HARGIS + ASSOCIATES, INC.
HYDROGEOLOGY • ENGINEERING

La Jolla Gateway
9171 Towne Centre Drive, Suite 375
San Diego, California 92122
Phone: 858.455.6500
Fax: 858.455.6533

October 2, 2017

VIA E-MAIL

Mr. David P. Bolin, CHG
Principal Hydrogeologist
ORANGE COUNTY WATER DISTRICT
18700 Ward Street
Fountain Valley, CA 92708

Re: Groundwater Modeling Scope of Work and Cost Estimate,
South Basin Groundwater Protection Project

Dear Mr. Bolin:

Hargis + Associates, Inc. (H+A) is providing this letter and associated attachments in response to your request for a scope of work and cost estimate to conduct groundwater modeling for the South Basin area of the Orange County Groundwater Basin as part of the South Basin Groundwater Protection Project (SBGPP).

Groundwater modeling will be conducted in support of Feasibility Study evaluations to develop an interim remedy that addresses regional contaminants of concern that have impacted groundwater within the South Basin. Specifically, the objective of the South Basin groundwater model is to simulate a flow field that is representative of groundwater flow conditions in the area to provide a tool that will aid in evaluation of interim remedial alternatives. The evaluations will be based on model-projected water levels and particle tracking using a flow-modeling approach.

SCOPE OF WORK

The groundwater modeling task will involve several subtasks including: Task 1a) Numerical groundwater flow model development; Task 1b) Numerical groundwater flow model calibration; Task 1c) Remedial alternative simulations; Task 1d), Sensitivity analysis; and Task 1e) Preparation of an appendix to the Feasibility Study report summarizing modeling activities.

Task 1a – Groundwater Flow Model Development

A groundwater flow model will be developed based on the hydrogeologic conceptual model of the regional and local groundwater system.

Other Offices:
Folsom, CA
Mesa, AZ
Tucson, AZ

Model Code

The following computer modeling codes will be used in the study: 1) the Hydrogeologic, Inc. (HGL), finite difference code MODFLOW-SURFACT (HGL, 1996 and 2011); MODFLOW-SURFACT is based on, and constitutes additional modules to, the U.S. Geological Survey code MODFLOW (McDonald and Harbaugh, 1988); and 2) MODPATH for particle tracking to evaluate flow direction and vertical gradients (Pollock, 1994).

Model Domain

A transient, three-dimensional groundwater flow model will be developed to simulate groundwater flow, recharge, and groundwater withdrawal within the model domain (SBGPP Model). The extent of the SBGPP Model domain will encompass the SBGPP with sufficient distance to the edges of the model such that potential effects from specified head boundaries along the edge of the model (discussed below) are minimized. Development of the flow model will require definition of the geometry of hydrostratigraphic units; the hydraulic parameters that control groundwater flow; the rates and locations of recharge and groundwater withdrawal; and the water level conditions along the model boundary.

Orange County Water District (OCWD) has developed a regional basin-wide model that includes the South Basin area that was most recently updated in 2011 (Basin Model). Where appropriate, parameters used in the OCWDs existing basin-wide model will be incorporated into the SBGPP Model, and refined to incorporate results of recent local field investigations in the South Basin.

Model Grid

It is anticipated that the model grid will be finite difference with finest grid spacing in the vicinity of the SBGPP, coarsening toward the edges of the model domain.

Model Layering

It is anticipated that the model will include the following layers:

- Layers 1 to 5 will represent equal thickness layers of the Shallow Aquifer system (Layer 1 of OCWD Basin Model). The top of Layer 1 will be land surface. The elevation of the bottom of the Shallow Aquifer system will be based on the OCWD Basin Model and updated based on lithologic data obtained since the 1999 Basin Model layering update. It is assumed that the underlying data (i.e. elevation picks from lithologic and geophysical logs) used to develop the bottom of the Shallow Aquifer system in the Basin Model will be provided by OCWD.

- Layer 6 will represent the finer-grained zone between the Shallow and Principal Aquifer systems. The elevation of the bottom of Layer 6 (top of the Principal Aquifer system) will be based on OCWD Basin Model.

