FORESTRY, FIRE & STATE LANDS
REQUEST FOR PROPOSALS
Cover Sheet

Project Title	Submarine groundwater discharge to Great Salt Lake: Significance to lake monitoring strategies, lake levels, and contaminant loadings
Lead Project Sponsor	U.S. Geological Survey
Project Contact	David L. Naftz
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Project Description / Abstract	Excellent networks have been established to monitor lake-level fluctuations and surface-water inflow and quality to Great Salt Lake (GSL). Historically, these monitoring data have been used by citizens, private consultants, academic institutions, and state and federal agencies for a variety of outreach, management, and research purposes. Despite these excellent monitoring networks, no similar network exists for monitoring the amount, chemical quality, or source(s) of groundwater discharge to GSL. A potential area of groundwater discharge to GSL was recently identified by the USGS (Naftz and others, 2009) and is in close proximity to a selenium contaminant plume associated with an abandoned metal smelting site. This plume contains selenium concentrations >10,000 μg/L and could represent an unmeasured and significant contaminant loading source to GSL. Failure to quantify and monitor the amount, source, and chemical quality of groundwater discharge to all areas of GSL will result in an incomplete understanding of how surface-water diversions, subsurface contaminant plumes, and groundwater development will ultimately impact the lake's water balance and water quality, resulting in ineffective and (or) misguided regulatory decisions. The proposed project will utilize a variety of geophysical (resistivity and temperature surveys), hydrologic (seepage meters, manometers, and piezometers), and geochemical tools (trace constituents, noble gases, and various environmental tracers) to measure the location, amount, source(s), age(s), and chemical quality of groundwater discharge to GSL. In addition, the proposed work will establish the foundations for a groundwater monitoring network in GSL.

	Amount Requested	Matching Funds (cash)	Total Project Cost
Project Funding	$ 48,550	$ 42,370	$ 90,920

PROJECT NARRATIVE

A. Principal investigator and project team members.

David L. Naftz, Bernard J. Stolp, and Frederick D. Day-Lewis, Hydrologists, U.S. Geological Survey

William P. Johnson and D. Kip Solomon, Professors, Geology & Geophysics, University of Utah

B. Sponsoring institution

U.S. Geological Survey (USGS), Utah Water Science Center, Salt Lake City, Utah

Non-regulatory, Federal Government Science Agency

Overhead rate to state institutions: 28%

C. Declaration of close associations of research team members with staff of the Division of Forestry Fire and State Lands, members of the Great Salt Lake Technical Team, or members of the Utah State Legislature.

David Naftz is the USGS representative on the GSLTT. Naftz serves as chairman on the GSLTT database subcommittee. W.P. Johnson regularly attends GSLTT meetings; however, he has no formal or informal relationships or collaborations with staff of the Utah Division of Forestry, Fire, and State Lands (UDFFSL) or members of the Utah State Legislature. Naftz does not have any association with the Utah State Legislature.

D. Plan of work

The goal of the proposed project is to establish a monitoring network that can be used to identify and monitor the quantity and quality of submarine groundwater discharge (SGD) to GSL. SGD is the net inflow of fresh water through an aquifer medium to an ocean, estuary, or lake. Arnow (1978) estimated that nearly 61,674,000 m^3/year of SGD enters GSL. Numerous anthropogenic compounds have been detected in groundwater adjacent to GSL and include arsenic, nitrate, pesticides, and volatile organic carbon compounds (Thiros, 2003). Although excellent networks have been established to monitor lake-level fluctuations (U.S. Geological Survey, 2009) and surface-water inflow and quality (Naftz and others, 2009), no monitoring network or associated data exists to quantify changes in the amount, chemical quality, or source(s) of groundwater inflow to GSL. This is a significant knowledge gap and monitoring network that needs to be filled as soon as possible.

