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: University of Utah/Westminster College/U.S.G.S (William Johnson contact)
Project Title: Brine/Fresh Layer Circulation and Elemental Cycling in the Great Salt Lake
Agency or Business Name (if applicable): University of Utah, Westminster College, USGS
Mailing Address: 115 South 1460 East City: Salt Lake City State: UT Zip: 84112
Phone: (801) 664-8289 - E-mail: william.johnson@utah.edu

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

1. Estimated Project Costs:

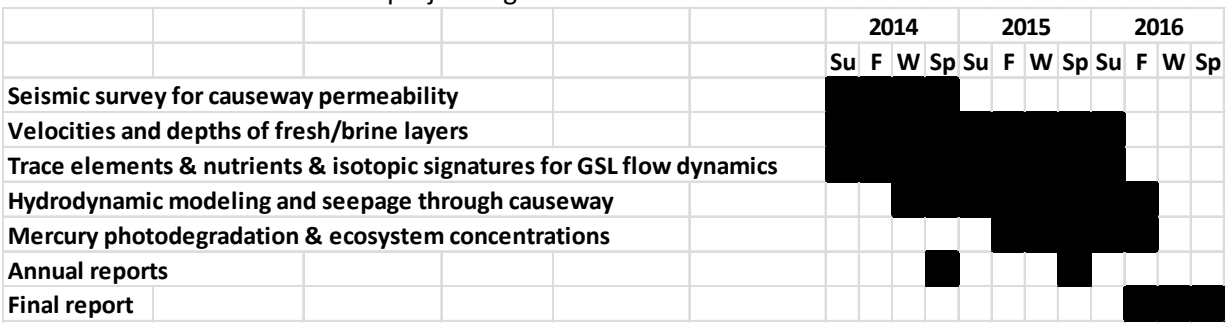
	Trace elements & nutrients & isotopic signatures for GSL flow dynamics	Mercury photodegradation & ecosystem trace element concentrations	Hydrodynamic modeling and seepage through causeway	Measured velocities, flows and depths fresh/brine layers	Seismic survey for causeway permeability	Subtotals
Labor	150,000	26,000	40,600	60,500	33,000	310,100
Materials	63,000	12,000	18,000	45,000	8,000	146,000
Equipment	60,000	26,000	5,000	12,000	8,000	111,000
Administration	27,300	6,400	6,360	24,000	6,000	70,060
Subcontract		2,000		2,000		4,000
Total requested	300,300	72,400	69,960	143,500	55,000	641,160
Other Sources of Funding	**U. Utah**	**Westminster**	**U. Utah**	**USGS**	**U. Utah**	
	54,000	14,000	18,000	23,860	9,000	118,860
Total project						760,020

Total project cost including other sources of funding: $ 760,020

2. The purpose of the project is to address major impoundments; e.g., Willard Bay, which are critical boundaries in the Great Salt Lake system. The Willard Bay impoundment provides a relatively deep freshwater resource for recreation, irrigation, and other uses on the eastern boundary of the hypersaline Great Salt Lake (GSL). The recent oil spill in Willard Bay brings into focus the vulnerability of the GSL to pipeline ruptures. It also highlights the vulnerability of the freshwater-influenced bays and the hypersaline South Arm of the GSL (Gilbert Bay) in the event of a major rupture (or ruptures) resulting from, for example, the significant probability (25%) of a major earthquake (> magnitude 6.5) in the next 50 years (Lund, 2013). The South Arm of GSL is of particular importance not only because of its hemispherically-important service as a staging area for migratory birds, but also for its utility as the basis for a major brine shrimp industry. Despite its importance, circulation and mixing between inflowing fresh waters, South Arm water, and deep brines within the South Arm is poorly understood. This circulation is complex, being driven by bi-directional flow from the hypersaline North Arm (Gunnison Bay), as well as freshwater-influenced bays (Bear River and Farmington Bays), and wind-driven seiche events (Beisner et al., 2009). In the event of a major rupture of oil pipelines

on the eastern boundary of GSL, this circulation in the GSL is not sufficiently well understood to develop models of contaminant spread and impacts that would support mitigation. The bi-directional flow through the Union Pacific Railroad causeway separating Gunnison and Gilbert Bays is poorly characterized, yet this impoundment exerts a far more profound influence on the GSL ecosystem than does the impoundment at Willard Bay. The Union Pacific causeway drives a major salinity difference between the north and south arms of the Great Salt Lake, which in turn drives a critical vertical salinity difference between the shallow and deep brine layers (SBL and DBL) of Gilbert Bay. Whereas the oxic SBL is a critical reservoir of photosynthetic phytoplankton that ultimately drive the brine shrimp industry, the DBL is an anoxic reservoir that is notable for having extremely high concentrations of methylmercury (Naftz et al., 2008; Swanson et al., 2014). Constantly cycled between the geochemical extremes of these brine layers are trace elements (e.g. As, Se, Cu, Pb, Fe, Al) and nutrients (C, N, and P). The brine layers must physically mix by mechanisms, and at locations, that are as yet uncharacterized because the circulation of the brine layers themselves is not well known. Brine layer circulation and mixing undoubtedly mediates trace element and nutrient cycling in the GSL system. Therefore, understanding brine circulation is integral to understanding trace element and nutrient cycling influences on the GSL ecosystem. The proposed project seeks to elucidate brine layer circulation and mixing in the GSL, and its timing is extremely fortuitous given the recent closing of the Union Pacific railroad causeway and the anticipated future construction of a bridge on the causeway to allow flow between the North and South Arms of the GSL. These abrupt changes in controlled flow will create ideal conditions for a major research project to determine the influence of flow across the causeway on DBL development, circulation, and eventual mixing with the SBL. This project seeks to capture DBL/SBL dynamics based on the impacts of closing and subsequent re-opening of the causeway culverts over the next two years, and the impacts this has on the development and circulation of the DBL. As such, this project seeks to characterize circulation and mixing of freshwater inputs and the brine layers in the South Arm, freshwater-influenced bays, and associated ecosystems of the GSL, while also seeking to capture dynamics of DBL decrease and rebound in response to closing and re-opening the causeway culverts or bridge. This information will be used to determine the effects of GSL circulation on trace element cycling and transport and critical points of interaction with the GSL ecosystem, and will provide the basis for future containment, mitigation, and clean-up plans in the event of an oil pipeline rupture.

3. The estimated time frame of the project is given below:



4. The project will concern the South Arm of the Great Salt Lake, including flows from the North Arm, Bear River Bay/Willard Spur, and Farmington Bay, as shown in the figure below.

5. The project will enhance and protect waterways affected by the Willard Bay diesel release and improve protection of emergency response, water quality, and impacts of trace element loads to habitat and wildlife. The project will address brine circulation and its role in trace element and nutrient cycling, thereby directly enhancing the ability of regulators and scientists to assess impacts of trace elements such as selenium, mercury, arsenic, and other toxic elements to the ecosystem. The project will address also water quality and emergency response by providing a hydrodynamic model of brine circulation in the Great Salt Lake and freshwater influenced bays that will serve to guide initial responders in mitigation efforts for major pipeline ruptures.

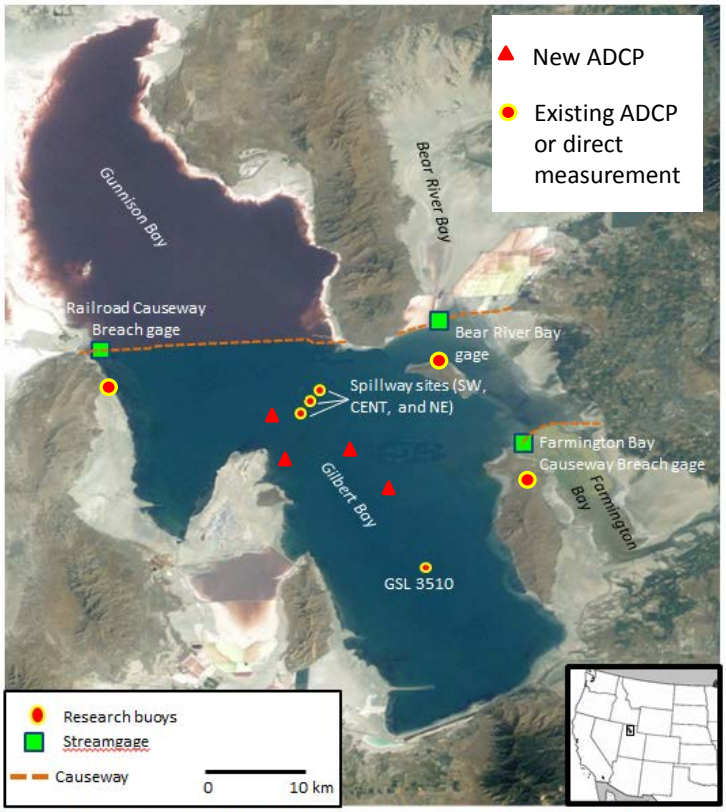


Image source: Image Science and Analysis Laboratory, NASA-Johnson Space Center. "The Gateway to Astronaut Photography of Earth." <http://eol.jsc.nasa.gov/scripts/sseop/photo.pl?mission=ISS002&roll=707&frame=87>06/25/2013 15:51:09>.

