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

☐ 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: **What is the role of nutrient and carbon cycles in sediments in contributing to water quality and ecological health of Farmington and Willard Bay Wetlands?**

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	**$ 148,098** (Includes faculty, student and post Doc salaries plus fringe benefits)
Materials	**$ 45,000 (**chemical supplies, field supplies, consumables, core facility charges etc**)**
Equipment	**$ 9,000 (**NPD detector for N2O gas**)**
Administration	$ **19,310 (**University indirect cost at 10 % of total direct**)**

TOTAL Willard SpurFunding Requested **$212,408**

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

Funding Source	**Amount**
U of U Student funding_____	$**30,096** (3rd year student fundig)
_____	$_____
_____	$_____

Total Amount of matching funding: $**30,096**_____

Total Project Cost (Requested + Matching Funds): $242,504_____

2. Estimated time frame of the project: From **August 15, 2014** To **August 14, 2017**

3. Purpose and need of the project

Regional significance, education and outreach: According to a study conducted by the Great Salt Lake Advisory Council Commission in 2011, it was concluded that the high level of uncertainty exists about the health of GSL wetlands due to the lack of historical and current data and a scientific understanding. **Willard Spur ecosystem** which includes standing water and acres of wetlands is currently under scrutiny by the Utah Division of Water Quality (UDWQ) due to recent anthropogenic threats to this ecosystem. These include discharge from the newly commissioned wastewater treatment plant (Willard Perry) and accidental oil spill from Chevron oil pipes. Although, ecological assessment based on extensive sediment and water column sampling reported good clean up, it is unarguably true that residual oil in the form of aromatic hydrocarbon may have affected the sediment composition and its biogeochemistry.

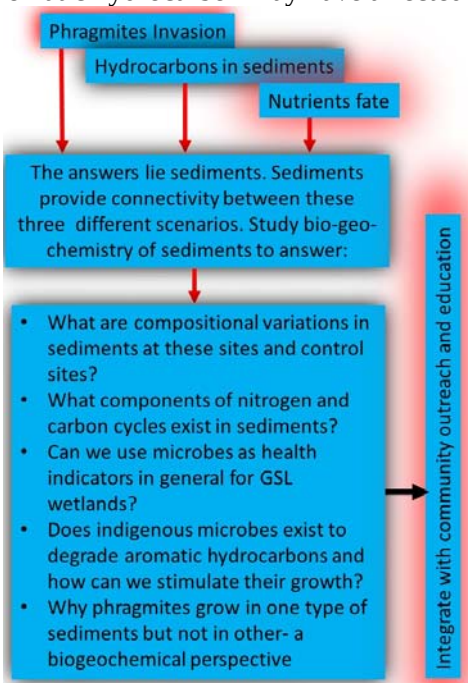


Figure 1: Figure demonstrating the need of the project and some key questions

Figure 1 shows the rationale behind three different but related research topics targeted in this project. They all have a common theme which is sediment biogeochemistry. In a broader sense, has the geochemistry in oil affected sediments changed after the spill as compared to a control site? **Are their indigenous microorganisms capable of degrading polycyclic hydrocarbons if any in the sediments**? PI's most recent research in Willard Spur Wetlands supported by UDWQ indicated the release and uptake of ammonia nitrogen in Willard Spur Wetland sediments during nutrient spike experiments. However, the nutrient spiking experiments were performed only for one site for protocol development and could not be continued for more sites due to funding constraints. Likewise, although not anthropogenic in nature, invasion of Phragmites especially in the Farmington Bay area, has been recognized by GSL Advisory Council as a threat to the health of the GSL ecosystem. Excessive growth of ***Phragmites*** can cause several ecological and hydrological challenges thus directly affecting the migratory birds in the GSL ecosystem, water quality and recreational values of GSL. Education and outreach is an integral component of this project.

Pending approval of this project, we will closely work with our partnering agencies UGS, DNR, Friends of Great Salt Lake and UDWQ such that the data obtained can be used to assess wetland health and functioning and, help managers in decision making.

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.

