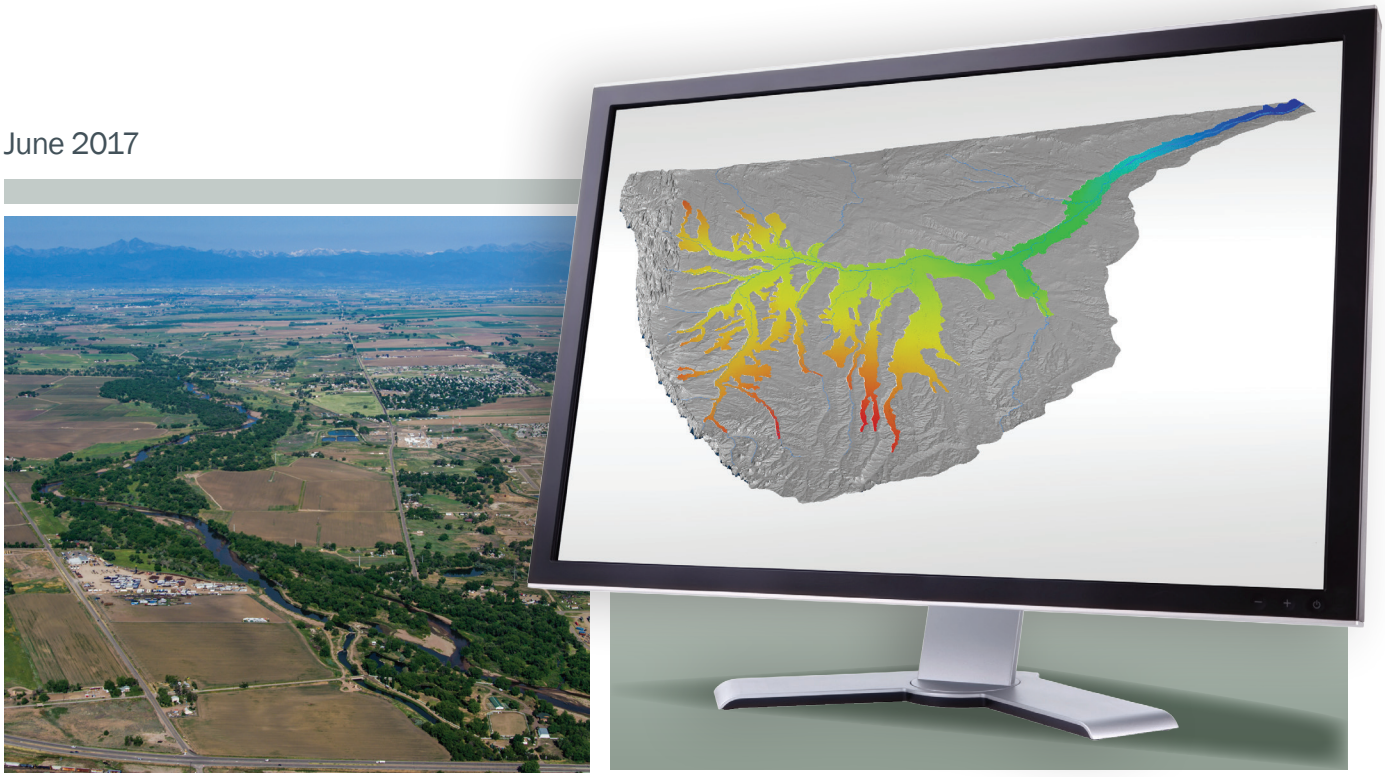
Brown AND Caldwell

FINAL REPORT | Prepared for
The Colorado Water Conservation Board and Division of Water Resources

South Platte Decision Support System Alluvial Groundwater Model Update Documentation

June 2017







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1527 Cole Blvd, Suite 300

Lakewood, CO 80401

Executive Summary

This report documents the update of a numerical groundwater flow model (model) developed for a major portion of the alluvial groundwater system of the South Platte River Basin (Basin). The model area includes the unconsolidated alluvial deposits of the mainstem South Platte River from Chatfield Reservoir downstream to the Colorado-Nebraska border and the connected, unconsolidated alluvial deposits of significant tributaries to the South Platte River. The model is constructed in MODFLOW, the widely used and accepted U.S. Geological Survey (USGS) groundwater simulation code. The updated model is a part of the continued, ongoing development of the South Platte Decision Support System (SPDSS), which in turn is a component of Colorado's Decision Support Systems (CDSS). CDSS is a joint effort of the Colorado Water Conservation Board (CWCB) and the Colorado Division of Water Resources (DWR) to develop publicly available data sets and analytical tools to assist in water resources management and planning activities within Colorado.

The model was developed to be a planning-level tool for the management of the alluvial aquifer associated with the South Platte River and its tributaries and is designed to simulate groundwater flow and groundwater/surface water interactions at a regional scale in the Basin (Figure ES-1).

The previous version of the model simulated the period from 1950 through 2006 and was completed and documented in 2013 by CDM-Smith for the CWCB and DWR.

The current modeling effort included:

- Extending the simulated period of the model from 1950 through 2012 based on additional hydrologic and water use data;
- Upgrading the model execution code from the MODFLOW-2000 version to the modern and currently supported MODFLOW-NWT version;
- Improving and streamlining the simulated water budget accounting process by incorporating the Partition Stress Boundaries (PSB) capability originally developed by the USGS for CDSS;
- Reducing the overall model input and output file sizes to improve the model's usability; and
- Providing improvements and updates to data processing procedures used in the generation of model input files.

This executive summary briefly describes the following: 1) extension of historical time-series data; 2) CDSS Toolbox/StateDGI updates and development of model input files; and 3) model simulation and calibration results.

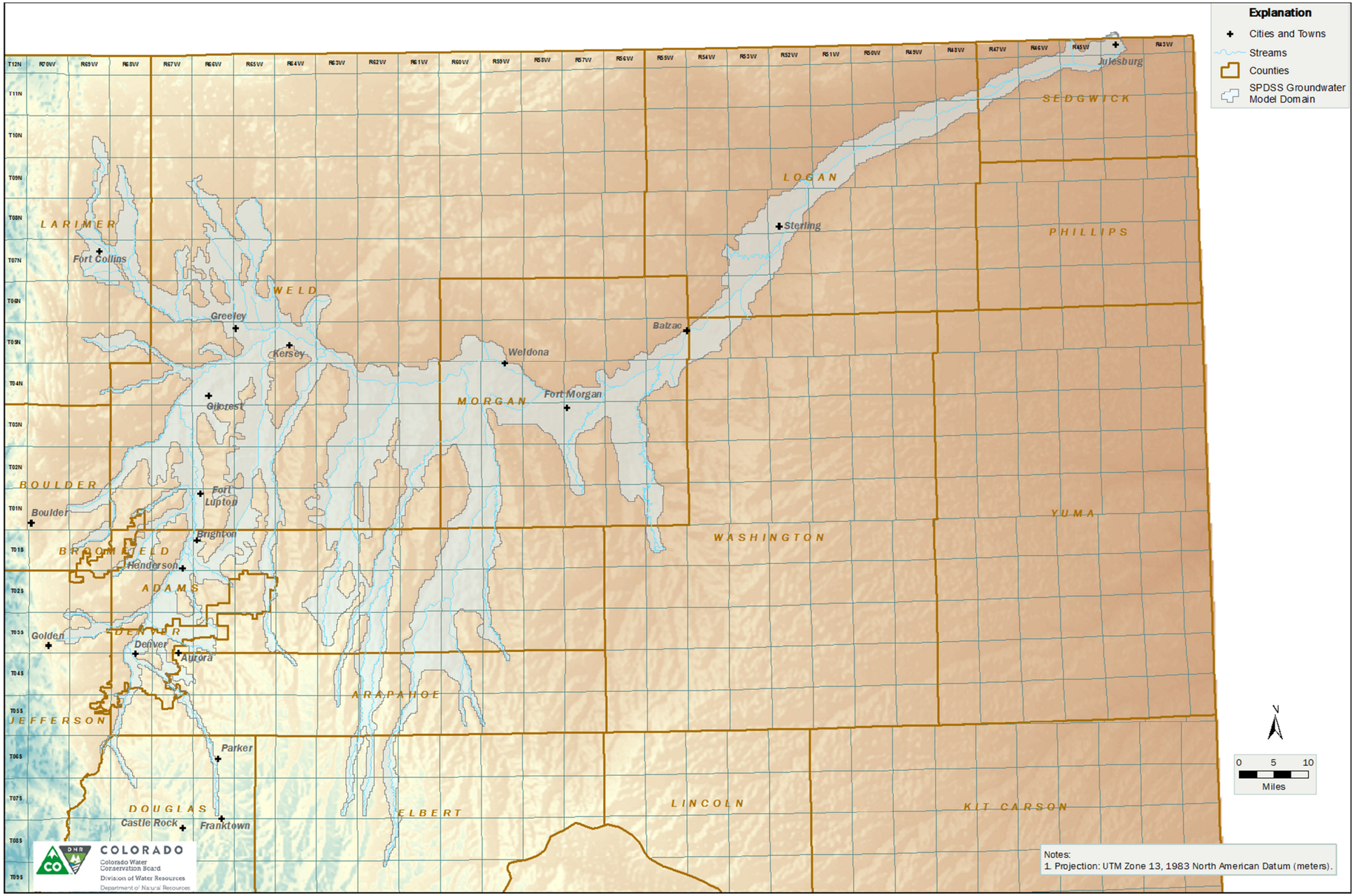

Figure ES-1. Model Study Area

Extension of Historical Time-Series Data

CDSS employs a "data-centered approach" to the development and use of analytical and numerical simulation models. In the data-centered approach, DWR's water resources database, HydroBase, provides the primary source of data underpinning the models. Table ES-1 lists the time-series data sets that were extended and describes the processes for extending the data sets. The extended data sets were used to develop model input files and reflect the most recent available data.

Table ES-1. Time-Series Data Set Extension Approach

Time-Series Data Set	Extension Approach
Alluvial underflow into model	The rates of monthly alluvial groundwater inflow entering the model domain at modeled tributary branches were calculated during the initial modeling effort and are constant year-to-year. The same values were used for the extended modeling period.
Bedrock fluxes	Bedrock fluxes were calculated using the USGS Denver Basin model. The USGS model simulation period of record ended in 2003. The 2003 fluxes were repeated for subsequent years of the model, including the extended modeling period.
Reservoir seepage	Reservoir seepage rates were assumed to be constant for a given soil type underlying the reservoirs. The seepage rates already in the initial model were used for the extended modeling period.
Streamflow routing components: streamflow, M&I discharges, and diversions	Historical streamflows and diversion records for the extended modeling period were collected from HydroBase by Wilson Water Group (SPDSS consumptive use analysis contractor) and were provided. Incomplete records were filled using regression or other suitable methods as described in the SPDSS Task 2 technical memorandum (Leonard Rice Engineers 2007). Tributary inflows at the edge of the model domain were estimated using the nearest downstream gage and then adding diversions occurring between the gage and the model boundary. See Appendix A of the main report for details on the data collection efforts. M&I discharge data were collected from the EPA database.
Precipitation	Historical monthly precipitation data from the key climate stations identified in the initial modeling effort were retrieved from HydroBase by Wilson Water Group and were provided. Missing data were filled using linear regression. The climate station weights used to distribute precipitation across the model domain and the percentages used to determine the amount of precipitation that becomes recharge (based on land use and soil types) were not changed from the initial modeling effort.
Consumptive-use model output: agricultural pumping, canal seepage, and irrigation recharge	Agricultural pumping, canal seepage, and irrigation recharge time-series data were estimated using StateCU model output. The consumptive-use modeling was completed by Wilson Water Group and results were provided. The model output contained monthly values for each parameter. See Appendix A of the main report for details on the data-collection efforts.
M&I pumping	The historical M&I pumping data were extended using a combination of data retrieved from HydroBase and data provided by the well users. HydroBase data were preferred to user-supplied data. Missing or incomplete records were filled using similar methods from the initial modeling effort. The availability of HydroBase data was limited during the initial modeling effort. Estimated values prior to 2006 were replaced with newly available HydroBase records when possible. See Appendix A of the main report for details on the data-collection efforts and filling procedures.

Table ES-1. Time-Series Data Set Extension Approach	
Time-Series Data Set	**Extension Approach**
Augmentation and recharge	Recharge areas: Augmentation recharge was estimated using recharge pond delivery records. Delivery records were retrieved from HydroBase and provided by Wilson Water Group. New recharge facilities that came on line during the extended modeling period were added to the model as part of the model update. Recharge and augmentation pumping: Historical recharge pumping records were compiled by Wilson Water Group and provided. Appropriate wells were identified with the help of the Division 1 Engineer's office. Pumping records were retrieved from HydroBase. Historical augmentation pumping records were also collected from HydroBase by Wilson Water Group and provided. The Division 1 Engineer's office assisted in identifying the appropriate wells. See Appendix A of the main report for details on the data-collection efforts.
Lateral boundary inflow fluxes	Lateral boundary inflow fluxes represent a combination of precipitation recharge, irrigation recharge, canal seepage, and pumping that occur outside the active model domain and that generate groundwater flux across the active model domain boundary. Existing tools were updated and used to combine the component fluxes and generate lagged boundary inflow values.

CDSS Toolbox/StateDGI Updates and Development of Model Input Files

During the model update effort, several CDSS tools and data management interfaces (DMIs) were updated and improved in a number of ways, including: modernizing code, removing redundant code, improving code performance and consistency, ensuring compatibility where possible with open source software by replacing code specific to proprietary compilers, and adding functionality. The updates and improvements to these tools are described in Table ES-2.

Table ES-2. CDSS Tools and DMIs Updated	
CDSS Tool/DMI	**Description of Updates**
CDSS Toolbox	The Python scripts were converted to use the modern ArcPy GIS environment, redundant code was removed, the logic of geoprocessing operations was checked to ensure that the scripts process data correctly. An updated CDSS Toolbox user manual is included as Appendix B of the main report.
State Data-Centered Ground Water Interface (StateDGI)	An issue was identified and resolved for the series of linked queries that locate groundwater model cells under irrigation canals and label each of those model cells with an identifier for the irrigation canal such that canal seepage recharge estimates from StateCU can be applied to those model cells. A second issue was identified and resolved for the series of linked queries that apportion partial irrigated acreage and pumping capacity between irrigation wells that serve multiple irrigated parcels.
State Pre-Processor (StatePP)	Support was added to produce MODFLOW input files that can be used with PSB to separate and individually track different water budget components. Updates were made to generate MODFLOW electronic input files that are of smaller and more manageable sizes. Additional code comments were added to better document the flow of the code in some places, and minor changes were made to the flow of the code to improve efficiency and speed of execution.
SFR2 Generator	Code was converted from older Visual Basic .NET source code to an ArcPy-based Python script that can be executed in ArcGIS. An ArcToolbox (.tbx) file was created that provides a graphical user interface to execute the script with the appropriate input parameters chosen by the user.
Lateral Boundary Processor	Several coding inefficiencies were found and improved, reducing the time to execute from over 10 hours to approximately 1 hour.

Table ES-2. CDSS Tools and DMIs Updated	
CDSS Tool/DMI	Description of Updates
g2gflow	Instructions specific to the proprietary Intel Fortran compiler were replaced with equivalent standard Fortran to make the code open-source compatible and compliant with all compilers that adhere to Fortran standards.
proc_rainfall	Instructions specific to the proprietary Intel Fortran compiler were replaced with equivalent standard Fortran to make the code open-source compatible and compliant with all compilers that adhere to Fortran standards.
proc_runoff	Code was updated to write estimated runoff values to a specific "RUNOFF" variable for each stream segment rather than adding them to the "FLOW" variable to simplify and improve reporting and analysis of the simulated water budget for streams represented by the model. Instructions specific to the proprietary Intel Fortran compiler were replaced with equivalent standard Fortran to make the code open-source compatible and compliant with all compilers that adhere to Fortran standards.

These tools along with other existing CDSS DMIs were used to generate the MODFLOW electronic input files for the updated model.

The updated model now uses the USGS code MODFLOW-NWT, a version of MODFLOW that uses more powerful numerical methods to solve the equations governing unconfined groundwater flow both more rigorously and quickly (Niswonger et al. 2011). An additional modification was made to the MODFLOW-NWT executable used for the updated model through the incorporation of PSB to simplify and improve the input, tracking, and reporting of each water budget component throughout the simulation.

Model Simulation and Calibration Results

The simulated water budget for the updated model was tabulated and evaluated for the 1950 to 2012 extended simulation period for both groundwater and surface water components. Tables ES-3 and ES-4 present the simulated average annual groundwater and surface water budgets. The following are some key observations on the simulated water budget:

- While groundwater volumes moving in and out of storage throughout the model domain are more than 400,000 acre-feet per year (ac-ft/yr) on average, the average annual net change in groundwater storage is approximately 53,000 ac-ft/yr of groundwater flow into groundwater sinks (e.g., wells, evapotranspiration) from storage.
- The largest average annual simulated inflow to the alluvial aquifer system is from the lateral boundary inflows (approximately 500,000 ac-ft/yr), followed by recharge from both irrigation return flows (more than 400,000 ac-ft/yr for irrigation from surface water sources and 140,000 ac-ft/yr for irrigation from groundwater) and canal seepage (approximately 360,000 ac-ft/yr).
- The largest average annual simulated groundwater outflow is to the surface water system as stream gain (more than 1.3 million ac-ft/yr), followed by agricultural irrigation pumping (approximately 450,000 ac-ft/yr).
- Stream gain (cited in the previous bullet) is the largest average annual surface water inflow, followed by the gaged stream inflows at the upper reaches of streams at the edge of the active groundwater model domain (slightly more than 800,000 ac-ft/yr).
- The largest simulated average surface water outflows are to stream diversions (averaging over 1.6 million ac-ft/yr), followed by streamflow out of the model domain in the South Platte River below Julesburg (approximately 400,000 ac-ft/yr).

Two types of model input demands for water are subject to the simulated availability of water in the model. Streamflow diversions are limited to the amount of simulated streamflow and groundwater

pumping from wells is limited where the simulated water level drops such that the simulated saturated thickness is relatively small fraction of the total alluvial aquifer thickness. In both cases, where the input demand for diversion or pumping is greater than the water simulated to be available, the model will simulate removal of only the available water. Overall, 98 percent of the streamflow diversion demand volume is met by the model for the 1950 through 2012 simulation period, and 97.6 percent of the groundwater irrigation demand volume is satisfied by the model. In comparison, the original model calibration effort required manually reducing agricultural irrigation pumping to 80 percent of the StateCU demand estimates.

Model calibration is the process of adjusting model input parameters to acceptably match model-simulated values of flows and groundwater levels to their field-measured equivalents. As with the previous effort, the updated model was calibrated to observed groundwater levels measured in wells, measured streamflows at stream gaging locations, and estimates of stream gain/loss. Limited additional calibration was performed during the updated model effort because the main objective was to update and extend the simulation period of the model. The primary calibration efforts focused on adjusting and updating the hydraulic conductivity values assigned to certain portions of the alluvial aquifer system based on additional information and hydrogeologic judgement. Model calibration was improved overall, improving the reliability of the model for performing future predictive simulations and other scenarios. Additional activities undertaken as part of the model update that improved calibration included:

- Minor flow routing corrections and adjustments to streambed elevations were made in some SFR2 streams.
- Estimates of M&I pumping inputs prior to recorded pumping volumes were updated based on water rights and other information.
- Processes for acquiring and inputting data from HydroBase and other data sources were enhanced using a data-centered approach and the information in those data sources were updated. (Of note was the effort by DWR staff to update the irrigation snapshot GIS data to improve the estimated groundwater irrigation pumping rates and spatial distribution of applied irrigation water through improved matching between irrigation wells and irrigated parcels.)

Table ES-3. Average Annual Simulated Groundwater Budget (ac-ft)			
Groundwater Flow Component		Average Annual	% of Total Inflow or Outflow
Inflow	Groundwater flow in from storage	463,794	19
	Stream loss to aquifer	309,886	13
	Precipitation recharge	103,639	4
	Surface water irrigation return flow recharge	405,918	17
	Groundwater irrigation return flow recharge	143,362	6
	Canal seepage recharge	361,223	15
	Recharge ponds	50,027	2
	Reservoir seepage recharge	31,314	1
	Alluvial underflow in	12,259	1
	Net bedrock flux	15,365	1
	Net lateral boundary flow	503,371	21
Outflow	Groundwater flow out to storage	410,145	17
	Alluvial underflow out below Julesburg	2,665	0
	Stream gain from aquifer	1,353,376	56
	Agricultural irrigation pumping	454,319	19
	M&I pumping	41,056	2
	Augmentation pumping	4,369	0
	Alfalfa ET	16,216	1
	Subirrigated meadow ET	11,698	0
	Phreatophyte ET	105,409	4
Total	Total in	2,400,157	100
	Total out	2,399,253	100
	In minus out	904	N/A
	% mass balance error	0.04	N/A

Table ES-4. Average Annual Simulated Surface Water Budget (ac-ft)			
Surface Water Flow Component		Average Annual	% of Total Inflow or Outflow
Inflow	Gaged surface water inflows	803,578	30
	Return flow and discharge inflows	223,149	8
	Ungaged surface water inflows	304,532	11
	Stream gain from aquifer	1,353,376	50
Outflow	Physical diversions	1,660,655	62
	Net flow change at selected tributary mouth gages	276,502	10
	Ungaged diversions	37,546	1
	Stream loss to aquifer	309,886	12
	Streamflow out below Julesburg	401,128	15
Totals	Total in	2,686,634	100
	Total out	2,685,717	100
	In minus out	-1,083	N/A
	% mass balance error	-0.04	N/A

To compare the updated model calibration to the initial modeling effort calibration, standard statistics of groundwater-level residuals (observed values minus simulated values) have been calculated for the 1950 to 2006 period. These statistics have been calculated over the entire model domain for all updated observation well locations and for the subset of wells only with surveyed elevation data (see Table ES-5).

Table ES-5. Bulk Groundwater-Level Calibration Statistics Comparison to Initial Model, 1950–2006				
Statistic	Surveyed Wells		Surveyed + Non-Surveyed Wells	
	Updated Model	Initial Model	Updated Model	Initial Model
Residual mean (ft)	0.30	-0.28	0.11	-1.89
Absolute residual mean (ft)	5.87	5.55	8.82	9.58
Residual standard deviation (ft)	8.28	8.33	13.01	14.88
Sum of squared errors (ft)	3.93E+05	3.98E+05	2.46E+06	3.27E+06
Root mean squared (RMS) error (ft)	8.28	8.34	13.01	15.00
Minimum residual (ft)	-25.14	-33.49	-55.28	-71.48
Maximum residual (ft)	39.77	38.57	55.12	74.38

Table ES-5. Bulk Groundwater-Level Calibration Statistics Comparison to Initial Model, 1950–2006				
Statistic	Surveyed Wells		Surveyed + Non-Surveyed Wells	
	Updated Model	Initial Model	Updated Model	Initial Model
Number of observations*	5,729	5,729	14,520	14,520
Range in observations (ft)	1906.19	1906.19	2268.23	2268.23
Scaled residual standard deviation (%)	0.43	0.44	0.57	0.66
Scaled absolute residual mean (%)	0.31	0.29	0.39	0.42
Scaled RMS error (%)	0.43	0.44	0.57	0.66
Scaled residual mean (%)	0.02	-0.01	0.00	-0.08

*Note: observations restricted to only those available for 1950-2006.

The average difference in measured versus simulated groundwater-level elevations is less than 1 foot for the updated model, indicating that simulated groundwater levels are overall similar to observed levels and not generally higher or lower then observed levels. Figure ES-2 below presents scatterplots of observed versus simulated groundwater-level elevations. The points on the scatterplot are clustered around the central line (the line of perfect matches between simulated and observed groundwater levels), indicating a close match between simulated and observed values and a lack of overall bias toward simulating high or low values (which is characteristic of a well-calibrated groundwater model).

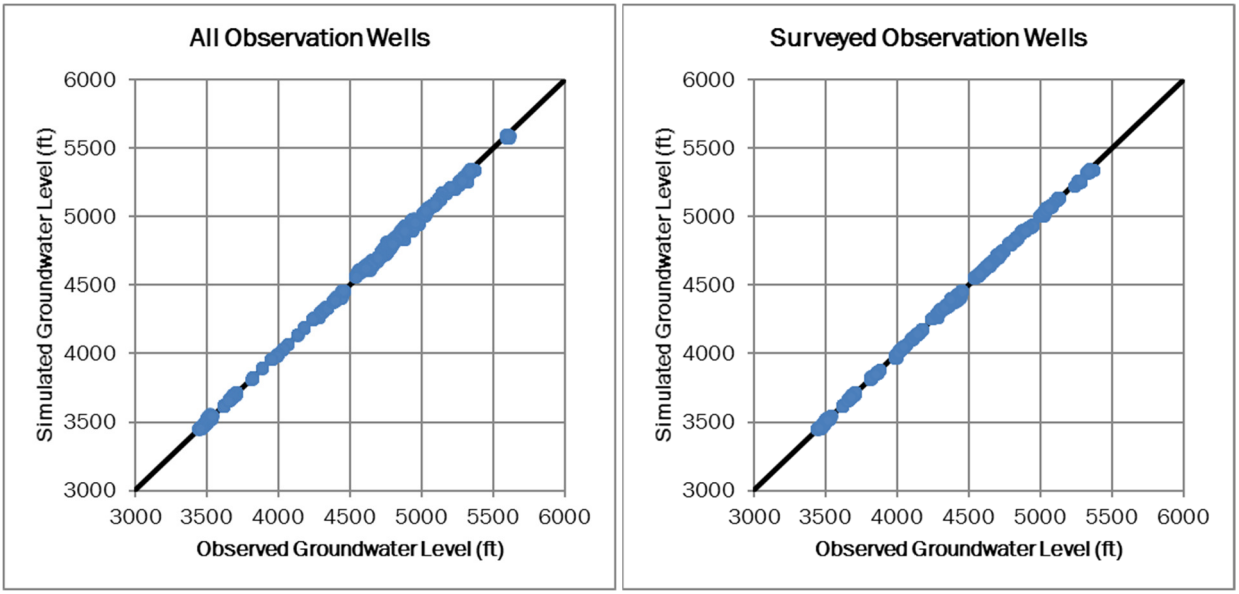

Figure ES-2. Observed vs. Simulated Groundwater-Elevation Scatterplots

The model is also qualitatively calibrated to measured streamflows and estimated stream gain/losses. Figure ES-3 presents comparisons between measured and simulated average annual streamflow volumes and demonstrates reasonable matches, especially along the mainstem of the South Platte River. Stream gains and losses to and from groundwater are not directly measureable and are therefore estimated using mass balance-based approaches. Because of inherent uncertainties in estimating stream gain/loss values, the corresponding simulated values of stream gain/loss are qualitatively compared in terms of overall magnitude and general seasonal patterns. The simulated stream gain/loss values along the South Platte River match reasonably well to the

estimated values, and an example comparison graph for the South Platte River between Fort Lupton and Kersey is shown in Figure ES-4.

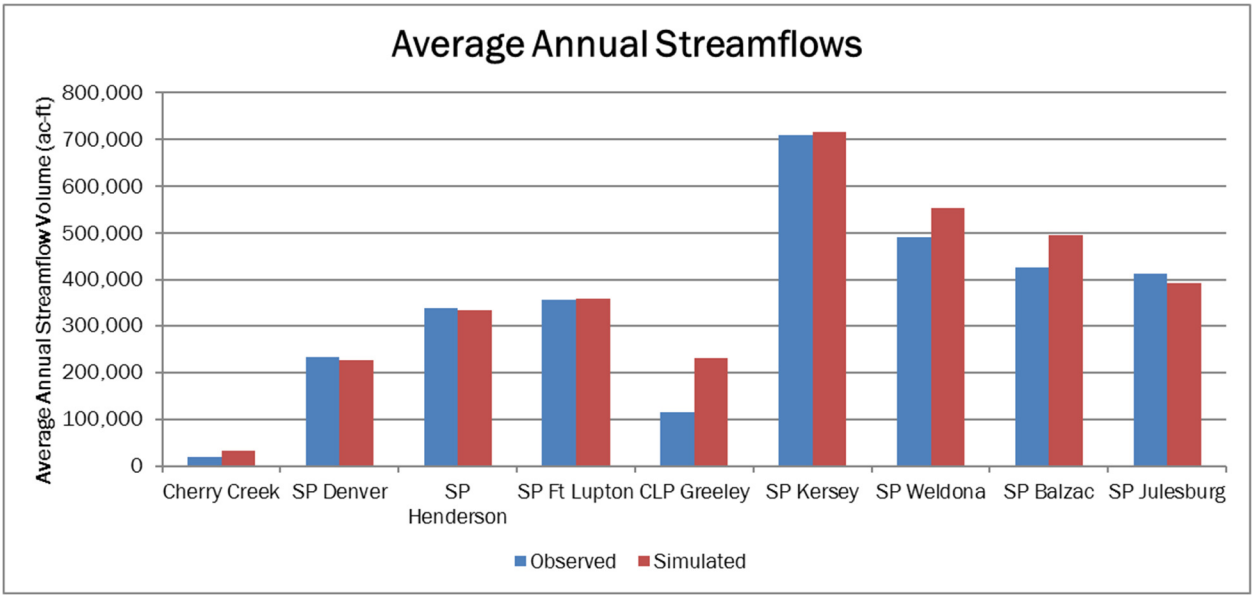

Figure ES-3. Comparison of Simulated and Measured Average Annual Streamflows

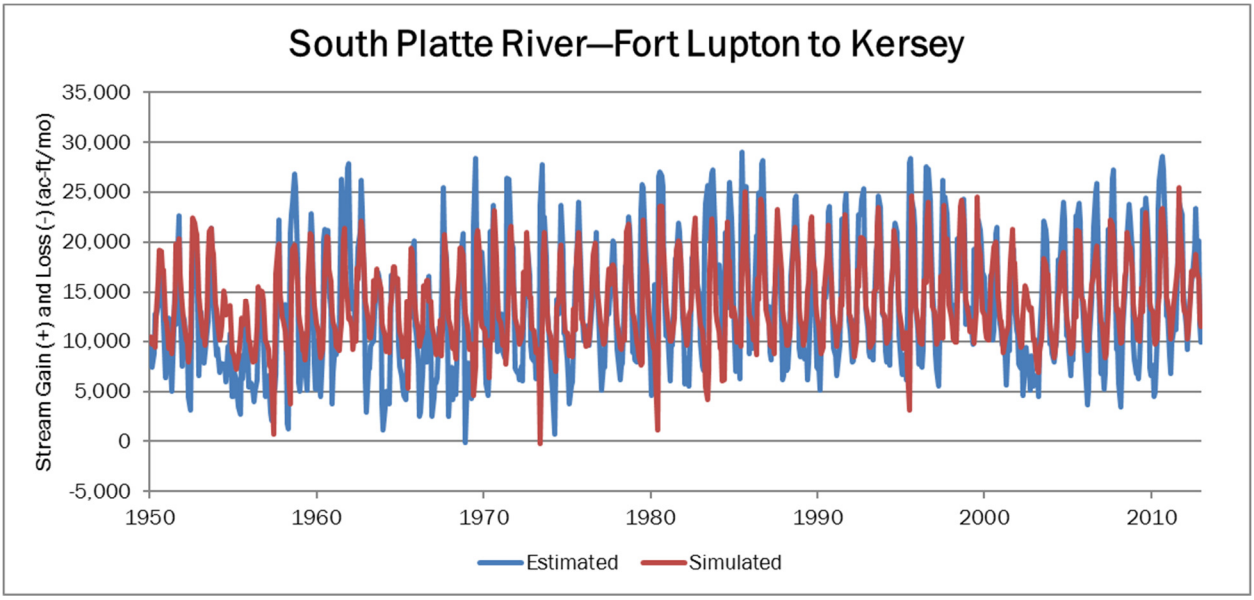

Figure ES-4. Simulated and Estimated Stream Gain/Loss, South Platte River Fort Lupton to Kersey

Summary

The completed update of the model and the model input development processes represents a significant upgrade to the SPDSS that will help to provide a better understanding of basin-scale groundwater flow and groundwater/surface water interactions in the Basin. The model is well calibrated and provides a platform for performing predictive future-casting simulations and other scenarios to help guide potential water management strategies and activities, and it can be utilized as a basis for refined local-scale models.

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List of Abbreviations

2D	two-dimensional
3D	three-dimensional
ac-ft	acre-feet
ac-ft/mo	acre-feet per month
ac-ft/yr	acre-feet per year
BAS	MODFLOW Basic package
Basin	South Platte River Basin
BC	Brown and Caldwell
CCWCD	Central Colorado Water Conservancy District
CDSS	Colorado's Decision Support Systems
CDM	CDM Smith
CDM 2013 Report	*South Platte Decision Support System Alluvial Groundwater Model Report*
CSV	comma-delimited text
CWCB	Colorado Water Conservation Board
DMI	data management interface
DNR	Colorado Department of Natural Resources
DWR	Division of Water Resources
EPA	U.S. Environmental Protection Agency
ET	MODFLOW Evapotranspiration package
ETS	MODFLOW Evapotranspiration Segments package
ft	feet
GAGE	MODFLOW Gage package
GB	gigabyte(s)
GIS	geographic information system
GMG	MODFLOW Geometric Multigrid Solver package
gpm	gallon(s) per minute
GUI	graphical user interface
HB	House Bill
ID	identifier
LPF	MODFLOW Layer Property Flow package
M&I	municipal and industrial
MB	megabyte(s)
model	South Platte Decision Support System Alluvial Groundwater Model
N/A	not applicable
NAD27	North American Datum of 1927
NAD83	North American Datum of 1983
NOAA	National Oceanic and Atmospheric Administration
NRCS	National Resources Conservation Service
NWT	MODFLOW Newton Solver package
PLSS	Public Land Survey System
PSB	MODFLOW Partition Stress Boundaries capability
QA/QC	quality assurance/quality control
RCH	MODFLOW Recharge package
RDGSS	Rio Grande Decision Support System
RMS	root mean square
SFR2	MODFLOW Streamflow Routing 2 package
SPDSS	South Platte Decision Support System
SQL	Structured Query Language
Ss	specific storage
State	State of Colorado
StateCU	State of Colorado's Consumptive Use Model
StateDGI	State Data-Centered Ground Water Interface
StatePP	State Pre-Processor
TIN	triangular irregular network
USGS	U.S. Geological Survey
UPW	MODFLOW Upstream Weighting Flow package
UTM	Universal Transverse Mercator
VBA	Visual Basic for Applications
VB.NET	Visual Basic .NET
WDID	Water District Identification
WEL	MODFLOW Well package
WWTP	wastewater treatment plant

Disclaimer

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Section 1

Introduction

The South Platte Decision Support System Alluvial Groundwater Model (model) is a planning-level groundwater model that simulates the effects of regional hydrologic drivers such as pumping and recharge on the South Platte alluvial aquifer and streamflows. The model is a part of the South Platte Decision Support System (SPDSS), which in turn is a component of Colorado's Decision Support Systems (CDSS). CDSS is a joint effort of the Colorado Water Conservation Board (CWCB) and the Colorado Division of Water Resources (DWR) to develop publicly available data sets and analytical tools to assist in water resources management and planning activities within Colorado.

The CWCB, in coordination with the DWR, retained Brown and Caldwell (BC) to update the model to include more recent data. In addition, CDM Smith (CDM) and Wilson Water Group provided assistance in describing the inputs and workflow of the existing model.

The completed update of the model and the model input construction processes represents a significant upgrade to the SPDSS that will help to provide a better understanding of basin-scale groundwater flow and groundwater-surface water interactions in the Basin. The model was updated from the initial version of the model in a number of key ways:

- Simulation period was extended from the end of 2006 through the end of 2012;
- Model inputs were updated through the Data-Centered Approach with improved underlying data from HydroBase and DWR Irrigation Snapshot GIS datasets;
- Several Data-Centered Approach Data Management Interfaces (DMIs) were modernized and improved, including the CDSS Toolbox, the State Data-Centered Ground Water Interface (StateDGI), the State Pre-Processor (StatePP), and the MODFLOW Streamflow Routing 2 Package (SFR2) Generator (SFR2 Generator);
- Model executable code was upgraded to the robust and fully-supported USGS MODFLOW-NWT (Niswonger et al. 2011);
- The Partition Stress Boundaries (PSB) capability was incorporated, which allows for improved and simplified analysis of model inputs and outputs related to the numerous water budget components of the model (Banta 2011);
- Model calibration was improved overall, improving the reliability of the model for performing future predictive simulations and other scenarios.

The model represents a platform for performing predictive future-casting simulations and other scenarios to help guide potential water management strategies and activities. The model can be used for analyzing and finding potential solutions to groundwater challenges in the Basin, such as high water table problems, and it can be utilized as a basis for refined local-scale models.

This report documents the extension of the simulated period of the model—as described in detail in the *South Platte Decision Support System Alluvial Groundwater Model Report* (CDM 2013 Report)—from the end of 2006 to the end of 2012, and describes updates to the processes for generating model input files, executing model simulations, and calibrating the model (CDM 2013).

1.1 Model Update Objectives

The primary objective of this modeling effort was to extend the simulated period of the model from 1950 through 2006 to 1950 through 2012 based on more recent hydrologic and water use data. Additional objectives included upgrading the model execution code from the U.S. Geological Survey's (USGS) MODFLOW-2000 version (MODFLOW-2000 is no longer supported by USGS) to the modern and currently supported MODFLOW-NWT version, incorporating improved simulated water budget accounting using the PSB developed in MODFLOW-CDSS, and providing improvements and updates to data processing procedures used in the generation of model input files.

The main objectives to be implemented under this model update effort were as follows:

- Extend historical time-series data
- Update CDSS Toolbox and StateDGI
- Develop MODFLOW input files
- Run extended model and update calibration

Each of these objectives is described in more detail in Sections 2 through 5. Modeling scenarios were part of the scope of this project and will be documented in a separate report.

1.2 Model Overview

The following section provides a high-level overview of the model. For detailed descriptions of the initial development of the model, please refer to the CDM 2013 Report (CDM 2013).

1.2.1 Model Area and Conceptual Model Description

The area of the model includes the unconsolidated alluvial deposits of the mainstem South Platte River from Chatfield Reservoir downstream to the Colorado-Nebraska border, and the connected, unconsolidated alluvial deposits of several significant tributaries to the South Platte River (see Figure 1-1, below). These alluvial deposits, which consist of predominantly sand and gravel with interbedded finer-grained silty and clayey floodplain deposits, present a contiguous alluvial aquifer system. The alluvial aquifer system is hydraulically connected to surface water streams, diversions, and reservoirs in the model area. The South Platte River Basin (Basin) alluvial aquifer is underlain by the consolidated sedimentary strata of the Denver Basin Group, and relatively minor groundwater flows are exchanged between the Denver Basin aquifer units and the alluvial aquifer.

The sediments of the alluvial aquifer are generally thin (less than 20 feet) in the upper reaches of tributaries and thicken to more than 300 feet farther downstream in the alluvial system along the mainstem South Platte River. Saturated alluvial aquifer thicknesses range from 0 feet to more than 200 feet near the Colorado-Nebraska border. Local hydraulic conductivity values of the most productive sand and gravel deposits may be up to 2,000 feet per day. Hydraulic conductivity values along the South Platte mainstem alluvium generally range from 200 to 600 feet per day, with lower hydraulic conductivity values along the margins of the alluvium and in the tributaries.

The Basin in northeastern Colorado provides the water used for a wide variety of economic activities including agriculture, municipal and industrial (M&I) uses, and recreation. Agricultural irrigation is the leading water use in the Basin and has resulted in the construction and maintenance of a large network of ditches and canals, associated storage reservoirs, and groundwater wells. Both surface water and groundwater resources are used for economic activities in the Basin, and significant groundwater-surface water interactions occur as a result of both natural and human-influenced processes.

Both natural and human-influenced processes contribute to the inflows and outflows of the South Platte alluvial aquifer system. For example, recharge to the alluvial aquifer is provided not only by deep percolation of precipitation, but also irrigation return flows, canal seepage, reservoir seepage, and augmentation recharge ponds. The groundwater inflows and outflows to the alluvial aquifer system are summarized below:

Alluvial Groundwater Inflow:

- Stream loss to groundwater
- Precipitation recharge
- Irrigation return flow recharge
- Augmentation pond recharge
- Canal seepage loss
- Reservoir seepage loss
- Alluvial aquifer underflow into the model domain
- Underflow from bedrock to alluvium

Alluvial Groundwater Outflow:

- Stream gain from groundwater
- Well pumping
- Subirrigated crop evapotranspiration
- Phreatophyte evapotranspiration
- Canal seepage gain from groundwater
- Reservoir seepage gain
- Alluvial aquifer underflow out from the model domain
- Underflow from alluvium to bedrock

The model accounts for each of these inflows and outflows as well as changes in groundwater storage. Additionally, the model accounts for surface stream inflows where the South Platte River and tributaries enter the active model domain and stream outflows where the South Platte River exits the model near the Colorado-Nebraska border. Estimating these groundwater inflows and outflows for the extended modeling period of 2007–12 represents one of the main tasks of the model update effort.

1.2.2 Data-Centered Approach

CDSS employs a "data-centered approach" to the use of analytical and numerical tools (including the model) in which data management interfaces (DMIs) enable connections between data sources such as DWR's HydroBase (DWR 2015) and geographic information system (GIS) data sets (DWR 2016). The data-centered approach allows updated data sets to be efficiently incorporated into tools such as the model.

For this update effort, the CDSS Toolbox, StateDGI, HydroBase, State of Colorado's Consumptive Use Model (StateCU) (DNR 2010), TSTool (DNR 2016) and StatePP all were used to extend the period simulated by the model. In some cases these tools were improved in their efficiency, functionality, and/or accuracy.

1.2.3 Numerical Model Description

The model was developed using MODFLOW, the industry standard groundwater flow-modeling code produced by USGS. The model is constructed using a MODFLOW grid of a single vertical layer, 655 rows and 848 columns aligned north–south and east–west with a uniform grid cell spacing of 1,000 feet that overlays the alluvial aquifer system as shown in Figure 1-1. The GIS horizontal location coordinate of the origin (southwest corner) of the model grid in Universal Transverse Mercator (UTM) coordinates in the North American Datum of 1983 (NAD83) in feet is X=1,579,065, Y=14,264,407, or in meters is X=481,300, Y=4,347,800. The model was previously based on a version of MODFLOW-2000 modified to better handle simulation of dewatered model cells (Harbaugh et al. 2000; Doherty 2001). USGS now considers MODFLOW-2000 to be superseded, and it no longer provides support for the code. The Doherty method of handling dewatered model cells, while being generally effective, was never formally adopted by USGS (Doherty 2001). As described in Section 4

below, the updated model is now based on MODFLOW-NWT (Niswonger et al. 2011). MODFLOW-NWT is a modern and supported version of MODFLOW that uses the Newton method and robust model solution techniques to handle dewatered model cells.

The initial construction and calibration of the model was documented in the CDM 2013 Report (CDM 2013). The CDM 2013 Report describes how model inputs were generated, including geometry of the base of the alluvium used as the bottom elevation of the model, distribution of hydraulic conductivity and storage parameter (i.e., specific yield) values, stream configuration and routing, and incorporation of previously mentioned groundwater and surface water inflows and outflows. Many of these groundwater and surface water flows are highly transient in nature and require the assembly of large amounts of time-series data.

1.3 Report Overview

For the updated model, the extension of time-series data from 2006 to 2012 is described in Section 2, below. Section 3 presents a description of updates to the CDSS Toolbox and StateDGI, and Section 4 includes a description of the development of the MODFLOW input files. A summary of the updated model calibration is presented in Section 5, and recommendations for further work are outlined in Section 6.

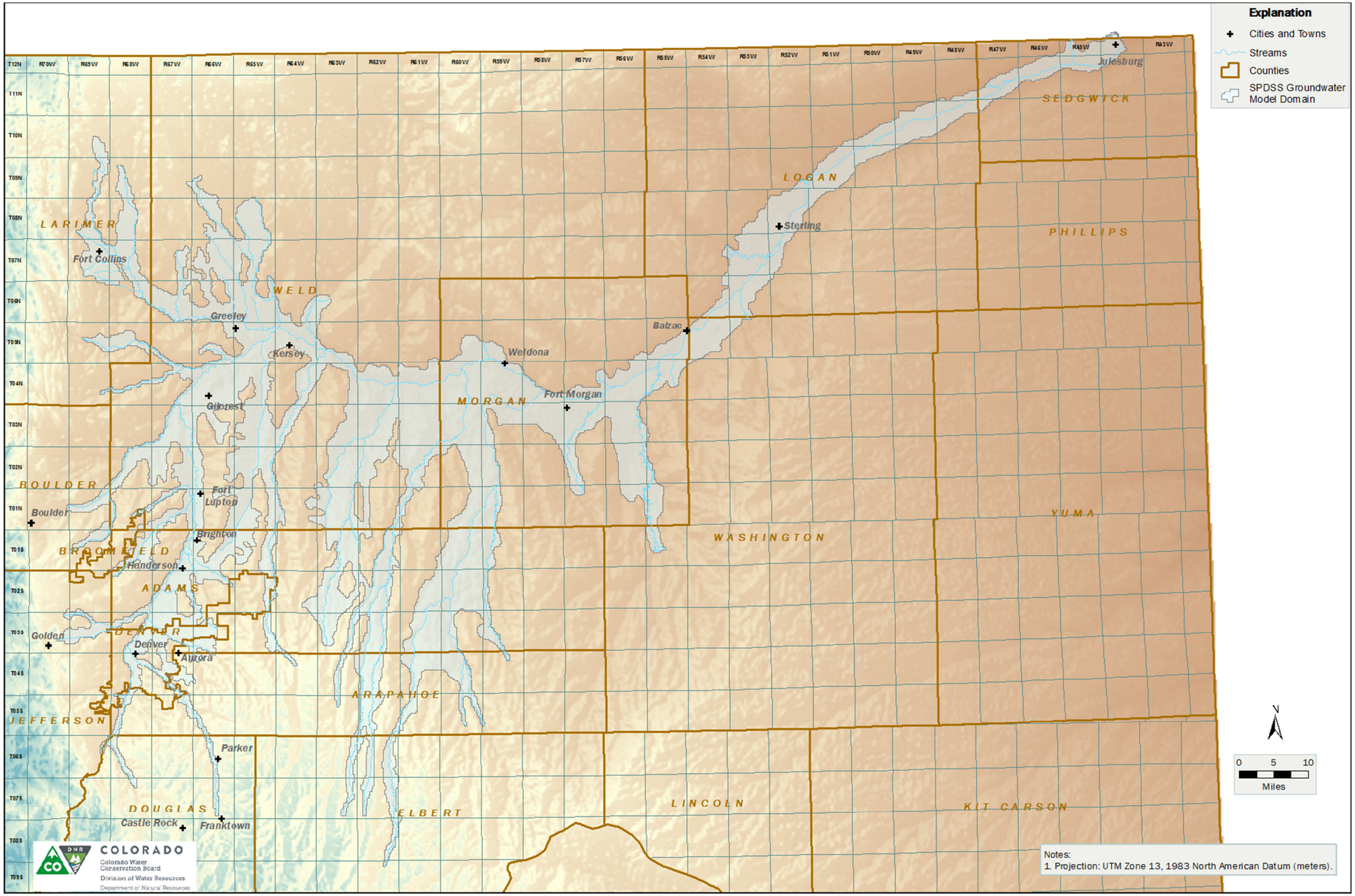


Figure 1-1. Model Study Area

Section 2

Extension of Historical Time-Series Data

The initial task for the model update was to extend the time-series data sets used to develop model input files with the most recent available data. A number of factors were considered when determining the end date for the extension period. The availability of flow, diversion, discharge, and climate data was investigated, in addition to considering the modeling periods for current SPDSS consumptive-use and surface water modeling efforts. To make all of the modeling efforts under SPDSS as cohesive as possible, the extended modeling period was set to align with the most recent consumptive-use and surface water models, which both ended in 2012. The SPDSS consumptive use modeling update is complete, and the surface water modeling effort should be finalized by December 2016.

In general, the time-series data update was focused on gathering post-2006 data to add to the previously developed 1950 to 2006 data. For some modeling input data sets, historical data were not available during the initial modeling effort conducted by CDM (hereinafter referred to as the "initial modeling effort"), but some historical data are now available, or major revisions to the historical data were conducted and are now available for use. In these instances, the newly acquired data were used to replace the existing time-series data for the entire period of record (1950 to 2012).

The extension of time-series data sets primarily on existing tools and approaches from the initial modeling effort. For some data sets, data-centered enhancements were implemented to streamline the previous data generation workflow. In these cases, workflows were modified to use standard tools and data sources and remove dependence on proprietary tools, user-edited data, and data formats incompatible with standard SPDSS processes.

This section provides a description of the data, data-processing steps, and approach used to extend time-series data sets. Workflow diagrams showing the entire process to generate MODFLOW input files, including the necessary input data, were also developed and are presented in this section.

2.1 Approach and Process

Existing tools and previously developed approaches for collecting and processing time-series data were used for the extension effort. The tools used for the initial and current modeling efforts include standard CDSS tools such as TSTool and StateDGI, as well as other common tools such as Excel spreadsheets and Access databases. StateDGI is a DMI specifically designed to store and output data for the StatePP tool that pre-processes data for MODFLOW and generates several MODFLOW input files. In addition to those tools, the original model development included a number of software tools for specific modeling processes that integrate into the workflow. A number of these existing processing tools were replaced and new processing tools were developed in an effort to improve and simplify certain workflows. Where possible, greater emphasis was focused on using TSTool and other data-centered approaches. Modified or new tools developed during the model update are described herein. The unmodified tools and processes developed during the initial modeling effort are described in detail in the CDM 2013 Report (CDM 2013).

2.1.1 Data Sources and Background

The primary source for hydrologic and spatial data for the model was the HydroBase database maintained by DWR (DWR 2015). The version of HydroBase used throughout the data-collection process was issued on March 4, 2015. Historical data collected from HydroBase included streamflow records, diversion records, climate data, M&I pumping records, recharge pond deliveries, irrigated areas, groundwater levels, soil types, land use, and demographic information.

The model is also closely integrated with other SPDSS basin-wide modeling efforts. The current basin-wide consumptive-use model (StateCU) was developed as a part of ongoing surface water model (StateMod) development efforts (DNR 2015). For the model, output from StateCU was used to estimate irrigation recharge, canal seepage, and irrigation well pumping. Wilson Water Group, the contractor managing the StateCU model, provided this output for use in the model. Therefore, the input data sets for both the SPDSS groundwater and surface water models have been prepared using consistent sources and data.

Some of the time-series data, such as M&I discharges and bedrock fluxes, were collected from non-decision support system data sources or models. Discharge data were collected from the U.S. Environmental Protection Agency (EPA) database, and bedrock fluxes were based on output from the USGS Denver Basin groundwater model (EPA 2015, Paschke 2011).

Data-centered enhancements were implemented during data collection and processing. These enhancements include increasing the use of TSTool commands to retrieve data stored in HydroBase, eliminating reliance on data not stored in HydroBase, and developing detailed workflow diagrams to explain the processing steps for each time series.

2.1.2 Approach Summary

In general, the extension of time-series data for each component was completed separately using individual approaches and processes. Table 2-1 provides a summary of the approaches and processes used to generate the time-series data for each component. Additional details for various components are provided in Appendix A of this report.

Table 2-1. Time-Series Data Set Extension Approach

Time-Series Data Set	Extension Approach
Alluvial underflow into model	The rates of monthly alluvial groundwater inflow entering the model domain at modeled tributary branches were calculated during the initial modeling effort and are constant year-to-year. The same values were used for the extended modeling period.
Bedrock fluxes	Bedrock fluxes were calculated using the USGS Denver Basin model. The USGS model simulation period of record ended in 2003. The 2003 fluxes were repeated for subsequent years of the model, including the extended modeling period period.
Reservoir seepage	Reservoir seepage rates were assumed to be constant for a given soil type underlying the reservoirs. The seepage rates already in the initial model were used for the extended modeling period.

Table 2-1. Time-Series Data Set Extension Approach	
Time-Series Data Set	**Extension Approach**
Streamflow routing components: streamflow, M&I discharges, and diversions	Historical streamflows and diversion records for the extended modeling period were collected from HydroBase by Wilson Water Group and were provided. Incomplete records were filled using regression or other suitable methods as described in the SPDSS Task 2 technical memorandum (Leonard Rice Engineers 2007). Tributary inflows at the edge of the model domain were estimated using the nearest downstream gage and then adding diversions occurring between the gage and the model boundary. See Appendix A for details on the data collection efforts. M&I discharge data were collected from the EPA database.
Precipitation	Historical monthly precipitation data from the key climate stations identified in the initial modeling effort were retrieved from HydroBase by Wilson Water Group and were provided. Missing data were filled using linear regression. The climate station weights used to distribute precipitation across the model domain and the percentages used to determine the amount of precipitation that becomes recharge (based on land use and soil types) were not changed from the initial modeling effort.
Consumptive-use model output: agricultural pumping, canal seepage, and irrigation recharge	Agricultural pumping, canal seepage, and irrigation recharge time-series data were estimated using the StateCU model output. The consumptive-use modeling was completed by Wilson Water Group and provided. The model output contained monthly values for each parameter. See Appendix A for details on the data-collection efforts.
M&I pumping	The historical M&I pumping data were extended using a combination of data retrieved from HydroBase and data provided by the well users. HydroBase data were preferred to user-supplied data. Missing or incomplete records were filled using similar methods from the initial modeling effort. The availability of HydroBase data was limited during the initial modeling effort. Estimated values prior to 2006 were replaced with newly available HydroBase records when possible. See Appendix A for details on the data-collection efforts and filling procedures.
Augmentation and recharge	Recharge areas: Augmentation recharge was estimated using recharge pond delivery records. Delivery records were retrieved from HydroBase and provided by Wilson Water Group. New recharge facilities that came on line during the extended modeling period were added to the model as part of the model update. Recharge and augmentation pumping: Historical recharge pumping records were compiled by Wilson Water Group and provided. Appropriate wells were identified with the help of the Division 1 Engineer's office. Pumping records were retrieved from HydroBase. Historical augmentation pumping records were also collected from HydroBase by Wilson Water Group and provided. The Division 1 Engineer's office assisted in identifying the appropriate wells. See Appendix A for details on the data-collection efforts.
Lateral boundary inflow fluxes	Lateral boundary inflow fluxes represent a combination of precipitation recharge, irrigation recharge, canal seepage, and pumping that occur outside the active model domain and that generate groundwater flux across the active model domain boundary. Existing tools were updated and used to combine the component fluxes and generate lagged boundary inflow values.

Table 2-2 below provides a summary of the approaches taken to extend the time-series data used to develop the calibration data sets.

Table 2-2. Calibration Data Set Extension Approach	
Calibration Data Set	**Extension Approach**
Observation water levels	Measurements of groundwater-level elevations were retrieved from HydroBase for monitoring well sites that were identified during the initial modeling effort.
Stream gain/loss estimates	Daily streamflow, diversion, and discharge data for the extension period (2007–12) were retrieved from HydroBase and added to existing stream mass balance spreadsheets for each identified reach. The new estimates of daily gain/loss for each reach were processed using the pilot point spreadsheets developed during the initial modeling effort and documented in the Task 46.2 technical memorandum (CDM 2008).
Streamflow at relevant gages	Streamflow gage data for the gages used in calibration were retrieved from HydroBase by Wilson Water Group and provided. Missing data were filled using linear interpolation.

2.2 Results

Extended time-series data were compiled in a number of formats. Most data were uploaded to the model database and geodatabase. StateCU model output was kept in its original format because it is read directly by the MODFLOW model input file pre-processor (StatePP). Some time-series data consisted of monthly values that were repeated for each year of the modeling period. Those data were extended by modifying a flag in the existing MODFLOW input files that indicated to the model that the current values are to be used for the extended modeling periods.

2.2.1 Data Descriptions and Processes for Extending Data Series

The following is a brief summary of the data collected for each time series in the model. Some time-series categories were lumped together because of their similarity and because similar processes were used to extend the data.

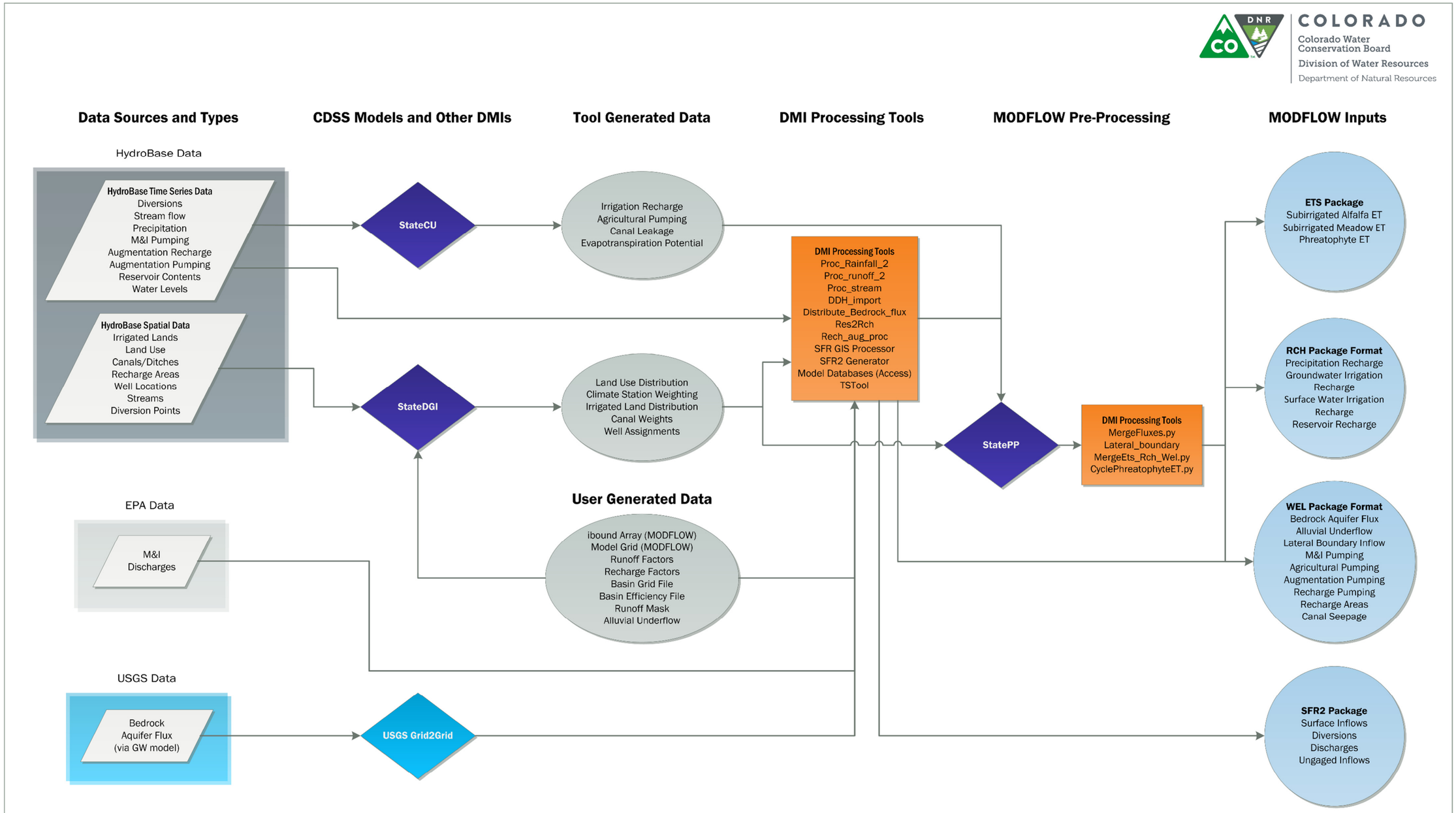
Detailed workflow diagrams for each time series, or group of time series, were developed to show the entire process of creating the extended time series and developing the MODFLOW input files. The diagrams show the source data and the final MODFLOW package that receives or uses the time-series data. Figure 2-1 below shows a generalized overview of the workflow for generating all of the time-series data. Some processing steps for certain time series are not shown for clarity.

2.2.1.1 Constant Time-series data: Alluvial Underflow, Bedrock Fluxes, and Reservoir Seepage

Data representing alluvial underflow, bedrock fluxes, and reservoir seepage are constant on a year-to-year basis, with monthly variation. These time series were updated by modifying the existing MODFLOW model input files to indicate that the previous values are to be repeated for stress periods in the extended model. The bedrock fluxes in the model from 2003 onward use the values from the last year of output from the USGS Denver Basin groundwater model, which ends in 2003 (Paschke 2011).

Reservoir seepage and alluvial underflow are constant monthly values repeated each stress period for the entire modeling period. Because no new data were introduced for the extension, an individual workflow diagram was not generated for these time series. However, their processes are shown in general terms on the workflow overview diagram in Figure 2-1, below.

The methodologies used to determine reservoir seepage and process bedrock fluxes are discussed in further detail in Appendix B of the CDM 2013 Report, while alluvial underflow is discussed in Appendix D of that report (CDM 2013).



Notes: 1) See Figures 2-2 through 2-6 for detailed workflows for individual tools and processes.

Figure 2-1. Model Workflow Overview

2.2.1.2 Streamflow Routing Components

SFR2 is used by the model to route surface water in stream channels and simulate the discharge from the aquifer to the stream (gaining stream) or discharge from the stream to the aquifer (losing stream). SFR2 uses a combination of streamflow gage data, stream diversions, discharges to the stream (e.g., municipal wastewater treatment effluent), and estimates of runoff from precipitation to calculate the flow and stage of the stream. A description of the data collection and time-series extension efforts for the components of SFR2 are highlighted below. Precipitation runoff is discussed near the end of Section 2.2.1.3, below. The complete SFR2 workflow, including all components, is shown on Figure 2-2, below. Additional background information about the components of SFR2 can be found in Appendices F and G of the CDM 2013 Report (CDM 2013).

2.2.1.2.1 Streamflow

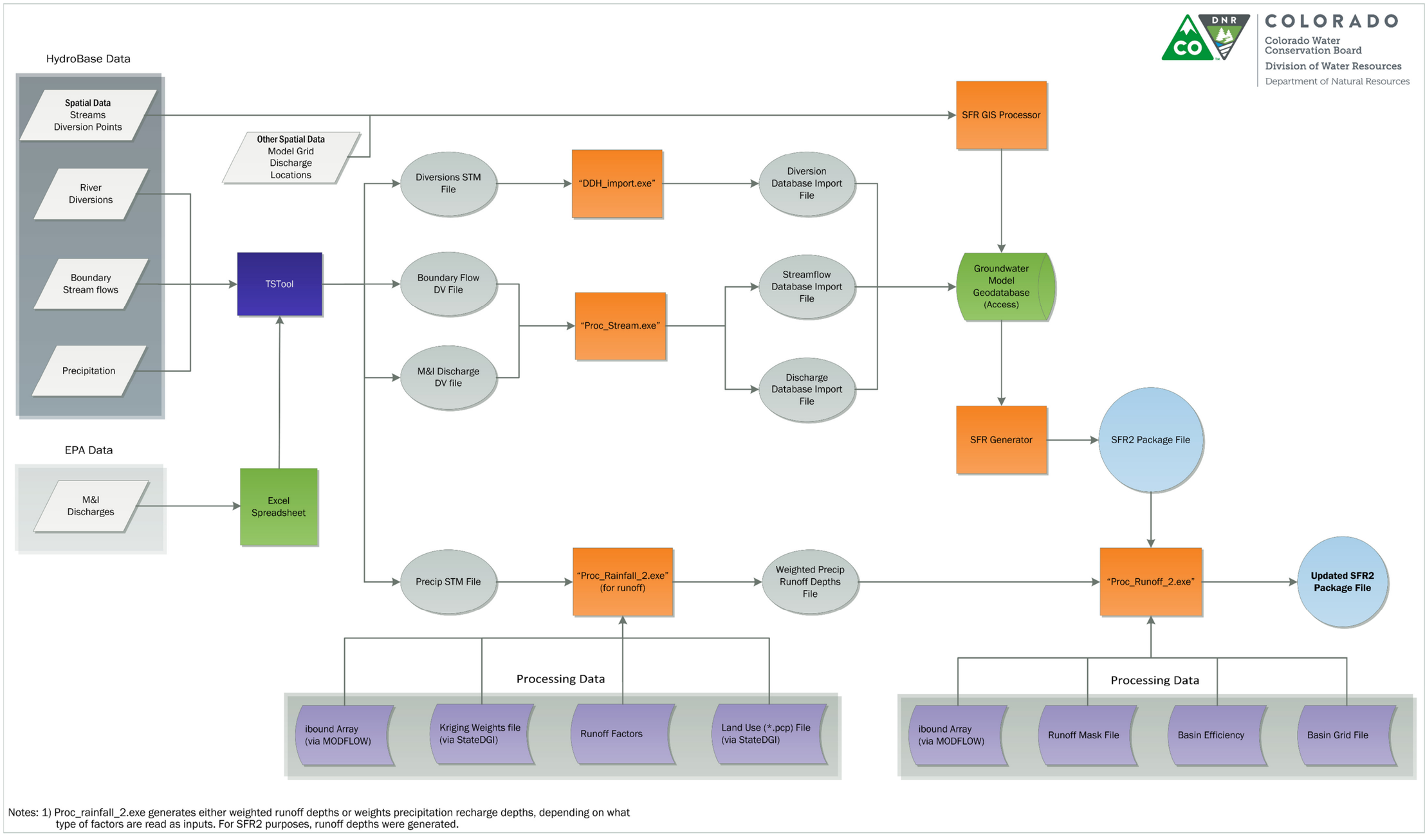
Streamflow data are used in the development of SFR2 and are based on USGS gage measurements at gages located near the model boundary on the South Platte River and major tributaries. Streamflow data were also used in the development of stream gain/loss estimates applied as calibration targets and discussed in Section 2.2.1.9.2, below. These data were retrieved from HydroBase using a TSTool command file. Missing data were filled using linear regression relationships with nearby gages. The regression relationships used to fill data for the model were the same as the relationships used in the SPDSS StateMod model that is currently under development. The filled data were uploaded to the model geodatabase and then processed with the SFR2 Generator to create the MODFLOW input files. Figure 2-2 below shows the complete workflow process for generating MODFLOW input files from streamflow data and the other components of SFR2.

2.2.1.2.2 Diversions

Canal diversions are also a component in SFR2. The diversion records are stored in HydroBase and were acquired and compiled using TSTool commands. Between 2006 and 2012, there were very few missing values in the records. Missing data were filled using an approach consistent with current StateCU and StateMod modeling efforts. The data-filling process uses a wet-dry-average pattern based on historical flow patterns at a nearby stream gage. The pattern file assigns a wet, dry, or average attribute for each month, and then—for any given month with missing data—the average monthly value corresponding to the pattern assignment is used to fill the data gap. Final data were uploaded to the SPDSS geodatabase for SFR2 Generator processing. The workflow for processing diversion data is a part of Figure 2-2.

2.2.1.2.3 Municipal and Industrial Discharges

Major M&I discharges from wastewater treatment plants (WWTPs) and power plants to the South Platte River and major tributaries are also included in SFR2. Unlike the streamflow and diversion data, discharges from M&I sources are not stored in HydroBase. Data were retrieved from the EPA database. Records were mostly complete for the extension period; however, some sites required filling. For small, intermittent data gaps, average monthly values were used to fill missing values. When data for municipal discharges were missing for longer consecutive periods, the values were filled using per-capita use and population data. This is the same approach used in the initial modeling effort to fill missing data prior to 2006 (CDM 2013). Missing industrial discharge data were filled with monthly average values. The processing steps for discharge data are also shown on Figure 2-2, below.



Notes: 1) Proc_rainfall_2.exe generates either weighted runoff depths or weights precipitation recharge depths, depending on what type of factors are read as inputs. For SFR2 purposes, runoff depths were generated.

Figure 2-2. SFR2 Development Workflow

2.2.1.3 Precipitation

Precipitation data were collected from HydroBase using TSTool commands for 29 weather stations located throughout the Basin. The weather stations are operated by the National Oceanic and Atmospheric Administration (NOAA) and are the same locations used in the initial modeling effort. Precipitation data collected from the stations were distributed across the model grid based on a set of weighting files, which indicated the relative weight that a particular weather station had for any given model cell. A weighting file was generated for each station using a kriging interpolation method. The farther the model cell was from a particular weather station, the lower the weight was for that station. The precipitation assigned to any given model cell represented the weighted sum of precipitation for multiple surrounding weather stations. The weather station weighting and precipitation distribution methods were developed during the initial modeling effort and were unchanged during the update process.

The recharge component resulting from precipitation was determined by using recharge factors that represent the percentage of precipitation that recharges the alluvial aquifer. The percentages are based on land cover types, soil classifications, and season. The recharge percentages used for the extended modeling period were the same as the percentages used in the initial modeling effort. The workflow for processing precipitation recharge data is shown in Figure 2-3, below. Further background information can be found in Appendix B of the CDM 2013 Report (CDM 2013).

The runoff component of precipitation was calculated in a similar way, but using a different set of percentages. The runoff percentages used for the extended modeling period were the same as the percentages used in the initial modeling effort. The runoff percentages were based on the same land cover and soil types as the recharge percentages. Precipitation runoff is a component of SFR2. The workflow diagram shown in Figure 2-2 includes the runoff processing. More information about SFR2 components can be found in Appendix G of the CDM 2013 Report (CDM 2013).

Missing or incomplete precipitation data were filled using linear regression relationships with nearby stations. The regression relationships are consistent with the initial modeling effort as well as the current StateCU and StateMod modeling efforts.

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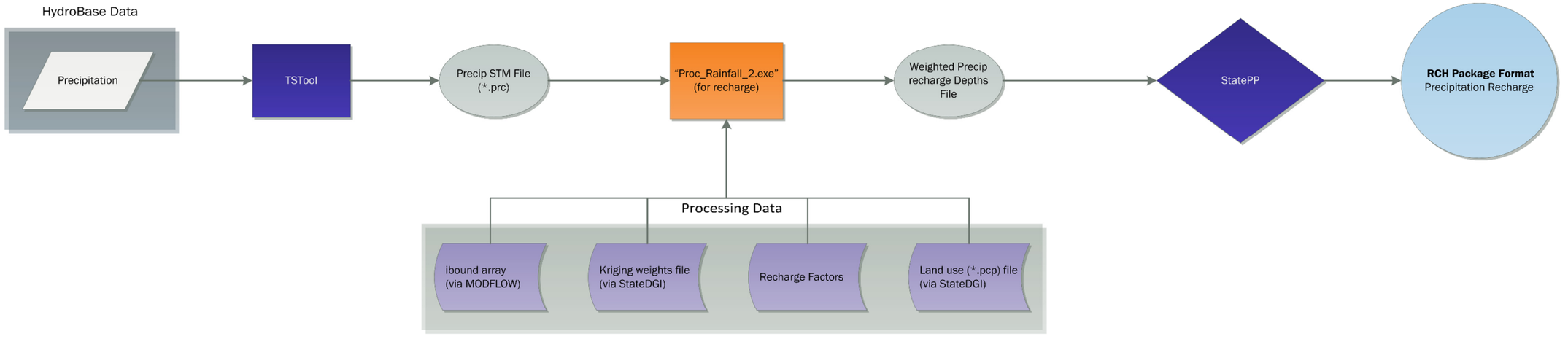


Notes: 1) Proc_rainfall_2.exe can be run with recharge factors to generate weighted recharge arrays or with "runoff" factors to generate weighted runoff arrays. Recharge arrays are used in the recharge package workflow.

Figure 2-3. RCH Development Workflow: Precipitation Recharge

2.2.1.4 Consumptive-Use Model Output

A number of model input time series are based on the output from the StateCU consumptive-use model. These include irrigation pumping, irrigation recharge, and canal seepage. An updated version of the basin-wide StateCU model was developed in support of SPDSS StateMod modeling efforts, in addition to other efforts. The model output was provided by Wilson Water Group, the consumptive-use model contractor for CWCB. The StateCU model uses GIS-based irrigated acreage "snapshots" (i.e., mapping) from HydroBase to determine the appropriate amount of irrigated area for each diversion structure in the model, and to determine which irrigation wells correspond to the particular parcels. The snapshots provide a quantification of the irrigated area and the crop types on a parcel-by-parcel basis for a given year. Snapshots are available from HydroBase for 1956, 1976, 1987, 2001, 2005, and 2010. The 2010 snapshot was added to the StateCU model for the model extension effort.

Additionally, all snapshots have been revised since completion of the initial groundwater modeling effort, with a focus on improving the well-to-parcel assignments. As a result, the current StateCU output is slightly different from the output used in the initial groundwater modeling effort. For consistency with the other modeling efforts in the Basin, the older StateCU output used in the initial groundwater modeling was replaced with the new StateCU output for the entire simulation period (1950 to 2012). The monthly values of irrigation pumping, irrigation recharge, and canal seepage are calculated by the StateCU model, and there are no missing or incomplete data. The data are read directly from the detailed water balance output from StateCU into the MODFLOW model pre-processor, StatePP, and converted into MODFLOW input files. The complete workflow for StateCU generated data is shown in Figure 2-4, below. Appendix B from the CDM 2013 Report provides additional information on methodologies and processes use for recharge data collection (CDM 2013).

