UTAH DIVISION OF WATER QUALITY
195 North 1950 West
PO Box 144870
Salt Lake City, Utah 84114-4870

Willard Bay Project Proposal Form

NOTE: Proposal must be no longer than 6 pages. Supplemental documents such as letters of support, information to demonstrate previous project implementation and other relative supportive documents may be submitted in addition to this form.

Applicant Name: Dr. Dan Bedford

Co-Applicant Name(s) (if applicable): Dr. Steve Burian

Project Title: **Developing Guidance for Stormwater Bioretention Design, Maintenance, Monitoring, and Adaptation in Utah**

Agency or Business Name (if applicable): **Weber State University and University of Utah**

Mailing Address: Miller Admin Building, 3850 Dixon Parkway Dept. 1027 City: Ogden State: UT

Zip: 84408 Phone: (801) 626-8091 E-mail: dbedford@weber.edu

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

1. Estimated Project Costs:

Labor	$ 333,930
Materials	$ 124,340
Equipment	$ -
Administration	$ 57,110
Miscellaneous (analytics, travel)	$ 46,325
TOTAL	**$ 561,705**

Other sources of project funding:

Source	Description	Approximate value
iUTAH	Post-doc salary, 1 year	$54,400
iUTAH	Technician support, 40 hours	$1,200
iUTAH	Data storage, hosting and on-line publishing	Not quantifiable, very expensive

Total project cost including other sources of funding: $ 617,305
(please include bids for labor, equipment, rentals, etc.) See Appendix A

The Following Questions are addressed in our Project Description:

2. Describe the purpose and need of the project:
3. Estimated time frame of the project with significant milestones (Note: Project must be completed with final reports filed by January 1, 2018): **Summer 2014 – Dec 2017**
4. Describe the location of the project with attached location map, including details on the total area that will be directly enhanced by the project: **Weber State University Campus**
5. Describe how the project will specifically enhance and protect waterways affected by the Willard Bay diesel release and improve the conditions of one or more of the following: wildlife, habitat, natural vegetation, water quality or emergency response:
6. Describe project's connectivity to other natural areas or projects that further enhance wildlife, habitat, natural vegetation, water quality or emergency response:
7. Describe any additional social benefits of implementing this project:
8. Project plans and details, including rights to work on specified piece of land:
9. Describe your experience in implementing projects of similar scope and magnitude:
10. Describe how ongoing maintenance of the project will be funded and carried out:
11. List consultants or agency partners that have participated in project development (below):

Dasch Houdeshel, iUTAH post-doctoral Fellow, Utah State University (801) 440-3395, d.houdeshel@aggiemail.usu.edu

Kevin Hansen, Associate Vice President /Facilities and Campus Planning, Weber State University, (801) 626-8022, Khansen@weber.edu)

Brian Hadley, Landscape Manger, Weber State University (801)-626-6553, brianhadley2@weber.edu

Michelle Baker, iUTAH Acting Director, Utah State University (435) 797-7131, Michelle.Baker@usu.edu

Signature D. Bedford Date 5/5/2014
Applicant

Signature Steven J Burian Date 5-2-2014
Co-Applicant (if applicable)

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Developing Guidance for Stormwater Bioretention Treatment Design, Maintenance, Monitoring, and Adaptation in Utah

Submitted by Dr. Bedford, WSU, and Dr. Burian, U of U

Project Description

We propose to install and monitor stormwater bioretention treatment systems at Weber State University (WSU) to advance the understanding of decentralized stormwater treatment in Utah, help promote urban runoff quality management in the Ogden River watershed, and develop guidance for stormwater bioretention design, maintenance, monitoring, and adaptation in Utah. WSU is ideally situated to lead this collaborative research because of our location in the Ogden River watershed, our commitment to sustainability, and the relationships we have built with the University of Utah (U of U) and Utah State University (USU) through the innovative Urban Transitions and Aridregion Hydrosustainability (iUTAH) project. Nitrogen in urban stormwater runoff is a well-known contributor to water quality impairment in xeric urban environments. Nitrogen (N) is particularly challenging for watershed and water quality managers because of the variety of natural and anthropogenic sources of N that are contained in precipitation and entrained in urban stormwater runoff (Vitousek *et al.*, 1997; Russell *et al.*, 1998; Schade *et al.*, 2002; Fenn *et al.*, 2003; Taylor *et al.*, 2005). Specific to the Willard Spur, the Utah Department of Water Quality states that in Willard Bay Reservoir, “the areas of greatest impact are urban stormwater runoff” (UDWQ 2014). Stormwater runoff introduces biologically available inorganic nitrogen (such as NO_3^- and NH_4^+) and organic nitrogen from urban surfaces throughout Weber County into the Ogden River and down to Willard Spur by way of diversions taken at the Slaterville Dam.

It is widely held that stormwater becomes contaminated with nitrogen as it is conveyed over urban landscapes (both hard and soft) and through stormwater infrastructure (Pitt and Clark, 2003; Davis *et al.*, 2009). Stormwater Green Infrastructure (GI) can be an element of urban watershed management that has the potential to treat nitrogen loading associated with runoff by capturing stormwater as close as possible to its point of generation. The EPA is strongly encouraging the use of GI to minimize the contamination of surface waters by urban runoff (U.S. EPA, 2011). However, the concept of GI as an engineered stormwater management system is young, especially in xeric climates, and there is uncertainty about the hydrologic implications of wide-spread GI implementation (Davis *et al*. 2009). Further, preliminary research conducted by iUTAH indicates that unfamiliarity with, and doubt about the effectiveness of, stormwater GI is a significant obstacle to its wider adoption by stormwater managers along the Wasatch Front (Armstrong, unpublished data). This project proposes to answer three central questions arising from the consideration of GI and stormwater runoff along the Wasatch Front outlined above:

1: What are the stormwater driven nitrogen contributions to Willard Bay from urban roofs, parking lots, and roads?

2: How does the implementation of stormwater GI affect water and nitrogen budgets of urban development within the Willard Bay drainage area?

3: What are the monitoring protocols and maintenance requirements to cost-effectively sustain bioretention at the institutional level along the Wasatch Front?

<u>To address these questions, we propose to implement bioretention stormwater GI on the WSU campus and monitor the hydrologic inputs and outputs of these facilities in order to calculate a water and nitrogen budget for urbanized drainage areas in Weber County.</u> We will use the construction of the proposed bioretention stormwater GI as an opportunity to host a GI

workshop for local water resources managers and engineers to discuss the intended hydrology of GI along the Wasatch Front. The data collected from the project will be integrated into coursework at Weber State and U of U, and the final water and nitrogen budgets will be calculated and disseminated in peer reviewed journals by a graduate student and post-doctoral researcher at the U of U. The proposed GI implementation, community engagement, and research will be supported by collaboration between professors at WSU and the U of U and will draw on infrastructure and support from Utah State University and the iUTAH project (see Appendix B.1). This research will support the creation of stormwater bioretention design guidance that includes protocols for maintenance, monitoring and adaptation of bioretention specific to the Wasatch Range.

