Salt River Project Integrated Watershed Forecasting and Reservoir Operations Support Tool

Proposal for WaterSMART – Applied Science Grants for Fiscal Year 2021
Funding Opportunity Number R21AS00289
Department of the Interior, Bureau of Reclamation

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Applicant:

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1. Executive Summary

Date: April 21, 2021

Applicant: Salt River Project, Tempe, Maricopa County, AZ

Salt River Project and their consultant Hazen and Sawyer, with the support of the Arizona Municipal Water Users Association, the cities of Tempe, Chandler and Scottsdale, will develop a real-time reservoir operation model capable of predicting changes to lake levels based on a continuous runoff simulation for the Salt and Verde rivers. The proposed modeling project will enhance SRP's ability to analyze and react to forecasted hydrological events in the watersheds that impact SRP and our stakeholders' operations and infrastructure. The model will forecast streamflow up to 360 hours at specified locations that have a direct impact on reservoir operations and will inform SRP's operations. This information will allow an early response to potential adverse flooding caused by storm events or landscape changes created by wildfire, promoting better communication and coordination of flood related releases and water quality issues.

Estimated project schedule and completion date: 1 year, September 2022 (assuming a start date of October 2021).

Is the project located on a Federal Facility?

The proposed project involves modeling analysis of the Salt and Verde River Reservoir system, which is owned by the Bureau of Reclamation and managed by the Salt River Project (SRP).

2. Technical Project Description

SRP's Surface Water (SW) team is responsible for the development of conjunctive water resource management planning for reservoir and groundwater pumping operations, for the coordination of emergency reservoir operations, and for weather forecasting in support of SRP's water and power business needs. Water resource planning assures an adequate and reliable source of water for SRP's shareholders. Emergency reservoir operations are vital to maintain the safety and integrity of the dams. Weather forecasting provides support for routine and emergency operation of the SRP's reservoir and electric distribution systems, which increase system reliability and safety and augment energy resource planning.

To accomplish these objectives, SRP's hydrologists, meteorologists and engineers monitor pertinent water and weather data. SRP's SW manages its water resources to sustain life and economic viability in the Salt River Valley (Valley), integrating its expertise in weather forecasting, hydrology, water operations, management, and planning.

Challenges to accomplishing these objectives result from different streamflow generation mechanisms across the watershed. Upstream of the reservoirs, high streamflow is generally confined to winter/early spring, resulting either from rainfall and snowmelt on saturated ground or intense rainfall and rain-on-snow. Downstream of the uppermost reservoirs, local tributaries can contribute significant local inflow not only during the cold season but also during the summer with intense local rainfall from convective storms. Changing landscape conditions from wildfire and forest restoration alter runoff efficiency and therefore create additional challenges.

To date, SRP has relied on separate forecasting products and modeling tools to manage and operate for these different objectives. This project proposes to develop an Operations Support Tool (OST) comprised of integrated watershed forecasting and reservoir operations models. The OST will allow SRP to both analyze the impacts of forecasted hydrological events in the watershed on the safety of dams and public downstream, and better manage the relationship between safety operations and the preservation of conservation storage in the reservoirs.

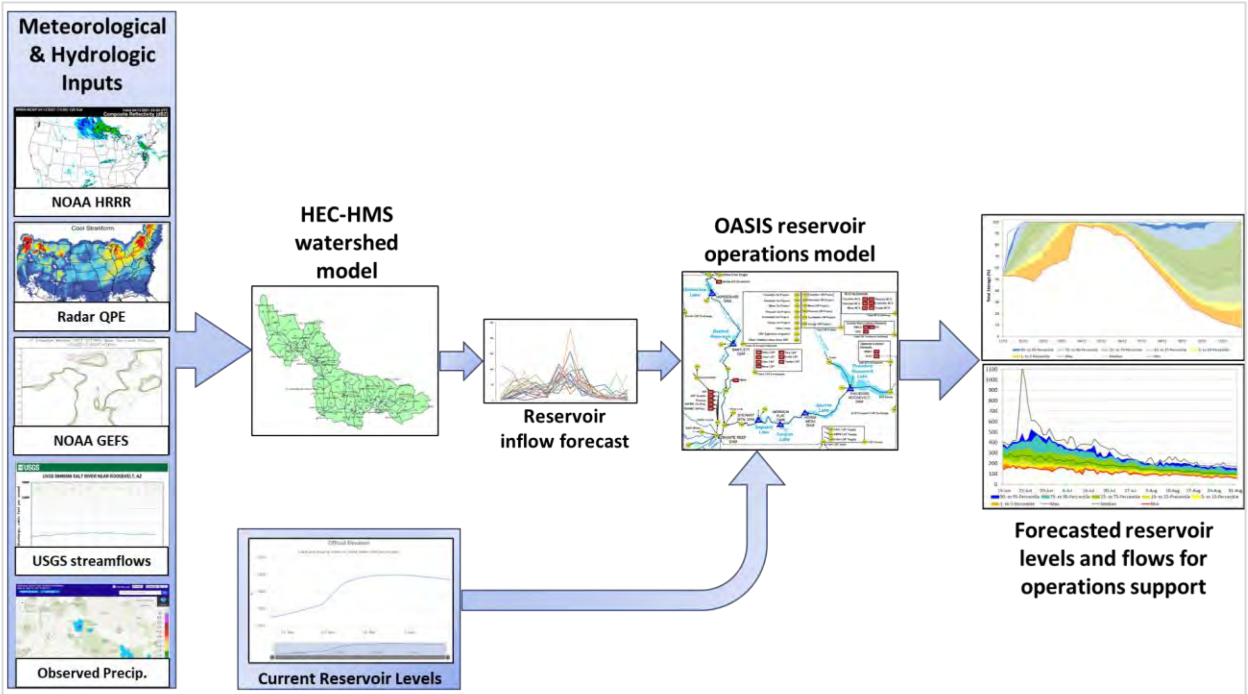

Figure 1. Proposed SRP OST integrated modeling framework

The proposed tool will leverage existing data sources, forecasts, and models, as shown in Figure 1. The tool will be used to:

- Automatically download and process meteorological forecasts: NOAA's High Resolution Rapid Refresh (HRRR), Radar Quantitative Precipitation Estimates (QPE) and Global Ensemble Forecast System (GEFS), along with other observed precipitation and streamflow data.
- Automatically enter the processed NOAA forecasts and other data into SRP's existing HEC-HMS watershed model to produce a forecast of inflows, multiple times a day.
- Use a modified version of SRP's Reservoir Planning Model, or RPM, to simulate system operations and track flows, spills, and deliveries down to the Granite Reef Diversion Dam (GRDD). The model will be modified to allow integration with the proposed inflow forecasts and to model operations on a sub-daily timestep. Provide post-processed output that allows quick dissemination of results, informing SRP staff on short-term emergency/safety operations and minimize adverse impacts on water supply reliability. This information can also be used to coordinate with stakeholders – the cities that receive water from SRP surface water – when hydrological events in the watersheds may impact the quality of water being delivered to their treatment facilities.

The following sections provide technical details on each component of the proposed integrated OST modeling framework.

