UTAH DIVISION OF WATER QUALITY

195 North 1950 West
PO Box 144870
Salt Lake City, Utah 84114-4870

Willard Bay Project Proposal Form

Applicant Name (if applicable): Dr. Ramesh Goel and Dr. Michael Barber

☐ Individual ☐ Non-Profit ☐ Govt. Agency X Academic ☐ Commercial ☐ Other

Business Name (if applicable): University of Utah

Mailing Address:110 S. Central Campus Drive, 2000 MCE

City: Salt Lake City State: _UT___ Zip: 84112___

Phone: 801_-581_-6110___ E-mail:ram.goel@utah.edu

Project Title: A deep understanding of sediment related sinks of dissolved oxygen in the Jordan River- integrating research with societal issues.

Grant Purpose (please check all applicable):

X Water Quality Improvement X TMDL Implementation ☐ Disaster Mitigation

☐ Manure Management X Education/Outreach ☐ Pollution Study

☐ Project Monitoring ☐ On-Site Wastewater ☐ Other

1. Estimated Project costs:

Labor	$ 163,498 (Includes faculty, student and post Doc salaries plus fringe benefits)
Materials	$ 40,000 (chemical supplies, field supplies, consumables etc)
Equipment	$ 15,000 (fDOM probe and TCD detector for GC)
Administration	$ 21,850 (University indirect cost at 10 % of total direct)

TOTAL Willard Spur Funding Requested **$242,548**

Other Funding Sources being used (EQIP, GIP, WRI, Local, In-kind labor, or other):

Funding Source	**Amount**
Civil Engineering, Matching funds for Post Doc	**$45, 210**
Total Amount of matching funding:	**$45, 210**

Total Project Cost (Requested + Matching Funds): **$287,758 (**Detailed budget and it Justification is included in the supplementary documents in the appendix**)**

2. Estimated time frame of the project: From **August 15, 2014** To **December 31, 2016**

3. **Purpose and need of the project:** Water sustainability requires integration of water quality and quantity issues with local economy and the society. The Jordan River, an urban stream, has been a subject of investigation with the ultimate goal of developing a TMDL for organic carbon. The water quality issues have been investigated for this urban stream with phased TMDL proposed for this watershed. However, the social and economic issues have not been addressed fully and as a result, the importance of Jordan River TMDL is not well disseminated in the local society. The Jordan River directly connects with the Great Salt Lake wetlands and, the water quality of the Jordan River affects the water quality and ecology of the Great Salt Lake wetlands. Furthermore, the Jordan River has great societal as well as environmental significance. The low DO in the lower Jordan River results in negative impacts to the environment as well as to the society and, these issues promoted the need of this project. The **environmental negative impacts** include; (1) adverse effects on stream habitats, (2) support to decaying processes leading to obnoxious gas production, (3) bad water quality due to increased turbidity and decreased light penetration leading to reduced primary production, (4) due to Jordan River's direct connectivity with the Great Salt Lake ecosystem, the possibility of overloading the GSL with extra pollutants affecting its recreational values and thousands of migratory birds. The **societal negative impacts** are; (1) in general, bad water quality reduces the recreational value of the river, (2) negative

impacts on river's beneficial uses, (3) bad aesthetics of the river due to bad water quality reflects people away rather than attracting them and, (4) decaying of matter produces greenhouse gases such as methane and nitrous oxide and, results in climate change and bad air quality in the valley.

The continued efforts by the Utah Division of Water Quality (UDWQ) directly and through third party funded projects have significantly improved our understanding about the Jordan River water quality. A phased TMDL approach for the Jordan River has been proposed and data gaps related to the organic matter have been identified in phase I. The understanding on coarse and fine particulate organic matter in the river has improved but not complete. From management point of view, load allocation requires knowledge about; (1) sources of organic matter (riparian versus WWTP), (2) the fate of organic matter in sediments as well in the water column and, **the spatial variability of dissolved organic carbon. How this spatial variability is associated with landuse changes**, (3) the effect of flow variations resulting in sediment disturbance and possibly increased sediment oxygen demand (SOD), (4) how data generated can be incorporated into modeling practices for decision making. For **societal benefits**, it is also important to integrate the community into ongoing and planned activities for the Jordan River TMDL. The research should be integrated into community outreach and educational components such that the management decisions made by UDWQ appeal to the local community. This Willard Spur funding proposal is a step forward to create the much needed synergy between the Jordan River Technical people (i.e UDWQ, researchers) and the community and, to better understand dissolved oxygen sinks in the lower Jordan River. This project presents opportunities to integrate data generated into the regulatory framework and like Principal Investigator's past efforts such as SOD in the Jordan River and Utah Lake, the data will help the managers make decisions.

The specific tasks of this project are to; (**T-1**) characterize dissolved organic matter in terms of its chemical composition (humic versus proteins) and relate this composition to fluorescence DOM (FDOM) and its biodegradability and, correlate spatial variability of DOM with land use changes. This task will directly address recent concerns that have been raised related to FDOM in the Jordan River, (**T-2**) understand methane gas fluxes at selected sites in the lower Jordan River and estimate how much DO sink is attributed to methane oxidation. This will directly address recent observations made by Salt Lake City about immediate DO sag in the Jordan River following Storm water events at certain locations. Undisputed proof that methane oxidation contributes to significant DO sink will directly inform managers and will help them make management decisions. The methane oxidation rates generated will help refine the QUALKW2 model, (**T-3**) In light of recent developments for possible new ammonia standards in Utah, understand all processes related to the nitrogen cycle in the Jordan River sediments and the water column. The rates of different nitrogen cycling processes (discussed later) will inform the mangers and stakeholder about whether we need to worry about ammonia and oxidized forms of nitrogen as the Jordan River flows in to the Great Salt Lake, (**T-4)** conduct SOD at varying flow conditions to see if the disturbed sediments (i.e causing release of organics) have any immediate effect on oxygen demand. This task is directly related to the recent discussion about increasing the flows in the lower Jordan River. The data from this task will guide manager whether changing flow will affect SOD. Finally (**T-5**) to create public educational programs to educate the local community and school children about the importance of the Jordan River and about how we can initiate community based programs to protect this important watershed. We will also incorporate **ethics** in our community based surveys. For example, is it ethical to dump the solid waste directly into the Jordan River by irresponsible people? How can we minimize it or stop it?

