Idaho Water Resources Research Institute
Annual Technical Report
FY 2007

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. IWRRI is relied upon by state and federal agencies and private water interests to provide the objective expertise to address 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; (5) To encourage and facilitate public involvement in water resource programs within the state; (6) To promote water education within the state at the K−12, undergraduate and graduate levels; and (7) To develop funding for needed research and encourage cooperation with other research organizations.

The projects funded during the 2006 104B Program Fiscal Year spanned the range of water issues facing the State of Idaho. This includes projects that investigate: the impact that irrigated agricultural activities have on an areas surface and ground water quality; identifying the occurrence of arsenic contamination in ground water resources in the major population center of the State; components of the water balance for the Snake River Plain, which is currently undergoing the largest water rights adjudication effort in the United States; and factors that affect water quality in some of northern Idaho's recreational lakes.

Seasonal variation in anthropogenic nutrient additions and food web response in a large deep lake (Lake Crescent, Olympic National Park)

Basic Information

Title:	Seasonal variation in anthropogenic nutrient additions and food web response in a large deep lake (Lake Crescent, Olympic National Park)
Project Number:	2005ID50B
Start Date:	3/1/2005
End Date:	6/30/2007
Funding Source:	104B
Congressional District:	01
Research Category:	Biological Sciences
Focus Category:	Water Quality, Surface Water, Non Point Pollution
Descriptors:	
Principal Investigators:	Stephanie Hampton, Brian Kennedy

Publication

1. Rosenberger, E.E., S.E. Hampton, S.C. Fradkin, B.P. Kennedy. 2008. Effects of shoreline development on the nearshore environment in large deep oligotrophic lakes. Freshwater Biology. In press.
2. Hampton, S.E., S.C. Fradkin, E.E. Rosenberger, and P.R. Leavitt. Disproportionate importance of nearshore habitat for the freshwater food web. In prep for Ambio.

Seasonal variation in anthropogenic nutrient additions and food web response in a large deep lake (Lake Crescent, Olympic National Park)

RESEARCH

Shoreline development is known to degrade water quality and nearshore habitat for lake biota. Deep nutrient-poor lakes – particularly prized for their fisheries and beauty in the Pacific Northwest – may be especially sensitive to shoreline development that affects nearshore habitat. Shallow nearshore water in a steep-sided basin comprises relatively little of the total volume and surface area, but may provide the most crucial breeding habitat for fishes and, potentially, the primary feeding habitat. Even if pollutants entering at the shore are not sufficient to change open water conditions, nearshore communities may exhibit biomass and compositional changes that have disproportionately large impacts on food webs dependent on these shallow waters. In Olympic National Park, Washington, Lake Crescent has modest residential development, and nuisance filamentous algal mats are now regularly observed at developed sites.

In May 2005, I brought on Elizabeth Seminet-Reneau as a M.S. student in the Fish & Wildlife department at UI to work on localized effects of nutrient pollution in Lake Crescent. Seminet-Reneau has a strong work and educational background in limnology, fisheries, and quantitative ecology. In her first year, she collected field samples of lake organisms to complete our stable isotope data set characterizing the food web structure of Lake Crescent. The data strongly suggest substantial dependence of the animal community on nearshore resources, as hypothesized. I am presently preparing a manuscript for submission to a peer-reviewed journal, with Seminet-Reneau as second author.

For her own distinct M.S. thesis research, Seminet-Reneau is currently involved in the collection and analysis of periphyton (attached algae) and macroinvertebrate samples, to determine how community composition shifts in response to localized nutrient pollution. As part of this work, she has begun collecting samples at Lake Pend Oreille and Coeur d'Alene Lake in Idaho so that she may make generalizations about periphyton and macroinvertebrate responses to localized pollution from septic systems. In the fall she will also set up experiments designed to determine electivity of macroinvertebrates for different types of periphyton – i.e., those commonly associated with sewage pollution vs. those associated with unpolluted shorelines in oligotrophic lakes. She has formalized her periphyton counting methods but has not yet begun enumeration of samples.

Importantly, we have found that in Lake Crescent, nutrient content of the water column is generally below detectable limits, and therefore differences in nutrient pollution among sites can not be discerned using standard methods. In a lake that is still oligotrophic such as Lake Crescent, but receiving nutrient inputs, monitoring the biota in the area where pollution enters is likely to give the first detectable "early warning" of ecosystem change. We had hoped to discern an anthropogenic nitrogen signal in the algae from polluted sites, but the signature of algae may be too variable for this distinction; there is some indication that macroinvertebrates may carry the signal with more fidelity. Seminet-Reneau's 2006 summer sampling will increase our power to detect anthropogenic signal among the macroinvertebrates. She plans to present her work at the annual meeting of the Washington Lake Protection Association in the

A. **PUBLICATIONS:** No manuscripts are published yet.
B. **INFORMATION TRANSFER PROGRAM:** No activities to report yet.
C. **STUDENT SUPPORT:**

Elizabeth Seminet-Reneau, M.S. Received May 2007

	Section 104 Awards		NIWR-USGS Internship	Supplemental Awards	Total
	Base Grants	Competitive Awards			
Undergrad.					
Masters		1			1
PhD.					
Post-Doc.					
Total		1			1

D. **NIWR-USGS STUDENT INTERNSHIP PROGRAM:** No internships on this project.
E. **NOTABLE ACHIEVEMENTS AND AWARDS:** No activities to report yet.

A Reconnaissance Study of Arsenic Distribution in the Shallow Aquifer of the Treasure Valley: Year 2

Basic Information

Title:	A Reconnaissance Study of Arsenic Distribution in the Shallow Aquifer of the Treasure Valley: Year 2
Project Number:	2005ID51B
Start Date:	3/1/2005
End Date:	9/30/2007
Funding Source:	104B
Congressional District:	1
Research Category:	Water Quality
Focus Category:	Water Quality, Toxic Substances, Hydrogeochemistry
Descriptors:	
Principal Investigators:	Shawn Benner, Shawn Benner

Publication

1. Busbee, M., Benner, S., Hoffman, B., Cosgrove, D. 2006. Controls and mechanisms governing geogenic arsenic mobilization in the Treasure Valley shallow aquifer, Southwestern Idaho. Eos Trans.AGU 87(52),Fall Meeting.
2. Schmitz, MD, McNamara JP, Benner SG, and Wilson J. 2007. Sr and U isotopes constrain shallow groundwater mixing and recharge at the Blackfoot−Snake confluence, Eastern Snake River Plain. Presented at the Idaho Water Summet, Boise Idaho, December 11−13, 2007.
3. Busbee, M. 2008. Factors controlling the concentration of arsenic in the treasure valley shallow aquifer, Idaho, M.S. Thesis Department of Geosciences, Boise State University

104b Project Title: A Reconnaissance Study of Arsenic Distribution in the Shallow Aquifer of the Treasure Valley

Project Summary

Perhaps the greatest emerging threat to water quality in Idaho is naturally occurring elevated arsenic in our groundwater-based drinking water supplies. In the most populated region of the state, the Treasure Valley, more than 40% of all tested drinking water wells exceed the new arsenic standard. The distribution of arsenic in the groundwater of southwest Idaho is complex and not well understood and the mechanism of release has not been identified. This project both examined existing hydrologic and geochemical datasets and conducted focused laboratory-based experiments to better understand arsenic release mechanisms in a research effort coordinated with state agencies.

Our work has produced number of important observations that support the conclusion that elevated arsenic concentrations in the Treasure Valley Aquifer are produced by irrigation waters leaching arsenic from surficial sediments to the underlying aquifer.

There are clear spatial trends in the distribution of arsenic in the Treasure Valley Aquifer with dissolved arsenic concentrations primarily elevated in two areas within the Treasure Valley; the first is in Canyon County and extends from Lake Lowell north and west and the second is located in Ada County north of the Boise River (Figure 1).

We have also conducted a comprehensive assessment of the well log data to reconstruct the previously observed redoximorphic boundary for the entire Treasure Valley as a continuation of work started by Donato et al. (2004). The most notable trend in this geologic dataset is the close correlation between the redoximorphic transition and both land surface and groundwater elevation, suggesting that the boundary may be a post depositional feature reflecting the historical water table across the Treasure Valley.

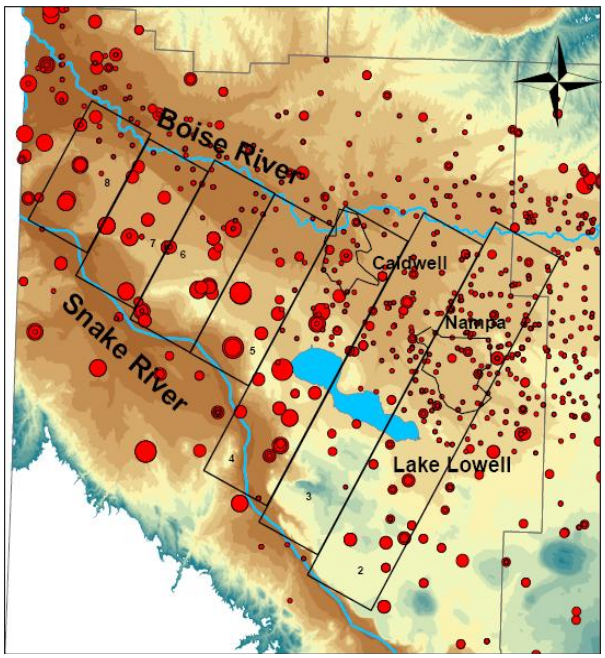

Figure 1. Treasure Valley arsenic concentrations. The size of the red circles increases with concentration.

Evaluation of existing chemical datasets in combination with grant collected samples, reveal a strong correlation between depth below the water table and arsenic concentrations with the majority of high arsenic wells sampling water from the upper 50 m of the aquifer (Figure 2). Furthermore, waters containing elevated arsenic concentrations are also oxic, not

reducing, in nature. These observations suggest that elevated arsenic in the Treasure Valley is, at least in part, derived from sediments at or near the water table and is supportive of a release mechanism *other than* reductive dissolution of iron oxides.

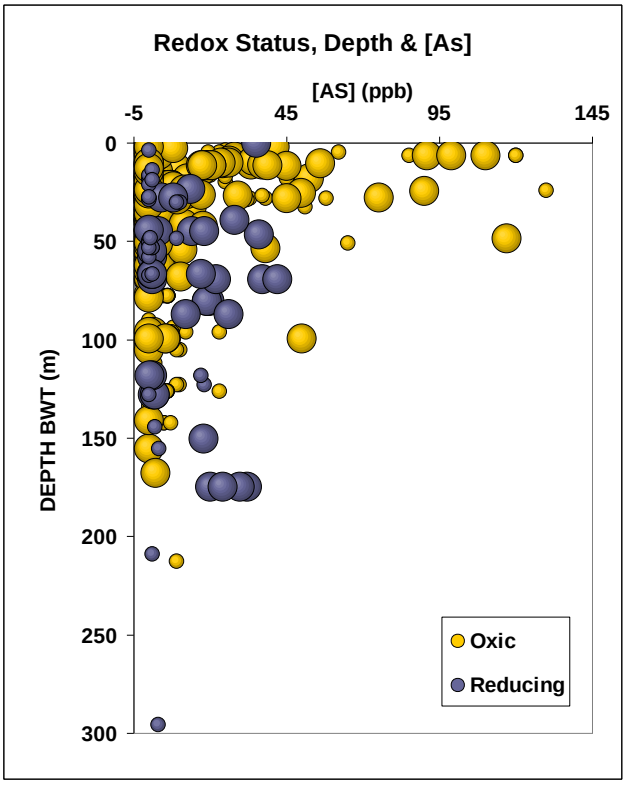

Figure 2. Arsenic concentration with depth below water table (BWT) and oxic vs. reducing conditions.

Sequential extractions conducted on near-surface sediments indicate the presence of significant amounts of easily mobilized arsenic. For example, the addition of Lake Lowell water to the sediments produces release of arsenic at concentrations of similar magnitude (up to 152 $\mu g\ L^{-1}$) to those seen within the aquifer.