- Layer 7 will represent an equal thickness of the upper-most portion of the Principal Aquifer system (Layer 2 of the OCWD Basin Model represents the entire thickness of the Principal Aquifer system).

Boundary Conditions

Time-varying specified head boundaries will be assigned around the perimeter of the aquifer layers (Shallow Aquifer layers 1 to 5, upper Principal Aquifer Layer 7) to approximate regional flow directions and gradients. For Shallow Aquifer layers 1 to 5, specified head values will be based largely on water levels generated by the Basin Model for time periods through 2011, and water level contours of measured water levels in the study area for the period 2012 to 2017. For the upper Principal Aquifer Layer 7, specified head values will be based on water level contours of measured water levels in monitor wells screened in the upper Principal Aquifer for the period 2012 to 2017 (period of available water levels). Prior to 2012, water levels in the upper Principal Aquifer will be estimated based on water levels generated by the Basin Model for the lower Principal Aquifer and adjusted using the relationship of upper Principal Aquifer to lower Principal Aquifer water levels observed in measured water levels during the period 2012 to 2017. Specified heads will be set at times corresponding to seasonal water level highs and lows, and linearly interpolated for the intervening time periods. It is assumed that water levels generated by the Basin Model for the Shallow and Principal Aquifer layers during seasonal water level highs and lows for the period 2007 to 2011, and available water level contours for the Shallow and Principal Aquifers, will be supplied by OCWD.

Hydraulic Parameters

As a starting point, the distribution of horizontal hydraulic conductivity within Layers 1 to 5 in the SBGPP Model will be based on cone penetrometer test logs generated as part of the SBGPP such that the cumulative transmissivity of SBGPP Model Layers 1 to 5 will be similar to the Basin Model Layer 1 and factoring aquifer test results from the SBGPP monitor wells. The horizontal hydraulic conductivity within the Principal Aquifer layer will be based on the OCWD Basin Model. The distribution of vertical hydraulic conductivity within model layers will be initially related to horizontal hydraulic conductivities. As a starting point, the distribution of confined and unconfined storage, within all model layers, will be based on the OCWD Basin Model. It is assumed that hydraulic parameters from the OCWD Basin Model will be provided by OCWD.

Recharge

Recharge to the model domain will be derived from precipitation infiltration, seepage from channels, and irrigation return flow. Distribution of recharge across the model domain will be based on identified land use from aerial photographs. Recharge rates will be derived from reclaimed water deliveries, estimated irrigation rates, and precipitation.

Groundwater Withdrawal

Groundwater withdrawal will be simulated within the model domain to represent operation of source site groundwater extraction and treatment systems (GETs). Groundwater withdrawal from active regional pumping wells in the vicinity of the SBGPP will not be simulated as the well screens are below the bottom-most layer of the SBGPP Model. It is assumed that model pumping rates and screened intervals for Source Site wells will be based on data provided by OCWD and is readily available.

Task 1b – Groundwater Flow Model Calibration

Model calibration will be performed to benchmark the model against measured groundwater conditions in the study area. The objective of the flow calibration will be to obtain an acceptable agreement between measured and projected groundwater levels, flow directions, and vertical gradients. The transient calibration model will simulate the time period from 2007 through 2017 such that a complete wet/dry precipitation cycle is simulated during a timeframe where sufficient water level data are available. Hydraulic parameters will be varied within reasonable ranges based on available data to achieve an acceptable match. It is assumed that model calibration will require up to ten model simulations.

Task 1c – Remedial Alternative Simulations

The calibrated groundwater flow model and associated particle tracking will be used for simulating alternative wellfield configurations to evaluate potential remedial alternatives. Specifically, the model will be used as a tool to develop the location and number of wells and estimated flow rates required for containment. It is assumed that the model future simulations will also include projected operations for regional pumping wells and source site GETs. In future simulations, the wet/dry cycle used in the ten year model calibration period will be repeated such that the desired total simulation time is achieved. It is assumed that up to five separate wellfields may be simulated concurrently.

Task 1d – Sensitivity Analysis

Sensitivity of the model wellfield simulation results to changes in storage, vertical and horizontal hydraulic conductivity, and recharge will be evaluated using the model. It is assumed that sensitivity analysis will consist of up to eight model simulations.