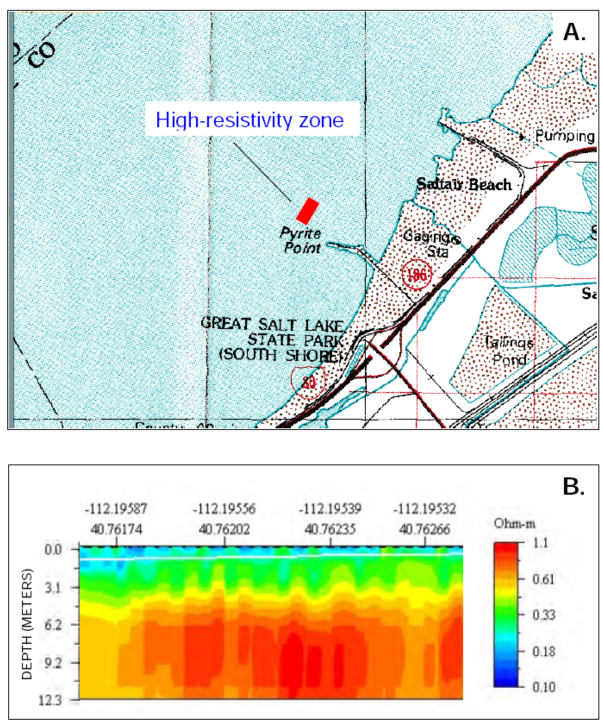

Figure 1. Location of a higher-resistivity zone along (*A*) survey transect l1f1, Great Salt Lake, Utah, and (*B*) cross section of electrical resistivity values. White horizontal line on electrical resistivity cross section denotes approximate position of surface water/sediment interface.

Groundwater in adjacent aquifer zones is much less saline than surface water in GSL, providing a large contrast in resistance to induced electrical currents. A reconnaissance-phase geophysical survey conducted by the USGS in 2007 was the first to document potential areas of SGD (fig. 1), as denoted by higher-resistivity zones, in off-shore areas along the southern tip of GSL (Naftz and others, 2009). This potential area of SGD is in close proximity to a selenium contaminant plume associated with an abandoned metal smelting site (Naftz and others, 2009) that has selenium concentrations >10,000 μg/L and could represent an unmeasured contaminant loading source to GSL (Naftz and others, 2009; Diaz and others, 2009). Failure to quantify and monitor the amount, source, and chemical quality of SGD to all areas of GSL will result in an incomplete understanding of how surface-water diversions, subsurface contaminant plumes, and groundwater development will ultimately impact the lake's water balance and water quality, resulting in ineffective and (or) misguided regulatory decisions.

Specific project objectives (goals) are to:

1. Utilize continuous electrical resistivity and continuous temperature measurements to identify offshore areas of potential SGD along southern and eastern perimeter areas of the south arm of GSL.
2. Utilize seepage meters to establish a seepage monitoring network that will measure the quantity of SGD in strategic offshore areas identified in objective 1.
3. Establish a groundwater quality and environmental tracer monitoring network in areas of confirmed SGD and measure the chemical quality, age, and source of SGD in GSL.
4. Summarize and archive the data in the USGS National Water Information System (NWIS) database and publish the results in a peer reviewed professional journal.

The approach to each of the four project objectives are discussed below:

Objective 1: Electrical resistivity surveying (Swarzenski and others, 2004) will be conducted in shallow areas (~ 1 m in depth) along shoreline parallel transects in the south arm of GSL. While the goal is to survey the entire perimeter of the south arm, this is not possible within the existing funding limitations. The highest priorities will be given to the southern and eastern shoreline areas (fig. 2). Electrode configurations will be optimized to give penetration depths of 10 to 25 m below the sediment/water interface. Inversion of the data will be performed using AGI EarthImager or similar software and results will be georeferenced with

Figure 2. Location of proposed resistivity survey lines (white) and fiber optic temperature survey lines (yellow) in the south arm of GSL. Lake level and associated water depth may alter the actual location of the proposed survey lines.

tracklines made available in ArcGIS coverages. At least one shoreline perpendicular transect will be completed to assess SGD associated with faults west of Antelope Island.

In addition to resistivity anomalies, SGD will have a large temperature contrast to surface-water temperatures in GSL during both the summer and winter time periods. During the mid-summer, water temperature in GSL will typically reach or exceed 30 °C. In contrast, SGD temperature will be less than 15 °C. This temperature contrast provides a mechanism to identify areas of SGD via continuous temperature monitoring along fiber optic cables placed on the lake bottom and continuously monitored for 3-day time periods (fig. 3) during mid-July to mid-August.

