Attachment 5 – Work Plan

Att5_LGA12_NSJCGBA_WrkPln_1of1

The work plan must be consistent with and support the budget and schedule. The level of detail must be sufficient for the work plan to function as the scope of work for the agreement and to allow reviewers to understand the level of effort of the work being performed as to further substantiate the cost estimates in the budget. If the applicant does not have an existing GWMP, then it should use this section to detail the process by which one will be created. The work plan should include, at a minimum, the following items:

- *Scope of the proposed project including (as appropriate) maps of agency area and area of proposed tasks;*
- *Specific purpose, goals, and objectives of the proposed project related to improving groundwater management and implementing the GWMP and/or where applicable the IRWM Plan;*
- *Work items to be performed under each task of the proposed tasks (consistent with the budget and schedule);*
- *Present a sound strategy for evaluating progress and performance at each step of the proposed project.*
- *Project deliverables for assessing progress and accomplishments, which include quarterly progress and final reports.*
- *If access to private property is needed, provide assurance that access can be granted. For example, if wells will be constructed or sampled on private land, submit a letter or agreement that demonstrates that access for well construction and monitoring on the property has been obtained.*
- *Explain the plan for environmental compliance and permitting, including a discussion of the following items: a description of the plan, proposed efforts, and approach to environmental compliance, including addressing any CEQA obligations in connection with the proposal; a listing environmental related permits or entitlements that are needed for the project; and any other applicable permits that will be required. Briefly describe the process and schedule for securing each permit/approval. Discuss necessary local drilling permits and the submittal of Well Completion Reports to DWR. Describe the proposed process for securing each environmental permit and any other regulatory agency approval.*

Long-term Project Need. The needs of the Eastern San Joaquin Region have been identified in collaboration with stakeholders through development of the Groundwater Management Plan, Integrated Regional Water Management Plan, and other efforts over the last 12 years. The existing regional groundwater model has served its purpose in assessing regional-scale opportunities and impacts. As IRWMP projects move toward implementation, a more detailed modeling effort is required to address opportunities, benefits, and impacts at a more localized level. The proposed project will the necessary tools to accomplish this.

The purpose of the Project is to develop a numerical groundwater flow model to enable analysis of potential recharge and groundwater banking projects within the Eastern San Joaquin IRWM Region. Proposed projects include the Stockton East Water Bank and the Freeport Element of the American River Utilization Strategy[9]. The San Joaquin County Groundwater Banking Model (the Model) will build on previous model efforts for the area by the USGS (Central Valley Hydrologic Model [CVHM])[10] and CDM (2007)[11] but provide more detail in the area of the proposed conjunctive use projects. The

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[9] GEI Consultants, 2011. *Freeport Element of the American River Use Strategy, Phase 1: Final Draft Feasibility Study.*

[10] Faunt, C. 2009. *Groundwater Availability of the Central Valley Aquifer, California*. USGS Professional Paper 1766

[11] CDM, 2007. As reported in chapter 6 of: Eastern San Joaquin Integrated Regional Water Management Plan, July 2007.

preliminary model boundary for the Project is approximately 15 miles east to west and 25 miles north to south and centered around the proposed project facilities (see Figure 1). The final model domain (see Section 4.1) will be determined based on a review of the available data and the results of the conceptual model development. Once completed and calibrated, the Model will be used to analyze various artificial recharge and recovery scenarios in order to establish operational criteria and provide support for environmental studies necessary for project implementation. The MODFLOW modeling package will allow linkage to the larger CVHM model, or for future expansion beyond the study area as funds become available.

Task 1 – Project Coordination, Planning and Meetings

It is anticipated that meetings will be necessary to coordinate obtaining and reviewing supplemental data, presenting model progress updates and preliminary model results, and answering questions regarding model results and findings. This task includes eight meetings in the Stockton area during the project, the duration of which is estimated to be approximately 12 months (see Figure 2 in Attachment 7). This task also includes monthly email status updates and periodic phone correspondence with San Joaquin County and other stakeholders.

Task 2 – Obtain and Review Data for Model Development

Data required to develop the groundwater flow model will build from the existing USGS geospatial database and datasets for the CVHM and data from CDM (2007). Supplemental data not available from the USGS will be obtained from various local and State entities including (but not limited to) San Joaquin County, Stockton East Water District, North San Joaquin Water Conservation District and others. The types of data to be requested includes well locations, borehole lithologic and geophysical logs, well construction information, historical groundwater levels, pumping test data, historical groundwater production data, historical artificial recharge data, groundwater quality data and land use/crop patterns. In addition, geologic and hydrogeologic reports for the area, soils maps, geologic maps, land use maps, precipitation data, evapotranspiration data, and streamflow data will also be required from published reports and public databases. Where possible, data will be acquired in electronic format as database or spreadsheet files. Maps and aerial coverages of data will be obtained as Geographic Information System (GIS) files to expedite the analysis.

