100,000 cubic feet per second (cfs) prior to the completion of the Garrison Dam (Lake Sakakawea). Annual peak flows typically have been between 30,000 and 45,000 cfs following dam completion. The largest flood since dam regulation occurred in 2011 following an unusually high snowpack season and an extreme week-long rain event in the headwaters. Flood releases from Garrison Dam began in May 2011 and peaked in June with a flow of approximately 150,000 cfs. The event had a discernible effect on the shape of the Missouri River reach below Garrison Dam and highlighted the need for quantifying the complex interaction between the fluvial geomorphology and human activities. A study was initiated in 2012 to 1) understand and quantify the historical effects of the dam in order to determine the impact of the 2011 flood on the channel configuration, morphology, and sediment dynamics; 2) determine flood impacts on islands, sand bars, and infrastructure; 3) predict channel change through time around the Bismarck-Mandan area through numerical modeling; 4) assess the post-flood delta in the upper section of Lake Oahe for potential ice jam issues and reservoir sedimentation; 5) determine the sources, sinks, and loads of sediment throughout the free-flowing reach; and 6) determine flood impacts on in-channel and floodplain large woody debris and standing trees for island maintenance, streambank erosion, fisheries, and navigation. Methods used for the development of a conceptual geomorphic model of the reach include interpretation of repeat aerial photography, analyses of historical streamgage data, historical cross-sectional surveys, collection and analyses of sediment cores, channel surveys, and the use of several dendrogeomorphic tools. Preliminary results for the study and description of the methods used for the conceptual geomorphic model of the reach will be presented.

# **A Study on the Effect of Flow Variation on the Existing Stability Condition at the Lower Mouth of the Plum Creek, Stanley County, South Dakota**

**Govinda Karki**

Graduate Research Assistant, Department of Agricultural and Biosystem Engineering, South Dakota State University, Agricultural Engineering (SAE), Box: 2120, Brookings, SD 57007, email: [govinda.karki@sdstate.edu](mailto:govinda.karki@sdstate.edu)

**Suzette Burckhard**

South Dakota State University, email: [Suzette.Burckhard@sdstate.edu](mailto:Suzette.Burckhard@sdstate.edu)

In this study, prevailing stability conditions and river dynamics of lower mouth of Plum Creek, near the Bad River were evaluated based on DEM that may exist due to flow variation. The study was conducted to classify Plum Creek based on Rosgen classification system to find the present stream type at selected segments. Flow analysis for varying discharge was performed in HEC-RAS after geospatial analysis of the DEM in HEC-GeoRAS which is essential for flow analysis. Bankfull flow was determined analytically. Hydraulic parameters were obtained from flow analysis, and geomorphic parameters were determined processing the HEC-RAS result in HEC-GeoRAS in GIS environment. These hydraulic and geomorphic parameters were used to determine river type and evaluate stability condition. Shield's equation was used to find flow dynamics of Creek. Threshold depth and slope required to entrain 90<sup>th</sup> percentile size of bed material at bankfull flow were calculated to determine if the existing depth and slope were sufficient to carry the available size of riverbed material without deposition.

The study found the bankfull discharge to be 18 m<sup>3</sup>/s (640 fps). The Creek was found to be a "C5c" type based on the Rosgen river classification, entrenchment ratio (ER) was greater than 2.2, width to depth (W/D) ratio greater than 12, and sinuosity was greater than 1.4 for all selected reaches. These results indicated that the selected reaches were in a moderately unstable, slightly entrenched, and meandered with high sinuosity, which indicates that, overall, the Creek is in a fair stable condition but inclined to poor condition. A change in flow is sufficient to change geomorphic parameters, however stream type and existing condition remains unchanged. Flow analysis for known median d<sub>50</sub> and d<sub>90</sub> size showed that the available depth and slope at bankfull flow was enough to carry the bed material without deposition.

