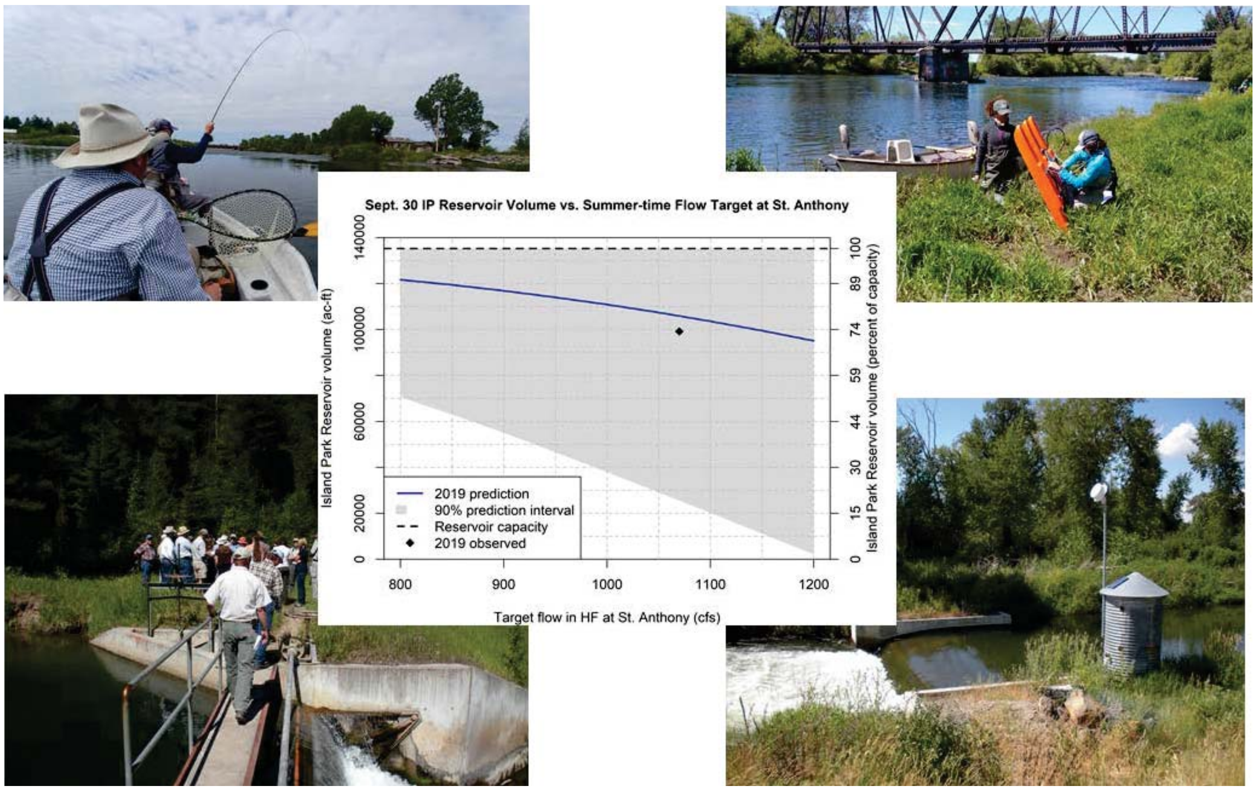
Predictive hydrologic modeling and real-time data access to support water resources planning and management in the Henry's Fork Watershed

U.S. Bureau of Reclamation WaterSMART Applied Science Grant Proposal

October 29, 2019



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List of Abbreviations and Acronyms

CWA	Clean Water Act
DOI	Department of the Interior
ESA	Endangered Species Act
ESPA	Eastern Snake Plain Aquifer
ESPAM	Eastern Snake Plain Aquifer Model
FMID	Fremont-Madison Irrigation District
FOA	Funding Opportunity Announcement
FTR	Friends of the Teton River
GIS	Geographic Information System
HFF	Henry's Fork Foundation
Reclamation	U.S. Bureau of Reclamation
TWUA	Teton Water Users Association

Technical Proposal and Evaluation Criteria

Executive summary

DATE: October 29, 2019

APPLICANT: Henry's Fork Foundation

P.O. Box 550

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The Henry's Fork Foundation (HFF), a nonprofit watershed conservation organization, proposes a three-year project to develop hydrologic models and a public hydrologic data web site that will support water-resources planning and management in the Henry's Fork Snake River watershed. The goal is to improve water-management precision and efficiency to meet irrigation demand while maintaining the watershed's world renowned trout fisheries and recovering water levels in two key aquifers. The project will develop five hydrologic models, apply these to stakeholder-driven scenarios, and develop a web site that will provide real-time access to modeling products and results, currently unavailable streamflow data, and watershed-specific climate, hydrologic, and water-management data. We will develop: 1) a groundwater-surface water model for the lower Henry's Fork, 2) an automated version of an existing manually implemented model of daily climatic and hydrologic conditions, 3) a groundwater-surface water model for Teton Valley 4) an irrigation-system optimization model for the whole watershed, and 5) a new version of an existing stochastic simulation model that predicts streamflow, irrigation demand, and need for reservoir draft at the beginning of irrigation season. All models will use accepted methodology and existing data sources and be developed on standard open-source platforms such as MODFLOW. Model development and scenario testing will be guided by stakeholder input via established collaborative groups in the watershed, including the Henry's Fork Watershed Council. The project directly addresses six of the water-management objectives of this FOA: water supply reliability, improved management of water deliveries, drought management activities, conjunctive use of ground and surface water, watershed health, and operational efficiency. The project indirectly addresses other objectives. The centerpiece of system management in the watershed is Island Park Reservoir, a Reclamation facility that stores water for Fremont-Madison Irrigation District (FMID). Thus, Reclamation and FMID are participating partners in the project. We propose to fund the project with $273,211 in federal funds, $183,175 in costs paid directly by the applicant, and $104,900 in third-party in-kind contributions. Federal funds will be used to pay web-development and modeling contractors and to purchase stream gage equipment, a computer, and software. The applicant will contribute staff and intern time, student housing, computing hardware and software, web-hosting and data transmission fees, travel, stream gage installation supplies, and consulting fees associated with permitting and environmental compliance. The majority of the in-kind contribution consists of professional services donated by a retired hydrogeologist who will oversee development of the Teton Valley groundwater model. The remaining in-kind contribution consists of stakeholder engagement.

PROJECT START DATE: October 1, 2020

PROJECT END DATE: September 30, 2023

The proposed project is not located on a Federal facility.

Technical project description and milestones

The project applicant is the Henry's Fork Foundation (HFF), a 501(c)3 non-profit fisheries and watershed conservation organization based in Ashton, Idaho. We are a Category B applicant as defined in this FOA. Our Category A partner is Fremont-Madison Irrigation District (FMID), which serves 1,900 spaceholders and agricultural water users in the Henry's Fork of the Snake River watershed. FMID is the sole entity that holds storage water rights in Grassy Lake and Island Park Reservoir, the two Reclamation storage reservoirs in the watershed. The project will inform management of these two Reclamation facilities.

The project involves hydrologic model development, public access to real-time streamflow data at locations not currently gaged by government agencies, development of a web site to host models and data generated by the project, and information dissemination to water managers and watershed stakeholders. The project timeline is given in Table 1.

Model development

Lower Henry's Fork groundwater-surface water model.

We propose to construct a model of groundwater-surface water interactions for the lower Henry's Fork, which is hydraulically connected with the regional Eastern Snake Plain Aquifer (ESPA). This model will be built from the response functions generated by the Eastern Snake Plain Aquifer Model (ESPAM), developed by the Idaho Department of Water Resources. It is a finite-difference groundwater model built in MODFLOW with 1-mile grid cells and one-month temporal resolution. Numerical response functions have solid and well understood foundation in the theory of partial differential equations and form the core of ESPAM implementation. We will use existing fine-scale field measurements of actual stream reach gains and losses to downscale the ESPAM response functions to a one-week time scale and to an appropriate spatial scale of stream reaches on the lower Henry's Fork. Reach boundaries will be defined by locations of existing stream gages, points of irrigation diversion, and geomorphic changes in the floodplain..

Real-time surface-water hydrology.