6. The project encompasses a large area spanning a range of salinities and associated ecosystems.

7. Social benefits include providing critical information to guide efforts of emergency responders, industry, regulators, scientists and non-governmental environmental groups in the protection of GSL ecosystem services.

8. All project activities will take place on public land, and permission will be requested for access to private or regulated land (e.g. causeway access). The project has five components: a) Determination of seepage through the railroad causeway material; b) Determination of velocities, flows, and depths of the brine/fresh layers throughout the GSL system; c) Development of a hydrodynamic model for the GSL; d) Carbon and other nutrient cycling in the circulating GSL system via isotope signatures and concentrations; e) Mercury and other trace element propagation from GSL into the surrounding ecosystem and its relationship to circulation.

a) To determine seepage through causeway material, seismic monitoring of ambient noise in the causeway will be used to determine the permeability variation across the causeway (Picozzi et al., 2009; Lin et al., 2013). One hundred wireless geophones, each with internal battery and GPS clock, will be spiked into the causeway using vehicle (preferred) or boat access. The geophones will monitor ambient noise for two weeks, and the signals between each site will be cross-correlated to first extract seismic surface waves and then infer permeability. Conventional hammer and shotgun active sources will also be used to complement the ambient noise imaging method. The permeability of the causeway, combined with various tracers measured upstream and downstream of the causeway, will be used to constrain seepage estimates. The ambient tracers to determine flow through the causeway can also be supplemented with added tracers (e.g. fluorescein) if needed to further constrain flow through the causeway.

b) The DBL exists in the two deepest areas of the south arm which are connected by a relatively narrow natural submerged "spillway" in Gilbert Bay. It has been assumed (Gwynn, 1998) that the DBL flow is solely northwest to southeast; whereas, recent hydroacoustic data for velocity and direction of flow across the spillway show that DBL flow can reverse for relatively short periods of time in response to (for example) wind events. In addition to having a poor understanding of the dynamics of DBL flow across the spillway, we lack information regarding the entrainment of DBL into the shallow brine, and whether this occurs predominantly at the southern boundary of the DBL, or whether entrainment occurs predominantly elsewhere to the north. For these reasons we propose to collect velocity and flow direction data (as well as depth) using acoustic Doppler (ADCP) at seven sites along a transect from the causeway to the southern limit of the DBL (figure above). As shown in the figure above, existing USGS projects with other state agencies presently support two ADCPs at the spillway, plus one at the railway causeway breach, plus one toward the southern end of the South Arm (3510), plus one at the Farmington Bay causeway, plus direct (impeller based) discharge measurement during flow at the Bear River Bay causeway. The proposed project would support an additional four ADCPs to extend coverage of the spillway in both the longitudinal (NW-SE) and transverse (SW-NE) directions to DBL flow (see figure above). This data will be essential to calibrating a hydrodynamic flow model to capture brine circulation dynamics within GSL.

c) The hydrodynamics and circulation of the southern arm of the Great Salt Lake will be modeled using the "Princeton Ocean Model" (POM), a numerical code widely and successfully applied to dozens of lacustrine and shallow marine settings throughout the world and documented in ~1400 peer-reviewed publications (http://www.ccpo.odu.edu/~tezer/POMDB/references.php) (e.g., Jewell et al., 1993; Jewell, 2010). With the availability of detailed lake bathymetry (Baskin, 2005), wind forcing and surface heat flux (Mesowest), and freshwater inputs (U.S. Geological Survey), the relative importance of a variety of physical forcings on lake circulation can be examined. Output from the model, in turn, can be used to examine the fate of chemical constituents under a variety of current and future scenarios.

d) Exchange of water, nutrients, organic carbon, and trace elements between the DBL and overlying mixed layer are poorly understood at present despite the importance of this exchange to ecosystem function. Elevated concentrations of dissolved and particulate organic matter and exchange with underlying sediments likely contribute to stabilization of metals in the DBL. Export of these metals to surface waters through entrainment and variable-depth grazing by brine shrimp may represent a major source of MeHg and other toxins to food webs. Conversely, sequestration of nutrients within the organic-rich DBL is thought to limit the productivity of algae within the GSL, (Stephens at Gillespie, 1976), with potential impacts on the brine shrimp industry and the GSL ecosystem.

We will use light stable isotope measurements (^{13}C, ^{2}H, ^{18}O, ^{15}N) to identify and quantify pathways of water, nutrient and carbon exchange between the DBL and surface water. We will also use stable isotopes of conservative elements strontium (Sr), uranium (U) and boron (B), which are reflective of the lithology of the different river basins and groundwater systems contributing to the GLS (Sr and U), and municipal waste water (B). Previous work has demonstrated that 1) H and O isotope ratios of GSL waters are closely related to salinity (Nielson and Bowen, 2010), 2) particulate organic matter in the DBL and mixed layer of Gilbert Bay differs in its C and N isotope composition (Wurtsbaugh and Jones, 2012), and 3) brine shrimp H, O, C, and N isotope values are strongly related to those of the environment in which they live and feed (Naftz et al., 2008; Nielson and Bowen, 2010). Strontium ($^{87}Sr/^{86}Sr$) and uranium ($\delta^{234}U$) isotopes have been used to reconstruct paleohydrologic changes in lakes (Ku and Luo, 1998; Placzek et al., 2011), including the fluctuations for the different lakes in Bonneville basin (Hart et al., 2010; McGee et al., 2012). Boron is a good tracer for municipal water

since it is usually concentrated in human waste and its isotopic signature ($\delta^{11}B$) remains unchanged during water treatment.

A number of trace elements are of interest in the GSL due to their elevated concentrations in organisms (mercury (Hg)) or in water relative to available thresholds developed for marine or freshwater biota (selenium (Se), arsenic (As), and copper (Cu)). Being redox sensitive, Hg, Se and As behaviors are largely governed by whether the aquatic environment is oxygen rich (e.g. shallow brine layer) versus anoxic (deep brine layer). In addition to redox effects, increased pH drives desorption of these oxyanions from surfaces (e.g. iron oxyhydroxide-coated surfaces) in aquatic systems (Carling et al., 2011). In contrast to the oxyanions, the behaviors of the cations (e.g. Cu and Mn) are predominantly driven by pH. The difference in redox conditions between the DBL and shallow brine layer is extreme (Diaz et al., 2009), and the difference in pH between the two layers is highly significant, one to two pH units (Diaz et al., 2009). Therefore, the transport and bioavailability of trace elements in the GSL is expected to be intimately tied to the circulation of these contrasting brine layers. Mercury provides a dramatic example of this interweaving of brine layer circulation and trace element bioavailability. The stability and concentrations of methylmercury (MeHg) are largely governed by photodemethylation (Sellers et al., 1996; Hammerschmidt and Fitzgerald, 2006), which decreases to an unknown extent with increasing salinity (Black et al., 2012) complexation by organic matter or sulfide (Swanson et al., 2014; Diaz et al., 2009; Gorski et al., 2006, 2008; Zhong et al., 2009), as well as the high sulfide content of the DBL (Swanson et al., 2014; Hintelmann et al., 1997), all of which are greatly elevated in the DBL.

On a bi-weekly to monthly basis we will measure (at sites indicated in the figure above) concentrations and isotopic signatures of the above elements in vertical depth profiles (surface to bottom of DBL) to identify vertical dispersion, and mixing of brine and fresh layers. Additional sites for measurements will be guided by the results of the hydrodynamic modeling, which will target areas that the models suggest are hotspots (and cold spots) for vertical mixing.

e) The extent to which the DBL may be a direct or indirect source of the methylmercury (MeHg) found at elevated concentrations in certain avian species (Naftz et al., 2008; Conover and Vest, 2009; Vest et al., 2009) and other organisms in the aquatic and terrestrial ecosystems of the GSL (e.g. brine shrimp and spiders, Saxton et al., 2013; Jones and Wurtsbaugh, 2014) is unknown, in large part due to a lack of understanding of brine layer circulation and pathways by which mercury is transferred between different biotic and abiotic reservoirs. Examining these connections requires understanding brine circulation. We will also employ cutting edge mass spectrometry to compare mercury isotopes in the DBL (and other potential sources of MeHg such as the shallow brine layer) to isotopic signatures in ecosystem components (Bergquist and Blum, 2007). Samples of brine flies, brine shrimp, spiders, and birds have already been collected from 2 sites on Antelope Island, along Farmington Bay and Gilbert Bay and are stored in freezers. These samples will be characterized for mercury isotopic signatures for comparison to brine layer samples to examine possible links between the brine layer mercury and elevated mercury in these organisms. Additional sampling of these organisms will be conducted as necessary to provide additional spatial and temporal coverage.

