



Gulf Coast Water Authority

Improving the GCWA-Daily-Hydro Water Availability Model

Response to Funding Announcement: BOR-DO-19-F012

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Executive Summary

Improving the GCWA-Daily Hydro Water Availability Model

Date: October 30, 2019
Applicant Name: Gulf Coast Water Authority
Texas City, Galveston County, TX

The Gulf Coast Water Authority (GCWA) provides water on a wholesale basis to customers in Galveston, Fort Bend, and Brazoria Counties, Texas (TX), including municipalities (e.g. Galveston, Sugar Land, Missouri City) as well as petro-chemical industries (e.g. Dow-UCC, Valero, INEOS, Marathon, Ascend). The majority of GCWA's water is diverted from the Brazos River, and the location of its diversions in the Lower Brazos basin cause GCWA's water availability to be dictated both by natural streamflow variations and the water usage behavior of upstream entities. To determine water availability under various streamflow and system-operation scenarios, GCWA utilizes a numerical water accounting model named "GCWA Daily-Hydro." Since its initial development in 2010, the GCWA Daily-Hydro model has evolved to simulate more of the water resources of the Lower Brazos Basin, providing GCWA with greater opportunities to forecast water availability under possible climatic and management constraints. Through this Applied Science Grant, GCWA intends to incorporate into the model additional water management options identified during GCWA's 2017-2019 WaterSMART project to update its drought contingency plan. Model enhancements will include simulating Brazos River streamflow losses, drought curtailment triggers, Brazos Watermaster operation methods, and water accounting for upstream junior-priority reservoir operation. GCWA will also fully document the resulting version of the model (V8), make the model publicly available, and detail the water availability options identified through the model's application. This project accomplishes the goals of this US Bureau of Reclamation (Reclamation) Funding Opportunity Announcement (FOA) in that: 1) it involves developing hydrologic information and water management tools, 2) it will improve GCWA's modeling and forecasting capabilities, 3) results from the modeling will be used to increase GCWA's water supply reliability, and 4) project results will lead GCWA to improve its drought management activities, thereby allowing GCWA to succeed in their mission to deliver a reliable, cost-effective quantity and quality of water to its vast and diverse customer base.

GCWA expects to complete the project within **1 year** from project commencement.

This proposed model enhancement project will include the simulation of water storage in eight (8) Federal reservoirs, including: Lake Whitney, Stillhouse Hollow Lake, Lake Belton, Lake Proctor, Somerville Lake, Lake Georgetown, Granger Lake, and Aquilla Lake.

Technical Project Description and Milestones

*GCWA is applying for this grant as a **Category A** applicant, with water delivery authority located in Texas, as originally enabled by the Texas Legislature through HB 1127 in 1965.*

GCWA Introduction

GCWA provides water on a wholesale basis to customers in Galveston, Fort Bend, and Brazoria Counties in Texas. GCWA employs a combination of canal conveyance, raw water pipeline infrastructure, and treated water production and conveyance facilities to serve a combination of industrial, municipal, and agricultural demands across these counties. Customers served by GCWA include municipalities (e.g. Galveston, Sugar Land, Missouri City) as well as petrochemical industries (e.g. Dow-UCC, Valero, INEOS, Marathon, Ascend). As GCWA is a wholesale provider, it is not clear how many end-users obtain their water from GCWA sources. GCWA provides water to more than 45 entities, with the exact number fluctuating from year to year (due to varying annual agricultural contracts). Some GCWA customers hold “firm water” contracts in that they expect their water to be available 100 percent of the time. Other GCWA customers hold “interruptible water” contracts in that they recognize their access to water will be reduced during drought periods. In 2015, GCWA provided users with 152,771 acre-ft of water, including 54,647 acre-ft for municipal usage, 21,091 acre-ft for agricultural usage, and 77,032 acre-ft for industrial usage. In 2011 GCWA provided customers with 316,297 acre-ft of water, with 94,411 acre-ft, 96,346 acre-ft, and 125,540 acre-ft for municipal, industrial, and agricultural purposes, respectively. Usage in 2011 was the highest ever achieved by GCWA, and usage in subsequent years has been reduced due to an overall reduction in irrigated acreage and general conservation measures by municipalities and industries.

To meet customer demands, GCWA must establish and maintain reliable water supplies. Currently, all water delivered to customers by GCWA stems from stream systems within the Brazos and San Jacinto-Brazos watersheds. GCWA owns multiple water rights authorizing the diversion of water from the Brazos River (Certificates of Adjudication – CoA 12-5168, 12-5171, and 12-5322) in Fort Bend County, TX. These certificates jointly authorize GCWA to divert up to a total of 379,932 acre-ft/yr at three diversion locations on the Brazos River, and with diversions having different priority dates under the Texas prior-appropriation doctrine. GCWA also has additional diversion rights totaling 53,500 acre-ft/yr from the Chocolate Bayou, Mustang Bayou, and Halls Bayou systems (CoA 11-5357), as well as 12,000 acre-ft/yr (CoA 11-5169) from Jones & Oyster Creek. Combined, GCWA’s water rights allow for annual diversions of up to 445,432 acre-ft/yr. However, rarely (if ever) has sufficient water been available to allow GCWA to divert such quantities, and GCWA customers have yet to require such quantities.

The Texas prior-appropriation system effectively allows senior water right holders to divert water before diversion access is granted to junior water right holders. As a result, GCWA must only rely on using water under its senior-most water rights, thereby potentially limiting water

supplies for customers during times of drought. To augment water available under its water rights, GCWA negotiated long-term stored water contracts with the Brazos River Authority (BRA). Water available under the BRA contracts comes in the form of releases from reservoirs located upstream in the Brazos River basin. These stored water releases are available during drought periods and they allow GCWA to ensure customer water deliveries when less water is available from GCWA's own water rights. GCWA pays a premium price for the water provided by BRA, as the BRA water supply is essentially a water insurance policy to prevent against loss of service to numerous industries, municipalities, and agricultural interests.

GCWA Daily-Hydro Water Availability Model

GCWA's mission is to provide water of sufficient quantity and quality to fully satisfy the needs of its customers. To compare needs and available supplies, GCWA developed the GCWA Daily-Hydro water availability model, a numerical computer model that simulates water availability within the Lower Brazos Basin. Initially created in 2010, this model performs daily water-allocation calculations using gauged streamflow records. The GCWA Daily-Hydro model applies water accounting and standard water budget techniques to simulate the delivery of water to permitted water right holders within the Lower Brazos Basin, and contains customized enhancements to better represent river diversion operations than other existing water availability models of the region (including Riverware models). The GCWA Daily-Hydro model differs from the official Water Availability Model (WAM) of the Brazos River Basin developed by the Texas Commission on Environmental Quality (TCEQ) in numerous ways, with the most significant differences being:

- GCWA Daily-Hydro is a **DAILY** model, whereas the WAM is **MONTHLY**
- GCWA Daily-Hydro uses gauged streamflow (available to the **present**), whereas the WAM uses naturalized flow only available for periods prior to **1998**

