

2011
WESTERN SOUTH DAKOTA
HYDROLOGY CONFERENCE

Program and Abstracts

**April 28, 2011
Rushmore Plaza Civic Center
Rapid City, South Dakota**

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2011 Western South Dakota Hydrology Conference

This program and abstracts book has been produced in conjunction with the 2011 Western South Dakota Hydrology Conference, held at the Rushmore Plaza Civic Center on April 28, 2011. The purpose of this book is to provide summaries of the presentations made during the conference.

The purpose of the 2011 Western South Dakota Hydrology Conference 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 conference 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 conference consists of four technical sessions, the John T. Loucks Distinguished Lecture, and a poster session. The topics of the technical sessions include research studies, floods, surface-water quality issues, remote sensing and climate, mining issues, and ground-water issues.

ACKNOWLEDGMENTS

Many people have contributed to this conference. 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, Dr. Victor Baker, is thanked for his time and perspectives. Registration help by Sheri Meier and Barbara Rowe (USGS) is greatly appreciated. Josh Lee (USGS) provided computer support for the conference.

The sponsoring organizations are thanked for support: South Dakota Department of Environment and Natural Resources, South Dakota Engineering Society, 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 and Dream Design, Inc. are thanked for sponsoring the reception for the evening social. The chairpersons for this conference were Kelli McCormick (South Dakota Department of Environment and Natural Resources), Joanne Noyes (South Dakota Department of Environment and Natural Resources), Jenifer Sorensen (South Dakota Engineering Society and Matrix Consulting Group, Inc.), 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), Daniel G. Driscoll (U.S. Geological Survey), and Van A. Lindquist (West Dakota Water Development District).

2011 WESTERN SOUTH DAKOTA HYDROLOGY CONFERENCE PROGRAM

**Thursday, April 28, 2011
Alpine/Ponderosa Rooms
Rushmore Plaza Civic Center**

7:00 – 8:00 a.m.	REGISTRATION	
8:00 – 9:10 a.m.	Plenary Session 1 in Alpine and Ponderosa Rooms – Overview of Select Research Studies (1.0 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 – 8:30 a.m.	Transient pressure analysis in core holes at the 4850-ft level at DUSEL	Larry Stetler , Hladysz Zbigniew , South Dakota School of Mines and Technology, Walter Weinig , and Roman Popielak , Golder Associates, Inc.
8:30 – 8:50 a.m.	Investigations of low-probability flood recurrence for the Black Hills of western South Dakota	Dan Driscoll , James O'Connor , Tessa Harden , U.S. Geological Survey, Matthew Bunkers , National Weather Service, Steve Sando , and Janet Carter , U.S. Geological Survey
8:50 – 9:10 a.m.	Overview of research activities on the geochemistry, geomorphology, and Quaternary history of alluvial sediment along the Lower Cheyenne and Belle Fourche Rivers, western South Dakota	John Stamm , U.S. Geological Survey, and Nicholas Geibel , U.S. Army Corps of Engineers
9:10 – 9:40 a.m.	REFRESHMENT BREAK in Rushmore F	
9:40 a.m. – 12:00 p.m.	Concurrent Session 2A in Alpine Room – Cheyenne River Studies (2.5 PDH) Moderator – Joanne Noyes , South Dakota Department of Environment and Natural Resources	Concurrent Session 2P in Ponderosa Room – Floods and Other Hazards (2.5 PDH) Moderator – Melissa Smith , National Weather Service
9:40 – 10:00 a.m.	<i>Biogeochemical factors controlling arsenic fate and transport within historical mining-impacted watersheds of western South Dakota – James Stone</i> , South Dakota School of Mines and Technology	<i>Perspectives obtained from examination of flood accounts for the Black Hills of western South Dakota – Janet Carter</i> and Dan Driscoll , U.S. Geological Survey
10:00 – 10:20 a.m.	<i>Concentrations of selected metals in alluvial deposits along the Lower Cheyenne and Middle Belle Fourche Rivers, western South Dakota – Galen Hoogestraat, John Stamm, Kathleen Neitzert, Barbara Rowe</i> , U.S. Geological Survey, and Nicholas Geibel , U.S. Army Corps of Engineers	<i>Flood-frequency analyses from paleoflood investigations for primary drainages in the east-central Black Hills of South Dakota – Tessa Harden, James O'Connor, and Dan Driscoll</i> , U.S. Geological Survey
10:20 – 10:40 a.m.	<i>Characterization of the alluvial sediment along the Lower Cheyenne and Belle Fourche Rivers in western South Dakota using direct-current electrical resistivity – Katrina Marini, Larry Putnam</i> , U.S. Geological Survey, and Nicholas Geibel , U.S. Army Corps of Engineers	<i>Regional perspectives from paleoflood investigations for primary drainages in the east-central Black Hills of South Dakota – Dan Driscoll, James O'Connor, and Tessa Harden</i> , U.S. Geological Survey
10:40 – 11:00 a.m.	<i>Arsenic speciation in sediment and pore waters of the historical mining-impacted Belle Fourche and Cheyenne River floodplains – Bryce Pfeifle, James Stone</i> , South Dakota School of Mines and Technology, John Stamm , U.S. Geological Survey, and Nicholas Geibel , U.S. Army Corps of Engineers	<i>Storm surge modeling in the Chesapeake Bay due to the probable maximum hurricane – Ahmed (Jemie) Dababneh</i> and Benjamin Ferguson , Paul C. Rizzo Associates, Inc.
11:00 – 11:20 a.m.	<i>A classification of alluvial landforms associated with mine tailings along the Belle Fourche River, western South Dakota – Jason Alexander, John Stamm, Brenda Woodward, and Paul Lamothe</i> , U.S. Geological Survey	<i>Rainfall estimates and hydrologic response for storm of July 29-30, 2010 in eastern South Dakota – Ryan Thompson</i> , U.S. Geological Survey, Michael Gillispie , National Weather Service, and Dan Driscoll , U.S. Geological Survey
11:20 – 11:40 a.m.	<i>Estimation of alluvial erosion and deposition rates at two temporal and spatial scales along the Belle Fourche River – Brenda Woodward, Jason Alexander, and James Howle</i> , U.S. Geological Survey	<i>Tsunami flooding due to a probable maximum earthquake in the Makran Subduction Zone – Ahmed (Jemie) Dababneh</i> and Paul Martinchich , Paul C. Rizzo Associates, Inc.

11:40 a.m. – 12:00 p.m.	<i>Geochronology of terrace deposits of the Belle Fourche and Cheyenne Rivers, western South Dakota, based on optically stimulated luminescence – Robert Hendricks, South Dakota School of Mines and Technology, John Stamm, Shannon Mahan, U.S. Geological Survey, and J. Foster Sawyer, South Dakota School of Mines and Technology</i>	<i>Probable maximum flood determination in an arid region on the south side of the Arabian Gulf – Paul Martinchich and Ahmed (Jemie) Dababneh, Paul C. Rizzo Associates, Inc.</i>
12:00– 1:30 p.m.	LUNCH with John T. Loucks Distinguished Lecture in Rushmore G Room – Dr. Victor Baker (1.0 PDH) University of Arizona Title: <i>Flood and Megaflood Paleohydrology</i>	
1:30 – 3:30 p.m.	Concurrent Session 3A in Alpine Room – Surface-Water Quality Issues (2.0 PDH) Moderator – Dr. Scott Kenner , South Dakota School of Mines and Technology	Concurrent Session 3P in Ponderosa Room – Remote Sensing and Climate (2.0 PDH) Moderator – Dr. Matthew Bunkers , National Weather Service
1:30 – 1:50 p.m.	<i>Water-quality standard suitability for Skunk Creek in eastern South Dakota using HSPF – Jason Lambert, RESPEC, and Scott Kenner, South Dakota School of Mines and Technology</i>	<i>Remote sensing for water quality monitoring and watershed assessment on the Lake Traverse Reservation – Jeppe Kjaersgaard, Mary O’Neill, Boras Shmagin, and James Sampson, South Dakota State University</i>
1:50 – 2:10 p.m.	<i>Development of acute and chronic temperature criterion for protection of cold-water fisheries in the Black Hills – Lacy Pomarleau, RESPEC, Scott Kenner, South Dakota School of Mines and Technology, and Cory Foreman, RESPEC</i>	<i>Simulating spatio-temporal water dynamics of landscape wetland complex for ecosystem services evaluation in Prairie Pothole Region, USA – Shengli Huang, Omar Abdul Aziz, Claudia Young, Devendra Dahal, Contractors to USGS EROS, and Shuguang Liu, USGS EROS</i>
2:10 – 2:30 p.m.	<i>Life-cycle assessment analysis of engineered stormwater control methods common to urban South Dakota watersheds – Tyler Hengen and James Stone, South Dakota School of Mines and Technology</i>	<i>A hydrological perspective for site suitability of biofuels production using satellite images – Ramesh Singh, Contractor to USGS EROS, Shuguang Liu, and Larry Tieszen, USGS EROS</i>
2:30 – 2:50 p.m.	<i>Monitoring stormwater quality in two drainage basins in Rapid City, South Dakota – Emily Fisher, Keri Schiferl, South Dakota School of Mines and Technology, Galen Hoogstraat, U.S. Geological Survey, and Scott Kenner, South Dakota School of Mines and Technology</i>	<i>Interpolating evapotranspiration estimates between satellite overpass dates – Jeppe Kjaersgaard, South Dakota State University, Richard Allen, and Ricardo Trezza, University of Idaho</i>
2:50 – 3:10 p.m.	<i>Spring Creek watershed implementation project – Brittney Molitor, Pennington County, Jared Oswald, and Justin Krajewski, RESPEC</i>	<i>Examination of the Missouri River water temperature record for evidence of change – Mark Anderson and Jeremy Warner, U.S. Geological Survey</i>
3:10 – 3:30 p.m.	<i>Water quality monitoring and hydraulic modeling for the Spring Creek watershed – Thomas Schmitz, Peter Rausch, and Scott Kenner, South Dakota School of Mines and Technology</i>	<i>Radar criteria indicating the presence of hail in High Plains thunderstorms – Shawn Honomichl and Andrew Detwiler, South Dakota School of Mines and Technology</i>
3:30 – 4:00 p.m.	REFRESHMENT BREAK in Rushmore F	
4:00 – 5:20 p.m.	Concurrent Session 4A in Alpine Room – Mining Issues (1.5 PDH) Moderator – Dr. Jenifer Sorensen , Matrix Consulting Group, Inc.	Concurrent Session 4P in Ponderosa Room – Ground-Water Issues (1.5 PDH) Moderator – Dr. Foster Sawyer , South Dakota School of Mines and Technology
4:00 – 4:20 p.m.	<i>A comparison of water usage for mineral and agricultural development for the Dewey-Burdock area – Mark Hollenbeck, Powertech</i>	<i>Sickness caused by onsite wastewater systems in the Black Hills – Perry Rahn, South Dakota School of Mines and Technology</i>
4:20 – 4:40 p.m.	<i>Removal of heavy metals from mine water with a limestone-based method – Arden Davis, David Dixon, South Dakota School of Mines and Technology, Cathleen Webb, Western Kentucky University, and Haile Betermariam, South Dakota School of Mines and Technology,</i>	<i>Groundwater mixing and flow characterization using hydrochemical data: Wind Cave and southern Black Hills – Andrew Long, Joshua Valder, U.S. Geological Survey, and Mark Ohms, National Park Service</i>
4:40 – 5:00 p.m.	<i>Reconnaissance investigation of bottom sediment metals and radionuclide concentrations within Black Hills region lakes and impoundments – Rohit Sharma, James Stone, Michelle Kelley, Aaron Oswald, and Christopher Lupo, South Dakota School of Mines and Technology</i>	<i>Estimating recharge to the High Plains aquifer in South Dakota using a soil-water balance approach – Anneka LaBelle, Kyle Davis, South Dakota School of Mines and Technology, Larry Putnam, U.S. Geological Survey, and Thomas Fontaine, South Dakota School of Mines and Technology</i>
5:00 – 5:20 p.m.	<i>To Bloom or Not to Bloom – P.V. Sundareshwar, South Dakota School of Mines and Technology, and Tom Durkin, NASA South Dakota Space Grant Consortium</i>	<i>Microgravity methods to investigate groundwater storage and specific yield in the Madison and Minnelusa aquifers – Karl Koth, South Dakota School of Mines and Technology, and Andrew Long, U.S. Geological Survey</i>