2.1 Watershed Forecasting Model

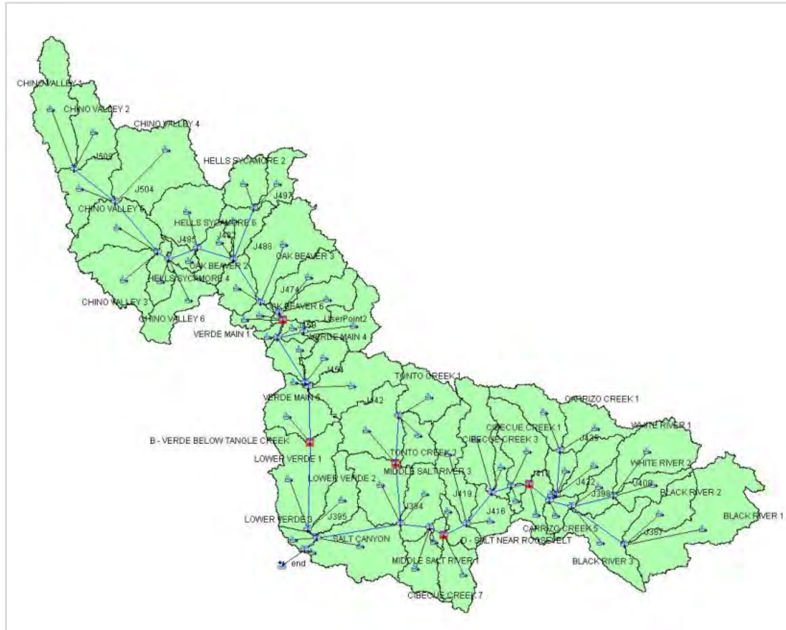

Figure 2. Schematic of SRP's HEC-HMS Watershed Model

The current SRP hydrologic model is based on the US Army Corps of Engineers' HEC-HMS software. The model (Figure 2) depicts the watersheds of the rivers Verde, Tonto, and Salt with a division of sub-watersheds capturing the various tributaries to each of these rivers, and the inflows to the SRP reservoirs excluding the Cragin Reservoir. In addition to rainfall-based runoff, the model is set up to evaluate and track the amount of snow accumulation or snow water equivalent (SWE), the timing and magnitude of snow melt, and the routing of the meltwater through the watersheds and into the reservoir. The hydrologic model uses a simplified snowmelt process driven by temperature and rainfall to evaluate. The current model parameters will be verified for rainfall-runoff events and snowmelt events and, as necessary, will be calibrated using updated USGS stream flow records, Natural Resources Conservation Service (NRCS) SNOTEL records, and rainfall events.

As part of this project, a digital elevation model (DEM) will be used to create a grid within the model that enables the use of grid files for calculations in the rainfall-runoff and snowmelt process. The Temperature Index Method[1] for snowmelt requires several gridded variables as input, including the observed initial SWE and initial cold content (CC). It also requires knowledge of the Antecedent Temperature Index Meltrate function (ATI Meltrate) and Antecedent Temperature Index Cold Content function (ATI Coldrate), which will define the rate for snowmelt or refreeze; these functions will be obtained through model calibration. Hydrologic model calibration will be performed for snow and rainfall events occurring during selected water years using observed SWE at various Arizona SNOTEL network stations and observed runoff at USGS gages.

Forecasting

Temperature, precipitation, and SWE forecast data will be obtained from NOAA NCEP HRRR or NOAA GEFS products. These data are provided in GRIB format: self-contained binary files commonly used to store weather data. The GRIB files for the entire continental U.S. (CONUS)

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[1] https://www.hec.usace.army.mil/confluence/hmsdocs/hmsguides/modeling-rain-on-snow-events

can be accessed through the NOAA website for the date of interest[2]. Downloadable GRIB files from NOAA for the entire CONUS will be extracted using the NOAA Weather and Climate Toolkit batch program[3] for the extents of the project to create an ASCII format raster file for each variable needed. Other GRIB files issued for variables such as snow depth and temperature at ground surface will also be downloaded to define or enhanced initial variables required, as shown in Table 1.

Table 1. Variables used for forecasting

NCEP HRRR GRIB Variable	Description	GRIB Variable
Initial Snow Water Equivalent	Initial snow depth based on actual measurements or zero if there is no snow	Water Equivalent of Accumulated Snow, WEASD
Temperature	Forecasted hourly temperature	Temperature 2 meters above ground, TMP
Precipitation	Forecasted hourly precipitation	Total Precipitation, APCP
Initial Cold Content ATI	Index that represents temperature of snowpack	Temperature at ground surface, TMP

Data Acquisition

The proposed framework will obtain pertinent data files required for hydrologic forecasting and for running the current hydrologic model. These files include digital elevation model (DEM) terrain, land cover grid file, radar rainfall, NRCS SNOTEL snow gage data, and USGS flow records for pertinent flow stations. It will use hourly NOAA NCEP HRRR or NCEP GEFS GRIB files for forecasted temperature at ground surface and above ground (2m), SWE, and precipitation accumulation as atmospheric boundary conditions.

GRIB File Processing

To create grid files that are compatible with the HEC-HMS project grid, ASCII raster files will need to be transformed using ArcPython scripts by using extraction, projection, and resampling functions that can be automated without needing to run ArcGIS. The process will be programmed using ArcPython scripts to ensure correct extents, projection, and raster cell size.

Each transformed raster file will be entered into a HEC-DSS database using an ASCII-to-DSS conversion tool which will ensure a correct path identifiable through the HEC-HMS program for each record or raster needed.

Alteration of Land Surface Parameters

An important consideration for SRP's operations is to estimate impacts of land parameter changes – such as burn scar areas from wildfires – on reservoir inflows. Alteration of the Curve Number (CN) grid contained in the HEC-HMS model would be required if there are land-use changes within the watershed. The project team will develop a GIS tool to modify the Curve Number grid

[2] ftp://ftp.ncep.noaa.gov/pub/data/nccf/com/hrrr/prod/hrrr.20210331/conus/
[3] https://www.ncdc.noaa.gov/wct/batch.php

to include newly updated wildfire areas or other land use alterations from data bases such as NOAA MODIS products for active fire and burned areas. The project team will research the best way to reflect how soil drainage properties are modified after burn events and the repercussions of these changes to the Curve Number grid.

Hydrologic Model Validation

Validations of the calibrated HEC-HMS model will be done at the outlets of various watersheds where snow and runoff gage data are available at the NRCS SNOTEL and USGS gages. Validation will be based on a selected set of water years that were not used in the calibration.

Automation

The project team will create a system that automatically executes the data acquisition, GRIB file processing, and HEC-HMS simulation at a frequency to match the publication of data by NOAA. The output of HEC-HMS will be automatically post-processed to provide the proper input for the OASIS model discussed in Section 2.2.

2.2 Data Integration and Reservoir Operations Model

SRP's Reservoir Planning Model (RPM) is built in OASIS (Operational Analysis and Simulation of Integrated Systems) water resources software. To date, SRP has used the long-term simulation mode of OASIS, analyzing water supply reliability using continuous records of inflow based on USGS gages. The RPM was also used to analyze the impacts of downscaled climate model outputs on reservoir operations in the recent SECURE Reservoir Operations Pilot Study [4] with Reclamation. Figure 3 shows the schematic of SRP's current RPM.

This project will add the Position Analysis (PA) mode of OASIS to the model, which – instead of using a single continuous trace of inflows – uses an ensemble of multiple traces of inflows. When the ensemble of inflows represents a real-time forecast, the OASIS simulation represents an ensemble forecast of the operation of the water supply system. The PA results can be used to generate probabilistic forecasts of reservoir levels and other important operational metrics. An extensive review of OASIS forecasting capabilities for use as an OST can be found in the National Academies of Science 2018 review of New York City's OST[5], which uses OASIS for reservoir and river basin modeling.

[4] https://www.usbr.gov/watersmart/pilots/docs/reports/Final_Reservoir_Operations_Pilot_Report-Salt_and_Verde_Az.pdf
[5] https://www.nap.edu/read/25218/chapter/1

[redacted]

The OASIS framework includes features for automatically generating flow forecasts that are used as input when simulating forecasted reservoir operations. Currently, the framework has features that are specific to the generation of statistically-based flow forecasts. The project team will further develop the framework to automatically input and format the streamflow forecasts produced from the HEC-HMS model as described in Section 2.1. HEC-HMS and OASIS use a common data storage system for timeseries data – the USACE's HEC-DSS database – which will streamline the effort from passing the data from HEC-HMS to OASIS.

Other data required for position analysis include real-time reservoir elevations, which are already collected and stored by SRP using the AQUARIUS framework. The OASIS framework currently includes features for automatically collecting observed data from various internet sources, such as the USGS Water Data web API. The team will further develop these features so that the OST will be able to collect observed data from SRP's AQUARIUS server. SRP ITS staff will work with the project consultants to develop this framework.

SRP's current RPM can be simulated on a monthly or daily timestep. In order to process and simulate the forecasts that would be developed under this framework, the RPM will be modified to handle a sub-daily timestep (likely hourly or six-hourly). Use of the smaller time step size will require refinements to the level of detail represented in RPM. Furthermore, it will require the addition of logic for reservoir spillways and gate outlet works, all of which can readily be handled using OASIS's built-in Operations Control Language (OCL). OCL will also be used to incorporate flow routing (channel storage) for more accurate representation of flow at key points downstream of the reservoirs. The modified sub-daily reservoir operations model will be validated using historical inflow records and operating data to ensure an accurate representation of the reservoir system.

