Idaho Water Resources Research Institute
Annual Technical Report
FY 2016

Introduction

The Idaho Water Resources Research Institute (IWRRI) is housed at the University of Idaho. IWRRI is dedicated to supporting and promoting water and water–related research, education, and information transfer throughout Idaho. IWRRI collaborates with researchers and educators from all Idaho state universities; staff of local, state, and federal agencies; and private water interests. The IWRRI is the only mechanism in the state that provides an autonomous statewide source of support for water research and training without regard to specific topic or discipline area. This is important because Idaho's water problems cross multiple topics and disciplines and compartmental approaches to these problems are less effective. State and federal agencies and private water interests rely upon IWRRI to provide objective expertise addressing the needs of the state and region. The Institute has been a strong proponent of education and outreach for both youth and adult audiences. It is through education that the public can make informed public policy decisions concerning water. It is also through education that individual citizens become engaged in the process through adjustments of their own attitudes and lifestyles.

Research Program Introduction

The Idaho Water Resources Research Institutes research program is comprised of the following objectives: (1) To work with state and federal agencies and non−government organizations to identify water research needs of the state and region; (2) To promote water−related research relevant to state and regional needs; (3) To stimulate, coordinate, and provide leadership for water resources research within Idaho universities and collaborate with sister institutions in adjoining states; (4) To cooperate with and assist state and federal agencies and non−governmental organizations for the benefit of the citizens of Idaho and the region; and (5) To develop funding for needed research and encourage cooperation with other research organizations. The Idaho Water Resources Research Institute was able to support four new research projects during the 2016 Project year using 104B program and state funds on: (1) linking agronomic soil phosphorus with water quality in Palouse (dryland) cropping systems; (2) the seasonal flux of environmental conditions and metal solutes in the shallow groundwater of an mining-impacted system; and, (3) engaging water resource stakeholders in long-term drought planning.

Linking Agronomic Soil-P with Water Quality in Palouse Cropping Systems

Basic Information

Title:	Linking Agronomic Soil-P with Water Quality in Palouse Cropping Systems
Project Number:	2015ID201B
Start Date:	3/1/2016
End Date:	2/28/2017
Funding Source:	104B
Congressional District:	ID-01
Research Category:	Water Quality
Focus Category:	Water Quality, Agriculture, Solute Transport
Descriptors:	None
Principal Investigators:	Daniel Strawn, Erin Brooks

Publications

There are no publications.

The goal of this proposed research was to link soil and topographic attributes with potential P runoff loss. We hypothesized that long-term application of P fertilizer, field-scale soil variability, and tillage management in the dryland cropping systems of the Northwest Wheat and Range Region (NWRR) creates a patchy distribution of soil P availability for crop uptake and runoff; with some areas deficient in plant available P, and other areas with excessive soluble/available P that leads to transport losses out of the agricultural watershed. Through our research, we have documented subsurface dissolved reactive P concentrations up to 0.2 mg/L in subsurface drainage effluent.

We have conducted field water sampling and measurement of waters soluble phosphorus from soil samples from 2015, 2008, and 1998. We extracted the soils to measure available total water soluble (TP) and orthophosphate (dissolved reactive phosphorus (DRP)). Phosphorus availability from the soil samples will be compared to measure how management and time has affected P availability in the soils. We set up three collection devices at the site to sample water outflow from the watershed: overland flow sampler, tile drain sampler, and stream sampler. From each sample we measured total, and dissolved reactive P. The data is in the process of being matched to data on outflow rates to calculate total loading per event (rain or snow melt). Figure 1 shows the data collected for the two years of the project.

We collected intact soil cores from three sites to investigate how macro-pore channels affect subsurface transport of phosphorus to tile drains, which feed streams Figure 2. Within the stream, we deployed an in- stream phosphorus analyzer that measures stream water reactive-P concentrations multiple time per day, allowing for measurement of DRP on a continuous basis. Using this in-stream sampler, we monitored for pulse events that are major contributors to surface water P loading Figure 3. Correlating the pulse events with watershed outflow and soil P availability provides us a more complete understanding of phosphorus-source vectors from an agronomic field into surface waters.

We have completed the research for the project, and the MS student in Water Resources is working on completing their thesis. This will result in two publications in 2017 or 2018.