In this project, we have support from wastewater districts discharging into the Jordan River, Salt Lake City responsible for managing storm water runoffs, River Networks trying to study the effect of flow variations. The data generated will be analyzed using statistical tools in such a manner that it can be used for decision making. **Moreover, the protocols developed can be used to address similar problems in other watersheds (i.e more broader impacts).** The data related to nitrogen cycling, methane gas and organic matter can be used as a reference data set for other watersheds. Please note that PI has been communicating with SCWA Environmental Consultants (Dr. Erica Gaddis) about doing sediment deposition and more re-aeration measurements and hence, these aspects are not included in this project.

4. **Describe the location of the project with attached location map, including details on the total area that will be directly enhanced by the project.** Our target watershed in this project is the Jordan River watershed although the methodology and protocols developed will be useful for other watersheds and Willard Spur sediments. As stated above, the Jordan River is directly connected to GSL wetlands and the health of the Jordan River directly affects the health of GSL wetlands. The Jordan River receives point inputs from four municipal wastewater treatment plants (WWTP) and, sediment and nutrients from non-points sources throughout the **800 square mile watershed**. The river is divided into the Upper Jordan River and the Lower Jordan River by the Surplus Canal diversion located near 2100 South. Between 60 and 80 percent of the Upper Jordan River annual stream flow is diverted and used to mitigate flooding and bank erosion in the Lower Jordan River. In 2004 and 2006, the lower and upper Jordan River segments respectively, were included on the Utah 303(d) list in accordance with the Clean Water Act, which required development of total maximum daily load (TMDL) estimates for temperature, dissolved oxygen, total dissolved solids, E. Coli, and salinity. This project directly addresses some of the priority areas identified in this phase I TMDL and recent meetings conducted by Jordan River Water Council and technical advisory committee. Maps of the Jordan River watershed are included in the appendix.

5. **Significance of the Project in improving Utah's waterways and water quality:** This project will directly enhance the Jordan River water quality. Water quality is a societal issue. Hence, the complete responsibility to improve the water quality of the Jordan River should not just be on the UDWQ. It should be realized by the society and the stakeholders. To promote the role of the society into the Jordan River TMDL, perhaps the best way is to integrate social issues and the community into the decision making. By society, we imply the common households, public, and the community at the Wasatch Front. The Jordan River is just not "a stream" which connects Utah Lake with the historically significant the Great Salt Lake ecosystem. An improved water quality will ultimately lead to the development of several programs which will benefit the local economy and the local society. More broadly, it will directly meet the expectations set in "Clean Water Act". Jordan River's connectivity to the Great Salt Lake ecosystem threatens the water quality of GSL ecosystem which supports local business, thousands of migratory birds and is known as one of the main attractions in Utah.

6. **Connectivity to other ecosystem components:** The Jordan River is hydraulically connected to the Utah Lake and the Great Salt Lake. However, it is not fully understood how water qualities of these three water bodies affect each other. Sediments and water are two important ecosystem components addressed in this project. Both these components are important because both are transported from the Utah Lake to the Jordan River and ultimately to the Great Salt Lake. At the ecosystem scale, **biotic and abiotic** factors form ecosystem components. Major abiotic components addressed will be turbidity, odor, pH, nutrients and organic matters. This project provides connectivity with stream habitats and microorganisms **as biotic components**. On a watershed scale basis, Jordan River is well connected with Riparian zones, several tributaries and terrestrial ecosystem.

7. **Additional social benefits:** The Jordan River flows through Salt Lake valley and represents an important aesthetic feature of Salt Lake City. The Jordan River has direct societal benefits in terms of domestic uses after prior treatment, recreation in terms of boating, wading and fishing, cold and warm water fisheries, dependency of wildlife and finally agricultural irrigation. Several biking and walking trails exist along the shore line of the Jordan River which not only provide health benefits to the society but also add to the wonderful landscape. Improving the water quality of the Jordan River will not only protect Utah's water under its 303(d) listing but also enhance/protect several societal benefits.

8. **Project plans and details:** To address the three data gaps (among many) identified above, the following tasks have been formulated.

(1) *Using mass spectrometry to characterize the dissolved organic matter present in the Jordan River (water column and pore water) in terms of its emitting fluorescence, biodegradability and chemical composition*.

This task will develop correlation between fDOM and total DOM. This task will directly address the recent concern raised about fDOM and its immediate contribution to DO sag. The probes of instrumental measurements can provide an estimate of fDOM but logically, not all organic matter emits fluorescence and what fraction of total DOM is fDOM. For example humic substance like fDOM generally reflects the refractory portion of organic matter and forms reservoir of organics in sediment.
Experimental: Water samples will be collected from Storm drainage, major tributaries at the event of raining (beginning, middle and end) to characterize for DOM. ***This is worth mentioning that the purpose of this task is not to calculate DOM loading in major tributaries which has already been performed or underway by other researchers***. Along with water column samples, we will also obtained pore water at selected sites in the lower Jordan River. These samples will be collected according EPA's approved protocols and will be stored on ice for immediate processing. The detailed sampling and analysis plan will be included in the final work plan. The collected samples will be processed for (1) direct fDOM measurement using commercially available probe, (2) mass spectrophotometry analysis after solvent extraction and, (3) biodegradability using BOD analysis. **The correlations developed and characteristics of DOM obtained in this task will inform UDWQ managers about** ; (1) whether fDOM is a good surrogate to monitor organic carbon dynamics in the Jordan River, (2) do they need to base their organic matter loading calculation on the total DOM or just on the biodegradable portion of total organic matter and, (3) whether flushing of sediments will release significant amount of DOM to cause problems in GSL wetlands.