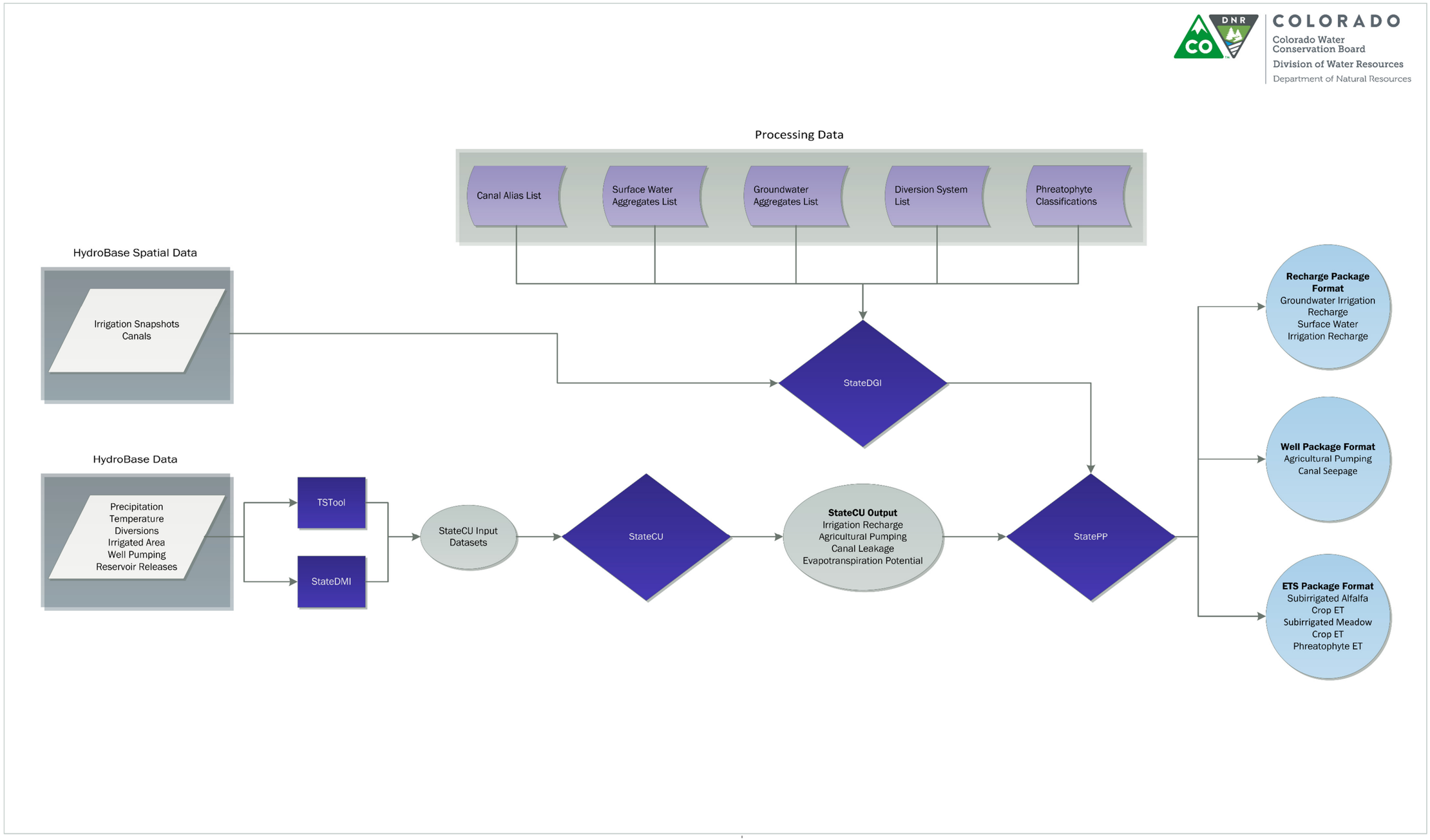


Figure 2-4. MODFLOW Package Development Workflow: Consumptive-Use Model Components

2.2.1.5 Municipal and Industrial Pumping

M&I pumping data were gathered from both HydroBase (using TSTool commands) and well users. Data from HydroBase were preferred for two reasons when both sources were available. One was to maintain a data-centered approach. The other was that the user-supplied data were often in annual pumping forms or were generalized, lumping pumping records from individual wells into a total pumping record for an entire wellfield. Data from HydroBase and the well users were generally in agreement. Larger discrepancies were investigated and addressed on a case-by-case basis. A detailed overview of the data collection and approach for filling missing or incomplete data is provided in Appendix A.

Because of the variation in the quality and completeness of available data, missing values were filled on a case-by-case basis for each well user. Pumping data were uploaded to the model database and exported in the appropriate format to be read by StatePP. The workflow for extending M&I pumping data is relatively straightforward and shown with sufficient detail on the workflow overview in Figure 2-1, above. Additional background information about the collection of M&I pumping can be found in Appendix C of the CDM 2013 Report, and the Task 41.3 technical memorandum (CDM 2006, 2013).

2.2.1.6 Recharge Areas

Intentional recharge of the alluvial aquifer for augmentation purposes occurs in recharge ponds and in canals throughout the Basin. The time-series data reflecting augmentation recharge were collected from HydroBase using TSTool commands. The data, which were compiled by Wilson Water Group, are consistent with current SPDSS consumptive-use and surface water modeling efforts. The number of recharge areas included in the extended version of the model has increased since the initial modeling effort. This is primarily a result of the rapid development of recharge areas that occurred in the Basin since 2006.

The data-collection efforts for recharge areas during the initial modeling effort relied on data that were either never in HydroBase (e.g., data from augmentation plan accounting forms) or data that have since been removed from HydroBase. The current augmentation recharge time series rely exclusively on data found in HydroBase. A comparison of historical augmentation recharge data from both the initial modeling effort and the current StateMod model revealed discrepancies at nearly all recharge sites. Most of the data discrepancies were small and were likely a result of rounding of the delivery record values. Some differences were much larger and could not be easily explained. However, the sum of augmentation recharge at all sites in the model was very similar.

After consultation with Wilson Water Group (the surface water model contractor) and a thorough review of the data, the augmentation recharge data set was used from the surface water model and replaced the existing data from the initial modeling effort for the entire modeling period. This approach offers two advantages. First, it is data-centered and easily repeatable. Second, the augmentation recharge data set is consistent with the current surface water model.

The workflow for extending the augmentation recharge time series is shown Figure 2-5, below. Appendix M of the CDM 2013 Report provides more details on the process used to generate the augmentation recharge time-series data (CDM 2013).

2.2.1.7 Recharge and Augmentation Pumping

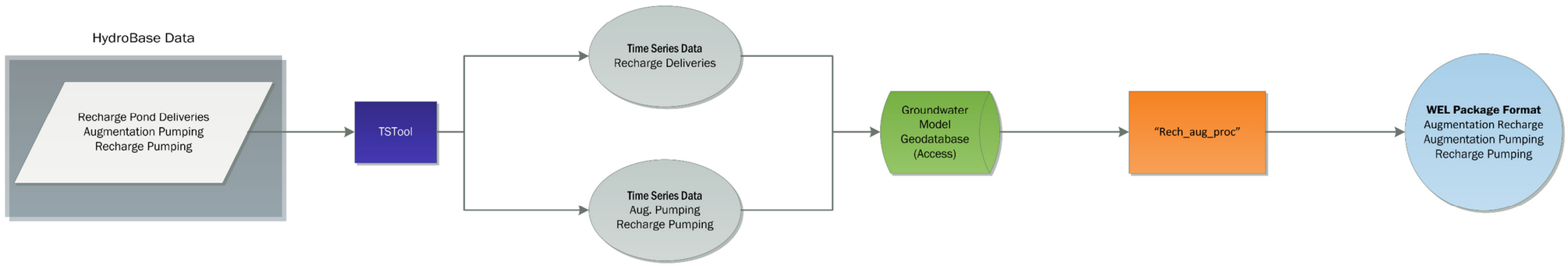
Recharge pumping represents water pumped from the alluvial aquifer that is delivered to recharge ponds. Augmentation pumping is water periodically pumped from the alluvial aquifer and delivered directly to the river to replace streamflow depletions from well pumping associated with augmentation plans. The time series for both types of pumping were retrieved from HydroBase using

TSTool commands. The list of wells used for recharge or augmentation purposes was provided by Wilson Water Group, which also consulted with DWR to determine the proper list of wells for each type of use.

The updated list of wells was different from the list of wells used in the initial modeling effort, which was a result of the different approach taken to identify recharge or augmentation wells. The initial modeling effort considered all wells with a decreed use of either recharge or augmentation and collected any records corresponding to the pumping under those uses. This resulted in a number of wells being identified that were used for recharge or augmentation pumping for a brief period and then never operated under that use again. Most of the pumping from these wells was in very small quantities and the pumping records were not always available in HydroBase. The updated approach identified wells that are used for augmentation or recharge on a regular or semi-regular basis. The goal was to create a data set that represents both past and potential future use of augmentation or recharge wells. After consultation with Wilson Water Group, BC adopted the updated data-collection approach and replaced the data from the initial modeling effort for the entire period of record. The updated approach is more data-centered and is consistent with the other modeling efforts in the Basin.

The workflow for recharge and augmentation pumping time-series extension is also shown on Figure 2-5, below. Additional information about the methodology used to collect augmentation and recharge pumping data can be found in Appendix M of the CDM 2013 Report (CDM 2013).

COLORADO
Colorado Water Conservation Board
Division of Water Resources
Department of Natural Resources

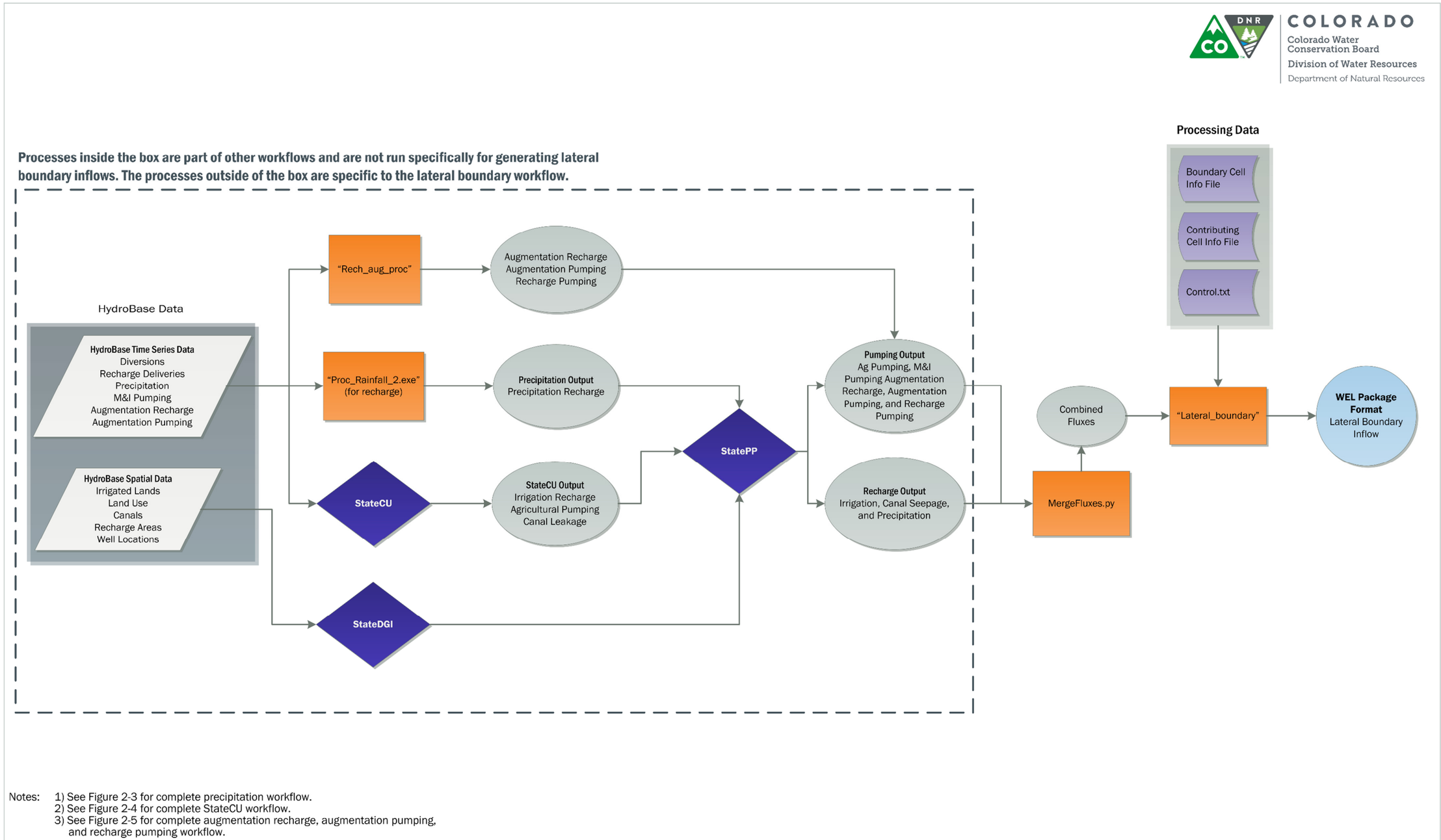


Recharge areas (ponds) are now modeled using a WEL package format file, which is better suited to represent their relatively sparse spatial distribution.

Figure 2-5. WEL Development Workflow: Augmentation Components

2.2.1.8 Lateral Boundary Inflow Fluxes

Lateral boundary fluxes are a composite of a number of individual time series that represent groundwater flux at the boundary of the active model domain. The fluxes at the model boundary are a result of irrigation, canal seepage, precipitation, augmentation recharge, and pumping that occur outside of the active model domain. The net flux from these inputs at the boundary is estimated with a software tool developed in the initial modeling effort. This tool uses output from StatePP for irrigation recharge; irrigation pumping; M&I well pumping; canal seepage, and precipitation, as well as values of augmentation recharge, and augmentation/recharge pumping occurring outside the active model domain. The locations of the inputs listed above are used to determine the shortest distances between individual inputs and the active model boundary. The distances are used to identify the boundary model cells that will receive the lateral inflow fluxes and to derive parameters for estimating the timing of the fluxes. The analytical Glover Equation is used to generate the timing of the fluxes (Glover and Balmer 1954). The tool uses this information to generate MODFLOW input files reflecting lateral boundary inflow fluxes. A detailed workflow diagram for the lateral boundary fluxes is shown on Figure 2-6, below. Further information regarding lateral boundary inflows can be found in Appendix D of the CDM 2013 Report (CDM 2013).



Notes: 1) See Figure 2-3 for complete precipitation workflow.
2) See Figure 2-4 for complete StateCU workflow.
3) See Figure 2-5 for complete augmentation recharge, augmentation pumping, and recharge pumping workflow.

Figure 2-6. Lateral Boundary Inflow Workflow

2.2.1.9 Calibration Data

The primary data used for model calibration include groundwater-level measurements, estimates of stream gain/loss on a reach-by-reach basis, and streamflow measurements. A description of the methods and approach used to generate each data set is provided below. Additional background information regarding the calibration data can be found in Appendix K of the CDM 2013 Report (CDM 2013).

2.2.1.9.1 Observation Water Levels

Groundwater-elevation data were retrieved from HydroBase for 560 wells located throughout the Basin. A comparison of groundwater-elevation data obtained from the most recent version of HydroBase and data collected during the initial modeling effort indicated that the measuring-point elevations have been updated for a number of the wells. The update in measuring-point elevations resulted in changes to observed groundwater elevations for these wells. A number of SPDSS and USGS monitoring wells have had water-level measuring points surveyed since the initial modeling effort, and these surveyed measuring-point elevations were incorporated into the observed water-level elevation data (Everett and Char 2015). Additionally, water-level measuring-point elevations at non-surveyed wells were checked against the 1/3 arc-second USGS three-dimensional (3D) Elevation Program Seamless DEM, and the measuring-point elevations were updated to the DEM elevation value for nine of the non-surveyed wells based on professional judgment (USGS 2015). For these wells where measuring-point elevation data were updated, groundwater-elevation data for the entire modeling period were calculated to ensure that the data reference a consistent measuring-point elevation.

Some water-level observation wells also have had horizontal location coordinates updated. First, 63 wells were updated with the horizontal location coordinates from the DWR irrigation snapshot GIS data sets. Second, 106 wells appeared to have had horizontal location coordinates that were UTM coordinates in the North American Datum of 1927 (NAD27), but had been reported as being in the NAD83. The difference between these two types of datum is approximately 600 feet on the ground. The discrepancy was noted when several wells from the Central Colorado Water Conservancy District (CCWCD) did not plot in locations that matched the Public Land Survey System (PLSS) information. After a review of well locations, the discrepancy between the UTM coordinates and the PLSS information clearly indicated that the UTM coordinates had a simple error in the datum, and the UTM coordinates were re-projected into the correct values for the NAD83 datum using GIS methods.

A number of monitoring well locations have been equipped with water-level transducers and continuously recording data-logging equipment. Datalogger measurements from these wells are available from HydroBase on a daily or average daily basis. To avoid biasedo weighting of water-level calibration statistics through the sheer volume of the data available for these wells, only the data point nearest to the end of each month were used in the water-level calibration data set. If applicable, water-level measurements prior to the installation of transducers and data-logging equipment at these wells were preserved in the water-level calibration data set.

2.2.1.9.2 Stream Gain/Loss Estimates

Estimates of stream gain and loss were calculated on a reach-by-reach basis using a mass balance approach developed during the initial modeling effort. Streamflow gage data were used along with measured diversions and M&I discharges to determine the net unmeasured gain or loss of flow along a particular stream reach on a daily time scale. The streamflow and diversion data were retrieved from HydroBase and the discharge data were collected from the EPA (see Section 2.2.1.2.3 for more detail).

The reaches are defined by the location of the stream gages. The daily net gain/loss value computed with the mass balance approach was constrained by a number of factors using the mass balance-based approach developed in initial modeling efforts. The process for quantifying gains/losses included an initial constraint that limits the daily gain/loss by the capacity of the aquifer to transmit water to and from the stream. The constrained daily values were then averaged over a multi-day period to account for the expected travel time in the reach. A longer moving average was then derived from the daily data to account for runoff events that can produce rapid but temporary 1- or 2-day increases in stream gains. The cumulative monthly constrained and averaged values were then used as the calibration targets for the stream gain/loss calculated by the model in SFR2. A more detailed description of the methodology and approach for estimating stream gain/loss is provided in Appendix E of the CDM 2013 Report (CDM 2013).

2.2.1.9.3 Streamflow at Relevant Gages

Streamflow data used for calibration were collected by Wilson Water Group and provided using the same procedures outlined in Section 2.2.1.2.1, above. The gage locations used for calibration are within the model domain and were used to check simulations of streamflow generated by SFR2. The same 13 sites identified during the initial modeling effort were used for calibration of the updated model. Additional background information regarding the calibration data can be found in Appendix K of the CDM 2013 Report (CDM 2013).

2.2.2 QA/QC Procedures

The procedures for quality assurance and quality control (QA/QC) were tailored to the individual data sets being reviewed. The following is an overview of the QA/QC that was conducted on the various types of data:

- Data received from Wilson Water Group: Data provided by Wilson Water Group included StateCU modeling output, precipitation time series, streamflow measurements, canal diversions, augmentation deliveries, and augmentation and recharge pumping. Excluding the StateCU output, these data were provided in the form of TSTool command files and TSTool output, and had undergone a level of QA/QC by Wilson Water Group prior to being delivered. Each TSTool command file was tested to make sure they ran without errors. All of the StateCU and TSTool outputs were examined for outliers and inconsistent trends.
- Constant time-series data: Time-series components that were constant from year to year were not changed during the extension effort. A brief review of the existing data was conducted and did not identify any issues with values used in the model.
- M&I pumping: Most of the M&I pumping data for the extended period were collected from HydroBase using TSTool commands. The command files were reviewed and checked for consistency. The extended data were compared to the data from the initial period of record to check for consistency and continuity. Unreasonably large increases or decreases in pumping were investigated on a case-by-case basis. Detailed descriptions of the development of M&I pumping data can be found in Appendix A of this report.
- Augmentation and recharge: Augmentation recharge in ponds and augmentation and recharge pumping data were retrieved from HydroBase using TSTool commands provided by Wilson Water Group. The commands and TSTool output were reviewed for consistency.
- Lateral boundary fluxes: The lateral boundary fluxes are represented by a combination of input sources including data from StateCU. QA/QC was conducted for the individual components prior to processing the lateral boundary fluxes as described in this section. The computed lateral boundary fluxes were spot-checked for consistency after processing.

- Processing tool output: The workflow to convert time-series data into MODFLOW model input files involves using processing tools developed by CDM. BC conducted an evaluation of each tool, which included a review of the source code and a review of the output files focusing on consistency and verifying expected results.

The methods described above represent the first round of QA/QC for the time-series data. Additional QA/QC was conducted after the MODFLOW input files were generated and model testing was initiated. The testing process provided an opportunity to discover data inconsistencies that were previously undetected.

2.3 Conclusions

The time-series data sets for the model were extended from the initial period of 1950 to 2006 to include data through 2012. Most of the effort was focused on developing the data for the extension period (2007–12); however, some time series were updated for the entire modeling period because of improvements to the available data and approach. This effort also included the extension of time-series data to be used for model calibration.

In general, the approach and tools used to extend the time series relied on concepts and tools from the initial modeling effort. The intent of the project approach was to streamline the extension effort using previous methods. To aid in understanding the existing tools and processes, detailed workflow diagrams were developed, and they are included with this report. The goal in creating the diagrams was to clarify the overall workflows, identify necessary input files and tools, and provide guidance for future users to develop time-series data sets. The refinement and clarification of the workflows and approaches used to develop time-series data for the model are intended to improve the quality and accuracy of the data used in the model and to reduce the effort required to generate time-series data in the future.

Section 3

CDSS Toolbox and StateDGI Updates

The CDSS Toolbox is a set of GIS DMIs implemented using Python scripts that provide users with a graphical user interface (GUI) for each tool within Esri's ArcToolbox™ software environment. Python is an open-source, high-level computer programming language with clear syntax that has been incorporated in ArcGIS for performing geoprocessing tasks and also has proved to be a powerful tool in performing several model input file processing tasks outside of ArcGIS. The CDSS Toolbox DMIs perform operations to process GIS data sets for use with other CDSS tools and DMIs, notably StateDGI, StateCU, StateMod, and StatePP. The CDSS Toolbox is intended to provide consistent, automated, and reproducible methods of developing the input files required for other CDSS tools.

StateDGI is a DMI specifically designed to store, process, and output data for StatePP. StateDGI is implemented via an Access-based geodatabase that also contains several additional data tables, forms, stored queries, and Visual Basic for Applications (VBA) scripts that generate input files for StatePP. StateDGI performs several spatial data processing tasks including locating the groundwater model cells containing irrigation wells, calculating the partial areas of irrigated parcels within individual groundwater model cells, and calculating the partial lengths of irrigation canals within individual groundwater model cells.

3.1 CDSS Toolbox Update

The primary objective of the CDSS Toolbox update was to update the scripts to operate within ArcGIS version 10.1, with additional objectives of reading both geodatabase feature classes and shapefiles as input, removing redundant code, checking the logic of geoprocessing operations, checking for consistent input data schema requirements, and ensuring that the scripts process data correctly.

The original CDSS Toolbox Python scripts were written for ArcGIS version 9.1. Python support within ArcGIS has evolved over the past several years, and a brief technical history is provided here. ArcGIS 9.1 (and thus the CDSS Toolbox) used the non-standard PythonWin (rather than standard open-source Python) package and accessed the ArcGIS geoprocessing components using the PythonWin win32com COM interface. Later versions of ArcGIS version 9 used standard versions of Python and accessed ArcGIS geoprocessing components using the Python-native arcgisscripting module. ArcGIS version 10 (all sub-versions) continues to use standard versions of Python, and includes the newer ArcPy module while continuing to support the older arcgisscripting module.

Because the Python scripting syntax between the PythonWin and arcgisscripting is virtually the same, updating the previous scripts to operate in ArcGIS version 10.1 requires only very minor code changes. However, after consultation with CWCB and DWR, the CDSS Toolbox scripts were updated to the newer ArcPy syntax because of the likelihood that Esri will end support for and remove the older arcgisscripting from ArcGIS in future versions. Performing the transition to ArcPy at this stage led to performing several of the additional objectives such as searching for redundant code, checking the logic of geoprocessing operations, and ensuring that the scripts process data correctly.

During the process of updating the CDSS Toolbox scripts, any updates to the original code that were not a simple conversion of arcgisscripting syntax to the equivalent ArcPy syntax were left in place but commented out to illustrate the changes and preserve a record of the previous code. Also, supplemental explanatory comments were added to the Python script source code to describe the flow of processing operations, and improved the messages output to users during execution of each tool.

An updated CDSS Toolbox user manual is included as Appendix B.

3.2 StateDGI Updates

The StateDGI Access database includes a series of linked queries to assist in determining the locations of groundwater wells, fractional areas, and lengths of irrigated parcels and irrigation canals. The queries serve as the basis for creating files that can be used as input to StatePP. These linked queries are in some cases very complex. As part of the scope of this model update effort, BC reviewed these queries for logical consistency and accuracy. During this review, two major inconsistencies that produced incorrect input files for StatePP were identified and corrected.

First, an issue was identified and resolved for the series of linked queries that produces files for StatePP that contain the Water District Identifier (WDID) of a canal and the partial length of the canal within each groundwater model cell to appropriately distribute canal seepage recharge. In some cases the WDIDs in StateDGI needed to be aliased to another WDID for StatePP to be able to appropriately match canal seepage estimates from StateCU. These situations occurred when multiple WDIDs for some canals were “aggregated” under a single WDID (e.g., multiple canals under a single ditch system may be aggregated to the WDID of the system’s main canal). Separate alias WDIDs are necessary to split seepage from the portion of a canal that carries water to a storage reservoir from the portion of the canal that carries water from the reservoir to irrigated lands because the timing and volumes of seepage are different in the supply and demand sections of the canal. The original StateDGI queries for canal lengths applied the aliased WDIDs one process step too soon in the chain of queries such that the lengths of any canals with aliased WDIDs had not been written to the canal file for StatePP, ultimately resulting in canal seepage recharge related to those canals not being added to the model.

Second, issues were found and resolved for the series of linked queries that produce files for StatePP that contain the WDID for an irrigation well, the acreage irrigated by the well, and the pumping capacity of the well. Irrigated parcels may receive water from a combination of surface water sources and groundwater wells, including instances of multiple surface water sources and multiple groundwater wells. In addition, many individual wells have the potential to supply water to multiple irrigated parcels. The series of linked queries is intended to calculate the proportions of irrigated acreage of each model cell to be irrigated by each well and the proportion of each well’s pumping capacity that can be applied to each irrigated parcel in each model cell. A Python script developed for QA/QC to sum the irrigated acreage for each parcel and pumping capacity for each well revealed that the previous versions of these linked queries had been incorrectly proportioning both irrigated acreage and pumping capacity. After reviewing the initial results from the Python QA/QC script, adjustments were made to many of these queries, and additional helper queries were added. StateDGI now produces well input files for StatePP that generate well pumping capacities and irrigated acreages that are correct and consistent with the values loaded into StateDGI from the irrigated lands GIS data sets.

Other minor updates to StateDGI included changes to data table field names to be consistent with current DWR data schema and compliance with current Access standards. Some stored queries still used a former standard (e.g., “WD_ID_7”) field name, and these were changed as appropriate to

current standard field names (e.g., “SW_WDID”). Many data tables and stored queries related to wells used the field name “TOP” for the depth of the top of well screen. The word TOP is a reserved word and statement in Structured Query Language (SQL) and is not accepted by ArcPy as a field name. All tables and queries in StateDGI with the field name TOP have now been changed to use the field name “TOP_” to avoid any possible confusion with the SQL TOP statement. Finally, in consultation with CWCB and DWR staff, the queries that return well pumping capacities are now limited to 2,000 gallons per minute (gpm) total for each individual well to reflect likely physical limits on pumping capacity.

Section 4

Development of Extended Model Input Files

The development of the model input files for the extended period is a multi-step process involving multiple DMIs and processing tools. During the development of model input files, several DMIs and data processing tools were updated and improved in terms of accuracy, efficiency, and functionality. This section describes the improvements to these DMIs and data processing tools as well as the development of the model files themselves.

4.1 File Directory Structure

Using a cohesive file directory structure was an overarching theme in the development of the model files. The use of an organized file and directory structure assists in tracking the flow of raw input data through the calculations and processing of the various CDSS DMIs and analysis tools through to the final MODFLOW input files.

The irrigated lands GIS data sets in CDSS are major data input sources to the model. The GIS data sets include the locations and areas of irrigated parcels, including the associated sources of water for irrigation and the locations and pumping capacities of irrigation wells. The irrigated lands GIS data sets prior to 2010 data sets were produced for the State by Riverside Technology, Inc. as "snapshots" for specific years based primarily on detailed aerial photograph interpretation (Riverside Technology 2007). The spatial information from irrigated lands snapshots was applied through time as described in Table 4-1.

Table 4-1. Irrigation Snapshot Years and Simulation Periods

Snapshot Year	Simulation Period
1956	1950–75
1976	1976–86
1987	1987–96
1997	1997–2000
2001	2001–04
2005	2005–09
2010	2010–12

StateDGI is capable of processing data from only one irrigated lands GIS data set snapshot at a time to produce input files for StatePP. By necessity, then, the StateDGI and StatePP processing must be performed separately for each simulation period corresponding to a snapshot. This results in one StateDGI subdirectory for each snapshot's simulation period. StatePP can also read in only a single set of input files from StateDGI. Additionally, the most straightforward method of producing separate

evapotranspiration input files for subirrigated meadow, subirrigated alfalfa, and riparian phreatophyte vegetation for PSB from StatePP is to perform separate StatePP processes. The spatial distribution of subirrigated crops is determined from the irrigated lands GIS data set snapshots and thus changes with each snapshot's simulation period. The spatial distribution of riparian phreatophyte vegetation used in the model remains constant through time, and the same annual cycle of monthly maximum evapotranspiration rates is applied each year. Consequently, a single StatePP run can be used for the entire simulation period to create the evapotranspiration input file for riparian phreatophyte vegetation.

Table 4-2 presents the file directory structure used for the model and generation of model input files for each simulation period through the StateDGI/StatePP process. Folder names below are in bold and descriptions are in italics. Closed circles denote primary subfolders, and open circles and closed squares denote subfolder secondary and tertiary hierarchy, respectively.

Table 4-2. Model File Directory Structure

StateDGI
○ **Snap1956**: *StateDGI output from 1956 irrigated lands GIS data set*
○ **Snap1976**: *StateDGI output from 1976 irrigated lands GIS data set*
○ **Snap1987**: *StateDGI output from 1987 irrigated lands GIS data set*
○ **Snap1997**: *StateDGI output from 1997 irrigated lands GIS data set*
○ **Snap2001**: *StateDGI output from 2001 irrigated lands GIS data set*
○ **Snap2005**: *StateDGI output from 2005 irrigated lands GIS data set*
○ **Snap2010**: *StateDGI output from 2010 irrigated lands GIS data set*
StatePP
○ **1950-1975a**: *StatePP output for 1950–75 including recharge, pumping, and alfalfa evapotranspiration*
○ **1950-1975m**: *StatePP output for 1950–75 including meadow evapotranspiration*
○ **1976-1986a**: *StatePP output for 1976–86 including recharge, pumping, and alfalfa evapotranspiration*
○ **1976-1986m**: *StatePP output for 1976–86 including meadow evapotranspiration*
○ **1987-1996a**: *StatePP output for 1987–96 including recharge, pumping, and alfalfa evapotranspiration*
○ **1987-1996m**: *StatePP output for 1987–96 including meadow evapotranspiration*
○ **1997-2000a**: *StatePP output for 1997–2000 including recharge, pumping, and alfalfa evapotranspiration*
○ **1997-2000m**: *StatePP output for 1997–2000 including meadow evapotranspiration*
○ **2001-2004a**: *StatePP output for 2001–04 including recharge, pumping, and alfalfa evapotranspiration*
○ **2001-2004m**: *StatePP output for 2001–04 including meadow evapotranspiration*
○ **2005-2009a**: *StatePP output for 2005–09 including recharge, pumping, and alfalfa evapotranspiration*
○ **2005-2009m**: *StatePP output for 2005–09 including meadow evapotranspiration*
○ **2010-2012a**: *StatePP output for 2010–12 including recharge, pumping, and alfalfa evapotranspiration*
○ **2010-2012m**: *StatePP output for 2010–12 including recharge, pumping, and alfalfa evapotranspiration*
○ PhreatET: *StatePP output for 1 year of annual cycle of monthly riparian phreatophyte vegetation ET then extended*

Table 4-2. Model File Directory Structure
MODFLOW
○ **SFR2_Generator**: *SFR2 input files created by the SFR2 Generator ArcToolbox tool including sample ArcMap file, SFR2 Generator Python script, and ArcToolbox .tbx file*
○ **Simulations**
▪ **Input files**: *MODFLOW input files from StatePP outputs combined for entire 1950–2012 simulation period + MODFLOW input files for performing warm-up simulation to produce initial heads for 1950–2012 simulation period*
▪ **SP2016_GW_Final**: *MODFLOW Name files and model outputs for warm-up and 1950- 2012 South Platte Alluvial Groundwater Model simulations*
▪ **Tools**: *Python utilities for extracting initial heads from end of the warm-up simulation and writing binary input files to plain text for inspection and QA/QC.*

4.2 Source Code Updates to StatePP and Other DMIs

During the course of the development of model input files, updates were made to StatePP and several of the CDSS DMIs used in the model development process. In the case of some DMIs, non-standard Fortran syntax specific to a proprietary compiler software was replaced with standard Fortran syntax to allow the Fortran source code to be portable to any standard Fortran compiler, including open-source compilers. The remaining updates to DMIs generally include improvements in functionality, accuracy, and efficiency.

4.2.1 StatePP

The StatePP is a Fortran-based software package that is designed to receive input from StateCU, StateDGI, and other CDSS DMIs and to then produce MODFLOW input files for the Recharge package (RCH), Evapotranspiration package (ET), Evapotranspiration Segments package (ETS), and Well package (WEL). The StatePP Fortran source code was reviewed and tested as part of this model update effort. Additional code comments were added to better document the flow of the code in some places, and minor changes were made to the flow of the code to improve efficiency and speed of execution of StatePP. Two major additions to the functionality of StatePP were also completed during this model update effort, as described in Sections 4.2.1.1 and 4.2.1.2 below.

4.2.1.1 Partition Stress Boundaries Capability Support

First, support was added to StatePP to produce MODFLOW input files that can be used with PSB to separate and individually track different water budget components. The initial version of the model included several water budget components in a single WEL—not only agricultural and M&I pumping, but also augmentation recharge pumping, lateral boundary fluxes, bedrock fluxes, and alluvial underflow. As such, WEL included most of the total simulated fluxes in and out of the initial model construct, and tracking each of these fluxes was extremely difficult. With PSB, several WEL input files may be specified, one for each of these separate water budget components.

PSB facilitates creation of multiple input files for several other MODFLOW boundary condition packages. For example, instead of recharge from precipitation, canal seepage, surface water irrigation return flows, and groundwater irrigation return flows being lumped into a single RCH input file, each these different sources of recharge can be tracked and accounted through the entire MODFLOW simulation. When the user invokes the new StatePP option to produce separate MODFLOW input, separate RCH input files are produced for precipitation, canal seepage, surface water irrigation return flows, and groundwater irrigation return flows. For ET and ETS input files that

are separate for phreatophyte vegetation versus individual subirrigated crops, the user must execute separate StatePP runs for each ET/ETS vegetation type.

4.2.1.2 MODFLOW Input File Size Reduction

Second, StatePP was updated through several different measures to generate MODFLOW electronic input files that are of smaller and more manageable sizes. The previous version of StatePP produced very large MODFLOW files for the model. For example, the 1950 to 2006 model ETS input file produced by the previous StatePP is slightly over 40 gigabytes (GB), a size that is very difficult to read and verify for correctness. The updated ETS input files now total less than 2 GB in file size, and each main ETS input file is less than 1 megabyte (MB) while each external array file is 2.1 MB in size such that each file can be read and reviewed easily. The reductions to MODFLOW input file sizes produced by StatePP were achieved through multiple methods, some of which are options the StatePP user can select. The two-dimensional (2D) arrays required in RCH, ET, and ETS represent the greatest proportion of the file size reductions. A new Fortran subroutine was added to StatePP to produce the 2D arrays. This subroutine checks internally whether an array is a constant value (e.g., zero irrigation recharge during non-irrigation season) and, if the values are constant, instead of writing out the entire array, the subroutine employs the MODFLOW "CONSTANT" keyword. This subroutine is also capable of writing the 2D arrays as external files in a binary format that is smaller than a plain text format. Because these binary files cannot be read directly, a Python script (bin2csv.py) is utilized that converts these binary files to comma-delimited text (CSV) files that can be read and array values checked.

Additionally, the decimal precision of array values written by StatePP was reduced to more appropriately reflect the likely precision of the input data. Another option allows the user to specify that canal seepage recharge is written using the WEL format rather than the RCH format. Equivalent values of canal seepage recharge can be entered into MODFLOW through either WEL or RCH because both represent specified flux boundary conditions. However, because in general canal seepage recharge is generally not spatially distributed very widely (i.e., is spatially confined along canal lengths), there is no canal seepage recharge over most model cells. As such, specifying the canal recharge fluxes at individual model cell locations with non-zero values using only WEL requires less overall data than specifying a 2D array of mostly zero values.

4.2.1.3 Recharge Spatial Weighting Corrections

Two minor issues were identified and corrected in the StatePP code during this effort. First, the application of user-specified spatial weighting of canal seepage was corrected. The previous version of the code was found to apply no weighting to the canal seepage recharge even if the user specified weighting values to certain canal lengths. For example, the North Sterling Canal has some sections that were assumed to have greater seepage, but that weighting was not previously applied. With the code fix, weighting of the seepage along those lengths is now being applied.

The second issue that was identified and corrected is the distribution of irrigation return flow recharge both volumetrically and spatially across each group of irrigated parcels that receive water from a structure. Note that in both cases of these issues, the previous version of StatePP was applying the appropriate volumetric fluxes of recharge, and the corrections are only for the spatial distribution (locations) of the recharge.

4.2.1.4 Additional StatePP User Input Flags

Additional flags were added to the StatePP Control File to allow users to specify whether the newly added options such as external binary array input files or PSB-compatible input files will be produced. If these new input flags are not included in a StatePP Control File, the updated StatePP

executable will ignore these new options. As a result, older StatePP Control Files will still be compatible with the updated executable.

The input new flags and values include:

- PSB options:
  - "ipsb" flag: specifies whether StatePP should produce PSB-compatible input files (value of 1) or not (value of 0).
  - "iwelcan" flag: specifies whether StatePP should produce canal seepage recharge in WEL format (value of 1) or RCH format (value of 0).
  - "cetid" flag: single-character value to append to end of output filename of ETS files to identify which vegetation type is represented in the file (e.g., "a" = alfalfa, "m" = meadow, "p" = phreatophyte).
- "binarray" flag: specifies whether StatePP should produce external binary arrays (value of 1) or not (value of 0).
- "ispoffset" flag: allows user to specify the initial overall model stress period number for a snapshot in data array headers and external binary array file names (e.g., the 1976 irrigation snapshot starts in stress period 133 of the model, so ispoffset = 133 would be used for processing the 1976 irrigation snapshot).
- An additional value of 2 is now allowed for the previously existing "no_alloc_recharge" flag to employ the new methodology to allocate recharge correctly both spatially and volumetrically; the previous values of 0 and 1 are still allowed to provide backward compatibility with previous StatePP runs.

4.2.2 SFR2 Generator and Precipitation Runoff Processor

The SFR2 Generator is a DMI that is designed to read SFR2 information from the SPDSS geodatabase (e.g., model cell locations of streams with information about stream geometry, inflows at the active model boundary, WWTP discharge inflows, etc.) and produce an SFR2 input file for MODFLOW. The previous version of the SFR2 Generator was translated from the older Visual Basic .NET (VB.NET) source code to an ArcPy-based Python script that can be executed in ArcGIS. An ArcToolbox (.tbx) file for the SFR2 Generator ArcPy script has also been created that provides a GUI to execute the script with the appropriate input parameters (Figure 4-1). The SFR2 input file produced by the new ArcPy script was compared to the equivalent SFR2 input file produced by the older VB.NET executable to verify that the contents are both equivalent and correct. The SFR2 Generator ArcPy script was further modified to write the SFR2 input file using appropriate and consistent numeric formats and spacing to allow for easier reading and checking of values written to the SFR2 input file.

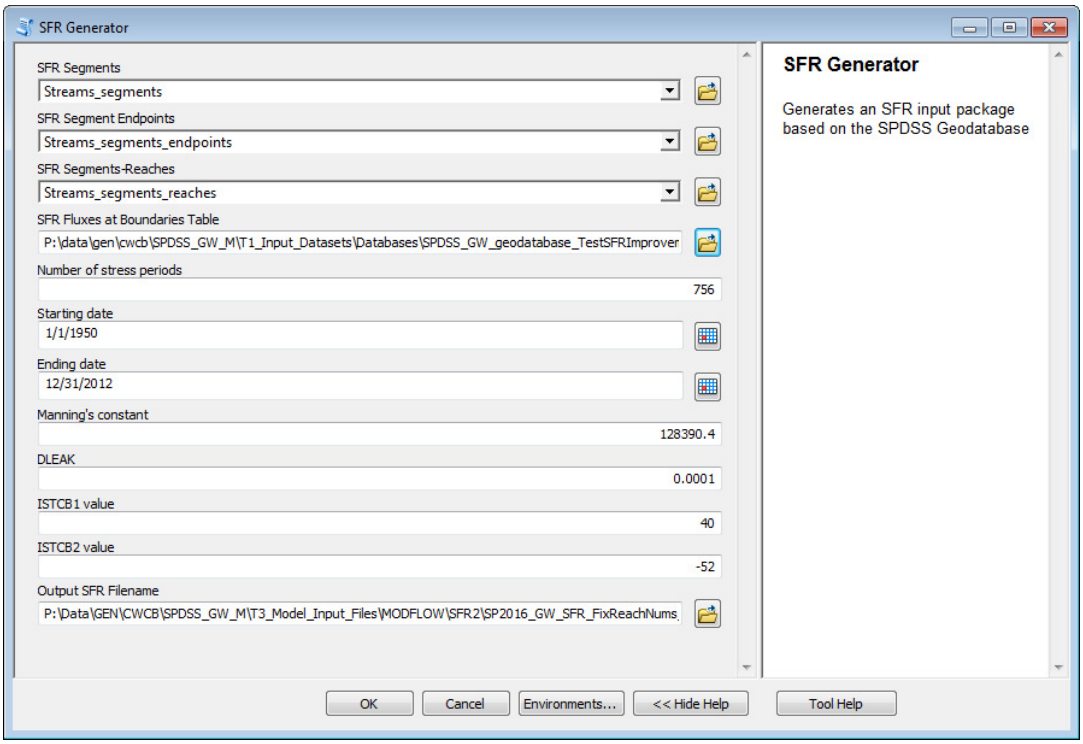


Figure 4-1. Example GUI to the SFR2 Generator DMI

The precipitation runoff processor "proc_runoff" DMI is a Fortran-based executable that reads values of precipitation runoff produced by the "proc_rainfall" DMI that processes precipitation into estimates of precipitation recharge and runoff (ungaged surface flow). The "proc_runoff" DMI reads in both the runoff estimates and the SFR2 input file produced by the SFR2 Generator, and then writes a new SFR2 input file that includes the runoff estimates to streams in SFR2. The "proc_runoff" DMI was updated to add the runoff estimates to the SFR2 "RUNOFF" input variable for each stream segment rather than the "FLOW" variable. The SFR2 "FLOW" input variable is intended to be used for inflow or outflow to or from a stream, such as discharges to the stream from a WWTP or water piped out of a stream for use (Niswonger and Prudic 2005). The SFR2 "RUNOFF" input variable is intended to be used for diffuse runoff (ungaged surface flow) entering a stream (Niswonger and Prudic 2005). The previous "proc_runoff" DMI added the precipitation runoff estimates to the "FLOW" input variable for stream segments including those streams with WWTP discharges or other inflows. This commingling of stream inflows and runoff did not allow the user to easily read and check that the correct inflow and runoff values are present in the SFR2 input file. The updated methodology of adding the runoff values to the "RUNOFF" input variable allows the user to check the values in the input file as well as track the runoff in MODFLOW output files. Finally, the "proc_runoff" code was improved to use the same numeric formats and spacing as the updated SFR2 Generator in the final SFR2 input files to allow the user to more easily check the values that have been written.

4.2.3 Lateral Boundary Processor

The Lateral Boundary Processor is a Fortran-based DMI that accumulates the effects of recharge and pumping from locations outside but tributary to the active model domain. These accumulated fluxes are applied at the active model cell nearest to the location of the flux with a lag time approximated using an approach based on the Glover Method, similar to how timing of stream depletions from pumping are calculated in Colorado (Glover and Balmer 1954). To allow an estimation of lagged flows originating before the model simulation period, but entering the active domain during the

simulation period, the fluxes from the simulation period are used during a "warm-up" period. Following the convention from the initial modeling effort, this warm-up period length was set at 80 years. To fill the flux data for this 80-year period, the model simulation period (1950 to 2012) fluxes are read by the code. Because the 63-year length of the model simulation period is less than the warm-up period length, the code returns to the data from the beginning of the simulation period and continues from the beginning to finish filling the warm-up period with data.

The original Lateral Boundary Processor code required more than ten hours to process these flows for the updated model. After a review of the Fortran source code, several coding inefficiencies were found and improved. The previous version of the code contained several time-consuming instructions to read and write data between disk and memory that were unnecessary. The flow of the previous version of the code in looping through data and performing calculations was also inefficient. Several of these loops were combined or reordered in the updated code to improve efficiency. These updates to the Lateral Boundary Processor code resulted in the execution time being reduced from more than ten hours to approximately one hour, and testing of the updated code versus the previous code revealed that both produce equivalent final output.

4.3 Model Input File Generation

Following the aforementioned updates to DMIs and other tools, updated MODFLOW input files for the model were developed using the process described below.

StateDGI. A copy of the initial updated StateDGI database was populated using the CDSS Toolbox with GIS data that do not change through time with each irrigation snapshot (i.e., the model grid, canal locations, and land cover for phreatophyte vegetation). The resulting StateDGI database was copied to a separate directory for each irrigation snapshot, and then the CDSS Toolbox was employed to upload the GIS information of irrigated parcels and wells for each irrigation snapshot. Finally, the StateDGI database file for each irrigation snapshot was opened in Access, and input files for StatePP were generated using the StateDGI main menu.

StatePP. For the periods corresponding to each irrigation snapshot, two StatePP runs were made. First, StatePP was run to generate PSB-compatible MODFLOW input files for precipitation recharge, surface water irrigation return flow recharge, groundwater irrigation return flow recharge, canal seepage recharge, irrigation pumping, M&I pumping, and alfalfa ET. Input files were created in RCH format for precipitation and irrigation return flow recharge, while an input file was created in WEL format for canal seepage recharge because of the narrow spatial extent of canal seepage. Input files were created in WEL format for groundwater pumping, and an input file was created in ETS format for alfalfa. A second StatePP run was executed for each irrigation snapshot period to create an ETS input file for subirrigated meadow ET.

In addition to the two StatePP runs described above, a third StatePP was run for one year (1950) to create the ETS input file for phreatophyte vegetation ET, because the spatial distribution of phreatophyte vegetation is assumed to not change through time, and the estimated monthly ET rate factors are cycled through each year without changes. A Python script (CyclePhreatophyteET.py) was used to create a final phreatophyte vegetation ETS input file that extends the annual cycle of monthly ET rates through the entire simulation period of 1950 through 2012. Table 4-3 summarizes the StatePP processing runs.

Table 4-3. Summary of StatePP Processing Steps		
StatePP Run Type	Period(s)	Water Budget Components (MODFLOW Package Type)
1	All irrigation snapshots	Precipitation recharge (RCH) Surface water irrigation return flow recharge (RCH) Groundwater irrigation return flow recharge (RCH) Canal seepage recharge (WEL) Groundwater pumping for irrigation (WEL) Groundwater pumping for M&I (WEL) ET from alfalfa (ETS)
2	All irrigation snapshots	ET from meadow subirrigation (ETS)
3	1 year	ET from phreatophyte vegetation (ETS)

StatePP was run with the new control flags for employing PSB, canal seepage recharge in WEL format, RCH and ETS arrays in external binary format files to reduce file sizes, and the new methodology to allocate recharge correctly both spatially and volumetrically. The "cetid" flag to identify the vegetation type of each ETS input file uses "a" for alfalfa, "m" for subirrigated meadow, and "p" for phreatophyte vegetation. The value of "ispoffset" was set to correctly identify the initial MODFLOW stress period of each irrigation snapshot.

Following these StatePP runs, a Python script was written to combine the MODFLOW input files from each irrigation snapshot period to single input files that cover the entire simulation period of 1950 through 2012.

Lateral Boundary Processor. The Lateral Boundary Processor reads the flux values from the unconsolidated materials outside the active model grid from a single input file in RCH format for the entire simulation period. A Python script (mergeFluxes.py) was written that reads each final recharge and pumping input file generated by StatePP through the process previously described, sums the fluxes in each MODFLOW stress period, and then writes out the fluxes in RCH format. The updated Lateral Boundary Processor code was used with this flux input and the existing input files (e.g., list of model cells at the edge of the active model domain) from the initial modeling effort.

SFR2. The SFR2 input file was created using the updated SFR2 Generator ArcPy Python script, and precipitation runoff estimates were added using the "proc_runoff" DMI as previously described.

Bedrock, Reservoir Seepage, and Alluvial Underflow Fluxes. Because these fluxes are assumed to remain constant from the end of the initial modeling effort's simulated period, the MODFLOW flags to reuse data from the initial model's final stress period were extended through the end of 2012.

Augmentation Recharge and Pumping. Pumping for recharge and streamflow augmentation was extracted from HydroBase as described in the previous sections, and the DMI "recharge_aug_proc" was used to format the pumping rates into WEL format. Recharge applied in recharge ponds was extracted from HydroBase as described in the previous sections. To reduce input file size by using the WEL input format rather than the RCH input format, the DMI "recharge_aug_proc" was used to format these recharge rates into WEL format, instead of the "proc_recharge_areas" DMI that produces much larger RCH formatted files.

MODFLOW Upstream Weighting Flow Package (UPW). UPW of MODFLOW-NWT replaces the Layer Property Flow package (LPF) from previous versions of MODFLOW when using the Newton Solver

package (NWT). The input format of UPW is nearly identical to the format of the LPF input file (Niswonger et al. 2011). Minor updates were made to the UPW file used in the updated model:

- Layer inter-cell transmissivity terms are now calculated using harmonic mean rather than logarithmic mean (Goode and Appel 1992)
- The specific storage (Ss) and specific yield terms are now specified as constant values rather than as arrays for simplicity and to reduce input file size
- Hydraulic conductivity values are now referenced from an external text file with appropriate numeric format

Discretization File. The updated discretization file now references external text files for model layer top and bottom elevations with appropriate numeric formats, and stress period time discretization for monthly model stress periods for 2007–12 have been added.

Output Control Package. The keyword "COMPACT BUDGET" was added to Data Set 1 of the Output Control package input file to reduce the total size of the output cell-by-cell budget file, and output specifications for the model stress periods for 2007–12 were added.

NWT Solver File. The NWT solver replaces the MODFLOW Geometric Multigrid Solver package (GMG) with the Doherty method of handling dewatered model cells used in the initial model (Doherty 2001). The input parameters for NWT were selected through a combination of professional judgment and experimentation for model solution stability and speed as well as overall model mass balance results.

Name File. The Name File lists the references to all the input and output files to be used in a MODFLOW simulation including the Fortran file unit numbers. The Name File was updated to reference input files from the "inputfiles" subdirectory as specified in Section 5.2, below. The updated Name File now references multiple WEL, RCH, and ETS input files for use with PSB identifiers for each water balance component represented by the input file.

MODFLOW Basic Package (BAS). The BAS input file contents remain as they have been from the initial modeling effort, but some numeric formats have been updated.

MODFLOW Gage (GAGE) Package. The GAGE input file contents remain unchanged from the initial modeling effort.

4.4 Model Code Executable Updates

The updated model uses MODFLOW-NWT, a version of MODFLOW that uses the Newton method to solve nonlinear equations such as those governing unconfined groundwater flow (Niswonger et al. 2011). The initial model used MODFLOW-2000 with modifications that prevent drying of model cells by maintaining a minimal simulated saturated thickness and transmissivity (Harbaugh et al. 2000; Doherty 2001). The Newton-based solution method represents a much improved method of avoiding these numerical instabilities and oscillations because of model cell drying and rewetting through a more mathematically rigorous yet efficient solution procedure. Furthermore, the MODFLOW-NWT code is fully supported by USGS.

An additional modification was made to the MODFLOW-NWT executable used for the model through the incorporation of PSB. PSB was originally included with a specialized version of MODFLOW known as MODFLOW-CDSS that was developed by USGS for CWCB as part of the overall CDSS effort (Banta 2011). MODFLOW includes several different types of boundary condition packages such as WEL, RCH, and ETS. Using PSB, the simulated groundwater flows through each of these boundary condition package types is tracked separately by MODFLOW, but all flows within each boundary condition package type are combined during the simulation. PSB allows MODFLOW to use multiple

input files for each boundary condition package type and track the flows from the boundaries specified in each individual input file separately. In the model, several different water budget components are included in each MODFLOW boundary condition package type. For example, WEL input includes well pumping for agricultural irrigation, well pumping for M&I use, well pumping for streamflow augmentation, well pumping for recharge re-timing, lateral boundary flows, alluvial underflow into the model, and bedrock fluxes. Without PSB, it is difficult to assess the impact of each individual water budget component on model results because WEL aggegates all the fluxes into a single flux for each model cell. With PSB, the simulated water budget for WEL is separated out into each individual contributing component and is much easier to understand, evaluate, and check for correctness.

One minor issue in the MODFLOW-NWT code's UPW and NWT packages was found and resolved during the course of the model update effort. The issue is related to speed of the model solution rather than an appreciable difference in final model solution results. The problem is related to the calculation of the derivative of the smoothing function used for model cell-to-cell conductance terms (Niswonger et al. 2011). This issue was resolved in the modified MODFLOW-NWT executable used for the updated model. The code issue and proposed correction have been communicated to the USGS code author, and the USGS code author confirmed both the code issue and the resolution (Niswonger 2016). Both the USGS code author and BC tested the corrected MODFLOW-NWT code on several models and confirmed that model outputs change insignificantly, but that the corrected code solves models more quickly. The next USGS release version of MODFLOW-NWT will contain this corrected code (Niswonger 2016).

Section 5

Extended-Period Model Simulation and Calibration Updates

The updated transient model input files for the extended model simulation period of 1950 through 2012 were used to develop a base model for simulation. The following subsections describe the updates to the MODFLOW executable used for the model, the simulated water budget results, and the updated model calibration.

5.1 Model Execution

The updated model is executed in two stages. First, the warm-up period simulation is executed to balance pre-1950 component fluxes, and the final head output array is extracted to a separate file using the Python utility "ExtractHdsAtSP_TS.py." Second, the 1950 to 2012 simulation is executed using the final head output from the warm-up period as the initial heads.

Model files are stored in two separate directories. The "SP2016_GW_Final" directory contains the MODFLOW-NWT executable and the MODFLOW Name files for each simulation, and this directory is also where all model outputs will be written. The "inputfiles" directory contains all other MODFLOW input files. This directory structure separating input and output files serves to create clear demarcation between model inputs and outputs, is easier to navigate, reduces file sizes by not having multiple copies of input files, and will allow for clear and straightforward model-predictive-scenario execution in the future. The command line batch file "batchrun.bat" will perform all of these operations.

5.2 Simulated Water Budget

The simulated water budget for the updated model was tabulated and evaluated for the entire 1950 to 2012 simulation period for both groundwater and surface water components. Evaluation of the simulated water budget for groundwater components was streamlined and improved through the incorporation of PSB to track these components individually through MODFLOW itself. Table 5-1 below summarizes the average monthly and annual simulated groundwater flow budget components. While groundwater moving in and out of storage throughout the model domain is more than 400,000 acre-feet per year (ac-ft/yr) on average, the average annual net change in groundwater storage is approximately 53,000 ac-ft/yr of groundwater flow into groundwater sinks (e.g., wells, evapotranspiration) from storage. Note that for MODFLOW-based groundwater models, flow from groundwater storage (i.e., a lowering of the water table or potentiometric surface) is accounted as an inflow to the model because flows from groundwater storage satisfy the outflow at a groundwater sink (such as a well), which is then accounted for as an outflow from the model. The largest average annual simulated inflow to the alluvial aquifer system is from the lateral boundary inflows (approximately 500,000 ac-ft/yr), followed by recharge from both irrigation return flows (more than 400,000 ac-ft/yr for irrigation from surface water sources and 140,000 ac-ft/yr for irrigation from groundwater) and canal seepage (approximately 360,000 ac-ft/yr). The largest average annual simulated groundwater outflow is to the surface water system as stream gain (more than 1.3 million ac-ft/yr), followed by agricultural irrigation pumping (approximately 450,000 ac-

ft/yr). Appendix C of this report summarizes the simulated groundwater budget for each month of the entire model simulation period.

Table 5-2 below summarizes the average monthly and annual simulated surface water flow budget components. The largest simulated surface water inflow is stream gain from groundwater discharge as stream baseflow (more than 1.3 million ac-ft/yr), followed by the gaged stream inflows at the upper reaches of streams at the edge of the active groundwater model domain (slightly more than 800,000 ac-ft/yr). Note that after accounting for stream loss in those reaches where surface water is simulated to be flowing to the aquifer, the simulated net groundwater discharge to stream baseflow still averages slightly more than 1.0 million ac-ft/yr. The largest simulated average surface water outflows are to stream diversions (averaging over 1.6 million ac-ft/yr), followed by streamflow out of the model domain in the South Platte River below Julesburg (approximately 400,000 ac-ft/yr). Appendix D of this report summarizes the simulated surface water budget for each month of the entire model simulation period.

Table 5-1. Average Monthly and Annual Simulated Groundwater Budgets (ac-ft)

	Groundwater Flow Component	January	February	March	April	May	June	July	August	September	October	November	December	Average Annual	% of Total Inflow or Outflow
Inflow	Groundwater flow in from storage	38,551	32,147	29,870	15,601	15,758	37,067	61,125	53,219	46,104	43,138	48,006	43,209	463,794	19
	Stream loss to aquifer	22,086	19,849	23,064	28,579	36,569	34,029	29,097	27,434	24,105	23,301	20,234	21,538	309,886	13
	Precipitation recharge	1,402	1,424	3,606	12,221	19,530	16,106	15,818	12,864	9,422	7,391	2,318	1,538	103,639	4
	Surface water irrigation return flow recharge	2,325	2,107	2,942	18,450	55,105	71,879	95,784	83,897	47,458	20,148	3,451	2,371	405,918	17
	Groundwater irrigation return flow recharge	0	0	20	1,482	8,982	24,555	41,270	39,639	22,513	4,857	45	0	143,362	6
	Canal seepage recharge	11,116	11,802	15,334	20,950	41,393	55,664	61,153	53,557	34,893	23,991	17,537	13,832	361,223	15
	Recharge ponds	3,528	3,929	7,478	7,586	4,680	5,003	1,261	1,465	2,519	6,541	3,212	2,824	50,027	2
	Reservoir seepage recharge	2,658	2,422	2,658	2,572	2,658	2,572	2,658	2,658	2,572	2,658	2,572	2,658	31,314	1
	Alluvial underflow in	1,040	948	1,040	1,007	1,040	1,007	1,040	1,040	1,007	1,040	1,007	1,040	12,259	1
	Net bedrock flux	1,307	1,191	1,307	1,264	1,305	1,262	1,303	1,302	1,260	1,302	1,260	1,302	15,365	1
	Net lateral boundary flow	42,909	38,574	41,702	39,919	41,162	40,201	42,438	43,382	42,652	44,270	42,598	43,565	503,371	21
Outflow	Groundwater flow out to storage	16,219	13,155	17,022	33,458	73,004	72,283	59,712	38,070	18,400	26,726	23,416	18,680	410,145	17
	Alluvial underflow out below Julesburg	253	234	259	265	298	283	198	144	138	169	192	231	2,665	0
	Stream gain from aquifer	103,043	93,437	100,778	97,150	106,133	111,701	136,731	136,380	125,856	123,019	111,463	107,685	1,353,376	56
	Agricultural irrigation pumping	0	0	79	5,348	30,380	80,306	128,329	121,492	71,966	16,271	149	0	454,319	19
	M&I pumping	2,379	2,277	2,526	3,122	3,826	4,454	5,564	4,916	4,132	3,163	2,359	2,338	41,056	2
	Augmentation pumping	720	676	545	435	282	125	142	212	266	192	218	555	4,369	0
	Alfalfa ET	0	0	5	327	1,302	3,394	4,196	4,008	2,242	739	3	0	16,216	1
	Subirrigated meadow ET	0	0	13	358	784	1,815	2,763	2,730	2,100	1,118	16	0	11,698	0
	Phreatophyte ET	4,065	4,349	7,581	9,243	12,315	15,088	15,278	12,411	9,309	7,200	4,339	4,232	105,409	4
Total	Total in	126,922	114,394	129,020	149,631	228,182	289,344	352,946	320,457	234,505	178,638	142,240	133,877	2,400,157	100
	Total out	126,679	114,128	128,808	149,707	228,325	289,448	352,914	320,362	234,409	178,599	142,154	133,720	2,399,253	100
	In minus out	243	267	211	-75	-142	-104	32	95	97	39	85	157	904	N/A
	% mass balance error	0.19	0.23	0.16	-0.05	-0.06	-0.04	0.01	0.03	0.04	0.02	0.06	0.12	0.04	N/A

Table 5-2. Average Monthly and Annual Simulated Surface Water Budgets (ac-ft)

	Surface Water Flow Component	January	February	March	April	May	June	July	August	September	October	November	December	Average Annual	% of Total Inflow or Outflow
Inflow	Gaged surface water inflows	17,984	16,935	22,193	45,109	156,839	225,329	128,163	82,095	41,329	27,332	21,597	18,671	803,578	30
	Return flow and discharge inflows	14,097	12,886	14,601	16,264	19,279	20,010	28,645	30,898	22,310	16,932	13,559	13,667	223,149	8
	Ungaged surface water inflows	5,868	6,468	14,783	36,969	54,742	43,217	42,208	35,878	26,762	21,593	9,581	6,462	304,532	11
	Stream gain from aquifer	103,043	93,437	100,778	97,150	106,133	111,701	136,731	136,380	125,856	123,019	111,463	107,685	1,353,376	50
Outflow	Physical diversions	54,106	55,394	70,734	93,169	189,300	259,809	272,082	231,540	155,139	120,290	90,922	68,169	1,660,655	62
	Net flow change at selected tributary mouth gages	23,963	20,466	24,279	28,439	26,114	23,002	13,870	13,793	24,376	28,347	25,598	24,257	276,502	10
	Ungaged diversions	1,619	1,678	2,583	5,755	9,995	4,495	2,452	2,170	1,594	1,726	1,793	1,686	37,546	1
	Stream loss to aquifer	22,086	19,849	23,064	28,579	36,569	34,029	29,097	27,434	24,105	23,301	20,234	21,538	309,886	12
	Streamflow out below Julesburg	39,873	32,760	31,864	38,518	70,896	74,943	20,408	12,162	12,337	16,600	18,915	31,853	401,128	15
Totals	Total in	140,991	129,727	152,356	195,493	336,993	400,257	335,747	285,251	216,257	188,877	156,200	146,485	2,684,634	100
	Total out	141,646	130,148	152,524	194,460	332,873	396,278	337,909	287,100	217,550	190,264	157,462	147,503	2,685,717	100
	In minus out	-655	-421	-168	1,033	4,120	3,979	-2,162	-1,848	-1,293	-1,387	-1,262	-1,019	-1,083	N/A
	% mass balance error	-0.46	-0.32	-0.11	0.53	1.23	1.00	-0.64	-0.65	-0.60	-0.73	-0.80	-0.69	-0.04	N/A

The mass balance errors of a model's simulated water budgets may indicate potential problems with the model solution or issues with model input or conceptual design. The overall mass balance error of a model should be less than 1 percent in all cases and approximately 0.5 percent or less in most cases (Anderson et al. 2015). Tables 5-1 and 5-2 above present simulated mass balances for groundwater and surface water averaged for each calendar month as well as averaged annually. Appendices D and E of this report present the simulated groundwater and surface water mass balances for each individual month and the total cumulative mass balance results. The total cumulative simulated groundwater mass balance error is 0.04 percent, and the groundwater mass balance errors are all less than 1 percent in each month. The total cumulative simulated surface water mass balance error is 0.03 percent. However, the surface water mass balance errors range from 0 to 3 percent in each month.

The likely explanation for the higher surface water simulated mass balance errors in some months is the transient nature of the flows in the model and the distance flows travel through the model domain such that surface water flows have not fully equilibrated by the end of each stress period. The low total cumulative mass balance error in the simulated surface water budget indicates a very reasonable overall simulated surface water mass balance error, as does the fact that the cumulative mass balance errors remain under 0.1 percent after the third year of simulation.

Two types of model input demands for water are subject to the simulated availability of water in the model. First, streamflow diversions are limited to the amount of streamflow simulated by SFR2 (Niswonger and Prudic 2005). Second, the MODFLOW-NWT code reduces pumping from WEL at model cells where the simulated water level drops such that the simulated saturated thickness is a small fraction of the total model thickness (Niswonger et al. 2011). In both cases, where the input demand for diversion or pumping is greater than the water simulated to be available, the model will simulate removal only of that available water.

Figure 5-1 below shows the percentage of streamflow diversion demand simulated to be met each year of the extended simulation period, and Figure 5-2 shows only 1999 through 2005 for comparison to the CDM 2013 Report Figure 4-32 (CDM 2013). The percentages of diversions met are generally lower in non-irrigation months when both streamflow and diversion rates are low. Because the overall diversion demand is low during these months, a small amount of diversion demand not being met at one location may lead to a lower percentage of diversion demand being met. On an annual basis, the model meets diversion demands at 95 percent or more each year (Figure 5-1).

Table 5-3 below presents volumes of average monthly diversion demand and diversions simulated by the model, showing that the non-irrigation season months have the lowest percentages of diversion demands met by the model while the irrigation season months of April through October have the highest percentages of diversions met. Overall, 98 percent of the input streamflow diversion demand volume is met by the model for the 1950 through 2012 simulation period.

Figure 5-3 below shows the percentage of agricultural irrigation groundwater pumping input demand that is satisfied by the model annually for the entire simulation period. The percentage of demand met by the model is nearly 100 percent in the early portion of the model simulation period, but declines slightly from the 1950s through the mid-1970s, and then generally stabilizes. Over the entire simulation period, 97.6 percent of the input groundwater irrigation demand volume is satisfied by the model. In comparison, the initial model calibration effort required manually reducing agricultural irrigation pumping to 80 percent of the StateCU demand estimates (CDM 2013).

Figure 5-4 below shows the percentage of M&I groundwater pumping input demand that is satisfied by the model annually for the entire simulation period. Over the entire simulation period, 95.6

percent of the input groundwater irrigation demand volume is satisfied by the model. During the 1950 through 2012 simulation period, 99.8 percent of the augmentation pumping demand is met by the model.

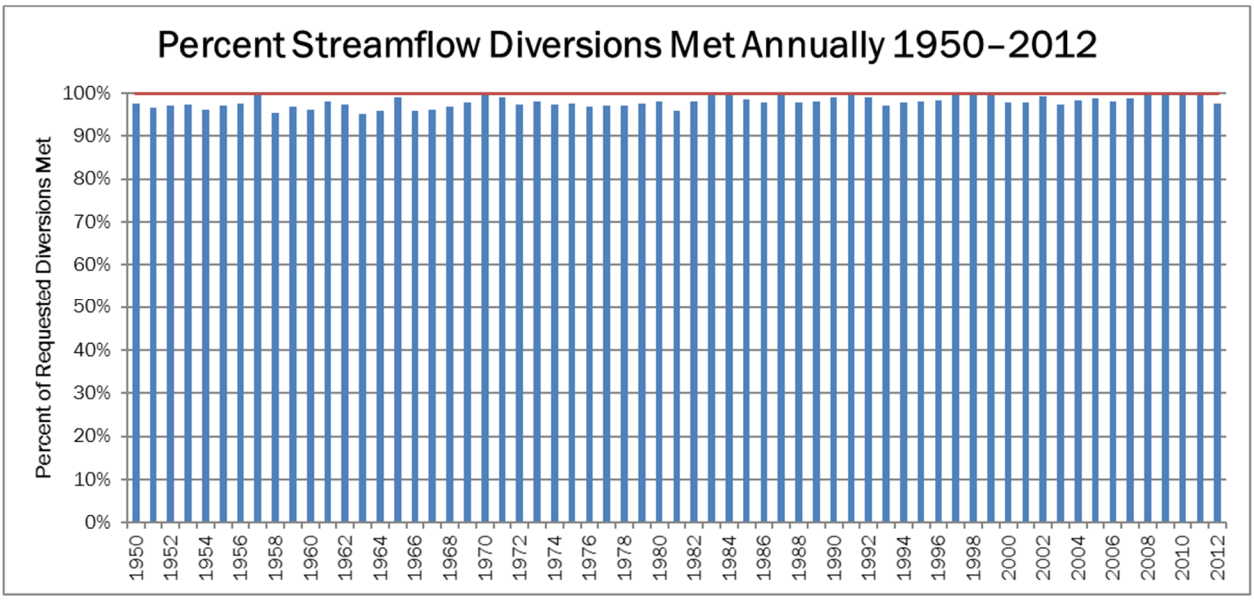


Figure 5-1. Percentage of Streamflow Diversions Met Annually by Updated Model 1950–2012

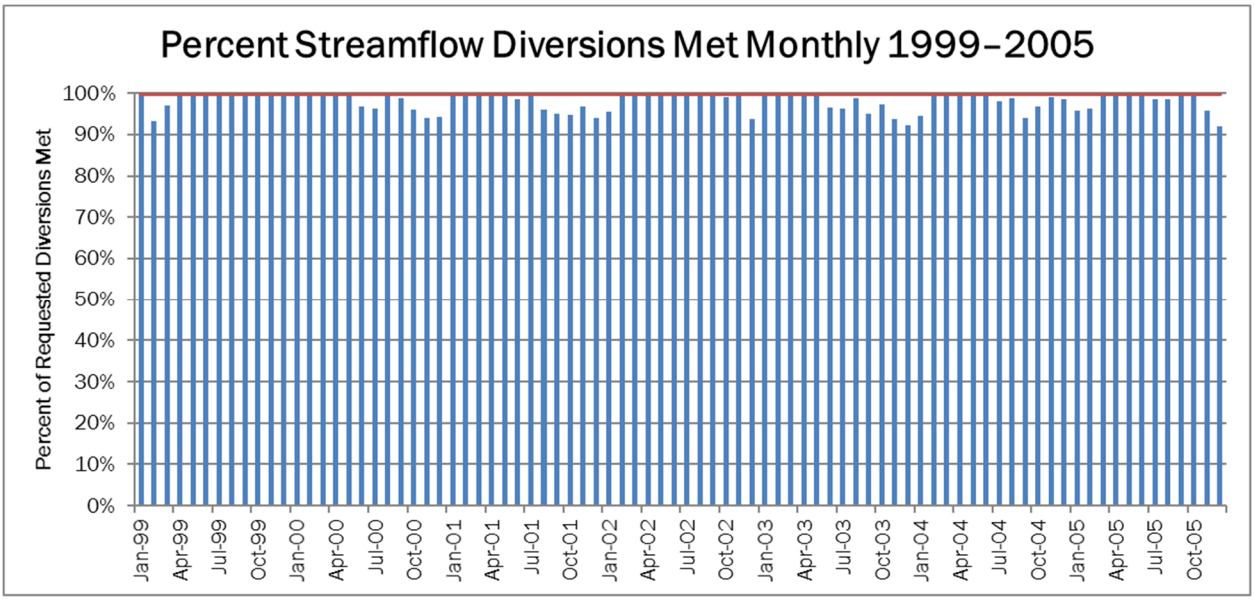


Figure 5-2. Percentage of Streamflow Diversions Met Monthly by Updated Model 1999–2005

Table 5-3. Summary of Streamflow Diversion Demand and Simulated Diversions			
Month	Average Diversion Demand (ac-ft/mo)	Average Simulated Diversions (ac-ft/mo)	% Diversion Demand Simulated to Be Met
January	58,063	54,106	93.2
February	58,554	55,394	94.6
March	74,157	70,734	95.4
April	93,580	93,169	99.6
May	189,482	189,300	99.9
June	261,356	259,809	99.4
July	274,988	272,082	98.9
August	235,117	231,540	98.5
September	156,524	155,139	99.1
October	123,822	120,290	97.1
November	95,481	90,922	95.2
December	73,129	68,169	93.2
Average annual	141,188	138,388	98.0

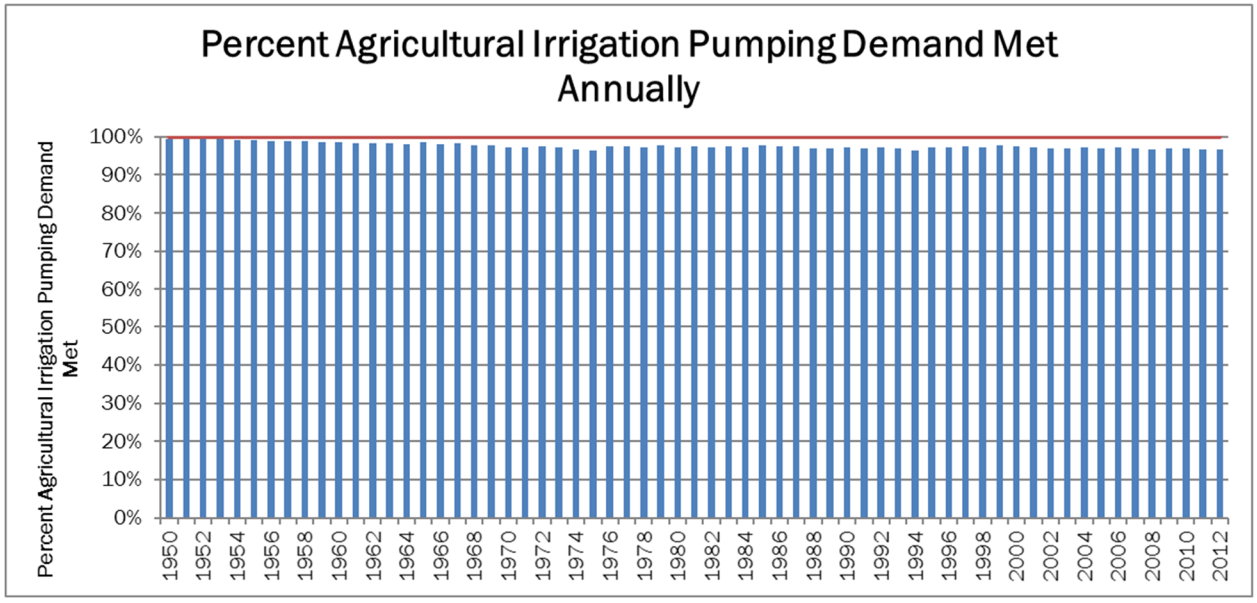


Figure 5-3. Percentage of Agricultural Irrigation Pumping Demand Met Annually

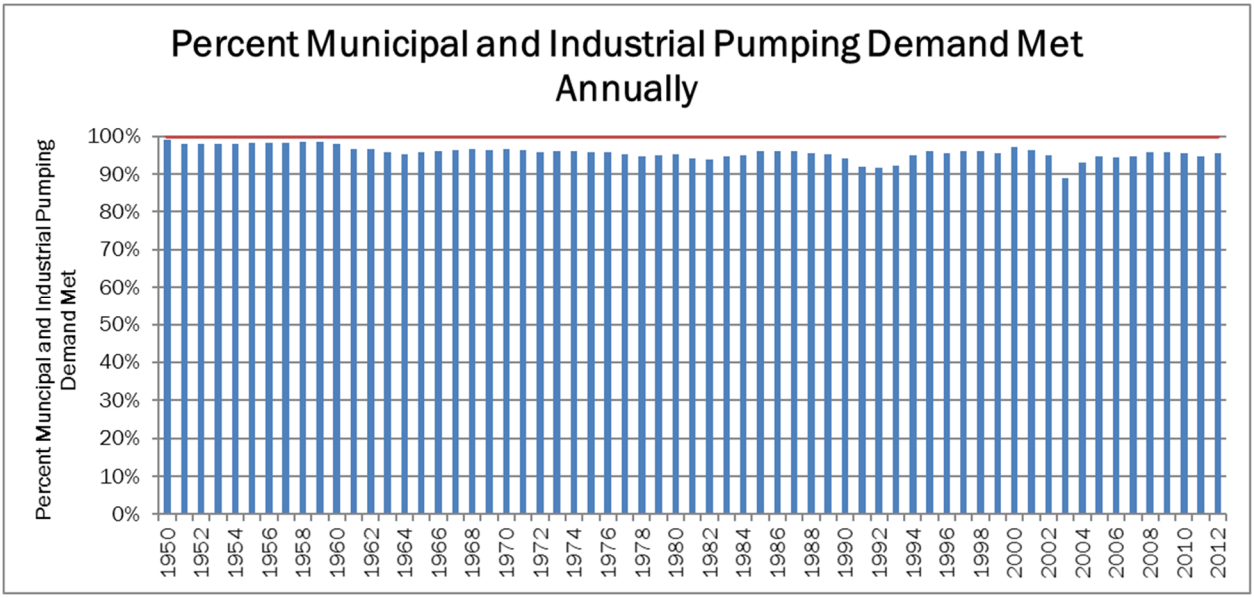


Figure 5-4. Percentage of M&I Pumping Demand Met Annually

5.3 Model Calibration

Model calibration is the process of adjusting model input parameters such that the model reasonably simulates field-measured values of surface flows and groundwater levels. The initial model effort performed limited model calibration on a steady-state version of the model, then more comprehensive calibration on the transient version for the 1999 to 2005 period, and finally a "validation" of the model's calibration for the 1950 to 2006 period. Because the primary objective of the model update effort was to update and extend the model simulation period, only limited additional calibration was performed during this effort. For the updated model effort, the simulated flows and groundwater levels were compared to field-measured values for the full extended 1950 to 2012 simulation period.

