



United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Arizona Water Science Center
520 North Park
Tucson, AZ 85719

January 18, 2024

Ms. Erin Young
Water Resource Manager
City of Flagstaff
2323 Walgreens St. Suite 1
Flagstaff, AZ 86004

Dear Ms. Young:

Enclosed is a signed digital copy of our standard joint-funding agreement for the project(s) Arizona Water Science Center Water Resources Investigations, during the period March 1, 2024 through September 30, 2026 in the amount of \$71,080 from your agency. U.S. Geological Survey contributions for this agreement are \$37,500 for a combined total of \$108,580. Please sign and return one fully-executed original to Rudy Richard at the address above.

Federal law requires that we have a signed agreement before we start or continue work. Please return the signed agreement by **February 29, 2024**. If, for any reason, the agreement cannot be signed and returned by the date shown above, please contact Jamie Macy by phone number (928) 556-7276 or email jpmacy@usgs.gov to make alternative arrangements.

This is a fixed cost agreement to be billed quarterly via Down Payment Request (automated Form DI-1040). Please allow 30-days from the end of the billing period for issuance of the bill. If you experience any problems with your invoice(s), please contact Alexis Lopez at phone number (520) 670-3339 or email at aslopez@usgs.gov.

The results of all work performed under this agreement will be available for publication by the U.S. Geological Survey. We look forward to continuing this and future cooperative efforts in these mutually beneficial water resources studies.

Sincerely,

James M Leenhouts
Director

Enclosure
24ZFJFA2100

**Form 9-1366
(May 2018)**

**U.S. Department of the Interior
U.S. Geological Survey
Joint Funding Agreement
FOR
Water Resource Investigations**

**Customer #: 600000790
Agreement #: 24ZFJA2100
Project #:
TIN #: 86-6000244**

Fixed Cost Agreement YES[X] NO[]

THIS AGREEMENT is entered into as of the October 1, 2023, by the U.S. GEOLOGICAL SURVEY, Arizona Water Science Center, UNITED STATES DEPARTMENT OF THE INTERIOR, party of the first part, and the City of Flagstaff party of the second part.

1. The parties hereto agree that subject to the availability of appropriations and in accordance with their respective authorities there shall be maintained in cooperation Water Resource Investigations (per attachment), 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) include In-Kind-Services in the amount of \$0.00.

- (a) \$37,500 by the party of the first part during the period March 1, 2024 to September 30, 2026
- (b) \$71,080 by the party of the second part during the period March 1, 2024 to September 30, 2026
- (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 cost, 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. The Parties acknowledge that scientific information and data developed as a result of the Scope of Work (SOW) are subject to applicable USGS review, approval, and release requirements, which are available on the USGS Fundamental Science Practices website (<https://www2.usgs.gov/fsp/>).

**Form 9-1366
(May 2018)**

**U.S. Department of the Interior
U.S. Geological Survey
Joint Funding Agreement
FOR
Water Resource Investigations**

**Customer #: 600000790
Agreement #: 24ZFJA2100
Project #:
TIN #: 86-6000244**

9. Billing for this agreement will be rendered quarterly. Invoices not paid within 60 days from the billing date will bear Interest, Penalties, and Administrative cost at the annual rate pursuant the Debt Collection Act of 1982, (codified at 31 U.S.C. § 3717) established by the U.S. Treasury.

USGS Technical Point of Contact

Name: Jamie Macy
Supervisory Hydrologist/Associate
Director for Studies
Address: 2255 North Gemini Drive
Flagstaff, AZ 86001
Telephone: (928) 556-7276
Fax: (928) 556-7112
Email: jpmacy@usgs.gov

Customer Technical Point of Contact

Name: Erin Young
Water Resource Manager
Address: 2323 Walgreens St. Suite 1
Flagstaff, AZ 86004
Telephone: (928) 213-2405
Fax:
Email: eyoung@flagstaffaz.gov

USGS Billing Point of Contact

Name: Alexis Lopez
Budget Technician
Address: 520 N. Park Ave
Tucson, AZ 85719
Telephone: (520) 670-3339
Fax:
Email: aslopez@usgs.gov

Customer Billing Point of Contact

Name: Stacy Brechler-Knaggs
Grants & Contracts Mgr.
Address: 211 W. Aspen Ave.
Flagstaff, AZ 86001
Telephone: (928) 213-2227
Fax:
Email: Sknaggs@flagstaffaz.gov