Since 2010, GCWA (and its consultants) have continuously refined the GCWA Daily-Hydro model to include simulations of new aspects of the GCWA water delivery system. For example, Version #1 (V1) was limited in scope to assessing only water available from GCWA's Brazos River water rights, whereas Version #2 (V2) included simulations of water available from the Brazos River as well as GCWA's sources on Chocolate and Mustang bayous. Versions #3-#6 included additional features, such as BRA contract water and hypothetical new reservoirs, which allowed the model to better reflect the true water management options available to GCWA. Later model versions also considered variations in GCWA customer demands, as well as variations in water allocation methods amongst GCWA and other water right holders on the Brazos River. The most recent model, Version 7 (V7), includes the ability to simulate enforced demand curtailment during drought stages as dictated by GCWA's drought contingency plan. V7 also includes updated GCWA firm contract demands, and allows for the simulation of multiple successive years of drought by giving the model user the ability to select which historical years to model in any preferred order. This allows GCWA to simulate three-successive historical drought years (1956, 2011, and 2009) and forecast how current (and expected future) GCWA customer needs would

have been satisfied through various GCWA water management strategies during such a simulated prolonged drought period. V7 of the GCWA Daily-Hydro model was created as part of the GCWA Drought Contingency Plan (DCP) Update process conducted under the Reclamation WaterSMART Grant R16AC00114 (2016-2019).

With each version of the GCWA Daily-Hydro model, GCWA has utilized the best available methods to determine its water reliability for customer delivery. Coupled with the release of certain model versions are reports that detail the model results and quantify GCWA’s ability to provide water to customers on a reliable basis. These reports and the quantified water availability numbers published by GCWA differ based on the model contents and modeling assumptions. One issue that has arisen between GCWA and its customers is that customers have occasionally made their own water resource decisions based on outdated GCWA model reports, resulting in inefficient water management practices and likely in water waste.

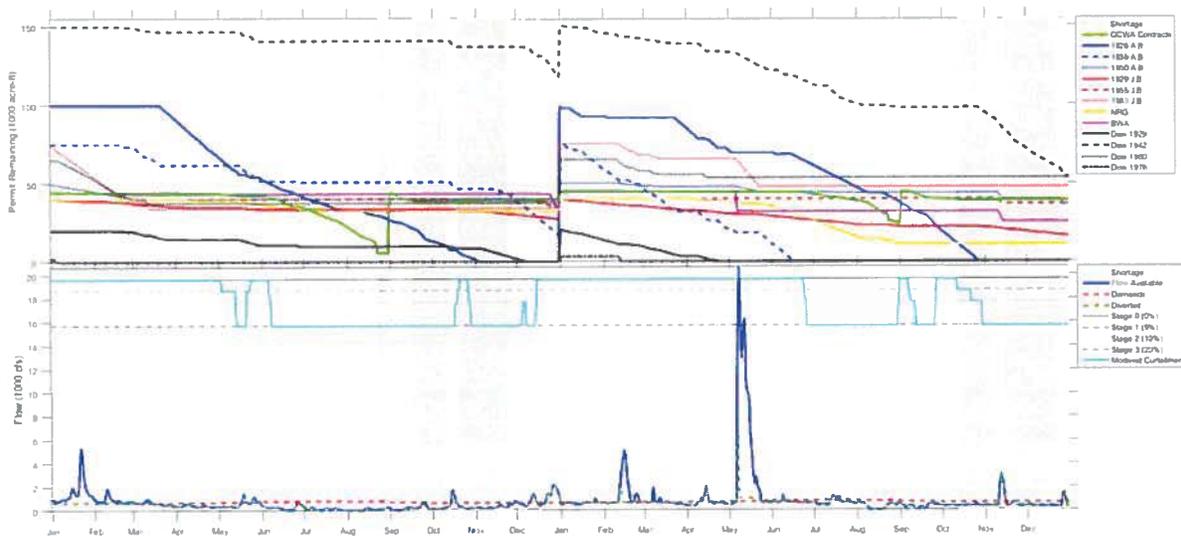


Figure 1 – GCWA Daily-Hydro (V7) model results showing shortages at the end of the calendar year.

Through this Applied Science Grant, GCWA intends to create Version 8 (V8) of the GCWA Daily-Hydro model, which will include numerous refinements identified during the 2016-2019 DCP Update project (Reclamation WaterSMART Grant R16AC00114). Each of the planned model refinements are discussed below, along with a timeline for their completion. GCWA also intends to make the model source code and documentation available to all interested parties so that other water managers working in similar environments may learn from and/or utilize GCWA’s analysis methods to fit their own specific areas of operation. This project will also result in an updated, publicly-available report detailing GCWA’s water availability calculations and the expected benefits from various considered water supply augmentation options.

Proposed Model Enhancements – V8 of GCWA Daily-Hydro

Under this Applied Science grant, GCWA intends to complete eleven (11) modeling tasks to further enhance its GCWA Daily-Hydro model and better simulate the physical system of the Lower Brazos Basin. These tasks are presented individually below.

Task #1 – Simulation of Brazos River Flow Losses

Prior to Version #4, the GCWA Daily-Hydro model algorithms adjusted streamflows in the Brazos River to account for expected flow losses between the US Geological Survey gauge at Hempstead and the GCWA diversion locations downstream on the Brazos River. After version #4, this functionality was removed as conflicting studies suggested varying streamflow gains and losses occur in this region based on the interaction between the Brazos River and the surrounding Brazos River Alluvial Aquifer. During the 2016-2019 DCP Update project, studies by GCWA customers suggested that streamflow gains are to be expected under most conditions, but that during prolonged drought periods losses between Hempstead and GCWA facilities were evident and quantifiable. Through this project, streamflow losses will be re-incorporated into the V8 model, and their impact will be quantified on computed water availability.

It is anticipated that the model user will be able to specify 6 model parameters dictating Brazos River Flow Losses:

- Parameter #1.** Streamflow threshold below which losses are incurred
- Parameter #2.** Duration of low streamflow required to trigger losses
- Parameter #3.** Losses between Hempstead and GCWA's Shannon Plant
- Parameter #4.** Losses between GCWA's Shannon and Briscoe Plants
- Parameter #5.** Losses between GCWA's Briscoe and May Plants
- Parameter #6.** Losses between GCWA's May Plant and Dow's diversion facility

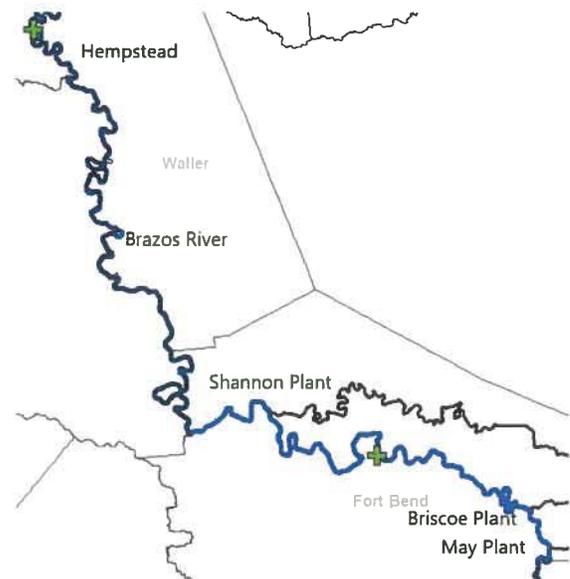


Figure 2 – Brazos River Downstream from Hempstead

Incorporating additional flow losses with increased downstream distance from Hempstead may affect GCWA's operations, as water usage could be optimized through favored diversions at the upper-most diversion location (Shannon Plant). In addition, utilizing a streamflow threshold (magnitude and duration) for applying losses better mimics the actual interactions between the Brazos River and the surrounding alluvial aquifer. The V8 model will not consider gains in streamflow from the alluvial aquifer during times when the streamflow exceeds the specified threshold. This remains a means in which the V8 model will conservatively calculate water availability for GCWA and other water right holders in the Lower Brazos Basin.