5.3.1 Model Input Changes

Several updates were made during the updated model calibration process. The primary calibration efforts focused on adjusting and updating the hydraulic conductivity values assigned to certain portions of the alluvial aquifer system based on additional information and hydrogeologic judgement. Additional activities undertaken as part of the model update also improved calibration. This section describes those updates to the model.

5.3.1.1 Hydraulic Conductivity

The model hydraulic conductivity values were modified in the following areas (see Figure 5-5):

- The vicinities of Gilcrest and Sterling based on information gleaned from evaluations of high water table conditions in these areas (BC 2015)
- Lost Creek Basin based on the calibrated hydraulic conductivity values from the USGS Lost Creek Designated Basin model (Arnold 2012)
- Model active domain margins where lower hydraulic conductivity values would be expected because of the presence of finer-grained alluvial deposits
- Areas showing large discrepancies between simulated and observed groundwater-level elevations

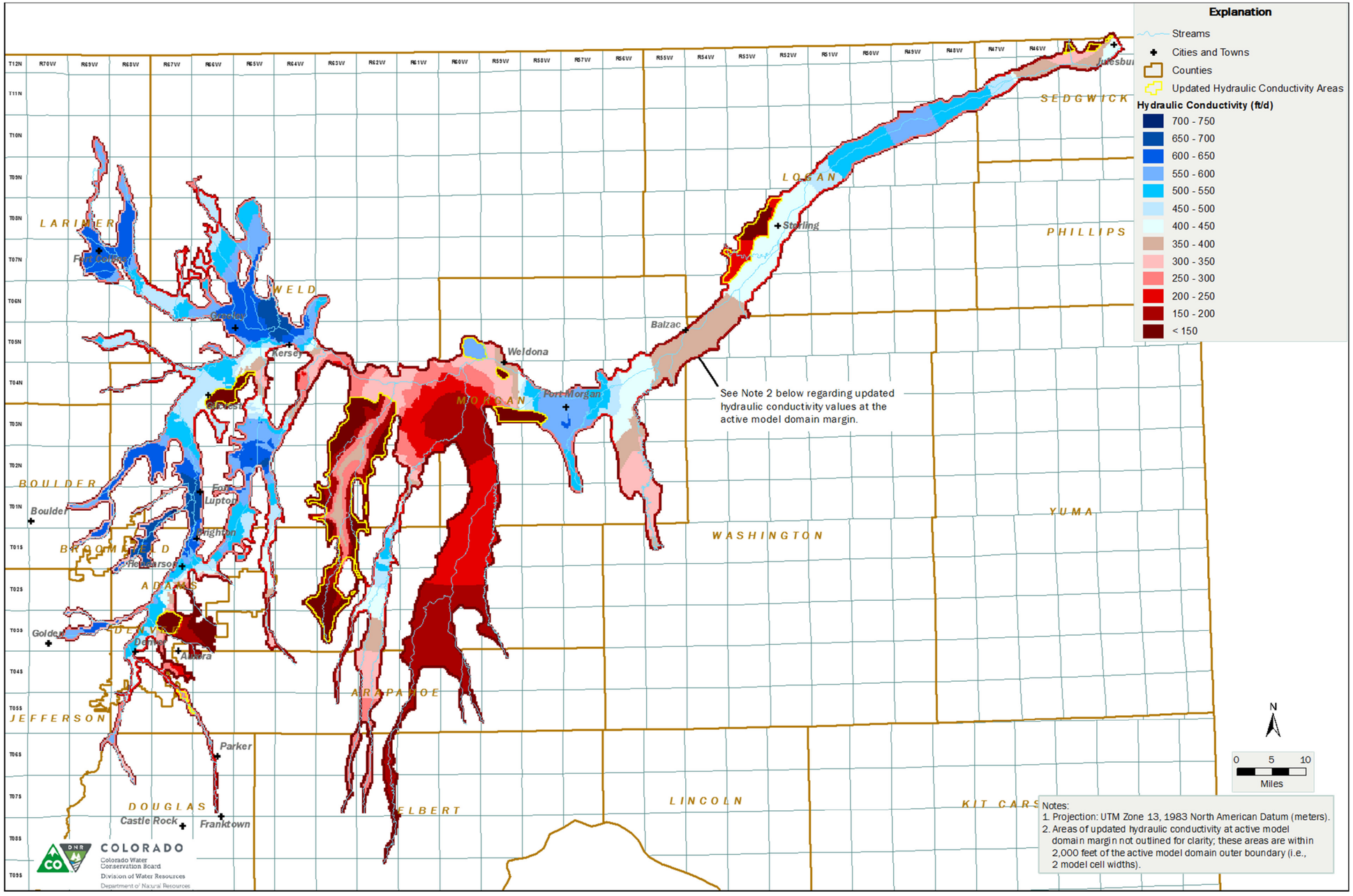


Figure 5-5. Updated Model Hydraulic Conductivity Distribution

5.3.1.2 SFR2 Updates

SFR2 was updated with minor fixes to the stream reach numbering (i.e., routing) of reaches in 4 (of the total 774) SFR2 segments and adjustments to stream top elevation values for some SFR2 segments based on observed groundwater levels in adjacent wells and updated USGS 1/3 arc-second resolution digital elevation models.

5.3.1.3 Municipal and Industrial Pumping

The groundwater pumping demand for M&I wells was reviewed and updated following the results of automated pumping reductions by the MODFLOW-NWT code during early model simulations. The input pumping demands at certain M&I wells have been reduced following review of well permits, available pumping records, well drilling logs, and other documentation as follows:

- Aurora: Wells 1, 2, 3, and 4 were drilled in July and August 1956; Wells 5 and 6 were drilled in December 1955, and Well 7 was drilled in August 1963. Pumping for each of these wells is now simulated to begin the month following the drilling of the well rather than January 1950. Further, after review of reported pumping rates for these wells 1990 through 2012, the estimated pumping rates for 1950-1989 have been reduced by 50 percent in the model inputs.
- COLO State W 4: Based on the well drilling log for the well, the well is screened in bedrock rather than alluvium, and pumping at this well was removed from the model.
- Klausner: A review of the well permits and decree for these wells indicates a total annual allocation of 145.3 ac-ft/yr rather than the 1,311 ac-ft/yr total pumping demand previously used in the model. The pumping rates for these wells have been adjusted to be 145.3 ac-ft/yr total with the same relative allocation of pumping among the four wells.
- Walker Well 3: A review of the well permit for this well indicates that it is an irrigation well, and this well is included in the DWR irrigation GIS data sets. As such, pumping demand for this well is appropriately simulated in the agricultural irrigation pumping demands, and this well was removed from the M&I pumping data sets.
- Wiggins Well 1: A review of the well permit for this well indicates that it was an agricultural irrigation well until 1994, when it was converted to municipal use. The annual appropriation for municipal use is 170.3 ac-ft/yr; therefore, starting in 1994, the simulated municipal pumping demand at this well is specified as 170.3 ac-ft/yr allocated evenly per month.

5.3.1.4 Additional Changes

Precipitation recharge in urban irrigated lands such as golf courses and parks is now assumed to follow the same pattern as precipitation recharge on agricultural irrigated lands. Previously, all urban land use GIS classifications were placed in a single category for precipitation processing.

The elevation of the bottom of the model (i.e., the bottom of alluvial materials) was adjusted upward in the area south of Gilcrest based on review of well logs and observed water levels.

Other model groundwater and surface water flow rates have changed because of updates in underlying data that feed into the model through the data-centered approach. Updates and improvements have been made to HydroBase, which provides streamflow, surface water diversion, climate, groundwater level, and other data to many of the inputs to the model through StateCU, StatePP, SFR2 Generator, and other DMIs. Also, DWR staff have performed updates and improvements to the irrigation snapshot GIS data sets, most notably improving the matching between irrigation wells and irrigated parcels, which in turn improves the estimated groundwater irrigation pumping rates and spatial distribution of applied irrigation water.

5.3.2 Groundwater-Level Calibration

Calibration of the model to observed groundwater levels was evaluated through both statistical and graphical assessments of simulated versus observed groundwater levels. As described in Section 2 above, the observed groundwater-level data set used for the model calibration evaluation was updated from the initial modeling effort to include additional wells, updated well datum surveyed elevations, and updates to well spatial locations. To compare the updated model calibration to the initial modeling effort calibration, standard statistics of groundwater-level residuals (observed values minus simulated values) have been calculated for the 1950 to 2006 period. These statistics have been calculated over the entire model domain for all updated observation well locations and for the subset of wells only with surveyed elevation data (see Table 5-4).

Table 5-4. Bulk Groundwater-Level Calibration Statistics Comparison to Initial Model, 1950–2006

Statistic	Surveyed Wells		Surveyed + Non-Surveyed Wells	
	Updated Model	Initial Model	Updated Model	Initial Model
Residual mean (ft)	0.30	-0.28	0.11	-1.89
Absolute residual mean (ft)	5.87	5.55	8.82	9.58
Residual standard deviation (ft)	8.28	8.33	13.01	14.88
Sum of squared errors (ft)	3.93E+05	3.98E+05	2.46E+06	3.27E+06
Root mean squared (RMS) error (ft)	8.28	8.34	13.01	15.00
Minimum residual (ft)	-25.14	-33.49	-55.28	-71.48
Maximum residual (ft)	39.77	38.57	55.12	74.38
Number of observations*	5,729	5,729	14,520	14,520
Range in observations (ft)	1906.19	1906.19	2268.23	2268.23
Scaled residual standard deviation (%)	0.43	0.44	0.57	0.66
Scaled absolute residual mean (%)	0.31	0.29	0.39	0.42
Scaled RMS error (%)	0.43	0.44	0.57	0.66
Scaled residual mean (%)	0.02	-0.01	0.00	-0.08

*Note: observations restricted to only those available for 1950-2006.

The residual mean is an indicator of whether the model is simulating water levels within the domain too high or too low on average, compared to the measured water levels. The updated model residual mean values are well within 1.0 foot for both the populations of all wells and surveyed wells only, indicating that the model is, on average, simulating water levels with virtually no bias toward higher or lower water levels for the 1950 to 2006 period. The absolute residual mean is an indicator of how well the model is matching measured values regardless of whether simulated values are higher or lower than the accompanying measured values. The updated model shows a very slight increase in the absolute residual mean for the surveyed wells, but an improvement in the absolute residual mean for the population of all wells. The residual standard deviation, sum of squared errors, and root mean squared error are measures of variability between the simulated and measured groundwater levels. Each of these statistics has improved for the updated model over the initial model. Scaling these statistics by the range in measured groundwater levels provides an indication of whether the discrepancies between the simulated and measured values are a small part of the overall model

response (Anderson and Woessner 1992). These scaled values are all less than 1 percent for both the initial and updated models, indicating that discrepancies between simulated and measured groundwater levels are a very small part of the model response.

The same suite of bulk calibration statistics was calculated for the updated model for the entire 1950 through 2012 simulation period, and these statistics are presented in Table 5-5 for both the population of surveyed observation wells and the population of all observation wells.

Table 5-5. Bulk Groundwater-Level Calibration Statistics for Updated Model 1950–2012

Statistic	Surveyed Wells	All Wells
Residual mean (ft)	0.80	0.80
Absolute residual mean (ft)	5.85	8.64
Residual standard deviation (ft)	8.53	12.84
Sum of squared errors (ft)	6.24E+05	3.03E+06
Root mean squared error (ft)	8.57	12.86
Minimum residual (ft)	-25.14	-55.28
Maximum residual (ft)	40.58	72.68
Number of observations	8,509	18,312
Range in observations (ft)	1,938.1	2,268.23
Scaled residual standard deviation (%)	0.44	0.57
Scaled absolute residual mean (%)	0.30	0.38
Scaled RMS error (%)	0.44	0.57
Scaled residual mean (%)	0.04	0.04

The residual mean values for the entire simulation period are within 1.0 foot, continuing to indicate very low bias toward simulating groundwater levels—on average either too low or too high. The absolute residual mean values for both observation well populations for the full 1950 to 2012 simulation period improved slightly compared to the initial 1950-2006 period. The statistics that are measures of variability between simulated and observed values increased slightly for the population of surveyed observation wells, but decreased slightly for the population of all observation wells. Overall, the bulk groundwater-level calibration statistics indicate that the updated model remains well calibrated to observed groundwater levels compared to both the initial model construct and the extended period of the updated model.

Graphical measures of groundwater model calibration to observed water levels include scatterplots of observed versus simulated groundwater-level elevations, maps of average groundwater-level residual value at each observation well location, and simulated versus observed hydrographs for transient models. Figure 5-6 below presents scatterplots of observed versus simulated groundwater elevations. A well-calibrated groundwater model should have the points of an observed versus simulated scatterplot cluster along the central line (dark black line of Figure 5-6), with the points

tightly clustering around the central line indicating a close match between observed and simulated values. The scatterplot points should also not consistently plot above or below the central line, indicating a lack of bias toward simulating groundwater levels higher or lower than the observed values.

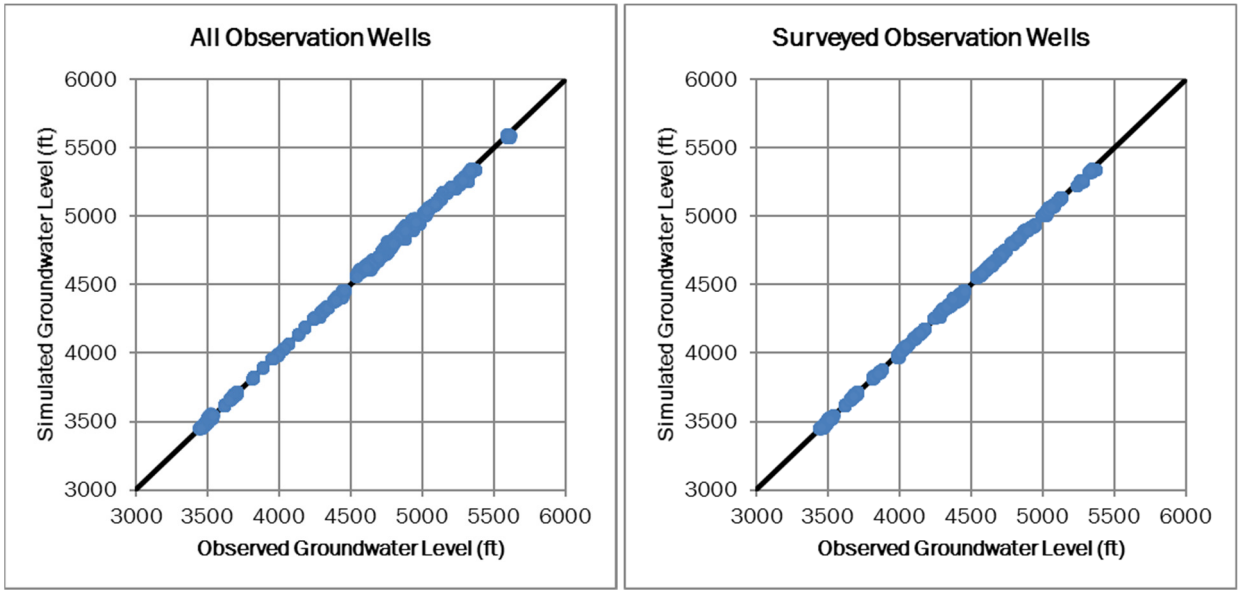


Figure 5-6. Observed vs. Simulated Groundwater-Elevation Scatterplots

Figure 5-7 below presents a map of average groundwater-level residuals at individual wells throughout the model domain. Figure 5-7 indicates that the updated model calibration has generally smaller positive and negative residuals and thus better calibration along the mainstem of the South Platte River, while larger positive and negative residuals occur along tributaries of the South Platte River, especially the designated groundwater basins to the east of Greeley and south of the river. Figure 5-8 shows a sample of observed versus simulated hydrographs, and Appendix E contains similar calibration groundwater-level hydrographs for all observation wells with 10 or more measured water levels. Overall, these measures demonstrate that the model is well calibrated to long-term observed groundwater levels.

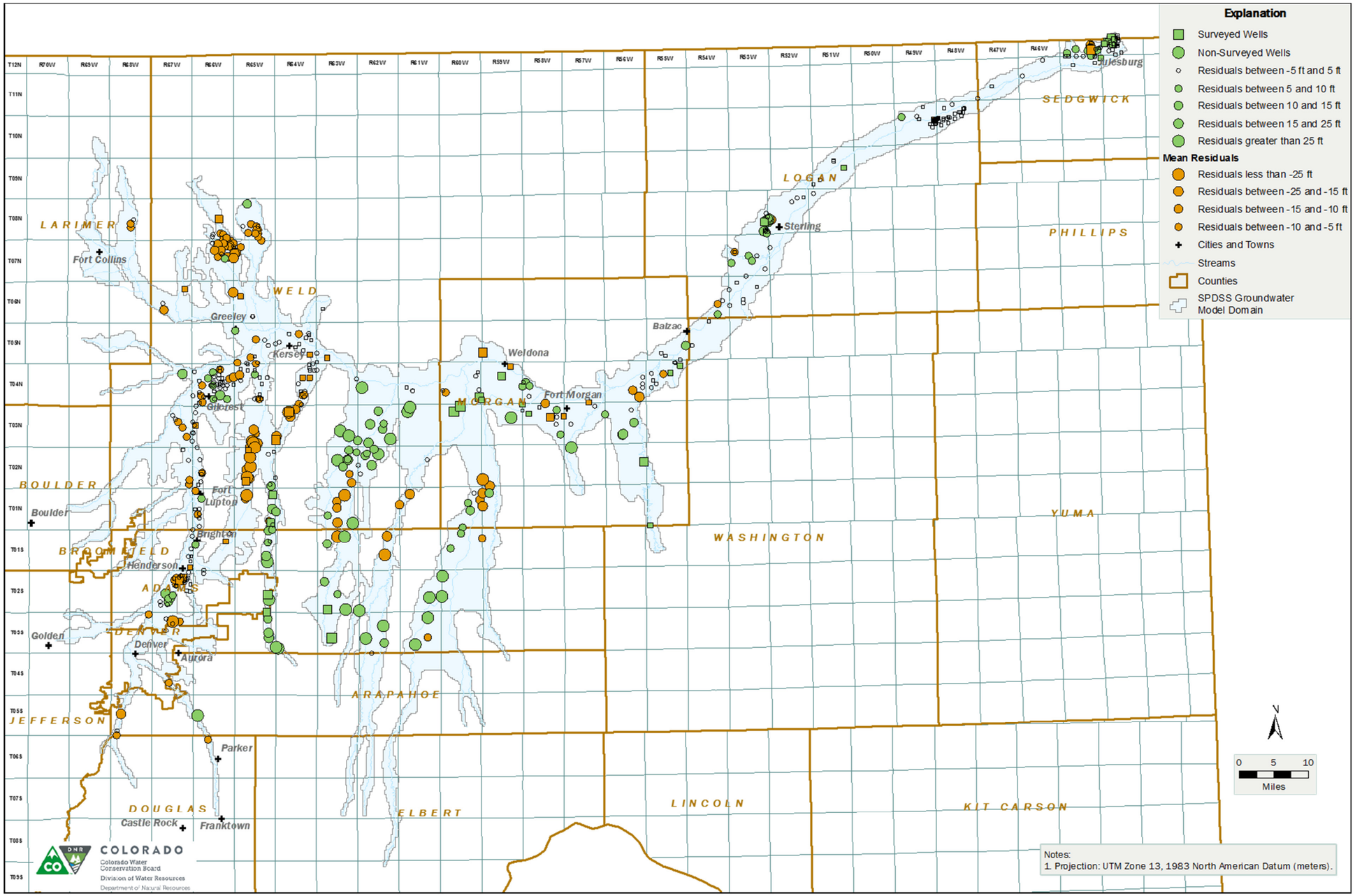


Figure 5-7. Mean Residuals at All Wells

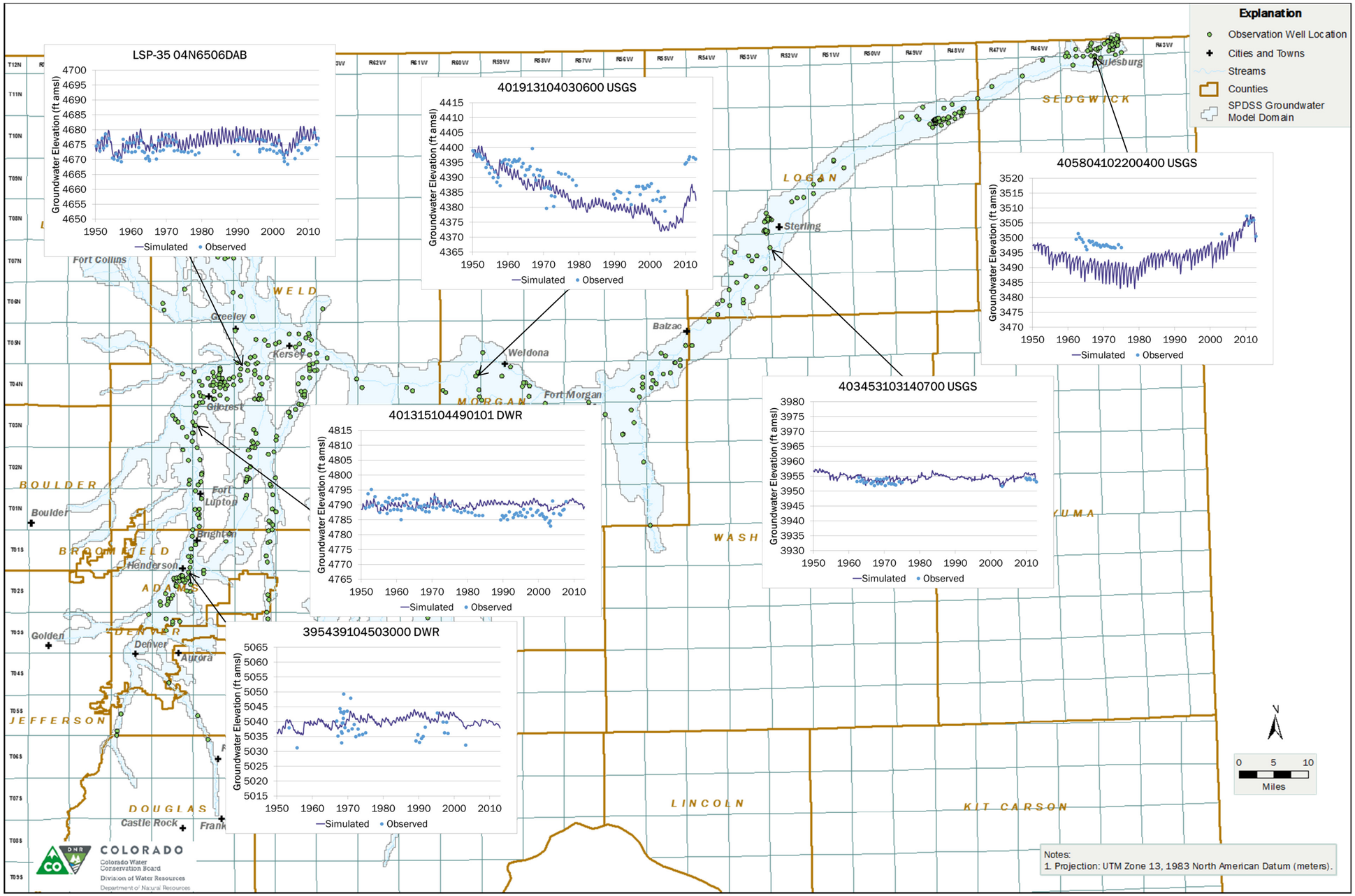


Figure 5-8. Sample Calibration Hydrographs

5.3.3 Streamflow Calibration

The model calculates streamflow within the domain and accounts for inflows, diversions, discharges, and simulation of stream gains/losses to and from the alluvial aquifer. Streamflows simulated by the model are compared to streamflow measurements at nine gages within the model domain:

- Cherry Creek at Denver
- South Platte River at Denver
- South Platte River at Henderson
- South Platte River at Fort Lupton
- Cache la Poudre River near Greeley
- South Platte River near Kersey
- South Platte River near Weldona
- South Platte River at Balzac
- South Platte River at Julesburg

Figure 5-9 compares the measured and simulated average annual streamflows at these stream gaging locations for the 1950 through 2012 simulation period. Similar to the initial modeling effort, average annual simulated streamflows from the updated model are significantly higher than those measured for Cherry Creek at Denver (75 percent higher than measured) and the Cache la Poudre at Greeley (99 percent higher than measured) (CDM 2013). The updated model is simulating average annual streamflows slightly higher than measured for the South Platte River at both Weldona (13 percent higher than measured) and Balzac (16 percent higher than measured). At the remaining five stream gaging locations, the simulated average annual streamflows are within 5% of the measured average values. Figures 5-10 through 5-18 present annual total streamflow volumes for each of the streamflow gaging locations. In general, the streamflows simulated in the updated model match measured streamflow values better at later times in the simulation period. This trend may be the result of improved accuracy in water-rights administration records during the later periods.

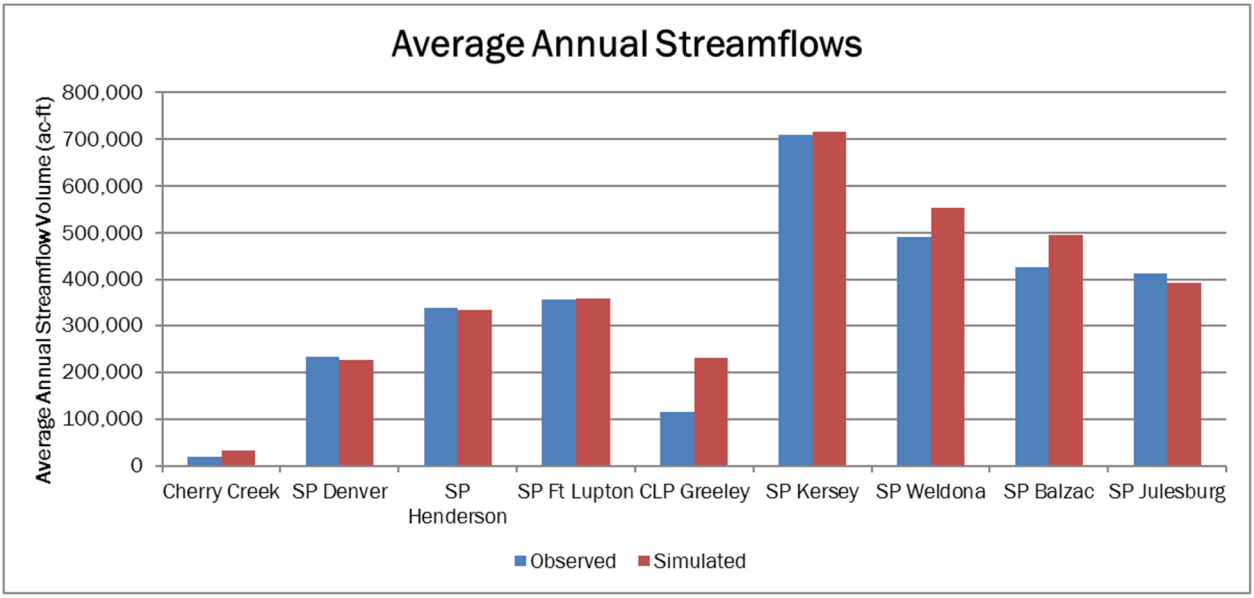


Figure 5-9. Comparison of Simulated and Measured Average Annual Streamflows

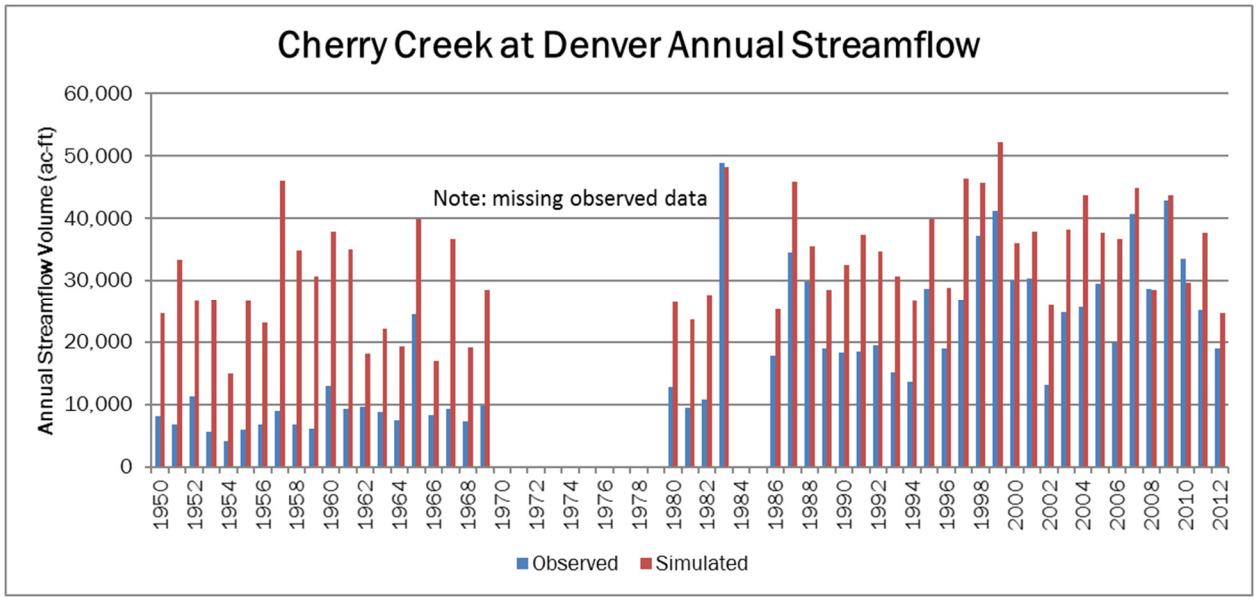


Figure 5-10. Simulated and Measured Annual Streamflow in Cherry Creek at Denver

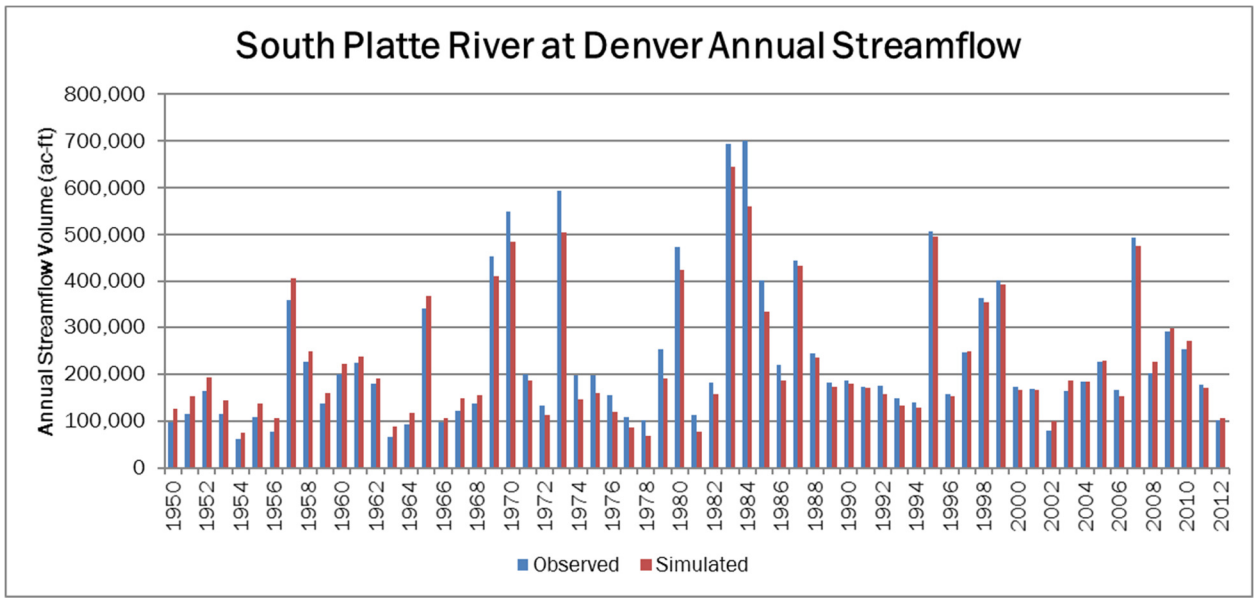


Figure 5-11. Simulated and Measured Annual Streamflow in the South Platte River at Denver

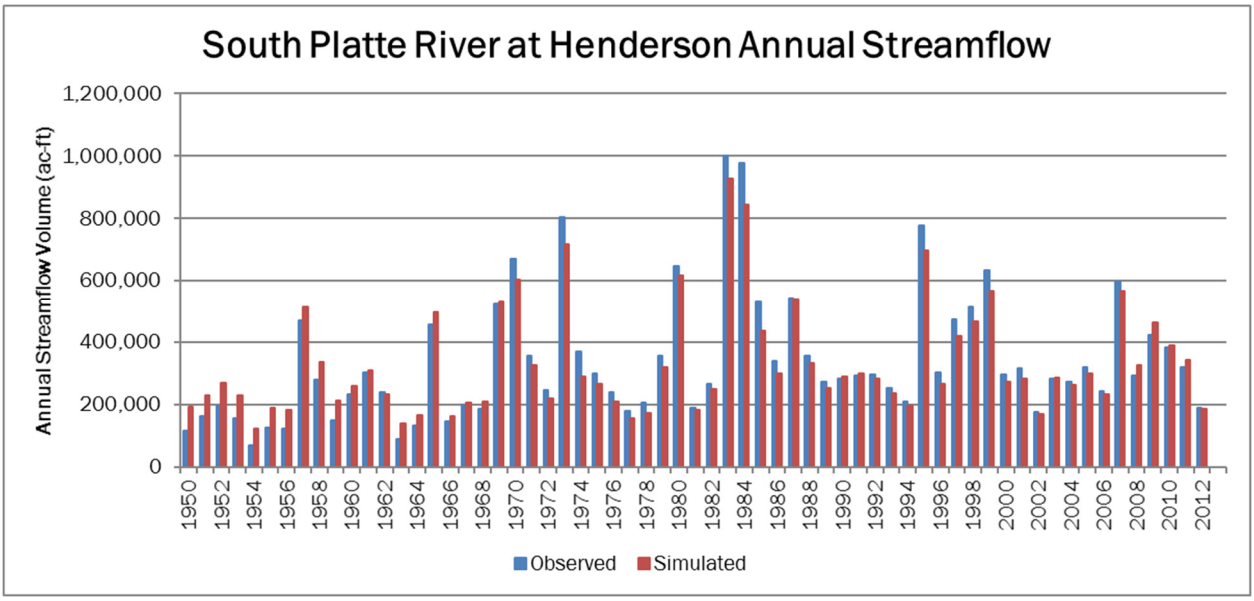


Figure 5-12. Simulated and Measured Annual Streamflow in the South Platte River at Henderson

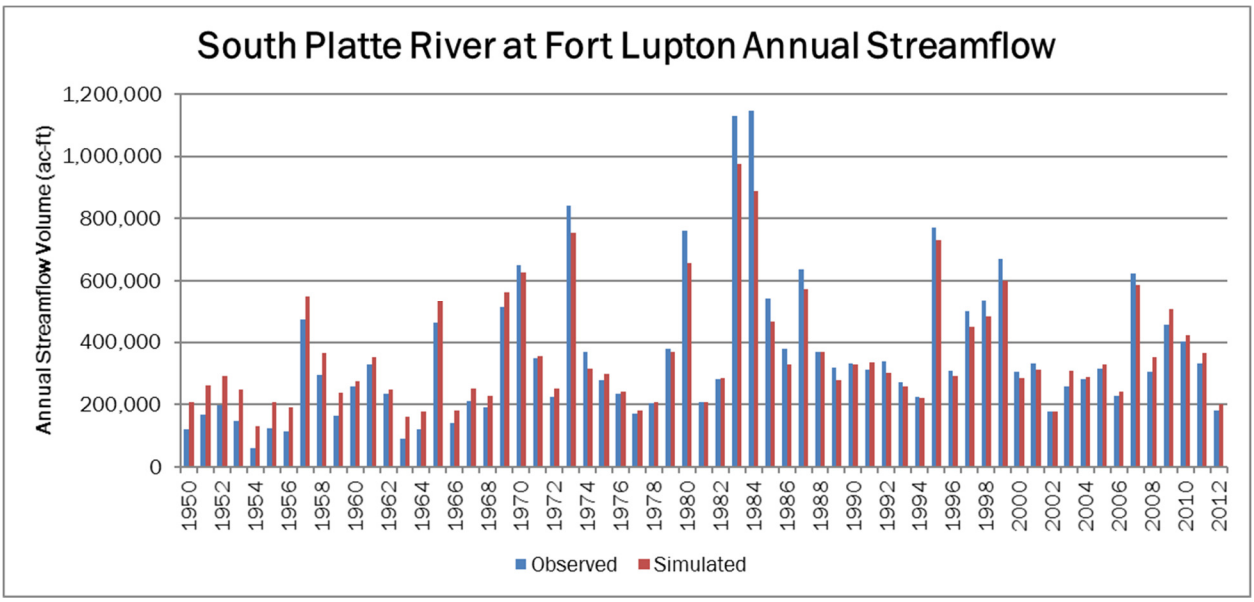


Figure 5-13. Simulated and Measured Annual Streamflow in the South Platte River at Fort Lupton

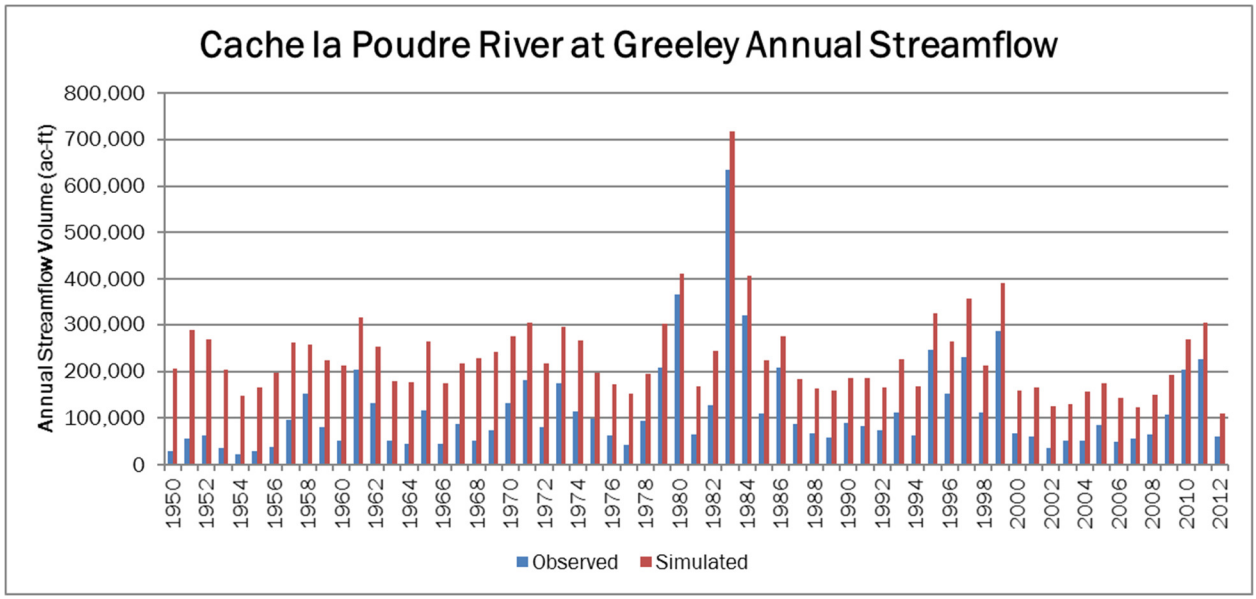


Figure 5-14. Simulated and Measured annual Streamflow in the Cache la Poudre River at Greeley

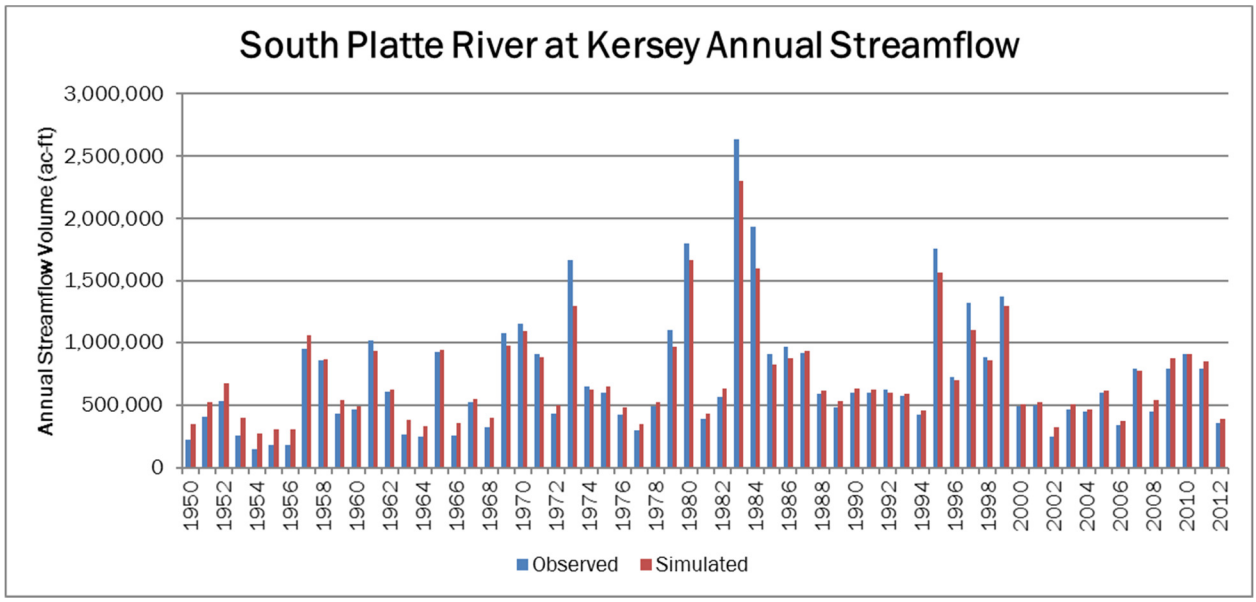


Figure 5-15. Simulated and Measured Annual Streamflow in the South Platte River at Kersey

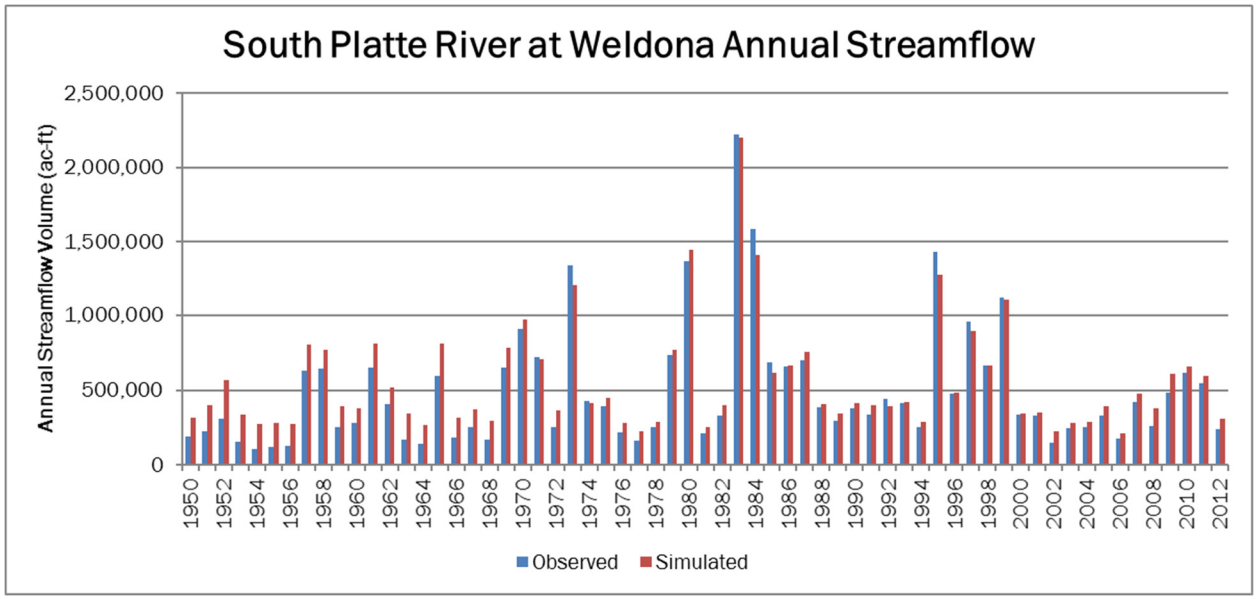


Figure 5-16. Simulated and Measured Annual Streamflow in the South Platte River at Weldona

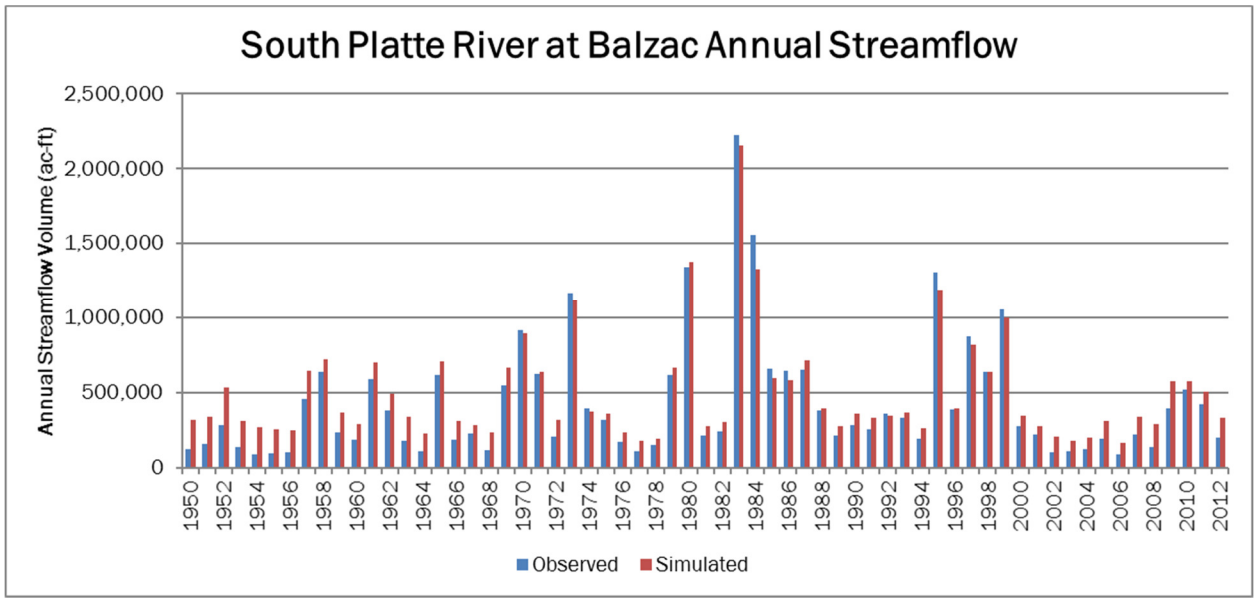


Figure 5-17. Simulated and Measured Annual Streamflow in the South Platte River at Balzac

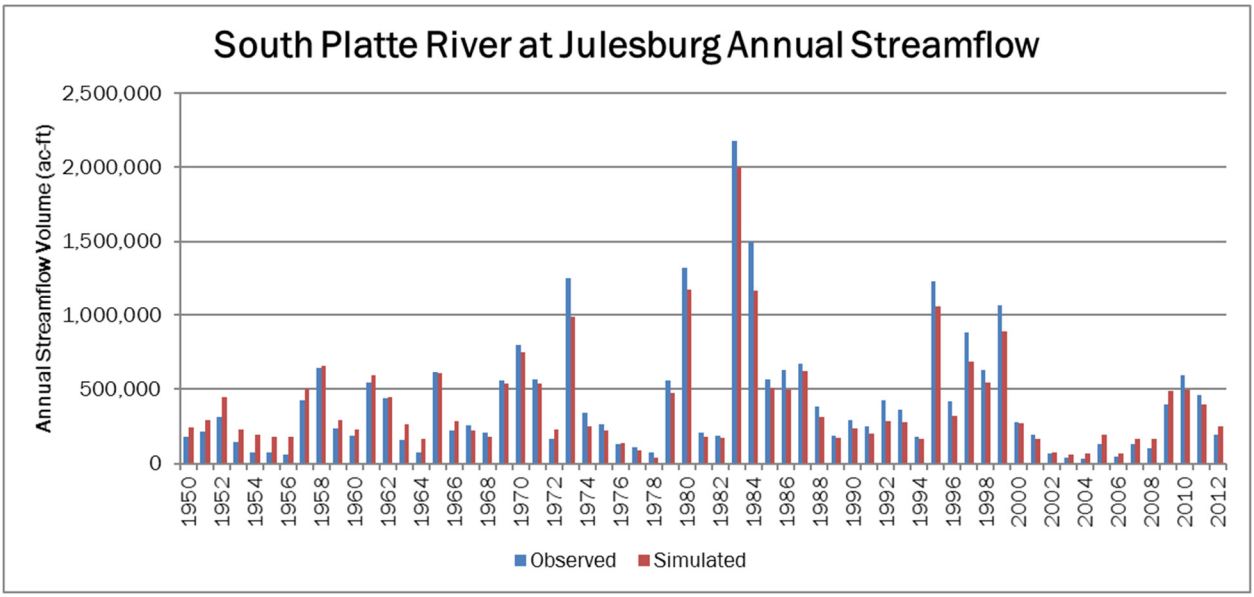


Figure 5-18. Simulated and Measured Annual Streamflow in the South Platte River at Julesburg

5.3.4 Stream Gain/Loss

Simulated stream gains/losses from and to the alluvial aquifer are compared to estimated values between the gages described in Section 5.3.3, above. In the absence of direct measurements of stream gains from groundwater and losses to groundwater, stream gain/loss may be estimated using a variety of mass balance approaches. These mass balance approaches involve subtracting the measured surface inflows to a given stream reach from the outflows from that reach, such that a positive mass balance is assumed to be the result of groundwater discharge to the stream and a negative mass balance is the result of stream loss to the underlying aquifer. As with the initial modeling effort, the "Pilot Point" water balance method was used to estimate stream gains/losses (CDM 2013; Capesius and Arnold 2012). The Pilot Point method as used for the model is based on a daily mass-balance approach in which extreme mass-balance values are subject to constraints on minimum and maximum stream gain/loss. Furthermore, the daily constrained mass-balance values are also smoothed using a moving-average approach with a moving average period of 15 days. Finally, monthly average stream-gain/loss estimates are calculated from the daily Pilot Point stream-gain/loss estimates, in order to compare with the model's monthly results.

As described in the initial model report, stream gains/losses are used as qualitative rather than quantitiative calibration parameters (CDM 2013). The inherent uncertainties in the estimation of actual stream gains/losses for the South Platte River and its tributaries make these estimates appropriate to be qualitative calibration parameters to be compared to the simulated values in terms of whether stream reaches are gaining or losing, the overall magnitude of stream gains/losses, and the seasonal patterns of stream gains/losses for reaches through time.

Figures 5-19 through 5-34 present hydrographs of the estimated and simulated monthly and cumulative stream gain/loss for the calibration reaches. Many of the simulated stream gain/loss reaches have less monthly and seasonal variation than the estimated values from the Pilot Point method while others (e.g., South Platte River between Fort Lupton and Kersey, Balzac, and Julesburg) show approximately the same magnitude of variations between estimated and simulated stream gain/loss. The updated model simulates Cherry Creek as a losing stream during most of the simulation period. Note that Cherry Creek Reservoir is not explicitly represented in the model, and this may partly explain discrepancies between the estimated and simulated stream gain/loss.

The Cache la Poudre River simulated stream gains are approximately 67% greater than those estimated by the Pilot Point method. The simulated stream gain/loss values along the South Platte River match reasonably well to the estimated values from the Pilot Point method. Of particular note is the excellent match between simulated and estimated streamflow stream gain-loss for the reach from Fort Lupton to Kersey.

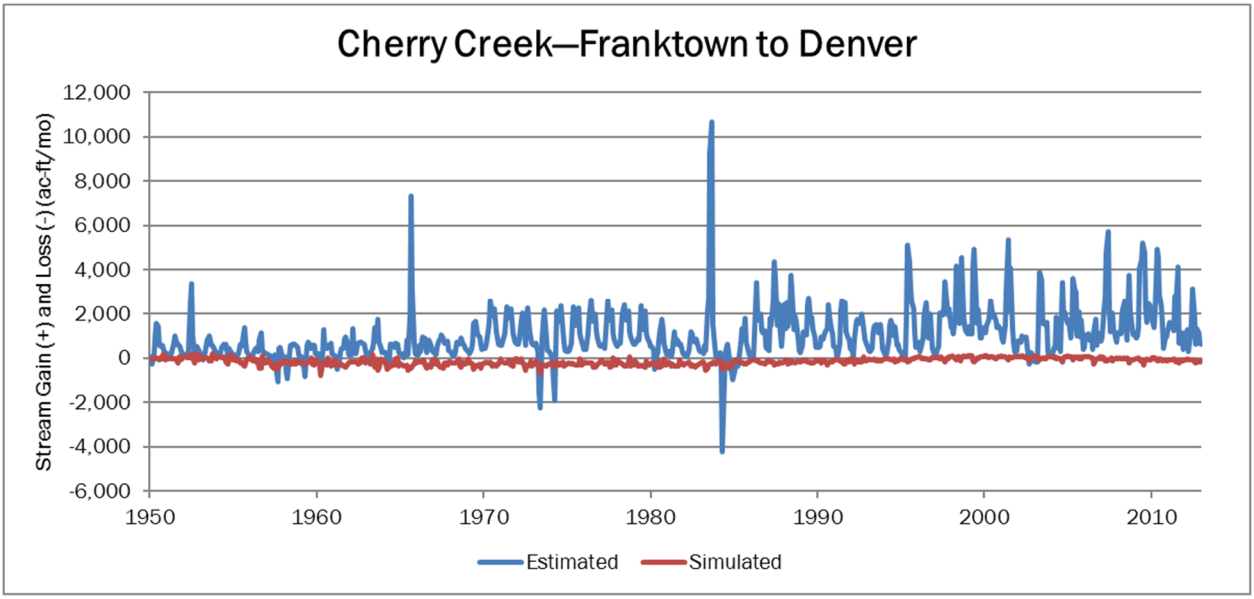


Figure 5-19. Simulated and Estimated Stream Gain/Loss, Cherry Creek Franktown to Denver

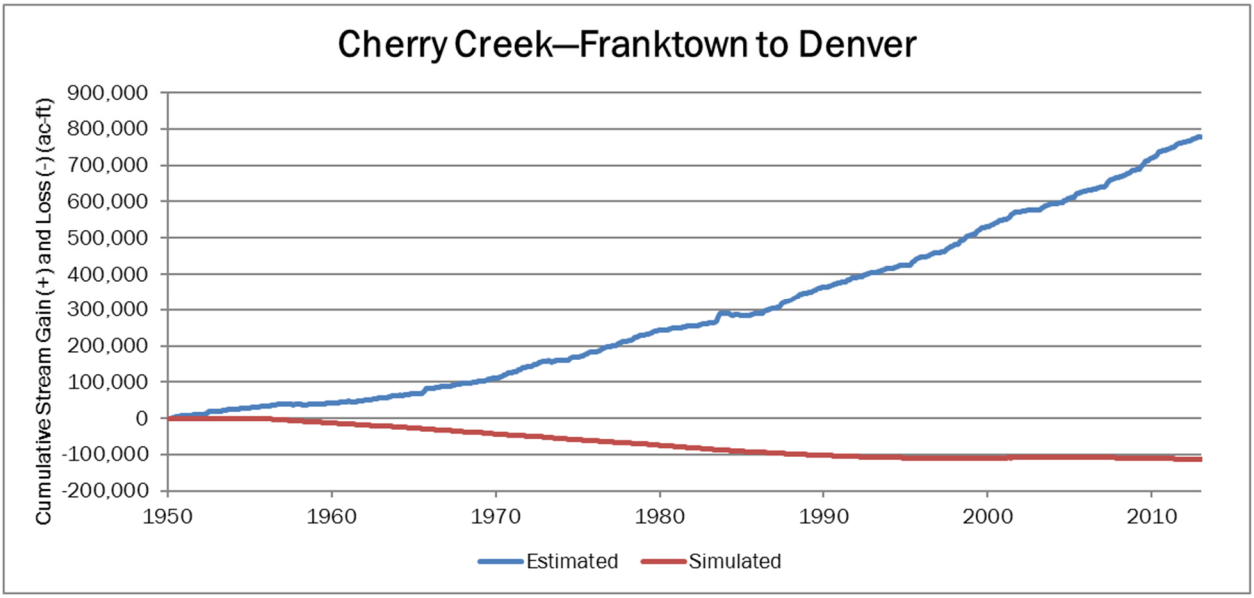


Figure 5-20. Simulated and Estimated Cumulative Stream Gain/Loss, Cherry Creek Franktown to Denver

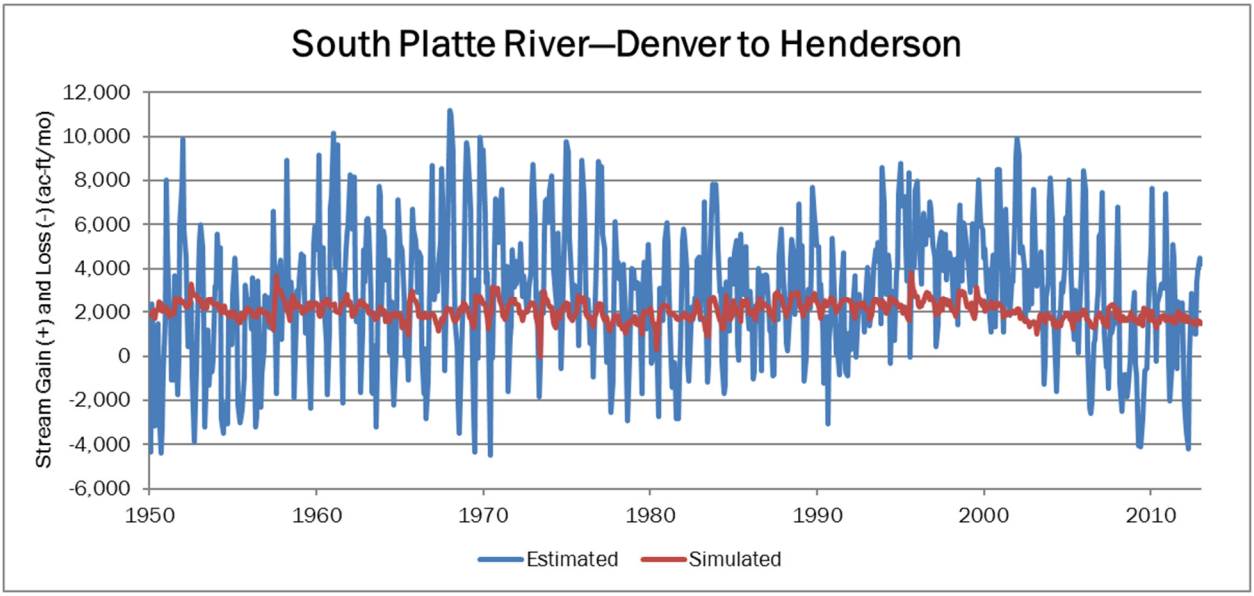


Figure 5-21. Simulated and Estimated Stream Gain/Loss, South Platte River Denver to Henderson

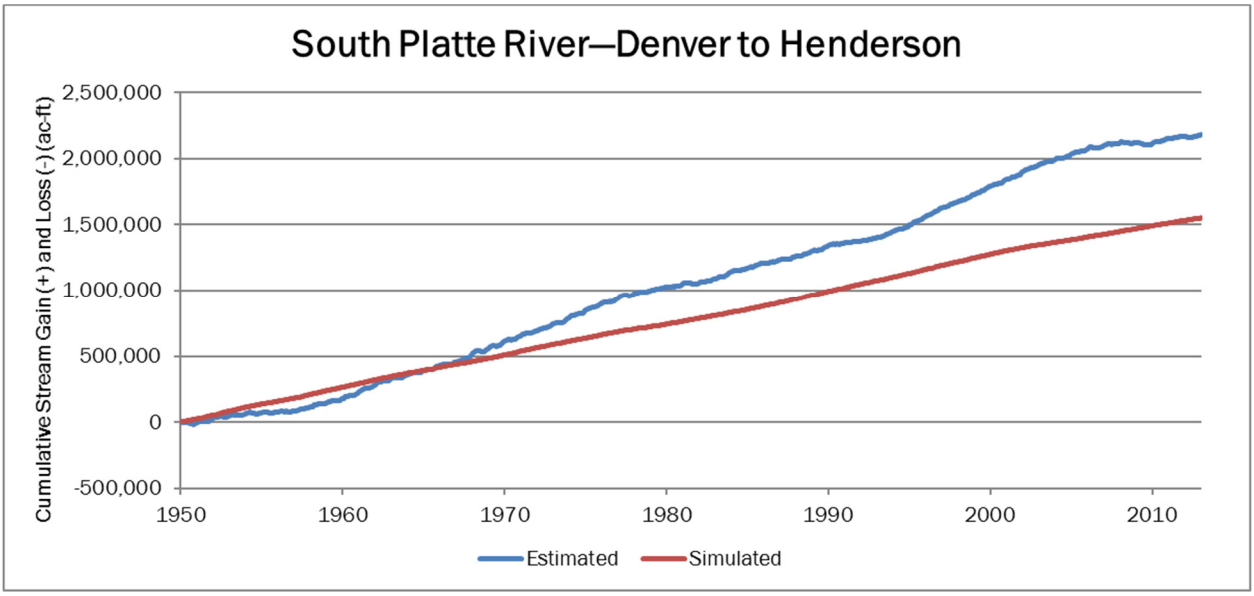


Figure 5-22. Simulated and Estimated Cumulative Stream Gain/Loss, South Platte River Denver to Henderson

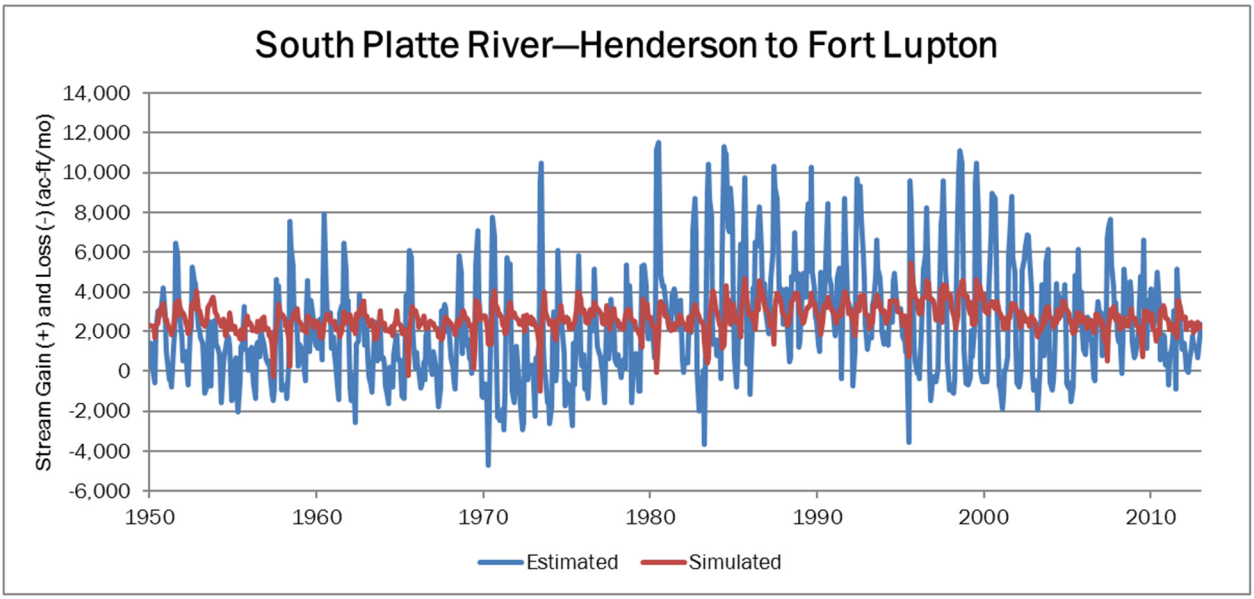


Figure 5-23. Simulated and Estimated Stream Gain/Loss, South Platte River Henderson to Fort Lupton

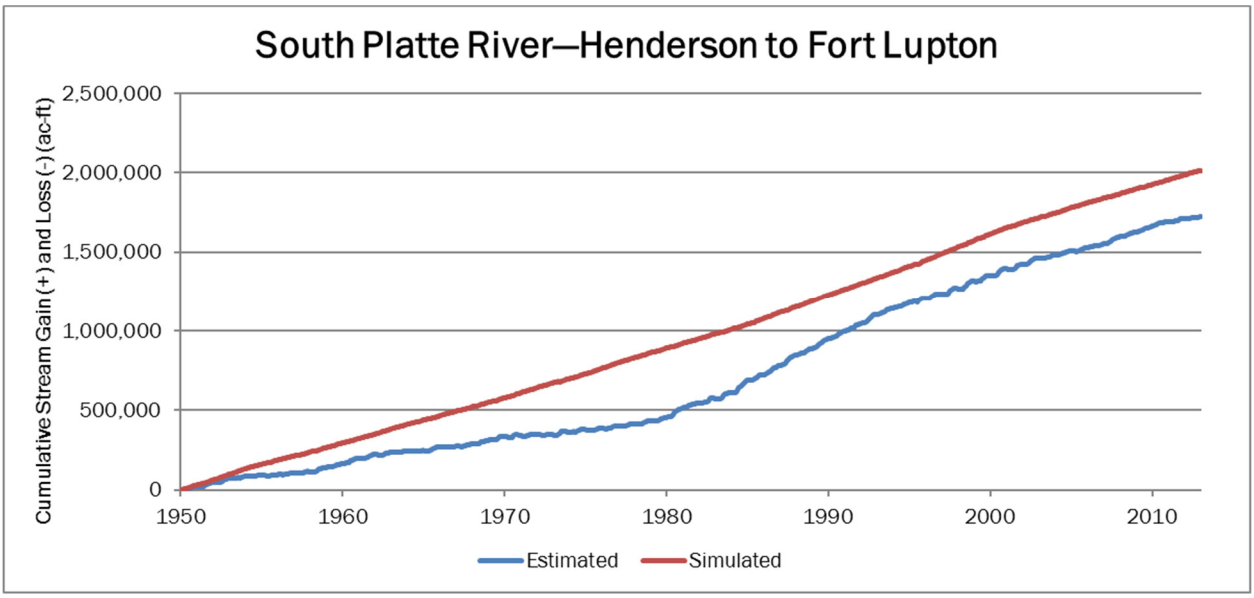


Figure 5-24. Simulated and Estimated Cumulative Stream Gain/Loss, South Platte River Henderson to Fort Lupton

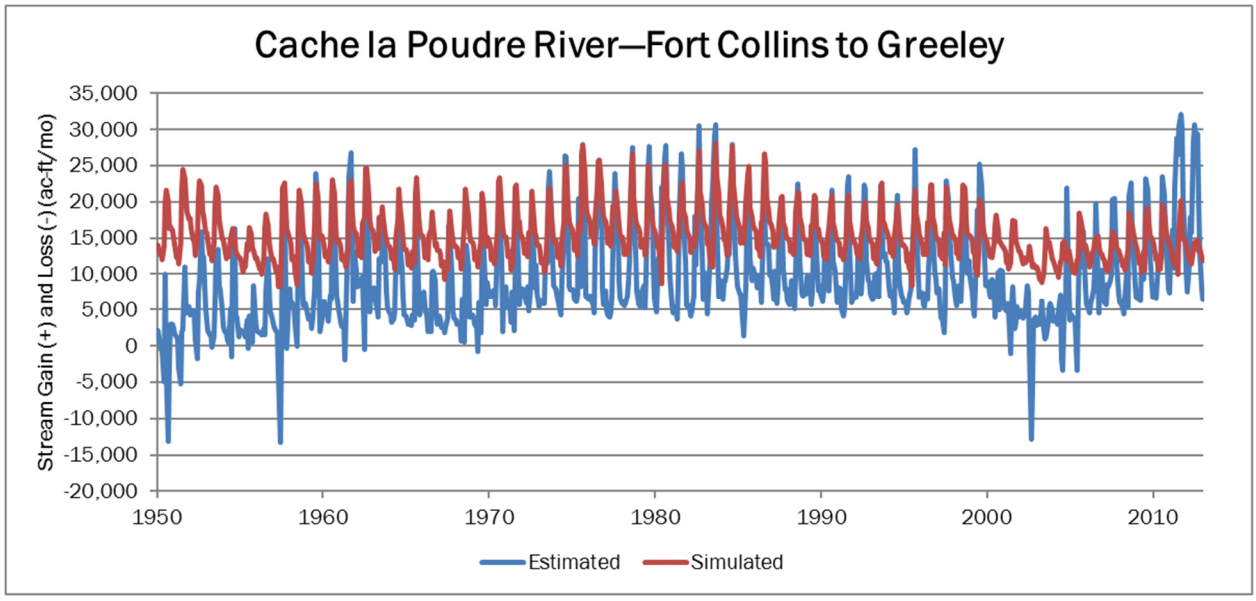


Figure 5-25. Simulated and Estimated Stream Gain/Loss, Cache la Poudre River Fort Collins to Greeley