Collectively, these observations support a conceptual model of arsenic release whereby infiltrating irrigation waters are promoting flushing and/or desorption of arsenic from the unsaturated and near-water table sediments. Ongoing work is focusing on evaluating this conceptual model through further field and laboratory experiments and observations.

Publications Resulting from the Project

Donato, M. M., K. W. Neely, B. Hoffman, S. Benner, 2005.Geochemical Processes And Mechanisms Of Arsenic Contamination In Southwestern Idaho Ground Water, in Proceedings Geological Society Of America Annual Meeting, October 16-19, Salt Lake City.

Busbee, M., Benner, S., Hoffman, B., Cosgrove, D. 2006. Controls and mechanisms governing geogenic arsenic mobilization in the Treasure Valley shallow aquifer, Southwestern Idaho. *Eos Trans. AGU* 87(52), Fall Meeting.

Busbee, M., Benner, S., Hoffman, B., Cosgrove, D. 2006. Controls and Mechanisms Governing Geogenic Arsenic Mobilization in the Treasure Valley Shallow Aquifer, Southwestern Idaho. *Idaho Water Resources Research Symposium* Nov. 18-19, Boise Idaho.

Busbee, M. 2008. Factors controlling the concentration of arsenic in the treasure valley shallow aquifer, Idaho, M.S. Thesis Department of Geosciences, Boise State University

Undergraduate and Graduate Student Researchers supported on the project

M.S. Graduate Student: Bernadette Hoffman, Graduated
M.S. Graduate Student: Monty Busbee, Graduated

Notable Achievements or Awards:

This project supported two M.S. thesis students (one in part, the second in entirety), was the central focus of 1 M.S. thesis, produced 4 conference proceedings, and a manuscript is in preparation for submittal to the peer-reviewed journal of *Applied Geochemistry*. This project directly led to a $50,000 grant from the Idaho Department of Environmental Quality to study uranium contamination in the Treasure Valley.

Award No. 04HQAG0205 – Initial Model Development of the Spokane Valley – Rathdrum Prairie Aquifer Project

Basic Information

Title:	Award No. 04HQAG0205 – Initial Model Development of the Spokane Valley – Rathdrum Prairie Aquifer Project
Project Number:	2005ID71S
Start Date:	7/20/2004
End Date:	9/30/2008
Funding Source:	Supplemental
Congressional District:	
Research Category:	Ground−water Flow and Transport
Focus Category:	Groundwater, Models, None
Descriptors:	
Principal Investigators:	John C. Tracy

Publication

1. Hsieh, P.A., M. Barber, B. Contor, A. Hossain, G. Johnson, J. Jones, and A. Wylie. 2007. Ground−Water Flow Model for the Spokane Valley−Rathdrum Prairie Aquifer, Spokane County, Washington, and Bonner and Kootenai Counties, Idaho. USGS Scientific Investigations Report 2007−5044
2. Murray, L., 2007. Boundary Condition Refinement and Quantification of Water Exchange Incorporating Long Term Variability of Perimeter Lakes with the Spokane Valley – Rathdrum Prairie (SVRP) Aquifer. M.S. Hydrology thesis on file with the University of Idaho Library, Moscow, ID.

ANNUAL REPORT: U.S. Geological Survey 104b Program
2005ID 71S: Award No. 04HQAG0205 – Initial Model Development of the Spokane Valley – Rathdrum Prairie Aquifer Project

Project Summary

This project was completed in September, 2005. The project final report was submitted to the USGS Water Resources Division Office in Boise Idaho in 2005. The summary provided in the final report is as follows:

GENERAL DESCRIPTION

This Cooperative Agreement was established to provide the Idaho Water Resources Research Institute with funding to become involved in initial efforts on the Spokane Valley – Rathdrum Prairie Modeling Project. This project is a collaborative effort of the USGS, the states of Idaho and Washington, and others. This initial stage was comprised of largely a planning effort, and the overall project is not scheduled for completion until 2008.

There were three specified tasks in the Cooperative Agreement. The following discussion provides a summary of how these tasks were addressed and potentially evolved in the project period. These tasks are intimately connected, so a complete separation of activities is not possible. Also provided are estimates of the funding expended on each of the tasks.

TASK A

Compile and review existing ground water/surface water models for the study area: conduct preliminary model runs using existing ground water/surface water models to evaluate model conceptual elements (boundary conditions, recharge and discharge, etc.); and identify additional data requirements.

A complete set of documents describing existing models in the Spokane Valley and Rathdrum Prairie has been assembled and reviewed. The Buchanan (1999) model has been the focus of our work because the model extent is similar to the scale of the present investigation. The Buchanan model has been run by all partners in the effort including IWRRI. This model has been selected as the basis from which the new model will evolve. Several steps in that evolution have already occurred in the partnership. Those steps include: a) conversion to operate in MODFLOW 2000, b) extension of the model domain to cover all areas of interest, c) refinement of the model grid, d) distribution of Buchanan aquifer properties and recharge and discharge to the new grid, e) conversion of lakes from fixed head to "river" cells, f) adjustment of aquifer thickness to represent present estimates. In the process of performing initial model runs, the modeling team (including IWRRI) has made assessments and recommendations of additional data requirements.

This task was also amended to include initiation of a review of the interconnection and flux between the aquifer and 9 lakes along the perimeter. A graduate student has been assigned to conduct the evaluation. Pressure transducers have been deployed in most of

the lakes and in nearby wells. The program procedures have been reviewed by the Modeling Team and some existing data analysis is underway.

Estimated Expenditures on Task: $27000

TASK B

Work with project partners to help to determine data requirements for numerical model development. Data requirements will include the collection of historical data and the collection of new field data. These data requirements will be meant to serve the needs of the ground water modeling task as well as more general project needs.

The IWRRI researchers have been working with the rest of the modeling team to identify future data requirements. Part of this effort is associated with performing preliminary model runs to gain an improved understanding of data deficiencies, consequently there is overlap between this task and the first task. Data deficiencies have been discussed in video and phone meetings with the rest of the Modeling Team and have been transmitted to the Program Technical Leadership Team(PTLT) in writing. The PTLT has been responsive and has also requested Modeling Team input on other data collection suggestions. The Modeling Team (including IWRRI) has responded.

Estimated Expenditures on Task: $7840

TASK C

Work with project partners to develop an FY05-07 work plan for developing a ground water/surface water model for the SVRP study area. This task will include meeting with project partners and interested constituents to determine modeling requirements and to determine what questions are to be addressed via ground water modeling so that the planned ground water/surface water modeling effort addresses project needs to the fullest extent possible. The SVRP Modeling Team will select the modeling code(s) to be used, and the modeling work plan will address both steady state and transient versions of the ground water/surface water model.

There have been multiple iterations on a modeling work plan within the modeling team. Within the process the roles of team members has become more refined. A draft work plan was submitted to the PTLT for comment. Those comments were subsequently addressed by the Modeling Team. The work plan continues to evolve as the project progresses. It has been developed such that modeling efforts will be complete in December 2006. It has been determined within the Modeling Team that MODFLOW 2000 will be used and that PEST will be applied to parameterize the model. The steady state model is under active development, efforts on the transient model (1995-2005 calibration period) will follow.

Estimated Expenditures on Task: $7839

Since the completion of this project the University of Idaho and the Idaho Water Resources Research Institute have been engaged in continued efforts on the development and application of the Spokane-Valley Rathdrum-Prairie Model. With funding from the U.S. EPA through the Idaho Department of Water Resources, the Institute continued in its partnership with the Washington Water Institute, the U.S. Geological Survey, the Idaho Department of Water Resources, and the Washington Department of Ecology. As a result of this effort a Modflow ground water flow model was developed and calibrated and documented in the final report *Ground-Water Flow Model for the Spokane Valley-Rathdrum Prairie Aquifer, Spokane County, Washington, and Bonner and Kootenai Counties, Idaho* (USGS Scientific Investigations Report 2007-5044), by Paul Hsieh, Michael Barber, Bryce Contor, Akram Hossain, Gary Johnson, Joseph Jones, and Allan Wylie. A second follow-up project again developed through EPA funding through the Idaho Department of Water Resources and the Washington Department of Ecology has jointly engaged the Washington and Idaho Water Institutes in model applications and is on-going.

Publications Resulting From the Project

The final project report and a M.S. thesis were partially the result of this project.

Hsieh, P.A., M. Barber, B. Contor, A. Hossain, G. Johnson, J. Jones, and A. Wylie. 2007. *Ground-Water Flow Model for the Spokane Valley-Rathdrum Prairie Aquifer, Spokane County, Washington, and Bonner and Kootenai Counties, Idaho.* USGS Scientific Investigations Report 2007-5044

Murray, L., 2007. *Boundary Condition Refinement and Quantification of Water Exchange Incorporating Long Term Variability of Perimeter Lakes with the Spokane Valley – Rathdrum Prairie (SVRP) Aquifer.* M.S. Hydrology thesis on file with the University of Idaho Library, Moscow, ID.

The model application projects which were outcomes of this work will result in several IWRRI publications and a journal article. These are presently at the early stages of preparation.

Undergraduate and Graduate Student Researchers Supported on the Project

Ms. Lindy Murray, a MS Hydrology student at the University of Idaho was partially funded under this project. Ms. Murray completed her MS Thesis titled: *Boundary Condition Refinement and Quantification of Water Exchange Incorporating Long Term Variability of Perimeter Lakes with the Spokane Valley – Rathdrum Prairie (SVRP) Aquifer.*

A geochemical investigation of groundwater sources in the Blackfoot River and Snake River floodplain

Basic Information

Title:	A geochemical investigation of groundwater sources in the Blackfoot River and Snake River floodplain
Project Number:	2006ID60B
Start Date:	3/1/2006
End Date:	5/15/2007
Funding Source:	104B
Congressional District:	First and Second
Research Category:	Ground−water Flow and Transport
Focus Category:	Groundwater, Water Supply, Hydrology
Descriptors:	None
Principal Investigators:	J. P Mcnamara, J. P Mcnamara

Publication

1. Wilson, J. 2008. An investigation of groundwater mixing in the Blackfoor River− Snake River floodplain using Sr and U isotopes. MS Thesis, Boise State University.

1. Title: A geochemical investigation of groundwater sources in the Blackfoot River and Snake River floodplain

2. Project Type: Research

3. Focus Categories: Groundwater, Hydrology, Water Supply

4. Research Category: Groundwater flow and transport

5. Keywords:

6. Start date: March 1, 2006

7. End date: May 15, 2007

8. Principal Investigator:

Dr. James McNamara, Professor
Boise State University
jmcnamar@boisestate.edu
Department of Geosciences
MG 225
1910 University Dr.
Boise, ID 83725

9. **Congressional District:** 1st and 2nd

Project summary

The purpose of this study was to assess the use of Strontium (Sr) and Uranium (U) isotopes to delineate groundwater sources in wells in the Blackfoot River – Snake River floodplain. The Blackfoot River is a major tributary to the Snake River at the southeastern border of the Eastern Snake River Plain (ESRP). The shared floodplain between the Snake and Blackfoot Rivers is roughly 50 sq. miles and is heavily irrigated for agriculture. Numerous canals extend from both rivers through the floodplain complicating the location of a groundwater divide and rendering it an ineffective demarcation of the Snake and Blackfoot River waters to the aquifer. Groundwater sources at the numerous wells in this floodplain are thought to be due to Snake and Blackfoot River mixing, however, proportions of that recharge are unknown.

The elements Sr and U show natural variations in their isotopic composition due to processes of radioactive decay. As dissolved species in natural waters, the isotopic compositions of Sr ($^{87}Sr/^{86}Sr$) and U ($^{234}U/^{238}U$) provide highly conservative tracers for quantifying mixing and recharge relationships between surface and groundwater. We have measured the Sr and U isotopic compositions of rivers, diversion canals, and groundwaters from several dozen shallow irrigation wells within the study area with the goal of apportioning recharge from each river (via direct riverine infiltration, canal seepage and irrigation) across the shallow aquifer. Key results are: 1) the Snake and Blackfoot Rivers upstream of the study site possess distinct isotope compositions that integrate differences in the bedrock geology of their catchments, with little seasonal

variability; 2) elevated solute concentrations in the wells are adequately described by evapotranspirative enrichment, while Sr and U isotopic ratios are insensitive to this physical process; 3) a set of binary mixing arrays between the two river end-members in Sr-U isotope space describe the majority of well data, and allow contours of quantitative apportionment of Snake versus Blackfoot water to be drawn across the aquifer; and 4) the influence of other water sources, including deep groundwater or other intermittent streams (e.g. Lincoln Creek), are identified and found to be restricted to the edges of the study site, consistent with present knowledge of the physical hydrology of the aquifer. We conclude that this isotopic approach can be readily applied to other hydrology problems in the state where water provenance is uncertain.