9. The team represents deep experience in implementing projects of similar scope and magnitude: William Johnson organized and co-directed the geochemistry portion of the UDWQ selenium quantitative standard project, which determined selenium loads to GSL, and rates of removal by sedimentation and volatilization. This project yielded eight peer-reviewed publications with Diaz, Oliver, and Beisner, and Naftz, as listed in Johnson's C.V.. Johnson also directed smaller projects for the WWTP consortium examining geochemistry related to submerged aquatic vegetation senescence, which yielded publications collaboratively developed with Theron Miller, Heidi Hoven,

and David Richards (see Carling et al. references in Johnson C.V.). Johnson co-directed the recently completed UDWQ Willard Spur test plot nutrient cycling project with Heidi Hoven for which manuscripts are in preparation. Additional smaller projects for the Utah Division of Forestry, Fire, and State Lands concerned mercury cycling in the Great Salt Lake, for which a publication is in review concerning the source of mercury in the DBL. Reports for these projects are available on request. The team includes several scientists with strong expertise in the proposed work, and with international recognition, as demonstrated in their curriculum vitae provided in the Supplementary Material. Frank Black has conducted environmental research on the transport, fate, bioaccumulation, and transformation of mercury in surface water, ground water, coastal oceans, the atmosphere, and in aquatic and terrestrial organisms, with 13 research articles and book chapters published on the topic. Recently this has involved research projects on the transfer of Hg, carbon, and nutrients from the GSL to surrounding terrestrial ecosystems, with one publication and 2 others currently in review (see Black C.V.). Cory Angeroth has worked for the USGS for 20 years, and has studied the Great Salt Lake since 2005, and was recently awarded a grant from FFSL to study DBL flow within the GSL. He has co-authored reports related to Great Salt Lake with Dave Naftz. Cory currently oversees the data collection section of the Utah Water Science Center. Gabriel Bowen has co-directed two major interdisciplinary limnology projects focused on Lake Michigan, and has previously worked on the isotopic chemistry of the Great Salt Lake and its ecosystems. He has published widely on light stable isotope tracers in hydrological and ecological systems.

10. The project has a three-year term after which deliverables such as the hydrodynamic models, tables of flows, chemical data, and final report will be provided to the funding agency and stakeholders.

11. List of partners participating in the project:

William Johnson/U. Utah	Salt Lake City, UT 84112	801-664-8289
Frank Black/Westminster College	Salt Lake City, UT 84105	801-832-2351
Cory Angeroth/U.S. Geological Survey	Salt Lake City, UT 84119	801-908-5048
Paul Jewell/U. Utah	Salt Lake City, UT 84112	801-581-6636
Diego Fernandez//U. Utah	Salt Lake City, UT 84112	801-587-9366
Gabriel Bowen//U. Utah	Salt Lake City, UT 84112	801-585-7925
Fan Chi Lin/U. Utah	Salt Lake City, UT 84112	801-581-4373

Signature _____ Date 04-24-2014

Signature _____ Date 4/24/14

Signature _____ Date 04/24/2014

Signature _____ Date 4/25/14

Signature _____ Date 4/25/14

Signature _____ Date 4/25/14

Signature _____ Date 4/25/14

Supplemental Documents

1. References cited
2. Letters of support from:
    a. The Great Salt Lake Ecosystem Project (Department of Natural Resources)
    b. Division of Forestry, Fire and State Lands
    c. Western Resource Advocates
    d. Friends of Great Salt Lake
3. Curriculum vitae

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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

April 30, 2014

Utah Department of Environmental Quality
Division of Water Quality
195 North 1950 West
Salt Lake City, Utah 84114

UDEQ,

The Utah Division of Wildlife Resources and its Great Salt Lake Ecosystem Program (GSLEP) would like to express its support for the project titled "Brine/Fresh Layer Circulation and Elemental Cycling in the Great Salt Lake."

The GSELP has developed an extensive sampling program to monitor brine shrimp population demographics to ensure a sustainable brine shrimp harvest and to maintain adequate food resources for migratory avifauna. One of the biggest unknowns in the lake at this time is the role of the deep brine layer. Nutrients, heavy metals and brine shrimp cysts are all known to reside in this layer; however, it is a mystery on how the constituents of the brine layer incorporate back into the system once sequestered in the brine layer. Our program is keenly interested in understanding how these brine and fresh layers interact.

Dr. Johnson's project is extremely timely. The creation and maintenance of the deep brine layer is believed to be a result of the connectivity of flows between the north part of Great Salt Lake (Gunnison Bay) and the south part (Gilbert Bay), which is separated by a rock-fill, railroad causeway. Because of recent safety concerns to the stability of the causeway, the Union Pacific Railroad has had to close two culverts that provided bi-directional flow through the causeway. To replace the bi-directional flow provided by the culverts, the Union Pacific Railroad will be building a new bridge. Understanding brine and fresh layer circulation through Dr. Johnson's project will provide valuable information that could guide the design of the bridge in the causeway.

The GSLEP has cooperated with United States Geological Survey, Westminster College and the University of Utah in the past, and I have been very pleased with these collaborative efforts. Any study that can help our program better understand Great Salt Lake processes with the deep brine layer circulation will allow us to better manage risks to the ecosystem in the future.

Sincerely,

John Luft
Program Manager
Great Salt Lake Ecosystem Program

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UTAH DNR WILDLIFE RESOURCES

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State of Utah
DEPARTMENT OF NATURAL RESOURCES
MICHAEL R. STYLER
Executive Director
Division of Forestry, Fire and State Lands
BRIAN L. COTTAM
Division Director / State Forester

April 29, 2014

Division of Water Quality
195 North 1950 West
Salt Lake City, Utah 84114

To whom it may concern:

I write this letter of support for Dr. William Johnson's grant proposal entitled "Brine/Fresh Layer Circulation and Elemental Cycling in the Great Salt Lake."

The Division of Forestry, Fire & State Lands recognizes the need to further understand the dynamics of brine circulation on the Great Salt Lake. As indicated in Dr. Johnson's proposal, numerous resources are impacted by the changes in lake salinity. Maintaining sustainable salinity levels is important for the Great Salt Lake ecosystem and the industries that rely on it. Understanding the DBL/SBL dynamics with regard to human modifications will provide the Division with more-detailed information on impacts to the salinity and overall health of the Great Salt Lake.

The team that has been proposed for this project, University of Utah, Westminster and USGS, is an impressive and highly-skilled consortium. The Division has funded Great Salt Lake research grants to each of this entities in recent years has been impressed by the quality of their work and depth of knowledge of the lake's unique features. It would be exciting to see the results of their collaboration.

Sincerely,

Laura B. Vernon
Sovereign Lands Planner

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WESTERN RESOURCE
ADVOCATES

April 25, 2014

William P Johnson, Ph.D.
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Salt lake City, Utah 84112

Dr. Johnson:

The Utah Office of Western Resource Advocates would like to offer its support for your proposed study focused on the interplay of flow circulation involving the shallow brine layer and the deep brine in Great Salt Lake and the influence of that circulation on trace element availability to the Lake's ecosystem. Your team includes an impressive group of researchers with national and international recognition in their areas of expertise – ranging from seismic evaluation of porosity to isotope tracers in natural systems. Given WRA's extensive involvement in encouraging the development of best available sound science for Great Salt Lake, and given the importance of the issue of salt balance and salt mixing, we believe that your proposed study is important and relevant to the entire Great Salt Lake ecosystem, from the freshwater wetlands to the hypersaline Gunnison Bay. Your study is especially important given the current situation with the Union Pacific causeway and it is certainly relevant and justifiable in the context of the Willard Bay settlement.

Good luck with your grant proposal. I look forward to seeing the results.

Yours,

Rob Dubuc
Staff Attorney
Utah Office

COLORADO • 2260 Baseline Road, Suite 200 • Boulder, CO 80302 • 303.444.1188 • Fax: 303.786.8054 • Email: info@westernresources.org
NEVADA • 204 N. Minnesota Street, Suite A • Carson City, NV 89703 • 775.841.2400 • Fax: 866.223.8365 • Email: info@westernresources.org
NEW MEXICO • 409 E. Palace Avenue, Suite 2 • Santa Fe, NM 87501 • 505.820.1590 • Fax: 505.820.1589 • Email: info@westernresources.org
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FRIENDS of GREAT SALT LAKE

P.O. Box 2665 • Salt Lake City, UT 84110-2665 • (801) 583-5593 • Fax (801) 581-9003 • www.fogsl.org

May 1, 2014

William P. Johnson, Ph.D.
Professor, Department of Geology & Geophysics
University of Utah
115 South 1460 East
Salt Lake City, Utah 84112

Dear Dr. Johnson,

Re: Brine/Fresh Layer Circulation and Elemental Cycling in the Great Salt Lake

FRIENDS of Great Salt Lake would like to offer its support for your proposed study focused on the interplay of flow circulation in Great Salt Lake and the impact that circulation has on the availability of trace elements to the Lake's ecosystem. I am very impressed by the group of researchers that you put together to conduct this study.

