Appendix U

Basin Study Scope of Work

TODD GROUNDWATER

February 3, 2022

PROPOSAL

To: Kern County Subbasin Groundwater Sustainability Agencies (GSAs)
Patty Poire, Kern County Subbasin GSP Plan Manager

From: Mike Maley, PG, CHG, Principal Hydrogeologist / Groundwater Modeler
Phyllis Stanin, PG, CHG, Vice President / Principal Geologist

Re: **Basin Study Proposal –** Comprehensive Update to Address Data Gaps with the Hydrogeological Conceptual Model, Water Budgets and Model Calibration of the Kern County Subbasin to Support GSP Implementation and Native Yield Study

The Kern County Subbasin (Subbasin or Basin) is designated as critically-overdrafted by the 2015 Sustainable Groundwater Management Act (SGMA) Basin Prioritization form the Department of Water Resources (DWR). The Subbasin is the largest groundwater basin in the State, encompassing a surface area of 1,792,000 acres (2,800 square miles), and water in the Subbasin is managed by a myriad of water districts, water storage districts, irrigation districts, and municipalities. To comply with SGMA in this large complex basin, local agencies have organized into 11 Groundwater Sustainability Agencies (GSAs) with 32 management areas within those GSAs. These GSAs coordinated on five Groundwater Sustainability Plans (GSPs), submitted in January 2020, that cover the entire Subbasin. These five coordinated GSP areas include the Kern Groundwater Authority (KGA) GSA, Kern River GSA, Buena Vista GSA, Henry Miller GSA and Olcese GSA. **Figure 1** shows locations of these areas within the Kern County Subbasin and their relationship to adjacent subbasins.

The Subbasin GSAs are cooperating on the implementation of their recently completed GSPs. These agencies manage a complex water supply system, a large portfolio of local and imported water sources, access to flood waters, local managed aquifer recharge projects, and numerous large groundwater banking projects (**Figure 2**), collectively providing both local and State-wide water supply and water quality benefits. Through ongoing coordination meetings, a consensus was reached that an important next step for GSP implementation is to support local decisionmakers with comprehensive, assessable technical information as they work through the policy, legal and water rights issues. To achieve this objective, this project, referred to herein as the ***Kern County Subbasin Study*** or ***Basin Study***, was developed.

The Basin Study project description was developed over the past year and includes input provided during several meetings with Subbasin GSAs, policymakers and stakeholders. Using this input, the general approach for the Basin Study evolved into a systematic, basinwide analysis to address technical data gaps in the hydrogeological conceptual model (HCM), water budgets and model calibration. To make the results of the Basin Study more accessible, a series of GIS maps and geodatabases will be developed. Incorporated in the Basin Study are multiple meetings and technical memoranda to provide

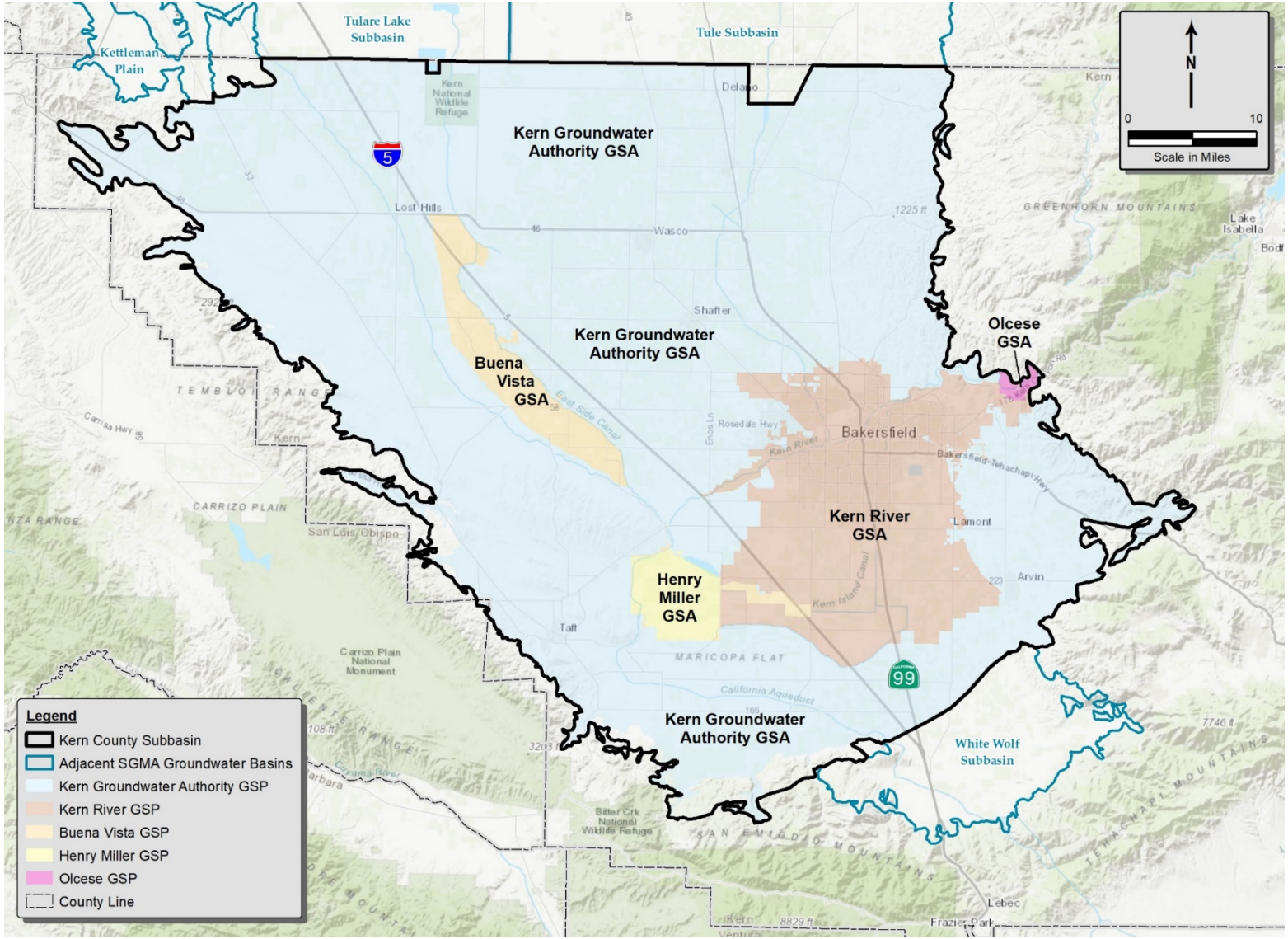


Figure 1: The Kern County Subbasin is located at the southern end of the San Joaquin Valley. The Kern County Subbasin GSAs coordinated on five GSPS that cover the entire Kern County Subbasin as shown.

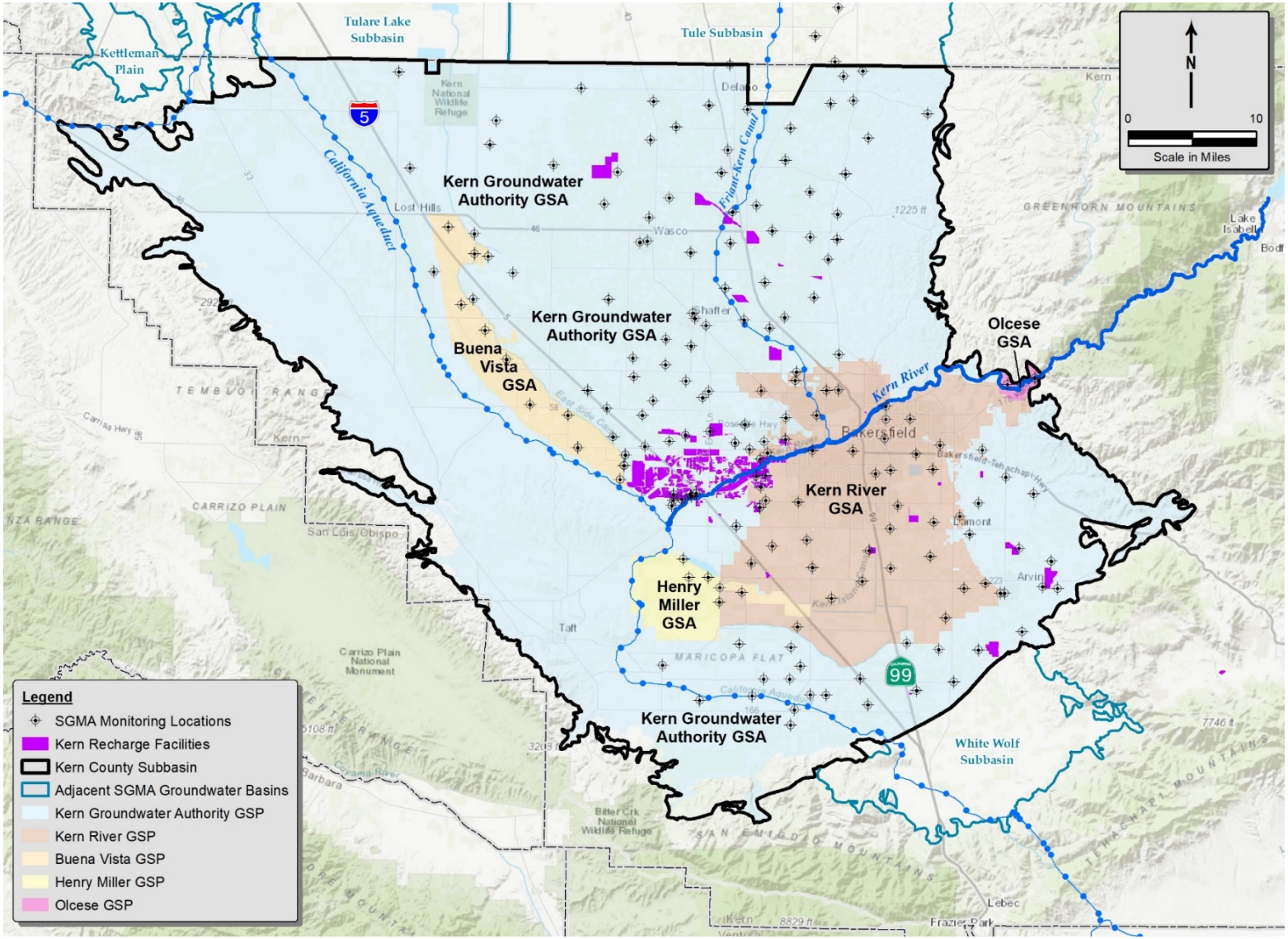


Figure 2: The Kern County Subbasins are coordinating upon implementation of the GSP Project and Management Actions. The map shows the locations of the major water import canals and current groundwater recharge locations.

opportunity update progress of the technical work during the project to answer questions, address comments and receive guidance.

The Basin Study is needed to support future policy decisions for achieving long-term sustainability of groundwater in the Basin. The goal of the Basin Study is to support multiple aspects of future GSP planning and implementation work by the Subbasin GSAs that will provide multiple benefits for a wide range of communities, water users and stakeholders including Underrepresented Communities. The following discussion provides additional details of the proposed approach (along with a scope of services, schedule, and budget) that demonstrate how the Basin Study will meet this goal.

PROJECT DESCRIPTION

As noted above, the general approach for the Basin Study is to develop as a systematic, basinwide analysis to address technical data gaps in the hydrogeological conceptual model (HCM) and water budgets update and recalibrate the basinwide model and provide multiple meetings and presentation to Subbasin GSAs, policymakers and stakeholders. The following discussion provides an overview project description. Additional details are provided in both the Approach and Scope-of-Work sections of this proposal. The project has been outlined into the following series of tasks:

- Address Data Gaps
    - Data Compilation and GIS Mapping
    - Hydrological Evaluation
    - Hydrogeological Evaluation
    - Water Budget Methodology Upgrades
- Kern County Specific Model (IWFM-Kern)
    - Model Upgrades
    - Model Calibration
- Coordination
    - Subbasin GSA meetings
    - Policymaker meetings
    - Stakeholder Meetings
    - Coordination with Outside Agencies and GSAs

Several management actions are included in the Subbasin GSPs to address data gaps and define goals for GSP implementation. A brief summary of these GSP management actions includes the following:

- Improve the understanding of the groundwater response to the implementation of projects and management actions,
- Support sustainable groundwater Supplies of Disadvantaged and Severely Disadvantaged Communities (DACs and SDACs) in order to provide “a safe, clean, affordable, and sufficient water supply to meet the needs of California residents, farms, and businesses”.
- Address data gaps in the hydrogeologic conceptual model including details on physical properties, geologic structures and confining clay layers that may affect subsurface flow.
- Improve groundwater characterization on the eastern and western margins of the Subbasin.
- Develop an improved determination of the input data to address data gaps for basinwide and local water budgets.
- Incorporate locally-derived HCM data from the Subbasin GSPs into the model to better represent subsurface groundwater flow within and out of the Subbasin.

- Improve model calibration to better simulate the implementation of projects and management actions, relationship to minimum thresholds and measurable objectives (MT/MO) and quantify subsurface flow within and out of the Subbasin.
- Continue analysis to support the determination of the Subbasin native yield, on both a technical and policy basis.

The Basin Study approach is designed to address data gaps in the HCM as identified during the GSP process; however, important local information is spread across several GSPs and management area plans within those GSPs. In addition, the Subbasin GSAs and local agencies have undertaken local projects that contain improvements to the HCM or address data gaps. Therefore, the next step is to coordinate with the Subbasin GSAs and local agencies to compile and integrate this information into the basinwide HCM. This multi-faceted work involves:

- Compilation and GIS mapping of Subbasin datasets,
- Evaluation of hydrology and hydrogeology for an improved Subbasin-wide HCM,
- Update data for local drinking water supplies including small water systems and domestic wells from DACs and SDACs,
- Updates and improvements on water budget methodology, and
- Incorporation of HCM and water budget components into the Subbasin Model,

Our approach assumes that this proposal is a technical study to address data gaps and update the overall Subbasin groundwater budget through a systematic analysis of the available data. Preliminary results will be provided to local water managers, policy makers and stakeholders for review so that relevant comments can be addressed as the technical work is being conducted. Additional details of the specific tasks to accomplish these tasks are described in the Approach and Scope of Work sections.

The Kern County Subbasin Coordination Agreement refers to the local groundwater-surface water model (C2VSimFG-Kern or Subbasin Model) as the agreed upon method for generating coordinated water budgets for the Kern County Subbasin. The model is well suited for estimating the impacts of projects and management actions on the Subbasin groundwater storage and is also well suited as a planning tool in meeting SGMA compliance. Appendices 2 and 4 of the Coordination Agreement include a technical report on the development and application of C2VSimFG-Kern for these purposes.

The current Subbasin model (C2VSimFG-Kern) remains as the southern extent of the DWR C2VSimFG regional model of the entire Central Valley. For the Basin Study, an upgraded Subbasin-focused Model (IWFM-Kern) will be developed through improvements to the existing model that simulates the Kern County Subbasin and local adjacent areas only. This approach will provide the framework for a more accurate water budget analysis to support ongoing GSP planning and implementation. The Basin Study will focus on several outstanding data gaps that included the following actions and model improvements:

- Improve streamflow simulations of the Kern River and Poso Creek
- Improve the geologic characterization of the Kern County portion of the Central Valley
- Improve simulation of deep percolation and small watersheds
- Review and update root zone parameters
- Develop a stand-alone Kern County Subbasin focused model
- Adjust the finite element grid to honor water management boundaries
- Quantify boundary flows around the Subbasin Boundary
- Utilize more complex water management features of IWFM
- Calibrate the improved model for the Subbasin.

The emphasis is to better represent local groundwater elevations in the four principal aquifers and provide higher accuracy in simulating changes in groundwater elevations over time. A key objective of the model recalibration is to improve the simulation of groundwater elevations relative to MT/MOs across the Subbasin to provide improved support to long-term GSP implementation planning. The calibrated IWFM-Kern model will produce an updated historical water budget and change in groundwater in storage estimates for the Subbasin in preparation of the 2025 GSP updates. To support ongoing GSP implementation, updated projected future water budgets will be run for Baseline and Climate Change scenarios over the 50-year planning and implementation horizon. These scenarios provide a basis of comparison for evaluating proposed sustainability management actions and projects over the SGMA planning and implementation horizon.

We recognize the need for transparency and effective communication of the data, methodologies, and results of the Basin Study throughout the process. Accordingly, multiple meetings and workshops with the Subbasin GSAs, policy makers and stakeholders are incorporated into the Basin Study. A basinwide GSP Management Action includes the following:

- Continuation of the Kern Subbasin Managers Group to coordinate water management activities in the Subbasin, including technical analysis, project management and coordination, identification of joint management opportunities and coordination of SGMA reporting requirements to DWR.

This group represents a wide range of water interests. Many of the DAC and SDAC communities are their own GSAs or Management Area in the GSAs, and are active participants in the Managers Group (**Figure 3**). We will provide regular updates on the progress of the Basin Study to the Managers Group throughout the duration of the project. Recognizing the water managers' experience, these meetings will also serve the role of a technical advisory committee to provide feedback and help improve the evaluations as they are underway.

The Basin Study also includes time and budget to support the GSAs for the stakeholder outreach process to interested parties including Underrepresented Communities, DACs and SDACs (**Figure 3**). Therefore, a significant time and budget is allotted to meetings to inform these parties of the ongoing progress and receive feedback on policy and Subbasin coordination issues related to the Basin Study. During this Study, each step will be vetted with local water managers, policy makers and stakeholders to provide an opportunity for these groups to review and comment on the technical study data, methodology and results. We have included time for collaboration with DWR, USGS California Water Science Center and local universities on our technical approach.

For each of the primary technical tasks, a technical memo and data package will be developed to provide preliminary results for review and comment. We will address comments received through this process and final versions will be included as attachments to the Technical Report to provide detailed documentation of data, methodology and results. The Final Technical Report will include a discussion of the Basin Study results intended for a more general audience that includes local policymakers, stakeholders, and other interested parties. The documentation will be included in the technical memoranda attachments to provide the details needed for a more technical audience. By structuring the final report to address both a general audience and a technical audience, our goal is to provide clear, defensible documentation for the wide range of parties interested in the Basin Study.