# **A Groundwater-Flow Model of the Black Hills Area: Madison and Minnelusa Aquifers**

**Jonathan D.R.G. McKaskey**

South Dakota School of Mines and Technology and U.S. Geological Survey, 1608 Mt. View Road, Rapid City, SD 57702, email: *jmckaskey@usgs.gov*

**Andrew J. Long**

U.S. Geological Survey South Dakota Water Science Center, 1608 Mt. View Road, Rapid City, SD 57702, email: *ajlong@usgs.gov*

More than 50 percent of the public drinking water systems in South Dakota rely solely on groundwater. The dependence on groundwater raises important questions regarding the Madison and Minnelusa aquifers in and near the Black Hills of South Dakota, including groundwater availability, the effects of water use or drought, mixing of regional flow and local recharge, and the effects of spring and well capture zones on the groundwater-flow system. These questions are best addressed with a three-dimensional numerical groundwater-flow model that includes the entire Black Hills area. This regional model of the Black Hills area currently is in the preliminary stages of development. Building several small-area models is not an efficient or cost-effective approach to address the concerns of multiple parties in the Black Hills area. Future studies requiring a high-resolution model grid for special focus areas of interest could insert nested models into the regional model.

As part of the preliminary model development, a three-dimensional hydrogeologic framework was constructed for the model area. In order to minimize artificial boundary effects for the simulation of groundwater-flow in the Black Hills area, the model area includes approximately 50,000 square miles, extending approximately 220 miles from the center of the Black Hills in all directions.

Structural-contour maps and well logs quantifying the top and bottom altitudes of the Madison and Minnelusa aquifers were aggregated from numerous previous investigations to construct continuous surfaces defining the hydrogeologic framework. The primary challenge in this aggregation was that structural-contour maps from different sources frequently were inconsistent for overlapping areas, usually as a result of varying resolution in spatial data. For these inconsistencies, a systematic workflow was developed to determine which source was most accurate or reliable and would be used in the final aggregation.

Potentiometric-contour maps delineating the hydraulic head of the Madison and Minnelusa aquifers are a result of aggregating numerous previous investigations using a method similar to the construction of structural-contour maps, with modifications based on additional groundwater-level measurements. The data were combined to construct continuous surfaces defining the regional potentiometric surface for the Madison and Minnelusa aquifers. The Minnelusa aquifer's resultant regional potentiometric map is largely similar to recent publications. The Madison aquifer's resulting potentiometric map enhances understanding of a trough, or valley-shaped feature, in the potentiometric surface extending from Rapid City through Philip and eastward. This trough was previously identified by Downey in U.S. Geological Survey Professional Paper 1402-E but not shown in many other recent publications. Results are preliminary and subject to further review.

# **Demonstrating the Nitrogen-Removal Effectiveness of Denitrifying Bioreactors for Improved Drainage Water Management**

## **Cynthuja Partheeban**

South Dakota State University, Box 2120, Brookings, SD 57007,  
email: *Cynthuja.partheeban@sdsstate.edu*

## **Jeppe Kjaersgaard**

South Dakota Water Resources Institute, South Dakota State University, Box 2120, Brookings,  
SD 57007, email: *jeppe.kjaersgaard@sdsstate.edu*

## **Christopher Hay**

Department of Agricultural and Biosystems Engineering, South Dakota State University,  
Brookings, SD 57007, email: *christopher.hay@sdsstate.edu*

## **Todd P. Trooien**

South Dakota State University, email: *Todd.Trooien@sdsstate.edu*

To reduce the nitrate loadings in tile drain water from agricultural fields, low-cost and simple technologies are needed. Denitrifying drainage bioreactors can provide cost-effective treatment of tile water at the field scale.

A woodchip bioreactor is made by routing drainage water through a buried trench filled with woodchips. These carbon (C) substrates (often fragmented wood-products) acts as a C and energy source to support denitrification; the multi-step conversion of nitrate (NO<sub>3</sub><sup>-</sup>) to inert nitrogen gas. Research is on-going to evaluate bioreactor nitrate removal efficiency including design, carbon substrates, tile systems and climate, and ways to reduce unwanted escape of nitrous oxide, hydrogen sulfide gasses and methyl mercury during the denitrification process. Several such bioreactors have been installed in the US and have shown promising results for nitrate removal.

The goal of this project is to evaluate the effectiveness of the bioreactors by determining the nitrate removal rate and cost per pound of nitrate removed by the bioreactors at the different locations. During 2012, we installed two bioreactors at different locations: One near Baltic, SD and one near Montrose, SD. We installed them by digging a trench about 5.5 ft deep and 20 ft wide. The length of the trench is dependent on the amount of water being treated which is dependent on the drained acreage and soil properties. Our design called for a trench 120 ft long. We installed inflow and outflow control structures to control the retention time of water. Two more bioreactors are scheduled to be installed in the spring of 2013. We will review the criteria for bioreactor design and share experiences from the installation of the bioreactors.