The OASIS framework contains flexible, script-based post-processing tools for extracting and computing specific system performance metrics from the simulation results. The performance metrics are displayed in data tables or plots. The project team will determine the most important performance metrics for informing operational decision making. Scripts will be prepared for the OST to present those metrics for quick and meaningful interpretation by SRP staff. If necessary, the post-processed output will be prepared for further post-processing and display in tools such as Excel, Power BI, or a web service. Figure 4 shows an example of how probabilistic output from OASIS can be displayed.

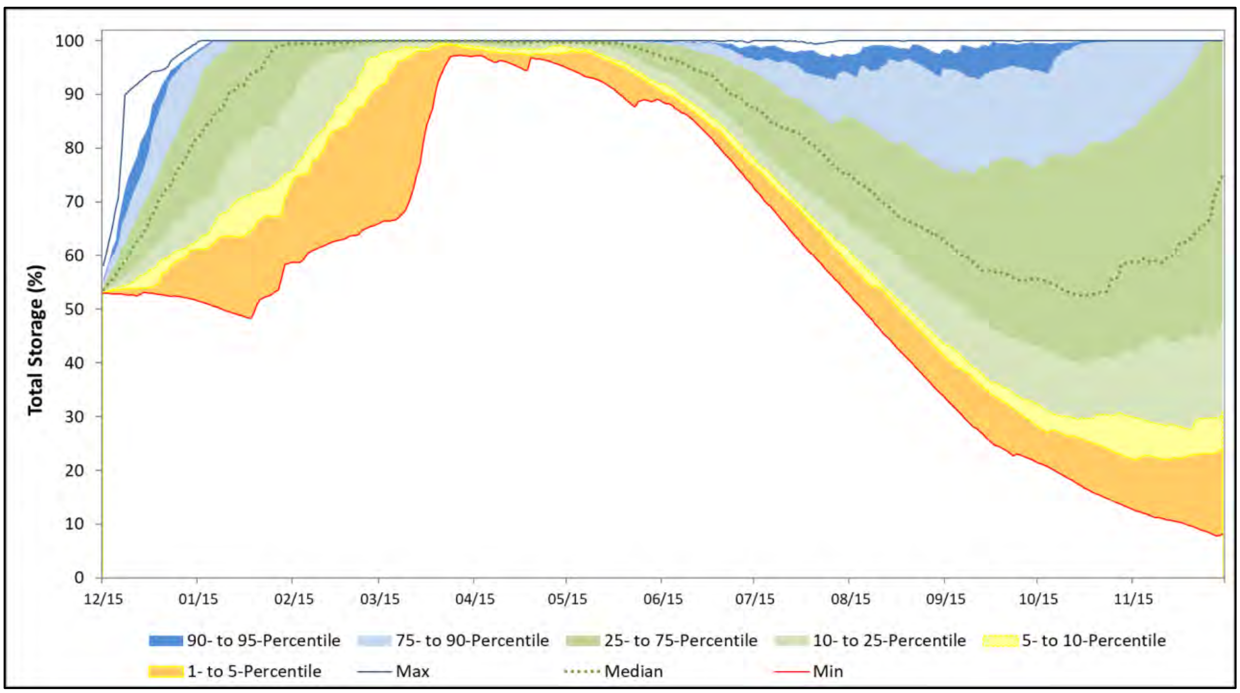

Figure 4. Sample Probabilistic Reservoir Forecast Plot

2.3 Project Location

This project will be completed in the Salt and Verde River watersheds that provide surface water to the Salt River Project in the Phoenix Metropolitan Area, shown in Figure 5. The OST will consist of a rainfall-runoff model, with a domain of the entire watershed areas as shown, and a reservoir operations model, with a domain from Roosevelt Lake and Horseshoe Lake on the Salt and Verde rivers, respectively, down to SRP's diversion dam at Granite Reef on the Salt River.

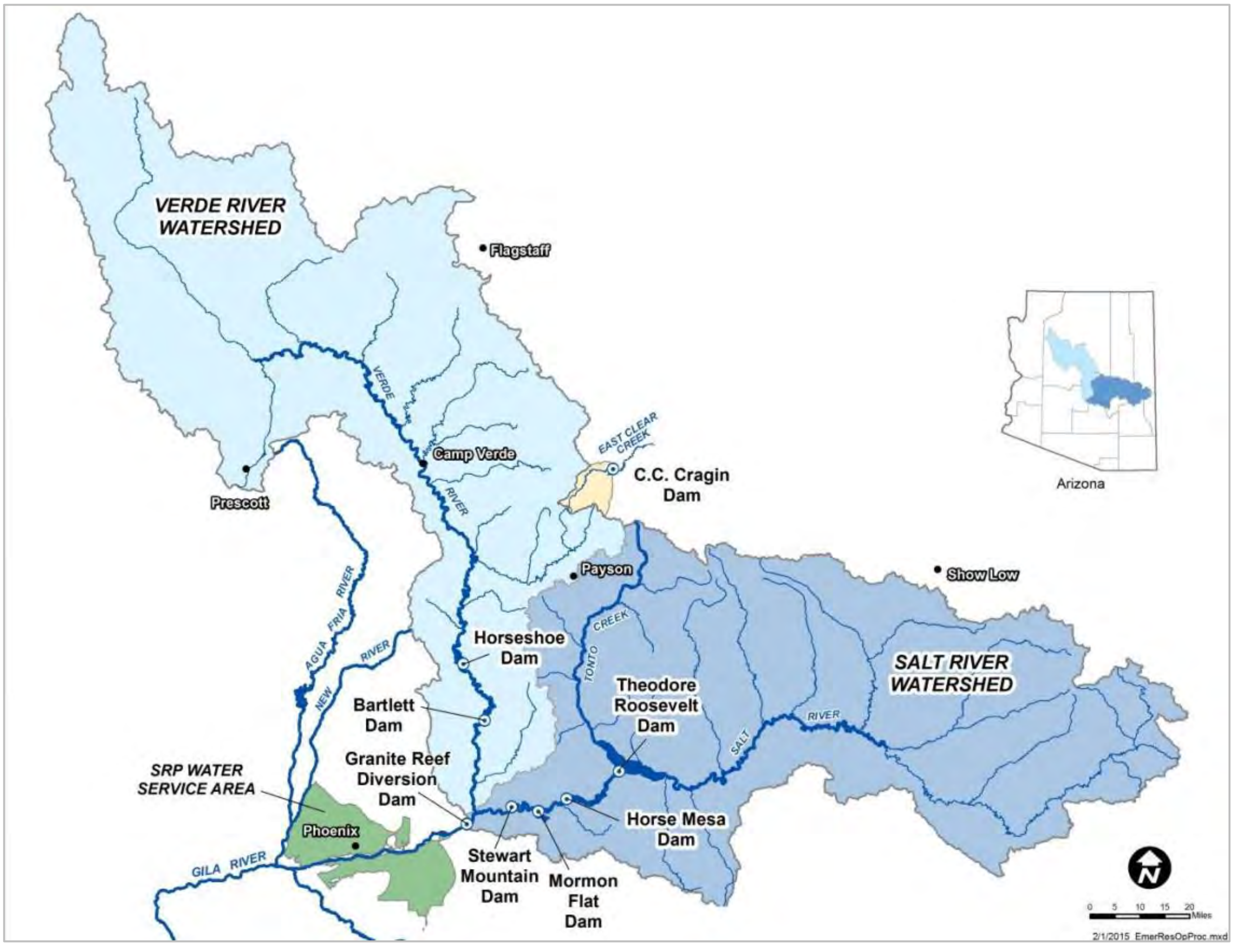

Figure 5. Project Location – Salt and Verde river watersheds

2.3.1 Data Management Practices

All spatial data used, and tools created for this project will be developed in industry standard formats compatible with GIS platforms. Specifically, the watershed modeling component of this project will require the acquisition of gridded binary (GRIB) files from NOAA, which will be extracted using NOAA's Weather and Climate Toolkit, and then processed (using ArcMap and ArcPython scripts) into a compatible format for use with the HEC-HMS project grid. A framework for automatically downloading and processing the files will be developed as part of this project.