Including losses in the manner discussed above will require re-structuring the model algorithms computing water availability at each simulated diversion location. GCWA anticipates this task to be completed and the resulting model functionality fully tested by the end of February 2020. Under this task, it may also be necessary to apply modeled losses to reservoir releases of BRA contract water. This additional loss modeling will be discussed below under Task #7.

Task #2 – Dynamic DCP Curtailment Modeling

Work under this task was necessitated during the 2016-2019 GCWA DCP Update project, for which the V7 model was created to simulate the impact of demand curtailment for GCWA customers. Under the V7 model, curtailment parameters from GCWA's 2012 DCP were hard-coded into the model algorithms, allowing for the forecasting of previous DCP curtailment rules on expected water availability. Under this task, GCWA will modify the V8 algorithms such that the user may specify curtailment parameters (trigger levels, timing, and curtailment quantities) as model input, thereby allowing for dynamic assessments of curtailment impacts on forecasted water availability. This task involves adjusting model input parameters and algorithms dealing with curtailment rule application. GCWA anticipates this task to be completed and the resulting model fully tested by the end of March 2020.

Task #3 – BRA Contract Modeling Update with Systems-Operations Water

GCWA utilizes contract water with BRA as a sort of "insurance policy" to maintain customer supplies during times of low naturally-occurring streamflow. Within the V7 model, contract quantities are utilized only when streamflow is insufficient to meet GCWA needs, and contract quantities are limited to those long-term contracts negotiated by GCWA prior to 2019. In May, 2019, however, BRA awarded GCWA a new long-term water contract for 36,362 acre-ft/yr of water, which was made available to BRA under its recently granted "Systems Operation" permit from the TCEQ. Within the V8 model, this new contract quantity will be incorporated into the simulation routines, and model results will be used to determine GCWA's ability to "firm-up" existing contractual commitments to its customers as well as to determine if any additional "firm" (or "interruptible") water may be made available to potential new customers.

Incorporating the new BRA contract water supply into the V8 model requires slight adjustments to the contract water algorithms. The majority of work under this task will involve quantifying the impact of the new contract water on GCWA water reliability, and determining how much firm and interruptible water (if any) may be provided to new GCWA customers. Under this task, the frequency of interruptible water deliveries will also be computed. GCWA anticipates this task to be completed and the resulting model functionality fully tested by the end of March 2020.

Task #4 – Modeling Additional GCWA Customer Demands

Upon notification of receipt of additional contract water from BRA in 2019, GCWA received numerous requests for additional water, both from existing and potential new customers. These new water requests will be added to existing customer demands within the V8 model, and GCWA's ability to satisfy these requests will be determined. Through this task, the V8 customer demands will be modified, likely by both hard-coded changes and through user-specified model input data assignments. Simulations will be performed to determine within what portion of the GCWA canal system additional demands may be satisfied, the frequency with which potential interruptible demands may be satisfied, and the amount of additional firm demands that may be satisfied through utilizing all of GCWA's planned and implemented water management strategies.

Incorporating the new demands into the V8 model requires adjustments to the demand specification algorithms, and possibly to the model input algorithms. The majority of work under this task will involve quantifying the impact of the new water demands on GCWA water reliability, and determining how much firm and interruptible water (if any) may be provided to new GCWA customers. Much of the work and analysis under this task will be undertaken in conjunction with the work performed under Task #3. GCWA anticipates this task to be completed and the resulting model functionality fully tested by the end of March, 2020.

Task #5 – Modeling Irrigation Water Demands

Within the V7 model, users have the ability to simulate demands for GCWA's irrigation customers who typically hold interruptible water contracts and do not have access to contract water provided by the BRA. Within the V8 model, algorithms will be adjusted to better simulate irrigation customer demands, and will incorporate usage of dedicated sources of additional water (sourced from BRA or other entities) that may be made available only to supplement irrigation water usage. The model user will be able to specify the category of irrigation expected, expected acreage to be irrigated, the application rate (acre-ft/acre) to be applied to the fields, and the timing of the water need. With respect to timing, irrigation for rice production will be allowed to occur in the first crop season (March-June), and possible into a second crop season (July-October) with different irrigated acreage and water application rates. The V8 model will also have the ability to simulate irrigation demands for non-rice crops, which may have a different water usage pattern than that resulting from rice irrigation. This functionality will allow GCWA to explore supply options for both current and future irrigation operations.

Incorporating proposed changes to irrigation demands into the V8 model requires significant re-development of the model's demand specification algorithms, as well as the model input algorithms. Analyses will also be required to assess the impact of the modified irrigation operations on water available for GCWA firm water customers, which could result in modified

GCWA policies regarding irrigation water delivery. GCWA typically considers water for irrigation to be an interruptible water demand, yet historically some irrigation customers have been considered as having firm water demands. The V8 model will incorporate irrigation demands as being either firm or interruptible water demands. GCWA anticipates this task to be completed and the resulting model functionality fully tested by the end of April 2020.

Task #6 - Simulating Benefits of Additional Reservoir Storage

Previous versions of the GCWA Daily-Hydro model included the capability of GCWA's developing additional water storage capacities, with simulated reservoirs located within GCWA's canal system and/or with the Brazos River watershed upstream of GCWA's Brazos River diversion facilities. Specifically, the model is capable of simulating: 1) a new reservoir at the upstream end of the GCWA A-Canal system, 2) a new reservoir at the upstream end of the GCWA B-Canal system, 3) a new reservoir adjacent to Texas City Reservoir (near the downstream end of the AB-Canal system), and 4) a new reservoir upstream of all GCWA diversion locations on the Brazos River (akin to modeling the impact of the proposed Allens Creek Reservoir). Errors in the reservoir modeling, however, were recently identified, and caused previously obtained modeling results to under-represent the reservoir's impacts on GCWA operations. With the V8 model, GCWA will correct the modeling errors with respect to potential new reservoirs, and will re-calculate the water supply and reliability impact of these reservoirs on GCWA's ability to reliably deliver water to customers. GCWA will also add the ability to simulate reservoir storage on the J-canal system, which could represent storage within both existing reservoirs (e.g. Liverpool Reservoir) or reservoirs to be constructed in the future.

