Project Title: Instruments acquisition to support groundwater research and graduate education at the College of Engineering & Physical Sciences (CEPS), University of Wyoming (UW)

Proposer: Ye Zhang; Professor; Dept. Geology & Geophysics

Total amount requested: 79,715 USD

Project Description:

(1) What is being requested

This proposal requests funding to purchase hydrological field instruments to support groundwater research and education at UW. These purchases will (1) **replace** existing, near-expiration water level sensors and accessories at three groundwater monitoring sites sponsored by past grants; (2) **buy new** hydrological instruments to collect data for research and proposal development. Details on the instruments, their purposes, and their costs are provided in five tables under Budget & Justifications. This proposal does not duplicate previous awards and the proposed instruments do not overlap with existing CEPS infrastructure.

(2) Why it is being requested

Water is important to society and the ecosystem. In the western U.S., growing population and climate change are stressing the region's water supplies. In areas where streamflow is depleted by drought, groundwater is explored as an alternative. At the same time, the West is experiencing forest disturbances and a key forest recovery pathway is linked to groundwater. Since 2014, my research group has drilled, instrumented, and tested groundwater monitoring wells in southeastern Wyoming to gain understanding of groundwater and its dependent ecosystem. At present, 40 wells are monitoring groundwater levels at 8 research sites in the Laramie Range, Snowy Range, and key mountain-front recharge areas in downstream basins. Most of the sites lie in high-elevation areas with limited human impacts, thus the monitored water levels reflect subsurface storage changes in response to climatic and ecological signals. Data and their interpretations are continuously being published by my research group & our collaborators.

The groundwater monitoring program was supported by past grants to my group and a current DOE-funded ecohydrology project in the Snowy Range that I'm leading. In total, ~1.5M has been committed to create this infrastructure. Today, many water level sensors have reached end of life and many accessories are damaged after long deployment. However, funding agencies do not support instrument maintenance which cannot be covered using new grants. Last year, I purchased 7 replacement sensors for one site using my indirect cost fund (IDC) reserved for emergencies. Similarly aged sensors at other sites need to be replaced soon (Tables 1 & 2) and my IDC is insufficient to cover this replacement. Southeastern Wyoming recently sustained a 6-year drought and our water level monitoring data suggest subsurface storage depletion followed by recovery in 2024. To model this multi-year hydrological variability with drought impact, my group is pioneering novel computational approaches integrating AI, remote sensing, and ground-based measurements. Facing climate change, **it is imperative to continue the current monitoring program to provide early drought warnings as well as field data to verify models.**

To be competitive for future grants, I also need to collect data not already being monitored in order to generate results for new proposals. As an example, the DOE-funded ecohydrology project in the Snowy Range has revealed key data needs and new research directions. After the Mullen Fire, seedling growth was found to be rapid on hillslopes next to wetlands. After drilling & instrumenting hillslope wells, we found that hillslope groundwater is modulated by wetland water levels. Because wetlands are protected areas inaccessible to drilling, the DOE project did not budget water level collection there. However, we've since acquired a site permit for collecting

wetland soil cores, thus water level sensors can now be deployed in wetlands. Such data (Tables 1&2) will provide essential information for understanding why forest recovery is robust in these wetland influenced areas. Moreover, novel environmental tracer technologies using dissolved solutes and gases (Tables 3-5) have been developed to allow the tracing of natural water from source precipitation to surface & subsurface sinks including biological pathways. Tracers collected from the current DOE sites will supply key information on plant water uses that will complement the ecohydrological data we're collecting. Joint interpretation of both data types will also improve the estimation of evapotranspiration, a heretofore unresolved problem in the study of headwater hydrology of the western mountains. **The DOE-funded Snowy Range project is well posed for new data collection that will help launch new research.**

(3) How the proposal will benefit CEPS and the Tier 1 Engineering Initiative

1.Excellence in Undergraduate Education: We routinely train undergraduate researchers on the theory, calibration, deployment, and maintenance of hydrological sensors. Undergraduate students have participated in field campaigns that led to paper co-authorships (see pictures from a well test: https://photos.app.goo.gl/umSqaoMsXuSrUCmV7). With investment into the groundwater monitoring program, we can provide new hands-on learning opportunities to students.

2.World-Class Research and Graduate Education: Graduate students will use the instruments and the data generated for cutting-edge groundwater research that will elevate the status of UW and CEPS among peer institutions. To my knowledge, a similar monitoring infrastructure spanning mountains to basins does not exist in the western U.S. However, UW provides no institutional support for this infrastructure which cannot be sustained using my IDC fund. With investment, we can build strength and become a leader in groundwater research in the West, which will help us compete for new grants.