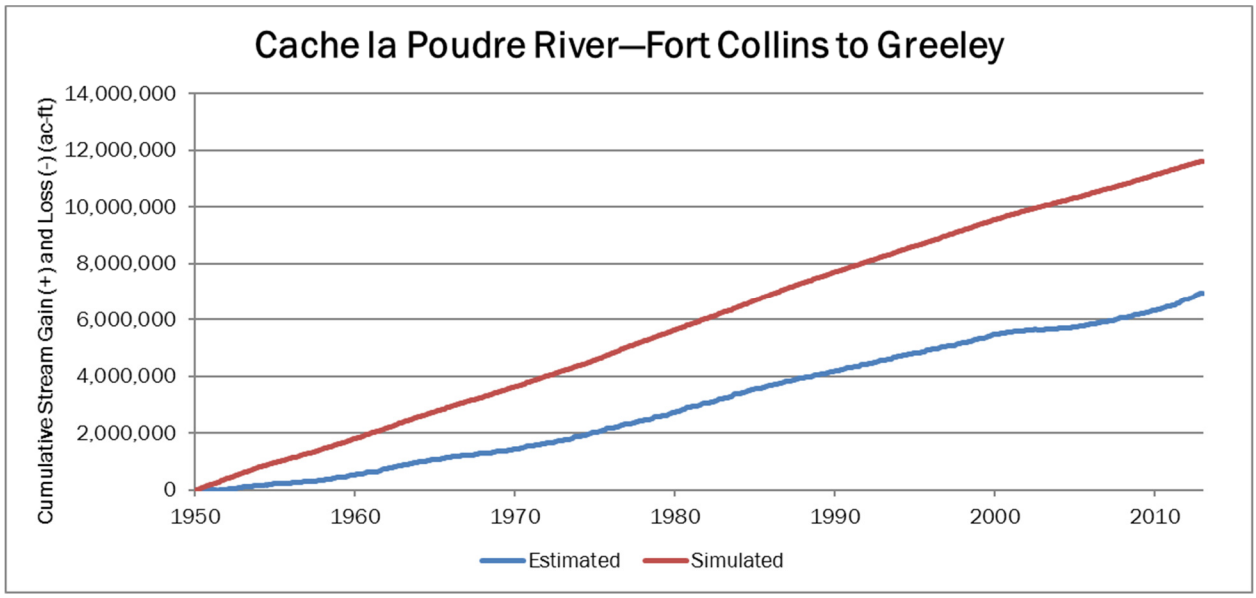


Figure 5-26. Simulated and Estimated Cumulative Stream Gain/Loss, Cache la Poudre River Fort Collins to Greeley

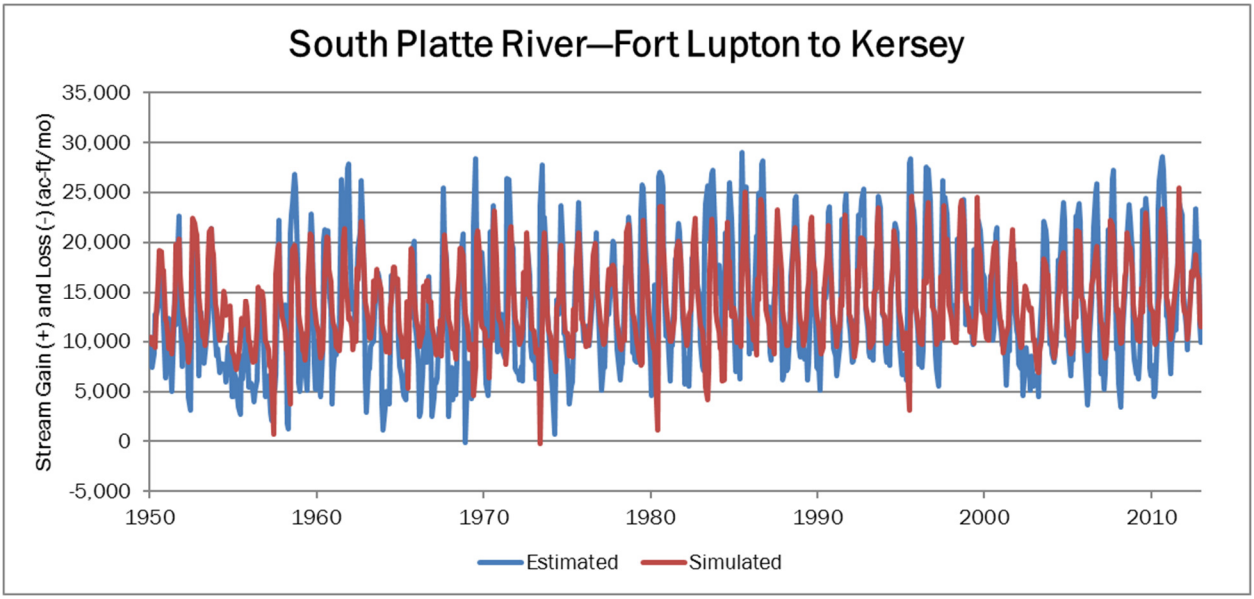


Figure 5-27. Simulated and Estimated Stream Gain/Loss, South Platte River Fort Lupton to Kersey

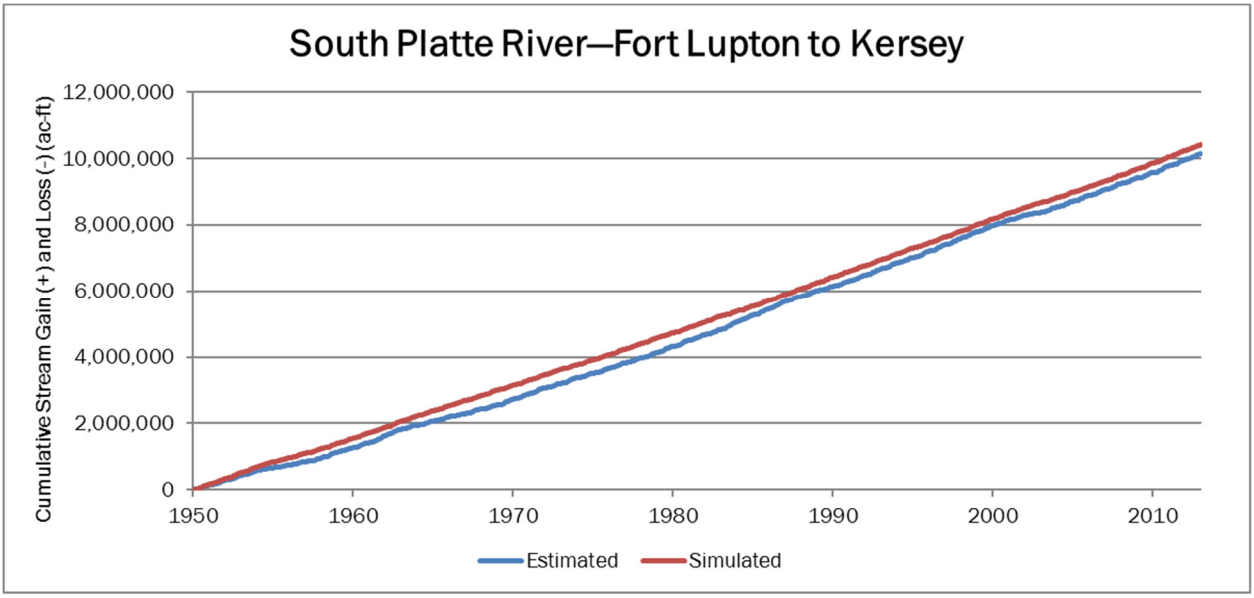


Figure 5-28. Simulated and Estimated Cumulative Stream Gain/Loss, South Platte River Fort Lupton to Kersey

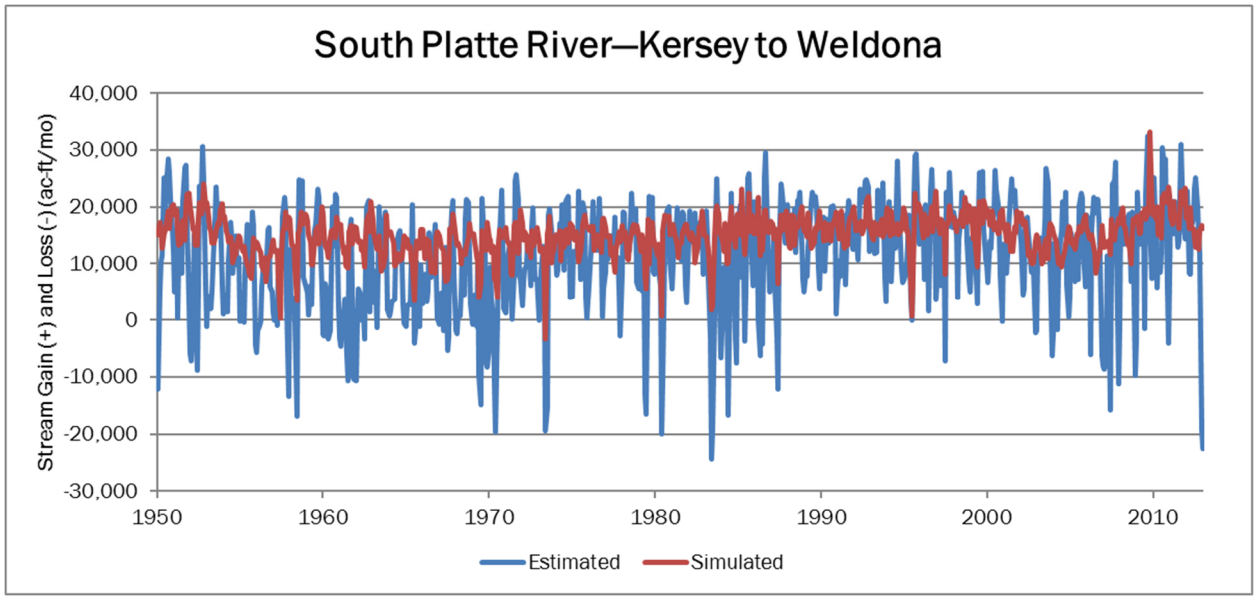


Figure 5-29. Simulated and Estimated Stream Gain/Loss, South Platte River Kersey to Weldona

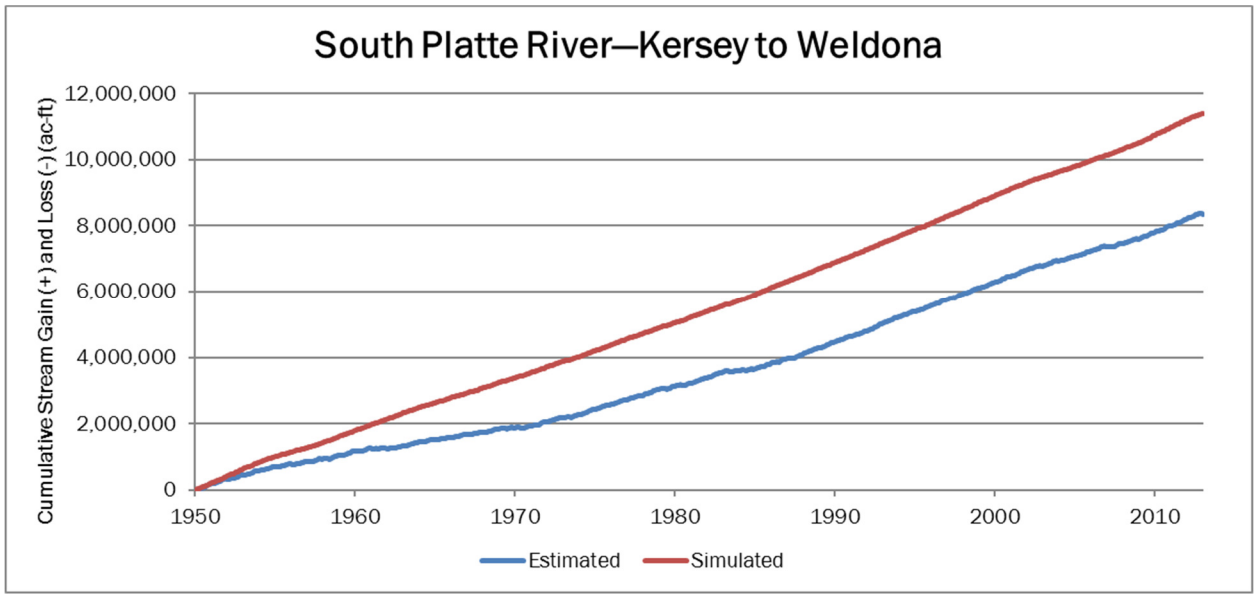


Figure 5-30. Simulated and Estimated Cumulative Stream Gain/Loss, South Platte River Kersey to Weldona

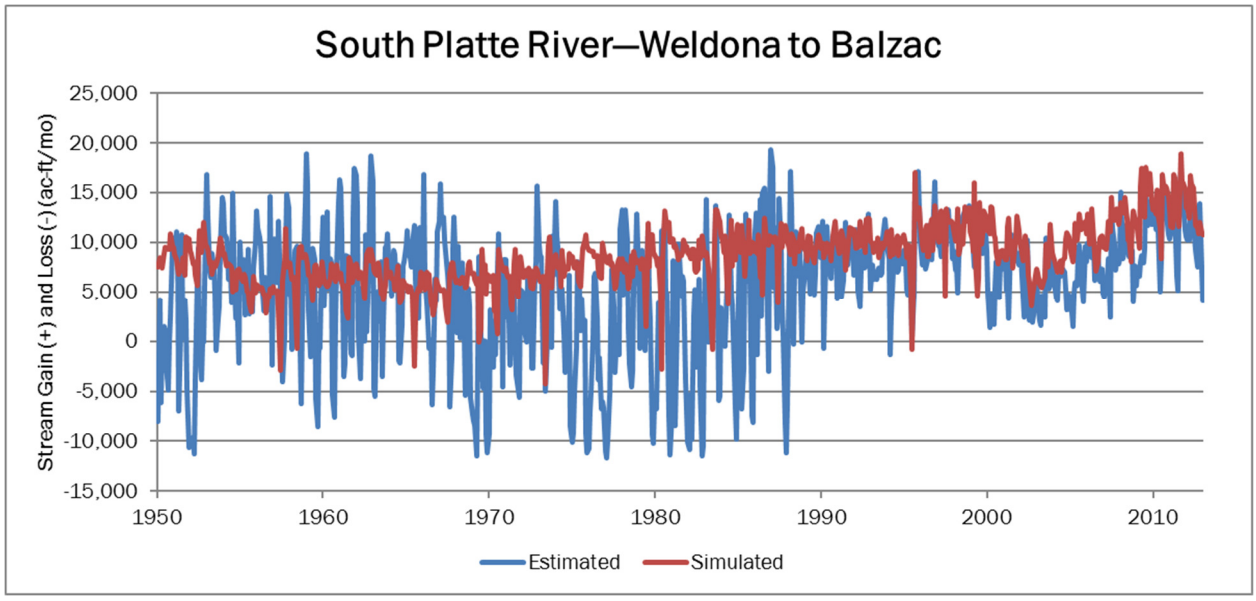


Figure 5-31. Simulated and Estimated Stream Gain/Loss, South Platte River Weldona to Balzac

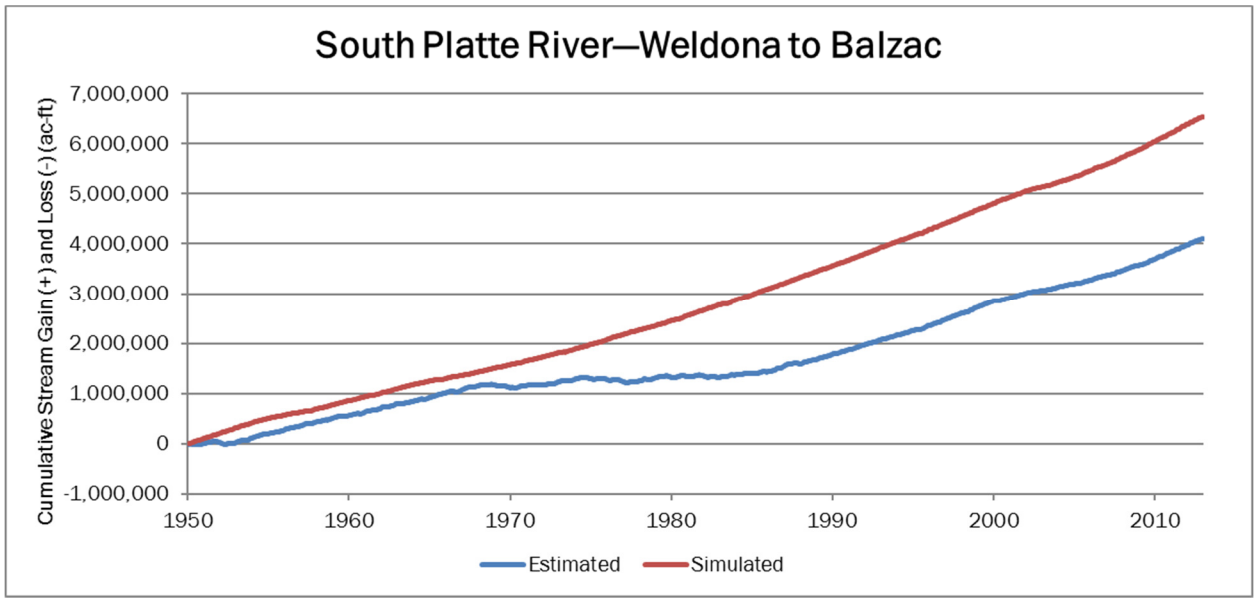


Figure 5-32. Simulated and Estimated Cumulative Stream Gain/Loss, South Platte River Weldona to Balzac

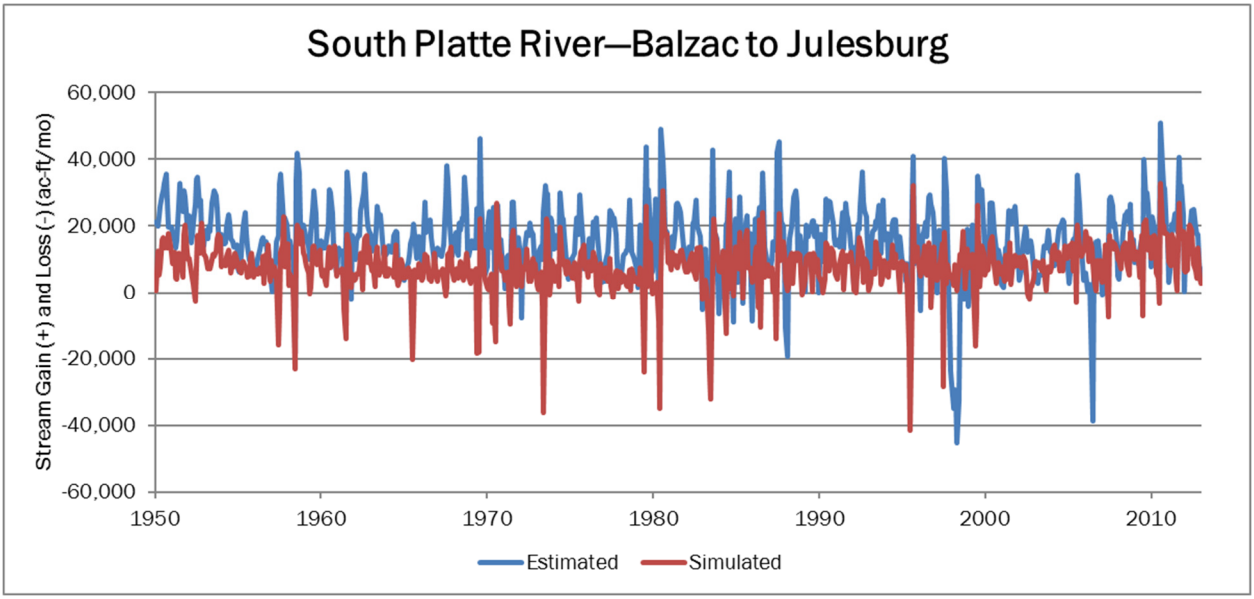


Figure 5-33. Simulated and Estimated Stream Gain/Loss, South Platte River Balzac to Julesburg

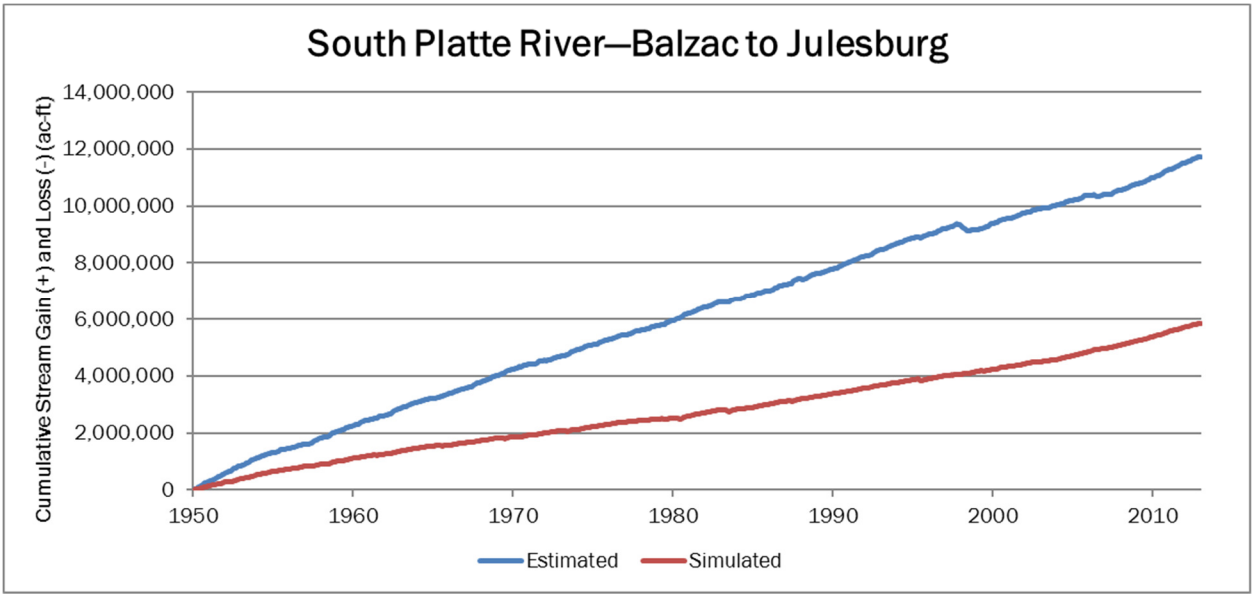


Figure 5-34. Simulated and Estimated Cumulative Stream Gain/Loss, South Platte River Balzac to Julesburg

5.3.5 Calibration Summary and Model Uncertainty/Limitations

The process for additional calibration of the updated model has involved the update of model input flows and adjustment of model parameters to improve the matches between simulated and measured historical groundwater levels and streamflows, along with simulated and estimated historical stream gain/loss values. The simulated results match the measured and estimated data to an acceptable degree or better for the stated objectives and intended uses of the updated model. The updated model is sufficiently calibrated to perform evaluations of potential future conditions and simulate other "what-if" types of scenarios.

The overall construction of the model and methodologies used to generate model inputs have not significantly changed from the initial version of the model. As such, the updated model, as well as any other groundwater flow model, is subject to the same types of uncertainties described in Section 5.2 of the CDM 2013 Report documenting the initial model construction (CDM 2013). These uncertainties include both model input geologic parameters (hydraulic conductivity values, aquifer storage parameter values, elevations of the base of alluvial materials, streambed conductance values) and flow rates (groundwater well pumping rates, recharge rates, ungaged surface water inflows, tributary surface water flows, diversion flows, return flows, reservoir seepage rates, bedrock-alluvium underflows, and lateral boundary flows).

The 1,000-foot model grid cell size is relatively highly refined for a regional-scale model and is appropriate for performing watershed-scale and mid-range scale analyses. If the model is used on a more localized scale, it may require refinement of the model grid discretization and the geologic model input parameters to appropriately simulate groundwater flow at a local scale. The updated model is best suited to answer regional-scale groundwater and surface-water management questions and other basin-scale analyses.

Section 6

Summary and Recommendations

6.1 Summary

The completed update of the model and the model input construction processes represents a significant upgrade to the SPDSS that will help to provide a better understanding of basin-scale groundwater flow and groundwater/surface water interactions in the Basin. The model was updated from the initial version of the model in a number of key ways:

- The simulation period was extended from the end of 2006 through the end of 2012
- Model inputs have been updated through the data-centered approach with improved underlying data from HydroBase and DWR Irrigation Snapshot GIS data sets
- Several data-centered approach DMIs have been modernized and improved, including the CDSS Toolbox, StateDGI, StatePP, and SFR2 Generator
- Model executable code was upgraded to the robust and fully supported USGS MODFLOW-NWT
- PSB was incorporated, which allows for improved and simplified analysis of model inputs and outputs related to the numerous water budget components of the model
- Model calibration was improved overall, improving the reliability of the model for performing future predictive simulations and other scenarios

The model provides a platform for performing predictive future-casting simulations and other scenarios to help guide potential water management strategies and activities. The model can be used for analyzing and finding potential solutions to groundwater challenges in the Basin, such as high water-table problems, and it can be utilized as a basis for refined local-scale models.

6.2 Recommendations

Through the model update effort, some additional items were identified that may further improve the model's ability to inform understanding of the groundwater flow and groundwater/surface water interactions in the Basin. While significant improvements have been made to the modeling process through the data-centered approach, additional potential future improvements have been identified for consideration as described below:

- For M&I pumping wells without available historical pumping data, review additional records (e.g., well permits and water-rights documentation) and refine the assumptions for estimating historical pumping rates, as well as the periods that wells are active.
- Combine the functionality of StatePP with CDSS Toolbox and StateDGI, potentially converting the StatePP code from Fortran to ArcPy-enabled Python scripts and classes.
- Add functionality to StatePP to read input information from StateDGI for multiple irrigation snapshot periods to allow StatePP to produce MODFLOW input files for entire simulation periods to negate the need to later combine MODFLOW input files from each irrigation snapshot period.
- Add functionality to StatePP to allow the code to read binary StateCU output.
- Add functionality to the Lateral Boundary Flow Processor to read separate MODFLOW WEL and RCH files when using PSB to avoid the additional step of needing to combine the separate files to a single file solely for the purpose of the Lateral Boundary Flow Processor.

- Store estimated ungaged surface flows from the "proc_rainfall" DMI in the SPDSS geodatabase for the SFR2 Generator to write directly to the SFR2 input file to avoid the additional steps of using the "proc_runoff" DMI, as well as maintaining an additional DMI.
- Review the SFR2 segments and routing to identify diversion segments that have no diversion flow and could be removed to simplify the SFR2 input files.
- Further review the SFR2 segment-assigned upstream and downstream streambed elevation values based on the 1/3 arc-second USGS National Elevation Dataset, and consider implementing specification of streambed elevations at individual SFR2 reaches through the SFR2 input "REACHINPUT" keyword.
- Review the current approach to developing model initial heads through a warm-up simulation that repeats 1950 monthly stresses for a number of years, especially in the areas of designated basins. Also consider other methods to develop initial heads, such as reducing model stresses during the warm-up period or contouring groundwater levels based on available data and hydrogeologic interpretation.
- Review the Glover-based approach for estimating lateral boundary flows and consider using a smaller period for the Lateral Boundary Flow Processor's warm-up period given the hydrologic and administrative changes that have occurred in the Basin.
- Review the representation of reservoirs and other surface water storage structures in the model:
  - Represent Cherry Creek Reservoir as a head-dependent boundary condition instead of a specified flux boundary condition. This reservoir has likely increased the volume of groundwater stored in the Cherry Creek alluvium upstream from the reservoir, and using a head-dependent boundary condition would better represent these conditions. This improved representation will likely improve the MODFLOW-NWT code reductions of pumping at the Aurora alluvial wellfield, the match of simulated groundwater levels to measured water levels at the calibration observation well location between the reservoir and the Aurora wellfield, and the stream gain/loss comparison for Cherry Creek.
  - Represent Chatfield Reservoir and the various irrigation supply reservoirs in the model domain using head-dependent boundary conditions, which may improve model calibration and performance.
- Perform additional model calibration with specific yield values.
- Investigate whether the stream gain/loss estimates may be improved by incorporating estimates of ungaged surface flows into the Pilot Point method.

During the continued development and extension of the SPDSS by CWCB and DWR, it is recommended that groundwater and surface water data continue to be collected and uploaded into HydroBase, which is maintained by DWR. These recommended activities include:

- Continue DWR monitoring of groundwater levels in existing alluvial wells and consider adding transducers and data-logging equipment to select wells where possible.
- Continue DWR efforts to identify, collect, and incorporate into HydroBase available groundwater levels and other data from the USGS and other federal agencies, other state agencies, local agencies, and private entities.
- Continue DWR's collection of well pumping data from agricultural, M&I, and augmentation wells on a monthly basis at a minimum for incorporation in HydroBase and, where possible, identify and incorporate historical well pumping data.

- During DWR's and CWCB's ongoing development and enhancement of SPDSS, continue to refine the surface water inputs to the model based on the results of the StateMod surface water modeling effort, and use the results of the model to inform the surface water model.
- Continue DWR's and CWCB's periodic updates (e.g., at approximately 5-year intervals) of the model with updated data from HydroBase to account for changes in basin operations since the previous model update and to include any improvements in data quality for historical data.

Section 7

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Appendix A: Extended Time Series Additional Documentation

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Transmittal Memo

To: Matt Lindburg, Brown & Caldwell
From: Kara Sobieski
Date: 12/16/2014, revised 2/13/2015
Re: SPDSS Model Interactions – Pilot Point Diversion Records

This transmittal reflects a revised time series of monthly historical diversions to support the development of the Pilot Point analysis. This deliverable meets the requirements outlined in Item 2 of the Model Interactions memo (GW_Inflow_Outflow_02-13-2015.docx, updated and included in this transmittal). The revisions reflect a simplified naming convention which eliminated the inclusion of many of the "non-typical structures" listed previously in Table 2.

The monthly historical diversion file (SP2015_GW_draft.ddh) contains monthly historical diversion data in acre-feet for the structures that are either located within or carry water through the active GW model area. Note that some structures with diversions in the SP2015_GW_draft.ddh file do not represent river headgate diversions and should not be treated as such. These "special" structures, shown in the **Table 1**, represent irrigation to land either downstream of off-channel reservoirs, lands irrigated from canals that deliver to more than one use, or reflect ground water only aggregate structures. These structures may have canal losses, non-consumed irrigation water, and pumping estimates in the final water budget output (*.dwb) from StateCU, and should be treated like any other structure when extracting information from the water budget output in StatePP. However, their headgate diversions represented in (SP2015_GW_draft.ddh) should be excluded in your efforts to estimate river gains and losses.

With the exception of the structures listed in Table 1, the remaining structures should be included in the Pilot Point method as they reflect actual river diversions. Note that the total diversions for some structures have been divided with portions assigned to a separate structure identifier; therefore it is the sum of these structures that reflect the total diversions. This applies to the following structures:

- Burlington Canal (0200802) = 0200805 + 023837_C
- Farmers Highline Canal (0700569) = 0700569 + 0700569_C
- Fisher Ditch (0700570) = 0700570 + 0700507_C

Additional notes:

- As denoted in the file name, the diversion data is draft and may change as SPDSS surface and consumptive use modeling efforts continue.
- WWG understands this initial Pilot Point effort does not require all the additional irrigation demand and ground water only structures, we have provided all of the structures in an effort to introduce the nomenclature and modeling identifiers for future deliverables.

Table 1
Structures to be Excluded for River Gains/Losses in SP2015_GW_draft.ddh file

StateCU Structure ID	Description
*WD*_AWP###	Aggregate Well Structure, designated by Water District and aggregate number
0100503_I	Riverside Canal Irrigation Demand
0100507_I	Bijou Canal Irrigation Demand
0100687_I	North Sterling Irrigation Demand
0103817_I	Jackson Lake Irrigation Demand
0200805_I	Denver-Hudson Canal Irrigation Demand
0200817_I	Evans No 2 Ditch Demand
0200828_I	Union Ditch Irrigation Demand
0200834_I	Lower Latham Ditch Irrigation Demand
0203837_I	FRICO-Barr Reservoir Irrigation Demand
0203876_I	Milton Reservoir Irrigation Demand
0300911_I	Larimer County Ditch Irrigation Demand
0300915_I	Cache La Poudre Ditch Irrigation Demand
0300919_I	Larimer Weld Canal Irrigation Demand
0300929_I	New Cache La Poudre Ditch Irrigation Demand
0300994_I	North Poudre Canal Irrigation Demand
0400521_I	Handy Ditch Irrigation Demand
0400524_I	Home Supply Ditch Irrigation Demand
0400530_I	Louden Ditch Irrigation Demand
0400532_I	Loveland Greeley Canal Irrigation Demand
0400588_I	Boulder Larimer County Irrigation Demand
0600537_C	Leggett Carrier to Panama Reservoir
0600537_I	Leggett Ditch Irrigation Demand
0600565_C	Leyner Cottonwood Carrier
0600565_I	Leyner Cottonwood Irrigation Demand
6400511_I	Harmony Ditch 1 Irrigation Demand

Memo

To: Brown & Caldwell
From: Kara Sobieski and Logan Callihan
Date: 3/17/2015
Re: Streamflow, Import and Export Data

The following summarizes the approach taken to determine the surface water flows within the ground water model boundary, the surface water inflows into the ground water model boundary, and the import and export components to/from the ground water model. The original data for this effort was developed in SPDSS Task 2, which identified key streamflow gages for both the SPDSS surface and ground water models. Streamflow data and import and export data has been reviewed, modified if necessary, and extended through 2013. Four separate StateMod formatted files are included with the deliverable as described below.

Surface Water Streamflow within the Ground Water Model

The file SP2015_SFwithinGW_032015.stm provides the time-series of historical streamflows at gages within the active ground water model boundary. Surface water flows within the ground water model are gaged streamflows located *within* the boundary of the ground water model. These gages were initially identified as key streamflow gages for the ground water model in SPDSS Task 2 based on the following criteria: key streamflow gages must have good or excellent records based on USGS ratings; have at least 70% of the records complete throughout the SPDSS study period (1950-2002 at the time); or have the best available data at an important location.

As part of the model extension, key streamflow gages within the ground water boundary were extended and filled through 2013. In general, the dataset was created by pulling monthly surface water flow records from HydroBase using TSTool and filling missing data based on the techniques outlined in the SPDSS Task 2 memoranda on stream gages and stream flow records. **Table 1** lists the surface water streamflow gages modeled *within* the SPDSS ground water model boundary.

Table 1. Surface Water Streamflows within the SPDSS Ground Water Model Boundary.

Water District	Structure ID[1]	Streamflow Gage
1	06754000	South Platte River near Kersey
1	06758500	South Platte River near Weldona
1	06759910 & 06760000	South Platte River at Cooper Bridge near Balzac & South Platte River at Balzac
2	06720500	South Platte River at Henderson
2	06721000	South Platte River at Fort Lupton
3	06752500	Cache La Poudre near Greeley
4	06744000	Big Thompson River at mouth near La Salle

Water District	Structure ID[1]	Streamflow Gage
5	06731000	St. Vrain Creek at mouth near Platteville
7	06720000	Clear Creek at Derby
8	06708000	South Platte River at Waterton
8	06709530 & 06709500	Plum Creek at Titan Road near Louviers & Plum Creek near Louviers
8	06710247, 06710245 & 06710000[2]	South Platte River below Union Ave at Englewood, South Platte River at Union Ave at Englewood & South Platte River at Littleton
8	06713500	Cherry Creek at Denver
8	06714000	South Platte River at Denver
9	06711500	Bear Creek at Sheridan
64	06764000	South Platte River at Julesburg

Source: HydroBase & SPDSS Task 2

Notes: [1] Multiple IDs indicate two gages were combined

[2] South Platte River at Littleton (06710000) is combined with South Platte River at Union (06710245). The Englewood Intake (0801013) is subtracted from the combined record, which is filled and then combined with South Platte River below Union (06710247).

Note, SPDSS Task 2 Figure 3 indicates the Cherry Creek at Denver gage (06713500) is also located within the groundwater model boundary. This gage, however, was identified only as a calibration gage and not filled.

Surface Water Inflows

The file SP2015_SWInflowToGW_032015.stm provides the time-series of historical river inflows to the active ground water model boundary. Surface water inflows, as recorded at streamflow gages, occur at the top of the main stem South Platte River and tributary basins upstream of the ground water model area. Missing data was filled based on techniques outlined in Task 2.

The ground water model boundary was spatially reviewed to identify streamflow gages that most represent the streamflow conditions at the ground water model boundary. In some instances, the streamflow gages have been adjusted to match the location of the boundary. For example, if the streamflow gage is located downstream of the ground water boundary, diversions located in between the actual location of the gage and groundwater boundary have been added to the gaged streamflow such that the gage reflects the inflow at the boundary. If the streamflow gage is located upstream of the groundwater boundary, diversions located between the actual location of the gage and the ground water boundary have been subtracted from the recorded streamflow resulting in the inflow at the boundary. **Table 2** lists the surface water inflows modeled in the SPDSS ground water model area by Water District and any diversions used to adjust the streamflow to the boundary.

Table 2. SPDSS Ground Water Model Area Surface Water Inflows.

Water District	Structure ID[1]	Streamflow Gage	Adjusted Streamflow by Adding (+) or Subtracting (-) Diversions
1	06753500	Lonetree Creek near Nunn	-
2	06720820	Big Dry Creek at Westminster	-
3	06752260	Cache La Poudre at Fort Collins	0300918, 0300919, 0300921, 0300922, 0300923 (+)
4	06741510	Big Thompson at Loveland	0400519, 0400503 0400541, 0400534, 0400532 (+)
4	06743500	Little Thompson River at Milliken	0400601, 0400599, 0400587 (+)
5	06725450	St. Vrain Creek below Longmont	-
6	06730200	Boulder Creek at North 75th	-
6	06730300	Coal Creek near Plainview	0600608, 0600605, 0600606, 0600609, 0600621, 0600615 (-)
7	06719505 & 06719500[2]	Clear Creek at Golden & Clear Creek near Golden	0700725, 0700502, 0700569, 0700698, 0700601 (-)
8	06712000	Cherry Creek near Franktown	0801362 (-)
8	06709530 & 06709500	Plum Creek at Titan Rd. near Louviers & Plum Creek near Louviers	-
8	PLACHACO[3]	South Platte River below Chatfield	0801007, 0801008, 0801009 (+)
9	06711500	Bear Creek at Sheridan	0900816 (+)

Source: HydroBase & SPDSS Task 2

Notes:
[1] Multiple IDs indicate two gages were combined
[2] Church Ditch (0700540) diverts between the locations of these two gages therefore the diversions were subtracted before the gages were combined
[3] The PLACHACO gage is filled with South Platte River at Littleton (06710000). See comment below Table 1 for how the South Platte River at Littleton gage is combined/filled, as the same methodology is applied for combining the Littleton gage with the PLACHACO gage.

Imports

The file SP2015_GW_IMP_032015.stm provides the time-series of imports into the active ground water model boundary. Imports into the ground water model represent any inflows that are diverted outside of the ground water model boundary but consumed within the active ground water model area. The imports can be characterized into two types, either imports used to meet municipal demands in the active ground water boundary or imports used to meet irrigation demands in the active ground water boundary. Below is a list of imports into the ground water model by type.

Municipal Imports. The following municipal imports divert water from outside the active ground water model boundary; however the consumptive use, the outdoor use return flows, and the waste water treatment return flows occur within the ground water model boundary.

- The following ditches divert above the active ground water model boundary for municipal use located within the active ground water model boundary:
    - Greeley Filters Pipeline (0300908)
    - Fort Collins Pipeline (0300906)

    - Loveland Pipeline (0400511)
- Denver Conduit No. 2 (0801002) – The Denver Conduit No. 2 is an underground pipeline that takes water from the Denver Intake (above the active ground water model boundary) to both the Platte Canyon and Marston Reservoirs for eventual treatment at the Marston Wastewater Treatment Plant and use within the Denver Water service area.
- Denver Foothills Pipeline No. 26 (0801017) – Denver Foothills Pipeline No. 6 delivers water from Strontia Spring Reservoir (above the active ground water model boundary) to the Foothills Water Treatment Plant and use within the Denver Water service area.
- Aurora Intake (0801001) – The Aurora Intake carries water from Strontia Springs Reservoir to regulate diversions to meet municipal demands.
- South Boulder Diversion Canal (0600590) – Denver Water's Northern System diverts transbasin and native water supplies from outside the ground water boundary to serve approximately 15 percent of Denver Water's demands in the ground water model. South Boulder Diversion Canal diverts from South Boulder Creek and conveys water to Ralston Reservoir and Moffat Treatment Plant.
- Diversions for the Cities of Thornton, Westminster and Northglenn – A majority of the Standley Lake Cities' supply is piped from Standley Lake (outside the active ground water model boundary) directly to the water treatment plant to serve these cities. The releases to the cities are available on a limited basis, generally from 1995 through 2006, in HydroBase under Standley Lake PL structures (IDs 0200991, 992, 993, 994). There is insufficient data in the records to utilize accurate filling techniques through TSTool to complete the records through the 1950 to 2012 study period. Therefore, the municipal demands for the Cities of Thornton, Westminster and Northglenn developed in SPDSS Task 66 are provided as an import to the ground water model.

Irrigation Imports. The following irrigation imports divert water from outside the active ground water model boundary; however the consumptive use and irrigation return flows occur within the ground water model boundary.

- North Poudre Canal (ID 0300994) - The North Poudre Canal diverts above the Cache La Poudre at Canyon near Ft. Collins streamflow gage to serve irrigated acreage under the North Poudre Irrigation Company (NPIC) within the ground water model. Additionally, NPIC acreage receives direct irrigation deliveries from Munroe Canal (0300905), also located outside the ground water model boundary. The diversions were combined and provided under ID 0300994.
- "South Side" Ditches (0300910, 0300913, 0300914) – The South Side ditch system is comprised of Pleasant Valley Canal (0300910), New Mercer Ditch (0300913), Larimer County No. 2 Ditch (0300914), and Arthur Ditch (0300918). Owned by the City of Fort Collins, the South Side ditch system is used primarily to irrigate parks and open space. All of these ditches, except for Arthur Ditch (0300918), divert outside of the groundwater boundary; however the consumptive use occurs within the boundary. Arthur Ditch (0300918) is not considered an import because it diverts within the ground water model boundary.
- The following ditches are part of off-channel reservoir systems that deliver water for irrigation within the ground water model boundary from both direct diversions outside the model boundary and off-channel storage within the model boundary. The irrigation

supply for each ditch is provided and does not only reflect total diversions at the ditch headgate.
    - Larimer County Ditch (0300911)
    - Cache La Poudre Ditch (0300915)
    - Handy Ditch (0400521)
    - Home Supply Ditch (0400524)
    - South Side Ditch (0400543)
    - Boulder Larimer Ditch (0400588)
    - Boulder White Rock Ditch (0600516)
    - Leyner Cottonwood Ditch (0600565)

- The following ditches divert outside the ground water model boundary to irrigated lands located within or on the edge of the ground water model boundary:
    - Dry Creek Ditch (0300912)
    - Taylor Gill Ditch (0301029)
    - Barnes Ditch (0400501)
    - George Rist Ditch (0400520)
    - Jim Eglin Ditch (0400596)
    - Osborne Caywood Ditch (0400600)
    - Green Ditch (0600528)
    - Church Ditch (0700540)
    - Farmers Highline Canal (0700569)
    - Wannamaker Ditch (0700698)
    - Lee Stewart Eskins Ditch (0700601)

Exports

The file SP2015_GW_EXP_032015.stm provides the time-series of exports from the active ground water model boundary. Exports from the ground water model boundary represent diversions that are used to meet demands and resulting consumptive use outside of the active ground water model area. Typically, the diversions are made below a surface water inflow stream gage but the consumptive use and returns occur outside outside of the ground water model area. The exports from the ground water model are summarized below.

Municipal Exports:

- Croke Canal (ID 0700553) – Croke Canal diverts below the Clear Creek near Golden streamflow gage and is the primary source of water stored in Standley Lake. Therefore the diversions take place within the ground water model area, but the storage and evaporative consumptive use takes place outside of the ground water model area. Standley Lake water is then released to serve the demands of the Standley Lake Cities (see the Municipal Imports section).

Transmittal Memo

To: Matt Lindburg, Brown & Caldwell
From: Kara Sobieski
Date: 7/16/2015
Re: SPDSS Model Interactions – Augmentation Plan Pumping and Recharge

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This transmittal reflects the following deliverables:

- **Canal Alias List (SP2015_GW_CanalAliasList.csv)**: This file contains a list of structures that are represented in the consumptive use and surface water model by an identifier other than their WDID (e.g. off-channel irrigation demands, diversion systems). This file was updated to reflect the new identifiers used by individual sub-basin surface water modelers. This file can be used to "translate" the canal assignments in the spatial coverage to match the structure identifiers used in the modeling effort. The file can be read directly into the StateDGI database and the "translations" are made before creating the final canal recharge file (*.can) read by StatePP.

- **Augmentation Well and Recharge Well Pumping (SP2015_GW_AugRch.gwp)**. This file contains a time series of historical pumping for the 1950 – 2013 period for each augmentation well and recharge well in the model. The list of augmentation and recharge wells used in the surface water modeling effort (shown below) was developed through discussions with Louis Flink at DWR in order to reflect only those wells that have been used recently for augmentation or recharge purposes. Note that these wells may also pump for irrigation or other uses, however this time series only reflects the augmentation or recharge pumping.

Modeled Augmentation Wells				Modeled Recharge Wells			
6405042	6405864	6406245	6406628	0109884	6405887	6406656	6406752
6405043	6405868	6406276	6406639	0109886	6406316	6406657	
6405071	6405901	6406279	6406664	0109887	6406330	6406658	
6405552	6406008	6406305	6406704	0110291	6406332	6406659	
6405556	6406073	6406337	6406705	6405031	6406475	6406666	
6405557	6406140	6406385	6406706	6405064	6406627	6406667	
6405604	6406164	6406527	6406707	6405084	6406649	6406685	
6405626	6406166	6406553		6405309	6406650	6406703	
6405857	6406180	6406554		6405310	6406654	6406709	
6405862	6406242	6406556		6405629	6406655	6406727	

- **Recharge Estimates by Recharge Area (SP2015_GW_RechargeArea.stm)**: This file contains a time series of historical recharge for the 1950 – 2012 period for each

recharge area that has recharge records in HydroBase (at the time of the query). The list of recharge areas included in this deliverable was originally developed during the House Bill 1278 modeling effort, and reflects 616 recharge areas. Of this total, 176 recharge areas are not currently reflected in the GW model and would need to be added. These recharge areas likely reflect those constructed after the development of the original GW modeling effort. Additionally, of the 671 recharge areas currently modeled in the GW model, 231 of those recharge areas do not have records in this deliverable. Reconciliation of this difference in records and recharge areas will need to be completed prior to incorporating this updated information.

Transmittal Memo

To: Matt Lindburg, Zach Wengrovius, Brown & Caldwell
From: Kara Sobieski
Date: November 17, 2015
Re: SPDSS Model Information – Basin-wide Scenario, Burlington System Overview, Summary of Model Changes

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This transmittal reflects the following deliverables:

- **South Platte River Basin-wide Consumptive Use Analysis**: This dataset includes consumptive use, irrigation return flows, and canal recharge information for irrigation and carrier structures in the entire South Platte Basin. This deliverable provides information on structures that are outside of the active ground water model boundary, but within the inactive boundary where they may have an impact on boundary conditions or lateral inflows. The dataset deliverable includes the basin-wide model input and output files; however, similar to the previously delivered ground water area subset scenario (sp2015GW_WCarriers), the detailed water budget output file (*.dwb) contains the bulk of information used for the ground water model. Note that other files previously developed based on information from the ground water area subset scenario (e.g. alias lists) and delivered have not been reproduced using the full scenario.

- **Burlington Ditch, FRICO-Barr, Henrylyn System Overview:** The Burlington, FRICO-Barr and Henrylyn Systems are represented in StateCU with several carriers and irrigation demands. A detailed overview of the system is provided *Task 5 - Key Structure Operating Memorandum – Burlington, FRICO–Barr, and Henrylyn Systems*; this summary provides specific information as to which structures reflect canal recharge and/or irrigation return flows and spatially where these return flows should be represented in the ground water model. Due to the complexity of these operations, the irrigation return flows are summarized in the first table, **Operations and Irrigation Recharge Approach,** and the canal recharge is summarized in the second table, **Canal Recharge Approach**. Refer to the figure at the end of this memo to assist with identification of canals and structures.

  As many of the demands (irrigation and reservoirs) included in these systems have a different conveyance loss, the total diversions through the Burlington Canal/O'Brian Canal Headgate (0200802) have been disaggregated and represented under three different model IDs: Denver-Hudson Canal (0200805), Little Burlington Canal (0200918), and Barr Lake Carrier (0203837_C). Therefore, no diversions, conveyance loss, or irrigation return flows associated to the primary Burlington Canal headgate (0200802) in the StateCU model. It is recommended the canal recharge assigned to this structure be

calculated by summing portions of the canal recharge estimated under these three different model IDs; see the **Canal Recharge Approach** table and the simplified figure below for the recommended calculations.

Operations and Irrigation Recharge Approach

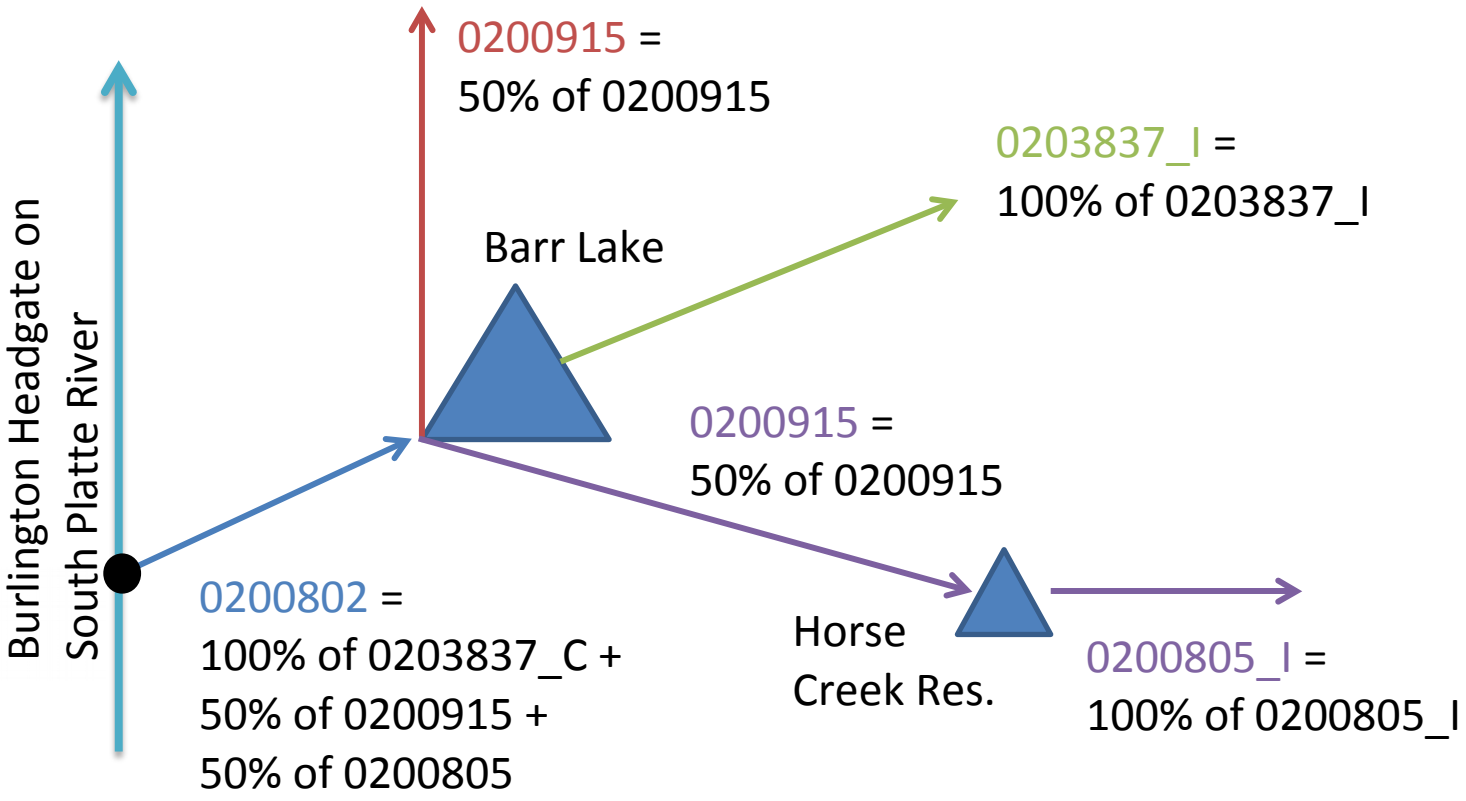
Model ID	Name	Operations	Irrigation Recharge
0200802	Burlington Canal	Carries direct diversions to Denver-Hudson Canal, Barr Lake, and Little Burlington system demands	N/A
0200805	Denver-Hudson Canal	Reflects total river diversions to Henrylyn Irrigation District (0200805_I) and Reservoirs (Horse Creek and Prospect Reservoirs)	N/A
0200805_I	Denver-Hudson Canal (Henrylyn) Irrigation Demand	Reflects portion of direct diversions to irrigation (after losses) and releases from reservoir to irrigation demand	Total return flows (recharge & overland) from irrigated lands assigned to 0200805 & 0200902
0200915	Little Burlington Canal	Reflects total river diversions to Little Burlington Canal irrigated lands	Total return flows from irrigated lands assigned to 0200915
0203837_C	Barr Lake Carrier	Reflects total diversion to storage in Barr Lake	N/A
0203837_I	Barr Lake Irrigation Demand	Reflects releases from Barr Lake to irrigation demand	Total return flows from irrigated lands assigned to 0203837

Canal Recharge Approach

Model ID	Name	Canal Length Reach in GIS	Canal Recharge Calculation
0200802	Burlington Canal	Burlington Canal headgate to Barr Lake	100% of conveyance loss in StateCU under 0203837_C + 50% of conveyance loss in StateCU under 0200805 + 50% of conveyance loss in StateCU under 0200915
0200805	Denver-Hudson Canal	Denver-Hudson Canal from Barr Lake to Horse Creek Reservoir	50% of conveyance loss in StateCU under 0200805 model ID
0200805_I	Denver-Hudson Canal (Henrylyn) Irrigation Demand	Denver-Hudson Canal from Horse Creek Reservoir to end of canal, including Box Elder Lateral	100% of conveyance loss in StateCU under 0200805_I model ID
0200915	Little Burlington Canal	Little Burlington Canal from Bar Lake to end of canal, including Brighton Lateral	50% of conveyance loss in StateCU under 0200915 model ID
0203837_C	Barr Lake Carrier	N/A – all conveyance loss included under 0200802 ID	N/A – all conveyance loss included under 0200802 ID
0203837_I	Barr Lake Irrigation Demand	Conveyance loss from Barr Lake to end of following outlet canals: Neres Canal East Neres Canal Beebe Canal E. Burlington Ext. Ditch Speer Canal	100% of conveyance loss in StateCU under 0203837_I model ID

W. Burlington Ext. Ditch

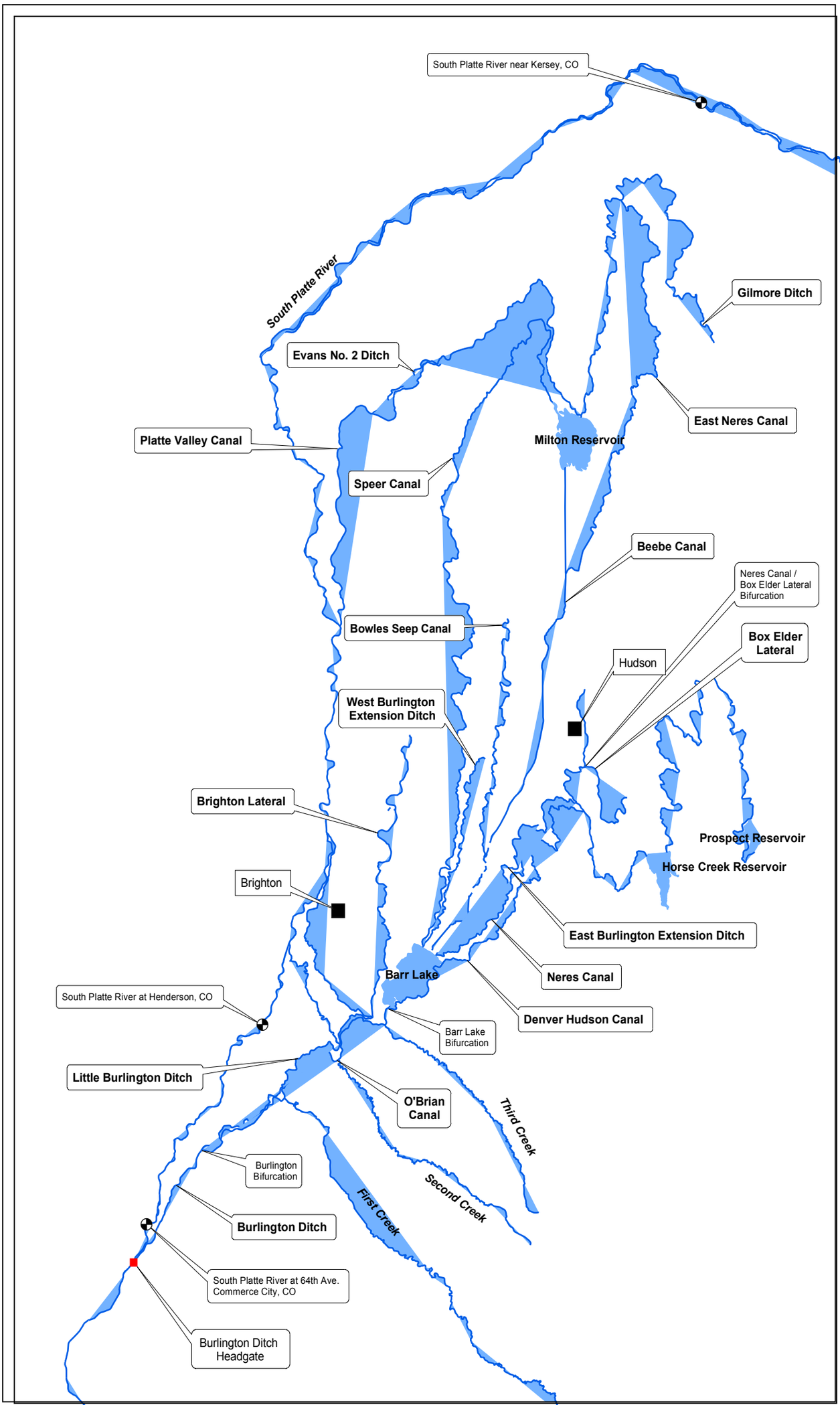
* The primary canals that carry water to irrigation demands have been included; other canals that carry multi-source water or may not be primary carriers have been excluded.



- **2008 to 2015 Model Changes**: The following table provides a summary of the model IDs that have changed or have been added/removed from the 2008 South Platte modeling effort to the 2015 modeling effort. There have been other changes (e.g. revised efficiencies, capacities, diversion amounts) implemented by the sub-basin modelers that are reflected in the 2015 model results but not explicitly listed below.

Model ID	Revision
01_ADP037	Disaggregated in 2015 Model, 0100643, 0100644, 0100835, and 0104486 modeled explicitly now
0200991 - 0200994	Added to the 2015 Model to reflect Standley deliveries to "Standley Lake Cities"; no irrigation or conveyance loss
0400502_D	Diversion system disaggregated in 2015 Model, 0400502 and 0400587 modeled explicitly
0500603_D & 0500603_I	Diversion system disaggregated in 2015 Model, 0500603, 0500564, 0500565, 0500568, 0500569, 0500570, 0500571, 0500572,

	0500573, 0500574, 0500575, 0500648 modeled explicitly
0600557	Added to the 2015 Model
05_ADP001	Divided up into two aggregate systems in 2015 Model, 05_ADP001 and 05_ADP002
0600597	Municipal structure, removed from 2015 Model
0600598	Municipal structure, removed from 2015 Model
0600599	Municipal structure, removed from 2015 Model
0600767	Municipal structure, removed from 2015 Model
0600800	Municipal structure, removed from 2015 Model
0600878	Municipal structure, removed from 2015 Model
0600889	Municipal structure, removed from 2015 Model
0600902	Municipal structure, removed from 2015 Model
0600943	Municipal structure, removed from 2015 Model
0700678	Added to the 2015 Model
0801*	Several municipal structures added/removed by sub-basin modeler, no irrigation or conveyance loss
2302*	Administrative gages in South Park revised model IDs from gage ID name (e.g. SFKANTCO) to HydroBase IDs (2302900)
AWP	Groundwater aggregates added/removed based on revised assignment of wells by DWR
0400521_I	Added as off-channel demand in 2015 Model
0400530_I	Added as off-channel demand in 2015 Model
0400532_I	Added as off-channel demand in 2015 Model
0400543_I	Added as off-channel demand in 2015 Model
0500563_I	Added as off-channel demand in 2015 Model
0500564_I	Added as off-channel demand in 2015 Model
0600501_C & 0600501_I	Added as off-channel demand in 2015 Model
0600516_I	Added as off-channel demand in 2015 Model
0600537_C & 0600537_I	Added as off-channel demand in 2015 Model
0600565_C & 0600565_I	Added as off-channel demand in 2015 Model
0700569_C	Added as off-channel demand in 2015 Model
0700570_C	Added as off-channel demand in 2015 Model
0801004_D	Removed diversion system designation (_D) in 2015 Model


South Platte River near Kersey, CO
South Platte River
Gilmore Ditch
Evans No. 2 Ditch
East Neres Canal
Platte Valley Canal
Milton Reservoir
Speer Canal
Beebe Canal
Neres Canal / Box Elder Lateral Bifurcation
Bowles Seep Canal
Box Elder Lateral
Hudson
West Burlington Extension Ditch
Brighton Lateral
Prospect Reservoir
Horse Creek Reservoir
Brighton
East Burlington Extension Ditch
Barr Lake
Neres Canal
South Platte River at Henderson, CO
Denver Hudson Canal
Barr Lake Bifurcation
Little Burlington Ditch
O'Brian Canal
Third Creek
Burlington Bifurcation
Second Creek
First Creek
Burlington Ditch
South Platte River at 64th Ave. Commerce City, CO
Burlington Ditch Headgate

Transmittal Memo

To: Matt Lindburg
From: Erin Wilson
Date: 12/12/2015
Re: SPDSS Model Interactions – Precipitation Recharge Files

This transmittal includes files required to develop the precipitation recharge input into the SPDSS ground water model. This deliverable meets the requirements outlined in item 1 of the Model Interactions memo (GW_Inflow_Outflow_12-12-2014.docx, updated and included in this transmittal).

1) Spreadsheet matching previous climate station IDs with new climate station IDs adopted by NOAA (HydroBaseClimateStation_newIDs). Note that the new climate station IDs are now stored in HydroBase and have been adopted for SPDSS consumptive use and surface water efforts.
2) Precipitation Recharge Grids for ArcMap (CDSSToolBox_climate_grids.zip). Note that these grids have not been revised to reflect the new climate station IDs adopted by NOAA.
3) Time series file with monthly total precipitation for each climate station, in standard StateMod format (SP2015.prc).
4) File previously submitted to CDM with GridID (row_column), climate station ID, and climate station weight (Grid_Precip_Wts.csv). This file was originally developed using StateDGI. We have replaced the previous NOAA climate station IDs with the new climate station IDs – this may allow you not to have to recreate the file or worry about the updating the gridded climate dataset at this time.

The climate station weight file (Grid_Precip_Wts.csv) is used in conjunction with the monthly precipitation by climate station file (SP2015.prc) and land use by category file (not included in this submittal) to estimate precipitation recharge in each ground water model cell. **Table 1** defines the initial recommended precipitation recharge by land use category, as a percent of total weighted precipitation, for the ground water model area as recommended in Task 64.

Table 1
Precipitation Recharge as Percentage of Total Precipitation

Land Use Category	Irrigation Season % April through October	Non-Irrigation Season November through March
ALFALFA_SOILA	23%	1%
ALFALFA_SOILB	14%	1%
ALFALFA_SOILC	4%	1%
ALFALFA_SOILD	2%	1%
CORN_SOILA	23%	1%
CORN_SOILB	14%	1%

CORN_SOILC	4%	1%
CORN_SOILD	2%	1%
DRY_BEANS_SOILA	23%	1%
DRY_BEANS_SOILB	14%	1%
DRY_BEANS_SOILC	4%	1%
DRY_BEANS_SOILD	2%	1%
FOREST_SOILA	1%	1%
FOREST_SOILB	1%	1%
FOREST_SOILC	1%	1%
FOREST_SOILD	1%	1%
GRASS_PASTURE_SOILA	23%	1%
GRASS_PASTURE_SOILB	14%	1%
GRASS_PASTURE_SOILC	4%	1%
GRASS_PASTURE_SOILD	2%	1%
NATIVE_VEGETATION_SOILA	1%	1%
NATIVE_VEGETATION_SOILB	1%	1%
NATIVE_VEGETATION_SOILC	1%	1%
NATIVE_VEGETATION_SOILD	1%	1%
ORCHARD_WO_COVER_SOILB	14%	1%
ORCHARD_WO_COVER_SOILC	4%	1%
ORCHARD_WO_COVER_SOILD	2%	1%
PHREATOPHYTE_SOILA	1%	1%
PHREATOPHYTE_SOILB	1%	1%
PHREATOPHYTE_SOILC	1%	1%
PHREATOPHYTE_SOILD	1%	1%
SMALL_GRAINS_SOILA	23%	1%
SMALL_GRAINS_SOILB	14%	1%
SMALL_GRAINS_SOILC	4%	1%
SMALL_GRAINS_SOILD	2%	1%
SOD_FARM_SOILA	23%	1%
SOD_FARM_SOILB	14%	1%
SOD_FARM_SOILC	4%	1%
SUGAR_BEETS_SOILA	23%	1%
SUGAR_BEETS_SOILB	14%	1%
SUGAR_BEETS_SOILC	4%	1%
URBAN_SOILA	1%	1%
URBAN_SOILB	1%	1%
URBAN_SOILC	1%	1%
URBAN_SOILD	1%	1%
VEGETABLES_SOILA	23%	1%
VEGETABLES_SOILB	14%	1%
VEGETABLES_SOILC	4%	1%
WATER_SOILA	0%	0%
WATER_SOILB	0%	0%
WATER_SOILC	0%	0%

WATER_SOILD	0%	0%
WATER_*ResWDID*_SOILA	0%	0%
WATER_*ResWDID*_SOILB	0%	0%
WATER_*ResWDID*_SOILC	0%	0%
WATER_*ResWDID*_SOILD	0%	0%

Brown AND Caldwell

1527 Cole Blvd, Suite 300
Lakewood, CO 80401

T: 303.239.5400
F: 303.239.5454

Memorandum

Subject: Procedures Used to Estimate M&I Pumping Data

Date: May 5, 2016

To: Andy Moore, Mary Halstead, and Emily LoDolce, CWCB and DWR

From: Matt Lindburg and Zach Wengrovius, Brown and Caldwell

Project: South Platte Decision Support System – Alluvial Groundwater Model Update
146767

Summary

Data were collected from various sources to extend the time series to December, 2012. The Groundwater Model Access database contains the previously determined pumping values[4] for January, 1950 to December, 2006. Data were also collected from some of the owners/operators of the wells and HydroBase records, when available.

First, HydroBase data were inserted where applicable to fill in the data for all years available. Then, M&I records obtained from the entities were filled in. For dates that have both sets of data, HydroBase data were applied. Next, the Access databases values were inserted to fill the time series to 12/2006 or when the earliest HydroBase record was available.

Lastly, data were filled in using the procedures described in the *Phase 3 Task 41.3 Estimation of Municipal and Industrial Pumping in the South Platte Alluvium Region Final** when applicable. For wells with no data available, the maximum estimated pumping will be set equal to the decreed pumping rate for each entity.

In the complete set of pumping data, from January, 1950 to December, 2003, the monthly pumping amounts are labeled according to their source. The pumping labels (sources) include:

- "Access" - Data previously used through 2006 in the Access database
- "Measured" - Data measured by owners/operators of well
- "HydroBase" - Data taken from HydroBase

See the following section for more detail on how the data were filled in for each well.

Detailed Descriptions of Procedures

The wells with pumping data in the Access database* (MI_Pumping) had their pumping time series extended until December, 2013. The procedures described below show in the detail how all dates were filled. The wells are organized according to their Well ID.

Aurora

- For all wells
  - 1/1950 to 10/2006 - Based on data in Access database
- For Aurora_Well_1, Aurora_Well_2, Aurora_Well_4, Aurora_Well_5 & Aurora_Well_6
  - 11/2006 to 10/2010 – Based on data provided by Aurora
  - 11/2010 to 12/2013 – Based on HydroBase data

        - Missing months filled in with zeros (no pumping) or measured pumping value.
        - Verified by looking at Aurora's measured data
- For Aurora_Well_3 &Aurora_Well_7
    - 11/2006 to 10/2013 – Based on data provided by Aurora

Aurora wells 1-4 were drilled July/August 1956, 5 & 6 were drilled in December 1955, and 7 was drilled in August 1963. Changed wells to not begin pumping until month after they were drilled. Also, after review of reported pumping rates 1990-2012, halved the estimated 1950-1989 pumping rates for these wells.

Brighton

- For all wells
    - 1/1950 to 12/2006 - Based on data in Access database
- For Brighton_Well_11, Brighton_Well_3, Brighton_Well_4, Brighton_Well_7, Brighton_Well_8 & Brighton_Well_9
    - 1/2007 to 10/2011 – Based on average of 2006 and 2013Assumed pumping in the last two years of record is the most representative of pumping records.
    - 11/2011 to 10/2013 – Based on HydroBase data
    - 11/2013 to 12/2013 –Based on average of 2006 and 2013
        - Assumed pumping in the last two years of record is the most representative of pumping records
- For rest of wells,
    - 1/2007 to 12/2013 – Based on 2006 data. Assumed pumping records most representative of current use.

Brush

- For all wells,
    - 1/1950 to 12/1965 - Based on data in Access database
    - 1/1966 to 10/2007 - Based on data provided by Brush
    - 11/2007 to 12/2013 - Based on HydroBase data
        - Missing months filled in with zeros or measured pumping value.
        - Verified by looking at Brush's data.

Carey Wells

- For all wells
    - 1/1950 to 12/2006- Based on Access database
    - 1/2007 to 12/2013
        - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

Cherry Creek (CCC) Wells

- For CCC_Well_1
    - 1/1950 to 12/2006 - Based on Access database
    - 12/2006 to 10/2007 - Based on average of 2004 & 2005 pumping
        - 2004 & 2005 years with measured data (Access database)
    - 11/2007 to 6/2011 - Based on HydroBase data
        - Blank values filled in with zeros, assumed zero pumping to reflect measured pumping trends
    - 7/2011to 12/2013 - Based on average of HydroBase data
- For CCC_Well_4 and CCC_Well_5,
    - 1/1950 to 12/2006 - Based on Access database
    - 12/2006 to 10/2007 - Based on average of 2004 & 2005 pumping
        - 2004 & 2005 years with measured data (Access database)
    - 11/2007 to 12/2013 - Based on HydroBase data

        - Blank values filled in with zeros, assumed zero pumping to reflect measured pumping trends

City Ice Wells

- For all wells,
    - 1/1950 to 12/2006 – Based on Access database
    - 12/2006 to 12/2013
        - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

CO State Wells

COLO STATE W 4 (COLO STATE W 3-8975-F) is screened from depth of 482' to 737' so clearly not alluvial and was removed

Denver Fire Department now occupies the property where COLO_STATE_W2, _3, and _5 are located; original wells were for leather tanning and other processing by Colorado By-Products which was sold to Beatrice Foods in 1965. Unclear how property was disposed of Beatrice or possibly Con-Agra after 1990 acquisition of Beatrice – i.e., when did industrial pumping stop? Private party sold property to CDOT in 1998 who then sold to City of Denver in 2004. NWT reduces pumping severely (<1% of pumping is achieved) which could be result of initial head issues in Denver area. Rates unchanged for now.

