DOCKET
08-AFC-2
DATE
RECD. JUN 03 2009

Update of the Fremont Valley Groundwater Model Response to California Energy Commission Comments Contained in the Preliminary Staff Assessment to the Beacon Solar Energy Project (Docket No. 08-AFC-2)

May 2009

Prepared for

AECOM
1220 Avenida Acaso
Camarillo, California

Prepared by

esi Environmental Simulations Inc.

Reinholds, Pennsylvania

CONTENTS

1.0 INTRODUCTION 1

1.1 Scope of Work *1*

1.2 CEC Review Comments *2*

2.0 MODEL CONSTRUCTION 5

2.1 Code Selection *5*

2.2 The Model Grid *5*

2.3 Boundary Conditions *7*

2.4 Model Parameters *11*

3.0 MODEL CALIBRATION 14

3.1 Calibration Concepts *14*

3.2 Calibration Results *15*

3.3 Model Verification *18*

3.4 Calibration Sensitivity Analysis *20*

3.5 Impact Assessment for BSEP *21*

3.6 Predictive Sensitivity Analysis *23*

4.0 REFERENCES 26

Appendices

Appendix A: Hydrographs for the Verification Run

Appendix B: Hydrographs for the Predictive Sensitivity Analysis

Appendix C: Numerical Groundwater Flow Model Electronic Files

Tables

Table 1 Summary of Calibrated Model Parameters for the Fremont Valley Model

Table 2 Residuals and Statistics for the Steady-state Calibration to Water Levels

Table 3 Residuals and Statistics for the Transient Calibration to Pump Test Drawdown

Table 4 Maximum Impact at Key Wells in Predictive Sensitivity Analysis

Figures

Figure 1 Model Area for the Project Beacon (Fremont Valley) Groundwater Flow Model Showing Boundary Conditions

Figure 2 Model Area for the Project Beacon (Fremont Valley) Groundwater Flow Model Showing Recharge Zones

Figure 3 Model Area for the Project Beacon (Fremont Valley) Groundwater Flow Model Showing Hydraulic Conductivity Zones

Figure 4 Observed vs. Simulated Water Levels for 1958

Figure 5 Observed vs. Simulated Drawdown from 3 On-Site Aquifer Tests

Figure 6a Calibrated Water Table Elevation Contours in the Fremont Valley - 1958 (Steady-State)

Figure 6b Calibrated Water Table Elevation Contours in the Fremont Valley – 1959 (Onset of agricultural pumping)

Figure 7 Hydrograph for Well 31S38E06E001M

Figure 8 Hydrograph for Well 31S37E36G001M

Figure 9 Hydrograph for Well 30S37E27H002M

Figure 10 Hydraulic Conductivity (K) Sensitivity Analysis

Figure 11 Specific Yield Sensitivity Analysis (Verification Run)

Figure 12 Fault Conductance Sensitivity Analysis

Figure 13 Recharge Sensitivity Analysis

Figure 14 Changes in Water Level (ft) After 5 Months of Construction Pumping at Well 48

Figure 15 Changes in Water Level (ft) After 5 years of Project Pumping at Well 48

Figure 16 Changes in Water Level (ft) After 30 years of Project Pumping at Well 48

Figure 17 Water Table Impact (ft) After 5 Months of Construction Pumping at Well 48

Figure 18 Water Table Impact (ft) After 5 Years of Project Pumping at Well 48

Figure 19 Water Table Impact (ft) After 30 Years of Project Pumping at Well 48

Figure 20 Changes in Water Level (ft) After 5 Months of Construction Pumping

Figure 21 Changes in Water Level (ft) After 5 Years of Project Pumping at Well 63

Figure 22 Changes in Water Level (ft) After 30 Years of Project Pumping at Well 63

Figure 23 Water Table Impact (ft) After 5 Months of Construction Pumping

Figure 24 Water Table Impact (ft) After 5 Years of Project Pumping at Well 63

Figure 25 Water Table Impact (ft) After 30 Years of Project Pumping at Well 63

Figure 26 Water Table Impact (ft) After 5 Months of Construction Pumping with Lower Specific Yield

LIST OF ACRONYMS

AF/yr	acre-feet per year
AFC	Application for Certification
ASTM	American Society for Testing and Materials
BSEP	Beacon Solar Energy Project
CEC	California Energy Commission
DEM	digital elevation model
EPA	United States Environmental Protection Agency
ESI	Environmental Simulations, Inc.
ET	evotranspiration
ft	feet
ft/d	feet per day
GHB	general-head boundaries
gpm	gallons per minute
HFB	Horizontal Flow Barrier
MGD	million gallons per day
NextEra	NextERA Energy, LLC
PSA	Preliminary Staff Assessment
USGS	United States Geological Survey

1.0 INTRODUCTION

1.1 Scope of Work

Environmental Simulations, Inc. (ESI) has prepared this groundwater flow model on behalf of AECOM Environment (AECOM) for their client NextEra Energy, LLC (NextEra, formerly FPL Energy, LLC). The model is part of a larger investigation of groundwater conditions below the proposed Beacon Solar Energy Project (BSEP), Kern County, California (referred to as the Project). The model was prepared as part of an Application for Certification (AFC) submitted to the California Energy Commission (CEC) on March 13, 2008.

The Project is located at the western edge of the Mojave Desert, just east of the extreme southern end of the Sierra Nevada Mountains. The Project is located along the California State Route 14 corridor, approximately four miles north-northwest of California City's northern boundary, approximately 15 miles north of the Town of Mojave, and approximately 24 miles northeast of the City of Tehachapi. Koehn Lake (usually dry) is located approximately five miles to the east-northeast.

The groundwater model was constructed and calibrated to assess resource sustainability and impacts to the groundwater basin and adjacent water supply wells from proposed groundwater withdrawal below the Project site. The groundwater model generally includes the Koehn Sub-basin of the larger Fremont Valley Groundwater basin just north of California City eastward to the edge of the valley fill sediments in Fremont Valley.

The model was calibrated to steady-state conditions assumed to be prevailing in 1958. This time period was chosen because a significant number of water level measurements were collected in the basin at that time. While there was some agricultural pumping in 1958, total withdrawals were low. The model was then further developed to simulate three aquifer tests conducted in 2008 on the Project site in support of the AFC.

The construction and calibration of the model is documented in this report. Information contained in the AECOM conceptual model report is not repeated in detail in the current report and was provided in the AFC (Appendix J2). The reader should, therefore, review both documents to get a good understanding of the basis for the groundwater model.

1.2 CEC Review Comments

The current document represents a revision to the original model for the Project. The original model submitted to the CEC in March 2008 was reviewed by the CEC and updated as part of the data response process. A summary of the CEC review of the groundwater model was provided in the Preliminary Staff Assessment (PSA), Soil and Water Resources Section dated April 2009 (docketed April 1, 2009). Preliminary comments to the PSA were provided by NextEra on April 8, 2009, and were discussed during a public meeting held on April 14, 2009 in California City. During that meeting, NextEra agreed to review the comments to the groundwater model and revise the model accordingly. The following revised model should also serve as a supplement and update to data already provided in the AFC and in response to Data Requests 104 through 123 (October 13 and December 8, 2008).

Appendix B of the PSA provided a detailed review of the groundwater model and presented six key findings and outstanding issues. These findings are summarized below along with a general response and reference to locations in this document where further discussion is provided:

1. The model assigns a constant 1,000 acre-feet per year (AF/yr) as inflow from the Antelope Valley (California City) along the southeastern edge of the model. The CEC believes that this inflow is currently less than 200 AF/yr.

   Response: The long-term verification simulation and predictive runs were modified such that the inflow along this boundary was 1,000 AF/yr in the steady state period (e.g. 1958) and linearly declined to 200 AF/yr in 2007. The inflow remained at 200 AF/yr through the predictive period.

2. The model uses drain cells to simulate discharge of groundwater to Koehn Lake, given that discharge to the lake ceased by 1976. Data and analysis presented by AECOM and SAMDA (1997) seem to indicate that groundwater discharge continued beyond 1976. The CEC also believe that the hydraulic conductivity of the aquifer beneath the lake should be lower due to clayey deposits in this area.

   Response: A response to this comment was provided in the May 1, 2009 Final Response to PSA Comments (page SW-15). Currently Koehn Lake is dry and is not receiving any groundwater discharge. Water levels in the closest well to the lake appear to be about 10 feet (ft) below the lake bed. At present, it is not interpreted that groundwater is discharging to the lake, though in the near future as the groundwater basin continues to recover it will discharge to the lake as it had prior to development of the Koehn Sub-basin. Additional discussion on this issue is contained in Chapter 3. A lower hydraulic conductivity zone was also added to the model beneath the lake to address the second part of this comment.

3. The model report did not document the constraints used to calibrate conductivity in the eastern valley area.

   Response: There is only limited data for the eastern valley area. Water levels in this area were used to constrain the calibration. However, there are no independent estimates of hydraulic conductivity in this area. As pointed out by the CEC, Koehler (1977) did not study this part of the basin. Additional discussion on this issue is contained in Chapter 3.

4. The magnitude, distribution, and timing of historical agricultural return flows are not explicitly considered by the model. The analysis by Leighton and Phillips (2003) for the Antelope Valley assumed a 10-year delay in agricultural return flows to percolate through the thick unsaturated zone and reach the water table.

   Response: This comment was addressed through an additional sensitivity analysis, which

is presented in Chapter 3.

5. The reported short-term pumping impacts during project grading activities need to be qualified as minimum impacts owing to possible delayed yield effects. The assumption is probably reasonable for long-term simulations; however the simulated water level response to shorter pumping periods may underestimate the short-term water level decline.

   Response: The aquifer system is simulated as a single-layer water table aquifer. With this type of model, the long-term impacts from dewatering are worst case in terms of drawdown impacts. However, in order to make all of the simulations more consistent, all predictive simulations include the full verification period (1958 to 2007) plus the 5-month construction period and the 30-year project period. In addition, one sensitivity simulation was added with the lower storage coefficients at the site to maximize local impacts from the 5-month construction period.

6. The model calibration was updated in December 2008, but a number of previously reported simulations were not updated to reflect changes in the modeled aquifer parameters.

   Response: All model simulations were run with the current model, which includes changes made in December 2008 and changes made to address these April 2009 comments.

2.0 Model Construction

2.1 Code Selection

The groundwater model for the Fremont Valley was constructed using the MODFLOW2000 model (Harbaugh et al, 2000) developed by the United States Geological Survey (USGS). MODFLOW2000 is the latest version of the MODFLOW family of models. MODFLOW is the most popular groundwater flow model used in the U.S. and has become the standard for groundwater flow modeling in the country. The model was designed using ESI's Groundwater Vistas software (ESI, 2005), which creates the MODFLOW2000 input files and allows for analysis of the results.

MODFLOW is capable of simulating steady-state or transient groundwater flow in one, two, or three dimensions. A wide variety of boundary conditions may be simulated, including constant head, constant flux (wells, recharge), and head-dependent flux (evapotranspiration, drains, rivers, streams, and general head) boundaries. The types of boundaries used in this model are described below. MODFLOW can simulate aquifer systems that are unconfined, confined, or a combination of confined and unconfined.

MODFLOW was chosen for this study because it has all of the requisite capabilities to simulate flow in the Fremont Valley and MODFLOW2000 was chosen in particular because it is one of the newest and most up-to-date versions of MODFLOW. MODFLOW is also thoroughly documented (McDonald and Harbaugh, 1988 and Harbaugh et al. 2000), and has been extensively tested (see for example Andersen, 1993).

2.2 The Model Grid

The flow of groundwater can be described using mathematical equations that form the basis for all computer models used in the field of hydrogeology. Computer models may be subdivided into two broad categories, called numerical and analytical models. Analytical models are exact solutions of the groundwater flow equations, and numerical models are approximate solutions.

Given the choice between an exact solution and an approximate one, it seems logical that one would choose an analytical model over a numerical model. However, analytical models are usually limited to ideal aquifers that are homogeneous with simple boundaries. Most real world aquifers are not that simple. Consequently, numerical models are used most often in practice.

Because numerical models are approximate, they typically compute hydraulic head (water levels) at fixed points within the aquifer. These points are called nodes or cells, and are often arranged in a rectangular pattern called a grid. There are many different types of numerical techniques that are used to solve the groundwater flow equations. MODFLOW2000 uses a technique called the finite-difference method.

The finite-difference technique requires that the aquifer system be divided into a set of discrete blocks or cells. These blocks are rectangular in shape and form the model grid. The process of creating the grid is call discretization. Water levels computed for a block represent the average water level over that rectangular region of the aquifer. Thus, adequate discretization is required to resolve features of interest, such as the location of the wells, faults, and basin boundaries in the Fremont Valley.

An algebraic equation that describes groundwater flow is written for each block in terms of the surrounding blocks, and the complete set of linear equations is iteratively solved until the change in head between iterations meets a set criterion. An iterative solution is required because the model is an approximate solution to the groundwater flow equations.

The model grid developed for the Fremont Valley covers approximately 320 square miles. The model domain measures approximately 9.5 miles from north to south and 34 miles from east to west. The southwest corner of the model grid is located at Easting 1,306,833 ft and Northing 12,748,208 ft. These coordinates are in UTM Zone 11N, NAD 1927, ft.

The model grid spacings vary from 250 ft to 1,000 ft. The model grid was finer in the vicinity of the Project site where the aquifer tests were simulated by the model. The model grid contains 66

rows, 206 columns, and 1 layer for a total of 13,596 cells. There are 8,033 active cells. The model simulates only the area up to the mountain blocks. Mountain block recharge was applied at the base of the mountain fronts using recharge cells. The model area is shown in **Figure 1**. No-flow cells are those outside the active portion of the model grid.

The model contains one layer representing the saturated valley fill deposits and was modeled as an unconfined aquifer. The elevation of the top of the model was interpolated from the USGS digital elevation model (DEM) for the area. Detailed data on the thickness of the aquifer was not available for the entire model domain. However, a thickness of 800 ft was assumed north of the Cantil Valley Fault and a thickness of 500 ft was assumed south of that same fault. These assumptions were based on a report by Koehler (1977).

2.3 Boundary Conditions

Once the aquifer system has been discretized, it is implicitly assumed that groundwater outside the model grid can be ignored. The model, however, must account for areas where groundwater enters or leaves the system. These effects are included in a model using boundary conditions. Ideally, boundary conditions should represent identifiable regional hydrologic features at which some characteristic of groundwater flow is easily described (Franke et al., 1984).

In the case of the current model, the regional hydrologic boundaries for the Fremont Valley are the edges of the surrounding mountain blocks or the basin boundaries. The Fremont Valley groundwater basin was assumed to extend from the Muroc Fault on the west to the eastern edge of the Fremont Valley.

Groundwater enters closed basins in California and Nevada in three main ways: (1) recharge from the mountain blocks, (2) infiltration of stream flow, and (3) lateral movement of water from adjacent basins. Groundwater leaves the basins through evapotranspiration (ET) by phreatophytes and through direct evaporation from the playa lakes. In the current model, water enters the basin from recharge and stream infiltration that occurs in the mountain blocks. The

area between the Muroc Fault and the Rand Mountains, just north of California City was assumed to be an area of groundwater inflow to the Fremont Valley. All groundwater that enters Fremont Valley is discharged to wells or to Koehn Lake, in the northeastern corner of the valley.

Numerical groundwater models, such as MODFLOW, use three types of boundary conditions to simulate ways in which water may enter or leave the model domain. These include the specified-head, specified-flux, and head-dependent flux boundaries. A description of each type is given below as applied in the current model. Boundary conditions (including wells) are shown in **Figure 1**.

The specified-head boundary condition is called a constant head in MODFLOW. The head or water level at a constant head boundary is specified independently of the simulation results and is fixed at the specified elevation throughout the simulation. Constant head boundaries were not used in the Fremont Valley model.

Specified flux boundary conditions are implemented in MODFLOW using wells, recharge, or no-flow (i.e., flux equals zero) cells. Constant flux boundary conditions (i.e., recharge) were used extensively in the Fremont Valley model to simulate flow of water into the basin from the mountain blocks. The flow rates were determined from the basin water budget presented in the conceptual model report (ENSR, 2008). This recharge was distributed to the model, as shown in **Figure 2**.

At steady state (circa 1958), mountain front recharge was divided into two sources, 10,500 AF/yr was assumed to occur near the mountain blocks and 4,500 AF/yr was assumed to infiltrate in stream channels emanating from the mountain blocks. Total recharge to the basin was therefore 15,000 AF/yr. These same recharge rates were assumed to be constant during the transient portion of the simulation as well.

In addition to recharge, some inflow (1,000 AF/yr) was assumed to come from the California City area through the gap between the Muroc Fault and the Rand Mountains into the Fremont

Valley (see AFC Appendix J2, ENSR 2008). This inflow was simulated with a series of injection wells in MODFLOW2000. Based on CEC Comment 1, this inflow from California City was reduced to 200 AF/yr by 2007 in the verification run. The inflow was decreased linearly over time.

Pumping in the valley in 1958 was assumed to be concentrated east of Koehn Lake in an agricultural area. Based on acreage and crop type (ENSR, 2008), a total pumping rate of 843 AF/yr was assumed in 1958. Pumping for the transient calibration was from three wells (numbers 43, 48, and 63) on the Project site. The latter will be described in more detail for the transient calibration.

No-flow boundaries are placed in a model where the aquifer is not present or where leakage of water into the model is negligible. No-flow boundaries were placed along the mountain blocks in the model and at basin boundaries.

Head-dependent flux boundary conditions are a hybrid between the specified head and specified flux boundary conditions. In a head-dependent flux boundary, the flux flow rate) of water into or out of the cell is computed by the model based upon the head calculated for the cell, the head specified for the boundary, and a conductance term. MODFLOW offers five different types of head-dependent flux boundary conditions, including the drain, river, stream, general-head, and ET packages. Each type is slightly different. Only general head and drain boundaries were used in the current model, as described below.

General-head boundaries (GHBs) are typically used at the lateral margins of a model to allow groundwater to enter or leave the model domain. GHBs were assigned in the current model to simulate inflow of water across the Muroc Fault. Heads were assigned to these GHB cells based on water level data from wells outside the basin, as presented in the conceptual model report (ENSR, 2008). The conductance of the GHB cells was based on the transmissivity of the aquifer derived during model calibration. **Figure 1** shows the location of the GHB cells.

The conductance value assigned to each GHB boundary cell is computed using the following equation:

$$C = (K\ w\ l)/D$$

Where C is the conductance value in units of square feet per day, K is the hydraulic conductivity of the aquifer in units of feet per day (ft/d), w is the width of the cell in ft, l is the saturated thickness of the cell in ft, and D is the distance to the external head assigned to the GHB in ft.

Koehn Lake was simulated as a drain boundary condition to allow groundwater to discharge to the lake when water levels rise above the lake bed elevation. This effect could also have been simulated using the MODFLOW ET package. However, using drains rather than ET keeps the model more stable. The ultimate effect of a drain is the same as ET. If the water level rises to a certain level, water is extracted. Below that level, water is not extracted. The USGS model of the Death Valley flow system also simulated all playa lakes as drains instead of ET, for example.

The elevation of the drain was taken from the USGS DEM of the area. The conductance was not sensitive during calibration and was computed with a vertical hydraulic conductivity of 1 ft/d (fine sand), bed thickness of 1 ft., and area of the grid cell containing the drain.

Fremont Valley is heavily faulted, as described in the conceptual model report. Faults included in the model include the Muroc Fault, Randsburg-Mojave Fault, Cantil Valley Fault, and the Garlock Fault. These faults are shown on **Figure 1**.

Faults in MODFLOW2000 are simulated using the Horizontal Flow Barrier (HFB) Package of Hsieh and Freckleton (1993). The HFB Package requires a value of hydraulic conductivity and a thickness. The thickness of each fault was assumed to be 1 ft for each HFB cell. The hydraulic conductivity values were determined through calibration to match water levels in the vicinity of each fault. The hydraulic conductivity of each fault will be described in the next section.

2.4 Model Parameters

Model parameters required by MODFLOW2000 for the model include aquifer hydraulic conductivity, fault hydraulic conductivity, and storage values for each cell in the model. Hydraulic conductivity determines the ease with which groundwater flows horizontally. Storage coefficients were also assigned for the transient portion of the model simulation. This section describes the final distribution of parameters in the model derived during calibration. The calibration process will be described in the next chapter.

The usual philosophy in model construction and calibration is to start with a simple distribution of parameters and add complexity (heterogeneity) as required during calibration. In calibrating the Fremont Valley model, the hydraulic conductivity distribution was initially homogeneous and additional hydraulic conductivity zones were added as necessary to match the observed water levels and changes in hydraulic gradient in the valley. The final ten hydraulic conductivity zones are shown in **Figure 3**.

The hydraulic conductivity values range from a low of 0.11 ft/d in the northeastern corner of the Project site to a high of 68.8 ft/d on the northern edge of the model. Hydraulic conductivity values were low in the eastern portion of the model in order to match very high water levels in that area. The hydraulic conductivity values for areas outside the Project site were derived mainly from the steady-state calibration. The transient calibration to the three on-site aquifer tests provided the detailed hydraulic conductivity on the Project site.

Hydraulic conductivity zone 6 was added to the model in response to CEC Comment 2 suggesting that lower conductivity sediments are present below Koehn Lake. The CEC believed that since the sediments beneath Koehn Lake contain more clay than surrounding sediments, the hydraulic conductivity should be lower. Zone 6 was added and the calibration was revised. The calibration did result in a slightly lower hydraulic conductivity of 15.3 ft/d in that area.

The specific yield in the aquifer was homogeneous for the areas outside the Project site and assigned a value of 0.11 (Koehler, 1977). Specific yield values on the site, as with hydraulic

conductivity, were calibrated to the aquifer test. These values ranged from 0.000435 to 0.00968. The same zone numbers were used for both storage and hydraulic conductivity. The final values for both storage and hydraulic conductivity are shown in **Table 1**.

Table 1 lists specific yield and storage coefficient values for zones 7 through 10 (on-site zones). The specific yield values were all 0.11 and were derived from Koehler's report of the area. These values are representative of the long-term decline and recovery of the water table in the valley due to agricultural pumping. The value of 0.11 was confirmed by comparison of several hydrographs in the area during model calibration. The storage coefficient values are smaller and represent values obtained from the calibration to short-term pumping tests at the Project site. The aquifer tests were not long enough to provide estimates of specific yield, which is the reason these values are different from the specific yield values.

The hydraulic conductivity values for each fault were also determined through calibration. These values range from a low of 3.7×10^{-5} ft/d for the Muroc Fault to a high of 1.0 ft/d for the Garlock Fault. The latter, with such a high value of hydraulic conductivity, would have little impact on groundwater flow. The hydraulic conductivity values are summarized on **Table 1** for each fault.

Model parameters, such as hydraulic conductivity, fault conductance, and specific yield, were derived through calibration to three different types of data. The first was a collection of water level measurements from 1958, thought to be close to equilibrium conditions. This was the steady-state calibration. The second set of measurements consisted of drawdowns measured during three short-term aquifer tests conducted at the Project site. The third dataset contained long-term hydrographs from 14 wells in the Fremont Valley.

The steady-state simulation and aquifer test simulations were calibrated together so that a consistent set of parameters could be derived. The long-term simulation from 1958 through 2007 was used as a verification run, as described in the next chapter.

The philosophy used was to keep the hydraulic conductivity values between the major faults homogeneous. During calibration of the aquifer tests, however, it became apparent that local heterogeneities could be identified by the aquifer tests. In order to match these tests better, four additional zones of hydraulic conductivity were added around each test well.

In addition, water levels at the northeast end of the valley were much higher than those to the west. The decision was made to keep the water budget for the valley at the initial estimate and adjust hydraulic conductivity downward in that area to increase water table elevations to match those northeastern wells. CEC Comment 3 (see Chapter 1) asked what constraints were used in the calibration of this area. Essentially the only data available in the northeast area were water levels in a few wells. No data regarding hydraulic characteristics of the aquifer exist in this area. However, this area is far removed from the Project site and inaccuracies in estimation of aquifer characteristics in the northeast area would not affect the predictions significantly. If anything, the very low hydraulic conductivity values used in the northeast area would increase drawdown from the Project site, making these values conservative in terms of model predictions.

The third type of calibration was to long-term hydrographs from 1958 through 2007. The purpose of this calibration was simply to confirm Koehler's specific yield estimate of 0.11. A detailed calibration to these hydrographs was not possible because pumping data for the area is only known in general. Koehler presents estimated total pumping for the valley from 1960 to 1976. Koehler did not give any indication as to the distribution of this pumping and no other data exists on pumping in the valley. Consequently, the pumping was distributed in the valley such that the total pumping rates matched Koehler's data and the locations were placed based on observed drawdown in the hydrographs from a few wells in the area. This calibration did corroborate Koehler's specific yield value and, in a regional sense, showed that the transmissivity in the model is reasonable.

3.0 Model Calibration

3.1 Calibration Concepts

It is important to understand the terms and concepts used in describing the calibration effort. Many of these terms come from the statistical literature and some are unique to groundwater modeling. Calibration is the process of adjusting parameters in the model so that the model-computed water levels match water levels measured in wells. Calibrating a groundwater model is difficult because we have relatively little information on subsurface conditions. Most of the parameters in a model, such as hydraulic conductivity, are only known at a few points where measurements have been taken. Even at those "known" points, the measurement of subsurface properties is an inexact science. Thus, calibration is a necessary part of groundwater modeling where the initial estimates of aquifer properties, entered when the model is first created, are changed so that the model computes more realistic water level elevations.

During the calibration, the model-computed water levels are compared to those water levels measured in wells. These measured water levels are called calibration targets or just targets. The targets represent water levels measured at a particular time during the simulation or they can represent steady-state conditions. In the case of the Fremont Valley model, steady-state conditions represent water levels measured in 1958 when water development in the valley was relatively minor. These water levels are not ideal, however, because they were measured over a range of dates and it is not clear how accurate these measurements were.

Accepted practice in groundwater modeling is to match water level elevations in a steady-state calibration and then water level changes during transient calibration. This was the approach taken in the Fremont Valley model. Measured water level elevations in ft above sea level were matched by the model for steady-state conditions and then changes in water levels for selected wells were matched transiently to three aquifer tests conducted on the Project site.

After each simulation, the target water levels are compared to model-computed water levels. The model-computed water levels are subtracted from the field measurements to produce a

residual. Positive residuals represent computed water levels that are lower than those measured in the field. Conversely, negative residuals are those where the model is computing water levels higher than the measured ones.

A statistical analysis is performed on the collection of residuals from all targets used in the model (Konikow, 1978). Simple statistics such as the mean, standard deviation (sometimes called root-mean-square error), and absolute mean are commonly used. The mean residual should be close to zero, indicating that the positive and negative residuals are balanced. The absolute mean is computed by making all residuals positive and thus represents the average error in the calibration. These statistical measures are used to determine the quality of the calibration. Goals should be established for acceptable values of the mean, standard deviation, and absolute mean. These goals are discussed later in this chapter.

In addition to statistics computed for residuals, the distribution of residuals should be analyzed during calibration. It is desirable to have positive and negative residuals randomly scattered throughout the model. Clustering of positive or negative residuals over large areas is called spatial bias. One goal of calibration is to reduce spatial bias as much as possible. It is virtually impossible, however, to eliminate spatial bias because of the lack of subsurface data.

In traditional calibration techniques, a relatively small number of zones are used to calibrate the model. Each zone covers many cells in the model and within each zone properties such as hydraulic conductivity are constant. The result is a piece-wise homogeneous aquifer configuration in which large areas of each aquifer have homogeneous properties. This was the approach used in the Fremont Valley model.

3.2 Calibration Results

There are many ways to assess the quality of a calibration. The Fremont Valley model calibration was assessed by comparing the calibration statistics to the goals used by ESI in all company modeling projects and by a visual comparison of hydrographs at selected wells.

What constitutes an acceptable calibration is very subjective. Woessner and Anderson (1992) suggest that goals should be established before the calibration starts. However, no standards have ever been put forth by American Society of Testing and Materials (ASTM) or in the scientific literature that describe what these goals should be. Goals were established in the protocol for this model, and are based on goals used by ESI in all models and goals which have undergone peer review from U.S. Environmental Protection Agency (EPA) and many state government agencies. These goals are summarized as follows:

- Residual standard deviation divided by range in head for all targets should be less than 0.10 (10 percent),
- Absolute residual mean divided by range in head for all targets should be less than 0.10 (10 percent),
- Residual mean divided by range in head for all targets should be less than 0.05 (5 percent), and
- There will be limited spatial bias in the distribution of residuals.

As previously discussed, a residual is the difference between a measured water level and the model-computed water level. The residual is calculated as the observed head minus the model-computed head. Thus, a negative residual occurs where the model-computed head is too high and a positive residual is where the model-computed head is too low.

The statistical analysis of the regional calibration is provided in **Table 2** for the steady-state calibration. The table shows the residual mean, residual standard deviation and absolute residual mean. The residual mean uses both positive and negative residuals and thus should be close to zero if the positive and negative residuals balance each other. The absolute residual mean is computed after all residuals are made positive and is thus an average error in the model.

The statistics for the Fremont Valley model calibration met the calibration goals described above. The goal for residual mean divided by range in head is 0.3 percent, well below the goal

of 5 percent. The standard deviation divided by range in head was 4.1 percent, again well below the goal of 10 percent. The absolute residual mean divided by range in head was 3.5 percent, significantly less than the goal of 10 percent. Therefore, all of these statistical measures are substantially better than the established goals.

In addition to statistics, another standard method of judging calibration quality is to plot the measured water levels versus the computed water levels. In a perfect calibration, the points would lie along a straight line at a 45-degree angle indicating that the computed water levels match the observed water levels exactly. In reality, this never happens; however, the spread of data points about the perfect line is an overall indication of spatial bias in the model. **Figure 4** shows that there is no large-scale bias in the calibration with each broad area having the same degree of scatter about the 45-degree line. The higher water levels in the regional model represent the eastern portion of the model domain, while the lower water levels are found in the center of the basin near Koehn Lake.

The transient calibration matched drawdown observed in three aquifer tests on the Project site. Wells 43, 48, and 63 were pumped for three days at a constant rate of about 2,000 gallons per minute (gpm). Drawdown was measured in three surrounding wells for each test and matched with the model. Four data points were chosen from each test at a time after pumping started of 0.5, 1.0, 2.0, and 3.0 days. All three tests were calibrated simultaneously to make sure that the hydraulic properties were consistent between all tests and the steady-state model.

The statistics for the transient calibration to the three aquifer tests also met the goals for model calibration, as shown in **Table 3**. The goal for residual mean divided by range in head is 2.4 percent, well below the goal of 5 percent. The standard deviation divided by range in head was 3.7 percent, again well below the goal of 10 percent. The absolute residual mean divided by range in head was 3.5 percent, significantly less than the goal of 10 percent. Therefore, all of these statistical measures are substantially better than the established goals. **Figure 5** shows that there is no large-scale bias in the transient calibration.

Figure 6a shows the the steady-state calibration for 1958 and compares to those mapped by Koehler (1977). Flow is from the west towards Koehn Lake and from the east towards Koehn Lake. Gradients are steepest in the east where the low hydraulic conductivity zones are located. The water table is somewhat discontinuous across the Randsburg-Mojave and Cantil Valley Faults. **Figure 6b** shows the water table contours in 1959 with the start of agricultural pumping in the valley and represents adjustments to the model to account for local pumping conditions that are apparent in Koehler's interpretation. This figure is also compared to the 1958 water level map developed by Kohler's (1977) and shows a better match to the water levels interpreted by Koehler (1977) for 1958.

3.3 Model Verification

In model verification, the calibrated model is applied to a different time period than the calibration period. If the only model inputs that need to change are related to stresses (e.g. pumping, recharge, etc.) then the calibration has been verified. That is, the hydraulic properties (hydraulic conductivity, storage, boundary conditions) have been shown to be valid for an untested time period. Thus, more confidence can be placed in the predictions than if the model had not been verified.

The Fremont Valley calibration was verified by simulating the period from 1958 through 2007. The primary verification period was from 1958 through 1976 because good estimates of agricultural pumping are available from Koehler (1977). After 1976, agricultural pumping had to be inferred from the water level hydrographs in the area.

While Koehler did estimate agricultural pumping from 1960 to 1976, he did not show the distribution of pumping. The location of pumping wells was estimated by using Koehler's water table map for 1976 that showed two cones of depression in the vicinity of the Project site and the Honda facility to the east. One cone of depression was located north of the Cantil Valley Fault and the other south of the fault. Five production well locations were placed in the model with two north of the fault and three south of the fault. More wells were placed south of the fault

because the cone of depression was much larger than the one to the north. Although the transmissivity is also lower south of the fault, it was found during verification that having three wells south of the fault produced a better match to the hydrographs.

Three wells in the vicinity of the pumping center had a long period of water level measurements from 1958 through the 1980s and 1990s. Most other wells had only short periods of water level measurements or were in areas relatively unaffected by the agricultural pumping. These wells were not used initially in the verification.

Well 31S38E06E001M lies south of the Cantil Valley Fault within the Honda test track. This well is closest to the largest cone of depression in Koehler's 1976 water table map. The hydrograph for this well is shown in **Figure 7**. The model predicts slightly more drawdown at the peak period of 1980. However, the overall match between observed and simulated water levels is very good.

Well 30S37E36G001M is close to the Cantil Valley Fault on the northern side of the Honda test track. This well has the longest period of record, as shown in **Figure 8**. The observed data oscillates over time, probably in response to seasonal pumping. The model was not designed to simulate seasonal pumping. Average pumping over each year was assumed. However, the match between the observed water levels and the simulated water levels is quite good.

Well 30S37E27H002M is north of the Cantil Valley Fault, about one mile north of the Honda test track. **Figure 9** shows that the model also matches quite well with the water level record of this well.

These three wells show that the model, without any changes except for pumping, can match a long-term water level record in the area of the Project site. This provides confidence in the predictive capabilities of the model.

In response to previous comments from the CEC on the verification run, additional hydrographs have been created for wells throughout the Fremont Valley that have long-term water level data. The locations and hydrographs for all long-term wells are provided in **Appendix A. Plate A-1** in **Appendix A** is a D-size a layout of the hydrographs referencing the wells within the Koehn Sub-basin. These same hydrographs will be used, along with other key points of interest, in the predictive sensitivity analysis presented at the end of this chapter.

Obviously no calibration is perfect and so there will always be mismatches between the model results and water levels measured in the field. The mismatch in the case of the Fremont Valley model is primarily due to lack of data on pumping locations and rates. This is most obvious in the long-term hydrographs that have been presented. For example, a couple of the hydrographs show steep recovery that the model cannot match because we did not place a pumping well at that location. Mismatch in the steady-state calibration is also related to lack of pumping knowledge. In the area between the Project site and Koehn Lake, some water levels show indications that pumping was occurring in that area. Other water levels do not show such affects. It is likely that 1958 was close to the time when agricultural pumping was just starting to increase significantly so there are local drawdown affects that the model cannot match because there is no knowledge of where those wells might have been and what rate they might have pumped.

3.4 Calibration Sensitivity Analysis

There are two main types of sensitivity analysis often performed in groundwater modeling studies. One is the sensitivity of the model calibration to changes in parameters. The second is the sensitivity of predictions to changes in parameters. Both were conducted in this study. The calibration sensitivity analysis is discussed in this section and the predictive sensitivity analysis is presented in a later section.

The purpose of a calibration sensitivity analysis is to document the relative importance of model parameters on calibration statistics. This provides the user and the CEC with additional

information about which parameters are most important to the calibration process. The most sensitive parameters are those that are usually best estimated in the calibration.

Eleven model simulations were run for each parameter. During each simulation, the parameter was multiplied by a factor between of 0.5 and 2.0 for hydraulic conductivity. Recharge and specific yield values were multiplied by factors between 0.1 and 10. The calibration statistics were compiled for each of these simulations. Graphs were created that plot the sum of squared residuals versus parameter multiplier. The sum of squared errors for a multiplier of 1.0 refers to the calibrated model parameters. **Figure 10** presents the results for hydraulic conductivity zones, **Figure 11** represents specific yield, **Figure 12** represents fault conductance, and **Figure 13** presents the recharge sensitivity analysis. When viewing the curves in **Figures 10 through 13**, flat curves are insensitive parameters and steep curves are sensitive parameters.

The most sensitive hydraulic conductivity zones in the calibration are zones 1 through 4, representing the central part of the aquifer in Fremont Valley. The zones on the Project site are not as sensitive because relatively few calibration targets are found in those zones. Specific yield is also very sensitive in the verification run (**Figure 11**) with Koehler's estimate of 0.11 providing the best calibration results. Three out of the four fault zones are very sensitive, including the Muroc Fault, the Cantil Valley Fault, and the Randsburg-Mojave Fault. Only the Garlock Fault was not sensitive during calibration. Recharge was also quite sensitive, which makes sense since that is the majority of the available water in the model.

3.5 Impact Assessment for BSEP

The calibrated model was used to predict the impact of a proposed 1,600 AF/yr withdrawal from a single on-site well along with higher pumping for five months during the initial phase of the Project. The verification simulation described in the last section was extended through 2010. The five-month construction period was added to that run in five 1-month stress periods, followed by 30 years of a constant pumping rate of 1,600 AF/y.

During the construction period, groundwater pumping will be higher than the long-term average pumping. The construction period was divided into five 1-month stress periods with 5.0 million gallons per day (MGD) for the first and last month and 10 MGD for the middle three months of construction. The pumping was assumed to be equally distributed between wells 41, 42, 47, 48, 49, 63, and the domestic well.

The long-term average pumping for the project lasted 30 years and assumed that one well was pumping continuously at a rate of 1,600 AF/yr. Two scenarios were simulated for the 30 year period. In the first, Well 48 was pumped and in the second, Well 63 was pumped.

Results of the predictive simulations are presented in two ways. The first shows the predicted change in water levels from water levels at the end of the verification run (2010). Because water levels are rising in the valley, these predictions mainly show higher water levels with project pumping. That is, the impact of the project is to simply reduce the amount of future rise in the water table (i.e., effect on overall groundwater recovery). The figures show a negative number which in the model indicates increasing water levels.

The second method of presenting the results shows the predicted impact from project pumping on the water level rise over the model period (i.e., either five or 30 years). The impact figures show the difference in water levels between those that would occur under the natural future rise in the water table without the Project and the added impact of project pumping. In other words, these figures essentially show how much less the well will rise as influenced by project pumping (i.e., effect on the amount of recovery).

Changes in water level and impacts are presented at the end of the construction period (five months after project start), at five years after the end of the construction period, and at 30 years after the end of the construction period. **Figures 14, 15, and 16** are the changes in water level (ft) for Well 48 pumping. **Figures 17, 18, and 19** are the impacts with Well 48 pumping. **Figures 20, 21, and 22** are the changes in water level with Well 63 pumping**. Figures 23, 24, and 25** are the impacts with Well 63 pumping. Since there is very little difference between the

figures with Well 48 pumping and Well 63 pumping, the Well 63 scenario will be discussed below.

Effect on the Regional Water Level Recovery

During the construction period (five months), the model predicts that changes in water level will be about 5 to 10 ft on the Project site (**Figure 20**). However, there will be no lowering of the water table off site due to the continued rise of the water table into the future. The change in water level after five years (**Figure 21**) and 30 years (**Figure 22**) show that the Project pumping will not result in any lowering of the water table, again due to the continued rise of the water table. The model predicts that the on-site water table rise will be about 35 ft after 30 years.

Effect on the Amount of Water Level Recovery

The impact of construction pumping is shown in **Figure 23**. Total impact on site will be about 12 ft but off-site areas will be affected by less than 1 foot. After five years of project pumping (**Figure 24**), the maximum off-site impact will be about 5 ft. With continuing pumping, Project impacts at 30 years (**Figure 25**) will be about 20 ft on site and 15 ft off site. The distance from the Project site to the 5 ft impact contour is about 3 miles. Little impact is observed to the southeast of the Cantil Valley Fault due to the barrier effect of the fault.

The CEC in Comment 5 pointed out that short-term impacts from construction pumping might be higher than those described above due to lower specific yield values observed in the aquifer testing. **Figure 26** presents the five month impacts from construction pumping with these lower specific yield values. These lower values result in an additional 5 ft of drawdown on site but the off-site effects are still less than 5 ft to the northeast of the site where the closest neighboring wells are located.

3.6 Predictive Sensitivity Analysis

A series of simulations were conducted to test the model response to changes in parameters, boundary conditions, and other assumptions. Because impacts are not significantly different

between Well 48 or Well 63 pumping, all simulations assume Well 63 is pumping in the future. Results are presented in **Appendix B** (model sensitivity), which includes hydrographs at the same wells from the verification as well as additional wells at key locations throughout the study area. **Plate B-1** in **Appendix B** is an E-size a layout of the hydrographs referencing the wells within the Koehn Sub-basin that were evaluated in sensitivity analysis. Maximum impacts at all wells are also shown in **Table 4**. Impacts shown in **Table 4** are the difference in future water levels with and without Well 63 pumping. Because water levels are rising in the valley, these impacts do not mean that these wells will experience a decline in water level. Rather, the amount of rise in water level will be less than if Well 63 were not pumping.

The following simulations were included in the sensitivity analysis:

- Hydraulic conductivity was increased by a factor of 2.0.
- Hydraulic conductivity was decreased by a factor of 0.5.
- Specific yield was increased by a factor of 2.0.
- Specific yield was decreased by a factor of 0.5.
- Cantil Valley Fault was removed.
- Hydraulic Conductivity Zone 7 (low-K on-site zone) was removed.
- Agricultural return flows were added with a 10-year lag.

Impacts greater than 10 ft are generally only seen in wells within a mile of Well 63. The exception is Well 30S37E34H02, which is 2.7 miles from Well 63 and has 11.4 ft of impact in the base case. This is true in virtually all of the sensitivity simulations. Worst-case impacts are predicted if the hydraulic conductivity is half the calibrated value. Even under those conditions, though, the extra impact is less than 10 ft. The next most sensitive parameter is specific yield. Lowering specific yield allows the impacts to propagate further during the 30 years of pumping.