(2) *Estimate methane formation and methane oxidation rates in the Jordan River sediments*. Methane is formed in sediments due to the decay of organic matter through methanogenesis. This process is mediated by methanogen archaea. On the other hand, methane oxidizing bacteria/archaea, known as methantrophs, can oxidize methane with oxygen, nitrite, nitrate, iron, manganese and sulfate as electron acceptors with the most common electron acceptor being the oxygen. Our methane gas formation rates at 1300S site and molecular fingerprints for methanotrophs clearly indicated the presence of methanogensis and methanotrophy and perhaps, the same is taking place at other sites in the lower Jordan River contributing to DO sinks. As the data on this aspect is minimal and the immediate DO sag following storm water events is still a puzzle, this tasks promises to fill an important data gap related to the phase II TMDL.
Experimental: From each sampled site, a 20 cm sediment core sample will be collected which will be split into two sub-sores each 10 cm in length in an anaerobic glove box. One of the sub cores will be used to measured methanogenesis rates and the other will be used to measure methane oxidation rates. We will minimally disturb the sub-cores to obtain "true" in situ rates because **poorly soluble substrates like methane are likely to be lost when the spatial structure of the sediment with its microzonation is disturbed**. To determine the methane oxidation rates and find out the oxygen equivalent ($CH_4+2O_2=CO_2+2H_2O$), we will use an innovative approach developed in our lab. The second sub-core, with minimum disturbance and in an anaerobic glove box will be transferred to a sub-core handler for methane oxidation experiments as shown in figure 1. After these oxidation experiments have been completed, after then only each sub-core will be used for the biogeochemical analysis.

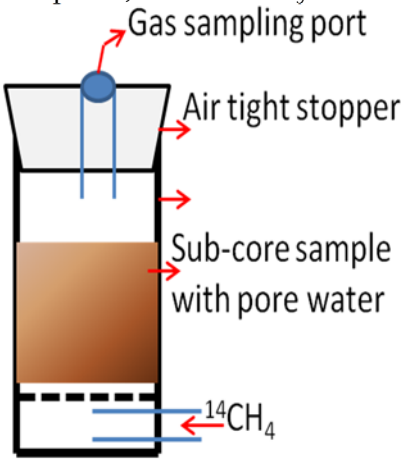
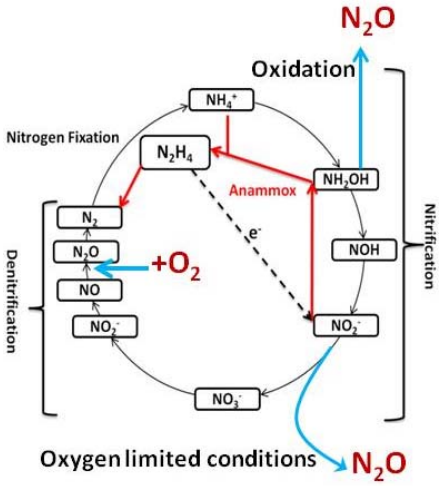


Figure 1 shows a simple set up that will be used to conduct methane oxidation experiments with minimum disturbance to core samples. Each sub-core will be inserted into a glass tube closed at the bottom. A perforated plate will hold the sub-core. After inserting the sub-core, the glass tube will be closed airtight. The stopper will have septa to grab gas samples for further analysis. $^{14}CH_4$ will be introduced from the bottom to simulate diffusion limitations of methane gas and its transport through microzones. Head space gases on the top of the sediment core will be measured before and during the experimental period. Methane gas will be introduce from the bottom of the core.
Figure 1: A schematic showing different set up $^{14}CH_4$ spiked experiments.

(3) *Estimate the extent of ammonia oxidation in the water column and sediments and, also evaluate other processes contributing to nitrogen cycling in the Jordan River sediments.* Figure 2 shows bacteria mediated nitrogen cycle. Ammonia loss through biological nitrification and nitrite/nitrate loss through

biological denitrification are two classical pathways of nitrogen loss in most ecosystems considered quite often. What are generally overlooked or ignored are anaerobic ammonia oxidation, dissimilatory nitrate reduction to ammonia and nitrogen fixing from the atmosphere. Dissimilatory nitrate reduction (DNR) is a process in which nitrate is reduced to ammonia through nitrite by a group of bacteria. With growing need for more stringent ammonia standards to protect Utah's water, dissimilatory nitrate reduction represents an important pathway for ammonia inputs. DNR bacteria can also generate significant amounts of ammonia in-situ. In this task, we will use evaluate rates of nitrification, denitrification and the presence of DNRA using functional gene approach.



We will collect sediment (top 2 cm) and water column samples from 5 sites in the lower Jordan River to evaluate nitrification, denitrification and dissimilatory nitrate reduction. The first two will be relatively easy to estimate using our routinely used techniques. The DNRA will be challenging because, much like in denitrification, nitrate first has to be reduced to nitrite and then nitrite is further reduced to ammonium. However, we will employ denitrification inhibitor to minimize the competition between denitrifiers and DNRA organisms. This task is also promoted by our recent whole community metagenomic analysis at 1300S site. We extracted total DNA and sequenced the whole community. We found functional gene participating in nitrification, denitrification, anaerobic ammonia oxidation, DNRA and aerobic and anaerobic methane oxidation.

Figure 2: Schematic a general representation of N cycle in aquatic environment (right side).

(4) *SOD at varying flow rates:* This protocol has already established in our Lab as several SOD measurements in Silver Creek, Jordan River, Utah Lake and State Canal have been already performed under UDWQ's funded project. In this project, we will use variable speed pump and conduct SOD measurements as detailed in Hogsett and Goel, (2013). SOD will be conducted at selected sites before flow change, during and after to evaluate the effect of flow changes and sediment immobilization.

(5) *Community outreach and education*: We conduct community outreach and education at three different levels; (1) direct community surveys to know what they think about the Jordan River and how we can improve the aesthetics of the Jordan River, (2) Summer workshop for local high school students to create future ambassadors for the Jordan River and, (3) integrating the findings from this project into graduate and undergraduate teaching. Apart from these, the research findings will also be presented at Jordan River council meeting, Salt Lake Watershed Symposium, WEAU conference, and national conferences. Annual and final reports will be submitted to UDWQ. A project website will be created at the University of Utah web server.

