

2015
WESTERN SOUTH DAKOTA
HYDROLOGY MEETING

Program and Abstracts

April 15, 2015
Rushmore Plaza Civic Center
Rapid City, South Dakota

With optional field seminars/trips
April 16, 2015

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2015 Western South Dakota Hydrology Meeting

This program and abstracts book has been produced in conjunction with the 2015 Western South Dakota Hydrology Meeting (13th annual), held at the Rushmore Plaza Civic Center on April 15, 2015. The purpose of this book is to provide summaries of the presentations made during the meeting.

The purpose of the 2015 Western South Dakota Hydrology Meeting is to bring together researchers from Federal, State, University, local government, and private organizations and provide a forum to discuss topics dealing with hydrology in western South Dakota. This meeting provides an opportunity for hydrologists, geologists, engineers, scientists, geographers, students, and other interested individuals to meet and exchange ideas, discuss mutual problems, and summarize results of studies. The meeting consists of four technical sessions, several keynote speakers, the John T. Loucks Distinguished Lecture, and a poster session. The topics of the technical sessions include reliability, vulnerability, and resiliency; geomorphology and geology; surface-water modeling and management; groundwater modeling; surface-water quality; groundwater and mapping; and flooding.

ACKNOWLEDGMENTS

Many people have contributed to this meeting. The many presenters are thanked for their contributions. The moderators are thanked for their help in streamlining the technical sessions. The help by many students from the South Dakota School of Mines and Technology with presentations and lights is greatly appreciated. The distinguished lecturer, Mr. Rob Harmon, is thanked for his time and perspectives. Keynote speakers Niek Veraart and Robert Hirsch are thanked for their time and perspectives. Registration help by Sheri Meier (USGS) and Denise Livingston (West Dakota Water Development District) is greatly appreciated. Josh Lee (USGS) provided computer support for the meeting.

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

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2015 WESTERN SOUTH DAKOTA HYDROLOGY MEETING PROGRAM

Wednesday, April 15, 2015
Alpine/Ponderosa Rooms and Rushmore F and G
Rushmore Plaza Civic Center

7:00 – 8:00 a.m.	REGISTRATION	
8:00 – 9:30 a.m.	Plenary Session 1 in Alpine and Ponderosa Rooms – Reliability, Vulnerability, and Resiliency (1.5 PDH) Moderator – Mark Anderson , Director of the U.S. Geological Survey South Dakota Water Science Center, Rapid City, SD	
8:00 – 8:10 a.m.	Welcome, general information	Mark Anderson and Daniel Driscoll , U.S. Geological Survey
8:10 – 8:50 a.m.	Integrated resilience: Creating lifecycle value and opportunity	Niek Veraart , Vice President, Louis Berger (<i>invited</i>)
8:50 – 9:30 a.m.	Hydrology in a changing world	Robert Hirsch , U.S. Geological Survey (<i>invited</i>)
9:30 – 10:10 a.m.	REFRESHMENT BREAK in Rushmore G – Sponsored by Mid Continent Testing Labs, Inc.	
10:10 a.m. – 11:50 p.m.	Concurrent Session 2A in Alpine Room – Geomorphology and Geology (1.5 PDH) Moderator – J. Foster Sawyer , South Dakota School of Mines and Technology	Concurrent Session 2P in Ponderosa Room – Surface-Water Modeling and Management (1.5 PDH) Moderator – Lacy Pomarleau , RESPEC
10:10 – 10:30 a.m.	<i>Effects of bedrock properties, erosion rates, and slope processes on landform evolution at Badlands National Park – Larry Stetler</i> , South Dakota School of Mines and Technology	<i>Changes in seasonality and timing of peak streamflow in the north-central United States, 1910-2012 – Karen Ryberg</i> , U.S. Geological Survey, F. Adnan Akyüz , North Dakota State Climate Office, Gregg Wiche , U.S. Geological Survey, and Wei Lin , North Dakota State University
10:30 – 10:50 a.m.	<i>Geomorphologic and hydrologic controls on flooding in the lower Big Sioux River Basin – Tim Cowman</i> , South Dakota Department of Environment and Natural Resources, Geological Survey Program	<i>Utilizing cloud seeding as a water management tool in western South Dakota – Andrew Detwiler</i> and Paul Smith , South Dakota School of Mines and Technology
10:50 – 11:10 a.m.	<i>The origin of Sevey Lake in western South Dakota – Perry Rahn</i> , South Dakota School of Mines and Technology, and John Stamm , U.S. Geological Survey	<i>Decision-support tools driven by watershed models – Seth Kenner</i> , Jason Love , and Paul Senne , RESPEC
11:10 – 11:30 a.m.	<i>Paleohydrology and the origin of Jewel Cave (Part 2) – Michael Wiles</i> , Jewel Cave National Monument	<i>Story Mill ecological restoration – Matthew Johnson</i> , RESPEC
11:30 – 11:50 a.m.		<i>Overview of the new HEC-RAS 5.0 2D Model – Mark Forest</i> , HDR
11:50– 1:40 p.m.	LUNCH in Rushmore F Room – with accompanying presentations (1.0 PDH) RESPEC overview: Cory Foreman John T. Loucks Distinguished Lecture: Rob Harmon , EnergyRM – <i>How Markets and People Can Keep Streams Flowing</i>	
1:40 – 3:00 p.m.	Concurrent Session 3A in Alpine Room – Groundwater Modeling (1.5 PDH) Moderator – Dan Driscoll , U.S. Geological Survey	Concurrent Session 3P in Ponderosa Room – Surface-Water Quality (1.5 PDH) Moderator – Scott Kenner , South Dakota School of Mines and Technology
1:40 – 2:00 p.m.	<i>Reactive transport modeling to evaluate post-mining site conditions at an in situ recovery uranium site – Ryan Truax</i> , James Stone , South Dakota School of Mines and Technology, Thomas Borch , Colorado State University, Raymond Johnson , Stroller Newport News Nuclear, Inc., and James Clay , Power Resources, Inc.	<i>Temperature total maximum daily load assessment for Whitewood Creek and Bear Butte Creek watersheds – Cory Foreman</i> , Tyler French , RESPEC, and Robert Smith , South Dakota Department of Environment and Natural Resources
2:00 – 2:20 p.m.	<i>RRAWFLOW: Rainfall-Response Aquifer and Watershed Flow Model – Andrew Long</i> , U.S. Geological Survey	<i>Resiliency of stream biofilms to alterations in climate and flow regime – Lisa Kunza</i> , South Dakota School of Mines and Technology
2:20 – 2:40 p.m.	<i>A groundwater-flow model of the Madison and Minnelusa aquifers in progress for the Black Hills, South Dakota and Wyoming – William Eldridge</i> and Andrew Long , U.S. Geological Survey	<i>Water-quality characteristics of stormwater in Rapid City, South Dakota, 2008–2014 – Galen Hoogstraal</i> , U.S. Geological Survey