4.0 Conclusions

The model calibration was adjusted slightly from the version presented in December 2008. A zone of lower hydraulic conductivity was added beneath Koehn Lake and the inflow of water from California City was reduced over time. These changes were made based on comments received from CEC.

The calibration results meet the goals established for calibration quality and are very similar to those presented in the previous version of the model. Results of the simulations under the new calibration show no significant change over the prior model predictions. In the previous model report, only impacts were shown. In the current model report the meaning of these impacts has been clarified. That is, the impact from the project will not be a lowering of water levels off-site but a reduction in the amount of recovery or water level rise in the future.

The predictive sensitivity analysis shows the degree of uncertainty in simulated impacts from project pumping. Impacts predicted in the sensitivity analysis are greater than 10 feet generally within a mile of Well 63 (the project pumping well). While one or two simulations showed impacts at greater distances, none were over 12 ft.

Model input files are provided in **Appendix C**.

5.0 References

ASTM, 1993. Standard Guide for Application of a Ground-Water Flow Model to a Site-Specific Problem, Standard D5447-93. American Society for Testing and Materials, Philadelphia, Pennsylvania, 15 p.

Anderson, M.P. and W.W. Woessner, 1992. Applied Groundwater Modeling; Simulation of Flow and Advective Transport. Academic Press, San Diego, California, 381 p.

Andersen, P.F., 1993. A Manual of Instructional Problems for the USGS MODFLOW Model. EPA, EPA/600/R-93/010.

ENSR, 2008. Conceptual Hydrogeologic Model and Numerical Groundwater Flow Model Developed for Fremont Valley,: Appendix J-2, Application for Certification, Beacon Solar Energy Project, Kern County, California: AECOM Environment, Camarillo, CA.

ESI, 2001. Groundwater Vistas User's Guide.

Franke, O.L., T.E. Reilly, and G.D. Bennett, 1984. Definition of Boundary and Initial Conditions in the Analysis of Saturated Groundwater Flow Systems - An Introduction, USGS Open-File Report 84-458. Reston, Virginia.

Harbaugh, A.W., E.R. Banta, M.C. Hill, and M.G. McDonald, 2000. MODFLOW-2000, The U.S. Geological Survey Modular Ground-Water Model – User Guide to Modularization Concepts and the Ground-Water Flow Process. USGS Open File Report 00-92.

Hsieh, P. and J. Freckleton, 1993. Documentation of a Computer Program to Simulate Horizontal-Flow Barriers Using the USGS MODFLOW Model. USGS Open File Report 92-477.

Koehler, J.H., 1977. Ground Water in the Koehn Lake Area, Kern County, California. USGS Water Resources Investigations Report 77-66.

Konikow, L.F., 1978. Calibration of Groundwater Models, in Proceedings of the Specialty Conferences on Verification of Mathematical and Physical Models in Hydraulic Engineering. College Park, Maryland, August 9-11, 1978.

McDonald, M.G. and A.W. Harbaugh, 1988. A Modular Three-dimensional Finite-difference Ground-water Flow Model. USGS TWRI, Book 6, Chapter A1.

SAMDA, 1997. Draft Initial Study/Proposed Negative Declaration SAMDA Water Exploration, Fremont Valley Ranch Water Management Project. Samda Incorporated, Santa Monica, California (Prepared for the Los Angeles Department of Water and Power).

Woessner, W.W. and M.P. Anderson, 1992. Selecting Calibration Values and Formulating Calibration Targets for Groundwater Flow Simulations. Proceedings of the NWWA Conference on Solving Ground-Water Problems with Models.

Tables

Table 1. Summary of Calibrated Model Parameters for the Fremont Valley Model.

Parameter Type	Zone	Location	Parameter Value	Units
Hydraulic Conductivity	1	Between Cantil Valley and Garlock Faults	20.00	ft/d
Hydraulic Conductivity	2	South of Cantil Valley Fault	43.51	ft/d
Hydraulic Conductivity	3	East End of Valley Between North of Cantil Valley Fault	0.40	ft/d
Hydraulic Conductivity	4	East End of Valley Between South of Cantil Valley Fault	0.53	ft/d
Hydraulic Conductivity	5	North of Garlock Fault	68.80	ft/d
Hydraulic Conductivity	6	Beneath Koehn Lake	15.30	ft/d
Hydraulic Conductivity	7	Northeast corner of Project Beacon Site	0.11	ft/d
Hydraulic Conductivity	8	Western edge of Project Beacon Site	51.70	ft/d
Hydraulic Conductivity	9	Central part of Project Beacon Site	50.23	ft/d
Hydraulic Conductivity	10	Southeastern corner of Project Beacon Site	58.08	ft/d
Specific Yield	1	Between Cantil Valley and Garlock Faults	0.1100	dimensionless
Specific Yield	2	South of Cantil Valley Fault	0.1100	dimensionless
Specific Yield	3	East End of Valley Between North of Cantil Valley Fault	0.1100	dimensionless
Specific Yield	4	East End of Valley Between South of Cantil Valley Fault	0.1100	dimensionless
Specific Yield	5	North of Garlock Fault	0.1100	dimensionless
Specific Yield	7	Northeast corner of Project Beacon Site	0.1100	dimensionless
Specific Yield	8	Western edge of Project Beacon Site	0.1100	dimensionless
Specific Yield	9	Central part of Project Beacon Site	0.1100	dimensionless
Specific Yield	10	Southeastern corner of Project Beacon Site	0.1100	dimensionless
Storage Coefficient	7	Northeast corner of Project Beacon Site	0.0138	dimensionless
Storage Coefficient	8	Western edge of Project Beacon Site	0.0097	dimensionless
Storage Coefficient	9	Central part of Project Beacon Site	0.0004	dimensionless
Storage Coefficient	10	Southeastern corner of Project Beacon Site	0.0027	dimensionless
Fault Hydraulic Conductivity	0	Garlock Fault	1	ft/d
Fault Hydraulic Conductivity	1	Cantil Valley Fault	0.00020	ft/d
Fault Hydraulic Conductivity	2	Randsburg-Mojave Fault	0.00197	ft/d
Fault Hydraulic Conductivity	3	Muroc Fault	0.000037	ft/d

Table 2. Residuals and Statistics for the Steadystate Calibration to Water Levels

Name	Easting	Northing	Observed Water Level (ft)	Computed Water Level (ft)	Residual (ft)
29S39E26A01	1,415,707	12,848,465	2,132.0	2,125.6	6.40
29S39E28H01	1,404,738	12,846,295	1,925.5	1,940.0	-14.49
29S39E35H01	1,414,297	12,841,453	1,924.0	1,935.8	-11.78
29S39E33H01	1,404,878	12,841,418	1,918.0	1,925.4	-7.43
29S39E33K01	1,402,374	12,841,438	1,919.0	1,923.4	-4.44
29S39E15M01	1,406,594	12,854,424	2,231.0	2,242.0	-10.97
29S39E22D01	1,405,542	12,852,476	2,112.0	2,103.9	8.07
29S39E32C01	1,396,105	12,843,818	1,911.0	1,932.6	-21.57
29S39E32E01	1,394,263	12,840,995	1,911.0	1,930.1	-19.05
30S38E24F01	1,385,320	12,820,257	1,927.0	1,906.6	20.35
30S38E08G01	1,365,192	12,830,553	1,927.0	1,912.1	14.87
30S38E20E01	1,363,433	12,821,072	1,922.0	1,913.9	8.07
30S38E20F01	1,363,523	12,821,071	1,924.0	1,913.7	10.35
30S38E20C03	1,363,682	12,822,161	1,923.0	1,911.6	11.39
30S38E20C04	1,364,695	12,821,970	1,923.0	1,908.5	14.54
30S38E20B01	1,364,931	12,821,750	1,916.0	1,908.0	8.01
30S38E34C02	1,375,193	12,811,468	1,912.0	1,904.1	7.94
30S38E32D01	1,362,351	12,810,675	1,937.0	1,926.1	10.88
30S38E31L01	1,359,431	12,807,973	1,928.0	1,936.0	-8.03
30S38E31F01	1,357,209	12,809,596	1,930.0	1,937.8	-7.79
30S38E30P01	1,359,201	12,812,015	1,933.0	1,930.5	2.51
30S38E30R01	1,361,027	12,812,799	1,941.0	1,925.7	15.34
30S38E30E01	1,356,898	12,814,548	1,942.0	1,937.5	4.48
30S38E19K01	1,359,453	12,819,691	1,944.4	1,926.3	18.08
30S37E24R02	1,356,779	12,817,678	1,944.0	1,934.3	9.67
30S37E24R01	1,355,948	12,818,123	1,951.0	1,935.5	15.46
30S38E19M01	1,356,950	12,819,933	1,944.0	1,931.5	12.46
30S37E24J01	1,356,145	12,820,013	1,949.3	1,933.1	16.11
30S37E24K01	1,355,637	12,819,945	1,956.0	1,934.2	21.75
30S37E24G01	1,354,993	12,821,152	1,949.0	1,934.3	14.67
30S37E24R01	1,354,524	12,821,977	1,951.0	1,934.5	16.55
30S37E24K02	1,354,473	12,819,847	1,952.0	1,936.7	15.31
30S37E23D01	1,346,198	12,821,639	1,935.0	1,948.7	-13.67
30S37E24M01	1,351,807	12,818,637	1,943.2	1,943.3	-0.05
30S37E25M01	1,351,677	12,814,525	1,944.0	1,947.4	-3.39
30S37E36G01	1,355,876	12,810,519	1,934.7	1,939.0	-4.31
30S37E36K01	1,355,850	12,808,007	1,955.0	1,942.6	12.45
30S37E36N01	1,352,108	12,806,734	1,930.5	1,950.5	-20.00
31S37E01H01	1,355,824	12,805,279	1,938.0	1,946.9	-8.89
31S37E01R01	1,356,623	12,801,414	1,929.0	1,952.5	-23.53
31S37E12H01	1,356,596	12,798,576	1,929.0	1,958.4	-29.40
31S37E13B01	1,355,070	12,795,170	1,962.0	1,965.2	-3.17
31S37E22Q01	1,343,783	12,785,375	1,990.7	1,996.1	-5.47
31S37E10A01	1,344,999	12,800,108	1,980.0	1,970.8	9.17
31S37E02P01	1,347,672	12,801,828	1,918.0	1,922.7	-4.66
31S37E02D01	1,347,201	12,805,472	1,925.0	1,928.6	-3.58
30S37E35Q01	1,349,959	12,806,755	1,952.0	1,954.2	-2.24
30S37E34F01	1,342,448	12,810,650	1,951.0	1,962.7	-11.68
30S37E34H01	1,346,025	12,810,214	1,949.0	1,958.6	-9.63
30S37E27P01	1,342,652	12,813,086	1,942.0	1,961.7	-19.72
30S37E28J01	1,338,946	12,809,594	1,975.0	1,965.1	9.90
30S37E26E01	1,346,463	12,815,268	1,951.0	1,955.2	-4.22
30S37E27H01	1,346,071	12,814,872	1,940.0	1,956.0	-16.03
30S37E26K01	1,349,050	12,814,442	1,948.0	1,951.8	-3.84
31S37E05M01	1,331,025	12,803,475	1,994.0	1,976.0	17.99
31S37E30F01	1,326,909	12,783,118	2,064.5	2,027.9	36.60
31S37E28P01	1,337,571	12,780,169	2,074.0	2,070.0	4.05
31S37E33H01	1,340,472	12,777,520	2,066.0	2,055.3	10.67
32S37E04D01	1,335,601	12,774,440	2,054.8	2,065.5	-10.69
32S37E04P01	1,338,378	12,770,095	2,065.1	2,069.0	-3.92
32S36E22B01	1,311,344	12,757,606	2,105.0	2,121.5	-16.51
30S38E05R01	1,367,517	12,833,661	1,899.0	1,916.0	-17.04
30S38E05R02	1,367,608	12,833,879	1,901.0	1,916.3	-15.26
30S38E08K01	1,365,187	12,830,044	1,929.0	1,910.8	18.21
30S38E30Q01	1,359,380	12,812,013	1,944.0	1,930.1	13.87
30S38E32E01	1,361,832	12,809,370	1,932.9	1,929.1	3.72
30S39E08A01	1,399,181	12,833,676	1,912.1	1,917.9	-5.83
30S38E08E02	1,362,357	12,830,289	1,954.0	1,950.4	3.65
30S38E20C01	1,364,783	12,821,860	1,918.0	1,908.3	9.68
30S38E30R02	1,361,029	12,812,906	1,943.0	1,925.5	17.50
29S39N29N01	1,394,465	12,843,831	1,914.0	1,932.0	-18.02
Residual Mean					**0.99**
Residual Standard Deviation					**13.49**
Absolute Residual Mean					**11.70**
Minimum Residual					**-29.40**
Maximum Residual					**36.60**
Range in Head					**332.00**
Residual Mean/Range					**0.3%**
Residual Standard Deviation/Range					**4.1%**
Absolute Residual Mean/Range					**3.5%**

Table 3. Residuals and Statistics for the Transient Calibration to Pump Test Drawdown.

Name	Time (d)	Pumping Well	Easting	Northing	Observed Drawdown (ft)	Computed Drawdown (ft)	Residual (ft)
46	0.5	43	1,342,509	12,804,500	0.15	0.06	0.09
46	1	43	1,342,509	12,804,500	0.30	0.21	0.09
46	2	43	1,342,509	12,804,500	0.57	0.63	-0.06
46	3	43	1,342,509	12,804,500	1.05	1.07	-0.02
50	0.5	43	1,338,386	12,803,743	0.04	0.00	0.04
50	1	43	1,338,386	12,803,743	0.26	0.00	0.26
50	2	43	1,338,386	12,803,743	0.53	0.02	0.51
50	3	43	1,338,386	12,803,743	0.85	0.05	0.80
USGS	0.5	43	1,339,694	12,801,248	3.20	3.12	0.08
USGS	1	43	1,339,694	12,801,248	5.70	5.87	-0.17
USGS	2	43	1,339,694	12,801,248	9.50	9.06	0.44
USGS	3	43	1,339,694	12,801,248	12.37	11.75	0.62
41	0.5	48	1,333,612	12,798,544	1.22	0.25	0.97
41	1	48	1,333,612	12,798,544	1.55	0.67	0.88
41	2	48	1,333,612	12,798,544	1.81	1.34	0.46
41	3	48	1,333,612	12,798,544	1.93	1.97	-0.04
47	0.5	48	1,329,846	12,797,459	1.14	0.44	0.70
47	1	48	1,329,846	12,797,459	1.57	0.86	0.71
47	2	48	1,329,846	12,797,459	2.25	1.41	0.84
47	3	48	1,329,846	12,797,459	2.75	1.89	0.86
49	0.5	48	1,334,463	12,800,146	0.12	0.12	0.00
49	1	48	1,334,463	12,800,146	0.22	0.39	-0.17
49	2	48	1,334,463	12,800,146	0.31	0.88	-0.57
49	3	48	1,334,463	12,800,146	0.41	1.35	-0.94
44	0.5	63	1,335,918	12,799,848	4.01	3.93	0.08
44	1	63	1,335,918	12,799,848	5.12	4.62	0.50
44	2	63	1,335,918	12,799,848	6.37	5.47	0.90
44	3	63	1,335,918	12,799,848	7.26	6.21	1.05
45B	0.5	63	1,336,096	12,801,531	0.43	0.14	0.29
45B	1	63	1,336,096	12,801,531	0.70	0.31	0.39
45B	2	63	1,336,096	12,801,531	0.86	0.70	0.16
45B	3	63	1,336,096	12,801,531	0.92	1.09	-0.17
49	0.5	63	1,334,463	12,800,146	5.05	4.47	0.58
49	1	63	1,334,463	12,800,146	5.66	5.08	0.58
49	2	63	1,334,463	12,800,146	6.09	5.83	0.26
49	3	63	1,334,463	12,800,146	6.17	6.49	-0.32
Residual Mean							**0.30**
Residual Standard Deviation							**0.45**
Absolute Residual Mean							**0.43**
Minimum Residual							**-0.94**
Maximum Residual							**1.05**
Range in Head							**12.25**
Residual Mean/Range							**2.4%**
Residual Standard Deviation/Range							**3.7%**
Absolute Residual Mean/Range							**3.5%**

Table 4. Maximum Impact at Key Wells in Predictive Sensitivity Analysis

		Maximum Impact (ft) With Well 63 Pumping							
Well	**Distance to Well 63**	**Base**	**K Times 2**	**K Times 0.5**	**Sy Times 2**	**Sy Times 0.5**	**No Canthill Fault**	**No Zone 7**	**Return Flow**
Pumping Well 63	0.0	24.5	16.3	34.6	20.2	26.6	15.7	22.1	24.0
31S37E08C001M	0.6	21.4	14.8	28.5	16.9	23.6	12.6	19.4	21.0
31S37E05M01	0.9	20.5	14.2	27.1	16.1	22.7	12.1	18.8	20.1
Pumping Well 48	1.0	21.2	14.8	27.7	16.6	23.5	12.0	19.2	20.8
31S37E10A01	1.9	2.9	2.4	4.8	1.6	4.2	8.4	2.8	2.9
30S37E34H02	2.7	11.4	8.5	14.0	8.2	13.1	6.4	11.8	11.2
31S37E14L01	3.0	2.6	2.2	3.9	1.3	3.8	7.7	2.5	2.5
30S37E27H002M	3.4	9.3	7.1	11.2	6.5	10.8	5.3	9.6	9.2
31S37E30F001M	3.6	2.0	0.5	2.7	0.8	3.4	6.6	1.8	2.0
Well 24	4.1	2.0	2.0	3.1	1.0	2.9	5.1	2.0	1.9
31S38E06E001M	4.2	1.9	2.0	3.0	1.0	2.7	4.7	1.9	1.8
30S37E36G001M	4.3	7.3	5.8	8.6	4.9	8.5	4.2	7.5	7.2
31S37E33H001M	4.5	0.6	0.3	1.0	0.1	1.6	2.1	0.6	0.6
31S37E35N001M	5.3	0.5	0.3	0.8	0.1	1.6	1.9	0.5	0.6
30S37E24J001M	5.4	5.4	4.4	6.4	3.5	6.5	3.1	5.6	5.4
30S38E32D03	5.6	1.3	1.7	1.9	0.6	1.8	2.9	1.3	1.2
30S38E19K01	5.9	4.5	3.7	5.2	2.9	5.4	2.5	4.7	4.5
30S38E03K002M	10.2	1.7	1.8	1.6	0.9	2.2	0.8	1.7	1.6
30S38E24F001M	10.2	0.3	1.2	0.1	0.1	0.6	0.5	0.3	0.2
29S39E32E001M	13.6	1.3	1.9	1.0	0.5	2.0	0.6	1.4	1.3
30S39E08A001M	13.7	0.4	1.2	0.2	0.1	0.9	0.5	0.4	0.3
29S39N29N01	13.9	1.3	1.9	1.0	0.5	2.0	0.6	1.4	1.3
29S39E33K001M	14.9	0.4	1.3	0.3	0.1	1.1	0.5	0.4	0.4
29S39E28H001M	15.8	1.1	1.9	0.7	0.4	1.9	0.5	1.2	1.1

Notes:

Impact is the change in head caused by pumping Well 63. Since water levels are rising, impacts are simply less rise in the future.

Distance is in miles

Base run is the calibrated model

K is hydraulic conductivity

Sy is specific yield

Return Flow simulates an added 30% of pumping which is then returned as recharge with a lag time of 10 years

Figures

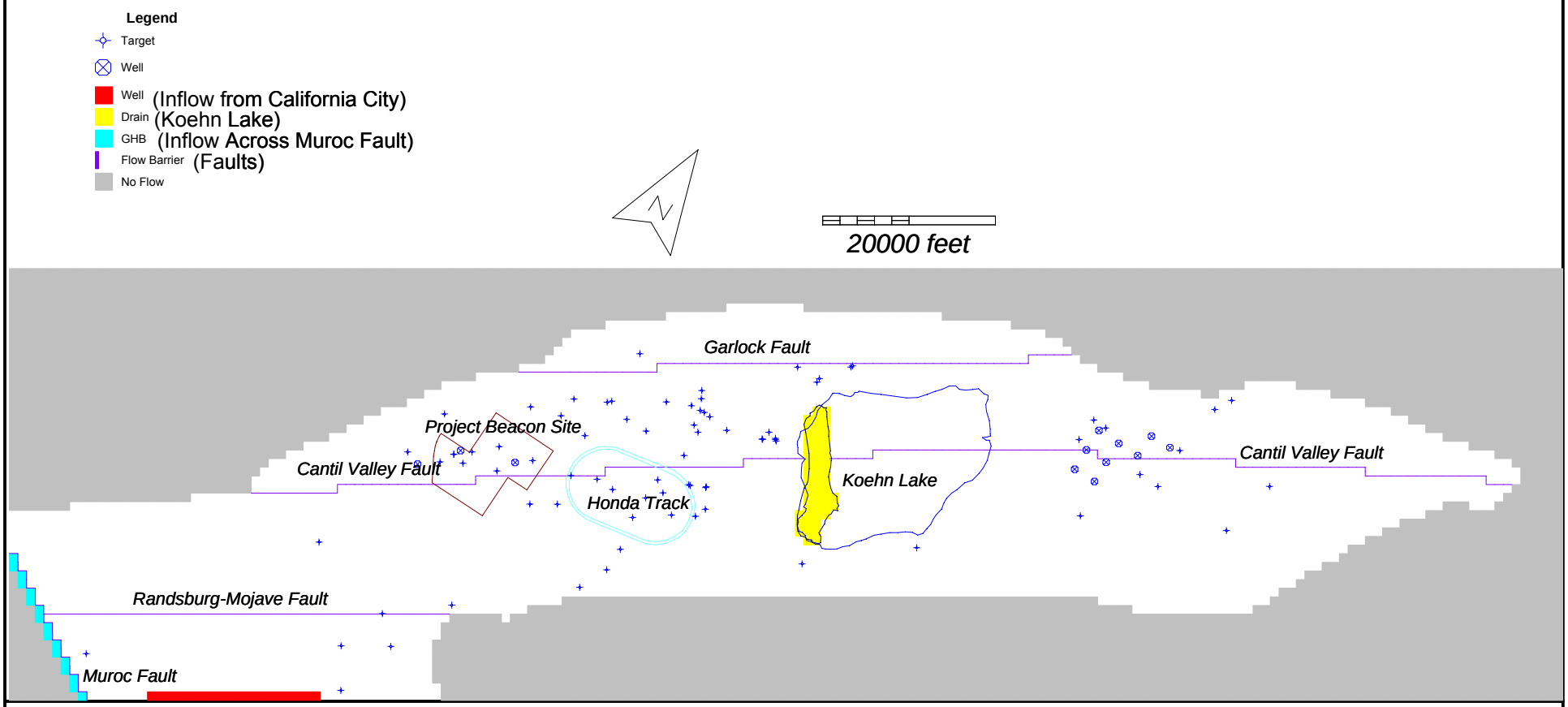


Figure 1. Model Area for the Project Beacon (Fremont Valley) Groundwater Flow Model Showing Boundary Conditions.

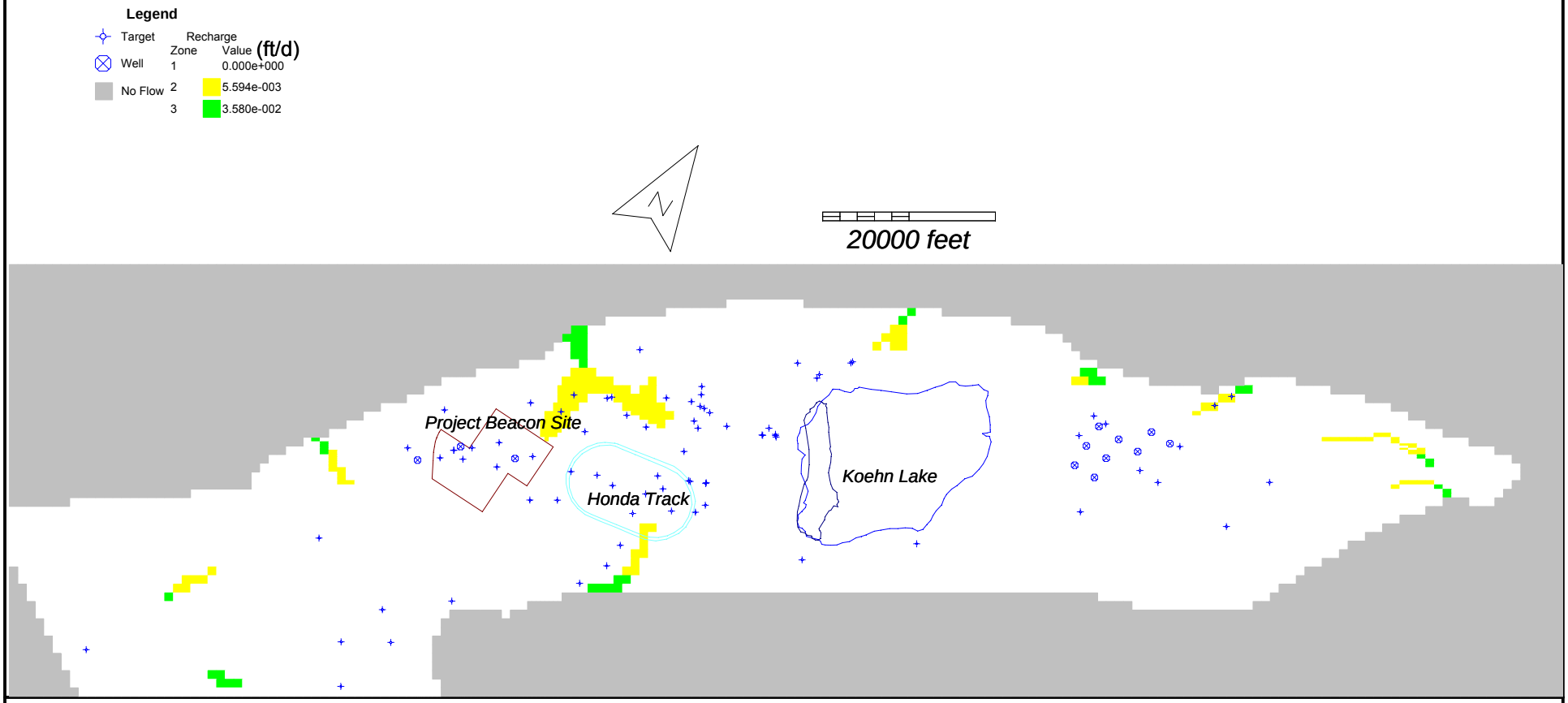


Figure 2. Model Area for the Project Beacon (Fremont Valley) Groundwater Flow Model Showing Recharge Zones.

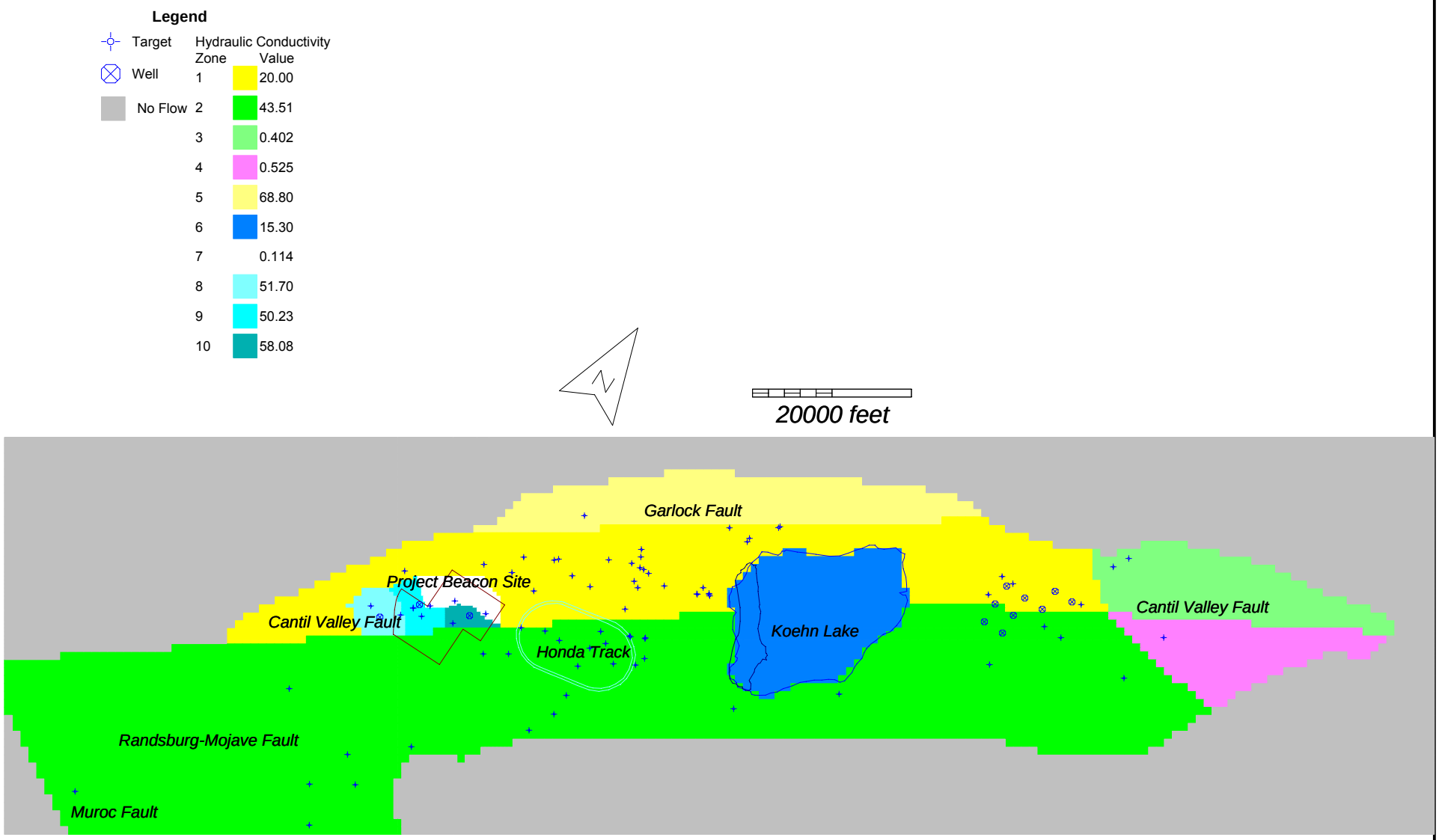


Figure 3. Model Area for Project Beacon (Fremont Valley) Groundwater Flow Model Showing Hydraulic Conductivity Zones.

Figure 4. Observed vs. Simulated Water Levels for 1958.

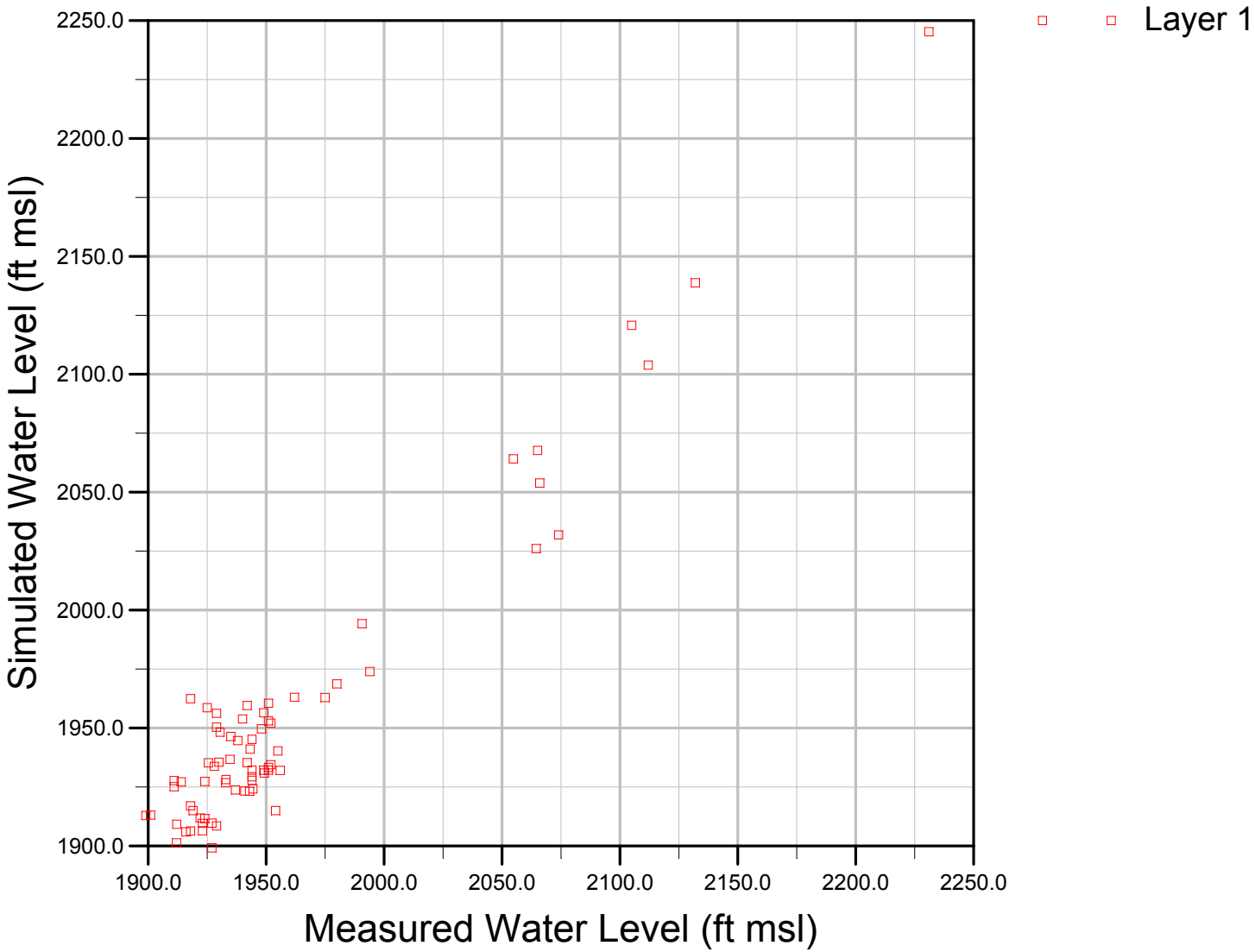
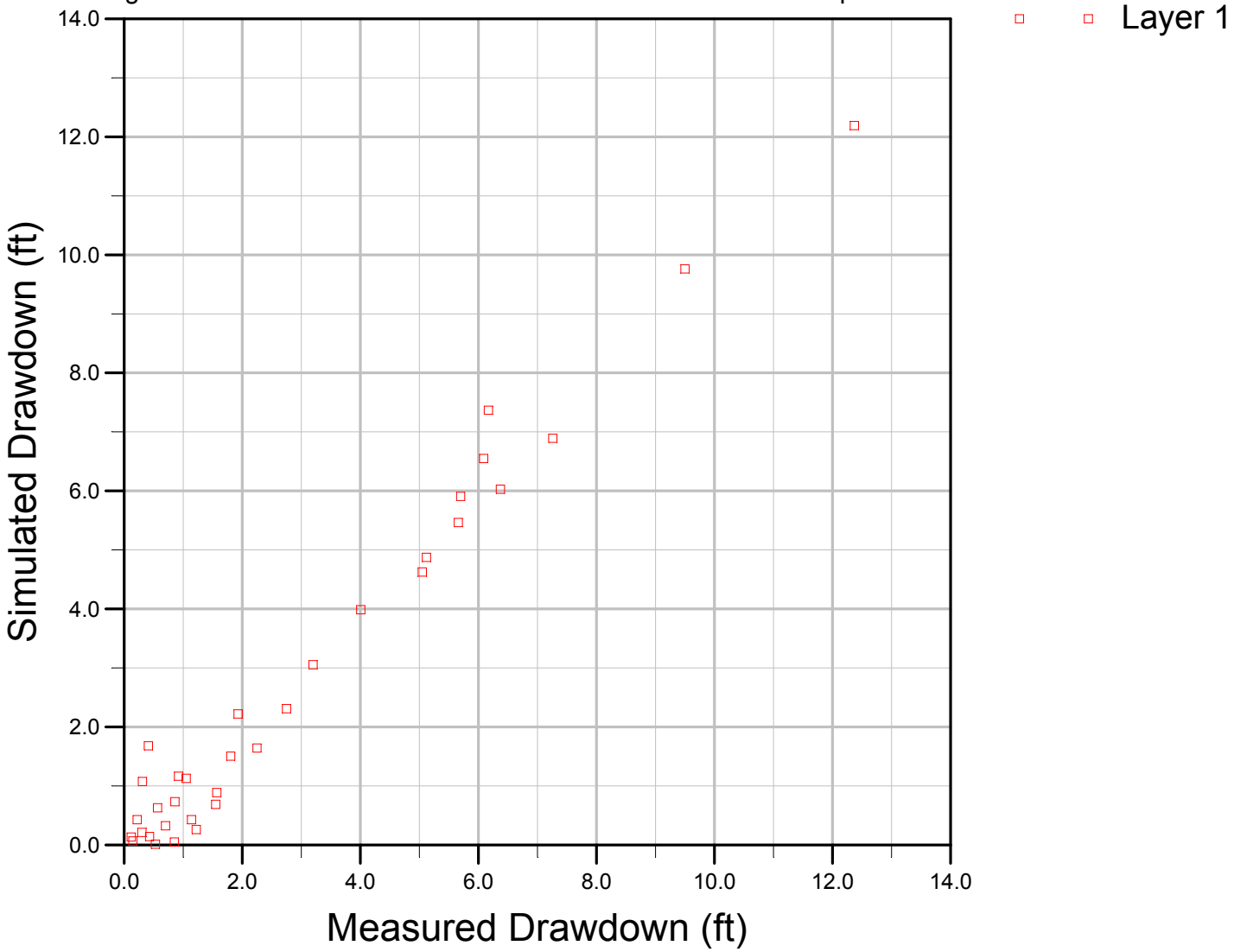
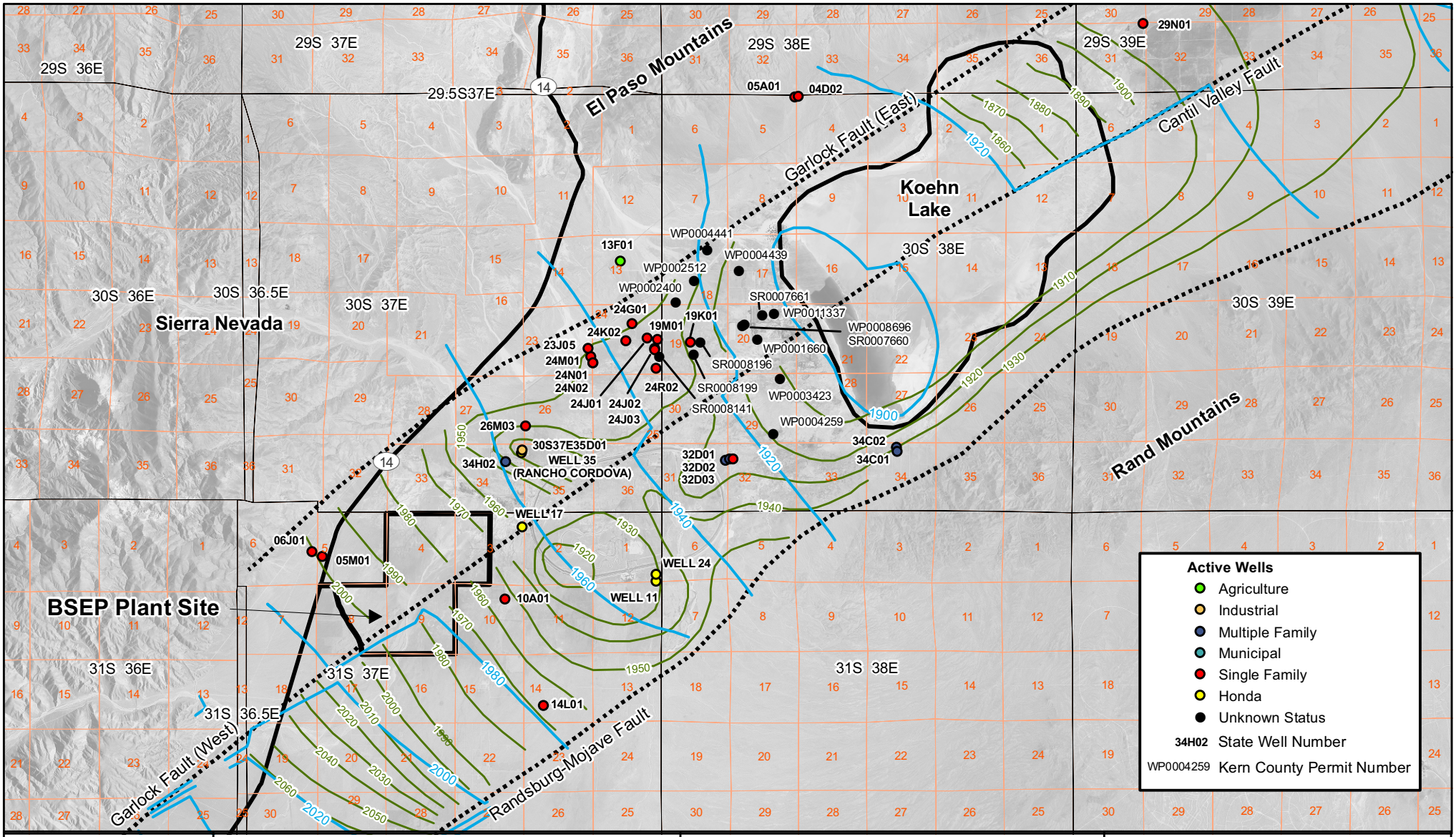