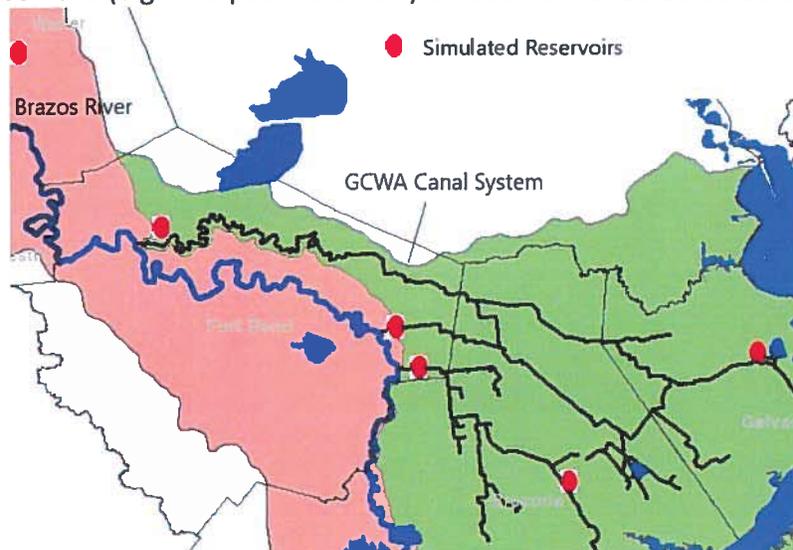


Figure 3 – Simulated Reservoirs (Red) to be included as optional features within the V8 model, showing their locations relative to the Brazos River and the GCWA canal system.

Simulating the benefits of additional reservoir storage within the V8 model will not require significant changes to the model algorithms or code. The majority of the effort under this task will be to analyze the model results and quantify the relative impact of each potential reservoir on GCWA's water reliability. Analyses will need to be conducted after implementing other

project tasks, as the amount of available reservoir storage accessible to GCWA could change its modeled water management practices and yield different overall water reliability results. GCWA anticipates this task to be completed and the resulting model functionality fully tested by the end of May 2020.

Task #7 - Adjusting Streamflow for Proper Upstream Reservoir Management

GCWA expects that work under this task will have the greatest impact on calculated water availability from the V8 model. During the 2016-2019 DCP Update project, GCWA developed a program to assess reservoir inflows and outflows on a daily basis for the eleven BRA System reservoirs in which the BRA is able to store water and from which the BRA releases GCWA contract water. This program, named the “Flow Prediction Tool (FPT),” was one of the “Mitigation Actions” GCWA developed to reduce the risk of drought, and it was designed to ensure that the BRA was allowing passage of inflows through its reservoirs at times when inflows were needed by GCWA and divertible under its senior water rights. Essentially the tool polices BRA’s and US Army Corps of Engineers actions regarding daily storage of inflows in its reservoirs. GCWA can utilize the tool to identify periods when it believes BRA should be passing inflows downstream but instead stored those inflows in its reservoirs (in violation of the State of Texas prior-appropriation doctrine). If such situations were to occur, GCWA could report its suspicions to the Brazos Watermaster, who would review the data and consult with BRA whether further reservoir releases were necessary.

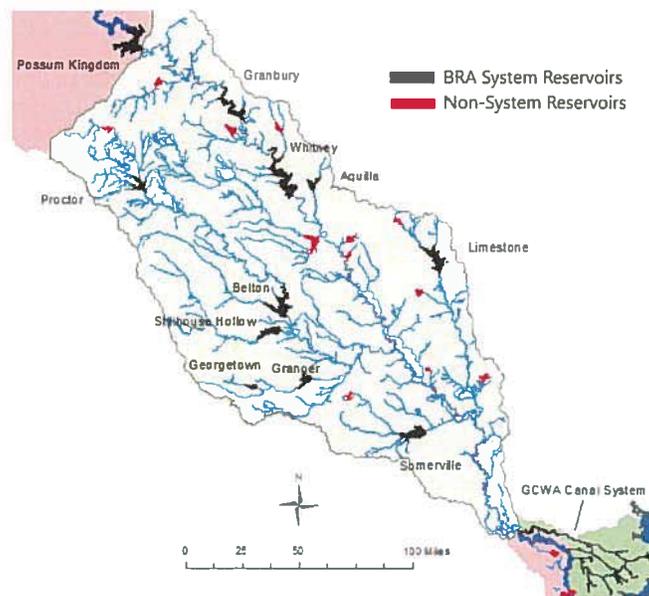


Figure 4 –Map of the Brazos River Watershed shown BRA System Reservoirs that may retain inflows divertible under GCWA’s senior water rights.

Neither the GCWA tool nor the Brazos Watermaster were in existence during 2011, which is generally regarded as the year when the least amount of streamflow occurred within the Lower Brazos Basin. However, at the time, BRA attempted to ensure compliance with the prior-appropriation doctrine by implementing an “inflow credit” system that GCWA and other

downstream users could utilize to receive water that GCWA and BRA agreed was improperly stored in reservoirs rather than passed through to downstream users. This credit system, while well intentioned, was not effectively implemented and did not provide downstream users with the water they deserved under the prior-appropriation doctrine. This resulted in entities like Dow Chemical Company and GCWA having to purchase emergency water supplies from BRA and other agencies in ensure their customers received needed water supplies during 2011. It is not yet known whether the purchase of these emergency supplies would have been necessary had BRA properly released reservoir inflows during the 2011 drought.

Through this task, GCWA will incorporate the FPT algorithms into the V8 model and will use them to adjust the streamflow hydrology used by GCWA in assessing water availability. This adjustment could result in an increase or decrease in streamflow (at Hempstead) compared to the gage flow records, and could therefore result in an increase or decrease in water available for diversion and use by GCWA and its customers. We suspect, based on the numerous credit-system discussions between GCWA and BRA, that the FPT when applied to 2011 data will determine that a large quantity of reservoir inflows was withheld and that GCWA should not have needed to purchase extra interruptible water to satisfy customer needs during the summer of 2011.

Implementing this task into the V8 model will require expansion of the model input data to include numerous streamflow and reservoir water level gages, with the data maintained and publically available from the US Geological Survey and US Army Corps of Engineers. As the algorithms are already functional and included within the FPT, less effort will be required to incorporate them into the V8 model. The V8 model input will be modified to include an “on/off” switch dictating whether streamflow data is to be adjusted during a given simulation, and it will then be necessary to analyze water reliability results with and without the adjustment. GCWA anticipates this task to be completed and the resulting model functionality fully tested by the end of May 2020.

Task #8 - Modeling Groundwater/Surface Water Conjunctive Use and ASR

Under this task, GCWA will incorporate results of the “Mitigation through Supplemental Groundwater Usage” analysis from the 2016-2019 GCWA DCP Update project into the V8 model as an additional water source for GCWA. Specifically, GCWA will include the usage of locally sourced groundwater, as needed, to supplement surface water availability for portions of the GCWA canal system. This groundwater will be simulated subject to the rules of the Brazoria County Groundwater Conservation District, the Fort Bend Subsidence District, and the Harris-Galveston Subsidence District. This task will also incorporate results of recent GCWA studies detailing potential groundwater usage from around its Mustang Reservoir (within Brazoria County).

Aside from using groundwater to supplement surface water supplies, the V8 model will also include simulations of aquifer storage and recovery (ASR) capabilities at various locations along the GCWA canal system. For simulations involving ASR, the V8 model will include water

diversions from the GCWA canal system (when water is plentiful), injecting the water into the local aquifer, and then retrieving a portion of the injected water during drought conditions. In simulations involving ASR, only water quantities will be modeled, and water quality/chemical interactions will not be computed. The purpose of these simulations will be to determine the viability of potential ASR projects with respect to water availability and recoverability.