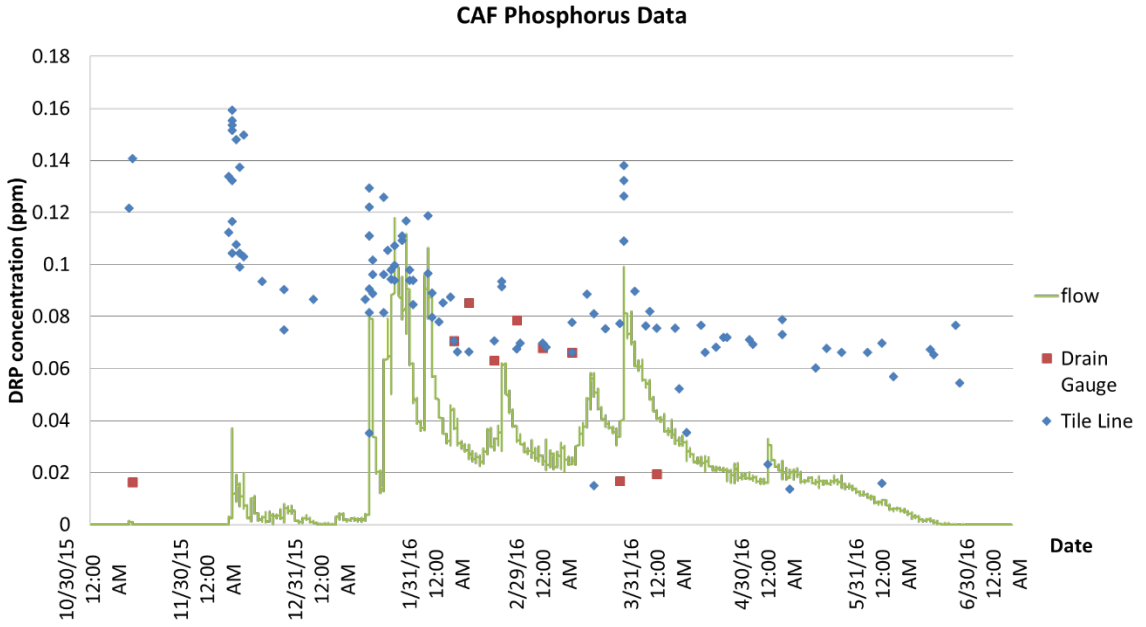


Figure 1. DRP concentrations in outflow from tile drain on Cook Agronomy Farm (blue dots). Green line is relative flow rate. Red squares are P concentration in sampling well.

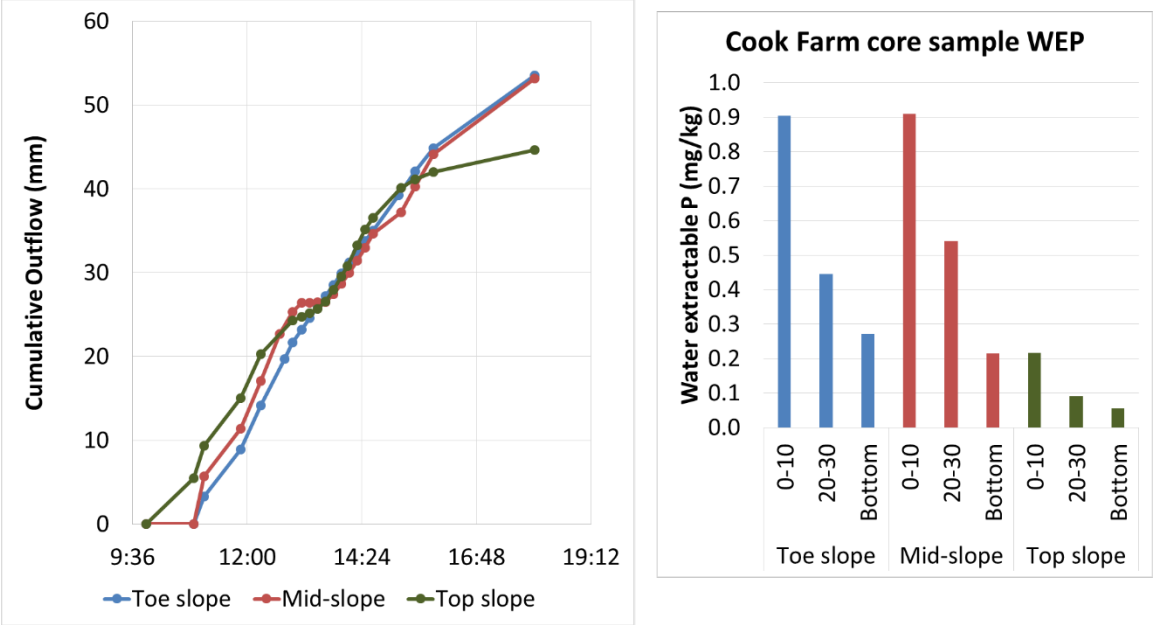


Figure 2. Flow rate from 25-cm wide cores from three landscape positions on the Cook Agronomy Farm (left panel). Water extractable P from three depths and three landscape positions (right panel).