# **Detecting Earth Surface Changes Using Archived 1954 Photography for Historic Surface and 2012 Lidar for Current Surface—Riley Pass CERCLA Site, Custer National Forest, Harding County, South Dakota**

## **Dan Seifert**

Geologist/On Scene Coordinator, USDA Forest Service--Custer National Forest,  
email: [dseifert@fs.fed.us](mailto:dseifert@fs.fed.us)

## **James Monty**

Remote Sensing Analyst, RedCastle Resources, Inc.

## **Jeremy Webb**

Remote Sensing Analyst, RedCastle Resources, Inc.

## **Haans Fisk**

Program Leader -- Remote Sensing Evaluation Application & Training, USDA Forest Service --  
Remote Sensing Applications Center

Riley Pass is a CERCLA site under the jurisdiction of the USDA Forest Service in northwest South Dakota. Strip mining and onsite processing to remove uranium from lignite coal beds occurred at Riley Pass during the 1950s and 1960s. Over 250 acres of bluffs were impacted when spoils and mine waste were pushed off the bluffs onto the slopes and prairie below. Primary contaminants are arsenic and radium-226. Lack of vegetation, fine soil textures, contiguous over-steepened slopes, and a flashy runoff regime have combined to aggravate hillslope rill and gully erosion. Below the mined bluffs, runoff is forming deep gullies, impacting water quality, and transporting contaminated sediments onto adjacent private lands.

Ongoing Riley Pass reclamation efforts will focus on restoring slopes to a more stable configuration and restoring hydrologic function. Current ground surface was precisely derived from high-resolution airborne lidar data while the pre-mining surface was derived photogrammetrically from 1954 panchromatic resource aerial photography. Project goals are to identify and quantify topographic differences between current and pre-mining ground surface conditions and compare current and pre-mining drainage patterns. This poster presents the methodology, results, and discussion for this project.

# **Ground-Water Quality and Relationships to Fault Zones and Mining Districts in Precambrian Crystalline Rocks of the Central Black Hills**

## **Micheal Tekle**

Department of Geology and Geological Engineering, South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57701,  
email: *micheal.tekle@mines.sdsmt.edu*

## **Arden D. Davis**

Department of Geology and Geological Engineering, South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57701,  
email: *Arden.Davis@mines.sdsmt.edu*

## **Alvis L. Lisenbee**

Department of Geology and Geological Engineering, South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57701,  
email: *Alvis.Lisenbee@sdsmt.edu*

## **Maribeth H. Price**

Department of Geology and Geological Engineering, South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57701,  
email: *Maribeth.Price@sdsmt.edu*

## **Katherine Aurand**

Department of Geology and Geological Engineering, South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57701,  
email: *katherine.aurand@mines.sdsmt.edu*

## **Jennifer Bednar**

Department of Geology and Geological Engineering, South Dakota School of Mines and Technology, 501 E. Saint Joseph Street, Rapid City, SD 57701,  
email: *jennifer.bednar@mines.sdsmt.edu*

In this work, concentrations of arsenic, iron, hardness, and nitrate in ground water were plotted on maps of the Mount Rushmore and Hill City quadrangles in the central Black Hills. Residents in this part of the Black Hills normally rely on water from wells in Precambrian crystalline aquifers because the Madison, Minnelusa, and Inyan Kara aquifers are not present. The Precambrian aquifers are less productive than major sedimentary aquifers such as the Madison, but they are a valuable resource because they typically provide sufficient water for small communities and individual homes. The permeability and storage capacity of the Precambrian aquifers are controlled by fractures. The Precambrian metamorphic and igneous rocks of the central Black Hills also are rich in mineral deposits that can cause water-quality problems because of arsenic, as well as iron and other metals. When water-quality data are plotted on Geographic Information Systems (GIS) maps of historical mining areas, abandoned mines, and fault zones, some spatial relationships become apparent. Arsenic concentrations in the Keystone area, for example, appear to be greatest in areas of faulting and mineralized zones in this historic mining district. In other areas of the Mount Rushmore and Hill City quadrangles, however, currently available water-quality information is too sparse to establish clear relationships, so a systematic ground-water sampling program is underway to provide more detailed data.