Figure 5. Observed vs. Simulated Drawdown from 3 On-Site Aquifer Tests





Map Location

Legend

- Predicted Water Table
- Groundwater Contour (feet amsl) (Koehler, 1977)
- Fault
- Township Range
- Sections
- BSEP Plant Site Boundary

Note: Fault locations are approximate
Source: Koehler, 1977

0 2 4 Miles

1:126,720

N W E S

BSEP

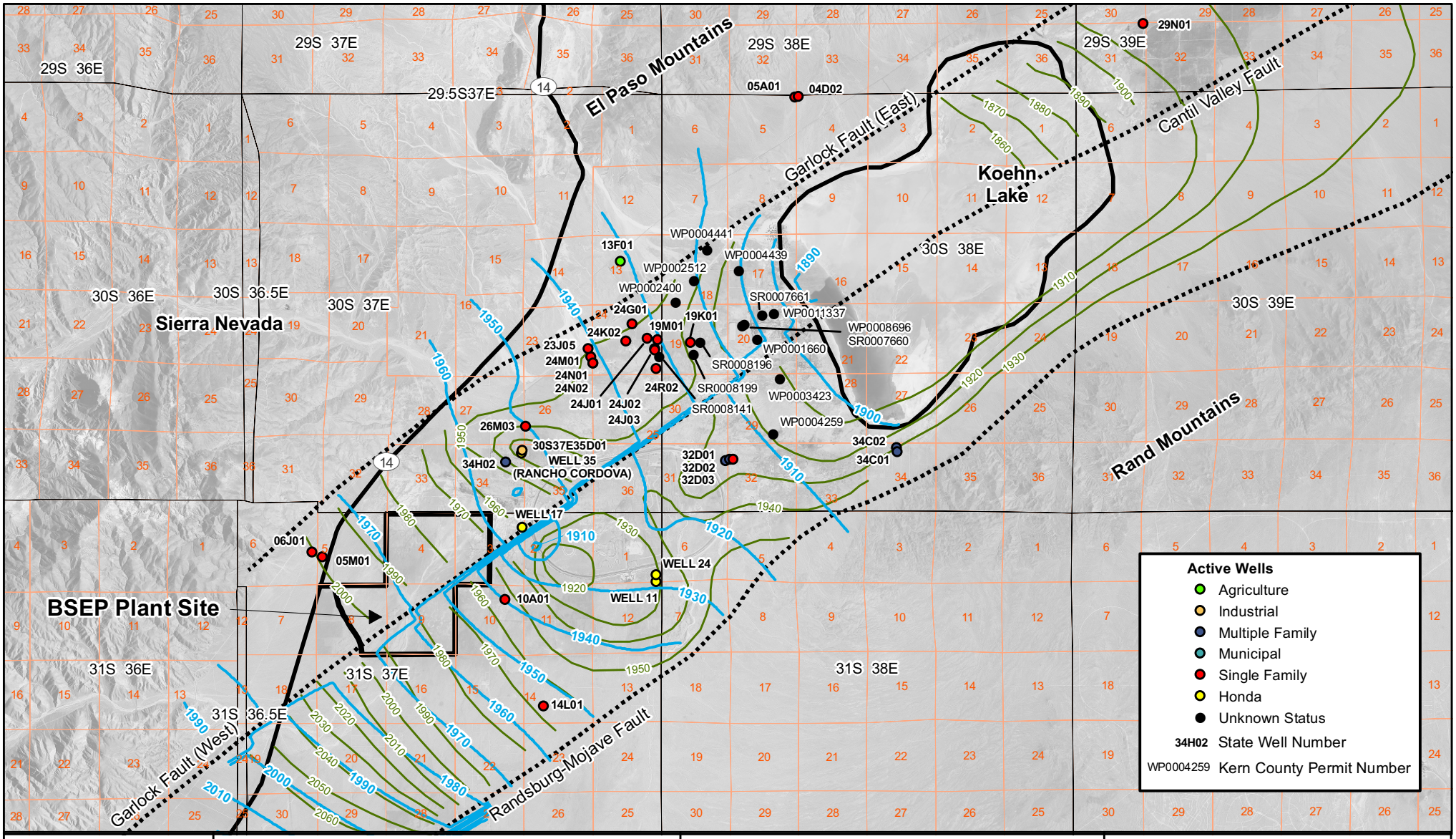
Figure 6a
Calibrated Water Table Elevation Contours in the Fremont Valley - 1958 (Steady-State)

Beacon Solar

AECOM

Project: 10056-014
Date: May 2009

J:\GIS\Projects\10056-Beacon\mxd\Updated GW Model Figures - May 09\Figure 6a.mxd



Map Location

Legend

- Predicted Water Table
- Groundwater Contour (feet amsl) (Koehler, 1977)
- Fault
- Township Range
- Sections
- BSEP Plant Site Boundary

Note: Fault locations are approximate
Source: Koehler, 1977

0 2 4 Miles

1:126,720

N W E S

BSEP

Figure 6b
Calibrated Water Table Elevation Contours in the Fremont Valley - 1959 (Onset of Agricultural Pumping)

Beacon Solar

AECOM

Project: 10056-014
Date: May 2009

J:\GIS\Projects\10056-Beacon\mxd\Updated GW Model Figures - May 09\Figure 6b.mxd

Figure 7. Hydrograph for Well 31S38E06E001M

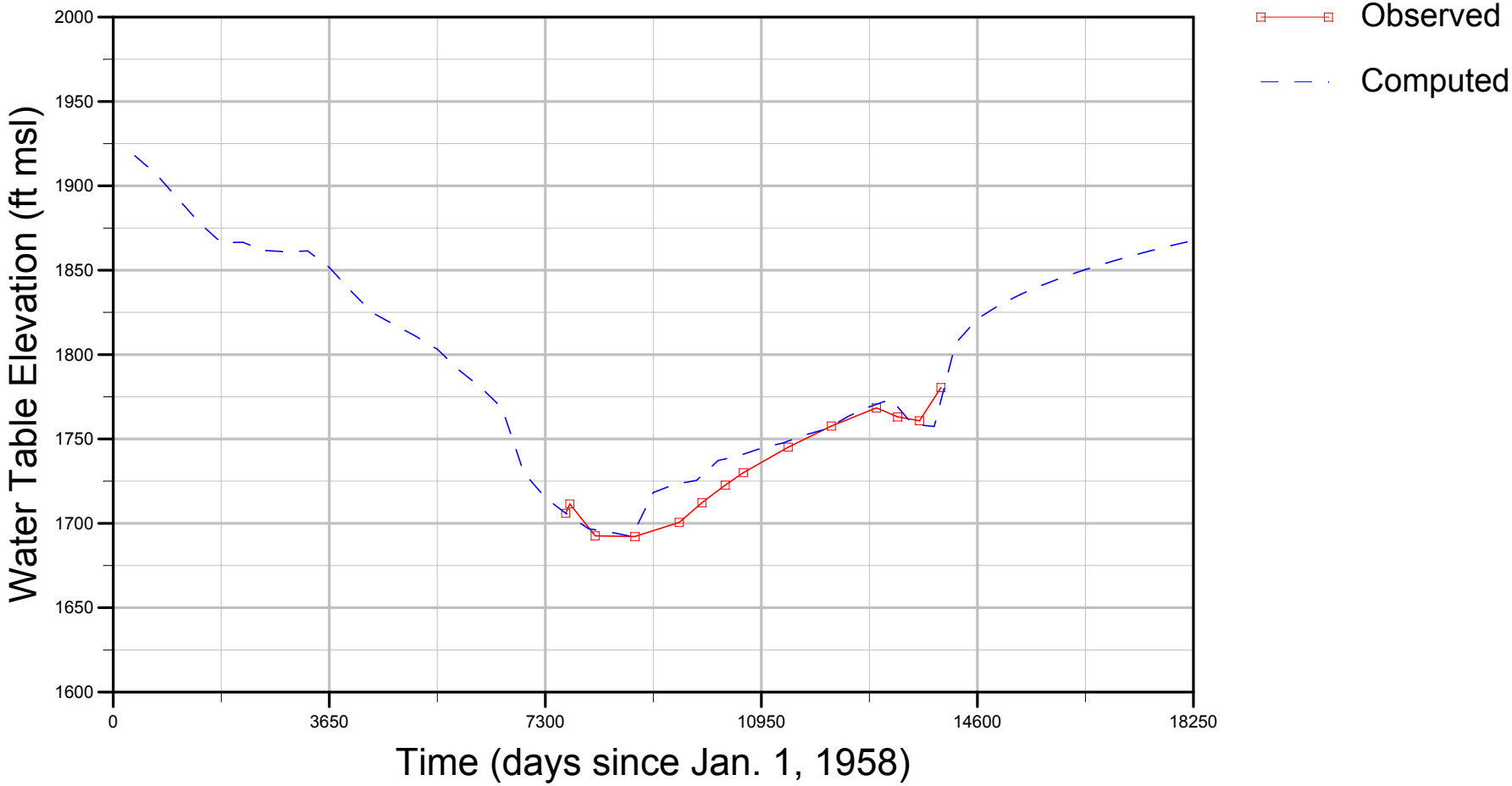


Figure 8. Hydrograph for Well 30S37E36G001M

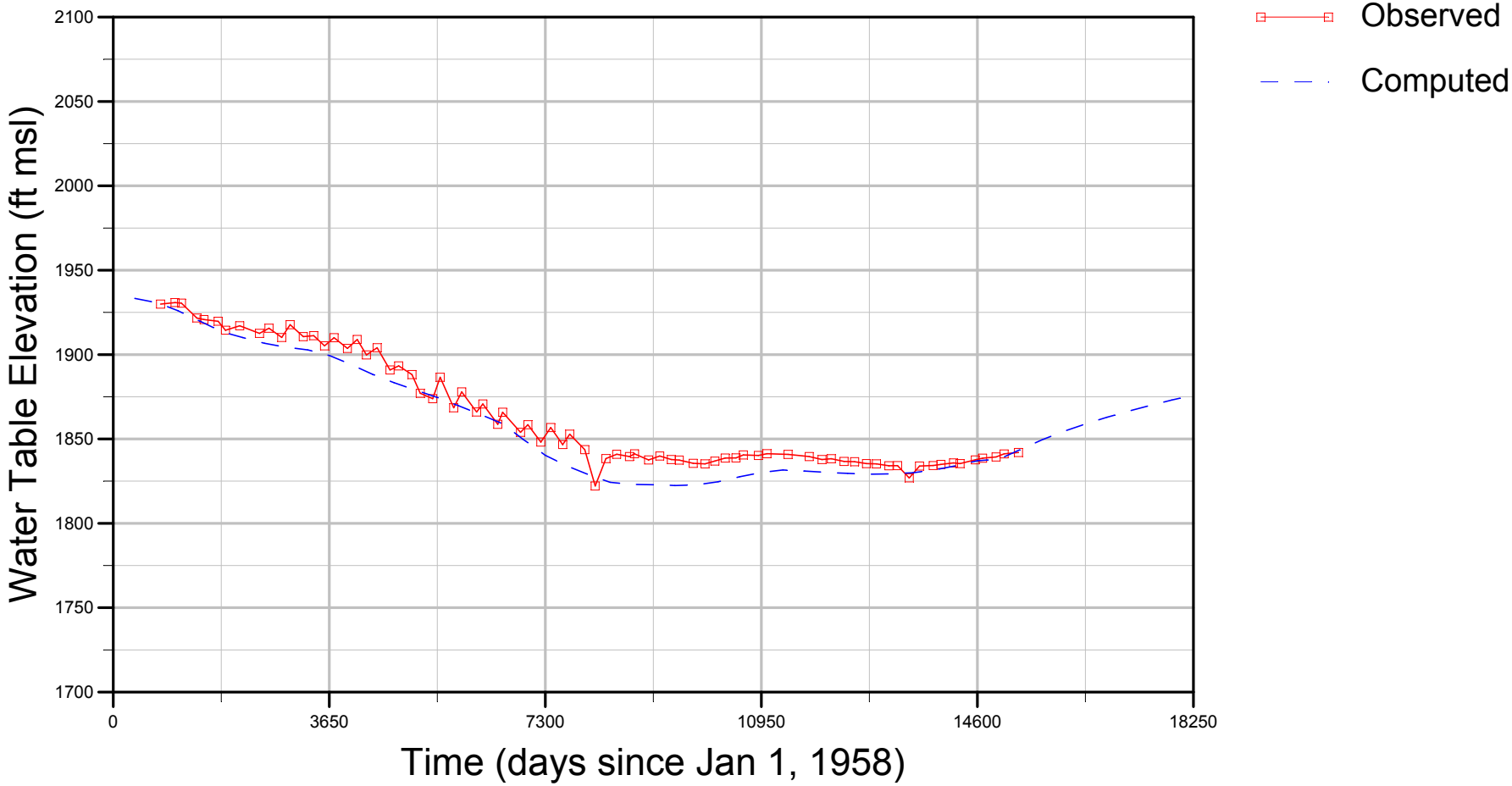


Figure 9. Hydrograph for Well 30S37E27H002M

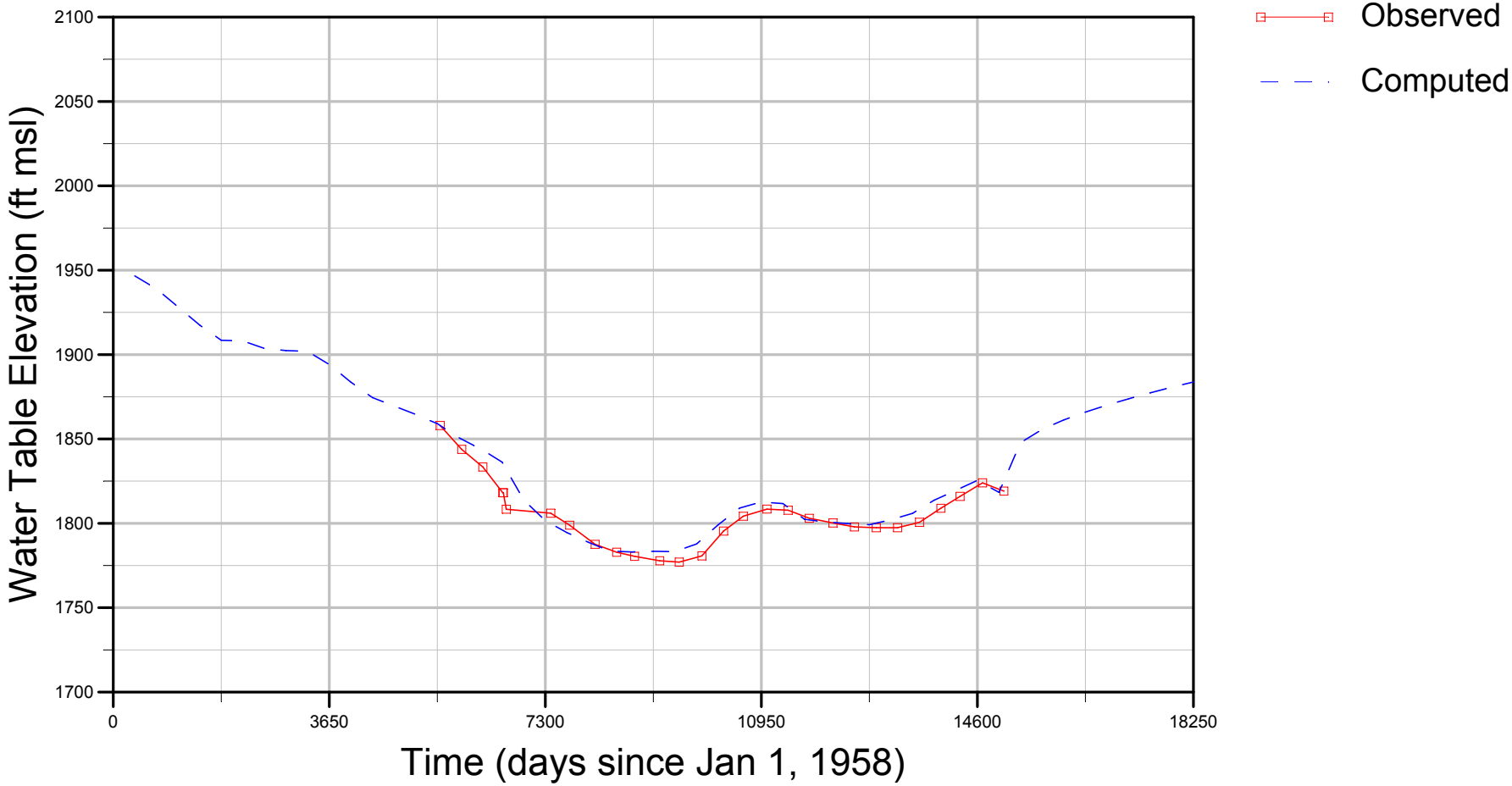


Figure 10. Hydraulic Conductivity (K) Sensitivity Analysis

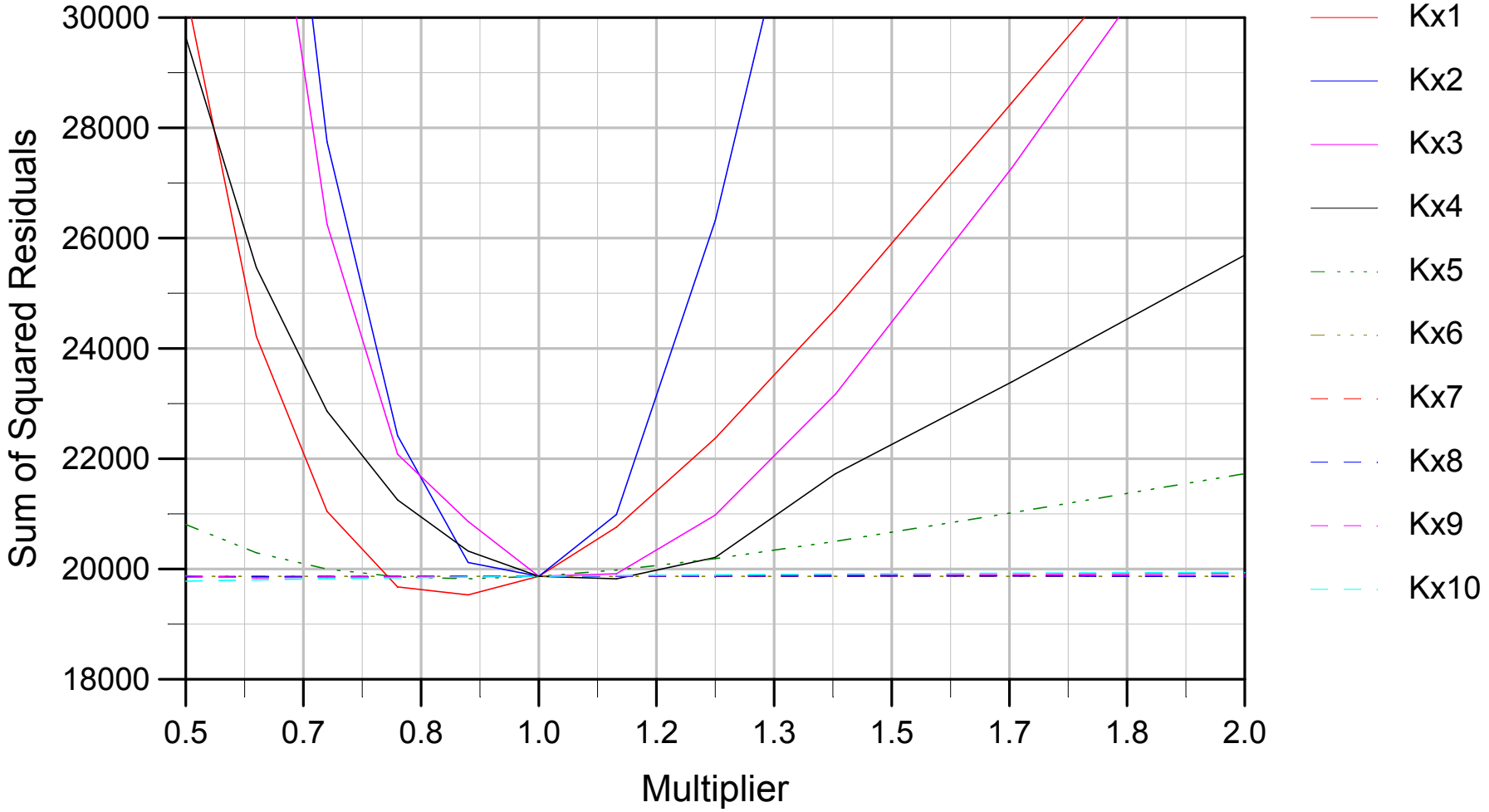


Figure 11. Specific Yield Sensitivity Analysis (Verification Run)

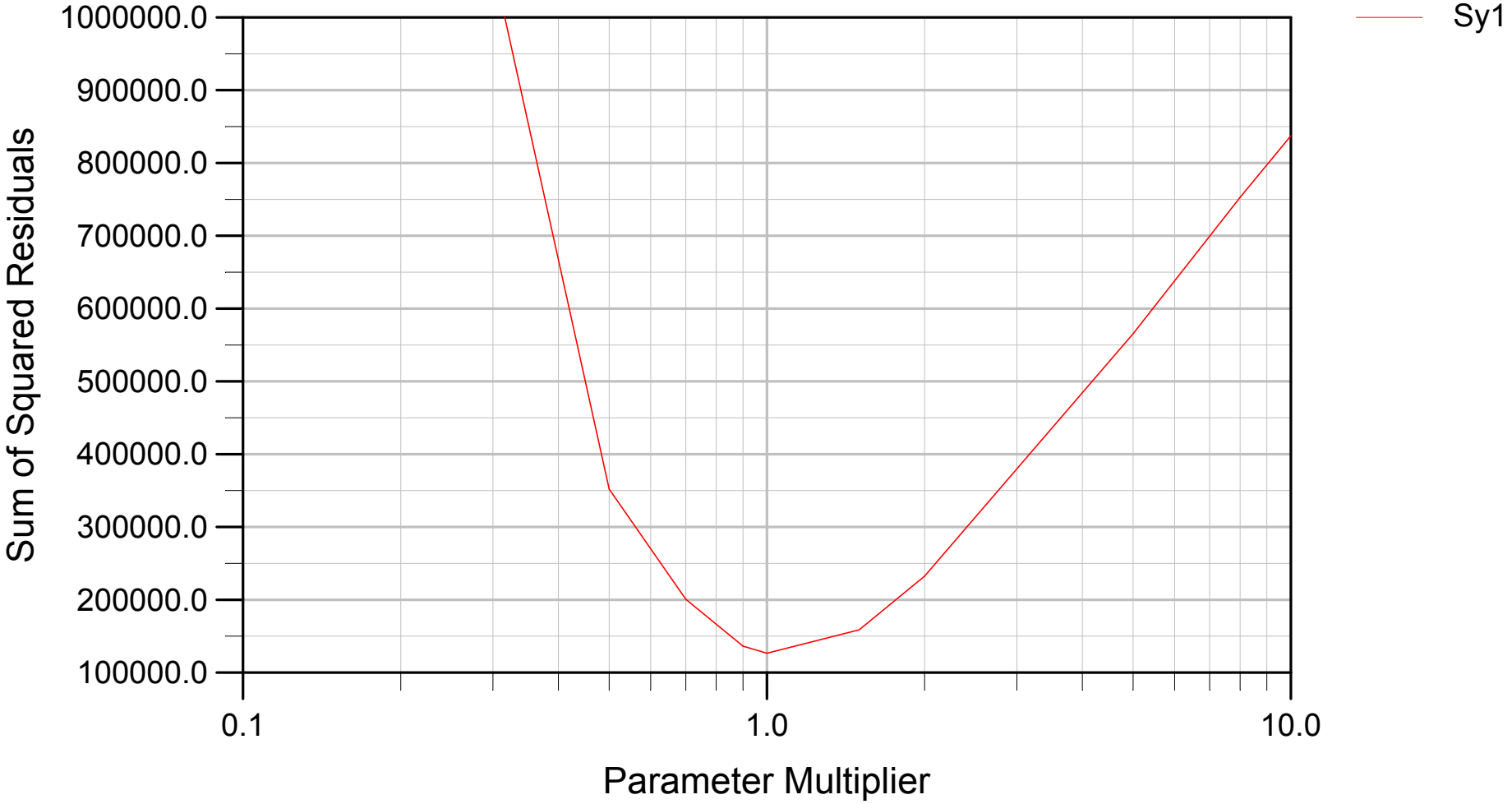


Figure 12. Fault Conductance Sensitivity Analysis

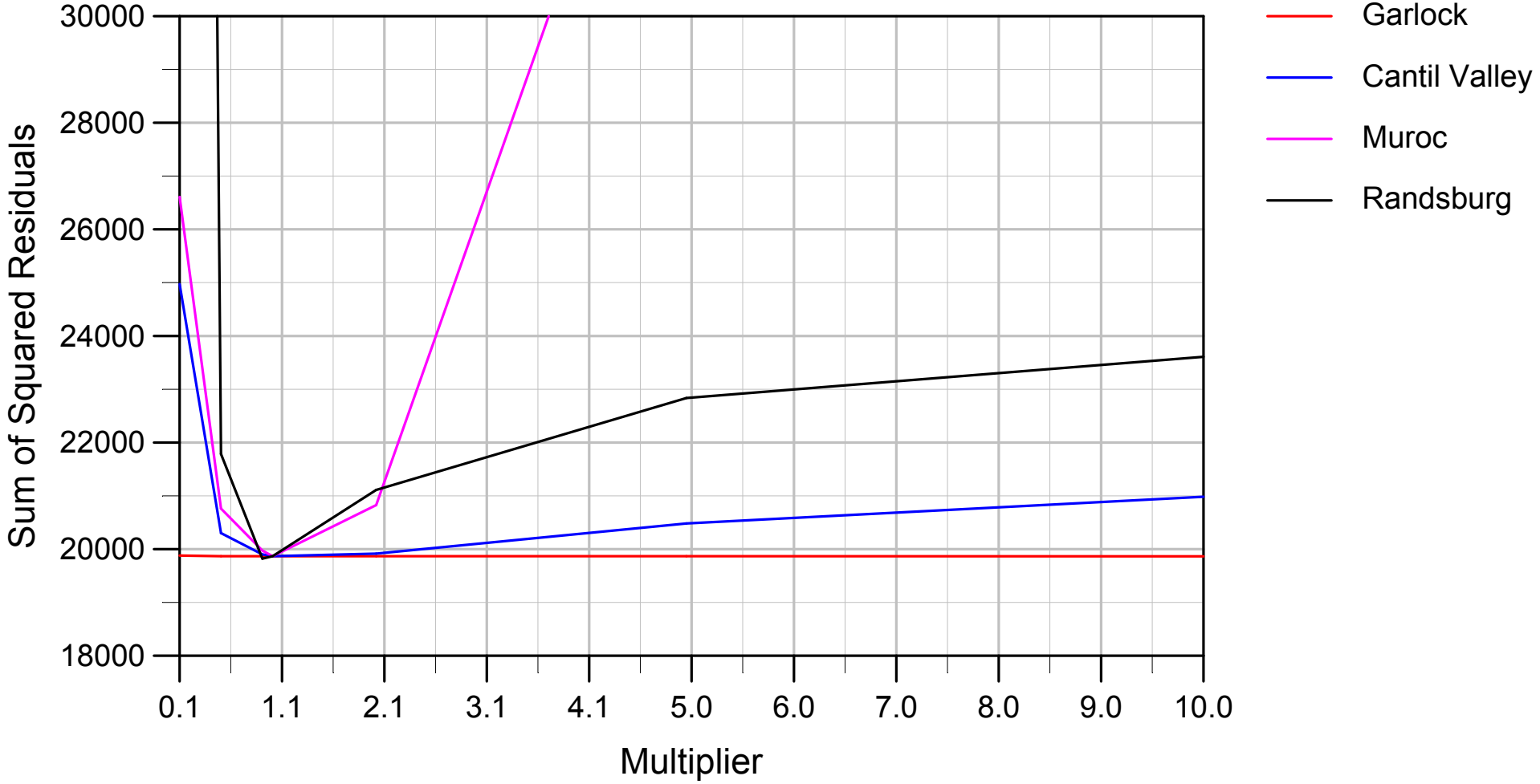
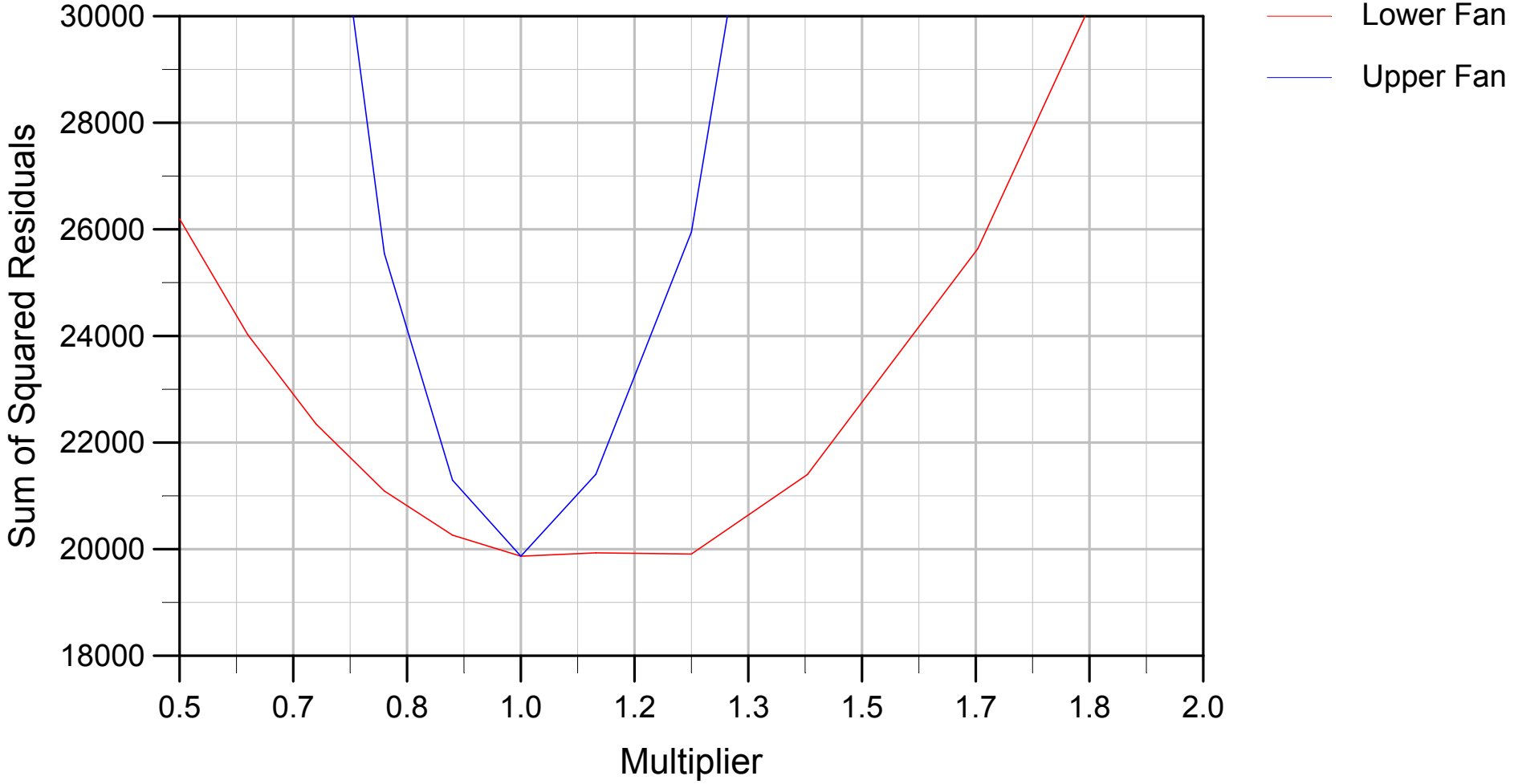
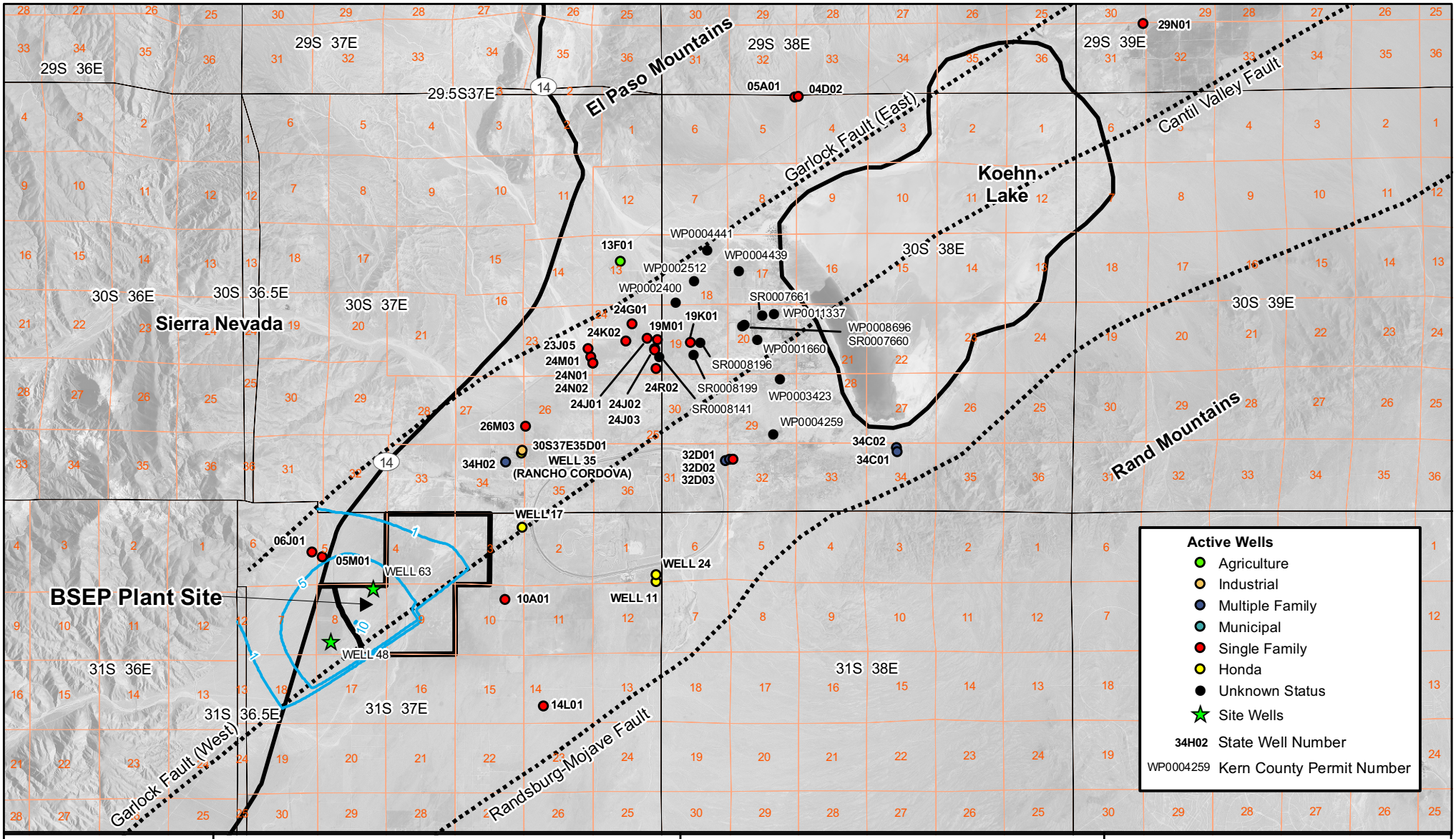


Figure 13. Recharge Sensitivity Analysis





Map Location

Legend

- Predicted Water Table
- Fault
- Township Range
- Sections
- BSEP Plant Site Boundary

Note: Fault locations are approximate
Source: Koehler, 1977

0 2 4 Miles

1:126,720

N W E S

BSEP

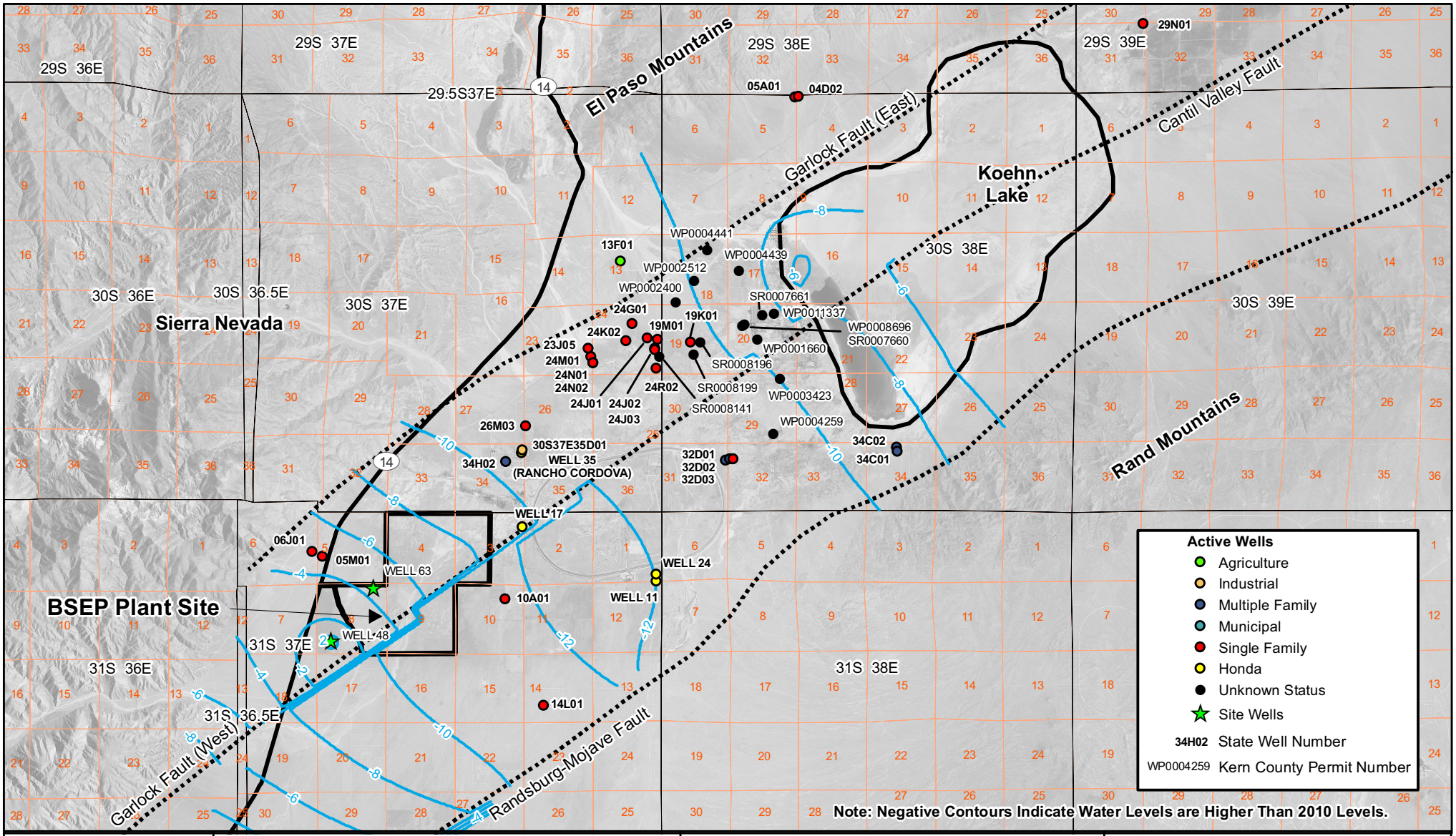
Figure 14
Changes in Water Level (ft)
After 5 Months of Construction
Pumping at Well 48

Beacon Solar

AECOM

Project: 10056-014
Date: May 2009

J:\GIS\Projects\10056-Beacon\mxd\Updated GW Model Figures - May 09\Figure 14.mxd



Map Location

Legend

- Predicted Water Level
- Fault
- Township Range
- Sections
- BSEP Plant Site Boundary

