2017-143

Form 9-1366
(April 2015)

U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

JOINT FUNDING AGREEMENT

Customer #:	6000004118/AZ090
Agreement #:	17CMAZ00500
Project #:	ZF00FMN
TIN #:	86-6000257
Fixed Cost Agreement	YES

FOR

WATER RESOURCES INVESTIGATIONS

THIS AGREEMENT is entered into as of the, 4th day of October, 2016 by the U.S. GEOLOGICAL SURVEY, UNITED STATES DEPARTMENT OF THE INTERIOR, party of the first part, and the CITY OF PRESCOTT, party of the second part.

1. The parties hereto agree that subject to availability of appropriations and in accordance with their respective authorities there shall be maintained in cooperation a programfor geochemistry work in the Big Chino Sub-basin as described in the attached workplan, herein called the program. The USGS legal authority is 43 USC 36C; 43 USC 50; and 43 USC 50b.

2. The following amounts shall be contributed to cover all of the cost of the necessary field and analytical work directly related to this program. 2(b) includes In-Kind Services in the amount of $0.00 .

   (a) by the party of the first part during the period

Amount	Date	to	Date
$0.00	October 1, 2016		September 30, 2019

   (b) by the party of the second part during the period

Amount	Date	to	Date
$202,810.00	October 1, 2016		September 30. 2019

   Total = $202,810

   (c) Contributions are provided by the party of the first part through other USGS regional or national programs, in the amount of: $0.00

   Description of the USGS regional/national program:

   (d) Additional or reduced amounts by each party during the above period or succeeding periods as may be determined by mutual agreement and set forth in an exchange of letters between the parties.

   (e) The performance period may be changed by mutual agreement and set forth in an exchange of letters between the parties.

3. The costs of this program may be paid by either party in conformity with the laws and regulations respectively governing each party.

4. The field and analytical work pertaining to this program shall be under the direction of or subject to periodic review by an authorized representative of the party of the first part.

5. The areas to be included in the program shall be determined by mutual agreement between the parties hereto or their authorized representatives. The methods employed in the field and office shall be those adopted by the party of the first part to insure the required standards of accuracy subject to modification by mutual agreement.

6. During the course of this program, all field and analytical work of either party pertaining to this program shall be open to the inspection of the other party, and if the work is not being carried on in a mutually satisfactory manner, either party may terminate this agreement upon 60 days written notice to the other party.

7. The original records resulting from this program will be deposited in the office of origin of those records. Upon request, copies of the original records will be provided to the office of the other party.

8. The maps, records, or reports resulting from this program shall be made available to the public as promptly as possible. The maps, records, or reports normally will be published by the party of the first part. However, the party of the second part reserves the right to publish the results of this program and, if already published by the party of the first part shall, upon request, be furnished by the party of the first part, at costs, impressions suitable for purposes of reproduction similar to that for which the original copy was prepared. The maps, records, or reports published by either party shall contain a statement of the cooperative relations between the parties.

9. USGS will issue billings utilizing Department of the Interior Bill for Collection (form DI-1040). Billing documents are to be rendered quarterly. Payments of bills are due within 60 days after the billing date. If not paid by the due date, interest will be charged at the current Treasury rate for each 30 day period, or portion thereof, that the payment is delayed beyond the due date. (31 USC 3717; Comptroller General File B-212222, August 23, 1983).

	U.S. Geological Survey United States Department of the Interior		City of Prescott
	USGS Point of Contact		**Customer Point of Contact**
Name:	James M. Leenhouts	Name:	Leslie Graser, Water Resource Manager
Address:	520 N. Park Ave., Suite 221 Tucson, AZ 85719	Address:	201 S. Cortez Prescott, AZ 86303
Telephone:	520-670-6671 x278	Telephone:	928-777-1144
Email:	leenhout@usgs.gov	Email:	leslie.graser@prescott-az.gov

Signatures and Date

Signature:	James M. Leenhouts 10/4/16	Signature:	
Date:		Date:	
Name:	James M. Leenhouts	Name:	~~Craig V. McConnell~~ Michael Lamar
Title:	Director	Title:	City Manager

Workplan to Collect Geochemical Data for an Improved Understanding of Recharge Location, Water Rock Interactions and Groundwater Residence Time in the Big Chino Sub-basin, Central Arizona

Prepared by: Kimberly Beisner, Alissa Coes, Don Pool, Jim Leenhouts
Date: August 23, 2016