Task 3 – Refine the Conceptual Model of the Project Area

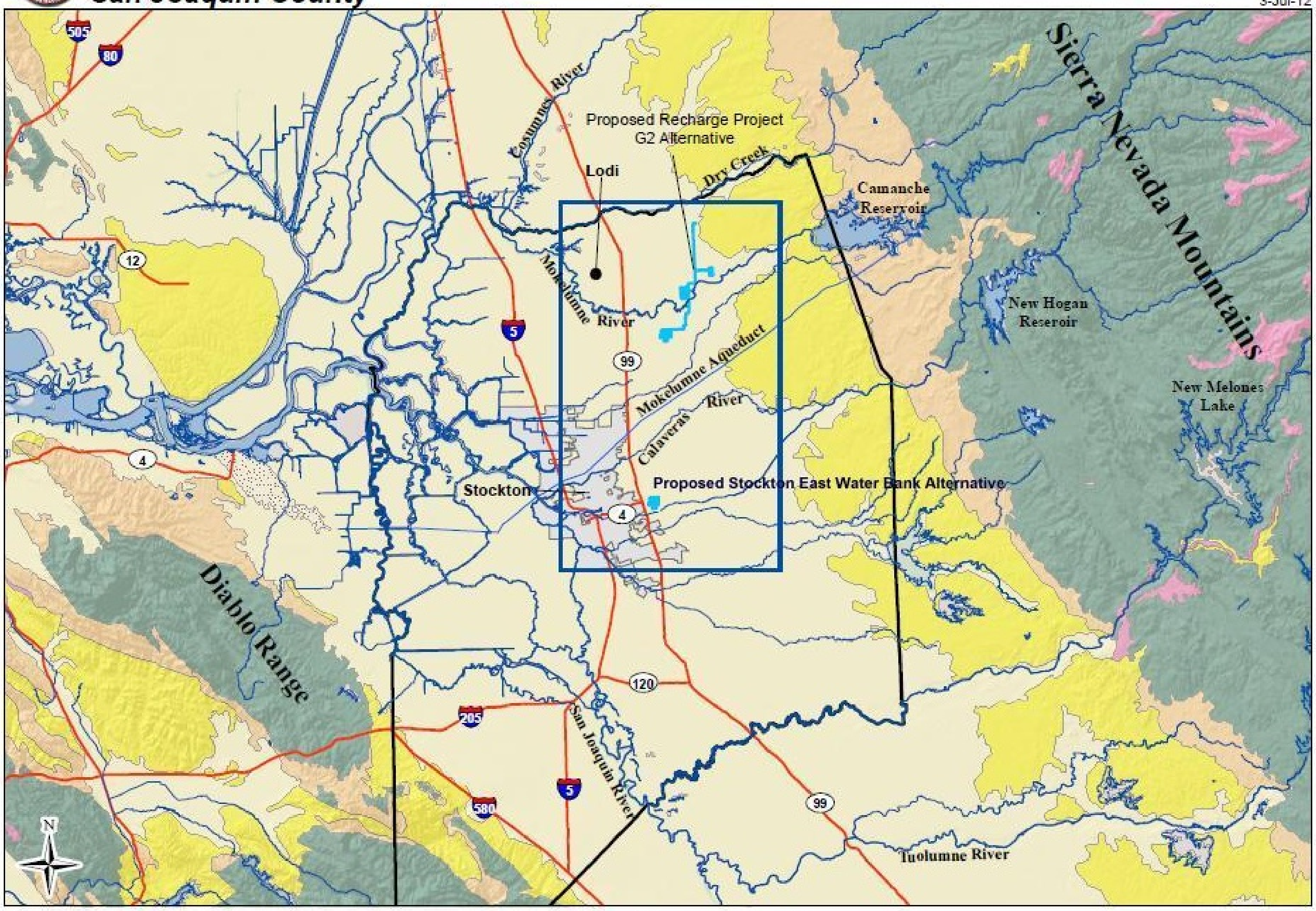
Subtask 3.1 Prepare and Analyze Detailed Hydrogeologic Cross Sections

In order to develop a more complete understanding of the stratigraphy (i.e. geologic layering) and aquifer system characteristics, it will be necessary to prepare detailed hydrogeologic cross sections across the Model Area (Figure 1). Six cross sections are proposed. Cross section locations will be selected to coincide with boreholes/wells with detailed lithologic and geophysical data. Other data to be included on the cross sections will include groundwater levels, well perforation intervals, groundwater quality data, isolated aquifer zone test data, and pumping test flowmeter data, as available. The cross sections along with the textural analysis (Subtask 3.2), will provide the basis for selection of model layer boundaries.