Note: Fault locations are approximate
Source: Koehler, 1977

0 2 4 Miles

1:126,720

N W E S

BSEP

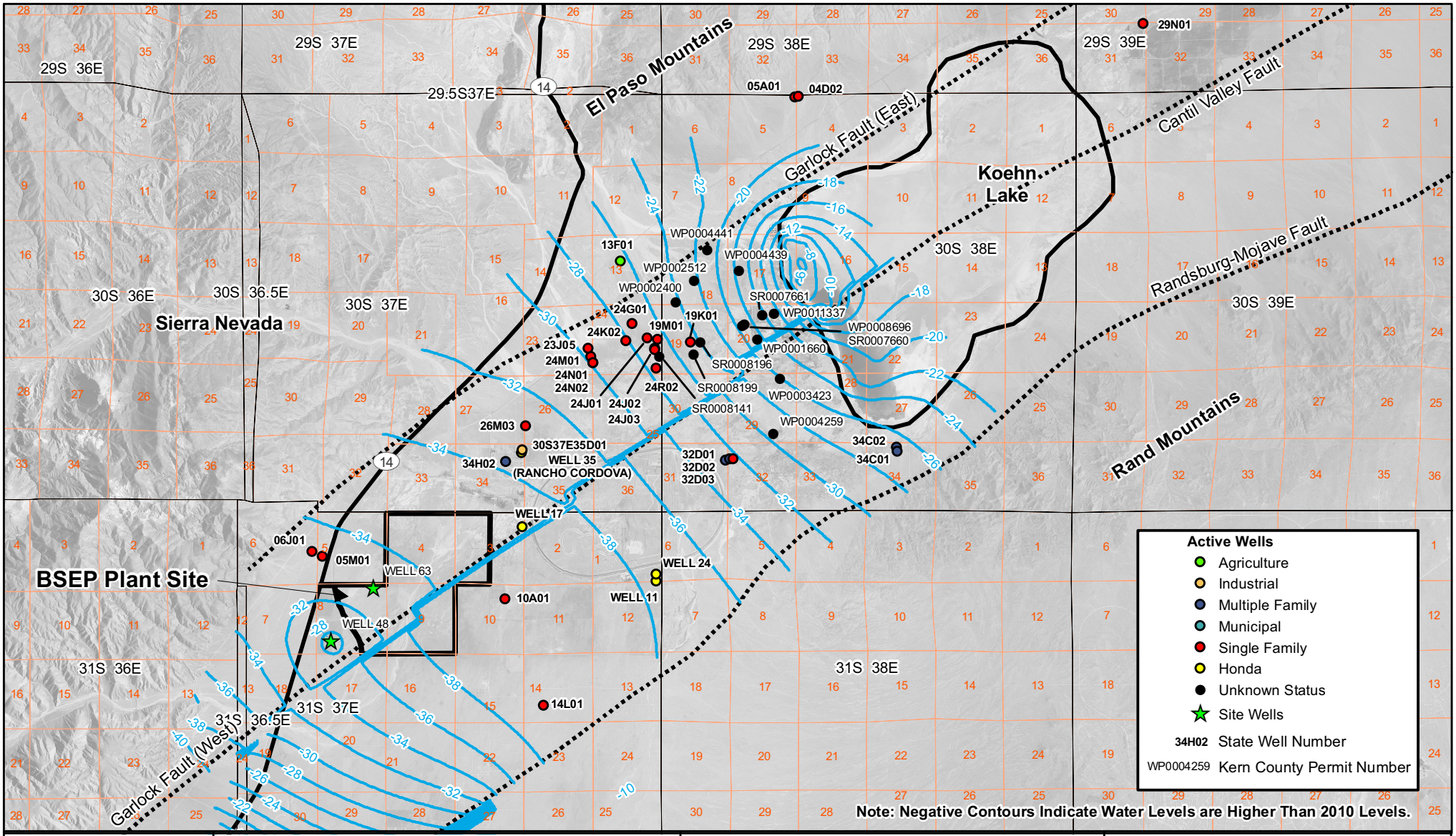
Figure 15
Changes in Water Level (ft)
After 5 Years of Project
Pumping at Well 48

Beacon Solar

AECOM

Project: 10056-014
Date: May 2009

J:\GIS\Projects\10056-Beacon\mxd\Updated GW Model Figures - May 09\Figure 15.mxd



Map Location

Legend

- Predicted Water Level
- Fault
- Township Range
- Sections
- BSEP Plant Site Boundary

Note: Fault locations are approximate
Source: Koehler, 1977

0 2 4 Miles

1:126,720

N W E S

BSEP

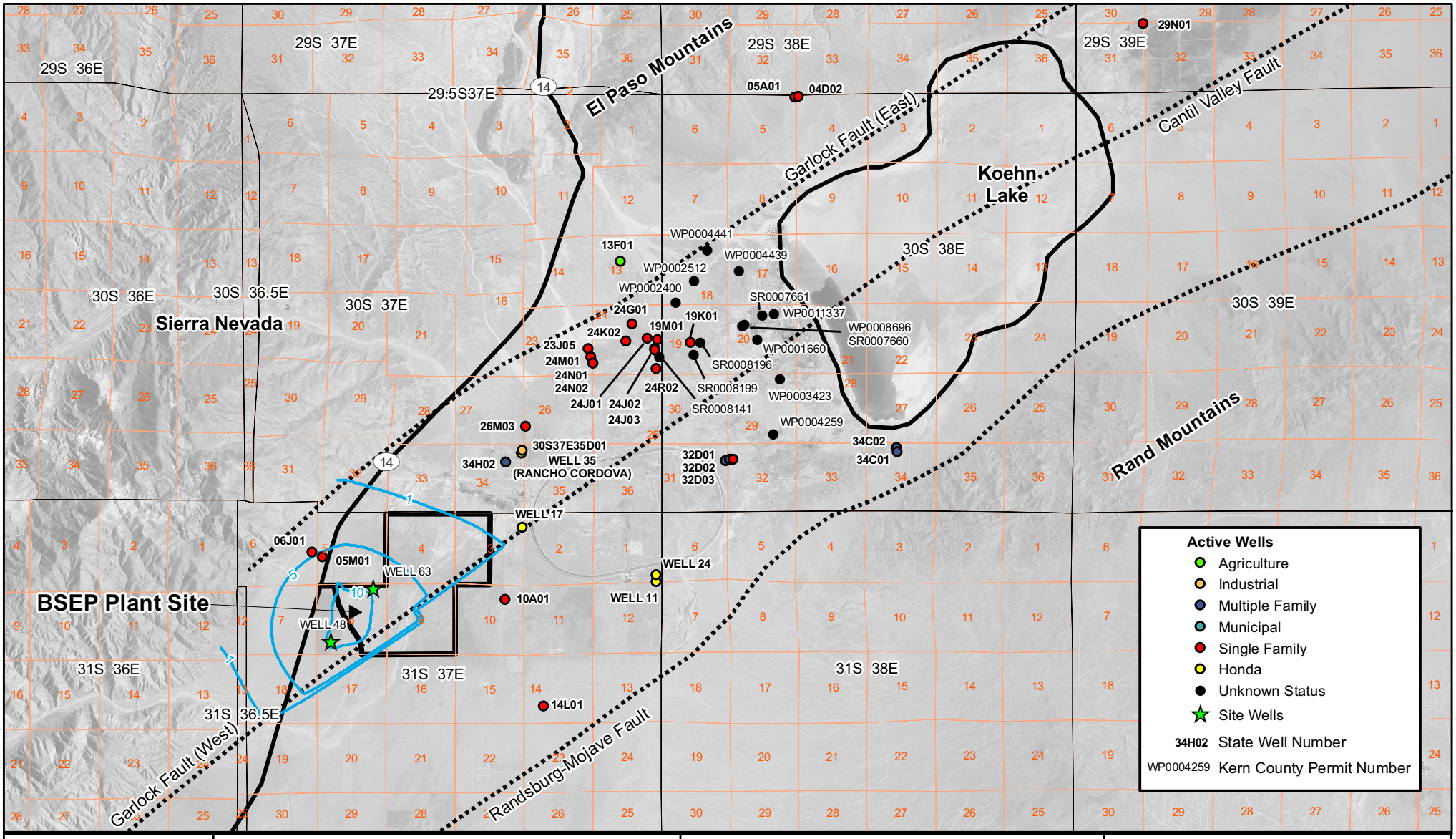
Figure 16
Changes in Water Level (ft)
After 30 Years of Project
Pumping at Well 48

Beacon Solar

AECOM

Project: 10056-014
Date: May 2009

J:\GIS\Projects\10056-Beacon\mxd\Updated GW Model Figures - May 09\Figure 16.mxd



Map Location

Legend

- Predicted Water Table
- Fault
- Township Range
- Sections
- BSEP Plant Site Boundary

Note: Fault locations are approximate
Source: Koehler, 1977

0 2 4 Miles

1:126,720

N W E S

BSEP

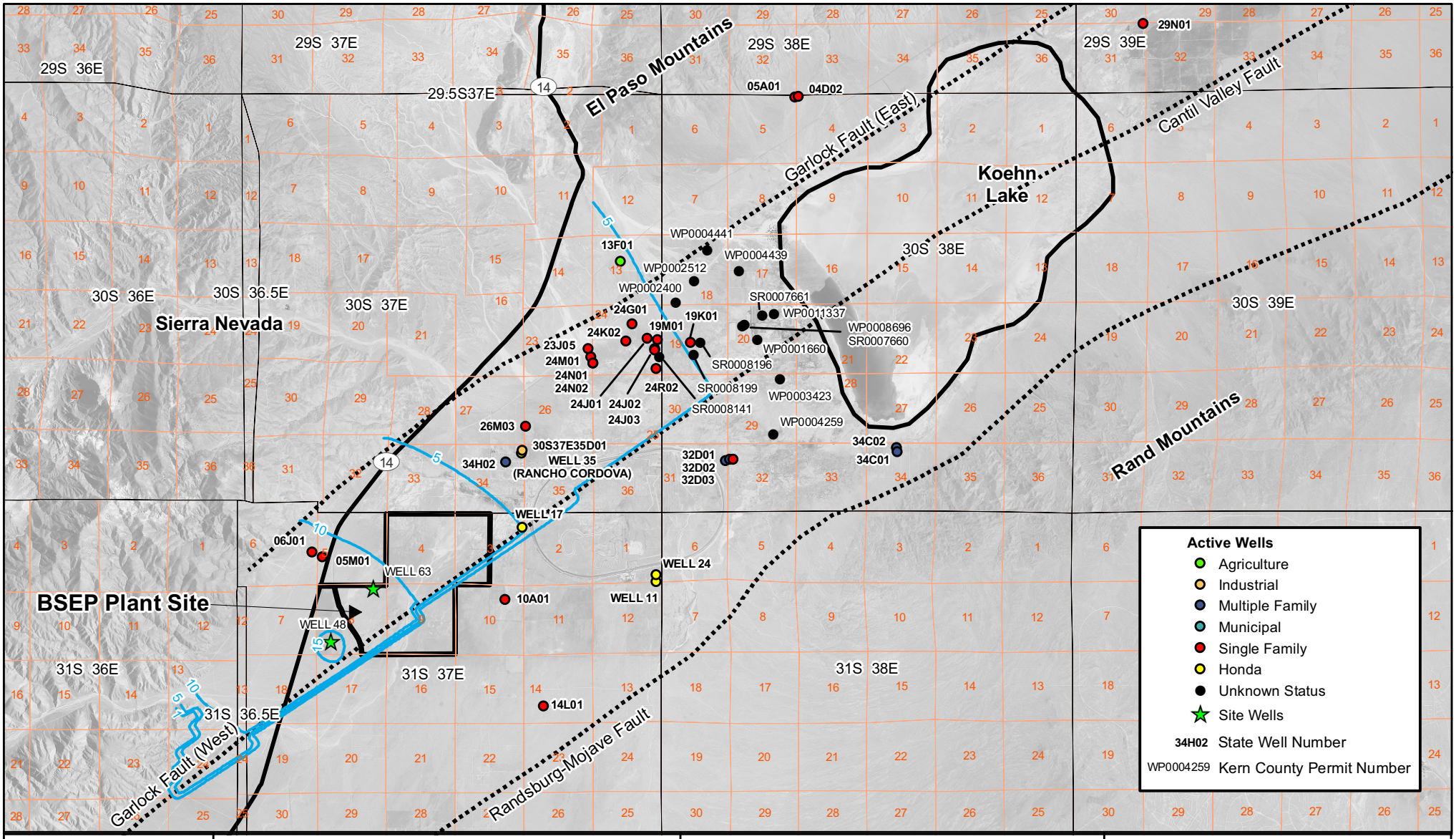
Figure 17
Water Table Impact (ft)
After 5 Months of Construction
Pumping at Well 48

Beacon Solar

AECOM

Project: 10056-014
Date: May 2009

J:\GIS\Projects\10056-Beacon\mxd\Updated GW Model Figures - May 09\Figure 17.mxd



Map Location

Legend

- Predicted Water Table
- Fault
- Township Range
- Sections
- BSEP Plant Site Boundary

Note: Fault locations are approximate
Source: Koehler, 1977

0 2 4 Miles

1:126,720

N W E S

BSEP

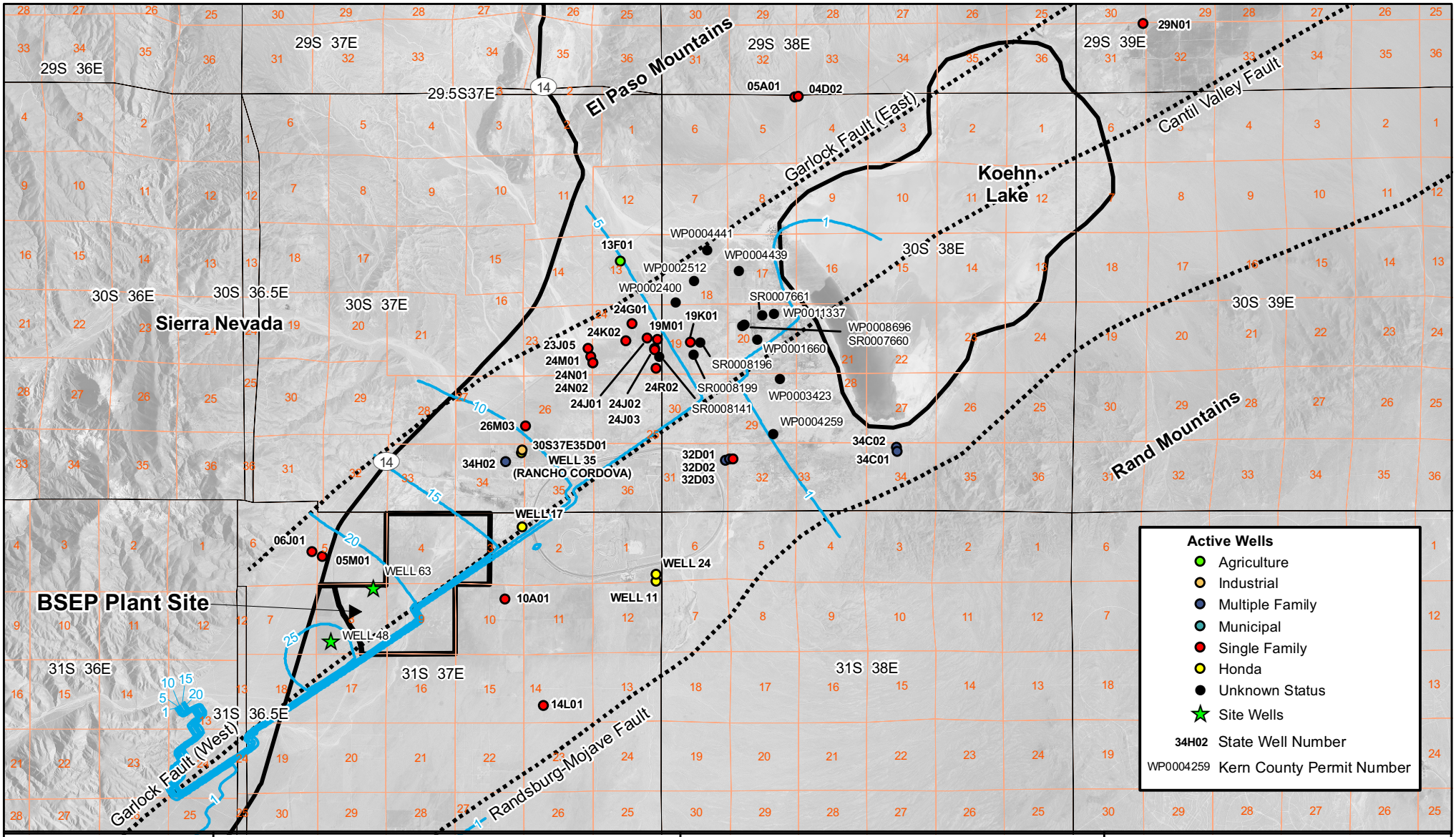
Figure 18
Water Table Impact (ft)
After 5 Years of Project
Pumping at Well 48

Beacon Solar

AECOM

Project: 10056-014
Date: May 2009

J:\GIS\Projects\10056-Beacon\mxd\Updated GW Model Figures - May 09\Figure 18.mxd



Map Location

Legend

- Predicted Water Table
- Fault
- Township Range
- Sections
- BSEP Plant Site Boundary

Note: Fault locations are approximate
Source: Koehler, 1977

0 2 4 Miles

1:126,720

N W E S

BSEP

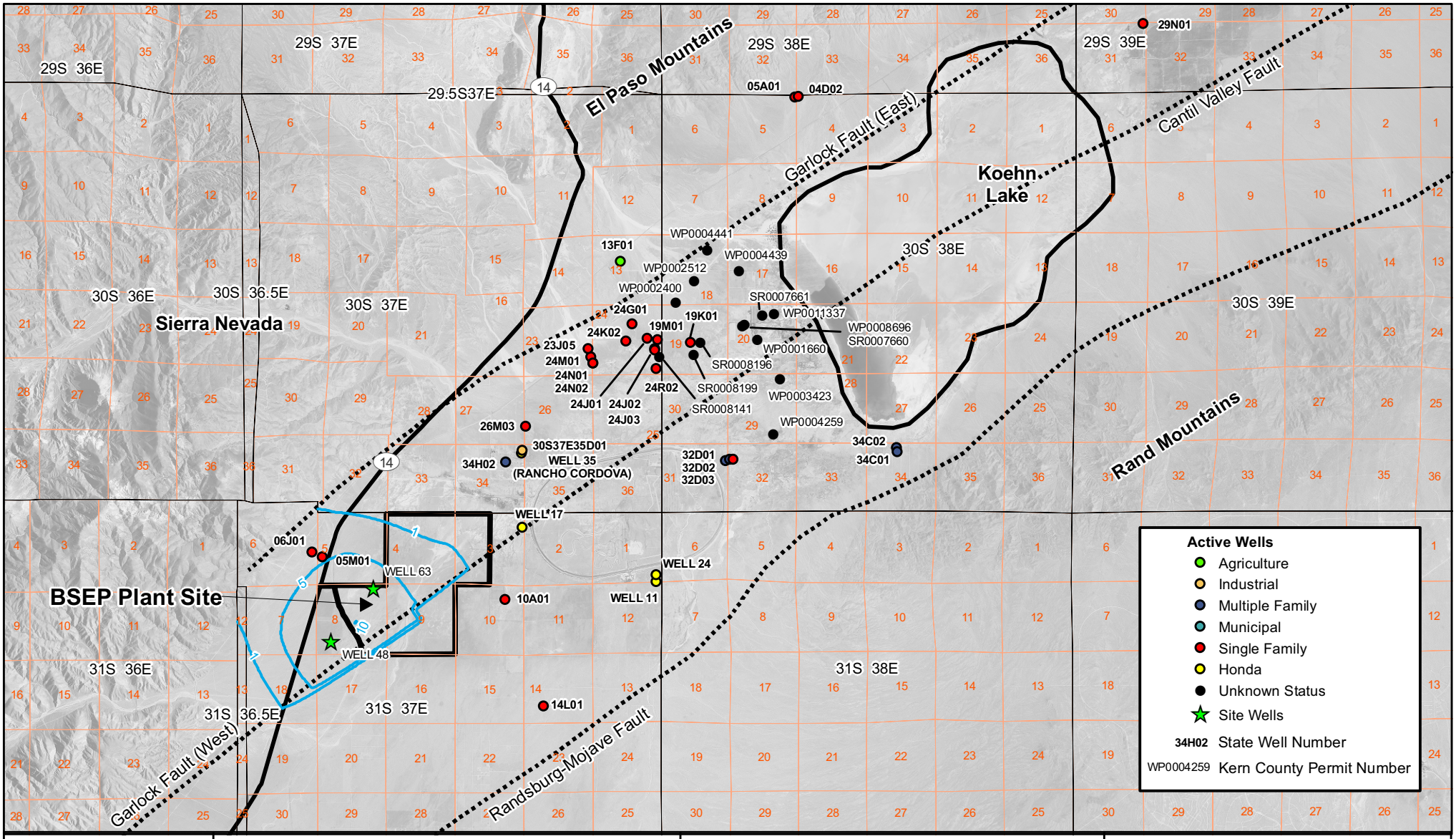
Figure 19
Water Table Impact (ft)
After 30 Years of Project
Pumping at Well 48

Beacon Solar

AECOM

Project: 10056-014
Date: May 2009

J:\GIS\Projects\10056-Beacon\mxd\Updated GW Model Figures - May 09\Figure 19.mxd



Map Location

Legend

- Predicted Water Table
- Fault
- Township Range
- Sections
- BSEP Plant Site Boundary

Note: Fault locations are approximate
Source: Koehler, 1977

0 2 4 Miles

1:126,720

BSEP

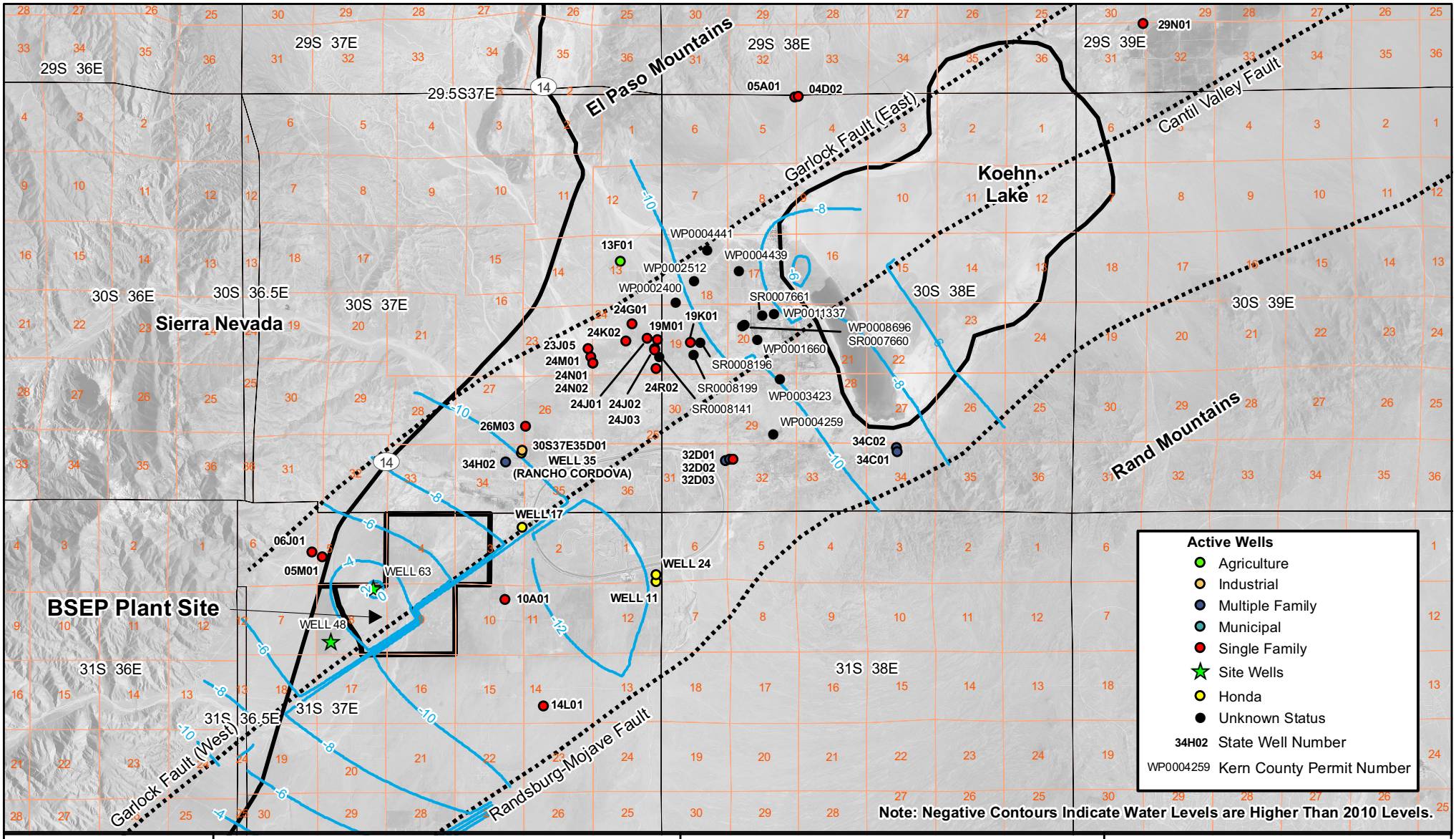
Figure 20
Changes in Water Level (ft)
After 5 Months of Construction
Pumping at Well 63

Beacon Solar

AECOM

Project: 10056-014
Date: May 2009

J:\GIS\Projects\10056-Beacon\mxd\Updated GW Model Figures - May 09\Figure 20.mxd



Map Location

Legend

- Predicted Water Table
- Fault
- Township Range
- Sections
- BSEP Plant Site Boundary

Note: Fault locations are approximate
Source: Koehler, 1977

0 2 4 Miles

1:126,720

N W E S

BSEP

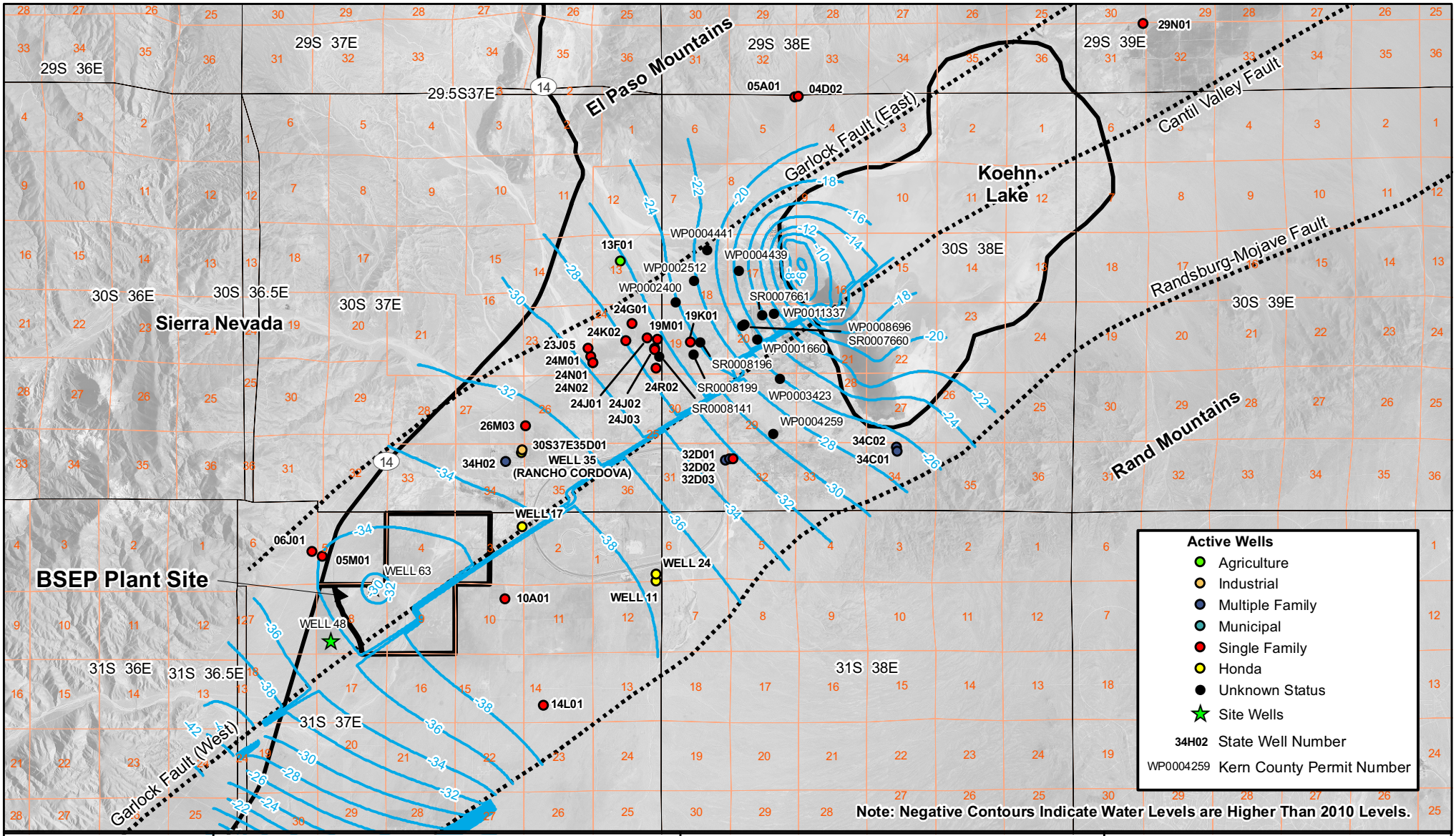
Figure 21
Changes in Water Level (ft)
After 5 Years of Project
Pumping at Well 63

Beacon Solar

AECOM

Project: 10056-014
Date: May 2009

J:\GIS\Projects\10056-Beacon\mxd\Updated GW Model Figures - May 09\Figure 21.mxd



Map Location

Legend

- WLchange_63_30year
- Fault
- Township Range
- Sections
- BSEP Plant Site Boundary

Note: Fault locations are approximate
Source: Koehler, 1977

0 2 4 Miles

1:126,720

N W E S

BSEP

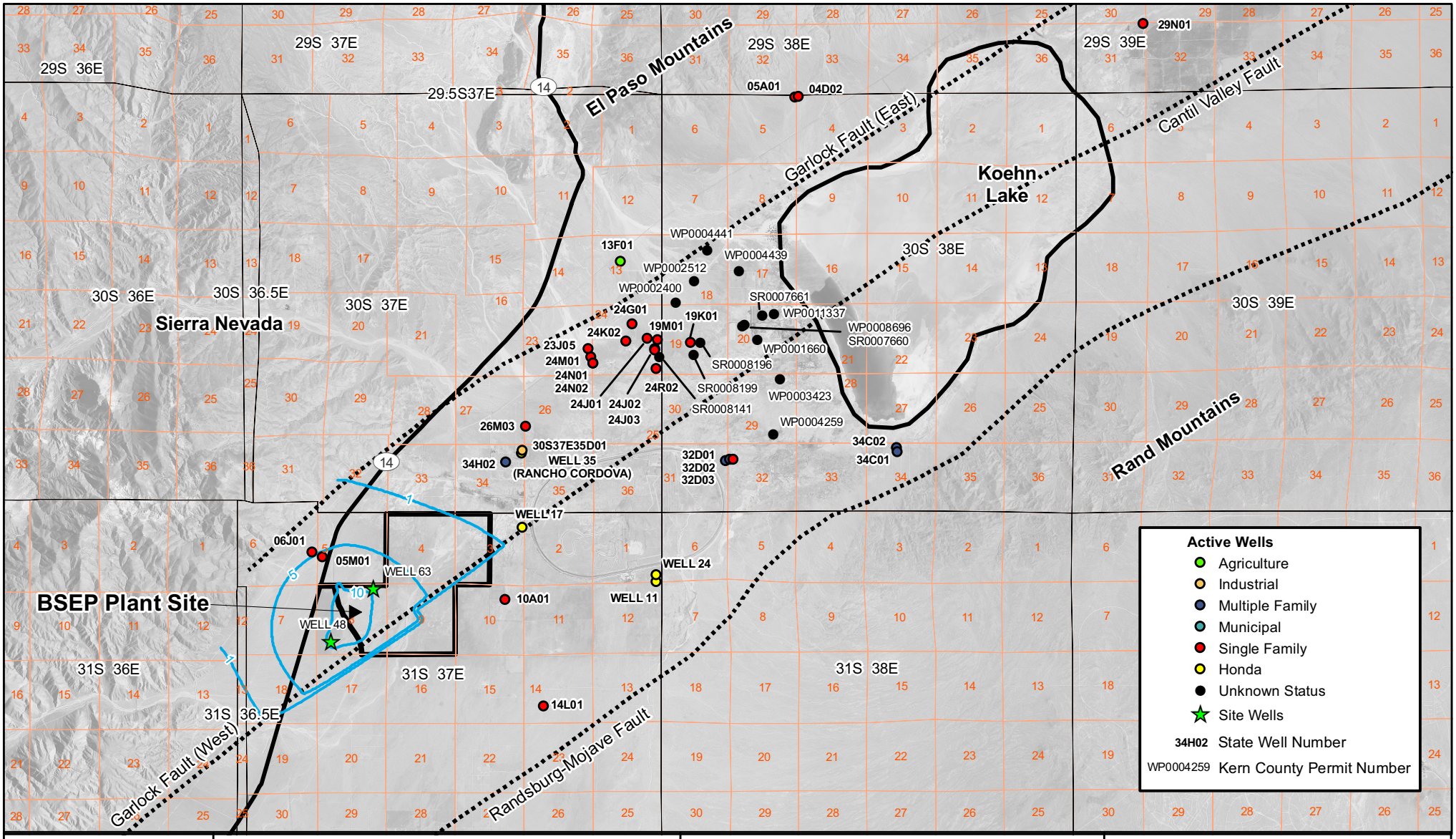
Figure 22
Changes in Water Level (ft)
After 30 Years of Project
Pumping at Well 63

Beacon Solar

AECOM

Project: 10056-014
Date: May 2009

J:\GIS\Projects\10056-Beacon\mxd\Updated GW Model Figures - May 09\Figure 22.mxd



Map Location

Legend

- Predicted Water Table
- Fault
- Township Range
- Sections
- BSEP Plant Site Boundary

Note: Fault locations are approximate
Source: Koehler, 1977

0 2 4 Miles

1:126,720

N W E S

BSEP

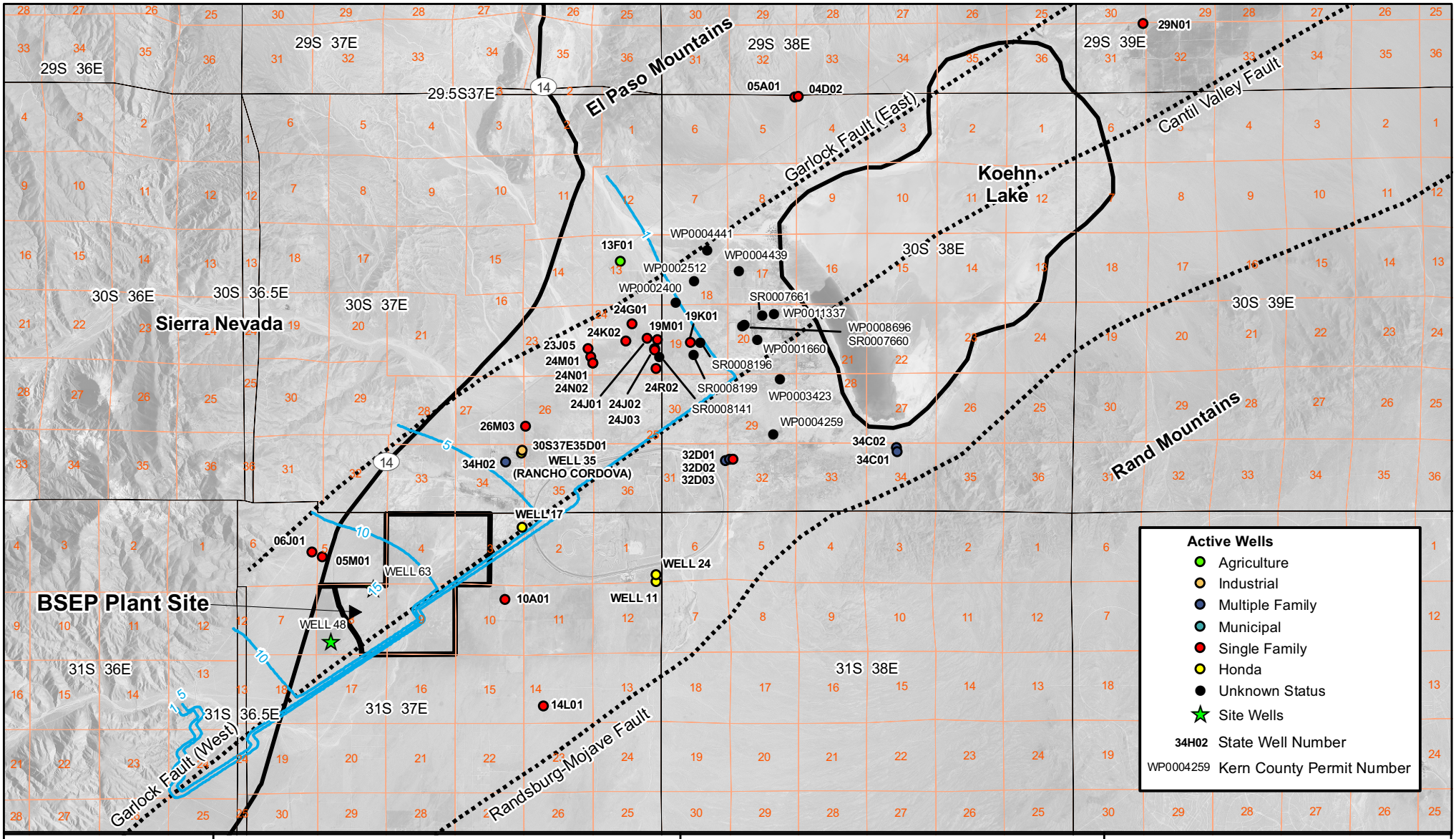
Figure 23
Water Table Impact (ft)
After 5 Months of Construction
Pumping at Well 63

Beacon Solar

AECOM

Project: 10056-014
Date: May 2009

J:\GIS\Projects\10056-Beacon\mxd\Updated GW Model Figures - May 09\Figure 23.mxd



Map Location

Legend

- Predicted Water Table
- Fault
- Township Range
- Sections
- BSEP Plant Site Boundary

Note: Fault locations are approximate
Source: Koehler, 1977

0 2 4 Miles

1:126,720

N W E S

BSEP

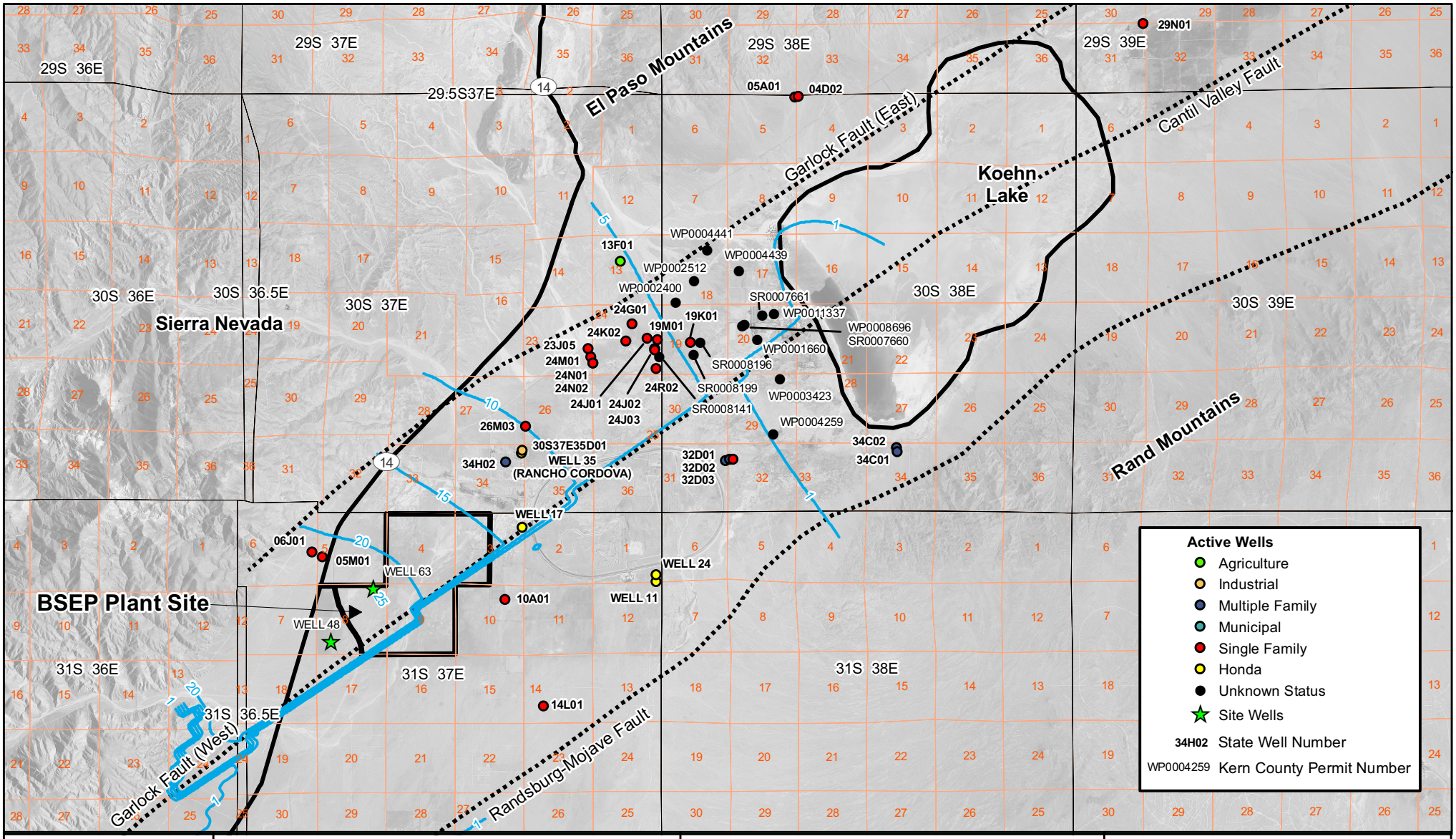
Figure 24
Water Table Impact (ft)
After 5 Years of Project
Pumping at Well 63

Beacon Solar

AECOM

Project: 10056-014
Date: May 2009

J:\GIS\Projects\10056-Beacon\mxd\Updated GW Model Figures - May 09\Figure 24.mxd



Map Location

Legend

- Predicted Water Table
- Fault
- Township Range
- Sections
- BSEP Plant Site Boundary