**U.S. Geological Survey
United States
Department of Interior**

City of Flagstaff

Signature

Signatures

By _____ Date: 01/18/2024

Name: James M Leenhouts

Title: Director

By _____ Date: _____

Name:

Title:

**A WORKPLAN FOR MONITORING THE C AQUIFER
OF THE MIDDLE TO LOWER
LITTLE COLORADO RIVER BASIN, ARIZONA
Three-Year Agreement, FY2024 to 2026**

*-A cooperative program with the Navajo Nation, the City of Flagstaff, Coconino Watershed Partnership,
Arizona Department of Water Resources, Arizona Public Service, and the U.S. Geological Survey-
Prepared by the U.S. Geological Survey Arizona Water Science Center*

INTRODUCTION:

In 2005 the Bureau of Indian Affairs Navajo Region (Navajo-BIA) and the U.S. Geological Survey (USGS) Arizona Water Science Center (AZWSC) established a cooperative groundwater-monitoring program for the C aquifer near Flagstaff, Arizona, that focuses on the middle to lower Little Colorado River Basin. The area of study specifically lies between Flagstaff and east of Winslow, Arizona, where the greatest potential for groundwater development exists. The monitoring program was established at the request of Navajo-BIA and the Navajo and Hopi Nations to develop a monitoring network that will help to understand the current base-flow conditions of the C aquifer in this area. The C aquifer is planned to be used by the tribes, the City of Flagstaff, and others to meet future water-supply demands. From 2005-2012, funding support to monitor the C aquifer was provided by the Navajo-BIA and the USGS, and in 2012 the City of Flagstaff joined the cooperative effort. The City of Flagstaff recognizes the importance of monitoring this critical area and their continued participation in the monitoring effort is important to the ongoing monitoring project. One benefit of having the City as a funding partner is that the USGS is able to provide cooperative funding to the program. The USGS can provide cooperative funding to non-federal partners such as the City of Flagstaff, but the USGS cannot contribute cooperative funds towards Navajo-BIA funding. Funding from the City of Flagstaff for the past eight years has made it possible for the USGS to match the City's funding. Another important benefit of funding from the City is that the Navajo-BIA funding support for the program is leveraged with the additional funding on an annual basis allowing BIA to continue funding support. The City of Flagstaff's participation in the cooperative group monitoring the C aquifer is central to continuing this work for the next three-year period and potentially longer.

In 2021, four other cooperators joined the effort to add a streamflow gage in Chevelon Creek. The Coconino Plateau Watershed Partnership (CPWP), Arizona Department of Water Resources (ADWR), Arizona Public Service (APS), and U.S. Fish and Wildlife contributed to expand the project. In 2022 and 2023, CPWP, ADWR, and APS continued to contribute to the C-aquifer Monitoring Program; CPWP funds come to USGS through the City of Flagstaff.

The C-aquifer is a large regional aquifer system in the Little Colorado River Basin with

potentially several hundred million acre-feet of water in storage (McGavock and others, 1986; Bills and others, 2000; Hart and Others, 2002; and Bureau of Reclamation, 2006). The aquifer is used as a source of water for domestic, municipal, industrial, agricultural, and recreational water uses where the water quality is good throughout the Little Colorado River Basin. Groundwater withdrawals from the C-aquifer in the Little Colorado River Basin totaled about 140,100 acre-feet in 1995 (Hart and others, 2002). This amount is a little less than half of the average annual, natural discharge from the basin of 319,000 acre- feet (Hart and others, 2002). Water demand mainly for municipal, industrial, and agricultural uses has resulted in substantial drawdown of the potentiometric surface (the water table) in the central and upper parts of the basin.

Continuing growth and development in northern Arizona has resulted in the continuing development of water supply from the C-aquifer in the middle and lower parts of the Little Colorado River Basin to meet future water demands. Several aquifer tests have been conducted in the area of the aquifer to the south of Leupp on the Navajo Reservation, along I-40 to the west of Winslow, and the area to the north of Moenkopi that indicated that the C aquifer in these areas is likely to be very productive (City of Flagstaff, 2014; Hoffmann and others, 2006; Bureau of Reclamation, 2005; and Hopi Tribe, 2003). The Navajo Nation has expressed concern that groundwater resources of the C aquifer in the Little Colorado River Basin are being affected by groundwater withdrawals for municipal, agriculture, and industrial water uses on the southwestern reservation boundaries.