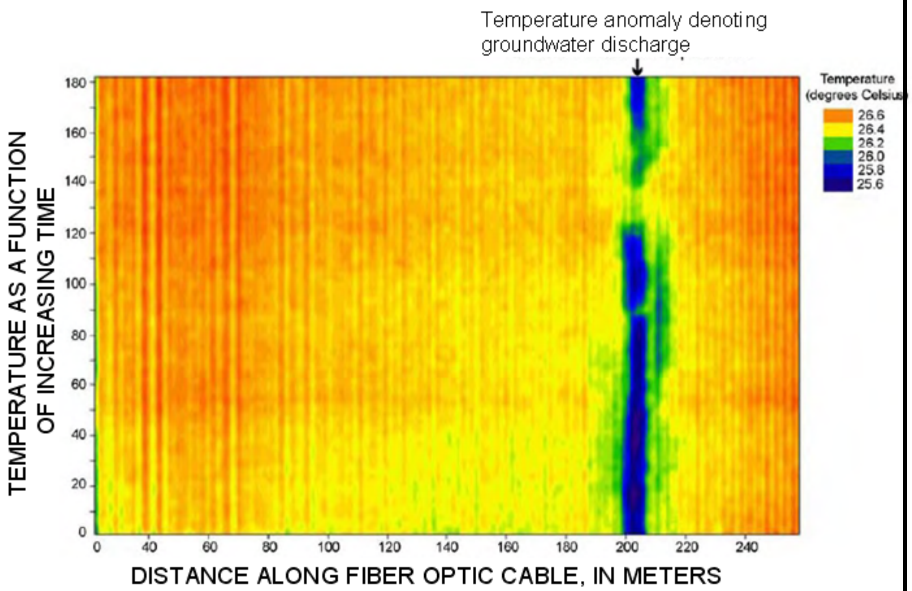

Figure 3. Two-dimensional display of temperature data showing thermal anomaly along a 300-meter fiber optic cable. Modified from Lane and others, 2008.

Fiber-optic distributed temperature sensing (FODTS) surveys will be conducted along 2-km cable lengths (Lane and others, 2008; Henderson and others, 2009) in areas of probable SGD (fig. 2) determined by the reconnaissance-phase resistivity survey conducted by the USGS in 2007 (Naftz and others, 2009). The FODTS system uses laser light traversing optical telecommunication fibers to continuously measure temperature along the entire fiber length. The FODTS system that the USGS owns is capable of measuring thermal resolution ranging from 0.1 to 0.01 °C, spatial resolution of 1 meter, and temporal resolution on the order of seconds to minutes. Analyses of the FODTS data will utilize time-series variance, continuous wavelet transform, and cross-wavelet transform techniques (Henderson and others, 2009) to identify regions of SGD for follow-up seepage measurements, water-quality/environmental tracer sampling, and inclusion into the monitoring network.

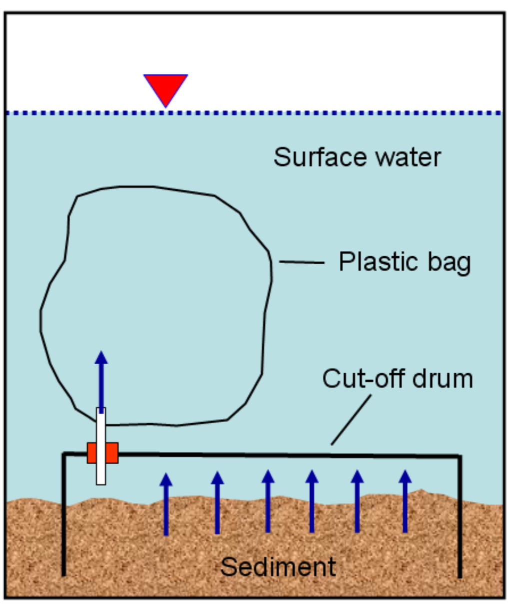

Figure 4. Half-barrel seepage meter that will be installed in areas of measured high resistivity (Rosenberry and Morin, 2004)

Objective 2: Areas displaying high resistivity and water temperature anomalies supporting the presence of SGD will be investigated further with seepage meters (fig. 4). The seepage meters (Lee, 1977) will be pushed into the lake-bed sediment by divers and the accumulated SGD will be measured after 2-4 week deployment periods. In areas with bioherms, the lake bottom will be hand excavated before installing the meters. Seepage meters will be installed at approximately 10 sites. Although each seepage meter will be removed after the measurements are completed, the location and measurement data from each seepage meter will be archived in the USGS NWIS database to provide the foundation for a SGD monitoring network in GSL.