The Project Manager has developed set of surface-water hydrologic models that use existing data from state and federal agencies such as U.S. Geological Survey (USGS) and the Idaho Department of Water Resources. These models are run once daily to generate and summarize climatic, hydrologic, and water-management data specific to the Henry's Fork Watershed. The data include parameters such as natural streamflow, reservoir evaporation, irrigation demand, return flows, accumulated moisture deficits, and long-term indicators of aquifer response that are critical to efficient and optimal management of the watershed's reservoir and irrigation system yet are not readily available in a single location and in real time. Currently, these models require manual data download and user initiation of computer programs. Outputs are then emailed manually to around 200 subscribers once each day. To increase distribution potential, we propose to develop computer code that will fully automate the existing models, run them several times each day, and publish the resulting information on a web site (described below). Automation will allow additional features and outputs to be added to the existing models such as current rates of change in streamflow and reservoir levels and projected conditions over the next 24-48 hours. The code will be written in R, for compatibility with the existing models and for seamless interface with the web site via the R Shiny package. A dedicated computer in the HFF office will run the models on a set time schedule and upload outputs to the web site.

Teton Valley groundwater-surface water model.
We propose to construct a groundwater model of the Teton Valley aquifer in MODFLOW, using the Groundwater Vistas V7 interface. This model will use existing input data to the greatest extent possible. To maximize the new model's utility in quantifying interactions between groundwater and surface water, the calibration objective function will use streamflow data in addition to groundwater levels, similar to what is done in calibrating ESPAM. The model will be constructed with the primary intent of quantifying streamflow response to different aquifer discharge and recharge regimes.

Henry's Fork irrigation system optimization model.
In an average year, natural streamflow meets irrigation demand until early July, when reservoir draft becomes necessary. Island Park Reservoir is drafted until mid-September, after which remaining irrigation demand can be met without storage draft. FMID and its spaceholders benefit from limiting reservoir draft and maximizing end-of-season reservoir carryover. Trout populations and recreational fishing experience in Island Park Reservoir and in the river reaches immediately upstream and downstream also benefit from limiting reservoir draft and maximizing carryover. An obvious way to maximize carryover for both irrigators and fisheries interests is to limit reservoir draft to only the amount of water needed to meet irrigation demand and account for stream reach losses, leaving stream channels dry downstream of the lowest points of diversion in the watershed. However, fisheries and wetland/riparian habitats in the lower reaches of the Henry's Fork, Fall River, and Teton River are compromised by this operational strategy, leading to a trade-off between maintaining reservoir carryover at the top of the watershed and streamflow at the bottom. We propose to construct a systems-optimization model of the Henry's Fork irrigation system that can be used to test reservoir-release and lower-watershed target-flow strategies to meet irrigation demand and maintain an optimal balance among reservoir carryover, fisheries in the upper watershed, and fisheries and aquatic habitat in the lower watershed. This model will use information and model components from the Lower Henry's Fork groundwater-surface water model and real-time hydrologic models described above. We will use formal interactions with stakeholders and potential model users to determine the modeling platform. To optimize utility and broad application of the model, we may develop two versions—one in a programming language and another in Excel. Model inputs will include outputs of previously described models developed by the proposed project, as well as existing data.

Short-term predictive models.
Over the past few years, the Project Manager has developed two seasonal predictive models, one run on April 1 to predict water supply and irrigation system management over the subsequent six months and another run on October 1 to predict water supply and reservoir fill over the non-irrigation season. Both models are based on statistical relationships among climatic variables, streamflow and irrigation demand, and both use only inputs known on April 1 and October 1, respectively, to model the upcoming six-month period. The models employ stochastic simulation; predictions and probability intervals are generated from 5,000 independent replicates from the same starting conditions. Probability distributions derived from residual variance in the statistical relationships are used to randomly select specific water years from the period of record to represent the potential range of outcomes that could occur from the given initial conditions. We propose to refine the existing irrigation-season model to include better predictions of stream reach gains, which have decreased over the past 30 years in response to increased irrigation

efficiency, and late-season diversion, which appears to have increased in recent years. These and other refinements will be made by limiting the data used in regression models to a period of record that better reflects current climatic, aquifer, and water-use conditions. Standard statistical methods such as time series analysis and information-theoretic model selection will be used to update the current statistical models with ones that perform better. We also propose to add functionality that will automatically update predictions in the middle of the irrigation season.

Scenario modeling.
In year three, the models described above, alone or in appropriate combinations, will be used to test potential future scenarios of climate, water use, aquifer conditions, and management. Scenario modeling will be done with input from stakeholders and managers so that the scenarios address future conditions of interest to them. The ultimate goal of scenario modeling is to identify particular water-management strategies that will ensure a reliable water supply for agriculture, fisheries, and aquifer stabilization in the future.

Stream gages

HFF currently conducts streamflow measurements at three stations: Buffalo River at Island Park, Teton River at Tetonia, and Henry's Fork at Parker-Salem Highway. The Buffalo River gage is a retired USGS station, and the Teton River gage is very close in location to another retired USGS station. The Henry's Fork station is on the lower Henry's Fork, in the middle of a long reach that has never been gaged. Streamflow at these locations can potentially improve water management, particularly to benefit fisheries and other aquatic resources under the constraints of meeting irrigation demand, but the data are currently not available to the public or in real time. We propose to automate collection, transmission, and web hosting of streamflow data at these stations. At each of the Buffalo River and Teton River stations, we will install a Campbell Scientific CS451 pressure transducer, which will connect to Campbell Scientific CR310 data logger with built-in Verizon 4G modem. The instruments will be powered with a 12-V DC supply and housed in an accompanying instrument box. The cell signal from each of these stations, as well as that from existing equipment at the Henry's Fork location, will be received by Campbell's proprietary LoggerNet software at a server in our office. We will establish and maintain rating curves at all three stations, and the latest rating will be applied to the raw pressure data to calculate streamflow. This calculation will occur on the local server during data processing, which will be done with custom code written in R. The R code will also filter erroneous data using algorithms we have already developed. The processed streamflow data will then be transmitted from the local server to Amazon S3 cloud storage and from there to a new data web site that will be developed as part of the proposed project. Any required permitting or environmental compliance will be conducted prior to equipment installation in the field.

Hydrologic data web site

This public web site will host the data and information produced by the real-time hydrology model, the real-time stream gage data, and capabilities for users to define and run their own water-management scenarios using web-based versions of some of the models developed in this project. The web site will be hosted on shinyapps.io and will be written primarily in R, using the Shiny package. Appropriate HTML and CSS code will be used as needed. The web site will allow users to browse static but frequently updated content, generate customized graphical representations of hydrologic parameters and download the underlying data and R code.

Information dissemination

Stakeholder meetings, to gather input on model development and to share results, will be done through regular meetings of the Henry's Fork Watershed Council, Henry's Fork Drought Management Planning Committee, and Teton Water Users Association (TWUA). Each of these are grassroots, collaborative water-management groups, the oldest being the Watershed Council, which has been facilitated by HFF and FMID since its founding in 1993. Other user outreach will occur continuously via HFF and Friends of the Teton River (FTR) social media, newsletters, e-newsletters, and fishing outfitter and guides events. The Project Manager will travel to Boise to present results to Idaho Water Users Association, Idaho Water Resource Board (IWRB), and nongovernmental organizations involved in water issues in Idaho.

Project location

All proposed work will occur in the Henry's Fork of the Snake River watershed, Idaho and Wyoming (Figure 1). All scientific products resulting from the proposed project apply directly to water management across the whole watershed. These products apply indirectly to management of the entire Snake River basin in Idaho, because the Henry's Fork lies at the headwaters of the Snake River and because management objectives and water-rights administration are implemented at the scale of the entire basin. Project management and administration, office space for staff and students, seasonal housing for students, and computing hardware and software will be housed at the HFF office in Ashton. The three stream gages at which field work will be performed are located at 44°25'N 111°22'W near the town of Island Park (Buffalo River), 43°49'N 111°14'W near the town of Tetonia (Teton River), and 43°55'N 111°46'W about 7 miles north of the City of Rexburg (Henry's Fork).

The Henry's Fork watershed contains three major subwatersheds, those of the Upper Henry's Fork, Fall River and Teton River. Mean annual basin yield is 2.54 million ac-ft, of which 1.1 million ac-ft per year is diverted from the surface water system for irrigated agriculture. About 1.66 million ac-ft leaves the Henry's Fork watershed as surface flow, and 600,000 ac-ft recharges the ESPA. About 250,000 acres in the watershed are irrigated to produce barley, alfalfa, potatoes, and wheat. Crop evapotranspiration on these acres is around 440,000 ac-ft, of which 310,000 ac-ft is met by irrigation and precipitation, leaving a shortfall of 130,000 ac-ft. This shortfall is generally accommodated by fallowing and partial-season irrigation.