Proposed groundwater development from the C-aquifer include: 1) Future water supply for communities in the western and southern parts of the Navajo Indian Reservation, 2) the future source of municipal water supply for the City of Flagstaff (Red Gap Ranch), 3) water supply for development along the I-40 corridor between Flagstaff and Winslow, and 4) water supply to support continuing development along the Little Colorado River Valley up gradient from Leupp. Future demands for groundwater resources in this area have the potential to affect groundwater withdrawals and the water quality in the basin, which may include a reduction to the base flow of perennial streams such as Clear Creek and Chevelon Creek (Leake and others, 2005; S.S. Papadopulos and Associates, Inc., 2005), or further reduce the availability of water to the Little Colorado River and Little Colorado River alluvium which are already affected by existing upstream water uses. Additional development of groundwater resources from other water-bearing zones in this area could also occur to improve water supplies for communities in the western and southern parts of the Navajo Indian Reservation with unknown impacts to the C aquifer. Arizona Public Service (APS) Cholla Power Plant closed one of its production units in April 2016. The power plant is scheduled to close the remaining two units by 2025. Since groundwater from the C aquifer is the sole source of water supply for the power plant for cooling, closure of the plant is expected to have impacts on the availability and quality of groundwater in the region.

OBJECTIVE:

The overall objective of the program is to establish current baseline information for the C aquifer before significant additional groundwater development occurs in the Flagstaff to east of Winslow area, and to monitor for long-term changes in groundwater levels, water use, water chemistry, and changes in the base flow of Clear Creek, Chevelon Creek, and the Little Colorado River.

Groundwater resources of the C aquifer in the Little Colorado River Basin are already being affected by current withdrawals for municipal, agriculture, and industrial water uses throughout the upper and middle parts of the basin. Potential, additional groundwater withdrawals from the C aquifer, especially east of Flagstaff toward the Little Colorado River, could compound the effects of groundwater withdrawals in the basin.

The specific objectives of this monitoring program are:

1. Establish current baseline conditions in the C aquifer prior to significant additional groundwater development.
2. Collect and provide information on groundwater resources for the protection of native and endangered species that depend on the base-flow discharge from the C-aquifer to Clear Creek, Chevelon Creek, and the Little Colorado River.
3. Document changes in flow and water-quality field parameters of the C-aquifer and adjacent water-bearing zones that may impact the use of these water resources.

PROJECT DESCRIPTION/SCOPE OF WORK:

The USGS proposes to continue operation and maintenance of a core monitoring network of selected wells and sampling sites during this 3-year cooperative agreement. The C-aquifer Monitoring Program work plan is dependent on funding from cooperators. If the full funding needs are not met, then the work plan is revised to include those tasks that can be funded at the available funding level. The monitoring network includes:

1. Five continuous-record observation wells, with satellite telemetry and quarterly check measurements, and additional maintenance as needed (fig.1, table 1). Real-time data are available from these sites at: <http://waterdata.usgs.gov/az/nwis/current/?type=gw>
2. Produce a daily values water-level record for these five sites for the current water year.
3. Measurement of quarterly water levels by the USGS at 17 observation wells located in the C aquifer between Flagstaff and Winslow, AZ (fig.1, table 2). Also includes quarterly and annual C-aquifer well data provided by the City of Flagstaff and Arizona

Department of Water Resources (ADWR) as part of this water-level network (figure 1).

4. Conduct one base-flow evaluations, when possible, consisting of up to 24 sites on Clear Creek, Chevelon Creek, and on the Little Colorado River from Chevelon Creek to Clear Creek for comparison to the base-flow evaluations conducted in the summers 2005, 2006, 2008, 2012, 2015, 2018, 2019, and 2022; fall 2017; and winter 2010 (fig.2).
5. One continuously-recording streamflow gage on Chevelon Creek (fig.3)
6. Maintain an interactive website on usgs.gov displaying information, sites, and data.
7. Work with the City of Flagstaff and the AZWSC Basic Data Section to develop additional streamflow-gaging stations for the study.
8. Work with other Federal, Tribal, State, and local partners to develop additional financial support for this study or with in-kind services, so that partners can be included as cost-sharing efforts.

