Scope of Work
South Metro Water Supply Authority
Aquifer Recharge Pilot Study

This Scope of Work is divided into four sections as suggested in the Grant Application Instructions. Section 1 provides a description of each major task associated with the project along with a functional description of who will be completing the work and a description of the deliverables associated with the task. Section 2 lists the key personnel proposed for the project along with a brief description of their relevant project experience. Section 3 presents a detailed breakdown of the costs to complete the study and Section 4 presents the proposed Project Schedule.

Section 1 Task Summary

Introduction and Background

In 2004, the Colorado Water Conservation Board (CWCB) completed the Statewide Water Supply Initiative (SWSI). That study included estimates of unmet water demands in the South Platte Basin will be over 40,000 acre-feet in the south Metro Denver area. This 40,000 AFY gap was based on assumption that existing levels of groundwater pumping could continue indefinitely. The southern Metro area relies on non-renewable groundwater supplies from the Denver Basin bedrock aquifers. These groundwater supplies are pumped at rates exceeding recharge, so they are considered non-renewable groundwater supplies. Legally, a large portion of the ground water from the Denver Basin bedrock aquifers is defined as non-tributary.

There has been a dramatic increase in groundwater withdrawals over the past two decades within the south Metro area, which has led to potentiometric surface declines. As a result, one of the key findings from SWSI is that continued reliance on nonrenewable, non-tributary groundwater supplies brings serious concerns over the reliability and sustainability of this supply along the Front Range area.

Water providers in the south Metro area have joined together as the South Metro Water Supply Authority (SMWSA) to coordinate on a variety of activities leading to more sustainable water supplies. In 2004 a study was completed on the effects of future pumping of the Denver Basin bedrock aquifers by south Metro water providers through 2050. This study concluded that substantial investment in new wells will be required just to meet current demands. Alternative sources of supply, including conservation, reuse and conjunctive use (combined surface and groundwater) were recommended as methods to extend the life of the bedrock aquifer supplies. A 2007 study conducted for the CWCB under Senate Bill 06-193 evaluated potential locations for underground water storage. This study identified several areas within the Denver Basin bedrock aquifers that would be good underground water storage locations. Good underground storage areas included most of the SMWSA area.

The SMWSA completed the South Metro Regional Water Master Plan in 2007. This report identified build out water demands, renewable water supply goals and potential sources of renewable supplies. In addition, this study also developed proposed regional infrastructure that will allow delivery of new renewable sources to be stored in surface and groundwater reservoirs. The current study would help the SMWSA evaluate whether aquifers are a viable storage option. The SMWSA members also understand the need to implement strategies to preserve the bedrock aquifers and in September 2007 began discussions on more coordinated management. Current plans include formal arrangements to share equipment, personnel and infrastructure in times of supply emergency, and developing a common resource pool for contracting drilling services.

Through the detailed groundwater studies conducted by CWCB under the South Platte Decision Support System project the SMWSA is also aware, that the bedrock aquifers vary significantly in their yield and impacts within the south Metro area. The SMWSA applied for and received a grant under the auspices of HB-1177 and the Metro Basin Roundtable to conduct a study of existing pumping and aquifers in the region to enable the Authority to more accurately evaluate the likely impacts of continued reliance on the non-renewable groundwater supplies in the south Metro Denver area and to explore more coordinated regional management of this precious resource. One of its member organizations, the Centennial Water and Sanitation District (CWSD) has implemented a successful full-scale aquifer storage and recovery (ASR) program for over a decade on over half of their wells, and others would also like to implement ASR projects. The SMWSA entities understand that a coordinated ASR program is as important as coordinated aquifer pumping. Due to delays in funding the Regional Aquifer Supply Assessment study began in early 2009 and will be completed by spring 2010. To expedite the process the current Aquifer Recharge Pilot Study should begin in summer 2010.