The most economically important and popular recreational trout fisheries are located on Henry's Lake and on the Henry's Fork upstream of the Teton River. Ecologically important Yellowstone Cutthroat Trout populations are found in the Teton River and its tributaries. Anglers from throughout the world travel to the Henry's Fork, which is widely considered to offer the best dry-fly fishing in the world. Annual angling use is 170,000 visitor days, and total fishing-related expenditure is $43 million. Ecologically valuable aquatic, wetland, and riparian habitats are found throughout the watershed, particularly along the Teton River and lower Henry's Fork.

The 35 largest canal companies in the watershed divert surface water at one or more of 40 major points of diversion. Most surface water is diverted through manually operated headgates into a 450-mile system of unlined, earthen canals. Conversion from traditional flood, border, and furrow application to sprinklers occurred between the late 1970s and early 1990s. The resulting loss of groundwater recharge incidental to irrigation has reduced stream reach gains.

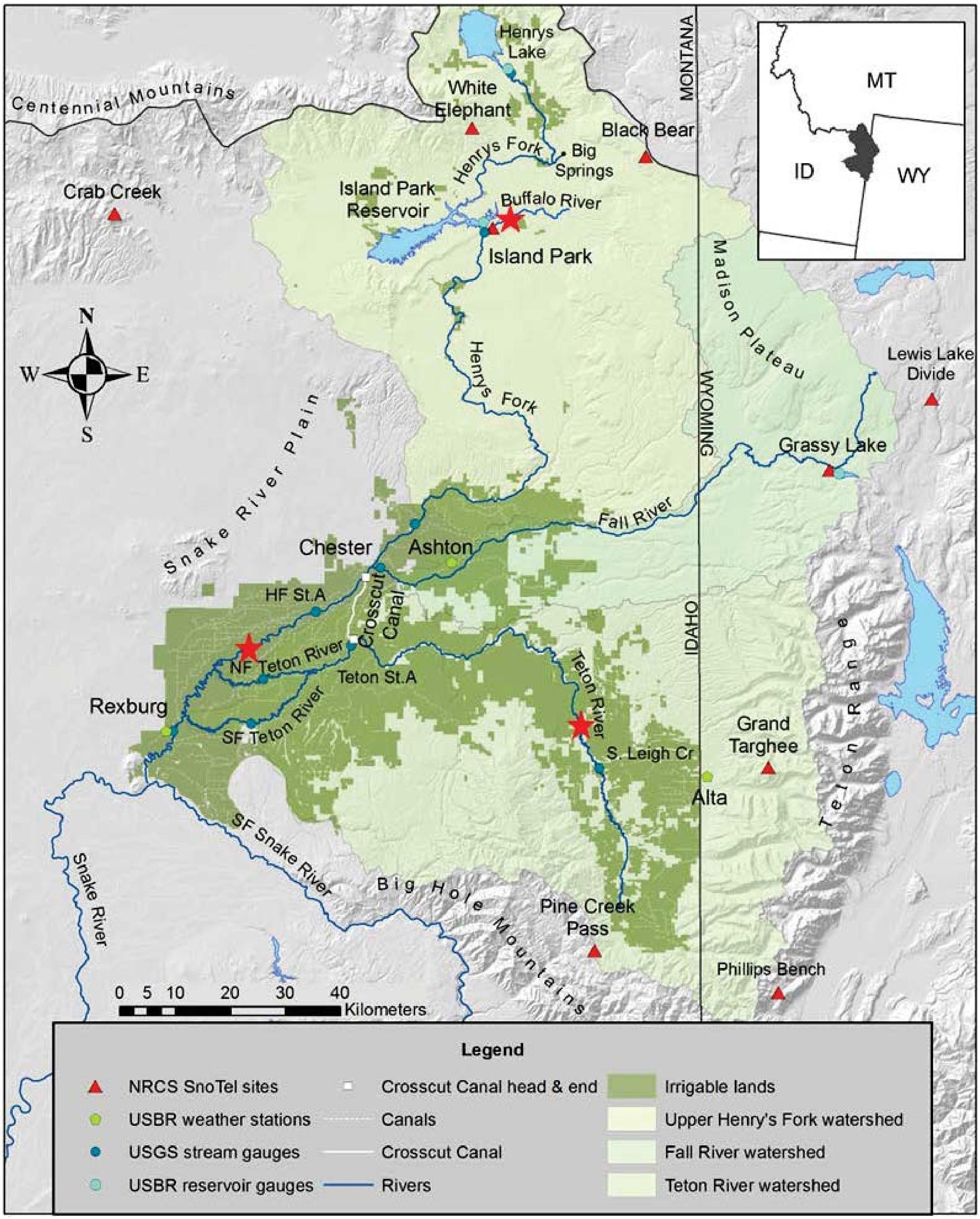

Figure 1. Map of the Henry's Fork watershed. Red stars indicate stream gages where project work will be performed.

In the median irrigation year, natural flow in the Henry's Fork watershed is insufficient to fill all water rights during a period of time that averages July 3 through September 13. During this time period, storage water is required to meet crop needs, especially on the lower Teton River. Storage need is met by three storage reservoirs in the watershed: Henry's Lake (90,000 ac-ft), Grassy Lake (15,180 ac-ft), and Island Park Reservoir (135,205 ac-ft). Henry's Lake was built in the early 1920s by North Fork Reservoir Company, a private corporation of shareholders. Grassy Lake and Island Park Reservoir are Reclamation facilities authorized in 1935 to store water for FMID spaceholders. Because both Henry's Lake and Island Park/Grassy Lake storage rights are junior to large storage rights elsewhere in the upper Snake River system, there are many years in which North Fork Reservoir Company and FMID do not receive their full allocation. The two Reclamation reservoirs lie in the upper Henry's Fork and Fall River subwatersheds, but the greatest need for storage water occurs on the lower Teton River, where streamflow drops very rapidly once high-elevation snow melts in June. To meet that need, the 1935 Reclamation included construction of the Crosscut Canal, which diverts water from the Henry's Fork immediately downstream of the Fall River confluence and delivers it to the Teton River (Figure 1). Because of its size and reliable groundwater-fed inputs, Island Park Reservoir shoulders the majority of the watershed's burden for storage and delivery and is drafted to around 45% full in an average irrigation season.

Data management practices

All data management for this project practices will conform to current data-management practices in the science and technology program of the applicant. These practices aim to minimize the likelihood of data loss, minimize required electronic memory, facilitate efficient transfer of data among internal and external users, maximize use of open-source software and platforms, document data sources and computational protocols, and maximize use of commonly used file types. All data will be stored electronically on a secure, multi-drive memory server in the applicant's office. The data will simultaneously be stored on at least one and in most cases two other memory devices, which may include a computer hard drive and either cloud storage or an external drive stored in a location other than the applicant's office. All spatial data will be developed in ArcGIS and stored in standard GIS formats. We will use open-source platforms and programming languages to the greatest extent possible and store all code as text files. All code and modeling processes will be thoroughly documented. All numerical data, will be stored as comma-delimited text files. Appropriate acknowledgment of original sources will appear in metadata accompanying data collected from external sources. Data made available for user download from the web site will be formatted as either comma-delimited or plain text. Static graphical products will be available as either pdf or png files. The data web site will serve as the primary mode of product delivery.

Evaluation criteria

Evaluation Criterion A—Benefits to water supply reliability

Describe how your project will benefit water supply reliability.

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

Located in the headwaters of the upper Snake River basin in eastern Idaho and western Wyoming (Figure 1), the 3,200 square-mile watershed of the Henry's Fork Snake River is a major source of water for irrigated agriculture both locally and regionally. At the same time, the watershed supports world renowned recreational trout fisheries, some of the largest populations of Yellowstone Cutthroat Trout remaining in their native range in Idaho, and ecologically important aquatic, wetland, and riparian habitats. The challenge of meeting irrigation needs while also maintaining fisheries and aquatic habitat has created substantial conflict among stakeholders in the watershed for decades and remains the single biggest management issue in the watershed today. Management of Island Park Reservoir is the centerpiece of the conflict between fisheries and irrigation in the watershed. Due to a variety of well understood chemical, physical, biological, and sociological factors, trout populations and recreational fishing experience in the reservoir itself and in the river reaches immediately upstream and downstream benefit from keeping the reservoir as full as possible throughout the year. During years when the reservoir is drafted heavily to meet irrigation demand downstream, low reservoir levels reduce survival of trout in the migratory reservoir-upper river fishery, high irrigation-season outflow increases turbidity and suspended-sediment concentrations in the river downstream, and low outflows during subsequent winter refill reduce survival of juvenile trout downstream. In the Teton River drainage, where native Yellowstone Cutthroat Trout are the primary species of concern, low streamflows during the summer limit trout survival and the ability of fish to migrate in and out of headwater tributaries to complete their life cycle.