The study area consist of two sub-ecosystems within the Great Salt Lake ecosystem. The maps of these two sub-ecosystems, connected hydraulically and possibly ecologically, are included in the appendix. A detailed sampling plan will be included with the final work plan pending approval of this proposal. In summary, the wetlands in spill affected area, sites in Ogden Bay WMA and Farmington Bay WMA, Bear River migratory bird refuge for Phragmites and sediments in the vicinity of Willard Perry WWTP discharge. We will also sample some reference control sites for comparison purposes. We will make sure that most of the sampling sites fall in the list of sampling sites used by UDWQ such that the generated data can be compared and disseminated in a contextual manner.

Areas Affected: Geographic Location: Great Salt Lake Wetlands, Utah, Counties: Salt Lake, Box Elder, Weber, Davis and Tooele, HUC Sub-region 1602 – Great Salt Lake The updated *National Wetlands Inventory* (NWI, 2008) estimated approximately 427,000 acres of wetlands bordering the Great Salt Lake.

5. Significance of the Project in improving Utah's waterways and water quality.

The proposed research directly addresses core "Monitoring and Assessment" and "water Quality" elements described in greater detail in Utah's 2011-2016 wetland program plan (http://water.epa.gov/type/wetlands/upload/utah-wpp.pdf). The three research areas, i.e phragmites invasion, the presence of polycyclic aromatic hydrocarbon and their subsequent degradation by indigenous bacterial community and the presence of excess nitrogen in Willard Spur wetland, are all related to Utah's water and address UDWQ's and local priorities. The Great Salt Lake is Utah's one of the most important water bodies with commercial as well as ecological significance. This research project will improve Utah's waterways and water quality by answering the following related questions through a robust experimental plan which has been developed based on Dr. Goel's recent visit to a wetland institute in the Netherlands and after reviewing the related literature.

1. At a mechanistic scale, how can we understand the spread of phragmites based on nitrogen, phosphorus and carbon cycle? What is the geochemistry and minerology of phragmites dominated sediments as compared to sediments in the vicinity where phragmites do not exist.
2. From ecosystem functioning point of view, what unique biological processes take place in the sediments of phragmites dominated area (i.e Farmington Bay WMA), oil affected Willard Bay wetlands and WWTP discharge affected Willard Spur wetland sediments.
3. If indigenous community capable of degrading aromatic hydrocarbons exist, how can we stimulate their growth to conduct natural attenuation of residual aromatics if any? This may require nutrient spiking in sediments which will be evaluated through lab scale serum bottles.
4. What nitrogen transformation processes are occurring in the sediments to control the N-dynamics?
5. What is the human perception about the excess growth of phragmites and excess contaminants in GSL ecosystem? How can we create innovative educational and outreach programs?

6. Connectivity to other ecosystem components.

The GSL watershed and the surrounding wetlands are of critical importance, and instrumental in the sustenance of the regional ecosystem. Farmington Bay wetlands receive discharges from point sources either directly or indirectly. Indirect discharges come through surface water body such as Jordan River and Bear Rivers. Hydraulically, the proposed study areas are connected with each other. At an individual ecosystem consists of both biotic and abiotic components. The main abiotic components composed of temperature, water current (hydrology), sunlight, wind, topography, rainfall and dissolved oxygen concentrations. Biotic components are animals, plants and microorganisms. Figure 2 presents a schematic showing how the results from this project will provide connectivity between several components.

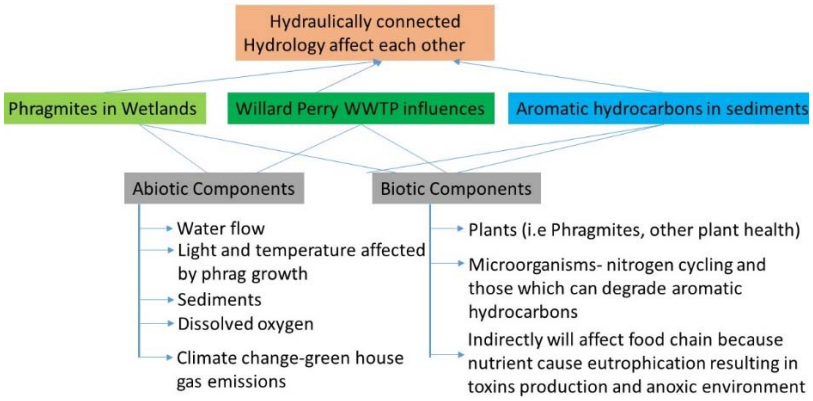


Figure 2: Shows connectivity between ecosystem components addressed in this project