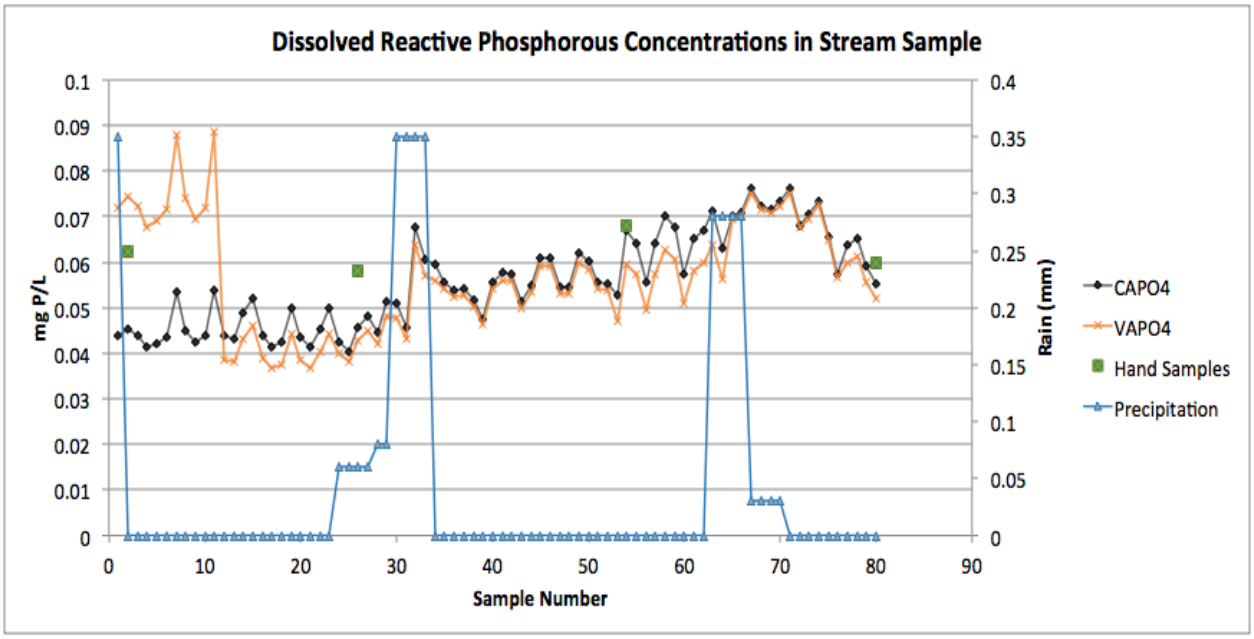


Figure 3. Concentration of DRP in stream outflow from the Cook Agronomy Farm watershed from 4/6/16 to 4/26/16. Samples taken at six hour intervals.

Impact:
Excess phosphorus and nitrogen in watersheds are causing severe degradation of water quality by promoting growth of algae and phytoplankton, impairing surface water for recreation and drinking, and severely deteriorating ecosystem health. Agriculture is one of the largest contributors of nutrients to surface waters. Because phosphorus is typically the limiting nutrient, it is the target of many TMDLs. Despite decades of best management practices, surface water concentrations of P are still increasing. It is proposed that the release of legacy P in soils and sediments are a major source of the continued P loading in surface waters. This is exacerbated by complex watershed processes that are not accounted for in best management practices.

With the increasing availability of GPS tracking and guidance systems, and crop yield monitors and variable rate fertilizer application technologies on agriculture equipment, precision agriculture techniques are more readily being implemented by farmers. This typically results in fields being divided into multiple management zones and treated with variable fertilizer rates. To date, the focus in precision agriculture has been on varying nitrogen rates. In the NWRR, nutrient management also includes annual addition of phosphorus fertilizer. P fertilizer application rates are based on traditional application rates. Given the variability in soil properties, and current efforts to increase precision agriculture management, there is a need to develop site- and crop-specific P fertilizer application strategies. This requires knowledge of speciation and availability of P in the soils, and how much and what type of P leaves the soil as surface runoff.