Task 1e – Model Appendix Preparation

Modeling activities will be summarized in an appendix to the Feasibility Study report. The appendix will include a detailed description of model development, calibration, well field simulations and sensitivity analysis results.

SCHEDULE AND COST

It is anticipated that the work described herein would commence in February 2018 and would be concurrent with preparation of the Feasibility Study. Estimated costs for this scope of work are included in Attachment 1.

CLOSING

We very much appreciate the opportunity to support the District on this project and look forward to our continued involvement on the project. If you have any questions or desire additional information, please contact us.

Sincerely,

HARGIS + ASSOCIATES, INC.

Christopher G.A. Ross, PG, CHG
Principal Hydrogeologist
Director of California Operations

Kevin L. Coons, PE
Principal Engineer/Project Manager

CGAR/KLC/jak

Attachment 1: Groundwater Modeling Cost Estimate, OCWD, South Basin Groundwater Protection Program

Attachment 2: Professional Resume, Stacia L. Prazen, PG, Senior Hydrogeologist, Hargis + Associates, Inc.

REFERENCES

Hydrogeologic, Inc., 1996. MODFLOW-SURFACT Software

_____, 2011. MODFLOW-SURFACT Software (Version 4.0)

McDonald, M.G., and A.W. Harbaugh, 1988. A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model. U.S. Geological Survey, Washington, D.C. 1988

Pollock, D.W., 1994. User's Guide for MODPATH/MODPATH-PLOT, Version 3: A particle tracking post-processing package for MODFLOW, the U.S. Geological Survey finite-difference ground-water flow model. September 1994

HARGIS + ASSOCIATES, INC.

Attachment 1

Groundwater Modeling Cost Estimate
OCWD - South Basin Groundwater Protection Project

			TASK 1a	TASK 1b	TASK 1c	TASK 1d	TASK 1e	
CATEGORY	**UNIT COST**	**UNITS**	**Groundwater Numerical Flow Model Development**	**Groundwater Numerical Flow Model Calibration**	**Model Remedial Alternative Simulations**	**Sensitivity Analysis**	**Prepare Modeling Appendix**	**TOTAL**
DIRECT LABOR								
Level 12	$260	hr	0	0	0	0	0	$0
Level 11	$210	hr	0	0	0	0	0	$0
Level 10	$190	hr	16	12	8	4	4	$8,360
Level 9	$170	hr	0	0	0	0	0	$0
Level 8	$150	hr	0	0	0	0	0	$0
Level 7	$135	hr	160	120	80	40	40	$59,400
Level 6	$120	hr	0	0	0	0	0	$0
Level 5	$110	hr	60	24	0	0	0	$9,240
Level 4	$100	hr	24	12	16	0	16	$6,800
Level 3	$85	hr	0	0	0	0	0	$0
Level 2	$70	hr	0	0	0	0	0	$0
Level 1	$60	hr	0	0	0	0	0	$0
Drafting 3	$75	hr	24	0	0	0	24	$3,600
Drafting 2	$65	hr	0	0	0	0	0	$0
Drafting 1	$55	hr	0	0	0	0	0	$0
Clerical	$40	hr	0	0	0	0	8	$320
Total Labor			$35,440	$22,320	$13,920	$6,160	$9,880	**$87,720**
EXPENSES								
Communications	3%	of Labor	$0	$0	$0	$0	$0	$0
Computer	$5	hr	0	0	0	0	0	$0
CAD Computer Usage	$10	hr	0	0	0	0	0	$0
Word Processing	$40	hr	0	0	0	0	0	$0
Airfare	$0	ea	0	0	0	0	0	$0
Auto	$55	day	0	0	0	0	0	$0
Lodging/Subsistence	$150	day	0	0	0	0	0	$0
Copies/Blueprints			$50	$50	$100	$50	$100	$350
Express Mail/Courier			$0	$0	$0	$0	$0	$0
Other			$0	$0	$0	$0	$0	$0
Total Expenses			$50	$50	$100	$50	$100	**$350**
EQUIPMENT, MATERIAL, AND SUBCONTRACTORS (Cost + 5%)								
Contractor			$0	$0	$0	$0	$0	$0
Laboratory			$0	$0	$0	$0	$0	$0
Materials and Supplies			$0	$0	$0	$0	$0	$0
Equipment Rental			$0	$0	$0	$0	$0	$0
Other			$0	$0	$0	$0	$0	$0
Total Equip, Material, and Subs		**5%**	$0	$0	$0	$0	$0	**$0**
TASK TOTAL			**$35,490**	**$22,370**	**$14,020**	**$6,210**	**$9,980**	**$88,070**