FRIENDS has always held that the best possible science should be the lodestar for our organization in protecting Great Salt Lake. This is especially true with regard to the impacts of the Union Pacific causeway and the impact that the causeway and the proposed bridge could have on the salt balance of the Lake going forward. I believe your study is a perfect use of the Willard Bay settlement and would provide tremendous insight for all of us to inform better management decisions for the sustainability of the Great Salt Lake Ecosystem. I wish you the best of luck with funding support for this important work.

In saline,

Lynn de Freitas
Executive Director
FRIENDS of Great Salt Lake

Biographical Sketch

William Paul Johnson, Associate Professor, Geology and Geophysics, University of Utah
135 South 1460 East, Salt Lake City, Utah, 84112-1183. (801) 581-5033.

APPOINTMENTS

2007-present	University of Utah, Department of Geology & Geophysics	Professor
2001-2007	University of Utah, Department of Geology & Geophysics	Associate Professor
1995-2001	University of Utah, Department of Geology & Geophysics	Assistant Professor
1994-1995	University of Arizona, Hydrology & Chem. Engineering	Research Associate
1993	Water Science, Inc.	Consultant
1990-1993	University of Colorado, Civil, Environ. & Arch. Eng.	Research Assistant
1987-1990	U.S. Geological Survey, Water Resources Division	Hydrologist
1984-1986	Dartmouth College Dept. of Earth Sciences	Research Assistant

PROFESSIONAL PREPARATION

1980-1983	B.A. degree in Geology. Whitman College, Walla Walla, WA.
1984-1986	M.S. degree in Geology. Dartmouth College, Hanover, NH.
1990-1993	Ph.D. in Civil and Environmental Engineering.
1994-1995	Post-doctoral research in bacterial transport in porous media, University of Arizona, Tucson

FIVE MOST RELEVANT PUBLICATIONS (* =corresponding author)

Swanson Neil P., Brooks Black, Abigail Rudd, Greg Carling, Diego P. Fernandez, John Luft, Jim Van Leeuwen, Mark Marvin-DiPasquale, W. P. Johnson*, Methyl Mercury Hotspots and Sources in the Great Salt Lake, Utah, adjacent freshwater bays and impounded wetlands, (in review).

Carling G.T., Diaz X, Ponce M., Perez L., Nasimba L, Pazmino E, Rudd A, Fernandez DP, Merugu S, Gale BK, and *Johnson W.P., 2013, Trace element concentrations and loads in three southern Ecuador rivers impacted by artisanal gold mining, Water, Air, and Soil Pollution, Volume 224(2).

Carling G.T, Richards D.C., Hoven H.M., Miller T., Fernandez D.P., Rudd A., Pazmino E., *Johnson W.P., 2012, Relationships of surface water, pore water, and sediment chemistry in wetlands adjacent to Great Salt Lake, Utah, and potential impacts on plant community health, Science of the Total Environment, 443, 798-811.

Carling G.T., Fernandez D.P., and Johnson W.P., 2012, Dust-mediated loading of trace and major elements to Wasatch Mountain snowpack, Sci. Tot. Env., 432, 65-77, doi:10.1016/j.scitotenv.2012.05.077.

Carling G.T., Fernandez D.P., Huang W., Rudd A., Pazmino E., *Johnson W.P., 2011, Trace element particulate pulse and diel variations in perimeter freshwater wetlands of Great Salt Lake, Utah, Chemical Geology, doi:10.1016/j.chemgeo.2011.01.001 .

FIVE ADDITIONAL PUBLICATIONS

Beisner K., *W.P. Johnson, D.L. Naftz, 2009, Selenium and trace element mobility affected by periodic interruption of meromixis in the Great Salt Lake, Utah, Science of the Total Environment, 407, 5263-5273.

Diaz X, D. Fernandez, D.L. Naftz, *W.P. Johnson, 2009, Size and Elemental Distributions of Nano- to Micro- Particulates in the Geochemically-stratified Great Salt Lake, App. Geochem., doi:10.1016/j.apgeochem.2009.04.031.

Oliver W., *W.P. Johnson, C.C Fuller, D.L. Naftz, 2009, Permanent selenium sedimentation flux from the Great Salt Lake, Utah, App. Geochem, 24 , 936-949.

Diaz X., D.L. Naftz, *W.P. Johnson, 2009, Selenium Mass Balance in the Great Salt Lake, Utah, Sci. Tot. Env. 407, 2333-2341.
Diaz X., W.A. Oliver, D.L. Naftz, *W.P. Johnson, 2009, Volatile Selenium Flux from the Great Salt Lake, Utah, Environ. Sci. Technol., 43 (1), pp 53–59, DOI: 10.1021/es801638w.

SYNERGISTIC ACTIVITIES

Advisory Board member Environmental Science & Technology Letters, ACS, Spring 2013 on.
Organizer International Workshop on Mining Impacts to Water Quality in Ecuador, May 2012.
Panel member National Science Foundation CBET Spring 2010-present
Executive Committee of the Academic Senate, University of Utah (August 2011 – present)
External reviewer for NSF National Center for the Environmental Implications of Nanotechnology (2009 to present).
Symposium co-convener American Chemical Society Colloids & Surfaces Meeting, Johns Hopkins University, June 2012
Utah Statewide Mercury Workgroup 2010-present
Symposium co-convener, American Geophysical Union, San Francisco, CA, December, 2011
UNESCO IHE Invited Research Director in Kampala, Uganda, Fall 2009
National Nanotechnology Initiative Environmental Health and Safety Panel for Research Directions, Fall 2009.

COLLABORATORS

Jim Vanderslice, University of Utah
David Britt, Utah State University
Bruce Gale, University of Utah
Tim Ginn, UC Davis
Markus Hilpert, Johns Hopkins U.
Diego Fernandez, University of Utah
Heidi Hoven, Weber State University
Frank Black, Westminster College

STUDENTS ADVISED (degree, date)

Zhang Pengfei, Ph.D. Geo. Eng., 2000
Li Xiqing, Ph.D. Env. Eng., 2006
Tong Meiping, Ph.D. Env. Eng., 2006
Diaz Ximena, Ph.D. Env. Eng. 2009
Carling Greg, Ph.D. Geology, exp. 2012
Pazmino Eddy, Ph.D. Geo. Eng., exp. 2015
Stenebraten, J., M.S. Geo. Eng., 1998
John, W., M.S. Geo. Eng., 1999.
Schmitz, P., M.S. Geo. Eng., 2000
Bao, G., M.S. Geological Eng, 2000
McIntosh, W., M.S. Geology, 2002
McGriff, M., M.S. Geology, 2002
Koch M., M.S. Public Health, 2004
Brow, C. M.S. Env., Eng., 2004
Beisner K., M.S. Geology 2008
Oliver W., M.S. Geology, 2008
Rudd A., M.S. Geological Eng., 2008
Pazmino E., M.S. Geological Eng., 2008
Manangon E., M.S. Geo. Eng., exp. 2012
Black B., M.S. Geo. Eng., exp. 2013
Swanson N., Geology, exp. 2013
Pierson J., Geology, exp. 2013

ADVISORS

Ph.D. advisor: Dr. Gary Amy, U. Colorado at Boulder
Post-doctoral advisor: Dr. Bruce Logan, The Pennsylvania State U

Biographical Sketch

Frank Black, Ph.D.
Chemistry Department, Westminster College
1840 South, 1300 East; Salt Lake City, UT 84105
fblack@westminstercollege.edu, 801-832-2351

Professional Preparation

Dartmouth College	BA, Environmental Earth Science	2000
University of California, Santa Cruz	PhD, Environmental Toxicology	2008
Princeton University	Post-doctoral scholar, Geosciences	2009-2011

Appointments

Assistant Professor, Chemistry Dept., Westminster College	2011-present
Post-doctoral scholar, Geosciences Dept., Princeton University	2009-2011
Fulbright Scholar and Visiting Researcher, University of Botswana	2008-2009
Research & Teaching Assistant, Environmental Toxicology Dept., UC Santa Cruz	2003-2008
Research Assistant, Swiss Federal Institute of Environmental Science and Tech (EAWAG)	2003
Research Assistant, Thayer School of Engineering, Dartmouth College	1999-2000
Teaching Assistant, Earth Sciences Department, Dartmouth College	1999-2000
Research Assistant, Geochemistry and Hydrology Depts., Sandia National Labs	1998-1999

Five recent products/publications related to proposal (**Denotes undergraduate co-author*)

Saxton*, H.J., Goodman*, J.R., Collins*, J.N., and **Black, F.J**., 2013. Maternal transfer of inorganic mercury and methylmercury in aquatic and terrestrial arthropods. *Environmental Toxicology and Chemistry*, 32: 2630–2636

Black, F.J., Poulin*, B.A., and Flegal, A.R., 2012. Factors controlling the abiotic photo-demethylation of monomethylmercury in surface waters. *Geochimica et Cosmochimica Acta,* 84: 492–507.