Other data downloads will include timeseries data of streamflows and precipitation from publicly accessible web services. The OST will require current reservoir levels to be read in from SRP's AQUARIUS database – SRP ITS staff will develop a framework to allow access to that data that adheres to SRP data security guidelines.

All downloaded data will be kept for an appropriate amount of time and then archived or deleted on a regular schedule to preserve storage space. SRP already has a dedicated server that they use to host the current version of RPM, and it is anticipated that that server will be utilized to host the OST, including all associated data downloads, and required ancillary software.

3. Evaluation Criteria

3.1 Evaluation Criterion A — Benefits to Water Supply Reliability

3.1.1 Describe the water management issue(s) that your project will address.

This project considers USBR's mission of meeting increasing water demands while protecting the public's investment in these structures by addressing dam safety, protection of public, and water supply stored for beneficial use for SRP shareholders and those entities that earn stored water credits. The Salt and Verde River Reservoir System SECURE Reservoir Operations Pilot Study published in 2020 by USBR and SRP identified that there is great uncertainty with climate change impacts to the Salt and Verde watershed hydrology in the future that may impact water supply into reservoirs. The Verde River Sediment Mitigation Appraisal Study currently being performed by USBR and SRP has also identified that sedimentation in the Verde Reservoir system is reducing capacity and impacting water supply and dam operations. With both issues impacting water storage and supply in the future, having tools that can enhance dam operations to benefit water supply is critical. Modernization of SRP's streamflow forecasting capability will give SRP's hydrologists and meteorologists greater ability to make operational decisions that directly benefit water supply considering climate change and sedimentation uncertainty in the future. Advanced warning from a modern forecast tool will also benefit flood release decisions that impact dam safety and the public downstream.

3.1.2 Explain how your project will address the water management issues identified in your response to the preceding bullet.

a. Water supply reliability: Advanced notice of local (ungauged) inflow into SRP's lower Salt reservoirs allows SRP to create space to capture inflows while minimizing or eliminating any release above SRP's water delivery obligations. SRP maintains approximately 20,000 acre-feet of space in Horse Mesa Dam to capture local inflows. Local inflows captured in the downstream reservoirs behind Stewart Mountain and Mormon Flat Dams can be pumped back upstream and stored behind Horse Mesa Dam.

b. Management of water deliveries: Advanced notice of local inflows into SRP's system can allow inflows to be pumped back and stored for later use and reduce the volume and magnitude of releases necessary to maintain the Safety of Dams and protection of the public. An early response can reduce the volume and magnitude while allowing for more time to communicate flood releases to those stakeholders who may impacted. The advanced waring allows unbridged crossings to be closed sooner, increasing public safety, and can mitigate impacts to businesses (i.e. Sand and Gravel), construction projects located within the Salt River channel as well as SRP's inlet channel to the Granite Reef Underground Storage Project, which is used by Valley Cities primarily to store long-term storage credits.

Advanced notice of flash floods downstream of Bartlett and Stewart Mountain Dam allows SRP to reduce releases from Bartlett Dam and Stewart Mountain Dams and/or reduce pumping. The water generated by the flash floods can then be diverted at Granite Reef Diversion Dam for delivery through SRP's canal and laterals to meet water delivery obligations. Conversely, if those flash floods develop over burn scars that create debris flows with poor water quality, SRP can release those flows into the Salt River below Granite Reef Diversion Dam. SRP will also work with our stakeholders, including Central Arizona Project, to bring uncompromised water into SRP's system to blend with the debris (ash and sediment laden) flow to improve the water quality, making it easier and less costly for the cities' water treatment plants to meet drinking water standards.

One possible option to maintain reservoir storage capacity from sedimentation being studied in the Verde River Sediment Mitigation Appraisal Study is sluicing infrastructure and a sluicing program for alternatives. Sluicing has a high water duty, so modern, more accurate forecasts provided by this project may be critical framework for an effective sluicing program.

SRP's Hydro Generation department typically schedules maintenance during late fall and early winter when hydrogeneration is not in demand. The maintenance often includes lake level restrictions and reduced release capacity at the Salt River dams. Advanced notice of local inflow will allow for more timely response to storm events, reducing the exposure of the work force to dangerous situations and reducing loss of materials, equipment, and time due to flooding.
c. Water marketing activities: N/A

d. Drought management activities: Maintaining a balance of surface water in the Salt and Verde reservoir systems is paramount to mitigate for unforeseen circumstances that reduce SRP's capability to meet delivery obligations from either Stewart Mountain Dam or Bartlett Dam. Forecasted inflows can help inform the timing of SRP's seasonal water delivery operations. Low flow projections will help determine the timing of when the water order can be switched from mostly the Verde River reservoir system or the Salt River reservoir system to achieve the desired surface water balance between the Salt and Verde reservoir systems.

e. Conjunctive use of ground and surface water: Flash floods or debris flows generated from burn scars can inform SRP's management on the need to decrease pumping and allow excess water to enter the delivery system or to increase pumping to help blend water with debris flow to improve water quality.

f. Water rights administration: Many of SRP's contracts allow for credit accrual as water storage increases in the Salt or Verde reservoirs. Alternatively, when SRP spills water (i.e., releases greater than our delivery obligations) those water storage credits can be spilled (lost) and therefore cannot be beneficially used. Advanced notice of flood flows reduces the amount of water released (spilled) to manage these flash floods and is a direct benefit to those entities with stored water credits. This includes the New Conservation Cities (Phoenix, Tempe, Scottsdale, Chandler, Mesa and Glendale), Fort McDowell Yavapai Nation, Salt River Pima Maricopa Indian Community, Gila River Indian Community and the Roosevelt Water Conservation District.

g. Ability to meet endangered species requirements: Potential for better water management could benefit the endangered species identified in the Horseshoe and Bartlett Reservoirs Habitat Conservation Plan and the Roosevelt Habitat Conservation Plan.

h. Watershed health: N/A

i. Conservation and efficiency: Advanced warning will allow SRP to store more water for beneficial use by either taking advantage of available storage within the Lower Salt Reservoir system or altering meeting SRP's delivery obligations to create additional reservoir capacity to capture forecasted inflow events. Additionally, advanced predictions of runoff would allow SRP to reduce pumping to save the water resource and reduce cost.

j. Other improvements to water supply reliability: Advanced warning of flood events allows SRP to prepare the delivery channel to the Granite Reef Underground Storage Project (GRUSP) facility and secure the culverts that deliver the water to GRUSP. Safeguarding the GRUSP culverts against flood releases larger than 10,000 cfs expedites the return to service of recharge facility and provides significant cost savings.

3.1.3 Describe to what extent your project will benefit one of the water management objectives listed in the preceding bullets.

The reservoirs on Salt and Verde Rivers managed by SRP are high hazard dams. Advanced warning of potentially adverse floods strongly supports our core mission of maintaining the Safety of Dams and protection of the public.

3.1.4 Explain how your project complements other similar applicable to the area where the project is located.

This project would be complimentary to numerous other streamflow models available to SRP. SRP relies on the CBRFC's streamflow model and an in-house event-based model (CLEMM). These models are used for emergency reservoir operations from high impact weather events, continuous streamflow modeling for situational awareness and daily reservoir operations, and long-range streamflow forecast needed for water resource planning. One of the most complimentary aspects would be the new methodological modeling approach that this proposed effort would take. The CBRFC's SAC-SMA model is a lumped hydrologic model that generalizes sub basins above gauged measurement points. SRP's event model is purely statistical based using old Soil Conservation Services statistical curves. The proposed method would use a distributive approach that models much smaller areas that include high resolution elevational areas at short temporal scales.

In addition, the added benefits of the proposed model would allow for greater flexibility with the models hydrometeorological inputs, land use categories, and the frequency/timing of the model's operations. The current suite of hydrologic models rely on hard coded inputs and initial states of which SRP has no control of. Recent catastrophic wildfires have limited our ability to correctly model the impacts of the burn scars on the surface water hydrology of the Salt and Verde river system. Also, scientific advancements within the science of atmospheric modeling have pushed out skilled forecast to well beyond what the current suite of models are able to use. Finally, climate change science indications of increased variability and changes in snow conditions makes this increased flexibility invaluable.