3.Productive Economic Development through Partnerships: Sustainable water resources is a cornerstone for economic development. At one of our monitored sites, the aquifer has been identified for potential development should population growth in Cheyenne outpace its water supply. Since 2015, our partner at the site has been the Cheyenne Board of Public Utilities who are interested in predicting the aquifer's behavior during droughts. The groundwater monitoring program and model results calibrated to site data will prove essential for decision making should Cheyenne develop this resource to support its growth.

4.K-14 STEM Education: Both the monitoring data and the training materials for undergraduate and graduate students can be developed into K-14 course modules to facilitate hands-on learning for students and teachers interested in understanding water resources. Such activities will also strengthen proposals that require projects to have a broader impact. Our research centering on groundwater and dependent ecosystems in southeastern Wyoming can lead to education and outreach activities if investment, as requested here, is made.

In summary, I request funding to continue the groundwater monitoring program in southeastern Wyoming and to collect new data for research and proposal development. The groundwater monitoring program is uniquely suited for studying climate change impacts on water supply and ecosystem. The associated research, education, and outreach will contribute to CEPS' Tier 1 Engineering Initiative. **Investment into this program is needed now**: without it, there will be missed opportunities when data from the monitoring sites are lost or new proposals not written due to the lack of means to replace and purchase the needed instruments.

Budget & Justifications:

The proposed instruments are organized by types and monitoring locations in the following 5 tables (**R**: replacements of expiring instruments; **N**: new instruments):

- Justifications for the instruments are provided under the "Comments" column;
- All vendors have verified UW's tax-exempt status. Some vendors supplied quotes (can provide upon request) while others post prices online to which links are provided;
- Costs of all instruments, including sensors and accessories, do not exceed 5,000 USD individually, thus no equipment purchase is requested;
- The proposed Snowy Range tracer study requires multiple instrument types (Tables 3-5);
- This proposal does not duplicate past awards. The ongoing DOE ecohydrology project only budgeted hillslope drilling in the Snowy Range.

Table 1. Water level loggers organized by the groundwater monitoring location.

Monitoring Sites		Non-vented water level loggers (# units)[*a]	Barologgers (# units)[*b]	Cost (USD)*	Comments
Laramie Range	**R**: Blair Wallis	LevelTroll400 (9)	BaroTroll (1)	895x10=8,950	▪ 9 bedrock monitoring wells: BW1-BW9; ▪ site elevation is similar thus one barologger is requested
Mountain front basin areas	**R**: Belvoir Ranch	LevelTroll400 (16)	BaroTroll (3)	895x19=17,005	▪ 10 riparian wells in the Casper Aquifer outcrop area ▪ 6 stream gauges in the same area
	R: Gov Gulch	LevelTroll400 (4)	BaroTroll (1)	895x5=4,475	▪ 1 single-completion well and 3 depths in a multi-level well
Snowy Range	**N**: site1 (GLEES)	LevelTroll400 (2)	BaroTroll (1)	895x3=2685	▪ 2 wetland soil bores
	N: site2 (Fall Creek)	LevelTroll400 (2)	BaroTroll (1)	895x3=2685	▪ 2 wetland soil bores
	N: site3 (Flemming)	LevelTroll400 (2)	BaroTroll (1)	895x3=2685	▪ 2 wetland soil bores
	N: site4 (Muddy Mtn)	LevelTroll400 (2)	BaroTroll (1)	895x3=2685	▪ 2 wetland soil bores

	N: site5 (Chimney Park)	LevelTroll400 (2)	BaroTroll (1)	895x3=2685	▪ 2 wetland soil bores
Estimated instrument cost*: 43,855 Estimated shipping cost (FedEx Ground)*: 702 Estimated total cost: **44,155**					
*Logger prices for U.S. purchasers not including shipping: https://in-situ.com/us/level-troll-400-data-logger https://in-situ.com/us/barotroll-data-logger *In-Situ shipping rate: https://in-situ.com/us/shipping-rates					

a For the Snowy Range, 2 non-vented water level loggers are requested for each site: one will be located inside wetland and another at the wetland's border with hillslope.

b For non-vented water level loggers, manufacturer recommends a barologger installed every 200 ft change in land surface elevation, thus the number of barologgers needed depends on site condition.

Table 2. Non-vented communication cables for LevelTroll400 loggers listed in Table 1.