5:30 – 7:00 p.m.	POSTER SESSION AND EVENING SOCIAL in Rushmore F	
	Black Hills Aquifer Atlas: Compilation of 1:24,000-scale Maps in a GIS Format	Alvis Lisenbee, Arden Davis, Maribeth Price, and Deborah Brewer , South Dakota School of Mines and Technology
	Characterization of Fe and S mineral phases associated with uraninite oxidation	Rajneesh Jaswal, Gursharan Singh, Emily Squillace , South Dakota School of Mines and Technology, Ravi Kukkadapu , Pacific Northwest National Laboratory, Brandy Stewart , Montana State University, S. Sevnic Sengor , University of California, Davis, Brent Peyton , Montana State University, Nicolas Spycher , Lawrence Berkley National Laboratory, Timothy Ginn , University of California, Davis, and Rajesh Sani , South Dakota School of Mines and Technology
	Monitoring bank erosion on the Missouri River on the Lower Brule Reservation	Kathleen Neitzert , U.S. Geological Survey, George Honeywell , Environmental Protection Office, Lower Brule Sioux Tribe, and Ryan Thompson , U.S. Geological Survey
	Monitoring bank erosion on the Missouri River on the Lower Brule Reservation with ground-based Light Detection and Ranging (LiDAR)	Ryan Thompson , U.S. Geological Survey, James Sanovia , Calvin Cutchall , Oglala Lakota College, Kathleen Neitzert , U.S. Geological Survey, George Honeywell , Environmental Protection Office, Lower Brule Sioux Tribe, and Charles Jason Tinant , Oglala Lakota College
	Geothermal resources of western South Dakota	Kelli McCormick , South Dakota Department of Environment and Natural Resources
	3-D Geologic modeling of an in situ uranium project in South Dakota	Crystal Hocking , RESPEC, and Matt Minnick , Colorado School of Mines
	Moving towards a technical specification for fluorescence excitation-emission mapping and absorbance analysis of colored dissolved organic matter	Michael Oweimrin and Adam Gilmore , HORIBA Jobin Yvon, Inc.
	Mat level hydrodynamic processes and distribution of <i>Didymosphenia geminata</i> blooms in Rapid Creek watershed, South Dakota	Mebratu Abessa , PV Sundareshwar , Scott Kenner , Andrew Detwiler , and Sikchiya Upadhayay , South Dakota School of Mines and Technology
	Analysis of bottom sediments for metal and radionuclide concentrations within Black Hills reservoirs	Michelle Kelley , James Stone , Rohit Sharma , Aaron Oswald , and Christopher Lupo , South Dakota School of Mines and Technology
	Effects of land management change on water quantity and quality in the James River Basin	Yiping Wu , Contractor to USGS EROS, and Shuguang Liu , USGS EROS

THURSDAY, APRIL 28, 2011
SESSION 1
8:00 – 9:10 A.M.

OVERVIEW OF SELECT RESEARCH STUDIES
(ALPINE/PONDEROSA ROOMS)

Transient Pressure Analysis in Core Holes at the 4850-ft Level at DUSEL

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Core holes drilled on the 4850-ft level of the DUSEL facility yielded comprehensive 3-D data including bedding orientation, fracture orientation, spacing, and aperture data, stress and strain data, and provided valuable insight into hydrology. 5,400 feet of core were collected from nine holes into Precambrian Yates amphibolites and Tertiary rhyolite dikes in the area where large cavities and laboratory modules are scheduled for construction. Several of the holes produced water flowing at low rates and yielding pressure and chemical data. Flow rates remaining below 0.25 gpm were monitored for up to 280 days and in all cases exhibited reductions in flow rate up to -60%. Wellheads were closed in June 2010 and pressure transients have been periodically recorded. Preliminary data were analyzed using the Horner time function. Six of the nine holes have demonstrated pressure increases ranging from 50 to 1000 psi. Pressure extrapolations indicate that maximum reservoir pressure should be expected to reach 1250 psi, equivalent to a water head extending to the 2000-ft level below grade. Macroscopic hydrologic properties based on computer simulations utilizing collected and modeled data indicate stress-dependent variations through three orders of magnitude in the upper few thousand feet. Below ~3000 feet, these properties were relatively uniform. Hydraulic conductivity variations were consistent with development of shallow and deep hydrologic systems. Flow through these systems varied also as functions of fracture properties, notably aperture. These results indicate wide latitude for flow rate, time, and source area yielding potential variations in water age and chemistry.

Investigations of Low-Probability Flood Recurrence for the Black Hills of Western South Dakota

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The Black Hills region has a history of exceptional flooding like that of June 9-10, 1972, when 238 people perished in the Rapid City and Keystone areas. Substantial progress has been made towards characterization of flood recurrence; however, continued research is needed to achieve thorough characterization for low-probability flooding.

A regional mixed-population approach was developed as part of a statewide flood-frequency analysis (see <http://pubs.usgs.gov/sir/2008/5104/>). This approach leverages a regional high-outlier population for estimating low-probability flood magnitudes (approximately 50- to 500-year recurrence intervals) while effectively fitting the log-Pearson Type III frequency distribution to more moderate values (ordinary-peaks population) in an annual flood series.

The National Weather Service collaborated with U.S. Geological Survey (USGS) in examining climatological factors affecting generation of heavy rain-producing thunderstorms, which are the primary drivers of extreme flooding in the Black Hills (see <http://pubs.usgs.gov/sir/2010/5187/>). Results indicate that maximum potential for heavy rain-producing thunderstorms is around the northeastern-southeastern periphery of the Black Hills. Flooding can be further intensified by the topography in this area, which includes steep slopes and narrow canyons with minimal potential for attenuation of flood flows. Examination of numerous historical flood accounts (see also <http://sd.water.usgs.gov/projects/FloodHistory/floodhistory.html>) provided a useful context and helped support the aforementioned results.

In 2008, the USGS began a paleoflood study involving four primary drainages (Spring, Rapid, Boxelder, and Elk Creeks) in cooperation with various Federal, State, and local agencies. Chronologies of multiple large flood events were developed using stratigraphic analysis of flood slack-water deposits, geochronology (primarily radiocarbon dating of entrained organic matter) and hydraulic analyses. Results indicate that over the last 2,000 years multiple floods with flows approaching or substantially exceeding 1972-scale floods have occurred in all four drainage basins. Future application of these results with a regional mixed-population approach may help improve flood-frequency characterization for rare events.

Overview of Research Activities on the Geochemistry, Geomorphology, and Quaternary History of Alluvial Sediment Along the Lower Cheyenne and Belle Fourche Rivers, Western South Dakota

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The Water Resource Development Act of 1999, which was amended in 2000, mandated a study of sediment contamination within the Cheyenne River watershed in western South Dakota. The headwaters of the Cheyenne River include the Black Hills, which has a history of gold mining and ore-milling operations since the discovery of placer gold by the Custer Expedition in 1874. The gold extraction process utilized mercury and cyanide compounds, and produced tailings that contained cadmium, arsenic, and selenium, among other metals. Mine tailings were discharged into Whitewood Creek in the Black Hills. Whitewood Creek drains to the Belle Fourche River, which is a tributary to the lower Cheyenne River. In 1981, an 18-mile stretch of Whitewood Creek was proposed as a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), or “Superfund,” site. Studies by the U.S. Geological Survey (USGS) in the 1980s indicated that arsenic concentrations were substantially elevated in alluvial sediment within the floodplain of Whitewood Creek, and continuing downstream to the Belle Fourche and lower Cheyenne Rivers.

In response to the Water Resources Development Act, the U.S. Army Corps of Engineers requested that the USGS perform field surveys and sampling of alluvial sediment along the lower Cheyenne and Belle Fourche Rivers. USGS research activities in 2009 included sampling of terrace deposits to estimate “background” or “uncontaminated” concentrations of metals in alluvial sediment. USGS research activities in 2010 included surveys and sampling within the active channel and floodplain (“potentially contaminated” sediments) at selected sites along the Cheyenne and Belle Fourche Rivers. Studies included sampling and geochemical analysis of floodplain sediment, geophysical resistivity surveys, geochemistry of water samples in saturated alluvial sediment, geomorphic mapping and dendrochronologic studies of floodplain and terrace deposits, Light Detection And Ranging (LiDAR) surveys of banks to determine bank erosion rates, and estimates of channel incision rates during the late Quaternary. A goal of the 2010 study was to place geochemical data into a geomorphic framework, one in which the extent and distribution of contaminated sediment could be related to river process and history. This presentation provides an overview of these studies, which are discussed in detail in associated talks at the 2011 Western South Dakota Hydrology Conference.

THURSDAY, APRIL 28, 2011
SESSION 2A
9:40 A.M. – 12:00 P.M.

CHEYENNE RIVER STUDIES
(ALPINE ROOM)

Biogeochemical Factors Controlling Arsenic Fate and Transport within Historical Mining-Impacted Watersheds of Western South Dakota

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Elevated sediment arsenic (As) exists within many historical mining-impacted watersheds of western South Dakota. In particular, my research group has investigated As fate and transport phenomena within two mining-impacted watersheds: the Cave Hills region of Harding County impacted by historical uranium mining activities; and the Whitewood Creek/Belle Fourche/Cheyenne River fluvial system impacted by Lead-area historical mining activities. Once arsenic is released to surface waters, the combination of intermittent fluvial processes and biogeochemical interactions largely control its fate and transport. Tri-valent arsenite (H_3AsO_3) dominates under reducing conditions, while penta-valent arsenate (H_2AsO_4^- and HAsO_4^{2-}) is thermodynamically stable under oxidized conditions. Sorption of both arsenite and arsenate to iron (hydr)oxides is highly dependent upon pH, competition from other anions for sorption sites, and solute concentrations. Enzymatic reductive dissolution of iron (hydr)oxides is recognized as a major re-mobilization mechanism for adsorbed As, and appears dependent upon the presence and activities of metal reducing bacteria (MRB), accessibility of organic carbon substrate [either as a source of metabolic energy (electron donor) or complexing agent], and the amount and availability of reactive iron. Field observations at our study sites suggest that As mobility within anoxic environments appear linked to iron and sulfur cycling at sediment redox boundaries. Seasonal shifts in sediment redox conditions due to changes in soil temperature, iron and oxygen availability, and flooding conditions appear to promote or hinder the ability of MRB sulfide production, shifting the iron/sulfide ion balance, and affecting aqueous As mobility within regional mining-impacted alluvial sediments.