The added benefits would not only prove useful for SRP's operations and planning but would likely drive improvements for all modeling efforts (including those of the NWS-CBRFC and USBR) of the Salt and Verde river system through increased knowledge gained through operating the proposed distributed hydrological model. This understanding would likely result in better planning for both operations and infrastructure related to a future climate.

3.2 Evaluation Criterion B — Need for Project and Applicability of Project Results

Explain how your project will result in readily useful applied science tools that meet an existing need:

The resulting applied science tool will be readily useful to SRP and may be applicable to other projects in the West, as detailed below.

3.2.1 Will the project result in an applied science tool(s) or information that is readily applicable, and highly likely to be used by water resource managers in the West?

a. Explain who has expressed the need and describe how and where the need for the project was identified.

The Surface Water group within SRP expressed the need for a timelier forecast of streamflow that my cause adverse implications on reservoir operations. The need was highlighted in September of 2019 when an anomalous, intense summer convective complex focused intense rainfall on the lower Salt reservoirs, generating local inflows near 50,000 cfs, which immediately overwhelmed the storage capacity and caused downstream reservoir releases near 40,000 cfs with little advance warning.

b. Will the results of your project inform water resource management actions and decisions immediately upon completion of the project, or will additional work be required?

The OST resulting from this project will immediately be utilized to inform management's operational decisions.

c. If applicable, will the results of your project be transferrable to other users and locations?

The Reservoir Planning Model and the HEC-HMS model for the Salt and Verde Watershed are specific to SRP; however, the technology and framework for the OST developed under this project would be transferrable to other facilities.

d. If the applicant is not the primary beneficiary of the project (e.g., Category B applicant), describe how the project beneficiaries have been or will be involved in planning and implementing the project? –

Not applicable.

3.3 Evaluation Criterion C — Project Implementation

3.3.1 Briefly describe and provide support for the approach and methodology that will be used to meet the objectives of the project.

The project will use readily available and established data sources and models to develop the proposed OST. As part of this proposal a methodology has been developed for each step of project implementation (as detailed in Section 2). HEC-HMS and OASIS models of SRP's watershed and reservoir system already exist and the project team includes staff with the necessary experience to leverage them to develop the OST within the proposed schedule and budget.

3.3.2 Describe the work plan for the project.

SRP and their consultant, Hazen and Sawyer, have developed a proposed workplan and schedule for each task of this project. The schedule, including detailed subtasks, is shown in Table 2, and the major milestones are outlined below it.

Table 2. Project Tasks, Schedule, and Milestones (capital letters)

			2021			2022								
Task	**Task/Subtask**		**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**
1 (ADMIN)	a	Kickoff												
	b	Project coordination/meetings												
2 (DATA MANAGMENT/ MODEL INTEGRATION)	a	Server setup/coordination/troubleshooting												
	b	Downloading and integrating forecast files with HEC-HMS												
	c	Coordinate overall operability and forecast integration of OASIS-HMS												
	d	Finalizing integration and server deployment											C	
3 (HEC-HMS)	a	Data collection												
	b	HEC-HMS model preparation												
	c	HEC-HMS model calibration/validation					A							
4 (RPM OASIS)	a	Configure OASIS to get data from AQUARIUS												
	b	Conversion of RPM to sub-daily timestep							B					
	c	Verification and QAQC												
	d	Create output files												
5 (DOCUMENTATION)	a	Documentation (final report)												
	b	Training SRP staff												D
	c	Meeting/webinar w/ USBR												

Milestones:

A. Updated, calibrated HEC-HMS model. By February 2022, we will have an updated, calibrated HEC-HMS model that can input meteorological forecasts, SWE, and ATI from NOAA, incorporate altered CN values to reflect recent burn areas, and output ensemble hydrologic forecasts for the Reservoir Operations Model.

B. Sub-daily RPM model. By April 2022, we will have an hourly or six-hourly Reservoir Operations Model that can input the forecasts generated by HEC-HMS and real-time reservoir elevations from the AQUARIUS framework.

C. OST deployment. By August 2022, we will have the functional integrated tool deployed on SRP's server.

D. Training and documentation. By September 2022, SRP staff will be fully trained on OST use and model documentation will be finalized, completing the project.

3.3.3 Provide a summary description of the products that are anticipated to result from the project.

The proposed OST project will result in the following products:

Product	Description
Forecast data collection and pre-processing tool	NOAA forecasts (as described in Section 2.1) and other required data will be downloaded, processed, and stored for use in modeling.
Hydrologic Forecast Model	An updated HEC-HMS model of the Salt and Verde river watersheds used to forecast inflows into SRP's reservoir system.
Reservoir Operations Model	A sub-daily OASIS model of SRP's reservoir system that will use ensemble inflow forecasts to project reservoir levels and downstream flows. Post-processing files will also be developed to display and interpret results.
Documentation	A report detailing the development of each component of the OST will be written as part of this project.

3.3.4 Identify staff with appropriate credentials and experience and describe their qualifications.

A project team, consisting of staff from SRP and their consultant Hazen and Sawyer, has been identified to implement the proposed OST. Figure 6 shows the task leads for the project. They will be supported by a group of experienced water resources practitioners with extensive experience developing similar tools, as described in the following section.

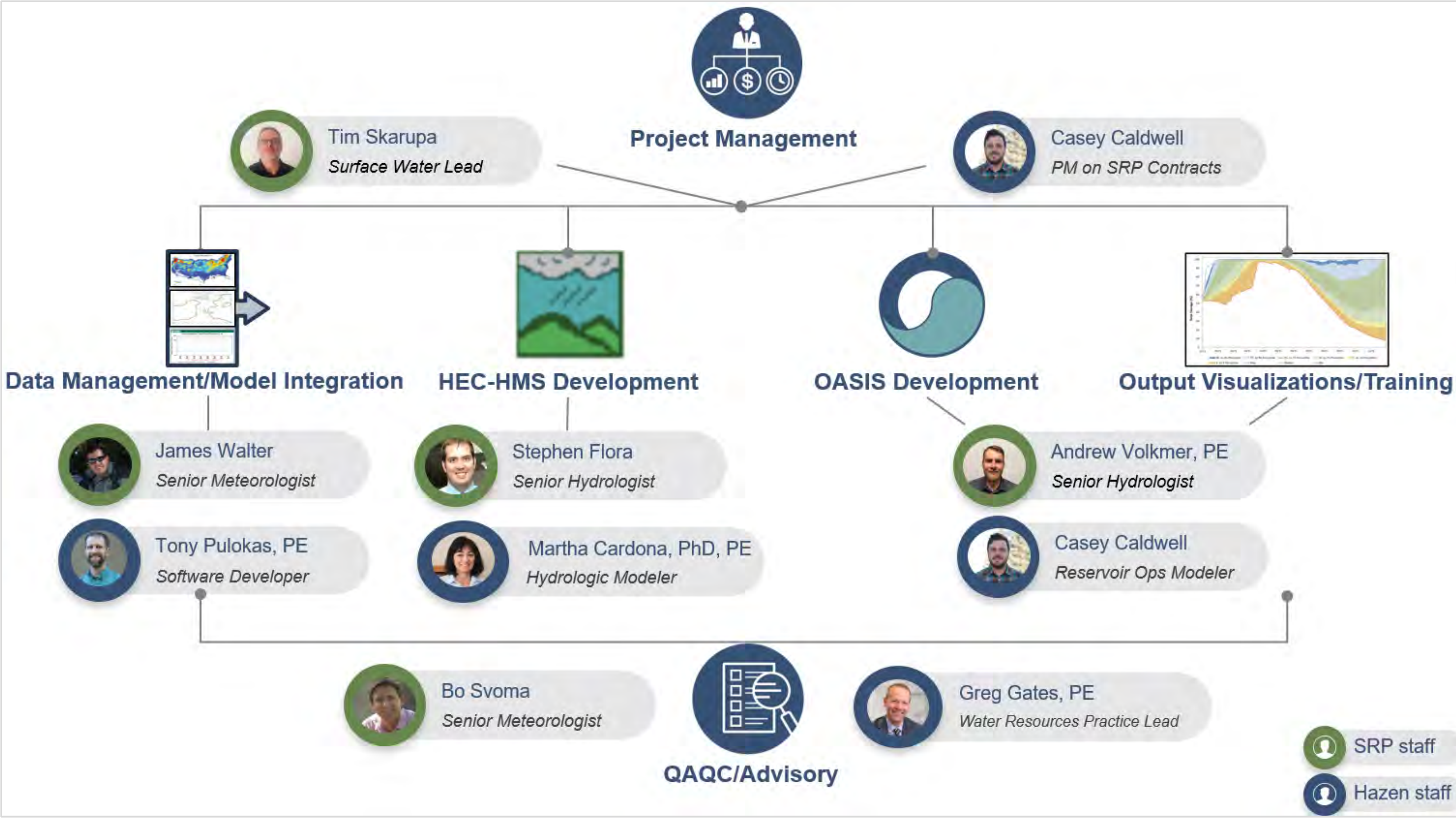

Figure 6. Project Team Organization

a. **Have the project team members accomplished projects similar in scope to the proposed project in the past either as a lead or team member?**