7. Additional social benefits

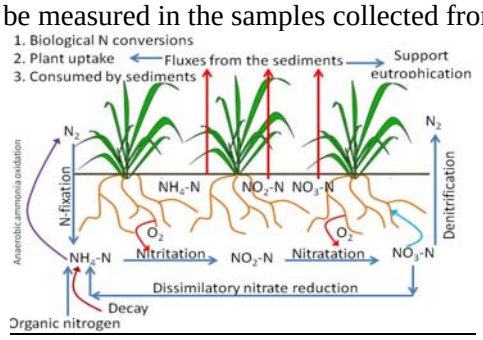
The GSL ecosystem carries tremendous social as well as economic benefits to the local community. Nationally, the GSL is regarded due to its extent, historical significance and being the biggest saline lake

in North America. It provides outstanding recreational and scenic values to the visitors from all over the nation. The brine shrimp business carries tremendous significance to the local economy. The Great Salt Lake is one of the most visited tourist destinations in Utah and hence, preserving it water quality and aesthetic nature are of utmost importance to the local authorities. Excessive growth of phragmites can alter flow conditions and create stagnant water patches which in turn is more susceptible to eutrophication resulting in nuisance smell (odor problems). The excessive carbon mass eventually will be decayed and leading to fermentive processes to occur which can generate methane gas. Methane gas is a potent greenhouse gas and has global societal significance. In summary, this research will support four additional societal benefits; (1) It will protect the recreational (in terms of tourism) and economical value, (2) provide data to understand methane and nitrous oxide emissions thus contributing to our understanding of global warming, (3) community based outreach through summer workshop and survey proposed in this project will create societal ambassadors to spread the significance of GSL ecosystem and, (4) the research results generated with directly contribute to UDWQ and EPA's mission of protecting nation's waters.

8. Project plans and details

To answer the questions posed before, we have formulated the following tasks. Each task is briefly detailed due to page limits. A detailed work plan will be submitted later on pending approval of this project.

<u>Task 1:</u> **Obtain biogeochemical signature in the rhizosphere of phgramites in dominated area and submerged aquatic vegetation in Willard Spur:** We will collect pore water and sediment samples from the rhizosphere at each site. The collected pore water will be analyzed for soluble metals (using ICP-MS), anions (using ion chromatography), ammonia nitrogen (using HACH low range), sulfate and sulfide, pH and dissolved organic carbon (using shimadzu total organic carbon analyzer). These parameters will also be measured in the samples collected from the water column.



<u>Figure 1</u>: Schematic of possible N transformation and consumption pathways in the rhizosphere

In the rhizosphere, we will study nitrogen cycling bacteria, more specifically those possibly participating in ammonia and nitrite oxidation, anaerobic ammonia oxidation, denitrification, methane oxidation, dissimilatory nitrate reduction and phosphorus accumulation. We will employ state of art metagenomic approach. Dr. Goel's lab is one of few in the Nation which has collected information on all nitrogen cycling genes and created a robust database though his international ties.

This task directly connects to the question how wetland health is related to rhizosphere dynamics and its biogeochemistry. UDWQ's efforts are mostly focused on above surface health indicators. This task will elucidate the importance of below surface processes in contributing to wetland health.

<u>Task 2:</u> Based on the biogeochemical data collected under the task 2, study the complete ecology of microbes participating in the nitrogen cycle in the rhizosphere and in sediments samples collected from the oil spill affected wetland sites: We will use functional gene approach rather than usual biomarkers and establish rates of different metabolic processes depicting nitrogen transformations and aromatic hydrocarbon degradation. This objective will focus on three aspects; (1) It will establish the important nitrogen transformation processes using functional gene approach in sediments enhancing our understanding on nitrogen handling capacity of sediments and, (2) It will inform whether we need to worry about any residual oil droplets left in the sediments because the presence of aromatic hydrocarbon degrading indigenous community will sustained the natural attenuation process. **Our new whole community transcriptomic approach**, which only targets functional genes will be able to reveal the identity of only those bacteria which are metabolically active. Figure 3 above lists the important processes related to N-cycle which we believe are relevant at wetland ecosystem and, directly relate to the wetland health. Wetlands are complex ecosystem. Different metabolic processes can be directly linked to wetland

health. For example, the presence of ammonia oxidizing archaea (rather than bacteria) represents ammonia limited conditions. This task will elucidate all metabolic processes occurring at selected sites and will inform managers about relative importance of carbon, nitrogen and P cycling at specific sites.