Task:	FY 2024				FY 2025				FY 2026			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Operate five continuous-recording observation wells and produce daily hydrographs												
Measure quarterly water levels												
Conduct baseflow investigation(s) in Clear Creek, Chevelon Creek, and the Little Colorado River												
Operate Chevelon Canyon streamflow gage												
Discrete Water Quality Samples – UAS Thermal												

DELIVERABLES:

The following deliverables will be provided to all cooperators based on the field data collected and on the above methodology. Data from the monitoring program are available online via the USGS National Water Information System (NWIS) and can be provided to the Navajo Nation and the City of Flagstaff upon request. Cooperators will also be provided courtesy review copies of planned reports that will be published by the USGS.

1. The USGS will publish on-line all data collected for the program with corresponding USGS site numbers on the USGS NWIS Web (tables 1 and 2).
<http://waterdata.usgs.gov/az/nwis/current/?type=gw>
2. USGS will provide additional miscellaneous data as appropriate related to this program, and as required by the USGS Data Management Protocol.

3. Copies of publications or reports that USGS presents at conferences or meetings.

TASK / BUDGET/TIMELINE FOR EACH FISCAL YEAR 2023-2025:

Task:	FY 2024	FY 2025	FY 2026
Manage the program - development, coordination, outreach and meetings, compile and analyze data <ul style="list-style-type: none"> - Labor (1 hydrologist) - Travel 	\$22,000	\$22,700	\$23,300
5 continuous-record observation wells <ul style="list-style-type: none"> - Labor (1 hydrologist, 1 hydrologic technician) - Travel - Supplies 	\$25,000	\$25,800	\$26,600
17 quarterly water-level measurements at observation wells <ul style="list-style-type: none"> - Labor (1 hydrologic technician) - Travel - Supplies 	\$8,000	\$8,200	\$8,500
Conduct one base-flow evaluations consisting of up to 24 sites on Clear Creek, Chevelon Creek, and the Little Colorado River from Chevelon Creek to Clear Creek <ul style="list-style-type: none"> - Labor (2 hydrologists, 6 hydrologic technicians) - Travel - Supplies 	\$20,000	\$20,600	\$21,218
Streamgauge operation <ul style="list-style-type: none"> - Labor (1 hydrologic technician) - Travel - Supplies 	\$20,700	\$21,300	\$22,000
Discrete Water-Chemistry Data Collection and/or UAS Thermal Imaging <ul style="list-style-type: none"> - Labor (2 hydrologists) - Travel - Supplies 	\$30,000	\$30,780	\$31,342
TOTAL:	\$125,700	\$129,380	\$132,960

Cost Sharing:

Funding Partners:	FY2024	FY2025	FY2026
BIA - Navajo Nation	\$80,000	\$82,400	\$84,900
City of Flagstaff	\$17,600	\$18,400	\$19,000
USGS (Cooperator Matching Funds)	\$12,500	\$12,500	\$12,500
Coconino Plateau Watershed Partnership	\$5,200	\$5,360	\$5,520
Arizona Public Service (APS)	\$5,200	\$5,360	\$5,520
Arizona Department of Water Resources (ADWR)	\$5,200	\$5,360	\$5,520
TOTAL:	\$125,700	\$129,380	\$132,960

PAST ACCOMPLISHMENTS:

1997-2005

Groundwater monitoring network supported by the National Park Service

2005

USGS and BIA establish current monitoring program

BIA primary funding partner, NPS no longer funding partner

Establish network of 24 quarterly observation wells

1st Base-flow evaluation of Chevelon Creek, Clear Creek, and part of the Little Colorado River

2006

3 USGS streamflow gaging stations established on Chevelon and Clear Creek.

5 Continuous recording, telemetered observation wells instrumented near Leupp and Winslow, AZ.

2nd Base-flow evaluation of Chevelon Creek, Clear Creek, and part of the Little Colorado River

2007

Program discontinued due to lack of funding

2008

Program re-established with BIA funding and ADWR in-kind support

3rd Base-flow evaluation of Chevelon Creek, Clear Creek, and part of the Little Colorado River

2010

4th Base-flow evaluation (1st winter evaluation)

2011-2012

5th Base-flow evaluation

USGS publication describing C aquifer results from 2005-2011

2015

Presentation of C-aquifer monitoring program to the Coconino Plateau Watershed Partnership

6th Base-flow evaluation

2016

Slug test of the Winslow-T well to verify aquifer connection

2017

7th Base-flow evaluation, (1st fall evaluation, September 2017)

2018

8th Base-flow evaluation

2019

9th Base-flow evaluation

Presentation of C-aquifer monitoring program to Coconino Plateau Watershed Partnership