The viability of ASR using high quality water from the Upper South Platte basin has been demonstrated through the successful CWSD operations, thus the objective of this investigation is to assess the suitability of using lower quality, higher TDS water from other sources. Implementation of this program requires identification of a source of available supplemental water, the infrastructure to deliver this water and a proximal well to use for the ASR testing. As part of the current study a series of location and water source specific activities must be undertaken to determine whether ASR is appropriate. These activities include:

- identifying potential wells in which to conduct ASR that are close to infrastructure that can deliver available water;
- determining the piping and other infrastructure needed to implement ASR;
- evaluating geochemical compatibility of the source water and the receiving aquifer to identify pretreatment requirements;

- conducting injection and recovery field tests on the pilot ASR well using water representative of water that is likely to be available to quantify recharge rates, changes in water chemistry and the potential to stabilize or reverse water level declines.

While each of these activities are needed to identify the feasibility of implementing an ASR project at a particular location, the results can be used to streamline and expedite the addition of future ASR wells recharging a similar quality of water to the same aquifer.

The CWSD ASR program has been successful and no adverse impacts to the aquifers or well yields have been reported. The water supply used for the CWSD project has generally been of high quality with relatively low total dissolved solids (TDS) and nutrient content. The source water for future projects envisioned for the SMWSA is unknown and may consist of water obtained from a supply such as potable reuse or water diverted from sources downstream of urban or agricultural areas. The potential for adverse geochemical reactions or microbial growth to occur in the well or adjacent formation can have a significant impact on the success of an ASR project. These potential impacts include but are not limited to:

- mineral precipitation (scaling) on well screens;
- reduction of aquifer permeability and well yield as a result of mineral precipitation and/or swelling of clays in the aquifer formation due to incompatibility of native and injected waters;
- mobilization of constituents in the aquifer materials resulting in water quality degradation during storage;
- microbial growth fouling the injection well or adjacent aquifer materials, and/or resulting in undesirable taste and odor in the recovered water.

Given this background, it is appropriate and opportune for a pilot-scale ASR testing program to be undertaken to evaluate the feasibility of implementing ASR in additional areas within the SMWSA region other than within the CWSD, and using water sources that are variable in quality but more likely to be available in the future for ASR programs.

Study Objectives

The objectives of the study are to:

1. Identify a source of renewable water to be used in a full-scale ASR program.

2. Assess existing infrastructure with appropriate capabilities to deliver this water, and determine wells that could be potentially connected to this water source using existing piping, or requiring minimal new piping.

3. Identify one well within areas identified in the SMWSA Regional Aquifer Supply Assessment study, with access to infrastructure capable of delivering the source water that might be suitable for retrofitting an ASR well. Undertake the necessary evaluations, including engineering conceptual-level design for retrofit, and geochemical analyses on the candidate ASR well to identify their infrastructure and pre-treatment requirements.

4. Undertake the design and construction needed to retrofit the candidate well for ASR pilot testing and associated pretreatment.

5. Conduct pilot-scale ASR testing and evaluate the feasibility of implementing long-term ASR operations with one well.

6. Provide a review of ongoing ASR programs in the Denver Basin and provide recommendations for full-scale implementation of ASR in the south Metro area, including water pre-treatment needs, well preparation and retrofitting, and O&M.

Tasks

This study is divided into three tasks, addressing each of the objectives. The following is a list and description of tasks to be completed under this work plan.

Task 1 Determine Source Water for ASR Program

Several potential sources of water exist for use in pilot-scale ASR testing. The SMWSA Master Plan identified sources of renewable supplies and one of these would likely be available in off-peak times during the non-growing season. The potential sources include Denver Water, under their pilot agreement with SMWSA; East Cherry Creek Valley through their western pipeline; Cottonwood WSD and ACWWA through their new treatment plant on Cherry Creek. Geochemical screening of the range of expected water quality for each of these sources will be done to assess potential issues, such as precipitation or dissolution reactions that may occur in the aquifer to determine its suitability, considering potential treatment or blending opportunities. Since a successful test requires an appropriate source, the infrastructure to deliver the water and a suitable well for the testing, this task will focus on identification of areas where each of the noted sources can be delivered. Wells that could be served by each of these sources will then be evaluated for suitability for the testing program.

Under this task different potential transmission routes will be reviewed to convey the identified source water to the ASR pilot test site. This will include identifying the conveyance routes and necessary infrastructure/connections required to convey water to the ASR well site. Infrastructure and connection requirements to supply this water will be undertaken as part of SMWSA's in-kind contribution to the project.