Publications and Presentations

Wilson, J. 2008. An investigation of groundwater mixing in the Blackfoor River- Snake River floodplain using Sr and U isotopes. MS Thesis, Boise State University.

Schmitz, MD, McNamara JP, Benner SG, and Wilson J. 2007. Sr and U isotopes constrain shallow groundwater mixing and recharge at the Blackfoot-Snake confluence, Eastern Snake River Plain. Presented at the Idaho Water Summet, Boise Idaho, December 11-13, 2007.

Students

Jennifer Wilson
MS in Hydrologic Science
Defended, will graduate in December 2008

Evaluation of levels of success of diagnostic and remediation efforts for nitrate contaminated ground waters with application to the Ashton, ID area.

Basic Information

Title:	Evaluation of levels of success of diagnostic and remediation efforts for nitrate contaminated ground waters with application to the Ashton, ID area.
Project Number:	2006ID65B
Start Date:	3/1/2006
End Date:	4/30/2007
Funding Source:	104B
Congressional District:	First
Research Category:	Water Quality
Focus Category:	Nitrate Contamination, Non Point Pollution, Groundwater
Descriptors:	
Principal Investigators:	Gary Steven Johnson, Mark Lovell

Publication

ANNUAL REPORT: U.S. Geological Survey 104b Program
2006ID 65B: *Evaluation of levels of success of diagnostic and remediation efforts for nitrate contaminated ground waters with application to the Ashton, ID area*.

Project Summary

This project has been completed. Subsequent activities related to nitrate monitoring and evaluation have continued however, largely at the Brigham Young University Idaho Campus in Rexburg Idaho. The BYU-I group has collected 43 additional water samples in the past year using two undergraduate students. Mr. Mark Lovell has been previously funded by this project has continued with his PhD research in the area through other means.

The following is a summary provided in the previous annual report.

Beginning fall 2005, Mark Lovell received partial funding in support of a sabbatical leave from Brigham Young University-Idaho (BYU-Idaho). This leave provided the opportunity for Lovell to attend the University of Idaho, Idaho Falls campus full time for two semesters. In addition to completing course work, research time was focused on three main topics:

- Procedures and techniques used to identify ground water contamination problems caused by excess nitrates and associated mitigation efforts to remediate the contaminated aquifers.
- The successful components of developing an undergraduate research experience (URE) and the adaptation and development of an ongoing research hydrologic field study for undergraduates.
- Application of case studies for nitrate contamination and remediation to the Ashton, Idaho area.

The great majority of resources provided by the grants have been devoted to two parts of the proposals; first, establishing and performing field activities including collecting water samples from domestic wells, measuring water table elevations, and processing samples using an ion chromatograph to evaluate concentrations of fluoride, chloride, nitrate, and sulfate; second, working with undergraduate students, training them how to participate in data acquisition and processing of samples.

In addition to funding provided through these grants, BYU-Idaho has and continues to support this program in several ways. While on sabbatical leave, partial salary support was provided to Mark Lovell. In addition, approximately $20,000 dollars worth of lab & field equipment were purchased and additional lab consumables, leveraging the supplies and equipment provided through these two grants. Major equipment purchased through BYU-Idaho includes a bench top ion chromatograph (Dionex IC-90) with manual injection, a Hach multi-probe (Quanta) to monitor discharge water to allow verification of pumping fresh formation waters prior to collecting water samples, and an electric tape for measuring depth to water table.

In the Idaho Department of Environmental Quality's (IDEQ) ranking of Nitrate Priority (Neely, 2005) the Ashton, Drummond, and Teton area was identified to rank #8 on the State of Idaho's top twenty-five Nitrate Priority Areas. Located approximately 30 miles north of Rexburg, Idaho home for the campus of BYU-Idaho, this seemed to be an ideal area to establish a groundwater study focused on nitrate contamination (figure 1). The regional setting of the Ashton area consists primarily of agricultural activities growing grains, alfalfa, potatoes, and some canola, in addition to a few cattle operations where herds are fed through the winter and then transported to summer pastures. There are also a growing number of residential sites with septic systems including the small town of Marysville which is located up gradient to the direction of ground water flow that provides drinking water for the town of Ashton. This combination of potential sources for nitrates makes it difficult to identify a unique source for the observed contamination problems.

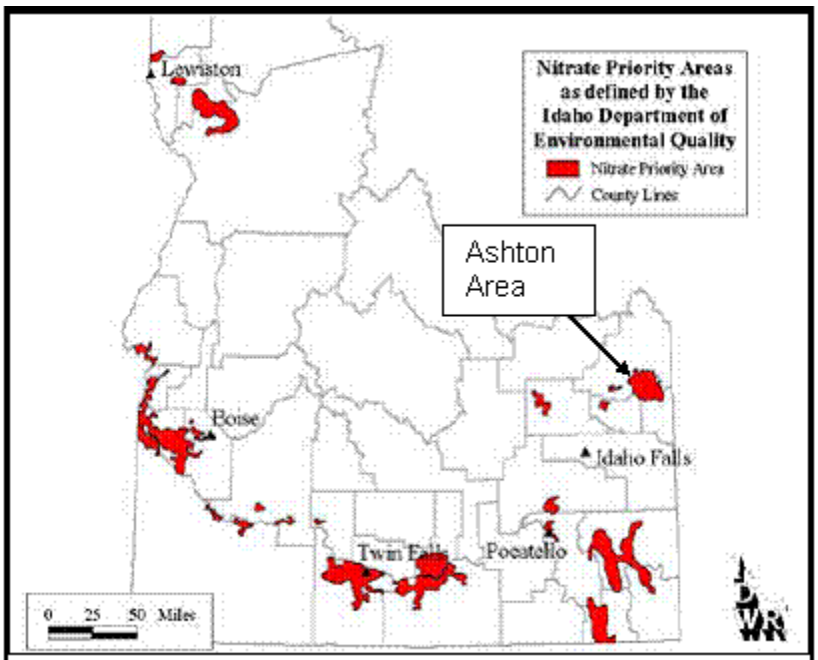

Figure 1. Nitrate Priority Areas modified from Neely 2005.

Funding was used to purchase two Hach Hydrolab-5 down-hole multi-probes, each with data-loggers, and probes for measuring nitrate, pH, specific conductance, and pressure transducers. The nitrate probes were known to have lower sensitivity (+/- 2 mg/l N as total Nitrogen) and a tendency to drift which required weekly calibration efforts. After deploying one of the probes in an abandoned well bore located approximately 10 feet from a small irrigation well, the data looked suspect (figure 2)

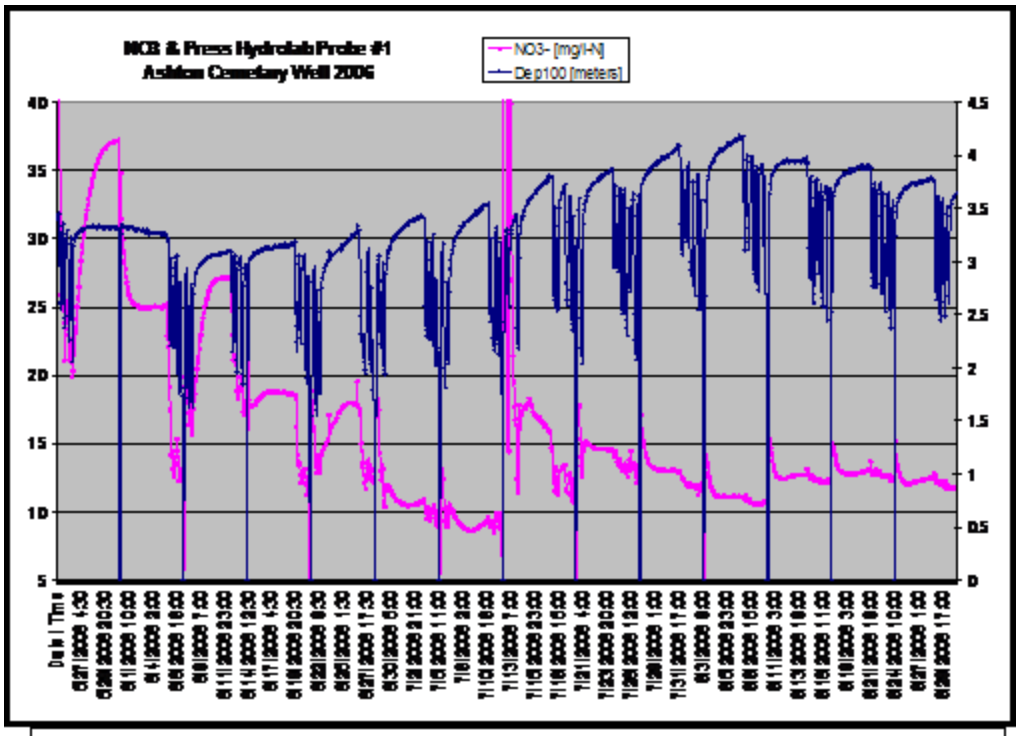

Figure 2. Nitrate and pressure data collected from probe #1.

In figure 2 we see the pressure response indicating water column thickness above the probe allowing identification of pumping events due to the associated drawdown. A zero value was added to the pressure data each time the probe was removed from the well for calibration. The observed nitrate concentrations appear to be diminished each time a pumping cycle occurs. This observation could possibly represent a type of mixing where shallow contaminated waters are being mixed with fresher water drawn in during the pumping cycle. Other observations of the data indicate that overall, nitrate concentrations were seen to decline throughout the year with the exception of the nitrate spike that occurred in mid July. In the small building which encloses the open well there is a sack of lawn fertilizer that is open. The spike may represent an inadvertent spill of some of the fertilizer on the floor that found its way into the well.

A second observation made possible from the data in figure 2 is the seasonal variation of the water table. The lowest observed water table is indicated to have occurred in early-June while the highest occurred in mid-August. It is interesting to note that maximum water-table elevation only persisted for about one week before beginning to decline.

To try and validate the nitrate response as seen by probe #1, the second Hydrolab was also deployed in the same well. Efforts were made to calibrate the probes on different days to allow one probe to be in the well monitoring when the second probe was pulled out, calibrated, data-downloaded, and then re-deployed. Figure 3 shows the data accumulated using probe #2 for nitrate concentration and for pressure/water table.

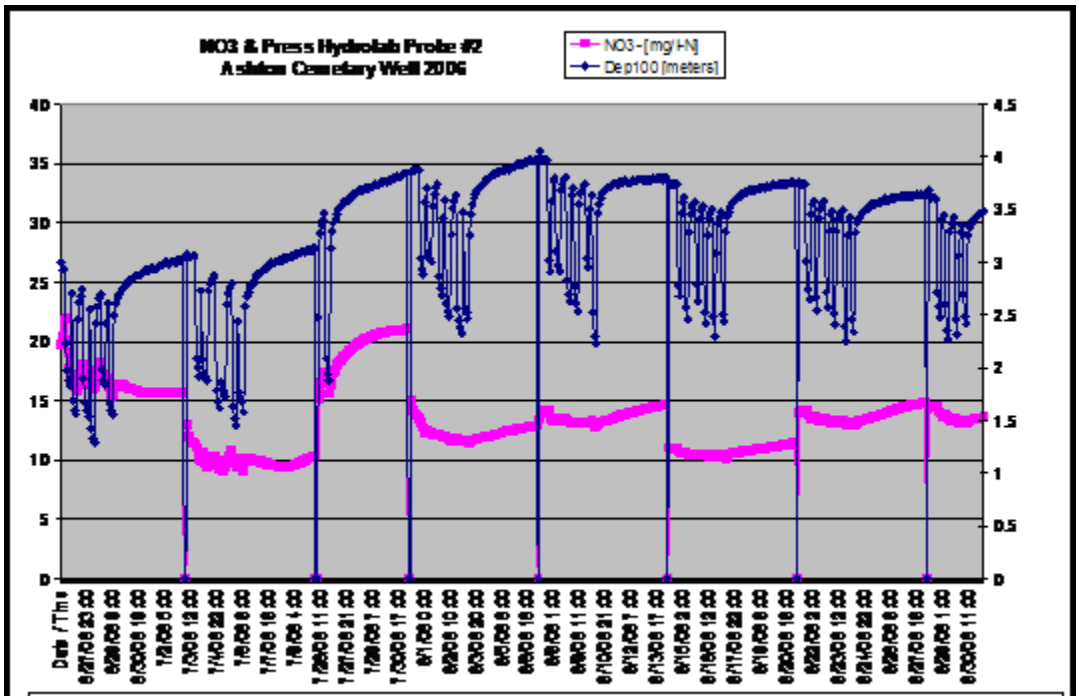

Figure 3. Nitrate and pressure data collected from probe #2.