2:40 – 3:00 p.m.	Comparison of a new stream base-flow estimation method in two basins using multivariate analysis in the Northern Great Plains – Jennifer Bednar and Andrew Long , U.S. Geological Survey	Potential organic carbon exports within the upper Rapid Creek watershed due to the current mountain pine beetle outbreak – Erik Vik , James Stone , Scott Kenner , Heidi Sieverding , Lisa Kunza , South Dakota School of Mines and Technology, and John Stamm , U.S. Geological Survey
3:00 – 3:40 p.m.	REFRESHMENT BREAK in Rushmore G	
3:40 – 5:00 p.m.	Concurrent Session 4A in Alpine Room – Groundwater and Mapping (1.5 PDH) Moderator – Kelli McCormick , South Dakota School of Mines and Technology	Concurrent Session 4P in Ponderosa Room – Flooding (1.5 PDH) Moderator – Melissa Smith , National Weather Service
3:40 – 4:00 p.m.	A continued examination at Sanford Laboratory's water quality - 2015 – John Scheetz , Sanford Underground Laboratory	Evaluation of post-fire runoff response to two high-intensity, short-duration thunderstorm events, Sioux and Ashland Ranger Districts, Custer National Forest, Montana – James (Andy) Efta , USDA Forest Service – Custer Gallatin National Forest
4:00 – 4:20 p.m.	Preliminary results of water-quality sampling from Precambrian wells in the Custer area of the southern Black Hills – Arden Davis , Alvis Lisenbee , Maribeth Price , Joseph Cange , and Victoria Bierwirth , South Dakota School of Mines and Technology	Hydrologic response and context for a high-elevation storm in the South Dakota Black Hills – Dan Driscoll , U.S. Geological Survey, Matthew Bunkers , National Weather Service, Galen Hoogstraal , U.S. Geological Survey, and Melissa Smith , National Weather Service
4:20 – 4:40 p.m.	Characterization of glacial aquifer hydrogeological framework using airborne electromagnetic surveys – Karl Koth and Joshua Valder , U.S. Geological Survey	CoCoRaHS: An incredible database for research – Scott Rudge , National Weather Service
4:40 – 5:00 p.m.	Ensuring flood resiliency, Oglala Lakota Arts and Business Incubator – John Wirries , KLJ	Geomorphic conditions following a high-elevation storm in the South Dakota Black Hills – Dan Driscoll , U.S. Geological Survey
5:20 – 7:30 p.m.	POSTER SESSION AND EVENING SOCIAL (with refreshments) in Rushmore G – Sponsored by WWC Engineering Moderator – Janet Carter , U.S. Geological Survey	
	Applicability of WRF-Hydro to western South Dakota	Lucas Barrett and William Capehart , South Dakota School of Mines and Technology
	Simulation of the effects of deforestation on headwater streams in the Black Hills, western South Dakota	Brian Freed , South Dakota School of Mines and Technology, John Stamm , U.S. Geological Survey, and Scott Kenner , South Dakota School of Mines and Technology
	Comparing nutrient cycling and metabolism in streams containing varying amounts of <i>Didymosphenia geminata</i> mat coverage in Grand Teton National Park	Jaime Haueter and Lisa Kunza , South Dakota School of Mines and Technology
	Missouri Basin River Forecast Center's River Stage Forecast Verification Webpage	Lisa Holts , National Weather Service/Missouri Basin River Forecast Center
	Establishing gene fingerprints of pathogenic bacteria along selected reaches of Rapid Creek	Linda DeVeaux , Lisa Kunza , and Kelsey Murray , South Dakota School of Mines and Technology
	Recent paleontological record of <i>Didymosphenia geminata</i> in Grand Teton National Park	Christopher Schiller , Jaime Haueter , and Lisa Kunza , South Dakota School of Mines and Technology
	Using low-cost adsorption materials to remove phosphorus from agricultural subsurface drainage	Bjorn Sellner , Guanghai Hua , Samia Amiri , Todd Trooien , Christopher Hay , Laurent Ahiablame , and Jeppe Kjaersgaard , South Dakota State University
	Reduction of turbidity in South Dakota construction site stormwater runoff using polyacrylamide	Jacob Humburg and Dr. Guanghai Hua , South Dakota State University
	Groundwater quality from aquifers in Precambrian rocks of the central Black Hills, Pennington County, South Dakota	Mackenzie Kester , Umit Yildiz , Andrew Clift , Kyle Hazelwood , Alvis Lisenbee , Arden Davis , and Maribeth Price , South Dakota School of Mines and Technology
	Climate factors contributing to streamflow inputs and extreme water-level deviations from long-term averages for Lakes Superior and Michigan-Huron	Mark Anderson and John Stamm , U.S. Geological Survey

Optional Field Seminars/Trips
Thursday, April 16, 2015

Times	Field Seminar/Trip
8:00 a.m. – 2:00 p.m.	Post-flood geomorphic conditions in Keough Draw and Ward Draw – Dan Driscoll , U.S. Geological Survey (4.0 PDH)
10:00 a.m. – 3:00 p.m.	Barrick Gold Corp and Sanford Lab wastewater treatment plants – Todd Duex , Barrick Gold Corp, and John Scheetz , Sanford Laboratory (4.0 PDH)
8:30 – 10:30 a.m.	Rapid City stormwater management practices – Galen Hoogstraat , U.S. Geological Survey (2.0 PDH)
9:00 a.m. – Noon	Belle Fourche Irrigation District (BFID) Operation and Water Conservation – Jared Oswald , RESPEC, and Bill Anderson , Belle Fourche Irrigation District Manager (3.0 PDH)

WEDNESDAY, APRIL 15, 2015
SESSION 1
8:00 – 9:30 A.M.

2015 THEME: RELIABILITY, VULNERABILITY, AND RESILIENCY
(ALPINE/PONDEROSA ROOMS)

Integrated Resilience: Creating Lifecycle Value and Opportunity

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In the face of devastation caused by severe weather events and other disasters, it can sometimes be difficult to realize that recovery efforts to re-build in a manner that is resilient against the next disaster can also create opportunities to re-energize and reposition the economy. A regionally coordinated, resilient approach to infrastructure investment can be a critical step toward preserving or stimulating the commercial viability and economic growth of communities and regions while improving the quality of life and natural environment. Recovery means more than simply rebuilding; it means rebuilding in ways that foster economic development while also making communities more resilient to withstand the impacts of disasters. To accomplish this, requires integration of local and regional benefits that can be implemented in an incremental manner with benefits generated in short and long term. It also requires resilience interventions to be coordinated across sectors to optimize resilience, maximize cost-efficiency, create investment and economic growth opportunities and obtain stakeholder and community support.

The paradigm shift from traditional response and recovery to an emphasis on resilience means that short-term recovery planning at the local level must inform the ability to conduct and fund longer-term resilience planning on a regional scale and across sectors. As communities and regions face increasingly complex and interconnected physical, economic and ecological systems, the challenge of identifying and addressing interdependencies across geography and infrastructure, natural and socioeconomic systems becomes increasingly challenging.

This presentation will share examples from resilience initiatives that will highlight the ways in which short-term recovery projects can be used as important building blocks to developing long-term resilience solutions. Specifically, the presentation will highlight key lessons learned from projects that required assessing key vulnerabilities and critical assets of communities impacted by Superstorm Sandy and other disasters; evaluating risk; and developing short-term stabilization actions as well as long-range, forward-looking approaches to recovery and rebuilding that provide opportunities for incremental market based investment to complement and leverage public initiatives throughout the resilience lifecycle.

WEDNESDAY, APRIL 15, 2015
SESSION 2A
10:10 A.M. – 11:50 A.M.

GEOMORPHOLOGY AND GEOLOGY
(ALPINE ROOM)

EFFECTS OF BEDROCK PROPERTIES, EROSION RATES, AND SLOPE PROCESSES ON LANDFORM EVOLUTION AT BADLANDS NATIONAL PARK

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Six fossil-bearing locations across the North Unit of Badlands National Park were monitored for three years yielding forty-nine precipitation-driven erosion samples (collected in sediment trays at the toe of monitored slopes), slope retreat data from thirteen slopes, and twenty-four bedrock samples. Slope data were collected using pins, scales, rules, and photogrammetry. Precipitation data were collected using tipping bucket gauges. Bedrock samples were disaggregated, wet sieved and laser sized. Geomechanical properties were obtained through Atterberg limits and undrained cohesion testing. Erosion data collected from sediment trays indicated that eastern sites generated $\sim 1/3$ more mass flux compared to western sites. Average mass flux rate in the east was 330 gm^{-2} and was 231 gm^{-2} for western sites. Mass flux was closely related to grain-size distribution of the sediment where coarser materials produced greater erosion. Increased clay content in fine-grained rock provided cohesion reducing erosivity. Scale data indicated an average slope retreat of 9.7 mm/yr where south-facing slopes averaged 7.9 mm/yr and north-facing slopes were 11.9 mm/yr . Photogrammetric-derived erosion rates were nearly identical to those measured using scales. Erosion models were developed based on slope aspect, formation, and location. The most erosive slope had a north aspect, consisted of Poleslide member rock, and was located in the east. Erosion occurring on individual slopes at specific locations varied although these data suggested a small variance. The greatest variation in erosion rates were between north- and south-facing slopes at 78%. Slope stability analysis indicated no slopes were in imminent danger of failure, even under saturated conditions. Sensitivity analysis indicated an $\sim 8\%$ increase in factor of safety with a 10% increase in cohesion. Conversely, an $\sim 1\%$ increase in factor of safety was realized with a 10% increase in friction angle. Overall, slope retreat at Badlands occurs at a rate of $\sim 1 \text{ cm/yr}$.

GEOMORPHOLOGIC AND HYDROLOGIC CONTROLS ON FLOODING IN THE LOWER BIG SIOUX RIVER BASIN

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In June 2014 large rain events in the lower Big Sioux River Basin created a large flood event. Flows at Akron, Iowa reached a record 108,000 cubic feet per second, exceeding the flows of a 100-year flood. Based on previous hydrologic studies and National Weather Service predictions, flows of similar magnitude were expected to reach the North Sioux City, South Dakota area with the flood pulse. Preparations were made at North Sioux City, McCook Lake, Dakota Dunes, and Sioux City to protect infrastructure and property from these predicted flows. Interstate 29, a major transportation route, was temporarily closed and traffic routed via a large detour.