SMWSA will be working with the consultant to identify sources of a renewable water supply as part of their in-kind contribution. These activities would include providing

data and location information where water would be available to tie into existing infrastructure.

Task 2 Evaluate Candidate ASR Wells

Results from the SMWSA Regional Aquifer Supply study, to be completed by spring 2010, and the results of Task 1 will be used to identify areas from which candidate wells will be evaluated. Criteria for selection of candidate wells within target areas will include but is not limited to:

- the aquifer in which the well is completed and well construction details;
- condition of the well, pump and piping;
- availability of monitoring wells
- ease of retrofitting for ASR operations;
- source(s) of water to be used in the pilot testing;
- proximity of pipelines from which source water can be delivered;
- proximity of power supplies;
- potential benefit to the aquifer in terms of water level recovery;
- geochemical modeling to identify potential reactions between source water and formation water and the associated source water pre-treatment requirements;
- site ownership, access, security, and cooperation of the well owner;
- regulatory and pilot testing permit requirements.

These and possibly other criteria will be used to evaluate and screen candidate wells so that one well will be selected for ASR pilot testing. The results of this task will be documented in a technical memorandum that will include discussion of the site selection criteria and screening, results of geochemical modeling, and identification of the target wells that will undergo pilot testing.

In addition, work under this task will include coordination with the SMWSA entities that currently have an ASR program to further evaluate the potential for full scale ASR in the South Metro Area.

SMWSA entities and their respective consultants will provide additional well information and services to support the evaluation of ASR candidate wells as part of the in-kind contribution.

Task 3 Design and Construction

This task includes the preparation of engineering criteria, drawings, and specifications needed to implement the ASR Pilot testing program. Specific elements will include:

- design documents and technical specifications for temporary piping connections and pumping facilities from recharge water source to pilot treatment unit and from pilot treatment unit to pilot recharge well site , including process schematics and unit treatment process sizing for up to a 0.5 million gallon per day (mgd) flow rate (350 gpm);

- evaluate the need for water pretreatment to meet recharge injection well regulatory requirements and to maximize geochemical compatibility with native groundwater;

- develop conceptual layouts, including a piping and pumping schematic, considering relative locations and infrastructure of pilot water source and pilot recharge well;

- prepare initial and final design documents for ASR injection/pumping, conveyance, and treatment units;

- identify field parameters to be monitored and frequency of monitoring in injection water and in recovered water throughout the operational testing period;

- obtain permits necessary for construction of the source water piping and pumping and operation of the injection well as may be required by the Colorado Division of Water Resources;

- procure construction subcontractors for the source water conveyance to the injection well, pumping and pre-treatment infrastructure and provide engineering guidance and inspection during construction;

- prepare a plan by which the water pumped from the ASR well can be used by the entity during the pilot testing period.

ASR pilot water source will be temporary (used only for duration of pilot test), and therefore will be treated using a temporary (e.g., trailer-based) treatment/water quality adjustment unit to meet recharge standards.

The results of this task will include engineering designs and specifications appropriate for the infrastructure and water quality treatment requirements for each pilot test well, subcontractor bid packages and contracts, and permits.

SMWSA entities and their respective consultants will provide detailed drawings, data and oversight for retrofitting existing water supply wells as a part of the in-kind contribution.

Task 4 Pilot ASR Testing and Regional Evaluation

The pilot testing will be conducted at one location using well completed in a single Denver Basin aquifer, and the results from the pilot test will be evaluated under this task. Previous experience in the region has shown the benefit of conducting multiple cycles of injection and recovery. The pilot test for this study are anticipated to undergo three 3 cycles of injection and withdrawal, with the duration of the injection cycles to be approximately one, two and four weeks. The recharged water will stay in the aquifer for up to twice the duration as the recharge cycle and then will be fully extracted prior to the next injection cycle. Aquifer hydraulics testing will be also be conducted during each injection/recovery cycle by analyzing pumping rates and water levels. Water quality sampling will be conducted each at beginning, middle and end of each recovery cycle for a full suite of drinking water parameters and for other constituents that will provide insight on chemical and biological reactions that may be occurring in the subsurface.