Cost Breakdown

Costs for this project will be distributed between WSU and the U of U. All construction costs and instrumentation will be managed by WSU, and scientific support (post-doc, M.S. student, and analytics) will be managed by the U of U. Construction, instrumentation, and analytical costs are shown in Appendix A.

Weber State Budget	**2014**	**2015**	**2016**	**2017**	**Total Cost**
Bedford Salary	$ 3,628	$ 3,628	$ 3,628	$ 3,628	$ 14,512
4 Undergrad Workers	$ 7,500	$ 15,000	$ 15,000	$ 15,000	$ 52,500
Bioretention Construction	$ 56,200	$ -	$ -	$ -	$ 56,200
Bioretention Instrumentation	$ 55,840	$ 600	$ 600	$ 600	$ 57,640
Cyber Infrastructure	$ 2,000	$ 500	$ 500	$ 500	$ 3,500
WSU Maintenance	$ 1,080	$ 1,560	$ 1,560	$ 1,560	$ 5,760
WSU Engagement and Signage	$ 2,000	$ 1,500	$ 1,500	$ 2,000	$ 7,000
Professor Fringe (44%)	$ 1,596	$ 1,596	$ 1,596	$ 1,596	$ 6,384
Student Fringe (10%)	$ 750	$ 1,500	$ 1,500	$ 1,500	$ 5,250
Total Direct Costs	$ 130,594	$ 25,884	$ 25,884	$ 26,384	$ 208,746
Indirect costs (0%)	$ 4,716	$ 7,603	$ 7,603	$ 7,603	$ 27,526
				Total WSU Budget	**$ 236,272**

U of U budget	**2014**	**2015**	**2016**	**2017**	**Total Cost**
Burian Salary	$ 5,170	$ 5,222	$ 5,274	$ 5,327	$ 20,993
Post-doc Salary	$	$ 24,000	$ 49,440	$ 50,923	$ 124,363
Grad Student Salary	$ 0	$ 24,000	$ 24,000	$ 0	$ 48,000
Analytical Costs	$ 4,607	$ 18,427	$ 18,427	$ 0	$ 41,461
Travel	$ 1,038	$ 1,275	$ 1,275	$ 1,275	$ 4,863
Professor Fringe (36%)	$ 1,861	$ 10,520	$ 19,697	$ 20,250	$ 52,328
Student Fringe (8%)	$ 0	$ 1,920	$ 1,920	$ 0	$ 3,840
Total Direct Costs	$ 12,676	$ 85,364	$ 120,033	$ 77,775	$ 295,849
Indirect costs (10%)	$ 1,268	$ 8,536	$ 12,003	$ 7,778	$ 29,585
				Total U of U Budget	**$ 325,434**
				Total Project Request	**$ 561,706**

Implementation Plan

Phase 1: construct bioretention gardens

The implementation of GI to reduce urban runoff within the Ogden River basin has the potential to have a profound effect on reducing total nitrogen inputs to Willard Bay, thus reducing the likelihood of future impairment. The first phase of our proposal is to construct four bioretention gardens on the WSU campus to treat runoff from up to four different urban surfaces (*e.g.* parking lots, driveways, and rooftops). Each garden will be designed according to the recommendations of Houdeshel *et al.* (2013) and instrumented with an inflow monitor, pressure transducers to measure depth in the storage reservoir, and meteorological (including soil moisture) sensors to model evapotranspiration (ET) similar to a previous project at the U of U (See Appendix C: Bioretention on the U of U Campus supplement). In addition, sampling points will be installed to collect inflow, outflow, and stored samples for water quality analysis. Construction will begin in the fall of 2014 and will be managed by Dr. Houdeshel, who is currently a post-doctoral fellow with the iUTAH project at Utah State University. Dr. Houdeshel and Dr. Bedford are working closely with WSU Facilities Management to design these gardens to meet project needs and to ensure the gardens function as sustainable stormwater infrastructure for the University (See Appendix B.2). We expect the proposed bioretention treatment systems and associated engagement activities to encourage the implementation of GI along the Wasatch Front by demonstrating the functionality of bioretention on the WSU campus.

Phase 2: Study hydrologic performance

Water Budget Research Plan

Understanding the hydrology of bioretention along the Wasatch Front is critical to prescribing climate-appropriate design, discussing policy implications such as water rights conflicts, and forming the foundation of a nitrogen budget. To measure the water inputs and outputs of the proposed bioretention mitigation facilities, we propose to install the following instrumentation at each garden:

- A weir and Level Troll 500^{tm} (In-situe.com) vented pressure transducer to measure inflow to the garden
- Sampling ports to collect inflow, outflow, and stored samples for water quality analysis
- Campbell Scientific ET 107 to measure atmospheric conditions and precipitation input, which will allow the calibration of stormwater models and the calculation of ET losses from the garden.
- Onset soil moisture sensors placed at four locations within each garden at 5 cm, 20 cm, and 50 cm below the garden surface in the topsoil layer and 20 cm below the storage layer in the sub-soil which will allow the quantification of soil water fluxes
- Hobo Water Level loggers that will measure the rate of exfiltration in the storage layer, or the rate at which water flows from the storage reservoir to the surrounding soils

All instrumentation will be deployed at the time of garden construction and will be overseen by Dr. Houdeshel, Dr. Bedford, and one iUTAH technician. Dr. Bedford will oversee the management of the instrumentation. The instrumentation at the sites will be managed by Dr. Bedford's undergraduate Weather and Climate class each fall. Four undergraduate research technicians will be hired to manage the instruments in spring and summer, with one student responsible for the instruments in each garden. The meteorological data will be collected and integrated into an annual ET model as a primary objective of Dr. Bedford's Weather and Climate course. This annual ET model will be compiled with the soil moisture sensor data, precipitation data, and stormwater inflow data which will be used to calculate the water budget for each garden by a M.S. student who will be managed by a post-doc in collaboration with Dr. Burian at the U of U. Three years of data will be compiled into annual water budgets, which will be compared to understand inter-annual variability and spatial variability within and among the mitigation gardens. The post-doc and the graduate student will both be available to help Dr. Bedford with instrumentation trouble-shooting when problems arise.