Note: Fault locations are approximate
Source: Koehler, 1977

0 2 4 Miles

1:126,720

N W E S

BSEP

Figure 25
Water Table Impact (ft)
After 30 Years of Project
Pumping at Well 63

Beacon Solar

AECOM

Project: 10056-014
Date: May 2009

J:\GIS\Projects\10056-Beacon\mxd\Updated GW Model Figures - May 09\Figure 25.mxd

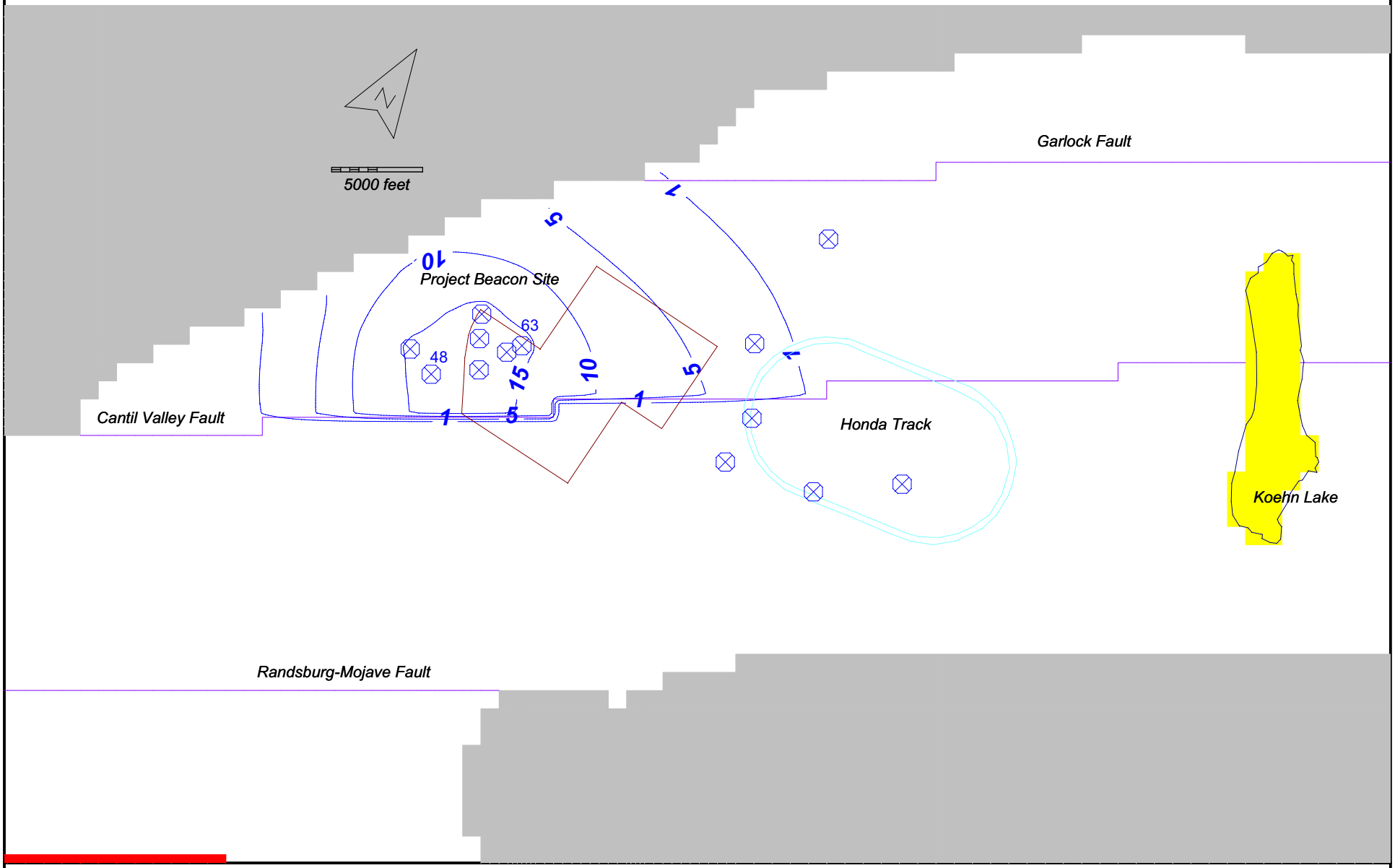
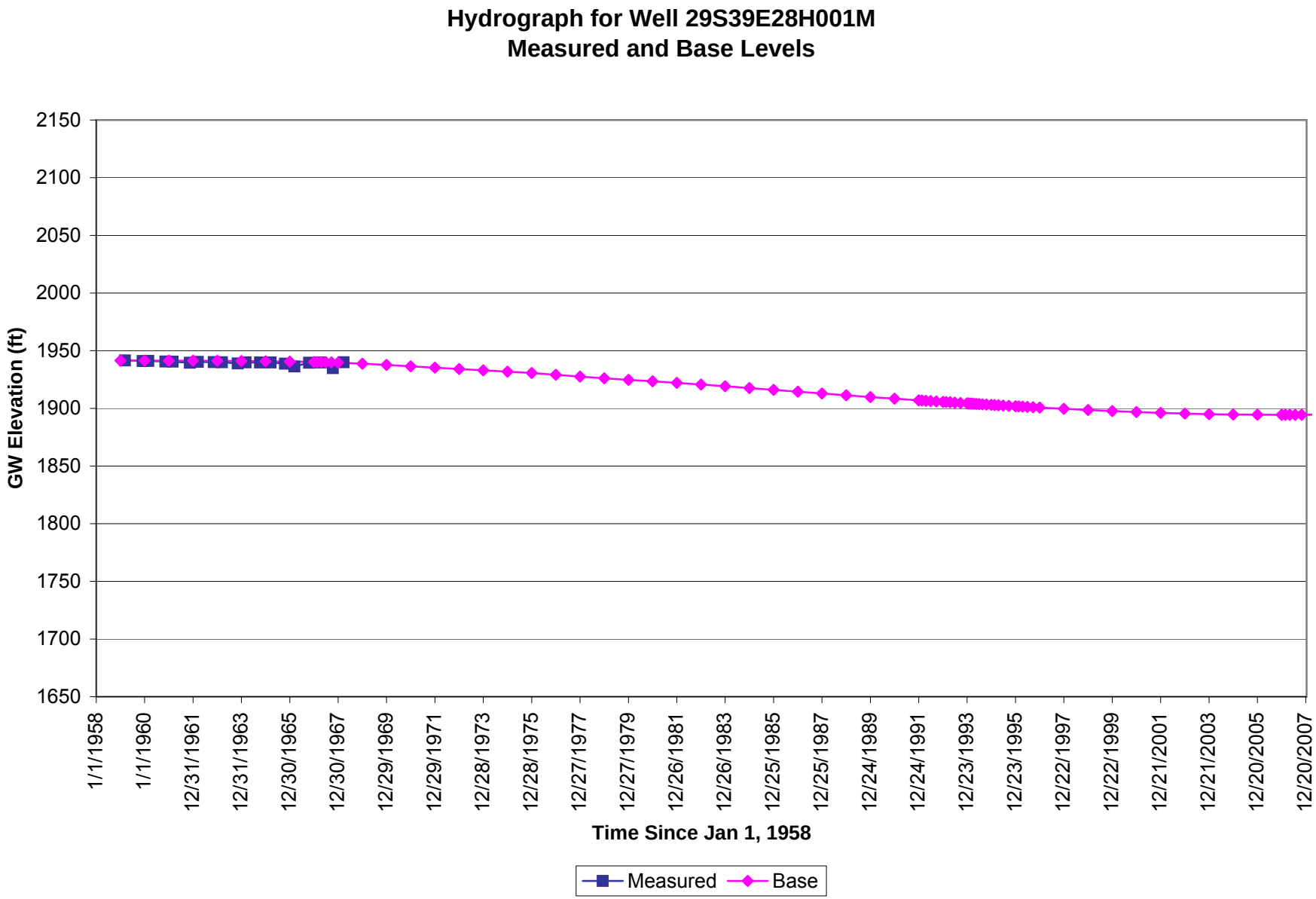
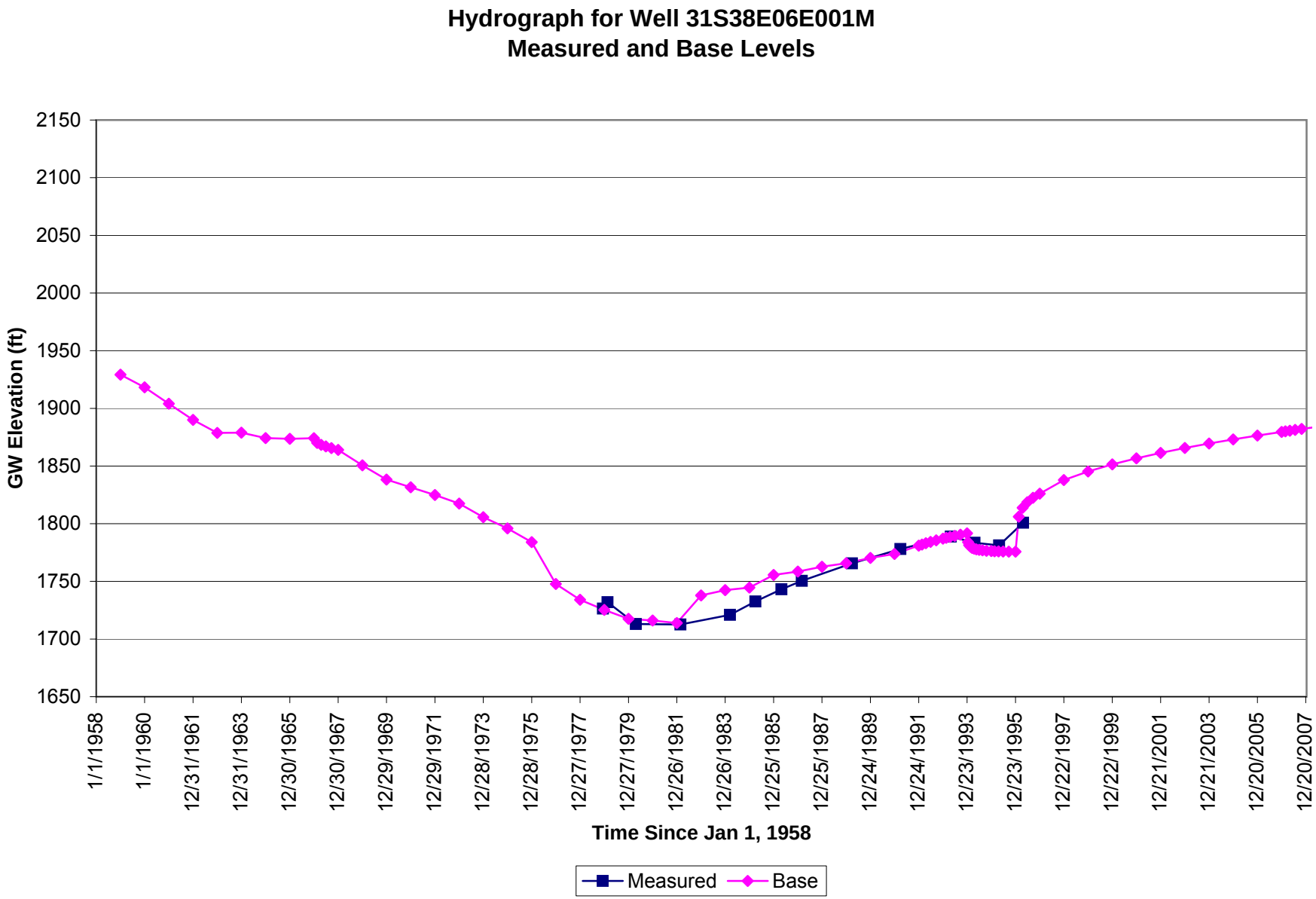


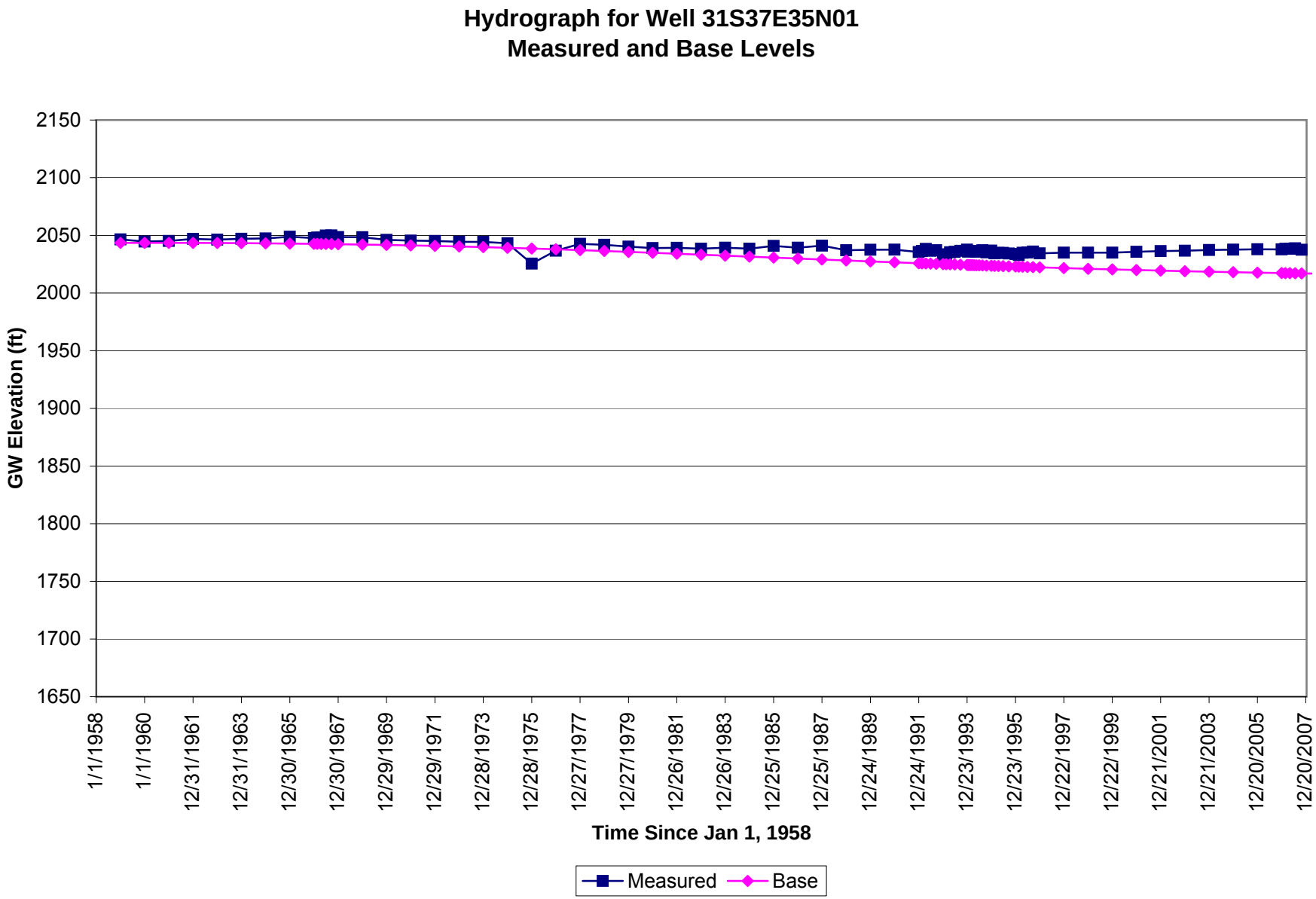
Figure 26. Water Table Impact (ft) After 5 Months of Construction Pumping with Lower Specific Yield.

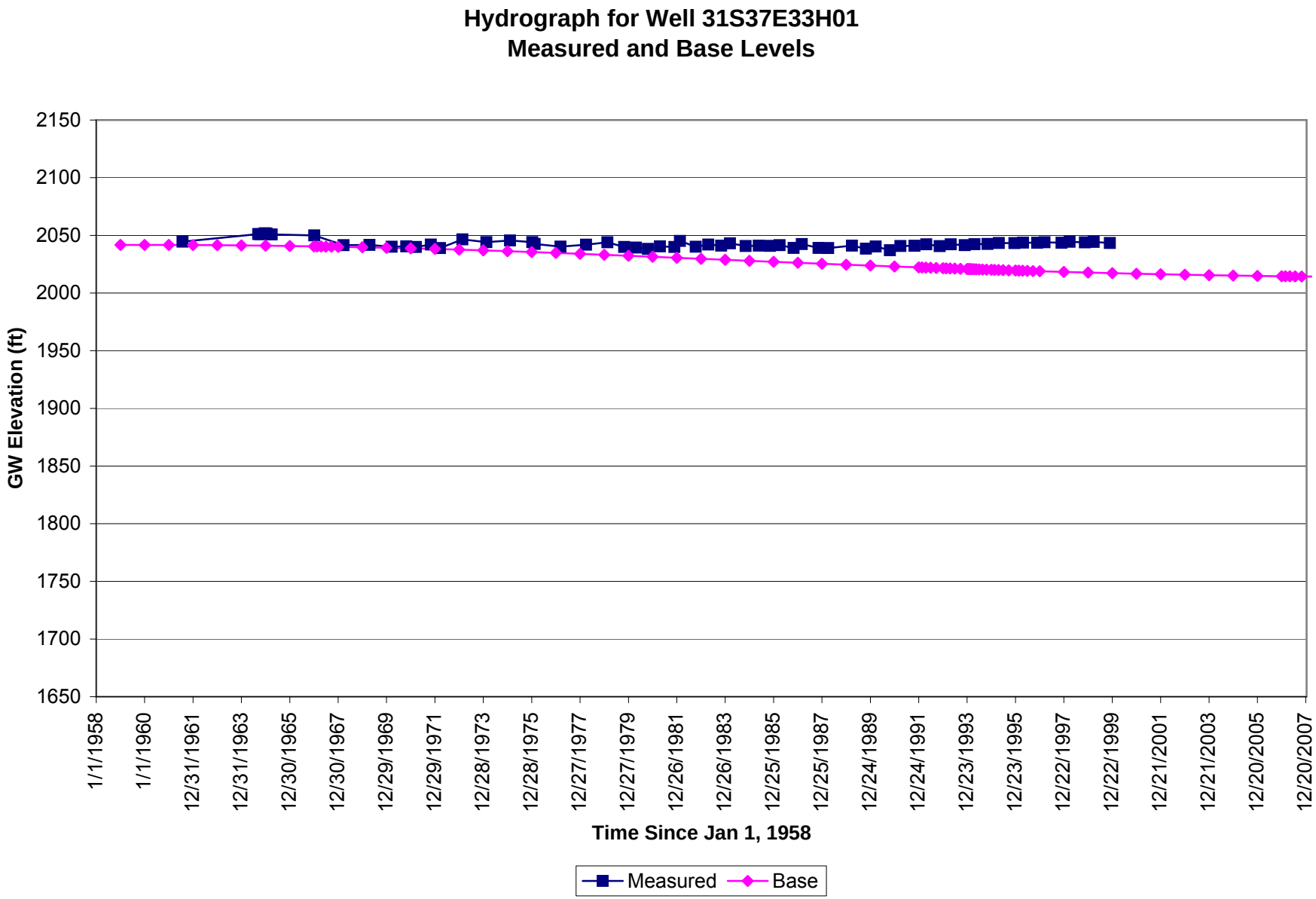
Appendix A

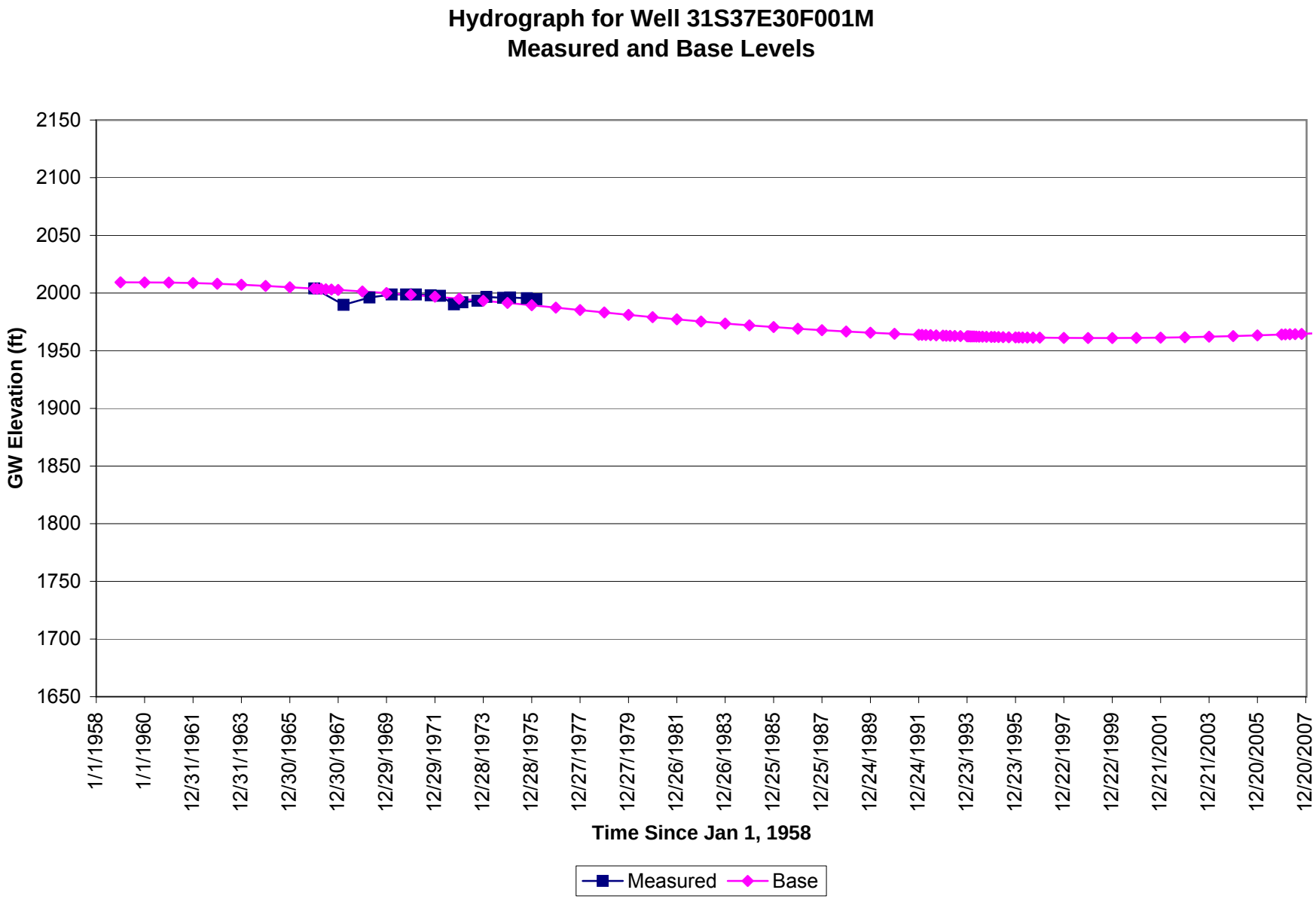
Hydrographs for the Verification Run

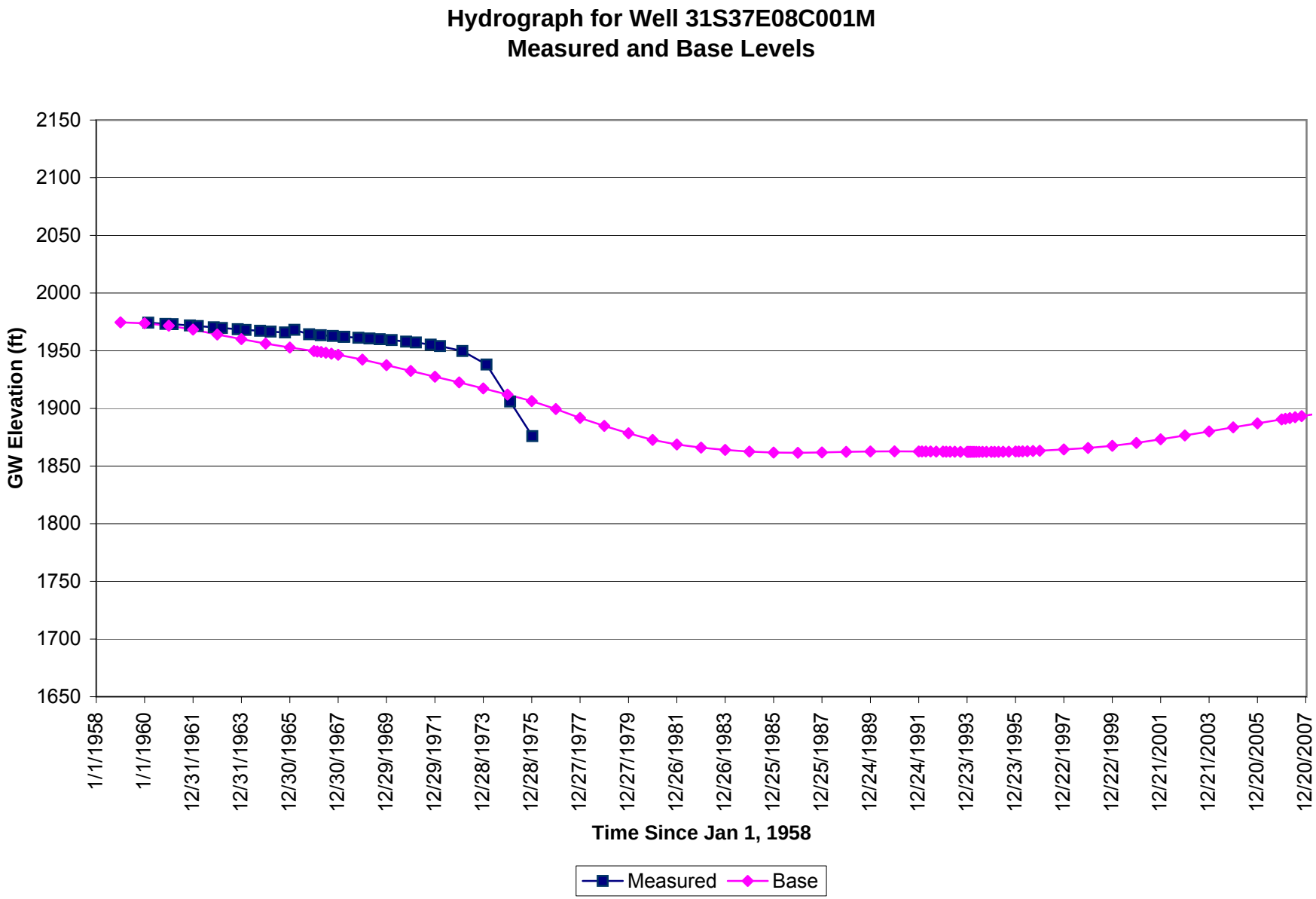

Hydrograph for Well 29S39E28H001M
Measured and Base Levels
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
12/31/1961
12/31/1963
12/30/1965
12/30/1967
12/29/1969
12/29/1971
12/28/1973
12/28/1975
12/27/1977
12/27/1979
12/26/1981
12/26/1983
12/25/1985
12/25/1987
12/24/1989
12/24/1991
12/23/1993
12/23/1995
12/22/1997
12/22/1999
12/21/2001
12/21/2003
12/20/2005
12/20/2007
Time Since Jan 1, 1958
Measured
Base

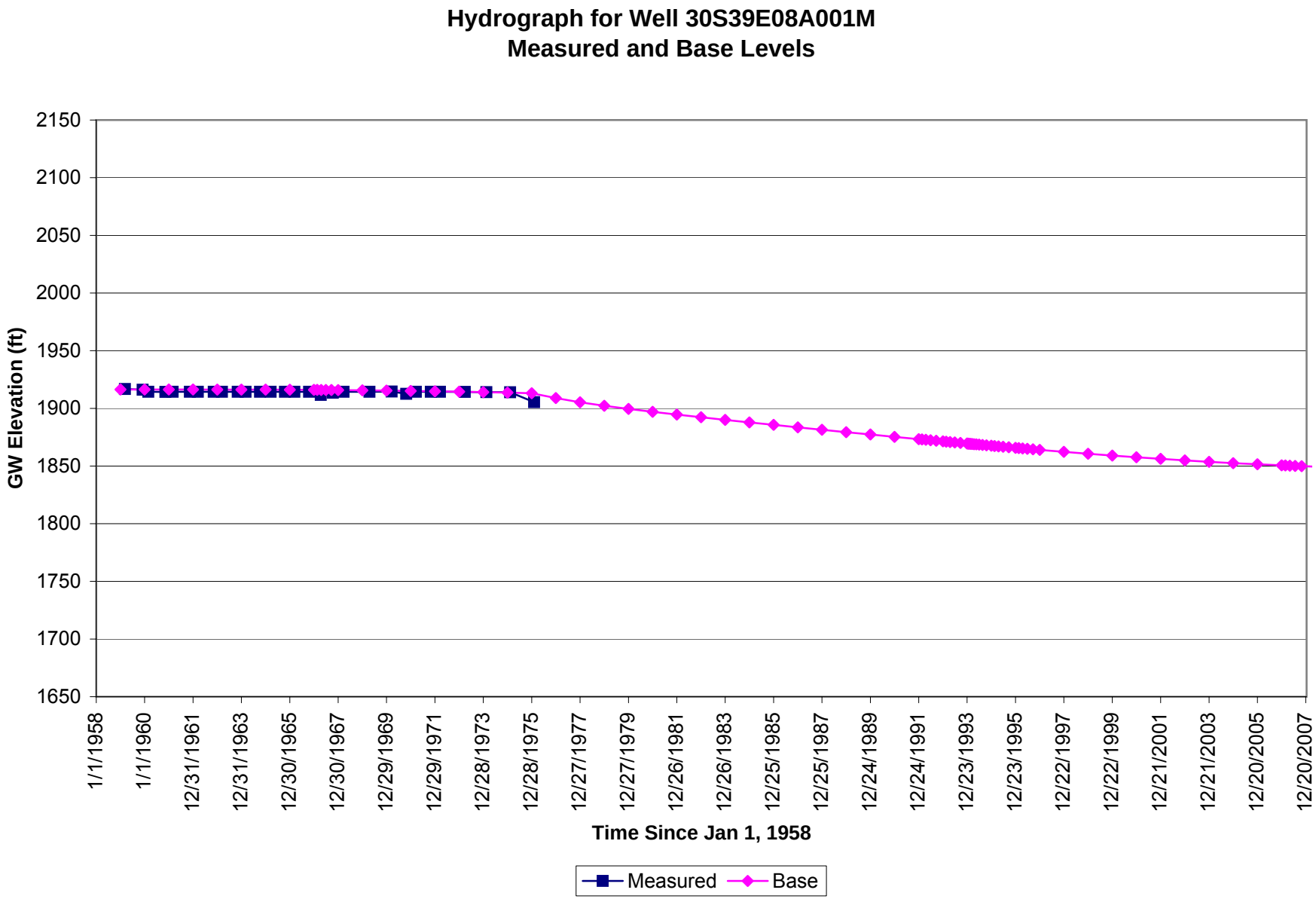

Hydrograph for Well 31S38E06E001M
Measured and Base Levels
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
12/31/1961
12/31/1963
12/30/1965
12/30/1967
12/29/1969
12/29/1971
12/28/1973
12/28/1975
12/27/1977
12/27/1979
12/26/1981
12/26/1983
12/25/1985
12/25/1987
12/24/1989
12/24/1991
12/23/1993
12/23/1995
12/22/1997
12/22/1999
12/21/2001
12/21/2003
12/20/2005
12/20/2007
Time Since Jan 1, 1958
Measured
Base

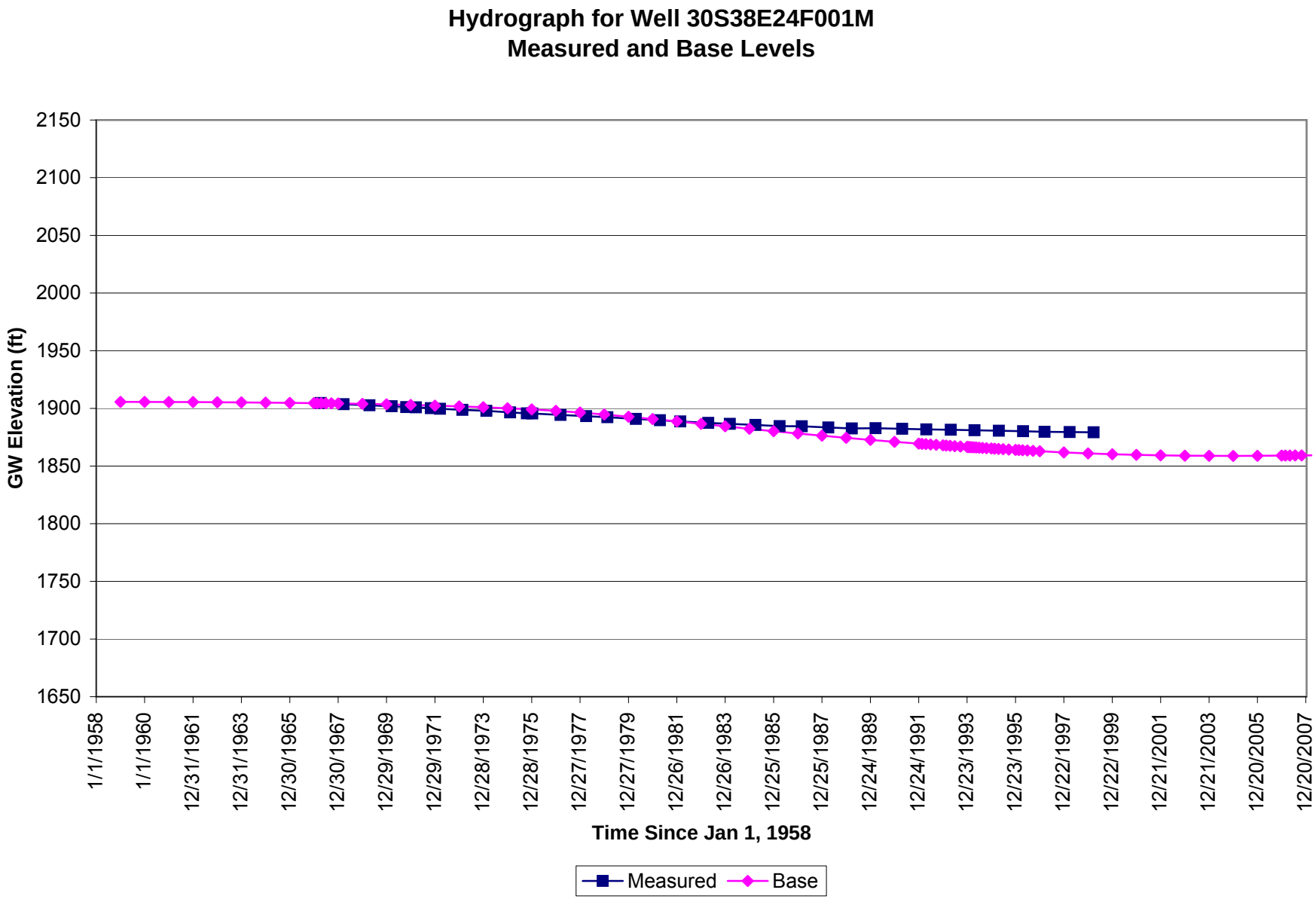

Hydrograph for Well 31S37E35N01
Measured and Base Levels
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
12/31/1961
12/31/1963
12/30/1965
12/30/1967
12/29/1969
12/29/1971
12/28/1973
12/28/1975
12/27/1977
12/27/1979
12/26/1981
12/26/1983
12/25/1985
12/25/1987
12/24/1989
12/24/1991
12/23/1993
12/23/1995
12/22/1997
12/22/1999
12/21/2001
12/21/2003
12/20/2005
12/20/2007
Time Since Jan 1, 1958
Measured
Base

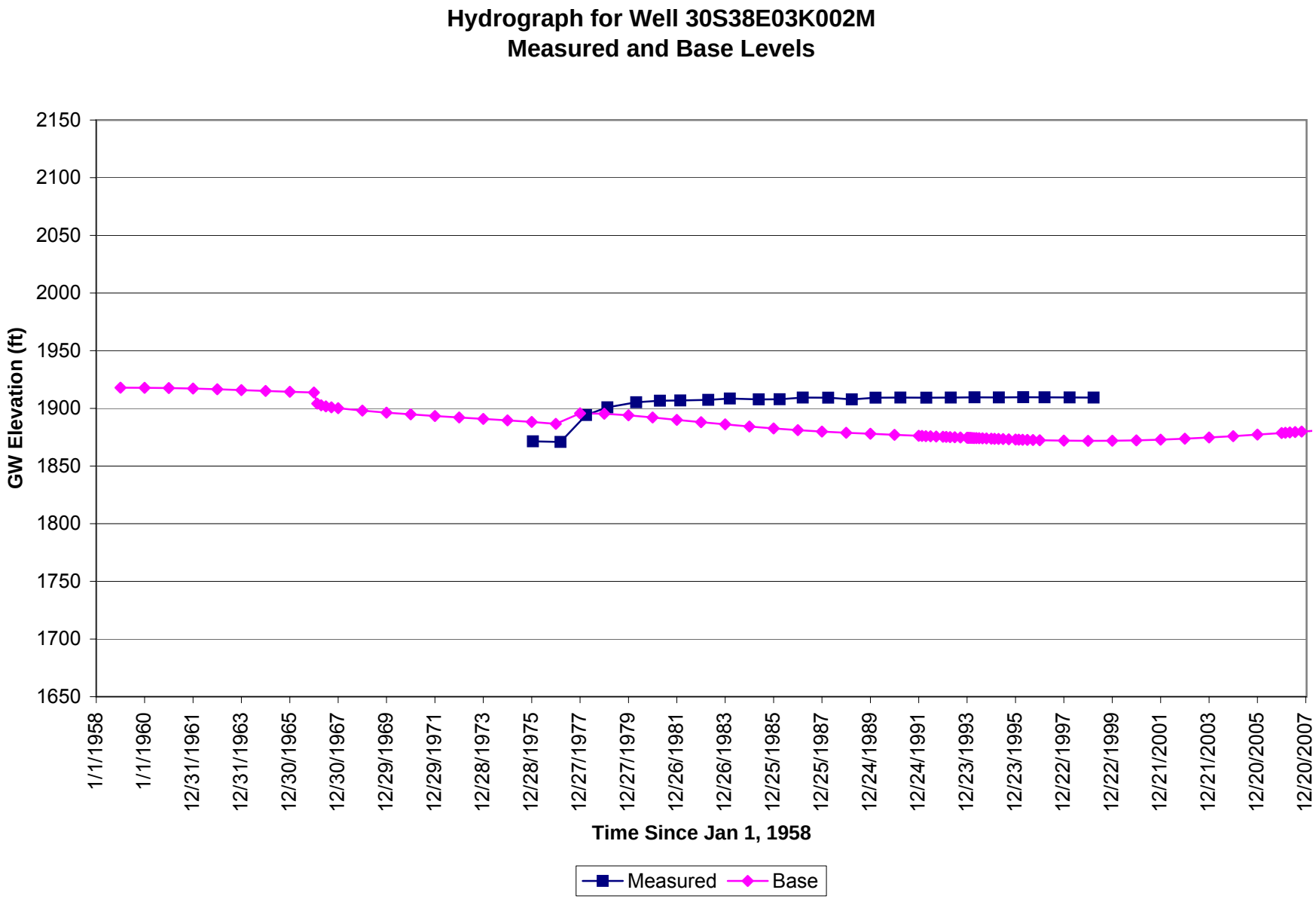

Hydrograph for Well 31S37E33H01
Measured and Base Levels
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
12/31/1961
12/31/1963
12/30/1965
12/30/1967
12/29/1969
12/29/1971
12/28/1973
12/28/1975
12/27/1977
12/27/1979
12/26/1981
12/26/1983
12/25/1985
12/25/1987
12/24/1989
12/24/1991
12/23/1993
12/23/1995
12/22/1997
12/22/1999
12/21/2001
12/21/2003
12/20/2005
12/20/2007
Time Since Jan 1, 1958
Measured
Base

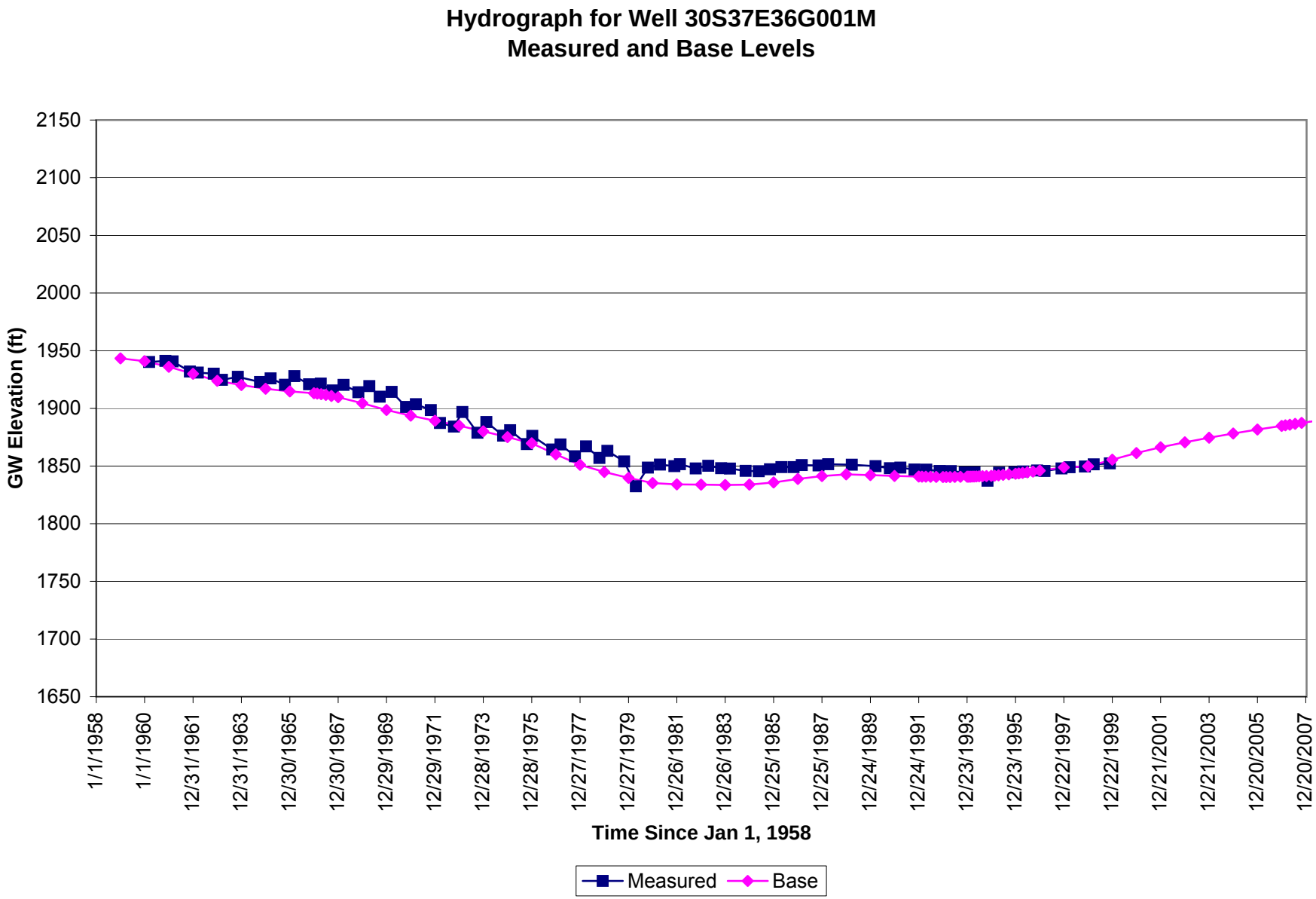

Hydrograph for Well 31S37E30F001M
Measured and Base Levels
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
12/31/1961
12/31/1963
12/30/1965
12/30/1967
12/29/1969
12/29/1971
12/28/1973
12/28/1975
12/27/1977
12/27/1979
12/26/1981
12/26/1983
12/25/1985
12/25/1987
12/24/1989
12/24/1991
12/23/1993
12/23/1995
12/22/1997
12/22/1999
12/21/2001
12/21/2003
12/20/2005
12/20/2007
Time Since Jan 1, 1958
Measured
Base

