

Grant Report, Project Submittals and Request for Payment
Arizona Department of Water Resources – Water Management Assistance Grant
CONTRACT NO: 2018-2051 IGA
Ephemeral Stream Monitoring to Estimate Groundwater Recharge in the Prescott AMA

Background: Understanding natural recharge quantities is an important component for water resource management in the Prescott Active Management Area (AMA). The Prescott AMA was established as one of three AMAs with a goal of reaching Safe-yield by 2025, but is the only Safe-yield AMA without an alternative water supply to help meet that goal. Natural recharge in the Prescott AMA makes up approximately 50% of the AMA’s water budget and is a critical factor in determining the alternative water resource requirements for reaching Safe-yield. However, natural recharge cannot be directly measured and must be inferred from other hydrologic data or estimated through complex groundwater models.

The most recent Prescott AMA Groundwater Model (Nelson and Yunker, 2014) in particular demonstrated the importance of understanding natural recharge mechanisms by utilizing time-varying estimates of natural recharge instead of utilizing annual averages and found that this approach provided a better fit to measured data. The 2014 Model indicates that approximately 75% of the groundwater recharge to the Prescott AMA Aquifer originates as streambed recharge in the ephemeral streams and resulted in an estimated increase in natural recharge of approximately 20% over previous estimates.

In order to verify the 2014 Model estimates, the Prescott AMA Groundwater Users Advisory Council (GUAC), working with the Upper Verde River Watershed Protection Coalition (Coalition) and Arizona Department of Water Resources (ADWR) Groundwater Modeling Section, identified locations for additional stream gages in the Prescott AMA that could provide direct measurement of seepage in two significant sources of ephemeral stream recharge – Granite and Lynx Creeks. Only one USGS gage on Granite Creek below Watson Lake provided stream flow data at that time. Additional gages were needed on Willow Creek, a significant tributary to Granite Creek, and on Lynx Creek at the upstream and downstream locations of the reach contributing to aquifer recharge.

Initially, a stream gaging proposal was developed with the USGS and an application for funding was proposed to USGS and ADWR. Ultimately the proposal was cost-prohibitive and another approach was developed. This included utilizing the existing gaging network and expertise of the Yavapai County Flood Control District (YCFCD). YCFCD maintains and operates numerous flood-warning stream gages on various streams in Yavapai County and several lake-level stage stations. Upon request by the Prescott AMA GUAC, YCFCD agreed to add three additional stations to their network and re-establish an existing station (Lynx Levee) where the stream channel had migrated some distance away from the gage. In return, YCFCD requested

only compensation for the construction costs and agreed to cover the maintenance and operation costs for the gages.

To facilitate the project, the Town of Prescott Valley (Town) agreed to act as the Contracting and Fiscal Agent to work with ADWR to develop the Grant Contract and facilitate payments of funds from the Water Management Assistance Program to YCFCD.

Project Deliverables:

According to the Grant Contract, two deliverables are required as listed below:

Deliverable 1: a) Report documenting the installation of three gages and the most up-to-date information collected from the gages since installation. b) The report shall include data such as stage discharge flow rates, as available, (providing highest resolution as possible), pick rates and times of events, as well as calibration methods. c) The Report shall also include a demonstration of how this data can be used to estimate recharge levels (providing estimated recharge amount), and how it can potentially affect the Prescott AMA Groundwater Model.

Deliverable 2: Report documenting the most up-to-date information collected from the three gages since installation. The report shall include at least six months of data such as stage discharge flow rates, as available, (providing highest resolution as possible), pick rates and times of events, as well as calibration methods. The Report shall also include a demonstration of how this data can be used to estimate recharge levels (providing estimated recharge amount), and how it can potentially affect the Prescott AMA Groundwater Model.

Schedule of Deliverables and Payments

DELIVERABLES	DUE DATE(S)	PAYMENTS (Not to Exceed)
Deliverable 1: Report on 3 existing gages and data collected	March 31, 2018	\$10,000
Deliverable 2: Final Report on 3 existing gages, providing data collected for at least 6 months	September 30, 2018	\$5,000
TOTAL AMOUNT		\$15,000

Submittals: Deliverables 1 and 2 are submitted as follows:

Deliverable 1a) Project Status: Based on the promise of repayment from the WMAP and Coalition, YCFCD installed three of the four initially proposed gages in 2016 and 2017. These include the lake level sensors at Willow Lake and Fain Lake and relocating the Lynx Levee gage. The only suitable location for the proposed lower Granite Creek gage is on private

property. Access could not be obtained from the landowner and the gage was removed from the project¹.

Data collected by YCFCD at these locations is documented below along with installation date and the website address. Data has been collected at each gage since installation date.

Willow Lake

Installed 3/28/17

<http://www.ycflood.com/weather/weather-stations-gauges/393-Willow-Lake>

Data Collected: Precipitation, Stage (feet), Spillway Discharge (cfs), Lake Storage (acre-feet).



Willow Lake Stage Gage, radar water level. Rain gage and data transmitter located on the dam.

Lynx Levee

Relocated 1/20/16

<http://www.ycflood.com/weather/weather-stations-gauges/443-Lynx-Creek-Levee>

Data Collected: Precipitation, Stage (feet), Stream Discharge (cfs)

¹ It may be possible to estimate Granite Creek contributions to the Verde River (and flow out of the Prescott AMA) by using other stage gages that have been installed in the Big Chino Sub-basin upstream of the Granite Creek confluence with the Verde River in combination with the downstream USGS Paulden gage.