Project Deliverables and milestones: The deliverables will include semi and annual reports. We will prepare a detailed quality assurance and project planning (QAPP) document prior to the commencement of the project.

	2014		2015				2016			
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Planning & QAPP										
Task 1										
Task 2										
Task 3										
Task 4										
Task 5										
Reports										

The final report will contain all results properly analyzed using statistical tools. The QAPP document will be included in the final report as well such that the protocols and methods can be used for other watersheds. A project website will be developed at the beginning of the project and this website will be updated periodically based on the progress of the project. The following table presents project milestones.

9. **Past experience in implementing similar projects:** The PI has been involved in several water quality related projects funded by federal and non federal sources. Some of the relevant projects are listed below

1. Evaluating the flux from sediments and the fate of nutrients in Great Salt Lake wetlands to integrate these findings into ongoing Wetland assessment and development efforts**.** Funding Source: US EPA Region VIII WDGP: **Status and Reporting Requirements**: Semiannual report (summer 2013, QAPP with SOPs, Annual report in 2014). Results also presented at EPA WDGP Conference in Salt Lake City, September, 2013.
2. Mercury methylation and its rates in Great Salt Lake Sediments: Funding Source was Utah Water Quality Board: **Status and Reporting Requirements**: Final project report submitted to UDWQ in 2009. This project evaluated rates of mercury methylation at three locations in Farmington Bay Wetlands. The microbial community participating in methylation was identified using molecular tools.
3. Response of water column in Willard Spur wetlands- protocol development: Duration; 5/2013-5/2014; **Status and Reporting Requirements:** Annual report submitted to UDWQ in December 2013
4. Sediment oxygen demand and Organic Carbon in Jordan River: Funding Source: UDWQ ($157, 925 & $137,500). PI brought SOD technology from USEPA Georgia office and helped UDWQ in its TMDL efforts. Absence of in-situ SOD values and organic carbon in sediments weresignificant data gaps which the PI helped the UDWQ in its TMDL efforts. **Status and Reporting Requirements**: Annual report submitted to UDWQ in 2012. One manuscript in peer reviewed journal, two under preparation and several conference papers.

10. **Maintenance of the project in future:** This is a 2.5 years project with August 2014 as the starting date. Dr. Ramesh Goel will be the principal investigator of this project. Quarterly meetings will be conducted to coordinate the project research, outputs and outcomes with UDWQ and other stakeholders. In these meetings, PI will make short presentations on the project progress till that date and short 2~3 page handouts will be distributed to all attendees on the project updates. If possible, the PI will merge some of the project meetings with Jordan River Watershed meetings. The PI will also submit semiannual reports to UDWQ. These reports will include detailed interim milestones and project details. A project website will be created for most recent updates on the project. Apart from the technical objectives of this project, the PI's other aim is to coordinate with UDWQ for future success of the project to accomplish; (1) transfer of results, (2) public education through presentations and summer workshop and computer animations, (3) transfer of analyzed and discussed data to UDWQ in the form of intermediate reports, annual and final project reports and, (4) dissemination of results through conferences and peer reviewed journal papers. We will develop/modify the Quality Assurance Project Plan (QAPP) for all lab and field scale protocols with discussion with UDWQ. In parallel, the PI will also submit research proposals to other federal agencies such as NSF, DNR, EPA and USDA.

11. **Participating agencies:** Please letters of support from Salt Lake County and CVWRF Wastewater District. Salt Lake City is responsible for storm water discharges and CVWRF discharges its treated effluent into the Jordan River through a creek. PI has been working with UDWQ and UDWQ by default will be the project partner. Other than this, we expect to work closely with the Utah State University, Utah Valley University and other community partners.

University of Utah	110 S. Central Campus Drive, 2000 MCE	801-581-6110
Name/Company	Address	Phone

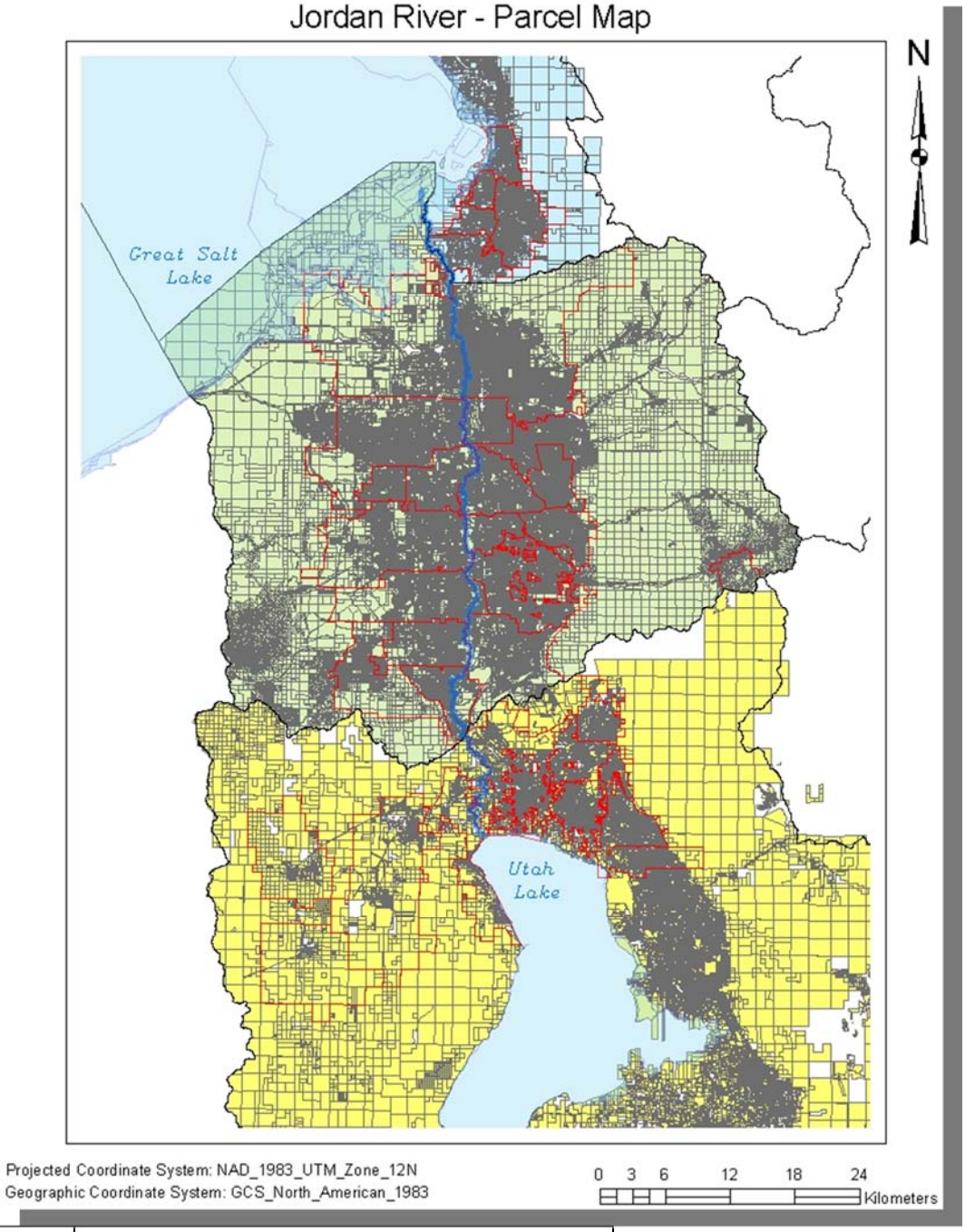
I am willing to: (1) comply with all applicable laws and work with designated technical personnel as assigned to the above–referenced project in preparation of project implementation; (2) submit detailed project information to the Utah Division of Water Quality as requested to evaluate water quality improvements; (3) not to apply any practices which would tend to defeat the purpose of the project; and (4) allow continued monitoring and evaluation of the project activities implemented on my property.

