WILDERMUTH ENVIRONMENTAL, INC.

November 18, 2015

San Juan Basin Authority Technical Advisory Committee
Attention: Andy Brunhart, Matt Collings, Thom Coughran, and Dan Ferons
c/o Dan Ferons, General Manager
Santa Margarita Water District
26111 Antonio Parkway
Rancho Santa Margarita, CA 92688

Subject: ***Fall 2015 analysis of storage in the San Juan Groundwater Basin***

Dear Messrs. Brunhart, Collings, Coughran, and Ferons:

Pursuant to our professional services agreement with the San Juan Basin Authority (SJBA), dated January 13, 2015, we are pleased to submit this letter report documenting the results of our fall 2015 analysis of groundwater storage in the San Juan Groundwater Basin (Basin).

Background and Objectives

Since early 2003, the SJBA has implemented a groundwater, surface water, and vegetation field monitoring program to comply with the conditions outlined in the SJBA's Permit for Diversion and Use of Water, No. 21074 (Permit 21074). Permit 21074 was issued by the State Water Resources Control Board (SWRCB) Division of Water Rights in October 2000 and amended in October 2011. The SJBA's monitoring program developed in 2001 focused primarily on collecting the data needed to satisfy the monitoring requirements included in Permit 21074.

In 2011, the SJBA hired Wildermuth Environmental, Inc. (WEI) to prepare an updated Groundwater and Facilities Management Plan (GFMP) for the long-term, sustainable management of the Basin's water resources. The final task of the GFMP was to recommend a monitoring program to collect the data needed to effectively manage the Basin (e.g. assess the impact to groundwater levels and groundwater quality as a result of implementing the Groundwater Management Plan) and comply with the amended Permit 21074 requirements.

To improve storage management, the GFMP monitoring program calls for a regional comprehensive groundwater-level survey and analysis of the Basin in the spring and the fall of each year. This information is used to calculate the volume of groundwater in storage. The storage calculation for the fall time period can be used as the starting point for the SJBA to determine an appropriate volume of pumping for the following year. The volume can be adjusted based on the spring storage calculation, which reflects the basin response to the wet season. The storage calculations during the spring and fall time periods are also used to evaluate compliance with Condition No. 14 of Permit 21074, which states:

> *Cumulative extractions by the permittee, senior right holders, and rights governed by private agreements with the permittee (see condition 7) shall not exceed recharge from return flows and precipitation. This condition is satisfied when groundwater storage is not less than one-half of the storage capacity in the alluvial groundwater basin.*

This letter report summarizes the methodology used to calculate groundwater storage and summarizes the analysis of groundwater levels and storage in the Basin for fall 2015.

Methodology

The information required to estimate the storage capacity and volume of water in storage include: the elevation of the effective base of the alluvial aquifer, groundwater-level elevation, and specific yield (a parameter that describes the quantity of water that a unit volume of aquifer, after being saturated, will yield by gravity). For the Basin, the total volume of groundwater in storage is also controlled by the elevation of the stream bottom within the study area, meaning that groundwater above the stream-bottom elevation would only temporarily remain in storage before flowing towards the stream and becoming surface water. Therefore, groundwater above the stream-bottom elevation is not included in the storage capacity computation.

A fine-grain, regional groundwater model of the Basin was developed by the Municipal Water District of Orange County (MWDOC) in support of the proposed ocean desalination project (GEOSCIENCE Support Services, Inc. [GSSI], 2013[1]). This groundwater basin uses a 15x15 meter grid and each model grid cell has uniquely-assigned aquifer properties that include specific yield and the elevation of the effective base of the alluvial aquifer. WEI used the MWDOC groundwater model boundary and the model grid and its associated aquifer properties to develop a GIS-based storage model for this analysis. Figure 1 is a map of the model boundary used for the storage analysis.

The following steps were performed to estimate the storage capacity and volume of water in storage: 1) develop a fine rectangular grid (i.e. GIS polygon layer) over the storage area, 2) set maximum groundwater-elevation constraints based on the stream bottom elevation, 3) compute the storage capacity of the Basin, and 4) compute the amount of groundwater in storage for fall 2015. These steps are described in more detail below.