Presentation of C-aquifer monitoring program at Geological Society of America Fall Meeting in Phoenix, Arizona (<https://gsa.confex.com/gsa/2019AM/webprogram/Paper339016.html>)

2020

Chevelon Creek streamflow gage (USGS 09398000 Chevelon Creek Near Winslow, AZ) was installed and began to collect streamflow data

2021

Presentation of C-aquifer monitoring program at the Coconino Plateau Watershed Partnership Educational Workshop

USGS publication describing C aquifer results from 2012-2019
(<https://pubs.usgs.gov/publication/ofr20211051>)

USGS publication of online geonarrative (<https://geonarrative.usgs.gov/caquifermonitoring/>)

2022

10th Base-flow evaluation

Uncrewed aerial systems (UAS) mapping of the upper perennial reaches of Clear Creek. UAS video of the upper perennial reaches of Clear Creek and Chevelon Creek

HISTORY OF FUNDING FOR THE C AQUIFER PROJECT:

C Aquifer Project	BIA Navajo	National Park Service	US Geological Survey	Arizona Dept. Water Resources	City of Flagstaff	Coconino Plateau Watershed Partnership	Arizona Public Service	US Fish & Wildlife
FY 1997		\$15,000						
FY 1998		\$15,000						
FY 1999		\$15,000						
FY 2000		\$15,000						
FY 2001		\$17,510						
FY 2002		\$17,510						
FY 2003		\$38,000						
FY 2004		\$18,000						
FY 2005	\$234,000							
FY 2006	\$278,840		\$3,860					
FY 2007			*\$25,000					
FY 2008	\$50,000							
FY 2009	\$57,197		\$10,149					
FY 2010	\$60,000			*\$4,400				
FY 2011	\$84,212		\$13,600	*\$4,400				
FY 2012	\$50,000		\$10,000	*\$4,500	\$10,000			
FY 2013	\$50,000		\$10,000	*\$4,500	\$10,000			
FY 2014	\$25,000		\$7,500	*\$4,600	\$10,000			
FY 2015	\$50,000		\$7,500	*\$4,600	\$10,000			
FY 2016	\$48,750		\$7,500	*\$5,000	\$10,000			
FY 2017	\$48,750		\$7,500	*\$5,000	\$10,000			
FY 2018	\$50,000		\$7,500	*\$5,000	\$10,000			
FY 2019	\$50,000		\$7,500	*\$5,000	\$10,000			
FY 2020	\$50,000		\$7,500	*\$5,000	\$16,700			
FY 2021	\$50,000		\$7,500	\$5,841	\$16,700	\$5,841	\$10,000	\$10,000
FY 2022	\$58,115		\$7,500	\$4,174	\$16,700	\$4,174	\$4,174	
FY 2023	\$50,000		\$7,500	\$4,174	\$16,700	\$4,174	\$4,174	

*In-kind services

TABLES AND FIGURES:

Table 1. Observation wells with satellite telemetry and quarterly check measurements.

Site Name	Site ID	Station Number
OW-1	351022111061801	05 145-05.92X05.31
OW-2B	351214111022101	05 145-02.25X03.18
OW-3A shallow	350959110562303	05 144-10.70X05.71(2)
Winslow T	345603110450301	(A18-15) 28aad
Winslow I-40	350002110355501	(A-19-16) 36dbb

Table 2. Quarterly observation wells measured by the USGS

Site name	Site ID	Station Number	Well owner
Sunshine Well	350706111014701	A-20-12H13CBB	Hopi
PW-1A	351023111062002	05 145-05.96X05.28 (2)	Navajo
PW-2B	351213111022101	A-21-12H 14C UNSURV	Navajo
OW-2A Shallow	351216111021902	05 145-02.14X03.14 (2)	Navajo
OW-2A Middle	351216111021903	05 145-02.14X03.14 (3)	Navajo
OW-2A Deep	351216111021904	05 145-02.14x03-14 (4)	Navajo
PW-2A	351218111021701	05 145-02.12X03.09	Navajo
PW-3	350957110562601	05 144-10.76X05.75	Navajo
OW-3A Deep	350959110562302	05 144-10.70X05.71 (2)	Navajo
OW-3C Shallow	350956110562002	05 144-10.67X05.72 (2)	Navajo
OW-3C Middle	350956110562003	05 144-10.67X05-72 (3)	Navajo
OW-3C Deep	350956110562004	05 144-10.67X05.72 (4)	Navajo