Results from this study will provide information on which soils pose the greatest risks for P runoff in a no-till field, as well as information on how much P is leaving the catchment through the drainage lines and entering into surface waters. The concentrations in the drain lines and stream indicate that P is flowing out of the drains at levels that would impair surface water quality. The water extractable P from the soils shows that P availability varies by location on the landscape, and by depth. It is proposed that no-till agriculture increases subsurface infiltration, and possibly movement of P to the lower soil profile. By comparing the 1998, 2008, and 2016 P distribution profiles, P mobilization potential will be measured. Information from this research will be used to design better agricultural practices to limit dissolved and particulate P runoff into surface waters.

Seasonal Flux of Environmental Conditions and Metal Solutes in Shallow Groundwater of the Mining-Impacted Upper CDA

Basic Information

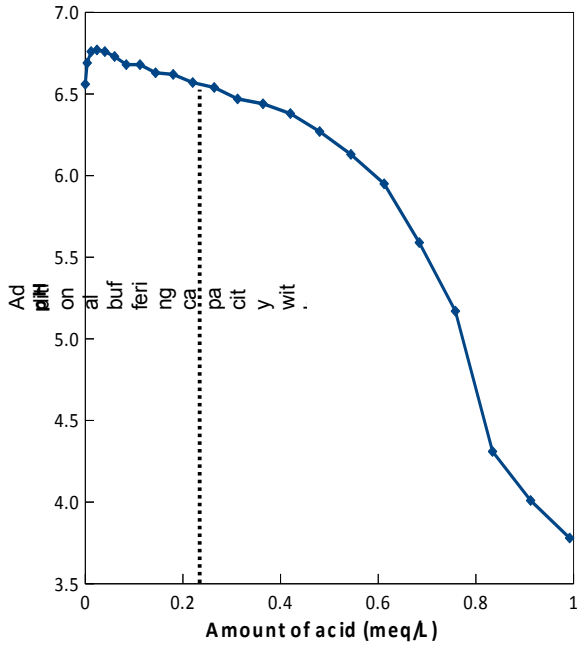
Title:	Seasonal Flux of Environmental Conditions and Metal Solutes in Shallow Groundwater of the Mining-Impacted Upper CDA
Project Number:	2016ID208B
Start Date:	3/1/2016
End Date:	2/28/2017
Funding Source:	104B
Congressional District:	ID-01
Research Category:	Ground-water Flow and Transport
Focus Category:	Solute Transport, Water Quality, Groundwater
Descriptors:	None
Principal Investigators:	Jeff Langman

Publications

There are no publications.

The purpose of this study was to examine the environmental conditions and metal particle size and form in mine drainage and the shallow groundwater along Canyon Creek in the mining-impacted Burke Canyon in the Coeur d'Alene Mining District. This study was used to preliminary evaluate the form and composition of metal nano- and micro-particles through different seasons to understand the influence of environmental conditions on the metal particle formation and transport. The study involved the collection of water samples from discharge exiting the abandoned Gem Mine and from shallow alluvium wells located upgradient and downgradient of the Gem Mine discharge. Analyses included the determination of metal and anion concentrations, particle size distributions, zeta potential (nanoparticle stability), and solution mineral preferences. This study was proposed as a pilot project for a future investigation to examine the formation, size, behavior, fate, and transport of metal nanoparticles as inorganic colloids and co-associated minerals in mining-impacted environments.

