PROCEEDINGS

for

Linking Water Research to Policy and Water Management
A Joint AWRA – MWCC Meeting

Montana Section American Water Resources Association
2015 Conference

October 7-9, 2015
Holiday Inn Downtown,
Missoula, MT

Contents

***These abstracts were not edited and appear as submitted by the author, except for some changes in font and format.**

THANKS TO ALL WHO MAKE THIS EVENT POSSIBLE!

- **The AWRA Officers**
  Joe Meek, President – Montana Department of Environmental Quality
  Todd Myse, Vice President – Montana Bureau of Mines and Geology
  Aaron Fiaschetti, Treasurer – Montana Department of Natural Resources & Conservation

- **Montana Watershed Coordination Council**
  Erin Faris-Olsen, Adam Sigler

- **Montana Water Center**
  Nancy Hystad,

And especially the conference presenters, field trip leaders, moderators, student judges and volunteers.

Joe Meek

Todd Myse

Arron Fiaschetti

Adam Sigler

Erin Farris-Olsen

Nancy Hystad

A special thanks to our generous conference sponsors!

Linking Water Research to Policy and Water Management
A Joint AWRA MWCC Meeting

Wednesday, October 7, 2015	
8:00 AM - 7:00 PM	**Registration in the atrium area**
9:30 AM- 1:00 PM	**Joint MWCC/AWRA Session. Panel Discussion: Restoration Success - Past, Present, Future.** (**Click on session title for details**). Parlors AB
1:30 - 5:30	**Field Trip – Load Buses at 1:15 in front of hotel. <u>Leaves Holiday Inn promptly at 1:30 PM</u> - Bag lunch & drink to be provided.**
6:00 - 7:00 PM	**Hydrophile 3-mile---5K Run/Walk. Starts at the Holiday Inn. Informal gather after the race at Tamarack Brewing (231 W Front)** *Dinner - on your own*
Thursday, October 8, 2015 **(morning session in Parlors AB)**	
7:30 AM	**Registration - Gather for Coffee and Conversation with Colleagues**
8:00	**Welcome with Introductions, Logistics, & Announcements - Joe Meek (MT AWRA PRESIDENT)** Parlors AB
8:10	**Wyatt Cross, Montana Water Center Director**
8:15	**Erin Farris-Olsen, Montana Watershed Coordination Council Director**
8:20	**KEYNOTE SPEAKER 1. Eloise Kendy The Nature Conservancy**
	Just Add Water: Historic Return of the Colorado River to its Delta in the US and Mexico
9:15	**KEYNOTE SPEAKER 2. Doug Jackson-Smith. Utah State University**
	Connecting the Dots. Bringing People into Research, Policy, and Water Management
10:10	Break
10:30	**Special Speaker Tim Davis - Montana Water (CSKT Compact, exempt wells, other WR issues)**
	Special Speaker Jason Mohr - Legislative Update
11:30	**Break for Lunch in the Atrium - provided to all registered conference attendees**

TECHNICAL SESSIONS

Thursday October 8, 2015 (cont'd) **Parlors C & D**

red indicates student presenters or posters

	Integrating Water Resource Management		***Groundwater***	
1:00 PM	**SESSION 1 Parlor C** **Moderator: Attila Folnagy**	**Speaker**	**SESSION 2 Parlor D** **Moderator: Tammy Swinney**	**Speaker**
1:00 PM	Integrating Water Management Needs into Science -The Ground Water Investigation Program (GWIP)	Abdo	Hydrogeologic Overview Of Big Sky Resort, Madison Mountain Range, Southwest Montana	Rose
1:20 PM	Gallatin Groundwater Mitigation Bank: Expediting New Water Uses In A Closed Basin	Kendy & Davis	Diel Variation In Stream Water Nitrate Concentrations Reflects Biological Nitrogen Loss From An Agricultural Landscape	Fordyce
1:40 PM	Agency Cooperation with a Local Watershed Organization; Data Collections, Holistic Planning.	Heikes-Knapton	Decoding The Climate In The Gallatin Watershed, Montana	Crowley
2:00 PM	GUARDIANS OF THE HOLOCENE: How Scientists And Water Users Combined Forces To Champion Three Montana Watersheds	Stanley	I Have To Do What To Get A New Water Right?? – Mitigation And Aquifer Recharge Options Elaborated.	Magruder
2:20 PM	Evolution Of A Stream Restoration Project: Prickly Pear Creek Project, A Case Study.	Wilbur	Stochastic Water-budget Analysis To Evaluate The Relative Importance Of Recharge/discharge Mechanisms In The Deep Aquifer, Kalispell Valley, Montana	Gebril
2:40 PM	Perspectives On River Restoration Science And Practice	Wilcox	Ground Water Nutrient Loading To Surface Water Streams And Lake Helena, Helena Valley, Montana	Swierc

3:00 PM **BREAK - POSTER SETUP (up till Fri morning break)**

Note: There is a special Watershed Funding Discussion from 3-5 pm in the Madison/Jefferson/Gallatin Room. See page 62 for a description of this special break-out session.

Be sure to visit the vendor displays

TECHNICAL SESSIONS

Thursday October 8, 2015 (cont'd) **Parlors C & D**

Time	*Riparian Restoration and Dynamics* SESSION 3 Parlor C Moderator: Andrew Wilcox	Speaker	*Water Quality* SESSION 4 Parlor D Moderator: Lynda Saul	Speaker
3:20 PM	A Brief History Of Stream Restoration In Montana	Dalby	Geochemistry Of Natural Acid Rock Drainage In The Anaconda-Pintler Mountain Range, Montana	Doolittle
3:40 PM	Natural Channel Design, A Reliable And Flexible Solution To Restoring Impacted Streams	Mangold	Natural Acid Rock Drainage Chemistry And Ferricrete Deposits Of The Judith Mountains, Montana	Edinberg
4:00 PM	Natural Water Management In The Upper Clark Fork River: Quantifying Loss Of Water Due To Beaver Pond Wetland Removal, And Cost-effective Restoration Options	Chadwick	Investigating Sources Of Water To Chief Plenty Coups Spring Near Pryor, Montana: Water Chemistry And Microbial Communities Reveal Seasonably Variable Contamination Pathways	Ewing
4:20 PM	Flow-related Water Quality Impairments In The Clark Fork And Kootenai Basins	Andis	Assessing the Effectiveness of a Riverine Wetland in Processing Nitrogen for Blacktail Creek in Butte, MT	Nagisetty
4:40:PM	Flow And Scour Constraints Of Pioneer Seedlings To Predict Uprooting Potential	Bywater-Reyes	Longitudinal, Seasonal, And Inter-annual Patterns Of Temperature And Discharge In The Upper Clark Fork River, Montana	Stafford

5:00 PM End Technical Session

Be sure to visit the vendor displays

5-7 PM	**POSTER SESSION and SOCIAL HOUR in the Atrium**
Alexander	Lake Helena Watershed Group
Barnhart	Investigation Of Hyporheic Microbial Biofilms As Indicators Of Heavy Metal Toxicity In The Clark Fork Basin, Montana
Barth	Big Sky Watershed Corps: Four Years Of Service On The Clark Fork
Bell M.	The Influence Of Topography And Spatial Patterns Of Soil Hydraulic Conductivity On Groundwater Response Across A Forested Hillslope.
Bell C.	Field Reconnaissance Investigation To Explain Elevated Arsenic And Nitrates In The Raven Road Area, Helena Montana
Blythe	Shallow Groundwater Quality And Geochemistry Of The Shields River Drainage Basin, Southwest Montana.
Boyk	Community Conservation: Watershed Restoration At Bozeman's Story Mill Park
Caldwell	Characterization Of Produced-Water Chemistry Of The Williston Basin, Montana, North Dakota, And South Dakota Through 2014
Carparelli	Management Intensive Grazing And Drought Resilience
Erich	Pesticide Monitoring By The MDA Groundwater Protection Program; Addressing Data Gaps For Management Needs.
Folnagy	Surface Water Data Collection And Application For Effective Water Management
Graves	Park Conservation District Jurisdictional Streams Mapping Project
Harrington	Much To Do About A Brownfield: Missoula White Pine And Sash Superfund Site.
Harwood	A Groundwater Contaminant Transport Site Investigation On The Fate Of Hexavalent Chromium Cr(VI), Mouat Industries Site, Columbus, Montana.
Herron-Sweet	Identifying And Prioritizing Aquatic Mitigation Project Sites In Montana
Holmes	Assessing The Capacity Of Natural Infrastructure To Increase Water Storage, Reduce Vulnerability To Floods, And Enhance Resiliency To Climate Change

Hoylman	Landscape Heterogeneity Modulates Forest Sensitivity To Climate
Hurley	Floating Islands For Wetland Restoration
Kelley	Nitrate-N And Nitrite-N Monitoring By MDA Groundwater Protection Program; Identifying Data Gaps And Adapting Data Collection To Address Program Goals And Management Needs.
Kreiner	The “behind-the-scenes Of Sampling And Analysis Plan Development: Linking Various Stakeholders Into Restoration Monitoring Design
Landers	Aquatic Food Webs And Heavy Metal Contamination In The Upper Blackfoot River
Landers	Wild Trout Recovery Shows Effectiveness Of 20 Years Of Blackfoot River Basin Restoration Efforts
Lynn	Strategies For Successfully Engaging Diverse Stakeholders In To Implement The Upper Gallatin River Watershed Restoration Plan
Miller	Summarizing Technical Water Resource Data For A General Audience: Gallatin State Of The Waters Report
Moore	Navigating Partnerships Amongst Conservation Professionals
Myers	Learning From The Past: Rethinking Riprap
Prescott	Bitterroot Watershed Restoration: Addressing Nonpoint Source Pollution
Schmidt	Watershed-Based GIS Interface For Riparian Vegetation Monitoring And Management
Stockfisch	A Collaborative Effort To Conserve Riparian Areas In The Flathead Valley
Stout	Integrating Drought Planning And Watershed Restoration
Sweet	The 2015 Climate Atlas Of Montana
Swinney	Groundwater Assessment Of The Logan Area, Gallatin County, Montana
Thomas	Inventory and Assessment of Poindexter Slough in the Beaverhead River Drainage near Dillon, Montana

Thomson	Determining Water Sources And Ages Via Isotope Geochemistry In Big Sky, Montana
Veth	Getting It On The Ground; How The Forest Service Implements Projects From Conception To Completion.
Vinyard	Algal Response To Reductions In Nutrient Loading In The Clark Fork River
Wall	Engaging Montana's Communities In Water Quality Research And Management
Washko	Understanding Restoration Success In The Big Hole Watershed By Addressing Post-restoration Biological And Community Responses Within The Context Of Project Summarization.
Watson	Furthering Rural, Community-driven Drought Mitigation In The Blackfoot Watershed
Wilson	Bozeman Creek E. Coli Microbial Source Tracking Summer 2015
Zimbric	Building Collaboration Around Water, Climate, And Agriculture In The Last Best Place

7:00 PM **Banquet** Parlors AB

7:30 PM **Special Speaker. Phil Farnes "*Reminiscing 60 years as a Snow Hydrologist - Then and Now*"**

8:30 PM **Photo Contest**

(Closing announcements)

TECHNICAL SESSIONS

Friday, October 9, 2015 Parlors C & D

7:00 AM **Gather for Coffee and Conversation with Colleagues**

	Climate and Water SESSION 5 Parlor C Moderator: Chuck Dalby	Speaker	***Water Issues and Management I*** SESSION 6 Parlor D Moderator: Willis Weight	Speaker
8:00 AM	Using Simple Dynamical Modeling To Assess Functional Differences Between Catchment Types	Heren-deen	Updates To Montana's MS4 General Permit	Peterson
8:20 AM	Using Data from Mountain Climate Sites for Operations of Water Resources	Farnes	Urban Stormwater Conservation Area	Sowles
8:40 AM	Implementation Of The Measurement, Supply, And Water Conservation Recommendations From The 2015 Montana State Water Plan	Folnagy	Impacts of Implementing Best Management Practices Within the Belle Fourche Irrigation District	Oswald
9:00 AM	The Montana Climate Office And $P = Q + E + \Delta S$	Sweet	Populating An Ecosystem-Scale Model To Support The Development Of A Selenium Water Quality Criterion For Lake Koocanusa That Is Protective Of Fish Species	Naftz
9:20 AM	Simulated Effects Of Climate Change On The Hydrology And Fish Assemblages Of Northern Great Plains Streams	Chase	PCB Remediation In Big Spring Creek: Using Science To Inform Management Decisions	Skaar
9:40 AM	Montana StreamStats	McCarthy	Connecting Soil Water, Groundwater And Streams To Inform Nitrogen Sources And Flux Through A Dryland Agricultural Landscape In The Upper Missouri River Watershed	Sigler

10:00 - 10:20 AM **BREAK** *Be sure to vote for a new Treasurer!*

TECHNICAL SESSIONS

Friday, October 9, 2015 Parlors C & D

10:20 AM ***Surface Water*** — **SESSION 7 Parlor C** | ***Water Issues and Management II*** — **SESSION 8 Parlor D**

	SESSION 7 Parlor C Moderator: Sharon Bywater –Reyes	**Speaker**	**SESSION 8 Parlor D** Moderator: Jennifer Harrington	**Speaker**
10:20 AM	The Yellowstone River Cumulative Effects Study- 15 Years In The Making A Framework For River & Floodplain Design:	Boyd	Gallatin Microplastics Initiative	Walenga
10:40 AM	The Clark Fork River Remediation And Restoration Project	Bucher	Missoula Wastewater Treatment Plant Moves Toward Zero Waste	Watson
11:00 AM	Using Channel Migration Mapping To Develop Restoration Strategies For the Plains Reach Of The Clark Fork River	Dunn	Fracking In Montana: What Are The Questions About Water?	Weight
11:20 AM	Benefits Of Using A 2-D Hydrodynamic Model (FLO-2D Vs. A 1-D Model (HEC-RAS) For Assessing Overland Flow Paths And Localized Floodplain Storage.	Lehigh	Satellite-guided Hydro-economic Analysis For Integrated Agricultural Land And Water Management	Maneta
11:40	TBA		Changing Water Consumption In A Changing Landscape: A GIS-based Approach To Comparing Domestic And Agricultural Consumption	Sutherland

12:00-12:15 ***BREAK***

12:15- 12:30 PM **CLOSING PLENARY Parlor CD**

Announcements - Officer, Photo Awards, Student Awards

1:00 PM **Ground Water Assessment Program Steering Committee Meeting – Parlor A**

KEYNOTE SPEAKER

Eloise Kendy, Ph.D.
Senior Freshwater Scientist
The Nature Conservancy
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Eloise joined The Nature Conservancy in 2006 to keep rivers flowing and healthy, in harmony with economic development. Based in Helena, Montana, she provides strategic and technical support to innovative water-sharing agreements across the West, including bi-national efforts to restore the Colorado River Delta in Mexico. With international colleagues, previously she developed and helped implement ELOHA (Ecological Limits of Hydrologic Alteration), a scientific framework to establish statewide streamflow criteria.

Dr. Kendy has written, lectured, and testified on environmental flows, groundwater–surface water interaction, and water management. Prior to joining the Conservancy, she was a consulting hydrogeologist, a hydrologist with the U.S. Geological Survey, a hydrologist and policy analyst with the International Water Management Institute, and a legislative aide to U.S. Senator Harry Reid. Her research has been published in *Water Resources Research, Ground Water, Hydrological Processes, Journal of Hydrology, Agricultural Water Management, Water Policy, Freshwater Biology, Water International*, *University of Montana Public Land and Resources Law Review*, and other journals.

She earned her Ph.D. in 2002 in Environmental Engineering from Cornell University (Ithaca, NY), her M.S. in 1986 in Hydrogeology from The University of Wisconsin (Madison), and her B.A. in 1983 in Geological Sciences from the University of California (Santa Barbara). She holds Professional Geologist and Hydrogeologist licenses in Washington State.

Abstract

Just Add Water: Historic Return of the Colorado River to its Delta, United States and Mexico

On May 15, 2014, the Colorado River reached the sea for the first time in decades. This was but one highlight of an unprecedented experiment in binational water management – the world's first transboundary water allocation for the environment. Minute 319, signed by Mexico and the United States in 2012, changes the way the two countries share water in the over-allocated Colorado River basin. One of its provisions is a "pulse flow" of 105,000 acre-feet of water released from Morelos Dam into the parched Colorado River delta. Delivered in March-May 2014, the pulse flow was intended to emulate the ecological functions of a natural flood, enabling native cottonwood and willow trees to germinate. Subsequent "base flows" nurture the seedlings until their roots extend to the water table. Restoration sites were strategically located about 50 miles downstream from the dam, where a high water table can sustain the newly established riparian forests. Using far less than one percent of the river's natural flow, this is the first step toward restoring the formerly resplendent delta, home to more than 380 bird species and a key stopover on the Pacific flyway. An interdisciplinary, international team of scientists defined the flow's delivery schedule to maximize native plant recruitment and minimize transmission losses. This presentation describes the experimental design, monitoring program, initial results, and surprises.

KEYNOTE SPEAKER

Doug Jackson-Smith

Dr. Douglas Jackson-Smith is a professor at Utah State University. He has been lead or co-investigator on numerous major grants focused on water issues. Although biophysical scientists are responsible for most research on water systems, Dr. Jackson-Smith views the challenges of water sustainability as essentially "people problems." He will provide examples of how integrating social science is critical to greater water sustainability.

SPECIAL SPEAKERS

Tim Davis, Administrator
Water Resources Division
Montana Department of Natural Resources and Conservation
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Tim Davis became Administrator of the Water Resources Division at the Montana Department of Natural Resources and Conservation in 2010. As the Water Resources Division Administrator, Tim oversees a dedicated staff who protect Montana's 350,000 filed water rights, review applications for new water rights appropriations and changes to existing water rights, market over 309,000 acre feet of water per year from 24 state projects, as well as administering Montana's dam safety, floodplain management, and statewide water planning statutes. Tim has worked on land and water use, community development, and natural resource issues for over 20 years. Tim grew up in Lander, Wyoming and now spends his free time playing in the mountains with his family including his beautiful wife and daughter and their two dogs.

Jason Mohr
Research Analyst
Montana Legislative Environmental Policy Office
Capitol Building, Room 171
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Mr. Mohr is a research analyst for the Legislative Environmental Policy Office. He works as staff for the House Fish, Wildlife, and Parks Committee and the Water Policy Interim Committee. He previously worked for the Legislative Audit Division.

Mr. Mohr has a bachelor's degree in chemistry from Adams State College (Colo.) and a master's degree in journalism from the University of Montana

BANQUET SPEAKER

Phil Farnes

Phil has been involved with the snow survey and water supply forecasting program in Montana and northern Wyoming since 1954. He has served as Civil Engineer, Hydrologist and Snow Survey Supervisor in Montana and Data Collection Office Supervisor for Montana and Northern Wyoming. Since retirement from the Soil Conservation Service, he has been a consultant specializing in mountain hydrology and climatology. Phil is Montana AWRA's first *Water Legend*.

Investigation of Hyporheic Microbial Biofilms As Indicators Of Heavy Metal Toxicity In The Clark Fork Basin, Montana

Elliot Barnhart, U.S. Geological Survey, 3162 Bozeman Ave., Helena, MT 59601, USA, (406) 457-5921, epbarnhart@usgs.gov Additional authors: Chiachi Hwang, Center for Biofilm Engineering, Montana State University, NicholasBouskill, Earth Sciences Division, Lawrence Berkeley National Laboratory, Michelle Hornberger, U.S. Geological Survey, Matthew Fields, Center for Biofilm Engineering, Montana State University.