Simulating the inclusion of groundwater sources and ASR within the V8 model will require code modification to ensure the usage meets all regulatory requirements for the areas in which the wells are located. This will include tracking individual customer annual surface water and groundwater usage to ensure compliance with subsidence district rules, as well as tracking water volumes injected into each aquifer/well over time. The majority of the effort under this task will be to analyze the model results and quantify the relative impact given wells on overall water reliability for GCWA. GCWA anticipates this task to be completed and the resulting model functionality fully tested by the end of June 2020, but could be completed earlier if the effort is undertaken simultaneously with other tasks.

Task #9 - Modeling Non-Priority Water Diversions

During the 2016-2019 GCWA DCP Update project, it was discovered that numerous GCWA customers were obtaining their own water supplies in addition to those provided by GCWA. Most of these supplies were to be delivered by GCWA through its canal system, thereby necessitating ensuring the canal system has sufficient conveyance capacity *and* developing an accounting system that can separate and distinguish between GCWA diversions under the priority system, diversions of BRA contract water, and diversions of customer water outside of the prior-appropriation system. During this task, the V8 model will be adjusted to track GCWA diversions and conveyance of water diverted by GCWA but provided to a specific client. Such diversions would be outside of the priority system, and could therefore potentially reduce the amount of water available to GCWA under its water rights.

As of October 30, 2019, GCWA is aware of three entities along its canal system that have obtained their own water supplies independent of GCWA. These entities include the City of Manvel and the City of Sugar Land, who have each received water contracts with BRA. Marathon-GBR has also received a water contract with BRA, and has obtained, or will soon obtain, rights to divert discharged wastewater from the City of College Station. The V8 model will include the capacity to model water deliveries to these entities, including both water from GCWA-owned sources and from customer-procured sources. The V8 model will also allow for simulating that the customer-owned sources have been “conveyed” to GCWA such that GCWA may use them to supply the needs of any of its customers as long as the customer who procured the source has, at minimum, access to the quantity of water it procured. The V8 model will also have the capability to simulate four (4) additional customer-owned water sources, should this capability be needed in the future.

Modeling non-priority water diversions within the GCWA Daily Hydro model will require code modification and increases in the number of tracked water accounts for GCWA customers. This

will require slight modifications to the code structure, as well as increases to the number of model input parameters used to turn model features “on” or “off” during a given simulation. GCWA anticipates this task to be completed and the resulting model functionality fully tested by the end of July, 2020, but could be completed earlier if the effort is undertaken simultaneously with other tasks.

Task #10 - Model Code Documentation

GCWA understands that computer model results are best accepted when the processes used to develop the results are both well-documented and accepted by model reviewers. Through this task, it is GCWA’s intention to provide interested parties the opportunity to review the V8 model and to develop their own level of confidence in and understanding of the model results. GCWA also hopes that by making its model available for review by other water resource managers, other organizations may benefit from the modeling expertise developed through this project.

Under this task, GCWA will strive to allow the V8 model to be fully reviewed, understood, and accepted by any entity that desires to do so. GCWA will fully document each model subroutine within the computer code, and will make all code available for download and usage on the GCWA website. GCWA will also develop a model user’s manual that details each modeling option, as well as both the hydrologic theory and computational theory included in the model algorithms. Deliverables for this task will include both the fully-annotated model code as well as a model user’s manual (provided in PDF format). The V8 model code is written for use with the Matlab software package, commercially available from Mathworks, Inc.

This task will be undertaken over the entire duration of the project, and will be completed by the project completion date (estimated to be December 31, 2020).

Task #11 - V8 Water Availability Reporting

Under this task, GCWA will utilize the V8 model, including all of the model revisions generated during completion of Tasks #1-10, to quantify water availability for GCWA customers under a variety of different model scenarios. The objective of this task is to provide both GCWA and its customers with a single, updated document that quantifies the water GCWA has the ability to reliably sell on both a firm and interruptible basis. This document will be made available on the GCWA website, and will be provided (in electronic format) to all GCWA customers upon request.

This task will be undertaken over the entire duration of the project, and will be completed by the project completion date (estimated to be December 31, 2020). The majority of the work under this task, however, will be completed after Tasks #1-9 have been completed, as water availability results will only be “final” after completion of all planned model revisions.

Project Location

As GCWA’s water availability is dictated by hydrologic conditions throughout the Brazos Basin, the planning area for this model enhancement project must include the majority of the Brazos River Basin. However, with the creation of the Brazos Basin Watermaster program in 2015, the TCEQ effectively separated the Brazos Basin into upper and lower portions, with the lower portion under the jurisdiction of the watermaster. As such, the overall contributing area for GCWA, and therefore the contributing area for this project includes the Brazos Basin watershed downstream of and including Possum Kingdom Lake (Figure 5). This region encompasses 21,903 square miles, and provides water to 1,227 water right holders authorized to divert by the TCEQ. Within the region there exist 47 active USGS streamflow gauges, as well as 21 reservoirs capable of storing at least 5,000 acre-ft of water. Modeling Task #7 spans the entire GCWA contributing area, whereas all other tasks are limited in geographic scope to the GCWA Service Area (Figure 6 on the next page).

