6. MODEL CALIBRATION

6.1 Calibration Strategy

Models are built to represent the physical system – not all of it, just what is necessary to simulate the important processes that govern it and that are important for the evaluation of specific management plans. Calibration is a process of the adjusting of independent variables within the model so that the model is capable of reproducing the response of the physical system to a known set of stresses. Given confidence in the calibration, the model can be used to estimate the behavior of the physical system for a different set of stresses. There are as many approaches to calibration as there are investigators. The approach used herein is elegantly simple and makes the best use of available data. Two main criteria were used for calibration: matching groundwater level histories at wells and matching the surface water discharge time history for the Santa Ana River at Prado Dam.

6.1.1 Matching Groundwater Levels at Wells

Matching groundwater levels at wells is an obvious approach. Model projections at well locations are simply compared to observations. Model estimates are temporally averaged – about 91 days over time, and spatially over a 200-foot by 200-ft cell. Water level measurements at wells are temporally specific to the moment of measurement, composited over as many as three layers, and can vary greatly over 91 days. Thus, there should be some differences attributable to model scale. The calibration process adopted herein was to:

- compare the observed groundwater level at a well to the computed groundwater levels for each layer in the cell in which the well was screened; and
- make adjustments as necessary to trial estimates of aquifer properties to improve the match between model-predicted and observed groundwater levels.

Wells were selected as model calibration targets based on:

- rigorous analysis of the continuity and quality of the water-level time history data;
- spatial well location; and
- well screen interval(s) relative to the model layering.

Water-level time histories for all wells in Chino Basin and Temescal Basin were plotted and analyzed. In order for a well to be selected as a calibration target, its time history was inspected for data density and continuity during the calibration period (1989-2001). Preference was given to wells with monthly or quarterly data, which is the typical data collection routine of municipal well owners. The quality of the data was determined through a visual analysis of the well's water-level time history, and through comparison with time histories of other nearby, similarly-constructed wells.

Figure 6-1 shows the location of the 45 wells used as model calibration targets. Note that the calibration target wells are located across the entire extent of the Chino Basin. City of Corona wells were used in the Temescal Basin. In addition, note the higher density of calibration target wells on the west side of Chino Basin. Because the west side of Chino Basin is comprised of at least two distinct aquifer-systems with significant head differences and head responses to pumping (see Section 2.3.3), it was necessary to select a greater number of wells in this area (with the appropriate screen intervals) to represent the shallow and deep aquifer-systems.

6.1.2 Matching Santa Ana River Discharge at Prado Dam

One of the key issues for the dry-year yield program is the impact of the dry-year yield program on rising groundwater. Through the OBMP, Watermaster is trying to maximize the yield of the Chino Basin by minimizing groundwater outflow in the Prado Basin area and by maximizing groundwater recharge in the Santa Ana River upstream of Prado Dam. The operation of the dry-year yield program needs to consider minimizing outflow to the Santa Ana River when water is being stored for dry-year use. To this end, the 2003 Watermaster Model was designed to simulate the surface water and groundwater interaction in the Santa Ana River and its tributaries in the lower Chino Basin. The calibration process adopted herein was to:

- compare the observed Santa Ana River discharge at Prado Dam to model-predicted discharges; and
- make adjustments as necessary to trial estimates of aquifer properties and streambed percolation rates to improve the match between model-predicted and observed surface water discharge.

The observed data for the Santa Ana River at Prado Dam was obtained from the USGS-published daily discharge data for Station 11074000. The location of Station 11074000 is shown in Figure 6-1.

6.2. Calibration Results

The initial calibration simulations were devoted to debugging input files and to ensuring that the hydrology for the model was correct. Subsequent calibration simulations focused on adjusting aquifer parameters to improve the match between observed and model-projected groundwater levels and Santa Ana River discharge at Prado Dam

6.2.1 Groundwater Levels at Wells

Appendix A contains plots of groundwater level time histories of observed and model-projected groundwater levels for 41 wells in the Chino Basin and four wells in the Temescal Basin. Figures 6-2 to 6-14 are a subset of these wells and include:

- Fontana Water Company F3A
- Cucamonga County Water District No. 30
- Ontario No. 17
- Upland No. 3
- Monte Vista Water District No. 10
- Pomona No. 11
- Chino No. 9
- Chino Hills No. 18A
- California Institution for Men No. 4
- Jurupa Community Services District No. 16
- Norco No. 11
- Parente ARC
- Excelsior

With few exceptions, the match of model-predicted groundwater levels to observed levels in the Chino Basin is excellent. The notable exceptions include Monte Vista Water District (MVWD) No. 10 and the Chino Hills wells 15B and 17. The 2003 Watermaster Model predicts groundwater levels at MVWD No 10 that are 20 to 40 feet higher than observed. Upon review of all the data and the conceptual model, the plausible explanations for these differences include the presence of a local-scale geologic feature that is not represented in the model or errors in the observed groundwater level data (incorrect qualification of the data, measurement error, or error in reference elevation).

