Some abstracts for
74th Annual Meeting of the Rocky Mountain Hydrologic Research Center

Friday, 3 April 2020 8:30 a.m. to 4 p.m. [CANCELLED as a result of COVID-19]

3215 Marine Street, Boulder, Colorado

Purpose: The annual meeting provides an opportunity for scientists and students working in the Rocky Mountain region to discuss their research in a relaxed, yet scientifically stimulating atmosphere. The meeting encourages interdisciplinary communication among professionals and students in the fields of ecology, engineering, environmental science, geology, hydrology, meteorology, and water resources.

Horse Creek near Rocky Mountain Hydrologic Research Center's property in Allenspark, Colorado.

Unfortunately, this annual meeting was cancelled for the first time because of the unusual situation caused by the COVID-19 pandemic, before many of the abstracts had been submitted. Moreover, there was insufficient time to switch to an online version of the meeting so these four abstracts are published retrospectively to provide a partial record of the meeting.

An observational framework for quantifying post-fire runoff and sediment response

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Wildfires are a complex and widespread problem across the western U.S. that dramatically alter watershed hydrology and increase sedimentation rates and concentrations of chemical constituents, such as nutrients, trace heavy metals, and dissolved organic matter (DOM). Though the dramatic effects of wildfires on water quality are known to exist, there are limited tools that provide water managers with an *a priori* assessment of potential impacts to specific watersheds. To address this gap in research, we developed laboratory-scale rainfall and wildfire simulators to measure the hydrologic, sedimentation, and water quality responses from soils subjected to a range of burn severities, rainfall intensities, and terrain slopes. The ultimate goal of this work is to develop a modeling tool to provide water managers with information on the potential impacts of a wildfire event on their systems.

For these laboratory simulations, soil samples were collected from a steep mountain catchment with a record of wildfires as recent as 2012—the Cache la Poudre (CLP) Basin near Fort Collins, CO—and were exposed to different combinations of burn severities, rainfall intensities, and representative terrain slopes. Runoff and infiltration generated by the rainfall simulator were collected from each soil sample, measured to ascertain runoff ratios, then analyzed for differences in sedimentation and chemical constituent fluxes across the three dimensions. These simulations allow for the analysis of the effects of the three controls on water quality individually, and jointly: necessary for a holistic understanding of wildfire effects at the catchment scale. Results from laboratory experimentation were compared with synthetic results from models to understand areas of disagreement. Synthetic results of sedimentation response were generated by the Revised Universal Soil Loss Equation, and infiltration and runoff amounts were modeled using HYDRUS 1D software to anticipate dominant factors and processes. Preliminary results from both the synthetic models and the laboratory experiments show that wildfire burn severity is the primary driving factor of sedimentation flux, and rainfall intensity and terrain slope have smaller, but positively contributing effects. More extensive results and conclusions from this analysis will be presented. These include issues related to model transferability and the longer-term goal of up-scaling to the catchment scale to create physical and statistical predictive models, with applications for water managers and water treatment plants in high-risk wildfire areas across the West.