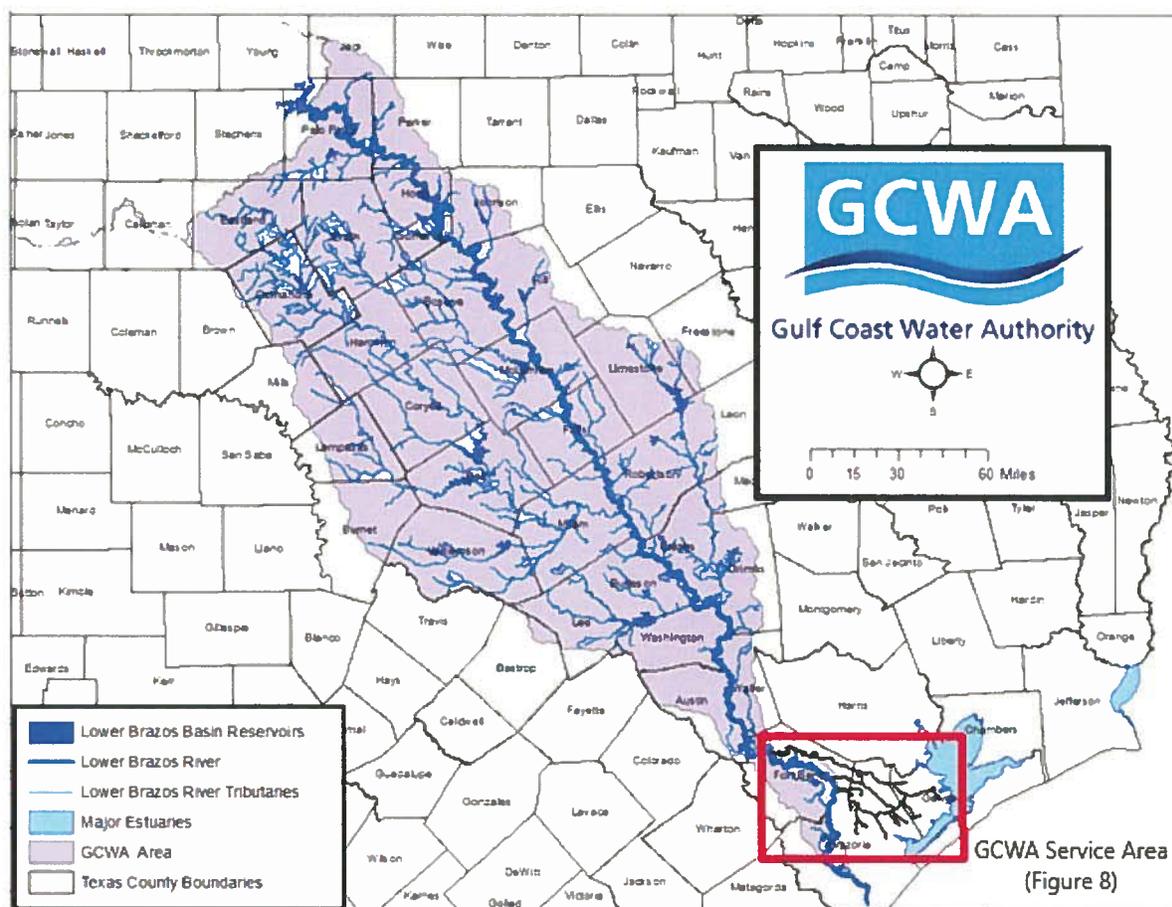


Figure 5- Brazos Basin Map showing the full extent of the GCWA DCP Update Planning Area, as well as the GCWA Service Area at the downstream end of the Brazos.

Figure 6 provides details of GCWA’s service area within Fort Bend, Brazoria, and Galveston Counties in Texas, and is visible in the lower-right hand corner of Figure 5. GCWA’s modeling tasks, with the exception of Task #7, are limited in scope to this geographic area.

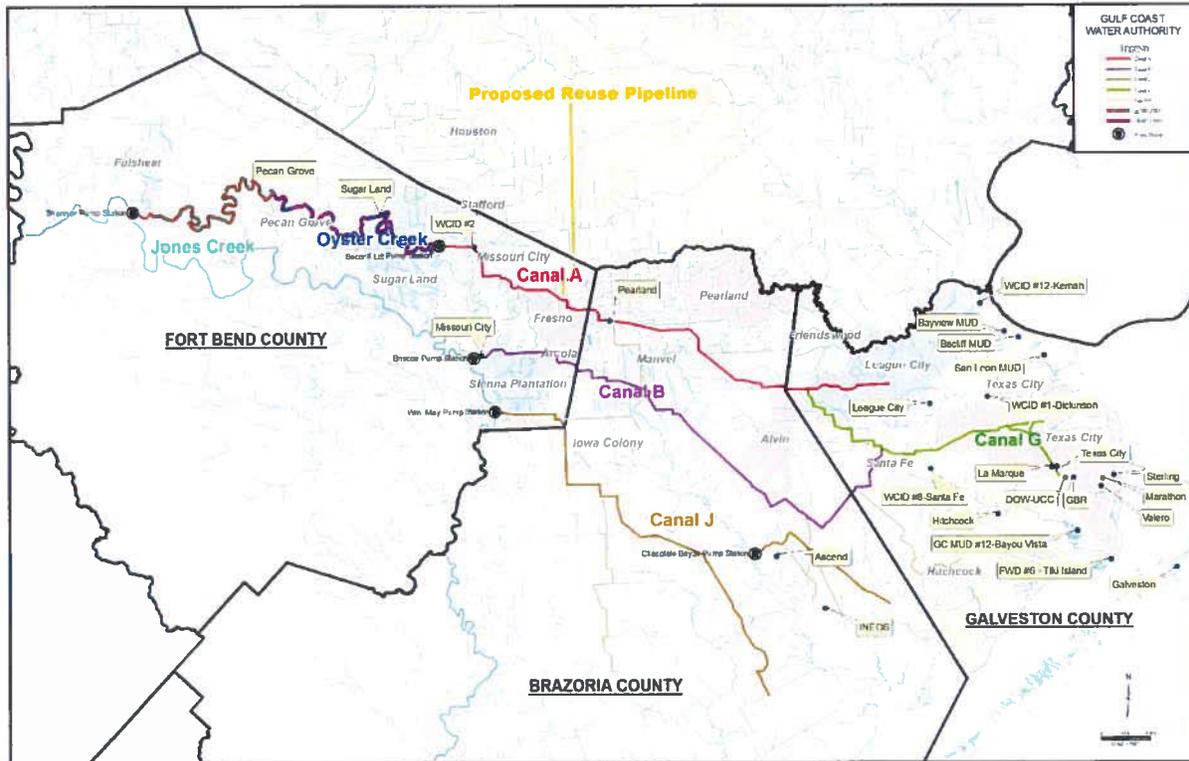


Figure 6 – GCWA’s Service Area showing canals and customer locations within Fort Bend, Brazoria, and Galveston Counties.

Data Management Practices

As stated under the description for Task #10, through this project GCWA intends to make its GCWA Daily Hydro model (V8) freely available for public review, scrutiny, and use. As such, we intend to make model files and supporting documentation concise yet detailed, complete with full comments and variable definitions. We are willing to adopt any form of data documentation or format standards suggested by Reclamation.

All geospatial data, including maps and map content, will be created using ArcGIS software stored in industry-standard formats.

Evaluation Criteria

Evaluation Criterion A – Benefits to Water Supply Reliability

1. Description of water management issues to be addressed through this project

GCWA utilizes the Daily Hydro model to assess the utility of water management strategies in increasing the reliability of water for its customers, especially during drought periods. Enhancing the model through this project effort will allow GCWA to better explore and evaluate water management strategies for increasing available supplies to continue to meet customer demands. The 2011 severe drought strained GCWA's ability to meet customer needs, and required GCWA to purchase additional contract water from the BRA. This contract water, however, largely went un-used, because neither BRA nor GCWA had the tools now available to manage and quantify GCWA's actual available water at that time. GCWA now utilizes the 2011 drought (and others) to model how GCWA customers would fare given the water resources options GCWA has now in place and those it is considering for the future. Thus through this model enhancement project, GCWA will be better able to forecast system response to meet customer demands during periods of severe and prolonged drought. It will have the ability to assess the relative utility of proposed projects (such as new reservoirs, groundwater/ASR wells, etc.) and thus determine the preferred method for maintaining and enhancing water availability for its customers.