Nitrogen Budget Research Plan

A nitrogen budget will be calculated by a post-doc at the U of U in parallel with the water budget that will be calculated by a M.S. student. One ISCO 6712C (www.isco.com) compact portable auto sampler will be set out at the inflow location to each of the four gardens by a Weber State undergraduate technician before a forecast storm once per month. The sampler will be programed to collect 24 discrete samples at flow-paced intervals to capture nitrogen input variability during storm events. After the storm event, water samples will be extracted from passive suction lysimeter ports buried beneath the storage reservoir to quantify the reduction in nitrogen concentration as the stormwater flows through the garden and infiltrates into the sub-soil. Passive precipitation collectors will be set out within each garden to collect precipitation samples for each storm event from which inflow samples are taken. This will allow the contribution of nitrogen from the contributing impervious surface to be separated from the nitrogen that was deposited in the precipitation. This will facilitate the quantification of the nitrogen contribution of different impervious surfaces and land uses to the Ogden and Willard Bays.

All water quality samples will be analyzed by a post-doc at the U of U. Nitrate (NO_3^-), nitrite (NO_2^-), and ammonium (NH_4^+) will be measured using a Metrohm 881 Compact IC (Metrohm, USA, Riverview, FL) equipped with anion and cation columns capable of measuring 0.02 mg/l for the three ions tested. Cadmium reduction will be used to measure total nitrogen and total phosphorus by Michelle Baker's lab at Utah State University. Organic nitrogen will be calculated as total nitrogen minus the sum of NO_3^--N, NO_2^--N, and NH_4^+-N. To minimize species transformation between sample collection and analysis, samples will be collected and filtered with a 0.45 μm filter within 24 hours of collection at Weber State by the undergraduate technicians, then will be refrigerated until transport to the U of U and Utah State University for analysis. Sample transport will be combined with travel for monthly project meetings. All samples will be mailed to the UC Davis Stable Isotope Facility for analysis of the ^{15}N ratio of the dissolved nitrate. Comparing the ^{15}N ratios of dissolved nitrate in the precipitation and the urban runoff will provide greater insight to the type of nitrogen sources that are being washed off of the contributing impervious areas (Mariotti *et al.*, 1981).

Plant biomass and the soil matrix must also be considered in the nitrogen budget. To address this, soil samples and leaf samples will be collected and analyzed for TN and ^{15}N isotopic ratios at the U of U Stable Isotope Ratio Facility for Ecological Research. Soil samples will be collected from 5 cm, 20 cm, and 50 cm below the garden surface in the topsoil layer and 20 cm below the storage layer in the sub-soil. Total leaf area will be calculated by developing algometric relationships between stem diameter and leaf area for each species in each garden, and total leaf biomass will be calculated by multiplying leaf area times average leaf g/m^2 for each species. Soil and leaf samples will be taken once yearly in early September to capture maximum leaf-out and maximum nitrogen concentrations in the leaves then tracked over two years. The two years of data will be compiled into annual nitrogen budgets, which will be compared to understand inter-annual variability and spatial variability within and among the mitigation gardens by the post-doc.

Phase 3: Community Education and Communication of Results

Stormwater Education at Weber State University

The primary education emphasis with the construction of the stormwater mitigation gardens will be the incorporation of the collected data into Dr. Bedford's Weather and Climate class and Dr. Burian's Sustainable Urban Water Engineering class. Additionally, WSU provides an ideal location to construct a GI demonstration site because of the diversity in curriculum offered and because of Weber State's prominent role in interacting with the Ogden community. Information will be communicated to people walking on campus by interactive signs that include QR codes that link to iUTAH data repositories (http://data.iutahepscor.org/mdf) so that curious observers can see the garden, read about what it does, and look up the flow, climate, and water quality data that will be used to quantify the water and nitrogen budgets of the garden. The bioretention gardens constructed previously at the U of U have become showpieces of campus tours (Appendix C) because of their student involvement in construction and because the gardens represent the U of U's commitment to sustainability. This commitment is also strong at Weber State and the proposed gardens will be incorporated into campus tours as well.

Green Infrastructure Education to Wasatch Front water resources professionals

The construction of these gardens will provide an excellent opportunity to demonstrate the GI design concept to local water resources managers and stormwater engineers. Two specific actives are proposed here. The first is a 2-hour workshop at Weber State that includes a thirty minute presentation to give an overview of GI along the Wasatch Front, then a tour of the bioretention gardens *as they are being constructed*. This demonstration will facilitate a discussion with water policy makers, water quality professionals, and stormwater drainage engineers about the intended hydrologic performance of bioretention GI facilities. The second is an update of the proposed research at a bioretention operation and maintenance meeting to be held for the same professional audience in 2017. Also, the proposed research will be presented at the annual American Water Resources Association (AWRA) Utah Chapter meeting and Salt Lake County Watershed Symposium in 2017. The research team has strong relationships with local chapters of the AWRA, the Water Environment Research Foundation, and the Utah Bar Association, and through these organizations, can offer workshops that count towards continuing education to professional engineers and lawyers licensed in Utah. Also, the research team can use relationships with local and State agencies developed through iUTAH to promote the proposed activities.

Publication of findings to local and national audiences

In addition to the final report that will be presented to the Division of Water Quality at the end of this study, the results of these efforts will be compiled into a bioretention design manual for DWQ that includes protocols for maintenance, monitoring and adaptation of bioretention specific to the Wasatch Range. Research results will also be submitted for publication to international peer-reviewed journals that focus on water resources. Additionally, our findings will be summarized into informational pamphlets for distribution on the internet or at informational kiosks throughout the Willard Bay and Logan River watersheds. We invite the opportunity to incorporate these displays in ongoing education efforts by DWQ. The bioretention gardens and engagement efforts will also be showcased at the 2017 WSU Intermountain Sustainability Summit, which has become a nationally attended event. These publication and engagement efforts will be the focus of the post-doc at the U of U in the final year of the project.

Summary

We propose to construct four bioretention gardens to treat urban stormwater runoff from the WSU Campus. These gardens will serve as the foundation for research to better understand the impacts of urban runoff on the Ogden River and to engage the Ogden River watershed community in how to utilize GI to mitigate these impacts. The total requested budget of $561,706 includes the construction of four bioretention at Weber State University, instrumentation to monitor the hydrologic and nutrient inputs and outputs of each bioretention garden, and support for undergraduate, graduate, and post-doctoral researcher at WSU and the U of U. The iUTAH project will provide support from a Post-doctoral Fellow for the first year of this project, support from the iUTAH field technicians to establish data communications, and support from the iUTAH Data and Modeling Federation to support on-line data publishing. Further, the PI team is working in collaboration with Ryan Dupont at Utah State University to submit a request for EPA Section 319 funds to replicate this study at bioretention sites in Salt Lake City and Logan. If this proposal is funded, it may serve as match to the EPA Section 319 proposal to expand the findings of this study from the site scale to the entire Wasatch Range metropolitan area. This proposal exemplifies the integration of stormwater mitigation, education, and research, and the proposed activities will inspire a new direction of urban stormwater management in the Ogden River watershed.