Water-saturated sediments that underlie a stream channel contain microbial biofilms that are often responsible for the majority of the metabolic activity in river and stream ecosystems. Metal contamination from mining effluent can modify the biofilm community structure, diversity, and activity. Developing a mechanistic understanding of the biofilm response to metal contamination could provide a useful bioindicator of metal toxicity due to the ease of standard biofilm sampling, environmental ubiquity of biofilms and the rapid response of biofilms to environmental perturbation and metal toxicity. Here we present data on the structure of the biofilm community (e.g., microbial population composition and diversity) and trace metal concentrations in water, bed sediment and biota (benthic insects) across 15 sites in the Clark Fork Basin. Sample sites were selected across a historically-monitored metal pollution gradient at shallow riffles with bed sediment predominantly composed of pebbles, cobbles, and sand. Bed-sediment samples (for biofilm analysis) were obtained from the top 20 centimeters of the hyporheic zone and sieved using sterile sieves to obtain homogeneous sediment samples with particle sizes ranging from 1.70 to 2.36 millimeters. Linear discriminant analysis and effect size statistical methods were used to integrate the metals concentration data (for water and benthic-insects samples) with the microbial community analysis to identify microbial biomarkers of metal toxicity. The development of rapid microbial biomarker tools could provide reproducible and quantitative insights into the effectiveness of remediation activities on metal toxicity and advances in the field of environmental biomonitoring.

Big Sky Watershed Corp: Four Years Of Service On The Clark Fork

Molly Barth, Big Sky Watershed Corps Member, Trout Unlimited, Big Sky Watershed Corps, 138 Mount Ave. Missoula, MT 59801, USA, mafbarth@gmail.com

The Big Sky Watershed Corps (BSWC) is an AmeriCorps program in partnership with the Montana Conservation Corps, Montana Association of Conservation Districts, and Montana Watershed Coordination Council . BSWC began in 2012 as a way to increase the capacity of watershed organizations throughout state of Montana while developing a cadre of young conservation professionals. BSWC members serve 10.5 months at their host site and focus on the programs three major goals: watershed health and protection, watershed education, and outreach and volunteer generation. BSWC members have contributed meaningful work throughout the Clark Fork River Basin over the past four years with the help of host site organizations such as Trout Unlimited, the Bitter Root Water Forum, Blackfoot Challenge, Clark Fork Coalition, Lolo National Forest/Lolo Watershed Group, Flathead Lakers, Watershed Restoration Council, and the Watershed Education Network. Past work includes restoration planning, research, monitoring, hands-on field projects, volunteer generation, and community education. Many BSWC members continue on to permanent watershed conservation related positions in their respective areas, further illustrating the immense capacity of the program to foster leaders who have can have huge positive impacts on restoration efforts in the Clark Fork River Basin.

The influence Of Topography And Spatial Patterns Of Soil Hydraulic Conductivity On Groundwater Response Across a Forested Hillslope

Mariah Bell, University of Montana, 32 Campus Drive, Watershed Hydrology Lab, Missoula, MT 59812, USA, (208) 819-6226, mariahbell.email@gmail.com, Additional Authors: Brener De Almeida Oliveira, University of Montana.

Hydrologic connectivity represents the development of a transient water table between hillslopes and streams and is a requisite for discharge in forested mountain landscapes. Many studies have indicated that topographic convergence of hillslope area leads to more sustained hydrologic connectivity to streams. However, we still do not fully understand how soil heterogeneity may lead to differences in subsurface flow rates, and therefore runoff contributions, across hydrologically connected hillslope positions. To address this knowledge gap we collected 260 measurements of saturated hydraulic conductivity (Ksat) across a 350,000 m2 hillslope in the Lubrecht Experimental Forest, MT. We will compare the spatial patterns of Ksat to shallow groundwater responses across a network of 30 recording wells and changes in streamflow measured at the base of the hillslope. Our preliminary analyses indicate that Ksat is lower in topographic low points relative to planar and divergent positions. These are also locations that exhibited more sustained hydrologic connectivity and elevated shallow groundwater heights. These initial observations suggest a linkage between landscape topography, soils, hydraulic conductivity and the duration and rate of source area contributions to streams.

Shallow Groundwater Quality And Geochemistry Of The Shields River Drainage Basin, Southwest, Montana

Daniel Blythe, hydrogeologist, Montana Bureau of Mines and Geology, Groundwater Assessment Program, 1505 W. Park Street, Butte, MT, 59701, USA, dblythe@mtech.edu.

In 2013 water samples were collected from 33 domestic wells, 2 springs, and 3 streams in the Shields River Basin (Basin) to describe groundwater quality and assess potential impacts from exploratory oil and gas drilling that took place from 2007 to 2009. Sample locations were selected near and distant from oil and gas drilling, and in areas susceptible to contamination. Samples from surface water sites were collected in October 2013 to characterize base flow. Samples were analyzed for major ions, trace metals, and water isotopes of oxygen and hydrogen. A subset (24) of samples were analyzed for tritium and organic constituents (GRO, DRO, BTEX, methane, ethylene, and ethane). Shallow groundwater and streams are generally calcium- or sodium-bicarbonate type water with total dissolved solids (TDS) concentrations less than 300 milligrams per liter (mg/L). Some wells produce either sodium-chloride or sodium-sulfate type water. The sodium water types suggest that ground water flow in bedrock is slow with more rock-water interaction. Water recharged prior to the mid-1950s (tritium < 0.8 TU) is generally a sodium type; whereas water recharged since the 1950s (tritium > 4 TU) is generally a calcium type. No dissolved organic constituents were detected, with the exception of trace concentrations.

Community Conservation: Watershed Restoration At Bozemans Story Mill Park

Katherine Boyk, Big Sky Watershed Corps Member, Greater Gallatin Watershed Council, PO Box 751, Bozeman, MT, 59771, USA, (406) 551-0804, katherine@greatergallatin.org.

Before the 54-acre Story Mill Community Park in north Bozeman opens to the public, the historic agricultural property is undergoing extensive stream and wetland restoration. Over a half-mile of the East Gallatin River, a critical floodplain of Bozeman Creek, and the largest wetland within the city are being enhanced to improve water quality on two impaired streams, filter urban stormwater runoff, reduce flooding, and improve wildlife habitat. This significant restoration project is the result of a unique partnership—led by the Trust for Public Land—between local nonprofits, scientists, governmental agencies, and supportive community members. Numerous stakeholder surveys have guided the park design and restoration process. An important component of the restoration work is ongoing monitoring projects, including research by Montana State University students and water quality monitoring by volunteer citizen scientists with Gallatin Stream Teams. This poster will outline the process of developing a restoration project through diverse partnerships, with an emphasis on stakeholder and community engagement.

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RESPEC

Montana University System Water Center

Montana Department of Environmental Quality (DEQ)

Aquatic Informatics

Montana Watershed Coordination Council

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Hydro Solutions Inc

Gallatin Local Water Quality District

The River Center — Center for Riverine Science and Stream Re-naturalization, The University of Montana

Montana AWRA

Characterization Of Produced-Water Chemistry Of The Williston Basin, Montana, North Dakota, And South Dakota Through 2014

Rod Caldwell, USGS, 3162 Bozeman Ave., Helena, MT 59601, USA, 406-457-5933, caldwell@usgs.gov. Additional authors: Zell Peterman, U.S. Geological Survey, Tanya Gallegos, U.S. Geological Survey .

Since 2004, the Williston Basin has experienced dramatically increased oil and gas production due to advancements in unconventional drilling technologies and large-scale energy development. During oil and gas extraction, large volumes of co-produced fluids are brought to the surface along with the targeted hydrocarbons. These co-produced fluids, termed produced waters, include formation water, hydraulic fracturing fluids, and other combinations of waters and chemicals used during the course of well drilling, development, and treatment. Produced waters may contain dissolved inorganic constituents, dissolved organic compounds, radionuclides, dispersed oil, bacteria, and solids. Although industry safeguards exist to minimize risks to ambient water quality, inadvertent releases of produced water to both surface-water and groundwater resources are of concern. The U.S. Geological Survey (USGS) evaluated historical (1935 to 2013) produced-water chemistry data and collected and analyzed additional water-chemistry samples from the Williston Basin. Collectively, these data have been used to characterize the produced-water chemistry of the region. Data have been compared to U.S. Environmental Protection Agency maximum contaminant levels (MCLs), secondary drinking water regulations (SDWRs), and aquatic life criteria (ALC). The USGS National Produced Waters Geochemical Database (NPWGD) includes data from nearly 3,500 sites (over 10,600 analyses) in the Williston Basin. These samples are typically sodium-chloride brines with a median total-dissolved solids (TDS) concentration of 273,500 milligrams per liter (mg/L), which is markedly greater than the TDS of modern sea water (34,500 mg/L) and also greater than the median concentration of samples from a primary aquifer used for drinking water, the upper Fort Union Formation (1,300 mg/L). TDS and major-ion concentrations in the NPWGD database range over several orders of magnitude. The USGS has collected produced waters from the Bakken and Three Forks Formations within the Williston Basin since 2010. Most of the sampled sites were in production for at least one year and treatment was discontinued before sampling in order to examine the "end-member" produced-water composition. Samples were analyzed for constituents including trace elements and selected isotopes of oxygen, hydrogen, radium, and strontium. Preliminary results indicate that oxygen, deuterium, and strontium isotopes may be used to distinguish water source(s). Similar to the NPWGD, the dominant water type is sodium-chloride brine; however, TDS concentrations are generally higher, with a median concentration of 325,000 mg/L compared to 250,000 mg/L for Bakken Formation samples in the NPWGD. Results from this sampling are much less variable with fewer outliers than found in the historical data. Although produced waters would not be considered a source of drinking water as nearly all exceed USEPA MCLs and SDWRs, even a small fraction of produced water introduced into a fresh water source could have detrimental impacts. The TDS of most samples were several hundred times higher than the SDWR of 500 mg/L. Combined radium-226 and radium-228 values, only available through the USGS sampling efforts, greatly exceeded the 5 picocurie per liter (pCi/L) MCL in all analyzed samples with a median value of nearly 3,700 pCi/L. Median ammonia values were about 2,000 mg/L, far exceeding the acute ALC of 7 mg/L.

Management Intensive Grazing And Drought Resilience

Chris Carparelli, Beaverhead Watershed Committee, Big Sky Watershed Corps, 229 N Pacific St., Dillon, MT, 59725, USA, beaverheadcd.bswc@gmail.com

Management intensive livestock grazing usually involves high stocking rates and frequent movement between numerous paddocks within a pasture. This management technique can be beneficial to livestock performance, grass productivity, soil health, and reduction of input costs. All of these benefits contribute to the economic and environmental resilience of a livestock operation to drought.

Water Quality In The Gallatin-Madison Ground Water Characterization Study

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The Montana Ground Water Assessment Program sampled 300 water wells and 20 springs between January 2008 and December 2012 completed in basin-fill and bedrock aquifers in the Jefferson, Gallatin, Upper Madison, and Lower Madison River basins. Most samples were analyzed for major ions and trace metals; but samples for radon (69 sites), tritium (108 sites), and oxygen and deuterium (163 sites) were also collected and analyzed. Total dissolved solids (TDS) concentrations ranged from 66 to 1,771 mg/L. Median TDS for basin-fill aquifers was 361 mg/L, and the median for bedrock aquifers was 368 mg/L. Most of the groundwater has a calcium-bicarbonate signature. Water from a few samples associated with Cretaceous sandstones and shales (Gallatin basin's Big Sky area) and basin-fill adjacent to warm water ascending faults from depth (Upper and Lower Madison basin) had sodium-bicarbonate signatures. In the upper and lower Madison basins, arsenic concentrations exceeded 10 □g/L at 31 sites; 30 results were from wells completed in basin-fill aquifers and one result from a well completed in a fractured bedrock aquifer. Nitrate concentrations ranged from non-detectable (at 93 sites) to 24 mg/L. Only three samples had concentrations above 10 mg/L—all from bedrock aquifers. Forty-four sites had concentrations between 2.0 and 10.0 mg/L, indicating potential human impact. Radon values ranged from 57-38,000 pCi/L. Five samples from four sites (three in the Upper Madison basin and one in the Jefferson basin) exceeded the EPA's 4,000 pCi/L Alternative Maximum Contaminant Level. Tritium results, measured in tritium units (TU), indicate that 87 samples are either "modern" (water recharged since the1960's; TU values between 5.0 and 15.0) or a mixture of "modern" and "pre-bomb" water (water recharged before the1950's; TU values >0.8 and < 5.0, or > 15.0). However, 21 sites, distributed equally between bedrock and basin-fill aquifers, had tritium values of < 0.8 TU indicating that the water recharged prior to the 1950's. Oxygen and deuterium isotopes plot close to the Global Water Meteoric Line and in a relatively tight cluster indicating a common meteoric origin. All the water-quality data are available from the GWIC database at (http://mbmggwic.mtech.edu).

Pesticide Monitoring By The MDA Groundwater Protection Program; Addressing Data Gaps For Management Needs.

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The Montana Agricultural Chemical Ground Water Protection Act and Administrative Rules states that the Montana Department of Agriculture (MDA) shall conduct monitoring programs to determine: 1) whether residues of agricultural chemicals are present in groundwater and 2) the likelihood of an agricultural chemical to enter groundwater. To fulfill these goals, the Montana Department of Agriculture Groundwater Protection Program (GWPP) has maintained a network of permanent monitoring wells (PMWs) throughout Montana and conducted localized regional special projects to monitor pesticides in groundwater since 1992. Monitoring data collected by the GWPP effectively addresses objective 1, but lacks supporting data sets needed to effectively address objective 2. We have identified program changes in data collection and management methods that we hope will add context to our analytical data, begin to address the likelihood of pesticides to enter groundwater, and eventually allow us to develop a ranked groundwater vulnerability model to identify future monitoring needs and support management recommendations. Pesticide presence in groundwater is closely linked to anthropogenic patterns in land use and management and hydrologic patterns affecting pesticide transport dynamics. Our long-term dataset (ten years from 2006-2015) points to the complexity of monitoring pesticides in groundwater. The most frequently detected analytes (≥10% detection frequency statewide) have similar chemical properties related to vadose zone transport, but have varied statewide spatial distribution and varied use patterns across varied landcover and land use. The influence of many factors affecting pesticide distribution in groundwater necessitates ancillary site data to predict the likelihood of any pesticides to enter groundwater, and to predict the presence of specific pesticides. Ancillary data will include in-field collection with CTD (conductivity, temperature, depth) sensors in all of our permanent monitoring wells and in-office collection of spatial information like geology, land use, and soils data from outside sources. Monitoring efforts will ideally be informed by understanding times and conditions under which pesticide presence and concentration at its maximum, and the ability to link pesticide presence in groundwater with land use and management patterns.

Surface Water Data Collection And Application For Effective Water Management

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The need for improved data collection, monitoring, and studies is identified throughout the 2015 Montana State Water Plan. This poster will provide a brief overview of the existing gaging network and plans to expand the network throughout Montana. Along with state, federal, and private cooperators, DNRC is in the process of establishing, operating, and maintaining a network of 100 permanent stream gages to gather and distribute real-time streamflow information on smaller streams and tributaries not monitored through the USGS Co-Op Program. These stream gages will be strategically placed and their data will be used to support decisions related to integrated management of Montana's water resources. DNRC and MBMG intend to collect and disseminate surface-water data in Montana as part of the Surface Water Assessment and Monitoring Program. Montana citizens will be able to use real-time streamflow information to implement plans and agreements that address locally developed drought, fish habitat, water leasing, or water supply objectives.

Park Conservation District Jurisdictional Streams Mapping Project

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Park Conservation District (Park CD) serves a variety of purposes in Park County and the greater Southwest Montana community, and its overarching goals, as stated in its mission, is "to guide Park County in the conservation and management of soil, water, cropland, grazing lands, weeds and small acreages by providing leadership in conservation planning, technical assistance, education resources, and resource management tools and inventories." As a portion of this goal, Park CD is tasked with administering the 310 law permitting process for landowners who which to engage in activity directly on perennial streams and rivers and their banks. This permitting process is important to ensure that projects do not significantly impact streams in irreparable ways and, through review of the project plans and inspection of the site, confirm that the proposed activity is done in a way that minimizes long term effects. Because the Act only provides jurisdiction over perennial streams, leaving intermittent streams outside its scope, landowners and the CD are both advantaged if they are able to ensure that the stream in question is truly perennial, and thus requiring the 310 permit. As part of my term serving with Park CD, I have been tasked with creating a jurisdictional map, in both electronic and paper forms, that will clearly delineate which streams are under the jurisdiction of the 310 law and therefore require permits. In creating this map, landowners will know in advance whether they will need to submit a permit for their proposed activity and the CD and its partners will know whether they will need to expend time and resources to review the project. In doing so, we are furthering conservation and ensuring that regulations are met in a more effective, and efficient, manner.

Much To Do About A Brownfield: Missoula White Pine And Sash Superfund Site.

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Since the development of the Hellgate Trading post, a flour mill and sawmill on the Clark Fork River in the 1800s, area industries have helped support Missoula. But such industries can leave a legacy of contamination. The Missoula White Pine and Sash (MWPS) mill on Missoulas north side used wood preservatives (pentachlorophenol and diesel mixtures) that leaked, over decades, into the soil and water. These chemicals could contaminate Missoulas sole-source aquifer, and ultimately affect public health. At MWPS, investigations and some mitigation and clean-up have been done over the two decades since the site was placed on the Montana Superfund National Priorities list. However, no final Record of Decision (ROD), stating the level of clean up required, was released until February 2015. Cleanup of hundreds of Montana 'brownfields', like MWPS, has been slowed by the amending of legislation and regulations over time. Many stakeholders will be affected by this long-awaited cleanup decision. However, the Montana Department of Environmental Quality (DEQ), the agency in charge of the Superfund site, only recognizes as stakeholders: Huttig Sash and Door (owners of White Pine Sash and Pole) and three current site property owners (the city of Missoula, Zip Beverage, and Scott Street Partners (SSLLP)). The residents that live next to the site are not considered stakeholders by the DEQ. To effectively remediate the MWPS site, changes are needed in the nature of of community involvement, the options for methods to clean the site, and the laws that currently govern the actions of the DEQ. Additional excavation is needed in key parts of the site, and In-situ and Ex-situ bioremediation of the surface and subsurface soil and the groundwater need to be explored.

A Groundwater Contaminant Transport Site Investigation On The Fate Of Hexavalent Chromium Cr(VI), Mouat Industries Site, Columbus, Montana.