Problem Statement

The future effect on flows in the Verde River from planned groundwater withdrawals in the Big Chino area to supply water to neighboring communities is uncertain. We know from fundamental principles that the effect will depend upon the locations of and rates of withdrawals and properties of the various aquifers in the region and how those aquifers are connected to one another and to the Verde River. Improved definition of: aquifer properties, interconnection between aquifers, and connection with the Verde River are needed before the effects of future withdrawals can be assessed with an acceptable degree of uncertainty. This uncertainty can be reduced through collection of data that better defines the characteristics of and connections between aquifers. Two types of data that provide independent but complimentary knowledge are hydrologic monitoring and geochemical analysis.

Hydrologic monitoring helps determine directions and amounts of flow, locations of discharge, aquifer properties, and responses of aquifers to imposed stresses. Geochemical assessment aids in understanding the sources and flowpaths of groundwater through analysis of chemical composition changes as it is transported from recharge areas, mixes with water from other recharge areas and aquifers, and discharges to the Verde River.

To understand the geochemical evolution of the groundwater, the geochemical signature of groundwater in the region needs to be documented in several recharge areas, various aquifers, and along groundwater flow paths as it moves toward the Verde River or other discharge locations. Therefore, the purpose of the proposed geochemical investigation is to develop an improved understanding of the sources and flowpaths of groundwater that discharges to and supports the base flow of the Verde River and other discharge locations.

The geochemical signature of each aquifer in the Big Chino sub-basin and how each aquifer contributes to flow at the headwaters of the Verde River is not well understood. Current understanding of the system includes knowledge of a basin fill aquifer which locally includes basalt flows and a confining layer that overlie a Paleozoic sedimentary aquifer. The Paleozoic sedimentary aquifer extends into the mountains surrounding Big Chino Wash where it may receive recharge. The mechanism and elevation of recharge to the Paleozoic sedimentary aquifer is not well understood. Nor is the location and timing of the recharge to the basin fill aquifer well understood. Improved understanding of each of these components of the aquifer system will help constrain both conceptual and numerical representations.

Relevance and Benefits

The results of this study will provide geochemical characterization of the aquifers in the Big Chino sub-basin that will indicate recharge elevations, water-rock interaction indicating groundwater flow paths, and groundwater residence times using the best available methods. Differences between aquifers and changes along groundwater flowpaths can indicate aquifer connectivity within the system. Stakeholders will also have a better understanding of hydrologic data needs through the spatial differences in groundwater geochemistry. Accordingly, the water-resource planning capabilities of federal, state, and local governmental agencies and offices with a stake in the upper and middle Verde Watershed area will benefit. The content of the work is consistent with and supports USGS Bureau Science Strategy *A Water Census of the United States: Quantifying, Forecasting, and Securing Freshwater for America's Future* in USGS Circular 1309: Facing Tomorrow's Challenges—U.S. Geological Survey Science in the Decade 2007-2017.

Approach

Previous studies have used major ion and stable isotope information to understand aspects of the groundwater system, but these do not provide a sufficient overall understanding of the system. This study proposes using a suite of geochemical analyses (noble gases, carbon-14, tritium, major ions, redox parameters, arsenic, stable and strontium isotopes) to gain an enhanced understanding of the geochemical signature of the aquifers present in the study area and how they contribute to the geochemical signature at the Verde River headwaters. Several well and spring sites have been sampled between 2011 and 2015 for the suite of geochemical analyses presented above and the stable isotope values for these sites are shown in figure 1. Additional samples from wells or springs will be collected in the following areas: the Paleozoic sedimentary aquifers upgradient to the northeast and southwest of Big Chino Wash, the Juniper Mountains, Big Black Mesa including Partridge Creek, Little Chino basin the area northeast of Paulden, between the wells at Big Chino Water Ranch and Paulden, in the basin fill aquifer along Big Chino Wash, the limestone aquifer near Hell Canyon, near Williamson Valley Wash and at the Upper Verde Springs.

The specific geochemical tasks for this study include sampling for stable isotopes and noble gases at groundwater (wells and springs) and streams. Specifically, the following analytes will be included in the geochemical analysis: water quality parameters (water temperature, pH, specific conductance, dissolved oxygen, oxidation reduction potential), major ions including alkalinity, nitrate, nitrite, ferric and ferrous iron, sulfide, arsenic, stable isotopes of oxygen and hydrogen, strontium isotopes, carbon-14, tritium, and noble gases including radon. Samples will be analyzed at the same laboratories as previously collected samples and labs are specified in table 1.

