

**SUMMARY OF COOPERATIVE STUDIES DURING 2006 AND WORK
PLAN FOR 2007, IN COOPERATION WITH
RAPID CITY, SOUTH DAKOTA**

Prepared for

City of Rapid City

by

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INTRODUCTION

The U.S. Geological Survey (USGS) and the city of Rapid City have had a long-term cooperative relationship to conduct hydrologic investigations to better understand the complex system that supplies water to Rapid City and the surrounding area. Rapid City has become a regional water supplier and demand for water within and beyond the city limits continues to increase steadily due to rapid population growth. As such, sound scientific information is needed to assess the consequences of future development and drought on water supplies and to maintain the delivery of high quality of water. This collaborative study plan is designed to assist the City with hydrologic data and additional interpretive information to better provide a sustainable, high-quality water supply.

City water supplies are obtained from wells completed in the Madison and Minnelusa aquifers, collection galleries in the alluvium along Rapid Creek, and surface water from Rapid Creek. The Madison and Minnelusa aquifers are vital water supplies for Rapid City and the surrounding areas. These aquifers are especially vulnerable to contamination in the Rapid City area because of: (1) bedrock outcrop areas west of Rapid City; (2) direct connections to potential surface contaminants through streamflow loss zones; and (3) fast travel paths through solution-enhanced openings and fractures. Collection galleries in the Rapid Creek alluvium also are supplied in part by springflow originating from the bedrock aquifers. Evaluations related to meeting future water supply demands and protecting these aquifers from contamination requires a better understanding of the characteristics of these important aquifers. These long-term objectives are being accomplished with a variety of hydrologic investigations conducted by the USGS. Funding has been provided through 50/50 cost-share arrangements between USGS and Rapid City.

The following sections provide a summary of activities completed during calendar year 2006, a proposed work plan for 2007, and proposed funding arrangements. Study priorities have been developed through consultation with the Rapid City Public Works Department and can be adjusted, as needed, to best address Rapid City's need for scientific information.

SUMMARY OF 2006 PROGRAM ACTIVITIES

Program activities during calendar year 2006 were divided among four general subject areas. These areas included: (1) hydrogeologic data collection and analysis; (2) ground-water flow path tracing; (3) numerical modeling; and (4) streamflow gaging. Streamflow gaging included support for five different gaging sites, per details provided in last year's work plan.

The hydrologic monitoring component has consisted of water-level monitoring with transducers and recorders at 9 Madison and Minnelusa wells. The decline in water-levels that has occurred recently because of below-normal precipitation slowed somewhat in 2006, especially in areas to the north. Water levels in the City Quarry observation wells, which are completed in the Madison and Minnelusa aquifers and located in northwest Rapid City, were at about the same level in October of 2006 as those observed in October of 2005. Water levels in a Madison observation well located near Jackson Springs declined about 4 feet from the water levels observed during this same time period in 2005. As new wells are completed in the Rapid City area, well information is added to the USGS data base and the wells are evaluated as potential future sampling sites for characterizing ground-water flow in the Rapid City area.

The ground-tracing component during 2006 focused on preparation of two reports describing several ground-water tracers including age-dating, water-quality, and injected dyes. The first report describes age-dating and water-quality tracing information that resulted from sampling 40 wells completed in the Madison aquifer in the Rapid City area. This work was funded in part by the City of Rapid City in cooperation with West Dakota Water Development District (WDWDD) and a grant from EPA. The interpretations in this draft report confirm and define in more detail ground-water flow paths that have been identified in previous ground-water tracer work conducted in cooperation with the city. A draft of this report is ready to begin the review process and will be published in a scientific journal. A second report describing the tracing of dyes injected in Spring Creek and Rapid Creek is in the draft stage and will be published as a U. S. Geological Survey Scientific Investigations Report.

Work continued on documentation of a numerical model for analysis of ground-water flow in the Madison and Minnelusa aquifers in the Rapid City area. Plans are to have a draft of this report ready for review early in 2007. An analysis of water budgets for several sub-regions was added to the documentation to provide insights on how specific zones in the Rapid City area may respond to stresses such as drought and increased withdrawals. A particle tracking program also was linked to the model to analyze ground-water flow directions. Flow directions determined through the ground-tracing efforts were useful in refining estimates of hydraulic properties for the aquifers.

PROPOSED WORK PLAN FOR 2007

Proposed program activities during calendar year 2007 are discussed in the six headings listed below and a planned funding distribution is listed in table 2 at the end of this discussion. Two additional categories of work (Items 5 and 6) have been added for consideration during 2007 based on preliminary discussions with City staff, including: (5) Reconnaissance Sampling for Taste and Odor Causing Organisms, and (6) Ground-water Tracing Methods for Assessment of Source Water Risk in a Karst Aquifer with Large Potential for Direct Surface-Water Influence. Item 5 would provide information that could be useful in evaluating the development of additional surface-water sources. Item 6 would involve another partnership with WDWDD to provide partial funding for a study primarily funded by a grant obtained from the Environmental Protection Agency (EPA). This work is relevant to assessing the vulnerability of potential new well production sites and evaluating requests to supply water to adjacent subdivisions. Consultation and program updates will be conducted during the year with City staff and adjustments in funding distribution may be made to best meet the needs of the City.