Due to spreading out and attenuation of the flood pulse in the Missouri River floodplain, the flows at North Sioux City were much less than predicted. Although severe flooding was experienced between Jefferson, South Dakota and North Sioux City, flood waters never reached Interstate 29 or the McCook Lake area.

Post-flood analysis showed that current models do not accurately portray the hydrology of this complex area. New study of this area is needed to accurately describe the hydrology of the lower basin. Hydrologic modeling that evaluates the impact of the wider Missouri River valley on flood waters and also accounts for different flow scenarios in the Missouri River is essential to accurately predict the impact of future flood events in the lower basin.

THE ORIGIN OF SEVEY LAKE IN WESTERN SOUTH DAKOTA

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Sevey Lake is a seasonally wet depression in S 17, T 3 N, R 8 E, approximately 5 miles (8 km) northwest of Ellsworth Air Force Base in western South Dakota. The 1:24,000-scale USGS topographic map for the Rapid City Northwest quadrangle shows this depression as slightly greater than 20 ft (6 m) deep extending over an area of approximately 0.5 square mile (1.3 km²). The depression lies within a very gently sloping prairie area between Elk Creek and Dry Creek and is the only known large depression in the Cretaceous-age shale areas of western South Dakota. The contact between the Cretaceous-age Carlile Shale and overlying Niobrara Formation lies along the western boundary of the depression, with the Niobrara Formation underlying the depression. No geologic structures (faults or folds) are mapped for the area around the depression.

Formation of the depression would post-date deposition of terrace gravel deposits of Elk Creek, which lie along a ridge north of the depression, and are 75 ft (23 m) above Sevey Lake. Otherwise, the depression would have filled with gravel. The age of the Elk Creek terrace is hypothesized to be similar to the age of the Sturgis terrace, which has similar relief above Rapid Creek, and has an estimated age of approximately 200,000 to 60,000 years ago. The depression may have formed as recently as Holocene time.

The origin of Sevey Lake could be subsidence due to dissolution of calcite cement within the Niobrara Formation, a calcareous shale that is approximately 220 ft (67 m) thick. As an alternative hypothesis, the depression might be the result of wind deflation, or a landslide. However, landslides are not mapped in the areas flanking the depression. Another hypothesis is that the depression formed by subsidence from anhydrite solution in the Pennsylvanian- and Permian-age Minnelusa Formation. Epstein (2005) described solution of anhydrite as the cause of numerous sinkholes and breccia pipes around outer edges of the Black Hills. Some of these reported breccia pipes extend up as far as the Lakota Formation, which is the lowermost Cretaceous-age formation in western South Dakota. If this is the case with Sevey Lake, the breccia pipe would extend all the way up to the Niobrara Formation, approximately 1,300 ft (400 m) above the Lakota Formation.

PALEOHYDROLOGY AND THE ORIGIN OF JEWEL CAVE (PART 2)

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Purpose

With over 175 miles (280 km) of mapped passages, Jewel Cave is the third longest cave in the world. Previous work has demonstrated an intimate relationship between the cave and the geologic structure, contacts, and topography, as they exist today, and has since been used to identify likely recharge and discharge areas. This paper explores the possibilities of when and how quickly the cave could have formed.

Results

The distribution of ellipsoidal quartzite clasts – scattered across 1,500 square miles (3,885 km²) of the western and southern flanks of the Black Hills – cross-cuts sedimentary rocks from the Pahasapa Limestone through the lower Spearfish shale. It provides a timing element for a Hills-wide event that can be correlated with the cave, particularly because one clast within Jewel Cave was emplaced before the deposition of calcite spar. A single U-Pb date places the spar at 26.5 to 37 Ma, the presumed end of dissolutional flow. A rough estimate of hydrologic properties shows that, under optimal abiotic conditions, there would have been sufficient flow to remove the entire volume of cave in less than two million years. However, this doesn't consider the potentially dramatic catalyzing effect of microbial metabolic activity.

Conclusions

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

WEDNESDAY, APRIL 15, 2015

SESSION 2P

10:10 A.M. – 11:50 P.M.

**SURFACE-WATER MODELING AND MANAGEMENT
(PONDEROSA ROOM)**

CHANGES IN SEASONALITY AND TIMING OF PEAK STREAMFLOW IN THE NORTH-CENTRAL UNITED STATES, 1910-2012

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Numerous studies have reported increases in precipitation in all seasons, with the largest changes observed in the fall, and researchers have linked a warming global climate to earlier snowmelt-driven runoff in some areas. For water-resource decision makers and emergency managers, it is important to understand the potential effects of changes in precipitation and temperature on peak streamflow timing and seasonality. A source of long-term information about the timing of flood events across the study area is the U.S. Geological Survey Peak Streamflow for the Nation dataset (<http://nwis.waterdata.usgs.gov/usa/nwis/peak>). However, one challenge of answering timing-related questions with this dataset is that, even in snowmelt-dominated areas, it is a mixed population of snowmelt/spring rain and summer/fall rain generated peaks. Therefore, a process was developed to divide the peaks from 1910-2012 into two populations, snowmelt/spring and summer/fall, using the historical distributions of peak dates for seven regions within the north-central US. The two series were then tested for the hypotheses that, because of changes in precipitation regimes, the odds of summer/fall peaks have increased and, because of temperature changes, snowmelt/spring peaks occur earlier. Logistic regression was used to model the odds of getting a summer/fall peak over the seven climatologically and geographically similar regions. When controlling for antecedent wet and dry conditions and geographic differences, the odds of summer/fall peaks occurring have increased across the study area. Linear regression analysis also showed that in northern portions of the study region, snowmelt/spring peaks are occurring earlier. These changes provide new opportunities (such as dams used for recreational or irrigation purposes catching higher summer/fall runoff) and reveal vulnerabilities (such as the potential need to modify operations of dams) for water interests. The knowledge gained can be used to increase the resiliency of water-related activities.

UTILIZING CLOUD SEEDING AS A WATER MANAGEMENT TOOL IN WESTERN SOUTH DAKOTA

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Cloud seeding is a potential tool for helping to manage regional water resources for a reliable more resilient water resource less vulnerable to seasonal and annual variability in precipitation. The purpose of this study is to estimate the impact of a sustained operational program of cloud seeding on water resources in western South Dakota, including the Black Hills region and surrounding plains. The effect of cloud seeding on precipitation tends to be multiplicative, rather than additive. Several decades of studies in the western US suggest that wintertime precipitation in mountainous regions can be augmented by 5 to 15% using cloud seeding. The scientific basis for enhancing wintertime precipitation over non-mountainous regions is not well established, although these areas may benefit from enhanced runoff from seeding over nearby mountainous regions. Summer precipitation is less predictable and more spatially variable. For summertime situations there is some theoretical and experimental support for increasing precipitation from seeding individual clouds. However, there is little statistical support from past field experiments for consistent broad area increases in precipitation from summer cloud seeding. A reasonable expectation is that a winter seeding program over the Black Hills can increase winter precipitation there by 5-15%, with overall annual precipitation increases of roughly one half the winter increase.

DECISION-SUPPORT TOOLS DRIVEN BY WATERSHED MODELS

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Watershed managers are faced with a difficult challenge of improving deteriorating surface water quality with shrinking financial resources. State-of-the-science watershed models are commonly used to characterize those conditions and support watershed management efforts by identifying cost-effective solutions. These models can be highly complex and beyond the technical understanding of the watershed managers, which can be difficult for managers to maximize the model's potential applications. The following tools have been created to put the power of watershed models in the hands of decision makers without requiring the extensive knowledge required to develop a high-quality watershed model.

This first tool was developed to provide decision makers with a user-friendly, comprehensive approach to use a watershed model to build custom scenarios with one or more best management practices (BMPs). The tool's framework consists of a Geographic Information System (GIS) for site selection or Hydrologic Simulation Program Fortran (HSPF) watershed model application to simulate fate and transport of pollutants, and a BMP database. The tool's value is in its simplification of a complex hydrologic and water quality model to estimate the significant nutrient sources in a watershed. Local watershed entities can incorporate their knowledge and expertise of BMP implementation into model simulations without needing extensive knowledge of the model. Decision makers then have a straightforward application designed to present strategic watershed management plans in terms they are familiar with.

The second tool was developed for the Sauk River Watershed District (SRWD) in Minnesota. Watershed districts such as the SRWD have the authority to fund projects based on benefits or contributions to water quality issues through the development of water management units. This tool estimates runoff coefficients with an HSPF model that takes into account land use, soils, and slope. Using GIS, coefficients were calculated for each land use within a parcel by using results from the calibrated HSPF model. All coefficients are area-weighted by parcel to determine relative contributions to surface water runoff and phosphorus loads within a management unit. The project costs addressing runoff volume or phosphorus loads can be distributed to land owners by parcel based on their relative contribution.