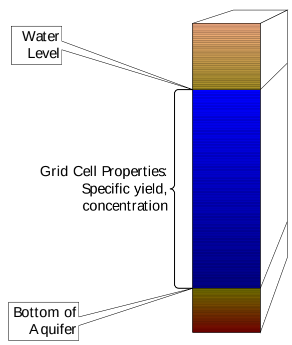
1. *Develop a fine rectangular grid and assign aquifer properties*. The grid cell size used in the calculation was the same size and extent as the MWDOC 15x15 meter grid (see Figure 1). The cell area, specific yield, and effective base of the alluvial aquifer values generated for the MWDOC model were applied within each cell.

[1] Geoscience Support Services, Inc. 2013. *Draft Report South Orange County Coastal Desalination Project Phase 3 Extended Pumping and Pilot Plant Testing Volume 3 – San Juan Basin Regional Watershed and Groundwater Models*. June 28, 2013.

2. *Set maximum groundwater-elevation constraints based on stream-bottom elevation.* To set constraints, a Digital Elevation Model (DEM) was generated using two-foot interval ground-surface elevation contours generated from LIDAR[2] data provided by the City of San Juan Capistrano. The DEM was generated using a topo-to-raster interpolation scheme in the Spatial Analyst extension in ArcGIS. Using the DEM, stream-bottom elevations were assigned to San Juan Creek, Arroyo Trabuco, and Oso Creek in two-foot increments along the stream, and were used to control the volume of storage in the grid cells along the axis perpendicular to the stream at each two-foot interval.

3. *Compute the storage capacity of the Basin.* The storage capacity of a grid cell is computed as:

$$SC_i = A_i * (WL_{max} - B_i) * SY_i$$



Where:

SC_i = storage capacity in the i^{th} grid cell (acre-feet [af])

A_i = grid cell area of the i^{th} grid cell (acres)

WL_{max} = streambed elevation constraint in i^{th} grid cell (ft above mean sea level [ft-amsl])

B_i = elevation of the effective base of the alluvial aquifer in the i^{th} grid cell (ft-amsl)

SY_i = specific yield in the i^{th} grid cell

The storage capacity of the Basin is the sum of the storage capacity of each grid cell in the storage model and is about 41,375 af.

[2] LIDAR, which stands for Light Detection and Ranging, is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. These light pulses—combined with other data recorded by the airborne system— generate precise, three-dimensional information about the shape of the Earth and its surface characteristics. http://oceanservice.noaa.gov/facts/lidar.html.

4. *Compute the volume of groundwater in storage.* For each period, all wells with a groundwater-elevation measurement were mapped and each well location was assigned a groundwater-elevation value representative of the fall 2015 period. The target date for selecting a fall groundwater-elevation was October 1st, plus or minus 30 days. Based on the representative groundwater elevations, equal-elevation contours were hand-drawn, digitized, and brought into GIS. Groundwater-elevations were assigned to each grid cell with an automated gridding program that interpolates between contours and groundwater-elevation measurement control points.

   As with storage capacity, the volume of groundwater in storage is controlled by the stream-bottom elevation. The groundwater elevation in a grid cell is constrained to be the minimum of the groundwater elevation estimated from the contour map or the nearby stream-bottom elevation. The end of time-period groundwater volume in a grid cell is computed as:

$$V_{i,t} = A_i * \left(WL_{i,t} - B_i\right) * SY_i$$

   Where:

   $V_{i,t}$ = volume of groundwater in i^{th} grid cell (af) at time t

   $A_{i,}$ = grid cell area of the i^{th} grid cell (acres)

   $WL_{i,t}$ = the lesser value of the average elevation of groundwater (ft-amsl) in the i^{th} grid cell at time t and the streambed elevation constraint in i^{th} grid cell

   B_i = elevation of the effective base of the alluvial aquifer in the i^{th} grid cell (ft-amsl)

   SY_i = specific yield in the i^{th} grid cell

Results

For fall 2015, Figure 2 shows: the storage model boundary (grey outline), wells with data available for fall 2015 (brown-filled circles), wells that have been used for contouring in past efforts but did not have fall 2015 data (small black-filled circles), the fall 2015 groundwater elevations used to develop contours (brown labels alongside wells), the fall 2015 elevation contours, and the grid cells that were determined to be dry after the contours were developed (pink shaded areas).