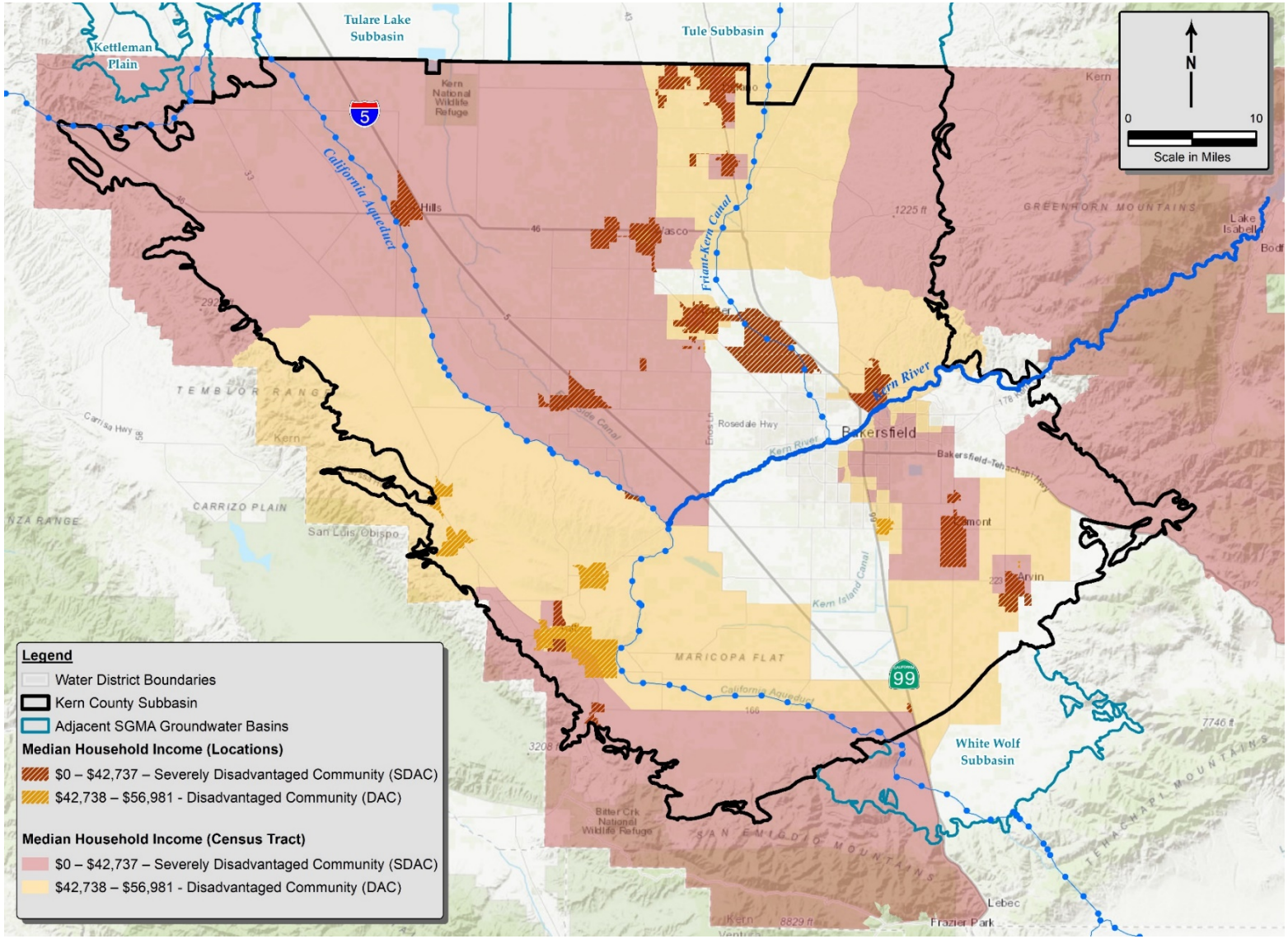


Figure 3: Large areas of the Kern County Subbasin is designated as Disadvantaged and Severely Disadvantaged locations and areas. Many of these DAC/SDAC communities are active participants that formed their own GSAs or Management Area within the GSAs.

STUDY OBJECTIVES

As provided above, this Basin Study involves a systematic, basinwide technical analysis of the water budget components and an updated Subbasin Model based on a comprehensive compilation and analysis of the relevant data. The overall objective is to provide local water managers, policy makers and stakeholders with a comprehensive and useful Subbasin-wide model to support planning and implementation efforts in achieving long-term groundwater sustainability for the Subbasin.

The primary objective of the Basin Study is to develop a ***systematic technical analysis to better represent the flow of groundwater and surface water into, through and out of the Subbasin*** based on data included in the Subbasin GSPs and supporting data and documentation. The approach is based on a comprehensive compilation and analysis of the relevant data to provide local water managers, policy makers and stakeholders with the data and information needed for evaluating basinwide groundwater resources. Our approach is to organize and evaluate local data to improve the representation of the HCM with respect to groundwater occurrence and flow, to refine associated water budget components at a local level and, where needed, to scale up to a more robust basinwide water budget determination.

A second objective is to update the Subbasin Model to ***provide a basinwide planning model designed to support SGMA compliance*** through a consistent basinwide approach for determining regional water budgets and evaluating groundwater and surface water conditions for the Subbasin. Neither C2VSimFG-Kern nor the proposed updated Subbasin Model (IWFM-Kern) are intended to supersede any local model in evaluating local water management or regulatory compliance. Rather, the Subbasin Model will provide basinwide water budgets, assess historical and projected future groundwater conditions, and evaluate long-term sustainability during GSP implementation.

The focus is to develop a ***technically credible analysis*** based on a comprehensive compilation and review of available data. We will develop key data sets and sources using the best available data. The basinwide data will be validated by comparison to detailed local data for multiple areas in different parts of the Subbasin, as available. The purpose of this process is to obtain agreement on the basic data sets that document the groundwater recharge and to determine the basinwide volumes and distribution for each component. This emphasis is necessary to make appropriate technical data available to policymakers as they address policy, legal and water rights issues during implementation of the Subbasin GSPs.

In addition, we recognize the need for ***transparency*** **and** ***effective communication*** of the data, methodologies, and results of the Basin Study throughout the process. Therefore, our approach includes collaboration with the GSAs, agencies and stakeholders. Accordingly, multiple meetings and workshops with the Subbasin GSP managers and policy decision-makers are incorporated into the scope and budget as well as provision of support to the GSAs for the stakeholder outreach process. Our approach includes interim documentation of each of the major technical tasks with sufficient time allowed in the schedule for review and comment periods by interested parties. Each task includes time to address these comments as they arise. In this manner, we can address issues and concerns during the process with the goal to achieve general agreement on the approach as the Basin Study progresses.

The Basin Study ***will benefit Underrepresented Communities includes DAC and SDAC areas*** by more fully integrating data for the small water systems and domestic wells that serve the DAC and SDAC areas (**Figure 3**) into a comprehensive basinwide analysis. The Basin Study will develop data analysis, GIS analysis and model tools to specifically evaluate the DAC and SDAC areas. By doing so, GSP Implementation can be evaluated for these areas using the same tools as used for the larger agricultural and urban water districts. These efforts will provide local water managers, policy makers and

stakeholders with the technical information necessary to ***meet the established State of California policy goals of AB 685, the Human Right to Water, that clean, safe, accessible and affordable drinking water is available for all residents***.

Ultimately, the Basin Study will need to ***align the technical analyses with policy decisions*** to protect water rights while supporting beneficial uses. To support this need, our approach is to vet the methodologies and results with local water managers, policy makers and stakeholders throughout the Basin Study. Additional time and budget are provided in this proposal to provide additional technical support to the Subbasin Policy Team for several months after the completion of the Basin Study. This support is intended to provide presentations, data summaries and model simulation results from the Basin Study to the Policy Team as they work through Subbasin sustainability issues such as long-term sustainability, GSP implementation, native yield definition and allocation.

The goal of this proposed work is to provide a technical assessment that better quantifies the Subbasin water budgets – both basinwide and locally – through a systematic analysis of available data. Additional details of our proposed approach (along with a scope of services, schedule, and budget) are provided in this proposal.

APPROACH

Because the model update was done concurrently with the development of the Subbasin GSPs, DWR's existing hydrogeologic conceptual model (HCM) and data management structure were maintained in C2VSimFG-Kern. This allowed the model update to focus on the water budget components and also recognized that the GSPs would contain improvements to the HCM and relevant data that could be later addressed in the model. The following provides additional information on the general approach to support the technical tasks included in this proposal.

Hydrogeological Conceptual Model (HCM)

The Kern County Subbasin is a large and geologically complex basin with regional faulting, folding and deposition of key horizons such as the Corcoran Clay, or E-Clay, layer (**Figure 4**). Because the basinwide model update was done concurrently with the development of the Kern County GSPs, DWR's existing HCM and data management structure were maintained in C2VSimFG-Kern. Therefore, the Basin Study will incorporate updates to the HCM using existing data from the GSPs, recent reports, new geophysical investigations, and well-established technical literature by USGS, DWR and others.

Four principal aquifers have been defined in the Subbasin by the Subbasin GSAs. A first step is to compile the data and supporting references from the GSPs for these four aquifers to define the horizontal and vertical extent of the aquifers and to document available aquifer characterization data. The distribution of the groundwater flow and recharge can be affected by the geology of the principal aquifers and the overlying unsaturated zone. The unsaturated zone may contain clay layers that form local perching horizons. Several of these features have been identified in the GSPs. We will compile a map of these areas to factor perching horizons into the analysis.

On the local level, several agencies are conducting new studies to evaluate HCM data gaps. Areas along the Subbasin margin are more geologically complex than the central part of the Subbasin (**Figure 4**). This geologic complexity has a strong influence on groundwater movement through the Subbasin. However, much of this geologic complexity was not included in the DWR version of the C2VSimFG-Beta model. We have included Aquilogic on the Project Team as a subconsultant. Aquilogic brings experience working for water districts and oil companies in the western Subbasin and will provide their expertise with the complex geology of these areas. Likewise, to address similar issues along the eastern and

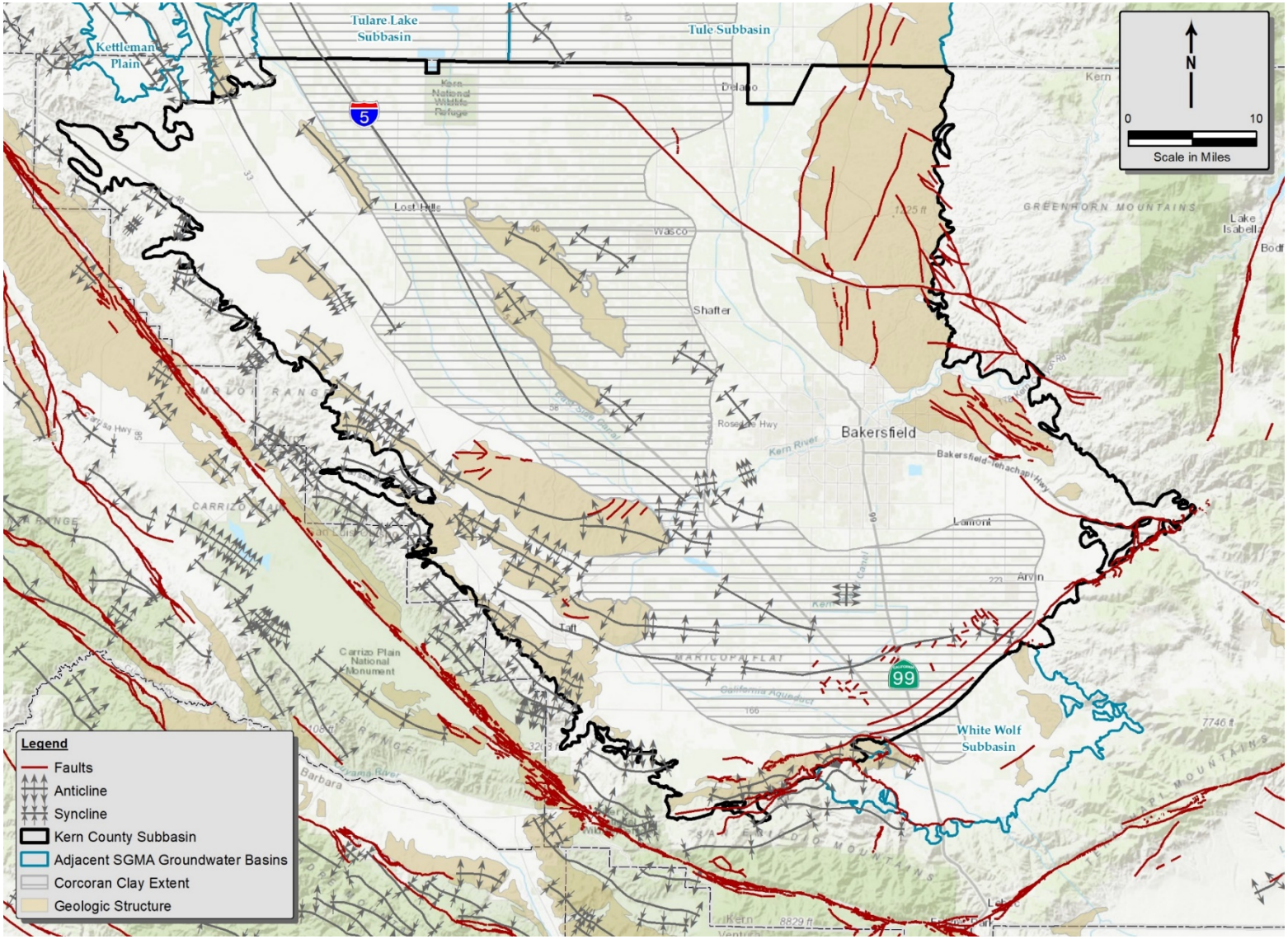


Figure 4: The Basin Study will more fully incorporate the geologically complexity of the Subbasin into the basinwide groundwater model to better represent groundwater condition in the Subbasin to support GSP implementation and planning.

southern Subbasin margins, we will coordinate with local GSAs in those areas to obtain local data and reports as well as discuss their hydrogeologic interpretations.

Several aquifer exemption areas for oilfield activities have been defined. An exempt aquifer is removed from protection as an Underground Source of Drinking Water[1] (USDW) and is not part of the groundwater basin. The exempt aquifer areas are often defined by bounding faults, geologic structures and stratigraphy (**Figure 4**) that restrict interaction with groundwater basin principal aquifers. However, the geology of these areas may affect subsurface groundwater flow or may intercept a portion of the groundwater flow or recharge. In many cases, the Subbasin GSPs have defined the exempt aquifer areas as located outside of the Subbasin. However, in a few cases, the exempt aquifer relationship to the Subbasin is more complex. For example, the exempt aquifer for the Kern River Oilfield is relatively shallow. Because of the variability with the exempt aquifer definitions, each of these areas will be assessed based on information in the GSPs, EPA aquifer exemption reports, Department of Conservation California Geologic Energy Management Division (CalGEM)[2] reports, and other supporting references to determine how best to represent the exempt aquifers in the HCM.

The Project Team will look to coordinate with various GSAs, water agencies and others in compiling the HCM data and reconciling any questions regarding the data. Proposed model revisions emphasize the need for coordination across multiple agencies during this Basin Study. In addition, the Basin Study includes time for local hydrogeological subconsultants to provide input on the understanding of the HCM for key areas where they have local expertise. The results of the compilation of the HCM updates from the GSPs will be mapped in GIS and incorporated into the IWFM-Kern model updates.

Geophysical Investigations

The HCM update will utilize new or newly-available geophysical data sets into the HCM update. Geophysical surveys use measurements of variations of physical properties (e.g. electrical, physical or chemical properties) as indirect means to evaluate geological conditions over large regional areas to within a single borehole. The advantage of these methods is a more consistent methodology that may allow for geologic insights or correlations that would be difficult to make using conventional methods. Incorporating the geophysical methods into the HCM is anticipated to further enhance the understanding the underlying geologic structure and correlation of key geologic horizons to identify groundwater recharge potential and understand in the influence of geology on groundwater flow. The Basin Study looks to include the use of the following geophysical methods:

- Airborne Electromagnetic (AEM) Surveys
- Satellite Evapotranspiration
- Geologic Seismic Surveys
- Borehole Geophysical Logs

The Subbasin GSAs are supporting the DWR Airborne Electromagnetic (AEM) Surveys that are scheduled to occur in the Kern County Subbasin in November 2021. The AEM surveys have the potential to help better characterize the geologic complexity along the basin margins (**Figure 4**) and help correlate those areas across the Subbasin. Once the results of the AEM surveys will be obtained from DWR, an appropriate geophysical subconsultant will be retained under the Basin Study to further analyze and interpret these data. The results of these AEM surveys and the additional analysis will be reviewed by the Project Team and the Subbasin GSAs. As the results of these new data sets become available, the

[1] As defined by the U.S. Environmental Protection Agency and regulated in the Underground Injection Control Program as part of the Safe Drinking Water Act.

[2] Renamed from Division of Oil, Gas, and Geothermal Resources (DOGGR) on January 1, 2021.

Project Team will coordinate with the Subbasin GSAs to evaluate and discuss how to incorporate these data into the HCM update.

Another geophysical method is the remote sensing imagery from Landsat satellites to calculate historic ETc rates on a basinwide scale. For the 2020 GSPs, the Subbasin used satellite ET data generated by Irrigation Training and Research Center (ITRC) at California Polytechnic State University, San Luis Obispo (**Figure 5**). The process is based on a surface energy balance that includes corrections for aerodynamic resistance using frequent LandSAT satellite thermal images along with an understanding of local cropping systems. This process has evolved from research to estimate actual ET over large areas with limited data availability using a semi-automated calibration procedure and spatially interpolating reference evapotranspiration (ETo) rates. The Subbasin GSAs are currently expanding use of another satellite ET method that incorporates the use of local weather stations and ground truthing to improve the ET estimates. The Basin Study will coordinate with the new ET consultants to improve ET estimates for estimating water use in the Subbasin.

The Basin Study will look to incorporate the results of other geophysical methods as available, such as seismic surveys and borehole logs. We will coordinate with local oil companies and others who may use seismic data, especially in the complex geologic areas in the western Subbasin, to help evaluate the local geology and groundwater conditions. We will review interpreted seismic data from documented sources to further the understanding the influence of underlying geologic structures on groundwater flow. In addition, many water districts, oil companies and others perform geophysical logs on boreholes and wells. These logs can help correlate clay layers and other geologic marker horizons. The seismic survey results and geophysical logs will be used to guide updated cross sections and maps of Subbasin geology.