STORY MILL ECOLOGICAL RESTORATION

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The Trust for Public Land, in partnership with the city of Bozeman and several other stakeholders, is creating a new 54-acre community park at the confluence of Bozeman Creek and the East Gallatin River. The overarching vision for the Story Mill Community Park is predominately a natural park that retains the open space and scenic character of the site and is inspired by the theme of rivers and water systems. Wetlands, riparian areas, and streams are being restored, and the restoration actions themselves are becoming featured elements in park educational programming.

Site degradation and loss of wetland and floodplain functions were caused by over a century of agricultural, industrial, commercial, and residential land uses. Restoring the natural fluvial processes along 2,460 feet of the East Gallatin River by removing concrete rubble, old machinery, and trash embedded in the channel and streambanks allows the river to once again scour pools and create a spawning and rearing habitat. Restoration of floodplains through the creation of a new 1.5 acre backwater slough on Bozeman Creek and by creating roughly 1.6 acres of new floodplain area on the East Gallatin River will reconnect these streams with their floodplains, which will improve flood storage and conveyance, reduce sedimentation that fouls fish habitat, and improve water quality by holding and infiltrating nutrients. The design approach for the stream and floodplain restoration, which relied on hydrologic and hydraulic modeling, will be discussed followed by a presentation of Phase I construction, which occurred in the fall of 2014.

OVERVIEW OF THE NEW HEC-RAS 5.0 2D MODEL

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A brief overview of the new HEC-RAS 2D model will be presented. HEC-RAS is a public domain software package developed and supported by the USACE, Hydrologic Engineering Center in Davis, California. Version 5 released in January 2015 is a substantial upgrade to the previous version 4.1 and adds a number of new features. The most prominent feature is the inclusion of a 2D modeling option. This addition allows a user to create 1D, combined 1D/2D and 2D models using HEC-RAS. The solution scheme used in HEC-RAS 5.0 for two dimensional analyses is an entirely new code that is uniquely different from other 2D models currently available in the marketplace. It's solution scheme allows modeling detail at the sub-grid level that allows for far greater computational efficiency compared to other 2D mesh or grid based tools while capturing the impacts of terrain details typically not captured by many other models when using a practical grid scale. This presentation will provide an overview of the computational processes used in the simulation, how it manages terrain data, options for representing terrain and drainage features within the model domain, use of diffusion or full dynamic solvers, viewing and exporting results and show some example applications for a variety of complex settings.

WEDNESDAY, APRIL 15, 2015

LUNCHEON

11:50– 1:40 P.M.

JOHN T. LOUCKS DISTINGUISHED LECTURE:

ROB HARMON

“HOW MARKETS AND PEOPLE CAN KEEP STREAMS FLOWING”

(RUSHMORE F ROOM)

WEDNESDAY, APRIL 15, 2015

SESSION 3A

1:40 – 3:00 P.M.

**GROUNDWATER MODELING
(ALPINE ROOM)**

REACTIVE TRANSPORT MODELING TO EVALUATE POST-MINING SITE CONDITIONS AT AN IN SITU RECOVERY URANIUM SITE

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In situ recovery (ISR) uranium mine restoration is generally based upon a return of the site to baseline conditions. Restoration is an expensive and time intensive task, and most sites are unable to restore the groundwater to baseline conditions for all constituents. However, as the water travels downgradient, the aquifer may possess some degree of natural contaminant attenuation that allows for restoration to alternate concentration limits. Surface complexation modeling provides useful insight into the physical removal capabilities of an aquifer that can aid stakeholders in better understanding restoration needs. To accomplish this, we present a 1-D Uranium transport surface complexation model of the Mine Unit 3 extension of the Highlands-Smith Ranch ISR site near Douglas, Wyoming. The modeling effort uses a general composite approach which incorporates batch tests with 4 core depths and 3 concentrations of $p\text{CO}_2$ for model calibration. PHREEQC was used for the geochemical and transport calculations and a parameter estimation software, PEST, was used to aid in model calibration. The results predict significant uranium plume retardation in terms of both peak concentration and velocity, and stress the importance of understanding site heterogeneity, $p\text{CO}_2$ concentrations, and calcium uranyl carbonate complexes for developing aquifer restoration strategies.

RRAWFLOW: RAINFALL-RESPONSE AQUIFER AND WATERSHED FLOW MODEL

Andrew J. Long

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The Rainfall-Response Aquifer and Watershed Flow Model (RRAWFLOW) is a lumped-parameter model that simulates variable streamflow, springflow, groundwater level, solute transport, or cave drip for a measurement point in response to precipitation, recharge, or solute injection. The RRAWFLOW model includes a time-series process to estimate recharge from precipitation and simulates the response to recharge by convolution; i.e., the unit hydrograph approach. Lumped-parameter models have only a small number of parameters that represent the overall hydrologic characteristics of the model area, as opposed to distributed-parameter models that include many spatially distributed parameters. For many applications, lumped models simulate the system response with equal accuracy to that of distributed models, but moreover, the ease of model construction and calibration of lumped models makes them a good choice for many applications.

The RRAWFLOW open-source code is written in the R language and is available at <http://sd.water.usgs.gov/projects/RRAWFLOW/RRAWFLOW.html>, along with an example model of springflow that includes all input and output files, a user's manual, and a quick-start guide for the novice. The user need not know the R language. The RRAWFLOW model provides professional hydrologists and students with an accessible and versatile tool for lumped-parameter modeling.

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

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The Madison and Minnelusa aquifers in the Black Hills region of South Dakota and Wyoming provide groundwater for agricultural, industrial, commercial, public, and domestic use. Both aquifers are vitally important water resources for the Northern Great Plains, which includes the Black Hills region. Groundwater use in the 21 counties surrounding the Black Hills increased from 1985 to 2005 by greater than 35%. To assess the effects of increased groundwater use and potential climatic changes on groundwater availability, the U.S. Geological Survey (USGS), in cooperation with the National Park Service, the city of Rapid City, and the West Dakota Water Development District, is constructing a regional numerical groundwater-flow model of the Madison and Minnelusa aquifers, with a focus on the Black Hills region. The groundwater model currently is under construction using the recently developed MODFLOW-USG (unstructured grid) groundwater modeling software. MODFLOW-USG was chosen because of its versatility in grid design and ability to simulate pipe flow in karst conduits. The total model area includes about 60,000 square miles located primarily in western South Dakota and northeastern Wyoming. Previous research for this project included creating seamless maps for the altitude tops and potentiometric surfaces of the Madison and Minnelusa aquifers and estimating recharge from precipitation and sinking streams. Estimated average groundwater recharge for the Black Hills region from precipitation on outcrop areas and sinking streams was 108 and 68 cubic feet per second (ft^3/s), respectively, for the Madison aquifer and 107 and 40 ft^3/s , respectively, for the Minnelusa aquifer. Groundwater-use estimates are in progress and are based on previous USGS estimates, State water-well databases, and withdrawal records provided by the city of Rapid City.

COMPARISON OF A NEW STREAM BASE-FLOW ESTIMATION METHOD IN TWO BASINS USING MULTIVARIATE ANALYSIS IN THE NORTHERN GREAT PLAINS

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Stream base-flow estimation is commonly performed by using graphical or chemical hydrograph separation methods that have limitations due to the spatial and temporal availability of data. Current graphical separation methods are limited in that they rely solely on streamflow records, whereas chemical methods are expensive and involve intense data collection. Graphical hydrograph separation methods are applicable to perennial and gaining streams but result in large uncertainty when applied to ephemeral or losing streams that are typical of dry climates.

A new methodology planned for development will consist of multivariate analysis to determine which spatial and temporal variables are the controlling factors for base flow. Data used in the development of this methodology will include geologic, hydrologic, climatic, land surface, and remotely sensed data that are widely available to the public. Factors considered will include geologic media, flow-duration curves, temporal variability of streamflow, stream type, precipitation, drought-severity index, land-surface slope, and vegetation. This research will examine differences in variables controlling base flow between dry and humid climates, perennial and ephemeral streams, and gaining and losing stream reaches. Although the accuracy of each variable will vary, the use of multivariate analyses will help compensate for those variables with low accuracy.

Base-flow estimates were previously calculated for all streams with available streamflow data located in the Williston and Powder River structural basins using the U.S. Geological Survey hydrograph separation software, PART; these streams, in addition to streams not previously analyzed, will be evaluated by using the methodology that is being developed. The study area for this research will include two river basins in the Northern Great Plains region: the Heart River Basin in southwestern North Dakota, which is located in the Williston structural basin, and the White River Basin in southwestern South Dakota.

WEDNESDAY, APRIL 15, 2015
SESSION 3P
1:40 – 3:00 P.M.