Signature_____  _____ Date May 05, 2014_____
Applicant

Signature __Signed electronically (Mike Barber)___Date May 05, 2014____
Co-Applicant (if applicable)

APPENDIX: Supplementary Documents

1. Jordan River watershed map
2. Support letter from Salt Lake City
3. Support Letter from Central Valley Water Reclamation discharging to Jordan River
4. Support Letter from River Networks
5. Budget and Justification
6. Dr. Ramesh Goel's CV
7. Dr. Michael Barber's CV



Reach #	Location
1	Farmington Bay to Davis County line
2	Davis County Line to North Temple
3	North Temple to 2100 S
4	2100 S to 6400 S
5	6400 S to 7800 S
6	7800 S to Bluffdale Rd.
7	Bluffdale Rd. to Salt Lake County line

Central Valley Water
Reclamation
Facility

Board Members
Jim Brass, Chair
Irvin H. Jones, Vice Chair
Nancy Groberg, Treasurer
Debra K. Armstrong
Benjamin Behunin
Rod Bushman
John Norton

General Manager
Thomas A. Holstrom, P.E.

Utah Division of Water Quality
P.O. Box 144870
Salt Lake City, Utah
84114-4870

May 5, 2014

Attn: Mr. Walt Baker, P.E., Director
Subject: Letter of Support for Research Activity

Dear Mr. Baker:

I am writing this letter of support and collaboration for Dr. Ramesh Goel's proposal to access the Willard Spur funding mechanism for ongoing research. Dr. Goel's proposal will investigate additional sinks of dissolved oxygen in the Jordan River sediments and the fate of nitrogen compounds in the River.

As we know, sediments in the lower Jordan River represent a great sink of dissolved oxygen. Although investigations related to the Phase I Jordan River TMDL clearly indicated organic matter to be the main contaminant of concern in the lower Jordan, its type and fate in sediments is still not understood. Dr. Goel's SOD study, funded by the Utah Division of Water Quality and the JR/FB WQC, was one of the main contributors to filling the data gap. Through this much needed research, Dr. Goel now wants to look into the sediments to reveal the identity of those mechanisms contributing to the DO sink. Understanding these mechanisms is necessary to develop better management strategies.

The second component of Dr. Goel's proposal is related to the fate of nitrogen compounds in the Jordan River. His preliminary study clearly shows a significant degree of denitrification occurring in the sediments of the Jordan River and his use of whole community identification, showing the presence of many nitrogen cycling genes, is needed research and will certainly assist the ongoing TMDL efforts. We fully support Dr.Goel's proposal and hope for its favorable review.

As a partner in this project, we will share our flow and water quality data with Dr. Goel . He will be invited to present in our group meetings. Please feel free to contact me at 801-973-9100 should you have any questions.

Sincerely,

Thomas A. Holstrom, P.E.
General Manager
Central Valley Water Reclamation Facility

JEFFRY T. NIERMEYER
DIRECTOR

SALT LAKE CITY CORPORATION

DEPARTMENT OF PUBLIC UTILITIES
WATER SUPPLY AND WATERWORKS
WATER RECLAMATION AND STORMWATER

RALPH BECKER
MAYOR

April 28, 2014

Mr. Walt Bake, P. E.
Utah Division of Water Quality
P.O. Box 144870
Salt Lake City, Utah 84114-4870

Subject: Dr. Ramesh Goel, University of Utah Civil and Environmental Engineering
Water Quality Monitoring, Jordan River

Dear Mr. Baker,

This letter is to document Salt Lake City Department of Public Utilities' support of Dr. Ramesh Goel's (University of Utah, Graduate Director - Environmental Engineering and Microbiology Lab, Civil & Environmental Engineering) proposed research regarding dissolved oxygen (DO) level reductions resulting from sediments and nitrogen transformations in the Jordan River.

As part of the State's phased TMDL of the Jordan River, DO levels have been observed to decline following storm water events. One of the theories and questions remaining to be answered in the characterization and solutions to solving the DO problem is that this may be in part attributable to the readily biodegradable organics (e.g., methane gas and nitrogenous compounds such as ammonia nitrogen) that are present in the river sediments. The research proposed by Dr. Goel will better the overall understanding regarding DO level reduction within the river to get us to the point of a specific and effective remedy of the Jordan River TMDL.