Black, F.J., Paytan, A., Knee, K.L., de Sieyes, N.R., Ganguli, P.M., Gray, E., and Flegal, A.R., 2009. Submarine groundwater discharge of total mercury and monomethylmercury to central California coastal waters. *Environmental Science and Technology*, 43: 5652–5659.

Black, F.J., Bokhutlo, T., Somoxa, A., Maethamako, M., Modisaemang, O., Kemosedile, T., Cobb-Adams, C., Mosepele, K., and Chimbari, M., 2011. The tropical African mercury anomaly: lower than expected mercury concentrations in fish and human hair. *Science of the Total Environment*, 409: 1967–1975.

Conaway, C.H., **Black, F.J.**, Weiss-Penzias, P., Gault-Ringold*, M., and Flegal, A.R., 2010. Mercury speciation in Pacific coastal rainwater, Monterey Bay, California. *Atmospheric Environment*, 44: 1788-1797.

Five other recent products/publications (**Denotes undergraduate co-author*)

Black, F.J., Conaway, C.H., and Flegal, A.R., 2012. Mercury in the marine environment. In: Mercury in the Environment: Pattern and Process, Michael S. Bank (Ed.), University of California Press, Berkeley, CA.

Black, F.J., Conaway, C.H., and Flegal, A.R., 2009. Stability of dimethyl mercury in seawater and its conversion to monomethyl mercury. *Environmental Science and Technology*, 43: 4056–4062.

Conaway, C.H., **Black, F.J.**, Gault-Ringold*, M., Pennington, J.T., Chavez, F.P., and Flegal, A.R., 2009. Dimethylmercury in coastal upwelling waters, Monterey Bay, California. *Environmental Science and Technology*, 43: 1305–1309.

Black, F.J., Bruland, K.W., and Flegal, A.R., 2007. Competing ligand exchange-sold phase extraction method for the determination of the complexation of dissolved inorganic Hg(II) in natural waters. *Analytica Chimica Acta*, 598: 318–333.

Sigg, L., **Black, F.**, Buffle, J., Cao, J., Cleaven, R., Davison, W., Galceran, J., Gunkel, P., Kalis, E., Kistler, D., Martin, M., Noel, S., Nur, Y, Odzak, N., Puy, J., Van Riemsdijk, W., Temminghoff, E., Tercier-Waeber, M.L., Toepperwien, S., Town, R.M., Unsworth, E., Warnken, K.W., Weng, L., Xue, H., Ozhang, A., 2006. Comparison of analytical techniques for dynamic trace metal speciation in natural freshwaters. *Environmental Science and Technology*, 40: 1934–1941.

Synergistic Activities

Science outreach at middle schools

Outreach to assist science teachers to develop new curriculum, teach model lessons, and foster interest by underrepresented groups in pursuing degrees in science. Many activities have been at schools servicing students from backgrounds underrepresented in science. These include Lakeview Middle School in Watsonville, CA (93% Hispanic students from migrant worker families, 83% qualify for free or reduced lunch), and Foundation Academy Charter School in inner city Trenton, NJ (>85% African American, >75% qualifying for free or reduced lunch).

Re-Thinking Science Learning and Teaching program

Member of curriculum design team for program that instructs professors and graduate students on how to incorporate inquiry activities into STEM courses in order to improve student outcomes and widen participation in STEM. Developed and taught course for the Minority Access to Research Careers (MARC) and Minority Biomedical Research Support (MBRS) programs. The inquiry activity developed was published: Quan, T., Yuh, P., and **Black, F.J.**, 2010. Central Dog-ma Disease Detectives: A molecular biology inquiry activity for undergraduates. *Learning from Inquiry in Practice Volume*, University of California Press.

Mentoring research by undergraduates and high school students

Mentored 13 undergraduate and 2 high school research projects since 2006. Over half have been women or from backgrounds underrepresented in science. Five undergrads are co-authors on peer reviewed publications, while 3 others are co-authors on manuscripts in review or preparation.

Science Fair Judge and Mentor

Judge at numerous school, county-wide, and state-wide science fairs for elementary, middle school, and high school divisions in California, Botswana, New Jersey, and Utah.

Collaborators and Other Affiliations

Collaborators and co-authors in the last 4 years: Thethela Bokhutlo, Rhodes U.; Ken Bruland, UCSC; Moses Chimbari, Okavango Research Center; Cristina Cobb-Adams, Princeton U.; Chris Conaway, USGS; Nicole David, SFEI; Kathryn Dickinson, NRCC; Russ Flegal, UCSC; Jean-Claude Frigon, NRCC; Priya Ganguli, UCSC; Neil Ganju, USGS; Ellen Gray, UCSC; Serge Guiot, NRCC; William Johnson, U. of U., Thebe Kemosedile, Okavango Research Center; Anne Kraepiel, Princeton U.; Scott P. MacQuarrie, NRCC; Mothusi Maethamako, Botswana DWNP; Patrick McGinn, NRCC; Lester McKee, SFEI; Ontlogetse Modisaemang, Botswana DWNP; Francois Morel, Princeton U.; Ketlhatlogile Mosepele, Okavango Research Center; Satish Myneni, Princeton U.; Stephen O'Leary, NRCC; Kyoung Park, NRCC; Adina Paytan, UCSC; Brett Poulin, U. of Colorado; Tiffani Quan, UCSF; David Schoellhamer, USGS; Nick de Sieyes, UC Davis; Aaron Somoxa, Botswana DWNP; Christine Stracey, Westminster College; Patrick Yuh UCSC; Peter Weiss-Penzias, UCSC; Crystal Whitney, NRCC.

PhD advisor: Russ Flegal, UCSC

Post-doctoral sponsors: Francois Morel, Satish Myneni, and Anne Kraepiel, all of Princeton University

Cory E. Angeroth

United States Geological Survey, Utah Water Science Center
2329 W. Orton Circle, Salt Lake City, UT 84119
Work Phone: 801-908-5048; angeroth@usgs.gov

EDUCATION:
B.S. in Hydrology 1996, College of Engineering and Mines, University of Arizona, Tucson, AZ

CURRENT POSITION:
Supervisory Hydrologist, GS-1315, United States Geological Survey, Utah Water Science Center, Salt Lake City, UT, May 2005 – present. Chief of the hydrologic surveillance and monitoring section. Responsible for all aspects of water related data collection, processing, review, and storage.

PREVIOUS POSITIONS:
Supervisory Hydrologist, GS-1315, United States Geological Survey, Arizona Water Science Center, Yuma, AZ May 2003 – May 2005. Field Office Chief – Responsible for the day to day operation of the office and staff.
Hydrologist, GS-1315, United States Geological Survey, Arizona Water Science Center, Tucson, AZ May 1996 – May 2003. Staff Hydrologist – Worked on several projects related to groundwater quality and availability.

SELECTED PUBLICATIONS:
Angeroth, C.E., 2002, *Characterization of Hydraulic Conductivity of the Alluvium and Basin Fill, Pinal Creek Basin near Globe, Arizona* Water-Resources Investigations Report 02-4205

Angeroth, C.E., Leake, S.A., Wagner B.J., 1999, *Preliminary Model Development of the Ground- and Surface- Water system in Pinal Creek* Basin, Arizona Proceedings of the Technical Meeting of the USGS Toxic Substances Hydrology Program, March 8-12, 1999, Columbia, South Carolina.

Naftz, D.L., **Angeroth, C.**, Freeman, M., Rowland, R., and Carling, G., 2013, Monitoring change in Great Salt Lake: EOS, Transactions of the American Geophysical Union, vol. 94, no. 3, p. 289-290.

Naftz, D.L., Carling, G.T., **Angeroth, C.**, Freeman, M., Rowland, R., and Pazmiño, E., accepted, Density stratified flow events in Great Salt Lake, Utah, USA: Implications for mercury and salinity cycling: Aquatic Geochemistry.

Naftz, D.L., **Angeroth, C.**, Whittier, N., and Krabbenhoft, D., in review, Using thermocline manipulation to remediate a reservoir with elevated mercury: Physical and biogeochemical results: Elementa: Science of the Anthropocene.

Naftz, D.L., **Angeroth, C.**, Kenney, T., Waddell, B., Silva, S., Darnall, N., Perschon, C., and Whitehead, J., 2008, Anthropogenic influences on the input and biogeochemical cycling of nutrients and mercury in Great Salt Lake, Utah, USA: Applied Geochemistry, vol. 23, p. 1731–1744.