SURFACE-WATER QUALITY
(PONDEROSA ROOM)

TEMPERATURE TOTAL MAXIMUM DAILY LOAD ASSESSMENT FOR WHITEWOOD CREEK AND BEAR BUTTE CREEK WATERSHEDS

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Water temperature is a key component in sustaining healthy aquatic life. The state of South Dakota recently developed and adopted new temperature standards for cold-water-fish life in the Black Hills. The state of South Dakota recently initiated a Total Maximum Daily Load (TMDL) assessment of the Whitewood Creek and Bear Butte Creek Watersheds to assess the temperature regime on 13 defined stream reaches classified as cold-water fisheries.

The Whitewood/Bear Butte Creek Watershed TMDL project integrates mechanistic modeling and remote sensing data to define an allowable heat loading for impaired reaches. Mechanistic modeling is being used to determine the daily allowable load as energy per unit volume of water. Remote sensing data and Geographic Information System (GIS) analysis are being used to allocate excess solar radiation caused by land cover disturbance. Specifically, the proposed TMDL project leveraged existing Hydrologic Simulation Program – Fortran (HSPF) modeling applications that were developed for Whitewood Creek and the Belle Fourche River Watersheds to simulate stream temperature in the project area.

The TMDL project was proposed with two phases. Phase I included HSPF model application setup and hydrology calibration for the Whitewood Creek and Bear Butte Creek Watersheds while Phase II includes calibrating and finalizing the temperature portion of the model application, running scenarios, and writing an assessment report with corresponding TMDL summaries for impaired reaches. The assessment report will incorporate the HPSF model application for determining allowable loads, determining the source allocation, and developing implementation strategies. The end product will be an assessment report with corresponding TMDL summaries for impaired reaches that include optimized, cost-effective, and realistic implementation plans.

RESILIENCY OF STREAM BIOFILMS TO ALTERATIONS IN CLIMATE AND FLOW REGIME

Lisa A. Kunza

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Stream biofilm accrual and disturbance may be influenced by weather patterns, climate alterations, and flow regime shifts. Biogeochemical fluxes associated with the stream biofilms can be driven by thickness and abundance of particular organisms. I will discuss how weather patterns and changes to the flow regime influence biofilms in two streams, Ditch Creek in Grand Teton National Park, WY and Rapid Creek below Pactola Dam, SD. Ditch Creek has N₂-fixation rates among the highest published in the literature. Unlike most streams, Ditch Creek N₂-fixation dominates N cycling processes at times. N₂-fixation in Ditch Creek fluctuates on multiple time-scales and results from diel, summer and yearly estimates will be presented along with weather and links to flow regime. Locally, Rapid Creek from Pactola Reservoir to Canyon Lake experiences periodic accumulations of biofilm including *Didymosphenia geminata*. I will talk about the alterations in flow regime in Rapid Creek during 2014 and the potential influence on *D. geminata* accrual and how that might influence biogeochemical fluxes and stream processes.

WATER-QUALITY CHARACTERISTICS OF STORMWATER IN RAPID CITY, SOUTH DAKOTA, 2008–2014

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High quality water in Rapid Creek as it flows through Rapid City, South Dakota is important to sustain its uses as a spawning habitat for a prized trout fishery, immersion recreation, and a source of municipal water for the City of Rapid City. This presentation describes the current (2008–2014) amount and composition of urban stormwater in selected drainage networks within the city of Rapid City, and helps evaluate the efficiency of wetland channels implemented as a best-management-practice used for stormwater pollutant removal. Stormwater data were collected in three drainage basins within Rapid City: Arrowhead, Meade-Hawthorne, and the Downtown drainage basins. Water-quality concentration information includes total suspended solids (TSS) and bacteria concentrations at all three drainage basins, and additionally nutrients and metals at the Downtown drainage basin.

For the Arrowhead and Meade-Hawthorne sites, event mean concentrations typically exceeded the TSS and bacteria beneficial use criteria for Rapid Creek by 1–2 orders of magnitude. Comparing the two drainage basins, median TSS event mean concentrations were greater at the Meade-Hawthorne outlet (516 milligrams per liter, mg/L) than the Arrowhead outlet (230 mg/L), and fecal coliform bacteria concentrations showed a similar pattern between the two basins. A comparison to relevant standards shows that stormwater from the Downtown drainage basin exceeds criteria for bacteria and TSS, but concentrations generally are below standards for nutrients and metals. Three wetland channels located at the outlet of the Downtown drainage basin were evaluated for their pollutant removal efficiency. Average reductions in TSS and lead concentrations were greater than 40 percent for all three wetland channels; total nitrogen, phosphorus, copper, and zinc concentrations were reduced by greater than 20 percent. Fecal coliform bacteria concentrations were reduced by about 21 and 36 percent at the 1st and 2nd Street wetlands, respectively, but showed a nearly zero percent reduction at the 3rd Street wetland. Chloride concentrations typically increased from inlet to outlet at the 2nd and 3rd Street wetlands.

POTENTIAL ORGANIC CARBON EXPORTS WITHIN THE UPPER RAPID CREEK WATERSHED DUE TO THE CURRENT MOUNTAIN PINE BEETLE OUTBREAK

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Mountain pine beetle (MPB) (*Dendroctonus Ponderosae*) infestations in pine dominated watershed (*Pinus spp.*) forests may affect drinking water supplies through increased loadings of dissolved organic material (DOM) and carbon (DOC), both of which within municipal water supplies are precursors to toxic disinfection by-products (DBP). Since 1996, the MPB has infested 174,000 hectares of forest within the Black Hills of South Dakota. The focus of this research is to quantify changes in source water quality related to organic carbon exports within the upper Rapid Creek watershed due to the MPB outbreak. Characterization of DOM will be completed using specific ultraviolet absorption (SUVA), parallel factor analysis (PARAFAC), and total organic carbon analysis (TOC) to develop a better understanding of current and potential carbon export budgets. Preliminary sampling and analysis efforts within the upper Rapid Creek and Rhoads Fork watersheds indicate organic carbon concentrations ranged between 1 and 20 mg/L TOC, with the higher concentrations exceeding those reported from Lodgepole Pine (*Pinus Contorta*) dominated watersheds of Colorado (5 mg/L peak) with similar MPB infestations and mortality. This MPB outbreak may necessitate long-term changes to watershed management as both the quantity and quality of local and regional surface water and groundwater resources may be impacted due to the MPB outbreaks.

WEDNESDAY, APRIL 15, 2015
SESSION 4A
3:40 – 5:00 P.M.

GROUNDWATER AND MAPPING
(ALPINE ROOM)

A CONTINUED EXAMINATION AT SANFORD LABORATORY'S WATER QUALITY – 2015

John Scheetz

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Sanford Laboratory continues to treat underground water and Homestake's tailing water through its Waste Water Treatment Plant for discharge to Gold Run and Whitewood creeks. Water quality from the underground continues to improve in terms of total dissolved solids, iron, sulfate, and ammonia. Arsenic concentrations have remained the same or slightly increased due to decreases in co-precipitation with iron. The concentration of carbonate ions has increased and reflects mineralogy of the pool and the host rock water passage way from Homestake's Open Cut. The Homestake tailing water has shown decreases in ammonia and total dissolved solids over the past six years, facilitating the discharge of Sanford Laboratory's water in terms of moderating discharge water temperature in the summer. Similarly, the warm water associated with the Laboratory pool water allows for passive treatment of ammonia residing in both tailing water and underground water in the winter. Discharge water continues to meet all permit requirements, which include concentration-based numerical requirements, whole effluent toxicity requirements, and bio-monitoring comparison data from upstream and downstream sites along Whitewood Creek.

PRELIMINARY RESULTS OF WATER-QUALITY SAMPLING FROM PRECAMBRIAN WELLS IN THE CUSTER AREA OF THE SOUTHERN BLACK HILLS

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This work examined the water quality of Precambrian crystalline aquifers in the Custer area of the southern Black Hills. During this on-going project, a total of 90 water samples from private wells will be collected and analyzed during 2014 and 2015. The information will be compiled along with data from available records of public water systems. Samples taken from private wells in the fall of 2014 have been analyzed for arsenic and nitrate concentrations, and for bacterial data. Preliminary results show that about 15% of private well samples exceeded 10 µg/L for arsenic, and another 20% were in the range of 7 to 8 µg/L. The arsenic is most likely from weathering of arsenopyrite in Precambrian metagraywacke and within mineralized zones. To date, no samples have exceeded 10 mg/L for nitrate concentrations, although several were close to that level. About 30% of the private well samples showed total coliform bacteria. Sampling of wells in the area will continue during the spring and early summer of 2015.