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Historical processing of Cr ore at the Mouat Industries site led to Cr contaminated groundwater within the city limits of Columbus, MT. This site has been listed on the Environmental Protection Agency's National Priority List since 1986. Soil remediation was conducted at the site in 1994 by excavating contaminated soils, mixing with an acid/ferrous sulfate solution (reducing hexavalent Cr (CrVI) to trivalent Cr (CrIII)), neutralizing the soil with lime, securing the soil into blocks with cement, and burying the blocks in an on-site in a repository. Portions of the contaminated soils that were below the clean-up threshold were not treated, but were used to backfill the excavated area. A liner was not placed above or beneath the repository, and the cover is clean foreign soil and gravel or grass. Aqueous Cr(VI), a carcinogen, remains present at variable concentrations, locally above the minimum contaminant level (MCL) within and down gradient of the site. Groundwater monitoring and sampling has been ongoing since 1996; however concerns remain about Cr mobility and transport off-site. The site has not met the criteria of two consecutive sampling events achieving total Cr levels less than 0.1 mg/L. As part of this investigation, water quality samples have been collected from 8 additional wells (22 total), leaching studies will be conducted on repository block material, sorption studies will evaluate the role of aquifer media in Cr transportation, and Cr(VI)/Cr(III) speciation data provides spatial variation and confirmation of the existence of Cr(VI). Data collected previously and data collected as part of this investigation will be used to characterize the site conditions. Geochemists workbench (GWB) and PhreeqcI geochemical modeling software are used to investigate the redox conditions, Cr speciation, saturation indices, and other geochemistry of the groundwater. GWB is used to simulate groundwater mixing through the repository and down gradient towards the Yellowstone River. GMS-MODFLOW is used to simulate groundwater flow conditions, hydrogeologic properties, and contaminant transport. Results of this study will be used to better identify sampling schedules based on groundwater flow and geochemistry.

Identifying And Prioritizing Aquatic Mitigation Project Sites In Montana

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In Montana, restoration-focused organizations face the daunting challenge of overwhelming restoration need with limited funds and personnel resources. Montana Aquatic Resources Services, Inc., (MARS) is approaching wetland and stream restoration, enhancement, and protection through multiple avenues including our Statewide In-Lieu Fee Mitigation Program and purchasing Channel Migration Easements on the Yellowstone River. MARS is also developing new markets through pioneering work in Groundwater Mitigation Banking and Water Quality Trading, both of which could provide funds for restoration work around Montana. As a Big Sky Watershed Corps member with MARS, I have been involved in the process of planning, prioritizing, negotiating, and evaluating potential restoration sites for our mitigation program. This poster lays out the process MARS undergoes to identify and prioritize potential restoration sites. It also reflects on some of MARS' challenges and lessons learned so far in our fledgling organization, and provides some specific examples of our project efforts. It is an evolving process, but one with great promise that we hope to improve upon and use to inform our future programs to conserve Montanas water into the future.

Assessing The Capacity Of Natural Infrastructure To Increase Water Storage, Reduce Vulnerability To Floods, And Enhance Resiliency To Climate Change

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Climate change is projected to affect the quantity, quality, and timing of water availability in Montana. These projections have raised concerns about water storage capacity in many basins in the state. The 2015 Montana State Water Plan identifies the need for increased water storage and retention as "an important tool for meeting future demands and responding to climate change" (MT DNRC, 2015). Recognizing the role that natural infrastructure (i.e., riparian areas, floodplains, and wetlands) plays in slowing runoff and promoting groundwater recharge (i.e., water storage), water managers are increasingly interested in quantifying natural storage potential. However, for natural storage projects to be successful there needs to be early engagement with various stakeholders to identify their perceptions and needs. This poster presents an overview of a research project designed to assess the capacity of natural infrastructure to increase water storage, reduce vulnerability to floods, and enhance resiliency to climate change. This research uses the Musselshell River basin, which experienced unprecedented flooding in 2011 and 2014, as a case study for assessing the potential for natural water storage. The objectives of the study include: 1) quantifying natural storage potential and 2) identifying socio-political barriers and opportunities for restoring and enhancing natural infrastructure in the basin.

Landscape Heterogeneity Modulates Forest Sensitivity To Climate

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Elevation dependent snowmelt magnitude and timing strongly influences net ecosystem productivity in forested mountain watersheds. However, previous work has provided little insight into how internal watershed topography may modulate plant available water, microclimate and therefore forest growth. We analyzed 331 tree cores from three coniferous tree species across a range of elevations, landscape positions and aspects in the Lubrecht Experimental Forest, Montana, USA. We compared the annual basal area increment (BAI) to measures of the annual climatic water deficit, hydro-meteorological data in sideslope and hollow positions, and topographic indices derived from a LiDAR digital elevation model. Results indicate strong relationships between measures of BAI and the topographic wetness index (TWI) , with differing slopes dependent on tree species (P. menziesii $r2 = 0.35$, P. ponderosa $r2 = 0.57$, L. occidentalis $r2 = 0.53$). Generally, trees located in wetter landscape positions (hollows) exhibited greater annual basal growth relative to trees located in drier landscape positions (sideslopes). At the watershed scale, we evaluated the relationships between convergence and divergence, LiDAR derived estimates of basal area and seasonal patterns of the Landsat derived Normalized Difference Vegetation Index (NDVI; 1984-2012).These indicated differential growth response due to elevation gradients, irradiance and local convergence and divergence. Wetter landscape positions have higher values of greenness and basal area than drier positions. These observations suggest that the topography of semi-arid watersheds is a necessary consideration for quantifying conifer productivity and resiliency, due to its impacts on local surface and subsurface water redistribution patterns.

Floating Islands For Wetland Restoration

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Floating treatment wetlands (FTW) provide a concentrated wetland effect by utilizing a buoyant matrix mat (made from recycled plastic) and natural vegetation to mimic what occurs naturally in healthy wetlands around the world. In addition to BOD and TSS removal, FTWs can also significantly reduce heavy metals, nitrate, ammonium and phosphate in a waterway. Aerobic and anaerobic bacteria colonizing on the expansive surface area of the floating matrix and among the roots and rhizomes of the plants provide the majority of the treatment. The nutrient reduction provided by FTWs makes this technology ideally suited for storm-water and domestic wastewater treatment in a wide range of situations, including those where advanced regulatory discharge permit limits must be met. While being particularly suited for wastewater applications, FTWs are well suited for applications such as wetland construction, restoration and enhancement, as well as fishery habitat and waterfowl nesting islands. The floating islands can be engineered to support large structures for use as monitoring stations, floating docks, and spawning platforms. The presentation will focus on the various applications of floating treatment wetlands as a tool for ecological restoration and the improvement of surface waters throughout the world.

Sediment Connectivity Between Post-fire Debris Flows And Stream Channels In A Mountain Watershed

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Steep mountain streams with a snowmelt-dominated hydrology may be heavily influenced by wildfire-related erosion from hillslopes. We present research on sediment routing from hillslope to channel by examining the persistence of geomorphic impacts on channels by post-fire debris flows in Rye Creek, Montana, USA. Large fires and debris flow events occurred as recently as 2001 but observed debris fans pre-exist those events and may date to hundreds of years ago. We conducted GIS slope analysis of the creek and determined channel slope is still dominated by the impact of debris flows and resulting fans. There exists a pattern of low slope in up-fan reaches and high slope in down-fan reaches due to upstream deposition and downstream erosion. We observe a greater concentration of large (cobble-sized) and more angular clasts proximal to debris fans than in downstream reaches not impacted by debris flow events. Field observations and grain size distribution curves show that higher amounts of fine grained material exist in up-fan reaches and also far downstream, in a reach not impacted by debris flows. This downstream control reach also exhibits a more uniform slope and greater meanders than areas adjacent to debris fans. Grain size distributions and measures of slope agree favorably with the conceptual model of channel response described by Hoffman and Gabet (2008) in Sleeping Child Creek, Montana, USA. This suggests that while debris flows may be short, punctuated events, their impact leaves a long-lasting legacy that controls channel morphology for long time periods.

Nitrate-N And Nitrite-N Monitoring By MDA Groundwater Protection Program; Identifying Data Gaps And Adapting Data Collection To Address Program Goals And Management Needs.

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The Montana Agricultural Chemical Ground Water Protection Act and Administrative Rules states that the Montana Department of Agriculture (MDA) shall conduct monitoring programs to determine: 1) whether residues of agricultural chemicals are present in groundwater and 2) the likelihood of an agricultural chemical to enter groundwater. To fulfill these goals, MDA created the Groundwater Protection Program (GWPP). Since 1992, GWPP has maintained a network of permanent monitoring wells (PMWs) and conducted localized regional-scaled special projects throughout Montana to monitor agrochemicals in groundwater. To evaluate the effectiveness of our program, we have performed a critical review of our nitrate and nitrite monitoring programs. Through our PMW network and special project sampling we have collected over 2000 samples spanning across the state. To date one nitrite detection exceeded the human health standard, while 26.7 % of PMW samples and 10.5 % of special project samples exceeded the human health standard for nitrate. Though we cannot contribute all of the observed elevated concentrations as solely due to agricultural practices, we can conclude that a high number of these wells are, at least, influenced by agricultural practices. The difficulty in identifying the source of nitrate in wells with elevated nitrate concentrations highlights our current inability to accomplish our second objective. However, we have identified changes to our program that, we hope, will allow us to begin addressing the likelihood of agricultural chemicals to enter groundwater. We are moving forward with increased collection of ancillary data, which will add additional context to our water quality data. Our push for collecting more complementary data will include; in-field collection with CTD (conductivity, temperature, depth) sensors in all of our permanent monitoring wells and in-office collection of spatial information like geology, land use, and soils data from outside sources. Our goal is to combine our water quality data with these complementary data sets to develop a ranked groundwater vulnerability model for Montana. This model will serve as a tool to identify future monitoring needs and support best management practice recommendations across the state.

The behind-the-scenes Of Sampling And Analysis Plan Development: Linking Various Stakeholders Into Restoration Monitoring Design

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The success of habitat restoration rests on the ability to learn from restoration success and failure and employ adaptive management strategies along the way. This can only be accomplished through the implementation of an effective monitoring program. To achieve such a feat, a guide for monitoring efforts should be precisely laid out before monitoring is conducted. For the first several months of my Big Sky Watershed Corps term at Broadwater Conservation District, I charted the course of a time-consuming and tedious monitoring planning process, and dragged project partners along for the ride. This presentation will endeavor to explain the developmental stages of the Deep Creek Sampling and Analysis plan, with an emphasis on how to satisfy the interests of both science-centered and management-centered stakeholders when developing such a plan.

Aquatic Food Webs And Heavy Metal Contamination In The Upper Blackfoot River

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Legacy mining contamination is a widespread issue affecting water quality and fish habitat in Montana. Acid mine drainage (AMD), characterized by low pH and abundant heavy metals, can reduce aquatic invertebrate and fish abundance, resulting in complete elimination of aquatic biota in extreme cases. The loss of key macroinvertebrate taxa can have significant implications for ecosystem function, reducing the rate of nutrient processing and prey availability for fish. Biological interactions also play an important role in the movement of heavy metals in aquatic ecosystems as contaminants accumulate in food sources and are transferred to higher trophic levels. As a result, evaluating aquatic community response to contamination levels may provide important insights into how AMD affects ecosystem function and biological movements of heavy metals. Numerous studies have observed changes in invertebrate community composition in response to heavy metal contamination as tolerance levels of specific taxa are exceeded. However, fewer studies have specifically evaluated how changes in aquatic food webs along a contamination gradient influence metals accumulation in biota and transfer to higher trophic levels. As contaminated sites are remediated, it is important to understand how the relationship between environmental contamination levels and aquatic community composition influences food availability and heavy metals exposure to upper trophic levels. This study seeks to evaluate aquatic community response and changes in food web structure along a contamination gradient in a mining impacted stream. Metals concentrations in water, sediment and biota and channel morphology data were collected from sites impacted by the Mike Horse Mining complex in the headwaters of the Blackfoot River, Montana. Sixteen sites were selected for this study including nine reference sites and seven sites impacted by mining. The Mike Horse Mine began operating in the early 1900's and has affected water quality in the upper Blackfoot river for over 100 years, most notably with the failure of a large tailings impoundment in 1975. The ultimate goal for this study is to utilize functional trait data for aquatic invertebrates to evaluate changes in life-history, morphology, mobility, and ecological traits along a contamination gradient. Changes in dominant functional traits of aquatic invertebrate communities may have important implications for exposure pathways, food availability for upper trophic levels, and biological transfer of contaminants and help guide remediation of mining impacted streams.

Wild Trout Recovery Shows Effectiveness Of 20 Years Of Blackfoot River Basin Restoration Efforts

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To recover wild trout populations in Montana's Blackfoot River, stream restoration efforts began in 1990 to improve degraded stream habitats. About 30 high priority tributaries received various combinations of channel reconstruction, instream habitat structures, instream flow restoration, fish ladders and screens , and modification of grazing practices. To assess the effectiveness of these efforts, wild trout abundance in 18 of the streams was monitored for a minimum of 5 years post-restoration from 1989 and 2010. Before restoration, average trout abundance was significantly lower in the degraded streams when compared to reference sites. But only 3 years after restoration, trout abundance had increased and was no longer significantly different from the reference sites. In 15 of the streams, trout abundance continued to improve over 5 to 20 years after restoration. In 3 streams abundance declined due to the return of heavy riparian grazing and detrimental irrigation practices. Trout responded more quickly using restoration techniques that emphasized irrigation and instream flow techniques and more slowly for streams that required full channel reconstruction. Native trout responded more strongly to restoration efforts in the upper basin compared to the lower basin. Long-term monitoring (1988-2014) shows increases native trout numbers throughout the main stem river.

Strategies For Successfully Engaging Diverse Stakeholders In To Implement The Upper Gallatin River Watershed Restoration Plan

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A Watershed Restoration Plan (WRP) cannot be successfully implemented without significant community support. Since completing the Upper Gallatin River WRP in 2012, the Gallatin River Task Force has worked to plan and implement several long-term restoration projects in the Upper Gallatin Watershed. Ultimately, the success of these projects relies not only on high-quality scientific data, but also on the enthusiastic buy-in of a diverse group of stakeholders. Big Sky, MT, a rapidly developing resort community in Gallatin County, is a uniquely challenging community to engage. Throughout my term as a Big Sky Watershed Corps member, I have looked for creative ways to educate and involve key stakeholders. This presentation will outline the principle strategies used to engage a community as long-term monitoring data is converted into action. entering the Four Corners area, and development continues to intensify demand on groundwater and decrease agricultural recharge, flow

Summarizing Technical Water Resource Data For A General Audience: Gallatin State Of The Waters Report

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The Gallatin Local Water Quality District (GLWQD) is preparing a State of the Waters Report. Motivation for this report is based on the fact that long term water level and water quality data from the GLWQD groundwater monitoring well network have only been evaluated in a piecemeal way and should be reviewed comprehensively. Although this data is publically available, many citizens probably do not know where to find it or how to interpret it. This is a report that will include summaries of findings from major projects that have been conducted over recent years, brief summaries on contaminated sites, water quality data, and new information on water level trends from the long-term monitoring network wells. This document is intended to be a means for conveying technical information in an easy-to-understand format for the general public as well as for water resource managers, while not sacrificing critical details or complexities. Avoiding misinterpretation by the report preparer or the reader is important. We will show how we chose to summarize and display the data, and describe challenges that arose while creating the report.

Navigating Partnerships Amongst Conservation Professionals

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The increasing challenge with conservation projects nowadays is they are oftentimes multifaceted and therefore require a broad range of expertise from community outreach to stream monitoring techniques. This can be viewed as an opportunity to form strong partnerships with conservation professionals. Strong partnerships help build expertise, leverage funding, and share information and accomplishments. For my Big Sky Watershed Corps term at Wildlife Conservation Society Community Partnerships Program, I navigated a variety of partnerships relating to different projects including planning the Wildlife Speaker Series and coordinating beaver mimicry work. This presentation will endeavor to explain the key components that comprise a strong partnership critical to successful conservation work.

Learning From The Past: Rethinking Riprap

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Learning from the past is imperative when planning for the future. When thinking in terms of river restoration we can look back and see what was effective and then adapt to new challenges as they arise. Fifty years ago one of the common river bank restoration practices was to stabilize banks with cars and tires, otherwise known as “Detroit Riprap.” As part of my term with the Sun River Watershed Group and the Cascade Conservation District for the Big Sky Watershed Corps Program, I took a journey up the Sun River to analyze how the cars are faring today. This presentation aims to show the link between river health and bank stabilization methods. I will be focusing on how the Detroit Riprap compares to more natural stabilization methods and show how we are working towards converting to a natural system to allow for optimal river health.

Watershed Education: Using Partnerships To Ensure The Longevity Of Educational Programs

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The Bitter Root Water Forum (BRWF), as the non-profit watershed group of the Bitterroot Valley, is the Valley’s resource on any water related topic. To reach water users where they intersect with the resource, BRWF partners with natural resource professionals to offer education opportunities that are relevant and tailored to specific audiences. Ongoing youth education includes the Earth Stewardship Program, which brings natural resource professionals into seventh grade classrooms; and the Future Irrigators of the Bitterroot Field Trip, which takes Future Farmers of America students out of the classroom on a tour of Bitterroot Valley irrigation. Adult education has included workshops and realtor continuing education courses, and now includes an irrigation tour of the Bitterroot Valley. BRWF has built a sustainable educational presence through strong partnerships with teachers, irrigation districts, real estate agents, the Bitterroot Conservation District, Montana Fish Wildlife and Parks, the Forest Service, and the Bitter Root Land Trust, among others. Together these partnerships ensure the future of environmental education for the Bitterroot Valley.

Their River. Their Culture: Community Participation In Improving Access And Identifying Restoration Needs On Missoulas Urban River Corridor.

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Since the removal of the Milltown Dam in 2008, the Clark Fork River in downtown Missoula has become a hub of river recreation. Now that the water flows cleaner and healthier, the river has exploded in popularity for swimming, kayaking, paddle boarding, tubing, and all other forms of floatable watercraft. With this influx of river users, the river banks are becoming excessively eroded and native riparian vegetation is depleting, along with a host of other issues. This summer, I spent the majority of my time recruiting, training, and coordinating members of the community to document and monitor the sources of this erosion occurring on the downtown stretch of river. Throughout the summer, volunteers counted river users and distributed surveys. The data they collected will be used to help craft a restoration and access plan for this stretch of river. This poster explains the importance of involving community members when finding solutions to watershed issues and highlights some successes and struggles that I encountered along the way.

Watershed-Based GIS Interface For Riparian Vegetation Monitoring And Management

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Invasive species management is handled by counties and and public agencies which operate within political boundaries that do not necessarily respect watershed boundaries. Because Saltcedar is a riparian weed that tends to respect watershed boundaries, a management tool that can reconcile county and agency based weed management with watershed-based weed propagation can be helpful. This is an interface that allows data entry into a catalog which is organized based on the nested-watershed principle, so that information entered into a field associated with a HUC12 subwatershed propagates down to it's corresponding HUC10 watershed. This information can be viewed in tables with reconfigurable data fields, displaying such information as Last Survey, Last Treatment, Saltcedar Present/Absent, Access Logistics, etc. for use in statewide or basin-wide prioritizing or strategizing, and is scalable and adaptable for future needs. Information on infested, surveyed, or otherwise interesting watersheds can be viewed in ArcMap alongside other relevant information, such as the locally relevant political boundaries. This can help ensure that if saltcedar management is to take place in an area, all weed managers upstream and downstream of that area can be contacted, and this can prevent problems including reinfestation of a managed area by an upstream seed source. Also, detailed maps including infestation information, relevant boundaries, and area logistics can be produced easily and distributed for use in funding applications or project proposals.