Subbasin Hydrology

The Subbasin hydrology consists of precipitation, streamflow and watershed runoff that falls or flows within or into the Subbasin (**Figure 6**). Runoff of precipitation both within the Subbasin and from the small watersheds surrounding the Subbasin is typically unmeasured; therefore, there is uncertainty associated with determining the volume. For this analysis, we will apply standard hydrologic methods for calculating runoff. Key sources are the Kern County Public Works Floodplain Management Department, the USGS California Water Science Center and DWR data analysis tools and methodologies applied to other areas in California, and studies by local agencies.

The hydrological analysis will evaluate rainfall and runoff for different areas of the Subbasin and for surrounding watersheds. The initial step is to compile local climatic and hydrologic data from the Subbasin GSAs and local agencies and regional studies by state and federal agencies. We will develop rainfall distribution maps to assess the volume of precipitation in different areas of the Subbasin using data from the PRISM Climate Group at Oregon State University and verifying with available local measured precipitation data. As assessment of differences between local rain gauges and PRISM data will be evaluated. If significant discrepancies are identified and verified, as assessment as to whether modification of the PRISM data are necessary will be made.

Surface water and diversions from local streams and imported sources represent the largest Subbasin water supply. The Basin Study includes ongoing annual updates and additional analysis of imported and local water supplies to continue to improve historical and future water budget assessments. We will coordinate with the Kern County Water Agency on published and unpublished methodologies, watershed analysis, hydrologic studies and surface water flow data to better represent surface water flow and conditions in the Subbasin. We will also coordinate with local water agencies on their water use practices and local hydrological studies to improve the application of these key water sources.

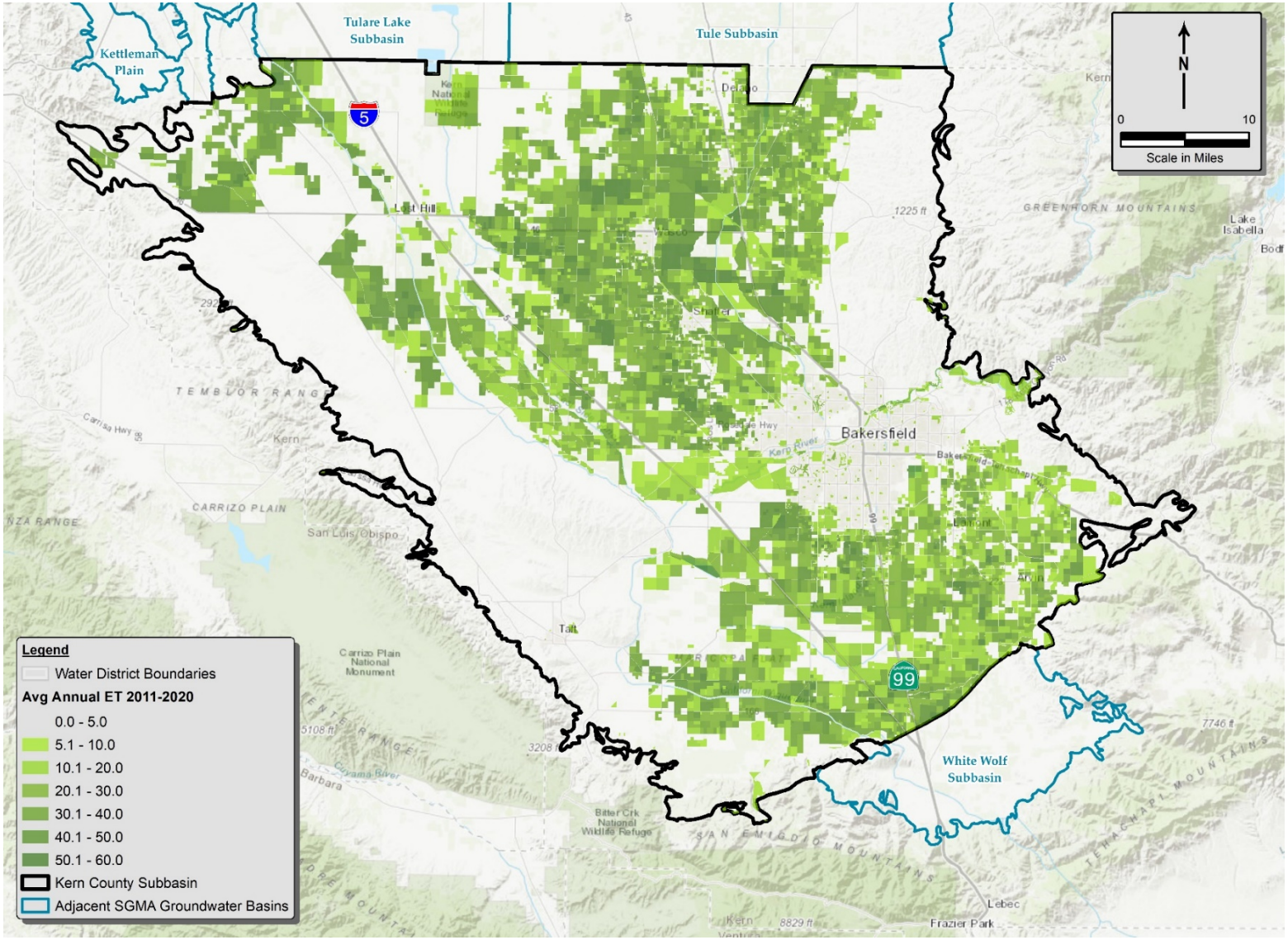


Figure 5: Agricultural crop demand is a major water use in the Subbasin. The Basin Study will evaluate different methods to use satellite-based ET geophysical data to improve water use estimates. .

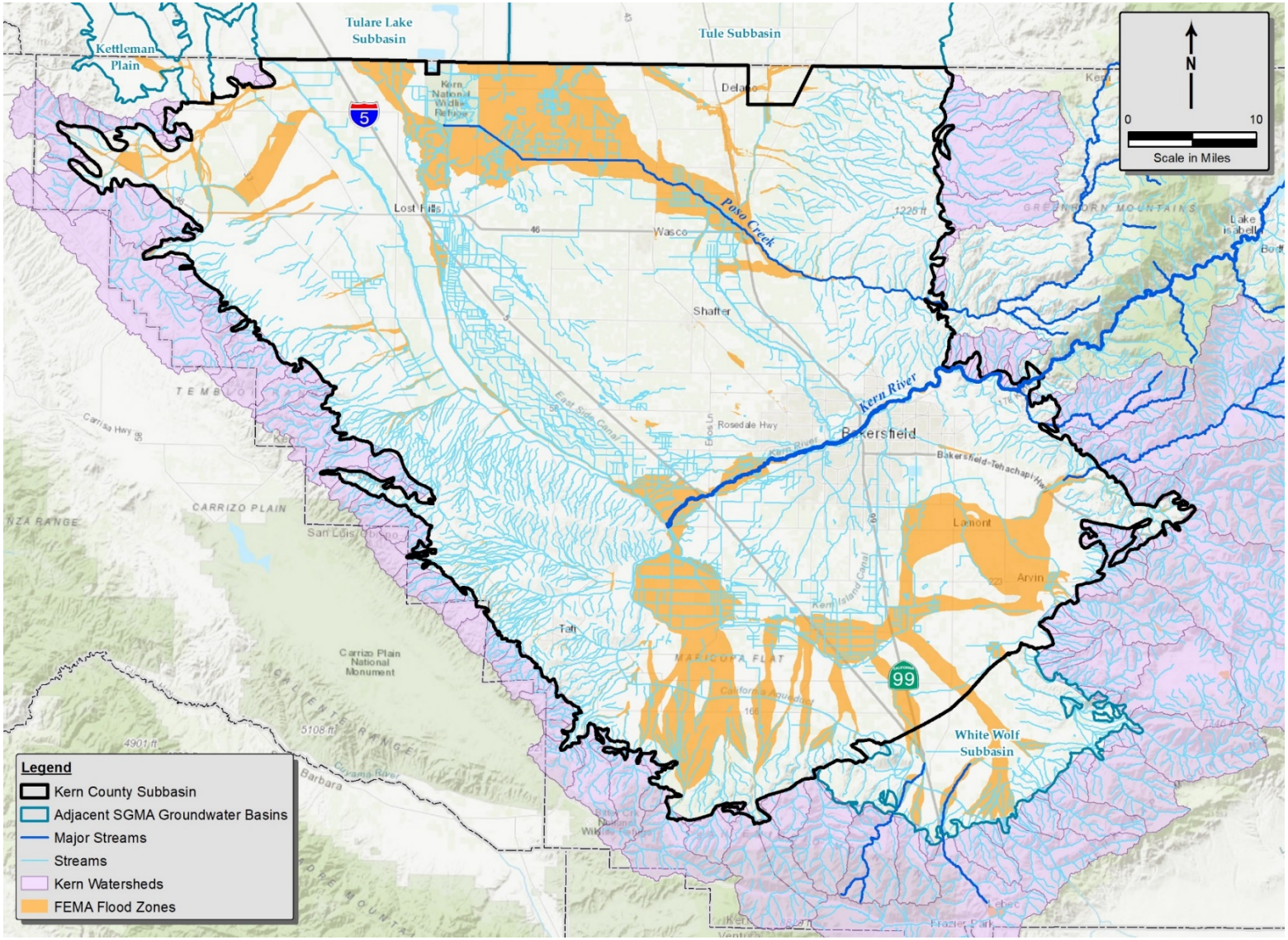


Figure 6: The hydrological analysis will evaluate rainfall and runoff for different areas of the Subbasin and for surrounding watersheds to identify and quantify the use of flood water from these ungauged streams for groundwater recharge for GSP implementation.

We will coordinate with local agencies to utilize their experience and data in evaluating the Subbasin hydrology. Due to hydrology data limitations , the general approach is to conduct these evaluations for limited areas with higher quality data to work out the details of applying the methodology and distributing parameters over areas of differing hydrologic characteristics. This work will focus on the surface conditions during rainfall, including a drainage assessment to evaluate surface runoff flow paths. Once the methodology and parameters are defined, the local evaluation will be scaled-up to a basinwide evaluation. By focusing on these local areas first, we can improve the efficiency in completing the hydrological evaluations.

The hydrology of the surrounding watersheds is distinctly different from those in the Subbasin. The goal of this subtask is to characterize the watershed areas to determine the volume of water from these areas that enter into the Subbasin. The hydrology assessment will examine the route of surface water runoff as it flows through the Subbasin, including the ultimate destination of high flows. We will also consider the potential for subsurface inflows from these watersheds based on available information.

We have included budget for Project Team subconsultants to help address specific issues on watershed and basin hydrology . The Basin Study includes time for local hydrological subconsultants to further evaluate local surface water conditions. In addition, we have added time for collaboration with DWR, USGS California Water Science Center and local universities on our technical approach to each hydrologic subtask.

Regional Floodplain Management

The Subbasin hydrology consists of precipitation, streamflow and watershed runoff that falls or flows within or into the Subbasin. Runoff of precipitation both within the Subbasin and from the small watersheds surrounding the Subbasin (**Figure 6**) is typically unmeasured; therefore, there is uncertainty associated with determining the volume. For this analysis, we will apply standard hydrologic methods for calculating runoff. Key sources are the Kern County Public Works Floodplain Management, the USGS California Water Science Center's and DWR's data analysis tools and methodologies applied to other areas in California, and a studies by local agencies.

The Kern County Public Works Floodplain Management Department has extensive hydrology data and resources, such as the Kern County Hydrology Manual used for engineering design of roads and bridges. Much of the data are available online; however, we will also coordinate with the Department to better incorporate this information into the hydrology portion of the Basin Study. The Department provides access to local FEMA floodplain maps (**Figure 6**) that can be used to better understand the flow of streams and floodwater through the Subbasin. Other local agencies and city public works departments have additional information on their local floodwater and stormwater management for recharge. We will coordinate through the Subbasin GSAs to compile information from these areas. Through this coordination with the County's Floodplain Management Department and other local public works departments, we anticipate that issues and opportunities will arise to better understand the recharge resulting from flood flows and to evaluate the use of local flood water for managed aquifer recharge.

An important new resource for evaluating runoff from ungauged watersheds is the USGS's updated Basin Characterization Model (BCM) Version 8 that provides a statewide database of hydrology parameters for California. As a referenced USGS source, BCM 8 provides a consistent hydrology methodology for the region. However, as a regional analysis, changes or refinements may be necessary. Therefore, we will review the BCM 8 data in comparison to local data (e.g., Kern County Public Works Floodplain Management) to verify its appropriateness to simulate runoff for the Subbasin. Any changes based on local data will be documented and communicated to the USGS.

DAC/SDAC, Small Water System and Domestic Water Supply

For the 2020 GSPs, the emphasis for assessing urban demand was on the metropolitan Bakersfield area, which represents about 75 percent of the local population (**Figure 7**). A comprehensive compilation of public and private water supply wells was developed for the KGA. For this, we will compile data on the water use, wells and distribution areas of the non-agricultural groundwater pumping for smaller cities, private water systems, and industrial uses from the Subbasin GSAs and local agencies.

An important goal of the Basin Study is to incorporate small water systems and domestic well owners, especially, to provide the Subbasin GSAs a better means to address water supply issues in underrepresented DAC and SDAC areas. DAC and SDAC areas cover large parts of the Kern County Subbasin (**Figure 3**). Several of the DAC and SDAC locations have formed their own GSAs, which have active participants in implementing the GSPs. Part of the challenge of addressing issues for DACs and SDACs is obtaining their water use data so that it can be integrated into the basinwide analysis. The Basin Study includes tasks to compile and integrate the DAC and SDAC water use and infrastructure into the basinwide analysis. We will coordinate with community water systems, small water suppliers, County agencies, Subbasin GSAs and other organizations (e.g. Tulare Kern Funding Area Disadvantaged Community Involvement Program) to gather water use and well information for the small water systems and domestic wells.

The Basin Study includes multiple steps to more fully integrate this data so that the small water system and domestic wells (**Figure 7**) that serve the DAC and SDAC areas can be evaluated using the same tools as used for the larger agricultural and urban water districts. The Basin Study will develop data analysis, GIS analysis and model tools to specifically evaluate the DAC and SDAC areas. By doing so, the Basin Study will support the local water managers, policy makers and stakeholders with the technical information necessary to meet the established State of California policy goals of AB 685, the Human Right to Water, that clean, safe, accessible and affordable drinking water is available for all residents.

Water Budget Methodology Update

The water budget methodology update will utilize a water balance approach similar to that used for the GSPs and the C2VSimFG-Kern model. The climate and hydrologic data will be evaluated over the historical period as that provides average hydrologic conditions as the basis for assessing the sustainable yield for the GSPs. The projected-future baseline scenario in the GSPs repeated the historical Subbasin hydrology, so this approach is consistent with and comparable to previous analyses.

The infiltration of precipitation, runoff and return flows into the subsurface is primarily controlled by soil properties and land use. We will map soil properties from local soil surveys to assess the runoff/infiltration partitioning of precipitation. We will review existing local land use and crop type maps and update them, as necessary. We will assess the magnitude and transport of surface runoff during high rainfall events. Consideration of recharge and evaporative losses of runoff to ephemeral lakes and ponded areas will be included. The analysis will also include secondary recharge of this water from return flows, wastewater disposal, conveyance seepage, runoff, and other mechanisms.

A soil moisture budget approach similar to that used for the C2VSimFG-Kern model will be used to assess the deep percolation below the root zone. The soil moisture budget will be updated to better assess the volume of applied water taken up by evapotranspiration and the remaining volume available for deep percolation below the root zone. The root zone properties from the model will be reviewed and updated as necessary to better reflect local conditions.

The use of satellite remote sensing data of evapotranspiration (ET) data has become a vital link in determining the agricultural water demand as part of the methodology to determine agricultural

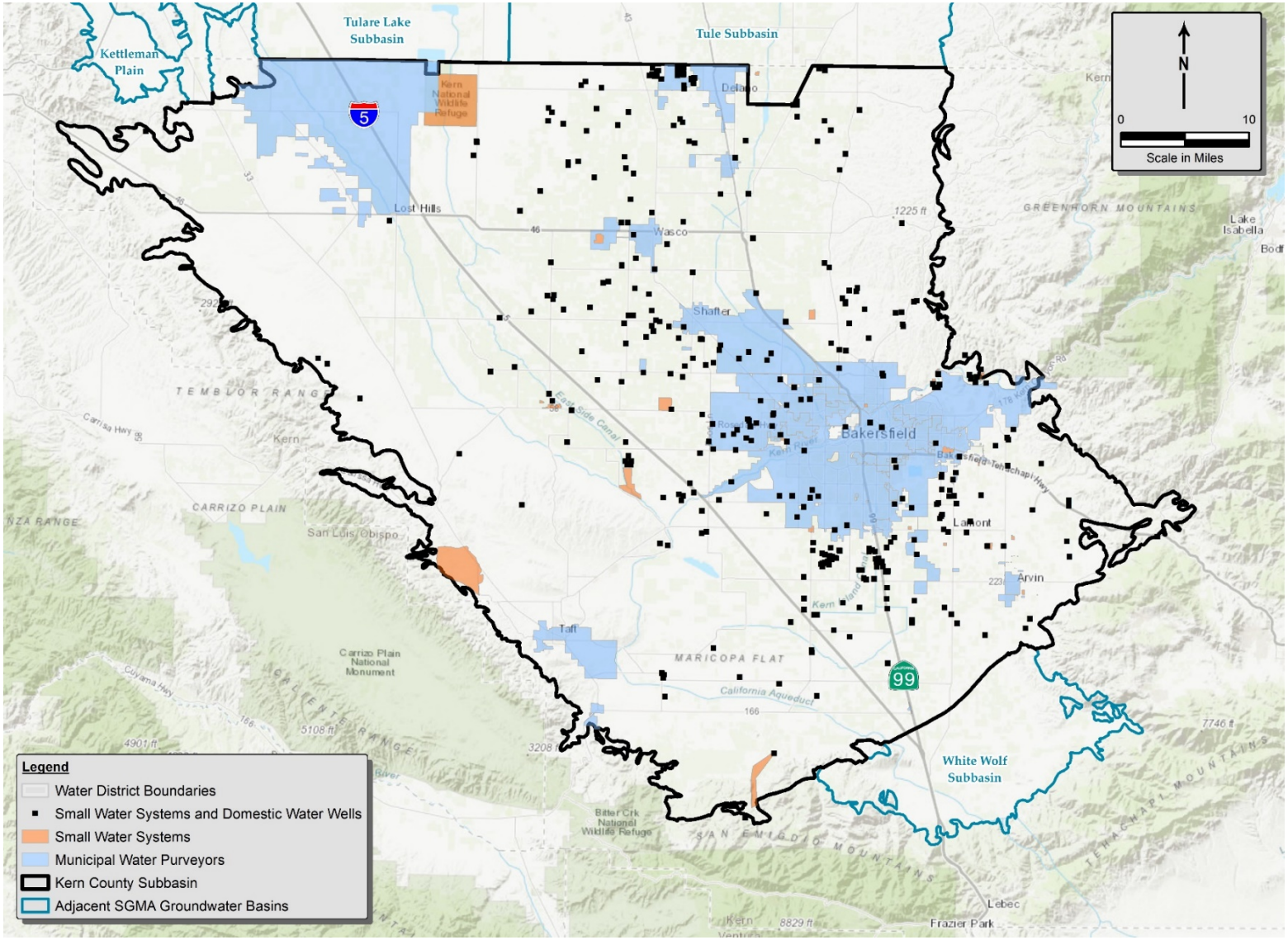


Figure 7: The Basin Study will further evaluate small water systems and domestic wells to help policymakers access clean, safe, accessible and affordable drinking water is available for all residents including underrepresented DAC and SDAC areas.

groundwater pumping (**Figure 5**). For the 2020 GSPs and recent Annual Reports, satellite remote sensing ET data from 1993 through 2020 were obtained from the Irrigation Training & Research Center (ITRC) based at California Polytechnic State University, San Luis Obispo. Currently, there are several options for satellite remote sensing ET data. Several local water districts have contracted with LandIQ for specialized, field-scale ET evaluations based on satellite data, local weather station data and field ground truthing. A new online service, OpenET, is now available that provides monthly ET mapping data from their website. In addition, DWR has the California Irrigation Management Information System (CIMIS) program that provides a network of automated weather stations in California that collect precipitation, ET and other weather data. The Subbasin GSAs are currently evaluating these options with respect to both providing a consistent basinwide methodology for water budgets and addressing local water management needs.