The water quality and hydraulic test data and trends will be evaluated for each pilot test well relative to pre-ASR test conditions and trends prior to its conversion to an ASR well and pilot operations. The analyses will be documented in a technical memorandum that:

- describes the pilot testing observed conditions and trends,
- identifies additional locations with the south Metro area in which ASR operations will be beneficial,
- estimates operational rates, storage and recovery volumes available and ASR costs for each area tested,
- evaluates infrastructure, treatment and O&M requirements for successful ASR in the pilot test areas,

In addition, in this task ASR well performance data from CWSD and potentially from other entities, will be obtained to evaluate the potential for ASR in the South Metro Region. This will include the analysis of readily available data such as: trends in specific injectivity and specific capacity over time, analysis of water quality trends, and maintenance history for ASR wells. Geophysical logs will be examined to assess lithologic characteristics and their relationship to the productivity trends for wells to assist in identifying criteria for selecting candidate wells for ASR.

The data collected from this pilot-scale ASR test and previous ASR testing in the area will be used to assess ASR potential in the region to manage existing and future water supplies. The opportunities and challenges of implementing a regional ASR program as stated in the SMWSA Water Master Plan will be discussed.

SMWSA will coordinate with entities and their consultants to schedule ASR field testing operation and provide technical review of field testing results and report as part of the in-kind contribution.

Deliverables

Technical memoranda will be prepared for each task as described above. The memoranda will provide documentation for the plans, specifications and operations needed to implement ASR projects elsewhere in the Denver Basin bedrock aquifers, thus serving as valuable guidance. The evaluation report will describe the pilot testing and results, providing much needed information to the State and others interested in pursuing ASR activities.

Section 2 Key Personnel

Relevant project experience for the key personnel proposed for the SMWSA Regional Water Supply Assessment are presented in this section.

Michael Smith. – Project Director

Mr. Smith has more than 35 years of experience directing and conducting investigations for water resources, mining, waste disposal, and remediation projects. His project experience has focused on the application of quantitative techniques to solve water resources and environmental problems. This work has included quantification of aquifer characteristics, assessment of recharge and basin safe yield, quantification of stream – aquifer interactions, assessments of well and well field performance, and development of both local- and regional-scale groundwater models. He is a licensed professional geologist in California.

Nicole Rowan, P.E. – Project Manager

Ms. Rowan has over 13 years of experience and is a senior project manager who focuses on water supply, watershed management and natural resources projects. She is the project manager for the Statewide Water Supply Initiative (SWSI) and for CDM's current contract with Colorado Department of Natural Resources (DNR) to provide technical support to the Interbasin Project Compact process. Ms. Rowan is managing the SMWSA Regional Aquifer Supply Assessment study.

Mark McCluskey, P.E. – Project Engineer

Mr. McCluskey has over 11 years of experience and is a project engineer who focuses on groundwater, water supply, and watershed management projects. He is the project manager for the groundwater component of the South Platte Decision Support System (SPDSS) and a project engineer with Colorado Department of Natural Resources (DNR) to provide technical support to the Interbasin Project Compact process. Mr. McCluskey has worked on several water supply and groundwater projects with South Metro entities such as the Town of Castle Rock, Castle Pines North and Castle Pines.

J. Gary Shaughnessy– Project Hydrogeologist

Mr. Shaughnessy has more than 35 years of experience in performing geologic, geotechnical, hydrogeologic, and similar investigations to characterize soil and rock conditions for the purpose of placement, constructing and permitting utility installations, tunnels, landfills, mines, and industrial facilities and for the development, evaluation, protection, and restoration of groundwater and soil resources. Mr. Shaughnessy has also served as resident engineer/scientist on projects involving the construction of tunnels, pipelines and other components of water and wastewater facilities and environmental remediation systems. He is a registered professional geologist (Oregon) specializing in engineering geology.

Since joining CDM in 1979, Mr. Shaughnessy has participated in innumerable geologic, geotechnical, and hydrogeologic investigations and evaluations throughout the United States. Based on project-specific needs, Mr. Shaughnessy has served as project manager, principal investigator, task leader, staff scientist, on-site coordinator for these projects. He has also applied various investigative techniques including geologic mapping by onsite survey, remote imagery, exploratory drilling and sampling of both soil and rock, installation of groundwater monitoring and production wells, water quality sample collection, aquifer performance testing, and surface and downhole geophysical methods. These investigations have encompassed all types of geologic settings and materials, including crystalline and sedimentary rocks, unconsolidated sediments; glaciated terrain; volcanic flows and pyroclastic units; fractured, faulted, and weathered bedrock materials; and manmade deposits. Mr. Shaughnessy is familiar with all aspects of these activities - from planning through implementation, execution and the reporting of results.

