Arvin-Edison Groundwater Flow Model and Decision Support Tool Updates and Upgrades

Request for Funding Opportunity No. R23AS00446

U.S. Department of the Interior, Bureau of Reclamation

WaterSMART - Applied Science Grants for Fiscal Year 2023

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Executive Summary

Date: 17 October 2023

Applicant: Arvin-Edison Water Storage District

Location: Arvin, Kern County, California

Project Summary: The Arvin-Edison Water Storage District (AEWSD or District) operates a vast network of water conveyance, groundwater recharge, and recovery well infrastructure to provide surface water and groundwater supplies to approximately 132,000 acres of prime agricultural land located in the southeastern portion of the San Joaquin Valley in Kern County, California. AEWSD is a member agency of the Arvin Groundwater Sustainability Agency (GSA) and the White Wolf GSA within the Kern County and White Wolf Subbasins, respectively, and is responsible for maintaining sustainable groundwater conditions within its jurisdictional area in response to newly imposed regulations of the California Sustainable Groundwater Management Act (SGMA). AEWSD recently developed an integrated numerical groundwater flow model (i.e., the Arvin-Edison Groundwater Flow Model or AEGFM) and an accompanying, web-based decision support tool (DST) that directly simulates the impacts of AEWSD's conjunctive use operations on groundwater conditions within the District. This grant application is seeking funding to update the AEGFM through current conditions and to add several new functionalities to the Arvin-Edison DST. These upgrades will enhance the District's abilities to predict groundwater level and land subsidence conditions and support the design and implementation of adaptive water supply projects and demand management actions under future hydrologic and water supply uncertainties. Specific aims of the Project include: (1) updating the historical AEGFM and DST through WY 2023; (2) integrating newly available hydrogeologic, geophysical, remote sensing, and land subsidence field monitoring data into the AEGFM and recalibrating the model as necessary to improve land subsidence simulation performance; (3) adding a land subsidence forecasting capability to the DST; and (4) improving the DST data pipeline to enable direct integration with the Kern County Subbasin and White Wolf Subbasin data management systems. The Project will improve drought resiliency by enabling AEWSD to more accurately forecast the impacts of water supply shortages on groundwater conditions in real-time, which will support the AEWSD Board of Directors' selection and optimization of water management programs and policies to ensure compliance with quantitative sustainability criteria defined for groundwater levels, storage, and land subsidence under SGMA. The Project will also improve transparency by providing a user friendly, web-based platform where Basin stakeholders can access and interact with the model and DST directly. The Project is supported by the Arvin Community Services District (ACSD), which provides drinking water to the severely disadvantaged community of Arvin (see Appendix A). The Project is identified in the South of Kern River (SOKR) Groundwater Sustainability Plan (GSP) and is a continuation of an ongoing conjunctive use modeling and DST development effort by the District that was initiated in early 2022.

Length of Time and Estimated Completion Date: The Project will take approximately 9 months to complete, anticipated to start in April 2024 and end in December 2024.

Is the proposed project located on a Federal facility?: The proposed project is not located on a Federal facility.

Technical Project Description

Applicant Category:

The Arvin-Edison Water Storage District (AEWSD or District) is a Category A applicant. AEWSD administers a 350,000-acre-foot Federal Water Contract, a 30-megawatt Federal power contract and a multitude of water management programs including one with Metropolitan Water District of Southern California. AEWSD has water delivery authority and is therefore eligible as a Category A applicant.

Detailed Project Description:

The Project covers the entirety of the AEWSD service area, located in southern Kern County, California. AEWSD includes the City of Arvin and approximately 132,000 acres of agricultural lands located within the Kern County Subbasin (California Department of Water Resources [DWR] Groundwater Subbasin No. 5-022.14) and White Wolf Subbasin (DWR Subbasin No. 5-022.18). Figure 1 shows the geographic location.

The Project will rely upon the Arvin-Edison Groundwater Flow Model (AEGFM) and accompanying Arvin-Edison Decision Support Tool (DST). The AEGFM and Arvin-Edison DST was developed by AEWSD in 2022 to support the District's ongoing conjunctive-use planning and Sustainable Groundwater Management Act (SGMA) implementation efforts. The AEGFM is a fully integrated numerical groundwater flow model that simulates historical and predicted hydrology, surface water supply, groundwater recharge and recovery operations, land use and groundwater extraction trends within AEWSD and calculates resulting groundwater elevations, water budget fluxes, and land subsidence conditions underlying the District. The Arvin-Edison DST was developed as an accompanying tool to the AEGFM that enables the District to run a 5-year projected simulation under a range of hydrologic and water supply availability assumptions through a user-friendly, web-based interface. The DST automatically creates input files and executes the projected AEGFM, post-processes results, and generates visualizations that allow District staff to quickly evaluate and compare the impacts of common operational decisions such as surface water delivery volumes and locations, groundwater extraction rates, and banking facility operations on future groundwater conditions underlying AEWSD. The AEGFM extent and grid is shown in Figure 1; an example of the Arvin-Edison DST interface is shown in Figure 2. A more detailed description of AEGFM and Arvin-Edison DST design elements and features are provided in Evaluation Criterion C of this grant application.