Lynx Levee, conduit from pressure transducer (left), data transmitter and rain gage (right)

Fain Lake

Installed 3/02/16

<http://www.ycflood.com/weather/weather-stations-gauges/458-Fain-Lake>

Data Collected: Precipitation, Stage (feet). Rating curve has not yet been developed for this site.



Fain Lake – transducer is below normal water level at dam, data transmitter and rain gage in photo background (circled).

Deliverable 1b) Data Collection and Calibration:

Background: The Yavapai County Flood Control District constructed and maintains all three gage sites as part of the Automated Local Evaluation in Real Time (ALERT) System flood warning system. The ALERT System originated in Yavapai County in 1989 with the design and implementation of the Sedona/Oak Creek flood warning system, and was followed shortly thereafter by the design and implementation of the Prescott area early warning system. Since that time the District has continued to expand the ALERT System to cover watersheds impacting communities within Yavapai County.

Currently the Yavapai County ALERT System network collects data from 107 rain gauges, 33 water level gauges and 15 weather stations through a network of 7 repeaters. In addition, YCFCD receives data the Flood Control District of Maricopa County which owns and operates 39 gauges in southern Yavapai County (39 rain, 7 stream, 3 weather stations), as well as data from Mohave County which owns and operates two gauges in western Yavapai County (one weather station).

All data is received at the YCFCD base station in Prescott and used to assess potential flooding threats in watersheds that impact Yavapai County. Data from historical rainfall and stream flow events also provides information to the County when determining potential drainage and roadway improvements.

In addition, the National Weather Service in Flagstaff receives the data and uses it to compare actual ground conditions (that observed in the gauges) with those observed in their radar imagery and other weather forecast products. This aids the National Weather Service in their determination to issue flood watches, flood warnings and severe weather advisories.

Other agencies that directly receive data from the gauge network include the Arizona Department of Water Resources (ADWR), Flood Control District of Maricopa County (FCDMC), Salt River Project (SRP) and the Colorado Basin River Forecast Center (CBRFC).

Precipitation: All sites include a tipping bucket rain gage. Data reports are provided twice per day when no precipitation is recorded, and as often as once per minute during a precipitation event. Current precipitation data are provided on the website links above for each station, or historic data is available from the Yavapai County Flood Control District office upon request at (928) 771-3197.

Stage and Flow Rate: The Fain Lake and Lynx Levee sites utilize pressure transducers to measure water levels. A radar installation is deployed at the Willow Lake dam site to measure water levels. Water level, or stage data, is reported to the base station twice per day if there has been no change and as often as once per minute if water levels change. Stage data is converted to flow rates at the Willow Lake and Lynx Levee sites through a stage-discharge relationship

based on a cross-section survey, but are not calibrated by field measurement during active flow events. The stage-discharge relationship has not been established at the Fain Lake site due to the unique characteristics at that site. ADWR has offered staff assistance in establishing this relationship. The site geometry is stable, formed by a concrete dam and bedrock so the stage-discharge relationship is applicable to historic stage data. Current stage and flow data are provided on the website links above for each station, or historic data is available from the Yavapai County Flood Control District office upon request at (928) 771-3197.

Deliverable 1c) Use of Data to Estimate Recharge and Benefit for the Prescott AMA Groundwater Model⁽²⁾:

For model calibration purposes, having multiple forms of calibration target data, esp. head and flow targets, as well as aquifer test (a-priori) data, provide much more robust, defensible and unique model calibrations. Large flow (and recharge) events can never be known with high precision, however, having general order-of-magnitude flow estimates combined with adjacent temporal water level changes, complement each other and provide excellent model constraints: This is a true case where “the whole – including heads *and* flows used in combination - is greater than (using) the sum of the parts”, separately.

Many of our regional-scale groundwater flow models including Santa Cruz-North, the Micro-basins, Prescott, Willcox and even Pinal and Hassayampa benefit from not only having groundwater discharge flow targets but also period flood recharge. In many of our model reports discuss the importance of using head *and* flow targets, thru presentation of inversion statistics. For reference, I always site the following USGS model calibration guidance document to explain the more technical aspects of these relations:

<https://water.usgs.gov/nrp/gwsoftware/modflow2000/WRIR98-4005.pdf>

Just having approximate flow rates between sites inform us about transmission losses (natural recharge). In addition, raw, unrated stage data (stage discharge relations not established yet...) informs us to the 1) streamflow residence time; and/or 2) frequency, number (and relative order-of-magnitude) of pulses which occur, with respect to time; these are valuable factors for calibrating seasonal recharge rates. The Prescott model employs seasonalized stresses periods. {IMHO more models need to use more (seasonalized) stress periods. }

Besides employing flow as calibration targets, having streamflow observations recorded over time offers an opportunity to evaluate changes in the watershed responses (urbanization, etc.)

² Narrative from ADWR Chief Modeler, Keith Nelson

and, IMHO, an opportunity for explore enhance recharge potential. Measuring streamflow is a win-win.

Deliverable 2 - Data Reports:

Data collected for the three gage sites are included in separate electronic folders submitted with this report for the period of record at each site (up to mid-2018 when the data was originally requested). They can also be found here:

- Gage Data YCFCD Fain Lake - <https://pvaz.sharefile.com/d-8a43bf8dfd974a6d>
- Gage Data YCFCD Lynx - <https://pvaz.sharefile.com/d-5272625e65bd44e7>
- Gage Data YCFCD Willow - <https://pvaz.sharefile.com/d-c78b5c3cd3754956>

Current data can be obtained from YCFCD at the website addresses listed in this report or by calling (928) 771-3197.