Concentrations of Selected Metals in Alluvial Deposits along the Lower Cheyenne and Middle Belle Fourche Rivers, Western South Dakota

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The Water Resources Development Act of 2000 mandated a study of sediment contamination within the Cheyenne River watershed in western South Dakota. In response, the U.S. Geological Survey (USGS), in cooperation with the U.S. Army Corps of Engineers, conducted field research and sampling of alluvial sediment in 2009–10. The headwaters of the Cheyenne River watershed include the Black Hills, which historically have been influenced by gold mining and milling operations since the discovery of gold by the Custer Expedition in 1874. The gold-extraction process at times utilized mercury and cyanide compounds, and tailings that contained high concentrations of arsenic, cadmium, and selenium, among other metals, were released into the streams. Previous studies indicated that arsenic concentrations are of particular concern.

USGS surveys in 2009 provided estimates of “background” or “uncontaminated” concentrations expected for alluvial sediment deposited by the Cheyenne and Belle Fourche Rivers by sampling the sediments of Quaternary terraces above the modern floodplains. The 2009 sediment samples were analyzed for a suite of 23 metals including arsenic and mercury. A maximum arsenic concentration of 34 parts per million (ppm) was observed in the uncontaminated samples; concentrations of mercury generally were less than laboratory reporting levels of approximately 34 parts per billion (ppb).

USGS surveys in 2010 included an investigation of the chemical composition of sediment from the active channel and floodplain (including sediments potentially “contaminated” by tailings). Samples were collected at and near the surface along multiple transects of the floodplain at selected sites, from vertical cores of floodplain sediment, and from bank exposures. Similar to the 2009 surveys, sediment samples were analyzed for 23 metals. Samples collected in alluvial sediment along the Belle Fourche River had concentrations of arsenic as high as 4,200 ppm (median of 300 ppm) and concentrations of mercury as high as 3,000 ppb (median of 160 ppb). Concentrations in the Cheyenne River floodplain farther downstream were lower, but were as high as 500 ppm for arsenic (median of 63 ppm) and 270 ppb for mercury (median of 64 ppb), both much higher than the maximum concentrations observed in uncontaminated sediments.

Characterization of the Alluvial Sediment along the Lower Cheyenne and Belle Fourche Rivers in Western South Dakota Using Direct-Current Electrical Resistivity

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Geophysical surveys at selected sites along the Belle Fourche and Cheyenne Rivers were conducted by the U.S. Geological Survey (USGS) in cooperation with the U.S. Army Corps of Engineers, Omaha District, in 2010 to characterize the alluvial sediments. The geophysical surveys were part of a study to analyze potential mine-tailing contamination in flood-plain deposits. Direct-current electrical resistivity surveys were made by the USGS along selected transects at one site on the Belle Fourche River and one site on the Cheyenne River to characterize the lateral extent and nature of alluvial sediments. An Advanced Geosciences Incorporated Super Sting R8 System¹ with 56 pins was used to make a series of electrical resistivity measurements. Eight transects were surveyed ranging from 100 to 3,000 feet in length. The data was processed with RES2DINV inversion software¹ to create an apparent resistivity profile of the subsurface. In general, saturated sand and gravel deposits will have higher resistivity than clay or shale.

Higher resistivity values were observed in the alluvial sediments at the Belle Fourche site than at the Cheyenne River site. The Cretaceous-age Pierre Shale, the underlying bedrock at both sites, had a very low resistivity (less than 15 ohm-meters) that could be distinguished from the more resistive overlying alluvial sediments. The thickness of the alluvial sediments ranged from about 1 to 15 feet in the flood plain. A transect across a meander that included terrace deposits had a maximum sediment thickness of about 45 feet overlying the Pierre Shale. A transect near the Belle Fourche River had a 3-foot sediment layer that had lower resistivity than the surrounding alluvial deposits. This sediment layer corresponded to a layer of iron-oxide rich tailings that were visible in the bank.

¹The use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Arsenic Speciation in Sediment and Pore Waters of the Historical Mining-Impacted Belle Fourche and Cheyenne River Floodplains

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Mineral extraction and waste disposal conducted in and near the town of Lead in western South Dakota, directly discharged spent gold mine tailings into Whitewood Creek from 1876 until 1977. Physical and chemical processes have resulted in substantial transport and deposition of arsenic-enriched materials within Whitewood Creek, the Belle Fourche and Cheyenne Rivers, and Lake Oahe (post 1958). Previous research has shown that historical sediment arsenic concentrations within the impacted floodplains range from greater than 10,000 micrograms per gram ($\mu\text{g/g}$) near the mouth of Whitewood Creek to greater than 400 $\mu\text{g/g}$ in the Cheyenne River near Lake Oahe. Geochemical arsenic interactions within sediment and pore waters were investigated to determine physical, chemical, and biological processes that may influence arsenic transport from active floodplain sediments. Sediment pore-water dialysis chambers (peepers) were deployed near the Belle Fourche and Cheyenne Rivers during a 2-week sampling period and their contents were analyzed for select trace element concentration to determine temporal and seasonal influences associated with sediment redox geochemistry. In parallel, sediment cores were collected adjacent to the peepers and analyzed for mineralogy, trace element concentration, redox characteristics associated with trace element binding affinities, and aerobic and anaerobic microbial substrate utilization efficiencies. At the Belle Fourche sampling site, sediment pore-water arsenic concentrations exceeded 2,500 micrograms per liter ($\mu\text{g/L}$), whereas the associated sediment arsenic concentrations ($\leq 1,010$ $\mu\text{g/g}$) and minimal microbial substrate utilization profiles suggest elevated pore-water arsenic exists due to abiotic geochemical processes. Pore-water arsenic concentrations were lower at the Cheyenne River site (350 $\mu\text{g/L}$) compared to the Belle Fourche River site. However, elevated microbial activities were observed indicating that, under the specific biogeochemical conditions, microbial-mediated arsenic dissolution processes were effective, even under low sediment arsenic concentrations (≤ 130 $\mu\text{g/g}$). This presentation will summarize the key research findings from on-going field work and laboratory analyses within the mining-impacted Belle Fourche and Cheyenne River alluvial systems.

A Classification of Alluvial Landforms Associated with Mine Tailings along the Belle Fourche River, Western South Dakota

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From the late 19th century until 1977 the Belle Fourche River received large volumes of milled tailings from gold mining operations near Lead, South Dakota. Previous research has indicated that these legacy tailings were enriched with arsenic, and substantial proportions were deposited along the river bottom and remain in storage within floodplain and terrace deposits along the valley bottom. These deposits represent a potential ongoing human health risk because the tailings in storage may be remobilized when the banks of the river are eroded from natural river planform adjustments. Estimation of the total mass of the tailings remaining in storage is difficult because the reach of the Belle Fourche River affected is approximately 190 kilometers long. Downstream of the Belle Fourche, approximately 160 kilometers of the lower Cheyenne River are also affected by the same mine tailings and arsenic-enriched sediments ultimately discharge into Lake Oahe, a reservoir on the Missouri River. In cooperation with the U.S. Army Corps of Engineers, we devised a method to classify alluvial landforms likely to contain arsenic-enriched sediments along a study area spanning the reach of the Belle Fourche River from Whitewood Creek to the Cheyenne River. Topographic, hydrologic, dendrochronologic, geochemical, and stratigraphic data are used to characterize and map alluvial deposits within the modern alluvial bottom. This method can be used as a tool for field-based and remotely-sensed investigations to rapidly identify deposits in the river bottomland that are likely to be enriched with arsenic, and, where field calibration data exists, to determine the possible magnitude of the enrichment. Additionally, this classification method could be extended to the lower Cheyenne River with additional input data.

Estimation of Alluvial Erosion and Deposition Rates at Two Temporal and Spatial Scales along the Belle Fourche River, South Dakota

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For nearly a century, the Belle Fourche River received large volumes of raw milled tailings from mining operations near Lead, South Dakota. The flow of mill tailings ceased in 1977 when a catchment was completed to impound the tailings. Previous research has indicated that substantial proportions of these legacy tailings were stored in the floodplains and terraces adjacent to the river. To understand the nature and magnitude of the ongoing risk associated with legacy mine tailings, the USGS, in cooperation with the U.S. Army Corps of Engineers, estimated alluvial erosion and deposition rates at two temporal and spatial scales along five reaches of the Belle Fourche River between Whitewood Creek and the Cheyenne River. At the reach scale, geomorphic maps of arsenic-enriched alluvial deposits were created by investigating the stratigraphy, sedimentology, and geochemistry of sediments in bank exposures of floodplains and terraces. The geomorphic maps were digitized into a GIS and used to construct time-series of deposition and erosion rates along each reach from 1938 to 2010. At the scale of individual banks and bars, ground-based LiDAR scans were taken before and after the spring high flow to estimate annual-scale rates of erosion and deposition. Our data indicate that substantial volumes of sediment may be eroded in individual years, substantial volumes of sediment can be deposited within a year, and the majority of the arsenic-enriched deposits that were present in 1977 remain in storage.

GEOCHRONOLOGY OF TERRACE DEPOSITS OF THE BELLE FOURCHE AND CHEYENNE RIVERS, WESTERN SOUTH DAKOTA, BASED ON OPTICALLY STIMULATED LUMINESCENCE

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Numerous studies have explored the Quaternary history of the rivers that drain the Black Hills of western South Dakota in an effort to relate terrace ages to Quaternary events such as isostatic uplift, climate change, and stream capture. The capture of the ancient headwaters of the Little Missouri River by the Belle Fourche River, a tributary of the Cheyenne River, may be of particular importance. This event increased the Cheyenne River watershed area by nearly 20 percent. Optically stimulated luminescence (OSL) dating of Quaternary terrace sediments along the Cheyenne and Belle Fourche Rivers was used to more accurately resolve the chronology of terraces in the watershed and better understand the history of this fluvial system, including the capture of the ancient headwaters of the Little Missouri River. Four terraces currently are recognized along streams draining the northern Black Hills. From oldest to youngest these are named Mountain Meadow, Rapid, Sturgis, and Farmingdale terraces. Five sites on Farmingdale terraces on the Belle Fourche and Cheyenne Rivers have yielded OSL dates ranging from 7.9 thousand years ago (ka) to 15.3 ka. These five terrace sites progressively rise in the downstream direction from 26 to 85 meters above the modern channel. These data indicate rapid incision rates of 2.0 to 9.7 meters per 1,000 years in the Holocene. OSL dates at a Sturgis terrace site indicate that it was deposited between 56.8 ka and 32.3 ka. Further upstream, the surface that was abandoned as a result of the capture of the Little Missouri River by the Belle Fourche River has sediment as young as approximately 30 ka indicating that the capture of the upper Little Missouri River occurred after deposition of the Sturgis terrace and before deposition of the Farmingdale terrace. This event may be responsible for the vigorous incision rates currently observed in the lower Cheyenne River system. Future research will include additional sampling and more detailed analyses of OSL data to provide a more complete chronology of terraces in the northern Black Hills.