- For all wells
    - 1/1950 to 12/2006 - Based on Access database
    - 1/2007 to0 12/2013
        - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

Continental (Suncor) Wells

- For all wells
    - 1/1950 to 12/2006 - Based on Access database
    - 1/2007 to 12/2013
        - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

CWSD Wells (Centennial)

- For all wells
    - 1/1950 to 12/2006 - Based on Access database
    - 1/2007 to 12/2013 - Based on data provided by Centennial Surf Club/Highlands Ranch

Dekalb Wells (Grand Mesa Eggs)

- For all wells
    - 1/1950 to 12/2006 - Based on Access database
    - 1/2007 to 12/2013
        - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

ECCV Wells (East Cherry Creek Water and Sanitation District)

- For all wells,
    - 1/1950 to 12/2006 - Based on Access database

- 1/2007 to 3/2008 - Based on average years 2004-2006 (complete years of measured data)
- 4/2008 to 10/2013 Based on HydroBase Data
  - Blank values filled in with zeros, assumed zero pumping to reflect measured pumping trends

Englewood Wells

- For Englewood_Well_1
  - 1/1950 to 03/2005 - Based on Access database
  - 04/2005 to 02/2009 - Based on data provided by Englewood
    - Missing values filled in with zeros. Pumping is for irrigation thus has no pumping during winter months.
  - 03/2009 to 10/2013 - Based on HydroBase records
    - Missing values filled in with zeros. Pumping is for irrigation thus has no pumping during winter months.
  - 11/2013 to 12/2014 - Based on data provided by Englewood
    - Missing values filled in with zeros. Pumping is for irrigation thus has no pumping during winter months.
- For Englewood_Well_2
  - 1/1950 to 06/2004 - Based on Access database
  - 7/2004 to 02/2009 Based on data provided by Englewood
    - Missing values filled in with zeros. Pumping is for irrigation thus has no pumping during winter months.
  - 3/2009 to 10/2013 Based on HydroBase records
    - Missing values filled in with zeros. Pumping is for irrigation thus has no pumping during winter months.
  - 11/2013 to 12/2014 - Based on data provided by Englewood
    - Missing values filled in with zeros. Pumping is for irrigation thus has no pumping during winter months.
- For Englewood_Well_3
  - 1/1950 to 2/2004 - Based on Access database
  - 3/2004 to 2/2009- Based on data provided by Englewood
    - Missing values filled in with zeros. Pumping is for irrigation thus has no pumping during winter months.
  - 3/2009 to 10/2013 - Based on HydroBase records
    - Missing values filled in with zeros. Pumping is for irrigation thus has no pumping during winter months.
  - 11/2013 to 12/2014 - Based on data provided by Englewood
    - Missing values filled in with zeros. Pumping is for irrigation thus has no pumping during winter months.

- For Englewood_Well_6
    - 1/1950 to 3/2001 - Based on Access database
    - 4/2001 to 3/2009 - Based on data provided by Englewood
        - Missing values filled in with zeros. Pumping is for irrigation thus has no pumping during winter months.
    - 4/2009 to 9/2013 - Based on HydroBase records
        - Missing values filled in with zeros. Pumping is for irrigation thus has no pumping during winter months.
    - 10/2013 to 12/2014 - Based on data provided by Englewood
        - Missing values filled in with zeros. Pumping is for irrigation thus has no pumping during winter months.
- For Englewood_Well_7
    - 1/1950 to 12/2006 - Based on Access database
    - 12/2006 to 12/2014 filled in with zeros – no more pumping with this well since 1999 per Englewood's information

Fort Lupton

- For all Fort_Luption_Well_1, Fort_Lupton_Well_2, Fort_Lupton_Well_3 and Fort_Lupton_Well_4
    - 1/1950 to 12/2006 - Based on Access database
    - 12/2006 to 10/2011
        - Fill in data with calculated average from 1980-2005 since those are measured pumping records
    - 11/2011 to 10/2013 - Based on HydroBase records
        - Fill in missing with calculated average from 1980-2005
- For Fort_Lupton_Well_5 and Fort_Lupton_Well_6
    - 1/1950 to 12/2006 - Based on Access database
    - 12/2006 to 12/2013
        - Fill in data with calculated average from 1980-2005

Fort Morgan

- For Fort_Morgan_Well_1, Fort_Morgan_Well_15, Fort_Morgan_Well_16, Fort _Morgan_Well_3, Fort_Morgan_Well_4 and Fort_Morgan_Well_5
    - 1/1950 to 12/2006 - Based on Access database
    - 12/2006 to 12/213- Based on HydroBase records when available
        - Missing values filled in with data provided by Fort Morgan
- For rest of wells,
    - 1/1950 to 12/2006 - Based on Access database
    - 1/2007 to 12/2013 - Based on data provided by Fort Morgan

Great Western Wells

- For all wells,
    - 1/1950 to 12/2006 - Based on Access database
    - 1/2007 to 12/2013
        - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

Greeley Wells

- For Greeley_Well_1, Greeley_Well_3, Greeley_Well_4 and Greeley_Well_5
    - 1/1950 to 12/2006 - Based on Access database
    - 1/2006 to 12/2013 - Based on data provided by Greeley
        - Missing values for Jan and Feb 2007, assumed zero pumping to reflect measured pumping trends
- For remaining wells,
    - 1/1950 to 12/2006 - Based on Access database
    - 1/2007 to 12/2013
        - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

Hibbs Well

- 1/1950 to 12/2006 - Based on Access database
- 1/2007 to 12/2013
    - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

Hillrose Well

- 1/1950 to 12/2006 - Based on Access database
- 1/2007 to 12/2013
    - Based on average of 2002-2005 measured monthly pumping records

Julesburg Wells

- For Julesburg_Well_3
    - 1/1950 to 10/1995 - Based on Access database
    - 10-1995 to 12/2006 - Based on hydro base
        - Missing values filled in with Access database values
    - 1/2007 to 10/2007
        - Filled in with a percentage of pumping according to the yearly totals provided by Julesburg

January	3.5%
February	3.6%
March	4.3%
April	6.9%
May	11.1%
June	13.6%
July	16.7%
August	14.1%
September	11.2%
October	6.9%
November	4.3%
December	3.8%

        - Have monthly records from 1998 to 2005, so calculated pumping % of yearly total average across years
    - 11/2007 to 12/2013 - Based on HydroBase records
        - Missing values filled in with a percentage of pumping according to the yearly totals provided by Julesburg
- For rest of wells,
    - 1/1950 to 12/2006- Based on Access database
    - 1/2007 to 12/2013
        - Based on HydroBase data
            - Filled in with a percentage of pumping according to the yearly totals provided by Julesburg
            - Average monthly percentages from 1998 -2005 data

Jan	3.5%
Feb	3.6%
March	4.3%
April	6.9%
May	11.1%
June	13.6%
July	16.7%
August	14.1%
September	11.2%
October	6.9%
November	4.3%
December	3.8%

KB Packing Wells

- For all wells
    - 1/1950 to 12/2006 Based on Access database

- 1/2007 to 12/2013
  - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

Kersey Wells

- For all wells
  - 1/1950 to 12/2006 - Based on Access database
  - 1/2007 to 12/2013
    - Access data shows trend of yearly pumping increases by 4.727 AF. (% increase = 2.56%). Continue this projection forward.

Klausner Wells

The original SPDSS Database had total monthly pumping (ac-ft/mo) of:

Klausner_Well_1	40.35
Klausner_Well_2	33.63
Klausner_Well_3	30.26
Klausner_Well_4	5.04

for a total monthly rate of approx. 109 ac-ft/mo or 1,311 ac-ft/yr. These pumping rates are unsustainable with MODFLOW-NWT turning the rates down as the alluvium desaturates. A review of well permits indicates that the 4 wells now have a total 145.3 ac-ft/year allocation for Nile oil field flooding since 1986. The 145.3 ac-ft/yr is based on average estimated consumptive use for previous irrigation. These wells and the parcels that were apparently irrigated are NOT in the irrigation snapshots. New approach is to assume that the average of 145.3 for consumptive use is a more reasonable rate for both the irrigation as well as the oil field flooding. Scale the original database pumping rates at each individual well to get to 145.3 ac-ft/yr + also account for numbers of days in each month; annual rates (ac-ft/yr) are:

Klausner_Well_1	53.7
Klausner_Well_2	44.7
Klausner_Well_3	40.2
Klausner_Well_4	6.7

Links to Klausner well permits:

http://www.dwr.state.co.us/WellPermitSearch/View.aspx?receipt=9000936

http://www.dwr.state.co.us/WellPermitSearch/View.aspx?receipt=9000937

http://www.dwr.state.co.us/WellPermitSearch/View.aspx?receipt=9000938

http://www.dwr.state.co.us/WellPermitSearch/View.aspx?receipt=9000939

Krueger Well

- For well
  - 1/1950 to 12/2006 - Based on Access database
  - 1/2007 to 12/2013 – Based on HydroBase records

- Missing data filled in with maximum estimated pumping equal to decreed rate (as previously done for the Access database)
- HydroBase records are sporadic and do not have complete years, so cannot use its average

La Salle Wells

- For all Lasalle_Well_1 and LaSalle_Well_2
  - 1/1950 to 12/2006 - Based on Access database
  - 1/2007 to 12/2013
    - Access estimated data shows trend of total yearly AF increases by 0.3051 AF. (% increase = 0.3507%). Continue this projection forward.
- For all Lasalle_Well_3, LaSalle_Well_4 and LaSalle_Well_5
  - 1/1950 to 12/2006 Based on Access database
  - 1/2007 to 12/2013- Based on HydroBase records
    - Missing data filled in
      - Access estimated data shows trend of total yearly AF increases by 0.3051 AF. (% increase = 0.3507%). Continue this projection forward.

Lauck Wells

- For all wells
  - 1/1950 to 12/2006 - Based on Access database
  - 1/2007 to 12/2013
    - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

Log Lane Well

- For all wells
  - 1/1950 to 12/2006 - Based on Access database
  - 1/2007 to 12/2013
    - Based on 2004, year of measured data
    - 5/2010 well abandoned so zero pumping afterwards

Lousberg

- For all wells
  - 1/1950 to 12/2006 - Based on Access database
  - 1/2007 to 12/2013
    - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

Mathews Wells

- For all Mathews_Well_2
  - 1/1950 to 12/2006 - Based on Access database

    - 1/2007 to 12/2013
        - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)
- For Mathews_Well_1
    - 1/1950 to 12/2006 - Based on Access database
    - 1/2007 to 10/2011
        - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)
    - 11/2011 to 12/2013 -Based on HydroBase data
        - Missing data filled in with maximum estimated pumping equal to decreed rate

McAtee Wells

- For McAtee_Well_3, McAtee_Well_4, McAtee_Well_8
    - 1/1950 to 10/2006 - Based on Access database
    - 11/2006 to 12/2013 -Based on HydroBase data
        - Missing data filled in with maximum estimated pumping equal to decreed rate
- For rest of wells,
    - 1/1950 to 12/2006 - Based on Access database
    - 1/2007 to 12/2013
        - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

MCQWC Wells

- MCQWC_Well_2, MCQWC_Well_3, MCQWC_Well4 and MCQWC_Well_5
    - 1/1950 to 10/2006 - Based on Access database
    - 11/2006 to 12/2013- Based on HydroBase records
        - Filled in with pumping average 2005-2006 because based on actual monthly data for individual wells
- MCQWC_Well_1
    - 1/1950 to 12/2006 - Based on Access database
    - 1/2007 to 12/2013
        - Filled in with pumping average 2005-2006 because based on actual monthly data for individual wells

Merino Well

    - 1/1950 – 12/2006- Based on Access database
    - 1/2007 – 12/2013 - Based on HydroBase records
        - Missing data November and December, 2013 filled in with HydroBase values for pumping in 2012

Milliken Well

- 1/1950 to 12/2006 - Based on Access database
- 1/2007 to 12/2013
  - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

Montfort Wells

- For Monfort_Well_6
  - 1/1950 to 12/2006 - Based on Access database
  - 1/2007 to 12/2013
    - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)
- For rest of wells
  - 1/1950 to 12/2006 - Based on Access database
  - 1/2007 to 12/2013
    - Based on HydroBase records
    - Filled in missing data with maximum estimated pumping equal to decreed rate

Ovid Well

- 1/1950 to 12/2006 Based on Access database
- 1/2007 to 12/2013
  - Used years 2004-2005 to determine monthly percentage of pumping because these years are actual monthly measurements, then applied that to the yearly totals provided by Ovid

Jan	6.4%
Feb	5.5%
March	7.3%
April	8.5%
May	11.5%
June	12.7%
July	14.8%
August	12.4%
Sept	12.1%
Oct	7.6%
Nov	2.3%
Dec	2.3%

Pack Corp Wells

- For all wells
  - 1/1950 to 12/2006 - Based on Access database
  - 1/2007 to 12/2013
    - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

Platteville Wells

- For all wells
    - 1/1950 to 12/2006 - Based on Access database
    - 1/2007 to 12/2013
        - Access estimated data shows trend of total yearly AF increases by 6.59 AF. (% increase = 3.056%). Continue this projection forward.

PWSD Well

- 1/1950 to 12/2006 Based on Access database
- 1/2007 to 12/2013
    - Based on pumping trend 1983-2005; same pumping each month. Continue forward.

SACWSD (South Adams County Water and Sanitation District) Wells

- For SACWSD_Well_1
    - 1/1950 to 10/1995 - Based on Access database
    - 11/1995 to 12/2013 - Based on HydroBase data
        - Missing data filled in with average 1996-2000, 2003-2006, 2008 (full years of HydroBase data)
- SACSWD_Well_10
    - 1/1950 to 10/2001 - Based on Access database
    - 11/2001 to 12/2013 - Based on HydroBase data
        - Missing data filled in with pumping from 2003 (only full year of measured data)
- SACWSD_Well_2
    - 1/1950 to 10/1995 - Based on Access database
    - 11/1995 to 12/2013 - Based on HydroBase data
        - Missing data filled in with average 1998-2001, 2005 (full years of HydroBase data)
- SACWSD_Well_3
    - 1/1950 to 12/2006 - Based on Access database
    - 1/2007 to 12/2013
        - Filled in with zeros because database shows no pumping from 1988-2006. Assume continues with no pumping.
- SACWSD_Well_4
    - 1/1950 to 10/1995 - Based on Access database
    - 11/1995 to 12/2013 - Based on HydroBase data
        - Missing values filled in with average 1996-2000, 2003, 2005 – 2006, 2012 (full years of HydroBase data)
- SACWSD_Well_5
    - 1/1950 to 12/2006 - Based on Access database

    - 1/2007 to 12/2013
        - Filled in with average of years 2000-2005 (measured data)
- SACWSD_Well_6
    - 1/1950 to 1/1996 - Based on Access database
    - 2/1996 to 12/2013 - Based on hydro base data
        - Missing data filled in with average of 1998-2000, 2003, 2012 (full years of Hydro-Base data)
- SACWSD_Well_7
    - 1/1950 to 1/1996 - Based on Access database
    - 2/1996 to 12/2013 - Based on hydro base data
        - Missing data filled in with average of 1998-2005, 2008(full years of HydroBase data)
- SACWSD_Well_8
    - 1/1950 to 1/1996 - Based on Access database
    - 2/1996 to 12/2013 - Based on hydro base data
        - Missing data filled in with average of 1998-2001, 2003-2006 (full years of Hydro-Base data)
- SACWSD_Well_9
    - 1/1950 to 1/1996 - Based on Access database
    - 2/1996 to 12/2013 - Based on hydro base data
        - Missing data filled in with average of 1996-2008 (full years of HydroBase data)

Sedgwick

- For Sedgwick_Well_2,
    - 1/1950 to 12/2006 - Based on Access database
    - 1/2007 to 11/2007
        - Filled in with Monthly Average 2010-2012 (complete years with measured data)
    - 1/2007 to 12/2013- Based on HydroBase data
        - Missing data filled in with monthly Average 2010-2012 (complete years with measured data)
- For rest of wells,
    - 1/1950 to 12/2006 - Based on Access database
    - 1/2007 to 12/2013
        - Access estimated data shows trend of total yearly AF increases by 0.046 AF. (% increase = 0.41025%). Continue this projection forward.

Sterling Beef Wells

- For all wells,
    - 1/1950 to 12/2006 - Based on Access database

- 1/2007 to 12/2013
  - Based on HydroBase records
  - Missing data filled in average from years 2007-2011 (full years of HydroBase records)

Sterling EW Wells

- 1/1950 to 12/2006 - Based on Access database
- 1/2007 to 12/2013
  - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

Sterling Wells

- For Sterling_Well_1, Sterling_Well_2, Sterling Well_3
  - 1/1950 to 10/1999 - Based on Access database
  - 10/1999 to 10/2006 - Based on HydroBase data
    - Missing data filled in with access data base (based on actual pumping records)
  - 11/2009 to 12/2013 - Based on HydroBase data
    - Missing data filled in with average of years (full years of measured data)
      - Well 1 average 2000-2003, 2007-2009, 2012
      - Well 2 average 2001-2002, 2005, 2007
      - Well 3 average 2000-2002, 2007-2009, 2012
- Sterling_Well_10, Sterling_Well_4
  - 1/1950 to 12/2006 - Based on access data base
  - 1/2007 to 12/2013- Based on HydroBase data
    - Filled in with average from years (full years measured data)
      - Well 10 average 2001-2003, 2005, 2007
      - Well 4 average 2001-2005
- Sterling_Well_5
  - 1/1950 to 5/2000 Based on Access database
  - 6/2000 to 12/2006 Based on HydroBase data
    - Missing data filled in with Access database values because Based on measured pumping for those years
  - 1/2007 to 12/2013
    - Based on HydroBase
    - Missing values filled in with 2005 pumping (full year measured data)
- Sterling_Well_6
  - 1/1950 to 10/1995 - Based on Access database
  - 11/1995 to 12/2006 - Based on HydroBase records

        - Missing records filled in with Access database
    - 1/2007 to 12/2013 - Based on HydroBase records
        - Missing values filled in with pumping from 2005 (year full data).
        - No pumping November - April, fill in with zeros to reflect pumping trends
        -
- Sterling_Well_7
    - 1/1950 to 12/1995 - Based on access
    - 1/1996 to 12/2006 - Based on HydroBase
        - Missing data filled in with Access database
    - 1/2007 to 12/2013 - Based on HydroBase
        - Missing values filled in with average 2001-2002, 2005
- Sterling_Well_8, Sterling_Well_9
    - 1/1950 to 12/2006 - Based on access data base
    - 1/2007 to 12/2013
        - Filled in with HydroBase data
        - Missing data filled in with average from years 2001-2005 (full years measured data)
        - No pumping November - April, fill in with zeros to reflect pumping trends

Swift Wells

- For all wells,
    - 1/1950 to 12/2006 - Based on hydro base
    - 1/2007 to 12/2013
        - Fill in with average from 2004, 2005 because actual pumping records

Thornton Wells

- For all wells,
    - 1/1950 to 12/2006 - Based on hydro base
    - 1/2007 to 12/2013
        - Fill in with average from 2002-2005 because actual measured pumping records

Valencia Wells

- For all wells
    - 1/1950 to 12/2006 - Based on Access database
    - 1/2007 to 12/2013
        - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

Walker Wells

- For all wells

- 1/1950 to 12/2006 - Based on Access database
- 1/2007 to 12/2013
  - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

Walker_Well_3 (permit 2498-F) is an irrigation well and is included in the irrigation snapshots, so removed from the M&I pumping

Wiggins

- For all wells
  - 1/1950 to 12/2006 - Based on Access database
  - 1/2007 to 12/2013
    - Maximum estimated pumping equal to decreed rate (as previously done for the Access database)

Wiggins_Well_1 was an irrigation well until 1994; after 1994 the annual appropriation for municipal use was 170.3 ac-ft/yr and that 170.3 ac-ft/yr rate spread evenly per month

XCEL Public Service Wells

- Xcel_well_1
  - 1/1950 to 10/2001 - Based on Access database
  - 11/2001 to 12/2006 - Based on HydroBase
    - Missing data filled in with access database
  - 1/2007 to 12/2013- Based on HydroBase
    - Missing data filled in with measured data given to us by XCEL
- Xcel_Well_3
  - 1/1950 to 10/2005 Based on access
  - 11/2005 to 12/2013 - Based on HydroBase records
    - Missing data filled in with measured data by XCEL
- Xcel_Well_2, Xcel_Well_4 and Xcel_Well_5
  - 1/1950 to 10/2005- Based on access
  - 11/2005 to 12/2013 - Based on measured data by XCEL

Additional Observations

There were some discrepancies in the Access database. Various wells included in the MI_Pumping_Wells_wGridLocation sheet but not included in MI_Pumping sheet. Those wells are shown in the table below.

Only wells with pumping records in the access data base (MI_Pumping) had their time series extended.

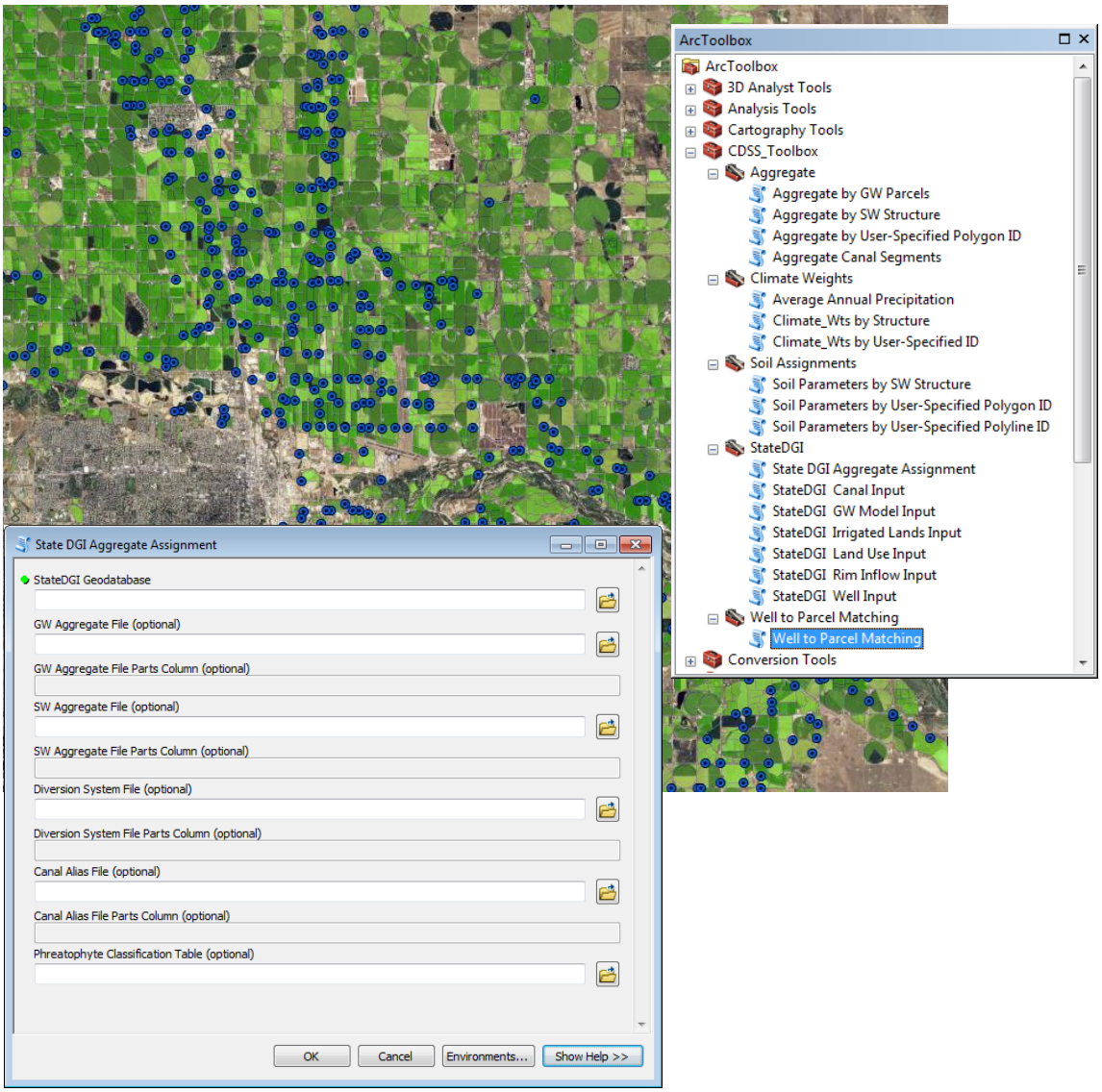
Well ID	CCCC_Well_2	CCCC_Well_3	Lasalle_Well_6	NCWA_Well_1	NCWA_Well_2	NCWA_Well_3	Walker_Well_3
Permit Number	15447	15450	3673	4862	13429	60767	2498
Well name	HOLLAND MARCUS W 2-15447	HOLLAND MARCUS W 3-15450	LASALLE TOWN OF 3673-F	N COLO W ASSN W 1-04862F	N COLO W ASSN W 2-13429F	60767-F	WALKER WELL 4-2498-F
X coordinate	510013.3	510013.3	525243	503077.6	503077.8	504056.3	582009
Y coordinate	4391564	4391564	4467052	4529678	4529476	4528865	4460598

Also, various wells were missing permit numbers. Those wells include:

- Brighton_Well_10
- Brighton_Well_12
- Brighton_Well_13
- Brighton_Well_14
- Brighton_Well_15
- Brighton_Well_16
- Brighton_Well_17
- Brighton_Well_18
- Brighton_Well_19
- CO_State_Well_2
- CO_State_Well_3
- Continental_Well_10
- Continental_Well_9
- Mathews_Well_2
- McAtee_Well_1
- McAtee_Well_2
- SACWSD_Well_1
- SACWSD_Well_3
- SACWSD_Well_5
- Thornton_Well_1
- Thornton_Well_5
- Walker_Well_2

Appendix B: CDSS Toolbox Manual Update

CDSS Toolbox Manual Update



April 2017

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Section 1

Introduction

The CDSS Toolbox is a set of GIS data management interfaces (DMIs) implemented using Python scripts that provide users with a graphical interface for each tool within Esri's ArcToolbox™ software environment. The CDSS Toolbox DMIs perform operations to process GIS data sets for use with other CDSS tools and DMIs, notably StateDGI, StateCU, StateMod, and StatePP. The CDSS Toolbox is intended to provide consistent, automated, and reproducible methods of developing the input files required for other CDSS tools.

The CDSS Toolbox was updated to allow the Python scripts to operate within ArcGIS version 10.1 (or higher), with additional objectives of reading both geodatabase feature classes and shapefiles as input, removing any redundant code, checking the logic of geoprocessing operations, checking for consistent input data schema requirements, and ensuring that the scripts process data correctly. Additionally, the Python scripts have been updated to use the newer ArcPy Python syntax rather the original arcgisscripting Python syntax because of the likelihood that in the future Esri will depreciate and remove the older arcgisscripting from ArcGIS. The user of the CDSS Toolbox should be familiar with the operation of ArcGIS Desktop software, particularly ArcMap and ArcToolbox.

The CDSS Toolbox is composed of five toolsets:

- Aggregate
- Climate Weights
- Soil Parameters
- StateDGI
- Well to Parcel Matching

The Aggregate, Climate Weights, and Soil Parameters toolsets are designed to be primarily used to generate input files for StateCU and StateMod. The StateDGI and Well to Parcel Matching toolsets are designed to be used primarily used to generate input files for StateDGI and StatePP to ultimately build model input files for MODFLOW-based groundwater models. Each of these toolsets contains one or more individual tools.

Each individual tool consists of an ArcPy script and an ArcToolbox graphical user interface (GUI) for the user to enter the appropriate information and spatial data sets to be processed by the script. The GUIs include embedded help information describing the overall intent of the tools, as well as descriptions of the appropriate inputs to the tools and the expected outputs. The GUIs also help guide the user to not use inappropriate inputs in three ways. First, the ArcToolbox interfaces will not allow the user to enter inappropriate types of data inputs through restrictions on the types of data allowed to be entered. For example, a user cannot specify a raster data set where a feature layer data set is the necessary data type, nor can a user specify a text field from an attribute table where an integer or numeric field is the necessary data type. Second, for each tool most inputs are required while some are optional. The GUI will return an error message if required inputs have not been entered by the user, and will return the user to the GUI with previous inputs intact such that the user does not have to start from the beginning. Third, the ArcToolbox GUIs have additional internal "validation" Python scripts that are executed before the main ArcPy scripts are executed. These validation scripts further check the specified input data sets to ensure that they are appropriate inputs to the ArcPy scripts. For example, the tools that use CDSS Irrigation Snapshot feature layers

as inputs are validated to check that they have the appropriate standard attribute fields (e.g., SW_WDID1, SW_WDID2,..., SW_WDID9 and GW_ID1, GW_ID2,... ,GW_ID20). If any of the input data sets return an error from the validation script, the user is informed of the issues with the specified input and returned to the GUI to correct them. Not all input data sets can be fully checked for potential errors before execution of the ArcPy script, so each tool generates a log file that lists the progress of the tool and information about errors if they occur so the user can perform any necessary corrections.

1.1 Installing and Loading the CDSS Toolbox

The CDSS Toolbox is contained in a single directory that includes the ArcToolbox file (CDSS_Toolbox.tbx) and the ArcPy scripts (*.py). The CDSS_Toolbox.tbx file contains the GUIs and help information for each individual tool, and the references to the location of the ArcPy scripts. The default location of the CDSS Toolbox is C:\CDSS\bin\Toolbox, and CDSS_Toolbox.tbx contains references to the ArcPy scripts in this location. This default location may be changed by the user, but the user will need to manually update the CDSS_Toolbox.tbx file's locations of the ArcPy scripts because ArcToolbox files do not retain relative paths to ArcPy scripts. It is recommended to use the default location.

Once the CDSS Toolbox is installed, the user can add the toolbox to the ArcToolbox interface within ArcMap. Begin by opening ArcToolbox by selecting **Geoprocessing** from the main menu, and then selecting **ArcToolbox** from the dropdown menu, or by selecting the red toolbox icon from the ArcMap standard toolbar. 

Now that the ArcToolbox interface window is open, right-click on the main ArcToolbox icon and select **Add Toolbox** from the popup menu. In the dialog window that appears, browse to the C:\CDSS\bin\Toolbox location, click once on CDSS_Toolbox.tbx, and select **Open**. (Note: do not double-click on CDSS_Toolbox.tbx because the dialog window will browse to the list of toolsets inside the CDSS Toolbox rather than adding the toolbox.)

CDSS_Toolbox should now appear as an entry within the main ArcToolbox interface. You can now enter the CDSS Toolbox and browse through the toolsets.

1.2 Overview of Using the CDSS Toolbox

Double-click on the CDSS_Toolbox icon to expand the list of toolsets contained within, and then double-click on each toolset's icon to expand the list of individual tools contained within each toolset. Double-click on a tool to open the GUI for the tool. The GUI allows the user to browse to the locations of input data sets, use dropdown menus to specify the appropriate attribute table fields as inputs, etc. If the help information for a tool is hidden, click the **Show Help** button in the lower left of the tool's GUI. The overview help information for the tool will be displayed to the right of the area for entering tool input, and if you click on an individual input element, the specific help for that input will appear instead of the overview information. To display the entire help information for a tool, click the **Tool Help** button in the lower left. To hide the help again, click the **Hide Help** button.

The following section and its subsections describe the usage of each individual tool organized by the five toolsets.

Section 2

Aggregate Toolset

Aggregate by GW Parcels

Summary

Note that this tool will be superseded by the StateDGI Aggregate Assignment tool in which groundwater aggregates are assigned through lists of WDIDs and Aggregate IDs rather than an intersection of aggregate area polygons with irrigated area feature layers. This tool remains for back-compatibility with previous modeling if needed.

The Aggregate by GW Parcels tool is used to combine parcels irrigated by groundwater well structures into user-defined aggregate areas. These groundwater well structures and their irrigated land are combined and given a unique Aggregate ID. The Aggregate ID is typically made up of nine characters identifying the river basin, Water District, and use of surface water. For example, 01ADP001 indicates the first area of diversion structures in the South Platte Basin (ADP) in Water District 1.

Usage

- Please use the StateDGI Aggregate Assignment tool instead; this tool remains for back-compatibility with previous modeling if needed
- Please use the StateDGI Aggregate Assignment tool instead; this tool remains for back-compatibility with previous modeling if needed

Parameter	Explanation	Data Type
Irrigated_Acreage_Feature_Layer	The attribute table for this polygon feature layer must be in the standard CDSS format, including fields for the parcel ID (PARCEL_ID), surface water IDs (SW_WDID1, SW_WDID2,....SW_WDID9), and groundwater IDs (GW_ID1, GW_ID2,...GW_ID20). Each parcel ID occupies one row in the attribute table, and multiple surface water or groundwater structures can be assigned to the parcel through numerated SW_WDID and GW_ID fields. Irrigated acreage feature layers have been created by river basin in support of CDSS modeling efforts and are available on the CDSS website (cdss.state.co.us).	Feature Layer
Aggregate_Areas__Polygon_Feature_ Layer	A polygon feature layer that defines the areas in which the groundwater parcels will be grouped.	Feature Layer
Aggregate_Attribute	The attribute field name in the Aggregate Areas feature layer that contains the Aggregate IDs that the groundwater parcels will be assigned to in the output table. This attribute can also be added to the Irrigated Acreage feature layer to create a new Irrigated Acreage feature class.	Field
Output_CSV_File	The output file is a comma-delimited text (CSV) file that contains the Aggregate ID, the groundwater WDID and structure acres. Note that this tool recomputes parcel areas based on the appropriate map units, then converts the area to acres and aggregates according to the Aggregate Area polygon coverage. Date and input parameters will be included in the header.	File
Add_Results_to_New_Feature_Class	If the "Add Results to New Feature Class" checkbox is selected, the Aggregate ID (if any) assigned to the structure in GW_ID1 will be appended as a new field in a copy of the Irrigated Acreage Feature Layer and saved as the new feature class.	Boolean

Parameter	Explanation	Data Type
New_Irrigated_Parcel_Feature_Class (Optional)	The output irrigated parcel feature class to be created if the "Add Results to New Feature Class" checkbox is selected.	Feature Class

Aggregate by SW Structure

Summary

Note that this tool has been superseded by the StateDGI Aggregate Assignment tool in which surface water aggregates are assigned through lists of WDIDs and Aggregate IDs rather than an intersection of aggregate area polygons with irrigated area feature layers. This tool remains for back-compatibility with previous modeling if needed.

The Aggregate by SW Structure tool is used to combine parcels irrigated by "non-key" surface water structures into user-defined aggregate areas. Non-key structures are generally defined in the CDSS modeling efforts as those surface water structures with sparse or no diversion records, structures diverting from a tributary not expected to be included in the water resources planning model, or structures irrigating a relatively small amount of land. These non-key structures and their irrigated land are combined and given a unique Aggregate ID. The Aggregate ID is typically made up of nine characters identifying the river basin, Water District, and use of surface water. For example, 01ADP001 indicates the first area of diversion structures in the South Platte Basin (ADP) in Water District 1. When non-key structures have irrigated lands in more than one aggregate polygon, the structure will be assigned to the aggregate containing the greatest structure area. Only those parcels that have an associated surface water ID not included in the "key" structure list will be aggregated and included in an Aggregate ID in the newly created Output Table.

Usage

- Please use the StateDGI Aggregate Assignment tool instead; this tool remains for back-compatibility with previous modeling if needed

Parameter	Explanation	Data Type
Irrigated_Acreage_Feature_Layer	The attribute table for this polygon feature layer must be in the standard CDSS format, including fields for the parcel ID (PARCEL_ID), surface water IDs (SW_WDID1, SW_WDID2,….SW_WDID9), and groundwater IDs (GW_ID1, GW_ID2,…GW_ID20). Each parcel ID occupies one row in the attribute table, and multiple surface water or groundwater structures can be assigned to the parcel through numerated SW_WDID and GW_ID fields. Irrigated acreage feature layers have been created by river basin in support of CDSS modeling efforts and are available on the CDSS website (cdss.state.co.us).	Feature Layer
Aggregate_Areas__Polygon_Feature_ Layer	A polygon feature layer that defines the areas in which the non-key surface water parcels will be grouped.	Feature Layer
Aggregate_Attribute	The attribute field name in the Aggregate Areas feature layer that contains the Aggregate IDs that the non-key surface water parcels will be assigned to in the output table. This attribute can also be added to the Irrigated Acreage feature layer to create a new Irrigated Acreage feature class.	Field

Parameter	Explanation	Data Type
Key_Structure_List__CSV (Optional)	This input file is optional—if no Key Structure List is provided, the tool will aggregate all parcels with an associated surface water WDID. The list file is a comma-delimited (CSV) file with one structure surface water WDID per line, with additional information about the structure separated by columns. These structure WDIDs will be excluded from the aggregation output CSV file. The surface water ID (SW_WDID) format in this file must match the 7-digit "text" format in the Irrigated Acreage Feature Layer. For example, if the structure is 503 in Water District 1, the SW_WDID must be "0100503."	File
Key_Structure_Column (Optional)	Column number of the SW_WDID in the Key Structure List. This column number must be specified if a Key Structure List is input.	Long
Output_CSV_File	The output file is a comma-delimited text (CSV) file that contains the Aggregate ID, the surface water WDID and structure acres. Note that this tool recomputes parcel areas based on the appropriate map units, then converts the area to acres and aggregates according to the Aggregate Area polygon coverage. Date and input parameters will be included in the header.	File
Add_Results_to_Feature_Class (Optional)	If the "Add Results to New Feature Class" checkbox is selected, the Aggregate ID (if any) assigned to the structure in SW_WDID1 will be appended as a new field in a copy of the Irrigated Acreage Feature Layer and saved as the new feature class. Note that because each irrigated parcel can be served by more than one structure (as defined by SW_WDIDx) it is also possible that a single parcel could be included in more than one aggregate. Only the Aggregate ID associated with SW_WDID1 will be appended in the new feature class.	Boolean
Output_Feature_Class (Optional)	If the "Add Results to New Feature Class" checkbox is selected, the Aggregate ID (if any) assigned to the structure in SW_WDID1 will be appended as a new field in a copy of the Irrigated Acreage Feature Layer and saved as the new feature class. Note that because each irrigated parcel can be served by more than one structure (as defined by SW_WDIDx) it is also possible that a single parcel could be included in more than one aggregate. Only the Aggregate ID associated with SW_WDID1 will be appended in the new feature class.	Feature Class

Aggregate by User-Specified Polygon ID

Summary

The Aggregate by User-Specified ID tool is used to combine any user-defined polygons into user-defined aggregate areas. As other tools specified that parcels served by groundwater or surface water were to be aggregated, this tool allows the user to spatially assign polygons from a feature layer to a user-defined set of aggregated areas. A standard formatted CDSS Irrigated Acreage feature layer is not required as an input for this tool. For example, if the polygon feature layer depicts alfalfa coverage and the aggregate area coverage is counties, this tool would provide the user with the area of alfalfa in each county. In this example, if the alfalfa polygon coverage overlaps county boundaries, the alfalfa parcels will be assigned to the county that contains the greatest alfalfa polygon boundary.

Usage

- The portions of user-defined polygons outside of the user-defined aggregate areas will not be retained
- The user may save the spatial result of this tool in the Output Feature Class

Parameter	Explanation	Data Type
Polygon_Feature_Layer	A feature layer of polygons to spatially assign to Aggregate Areas (e.g., alfalfa parcels).	Feature Layer
Polygon_Attribute	The attribute field name in the Polygon Feature Layer attribute table that contains the Polygon IDs to be used in the aggregation assessment.	Field
Aggregate_Areas__Polygon_Feature_ Layer	A polygon feature layer that defines the areas in which the polygons will be grouped (e.g., counties).	Feature Layer
Aggregate_Attribute	The attribute field name in the Aggregate Areas Feature Layer that contains the Aggregate IDs the polygons will be assigned to in the output CSV file. This attribute can also be added to the original polygon feature layer to create a new feature class.	Field
Output_CSV_File	The output file is a comma-delimited text (CSV) file that contains the Aggregate ID, the Polygon ID, and total acres. Note that this tool re-computes the user-defined polygon areas based on the appropriate map units, then converts the area to acres and aggregates according to the Aggregate Area polygon coverage. Date and input parameters will be included in the header.	File
Add_Results_to_Feature_Class (Optional)	If the "Add Results to New Feature Class" checkbox is selected, the Aggregate ID will be appended as a new field to a copy of the original Polygon feature layer input and saved as the new feature class.	Boolean
Output_Feature_Class (Optional)	If the "Add Results to New Feature Class" checkbox is selected, the Aggregate ID will be appended as a new field to a copy of the original Polygon feature layer input and saved as the new feature class.	Feature Class

Aggregate Canal Segments

Summary

This tool summarizes the polyline segments of a feature layer of canals by surface water ID (SW_WDID) attribute. The feature layer of canals must have the fields in its attribute table be in the standard CDSS canal format.

Usage

- The resulting CSV file from this tool can be uploaded to StateDGI using the StateDGI Aggregate Assignment tool

Parameter	Explanation	Data Type
Canals_Feature_Layer	A feature layer of canals where the attribute table for this polyline feature layer must be in the standard CDSS format. The polyline segments will be summarized by the surface water ID (SW_WDID) attribute.	Feature Layer
WDID_Attribute_Field	Field in the Canals Feature Layer containing the SW_WDID values.	Field
Output_CSV_File	The output file is a comma-delimited text (CSV) file that contains the Surface Water ID (WDID) and total length in feet of the canals. Note that polyline segment lengths are not recomputed but are based on the "Length" field and units in the Canal feature layer. Date and input parameters will be included in the header.	File

Section 3

Climate Weights Toolset

Average Annual Precipitation

Summary

The Average Annual Precipitation tool spatially computes the average annual precipitation, as defined by the Average Annual Precipitation Raster, for a user-defined set of polygons, generally representing drainage basins. This tool is generally used to define average annual precipitation drainages above StateMod baseflow nodes. Average annual precipitation and drainage area are used to distribute natural streamflow gains to baseflow nodes on ungaged tributaries.

Usage

- This tool requires the Spatial Analyst extension to ArcMap

Parameter	Explanation	Data Type
Polygon_Feature_Layer	Feature layer of user-defined polygons in which average annual precipitation will be calculated.	Feature Layer
Polygon_Attribute	The attribute field name in the Polygon Feature Layer that contains the Polygon IDs to be used in the summarization assessment.	Field
Average_Annual_Precipitation_Raster	Average Annual Precipitation Raster data set.	Raster Layer
Output_CSV_File	Output comma-delimited file of spatially averaged annual precipitation for each Polygon ID in the Polygon Feature Layer.	File
Append_to_Feature_Class	If the "Append to Feature Class" checkbox is selected, the average annual precipitation for each Polygon ID will be appended as a new field in a copy of the Polygon Feature Layer and saved as the new feature class.	Boolean
New_Output_Feature_Class (Optional)	If the "Append to Feature Class" checkbox is selected, the average annual precipitation for each Polygon ID will be appended as a new field in a copy of the Polygon Feature Layer and saved as the new feature class.	Feature Class

Climate_Wts by Structure

Summary

The Climate Weight by Structure Tool assigns weights for CDSS standard irrigated acreage polygon feature layers based on the features' distances from local NOAA climate stations. This tool uses the Zonal Statistics tool of Spatial Analyst. The tool requires input of four parameters: the Assignment Layer, the ID Field, the Climate Weight Rasters, and a threshold weight below which a weight for a climate station will not be assigned. Optionally, a workspace of Orographic Correction rasters may be specified.

Irrigated Acreage Feature Layer

The irrigated acreage feature layer must be a polygon feature layer in the standard CDSS format with fields for PARCEL_ID, SW_WDID1, GW_ID1, etc.

Climate Weight Rasters

The Climate Weight Rasters are applied to the Assignment Layer in the process of assigning climate station weights to the specified shapefile. The grid was developed through Linear Interpolation of NOAA Climate Station locations. The general process for development of the Climate Weight Rasters was:

- Varying weights are applied, based on the distance from each station, ranging from 1.0 at the station itself to 0.0 at each adjacent station.
- A Triangular Irregular Network (TIN) is created by joining the location of each climate station into a series of triangles that cover the entire region of interest. The triangular network defined around each climate station can be adjusted, if necessary, to reflect engineering judgment (elevation consideration, topographic influences, extrapolation, etc.).
- At the selected climate station, each triangle vertex is assigned a value of one while all other vertices are assigned a value of zero.
- A grid is then created for each climate station as a linear interpolation of each triangle in the TIN. This automated process is then repeated for each climate station.

The final product is a spline interpolation with linear basis functions. This ensures that the sum of the weights at any point equal 1 and that at a particular climate station, the weight for that climate station is equal to 1. It also ensures that all weights are greater than zero, which is not always guaranteed by other interpolation methods. By using Spatial Analyst extension, the weights are stored as separate rasters and can be combined easily for a point location or summarized for any polygon area.

Usage

- This tool requires the Spatial Analyst extension to ArcMap

Parameter	Explanation	Data Type
Irrigated_Acreage_Feature_Layer	The attribute table for this polygon feature layer must be in the standard CDSS format, including the parcel ID (PARCEL_ID), surface water ID (SW_WDID1, SW_WDID2,...,SW_WDID9), and groundwater ID (GW_ID1, GW_ID2,...,GW_ID20). Each parcel ID occupies one row in the attribute table, and multiple surface water or groundwater structures can be assigned to the parcel through numerated SW_WDID and GW_ID fields. Irrigated acreage feature layers have been created by river basin in support of CDSS modeling efforts and are available on the CDSS website (cdss.state.co.us).	Feature Layer

Parameter	Explanation	Data Type
Climate_Station_Weighting_Rasters	The series of climate station weighting rasters with computed weights based on the distance to the nearest climate station to be used in the analysis. To add rasters click on the "open-folder" icon to navigate to the climate station weight rasters. Select any number of climate station weight rasters for use in the analysis, holding down the Ctrl key to select more than one climate station weight raster at a time. Each selected climate station weight raster will populate the area below the Climate Station Weight Raster navigation box. (Note that the top navigation box next to the "open-folder" icon will remain empty.) The controls next to the populated area are basic Esri tools and although the up and down arrows are functional, the order of the climate station grids does not matter. Use the "X" icon to delete climate station grids. Climate station weighting rasters for the SPDSS study area have been created in support of SPDSS modeling efforts, as described in the SPDSS Technical Memorandum *Task 53.3: Assign Key Climate Information to Irrigated Acreage and Reservoirs*, February 1, 2006. The SPDSS Climate Station Weighting Rasters are available on the CDSS website (cdss.state.co.us).	Multiple Value
Precipitation_Orographic_Correction_ Raster_Directory (Optional)	The directory of grids that contains computed orographic weights based on the ratio of average annual precipitation at a climate station to the average annual precipitation at the structure location. Orographic adjustments are applied to precipitation data typically when irrigated parcels are at an elevation higher than nearby climate stations. To add orographic correction grids click on the "open-folder" icon to navigate to the folder containing the grids. Orographic corrections will be assigned only to their respective climate stations if the climate station was selected as a "weighted" station. For example, if the "2220" climate station grid was the only one selected, then the tool will use only the 2220 orographic correction grid when determining orographic adjustments. This is an optional input; if no orographic correction grid is provided then no orographic adjustments will be assigned for the ID field in the Output CSV File. The SPDSS Orographic Adjustment grids are available on the CDSS website (cdss.state.co.us).	Workspace
Threshold_Weight	Minimum weight assigned to a climate station. The default is 0.05 or 5%. If the minimum weight assigned to any climate station is less than the Threshold Weight, the weights assigned to the other stations will be adjusted to ensure that all the weights sum to 1.0 for each structure.	Double
Output_CSV_File	The output file is a comma-delimited (.csv) file that contains the Polygon IDs, Climate Station IDs, weights, and orographic correction factors. An orographic factor is provided for each assigned climate station if the Precipitation Orographic Correction Grid Directory is provided by the user. If the minimum weight assigned to any climate station is less than the Threshold Weight, the weights assigned to the other stations will be adjusted to ensure that all the weights sum to 1.0 for each unique value in the ID Field. Date and input parameters will be included in the header.	File

Climate_Wts by User-Specified ID

Summary

The Climate Weight by User-Specified ID Tool assigns weights for a polygon or point feature layer based on the features' distances from local NOAA climate stations. This tool uses the Zonal Statistics and Extract Values to Points tools of Spatial Analyst. The tool requires input of four parameters: the Assignment Layer, the ID Field, the Climate Weight Rasters, and a threshold weight below which a weight for a climate station will not be assigned. Optionally, a workspace of Orographic Correction

rasters may be specified, and the user may also opt to have weights assigned for the centroids of input polygon features rather than averaged over the areas of the polygons.

- Assignment Layer

  The assignment layer may be any Polygon Feature Layer (e.g., Water District boundaries or groundwater model grid cells) or a Point Feature Layer (e.g., groundwater model grid nodes). If using polygons, the user may opt to have the tool internally calculate the polygon centroids and assign weights based on the centroid points. The feature layer must include an attribute field that identifies each polygon or point to be linked to the Climate Weight Grid during the operation.

- ID Field

  The ID Field is the attribute table field of the Assignment Layer that climate weights will be applied to. For example, if a feature layer of irrigated acreage within Division 1 is selected as the Assignment Layer, then the climate station weights that represent each parcel of irrigated land in the shapefile can be obtained by selecting the Parcel ID field as the ID Field parameter.

- Climate Weight Rasters

  The Climate Weight Rasters are applied to the Assignment Layer in the process of assigning climate station weights to the specified shapefile. The grid was developed through Linear Interpolation of NOAA Climate Station locations. The general process for development of the Climate Weight Rasters was:

  - Varying weights are applied, based on the distance from each station, ranging from 1.0 at the station itself to 0.0 at each adjacent station.
  - A triangular irregular network (TIN) is created by joining the location of each climate station into a series of triangles that cover the entire region of interest. The triangular network defined around each climate station can be adjusted, if necessary, to reflect engineering judgment (elevation consideration, topographic influences, extrapolation, etc.).
  - At the selected climate station, each triangle vertex is assigned a value of 1 while all other vertices are assigned a value of zero.
  - A grid is then created for each climate station as a linear interpolation of each triangle in the TIN. This automated process is then repeated for each climate station.

The final product is a spline interpolation with linear basis functions. This ensures that the sum of the weights at any point equal 1 and that at a particular climate station, the weight for that climate station is equal to 1. It also ensures that all weights are greater than zero, which is not always guaranteed by other interpolation methods. By using Spatial Analyst extension, the weights are stored as separate rasters and can be combined easily for a point location or summarized for any polygon area.

Usage

- This tool requires the Spatial Analyst extension to ArcMap

Parameter	Explanation	Data Type
Assignment_Layer	A feature layer of polygons (e.g., Surface Water Aggregate Areas) or points (e.g., groundwater model grid nodes) to which the tool will assign spatially averaged climate station weights.	Feature Layer

Parameter	Explanation	Data Type
ID_Field	The attribute field name in the Assignment Layer that contains the IDs on which to summarize for the weight assignment analysis (e.g., Aggregate ID).	Field
Climate_Station_Weight_Rasters	The series of climate station weighting rasters with computed weights based on the distance to the nearest climate station to be used in the analysis. To add rasters click on the "open-folder" icon to navigate to the climate station weight rasters. Select any number of climate station weight rasters for use in the analysis, holding down the Ctrl key to select more than one climate station weight raster at a time. Each selected climate station weight raster will populate the area below the Climate Station Weight Raster navigation box. (Note that the top navigation box next to the "open-folder" icon will remain empty.) The controls next to the populated area are basic Esri tools and although the up and down arrows are functional, the order of the climate station grids does not matter. Use the "X" icon to delete climate station grids. Climate station weighting rasters for the SPDSS study area have been created in support of SPDSS modeling efforts, as described in the SPDSS Technical Memorandum *Task 53.3: Assign Key Climate Information to Irrigated Acreage and Reservoirs*, February 1, 2006. The SPDSS Climate Station Weighting Rasters are available on the CDSS website (cdss.state.co.us).	Multiple Value
Precipitation_Orographic_Correction_ Raster_Directory (Optional)	The directory of grids that contains computed orographic weights based on the ratio of average annual precipitation at a climate station to the average annual precipitation at the structure location. Orographic adjustments are applied to precipitation data typically when irrigated parcels are at an elevation higher than nearby climate stations. To add orographic correction grids click on the "open-folder" icon to navigate to the folder containing the grids. Orographic corrections will be assigned only to their respective climate stations if the climate station was selected as a "weighted" station. For example, if the "2220" climate station grid was the only one selected, then the tool will use only the 2220 orographic correction grid when determining orographic adjustments. This is an optional input; if no orographic correction grid is provided then no orographic adjustments will be assigned for the ID field in the Output CSV File. The SPDSS Orographic Adjustment grids are available on the CDSS website (cdss.state.co.us).	Workspace
Threshold_Weight	Minimum weight assigned to a climate station. The default is 0.05 or 5%. If the minimum weight assigned to any climate station is less than the Threshold Weight, the weights assigned to the other stations will be adjusted to ensure that all the weights sum to 1.0 for each structure.	Double
Centroid_Analysis	Check this box to perform a centroid-based climate station weight analysis. The default for this tool is to perform an area-weighted climate weight station analysis. In the centroid-based assignment, the set of climate station weights determined at the centroid of the polygon will be assigned to the entire polygon. The centroid-based analysis is typically used for very small polygons (e.g., model cells) where the climate station weights would not vary greatly over the polygon area. This option is recommended when assigned climate weights to a groundwater model grid to enhance the tool performance.	Boolean
Output_File	The output file is a comma-delimited (.csv) file that contains the unique values from the Assignment Layer's ID Field, Climate Station IDs, weights, and orographic correction factors. An orographic factor is provided for each assigned climate station if the Precipitation Orographic Correction Grid Directory is provided by the user. If the minimum weight assigned to any climate station is less than the Threshold Weight, the weights assigned to the other stations will be adjusted to ensure that all the weights sum to 1.0 for each unique value in the ID Field. Date and input parameters will be included in the header.	File

Section 4

Soil Assignments Toolset

Soil Parameters by SW Structure

Summary

The Soil Parameters by SW Structure tool allows the user to spatially assign soil parameters to structures in the Irrigated Acreage Feature Layer. The Soil Parameter Feature Layer will typically reflect available water content or permeability. This tool prorates the soil parameters for each parcel, as defined by the Soil Parameter Feature Layer, and then summarizes the soil parameters for the parcels by structure. Only parcels with a surface water ID (SW_WDID) in the Irrigated Acreage Feature Layer will be assigned soil parameters. The SPDSS Technical Memorandum *Task 57: Assign Soil Moisture Water Holding Capacity to Structures*, March 2008, describes the process of assigning available water content values to surface water structures in the South Platte Basin modeling efforts.

Usage

- The portions of irrigated acreage polygons outside of the soil parameter polygon areas will not be retained
- The user may save the spatial result of this tool in the Output Feature Class

Parameter	Explanation	Data Type
Irrigated_Acreage_Feature_Layer	The attribute table for this polygon feature layer must be in the standard CDSS format, including the parcel ID (PARCEL_ID), surface water ID (SW_WDID1, SW_WDID2,...,SW_WDID9), and groundwater ID (GW_ID1, GW_ID2,...,GW_ID20). Each parcel ID occupies one row in the attribute table, and multiple surface water or groundwater structures can be assigned to the parcel through numerated SW_WDID and GW_ID fields. Irrigated acreage feature layers have been created by river basin in support of CDSS modeling efforts and are available on the CDSS website (cdss.state.co.us). Only parcels with a surface water ID will be assigned soil parameters.	Feature Layer
Soil_Parameter_Feature_Layer	Polygon feature layer of soil parameters. For CDSS, Statewide soil permeability and available water content coverages were derived from the Natural Resources Conservation Service (NRCS) STATSGO database. The coverages are available on the CDSS website (cdss.state.co.us).	Feature Layer
Soil_Parameter_Attribute	The attribute field name in the Soil Parameter feature layer that contains the soil parameter ID that will be assigned to the surface water structures (e.g., AWC for available water capacity).	Field
Output_CSV_File	Output comma-delimited (.csv) file that contains the SW_WDIDs and soil parameter values.	File
Add_Results_to_New_Feature_Class	If the "Add Results to New Feature Class" checkbox is selected, the Soil Parameter ID will be appended as a new field to a copy of the original Irrigated Acreage feature layer input and saved as the new feature class.	Boolean
New_Output_Feature_Class (Optional)	If the "Add Results to New Feature Class" checkbox is selected, the Soil Parameter ID will be appended as a new field to a copy of the original Irrigated Acreage feature layer input and saved as the new feature class.	Feature Class

Soil Parameters by User-Specified Polygon ID

Summary

The Soil Parameters by User-Specified Polygon ID tool allows the user to spatially assign soil parameters, as defined in the Soil Parameter Feature Layer, to a user-defined attribute in the Polygon Feature Layer. The Soil Parameter Feature Layer will typically reflect available water content or permeability. This tool calculates an area-weighted average soil parameter for each of the polygons in the Polygon Feature Layer. For example, in CDSS analyses the Polygon Feature Layer typically represents Aggregate Areas for surface water structures and this tool will assign area-weighted soil parameters to each Aggregate Area. The SPDSS Technical Memorandum *Task 57: Assign Soil Moisture Water Holding Capacity to Structures*, March 2008, describes the process of assigning available water content to aggregate surface water structures in the South Platte Basin modeling efforts.

Usage

- The portions of soil parameter areas outside of the user-defined polygons will not be retained
- The user may save the spatial result of this tool in the Output Feature Class

Parameter	Explanation	Data Type
Polygon_Feature_Layer	A feature layer of polygons to spatially assign soil parameters to (e.g., SW Aggregate Areas developed by the Aggregate Tool).	Feature Layer
Polygon_Attribute	The attribute field name in the Polygon Feature Layer that contains the Polygon IDs used in the weight assignment analysis (e.g., Aggregate ID).	Field
Soil_Parameter_Feature_Layer	Polygon feature layer of soil parameters. For CDSS, Statewide soil permeability and available water content coverages were derived from the Natural Resources Conservation Service (NRCS) STATSGO database. The coverages are available on the CDSS website (cdss.state.co.us).	Feature Layer
Soil_Parameter_Attribute	The attribute field name in the Soil Parameter feature layer that contains the soil parameter ID that will be assigned to the user-specified polygons (e.g., AWC for available water capacity)	Field
Output_CSV_File	The output file is a comma-delimited text file (.csv) that contains the Polygon ID and the average area-weighted soil parameter. Date and input parameters will be included in the header.	File
Add_Results_to_New_Feature_ Class (Optional)	If the "Add Results to New Feature Class" checkbox is selected, the Soil Parameter ID will be appended as a new field to a copy of the original Polygon feature layer input and saved as the new feature class.	Boolean
Output_Feature_Class (Optional)	If the "Add Results to New Feature Class" checkbox is selected, the Soil Parameter ID will be appended as a new field to a copy of the original Polygon feature layer input and saved as the new feature class.	Feature Class

Soil Parameters by User-Specified Polyline ID

Summary

The Soil Parameters by User-Specified Polyline ID tool allows the user to spatially assign soil parameters, as defined in the Soil Parameter Feature Layer, to a user-defined attribute in the

Polyline Feature Layer. The Soil Parameter Feature Layer will typically reflect available water content or permeability. This tool calculates a length-weighted average soil parameter for each of the polylines in the Polyline Feature Layer. The output table will include one Soil Parameter value for each Polyline ID. For example, in CDSS analyses, the Polyline Feature Layer typically represents canals, whereby the tool will assign length-weighted permeability to each canal for use in estimating canal efficiencies. The SPDSS Technical Memorandum *Task 56: Conveyance and Application Efficiencies*, March 2008, describes the process of using weighted permeability to estimate canal efficiencies in the South Platte Basin modeling efforts.

Usage

- The information from soil parameter areas outside of the user-defined polylines will not be retained
- The user may save the spatial result of this tool in the Output Feature Class

Parameter	Explanation	Data Type
Polyline_Feature_Layer	A feature layer of polylines to spatially assign soil parameters to (e.g., canals).	Feature Layer
Polyline_Attribute	The attribute field name in the Polyline Feature Layer used that contains the Polyline IDs in the weight assignment analysis (e.g., SW_WDID).	Field
Soil_Parameter_Feature_Layer	Polygon feature layer of soil parameters. For CDSS, Statewide soil permeability and available water content coverages were derived from the Natural Resources Conservation Service (NRCS) STATSGO database. The coverages are available on the CDSS website (cdss.state.co.us).	Feature Layer
Soil_Parameter_Attribute	The attribute field name in the Soil Parameter feature layer that contains the soil parameter ID that will be assigned to the user-specified polylines (e.g., AWC for available water capacity).	Field
Output_CSV_File	The output file is a comma-delimited text (.csv) file that contains the Polyline ID and the average length-weighted soil parameter. Date and input parameters will be included in the header.	File
Add_Results_to_Feature_Class (Optional)	If the "Add Results to New Feature Class" checkbox is selected, the Soil Parameter ID will be appended as a new field to a copy of the original Polyline feature layer input and saved as the new feature class.	Boolean
Output_Feature_Class (Optional)	If the "Add Results to New Feature Class" checkbox is selected, the Soil Parameter ID will be appended as a new field to a copy of the original Polyline feature layer input and saved as the new feature class.	Feature Class

Section 5

StateDGI Toolset

State DGI Aggregate Assignment

Summary

The required inputs for this analysis are the StateDGI Geodatabase and one or more of the Groundwater Aggregate IDs, Surface Water Aggregate IDs, Diversion System List, Canal Alias List, or the Phreatophyte Classification Table. The StateDGI Aggregate Assignment tool must be run only after all other pertinent StateDGI tools have been run and inputs have been loaded into the database. If any other StateDGI tool is rerun the Aggregate Assignment tool must be rerun afterward.

Usage

This tool loads the Groundwater Aggregate IDs, Surface Water Aggregate IDs, Diversion System List and Canal Alias List and the Phreatophyte Classification Table into the StateDGI Access database.

Parameter	Explanation	Data Type
StateDGI_Geodatabase	The StateDGI database that will be used for storing and processing the information of a specific groundwater model simulation.	Workspace
GW_Aggregate_File (Optional)	A comma-delimited list of parcels served by groundwater only that will be modeled as aggregates and the Aggregate ID to which each parcel is assigned. The format of this file must be in column with the Aggregate ID in the first column and the Parcel ID in the second column. The output file from the superseded Aggregate by GW Parcels tool is in the correct format and can be used for this input. The output file from the superseded Aggregate by GW Parcel tool is also in the correct format and can be used for this input. This input is optional only if all irrigated acreage is assigned to surface water sources.	File
GW_Aggregate_File_Parts_Column (Optional)	Column number of the GW_IDs assigned to an Aggregate ID in the Groundwater Aggregate List. This column number must be specified if a Groundwater List is input. The Aggregate by Groundwater Parcel Tool default is column 2.	Long
SW_Aggregate_File (Optional)	A comma-delimited list of surface water structures that will be modeled as aggregates and the Aggregate ID to which each surface water structure ID is assigned. The output file from the superseded Aggregate by SW Parcel can also be used for this input. The Aggregate ID must be in the first column of this list.	File
SW_Aggregate_File_Parts_Column (Optional)	Column number of the SW_WDIDs assigned to an Aggregate ID in the Surface Water Aggregate List. This column number must be specified if a Surface Water Aggregate List is input.	Long
Diversion_System_File (Optional)	A comma-delimited list of surface water structures that will be modeled as diversion systems and the primary SW_WDID each surface water structure ID is assigned to. The Diversion System ID must be in the first column of this list.	File
Diversion_System_File_Parts_Column (Optional)	Column number starting each list of the SW_WDIDs assigned to a diversion system in the Diversion System List. This column number must be specified if a Diversion System List is input.	Long
Canal_Alias_File (Optional)	A comma-delimited list of canal structures that will be reassigned a canal alias ID to represent a modeling difference between two portions of a canal. The Canal Alias ID must be in the first column of this list.	File

Parameter	Explanation	Data Type
Canal_Alias_File_Parts_Column (Optional)	Column number starting each list of the SW_WDIDs reassigned by the Canal Alias List. This column number must be specified if a Canal Alias List is input.	Long
Phreatophyte_Classification_Table (Optional)	A comma-delimited file containing the list of Land Use Types, as provided in the Land Use GIS Coverage, to be included in the StatePP Phreatophyte (.etz) file and the name of the land use types that will ultimately be shown in the StatePP Phreatophyte (.etz) file. The two columns can show the same name if no renaming is necessary. If a Phreatophyte Classification Table is not provided, the StatePP Phreatophyte (.etz) file will be empty.	File

StateDGI Canal Input

Summary

The StateDGI Canal Input tool loads a user-specified feature layer for canals into the user-specified StateDGI Personal Geodatabase (.mdb). If a CDSS Groundwater Model Grid feature layer has been previously loaded into the StateDGI geodatabase using the StateDGI GW Model Input tool, the canals and groundwater model grid feature layers will be intersected. The tool assigns standard feature class and table names in the State DGI geodatabase based on existing queries stored in the database.

The output feature layer names that are loaded into the geodatabase are listed below. These names are consistent with the names used in existing database queries:

- canals
- canal_cells

Usage

- The intersection command used in the tool is executed as a Feature Identifier (FID)-only intersection. Therefore, the attribute fields from the original feature layers will not appear in the output feature layers.
- Files created from previous model runs are overwritten with each execution of the tool.

Parameter	Explanation	Data Type
StateDGI_Geodatabase	This database will be used for storing and processing the information of a specific StateDGI model simulation.	Workspace
Canal_Feature_Layer	The canal feature layer must be in the standard CDSS format for canal feature layers.	Feature Layer
Default_Recharge_Weight	Default single value of recharge weighting if variable weighting not to be supplied from an attribute in the canal feature layer or from another feature layer.	Double
Apply_Variable_Recharge_Weighting	Check this box to specify variable recharge weights either through an attribute field in the canal feature layer or a separate feature layer containing the recharge weights.	Boolean

Parameter	Explanation	Data Type
Canal_Weight_Attribute (Optional)	The relative value of canal seepage recharge into the groundwater model can be adjusted by specifying a weight value. This weight value can be specified in one of two methods, the Canal Weight Attribute or Recharge Weight Feature Layer. The default of the tool is for all canal segments to receive the same relative weight of 1 if neither a Canal Weight Attribute field nor a Recharge Weight Feature Layer/Attribute pair is selected below. If a Canal Weight Attribute field is selected, any information in the Recharge Weight Feature Layer/Attribute parameters below will be ignored. If a field named "Weight" is present in the Canal Feature Layer, but the "Weight" field is not selected as the Canal Weight Attribute field, the values from the Canal Weight Attribute field will overwrite the values in the "Weight" field in the final Canal Feature Layer in the geodatabase.	Field
Use_Weights_from_Recharge _Weight_Feature_Layer	The relative value of canal seepage recharge into the groundwater model can be adjusted by specifying weight values from polygons in the specified Recharge Weight Feature Layer. This feature layer must have a Recharge Weight Attribute field selected below with values between 0 and 1 for each polygon (e.g., based on soil type). These weights will be spatially assigned to the canals through an intersection method. If a field named "Weight" is present in the Recharge Weight Feature Layer, but the "Weight" field is not selected as the Recharge Weight Attribute field, the values from the Recharge Weight Attribute field will overwrite the values in the "Weight" field in the final Canal Feature Layer in the geodatabase. Note that if a Canal Weight Attribute is selected above, any information in the Recharge Weight Feature Layer/Attribute parameters below will be ignored.	Boolean
Recharge_Weight_Feature_Layer (Optional)	The relative value of canal seepage recharge into the groundwater model can be adjusted by specifying weight values from polygons in the specified Recharge Weight Feature Layer. This feature layer must have a Recharge Weight Attribute field selected below with values between 0 and 1 for each polygon (e.g., based on soil type). These weights will be spatially assigned to the canals through an intersection method. If a field named "Weight" is present in the Recharge Weight Feature Layer, but the "Weight" field is not selected as the Recharge Weight Attribute field, the values from the Recharge Weight Attribute field will overwrite the values in the "Weight" field in the final Canal Feature Layer in the geodatabase. Note that if a Canal Weight Attribute is selected above, any information in the Recharge Weight Feature Layer/Attribute parameters below will be ignored.	Feature Layer
Recharge_Weight_Attribute (Optional)	The relative value of canal seepage recharge into the groundwater model can be adjusted by specifying weight values from polygons in the Recharge Weight Feature Layer selected above. This feature layer must have a Recharge Weight Attribute field selected here with values between 0 and 1 for each polygon (e.g., based on soil type). These weights will be spatially assigned to the canals through an intersection method. If a field named "Weight" is present in the Recharge Weight Feature Layer, but the "Weight" field is not selected as the Recharge Weight Attribute field, the values from the Recharge Weight Attribute field will overwrite the values in the "Weight" field in the final Canal Feature Layer in the geodatabase. Note that if a Canal Weight Attribute is selected above, any information in the Recharge Weight Feature Layer/Attribute parameters below will be ignored.	Field

StateDGI GW Model Input

Summary

The StateDGI GW Model Input tool loads a user-specified CDSS Groundwater Model grid feature layer into the user-specified StateDGI personal (.mdb) geodatabase. If feature layers representing Canals,

Ground Cover, Irrigated Parcels, Rim Inflow, or Wells feature layers have been previously loaded into the StateDGI geodatabase using the StateDGI GW Model Input tool, the groundwater model grid feature layer will be intersected with these feature layers. The tool assigns standard feature class and table names in the State DGI geodatabase based on existing queries stored in the database. The output feature layer names that are loaded into the geodatabase are listed below. These names are consistent with the names used in existing database queries:

- model
- model_layer
- canal_cells
- ground_cover_cells
- parcel_cells
- parcel_center_cells
- riminflow_cells
- wells_cells

Usage

- The intersection command used in the tool is executed as an FID-only intersection. Therefore, the attribute fields from the original feature layers will not appear in the output feature layers.
- Files created from previous model runs are overwritten with each execution of the tool.

Parameter	Explanation	Data Type
StateDGI_Geodatabase	This StateDGI personal geodatabase (.mdb) will be used for storing and processing the information of a specific StateDGI model simulation.	Workspace
Ground_Water_Model_Grid_ Feature_Layer_Input	The groundwater model grid polygon feature layer must be in the standard format for model feature layers with the following fields for each model cell: • ROW: model row of cell • COL: model column of cell • GND_ELEV: ground surface elevation at cell • BOT_LYRn: bottom elevation of model cell for layer n; e.g., for a model with 3 layers the feature layer attribute table should contain BOT_LYR1, BOT_LYR2, and BOT_LYR3 This feature layer will be intersected with other feature layers as they are loaded into the database.	Feature Layer

StateDGI Irrigated Lands Input

Summary

The StateDGI Irrigated Land Input tool loads a user-specified Irrigated Parcels snapshot feature layer into the user-specified StateDGI personal geodatabase (.mdb). The centroids of each irrigated parcel are created and added to the geodatabase. If a CDSS Groundwater Model Grid feature layer has been previously loaded into the StateDGI geodatabase using the StateDGI GW Model Input tool, the irrigated lands and groundwater model grid feature layers will be intersected. The tool assigns standard feature class and table names in the State DGI geodatabase based on existing queries stored in the database.

The output feature layer names that are loaded into the geodatabase are listed below. These names are consistent with the names used in existing database queries:

- ground_cover
- ground_cover_cells
- parcels
- parcel_cells
- parcel_center_cells

Usage

- The intersection command used in the tool is executed as an FID-only intersection. Therefore, the attribute fields from the original source feature layers will not appear in the output feature layers in the StateDGI database.
- Files created from previous model runs are overwritten with each execution of the tool.

Parameter	Explanation	Data Type
StateDGI_Geodatabase	This database will be used for storing and processing the information of a specific StateDGI model simulation.	Workspace
Irrigated_Acreage_Feature_Layer	A polygon feature layer that contains irrigated parcels, crop type, irrigation method, and water supply data. The feature layer must be provided in the standard CDSS format. Irrigated acreage feature layers have been created by river basin in support of CDSS modeling efforts and are available on the CDSS website (cdss.state.co.us). The feature layer must include the final surface water and well assignments by parcel. This feature layer will be loaded into the specified database and is then processed for use by StateDGI.	Feature Layer
Default_Recharge_Weight	Default single value of recharge weights (0.0–1.0) to apply to the irrigated parcels.	Double
Apply_Variable_Recharge_Weighting	Check this box to select either an attribute field in the specified Irrigated Acreage Feature Layer or a separate Recharge Weight Feature layer to supply variable recharge weights.	Boolean
Irrigated_Acreage_Weight_Attribute (Optional)	The attribute field with the recharge weights (0.0–1.0) in the specified Irrigated Acreage Feature Layer.	Field
Use_Weights_from_Recharge_ Weight_Feature_Layer (Optional)	Check this box to select a feature layer to supply recharge weights.	Boolean
Recharge_Weight_Feature_Layer (Optional)	An optional input feature layer with relative weights defined by polygon, for instance based on soil type. This feature layer must have a "Weight" field with values between 0 and 1 for each polygon. The relative weights of inefficient irrigation recharge into the groundwater model will be spatially assigned to the irrigated acreage. For example, a parcel with a relative weight of "0.5" will receive an assignment of half the amount of available recharge as compared to a parcel with a relative weight of "1.0."	Feature Layer
Recharge_Weight_Attribute (Optional)	The attribute field with the recharge weights in the specified Recharge Weight Feature Layer.	Field

StateDGI Land Use Input

Summary

The StateDGI Irrigated Land Use Input tool loads a user-specified Land Use feature layer into the user-specified StateDGI personal geodatabase (.mdb). If a CDSS Groundwater Model Grid feature layer has been previously loaded into the StateDGI geodatabase using the StateDGI GW Model Input tool, the land use and groundwater model grid feature layers will be intersected. The tool assigns standard feature class and table names in the State DGI geodatabase based on existing queries stored in the database.

The output feature layer names that are loaded into the geodatabase are listed below. These names are consistent with the names used in existing database queries:

- ground_cover
- ground_cover_cells

Usage

- The intersection command used in the tool is executed as an FID-only intersection. Therefore, the attribute fields from the original shapefiles will not appear in the output shapefiles.
- Files created from previous model runs are overwritten with each execution of the tool.