Unfortunately, probe #2 experienced a mechanical (electronics) failure and several weeks worth of data were lost due to inability to communicate with the probe to download data and for the time lost while the probe was sent to the manufacturer for repairs. Figure 4 shows the nitrogen values for both probes compared on one chart. With the exceptions of the first week that probe #2 was used and the first week of use after probe #2 was repaired, the concentration of nitrates observed by the two probes is similar but there are differences in the shape of the responses that still needs to be evaluated.

The specific conductance of the water as measured by the Hydrolabs over the season showed a continuous trend to fresher waters from the start of measurements until about the end of July. Measurements by probe #1 show a step-wise patter because the wrong scale was selected for recording the data allowing the instrument to record 600 or 700 µS/cm (see figure. 5).

In addition to work related to using the down-hole Hydrolabs, water samples were also collected during the 2006 field season. Over 90 samples were collected from 21 sites using the Hach multi-probe to monitor water parameters at the time of pumping. Titrations using sulfuric acid were performed in the field to establish concentration of $CaCO_3$, and all samples were analyzed within 48 hours using the ion chromatograph (IC) to establish concentrations of fluoride, chloride, nitrate, and sulfate. The IC runs also analyzed samples for nitrite, bromide, and phosphate but these compounds were not detected.

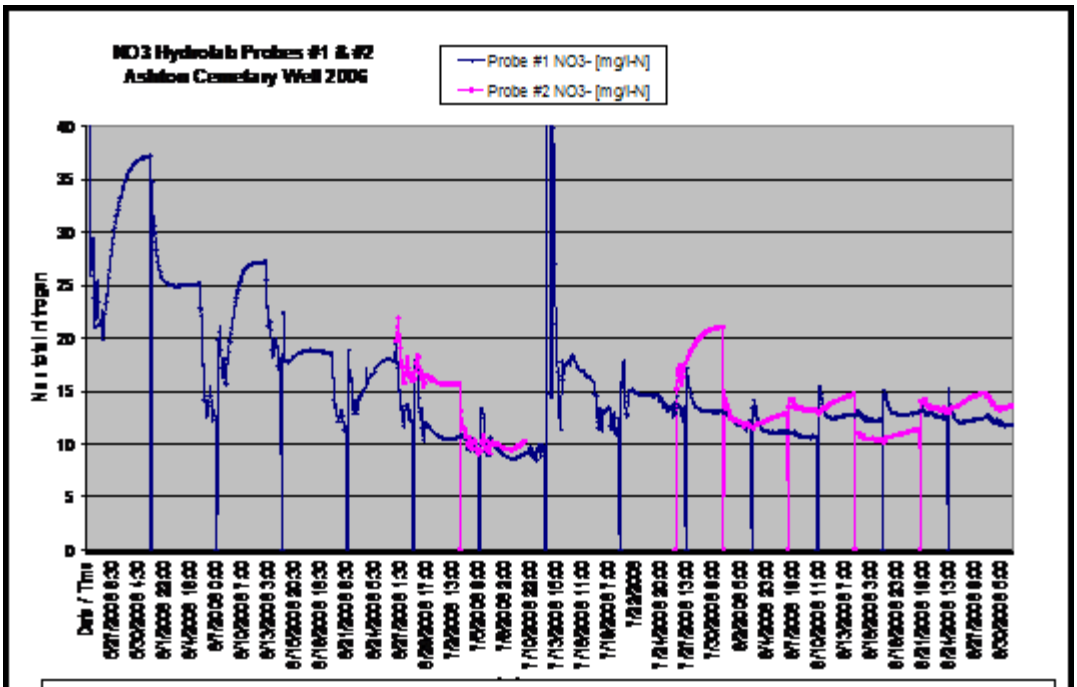

Figure 4. Nitrate values compared for both probes #1 and #2.

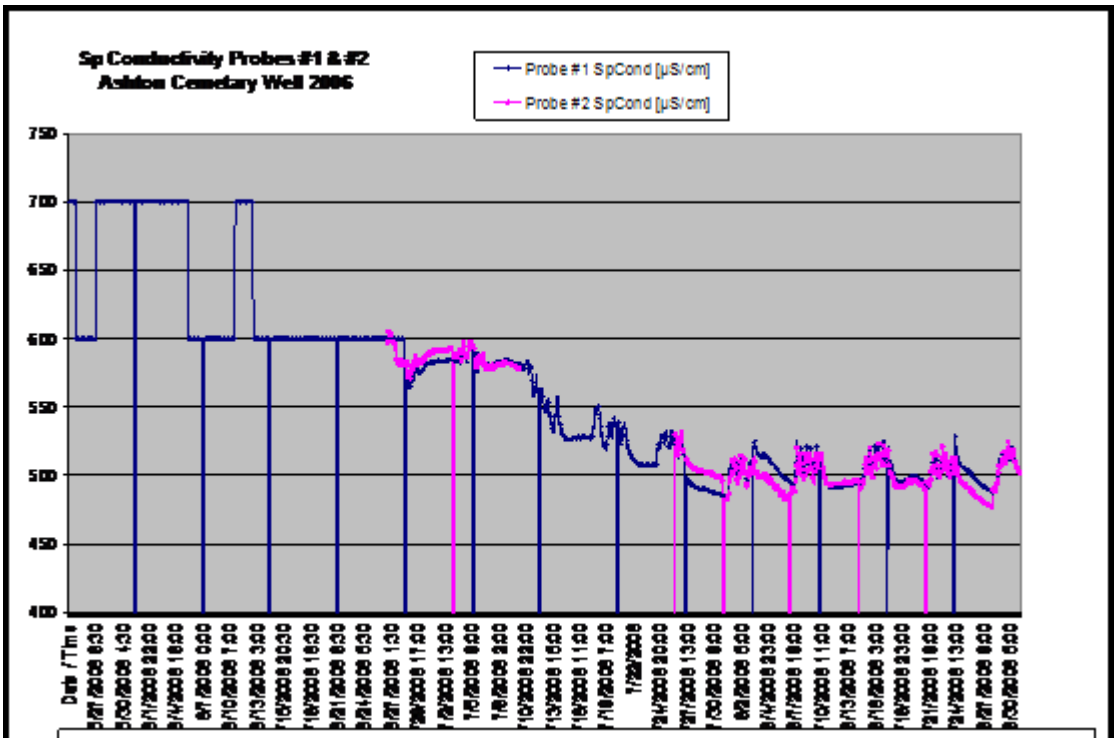

Figure 5. Probes #1 and #2 showing values for specific conductance.

After the first couple of weeks of sampling it became apparent that water table elevation information was highly desirable causing the abandonment of monitoring in some wells in favor of other wells which could be accessed for measuring water table elevations. Thirteen of the twenty-one sites sampled provided access to measure water table elevations. Work continues creating maps of the water table trying to represent the changes of elevation through time for the 2006 water season. The water table appears to act somewhat like a trap door, hinged along the Henrys Fork of the Snake River where the river has downcut into the aquifer. Numerous springs located along the south side of the river and projected elevations of the water table to the canyon wall based upon well measurements support this interpretation. To the south side of the valley, closer to Fall River, changes in water table elevation throughout the summer varied by nearly 10 feet while wells closer to the Henrys Fork showed only two-three feet of seasonal change.

Publications Resulting from the Project

None to date

Undergraduate and Graduate Student Researchers Supported

One PhD graduate student at the University of Idaho, Mark Lovell, has been funded by and participated in this research. Mr. Lovell has served as advisor and directed the work of multiple BYU-Idaho undergraduates in this project.

Three BYU-Idaho undergraduate students have been engaged in this project in 2006-2007. In the 2007-2008 academic year two additional undergraduate students were involved.

Wetlands as Sinks for Metal(loid)s in Mining−contaminated Coeur d'Alene Basin Soils

Basic Information

Title:	Wetlands as Sinks for Metal(loid)s in Mining−contaminated Coeur d'Alene Basin Soils
Project Number:	2007ID72B
Start Date:	3/1/2007
End Date:	6/30/2008
Funding Source:	104B
Congressional District:	First
Research Category:	Water Quality
Focus Category:	Geochemical Processes, Wetlands, Water Quality
Descriptors:	None
Principal Investigators:	Matthew Morra

Publication

Title: Wetlands as Sinks for Metal(loid)s in Mining-contaminated Coeur d'Alene Basin Soils

Principal Investigator:
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Project Summary

Mining activities within the Coeur d'Alene (CDA) Basin have resulted in large areas of metal contamination far beyond the designated Bunker Hill Mining and Metallurgical Superfund Site, contaminating the CDA River and CDA Lake. It will be impossible to remove and dispose of contaminated sediments within the CDA Basin and Lake CDA, and thus management decisions that protect the environment and human health are required. Our recent investigations indicate that continuously reduced sediments of ponds located in CDA River flooplain tailings contain soluble metal(loid) concentrations far less than similarly contaminated lake sediments experiencing active redox cycling. Analyses of plant tissues obtained from aquatic macrophytes within these ponds have confirmed that this stable redox environment decreases metal(loid) bioavailability. However, in preliminary investigations we observed that seasonal redox changes occurring in surrounding agricultural fields appear to mobilize metal(loid)s such that pond waters experience severe contaminant inputs during the spring. We propose that ponds strategically placed with respect to hydrologic gradients might be used as sinks to sequester metal(loid)s released from contiguous agricultural fields, thus decreasing contaminant mobility and bioavailability. Our objective is to determine the potential for ponds located within the floodplain of the CDA River to act as a sink for Cd, Zn, As, Cu, and Pb mobilized during seasonal changes in soil redox. We will achieve this goal by characterizing changes in soluble metal concentrations in ponds located in the contaminated floodplain during the course of one calendar year.

Total metal(loid) concentrations in the sediment of a contaminated pond within the Coeur d'Alene Basin were determined on sediment digests using Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES) (Fig. 1). We have confirmed that pond sediments are similar in contamination levels as those in Lake CDA. We are in the process of securing pond waters on a monthly basis and measuring total metal(loid) concentrations using ICP-Mass Spectrometry. Extreme flooding during the spring of 2008 has delayed some of our sampling trips. A new water sampler has been purchased and tested in order to acquire water samples from different depth increments within the ponds. We have developed the methods for anion analysis using ion chromatography (IC) and alkalinity using titration techniques. A complete anion-cation balance will be calculated for each of the water samples to assess measurement accuracy.

Our overall goal is to suggest management strategies for contaminated floodplain soils that will decrease the mobility and bioavailability of harmful metal(loid)s. We ultimately wish to 1) determine if wetlands in metal(loid)-contaminated areas can be used as contaminant sinks, 2) delineate spatial and temporal variables that control the extent of metal(loid) sequestration,

and 3) elucidate the responsible biogeochemical processes. Our studies will help in determining if the creation of wetlands might be used to sequester metals, thereby preventing their further dispersal in the environment.