THURSDAY, APRIL 28, 2011
SESSION 2P
9:40 A.M. – 12:00 P.M.

FLOODS AND OTHER HAZARDS
(PONDEROSA ROOM)

Perspectives Obtained from Examination of Flood Accounts for the Black Hills of Western South Dakota

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The Black Hills area of western South Dakota has a history of exceptional floods like the catastrophic flooding of June 9-10, 1972, in which at least 238 people perished in the Rapid City and Keystone areas. A rich chronology of historical flood accounts dating back to 1877 recently was compiled by the U.S. Geological Survey (USGS) and provides many useful perspectives regarding the recurrence of low-probability floods in the area. The historical accounts have been especially useful in providing a context for other for recent large-scale flood events, as described in a recently published USGS report titled "Thunderstorms and flooding of August 17, 2007, with a context provided by a history of other large storm and flood events in the Black Hills area of South Dakota." This report is available at <http://pubs.usgs.gov/sir/2010/5187/>, and the companion flood chronology is available at <http://sd.water.usgs.gov/projects/FloodHistory/floodhistory.html>.

The earliest documented loss of life occurred in 1878 along Beaver Creek (near Buffalo Gap) where 11 deaths occurred when a wagon camp was demolished by flash flooding. Details are sketchy regarding a rise of 25 feet that was reported for "confined places" along the Redwater River in 1882; however, the account also alludes to transport of "rocks weighing hundreds of pounds" that indicates the possibility of an exceptional flood. "Benchmark" flooding occurred in May of 1883, with extremely high flows reported throughout the northern and central Black Hills area that resulted from heavy rainfall on top of snowmelt. Damage was especially severe in Deadwood, and substantial flooding was reported at many other locations throughout the Black Hills.

The year 1907 was especially noteworthy, with wet antecedent conditions and widespread flooding through at least the end of May, which may have exacerbated severe and large-scale flooding that developed from an exceptional thunderstorm on June 12. Flooding was especially severe in Deadwood and Piedmont, and a peak flow of 16,000 cubic feet per second (ft³/s) occurred along Boxelder Creek near Nemo.

The Fall River near Hot Springs has one of the most robust flood histories in the area. Large flows were recorded on September 4, 1938, for streamgages along the Fall River (13,100 ft³/s) and Beaver Creek (11,700 ft³/s), which in combination with reported heavy flooding for Lame Johnny Creek, provide an indication of a storm system that produced some of the most substantial flooding for which peak-flow records are available. Historical accounts indicate comparable flooding during 1937 in Hot Springs, and these two events, along with several other floods, were instrumental in driving subsequent construction of two flood control dams upstream from the town. Design documents for the dams provide accounts of an 1884 flood with a stage that exceeded that of 1937 by 7 feet. The presentation will provide an overview of some of the most noteworthy accounts such as these.

Flood-Frequency Analyses from Paleoflood Investigations for Primary Drainages in the East-Central Black Hills of South Dakota

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The Black Hills region has a history of catastrophic flash flooding like that of June 9-10, 1972, when 238 people perished in the Rapid City and Keystone areas. Annual peak-flow maxima resulting from this storm were recorded for 24 streamgages along the east-central Black Hills. Eleven of these maxima still remain as record flows and many are about an order of magnitude larger than the next largest peaks in the systematic peak-flow records. Peak-flow characterization is confounded by the overwhelming abundance of these exceptional high outliers in the short-term data sets.

In 2008, the U.S. Geological Survey initiated a paleoflood study involving four primary drainages (Boxelder, Elk, Rapid and Spring Creeks) in cooperation with various Federal, State, and local agencies. The objective of this study is to achieve improvement regarding regional low-probability flood characterization. This study has relied primarily on stratigraphic analysis of flood slack-water deposits, geochronology, and hydraulic analyses to develop chronologies of multiple large floods within the last 1,000 to 2,000 years. Robust chronologies of numerous floods approaching or exceeding 1972-scale flooding were documented for all four streams.

Several statistical approaches were used for flood-frequency analyses; however, approaches for incorporation of paleoflood datasets are not necessarily well refined. For all of the approaches used, the 95-percent confidence limits for relatively large recurrence intervals (low-probability floods) were substantially reduced by incorporating paleoflood data into the analyses. An overview of primary results will be presented.

Regional Perspectives from Paleoflood Investigations for Primary Drainages in the East-Central Black Hills of South Dakota

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In 2008, the U.S. Geological Survey initiated a paleoflood study involving four primary drainages along the east-central Black Hills (Boxelder, Elk, Rapid, and Spring Creeks) in cooperation with several Federal, State, and local agencies. Peak-flow data from systematic streamflow records were supplemented with stratigraphic evidence of especially large floods over approximately the last 2,000 years, thereby substantially expanding the record of rare floods and allowing for much more confident prediction of the frequency and magnitude of low-probability floods. This presentation will provide regional perspectives derived from collective examination of results for all four drainages.

Evidence for the highest concentration of exceptionally large floods was found in the Elk Creek study reach, which has a drainage area of 40 square miles (mi^2). A single site provided stratigraphic evidence of four floods exceeding 75,000 cubic feet per second (ft^3/s) and a fifth flood of at least 51,000 ft^3/s within the last 2,000 years; however, no sites were found where chronologies of more moderate flooding could be obtained. Two sub-reaches along Boxelder Creek (areas of 98 and 112 mi^2) provided comparable chronologies of somewhat smaller but more frequent flooding than for Elk Creek. Differences in chronologies between Elk and Boxelder Creek may derive primarily from availability of paleoflood evidence (or lack thereof) as opposed to actual flood-flow characteristics. Resulting flood-frequency analyses for all three reaches are similar, however, after normalizing relative to drainage area raised to the 0.6 power. Normalized results also indicate substantially larger flood susceptibility for both drainages than for Spring Creek (171 mi^2), which probably owes to differences in climatology and basin morphometry.

A primary issue for applying the results of paleoflood investigations along Rapid Creek is that 321 mi^2 of the 376 mi^2 drainage area for a downstream study reach (near Rapid City) is regulated by Pactola Dam. Paleoflood investigations for an upstream reach (292 mi^2), however, indicate a chronology of flooding that is much less robust (less frequent and much smaller floods) than for the downstream reach. Normalized results for lower Rapid Creek, relative to the intervening drainage area of 84 mi^2 between the two reaches, are comparable with those for Elk and Boxelder Creek and may provide a viable approach for applying results for the regulated reach downstream from Pactola Dam.

Storm Surge Modeling in the Chesapeake Bay due to the Probable Maximum Hurricane

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The characteristics of the Probable Maximum Hurricane (PMH) were developed for a critical hurricane track affecting the Chesapeake Bay. The Probable Maximum Storm Surge (PMSS) due to the PMH at a typical location in the Chesapeake Bay was modeled using the industry standard software, and results were compared to results using an empirical method. The characteristics of the PMH, including wind speed, forward speed, and central pressure were developed using guidance from the National Oceanic and Atmospheric Administration (NOAA) and the International Institute for Infrastructural Hydraulic and Environmental Engineering (IHE). The track and parameters of the PMH were used as inputs into the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) software developed by NOAA. Antecedent water conditions were also evaluated. Together with the storm surge height predicted by SLOSH, a PMSS height was determined.

For comparison to the SLOSH results, the PMSS at the location of interest was calculated using an empirical method. This method was developed by the United States Army Corps of Engineers (USACE) in 1959 specifically for the Chesapeake Bay and is based on major hurricanes prior to 1959, especially the hurricane of 1933.

The peak PMSS water surface elevation modeled by the SLOSH software was 17.5 feet (ft) NGVD-29, which is 13.1 ft above the antecedent water level and takes into account the 20% accuracy of the SLOSH software. This was lower than the PMSS elevation of 20.4 ft NGVD-29 predicted by the empirical method.

Rainfall Estimates and Hydrologic Response for Storm of July 29-30, 2010, in Eastern South Dakota

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Exceptionally heavy rainfall occurred in eastern South Dakota on the night of July 29 through the early morning of July 30, 2010. The storm duration was about 6 hours and rainfall totals of about 5 to 11 inches occurred over an area of about 400 square miles in extreme southeastern Hand County and extreme southwestern Beadle County, extending southeastward through much of Jerauld County and into Sanborn County. These totals largely exceed estimated 6-hour storm totals (from the Rainfall Frequency Atlas of the United States) of about 4 inches for a 100-year recurrence interval. Similarly, rainfall totals in some areas largely exceed the estimated 24-hour storm total of about 5.5 inches for a 100-year recurrence interval.

Some of the heaviest rainfall occurred along the relatively steep eastern flanks of the Wessington Hills and the heaviest runoff was generated in areas of steepest topography such as within the drainage area for Rose Hill Dam, which failed on the night of July 29. Determinations of peak flow were made for various locations in the storm vicinity. The largest peak flow determined was 12,500 cubic feet per second (ft^3/s) along Sand Creek upstream from Rose Hill Dam. A smaller peak flow of 7,900 ft^3/s was determined for discontinued streamgage 06476500, Sand Creek near Alpena, which is located about 20 miles southeast (downstream) from Rose Hill Dam. The annual peak-flow record for streamgage 06476500 dates back to 1950 and the 2010 peak exceeded the previous largest peak (2,240 ft^3/s in 1960) by a factor of about three and one-half. Another record-breaking peak flow of 7,280 ft^3/s was recorded on July 31 at streamgage 06477500, Firesteel Creek near Mount Vernon. This peak is about 10 percent larger than the previous largest peak, for a peak-flow record that dates back to 1956.

Tsunami Flooding Due to a Probable Maximum Earthquake in the Makran Subduction Zone

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The characteristics of the Probable Maximum Tsunami (PMT) generated by the Probable Maximum Earthquake (PME) at the Makran Subduction Zone (MSZ) where a historic tsunami originated in 1945 was evaluated. The wave run-up/down resulting from the PMT was computed at a typical location in the south central portion of the Arabian Gulf. Seven earthquake scenarios were developed to identify the characteristics of the PME. A separate Seismic Hazard Analysis was conducted to determine the magnitude of the PME. The seven earthquake scenarios were first examined using the European Commission Tsunami model (ECJRC) to determine tsunami scenarios that could impact the site. Later on, Delft3D-FLOW was utilized to compute the wave height near the site.

A sensitivity analysis was conducted on the following parameters: bathymetry, tide factor, layout of the site, and modeling techniques. The total high PMT was computed to be 4.8 meters (m) above Mean Sea Level (MSL) while the total low PMT was computed to be -4.3 m MSL.