Parameter	Explanation	Data Type
StateDGI_Geodatabase	This database will be used for storing and processing the information of a specific StateDGI model simulation.	Workspace
Land_Use_Feature_Layer	A polygon feature layer that contains land use/land cover information.	Feature Layer
Land_Use_Attribute	The field in the Land Use Feature Layer containing the identifier for the land use/land cover type	Field
Default_Recharge_Weight	Default single value of recharge weights (0.0–1.0) to apply to the irrigated parcels.	Double
Apply_Variable_Recharge_Weighting	Check this box to select either an attribute field in the specified Land Use Feature Layer or a separate Recharge Weight Feature layer to supply variable recharge weights.	Boolean
Land_Use_Weight_Attribute (Optional)	The attribute field with the recharge weights (0.0–1.0) in the specified Land Use Feature Layer.	Field
Use_Weights_from_Recharge_ Weight_Feature_Layer	Check this box to select a feature layer to supply recharge weights.	Boolean
Recharge_Weight_Feature_Layer (Optional)	An optional input feature layer with relative weights defined by polygon, for instance based on soil type. This feature layer must have a "Weight" field with values between 0 and 1 for each polygon. The relative weights of inefficient irrigation recharge into the groundwater model will be spatially assigned to the irrigated acreage. For example, a parcel with a relative weight of "0.5" will receive an assignment of half the amount of available recharge as compared to a parcel with a relative weight of "1.0."	Feature Layer
Recharge_Weight_Attribute (Optional)	The attribute field with the recharge weights in the specified Recharge Weight Feature Layer.	Field

StateDGI Rim Inflow Input

Summary

The StateDGI Rim Inflow tool loads a user-specified feature layer for rim inflow recharge into the user-specified StateDGI Personal Geodatabase (.mdb). If a CDSS Groundwater Model Grid feature layer has been previously loaded into the StateDGI geodatabase using the StateDGI GW Model Input tool, the rim inflow recharge and groundwater model grid feature layers will be intersected. The tool assigns standard feature class and table names in the State DGI geodatabase based on existing queries stored in the database.

The output feature layer names that are loaded into the geodatabase are listed below. These names are consistent with the names used in existing database queries:

- riminflow
- riminflow_cells

Usage

- The intersection command used in the tool is executed as an FID-only intersection. Therefore, the attribute fields from the original feature layers will not appear in the output feature layers.
- Files created from previous model runs are overwritten with each execution of the tool.

Parameter	Explanation	Data Type
StateDGI_Geodatabase	This database will be used for storing and processing the information of a specific StateDGI model simulation.	Workspace
Rim_Inflow_Feature_Layer	The rim inflow feature layer defines the spatial extent of rim inflow. The feature layer must be in the standard CDSS format for rim inflow feature layers including attribute table fields for ID, Name, Weight, DIV (Water Division), WD (Water District), SW_WDID, and include the rim inflow IDs appropriate for the model.	Feature Layer
Default_Recharge_Weight	Default single value of recharge weights (0.0–1.0) to apply to the rim inflows.	Double
Apply_Variable_Recharge_Weighting	Check this box to select either an attribute field in the specified Rim Inflow Feature Layer or a separate Recharge Weight Feature layer to supply variable recharge weights.	Boolean
Rim_Inflow_Weight_Attribute (Optional)	The attribute field with the recharge weights (0.0–1.0) in the specified Rim Inflow Feature Layer.	Field
Use_Variable_Recharge_Weight_ Feature_Layer	Check this box to select a feature layer to supply recharge weights.	Boolean
Recharge_Weight_Feature_Layer (Optional)	An optional input feature layer with relative weights defined by polygon, for instance based on soil type. This feature layer must have a "Weight" field with values between 0 and 1 for each polygon. The relative weights of inefficient irrigation recharge into the groundwater model will be spatially assigned to the irrigated acreage. For example, a parcel with a relative weight of "0.5" will receive an assignment of half the amount of available recharge as compared to a parcel with a relative weight of "1.0."	Feature Layer
Recharge_Weight_Attribute (Optional)	The attribute field with the recharge weights in the specified Recharge Weight Feature Layer.	Field
Default_Rim_Inflow_Layer_Value	Default single value of the groundwater model layer to which rim inflow recharge will be assigned.	Long

Parameter	Explanation	Data Type
Specify_Multiple_Model_Layers	Check this box to select either an attribute field in the specified Rim Inflow Feature Layer or a separate Recharge Model Layer Feature layer to assign multiple groundwater model layers.	Boolean
Model_Layer_Attribute (Optional)	The attribute field with the groundwater model layer assignments in the specified Rim Inflow Feature Layer.	Field
Use_Feature_Layer_for_Multiple_ Model_Layers (Optional)	Check this box to select a feature layer to supply rim inflow groundwater model layer assignments.	Boolean
Recharge_Model_Layer_Feature_Layer (Optional)	An optional input feature layer with groundwater model layer assignments for rim inflow recharge.	Feature Layer
Recharge_Model_Layer_Attribute (Optional)	The attribute field with the model layer assignments in the specified Recharge Model Layer Feature Layer.	Field

StateDGI Well Input

Summary

The StateDGI Well Input tool loads a user-specified feature layer for wells into the user-specified StateDGI Personal Geodatabase (.mdb). If a CDSS Groundwater Model Grid feature layer has been previously loaded into the StateDGI geodatabase using the StateDGI GW Model Input tool, the wells and groundwater model grid feature layers will be intersected. The tool assigns standard feature class and table names in the State DGI geodatabase based on existing queries stored in the database.

The output feature layer names that are loaded into the geodatabase are listed below. These names are consistent with the names used in existing database queries:

- wells
- wells_cells

Usage

- The intersection command used in the tool is executed as an FID-only intersection. Therefore, the attribute fields from the original feature layers will not appear in the output feature layers.
- Files created from previous model runs are overwritten with each execution of the tool.

Parameter	Explanation	Data Type
StateDGI_Geodatabase	This database will be used for storing and processing the information of a specific StateDGI model simulation.	Workspace
Well_Feature_Layer	A point feature layer that contains irrigation well locations. The feature layer must be provided in the standard CDSS format. Irrigation well feature layers have been created by river basin in support of CDSS modeling efforts and are available on the CDSS website (cdss.state.co.us). This feature layer will be loaded into the specified database and is then processed for use by StateDGI.	Feature Layer

Section 6

Well to Parcel Matching Tool

Well to Parcel Matching

Summary

The Well to Parcel tool uses several geoprocessing tasks to assign irrigation wells to the parcels that they irrigate. Irrigated parcels served by groundwater are determined based on IRRIG_TYPE attribute field values being "Sprinkler" or SW_WDID1 attribute field values being blank. This tool creates a Personal Geodatabase named "well_parcel.mdb" in the path to the output file to use as a geoprocessing workspace.

The wells are assigned to parcels in one of three types (Type I, II, or IV) based on the following geoprocessing logic:

- Type I wells are those that lie within the parcel that it irrigates. These wells are assigned by intersecting the wells feature layer with the irrigated parcels feature layer.
- Type II wells are identified as those wells that do not lie within the parcel that they irrigate, but are within 0.25 mile of the parcel. These wells are assigned by querying and performing a buffer operation on a layer feature class created once the input feature layers have been copied into the geodatabase.
- Type IV wells are identified as those wells that are more than 0.25 miles from—but still within 5 miles of—an irrigation parcel and have not been identified as either Type I or Type II wells. The feature layer created above is again queried to determine these wells and copy them into the geodatabase.

(Note that Type III wells are not currently used for either of the RGDSS or SPDSS groundwater modeling efforts.)

Usage

- The user may save the spatial result of this tool in the Output Feature Class

Parameter	Explanation	Data Type
Well_Feature_Layer	The Well Feature Layer is a point coverage of wells that will be matched to parcels in the Irrigated Acreage Feature Layer. The Well Feature Layer should include wells permitted for irrigation.	Feature Layer
Well_ID_Attribute	The attribute field name in the Well Feature Layer that contains the unique Well ID that the parcels will be matched to in the output table.	Field
Irrigated_Acreage_Feature_Layer	The attribute table for this polygon feature layer must be in the standard CDSS format. Irrigated acreage feature layers have been created by river basin in support of CDSS modeling efforts and are available on the CDSS website (cdss.state.co.us).	Feature Layer
Output_File	The output file is a comma-delimited (.csv) file that contains the irrigated parcel ID, well ID, type of match, and distance between the parcel and the well. Date and input parameters will be included in the header.	File

Parameter	Explanation	Data Type
Add_Results_to_New_Feature_Class (Optional)	If the "Add Results to New Feature Class" checkbox is selected, the well ID, type of match and distance between the parcel and the well will be exported as a new feature class in the standard CDSS format.	Boolean
New_Output_Feature_Class (Optional)	If the "Add Results to New Feature Class" checkbox is selected, the well ID, type of match and distance between the parcel and the well will be exported as a new feature class in the standard CDSS format.	Feature Class

Appendix C: Simulated Monthly Groundwater Budgets

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Jan. 1950	42,918	25,660	1,257	160	0	149	0	2,658	1,040	1,590	39,857	115,289	12,303	334	96,673	0	845	0	0	0	4,437	114,592	696	0.61
Feb. 1950	39,633	18,772	1,224	197	0	11,824	0	2,400	940	1,436	35,456	111,882	6,341	270	99,961	0	719	0	0	0	4,371	111,662	220	0.20
Mar. 1950	35,449	23,504	1,287	1,521	0	9,328	0	2,658	1,040	1,589	38,600	114,975	7,669	318	97,613	0	873	0	0	0	7,956	114,428	547	0.48
Apr. 1950	8,562	28,942	13,151	28,569	107	17,007	0	2,572	1,007	1,538	36,914	138,369	30,446	308	96,535	283	1,267	0	3	57	9,547	138,446	-77	-0.06
May 1950	11,495	28,111	16,267	68,702	4,120	35,820	0	2,658	1,040	1,589	38,099	207,901	63,574	290	117,895	11,560	1,751	0	797	447	11,584	207,897	4	0.00
Jun. 1950	21,226	25,159	11,496	106,979	13,540	65,950	0	2,572	1,007	1,537	37,496	286,963	99,123	249	131,531	36,825	2,156	0	2,285	963	13,796	286,927	37	0.01
Jul. 1950	27,855	28,192	14,637	84,173	19,454	48,033	0	2,658	1,040	1,587	39,897	267,527	47,076	278	139,850	56,444	2,661	0	3,452	2,405	15,498	267,663	-136	-0.05
Aug. 1950	61,295	21,543	4,311	65,426	31,118	37,819	0	2,658	1,040	1,588	40,609	267,407	17,519	285	136,595	89,767	2,504	0	4,513	3,371	12,733	267,288	120	0.04
Sep. 1950	49,910	23,499	8,443	40,931	24,875	28,872	0	2,572	1,007	1,537	39,555	221,200	7,046	276	123,729	72,112	1,945	0	2,572	3,332	9,777	220,789	412	0.19
Oct. 1950	42,499	18,306	1,385	40,175	6,379	22,661	0	2,658	1,040	1,589	40,902	177,594	16,822	256	129,799	17,891	1,590	0	1,656	2,305	7,293	177,611	-17	-0.01
Nov. 1950	51,357	19,451	1,803	3,333	102	19,299	0	2,572	1,007	1,537	39,405	139,866	16,886	264	116,669	304	1,008	0	32	28	4,415	139,608	258	0.18
Dec. 1950	49,342	19,858	791	1,380	0	14,120	0	2,658	1,040	1,589	40,362	131,140	10,910	279	114,254	0	1,205	0	0	0	4,213	130,861	279	0.21
Jan. 1951	41,280	21,754	2,245	718	0	10,255	0	2,658	1,040	1,589	39,771	121,310	8,660	290	106,365	0	1,322	0	0	0	4,051	120,688	622	0.51
Feb. 1951	38,014	18,589	1,841	213	0	15,882	0	2,400	940	1,435	35,370	114,685	8,282	247	100,491	0	1,178	0	0	0	4,182	114,380	305	0.27
Mar. 1951	35,853	23,515	1,610	1,553	0	7,757	0	2,658	1,040	1,589	38,543	114,119	9,322	297	94,931	0	1,286	0	0	0	7,728	113,564	555	0.49
Apr. 1951	14,191	30,181	13,013	18,183	13	14,557	0	2,572	1,007	1,538	36,858	132,113	29,053	311	91,681	31	1,704	0	1	5	9,578	132,363	-250	-0.19
May 1951	10,031	30,091	19,025	67,882	4,231	41,996	0	2,658	1,040	1,588	38,174	216,718	78,255	302	110,609	11,802	2,236	0	1,133	606	11,893	216,836	-119	-0.05
Jun. 1951	13,931	28,087	16,911	101,410	9,835	64,539	0	2,572	1,007	1,537	37,775	277,602	106,350	287	124,459	27,322	2,580	0	1,474	585	14,786	277,843	-240	-0.09
Jul. 1951	37,261	25,595	12,682	100,158	25,662	60,864	0	2,658	1,040	1,588	40,425	307,934	69,327	289	143,501	69,972	3,270	0	3,413	2,097	16,068	307,936	-2	0.00
Aug. 1951	16,092	36,171	25,145	79,859	20,229	51,436	0	2,658	1,040	1,587	41,673	275,888	64,922	335	133,262	55,466	3,026	0	2,305	2,184	14,799	276,298	-410	-0.15
Sep. 1951	37,130	21,369	9,016	56,149	12,394	37,380	0	2,572	1,007	1,536	40,980	219,532	20,991	289	145,824	35,763	2,347	0	2,031	2,073	10,301	219,621	-89	-0.04
Oct. 1951	45,079	24,347	13,994	22,318	1,950	28,009	0	2,658	1,040	1,587	42,432	183,414	23,130	280	143,756	5,495	1,917	0	431	614	7,565	183,189	225	0.12
Nov. 1951	56,495	19,943	2,014	1,163	0	18,752	0	2,572	1,007	1,536	40,766	144,249	13,359	281	124,675	0	1,273	0	0	0	4,594	144,183	66	0.05
Dec. 1951	46,072	20,992	2,117	4,646	0	14,575	0	2,658	1,040	1,588	41,680	135,367	10,683	298	118,425	0	1,249	0	0	0	4,453	135,108	259	0.19
Jan. 1952	46,411	20,110	361	243	0	13,219	0	2,658	1,040	1,588	41,094	126,724	7,038	303	113,483	0	1,344	0	0	0	4,206	126,374	351	0.28
Feb. 1952	37,151	20,978	1,702	2,972	0	7,735	0	2,486	973	1,486	37,859	113,343	6,880	297	99,615	0	1,242	0	0	0	4,740	112,775	568	0.50
Mar. 1952	34,949	25,047	3,844	432	0	9,489	0	2,658	1,040	1,589	39,806	118,852	7,570	327	100,853	0	1,310	0	0	0	8,224	118,284	568	0.48
Apr. 1952	12,546	31,759	14,440	10,359	44	18,051	0	2,572	1,007	1,537	38,034	130,350	24,523	332	93,496	108	1,758	0	2	14	10,143	130,376	-27	-0.02
May 1952	2,418	41,002	27,177	58,371	2,229	45,216	0	2,658	1,040	1,587	39,148	220,847	96,058	395	100,955	6,073	2,305	0	516	415	14,339	221,056	-209	-0.09
Jun. 1952	31,565	24,658	5,841	116,671	22,898	85,141	0	2,572	1,007	1,536	38,435	330,323	114,616	347	127,637	62,156	2,673	0	4,121	2,305	16,597	330,451	-127	-0.04
Jul. 1952	65,497	21,841	6,419	96,885	37,461	57,862	0	2,658	1,040	1,588	40,882	332,133	42,970	319	153,297	104,343	3,411	0	6,484	5,031	16,241	332,097	36	0.01

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Aug. 1952	47,501	26,948	12,447	82,727	36,348	48,722	0	2,658	1,040	1,587	41,878	301,857	26,119	321	145,013	102,826	3,152	0	6,050	4,471	13,712	301,664	193	0.06
Sep. 1952	62,795	19,305	3,489	56,418	27,303	35,548	0	2,572	1,007	1,537	41,101	251,074	9,214	280	141,658	78,995	2,430	0	4,092	4,480	9,843	250,992	83	0.03
Oct. 1952	51,966	18,062	2,248	33,920	2,671	29,379	0	2,658	1,040	1,588	42,597	186,129	18,300	252	148,160	8,078	1,971	0	466	1,413	7,213	185,851	278	0.15
Nov. 1952	55,561	20,656	3,485	2,587	0	14,532	0	2,572	1,007	1,537	40,887	142,824	15,676	266	121,017	0	1,287	0	0	0	4,508	142,753	70	0.05
Dec. 1952	52,420	19,861	885	820	0	14,253	0	2,658	1,040	1,589	41,773	135,300	10,298	285	118,844	0	1,257	0	0	0	4,310	134,993	307	0.23
Jan. 1953	45,990	20,622	1,281	480	0	13,216	0	2,658	1,040	1,589	41,111	127,988	8,380	288	113,551	0	1,368	0	0	0	4,069	127,657	331	0.26
Feb. 1953	35,348	20,483	2,479	531	0	10,958	0	2,400	940	1,436	36,565	111,140	7,845	269	96,861	0	1,223	0	0	0	4,409	110,607	532	0.48
Mar. 1953	36,934	22,457	3,090	2,097	0	8,707	0	2,658	1,040	1,589	39,857	118,430	5,958	295	102,436	0	1,334	0	0	0	7,798	117,822	608	0.52
Apr. 1953	22,456	27,274	13,066	4,803	5	9,711	0	2,572	1,007	1,538	38,077	120,509	11,815	304	96,955	13	1,784	0	0	1	9,399	120,272	237	0.20
May 1953	7,601	29,082	15,741	54,422	918	30,895	0	2,658	1,040	1,589	39,193	183,139	55,320	292	110,701	2,444	2,339	0	184	131	11,743	183,154	-15	-0.01
Jun. 1953	21,576	26,843	13,929	107,396	15,318	63,016	0	2,572	1,007	1,537	38,494	291,687	99,307	270	127,052	43,229	2,709	0	3,052	1,783	14,354	291,756	-69	-0.02
Jul. 1953	33,230	29,592	16,970	94,819	27,718	56,169	0	2,658	1,040	1,588	41,017	304,801	58,428	288	140,574	78,747	3,524	0	4,427	3,011	15,815	304,814	-12	0.00
Aug. 1953	51,179	24,945	9,176	79,833	35,950	46,934	0	2,658	1,040	1,588	42,168	295,473	24,789	295	140,905	103,136	3,254	0	5,545	4,320	13,067	295,311	161	0.05
Sep. 1953	78,600	18,750	1,183	51,118	37,128	32,858	0	2,572	1,007	1,538	41,446	266,199	5,462	262	132,439	106,020	2,507	0	4,732	5,156	9,457	266,034	165	0.06
Oct. 1953	43,262	18,955	2,910	35,832	5,560	24,975	0	2,658	1,040	1,589	43,011	179,793	16,040	250	134,490	16,643	2,021	0	765	2,233	7,225	179,666	126	0.07
Nov. 1953	56,192	18,678	2,818	4,502	58	18,949	0	2,572	1,007	1,538	41,281	147,596	18,683	235	122,534	164	1,310	0	0	42	4,294	147,262	334	0.23
Dec. 1953	47,811	21,499	1,612	557	0	11,024	0	2,658	1,040	1,590	42,135	129,927	13,054	282	110,792	0	1,281	0	0	0	4,302	129,711	216	0.17
Jan. 1954	45,225	20,110	513	217	0	12,615	0	2,658	1,040	1,591	41,420	125,391	9,905	285	109,178	0	1,376	0	0	0	4,035	124,779	612	0.49
Feb. 1954	37,456	17,840	120	1,155	0	10,377	0	2,400	940	1,438	36,785	108,510	7,104	255	95,526	0	1,230	0	0	0	4,290	108,406	104	0.10
Mar. 1954	36,737	21,806	2,248	1,982	0	7,574	0	2,658	1,040	1,592	40,059	115,697	5,814	287	100,144	0	1,342	0	0	0	7,571	115,158	539	0.47
Apr. 1954	29,216	21,450	2,797	25,447	4,960	15,144	0	2,572	1,007	1,541	38,248	142,381	11,647	268	99,867	15,308	1,797	0	2,007	2,121	8,851	141,867	514	0.36
May 1954	21,386	23,940	7,951	68,676	11,212	34,618	0	2,658	1,040	1,592	39,484	212,558	48,620	269	114,827	31,503	2,361	0	2,350	1,556	10,998	212,484	73	0.03
Jun. 1954	56,140	23,381	5,682	63,857	33,068	36,369	0	2,572	1,007	1,540	38,553	262,170	28,545	250	112,152	93,953	2,735	0	6,966	4,433	12,929	261,963	207	0.08
Jul. 1954	91,771	32,298	12,565	56,699	65,353	34,066	0	2,658	1,040	1,591	40,361	338,403	15,171	234	107,984	182,349	3,638	0	7,830	6,295	14,458	337,959	445	0.13
Aug. 1954	79,229	28,780	10,176	48,333	55,997	30,067	0	2,658	1,040	1,591	40,889	298,761	7,503	191	109,824	154,484	3,404	0	6,364	4,802	11,574	298,146	615	0.21
Sep. 1954	67,650	25,352	7,598	30,384	37,968	17,843	0	2,572	1,007	1,540	39,868	231,782	3,099	176	101,111	107,530	2,647	0	3,778	4,130	8,705	231,177	605	0.26
Oct. 1954	40,042	19,559	2,313	26,496	5,476	17,686	0	2,658	1,040	1,592	41,221	158,084	23,299	178	106,153	16,438	2,158	0	1,072	2,095	6,562	157,955	129	0.08
Nov. 1954	39,882	19,558	1,254	7,612	44	15,291	0	2,572	1,007	1,541	39,593	128,354	25,644	179	96,711	127	1,442	0	0	42	4,014	128,159	195	0.15
Dec. 1954	38,264	21,006	1,337	1,617	0	9,861	0	2,658	1,040	1,593	40,462	117,837	17,027	210	95,262	0	1,413	0	0	0	3,928	117,840	-3	0.00
Jan. 1955	34,934	21,114	1,074	296	0	6,910	0	2,658	1,040	1,593	39,815	109,435	12,957	233	90,767	0	1,513	0	0	0	3,793	109,264	171	0.16
Feb. 1955	29,072	19,791	1,398	173	0	7,555	0	2,400	940	1,439	35,408	98,176	11,225	226	80,808	0	1,453	0	0	0	4,082	97,794	382	0.39

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Mar. 1955	28,752	21,696	2,361	3,483	0	10,949	0	2,658	1,040	1,593	38,594	111,125	11,842	244	89,951	0	1,675	0	0	0	7,100	110,812	312	0.28
Apr. 1955	18,724	21,089	2,763	21,337	1,458	13,615	0	2,572	1,007	1,542	36,857	120,963	18,116	244	87,211	3,970	2,236	0	328	418	8,428	120,951	11	0.01
May 1955	17,032	29,210	13,899	58,958	11,307	31,817	0	2,658	1,040	1,593	38,000	205,513	57,445	267	96,115	33,463	2,813	0	2,466	1,853	11,091	205,514	0	0.00
Jun. 1955	21,723	30,242	17,856	56,850	17,441	35,230	0	2,572	1,007	1,541	37,127	221,588	51,291	251	99,828	49,106	3,367	0	2,854	1,653	13,262	221,612	-24	-0.01
Jul. 1955	102,023	30,793	11,807	52,946	66,499	32,081	0	2,658	1,040	1,591	39,088	340,526	19,164	239	102,040	187,601	4,271	0	6,765	5,500	14,516	340,096	430	0.13
Aug. 1955	64,915	33,485	15,765	56,691	58,078	33,460	0	2,658	1,040	1,591	39,824	307,507	19,442	192	101,015	160,323	3,913	0	5,325	4,502	12,073	306,785	722	0.23
Sep. 1955	34,703	26,240	12,669	41,125	24,676	25,237	0	2,572	1,007	1,539	39,080	208,849	16,000	161	105,949	69,806	3,114	0	2,200	2,817	8,769	208,816	33	0.02
Oct. 1955	38,596	18,965	2,921	24,174	4,941	20,439	0	2,658	1,040	1,591	40,570	155,895	22,233	164	107,387	15,025	2,356	0	640	1,564	6,593	155,962	-67	-0.04
Nov. 1955	38,968	20,589	2,750	2,520	0	10,409	0	2,572	1,007	1,540	38,993	119,348	23,145	191	90,134	0	1,568	0	0	0	4,175	119,213	135	0.11
Dec. 1955	37,897	19,241	633	994	0	9,721	0	2,658	1,040	1,592	39,853	113,628	14,513	218	93,003	0	1,540	0	0	0	3,993	113,266	362	0.32
Jan. 1956	33,377	20,278	1,408	460	0	9,296	0	2,658	1,040	1,592	39,240	109,350	13,687	235	89,761	0	1,688	0	0	0	3,808	109,180	170	0.16
Feb. 1956	28,205	19,746	1,746	253	0	8,450	0	2,486	973	1,489	36,161	99,510	10,936	229	82,128	0	1,671	0	0	0	4,217	99,181	329	0.33
Mar. 1956	27,705	21,477	1,774	2,565	0	9,926	0	2,658	1,040	1,592	38,095	106,831	12,052	246	85,265	0	1,817	0	0	0	7,171	106,552	279	0.26
Apr. 1956	15,160	22,432	4,977	17,287	35	12,229	0	2,572	1,007	1,541	36,455	113,694	19,892	239	82,525	105	2,385	0	3	33	8,530	113,711	-16	-0.01
May 1956	18,070	27,862	10,088	73,849	11,962	40,609	0	2,658	1,040	1,592	37,781	225,511	82,788	253	93,635	32,358	3,018	0	1,350	861	11,279	225,542	-30	-0.01
Jun. 1956	55,359	22,802	8,890	85,028	37,795	48,135	0	2,572	1,007	1,541	37,273	300,403	59,570	229	109,543	106,190	3,555	0	4,990	3,294	12,899	300,271	132	0.04
Jul. 1956	41,346	37,109	25,228	65,638	41,254	36,030	0	2,658	1,040	1,591	39,570	291,465	35,986	247	110,349	117,381	4,492	0	4,556	3,450	14,897	291,358	107	0.04
Aug. 1956	73,691	24,424	10,573	56,340	53,523	32,662	0	2,658	1,040	1,591	40,337	296,841	10,088	202	113,967	147,880	4,179	0	4,536	4,051	11,713	296,616	225	0.08
Sep. 1956	75,087	18,624	1,306	39,249	40,390	21,609	0	2,572	1,007	1,540	39,415	240,800	3,922	177	103,014	113,151	3,328	0	3,756	4,568	8,695	240,611	189	0.08
Oct. 1956	43,739	17,564	1,630	27,134	8,569	16,506	0	2,658	1,040	1,592	40,783	161,214	17,782	161	105,134	25,474	2,517	0	1,230	2,235	6,457	160,991	223	0.14
Nov. 1956	40,937	21,260	3,293	2,082	1	10,148	0	2,572	1,007	1,541	39,175	122,014	26,491	207	89,267	3	1,734	0	0	2	4,142	121,845	169	0.14
Dec. 1956	38,754	18,848	2,001	1,081	0	12,096	0	2,658	1,040	1,593	39,997	118,068	17,544	205	94,621	0	1,704	0	0	0	3,878	117,952	115	0.10
Jan. 1957	34,316	20,314	1,153	1,198	0	7,192	0	2,658	1,040	1,569	39,323	108,764	16,067	234	86,497	0	1,816	0	0	0	3,794	108,408	356	0.33
Feb. 1957	29,269	17,615	1,109	1,093	0	9,322	0	2,400	940	1,417	34,968	98,133	12,439	205	79,600	0	1,761	0	0	0	3,993	97,999	134	0.14
Mar. 1957	28,194	20,883	1,994	3,245	0	8,516	0	2,658	1,040	1,569	38,099	106,199	12,439	241	84,147	0	2,005	0	0	0	7,130	105,962	236	0.22
Apr. 1957	9,034	37,057	24,337	4,992	0	16,555	0	2,572	1,007	1,517	36,452	133,523	43,735	244	78,420	0	2,549	0	0	0	8,763	133,711	-187	-0.14
May 1957	1,876	69,511	43,255	14,527	49	44,389	0	2,658	1,040	1,566	37,648	216,520	130,200	389	67,770	121	3,202	0	0	2	14,989	216,673	-153	-0.07
Jun. 1957	20,810	38,513	12,699	81,590	16,508	72,904	0	2,572	1,007	1,515	36,814	284,932	124,984	380	90,722	44,952	3,738	0	1,641	891	18,187	285,497	-564	-0.20
Jul. 1957	41,537	29,346	14,531	121,272	36,104	86,594	0	2,658	1,040	1,565	39,256	373,905	107,694	319	135,862	100,631	4,641	0	3,993	3,153	17,742	374,035	-129	-0.03
Aug. 1957	35,501	27,039	14,843	103,012	34,849	68,055	0	2,658	1,040	1,565	40,766	329,328	66,265	279	143,174	94,789	4,212	0	4,164	2,997	13,869	329,749	-422	-0.13
Sep. 1957	47,506	18,431	5,041	68,820	21,436	47,315	0	2,572	1,007	1,509	40,422	254,059	30,355	213	146,111	59,685	3,375	0	2,558	2,564	9,322	254,183	-124	-0.05

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Oct. 1957	33,293	25,943	11,484	23,664	4,301	24,307	0	2,658	1,040	1,559	42,182	170,430	24,665	251	120,780	12,605	2,552	0	713	1,057	7,785	170,407	23	0.01
Nov. 1957	51,064	19,043	1,438	2,818	0	16,590	0	2,572	1,007	1,510	40,702	136,743	18,468	261	111,397	0	1,785	0	0	1	4,650	136,561	183	0.13
Dec. 1957	50,718	17,883	267	1,742	0	14,901	0	2,658	1,040	1,561	41,602	132,373	12,294	259	113,586	0	1,750	0	0	0	4,246	132,135	238	0.18
Jan. 1958	41,513	22,902	1,110	708	0	5,302	0	2,658	1,040	1,561	40,958	117,752	12,806	312	98,217	0	1,884	0	0	0	4,305	117,524	227	0.19
Feb. 1958	32,019	20,005	2,040	346	0	7,806	0	2,400	940	1,410	36,424	103,390	8,078	281	88,186	0	1,860	0	0	0	4,535	102,941	450	0.44
Mar. 1958	28,909	24,433	4,715	1,464	0	8,003	0	2,658	1,040	1,561	39,670	112,452	9,314	318	92,249	0	2,111	0	0	0	8,075	112,067	385	0.34
Apr. 1958	17,018	31,108	13,137	3,530	18	7,522	0	2,572	1,007	1,511	37,884	115,307	20,582	323	81,510	44	2,647	0	0	4	10,095	115,205	101	0.09
May 1958	5,140	67,796	27,342	32,572	5,962	32,837	0	2,658	1,040	1,560	38,842	215,750	104,883	485	71,758	16,155	3,316	0	1,781	1,062	16,819	216,259	-509	-0.24
Jun. 1958	37,582	27,754	16,427	89,099	24,385	63,908	0	2,572	1,007	1,509	37,815	302,059	84,489	334	123,135	68,013	3,843	0	4,288	2,152	16,046	302,301	-242	-0.08
Jul. 1958	40,904	30,536	22,889	95,433	28,915	57,032	0	2,658	1,040	1,555	40,028	320,990	63,768	292	148,847	81,197	4,791	0	4,147	2,815	15,443	321,301	-311	-0.10
Aug. 1958	71,628	21,521	7,057	87,331	49,249	56,102	0	2,658	1,040	1,555	41,080	339,221	36,205	238	142,032	134,190	4,350	0	5,817	4,119	12,173	339,124	97	0.03
Sep. 1958	35,497	23,714	10,362	61,316	23,359	37,029	0	2,572	1,007	1,505	40,530	236,892	21,333	207	130,303	66,131	3,487	0	2,997	3,168	9,187	236,814	78	0.03
Oct. 1958	47,024	19,235	3,251	24,268	5,999	22,638	0	2,658	1,040	1,556	42,191	169,859	14,102	193	125,408	17,754	2,641	0	876	1,761	6,924	169,660	199	0.12
Nov. 1958	52,739	18,863	1,358	3,799	25	15,418	0	2,572	1,007	1,506	40,598	137,886	18,571	218	112,721	77	1,854	0	2	8	4,249	137,700	186	0.14
Dec. 1958	43,610	20,155	2,388	2,419	0	16,065	0	2,658	1,040	1,557	41,493	131,385	14,998	243	110,031	0	1,824	0	0	0	4,092	131,188	197	0.15
Jan. 1959	37,812	21,174	2,309	1,947	0	12,751	0	2,658	1,040	1,557	40,862	122,110	11,192	255	104,451	0	1,998	0	0	0	3,916	121,813	298	0.24
Feb. 1959	31,807	19,560	1,948	1,211	0	10,657	0	2,400	940	1,407	36,349	106,279	8,695	236	90,717	0	1,938	0	0	0	4,212	105,798	481	0.45
Mar. -1959	28,008	24,554	5,857	1,599	0	12,084	0	2,658	1,040	1,557	39,636	116,994	12,405	277	94,117	0	2,229	0	0	0	7,611	116,638	356	0.30
Apr. 1959	21,310	29,567	8,621	2,769	10	9,507	0	2,572	1,007	1,507	37,884	114,755	19,659	300	82,170	27	2,793	0	0	4	9,685	114,638	117	0.10
May 1959	2,832	38,350	26,096	40,266	1,759	33,558	0	2,658	1,040	1,556	38,959	187,075	70,483	326	95,143	4,876	3,483	0	352	366	12,580	187,609	-534	-0.28
Jun. 1959	44,487	22,646	7,551	102,900	30,601	64,695	0	2,572	1,007	1,504	38,112	316,075	87,715	252	121,398	83,115	4,077	0	3,718	1,992	13,710	315,978	98	0.03
Jul. 1959	69,512	23,150	7,289	100,602	52,228	57,674	0	2,658	1,040	1,553	40,498	356,203	47,198	217	138,322	141,665	5,029	0	5,898	3,599	14,227	356,154	49	0.01
Aug. 1959	74,584	23,473	5,249	86,447	61,299	51,899	0	2,658	1,040	1,553	41,674	349,877	23,847	185	131,072	166,485	4,554	0	6,720	4,760	11,775	349,400	477	0.14
Sep. 1959	27,109	26,695	13,592	57,180	24,681	33,795	0	2,572	1,007	1,503	41,107	229,240	25,820	174	119,816	66,698	3,662	0	1,642	2,156	9,191	229,159	81	0.04
Oct. 1959	38,532	29,286	16,921	6,784	2,051	26,589	0	2,658	1,040	1,553	42,768	168,182	36,226	190	115,299	5,849	2,771	0	134	481	7,260	168,208	-27	-0.02
Nov. 1959	54,012	17,958	484	485	0	22,861	0	2,572	1,007	1,503	41,114	141,997	21,252	193	114,413	0	1,966	0	0	0	4,184	142,008	-12	-0.01
Dec. 1959	42,854	20,243	339	1,405	0	14,825	0	2,658	1,040	1,554	41,989	126,907	14,083	232	106,402	0	1,920	0	0	0	4,100	126,737	170	0.13
Jan. 1960	37,975	22,136	1,777	801	0	8,483	0	2,658	1,040	1,554	41,314	117,737	11,967	257	99,015	0	2,049	0	0	0	3,970	117,258	479	0.41
Feb. 1960	31,651	21,311	2,989	551	0	7,235	0	2,486	973	1,454	38,030	106,680	8,950	242	90,621	0	2,054	0	0	0	4,360	106,226	453	0.43
Mar 1960	27,756	25,118	2,202	955	0	11,180	0	2,658	1,040	1,554	40,005	112,469	13,733	267	88,019	0	2,242	0	0	0	7,709	111,971	497	0.44
Apr. 1960	11,535	29,090	10,761	17,831	881	17,916	0	2,572	1,007	1,504	38,229	131,327	27,057	279	88,916	2,474	2,816	0	252	277	9,406	131,477	-150	-0.11

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
May 1960	7,951	30,695	18,847	64,734	7,919	51,369	0	2,658	1,040	1,553	39,490	226,256	75,104	259	112,457	21,810	3,513	0	1,066	653	11,439	226,301	-44	-0.02
Jun. 1960	40,825	23,065	8,217	98,481	29,997	65,094	0	2,572	1,007	1,503	38,811	309,572	75,326	216	127,877	82,675	4,112	0	4,090	2,005	13,215	309,516	57	0.02
Jul. 1960	48,425	28,473	13,628	102,579	44,149	57,158	0	2,658	1,040	1,553	41,238	340,901	55,840	214	136,388	120,410	5,083	0	4,934	3,294	14,736	340,899	1	0.00
Aug. 1960	89,179	21,138	2,246	82,059	67,397	47,953	0	2,658	1,040	1,551	42,372	357,594	18,059	175	131,653	178,427	4,602	0	7,116	5,570	11,714	357,314	280	0.08
Sep. 1960	56,191	22,627	5,930	50,623	36,838	30,619	0	2,572	1,007	1,501	41,715	249,623	8,900	149	118,204	101,942	3,694	0	3,544	3,932	8,830	249,194	429	0.17
Oct. 1960	35,465	25,686	13,418	24,565	5,101	28,657	0	2,658	1,040	1,550	43,313	181,452	28,982	149	125,714	15,211	2,793	0	752	1,146	6,671	181,418	34	0.02
Nov. 1960	49,925	20,505	762	414	54	13,415	0	2,572	1,007	1,501	41,584	131,738	21,367	178	103,599	182	1,978	0	29	8	4,208	131,547	191	0.15
Dec. 1960	39,903	22,468	2,718	1,803	0	13,539	0	2,658	1,040	1,551	42,438	128,119	17,672	219	103,786	0	1,930	0	0	0	4,090	127,697	422	0.33
Jan. 1961	38,862	20,466	185	518	0	13,182	0	2,658	1,040	1,552	41,735	120,197	12,389	234	101,551	0	2,035	0	0	0	3,854	120,063	134	0.11
Feb. 1961	31,408	19,288	1,005	780	0	10,698	0	2,400	940	1,402	37,105	105,025	9,256	214	89,262	0	1,969	0	0	0	4,090	104,791	233	0.22
Mar. 1961	26,683	25,711	7,853	860	0	11,913	0	2,658	1,040	1,551	40,456	118,725	15,775	234	92,927	0	2,215	0	0	0	7,275	118,427	299	0.25
Apr. 1961	22,283	25,108	5,453	4,335	21	17,364	0	2,572	1,007	1,502	38,638	118,282	15,834	240	90,596	52	2,789	0	0	8	8,694	118,213	69	0.06
May 1961	3,755	43,266	29,646	47,515	2,220	42,090	0	2,658	1,040	1,550	39,778	213,520	99,115	309	91,877	5,881	3,474	0	159	197	12,729	213,741	-221	-0.10
Jun. 1961	28,215	44,522	13,579	63,285	24,546	45,282	0	2,572	1,007	1,500	38,746	263,254	79,801	364	91,207	66,101	4,049	0	2,905	1,590	17,478	263,495	-242	-0.09
Jul. 1961	41,834	29,177	24,798	102,121	31,557	56,623	0	2,658	1,040	1,549	40,792	332,150	76,542	278	146,474	83,916	5,032	0	2,712	1,766	15,622	332,342	-192	-0.06
Aug. 1961	42,427	27,447	15,455	95,563	43,147	58,804	0	2,658	1,040	1,549	41,840	329,930	48,800	228	143,691	113,296	4,566	0	3,734	3,056	12,549	329,919	12	0.00
Sep. 1961	12,379	35,063	26,077	48,704	10,044	39,983	0	2,572	1,007	1,498	41,408	218,735	55,087	241	121,991	26,717	3,690	0	402	584	10,422	219,133	-398	-0.18
Oct. 1961	49,743	26,048	4,107	5,755	3,909	13,639	0	2,658	1,040	1,549	43,121	151,568	17,715	272	110,529	10,671	2,790	0	331	850	8,388	151,545	23	0.02
Nov. 1961	46,619	21,679	1,288	1,259	0	12,804	0	2,572	1,007	1,500	41,422	130,150	15,400	276	107,406	0	1,977	0	0	0	4,935	129,993	157	0.12
Dec. 1961	43,745	22,543	760	1,629	0	8,322	0	2,658	1,040	1,550	42,270	124,518	10,946	311	106,431	0	1,930	0	0	0	4,727	124,346	172	0.14
Jan. 1962	38,827	23,886	2,554	385	0	5,072	0	2,658	1,040	1,539	41,598	117,559	8,824	324	101,351	0	2,048	0	0	0	4,479	117,025	533	0.45
Feb. 1962	30,962	20,703	1,567	647	0	10,683	0	2,400	940	1,390	36,992	106,285	9,129	282	89,650	0	1,980	0	0	0	4,756	105,797	488	0.46
Mar. 1962	35,489	22,801	1,443	1,420	0	7,782	0	2,658	1,040	1,540	40,291	114,464	6,401	315	96,723	0	2,237	0	0	0	8,266	113,942	521	0.46
Apr. 1962	15,208	23,852	3,995	23,655	1,765	22,658	0	2,572	1,007	1,490	38,476	134,678	22,028	284	94,348	4,734	2,814	0	356	456	9,699	134,719	-41	-0.03
May 1962	14,879	28,464	18,960	82,018	11,351	46,618	0	2,658	1,040	1,537	39,865	247,391	77,304	278	121,804	30,631	3,500	0	1,319	721	11,819	247,377	14	0.01
Jun. 1962	12,500	37,335	29,931	62,568	16,655	42,954	0	2,572	1,007	1,470	39,302	246,294	65,112	310	113,047	45,379	4,089	0	2,074	1,365	15,184	246,561	-267	-0.11
Jul. 1962	48,350	26,209	17,283	103,975	39,286	62,661	0	2,658	1,040	1,519	41,746	344,728	67,010	281	141,252	108,742	5,069	0	3,972	2,552	15,864	344,743	-15	0.00
Aug. 1962	55,689	20,908	7,477	97,682	47,735	58,646	0	2,658	1,040	1,519	42,842	336,196	38,776	223	148,154	124,423	4,588	0	4,378	3,360	12,351	336,253	-58	-0.02
Sep. 1962	37,387	17,731	3,000	66,471	16,923	40,847	0	2,572	1,007	1,471	42,194	229,603	25,475	177	140,055	46,286	3,696	0	2,465	2,326	9,076	229,555	49	0.02
Oct. 1962	52,454	22,091	6,055	16,607	7,274	17,324	0	2,658	1,040	1,520	43,770	170,792	13,458	219	122,533	21,098	2,795	0	1,302	1,798	7,339	170,543	249	0.15
Nov. 1962	59,117	18,211	1,641	1,936	134	19,763	0	2,572	1,007	1,467	42,070	147,918	19,068	216	121,623	395	1,977	0	0	56	4,228	147,564	355	0.24

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Dec. 1962	48,270	19,780	772	692	0	13,413	0	2,658	1,040	1,508	42,894	131,027	12,957	246	111,507	0	1,930	0	0	0	4,132	130,772	255	0.19
Jan. 1963	41,835	21,585	2,054	197	0	9,270	0	2,658	1,040	1,509	42,158	122,306	11,589	265	103,782	0	2,039	0	0	0	4,001	121,675	631	0.52
Feb. 1963	36,070	18,329	762	106	0	11,718	0	2,400	940	1,363	37,467	109,155	8,607	240	93,641	0	1,963	0	0	0	4,222	108,674	481	0.44
Mar. 1963	33,518	25,060	3,343	561	0	6,522	0	2,658	1,040	1,509	40,787	114,998	11,038	293	93,144	0	2,209	0	0	0	7,826	114,510	488	0.43
Apr. 1963	24,596	20,081	3,742	28,259	3,276	16,799	0	2,572	1,007	1,460	38,947	140,739	15,346	253	103,042	9,008	2,777	0	664	865	8,704	140,658	81	0.06
May 1963	43,524	21,620	5,637	74,187	25,878	39,866	0	2,658	1,040	1,509	40,204	256,124	43,729	249	119,052	72,112	3,440	0	4,215	2,611	10,528	255,938	186	0.07
Jun. 1963	36,924	33,907	22,432	62,077	35,219	37,727	0	2,572	1,007	1,457	39,352	272,675	46,496	231	107,235	94,883	4,046	0	4,146	2,336	13,168	272,541	134	0.05
Jul. 1963	101,273	27,398	10,802	74,336	78,452	41,171	0	2,658	1,040	1,499	41,445	380,074	21,139	214	120,209	206,723	5,038	0	6,842	5,682	13,908	379,753	320	0.08
Aug. 1963	28,893	36,316	25,486	65,469	42,292	39,597	0	2,658	1,040	1,498	42,179	285,428	33,396	180	116,336	112,648	4,604	0	3,241	2,823	11,964	285,193	236	0.08
Sep. 1963	17,216	31,514	20,453	49,271	19,362	34,931	0	2,572	1,007	1,449	41,415	219,191	33,822	162	115,574	53,384	3,708	0	1,804	2,196	9,005	219,656	-465	-0.21
Oct. 1963	55,951	19,347	4,052	21,926	12,814	26,733	0	2,658	1,040	1,498	43,050	189,068	14,644	155	122,282	37,431	2,803	0	2,083	2,634	6,618	188,651	417	0.22
Nov. 1963	47,245	20,443	1,004	3,136	327	11,577	0	2,572	1,007	1,450	41,522	130,282	21,627	193	100,998	948	1,987	0	16	101	4,199	130,070	212	0.16
Dec. 1963	41,161	21,159	1,273	1,481	0	11,069	0	2,658	1,040	1,499	42,446	123,786	16,453	231	100,608	0	1,948	0	0	0	4,090	123,331	456	0.37
Jan. 1964	38,519	19,917	543	1,310	0	11,887	0	2,658	1,040	1,499	41,761	119,134	12,268	239	100,267	0	2,060	0	0	0	3,822	118,655	479	0.40
Feb. 1964	32,665	20,032	1,602	883	0	9,718	0	2,486	973	1,403	38,463	108,225	9,967	226	91,288	0	2,097	0	0	0	4,213	107,791	434	0.40
Mar. 1964	30,942	22,602	2,708	293	0	11,018	0	2,658	1,040	1,492	40,447	113,201	10,401	240	92,720	0	2,312	0	0	0	7,149	112,823	378	0.33
Apr. 1964	16,591	26,895	11,019	8,129	237	12,568	0	2,572	1,007	1,444	38,633	119,095	19,674	238	87,016	593	2,886	0	49	126	8,565	119,147	-52	-0.04
May 1964	11,594	32,280	16,703	72,569	11,910	39,168	0	2,658	1,040	1,491	39,878	229,292	78,250	236	103,800	30,926	3,552	0	1,022	655	10,989	229,431	-139	-0.06
Jun. 1964	39,815	26,078	13,530	69,671	28,578	46,397	0	2,572	1,007	1,443	39,076	268,165	49,731	193	117,515	78,693	4,263	0	3,768	1,957	12,188	268,309	-144	-0.05
Jul. 1964	94,252	27,740	7,124	88,778	82,874	50,187	0	2,658	1,040	1,491	41,341	397,484	32,838	192	117,999	214,510	5,198	0	7,284	5,659	13,612	397,292	192	0.05
Aug. 1964	78,563	28,121	6,139	67,471	68,403	38,343	0	2,658	1,040	1,491	42,299	334,530	12,999	167	112,861	181,224	4,647	0	5,956	4,694	11,302	333,850	680	0.20
Sep. 1964	59,103	24,163	5,320	40,101	38,000	22,785	0	2,572	1,007	1,443	41,592	236,086	7,481	141	105,630	103,753	3,748	0	3,055	3,416	8,411	235,635	451	0.19
Oct. 1964	46,586	18,349	1,325	28,567	7,343	19,718	0	2,658	1,040	1,492	43,062	170,140	26,053	130	109,244	22,165	2,806	0	997	2,281	6,335	170,011	129	0.08
Nov. 1964	41,751	19,156	2,009	7,678	7	14,635	0	2,572	1,007	1,444	41,386	131,645	25,262	151	100,252	21	1,979	0	0	5	3,845	131,516	130	0.10
Dec. 1964	39,454	20,901	628	363	0	11,584	0	2,658	1,040	1,492	42,250	120,370	19,711	188	94,586	0	1,940	0	0	0	3,827	120,251	119	0.10
Jan. 1965	33,777	21,269	2,082	237	0	11,436	0	2,658	1,040	1,454	41,547	115,500	15,824	202	93,414	0	2,075	0	0	0	3,656	115,171	329	0.29
Feb. 1965	27,891	19,884	2,162	512	0	8,561	0	2,400	940	1,314	36,953	100,617	12,174	196	81,916	0	2,103	0	0	0	3,940	100,329	288	0.29
Mar. 1965	28,636	21,618	2,510	1,685	0	10,919	0	2,658	1,040	1,454	40,236	110,756	11,053	210	89,893	0	2,462	0	0	0	6,883	110,500	256	0.23
Apr. 1965	13,993	23,865	5,999	21,553	1,457	16,386	0	2,572	1,007	1,407	38,448	126,687	26,176	206	84,458	3,954	3,058	0	235	279	8,270	126,636	51	0.04
May. 1965	9,737	31,774	20,753	68,551	9,977	40,277	0	2,658	1,040	1,453	39,674	225,895	80,905	221	101,994	26,910	3,723	0	1,059	495	10,624	225,932	-37	-0.02
Jun. 1965	4,677	68,827	38,122	36,517	10,802	58,563	0	2,572	1,007	1,404	38,842	261,334	128,365	354	78,452	29,716	4,673	0	1,344	1,027	18,024	261,954	-620	-0.24

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Jul. 1965	35,452	45,046	30,200	81,918	38,763	55,088	0	2,658	1,040	1,450	41,220	332,834	86,375	348	114,214	102,621	5,573	0	2,882	2,049	18,925	332,987	-153	-0.05
Aug. 1965	45,331	27,198	9,386	87,874	48,626	60,907	0	2,658	1,040	1,450	42,369	326,838	43,704	283	128,466	127,407	4,915	0	4,470	3,465	14,171	326,882	-44	-0.01
Sep. 1965	19,179	28,334	18,812	49,616	9,296	35,042	0	2,572	1,007	1,403	41,871	207,132	44,218	268	122,740	24,568	4,003	0	449	742	10,580	207,566	-434	-0.21
Oct. 1965	50,941	24,511	6,546	9,086	5,088	9,416	0	2,658	1,040	1,451	43,500	154,237	15,792	290	110,714	14,276	2,960	0	503	1,357	8,108	154,001	236	0.15
Nov. 1965	49,268	18,138	230	2,696	442	13,537	0	2,572	1,007	1,405	41,838	131,133	14,555	269	108,119	1,178	2,094	0	22	102	4,597	130,935	198	0.15
Dec. 1965	42,809	21,132	2,053	689	0	9,663	0	2,658	1,040	1,450	42,701	124,194	12,270	294	104,917	0	2,054	0	0	0	4,420	123,955	239	0.19
Jan. 1966	37,261	21,637	1,062	1,309	0	5,878	0	2,658	1,040	1,450	42,026	114,323	9,860	310	97,279	0	2,169	0	0	0	4,243	113,861	462	0.40
Feb. 1966	30,483	20,187	1,486	697	0	4,925	0	2,400	940	1,310	37,378	99,805	7,689	279	84,682	0	2,208	0	0	0	4,506	99,364	441	0.44
Mar. 1966	38,171	19,609	1,169	853	0	13,132	0	2,658	1,040	1,451	40,695	118,778	8,802	270	99,588	0	2,566	0	0	4	7,367	118,596	182	0.15
Apr. 1966	17,110	24,621	8,874	16,275	87	13,827	0	2,572	1,007	1,404	38,873	124,652	17,459	258	94,506	225	3,157	0	52	233	8,672	124,563	89	0.07
May 1966	35,688	20,946	3,419	64,593	21,528	34,678	0	2,658	1,040	1,451	40,014	226,016	38,575	235	109,979	57,789	3,810	0	2,790	2,144	10,469	225,792	225	0.10
Jun. 1966	33,189	30,792	19,361	57,590	29,766	32,854	0	2,572	1,007	1,404	39,013	247,547	39,379	244	103,703	80,550	4,681	0	3,665	2,294	12,949	247,466	81	0.03
Jul. 1966	95,589	30,457	11,175	74,400	80,388	42,401	0	2,658	1,040	1,450	41,105	380,664	26,669	235	110,601	210,772	5,580	0	6,881	5,663	13,912	380,312	352	0.09
Aug. 1966	42,205	32,142	14,646	66,275	52,506	38,460	0	2,658	1,040	1,450	41,958	293,341	19,575	207	108,648	139,541	4,921	0	4,666	3,880	11,594	293,032	309	0.11
Sep. 1966	24,219	32,180	21,168	39,667	24,999	28,689	0	2,572	1,007	1,403	41,234	217,137	26,656	191	103,918	69,343	4,003	0	1,826	2,385	8,775	217,097	40	0.02
Oct. 1966	39,697	22,326	6,429	17,995	5,511	21,850	0	2,658	1,040	1,450	42,769	161,725	22,699	174	111,510	15,996	2,960	0	618	1,328	6,495	161,780	-55	-0.03
Nov. 1966	43,862	18,622	1,001	1,116	17	14,217	0	2,572	1,007	1,403	41,186	125,004	19,313	180	99,322	53	2,083	0	0	6	3,928	124,886	118	0.09
Dec. 1966	37,637	20,809	421	406	0	12,485	0	2,658	1,040	1,451	42,115	119,023	17,480	221	94,912	0	2,047	0	0	0	3,900	118,560	462	0.39
Jan. 1967	32,115	21,346	1,628	1,613	0	8,870	0	2,658	1,040	1,451	41,522	112,242	13,176	229	92,545	0	2,251	0	0	0	3,690	111,891	352	0.31
Feb. 1967	29,954	18,266	685	424	0	8,443	0	2,400	940	1,308	36,984	99,404	8,962	208	83,760	0	2,307	0	0	0	3,888	99,123	281	0.28
Mar. 1967	27,194	21,610	1,989	2,985	14	8,450	0	2,658	1,040	1,448	40,304	107,692	9,379	226	88,126	30	2,710	0	0	36	6,884	107,391	302	0.28
Apr. 1967	8,475	31,595	19,324	29,109	2,869	20,556	0	2,572	1,007	1,400	38,574	155,480	45,968	215	88,095	8,513	3,337	0	489	639	8,263	155,518	-38	-0.02
May 1967	2,960	42,248	36,126	44,777	4,464	30,925	0	2,658	1,040	1,446	39,771	206,415	81,087	256	96,278	12,809	4,008	0	805	401	11,064	206,707	-292	-0.14
Jun. 1967	7,801	43,403	34,791	23,522	8,429	46,270	0	2,572	1,007	1,398	38,732	207,924	73,249	282	89,641	23,748	5,065	0	1,259	622	14,372	208,238	-314	-0.15
Jul. 1967	29,182	38,414	23,040	69,948	35,239	52,256	0	2,658	1,040	1,443	40,629	293,849	66,522	275	104,765	94,074	5,940	0	3,380	2,942	16,070	293,968	-119	-0.04
Aug. 1967	47,079	24,064	8,815	100,195	47,468	59,089	0	2,658	1,040	1,444	41,398	333,250	60,062	212	130,531	119,198	5,173	0	3,460	2,556	12,255	333,447	-197	-0.06
Sep. 1967	54,385	21,381	5,466	58,670	39,056	41,569	0	2,572	1,007	1,398	40,879	266,383	21,839	174	120,772	104,904	4,227	0	2,724	2,803	8,923	266,366	17	0.01
Oct. 1967	45,704	19,957	4,041	22,524	9,354	31,341	0	2,658	1,040	1,445	42,709	180,773	18,863	163	121,217	27,784	3,092	0	1,087	1,611	6,672	180,489	284	0.16
Nov. 1967	42,947	19,994	2,249	6,059	9	15,853	0	2,572	1,007	1,399	41,296	133,386	22,796	182	104,027	25	2,188	0	0	5	4,110	133,333	54	0.04
Dec. 1967	37,425	22,669	2,593	392	0	11,822	0	2,658	1,040	1,446	42,347	122,392	17,897	231	97,913	0	2,130	0	0	0	4,083	122,254	138	0.11
Jan. 1968	34,013	21,472	647	3,886	0	8,554	0	2,658	1,040	1,447	41,766	115,484	14,208	247	94,756	0	2,258	0	0	0	3,893	115,361	122	0.11

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Feb. 1968	30,248	19,616	1,704	178	0	11,878	0	2,486	973	1,354	38,551	106,989	9,904	228	89,918	0	2,410	0	0	0	4,211	106,671	318	0.30
Mar. 1968	25,938	22,633	2,085	4,843	0	10,479	0	2,658	1,040	1,447	40,626	111,750	11,148	250	90,010	0	2,734	0	0	0	7,318	111,460	290	0.26
Apr. 1968	11,456	26,594	10,557	17,711	1	17,208	0	2,572	1,007	1,401	38,852	127,359	25,530	237	89,757	29	3,355	0	0	3	8,610	127,521	-163	-0.13
May 1968	7,531	28,505	16,018	59,741	3,397	33,763	0	2,658	1,040	1,447	39,987	194,087	62,671	236	106,784	9,016	4,023	0	409	294	10,723	194,155	-69	-0.04
Jun. 1968	42,349	24,766	8,022	88,487	34,119	54,663	0	2,572	1,007	1,397	39,097	296,478	73,460	214	111,882	87,557	5,063	0	3,195	2,122	12,899	296,391	87	0.03
Jul. 1968	52,243	29,902	11,776	94,323	53,746	51,185	0	2,658	1,040	1,443	41,534	339,851	50,060	209	125,055	135,835	5,936	0	4,635	3,530	14,453	339,712	139	0.04
Aug. 1968	37,470	29,473	16,551	81,822	41,985	50,976	0	2,658	1,040	1,443	42,660	306,079	45,034	204	126,160	111,606	5,176	0	3,388	2,493	11,961	306,023	56	0.02
Sep. 1968	67,231	18,809	2,102	52,910	43,110	36,006	0	2,572	1,007	1,397	41,949	267,093	8,976	151	122,600	115,878	4,224	0	3,221	3,039	8,502	266,590	503	0.19
Oct. 1968	47,604	20,983	4,764	21,374	8,840	26,014	0	2,658	1,040	1,444	43,560	178,281	21,715	145	118,926	25,411	3,086	0	920	1,647	6,467	178,317	-36	-0.02
Nov. 1968	45,837	20,585	2,349	3,339	12	14,743	0	2,572	1,007	1,397	41,908	133,750	23,891	173	103,519	37	2,185	0	0	2	3,969	133,776	-26	-0.02
Dec. 1968	41,308	21,523	1,121	599	0	11,430	0	2,658	1,040	1,444	42,843	123,967	18,082	216	99,487	0	2,128	0	0	0	3,913	123,825	142	0.11
Jan. 1969	37,641	19,990	647	980	0	12,166	0	2,658	1,040	1,444	42,177	118,743	12,836	218	99,403	0	2,253	0	0	0	3,639	118,349	393	0.33
Feb. 1969	32,454	18,447	770	760	0	9,399	0	2,400	940	1,305	37,520	103,996	9,395	198	88,003	0	2,318	0	0	0	3,848	103,764	232	0.22
Mar. 1969	30,552	23,132	1,994	550	0	10,240	0	2,658	1,040	1,445	40,896	112,507	13,147	228	89,183	0	2,723	0	0	0	6,907	112,188	319	0.28
Apr. 1969	15,580	25,276	9,844	17,215	3,758	15,564	0	2,572	1,007	1,398	39,074	131,289	17,336	211	90,628	10,234	3,343	0	666	800	8,098	131,317	-28	-0.02
May 1969	2,665	63,230	32,730	48,001	9,371	54,377	0	2,658	1,040	1,443	40,310	255,825	133,521	362	77,496	24,517	4,025	0	891	737	14,582	256,131	-306	-0.12
Jun. 1969	19,046	54,679	20,580	52,921	27,428	52,796	0	2,572	1,007	1,395	39,333	271,758	85,228	407	84,760	72,643	5,109	0	3,364	1,890	19,045	272,448	-690	-0.25
Jul. 1969	70,579	28,580	17,992	108,335	58,626	69,987	0	2,658	1,040	1,441	41,483	400,723	69,993	263	150,827	149,106	5,959	0	5,427	3,964	15,293	400,832	-109	-0.03
Aug. 1969	68,184	26,986	11,390	89,726	66,636	53,787	0	2,658	1,040	1,441	42,614	364,461	31,064	217	135,643	169,887	5,164	0	5,761	4,436	12,225	364,397	64	0.02
Sep. 1969	39,297	23,863	10,358	50,221	25,681	36,586	0	2,572	1,007	1,395	42,109	233,088	20,834	161	125,087	68,723	4,222	0	2,469	2,627	8,976	233,097	-10	0.00
Oct. 1969	28,094	37,271	32,026	6,244	610	29,904	0	2,658	1,040	1,440	43,797	183,084	59,303	187	111,568	1,593	3,129	0	7	84	7,435	183,306	-223	-0.12
Nov. 1969	44,091	22,046	1,585	1,024	0	20,209	0	2,572	1,007	1,395	42,215	136,143	24,982	227	104,042	0	2,227	0	0	0	4,583	136,062	82	0.06
Dec. 1969	41,195	23,622	830	1,343	0	8,344	0	2,658	1,040	1,442	43,200	123,674	17,475	274	99,131	0	2,167	0	0	0	4,534	123,581	93	0.08
Jan. 1970	39,058	23,397	247	1,980	0	4,867	0	2,658	1,040	1,441	42,575	117,263	13,857	305	96,260	0	2,372	0	0	0	4,384	117,178	85	0.07
Feb. 1970	33,305	19,933	193	1,036	0	6,766	0	2,400	940	1,300	37,910	103,782	9,666	274	86,443	0	2,429	0	0	0	4,572	103,385	398	0.38
Mar. 1970	27,260	24,552	5,034	660	0	11,767	0	2,658	1,040	1,439	41,302	115,713	10,588	287	93,707	0	2,886	0	0	0	7,893	115,361	351	0.30
Apr. 1970	17,222	37,793	9,504	1,953	38	8,068	0	2,572	1,007	1,393	39,472	119,021	29,382	350	74,791	86	3,500	0	8	29	10,891	119,037	-16	-0.01
May 1970	20,764	35,466	10,835	52,644	15,985	39,630	0	2,658	1,040	1,439	40,663	221,125	69,756	367	88,464	41,690	4,207	0	1,117	1,413	14,296	221,310	-185	-0.08
Jun. 1970	17,931	51,345	23,452	68,860	25,049	50,882	0	2,572	1,007	1,392	39,694	282,183	98,618	434	88,633	65,819	5,239	0	2,261	1,868	19,732	282,604	-421	-0.15
Jul. 1970	71,430	24,479	12,926	110,648	60,038	76,241	0	2,658	1,040	1,438	41,959	402,857	67,655	264	153,233	150,386	6,174	0	4,809	4,155	16,284	402,961	-104	-0.03
Aug. 1970	75,002	23,395	7,968	100,165	64,328	62,397	0	2,658	1,040	1,438	43,022	381,414	38,311	195	150,571	163,902	5,298	0	6,079	4,663	12,327	381,347	67	0.02

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Sep. 1970	32,891	25,050	12,436	53,133	22,636	41,642	0	2,572	1,007	1,392	42,477	235,237	28,699	165	126,031	62,639	4,323	0	1,901	1,830	9,642	235,230	7	0.00
Oct. 1970	52,592	23,629	7,501	6,607	3,152	23,494	0	2,658	1,040	1,439	44,114	166,226	25,676	198	118,853	9,486	3,246	0	402	1,009	7,382	166,252	-26	-0.02
Nov. 1970	43,051	21,431	2,323	2,406	0	16,263	0	2,572	1,007	1,393	42,431	132,876	20,649	228	105,100	0	2,351	0	0	0	4,586	132,914	-38	-0.03
Dec. 1970	43,123	20,646	663	2,429	0	12,262	0	2,658	1,040	1,440	43,375	127,636	15,033	262	105,502	0	2,284	0	0	0	4,416	127,497	139	0.11
Jan. 1971	37,967	22,713	1,908	1,409	0	6,698	0	2,658	1,040	1,440	42,734	118,568	12,120	288	99,036	0	2,396	0	0	0	4,273	118,113	455	0.38
Feb. 1971	30,141	20,775	2,525	1,622	0	9,200	0	2,400	940	1,301	38,068	106,972	9,971	266	89,378	0	2,432	0	0	0	4,539	106,586	387	0.36
Mar. 1971	31,875	22,384	2,635	1,929	0	10,895	0	2,658	1,040	1,440	41,484	116,341	9,445	290	95,543	0	2,857	0	0	0	7,864	115,998	343	0.29
Apr. 1971	8,522	38,340	22,339	7,520	9	14,740	0	2,572	1,007	1,393	39,706	136,148	40,425	331	81,556	21	3,558	0	1	11	10,482	136,385	-237	-0.17
May 1971	8,698	41,151	14,400	31,834	5,954	29,366	0	2,658	1,040	1,439	40,784	177,325	56,005	399	83,611	16,712	4,282	0	1,124	1,046	14,581	177,760	-435	-0.24
Jun. 1971	52,098	23,244	8,032	91,285	36,728	73,786	0	2,572	1,007	1,393	39,636	329,780	78,874	271	123,292	98,892	5,291	0	5,198	3,484	14,492	329,793	-13	0.00
Jul. 1971	72,068	21,834	7,088	116,752	60,205	74,747	0	2,658	1,040	1,439	42,074	399,906	65,607	218	146,967	157,098	6,191	0	5,076	4,046	14,597	399,800	105	0.03
Aug. 1971	67,125	25,516	7,675	93,972	63,267	56,336	0	2,658	1,040	1,439	43,383	362,411	32,233	181	136,705	165,424	5,333	0	5,998	4,460	11,951	362,285	126	0.03
Sep. 1971	21,468	33,160	21,890	41,371	14,131	33,791	0	2,572	1,007	1,392	42,859	213,640	46,936	197	112,423	38,411	4,329	0	656	870	10,024	213,846	-206	-0.10
Oct. 1971	57,071	20,444	4,683	6,173	3,322	19,851	0	2,658	1,040	1,439	44,523	161,205	21,515	192	118,124	9,776	3,309	0	36	965	7,274	161,192	13	0.01
Nov. 1971	52,942	17,757	532	1,760	0	20,198	0	2,572	1,007	1,393	42,776	140,938	19,334	202	114,693	0	2,390	0	0	0	4,234	140,854	84	0.06
Dec. 1971	40,973	21,472	600	1,842	0	13,216	0	2,658	1,040	1,440	43,687	126,928	15,982	249	103,654	0	2,318	0	0	0	4,254	126,457	471	0.37
Jan. 1972	36,026	23,226	1,595	1,241	0	6,898	0	2,658	1,040	1,420	43,028	117,132	13,068	281	96,742	0	2,416	0	0	0	4,170	116,678	454	0.39
Feb. 1972	31,637	19,440	752	2,012	0	13,695	0	2,486	973	1,329	39,642	111,966	10,103	256	94,364	0	2,540	0	0	0	4,472	111,735	231	0.21
Mar. 1972	34,300	20,889	1,433	2,016	62	14,436	0	2,658	1,040	1,420	41,709	119,964	10,009	256	98,788	174	2,920	0	0	60	7,422	119,628	336	0.28
Apr. 1972	14,247	26,977	12,397	31,065	3,957	22,708	0	2,572	1,007	1,367	39,882	156,181	31,428	242	98,115	12,157	3,574	0	808	1,091	8,752	156,167	14	0.01
May 1972	22,325	25,203	10,751	64,976	14,563	37,433	0	2,658	1,040	1,410	41,099	221,459	43,262	226	116,325	42,864	4,226	0	2,341	1,580	10,556	221,381	78	0.04
Jun. 1972	27,881	33,183	20,794	70,186	29,767	56,382	0	2,572	1,007	1,364	40,164	283,300	64,903	221	109,016	83,805	5,157	0	4,084	2,748	13,443	283,379	-79	-0.03
Jul. 1972	67,009	25,545	8,748	94,261	54,820	53,269	0	2,658	1,040	1,410	42,398	351,158	39,159	200	133,033	149,749	6,159	0	5,075	3,703	14,049	351,128	30	0.01
Aug. 1972	29,468	33,279	21,247	75,019	40,907	45,026	0	2,658	1,040	1,404	43,315	293,363	35,048	193	122,455	111,992	5,268	0	3,384	2,618	12,316	293,274	88	0.03
Sep. 1972	60,424	26,392	12,463	26,435	32,589	29,605	0	2,572	1,007	1,358	42,454	235,298	8,578	148	114,078	93,747	4,370	0	2,419	2,590	8,957	234,887	412	0.18
Oct. 1972	42,621	21,679	4,332	18,133	7,579	22,140	0	2,658	1,040	1,404	43,955	165,542	18,723	160	110,797	22,602	3,391	0	1,286	1,528	6,955	165,443	99	0.06
Nov. 1972	39,959	22,605	7,283	1,631	0	21,685	0	2,572	1,007	1,358	42,294	140,394	28,693	172	104,898	0	2,408	0	0	0	4,181	140,351	43	0.03
Dec. 1972	39,204	23,305	1,888	129	0	10,723	0	2,658	1,040	1,403	43,295	123,645	19,755	229	96,972	0	2,344	0	0	0	4,196	123,497	148	0.12
Jan. 1973	30,644	24,975	3,048	1,799	0	7,438	0	2,658	1,040	1,400	42,697	115,699	17,086	265	91,485	0	2,432	0	0	0	4,131	115,399	299	0.26
Feb. 1973	29,865	19,129	394	1,663	0	8,460	0	2,400	940	1,265	38,016	102,131	9,922	239	84,812	0	2,471	0	0	0	4,347	101,791	340	0.33
Mar. 1973	25,244	24,682	6,481	2,044	0	13,157	0	2,658	1,040	1,400	41,443	118,149	14,392	261	92,837	0	2,902	0	0	0	7,582	117,975	173	0.15

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Apr. 1973	10,314	38,083	20,211	5,205	2	9,143	0	2,572	1,007	1,354	39,624	127,513	35,616	301	78,253	7	3,494	0	2	1	9,979	127,653	-141	-0.11
May 1973	4,229	89,892	24,146	24,914	315	17,385	0	2,658	1,040	1,398	40,725	206,703	119,402	548	64,032	876	4,106	0	59	95	18,200	207,317	-614	-0.30
Jun. 1973	40,989	28,168	7,768	81,746	25,149	63,959	0	2,572	1,007	1,350	39,656	292,365	83,167	366	109,066	71,308	5,241	0	3,180	2,144	18,019	292,491	-126	-0.04
Jul. 1973	58,498	25,660	16,426	110,472	42,061	75,800	0	2,658	1,040	1,394	42,036	376,044	83,523	270	150,460	113,428	6,145	0	3,462	2,782	16,210	376,280	-236	-0.06
Aug. 1973	78,135	20,635	4,592	102,046	59,873	63,782	0	2,658	1,040	1,394	43,343	377,499	41,848	208	150,792	157,589	5,332	0	5,477	4,226	11,972	377,443	56	0.01
Sep. 1973	29,720	35,890	24,252	37,927	15,878	23,313	0	2,572	1,007	1,348	42,862	214,770	36,654	259	112,874	47,285	4,351	0	1,374	1,537	10,540	214,874	-104	-0.05
Oct. 1973	61,304	24,322	3,744	7,774	10,357	7,238	0	2,658	1,040	1,394	44,584	164,414	10,315	282	106,197	31,528	3,361	0	2,031	2,465	8,048	164,228	185	0.11
Nov. 1973	44,242	20,519	3,628	2,291	14	11,618	0	2,572	1,007	1,349	42,830	130,069	19,106	262	103,427	39	2,419	0	0	5	4,612	129,870	199	0.15
Dec. 1973	36,345	22,765	4,797	3,290	0	14,535	0	2,658	1,040	1,395	43,771	130,596	17,437	280	105,989	0	2,349	0	0	0	4,374	130,430	166	0.13
Jan. 1974	33,817	22,860	1,991	1,860	0	8,828	0	2,658	1,040	1,376	43,169	117,599	12,164	304	97,995	0	2,450	0	0	0	4,264	117,177	422	0.36
Feb. 1974	31,844	19,685	1,440	736	0	11,258	0	2,400	940	1,244	38,405	107,952	10,237	270	90,080	0	2,483	0	0	0	4,455	107,524	428	0.40
Mar. 1974	26,112	23,846	5,226	3,190	0	19,805	0	2,658	1,040	1,377	41,870	125,124	15,877	279	98,144	0	2,948	0	0	0	7,719	124,967	157	0.13
Apr. 1974	13,195	31,624	13,761	5,872	319	15,207	0	2,572	1,007	1,332	40,021	124,910	24,371	285	86,090	821	3,598	0	45	61	9,681	124,953	-43	-0.03
May 1974	38,528	18,935	1,227	77,203	19,919	54,504	0	2,658	1,040	1,377	41,299	256,689	59,582	238	117,692	58,618	4,378	0	3,423	2,248	10,662	256,840	-151	-0.06
Jun. 1974	30,226	30,432	21,345	85,926	28,941	62,644	0	2,572	1,007	1,331	40,560	304,984	81,329	217	117,818	82,372	5,299	0	3,093	1,825	13,183	305,137	-153	-0.05
Jul. 1974	59,370	30,732	14,680	110,604	56,296	64,544	0	2,658	1,040	1,375	43,076	384,376	65,956	201	136,948	152,056	6,294	0	5,031	3,776	14,111	384,373	3	0.00
Aug. 1974	49,207	22,675	5,144	96,224	45,886	55,943	0	2,658	1,040	1,376	44,356	324,508	39,197	145	137,550	123,659	5,331	0	3,990	3,161	11,410	324,443	65	0.02
Sep. 1974	46,180	23,180	4,852	40,572	22,836	32,350	0	2,572	1,007	1,316	43,720	218,584	17,585	143	115,476	67,247	4,387	0	2,059	2,313	9,094	218,304	280	0.13
Oct. 1974	43,700	23,776	7,748	17,029	7,226	23,588	0	2,658	1,040	1,359	45,350	173,475	21,420	160	117,073	21,832	3,389	0	1,063	1,450	6,967	173,353	122	0.07
Nov. 1974	46,494	19,982	2,311	4,777	29	18,723	0	2,572	1,007	1,315	43,577	140,787	23,325	175	110,500	98	2,413	0	7	7	4,155	140,680	108	0.08
Dec. 1974	41,028	20,605	467	4,100	0	16,521	0	2,658	1,040	1,359	44,472	132,251	18,231	217	107,314	0	2,345	0	0	0	4,036	132,144	107	0.08
Jan. 1975	36,120	21,017	434	3,587	0	12,003	0	2,658	1,040	1,360	43,761	121,981	13,208	236	101,809	0	2,457	0	0	0	3,859	121,569	413	0.34
Feb. 1975	32,495	19,577	879	1,348	0	12,485	0	2,400	940	1,229	38,918	110,270	12,581	224	90,775	0	2,493	0	0	0	4,148	110,220	50	0.05
Mar. 1975	32,708	21,257	2,489	2,904	0	17,115	0	2,658	1,040	1,360	42,384	123,916	12,315	230	101,090	0	2,896	0	0	0	7,097	123,627	288	0.23
Apr. 1975	12,089	27,540	11,285	15,032	24	20,242	0	2,572	1,007	1,316	40,470	131,578	24,483	231	94,624	73	3,539	0	1	2	8,624	131,577	0	0.00
May 1975	2,768	40,066	40,371	75,962	1,462	41,919	0	2,658	1,040	1,358	41,727	249,329	116,067	269	113,082	4,427	4,117	0	169	100	11,295	249,526	-197	-0.08
Jun. 1975	25,022	34,110	13,668	62,074	22,540	53,811	0	2,572	1,007	1,311	40,817	256,933	64,434	277	102,722	65,957	5,069	0	2,238	1,493	14,875	257,066	-133	-0.05
Jul. 1975	37,329	29,375	18,262	138,818	40,796	80,404	0	2,658	1,040	1,344	43,298	393,325	111,446	247	143,868	111,385	6,068	0	2,742	1,812	15,674	393,243	82	0.02
Aug. 1975	46,977	24,120	10,139	109,794	43,957	64,346	0	2,658	1,040	1,345	44,862	349,237	53,495	204	152,492	119,796	5,167	0	3,339	2,321	12,528	349,344	-106	-0.03
Sep. 1975	48,368	18,628	3,438	58,665	25,318	44,904	0	2,572	1,007	1,302	44,559	248,760	13,866	162	142,614	74,262	4,302	0	2,323	2,047	9,197	248,774	-14	-0.01
Oct. 1975	63,498	18,731	2,341	18,190	6,423	20,859	0	2,658	1,040	1,346	46,296	181,382	15,370	159	132,929	20,109	3,364	0	970	1,490	6,899	181,290	93	0.05