The Chino Hills wells 15B and 17are perforated in the deeper aquifers in the City of Chino area. New data, available from Watermaster's Ayala Park piezometers that became available after the development of the conceptual model indicates that groundwater levels in the aquifers produced by Chino Hills wells 15B and 17 recover very slowly, hydraulic conductivity is low, and that the area has limited recharge. Upon review of all the data and the conceptual model, the plausible explanations for the differences include: the temporal and spatial scale of the model may be too large to compute representative groundwater levels at these wells; the conceptual model needs to be updated to include new data from the Ayala Park piezometers; and/or errors in the observed groundwater level data (incorrect qualification of the data, measurement error, or error in reference elevation). Watermaster plans to conduct pump tests on some deep wells in this area in the Fall 2003 as part of the implementation of the Interim Management Plan for Management Zone 1 (WEI, 2003). Watermaster should attempt a local calibration of the 2003 Watermaster Model in the City of Chino area in early 2004 using these pump test data.

The match of model-predicted groundwater levels to observed levels in the Temescal Basin is excellent.

6.2.2 End of Calibration Groundwater Levels

Figures 6-15a, 6-15b, and 6-15c illustrate the model-estimated groundwater levels for Layers 1, 2 and 3, respectively. In the eastern two-thirds of the Chino Basin, there is very little difference between groundwater levels in Layers 1, 2, and 3 where the layers are saturated. In the western part of the Chino Basin underlying the City of Chino and in the areas extending slightly north, east, and south of the City, there are several fine-grained layers that act as confining units and significant differences in groundwater levels between the layers are being predicted by the model.

Figures 6-16a, 6-16b, and 6-16c illustrate the model-predicted change in groundwater levels over the period 1989/1990 through 2000/2001 for Layers 1, 2, and 3, respectively. Some of the groundwater level changes shown on the boundaries of the western, northeastern and Prado Dam reservoir parts of the Chino Basin may be caused in part by errors in groundwater elevations assumed for the start of the calibration in Fall 1989. These are areas where groundwater levels were extrapolated to estimate the initial groundwater levels. As such, the change in groundwater levels in these areas may be modeling artifacts and not real changes in groundwater levels.

A pumping depression is starting to form in the area of the Chino-1 Desalter well field. Model-projected and observed groundwater levels have declined during the calibration period in the north central and northeastern parts of Chino Basin, and in an area adjacent to the Jurupa Hills where JCSD pumps heavily. Model-projected and observed groundwater levels have increased slightly on the western edge of Chino Basin near the City of Chino and in the area north of the Santa Ana River near Jurupa.

6.2.3 Santa Ana River Discharge at Prado Dam

Table 6-1 lists the model projected and observed discharges for the Santa Ana River at Prado Dam. This information is plotted in histogram form in Figure 6-17a and in a regression form (measured vs. model projected) in Figure 6-17b. The calibration is excellent. The average difference is about 5 percent and the average absolute difference is about 10 percent. The greater differences occur due to stormwater runoff and not streambed recharge and rising groundwater. The coefficient of determination (R^2) is the fraction of variance in the observed data that is predicted by the model. As a result of this calibration, the coefficient of determination is 0.96, which means that the model reproduces 96 percent of the variance in the observed data. This is an excellent result.

6.2.4 Final Aquifer Properties

The aquifer properties estimated from calibration are shown graphically as follows

- Figures 6-18a, 6-18b and 6-18c illustrate the spatial distribution of hydraulic conductivity for Layers 1, 2, and 3, respectively
- Figures 6-19a, 6-19b, and 6-19c illustrate the spatial distribution of vertical hydraulic conductivity for Layers 1, 2, and 3, respectively
- Figures 6-20a, 6-20b, and 6-20c illustrate the spatial distribution of specific yield for Layers 1, 2, and 3 respectively

The storage coefficient was assumed to be 0.0001 for the entire model domain.

6.2.5 Hydrologic Balance

The hydrologic balance for the 2003 Watermaster Model that was a result of this calibration is shown by management zone in Tables 6-2a through 6-2e. Most of the recharge components were independent of the groundwater model with the exception being recharge of Santa Ana River and its tributaries near the river where groundwater levels can influence recharge and rising groundwater. That most of the recharge components were independently estimated and contribute to an excellent groundwater calibration strongly implies that these independent recharge estimates are reasonably accurate for the calibration period.

The hydrologic balance includes estimates of groundwater flow between management zones. Of particular interest is the groundwater flow from Chino North, Chino South, and Temescal MZs to the PBMZ and subsequent contributions to rising water at Prado Dam. Table 6-3 lists the inflow components to the PBMZ and includes a reckoning of the volumes of rising water at Prado Dam from the inflowing management zones. These estimates were made by assuming that half of the stream flow recharge in the PBMZ contributes to rising water and that remaining rising water is allocated to the inflowing management zone based on the magnitude of groundwater inflow to the PBMZ. Over the calibration period, the average rising water contribution from the Chino North and Chino South MZs is estimated to be 2,300 acre-ft/yr and 700 acre-ft/yr, respectively, or about 3,000 acre-ft/yr from the Chino Basin.

The total storage in the Chino Basin declined during the calibration period from a high of 6,220,000 acre-ft in Fall 1989 to 5,940,000 acre-ft in Fall 2001 – a decline of about 280,000 acre-ft. Figure 6-18 shows the estimated groundwater storage for the Chino Basin during the calibration period. A part of this decline is a modeling artifact due to assumed initial groundwater levels on the margins of Chino Basin. After 1993, there is a monotonic drop in storage. Analysis of Tables 6-2a through 6-2e indicates that this decline in storage is almost completely in the Chino North MZ and is caused by increased groundwater production after 1993.