PROJECT PROPOSAL

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Project Number:

1. Project Title: **Advanced Water Treatment Technologies Demonstration**

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3. Statement of Work: See Page 2

4. Duration of the Project: August 22, 2016 to February 21, 2020

5. Specified Deliverable Items:

As described in the Statement of Work

6. Equipment: None

7. Budget and Description: See Page 13

3. Statement of Work

Advanced Water Treatment Technologies Demonstration

A. Introduction and Background

Staff from the Northern Nevada Water Planning Commission, City of Reno, City of Sparks, Truckee Meadows Water Authority, and Washoe County (Regional Team) is jointly developing a feasibility study to evaluate whether the State of Nevada's proposed "exceptional quality" standard for recycled water offers regional long-range water supply benefits. *Exceptional quality* recycled water, achieved through a series of advanced water treatment processes, is being proposed to permit the use of recycled water for groundwater augmentation. The Regional Team envisions a feasibility study occurring over the next 5 years that consists of multiple elements including cost/benefit analysis, regulatory formulation, public engagement, advanced treatment pilot testing, geotechnical investigations, and field scale treatment demonstration projects.

A growing number of national and international communities have developed advanced treated recycled water projects to offer an efficient use of water resources, defer expenditures on future water importation projects, provide a local drought proof water supply, and craft a more resilient total water management strategy. Within the water sector, projects utilizing advanced treatment for recycled water are typically referred to as potable reuse projects. While the Regional Team seeks to develop a more comprehensive assessment through a demonstration-scale groundwater replenishment project, there is no current plan to augment local potable water supplies at full scale. A panel of international water reuse experts is guiding the Regional Team's feasibility phase activities.

Independently, the advanced water treatment investigations would be conducted over the next 3 to 4 years, led by researchers at University of Nevada, Reno (UNR). UNR will develop: the technological justification for selecting the advanced water treatment systems; establish the field scale demonstration project design basis and testing plan; assist acquiring the necessary water treatment equipment; assist during the installation of the demonstration project; conduct startup of the treatment facility optimizing the treatment unit processes; perform monitoring and testing of the operating strategies, process control, and performance parameters during steady state operations; analyze data, and prepare a final report. The specific goals, tasks, and project team are described in this scope document in addition to a tentative project schedule and preliminary budget.

Technological options considered for advanced treatment of recycled water to meet drinking water standards include a reverse-osmosis (RO) based treatment train and a biological filtration based treatment train. The former has the distinct disadvantage of sidestream RO brine disposal for inland regions. Therefore, to meet the study goals, the recycled water will be further treated through a series of advanced water treatment processes, likely including biological activated carbon (BAC) filtration, advanced oxidation, UV disinfection, and soil aquifer treatment (SAT). A further review of the

applicability of this treatment vis-à-vis other alternatives will be explored during the initial stages of this project.

B. Project Goals

The overall goal of the project is to develop two field scale advanced recycled water treatment demonstration projects. Each demonstration project is envisioned to operate 9-12 months. The specific goals are as follows:

1. Develop the plans for scale and sequence of technical components for the field scale demonstration project.
2. Develop operational testing plans including day-to-day operation, monitoring, analytical testing, data analysis and modeling, and risk management for implementation.
3. Develop potential strategies for groundwater augmentation utilizing both infiltration basins and direct injection wells.
4. Operate and collect data, conduct data analysis, and prepare full scale implementation needs report.

C. Project Tasks

In order to achieve the overall project goal and specific goals identified above, UNR will perform the following tasks under this project. The tasks are further outlined below to describe the scope of the study.

C.1. Project Rationale and Justification for Advanced Treated Recycled Water in the Truckee Meadows

a. Review current scenarios/plans of water use/reuse, water resources availability, and recycled water management in the Truckee Meadows region

b. Determine the required level of treating recycled water to meet exceptional quality standards.

c. Identify economic, environmental, and social benefits within the region

d. Conduct triple bottom line analysis of current water management versus the future water management scenario including utilizing advanced treated recycled water meeting exceptional quality standards.

e. Develop a statement of opportunity for recycled water in the region

Deliverables: Produce a vision/planning document based on current scenarios and future needs documenting whether advanced treated recycled water should be implemented for sustainable water management in the Truckee Meadows region.

Task Period: 4 months

C.2. Critical Review of Technologies that can meet Nevada DEP Regulations/ Requirements

a. Review of Draft Nevada Regulations/Requirements
    i. *Develop comments jointly with Regional Team and Expert Panel*
b. Identify Potential Advanced Treatment Options
    I. *RO based Systems*
    II. *BAC based Systems*
    III. *Other Treatment Options*
c. Evaluate Case Studies
    I. *Water Research Foundation Work*
    II. *Pilot Studies*
    III. *Full Scale Facilities*
d. Identify selected alternative treatment train for demonstration project

Deliverables: Produce a Tech Memo of possible alternatives and the selected alternative for a treatment train that can meet the Nevada DEP regulations/ requirements either by infiltration and/or injection into the groundwater.