As a stakeholder and partner with this and other projects related to the Jordan River, we will provide Dr. Goel with flow and water quality data as possible. Please feel free to contact me should you have any questions.

Sincerely

Jeff Niermeyer P.E.
Director
Salt Lake City Public Utilities

1530 SOUTH WEST TEMPLE, SALT LAKE CITY, UTAH 84115
TELEPHONE: 801-483-6900 FAX: 801-483-6818
WWW.SLCGOV.COM

May 05, 2014

Mr. Walt Baker
Utah Division of Water Quality

Dear Walt:

I am writing this letter to support Dr. Ramesh Goel's proposal to UDWQ. Dr. Goel's proposals to study additional sources of dissolved oxygen sinks with particular emphasis on determining methane oxidation, estimating organic matter degradability, determining sediment oxygen demand and evaluating nitrogen cycling are important. Dr. Goel's past research related to the organic carbon in sediments were used by us to set preliminary framework for Jordan River sediment transport. I am sure the research proposed will generate similar applied results and will be helpful for Jordan River phase II TMDL. We will continue working with Dr. Goel in future efforts related to Jordan TMDL and restoration of the river.

As a partner in the Lower Jordan River Flow Project, we will share our flow and water quality data with Ramesh. That Project is investigating how changes in flow management on the Lower Jordan could help improve water quality, and Dr. Goel's findings will be of great utility in that effort. He will be invited to present in our group meetings, and to share his insights in order to improve the Project. I am also sure that Dr. Goel's research will result in significant findings to help UDWQ develop water quality and restoration strategies. Please feel free to contact me should you have any questions.

Sincerely,

Merritt Frey
River Habitat Program Director
River Network
Office: 801-486-1224
Email: mfrey@rivernetwork.org

South Davis Sewer District

Mailing Address:
PO Box 140111 • Salt Lake City, Utah 84114-0111

Office Location:
1800 West 1200 North • West Bountiful, Utah 84087

Phone (801) 295-3469 • *Fax* (801) 295-3486

May 1, 2014

Mr. Walter L. Baker
Utah Division of Water Quality
PO Box 144870
Salt Lake City, Utah 84114-4870

RE: Dr. Ramesh Goel grant proposal

Dear Walt:

I am writing this letter to express the South Davis Sewer District's support for Dr. Ramesh Goel's proposal for Division of Water Quality funding. Ramesh's proposal will investigate the role of methane gas oxidation, ammonia oxidation and composition of organic matter in the Jordan River. These are important data gaps that Ramesh has identified and that will directly affect The Jordan River TMDL. The work that Ramesh has done in the past on the environmental processes in the Jordan River has been invaluable.

As a partner in this project, we will share our flow and water quality data with Ramesh and support this project in any way that we can. He will be invited to present at the Water Quality Group group meetings. I am sure that Dr. Goel's research findings will be of significant help in developing DWQ's Wetland Program. Please feel free to contact me should you have any questions.

Sincerely

Dal Wayment, P.E.
General Manager
South Davis Sewer District

Budget and Justification

	Year 1	Year 2	Year 3		U of U Cost share
Dr. Goel (one month summer support**)**	$0.00	$9,700.00	$9,700.00		
Dr. Barber (No support- In kind**)**	$0.00	$0.00	$0.00		
Student (One graduate student for 2.5 years**)**	$6,000.00	$18,000.00	$24,000.00		
Post Doc (@37 %/year from DWQ and 13% from U**)**	$0.00	$30,000.00	$30,000.00		$30,000.00
Fringe (37 % for Goel and Post Doc and 14 % for student**)**	$840.00	$17,209.00	$18,049.00		$11,100.00
Total Labor	$6,840.00	$74,909.00	$81,749.00	$156,658.00	$41,100.00
Supplies (For extensive field sampling, lab analysis**)**	$2,000.00	$20,000.00	$20,000.00	$40,000.00	
Equipment (fDOm probe and TCD detector for GC**)**	$15,000.00	$0.00		$0.00	
Subtotal	$23,840.00	$94,909.00	$101,749.00	$196,658.00	
				$0.00	
Overhead	$2,384.00	$9,490.90	$10,174.90	$19,665.80	$4,110.00
	$26,224.00	$104,399.90	$111,923.90	$242,547.80	$45,210.00
Total Project Budget					**$287,758**

Personnel: One month summer salary support for Dr. Goel in 2nd and 3rd years of the project is included. Please note that no support in the first month and for all three for Dr. Barber are included in the budget. A graduate student is included in the budget. His salary is charged at $2,000 per month. The graduate student will be charged for 3 months in the first year, 9 months in the second and 12 months in the third year. Support for other months in the first and second year for the graduate student will be leveraged from other projects. A post doc with experience in stream ecology will be hired at the beginning of the second year for 2 years. Partial salary of the post doc will be paid by the University of Utah as a cost share to the project. Please note that this is not in-kind but absolute dollar amount that will be added to the project directly.

Fringe Benefits: Faculty and post doc salaries are charged at 37 % and student salary is at 14 %.

Supply and Travel: The supply is included to cover chemicals, molecular chemicals, core facility charges, consumables and supply for Ion and gas chromatographs. As evident from the research plan, this project is primarily field and lab activities centered. The supply budget also includes cost of local travel.

Indirect cost: It is charged at 10 % of the total direct project cost.