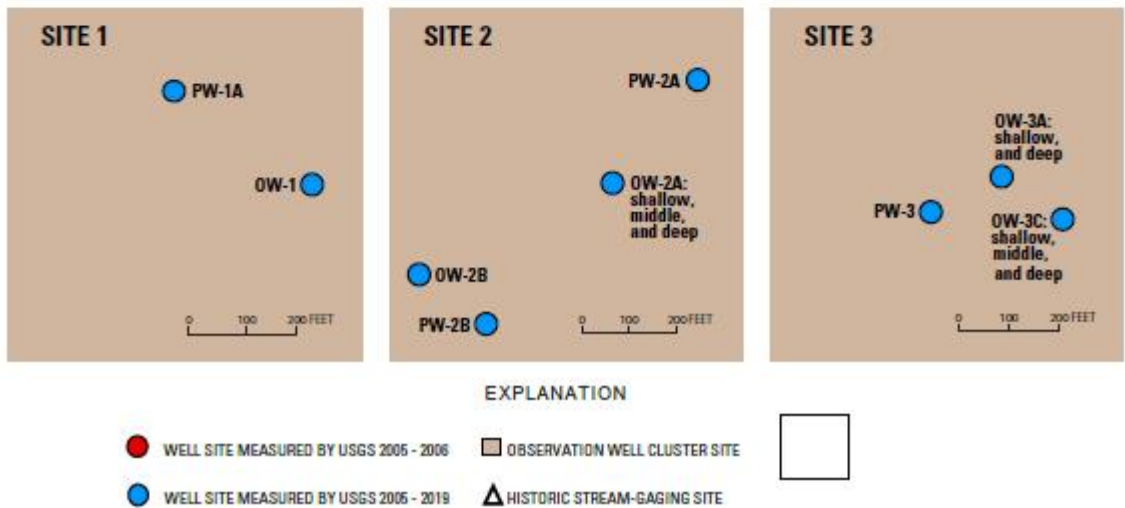
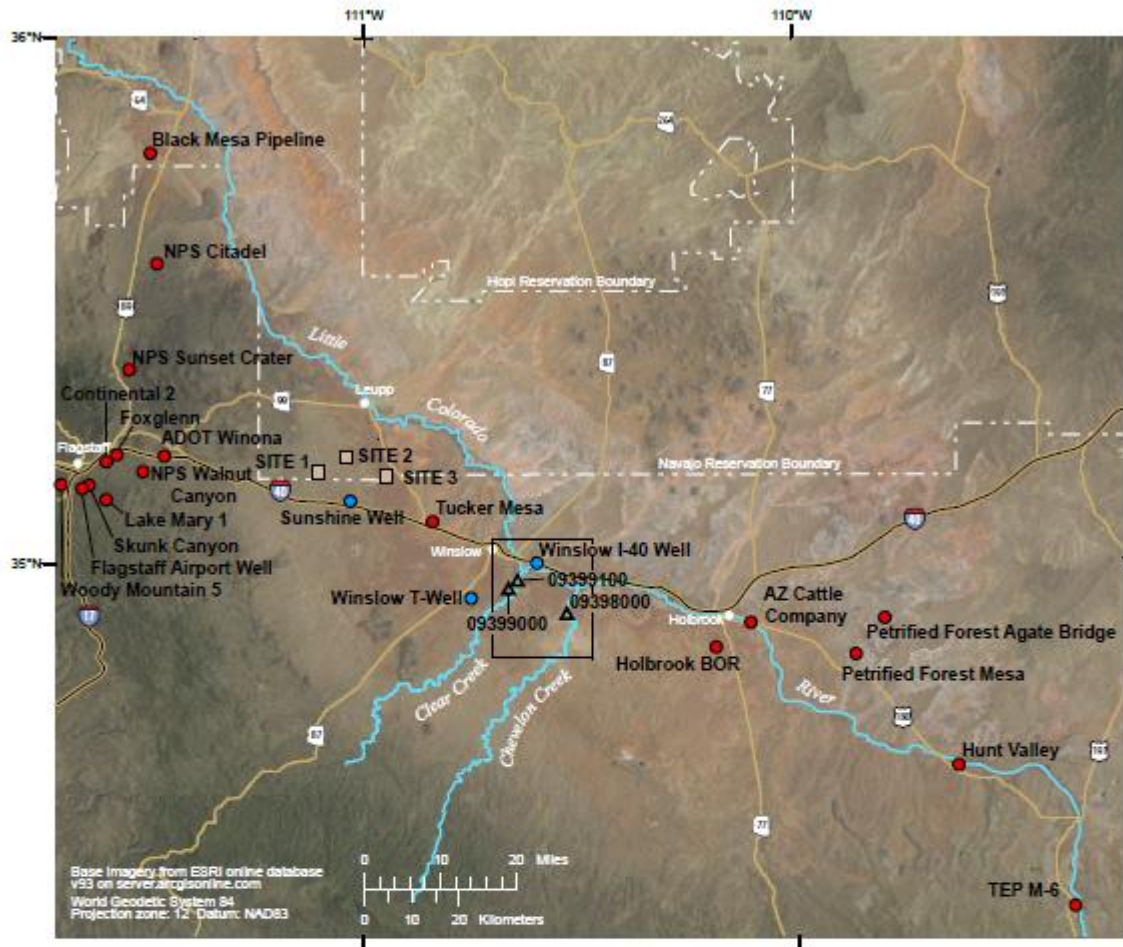