Objective 3: In areas of measurable SGD that was quantified in objective 2, piezometers will be installed and used to measure water levels and provide water and dissolved gas samples for chemical and isotopic analyses (fig. 5). The samplers will consist of 5-cm diameter stainless steel tubing with a hardened conical drive point at the end. The bottom 25 cm of the sampler will be slotted to allow entry of SGD. Each piezometer will be manually driven to at least 1 m below the lake bottom using a sliding hammer. A peristaltic pump will be used to develop each piezometer and specific conductance will be monitored to insure that each well is in connection with SGD. After development, the piezometers will be allowed to recover and equilibrate for 3 to 5 days. After recovery, water levels in each piezometer will be measured relative to lake level with a manometer (Kennedy and others, in press). Field parameters (pH, water temperature, specific conductance, dissolved oxygen, ORP, TDG, Fe^{2+}, sulfide) will be measured with a multi-parameter water-quality probe and field kits. Vertical hydraulic conductivity of the aquifer sediments will be measured with a standard falling-head field permeameter test (Genereux and others, 2008). A minimum of 15 piezometers will be installed and measured.

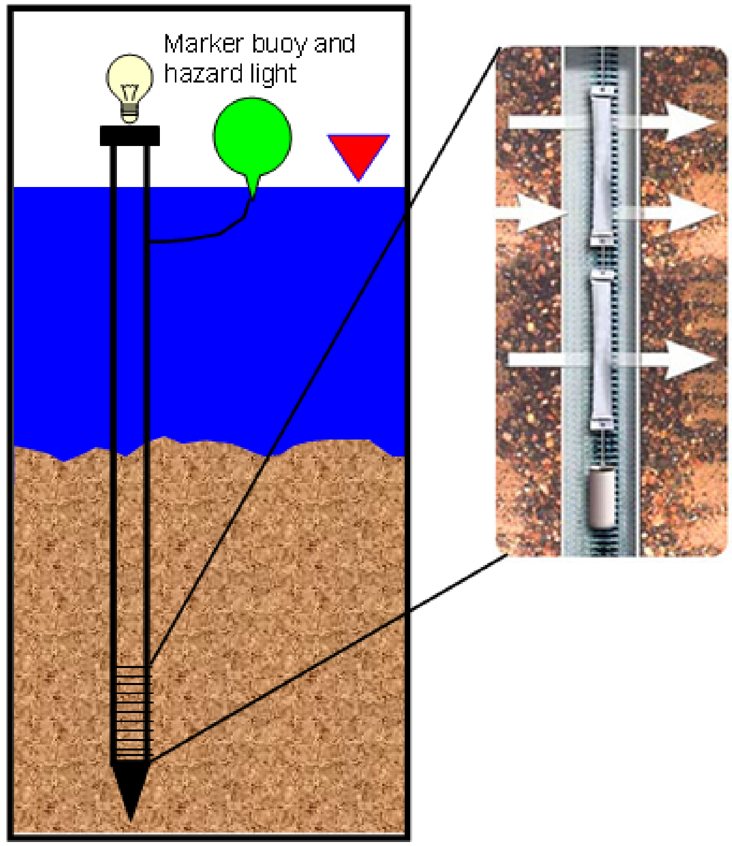

Figure 5. Schematic diagram showing installation of drive-point monitoring wells in the sediments beneath Great Salt Lake. After well development, passive diffusion samplers will be used for the collection of water samples (dissolved major and trace constituents) and dissolved gases for age-dating and source determination of SGD.