<u>Task 3:</u> Conduct laboratory scale microcosm tests to evaluate nitrogen transformation, methane formation and aromatic hydrocarbon degradation rates: We will grab representative sediments samples and use them to conduct laboratory scale serum bottle tests to evaluate; (1) nitrification rates, (2) denitrification rates, (3) dissimilatory nitrate reduction producing ammonia and, (4) anaerobic ammonia oxidation (anammox). We will also measure nitrous oxide and methane gas formation rates. With sediment samples collected from Willard Bay oil spill site, we will evaluate aromatic hydrocarbon degradation tests in which the tests matrix will be consist of spiking with aromatic hydrocarbons (i.e benzene, toluene, naphthalene), positive and negative controls. A detailed experimental plan will be included with the final project plan. Wetlands are known for contaminant removal and efficient microbial process shows wetland functioning. Rates can help managers determining how much nitrogen loading can be applied to natural wetlands. This task will provide useful data in this context. The aromatic degradation rates can be used to determine the natural attenuation potential of oil spill site.

<u>Task 4:</u> Evaluate the presence of fragmites on water quality and eutrophication: Fragmites can alter flows and isolate segments of water in wetlands. In relatively stagnant waters, nutrient concentrations can rise due to fluxes from the sediments resulting in deteriorated water quality. In this task, out hypothesis is that the phragmites dominated wetlands segments will have low water quality in terms of nutrients, chlorophyll a, cyanotoxins that those segments without phragmites but in the close vicinity to each other. We will obtain water samples from these sites and analyze for different parameters. Statistical tools such as chi phearson test or two way ANOVA tests will be used to evaluate the significant level in differences. This task will directly inform managers whether the presence of phragmites causes invasion problems or it also causes water quality deterioration as well.

<u>Task 5:</u> Develop education and outreach components and integrate the findings: We will conduct summer workshop for k12 student and technical workshop consisting of local regulatory agencies, local Universities, international wetland ecologist and USEPA personnel at the University of Utah at least once during the course of this project. We will create short videos on GSL ecosystem to demonstrate its importance to the local community. These videos will be posted at the project web site. Dr. Goel will integrate the project findings in his graduate and undergraduate courses.

<u>Task 6:</u> Research dissemination, final reports and milestones: Periodic project status and annual reports will be submitted to UDWQ. Research findings will also be disseminated through local and national conferences. The final project report, QAPP document and videos will be delivered to UDWQ to be posted at UDWQ website. The following table shows important milestones. *This is a 3-year project.*

	Year 1				Year 2				Year 3			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Planning & QAPP												
Task 1												
Task 2												
Task 3												
Task 4												
Task 5												
Task 6												

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: **<u>Status and Reporting Requirements</u>**<u>: Semiannual report (summer 2013, QAPP</u>

with SOPs approved by EPA, 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. Integrated Design, Modeling, and Monitoring of Geologic Sequestration of Anthropogenic Carbon Dioxide to Safeguard -Sources of Drinking Water (Co-PI): Duration; 11/2009 to 11/2012) Source of Funding: U.S EPA. **Status and Reporting Requirements**: Annual reports submitted to EPA in 2010, 2011, 2013.
5. 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 three years project with 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.

11. Participating agencies

PI has been working with UDWQ on funded research projects since 2008. We expect to have several agencies and stakeholders on board. More specifically, we are sure to work closely with UDWQ, UGS, DNR, friends of Great Salt Lake, Community members and wastewater districts. Support letters are included in the appendix.