James Kriss, P.E. – Project Engineer

Mr. Kriss has 15 years of experience in the civil engineering field and has provided design support and project management for projects including general civil design, hydraulic evaluations, water, wastewater, storm water, and construction management projects. Design experience includes raw and potable water pipelines, pump station design, layout, and configuration, and wastewater treatment plant improvements and modifications. Hydraulic design experience includes modeling of water supply distribution systems, treated water master planning, hydrology, and hydraulics. Construction management experience includes Resident Engineer and General Services support for multiple construction projects. Mr. Kriss served as project manager for design of the District's Northern Water Supply Project Water Transmission Pipeline, involving 31-miles of 48-inch steel pipeline. Mr. Kriss also served as project engineer for the final design of the Western Well Field Connection Project for the ECCV Water and Sanitation District, which involved construction of 42-inch through 4-inch transmission pipelines to connect the existing Western Well field to the Western Pump Station.

South Metro Water Supply Authority Staff and Engineering Support Team

The following South Metro Water Supply Authority staff and support team Engineers/Geologists will be contributing to this project:

- Rod Kuharich
- Britta Strother
- Mark Palumbo
- Curtis Wells
- Courtney Hemenway
- John Halepaska
- Bruce Lytle
- Scott Mefford
- Chris Sanchez

It is anticipated the people listed above will provide expertise, data and analysis as requested by the consultant during the study as a part of South Metro Water Supply Authorities in-kind contribution.

Section 3 Budget

A detailed breakdown of the estimated labor and other direct costs for the proposed project is presented on the following pages. The cost estimates may be revised based as additional information on well locations becomes available; any revisions will be incorporated into the final budget.

The costs associated with ASR pilot testing are developed with the following key assumptions. Other assumptions are listed in the attached budget page:

- one existing well will be selected and retrofitted for ASR operations;
- potable water will be provided by the cooperating entities as part of in-kind cost sharing;
- technical analyses will be conducted concurrently and single technical memoranda will be produced for each task.

Cost Estimates for SMWSA Aquifer Recharge Pilot Study

Updated 7/9/10

Staff Classification and Est. LOE

		Principal		Sr Eng/Geo.		Proj. Eng/Geo		Staff Eng/Geo		Clerical/Drafting			Other	Outside	Total
			$ 200		$ 195		$ 130		$ 100		$ 85	Total	Direct	Professional	Task
Task	Activity	Hrs	Cost	Hrs	Cost	Hrs	Cost	Hrs	Cost	Hrs	Cost	Hrs	Costs	Costs	Cost
Task 1	Identify Recharge Water Sources	8	$ 1,600	16	$ 3,120	40	$ 5,200	40	$ 4,000	8	$ 680	112	100	$ -	$ 14,700
Task 2	Evaluate Candidate Wells	8	$ 1,600	20	$ 3,900	60	$ 7,800	60	$ 6,000	8	$ 680	156	200	$ -	$ 20,180
Task 3	Permitting	8	$ 1,600	24	$ 4,680	40	$ 5,200	40	$ 4,000	20	$ 1,700	132	300	$ -	$ 17,480
Task 3	Retrofit and Piping Design	4	$ 800	20	$ 3,900	50	$ 6,500	50	$ 5,000	40	$ 3,400	164	300	$ -	$ 19,900
Task 3	Construction and Oversight	4	$ 800	20	$ 3,900	40	$ 5,200	110	$ 11,000	20	$ 1,700	194	1000	$ -	$ 23,600
Task 4	Field Testing and Post-Field Analysis	4	$ 800	20	$ 3,900	40	$ 5,200	140	$ 14,000	20	$ 1,700	224	1000	$ 389,000	$ 415,600
Task 4	Reporting and Communications	20	$ 4,000	30	$ 5,850	100	$ 13,000	120	$ 12,000	40	$ 3,400	310	290	$ -	$ 38,540
	Totals	56	$ 11,200	150	$ 29,250	370	$ 48,100	560	$ 56,000	156	$ 13,260	1292	$ 3,190	$ 389,000	$ 550,000