Despite long-standing challenges of managing water for irrigation and fisheries, new concerns and issues associated with declining aquifer levels have increased in recent years and present their own management challenges. The Henry’s Fork Basin Study and supporting technical documents, completed in 2015 by Reclamation and the IWRB, identified the greatest water needs in the Henry’s Fork watershed as those of irrigated agriculture, fisheries, and stabilization of the ESPA. Because of substantial intersection among irrigation, fisheries, and aquifer levels, management of water resources to meet these three needs has become more complex. The goal of this project is to improve water-management precision and efficiency to meet irrigation demand while maintaining the watershed’s world renowned trout fisheries and recovering water levels in the ESPA and in the local Teton Valley aquifer.

To quantify the amount of water needed to meet these demands, the Basin Study projected future water-supply needs—in addition to those already existing in the basin—at around 130,000 ac-ft for agriculture, 200,000 ac-ft for fisheries, and 600,000 ac-ft for stabilization of the ESPA as a whole. More recent analyses have refined these numbers somewhat. An analysis of water availability for managed aquifer recharge conducted by the IWRB, nformed by actual recharge operations over the past few years and planned infrastructure improvements, suggests that around 120,000 ac-ft of managed aquifer recharge per year on the ESPA is a reasonable figure for the Henry’s Fork watershed. In the smaller Teton Valley aquifer, where water-table levels have fallen by up to 50 feet in some locations, local water users and stakeholders have set an annual target of 30,000 ac-ft of additional groundwater recharge. The fisheries estimate is based on outdated methods and data; more recent analysis suggests that streamflow requirements for fisheries, after allowing for fisheries needs already met by normal irrigation storage and delivery operations, is around 60,000 ac-ft. With these revised estimates, future demands total around 340,000 ac-ft per year. This is 13% of the Basin’s mean annual yield of 2.54 million ac-ft and 40% more than the 240,385 ac-ft combined capacity of the basin’s three storage reservoirs. The Basin Study also found that meeting these needs will become more challenging in expected future climatic conditions, which will be characterized by increased variability in water supply, earlier snowmelt, and decreased summertime streamflow.

The drought of 2013-2016, which was the most severe in the upper Henry's Fork watershed since the late 1930s, provided some insight into future climatic conditions and helped watershed stakeholders quantify water-supply needs based on actual data from what is currently considered a "worst-case scenario." In irrigation year 2014, reservoir spaceholders in the Henry's Fork watershed received only 60% of their storage allocation, a shortage of 96,000 ac-ft. In 2016, water availability for irrigation was limited by shortages of both storage water and natural flow, reducing total diversion by around 36,000 ac-ft when compared with the 2001-2018 average. Streamflow that year in the lower part of the watershed fell below summertime fisheries conservation targets by about 30,000 ac-ft. During subsequent fill of Island Park Reservoir, which was drafted to 15% of capacity, winter outflow from the dam fell short of fisheries targets by 36,200 ac-ft. These figures show that during recent drought conditions, shortfall for agriculture and fisheries combined was around 200,000 ac-ft. Adding realistic aquifer recharge targets puts total unmet need in dry years at around 350,000 ac-ft. This project addresses the need to reliably supply this unmet need year in and year out in the future.

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

Our project provides scientific tools and monitoring to support a three-pronged water-management strategy consisting of 1) precision irrigation-system operations, 2) on-farm irrigation demand reduction, and 3) managed aquifer recharge. These strategies were all presented as alternatives in the 2015 Basin Study but did not gain much on-the-ground traction until after the 2016 drought. Since then, collaborative stakeholder groups, including the Henry's Fork Drought Management Planning Committee and the TWUA, have formally recognized the value of precision system operation and managed aquifer recharge as viable ways to increase water-supply reliability without construction of economically and environmental costly storage reservoirs. Meanwhile, conservation organizations have developed programs to reduce on-farm irrigation demand through leases, market-based water exchanges, and alternative crop strategies. Although acceptance of these irrigation demand reduction strategies among agricultural producers is not yet widespread, some farmers, canals companies and irrigation districts are taking advantage of administrative and market-based opportunities to reduce demand, usually transferring the unused irrigation water to managed aquifer recharge.

Specifically, our project provides short-term predictions and real-time data to optimize system management during irrigation season and long-term predictions and scenario modeling to plan for and monitor the success of long-term management strategies.

a. **Water supply reliability**. During any given irrigation season, objectives for minimizing draft of Island Park Reservoir are in direct conflict with objectives for maximizing streamflow in the lower Henry's Fork. Our short-term information will be used on a real-time basis to manage the reservoir and canal system to the highest precision possible to meet lower-watershed irrigation demand and streamflow targets with the minimum amount of reservoir draft. Our seasonal-scale model will be used to set optimal lower-watershed targets at the beginning of an irrigation season, given water-supply data available at that time. At the longest time scales, our models will be used to set objectives for long-term projects such as irrigation demand reduction and managed aquifer recharge, which are designed to increase natural streamflow during the summer, thereby reducing demand on the reservoir system. In good water years, water saved through both short-term and long-term actions can be reassigned to aquifer recharge, thereby storing it in the aquifer to buffer against future dry years. The success of these long-term actions will be monitored with high precision by two of the three proposed real-time gages (Henry’s Fork and Teton River). The third gage (Buffalo River) will be the only real-time gage located on an unregulated stream in the Henry’s Fork headwaters and will serve to track long-term watershed response to climate change.

b. **Management of water deliveries**. As mentioned above, one of the key strategies to increase reliability of water supply is to increase reservoir carryover, which in turn, is accomplished through precision management. The real-time and short-term models will contribute to increased precision of water deliveries, as described above.
c. **Water marketing activities**. The project does not directly address water marketing activities but supports them indirectly through new real-time streamflow monitoring at the Teton River and Henry’s Fork gages. The long-term models and scenario simulations will help develop quantitative goals needed to attain the 350,000 ac-ft goal.
d. **Drought management activities**. HFF, FMID, and Reclamation are members of the Henry’s Fork Drought Management Planning Committee, which was created by a Congressional Act that transferred ownership of the Crosscut Canal from Reclamation to FMID. The Drought Management Plan was completed in 2005 and signed by FMID, North Fork Reservoir Company, Reclamation, HFF, Trout Unlimited, and The Nature Conservancy. These six entities form the core of the Committee and utilize our data or models four times each year to set general operational strategies for managing the reservoir to benefit fisheries as much as possible under the legal system that governs storage and delivery of irrigation water. Other Committee participants include staff from Idaho Department of Fish and Game, Idaho Department of Water Resources, and Fall River Rural Electric Cooperative.
e. **Conjunctive use of ground and surface water**. We will construct two groundwater-surface water models, one for the Teton Valley alluvial aquifer and one for interaction between the lower Henry’s Fork and the ESPA. These models will be used to quantify streamflow response to managed aquifer recharge and changes in irrigation practices and aid in development of long-term recharge strategies and goals.
f. **Water rights administration**. This project will not directly address water rights administration, although the sort-term predictive models can be used to predict dates on which given water rights will fall out of priority during the irrigation, allowing irrigation managers and producers to plan cropping decisions and anticipate need for storage water.
g. **Ability to meet endangered species requirements**. The project does not directly address ESA issues. In the long term, if the strategies supported by our models keep Yellowstone Cutthroat Trout populations viable in the Teton River, that species is less likely to be listed under ESA.
h. **Watershed health**. The project will contribute to watershed health by providing real-time streamflow data in three ecologically important stream reaches and by providing modeling support for refinement of the lower-watershed streamflow target. That target is currently based on anecdotal information and stakeholder consensus and not on modeling of tradeoffs between fisheries and aquatic habitat in the lower Henry’s Fork and that in

the upper Henry's Fork. This project will provide the first tools available to formally quantify that tradeoff and actively enhance fisheries in the lower Henry's Fork.

i. **Conservation and efficiency**. The project will contribute to water conservation and operational efficiency by providing short-term and real-time information to support precision operation of the reservoir and irrigation system in the Henry's Fork watershed.

j. **Other improvements to water supply reliability**. All are described above.