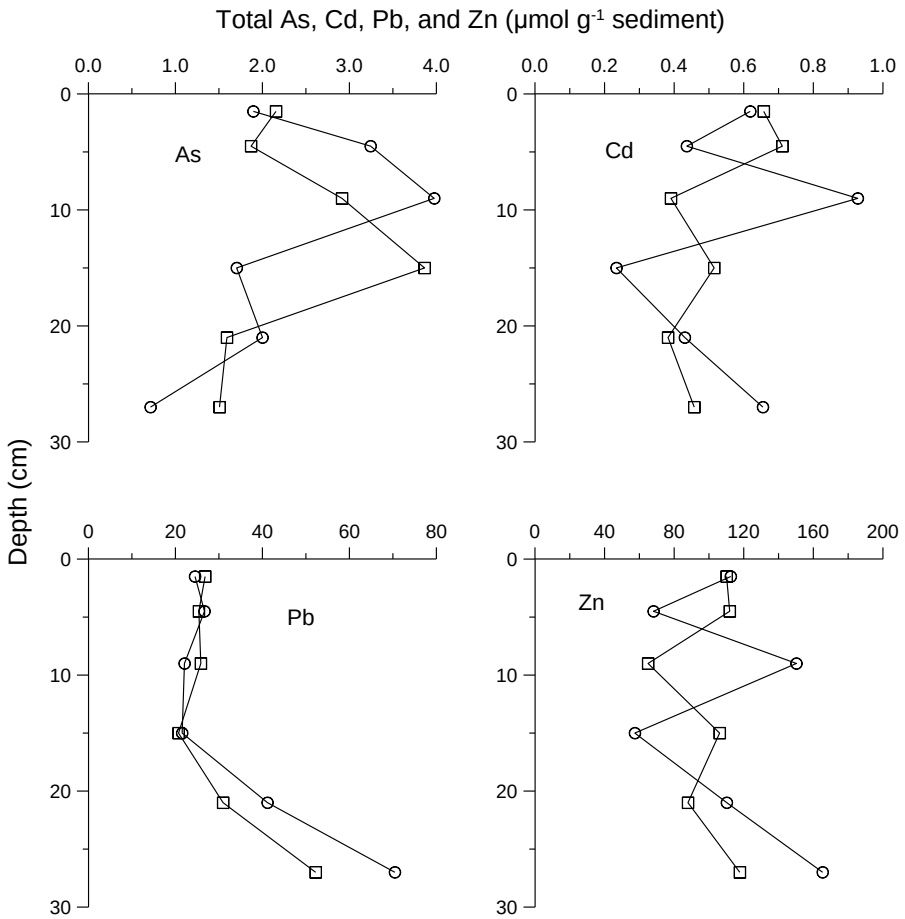

Fig. 1. Total elemental concentration of As, Cd, Pb, and Zn within contaminated sediments obtained from a pond within the Coeur d'Alene Basin. Each line represents a replicate core.

Undergraduate and Graduate Student Researchers supported on the project

Meghan Carter is an M.S. student in the new Water Resources degree program working on the project concurrently as she pursues a J.D. degree. Although not funded by USGS, an undergraduate student from Ohio Wesleyan University named Devon Rayasa is also working on the project. Devon is participating in the NSF program entitled "Environmental Research Experiences for Students from Groups Underrepresented in Science and Engineering".

Selenium Biogeochemistry in the Hyporheic Zone of Streams within the Blackfoot River Watershed

Basic Information

Title:	Selenium Biogeochemistry in the Hyporheic Zone of Streams within the Blackfoot River Watershed
Project Number:	2007ID73B
Start Date:	3/1/2007
End Date:	2/29/2008
Funding Source:	104B
Congressional District:	First
Research Category:	Water Quality
Focus Category:	Hydrogeochemistry, Non Point Pollution, Sediments
Descriptors:	None
Principal Investigators:	Daniel Strawn, Gregory Moller, Matthew Morra

Publication

East Mill Creek (June 2007 and September 2007) Summary Report

Libbie Oram
University of Idaho

The following report is a summary description of our East Mill Creek (EMC) sampling June 2007 and September 2007. Our objectives were to sample EMC sediment pore water geochemistry, including Selenium (Se) concentrations and speciation at three to six sites. At each site, we collected stream water samples, pore water samples using a mini drivepoint sampler placed in the stream sediments, and sediment core samples (Figure 2), and we measured water characteristics such as pH, dissolved oxygen levels, conductivity, alkalinity, and concentrations of various anions and cations.

On June 2 – 6, 2007, we sampled EMC at 6 sites (Figures 1 and 2). In September 2007, we sampled 3 sites (Figure 1). Site 1 is the same as June 07 site 6, Site 2 is the same as June 07 site 2, and site 3, the same as June 07 site 4. The sites are termed as waypoints in Table 1.

We recently completed the spring sampling event for 2008 on June 4-9. In this trip we conducted a stream tracer experiment to characterize the physical movement of water between the stream water and sediments. A sample trip to Stanford Synchrotron Radiation Laboratory was also recently completed (June 25- 30) to collect speciation data on sediment samples. Data processing for these two experiments is ongoing. The fall 2008 sampling event will occur in late August.

Surface Water

Stream water Se levels in June ranged from 160 to 240 µg L^{-1} in the six sites studied. Stream water Se levels in September ranged from 40 to 50 µg L^{-1} at three sites (Table 1). In June, we also collected 2 samples upstream, less than 1 mile from Maybe Canyon Mine, with Se levels of 850 and 880 µg L^{-1}. There is a trend of decreasing Se levels with downstream flow in June (distance downstream from maybe Canyon Mine), likely attributable to dilution, dispersion, and sequestration in sediments. Speciation data shows that Se in the stream water from both June and September is dominated by Se(VI) species, with little Se(IV) as expected.

Pore Water

Total Se in EMC pore water in June 2007 ranged from 3.2 to 170 µg L^{-1} (Table 1). Total Se in EMC pore water in September 2007 ranged from <1 to 58 µg L^{-1} (Table 1). Ground water (water collected at greater than 50 cm depth) was collected for June 2007 sites 1-4, and Se levels ranged from 5.2 to 41 µg L^{-1} (Table 1). Ground water collected in September 2007 was 45 µg L^{-1} at waypoint 1 and 73 µg L^{-1} at waypoint 3. Se concentrations in pore water in June and September decreased significantly with depth at all sites above detection limits except for waypoint 1 during both sampling dates. Waypoint 1 sediment was highly composed of sand-sized particles at all depths compared to the other sites, and likely has greater surface water – pore water interaction. Dissolved Se in the pore water is also in the Se(VI) phase for both sampling dates, however some soluble organic phases may be present. Se(IV) in most samples was slightly below IC-ICP-MS detection limits (5 µg L^{-1}) and is not reported.

Sediments

Total Se in sediment cores in June 2007 (2 samples) decreased with depth and ranged from 4.8 to 28 µg g^{-1} (Table 1). Previous results (September 2006) showed solid phase Se ranging from 5.1 – 69 µg g^{-1} at nearby sites. Se was not measured in cores from sites 3, 4, 5, and 6. Total solid phase Se in sediment cores ranged from 1.4 to 230 µg g^{-1} at all three sites in September 2007 (Table 1), and varied with depth at site 1, increased with depth at site 2, and was relatively stable (after the surface depth) at site 3. Samples within a few feet of one another in the sediments, site 1 core 1 and site 1 core 2, vary significantly even at the same depth (i.e., 16 and 100 µg g^{-1} Se).

Conclusions

Current results generally show high Se concentrations in surface water and groundwater, with variable Se concentrations in sediment pore water. Results show variability in pore water Se concentrations and solid phase Se concentrations with depth beneath the sediment, suggesting dilution, limited stream water influx, or chemical sequestration processes occur in the hyporheic zone. Results also show consistent Se speciation (Se(VI)) with depth, sampling site, and season in pore water and surface water. Results further show high spatial variability, and future sampling will focus on sampling one waypoint three times, 10m between each sampled location. Results further indicate that numerous interdependent factors may affect Se levels, species, and attenuating or releasing mechanisms in EMC sediments and pore water. These factors may include ground water and surface water flux, dissolved oxygen levels, depth below the sediment surface, organic carbon content, and sediment particle size. Additional sampling in 2008, characterization of stream water influx using a tracer study, and characterization of solid-phase Se speciation at synchrotron facilities will allow further interpretation of the data.

Further Considerations

Four potentially significant processes:

- GW (ground water) influx into sediments, dilution or concentration of Se (physical)
- SW (stream water) influx into sediments (physical)
- Sequestration by sediments (chemical)
- Release/Dissolution from sediments (chemical)

Specific Questions:

- What do large changes in PW Se concentration profiles show?
- What is the relative importance of GW influence or flux at 0-3 cm? at deeper depths?
- What is the relative importance of SW infiltration at 0-3 cm? at deeper depths?
- What is the relative importance of chemical processes releasing Se?
- What is the relative importance of chemical processes sequestering Se?
- Is the Se in pore waters sequestered, diluted by GW, or does it flux back out into the water column?
- Is the decrease in Se with depth do to dilution by ground water, limits on surface water diffusion, or sequestration (chemical processes)?

- Where data shows higher Se concentrations in PW than SW, can we suggest that sediments are a source of Se *or* sediments are trapping Se that fluxed from SW at one time in clay layers?

Table 1. Se speciation and concentration data from June 2007 and September 2007 of surface water, pore water, sediments, and ground water. Water Se is measured in µg L^{-1} and sediment Se is measured in µg g^{-1}. BDL indicated values below detection limits. All *data (June 2007 data from Waypoint 1, 3, 4, and 6) are not quantitatively reliable.

Jun-07															
	Surface Water Se			**Pore Water Se**					**Sediment Se**			**Ground Water Se**			
Waypoint 1*	*SeIV*	*SeVI*	*total Se*	*Depth*		*SeIV*	*SeVI*	*total Se*	*Depth*	*total Se*		*Depth*	*SeIV*	*SeVI*	*total Se*
(Jun 2007 site 6,	5	130	160	3cm	A	BDL	130	160							
Sep 2007 site 1)			160	6cm	B	BDL	130	160							
				9cm	C	BDL	130	160							
Waypoint 2															
(Jun 2007 site 2,	0	130	180	3cm	A	5	150	170	1, 2-4cm	8, 4.8		>50cm			26
Sep 2007 site 2)			190	6cm	B	BDL	50	60	5-7cm	5.7					
									8-10cm	6.7					
Waypoint 3*															
(Jun 2007 site 4,	BDL	190	230	3cm	A	BDL	70	90				>50cm			15
Sep 2007 site 3)			240	6cm	B	BDL	60	70							
				9cm	C	BDL	20	30							
Waypoint 4*															
(Jun 2007 site 5)	BDL	130	170	3cm	A	BDL	120	140							
			160	6cm	B	BDL	10	20							
				9cm	C	BDL	BDL	BDL							
Waypoint 5															
(Jun 2007 site 1)	BDL	130	200	3cm	A	BDL	120	160	1-3cm	28		>50cm			41
			180	6cm	B	5	40	60	4-6cm	14					
									7-9cm	14					
									10-12cm	6.3					
									13-15cm	5.7					
									16-18cm	5.3					
Waypoint 6*															
(Jun 2007 site 3)	BDL	150	210	3cm	A	BDL	BDL					>50cm			5.2
			210	6cm	B	BDL	BDL	9.3							
				9cm	C	BDL	BDL	3.2							
Sep-07															
	Surface Water Se			**Pore Water Se**					**Sediment Se**			**Ground Water Se**			
Waypoint 1	*SeIV*	*SeVI*	*total Se*	*Depth*		*SeIV*	*SeVI*	*total Se*	*Depth*	*core 1*	*core 2*	*Depth*	*SeIV*	*SeVI*	*total Se*
(Jun 2007 site 6,	0	30	40	3cm	A	10	25	34	0-3 cm	100	16	44cm	BDL	30	45
Sep 2007 site 1)			40	6cm	B	BDL	20	24	4-6 cm	230	9.7				
				9cm	C	BDL	5	7	7-9cm	85					
				12cm	D	BDL	35	46	10-12cm	130					
				15cm	E	BDL	45	58	13-15cm	89					
				18 cm	F	BDL	15	24	16-18cm	21					
									19-21cm	12					
									22-24cm	9.5					
Waypoint 2															
(Jun 2007 site 2,	0	30	40	3cm	A	BDL	20	26	0-3 cm	13					
Sep 2007 site 2)			40	6cm	B	0	10	8.7	4-6 cm	6.9					
				9cm	C	0	0	1.2	7-9cm	6.6					
				12cm	D	0	0	1	10-12cm	9.6					
				15cm	E	0	0	< 1	13-15cm	39					
				18 cm	F	0	0		16-18cm	53					
									19-21cm	42					
									22-24cm	41					
									25-27cm	44					
Waypoint 3															
(Jun 2007 site 4,	0	30	50	3cm	A	BDL	15	26	0-3 cm	28		77cm	BDL	45	73
Sep 2007 site 3)			50	6cm	B	0	0	3.8	4-6 cm	1.9					
				9cm	C	0	0	1.6	7-9cm	1.7					
				12cm	D	0	0	< 1	10-12cm	1.9					
				15cm	E	0	0	1.2	13-15cm	1.6					
									16-18cm	1.6					
									19-21cm	1.5					
									22-24cm	1.7					
									25-27cm	1.4					
									28-30cm	1.5					