Naftz, D.L., **Angeroth, C.**, Kenney, T., Waddell, B., Silva, S., Darnall, N., Perschon, C., and Whitehead, J., 2008, Reply to the comment on 'Anthropogenic influences on the input and biogeochemical cycling

of nutrients and mercury in Great Salt Lake, Utah, USA': Applied Geochemistry, vol. 23, p. 3854-3855.

Lind, C.J., Creasey, C.L., **Angeroth, C.E.,** *In-situ Alteration of Minerals by Acidic Ground Water Resulting from Mining Activities: Preliminary Evaluation of Method*. Journal of Geochemical Exploration, Vol. 64 (1998) pages 293 – 305.

Gabriel J. Bowen

Geology & Geophysics and Global Change & Sustainability Center
115 South, 1460 East
Salt Lake City, UT 84112
(801)585-7925
gabe.bowen@utah.edu

Professional Preparation:

University of Michigan	Geological Sciences	*B.S. w/ highest honors*, 4/99
University of California Santa Cruz	Earth Sciences	*Ph.D.*, 12/03
University of California Santa Cruz	Earth Sciences	1/04 – 2/04
University of Utah	Isotope Geology/Ecology	3/04 – 12/05

Appointments:

07/12 – present	**University of Utah**, Salt Lake City, Utah *Associate Professor*, Geology & Geophysics
08/10 – 06/12	**Purdue University**, West Lafayette, Indiana *Associate Professor*, Earth and Atmospheric Sciences
01/06 – 07/10	**Purdue University**, West Lafayette, Indiana *Assistant Professor*, Earth and Atmospheric Sciences
03/04 – 12/05	**University of Utah**, Salt Lake City, Utah *Postdoctoral Research Associate*, Biology

Ten of 84 Publications:

Bowen G. J., Kennedy C. D., Henne P. D. and Zhang T. (2012) Footprint of recycled water subsidies downwind of Lake Michigan. *Ecosphere*, 3, 53. doi:10.1890/ES12-00062.1.

Bowen G. J., West J. B., Zhao L., Takahashi G., Miller C. C. and Zhang T. (2012) Cyberinfrastructure for isotope analysis and modeling. *Eos: Transactions of the American Geophysical Union*, 93, 185-187.

Bowen G. J., Kennedy C. D.*, Liu Z.* and Stalker J.* (2011) Water balance model for mean annual hydrogen and oxygen isotope distributions in surface waters of the contiguous USA. *Journal of Geophysical Research*, 116, G04011. doi:10.1029/2010JG001581.

Kennedy C. D., Bowen G. J. and Ehleringer J. R. (2011) Temporal variation of oxygen isotope ratios ($\delta^{18}O$) in drinking water: Implications for specifying location of origin with human scalp hair. *Forensic Science International*, 208, 156-166. doi:10.1016/j.forsciint.2010.11.021.

Liu Z., Bowen G. J. and Welker J. M. (2010) Precipitation isotope gradients reflect atmospheric circulation over the conterminous United States. *Journal of Geophysical Research*, 115, D22120, doi:10.1029/2010JD014175.

Bowen G. J. (2010) Isoscapes: Spatial pattern in isotopic biogeochemistry. *Annual Review of Earth and Planetary Sciences*, 38, 161-187.

Nielson K. E., Bowen G. J. (2010) Hydrogen and oxygen in brine shrimp chitin reflect environmental water and dietary isotopic composition. *Geochimica et Cosmochimica Acta*, 74, 1812-1822.

West J. B., Bowen G. J., Tu K. P. and Dawson T. E., eds., (2010) *Isoscapes: Understanding Movement, Pattern and Process on Earth Through Isotope Mapping*. 487 pp. Springer.

Bowen G. J. (2008) Spatial analysis of the intra-annual variation of precipitation isotope ratios and its climatological corollaries. *Journal of Geophysical Research - Atmospheres*, 113, D05113.

Bowen G. J., Ehleringer J. R., Chesson L. A., Stange E. and Cerling T. E. (2007) Stable isotope ratios of tap water in the contiguous USA. *Water Resources Research*, 43, W03419.

Synergistic Activities:

- Developed waterisotopes.org and isomap.org, providing isotope data and analytics to >600 visitors/month.
- Instructor, short course on *Stable Isotopes in Ecology* (University of Utah; 2012, 2011, 2010, 2009, 2008, 2007, 2006) and Urbino Summerschool in Paleoclimatology (2012, 2011, 2008, 2006).
- Peer reviewer for > 40 journals, 3 book editors, and 8 funding agencies including NSF.
- Mentor for Jefferson High School "Science Research" program (2011, 2009, 2007).
- Undergraduate research mentor (3 current, 9 former).

Collaborators and Co-Editors:

Conflict	Affiliation	Conflict	Affiliation	Conflict	Affiliation
Abels, H. A.	Univ. Utrecht	Huber, M.	Purdue Univ.	Riggs, E.	Texas A&M Univ.
Bataille, C.P.	Purdue Univ.	Hyodo, A.	Texas A&M	Robins, R. J.	Univ. of Nantes
Billault, I.	Univ. Paris-Sud	Jafvert, C. T.	Purdue Univ.	Rodrigues, C.	Univ. of Lisbon
Bloch, J. I.	Univ. of Florida	Johnson, K.	Denver Mus. Nat. and Sci.	Sachse, D.	Univ. Potsdam
Bowen, B. B.	Purdue Univ.	Kahmen, A.	ETH Zurich	Schmidt, H.-L.	Texas A&M Univ.
Boyer, D. M.	SUNY	Kalangi, A.	Amazon.com	Schneider-Mor, A.	Stanford Univ.
Bralower, T. J.	Penn. State Univ.	Kendall, C.	USGS	Schwarcz, H. P.	McMaster Univ.
Brunner, M.	BOKU-UFT, Austria	Kennedy, C. D.	USDA	Secord, R.	Univ. of Nebraska
Buzan, J.R.	Purdue Univ.	Koch, P. L.	UC Santa Cruz	Sessions, A. L.	Cal Tech
Buzon, M. R.	Purdue Univ.	Kraus, M. J.	Univ. of Colorado	Simonetti, A.	Univ. Notre Dame
Cerling, T. E.	Univ. of Utah	Kump, L. R.	Penn. State Univ.	Smith, G. J.	PSU
Chesson, L. A.	Univ. of Utah	Lai, C. T.	San Diego State Univ.	Snell, K. E.	UC Santa Cruz
Chikaraishi, Y.	JAMESTEC	Lee, H.	Purdue Univ.	Srinivasaraghavan, V.	Purdue Univ.
Clyde, W. C.	Univ. of New Hampshire	Li, Qian	IVPP	Stalker, J. C.	Jacksonville Univ.
Conlee, C. A.	Texas St. Univ.	Lindemann, T. L.	Penn. State Univ.	Steiman, S.	Coffee Consulting, HI
Dawson, T. E.	UC, Berkeley	Liu, Z.	Univ. of Tokyo	Still, C. J.	UC, Santa Barbara
Diefendorf, A. F.	Penn. State Univ.	Lourens, L. J.	Univ. of Utrecht	Tarozo, R.	Brown
Dostie, P.	Mammoth Lakes PD	Magill, C.	Penn. State Univ.	Thomas, E.	Yale Univ.
Eccles, L.	Penn. State Univ.	Maguas, C.	Univ. of Lisbon	Thompson, A. H.	Washington DC
Ehleringer, J. R.	Univ. of Utah	Martinez del Rio, C.	Univ. of Wyoming	Ting, S.	Louisiana State Univ.
Feakins, S. J.	USC	McInerney, F. A.	Northwestern Univ.	Toney, J. L.	Brown Univ.
Fekete, B	City College of New York	Meng, J.	AMNH	Tong, Y.	IVPP, China
Fogel, M. L.	Carnegie Inst.	Miller, C. C.	Purdue Univ.	Troy, C.	Purdue Univ.
Fox-Dobbs, K.	Univ. of Puget Sound	Mittal, S.	Texas A&M Univ.	Tu, K. P.	UC, Berkeley
Freeman, K.	Pennsylvania State Univ.	Moore, D.W.	Texas A&M	Valenzuela, L.	Univ. of Utah
Fricke, H.E.	Colorado College	Nielson, K.	Purdue Univ.	van der Meer, M.T.J.	NIOZ
Gall, H.	Purdue	Nogueira, J.M.F.	Univ. of Lisbon	VanDeVelde, J. H.	Purdue Univ.
Gautz, L.	Univ. of Hawaii	Noone, D.	Univ. of Colorado	Vaughn, B. H.	Univ. of Colorado
Gibson, J.	Univ. of Victoria	Noren, A.	LacCore	Wang, Yuanquing	IVPP, China
Gingerich, P. D.	Univ. of Michigan	O'Grady, S.	Utah Division of Wildlife	Wassenaar, L. I.	Univ. of Saskatchewan
Goldner, A.P.	Purdue Univ.	Pagani, M.	Yale Univ.	Welker, J. M.	Univ. of Alaska, Anchorage
Harrington, G. J.	Univ. of Birmingham	Park, T.	Salt Lake County Sheriff Dept.	West, J. B.	Texas A&M Univ.
Henne, P.	ETH Zurich	Passey, B. H.	Johns Hopkins Univ.	White, J. W. C.	Univ. Colorado Boulder
Hilgen F. J.	Univ. Utrecht	Podlesak, D. W.	Los Alamos N.L.	Wing, S. L.	Smithsonian Inst.
Hobson, K. A.	Univ. of Saskatchewan	Polissar, P.	Columbia Univ.	Wolf, N.	Univ. of Wyoming
Hoogewerff, J.	Univ. of East Anglia	Prohaska, T.	BOKU-UFT, Austria	Zachos, J. C.	UC, Santa Cruz
Hook, T.	Purdue Univ.	Qian, L.	IVPP	Zhang, T.	Purdue Univ.
Huang, Y.	Brown	Rapolu, N.	Purdue Univ.	Zhao, L.	Purdue Univ.