Passive diffusion samplers (fig. 5) for both dissolved gases and inorganic solutes will be placed within the 25-cm slotted interval of selected piezometers and allowed to equilibrate for a minimum of 14 days with SGD. At the end of the equilibration period, the passive samplers will be recovered and analyzed for the constituents listed in Table 1. Due to the navigation hazards associated with the long-term deployment of piezometers, each piezometer will be removed after sampling has been completed; however, the location and associated geochemical and hydrologic information will be stored in the USGS NWIS data base to allow for future monitoring of changes in SGD at each of the original locations.

Table 1. List of chemical constituents the will be determined in passive solute and dissolved gas samples of SGD, Great Salt Lake, Utah.

Constituent(s)	Research laboratory	Justification
Major ions	Univ. of Utah ICP-MS lab	Basic water type and water source
Nutrients	USGS NWQL	Nutrient loads to GSL contributed by SGD
Trace elements	Univ. of Utah ICP-MS lab	Contaminant loads to GSL contributed by SGD, source(s), and biogeochemical processes controlling these contaminants. New selenium standard for GSL does not account for selenium loads contributed by SGD.
Total and methyl mercury	Univ. of Utah environmental Hg lab	Mercury concentrations in SGD have not been previously measured. Given the organic-rich, near-surface sediments in GSL, methyl mercury concentrations and associated loads could be high.
Dissolved gases (Kr, Ar, Ne, Xe, N)	Univ. of Utah dissolved gas lab	Recharge elevation, recharge temperature, biogeochemical processes, and source(s) of SGD
Tritium and helium	Univ. of Utah dissolved gas lab	Age of SGD
Stable isotopes ($\delta^{18}O$ and δD)	Univ. of Utah dissolved gas lab	Source(s) and geochemical processes controlling SGD

Objective 4: All the groundwater and water-quality data will be archived in the USGS NWIS database (http://waterdata.usgs.gov/ut/nwis/qw/), which is available over the internet to all interested parties as well as seamless inclusion into the GSL database being developed by Utah State University and UDFFSL. In addition, a new feature called NWIS Mapper is now available and provides a "clickable" map interface for more user friendly access to the project data (fig. 6).

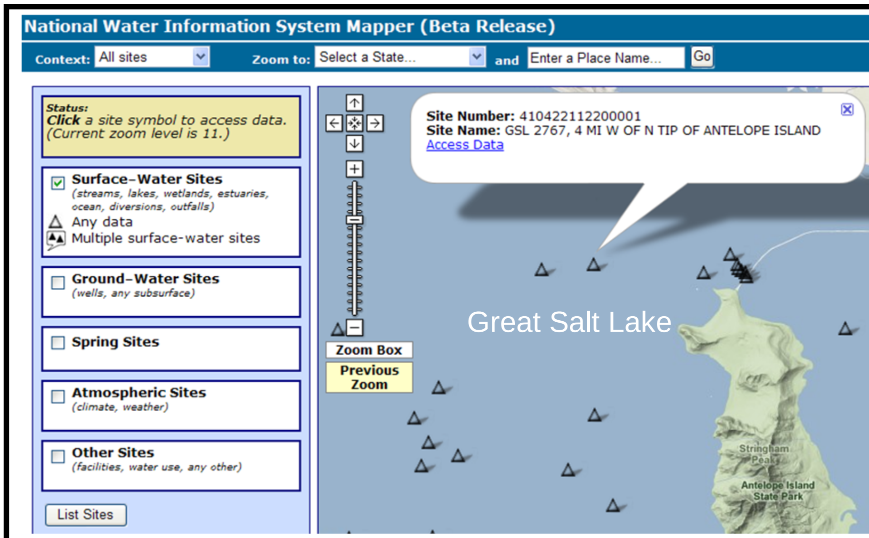

Figure 6. Example of the NWIS Mapper interface now available to access water-quality and groundwater data generated by the proposed study.

Interim study results will be provided to UDFFSL via a progress report by June 30, 2010. A final report of the study results will be completed and submitted to a peer-reviewed journal (*Environmental Science and Technology, Ground Water, Water Resources Research*, or a journal of similar standing) on or before June 30, 2011. Results published in the report will include: (1) maps of near-shore areas with SGD zones confirmed by resistivity and (or) FODTS surveys; (2) estimates of lake-wide SGD; (3) probable source(s) and age(s) of SGD; (4) summaries and implications of water-quality associated with SGD; and (5) estimates of chemical loadings of selected trace constituents (i.e. selenium, arsenic, mercury) to GSL via SGD.