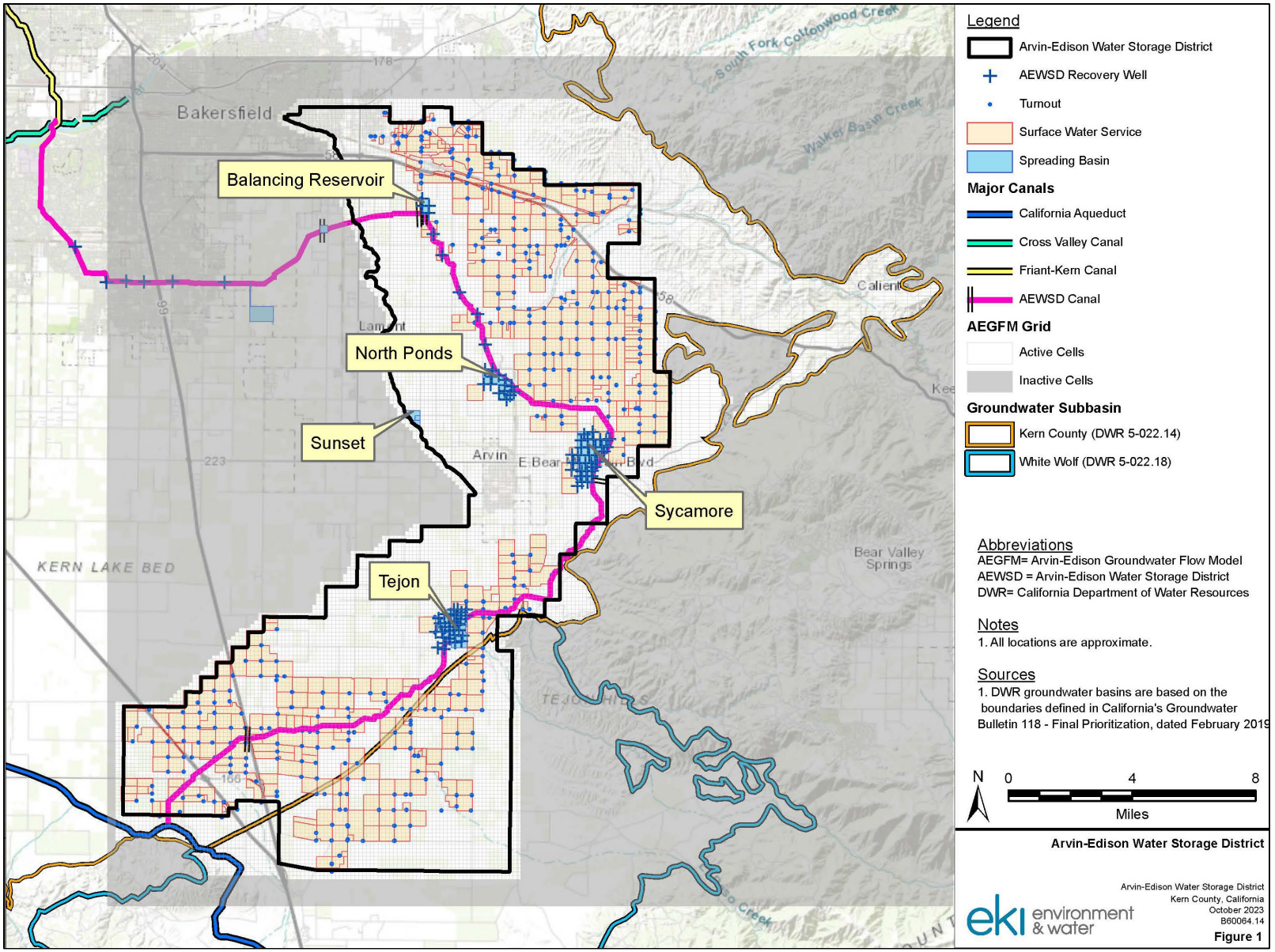

Figure 1 - Project location, including AEWSD service area and water infrastructure facilities and the AEGFM grid

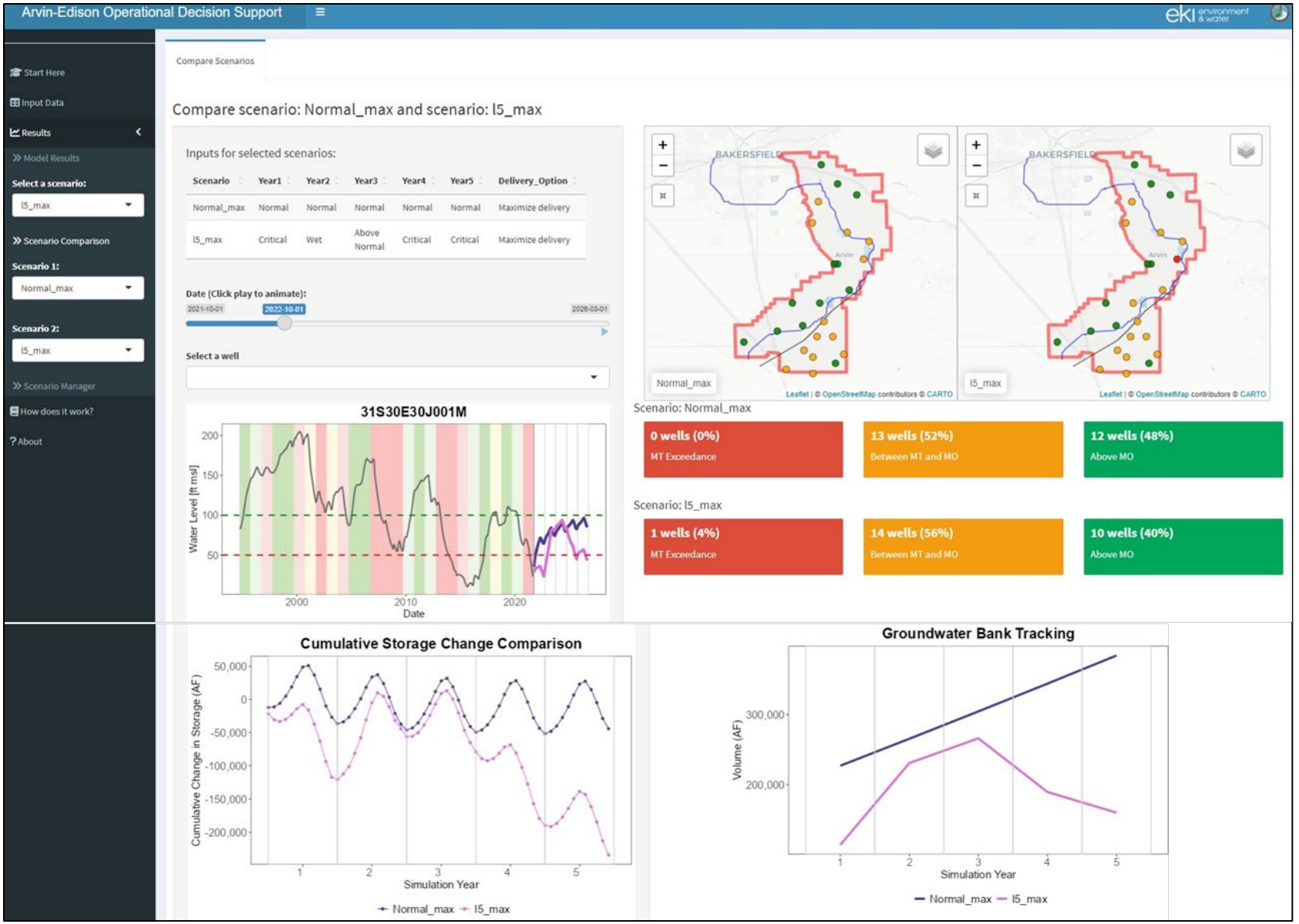

Figure 2 – Example of the "Compare Scenarios" feature of the Arvin-Edison DST.

Completion of the AEGFM and DST in 2022 has demonstrably improved AEWSD's ability to design and implement adaptive conjunctive use policies and projects in response to climate stresses and water supply uncertainty. For example, the AEGFM and DST were recently utilized to identify ideal sites for installation of two new production wells intended to increase the District's water supply reliability while minimizing impacts to water level and land subsidence conditions in response to ongoing drought conditions. However, as is the case with any numerical groundwater flow model, the AEGFM is subject to uncertainties and data gaps in hydrogeologic conceptualization, model parameterization, calibration data, and simulated stresses which may collectively limit its accuracy in predicting historical and future groundwater conditions. Furthermore, numerical models must be routinely updated with new, transient stress inputs and periodically recalibrated to recently collected monitoring and hydrogeologic data and information to remain relevant for application in ongoing policy and programmatic decision-making efforts.

Through continued interaction with and use of the AEGFM and Arvin-Edison DST, AEWSD staff and stakeholders have identified the following critical tasks which are needed to address existing uncertainties and improve AEGFM performance and to further enhance the DST's robustness as an effective tool for ongoing decision-making in the face of continued water scarcity challenges experienced by the District:

Task 1. Update the Historical AEGFM and DST through Water Year 2023

The historical AEGFM currently covers the period of DWR Water Years (WY) 1995 through 2021 (i.e., October 1994 – September 2021). Similarly, initial conditions for the short-term (5-year) projected simulation within the Arvin-Edison DST are currently based on outputs from the historical AEGFM at the end of WY 2021. Under Task 1, AEGFM will be extended through the end of DWR WY 2023 (i.e., through September 2023) and validated with recently collected groundwater elevation data from the District's groundwater elevation monitoring program. Simulated groundwater elevation outputs from the extended AEGFM will then be integrated into the DST to update initial conditions for the short-term (5-year) DST simulation reflective of the end of WY 2023.

Task 2. Refine AEGFM Land Subsidence Package Using Newly Available Hydrogeologic and Land Subsidence Monitoring Datasets

At the time of AEGFM development, very limited monitoring data existed to evaluate the threshold groundwater elevations at which inelastic subsidence has historically been triggered within the District. Furthermore, limited hydrogeologic data was available to inform selection of key parameters within the model that control land subsidence. This resulted in a limited reliability of the model to predict future land subsidence occurrence, especially under future drought conditions where groundwater elevations are likely to drop below the historic low elevations that have triggered land subsidence in the past. Under Task 2, AEWSD will incorporate the data and results from new hydrogeologic and land subsidence investigations recently completed on behalf of the Kern County Subbasin Groundwater Sustainability Agencies (GSAs), DWR's statewide aerial electromagnetic (AEM) geophysical survey, and other data-gap filling efforts conducted by AEWSD and neighboring agencies to revisit and refine AEGFM land subsidence parameters and improve the model fit to historical land subsidence conditions observed across the District.