Graduate and Postdoctoral Advisors:
Thure Cerling, Postdoctoral Advisor, Univ. of Utah; *James Ehleringer*, Postdoctoral Advisor, Univ. of Utah; *Paul Koch*, Graduate Advisor.

Graduate Students (5) and Postdoctoral Researchers (4) Advised (current except as indicated): *Crystal Tulley-Cordova*, Ph.D.; *Yusuf Jameel*, Ph.D.; *Bianca Maibauer*, M.S.; *Clement Bataille*, Ph.D.; *Justin VanDeVelde*, Ph.D., 2012; *Stephen Good*, Post-Doc; *Casey Kennedy*, Post-Doc, 2008-2011; *Zhongfang Liu*, Post-Doc, 2009-2011; *Aya Schneider-Mor*, Post-Doc, 2007-2009; *Jeremy Stalker*, Post-Doc 2010-2011.

Dr. Fan-Chi Lin

Professional Preparation

National Tsing Hua University	Physics	2000	B.S.
Drexel University	Physics	2005	A.M.
University of Colorado Boulder	Geophysics	2009	Ph.D.
University of Colorado Boulder	Geophysics	2009 – 2011	
California Institute of Technology	Geophysics	2011 – 2013	

Appointments

Assistant Professor, University of Utah	10/2013 –
Director's Post Doctoral Fellowship, California Institute of Technology	5/2011 – 9/2013
Postdoctoral Researcher, University of Colorado Boulder	11/2009 – 4/2011

Five Peer-Reviewed Papers Most Relevant to Proposed Research:

Lin, F.C.,D. Li, R. W. Clayton, and D. Hollis (2013), High-resolution 3D shallow crustal structure in Long Beach, California: Application of ambient noise tomography on a dense seismic array, *Geophysics*, 78(4), Q45-Q56,doi:10.1190/geo2012-0453.1.

Lin, F.C.,B. Schmandt, and V.C . Tsai (2012), Joint inversion of Rayleigh wave phase velocity and ellipticity using USArray: constraining velocity and density structure in the upper crust, *Geophys. Res. Letts*., 39, L12303, doi:10.1029/2012GL052196.

Lin, F.C.,V. Tsai, and M.H. Ritzwoller (2012), The local amplification of surface waves: A new observable to constrain elastic velocities, density, and anelastic attenuation, *J. Geophys. Res*., 117, B06302, doi:10.1029/2012JB009208.

Lin, F.C., M.H. Ritzwoller, Y. Yang, M.P.Moschetti, and M.J. Fouch (2011), Complex and variable crustal and uppermost mantle seismic anisotropy in the western United States, *Nature Geoscience*, 4, 55-61, doi:10.1038/ngeo1036.

Moschetti, M.P., M.H. Ritzwoller, F.C. Lin, and Y. Yang (2010), Crustal shear velocity structure of the western US inferred from ambient noise and earthquake data, *J. Geophys. Res*., 115, B10306, doi:10.1029/2010JB007448.

Five Other Significant Publications:

Lin, F.C.,V.C. Tsai, B. Schmandt, Z. Duputel, and Z. Zhan (2013), Extracting Seismic Core Phases with Array Interferometry, *Geophys. Res. Letts*., 40, doi:10.1002/grl.50237.

Savage, M.K., F.C. Lin, and J. Townend (2013), Ambient noise cross-correlation observations of fundamental and higher-mode Rayleigh wave propagation governed by basement resonance, *Geophys. Res. Letts*., 40, doi:10.1002/grl.50678.

Lin, F.C. and M.H. Ritzwoller (2011), Helmholtz surface wave tomography for isotropic and azimuthally anisotropic structure, *Geophys. J. Int*., 186, doi: 10.1111/j.1365-

246X.2011.05070.x.

Moschetti, M.P., M.H. Ritzwoller, F.C. Lin, and Y. Yang (2010), Seismic evidence for widespread western-US deep-crustal deformation caused by extension, *Nature*, 464, Number 7290, 885-889.

Lin, F.C., M.H. Ritzwoller, and R. Snieder (2009), Eikonal Tomography: Surface wave tomography by phase-front tracking across a regional broad-band seismic array, *Geophys. J. Int.*, doi: 10.1111/j.1365-246X.2009.04105.x.

Synergistic Activities:

Reviewer for J. Geophys. Res., Geophys. Res. Lett., Geophys. J. Int., Earth Planet Sci. Lett., Geophysics, Bull. Seismol. Soc. Am., and NSF proposals.

Convener and Chair for Seismology Special Session, Western Pacific Geophysics Meeting, 2010.

GSH/Charlie & Jean Smith Scholarship, 2008; Denver Geophysical Society Scholarship, 2008; Geophysical Journal International Student Author Award, 2008; American Geophysical Union Outstanding Student Paper Award, 2009; Director's Post Doc Fellowship, Seismological Laboratory, Caltech, 2011.

American Geophysical Union, member, 2006-present.

Member of Transportable Array Advisory Committee (TAAC), 2014-present.

Collaborators (2008-2014):

Prof. Robert W. Clayton (Caltech)
Prof. Matthew J. Fouch (Arizona State)
Dr. Monica D. Kohler (Caltech)
Prof. Peter Molnar (U. Colorado)
Dr. Morgan P. Moschetti (USGS)
Prof. Michael H. Ritzwoller (U. Colorado)
Prof. Martha Savage (Victoria U. Wellington)
Prof. Brandon Schmandt (U. New Mexico)
Prof. Anne Sheehan (U. Colorado)
Prof. Roel Snieder (Colorado Sch. Mines)
Prof. John Townend (Victoria U. Wellington)
Prof. Victor C. Tsai (Caltech)
Prof. Yingjie Yang (Macquarie U.)

Graduate Advisors and Postdoctoral Sponsors:

Michael H. Ritzwoller, Department of Physics, University of Colorado Boulder
Michael C. Gurnis, Seismological Laboratory, California Institute of Technology
Victor C. Tsai, Seismological Laboratory, California Institute of Technology

Total Number of Graduate Students Advised: 0

Total Number of Post-Doctoral Scholars Sponsored: 0

DIEGO P. FERNANDEZ - BIOGRAPHICAL SKETCH

Address:

Department of Geology and Geophysics
University of Utah
Salt Lake City, Utah 84112
Phone: 801 587 9366
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(i) PROFESSIONAL PREPARATION:

1986 University of Buenos Aires, Argentina, Chemistry, Licenciado.
1991 University of Buenos Aires, Argentina, Physical Chemistry, PhD.
1992-1994 National Institute of Standards and Technology, Gaithersburg, Maryland, USA, Guest Researcher, Thermophysics Division.

(ii) PROFESSIONAL APPOINTMENTS:

2006-present Research Assistant Professor, Geology and Geophysics, University of Utah.
2001-2006 Research Associate, Geological and Planetary Sciences, California Institute of Technology, Professor Jess Adkins group.
1997-2001 Assistant Professor, Department of Chemistry, School of Engineering, University of Buenos Aires, Argentina.
1996-1997 Research Staff, Department of Inorganic, Analytical and Physical Chemistry, School of Sciences, University of Buenos Aires, Argentina.
1991-1995 Research Staff, Department of Reactor Chemistry, Atomic Energy Commission, Argentina.
1982-1986 Lab technician, Department of Nuclear Fuels, Atomic Energy Commission, Argentina.

(iii) PUBLICATIONS
FIVE MOST RELEVANT TO PROPOSED PROJECT:

Tipple BJ, Chau T, Chesson LA, Fernandez DP, Ehleringer JR, Isolation of strontium pools and isotope ratios in modern human hair *Analytica Chimica Acta* 798 (2013), 64-73.

Carling, GT, Fernandez, DP, Johnson, WP, Dust-mediated loading of trace and major elements to Wasatch Mountain snowpack. *Science of the Total Environment* 432, pp. 65-77, 2012.