CHARACTERIZATION OF GLACIAL AQUIFER HYDROGEOLOGICAL FRAMEWORK USING AIRBORNE ELECTROMAGNETIC SURVEYS

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Electromagnetic surveys have been used for enhanced lithological characterizations in well-logging activities for decades; more recently, equipment has become available for airborne electromagnetic (AEM) surveys using helicopters and fixed-wing aircraft. This advancement allows for continuous electromagnetic surveys that cover broad areas; thus, improving the ability of hydrologists to characterize complex hydrogeological frameworks around the world.

One such complex hydrogeological setting that exists in South Dakota is buried valley glacial aquifer systems. Buried channels are not identifiable from surface geology because they commonly are covered by glacial drift. Traditionally, these glacial features have been located by drilling test holes at regularly spaced intervals, and by sparse or coarsely resolved ground-based geophysical methods. As a result, these methods might miss high-transmissivity, water-bearing buried channels that are smaller than the intervals between survey lines or test holes. Implementation of these traditional methods also is encumbered by high costs and hindered access to target areas of interest. These problems are addressed by AEM surveys, which typically cost less than traditional methods per line-kilometer of survey and may be deployed to areas inaccessible by land transportation or that may be largely covered by anthropogenic development.

Another advantage of AEM surveys over traditional methods is the ability for hydrologists to use the processed data to accurately define aquifer properties and boundaries. Simulation of groundwater flow using models can be improved with the nearly continuous resolution of aquifer properties generated by AEM surveys. In this way, these geophysical methods are invaluable in creating groundwater models for sustainable resource management.

ENSURING FLOOD RESILIENCY, OGLALA LAKOTA ARTS AND BUSINESS INCUBATOR

John Wirries

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In much of the United States, FEMA has mapped the 100 year floodplain. However, there are no maps on the Pine Ridge Indian Reservation in South Dakota. The Artspace group intends to build an Oglala Lakota Arts and Business Incubator adjacent to Three Mile Creek southwest of Kyle, SD. To ensure resiliency of the facility, it was necessary to determine the 100 year flood elevations, also known as base flood elevations (BFE), the floodplain extents and anticipated water velocities. A quick analysis predicted a change in the BFE of ten feet adjacent to the site. A two dimensional model was created in XPSWMM to verify the flow paths and floodplain extents. This allowed verification that higher elevations at the upstream end did not find a path through the site. The data from the two dimensional model was entered into the traditional one dimensional HEC-RAS model which is needed for agency review. The results from XPSWMM and HEC-RAS were compared to ensure consistent results which lead to determination that the site was outside the floodplain.

Results from both modeling efforts were exported to GIS to allow for analysis and presentation to the client. The two dimensional model results in particular, offered a unique insight into flows and velocities that are easily conveyed to non-water professionals.

KLJ has a business office in Rapid City, South Dakota.

WEDNESDAY, APRIL 15, 2015
SESSION 4P
3:40 – 5:00 P.M.

FLOODING (PONDEROSA ROOM)

EVALUATION OF POST-FIRE RUNOFF RESPONSE TO TWO HIGH-INTENSITY, SHORT-DURATION THUNDERSTORM EVENTS, SIOUX AND ASHLAND RANGER DISTRICTS, CUSTER NATIONAL FOREST, MONTANA

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Elevated post-fire runoff response resulting from loss of ground cover and plant canopy, increased incidence of soil water repellency, and loss of soil organic matter is commonly observed following wildfires throughout the western United States (e.g. Wagenbrenner et al. 2015). Accurate modeling of the magnitude of post-fire runoff, however, has been found to be extremely challenging. This is especially true for the northern Great Plains of southeast Montana and northwest South Dakota, where there is limited record of post-fire rainfall-runoff response and where relatively few efforts have been made to model that response.

During August and September 2013, two 25-year (or slightly less), 30-minute precipitation events impacted burn scars from wildfires that burned in 2012 in southeast Montana on Forest Service administered lands. Following these events, efforts were made to reconstruct the magnitude of rainfall-runoff response and compare it to model estimates made during Burned Area Emergency Response (BAER) post-fire resource assessments.

Both storms likely yielded peak flow responses in excess of the 500-year recurrence interval event, with the Wilbur Creek peak flow event potentially being among the largest recorded for watersheds of similar size in the Ashland, MT area. Hydrologic analysis completed during 2012 BAER assessments significantly under-predicted the magnitude of peak flows observed one year post-fire. Future hydrologic analysis should consider using 25-year or greater precipitation event recurrence intervals for sizing infrastructure to accommodate post-fire peak flows in the northern Great Plains of southeast Montana and northwest South Dakota. More investigation of modeled outputs for watersheds of varying sizes with varying burn severities coupled with further observation of rainfall-runoff dynamics in southeast Montana is required to better refine future peak flow estimates.

HYDROLOGIC RESPONSE AND CONTEXT FOR A HIGH-ELEVATION STORM IN THE SOUTH DAKOTA BLACK HILLS

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A group of thunderstorms produced more than 4 inches of rain during four consecutive 30-minute periods of progressively intense rainfall across a small high-elevation part of the northern Black Hills on August 5, 2014. Rainfall totals and intensities were estimated from observer reports and from the Weather Surveillance Radar-1988 Doppler that is located just north of New Underwood, South Dakota. The maximum observed rainfall was about 4.5 inches, which is approximately equal to the 3-hour, 200-year recurrence interval precipitation estimate for this area.

The most noteworthy hydrologic response was in two small tributaries to East Spearfish Creek. Keough Draw produced a peak flow of 340 cubic feet per second from a drainage area of 1.0 square mile and Ward Draw produced 160 cubic feet per second from an area of 2.9 square miles. The flood peaks attenuated quickly in progressing downstream owing to diminishing precipitation and widening of the valley bottoms. A peak flow of only 91 cubic feet per second was measured further downstream at U.S. Geological Survey streamgauge 06430770 along Spearfish Creek, which has a drainage area of 65.0 square miles.

Keough Draw and Ward Draw are located along the northeastern extent of the Limestone Plateau, an area in the west-central Black Hills that characteristically produces smaller peak flows than surrounding areas, relative to drainage area. Contributing factors include low topographic relief, high infiltration capacities of bedrock outcrops, and generally smaller potential for exceptionally strong rain-producing thunderstorms in the higher elevations of the Black Hills. Relative to the drainage area, maximum peak flows for some Black Hills streamgages outside the Limestone Plateau are about an order of magnitude larger than for Keough Draw and Ward Draw. However, the peak flows for Keough Draw and Ward Draw that resulted from the August 5, 2014, thunderstorms are by far the largest known flows—relative to drainage area—ever documented for the high-elevation Limestone Plateau area.

CoCoRaHS: AN INCREDIBLE DATABASE FOR RESEARCH

Scott J. Rudge

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The Community Collaborative Rain, Hail and Snow network (CoCoRaHS) took roots back in 1998 in the Fort Collins, Colorado area following a devastating flood the previous year. Since then, the program has expanded to all 50 states and also into Canada. This program accepts volunteers to take and record daily precipitation measurements at their home, school, or workplace. Volunteers then input this precipitation data into the CoCoRaHS website, providing a national snapshot of precipitation each day. This is one of the main goals of the CoCoRaHS program – “To provide accurate high-quality precipitation data to observers, decision makers and other end-users on a timely basis.”

The CoCoRaHS community continues to grow, with nearly 20,000 volunteers currently taking precipitation measurements. Recruitment is easy, just locate the CoCoRaHS website and click on the “Join CocoRaHS” icon. The website provides training on how to best measure liquid and frozen precipitation, and how to input the data into the website. Many additional opportunities are provided to volunteers through the website, including routine blogs and newsletters that keep volunteers informed and educated.

Can a citizen based observation system compare favorably to more sophisticated ways of collecting precipitation data? CoCoRaHS volunteers must be doing an adequate job, as NOAA’s River Forecast Centers and National Weather Service offices are using CoCoRaHS observations as ground truth to fill in the voids where official observations are few and far between. CoCoRaHS reports can be vital to field studies where traditional observations are not available. Additionally, automated equipment has always been poor in the measurement of snow. CoCoRaHS observers have the training available through the website to make reasonable snow measurements, given some challenging situations. Where official data is sparse, CoCoRaHS observers can step in and provide much needed data for critical water/snow research projects.