A Collaborative Effort To Conserve Riparian Areas In The Flathead Valley

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Abstract submission for a Poster Presentation at 2015 MWCC/AWRA conference: Title - A Collaborative Effort to Conserve Riparian Areas in the Flathead Valley Submitted by - Megan Stockfisch, Big Sky Watershed Corps and Flathead River to Lake Initiative Date - 7/30/2015 The Flathead River to Lake Initiative (R2L) is a network of landowners, agencies, and non-profit organizations working to protect and enhance critical lands within the Flathead River valley. R2L partners have protected over 5,000 acres of prime habitat and farm land within the 100-year floodplain and restored nearly 4 miles (20 acres) of riparian areas. To supplement this protection, R2L partners also offer riparian restoration assistance to landowners. Through a partnership with the Big Sky Watershed Corps, partners have been able to implement the River Steward Program, which helped partners improve coordination to plan, implement, and maintain restoration projects. In addition, the River Steward Program has enabled the implementation of a comprehensive monitoring program to evaluate the success of restoration efforts and inform future practices. The Flathead watershed consists of a delicate harmony between water, soil, plants, animals and people. Our collaboration allows R2L partners to visualize this relationship from multiple perspectives, and bring together a range of expertise in such areas as: land protection, water quality, soil health, plant diversity, wildlife habitat, and best management practices. This approach enables partners to best serve the Flathead Valley Community by holistically addressing natural resource concerns. As the saying goes: "It takes a village to raise a child." Or in this case: to preserve our natural heritage.

Integrating Drought Planning And Watershed Restoration

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Developing a watershed restoration plan is an essential step for watershed groups beginning the process of restoring impaired streams to meet water quality standards. This planning process is necessary for prioritizing activities, identifying projects, and implementing restorative management. Drought planning can and should be a component of the activities outlined in a WRP. This poster will demonstrate projects and concepts that can benefit water quality and drought resilience using examples of restoration activities in development in the Ruby River watershed. Moreover, it will highlight the importance of planning on the sub-watershed level to make cumulative gains for the greater watershed area. It will also address the need for a diverse set of management practices to simultaneously address the effects of drought and water quality impairments using examples from the Ruby River WRP.

The 2015 Climate Atlas of Montana

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Montana benefits from a mix of maritime and continental climates that generate a high-quality water supply. We rely on that water supply. It grows our food, supports our recreation, and provides for our industries and communities. Climate variability can foster uncertainty about local water availability, which underscores the need to better understand trends in Montanas climate as how it varies over time and geographically. The Montana Climate Office produced the "Climate Atlas of Montana" to spark a conversation about how climate relates to the resources and industries we depend upon. As a living document, this collection of maps characterizes just a portion of what is understood about Montana's climate. The atlas draws from climate station data and satellite data to produce a statewide representation of time series data with examples of derived products. Perhaps it will provide some with a better understanding. It may inspire one to question and offer new insights into the complexities of Montanas climate.

Groundwater Assessment Of The Logan Area, Gallatin County, Montana

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The unincorporated community of Logan, in the northwestern corner of Gallatin County, Montana, is situated on a small alluvial terrace adjacent to the Gallatin River and is surrounded by exposed bedrock. Homes in the area are on small lots and use exempt wells for water supply and individual septic systems for wastewater treatment. There have been complaints of surfacing sewage in the past and some residents have expressed concerns that contaminated groundwater associated with septic systems, the nearby Logan landfill, and historical land use by the railroad in the area were negatively impacting their drinking water. Groundwater-quality data from the early to mid-2000's documented elevated levels of nitrate-N (nitrate+nitrite as nitrogen) in several domestic wells that exceeded the EPA MCL of 10 mg/L. In 2013, fifteen domestic wells were sampled to further evaluate drinking water quality. Water samples were analyzed for nitrate-N, chloride, boron, sodium, arsenic, iron, manganese, total coliform and E. coli bacteria, volatile organic compounds and several field parameters (pH, specific conductivity, dissolved oxygen, water temperature). Results from the targeted sampling indicate 6 of the 15 wells appear to show some evidence of impact from septic systems, with nitrate-N above 2 mg/L. Two of these wells had nitrate-N levels of 20.5 mg/L and 21.5 mg/L. Some of the wells showed high specific conductivity and/or chloride levels which are consistent with wastewater contamination, but not all showed this relationship. There was only a weak positive correlation between nitrate-N concentrations and chloride concentrations. Few wells showed both E. coli bacteria and elevated nitrate-N. Some of the E. coli bacteria and total coliform bacteria positive results could come from poor well sanitation conditions. Several wells were sampled for volatile organic compounds with no detectable levels, suggesting direct contamination from the landfill and railroad is relatively unlikely.

INVENTORY AND ASSESSMENT OF POINDEXTER SLOUGH IN THE BEAVERHEAD RIVER DRAINAGE NEAR DILLON, MONTANA

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Students in Environmental Field Studies class at the University of Montana Western (UMW) in Dillon, Montana conducted a baseline inventory and assessment of Poindexter Slough, a former channel of the Beaverhead River located approximately 3.0 miles south of Dillon, MT. During the period of September 22nd to October 15th, 2014, the students assessed the stream morphology, in-stream macroinvertebrates, riparian vegetation and stream habitat for the entire 4.73-mile length of Poindexter Slough. The purpose of the study was to gather baseline data to assess a fish-related riparian restoration and improvement project by the Montana Fish, Wildlife and Parks and The Beaverhead Watershed Committee. The project was supervised by Dr. Robert C. Thomas, Professor of geology in the Environmental Sciences Department at UMW. The study area included twenty-two cross-sections placed from the diversion of the slough

Determining Water Sources And Ages Via Isotope Geochemistry In Big Sky, Montana

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The Big Sky Ski Resort in southwest Montana is experiencing rapid growth, in both permanent and tourist populations. With ongoing construction of new housing, businesses, and recreational facilities, a primary concern is the availability of a sustainable source of good quality water to supply both current and future development needs. The Montana Bureau of Mines and Geology Groundwater Investigation Program is conducting a study of the water resources of the Big Sky area. Questions to be answered include: what are the existing sources of groundwater; how productive are these aquifers; what is the quality of the water for consumptive use; and what is the long-term, sustainable capacity of each aquifer as a water source? The geology of Big Sky is complex and varied. Numerous faults and folds cut through the geology of the area, distorting and displacing segments of the aquifers, creating aquifer fragments that are small in areal extent, localized, and isolated. Aquifers tapped by wells and used as water sources for the resort homes and facilities include a sand and gravel aquifer at Meadow Village, fractured dacite limbs of the “Christmas tree” laccolith that forms the core of Lone Peak, and Cretaceous-aged sediments composed of thin sandstone layers interbedded with shales and some limestone. Geologic units that are good aquifers in one part of the study area may be dry, have low production rates, or have poor water quality in others. Determinations need to be made as to the locations of groundwater divides, sources of groundwater recharge, travel and retention of groundwater through the aquifers, and what flowpaths groundwater takes through the system. These determinations can be made, in part, by analyzing concentrations of the isotopes oxygen-18 and deuterium in the water. Isotopically light water is generally composed of snowmelt, while heavier waters are sourced from rain. Waters with similar isotope concentrations may have similar ages, and samples from different areas with similar isotope concentrations may indicate those locations are on the same groundwater flowpath. Analysis of levels of carbon-13 isotope (in both organic and inorganic carbon) may also indicate the period of time since the water entered the groundwater system and may assist in identifying connections between water sources. This poster presents a preliminary analysis of selected isotopes from groundwater and surface water in the Big Sky Resort area.

Getting It On The Ground; How The Forest Service Implements Projects From Conception To Completion.

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This poster shows the process of implementing projects at a large Federal Agency. I explain and decrypt the three main methods, EIS (Environmental Impact Statement), EA (Environmental Assessment) and CE (Categorical Exclusion) which the Forest Service uses to implement projects. Utilizing an actual project as a case study I examine the process from its conception as a project that will meet specific targets, through the planning phase, and into implementation and monitoring.

Algal Response To Reductions In Nutrient Loading In The Clark Fork River

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In the 1980s, much of the Clark Fork River was impaired by nuisance algae as a result of excess nutrients. By the 1990s, stakeholders developed a Voluntary Nutrient Reduction Plan (VNRP) which was accepted as meeting the requirement for a TMDL. The goals of the VNRP were to reduce loads of Total Nitrogen (TN) and Total Phosphorus (TP) to the river, reduce instream nutrient levels to summer targets, which are below nutrient saturation breakpoints, and to reduce algae levels (Chlorophyll a and Ash-free dry mass) to summer targets. In 2004, the Missoula Wastewater Treatment Plant (the rivers largest point source of nutrients) received a major upgrade, and by 2010 nutrient reduction procedures there became more consistent and reliable. Over the past 30 years, TN and TP loads to the river from the Missoula WWTP have been reduced by 70 and 85% respectively, even as the number of households and businesses served have increased by 14%. A study of 17 years of summer data from 1998-2014, covering 383km of the Clark Fork, shows that nutrient reduction efforts have produced improvements at some sites, and have at least prevented significant increases in algal and nutrient levels elsewhere. Despite a 20% increase in population in Missoula over the decade of the VNRP, TP and TN loads have decreased due to improvements in the towns wastewater treatment plant. TP concentrations downstream of the WWTP fell below the VNRP target of 39 µg/l, and TN concentrations met targets of 300 µg/l by 2007. The study found that, in order to control nuisance algae levels, nutrient levels should be decreased below saturation breakpoints or even to natural background levels.

Engaging Montanas Communities In Water Quality Research And Management

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Groundwater Outreach and Research The Well Educated program is a statewide well testing program that assists private well owners in testing their water quality. This program provides guidance on water quality testing, interpreting results, and how to protect groundwater resources. In the last ten years, Well Educated has reached over 4,000 participants in over 40 counties, and the Well Educated database contains over 55,000 water quality data points. These data points are used to identify local issues to guide more focused testing, education, and research. Well Educated data from Judith Basin and Fergus counties fostered local interest in nitrate testing in 2009-10 which helped establish datasets and relationships that were central to initiation of the Judith River Watershed Nitrogen Project (JRWNP). The JRWNP is a USDA funded participatory research project with university researchers working in cooperation with local farmers. The goals of the project are to work with local farmers to understand sources of groundwater nitrate and identify alternative farm management practices to keep more nitrogen in crops and out of groundwater. Surface Water Outreach and Research MSUEWQ works with watershed groups across the state to engage and educate local communities on water quality issues in their watershed through citizen based data collection. MSUEWQ provides technical assistance to these locally led efforts to enhance the quality of citizen collected data so that it can be used to inform management decisions. Technical assistance includes guidance in articulating goals and objectives for the use of the data, writing of sample analysis plans and standard operating procedures, monitoring training, data management and public presentations. Recently, MSUEWQ has released a pilot web platform for engaging citizens in collection, storage and visualization of water data. With these webpages, volunteers can upload data that they collected and have it appear almost instantly on the graph. Where possible, these data are presented alongside relevant data from USGS or other data providers. MSUEWQ has created webpages for the Musselshell Watershed Coalitions salinity monitoring and the Madison Stream Teams turbidity monitoring and is exploring possibilities for expansion in the future.

Understanding Restoration Success In The Big Hole Watershed By Addressing Post-restoration Biological And Community

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Restoration work often places a heavy emphasis on a specific sites conservation measure, but neglects to address the measures biological and anthropologic impacts once the project has been completed. By focusing not only on the conservation measure, but also on the habitat outcome and, biological response, the success of a restoration project can be quantified and shared. More importantly significant conclusions can be drawn from past projects that can call out inefficiencies and highlight valuable techniques that improve future restoration work. The last 20 years of restoration work in the Big Hole watershed has been performed swiftly and successfully, but with little documentation. Projects often focused on conservation measures and immediate restoration goals, with little design for post-monitoring follow up. As the Big Hole Watershed Committee continues to administer large restoration projects, the need for a standardized project summary and post-project protocol was paramount. First, projects were separated by their conservation measures into the three categories: Fisheries, Irrigation and Riparian restoration. Field visits and landowner interviews were conducted to assess biological and community responses. Combined with the information gleaned from grant applications and project reports, project summaries were drafted. A protocol detailing post-monitoring and project summarizing was then completed. With the addition of the project sites entered into GIS, the project summaries and protocols, when complete, will provide an effective tool for documenting and analyzing the last 20 years of restoration work carried out within the Big Hole Watershed.

Furthering Rural, Community-driven Drought Mitigation In The Blackfoot Watershed

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Numerous ranchers, business owners, anglers, and others within the Blackfoot Watershed rely on the presence of its water resources to support their livelihood; some have for generations. The same folks who are dependent on that water supply have also experienced hardships and conflicts due to recent, prolonged periods of drought, as well as increasing pressures on the Blackfoot River and its tributaries. Prior accumulation of these problems prompted the creation of a community-driven solution to mitigate the negative effects of drought and to resolve sharing resources fairly. As a collaborative effort among the Blackfoot Challenge, community members, and local, conservation agencies, the Blackfoot Drought Response Plan began. The Drought Response Plan is an effort to engage many types of water - users in voluntary conservation measures during times of drought. Irrigators voluntarily reduce their water use, fishing outfitters and anglers follow fishing restrictions, and residents are informed about conserving water when drought conditions are present in the Blackfoot Watershed. The numerous groups targeted within the plan present a strategy of "shared sacrifice." This approach ensures that while individuals must compromise their water use, the burden is shared and the greater community benefits. Recently, the Blackfoot Challenge, in partnership with the Big Sky Watershed Corps, has worked to update information and communications regarding the numerous participants and audience members related to the Drought Response Plan. Specifically, phone calls to the 80 plus irrigators who voluntarily implement water conservation measures helped to provide updates on land transfers, water rights adjudication results, and upgrades to irrigation systems on file with the Blackfoot Challenge as a way to record their water conservation measures. In addition, work was done to have a custom database built to better track and organize those communication efforts, and the information gathered. At the same time, media publications efforts have been increased to better communicate with the angling community on sustainable fishing practices, and any potential fishing restrictions in place for this year. As a result of the work done to update gathered data and improve communications, the Blackfoot Challenge now has supporting information to guide their future actions involving implementation of long-term water conservation, development of stream restoration projects, and recruitment of new irrigators to participate in the voluntary Blackfoot Drought Response Plan.

Field Reconnaissance Investigation To Explain Elevated Arsenic And Nitrates In The Raven Road Area, Helena Montana

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An applied field problem was conducted by the spring 2015 Environmental Studies Methods class (ES 304) in collaboration with Lewis & Clark County (L&CC) and the Department of Environmental Quality (DEQ) in the Raven Road area of Helena Montana. Elevated nitrates ($NO3^-$) above the maximum contaminant level (MCL) of 10 mg/L were observed in preliminary water-quality samples collected from wells in the area. In addition, elevated Arsenic (As) levels above the maximum contaminant level (MCL) of 10 µg/L were also observed. Carroll students were given the opportunity to measure water levels in residential wells, collect water samples, and evaluate the geology and hydrogeology of the immediate area to determine whether sources for the nitrates or arsenic could be identified. The field investigations and sampling events were conducted in March 2015 and the results of water analyses showed that approximately half of the wells sampled exceeded the MCL for Arsenic. Elevated values for Nitrate and Uranium were also found. Plots of the data are shown in the poster. Subsurface geology and faults were plotted on cross-sections using well-log data. The water table surface was mapped using static water levels in tested wells. Results of this study will be used by DEQ , L&CC and residents to make decisions about resolving water- quality concerns. Funding for water analyses were provided by the local agencies. Our advisors were Dr. Willis Weight and Dr. Patricia Heiser.

Bozeman Creek E. Coli Microbial Source Tracking Summer 2015

Beth Wilson, Big Sky Watershed Corps Member, Gallatin Local Water Quality District, 215 West Mendenhall, Suite 300, Bozeman, MT, 59715, 406-582-3168, beth.wilson@gallatin.mt.gov, Additional Authors: Tammy Swinney, Gallatin Local Water Quality district, Torie Haraldson, Gallatin Local Water Quality district, Christine Miller, Gallatin Local Water Quality district.

Bozeman Creek in Bozeman, Montana is listed on the Montana Department of Environmental Quality 303(d) list of impaired water bodies for E. coli bacteria. The Lower Gallatin Planning Area TMDLs & Framework Water Quality Improvement Plan (March 2013) states that Bozeman Creek does not meet water quality standards for E. coli. In September 2013, the Gallatin Local Water Quality District (GLWQD) conducted a one day sampling event for E. coli to be analyzed for fecal source identification using microbial source tracking (MST) methods. Microbial source tracking methods use specific genetic biomarkers in the E. coli bacteria to identify the source animal. In this study, water samples were analyzed for dog and human biomarkers. Results indicated human-sourced E. coli was a major contributor of fecal pollution at three of the four sample sites, while dog-sourced E. coli was a minor contributor at two of the four sample sites. This was a single sampling event, yet it raised concern about human-sourced E. coli as a major contributor of fecal pollution in Bozeman Creek. In summer 2015, E. coli MST screening will be conducted on Bozeman Creek and a tributary stream in an effort to isolate the source(s) of human and dog fecal pollution. Three synoptic sampling events will be conducted at four sites on Bozeman Creek and one site on Matthew Bird Creek. Samples will be analyzed for E. coli MST, E. coli bacteria, F-, and Cl-. Preliminary findings will be presented in a poster.

Building Collaboration Around Water, Climate, And Agriculture In The Last Best Place

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Montana and other states in our region are struggling with conflict derived from severe drought and prolonged legal battles between irrigators, municipalities, tribes, and conservation interests. One Montana is determined to be part of the solution and we have begun to facilitate a collaborative working group that is made of up of Montana's Climate Office, the Montana Association of Conservation Districts, Montana's Extension Service, Montana's Institute on Ecosystems, the Montana Watershed Coordination Council, and Ag Industry groups. This group, under One Montana's guidance, aims to set a climate research agenda defined by agricultural producer input and collaboration, and ultimately work together to deliver research products on the ground in a credible and effective manner. We are also supporting the Montana Institute on Ecosystem's effort to build a sustainable and scalable state-level climate assessment that emphasizes stakeholder engagement at every stage of the process and includes tangible adaptation action. We are on the cusp of something truly innovative, and we believe other states will be able to utilize this as a model once we realize our potential and demonstrate strategic success.

ORAL PRESENTATION SESSION Abstracts in alphabetical order

Integrating Water Management Needs Into Science - The Ground Water Investigation Program (GWIP)

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The Montana Ground Water Investigation Program (GWIP) was created by the State legislature to provide information useful for improved water management. The Ground Water Assessment Steering Committee considers many criteria when ranking projects, including the likelihood that findings will be useful to by water managers. Future use of potential research results is a challenging criterion because the terms water manager and potential water-management action are nebulous and are potentially applied to ranchers who must decide whether to open a flood gate; agency staff who are enforcing regulations; legislators crafting statute; and others. Managers have recently implemented water management actions based on results from several GWIP studies, and how the project results are being used will be useful to the Steering Committee as it ranks future projects. At the local scale, the Hamilton Project has determined canal seepage rates

that are useful to ditch companies for developing stage rating curves, quantifying flows, and assessing water delivery efficiency. Groundwater surface water interaction results from the Stevensville Project are providing guidance to the Montana Department of Natural Resources and Conservation (DNRC) and a landowner working on an application to change an irrigation source from surface water to groundwater. The North Hills and Scratchgravel study areas contained temporary controlled groundwater areas and GWIP investigations were partly initiated to evaluate whether controlled groundwater areas should become permanent. In both cases, the DNRC allowed the temporary controlled groundwater areas to expire. Other actions include the Lewis and Clark County Planning Board's decision to establish a 10-acre minimum lot size in the Scratchgravel Hills which will lessen well interferences between neighbors. Some developers in the North Hills have adjusted plans to limit pumping rates to 10 gpm, and to allow only small lawns. The Montana Department of Environmental Quality (DEQ) has used GWIP project data to generate basic site information for sub-division applications within the Helena Valley. The Boulder River Project has not yet produced specific on-the-ground water management actions, but it does clearly show how a research project can be based on agricultural concerns. In open workshop settings, preliminary findings have been discussed by landowners, county commissioners, and agency staff. These groups are developing options to use the GWIP study results to inform water-management.