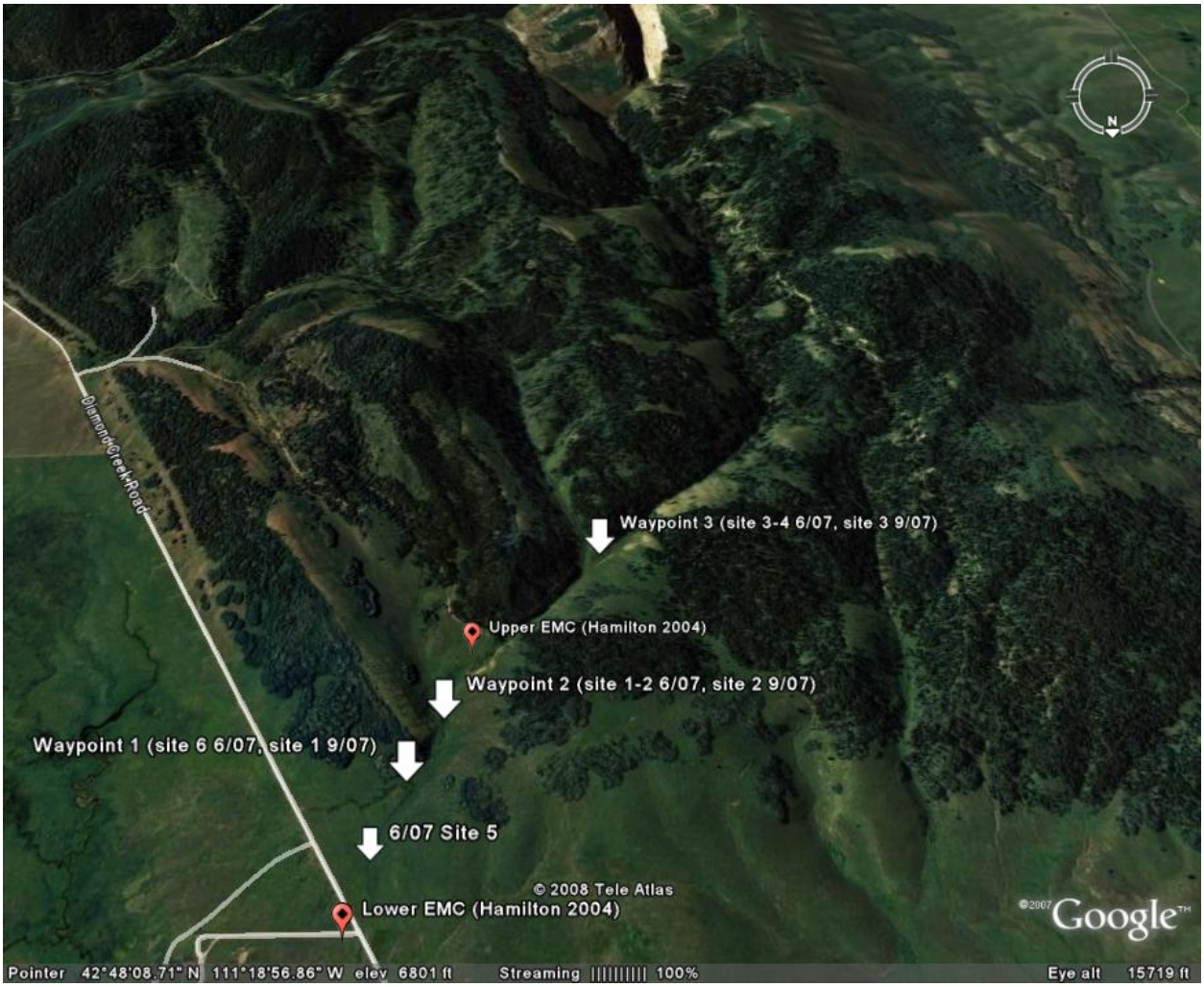

Figure 1. Google EarthTM image of East Mill Creek sampling sites from June and September 2007. Approximate locations of sampling sites are marked with white arrows. White lines indicate roads. Sampling sites from Hamilton (2004) are also shown.

Figure 2. Example of sampling apparatus in East Mill Creek at site 5 (June 2007). Pore water sampler is installed in the creek, which is connected to a peristaltic pump on the table. A sediment core is also shown.

Student Participation and Accomplishments

Libbie Oram is the PhD student working on this project, and expects to complete her dissertation by next summer. We supported two undergraduate interns on the project. There are several interesting results coming out of this research, and I am certain our work will provide new insights into Se risks and management. Below I list some of the progress and highlights of our Se research in the BFR watershed.

2007

- $15 K funding from IWRI for 1 year of sampling
- IDWR $5K match
- 3 sampling events completed (see data summary above)

2008

- Libbie Oram's Master thesis research on Blackfoot River research accepted for publication in Environmental Science and Technology (the best journal for environmental science research).

    - Libbie Oram, Daniel Strawn, Mathew Marcus, Sirine Fakra, Greg Moller. 2008. Macro- and Microscale Investigation of Selenium Speciation in Blackfoot River, Idaho Sediments. Environmental Science and Technology. In press.
- Libbie Oram presented data to Graduate student Research Expo. Second place award.
- $3K grant from UI Grad. Student Association to conduct 2008 sampling.
- $3K grant from Jeffrey Braatne Memorial foundation for graduate student research on riparian system research
- Six day field trip to East Mill Creek for stream sampling accomplished June 4, 2008.
- Acceptance of abstract to International Goldschmidt Geochemistry meeting for student presentation. Presentation July 2008.
- $1K grant from Graduate Student Association to attend Goldschmidt conference.
- Five day trip to Stanford Synchrotron Radiation Laboratory planned for June 25, 2008 to analyze sediments.
- Six day trip to East Mill Creek planned for fall 2008. USGS scientist from USGS office in Menlo Park planning on attending.

2009

- Dissertation completed
- Manuscripts on research findings submitted to peer review journal.

Additional Pictures

Information Transfer Program Introduction

During the 2007 Fiscal Year, 104B program and state funds were used to support the Idaho Water Resources Research Institute Information and Technology Transfer Program. This program includes efforts to reach all water resource stakeholders in the state, from K to Grave. These efforts include; Water Education Workshops for Teachers (300 teachers were trained in 10 workshops across Idaho); Youth events across the state which include Water Awareness week (over 14,000 attendees), Youth Water Festivals in Moscow, Lewiston and Weiser (600 attendees) and Salmon and Steelhead Days (840 attendees); and a state wide water resources seminar series delivered via a compressed video system to Boise, Moscow, Pocatello, Idaho Falls and Coeur d'Alene (20 seminars during the year).

In addition, during the 2007 Program Year, training opportunities for water professionals were expanded through initiated interactions with the newly developed Boise Watershed Center. IWRRI also worked with Boise State University on a GK12 grant to increase water resource outreach activities connected to Foothills Learning Center and Discovery Center in Boise, ID. Finally, IWRRI developed or sponsored four water resources workshops or conferences focusing on specific water resources issues of interest across the state, region and nation. These meetings were: University Council on Water Resources Annual Conference – Boise, ID July 2007; The Palouse Water Summit – Moscow, ID October 2007; The Idaho Environmental Summit – Boise, ID November 2007; Idaho Water Users Conference – Boise, ID January 2008.

In addition to these activities, two Information Transfer projects were completed during the current reporting period, with summary reports for these projects given below.

A spreadsheet tool to derive economic demand for irrigation water from crop price, evapotranspiration/yield relationships and irrigation application efficiency

Basic Information

Title:	A spreadsheet tool to derive economic demand for irrigation water from crop price, evapotranspiration/yield relationships and irrigation application efficiency
Project Number:	2007ID78B
Start Date:	3/1/2007
End Date:	2/29/2008
Funding Source:	104B
Congressional District:	01 &02
Research Category:	Social Sciences
Focus Category:	Economics, Water Supply, Irrigation
Descriptors:	None
Principal Investigators:	Bryce Contor, Richard Allen, Garth Taylor

Publication

1. Idaho Water Resources Research Institute technical report 200803, "Spreadsheet Tool for Estimating Economic Demand for Irrigation Water Using Commodity Prices and Evapotranspiration Production Functions: IDEP" is in final review with the co−investigators. It will be accompanied by an English−units and SI−units version of the tool.

Summary of activity for USGS 104b project 2007ID78B "A spreadsheet tool to derive economic demand for irrigation water from crop prices, evapotranspiration/yield relationships and irrigation application efficiency."

Project Summary

The project has produced a spreadsheet tool that applies readily-available yield, acreage and irrigation data to crop market prices and produces an estimate of economic demand for irrigation water. Estimates of elasticity of demand are also produced, and the tool incorporates a climate-change worksheet to estimate the impact that increased evapotranspiration might have on demand for irrigation water. A single crop may be evaluated or an aggregation of up to six crops. Figure 1 illustrates sample output for an aggregate demand for multiple crops. The exact result of the summation is available in tabular form or graphically, as represented by the dark line in Figure 1. Two different estimates of differentiable demand equations are also produced for mathematical applications that require a single equation of demand.

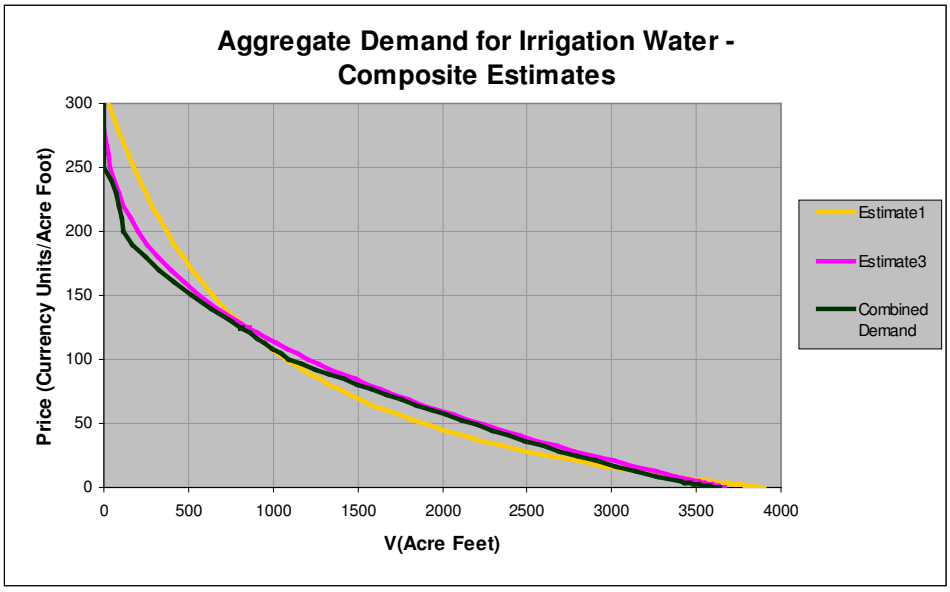

Figure 1

Publications Resulting from Project

Idaho Water Resources Research Institute technical report 200803, "Spreadsheet Tool for Estimating Economic Demand for Irrigation Water Using Commodity Prices and Evapotranspiration Production Functions: *IDEP*" is in final review with the co-investigators. It will be accompanied by an English-units and SI-units version of the tool.