HARGIS + ASSOCIATES, INC.
Hydrogeology & Engineering

STACIA L. PRAZEN, PG
Senior Hydrogeologist

Services: Water Resources, Environmental, Mining, & Litigation Support

Education

M.S., Geological Sciences with emphasis in Hydrogeology, San Diego Sate University, San Diego, California, 2001

B.S., Environmental Geology, Northern Arizona University, Flagstaff, Arizona, 1997.

Professional Registrations

Registered Geologist, California, 2005

Contact Us

http://www.hargis.com

sprazen@hargis.com

Summary of Experience

Ms Prazen has professional experience in hydrogeology and geology since 1998. Current professional responsibilities include project direction, investigation and assessment of soil and groundwater contamination; soil and water quality monitoring and data evaluation; aquifer testing; monitor well construction and development; preparation of data submittals and reports; development of 3-dimensional models and animations using CTech Development Corporation's Environmental Visualization System (EVS) software; development and simulation of 3-dimensional numerical soil vapor and groundwater flow and transport models, performance evaluations of groundwater remedial actions. Previous experience in water resources research and unsaturated zone research.

Areas of Expertise

Soil and Groundwater Contamination Studies

- Conducted evaluations of performance of groundwater treatment systems for several Sites in Southern California and a Site in Nevada including development of multiple lines of evidence to support performance conclusions. Evaluations included various capture zone analyses, mass balance calculations, and review of concentration trends.

- Conducted evaluations of performance of soil vapor treatment systems for several Sites in Arizona.

- Conducted analytic evaluations of hydraulic data, including capture zone analyses, to aid in development and design of multiple groundwater remediation systems for multiple Sites in Southern California in support of a Resource Conservation and Recovery Act (RCRA) feasibility study.

- Prepared RCRA remedial investigation workplans and reports for several Sites in Southern California and Arizona contaminated with hydrocarbons, semivolatiles, and volatile organic compounds (VOCs) in soils and groundwater.

- Performed data analysis of soil and groundwater contamination for use in remedial investigations and feasibility studies at multiple Sites in Southern California

Selected Representative Professional Assignments

Soil and Groundwater Contamination Studies

Boeing El Segundo
Boeing C-1
Boeing EDD Torrance
Raytheon Fullerton sites
Boeing Neosho
Boeing Rancho Cordova
Montrose Torrance
Boeing Compton
Montrose Henderson
ADEQ East Central Phoenix
Beckman Fullerton
Playa Vista
OCWD South Basin
Omega Superfund

Aquifer Testing and Analysis

OMWD
Boeing C-1
Boeing Compton
Boeing Rancho Cordova
Beckman Fullerton

GIS and Groundwater Modeling

Boeing C-1
Boeing Compton
Boeing Rancho Cordova
Boeing EDD Torrance
OMWD
Montrose Henderson
Raytheon Fullerton
Beckman Fullerton
Omega Superfund
ADEQ East Central Phoenix
Playa Vista

Litigation Support

UTC
Red Rock

Water Resources

SDCWA
OMWD

Areas of Expertise Continued

- Conducted interpretation of hydrogeologic data including water levels, lithology, and subsurface contamination to develop site conceptual models at Sites in Southern California

- Conducted site monitoring activities including water level elevation measurement, groundwater sampling, well construction and design, cone penetrometer testing at multiple Sites in Southern California.

- Compiled and evaluated hydrogeologic data including ground water levels, spring flow, stream flow, and precipitation to aid in development of a site conceptual model of a complex karst system at a Site in Missouri.

Aquifer Testing and Analysis

- Conducted slug, step, and short and long term constant rate aquifer testing at various Sites in Southern California.