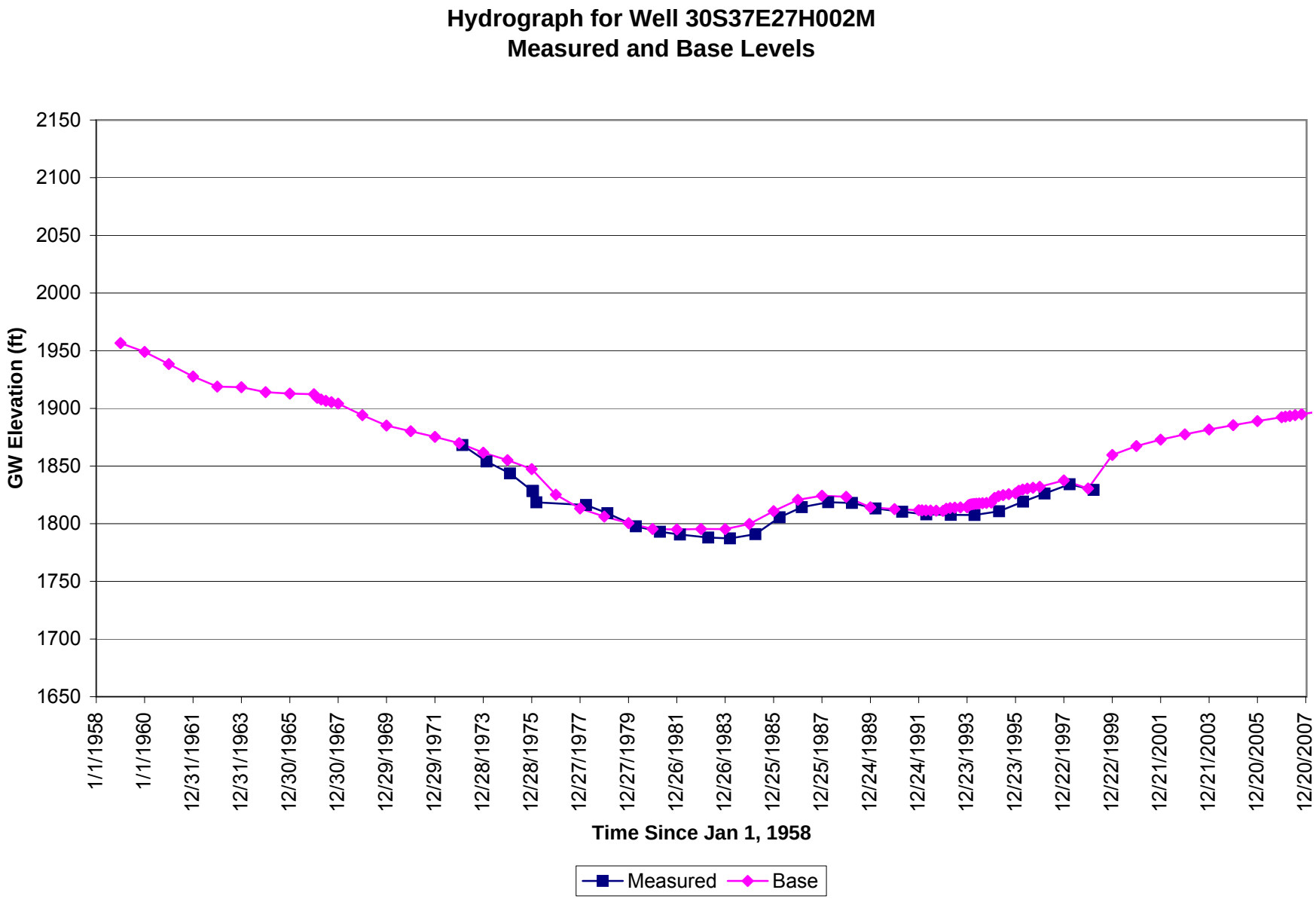

Hydrograph for Well 31S37E08C001M
Measured and Base Levels
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
12/31/1961
12/31/1963
12/30/1965
12/30/1967
12/29/1969
12/29/1971
12/28/1973
12/28/1975
12/27/1977
12/27/1979
12/26/1981
12/26/1983
12/25/1985
12/25/1987
12/24/1989
12/24/1991
12/23/1993
12/23/1995
12/22/1997
12/22/1999
12/21/2001
12/21/2003
12/20/2005
12/20/2007
Time Since Jan 1, 1958
Measured
Base

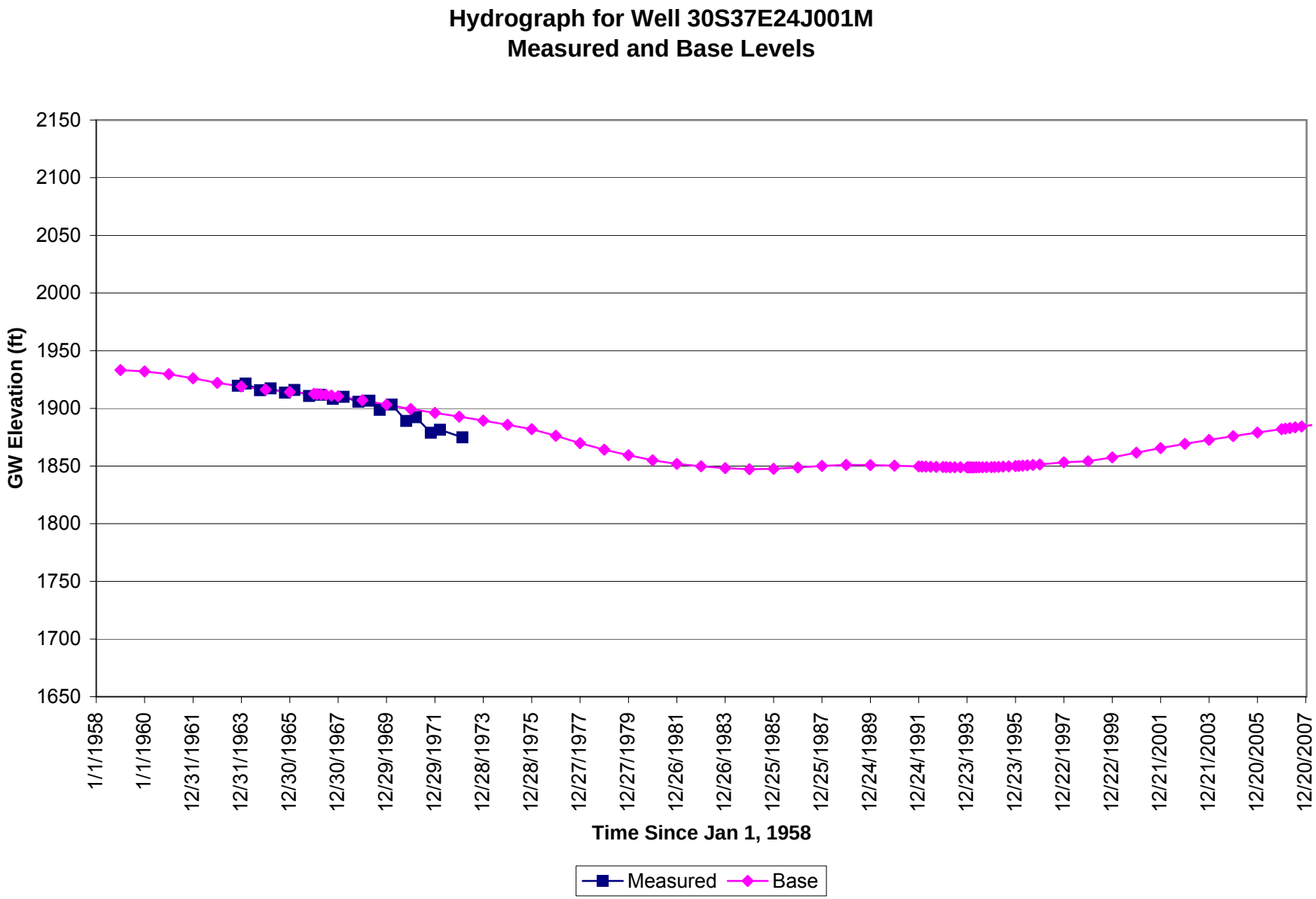

Hydrograph for Well 30S39E08A001M
Measured and Base Levels
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
12/31/1961
12/31/1963
12/30/1965
12/30/1967
12/29/1969
12/29/1971
12/28/1973
12/28/1975
12/27/1977
12/27/1979
12/26/1981
12/26/1983
12/25/1985
12/25/1987
12/24/1989
12/24/1991
12/23/1993
12/23/1995
12/22/1997
12/22/1999
12/21/2001
12/21/2003
12/20/2005
12/20/2007
Time Since Jan 1, 1958
Measured
Base

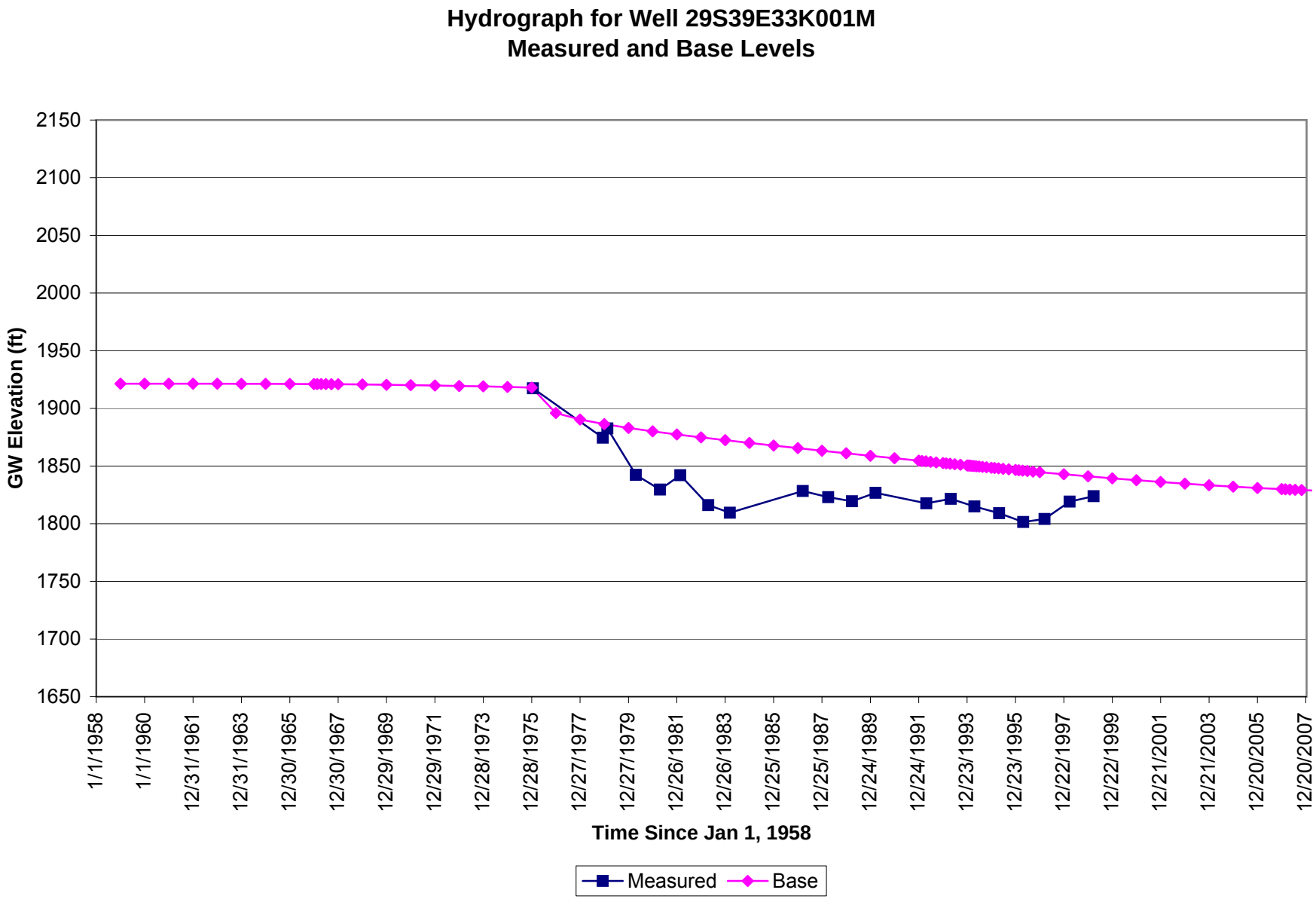

Hydrograph for Well 30S38E24F001M
Measured and Base Levels
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
12/31/1961
12/31/1963
12/30/1965
12/30/1967
12/29/1969
12/29/1971
12/28/1973
12/28/1975
12/27/1977
12/27/1979
12/26/1981
12/26/1983
12/25/1985
12/25/1987
12/24/1989
12/24/1991
12/23/1993
12/23/1995
12/22/1997
12/22/1999
12/21/2001
12/21/2003
12/20/2005
12/20/2007
Time Since Jan 1, 1958
Measured
Base

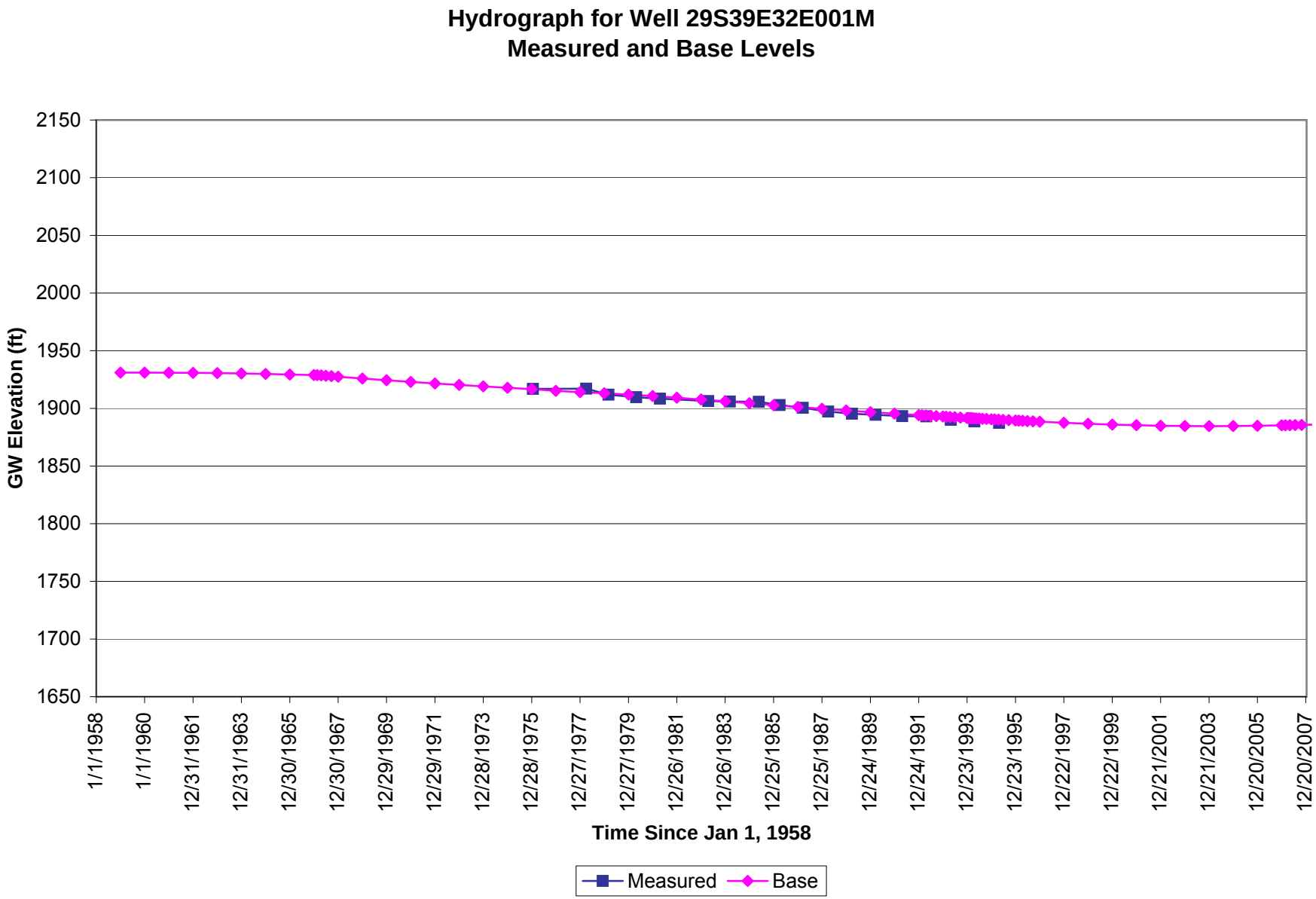

Hydrograph for Well 30S38E03K002M
Measured and Base Levels
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
12/31/1961
12/31/1963
12/30/1965
12/30/1967
12/29/1969
12/29/1971
12/28/1973
12/28/1975
12/27/1977
12/27/1979
12/26/1981
12/26/1983
12/25/1985
12/25/1987
12/24/1989
12/24/1991
12/23/1993
12/23/1995
12/22/1997
12/22/1999
12/21/2001
12/21/2003
12/20/2005
12/20/2007
Time Since Jan 1, 1958
Measured
Base


Hydrograph for Well 30S37E36G001M
Measured and Base Levels
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
12/31/1961
12/31/1963
12/30/1965
12/30/1967
12/29/1969
12/29/1971
12/28/1973
12/28/1975
12/27/1977
12/27/1979
12/26/1981
12/26/1983
12/25/1985
12/25/1987
12/24/1989
12/24/1991
12/23/1993
12/23/1995
12/22/1997
12/22/1999
12/21/2001
12/21/2003
12/20/2005
12/20/2007
Time Since Jan 1, 1958
Measured
Base


Hydrograph for Well 30S37E27H002M
Measured and Base Levels
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
12/31/1961
12/31/1963
12/30/1965
12/30/1967
12/29/1969
12/29/1971
12/28/1973
12/28/1975
12/27/1977
12/27/1979
12/26/1981
12/26/1983
12/25/1985
12/25/1987
12/24/1989
12/24/1991
12/23/1993
12/23/1995
12/22/1997
12/22/1999
12/21/2001
12/21/2003
12/20/2005
12/20/2007
Time Since Jan 1, 1958
Measured
Base


Hydrograph for Well 30S37E24J001M
Measured and Base Levels
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
12/31/1961
12/31/1963
12/30/1965
12/30/1967
12/29/1969
12/29/1971
12/28/1973
12/28/1975
12/27/1977
12/27/1979
12/26/1981
12/26/1983
12/25/1985
12/25/1987
12/24/1989
12/24/1991
12/23/1993
12/23/1995
12/22/1997
12/22/1999
12/21/2001
12/21/2003
12/20/2005
12/20/2007
Time Since Jan 1, 1958
Measured
Base

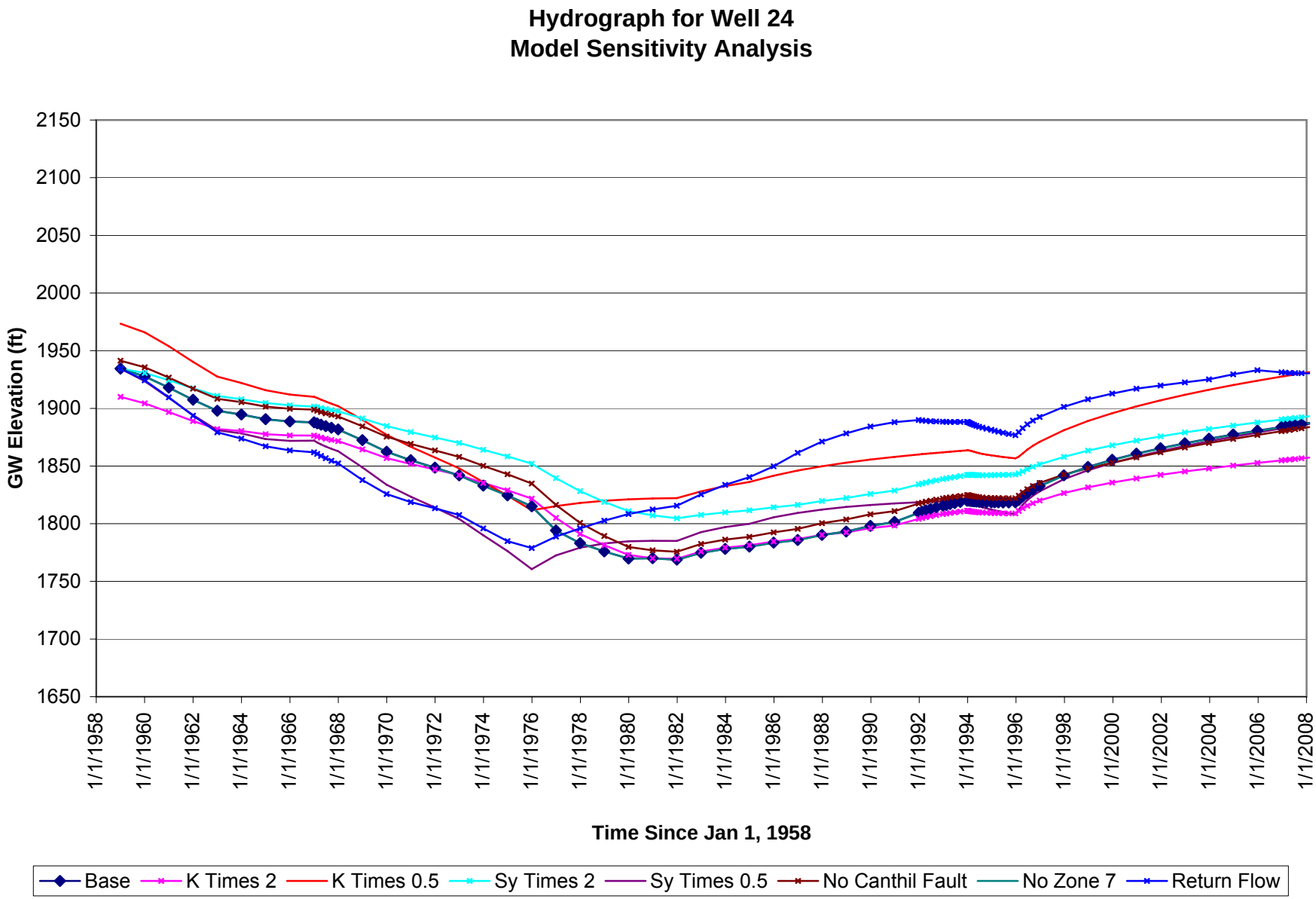

Hydrograph for Well 29S39E33K001M
Measured and Base Levels
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
12/31/1961
12/31/1963
12/30/1965
12/30/1967
12/29/1969
12/29/1971
12/28/1973
12/28/1975
12/27/1977
12/27/1979
12/26/1981
12/26/1983
12/25/1985
12/25/1987
12/24/1989
12/24/1991
12/23/1993
12/23/1995
12/22/1997
12/22/1999
12/21/2001
12/21/2003
12/20/2005
12/20/2007
Time Since Jan 1, 1958
Measured
Base

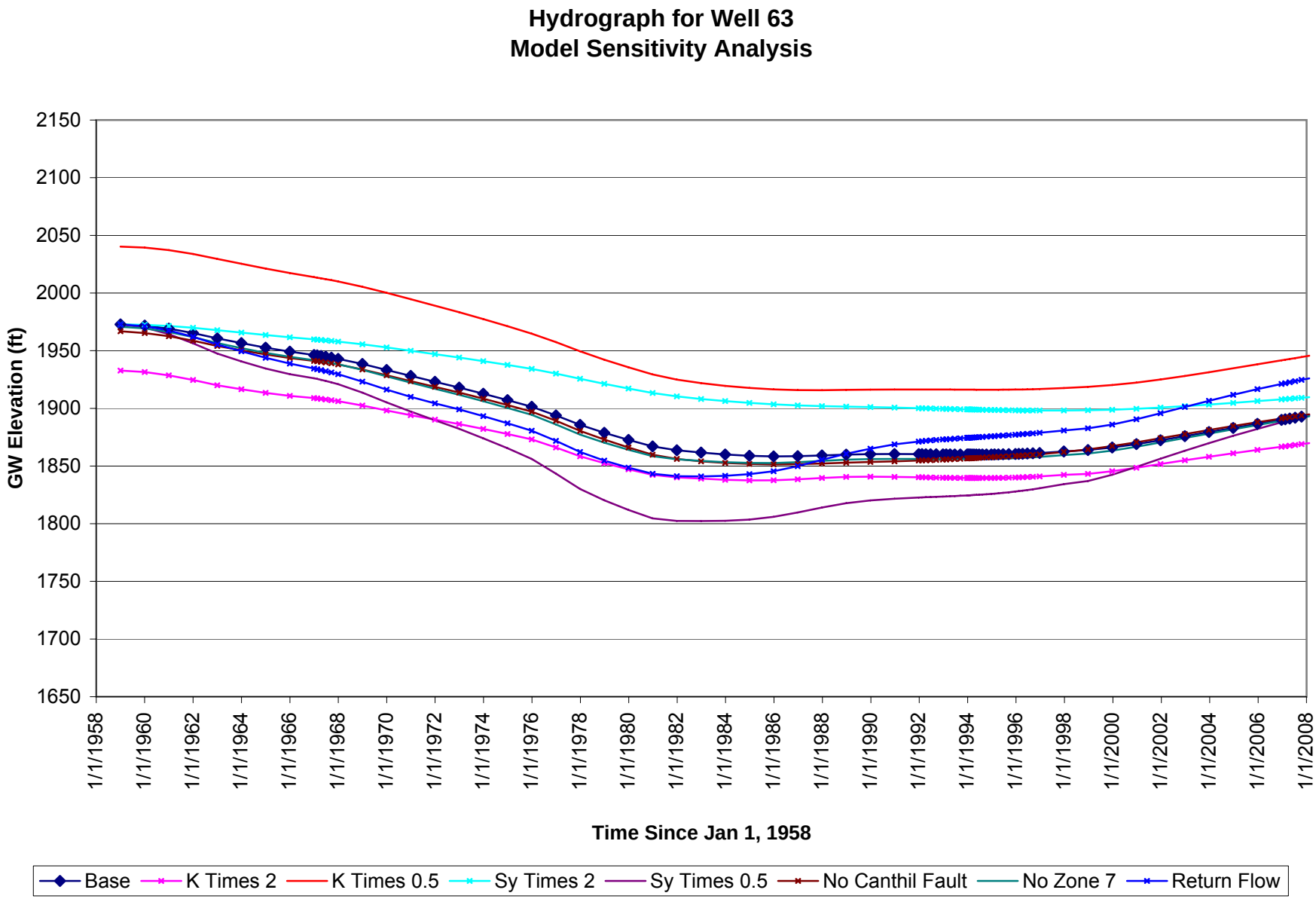

Hydrograph for Well 29S39E32E001M
Measured and Base Levels
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
12/31/1961
12/31/1963
12/30/1965
12/30/1967
12/29/1969
12/29/1971
12/28/1973
12/28/1975
12/27/1977
12/27/1979
12/26/1981
12/26/1983
12/25/1985
12/25/1987
12/24/1989
12/24/1991
12/23/1993
12/23/1995
12/22/1997
12/22/1999
12/21/2001
12/21/2003
12/20/2005
12/20/2007
Time Since Jan 1, 1958
Measured
Base

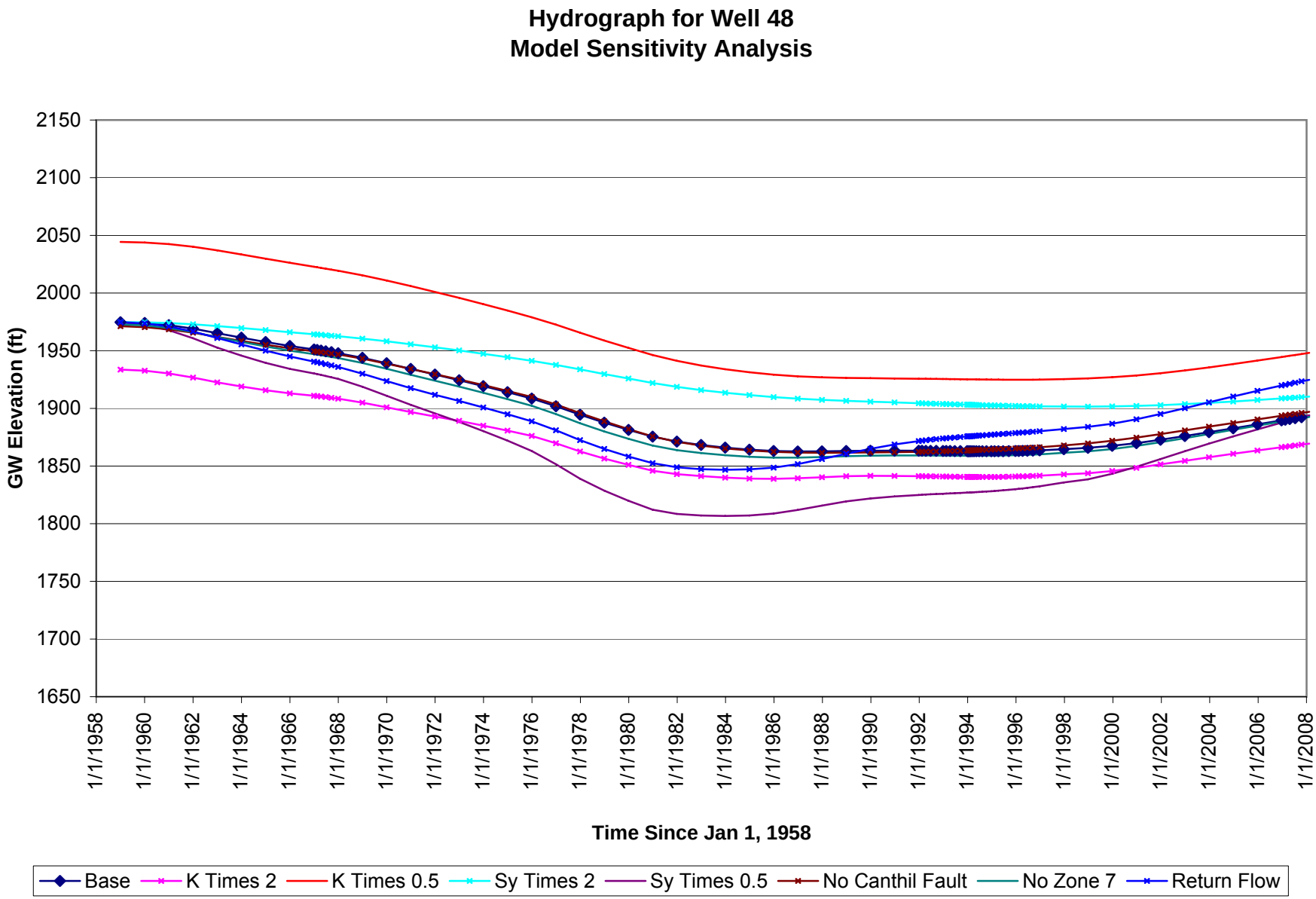
Hydrograph for Well 30S37E27H002M
Measured and Base Levels
Hydrograph for Well 30S37E24J001M
Measured and Base Levels
Hydrograph for Well 30S38E03K002M
Measured and Base Levels
Hydrograph for Well 29S39E32E001M
Measured and Base Levels
Hydrograph for Well 29S39E28H001M
Measured and Base Levels
Hydrograph for Well 29S39E33K001M
Measured and Base Levels
Hydrograph for Well 31S37E08C001M
Measured and Base Levels
Hydrograph for Well 30S39E08A001M
Measured and Base Levels
Hydrograph for Well 31S37E30F001M
Measured and Base Levels
Hydrograph for Well 30S38E24F001M
Measured and Base Levels
Hydrograph for Well 30S37E36G001M
Measured and Base Levels
Hydrograph for Well 31S37E33H01
Measured and Base Levels
Hydrograph for Well 31S37E35N01
Measured and Base Levels
Hydrograph for Well 31S38E06E001M
Measured and Base Levels
GW Elevation (ft)
Time Since Jan 1, 1958
Base
Measured
Garlock Fault
Calico Fault
Rattlesnake Canyon Fault
Barstow-Mojave Fault
29S39E28H01
29S39E33K01
29S39E32E01
30S38E03K02
30S39E08A01
30S37E24J01
30S38E24F01
30S37E27H01
30S37E36G01
31S38E06E01
BSEP PLANT SITE
31S37E08C01
31S37E30F01
31S37E33H01
31S37E35N01
LEGEND
30S37E36G01 Well Used in Model Calibration with State Well Number
BSEP Plant Site Boundary
Faults
OR
ID
NV
UT
CA
AZ
N
S
E
W
0.5 0.25 0 0.5 1
Miles
BSEP
Plate A-1
Summary Hydrographs
for Verification Run
Beacon Solar
AECOM
Project: 10056-014
Date: May 2009
J:\GIS\Projects\10056-Beacon\mxd\hydrographs-5_18_09\measure_Predicted-poster.mxd

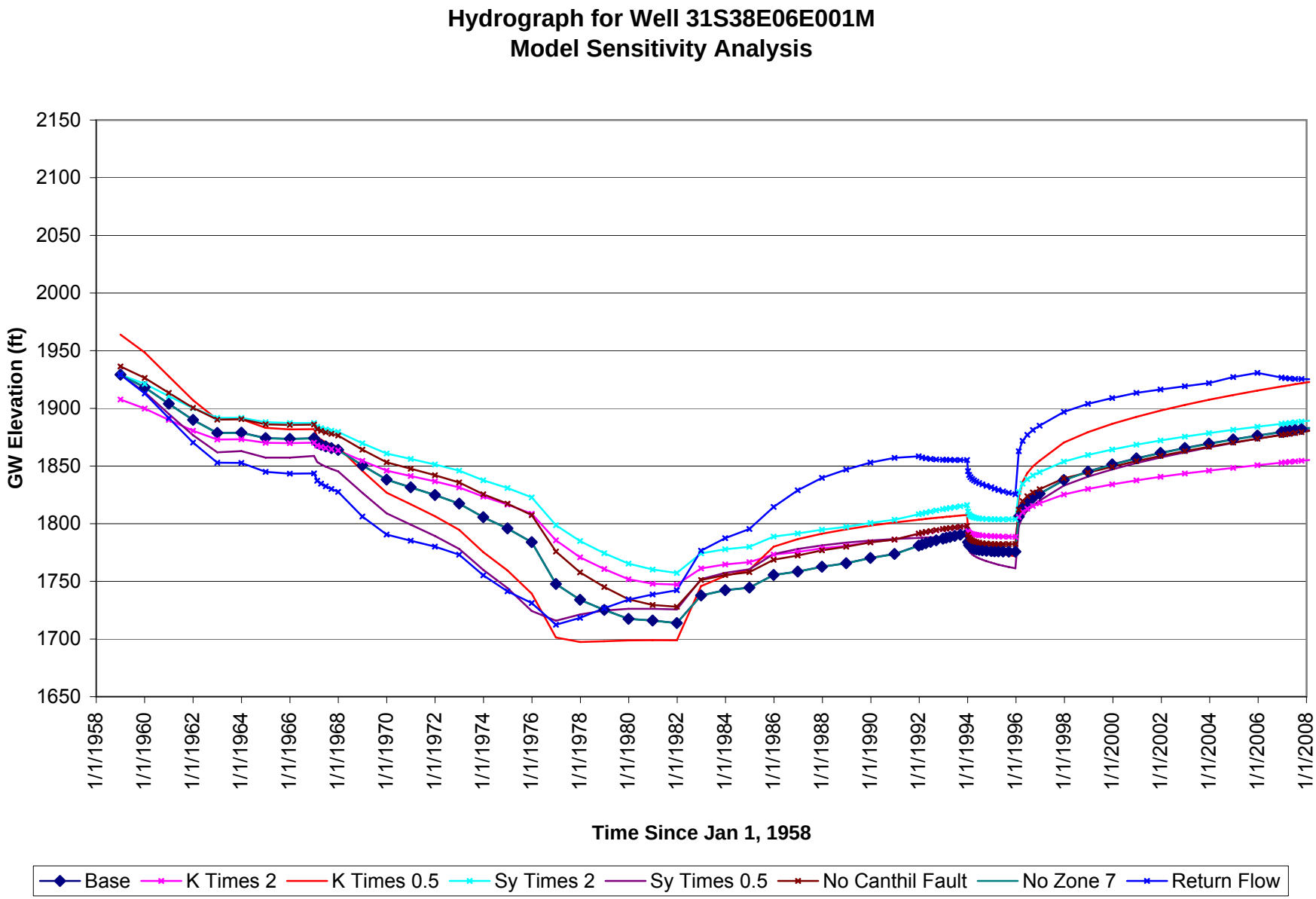
Appendix B

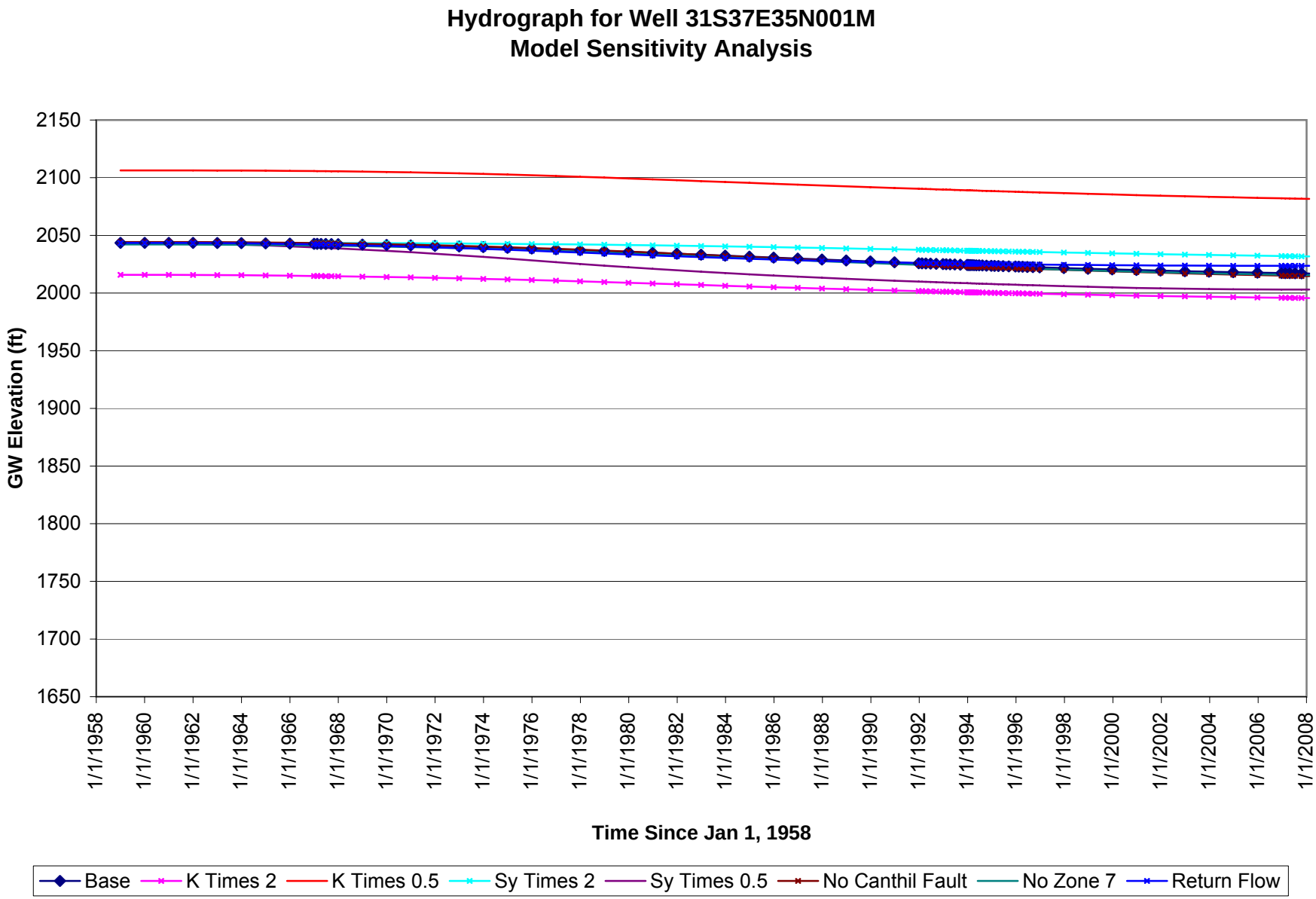
Hydrographs for the Predictive Sensitivity Analysis