The incorporation of new hydrogeologic and land subsidence monitoring data and associated refinements to model parameterization proposed under Task 2 will reduce uncertainties and improve AEGFM calibration performance to historical observed land subsidence rates. Additionally, updating the historical data will enhance the model's ability to reliably predict the relationship between future water level declines and land subsidence occurrence within the District. These improvements will thereby make the AEGFM a more effective tool for ongoing decision-making efforts, particularly during times of drought when water level declines are most prevalent and where optimized groundwater management practices are essential for preventing Undesirable Results due to land subsidence within the District.

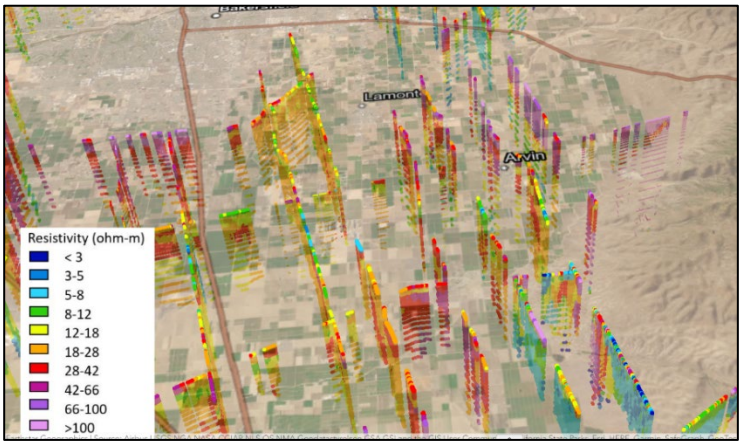

Figure 3 – DWR 2023 AEM Survey Data Results within AEWSD

Task 3. Add Land Subsidence Forecasting Capability to Arvin-Edison DST

While the AEGFM directly simulates historical land subsidence conditions within AEWSD, the Arvin-Edison DST currently does not include a predictive land subsidence functionality, in part due to the challenges and uncertainties associated with calibrating land subsidence model parameters as mentioned above and discussed in further detail under the *Evaluation Criterion C* section below. After completing the necessary model updates and upgrades described under Tasks 1 and 2, AEWSD will incorporate the improved CSUB package and add a predictive land subsidence functionality to the DST under Task 3. This effort will likely involve reconfiguring the DST back-end to include the CSUB functionality within the 5-year projected AEGFM and adding new panels, maps, and/or graphical components to the front-end interface that visualize land subsidence occurrence across the District and at AEWSD's land subsidence Representative Monitoring Site (RMS) locations. Completion of Task 3 will allow AEWSD staff to concurrently evaluate the impacts of various operational and management alternatives on both water level and land subsidence trends within the District, thus providing a more comprehensive set of information to support adaptive decision-making under a range of hydrologic and water supply uncertainties while ensuring continued SGMA compliance.

Task 4. Improve DST Data Pipeline to Enable Direct Integration with the Kern Subbasin and White Wolf Subbasin Data Management Systems

As part of SGMA implementation, the Kern County and White Wolf Subbasin GSAs have invested considerable resources to compile existing monitoring and operations datasets into common, subbasin-wide data management systems (DMS) to facilitate data-sharing and coordination objectives outlined in the Subbasin Groundwater Sustainability Plans (GSPs) and to meet SGMA monitoring and reporting requirements. These DMS are routinely updated with SGMA monitoring (e.g., water level, land subsidence, water quality) and agency operations (e.g., surface water import, banking, and groundwater production) data collected from individual GSAs throughout

the water year, and are used to inform regional model updates, prepare SGMA Annual Reports, and submit biannual monitoring data to DWR.

As mentioned above, initial conditions for the Arvin-Edison DST projected simulations are currently assigned using final outputs from the historical AEGFM. Under Task 4, AEWSD will refine the Arvin-Edison DST data pipeline to directly integrate with the Kern County and White Wolf Subbasin DMS and will develop a process to automatically update initial conditions for the 5-year projected DST simulations to reflect the most recent available data obtained from the Subbasin DMS. This effort will enable DST simulations to be reflective of current groundwater conditions within and surrounding AEWSD and will help ensure that insights gleaned from the DST by AEWSD decision-makers, including risk assessments regarding quantitative impacts to groundwater levels and land subsidence based on specific operational and management objectives, are based on the best available data and information. This feature will be especially critical to improving the reliability of DST outputs during times of drought, where short-term impacts to the groundwater system due to water supply shortages and increased groundwater production demands may not be fully reflected in the latest outputs from the historical AEGFM, specifically if the historical AEGFM has not undergone a recent update.

Goals:

The primary goals of this Project are to update and improve AEWSD's existing modeling and decision support tools to aid AEWSD staff and Board of Directors in making informed policy decisions regarding adaptive conjunctive use operational and management strategies, so to ensure AEWSD can continue to avoid Undesirable Results related to groundwater overdraft conditions and meet SGMA compliance under future hydrologic and water supply uncertainties.

Evaluation Criteria

Evaluation Criterion A—Water Management Challenge(s) (30 points)

1. *Describe the water management challenge(s). Describe in detail the water management challenge is occurring within your project area. Describe the severity of the challenge to be addressed with supporting details.*

AEWSD operates a vast network of water conveyance, groundwater recharge, and recovery well infrastructure to provide surface water and groundwater supplies to approximately 132,000 acres of prime agricultural land located in the southeastern portion of the San Joaquin Valley in Kern County, California. Groundwater levels within AEWSD and vicinity are responsive to both natural climatic conditions (i.e., precipitation and evapotranspiration) and imported surface water availability. As shown in Figure 4, according to the U.S. Drought Monitor[1], Kern County experienced three long-term droughts over the last 20 years, most recently with an extreme drought over WYs 2021 and 2022, with WY 2021 being the driest year on record.

[1] https://droughtmonitor.unl.edu/DmData/TimeSeries.aspx

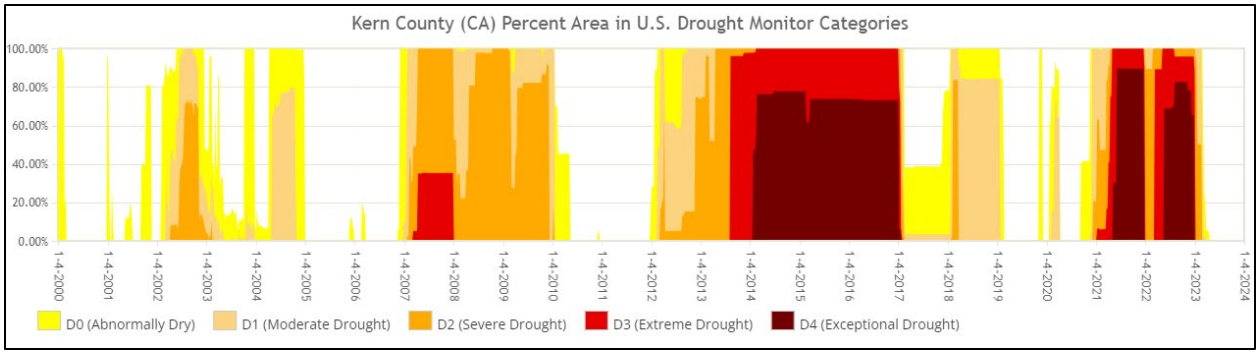

Figure 4 - Percent Area Experiencing Drought in Kern County, 2000 to 2023

AEWSD's imported surface water availability and corresponding groundwater demands are highly dependent on hydrologic conditions and thus have been increasingly negatively impacted by drought conditions experienced over the past two decades. AEWSD maintains a contract for 40,000 acre-feet per year (AFY) of Class 1 water and up to 311,675 AFY of Class 2 water from the Friant Division of the Central Valley Project (CVP), and secures additional imported supplies through purchases, transfers, and exchanges with other water agencies throughout the San Joaquin Valley. As shown in Figure 5, AEWSD has not received its full Class 1 allocation in 7 of the last 16 years since the first extreme drought began in WY 2007.