2. How will this project address water management issues from #1?

a. Water Supply Reliability

Through this project, the enhancements made to the GCWA Daily-Hydro model will allow GCWA to more accurately determine water supplies for customers, based on the recent most severe drought periods and currently considered water supply enhancement and management options. Correcting 2011 streamflows for improper reservoir storage practices (Task #7), adding reservoir storage for GCWA use (Task #6), developing further DCP curtailment modeling capabilities (Task #2), and assessing conjunctive use benefits (Task #8) will all likely increase water supply reliability. In contrast, simulating Brazos River flow losses (Task #1) and increasing both customer demands (Task #4, Task #5) and simulating non-priority diversions (Task #9) will tend to decrease water supply reliability. The net-result of all changes is only calculable after completion of the model enhancements.

d. Drought Management Activities

All proposed model enhancement tasks are crucial for guiding GCWA's drought management activities, as the resulting model will be better equipped to represent GCWA's physical environment and track water supplies. GCWA's modeling for potential new reservoirs, for

example, will determine the benefits derived from each modeled reservoir, and these benefits can then be weighed against the likely project costs (monetary and otherwise). With the V8 model, GCWA expects to better identify and quantify their vulnerability to severe droughts, and can therefore better quantify needs to supplement supplies to maintain customer water deliveries during drought periods.

e. Conjunctive Use of Groundwater and Surface Water

Task #8 of this modeling project explicitly deals with the use of locally-sourced groundwater to supplement surface water supplies during drought periods. It will also demonstrate the potential benefits of aquifer storage and recovery systems that could be constructed along GCWA's canal systems to store water during wet periods and make it available during dry periods. The V8 model will allow GCWA to better determine the yields of potential ASR systems based on expected groundwater recovery rates and the model-determined magnitude and frequency with which excess water supplies are available for underground injection. The modeling will also incorporate the various water supply accounting rules dictated by the local groundwater conservation districts, which will constrain the extent to which GCWA will be able to utilize the wells. These constraints will also potentially limit the utility of the water management strategy, possibly making it less viable than other strategies available to GCWA.

f. Water Rights Administration

As the GCWA Daily-Hydro model simulates the administration of GCWA's various water rights, it provides guidance to GCWA staff as to which water right should be utilized under given flow conditions in an attempt to maximize senior-priority water right availability (and BRA contract water availability) later in the calendar year. The enhanced algorithms within the V8 model will provide guidelines for GCWA staff when staff makes weekly requests to the Brazos Watermaster for permission to divert water under its various water rights.

3. To what extent will the project benefit water supply reliability?

Since its creation in 2010, GCWA has relied upon the GCWA Daily Hydro model to inform staff decisions regarding the management of GCWA's available water supplies. The model is also extremely beneficial in quantifying GCWA's ability to deliver customer-needed water quantities under past observed hydrologic conditions. Enhancing model capabilities through this project will make the model more accurately reflect the GCWA water system, and will therefore provide more accurate and beneficial results for GCWA and its customers. GCWA expects water supply reliability to increase as a result of the expected streamflow adjustments due to reservoir storage (Task #7), and they expect to demonstrate how the newly-acquired contract water from BRA (Task #3) can be utilized to both "firm-up" existing customer supplies and leverage GCWA's existing supplies so that they may offer firm and interruptible water delivery to additional potential customers.

4. How will this project compliment similar projects within GCWA's area?

The only similar water availability model covering GCWA's service area is the official WAM model for the Brazos Basin that is developed and maintained by the TCEQ. This official model is used for water right permitting and long-term statewide water planning. While the WAM model is applicable for those purposes, it is not designed to truly consider all water management options unique to the Lower Brazos and GCWA system. GCWA considers the GCWA Daily Hydro model to be a more applicable model for assessing the nuances of its water system and operations. GCWA hopes that through Task #10 and Task #11, (i.e., model documentation and dissemination) that other entities throughout Texas will recognize the benefits of the GCWA Daily Hydro approach to water management with respect to those from the WAM. Concepts within the GCWA Daily Hydro algorithms are directly applicable to other locations within Texas and throughout the US West, and GCWA hopes to demonstrate how these concepts may be applied to enhance water availability modeling for system operation.

Evaluation Criterion B – Need for Project and Applicability of Project Results

GCWA has a need to ensure it is able to provide sufficient water to meet the growing demands of its customers. In turn, GCWA customers have a need to believe GCWA can meet their water delivery obligations. Deliverables from this project, including both the V8 model and its documentation, will address both these needs, and will provide both sides with confidence that available water resources are being properly managed. All of GCWA's current and potential customers who have previously reviewed GCWA modeling reports and attended meetings at which modeling results were discussed have expressed praise for GCWA's continued efforts to improve reliability. GCWA's largest municipal customer, the City of Galveston, has expressed support for this project; the letter of support is attached.

1. Does the project meet an existing need identified in the 17 Western States?

Results from this project will certainly benefit GCWA and enhance GCWA's ability to manage its water supply reliability. Most of the needs addressed in this project were identified during GCWA's 2016-2019 DCP Update project. GCWA hopes that through public dissemination of the V8 model and documentation, other water resource managers within the 17 Western States will be able to learn from and apply GCWA's techniques to enhance their own water supply systems. GCWA has provided a letter of project support from its largest municipal customer, the City of Galveston.

2. Will the project result in tools or information that is likely to be used by water resource managers in the West?

YES. GCWA believes the V8 model resulting from this project itself be useful to other water resource managers, and that the information it provides will lead those managers to improved water resource strategies for their own jurisdictions.

a. How will the project results be used?

GCWA will use the project results to evaluate the relative merit of various water supply enhancement strategies, and to inform customers (and regulators) of their ability to deliver promised contractual supplies. GCWA intends for others to utilize the concepts inherent within the V8 model in site-specific customized models of their areas of interest, and to improve mathematical simulations of water reliability.

b. Will the results be immediately applicable?

GCWA will immediately apply model results to enhancing its water supply reliability, and has done so based on all results derived from previous versions of the model. GCWA's most immediate goal that will be achievable based on these results is to determine if the BRA system-operations water it obtained in 2019 is sufficient to both "firm up" existing customer water supplies and to possibly develop new customer contracts for water delivery. GCWA will also be able to weigh the costs and benefits from groundwater usage/ASR and the construction and operation of new surface water reservoirs.

c. Will the results of the project be transferrable to other users and locations?

The V8 model itself is customized to apply only to the Lower Brazos River Basin. However, the concepts behind the model algorithms are applicable to all basins throughout Texas, and likely many basins throughout the US West in which prior-appropriation doctrine is the standard water policy. Results of the project for GCWA can be used as a guide for action by other water resource managers.

Evaluation Criterion C – Project Implementation

GCWA is capable of proceeding with the project immediately upon receipt of the grant award from Reclamation. The first step will be to procure the services of a modeling consultant following the procedures required under 2 CFR §200.317-200.326. GCWA does not intend to utilize GCWA staff time or expertise on this project, with the exception of project management duties. Previous versions of the GCWA Daily Hydro model were developed by hired consultants, who then provided GCWA staff training on the model usage. In total, GCWA has spent \$321,000 developing V1-V7 of the GCWA Daily-Hydro model, and based on this experience we believe that the \$60,000 total project budget developed for the tasks presented herein is reasonable and sufficient. We also believe the work can be completed within the one-year timeframe proposed herein.

1. Project Objectives and Methodology

The project objective is the continued enhancement of GCWA's water reliability through improving the Daily Hydro water availability model. Our modeling consultant will implement all project tasks at the direction of GCWA Project Manager Jake Hollingsworth.

2. Describe the Work Plan for the Project.

GCWA anticipates the project will be completed in 2020, following the task schedule shown in Figure 7, and assuming our consultant (once selected) is able to start the project in January 2020. Completion of each task is considered a “milestone” for this project effort. GCWA will ensure work progresses according to the schedule shown in Figure 7.