Flow-related Water Quality Impairments In The Clark Fork And Kootenai Basins

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As in most western states, 'water is for fighting over' in Montana. Population growth, energy development and climate change all contribute to increased scarcity of this resource. And increasingly, the connection between water quality and water quantity is being recognized as it was in the recently released Montana state water plan. Unfortunately, water quality and water quantity are managed by different agencies. The Environmental Protection Agency (EPA) and the Montana Department of Environmental Quality (DEQ) list many streams as impaired (unable to support their beneficial uses) due to insufficient flows. The Montana Department of Fish, Wildlife and Parks (FWP) also lists streams as Chronically or Acutely Dewatered on the basis of fish habitat suitability. However, it is the Montana Department of Natural Resources (DNRC) that actually allocates water rights and regulates use. DEQ records indicate that 1086 miles of streams (24% of assessed stream miles) are impaired by insufficient flow in the Clark Fork & Kootenai basins. In addition, many other types of impairment are exacerbated by low flows (including temperature, dissolved oxygen, metal, and nutrient pollution). Along with low flows, these types of impairments affect 2356 miles of streams (52% of assessed stream miles) in these basins. While basin closures help to prevent worsening water quality, they cannot correct existing problems. And basin closures are not imposed for water quality reasons, but more withdrawals would affect other consumptive water users. Many TMDLs and Water Quality Restoration Plans indicate that low flows due to high consumptive use contribute to these impairments. Strategies to improve water quality by reducing consumptive use include: switching to crops that require less water, drought management plans in which users stagger water use, retiring irrigated crop land with low productivity, water leasing and purchase for instream flows. In addition, restoration of natural storage capacity of watersheds can help restore flows and benefit water quality. DEQ, DNRC and DFWP should cooperate on identifying and funding high priority projects for water quality improvement through flow restoration.

The Yellowstone River Cumulative Effects Study—15 Years In The Making

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The Yellowstone River Cumulative Effects Analysis (CEA) is reaching completion after 15 years of planning and project execution. The CEA consists of an interdisciplinary evaluation of human activities that affect the condition and behavior of 565 miles of the Yellowstone River, as well as a characterization of primary economic sectors that drive those activities. The basis of the study is an assessment of trends in hydrology, geomorphology, physical features construction, land use, and riparian conditions throughout the corridor from 1950 through 2011. These results were then used to empirically characterize physical alterations, and to provide a foundation for considering secondary influences on water quality and aquatic and terrestrial biota. Primary datasets include aerial imagery, LiDAR topography, a physical features inventory, hydrologic analyses, hydraulic modeling, reach-scale geomorphic assessment, riparian mapping, avian sampling, fisheries sampling, nutrient modeling, and land use mapping. A geomorphic reconnaissance undertaken in 2004 segmented the river into 88 reaches and became the foundation for spatial data analysis. Hydraulic modeling evaluated the changes in floodplain connectivity resulting from both hydrologic alterations and construction of dikes and levees. Riparian and land use mapping documented land use change and associated shifts in riparian character and extent. Avian assessments characterized bird populations and habitat, and a fisheries study was performed to evaluate fish distributions and habitat preferences. Water quality assessment included SPARROW modeling of primary sources of nitrogen and phosphorous in the watershed. A cultural inventory was performed to ascertain the range of human perspectives regarding the Yellowstone River, and socioeconomic data were summarized to provide context of economic development. These baseline studies were then integrated within a Geographic Information System and combined with other preexisting data to determine the impacts of human development in the Yellowstone River corridor. Results show that the river and its historic floodplain have been highly impacted by flow alterations on the Bighorn River. Thousands of acres of floodplain have become isolated due to flow alterations and physical features, and tens of miles of side channels have been blocked. Over 100 miles of streambank have been armored. These physical impacts have altered rates of floodplain turnover, rates of riparian recruitment, quality and extent of fisheries habitat, and risk of cowbird parasitism in cottonwood forests. In order to optimize the long-term function of this remarkable river, a series of Recommended Practices have been developed. Public meetings for the CEA will be held in mid-October 2015, and the project is slated for completion by the end of the calendar year. Perhaps most importantly, the Yellowstone River CEA reflects a remarkable level of perseverance on the part of the Yellowstone River Conservation District Council, Technical Advisory Committee, Resource Advisory Council, and countless other contributors including federal, state, and local government agencies, contractors, and citizens.

A Framework For River And Floodplain Design: The Clark Fork River Remediation And Restoration Project

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The Clark Fork River Remediation and Restoration project in western Montana will eventually remove or treat contaminated mine waste along 47 miles of river and restore the streambanks and floodplain throughout the reach from Warm Springs Ponds to the confluence with the Little Blackfoot River. To accomplish this task, the Montana Department of Environmental Quality (DEQ) and the Department of Justice through its Natural Resource Damage Program (NRDP) are using a team of engineers and scientists to investigation existing conditions, develop designs, and oversee construction by contractors. Design teams are assigned specific reaches of the river for plan development, where each design consists of one or two of the 23 phases that make up the entire project site. To successfully manage these multiple designs, DEQ and the NRDP require a coordinated design effort that follows mutually agreed upon design protocols that guide and shape the river and floodplain designs. This presentation explains how DEQ, NRDP and their consultants have constructed a design framework that leads the design teams from stated project objectives through design criteria development to a comprehensive, implementable design plan for each design phase. The project goals and objectives as stated in the Record of Decision for this Superfund site and the NRDP Restoration Plan determine the basis for the design. From these foundations, design criteria are built that include all aspects of the design plan: contaminant removal or treatment, floodplain reconstruction, streambank reconstruction, as well as occasional needed channel reconstruction. Important design criteria that vary from phase to phase of this project address the landowner constraints such as pasturage and irrigation operations. Another set of design criteria guide the vegetation design and its integration with floodplain design and landowner requirements. Finally, design criteria for specific restoration components that are funded independent from remediation are developed to promote additional values such as riparian and aquatic habitat improvements. These design criteria have been developed through multiple design efforts, and each additional design phase on the Clark Fork River builds on the design criteria previously developed with adjustments as needed for new and differing conditions. After the design criteria are agreed upon by the design team and DEQ and NRDP, a proposed design is developed which reflects specific streambank designs, geomorphic concerns, floodplain vegetation planting approaches, and infrastructure requirements. This design is reviewed by the agencies, landowners and an independent design review team. After consideration of input from these reviews, the final plan set is developed and reviewed for implementation on site. Thus, each new design effort is connected to previous designs yet also incorporates site specific requirements and the evolving thinking of all project participants on state-of-the-art stream and floodplain design.

Flow And Scour Constraints Of Pioneer Seedlings To Predict Uprooting Potential

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Survival of pioneer woody seedlings is vital for maintenance of riparian forests that provide ecosystem services, such as bank stability. Despite their importance and money spent to restore riparian areas in Montana and the broader West, we currently lack the ability to predict under which conditions seedlings survive. We conducted seedling uprooting experiments to quantify the flow and scour constraints of cottonwood seedling mortality on the Bitterroot River, MT by uprooting seedlings laterally with and without simulated scour, and recording the force with a gauge. By setting drag forces driving uprooting equal to measured anchoring forces resisting uprooting, and solving for the threshold velocity at or above which seedlings would uproot, we constrained uprooting velocities for seedlings with and without scour. Our experiment showed that although seedlings are safe under most flow conditions, with mobility of the bed in the form of scour seedlings become at risk to mortality. We linked these constraints to a numerical model of flow that allows us to predict velocity and sediment transport potential spatially for floods of different magnitude. We identified both seedling safe sites and areas at risk to scour, and conclude the spatial variability of velocities and scour potential must be considered to predict seedling survival.

Natural Water Management In The Upper Clark Fork River: Quantifying Loss Of Water Due To Beaver Pond Wetland Removal, And Cost-effective Restoration Options

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The near extirpation of beavers from the 1600s through early 1900s is one of the most widespread and devastating impacts on Western streams and the species dependent on them. Beaver pond complexes, which generally consist of a series of beaver dams and ponds, dramatically reduce the energy of stream runoff flows and promote overbank flow, allowing for aquifer recharge and increasing cold groundwater inputs to streams in base flow conditions. We estimated historic and current presence of beaver in the

Clark Fork River watershed upstream of Garrison, MT, using habitat suitability modeling and extensive ground-truthing. The resulting habitat suitability model output served as the basis for estimating habitat restoration potential by beaver or using restoration techniques estimating beaver. Using literature values and preliminary monitoring results from passive restoration projects, we derived a range of estimated values for water storage potential behind beaver dams and potential beaver dam density in the watershed. We combined this information with our model results to estimate the potential for additional natural water storage in the upper Clark Fork watershed.

Simulated Effects Of Climate Change On The Hydrology And Fish Assemblages Of Northern Great Plains Streams

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Fish in streams in the northern Great Plains live "on the edge" because water quantity and quality are often close to ecological tolerance limits. Changes in streamflow associated with global climate change may substantially alter habitat in Great Plains streams. The goal of this study is to predict the effects of climate change on the hydrology and fish assemblages of northern Great Plains streams. Predicted changes in precipitation and air temperature will be linked to changes in streamflow and in turn, fish assemblages by using empirically derived relations between streamflow and fish assemblages as follows: (1) simulate current or "baseline" daily streamflows for seven watersheds in eastern Montana using the Precipitation-Runoff Modeling System (PRMS) and existing precipitation and temperature data; (2) model relations between the simulated baseline streamflows and basin characteristics to estimate streamflow statistics at about 1,500 fish sample sites in eastern Montana; (3) model relations between baseline streamflow characteristics and fish assemblage structures at these fish sample sites; (4) simulate future daily streamflows for the seven watersheds using PRMS and projected precipitation and temperature output from the RegCM3 regional climate model; (5) model relations between simulated future streamflows and current basin characteristics to estimate streamflow statistics at the fish sample sites; and (6) model future fish assemblage structures based on future streamflow projections. Index of Biotic Integrity scores will be calculated for the 1,500 fish sample sites to identify areas of primary conservation concern and compare them to the areas that are most likely to change.

Decoding The Climate In The Gallatin Watershed, Montana

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Streamflow data from the Gallatin River at Logan, Montana were analyzed in an attempt to identify long-term trends and to determine correlations between streamflow, precipitation/snowpack, groundwater levels, and water use in the Gallatin Basin. We analyzed 86 years of continuous streamflow measurements using the "R" open source statistical program and the Exploration and Graphics for RivEr Trends (EGRET) software package developed by the USGS. Annual and seasonal (winter, spring, summer, fall) flow statistics (min, max, median, 7-day min, and discharge variability) were calculated; seasonal trend analysis and lowess smoothing were used to assess long-term trends. The winter season (Dec.-Feb.) was used to assess long-term changes to baseflow (groundwater discharge). Over the period of record (1929 – 2014) the mean annual flow generally increased between 1929 and 1970 and decreased from 1970 to the present. The 7-day minimum (low-flow statistic) shows a decreasing trend in all seasons since the 1970's, however the summer mean shows a slightly increasing trend over the past 20 years. During baseflow periods the maximum daily, mean daily, and 7-day minimum have all been decreasing since about 1970. Over the period of record (1929 – 2014) the mean annual flow has generally increased from 1929 to 1970 and decreased from 1970 to the present. The decreased streamflow since 1970 coincides with decreased precipitation (rain and snow) in the Gallatin basin and an increase in average annual temperature (Prism and NRCS Snowtel Data).
Groundwater development in the basin from 1985-2010, as measured by the number of wells, increased by 64%, while the population increased about 47%. Since 1985, groundwater use in Gallatin Co. ranged between 10-24 million gallons/day (Mgal/d) whereas surface water use ranged between 310-480 Mgal/d. The

Mgal/d. The primary water use in the Gallatin Basin is irrigation (60-75% of total water use). Irrigation practices have changed over the last 15 years; flood irrigation has decreased, while sprinkler irrigation has increased or remained relatively stable (USGS Surface Water Data for the Nation). Groundwater levels in the basin's shallow aquifers have generally been stable over the past 20 years (MBMG GWIC). The results indicate that streamflow is predominantly controlled by precipitation. Baseflow and streamflow in the Gallatin River have been declining since about 1970. These changes are not correlated with the increasing number of wells or population in the basin. Temperature increases and decreased snowpack have resulted in earlier peak streamflow and less late summer groundwater discharge to the Gallatin River. Long-term data and computational analysis of environmental data can help decode the effects of climate and human activities on natural resources.

A Brief History Of Stream Restoration In Montana

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Stream restoration is currently a multi-billion dollar, nationwide enterprise enjoying the focus of numerous professional organizations, universities, policy, and citizen groups. The challenge of restoring damaged riverine ecosystems has driven interdisciplinary river science and policy as no other contemporary catalyst but it hasn't always been that way. The earliest years of restoration, or more appropriately named fish habitat manipulation in Montana (and nationwide) evolved from make-work programs during the 1930s depression. Subsequent efforts in the 1960s and 1970s drew from that experience and traditional civil engineering, river mechanics. The Rosgen-based enterprise, initiated in the 1980s, spawned a new geomorphic approach to river restoration, brought fluvial geomorphology out of the closet, helped create the river-restoration market, and ultimately provided incentives for academics to contribute to the current state of the art. Montana has both lagged and lead the nation in river restoration and preservation efforts. The Stream Protection Act of 1963 and Natural Streambed and Land Preservation Act of 1975 established permitting systems requiring integration of protection measures into stream alterations. The River Restoration Program (now known as Future Fisheries) enacted by the 1989 legislature recognized conservation of streams is of vital social and economic importance to Montana and established a funding for river and fishery restoration. Other programs including MTDEQs 319 Program and DNRCs Loan and Grant Program provide additional funding sources. Montana has developed a vibrant river-restoration industry with over 30 Montana-based consultants and several University programs (MSUs Watercourse and UMs Center for Riverine Science) providing access to rapidly improving, cutting-edge science essential to effective stream restoration.

Geochemistry Of Natural Acid Rock Drainage In The Anaconda-Pintler Mountain Range, Montana

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Mt. Evans is located in the Anaconda-Pintler mountain range of southwest Montana approximately 22 km southwest of Anaconda. Mt. Evans appears a reddish orange on Google Earth amongst the rest of the mountain range which is a grey white color, indicating the presence of limonite staining and probable buried sulfide mineralization. Two streams draining opposite sides of the mountain (Sullivan Creek and East Fork Twin Lakes Creek) have conspicuous white coatings on boulders that are clearly visible with Google Earth. The geology consists of Mesoproterozoic metasedimentary rock (pyrite-bearing muscovite-biotite schist) intruded by multiple episodes of granitic to dioritic dikes and plutons. During a mineral resource assessment in the 1980s, the USGS suggested that the Mt. Evans area could be the top of a porphyry Cu-Mo system. However, this is not an area with historic mining and no evidence has been found to indicate exploration for mineral deposits was ever done. The purpose of the present study is to characterize the geochemistry of the streams draining Mt. Evans, and to speculate as to the nature of the bedrock source of the acidic drainage. Both Sullivan Creek and the East Fork of Twin Lakes Creek (EFTLC) have pHs that range from < 4.0 in their headwaters to > 7.0 in their lower reaches. The headwaters of both streams exceed Montana water quality standards (chronic aquatic life) for cadmium, copper, nickel, and zinc, and are also elevated in aluminum, cobalt, fluoride, iron, manganese, sulfate, and rare earth elements (e.g., up to 200 □g/L Ce). Dissolved aluminum loads are estimated at ~20 kg/day and ~ 5 kg/day for upper EFTLC and upper Sullivan

Creek, respectively. Hydrous metal oxides coat gravel and boulders in the streambed and are orange-red in headwater springs (pH < 4), white in the middle reaches (4 < pH < 6), and brown-black in the lower reaches (pH > 6). Based on XRF, SEM, and micro-Raman analyses (in progress), the white precipitates are mostly hydro-basaluminite (Al4SO4(OH)10·5H20), whereas the dark coatings are a mixed Mn-Fe oxide, possibly birnessite. The concentrations of "cationic" trace metals (e.g., Co, Cu, Pb, Zn) in the secondary crusts tend to increase with distance downstream, whereas the "anionic" trace elements (e.g., As, P, S) show the opposite trend. A pre-modern ferricrete deposit near the headwaters of Sullivan Creek has a similar trace element chemistry to the precipitates forming today in the nearby stream. The acid rock drainage in these streams is clearly related to the limonite-rich color anomaly on Mt. Evans. Investigations are in progress to determine the nature of this hydrothermal mineralization and will be reported elsewhere.

Using Channel Migration Mapping To Develop Restoration Strategies For The Plains Reach Of The Clark Fork River

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Channel Migration Mapping along the 8-mile Plains Reach of the Clark Fork River provided the foundation for a suite restoration alternatives and potential projects to improve riparian conditions and restore natural channel processes while protecting critical infrastructure and economically important lands. A Channel Migration Zone (CMZ) analysis was conducted to examine historic channel migration and evaluate future channel migration scenarios for this large wandering gravel bed river. The CMZ analysis included a geomorphic assessment of the Historical Migration Zone (HMZ), the development of an Erosion Buffer, identification of Avulsion Potential Areas, and incorporation of Restricted Migration Areas. At 14 identified eroding streambanks, erosion was assessed over an 18-year time frame extending from 1995 through 2013. Areas of actively eroding streambank at the outsides of meander bends and along mid-channel bars were identified through a review of aerial imagery and digitally mapped in GIS. For each eroding streambank, erosion was measured in GIS at 20 cross-sections and the average rate of retreat was calculated. Based on the mean annual retreat rate, erosion over the next 20 years was estimated for each eroding streambank. To address accelerated rates of streambank erosion, potential sites for streambank stabilization and revegetation, floodplain revegetation, and flow enhancement in side channels were identified. In areas where streambank stabilization activities are proposed, development of a 150-foot wide vegetated riparian buffer was recommended based on a mean annual retreat rate of 7.6 feet for the Plains Reach. For streambanks left to erode, floodplain planting areas generally exclude the area identified within the estimated 20-year erosion zone to allow time for the vegetation to become established before it is adjacent to the channel. Channel Migration Mapping along the Plains Reach of the Clark Fork River indicates that ongoing lateral channel migration will likely impact both critical infrastructure and economically important lands and a restoration approach that includes the entire Channel Migration Zone is beneficial.