References

Arnow, T., 1978, Water budget and water-surface fluctuations, Great Salt Lake, Utah: U.S. Geological Survey Open-File Report 78-912, 21 p.

Diaz, X., Johnson, W.P., and Naftz, D.L., 2009, Selenium mass balance in the Great Salt Lake, Utah: Science of the Total Environment, vol. 407, Issue 7, p. 2333-2341.

Genereux, D.P., Leahy, S., Mitasova, H., Kennedy, C.D., and Corbett, D.R., 2008, Spatial and temporal variability of streambed hydraulic conductivity in West Bear Creek, North Carolina, USA: Journal of Hydrology, vol. 358, p. 332-353.

Henderson, R.D., Day-Lewis, F.D., and Harvey, C.F., 2009, Investigation of aquifer-estuary interaction using wavelet analysis of fiber-optic temperature data: Geophysical Research Letters, vol. 36, L06403, doi:10.1029/2008GL036926.

Kennedy, C.D., Genereux, D.P., Corbett, D.R., and Mitasova, H., in press, Spatial and temporal dynamics of coupled groundwater and nitrogen fluxes through a streambed in an agricultural watershed: Water Resources Research.

Lane, J.W., Jr., Day-Lewis, F.D., Johnson, C.D., Dawson, C.B., Nelms, D.L., Eddy-Miller, C.A., Wheeler, J.D., Harvey, C.F., and Karam, H., 2008, Fiber-optic distributed temperature sensing: A new tool for assessment and monitoring of hydrologic processes, in Symposium on the Application of Geophysics to Engineering and Environmental Problems, April 6-10, 2008, Philadelphia, Pennsylvania, Proceedings: Denver, Colorado, Environmental and Engineering Geophysical Society, 9 p.

Lee, D.R., 1977, A device for measuring seepage flux in lakes and estuaries: Limnology and Oceanography, vol. 22, no. 1, p. 140-147.

Naftz, D.L., Johnson, W.P., Freeman, M.L., Beisner, Kimberly, Diaz, Ximena, and Cross, V.A., 2009, Estimation of selenium loads entering the south arm of Great Salt Lake, Utah, from May 2006 through March 2008: U.S. Geological Survey Scientific Investigations Report 2008–5069, 40 p.

Rosenberry, D.O., and Morin, R.H., 2004, Use of an electromagnetic seepage meter to investigate temporal variability in lake seepage: Ground Water, vol. 42, no. 1, p. 68-77.

Swarzenski, P., and others, 2004, Novel geophysical and geochemical techniques used to study submarine groundwater discharge in Biscayne Bay, Florida: U.S. Geological Survey Fact Sheet 2004-3117, 4 p.

Thiros, S.A., 2003, Quality and sources of shallow ground water in areas of recent residential development in Salt Lake Valley, Salt Lake County, Utah: U.S. Geological Survey Water-Resources Investigations Report 03-4028, 74 p.

U.S. Geological Survey, 2009, Great Salt Lake water-level data: National Water Information System: http://waterdata.usgs.gov/ut/nwis/uv/?site_no=10010000&PARAmeter_cd=72020, accessed on May 21, 2009.

The proposed budget will be adequate to achieve our stated goals via the proposed approach.

E. Importance of the project to the management of Great Salt Lake.

Excellent networks have been established to monitor lake-level fluctuations and surface-water inflow and quality to GSL. Historically, these monitoring data have been used by citizens, private consultants, and state and federal agencies for a variety of outreach, management, and research purposes. Despite these excellent monitoring networks, no similar network exists for monitoring the amount, chemical quality, or source(s) of groundwater discharge to GSL. Failure to quantify and monitor groundwater inputs to GSL will result in an incomplete understanding of how surface-water diversions, subsurface contaminant plumes, and groundwater development will ultimately impact the lake's water balance and water quality, resulting in potentially misguided regulatory decisions. Public concern regarding the importance of monitoring groundwater inflow and associated selenium loadings into GSL is exemplified by a recent editorial in the *Salt Lake Tribune* (fig. 7) concerning the new selenium standard set for the lake and whether this standard is low enough to protect migratory waterfowl and abide by various international treaties. The new selenium standard was set without any knowledge of groundwater selenium loadings to GSL.