The selected project team has extensive experience in the areas necessary to complete the proposed project, as detailed below. Additionally, the SRP team members James Walter, Bo Svoma, Andrew Volkmer, Stephen Flora and Tim Skarupa were co-authors of the *Salt and Verde River Reservoir System SECURE Reservoir Operations Pilot Study*. The project team will also have access to SRP's ITS and Data Management groups to ensure that the OST will be deployed on SRP servers and have access to data sources needed to run forecasts.

<u>Salt River Project Key Staff:</u>

Tim Skarupa. *Project manager and reservoir operations advisor.* Mr. Skarupa has 18 years of experience in reservoir operations, streamflow forecasting and emergency management. He is a senior hydrologist that specializes in day-to-day operations, emergency operations and short and long-term water supply planning. He was a technical advisor for the development of SRP's Reservoir Planning Model and continues to provide analysis and verification of model results.

Andrew Volkmer, PE. *Reservoir operations modeling lead*. Mr. Volkmer specializes in reservoir modeling for water resources planning, water infrastructure projects, and water supply development for the Salt and Verde Reservoir System using the Reservoir Planning Model developed specifically for SRP. He is a senior hydrologist and has experience with hydrologic modeling and reservoir operations.

James Walter. *Data management and model integration lead.* Mr. Walter is a senior meteorologist within SRP's Surface Water group. He has almost 20 years of experience, specifically in quantitative precipitation forecast used in day-to-day operations, and emergency reservoir operations. In addition, he has gained an extensive knowledge of the hydrometeorology of the Salt and Verde watersheds through scientific inquiry, monitoring/situational awareness of Watershed conditions, precipitation QA/QC work, and snow measurements which have been beneficial to his efforts in seasonal streamflow forecasting.

Stephen Flora, RG. *Hydrologic modeling lead.* Mr. Flora is a Senior Hydrologist with 20 years of experience working as a hydrologist/geologist within Arizona and specializes in water supply planning, reservoir operations, streamflow forecasting, and watershed monitoring for SRP's surface water group. Additionally, he has extensive knowledge of the Salt and Verde watersheds and currently uses the Reservoir Planning Model developed specifically for SRP in various water supply planning projects.

Bohumil M. Svoma, PhD. *QAQC and advisory lead.* A Senior Meteorologist, Dr. Svoma has published 29 peer-reviewed research articles in the fields of climatology/meteorology, and his current research interests are focused on improving the predictability of Arizona precipitation and streamflow from sub-seasonal through decadal time scales. Dr. Svoma's operational duties include watershed monitoring and weather forecasting, focusing on watershed precipitation in the winter and Phoenix area temperature and thunderstorm activity in the summer. Before joining SRP, Dr.

Svoma was an Assistant Professor of Atmospheric Sciences at the University of Missouri from 2013-2017. He received his PhD in Geographical Sciences at Arizona State University in 2011 and BS degrees in Mathematics and Geographical Sciences from Arizona State University in 2007.

Brian Skerven, GISP. *Hydrologic modeling support.* Mr. Skerven has over 20 years of GIS experience focusing on surface water hydrology and hydrologic modeling. His work includes area drainage master studies, reservoir inflow modeling and flood inundation mapping using applications such as ArcPro, ArcHydro, HEC-HMS, HEC-RAS and FLO-2d.

<u>Hazen and Sawyer (consultant) Key Staff:</u>

Casey Caldwell. *Project manager and reservoir operations modeling lead.* Mr. Caldwell has 15 years of experience developing simulation and forecast models for water utilities and other entities. He was the PM and model lead for the development of SRP's Reservoir Planning Model and continues to support SRP in their use and refinement of the model.

Tony Pulokas, PE. *Data management and model integration lead.* Mr. Pulokas has over 20 years of experience developing and customizing water resource modeling programs, database systems and user-friendly interfaces. He is the principal developer of the OASIS software and has extensive experience creating tools for collecting and generating forecasts for use in OASIS models.

Martha Cardona, PhD, PE. *Hydrologic modeling lead.* Dr. Cardona has over 20 years of experience in leading hydrologic and hydraulic modeling studies for water supply and stormwater systems. Her work includes evaluation of large and small watersheds using a wide range of software packages, including hydraulic and hydrologic tools such as ArcSWAT, TR-55, HEC-HMS, HEC-RAS 1D and 2D, PCSWMM, XPSWMM and water management and availability software HEC-ResSim and OASIS.

Greg Gates, PE. *QAQC and advisory lead.* Mr. Gates, Hazen's Corporate Water Resources Practice Lead, specializes in long-term integrated planning with projects primarily in the in the Western United States. He is a nationally recognized leader in water supply modeling related to water rights, water supply availability, and infrastructure siting/sizing.

b. Is the project team capable of proceeding with tasks within the proposed project immediately upon entering into a financial assistance agreement?

SRP and Hazen and Sawyer have committed that the project team has the availability to proceed immediately with the project upon entering into a financial assistance agreement.

3.4 Evaluation Criterion D — Dissemination of Results

Explain how project results will be disseminated, including:

3.4.1 Describe how the tools, frameworks, or analyses being developed will be disseminated, communicated, or made available to water resources managers who may be interested in the results.

a. If the applicant is the primary beneficiary of the project, explain how the project results will be communicated internally, and to interested stakeholders and interested water resources managers in the area, if appropriate.

Hazen and Sawyer will conduct a training upon completion of the OST to train SRP on the use of and how to analyze results from the integrated modeling tool. This training will build upon the collaboration in development of the OST, a critical aspect throughout the project. It is anticipated that SRP will have a large team of staff experienced with OST to ensure internal collaboration and redundancy with its use. Post-processing files will ensure that model outputs can be analyzed quickly and easily communicated internally, and when appropriate, to regional stakeholders, such as the Valley Cities that rely on SRP water supplies.

Additionally, a report will be written documenting the methodology of developing the OST that can be referenced internally and also used by other interested water resources managers as a generalized guide for developing a similar framework.

It is also anticipated that the results of this project will be presented at future appropriate conferences, such as those hosted by local and national chapters of AWWA or AWRA.

b. If the applicant is not the primary beneficiary of the project (e.g., universities or research institutes), describe how project results will be communicated to project partners and interested water resources managers in the area.

Not applicable.

4. Project Budget

4.1 Funding Plan and Letters of Funding Commitment

Salt River Project is pleased to provide financial support for the grant opportunity R21AS00289 if the proposal is selected for funding by the United States Bureau of Reclamation. SRP will contribute funding of $94,785 over the duration of the project with funds to be available by July of 2021. In addition, SRP staff will commit 597 of in-kind hours to the project budgeted for $60,230, for a total contribution of $155,015.

4.2 Budget Proposal

The total estimated budget for this proposal is $310,030, with the costs to be paid by SRP and Federal funding shown in Table 3.

Table 3. Total Project Cost

Source	Amount
Costs to be reimbursed with the requested Federal funding	$155,015
Costs to be paid by the applicant (financial and in-kind)	$155,015
Value of third-party contributions	$0
Total Project Cost	**$310,030**

Table 4 details the budget estimate for each major project task and subtask of the proposed project.