Student Research Support

None

Notable Achievements and Award

Co-investigator Garth Taylor showed a prototype version of the tool to the organizers at the Western Agricultural Economics conference in Montana in June 2008 and was invited to present an impromptu session on the tool for water economists at the conference.

Idaho Water Resources Information and Needs Assessment: Extended Analysis and Enhanced Information Transfer

Basic Information

Title:	Idaho Water Resources Information and Needs Assessment: Extended Analysis and Enhanced Information Transfer
Project Number:	2007ID93B
Start Date:	3/1/2007
End Date:	2/29/2008
Funding Source:	104B
Congressional District:	First
Research Category:	Social Sciences
Focus Category:	Management and Planning, Water Quantity, Water Quality
Descriptors:	None
Principal Investigators:	Charles Harris, Jan Boll

Publication

Statement of State Water Problem

With over 92,000 miles of rivers and streams and more than 100 lakes, water appears to be inexhaustible. However, the allocation of all of the surface water supplies, the current seven-year drought, transboundary issues surrounding aquifers, and increasing demand for water to protect ecosystem services has increased awareness of the state's limited water supply, as the interconnectedness of surface water and groundwater have become increasing apparent with on-going water shortages. Growing demand for water stems from multiple factors including urban population growth, agricultural needs, tribal water development, energy demand, habitat requirements, recreational use, and aesthetic values. Complicating these growing demands have been the recent droughts that affected the West during the late 1990's and early 2000's, which have been increasing previous stresses on aquifers and rivers caused by decades of groundwater pumping and changing irrigation practices. Idaho withdraws about 9 billion gallons of groundwater per day, four percent of which comprises 95 percent of public drinking water. Of the rest of the total groundwater withdrawn, 60 percent is used by agriculture, particularly sugar beets, potatoes, and barley, while the remaining 36 percent is used by industries that include aquaculture, food processing, fertilizer production and high-tech manufacturing. Five critical groundwater areas are located around the state and twelve groundwater management areas. Each area either has or is approaching insufficient groundwater supplies to provide a reasonably safe supply for irrigation or other uses at the current or projected rates of withdrawal.

These water supply issues have spurred the Idaho legislature and water management agencies to rethink management of the state's water resources. This project will enable Idaho's universities to focus their water resources research on responding to the challenges faced by the diverse water resource stakeholders. The proposed research would extend analysis and enhance information transfer for the results of a project conducted as part of a project initially funded by the Inland Northwest Research Alliance (INRA). The original INRA proposal explained the need to conduct a detailed but regional assessment of the information and research needs of water resource stakeholders related to increasing competition for scarce water supplies; the study, which was funded and is scheduled to end in May 2007, is assessing priorities for research on water resources in a five-state area, including AK, UT, WA, and MT as well as Idaho. Given the regional focus of this project, data generated are being compiled and analyzed primarily at a regional level. Therefore, the purpose of this proposal is to secure funding to analyze the results of the data generated in the State of Idaho at a more detailed, fine-grained level, and to disseminate the results of that analysis to appropriate publics and stakeholders across that state. The extended analyses of data already generated by 69 stakeholders within the state and the enhanced technical transfer of the analyses will provide universities, agencies, tribes, nongovernmental organizations, and private industry with focused priorities of needed research.

Statement of results or benefits.

Results and benefits of the proposed project can be tied to elements of Section 104(b) of the Water Resources Research Act of 1984, which requires that Institutes or Centers "plan, conduct, or otherwise arrange for competent research that fosters:

(A) the entry of new research scientists into the water resources fields,
(B) training and education of future water scientists, engineers, and technicians,"

Related results/benefits:
This project would further the training, experience and expertise of a recent Ph.D. and further the UI's WoW Initiative, which is building a WR Program to better educate future water scientists and engineers.

"(C) the preliminary exploration of new ideas that address water problems or expand understanding of water and water-related phenomena,"

Related results/benefits:
This project will provide universities, agencies, tribes, nongovernmental organizations, and private industry with focused priorities of needed research that addresses the challenges currently facing water resource managers and stakeholders. Analyses will be conducted on the data to identify commonalities among water resource management challenges and research needs at multi-levels including: state-level, ecoregion-level, agency-level, tribal-level, nongovernmental organization-level, and private industry-level.

As funding for research has become increasingly scarce in recent years, this information will enable water resource managers to: more effectively collaborate with university researchers; create partnerships among agencies, tribes, organizations, industries, and universities; and more efficiently target funding of prioritized research projects that have maximum future practical significance.

"and (D) the dissemination of research results to water managers and the public."

Related results/benefits:
A press release and news conference would announce the availability of the results of this research, which would be distributed as a final report to all involved stakeholders and other interested publics. The report also would be made available for dissemination by the IWRRI, as well as on its Web-site and the sites of other water-related entities around the state of Idaho, including the UI Water Resources Program and the Idaho Departments of Water Resources and of Ecology, among others.

Nature, scope, and objectives of the project, including a timeline of activities.
This purpose of this project is to analyze the results of the data generated for a regional project at the state level and to disseminate the findings of the state analyses to universities, agencies, tribes, organizations, and private industry in Idaho. The objectives of this project include: (1) to analyze information generated through interviews with diverse water resource stakeholders throughout the State of Idaho, focusing on the research and information needs to address state-wide issues, such as drought and a secured water supply of high quality, in face of population growth and patterns of change in water availability, demand and use; and (2) to disseminate the results of the extended analysis to water resource stakeholders throughout the state, and to make the information publicly accessible. Analyses of water resource management challenges and information needs will employ thematic coding to assess the relative importance of the different information needs identified by the stakeholders.

Proposed Timeline of Activities

March 2007:

- Purchase qualitative analysis computer software
- Upload interview summaries
- Develop coding themes
- Assess the quality of coding themes through peer debriefing

April-May 2007:

- Code all interview summaries
- Establish inter-rater reliability of coded interview summaries
- Transcribe portions of interviews to develop examples of themes for report

May-June 2007:

- Write report; submit for peer-review
- Begin information transfer

June-July 2007:

- Complete report
- Continue and complete information transfer

Methods, procedures, and facilities

A hermeneutic approach to data analysis will be employed to facilitate the analysis of themes within interviews and themes across interviews, as the interpretation of text "is a circular relationship:" that is, the meaning of the whole emerges through understanding of its parts, while the parts, when considered holistically, synergistically create a whole that is greater than the sum of its parts (Gadamer, 1976). The qualitative analysis computer program QSR NVivo will be used to facilitate the thematic coding process and the compilation of text referencing each code. Thematic coding will be the primary method, with peer debriefing and multiple coders employed for quality assurance. Peer debriefing will be employed to develop codes for quality assurance. Additionally, inter-rater reliability will be employed after all of the texts are coded to ensure the quality of interpretations made upon the text (i.e., interview summaries), which will require 10% of the interview summaries to be coded (by a researcher who did not code all of the interview summaries) to establish a minimum of 90% agreement of coded text. Once trustworthiness of the coded themes is establish via peer debriefing and inter-rater reliability, a qualitative methodology will be employed to analyze the emergent themes for each of these topics with a differential analysis: Analyses will be conducted on the data to identify commonalities at multi-levels including state-level, ecoregion-level, agency-level, tribal-level, nongovernmental organization-level, and private industry-level. A formal report will then be written documenting this analytical process and its results. That formal report will be submitted for peer review, as well as for formal comment by stakeholders and other interested publics, and a final draft prepared. It will be made available for dissemination by the IWRRI, as well as on its Web-site and those of other entities around the state of Idaho, including the UI Water Resources Program and the Idaho Departments of Water Resources and of Ecology, as well as water districts and watershed management groups, among others. A press release and news conference would announce the availability of the results.

Gadamer, H.-G. (1976). The historicity of understanding. In P. Connerton (Ed.), *Critical sociology: Selected readings* (pp. 117-133). Harmondsworth: Penguin Books Ltd.

Related research. (Research projects only)
Research has investigated and assessed needs relating to water and other natural resources; however, it has not done so at an in-depth, state-level level, where that analysis has focused on the region of the Inland Northwest. In particular, it has not analyzed these needs from the perspectives of different stakeholders and governmental agencies within a state, or across that state's different geographic regions. Examples of related literature include:

Firth, P. L. (1998). Fresh water: Perspectives on the integration of research, education, and decision making. *Ecological Applications*, 8(3), 601-609.

Jiagge, M. A. (1999). Information needs assessment. A case study of the information needs of staff of the Water Research Institute (CSIR). Dissertation submitted in partial fulfillment of the requirements for the Degree of Master of Arts in Library Studies, University of Ghana, Legon.

Kavlock, R.J., Daston, G.P., DeRosa, C., Fenner-Crisp, P., Gray, L.E., Kaattari, S., Lucier, G., Luster, M., Mac, M.J., Maczka, C., Miller, R., Moore, J., Rolland, R., Scott, G., Sheehan, D.M., Sinks, T., and Tilson, H.A. (1996). Research needs for the risk assessment of health and environmental effects of endocrine disruptors: a report of the U.S. EPA-sponsored workshop. *Environmental Health Perspective*, 104(4), 715-740.

Lawrence, A. W., Miller, J. A., and Hayes, T. D. (1995). Regional assessment of produced water treatment and disposal practices and research needs. SPE/EPA exploration & production. Environmental Conference, Houston TX, 27-29 March 1995, pp. 373-392.

McCauley, D. J., DeGraeve, G. M., Linton, T. K. (2000). Sediment quality guidelines and assessment: Overview and research needs. *Environmental Science & Policy*, 3(1), 133-144.

Nowak, P., Shepard, S., and Weiland, C. (1996). Utilizing a needs assessment in water quality program implementation for the Lake Mendota watershed. *The Farm Practices Inventory (FPI) Report 2.* Madison (WI): University of Wisconsin Environmental Resource Center.

Scheraga, J. D., and Furlow, J. (2001). From assessment to policy: Lessons learned from the U.S. National Assessment. *Human Ecological Risk Assessment*, 7(5), 1227-1246.

Smythe, K. D., Bernabo, J. C., Carter, T. B., and Jutro, P. R. (1996). Focusing biodiversity research on the needs of decision makers. *Environmental Management*, 20(6), 865-872.

Taylor, J. S. (1989). *Assessment of potable water membrane applications and research needs*. Denver, CO: The Foundation: American Water Works Association.

Training potential
N/A

Investigators' qualifications

Charles C. Harris, Jr.

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Academic Training

University of Michigan, Ann Arbor, Michigan, 1983, Ph.D., Natural Resources
Colorado State University, Ft. Collins, Colorado, 1978, M.S., Recreation Resources.
Oberlin College, Oberlin, Ohio, 1973, B.A., English Literature.

Appointments/Professional Experience

1998 - present. Professor, Department of Conservation Social Sciences, College of Natural Resources, University of Idaho.

1998 - present. Director and chair, Master of Natural Resources Program, College of Natural Resources, University of Idaho.

1996 – present. Member of Environmental Sciences Program faculty, University of Idaho. Serve on ES Core (Steering) Committee, attend ES Faculty meetings.

1984-1998. Assistant,/Assoc. Professor, Dept. of Resource Recreation & Tourism, College of Natural Resources

1996 - present. Member of Environmental Sciences Program faculty, University of Idaho.

Related Publications

Cohen, K., N. Sanyal, L. Higgins & C. Harris. In process. Designing community coaching based program initiatives: A formative evaluation program model. Journal of Extension.

Cohen, K., N. Sanyal, & C. Harris. In process. Community coaching: Answering the call for innovative approaches to community-based development initiatives. Journal of Program Planning & Evaluation.

Smaldone, D., C.C. Harris, and N. Sanyal. In process. The role of time and locale in relation to place attachment. J. of Leisure Research.

Smaldone, D., C.C. Harris, and N. Sanyal. 2005. Place attachment and managing for critical park issues in Grand Teton National Park. *Journal of Park & Recreation Administration* 23 (1): 90-114.