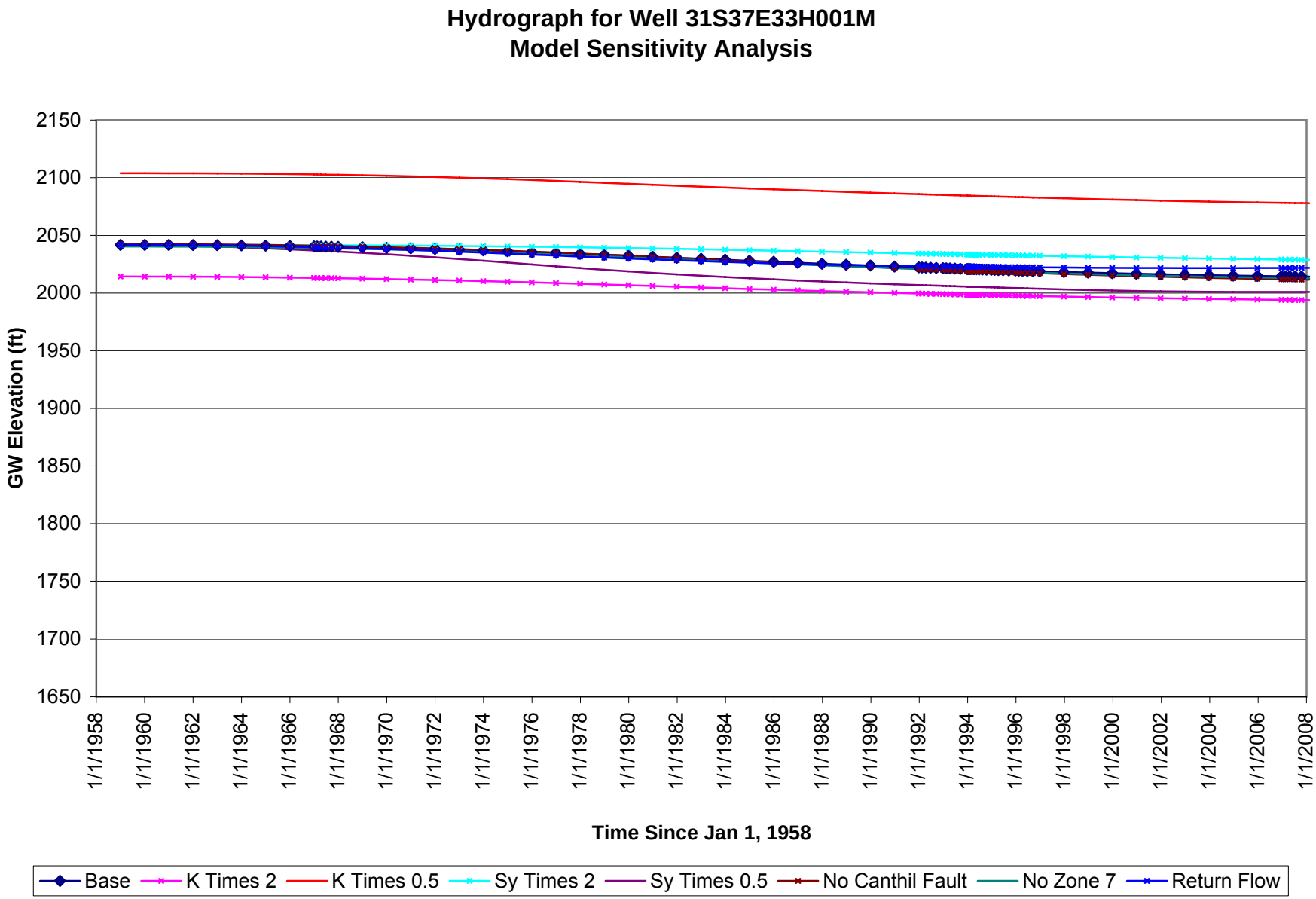

Hydrograph for Well 24
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

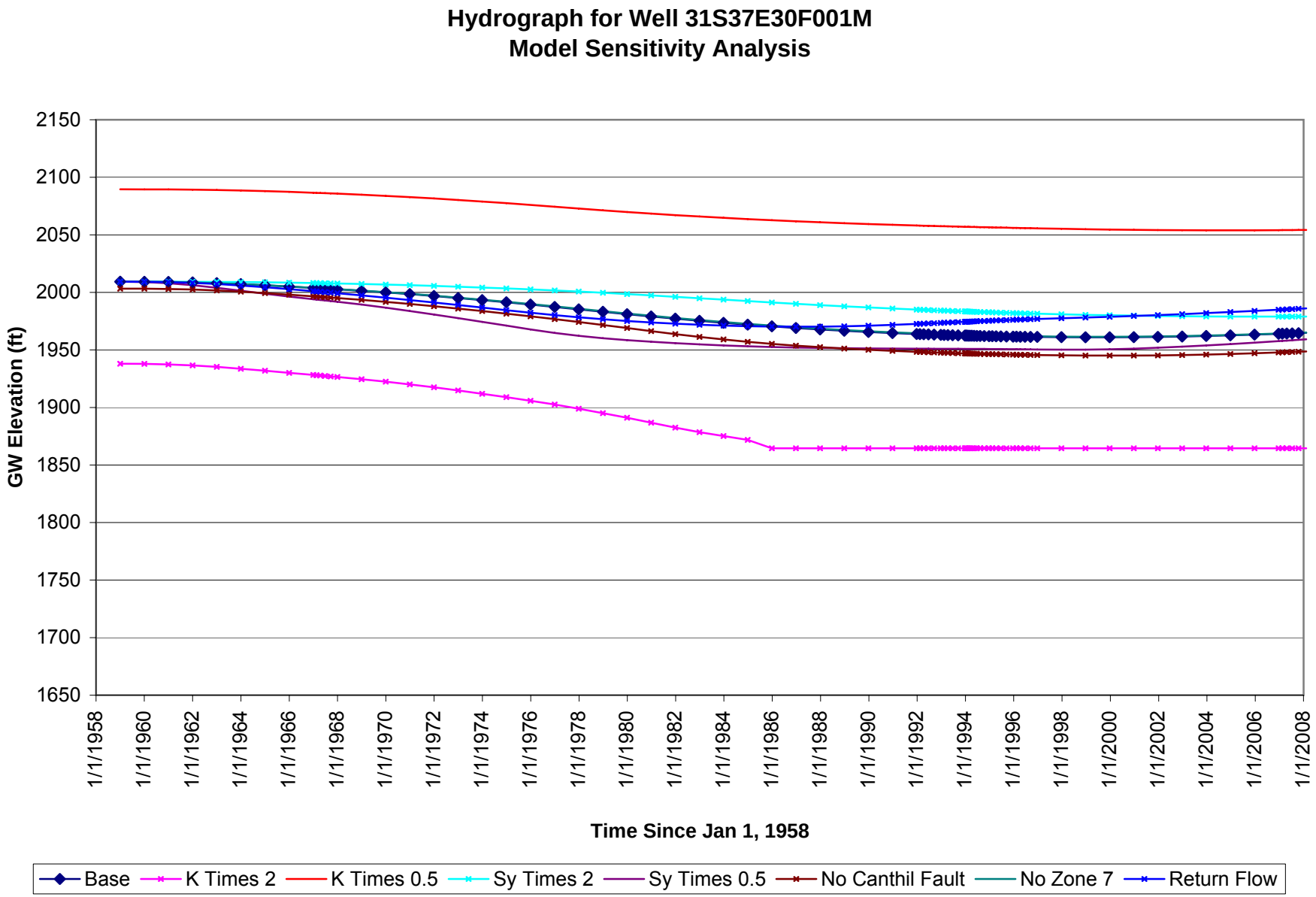

Hydrograph for Well 63
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

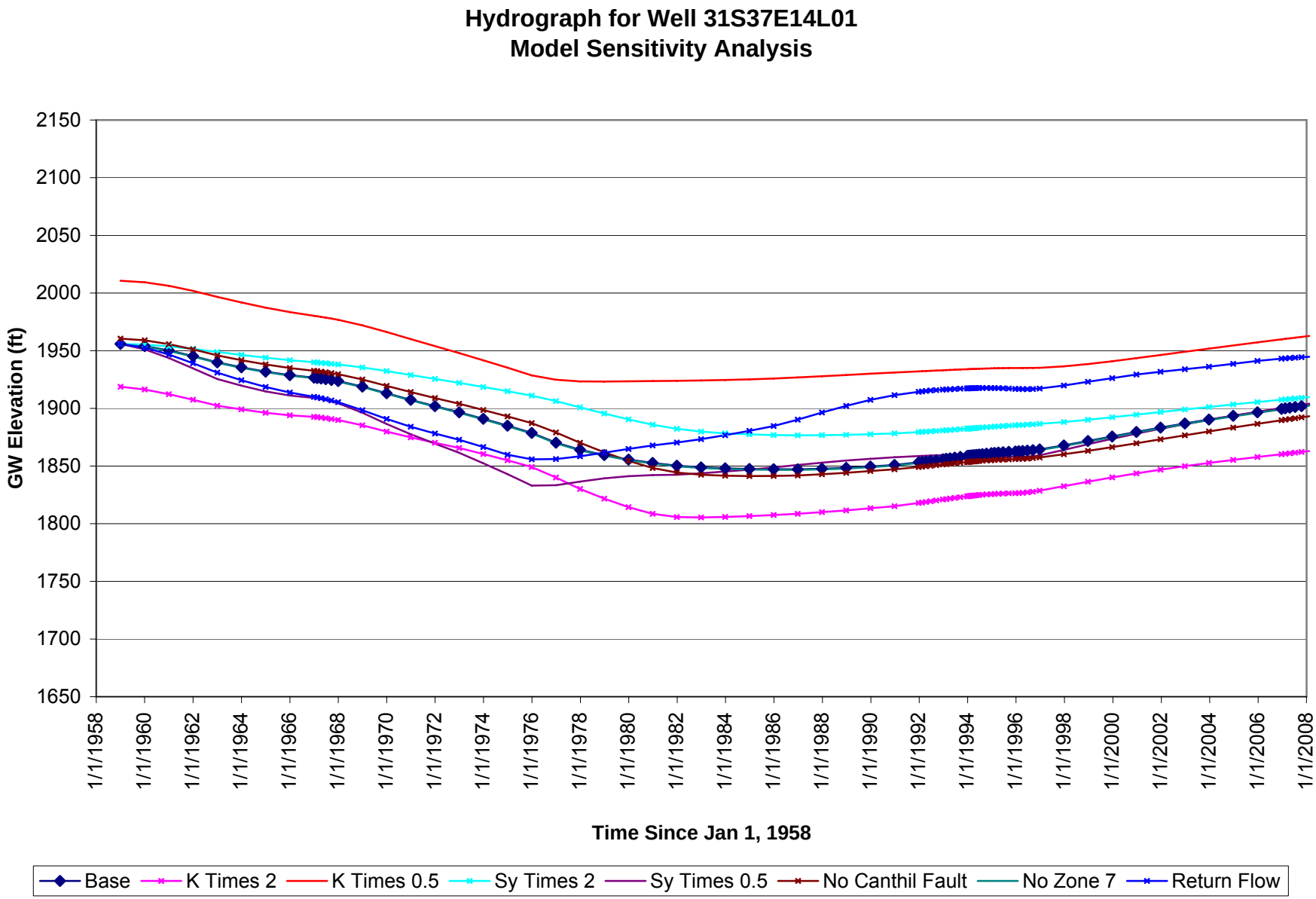

Hydrograph for Well 48
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

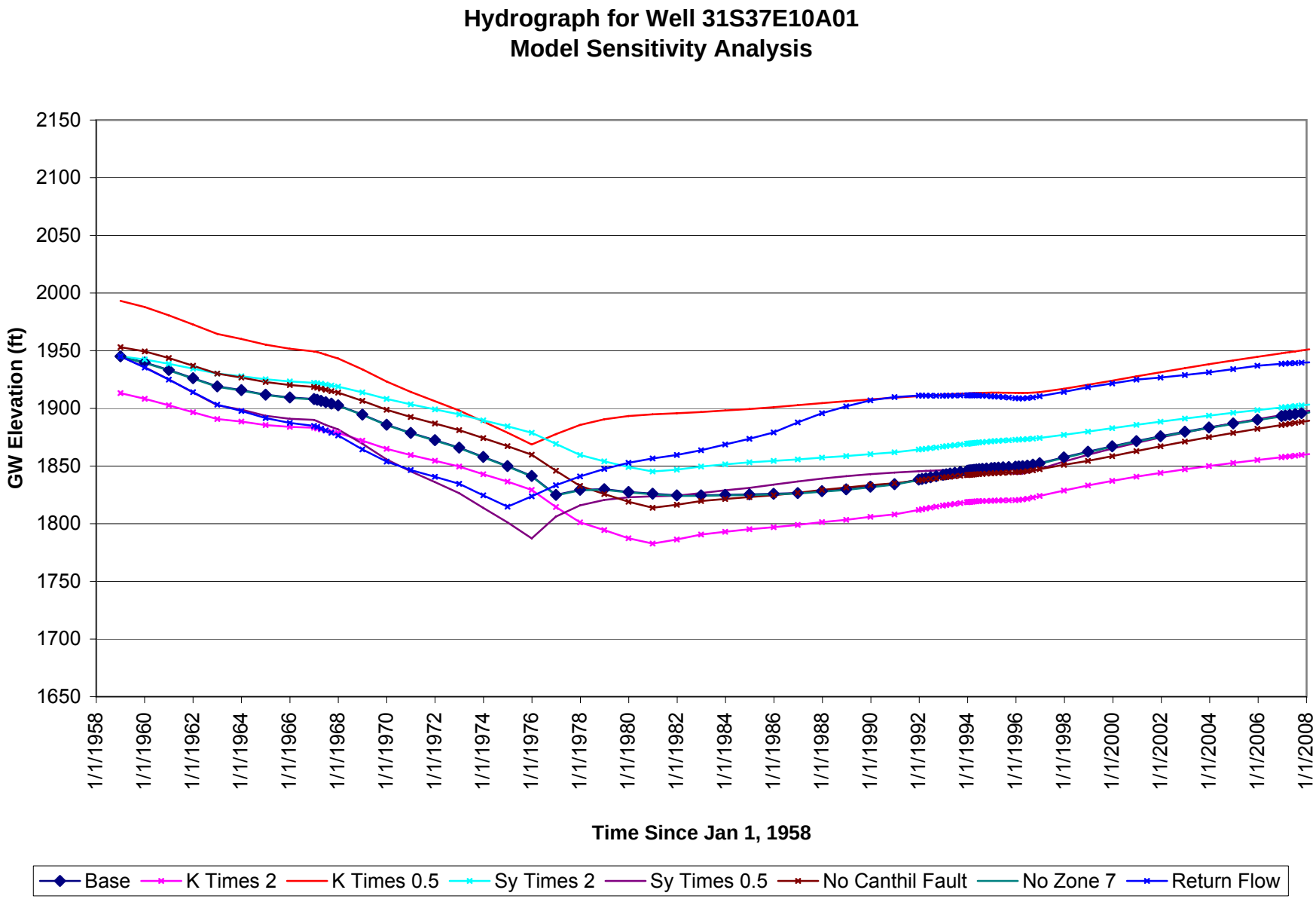

Hydrograph for Well 31S38E06E001M
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

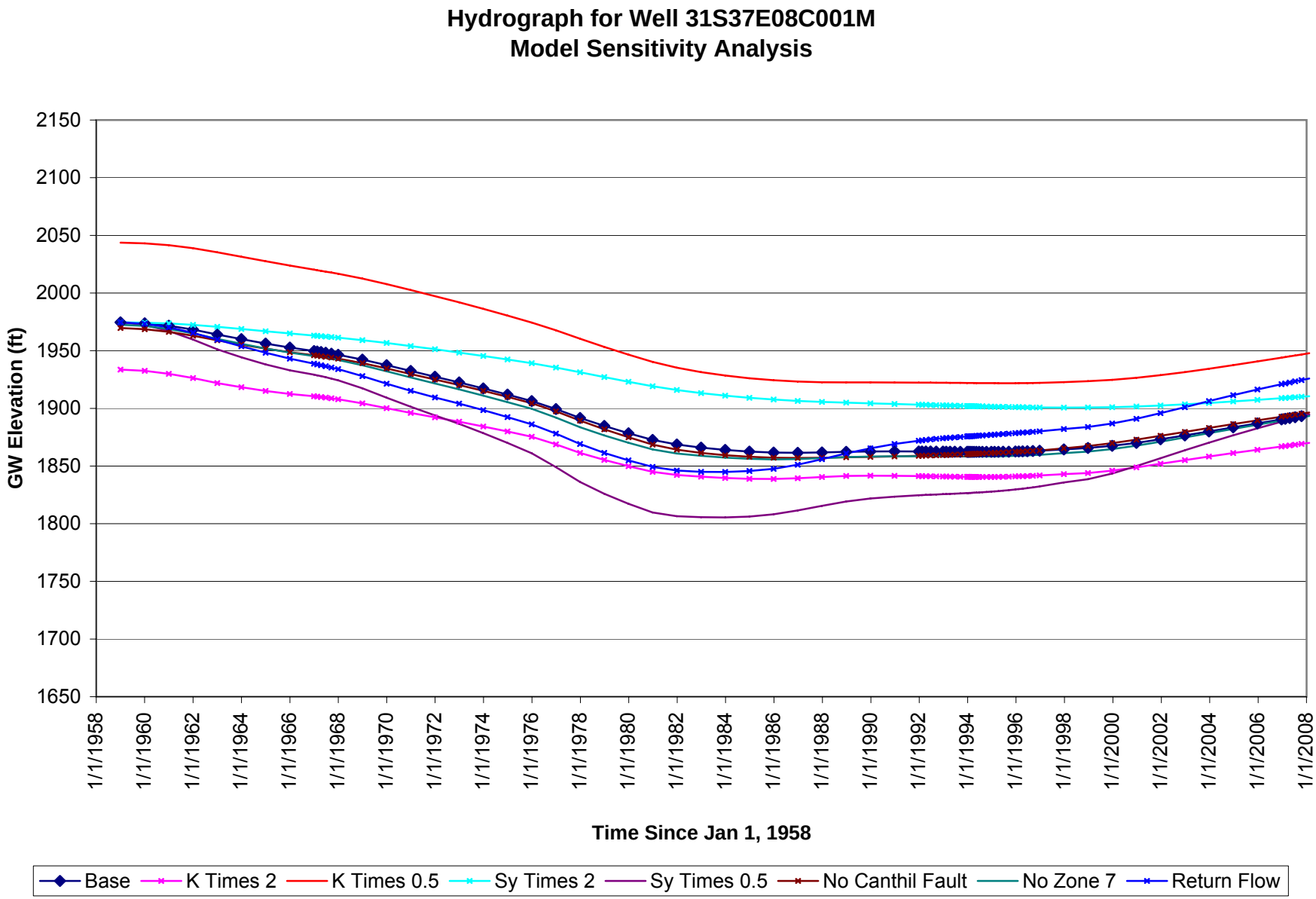

Hydrograph for Well 31S37E35N001M
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

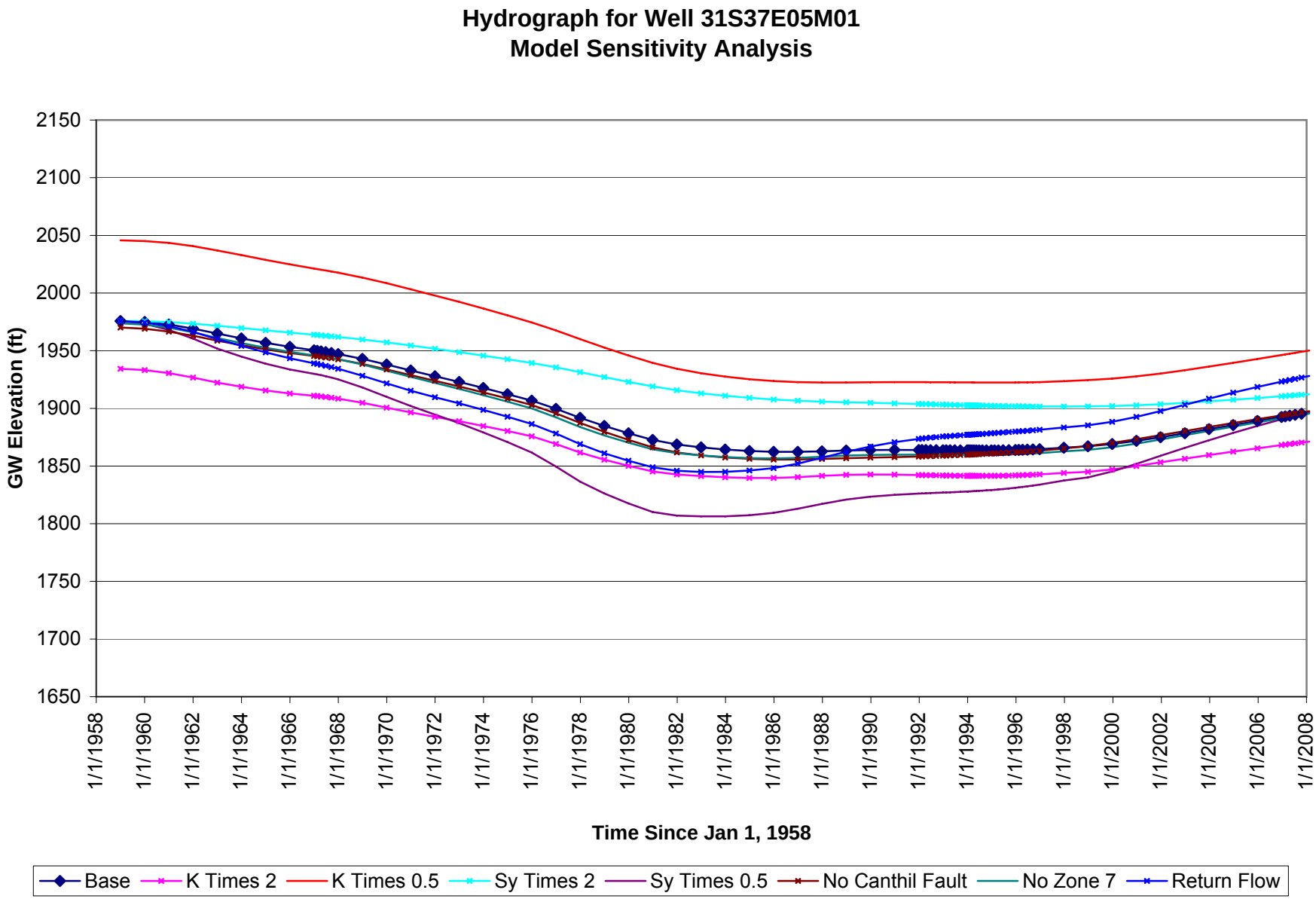

Hydrograph for Well 31S37E33H001M
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

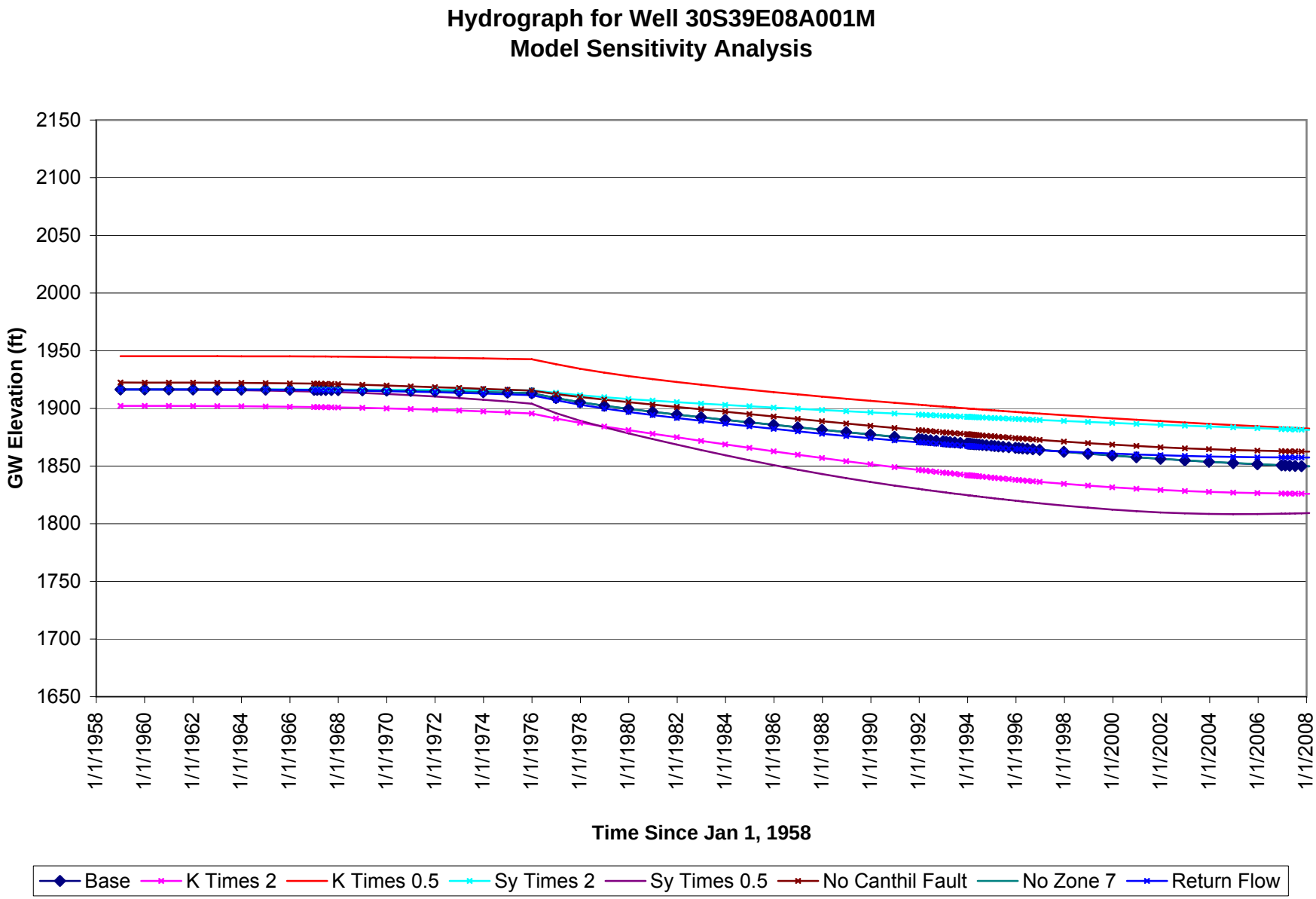

Hydrograph for Well 31S37E30F001M
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

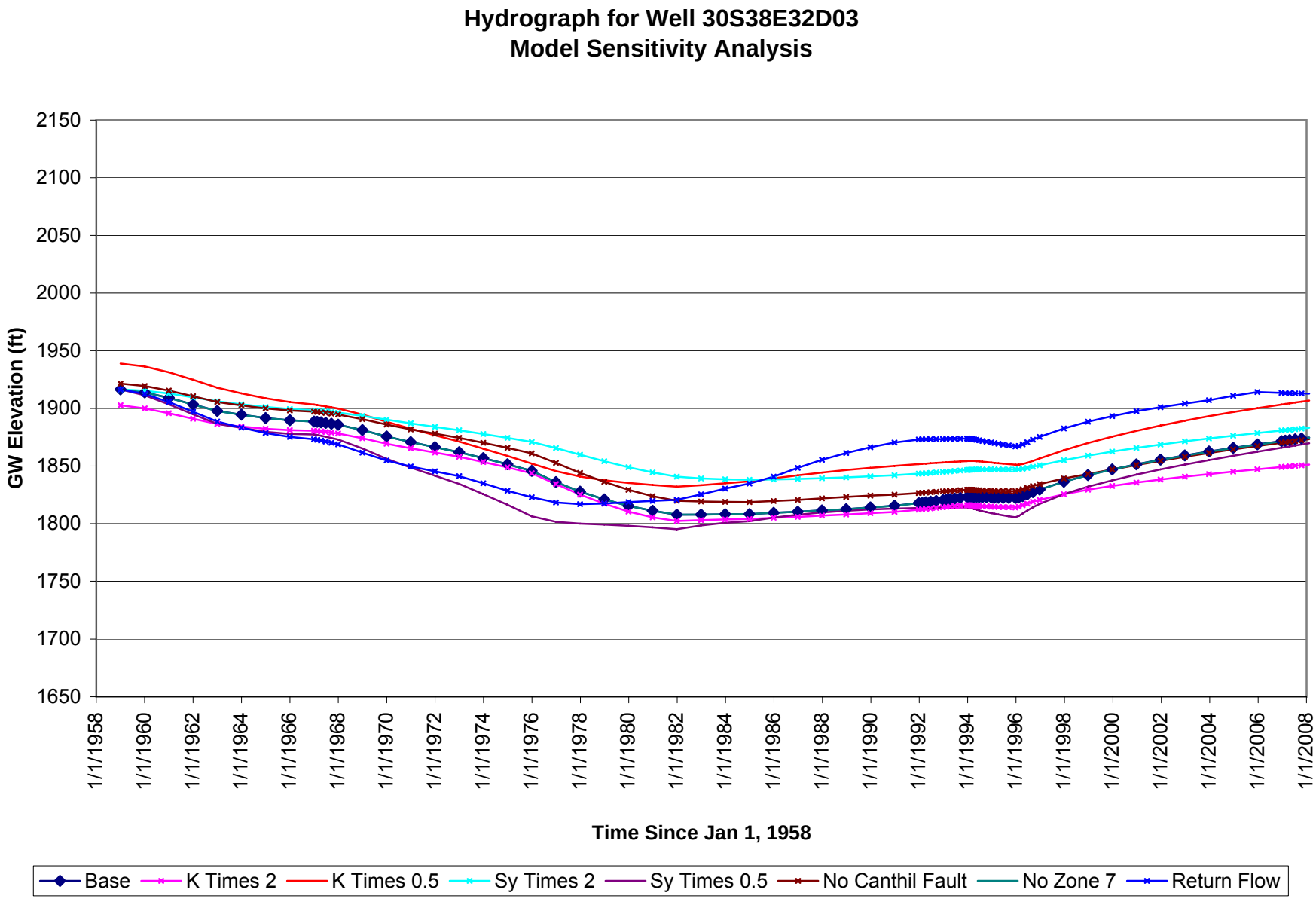

Hydrograph for Well 31S37E14L01
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

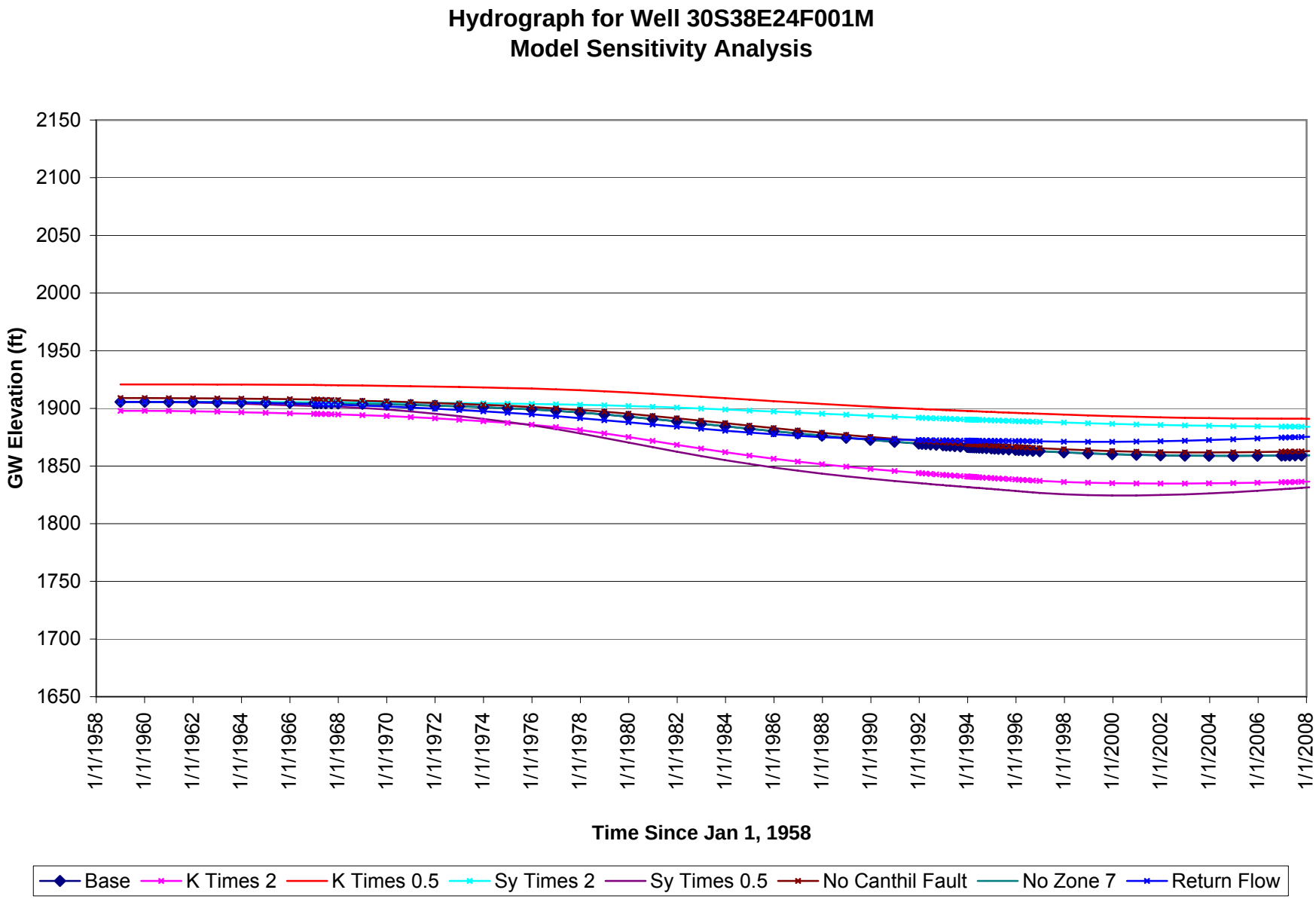

Hydrograph for Well 31S37E10A01
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

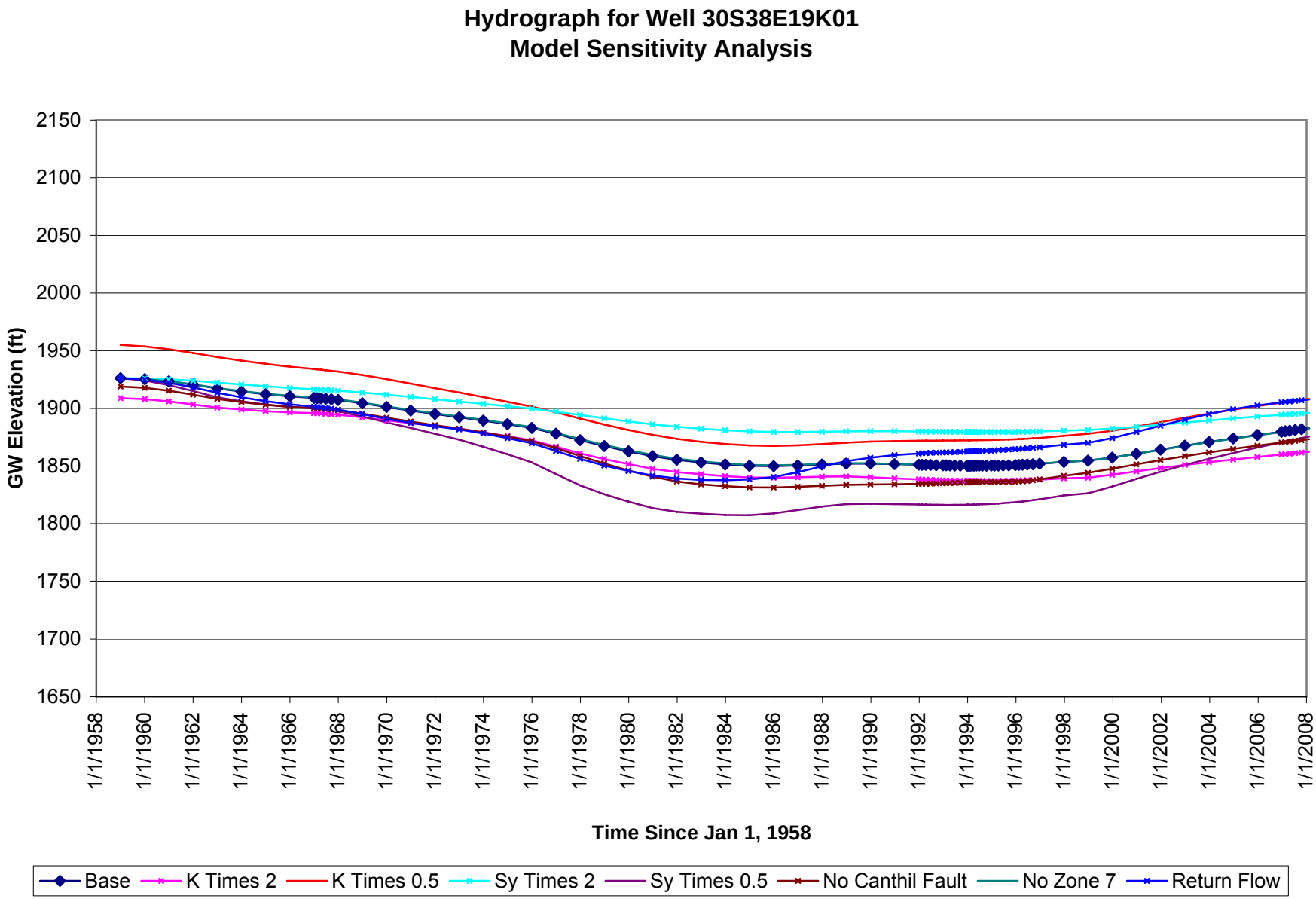

Hydrograph for Well 31S37E08C001M
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

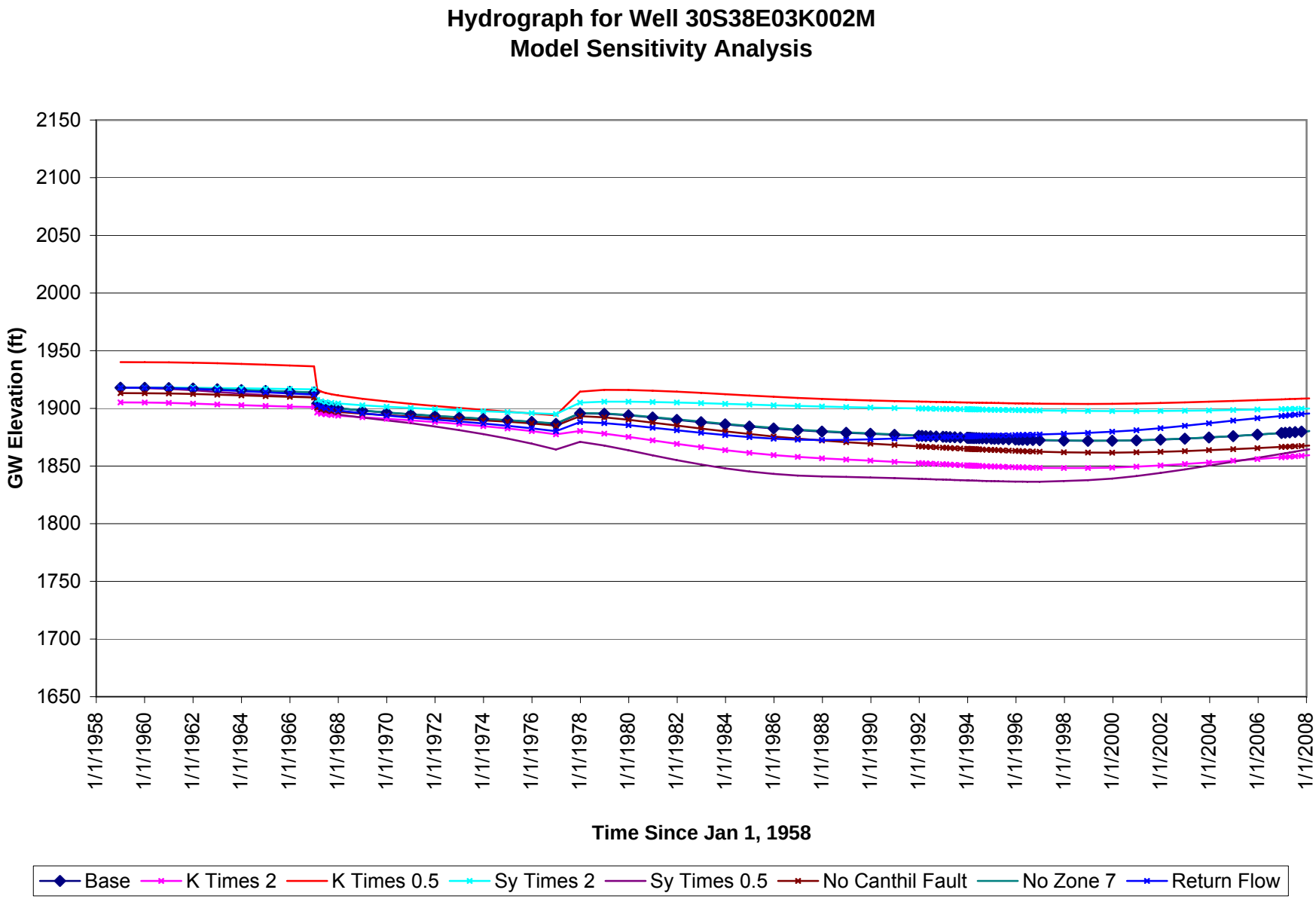

Hydrograph for Well 31S37E05M01
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