Table 1. Graphical timeline of proposed research activities (highlighted in green), community engagement activities (highlighted in orange), and education activities (highlighted in blue).

	2014		2015				2016				2017			
Quarter	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Construction of Bioretention Gardens	X													
Hydrologic Data streaming to iUTAH federation		X	X	X	X	X	X	X	X	X				
Nitrogen samples collected and analyzed		X	X	X	X	X	X	X	X	X				
Soil and plant sampling					X				X					
GI construction and maintenance workshops	X												X	
AWRA Annual Conference Presentation												X		
Salt Lake County Watershed Symposium														X
Weber State Sustainability Summit				X								X		
Bioretention design guide												X	X	X
Weather and Climate WSU					X	X			X	X			X	X
Sustainable Urban Water Engineering, U of U		X							X	X				
Final report preparation and submission													X	X

References

Armstrong, A. 2014. Prelim. data, Utah Stormwater Managers Survey, carried out by iUTAH and the Utah Storm Water Advisory Committee.

Davis, A.P., Hunt, W.F., Traver, R.G., Clar, M., 2009. Bioretention technology: Overview of current practice and future needs. Journal of Environmental Engineering 135, 109-117.

Fenn, M.E., Haeuber, R., Tonnesen, G.S., Baron, J.S., Grossman-Clarke, S., Hope, D., Jaffe, D.A., Copeland, S., Geiser, L., Rueth, H.M., 2003. Nitrogen emissions, deposition, and monitoring in the western United States. BioScience 53, 391-403.

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Taylor, G.D., Fletcher, T.D., Wong, T.H., Breen, P.F., Duncan, H.P., 2005. Nitrogen composition in urban runoff—implications for stormwater management. Water Research 39, 1982-1989.

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Bioretention Construction and Instrumentation Costs

Bioretention Construction	Source	Quantity	Unit	Unit Cost	Total Cost
Excavation	WSU facilities	6	days	$ 500	$ 3,000
Disposal of Excess Soil Offsite	WSU facilities	20	load	$ 235	$ 4,700
Expanded shale	Utelite	50	cubic yard	$ 55	$ 2,750
Materials delivery	Utelite	50	cubic yard	$ 36	$ 1,800
Plants	Progressive Plants	40	plants	$ 20	$ 800
Stormdrain inlet modification	WSU facilities	1	ea.	$ 1,000	$ 1,000
Bioretention sub-total (per garden)					**$ 14,050**
Bioretention total for 4 gardens					**$ 56,200**

Construction costs justification: Excavation will be managed by WSU and will include the re-use of on-site topsoil; six days represents the cost of three heavy equipment operators (and equipment) for two days. Expanded shale is the preferred medium for the sub-grade storage layer because of its high pore-space and its ability to sorb metals and nutrients found in stormwater. 1-gallon plants are recommended when available to improve establishment success. Stormdrain inlet modifications will be designed in collaboration by Dr. Houdeshel and Mar, Halverson, WSU director of planning and construction, to inflow to the test systems can be accurately measured and to maintain flood control in the event of a large (10 yr or greater) storm events.

Bioretention Instrumentation	Source	Quantity	Unit	Unit Cost	Total Cost
Basic ET weather station	Campbell Sci	1	station	$ 3,600	$ 3,600
Misc. mounting equipment		1	station	$ 100	$ 100
soil moisture sensors	Onset	16	ea.	$ 120	$ 1,920
soil moisture sensor data logger	Onset	4	ea.	$ 235	$ 940
soil media pressure transducer	Solnist	3	ea.	$ 300	$ 900
Inflow pressure transducer	In-situ	1	ea.	$ 1,500	$ 1,500
ISCO auto sampler	ISCO	1	ea.	$ 4,000	$ 4,000
Vacuum pump	Fisher Sci	1	ea.	$ 1,000	$ 1,000
Instrumentation total (per garden)					**$ 13,960**
Instrumentation total for 4 gardens					**$ 55,840**

Construction cost justification: The listed instrumentation is required to complete the research objectives described in the research budget. A contingency of $600 per year has been added to repair or replace damaged sensors. Vacuum pump is required for sample filtration at the time of sampling to minimize nitrogen species transformation and may also be used to extract samples from lysimeter ports. Lysimeter ports consist of a pvc tube, and will be covered under Misc. mounting equipment.

Cyber Infrastructure Costs	Source	Quantity	Unit	Unit Cost	Total Cost
Network Interface Link	Campbell Sci	1	ea.	$ 295	$ 295
RF450 Radio receiver	Campbell Sci	1	ea.	$ 1,000	$ 1,000
Misc. cables, connectors, software		1	ea.	$ 705	$ 705
Cyber Infrastructure total					**$ 2,000**

Cyber infrastructure cost justification: The climate and weather data will be relayed to a receiving station that will translate the radio signal into a digital signal, which will then be sent to iUTAH technicians at USU. Techs will be able to control instrumentation through this connation as well. Includes allowance for proprietary software licenses from ISCO or Campbell and $500 annual maintenance.

Expected Analytical Costs

Analytics	Lab	Samples per garden	Number of Storms	Number of Gardens	Cost Each	Total Cost
Air and Water Quality						
Anion IC	U of U geology	8	12	4	$ 6.00	$ 2,304
Cation IC	U of U geology	8	12	4	$ 6.00	$ 2,304
Total N and Total P	USU Baker Lab	8	12	4	$ 6.00	$ 2,304
Dissolved NO3 15N	UC Davis SIF	1	12	4	$ 25.00	$ 1,200
Aqueous N Sub-total						$ 8,112
Soil and plants						
TN,TC,13C, 15N, soil	U of U SIRFER	4	12	4	$ 7.50	$ 1,440
TN, TC, 13C,15N, vegetation	U of U SIRFER	20	12	4	$ 7.50	$ 7,200
Soil and plants subtotal						$ 8,640
Analytics sub total per year						**$ 16,752**
10% contingency per year						$ 1,675
Analytics total per year						$ 18,427
Analytics total for two years						**$ 36,854**
First year analytics testing						**$ 4,607**
				Analytical Total	**$**	**41,461**

Justification: Sample prices are set by each respective lab; discounts for in-university submission are included. Pre-submission processing will be done by WSU undergraduate technicians and U of U post-doc. 10% contingency is required to provide pre-processing materials (*e.g*. filters and shipping costs to UC Davis) and quality control (blind blanks and standards). The first year analytics testing, which is equal to three months of sampling, will be used to rigorously test sampling techniques and equipment, including sample blanks and standards.