Probable Maximum Flood Determination in an Arid Region on the South Side of the Arabian Gulf

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The probable maximum flood study was performed for an area on the south central side of the Arabian Gulf. The study presented unique challenges: the area is very arid; rainfall data records go back only 20 to 50 years; there is rarely any observed surface runoff; there are no distinct drainage conveyances, thus no recorded runoff data; and there are no prescribed methods for determining the probable maximum flood for the area. Due to a lack of prescribed methodologies to determine the probable maximum precipitation, a statistical analysis was performed to estimate an extreme (1×10^{-6} return frequency interval) precipitation event from available data for several rainfall gages in the area. Also, methods published by the World Meteorological Organization (WMO) were used to estimate precipitation, and the results were compared to the area-specific study results and the frequency analysis.

The basin drainage is composed of several distinct regions with very different hydrologic response characteristics (infiltration, runoff, and transmission). The distinct regions included: coastal areas; sabkhas (or dry lakebeds); sandy areas, both developed and undeveloped; and deep sand dune areas. Data from double-ring infiltration tests were used to determine infiltration characteristics, and methods were developed to account for surface storage in rolling, undulating areas, both within sabkhas and dune-like areas. A runoff model was created using the United States Army Corps of Engineers (USACE) HEC-HMS software. A surface flow model was created using the USACE HEC-RAS software to determine water levels near the area. The water level of the Gulf, including tidal rise and coincidental surges, formed the downstream boundary of the HEC-RAS surface flow model.

THURSDAY, APRIL 28, 2011
LUNCHEON
12:00– 1:30 P.M.

JOHN T. LOUCKS DISTINGUISHED LECTURE
FLOOD AND MEGAFLOOD PALEOHYDROLOGY
(RUSHMORE G ROOM)

THURSDAY, APRIL 28, 2011

SESSION 3A

1:30 – 3:30 P.M.

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

Water-Quality Standard Suitability for Skunk Creek in Eastern South Dakota using HSPF

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Skunk Creek has less stringent bacteria water-quality standards than the downstream receiving water body, the Big Sioux River. In this research hydrologic and pathogenic watershed models were developed to evaluate the influence of approved beneficial use criteria for Skunk Creek on the attainability of beneficial use criteria for the Big Sioux River. Simulation scenarios were used to represent the influence of Skunk Creek on the water quality of the Big Sioux River. Model results indicate that Skunk Creek contributes nearly half of the bacterial load to the Big Sioux River – specifically, TMDL Reach 10 through the city of Sioux Falls – and remains a significant contributor in TMDL Reaches 11 and 12 east of the city as well. The hydrologic and pathogenic models were used as tools to simulate management scenarios, primarily focused on attainment of beneficial uses in TMDL Reach 10. In TMDL Reach 10, simulation scenarios predict a 60% reduction in the frequency of concentrations exceeding the daily maximum criterion by regulating Skunk Creek at Big Sioux River water quality standards for immersion recreation. Moreover, South Dakota Surface Water Quality Standards Section 74:51:01:04 clearly state waters from one body to another may not cause exceedance of the receiving water body's criteria. These results indicate water quality standards for Skunk Creek need to be changed to achieve water quality standards on the Big Sioux River.

Development of Acute and Chronic Temperature Criterion for Protection of Cold-Water Fisheries in the Black Hills

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Water temperature is a key component in sustaining healthy aquatic life. Historical stream temperature data and data collected during several studies in the Black Hills over the past 8 years show that the current South Dakota temperature criteria, 18.3°C (65°F) for cold-water permanent and 23.9°C (75°F) for cold-water marginal fish life propagation, are exceeded. This data shows that the current temperature criteria are exceeded during critical times of the year (high air temperature and low flows during July and August). During these critical periods, temperature criteria are not exceeded continuously throughout the day and are below the criterion a percent of the day. Although many stream segments in the Black Hills are listed as exceeding the temperature criteria, they are actually sustaining natural fish populations. When allowed to recover at lower temperatures during a diurnal period, fish can survive brief daily exposure to otherwise lethal temperatures. Each fish species has a different set of optimal temperatures that are based on the temperature of the water that the fish are acclimated to.

The goal of this project is to establish regionally based temperature criterion for cold-water fisheries that reflects the variability of natural parameters affecting temperature in the Black Hills of South Dakota. The project goal will be met by accomplishing four objectives: (1) identifying growth (chronic) and lethal (acute) temperature thresholds based on a literature review of fish tolerances, (2) compiling data to evaluate current temperature regimes, (3) evaluating current beneficial use attainment, and (4) determining streams that would be considered impaired based on the recommended temperature criteria. The recommendations will be presented to the South Dakota Department of Environment and Natural Resources to give a better representation of streams that are not meeting the cold-water fishery beneficial use because of temperature exceedances.

Life Cycle Assessment Analysis of Engineered Stormwater Control Methods Common to Urban South Dakota Watersheds

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This research focuses on the development of life cycle assessment (LCA) models for evaluating the design, construction, and performance of engineered (active and passive) stormwater control measures (SCM's), otherwise known as best management practices (BMP's), common to South Dakota urban watersheds. Deployment of engineered SCM's are typically required to meet Clean Water Act and EPA Phase II Stormwater Permit Rules criteria, however selection criteria generally focuses on construction, operations costs, and treatment criteria (e.g., NPDES permit requirements), with little consideration towards LCA-determined environmental burdens associated with BMP selection. LCA provides a holistic view of the environmental impacts associated with a product or process from a "cradle to grave" perspective following international standards developed by the International Organization for Standardization, ISO (e.g., ISO 14040:2006 and ISO 14044:2006). Mandates requiring LCA evaluations are becoming increasingly common within state governments and industries as part of sustainability efforts. This presentation will summarize our preliminary LCA evaluations completed for runoff treatment (e.g., sand filters and other manufactured devices) and vegetated runoff volume reduction (e.g., bioretention and bioinfiltration) SCM methods.

Monitoring Stormwater Quality in Two Drainage Basins in Rapid City, South Dakota, 2010

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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 in conjunction with the city of Rapid City began stormwater monitoring in 2008 within the Arrowhead drainage basin (a tributary to Rapid Creek). Results of this monitoring program indicated high concentrations of fecal coliform bacteria within the drainage basin. In 2010, the monitoring efforts were expanded to include an additional drainage basin and two detention ponds.

Samples for analysis of total suspended solids (TSS) and fecal coliform were collected during storm events at two automatic water-quality sampling stations in the Arrowhead drainage basin and one station in the Meade-Hawthorne drainage basin in 2010, allowing for comparison of water quality in two similarly sized basins, but with contrasting land uses and drainage types. The Arrowhead drainage basin consists primarily of open natural conveyance channels, whereas the Meade-Hawthorne drainage basin is largely concrete conveyance. Twelve storms were sampled during the spring, summer, and early fall months of 2010. Storms ranged from long-duration, low-intensity storms to short duration, high-intensity thunderstorms. Higher event mean concentrations were observed in the Meade-Hawthorne drainage basin (average of 850 milligrams per liter (mg/L) and 46,000 colony forming units per 100 milliliters (CFU/100 mL) for TSS and fecal coliform, respectively) than in the Arrowhead drainage basin (390 mg/L and 17,000 CFU/100 mL, respectively). The average runoff/rainfall volume ratio was more than three times greater in the Meade-Hawthorne drainage basin than the Arrowhead drainage basin, indicating more infiltration losses in the Arrowhead drainage basin.

In conjunction with this stormwater monitoring program, sediment samples were collected to determine the presence, survival, and growth of fecal coliform in the sediment. Midstream and bank material fecal coliform sediment samples were collected following three storm events. Three sampling sites were selected in each basin at which sediment samples were collected every other day for analysis of fecal coliform for approximately 8 days following the storm event. The mean fecal coliform concentration of the samples collected in the Meade-Hawthorne drainage basin of approximately 1,638 most probable number per gram-dry (mpn/g-dry) was higher than the mean in the Arrowhead drainage basin of approximately 1,079 mpn/g-dry. An examination of the potential fecal coliform loading due to bottom sediment re-suspension was made.

Spring Creek Watershed Implementation Project

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High levels of fecal coliform bacteria in recreational waters can elevate the risk of humans contracting waterborne illnesses and may indicate the presence of other pathogens in a waterbody. Spring Creek is a small mountain stream located in the Black Hills of South Dakota. Spring Creek's assigned beneficial use, immersion recreation, is impaired because fecal coliform levels exceed water-quality standards. The impaired segment of Spring Creek is over 31 miles in length and extends from its headwaters to Sheridan Lake. Spring Creek's watershed above Sheridan Lake encompasses approximately 93,000 acres. Land use is primarily silviculture, recreation, residential, and grazing. The only municipality located in the watershed is the city of Hill City. In 2008, the South Dakota School of Mines and Technology (SDSM&T), along with the South Dakota Department of Environment and Natural Resources (SD DENR), completed the fecal coliform bacteria Total Maximum Daily Load (TMDL) for Spring Creek. The assessment indicated that approximately 60 percent of the bacteria load originates from livestock and grazing. The remaining load originates from urban runoff (14 percent) and other human sources (15 percent), including failing septic and leaking sanitary sewers.

In 2010, Pennington County received Clean Water Act Section 319(h) funds from the SD DENR to reduce fecal coliform loading by implementing Best Management Practices (BMPs). Project participants will implement 15 pilot projects to demonstrate and promote on-site wastewater treatment and riparian BMPs. Additionally, Pennington County and the Spring Creek Watershed Advisory Group will develop a strategic plan, stormwater management plan, and an on-site wastewater management plan that will prioritize BMP implementation and public outreach efforts in the watershed. In 2010, ambient and storm event water-quality monitoring was performed to help develop a baseline condition that will ensure that BMPs are effective and proper BMPs are being implemented.

Water Quality Monitoring and Hydraulic Modeling for the Spring Creek Watershed

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A water quality monitoring project for the Spring Creek Watershed in western South Dakota was completed in the fall of 2010. The area of focus was Spring Creek Watershed upstream from Sheridan Lake. Sampling locations were strategically chosen throughout the watershed based on previous monitoring efforts and areas of potentially high constituent loading. Ambient water samples were collected monthly April-August 2010 at seventeen locations within the watershed. Six composite storm event samples were collected at four sites. Water quality samples were analyzed for fecal coliform, E. coli, total phosphorus, total suspended solids (TSS), and nitrate-nitrite.

Spring Creek is currently listed as impaired for fecal coliform bacteria. Sample data indicate that exceedances in fecal coliform and other constituents are entirely driven by storm events. Increases in fecal coliform, TSS, and total phosphorus concentrations were apparent at the four sample sites during high intensity rainfall. Increased loading occurred immediately downstream of Hill City as a result of the urban influence on the watershed. Results indicate that Mitchell Lake, downstream of Hill City, is acting as a sediment sink for Spring Creek. A hydrologic model of the Spring Creek Watershed is being developed using Hydrologic Simulation Program Fortran (HSPF). The objective of the modeling effort is to help identify the most effective areas for Best Management Practice Implementation (BMP) and most effective types of BMPs to employ. The project goal is to bring Spring Creek into compliance for fecal coliform/E. coli by effective BMP implementation over the next ten years.

THURSDAY, APRIL 28, 2011
SESSION 3P
1:30 – 3:30 P.M.