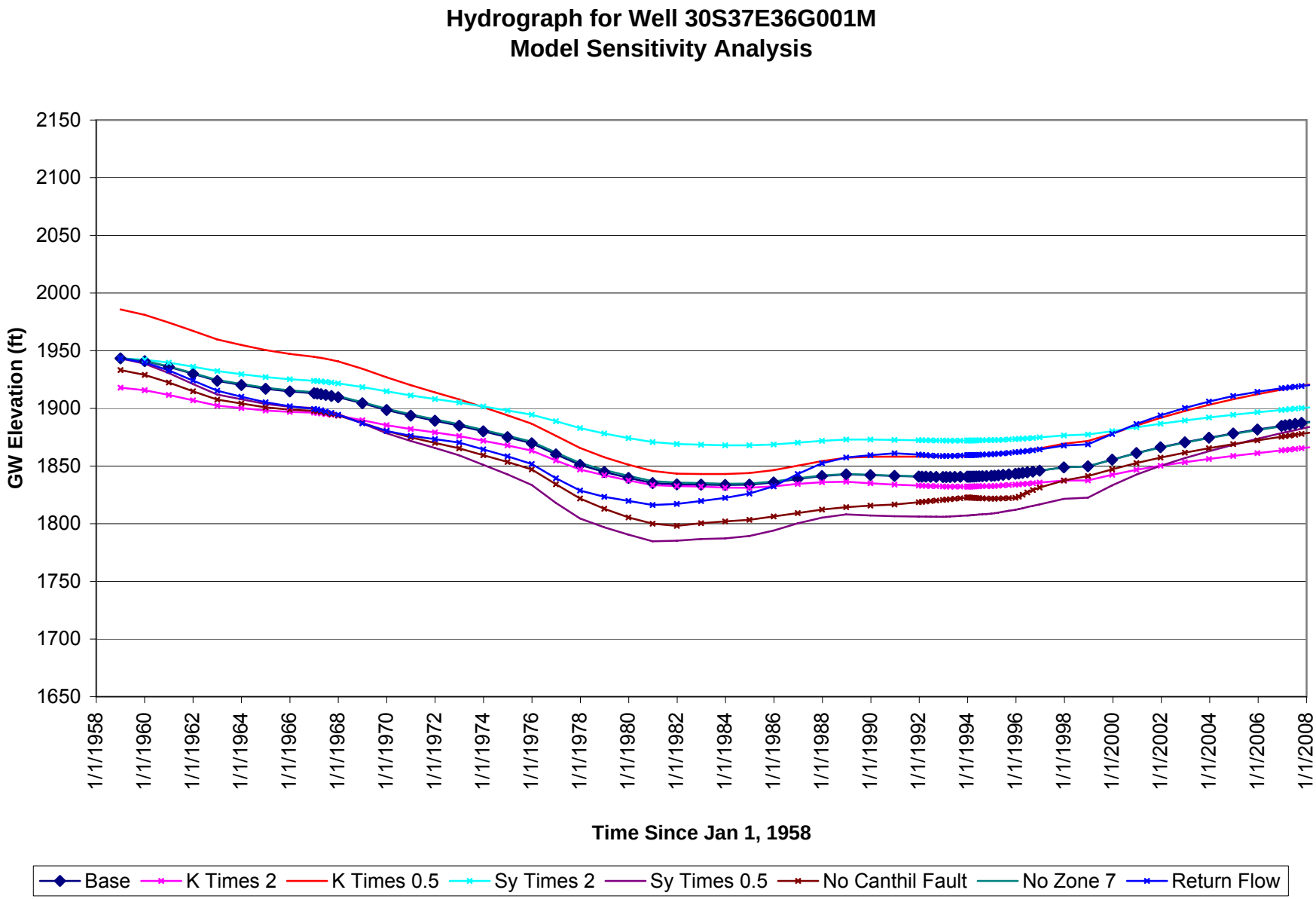

Hydrograph for Well 30S39E08A001M
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

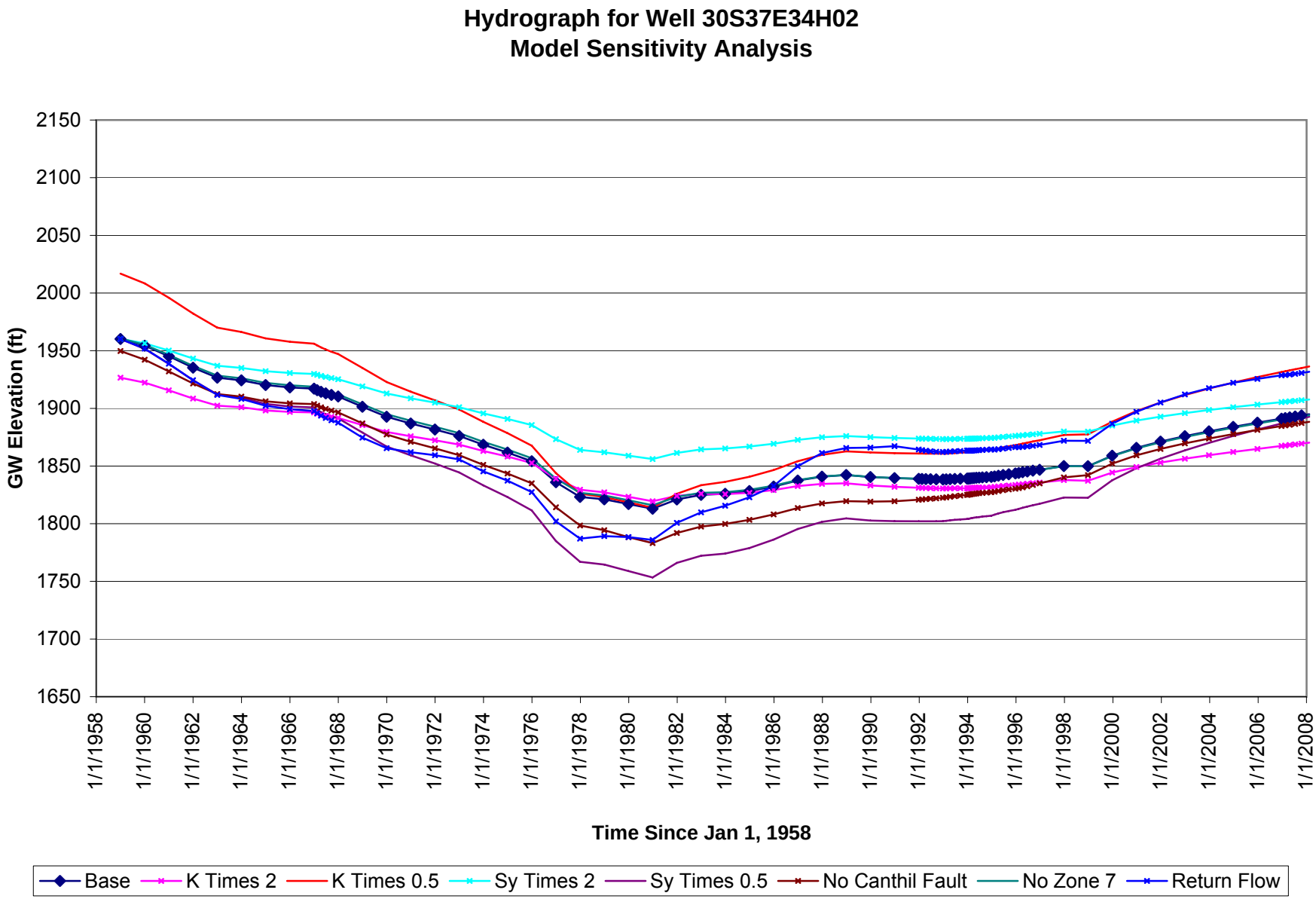

Hydrograph for Well 30S38E32D03
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

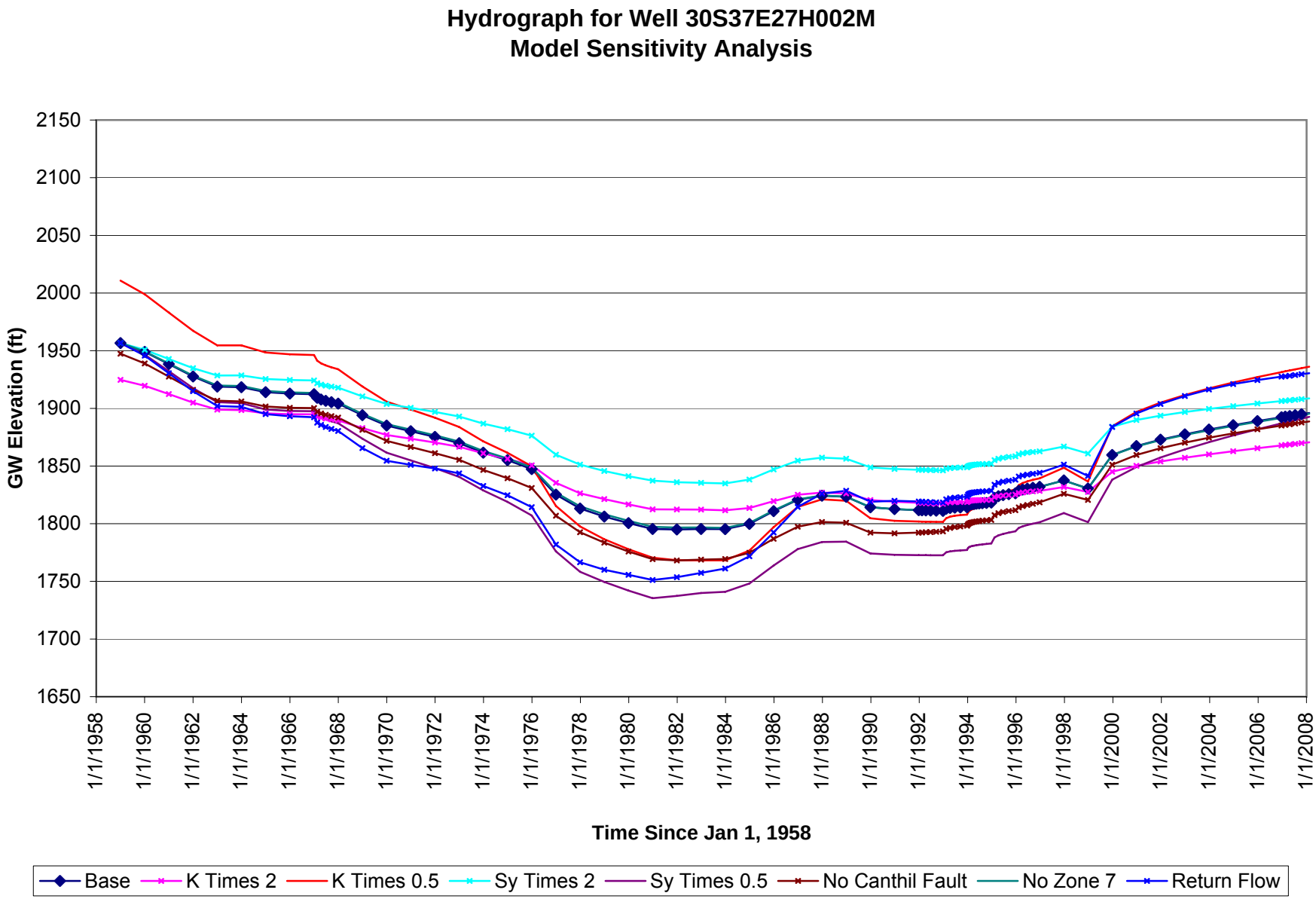

Hydrograph for Well 30S38E24F001M
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

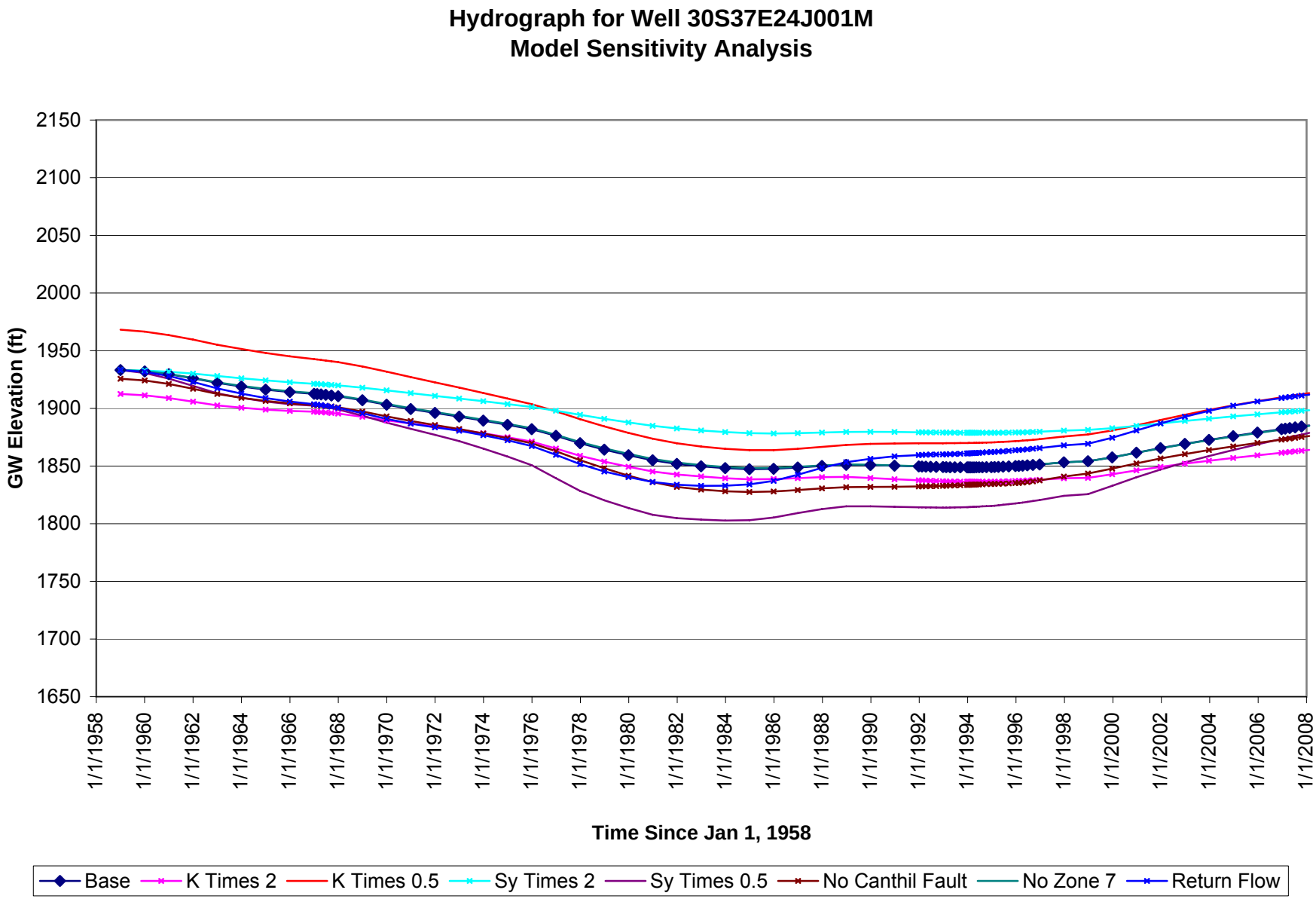

Hydrograph for Well 30S38E19K01
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

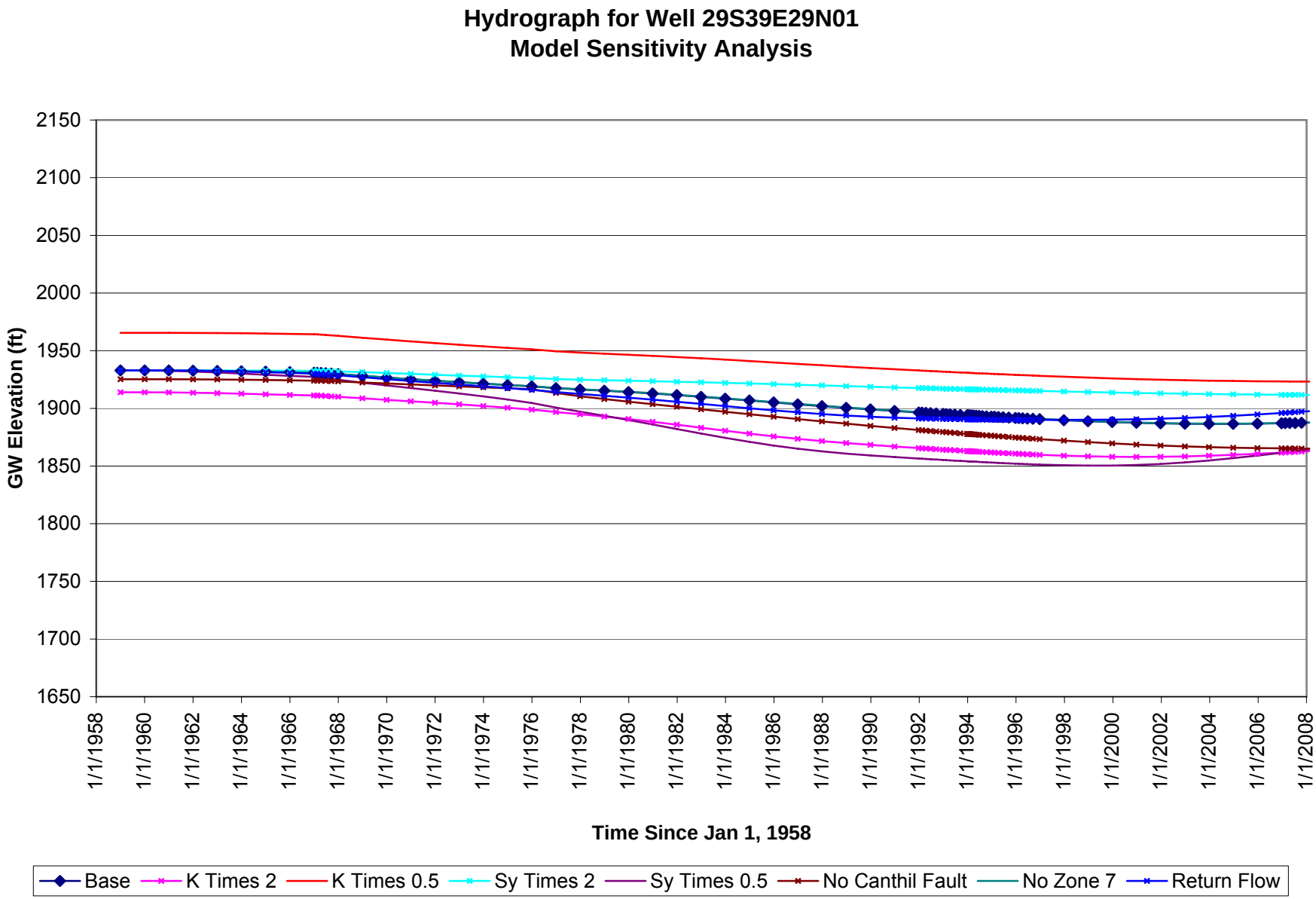

Hydrograph for Well 30S38E03K002M
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

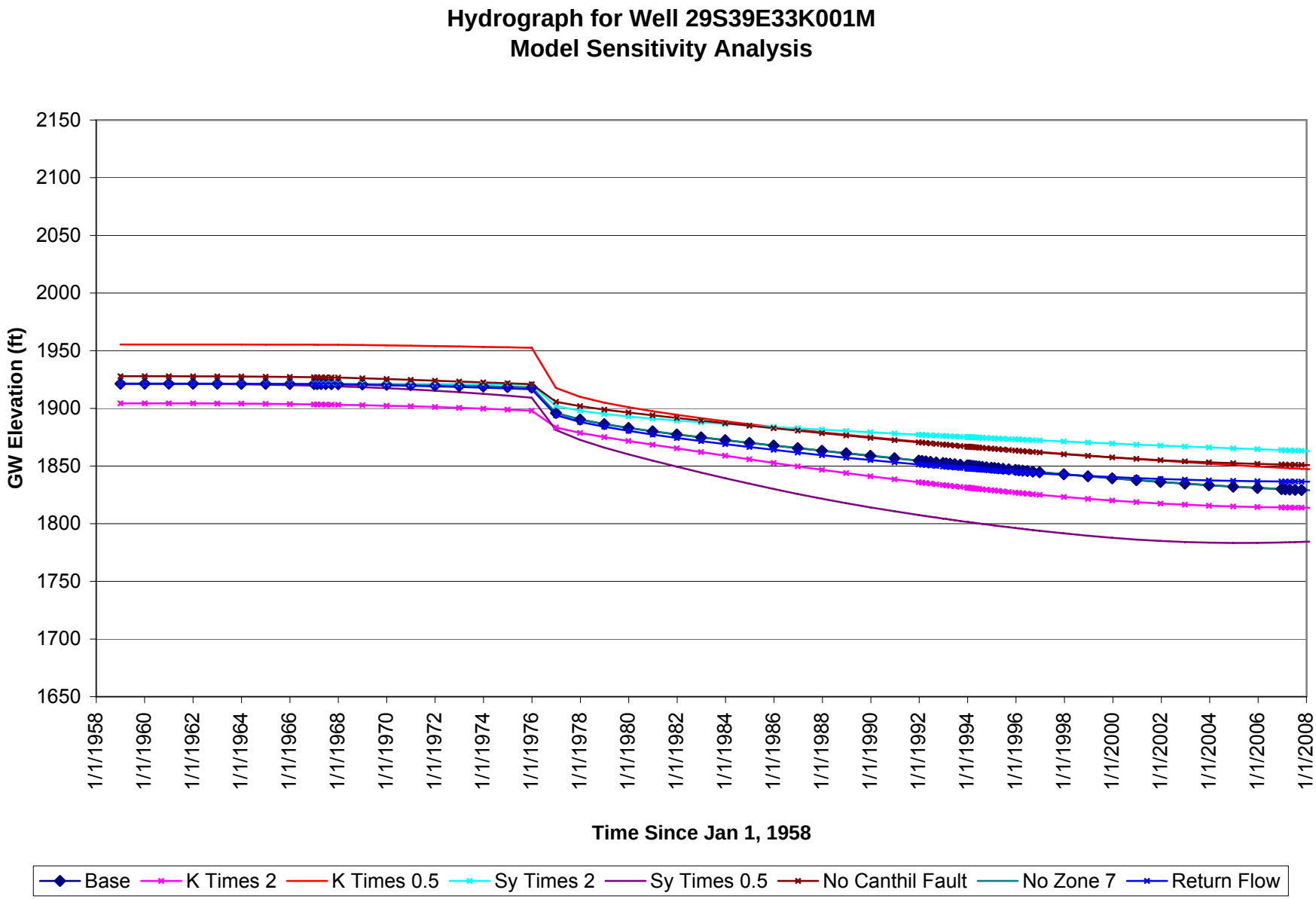

Hydrograph for Well 30S37E36G001M
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

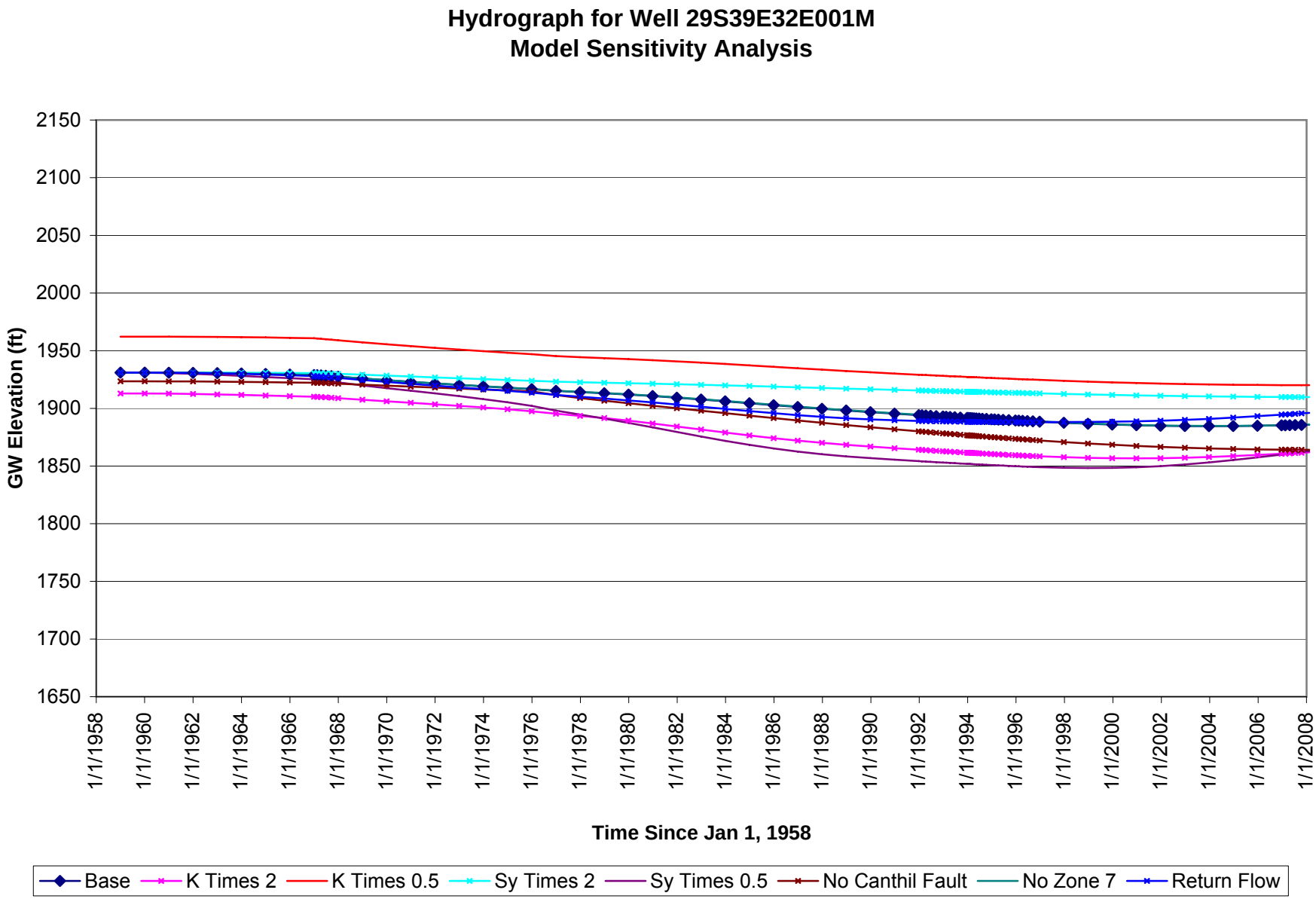

Hydrograph for Well 30S37E34H02
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

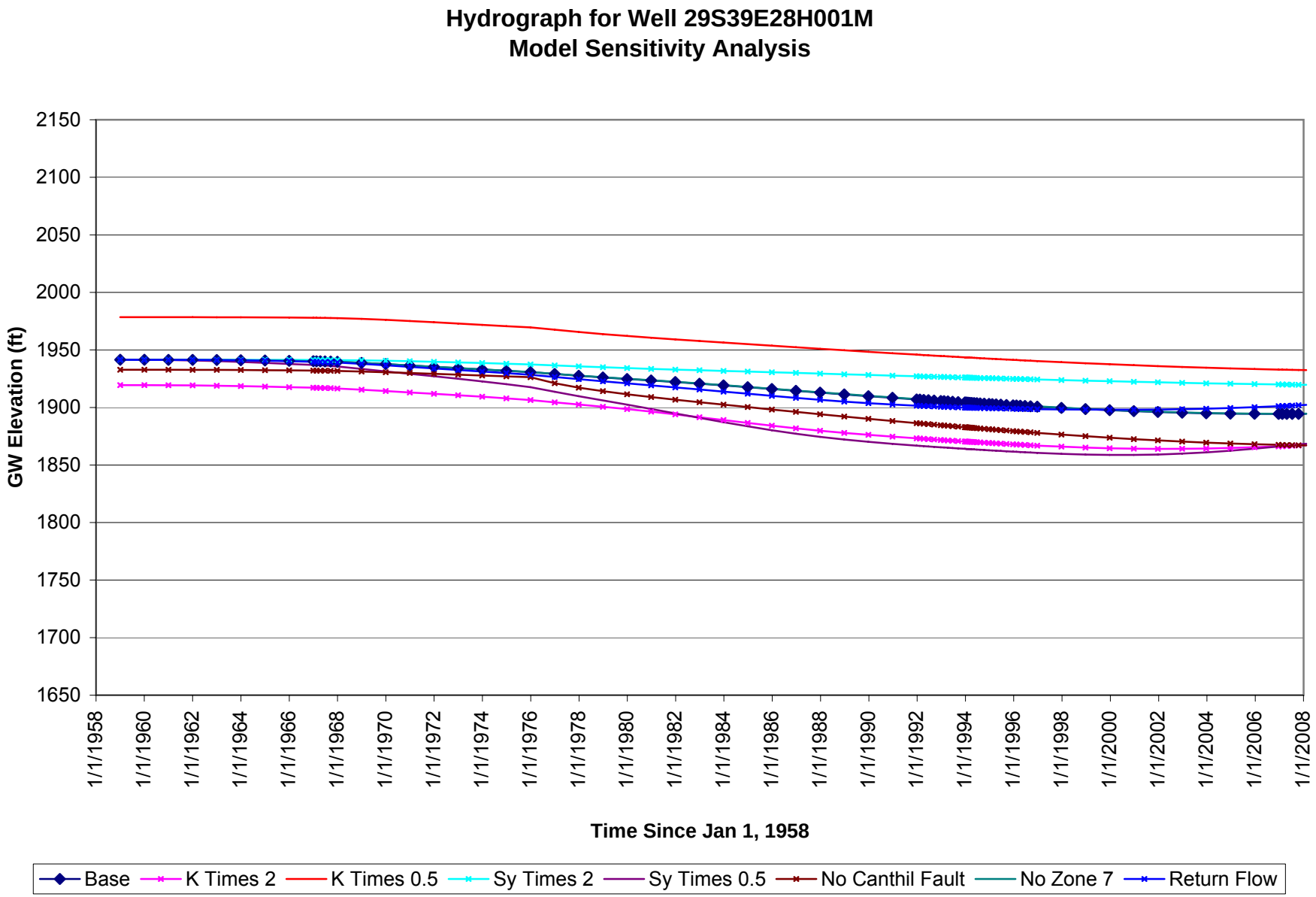

Hydrograph for Well 30S37E27H002M
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow

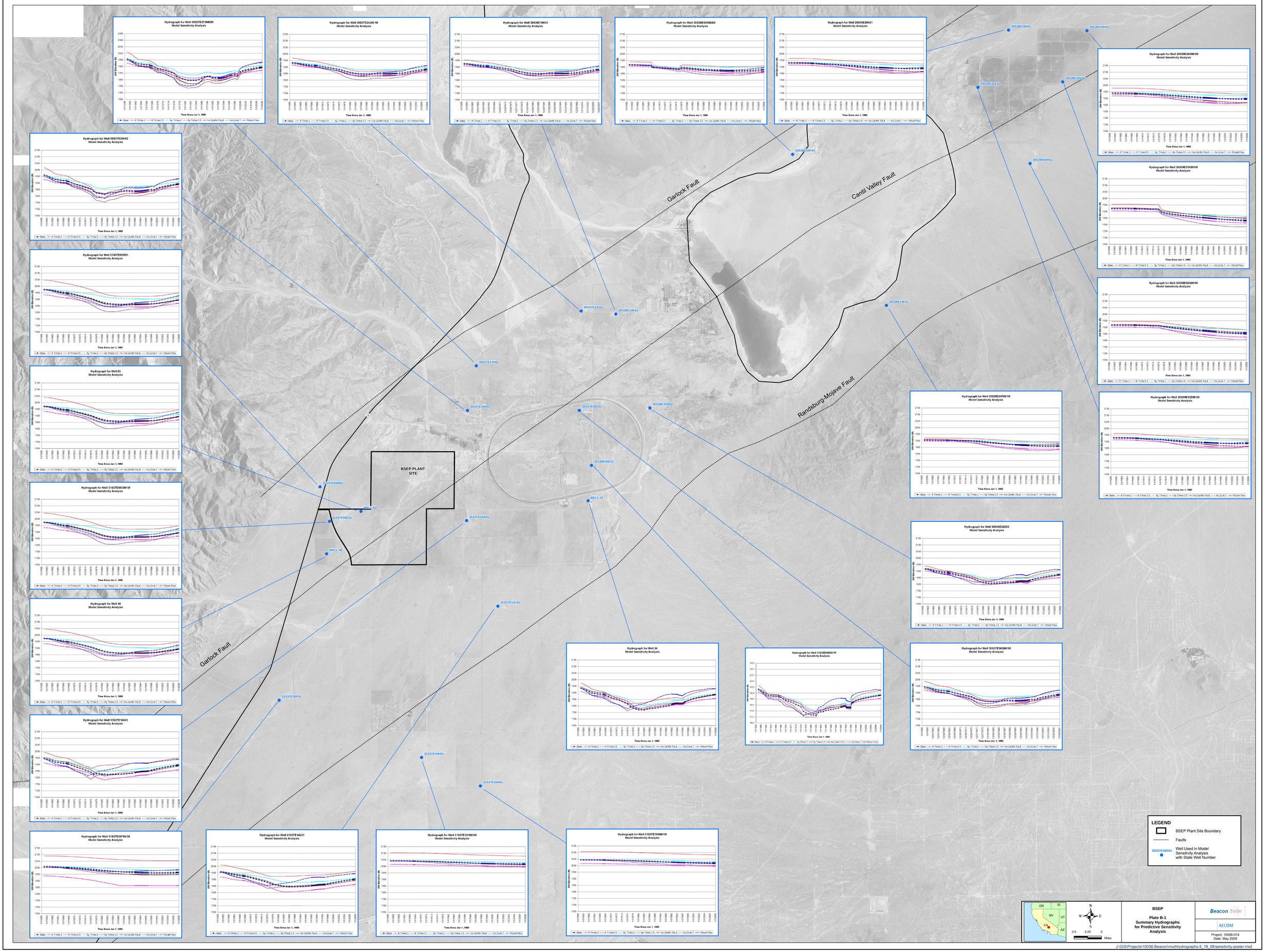

Hydrograph for Well 30S37E24J001M
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow


Hydrograph for Well 29S39E29N01
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow


Hydrograph for Well 29S39E33K001M
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow


Hydrograph for Well 29S39E32E001M
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow


Hydrograph for Well 29S39E28H001M
Model Sensitivity Analysis
GW Elevation (ft)
2150
2100
2050
2000
1950
1900
1850
1800
1750
1700
1650
1/1/1958
1/1/1960
1/1/1962
1/1/1964
1/1/1966
1/1/1968
1/1/1970
1/1/1972
1/1/1974
1/1/1976
1/1/1978
1/1/1980
1/1/1982
1/1/1984
1/1/1986
1/1/1988
1/1/1990
1/1/1992
1/1/1994
1/1/1996
1/1/1998
1/1/2000
1/1/2002
1/1/2004
1/1/2006
1/1/2008
Time Since Jan 1, 1958
Base
K Times 2
K Times 0.5
Sy Times 2
Sy Times 0.5
No Canthil Fault
No Zone 7
Return Flow


Hydrograph for Well 30S37E27H002M
Model Sensitivity Analysis
Hydrograph for Well 30S37E24J001M
Model Sensitivity Analysis
Hydrograph for Well 30S38E19K01
Model Sensitivity Analysis
Hydrograph for Well 30S38E03K002M
Model Sensitivity Analysis
Hydrograph for Well 29S39E29R01
Model Sensitivity Analysis
Hydrograph for Well 29S39E20H001M
Model Sensitivity Analysis
Hydrograph for Well 30S37E34H02
Model Sensitivity Analysis
Hydrograph for Well 29S39E33K001M
Model Sensitivity Analysis
Hydrograph for Well 31S37E05M01
Model Sensitivity Analysis
Hydrograph for Well 30S39E08A001M
Model Sensitivity Analysis
Hydrograph for Well 63
Model Sensitivity Analysis
Hydrograph for Well 30S38E24F001M
Model Sensitivity Analysis
Hydrograph for Well 29S39E32E001M
Model Sensitivity Analysis
Hydrograph for Well 31S37E08C001M
Model Sensitivity Analysis
Hydrograph for Well 30S38E32D03
Model Sensitivity Analysis
Hydrograph for Well 48
Model Sensitivity Analysis
Hydrograph for Well 24
Model Sensitivity Analysis
Hydrograph for Well 31S38E06E001M
Model Sensitivity Analysis
Hydrograph for Well 30S37E36G001M
Model Sensitivity Analysis
Hydrograph for Well 31S37E10A01
Model Sensitivity Analysis
Hydrograph for Well 31S37E30F001M
Model Sensitivity Analysis
Hydrograph for Well 31S37E14L01
Model Sensitivity Analysis
Hydrograph for Well 31S37E33H001M
Model Sensitivity Analysis
Hydrograph for Well 31S37E35N001M
Model Sensitivity Analysis
Garlock Fault
Cantil Valley Fault
Randsburg-Mojave Fault
BSEP PLANT SITE
30S37E27H03
30S37E14H02
30S37E36G01
30S38E32D03
31S38E06E03
31S37E05M01
WELL 63
31S37E08C01
31S37E10A01
WELL 48
WELL 24
31S37E14L01
31S37E30F01
31S37E33H01
31S37E35N01
LEGEND
BSEP Plant Site Boundary
Faults
30S37E36G01 Well Used in Model Sensitivity Analysis with State Well Number
OR
ID
NV
UT
CA
AZ
N
W
E
S
0.5
0.25
0
Miles
BSEP
Plate B-1
Summary Hydrographs for Predictive Sensitivity Analysis
Beacon Solar
AECOM
Project: 10056-014
Date: May 2009
J:\GIS\Projects\10056-Beacon\mxd\hydrographs-5_18_09\sensitivity-poster.mxd

Appendix C

Numerical Groundwater Model Electronic Files – See Attached CD

BEFORE THE ENERGY RESOURCES CONSERVATION AND DEVELOPMENT COMMISSION OF THE STATE OF CALIFORNIA

APPLICATION FOR CERTIFICATION FOR THE BEACON SOLAR ENERGY PROJECT	DOCKET NO. 08-AFC-2 **PROOF OF SERVICE** (Revised 4/28/09)

APPLICANT	**COUNSEL FOR APPLICANT**	**ENERGY COMMISSION**
Scott Busa Kenneth Stein, J.D. Meg Russell Duane McCloud Guillermo Narvaez, P.E. NextEra Energy Resources 700 Universe Blvd. Juno Beach, FL 33408 Scott.busa@nexteraenergy.com Kenneth.stein@nexteraenergy.com Meg.Russell@nexteraenergy.com Duane.mccloud@nexteraenergy.com Guillermo.narvaez@nexteraenergy.com Diane Fellman, Director West Region NextEra Energy Resources 234 Van Ness Avenue San Francisco, CA 94102 Diane.fellman@nexteraenergy.com	Jane Luckhardt, Esq. Downey Brand, LLP 621 Capitol Mall, 18th Floor Sacramento, CA 95814 jluckhardt@downeybrand.com	Karen Douglas Commissioner and Presiding Member kldougla@energy.state.ca.us Jeffrey D. Byron Commissioner & Associate Member jbyron@energy.state.ca.us Kenneth Celli Hearing Officer kcelli@energy.state.ca.us
APPLICANT CONSULTANT Sara Head, Vice President AECOM Environment 1220 Avenida Acaso Camarillo, CA 93012 Sara.head@aecom.com	**INTERESTED AGENCIES** California ISO 151 Blue Ravine Road Folsom, CA 95630 e-recipient@caiso.com	Eric K. Solorio Project Manager esolorio@energy.state.ca.us Jared Babula Staff Counsel jbabula@energy.state.ca.us
Bill Pietrucha, Project Manager Jared Foster, P.E. Worley Parsons 2330 E. Bidwell, Suite 150 Folsom, CA 95630 Bill.Pietrucha@worleyparsons.com Jared.Foster@worleyparsons.com	**INTERVENORS** Tanya A. Gulesserian Marc D. Jacobs Adams Broadwell Joseph & Cardozo 601 Gateway Boulevard, Suite 1000 South San Francisco, CA 94080 **E-MAIL PREFERRED** tgulesserian@adamsbroadwell.com	Public Adviser's Office publicadviser@energy.state.ca.us

Declaration of Service

I, Shawn Prentiss, declare that on June 2, 2009, I served and filed copies of the attached **Update of the Fremont Valley Groundwater Model.** The original document, filed with the Docket Unit, is accompanied by a copy of the most recent Proof of Service list, located on the web page for this project at: www.energy.ca.gov/sitingcases/beacon. The document has been sent to both the other parties in this proceeding (as shown on the Proof of Service List) and to the Commission's Docket Unit, in the following manner:

(check all that apply)

For Service to All Other Parties

____ sent electronically to all email addresses on the Proof of Service list;

__X__ by personal delivery or by depositing in the United States mail at Sacramento, California with first-class postage thereon fully prepaid and addressed as provided on the Proof of Service List above.

For Filing with the Energy Commission

__X__ sending an original paper copy mailed, to the address below;

OR

____ depositing in the mail an original and 12 paper copies as follow:

California Energy Commission
Attn: Docket No. 08-AFC-2
1516 Ninth Street, MS-4
Sacramento, CA 95814-5512

docket@energy.state.ca.us

I declare under penalty of perjury that the foregoing is true and correct.

Shawn Prentiss

1001627.3