EXPERIMENTAL PROGRAM
TO STIMULATE
COMPETITIVE RESEARCH

29 April 2014

Emily Bartusek
Willard Bay Mitigation Proposals
Utah Division of Water Quality
PO Box 144870
Salt Lake City, UT 84114

Dear Emily Bartusek,

As acting Director of the innovative Urban Transitions and Aridregion Hydro-sustainability (iUTAH) project, I am writing to confirm support for the Willard Bay Mitigation proposal submitted by Dr. Bedford and Dr. Burian. Specifically, I would like to commit the following in-kind contributions if the proposal is successful:

- Project design and management support from Dr. Dasch Houdeshel, an iUTAH Post-doctoral Fellow, from the project start through July 2015
- Technical support to assist with instrumentation installation and data communications/storage from an iUTAH field instrument technician
- Any support required that is directly related to data communications, storage, and display on the iUTAH data federation (http://data.iutahepscor.org/mdf/)

This support is intended as in-kind, with no intention of transferring money of any denomination to the Utah Division of Water Quality or to allow iUTAH funds to be used to purchase materials or support activities directly related to the project proposed by Dr. Burian and Dr. Bedford.

In addition to the in-kind contributions specifically listed above, I lend my full support to this proposal because I agree with Dr. Burian and Dr. Bedford that this proposal exemplifies the integration of stormwater mitigation, education, and research, and that the activities described in their proposal will inspire a new direction of urban stormwater management across the Wasatch Range metropolitan area.

Sincerely,

Michele A. Baker

Michelle A. Baker
Utah NSF EPSCoR Acting Director

Utah Experimental Program to Stimulate Competitive Research
650 E 1600 N Logan, UT 84341 (435) 797-2466
www.utepscor.org

WEBER STATE UNIVERSITY

April 25, 2014

To: Utah Division of Water Quality
Attn: Mike Allred
Willard Bay Mitigation Proposals

From: Kevin Hansen
Associate Vice President/Facilities and Campus Planning
Weber State University
2301 University Circle
Ogden, UT 84408
KHansen@Weber.edu

Subject: Weber State University support for the Stormwater Mitigation, Education, and Research proposal

Dear Mike Allred,

I am writing to offer my full support of the proposed Stormwater Mitigation, Education, and Research proposal Dr. Burian and Dr. Bedford are submitting for Willard Bay Mitigation Project funds. We are excited to host four proposed stormwater bioretention gardens because we feel that these gardens align well with our University's goals to provide an excellent educational experience for our students and to be a national leader of sustainability. Further, I look forward to the opportunity to engage water quality managers from across the Wasatch Front in the proposed workshops. Dr. Bedford and Dr. Houdeshel are working closely with myself, the WSU Director of Campus Planning, and the WSU Landscape Manager to identify the optimal locations to install the four bioretention gardens to ensure the success of this project and to ensure the bioretention gardens become a sustainable component of the Weber State University campus after the project ends.

Further, the results of this study will improve our understanding of how different impervious areas contribute to stormwater quality impairment, and we will use these results to guide future stormwater management on the Weber State University campus. We look forward to facilitating construction of the four bioretention gardens, and we will assume responsibility for the management and upkeep of the stormwater gardens at the end of the project.

Sincerely,

Kevin Hansen
Associate Vice President/Facilities and Campus Planning
Weber State University

Facilities Management
2301 University Circle, Ogden, UT 84408-2301 | Ⓟ 801-626-6331 | Ⓕ 801-626-7488

Office of
SPONSORED PROJECTS
VP FOR RESEARCH | THE UNIVERSITY OF UTAH

May 2, 2014

Office of Sponsored Projects
Weber State University
Miller Admin. Bldg. Rm 102
c/o James Taylor

RE: Burian, Steve; University of Utah **Letter of Intent to Enter Into a Sub-contractual Agreement**

To Whom It May Concern;

The University of Utah offers the following information and intends to enter into good faith negotiations toward a subcontract with Weber State University after an award is made for the following proposal:

Prime Sponsor Name: Division of Water Quality
Prime Sponsor Solicitation:
Due Date:
University of Utah PI: Steve Burian
Proposal Title: Developing Guidance for Storm water Bioretention Design, Maintenance, Monitoring, and Adaption in Utah

	Total Budget
Direct	$295,849.00
F&A	$29,585.00
Total	$325,434.00

Contractual contact for subrecipient proposal:

Heidi Harris
Sponsored Projects Officer
University of Utah, Office of Sponsored Projects
1471 E Federal Way
Salt Lake City UT 84102
801-581-4913
Heidi.harris@osp.utah.edu

The proposal budget for our organization is approved

N/A Cost Sharing and /or matching commitments are approved and attached

X A copy of our most recent rate agreement can be viewed at http://osp.utah.edu/resources/quick-reference/fa-rates.php

X We have reviewed all prime agency representations and certifications and by signing this letter, certify to all which are applicable to us.

X We reviewed the prime agency terms as applicable to this proposal and by signing this letter, certify to all which are applicable to us.

X We have a current A-133 audit. The audit results letter with a link to the actual audit can be viewed at: http://osp.utah.edu/resources/quick-reference/audit-report.php

N/A This proposal requires human subjects and our organization has in place all required and approved Institutional Review Board processes.
Compliance # FWA00003745

N/A This proposal requires animals and our organization has in place all required and approved Institutional Care and Use Committee processes.
Compliance # A-3031-01

Regards,

Brent K. Brown
Director, Office of Sponsored Projects

Bioretention

on the University of Utah Campus

A summary of design recommendations from the partnership between the Urban Water Group and the Sustainable Campus Initiative Fund

2014

Department of Civil & Environmental Engineering
THE UNIVERSITY OF UTAH

Sustainable Campus Initiative Fund
SCIF

April 30, 2014

To: Sue Pope
Landscape and Open Space Coordinator
University of Utah Facilities Management

From: Dasch Houdeshel
Dept. of Civil and Environmental Engineering
University of Utah

Subject: Design and Hydraulic Performance of Bioretention at the University of Utah

Dear Sue Pope,

Thank you for your continued support of the efforts to implement bioretention demonstration gardens by the Office of Sustainability and of the students in the Civil and Environmental Engineering Department. Together through the Sustainable Campus Initiative Fund four bioretention gardens that treat runoff from impervious surfaces have been built and studied on campus since 2010. In addition to taking a small step towards a more sustainable campus, three of these gardens have been the subject of two master's theses (Heiberger, 2013; Steffen, 2013) and two peer-reviewed journal articles (Houdeshel et al., 2012; Houdeshel and Pomeroy, 2013). This document highlights the design of these gardens, hydrologic performance, performance of the plants used, and recommendations for future implementation.