GEOMORPHIC CONDITIONS FOLLOWING A HIGH-ELEVATION STORM IN THE SOUTH DAKOTA BLACK HILLS

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A group of thunderstorms produced more than 4 inches of rain during a two-hour period of progressively intense rainfall across a small high-elevation part of the northern Black Hills on August 5, 2014. Documented peak flows included 340 cubic feet per second from a drainage area of 1.0 square mile in Keough Draw and 160 cubic feet per second from an area of 2.9 square miles in Ward Draw. These drainages are located along the northeastern margin of the Limestone Plateau, a high area of the west-central Black Hills that characteristically produces much smaller peak flows than surrounding areas, relative to drainage area. Contributing factors include low topographic relief, high infiltration capacities of the limestone bedrock, and generally smaller potential for exceptionally strong rain-producing thunderstorms in the higher elevations of the Black Hills. For many watersheds in other more flood-prone parts of the Black Hills, maximum recorded peak flows are about an order of magnitude larger than those for Keough Draw and Ward Draw, relative to the drainage area. However, the peak flows for Keough Draw and Ward Draw that resulted from the August 5, 2014, thunderstorms are by far the largest recorded flows—relative to drainage area—ever documented for the high-elevation Limestone Plateau area.

Estimation of return periods for low-probability flood events for streams in and near the Limestone Plateau historically has been extremely challenging due to a sparse streamgaging network, short records, and a relative dearth of large peak flows. Many drainages within and near the Limestone Plateau demonstrate visible evidence of long-term flow stability or a relative absence of high-flow conditions. Such evidence includes unique in-stream and riparian vegetation conditions, large accumulations of organic matter within or near highly stable stream channels, and small or absent channels within drainage bottoms. Examination of geomorphic evidence in Keough Draw and Ward Draw provided interesting insights regarding long-term peak-flow conditions. Specific examples included dislodging of travertine deposits from the channel and exposure of high-energy deposits (boulder bars) from previous high-flow events.

WEDNESDAY, APRIL 15, 2015
POSTER SESSION AND EVENING SOCIAL
5:20 – 7:30 P.M.

(RUSHMORE G ROOM)

APPLICABILITY OF WRF-HYDRO TO WESTERN SOUTH DAKOTA

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With a changing climate and an increased stress on existing water resources, integrating hydrologic and weather and climate prediction is increasingly important for operational and societal decision-making as well as scientific studies. The Weather Research and Forecasting model (WRF) has been a leading tool in research and prediction. Recently, National Center for Atmospheric Research (NCAR) has released a version of WRF that integrates terrestrial and stream hydrology into its predictive framework. This model, WRF-Hydro, was developed to be coupled to a dynamic atmospheric model or run uncoupled (driven with existing precipitation and evaporative forcings). WRF-Hydro provides the ability to examine hydrologic impacts from events in a distributed (rasterized) framework at the same or higher resolution as the overlying atmospheric model or forcing dataset. WRF-Hydro also has the ability to analyze and model a variety of processes such as land-atmosphere energy budgets, evapotranspiration, soil moisture, subsurface flow, and surface runoff. To assess the applicability of WRF-Hydro to the Black Hills and Western South Dakota (e.g., the Cheyenne River Basin), we are comparing WRF-Hydro to other hydrologic models in use over the region (e.g., Hydrologic Engineering Center's River Analysis System model, HEC-RAS) and the resulting actual conditions following a rainfall event.

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

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Similar to elsewhere in the Rocky Mountains, mountain pine beetle (*Dendroctonus ponderosae*) infestation has affected large areas of the central and southern Black Hills of western South Dakota. The hydrologic response of watersheds to pine beetle infestation has been studied by other researchers, but typically for sub-alpine settings where runoff is dominantly derived from snowpack. There is a need for studies of the hydrologic response of ponderosa pine (*Pinus ponderosa*) forests, which are not a snow-dominated system, but are rather semi-arid settings where evapotranspiration potentially plays a greater role in the hydrologic budget. The Runoff-Response Aquifer and Watershed Flow (RRAWFLOW) model has been successfully used to model springflow in the Black Hills, including Rhoads Fork Spring in the headwaters of Rapid Creek. RRAWFLOW will simulate changes in the hydrologic response since 2008 of Rhoads Fork Spring to the cycle of beetle infestation, tree mortality, and regrowth. Projected response to 2050 will be simulated by RRAWFLOW on the basis of climate model simulations. This study is a cooperative effort between the U.S. Geological Survey, South Dakota School of Mines and Technology, and the City of Rapid City.

COMPARING NUTRIENT CYCLING AND METABOLISM IN STREAMS CONTAINING VARYING AMOUNTS OF *DIDYMOSPHENIA GEMINATA* MAT COVERAGE IN GRAND TETON NATIONAL PARK

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Didymosphenia geminata is a freshwater alga, which has recently gained attention for its ability to produce an abundance of extracellular stalk material (aka mats) in oligotrophic streams. These benthic mats can cover entire stream beds up to 20 cm thick. Although several studies focus on the environmental conditions of streams where *D. geminata* mats are found, less is known regarding the effects of *D. geminata* mats on stream ecosystem functions like nutrient cycling and metabolism. We examined three streams in Grand Teton National Park, all of which are lake outlets and within 10 km of each other, but display varying amounts of mat coverage. Lake Creek had thick mats covering >70% of substrate for more than 1 km, Taggart Creek contained *D. geminata* with patchy mat development, and Bradley Creek had no *D. geminata* mat presence. We measured whole-stream metabolism in Lake and Bradley Creeks in order to quantify the effects that *D. geminata* mats may have on primary productivity and ecosystem respiration. Using chambers, we measured phosphate uptake, nitrogen fixation, and denitrification in all three streams. As all biota depend on N and P for growth and reproduction, understanding how *D. geminata* mats influence cycling of these essential nutrients is important for understanding how much of an influence these mats are having on stream ecosystem processes and function. Disturbances by *D. geminata* mats to stream metabolism and nutrient cycling may cause ecological and economic impacts, such as altering food web dynamics and shifting of energy pathways.

MISSOURI BASIN RIVER FORECAST CENTER'S RIVER STAGE FORECAST VERIFICATION WEBPAGE

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The NOAA's NWS Missouri Basin River Forecast Center (MBRFC) has developed and implemented a verification webpage for all its river stage forecast locations. This webpage is available to the state/federal partners as well as the public and used to view and evaluate long term verification statistics. The river forecast center provides forecast services for 425 forecast locations across the Great Plains of the United States, and of these, 41 locations are in South Dakota. The MBRFC frequently gets questions from users regarding the quality of river forecasts, and as a result, they have been addressed through this service.

The verification webpage was designed to be user friendly and to cater to varying degrees of knowledge. Users have the ability to find their forecast location by the servicing Weather Forecast Office or river basin. Several statistical metrics are considered including: forecast vs observed scatterplot, sample size of data, Mean Absolute error (MAE), Mean Error (ME), Root Mean Squared Error Skill Score (RMSE-SS), Pearson's Correlation (CORR), Probability of Detection (POD), and Hydrologic False Alarm Rate (HFAR). Each metric can be viewed by calendar year or forecast lead time in six hour increments.

This page allows all users to better track all the varying details of each forecast location, including under and over forecasting. Forecasters are able to use these statistics to help make decisions while forecasting flood events and find ways to improve long term forecast quality in the model. Users, who are asking about forecast quality, can also use the information to help in their decision making process through the understanding of variability that could come with a forecast.

ESTABLISHING GENE FINGERPRINTS OF PATHOGENIC BACTERIA ALONG SELECTED REACHES OF RAPID CREEK

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

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

We propose to apply common molecular biology techniques to assay the pathogenic potential of organisms in the impaired areas of Rapid Creek. This will allow the creation of a genetic fingerprint, and may provide a way to pinpoint the source of contamination. With this new monitoring metric, we can determine how many variants of a particular pathogenic gene are present, measure the biodiversity of the water, and track changes over time. The information generated by this project could lead to the implementation of new monitoring metrics as best management practices are developed for watersheds across the country.

RECENT PALEONTOLOGICAL RECORD OF *DIDYMOSPHENIA GEMINATA* IN GRAND TETON NATIONAL PARK

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Didymosphenia geminata, a freshwater diatom, is beginning to exhibit invasive-like behavior, while having a poorly understood effect upon lotic ecology. While traditionally considered a boreal species, it has become more prevalent in temperate regions since the early 2000s, including locally in Rapid Creek as well as in Phelps Lake in Grand Teton National Park. Along with its apparent range expansion, *D. geminata* can produce copious amounts of stalk material creating benthic mats up to 20cm thick. Currently, the controversy in management of this diatom tends to be associated with whether *D. geminata* is considered native or non-native. Diatom valves are preserved in lake sediments, thus providing the means to examine whether *D. geminata* was present historically in the ecosystem. We examined cores from three freshwater systems in Grand Teton National Park for historical occurrences of *D. geminata*. Phelps Lake contains *D. geminata* mats yearly in its outlet Lake Creek. Bradley Lake lacks *D. geminata* mats in the outlet. *D. geminata* has not been previously observed in the Oxbow Bend of the Snake River, but is at a high risk for introduction due to its location just below Jackson Lake Dam and high recreational traffic. To investigate potential rationale for *D. geminata* presence/absence *Cymbella mexicana*, *Cymbella janischii*, and *Asterionella formosa* abundances are tallied. *C. mexicana* and *C. janischii* are taxa closely allied to *D. geminata* and confirm the presence of a suitable epiphytic habitat. *A. formosa* is utilized as a proxy for nitrogen saturation. Since modern *D. geminata* mats are associated with phosphorus depletion, we investigate nitrogen saturation as a cause of phosphorus depletion and *D. geminata* abundance.