Natural Acid Rock Drainage Chemistry And Ferricrete Deposits Of The Judith Mountains, Montana

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The Judith Mountains are a low-elevation "island" mountain range in east-central Montana composed of a series of laccoliths and stocks cut by coarse-grained alkali granite and tinguaite dikes. The geology of the Judiths in the vicinity of Red Mountain and Judith Peak, two of the tallest mountains in the range, is conducive to the creation of headwater streams that are naturally acidic. Extensive limonite staining on Red Mountain attests to the widespread presence of disseminated pyrite in hydrothermally altered porphyry rock. However, no major historical mining operations are known to the area. The acidic streams undergo neutralization in pH as they travel downstream due to the influx of alkaline groundwater and tributary streams. The change in character of the water is related to a change in geology from mineralized porphyry intrusions at the summit of the range to Paleozoic and Cretaceous sediments, including the Madison Limestone, in the foothills. This study is the conclusion of a multiple-year project in the Judiths examining the geochemistry of three streams that drain opposing sides of the Red Mountain porphyry. Whereas previous Montana Tech students have focused on Collar Gulch and Armells Creek, Chicago Gulch (aka Fords Creek) is the primary focus of this project. The local Bureau of Land Management (BLM) office plans to use these data to guide decisions regarding future land use issues in the Judith Mountains. Results from ICP-AES, ICP-MS and IC analysis of synoptic water samples quantify spatial trends in pH and metal concentrations and loads. White Al-hydroxide flocs are actively forming where the stream pH transitions from < 5 to >5. This white precipitate is rich in trace metals, including As, Pb and Zn. Sample sites with pH < 4 have higher iron content, with abundant pre-modern ferricrete deposits next to the stream. Alluvial (in-stream) ferricrete forms where pH transitions from < 3.5 to > 3.5, whereas broad ferricrete terraces form outside the stream channel where Fe2+-rich groundwater emerges as springs and is oxidized to ferrihydrite, schwertmannite, jarosite, and/or goethite., depending on the environmental conditions. All water samples collected in the upper reaches of Chicago Gulch exceed Montana water quality standards for protection of aquatic life for lead, cadmium, zinc, and copper, as well as human health standards for thallium. Dissolved lead concentrations are especially high in the headwaters of Chicago Gulch (up to 2 mg/L), as well as in upper Collar Gulch, indicating the possible presence of a weathered lead-sulfide deposit in the subsurface. Lab experiments interacting deionized water with weathered porphyry rock from Red Mountain produce acidic leachates that have elevated metals and sulfate concentrations. Data collected throughout the 4-year project are being compiled to establish metal load "rating curves". All three streams (Armells, Collar, and Chicago Gulch) show a positive linear relationship when metal load is plotted against streamflow for most of the trace metals of interest (e.g,. Al, Cd, Cu, Zn, Mn,, Tl).

Investigating Sources Of Water To Chief Plenty Coups Spring Near Pryor, Montana: Water Chemistry And Microbial Communities Reveal Seasonably Variable Contamination Pathways

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Identifying sources of water is essential to addressing recent episodes of fecal contamination at Chief Plenty Coups Spring and in Pryor Creek, Montana. Plenty Coups spring is highly culturally significant to the Crow Tribe and its contamination presents a health risk to the community. We investigated water supplying Plenty Coups spring through targeted sampling of both the spring and local surface waters during 2014-2015. Analysis of water isotopes, dissolved organic carbon and nitrate, along with microbial community DNA sequencing, show distinct seasonal trends pointing to variable hydrologic flowpaths and potential septic contamination in summer. The spring is positioned at the toe of an alluvial fan hosting a shallow, unconfined aquifer recharged by mountain front stream runoff. Irrigation canals on the fan likely enhance seasonal effects through addition of water from Pryor Creek at the fan surface. Water isotope results support this interpretation, and microbial community data provide detailed insight about connections between land use and water quality.

USING DATA FROM MOUNTAIN CLIMATE SITES FOR OPERATIONS OF WATER RESOURCES

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Mountain climatic data, primarily from SNOTEL (snow survey telemetry) and snow course measurements can be used to estimate many hydrologic parameters. Seasonal streamflow originating primarily from the mountain snowpack can vary from 50 to 160% average and timing of hydrologic events can vary over a span of seven to eight weeks. By comparing historic data, realistic estimates can be made of subsequent seasonal runoff, date of peak flow, amount of peak flow and recession flows. Data can be used for reservoir operations, flood warnings, hydroelectric generation, irrigation, low flows, fisheries, sediment transport, wildlife response and management decisions relative to flow regimes. Data can be used to develop average annual precipitation maps which in turn can be used with cover types to estimate streamflow from ungagged watersheds. Changes in runoff as result of forest fires, logging, or insect infestations in forests can be estimated. Trends of various mountain climatic parameters can be determined. Kinds of data available and the relationship between data collected at monitoring sites and how it is used to estimate many of the hydrologic conditions will be presented.

Implementation Of The Measurement, Supply, And Water Conservation Recommendations From The 2015 Montana State Water Plan

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The 2015 Montana State Water Plan offers recommendations to guide water policy to ensure an adequate supply of water to meet current beneficial uses and future demands. The Department of Natural Resources and Conservation (DNRC) is beginning work with various partners to implement the plans recommendations, including the funding and implementation of efforts and programs to better manage the states water monitoring networks, conduct water supply studies, and to promote improved water conservation. Along with state, federal, and private cooperators, DNRC is in the process of establishing, operating, and maintaining a statewide real-time stream gaging network. These gages are intended to support the administration of water rights and local water management planning. DNRC has partnered with the Bureau of Reclamation to conduct a basin-wide physical water availability and water management assessment in the Upper Missouri Basin. This study is being conducted under the Department of the Interior's WaterSMART Program and the results will provide options for meeting water demands based on future climate scenarios. Water conservation efforts include the identification and control of artesian flowing wells in the Lower Missouri Basin using state and federal grant funding. The goal of the project is to diminish the rate of declining head pressures in areas of the state with flowing artesian wells. Additionally, DNRC is exploring the water right permitting implications, feasibility, costs, and benefits of using shallow aquifer recharge in riparian/floodplain settings to improve late season baseflows. Implementation of these recommendations will provide the people of Montana with the information necessary to meet current and future water uses.

Diel Variation In Stream Water Nitrate Concentrations Reflects Biological Nitrogen Loss From An Agricultural Landscape

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Understanding nitrogen losses from agricultural systems is crucial to managing water quality, soil health, and economic outcomes for growers. Nitrate concentrations in streams reflect these losses, but their assessment is complicated by biogeochemical processes occurring in streams over diel (daily) time scales. As part of a larger project examining nitrogen use and water quality in the Judith River Watershed, we measured diel fluctuations in basic water quality characteristics and stream flow at two sites on a low-order stream in late July 2014. Stream temperature, dissolved oxygen, and pH varied diurnally at both upstream and downstream sites. Specific conductivity, dissolved organic carbon (DOC), and nitrate exhibited diel variation downstream only. DOC and nitrate concentrations were inversely correlated ($r = -0.79$) at the downstream site, suggesting nitrate removal via denitrification and/or heterotrophic biomass assimilation. Analyses of $\delta^{15}N$ and $\delta^{18}O$ in nitrate at these sites in 2012 further support this interpretation. Diel variations in water quality also demonstrated that daily average nitrate concentrations would have been underestimated by a daytime measurement alone (in our case by up to 3% for a measurement at 16:00). This supports observations that nitrogen leaching from soils is substantially greater than implied by downstream load measurements, highlighting the potential importance of in-stream biological processing as a path of nitrogen loss from the landscape.

Stochastic Water-budget Analysis To Evaluate The Relative Importance Of Recharge/discharge Mechanisms In The Deep Aquifer, Kalispell Valley, Montana

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Potential recharge and discharge mechanisms for the Kalispell Valleys deep aquifer have been identified, but groundwater flow must be better quantified to understand their relative importance. Recharge to the deep aquifer occurs from fracture flow in bedrock along the Swan, Whitefish, and Salish Mountain fronts.

Recharge can also occur as stream leakage where they enter the valley and from shallow aquifers where intervening confining layers are thin or discontinuous. The deep aquifer discharges into Flathead Lake, however, the flow path is beneath the lake and total discharge is poorly known. Wells also extract water from the deep aquifer. A simplified water-budget analysis for the entire deep aquifer will assess recharge and discharge mechanisms, assuming steady-state conditions and no flow through overlying confining layers or to/from the surrounding bedrock. The analysis will use stochastic Monte Carlo techniques to account for uncertainties associated with aquifer heterogeneity, groundwater gradients, and pumping. The Monte Carlo technique yields results as probabilistic distributions. For the deep aquifer, the analysis will estimate total inflow from different mechanisms (i.e. recharge from mountain ranges, stream leakage, and other sources). Total outflow will be calculated as the total inflow less withdrawals by wells and will represent discharge to Flathead Lake and other recipients. Total outflow will be compared with discharge to Flathead Lake calculated separately by another water-budget analysis and based on a control volume near the lakes north shore. The comparison will help assess the basic assumptions for the aquifer-wide analysis and potentially identify other recharge/discharge mechanisms. If total outflow is higher than the calculated discharge to the lake, groundwater is likely flowing to other recipients, such as springs. If total outflow is less than the calculated discharge to the lake, then the aquifer likely receives recharge from unidentified sources, such as vertical leakage from confining layers. If total outflow is similar to calculated discharge to the lake, potential recharge sources such as confining layers may not be significant, or be potentially, offset by other discharge.

Using Simple Dynamical Modeling To Assess Functional Differences Between Catchment Types

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Catchment classification based on functional attributes has long been a goal of watershed hydrology. Recently there have been a number of efforts to classify catchments based on water storage/runoff relationships. Here we use mathematical storage/discharge relationships to assess differences in discharge regimes between replicated sets of three catchment types, as defined by soil-geomorphic assemblages (sloping bog, forested wetland, and upland forest). Comparison of within-type and between-type variation tests the ability of this approach to capture functional differences between these catchment types. Additionally, comparison with soil water table depth data provides a check on the realism of the modeled storage/discharge function. As a result we are able to assess the utility of storage/discharge modeling to capture real-world differences in watershed functioning.

Benefits Of Using A 2-D Hydrodynamic Model (FLO-2D) Vs. A 1-D Model (HEC-RAS) For Assessing Overland Flow Paths And Localized Floodplain Storage.

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TREC was retained in 2013, to investigate an unstable braided section of Warm Springs Creek near Anaconda, MT that posed a threat to downstream infrastructure and could potentially impact the health of the stream and riparian corridor. Following 2011 spring runoff (largest on record), debris jams redirected a significant portion of the total channel flow outside the primary riparian corridor. A highly unstable reach resulted in which out-of-bank flows might be prevented from returning to the main stream channel. The design required intricate hydraulic modeling to evaluate floodplain storage options that redirect flows back to the channel while continuing to allow floodplain interaction, and associated ecological benefits, that might typically be impeded using a traditional levee design. Given the complexities of the out-of-bank flow paths, floodplain dynamics, and storage alternatives, a 2-D hydrodynamic model was chosen to evaluate the system under both existing and proposed conditions. Modeling scenarios included complex features such as split-channel flow, unconfined floodplain, a perched channel reach, storage features, and several small bridges. The model was validated for both low and high flow conditions using field survey and aerial images during flood events. Ultimately, the model was an invaluable tool for project design and allowed the team to evaluate the effectiveness of various alternatives as they related to the design objectives. Design considerations evaluated within the model included: • River overbank flooding • Unconfined alluvial fan flows • Flow obstruction and floodplain storage loss • Downstream flood mitigation • Water Quality and Infiltration • Channel and floodplain storage design Modeled results indicated that the placement of several strategically located floodplain storage areas would alleviate downstream flooding issues, promote long-term channel stability, and effectively redirect out-of-bank flows back to the primary channel. Discussion will include an overview of modeling inputs and data requirements, pros and cons of 2-D modeling vs. 1-D modeling, along with presentation of modeling results and how closely they reflect observed flooding conditions.

I Have To Do What To Get A New Water Right?? – Mitigation And Aquifer Recharge Options Elaborated.

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Water availability for new uses, including development, population growth, and fishery restoration is in short supply in the Clark Fork Basin. Basin Closure and the fact that surface water flows are often less than the existing water rights on a source (called over-allocation) require new and changed water uses to develop plans to re-allocate water to eliminate depletions of surface water. Mitigation and aquifer recharge are the two primary mechanisms used to offset surface water depletions and provide a mechanism for new water uses to be permitted. But mitigation and aquifer recharge is far from simple to accomplish. I will discuss mitigation options for three examples of new water use in this Basin: new municipal water use in the Bitterroot Basin Closure, new subdivision water use in the Middle Clark Fork where the river is over-allocated due to hydropower water rights, and an instream flow change for fishery habitat restoration in the Upper Clark Fork Basin Closure. The talk will cover challenges to each of these situations and possible options which would allow each project to move forward. These examples are specific to the Clark Fork Basin but the principles apply to other water limited areas of Montana.

Satellite-guided Hydro-economic Analysis For Integrated Agricultural Land And Water Management

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Increasing water demands associated with economic growth and agricultural development in Montana will exacerbate the already considerable strain on Montana's water resources during drought periods. To ensure a sustainable future for Montana's agriculture and with current water sources mostly committed, future water management options will need to consider the development of new water supplies or envision ways to improve the operation of existing ones. Managing climatic cycles on agricultural production, on agricultural land allocation, and on the state of active and projected water sources is difficult. This is because in addition to the uncertainties associated to climate projections it is hard to anticipate how farmers will respond to climatic, economic and policy incentives. Very few of the available operational systems to inform water planning and agricultural policy incorporate farmer's adaptive behavior. Overall, the challenges that policy makers and water managers face to mitigate the impact of water shortage are agronomic, economic and environmental and therefore must be approached from an integrated multidisciplinary point of view. Existing observation technologies, in conjunction with models and assimilation methods open the opportunity for novel interdisciplinary analysis tools to support policy and decision making. We present an integrated modeling and observation framework driven by satellite remote sensing and other ancillary information from regional monitoring networks to enable robust regional assessment and prediction of drought impacts on agricultural production, water resources, management decisions and socioeconomic policy. The core of this framework is a hydroeconomic model of agricultural production that assimilates remote sensing inputs to quantify the amount of land and water farmers allocate for each crop they choose to grow on a seasonal basis in response to changing climatic conditions, including drought. A regional hydroclimatologic model provides biophysical constraints to an economic model of agricultural production based on a class of models referred to as positive mathematical programming (PMP). A recursive Bayesian update method is used to adjust the model parameters by assimilating information on crop acreage, production, and crop evapotranspiration estimated from high-spatial resolution satellite remote sensing. We are developing new land parameter records adapted for agricultural application by merging relatively fine scale, calibrated spectral reflectance time series with similar spectral information from coarser scale and more temporally continuous global satellite data records. These new products will be used to generate field scale estimates of LAI and FPAR, which will be used with regional surface meteorology and biophysical data to estimate crop production including C4 crop types. This integrated framework provides an operational means to monitor and forecast what crops will be grown and how farmers will allocate land and water under expected adverse conditions, and the resulting consequences for other water users. It will also permit evaluation of impacts of water policy and changes in food prices on rural community livelihoods. The Bayesian update framework constitutes an efficient method for the identification of the production function parameters and provides valuable information on the associated uncertainty of the forecasts.

Natural Channel Design, A Reliable And Flexible Solution To Restoring Impacted Streams

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Natural channel design has slowly become a proven alternative to rigid channel armoring on flood conveyance and stream remediation projects. With an ever increasing value placed on streams and riparian ecosystems, permitting agencies favor the natural channel concept and recognize the dynamic nature of stream systems. As a result, permitting of a soft natural channel design is often streamlined and strict performance standards are avoided which reduces maintenance obligations and liability. Key advantages of natural channel design include utilization of onsite resources and field fitting yielding more sustainable and naturally aesthetic landscapes and positive public perception. Multiple Montana stream restoration projects will be presented that involve re-establishing natural channel functions to improve surface water quality and overall ecosystem through development of self-sustaining vegetation and bank treatments to facilitate long-term system stability. Attention will be given to one of the more versatile tools in the natural channel designers toolbox, willow revetments. Willows are relatively easy to transplant and develop broad root systems rapidly, making them ideal for bank stabilization measures. Native rhizomatous species have excellent survival rates and promote broad natural recruitment that further increases bank stability with time. Willow revetment techniques that will be discussed include vegetated soil lifts, vertical willow bundles, brush trenches, wetland sod with willow stakes, and mature willow transplants. General discussion will include design strategy and details, construction implementation and lessons learned.

Montana Stream Stats

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The Wyoming-Montana Water Science Center of the U.S. Geological Survey is developing StreamStats for use in Montana. StreamStats is a Web-based Geographic Information System (GIS) that provides users with access to an assortment of analytical tools that are useful for water-resources planning and management, and for engineering design applications, such as the design of bridges. StreamStats allows users to easily obtain streamflow statistics, drainage-basin characteristics, and other information for user-selected sites on streams. The Montana StreamStats presentation will provide an overview of current studies in Montana which include computed streamflow statistics at gaged locations, regression equations for estimating streamflow statistics at ungaged locations, and a brief overview of using StreamStats for retrieving computed statistics and estimates of streamflow at user-selected locations.

Populating An Ecosystem-Scale Model To Support The Development Of A Selenium Water Quality Criterion For Lake Koocanusa That Is Protective Of Fish Species

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Historic- and present-day coal mining in Canada have significantly degraded water quality in the Elk and Fording rivers which drain into Lake Koocanusa, a transboundary reservoir in British Columbia and Montana. Due to increasing selenium (Se) loading from coal mining to these rivers, the Montana Department of Environmental Quality (MT DEQ) has identified Lake Koocanusa as threatened by Se under Section 303 (d) of the U.S. Clean Water Act. Also of concern are increasing nitrate loads to Lake Koocanusa associated with explosive residues from coal mining. Coal mine expansions in southeastern British Columbia over the next 30 years are likely to increase Se and nitrate loads to Lake Koocanusa beyond current levels. In response to the potential threats to Montana's water quality, scientists from the U.S. Army Corp of Engineers (USACE), U.S. Geological Survey (USGS), U.S. Environmental Protection Agency (USEPA), and MT DEQ have recently proposed and initiated studies on Lake Koocanusa to assess ecosystem impacts on aquatic and fish communities and to establish a water quality criterion to protect aquatic resources. Based on empirical load modeling results from data compiled by the USGS and MT DEQ, annual Se loads entering Lake Koocanusa have increased from 2,600 kilograms (kg) in 1992 to over 13,000 kg in 2012, representing more than a 5-fold increase over 20 years. Significant investigations on the aquatic effects of Se and nitrate have also been conducted in the Elk River; however, adequate study has not been conducted in Lake Koocanusa, which is thought to be the most sensitive aquatic ecosystem in the watershed. In 2015, sediment traps were deployed at two locations on Lake Koocanusa (international boundary and forebay) to begin characterizing the partitioning of Se between water and particulate phases to support ecosystem-scale modeling. In addition, continued monitoring efforts to characterize water quality in the reservoir have also been undertaken. Topics that will be presented include: (1) updated load modeling results of Se entering Lake Koocanusa and probable Se load removal from treatment plants in British Columbia; (2) seasonal changes in distribution coefficients (Kd) between dissolved (< 0.45 micron) and particulate phase Se in Lake Koocanusa south of the international border; (3) seasonal changes, including longitudinal and vertical variation in the concentration of dissolved Se species (Se+4, Se+6, MeSe+4) at the international boundary and forebay areas of the reservoir; and (4) future study needs.