To fill in the data gaps, 7 groundwater samples will be collected in summer 2017 and then 7 additional samples will be collected in summer 2018. The Upper Verde Springs and the USGS Verde River near Paulden gage (09503700) will be sampled in summer 2017 and 2018 as well for a total of 16 groundwater samples and 2 surface-water samples.

Periodic monthly sampling of stable isotopes in baseflow at the USGS Verde River near Paulden gage helps to define variations in sources of groundwater discharge to the river caused by variations in

climate and recharge or well withdrawals. Continued sampling at the Paulden stream gage is part of the proposed geochemistry work and samples from the USGS Williamson Valley Wash gage (09502800) will be added to the sampling plan.

The challenges in collecting representative groundwater samples are obtaining permission from land owners, identifying the type of pump present at the site (pumps that introduce air into the sample result in bad dissolved gas samples), and if no pump is present the depth to water needs to be less than 250 feet for us to use our portable submersible pump. We have the option to contract with a drilling organization to obtain a pump that can pump deeper than 250 feet if needed, but the cost will be greater.

Quality Assurance

Replicate, and blank samples will be collected in accordance with the USGS National Field Manual for the Collection of Water-Quality Data (USGS, variously dated) with the types and amounts outlined in table 1. A replicate and field blank will be collected during the 2017 and 2018 sampling seasons. Two replicates of stable isotopes at USGS gage sites will be collected each year for 2017-2019. Blank data will be combined with previous field blanks to understand concentrations of major ions and arsenic in the sampling equipment relative to environmental concentrations. Replicate data will also be combined with previous replicate data to quantify the variability of measured constituents.

Table 1: Quality assurance sample collection plan

Analyte	Analyzing Laboratory	Replicate		Blank	Total QAQC Samples		Total Environmental Samples	
Water Quality Parameters	USGS field measurement	2		2 (specific conductance)	4		18	
Major Ions, redox and Arsenic	USGS National Water Quality Laboratory	2		2	4		18	
Stable Isotopes ($\delta^{18}O$ and $\delta^{2}H$) – gage samples separated	USGS Reston Stable Isotope Laboratory	2	6	--	2	6	18	60
Strontium Isotopes	USGS Metal Isotope Lab (Menlo Park, CA)	2		--	2		18	
Carbon-14 and $\delta^{13}C$	Woods Hole (USGS contract)	2		--	2		18	
Noble Gases and Tritium	USGS Noble Gas Laboratory	2		--	2		18	