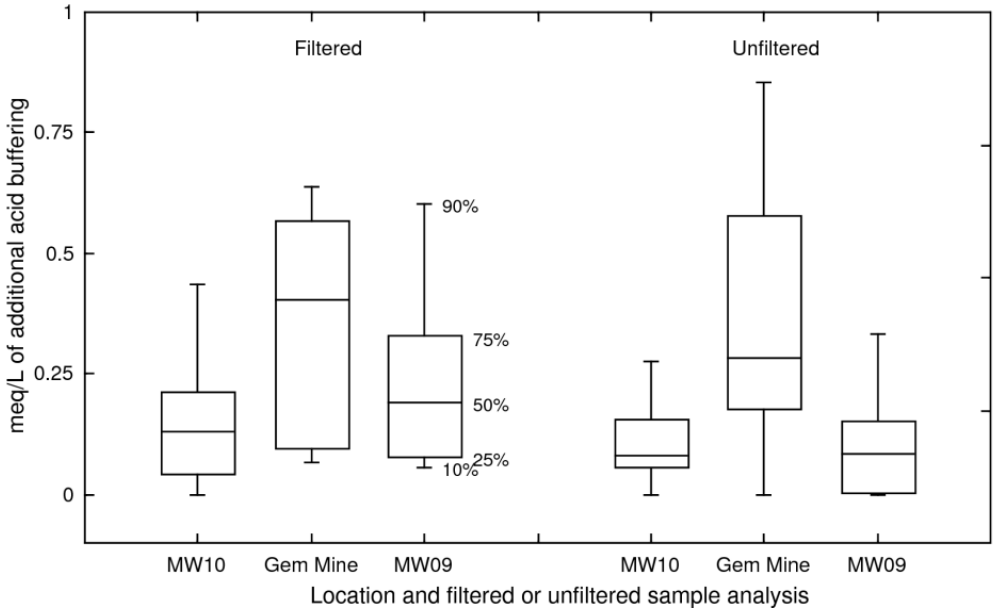
Results of the study indicate an alteration of the groundwater geochemistry in Burke Canyon from introduction of mine discharge from the abandoned Gem Mine located. Water temperature, pH, conductivity, sulfate, manganese, and zinc all increased in groundwater from the upgradient well to the downgradient well because of the mine discharge and infiltration to the shallow aquifer. The most interesting result was the identification of a masked acid buffering capacity in the mine discharge and groundwater because of the presence of metal-carbonate nanoparticles. Because of the formation of transportable carbonate nanoparticles from weathering of carbonate deposits associated with the metal-sulfide ore bodies within the Coeur d'Alene Mining District, a portion of the carbonate in solution (nanoparticle form) was restricted from interacting with the solution and influencing pH. The amount of masked acid buffering capacity was determined through alkalinity (filtered sample) and acid neutralizing capacity (unfiltered sample) analyses where sulfuric acid was introduced to the samples, which produced



an increase in pH with disassociation of the metal-carbonate nanoparticles (example shown in Fig. 1).

Figure 1. Example of the additional acid buffering capacity because of the presence of metal-carbonate nanoparticles.

The median additional buffering capacity of the Gem Mine discharge was 0.4 meq/L (Fig. 2, filtered) equal to 0.2 mM of $ZnCO_3$ or 25 mg/L of $ZnCO_3$ or 13 mg/L of Zn, which is similar to the median Zn concentration of 15.5 mg/L detected in the Gem Mine discharge. It is possible that the difference in values may be represented by rhodochrosite ($MnCO_3$) nanoparticles, given the prevalence of $MnCO_3$ found within the ore bodies and oxidized zones of the Coeur d'Alene Mining District and a median Mn concentration of 4.2 mg/L in filtered Gem Mine discharge. This additional buffering capacity was primarily present in the mine discharge, but was identified at a smaller scale in the groundwater samples (Fig. 2). This indication of $ZnCO_3$ (smithsonite) nanoparticles responsible for the masked buffering corresponds to a likely detachment of $ZnCO_3$ nanoparticles with weathering as opposed to solution formation (colloid formation) of such particles. Geochemical equilibration of the Gem Mine water chemistry indicated undersaturation of smithsonite and rhodochorosite, which support the conclusion of nanoparticle release instead of colloid formation in the discharge with transport from the weathered source to the outlet point. This conclusion of smithsonite nanoparticle detachment and transport in mine drainage is supported by zeta potential results (Fig. 3) that indicate a semi-stable nanoparticle present in



solution in the mine discharge.

Figure 2. Distribution of additional acid buffering capacity with presence of the metal-carbonate nanoparticles in Gem Mine discharge and nearby groundwater.