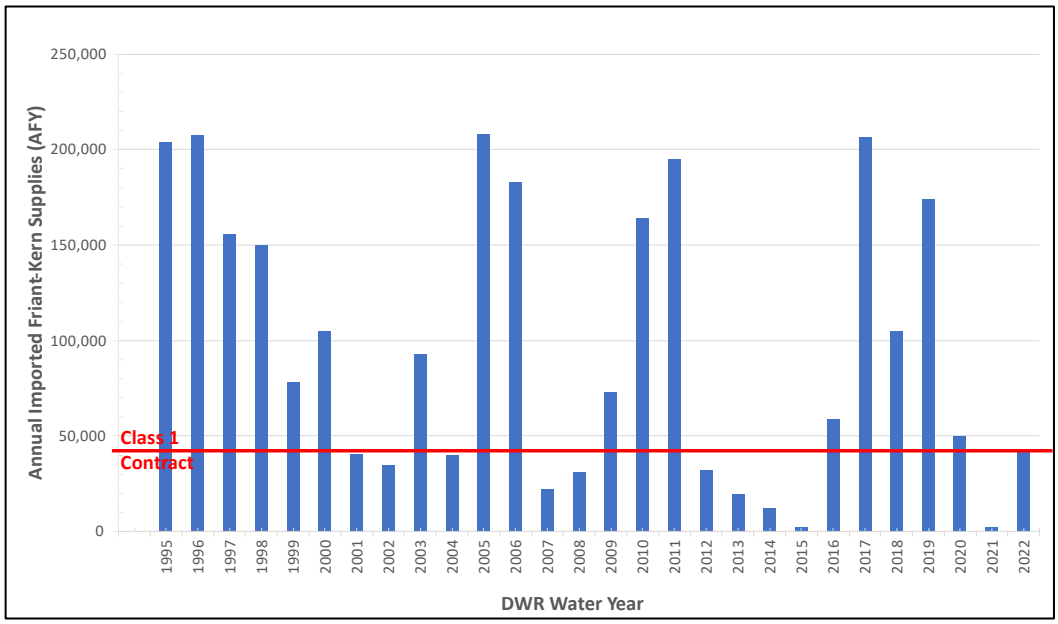

Figure 5 – AEWSD Annual Friant Kern Imports vs. Contracted Supplies, WY 1995 - 2022

As such, landowners within the District have increasingly relied on groundwater pumping to meet residual agricultural and industrial water demands, resulting in recent groundwater level declines, loss in groundwater storage, and land subsidence occurrence across the District as overdraft conditions continue to worsen over time. Figure 6 demonstrates how over 14 inches of subsidence has been measured in portions of AEWSD since DWR began providing Interferometric Synthetic Aperture Radar (InSAR) data in June 2015, with the greatest rates occurring along the District's critical water conveyance infrastructure including its canal, spreading basin, and extraction well facilities. AEWSD already invested $3.7 million in 2018—2019 to repair damage

and restore freeboard within its lined canal system due to localized land subsidence impacts that occurred during and after the WY 2012–2016 drought. If left unmitigated, continued land subsidence will ultimately result in more extensive damage to AEWSD's critical water infrastructure and disruption of AEWSD's water conveyance, storage, and groundwater extraction capabilities, which represents an existential threat to AEWSD and local stakeholders.

Furthermore, as a member agency of the Arvin GSA in the Kern County Subbasin and White Wolf GSA in the White Wolf Subbasin, newly imposed SGMA regulations require AEWSD to manage its groundwater system to quantitative Minimum Thresholds (MTs) and Measurable Objectives (MOs) defined for relevant sustainability indicators to the District, which include groundwater levels, storage, land subsidence, and water quality. As such, there is a critical need for AEWSD to design and implement adaptive groundwater management programs and policies and to develop optimized approaches for their delivery, groundwater banking, and extraction well operations in order to ensure continued SGMA compliance under future hydrologic and water supply availability uncertainties.

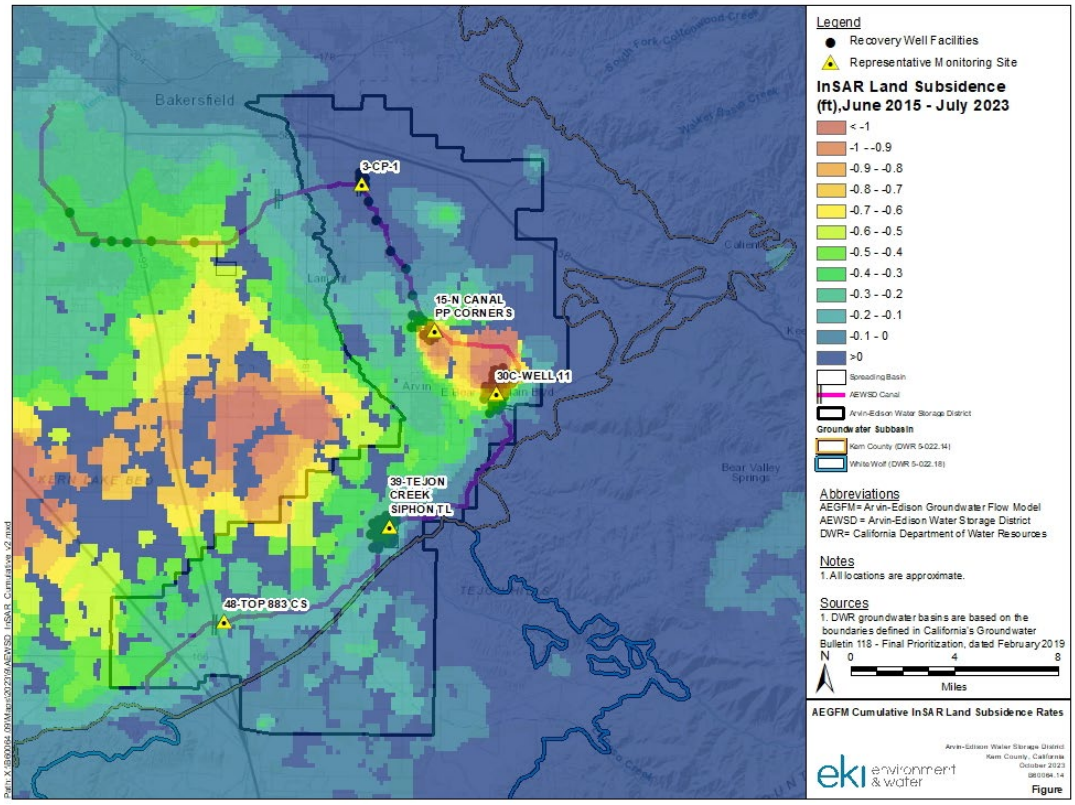

Figure 6 – InSAR Cumulative Land Subsidence within AEWSD, June 2015 – July 2023

2. Describe the concerns or outcomes if this water management challenge is not addressed?

Failure to address the water management challenges described above will result in the occurrence of Undesirable Results to beneficial users and critical infrastructure associated with groundwater level declines, loss in groundwater storage, land subsidence, and water quality degradation and a lack of ability for the Arvin GSA and White Wolf GSA to operate their groundwater systems to long-term SGMA compliance. Per Title 23 of the California Code of

Regulations, "Undesirable Results occur when significant and unreasonable effects for any of the sustainability indicators are caused by groundwater conditions occurring throughout the basin" (23-CCR §354.26). Specific negative impacts to beneficial users and uses of groundwater within AEWSD may include the dewatering and/or contamination of domestic, production, and public supply wells, increased groundwater production costs, damage to critical water conveyance infrastructure, reduced water supply reliability, and increased vulnerability to drought conditions.