7/12/12 rev7

San Joaquin County

Local Groundwater Assistance Grant Program



NAD 83 UTM Zone 10
Central Meridian: -123

Map Features

- Proposed Model Domain
- Proposed Recharge Project G2 Alternative
- Quaternary Alluvial Deposits
- Quaternary Sand Deposits
- Plio-Pliestocene Loosely Consolidated Deposits
- Tertiary Sedimentary Rocks
- Tertiary Igneous Rocks
- Mesozoic & Paleozoic Rocks
- Water Courses
- Freeways
- Stockton City Limits
- San Joaquin County

Basemap source esri.com.

Geology modified from USGS Open-File Report 2005-1305.

DRAFT

Proposed Project and Model Domain

Figure 1

Subtask 3.2 Enhanced Textural Analysis

A sediment-texture analysis will be done following the methodologies developed by the USGS for its CVHM. The sediment-texture analysis will primarily provide initial estimates of hydraulic conductivity for the MODFLOW model but will also provide supplementary benefits to the management of groundwater banking in the region. Two sets of sediment-texture data will be used: those from the USGS CVHM, and those developed by the project team performing the work for the Stockton East Water District. Existing USGS sediment-texture data will be utilized for the area of the localized numerical groundwater-flow model in USGS' MODFLOW code. [12] To enhance the sediment texture data available from the USGS' CVHM sediment-texture dataset for the local-area MODFLOW model, additional geologic data from within and adjoining the MODFLOW model area will be added to increase the density of information for a geospatial analysis. These additional data will be obtained from well and borehole lithologic-logs from the California Department of Water Resources, as well as from other sources across the model domain area. The sediment-textural analysis will be conducted using high-quality lithologic logs vetted from those obtained in the model area search, in combination with the USGS datasets. The selected lithologic logs will be reduced to a binary classification of texture as described in CVHM (i.e. each thickness of units described as primarily sand would be coded 1, and each thickness of units described as primarily clay would be coded 0). The binarily-reduced lithologic data will then be sampled for the percent-coarse over a 50-foot thickness as used for CVHM, or over a smaller sampling thickness as indicated by the data and the model vertical grid refinement. This provides each percent-coarse variable with an X, Y, and Z coordinate for geospatial analysis.

A geospatial sediment-texture analysis will then be conducted on the percent-coarse parameter using publicly available geostatistical software for kriging interpolation of the texture data, such as the library of codes from Stanford University (Geostatistical Software Library, a.k.a. GSLIB; Stanford University n.d.).[13] Proprietary geostatistical software that has not undergone peer review will not be used for the work in order to avoid the potential for mathematical error and to enable reproducibility of results by any end user or subsequent user of the geospatial textural analyses.

Results of the sediment-texture analysis will then be used to generate starting values of hydraulic conductivity for calibration of the MODFLOW model. Initial values for hydraulic conductivity will be estimated following the CVHM methodology for estimating hydraulic conductivity in the San Joaquin Valley (Figure C14 and related text at pp. 154–160 of USGS Professional Paper 1766, CVHM). These initial values will be utilized, along with groundwater elevation data, extraction data, and estimates of groundwater recharge to calibrate hydraulic conductivity using inverse parameter fitting routines. The relative relationships of hydraulic conductivity from textural analysis will be maintained during model calibration. This methodology will produce better relative estimates of conductivity laterally and

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[12] USGS Sediment Texture Datasets are available to the public at https://docs.google.com/viewer?url=http%3A%2F%2Fca.water.usgs.gov%2Fprojects%2Fcvhm%2Fwell-log-texture.xls

[13] Stanford University. n.d. Geostatistical Software Library (GSLIB). (A collection of public domain mathematical computer codes compiled over more than a decade by a variety of researchers at Stanford University).

vertically that will be particularly beneficial in evaluating vertical recharge projects and lateral movement of groundwater.

Further to the value in calibrating the MODFLOW model, the sediment texture analysis will provide new insight about potential connections between aquifer units within areas of proposed groundwater banking. This will enable a better understanding of the impacts of groundwater banking on groundwater availability in an area, the potential impacts of groundwater mounding from water banking, the change in relative pressures in different aquifer units, and the optimal locations for both withdrawal of water and the addition of water in place and time.