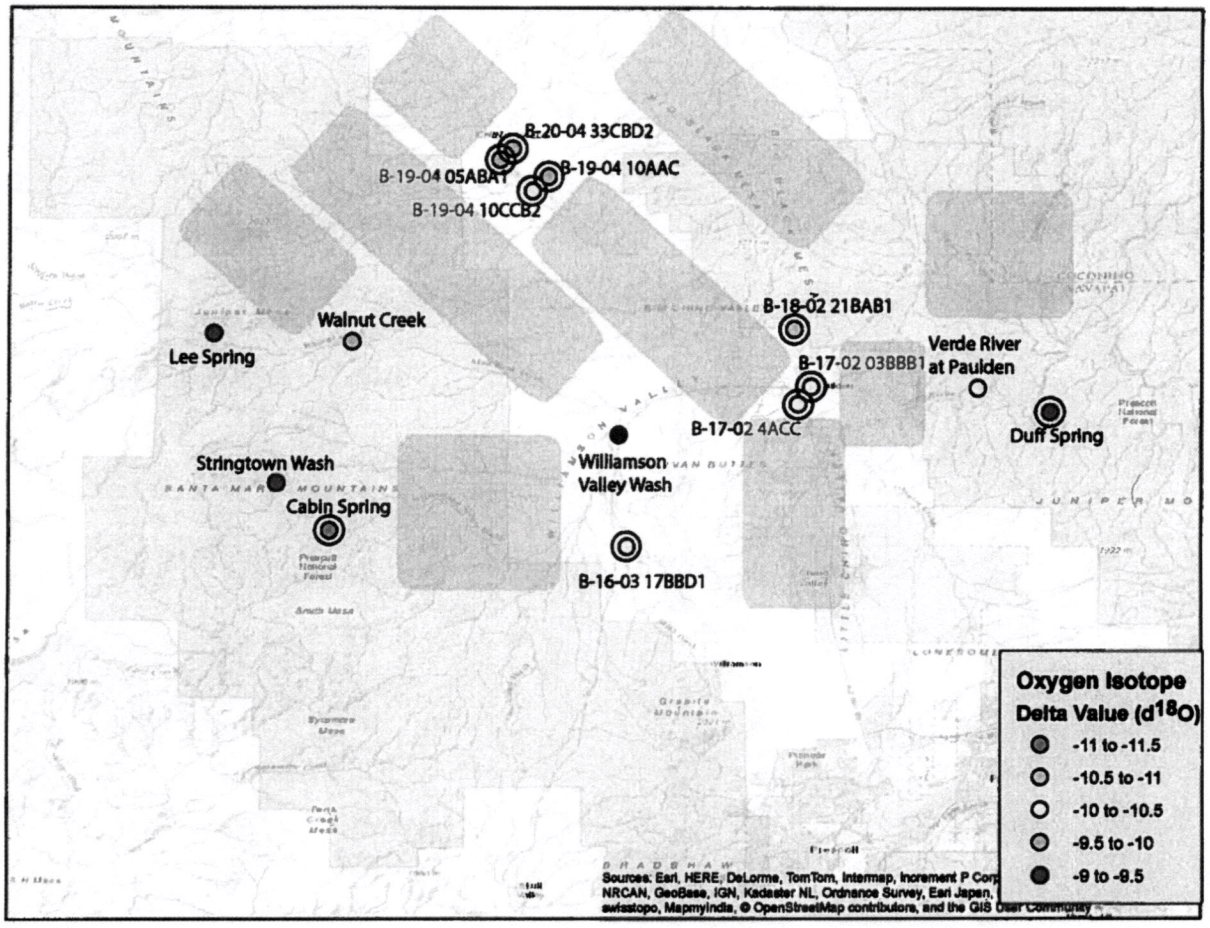

Figure 1. Oxygen isotope delta values for well, spring and surface water samples from the Big Chino study area. Sites with a second outline circle indicate sites with noble gases, carbon-14, tritium, major ions, arsenic, stable and strontium isotope data. Shaded areas indicate locations to collect groundwater samples to add to the current data set.

Communications and Deliverables

The geochemical samples collected during this study will help define the recharge sources, flowpaths, residence times, and discharge locations of groundwater present in the aquifers of interest in Big Chino sub-basin. The geochemistry of the Upper Verde Springs will be compared with the geochemistry of the aquifers in the system and contributions from the various source aquifers will be modeled using PHREEQC and or NETPATH. Results will be synthesized into a USGS series report or peer-reviewed journal article after all of the data have been collected and summaries of progress will be presented to the Big Chino working group annually or more frequently as necessary.

Communications between the cooperators and USGS will be accomplished through informal and formal communications. Informal communications will be via telephone and email. It will include exchange of data, clarification of previous work products, and discussion of details regarding data

collection methods, siting, and other similar topics as necessary. Informal cooperator interaction will be welcomed throughout the project.

Reports publication

Publication of peer-reviewed and publicly released reports documenting methods and results will play an essential role in building confidence in project results for the cooperators and for the public as a whole. Study results will be formally released in a peer reviewed USGS-series report or journal article and become publically available upon release; however, the cooperators will be engaged in the process throughout the investigation and will be aware of findings. Report products will have two independent colleague reviews. Until final USGS approval of reports, results cannot be publically released. Water quality data will be published annually on NWISWeb. All data collection will follow the USGS National Field Manual for the Collection of Water-Quality Data (USGS, variously dated), be subject to QA/QC data checking procedures in place for the Arizona Water Science Center, and be archived in USGS National Water Information System (NWIS) database.

A USGS-series report or journal article will be published as part of this project. The report will analyze geochemical data from previous studies; Knauth and Greenbie, 1997, Wirt and Hjalmarson, 2000, Wirt and others, 2005, Blasch and others, 2006, Bills and others, 2007, and Beisner and others, 2016 together with samples collected at 8 wells and 4 springs between 2011 and 2015, in addition to the 16 proposed groundwater samples, 2 surface water samples from the Verde River at Paulden and stable isotope surface water samples from the Verde River at Paulden and Williamson Valley gages. The geochemical results will help define recharge elevation and water rock interactions along the groundwater flow path. The results will be compared with the water-quality data obtained for the Verde River at Paulden and Williamson Valley Wash. Cooperators will be given the opportunity to provide a courtesy review and comment on articles prior to submission to peer review.