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

a. **Water supply reliability**. During the 2018 and 2019 irrigation seasons, preliminary versions of the irrigation-season predictive and real-time hydrology models were used by the Drought Management Planning Committee to set the lower-watershed streamflow target and by FMID and USBR to determine Island Park Reservoir draft to meet irrigation demand and the streamflow target. In each year, the streamflow target was met to within 10% (1,085 cfs vs. a target of 1,000 cfs in 2018 and 1,070 cfs vs. a target of 1,000 cfs in 2019). Statistical analysis showed that after accounting for natural streamflow and irrigation demand, the precision with which the streamflow targets were met increased reservoir carryover by around 14,000 ac-ft relative to the long-term average streamflow at the target gage. In both years, reservoir carryover was around 99,000 ac-ft (73% full), so use of model outputs increased carryover by 16%. Although 14,000 ac-ft is only 4% of the long-term goal of 350,000 ac-ft, had models predicted that the upcoming year would be dry, the target would have been set lower, which would have produced more savings, for example 20,000 ac-ft if the target were reduced to 900 cfs. Currently, the models are run manually every morning and the output delivered daily (on weekdays) via email. Sometimes this process delivers the information after the dam tender at Island Park is no longer available to make changes, and the necessary adjustments are not made until the next day or even after a weekend. The project will develop automated versions of the models, which will run several times each day. The results will be uploaded automatically to a web site, where it will be available continuously. Based on operations in 2018 and 2019, automation and real-time data access will save another 3,000 ac-ft in reservoir carryover. Increased model capabilities and improved predictions could save another 1,000 ac-ft. Thus, we estimate that the real-time models alone will increase carryover by 18,000 to 25,000 ac-ft. Rough calculations of streamflow response to ongoing and planned managed aquifer recharge suggest that late-summer stream reach gains in the Henry's Fork watershed will increase by about 100 cfs over the next few decades. Although implementation of managed recharge is not a direct activity of this grant, this streamflow response would increase Island Park carryover by around 13,000 ac-ft. Thus, anticipated increases in carryover resulting directly and indirectly from the project are on the order of 33,000 ac-ft, compared with long-term average carryover of around 60,000 ac-ft. This amounts to around 10% of the long-term goal of 350,000 ac-ft. The biggest gains in water-supply reliability are likely to be made through long-term demand-reduction and marketing activities, with quantitative goals determined by the output of our scenario modeling.

b. **Management of water deliveries**. Savings in reservoir carryover because of improved deliveries are the same as those reported above. More precise deliveries also have the potential to reduce costs to canal companies of using storage water that is delivered but not needed during the lag time between reduction in on-farm application and adjustments at the reservoir. Based on operations in 2018, reducing the time between changes in on-farm use and reservoir adjustments could save around 3,000 ac-ft, worth $18,000 to $51,000, depending on the price of storage water during a given season.

c. **Water marketing activities**. No quantification of project effects is possible ahead of model development and application.
h. **Drought management activities**. The seasonal and long-term models produced by this project will be used by the Henry's Fork Drought Management Planning Committee in its quarterly meetings. Water savings likely to occur through decisions made by the Committee are the same as those described above.
i. **Conjunctive use of ground and surface water**. Current and planned future managed aquifer recharge activities supported by this project will increase streamflow in the Henry's Fork watershed by around 100 cfs, as mentioned above. However, because most of the water recharged on the ESPA in the Henry's Fork watershed returns to the surface-water system downstream of the watershed, these activities will increase baseflow in the Snake River as a whole by around 200 cfs.
j. **Water rights administration**. No quantification of project effects is possible.
k. **Ability to meet endangered species requirements**. No direct quantification of project effects is possible, but listing of Yellowstone Cutthroat Trout under ESA would have disastrous effects on the agricultural economy in the upper Snake River basin. That economy is worth around $10 billion.
k. **Watershed health**. Each 10-cfs increase in winter streamflow downstream of Island Park Dam increases the trout population there by around 1.7 percent over the long-term average. The increases in Island Park Reservoir carryover cited above would increase winter streamflow by around 150 cfs, which would increase the trout population by 25%. This increase is well outside of measurement error and would directly increase angler catch rates. In addition, three-year average Island Park Reservoir carryover since 2017 is the highest it has been since the late 1990s. Kokanee Salmon migrated upstream out of Island Park Reservoir into the upper Henry's Fork in the fall of 2019 for the first time in over 20 years. Because fish in the spawning run are three years old, the sudden appearance of Kokanee in the upper Henry's Fork after a 20-year absence is likely due to three consecutive years of high reservoir carryover, showing that ecological response to consistent, modest increases in reservoir carryover can be swift and substantial.
l. **Conservation and efficiency**. Quantitative effects of the project and water conservation and operational efficiency are discussed above.
m. **Other improvements to water supply reliability**. Discussed above.

4. *Explain how your project complements other similar [projects] applicable to the area where the project is located?*

The proposed project fits seamlessly into ongoing applied science and monitoring activities of the applicant and its partners. These projects include water-quality monitoring watershed-wide, recreational use and economic value studies, and investigations of aquatic ecology and productivity in Henry's Lake, Island Park Reservoir, and the upper Henry's Fork. The project also complements three projects recently funded by Reclamation WaterSMART grants. The first of these is the TWUA, which was supported by WaterSMART Cooperative Planning Phase 1 and 2 grants. Those grants resulted in development of the aquifer recharge goals for the Teton

Valley aquifer that are mentioned above. FMID and Egin Bench Canals recently received WaterSMART Small Infrastructure grants for installation of remote-controlled headgates at key locations in the watershed. HFF committed in-kind and cash match to the FMID project and will conduct all of the stream gage installation and rating required to support that project. When informed by information produced by this project, automation has the potential to increase Island Park Reservoir carryover by an additional 3,000 ac-ft.

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:

1. *Does your project meet an existing need identified by a water resource manager(s) within the 17 Western States?*

Yes, this project meets an existing need identified by Idaho water managers.

a. *Explain who has expressed the need and describe how and where the need for the project was identified.*
   The need addressed by this project was identified by the Henry's Fork Basin Study, completed in 2015 by Reclamation and the Idaho Water Resource Board, with stakeholder engagement conducted through the Henry's Fork Watershed Council. Aquifer management objectives for the ESPA were identified earlier by the Idaho Water Resource Board in its 2009 ESPA Comprehensive Aquifer Management Plan.

b. *Provide letters of support from any resource managers, stakeholders or partners that have stated they will benefit from the project.*
   Letters of support from the following managers, stakeholders and partners are attached to the proposal.

2. *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?*

Because the models, data, and products developed through this proposal are site-specific and designed to meet water-management goals in our watershed, the tools will not be immediately applicable to other watersheds. However, our methodology, model construction, and data web site structure are likely to be useful to water managers and water conservation groups elsewhere in the West. To increase the probability that our tools will be adapted for use in other watersheds, we will use open-source modeling platforms and provide code to interested parties.

a. *How will the project results be used?*
   Real-time data and model output will be used by Reclamation water managers, FMID staff, commercial fishing outfitters and guides, and other watershed stakeholders to make daily management, business and river-use decisions related to current and projected short-term climate, streamflow, reservoir levels, and irrigation demand. Short-term models will be used by members of the Henry's Fork Drought Management Planning Committee to set water-management objectives and strategies for each quarter. Long-term models will be used by water-resource planners in state and federal agencies, water users, conservation groups, and other watershed stakeholders to set goals and strategies to ensure a reliable water supply and viable fisheries and aquatic resources in the future.

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

Results of the project will inform water management actions immediately upon completion of each project task. The collaboration, stakeholder organizations, and communication mechanisms needed to immediately use new information are already in place in the watershed. Scientific information and tools produced previously by HFF are already used on a daily basis to inform water management, and we expect information and tools produced by this project to be used immediately upon completion.

c. *Will the results of your project be transferrable to other users and locations?*
The methodology, model types, and web site template will be readily transferrable to other users and locations, although the specific models and outputs generated by this project will be applicable only in the Henry's Fork watershed.

d. *If the applicant is not the primary beneficiary of the project, describe how the project beneficiaries have been or will be involved in planning and implementing the project?*
The applicant and its formal partners are the primary beneficiaries of this project. However, all watershed stakeholders will be able to participate in the project through public meetings of the Henry's Fork Watershed Council.

Evaluation Criterion C—Project implementation

Describe your project implementation plan:

1. *Describe the objectives of the project and the methodology and approach that will be undertaken.*

The project has four components:

- Development of real-time, short-term, and long-term hydrologic models;
- Public access to new real-time streamflow data;
- Development of a public web site to host models and data generated by the project, and
- Information dissemination to water managers and watershed stakeholders.

Technical details of methodology for completion of each of these four project components and individual component objectives are given in the *Technical project description and milestones* section above. The timeline for completion of project tasks appears in Table 1.

2. *Describe the work plan for the project.*

The Project Manager will oversee all work performed on the project by staff, contractors, and project partners and will convene regular meetings of all or parts of the project team so that all members have a common vision for the project and are kept up to date on progress by others. The Project Manager will solicit and encourage input from all team members and facilitate collaborative work, rather than micro-managing the team and its work. A schedule of tasks, responsibilities and completion targets are given in Table 2.