Subtask 3.3 Assess the Lateral and Vertical Extents of Aquifer Parameters

It will be necessary to define initial aquifer parameter values and refine their spatial distribution across the Model Area. Parameters include horizontal hydraulic conductivity, vertical hydraulic conductivity, and specific storage. Initial hydraulic conductivity values derived from the textural analysis will be constrained to pumping test data and specific capacity data. These data will also be used to establish spatial zones of equal aquifer parameter values across the model area and for each layer. Aquifer parameter zones will be developed in GIS and exported to the model. The initial values for each zone will be refined further through the calibration process.

Subtask 3.4 Prepare Groundwater Level Hydrographs for Calibration Target Wells and Boundary Condition Wells

Groundwater level hydrographs will be generated for wells located within the Model Area that have been identified as calibration targets or to help constrain boundary conditions. Considerations for selection of wells as calibration targets or boundary conditions will include the well perforation interval, completeness and reliability of the record, and well location. If possible, the spacing of the wells will be sufficient to provide transient groundwater level trends in the areas of proposed projects and major hydrogeologic regions of the Model. Groundwater level hydrographs for numerous wells in the Model Area have already been compiled. These data will be processed into a form for input to the Model. The budget for this task includes processing of up to 50 long-term hydrographs (e.g. 1980 to present) in the Model Area.

Subtask 3.5 Prepare Groundwater Level Contour Map

A groundwater level contour map will be generated for the start of the transient calibration period to serve as the initial head distribution. The map will be digitized into an electronic format for export to the Model.

Subtask 3.6 Analyses of Historical Land Use and Irrigation Demand

The land use for a significant portion of the Model Area is agricultural and most of the agricultural water demand is met from groundwater pumping. Because agricultural well pumping is rarely metered, it will be necessary to develop production estimates based on published crop water demands and maps of cropping patterns in the Model Area. Spatial and temporal cropping patterns will be refined from the USGS model, as well as in consideration of published digital land use maps from the California Department of Water Resources and those under development for the Eastern San Joaquin IRWMP Update. Groundwater production will be developed for the agricultural areas based on land use and associated crop water demand.

Subtask 3.7 Analyses of Precipitation and Evapotranspiration

Climatic data will be obtained from the USGS CVHM model, the California Irrigation Management Information System database, and other public domain sources of information. The spatial and temporal precipitation data will be analyzed to develop refined estimates of areal recharge for the Model. Evapotranspiration data will also be analyzed for application to surface water and shallow groundwater within the Model Area. Adjustments in production estimates will be made in areas where crop water demand is also achieved with surface water deliveries.

Subtask 3.8 Analysis of Stream Flow Data

The interaction between surface water and groundwater in the Model Area will be addressed through an analysis of stream flow data. For rivers within the Model Area that were included in the USGS CVHM model e.g. Mokelumne River), the existing data will be refined for incorporation into the Model. Surface water flow data for the Calaveras River, and others that transect the Model Area, will be obtained from public domain databases. It will also be necessary to conduct an analysis of stream channel width, depth and characteristics (e.g. Manning's Coefficient) for each major river/stream in the Model Area.

Task 4 – Design the Numerical Model

The groundwater flow model for the Project Area will be developed using the United States Geological Survey's (USGS's) code MODFLOW, a highly versatile three dimensional, finite difference numerical groundwater flow modeling code that is public domain software and widely accepted in the groundwater industry for regional flow modeling problems. Model development, pre-processing and post-processing will be conducted using an accepted user interface program.

Subtask 4.1 Refine the Model Domain and Design the Grid

A preliminary model domain has been identified for the purposes of collecting data during Task 1 activities. After developing the conceptual model and identifying an optimum grid size, it may be necessary to modify the domain slightly, and then incorporate the grid into the domain of the model. The grid size and orientation will take into consideration the possibility that the model may be expanded in the future to incorporate a larger portion of San Joaquin County.

Subtask 4.2 Establish Model Layers

As with previous models of the area, it will be necessary to develop multiple layers within the model. Layers define hydrogeologic horizons with similar properties or characteristics such as hydraulic connectivity, confinement or other. Previous models of the area have different layering schemes, and where possible, this modeling effort will build upon the previous work.

The primary tool for defining the layer boundaries for the model will be the hydrogeologic cross sections and enhanced texture analysis developed in Subtasks 3.1 and 3.2. Once the layers have been identified, it will be necessary to develop structure contour maps of layer surfaces for incorporation into the model. The land surface for the model will be imported from Digital Elevation Maps (DEMs) provided by the USGS. Structure contour maps of subsurface layer boundaries will be digitized into electronic format and imported into the model. The scope of work assumes up to four model layers.