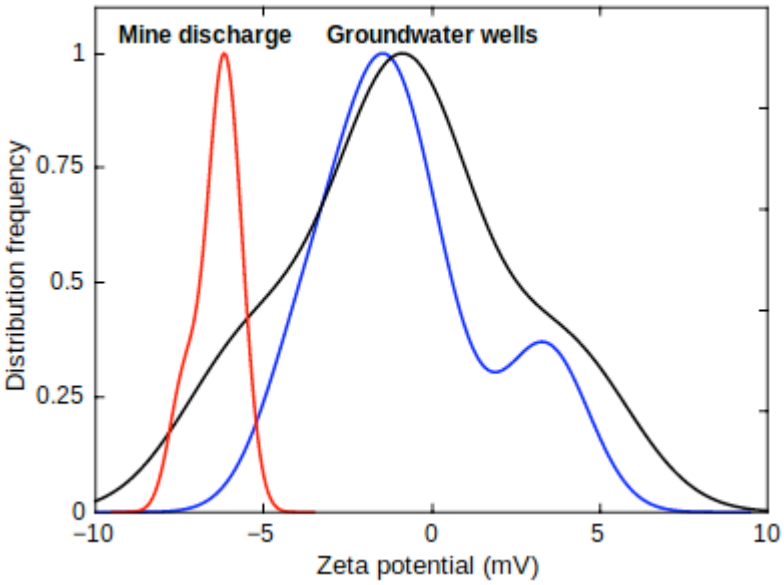


Figure 3. Zeta potential distribution for water samples from the Gem Mine discharge and associated groundwater wells.

Overall, the detection of smithsonite nanoparticles with masked acid buffering capacity helped to explain the alteration of shallow groundwater geochemistry with introduction of the Gem Mine discharge. The limited stability of the nanoparticles in the Gem Mine discharge allow for transport under stable geochemical conditions (discharge solution conditions), but with discharge to the surface environment and infiltration to the alluvial aquifer, degradation of the nanoparticles is occurring and altering the environmental conditions and chemistry of the groundwater. Additionally, the identification of the detachment of a metal-carbonate nanoparticle with weathering of a carbonate deposit aligns with recent promulgation of the theory of carbonate nanoparticle detachment (Levenson and Emmanuel 2017) as opposed to the widely accepted theory of carbonate dissolution and release of free ions.

References:

Levenson Y, Emmanuel S (2017) Repulsion between calcite crystals and grain detachment during water–rock interaction. Geochem Perspect Lett 133–141. doi: 10.7185/geochemlet.1714

Information Transfer Program Introduction

The Idaho Water Resources Research Institutes Outreach and Information Transfer program is comprised of the following objectives: (1) to encourage and facilitate public involvement in water resource programs within the state; and (2) to promote water education within the state at the K−12, undergraduate and graduate levels. During the 2016 Program Year, 104B program and state funds were used to support the Idaho Water Resources Outreach and Engagement Effort, described in more detail below.

Idaho Drought Planning

Basic Information

Title:	Idaho Drought Planning
Project Number:	2016ID209B
Start Date:	3/1/2016
End Date:	6/1/2017
Funding Source:	104B
Congressional District:	ID-01
Research Category:	Climate and Hydrologic Processes
Focus Category:	Drought, Management and Planning, Law, Institutions, and Policy
Descriptors:	None
Principal Investigators:	Mark David Solomon

Publications

There are no publications.

No single state or federal agency in Idaho is tasked with comprehensive drought planning outside of its specific mission, nor is there an assemblage of agencies with drought planning as their objective. In 2015, IWRRI was asked by state and federal agencies to spark creation of a comprehensive Idaho drought plan. As a respected, impartial and trusted statewide water resource research institution, IWRRI was and is uniquely positioned to facilitate comprehensive Idaho drought planning as part of IWRRI's information transfer and outreach mission.

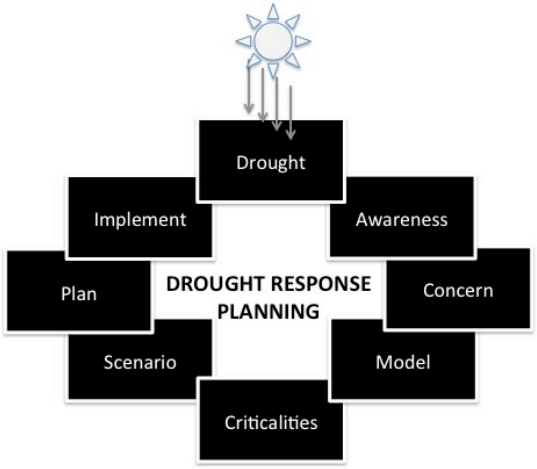
IWRRI conducted one-on-one meetings with representatives of state agencies, federal agencies, agricultural water users, energy companies, NGOs, cites, counties, and other critical stakeholders to secure willingness of entities to engage in comprehensive drought planning. IWRRI secured agreement to participate from key entities, including: USGS Idaho Water Science Center, US Bureau of Reclamation Upper Snake River Area Office, U.S. Forest Service, Natural Resources Conservation Service, Coeur d'Alene Tribe, Idaho Department of Water Resources, Idaho Department of Lands, Idaho Department of Agriculture, Idaho Water Users Association, Idaho Groundwater Association, Idaho Power Company, Idaho Rivers United, and Idaho Conservation League, as well as UI faculty in appropriate disciplines (climate change, hydrology, economics, urban planning, water resources management). Plenary session presentations were made to the Idaho Water Users Association Annual Water Law Symposium and the Idaho Association of Counties Annual Mid-Winter Conference.