Development of the two groundwater models, the system optimization model, and data web site will be conducted by contractors, consultants, both paid and volunteer. Development of the real-time models and the short-term predictive model will be conducted by a modeling assistant under close supervision of the Project Manager. The modeling assistant will also contribute to other modeling and coding tasks as needed. Scenario modeling will be conducted collaboratively by the scientific team, with most of the detailed implementation done by the modeling assistant. Models will be developed in the order presented in Table 1 so that models and tasks needed for development of subsequent models are completed first. Field work on the stream gages will be conducted by permanent HFF staff, assisted seasonally by undergraduate student interns. Coding

Table 1. Timeline of project tasks. Shading indicates task performance during a given quarter.

TASKS	FY 2021				FY 2022				FY 2023			
	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep
Model development												
Lower Henry’s Fork	■	■	■	■								
Real-time hydrology	■	■	■	■								
Teton Valley GW	■	■	■	■	■	■	■	■				
System optimization					■	■	■	■				
Seasonal predictions					■	■	■	■				
Scenario modeling									■	■	■	■
Stream gages												
Permits, compliance	■	■										
Installation			■	■	■							
Rating			■	■	■	■	■	■	■	■	■	■
Data web site												
Design	■	■										
Code outline			■	■								
Stream gages live					■	■						
Real-time models							■	■				
Media integration									■	■		
End-user modeling											■	■
Information dissemination												
Stakeholder mtgs.	■	■	■		■	■	■		■	■	■	
User outreach	■	■	■	■	■	■	■	■	■	■	■	■
Project administration												
Semi-annual reports		■		■		■		■		■		
Final report												■

necessary to interface the real-time stream gages with the data web site will be done or overseen by the web site development consultant. The data web site will be developed in phases, starting with design and code outline. As other project tasks such as the stream gages and real-time models are completed, these will be added to the web site to provide information to managers and stakeholders as soon as possible, while other project components are still under development. Stakeholder meetings and outreach will be conducted by HFF staff and by project partners.

1. *Describe the availability and quality of existing data and models applicable to the project.*

Because of the importance of water resources of the Henry’s Fork Watershed, it is arguably one of the most well studied basins in the West. Basic hydrologic, climatic, and water-management data are collected at daily or even finer temporal resolution by state and federal agencies at dozens of long-term stations. Daily streamflow, reservoir, and diversion data from all reservoirs,

Table 2. Schedule of task responsibilities and completion milestones.

PRODUCTS	Primary responsibility	Supporting personnel	Completion
Models			
Lower Henry's Fork	Christina Morrisett	HFF staff, intern, Utah State faculty	Aug. 2021
Real-time hydrology	Rob Van Kirk	Modeling assistant	Sep. 2021
Teton Valley GW	Heidi Blischke	Modeling assistant, FTR staff	Sep. 2022
System optimization	Christina Morrisett	HFF staff, intern, Utah State faculty	Aug. 2022
Seasonal predictions	Rob Van Kirk	Modeling assistant	Sep. 2022
Scenario outputs	Rob Van Kirk	Heidi Blischke, modeling assistant	Aug. 2023
Stream gages			
Permits, compliance	Rob Van Kirk	Aquatic Resources Coordinator	Mar. 2021
Installation	Rob Van Kirk	HFF staff and intern	Dec. 2021
Rating curves	Rob Van Kirk	HFF staff and intern	Sep. 2023
Data web site			
Design	Melissa Muradian	Jamie Laatsch	Mar. 2021
Code outline	Melissa Muradian		Sep. 2021
Stream gages live	Melissa Muradian	HFF staff and intern	Mar. 2022
Real-time models	Melissa Muradian	Rob Van Kirk, modeling assistant	Sep. 2022
Media integration	Melissa Muradian	Jamie Laatsch	Mar. 2023
End-user modeling	Melissa Muradian	Rob Van Kirk, modeling assistant	Sep. 2023
Information dissemination			
Stakeholder mtgs.	Jamie Laatsch	HFF, FMID, and FTR staff	Sep. 2023
User outreach	Jamie Laatsch	Morrisett, Van Kirk, FTR staff, intern	Sep. 2023
Project administration			
Semi-annual reports	Rob Van Kirk	Darcy Janssen	Mar. & Sep.
Final report	Rob Van Kirk	Darcy Janssen	Sep. 2023

points of diversion, and major streams have a common record dating back to water year 1978. Consistent climate data are available at nine SnoTel stations and three Reclamation weather stations for the period 1989-2019. GIS layers of land cover, irrigated lands, hydrography, geology, etc. are available at high resolution for most of the watershed. The Project Manager has been working with these and other data sets since 1995 and has already compiled most of the basic data required for this project. Other project team members have also worked with standard data sets and many have collected their own data through HFF research and monitoring. Development of the Teton Valley groundwater model will require the most data compilation of any of the project tasks, but FTR staff and TWUA members will provide in-kind assistance to the modeling team in compiling needed data. Overall, the project team will be able to spend most its time on modeling and tool development and relatively little time on data compilation.

2. *Identify staff with appropriate credentials and experience, and describe their qualifications.*

Rob Van Kirk: HFF Senior Scientist and Project Manager.
Rob is trained as a mathematical modeler and holds an M.S. in Environmental Systems and a Ph.D. in Mathematics. He has worked in collaborative water resource research and management in the Snake River basin since 1994, both as a staff member of HFF and as a professor at Idaho State University and Humboldt State University. Over that time, he has received over $1.4 million in competitive grants, published 34 peer-reviewed scientific papers and book chapters, authored or co-authored over 30 technical reports, and completed 25 projects as a consultant for a variety of agencies and organizations, including U.S. Forest Service, U.S. Fish and Wildlife Service, IWRB, Idaho Department of Fish and Game, Trout Unlimited, and The Nature Conservancy. Most of his professional work has focused on the intersection of hydrology, water management, and fisheries, including modeling of groundwater-surface water interactions on the ESPA. Since 2011, he has contributed technical work to the Henry's Fork Basin Study and to the IRWB's managed aquifer recharge program.

Heidi Blischke: Groundwater Modeling Consultant
Heidi is registered professional geologist with B.S. and M.S. degrees in Geology. She recently retired from GSI Water Solutions after a 33-year career in hydrogeology. Heidi has worked for universities, agencies and consulting firms, primarily in the area of contaminant transport and cleanup. She has a wide range of experience in field, laboratory, modeling, and regulatory aspects of environmental contamination, including development of groundwater models. She received a personal commendation from the Governor of Oregon for her innovative work on evaluation of contaminated sediments at Portland harbor site.

Christina Morrisett: HFF Doctoral Research Associate and Ph.D. Student at Utah State
Christina holds a B.S. in Earth Systems and a M.S. in Fisheries and Aquatic Sciences. She worked in in HFF's Science and Technology program as an intern and then research assistant from June 2015 to July 2016, completing a variety of fisheries and hydrologic modeling projects, including an assessment of water availability for managed aquifer recharge for the IWRB. Christina returned to HFF in 2018 a Doctoral Research Associate. She is working on a Ph.D. in Watershed Science at Utah State University, where she is studying links among ecology, hydrology, and sociology to address multi-stakeholder water management challenges.

Melissa Muradian: Data Website Consultant
Melissa holds a B.S. in Mathematics and a M.S. in Quantitative Ecology and Resource Management. She worked as a Research Associate for HFF from 2015 to 2018, developing and directing HFF's water quality program. During that time she built a network of 11 automated water-quality sondes, wrote R code to process 15-minute data from seven sensors in each sonde, and developed a custom data web site that hosts real-time data transmitted from the sonde network. She developed the web site from scratch, writing all of the code herself or with assistance from student interns. Since late 2018, she has worked part-time remotely as HFF's water-quality data consultant, focusing most of her time on maintaining and improving the water-quality data web site, which will form a template for the web site developed in this project.

Jamie Laatsch: HFF Communications Manager
Jamie holds a B.S. in Natural Resources and Environmental Science and a M.S. in Human Dimensions of Ecosystem Science and Management. She has worked at HFF since 2015 and has been HFF's communications manager since 2018. Jamie handles all aspects of external communications with HFF's constituency, using multi-media, audience-specific communication strategies to promote understanding of complex scientific and management issues.

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?*
   Yes. The two senior personnel on this project have served as project lead or team member on numerous projects similar in scope or even larger than the proposed project. The three junior team members have successfully completed smaller projects while at HFF and have worked in teams with each other and with the Project Manager.
b. *Is the project team capable of proceeding with tasks within the proposed project immediately upon entering the financial assistance agreement?*
   Yes.