For the Basin Study, our approach is to evaluate the various sources of ET data and correlate them to local areas of measured agricultural water demand. We will coordinate our analysis with the work on this issue being done by the various agencies, GSAs and water districts. The Basin Study includes budget for local subconsultants that specialize in ET data analysis to provide further evaluate the ET data sets and provide an assessment on how better to utilize ET data for determining water demand.

Native Yield Study

During the process of working through the water budget allocations for the entire Kern County Subbasin with the GSAs, the native yield was one of the most critical supply sources to be coordinated. Because of this, we recognize that the development of the native yield is an important yet sensitive topic. Therefore, a major goal of the Basin Study is to provide the necessary technical data to the local water managers, policy makers and stakeholders that they need as they consider the policy, water rights and other legal issues necessary to define the components of basinwide groundwater resources used to determine the available native yield.

The Basin Study provides a technical study to address data gaps and update the overall Subbasin groundwater budget through a systematic analysis of the available data. We understand that the definition of the native yield will be developed by the Kern County Subbasin GSAs and local stakeholders. Incorporated in this study are multiple meetings to provide opportunity to review the technical work during the course of the study to help policymakers in developing a consensus of the components of the natural groundwater recharge for future deliberations to determine the allocation of groundwater resources.

Kern County Subbasin Focused Model

For the Subbasin GSPs, DWR's C2VSimFG-Beta model was modified with locally-derived historical data to better represent local water conditions for the 2020 Subbasin GSPs (**Figure 8**). To improve the model for the 2020 GSPs, historical surface water diversions, water bank recharge and water bank withdrawal information was collected from local GSAs, management areas, water agencies and purveyors and was incorporated into the C2VSimFG-Kern model. Urban land use was restricted to developed areas, and urban populations and per-capita water demands were updated. Model structural changes related to the HCM (elements, streams, stratigraphy, etc.) were not modified although some model parameters were adjusted to improve model performance in specific geographic areas. Due to time limitations associated with the January 2020 GSP submittal date, additional model calibration was not performed but was listed as a data gap to be included in future work.

As recommended in Appendices 2 and 4 of the Coordination Agreement, a separate local groundwater model specific to the Kern County Subbasin is proposed (**Figure 8**). As indicated in recent discussions, DWR has decided not to fully incorporate all of our current C2VSimFG-Kern revisions into their next

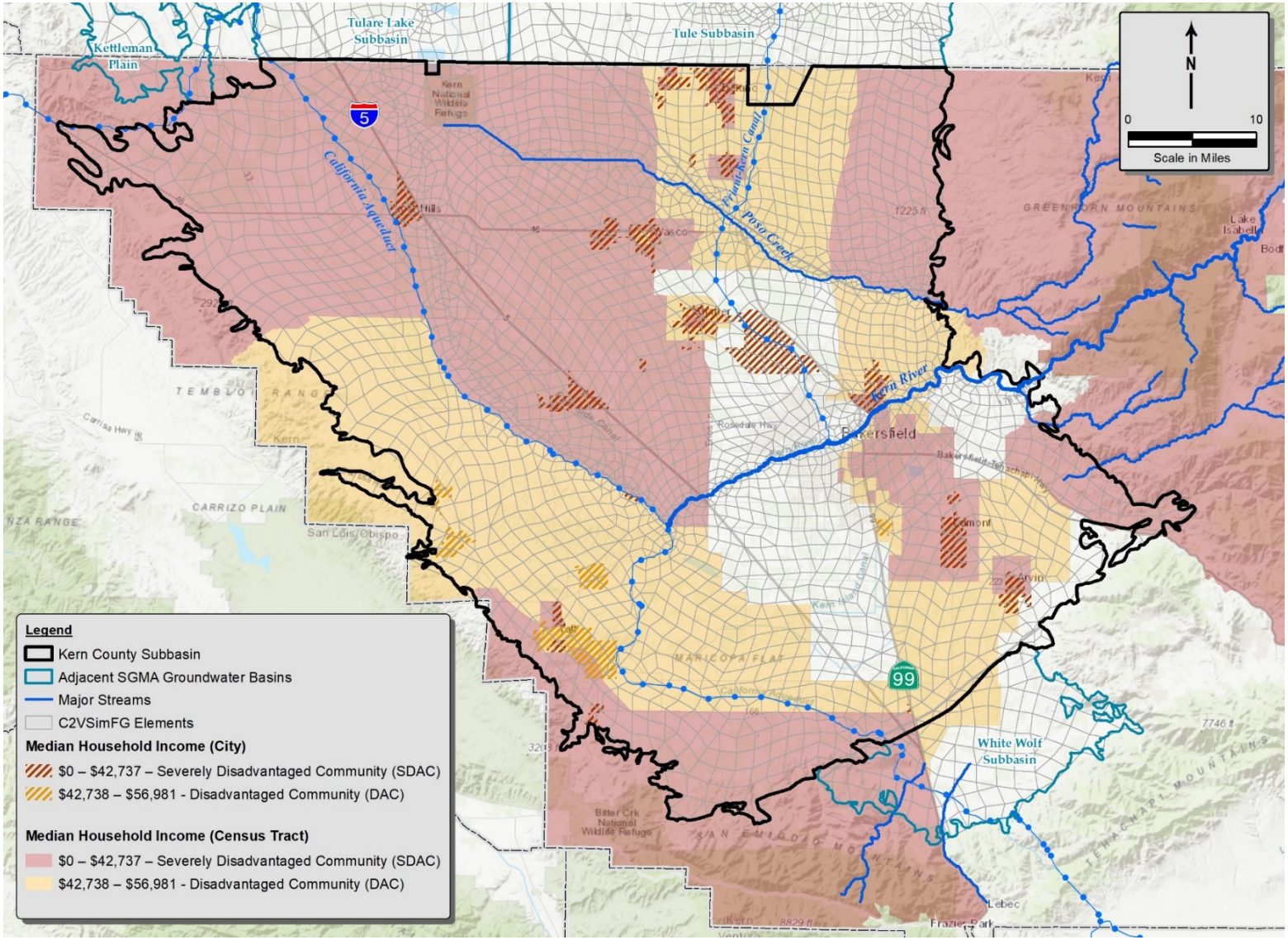


Figure 8: The Basin Study will develop and recalibrate Subbasin-focused model to improve simulation of groundwater conditions. One objective is to more fully represent DAC/SDAC area by using the same tools as used for the larger agricultural and urban water districts.

model update. Rather, DWR is maintaining a higher-level regional approach to their simulations that will either not include the Kern County local revisions or will upscale them to their broader sub-regional approach. It is not in the best interest of the Subbasin GSAs to continually have to catch up with regional updates to the DWR model that are not relevant to Kern County. A Subbasin focused model can be developed while still maintaining consistency with ongoing DWR modeling efforts.

This approach sets the stage for improving the current C2VSimFG-Kern model to better support the needs of the Subbasin GSAs. A key objective of the Basin Study is to better determine water budgets and to better incorporate small water systems for DAC and SDAC communities in the basinwide model (**Figure 8**). In addition, running a full Central Valley simulation model limits access to features of the IWFM model code that would be better suited to Kern County, imposes longer model run times, and produces overly large file sizes that are more difficult to update. A Subbasin focused model (IWFM-Kern) allows for structural changes to the model – such as re-gridding to better represent local features and jurisdictions – that will provide an improved modeling framework for simulating local conditions and providing water budgets for the Subbasin GSAs.

During the model update, two versions of the model will be maintained. While the upgraded Subbasin model (IWFM-Kern) is being developed and recalibrated as outlined in this proposal, the current (2020 GSP version) of the model (C2VsimFG-Kern) will continue to be used to provide consistent water budget and change in storage results for Annual Reports. Ongoing annual updates to surface water supplies and water demand will be utilized for both models as part of the Basin Study. After the IWFM-Kern model is calibrated and accepted by the Subbasin GSAs, the IWFM-Kern results will be used to support future SGMA reporting to present revised water budgets, change in storage and sustainable yields.

Coordination with Adjacent Groundwater Basins

GSP regulations also require an evaluation of whether a GSP in one subbasin has the potential to adversely affect the ability of an adjacent subbasin to achieve its sustainability goals. The Subbasin GSAs need a means to verify conditions across boundaries with adjacent subbasins to understand potential adverse impacts on either subbasin across the shared boundary.

IWFM-Kern will require definition of a northern boundary condition to simulate groundwater flow. The northern boundary condition would be placed several miles north of the Subbasin boundary to allow for an appropriate simulation of groundwater flow near and across the boundary (**Figure 8**). Significant uncertainty currently exists regarding the rates and timing of groundwater flows across the northern Kern County Subbasin boundary with the Tulare Lake and Tule Subbasins. Because both of the northern adjacent basins use groundwater models to forecast their projected-future groundwater conditions, the Project Team would coordinate the exchange of data among the different models to provide the best first evaluation of potential adverse effects. Therefore, implementing these model improvements will provide a more robust simulation of groundwater flow across the northern Subbasin boundary.

Similarly, IWFM-Kern will also require definition of a southern boundary condition to simulate groundwater exchange across the Kern County and the White Wolf Subbasin boundary (**Figure 8**) that is defined by the White Wolf Fault. Definition of an appropriate boundary condition will require coordination with the White Wolf GSA for an exchange of information. Because the Kern County and White Wolf GSAs now maintain independent models for their respective basins, no updates are planned for the White Wolf Subbasin through the Basin Study as was done during the C2VSimFG-Kern development for the 2020 Subbasin GSPs.

Model Recalibration

The upgraded Subbasin model (IWFM-Kern) is a regional planning model designed to support SGMA compliance through a consistent basin-wide approach for evaluating groundwater and surface water conditions for the Subbasin (**Figure 8**). IWFM-Kern is not intended to supersede any local model but rather to represent local model data in assessing the basin-wide conditions. .

Our approach focuses on sequencing of work in a stepwise, systematic manner. As part of this approach, the IWFM model would be functional after the completion of each task. We have included—as a quality assurance process—a step to run a model simulation following each subtask to verify the model results at the calibration targets and ensure that model input parameters are performing as expected. This process will identify potential model setup issues during each subtask so that they can be appropriately addressed as the work proceeds. Therefore, at the end of this process, we can proceed directly to the final calibration task, avoiding potential schedule delays.

The model upgrade includes incorporating data from available local models as a method to maintain consistency of modeling approaches in the Subbasin. Local models will, however, contain local scale data pertinent to local conditions and the specific purpose of that model. As a regional planning model, data from local models would be "scaled-up" to provide input to IWFM-Kern at the appropriate Subbasin-scale.

During the calibration process, aquifer properties and boundary conditions will be varied within an acceptable range until the closest fit of the simulated versus measured groundwater elevation data is achieved. Because there are multiple combinations of aquifer properties and boundary conditions that can be used to match a single set of groundwater elevation data, it is important to calibrate the model over a long historical period that contains varying hydrologic conditions. This will demonstrate that the model has the capability of simulating historical changes in groundwater elevations and surface water flows in the Basin. Localized areas can be further calibrated by evaluating short term conditions related to multi-day aquifer pumping tests.

The IWFM-Kern model calibration will be performed using data received from the GSPs, generated during this Basin Study, or from other appropriate sources. Following the recalibration, the historical and projected future baseline scenarios will be rerun. This will also serve as a validation step to check the recalibrated model results.

GSP Implementation and MT/MO Simulations

A key objective of the model recalibration is to improve the simulation of groundwater elevations relative minimum thresholds and measurable objectives (MT/MO) across the Subbasin to provide improved support to long-term GSP implementation planning (**Figures 2 and 8**). The emphasis is to better represent local groundwater elevations in the four principal aquifers and provide higher accuracy in simulating changes in groundwater elevations over time. The calibrated IWFM-Kern model will produce an updated historical water budget and change in groundwater in storage estimates for the Subbasin in preparation of the 2025 GSP updates.

To support ongoing GSP implementation, updated projected future water budgets will be run for Baseline and Climate Change scenarios over the 50-year planning and implementation horizon. These scenarios provide a basis of comparison for evaluating proposed sustainability management actions and projects over the SGMA planning and implementation horizon.

Subsidence

SGMA requires that GSAs assess subsidence within basins and set MT/MOs to avoid significant impacts from this undesirable result. To support that, DWR has expanded the capability of simulating land subsidence with their latest version of the regional C2VSimFG model. For the 2020 GSPs, land subsidence was not included in the Subbasin modeling because the simulation results were questionable. However, DWR has improved simulation methods for simulating the effects of land subsidence on groundwater levels and storage.

We envision that the development of the capability to simulate subsidence will be a long-term process that will extend beyond the Basin Study. For the Basin Study, the objective is to incorporate the subsidence modeling capability in the current DWR model and evaluate how effective the current DWR data sets are in simulating subsidence. The Basin Study assessment will be coordinated with other currently ongoing work by the Subbasin GSAs to evaluate historical subsidence, increase subsidence monitoring and improve the conceptual understanding of the hydrogeological factors that control the rate of subsidence. We will also coordinate our model evaluation with the DWR modeling team in order to improve the future capability to simulate subsidence through collaboration.

The model computes aquitard compaction due to specified changes in groundwater levels within an adjacent aquifer. During the sediment compaction associated with subsidence, the water in sediment pore spaces is forced out of clay layers as the sediments are forced into a tighter configuration. The volume of compaction is equal to the volume of groundwater expelled from the clay layers. This is a one-time release of groundwater from storage, but it can represent a substantial volume of water. However, once the water is expelled and the structure rearranged, the compaction represents a permanent loss of water storage volume in the clay layers. The volumetric compaction of the clay layers in the subsurface is transmitted to the land surface where it is manifested as land subsidence. The simulation of land subsidence evaluates the change in the storage capacity of the clay layers and tracks the release of groundwater in storage from the clay layers. The land surface deformation is calculated as the volume reduction in the clay layer distributed over the affected area.

For the model upgrade, the land subsidence data and model parameters from DWR and USGS will be reviewed in context of the HCM review (**Figure 4**). The Subbasin GSAs are working on differentiating land subsidence caused by oil field operations from subsidence related to groundwater pumping. A validation process will be applied to the IWFM-Kern model, which will involve comparison of the overall distribution and magnitude of simulated land surface deformation with recent Kern County subsidence data. Adjustments may be made as necessary to achieve reasonable simulation results with respect to location and magnitude of recent subsidence.

In addition, the Subbasin GSAs are developing a long-term subsidence monitoring system along with continued assessment of the Interferometric Synthetic-Aperture Radar (InSAR) data. The results from this monitoring will continue to be evaluated. As noted in the KGA GSP, additional monitoring is necessary to address data gaps that prevent reliable tracking and assessment of the causes of subsidence in specific areas of interest within the Kern Subbasin. Concurrently with the Basin Study, the Subbasin GSAs are planning to install extensometers along critical infrastructure, focusing initially on the California Aqueduct and Friant-Kern Canal. Incorporating the subsidence capability into the model now will aid in future subsidence assessments after the Basin Study as this new monitoring data become available.

Due to the overall importance of land subsidence to the SGMA process, an objective for the Basin Study is to incorporate a capability to simulate subsidence at a level comparable to that used by DWR in their C2VSimFG simulations. Therefore, the IWFM-Kern model simulations will focus primarily on the effect of

compaction on determination of the water budgets. Additional subsidence monitoring and data evaluation are being planned; therefore, it is premature to conclude that the Subbasin Model will have the full capacity to simulate the land deformation aspects of subsidence. However, the long term objective is to coordinate the modeling efforts with the future Subbasin subsidence monitoring and data evaluations to improve the capability of the model to simulate effects of land deformation over time.

Deliverables

For each of the primary technical tasks, a technical memo and data package will be developed to provide local water managers, policy makers and stakeholders with preliminary results for review and comment. Final technical memoranda will address comments and be included as attachments to the final technical report to provide detailed documentation of data, methodology and results.

The Final Technical Report will include a discussion of the Basin Study results in more general terms for an intended audience that includes local policymakers, stakeholders, and other interested parties. The technical documentation will be included in the technical memoranda attachments. By structuring the final report to address both a general audience and a technical audience, our goal is to provide clear, defensible documentation for the wide range of parties interested in the Basin Study.

The results of the Basin Study will include a series of GIS maps and geodatabases to support the Subbasin GSAs and policymakers on future SGMA planning and implementation work. The GIS data will provide a framework to evaluate both local and basinwide conditions within the Subbasin.