The planning process agreed to examines acute criticalities in the context of chronic water scarcity, identifying vulnerabilities at the sub-basin and larger scale with a thirty-year planning horizon (2046) at ten-year time steps. The term "criticality" is used here to mean geo-located system vulnerabilities that if exposed to drought conditions have the inherent potential to create out-sized effects in their sub-basin or beyond. Criticalities may take many forms including infrastructure capacity, hydrologic function, ecologic function, public health, water rights, water quality, regulatory rules, etc. Generally, chronic water scarcity induces system adaptation over time. Acute criticalities induced by water scarcity may, however, precipitate system chaos. As such, the five-part planning process described below is designed to report anticipated chronic conditions and to plan responses to identified acute criticalities:

1) Climate Change Effects Modeling: Climate change will be modeled using data and modeling provided by the UI Applied Climate Science Lab, who will also apply the results to modeling of changes in wildfire frequency, intensity and distribution. UI and IWRRI scientists will lead application of climate change and wildfire modeling outputs to hydrograph modeling. Existing modeling performed by project collaborators will be collected, vetted and included as appropriate to minimize duplication of efforts and speed the process.
2) Update 2001 Idaho Drought Plan: The results of climate change effects modeling will be used to update the 2001 Idaho Drought Plan. This first phase planning product will provide agency managers and water users information to appropriately plan for and manage Idaho's water resources for short-term drought while the long-term drought plan is developed and implemented over time.
3) Criticalities: Criticalities will be identified and prioritized in a stakeholder-driven process of iterative workshops distributed across the major river basins of the state (i.e. Bear Lake, upper Snake, mid-Snake, Boise, Weiser/Payette, Salmon, Clearwater, Panhandle). Scoping workshops will be held to elicit stakeholder identification of potential criticalities and to engage a diverse set of stakeholders in the planning process. Analysis of modeling outputs will expand or delete the list of potential criticalities. A second set of workshops will bring the analysis back to the stakeholders for verification followed by prioritization by the steering committee.
4) Scenario Planning: Stakeholders affected by high-priority criticalities will be invited to participate in facilitated scenario response planning workshops, supported by researchers

with expertise in the nature of the particular criticality. The purpose of the scenario planning is twofold: to role play likely responses to triggering of a criticality, and to identify where actions need to be taken to fill a data or framework gap to preclude undesired scenario responses. Where possible, given time and resource restraints of the planning process, researchers will be engaged to fill the identified gaps. Where not possible, gaps will be prioritized and assembled into a follow-on proposal for funding when sources are available.

5) Report: Results of the process will be assembled into a draft report and taken to stakeholders as per step 2. Following incorporation of feedback and comments from stakeholders and the steering committee, a second phase plan for addressing the highest priority Idaho drought criticalities will be completed and incorporated into the updated Idaho Drought Plan.



Initial steps to develop funding for the multi-year planning process are underway with drought-specific funding programs administered by the Federal Emergency Management Agency and U.S. Bureau of Reclamation identified for proposal development by IWRRI and submission by the State of Idaho. IWRRI is trialing a proof-of-concept project as part of its 2017 104B supported research in the Magic Valley area of the East Snake Plain in southern Idaho. The project is examining the potential vulnerability of the Idaho dairy industry to water right administration under a long-term drought scenario.

Stakeholder Engagement, Outreach and Education

Basic Information

Title:	Stakeholder Engagement, Outreach and Education
Project Number:	2016ID210B
Start Date:	3/1/2016
End Date:	6/1/2017
Funding Source:	104B
Congressional District:	ID-01
Research Category:	Not Applicable
Focus Category:	Education, None, None
Descriptors:	None
Principal Investigators:	Mark David Solomon, Brant G Miller, Julie Scanlin

Publication

1. Squires, A., Jennewein, J., Engels, M., Miller, B., & Eitel, K. B. (Fall 2016). Integrating Watershed Science in High School Classrooms: The Confluence Project Approach. CLEARING, 14-17.