(1) Hydrogeologic Data Collection and Analysis

Daily water-level monitoring will be continued at the same 9 observation wells completed in the Madison and Minnelusa aquifers. New wells completed in the Madison and Minnelusa aquifers will be inventoried and entered into the USGS data base. Site visits will be made to determine accurate locations, land-surface and water-level altitudes, and characterize the wells as potential sampling sites for ground-water tracers.

Some additional data collection could be considered when production well RC-12 comes on line. Potential efforts could include aquifer testing and collection of ground-water tracer information. Funding for this activity is not included in the preliminary funding breakdown for 2007; however, adjustments in other activities could be made to accommodate such work, through consultation with City staff.

(2) Ground-water Tracers

Ground-water tracing efforts will include publication of two reports described previously in the 2006 summary: a USGS scientific investigations report that documents dye tracing results in the Rapid City area and a journal article that documents the analysis of flow paths based on interpretation of age-dating parameters, specific conductance, and nitrate. Additional

interpretations could be made from ground-water tracer and geochemical data in relation to Rapid City production wells. Potential publications include a scientific journal article that describes a mixing model that characterizes ground-water sources and residence times for Rapid City wells in more detail.

(3) Numerical Modeling

The focus of the numerical modeling efforts during 2007 will be on completing the publication of a USGS report documenting calibrated steady state and transient models of the Madison and Minnelusa aquifers. The analysis of ground-water flow conditions and water budgets described in the report will be a useful resource for consideration in development of the City's Utility System Master Plan. Future uses of the model would include evaluating areas where limitations may exist for increased large-scale production wells and assessing effects of drought.

(4) Streamflow Gaging

Streamflow gaging at five locations (Rapid Creek below the Sewage Plant, Rapid Creek near Farmingdale, Rapid Creek at Jackson Boulevard, Rapid Creek below Pactola Dam, and Rapid Creek below Deerfield Dam) will be partly funded in water year 2007 by the cooperative agreement with Rapid City, which is similar to the 2006 agreement. Partial funding for an additional site (Rapid Creek at Rapid City) was added to the funding table (table 1) for 2007. This site, which has a long-term record, has previously been funded entirely by the Corps of Engineers (COE). However, COE will fund only one-half of the cost of operation of this gage in water year 2007. USGS plans to contribute \$3,250 from an expected increased in our National Streamflow Information Program (NSIP). Therefore, we are requesting from the City \$3,250 or 1/4th of the cost of the gage operation for the Rapid Creek at Rapid City gage.

Total funding from the City for the gaging program would consist of \$19,329 that would be matched with \$16,079 in Coop matching funds from USGS, plus \$3,250 from the USGS' NSIP program. Additional funding from other cooperative arrangements also is shown in table 1.

Table 1. Proposed funding distribution for streamflow gages for water year 2007 including contributions from Rapid City, other cooperators, and USGS.

Rapid Creek at Rapid City					
	Unmatched Federal Funding	State and Local Cooperators	USGS match		
U.S. Corp of Engineers	\$6,500				
Rapid City		\$3,250			
Subtotals	\$6,500	\$3,250	(1)	\$9,750	
Rapid Creek below Sewage Plant					
		State and Local Cooperators	USGS match		
Rapid City		\$6,500	\$6,500		
Subtotals		\$6,500	\$6,500	\$13,000	
Rapid Creek near Farmingdale					
		State and Local Cooperators	USGS match		
DENR		\$3,250	\$3,250		
Rapid City		\$3,250	\$3,250		
Subtotals		\$6,500	\$6,500	\$13,000	
Rapid Creek at Jackson Boulevard (telemetry and stage record)					
		State and Local Cooperators	USGS match		
Rapid City		\$2,127	\$2,127		
Subtotals		\$2,127	\$2,127	\$4,254	
Rapid Creek below Pactola Dam and below Deerfield Dam (two gages)					
	Unmatched Federal funding	State and Local Cooperators	USGS match		
USBR	\$5,602				
Rapid City		\$4,202	\$4,202		
SDGF&P		\$2,100	\$2,100		
RVWCD		\$2,100	\$2,100		
Subtotals	\$5,602	\$8,402	\$8,402	²\$22,406	
Summary of Funding for all Gages					
Gage	Rapid City	Unmatched Federal funding	State and Local Cooperators	USGS Match	Gage Total
Rapid Creek at Rapid City ¹	\$3,250	\$6,500		(1)	\$9,750
Rapid Creek below Sewage Plant	\$6,500			\$6,500	\$13,000
Rapid Creek near Farmingdale	\$3,250		\$3,250	\$6,500	\$13,000
Rapid Creek at Jackson Boulevard	\$2,127			\$2,127	\$4,254
Rapid Creek below Pactola and Deerfield ²	\$4,202	\$5,602	\$4,200	\$8,402	\$22,406
Total Funding	\$19,329	\$12,102	\$7,450	\$23,529	\$62,410

¹Total annual operating costs are \$13,000 for the Rapid Creek gage at Rapid City. USGS Coop matching funds are not available for this gage; however, funding of \$3,250 will be provided by USGS from the NSIP program.