PROPOSED SCOPE OF SERVICES

The scope-of-services involve eight tasks in a stepwise process for accomplishing the Basin Study:

Task 1: Data Compilation and GIS Mapping
Task 2: Hydrological Evaluation
Task 3: Hydrogeological Evaluation
Task 4: Water Budget Methodology Upgrades
Task 5: IWFM-Kern Model Upgrades
Task 6: IWFM-Kern Calibration
Task 7: Technical Report
Task 8: Project Coordination and Meetings

Each task is described in detail below.

Task 1: Data Compilation and GIS Mapping

Task 1 involves gathering data necessary for the water budgets, incorporating the data into a GIS format, and performing an initial assessment of the data. This initial work will center around the basic climatic, hydrologic and physical data for the Subbasin. The assessment of precipitation is the initial step, which provides the foundation to assess groundwater recharge. Second, data sets will be compiled on the physical properties of the basin and surrounding watersheds that control the runoff-infiltration portioning of the rainfall. Finally, relevant GSP references from previous studies will be compiled that serve as a source of data and/or assessment of hydrologic processes in Subbasin. Several subtasks for Task 1 are outlined below:

- **Subtask 1.1 - Historical Precipitation Data**: Todd Groundwater will compile regional precipitation data from the PRISM Climate Group at Oregon State University. PRISM provides both daily and monthly rainfall data for Kern County. The PRISM data will be verified by comparison with available local precipitation measurements. Data will be mapped using GIS to evaluate regional precipitation patterns. Monthly and annual precipitation totals will be calculated. Periods of high-intensity rainfall will be evaluated on a daily scale to assist in evaluating runoff during high rainfall events.
- **Subtask 1.2 - Basin and Surrounding Watershed Hydrology Data**: Data on the physical properties of the surrounding watersheds will be compiled and mapped using GIS. We will compile relevant previous studies from state and federal agencies on the regional hydrology of the Subbasin. We will also request available hydrologic studies from local agencies. A bibliography of relevant studies will be developed.
- **Subtask 1.3 – GIS Mapping of Subbasin Data:** Data on physical properties within the Subbasin will be compiled and mapped using GIS. These address land use, vegetation types, geology, soil properties, ET, slope, 2020 census data and other relevant information. Todd Groundwater already has much of the data; we will review and update data, as necessary.
- **Subtask 1.4 – Small Water Systems and Private Wells Data**: To support GSP development, considerable work was performed to document small water systems and other private wells for industrial or domestic use, many of these are in DAC and SDAC areas. Data from the Subbasin GSAs will be compiled to better represent the local pumping depths in the model update.

- **Subtask 1.5 – Subbasin GSA Data Coordination**: The Project Team will coordinate with each of the GSAs, water districts and local agencies to collect relevant data and reports (e.g., HCM information) to incorporate into the Basin Study. This coordination will consist of a numerous online meetings, phone calls and site visits with individual agencies. The goal will be to compile and synthesize as complete a set of local data as possible. In addition, these meetings will provide a forum to better understand local conditions, listen to concerns and generate ideas to improve the Basin Study.
- **Subtask 1.6 – Compile New Regional Data and Reports**: New regional data sets, reports and geodatabases (e.g., DWR's AEM surveys, the USGS's BCM 8 update for California, and the OpenET data) will be compiled and reviewed. We will download and organize available online data, reports and GIS geodatabases. The goal is to compile and synthesize the key regional data sets that are relevant to the Basin Study. In addition, we will contact local, state and federal agencies (e.g. DWR, USGS, USBR and Kern County Public Works) to establish a working relationship to utilize their knowledge and experience to improve the Basin Study.
- **Subtask 1.7 - Task 1 Technical Memorandum (TM) / Data Package**: The data sources, methodology and analysis will be documented in a technical memorandum (TM), along with a data package of climate and hydrological data in GIS format. A draft TM will be issued for review and comment by Subbasin GSAs. The final TM will be addressed in Task 7 for the final report.

The results of this compilation will be summarized using tables and GIS maps that transfer the data into a consistent format to illustrate a range of conditions and identify potential data gaps. An assessment of these data will be performed to determine the overall strengths and weaknesses of the different data sets. The schedule includes time for presentation and review of this information by local water managers, policy makers and stakeholders under Task 8.

Task 2: Hydrological Evaluation

Task 2 includes additional work on the local hydrology. A primary focus of the hydrological evaluation is to determine the runoff-infiltration portioning of rainfall for different areas of the Subbasin and surrounding watersheds. These areas have little to no measured flow data, so a methodology is needed to better understand the volume of runoff and the partitioning to its ultimate destination. This will focus first on the surface conditions during rainfall, including a drainage assessment to evaluate transport of surface runoff. Task 2 also includes compilation of gauge data and channel characteristics for stream and major conveyance canals in preparation for developing a more robust simulation method of simulating surface water and diversions in the model. This hydrological analysis help identify and quantify the use of flood water from these ungauged streams for groundwater recharge to supports GSP Implementation.

A soil moisture budget approach, similar to that incorporated into the C2VSimFG-Kern model, will be used to assess the volume of the recharge taken up by evapotranspiration and the remaining volume available for deep percolation below the root zone. The root zone properties from the model will be reviewed and updated as necessary to better reflect local conditions. Initial work on the influence of geology will be developed with emphasis on the complex geology along the Subbasin margins, oil field aquifer exemptions, and distribution of key confining layers such as the E-clay.

The approach is to conduct these evaluations for local areas with higher quality data to work out the details of applying the methodology and distributing parameters over areas of differing hydrologic characteristics. We have added time to each subtask for coordination with local agencies and

stakeholders to review our methodology to estimate groundwater recharge based on local data and water management practices. We have included budget for subconsultants (i.e., Aquilogic) to provide their expertise in addressing specific issues such as watershed hydrology and HCM issues along the western Subbasin margins. In addition, we have added time for collaboration with DWR, USGS California Water Science Center and local universities on our technical approach to each subtask.

Once the methodology and parameters are defined, then the evaluation will be scaled up to a basinwide evaluation. By focusing on these local areas first, we can improve the efficiency in completing the hydrological evaluations. Several subtasks are outlined below that provide details and sequencing of this work:

- **Subtask 2.1 - Watershed Hydrological Assessment**: The hydrology of the surrounding watersheds is distinctly different from those within the Subbasin. The goal of this subtask is to characterize the upstream watershed areas to determine the volume of runoff, baseflow and subsurface inflow emanating from these areas into the Subbasin. The hydrology assessment will also examine the route of surface water runoff as it flows through the Subbasin, including the ultimate destination of high flows. We will also consider the potential for subsurface inflows from these watersheds based on available information. This subtask will better quantify flood flows from ungauged streams to identify areas for the potential groundwater recharge.
- **Subtask 2.2 - Basin Hydrological Assessment**: The hydrology assessment will primarily follow the soil moisture budget approach used in the C2VSimFG-Kern model to ensure consistency of methods. We have many of the required parameters in the model already. However, the mapping of the climate, hydrologic, physical, and other properties throughout the Subbasin will be reviewed and updated, as necessary. This subtask will provide data to help identify areas for the potential groundwater recharge from flood flows.
- **Subtask 2.3 - Stream and Conveyance Hydrological Assessment:** Streamflow and diversion data from local hydrographic reports, water district data and other sources will be compiled and organized for the groundwater recharge assessment. We will develop a process to track the distribution of streamflow within the Subbasin separately from water imported from outside of the basin. A process also will be developed to track use of diverted streamflow for agricultural irrigation, municipal water supply, groundwater banking, lake level management and other uses.
- **Subtask 2.4 - Task 2 Technical Memorandum (TM) / Data Package**: The methodology and analysis will be documented in a technical memorandum (TM), along with a data package, which will summarize the Subbasin and watershed hydrological assessments. A draft TM will be issued for review and comment by Subbasin GSAs. Comments will be addressed in the final TM and incorporated into the final report as described in Task 7.

The results of this compilation will be summarized using tables and GIS maps that put the hydrological and water budget components into a consistent format to illustrate the potential range of conditions and identify potential data gaps. An assessment of these data will be performed to determine the overall strengths and weaknesses of the different data sources. The schedule includes time for presentation and for review of this information by local water managers, policy makers and stakeholders under Task 8.

Task 3: Hydrogeological Evaluation

As described in the Approach section above, several modifications were made to the HCM during the C2VSimFG-Kern development. Task 3 includes a review of the HCM presented in the GSPs to better

represent basinwide geologic and hydrogeologic conditions in the model. We will conduct a rigorous and systematic model update that will make the HCM more consistent with the Subbasin GSPs and supporting references to the extent reasonable and with consensus among Subbasin GSAs. Additional data that have become available, including geophysical investigations such as the results of the DWR-sponsored Airborne Electromagnetic (AEM) surveys data, will be reviewed and incorporated as appropriate. Several subtasks are outlined below that provide details and sequencing of this work:

- **Subtask 3.1 -Subbasin HCM Review:** This subtask will involve compiling the HCM updates from the GSPs and supporting references. This subtask will focus on defining the relevant character of the physical geological structure of aquifer layers including hydrogeologically significant clay layers, geologic structure and faults. These will be mapped and reviewed for consistency. We will work in coordination with the GSAs to identify questions regarding the interpretations; issues with interpretation will be presented to the appropriate GSAs and local agencies for reconciliation.
- **Subtask 3.2 - Geologic Features that Affect Groundwater Flow:** This subtask involves identification of the locations and characteristics of natural features that affect groundwater recharge and movement (e.g. faults, folds, bedrock ridges, stratigraphy, and clay layers). This includes representation of exempt aquifers that may affect definition of the accepted horizontal and vertical bounds of the Subbasin as presented in the 2020 GSPs. This subtask includes interpretation of geophysical investigations including AEM surveys, seismic surveys and borehole geophysical logs.
- **Subtask 3.3 - Update Principal Aquifer Maps:** Model layer elevations will be developed to better align with the geometry from detailed geologic and HCM information in the Subbasin GSPs, other technical studies and local groundwater models. The four Principal Aquifers identified in the Subbasin will be differentiated based on definitions from local management area GSPs and supporting data. This subtask will include review of groundwater elevation maps for each of the four Principal Aquifers for consistency with the HCM and modifications as necessary. Updated maps will be used in model calibration.
- **Subtask 3.4- Assessment of Geology on Recharge:** This subtask will identify the key geological features that may affect groundwater recharge. These include the geology of the unsaturated zone and principal aquifers. Maps will be compiled of the four principal aquifers, local clay layers that form local perching horizons, and aquifer exemption areas for oilfield activities. This will incorporate the use of geophysical investigations for helping identify areas of groundwater recharge.
- **Subtask 3.5 – Subsidence Data Review:** This subtasks involves review of available data from the Subbasin GSPs, and their supporting references, on the location and timing of land subsidence in the Subbasin. We will compile and review available data from DWR, USGS and other appropriate sources for parameters for simulating subsidence include the composite thickness and mechanical properties of compressible layers. We will coordinate with Subbasin GSAs on their ongoing subsidence monitoring and investigations to differentiate subsidence associated with groundwater pumping from oil field operations or other causes.
- **Subtask 3.6 - Task 3 Technical Memorandum (TM) / Data Package**: The methodology and analysis will be documented in a technical memorandum (TM), along with a data package, which will summarize the Subbasin and watershed hydrogeological assessments. A draft TM will be issued for review and comment by Subbasin GSAs. Comments will be addressed in the final TM and incorporated into the final report as described in Task 7.

It is assumed that information on the key local conditions will be provided by GSAs and MAs. The Project Team will compile the HCM data and work to link these together. If information and maps are inconsistent across the Subbasin, specific issues will be identified for reconciliation by the appropriate GSAs and MAs.

Task 4: Water Budget Methodology Updates

Task 4 consists of an assessment of the volume and distribution of primary water budget components within the Subbasin. The methodology used for calculating the basinwide water budget components will be reviewed based on the data and methodologies developed in the preceding tasks. For the water budget update, the distribution of groundwater recharge will be evaluated with respect to the four principal aquifers. Potential losses of recharge to perched groundwater systems or exempt aquifers will be considered. Based on this assessment, an evaluation of the key water budget components will be developed. Subtasks for Task 4 are outlined below:

- **Subtask 4.1 – Municipal, Industrial and Private Water Use Updates:** This subtask will update and resolve remaining issues with municipal, industrial and other private water users. Emphasis will be on collecting information to support model updates that distribute urban and other groundwater pumping more accurately. Additional emphasis will be placed on characterizing water supply for DAC/SDAC communities to develop improved capacity to identify these areas for future water budgets.
- S**ubtask 4.2 - Surface Water Supply and Use Updates:** We will coordinate data on streamflow and surface water imports from local hydrographic reports, water district data and other sources. To verify proper accounting of water supplies, we will compare these data to systemwide documentation of water deliveries by the State Water Project and Federal Water Project plus the Kern River diversions by DWR, US Bureau of Reclamation (USBR), Kern County Water Agency and the Kern River watermaster. We will tabulate water uses of diverted surface water for agricultural irrigation, municipal water supply, groundwater banking, overdraft correction, lake level management and other uses. The analysis will address secondary recharge of this water from return flows, wastewater disposal, conveyance seepage, runoff and other mechanisms. We will review water conveyance data to assess seepage rates for the purpose of computing the groundwater recharge and improving representation in the model. We will update managed aquifer recharge and groundwater banking information.
- **Subtask 4.3 – Calculated Groundwater Demand Updates**: This task will involve remapping ET with updated land use information in order to develop an improved methodology to distribute agricultural pumping based on local ET rates and crop types. We will revise the methodology for determining urban outdoor and undeveloped area water demand based on distribution of ET rates and land use types. It is anticipated that the assessment will employ the IWFM Demand Calculator (IDC) tool, which is a standalone module of the C2VSimFG-Kern model. The IDC tool tracks return flows through the soil zone from precipitation and applied water separately to allow for a determination of return flows.
- **Subtask 4.4 – Water Supply and Demand Review:** This task will involve review water supply and demand updates for consistency and accuracy and make revisions as necessary to develop final water supply and demand results for the basin. We will incorporate results into the GIS based mapping system.
- **Subtask 4.5 – Basinwide Groundwater Recharge Evaluation**: Using the results from Subtask 3.2, we will further assess the volume and distribution of groundwater recharge with

respect to the underlying aquifers, with a focus on each of the four principal aquifers. Recharge to perched groundwater systems or oil-field aquifer exemptions will be assessed as to whether any of that recharge migrates into a principal aquifer within the timescale relevant to GSP Planning. Based on this assessment, we will develop a preliminary estimate or range of estimates for potential Subbasin groundwater recharge from the different processes.

- **Subtask 4.6 - Task 4 Technical Memorandum (TM) / Data Package**: The methodology and analysis will be documented in a technical memo, along with a data package summarizing the groundwater recharge evaluation. A draft TM will be issued for review and comment by Subbasin GSAs. The final TM will be addressed in Task 7 for the final report.

The results of this compilation will be summarized using tables and GIS maps that put the distribution of the water budget into a consistent format to illustrate the potential range of conditions and identify potential data gaps. An assessment of these data will be performed to determine the overall strengths and weaknesses of the different data sets.

Task 5: IWFM-Kern Model Upgrades

Developing a Kern County-focused model requires determining how to represent the areas outside of Kern County in future simulations with the focus on the northern Subbasin boundary and how far beyond the boundary to extend the model. The key objectives of this task include the following:

- Coordinate with adjacent subbasins to better quantify boundary flow simulations based on shared data.
- Develop a stand-alone Kern County Subbasin model to provide a more efficient platform focused on Kern County conditions and data.

The C2VSimFG-Kern finite element grid developed by DWR is not well optimized for evaluating conditions in Kern County and may be a limiting factor in implementing the planned model upgrades. The approach for modifying the C2VSimFG-Kern finite element grid is to prioritize the key hydrologic features and water management boundaries that should be considered. Anticipated tasks to be included in the prioritization are:

- Align grid with surface water features such as rivers, major creeks and major canals.
- Align grid with water management boundaries, urban areas and major riparian or groundwater dependent ecosystem locations.
- Prioritize element density to be highest in high stress locations such as wellfield and banking areas.
- Define a maximum element size for irrigated agricultural areas.
- Apply larger elements over undeveloped areas.
- Consider grid alignment for simulation of the four principal aquifers.
- Identify and address problematic areas such as exempt aquifers, etc.

During the C2VSimFG-Kern modeling for the 2020 GSPs, several agencies noted inconsistencies in the application or results of the managed water supply and demand. These were noted as limitations in the 2020 C2VSimFG-Kern Model Report that would be addressed in future model updates. The key objectives of this task include the following:

- Improve simulation of rivers to better represent streamflow of the Kern River and Poso Creek.

- More fully utilize the water management simulation features of IWFM to provide increased accuracy of water supply, distribution and demands.
- Remap the areal distribution of land uses including agricultural, urban, riparian and native.
- Update root zone and agricultural parameters to better simulate deep percolation and small watershed inflows.

The Project Team will prioritize the IWFM features for streams and the IDC functions that should be adjusted. It is anticipated that the focus will be on features with the most significant impact on the water budget.

Flows in the Kern River channel, including local stream-groundwater interactions, are not well replicated and surface water diversions are not dynamically simulated. Some rejected recharge occurs in the Kern Fan area in very wet years, with significant outflow of groundwater to the Kern River especially in the Kern Fan banking area (i.e., rejected recharge). One key issue is the DWR selection of stream simulation options; those options allowed streambed conductance to be varied as a function of stage but did not consider changes to the width, or wetted perimeter, of the stream. This approach works for northern California streams but is not sufficient for simulating the highly variable flows that occur on the Kern River and Poso Creek. These selected options apply to the entire C2VSim model and illustrate why it is important to develop a Kern Subbasin-only model. To address this, the stream simulation options will be changed to other more appropriate options that are also available in IWFM.