In March 2023, DWR deemed the Kern County Subbasin "inadequate" following initial revisions to the GSPs to address deficiencies on the Subbasin Plan identified by DWR. Oversight of the Kern County Subbasin is transitioning to the State Water Resources Control Board (SWRCB) as part of the State Intervention process under SGMA (California Water Code [CWC] §10735.2). GSAs in the Kern County Subbasin, including the Arvin GSA, are currently revising the GSPs and coordinating with the SWRCB to avoid a probationary designation. Failure to address adverse groundwater conditions and achieve compliance with SGMA could result in the imposition of an interim plan by the SWRCB. The White Wolf Subbasin GSP is currently under review by DWR but is at risk of a similar outcome should Undesirable Results occur.

3. *Explain how your project will address the water management issues identified in your response to the preceding bullets and provide support for your response.*

Comprehensive risk assessment and proactive management of groundwater level and land subsidence conditions under future hydrologic and water supply uncertainties is crucial to mitigate the negative outcomes described above. The updates and upgrades to the AEGFM and Arvin-Edison DST proposed by this Project are critical for improving the tools' effectiveness in addressing these challenges and supporting the District's decision making. Updating the historical AEGFM to current conditions and incorporating the latest available hydrogeologic data and information will improve the reliability of model-predicted groundwater level and land subsidence conditions within the District. Adding a land subsidence forecasting capability to the DST will allow AEWSD staff to directly evaluate how ongoing conjunctive use operational, policy and management decisions will impact land subsidence conditions within specific areas of the District under different hydrologic and water supply availability assumptions. Finally, providing the capability to automatically update the DST with the latest monitoring data from the Kern County and White Wolf Subbasin DMS will ensure that insights generated from the DST continue to remain realistic and reflective of current conditions. Collectively, the Project will improve drought resiliency by enabling AEWSD to more accurately forecast the impacts of water supply shortages on groundwater conditions in real-time and will support the AEWSD Board of Directors' selection and optimization of water management programs and policies to ensure continued compliance with quantitative sustainability criteria defined for groundwater levels, storage, and land subsidence under SGMA.

Evaluation Criterion B—Project Benefits (30 points)

1. *Describe how the need for the project was identified. Was the proposed project identified using a collaborative process with input from multiple and diverse stakeholders?*

The need for the Project was identified by AEWSD staff, stakeholders, and technical advisors through continued interaction with and use of the AEGFM and Arvin-Edison DST and in response

to persistent water scarcity challenges and overdraft conditions experienced by beneficial users of groundwater within the District.

2. *Describe how the tool, method, or information will be applied and when will it be applied.*
    - *Will the tool or information be used immediately or will additional work need to be done before the tool will be used?*

The updated AEGFM and DST will be applied immediately upon completion of revisions and is expected to be used routinely to inform ongoing policy and management decisions such as optimizing water deliveries, banking, and recovery pumping operations, implementing groundwater pumping allocations or other demand management actions, and prioritizing water supply projects such as the expansion of AEWSD's surface water service area (SWSA) and spreading basin facilities.

3. *Describe, in detail, the extent of benefits that can be expected to occur upon implementation of the project, and provide support for your responses.*
    - *Who will use the tool or data developed under this proposal and **how** will they benefit from the project? Support could include but is not limited to letters from stakeholders expressing support for the project and explaining how they will benefit.*

AEWSD staff and water managers will primarily use the tool and data developed therein, and information will be disseminated to the AEWSD Board of Directors to aid in policy decisions. The implementation of this Project is expected to yield significant benefits to all beneficial users of groundwater within the District by improving AEWSD's abilities to predict the occurrence of and proactively design and implement adaptive policies to prevent and/or mitigate Undesirable Results associated with groundwater overdraft conditions and thus maintain continued compliance with SGMA regulations.

- *How will the project improve **water management decisions**?*

Specific water management decisions that will be improved by the Project include:

Water Supply Allocations: Enhanced abilities to predict groundwater elevation and land subsidence impacts across the District will help AEWSD water managers optimize allocation of its imported surface water supplies between direct delivery to customers within its SWSA and groundwater banking to maximize water level benefits during wet years when supplies are abundant and minimize water level impacts during dry years when supplies are limited or entirely unavailable.

Targeted Delivery, Banking, and Recovery: The tool will help AEWSD managers determine where, when, and how much water to deliver to individual SWSA units versus how much to recharge and/or recover at individual spreading and extraction well facilities. The information that this tool provides to District water managers will enable continued sustainable management of the groundwater system to quantitative MTs and MOs defined for water levels and land subsidence at individual SGMA RMS locations and to prevent Undesirable Results, such as damage to water infrastructure resulting from land subsidence.

Groundwater Demand Management: For the portions of AEWSD located outside the SWSA that are solely dependent on groundwater for agricultural irrigation, these improvements will enable water managers to identify targeted, quantitative groundwater pumping allocations or other demand reduction measures during dry periods to help minimize groundwater level declines and prevent occurrence of land subsidence.

Water Supply Project Prioritization: The tool will help AEWSD identify areas at high risk of future water level and land subsidence impacts and inform the prioritization and siting of future water supply projects, such as expansion of the existing SWSA, development of new groundwater banking facilities, and/or installation of new extraction wells.

Drought Management Activities: The updated groundwater flow model with integrated land subsidence data provides a better understanding of the available groundwater reserves during drought conditions which allows for proactive drought management planning, including the identification of sustainable pumping rates and the potential need for alternative water sources and their impact on land subsidence. During a severe drought, the DST can help water authorities make informed decisions about groundwater usage limits and the feasibility of groundwater banking or storage programs to mitigate the effects of water scarcity.

Conjunctive Use of Groundwater and Surface Water: Improving land subsidence predictions and adding a land subsidence forecasting capability into the DST enables a more holistic, programmatic approach to conjunctive use management. AEWSD water managers can better coordinate the use of groundwater and surface water resources to minimize subsidence-related risks and ensure continued SGMA compliance under future drought conditions.

- *Describe if the results of your project will be **applicable elsewhere**. What additional work would need to be done to make the project results transferable to others?*

A majority of numerical groundwater flow models utilize the AEGFM's underlying software platform (i.e., the United States Geological Survey (USGS) MODFLOW program) to evaluate groundwater management decisions and their impacts on groundwater level and land subsidence conditions. Furthermore, the Arvin-Edison DST is developed using open-source software that can be easily repurposed for similar applications. The techniques employed to develop and update the AEGFM and DST can therefore be adapted for use in other groundwater modeling and management applications. This project can serve as a valuable template for other water agencies, specifically in the San Joaquin Valley where hydrogeologic conditions and water management frameworks are often similar to those encountered in AEWSD. Achieving this will require robust technical coordination and information-sharing to facilitate the development of complementary tools that suit the individual needs of other water managers in the region.

- *To what extent will the project address the water management challenges described in E.1.1.?*

By improving the reliability and capabilities of the AEGFM and DST, the Project will make a substantial and immediate contribution to the water management challenges faced by AEWSD in the various manners detailed above.