This work was made possible by the Urban Water Group Faculty Advisors Dr. Christine Pomeroy and Dr. Steve Burian in the Civil and Environmental Engineering Department as well as student Project Executives Dasch Houdeshel, Thomas Walsh, and John Heiberger. Additional support was provided by Urban Water Group students Jen Steffen, Austin Orr, and Kristianne Sandoval as well as the American Water Resources Association and Water Environment Federation Student Chapters.

For Further information please contact:

Christine Pomeroy
Associate Professor
Civil and Environmental Engineering
Christine.Pomeroy@utah.edu

Dasch Houdeshel
Post-doctoral Fellow
iUTAH Project
D.Houdeshel@utah.edu

Sincerely,

Dasch Houdeshel

Introduction: What is Bioretention?

Bioretention is a new stormwater management practice that utilizes engineered ecosystems to reduce pollutant loading to receiving waters such as Red Butte Creek. Bioretention maximizes water storage in specifically designed gardens so runoff can be infiltrated into the ground or transpired by plants as it would have prior to development. The intent of bioretention is to capture and treat small, frequent storms. Bioretention is not intended to replace large flood control infrastructure, although bioretention can reduce the demands of large conveyance systems as the impervious areas these systems are expected to drain increases with development. Additionally, if bioretention is installed as an alternative to traditional landscaping, implementation of bioretention stormwater management approaches may relieve emerging stress on regional water supply in arid and semi-arid locations by creating an attractive no-irrigation landscaping alternative. However, the majority of previous work that describes the design, function, and benefit of bioretention was conducted in mesic climates that receive 30” to 60” of precipitation annually. The Wasatch front received 14” to 20” of precipitation, most of which falls out of phase with the growing season. The local climate provides unique challenges to designing bioretention capable of sustaining the engineered ecosystems that drive the stormwater treatment.

In collaboration with the University of Utah Office of Sustainability and Facilities Management, students from the department of Civil and Environmental Engineering designed three bioretention gardens that collect stormwater runoff from impervious surfaces on the University of Utah campus. These gardens were designed to function as: 1) stormwater control measures based on 20 years of historical precipitation data, and 2) to promote the growth of regionally-native vegetation <u>without</u> supplemental irrigation in the harsh cold-desert climate of the Wasatch Front. Photos of fully developed bioretention gardens on campus are shown in Figure 1. The date of construction, garden size, and construction costs of the three gardens are listed in Table 1, and the location of these gardens is shown in Figure 2. Hydrologic monitoring equipment was installed in each garden at the time of construction, with different instrumentation installed in each garden to address different hydrologic questions. These questions included:

1) How much rain can the tested design of bioretention contain?
2) How fast does the gravel reservoir empty after a storm?
3) Where does the water from the gravel reservoir go?
4) Does the vegetation need supplemental irrigation?

Figure 1. Established bioretention gardens (SCIF 1 at left, SCIF 2 at right).

Table 1. Reference names, construction date, garden size, contributing impervious areas, and cost for three bioretention gardens constructed on the University of Utah campus.

	Construction Date	Garden area	Drainage Area	Cost
SCIF 1	May 2010	1,800 ft^2	22,000 ft^2	$15,000
SCIF 2	October 2010	1,500 ft^2	1,800 ft^2	$19,000
SCIF 3	April 2012	2,200 ft^2	73,000 ft^2	$20,000

Thanks to the efforts of many graduate students, the Urban Water Group has begun to answer these questions:

1) The Bioretention SCIF 1 garden starts to overflow after 0.9" of rain, but because of the slope the garden was built on, 40% of the gravel reservoir is never utilized (Steffen, 2013).

2) Drain rates vary between Seasons because of the contribution of evapotranspiration by the plants: drain rates are fastest in late spring and early summer.
   - SCIF 1: once full, SCIF 1 takes 6-8 days to drain, depending on season. Infiltration rates were measured to be about 0.5" per hour (Steffen, 2013);
   - SCIF 2: infiltration rates vary greatly within the garden due to heterogeneous soils and ranged from 0.25"/hr to 8"/hr (Heiberger, 2013.

3) The water from the storage layer is: evapotranspired by plants, infiltrated vertically to a depth greater than 12 feet below the storage reservoir, and infiltrated laterally up to 10 feet.
   - For small summer and spring storms, as much as 80% of a single inflow event is likely used by plants; in winter, over 95% of inflow is infiltrated and not used by plants (Steffen, 2013);

- Annually, less than 15% of total inflow is used by the vegetation (Orr, 2013)
- Water infiltrates to 6' below the garden between 24 and 48 hours after an inflow event (Heiberger, 2013);
- Water infiltrated to 12' below the garden between 7 and 14 days after a wetting event (Heiberger, 2013);
- Water saturated soils laterally, or horizontally, to a distance of 10 feet around the basin within 72 hours after an inflow event (Heiberger, 2013).

4) After establishment, vegetation in bioretention needs no additional irrigation.
   - If planed in early spring (before May1) or fall (After Sept 15), vegetation should not need any irrigation except when planting;
   - If planted in summer (May 1 – Sept 15), weekly irrigation is needed for the first few months of establishment but only through the first summer (Houdeshel and Pomeroy, 2013).