Task Period: 4 months

C.3. Basis of Design for the Demonstration Project

a. WRF Recycled Water Characteristics
b. Potential Method of Drinking Water Augmentation (injection or infiltration)
c. Treatment Objectives
d. Design Basis of Individual Treatment Units
e. Treatment Train Alternatives
    i. *Process units, sizing, redundancy, configuration, etc.*
    ii. *Includes soil aquifer treatment systems developed in collaboration with hydrologists from TMWA and Washoe County.*
f. Identification and Selection of Commercially Available Unit Operations/Processes for the Selected Treatment Train

Deliverables: Develop the document containing design basis of the demonstration project including process design of the selected train and unit selection. Detailed drawings and non-process design will be conducted by the Regional Team with assistance from UNR.

Task Period: 4 months

C.4. Demonstration System Testing Plan

UNR will prepare a testing plan for the project which will include the following elements:

a. Different demonstration testing phase and the goal(s) and end points of each phase.
b. Operating conditions of each unit and the overall treatment train under each phase
c. Duration of operation in each phase

d. Sampling and monitoring locations
e. Sampling and analysis plan
f. Data validation and QA/QC plan
g. Reporting methodology
h. Safety procedures
i. Troubleshooting protocols.

Deliverables: Produce a testing plan document which will serve as the operating manual for the demonstration project advanced treatment system.

Task Period: 4 months

C.5. Demonstration System Equipment Procurement and Installation

a. Assist the regional team in procurement of equipment and auxiliary services needed for the advanced treatment train
b. Assist the regional team during construction/installation of the equipment, piping, control systems, etc., and ensure all the design criteria are satisfied.
c. Review and keep on file manufacturers information on maintenance, operation, and troubleshooting of equipment

Deliverables: Produce a document that will record all the equipment and supplies procured, any variations to the equipment identified in the design basis document, and keep on file all manufacturers information including any standard procedures (for operation and maintenance).

Task Period: 4 months

C.6. Treatment System Shakedown and Startup

Once the construction of the field scale demonstration system is completed, UNR team will conduct shakedown and startup.

a. Coordinate with each equipment vendor and conduct startup of each unit including any manufacturer training and operational procedures during startup.
b. Conduct treatment train unit process integration and startup of all units in sequence to ensure hydraulic, process, instrumentation and control, and mechanical integrity.
c. Develop any additional information needed for the treatment train operation and maintenance for routine, steady state operation.

Deliverables: Startup of the advanced treatment train of the demonstration system. Modify the operations and maintenance document developed during testing plan development in C.4 to include additional information needed for the operation and maintenance of the treatment train. File containing all manufacturer's information.

Task Period: 2 months

C.7. Steady State Operation of the Treatment Train and Data Collection

a. Filtration Testing & Optimization (Granular Media, Ozone, Membrane & BAC, Advanced Oxidation (Ultraviolet and Peroxide [AOP]), and Disinfection)

UNR will maintain continuous operation of a single (or parallel units) conventional filtration with granular media filter, a single membrane filter, ozone treatment unit, a single biological activated carbon (BAC) filter, and an advanced oxidation process unit. Additional treatment process, such as pretreatment, ultra-filtration, GAC, may also be evaluated based upon the project needs.

Operations should have the flexibility to load the granular medium filters to higher hydraulic loading rates. The impacts of high hydraulic loading rates on filter performance and backwash requirements will be a study objective. Multiple influent turbidity values (high and average) will be tested. UNR team will operate the demonstration system for two years after startup and optimization period, which is expected to occur during the first two months. In addition to testing for exceptional quality standards, routine water quality monitoring such as turbidity, total suspended solids (TSS), total organic carbon (TOC), pH, temperature will be conducted over the course of the testing. The use of fluorescence excitation-emission spectroscopy (FEEM) analytical techniques for organic matter characterization will be evaluated and may be implemented during the course of the study.