The following table shows the time history of the estimated groundwater in storage for the period of fall 2012 through fall 2015.

Point in Time of Estimation	Groundwater in Storage[3] (af)	Percentage of Total Capacity
Fall 2012	28,297	68%
Spring 2013	28,540	69%
Fall 2013	25,855	62%
Spring 2014	26,269	63%
Fall 2014	24,864	60%
Spring 2015	26,555	64%
Fall 2015	**27,623**	**67%**

The volume of water in storage for fall 2015 has increased by about three percent relative to spring 2015. The increase relative to fall 2014 is about seven percent. This increase in storage is likely due to (1) the increase in precipitation for the October 2014 to September 2015 period (about 3 inches), compared to the total for the October 2013 to September 2014 period (about 7 inches)[4]; (2) the reduction in groundwater production by the City of San Juan Capistrano pursuant to its Drought Operation Plan and in accordance with SJBA Resolution 2015-07-01; and (3) the continued shutdown of the South Coast Water District's Groundwater Recovery Facility.

Conclusions and Recommendations

Based on the available data and the assumptions of this analysis, the Basin is about 67 percent full as of fall 2015. Thus, Condition No. 14 of Permit 21074 is satisfied, and no restrictions on pumping are required to comply with this permit condition. Conservatively assuming that the drought will continue and there will be no net inflow to the Basin, there is about 6,900 af of water that could be pumped (by all producers) before triggering the 50 percent bright-line metric in Permit 21074. However, other conditions in Permit 21074, such as Condition 23 (riparian vegetation health) and Condition 17 (water quality degradation), may limit how much and where this water could be extracted. Additional considerations beyond the permit constraints should also be evaluated by the TAC and the Board in determining an appropriate production volume for the remainder of calendar year 2015 and for calendar year 2016, including, but not limited to

[3] WEI's consensus best professional judgment of the error in an analysis for calculating total storage using model-generated specific yield values, hand contoured groundwater elevations based on measured data, and GIS to interpolate between contours is plus or minus ten percent of the calculated result.

[4] As measured at station Ortega KCASANJU2: http://www.wunderground.com/personal-weather-station/dashboard?ID=KCASANJU2#history

anticipated private groundwater production, agency production goals, and policy objectives (e.g., how much water should be reserved in storage for times of "drought").

Please call us if you have any questions or concerns regarding the analysis contained herein.