Gustanski, J.A., Harris, CC., and Van Tassel, L. 2005. Cost-Effectiveness of Washington State's Grazing Program. Final Report. Joint Legislative Audit and Review Committee, Washington State Legislature.

Becker, D., Harris, C.C., E. Nielsen, and W.J. McLaughlin. 2004. A Comparison of a Technical and a Participatory Application of Social Impact Assessment. *Impact Assessment and Project Appraisal* 22(3): 177-189.

Harris, C.C., E. Nielsen, D. Becker, and W.J. McLaughlin. 2003. Innovative Community Assessments for Sustainable Resource Management: The Case of Salmon-Recovery on the Lower Snake River. *Impact Assessment and Project Appraisal*.21(2): 109-118.

Becker, D., Harris, C.C., McLaughlin, W.J., and Nielsen, E. 2003. A Participatory Approach to Social Impact Assessment: The Interactive Community Forum. *Environmental Impact Assessment Review* 21(3): 367 – 382.

Harris, C.C., P. Cook, J. O'Laughlin. 2003. Resource-Based Economic Development in Idaho and the Inland Northwest: Resource Management Policies and Community Impacts. Policy Analysis Group Report No. 22. Idaho Forest, Wildlife and Range Policy Analysis Group (PAG), University of Idaho, Moscow.

Brown, G., P. Reed, and C.C. Harris. 2002. Testing a Place-Based Theory for Environmental Evaluation: an Alaska Case Study. *Applied Geography* 22(1): 49-76.

Harris, C.C., W.J. McLaughlin, D.R. Becker and E.A. Nielsen. 2001. Impacts of Salmon Recovery Efforts on Towns and Cities in the Pacific Northwest of the U.S.: Results from a Community-Based C&I Assessment. In, A. Franc, O. Laroussinie, T. Karjalainen, (eds.), *Criteria and Indicators for Sustainable Forest Management at the Forest Management Unit Level*, pp. 29-44. European Forest Institute, Joensuu, Finland.

Russell, K., and Harris, C.C. 2001. Dimensions of community autonomy in timber communities in the Inland Northwest. *Society and Natural Resources* 14: 21-38.

Harris, C.C. (With Foster Wheeler Environmental Corporation) 2001. Analysis and evaluation of the "Recreation and Tourism Analysis" produced for the "Lower Snake River Juvenile Salmon Migration Feasibility Study: Feasibility Report and Environmental Impact Statement." Study report completed for the U.S. Army Corps of Engineers, under contract to Foster Wheeler Environmental Corporation, Bothell, Washington. 112 pp. Available on-line: <http://www.nww.usace.army.mil/lsr/products.htm>

Harris, C.C., McLaughlin, W.J., G. Brown, and D. Becker. 2000. An assessment of small rural communities in the Interior and Upper Columbia River basins. General Technical Report GTR-PNW-477. USDA Forest Service, Pacific Northwest Experiment Station, Portland.

Harris, C.C., Brown, G., and W.J. McLaughlin. 1998. How resilient are rural communities in the Interior Columbia Basin Ecosystem? *Journal of Forestry* 96(2): 11-15.

Activities/Experience Relevant to Proposed Project

- Served as social scientist on numerous natural resource projects – currently on Steering Committee for UI Water Resources Program, and planning committee for Palouse Basin Water Summit.
- Apply sociology, social psychology and economics to variety of natural resource topics, including: Assessment of impacts of resource-management activities on Western communities; methods for resource conflict management and resolution; social impact assessment; recreation & amenity values, and regional economics of rural communities; rural community self-assessment conducted for the Interior Columbia Basin Ecosystem Management Project; community-based social impact assessment of proposed efforts to restore salmon populations in the lower Snake River; benefit-cost analyses of rangeland, recreation, & other resource management policies; organizational psychology of resource management agencies; comprehensive planning for Latah County & City of Moscow.
- Teaching has included courses on integrated planning, human dimensions of ecosystem management, restoration ecology, decision-making for watershed management, and resource economics and policymaking.

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Professional Preparation

1995 Ph.D., Cornell University, Dept. of Agricultural and Biological Engr., Ithaca, N.Y.
1988 M.S., The Agricultural University of Wageningen, Dept. of Land and Water Use, Wageningen, The Netherlands.
1988 M.S., University of Idaho, Dept. of Agricultural Engineering, Moscow, I.D.
1985 B.S., The Agricultural University of Wageningen, Dept. of Land and Water Use, Wageningen, The Netherlands.

Appointments

2006-present Director of Water of the West, College of Graduate Studies, University of Idaho, Moscow, ID
2002-present Associate professor, Dept. of Biological and Agricultural Engineering, University of Idaho, Moscow, ID
2004-present Adjunct professor, Environmental Science Program, University of Idaho, Moscow, ID
2003(Aug)-2004(Jun), Visiting Professor, Department of Water Resources, Hydrology and Quantitative Water Management Group, Wageningen, The Netherlands.
2001-present Affiliate Professor, CATIE (Centro Agronómico Tropical de Investigación y Enseñanza), Turrialba, Costa Rica.
1996-2002 Assistant professor, Dept. of Biological and Agricultural Engineering, University of Idaho, Moscow, ID
1995 - 1996 Coordinator of Cornell's Hydrology/GIS Group for the New York City Watershed Filtration Avoidance Project. Funded through Watershed Agricultural Council, Walton, NY.
1989 - 1995 Research Scientist, Fate of Agricultural Chemicals on Coastal and River Bottom Lands: Monitoring, Modeling and Agronomic Aspects, Water Resources Assessment and Protection Program of the National Research Initiative Competitive Grants Proposal no. 9403179 USDA Grant No. 94-37102-0837; Locating Soil Layers in the Vadose Zone with Non-Destructive Methods. USDA-CSRS Grant No. 91-34214-6024; Using Ground Penetrating Radar to Improve Monitoring and Predicting Preferential Solute Movement in Sandy Soils. USGS Grant No. 14-08-0001-G1921; Preventing Pesticide Contamination of Aquifers by Best Management Practices. USGS Grant No. 14-08-0001-G1907; Water Management, NY State No. 123-8388-379

Selected Publications (last five years)

1. Brooks*, E.S. and **J. Boll**. 2007. Distributed and integrated response of a GIS-based distributed hydrologic model. *Hydrologic Processes* (in press).
2. Hilberts, A.G.J., P.A. Troch, C. Paniconi, and **J. Boll**. 2007. Low-dimensional modeling of hillslope subsurface flow: the1 relationship between rainfall, recharge, and unsaturated storage dynamics. *Water Resour. Res.* (in press).
3. de Rooij, Gerrit H. Olaf A. Cirpka, Frank Stagnitti, Saskia H. Vuurens, and **Jan Boll**. 2006. Solute transport and dilution in heterogeneous soils: analyzing multicompartment percolation sampler data. *Vadose Zone Journal* 5: 1086-1092.
4. Gorsevski, P.V., P.E. Gessler, **J. Boll**, W.J. Elliot, R.B. Foltz. 2006. Spatially and temporally distributed modeling of landslide susceptibility. *Geomorphology* 80(3-4): 178-198.
5. Brooks*, E.S., **J. Boll**, W.J. Elliot and T. Dechert. 2006. A GPS/GIS-based approach for sediment detachment and delivery modeling on large road networks using WEPP. *Journal of Hydrologic Engineering.* 11(5):418-426.

6. Dai*, X and **J. Boll**. 2006. Deposition of *Cryptosprodium Parvum* and *Giardia Lamblia*. *Water Research.* 40(6):1321-1325
7. Sánchez*, M. and **J. Boll**. 2005. The effect of flow path and mixing layer on phosphorus release: Physical mechanisms and temperature effects. *Journal of Environmental Quality.* 34:1600-1609.
8. Brooks*, E.S., **J. Boll**, and P.A. McDaniel. 2004. An experiment to determine the lateral saturated hydraulic conductivity. *Water Resour. Res* 40, W04208, doi: 10.1029/2003WR002858.
9. Dai*, X., **J. Boll**, M.A. Hayes*, and D.E. Aston. 2004. Adhesion of *Cryptosporidium parvum* and *Giardia lamblia* to Solid Surfaces: the role of surface charge and hydrophobicity. *Colloids and Surfaces, B: Biointerfaces* 34(4):259-263.
10. O'Geen, A.T., P.A. McDaniel, **J. Boll** and E.S. Brooks*. 2003. Hydrologic Processes in Valley Soilscapes of the Eastern Palouse Basin in Northern Idaho, *Soil Sci.* 168(12):846-855.
11. Dai*, X., and **J. Boll**. 2003. Evaluation of Attachment of *Cryptosporidium Parvum* and *Giardia Lamblia* to Soil Particles. J. Environ. Qual. 32: 296-304
12. O'Geen, A.T., P.A. McDaniel, **J. Boll**. 2002. Chloride distributions as indicators of vadose zone stratigraphy in semiarid loess deposits. *Vadose Zone Journal* 1:150-157.

Reports:

1. Gravelle, J., Brooks*, E.S and J. Boll. 2005. Comparison of the Cumulative Watershed Effects method and the WEPP:Road model for estimating total sediment load from roads in the Potlatch River basin. Task 2. Technical Report, Submitted to the Idaho Department of Water Quality on 5/21/05. 25 p.
2. Brooks*, E.S. and J. Boll. 2005. Validation of the WEPP model for sediment delivery from non-forested roads. Task 3. Technical Report, Submitted to Idaho Department of Water Quality on 12/1/05. 53 p.
3. Boll, J., E.S. Brooks*, and D. Trauemer. 2002. Sediment Data Collection and Data Management for the South Fork Clearwater River Subbasin Assessment and TMDL. Final report to Idaho Department of Environmental Quality (Agreement No. C109).
4. Boll, J., E.S. Brooks*, and D. Traeumer. 2001. Hydrologic and Sediment Delivery Analysis of Agriculturally Dominated Watersheds in the Clearwater River Basin. Final report to Idaho Soil Conservation Commission.

* Authors with asterisk are former students associated with Dr. Boll's research program

Other Activities

2004–present: Leader of interdisciplinary team of UI faculty and students in USDA-CSREES Conservation Effectiveness Assessment Program. This project was one of four in the nation when awarded. This project's research watershed integrates physical sciences, agricultural economics and rural sociology, and has an outreach component.

2001-06: Steering committee and active participant in the UI IGERT project (team-based research on Tropical Biodiversity and Sustainable Production in Tropical and Temperate Fragmented Landscapes). I also serve as major professor for one IGERT Ph.D. student, whose research takes place in Costa Rica.

2001-2003, Mentor & Participant, National Science Foundation Research Experiences for Undergraduates Intern Program, Environmental Science, University of Idaho

2000-present, National Science Foundation (CAREER): Coordinator of Research and Education Watershed (Paradise Creek Watershed) & Water Agricultural Council and Monitoring Committee for Paradise Creek watershed, Moscow, ID

1996-present: active in the Environmental Science Program since 1996. In 2005, I received the Outstanding Faculty Award in Environmental Science.

Student Support

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR−USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	8	0	0	0	8
Masters	5	0	0	1	6
Ph.D.	2	0	0	0	2
Post−Doc.	0	0	0	0	0
Total	15	0	0	1	16

Notable Awards and Achievements

For Project ID 2005 50B, Elizabeth Rosenberger received a student award for this work, from the Washington Lake Protection Association in 2006. This work gave her the experience to successfully compete for a contract from NOAA Fisheries for fisheries data analysis post−graduation, and a career−track job in water quality for Whatcom County, Washington. Jessie Duvall has been accepted to medical school at the University of Washington after receiving her B.S., and Scott Florin's experience on this project led to seasonal work with the National Park Service and later a 2−yr position as a Research Technician at Washington State University.

For Project ID 2005 51B, This project supported two M.S. thesis students (one in part, the second in entirety), was the central focus of 1 M.S. thesis, produced 4 conference proceedings, and a manuscript is in preparation for submittal to the peer−reviewed journal of Applied Geochemistry. This project directly led to a $50,000 grant from the Idaho Department of Environmental Quality to study uranium contamination in the Treasure Valley.

Publications from Prior Years