RAMESH K. GOEL
Associate Professor, Environmental Engineering
Civil & Environmental Engineering
University of Utah- Salt Lake City
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Salt Lake City, UT-84112

Professional Preparation

Institution	*Major/Area*	*Degree*	*Year*
Jadavpur University	Civil Engineering	BS	1994
Jadavpur University	Environmental Engineering	MS	1996
University of South Carolina	Environmental Engineering	Ph.D.	2003
University of Wisconsin, Madison	Environmental Engineering	Post Doc	2005

(a) Appointments

July 2011- present- Associate professor, Environmental Engineering, UU, Salt Lake
January 2006- June 2011-Assistant professor, Environmental Engineering, UU, Salt Lake
August 03-December 06- Post Doc- Environmental Engineering, UW, Madison (**with Dr. Noguera**)
January 01- August 03 –Research Assistant-Environmental Engineering- USC, Columbia
July 96 – September 99- Engineer- CES (I) Ltd, India
July 94 – July 96- Graduate Research Assistant- Jadavpur University, India

(C) Products

Products most closely related to the proposed research

1. Hogsett, M. and Goel, R. (2013). Evaluating dissolved oxygen dynamics at sediment-water interface in an urbanized river, in print in environmental Engineering Science.
2. Hogsett, M. and Goel, R. (2013). Assessing organic carbon loads in sediments of an urbanized stream. Under review.
3. Hogsett, M and Goel, R. (2012). Sediment-Water Column Dissolved Oxygen Interactions in an Urbanized Stream. *85th Annual Conference of the Water Environment Federation,* New Orleans October 2012.
4. Kotay, S.M., Mansell,B., Hogsett, M., Pei, H. and Goel, R. (2013). Anaerobic Ammonia Oxidation (ANAMMOX) for Side-stream Treatment of Anaerobic Digester Filtrate -process performance and microbiology. In print in Biotechnology and Bioengineering.
5. Tahir, S., Haries, J. and **Goel, R**. (2009). Setting up TMDL for Jordan River-Role of Sediment Oxygen Demand and Nutrient Flux. WEF TMDT Conference, Minnesota September, 2009.

Other relevant products

1. Choi, J., Kotay, S.M. and Goel, R. (2010). Various physico-chemical stress factors cause prophage induction in *Nitrosospira multiformis* 25196-an ammonium oxidizing bacteria. *Water Research*; 44: 4550-4558.
2. Kotay, S.M., Datta, T and **Goel, R**. (2009) Microbial ecology of viruses in an EBPR activated sludge process performing phosphorus release under aerated-anaerobic Condition. *American Society of Microbiology*; 109th General Meeting; May 17-21 in Philadelphia, PA.
3. Datta, T., Liu, Y. and Goel, R. (2009). A novel treatment approach to simultaneously achieve nutrient removal and sludge reduction in activated sludge process. *Chemosphere*;76: 697-705.

4. Srinivasan, S., Harrington, G., Xagoraraki, I. and **Goel, R**. (2008). Factors Affecting Bulk to Total Bacteria Ratio in Drinking Water Distribution Systems. *Water Research;* 42: 3393 – 3404.
5. **Goel R.** and Noguera**. (2006)** Evaluation of Sludge Yield and Phosphorus Removal in a Cannibal Solids Reduction Process. *ASCE- Journal of Environmental Engineering; 132: 1331-1337***.**

(d) Synergistic Activities:

1. Serving on WEFTEC Research Symposium, WEF Disinfection Committee.
2. Graduate Director: Civil & Environmental Engineering, University of Utah
3. Reviewer for NSF's Environmental Engineering, Environmental Sustainability, IGERT, SBIR Panels.
4. Participating in on campus Hi-GEAR and MESA educational outreach activities for k12.
5. Participating in undergraduate research program (UROP) at the University of Utah.
6. Director for Intermountain Junior Science and Humanities Symposium at the U.
7. Participates in Undergraduate Research Program at the University of Utah.

(e) Collaborators and Other Affiliations

*Collaborators***. Michelle Baker (Utah State),** Dr. Roger Hendrix, U of Pittsburg, PA, Dr. Sherwood Casjens (Utah), Dr. Sukalyan Sengupta (Umass, Dartmouth), Dr. S. Krishnaswamy (MKU, India), Dr. Sekhar Muddu (IISc, India), Dr. Dhritiman Ghosh, University of Tennessee, Dr. Steve Borwn (ORNL), Dr. Jordan Peccia (Yale University, Dr**.** John Novak (Virginia Tech), Ryan Dupont and Darwin Sorensen (Utah State University), Kyle Gorder (Hill Air Force, Utah), Ashutosh Tiwari (Materials Science, U of U), Keith Roper (Chemical Engineering, U of U), William Johnson (Geology and Geophysics, U of U), Greg Harrington (University of Wisconsin), Joseph Flora (University of South Carolina), Daniel Noguera (University of Wisconsin), Francis De Los Reeyes (NC State University), Phil Heck (Brown & Caldwell), Ilya Zarov (Chemistry, U of U), Agnes Ostafin (Material Science, U of U) and Jeanny Wang (MWH Inc), Dr. James Barnard, Black and Veatch.

Current Students: Ramin N. (Ph.D), Mitch Hogsett (Ph.D), Pei Huangi (PhD), Amir Motlagh (PhD), Sha Hu (PhD), Ksheeraja (Masters), Amina Khatun (Masters) and Shireen Meher Kotay (Post Doctoral). Total number = 8,

Past Students: Tania Datta (PhD, Assistant Professor, Tennessee Tech), LeeAnn Racz (PhD, currently assistant professor at AFIT), Liang Li (Associate Professor, Shanghai), J Choi (Research Faculty, South Korea), Ksheeraja (MS thesis) Bryan Mansell (Brown & Caldwell), Ran Jing (PhD student, U of Hong Kong), Liu Yanjie (Master's, currently at Ch2M Hill), Yidan Guo (Master's, currently working), Udarka Karra, Masters, currently doctoral student with Baikun Li at Uconn), total number = 5

PhD Thesis Advisor: **Dr. Joseph Flora**, University of South Carolina, Columbia.

Post Doc Advisor: **Dr. Daniel Noguera**, University of Wisconsin, Madison.