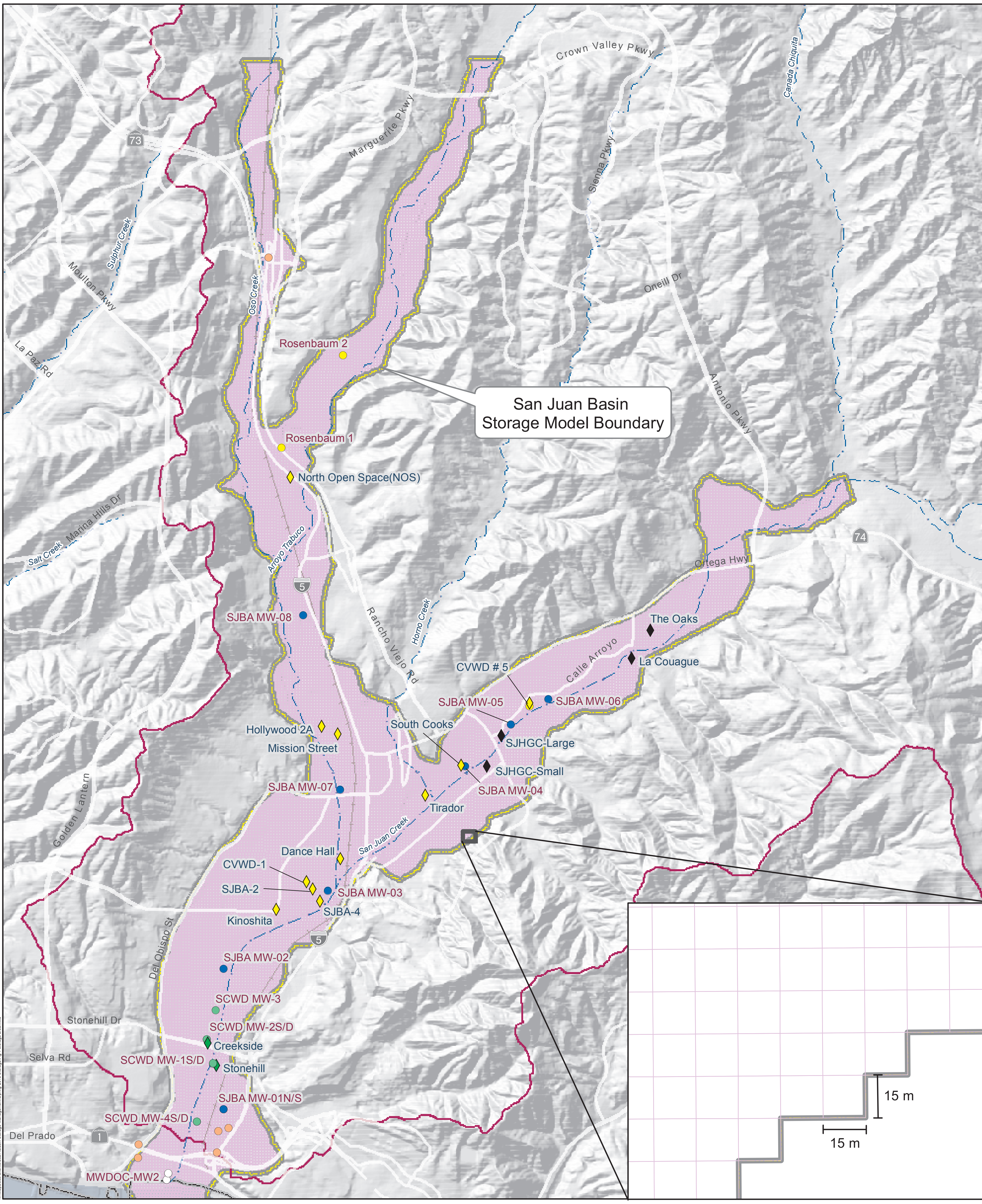
Very truly yours,

Wildermuth Environmental, Inc.

Mark J. Wildermuth, PE
President, Principal Engineer

Samantha S. Adams
Principal Scientist

Enclosure: Figures 1-2b



Main Features

Monitoring Well Network

Kinoshita	City of San Juan Production Well
Stonehill	South Coast Water District Production Well
SJHGC - Small	Private User Production Well
SJBA MW-01N	San Juan Basin Authority Monitoring Well
SCWD MW 1S/1D	South Coast Water District Monitoring Well
	City of San Juan Inactive Production Monitoring Well
	LUST Site Monitoring Well
	Other Monitoring Wells