REMOTE SENSING AND CLIMATE
(PONDEROSA ROOM)

Remote Sensing for Water Quality Monitoring and Watershed Assessment on the Lake Traverse Reservation: A Landsat Education and Research Project

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During the summer of 2010, three student interns from Sisseton Wahpeton Tribal College along with researchers from South Dakota State University engaged in a pilot project to assess the feasibility of using Landsat imagery to determine water transparency in reservation lakes in northeastern South Dakota. The students were trained to assist with data collection, image processing, and spatial and statistical analyses. Secchi depth measurements and lake algae bloom observations were made on cloud-free Landsat overpass days. Measurement locations were georeferenced using GPS. Field observations and satellite image classification and interpretation techniques were used to create a land use map for the watershed and explore possible land-use-related causes of the variation in water transparency. The results of this project included a better understanding of the relationship between land use and water quality in reservation lakes.

Simulating Spatio-Temporal Water Dynamics of Landscape Wetland Complex for Ecosystem Services Evaluation in Prairie Pothole Region, USA

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The intra- and inter-annual hydrological dynamics of wetland landscape complexes in the U.S. Prairie Pothole Region are ecologically and economically important for ecosystem services such as flood reduction, water quality improvement, biodiversity enhancement, carbon management, aquifer recharge, and crop production. Quantification of the dynamics has been hampered by coarse digital elevation model, limited cloud-free satellite images, complicated water regime, and various sizes of numerous wetlands. We used twenty-six Landsat images (1984-2009), eleven aerial-photos (since 1952), monthly Palmer Drought Severity Index (1895-1910), one Light Detection And Ranging (LiDAR) dataset (acquired on 17 May 2008), and hydrological modeling to simulate the water change dynamics of wetland complex at landscape level. Our hydrological model were formulated based on water budget and included components such as evapotranspiration, snow accumulation and melting, surface runoff, fill-and-spill flow, basin merging, and ground water flow. The wetlands consist of closed or open permanent, semi-permanent, seasonal, and temporary wetlands. Research outcomes have been and will be used to estimate the floodwater mitigation potential, assess the annual water fowl production, model the green-house gas emissions, and evaluate the habitat fragmentation.

A Hydrological Perspective for Site Suitability of Biofuels Production Using Satellite Images

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There is growing demand for biofuel feedstock production in the Great Plains for meeting the goal of producing 36 billion gallons of biofuels by 2022 under the Energy Independence and Security Act of 2007. This will require changes in existing land use/land cover for producing the biofuel feedstocks. The increasing demand of water for growing biofuel feedstocks and processing will affect the hydrological cycle. Increased biofuels acreages will also affect carbon sequestration and greenhouse gas emissions. The National Research Council has reported wide ranging water quality, water quantity, and related land resource implications of biofuels production in the United States (NRC 2008). We will present a hydrological perspective for selecting suitable sites using satellite images and modeling approaches for biofuels production. Information on changes in water use due to biofuel production will help policy and decision makers make the best use of limited water resources.

Interpolating Evapotranspiration Estimates Between Satellite Overpass Dates

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Satellite based surface energy balance models are now routinely operated to produce evapotranspiration (ET) products on an operational basis for use in water resources management. Landsat satellite imagery is commonly used to produce estimates of ET at field scale with energy balance methods because of the onboard thermal imager and the high spatial resolution. Two Landsat satellites are currently in operation, Landsat 5 and Landsat 7, each flying in the same orbit but eight days apart.

Because of cloudiness not all images or portions of images are suitable for processing. Although areas having cloud cover vary between different dates, it is common to find only one good image per month suitable for processing. As a result, monthly and ultimately seasonal ET depths are generally based on only one "snapshot" of ET per month. The monthly depths are determined by interpolating a relative ET fraction (ET_rF , where $ET_rF = ET / ET_r$, and ET_r is tall reference ET computed from weather data) determined by energy balance for the image dates to all days falling between image dates using a cubic spline function and multiplying by the corresponding daily reference ET. A potential shortfall in basing integrated ET averages on periodic snapshots from satellite is that local or regional precipitation events antecedent to the satellite images may unduly dominate the ET_rF image and may not represent evaporation from rainfall averaged over the monthly period. In addition, some rain events may occur in between satellite images that are not 'seen' in a subsequent image, and therefore those evaporation amounts are not fully accounted for.

ET_rF derived from the satellite overpass date and the METRIC surface energy balance model was adjusted to account for background evaporation from soil caused by rainfall over monthly or longer integration periods. The result of the adjustment is an ET_rF image and consequently final ET map that better represents the average evaporative conditions over the period. The ET_rF for each image pixel is adjusted by the ratio of the average evaporation over the month from bare soil to the evaporation estimated for the image date. This ratio is moderated using the Normalized Difference Vegetation Index (NDVI) to account for shading effects of vegetation on reducing the signature of evaporation from soil.

Examination of the Missouri River Water Temperature Record for Evidence of Change

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The historical record of water temperature for the Missouri River was compiled and examined for evidence of changing conditions. The long-term records examined consisted of three U.S. Geological Survey (USGS) stations, Missouri River at Toston, Montana (station 06054500), Missouri River below Garrison Dam, North Dakota (stations 06339000 and 06338490), and Missouri River at Nebraska City, Nebraska (station 06807000), and reservoir outflow records collected by the U.S. Corps of Engineers at Garrison Dam in North Dakota and Oahe and Gavins Point Dams in South Dakota. Daily temperature values at the reservoir release sites are available for the period of record, 1967 to present, with some missing values. The record at the USGS station at Toston, Montana, extends from 1977 to present. The USGS station below Garrison Dam was moved upstream about 8 miles to the Dam outlet in 1971 but analyzed as one record from 1952 to 1989. The record for USGS station, Missouri River at Nebraska City, extends from 1952 to 2009, but no data are available for the period 1977 to 1991. All available data were examined for evidence of water temperature change for two indicator parameters— (1) long-term change over the respective period of record, and (2) any change in the date of the annual maximum temperature. Some evidence exists that indicates the river is warming over time, especially for the reach downstream from the reservoirs, as indicated by the Missouri River station at Nebraska City.

Radar Criteria Indicating the Presence of Hail in High Plains Thunderstorms

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Reflectivity observations from operational National Weather Service (NWS) radars are used by forecasters to deduce the presence of hail in thunderstorms. Reflectivity greater than 55 dBZ in regions above the freezing level is typically taken to indicate the presence of hail greater than $\frac{3}{4}$ " in diameter. The vertically integrated reflectivity also is used to derive an estimate of the vertically integrated liquid (VIL) in a storm that also can be used as a diagnostic for the presence of hail. Using a unique data set including airborne in situ observations of hail and co-located reflectivity and VIL measurements in a group of High Plains thunderstorms, we extend this relationship to a continuous trend between reflectivity and/or VIL, and maximum hail size.

THURSDAY, APRIL 28, 2011

SESSION 4A

4:00 – 5:20 P.M.

**MINING ISSUES
(ALPINE ROOM)**

A Comparison of Water Usage for Mineral and Agricultural Development for the Dewey-Burdock Area

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This presentation addresses several aspects of Powertech (USA) Inc.'s proposed uranium in-situ recovery (ISR) project at the Dewey-Burdock site near Edgemont, SD. An overview of the ISR process and Dewey-Burdock ISR Project site covers the basics of these activities.

Briefly, the ISR process involves pumping fortified native water through wells, intersecting an ore body, solubilizing and pumping the mineral to the surface for recovery while recycling most of the water.

The status of the following state and federal regulatory review of permit and license applications will be described:

- Underground Injection Control Permit – US Environmental Protection Agency
- Underground Injection Control Permit –Department of Environment and Natural Resources
- Source Material License – US Nuclear Regulatory Commission

Finally, a comparison of gross surface area economic values for agriculture vs mineral development will be made. Land contains many valuable resources; both intrinsic and extrinsic. In the case of the proposed Dewey-Burdock Project, the primary intrinsic land resources include agriculture (cattle grazing) and mineral development (i.e., uranium recovery). Both involve the usage of water, a renewable sustainable resource. In this presentation, both uses are converted to a dollar value so that an assessment can be made. Although the Dewey-Burdock ISR operations will not preclude livestock grazing, a comparison between grazing only and mineral development only will be made and a dollar value for both resources estimated.

The intrinsic value of mineral development (i.e., uranium recovery) using the environmentally-friendly in situ recovery process far exceeds the intrinsic agricultural land use of grazing. As an added bonus, during the entire operation of the proposed Dewey-Burdock Project, livestock grazing can occur simultaneous with mineral recovery and, in the case of land application of waste water, agricultural development may be enhanced.

Removal of Heavy Metals from Mine Water with a Limestone-Based Method

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The Gilt Edge Superfund Site is a former heap-leach gold mine that currently is being remediated. Mine runoff water is treated before release from the site. The field pH, before treatment, is about 3, and the water contains arsenic and heavy metals, in addition to sulfate concentrations of about 1400 to 1500 mg/L. A sample of pre-treatment water showed a cadmium concentration was 0.146 mg/L and a lead concentration was 0.049 mg/L. With field samples of water from the site, a limestone-based method reduced cadmium and lead concentrations below the limit of detection of 0.001 mg/L. The results are significant because previous research with the limestone-based method mainly had involved samples prepared with distilled water in the laboratory, in which interference of other ions such as sulfate did not occur. The research indicates the potential for broader field applications of the limestone-based removal method.

Reconnaissance Investigation of Bottom Sediment Metals and Radionuclide Concentrations Within Black Hills Region Lakes and Impoundments

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A field sampling reconnaissance effort was initiated during the winter of 2010/2011 to determine the presence of metals and radionuclides within the bottom sediments of seven major Black Hills region lakes and impoundments, including Angostura, Belle Fourche, Deerfield, Keyhole, LAK, Pactola, and Sheridan. Over 900 abandoned mines sites exist within the Black Hills region of South Dakota and Wyoming, however there is limited knowledge regarding the contribution of metals and radionuclides emanating from many of these mine sites into regional watersheds. The objectives of this research were to: [1] determine the extent of anthropogenic-influenced watershed impacts through the determination of sediment metals concentrations and metal enrichment factors, and [2] evaluate the potential of geochemically-influenced metal remobilization within waterbody sediments. Sediment cores (up to 93cm length) were divided into 2 or 3 cm slices to depth and analyzed for water content, loss of ignition, carbon content, and metal and radionuclide concentration. Pearson product moment correlations were established to determine inter-core metal correlations, while sediment enrichment factors were determined relative to background concentrations from non-mining impacted sediments. This presentation will summarize the key findings from these reconnaissance investigation efforts.

To Bloom or Not to Bloom — A Didymo Story from Rapid City to Chile

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The recent global occurrence of *Didymosphenia geminata* blooms in temperate streams has been perplexing in its pace of spread and the paradoxical nature of the nuisance growths. The blooms occur primarily in oligotrophic streams and rivers, where phosphorus (P) availability often limits primary production. We reveal a biogeochemical process by which *D. geminata* mats concentrate P from flowing waters. First, the mucopolysaccharide stalks of *D. geminata* adsorb both iron (Fe) and P. Second, enzymatic and bacterial processes interact with Fe to increase the biological availability of P, creating a positive feedback between total stalk biomass and high growth rates. Thus, stalk affinity for Fe, iron-phosphorus biogeochemistry, and synergy between watershed disturbance and climatic factors explain the paradoxical blooms and the recent global spread of this invasive aquatic species. These mechanisms will be discussed in the context of recent blooms in Patagonian Rivers in Chile, Rapid Creek, and unconfirmed reports of Didymo blooms from Bear Butte Creek in the Black Hills since the early 1990's.