F. Project relationship to the four "hot topics" listed in 1.0 Statement of Intent.

The proposed work addresses three of the five "hot topics": (1) **Monitoring**—establishes the infrastructure and techniques needed to establish and maintain a groundwater monitoring network in GSL; (2) **Methods to assess habitat quality**—habitat quality is directly related to maintaining water levels in GSL and this study will determine groundwater contributions to the overall water balance and resultant habitat quality; and (3) **Mercury**—No measurements have been made regarding the total or methyl mercury concentration in groundwater entering GSL. The proposed study will measure mercury and other trace element loadings contributed to GSL from SGD.

OUR VIEW

By the Tribune Editorial Board

Chemical limit

Selenium standard too high

A debate over how much selenium to allow in the Great Salt Lake has federal and state agencies arguing over an international treaty. In the balance is the health of the lake and the safety of millions of migratory birds that use it as an intercontinental way station.

We are on the side of the birds.

Sewer districts in the Salt Lake Valley and Kennecott Utah Copper have long used the lake as a dump for selenium and other chemicals. Utah's first selenium standard for the lake went into effect last month. It's too high.

The limit allows chemical levels high enough to kill 10 percent of developing birds before they hatch. According to the U.S. Fish and Wildlife Service, regulations that accept such high numbers of bird deaths are illegal and violate the international Migratory Bird Treaty signed by Canada, Mexico, Russia, Japan and the United States, as well as federal law and a presidential order.

Figure 7. Editorial appearing in the May 31, 2009, edition of the *Salt Lake Tribune* concerning the new selenium standard and associated selenium loads entering Great Salt Lake.

G. Related work done or in progress by principal investigator and members of the project team.

The principal investigators have worked previously on the Great Salt Lake and Farmington Bay in the context of nutrients, mercury, stable isotopes, selenium, continuous resistivity profiling, and hydroacoustic applications to GSL currents.

Previous work has yielded the following information products (partial list):

Naftz, D.L., Stephens, D.W., Callender, E., and Van Metre, P.C., 2000, Reconstructing historical changes in the environmental health of watersheds by using sediment cores from lakes and reservoirs in Salt Lake Valley, Utah: U.S. Geological Survey Fact Sheet FS-164-00, 6 p.

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.

Oliver, W., Fuller, C., Naftz, D.L., Johnson, W.P., Diaz, X., 2009, Estimating selenium removal by sedimentation from the Great Salt Lake, Utah": Applied Geochemistry, vol. 24, p. 936-949.

Diaz, X., Johnson, W.P., Fernandez, D., and Naftz, D.L., in press, Size and Elemental Distributions of Nano- to Micro- Particulates in the Geochemically-Stratified Great Salt Lake: Applied Geochemistry.

Naftz, D.L., Fuller, C., Cederberg, Krabbenhoft, D., Whitehead, J., Garberg, J., and Beisner, K., 2009, Mercury inputs to Great Salt Lake, Utah: Reconnaissance-phase results. In: A. Oren, D. Naftz, P. Palacios and W.A. Wurtsbaugh (eds). Saline Lakes Around the World: Unique Systems with Unique Values. Natural Resources and Environmental Issues, volume XV. S.J. and Jessie E. Quinney Natural Resources Research Library, Logan, Utah, USA.

Beisner, K., Naftz, D.L., and Johnson, W.P., 2009, Evidence and implications of movement of the deep brine layer in the South Arm of Great Salt Lake, Utah. In: A. Oren, D. Naftz, P. Palacios and W.A. Wurtsbaugh (eds). Saline Lakes Around the World: Unique Systems with Unique Values. Natural Resources and Environmental Issues, volume XV. S.J. and Jessie E. Quinney Natural Resources Research Library, Logan, Utah, USA.

Jones, B.F., Naftz, D.L., Spencer, R.J., and Oviatt, C.G., 2009, Geochemical Evolution of Great Salt Lake, Utah, USA: Aquatic Geochemistry, vol. 15, p. 95–121.