Schedule

Table 2. Proposed project timeline for geochemical sampling

Geochemistry	YEAR 1				YEAR 2				YEAR 3	
	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr
	FY17		FY18				FY19			
	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Analysis of well database and selection of planned sampling sites	■				■					
Geochemical sampling at well sites		■				■				
Stable isotope monitoring of base flow at the Paulden and Williamson Valley gages	■	■	■	■	■	■	■	■	■	■
Analysis of data and publication of report							■	■	■	■

Budget

Table 3. Budget for geochemical sampling by funding year

Task	Cost per Sample	Federal FY Year		
		17	18	19
Geochemical sampling including travel costs and personnel time	$1,800	$18,000	$18,000	
Data management	$340	$3,400	$3,400	
Geochemical suite analysis – including replicate samples	$4,100	$41,000	$41,000	
Major ion, redox and arsenic blanks	$405	$405	$405	
Monthly sampling for stable isotopes in baseflow at the Paulden and Williamson Valley gages – including replicate analysis	$200	$4,400	$4,400	$4,400
Analysis of data and publication of report	--	$4,000	$4,000	$56,000
Total		$71,205	$71,205	$60,400

Selected References

Beisner, K.B., Paretti, N.V., Tucci, R., 2016, Analysis of stable isotope ratios ($\delta^{18}O$ and $\delta^{2}H$) in precipitation of the Verde River Watershed, Arizona 2003-2014, U.S. Geological Survey Open-File Report 2016-1053.

Bills, D.J., Flynn, M.E., and Monroe, S.A., 2007, Hydrogeology of the Coconino Plateau and adjacent areas, Coconino and Yavapai Counties, Arizona: U.S. Geological Survey Scientific Investigations Report 2005–5222, 101 p., 4 plates.

Blasch, K.W., Hoffmann, J.P., Graser, L.F., Bryson, J.R., and Flint, A.L., 2006, Hydrogeology of the upper and middle Verde River watersheds, central Arizona: U.S. Geological Survey Scientific Investigations Report 2005–5198,102 p., 3 plates.

Knauth, L.P., and Greenbie, M., 1997, Stable isotope investigation of ground-water-surface-water interactions in the Verde Rivers headwaters area: Arizona State University Department of Geology report in fulfillment of Arizona Water Protection Fund Grant #95–001, administered by Arizona Department of Water Resources, 28 p.

U.S. Geological Survey, 2007, Facing tomorrow's challenges—U.S. Geological Survey science in the decade 2007–2017: U.S. Geological Survey Circular 1309, x + 70 p.

U.S. Geological Survey, variously dated, National field manual for the collection of water-quality data: U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chaps. A1–A9, available online at http://pubs.water.usgs.gov/twri9A

Wirt, L., and Hjalmarson, H.W., 2000, Sources of springs supplying base flow to the Verde River headwaters, Yavapai County, Arizona, U.S. Geological Survey Open-File Report 99-0378.

Wirt, Laurie, DeWitt, Ed, and Langenheim, V.E., eds., 2005, Geologic Framework of Aquifer Units and Ground-Water Flowpaths, Verde River Headwaters, North-Central Arizona: U.S. Geological Survey Open-File Report 2004-1411.

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
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October 4, 2016

6000004118/AZ090
Craig V. McConnell, City Manager
City of Prescott
201 S. Cortez
Prescott, Arizona 86303

Dear Mr. McConnell:

Enclosed are two copies of a Joint Funding Agreement (JFA) between the City of Prescott and the U.S. Geological Survey for the period October 1, 2016 through September 30, 2019 for geochemistry work as described in the workplan. Billing will be on a quarterly basis and the bills will be mailed in December, March, June and August. Work performed with funds from this agreement will be conducted on a fixed-price basis. The results of all work under this agreement will be available for publication by the USGS.

Please return a signed copy of the JFA to this office. We are pleased to conduct this work for the City of Prescott. If you have any questions, please contact Kim Beisner at (520) 671-6671 ext. 308.

Sincerely,

James M. Leenhouts
Director

Enclosures (2)