Outside Professional Services (OPs), per well	per well	for 2 wells
Well Evaluation and Rehabilitation (video log, cleaning, test pumping)	$ 56,000	$ 112,000
Retrofit with ASR valve and specialized instrumentation	$ 30,000	$ 60,000
Wellhead Modification and Injection Water Supply Piping	$ 55,000	$ 110,000
Wellhead Water Quality Instrumentation	$ 5,500	$ 11,000
Laboratory Analyses	$ 33,000	$ 66,000
OP contingency	$ 15,000	$ 30,000
Total OPs	**$ 194,500**	**$ 389,000**

Total Engineering Labor	$ 161,000
Outside Professional Services (OPs) for 2 wells	$ 389,000
Total Grant Request	**$ 550,000**

Total Grant Request	$ 550,000
In-kind Match	$ 110,000
Project Total	**$ 660,000**

Costing Assumptions

The evaluations will occur sequentially to allow for a rental ASR valve.
Source water for ASR testing will be potable water and will be available near well
Cost of injection water is not included and will be provided by the cooperating entity
Design injection rate is 350 gpm
Task 2 includes geochemical modeling and water compatibility evaluation, well video and an initial 24-hr drawdown/recovery test
Existing well pump can be used with minimal maintenance/modification; all pump costs will be born by the Cooperating entity
Thorough well evaluation and rehabilitation will be performed prior to pilot testing
Nearby production well can serve as a monitoring well for water levels, no monitoring well needed for water quality.
Source water will be conveyed to well using existing piping from well with tie-in to potable supply
Minimal wellhead infrastructure needed (flush valve, instrumentation, backflow preventer)
Connection of injection well to potable water line (providing injection water to well) and existing water line (from well) requires single excavation
Testing will consist of 3 cycles of injection, storage, and withdrawal, with increasing injection volumes and periods of storage between.final with increasing periods of storage between
Water quality samples to be collected at beginning, middle and end of both injection and recovery cycles for up to 20 samples per well
No discharge permit needed for pumping to waste at beginning of each injection and recovery cycle
Laboratory cost assumes 20 sets of full drinking water parameters, offsite lab

In-Kind Cost Estimates for SMWSA Aquifer Recharge Pilot Study

Updated 7/9/10

South Metro Water Authority Members	In-House		Consultant		Total
	Rate	Hours	Rate	Hours	
South Metro Water Authority	$65	38	$160	20	$5,700
Arapahoe County Water and Wastewater Authority	$65	10	$120	24	$3,500
Castle Pines Metropolitan District	$65	10	$160	18	$3,500
Castle Pines North Metropolitan District	$65	10	$160	18	$3,500
Centennial Water & Sanitation District	$65	70	$160	85	$18,200
Cottonwood Water and Sanitation District	$65	10	$160	18	$3,500
East Cherry Creek Valley Water & Sanitation District	$65	70	$160	85	$18,200
Inverness Water & Sanitation District	$65	10	$160	18	$3,500
Meridian Metropolitan District	$65	10	$160	18	$3,500
Parker Water & Sanitation District	$65	70	$160	85	$18,200
Pinery Water & Wastewater District	$65	10	$160	18	$3,500
Roxborough Park Metropolitan District	$65	10	$160	18	$3,500
Stonegate Village Metropolitan District	$65	10	$140	20	$3,500
Town of Castle Rock	$65	70	$160	85	$18,200
				Total	$110,000

This is the anticipated in-kind estimate for SMWSA member agencies for this project.

SMWSA Aquifer Recharge Pilot Study Schedule

Updated 7/9/10

Task	90 days	180 days	270 days	360 days	450 days	540 days	630 days	720 days
Notice to Proceed								
1. Identify Sources								
2. Identify Wells								
3. Well Retrofitting								
4. Testing and Analyses								

* Schedule based off number of days after receiving the notice to proceed

Section 4 Project Schedule

The proposed project schedule is presented on the following pages. The schedule is presented as yearly quarter from contract inception. It is anticipated that the project will be completed within approximately 2 years (8 quarters), depending on the availability of water for the pilot testing.