# **A Comparison of Groundwater Recharge Estimation Methods in the Williston and Powder River Structural Basins in the Northern Great Plains**

**Katherine R. Aurand**

South Dakota School of Mines and Technology, 501 East Saint Joseph Street, Rapid City, SD 57701, email: *Katherine.aurand@mines.sdsmt.edu*

The water-table fluctuation (WTF) and chloride mass-balance (CMB) methods were used as a comparison to a numerical soil-water-balance (SWB) model to estimate groundwater recharge in the Williston and Powder River structural basins in the Northern Great Plains. Recharge was estimated for glacial deposits and exposed areas of the Lower Tertiary and Upper Cretaceous aquifer systems in the Dakotas, Montana, Wyoming, Saskatchewan, and Manitoba. The WTF and CMB methods were applied to local areas with available groundwater-level and chloride data. The SWB model consisted of 1 km<sup>2</sup> grid cells across the entire study area.

The WTF method uses easily accessible groundwater-level data to estimate groundwater recharge under the assumption that rises in unconfined groundwater levels are a result of recharge from precipitation. For this assumption to be valid, only recharge to unconfined aquifers can be estimated by this method. Recharge is then calculated by multiplying the specific yield of the aquifer by the change in water level. The CMB method determines the rate of recharge to an aquifer based on the chloride concentration in the groundwater and the rate of atmospheric chloride deposition. An assumption with this method is that all chloride in the aquifer is derived from atmospheric deposition, although other sources of chloride can be accounted for if known. Both the WTF and CMB methods inherently take into account mechanisms of flow through the unsaturated zone and are simple to apply. The SWB model is based on a modified Thornthwaite-Mather approach and is used to estimate recharge as infiltration below the root zone to each model cell on a daily time step. Inputs for the SWB model include daily precipitation and air temperature data, land-use classification, soil type, and surface-water flow direction for each model cell. The sources and sinks of water within each grid cell are determined by the SWB model on the basis of input data. Recharge is then calculated as the difference between the change in soil moisture and the flow rates of sources and sinks.

# Using Light Detection and Ranging (LiDAR) to Monitor Bank Erosion along Big Bend on the Missouri River (Mnisosa Wakpa)

**Willis Zephier**

Oglala Lakota College, Math and Science Department

**James Sanovia**

Oglala Lakota College, Math and Science Department, email: *jsanovia@olc.edu*

The Lower Brule project focuses on erosion issues on the Big Bend of the Missouri River, which is located on the Lower Brule Sioux Tribe (LBST) Reservation in South Dakota. The Big Bend is the largest remaining meander of the Missouri river in central South Dakota and over the years the erosion of the meander has increased. Using a Terrestrial Light Detection and Ranging (LiDAR) and Real-Time Kinematic GPS (RTK-GPS) some bank erosion areas are now being calculated at 20-30 feet per year and the river is now encroaching on and threatening of the tribe's water systems. Working with the USGS and LBST, Oglala Lakota College is helping monitor the erosion at selected sites. The first LiDAR phase (Feb. 2011) of the project involved surveying the meander using LiDAR to be used as our datum. The project also archived geographic information systems (GIS) basedata for the area. Basedata included 10 meter elevation models, water flow, geology and soil data. The second year of LiDAR data shows the increase of erosion increased in some areas from 8 feet to 30 feet per year. LiDAR data from February 2011 and March 2013 will be analyzed for area and volume differences as well as combined to show visual differences. LiDAR data along with soil and geology data can help us to better understand soil erosion rates on those sections of the Missouri River. With this information we will assist the tribe in evaluating the effectiveness of the current mitigation measures they are using to control erosion. In addition, working with the USGS, we will seek to evaluate other strategies and mitigation measures that can be employed to delay, or stop the erosion in the future.

# **A Resource Inventory of Selected Sites Along the White Clay Fault in Southwest South Dakota**

**Lilly Jones**

Oglala Lakota College, 1770 Degeest Drive, Rapid City, SD 57703,  
email: *Ljones15807@olc.edu*

A geologic and paleontologic resource inventory for two selected outcrops adjacent to each other in the region of the White Clay Fault on the Pine Ridge Indian Reservation was begun in the summer of 2012.

These sites were selected for study due to the following features: evidence of thrust-faulting, an extensive erosional unconformity and talus piles of non-articulated fossils ranging in age from the Cretaceous through the Pleistocene.

The outcrops selected for this inventory are both on the upside of the White Clay Fault. The southern outcrop belongs to the Late Cretaceous Niobrara Formation while the northern outcrop belongs to the Eocene-Oligocene White River Group; a span of approximately 50 million years.

This resource inventory represents one of a series of steps being taken by students and faculty at Oglala Lakota College to map and catalogue the natural resources of the Pine Ridge Indian Reservation.