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 _____

Applicant

APPENDIX

1. Maps, (2) Goel CV, (3) Budget Justification, (4) Letters of support from DNR, UGS, Friends of GSL.

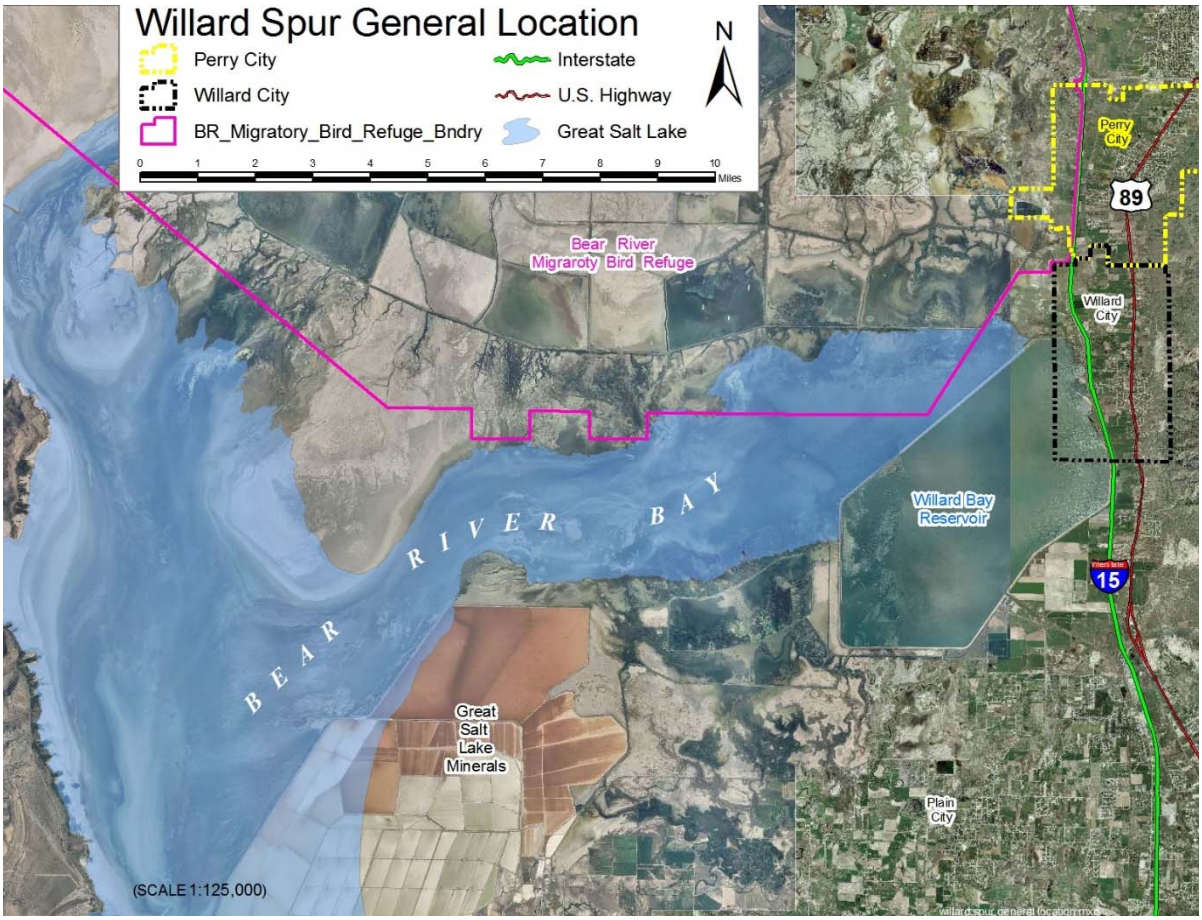


Figure A: Study Site: Willard Spur Wetlands. (Source: Taken from http://www.willardspur.utah.gov)