Table 4. Detailed Project Budget

			Hours																				Cost	
			Consultant									SRP												
Task		Subtask / Description	AE	SP	A	A	SA	SA	SA	VP	Sub-	PM	SH	SM	SM	SH	DA	SG	WITS	UM	Sub-total	Grand Total	[redacted]	Grand Total
			[redacted]																					
1 (ADMINISTRATIVE)	a	Kickoff	0	8	8	2	8	4	4	2	36	2	2	2	2	2	0	2	2	2	16	52		$ 8,927
	b	Project coordination/meetings	0	56	40	2	20	20	10	2	150	36	36	28	28	28	0	6	3	6	171	321		$ 43,870
2 (DATA MANAGMENT/ MODEL INTEGRATION)	a	Server setup/coordination/troubleshooting	0	4	0	0	16	0	0	0	20	0	0	0	0	0	0	0	60	0	60	80		$ 11,418
	b	Downloading/integrating forecast files with HMS	82	0	36	0	0	0	0	0	118	0	0	0	0	0	0	0	0	0	0	118		$ 16,030
	c	Coordinate OASIS - HMS integration	20	0	10	0	5	0	0	0	35	4	8	2	2	8	0	4	0	1	29	64		$ 7,882
	d	Finalizing integration and server deployment	20	0	10	0	45	0	0	0	75	0	0	0	0	0	0	0	0	0	0	75		$ 13,355
3 (HEC-HMS DEVELOPMENT)	a	Data collection	39	0	13	4	0	0	0	0	56	4	10	10	10	10	8	0	0	0	52	108		$ 12,301
	b	HEC-HMS model preparation	48	0	26	0	0	0	0	0	74	6	12	4	4	12	0	12	0	0	50	124		$ 14,675
	c	HEC-HMS model calibration/validation	150	0	73	40	0	0	0	0	263	10	16	10	10	16	0	10	0	0	72	335		$ 45,271
4 (RPM OASIS DEVELOPMENT)	a	Configure OASIS to get data from AQUARIUS	0	0	0	0	40	0	0	0	40	0	0	0	0	0	0	0	0	0	0	40		$ 8,179
	b	Conversion of RPM to sub-daily timestep	0	80	0	0	60	40	20	0	200	6	6	2	2	6	0	0	0	2	24	224		$ 38,750
	c	Verification and QAQC	0	40	0	20	40	40	20	0	160	8	8	2	2	8	0	0	0	0	28	188		$ 32,934
	d	Create output files	0	16	0	0	16	16	0	0	48	0	0	0	0	0	0	0	0	0	0	48		$ 8,890
5 (DOCUMENTATION & TRAINING)	a	Documentation (final report)	8	24	16	8	16	16	8	4	100	2	2	2	2	2	0	2	0	1	13	113		$ 20,043
	b	Training SRP staff	0	20	20	0	20	20	0	0	80	8	8	8	8	8	0	0	0	0	40	120		$ 18,706
	c	Meeting/webinar with USBR	0	4	4	0	4	0	0	0	12	4	4	4	4	4	0	4	0	18	42	54		$ 8,799
		Total	**367**	**252**	**256**	**76**	**290**	**156**	**62**	**8**	**1467**	**90**	**112**	**74**	**74**	**104**	**8**	**40**	**65**	**30**	**597**	**2064**	[redacted]	**$ 310,030**

Labor Classifications	
Consultant	VP - Vice President
	SA - Senior Associate
	A - Associate
	SP - Senior Principal Scientist
	AE - Assistant Engineer
SRP	PM - Project Manager
	SH - Senior Hydrologist
	SM - Senior Meterologist
	DA - Data Analytics
	WITS - Water IT Services
	SG - Senior GIS Analyst
	UM - Upper Management

4.3 Budget Narrative

Salaries and Wages

The total in-kind contribution based on SRP's project team is $60,230 for a total of 597 hours. The portion of wages included in the in-kind contribution is $33,460. SRP does not typically disclose hourly rates or salaries of employees; therefore, the wages provided represent average hourly wages by department involved in supporting this project (Table 5).

Table 5. SRP Wages and Hours

Surface Water		Average Wage	Hours
	Tim Skarupa, Surface Water Lead	[redacted]	90
	Senior Hydrologist	[redacted]	112
	Senior Hydrologist	[redacted]	104
	Senior Meteorologist	[redacted]	74
	Meteorologist 2	[redacted]	74
	Data Analytics	[redacted]	8
Cartographics &GIS Services			
	Senior Analylst	[redacted]	40
Water IT Servcie			
	IT Specialist	[redacted]	65
Management		[redacted]	30

Fringe Benefits

The total in-kind contribution based on SRP's project team is $60,230 for a total of 597 hours. The portion of fringe benefits included in the in-kind contribution is $26,770. Overhead, Sick, Vacation, Holiday, Leave and payroll tax are included in fringe benefits. (**Table 6**).

Table 6. SRP Fringe Benefits and Hours

Surface Water	Fringe	Hours
Tim Skarujpa, Surface Water Lead	[redacted]	90
Senior Hydrologist	[redacted]	112
Senior Hydrologist	[redacted]	104
Senior Meteorologist	[redacted]	74
Meteorologist 2	[redacted]	74
Data Analytics	[redacted]	8
Cartographics &GIS Services		
Senior Analylst	[redacted]	40
Water IT Servcies		
IT Specialist	[redacted]	65
Management	[redacted]	30

Travel

There are no travel costs associated with this project.

Equipment

There are no equipment costs associated with this project.

Materials and Supplies

There are no materials and supplies costs associated with this project.

Contractual

Hazen and Sawyer, SRP's consultant for water resources modeling, will lead development on the OST, with associated cost estimates detailed for each task in the budget shown in Table 4 in Section 4.2, for a total contractual cost of $249,800. SRP will use their existing ongoing support contract with Hazen and Sawyer to procure this portion of the project. The total contractor cost for this project will not exceed the Simplified Acquisition Threshold of $250,000.

Third-Party In-Kind Contributions

No Third-Party In-Kind Contributions will be used for this project.

Environmental and Regulatory Compliance Costs

These costs are not applicable to this project.

Other Expenses

There are no other expenses associated with this project.

Indirect Costs

There are no indirect costs associated with this project.

5. Environmental and Cultural Resources Compliance

The proposed project will produce a modeling tool to continuously predict streamflow's impact on reservoir operations in real-time; therefore, there will be no impacts to environmental or cultural resources.

Will the proposed project impact the surrounding environment (e.g., soil [dust], air, water [quality and quantity], animal habitat)?
Not applicable since this proposed project is limited to developing a modeling tool.

Are you aware of any species listed or proposed to be listed as a Federal threatened or endangered species, or designated critical habitat in the project area? If so, would they be affected by any activities associated with the proposed project?
Not applicable since this proposed project is limited to developing a modeling tool.

Are there wetlands or other surface waters inside the project boundaries that potentially fall under CWA jurisdiction as "Waters of the United States?" If so, please describe and estimate any impacts the proposed project may have.
Not applicable since this proposed project is limited to developing a modeling tool.

When was the water delivery system constructed?
Theodore Roosevelt Dam – 1911
Horse Mesa Dam – 1927
Mormon Flat Dam – 1925
Stewart Mountain Dam – 1930
Horseshoe Dam – 1946
Bartlett Dam – 1939
Granite Reef Diversion Dam – 1908

Will the proposed project result in any modification of or effects to, individual features of an irrigation system (e.g., headgates, canals, or flumes)? If so, state when those features were constructed and describe the nature and timing of any extensive alterations or modifications to those features completed previously.
Not applicable since this proposed project is limited to developing a modeling tool.

Are any buildings, structures, or features in the irrigation district listed or eligible for listing on the National Register of Historic Places?
Not applicable since this proposed project is limited to developing a modeling tool.

Are there any known archeological sites in the proposed project area?
Not applicable since this proposed project is limited to developing a modeling tool.

Will the proposed project have a disproportionately high and adverse effect on low income or minority populations?
Not applicable since this proposed project is limited to developing a modeling tool.