THURSDAY, APRIL 28, 2011
SESSION 4P
4:00 – 5:20 P.M.

GROUND-WATER ISSUES
(PONDEROSA ROOM)

Sickness caused by onsite wastewater systems in the Black Hills

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Nearly ten thousand onsite wastewater systems exist in rural areas of the Black Hills. Ground water contamination from septic systems includes increasing nitrate concentration as well as high coliform and fecal bacteria concentration, particularly in dense subdivisions (Putnam et al., 2008). Sickness (gastro-intestinal distress) has occurred at several places, but firm documentation by the South Dakota Department of Environment and Natural Resources (DENR) is available only at two locations:

- Rockerville Campground. On August 30, 1986, participants of a “Volksmarch” drank water at this campground and 135 out of 181 people became sick. The sickness consisted of diarrhea, vomiting, abdominal cramping and nausea. The campground well is 25 ft deep, and has a static level of 16 ft. The well penetrates artificial fill and alluvial deposits overlying schist, and is 100 ft downgradient from the septic tank. On September 8, 1986, DENR found 40 fecal coliform/100 ml in the well, and a dye test on October 1, 1986, showed the travel time from the septic tank to the well is approximately one day.
- Camp Paha Sapa. This former Girl Scout camp is located approximately 5 miles south of Deadwood. On June 19, 1995, 35 out of 47 girl scouts got sick, sending some to the hospital. The sickness led to the closure of the camp which was later sold to a private party. DENR officials confirmed the presence of fecal coliform in the well water and implicated the septic system, which was located 168 ft away. The well log shows overburden from 0 to 13 ft, and schist from 13 to 104 ft total depth; the static level is 32 ft. In 1997 the facility was rented to the South Dakota School of Mines and Technology for use as a geology field camp. A chlorinator had been installed on the water line from the well to the mess hall, but it did not chlorinate the water going to the shower house. As a result, students became ill with nausea, diarrhea, fatigue, and other symptoms of gastro-intestinal distress. In 2006 a 160 ft deep well was drilled, and the camp is now called Kamp Kinship.

Gastro-intestinal sickness events have also been observed at the Nemo Guest Ranch, and septic drainage issues have been described at Johnson Siding. These locations are less documented by DENR. Both these locations and the two documented events described above are all within Precambrian terrain. The two documented events occurred where a short travel time (~ one day) was observed (or inferred) from the wastewater drain field to the water supply well. The contaminant pathway is most likely through fractures in the Precambrian metamorphic rocks and/or through coarse alluvial deposits. The cases involve a well downgradient and less than approximately 200 ft to the septic disposal system. The sicknesses were incurred by visitors at a campground, and involve the temporary high use of a well and disposal system at a facility where locals seemed to be immune from the bacteria.

Groundwater Mixing and Flow Characterization Using Hydrochemical Data: Wind Cave And Southern Black Hills

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Principal component analysis (PCA) and cluster analysis, applied to multivariate hydrochemical data, were used to identify broad hydrogeologic domains, which then were used as a basis for an end-member mixing model. Simulated end-member waters, or sources of inflow, were mathematically mixed in an attempt to reproduce observed hydrochemistry for sampled wells and springs. This method helped to characterize hydrologic associations and interactions between the domains. Previous approaches using PCA with end-member mixing typically have assumed that the extreme-value samples identified by PCA represent the hydrochemistry of end-member waters. The approach presented here is somewhat different from previous work in that (1) end members were not assumed to have been sampled but rather were estimated, (2) end-member mixing was quantified in relation to hydrogeologic domains, which focused model results on macro-scale hydrologic processes rather than individual wells and springs, and (3) the number of end members was determined from a series of cluster analyses. This approach was applied to characterize groundwater mixing and flow in the karstic Madison and related aquifers surrounding Wind Cave in the southern Black Hills of South Dakota. Hydrochemical data included common ions and stable isotopes of oxygen and hydrogen ($\delta^{18}\text{O}$, $\delta^2\text{H}$). Five end-member waters and the relative end-member contributions for sampled sites were estimated by inverse methods applied to the end-member mixing model. The relative end-member contributions estimated for each hydrogeologic domain provided insight into groundwater mixing and flow. For example, the domain encompassing Wind Cave received 40 percent of its groundwater from the Precambrian aquifer end member, 48 percent from recharge to exposed areas of the Madison and Minnelusa aquifers (two end members), and 12 percent from regional groundwater flow (two end members).

Estimating Recharge to the High Plains Aquifer in South Dakota using a Soil-Water Balance Approach

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Estimating recharge is an important water budget component in characterizing groundwater flow in the High Plains aquifer in south-central South Dakota. A soil-water-balance program (SWB) was used to provide an improved estimate of spatial and temporal variations in groundwater recharge to the High Plains aquifer. SWB calculates recharge by using soil and land-use geographic information system data layers in combination with tabular climatological data. The SWB code is based on a modified Thornthwaite-Mather soil-water-balance approach, with components of the soil-water balance calculated at a daily time step.

Recharge was estimated for two study areas in the High Plains aquifer in South Dakota. The Pine Ridge study, in cooperation with the Oglala Sioux Tribe, is located in the western part of the High Plains aquifer and includes outcrops of the Tertiary-age Ogallala and Arikaree Formations. The Tripp-Gregory study, in cooperation with the Rosebud Sioux Tribe, is located on the eastern part and includes mostly outcrops of the Ogallala Formation. Average annual precipitation (1985-2009) was 19.5 inches per year (in/yr) in the Pine Ridge study area and 25.7 in/yr in the Tripp-Gregory study area.

Preliminary estimates of recharge for the Pine Ridge study area (1985-2009) averaged 2.6 in/yr or 13.3 percent of average annual precipitation. The annual recharge rate ranged from 1.0 to 5.5 in/yr. Estimates of evapotranspiration from the soil zone averaged 12.8 in/yr. Preliminary estimates of recharge for the Tripp-Gregory study area (1985-2009) averaged 4.3 in/yr or 16.7 percent of average annual precipitation. The annual recharge rate ranged from 1.0 to 9.0 in/yr. Estimates of evapotranspiration from the soil zone averaged 13.9 in/yr. Preliminary work showed that the SWB code produces a recharge estimate that is at the upper range of previously published estimates of 8 to 15 percent of annual precipitation for the High Plains aquifer in South Dakota.

Microgravity Methods to Investigate Groundwater Storage and Specific Yield in the Madison and Minnelusa Aquifers

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Microgravity measurements made from 2009 to 2010 over the Madison and Minnelusa aquifers in the Black Hills of South Dakota were used to investigate groundwater storage changes and specific yield in unconfined areas of these aquifers. Time-lapse microgravity surveys indicate temporal gravity changes as a result of changing groundwater mass. Two separate areas were monitored in this study. The first area, Doty, is located on outcrops of the Madison Limestone and Minnelusa Formation to the northwest of Rapid City, and consists of 11 gravity stations. The second survey is located to the south of Rapid City with one station on the rim of Spring Canyon near the area where Spring Creek sinks into the Madison aquifer and one station on Precambrian rocks with negligible porosity. High-sensitivity absolute and relative gravimeters were used to measure groundwater storage volume with an accuracy of about ± 0.5 feet of height per unit area of aquifer. Comparison of the gravity measurements with water-level data from an observation well located near the southern survey site permitted calculation of specific yield values ranging from 0.079 to 0.278 for the Madison aquifer directly below the gravity station at Spring Canyon. Spatially and temporally separated microgravity data for the Doty site indicated highly heterogeneous porosity, particularly in the Madison aquifer, as well as unsaturated-zone dynamics that are not easily characterized. For example, during a time period when the water table was rising resulting in an increase of groundwater mass in the saturated zone, measured gravity decreased. However, a large negative mass change in the unsaturated zone, possibly resulting from the draining of perched groundwater, might explain the gravity decrease. This study was conducted by the U.S. Geological Survey in cooperation with West Dakota Water Development District, South Dakota Department of Environmental and Natural Resources, and Lawrence County.

THURSDAY, APRIL 28, 2011

POSTER SESSION

5:30 – 7:00 P.M.

(RUSHMORE F ROOM)

Black Hills Aquifer Atlas: Compilation of 1:24,000-scale Maps in a GIS Format

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The Black Hills Aquifer Atlas involves the compilation of 1:24,000-scale maps into a geographic information systems (GIS) format for distributing information about ground water to the public through a web site. In recent years, the West Dakota Water Development District has sponsored numerous studies of 1:24,000-scale quadrangles in the Black Hills. Major water-bearing units are the Madison, Minnelusa, and Inyan Kara aquifers. The maps produced from the work include: (1) structural contour maps of the tops of the aquifers, (2) depth-to-aquifer maps, (3) aquifer susceptibility maps, and (4) aquifer vulnerability maps. Aquifer susceptibility involves the inherent hydrologic and geologic characteristics that make an aquifer sensitive to potential contaminant sources, without regard to the presence of human influences. Aquifer vulnerability maps show the risk associated with human influences such as transportation, residential development, and industrial activities.

A general template has been developed for GIS compilation of maps for each quadrangle. With this format, the data for all quadrangles are compatible and can be combined into larger maps. The template currently is applied to the Black Hawk, Rapid City West, and Rockerville quadrangles to ensure edge-matched compatibility with maps of adjacent quadrangles. Similar maps are under development for adjacent quadrangles with crystalline bedrock aquifers of the Precambrian core of the Black Hills.

Characterization of Fe and S Mineral Phases Associated with Uraninite Oxidation

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Subsurface bacteria including sulfate reducing bacteria (SRB) can reduce soluble U(VI) to insoluble U(IV) with subsequent precipitation of uraninite (UO₂). However, it has been shown that SRB-mediated uraninite nanocrystals can be reoxidized (and thus remobilized) by Fe(III)-(hydr)oxides, common constituents of soils and sediments, once the electron donor is exhausted. This reoxidation has also been shown to occur under sulfate reducing conditions; however the mechanism of this process remains unresolved. To understand these mechanisms, *Desulfovibrio desulfuricans* G20 (SRB) was grown in lactate-limited medium containing 2 mM or 180 μ M U(VI). After U(VI) reduction, to stimulate the U reoxidation, hematite-goethite (15 mmol of Fe(III)/L) or FeCl₃ (15 mM) was spiked under anaerobic conditions. Fe or S secondary minerals formed during U reoxidation were analyzed using Mössbauer, XRD, HR-TEM, EDS, and SEAD. Results showed that no goethite peaks were present in the samples, and a fraction (~20-25%) of the hematite was transformed. All treatments irrespective of the Fe(III) sources (hematite or FeCl₃) or with or without U(VI) gave a similar "iron sulfide" products. The iron sulfide was very unstable in air (when samples were exposed to air for 1 h - Fe(II) phase was disappeared). XRD data showed no iron sulfide compounds probably due to amorphous phases in nature of the samples or low concentrations of crystalline forms. Mössbauer data also showed that these iron sulfide products were not mackinawite, siderite, or pyrite. In addition to Mössbauer and XRD, HR-TEM, EDS, SEAD showed various forms of iron sulfides (most of the amorphous), and intracellular and extracellular coexistence of uraninite and iron sulfides. However, Mössbauer data of the sample and its temperature behavior suggested that the precipitate could be greigite. Roles of various iron sulfides in reoxidation are currently being studied. These results would be applicable in the assessment of long term sequestration of U by SRB.