San Juan Basin Storage Model Boundary

San Juan Creek Watershed Boundary

Streams and Creeks

Produced by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: LBB

Date: 20151113

0 1,000 2,000 Feet

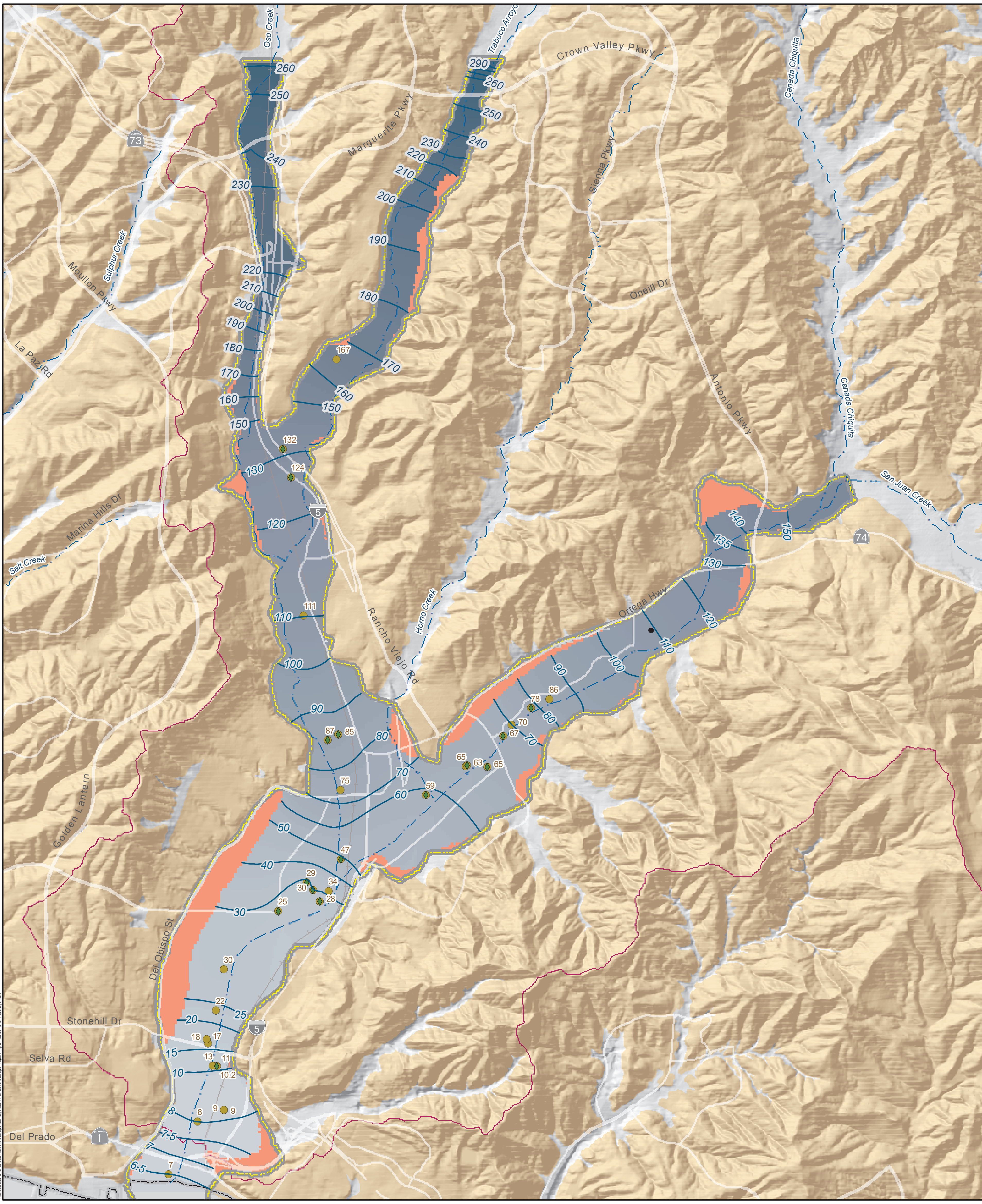
0 0.25 0.5 Miles

SAN JUAN BASIN AUTHORITY

Fall 2015 Groundwater Storage Analysis

San Juan Basin Storage Model Boundary

Figure 1



-10- Fall 2015 Groundwater Elevation Contour (ft amsl)

Fall 2015 Groundwater Elevation, ft amsl

300 ft amsl

0 ft amsl

Fall 2015 Dry Model Grid Cells

10 Wells with Groundwater Elevation Data Available in Fall 2015

Wells without Available Data for Fall 2015 Contouring

Production Well

San Juan Basin Storage Model Boundary

San Juan Creek Watershed Boundary

Streams and Creeks

Geologic Features

Younger Alluvial Deposits

Older Alluvial Deposits, Landslides, and Tertiary Sedimentary Bedrock

Source of Geologic Features: CGS Special Report 217.

Final Fall 2015 Groundwater Elevation and Areas with Water in Storage

Figure 2

Produced by:

WEI
WILDERMUTH ENVIRONMENTAL, INC.

Author: LBB

Date: 20151117

0 1,000 2,000 Feet

0 0.25 0.5 Miles

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Fall 2015 Groundwater Storage Analysis