Monitoring Sites		Estimated length	Cost (USD)*	Comments
Laramie Range	**R**: Blair Wallis	BW1: 15 m BW2: 15 m BW3: 10 m BW4: 15 m BW5: 15 m BW6: 16 m BW7: 15 m BW8: 16 m BW9: 16 m	BW1: 15 m x (75/m) =1125 BW2: 15 m x (75/m) =1125 BW3: 10 m x (75/m) = 750 BW4: 15 m x (75/m) =1125 BW5: 15 m x (75/m) =1125 BW6: 16 m x (75/m) =1200 BW7: 15 m x (75/m) =1125 BW8: 16 m x (75/m) =1200 BW9: 16 m x (75/m) =1200	▪ Cable length varies and is determined by the depth to water in each well;
	R: Belvoir Ranch	LGC-Casper: 6 m	6 m x (135/m) = 810	▪ Sensor/cable are missing from this well and need to be re-deployed
Snowy Range	**N**: site1 (GLEES)	4 m	4 m x (80/m) x 2 (units)= 640	▪ 2 wetland soil bores
	N: site2 (Fall Creek)	4 m	4 m x (80/m) x 2 (units)= 640	▪ 2 wetland soil bores
	N: site3 (Flemming)	4 m	4 m x (80/m) x 2 (units)= 640	▪ 2 wetland soil bores
	N: site4 (Muddy Mtn)	4 m	4 m x (80/m) x 2 (units)= 640	▪ 2 wetland soil bores
	N: site5 (Chimney Park)	4 m	4 m x (80/m) x 2 (units)= 640	▪ 2 wetland soil bores

Estimated cost*:	15,585
Estimated shipping cost (FedEx Ground):	250
Estimated total cost:	**15,835**
*Prices quoted: 160 USD/m for cable length <4 m; 80 USD/m for cable length 4-6 m; 75 USD/m for cable length 6-16 m	

Table 3. Purge pumps, sampling pumps, and accessories for carrying out an environmental tracer study at high-elevation (>7000 ft a.m.s.l.) sites in the Snowy Range. The official quotes can be provided upon request.

N: Disposable Geotech 2" Geosquirt (portable purge pump) for well development:		
Quoted cost:	175 USD x 10 (unit) =	1,750
Quoted shipping cost:		45
Estimated total cost:		1,795
N: Portable Geotech 2" Bladder Pump & Control Unit & Accessories for well sampling:		
Quoted cost:	4,436 x 1 system (pump, control unit, 4 tubings, 4 bladders, crimp, others) =	4,436
Quoted shipping cost:		125
Estimated total cost:		4,561
Total cost including shipping:		**6,356**

Table 4. Downhole diffusion samplers & accessories for the tracer study in the Snowy Range.

	Monitoring sites	Number of units	Cost (USD)*	Comment
Snowy Range	**N**: site1 (GLEES)	2	754 x 2= 1,508	▪ 1 bedrock monitoring well ▪ 1 wetland soil bore
	N: site2 (Fall Creek)	2	754 x 2= 1,508	▪ 1 bedrock monitoring well ▪ 1 wetland soil bore
	N: site3 (Flemming)	2	754 x 2= 1,508	▪ 1 bedrock monitoring well ▪ 1 wetland soil bore
	N: site4 (Muddy Mtn)	2	754 x 2= 1,508	▪ 1 bedrock monitoring well ▪ 1 wetland soil bore
	N: site5 (Chimney Park)	2	754 x 2= 1,508	▪ 1 bedrock monitoring well ▪ 1 wetland soil bore
Estimated cost*: 7,540 Estimated coolers (5 units) + shipping cost: 704 Estimated total cost: **8,244**				
*Research rates quoted by the U of Utah Gas Laboratories: https://noblegaslab.utah.edu/services-pricing.php Tritium: 316 per sampler Dissolved gases (advanced diffusion sampler): 418 per sampler Airline tubing: 20 Total cost per well/borehole: 754				

Table 5. Downhole electrical conductivity (EC) loggers for the tracer study in the Snowy Range.

	Monitoring sites	Number of units	Cost (USD)*	Comment
Snowy Range	**N**: site1 (GLEES)	1	985 x 1 = 985	▪ 1 bedrock monitoring well
	N: site2 (Fall Creek)	1	985 x 1 = 985	▪ 1 bedrock monitoring well
	N: site3 (Flemming)	1	985 x 1 = 985	▪ 1 bedrock monitoring well
	N: site4 (Muddy Mtn)	1	985 x 1 = 985	▪ 1 bedrock monitoring well
	N: site5 (Chimney Park)	1	985 x 1 = 985	▪ 1 bedrock monitoring well
Estimated cost*: 4,925 Estimated shipping cost: 200 Estimated total cost: **5,125**				
*Price is available at: https://www.onsetcomp.com/products/data-loggers/u24-001				

Summary:

Table 1	44,155
Table 2	15,835
Table 3	6,356
Table 4	8,244
Table 5	5,125
Grand total (requested):	**79,715**