A number of modifications to the HCM and aquifer parameters were noted during the C2VSimFG-Kern development; therefore, updates to the HCM are necessary. Task 5 includes a more rigorous and systematic model update that builds on Task 3 and will revise the HCM and aquifer parameters in IWFM-Kern to be more consistent with the Subbasin GSPs. For the development and setup of the IWFM-Kern model, the following tasks are proposed:

- **Subtask 5.1 – Develop Kern County Subbasin Model Domain** - To develop the Kern County Subbasin focused version of the model, all of the elements north of the boundary condition would be removed from the model input files. This will require developing a new boundary condition some distance north of the Kern County Subbasin boundary. For this, an initial assessment of the measured and simulated groundwater levels will be made to simulate the transition of groundwater conditions with the neighboring subbasins. A key part of this scope of work is to coordinate with GSAs in neighboring Tulare Lake and Tule Subbasins to the north to obtain groundwater level data and simulation results to help in defining the northern boundary condition. Because both of the northern adjacent subbasins have groundwater models that forecast their projected-future groundwater conditions, the exchange of data will include results from the various models. It is anticipated that the GSAs in neighboring groundwater subbasins will request similar data sets from the Kern County Subbasin. The Project Team will work with the Subbasin GSA representatives on this coordination process.
- **Subtask 5.2 Refine Model Grid** - Once the prioritization of the finite element grid modification is decided, a modified grid will be developed. Finite grid generation software will be used to map the elements and nodes to the appropriate geographic locations based on the prioritization. Model input data will be remapped to the revised finite element grid. Modification of the finite element grid is a time-consuming process; therefore, it is assumed that the finite element grid will be finalized during subtask 5.2 and no further modifications of the grid will be conducted in later tasks of the model upgrade. The upgraded IWFM-Kern model will be assessed by comparing simulated groundwater levels with those from C2VSimFG-Kern for both the historical

and projected future simulations; this work includes post-processing of the scenario results to provide the necessary tables, graphs and maps to sufficiently validate the model modifications.

- **Subtask 5.3 - Redefine Model Hydrology –** The simulation of hydrologic features in the model will be modified based on the results of the hydrological evaluation in Task 2. The streams will be remapped and additional streams and major conveyance will be added to the model to better simulate water flow and diversions. As mentioned previously, the simulation method of streams and major conveyance in the model will be modified to take advantage of more appropriate streamflow simulation options than are available in IWFM. Input files for streams and major conveyance that are included in the model will be modified to define the streambed conductance as a function of stage and wetted perimeter of the stream. Small watershed input files will be updated based on information developed in the preceding tasks. Model input parameters for defining runoff and other hydrologic conditions will be reviewed and updated.
- **Subtask 5.4 - Compile and Review Model Aquifer Parameters:** Aquifer property information will be compiled from the 2020 GSPs, their supporting references and available groundwater models. These will be reviewed and tabulated to define the spatial distribution and variation of model aquifer parameters.
- **Subtask 5.5 - Update Urban Water Management Parameters:** The urban water supply and demand components of the model will be updated as part of the Task 5 model upgrades. The model will continue to use the UWMP style of demand estimation that had been used in the C2VSimFG-Kern simulations. Simulated urban areas will be redefined to better represent smaller cities, DAC/SDAC communities, small water systems, and industrial and domestic water users. Handling of recycled and wastewater will be reviewed and updated to better represent local conditions, as needed.
- **Subtask 5.6 - Update Root Zone Properties:** The IDC function in the model will also be updated. The data developed in the preceding tasks will be incorporated into the root zone modules. This will focus on the soil, root zone and agricultural parameters to better simulate deep percolation and small watershed inflows. We will incorporate the results of the ET data evaluation to better simulate agricultural water demand.
- **Subtask 5.7 – Update Hydrogeological Conceptual Model Parameters:** Based on the work from preceding tasks including Task 3, the model layer elevations will be modified to better align with the geometry from detailed geologic and HCMs in the Subbasin GSPs, other technical studies and local groundwater models. The four Principal Aquifers will be delineated in the model based on local management area GSPs and supporting data. Aquifer property information will be compiled from the 2020 GSPs and from available groundwater models and considered for incorporation. Parameters (from Subtask 5.4) will be reviewed to refine the spatial distribution and variation of aquifer parameters in the model. Locations and characteristics of natural features that affect groundwater recharge and movement (faults, ridges, clays) will be identified and considered for incorporation into the model. This includes representation of exempt aquifers that may affect the definition of the accepted horizontal and vertical bounds of the Subbasin as presented in the 2020 GSPs.
- **Subtask 5.8 – Update Managed Water Supply and Use Methods:** During the Basin Study, the ongoing updates of water supply and use data for model updates will be maintained and incorporated into the IWFM-Kern model. Annual surface water and groundwater supply and use summaries will be coordinated with Subbasin GSAs. Modifications to water management or

distribution input parameters will be incorporated based on data provided by the Subbasin GSAs as part of the Basin Study.

- **Subtask 5.9 – Add Subsidence Capability:** The subsidence simulation capability from DWR's latest version of C2VSimFG will be incorporated into IWFM-Kern including the subsidence-related parameters and data sets. In preparation for Task 6 subsidence validation, we will identify potential issues, areas of concern and the range of potential parameter values.

The results of these model upgrades will be summarized in the technical memorandum following the completion of Task 7. This TM will include a comprehensive summary of the data and methods used to setup the model to provide an appropriate level of documentation to support the model use for SGMA planning purposes. The schedule includes time for presentation and review of this information by local water managers, policy makers and stakeholders under Task 8.

Task 6: IWFM-Kern Model Calibration

During the calibration process, the aquifer properties and boundary conditions will be varied within an acceptable range until the closest fit of the simulated versus measured groundwater elevation data is achieved. Because there are multiple combinations of aquifer properties and boundary conditions that can be used to match a single set of groundwater elevation data, it is important to calibrate the model over a long historical period that contains varying hydrologic conditions. This will demonstrate that the model can simulate historical changes in groundwater elevations and surface water flows in the Basin. Localized areas can be further calibrated by evaluating short term conditions related to multi-day aquifer pumping tests.

The IWFM-Kern model calibration will be performed using data from the preceding tasks. Following the model calibration, the historical and projected future baseline scenarios will be rerun. This task serves as a validation step to check that the results can be reproduced using the upgraded model. This will be conducted concurrently with the water budget updates, so any issues found in the model calibration can be addressed.

- **Subtask 6.1 - Calibration of IWFM-Kern Model:** Model calibration will consist of history-matching of simulated versus measured groundwater elevation data. Calibration will be performed by comparing simulated versus measured groundwater elevation data. Long-term historical calibration will be conducted over the 1994 to 2024 simulation period that includes wet, dry, and normal years with varying degrees of pumping. Calibrating the model over a long period of variable hydrologic conditions constrains the calibration to reduce uncertainty. Assessment of calibration will be performed by using a series of metrics to evaluate the calibration results including a statistical analysis of simulated to measured groundwater levels, hydrograph trends, and groundwater gradients.
- **Task 6.2 - Generate Revised Historical Water Budgets:** We will use the IWFM Z-Budget feature to develop the Subbasin water budgets from IWFM-Kern. The water budgets will quantify the required elements required for SGMA including simulation results for subsurface inflows and outflows, managed aquifer recharge, irrigation pumping and return flows.
- **Task 6.3 – Sensitivity Analysis:** The model provides a platform to vary parameters used to assess the relative sensitivity of variations in the data on the model results. The model sensitivity analysis will be conducted to screen for the most sensitive parameters.
- **Task 6.4 – Update SGMA Projected-Future Scenarios:** The projected future baseline scenarios will be rerun using the updated IWFM-Kern model. Projected future water budgets for the

Subbasin will be developed to evaluate the performance of proposed management actions with respect to achieving groundwater sustainability. Based on these results, participating agencies will be asked to provide updated lists of projected future management actions to be implemented by WY2040. The updated model results will be compared to the 2020 GSP model results as a validation step in assessing calibration.

- **Subtask 6.5 –Subsidence Model Validation:** The IWFM-Kern model will go through a validation process to evaluate the simulation results relative to the Kern County subsidence data. Adjustments may be made as necessary to achieve reasonable consistency of the overall distribution and magnitude of land surface deformation with respect to subsidence data. The IWFM-Kern model scenario results will primarily focus on the effect of land subsidence on water budgets with a more qualitative assessment of the trend and magnitude of land deformation in a manner consistent with the practices used by DWR in utilizing their C2VSimFG model simulation results.
- **Task 6.6 – Task 5 & 6 Technical Memorandum (TM) / Data Package**: A technical report will be developed that documents the work performed for the model recalibration. The technical report will provide the technical basis for setting up the baseline, documenting the model results, and developing the projected water budgets. The modeling results and water budgets produced for the Technical Report will be consistent with DWR's SGMA guidelines and BMPs. It is anticipated that this report will provide sufficient compliance for all GSAs in the Subbasin for the GSP requirements of current and historical water budgets.

The results of Task 6 will produce an updated historical water budget and change in groundwater in storage estimates for the Subbasin in preparation of the 2025 GSP updates. Projected future water budgets will be run for Baseline conditions and Climate Change Conditions over the 50-year planning and implementation horizon. These scenarios provide a basis of comparison for evaluating proposed sustainability management actions and projects over the SGMA planning and implementation horizon. The emphasis is to better represent local groundwater conditions including groundwater levels in the four principal aquifers and provide higher accuracy in simulating changes in groundwater levels over time.

Final updates for the projected-future scenarios are not part of this scope of work and will be performed as part of the scope of work to support the 2025 GSP development. That is because the final projected future model updates will depend upon input from the Subbasin GSAs, including their updated lists of projected future management actions to be implemented by WY2040 based on the 2025 GSP updates. For the 2025 GSP Updates, the projected future water budgets for the Subbasin will be developed using the recalibrated model to evaluate the performance of proposed management actions with respect to achieving groundwater sustainability.

Task 7: Technical Report

A technical report will be developed that documents the work performed for this scope of work. The technical report will provide the technical basis for the data compilation, hydrologic evaluations, HCM updates and water budget methodology updates for the Subbasin and the surrounding watersheds. The Technical Report will provide a concise discussion of the water budget results in a more general manner for an intended audience that includes local policymakers, stakeholders, and other interested parties. The more detailed technical documentation will be provided by the subtask TMs that will be included as appendices to the Technical Report. Several subtasks for Task 7 are outlined below:

- **Subtask 7.1 - Finalize TMs as Technical Report Attachments**: The Task 1 through 6 technical memos will be finalized by addressing comments. The finalized TMs will be included as attachments to the final technical report to provide detailed documentation of data, methodology and results.
- **Subtask 7.2 - Draft Technical Report**: The draft Technical Report will focus on a discussion of the water budgets and model calibration results in a more user-friendly format for local decisionmakers. A summary of the data and analysis used for the Basin Study will be provided in the report with reference to the attached TMs.
- **Subtask 7.3 - Final Technical Report**: The draft technical report will be finalized by making revisions that address comments.
- **Subtask 7.4 – Final GIS Maps and Geodatabase**: This task involves compilation of a final set of GIS map files and a geodatabase that includes data generated by Basin Study. The GIS files will be incorporated into the Subbasin Data Management System (DMS) to make the information available to all Subbasin GSAs and to archive the data for future use.

For costing purposes, we assume that the draft technical report will require two draft versions. An Administrative Draft Technical Report will be prepared. Comments will be incorporated into a Draft Technical Report for stakeholder review and comments. The Final Technical Report will address final comments. Electronic submittal is assumed for each version.

Task 8: Project Coordination and Meetings

This task covers project coordination and meetings with the Subbasin GSAs, policymakers, local stakeholders and outside agencies throughout the project. A high level of interaction is included in this task to allow for transparency in performing the analysis, to receive feedback on the methods, and to engage in discussion of the issues involved with updating the water budgets and recalibrating the model. Several subtasks for Task 8 are outlined below:

- **Subtask 8.1 - GSA Coordination and Water Manager Meetings**: The Subbasin water managers have regular meetings to discuss water issues. We anticipate providing a series of update presentations on the progress of the Basin Study. Recognizing the water managers' experience, these meetings will also serve the role of a technical advisory committee to provide feedback and help improve the evaluations as they are underway. Regular updates are anticipated to be provided to all the Subbasin GSA every 2 to 3 months throughout the duration of the project in Bakersfield. Additional updates are planned to be conducted via online meetings.
- **Subtask 8.2 - Policy Team and Stakeholder Updates**: A series of presentations to the Kern County Subbasin Policy Team are included. In addition, we include time and budget for technical support for presentations to local stakeholders as part of the stakeholder outreach process by the GSAs. It is assumed that the content of these will be similar. It is further anticipated that these events will be coordinated to minimize travel expenses. Six updates are included in the budget.
- **Subtask 8.3 – Coordination with Outside Agencies and GSAs**: This subtask includes collaboration with DWR, USGS California Water Science Center, Kern County Public Works and local universities on our technical approach for each of the tasks. This subtask also includes coordination with GSAs from adjacent Groundwater Basins to better quantify boundary flow simulations based on shared data with GSAs in adjacent basins. Because the adjacent subbasins have separate groundwater models, this coordination includes the exchange of simulation

results from the various models. This subtask assumes that much of this coordination can be completed through a series of online meetings and phone calls.

- **Subtask 8.4 – Post-Basin Study Policy Team Coordination:** This subtask provides for technical support to the Subbasin Policy Team for several months after completion of the Basin Study. This is intended to include additional presentations, data requests, simulation results or other Basin Study information to support the Policy Team as they work through issues concerning the Subbasin sustainability, GSP implementation, native yield and allocation. It is understood that this is a long-term process by the Policy Team; therefore, the budget for this subtask is of limited scope and duration related to providing technical support as related to the Basin Study. This subtask will be conducted on a time and materials basis while budget is available. Other requests may be considered as an extra scope-of-work.
- **Subtask 8.5 – Project Coordination:** This subtask covers project coordination with the client throughout the project. Coordination will include project planning, on-going communications and project status updates. We assume that communication during the project will be conducted via emails, telephone and/or web meetings, if needed. Todd Groundwater will track schedule and budget monthly. Invoices will clearly show team members, hours, costs, and progress on project tasks. A monthly progress report will be prepared for each invoice showing progress made during the month, next steps for the following billing cycle, and status of both schedule and budget.

In addition to attendance and travel to each of the meetings, the Task 8 budget includes preparation time for development of PowerPoint presentations and other meeting materials for each of meeting. Preparation also allows time for review of technical work and preparation for anticipated questions. Included in the subtasks is an initial set of meetings anticipated to outline the general approach of the Basin Study with local water managers, policy makers and stakeholders. The objective is to introduce the Basin Study and get initial feedback on data, methodology and objectives. Subsequent meetings will be scheduled and facilitated through the Kern County GSP Planning Coordinator.

COST ESTIMATE AND SCHEDULE

The approach for the Basin Study is a comprehensive and detailed data analysis for the entire Subbasin. Our budget includes time for a detailed technical analysis building on a comprehensive data compilation and analysis to address questions and concerns about the HCM and water budget estimates from the 2020 GSPs.

A cost estimate summary to complete the proposed scope of work is provided below in **Table 1** with a more detailed cost estimate in **Table 2** (located following the text). As summarized on **Tables 1** and **2**, the proposed scope of work is estimated to total **$2,910,450**. Costs include labor, fees, subconsultants and expenses for each project task. Todd Groundwater will track schedule and budget monthly. Invoices will clearly document costs relative to the budget and progress on project tasks relative to the schedule. A monthly progress report will be prepared for each invoice showing progress made during the month, next steps for the following billing cycle, and status of both schedule and budget.

Included in the budget is a local cost-share of $164,865, which is about 7.5 percent of the shared cost by the Subbasin GSAs. The local cost share is shown as two items. The first local cost share item is preparation of the WY2021 Annual Report. The second local cost share item is $100,000 for additional independent technical studies to support the Basin Study.

TABLE 1 – Budget Summary to Complete the Basin Study

GRANT TASKS	ESTIMATED COST
Task 1: Data Compilation and GIS Mapping	$166,040
Task 2: Hydrological Evaluation	$364,050
Task 3: Hydrogeological Evaluation	$554,580
Task 4: Water Budget Methodology Upgrades	$513,040
Task 5: IWFM-Kern Model Upgrades	$422,340
Task 6: IWFM-Kern Calibration	$315,800
Task 7: Technical Report	$231,540
Task 8: Project Coordination and Meetings	$343,060
GRANT TOTAL	$2,910,450
LOCAL COST SHARE	**ESTIMATED COST**
Task 1: WY2021 Annual Report	$64,865
Task 2: Independent Technical Studies	$100,000
LOCAL COST SHARE TOTAL	$164,865

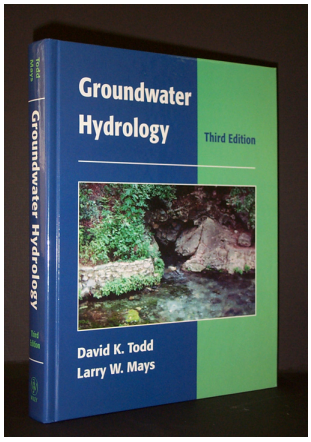
The Todd Groundwater Team can initiate the project within 30 days of the receipt of a notice-to-proceed. The total length of the project is anticipated to occur over about 44 months with most of the technical work being conducted over the first 24 months. The project duration also includes a period following the completion of the Basin Study for ongoing technical support and coordination with the Subbasin Policy Team. The schedule allows time for key management actions to evolve during the period so that additional data are available for the model upgrade. It is assumed that the work of the Project Team is focused on incorporating data for the Model Upgrade. It is assumed that the Project Team will rely on data provided by the local GSAs and MAs so that the Model Upgrade is consistent with the data and interpretations presented in the GSPs for their areas.

Table 3 presents the projected start date for the Basin Study. In order to meet the pending 2025 GSP Update submittal date with appropriate public review periods, an assumed start date of the technical work of April 2022 is necessary. If the actual start date is delayed after April 2022, it may be necessary to reprioritize the Basin Study tasks for focus on those that can be accomplished in order to meet the 2025 GSP Update timeline.

Todd Groundwater may utilize additional subconsultants or contract employees in order to meet the project schedule. In addition, we include budget for specific subconsultants as a part of the Project Team. We have included Hydrolytics LLC on the Project Team as a subconsultant who previously teamed with Todd Groundwater on the C2VSimFG-Kern development for the 2020 GSPs. Hydrolytics brings considerable experience with the IWFM model code and working with DWR. In addition, Aquilogic is included in the Project Team to help address specific issues such as watershed hydrology and HCM issues along the western Subbasin margin.