Task Description	#	2020 Project Timeline											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Simulation of Brazos River flow losses	1	█	█										
Dynamic DCP Curtailment modeling	2		█	█									
BRA Contract Modeling Update with Systems-Operations Water	3		█	█									
Modeling additional GCWA customer demands	4		█										
Modeling irrigation water demands	5				█								
Simulating Benefits of Additional Reservoir Storage	6					█							
Adjusting Streamflow for Proper Upstream Reservoir Management	7		█	█	█								
Modeling Groundwater/Surface Water Conjunctive Use	8					█	█						
Modeling Non-Priority Water Diversions	9						█	█					
Model Code Documentation	10	█	█	█	█	█	█	█	█	█	█	█	█
V8 Water Availability Reporting	11								█	█	█	█	█

Figure 7 – Project Work Plan – GCWA Daily Hydro V8 Model Development

3. Availability and Quality of Existing Data and Models

GCWA has the model code for V7 of the GCWA Daily-Hydro model, from which the V8 model will be created. GCWA will provide the model code and all existing model documentation and past reports to the selected consultant upon project commencement.

4. Project Staff Expertise

GCWA employs staff engineers tasked with maintaining the GCWA canal system and operation. These engineers guide a support staff of canal runners, operators, water treatment professionals, and maintenance technicians. All staff will be able to assist in the development of the V8 model, yet the majority of the project effort will be undertaken by a project consultant hired specifically for this project. Project Manager Jake Hollingsworth is GCWA’s Strategy and Performance Manager, and has worked with previous modeling consultants in developing the Daily-Hydro model.

5. Product Description

Deliverables from this project will include the fully-documented GCWA Daily Hydro Model V8 source code, a model User’s Manual, and a report detailing GCWA’s water availability under various water management strategies. Deliverables will be made publically available on the GCWA website. Geospatial data generated during the project (if any) will be provided in ArcGIS standard formats.

Evaluation Criterion D – Dissemination of Results

The results of this project will include the revised GCWA Daily-Hydro (V8) model code, documentation of all model options and functions, and a detailed report describing GCWA's water availability. One of GCWA's goals for this modeling effort is for the results to be understood and accepted by customers, stakeholders, regulators, and members of the general public with interest in GCWA operations and water management. GCWA recognizes the importance of peer-review for assessing model results and gaining stakeholder acceptance of those results. As such, GCWA pledges to make the V8 model code publically available on its website, along with the model documentation and the report describing GCWA's computed water availability. GCWA will require that its Project Manager host two meetings at which the model and model results will be discussed. Meetings will be held at GCWA facilities and will be open to any interested party. At the first meeting, GCWA will present the V8 model and model results related to GCWA's water availability. After this meeting, each interested party will review the model and its documentation in preparation for the second meeting. At the second meeting, to occur not-earlier than 1-month after the first meeting, GCWA will solicit feedback and answer questions. GCWA will also participate in at least one Reclamation-sponsored webinar to disseminate deliverables and discuss application of deliverables to management questions.

Evaluation Criterion E – Department of the Interior Priorities

We believe this project supports Department of Interior Priority 1.a as listed in the FOA:

“Utilize science to identify best practices to manage land and water resources and adapt to changes in the environment.”

Through this project, GCWA will develop improved modeling capabilities which it will utilize to better manage the water resources of the lower Brazos River Basin and to ensure that available water is allocated to users (including aquatic and riparian species) subject to the laws of Texas and the USA. The improved modeling will also allow GCWA to adapt to changes in the environment should those changes result in either increasing or decreasing streamflow on short-term or longer-term bases.

We believe this project also supports Department of Interior Priority 4.a as listed in the FOA:

“Reduce the administrative and regulatory burden imposed on U.S. industry and the public.”

Through this project, GCWA will have developed a tool for monitoring reservoir releases for compliance with Texas laws regarding the prior-appropriation method of water allocation. With this tool, GCWA will be able to demonstrate compliance with existing laws, thereby eliminating the need for similar efforts by regulators at the TCEQ. The tool will provide such administrators and regulators with a means of further supporting efforts to manage the water resources of the Brazos Basin.

Project Budget

Funding Plan

GCWA will provide the non-Federal share of this project budget using funds available from its general revenue accounts.

Table 1 – Total Project Cost Table

SOURCE	AMOUNT
Costs to be reimbursed with the requested Federal funding	\$30,000
Costs to be paid by the applicant	\$30,000
Value of third-party contributions	\$0
TOTAL PROJECT COST	\$60,000

Budget Narrative

ALL project costs will go toward the hiring of a consultant who will be responsible for completing all project tasks at the direction of GCWA staff. No GCWA staff labor will be funded through this project, and as such, no funds will be allocated to: Salaries and Wages, Fringe Benefits, Travel, Equipment, Materials and Supplies, Third-Party In-Kind Contributions, Environmental and Regulatory Compliance, Other Expenses, or Indirect Costs.

Budget estimates for the Contractual work will be provided upon selection of the consultant, subject to procurement rules specified in 2 CFR §200.320. Should the consultant and GCWA determine that completion of the project work requires funds in excess of the “TOTAL PROJECT COSTS” shown in Table 1, the GCWA will commit additional funds. Costs to be reimbursed with Federal funding will NOT exceed \$30,000.

Environmental and Cultural Resource Considerations

This project involves enhancing a numerical model of water availability in the Lower Brazos Basin. It does not involve any actions with would have direct environmental or cultural resource considerations. Below are answers to the questions required per section H.1 of the FOA.

- **QUESTION:** Will the proposed project impact the surrounding environment (e.g., soil [dust], air, water [quality and quantity], animal habitat)? Please briefly describe all earth-disturbing work and any work that will affect the air, water, or animal habitat in the project area. Please also explain the impacts of such work on the surrounding environment and any steps that could be taken to minimize the impacts.

ANSWER: This project will not impact the surrounding environments, does not involve earth-disturbing work, and will not affect the air, water, or animal habitat in the project area.

- **QUESTION:** 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?

ANSWER: GCWA is unaware of any species listed or proposed to be listed as a Federal threatened or endangered species, or designated critical habitat in the project area.

- **QUESTION:** 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.

ANSWER: There are numerous waterbodies within the GCWA source watershed that likely fall under CWA jurisdiction as “Waters of the United States.” This project will not impact these waters as this project involves only computer modeling.

- **QUESTION:** When was the water delivery system constructed?

ANSWER: The canal system utilized by GCWA was originally constructed in the 1920s.

- **QUESTION:** 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.

ANSWER: This project will not result in any modification of or effects to individual features of an irrigation system.

- **QUESTION:** Are any buildings, structures, or features in the irrigation district listed or eligible for listing on the National Register of Historic Places? A cultural resources specialist at your local Reclamation office or the State Historic Preservation Office can assist in answering this question.

ANSWER: Question not applicable.

- **QUESTION:** Are there any known archeological sites in the proposed project area?

ANSWER: GCWA is unaware of any archeological sites within the proposed project area.

- **QUESTION:** Will the proposed project have a disproportionately high and adverse effect on low income or minority populations?

ANSWER: No.

- **QUESTION:** Will the proposed project limit access to and ceremonial use of Indian sacred sites or result in other impacts on tribal lands?

ANSWER: No.

- **QUESTION:** 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?

ANSWER: No.

Required Permits or Approvals

No permits or approvals are required for this proposed modeling project.