Chesson LA, Tipple BJ, Mackey GN, Hynek SA, Fernandez DP, Ehleringer JR, Strontium isotopes in tap water from the coterminous USA, *Ecosphere* 3 (2012), DOI: 10.1890/es12-00122.1.

Carling, GT, Fernandez, DP, Rudd, A, Pazmino, E, Johnson, WP, Trace element diel variations and particulate pulses in perimeter freshwater wetlands of Great Salt Lake, Utah. *Chemical Geology* 283 (1-2), pp. 87-98, 2011.

Diaz X, Fernandez DP, Naftz DL, Johnson WP, Size and Elemental Distributions of Nano- to Micro- Particulates in the Geochemically-stratified Great Salt Lake, *Applied Geochemistry* doi:10.1016/j.apgeochem.2009.04.031, 2009.

FIVE OTHER SIGNIFICANT PUBLICATIONS:

Brown FH, Nash BP, Fernandez DP, Merrick HV, Thomas RJ. Geochemical composition of source obsidians from Kenya, *Journal of Archaeological Science*, 40, 3233-3251, 2013.

Fernandez DP, Gagnon AC, Adkins JF, An isotope dilution ICP-MS method for Mg/Ca and Sr/Ca in calcium carbonates, *Geostandards and Geoanalytical Research,* 35 23-37*,* 2011.

Partin, JW, Cobb, KM, Adkins, JF, Clark, B., and Fernandez, DP, Millennial-scale trends in west Pacific warm pool hydrology since the Last Glacial Maximum, *Nature* 449, 452, 2007.

Gagnon AC, Adkins, JF, Fernandez, DP, and Robinson, LF, Sr/Ca and Mg/Ca vital effects correlated with skeletal architecture in a scleractinian deep-sea coral and the role of Rayleigh fractionation, *Earth and Planetary Science Letters* 261, 280-295, 2007.

Robinson LF, Adkins JF, Keigwin LD, Southon J, Fernandez DP, Wang SL, Scheirer DS, Radiocarbon variability in the western North Atlantic during the last deglaciation, *Science* 310 (5753): 1469-1473, 2005.

(iv) SYNERGISTIC ACTIVITIES:

2007-present ICP-MS lab Director, Dept. Geology and Geophysics, University of Utah.
2011-present Strontium Isotope Lab Co-Director, Dept. Geology and Geophysics, University of Utah.

1996-present Train >60 students/postdoctoral scholars in mass spectrometry and spectroscopy.

2000 New science lab in ~700 high schools in Argentina: training of >100 high-school teachers in computer assisted experiments using sensors and interfaces. Ministry of Education, Argentina.

1996-2000 Director, Physical-chemical testing lab for agrochemicals, University of Buenos Aires, School of Science.

Database and correlation for the Static Dielectric-Constant of Water and Steam, Fernandez DP, Mulev Y, Goodwin ARH, and Sengers J, *Journal of Physical and Chemical Reference Data* 24, 33-69, 1995; and Fernandez DP, Goodwin ARH, Lemmon EW, Sengers J, Williams RC, *Journal of Physical and Chemical Reference Data* 26, 1125-1166, 1997.

(v) COLLABORATORS AND OTHER AFFILIATIONS:

(a) RECENT COLLABORATORS:
JF Adkins, S Breitenbach, FH Brown, GT Carling, TE Cerling, KC Cobb, D. Deubner, X Diaz, JR, Ehleringer, AC Gagnon, WP Johnson, R Larson, D Marchetti, D Naftz, BP Nash, K Nicoll, LF Robinson.

(b) GRADUATE AND POSTDOCTORAL ADVISORS:
RJ Fernandez Prini (University of Buenos Aires); JMH Levelt-Sengers (NIST)

(c) THESIS ADVISOR AND POST-GRADUATE SCHOLARS:
PhD Glen Mackey (current); MS Lihai Hi (current); committee member for 12 MS and 9 PhD; direct and co-direct 6 undergraduate research projects.

Paul W. Jewell

(a) Professional Preparation

Beloit College	Geology	B.S. 1978
University of Utah	Geology	M.S. 1984
Princeton University	Geology	Ph.D. 1989

(b) Appointments

1996 - present Associate Professor, Dept. Geology and Geophysics, University of Utah

1989 - 1996 Assistant Professor, Dept. Geology and Geophysics, University of Utah

1988 – 1994 Geological Consultant and Project Geologist, Aurtex, Inc

1980 - 1981 Associate Geologist, University of Utah Res. Institute, Salt Lake City

(c) (i) Publications - five most related to the proposed project (*denotes student)

Anderson, R. B*., D. L. Naftz, F. D. Day-Lewis, R. Henderson, D. O. Rosenberry, and P. W. Jewell, 2014, Quantity and quality of groundwater discharge in a hypersaline lake environment, *Journal of Hydrology*, v. 512, 177-94..

Skorko, K. W*., P. W. Jewell, K. Nicoll, 2011, Fluvial response to an historic low stand of the Great Salt Lake, Utah: *Earth Surface Processes and Landforms,* v. 37, p. 143-156

Jewell, P. W., and K. Nicoll, 2011, Wind regimes and aeolian transport in the Great Basin, U.S.A.: *Geomorphology*, v. 129, p. 1-13.

Jewell, P. W., 2009, Stratification controls of pit mine lakes, *Mining Engineering*, v. 60, p. 74-79

Joyce, J. A.*, and P. W. Jewell, 2003, Physical controls of methane ebullition from reservoirs and lakes: *Environmental and Engineering Geoscience*, v 9, p. 77-88..

(c) (ii) Publications – five other significant (*denotes student)

Jewell, P. W., and R. L. Bruhn, 2013, Evaluation of Wasatch fault segmentation and slip rates using Lake Bonneville shorelines, *Journal of Geophysical Research* v. 118, p.2528-2843.

Jewell, P. W., K. W. Skorko*, and J. C. Fernandez, 2010, LiDAR analysis of an urban alluvial system: Jordan River, Utah: *Association of Environmental and Engineering Geologists News*, v. 54, No. 1, p. 20-22 (invited submission).

Jewell, P. W., 2010, River incision, circulation, and wind regime of Pleistocene Lake Bonneville, U.S.A.: *Paleoecology, Paleoclimatology, and Paleogeography*, v. 294, p.41-50.

Jewell, P. W., 2007, Morphology and paleoclimate significance of Pleistocene Lake Bonneville spits: *Quaternary Research*, v. 68, p. 421-430.

Jewell, P. W., 2000, Bedded barite in the geologic record, *in* C. R. Glenn, J. Lucas, and L. Prevot, editors., Marine authigenesis: from global to microbial: *SEPM Special Publication 66*. p. 147-161.

(d) Synergistic Activities

- Education Outreach Chair, Utah Geological Assocation (2003-present). Responsible for coordinating outreach activities to K-12 schools in the Salt Lake area.
- Geological Engineering Program Evaluator, American Board of Engineering and Technology, 2004-present. Responsible for evaluating professional undergraduate engineering programs throughout the United States.
- Ad Hoc consultant on water resource issues, Friends of the Great Salt Lake, 2009-present

(e) Collaborators & Other Affiliations

-- Science Collaborators: Marjorie Chan, Ronald Bruhn, William Johnson (Department of Geology and Geophysics, University of Utah); Kathleen Nicoll, Rick Forster (Department of Geography, University of Utah); Kevin Perry (Department of Atmospheric Sciences, University of Utah); Jim Trexler (University of Nevada, Reno); Norman Silberling, Kathy Nicols (U. S. Geological Survey, Denver); David Naftz, (U.S. Geological Survey, Helena, Montana); Jack Oviatt (Kansas State University); Chris Okubo (U.S. Geological Suvery, Flagstaff, Arizona); Tim Parker, Bruce Bills (NASA Jet Propulsion Laboratory, Pasadena, California); Juan Fernandez (National Center for Airborne Laser Mapping).

-- Graduate Advisors: Ph.D – Robert Stallard, George Mellor, Princeton University
M.S. – William Parry, University of Utah

-- Thesis Advising:

- Christopher Bradbury (B. S., M. S., University of Utah). 2012 – present
- Paul Thomas (B. S., Northeastern University). 2012 – present
- Theresa Morrison (B. S., Kutztown University). 2011 – 2013
- James Schloss (B.S. University of Colorado (Civil Engineering). 2010-2012. M.S. degree "*An interdisciplinary geological characterization and Holocene geomorphic landslide investigation in Red Butte Canyon, Utah*"
- Daren Nelson (B.S., Utah State University; M.S., University of Idaho). 2006-2012. Ph.D. degree. Thesis title: "*The geomorphic and stratigraphic development of the transgressive record of Lake Bonneville: implications for climate change during the Late Pleistocene*"
- Richard Beau Anderson (B.S., University of Utah); 2009 – 2012; M.S. degree. Thesis title: "*Quantity and quality of groundwater discharge in a hypersaline lake environment*"

Current member of 1 Ph.D. and 4 M.S. committees