Furthermore, the Basin Study includes budget for additional local subconsultants with experience in the Subbasin to provide input on specific issues to address key areas of the Basin Study where they have local expertise. Todd Groundwater will coordinate with the GSP Plan Manager prior to incorporating additional subconsultants into the project. To initiate this process, a specific task must be nominated by either the GSP Plan Manager or Subbasin GSA as relevant to the completion of the Basin Study. To utilize the budget, a proposal for a specific scope of work related to the Basin Study must be developed by the potential subconsultant. The draft proposal will be initially reviewed by the GSP Plan Manager and Project Manager for its technical relevance, priority, budget and schedule. The potential subconsultant will coordinate with the GSP Plan Manager and Project Manager to address issues and concerns. If accepted by the GSP Plan Manager and Project Manager, the draft proposal will be presented to the Subbasin GSAs to assess and prioritize whether this proposed work will be funded under the Basin Study budget. The acceptance of all the Subbasin GSAs will be necessary for proposal to be supported under the Basin Study budget.

KEY PROJECT TEAM PERSONNEL



Todd Groundwater is a consulting firm specializing in groundwater studies, including evaluation, monitoring, modeling, management, and protection of groundwater resources. Our firm was founded in 1978 by Dr. David Keith Todd, internationally recognized expert in groundwater and author of the textbook, *Groundwater Hydrology*.

Todd Groundwater's professional staff members have advanced degrees in civil engineering, geology, hydrogeology, geography, and environmental sciences. All senior geologists and engineers are professionally registered in California and all senior geologists also are certified hydrogeologists. While providing the breadth of training and experience needed for groundwater planning, management, development, and protection, we have remained a small firm to provide specialized and responsive groundwater services to our clients. Todd Groundwater provides its clients with reliable and consistent service from a cohesive team. Based in Alameda, Todd Groundwater provides consulting services throughout California, with numerous clients in the Central Valley and Kern County. Our focus is groundwater, with most of our work conducted for California public agencies: water agencies, cities, and counties. We provide the full range of groundwater services with a focus on groundwater basin management, particularly compliance with the Sustainable Groundwater Management Act (SGMA).

Todd Groundwater is pleased to offer an experienced team for the water budget updates and model calibration. The leaders of the Project Team include the following:

- Phyllis Stanin will serve as the Principal-In-Charge and will be responsible for overseeing the Todd Groundwater team performance to ensure responsive service during the course of this project. Phyllis has a long history of supporting a wide range of projects in the Subbasin.
- Mike Maley will serve as Project Manager. He has 30 years of hydrogeological and groundwater modeling experience. As the Project Manager and Lead Modeler for development of the C2VSimFG-Kern integrated surface water/groundwater model, Mike offers unique knowledge and understanding of all of the Subbasin-wide surface water and groundwater data sets necessary for updating and calibrating the Subbasin Model.

The project leaders will be assisted by Todd Groundwater staff with specialized groundwater modeling, surface water hydrology, and GIS experience, as needed. Additional administrative staff will provide graphics and administrative support. We have identified some key subconsultants who bring valuable local and subject expertise to support this project; they are listed in the following project team biographies. In addition, we have added time for collaboration with DWR, USGS California Water Science Center and local universities on our technical approach. Todd Groundwater may utilize additional subconsultants or contract employees who bring additional local and subject expertise that is considered beneficial to the successful completion of this project. Todd Groundwater will coordinate with the GSP Plan Manager prior to incorporating additional subconsultants into the project.

Todd Groundwater proposes a selected team, who bring groundwater basin management experience, SGMA expertise, requisite technical skills, knowledge of the Kern County Groundwater Subbasin, and understanding of Kern County groundwater users. Leaders of the Project Team from Todd Groundwater, Hydrolytics LLC and Aquilogic are described below. More detailed resumes of key personnel can be provided upon request.

Phyllis Stanin, PG, CEG, CHG, Principal in Charge

Phyllis Stanin, Vice President and Principal Geologist will serve as Principal in Charge. She has been a professional geologist for more than 40 years with expertise in hydrogeology and groundwater basin management. She has prepared numerous groundwater management plans and several groundwater sustainability plans — including in the Kern County Subbasin and other subbasins in the San Joaquin Valley. She has had the opportunity to work with many of the Subbasin managers in the Kern County Subbasin and has worked with several of the DWR SGMA staff for many years. As such, she is highly qualified to provide overall guidance for this important project.

She also serves as the Watermaster Engineer for the Antelope Valley Watermaster and has provided key technical guidance to establishment of rules, regulations, and procedures as the Basin implements the adjudication and Final Judgment. She has also managed water resource monitoring, tracking of groundwater production, meter specifications, well permitting, documentation of groundwater quality, database development, and annual reporting for the Watermaster.

Michael Maley, PE, PG, CHG, CEG, Project Manager

Mike Maley, Senior Hydrogeologist, will serve as Project Manager and Technical Leader. Mike is both a licensed professional geologist and civil engineer with more than 30 years of experience in water resources and environmental projects, with expertise in numerical modeling and handling large data sets. He is an experienced project manager who has successfully managed large, complex projects. He has also supported grant management by public agencies by providing clear project summaries and other supporting data to meet DWR requirements.

Mike has extensive Kern County Subbasin experience through his work with local agencies in developing the Subbasin Model (C2VSimFG-Kern), preparing GSPs, developing the post-GSP Annual Report and conducting groundwater analyses for local groundwater projects. Mike has developed a strong working relationships with all of the key Project Team staff; this will facilitate project coordination. As Project Manager, Mike will serve as the primary point of contact with the Kern County Planning Coordinator and GSA member agencies. He will be responsible for communicating project status, overseeing the execution of the work, schedule, and budget, participating in public meetings, and coordinating team efforts.

Eugene B. (Gus) Yates, PG, CHG, Senior Hydrologist

Gus Yates is an accomplished hydrogeologist and water resources expert. His 30 years of experience—initially with the USGS and also as a consulting hydrogeologist—has been science-based and focused on projects that require critical thinking skills and the application of hydrologic principles and methods.

Mr. Yates brings substantial experience with GWMPs and GSPs, including surface water/groundwater interaction, GDE assessments, and application of numerical models. He was primary author of the original GWMP for San Benito County Water District and is a key contributor to the North San Benito Basin GSP with responsibility for identification of interconnected surface water and GDEs and for update and expansion of the basin-wide numerical model, which is being applied to evaluate groundwater budgets (including inter-basin flow and future climate change) and sustainability criteria. He has been project manager, numerical modeler, and primary author of the Arroyo Seco GSP. Mr. Yates also brings considerable knowledge of Southern California hydrology including surface water modeling and groundwater-surface water interactions assessments for three recent GSPs in Riverside County.

Charles F. Brush, PhD, PE, Groundwater Modeler (Hydrolytics, LLC)

Dr. Brush has 23 years of comprehensive civil engineering experience in both the public and private sectors. During his 20 years with the USGS and California Department of Water Resources (DWR), Dr. Brush developed several groundwater flow models and integrated hydrologic models using the IWFM and MODFLOW applications. Dr. Brush was the principal developer of DWR's California Central Valley Groundwater-Surface Water Simulation Model (C2VSim). Dr. Brush's private sector work has included supporting DWR in updating the C2VSim model, working with local stakeholders in Kern, Colusa and Tehama Counties to update local portions of the C2VSim model for use in GSP development, and assisting in the development and calibration of other Central Valley models.

Dr. Brush has completed numerous hydrologic modeling studies including Central Valley water use under climate change, streamflow impacts of groundwater pumping and water transfers, and economic impacts of water shortages. Dr. Brush has also conducted technical reviews of numerous models, including the USGS Central Valley Hydrologic Model (CVHM) and MODFLOW FARM Package. Dr. Brush has served on advisory committees, including the Groundwater Resources Association Technical Advisory Committee (GRA TAC) and Northern Sacramento Valley Technical Advisory Committee. Dr. Brush recently led the GRA TAC's review of DWR's draft 2020 California Groundwater report (Bulletin 118). Dr. Brush's expertise in software applications includes MODFLOW, IWFM/IDC, PEST, ArcMap and python.

Thomas Watson, PE, Principal Geologist (Aquilogic)

Tom Watson has over 35 years of experience with an emphasis on complex groundwater investigations, environmental regulatory negotiations, and conjunctive water reuse strategies. Tom is a licensed California Professional Geologist (PG) and is licensed as a California Engineering Contractor ("A" license). Tom leads Aquilogic company initiatives in water reuse and conjunctive use, marginal groundwater development, and water issues facing municipal clients. Tom is assisting several clients in Kern County with the development of a Chapter Groundwater Sustainability Plan (GSP) for the Westside Water Districts. Tom is also assisting the largest oil and natural gas producer by acreage in the State with an assessment of produced oil field water for disposal and beneficial reuse. In Kings County, Tom is working on the design, siting, and construction of a new water supply well to support oil field operations. In eastern San Diego County, Tom is assisting a key stakeholder in assessing technical issues related to a basin-wide groundwater flow model and the development of a GSP to establish the sustainable yield and set preliminary groundwater pumping allocations.

Maureen Reilly, PE: Senior Water Resources Engineer

Maureen Reilly has 15 years of experience in groundwater, environmental, and information systems projects. She is experienced in analytical and semi-analytical groundwater modeling programs, numerical methods, water quality analysis, monitoring, data management, and reporting in the context of groundwater basin management, including compliance with the Sustainable Groundwater Management Act (SGMA). She has contributed her data management skills, experience with water supply and demand analyses, and knowledge of water budgets to GSPs in multiple groundwater basins. She has served as the lead data manager and analyst for the Kern River GSA. She processed the METRIC and other data for the C2VSim Update. For the Kern Fan Model, she built the database, developed model input files, completed the final model calibration and ran project scenarios.

Brent M. Johnson, PG, Associate Geologist

Brent Johnson is an Associate Geologist with more than eight years of experience as a consulting geologist. He brings experience contributing to multiple Groundwater Sustainability Plans (GSPs) in Riverside County and the Central Valley. For a recent hydrogeologic conceptual model (HCM), he developed lithologic and geospatial information for a GIS database and helped determine final alignment of cross section transects to show the highest resolution of subsurface conditions. Mr. Johnson generated geologic cross sections based on surficial geology, lithologic data, and existing fault datasets, which were incorporated into the HCM. In addition, he has extensive field experience including soil and groundwater sample collection, well drilling oversight, design and construction; and groundwater level monitoring. He is skilled in data management and water quality analysis.

Arden Wells, MS, GIT, Staff Hydrogeologist

Arden Wells is a hydrogeologist with experience specializing in groundwater quality and groundwater resources management. Her experience ranges from geochemical statistical analyses to preparation of Groundwater Sustainability Plans. She is working with the Watermaster Engineer in Antelope Valley with responsibilities for tracking groundwater use (production, transfers, wastewater and recycled water) and importation of SWP water (use, storage, imported water return flows). Her field experience includes construction oversight for well installation, groundwater sample collection, and groundwater level monitoring. She is familiar with the Sustainable Groundwater Management Act (SGMA) and is contributing to several Groundwater Sustainability Plans (GSPs).

Nicole Grimm, MS, Staff Hydrologist

Nicole Grimm has worked on projects focused on drinking water, stormwater, and groundwater. From these projects she has gained experience in laboratory testing, data collection and analysis, water quality monitoring and analysis, mapping in Geographic Information Systems (GIS), and isotope hydrology for water budget analysis. She worked with the Groundwater Sustainability Agency (GSA) in Butte County on their Groundwater Sustainability Plan and analyzed stable isotopes of water and noble gas recharge temperature to gain information on aquifer recharge sources for flow patterns. She compared the results to independently computed residence times from the Integrated Water Flow Model (IWFM). She is assisting with preparation of GSPs and annual reports.

Mike Wottrich, GIS and Database Analyst

Mike Wottrich employs a data-driven approach to providing a variety of geographic information, database management, and infographic services. His experience includes the production and maintenance of various tabular and graphic representations for reports, presentations, and exhibits. He has advanced skills with various data-driven software like ArcGIS Desktop, SQL Server Management Studio, EVS and other specialized software to aid the production of high-quality maps and infographics. He also has extensive experience with the automation of complex and/or repetitive tasks to help with the standardization of data input and output processes using software including Visual Studio and FME. As Graphics Coordinator, Mr. Wottrich is also responsible for final QA/QC of all Todd Groundwater graphics. In addition to his technical skills, he also provides a keen sense of design.

Table 2. DRAFT Total Budget Estimate - Kern County Subbasin Water Budget Upgrade and Model Calibration

Todd Groundwater

Job Name: Comprehensive Update to Address Data Gaps with the Hydrogeological Conceptual Model, Water Budgets and Model Calibration of the Kern County Subbasin to Support GSP Implementation and Native Yield Study (Basin Study)
Client: Kern County Subbasin GSAs
Date: November 16, 2021
Todd Job Number: TBD