USING LOW-COST ADSORPTION MATERIALS TO REMOVE PHOSPHORUS FROM AGRICULTURAL SUBSURFACE DRAINAGE

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Agricultural subsurface drainage can transport a large amount of nitrate and phosphate from the fields to surface waters, which contributes substantially to the eutrophication and algal blooms of the receiving water bodies. Denitrification bioreactors have been developed to remove nitrate from subsurface drainage. However, effective technologies are needed to reduce phosphate concentrations in drainage water in order to protect natural water resources. The objective of this project is to evaluate the capacity of several low-cost adsorption materials to remove phosphate from subsurface drainage. These materials include: limestone, calcite, zeolite, biochar, iron filings, steel slag, and steel chips and turnings. We will perform short-term batch studies and long-term column experiments to determine the capacity of the selected natural mineral and industrial byproducts to remove phosphate from simulated subsurface drainage. We will evaluate the impact of temperature, pH, reaction time, and other factors on the adsorption and desorption using these materials. Based on the results of batch and column experiments, one material will be selected for field-scale installation for subsurface drainage treatment. This study will provide key information about the use of phosphate adsorption media for phosphate removal from subsurface drainage.

REDUCTION OF TURBIDITY IN SOUTH DAKOTA CONSTRUCTION SITE STORMWATER RUNOFF USING POLYACRYLAMIDE

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Construction projects usually require large areas of land disturbance which may result in accelerated soil erosion. Excessive sediment from construction activities can negatively impact the water quality of receiving water bodies. There has been an increasing interest in using polyacrylamide (PAM) to control construction site erosion and reduce runoff turbidity levels. PAM is a class of long-chain polymers that can stabilize and flocculate soils and other materials. The objective of this project is to evaluate factors affecting PAM flocculation of soils from South Dakota construction sites. Some of the experimental conditions include varying polymer dosage and type, experimental temperature, calcium and organic matter concentrations, and pH. Further research includes looking more closely at the formation of flocs and measuring residual PAM concentration and zeta potential in the solution to try to determine what mechanisms control the floc formation, as well as the effectiveness of the flocculant.

GROUNDWATER QUALITY FROM AQUIFERS IN PRECAMBRIAN ROCKS OF THE CENTRAL BLACK HILLS, PENNINGTON COUNTY, SOUTH DAKOTA

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From 2013 through 2015, faculty members and students in the Department of Geology and Geological Engineering at the South Dakota School of Mines and Technology, in conjunction with the West Dakota Water Development District, conducted a survey of drinking-water quality from aquifers in the Precambrian core of the Black Hills, in the western half of Pennington County. The study area includes the Hill City, Silver City, Rochford, Keystone, and Mystic areas. Samples were collected by students from private water wells in the community, providing a free-of-cost analysis to the sample donors. Samples were analyzed for hardness, calcium, magnesium, nitrate, arsenic, sulphate and for the presence of total and fecal coliform bacteria. The analyses were performed by Midcontinent Testing Laboratories Inc. in Rapid City. As of March 1, 2015, 208 samples have been collected, with 99 (47.5%) exceeding 180 mg/l in hardness, considered by the USGS to be the threshold for water considered “very hard”. Seven of the samples (3.4%) exceeded 10 mg/L for nitrate, and 37 (17.8%) contained arsenic concentrations of 0.010 mg/L or greater. The threshold numbers are the EPA standard levels for drinking water contaminants for public water supplies. Coliform bacteria were detected in 89 (42.8%) of the samples, whereas fecal coliform bacteria were detected in 18 (8.6%) of the samples. The study is ongoing, with an anticipated 250 samples being collected by the end of the study in 2015.

CLIMATE FACTORS CONTRIBUTING TO STREAMFLOW INPUTS AND EXTREME WATER-LEVEL DEVIATIONS FROM LONG-TERM AVERAGES FOR LAKES SUPERIOR AND MICHIGAN-HURON

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The Great Lakes are a highly valued freshwater resource of the United States and Canada. The Lakes are the focus of a science-based restoration program, known as the Great Lakes Restoration Initiative (GLRI). Physical and chemical factors, such as inflows and nutrient loads to the Great Lakes can affect ecosystem function, contribute to the spread of invasive species and increase the occurrence of harmful algal blooms. Since about 1999, water levels in Lakes Superior and Michigan-Huron have been at or below the long-term average (1918 to present). Analyses of streamflow trends for the period 1960 to 2012 in watersheds draining into Lakes Superior and Michigan-Huron showed a long-term decline in average inflows, which helps to explain the persistently below-average lake levels. Recent climatic conditions of October 2013 to August 2014 have contributed to a rapid rise in lake levels, most notably in Lake Superior. Lake Superior recently reached an elevation of 602.56 feet above sea level in August 2014, which is the highest level in 17 years. Coincident with this recovery was the development of a large algal bloom in Lake Erie in August of 2014 that shut down the Toledo, Ohio municipal water supply. These anomalous, extreme deviations from long-term average lake levels will be examined to better understand the forcing factors that contributed to changes in inflow volumes and lake-levels. Particular focus will be given to the climatology of years when changes in lake levels are most pronounced, such as; the measured lake-level declines during 1964-1965 and 1998-2000; and lake-level rises during 1973-1974, 1987-1989, and 2013-2014. The climatology of years with periods of algal blooms will also be examined such as, 2003, 2008, 2011 and 2014.

THURSDAY, APRIL 16, 2015
FIELD SEMINARS/TRIPS
PRE-REGISTRATION REQUIRED

Post-flood geomorphic conditions in Keough Draw and Ward Draw

Description: This trip goes to Keough and Ward Draws in the northern Black Hills to look at geomorphic conditions following a storm event that produced more than 4 inches of rain during a 2-hour period on August 5, 2014. Bring a lunch and water-resistant boots and clothing.

Leader: Dan Driscoll (U.S. Geological Survey)

Meeting time: 8 a.m.

Meeting location: Parking lot on east side of Civic Center (Holiday Inn side), 505 N. 5th Street, Rapid City, SD

Duration: This field trip will require at least 4 to 5 hours and may take most of the day, if participants want to spend the time. (4.0 PDH)

- Driving time from Rapid City is about 2 hours round trip and will include about 20 miles of gravel.
- We will first hike in and out of Keough Draw (~3 miles total).
- Depending on weather and interest of participants, we could also go into Ward Draw (~4 mile hike), where some different sights/perspectives can be seen.

Barrick Gold Corp and Sanford Lab wastewater treatment plants

Description: We will begin the tour at the WWTP for Barrick Gold in Central City. At 1 p.m., we will tour the Sanford Lab WWTP. Please bring a sack lunch or lunch on your own at noon.

Leaders: Todd Duex (Barrick Gold Corp) and John Scheetz (Sanford Lab)

Meeting time: 10 a.m.

Meeting location: Barrick WWTP in Central City.

Duration: 5 hours (4.0 PDH)

Rapid City stormwater management practices

Description: We will visit several stormwater outfalls within Rapid City along Rapid Creek and examine the various control features used (retention ponds and wetland channels). We will showcase an area where stormwater quality and discharge information was collected during 2013-14, with a short demonstration on data collection techniques.

Leader: Galen Hoogestraat (U.S. Geological Survey)

Meeting time: 8:30 a.m.

Meeting location: east side Civic Center parking lot (Holiday Inn side), 505 N. 5th Street, Rapid City, SD. Approximately 1 mile trip walking each way with 3 site stops. Additional locations may require vehicle travel (TBD).

Duration: 2 hours (2.0 PDH)

Belle Fourche Irrigation District (BFID) Operation and Water Conservation

Description: We will be touring several sites within the BFID to provide an understanding of how the District is operated as well as provide examples of water conservation measures that have been implemented in the past several years.

Leaders: Jared Oswald (RESPEC) and Bill Anderson (BFID Manager)

Meeting time: 9 a.m.

Meeting location: Belle Fourche USDA Service Center – 1837 5th Ave. South, Belle Fourche, SD

Duration: 3 hours (3.0 PDH)