Assessing The Effectiveness Of A Riverine Wetland In Processing Nitrogen For Blacktail Creek In Butte, MT

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Silver Bow Creek (Blacktail Creek to Warm Springs Creek) is listed as impaired for nitrates, total nitrogen and total phosphorus in the Montana 2014 draft 303(d) list. Blacktail Creek (BTC), a head water to Silver Bow Creek, flows approximately 17 miles before entering Silver Bow Creek in Butte, MT. Nutrient concentrations in BTC are significantly higher than the Montana Department of Environmental Quality (DEQ) target concentrations. In the literature, wetlands have been popularly used as an effective Best

Management Practice (BMP) to process nutrients. While there has been enough research conducted on the effectiveness of constructed wetlands, little research has been conducted on riverine wetlands that are hydrologically connected to the streams. For this study we have chosen a historically excavated wetland (KOA wetland) on the flood plain of the BTC. The inflow into the KOA wetland may come from BTC floodplain overflow, surface water runoff and groundwater. The KOA wetland has a culvert at its outlet that allows water from the wetland to flow into BTC. This study investigates the hydrologic connection between BTC and the KOA wetland and nitrate removal potential of the KOA wetland. The hydrologic connection between the riverine wetland and BTC was evaluated using two approaches: wetland inundation modeling using HEC-RAS and monitoring water level changes. From the preliminary results, it is observed that there is no significant hydraulic connection (both surface and sub-surface) between KOA wetland and the BTC. From the KOA wetland pond nutrient monitoring, it is noted that the KOA wetland could remove nitrogen; however, the wetland is also contributing phosphate to the stream. The presentation will discuss the recommendations on how to hydraulically connect the BTC to the KOA pond to facilitate nitrogen removal. This study is significant in that an on-going proposed stream restoration of a stretch of BTC will provide the opportunities to hydraulically connect the riverine wetlands to the BTC for the purpose of nitrogen removal.

IMPACTS OF IMPLEMENTING BEST MANAGEMENT PRACTICES WITHIN THE BELLE FOURCHE IRRIGATION DISTRICT

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The Belle Fourche River is a tributary to the Cheyenne River. The 4,614,400-acre watershed is located in Hydrologic Units (HU) 10120201, 10120202, and 10120203. Approximately 2.1 million acres of the watershed are located in South Dakota, 2.4 million acres are in Wyoming, and the remainder is in Montana. The Belle Fourche River has been identified by the South Dakota Department of Environment and Natural Resources (SD DENR) as impaired because of elevated concentrations of total suspended solids (TSS). A TSS total maximum daily load (TMDL) was approved by the U.S. Environmental Protection Agency in 2003 for both streams. The Belle Fourche Irrigation District (BFID), identified in the TMDL as a significant contributor to TSS loading, delivers water to 57,183 acres of farmland through its 94 miles of open main channel and 450 miles of open lateral ditches. This presentation will discuss the complete water management system that was developed for the BFID and its individual irrigators. This system was designed to reduce the amount of sediment-laden flows entering the streams by increasing the overall delivery efficiency of the BFID. The components of this management system include the automation of several check structures, head gates, and flow measuring devices along the main canals and laterals; canal lining; software to automate the water order and billing system; on-farm irrigation scheduling; and conversion from flood to sprinkler irrigation. Implementing these Best Management Practices (BMPs) has resulted in several benefits from both an environmental and cost perspective. Before developing the complete water management system, the BFID operated the canals manually and performed all calculations to determine water orders, water billing, and water mass balance by hand. This was extremely labor intensive and led to inefficiencies in transporting the water from the dam to the farmers fields. The new water management system provides timely information to support the daily decision-making process. The system allows BFID personnel to assess and manage the entire system to better offset fluctuations in deliveries caused by rainfall, heat, or equipment malfunctions while substantially reducing the amount of time and effort required to perform their daily tasks. Implementation has also resulted in significant reduction of sediment-laden return flows to the Belle Fourche River.

Updates To Montana's MS4 General Permit

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Several cities and counties within Montana have storm sewer systems which are regulated under the Montana Department of Environmental Quality’s (MDEQ) General Permit for Storm Water Discharge Associated with Small Municipal Separate Storm Sewer System (MS4). The primary goal of the MS4 permit program is reduce the discharge of pollutants associated with stormwater runoff to surface waters of the State. In an effort to continually increase the programs effectiveness at reducing pollutants in stormwater discharges, MDEQ issues a new MS4 General Permit every five years. A working group of impacted stakeholders was created to address concerns with Montana’s MS4 program prior to the issuance of the next permit, which will become effective in January, 2017. The stakeholders include the seven cities covered under the general permit, MDEQ, the US EPA, and several environmental organizations. HDR is providing technical assistance to the seven cities as they work through this process with MDEQ. HDR is also creating standard templates for documents which will aid the cities as they manage their MS4's. This presentation will describe the primary components of Montana's current MS4 General Permit and introduce some the standard templates which are being created for the cities use.

Watershed Education: Using Partnerships To Ensure The Longevity Of Educational Programs

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The Bitter Root Water Forum (BRWF), as the non-profit watershed group of the Bitterroot Valley, is the Valleys resource on any water related topic. To reach water users where they intersect with the resource, BRWF partners with natural resource professionals to offer education opportunities that are relevant and tailored to specific audiences. Ongoing youth education includes the Earth Stewardship Program, which brings natural resource professionals into seventh grade classrooms; and the Future Irrigators of the Bitterroot Field Trip, which takes Future Farmers of America students out of the classroom on a tour of Bitterroot Valley irrigation. Adult education has included workshops and realtor continuing education courses, and now includes an irrigation tour of the Bitterroot Valley. BRWF has built a sustainable educational presence through strong partnerships with teachers, irrigation districts, real estate agents, the Bitterroot Conservation District, Montana Fish Wildlife and Parks, the Forest Service, and the Bitter Root Land Trust, among others. Together these partnerships ensure the future of environmental education for the Bitterroot Valley.

Hydrogeologic Overview Of Big Sky Resort, Madison Mountain Range, Southwest Montana

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Hydrogeologic Overview of Big Sky Resort, Madison Mountain Range, Southwest Montana By James Rose Montana Bureau of Mines and Geology Ground Water Investigation Program Montana AWRA October 7-9, 2015 The Big Sky Resort (Big Sky) area covers about 60 square miles in mountainous terrain primarily within the watersheds of the South Fork and Middle Fork of the West Fork of the Gallatin River, and in the Jack Creek drainage immediately to the west. Jack Creek is a tributary of the Madison River located on the west slope of Lone Mountain. All of the watersheds are closed basins. Big Sky relies on groundwater to provide drinking water, to irrigate lawns, and irrigate four golf courses. PWS systems are established in Meadow Village, Big Sky Mountain Village, Spanish Peaks, Yellowstone Club, and Moonlight Basin. There are 142 wells designated as PWS wells and 361 domestic wells for individual homes within the area. Recent, rapid development has area planners concerned about locating additional sources of water to supply the growth. Due to the unknown sustainable capacity of the aquifers, operators have put PWS users on restrictions for non-essential water use like lawn watering, as a conservation measure. Because of these concerns, Montana Bureau of Mines and Geology (MBMG) Ground Water Investigation Program (GWIP) is undertaking a study to define the boundaries of the separate aquifers, their sustainable capacities, and their relationships within the hydrologic system. Meadow Village, the largest PWS system, gets water from five wells completed in a sand and gravel aquifer beneath the Meadow Village Golf Course. The aquifer underlies 0.7 mi2, has a saturated thickness of 2 to 40 feet, and is underlain by nearly impermeable black shale. The other eight aquifers are in thin, Cretaceous sandstone or limestone, and a few wells are completed in highly fractured sills of a Cretaceous dacite intrusive. The geology of the eight Cretaceous aquifer formations is complex. Structural folding and faulting during mountain building, and by intrusion of the igneous dacite laccolith that forms Lone Peak, have distorted and displaced segments of the aquifer formations into isolated blocks. This separation creates local, smaller aquifer bodies within the same formations. MBMG-GWIP investigators using well-drillers logs, geologic maps, and water-quality analyses from sampled wells have identified nine separate aquifer formations used as water sources at Big Sky. Continuing investigations will define individual segments of the aquifers separated by geologic structures. Well drilling over the last 40 years at Big Sky has been problematic with some drilling attempts producing adequate supplies of good quality water, but many other attempts have failed. To date there is no comprehensive understanding of where to drill for water and what conditions to expect. Establishing water-supply sources is challenged by aquifer sustainability, productivity, water quality and accessible drilling depths. The results of the MBMG-GWIP investigation will assist planners to develop water resource management policies and to identify acceptable aquifers and drilling locations. Future numeric modelling will provide sustainability information for the Meadow Village aquifer.

PCB Remediation In Big Spring Creek: Using Science To Inform Management Decisions

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Big Spring Creek, near Lewistown, Montana, was contaminated with polychlorinated biphenyls (PCBs) resulting from the erosion of PCB-laden paint that was applied to the upper and lower station raceways of the Big Springs Creek State Fish Hatchery in the 1960s and 70s. Between 1981, when PCBs were first discovered in fish tissues immediately upstream of Lewistown, it took collaborative monitoring efforts between multiple agencies and private citizens to determine the source of PCBs in 2003 with the aid of 319 funding through the Fergus County Conservation District. Shortly after, a citizen Advisory Council comprised of state, county, and city officials, and private citizens was formed to assist in choosing an acceptable clean-up alternative for the Creek. Based on feedback from the Council and approval from the USEPA, suction dredging of the upper 2.77 miles of the Creek above the East Fork was chosen as the preferred alternative. It was estimated that remediation of the hatchery-contaminated raceways and the contaminated creek sediments could lower the PCB contamination in Big Spring Creek to meet TMDL sediment criteria of 0.189 mg/kg and ultimately remove "do not eat" consumption advisory on trout in the upper creek. Indeed, in 2013 after a three year clean-up effort, PCB concentrations in fish were found to be at levels that no longer warranted a catch and release advisory, and recent sediment monitoring has shown a >90% reduction in PCBs in the creek sediments. Overall, decades of collaboration and using science to inform management decisions have restored one of Montanas most unique streams.

Connecting Soil Water, Groundwater And Streams To Inform Nitrogen Sources And Flux Through A Dryland Agricultural Landscape In The Upper Missouri River Watershed

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Nitrate concentrations in groundwater are increasing in many agricultural watersheds across the United States. Aquifers of the Northern Great Plains have experienced elevated nitrate for decades, although they are often underrepresented in national studies. In the Northern Great Plains, dryland agriculture is a potentially large source of groundwater nitrate that may also be associated with loss of soil fertility and/or soil organic matter, threatening the long-term sustainability of these important food production systems. Yet explicit fluxes of nitrate between soils, groundwater and streams are often hard to quantify due to subsurface heterogeneity and complex biotic-abiotic interactions that are difficult to observe directly. We focus on a 24,400 ha terrace landform in central Montana that is more than 90% cultivated and hosts a shallow unconfined aquifer that is hydrologically isolated from mountain front stream recharge. As a result of its physical isolation, all groundwater in the shallow aquifer is derived from infiltration through soils at the terrace surface. Over a three year period, we monitored streams draining the terrace aquifer, along with wells, springs, and soil water samples collected from lysimeters on the terrace and an adjacent landform. Variability in ionic composition of all water samples suggests groundwater chemistry is aligned spatially with the distribution of soil salinity represented in SURGO soil map unit characteristics. In non-saline soil areas, groundwater ionic composition aligns with geochemical composition of cultivated loess soils observed directly in soil water samples and soil extracts. Stream ionic composition reflects a direct groundwater origin after accounting for nitrogen losses that may be explained by riparian biological processes. At the terrace scale, the annual flux of nitrogen leaving the landform in surface water is 5-13 kg N ha-1 yr-1 which is 16-43 percent of the N flux rates reported by Goolsby et al. (2001) for the highest yielding basins of the Midwest. These values represent a lower bound on rates of nitrate leaching from the cultivated soils of the terrace.

Urban Stormwater Conservation Area

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In 2013 the City of Billings, the largest city in Montana, brought together a team of engineers, wetland and vegetation specialists and landscape architects to design Shiloh Conservation Area (SCA) on 66 acres of city owned land. Completed in the fall of 2014, this land now serves as stormwater treatment, flood attenuation and a recreational area with trails for the Citys residents as the City expands residential and commercial development into existing agricultural lands. The SCA provides a unique opportunity to evaluate new techniques for stormwater management in Montana. To address water quality and flood attenuation, the site includes several features such as sediment ponds, detention ponds with wetland fringes, and wetland cells. Wetlands have been divided into three planting zones relative to water depth. Native species range from those that prefer deeper waters such as hardstem bulrush (Schoenoplectus acutus) and softstem bulrush (Schoenoplectus tabernmontani) to those that prefer shallow waters and/or moist soils such as common spikerush (Eleocharis palustris) and Arctic rush (Juncus arcticus). The seven wetland cells include deeper cells encouraging biouptake processes and shallower cells with a gravel lining to encourage microbial activity. Native woody vegetation such as Bebb willow (Salix bebbiana) and Red-osier dogwood (Cornus sericea) is strategically placed around water bodies to decrease temperatures, potentially decrease browse from geese and create habitat. The site design incorporates a water control system that allows for fine-tuned control of flows and water surface elevations in all water bodies and wetlands. The entire site can be drained for maintenance purposes, or can be used to store water during large flow events. Additionally, water control allows the option to drain wetlands to discourage organic matter build up and monoculture development. Several water quality sampling access points have also been incorporated to allow easy and frequent monitoring. The site will be monitored to evaluate metrics such as water quality improvements, vegetation establishment and survival, sediment build-up and flow control methods. Using these and other metrics, adaptive management will be applied to ensure the site is functioning as effectively and efficiently as possible. This may include actions such as increasing or decreasing the volume of water entering the wetland cells depending on water quality results. Lessons learned from this project could be applied to future, similar projects in and around Billings and in other developing areas of Montana.

Longitudinal, Seasonal, And Inter-annual Patterns Of Temperature And Discharge In The Upper Clark Fork River, Montana

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As the Upper Clark Fork River continues to recover from metals pollution it is increasingly evident that other issues that may limit salmonid abundance, such as low discharge and high temperatures, should be considered in restoration efforts. Accordingly, summer discharge and temperature data from USGS and FWP were analyzed from sites throughout the Upper Clark Fork to quantify longitudinal, seasonal, and inter-annual patterns. Based on wetted perimeter and hydrological statistics considerations, low discharge is of particular concern in the upper study reaches. In years of low discharge, mid July to early September is the primary time frame of concern for low flows. High summer water temperatures were particularly evident in the upper and middle study reaches. In low discharge years summer water temperatures were higher and these temperature concerns initiated earlier in the season. In these low discharge years, early July to mid August is of particular concern for elevated water temperatures. The discharge and temperature findings from this research provide a fundamental template to guide ongoing efforts to augment flows and reduce water temperatures during summer in the Upper Clark Fork River.

GUARDIANS OF THE HOLOCENE: How Scientists And Water Users Combined Forces To Champion Three Montana Watersheds

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Watershed management projects can move forward with amazing grace given the right combination of good research, funding, and stakeholder participation. From a funders perspective, there are common threads to all successful watershed projects regardless of the size of the watershed or the size of the problem. This presentation uses examples from three different Montana projects of varying size to illustrate the shared factors that successfully link science and water resource management to long-term sustainable improvements in the health and use of a watershed.

Changing Water Consumption In A Changing Landscape: A GIS-based Approach To Comparing Domestic And Agricultural Consumption

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When subdivisions supported by exempt wells replace irrigated agriculture; most people recognize that water consumption changes. There are many factors that contribute to net water consumption when land use changes, and one of the most important is evapotranspiration (ET). To better understand how ET might change, the Groundwater Investigation Program (GWIP) estimated ET for pre- and post-development water uses in the Four Corners area of the Gallatin Valley. ET was evaluated for two subdivided parcels that were historically agricultural. The subdivisions represent two common types of development: high-density or small lot subdivisions; and low-density or large-lot subdivisions. Using the 2013 NAIP data, a GIS analysis of spectral imagery provided irrigated lawn sizes that were used to calculate ET. Domestic (in-home) consumption, as determined by the Montana Department of Natural Resources and Conservation (DNRC) for Bozeman, was applied to the homes in the subdivision and combined with the lawn consumption. Aerial NAIP imagery from 1995 indicates that the two parcels were entirely cropped 20 years ago, either grazed as pasture or cut for hay. In 2013, both parcels had been developed. Agrimet data were the basis for calculating the water consumption of hay and pasture grasses. Comparison of the data sets suggests that on a per-acre basis, subdivisions consume less water than do agricultural uses, despite the high ET consumption by lawn grass. Additionally, high density subdivisions used approximately 0.2 acre feet per acre less water than did low density subdivisions because of the smaller irrigated area per lot. The data suggest that subdivision of irrigated agricultural land may result in decreased water consumption; up to one acre foot per year depending on the type of crop previously grown and the subdivision density.

The Montana Climate Office And $P = Q + E + \Delta S$

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The Montana Climate Office, reformed in 2012, compiles climate-related data layers for Montana as a component of its climate data stewardship role under the Montana Spatial Data Infrastructure program. Climate data (e.g. precipitation, evapotranspiration, temperature) are requisite for characterizing the water balance across watersheds, but face similar challenges as surface water or groundwater datasets – the constraint of currently available data, the complexity of hydrologic systems, and steady-state versus transient systems. This presentation will provide background on datasets available through the Montana Climate Office, their constraints, guiding criteria that may assist a user in determining the appropriate use of a dataset, and discussion on future work.

Ground Water Nutrient Loading To Surface Water Streams And Lake Helena, Helena Valley, Montana

James Swierc, Hydrogeologist, Lewis & Clark County, Water Quality Protection District, 316 North Park Room 220, Helena,MT, 59623, USA, (406) 457-8585, jswierc@lccountymt.gov.

The Helena Valley is located along the eastern margin of the Rocky Mountains of west-central Montana, with a watershed situated between the continental divide to the west, and the Missouri River to the east. Ground water in the downgradient area of the valley shows a strong upward vertical gradient which generally increases with depth. Lake Helena, created by Hauser Dam on the Missouri River, fills the lower valley elevations with lake levels controlled by the Missouri River. The creation of Lake Helena raised the water table in the lower valley, mitigated by installation of a series of tile drains to lower the water table for agriculture. The drains route ground water back to Lake Helena through a series of surface water ditches. The Helena Valley Non-Point Source Assessment Project utilized drains as sampling points for ground water to characterize and differentiate nutrient loading to the system from agriculture and areas with high densities of septic systems. The sampling program included Nitrate and total Phosphorus at 12 locations on an approximate bi-weekly frequency between Spring 2013 and Fall 2014. Specialized sampling included isotopes of Oxygen and Deuterium of water for several events, and Nitrogen and Oxygen isotopes of dissolved nitrate. Nutrient loading rates are estimated using flow measurements from drains. The detailed data sets from 12 locations show seasonal variations to loading rates across the valley, with increasing nitrogen and phosphorus during summer irrigation season and declines during the winter. The nutrient data coupled with chloride/bromide ratios show variable loading rates of nutrients to groundwater, suggesting a relationship with agriculture. In other areas, irrigation waters appear to flush nutrients derived from septic systems from the top of the water table. The isotope data support conclusions based on upgradient land use patterns to partially distinguish between agriculture and septic systems as nutrient sources to ground water. The data results compiled with ground and surface water data from previous and ongoing studies allow for estimates of nutrient loading rates to Lake Helena from different sources. The results indicate that the loading estimates developed for the Lake Helena Watershed TMDL overestimate the actual loading to the system.