Bringing Water Resources Education to the K-12 Classroom

IWRRI provides support for place-based and traditional watershed education programs for K-12 students. The Confluence Project (TCP) engages teachers and students in place and project-based curricular approaches. TCP is a watershed and climate science curricular approach that is infused with Indigenous knowledge, providing K-12 teachers with a model to take back to their classrooms. TCP uses a series of field experiences that help students better understand issues related to water as a critical resource. In 2016, TCP expanded to southeastern Idaho reaching approximately 300 Idaho students.

In the Treasure Valley (Boise area), students used TCP provided equipment with the TCP curriculum to conduct a study on a local water quality issue. Several groups chose to measure water quality before and after the use of natural filters like native grasses and wetlands. Some groups chose to look at topics surrounding snow science and impacts on water quality such as cloud seeding and the use of ice melt. Other groups looked at the impacts of large-scale monocultures and the differences in water quality as it compares to other forms of land use like permaculture. Students also used the equipment to examine the downstream impacts of water pollution on macro-invertebrates. Students worked with mentors from Boise State University to collect and analyze data, create a research poster, and presented their research posters at TCP's science night on May 12th at Vision Charter School. The equipment used to collect data and do research aligned with the Confluence Project curriculum and enabled students to better understand the broader topic of water quality as it specifically relates to agriculture, snow science, and stream and river science.

In southeastern Idaho, approximately 60 Environmental Science students at Teton High School participated in this year's TCP program. During the week of Feb 6th, TCP personnel traveled to Driggs, Idaho to provide teacher support before and during the Snow Science field experience. This support included scouting field locations, meeting with partner organization, arranging gear, teaching in class pre-field experience lessons, facilitating the field experience, and managing field data. Grand Targhee Ski Resort supported this field experience with staff from their Nature center securing snow shoes for the students, providing on-site classroom space, and selecting appropriate field sampling locations. During the field experience students dug a total of 10 snow pits to ground level (>2 m of snow in places) and collected data on the snow water equivalent in each layer of the snow pack. In addition, they got a basic introduction to avalanche safety and background on changing snow pack conditions in the NW as a result of climate change. As part of the post lesson the students compared their field data with data collected at the Grand Targhee's SNOTEL site in order to better understand how water forecasts are generated. Feedback from the students was very positive, with many indicating that this was their first introduction to snow science (and snowshoes) and that they greatly appreciated gaining an understanding of how a snow pack changes over time.

The Idaho Water Resources Research Seminar Series

Beyond supporting K-12 education, IWRRI provided a state-wide water resources seminar series during the Fall semester of 2016, delivered via a compressed video system to Boise, Moscow, Pocatello, Idaho Falls and Coeur d'Alene. During project year 2016, IWRRI increased its seminar and professional outreach activities in Northern Idaho via its new Lake Social Ecological Systems (LaSES) lab at UI-Coeur d'Alene, hosting world-renowned limnologist Jorg Imberger for a series of public lectures and workshops associated with the grand opening of the lab.

The Idaho Travel Grant Program

During Project Year 2015, travel support was provided to faculty and researchers at the University of Idaho. Support was additionally provided for the Interim Director to attend the 2016 Annual National Institutes of Water Resources meeting and for stakeholder engagement meetings across Idaho.

Additional Activities

In 2016, IWRRI sponsored or provided support for several public water resources conferences and symposiums including: the Spokane River Forum, attended by over 500 people over three days; the Idaho Environmental Education Association (IdEEA) annual conference attended by 200 K-12 educators; the Idaho Water Users Association Annual Conference; and the Boise River Enhancement Network's annual Boise River Bash. Interim Director Solomon provided plenary session presentations to the Spokane River Forum, the Idaho Water Users Association Water Law Symposium, the annual Idaho Water Quality Workshop, the Idaho Association of Counties, the Our Gem (Coeur d'Alene Lake) Symposium, and the Idaho Chapter of the American Water Resources Association. IWRRI continues its support of the Idaho State Chapter of the American Water Resources Association by recruiting members and providing sponsorship and publicity for several of its events. Interim Director Solomon is on the ad hoc steering committee planning the Fall 2017 Idaho's Changing Climate Summit.

USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	0	0	0	0	0
Masters	3	0	0	0	3
Ph.D.	0	0	0	0	0
Post-Doc.	0	0	0	0	0
Total	3	0	0	0	3

Notable Awards and Achievements

One of The Confluence Project graduate students was awarded Idaho Informal Environmental Educator of the Year.