Figure 1. Locations of observation wells and discontinued streamflow-gaging station sites included in this study, northeastern Arizona. A detailed view of the well cluster sites near Leupp is shown below the map. Sections modified from Hoffmann and others, 2006.

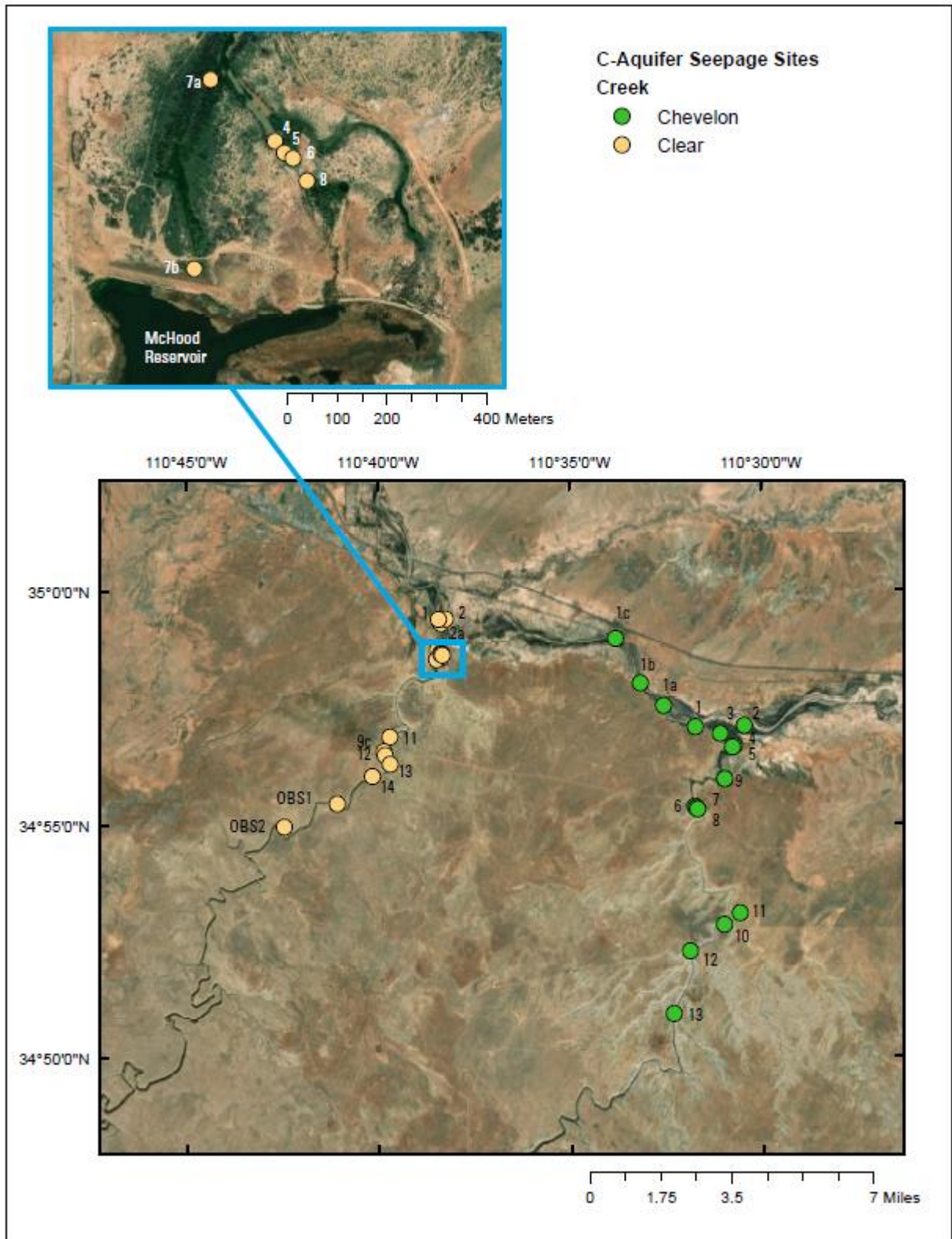