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Nov. 1975	47,701	21,701	4,085	5,055	0	17,095	0	2,572	1,007	1,302	44,461	144,980	22,134	193	115,797	0	2,419	0	0	0	4,268	144,811	168	0.12
Dec. 1975	43,631	21,146	1,644	4,284	0	17,783	0	2,658	1,040	1,346	45,388	138,921	18,552	225	113,465	0	2,366	0	0	0	4,137	138,744	177	0.13
Jan. 1976	38,646	21,730	1,024	4,542	0	14,164	0	2,658	1,040	1,347	44,711	129,862	14,419	250	108,578	0	2,469	0	0	0	3,986	129,703	159	0.12
Feb. 1976	35,225	19,123	1,222	4,638	0	16,883	0	2,486	973	1,260	41,195	123,005	10,945	222	104,618	0	2,599	0	0	0	4,250	122,635	370	0.30
Mar. 1976	32,207	22,516	2,372	4,181	0	18,996	0	2,658	1,040	1,347	43,294	128,611	12,320	238	105,522	0	2,958	0	0	0	7,256	128,293	317	0.25
Apr. 1976	13,686	26,359	11,927	24,248	208	21,967	0	2,572	1,007	1,303	41,364	144,642	28,665	223	102,907	663	3,695	0	29	64	8,590	144,835	-194	-0.13
May 1976	9,422	29,619	21,026	62,845	6,138	38,604	0	2,658	1,040	1,346	42,558	215,256	60,477	214	120,387	18,618	4,317	0	376	380	10,429	215,198	58	0.03
Jun. 1976	55,367	22,804	7,065	90,313	30,855	52,416	0	2,572	1,007	1,295	41,614	305,307	60,608	100	125,035	96,594	5,397	0	3,263	2,061	12,184	305,240	67	0.02
Jul. 1976	66,141	31,981	13,964	99,321	51,491	57,490	0	2,658	1,040	1,333	44,179	369,597	53,584	-22	131,345	157,754	6,449	0	3,680	2,697	13,908	369,395	202	0.05
Aug. 1976	52,829	29,863	10,112	88,759	45,990	57,827	0	2,658	1,040	1,333	45,329	335,739	37,971	-62	131,676	141,658	5,430	0	3,891	3,165	11,750	335,479	261	0.08
Sep. 1976	33,900	32,158	15,782	48,315	25,280	35,181	0	2,572	1,007	1,290	44,707	240,191	22,039	-44	120,671	80,067	4,490	0	1,694	1,902	9,176	239,996	195	0.08
Oct. 1976	56,719	21,812	3,601	11,923	5,017	25,629	0	2,658	1,040	1,333	46,411	176,144	22,300	23	125,539	16,250	3,452	0	756	1,197	6,709	176,225	-82	-0.05
Nov. 1976	48,407	19,841	603	4,168	0	20,159	0	2,572	1,007	1,291	44,522	142,570	21,591	64	114,503	0	2,442	0	0	0	4,002	142,603	-33	-0.02
Dec. 1976	42,642	21,097	343	2,213	0	18,282	0	2,658	1,040	1,334	45,369	134,979	18,329	95	110,129	0	2,384	0	0	0	3,874	134,811	167	0.12
Jan. 1977	36,308	21,942	727	3,984	0	14,880	0	2,658	1,040	1,335	44,616	127,491	15,954	132	105,078	0	2,486	0	0	0	3,733	127,383	109	0.09
Feb. 1977	31,675	18,503	314	3,879	0	15,395	0	2,400	940	1,206	39,636	113,949	10,507	124	96,949	0	2,516	0	0	0	3,898	113,994	-45	-0.04
Mar. 1977	32,146	24,119	3,051	3,709	0	13,035	0	2,658	1,040	1,335	43,134	124,228	12,951	167	100,816	0	2,954	0	0	0	7,023	123,911	317	0.26
Apr. 1977	10,994	31,722	19,708	25,351	1,389	23,778	0	2,572	1,007	1,292	41,200	159,012	40,500	167	100,985	4,597	3,627	0	340	505	8,402	159,123	-111	-0.07
May 1977	33,980	26,748	14,123	53,842	17,143	33,085	0	2,658	1,040	1,334	42,440	226,394	34,144	168	116,096	56,347	4,358	0	3,059	2,078	10,086	226,334	60	0.03
Jun. 1977	67,230	28,932	11,122	77,636	45,009	48,098	0	2,572	1,007	1,291	41,495	324,392	41,776	64	113,535	142,162	5,277	0	5,873	3,313	12,143	324,143	248	0.08
Jul. 1977	66,879	39,423	22,326	69,231	58,737	45,877	0	2,658	1,040	1,333	43,720	351,225	32,947	-31	111,363	178,436	6,274	0	4,422	3,555	13,722	350,687	539	0.15
Aug. 1977	56,014	29,939	10,607	75,178	48,188	47,610	0	2,658	1,040	1,326	44,381	316,939	25,820	-48	117,523	148,789	5,286	0	4,039	3,826	11,247	316,481	458	0.14
Sep. 1977	68,453	20,632	1,459	43,116	32,095	29,062	0	2,572	1,007	1,280	43,345	243,021	5,491	-22	114,775	102,519	4,502	0	3,428	4,042	8,113	242,847	173	0.07
Oct. 1977	47,673	20,099	739	25,596	5,596	20,029	0	2,658	1,040	1,324	44,806	169,560	24,439	14	113,925	18,893	3,436	0	713	2,048	6,179	169,647	-87	-0.05
Nov. 1977	43,051	22,547	1,854	4,640	21	14,075	0	2,572	1,007	1,282	42,990	134,038	27,547	59	99,947	73	2,423	0	0	24	3,842	133,914	124	0.09
Dec. 1977	40,475	20,079	695	3,504	0	17,222	0	2,658	1,040	1,325	43,896	130,895	19,899	80	104,776	0	2,360	0	0	0	3,633	130,748	147	0.11
Jan. 1978	32,991	22,061	1,712	3,156	0	14,235	0	2,658	1,040	1,325	43,233	122,412	18,051	112	98,043	0	2,462	0	0	0	3,505	122,172	240	0.20
Feb. 1978	30,423	19,058	1,191	2,029	0	14,683	0	2,400	940	1,197	38,479	110,400	13,903	111	90,034	0	2,444	0	0	0	3,706	110,196	204	0.18
Mar. 1978	31,622	21,793	1,165	1,524	3	16,566	0	2,658	1,040	1,326	41,950	119,646	13,527	124	96,257	9	2,835	0	0	2	6,528	119,282	364	0.30
Apr. 1978	15,270	26,608	9,671	22,080	2,987	19,069	0	2,572	1,007	1,283	40,111	140,657	26,529	129	90,593	10,018	3,605	0	754	1,103	7,894	140,626	30	0.02
May 1978	2,738	40,239	34,646	38,120	6,343	44,536	0	2,658	1,040	1,324	41,361	213,005	77,382	151	98,328	20,963	4,289	0	908	440	10,610	213,071	-66	-0.03

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Jun. 1978	28,390	31,892	14,662	89,734	24,084	68,413	0	2,572	1,007	1,281	40,498	302,531	94,122	76	108,372	76,970	5,406	0	2,651	1,879	13,146	302,623	-91	-0.03
Jul. 1978	83,341	24,917	7,246	113,276	53,996	67,418	0	2,658	1,040	1,323	43,111	398,327	64,109	-39	136,636	169,980	6,482	0	4,435	3,112	13,592	398,307	20	0.00
Aug. 1978	55,174	27,925	8,354	98,827	42,583	57,268	0	2,658	1,040	1,324	44,561	339,714	48,036	-96	136,368	132,809	5,536	0	3,367	2,210	11,372	339,602	112	0.03
Sep. 1978	79,934	18,420	375	47,903	36,079	32,331	0	2,572	1,007	1,282	44,034	263,936	6,257	-121	124,313	114,650	4,656	0	3,101	2,673	8,152	263,683	254	0.10
Oct. 1978	37,827	25,071	10,481	23,650	3,651	22,250	0	2,658	1,040	1,325	45,653	173,607	33,116	-41	117,306	11,892	3,531	0	396	895	6,458	173,551	56	0.03
Nov. 1978	48,775	20,852	1,089	2,715	1	16,289	0	2,572	1,007	1,282	43,772	138,354	25,275	12	106,726	3	2,425	0	0	1	3,931	138,372	-18	-0.01
Dec. 1978	38,491	22,266	2,611	3,454	0	15,957	0	2,658	1,040	1,325	44,654	132,455	21,059	54	105,113	0	2,369	0	0	0	3,804	132,398	57	0.04
Jan. 1979	34,723	22,207	1,253	4,711	0	14,330	0	2,658	1,040	1,273	43,935	126,130	19,594	97	100,257	0	2,472	0	0	0	3,675	126,094	36	0.03
Feb. 1979	29,335	20,289	555	3,075	0	10,854	0	2,400	940	1,150	39,062	107,661	12,735	112	88,360	0	2,498	0	0	0	3,966	107,670	-10	-0.01
Mar. 1979	29,454	24,228	7,786	1,552	0	20,442	562	2,658	1,040	1,273	42,532	131,527	20,324	117	101,223	0	2,937	0	0	0	6,832	131,433	95	0.07
Apr. 1979	15,370	28,235	11,800	9,744	219	29,053	3,754	2,572	1,007	1,231	40,643	143,627	34,657	122	96,041	788	3,659	0	66	105	8,314	143,751	-124	-0.09
May 1979	4,664	45,885	28,489	36,489	3,886	39,425	2,026	2,658	1,040	1,271	41,776	207,608	90,198	222	87,392	12,209	4,279	0	543	446	12,712	208,001	-393	-0.19
Jun. 1979	14,096	60,816	24,548	60,458	16,102	46,339	1,341	2,572	1,007	1,228	40,513	269,021	106,831	358	83,196	51,028	5,396	0	1,921	1,429	19,099	269,257	-236	-0.09
Jul. 1979	81,187	22,223	10,793	121,888	39,376	76,454	464	2,658	1,040	1,270	42,701	400,054	82,700	121	161,142	128,379	6,548	0	3,752	2,641	14,856	400,139	-85	-0.02
Aug. 1979	17,263	37,210	30,089	76,076	23,217	52,866	532	2,658	1,040	1,268	43,937	286,156	59,434	124	128,958	75,525	5,405	0	1,753	1,306	13,874	286,378	-222	-0.08
Sep. 1979	84,571	20,033	5,215	47,115	37,705	37,144	644	2,572	1,007	1,228	43,355	280,590	7,872	34	131,945	121,126	4,647	0	2,770	2,684	9,246	280,325	264	0.09
Oct. 1979	45,830	22,409	7,092	24,799	6,581	26,615	993	2,658	1,040	1,267	45,010	184,297	20,856	76	128,475	21,760	3,531	0	1,029	1,485	6,941	184,153	143	0.08
Nov. 1979	40,712	25,009	5,813	6,471	1	14,524	404	2,572	1,007	1,222	43,269	141,005	27,397	145	106,456	3	2,461	0	0	0	4,467	140,928	77	0.05
Dec. 1979	38,678	25,704	3,021	4,525	0	11,311	381	2,658	1,040	1,263	44,224	132,806	22,966	205	102,656	0	2,381	0	0	0	4,500	132,708	98	0.07
Jan. 1980	34,172	25,207	3,200	4,100	0	8,634	1,365	2,658	1,040	1,264	43,605	125,245	19,055	234	98,822	0	2,509	0	0	0	4,354	124,974	272	0.22
Feb. 1980	29,970	23,360	1,728	3,991	0	9,996	813	2,486	973	1,183	40,212	114,712	16,748	234	89,969	0	2,600	0	0	0	4,880	114,431	280	0.24
Mar. 1980	28,352	26,057	5,033	2,312	0	15,138	901	2,658	1,040	1,264	42,289	125,043	17,000	253	96,297	0	2,947	0	0	0	8,321	124,818	226	0.18
Apr. 1980	12,968	40,793	14,124	8,720	9	12,504	1,994	2,572	1,007	1,223	40,411	136,327	42,318	314	78,903	23	3,629	0	0	4	11,383	136,573	-246	-0.18
May 1980	3,725	88,847	22,677	26,473	1,426	29,438	2,531	2,658	1,040	1,263	41,361	221,439	123,928	581	69,672	4,163	4,228	0	91	215	19,222	222,100	-661	-0.30
Jun. 1980	50,420	27,898	5,435	97,572	28,852	83,243	1,435	2,572	1,007	1,222	40,077	339,733	96,530	393	118,305	93,425	5,480	0	3,129	2,703	19,929	339,894	-161	-0.05
Jul. 1980	84,851	25,392	15,150	115,912	42,233	82,431	496	2,658	1,040	1,262	42,397	413,822	73,555	140	171,060	138,727	6,549	0	4,272	3,081	16,498	413,883	-61	-0.01
Aug. 1980	69,800	23,132	9,060	100,928	40,132	63,641	626	2,658	1,040	1,262	43,653	355,931	41,538	51	158,440	130,394	5,532	0	4,221	2,882	12,912	355,971	-39	-0.01
Sep. 1980	72,411	21,733	5,904	49,586	31,245	41,722	601	2,572	1,007	1,222	43,121	271,125	7,714	41	139,781	103,680	4,603	0	2,942	2,818	9,312	270,890	235	0.09
Oct. 1980	55,985	18,349	1,754	28,456	6,094	26,918	384	2,658	1,040	1,258	44,849	187,745	19,006	91	134,996	20,523	3,524	0	949	1,462	6,982	187,534	211	0.11
Nov. 1980	49,115	20,755	1,756	7,671	11	19,232	530	2,572	1,007	1,215	43,128	146,993	26,712	162	113,231	40	2,462	0	0	8	4,383	146,999	-6	0.00
Dec. 1980	48,345	20,160	252	5,238	0	16,286	210	2,658	1,040	1,257	44,122	139,568	19,956	207	112,616	0	2,402	0	0	0	4,235	139,416	152	0.11

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Jan. 1981	37,909	21,162	788	6,653	0	16,986	3,323	2,658	1,040	1,257	43,526	135,301	19,241	239	109,142	0	2,528	0	0	0	4,062	135,213	88	0.07
Feb. 1981	35,524	17,777	812	6,988	0	17,961	4,279	2,400	940	1,136	38,753	126,570	17,631	210	102,151	0	2,320	0	0	0	4,147	126,460	111	0.09
Mar. 1981	26,242	25,440	9,255	7,565	6	18,066	7,000	2,658	1,040	1,256	42,281	140,808	24,530	225	106,007	16	2,518	0	0	1	7,453	140,750	57	0.04
Apr. 1981	26,882	25,364	10,747	22,990	7,193	21,799	2,006	2,572	1,007	1,215	40,443	162,218	18,957	213	103,665	23,932	3,247	0	1,705	1,909	8,611	162,240	-22	-0.01
May 1981	4,960	37,625	34,180	48,301	6,486	33,633	5,234	2,658	1,040	1,253	41,624	216,994	66,346	256	111,391	22,042	3,819	0	1,246	723	11,322	217,145	-150	-0.07
Jun. 1981	56,317	27,202	10,207	64,918	33,782	46,244	3,897	2,572	1,007	1,213	40,501	287,858	35,975	229	112,774	112,599	4,460	0	5,344	3,245	13,190	287,816	42	0.01
Jul. 1981	46,609	30,374	20,742	93,497	34,597	57,899	1,369	2,658	1,040	1,252	42,559	332,598	62,752	139	131,251	113,577	5,661	0	2,954	1,913	14,210	332,457	141	0.04
Aug. 1981	49,786	26,027	10,962	81,412	37,034	52,774	1,351	2,658	1,040	1,253	43,472	307,768	31,432	70	133,298	120,003	5,113	0	3,555	2,651	11,568	307,690	78	0.03
Sep. 1981	66,247	20,022	3,190	52,357	29,807	36,061	1,672	2,572	1,007	1,213	42,757	256,904	14,196	83	126,205	98,393	4,270	0	2,283	2,424	8,509	256,365	539	0.21
Oct. 1981	40,883	23,232	5,973	27,188	5,011	25,733	1,024	2,658	1,040	1,254	44,389	178,385	25,707	121	122,788	17,234	3,381	0	927	1,317	6,683	178,157	227	0.13
Nov. 1981	49,074	19,790	853	4,297	159	19,544	554	2,572	1,007	1,215	42,666	141,731	24,838	162	109,613	552	2,474	0	0	85	4,069	141,792	-61	-0.04
Dec. 1981	42,129	21,607	1,310	2,574	0	15,358	838	2,658	1,040	1,249	43,575	132,339	20,398	197	105,177	0	2,407	0	0	0	4,000	132,179	161	0.12
Jan. 1982	36,119	21,237	823	4,704	0	13,986	403	2,658	1,040	1,248	42,953	125,171	17,063	220	101,216	0	2,490	0	0	0	3,852	124,842	329	0.26
Feb. 1982	31,626	18,277	419	4,172	0	15,576	412	2,400	940	1,128	38,247	113,197	12,870	197	93,495	0	2,310	0	0	0	4,039	112,911	286	0.25
Mar. 1982	34,596	20,273	1,701	3,909	0	15,251	898	2,658	1,040	1,249	41,711	123,285	11,268	207	101,954	0	2,558	0	0	0	6,992	122,980	306	0.25
Apr. 1982	23,536	19,540	2,651	26,083	1,035	18,518	644	2,572	1,007	1,209	39,905	136,701	17,073	193	103,889	3,533	3,338	0	150	397	8,043	136,617	83	0.06
May 1982	5,304	35,549	27,566	54,836	6,752	36,747	413	2,658	1,040	1,247	41,086	213,199	68,286	214	106,275	22,839	3,885	0	747	429	10,612	213,288	-89	-0.04
Jun. 1982	13,964	32,888	26,698	59,482	12,557	50,326	951	2,572	1,007	1,206	40,074	241,724	68,584	229	110,740	42,279	4,446	0	1,607	842	13,180	241,907	-184	-0.08
Jul. 1982	38,053	30,422	19,897	110,983	29,689	71,280	869	2,658	1,040	1,245	42,385	348,522	96,446	230	127,985	99,200	5,681	0	2,432	1,475	15,127	348,575	-53	-0.02
Aug. 1982	47,694	24,868	11,792	99,268	35,366	70,806	1,062	2,658	1,040	1,245	43,604	339,403	50,509	145	148,546	117,610	5,135	0	3,345	2,145	11,850	339,284	119	0.04
Sep. 1982	27,906	26,876	15,829	47,646	20,084	45,144	2,548	2,572	1,007	1,204	43,159	233,976	21,899	118	128,262	67,601	4,229	0	1,266	1,275	9,282	233,931	45	0.02
Oct. 1982	46,211	21,978	6,370	16,064	3,599	34,200	3,920	2,658	1,040	1,245	44,908	182,193	27,409	145	130,777	12,340	3,339	0	468	865	6,973	182,315	-122	-0.07
Nov. 1982	46,101	19,847	2,410	3,760	0	19,341	6,804	2,572	1,007	1,206	43,208	146,255	24,372	163	115,071	0	2,462	0	0	0	4,234	146,302	-46	-0.03
Dec. 1982	40,045	26,865	2,858	5,170	0	8,983	2,485	2,658	1,040	1,246	44,142	135,493	24,946	257	103,202	0	2,420	0	0	0	4,549	135,375	118	0.09
Jan. 1983	37,856	23,700	199	7,562	0	7,211	1,917	2,658	1,040	1,247	43,512	126,902	18,174	287	101,450	0	2,489	0	0	0	4,395	126,795	106	0.08
Feb. 1983	32,857	19,974	404	6,134	0	8,189	5,709	2,400	940	1,127	38,734	116,469	17,059	260	92,175	0	2,307	0	0	0	4,602	116,402	67	0.06
Mar. 1983	19,663	30,760	11,271	5,466	0	17,862	7,047	2,658	1,040	1,246	42,209	139,222	34,435	303	93,440	0	2,513	0	0	0	8,604	139,294	-72	-0.05
Apr. 1983	9,501	47,471	21,141	6,448	4	12,778	7,665	2,572	1,007	1,205	40,380	150,173	56,783	383	78,200	10	3,108	0	0	1	12,140	150,624	-451	-0.30
May 1983	4,144	69,664	30,102	23,143	85	16,959	9,516	2,658	1,040	1,235	41,428	199,975	101,302	531	76,399	296	3,833	0	9	13	18,121	200,504	-529	-0.26
Jun. 1983	5,195	80,726	27,483	46,645	5,391	30,476	6,011	2,572	1,007	1,194	39,963	246,661	118,323	663	81,526	17,379	4,340	0	422	569	24,088	247,310	-648	-0.26
Jul. 1983	61,431	31,901	15,135	112,861	36,092	80,883	2,426	2,658	1,040	1,233	41,876	387,535	94,910	364	138,077	119,867	5,656	0	3,280	2,167	23,278	387,599	-65	-0.02

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Aug. 1983	66,020	26,174	15,351	98,344	37,149	76,947	2,934	2,658	1,040	1,232	43,084	370,932	54,669	197	166,025	122,511	5,158	0	4,058	2,415	15,933	370,966	-34	-0.01
Sep. 1983	74,217	17,895	1,959	52,049	25,059	42,722	1,865	2,572	1,007	1,194	42,814	263,352	10,346	162	149,120	83,654	4,312	0	2,421	2,330	10,961	263,306	47	0.02
Oct. 1983	61,848	19,216	2,265	20,207	3,037	19,686	5,944	2,658	1,040	1,234	44,664	181,801	21,002	218	137,225	10,539	3,429	0	42	863	8,188	181,507	294	0.16
Nov. 1983	48,504	22,581	6,500	5,043	2	11,275	7,178	2,572	1,007	1,195	43,027	148,882	22,577	252	118,332	7	2,495	0	0	0	5,034	148,697	185	0.12
Dec. 1983	51,371	22,219	1,853	933	0	6,695	3,541	2,658	1,040	1,235	43,971	135,517	15,624	289	111,912	0	2,450	0	0	0	4,941	135,217	300	0.22
Jan. 1984	47,377	22,266	1,186	636	0	2,533	2,655	2,658	1,040	1,236	43,351	124,939	11,522	307	105,548	0	2,524	0	0	0	4,712	124,614	325	0.26
Feb. 1984	36,319	21,881	2,612	1,411	0	6,027	2,796	2,486	973	1,157	39,968	115,629	11,110	292	96,061	0	2,422	0	0	0	5,208	115,093	536	0.46
Mar. 1984	35,698	22,709	5,571	3,248	0	18,096	3,359	2,658	1,040	1,237	42,031	135,647	14,990	281	109,441	0	2,553	0	0	0	8,326	135,592	55	0.04
Apr. 1984	14,108	41,098	21,005	3,191	5	17,271	4,980	2,572	1,007	1,196	40,157	146,590	46,008	349	85,606	13	3,161	0	0	1	11,693	146,830	-241	-0.16
May 1984	6,927	47,154	11,384	30,983	4,753	35,526	7,966	2,658	1,040	1,235	41,223	190,849	68,848	439	84,899	15,529	4,053	0	325	527	16,815	191,435	-587	-0.31
Jun. 1984	37,348	30,507	14,577	74,936	23,754	61,475	3,558	2,572	1,007	1,195	40,118	291,048	67,742	339	114,458	80,898	4,504	0	2,952	1,857	18,360	291,111	-62	-0.02
Jul. 1984	76,369	22,744	12,593	126,191	41,893	95,147	1,105	2,658	1,040	1,235	42,511	423,484	90,187	126	166,716	138,887	5,710	0	3,670	2,074	16,169	423,539	-55	-0.01
Aug. 1984	32,236	36,208	16,969	98,264	32,022	74,681	2,769	2,658	1,040	1,234	43,820	341,902	69,334	147	138,522	108,177	5,089	0	3,350	1,834	15,719	342,171	-269	-0.08
Sep. 1984	53,617	22,823	3,710	50,454	22,478	36,283	2,436	2,572	1,007	1,195	43,404	239,979	10,443	175	132,519	76,821	4,294	0	2,323	1,674	11,385	239,634	345	0.14
Oct. 1984	37,747	37,855	22,332	9,736	1,108	14,342	5,396	2,658	1,040	1,234	45,162	178,610	45,649	289	115,771	3,740	3,301	0	29	122	9,780	178,682	-72	-0.04
Nov. 1984	54,415	21,003	430	3,814	0	9,748	6,246	2,572	1,007	1,196	43,445	143,875	18,947	291	116,345	0	2,414	0	0	0	5,608	143,605	271	0.19
Dec. 1984	56,205	19,527	1,402	4,650	0	15,017	2,897	2,658	1,040	1,236	44,349	148,983	17,291	287	123,954	0	2,371	0	0	0	4,899	148,803	180	0.12
Jan. 1985	44,856	21,568	2,222	5,026	0	10,848	1,727	2,658	1,040	1,215	43,726	134,886	13,623	298	113,648	0	2,436	0	0	0	4,633	134,639	247	0.18
Feb. 1985	35,678	19,733	1,100	6,512	0	10,480	1,525	2,400	940	1,098	38,911	118,378	12,323	273	98,170	0	2,239	0	0	0	4,930	117,936	442	0.37
Mar. 1985	46,938	19,384	1,497	2,349	2	24,651	6,154	2,658	1,040	1,216	42,358	148,247	15,288	244	122,342	5	2,508	0	0	1	7,802	148,190	57	0.04
Apr. 1985	10,963	27,937	15,478	25,351	2,151	30,635	7,131	2,572	1,007	1,171	40,529	164,924	36,453	245	107,145	7,630	3,306	0	319	374	9,576	165,049	-124	-0.08
May 1985	19,275	36,680	14,652	43,463	14,567	38,322	7,527	2,658	1,040	1,207	41,825	221,216	46,709	318	100,790	51,176	4,015	0	2,815	1,819	13,693	221,335	-119	-0.05
Jun. 1985	31,888	27,299	14,213	100,398	23,933	70,597	3,725	2,572	1,007	1,168	41,064	317,862	84,363	274	126,276	83,040	4,711	0	2,612	1,305	15,368	317,950	-87	-0.03
Jul. 1985	34,836	32,438	27,893	104,001	28,332	71,156	1,340	2,658	1,040	1,205	43,563	348,461	70,524	171	154,655	97,405	5,837	0	2,739	1,563	15,666	348,562	-101	-0.03
Aug. 1985	70,943	19,533	2,988	105,373	41,021	70,615	2,483	2,658	1,040	1,202	44,554	362,411	41,677	69	161,208	136,323	5,230	0	3,652	2,098	12,032	362,289	121	0.03
Sep. 1985	30,307	28,432	15,142	44,171	10,329	34,426	4,395	2,572	1,007	1,163	43,798	215,742	32,364	158	130,477	36,963	4,223	0	859	864	9,923	215,831	-89	-0.04
Oct. 1985	47,669	23,755	5,549	11,811	1,472	22,615	9,386	2,658	1,040	1,202	45,366	172,523	31,284	207	124,481	5,152	3,328	0	0	319	7,820	172,592	-68	-0.04
Nov. 1985	44,013	23,053	4,603	3,149	0	15,038	6,352	2,572	1,007	1,164	43,534	144,484	23,591	233	113,273	0	2,479	0	0	0	4,830	144,407	77	0.05
Dec. 1985	43,230	24,138	2,632	5,409	0	6,667	3,044	2,658	1,040	1,202	44,462	134,483	19,231	279	107,585	0	2,435	0	0	0	4,821	134,351	132	0.10
Jan. 1986	45,564	22,015	463	2,480	0	6,061	2,244	2,658	1,040	1,201	43,826	127,551	13,154	288	106,785	0	2,526	0	0	0	4,501	127,253	298	0.23
Feb. 1986	38,366	18,586	1,505	3,309	0	13,619	1,645	2,400	940	1,085	39,003	120,460	12,279	238	100,859	0	2,350	0	0	0	4,531	120,258	202	0.17

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Mar. 1986	37,834	20,078	1,509	5,868	20	22,642	9,236	2,658	1,040	1,202	42,511	144,597	17,004	239	116,773	63	2,709	0	0	2	7,618	144,408	189	0.13
Apr. 1986	15,245	36,818	17,212	8,521	1,480	16,539	6,997	2,572	1,007	1,162	40,677	148,231	38,753	302	89,958	5,098	3,301	0	73	130	10,648	148,263	-32	-0.02
May 1986	22,207	24,944	14,779	62,811	9,373	51,254	5,224	2,658	1,040	1,200	42,014	237,504	53,850	228	134,197	32,535	4,156	0	793	548	11,266	237,573	-68	-0.03
Jun. 1986	29,211	40,843	14,562	82,669	23,297	59,387	6,744	2,572	1,007	1,155	41,193	302,641	88,546	319	104,098	82,317	4,671	0	3,597	1,923	17,228	302,699	-59	-0.02
Jul. 1986	61,331	23,332	10,556	129,406	36,727	86,138	1,191	2,658	1,040	1,190	43,665	397,236	79,295	137	166,199	125,263	5,953	0	3,399	1,988	15,036	397,268	-32	-0.01
Aug. 1986	57,669	23,081	7,622	99,221	37,122	64,135	1,369	2,658	1,040	1,191	44,796	339,905	35,610	114	156,098	124,608	5,350	0	3,636	1,991	12,256	339,664	241	0.07
Sep. 1986	46,885	25,004	6,805	48,315	19,422	32,315	3,372	2,572	1,007	1,153	44,077	230,927	13,930	188	131,349	67,690	4,406	0	1,914	1,364	9,894	230,736	191	0.08
Oct. 1986	42,673	27,803	12,340	13,326	3,103	18,805	6,450	2,658	1,040	1,191	45,662	175,052	27,051	218	124,360	11,097	3,421	0	406	672	7,781	175,006	46	0.03
Nov. 1986	46,050	21,389	2,962	3,852	0	19,923	6,029	2,572	1,007	1,153	43,892	148,829	25,464	214	115,918	0	2,489	0	0	0	4,642	148,727	101	0.07
Dec. 1986	43,358	22,654	1,566	5,665	0	15,369	3,230	2,658	1,040	1,192	44,859	141,592	20,795	258	113,436	0	2,435	0	0	0	4,549	141,472	119	0.08
Jan. 1987	37,532	22,432	1,295	7,069	0	12,708	2,529	2,658	1,040	1,187	44,226	132,677	15,426	271	109,828	0	2,517	0	0	0	4,305	132,347	330	0.25
Feb. 1987	28,816	21,442	4,580	4,488	0	13,932	5,557	2,400	940	1,072	39,371	122,598	16,153	242	99,059	0	2,349	0	0	0	4,546	122,348	249	0.20
Mar. 1987	29,103	27,301	4,195	3,682	0	10,754	9,677	2,658	1,040	1,187	42,913	132,510	19,313	307	101,443	0	2,569	0	0	0	8,571	132,203	307	0.23
Apr. 1987	20,020	26,207	6,107	9,568	702	24,479	10,520	2,572	1,007	1,149	41,071	143,402	25,860	290	101,005	2,690	3,306	0	63	68	10,130	143,412	-10	-0.01
May 1987	3,517	57,005	39,588	43,731	4,475	38,232	5,629	2,658	1,040	1,184	42,355	239,414	108,072	421	94,524	15,974	4,094	0	586	276	15,976	239,923	-509	-0.21
Jun. 1987	39,741	31,833	18,261	67,369	24,906	56,901	4,518	2,572	1,007	1,146	41,305	289,558	54,573	349	120,442	87,135	4,735	0	4,178	1,354	16,895	289,660	-103	-0.04
Jul. 1987	90,093	23,296	11,129	98,185	44,415	64,424	923	2,658	1,040	1,184	43,362	380,709	45,399	185	156,779	150,710	6,265	0	4,904	1,646	14,802	380,691	18	0.00
Aug. 1987	34,925	28,666	14,371	89,655	28,197	54,732	1,427	2,658	1,040	1,184	44,057	300,912	40,223	180	139,853	97,796	5,320	0	3,414	1,139	12,936	300,861	51	0.02
Sep. 1987	50,989	22,219	5,539	38,360	17,097	30,942	3,773	2,572	1,007	1,146	43,178	216,822	7,294	185	130,673	61,186	4,361	0	2,296	982	9,613	216,590	231	0.11
Oct. 1987	43,563	21,553	5,324	19,073	3,551	27,927	7,595	2,658	1,040	1,185	44,678	178,146	21,539	176	131,256	13,157	3,500	0	595	633	7,167	178,022	124	0.07
Nov. 1987	41,295	21,843	4,889	3,740	0	22,917	8,814	2,572	1,007	1,147	42,942	151,167	25,162	202	118,986	6	2,483	0	0	0	4,351	151,190	-23	-0.02
Dec. 1987	40,429	24,368	3,082	1,815	0	12,638	3,754	2,658	1,040	1,186	43,940	134,911	19,485	252	108,175	0	2,448	0	0	0	4,417	134,778	133	0.10
Jan. 1988	44,388	25,349	2,061	1,510	0	2,283	789	2,658	1,040	1,187	43,398	124,663	17,505	299	99,705	0	2,515	0	0	0	4,432	124,456	207	0.17
Feb. 1988	32,305	23,122	1,389	3,370	0	6,912	1,128	2,486	973	1,111	40,093	112,890	12,768	291	91,986	0	2,447	0	0	0	4,970	112,461	428	0.38
Mar. 1988	32,943	23,218	4,597	2,320	0	19,597	7,095	2,658	1,040	1,188	42,250	136,906	17,667	277	108,291	0	2,575	0	0	0	7,930	136,740	166	0.12
Apr. 1988	21,235	22,082	5,195	14,570	152	27,934	10,630	2,572	1,007	1,150	40,460	146,987	25,168	238	108,558	603	3,305	0	18	17	9,012	146,918	68	0.05
May 1988	3,005	38,006	33,287	48,621	3,961	43,145	5,832	2,658	1,040	1,186	41,759	222,500	79,926	293	111,432	14,327	4,194	0	278	158	12,156	222,765	-265	-0.12
Jun. 1988	56,876	24,904	10,113	86,678	33,633	65,361	5,790	2,572	1,007	1,147	40,937	329,016	65,481	196	124,827	114,767	4,713	0	4,203	1,203	13,575	328,965	50	0.02
Jul. 1988	66,875	25,263	12,381	97,586	41,031	62,330	1,257	2,658	1,040	1,186	43,323	354,931	49,092	194	140,216	139,665	6,096	0	3,968	1,291	14,331	354,853	78	0.02
Aug. 1988	54,044	25,116	10,092	97,425	38,677	59,610	1,081	2,658	1,040	1,186	44,186	335,115	43,630	106	138,927	129,864	5,369	0	3,772	1,157	12,059	334,884	231	0.07
Sep. 1988	41,156	23,568	10,514	45,550	17,232	38,928	1,615	2,572	1,007	1,148	43,351	226,639	14,144	124	135,321	61,026	4,403	0	1,859	757	8,835	226,467	172	0.08

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Oct. 1988	56,582	19,073	441	21,957	8,171	27,644	905	2,658	1,040	1,187	44,938	184,596	11,934	142	129,586	29,899	3,581	0	1,705	941	6,678	184,465	130	0.07
Nov. 1988	48,159	20,912	845	3,948	67	18,302	1,916	2,572	1,007	1,150	43,203	142,079	24,252	166	110,508	249	2,567	0	0	12	4,185	141,939	141	0.10
Dec. 1988	39,843	25,689	2,614	2,278	0	11,917	4,511	2,658	1,040	1,188	44,200	135,939	24,854	236	103,905	0	2,482	0	0	0	4,339	135,817	122	0.09
Jan. 1989	35,974	24,583	3,063	2,902	0	10,124	2,943	2,658	1,040	1,188	43,632	128,106	18,166	261	102,670	0	2,562	0	0	0	4,167	127,826	280	0.22
Feb. 1989	30,521	20,926	1,889	2,087	0	10,801	3,965	2,400	940	1,074	38,915	113,518	13,517	240	92,619	0	2,372	0	0	0	4,440	113,188	330	0.29
Mar. 1989	36,454	20,552	1,517	1,314	0	18,957	8,520	2,658	1,040	1,189	42,481	134,681	15,715	236	108,570	0	2,620	0	0	0	7,403	134,543	139	0.10
Apr. 1989	22,750	22,234	6,157	23,575	2,892	22,940	3,459	2,572	1,007	1,151	40,681	149,417	18,674	211	108,087	10,424	3,315	0	162	111	8,409	149,394	23	0.02
May 1989	24,591	27,406	13,883	73,860	13,578	43,871	909	2,658	1,040	1,190	42,034	245,021	59,609	202	118,755	49,172	4,001	0	2,019	565	10,545	244,869	153	0.06
Jun. 1989	19,720	29,971	23,466	58,038	16,193	53,106	2,285	2,572	1,007	1,151	41,054	248,564	47,176	184	121,548	59,275	4,458	0	2,839	736	12,516	248,731	-167	-0.07
Jul. 1989	44,906	32,828	19,646	108,059	35,959	59,741	783	2,658	1,040	1,188	43,218	350,027	74,199	89	131,423	119,382	5,890	0	3,016	1,249	14,713	349,960	66	0.02
Aug. 1989	40,391	26,217	15,098	83,319	28,808	54,477	405	2,658	1,040	1,189	44,112	297,715	34,483	78	141,995	100,227	5,158	0	3,048	982	11,705	297,675	39	0.01
Sep. 1989	31,534	25,970	15,079	35,041	13,416	36,425	7,191	2,572	1,007	1,150	43,316	212,701	21,057	95	128,309	48,088	4,348	0	1,333	667	8,823	212,722	-21	-0.01
Oct. 1989	38,715	23,087	4,143	19,304	5,125	25,441	11,420	2,658	1,040	1,189	44,864	176,986	24,357	137	121,342	19,119	3,462	0	887	665	7,020	176,990	-4	0.00
Nov. 1989	50,769	18,632	386	2,562	58	19,501	2,269	2,572	1,007	1,152	43,125	142,031	19,591	145	115,389	210	2,520	0	0	6	4,142	142,003	28	0.02
Dec. 1989	41,854	22,379	1,544	2,368	0	13,947	527	2,658	1,040	1,191	44,101	131,608	17,162	195	107,537	0	2,433	0	0	0	4,122	131,449	160	0.12
Jan. 1990	34,658	23,585	2,927	3,006	0	13,716	4,807	2,658	1,040	1,191	43,523	131,110	19,284	226	104,978	0	2,544	0	0	0	3,997	131,029	82	0.06
Feb. 1990	29,390	20,857	946	2,387	0	10,980	5,752	2,400	940	1,076	38,817	113,546	14,985	218	91,369	0	2,399	0	0	0	4,329	113,299	247	0.22
Mar. 1990	19,306	30,197	11,243	2,545	0	17,653	14,142	2,658	1,040	1,190	42,412	142,386	33,309	266	98,074	0	2,654	0	0	0	8,142	142,444	-59	-0.04
Apr. 1990	15,172	25,828	6,745	12,562	431	21,365	8,512	2,572	1,007	1,152	40,696	136,041	24,380	254	97,338	1,484	3,215	0	5	8	9,540	136,223	-182	-0.13
May 1990	15,129	26,434	14,685	65,414	5,640	40,591	1,333	2,658	1,040	1,190	42,027	216,141	57,665	226	122,060	20,624	4,069	0	246	155	10,999	216,044	98	0.05
Jun. 1990	68,211	20,845	4,449	75,637	33,753	62,644	4,092	2,572	1,007	1,152	41,061	315,423	48,885	157	123,850	119,368	4,515	0	4,378	1,403	12,642	315,197	226	0.07
Jul. 1990	31,872	33,223	24,202	95,486	24,721	57,229	957	2,658	1,040	1,190	43,331	315,908	70,397	126	131,261	89,145	5,566	0	3,315	1,164	14,936	315,909	-2	0.00
Aug. 1990	33,187	28,443	16,805	94,944	26,747	51,642	1,394	2,658	1,040	1,189	44,190	302,239	44,758	89	141,949	94,237	4,973	0	2,847	1,024	12,366	302,241	-1	0.00
Sep. 1990	43,135	24,231	11,945	51,983	24,843	39,478	3,062	2,572	1,007	1,151	43,412	246,819	10,874	85	132,495	86,984	4,262	0	1,979	906	9,191	246,776	42	0.02
Oct. 1990	44,105	23,112	6,496	14,209	3,763	26,943	11,120	2,658	1,040	1,189	45,045	179,681	26,894	141	126,808	14,421	3,365	0	505	571	7,095	179,798	-117	-0.07
Nov. 1990	46,255	21,163	3,993	3,322	24	22,264	4,564	2,572	1,007	1,151	43,323	149,637	27,717	167	114,850	110	2,492	0	0	6	4,323	149,664	-27	-0.02
Dec. 1990	46,849	21,238	569	1,491	0	13,914	892	2,658	1,040	1,194	44,353	134,198	18,126	214	108,918	0	2,515	0	0	0	4,257	134,030	168	0.13
Jan. 1991	39,154	22,791	1,195	2,179	0	8,720	4,063	2,658	1,040	1,195	43,803	126,797	18,654	244	100,978	0	2,585	0	0	0	4,171	126,632	164	0.13
Feb. 1991	35,240	18,123	179	903	0	13,727	7,347	2,400	940	1,080	39,076	119,015	14,512	217	97,484	0	2,342	0	0	0	4,324	118,879	135	0.11
Mar. 1991	31,240	21,163	2,403	3,308	0	18,532	14,990	2,658	1,040	1,196	42,670	139,201	20,213	235	108,695	0	2,610	0	0	0	7,433	139,185	16	0.01
Apr. 1991	17,785	23,312	7,755	29,310	2,156	21,903	3,428	2,572	1,007	1,157	40,838	151,224	24,982	206	105,150	8,383	3,284	0	260	251	8,594	151,109	115	0.08

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
May 1991	20,365	28,351	18,360	60,031	11,538	40,381	565	2,658	1,040	1,195	42,093	226,578	50,831	219	114,985	43,181	4,133	0	1,736	604	10,800	226,489	88	0.04
Jun. 1991	32,166	34,688	19,842	60,866	23,709	59,679	8,299	2,572	1,007	1,156	41,039	285,023	67,633	229	106,947	86,551	4,603	0	3,773	1,018	14,341	285,096	-73	-0.03
Jul. 1991	37,498	34,058	23,667	104,038	30,719	64,073	619	2,658	1,040	1,192	43,248	342,810	73,069	43	140,267	105,073	5,869	0	2,640	1,019	14,844	342,823	-13	0.00
Aug. 1991	38,998	27,160	14,264	96,579	30,879	60,097	1,238	2,658	1,040	1,192	44,163	318,267	45,672	13	144,411	106,650	5,254	0	2,883	966	12,317	318,165	102	0.03
Sep. 1991	40,501	23,047	8,261	45,706	18,018	35,689	7,310	2,572	1,007	1,154	43,411	226,678	14,386	84	131,450	64,338	4,418	0	1,859	892	9,297	226,725	-47	-0.02
Oct. 1991	48,389	21,584	4,929	14,464	5,116	20,470	13,479	2,658	1,040	1,194	45,071	178,394	21,446	132	125,050	19,538	3,488	0	1,018	579	7,179	178,429	-35	-0.02
Nov. 1991	46,023	21,694	6,710	3,576	0	24,350	1,289	2,572	1,007	1,155	43,408	151,784	27,073	134	117,600	0	2,640	0	0	0	4,272	151,719	65	0.04
Dec. 1991	43,101	19,553	393	3,906	0	20,882	5,638	2,658	1,040	1,194	44,470	142,837	19,998	169	115,963	0	2,514	0	0	0	4,107	142,751	86	0.06
Jan. 1992	35,514	25,142	3,374	4,297	0	9,800	4,477	2,658	1,040	1,195	43,931	131,428	22,586	232	101,693	0	2,587	0	0	0	4,214	131,312	116	0.09
Feb. 1992	32,902	20,544	365	2,902	0	10,754	7,085	2,486	973	1,119	40,607	119,738	15,857	232	96,221	0	2,490	0	0	0	4,663	119,463	275	0.23
Mar. 1992	20,028	30,930	11,597	1,308	0	16,668	13,492	2,658	1,040	1,195	42,857	141,773	33,275	277	97,154	0	2,601	0	0	0	8,523	141,830	-57	-0.04
Apr. 1992	24,442	21,661	5,124	15,556	4,327	25,097	11,465	2,572	1,007	1,156	41,089	153,496	15,634	225	107,012	16,584	3,333	0	896	560	9,220	153,464	31	0.02
May 1992	48,800	21,199	6,534	72,166	19,553	47,917	406	2,658	1,040	1,195	42,498	263,966	47,244	195	126,437	71,750	4,101	0	2,638	797	10,685	263,846	119	0.05
Jun. 1992	27,316	28,888	25,993	61,342	17,632	52,016	1,757	2,572	1,007	1,156	41,585	261,264	47,664	212	125,904	66,543	4,487	0	2,929	866	12,818	261,423	-159	-0.06
Jul. 1992	44,238	27,859	17,751	93,134	28,942	57,262	1,116	2,658	1,040	1,193	43,776	318,971	51,693	209	140,434	103,182	5,725	0	2,757	1,023	13,856	318,878	93	0.03
Aug. 1992	18,313	32,616	22,971	88,653	21,782	51,272	5,069	2,658	1,040	1,193	44,537	290,104	60,386	180	133,811	75,868	5,106	0	1,607	670	12,581	290,209	-106	-0.04
Sep. 1992	52,871	18,083	1,610	46,290	18,029	33,510	6,773	2,572	1,007	1,155	43,616	225,516	10,743	126	132,991	64,523	4,366	0	2,541	1,153	9,019	225,461	55	0.02
Oct. 1992	39,097	20,856	4,018	23,649	3,891	23,367	13,084	2,658	1,040	1,197	45,132	177,990	22,842	180	128,545	14,776	3,459	0	521	606	7,012	177,940	50	0.03
Nov. 1992	39,729	20,718	4,340	4,572	0	21,666	9,577	2,572	1,007	1,160	43,404	148,744	26,642	184	115,140	0	2,478	0	0	0	4,261	148,706	39	0.03
Dec. 1992	42,955	23,250	1,852	2,872	0	10,288	3,588	2,658	1,040	1,199	44,457	134,160	22,637	249	104,282	0	2,482	0	0	0	4,386	134,036	124	0.09
Jan. 1993	40,282	22,066	1,146	1,952	0	7,697	3,484	2,658	1,040	1,200	43,901	125,426	17,457	269	100,627	0	2,697	0	0	0	4,214	125,264	162	0.13
Feb. 1993	30,111	19,990	3,308	2,354	0	11,040	3,900	2,400	940	1,084	39,179	114,306	14,648	238	92,078	0	2,582	0	0	0	4,435	113,981	325	0.28
Mar. 1993	33,108	22,036	2,491	1,111	0	14,061	7,770	2,658	1,040	1,200	42,796	128,271	16,489	268	100,753	0	2,594	0	0	0	7,820	127,924	347	0.27
Apr. 1993	13,529	28,806	14,171	7,842	17	21,087	15,017	2,572	1,007	1,161	40,992	146,201	31,647	254	101,585	55	3,405	0	4	4	9,255	146,211	-10	-0.01
May 1993	22,946	23,896	11,871	63,434	8,638	45,804	480	2,658	1,040	1,199	42,319	224,286	54,517	224	122,159	31,734	4,216	0	438	195	10,708	224,190	95	0.04
Jun. 1993	26,049	29,206	19,731	70,102	18,804	61,820	5,002	2,572	1,007	1,159	41,334	276,785	65,430	205	121,339	69,304	4,571	0	2,324	664	13,038	276,876	-91	-0.03
Jul. 1993	52,671	26,633	11,833	114,281	33,455	69,207	564	2,658	1,040	1,198	43,688	357,226	69,249	118	143,542	119,612	5,891	0	3,324	1,340	14,115	357,189	37	0.01
Aug. 1993	41,788	24,975	11,993	100,863	28,079	53,535	992	2,658	1,040	1,197	44,790	311,910	48,237	108	146,097	96,998	5,315	0	2,325	965	11,843	311,888	22	0.01
Sep. 1993	29,809	28,669	14,087	41,428	13,226	29,359	10,012	2,572	1,007	1,159	44,110	215,438	27,638	162	123,903	47,925	4,429	0	1,134	589	9,679	215,459	-22	-0.01
Oct. 1993	33,003	28,517	14,570	12,797	1,818	18,427	11,597	2,658	1,040	1,197	45,785	171,410	31,248	216	121,511	6,961	3,728	0	121	193	7,557	171,534	-124	-0.07
Nov. 1993	41,874	20,859	4,182	4,253	0	27,811	5,992	2,572	1,007	1,159	44,028	153,736	30,792	200	115,602	0	2,683	0	0	0	4,446	153,724	12	0.01

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Dec. 1993	42,454	20,022	985	5,953	0	19,350	2,594	2,658	1,040	1,198	45,028	141,282	18,445	229	115,768	0	2,474	0	0	0	4,242	141,158	124	0.09
Jan. 1994	39,773	22,153	2,129	2,691	0	11,733	4,395	2,658	1,040	1,199	44,428	132,199	16,896	254	108,066	0	2,717	0	0	0	4,095	132,027	172	0.13
Feb. 1994	33,907	20,303	1,375	977	0	11,103	4,136	2,400	940	1,084	39,627	115,851	14,690	238	93,951	0	2,169	0	0	0	4,422	115,470	381	0.33
Mar. 1994	30,352	20,986	1,479	7,617	0	21,797	9,408	2,658	1,040	1,200	43,264	139,802	21,054	246	108,642	0	2,290	0	0	0	7,539	139,771	31	0.02
Apr. 1994	12,407	27,267	12,009	27,067	551	26,923	5,920	2,572	1,007	1,161	41,441	158,324	38,139	226	105,410	2,273	3,350	0	87	62	8,923	158,470	-146	-0.09
May 1994	33,445	23,783	7,870	71,625	16,416	53,237	783	2,658	1,040	1,199	42,805	254,861	55,150	196	121,721	60,875	3,780	0	1,731	624	10,733	254,809	52	0.02
Jun. 1994	61,891	24,797	8,868	87,486	35,255	61,712	623	2,572	1,007	1,161	41,832	327,203	53,858	144	121,835	126,977	4,405	0	5,343	1,504	12,886	326,954	249	0.08
Jul. 1994	72,744	23,851	9,179	91,777	38,898	51,409	567	2,658	1,040	1,200	44,068	337,392	37,308	51	139,101	135,822	5,964	0	3,854	1,338	13,533	336,971	420	0.12
Aug. 1994	72,991	27,256	11,096	70,733	43,561	43,478	341	2,658	1,040	1,199	44,788	319,142	19,020	-43	128,877	148,759	5,351	0	3,903	1,219	11,407	318,492	650	0.20
Sep. 1994	62,569	21,413	4,319	43,068	25,632	31,050	989	2,572	1,007	1,161	43,737	237,518	7,431	-20	120,840	91,797	4,805	0	2,763	1,269	8,436	237,321	197	0.08
Oct. 1994	34,050	33,532	17,531	13,018	4,117	20,315	17,577	2,658	1,040	1,199	45,204	190,242	47,179	101	115,079	15,848	3,794	0	816	510	7,070	190,395	-153	-0.08
Nov. 1994	47,994	20,121	2,413	3,624	0	19,234	2,431	2,572	1,007	1,161	43,423	143,980	26,457	106	110,627	0	2,637	0	0	0	4,112	143,939	41	0.03
Dec. 1994	44,776	20,055	1,359	3,143	0	20,945	523	2,658	1,040	1,201	44,419	140,119	21,310	137	112,173	0	2,547	0	0	0	3,890	140,058	62	0.04
Jan. 1995	38,355	20,434	1,041	2,398	0	17,388	616	2,658	1,040	1,164	43,837	128,930	16,171	152	106,089	0	2,684	0	0	0	3,684	128,782	148	0.12
Feb. 1995	31,954	19,705	2,156	936	0	14,298	611	2,400	940	1,051	39,106	113,157	13,496	151	92,817	0	2,447	0	0	0	3,956	112,867	290	0.26
Mar. 1995	33,230	20,833	1,645	2,458	0	17,084	2,286	2,658	1,040	1,164	42,719	125,118	14,026	165	101,040	0	2,736	0	0	0	6,898	124,865	253	0.20
Apr. 1995	10,387	31,467	17,522	16,423	0	21,838	14,188	2,572	1,007	1,126	40,931	157,462	45,388	193	100,171	0	3,315	0	0	0	8,564	157,630	-168	-0.11
May 1995	1,330	58,674	34,870	29,519	357	38,421	18,854	2,658	1,040	1,161	42,199	229,084	122,382	329	86,507	1,311	4,218	0	2	7	14,472	229,229	-145	-0.06
Jun. 1995	4,855	93,759	33,887	29,931	6,824	29,668	13,581	2,572	1,007	1,121	40,899	258,104	126,143	568	76,457	26,317	4,994	0	1,235	418	22,655	258,786	-682	-0.26
Jul. 1995	58,853	34,557	9,489	93,093	35,436	78,075	6,692	2,658	1,040	1,159	42,801	363,852	80,282	380	121,493	127,496	6,158	0	4,383	1,549	22,185	363,927	-75	-0.02
Aug. 1995	100,508	19,330	4,914	111,856	42,421	74,871	1,522	2,658	1,040	1,160	43,780	404,061	53,086	136	180,623	146,107	5,432	0	4,294	1,568	12,841	404,087	-26	-0.01
Sep. 1995	22,732	27,995	18,735	63,422	13,365	45,190	7,579	2,572	1,007	1,117	43,410	247,125	41,268	180	141,885	47,613	4,435	0	964	542	10,313	247,199	-74	-0.03
Oct. 1995	57,905	21,159	3,844	10,588	4,125	21,382	11,225	2,658	1,040	1,155	45,380	180,463	21,659	210	131,186	15,106	3,327	0	476	618	7,837	180,419	43	0.02
Nov. 1995	54,804	19,036	2,404	1,192	62	18,287	8,435	2,572	1,007	1,118	43,794	152,712	20,824	211	124,580	191	2,370	0	0	11	4,479	152,666	46	0.03
Dec. 1995	47,204	19,889	356	1,041	0	17,909	6,035	2,658	1,040	1,157	44,854	142,143	17,980	234	117,024	0	2,400	0	0	0	4,309	141,947	196	0.14
Jan. 1996	41,184	23,035	2,206	1,310	0	9,229	5,247	2,658	1,040	1,157	44,347	131,413	18,673	263	105,311	0	2,734	0	0	0	4,257	131,237	176	0.13
Feb. 1996	35,157	20,369	408	1,832	0	9,152	4,536	2,486	973	1,083	41,035	117,031	12,010	254	97,052	0	2,641	0	0	0	4,695	116,652	379	0.32
Mar. 1996	30,040	23,469	4,436	2,394	0	16,994	9,700	2,658	1,040	1,158	43,305	135,194	16,452	264	107,957	0	2,569	0	0	0	7,802	135,045	149	0.11
Apr. 1996	17,493	21,367	5,542	31,369	1,037	28,551	6,408	2,572	1,007	1,121	41,538	158,005	27,503	222	114,220	3,879	3,380	0	131	84	8,653	158,072	-67	-0.04
May 1996	8,632	32,359	24,139	81,301	7,316	54,954	4,284	2,658	1,040	1,157	43,094	260,934	94,466	237	122,844	27,599	4,074	0	264	103	11,597	261,184	-250	-0.10
Jun. 1996	39,748	29,547	15,826	69,760	24,750	68,962	12,387	2,572	1,007	1,117	42,387	308,064	70,908	156	122,683	91,561	4,655	0	3,063	869	14,212	308,107	-43	-0.01

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Jul. 1996	41,908	30,156	20,737	108,270	29,553	72,492	1,493	2,658	1,040	1,150	44,827	354,285	67,027	69	155,533	106,555	6,518	0	2,940	1,077	14,585	354,303	-18	-0.01
Aug. 1996	48,091	24,533	11,173	97,608	30,412	60,515	1,600	2,658	1,040	1,150	45,747	324,526	38,775	97	154,736	108,674	5,386	0	3,432	1,394	11,979	324,473	54	0.02
Sep. 1996	30,438	36,139	20,110	36,678	13,956	28,693	9,190	2,572	1,007	1,112	44,954	224,850	32,192	197	124,414	50,984	4,383	0	1,402	732	10,562	224,867	-17	-0.01
Oct. 1996	54,314	21,527	3,202	10,650	6,314	26,433	11,135	2,658	1,040	1,150	46,549	184,973	18,732	200	129,951	23,430	3,560	0	670	712	7,646	184,902	71	0.04
Nov. 1996	53,742	18,357	1,201	2,933	3	23,067	8,392	2,572	1,007	1,114	44,719	157,108	23,804	181	126,158	12	2,590	0	0	0	4,357	157,101	6	0.00
Dec. 1996	46,738	21,726	263	2,308	0	11,294	6,044	2,658	1,040	1,152	45,692	138,916	18,557	231	112,719	0	2,877	0	0	0	4,358	138,741	175	0.13
Jan. 1997	42,535	23,174	2,082	1,248	0	6,946	3,448	2,658	1,040	1,153	45,087	129,370	16,152	257	106,089	0	2,469	0	0	0	4,212	129,179	192	0.15
Feb. 1997	32,812	19,842	1,947	1,545	0	11,317	6,787	2,400	940	1,042	40,223	118,855	14,137	227	97,261	0	2,425	0	0	0	4,422	118,472	383	0.32
Mar. 1997	33,667	21,814	1,533	2,618	0	15,926	12,723	2,658	1,040	1,154	43,925	137,057	16,309	248	109,706	0	2,942	0	0	0	7,718	136,923	134	0.10
Apr. 1997	12,763	25,927	11,898	25,736	8	27,502	11,414	2,572	1,007	1,116	42,125	162,068	39,963	228	109,650	31	3,085	0	1	0	9,109	162,067	1	0.00
May 1997	13,289	26,521	15,256	89,635	6,803	64,006	2,356	2,658	1,040	1,153	43,566	266,283	94,579	206	130,335	25,880	4,019	0	261	266	11,060	266,606	-323	-0.12
Jun. 1997	27,921	65,067	23,475	45,770	19,281	45,638	14,719	2,572	1,007	1,112	42,508	289,070	92,802	425	92,015	74,595	4,545	0	3,308	1,762	19,922	289,372	-302	-0.10
Jul. 1997	53,583	30,744	27,187	117,940	26,292	71,602	2,375	2,658	1,040	1,147	44,800	379,368	94,836	190	165,053	94,334	5,768	0	1,637	1,320	16,465	379,603	-236	-0.06
Aug. 1997	29,368	37,087	28,027	62,039	26,314	56,989	6,376	2,658	1,040	1,145	45,762	296,804	39,851	185	140,654	92,568	5,045	0	2,621	1,393	14,506	296,822	-18	-0.01
Sep. 1997	55,171	23,029	7,519	52,812	26,710	43,948	5,650	2,572	1,007	1,109	44,934	264,461	11,121	154	138,087	95,539	4,204	0	2,663	1,998	10,389	264,155	306	0.12
Oct. 1997	36,279	30,544	15,901	17,144	3,947	23,132	8,937	2,658	1,040	1,145	46,586	187,312	30,699	231	128,204	14,989	3,681	0	534	666	8,313	187,317	-5	0.00
Nov. 1997	48,625	22,818	2,064	2,177	0	13,987	5,764	2,572	1,007	1,109	44,861	144,985	21,320	253	115,410	1	2,834	0	0	0	5,037	144,855	129	0.09
Dec. 1997	46,279	23,184	2,028	2,079	0	10,636	5,989	2,658	1,040	1,147	45,835	140,876	18,310	281	114,833	0	2,422	0	0	0	4,821	140,666	209	0.15
Jan. 1998	45,585	23,781	548	1,335	0	4,337	3,272	2,658	1,040	1,148	45,262	128,965	14,970	311	105,751	0	3,030	0	0	0	4,689	128,750	215	0.17
Feb. 1998	37,015	19,532	1,757	1,416	0	12,422	5,742	2,400	940	1,038	40,367	122,628	13,844	265	100,747	0	2,806	0	0	0	4,782	122,444	184	0.15
Mar. 1998	29,464	24,536	3,128	2,987	0	15,220	11,795	2,658	1,040	1,149	44,041	136,019	16,748	297	106,862	0	3,152	0	0	0	8,578	135,638	381	0.28
Apr. 1998	8,914	31,369	11,269	19,104	323	28,988	17,081	2,572	1,007	1,112	42,197	163,936	48,137	315	99,838	1,098	3,742	0	18	10	11,072	164,229	-293	-0.18
May 1998	17,406	28,615	14,505	62,809	11,502	62,785	7,986	2,658	1,040	1,149	43,490	253,946	69,372	300	121,227	44,134	4,525	0	595	575	13,325	254,052	-106	-0.04
Jun. 1998	43,927	23,915	11,081	85,677	21,898	63,139	6,482	2,572	1,007	1,111	42,548	303,355	57,754	276	138,977	82,631	5,076	0	2,778	1,457	14,526	303,477	-122	-0.04
Jul. 1998	25,858	34,784	31,990	114,050	22,474	71,132	3,214	2,658	1,040	1,146	45,091	353,437	90,217	219	152,629	83,491	6,372	0	2,581	1,518	16,614	353,641	-204	-0.06
Aug. 1998	69,332	21,495	7,715	89,888	34,138	65,295	3,642	2,658	1,040	1,146	46,120	342,470	30,816	146	163,229	124,294	5,745	0	3,631	2,009	12,528	342,399	72	0.02
Sep. 1998	59,457	22,041	5,780	54,304	25,734	43,510	6,113	2,572	1,007	1,109	45,359	266,985	11,413	105	143,020	93,198	4,821	0	2,772	2,104	9,505	266,936	49	0.02
Oct. 1998	41,270	30,982	15,093	13,235	4,718	18,750	15,692	2,658	1,040	1,146	47,037	191,621	32,065	227	128,090	17,980	3,680	0	672	784	8,104	191,602	19	0.01
Nov. 1998	51,767	19,680	2,468	2,071	160	20,852	14,521	2,572	1,007	1,109	45,340	161,547	26,568	213	126,627	579	2,839	0	11	34	4,625	161,495	52	0.03
Dec. 1998	48,326	21,644	1,654	1,170	0	13,531	6,504	2,658	1,040	1,147	46,344	144,018	18,921	250	117,308	0	2,791	0	0	0	4,548	143,817	201	0.14
Jan. 1999	44,832	21,543	1,123	1,468	0	10,815	4,282	2,658	1,040	1,148	45,736	134,646	15,229	265	112,144	0	2,495	0	0	0	4,289	134,420	226	0.17

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Feb. 1999	39,329	18,794	597	1,113	0	8,821	3,804	2,400	940	1,037	40,787	117,623	11,539	242	98,838	0	2,355	0	0	0	4,497	117,471	153	0.13
Mar. 1999	36,498	19,986	1,293	6,977	0	18,956	13,273	2,658	1,040	1,149	44,524	146,354	15,900	253	119,835	0	2,625	0	0	0	7,590	146,203	151	0.10
Apr. 1999	3,243	41,499	41,961	22,660	0	29,496	14,234	2,572	1,007	1,108	42,768	200,549	82,476	289	104,677	2	3,105	0	0	0	10,318	200,867	-318	-0.16
May 1999	10,361	54,136	19,970	28,533	6,124	33,824	13,893	2,658	1,040	1,144	44,032	215,716	78,677	425	90,532	24,353	3,914	0	1,226	933	16,335	216,394	-678	-0.31
Jun. 1999	35,409	39,987	13,327	62,339	24,926	56,131	9,179	2,572	1,007	1,107	42,616	288,600	61,259	416	102,850	94,919	4,393	0	3,367	1,896	19,731	288,831	-231	-0.08
Jul. 1999	85,805	24,196	15,516	108,235	38,093	76,767	3,252	2,658	1,040	1,145	44,660	401,367	65,344	183	170,253	138,416	5,703	0	3,483	1,940	16,088	401,411	-44	-0.01
Aug. 1999	23,776	34,693	23,919	79,826	26,209	56,819	8,841	2,658	1,040	1,144	45,536	304,461	46,708	265	139,066	94,424	4,959	0	2,462	1,419	15,309	304,611	-150	-0.05
Sep. 1999	39,470	27,773	17,631	35,623	15,648	29,922	8,019	2,572	1,007	1,107	44,803	223,573	14,728	253	133,566	57,599	4,086	0	1,162	780	11,297	223,471	102	0.05
Oct. 1999	59,601	20,300	2,623	12,907	4,573	21,175	13,729	2,658	1,040	1,145	46,531	186,281	21,226	253	134,262	17,082	3,347	0	645	1,100	8,249	186,165	116	0.06
Nov. 1999	52,363	19,429	1,306	2,237	299	14,089	9,347	2,572	1,007	1,109	44,825	148,582	18,130	257	121,458	1,040	2,475	0	0	78	4,869	148,308	275	0.18
Dec. 1999	47,331	22,217	917	1,749	0	8,893	5,505	2,658	1,040	1,147	45,834	137,291	16,126	306	113,443	0	2,373	0	0	0	4,845	137,093	198	0.14
Jan. 2000	43,389	21,726	983	1,387	0	10,092	7,406	2,658	1,040	1,114	45,294	135,090	15,760	315	111,481	0	2,647	0	0	0	4,611	134,814	276	0.20
Feb. 2000	37,983	20,069	1,219	1,277	0	10,026	4,637	2,486	973	1,043	41,859	121,572	11,237	298	102,146	0	2,588	0	0	0	5,048	121,317	255	0.21
Mar. 2000	28,018	23,841	6,141	3,100	3	16,303	18,601	2,658	1,040	1,114	44,165	144,984	20,191	307	113,282	10	2,746	0	0	2	8,382	144,921	63	0.04
Apr. 2000	21,708	23,344	8,307	23,517	4,603	29,213	17,948	2,572	1,007	1,078	42,363	175,658	23,397	267	119,232	18,590	3,394	0	671	895	9,278	175,722	-64	-0.04
May 2000	36,222	26,773	14,963	62,891	16,557	50,311	4,223	2,658	1,040	1,113	43,740	260,492	49,851	227	127,521	64,883	4,183	0	1,877	886	10,942	260,370	122	0.05
Jun. 2000	72,044	22,659	6,792	86,003	35,683	58,642	957	2,572	1,007	1,077	42,780	330,218	46,238	99	129,651	131,280	4,664	0	3,808	1,765	12,462	329,967	251	0.08
Jul. 2000	89,445	28,169	9,810	85,937	51,560	51,982	803	2,658	1,040	1,102	44,936	367,442	27,246	-46	131,075	182,038	5,721	0	5,139	2,443	13,652	367,268	174	0.05
Aug. 2000	60,331	33,084	15,358	75,268	42,541	47,614	726	2,658	1,040	1,092	45,493	325,205	25,332	-90	125,782	150,836	5,361	0	4,172	1,998	11,545	324,937	269	0.08
Sep. 2000	40,227	26,537	12,278	40,333	17,269	31,751	390	2,572	1,007	1,057	44,488	217,908	17,409	16	120,551	63,924	4,403	0	1,671	1,009	8,734	217,717	191	0.09
Oct. 2000	44,781	24,088	7,704	16,759	4,120	26,668	1,301	2,658	1,040	1,093	46,110	176,321	29,460	72	120,235	15,399	3,476	0	315	640	6,758	176,354	-33	-0.02
Nov. 2000	46,240	20,930	2,066	2,135	0	19,768	1,554	2,572	1,007	1,058	44,424	141,754	25,888	105	108,390	0	3,103	0	0	0	4,167	141,652	102	0.07
Dec. 2000	42,017	21,044	1,268	1,301	0	15,455	2,525	2,658	1,040	1,094	45,470	133,874	19,825	142	106,763	0	3,081	0	0	0	3,998	133,808	65	0.05
Jan. 2001	34,314	23,228	2,030	1,560	0	13,386	9,721	2,658	1,040	1,095	44,930	133,962	25,588	181	101,411	0	2,837	0	0	0	3,916	133,933	29	0.02
Feb. 2001	26,868	21,440	1,846	1,810	0	11,410	11,333	2,400	940	989	40,097	119,132	22,452	183	89,500	0	2,634	0	0	0	4,287	119,056	76	0.06
Mar. 2001	26,137	22,459	3,767	4,670	0	19,531	16,603	2,658	1,040	1,085	43,813	141,763	23,246	186	108,178	0	2,926	0	0	0	7,242	141,778	-15	-0.01
Apr. 2001	10,403	31,159	16,816	9,508	1,033	23,482	32,635	2,572	1,007	1,046	42,038	171,700	48,799	236	106,539	3,582	3,389	0	122	96	9,244	172,007	-307	-0.18
May 2001	6,673	38,468	30,466	35,811	7,074	41,828	15,650	2,658	1,040	1,078	43,366	224,113	68,976	273	108,567	28,874	4,089	0	1,583	474	11,794	224,630	-517	-0.23
Jun. 2001	77,164	23,897	9,146	66,946	35,969	49,749	9,911	2,572	1,007	1,044	42,237	319,641	36,859	220	122,686	134,379	4,698	0	5,809	2,247	12,533	319,432	210	0.07
Jul. 2001	36,470	36,488	29,493	93,015	31,414	57,647	1,894	2,658	1,040	1,077	44,341	335,538	72,083	166	123,905	113,664	5,854	0	3,359	1,928	14,527	335,487	51	0.02
Aug. 2001	69,625	24,877	8,206	84,985	41,336	55,195	1,289	2,658	1,040	1,078	45,029	335,318	29,443	63	131,931	148,433	5,467	0	5,524	2,792	11,469	335,121	197	0.06