Diaz, X., Johnson, W.P., and Naftz, D.L., 2009, Selenium mass balance in the Great Salt Lake, Utah: Science of The Total Environment, vol. 407, p. 2333-2341.

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Naftz, D.L., Johnson, W.P., Freeman, M.L., Beisner, Kimberly, Diaz, Ximena, and Cross, V.A., 2009, Estimation of selenium loads entering the south arm of Great Salt Lake, Utah, from May 2006 through March 2008: U.S. Geological Survey Scientific Investigations Report 2008–5069, 40 p.

The principal investigators are currently (2009) involved in three projects associated with GSL that are in progress: (1) Construction and application of a hydrodynamic and water-quality model of the south arm of GSL (Utah Division of Wildlife Resources) and (2) Biogeochemical cycling of mercury in four perimeter wetlands surrounding Great Salt Lake (Utah Division of Water Quality), and Diel variation in mercury loads from Farmington Bay (Utah Division of Forestry, Fire, and State Lands).

H. Specifics concerning deliverable(s) due to the Division of Forestry Fire and State Lands by June 30, 2010 and June 30, 2011.

Deliverables include:

1. All groundwater and water-quality data will be archived in the USGS NWIS database as it is generated throughout the project. These data will be available over the internet to all interested parties as well as seamless inclusion into the GSL database currently in development by Utah State University and UDFFSL.
2. Interim study results will be provided to UDFFSL via a progress report and oral presentation at a GSL Tech Team meeting by June 30, 2010.
3. A final report of the study results will be completed and submitted to UDFFSL and a peer-reviewed journal on or before June 30, 2011.

COLLABORATION/PROJECT PARTNERS

A. Identify partners and their contributions to the proposed project.

William P. Johnson, Univ. of Utah – analytical support and scientific support
D. Kip Solomon, Univ. of Utah – analytical support and scientific support
USGS Branch of Geophysics – geophysical support and equipment

B. Letters of commitment describing the specific commitment (provided by the project partner and included as an appendix).

Refer to appendix.

C. Potential for future leverage associated with the research project.

The USGS and the principal investigator are involved in multiple studies and monitoring programs associated with the hydrology, water quality, and biogeochemistry of GSL and the surrounding wetlands. In addition, the principal investigator regularly collaborates with State and University researchers studying multiple aspects of GSL. Given these ongoing studies and collaborative arrangements, it is highly likely that results from the proposed study can be leveraged in future research and monitoring programs. For example, it is anticipated that results from the proposed work will provide the foundation and future leverage for a long-term monitoring of the quantity and quality of submarine groundwater discharge to GSL. In addition, it is also highly likely that measurement and monitoring techniques demonstrated in this study can be leveraged to similar research goals in the perimeter wetlands of GSL. Finally, results from the proposed study may be leveraged to initiate more site specific studies to identify previously unknown pollution sources and associated PRPs to groundwater entering GSL.

PROJECT BUDGET AND SCHEDULE

A. Total Projected Costs by Category.

Budget Category	**Grant funds requested**	**Matching Funds** (Cash)	**Total**
Personnel	$17,916	$11,946	$29,862
Equipment	$2,820	$1,880	$4,700
Materials/Supplies	$2,700	$1,800	$4,500
Travel	$2,700	$1,800	$4,500
Analytical support	$8,820	$5,880	$14,700
Administrative Overhead	$13,594	$9,064	$22,658
Total Project Cost	$48,550	$32,370	$80,920

In addition to the matching funds (cash) of $32,370 provided by the USGS, we will also purchase 2 km of fiber optic cable for use in the temperature surveys of GSL to identify areas of submarine groundwater discharge. This represents an additional cash contribution of $10,000 for a total match of **$42,370**.

B. Schedule

Activity	2010				2011			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Resistivity and temperature surveys		■						
Analyze resistivity data			■					
Install/measure seepage meters			■	■				
Interim report and presentation			■					
Install and sample piezometers			■	■				
Upload data to NWIS		■	■	■	■	■		
Lab analysis				■	■	■		
Report preparation				■	■	■	■	
Final report to UDFFSL							■	

APPENDICES

A. Resumes of key project team members.

APPENDICES

B. Letters of support from community leaders, community groups, agencies, etc.

APPENDICES

C. Letters of commitment from declared partners