Gallatin Microplastics Initiative

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Microplastics are particles of plastic smaller than 5mm in size, that are highly prevalent in marine environments. Studies show that toxins, metals and microbes attach readily to these plastic particles, which then enter the food chain, potentially causing serious issues for aquatic life. Researchers believe that microplastics are doing similar harm in freshwater environments, and there is a need for further exploration. The Gallatin Microplastics Initiative study will evaluate the abundance and types of microplastics in the Gallatin Watershed, Montana. During our initial sampling effort (n=10) in the main Gallatin and East Gallatin rivers, we found microplastics present in the water column at each sampling site, with a maximum of 86 pieces in one liter of water. Based on these findings, we expect to find microplastic pollution present throughout the watershed. During the first phase of our survey, which launches in September 2015, we will utilize 50-plus volunteers to collect a comprehensive and scientifically robust data set. Our research partners will analyze these samples to help us gain an understanding of the abundance, distribution and types of microplastic pollution present. Water samples will be collected every 10km along the Gallatin River and its major tributaries four times a year over the course of the next five years. Using the findings of the study, ASC will work alongside our partners—the Montana Water Center, Upper Missouri Waterkeeper, Gallatin Local Water Quality District and Gallatin River Task Force—to inform consumer choice, support legislative action, and influence corporate responsibility and innovation, in an effort to reduce plastic pollution in these local waters and downstream. The implications of our research on water management may include the addition of stricter water quality standards, changes for wastewater treatment facilities, and further monitoring of this emerging pollutant.

Missoula Wastewater Treatment Plant Moves Toward Zero Waste

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Since the construction of Missoulas first waste water plant in 1962, the plant has undergone many upgrades. The primary treatment system was upgraded to secondary treatment in 1974. The plants capacity grew from 9 MGD in 1998 to 12 MGD by 2007. Over the past 30 years, loads to the river of nitrogen and phosphorus have been reduced by 70 and 85% respectively, even as the number of households and businesses served have increased by 14%. Surprisingly, despite the increasing number of people served by the plant, influent water to the plant has been dropping recently, thanks to water conservation efforts. The most recent major upgrade to the Missoula WWTP involved the installation of a Biological Nutrient Removal system (using the Modified Johannesburg Process) in 2004. And starting in 2014, some of the effluent is being used to irrigate a nearby hybrid poplar plantation. Currently, the plantation takes about 12% of the effluent during the irrigation season (5% of the annual discharge). As the trees reach maturity, they are expected to use 20% of the irrigation season discharge (8% of the annual discharge). The city of Missoula is exploring using the remainder of the effluent for irrigation. A recent nutrient budget constructed for the WWTP showed that over 90% of the phosphorus entering the plant is captured as biosolids that is made into compost by Ekocompost; only 10% of the P enters the river. About 30% of the nitrogen is captured as biosolids, 20% enters the river, and almost 50% is apparently removed by denitrification. While the plant and the nearby plantation greatly reduce nutrient loading to the river, the plant does use a lot of energy. The plants energy use accounted for about 36% of Missoula city governments greenhouse gas emissions in 2008. However, on an annual basis, the plant captures about 50% of the methane generated by the digesters and uses it to heat digesters. The city is now studying capturing 100% of the methane to generate electricity to run pumps at the plant.

Fracking In Montana: What Are The Questions About Water?

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Oil and gas (O&G) is part of Montanas natural resources. Development of natural gas through hydraulic fracturing or fracking has the potential to yield both positive and negative outcomes. While the industry is at a point of quiescence because of the increased availability of reserves it makes sense to have a discussion now of the issues related to the practice of fracking and its impacts on Montanas landowners and residents before development gears up once again. A whitepaper made possible by funding from the Montana Farmers Union is set for release on September 1, 2015. The purpose of the paper is to provide informed context to readers so that questions associated with the practice of fracking related to water quantity and quality and other issues; such as air quality, economics, landowner, local verses State control, and policy questions can be discussed from a Montana perspective. This presentation presents some of the major issues associated with water quantity and quality to the scientific community. It is hoped that members of this community will be part of future discussions that will lead to better policy decisions that will help insure that Montanas citizens will help guide the outcomes.

Evolution Of A Stream Restoration Project: Prickly Pear Creek Project, A Case Study.

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The Prickly Pear Creek Stream Restoration Project was a major project on the primary stream of the watershed undertaken to address past agricultural impacts, man-made altered hydrologic conditions, excessive erosion, sedimentation as one of the listed pollutants impairing the stream function, limited floodplain storage capacity, and habitat improvements for the trout fishery. The project that began approximately ten years ago is good case study of the development of a stream restoration project from inception, expanding opportunities for project goals, project extent, and design. The implementation of the project was possible by having and adding numerous collaborative partners, finding sufficient funding, and dealing with obstacles related to timing and a changing regulatory permitting process. The lessons learned through the design and implementation of this project can be useful for developing future projects. A private landowner started this project at Lake Helena Watershed Group meeting by expressing his concerns about a deeply incised stream causing excessive erosion of the stream banks and potentially threatening a wetland complex on the property. After some initial site visits and discussions of the issues and what could be done to address them, a grant from the DEQ 319 Non-Point Pollution Source Program grant was obtained to conduct a restoration project on the site with the primary objectives of addressing the sediment loading to the stream while improving habitat for the local fishery. Over time additional partners, funding, and goals were added including more fisheries and habitat improvements, addressing natural stream function, riparian improvements, improved grazing management, and increasing floodplain capacity. Several years into the project planning, the upstream property came into public ownership as a new Fish, Wildlife and Park fishing access site. The property was added to the project with the additional task of restoration of a severely impacted spring creek tributary of Prickly Pear Creek. During the permitting process in the fall of 2014 as contracting for construction was being readied, requirements for an engineering review of the project design to obtain the County Floodplain Permit were mandated. This review of the project required modeling of the historic floodplain and base flood elevations from 1985 (FEMA Detailed Study Area), current floodplain condition, and proposed floodplain after the proposed project work. The modeling and review indicated the project work would not raise base flood elevations, however current conditions indicated a previous change and the floodplain permit issued for the project required an after project survey, additional modeling, and application to FEMA for a Letter of Map Revision for the floodplain hazard map of the project area. Additional funds were raised to allow construction of the project to begin in March 2015. Completion of the project construction in May 2015 was complicated by construction exceeding original estimates of time and budgets. Issues included amount of earthen material needed to be moved, limited availability of on-site rock, gravel, and woody materials, timing delays impacting revegetation efforts, and the amount of waste materials found onsite leading to expenditures exceeding budgeted costs.

Perspectives On River Restoration Science And Practice

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River restoration is one of the most prominent areas of applied water-resources science. In this presentation, we share perspectives on how river restoration has evolved, particularly during the last decade. From an initial focus on enhancing fish habitat or river appearance, primarily through structural modification of channel form, restoration has expanded to incorporate a wide variety of management activities designed to enhance river process and form. Restoration is conducted on headwater streams, large lowland rivers, and entire river networks in urban, agricultural, and less intensively human-altered environments. We examine social and scientific challenges for implementing river restoration, including relationships between physical complexity biogeochemical / stream ecosystem function, understanding sediment dynamics, and increasing appreciation of the importance of incorporating climate change considerations and resiliency into restoration planning. Changes in river restoration within the past decade include development of new tools and technologies; different types of process-based restoration focused on lateral and longitudinal connectivity; growing recognition of the importance of biological-physical feedbacks in rivers; increasing expectations of water quality improvements from restoration; and more effective communication between practitioners and river scientists.

Gallatin Groundwater Mitigation Bank: Expediting New Water Uses In A Closed Basin

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Excessive river flow depletion is the leading cause of freshwater species imperilment in the West. Major aquifers that feed Western rivers are similarly depleted. Yet nearly every western state allows unlimited groundwater pumping from those very aquifers, further reducing streamflow in the rivers that they feed. The only way to forestall further degradation is to cap withdrawals of both groundwater and surface water. Last fall, through judicial order, Montana became the first state to do so. How did we get to this point? How did science inform the policy? And how can a groundwater mitigation bank ensure that limiting supplies need not burden current and future water users? In the 1980's, Montana was one of the first states to allow instream flow rights and reservations to protect native fisheries. By 1990, it became evident that surface water in many Montana basins in Montana was fully allocated to offstream uses and instream flows. Accordingly, the legislature closed several basins to new surface-water rights. But instead of stopping streamflow depletion, the policy drove new water users to pump groundwater from alluvial aquifers. Senior water users in the Smith River posed objections, supported by expert testimony on the hydraulic connection between groundwater and surface water. The case went to the Montana Supreme Court, which ruled that the Department of Natural Resources and Conservation (DNRC) must permit groundwater and surface water as a single hydrologic resource. In the Gallatin Valley, Utility Solutions, informed by groundwater modeling, showed how artificial recharge could preclude adverse affects of changing surface-water irrigation rights to groundwater domestic rights. Subsequently, new DNRC rules embraced this approach. Rather than follow this lead, however, subdivision developers continued to drill new wells under a permit exemption for isolated, small wells. In October 2014, Montana District Court Judge Sherlock closed the exempt-well “loophole" by requiring multiple wells for a single project or development to go through water rights permitting. The consequent pressure that an increased permit load will put on the DNRC, permit applicants, and potential objectors threatens to undo the progress that has been made. A mitigation bank would resolve most of these challenges by facilitating water transfers from one purpose to another without harming existing users. The bank would acquire water rights from willing sellers, typically agricultural irrigators, and sell mitigation water to applicants for new groundwater uses, such as subdivision developers. In turn, new users are spared the challenges of locating willing sellers and navigating the complex regulatory process themselves, and impacts of the new uses are more effectively offset. Artificially recharging banked water into the aquifer via wetlands and streams maintains current streamflow patterns, while providing additional benefits to those natural systems. This is a fragile time. If the cap hinders economic development, then it may not survive the next legislature. If, on the other hand, a groundwater mitigation bank helps supply new water users while meeting regulatory requirements that protect other users and the environment, then it will pave the way for sustainable water use across the West.

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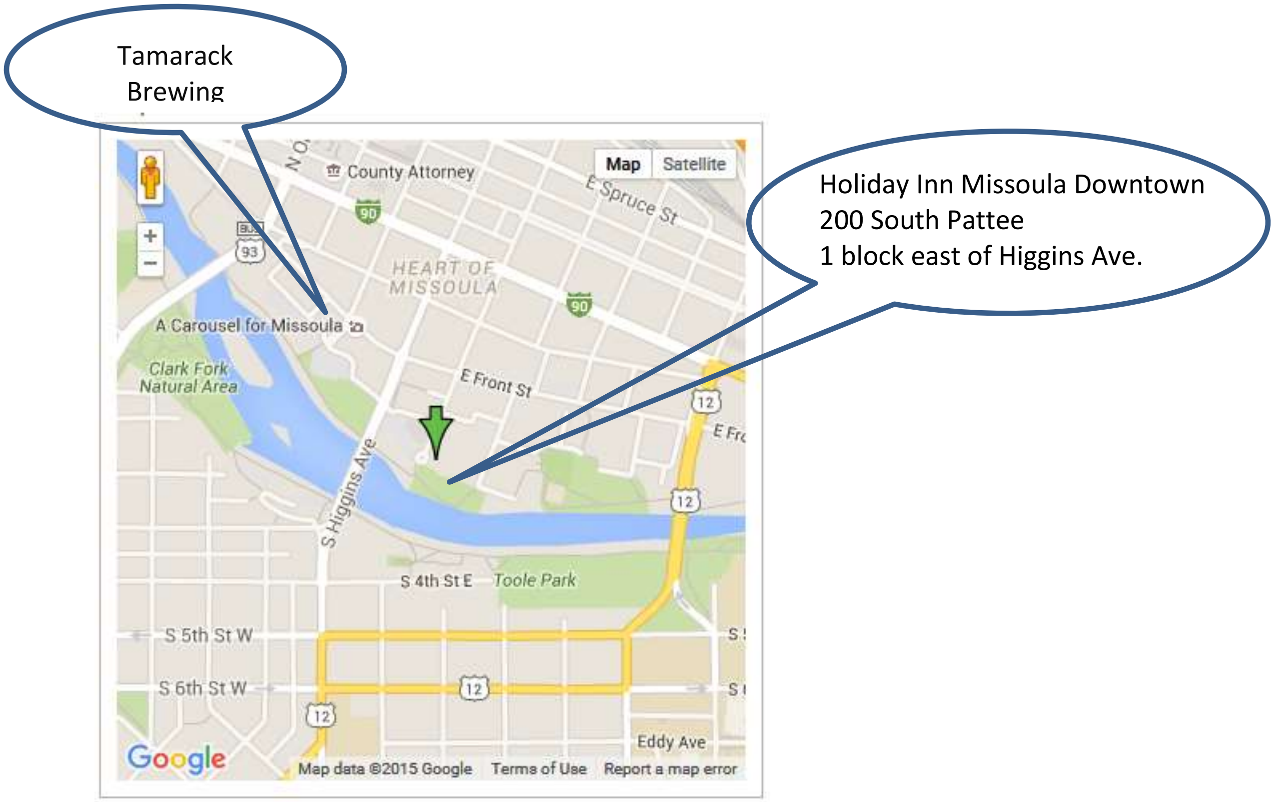
Joe	Zimbric	One Montana	Bozeman
Dionne	Zoanni	Montana State University-Bozeman	Bozeman


Tamarack Brewing
Holiday Inn Missoula Downtown
200 South Pattee
1 block east of Higgins Ave.
Map
Satellite
County Attorney
E Spruce St
HEART OF MISSOULA
A Carousel for Missoula
Clark Fork Natural Area
E Front St
S Higgins Ave
S 4th St E
Toole Park
S 5th St W
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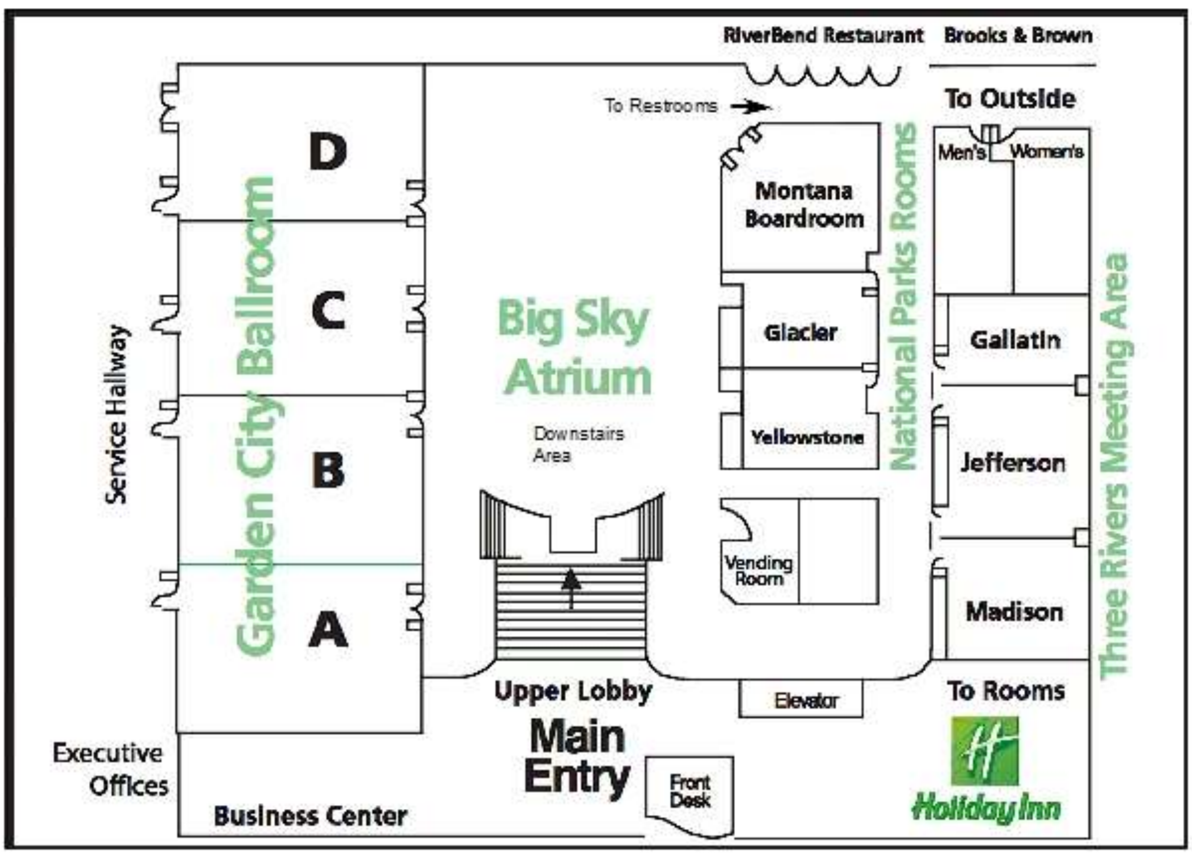
RiverBend Restaurant
Brooks & Brown
To Outside
To Restrooms
Men's
Women's
Montana Boardroom
National Parks Rooms
Glacier
Yellowstone
Vending Room
Gallatin
Jefferson
Madison
Three Rivers Meeting Area
Service Hallway
Garden City Ballroom
D
C
B
A
Big Sky Atrium
Downstairs Area
Upper Lobby
Main Entry
Front Desk
Elevator
To Rooms
Holiday Inn
Executive Offices
Business Center

Special Break-out Session

Watershed Funding Discussion

Event: MWCC/AWRA 2015 Symposium Special Break-out Session
Date: October 8th, 2015 Time: 3:00 pm to 5:00 pm
Location: Holiday Inn Downtown, Missoula, MT Madison/Jefferson/Gallatin Rooms

Background

Most watershed groups face a continual battle of trying to find funding for projects and trying to build and maintain capacity. MWCC felt it would be helpful to gather together some of the key funding organizations and hear from them about their activities and opportunities to support both projects and capacity-building. We wish to thank the individuals and organizations who have agreed to participate as panelists in this important conversation.

To facilitate discussion, DEQ and MWCC have assembled and updated a spreadsheet containing contact and application information for many of the funding organizations that work with Montana watershed groups. The spreadsheet will be provided to meeting participants as they arrive for the panel discussion. If you know of any additional funding sources, please come see Mark Ockey after the meeting or send him an email at mockey@mt.gov.

Definitions

To avoid confusion, we ask that folks consider adopting the following definitions for the purpose of the panel discussion.

- **Watershed Group**: any organization, public or private, that engages in stream or riparian restoration, pollution prevention, or aquatic resource conservation on a local or regional level. This may include watershed councils, conservation districts, non-profits, private foundations, local chapters of wildlife groups (TU, DU, WU, Audubon), etc.
- **Capacity**: the basic skills and resources necessary for watershed groups to operate. This may include base funding for employees and work spaces, technical skills, grant/contract management abilities, web tools and promotional materials, fiscal management tools, board development and engagement, etc.

Format

The format for the discussion will go as follows:

1. Each panelist, in turn, will answer a series of six questions regarding the funding programs they represent.
2. Following each presentation, the presenter will be given 5 minutes to answer questions from the audience.
3. After all presenters have had a chance to speak, any remaining time will be opened up for additional questions from the audience.

Panel Questions

1. State your name, title, and the name of the organization you represent.
2. Briefly describe the funding program(s) available through your organization.
3. Describe an “ideal project” that your organization might fund (could be either real or hypothetical).
4. What are the primary pitfalls and shortcomings you typically see in funding applications or requests?
5. What does your organization do to support watershed group capacity-building?
6. What’s on the horizon for your funding program(s), and how can groups become involved or stay informed?

Panelists

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