Proposed Project	Principal 255 $/hr		PM/Technical Lead 240 $/hr		Sr Hydrologist 235 $/hr		Sr Water Engineer 235 $/hr		Associate Geologist 185 $/hr		Staff Hydrogeologist 150 $/hr		Staff Hydrologist 145 $/hr		Technical Labor Subtotal		GIS / Graphics 135 $/hr		Admin 125 $/hr		Hydrolytics, LLC 180 $/hr		Other Subconsultant Costs	Other Direct Costs	Total Todd Groundwater Costs
	hours	$	hours	$	hours	$	hours	$	hours	$	hours	$	hours	$	hours	$	hours	$	hours	$	hours	$			
Task 1 Data Compilation and GIS Mapping																									
Subtask 1.1 - Historical Precipitation Data	0	$ -	24	$ 5,760	0	$ -	0	$ -	0	$ -	0	$ -	64	$ 9,280	88	$ 15,040	12	$ 1,620		$ -	0	$ -	$ -	$ -	$ 16,660
Subtask 1.2 - Basin and Surrounding Watershed Hydrology Data	0	$ -	8	$ 1,920	24	$ 5,640	0	$ -	0	$ -	40	$ 6,000	80	$ 11,600	152	$ 25,160	8	$ 1,080		$ -	0	$ -	$ -	$ -	$ 26,240
Subtask 1.3 - GIS Mapping of Basin Data	2	$ 510	24	$ 5,760	0	$ -	0	$ -	40	$ 7,400	64	$ 9,600	0	$ -	130	$ 23,270	44	$ 5,940		$ -	0	$ -	$ -	$ -	$ 29,210
Subtask 1.4 - Small Water Systems and Private Wells Data	2	$ 510	8	$ 1,920	0	$ -	20	$ 4,700	0	$ -	64	$ 9,600	0	$ -	94	$ 16,730	28	$ 3,780		$ -	0	$ -	$ -	$ -	$ 20,510
Subtask 1.5 – Subbasin GSA Data Coordination	8	$ 2,040	64	$ 15,360	0	$ -	0	$ -	16	$ 2,960	16	$ 2,400	24	$ 3,480	128	$ 26,240	16	$ 2,160		$ -	0	$ -	$ -	$ -	$ 28,400
Subtask 1.6 – Compile New Regional Data and Reports	4	$ 1,020	12	$ 2,880	0	$ -	12	$ 2,820	60	$ 11,100	0	$ -	40	$ 5,800	128	$ 23,620	24	$ 3,240		$ -	0	$ -	$ -	$ -	$ 26,860
Subtask 1.7 - Task 1 TM / Data Package	2	$ 510	24	$ 5,760	8	$ 1,880	0	$ -	16	$ 2,960	8	$ 1,200	24	$ 3,480	82	$ 15,790	12	$ 1,620	2	$ 250	0	$ -	$ -	$ 500	$ 18,160
Total	18	$ 4,590	164	$ 39,360	32	$ 7,520	32	$ 7,520	132	$ 24,420	192	$ 28,800	232	$ 33,640	802	$ 145,850	144	$ 19,440	2	$ 250	0	$ -	$ -	$ 500	$ 166,040
Task 2 Hydrological Evaluation																									
Subtask 2.1 - Watershed Hydrological Assessment	2	$ 510	40	$ 9,600	80	$ 18,800	0	$ -	0	$ -	0	$ -	160	$ 23,200	282	$ 52,110	24	$ 3,240		$ -	0	$ -	$ 75,000	$ -	$ 130,350
Subtask 2.2 – Basin Hydrological Assessment	2	$ 510	88	$ 21,120	0	$ -	0	$ -	0	$ -	88	$ 13,200	200	$ 29,000	378	$ 63,830	24	$ 3,240		$ -	0	$ -	$ 75,000	$ -	$ 142,070
Subtask 2.3 - Stream and Conveyance Hydrologic Assessment	8	$ 2,040	40	$ 9,600	0	$ -	80	$ 18,800	0	$ -	0	$ -	80	$ 11,600	208	$ 42,040	24	$ 3,240		$ -	0	$ -	$ -	$ -	$ 45,280
Subtask 2.4 - Task 2 TM / Data Package	4	$ 1,020	80	$ 19,200	16	$ 3,760	24	$ 5,640	40	$ 7,400	0	$ -	48	$ 6,960	212	$ 43,980	12	$ 1,620	2	$ 250	0	$ -	$ -	$ 500	$ 46,350
Total	16	$ 4,080	248	$ 59,520	96	$ 22,560	104	$ 24,440	40	$ 7,400	88	$ 13,200	488	$ 70,760	1,080	$ 201,960	84	$ 11,340	2	$ 250	0	$ -	$ 150,000	$ 500	$ 364,050
Task 3 Hydrogeological Evaluation																									
Subtask 3.1 - Subbasin HCM Review	16	$ 4,080	200	$ 48,000	16	$ 3,760	24	$ 5,640	120	$ 22,200	160	$ 24,000	40	$ 5,800	576	$ 113,480	48	$ 6,480		$ -	0	$ -	$ 100,000	$ -	$ 219,960
Subtask 3.2 - Geologic Features that Affect Groundwater Flow	8	$ 2,040	80	$ 19,200	40	$ 9,400	0	$ -	40	$ 7,400	120	$ 18,000	0	$ -	288	$ 56,040	24	$ 3,240		$ -	0	$ -	$ 50,000	$ -	$ 109,280
Subtask 3.3 - Update Principal Aquifer Maps	4	$ 1,020	48	$ 11,520	0	$ -	0	$ -	0	$ -	64	$ 9,600	0	$ -	116	$ 22,140	24	$ 3,240		$ -	0	$ -	$ -	$ -	$ 25,380
Subtask 3.4 - Assessment of Geology on Recharge	8	$ 2,040	64	$ 15,360	0	$ -	0	$ -	0	$ -	40	$ 6,000	60	$ 8,700	172	$ 32,100	24	$ 3,240		$ -	0	$ -	$ 50,000	$ -	$ 85,340
Subtask 3.5 - Subsidence Data Review	2	$ 510	48	$ 11,520	0	$ -	0	$ -	80	$ 14,800	0	$ -	0	$ -	130	$ 26,830	8	$ 1,080		$ -	0	$ -	$ 50,000	$ -	$ 77,910
Subtask 3.6 - Task 3 TM / Data Package	8	$ 2,040	72	$ 17,280	8	$ 1,880	0	$ -	24	$ 4,440	24	$ 3,600	24	$ 3,480	160	$ 32,720	24	$ 3,240	2	$ 250	0	$ -		$ 500	$ 36,710
Total	46	$ 11,730	512	$ 122,880	64	$ 15,040	24	$ 5,640	264	$ 48,840	408	$ 61,200	124	$ 17,980	1,442	$ 283,310	152	$ 20,520	2	$ 250	0	$ -	$ 250,000	$ 500	$ 554,580
Task 4 Water Budget Methdology Upgrades																									
Subtask 4.1 - Municipal, Industrial and Private Water Use Updates	4	$ 1,020	44	$ 10,560	0	$ -	64	$ 15,040	0	$ -	88	$ 13,200	0	$ -	200	$ 39,820	16	$ 2,160		$ -	0	$ -	$ -	$ -	$ 41,980
Subtask 4.2 - Surface Water Supply and Use Updates	4	$ 1,020	48	$ 11,520	24	$ 5,640	40	$ 9,400	0	$ -	0	$ -	160	$ 23,200	276	$ 50,780	12	$ 1,620		$ -	0	$ -	$ -	$ -	$ 52,400
Subtask 4.3 – Calculated Groundwater Demand Updates	4	$ 1,020	80	$ 19,200	40	$ 9,400	40	$ 9,400	0	$ -	120	$ 18,000	140	$ 20,300	424	$ 77,320	12	$ 1,620		$ -	0	$ -	$ 100,000	$ -	$ 178,940
Subtask 4.4 - Water Supply and Demand Review	6	$ 1,530	80	$ 19,200	8	$ 1,880	40	$ 9,400	0	$ -	112	$ 16,800	0	$ -	246	$ 48,810	16	$ 2,160		$ -	0	$ -	$ -	$ -	$ 50,970
Subtask 4.5 - Basinwide Groundwater Recharge Evaluation	8	$ 2,040	120	$ 28,800	40	$ 9,400	40	$ 9,400	0	$ -	160	$ 24,000	160	$ 23,200	528	$ 96,840	24	$ 3,240		$ -	0	$ -	$ 25,000	$ -	$ 125,080
Subtask 4.6 - Task 4 TM / Data Package	8	$ 2,040	88	$ 21,120	16	$ 3,760	40	$ 9,400	0	$ -	64	$ 9,600	80	$ 11,600	296	$ 57,520	40	$ 5,400	2	$ 250	0	$ -	$ -	$ 500	$ 63,670
Total	34	$ 8,670	460	$ 110,400	128	$ 30,080	264	$ 62,040	0	$ -	544	$ 81,600	540	$ 78,300	1,970	$ 371,090	120	$ 16,200	2	$ 250	0	$ -	$ 125,000	$ 500	$ 513,040
Task 5 IWFM-Kern Model Upgrades																									
Subtask 5.1 - Develop Kern County Subbasin Model Domain	8	$ 2,040	80	$ 19,200	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	88	$ 21,240	16	$ 2,160		$ -	152	$ 27,360	$ -	$ -	$ 50,760
Subtask 5.2 - Refine Model Grid	0	$ -	80	$ 19,200	0	$ -	0	$ -	0	$ -	0	$ -	104	$ 15,080	184	$ 34,280	60	$ 8,100		$ -	120	$ 21,600	$ -	$ -	$ 63,980
Subtask 5.3 - Redefine Model Hydrology	8	$ 2,040	40	$ 9,600	24	$ 5,640	40	$ 9,400	0	$ -	0	$ -	48	$ 6,960	160	$ 33,640	16	$ 2,160		$ -	88	$ 15,840	$ -	$ -	$ 51,640
Subtask 5.4 - Compile and review model aquifer parameters	4	$ 1,020	24	$ 5,760	0	$ -	0	$ -	0	$ -	64	$ 9,600	0	$ -	92	$ 16,380	24	$ 3,240		$ -	16	$ 2,880	$ -	$ -	$ 22,500
Subtask 5.5 - Update Urban Water Management Parameters	2	$ 510	24	$ 5,760	0	$ -	16	$ 3,760	0	$ -	64	$ 9,600	0	$ -	106	$ 19,630	16	$ 2,160		$ -	64	$ 11,520	$ -	$ -	$ 33,310
Subtask 5.6 - Update Root Zone Properties	2	$ 510	44	$ 10,560	0	$ -	16	$ 3,760	24	$ 4,440	0	$ -	24	$ 3,480	110	$ 22,750	8	$ 1,080		$ -	100	$ 18,000	$ -	$ -	$ 41,830
Subtask 5.7 - Update Hydrogeological Conceptual Model Parameters	8	$ 2,040	24	$ 5,760	0	$ -	0	$ -	0	$ -	40	$ 6,000	0	$ -	72	$ 13,800	8	$ 1,080		$ -	200	$ 36,000	$ -	$ -	$ 50,880
Subtask 5.8 – Update Managed Water Supply and Use Methods	4	$ 1,020	48	$ 11,520	0	$ -	40	$ 9,400	0	$ -	88	$ 13,200	0	$ -	180	$ 35,140	8	$ 1,080		$ -	200	$ 36,000	$ -	$ -	$ 72,220
Subtask 5.9 - Add Subsidence Capability	4	$ 1,020	40	$ 9,600	0	$ -		$ -	24	$ 4,440	0	$ -	0	$ -	68	$ 15,060	16	$ 2,160		$ -	100	$ 18,000	$ -		$ 35,220
Total	40	$ 10,200	404	$ 96,960	24	$ 5,640	112	$ 26,320	48	$ 8,880	256	$ 38,400	176	$ 25,520	1,060	$ 211,920	172	$ 23,220	0	$ -	1040	$ 187,200	$ -	$ -	$ 422,340

Table 2. DRAFT Total Budget Estimate - Kern County Subbasin Water Budget Upgrade and Model Calibration

Todd Groundwater

Job Name: Comprehensive Update to Address Data Gaps with the Hydrogeological Conceptual Model, Water Budgets and Model Calibration of the Kern County Subbasin to Support GSP Implementation and Native Yield Study (Basin Study)
Client: Kern County Subbasin GSAs
Date: November 16, 2021
Todd Job Number: TBD

Proposed Project	Principal 255 $/hr		PM/Technical Lead 240 $/hr		Sr Hydrologist 235 $/hr		Sr Water Engineer 235 $/hr		Associate Geologist 185 $/hr		Staff Hydrogeologist 150 $/hr		Staff Hydrologist 145 $/hr		Technical Labor Subtotal		GIS / Graphics 135 $/hr		Admin 125 $/hr		Hydrolytics, LLC 180 $/hr		Other Subconsultant Costs	Other Direct Costs	Total Todd Groundwater Costs
	hours	$	hours	$	hours	$	hours	$	hours	$	hours	$	hours	$	hours	$	hours	$	hours	$	hours	$			
Task 6 IWFM-Kern Model Calibration																									
Subtask 6.1 - Calibration of IWFM-Kern Model	2	$ 510	160	$ 38,400	0	$ -	24	$ 5,640	0	$ -	0	$ -	44	$ 6,380	230	$ 50,930	0	$ -		$ -	260	$ 46,800	$ -	$ -	$ 97,730
Subtask 6.2 - Generate Revised Historical Water Budgets	2	$ 510	40	$ 9,600	0	$ -	0	$ -	0	$ -	0	$ -	40	$ 5,800	82	$ 15,910	0	$ -		$ -	40	$ 7,200	$ -	$ -	$ 23,110
Subtask 6.3 – Sensitivity Analysis	2	$ 510	24	$ 5,760	0	$ -	0	$ -	0	$ -	0	$ -	16	$ 2,320	42	$ 8,590	0	$ -		$ -	60	$ 10,800	$ -	$ -	$ 19,390
Subtask 6.4 – Update SGMA Projected-Future Scenarios	2	$ 510	80	$ 19,200	0	$ -	0	$ -	0	$ -	24	$ 3,600	40	$ 5,800	146	$ 29,110	0	$ -		$ -	120	$ 21,600	$ -	$ -	$ 50,710
Subtask 6.5 - Subsidence Model Validation	2	$ 510	24	$ 5,760	0	$ -	0	$ -	30	$ 5,550	0	$ -	0	$ -	56	$ 11,820	10	$ 1,350		$ -	96	$ 17,280	$ -	$ -	$ 30,450
Subtask 6.6 - Subtask 5 & 6 TM / Data Package	24	$ 6,120	140	$ 33,600	0	$ -	24	$ 5,640	24	$ 4,440	0	$ -	88	$ 12,760	300	$ 62,560	40	$ 5,400	2	$ 250	140	$ 25,200	$ -	$ 1,000	$ 94,410
Total	34	$ 8,670	468	$ 112,320	0	$ -	48	$ 11,280	54	$ 9,990	24	$ 3,600	228	$ 33,060	856	$ 178,920	50	$ 6,750	2	$ 250	716	$ 128,880	$ -	$ 1,000	$ 315,800
Task 7 Technical Report																									
Subtask 7.1 - Finalize TMs as Technical Report Attachments	24	$ 6,120	64	$ 15,360	8	$ 1,880	0	$ -	24	$ 4,440	56	$ 8,400	164	$ 23,780	340	$ 59,980	16	$ 2,160	2	$ 250	24	$ 4,320	$ -	$ -	$ 66,710
Subtask 7.2 - Draft Technical Report	24	$ 6,120	120	$ 28,800	48	$ 11,280	20	$ 4,700	48	$ 8,880	88	$ 13,200	88	$ 12,760	436	$ 85,740	40	$ 5,400	2	$ 250	64	$ 11,520	$ -	$ 1,000	$ 103,910
Subtask 7.3 - Final Technical Report	8	$ 2,040	72	$ 17,280	8	$ 1,880	0	$ -	12	$ 2,220	24	$ 3,600	16	$ 2,320	140	$ 29,340	24	$ 3,240	2	$ 250	12	$ 2,160	$ -	$ 1,000	$ 35,990
Subtask 7.4 - Final GIS Maps and Geodatabase	2	$ 510	12	$ 2,880	2	$ 470	2	$ 470	16	$ 2,960	8	$ 1,200	24	$ 3,480	66	$ 11,970	80	$ 10,800		$ -	12	$ 2,160	$ -		$ 24,930
Total	58	$ 14,790	268	$ 64,320	66	$ 15,510	22	$ 5,170	100	$ 18,500	176	$ 26,400	292	$ 42,340	982	$ 187,030	160	$ 21,600	6	$ 750	112	$ 20,160	$ -	$ 2,000	$ 231,540
Task 8 Project Coordination and Meetings																									
Subtask 8.1 – GSA Coordination and Water Manager Meetings	64	$ 16,320	160	$ 38,400	40	$ 9,400	0	$ -	40	$ 7,400	0	$ -	40	$ 5,800	344	$ 77,320	24	$ 3,240		$ -	64	$ 11,520	$ -	$ 6,000	$ 98,080
Subtask 8.2 - Policy Team and Stakeholder Updates	64	$ 16,320	64	$ 15,360	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	128	$ 31,680	24	$ 3,240		$ -	8	$ 1,440	$ -	$ 3,000	$ 39,360
Subtask 8.3 - Coordination with Outside Agencies and GSAs	32	$ 8,160	80	$ 19,200	24	$ 5,640	8	$ 1,880	24	$ 4,440	8	$ 1,200	0	$ -	176	$ 40,520	24	$ 3,240		$ -	24	$ 4,320	$ -	$ 2,000	$ 50,080
Subtask 8.4 - Post-Basin Study Policy Team Coordination	40	$ 10,200	140	$ 33,600	8	$ 1,880	0	$ -	16	$ 2,960	6	$ 900	64	$ 9,280	274	$ 58,820	64	$ 8,640		$ -	8	$ 1,440	$ -	$ 5,000	$ 73,900
Subtask 8.5 - Project Coordination	80	$ 20,400	220	$ 52,800	0	$ -	0	$ -	0	$ -	0	$ -	0	$ -	300	$ 73,200	0	$ -	24	$ 3,000	8	$ 1,440	$ -	$ 4,000	$ 81,640
Total	280	$ 71,400	664	$ 159,360	72	$ 16,920	8	$ 1,880	80	$ 14,800	14	$ 2,100	104	$ 15,080	1,222	$ 281,540	136	$ 18,360	24	$ 3,000	112	$ 20,160	$ -	$ 20,000	$ 343,060
GRAND TOTAL	526	$ 134,130	3188	$ 765,120	482	$ 113,270	614	$ 144,290	718	$ 132,830	1702	$ 255,300	2184	$ 316,680	9414	$ 1,861,620	1018	$ 137,430	40	$ 5,000	1980	$ 356,400	$ 525,000	$ 25,000	$ 2,910,450

Table 3. DRAFT Schedule - Kern County Subbasin Water Budget Upgrade and Model Calibration (Basin Study)

Todd Groundwater

Job Name: Comprehensive Update to Address Data Gaps with the Hydrogeological Conceptual Model, Water Budgets and Model Calibration of the Kern County Subbasin to Support GSP Implementation and Native Yield Study (Basin Study)
Client: Kern County Subbasin GSAs
Date: February 3, 2022
Todd Job Number: TBD

	2022												2023												2024												2025											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task 1 Data Compilation and GIS Mapping																																															
Subtask 1.1 - Historical Precipitation Data				■	■																																										
Subtask 1.2 - Basin and Surrounding Watershed Hydrology Data				■	■																																										
Subtask 1.3 - Small Water Systems and Private Wells Data				■	■																																										
Subtask 1.4 - GIS Mapping of Basin Data				■	■	■	■	■																																								
Subtask 1.5 – Subbasin GSA Data Coordination				■	■	■	■	■																																								
Subtask 1.6 – Compile New Regional Data and Reports					■	■	■	■																																								
Subtask 1.7 - Task 1 TM / Data Package							■	■	■																																							
Task 2 Hydrological Evaluation																																																
Subtask 2.1 - Watershed Hydrological Assessment							■	■	■	■	■																																						
Subtask 2.2 – Basin Hydrological Assessment							■	■	■	■	■																																						
Subtask 2.3 - Stream and Conveyance Hydrologic Assessment								■	■	■	■	■																																					
Subtask 2.4 - Task 2 TM / Data Package										■	■	■	■																																				
Task 3 Hydrogeological Evaluation																																																
Subtask 3.1 - Subbasin HCM Review					■	■	■	■	■	■	■	■	■	■	■	■	■																															
Subtask 3.3 - Geologic Features that Affect Groundwater Flow								■	■	■	■	■	■	■	■	■	■																															
Subtask 3.4 - Assessment of Geology on Recharge								■	■	■	■	■	■	■	■	■	■																															
Subtask 3.2 - Update Principal Aquifer Maps												■	■	■	■	■	■	■																															
Subtask 3.5 - Subsidence Data Review													■	■	■	■	■	■																															
Subtask 3.6 - Task 3 TM / Data Package																		■	■																													
Task 4 Water Budget Methdology Upgrades																																																
Subtask 4.1 - Municipal, Industrial and Private Water Use Updates							■	■	■	■	■	■																																			
Subtask 4.2 - Surface Water Supply and Use Updates									■	■	■	■	■	■	■	■																															
Subtask 4.3 – Calculated Groundwater Demand Updates											■	■	■	■	■	■	■	■	■																													
Subtask 4.4 - Basinwide Groundwater Recharge Evaluation														■	■	■	■	■	■	■																											
Subtask 4.5 - Water Supply and Demand Review																			■	■	■	■																									
Subtask 4.6 - Task 4 TM / Data Package																			■	■	■	■																									
Task 5 IWFM-Kern Model Upgrades																																																
Subtask 5.1 - Develop Kern County Subbasin Model Domain							■	■	■																																							
Subtask 5.2 - Refine Model Grid								■	■	■	■	■	■	■	■																																	
Subtask 5.3 - Redefine Model Hydrology											■	■	■	■	■	■	■	■																													
Subtask 5.4 - Compile and review model aquifer parameters											■	■	■	■	■	■	■	■																													
Subtask 5.5 - Update Urban Water Management Parameters											■	■	■	■	■	■	■	■																													
Subtask 5.6 - Update Root Zone Properties																■	■	■	■	■	■																											
Subtask 5.7 - Update Hydrogeological Conceptual Model Parameters																■	■	■	■	■	■																											
Subtask 5.8 – Update Managed Water Supply and Use Methods																		■	■	■	■	■	■	■																							
Subtask 5.9 - Add Subsidence Capability																			■	■	■	■	■	■																							
Task 6 IWFM-Kern Model Calibration																																																
Subtask 6.1 - Calibration of IWFM-Kern Model																	■	■	■	■	■	■	■	■	■	■	■																			
Subtask 6.2 - Generate Revised Historical Water Budgets																									■	■	■	■	■	■																	
Subtask 6.3 – Sensitivity Analysis																											■	■	■	■																	
Subtask 6.4 – Update SGMA Projected-Future Scenarios																											■	■	■	■																	
Subtask 6.5 - Subsidence Model Validation																									■	■	■																			
Subtask 6.6 - Subtask 5 & 6 TM / Data Package																									■	■	■	■	■	■	■															
Task 7 Technical Report																																															
Subtask 7.1 - Finalize TMs as Technical Report Attachments																	■	■	■	■	■	■	■	■																							
Subtask 7.2 - Draft Technical Report																											■	■	■	■	■	■	■														
Subtask 7.3 - Final Technical Report																																	■	■	■	■											
Subtask 7.4 - Final GIS Maps and Geodatabase																																	■	■	■	■											
Task 8 Project Coordination and Meetings																																															
Subtask 8.1 – GSA Coordination and Water Manager Meetings				*	*		*	*			*		*	*			*			*			*			*			*			*			*										
Subtask 8.2 - Policy Team and Stakeholder Updates								*			*		*	*			*			*			*			*			*			*			*										
Subtask 8.3 - Coordination with Outside Agencies and GSAs																																															
Subtask 8.4 - Post-Basin Study Policy Team Coordination																														*			*			*				*			*			
Subtask 8.5 - Project Coordination																																															