Arsenic concentrations and fluxes in major rivers of Yellowstone National Park

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Yellowstone National Park (YNP) has more than 10,000 thermal features and most contain elevated dissolved arsenic concentrations (0.1 – 15 mg/L). Arsenic transport through and downstream of YNP impacts aquatic habitats and water resources posing threats to aquatic, wildlife, and human health. We have quantified the amount and fate of arsenic discharging from thermal features and exiting YNP in major rivers. Arsenite (As(III)), is often the main arsenic species at the thermal source and it rapidly oxidizes to arsenate (As(V)) along the drainage. Arsenic transport in rivers and creeks in YNP is conservative because arsenate does not sorb to sediments due to high pH (7-9), arsenic specific sorption sites are likely saturated with arsenic or other sorbed solutes (e.g. silica), and there is very little iron entering the rivers to coprecipitate arsenic. Since arsenic is conservative in YNP rivers, specific conductance can be used as a surrogate measurement. Despite arsenic having very little influence on specific conductance (As transference numbers are less than 0.1%), the ratios of arsenic to the major dissolved ions (chloride, bicarbonate, and sodium) are constant for each river. This constant ratio allows for specific conductance to be used as a surrogate measurement for arsenic concentrations. Continuous (15 min) specific conductance measurements at monitoring sites along YNP's major rivers (Madison, Firehole, Gibbon, Yellowstone, Gardner, Snake, and Falls) has been used since 2010 to monitor chloride concentrations and fluxes for the purpose of monitoring thermal activity. At each monitoring site, arsenic-specific conductance correlations ($R^2 > 0.96$) were developed by analyzing water samples collected over a wide range of discharges. Using the continuous specific conductance data and the arsenic-specific conductance correlations, the arsenic concentrations and fluxes have been estimated. Arsenic concentrations are highest during baseflow conditions at all river monitoring sites. The highest concentrations are in the Firehole (~400 µg/L), Madison (~300 µg/L), and Gibbon (~150 µg/L) Rivers. Additionally, approximately 180,000 kg of arsenic are transported annually from YNP via the Madison (110,000 kg/yr), Yellowstone (46,000 kg/yr), Snake (13,000 kg/yr), and Falls (8,000 kg/yr) Rivers.

Spectrum of bank erosion along Powder River

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Powder River is an alluvial river flowing northward across central Wyoming and southeastern Montana in the western USA. Annual bank erosion, along a 90-km study reach of the river starting near the Wyoming-Montana state line, has been measured throughout a 44-year period at 17 channel cross sections. Whereas many bank erosion studies have focused on single bends with known high erosion rates, these sections represent different types of reaches, and thus provide a representative dataset that characterizes an entire river reach. During the period covered by this analysis (1978-2019) annual peak daily discharge ranged from 22.7 to 779 $m^3 s^{-1}$, and bank-full flow was ~175 $m^3 s^{-1}$. For the 17 sections, the average river width, *w*, was 49 $\pm$ 11 m, and the radius of curvature, *R*, ranged from 82 m to ~73000 m for a straight reach. Banks are composed of two layers with silt and clay overlaying sand and gravel and heights that range from 0.5 to 3.7 m.

Annual bank erosion was temporally and spatially episodic. Therefore, for statistical purposes plus the lack of replicates at any annual peak daily discharge, the erosion data were grouped into four discharges classes (22.7-50, 50-100, 100-200, and 200-800 $m^3 s^{-1}$). Of the 367 measurements, 71 % represented bank erosion, and 29 % zero erosion. Zero erosion was characteristic of all discharge classes suggesting that discharge was not the only controlling factor. The lowest two discharge classes were not statistical different (p=0.6), whereas the larger two classes were statistical different from themselves and from the lower two classes ($p<0.008$). Within each discharge class, the bank erosion had a weak dependence on *R/w* ($R^2<0.35$), which is commonly accepted as a major controlling factor of bank erosion. South-facing banks thaw out sooner than banks with other aspects and are possibly more vulnerable to erosion. Therefore, the data were regrouped into four aspect classes (north, east, south, and west). For discharge classes >50 $m^3 s^{-1}$, south-facing bank erosion was significantly greater ($p<0.034$) than erosion on north-facing and east-facing banks. This tendency of increased erosion for south-facing banks may explain previous observations in the literature of bend migration along the lower reach of Powder River that consists predominately of downriver translation and negligible lateral migration.

Hazardous Hydraulics at Low-Head Dams

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Throughout the United States, there are hundreds of stream diversions and small power dams that are called low-head dams. These 5 to 15-foot high dams are known as run of the river dams.

Low-head dams are also known as “drowning machines” because under certain conditions they have submerged hydraulic jumps that can entrap boaters, swimmers, tubers, and fishers. These dams also create latent hazards for the first responders, such as firefighters, who work to rescue entrapped boaters, swimmers, tubers, and fishers.

The dangerous hydraulics of low head dams are misleading and can create reverse roller, from which escape is nearly impossible.