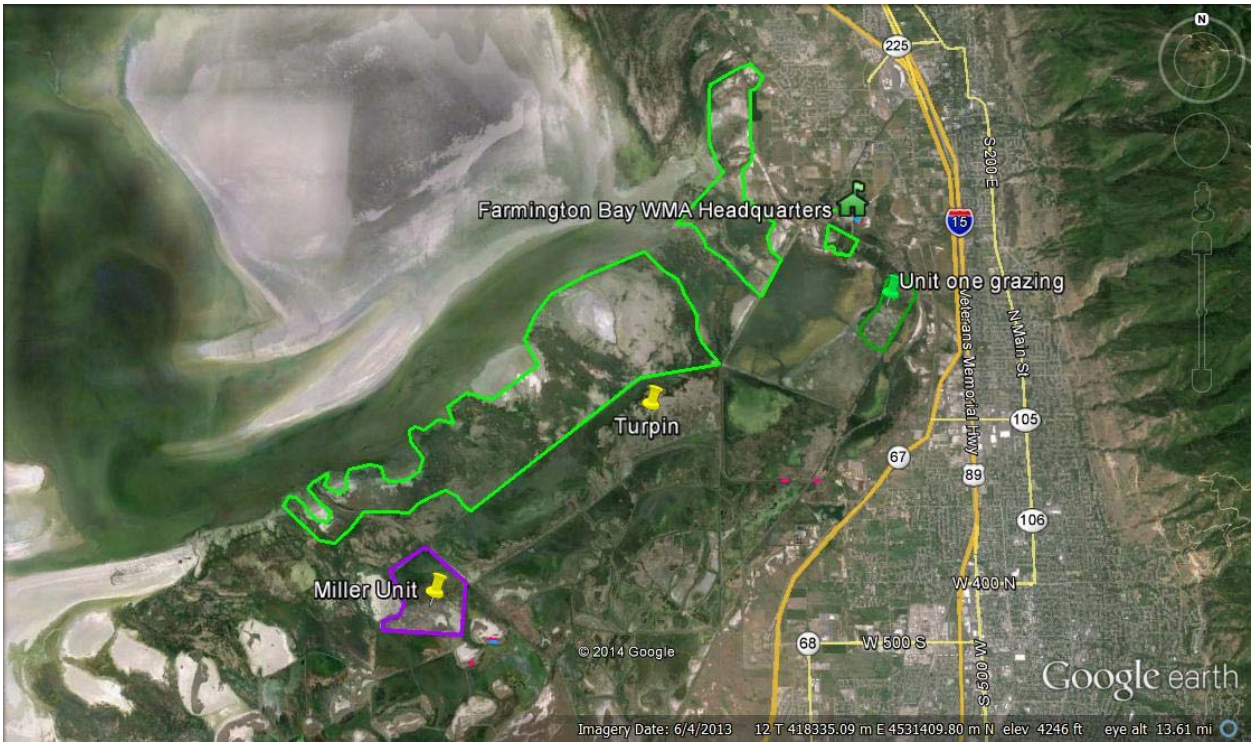


Figure B: Phragmites dominated Farmington Bay Wetlands. (Shared by Mr. Rich Hansen, UDNR)

RAMESH K. GOEL
Associate Professor, Environmental Engineering
Civil & Environmental Engineering
University of Utah- Salt Lake City
122 South Central Campus Drive, 104 EMRO
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.

Budget and Justification

	Year 1	Year 2	Year 3, cost share	
Dr. Goel	$9,700.00	$9,700.00	$0.00	
Student	$24,000.00	$24,000.00	$24,000.00	
Post Doc		$40,000.00	$0.00	
Undergraduate	$6,000.00	$6,000.00	$0.00	
Fringe	$6,949.00	$21,749.00	$3,360.00	
Total Labor	**$46,649.00**	**$101,449.00**	**$27,360.00**	
Supplies and travel	**$25,000.00**	**$20,000.00**	**$0.00**	
Equipment				
Subtotal	$71,649.00	$121,449.00	$27,360.00	
Overhead	$7,164.90	$12,144.90	$2,736.00	
Total Project Cost	$78,813.90	$133,593.90	$30,096.00	**$242,504**

Budget Justification

Personnel: One month summer salary support for Dr. Goel in 1st and 2nd years of the project is included. A graduate student at PhD level is included in the budget. The graduate student's salary is charged at $2,000 per month for the first two years. Student salary for the third year will be paid by the PI from other projects as a cost share. Please note that this is not in-kind but absolute dollar amount that will be added to the project directly. A post doc with experience in wetland ecology will be hired at the beginning of the second year for 1 year.

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.