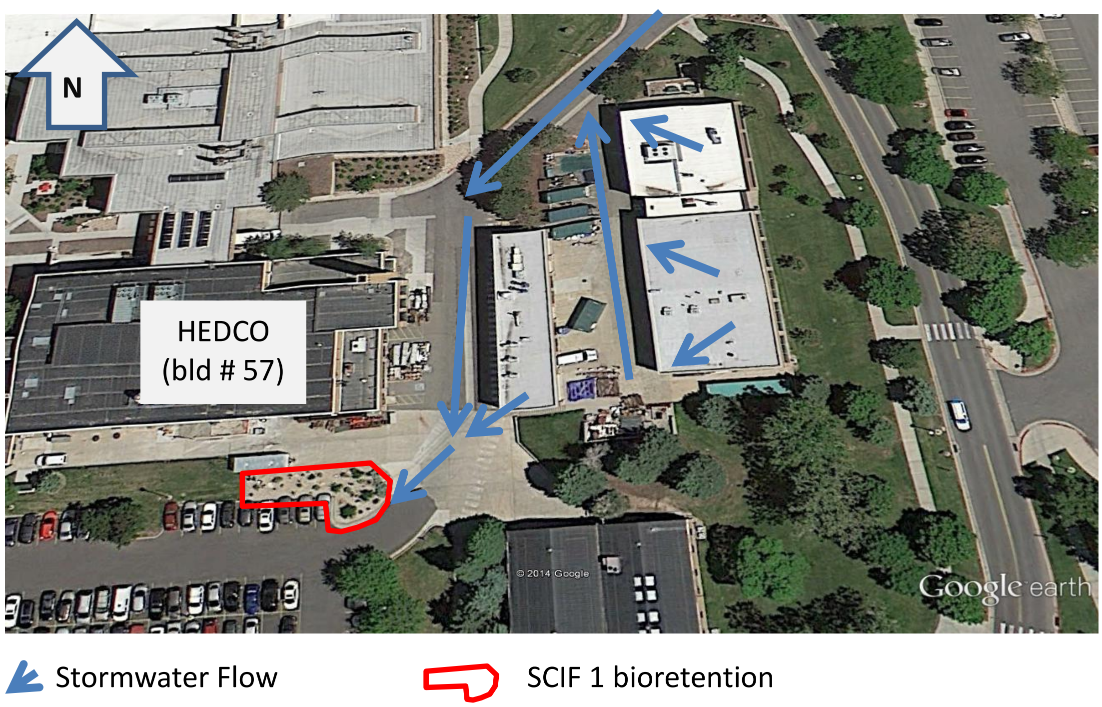

Figure 2a. SCIF 1 garden location on the south side of the HEDCO building.

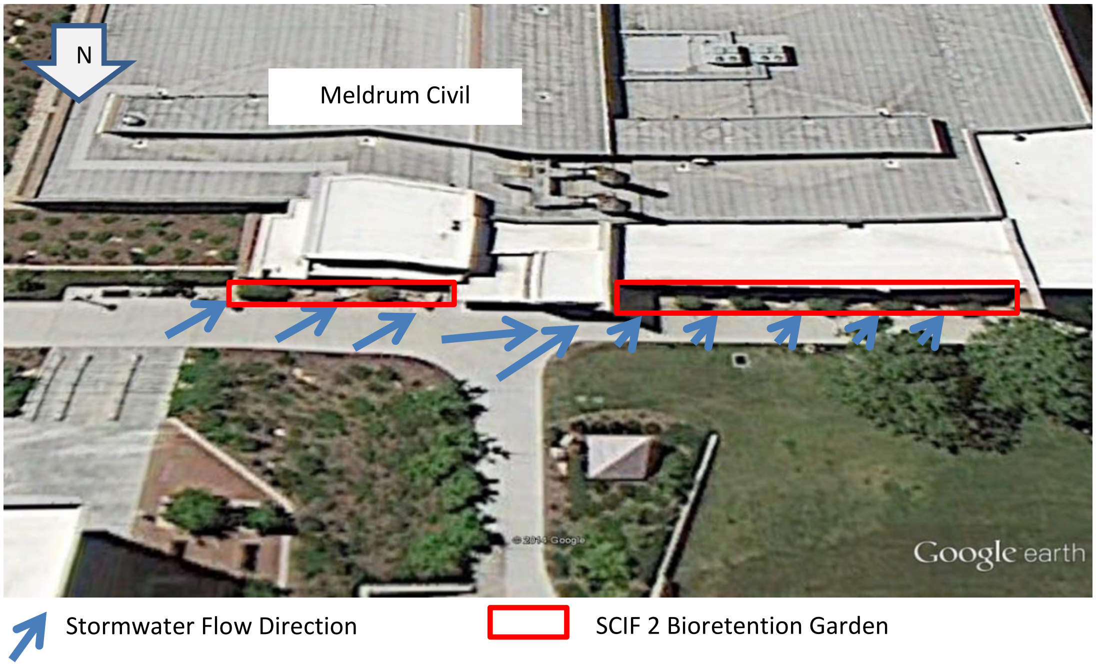

Figure 2b. SCIF 2 bioretention garden located on the north side of the Meldrom Civil and Environmental Engineering Building

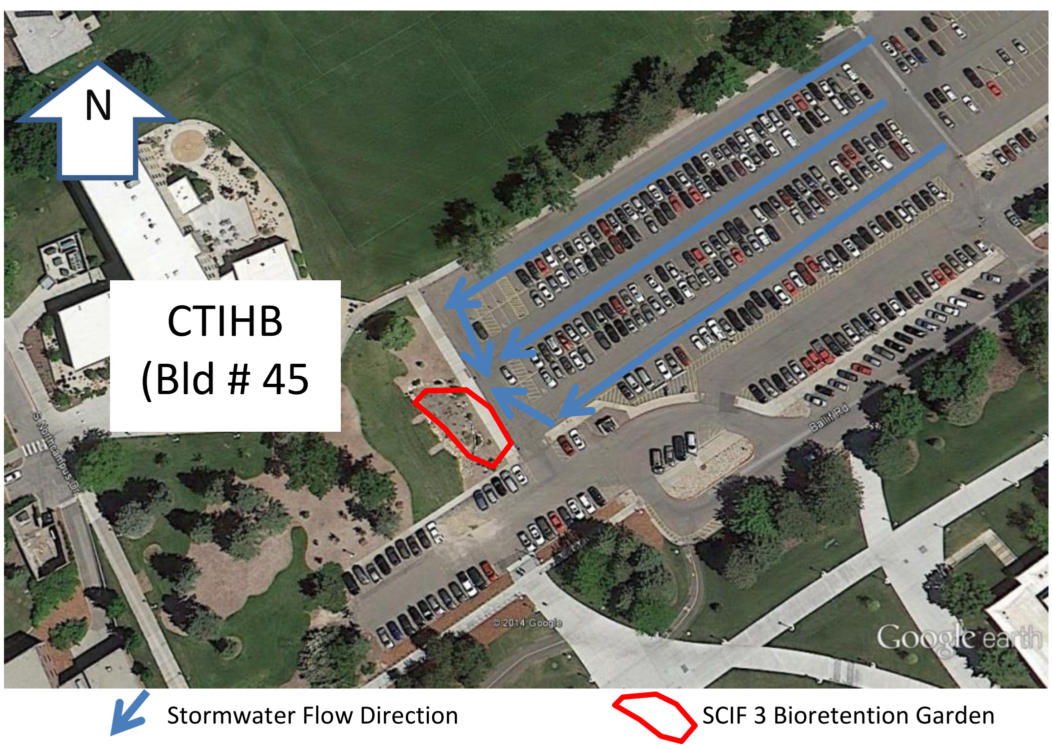

Figure 2c. SCIF 3 bioretetnion garden south-east of the Carolyn Tanner Irish Humanities Building