Additionally for BAC, the performance of BAC filter will be evaluated by monitoring the reduction and fate of additional water quality constituents such as nitrosodimethylamaine (NDMA) unregulated trace organic compounds, biodegradable ozone byproducts (e.g., aldehydes), and all other parameters identified in the testing plan.

b. Ozonation Testing and Optimization

It is proposed to make use of a single ozone generation system that delivers gaseous ozone feed to multiple injection and contact skids. Optimal ozone dose for each case will be determined by monitoring removal of indicator compounds and formation of byproducts such as bromate. Mitigation strategies for byproducts will be developed, if necessary. Several samples will be taken before and after the ozone unit for a number of analyses including ultra-violet transmittance (UVT), TOC, and indicator screening analysis. Total coliform testing and miscellaneous field measurements (pH, turbidity, etc) will be conducted. On-line monitoring of UVT and TOC may be implemented.

c. Steady-State Operations and Monitoring

The demonstration units will be operated continuously to the extent practicable. UNR will oversee the demonstration system operations and monitoring for approximately two years. During the steady-state period, the optimized ozone dosage will be maintained and the biological activity of the carbon column will be monitored regularly. During this period, UNR will perform routine monitoring and sample analyses, for which frequency and number will be described in the sampling plan.

Quality assurance sampling and testing will occur at the Truckee Meadows Water Reclamation Facility certified laboratory.

It is expected the Regional Team will contract directly with a certified laboratory for more complex or unique analyses, such as for unregulated organic compounds, specific pathogens, and specific compounds identified under Ozone-BAC system monitoring below. UNR will conduct the sampling for these samples and receive the results.

d. Data Analysis

UNR will evaluate the monitoring results and prepare a demonstration test report on the performance of the demonstration system. The report will summarize contaminant removal, system reliability, feasibility, TOC reduction, disinfection performance and byproduct formation, and long-term benefits to the community.

e. Sampling (Throughout Demonstration Testing)

Sampling will be conducted during the entire demonstration system testing from startup to completion. Under this task, UNR will conduct all of the activities outlined in the testing plan.

The following preparation activities will be conducted prior to each sampling event.

- Order required sample bottles and blank water from analytical laboratories.
- Prepare and apply sample bottle labels.
- Prepare chain-of-custody (COC) forms.
- Obtain all necessary equipment specified in testing plan.
- Provide and calibrate field meters.

All samples will be collected as grab samples using clean sampling techniques as specified in the testing plan. Under this task, UNR will conduct the following activities during each sampling event.

- Conduct preparation activities listed above prior to each event.
- Mobilize field team of two people to collect samples per testing plan guidance.
- Package collected samples in coolers with ice.
- Complete COC forms.
- Deliver samples to the analytical laboratory for analysis within maximum allowable holding times.

Clean sampling techniques will be followed during full sampling events, which include avoiding use of sunscreen, cigarettes, fragrances, deodorants, antibacterial soaps, insect sprays and caffeinated products.

f. Sampling and Analysis Plan

A Sampling and Analysis Plan (SAP) will be included in the testing plan prior to the startup of the system. SAP will contain detailed QA/QC program, sampling procedure, sample preservation, holding times, instrumentation calibration procedure and data collection and analysis methods. At

the present, it is anticipated that UNR will conduct all the conventional analyses in-house, and all the advanced analyses will be conducted by an external laboratory contracted separately by the Regional Team. UNR will conduct the sampling and sample delivery to the external lab. UNR will conduct analysis of media microbial ecology from BAC filters.

Potential constituents to be monitored during Optimization and Steady-State Operation include the following shown in Table 1:

Table 1. Potential list of conventional constituents to be measured/monitored and purpose

Constituent	**Advanced Recycled Water Treatment Sampling Location**	**Purpose**
pH/Alkalinity	Influent and Effluent	General Characteristics
Turbidity	Influent and Effluent	Particle Content and Removal
Coliforms, Total and Fecal	Influent and Effluent	Disinfection Efficiency
Conductivity	Influent and Effluent	General Characteristics
Nitrogen Species and Total N	Influent and Effluent	General Characteristics and BAC Efficiency
Phosphate and Total P	Influent and Effluent	General Characteristics and BAC Efficiency
Dissolved Oxygen	Influent and Effluent	BAC Treatment Needs
Dissolved Ozone	Reactor and Effluent	Ozone Dose Determination
BOD/COD	Influent and Effluent	General Characteristics
TOC/DOC	Influent and Effluent	Organic Carbon Content
UV Transmittance	Influent	UV Transmissability for Disinfection
Bromide and Bromate	Influent and Effluent	Disinfection Byproducts

Pathogens, Contaminants of Emerging Concern and Process Monitoring Specific to Ozone-BAC System

BAC performance will be evaluated by monitoring a suite of regulated and unregulated organic compounds (e.g. CECs, TOC, AOC, THMs, HAA, Nitrosamines, Nitrosoamine precursors, DBP formation potential, SUVA, media microbial ecology). CECs monitoring will include a shortlist of indicator compounds including flame retardants (TCEP, TCPP and TDCPP), pharmaceuticals (meprobamate), contrast media (iopromide), NDMA, NDMA precursors, biodegradable organics (formaldehyde and ethyl glyoxal) and THMs (chloroform). CECs, regulated/unregulated organic

compounds, and pathogens will be measured by external laboratory using the samples supplied by UNR.