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

The primary products are the five hydrologic models described in the *Technical project description* section, results from the scenario modeling, and the data web site that will host all of the project's models and data. Additional products include chapters in Ms. Morrisett's Ph.D. dissertation and outreach materials such as blog posts, newsletter articles, and presentations. Semi-annual performance and final reports will be submitted as required.

Evaluation Criterion D—Dissemination of results

Explain how project results will be disseminated, including:

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

The web site produced by the project will be the primary mode of information dissemination. In addition, the Project Manager will present result of the project to the Idaho Water Users Association, the Idaho Water Resource Board, and a formal conference of nongovernmental organizations involved in water issues in Idaho.

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 resource managers in the area, if appropriate.*
   All aspects of the project will be communicated at meetings of the Henry's Fork Watershed Council, Henry's Fork Drought Management Planning Committee, and Teton Water Users Association. These meetings are attended regularly by state and federal water managers, local water users and irrigation entities, other government agencies, nongovernmental organizations, and elected officials or their staffs. In addition, HFF and Friends of the Teton River will disseminate information to recreational user groups, including commercial fishing outfitters and guides, via newsletters, social media, and in-person meetings.

b. *If the applicant is not the beneficiary of the project describe how project results will be communicated to project partners and interested water resource managers in the area.*
   NA
c. *Explain why the chosen approach is the most effective way to disseminate the information to end users in a usable manner.*
   The collaborative water management groups in the watershed were formed primarily to address challenging water management issues and have become well established as the primary venue for exchanging information among stakeholders. This project will take advantage of these established groups and their regular meeting schedules.

Criterion E: Department of Interior Priorities

Explain how your project supports Department of Interior Priorities (at least one priority):

1. *Creating a conservation stewardship legacy second only to Teddy Roosevelt*.

HFF is the only organization whose sole mission it to conserve, restore and protect the unique, fish, wildlife and aesthetic qualities of Henry's Fork Watershed. Because of its proximity to Yellowstone National Park, world-class fisheries, abundant wildlife, and regionally important water resources, the Henry's Fork is treasured by visitors and residents alike. The 2,500 members of HFF have entrusted the organization with preserving these resources in perpetuity. This project is key to achieving this conservation legacy.

   a. *Utilize science to identify best practices to manage land and water resources and adapt to changes in the environment.*
      HFF's primary mode of mission accomplishment is science-based collaboration. HFF has been a leader in conducting applied science in the watershed for over 30 years. Its current Science and Technology program includes work in water quality and stream ecology, hydrology and water management, fisheries biology, and social science. Over the past few years, research in each of these areas has focused on response of these resources and adaptation of their management to climate change. This project will accelerate HFF's ability to conduct urgently needed research into water supply reliability in a changing climate and bring the information to managers and stakeholders in a timely manner.
   b. *Review DOI water storage, transportation, and distribution systems to identify opportunities to resolve conflicts and expand capacity.*
      This project directly addresses conflicts between fisheries and irrigation and will improve management of Reclamation storage facilities in the watershed. The tools developed in this project will help Reclamation manage these facilities to improve water supply reliability for all stakeholders, thereby reducing conflict.
   c. *Foster relationships with conservation organizations advocating for balanced stewardship and use of public lands.*
      Although this project addresses water resources rather than land use, HFF's local, regional, and national partners, many of which will participate in the project through the Henry's Fork Watershed Council, are all committed to balanced use of public resources.
2. *Restoring trust with local communities*.
   a. *Be a better neighbor with those closest to our resources by improving dialogue and relationships with persons and entities bordering our lands.*

Through its co-facilitation of the Henry's Fork Watershed Council with FMID, HFF has established itself as a leader in building community among diverse stakeholders. Reclamation and U.S. Bureau of Land Management regularly attend Watershed Council meetings, and this project will specifically engage Reclamation, increasing its visibility in the watershed and interaction with watershed stakeholders.

b. *Expand the lines of communication with Governors, state natural resource offices, Fish and Wildlife offices, water authorities, county commissioners, Tribes, and local communities.*
   All of these groups are on the Watershed Council mailing list and receive notifications of all Council activities. At one time or another, all of these groups have attended Council meetings, particularly the annual watershed tour, which always draws elected officials and/or their staffers. Through the three-year life of this project, almost all of these groups will attend Council meetings and engage in the project. Based on previous large projects such as this, we expect increased interest and attendance at meetings devoted to the project.

Environmental and cultural resources compliance

Note that the project area consists of the entire Henry's Fork watershed, since the proposed project will inform watershed-wide management of water resources. However, as this is primarily a modeling and data-access project, most project work will be conducted at the applicant's offices. The only field/in-river work associated with the project is associated with installation and maintenance of stream gaging equipment. This work will occur at developed sites where gaging equipment already exists. All three sites are located at bridges within highway rights-of-way.

- *Will the project impact the surrounding environment?*
  No.
- *Are you aware of any species listed or proposed as listed as Federal threatened or endangered species, or designated critical habitat in the project area? If so, would they be affected by any activities associate with the proposed project?*
  The Yellow-billed Cuckoo is listed as threatened and is found in the lower watershed. A designated critical habitat area is located in riparian forest along the lower Henry's Fork. No project activities will occur in the designated critical habitat area.
- *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.*
  Numerous wetlands and waters in the Henry's Fork Watershed fall under CWA jurisdiction. To our knowledge, none occur in the highway rights-of-way where stream gaging work is proposed.
- *When was the water delivery system constructed?*
  Private systems were built between 1879 and 1930. Reclamation facilities were authorized in 1935 and constructed between then and 1939.
- *Will the proposed project result in any modification of or effects to, individual features of an irrigation system?*
  No.
- *Are any buildings, structures, or features in the irrigation district listed or eligible for listing on the National Register of Historic Places?*
  NA. The applicant is not an irrigation district, and none of the proposed field work will take place on lands or infrastructure within the partnering irrigation district.
- *Are there any known archeological sites in the proposed project area?*
  No known archeological sites occur in the highway rights-of-way where stream gaging work is proposed.
- *Will the proposed project have a disproportionately large high and adverse effect on low income or minority populations?*
  No.
- *Will the proposed project limit access to and ceremonial use of Indian sacred sites or result in other impacts on tribal lands?*
  No.
- *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?*

No. All field work will occur in highway rights-of-way, where disturbance of native vegetation has already occurred. Potential for spread of aquatic invasive species will be minimized through standard practices of washing field equipment and waders.

Required permits or approvals

The applicant has already obtained permits and approvals from appropriate agencies for installation and maintenance of existing stream gaging equipment, some of which will be upgraded as part of the proposed project. Any required permits for new equipment installations will be obtained prior to installation if needed. Because new equipment will be installed in locations of existing equipment, the original permits and approvals are likely to be applicable. However, we will perform an environmental compliance and permitting review prior to any field work associated with this project.

Project Budget

We propose a three-year project budget of $561,286, of which $273,211 (48.7%) is federal funding requested in this application (Table 3). The federal funds will be used to primarily to pay contractors and consultants ($261,046). The remaining federal funds ($12,165) will be used to purchase stream gaging and computing equipment and software.

Funding plan and letters of funding commitment

Non-federal match will total $288,075 (51.3 % of project budget), of which $183,174 will be costs paid by the applicant using nonfederal funds. The applicant's share of match includes salaries, equipment and supplies, environmental compliance reporting, student internships, web hosting and data transmission fees, and seasonal housing for undergraduate and graduate students. All of this funding will come from private donations to HFF obtained through HFF's normal fundraising mechanisms and schedules. As indicated in the official resolution, HFF's Board of Directors commits to ensuring that non-federal contributions to HFF will be sufficient over the life of the project to meet the proposed match commitment. HFF's match commitment does not depend on any pending grant or loan requests.

The remaining non-federal match will come from in-kind contributions from senior team member Heidi Blischke ($77,000), FTR ($25,200), and FMID ($2,700). The commitment and valuation of these contributions are documented in the attached letters of commitment. Heide Blischke will donate 1,000 hours of her time as a registered professional geologist to development and application of the Teton Valley aquifer model. FMID and FTR will each facilitate stakeholder meetings. FTR will also assist in compiling data needed for the Teton Valley aquifer model.

Table 3. Total project costs.

SOURCE	AMOUNT	PERCENT OF TOTAL
Costs to be reimbursed with the requested Federal funding	$273,211	48.7%
Costs to be paid by the applicant	$183,175	32.6%
Value of third-party contributions	$104,900	18.7%
TOTAL PROJECT COST	$561,286	100%

Budget Proposal

The budget proposal appears in Table 4.