Bioretention Design for the Wasatch Front

The bioretention design implemented by the Urban Water Group includes, from the bottom up, a 2’ gravel storage layer, a 2’ topsoil layer, weed barrier, and a 3” to 10” decorative gravel on top (Figure 3). These gardens are un-lined on the bottom. The storage layer provides short-term storage volume during and after precipitation and/or melting events to allow infiltration of a large drainage area over a small footprint. The topsoil layer provides a medium for plants to establish during the 1st year, and to develop an extensive web of roots to facilitate nutrient uptake from stormwater. The weed barrier acts to reduce evaporative losses and prevent unwanted weeds that can rapidly deplete soil moisture content. Light-colored decorative gravel is prescribed here instead of mulch to reduce maintenance, fortify the site against damage during flooding, and reduce albedo. Mixtures of sizes, colors, and textures can be used to achieve a desired appearance or architectural objective. Large boulders can also be placed within the facility and curbing can be placed around the facility to protect vegetation against trampling (Houdeshel *et al*., 2012).

Selecting the appropriate vegetation for use in bioretention is critical to the sustainability of the garden. A mixture of regionally native bunchgrasses, shrubs, and trees should be used to insure climate adaptation and physical traits that will insure long-term hydrologic performance. Aspect of the gardens in relation to adjacent buildings is critical to plant selection because the pallet of native drought-tolerant plants that can grow in shady locations is small; likewise, some plants that do well in the shade will not tolerate the temperature extremes of locations adjacent to the south or west side of a building. A list of plants that have been tested in bioretention on the University of Utah campus, including subjective plant survival, is given in Table 2.

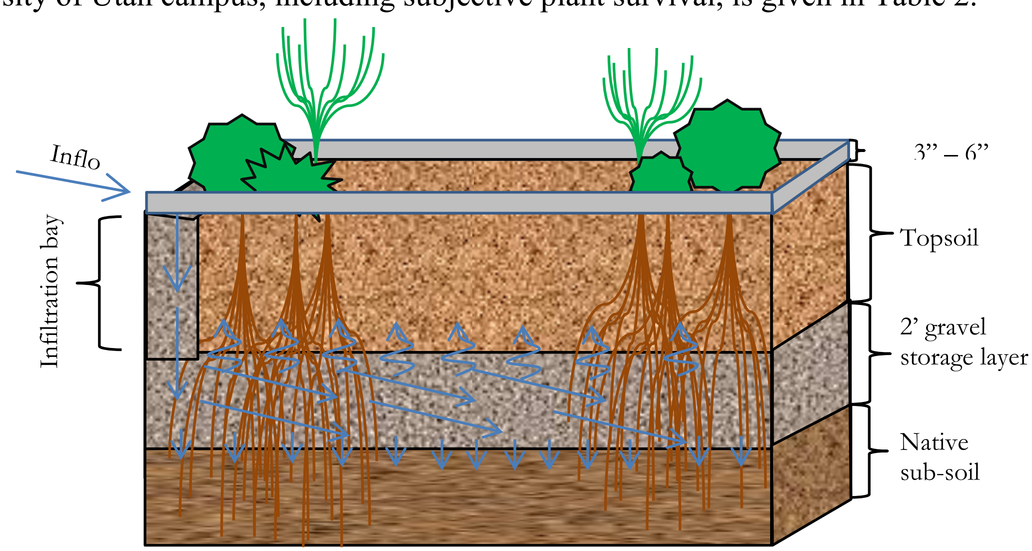

Figure 2. Bioretention design tested by the Urban Water Group on the University of Utah campus

Table 2. Qualitative survivorship or species planted in two bioretention gardens two summers after establishment. The SCIF 1 utilized drip irrigation for the first summer, and receives full sun plus radiation from the adjacent building to the north. SCIF 2 was not irrigated except during planting, and receives partial sun as it is shaded by a building to the north. SCIF 3 was not irrigated except during planting and receives full sun.

Species name	Common name	Form	Garden	Number of Individuals	Performance
Schizachyrium scoparium	Little bluestem	Bunchgrass	SCIF 1	8	★★
Bouteloua gracilis	Blue gramma	Bunchgrass	SCIF 1	8	★★
Sorghastrum nutans	Indiangrass	Bunchgrass	SCIF 1	8	★★
Pascopyrum smithii	Western wheat grass	Bunchgrass	SCIF 1	8	★★★
Rosa woodsii	Wood rose	Shrub	SCIF 2	4	★★
Rhus aromatica	Fragrant sumac	Shrub	SCIF 1 & 2	8	★★
Fallugia paradoxa	Apache plume	Shrub	SCIF 1	2	★
Chrysothamnus nauseosus	Rubber rabbitbrush	Shrub	SCIF 1	6	★★★
Atriplex canesence	Saltbrush	Shrub	SCIF 3	6	★★★
Juniperus osteosperma	Utah juniper	Tree	SCIF 1	2	★★
Cercocarpus ledifolius	Curly mahogany	Tree	SCIF 1	3	★★
Cercocarpus ledifolius	Curly mahogany	Tree	SCIF 2	4	★
Artemisia tridentata	Sagebrush	Shrub	SCIF1	6	0
Cercocarpus montanus	Mountain mahogany	Shrub	SCIF1 & 2	3	★★
Mahonea repens	Hollyleaved barberry	Shrub	SCIF 2	15	★★
Delphinium bicolor	Low larkspur	Flower	SCIF 2	6	★★★
Stanleya pinata	Prince's Plume	Flower	SCIF 3	4	★★

Note: Performance based on qualitative observations of two bioinfiltration gardens. Plant performance key: 0 = died, ★ = survived, ★★ = very healthy, ★★★ = natural recruitment

Recommendations for future implementation

From the information gathered sine 2010 through the use of instrumentation and observation, the following recommendations are suggested for Bioretention garden implementation.

- Bioretention gardens do not require supplemental irrigation after establishment.
- If bioretention gardens are planted before May 1 or after September 15, plants will establish if watered only when planted.
- A bioretention garden surface area should be about 5% of the contributing impervious area.
- Utelite^{tm} brand expanded shale is the preferred medium to use in the gravel storage layer because of its high void space and ability to retain stormwater contaminants.
- If a bioretention garden is installed on a slope, check dams should be incorporated into the design of the storage layer to maximize the effectiveness of the storage layer.
- A forebay at the bioretention garden inlet that is made of 2” to 3” coble that directs the stormwater directly to the below-ground storage layer is imperative to maintaining hydraulic function.
- Forebays should be cleaned annually by removing the fine sediments that accumulate at the inlet to improve appearance and hydraulic function.

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