4. *Explain how your project complements other similar efforts in the area where the project is located. Will your project complement or add value to other, similar efforts in the area, rather than duplicate or complicate those efforts? Are there other similar efforts in the area that have used a similar methodology successfully which can be complimented? Applicants should make a reasonable effort to explore and briefly describe related ongoing projects. Consider efforts by any Federal, state, local agency, or non-governmental organizations.*

The Kern County Subbasin is actively working to develop a subbasin-wide groundwater flow model (C2VSimFG-Kern). Similarly, the White Wolf Subbasin maintains a subbasin-wide groundwater flow model (WWGFM). Although the AEGFM and DST are specific to AEWSD's local conditions and operations, it is expected that improvements to the AEGFM will directly inform and benefit the simulation of AEWSD in both C2VSimFG-Kern and the WWGFM subbasin-wide models.

Other larger scale models of the entire California Central Valley that are currently in development or under refinement include the USGS Central Valley Hydrologic Model (CVHM2) and the DWR C2VSim-FG. Through the Kern County and White Wolf Subbasin modeling processes, data and model inputs are shared with DWR to improve simulation of groundwater conditions in C2VSim-FG.

Evaluation Criterion C—Project Implementation (20 points)

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

The AEGFM utilizes the USGS computer code MODFLOW 6 (Langevin et al., 2022); MODFLOW is a widely used numerical groundwater flow model code and is publicly available and supported by the USGS. MODFLOW 6 is the most up to date, core version of MODFLOW used to simulate coupled groundwater/surface-water systems, solute transport, aquifer-system compaction, land subsidence and groundwater management processes, and is an appropriate and effective computer code to solve the groundwater flow equation.

The AEGFM grid consists of 220 rows and 172 columns of cells that cover the entire AEWSD service area and its vicinity. The rectangular cells have a fine resolution of 660 feet (ft) by 660 ft (i.e., 10 acres) in the AEWSD service area and expand to 1,960 ft by 660 ft (i.e., 30 acres) in the eastern areas outside the District. The historical AEGFM simulates the period October 1994 through September 2021 using monthly stress periods; the model was calibrated to data through September 2016 and was tested against data from October 2016 to September 2021 as part of model verification.

The Arvin-Edison DST was developed as an accompanying tool to the AEGFM that allows the District to evaluate the impacts of common operational decisions, such as surface water delivery volumes and locations, groundwater pumping rates, and banking facility operations, on groundwater conditions underlying AEWSD. The DST is comprised of a dashboard built in R Shiny and run on a web browser. It has a user-friendly front end interface that allows District to create model scenarios, run the AEGFM, and evaluate and compare results with only a few clicks. Specifically, The DST interface contains multiple input panels where the District can specify

assumptions regarding future hydrology and water supply availability, how to deliver water to meet demands, whether there is a groundwater allocation on private pumpers, how to distribute water between SWSA units and spreading basins, and where to recover banked water from District wellfields. A fully integrated backend generates model input files, executes a projected 5-year AEGFM simulation, post processes outputs, and creates key visualizations automatically. After the model simulation is complete, the user can review critical time-series outputs typically used by AEWSD staff and board members to inform decision-making. These include hydrographs at SGMA representative monitoring sites relative to established MTs and MOs, maps of water level changes across the District, and graphical outputs that track groundwater recharge and recovery operations, water supply portfolios, water budget fluxes, and cumulative change in groundwater storage throughout the simulation period. The user can also directly compare model outputs between two scenarios, including reviewing relative changes in water levels at SGMA wells, impacts on groundwater storage, and balances within the District's groundwater banks between scenarios. This enables rapid evaluation of groundwater conditions and SGMA compliance under variable hydrologic conditions and/or operational management schema. A more detailed description of DST features including animations can be found at the following website: *https://www.ekiconsult.com/practice-areas/water-resources/dst/dst_gw/*

A more detailed description of the methodologies proposed for each Task is provided below.

Task 1. Update the Historical AEGFM and DST through Water Year 2023

Task 1 efforts will consist of updating all transient input datasets, including District operations (i.e., surface water deliveries, groundwater banking, recovery groundwater pumping), land use, evapotranspiration, municipal and industrial groundwater pumping data, and boundary conditions information to simulate groundwater flow conditions within the District through September 2023. Consistent with the development of the original historical AEGFM, we will employ the most reliable data sources to update the AEGFM through WY 2023. These data sources include, but are not necessarily limited to: (1) water supply, groundwater banking, recovery well pumping, water level monitoring, and land use field data collected from AEWSD staff; (2) climate data obtained from PRISM; (3) satellite-based evapotranspiration (ET) estimates developed with funding from Kern County and White Wolf Subbasin GSAs (e.g., ITRC-METRIC, LandIQ); (4) public water system usage data obtained from the SWRCB Division of Drinking Water (DDW); and (5) boundary conditions data from the Kern County and White Wolf Subbasin DMS and regional models mentioned above.

The extended AEGFM will be validated with recently collected groundwater elevation data from the District's groundwater elevation monitoring program from October 2021 – September 2023 and model parameters will be adjusted to achieve better water level calibration fit statistics (e.g., model residuals, root-mean square errors [RMSE]) as necessary. This may involve making both manual and computer-assisted adjustments to aquifer transmitting parameters such as hydraulic conductivity and storativity coefficients. Simulated groundwater elevation outputs from the extended AEGFM will then be integrated into the DST to update initial conditions for the short-term (5-year) DST simulation reflective of the end of WY 2023.

Task 2. Refine AEGFM Land Subsidence Package Using Newly Available Hydrogeologic and Land Subsidence Monitoring Datasets

Existing uncertainties in land subsidence simulation within AEGFM are primarily driven by two main categories: (1) uncertainty in land subsidence parameters defined in the MODFLOW6 Skeletal Storage, Compaction, and Subsidence (CSUB) package, and (2) a general lack of historical land subsidence monitoring data necessary for adequate model calibration.

Regarding CSUB parameterization uncertainty, the AEGFM currently relies on a simplified categorization process that averages lithology information collected from borehole log interval data process to identify and map the relative proportions of coarse- and fine-grained materials within each model layer, which might lead to oversimplifications in representing the presence and extent of fine-grained interbeds triggering land subsidence, particularly in areas with high proportions of fine-grained materials such as in the Corcoran Clay unit. Under Task 2, AEWSD will incorporate the results and data from recently completed hydrogeologic and land subsidence investigations, geophysical surveys, and other data-gap filling efforts to revisit and refine the representation of fine-grained interbeds and associated parameters in the CSUB package across the model domain. These datasets include, but are not necessarily limited to, DWR's 2023 statewide AEM Geophysical Survey[2], the 2023 Lawrence Berkeley National Laboratory (LBNL)[3] and Earth Consultants International (ECI)[4] land subsidence studies completed on behalf of the Kern Subbasin GSAs, and recently collected borehole log, geophysical, and aquifer pumping test data collected by AEWSD and other groundwater management agencies within the Kern Subbasin.

At the time of AEGFM development, very limited monitoring data existed to evaluate the threshold groundwater elevations at which inelastic subsidence has historically been triggered within the District. Furthermore, simulation of land subsidence using "no-delay" interbeds, which assumes an instantaneous ground surface displacement due to water release from storage, may result in a potential overestimation of land subsidence rates specifically in areas of the District where fine-grained materials are present at a high proportion (e.g., within the Corcoran Clay unit) and where residual land subsidence has historically been observed several years after drought conditions even after water levels have recovered[5]. Under Task 2, AEWSD will compile additional land subsidence monitoring data collected on and after October 2021 (i.e., the end of the original AEGFM historical period) to inform further updates to CSUB parameters controlling land subsidence occurrence within the AEGFM. These datasets include, but are not necessarily limited to, monthly InSAR satellite land subsidence monitoring data provided by DWR, continuous global

[2] Behroozmand, A. et al., 2023. DWR Statewide Airborne Electromagnetic Survey Project, Data Report for Survey Area 4 Kern County and White Wolf Groundwater Subbasins. Report, dated March 2 2023. https://data.cnra.ca.gov/dataset/9494c429-49d0-4b6a-842f-256f8775

[3] Lawrence Berkeley National Laboratory (LBNL), 2023. Draft report submitted to Patricia Poire, dated June 2023.