GARY R. HERBERT
Governor

SPENCER J. COX
Lieutenant Governor

State of Utah

DEPARTMENT OF NATURAL RESOURCES

MICHAEL R. STYLER
Executive Director

Division of Wildlife Resources

GREGORY J. SHEEHAN
Division Director

May 1, 2014

Dr. Ramesh Goel
Associate Professor
Civil & Environmental Engineering Department
University of Utah

Subject: Letter of support for Dr. Goel's research in the wetlands of the Great Salt Lake.

Dear Dr. Goel,

Farmington Bay WMA managers support your research proposal which focuses the ecological understanding on why ***Phragmites*** flourish in certain segments of the Great Salt Lake wetlands. Your proposal which also includes understanding microbial processes and nutrient cycling in the rhizosphere of GSL wetlands in the areas with and without ***Phragmites*** is very interesting and has the potential to be transformative and may provide us with important information about these invasive species. Evaluating the presence of the microbial community capable of degrading oil particles is also noteworthy and can boost efforts for natural attenuation of an oil contaminated site. The sampling and analysis you performed last year for nutrients and microbial diversity (especially nitrifiers) in the Farmington Bay WMA wetlands and participation in our wetland meetings has been very beneficial in our efforts to understand this critical ecosystem. It is also understood that you are one of the leading researchers in microbial diversity as the recipient of the prestigious presidential award (NSF-CAREER), for your microbiology research. You use advanced molecular tools like stable isotope probing, molecular cloning and sequencing and even microbial genomics to reveal the identity and functionality of complex microbial populations. Your work related to bacteria contributing to nitrogen cycling in Great Salt Lake wetlands and in wastewater treatment plants is commendable. In summary, I fully support this proposal.

We will grant you access and will assist with your sampling where it is necessary. You will be invited to present your data at our Farmington Bay WMA wetland meetings. I am looking forward to working with you on the proposed research.

Sincerely,

Rich Hansen
Farmington Bay WMA Manager

1594 West North Temple, Suite 2110, PO Box 146301, Salt Lake City, UT 84114-6301
telephone (801) 538-4700 • facsimile (801) 538-4709 • TTY (801) 538-7458 • *www.wildlife.utah.gov*

GARY R. HERBERT
Governor

GREG BELL
Lieutenant Governor

State of Utah
DEPARTMENT OF NATURAL RESOURCES

MICHAEL R. STYLER
Executive Director

Utah Geological Survey
RICHARD G. ALLIS
State Geologist/Division Director

March 29, 2014

Utah Division of Water Quality
Emily Bartusek
195 North 1950 West
PO Box 144870
Salt Lake City, Utah 84114-4870

Dear Ms. Bartusek:

The Wetland Section of the Utah Geological Survey would like to express our support of Dr. Ramesh Goel's proposal for funding through the Willard Bay Settlement Project. Dr. Goel's proposed research will provide insight into the ecology of Phragmites in Great Salt Lake wetlands which is an important component of understanding integrity and water quality issues.

Thank you for your time and consideration.

Sincerely,

Jennifer Jones
Wetland Section Coordinator
Utah Geological Survey
1594 W. North Temple
PO 146100
Salt Lake City, UT 84114
801.537.3376

FRIENDS of
Great Salt Lake

PO Box 2655
Salt Lake City, UT 84110-2655
www.fogsl.org

April 4, 2014

To Whom It May Concern:

FRIENDS of Great Salt Lake is a nonprofit organization whose mission is to preserve and protect the Great Salt Lake Ecosystem through education, research, and advocacy.

We are pleased to submit this letter in support of Dr. Ramesh Goel's proposal to look into nutrient dynamics in the plant root zone of Great Salt Lake wetlands. Dr. Goel's continuing work in this area is important because it will help address significant gaps in our understanding about the role microbes play in the cycling of metals and nutrients in the Great Salt Lake Ecosystem.

Dr. Goel has been an active participant in local conferences and community meetings related to Great Salt Lake and its wetlands. He has written articles about his work in our newsletter, and presented at the 2012 Great Salt Lake Issues Forum hosted by FRIENDS. He will be invited to present the findings of this project with Great Salt Lake stakeholders in the future.

I hope you will give strong consideration to Dr. Goel's proposal. Thank you.

In saline,

Lynn de Freitas

Lynn de Freitas
Executive Director
FRIENDS of Great Salt Lake