Subtask 4.3 Establish Boundary Conditions

Boundary conditions will need to be established for the model domain. This will include conditions for the model boundaries, wells, recharge basins, and any unlined canals. The locations of key features for the model (e.g. wells, recharge basins, unlined canals, etc.) will be obtained from existing models, databases, or GIS datasets. The pre-calibration initial head distribution will also be imported from the groundwater contour map generated in Subtask 3.5. The budget for this task assumes that the locations of wells and recharge basins will be provided as GIS-compatible electronic files by San Joaquin County (SJC).

Subtask 4.4 Prepare Model Input Files

The groundwater flow model will be developed and calibrated for the period between 1982 and 2012. The 30 year transient calibration period encompasses multiple wet and dry hydrologic cycles and will enable calibration of a wide range of historical groundwater level changes. Stresses in the model such as pumping and recharge will be applied on a monthly basis (monthly stress periods).

Model input files will be developed using monthly stress periods for the 30 year transient period for the inflow and outflow factors that impact the water balance of the model. These include, but are not necessarily limited to, the following:

- Areal recharge from precipitation
- Streamflow
- Return flow recharge
  - Septic return flow
  - Agricultural irrigation return flow
  - Municipal and industrial return flow
- Artificial recharge
- Agricultural production
- Municipal production
- Evapotranspiration

Where possible, model datasets from the existing models will be used to develop input files. However, it will be necessary to refine existing datasets to accommodate the monthly stress periods and incorporate individual pumping wells into the model.

Task 5 – Calibrate the Groundwater Flow Model

Subtask 5.1 Model Calibration

The groundwater flow model will be calibrated using the history-matching technique whereby model input parameters will be adjusted until model-generated groundwater levels and surface water flow provide an acceptable match with measured groundwater levels and surface water flow. The calibration will be conducted as a two-step process including a steady-state calibration of initial heads and a transient calibration for the 30-year period from 1982 to 2012. The calibration will be optimized through an inverse parameter estimation process. The adequacy of the model calibration will be determined using statistical methods.

Subtask 5.2 Sensitivity Analysis

Following calibration, a sensitivity analysis will be conducted to determine which input parameters have the greatest impact on the model results and assess the adequacy of model calibration. This will be conducted by rerunning the model after increasing the value of model input parameters by 20 percent and then again after decreasing input parameter values by 20 percent. The results of the sensitivity analysis will be plotted on graphs and presented in the summary report described in Task 7.

Task 6 – Analysis of Proposed Project Operations Using the Calibrated Model

The groundwater flow model will be used to analyze potential changes in groundwater levels associated with recharge operations for the Stockton East Water Bank and Freeport Element of the American River Utilization Strategy. Specifically, the analysis will focus on recharge for the G2 Alternative at proposed facilities along the Mokelumne River, as well as in the vicinity of the Stockton East Water Bank (see Figure 1).

Subtask 6.1 Develop Project Operational Scenarios

In order to evaluate groundwater impacts from the G2 Alternative, it will be necessary to develop detailed project operational scenarios for the analysis with the calibrated model. The scenarios will identify the timing, location and amounts of recharge for inputs into the model for a 20-yr predictive period. Assumptions will also need to be developed for future land use/agricultural pumping, municipal pumping, hydrology, and other factors that impact the water balance over the 20-yr simulation period. The scope of work is based on development of three operational scenarios.

Subtask 6.2 Analysis of Operational Scenarios with the Model

Input files will be developed for each project operational scenario (three scenarios). Output from model runs will be used to develop groundwater contour maps, maps showing potential groundwater level changes associated with the Project, and hydrographs of up to ten observation wells in the Project area showing change in groundwater elevation over time.

Task 7 – Prepare a Report of Model Analysis Findings

The groundwater flow model development, calibration, and analysis will be summarized in a report that will include the following:

- A background and purpose for the model
- A description of the hydrogeologic setting and conceptual model
- A description of the modeling methodology
- A description of the model design
- Results of the model calibration
- Results of the sensitivity analysis
- A description of the model scenario evaluated with the model
- Results of the analysis of the model scenario
- Conclusions

The report will include maps showing the model area, hydrogeologic setting, wells and recharge basins, boundary conditions, input parameter distribution and model analysis results. Detailed cross sections will be provided on Plates at the end of the report. Supporting data and information will be provided in appendices as appropriate.

CEQA Compliance and Property Access. Development of the Groundwater Banking Model and scenario testing will not require environmental documentation nor access to private property. Once operational, the model will be useful in support of required project implementation environmental documentation and property access agreements.