[4] Earth Consultants International, Inc. (ECI), 2023. Updated Differential Interferometric Synthetic Aperture Radar (DInSAR) Study of Subsidence in the Kern County Subbasin (KCS). Draft report submitted to Patricia Poire, dated June 2023. Subject to attorney-client privilege.

[5] Lees, M., Knight, R., and Smith, R., 2022. Development and Application of a 1D Compaction Mo0del to Understand 65 Years of Subsidence in the San Joaquin Valley. Water Resources Research, Vol 58 Issue 6, dated June 2022. https://doi.org/10.1029/2021WR031390C

positioning system (GGPS) station data provided by the USGS, and periodic land subsidence benchmark survey data collected by AEWSD and other monitoring entities within the Kern County Subbasin as part of SGMA implementation.

As with water level calibration, adjustments to CSUB parameters will be made to achieve better land surface elevation and change in elevation calibration fit statistics (e.g., model residuals, RMSE) as necessary. This may involve making both manual and computer-assisted adjustments to CSUB parameters such as skeletal storage and preconsolidation stress coefficients.

Task 3. Add Land Subsidence Forecasting Capability to Arvin-Edison DST

Under Task 3, the CSUB component of the AEGFM will be reconfigured to be compatible with the 5-year projected model files and added to the back-end modeling workflow of the DST to enable direct simulation of land subsidence within the DST. Similarly, the front-end interface of the DST will be revisited to add new panels, maps, and/or graphical components that visualize land subsidence occurrence across the District and at AEWSD's land subsidence RMS locations.

Task 4. Improve DST Data Pipeline to Enable Direct Integration with the Kern Subbasin and White Wolf Subbasin Data Management Systems

Under Task 4, AEWSD will reconfigure the DST back-end to retrieve data from the Kern County and White Wolf Subbasin DMS (likely through direct API integration) and will develop a process to automatically update initial conditions for the 5-year projected DST simulations to reflect the most recent available data obtained from the Subbasin DMS. This effort may involve additional back-end processing routines that relate newly obtained water level monitoring data to previous representations of initial conditions and perform adjustments to core MODFLOW input files that assign initial groundwater elevations within the AEGFM. Additional functionalities may be added to the DST front-end interface that allow the user to retrieve new data from the external DMS and trigger an initial conditions update, e.g., via a new "hot button" in the input panel.

2. *Describe the work plan for implementing the proposed scope of work.*

Table 1 - Work Plan

Task	Budget	Apr '24	May '24	Jun '24	Jul '24	Aug '24	Sep '24	Oct '24	Nov '24	Dec '24
Task 1: Update the Historical AEGFM and DST through Water Year 2023	$45,000									
Task 2: Refine AEFGM Land Subsidence Package Using Newly Available Hydrogeologic and Land Subsidence Monitoring Datasets	$50,000									
Task 3: Add Land Subsidence Forecasting Capability to Arvin-Edison DST	$30,000									
Task 4: Improve DST Data Pipeline to Enable Direct	$50,000									

Integration with the Kern Subbasin and White Wolf Subbasin Data Management Systems										
Task 5: Grant Management	$15,000									

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

The anticipated deliverables for this Project include:

- An updated set of AEGFM historical model files that reflect the AEGFM revisions proposed in Tasks 1 and 2 (*electronic product*);
- An updated version of the (web-based) Arvin-Edison DST that reflect the DST revisions proposed in Tasks 1 through 4 (*electronic product*); and
- A brief technical memorandum documenting all updates made to the AEGFM and Arvin-Edison DST (*written report*).

4. *Who will be involved in the project as project partners? What will each partner or stakeholder's role in the project be? How will project partners and stakeholder be engaged in the project and at what stages?*

AEWSD is the only entity involved in the Project. Throughout project development, stakeholders will be informed on progress during the regular AEWSD Board meeting updates. Furthermore, the Kern County and White Wolf Subbasin GSAs will be engaged as part of Task 4 to ensure successful integration with the subbasin-wide data management systems.

5. Identify staff with appropriate credentials and experience and describe their qualifications. Describe the process and criteria that will be used to select appropriate staff members for any positions that have not yet been filled. Describe any plans to request additional technical assistance from Reclamation or via a contract. Please answer the following:

AEWSD has retained consultant EKI Environment & Water (EKI) to provide technical support for SGMA implementation, including ongoing implementation of the AEWSD and DST. The EKI team has extensive experience developing and applying groundwater models and DST interfaces, including leading the development of the original AEGFM and Arvin-Edison DST. AEWSD will not request additional technical assistance from Reclamation.

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

The project team led the development of the original AEGFM and Arvin-Edison DST. The team is well prepared to carry out the proposed Project.

   b. *Is the project team capable of proceeding with tasks within the proposed project immediately upon entering into a financial assistance agreement? If not, please explain the reason for any anticipated delay.*

The project team will proceed immediately upon entering into a financial assistance agreement.

Evaluation Criterion D—Dissemination of Results (10 Points)

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

Results and interpretations obtained from the updated AEGFM and DST will be presented at regular AEWSD Board meetings, which are open to the public, and will be published on AEWSD's website (https://aewsd.org/). The Board will provide direction and policy decisions on what actions should be taken to build on Project results. The DST will help translate model results into an easily digestible and understandable format for policy makers and public stakeholders.

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

Not applicable.

- *Describe how the project results will be shared with other water managers in the West that could use the information to support water management objectives.*

Given the complexity and inextricably intertwined nature of groundwater management within the region, it is anticipated that Project results will be shared amongst water managers across Kern County and beyond. Furthermore, techniques developed and lessons learned from the Project are anticipated to be presented at regional water management conference(s). For instance, the original AEGFM and DST were presented at the Groundwater Resources Association of California (GRA) *Western Groundwater Congress* conference in September 2023.

Evaluation Criterion E—Presidential and Department of the Interior Priorities (10 points)

- *If applicable, describe how the project addresses climate change and increases resiliency. For example, does the project help communities respond to or recover from drought or reduce flood risk?*

The Project addresses a critical need to better forecast the impacts of future climate and water supply availability uncertainties on future groundwater conditions and ongoing SGMA compliance. The Project will allow for AEWSD to identify and adaptively mitigate impacts to groundwater level and land subsidence conditions due to drought, climate change, and other water supply uncertainties.

- *How will the project build long-term resilience to drought? How many years will the project continue to provide benefits? Please estimate the extent to which the project will build resilience to drought and provide support for your estimate.*

The Project will strengthen the District's resiliency to drought by providing for an informed means of designing and implementing adaptive conjunctive use programs and policies to maximize operational flexibility and ensure continued sustainable management of AEWSD's underlying groundwater system during drought periods. The AEGFM and DST are able to provide continued benefits for as long as they are maintained and kept up to date.

- *Will the proposed project reduce greenhouse gas emissions by sequestering carbon in soils, grasses, trees, and other vegetation? Does the proposed project seek to reduce or mitigate climate pollutions such as air or water pollution? Does the proposed project contribute to climate change resiliency in other ways not described above?*

The Project will help AEWSD plan adaptive policies and management actions to ensure continued, secure access to groundwater supplies for all beneficial users within the District. By optimizing future conjunctive use operations, AEWSD aims to allow landowners to maintain crops instead of permanently fallowing, thereby maintaining vegetative cover. Additionally, the updated AEGFM and DST will help maintain groundwater levels and prevent land subsidence, thereby reducing emissions created by pumping deeper groundwater and repairing damaged infrastructure.