Monitoring Bank Erosion on the Missouri River on the Lower Brule Reservation

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The Lower Brule Sioux Tribe (LBST) is very concerned about bank erosion on the Missouri River on the Lower Brule Reservation in western South Dakota. The Missouri River and the two lakes formed by the dams, Lake Sharpe and Lake Francis Case, form the northern and eastern boundary of the LBST Reservation. Shoreline erosion has occurred along a large portion of this border. LBST estimates that the Reservation is losing shoreline in some locations at a rate of approximately 8 feet per year.

To address these concerns, the LBST Environmental Protection Office's Water Quality Program, in cooperation with the U.S. Geological Survey and the Oglala Lakota College, is monitoring a portion of the Missouri River's shoreline for bank erosion. The study area for this project consists of a 7-mile stretch of shoreline with major bank loss. This area was chosen because of the high rate of bank loss and because the LBST Rural Water plant's intake location is within the study area.

The physical changes that occur along the Missouri River bank will be monitored utilizing the following technological efforts at varied times during the 2-year study:

- Real-Time Kinematic (RTK) global positioning satellite equipment to establish precise shoreline location;
- ground-based Light Detection And Ranging (LiDAR) to map banks at selected locations; and
- flights using a small Unmanned Aerial System (UAS) to monitor the changes in bank erosion for the 7-mile stretch along the shoreline.

RTK data are used to establish the shoreline location at any point during the study, LiDAR data will provide high-resolution surface elevation data, and UAS flights will be used as a reconnaissance and surveillance tool to capture video and still pictures. Results from each of these efforts will be analyzed to investigate the location and rate of erosion. The LBST will use the results to assess the need for possible changes in the potential permitting of water resources.

Monitoring Bank Erosion on the Missouri River on the Lower Brule Reservation with Ground-based Light Detection and Ranging (LiDAR)

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The Lower Brule Sioux Tribe (LBST) is very concerned about bank erosion on the Missouri River on the Lower Brule Reservation in western South Dakota. The Missouri River and the two lakes formed by the dams, Lake Sharpe and Lake Francis Case, form the northern and eastern boundary of the LBST Reservation. Shoreline erosion has occurred along a large portion of this border.

The U.S. Geological Survey (USGS), in cooperation with the LBST Environmental Protection Office's Water Quality Program and the Oglala Lakota College (OLC) of the Oglala Sioux Tribe, is investigating the current physical properties of the Missouri River banks in a 7-mile stretch of shoreline near the community of Lower Brule. The physical changes that occur along the Missouri River shoreline will be monitored during the 2-year study period to provide data on the rate of erosion at selected locations.

Sites representing a variety of bank conditions were selected at five locations near Lower Brule. Real-Time Kinematic (RTK) global positioning satellite equipment was used to establish precise locations of primary and secondary reference marks at each site. Also, while developing the sites, "bankshots" (RTK readings at the current bank location) were recorded. These readings and aerial imagery are being used to investigate the erosion that took place before this study began, but higher resolution information is required to accurately quantify localized bank-erosion rates.

Ground-based Light Detection And Ranging (LiDAR) is a technique to obtain precise land-surface elevation data. The OLC and USGS used a High-Definition Surveying Scanning (HDS3000) system by Leica Geosystems™ with Cyclone 5.1 scanning and point processing software applications¹ to scan the sites during the winter of 2011. LiDAR will be used again in 2012. The results will provide high-resolution data to record the amount of bank erosion on the Missouri River at selected sites on the Lower Brule Reservation by measuring the change in shoreline between the winters of 2011 and 2012.

¹The use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Geothermal Resources of Western South Dakota

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Some of the highest geothermal gradients east of the Rocky Mountains occur in south-central and southwestern South Dakota, although actual aquifer temperatures in south-central South Dakota are relatively low from the perspective of geothermal systems (typically $<130^{\circ}$ F for gradients $>4.0^{\circ}$ F per 100 ft). Aquifer temperatures of $>212^{\circ}$ F have been measured in the Williston Basin in northwestern South Dakota, although geothermal gradients in this region are typically $<2.5^{\circ}$ F per 100 ft. Aquifer temperatures in many areas of South Dakota are adequate for direct heating of buildings and for aquaculture. Electricity for local use could be generated from co-produced hot water from the oil fields of northern Harding County (Williston Basin) coupled with a binary cycle (secondary fluid) system. Water quality issues within the State's geothermal aquifers can complicate exploitation. Poor water quality can lead to scaling or corrosion issues that are detrimental to geothermal heat production. Parameters of concern include alkalinity, pH, chloride, sulfide, and total dissolved solids.

The fundamental question for South Dakota in assessing its future geothermal potential is: What is the source of heat? If the high geothermal gradient in the south-central part of the state is due to water circulating in deep crustal fractures, then temperatures of over 400° F may be present at 2 to 4 miles depth. This scenario may favor an enhanced geothermal system to produce electricity.

3-D Geologic Modeling of an In Situ Uranium Project in South Dakota

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Powertech Uranium Corporation has proposed to conduct in situ mining within a uranium-enriched ore deposit known as the Dewey-Burdock project. The project is located on the southwest flank of the Black Hills, approximately 12 to 15 miles north-northwest of Edgemont, South Dakota. A comprehensive understanding of the geology is required for permitting, conceptual geohydrology modeling, mine design, ore reserve calculations, and public relations visualization. A 3-D geologic model for the proposed permit area was built in Mining Visualization Systems (MVS), a 3-D visualization software package by C Tech Development Corporation.

Site data consists of approximately 4,000 historical Tennessee Valley Authority (TVA) exploration holes, and interpreted ore grade maps augmented with data from the current exploration process. The model targets the consolidated sedimentary rocks of Jurassic and Cretaceous age that comprise and bound the Inyan Kara group which hosts the uranium ore. A general 3D stratigraphic model was built to create isopach and structure contour maps and constraining surfaces for an ore interpolation grid. Detailed lithologic submodels were built along the ore body to identify ore bearing sand units, confining aquitards, and general cross-sections. Interpolated ore bodies were generated to facilitate well field design and reserve calculations. An ESRI geodatabase contains the model data and products for distribution via an ArcServer based website and ArcExplorer.

Moving Towards a Technical Specification for Fluorescence Excitation-Emission Mapping and Absorbance Analysis of Colored Dissolved Organic Matter

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Colored dissolved organic matter (CDOM) measurements with fluorescence and absorbance are important for evaluating a wide variety natural and industrial water sources. However, uncertainties and ambiguities continue to be propagated regarding interpretation of CDOM spectral data due to the variety of instruments, sampling chemistry conditions and types of analysis algorithms. Recent efforts have focused on standardization and interlaboratory comparisons of CDOM samples with respect to preparation, spectroscopic evaluation and mathematical analysis. This study deals with correlating absorbance and fluorescence data measured with the same sample to minimize interlaboratory variation. The theoretical significance of true simultaneous acquisition of the corrected (NIST Traceable) absorbance spectrum and fluorescence excitation spectral profile and excitation emission map is discussed as a means to provide the least ambiguous spectral data. Key issues considered are the variations introduced by 'serial' acquisitions of absorbance and fluorescence data. Variation can be caused by the different light-exposure history (especially UV) in the instruments, dissolved oxygen content associated with temperature changes and oxidation kinetics of the CDOM and in many cases concentration- and pH-related changes associated with diluting and pH buffering of the CDOM sample, respectively. Concentration changes in CDOM can be associated with optical anomalies including self-quenching and -absorption which systematically alter the fluorescence spectrum. Clearly, monitoring the absorbance and fluorescence simultaneously would deal with the above sampling variations and facilitate correcting the absorbance based fluorescence anomalies. The proposed method(s) described will be discussed in view of their potential to serve as the basis for an international technical specification in terms of the optical instrument and sampling conditions for CDOM analysis and reporting.

Mat Level Hydrodynamic Processes and Distribution of *Didymosphenia Geminata* Blooms in Rapid Creek Watershed, South Dakota

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Didymosphenia geminata (here after called Dg) is a freshwater diatom that has invaded and colonized many of the world's oligotrophic streams and rivers, including Rapid Creek in western South Dakota. To investigate distribution of Dg blooms in Rapid Creek watershed, we conducted measurements of stream flow, biomass, Creek water, bed sediment and Dg mat tissue chemistry from 2008-2009 except in the winter. To evaluate the synergy between the creek chemistry, hydraulics and mat development, we calculated water residence time, eddy lifetime and hydrodynamic stability parameters, Reynolds number and Froude number.

The measurement of the creek chemistry in the study area has little variation and is in a good agreement with the existing studies conducted in this watershed. However, Dg mat development is limited to relatively stable flow regimes in a good agreement with several studies conducted in other watersheds. Likewise, increased eddy lifetime subjected to channel substrate and the feedback from mat development appears to affect mat establishment. While the relationship between stream flow and biomass is hyperbolic, this study revealed that the biomass distribution has strong relationship with the water residence time ($r^2=0.78$, $p<0.05$). The feedback from mat development alters stream flow, creating low flow conditions around it, resulting in minimal surface water throughflow in the mat. Negative relationship between algal mat development and free stream or near bed velocities have been reported in several studies conducted in other watersheds. However, the results of this study revealed that mat level processes such as eddy lifetime, water residence time and hydrodynamic stability are likely important predictors of differential distribution of Dg mat within a stream. The presentation will discuss how mat level hydrodynamic processes impact Dg biomass distribution in Rapid Creek watershed.

Analysis of Bottom Sediments for Metal and Radionuclide Concentrations within Black Hills Reservoirs

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A field sampling reconnaissance effort was initiated during the winter of 2010/2011 to determine the presence of metals and radionuclides within the bottom sediments of seven Black Hills reservoirs, including Angostura, Belle Fourche, Deerfield, Keyhole, LAK, Pactola, and Sheridan. The Black Hills region has a long history of mining activities dating back to the late 1800s. There are currently more than 900 known abandoned mine sites within the Black Hills, of which many are long term and significant sources of metal and radionuclide loading into local and regional watersheds. Sediment cores were collected and divided into 2 or 3 cm slices to depth and analyzed for water content, loss of ignition (carbon content), and metal and radionuclide concentration [via X-ray fluorescence spectrometry (XRF)]. This presentation will discuss methods of sample collection and analysis, and will summarize key findings from this preliminary reconnaissance investigation effort.

Effects of Land Management Change on Water Quantity and Quality in the James River Basin

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Biofuels have become important transportation fuels and their use is likely to expand. This study is to quantify the long-term water quality impacts of land management changes associated with increased demands for corn in the James River Basin. Using the hydrological/water quality model, Soil and Water Assessment Tool (SWAT), we investigated the potential effects of different crop rotation (corn-soybean, corn-corn-soybean, and continuous corn) on water yield and nitrate nitrogen (NO₃-N) load at the watershed scale.