- Provided analysis of aquifer test data using conventional aquifer testing analysis methods to estimate hydraulic parameters. Conducted analysis of aquifer test data using non-traditional methods including simulation of aquifer tests using a 3-dimensional groundwater flow model to aid in conceptual model design.

GIS and Groundwater Modeling

- Developed 3-dimensional numerical groundwater flow and transport models for multiple sites in California and conducted simulations for use in development of design and evaluation of feasibility of various remedial alternatives including pump and treat and in-situ methods. Utilized the United States Geological Survey MODFLOW, MODFLOW Surfact, MODPATH and MT3DMS software programs with the Groundwater Vista's user interface.

- Developed 3-dimensional numerical soil vapor flow models for multiple sites in California and Arizona and conducted simulations for use in evaluation of feasibility and effectiveness of various Soil Vapor Extraction remedial alternatives. Utilized MODFLOW Surfact, MODPATH, and various unsaturated zone models.

- Developed a 3 dimensional numerical groundwater flow and transport model at a Site in southern California to evaluate effects of geologic heterogeneity on the effectiveness of remedial alternatives.

- Developed a regional 3-dimensional numerical groundwater flow and transport model for a groundwater basin in San Diego County for use in evaluating the feasibility of an aquifer storage and recovery program.

- Conducted capture analyses using MAPWINDOW GIS and KT3D water level krigging and particle tracking to aid in periodic evaluations of a groundwater treatment system at Sites in Nevada and California.

Selected Representative Publications

Berryman, S. L., 2001. "Soil Moisture Variations in a Riparian Wetland" Master's Thesis, San Diego State University, San Diego, California.

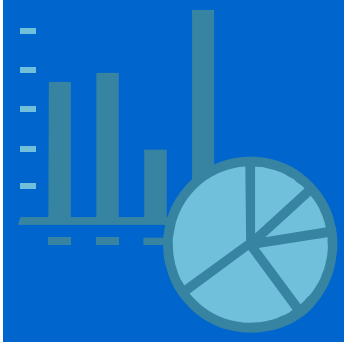
Selected Professional Development Courses

MODFLOW-USG Seminar

4-Day CTECH Corporation Environmental Visualization System (EVS) Course

40-Hour HAZWOPER Course

8-Hour CPR/First Aid Course



Areas of Expertise Continued

- Developed 3-dimensional conceptual models of subsurface conditions and plume configurations using CTech Development Corporation Environmental Visualization System (EVS) software at multiple sites in California, Arizona, and Nevada. Prepared animations and graphics for visualization purposes, and various data evaluations to aid in 3-dimensional groundwater flow and transport model development. Prepared data evaluations at a Site in Nevada for use in evaluating effectiveness of an in-place remediation system. Prepared data evaluations at a Site in Arizona for use in allocating remediation costs amongst potential responsible parties involved in litigation.

- Conducted monitored natural attenuation analyses using BIOCHLOR.

- Managed and visualized soil and groundwater analytical data using GIS at multiple Sites

Litigation Support

- Provided technical review of site characterization including hydrogeologic conditions, extent of soil and groundwater contamination, determined appropriateness of remedial activities performed, and participated in production of an expert witness report for an industrial client as part of an insurance cost recovery litigation.

- Qualified National Contingency Plan compliance for cost recovery litigation at a Superfund Site in California.

- Conducted plume volume and mass calculations using a 3-dimensional groundwater model for use in cost allocation.

Water Resources Studies

- Installed, monitored and analyzed data from temperature probes and precipitation collectors in the Southern California desert to evaluate potential groundwater recharge rates as part of a regional chloride deposition study

- Participated in acquisition and development of hydrogeologic data in the vicinity of a new man made reservoir for municipal water supply to evaluate changes in groundwater conditions due to the reservoir.

Unsaturated Zone Research

- Conducted a baseline hydrologic study to evaluate soil moisture and stress conditions in native riparian vegetation along a Southern California River to predict if a significant drop in groundwater level would have a negative effect on vegetation. Involved installation of tensiometers and evaluation of soil moisture, precipitation, river flow, and vegetation stress measurements