Michael Ernest Barber
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Salt Lake City, Utah 84112
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(a) Professional Preparation

University of New Hampshire	Civil Engineering	BS, 1981
Purdue University	Civil Engineering	MS, 1983
University of Texas at Austin	Civil Engineering	Ph.D., 1991

(b) Appointments

2013 – Present	Chair and Professor, Department of Civil and Environmental Engineering University of Utah, UT
2001 – 2013	Director, State of Washington Water Research Center
2008 – 2013	Professor, Department of Civil and Environmental Engineering Washington State University, Pullman, WA
1999 – 2008	Associate Professor, Department of Civil and Environmental Engineering Washington State University, Pullman, WA
1994 – 1999	Assistant Professor, Department of Civil and Environmental Engineering Washington State University, Pullman, WA
1991 – 1994	Assistant Professor, Tulane University, New Orleans, LA
1988 – 1991	Research Assistant, University of Texas, Austin, TX
1983 – 1988	Project Engineer, KKBNA Inc., Wheat Ridge, CO
1981 – 1982	Teaching Assistant, Purdue University, West Lafayette, IN
Summer 1980, 81	Civil Engineer, US Army Corps CRREL, Hanover, NH

(c) Products

Products most closely related to the proposed research

G. Wang, M.E. Barber, S. Chen, and J.Q. Wu, (2013). "SWAT Modeling with Uncertainty and Cluster Analyses of Tillage Impacts on Hydrological Processes," Stochastic Environmental Research and Risk Assessment, accepted and published online 22 May 2013, DOI 10.1007/s00477-013-0743-9.

H. Qiu, D.R. Huggins, J.Q. Wu, M.E. Barber, D.K. McCool and S. Dun, (2011). "Residue Management Impacts of Field-Scale Snow Distribution and Soil Water Storage," Transactions of the ASABE, Vol 54, No. 5, pp 1615-1625.

E. Pruneda, M.E. Barber, D. Allen, and J. Wu, (2010). "Use of Stream Response Functions to Determine Impacts of Replacing Surface-Water Diversions with Groundwater Withdrawals," Hydrogeology Journal, Vol 18, pp. 1077-1092.

Z.M. Al-houri, M.E. Barber, D.R. Yonge, J.L. Ullman, and M.W. Beutel, (2009). "Impacts of Frozen Soils on the Performance of Infiltration Treatment Facilities," Cold Regions Science and Technology, Vol 59(1), 51-57.

M.E. Barber, A. Hossain, J.J. Covert and G.J. Gregory, (2009). "Augmentation of Seasonal Low Stream Flows by Artificial Recharge in the Spokane Valley-Rathdrum Prairie Aquifer of Idaho and Washington," Hydrogeology Journal, Vol 17, pp 1459-1470.

Other relevant products

R.L. Mahler, M. Gamroth, P. Pearson, F. Sorenson, M.E. Barber, and R. Simmons, (2010). "Information Sources, Learning Opportunities, and Priority Water Issues in the Pacific Northwest," Journal of Extension, Vol 48(2), 1-9.

S.S. Nelson, D.R. Yonge, and M.E. Barber, (2009). "The Effects of Road Salts on Heavy Metal Mobility in Two Eastern Washington Soils," Journal of Environmental Engineering, American Society of Civil Engineers, Vol 135, No. 7, pp 505-510.

R. Leek, J.Q. Wu, L. Wang, T.P. Hanrahan, M.E. Barber, and H. Qiu, (2009). "Heterogeneous Characteristics of Water Movement Through Streambed Sediments of the Touchet River, Southeastern Washington, USA," Hydrological Processes, Vol 23, No. 8, pp 1236-1246.

G.N. Teasdale and M.E. Barber, (2008). "Aerial Assessment of Ephemeral Gully Erosion from Agricultural Regions in the Pacific Northwest" ASCE Journal of Irrigation and Drainage Engineering, Vol 134, No. 6, pp 807-814.

M.E. Barber, F. Loge, A. Al-Omari, and M. Fayyad, (2008). "Water Quality and Quantity in Jordan's Dead Sea Wadis," Water International, Vol 3, No. 3, pp 369-379.

G. Fu, M.E. Barber and S. Chen, (2007). "The Impacts of Climate Change on Regional Hydrological Regimes in the Spokane River Watershed," Journal of Hydrologic Engineering, American Society of Civil Engineers, Vol 12, No. 5, pp 452-461.

(d) Synergistic Activities

- Director of the State of Washington Water Research Center, a network of 54 Institutes having a mission of disseminating information on water resources.
- Co-PI in a regional water quality coordination grant with Alaska, Idaho, Oregon and Washington to promote synergistic education, research, and extension activities.
- Past-President 2010-2011 of the University Council of Water Resources (UCOWR) which promotes water resources education.
- Registered Professional Engineer in State of Colorado
- Member of American Geophysical Union

(e) Collaborators & Other Affiliations

- **Collaborators and Co-Editors:**

Diana Allen, Simon Fraser University; Dan Ames, Idaho State University; Richelle Allen-King, SUNY Buffalo; Gail Andrews, Oregon State University; Reda Bakeer, Tulane University; Matt Betts, Oregon State University; Jan Boll, University of Idaho; Erin Brooks, University of Idaho; Michael Cochrane, Northwest Indian College; Bryce Contor, University of Idaho; Bernard Engel, Purdue University; Michael Gamroth, Oregon State University; James Gosz, University of Idaho; Rollin Hotchkiss, BYU; Gary Johnson, University of Idaho; Steve Juul, US Army Corps of Engineers; Doug Kane, University of Alaska; Frank Loge, University of California Davis; Robert Mahler, University of Idaho; Rabi Mohtar, Purdue University; Thanos Papanicolaou, University of Iowa; David Sammons, University of Florida; Alistair Smith, University of Idaho; Fred Sorensen, University of Alaska; Mark Stone, University of New Mexico; David Tarboton, Utah State University; Jeff Ullman, University of Florida

- **Graduate Advisors and Postdoctoral Sponsors:**
  PhD Advisor: Professor Neal Armstrong, University of Texas, Austin, TX. Current: Professor
  MS Advisor: Professor Donald Gray, West Virginia University, Morgantown, VA. Current: Professor

- **Thesis Advisor (7 Total) and Postgraduate-Scholar Sponsor:** Elizabeth Milburn (WSU), Erik Pruneda (WSU), Zail Al-Houri (WSU), Katie Mozes (WSU), Laura Garcia (WSU), Travis Lopes (WSU), SM Rashid (WSU), Colt Shelton (WSU).