- *Please use the Council on Environmental Quality's interactive Climate and Economic Justice Screening Tool, available online at Explore the map - Climate & Economic Justice Screening Tool (geoplatform.gov) to identify any disadvantaged communities that will benefit from your project.*

AEWSD overlies eight census tracts (06029006201, 06029006202, 06029006301, 06029006303, 06029006304, 06029006007, 06029005204, 06029001000) that are considered disadvantaged according to the Climate and Economic Justice Screening Tool, due to low income and associated socioeconomic thresholds in combination with climate change, energy, housing, and legacy pollution challenges. The Project area covers the severely disadvantaged community of Arvin and is supported by ACSD (see Appendix A), which relies 100% on groundwater supplies to provide drinking water to residents within the City of Arvin.

- *If applicable, describe how the project benefits those disadvantaged or underserved communities identified using the tool.*

The Project will increase the reliability of water supplies for residents within the severely disadvantaged community of Arvin and other domestic water users within the disadvantaged areas outlined above by providing an enhanced ability for AEWSD to plan for and mitigate groundwater elevation declines and land subsidence occurrence under future hydrologic and water supply uncertainties. This will allow AEWSD to maintain water levels so to prevent domestic wells from going dry, limit exposure to groundwater contamination owing to water level declines, and prevent negative economic consequences associated with land subsidence in these areas.

- *If applicable, describe how the project directly serves and/or benefits a Tribe, supports Tribally led conservation and restoration priorities, and/or if the project incorporates or benefits Indigenous Traditional Knowledge and practices.*

The project will not directly benefit Tribal Nations.

~~~ END OF TECHNICAL PROPOSAL AND CRITERIA SECTION~~

Project Budget

The non-federal, local cost share of the project will be borne entirely by AEWSD and is anticipated to be funded by the District's general fund.

Table 2 - Summary of non-Federal and Federal funding sources

FUNDING SOURCES	AMOUNT
Non-Federal Entities	
Arvin-Edison Water Storage District	$ 95,000
Non-Federal Subtotal	$ 95,000
REQUESTED RECLAMATION FUNDING	$ 95,000
TOTAL PROJECT COST	**$ 190,000**

Budget Narrative

Salaries and Wages

Salaries and wages will not be included the requested grant funding.

Fringe Benefits

Fringe benefits will not be included the requested grant funding.

Travel

There are no travel costs included in the requested grant funding.

Equipment

There are no project equipment costs included in the requested grant funding.

Materials and Supplies

There are no materials and supplies costs included in the requested grant funding.

Contractual

All work will be performed by consultants. Detailed consultant fee estimates are included in Appendix B showing the expected number of hours associated with each task and subtask.

Third-Party In-Kind Contributions

There are no third-party contributions for this project.

Environmental and Regulatory Compliance Costs

There are no environmental and/or regulatory compliance costs for this project.

Other Expenses

No other expenses are included in the requested grant funding.

Indirect Costs

There are no indirect costs included in the requested grant funding.

Environmental and Cultural Resources Compliance

- *Will the proposed project impact the surrounding environment (e.g., soil [dust], air, water [quality and quantity], animal habitat)?*

Not applicable. The proposed Project consists solely of computer modeling and thus will not impact the surrounding environment. There will be no earth-disturbing work and no impacts to air, water, or animal habitat.

- *Are you aware of any species listed or proposed to be listed as a Federal threatened or endangered species, or designated critical habitat in the project area? If so, would they be affected by any activities associated with the proposed project?*

Not applicable. The proposed Project consists solely of computer modeling and thus will not affect any endangered species or critical habitats.

- *Are there wetlands or other surface waters inside the project boundaries that potentially fall under CWA jurisdiction as "Waters of the United States"? If so, please describe and estimate any impacts the proposed project may have.*

Not applicable. The proposed Project consists solely of computer modeling and thus will not impact any wetlands or surface waters.

- *When was the water delivery system constructed?*

Not applicable. The proposed Project consists solely of computer modeling and thus will not utilize water delivery system(s).

- *Will the proposed project result in any modification of or effects to, individual features of an irrigation system (e.g., headgates, canals, or flumes.*

Not applicable. The proposed Project consists solely of computer modeling and thus will not result in any modification of or effects to individual features of an irrigation system.

- *Are any buildings, structures, or features in the irrigation district listed or eligible for listing on the National Register of Historic Places?*

It is not certain whether any buildings, structures, or features in the District listed or eligible for listing on the National Register of Historic Places; however, the proposed Project consists solely of computer modeling and thus will not affect any such features.

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

No known archeological sites are present in the proposed Project area.

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

No. Any effects on low income or minority populations are expected to be positive, as the Project will allow for better planning and more efficient management of water resources.

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

Not applicable. The proposed Project consists solely of computer modeling and thus will have no effects on Indian sacred sites or tribal lands.

- *Will the proposed project contribute to the introduction, continued existence, or spread of noxious weeds or non-native invasive species known to occur in the area?*

Not applicable. The proposed Project consists solely of computer modeling and thus will not contribute to the introduction, continued existence, or spread of any noxious weeds or non-native invasive species.

Required Permits or Approvals

No permits or approvals are required for this project.

Overlap or Duplication of Effort Statement

There is no overlap between the proposed Project and any other active or anticipated proposals or projects. Furthermore, this proposal is not in any way duplicative of any proposal or project that has been or will be submitted for funding consideration to any other potential funding source.

Conflict of Interest Disclosure Statement

No actual or potential conflict of interest exists at the time of this proposal's submission.

Uniform Audit Reporting Statement

The District was not required to submit a Single Audit Report for the most recently closed fiscal year (FY 2022).

Appendix A: Letters of Support

ARVIN COMMUNITY
SERVICES DISTRICT

Serving the Community of Arvin
since November 26, 1956

DIRECTORS

Aurelio Reyna, President
Maria Alvarez, Vice President
Rafael Gallardo, Director
Maria Pantoja, Director
Adam Ojeda, Director

STAFF

Raul Barraza, Jr., General Manager
Alexis Gaona, Chief Operator

CONSULTANTS

Dee Jaspar, District Engineer
Alan J. Peake, Legal Counsel

October 13, 2023

Arvin-Edison Water Storage District
Attn: Jeevan Muhar, Engineer-Manager
P.O. Box 175
Arvin, CA 93203

Re: Letter of Support for Arvin-Edison Water Storage District's Application for the USBR WaterSMART Applied Science Grant for Fiscal Year 2023 No. R23AS00446

To Whom It May Concern,

This letter is to offer support for Arvin-Edison Water Storage District's (AEWSD) application for the WaterSMART Applied Science Grant for Fiscal Year 2023. AEWSD's *Arvin-Edison Groundwater Flow Model and Decision Support Tool Updates and Upgrades* Project will be a benefit to the region by providing a tool that can used utilized to support Sustainable Groundwater Management Act (SGMA) compliance, provide ongoing operational decision support, and scenario testing to ensure continued successful water management in our region.

Arvin CSD recognizes the value of projects that can increase water management flexibility and water supply reliability in rural communities. This project aligns with AEWSD and Arvin CSD's water management goals to achieve long-term sustainability and to provide continued access to safe and reliable water supplies for all stakeholders within our collective service areas.

Sincerely,

Raul Barraza, Jr.

309 Campus Drive
Arvin, CA 93203

Phone 661.854.2127
Fax 661.854.8230

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