Will the proposed project limit access to and ceremonial use of Indian sacred sites or result in other impacts on tribal lands?
Not applicable since this proposed project is limited to developing a modeling tool.

Will the proposed project contribute to the introduction, continued existence, or spread of noxious weeds or non-native invasive species known to occur in the area?
Not applicable since this proposed project is limited to developing a modeling tool.

6. Required Permits or Approvals

The proposed project will produce a modeling tool to continuously predict streamflow’s impact on reservoir operations in real-time; therefore, there are no permits or approvals required.

7. Letters of Support

SRP has received four letters in support of this project, from the following regional stakeholders:

The Arizona Municipal Water Users Association (AMWUA)
The City of Chandler
The City of Scottsdale
The City of Tempe

The letters are included in the Appendix to this document.

8. Official Resolution

MEMORANDUM

April 20, 2021

Subject: Official Resolution for WaterSMART Grant Opportunity R21AS00289

To whom it may concern,

SRP operates four dams on the Salt River and two dams on the Verde River in central Arizona along with 270 groundwater wells to conjunctively manage the water supply to meet shareholder and contractual delivery obligations within SRP's service territory, which encompasses the Phoenix metropolitan area. Well over 2 million residents depend upon SRP water resources for their water supplies

Given the importance of the safety of dams, protection of the public, and maintaining a reliable water supply, SRP is very supportive of this effort to modernize our streamflow forecasting capabilities to continuously inform reservoir operations. This project will allow for more timely response to adverse flooding reducing the risk to the dams and potentially decreasing flood releases downstream while storing additional water for beneficial use. Landscape changes such as burn scars can be incorporated into the model to better predict the timing and magnitude of ash laden debris flows resulting from flash flood producing rains on recently burned areas. More timely response will improve communication and coordination between our stakeholders regarding flood releases and potential water quality issues associated with debris flows.

On behalf of the Salt River Project (SRP), I am pleased to provide this letter of financial commitment for necessary funding and in-kind contributions specified in the funding plan for WaterSMART Grant Opportunity R21AS00289. Tim Skarupa, SRP, Project Manager, will work with Reclamation to meet established deadlines

Sincerely,

Dave Roberts

Dave Roberts, SRP, Associate General Manager of Water Resources.

Cc: Tim Skarupa
Surface Water Lead
tim.skarupa@srpnet.com
602-236-2374

Appendix A: Letters of Support

amwua
ONE FOR WATER

April 20, 2021

Bruce Hallin
Salt River Project
P.O. Box 52025, PAB56T
Phoenix, AZ 85072-2025

Dear Mr. Hallin,

I am writing in support of the Salt River Project's (SRP) application for a WaterSMART grant from the United States Bureau of Reclamation to provide funds for development of SRP's proposed forecasting and reservoir operations tool.

The Arizona Municipal Water Users Association (AMWUA) is a non-profit organization comprised of the ten major cities in the Phoenix metropolitan region. The ten AMWUA municipalities collectively provide water to more than 3.6 million residents, more than half of the State's population, and to the businesses and industries that are Arizona's economic engine. AMWUA collaborates with and advocates for its members on water policies and management that safeguard their water resources and supports smart technology to better manage the SRP water system.

SRP's water system provides a critical water resource to the AMWUA municipalities. The proposed modeling project will enhance SRP's ability to analyze and react to forecasted hydrological events in the Salt and Verde watersheds. This will benefit the AMWUA cities by increasing their preparedness for potential adverse flooding and water quality issues that can arise from using SRP water diverted at the Granite Reef Dam. This proposed project will promote better coordination and cooperation between SRP, the AMWUA cities, and other regional stakeholders to manage our water resources using the best available science.

We certainly hope that SRP will receive a WaterSMART grant for this important modeling project.

Sincerely,

Warren Tenney

Warren Tenney
Executive Director

cc: Tim Skarupa, SRP Surface Water Lead

4/16/2021

To: Bruce Hallin, SRP, Director Water Supply
From: Gregg Capps, City of Chandler, Water Resource Manager

Subject: Letter of Support for Salt River Project (SRP) forecasting and reservoir operations support tool

Dear Mr. Hallin,

I am pleased to submit this letter of support for SRP's grant application to receive United States Bureau of Reclamation funding support for its proposed forecasting and reservoir operations support tool.

The proposed modeling project will enhance SRP's ability to analyze and react to forecasted hydrological events in the Salt and Verde watersheds. This will benefit the City of Chandler by being better prepared for potential adverse flooding and water quality issues that can arise from using SRP water diverted at the Granite Reef Dam. This proposed project will promote better coordination and cooperation between SRP, City of Chandler, and other regional stakeholders to manage our water resources using the best available science.

If you have any further questions regarding this matter, please contact Tim Skarupa at Tim.Skarupa@srpnet.com or by telephone at (602) 236-2374.

Sincerely,

Gregg Capps

Contact Information:

Gregg Capps
P.O. Box 4008, MS-413
Chandler, AZ 85224-4008
480-782-3585
gregg.capps@chandleraz.gov

Bruce Hallin
P.O. Box 52025, PAB56T
Phoenix, AZ 85072-2025
602-236-3212
bruce.hallin@srpnet.com

Cc:
Tim Skarupa,
Surface Water Lead

SCOTTSDALE WATER
9379 E San Salvador Drive
Scottsdale, AZ 85258
Phone: 480-312-5685
ScottsdaleAZ.gov/Water

4/20/2021

To: Bruce Hallin
Salt River Project, Director Water Supply
P.O. Box 52025, PAB56T
Phoenix, AZ 85072-2025
bruce.hallin@srpnet.com

Subject: Letter of Support for Salt River Project (SRP) forecasting and reservoir operations support tool

Dear Mr. Hallin,

On Behalf of Scottsdale Water, I am pleased to submit this letter of support for Salt River Project's (SRP) grant application to the U.S. Bureau of Reclamation WaterSMART grant funding program for its proposed forecasting and reservoir operations support tool.

The proposed modeling project will enhance SRP's ability to analyze and react to forecasted hydrological events in the Salt and Verde river watersheds. We believe this will benefit the City of Scottsdale by being better prepared for potential adverse flooding and water quality issues that can arise from using SRP water diverted at the Granite Reef Dam that is delivered to our Chaparral Water Treatment Plant. This proposed project will promote better coordination and cooperation between SRP, City of Scottsdale, and other regional stakeholders to manage our water resources using advance technology and robust modeling tools.

If you have any further questions regarding this matter, please contact Tim Skarupa at Tim.Skarupa@srpnet.com or by telephone at (602) 236-2374.

Sincerely,

Gretchen Baumgardner
City of Scottsdale, Water Policy Manager

Contact Information:
GBaumgardner@ScottsdaleAZ.gov
9388 E. San Salvador Drive
Scottsdale, AZ 85258
(480) 312-5009

Cc: Tim Skarupa, Surface Water Lead

City of Tempe
Municipal Utilities Department
Mail Stop 23-1
255 E. Marigold Ln
Tempe, AZ 85281
www.tempe.gov

April 21, 2021

Bruce Hallin
Salt River Project
Director of Water Supply
P.O. Box 52025, PAB56T
Phoenix, AZ 85072-2025
602-236-3212
bruce.hallin@srpnet.com

Subject: **Letter of Support for Salt River Project (SRP) forecasting and reservoir operations support tool**

Dear, Mr. Hallin,

I am pleased to submit this letter of support for SRP's grant application to receive United States Bureau of Reclamation funding support for its proposed forecasting and reservoir operations support tool.

The proposed modeling project will enhance SRP's ability to analyze and react to forecasted hydrological events in the Salt and Verde watersheds. The City of Tempe will benefit by being better prepared for potential adverse flooding and water quality issues that may arise from using SRP water diverted at the Granite Reef Dam. The proposed forecasting and reservoir operations support tool will promote better coordination and cooperation between SRP, City of Tempe and other regional stakeholders to manage our water resources utilizing the best available science.

Sincerely,

Terrance Piekarz

Terrance Piekarz
City of Tempe
Municipal Utilities Director
255 E. Marigold Lane
Tempe, AZ 85281
480-350-2660
terrance_piekarz@tempe.gov

CC: Tim Skarupa
SRP
Surface Water Lead
602-236-2374
Tim.Skarupa@srpnet.com