Budget Narrative

Salaries and wages

All salaries and wages included in the budget will be paid to regular HFF employees at their current hourly rate.

Rob Van Kirk, HFF Senior Scientist and Project Manager
Rob will devote one-third of his total work time (693 hours) to the project in each of the three years, for a total of 2,080 hours over the life of the project. Of this time, 360 hours (17%) will be spent on project management and administration, 300 hours (14%) on development of the data web site, 125 hours (6%) on information dissemination, 370 hours (18%) on development of the Teton Valley aquifer model, and 185 hours (9%) on each of the lower Henry's Fork, real-time, optimization, short-term prediction, and scenario models.

Jamie Laatsch, HFF Communications Manager
Jamie will contribute 304 hours per year to the project, all devoted to information dissemination and stakeholder engagement. This includes 24 hours per year on Henry's Fork Watershed Council meetings, 200 hours per year on direct information dissemination via various media outlets, and 80 hours per year assisting with design aspects of the data web site.

HFF Finance Manager
200 hours per year managing all aspects of payroll, finances, and financial reporting for the project.

HFF Conservation Technician
232 total hours: 168 hours conducting streamflow measurements to support rating-curve development at the stream gage stations and 64 hours installing and maintaining equipment at the stream gage sites.

HFF Aquatic Resources Coordinator
168 total hours conducting stream measurements to support rating-curve development at the stream gage stations.

HFF Landowner Outreach Manager
80 total hours on the lower Henry's Fork groundwater model.

HFF Executive Director
15 hours per year facilitating Henry's Fork Watershed Council meetings and attending Drought Management Planning Committee meetings.

Fringe benefits

Benefits will be paid to these employees at their current, respective rates, calculated as a percentage of the total salary each employee will contribute to the project. Fringe benefits

Table 4. Budget proposal.

BUDGET ITEM DESCRIPTION	COMPUTATION		Quantity Type	TOTAL COST
	$/Unit	Quantity		
Salaries and Wages				
Manager: Rob Van Kirk, Senior Scientist	$43.75	2080	hour	$91,000.00
Jamie Laatsch, Communications Manager	$22.21	912	hour	$20,255.52
Finance Manager	$20.00	600	hour	$12,000.00
Conservation Technician	$17.00	232	hour	$3,944.00
Aquatic Resources Coordinator	$21.63	168	hour	$3,633.84
Landowner Outreach Manager	$29.22	80	hour	$2,337.60
Executive Director	$46.63	45	hour	$2,098.35
Fringe Benefits				
Manager: Rob Van Kirk, Senior Scientist	7.5%	$91,000.00	salary	$6,825.00
Jamie Laatsch, Communications Manager	11.4%	$20,255.52	salary	$2,309.13
Finance Manager	12.1%	$12,000.00	salary	$1,452.00
Conservation Technician	30.7%	$3,944.00	salary	$1,210.81
Aquatic Resources Coordinator	12.5%	$3,633.84	salary	$454.23
Landowner Outreach Manager	17.4%	$2,337.60	salary	$406.74
Executive Director	16.1%	$2,098.35	salary	$337.83
Travel				
Local	$0.58	2468	mile	$1,431.44
Non-local	$834.30	3	trip	$2,502.90
Equipment				
Computers and software	$8,311.94	1	EA	$8,311.94
Stream gaging equipment	$3,181.50	2	EA	$6,363.00
Supplies and Materials				
Stream gage installation supplies	$133.75	2	EA	$267.50
Contractors/Consultants				
Melissa Muradian, Data Website Developer	$35.00	3000	hour	$105,000.00
Modeling assistant (to be recruited)	$25.00	3000	hour	$75,000.00
Christina Morrisett (Utah State University)	$40,523.00	2	year	$81,046.00
Third-party In-kind				
Heidi Blischke, Groundwater Modeler	$77.00	1000	hour	$77,000.00
Friends of the Teton River	$50.00	504	hour	$25,200.00
Fremont-Madison Irrigation District	$60.00	45	hour	$2,700.00
Environmental and regulatory compliance				
Compliance verification and report	$3,000.00	1	EA	$3,000.00
Other expenses				
Undergraduate student internships	$6,250.00	3	EA	$18,750.00
Graduate student housing	$125.00	32	week	$4,000.00
Web hosting and data transmission fees	$1,088.00	2.25	year	$2,448.00
TOTAL DIRECT COSTS				$ 561,285.83
Indirect Costs				$0.00
TOTAL ESTIMATED PROJECT COSTS				$561,285.83

include health insurance and IRA contributions. Rates differ across employees because of different health insurance coverage and IRA selections.

Travel

Local travel of 2,468 miles will be required to install remote-transmission equipment at the Buffalo River and Teton River gage stations and to conduct streamflow measurements. Two trips to each of Buffalo River (54 mi RT) and Teton River (60 mi RT) will be required for equipment installation (total 228 miles). Streamflow measurements will be made at each of the three locations 14 times during the project to develop rating curves. Mileage to the Henry's Fork gage station is 46 miles, so the total mileage for streamflow measurements is 2,240 miles. Mileage rate is the standard federal rate of $0.58 per mile.

The Project Manager will make three trips to Boise, ID to present project results, respectively, to the Idaho Water Users Association annual meeting, a regular meeting of the IWRB, and a biennial nongovernmental organization water conference. Mileage to Boise is 660 mi RT per trip. Each trip will require two nights lodging, valued at the federal lodging rate of $137 per night. Federal meals and incidental expenses total $71 per day. Each trip will include one full day of per diem, in addition to one first travel day and one last travel day. This results in an allowable federal rate of $834.3 per trip.

Equipment

Two computers will be purchased for the project, one on which to develop the Teton Valley groundwater model ($2601.97) and one to serve as the server for the remote data transmission and web site ($1,159.97). These prices were obtained from Dell's web site based on required memory, processor speed, and monitor resolution for each machine. The Groundwater Vistas7 software required to develop the Teton Valley groundwater model costs $2,250, with an additional $950 for training. These cost estimates were obtained from the web site of RockWare, the software vendor. Other software costs include LogMeIn at $350 per year, which is required for the data web site consultant to work remotely on machines physically housed at HFF's office, and ArcGIS at $100 per year.

The new stream gage equipment that will be installed at each of the Buffalo River and Teton River stations includes a Campbell Scientific CS451 pressure transducer ($885), and Campbell Scientific CR310 data logger/modem, with antenna, instrument shelter, and power supply ($2,296.5). These prices are what HFF recently paid for this equipment.

Supplies and materials

Each of the Buffalo River and Teton River stream gages will require a staff plate at $33.75 (from Forestry Suppliers), and $100 in installation hardware and supplies.

Contractors/consultants

Melissa Muradian, Data Web Site Developer: 1,000 hours per year at $35 per hour. All of her time will be spend on development of the web site.

Modeling Assistant: 1,000 hours per year at $25 per hour. The assistant will support all modeling programming efforts, as needed.

Christina Morrisett, Utah State University: Two years at $40,253 per year. This includes her salary ($23,400), health insurance ($1,908), tuition and fees ($1,000), salary for faculty supervisor ($3,945), travel ($6,000), and miscellaneous on-campus expenses ($4,000).

Third-party in-kind

Heidi Blischke: 1,000 hours total valued at $77 per hour. Her letter of commitment explains and justifies the hourly rate.

Friends of the Teton River: 168 hours per year at $50 per hour to conduct stakeholder meetings and assist with data compilation.

Fremont-Madison Irrigation District: 15 hours per year at $60 per year to facilitate Henry's Fork Watershed Council meetings and chair Drought Management Planning Committee meetings.

Environmental and regulatory compliance

HFF will pay an external consultant up to $3,000 in estimated costs to conduct an environmental compliance and permitting check.

Other expenses

The equivalent of three undergraduate internships (400 hours per internship) will be devoted to the project. Each 10-week (400 hours) summer intern is paid a stipend of $5,000 and is housed in HFF's campus dormitory facility. Housing is valued at $125 per week.

HFF will also providing housing for Christina Morrisett when she is in the watershed conducting work on this project, versus on campus at Utah State University (200 miles away from the project location). She will spend 16 weeks of each of two years in the watershed, valued at $125 per week.

Web hosting fees for the data web site on shinayapps.io is $440 per year. Verizon cell lines for real-time data transmission cost $18 per month per gage station. Because the transmission equipment will not be installed and operational until the fourth quarter of year one, the budget includes 2.25 years of cost for web hosting and data transmission fees.

Indirect costs

No indirect costs are included.