Additional analyses as required will be conducted to meet regulatory requirements for advanced treated recycled water for infiltration and injection options. UNR is responsible for sample collection and delivery to the external lab as needed.

Preliminary Sampling Plan for the Advanced Treatment Train

Based on the preliminary identification of advanced treatment train for the demonstration project, the following key locations will be sampled for different analyses.

- Influent to the advanced treatment train (State of Nevada Class A reclaimed water)
- Treated water produced by the advanced treatment train
- Intermediate points in the treatment train likely to include effluents from chemical pretreatment, filtration (membrane and/or media), ozonation, biofiltration, advanced oxidation, and disinfection

The sampling frequency for routine process monitoring and unit/system performance (conventional constituent list in Table 1) will be once per week during the advanced treatment train startup and steady state operation. Furthermore, the system will be sampled and monitored for detailed performance under steady state conditions once a quarter for a week during which all parameters will be measured. This sampling campaign will collect at least 3 samples on different days within a week. A detailed sampling plan including frequency of sampling and measurement for pathogens, CECs and specific organic contaminants will be determined during the detailed sampling plan development stage.

Baseline characterization of WRF treated effluent will be conducted by weekly sampling during the period of system shakedown and startup (as in C.6) for determining the level of treatment needed for different regulated and unregulated chemical parameters. Additionally, physicochemical characterization parameters such as pH, alkalinity, temperature, conductivity, turbidity, BOD/COD, TOC/DOC, Nitrogen Species (ammonia, nitrite, nitrate, and total nitrogen/organic nitrogen) and Phosphorous species will be conducted for the WRF effluent (feed to the advanced treatment train).

Deliverables: Quarterly progress reports documenting the performance of the individual units and overall treatment train based on the parameters monitored and measured.

Task Period: 24 months

C.8. Reporting

a. UNR will attend monthly update meetings of the regional team and provide verbal updates to the team about the progress of the tasks.

b. UNR will provide a task report for each task of the demonstration project that UNR is responsible for development and operation. For tasks lasting longer than 3 months, a quarterly progress report will be produced.
c. UNR will review comments provided by the regional team and modify reports with the comments addressed within 30 days after receiving the comments.
d. A final draft report and a final report will be prepared at the end of the project by UNR.
e. UNR will also prepare publications and presentations for conferences and journals, with the approval of regional team.

Deliverables: Progress reports, task reports, final draft report, final report, and presentations and publications.

Task Period: Continuous for the duration of the project

C9. Workshops and Meetings

a. UNR will conduct quarterly project meetings at UNR for the regional team to discuss the progress of the demonstration project.
b. UNR will conduct twice a year workshops with the independent panel to discuss project progress and receive feedback.
c. UNR will conduct once a year workshop with the regional team, other utilities conducting demonstration projects, selected and invited professional community from different agencies and organizations in Nevada and the rest of the country.

Deliverables: Meeting minutes and workshop proceedings that will be documented in progress and other project reports.

Task Period: Continuous for the duration of the demonstration project

D. Project Team

UNR project team will consist of the Principal Investigator, Dr. Krishna Pagilla, PE, two PhD students (likely Vijay Sundaram and Laura Haak), Staff Research Associate, and an undergraduate student assistant. Additional faculty and staff at UNR will be used for unique and supplementary tasks as needed with approval from the Regional Team.

E. Project Schedule

The project schedule for UNR tasks will extend over a period of 3-1/2 years as per the schedule developed for the overall demonstration project shown in Table below. A detailed project schedule for UNR involvement outlining the exact duration of each task described above and the respective deliverables will be developed during the first quarter of the project after the scope has been refined by the Regional Team. Furthermore, the schedule will include some task period overlapping during the early stages of the project.

F. Other Provisions

The following items are potential tasks during the demonstration period and are not included in the scope described above.

a. Simultaneous operation of two advanced treatment trains (same or different) at one site or two different sites
b. Monitoring and testing of samples collected from the injection and/or infiltration sites during SAT
c. Procurement of equipment from different vendors (although UNR will assist in identifying and selecting the equipment) including obtaining quotes and receiving.
d. Detailed design drawings of the demonstration system (civil site, process mechanical, electrical, instrumentation, and others)
e. Installation of the equipment (although UNR will assist during installation) at the demonstration site
f. UNR will provide reasonable assistance to the regional team in other tasks with the overall demonstration project as needed during the overall project duration.
g. UNR will provide assistance to the regional team as needed for regulatory review of the demonstration project by NDEP or other regulatory bodies during the project.
h. Any additional tasks that need to be conducted will be undertaken only after approval from the regional team.