Figure 2. Locations of C-aquifer baseflow investigation sites along Clear Creek, Chevelon Creek, and the Little Colorado River, northeastern Arizona.

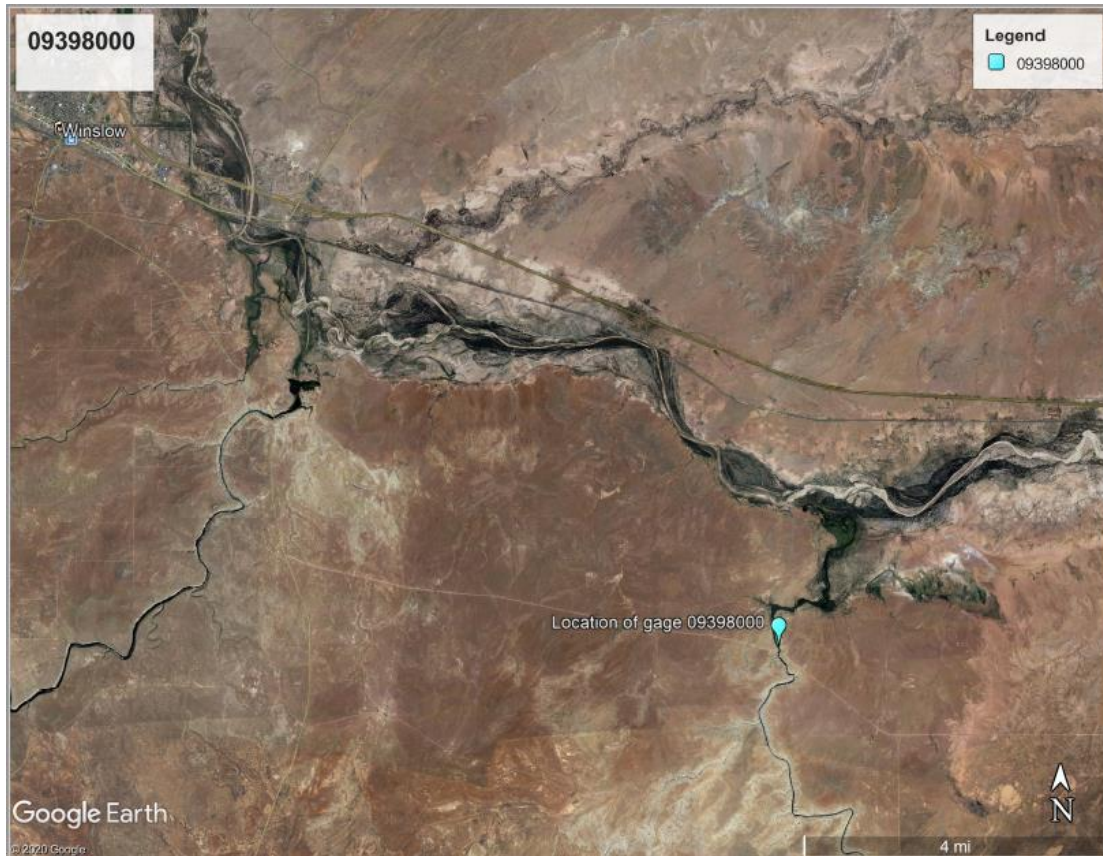


Figure 3. Location of streamgage Chevelon Creek near Winslow, AZ (09398000) (GPS coordinates: $34^{\circ}55'29.03''\text{N}$, $110^{\circ}31'45.20''\text{W}$).