²Total annual operating costs are \$13,000 for the gage below Pactola Dam and \$9,406 for the gage below Deerfield Dam, which is only operated during March through September.

(5) Reconnaissance Sampling for Taste and Odor Causing Organisms

Micro-organisms are present in some natural water and streambed sediments that can cause taste and odor problems when the water is chlorinated and finished for drinking water. During periods of high water demand, primarily during the irrigation season, Rapid City augments its ground-water supply with surface-water from Rapid Creek. Taste and odor problems have occurred in the past in Rapid City (1988 and 1999). Canyon Lake and the Cleghorn Springs Fish Hatchery were suspected sources or at least contributing factors. Many cities have similar problems and upon investigation found the production of geosmin and 2-methyl isoborneol (MIB) to be the causal organisms. The primary sources of geosmin and MIB are cyanobacteria, also known as blue-green algae. A reconnaissance effort is proposed for 2007 and 2008 that would characterize the presence of known taste and odor causing bacteria such as cyanobacteria. Sampling would occur at several locations along Rapid Creek and within Canyon Lake. The decommissioning of the Cleghorn Springs Fish Hatchery for the next two years (2007-2008) during reconstruction provides an excellent opportunity to discriminate and isolate potential sources. Samples would be collected seasonally in order to determine if these organisms are present, and to determine if geosmin or MIB are present at levels that could cause taste and odor problems. The funding for this activity (table 2) assumes that three sample sets will be collected in FY07.

(6) Ground-water Tracing Methods for Assessment of Source Water Risk in a Karst Aquifer with Large Potential for Direct Surface-Water Influence

This study is being initiated in cooperation with WDWDD, and objectives of the study are to (1) evaluate continuous temperature monitoring as a potential indicator of fast flowpaths connecting sinking streams to wells completed in the Madison aquifer; and (2) to develop improved methods to estimate the mixing proportions of young and old ground water over varying time scales based on fluorescent dye, temperature, and CFCs. Three public supply wells just beyond the Rapid City limits have been identified as having direct connections to Spring Creek from previous dye testing conducted in cooperation with the City of Rapid City and WDWDD. Examination of limited existing temperature data for these wells indicates that ground-water temperatures may correlate strongly with surface-water temperature in Spring

Creek, and additional data would be extremely useful for identifying and characterizing possible relations. Also, implementation of the Environmental Protection Agency's Ground Water Rule could potentially affect some wells completed in the Madison aquifer and result in treatment requirements that would be difficult for small water systems to implement. Future monitoring requirements at sites with direct connections could increase requests for the City of Rapid City to become a regional water supplier.

Gross funding for this tracing methods study of \$120,000 is partly funded by a grant from the Environmental Protection Agency to West Dakota Water Development District (WDWDD) for \$32,897. WDWDD is supplying an additional \$12,303. A funding contribution of \$12,300 is requested from the City of Rapid City. These three amounts would be matched by a contribution from the USGS of \$57,500. An additional in-kind contribution of \$5,000 would be provided by WDWDD for administrative services.

PLANNED FUNDING BREAKDOWN FOR 2007

A preliminary breakdown of approximate funding allocations among planned program activities is listed in table 2. Planned work efforts and associated funding are to be on a calendar year basis for 2007, with the exception of Item 4 (streamflow gaging), which will be for water year 2007 (Oct. 1, 2006 through Sept. 30, 2007). A 50/50 cost share between Rapid City and USGS is identified for all program components except Item 4 (streamflow gaging), for which an effective 50/50 cost share also is accomplished through the NSIP funding provided by USGS (as footnoted in tables 1 and 2). This preliminary distribution of program funding is subject to modification during 2007, depending on possible changes in priorities established through discussions with Rapid City staff.

Table 2. Preliminary planned breakdown of funding allocations for 2007

Item number	Proposed activity	Rapid City share	USGS share	Total
1	Hydrogeologic data collection and analysis	\$14,371	\$14,371	\$28,742
2	Ground-water tracers	\$30,000	\$30,000	\$60,000
3	Numerical modeling	\$35,000	\$35,000	\$70,000
4	Streamflow gaging ¹	\$19,329	\$16,079	\$35,408
5	Reconnaissance sampling for taste and odor causing organisms	\$27,000	\$27,000	\$54,000
6	Ground-water Tracing Methods for Assessment of Source Water Risk in a Karst Aquifer with Large Potential for Direct Surface-Water Influence	\$12,300	\$12,300	\$24,600
Totals to be shown on Joint Funding Agreement		\$138,000	\$134,750	\$272,750

¹ Additional funding of \$3,250 for the streamflow gaging program will be provided by USGS through the NSIP program, to accomplish an effective 50/50 match.