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Sep. 2001	45,029	25,145	10,217	42,209	22,321	34,694	8,554	2,572	1,007	1,043	44,126	236,917	13,087	133	121,548	83,276	4,636	0	3,391	2,014	8,774	236,859	58	0.02
Oct. 2001	42,111	20,439	3,024	21,775	5,320	25,945	17,172	2,658	1,040	1,079	45,746	186,308	27,090	165	125,985	20,201	3,919	0	1,004	1,153	6,751	186,268	40	0.02
Nov. 2001	39,160	21,509	3,817	4,071	31	18,720	11,781	2,572	1,007	1,044	44,060	147,774	29,828	194	110,340	110	3,115	0	0	19	4,174	147,779	-6	0.00
Dec. 2001	44,888	20,066	348	1,498	0	17,342	4,447	2,658	1,040	1,075	45,118	138,480	21,862	214	109,329	0	3,025	0	0	0	3,983	138,414	66	0.05
Jan. 2002	36,335	20,123	1,611	2,623	0	19,953	4,918	2,658	1,040	1,071	44,608	134,938	20,187	216	107,776	0	2,965	0	0	0	3,736	134,880	58	0.04
Feb. 2002	31,049	18,794	893	1,400	0	14,379	4,964	2,400	940	967	39,854	115,642	14,192	204	93,897	0	3,021	0	0	0	4,040	115,354	288	0.25
Mar. 2002	27,901	21,889	2,675	2,411	0	16,029	6,318	2,658	1,040	1,071	43,609	125,601	13,760	224	101,088	0	3,280	0	0	0	7,132	125,484	117	0.09
Apr. 2002	27,295	19,179	1,655	25,713	4,582	21,576	13,523	2,572	1,007	1,037	41,842	159,980	20,344	226	106,642	18,437	4,143	0	1,180	798	8,176	159,946	34	0.02
May 2002	41,600	25,208	9,906	57,587	18,084	35,885	1,173	2,658	1,040	1,072	43,053	237,266	37,180	209	109,845	70,998	4,770	0	2,677	1,214	10,129	237,022	244	0.10
Jun. 2002	81,277	29,712	13,664	56,159	39,557	36,835	555	2,572	1,007	1,036	41,732	304,107	23,709	188	104,077	150,160	4,794	238	6,484	2,314	11,825	303,790	317	0.10
Jul. 2002	137,631	27,459	4,778	52,828	65,347	34,890	288	2,658	1,040	1,072	43,411	371,402	9,547	87	100,523	229,967	5,875	746	7,905	3,745	12,773	371,167	235	0.06
Aug. 2002	96,549	33,588	12,623	38,063	50,808	23,356	255	2,658	1,040	1,071	43,523	303,533	6,704	0	92,945	177,714	5,391	1,228	5,461	2,946	10,743	303,132	401	0.13
Sep. 2002	58,152	26,639	6,652	30,399	25,840	20,114	228	2,572	1,007	1,037	42,215	214,854	9,656	-19	89,198	95,563	4,851	1,550	3,065	2,225	8,060	214,149	705	0.33
Oct. 2002	29,115	26,948	8,425	27,130	2,625	18,224	1,355	2,658	1,040	1,072	43,604	162,196	47,026	21	92,998	10,521	3,806	579	468	379	6,393	162,191	5	0.00
Nov. 2002	40,368	20,442	1,486	2,412	0	13,581	2,791	2,572	1,007	1,035	42,024	127,718	31,236	66	89,122	0	3,125	373	0	0	3,868	127,791	-72	-0.06
Dec. 2002	35,494	19,136	159	2,747	0	15,918	6,218	2,658	1,040	1,065	43,061	127,495	25,681	123	94,411	0	3,311	317	0	0	3,678	127,521	-26	-0.02
Jan. 2003	31,008	19,724	453	3,033	0	13,860	8,161	2,658	1,040	1,065	42,578	123,580	24,810	154	91,676	0	3,087	187	0	0	3,533	123,445	135	0.11
Feb. 2003	25,183	19,528	2,132	896	0	11,310	7,486	2,400	940	962	38,047	108,884	21,394	158	80,404	0	2,824	171	0	0	3,868	108,820	64	0.06
Mar. 2003	15,993	26,583	10,195	3,076	1	19,200	10,573	2,658	1,040	1,064	41,659	132,041	35,232	219	86,580	3	2,858	178	0	3	7,057	132,130	-89	-0.07
Apr. 2003	12,290	29,094	16,435	22,737	4,163	32,297	2,333	2,572	1,007	1,029	40,122	164,078	45,426	215	88,087	17,260	3,063	0	1,171	705	8,336	164,262	-184	-0.11
May 2003	22,677	31,496	17,359	38,207	14,053	45,933	4,051	2,658	1,040	1,063	41,549	220,087	49,613	211	95,979	56,499	3,343	0	2,869	1,071	10,468	220,053	34	0.02
Jun. 2003	24,992	29,923	17,076	66,680	18,988	67,935	5,572	2,572	1,007	1,027	40,648	276,420	74,653	183	107,931	73,438	3,796	203	2,722	1,002	12,619	276,548	-128	-0.05
Jul. 2003	97,637	23,944	6,593	84,447	47,356	53,944	374	2,658	1,040	1,062	42,819	361,874	39,568	59	120,251	173,587	5,142	776	6,638	2,756	13,015	361,792	82	0.02
Aug. 2003	47,321	33,762	18,796	77,138	35,048	47,374	789	2,658	1,040	1,061	43,493	308,481	44,794	-96	114,422	125,890	4,751	1,704	3,496	2,293	11,204	308,459	22	0.01
Sep. 2003	41,459	20,747	4,029	44,597	15,722	35,363	423	2,572	1,007	1,028	42,540	209,486	16,017	-53	113,633	60,611	4,044	2,869	2,632	1,305	8,324	209,381	105	0.05
Oct. 2003	36,484	19,249	1,690	29,495	6,578	27,101	15,530	2,658	1,040	1,063	44,085	184,973	27,490	-6	116,477	26,488	3,619	1,600	1,846	1,068	6,423	185,006	-33	-0.02
Nov. 2003	46,346	19,339	1,067	3,178	18	16,385	3,345	2,572	1,007	1,030	42,463	136,750	28,736	42	100,058	68	2,858	1,115	0	7	3,920	136,805	-54	-0.04
Dec. 2003	38,312	20,431	1,451	1,705	0	15,935	5,756	2,658	1,040	1,064	43,513	131,865	24,441	101	99,530	0	3,018	929	0	0	3,818	131,837	27	0.02
Jan. 2004	33,180	19,892	1,262	1,370	0	16,624	13,301	2,658	1,040	1,065	43,003	133,395	25,440	136	100,847	0	2,928	472	0	0	3,626	133,449	-55	-0.04
Feb. 2004	23,662	18,806	1,775	3,699	0	17,477	14,960	2,486	973	996	39,761	124,596	23,257	146	94,001	0	2,780	374	0	0	4,036	124,593	2	0.00
Mar. 2004	28,337	20,480	1,671	3,857	172	11,773	9,913	2,658	1,040	1,066	41,998	122,965	20,516	206	91,386	674	2,853	220	3	108	7,034	123,000	-35	-0.03

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Apr. 2004	14,250	27,202	13,712	38,186	4,352	26,153	1,615	2,572	1,007	1,030	40,323	170,401	45,204	202	92,600	18,640	3,288	0	1,400	646	8,387	170,366	35	0.02
May 2004	29,035	27,222	14,169	60,708	14,355	37,841	1,193	2,658	1,040	1,064	41,631	230,915	45,294	174	108,833	58,728	3,803	112	2,919	919	10,157	230,940	-25	-0.01
Jun. 2004	26,932	30,537	18,898	63,954	18,355	43,434	994	2,572	1,007	1,028	40,555	248,265	47,918	154	104,868	74,676	3,807	178	2,911	1,194	12,505	248,210	55	0.02
Jul. 2004	49,357	28,406	13,936	76,144	29,650	51,868	785	2,658	1,040	1,062	42,458	297,365	39,705	93	116,453	115,196	4,967	1,318	3,827	1,752	13,774	297,083	282	0.09
Aug. 2004	35,946	28,536	14,374	74,140	26,036	49,874	3,246	2,658	1,040	1,062	42,985	279,898	38,930	-23	119,227	98,034	4,511	2,650	3,012	1,764	11,703	279,807	91	0.03
Sep. 2004	23,580	24,532	12,752	61,178	13,298	39,079	3,292	2,572	1,007	1,028	42,017	224,336	31,508	-18	121,523	52,686	3,926	3,005	1,570	1,577	8,715	224,493	-157	-0.07
Oct. 2004	28,786	22,981	8,167	26,250	5,479	32,379	14,516	2,658	1,040	1,063	43,610	186,929	34,380	27	118,005	22,060	3,112	504	1,208	810	6,886	186,992	-63	-0.03
Nov. 2004	47,598	19,995	3,932	3,721	6	19,321	4,951	2,572	1,007	1,029	42,085	146,215	29,546	87	109,171	23	2,453	910	2	1	4,145	146,339	-124	-0.08
Dec. 2004	41,277	19,463	799	1,776	0	18,794	6,697	2,658	1,040	1,064	43,151	136,719	23,082	144	106,094	0	2,675	799	0	0	3,984	136,778	-58	-0.04
Jan. 2005	34,088	20,268	2,055	1,225	0	18,646	11,492	2,658	1,040	1,065	42,679	135,215	24,039	163	103,436	0	3,037	869	0	0	3,753	135,296	-82	-0.06
Feb. 2005	28,762	17,262	596	1,927	0	16,749	15,906	2,400	940	962	38,139	123,642	22,531	167	93,356	0	2,745	830	0	0	4,015	123,644	-2	0.00
Mar. 2005	26,593	20,644	3,276	2,766	2	19,481	11,451	2,658	1,040	1,065	41,740	130,716	18,797	202	100,476	4	3,095	1,096	0	1	7,021	130,691	24	0.02
Apr. 2005	6,350	32,536	18,594	21,822	596	28,348	33,119	2,572	1,007	1,029	40,097	186,070	71,368	254	98,866	2,409	3,548	353	81	274	9,135	186,289	-219	-0.12
May 2005	13,982	27,207	13,208	62,194	8,456	59,968	13,246	2,658	1,040	1,063	41,460	244,482	77,965	245	113,233	34,799	4,412	480	1,247	999	11,113	244,494	-11	0.00
Jun. 2005	11,057	42,962	30,349	55,670	12,555	56,751	44,590	2,572	1,007	1,027	40,511	299,050	112,794	328	111,830	50,851	4,652	331	1,671	1,141	15,967	299,564	-514	-0.17
Jul. 2005	88,779	22,360	8,343	90,098	32,411	57,447	1,149	2,658	1,040	1,062	42,640	347,986	47,660	250	144,028	127,536	6,173	164	4,662	3,321	14,268	348,063	-77	-0.02
Aug. 2005	44,239	26,395	11,797	83,312	24,661	51,824	2,197	2,658	1,040	1,062	43,400	292,585	38,481	100	135,473	94,690	5,127	794	3,550	2,384	11,839	292,438	147	0.05
Sep. 2005	53,833	20,007	2,918	52,042	19,706	35,308	2,641	2,572	1,007	1,028	42,537	233,600	10,332	41	126,417	77,256	4,885	657	2,942	2,286	8,783	233,599	1	0.00
Oct. 2005	19,307	32,989	23,482	19,617	1,613	32,369	27,738	2,658	1,040	1,061	44,191	206,066	62,657	133	124,598	6,796	3,499	509	216	478	7,372	206,258	-192	-0.09
Nov. 2005	50,194	18,444	1,491	6,705	220	21,557	1,859	2,572	1,007	1,028	42,658	147,735	23,145	181	116,202	877	2,945	0	47	73	4,287	147,757	-22	-0.01
Dec. 2005	42,603	19,398	973	3,873	0	16,660	5,967	2,658	1,040	1,063	43,702	137,938	18,766	223	111,807	0	2,990	0	0	0	4,113	137,900	38	0.03
Jan. 2006	34,996	18,172	454	5,282	0	20,276	14,174	2,658	1,040	1,064	43,147	141,263	20,819	226	113,376	0	3,036	0	0	0	3,774	141,230	33	0.02
Feb. 2006	30,612	17,250	1,010	4,582	0	16,468	5,757	2,400	940	962	38,502	118,483	14,167	207	97,136	0	2,746	0	0	0	4,007	118,262	220	0.19
Mar. 2006	23,685	23,468	4,710	3,303	3	14,994	18,309	2,658	1,040	1,064	42,074	135,310	24,246	283	100,245	6	3,098	0	0	1	7,438	135,317	-7	-0.01
Apr. 2006	33,765	19,912	3,655	28,983	6,518	25,305	13,443	2,572	1,007	1,030	40,341	176,532	23,382	263	110,529	26,983	3,550	0	1,670	1,843	8,305	176,523	9	0.01
May 2006	44,471	23,239	6,423	63,228	18,591	41,269	1,191	2,658	1,040	1,064	41,620	244,795	39,077	237	111,530	74,697	4,412	0	2,968	1,517	10,117	244,555	240	0.10
Jun. 2006	93,970	22,643	4,808	66,031	39,282	46,134	1,018	2,572	1,007	1,031	40,613	319,108	31,305	212	107,318	154,024	4,656	108	5,829	3,451	11,759	318,661	447	0.14
Jul. 2006	52,359	33,316	17,630	68,719	33,780	46,552	1,127	2,658	1,040	1,064	42,623	300,868	35,281	43	108,598	129,194	6,132	766	4,279	2,888	13,426	300,608	260	0.09
Aug. 2006	42,073	32,181	13,177	63,576	28,587	39,898	1,336	2,658	1,040	1,063	43,121	268,710	24,382	-60	111,362	108,698	5,117	1,010	3,816	2,641	11,449	268,416	294	0.11
Sep. 2006	31,291	23,403	8,043	46,395	9,888	30,716	1,945	2,572	1,007	1,029	42,096	198,384	24,728	-7	114,512	41,227	4,871	1,368	1,595	1,772	8,352	198,418	-34	-0.02
Oct. 2006	24,386	25,971	10,897	31,871	2,544	27,439	5,897	2,658	1,040	1,063	43,635	177,400	41,923	25	113,097	10,618	3,485	697	372	622	6,685	177,525	-124	-0.07

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Nov. 2006	47,161	18,465	1,127	5,693	3	19,387	2,292	2,572	1,007	1,030	42,042	140,778	26,047	66	106,730	13	2,937	945	0	1	3,946	140,685	93	0.07
Dec. 2006	31,824	24,631	6,482	3,466	0	17,869	5,097	2,658	1,040	1,064	43,080	137,212	27,878	127	99,513	0	2,983	2,750	0	0	3,948	137,200	12	0.01
Jan. 2007	34,153	25,637	2,375	1,807	0	15,488	12,122	2,658	1,040	1,064	42,557	138,902	25,649	171	98,079	0	2,680	8,613	0	0	3,763	138,955	-53	-0.04
Feb. 2007	25,871	21,913	1,045	3,416	0	18,217	13,443	2,400	940	962	38,002	126,209	21,143	160	90,492	0	2,340	8,006	0	0	3,980	126,121	88	0.07
Mar. 2007	20,244	23,299	3,770	4,154	9	31,519	23,254	2,658	1,040	1,065	41,547	152,558	36,158	186	101,038	24	2,531	5,483	0	3	7,088	152,510	48	0.03
Apr. 2007	5,917	33,268	19,180	18,420	354	39,034	36,614	2,572	1,007	1,029	39,888	197,284	77,114	231	102,715	1,387	2,916	3,799	82	249	9,062	197,555	-271	-0.14
May 2007	8,876	48,945	20,878	52,593	7,738	58,391	63,576	2,658	1,040	1,062	41,195	306,953	140,073	352	106,522	32,665	3,947	7,461	1,547	867	13,819	307,252	-299	-0.10
Jun. 2007	46,276	25,488	9,695	72,189	21,661	73,165	23,080	2,572	1,007	1,028	40,237	316,397	71,659	333	130,773	87,615	4,768	1,477	3,748	2,121	14,121	316,614	-218	-0.07
Jul. 2007	60,625	27,994	16,725	82,607	27,048	56,952	2,532	2,658	1,040	1,062	42,421	321,663	52,217	260	135,793	105,340	6,052	856	3,557	2,847	14,854	321,776	-113	-0.04
Aug. 2007	35,595	32,089	21,802	75,871	22,819	57,147	4,111	2,658	1,040	1,061	43,202	297,395	47,603	139	138,064	87,594	5,202	1,209	3,259	2,415	11,941	297,426	-31	-0.01
Sep. 2007	36,814	22,500	7,429	53,033	15,543	41,504	3,861	2,572	1,007	1,027	42,406	227,696	17,321	100	129,917	61,371	4,953	789	1,917	2,467	8,939	227,775	-79	-0.03
Oct. 2007	31,396	22,767	5,951	31,330	4,481	29,872	14,855	2,658	1,040	1,062	44,121	189,533	29,704	117	126,187	18,747	3,365	2,544	805	1,103	7,026	189,599	-66	-0.03
Nov. 2007	54,554	19,103	734	3,052	109	16,727	7,640	2,572	1,007	1,029	42,607	149,134	26,657	187	113,584	462	2,710	1,207	0	62	4,265	149,133	1	0.00
Dec. 2007	38,461	23,970	4,694	1,860	0	17,442	21,395	2,658	1,040	1,063	43,718	156,301	28,991	241	114,463	0	2,968	5,628	0	0	4,114	156,406	-105	-0.07
Jan. 2008	37,085	22,778	609	1,605	0	18,152	25,977	2,658	1,040	1,064	43,211	154,180	25,279	245	114,064	0	3,108	7,665	0	0	3,833	154,195	-15	-0.01
Feb. 2008	29,646	22,463	1,305	2,119	0	21,929	21,054	2,486	973	996	39,985	142,956	23,822	243	104,647	0	2,749	7,028	0	0	4,339	142,828	127	0.09
Mar. 2008	28,624	22,101	1,648	2,006	0	17,690	23,272	2,658	1,040	1,065	42,208	142,313	21,493	267	105,953	0	2,816	4,169	0	0	7,478	142,176	137	0.10
Apr. 2008	14,389	22,536	6,533	28,059	426	28,081	21,672	2,572	1,007	1,030	40,468	166,774	37,594	274	112,265	1,726	3,292	2,651	141	318	8,716	166,977	-203	-0.12
May 2008	21,507	24,922	11,682	67,195	8,707	43,294	4,576	2,658	1,040	1,064	41,683	228,329	55,148	274	118,991	35,528	4,198	1,174	1,273	864	10,840	228,290	39	0.02
Jun. 2008	42,741	25,289	11,947	77,939	20,887	58,924	2,536	2,572	1,007	1,030	40,669	285,541	61,674	179	117,953	82,775	5,025	837	2,509	1,376	13,123	285,451	90	0.03
Jul. 2008	66,530	26,777	11,467	81,037	30,796	51,178	2,199	2,658	1,040	1,064	42,895	317,642	42,271	102	127,091	119,381	6,650	943	3,800	2,642	14,638	317,517	124	0.04
Aug. 2008	12,910	42,802	41,929	66,776	10,490	43,247	10,731	2,658	1,040	1,061	43,671	277,315	88,254	18	127,737	40,290	5,579	1,447	603	546	13,174	277,647	-333	-0.12
Sep. 2008	35,534	22,205	10,751	46,331	13,061	38,526	8,739	2,572	1,007	1,027	42,825	222,579	20,009	-50	133,455	51,334	4,948	898	1,447	1,310	9,270	222,622	-43	-0.02
Oct. 2008	32,116	21,710	6,373	25,503	3,987	32,104	22,000	2,658	1,040	1,062	44,532	193,085	31,113	30	132,002	16,644	3,106	1,441	738	969	7,203	193,247	-162	-0.08
Nov. 2008	56,305	18,777	1,502	2,161	161	16,045	5,273	2,572	1,007	1,028	42,957	147,788	22,830	121	115,737	642	2,776	1,215	0	83	4,376	147,779	10	0.01
Dec. 2008	44,935	22,124	2,151	2,524	0	17,956	10,152	2,658	1,040	1,063	44,039	148,643	21,787	173	113,726	0	2,865	5,756	0	0	4,189	148,497	146	0.10
Jan. 2009	41,049	21,775	1,101	2,282	0	21,121	12,713	2,658	1,040	1,064	43,491	148,295	21,887	193	112,457	0	2,811	6,960	0	0	3,903	148,212	84	0.06
Feb. 2009	33,151	19,121	616	2,079	0	16,364	14,354	2,400	940	962	38,817	128,804	16,846	189	98,809	0	2,618	6,141	0	0	4,144	128,747	57	0.04
Mar. 2009	21,307	22,873	2,869	5,449	1	22,767	36,552	2,658	1,040	1,065	42,450	159,030	34,056	264	109,275	3	2,742	5,139	0	0	7,642	159,122	-91	-0.06
Apr. 2009	4,229	37,487	24,952	23,581	284	31,613	55,571	2,572	1,007	1,028	40,813	223,137	86,757	318	115,539	1,115	3,023	6,500	134	139	9,981	223,505	-368	-0.16
May 2009	15,329	28,865	17,243	63,268	8,930	59,002	20,288	2,658	1,040	1,062	42,231	259,915	74,749	351	128,749	36,148	3,887	1,501	1,465	1,079	12,128	260,056	-140	-0.05

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Jun. 2009	16,922	49,357	29,919	42,501	13,761	50,935	65,112	2,572	1,007	1,027	41,172	314,285	112,793	501	117,137	56,257	3,815	1,655	2,482	1,129	19,009	314,777	-493	-0.16
Jul. 2009	45,156	30,739	24,554	88,820	20,582	63,604	19,098	2,658	1,040	1,060	43,222	340,534	78,920	388	155,934	79,629	5,363	526	1,857	1,241	16,962	340,820	-286	-0.08
Aug. 2009	46,468	23,523	13,604	79,223	18,454	53,348	8,863	2,658	1,040	1,060	43,962	292,203	44,819	341	155,011	70,686	4,521	311	2,010	1,658	13,014	292,370	-167	-0.06
Sep. 2009	34,929	23,210	9,620	49,360	12,579	41,737	14,440	2,572	1,007	1,026	43,089	233,569	21,725	325	143,551	49,526	4,529	796	1,602	1,649	9,887	233,590	-22	-0.01
Oct. 2009	20,953	27,844	15,594	26,196	688	34,534	51,577	2,658	1,040	1,061	44,768	226,913	58,935	391	152,472	2,781	2,815	1,074	71	241	8,235	227,015	-102	-0.05
Nov. 2009	47,813	20,224	2,278	5,410	0	19,052	22,687	2,572	1,007	1,027	43,231	165,302	27,677	406	126,390	0	2,908	2,979	0	0	4,856	165,217	85	0.05
Dec. 2009	51,470	23,244	2,619	3,388	0	13,450	10,537	2,658	1,040	1,062	44,398	153,866	21,346	434	118,595	0	3,085	5,628	0	0	4,724	153,812	54	0.04
Jan. 2010	48,325	20,993	327	7,095	0	20,385	15,342	2,658	1,040	1,063	43,941	161,170	22,472	394	124,008	0	2,509	7,508	0	0	4,197	161,088	82	0.05
Feb. 2010	35,577	19,615	1,894	5,792	0	18,409	18,602	2,400	940	961	39,267	143,456	17,633	336	112,036	0	2,287	6,654	0	0	4,398	143,345	111	0.08
Mar. 2010	20,790	24,023	3,990	8,294	3	27,318	51,026	2,658	1,040	1,064	42,954	183,160	45,901	433	119,620	6	2,542	6,607	0	1	8,173	183,283	-123	-0.07
Apr. 2010	6,024	36,211	22,716	22,081	210	30,590	41,267	2,572	1,007	1,028	41,260	204,966	76,730	515	107,928	718	2,950	5,702	44	88	10,925	205,599	-634	-0.31
May 2010	13,005	33,884	16,306	40,393	6,987	40,860	28,949	2,658	1,040	1,061	42,467	227,610	62,669	546	111,846	27,879	3,690	3,942	1,558	1,324	14,611	228,065	-454	-0.20
Jun. 2010	24,897	41,659	26,209	64,101	18,218	52,633	18,359	2,572	1,007	1,026	41,239	291,920	79,893	581	108,887	72,264	4,336	1,063	3,410	2,429	19,336	292,197	-278	-0.10
Jul. 2010	79,315	24,877	14,996	91,721	25,888	63,500	3,744	2,658	1,040	1,060	43,301	352,099	51,082	418	170,283	101,679	5,658	197	3,581	3,353	15,899	352,149	-50	-0.01
Aug. 2010	46,203	24,882	14,063	85,530	22,748	57,437	7,103	2,658	1,040	1,060	44,076	306,800	38,082	313	156,177	87,821	5,046	203	3,374	2,789	12,943	306,748	52	0.02
Sep. 2010	79,063	16,855	808	49,860	22,779	40,048	4,515	2,572	1,007	1,027	43,261	261,793	5,646	270	145,691	89,541	4,687	110	3,010	3,377	9,285	261,617	176	0.07
Oct. 2010	37,722	19,843	4,357	32,169	6,359	32,546	23,601	2,658	1,040	1,062	44,994	206,352	27,230	335	138,351	26,359	3,029	409	1,312	1,919	7,378	206,322	30	0.01
Nov. 2010	60,425	17,961	1,854	4,187	42	21,842	7,005	2,572	1,007	1,028	43,425	161,349	24,160	369	128,081	187	2,856	1,223	0	29	4,368	161,273	75	0.05
Dec. 2010	51,036	19,566	1,096	2,852	0	19,920	12,602	2,658	1,040	1,063	44,566	156,400	20,678	379	124,138	0	2,795	4,216	0	0	4,204	156,409	-9	-0.01
Jan. 2011	42,614	22,984	1,738	2,414	0	15,017	12,964	2,658	1,040	1,064	44,071	146,563	21,169	384	111,658	0	2,846	6,182	0	0	4,131	146,370	193	0.13
Feb. 2011	30,172	21,488	2,147	2,913	0	15,378	18,638	2,400	940	961	39,389	134,427	20,111	349	100,232	0	2,584	6,427	0	0	4,484	134,186	241	0.18
Mar. 2011	26,169	19,963	979	6,366	47	23,859	41,302	2,658	1,040	1,065	43,087	166,535	29,030	376	121,658	127	2,644	5,126	0	38	7,635	166,634	-99	-0.06
Apr. 2011	16,461	25,169	10,577	37,888	1,821	27,579	24,433	2,572	1,007	1,030	41,316	189,853	41,990	434	121,595	7,590	3,075	5,028	388	787	9,091	189,978	-125	-0.07
May 2011	4,038	36,986	32,504	46,460	3,785	44,774	29,672	2,658	1,040	1,062	42,603	245,583	84,044	531	124,244	16,316	3,869	2,545	1,136	649	12,564	245,898	-315	-0.13
Jun. 2011	47,811	30,179	10,172	60,555	24,462	68,266	23,804	2,572	1,007	1,028	41,543	311,398	70,793	527	114,162	97,958	4,242	1,350	3,632	2,304	16,438	311,405	-7	0.00
Jul. 2011	37,610	38,297	20,200	85,382	26,361	78,492	9,788	2,658	1,040	1,061	43,719	344,607	80,533	537	125,538	106,022	5,313	949	3,250	2,717	19,752	344,611	-4	0.00
Aug. 2011	78,319	18,683	6,968	86,253	27,029	66,148	2,742	2,658	1,040	1,062	44,579	335,480	34,191	419	168,400	106,527	4,905	441	4,245	3,414	13,031	335,572	-92	-0.03
Sep. 2011	47,751	21,549	9,130	45,838	16,458	43,945	12,861	2,572	1,007	1,027	43,805	245,946	16,292	365	144,009	66,253	4,337	359	2,261	2,318	9,744	245,938	8	0.00
Oct. 2011	28,996	25,010	13,869	27,067	4,183	34,150	27,806	2,658	1,040	1,061	45,577	211,417	39,055	389	141,391	17,253	3,479	626	703	1,072	7,627	211,593	-176	-0.08
Nov. 2011	56,186	18,456	2,324	4,821	23	23,327	11,463	2,572	1,007	1,028	43,980	165,187	25,458	395	129,907	80	3,171	1,570	0	15	4,535	165,131	56	0.03
Dec. 2011	48,822	23,599	2,137	3,961	0	12,957	9,851	2,658	1,040	1,063	45,147	151,234	24,855	443	113,801	0	3,198	4,079	0	0	4,699	151,074	160	0.11

Table C-1. Simulated Monthly Groundwater Budgets (ac-ft)

Month/Year	Inflows												Outflows										Mass Balance	
	Groundwater Flow In from Storage	Stream Loss to Aquifer	Precipitation Recharge	Surface Water Irrigation Return Flow Recharge	Groundwater Irrigation Return Flow Recharge	Canal Seepage Recharge	Augmentation Recharge Ponds	Reservoir Seepage Recharge	Alluvial Underflow In	Net Bedrock Flux	Net Lateral Boundary Flow	Total In	Groundwater Flow Out to Storage	Alluvial Underflow out below Julesburg	Stream Gain from Aquifer	Agricultural Irrigation Pumping	M&I Pumping	Augmentation Pumping	Alfalfa ET	Subirrigated Meadow ET	Phreatophyte ET	Total Out	In Minus Out	% Error
Jan. 2012	43,666	23,006	412	4,351	0	15,501	16,006	2,658	1,040	1,064	44,649	152,353	24,245	446	113,285	0	2,933	6,898	0	0	4,469	152,276	76	0.05
Feb. 2012	29,220	24,671	3,952	6,294	0	14,827	18,843	2,486	973	995	41,292	143,554	25,368	420	103,086	0	2,574	6,953	0	0	5,083	143,484	70	0.05
Mar. 2012	33,939	20,156	328	5,864	894	21,479	33,909	2,658	1,040	1,064	43,573	164,906	21,750	432	120,983	3,827	2,695	6,346	293	589	8,043	164,958	-52	-0.03
Apr. 2012	40,483	24,236	10,508	35,774	9,802	29,743	16,288	2,572	1,007	1,029	41,769	213,211	27,546	434	122,191	41,810	3,736	3,360	2,447	2,425	9,150	213,099	112	0.05
May 2012	59,677	22,605	9,400	56,668	19,730	38,599	3,315	2,658	1,040	1,064	43,034	257,790	28,705	403	127,045	80,341	4,688	570	3,075	1,982	10,985	257,793	-3	0.00
Jun. 2012	111,987	22,360	6,217	56,948	43,277	45,684	2,319	2,572	1,007	1,029	41,794	335,194	17,087	336	118,591	169,981	5,205	429	6,463	4,778	12,337	335,208	-14	0.00
Jul. 2012	68,191	30,214	16,042	62,021	36,694	46,536	2,574	2,658	1,040	1,063	43,564	310,598	23,527	87	117,257	140,011	5,868	1,717	4,549	3,983	13,606	310,605	-7	0.00
Aug. 2012	99,517	20,666	2,282	53,000	39,580	37,586	1,869	2,658	1,040	1,064	43,867	303,129	7,427	-49	114,922	152,512	5,419	2,381	5,127	4,561	10,845	303,143	-15	0.00
Sep. 2012	36,992	27,109	11,763	39,922	10,489	26,296	2,023	2,572	1,007	1,029	42,711	201,912	29,779	7	108,530	42,318	5,160	4,328	1,392	1,880	8,498	201,893	19	0.01
Oct. 2012	36,522	21,364	7,291	25,113	2,744	24,935	7,770	2,658	1,040	1,064	44,213	174,713	33,193	50	117,323	11,272	3,148	2,135	260	762	6,529	174,672	41	0.02
Nov. 2012	48,156	19,820	1,273	2,632	53	15,044	2,292	2,572	1,007	1,030	42,563	136,441	27,665	123	99,240	192	2,753	2,179	0	25	4,100	136,276	165	0.12
Dec. 2012	42,982	22,550	976	755	0	10,263	7,949	2,658	1,040	1,065	43,620	133,860	23,910	198	97,971	0	2,759	4,880	0	0	4,064	133,782	77	0.06

Appendix D: Simulated Monthly Surface Water Budgets

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jan. 1950	14,672	11,154	7,465	7,419	96,673	137,383	4,863	40,229	1,660	25,660	65,071	137,484	-101	-0.07	137,383	137,484	-101	-0.07
Feb. 1950	23,265	11,302	5,838	3,508	99,961	143,875	66,530	34,057	1,460	18,772	23,379	144,197	-322	-0.22	281,257	281,681	-423	-0.15
Mar. 1950	17,783	10,766	6,879	3,831	97,613	136,871	33,773	37,919	1,254	23,504	40,767	137,217	-346	-0.25	418,129	418,897	-769	-0.18
Apr. 1950	22,153	9,075	8,386	49,082	96,535	185,231	78,742	43,075	1,877	28,942	32,055	184,692	539	0.29	603,359	603,589	-230	-0.04
May 1950	59,176	14,115	11,583	51,929	117,895	254,697	159,079	51,355	2,145	28,111	10,881	251,570	3,127	1.24	858,056	855,159	2,897	0.34
Jun. 1950	193,387	34,083	20,079	36,503	131,531	415,583	300,554	80,788	1,592	25,159	1,174	409,268	6,315	1.53	1,273,639	1,264,427	9,212	0.73
Jul. 1950	75,927	18,465	22,009	30,865	139,850	287,116	211,614	36,666	1,614	28,192	11,587	289,674	-2,558	-0.89	1,560,755	1,554,101	6,654	0.43
Aug. 1950	26,713	9,796	25,414	11,901	136,595	210,420	149,998	28,121	1,211	21,543	11,876	212,749	-2,329	-1.10	1,771,175	1,766,850	4,325	0.24
Sep. 1950	30,901	7,430	12,796	26,161	123,729	201,017	126,259	39,452	1,407	23,499	10,099	200,715	302	0.15	1,972,191	1,967,565	4,627	0.23
Oct. 1950	13,394	7,610	7,493	4,115	129,799	162,410	104,024	34,865	1,017	18,306	5,634	163,846	-1,436	-0.88	2,134,601	2,131,411	3,190	0.15
Nov. 1950	21,391	12,191	6,884	9,622	116,669	166,756	92,633	38,512	1,052	19,451	15,418	167,066	-310	-0.19	2,301,357	2,298,477	2,880	0.13
Dec. 1950	10,051	12,095	7,253	2,681	114,254	146,334	71,177	36,194	1,079	19,858	19,026	147,334	-1,000	-0.68	2,447,691	2,445,811	1,880	0.08
Jan. 1951	12,653	9,343	7,169	9,084	106,365	144,614	58,304	38,387	1,095	21,754	25,364	144,904	-290	-0.20	2,592,305	2,590,715	1,590	0.06
Feb. 1951	12,886	10,139	6,433	8,196	100,491	138,145	71,593	34,451	1,207	18,589	12,927	138,768	-623	-0.45	2,730,450	2,729,483	967	0.04
Mar. 1951	11,899	9,374	7,067	12,255	94,931	135,525	42,140	37,477	1,207	23,515	31,735	136,073	-548	-0.40	2,865,975	2,865,556	419	0.01
Apr. 1951	29,382	11,328	24,560	35,530	91,681	192,481	66,562	50,601	2,525	30,181	41,023	190,893	1,588	0.83	3,058,456	3,056,448	2,007	0.07
May 1951	165,826	29,628	8,451	50,535	110,609	365,048	194,543	110,207	2,492	30,091	20,906	358,239	6,810	1.88	3,423,504	3,414,687	8,817	0.26
Jun. 1951	273,550	90,709	8,519	49,021	124,459	546,259	293,534	192,817	1,950	28,087	22,521	538,909	7,351	1.35	3,969,764	3,953,596	16,168	0.41
Jul. 1951	168,560	43,215	22,338	33,182	143,501	410,795	274,126	92,325	1,842	25,595	18,185	412,073	-1,278	-0.31	4,380,559	4,365,669	14,889	0.34
Aug. 1951	89,432	85,853	16,985	77,103	133,262	402,635	219,580	100,730	3,342	36,171	43,709	403,531	-896	-0.22	4,783,194	4,769,200	13,994	0.29
Sep. 1951	52,050	13,668	21,596	22,543	145,824	255,681	161,156	56,489	1,349	21,369	17,567	257,929	-2,249	-0.88	5,038,875	5,027,130	11,745	0.23
Oct. 1951	29,165	22,217	11,563	46,140	143,756	252,840	150,320	68,837	1,927	24,347	11,602	257,034	-4,194	-1.64	5,291,715	5,284,164	7,551	0.14
Nov. 1951	23,574	28,143	12,866	10,142	124,675	199,400	97,927	57,933	1,342	19,943	24,381	201,527	-2,127	-1.06	5,491,116	5,485,691	5,425	0.10
Dec. 1951	20,829	23,417	6,474	8,648	118,425	177,793	72,567	54,102	1,349	20,992	29,719	178,729	-936	-0.53	5,668,908	5,664,420	4,489	0.08
Jan. 1952	19,044	26,622	6,683	733	113,483	166,565	63,639	50,254	1,316	20,110	32,307	167,626	-1,060	-0.63	5,835,474	5,832,045	3,428	0.06
Feb. 1952	17,080	22,198	6,562	5,034	99,615	150,490	39,673	47,440	1,083	20,978	41,926	151,101	-612	-0.41	5,985,963	5,983,146	2,817	0.05
Mar. 1952	20,333	25,020	9,912	21,432	100,853	177,551	38,618	58,513	1,534	25,047	53,970	177,681	-130	-0.07	6,163,514	6,160,827	2,687	0.04
Apr. 1952	51,933	54,709	7,002	45,025	93,496	252,165	64,942	86,846	3,695	31,759	63,359	250,601	1,564	0.62	6,415,680	6,411,428	4,251	0.07
May 1952	215,518	157,452	8,049	75,294	100,955	557,269	198,633	192,418	7,614	41,002	111,414	551,081	6,188	1.12	6,972,948	6,962,509	10,439	0.15
Jun. 1952	368,879	190,105	13,757	16,413	127,637	716,791	388,858	242,589	2,602	24,658	51,205	709,913	6,878	0.96	7,689,739	7,672,422	17,317	0.23

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jul. 1952	123,026	35,962	29,178	17,047	153,297	358,511	258,699	62,432	1,340	21,841	19,478	363,790	-5,280	-1.46	8,048,250	8,036,212	12,037	0.15
Aug. 1952	92,611	25,362	26,087	36,380	145,013	325,453	212,791	60,458	1,424	26,948	24,715	326,337	-884	-0.27	8,373,703	8,362,549	11,154	0.13
Sep. 1952	50,446	11,975	19,703	10,105	141,658	233,886	157,341	49,313	1,041	19,305	8,480	235,479	-1,593	-0.68	8,607,589	8,598,029	9,560	0.11
Oct. 1952	19,409	14,912	7,884	5,465	148,160	195,829	138,039	41,078	1,002	18,062	3,215	201,396	-5,566	-2.80	8,803,418	8,799,424	3,994	0.05
Nov. 1952	14,257	16,015	7,037	12,373	121,017	170,699	84,993	47,094	1,110	20,656	18,289	172,143	-1,444	-0.84	8,974,118	8,971,567	2,550	0.03
Dec. 1952	15,776	16,886	7,506	2,197	118,844	161,209	75,170	42,169	1,068	19,861	24,219	162,487	-1,278	-0.79	9,135,326	9,134,054	1,272	0.01
Jan. 1953	15,769	16,361	7,531	4,695	113,551	157,907	66,897	44,546	1,185	20,622	25,142	158,391	-484	-0.31	9,293,233	9,292,446	787	0.01
Feb. 1953	17,593	13,688	6,507	10,458	96,861	145,107	52,238	42,407	1,158	20,483	29,119	145,406	-299	-0.21	9,438,340	9,437,851	489	0.01
Mar. 1953	15,569	14,419	7,529	11,899	102,436	151,852	53,037	43,897	1,422	22,457	31,609	152,423	-571	-0.38	9,590,192	9,590,274	-82	0.00
Apr. 1953	18,127	14,983	7,563	34,577	96,955	172,205	58,966	46,319	1,746	27,274	37,631	171,937	268	0.16	9,762,396	9,762,211	185	0.00
May 1953	87,931	16,072	13,892	48,254	110,701	276,850	147,297	68,201	6,336	29,082	22,189	273,105	3,745	1.36	10,039,246	10,035,316	3,930	0.04
Jun. 1953	228,177	55,694	16,568	37,985	127,052	465,476	282,537	132,325	2,128	26,843	13,359	457,191	8,285	1.80	10,504,722	10,492,507	12,215	0.12
Jul. 1953	124,673	31,607	18,257	46,007	140,574	361,119	242,634	73,009	3,043	29,592	15,056	363,334	-2,215	-0.61	10,865,840	10,855,841	9,999	0.09
Aug. 1953	90,906	14,998	29,837	26,473	140,905	303,119	212,561	50,623	1,467	24,945	15,384	304,980	-1,861	-0.61	11,168,959	11,160,821	8,138	0.07
Sep. 1953	40,740	10,233	18,381	4,121	132,439	205,914	137,452	43,831	1,129	18,750	6,349	207,511	-1,597	-0.77	11,374,873	11,368,332	6,542	0.06
Oct. 1953	17,854	10,075	10,728	8,358	134,490	181,504	120,070	38,084	1,044	18,955	5,076	183,229	-1,725	-0.95	11,556,378	11,551,561	4,817	0.04
Nov. 1953	16,496	14,390	8,310	10,118	122,534	171,848	105,434	43,414	1,128	18,678	4,266	172,921	-1,073	-0.62	11,728,226	11,724,482	3,744	0.03
Dec. 1953	14,314	14,129	9,588	9,309	110,792	158,133	63,295	44,436	1,258	21,499	28,754	159,242	-1,109	-0.70	11,886,358	11,883,724	2,634	0.02
Jan. 1954	14,244	13,668	9,714	2,744	109,178	149,548	62,403	40,027	1,308	20,110	26,562	150,411	-863	-0.58	12,035,906	12,034,135	1,772	0.01
Feb. 1954	13,153	9,705	8,047	934	95,526	127,364	52,821	33,755	1,120	17,840	22,425	127,961	-596	-0.47	12,163,270	12,162,095	1,175	0.01
Mar. 1954	10,795	9,653	7,717	7,418	100,144	135,727	48,163	36,180	1,305	21,806	28,797	136,250	-523	-0.38	12,298,998	12,298,345	652	0.01
Apr. 1954	13,675	4,925	13,384	11,248	99,867	143,099	71,294	30,371	978	21,450	19,271	143,363	-264	-0.18	12,442,097	12,441,709	388	0.00
May 1954	92,762	6,872	14,568	19,144	114,827	248,173	165,426	40,420	1,168	23,940	12,861	243,815	4,358	1.77	12,690,270	12,685,523	4,746	0.04
Jun. 1954	85,348	9,912	22,001	14,749	112,152	244,163	164,009	39,796	1,087	23,381	14,801	243,073	1,090	0.45	12,934,432	12,928,597	5,836	0.05
Jul. 1954	69,118	15,571	14,878	35,378	107,984	242,929	155,893	33,452	2,371	32,298	20,445	244,459	-1,530	-0.63	13,177,361	13,173,055	4,306	0.03
Aug. 1954	51,669	8,851	15,045	21,898	109,824	207,288	138,673	26,907	2,440	28,780	11,686	208,486	-1,198	-0.58	13,384,649	13,381,541	3,108	0.02
Sep. 1954	20,705	4,582	13,679	22,506	101,111	162,583	92,075	31,901	1,073	25,352	12,462	162,864	-281	-0.17	13,547,231	13,544,405	2,827	0.02
Oct. 1954	18,580	7,280	7,798	5,427	106,153	145,237	86,263	32,917	884	19,559	6,096	145,719	-482	-0.33	13,692,468	13,690,124	2,344	0.02
Nov. 1954	11,593	8,037	7,978	4,899	96,711	129,217	68,720	37,079	889	19,558	3,875	130,121	-904	-0.70	13,821,685	13,820,245	1,440	0.01
Dec. 1954	9,625	9,992	6,718	6,090	95,262	127,687	61,097	34,790	952	21,006	10,730	128,573	-887	-0.69	13,949,372	13,948,818	553	0.00

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jan. 1955	9,038	9,956	6,940	3,882	90,767	120,584	47,587	33,433	990	21,114	17,941	121,065	-481	-0.40	14,069,956	14,069,883	73	0.00
Feb. 1955	8,248	9,382	6,149	7,193	80,808	111,780	38,609	31,241	972	19,791	21,353	111,965	-186	-0.17	14,181,735	14,181,848	-113	0.00
Mar. 1955	9,094	11,439	6,571	12,489	89,951	129,544	54,091	35,956	1,138	21,696	16,892	129,773	-229	-0.18	14,311,279	14,311,621	-342	0.00
Apr. 1955	15,706	7,159	10,558	7,967	87,211	128,601	62,961	29,457	992	21,089	13,983	128,483	118	0.09	14,439,880	14,440,104	-224	0.00
May 1955	89,156	8,848	15,563	51,092	96,115	260,774	152,975	44,833	6,966	29,210	22,695	256,679	4,095	1.58	14,700,654	14,696,783	3,871	0.03
Jun. 1955	133,028	22,695	7,354	43,887	99,828	306,791	181,516	70,566	2,694	30,242	17,864	302,881	3,910	1.28	15,007,446	14,999,665	7,781	0.05
Jul. 1955	62,108	12,912	20,958	39,658	102,040	237,676	144,440	40,982	1,406	30,793	22,199	239,819	-2,144	-0.90	15,245,121	15,239,484	5,637	0.04
Aug. 1955	75,552	19,425	13,736	44,784	101,015	254,512	165,330	39,293	1,708	33,485	15,378	255,194	-683	-0.27	15,499,633	15,494,678	4,955	0.03
Sep. 1955	36,163	8,045	10,015	36,563	105,949	196,735	125,982	36,542	1,462	26,240	6,849	197,075	-340	-0.17	15,696,368	15,691,753	4,614	0.03
Oct. 1955	14,905	9,828	7,470	8,780	107,387	148,370	96,248	32,405	997	18,965	1,845	150,458	-2,088	-1.40	15,844,738	15,842,212	2,526	0.02
Nov. 1955	11,983	12,562	6,441	8,429	90,134	129,548	60,718	37,013	1,232	20,589	10,983	130,536	-987	-0.76	15,974,286	15,972,748	1,538	0.01
Dec. 1955	10,856	11,701	6,707	2,440	93,003	124,707	56,505	34,073	1,225	19,241	14,607	125,650	-943	-0.75	16,098,993	16,098,397	595	0.00
Jan. 1956	8,905	9,581	7,026	5,735	89,761	121,008	47,226	33,504	1,219	20,278	19,353	121,580	-572	-0.47	16,220,001	16,219,978	23	0.00
Feb. 1956	8,553	8,434	6,483	10,506	82,128	116,104	42,686	32,087	1,227	19,746	20,695	116,441	-337	-0.29	16,336,105	16,336,419	-313	0.00
Mar. 1956	18,816	9,551	6,943	10,178	85,265	130,754	53,706	33,944	1,324	21,477	20,362	130,813	-59	-0.05	16,466,860	16,467,232	-373	0.00
Apr. 1956	17,127	7,438	7,003	16,652	82,525	130,746	56,939	34,043	1,400	22,432	15,335	130,149	597	0.46	16,597,605	16,597,381	224	0.00
May 1956	166,174	29,311	11,614	36,234	93,635	336,969	193,179	85,144	1,778	27,862	20,888	328,851	8,118	2.44	16,934,574	16,926,232	8,342	0.05
Jun. 1956	195,625	44,644	9,182	22,492	109,543	381,486	248,760	97,431	1,149	22,802	8,284	378,426	3,060	0.81	17,316,061	17,304,658	11,403	0.07
Jul. 1956	70,898	18,238	16,294	61,678	110,349	277,456	166,424	48,933	1,930	37,109	26,305	280,703	-3,246	-1.16	17,593,517	17,585,361	8,156	0.05
Aug. 1956	51,754	14,486	13,349	35,477	113,967	229,033	160,630	35,813	2,852	24,424	6,962	230,682	-1,649	-0.72	17,822,550	17,816,042	6,508	0.04
Sep. 1956	24,603	6,679	17,681	2,293	103,014	154,270	100,883	25,998	967	18,624	9,569	156,042	-1,772	-1.14	17,976,820	17,972,084	4,735	0.03
Oct. 1956	13,030	8,238	7,049	4,538	105,134	137,988	89,795	30,799	971	17,564	1,608	140,737	-2,749	-1.97	18,114,808	18,112,822	1,986	0.01
Nov. 1956	11,186	13,282	6,149	12,620	89,267	132,503	49,089	39,658	1,062	21,260	22,038	133,107	-604	-0.46	18,247,311	18,245,929	1,382	0.01
Dec. 1956	9,184	13,071	6,595	6,861	94,621	130,332	67,384	35,607	1,003	18,848	8,527	131,368	-1,036	-0.79	18,377,643	18,377,297	345	0.00
Jan. 1957	9,001	10,465	6,829	4,541	86,497	117,334	40,136	34,220	1,098	20,314	22,063	117,830	-497	-0.42	18,494,976	18,495,127	-151	0.00
Feb. 1957	11,001	9,652	6,134	7,879	79,600	114,266	52,219	31,910	1,088	17,615	11,677	114,508	-242	-0.21	18,609,242	18,609,636	-394	0.00
Mar. 1957	10,014	9,859	6,843	11,018	84,147	121,880	47,192	34,480	1,181	20,883	18,538	122,275	-394	-0.32	18,731,123	18,731,910	-788	0.00
Apr. 1957	56,762	21,710	7,473	78,721	78,420	243,086	104,722	71,426	5,775	37,057	21,155	240,136	2,950	1.22	18,974,208	18,972,046	2,162	0.01
May 1957	305,038	184,462	8,735	133,276	67,770	699,281	205,237	233,413	21,416	69,511	162,549	692,126	7,155	1.03	19,673,489	19,664,172	9,317	0.05
Jun. 1957	441,259	220,107	8,473	30,307	90,722	790,870	331,299	270,073	8,826	38,513	136,316	785,027	5,842	0.74	20,464,359	20,449,200	15,159	0.07

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jul. 1957	305,709	128,633	10,067	33,091	135,862	613,362	410,759	129,730	3,225	29,346	40,291	613,352	10	0.00	21,077,721	21,062,552	15,169	0.07
Aug. 1957	147,243	40,568	25,949	48,559	143,174	405,493	288,466	67,820	3,079	27,039	21,716	408,119	-2,625	-0.65	21,483,214	21,470,670	12,544	0.06
Sep. 1957	63,769	19,354	12,178	12,853	146,111	254,266	188,879	47,982	1,503	18,431	2,289	259,084	-4,819	-1.88	21,737,480	21,729,755	7,725	0.04
Oct. 1957	45,950	31,958	18,563	38,335	120,780	255,586	132,682	64,613	2,371	25,943	31,486	257,096	-1,510	-0.59	21,993,065	21,986,851	6,215	0.03
Nov. 1957	33,979	38,438	7,422	8,061	111,397	199,296	85,463	59,195	1,700	19,043	35,918	201,319	-2,022	-1.01	22,192,362	22,188,169	4,193	0.02
Dec. 1957	24,266	30,777	7,344	2,288	113,586	178,260	88,263	50,092	1,523	17,883	22,253	180,014	-1,754	-0.98	22,370,622	22,368,183	2,439	0.01
Jan. 1958	21,714	23,304	11,919	6,607	98,217	161,761	25,367	46,994	1,563	22,902	65,927	162,752	-991	-0.61	22,532,383	22,530,935	1,447	0.01
Feb. 1958	22,179	21,079	6,729	8,689	88,186	146,863	30,679	44,659	1,720	20,005	50,090	147,152	-290	-0.20	22,679,246	22,678,088	1,158	0.01
Mar. 1958	25,876	24,816	9,386	18,611	92,249	170,938	29,918	53,344	2,194	24,433	61,203	171,092	-153	-0.09	22,850,184	22,849,179	1,005	0.00
Apr. 1958	51,539	34,525	7,200	42,251	81,510	217,027	44,136	66,304	2,833	31,108	71,432	215,812	1,214	0.56	23,067,210	23,064,991	2,219	0.01
May 1958	332,712	277,953	8,656	87,319	71,758	778,398	149,919	249,905	8,470	67,796	293,924	770,015	8,383	1.08	23,845,608	23,835,006	10,602	0.04
Jun. 1958	253,211	107,861	9,259	43,180	123,135	536,646	315,101	135,229	2,637	27,754	54,143	534,864	1,782	0.33	24,382,255	24,369,871	12,384	0.05
Jul. 1958	80,304	23,601	21,118	57,457	148,847	331,327	244,391	39,374	1,701	30,536	19,444	335,446	-4,119	-1.24	24,713,581	24,705,316	8,265	0.03
Aug. 1958	57,920	25,693	33,862	21,905	142,032	281,412	225,107	30,161	1,296	21,521	6,328	284,412	-3,000	-1.06	24,994,993	24,989,728	5,265	0.02
Sep. 1958	36,926	11,907	16,086	27,246	130,303	222,467	159,108	31,571	1,105	23,714	7,876	223,374	-907	-0.41	25,217,460	25,213,103	4,357	0.02
Oct. 1958	19,399	17,116	8,202	10,207	125,408	180,333	116,423	42,129	1,157	19,235	3,343	182,286	-1,954	-1.08	25,397,793	25,395,389	2,404	0.01
Nov. 1958	13,767	19,026	7,958	7,356	112,721	160,828	83,559	42,615	1,259	18,863	15,837	162,134	-1,306	-0.81	25,558,621	25,557,523	1,098	0.00
Dec. 1958	20,292	19,202	9,210	8,279	110,031	167,014	82,106	43,992	1,358	20,155	20,048	167,659	-645	-0.39	25,725,635	25,725,182	453	0.00
Jan. 1959	17,158	17,041	8,378	12,690	104,451	159,719	70,665	43,571	1,174	21,174	23,901	160,485	-766	-0.48	25,885,353	25,885,667	-314	0.00
Feb. 1959	19,522	16,627	7,236	12,885	90,717	146,987	59,306	42,968	1,673	19,560	23,487	146,994	-7	0.00	26,032,341	26,032,661	-320	0.00
Mar. 1959	19,361	20,709	8,258	23,947	94,117	166,392	54,213	49,817	2,375	24,554	35,697	166,656	-264	-0.16	26,198,733	26,199,317	-584	0.00
Apr. 1959	55,549	35,091	7,570	28,538	82,170	208,918	45,470	62,052	7,744	29,567	62,389	207,222	1,696	0.82	26,407,651	26,406,539	1,112	0.00
May 1959	126,453	62,874	8,768	73,520	95,143	366,758	160,376	89,179	9,168	38,350	66,268	363,342	3,417	0.94	26,774,409	26,769,881	4,529	0.02
Jun. 1959	227,567	69,254	12,972	18,437	121,398	449,629	299,795	108,045	2,118	22,646	11,381	443,985	5,643	1.26	27,224,038	27,213,866	10,172	0.04
Jul. 1959	92,287	29,207	32,965	18,868	138,322	311,650	255,187	30,305	1,285	23,150	5,213	315,140	-3,491	-1.11	27,535,688	27,529,006	6,681	0.02
Aug. 1959	79,892	27,102	32,460	13,398	131,072	283,924	225,614	27,130	1,223	23,473	7,593	285,033	-1,109	-0.39	27,819,611	27,814,039	5,573	0.02
Sep. 1959	42,030	18,580	17,803	40,722	119,816	238,950	152,469	45,847	1,624	26,695	11,475	238,110	841	0.35	28,058,562	28,052,149	6,413	0.02
Oct. 1959	40,003	28,883	10,868	49,829	115,299	244,881	134,098	66,691	1,943	29,286	13,629	245,647	-766	-0.31	28,303,443	28,297,795	5,648	0.02
Nov. 1959	25,882	26,263	7,391	3,948	114,413	177,896	99,936	49,908	1,324	17,958	10,865	179,992	-2,096	-1.17	28,481,339	28,477,787	3,552	0.01
Dec. 1959	21,237	23,975	10,209	2,166	106,402	163,989	71,274	46,945	1,461	20,243	25,234	165,158	-1,168	-0.71	28,645,329	28,642,945	2,384	0.01

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jan. 1960	12,103	16,990	7,849	7,741	99,015	143,698	44,046	41,374	1,363	22,136	35,836	144,755	-1,057	-0.73	28,789,027	28,787,700	1,326	0.00
Feb. 1960	15,628	17,662	6,890	18,029	90,621	148,830	53,043	44,685	1,621	21,311	28,199	148,859	-29	-0.02	28,937,856	28,936,559	1,297	0.00
Mar 1960	63,468	34,064	8,157	10,172	88,019	203,881	68,827	61,721	10,133	25,118	37,908	203,706	174	0.09	29,141,737	29,140,265	1,471	0.01
Apr. 1960	67,744	19,488	8,002	36,568	88,916	220,717	83,595	52,228	11,457	29,090	43,696	220,066	651	0.30	29,362,454	29,360,332	2,123	0.01
May 1960	174,631	50,575	8,972	48,968	112,457	395,603	234,307	92,916	16,679	30,695	15,704	390,302	5,301	1.35	29,758,057	29,750,633	7,424	0.02
Jun. 1960	232,082	56,513	13,589	20,115	127,877	450,176	296,878	118,844	3,923	23,065	3,528	446,238	3,938	0.88	30,208,233	30,196,871	11,362	0.04
Jul. 1960	99,895	27,365	32,258	33,841	136,388	329,748	250,345	40,205	2,010	28,473	12,101	333,134	-3,386	-1.02	30,537,981	30,530,005	7,976	0.03
Aug. 1960	66,891	17,527	30,641	5,862	131,653	252,574	199,517	25,954	1,225	21,138	8,377	256,212	-3,638	-1.43	30,790,555	30,786,217	4,338	0.01
Sep. 1960	40,499	12,324	14,947	16,496	118,204	202,469	136,446	34,287	1,175	22,627	8,084	202,619	-150	-0.07	30,993,024	30,988,836	4,188	0.01
Oct. 1960	20,400	19,044	9,350	43,910	125,714	218,417	135,427	54,782	2,017	25,686	2,189	220,100	-1,683	-0.77	31,211,441	31,208,937	2,505	0.01
Nov. 1960	16,635	20,321	7,950	3,581	103,599	152,086	74,061	45,862	1,774	20,505	11,614	153,816	-1,730	-1.13	31,363,527	31,362,752	775	0.00
Dec. 1960	18,379	19,883	7,965	13,607	103,786	163,619	67,657	48,851	1,920	22,468	23,329	164,225	-606	-0.37	31,527,146	31,526,978	169	0.00
Jan. 1961	30,472	18,554	7,848	1,383	101,551	159,809	69,953	43,474	1,865	20,466	24,778	160,536	-728	-0.45	31,686,955	31,687,514	-559	0.00
Feb. 1961	19,115	15,594	6,716	6,684	89,262	137,371	57,306	38,826	1,998	19,288	20,485	137,901	-530	-0.39	31,824,326	31,825,416	-1,089	0.00
Mar. 1961	24,778	20,293	7,497	28,536	92,927	174,031	75,159	50,800	3,109	25,711	19,087	173,866	165	0.09	31,998,357	31,999,281	-924	0.00
Apr. 1961	36,393	17,021	7,413	17,969	90,596	169,392	64,847	48,167	5,290	25,108	25,553	168,965	427	0.25	32,167,749	32,168,246	-497	0.00
May 1961	170,829	88,123	8,626	86,958	91,877	446,413	174,632	132,567	11,991	43,266	76,698	439,154	7,259	1.64	32,614,162	32,607,400	6,761	0.02
Jun. 1961	254,807	232,245	9,239	36,219	91,207	623,717	222,191	193,668	3,883	44,522	155,532	619,796	3,921	0.63	33,237,879	33,227,197	10,682	0.03
Jul. 1961	96,511	27,365	19,833	58,656	146,474	348,840	247,513	45,750	3,620	29,177	25,620	351,680	-2,840	-0.81	33,586,719	33,578,876	7,842	0.02
Aug. 1961	103,662	26,497	29,528	41,946	143,691	345,324	258,833	44,070	3,914	27,447	11,089	345,354	-30	-0.01	33,932,043	33,924,231	7,812	0.02
Sep. 1961	88,839	44,659	10,222	81,733	121,991	347,443	169,053	94,150	4,398	35,063	43,070	345,734	1,710	0.49	34,279,487	34,269,964	9,522	0.03
Oct. 1961	65,373	72,328	9,089	13,376	110,529	270,696	92,485	86,099	2,669	26,048	65,758	273,059	-2,363	-0.87	34,550,183	34,543,023	7,159	0.02
Nov. 1961	47,493	62,479	10,510	6,833	107,406	234,720	81,949	68,919	2,474	21,679	61,790	236,811	-2,091	-0.89	34,784,902	34,779,834	5,068	0.01
Dec. 1961	31,783	43,056	10,028	2,898	106,431	194,196	37,371	56,053	2,111	22,543	77,715	195,793	-1,597	-0.82	34,979,099	34,975,628	3,471	0.01
Jan. 1962	28,386	35,755	10,193	11,721	101,351	187,406	24,877	56,836	2,162	23,886	80,217	187,978	-572	-0.30	35,166,505	35,163,605	2,899	0.01
Feb. 1962	34,835	45,684	7,322	8,071	89,650	185,562	53,187	52,481	2,524	20,703	56,914	185,809	-248	-0.13	35,352,066	35,349,415	2,652	0.01
Mar. 1962	31,465	40,800	7,888	4,738	96,723	181,614	41,292	49,955	2,519	22,801	65,942	182,510	-896	-0.49	35,533,680	35,531,925	1,755	0.00
Apr. 1962	89,842	35,002	8,350	15,829	94,348	243,371	112,155	56,482	7,404	23,852	41,951	241,844	1,528	0.63	35,777,051	35,773,769	3,283	0.01
May 1962	162,664	27,493	9,418	44,532	121,804	365,911	231,569	70,014	3,377	28,464	27,007	360,431	5,480	1.51	36,142,962	36,134,200	8,762	0.02
Jun. 1962	176,839	65,165	9,549	67,099	113,047	431,698	202,741	120,065	2,456	37,335	65,422	428,020	3,679	0.86	36,574,661	36,562,219	12,441	0.03

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jul. 1962	127,055	76,095	12,375	42,901	141,252	399,677	291,591	52,297	1,980	26,209	28,510	400,588	-910	-0.23	36,974,338	36,962,807	11,531	0.03
Aug. 1962	65,410	27,485	41,248	15,869	148,154	298,166	238,056	31,356	1,437	20,908	8,709	300,467	-2,300	-0.77	37,272,504	37,263,273	9,231	0.02
Sep. 1962	33,722	21,021	19,372	7,620	140,055	221,790	168,686	34,989	1,275	17,731	1,126	223,808	-2,018	-0.91	37,494,294	37,487,081	7,213	0.02
Oct. 1962	24,584	25,097	9,667	14,688	122,533	196,569	101,019	50,791	1,607	22,091	21,768	197,275	-706	-0.36	37,690,863	37,684,356	6,507	0.02
Nov. 1962	19,004	22,519	8,298	7,875	121,623	179,319	95,275	50,924	1,273	18,211	15,265	180,948	-1,629	-0.90	37,870,183	37,865,304	4,879	0.01
Dec. 1962	18,904	23,489	8,280	1,989	111,507	164,168	70,651	47,427	1,346	19,780	26,246	165,451	-1,282	-0.78	38,034,351	38,030,755	3,596	0.01
Jan. 1963	10,373	20,204	8,235	8,381	103,782	150,974	52,016	42,367	1,476	21,585	34,768	152,213	-1,239	-0.82	38,185,325	38,182,968	2,357	0.01
Feb. 1963	14,310	19,476	6,896	3,027	93,641	137,350	51,989	37,536	1,569	18,329	28,264	137,686	-336	-0.24	38,322,675	38,320,654	2,021	0.01
Mar. 1963	17,946	18,760	10,810	17,323	93,144	157,983	28,078	47,812	1,832	25,060	55,287	158,069	-85	-0.05	38,480,658	38,478,723	1,935	0.01
Apr. 1963	18,665	9,593	13,534	6,390	103,042	151,224	78,605	31,631	1,209	20,081	20,018	151,544	-320	-0.21	38,631,882	38,630,267	1,616	0.00
May 1963	87,793	8,192	24,580	14,959	119,052	254,576	184,260	31,405	1,042	21,620	12,553	250,881	3,695	1.46	38,886,458	38,881,147	5,311	0.01
Jun. 1963	96,027	29,743	12,363	73,968	107,235	319,336	185,882	76,783	2,116	33,907	16,997	315,686	3,650	1.15	39,205,795	39,196,834	8,961	0.02
Jul. 1963	55,683	11,403	30,797	23,081	120,209	241,174	172,905	25,460	1,093	27,398	17,691	244,547	-3,373	-1.39	39,446,968	39,441,380	5,588	0.01
Aug. 1963	65,842	20,067	19,319	64,750	116,336	286,315	190,358	41,712	1,705	36,316	15,173	285,264	1,051	0.37	39,733,283	39,726,644	6,639	0.02
Sep. 1963	56,840	20,038	13,321	47,346	115,574	253,119	155,038	53,594	1,617	31,514	10,651	252,413	706	0.28	39,986,402	39,979,057	7,345	0.02
Oct. 1963	19,842	14,736	9,883	9,870	122,282	176,612	117,356	42,088	1,019	19,347	2,915	182,725	-6,113	-3.40	40,163,014	40,161,783	1,232	0.00
Nov. 1963	16,927	18,678	8,653	4,141	100,998	149,398	62,780	44,834	935	20,443	21,424	150,416	-1,018	-0.68	40,312,413	40,312,199	214	0.00
Dec. 1963	16,653	18,879	8,819	5,615	100,608	150,575	54,826	42,773	1,071	21,159	31,649	151,477	-902	-0.60	40,462,988	40,463,676	-688	0.00
Jan. 1964	13,534	17,000	9,095	3,319	100,267	143,214	57,682	38,335	1,130	19,917	27,109	144,172	-959	-0.67	40,606,201	40,607,848	-1,647	0.00
Feb. 1964	12,009	13,700	8,492	9,110	91,288	134,599	53,712	36,669	1,260	20,032	23,267	134,939	-339	-0.25	40,740,801	40,742,787	-1,986	0.00
Mar. 1964	19,144	14,663	10,345	13,936	92,720	150,808	59,766	43,046	2,264	22,602	23,230	150,908	-100	-0.07	40,891,608	40,893,694	-2,086	-0.01
Apr. 1964	24,222	16,879	9,486	29,709	87,016	167,311	68,388	44,478	4,171	26,895	22,942	166,874	437	0.26	41,058,920	41,060,568	-1,649	0.00
May 1964	106,798	17,877	16,985	47,037	103,800	292,497	181,043	51,512	2,668	32,280	20,683	288,186	4,312	1.49	41,351,417	41,348,754	2,663	0.01
Jun. 1964	131,834	22,556	10,195	29,628	117,515	311,729	215,280	66,565	1,914	26,078	3,318	313,154	-1,426	-0.46	41,663,146	41,661,909	1,237	0.00
Jul. 1964	94,612	17,558	30,260	20,143	117,999	280,572	213,802	30,904	1,412	27,740	8,219	282,077	-1,505	-0.54	41,943,718	41,943,986	-268	0.00
Aug. 1964	61,341	13,596	26,258	14,793	112,861	228,849	162,578	27,031	1,223	28,121	11,234	230,187	-1,338	-0.58	42,172,566	42,174,172	-1,606	0.00
Sep. 1964	25,454	9,669	12,911	11,005	105,630	164,669	105,507	26,291	1,094	24,163	8,749	165,804	-1,135	-0.69	42,337,236	42,339,976	-2,741	-0.01
Oct. 1964	11,246	13,385	9,524	3,478	109,244	146,877	97,306	30,366	986	18,349	1,474	148,481	-1,604	-1.09	42,484,112	42,488,457	-4,345	-0.01
Nov. 1964	11,944	16,316	8,467	9,080	100,252	146,059	81,641	40,279	1,177	19,156	3,750	146,003	57	0.04	42,630,172	42,634,460	-4,288	-0.01
Dec. 1964	12,855	15,904	8,907	4,131	94,586	136,382	63,080	39,277	1,171	20,901	12,721	137,150	-769	-0.56	42,766,553	42,771,610	-5,057	-0.01

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jan. 1965	11,713	13,920	8,621	9,203	93,414	136,871	63,660	38,101	1,194	21,269	13,296	137,520	-649	-0.47	42,903,424	42,909,130	-5,705	-0.01
Feb. 1965	11,039	13,053	7,509	9,730	81,916	123,247	50,763	34,693	1,175	19,884	16,987	123,503	-256	-0.21	43,026,671	43,032,633	-5,961	-0.01
Mar. 1965	12,861	14,102	8,668	12,028	89,893	137,553	64,102	38,460	1,573	21,618	12,118	137,871	-318	-0.23	43,164,224	43,170,503	-6,279	-0.01
Apr. 1965	29,290	13,612	11,369	24,477	84,458	163,205	83,799	41,633	1,965	23,865	11,271	162,533	672	0.41	43,327,429	43,333,037	-5,607	-0.01
May. 1965	107,038	16,760	16,446	50,000	101,994	292,238	185,506	54,695	2,531	31,774	13,067	287,574	4,664	1.61	43,619,667	43,620,611	-944	0.00
Jun. 1965	401,171	227,995	10,484	98,307	78,452	816,410	306,115	232,519	36,774	68,827	163,777	808,013	8,397	1.03	44,436,076	44,428,623	7,453	0.02
Jul. 1965	250,366	119,104	12,052	92,722	114,214	588,458	267,072	148,126	6,017	45,046	121,677	587,939	520	0.09	45,024,535	45,016,562	7,973	0.02
Aug. 1965	176,026	84,626	18,306	23,296	128,466	430,720	269,497	84,270	4,623	27,198	47,602	433,189	-2,469	-0.57	45,455,255	45,449,751	5,504	0.01
Sep. 1965	66,801	30,500	22,981	54,832	122,740	297,854	148,104	65,379	3,629	28,334	53,451	298,897	-1,043	-0.35	45,753,109	45,748,648	4,461	0.01
Oct. 1965	40,087	34,596	12,172	14,481	110,714	212,050	66,695	56,801	2,500	24,511	64,010	214,517	-2,467	-1.16	45,965,159	45,963,165	1,994	0.00
Nov. 1965	25,816	24,689	8,186	2,800	108,119	169,610	54,767	51,038	1,776	18,138	45,782	171,500	-1,890	-1.11	46,134,769	46,134,664	104	0.00
Dec. 1965	19,600	26,487	11,099	6,473	104,917	168,576	46,226	44,196	1,911	21,132	56,700	170,165	-1,588	-0.94	46,303,345	46,304,829	-1,484	0.00
Jan. 1966	17,741	26,187	10,534	2,398	97,279	154,140	22,813	42,701	1,814	21,637	65,761	154,727	-587	-0.38	46,457,485	46,459,556	-2,071	0.00
Feb. 1966	17,380	22,479	6,738	10,283	84,682	141,561	22,328	41,652	2,021	20,187	55,615	141,802	-241	-0.17	46,599,045	46,601,358	-2,313	0.00
Mar. 1966	21,582	19,839	8,297	2,983	99,588	152,289	62,319	41,847	2,421	19,609	26,713	152,908	-619	-0.41	46,751,335	46,754,266	-2,932	-0.01
Apr. 1966	21,460	11,586	8,694	24,088	94,506	160,332	70,798	37,009	2,778	24,621	25,175	160,381	-49	-0.03	46,911,667	46,914,647	-2,980	-0.01
May 1966	79,378	7,615	25,018	9,410	109,979	231,399	156,670	38,102	2,088	20,946	10,390	228,196	3,203	1.39	47,143,066	47,142,843	223	0.00
Jun. 1966	87,394	17,480	12,361	45,568	103,703	266,506	157,576	53,525	1,597	30,792	20,351	263,839	2,667	1.01	47,409,572	47,406,683	2,890	0.01
Jul. 1966	67,150	14,956	28,379	26,860	110,601	247,946	173,389	27,353	1,879	30,457	16,884	249,962	-2,016	-0.81	47,657,518	47,656,645	873	0.00
Aug. 1966	61,797	13,462	26,483	32,938	108,648	243,328	163,524	30,816	1,294	32,142	15,600	243,375	-47	-0.02	47,900,846	47,900,020	826	0.00
Sep. 1966	31,952	19,238	12,383	43,746	103,918	211,237	122,362	43,798	1,429	32,180	11,318	211,086	151	0.07	48,112,083	48,111,106	977	0.00
Oct. 1966	18,824	14,909	10,564	16,069	111,510	171,876	106,925	39,158	1,290	22,326	3,438	173,137	-1,261	-0.73	48,283,959	48,284,243	-285	0.00
Nov. 1966	13,148	14,607	11,187	4,413	99,322	142,677	78,460	39,185	1,159	18,622	6,325	143,751	-1,074	-0.75	48,426,635	48,427,994	-1,358	0.00
Dec. 1966	10,939	14,994	12,777	1,484	94,912	135,106	57,645	35,888	1,172	20,809	20,509	136,023	-917	-0.68	48,561,742	48,564,017	-2,275	0.00
Jan. 1967	11,997	14,006	12,444	7,962	92,545	138,954	60,549	37,643	1,328	21,346	18,474	139,341	-387	-0.28	48,700,696	48,703,358	-2,662	-0.01
Feb. 1967	10,156	11,053	9,651	3,612	83,760	118,231	52,474	31,983	1,163	18,266	14,804	118,691	-460	-0.39	48,818,927	48,822,049	-3,122	-0.01
Mar. 1967	9,537	10,843	10,756	7,375	88,126	126,637	55,300	34,955	1,143	21,610	13,913	126,921	-284	-0.22	48,945,563	48,948,969	-3,406	-0.01
Apr. 1967	19,574	13,818	11,897	62,003	88,095	195,386	98,029	53,408	2,485	31,595	8,508	194,025	1,361	0.70	49,140,950	49,142,995	-2,045	0.00
May 1967	77,332	14,395	11,967	94,690	96,278	294,663	145,453	73,780	3,671	42,248	26,005	291,158	3,505	1.20	49,435,612	49,434,152	1,460	0.00
Jun. 1967	166,431	99,007	12,534	93,112	89,641	460,726	218,235	135,734	5,116	43,403	53,763	456,251	4,475	0.98	49,896,338	49,890,403	5,935	0.01

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jul. 1967	125,432	91,372	14,592	68,918	104,765	405,079	228,813	92,336	4,645	38,414	42,192	406,400	-1,321	-0.33	50,301,417	50,296,803	4,614	0.01
Aug. 1967	77,258	25,288	43,714	25,464	130,531	302,255	231,174	35,372	1,934	24,064	11,009	303,553	-1,298	-0.43	50,603,672	50,600,357	3,316	0.01
Sep. 1967	46,046	19,010	21,974	15,550	120,772	223,352	159,704	37,257	1,260	21,381	4,424	224,027	-675	-0.30	50,827,024	50,824,384	2,640	0.01
Oct. 1967	24,684	20,033	12,296	16,923	121,217	195,154	131,562	44,032	1,536	19,957	1,719	198,806	-3,652	-1.85	51,022,178	51,023,190	-1,012	0.00
Nov. 1967	21,960	21,662	5,785	9,934	104,027	163,369	85,051	48,552	1,646	19,994	8,915	164,158	-789	-0.48	51,185,547	51,187,348	-1,801	0.00
Dec. 1967	17,438	19,145	5,925	10,626	97,913	151,047	55,129	45,789	1,544	22,669	26,970	152,099	-1,052	-0.69	51,336,593	51,339,447	-2,854	-0.01
Jan. 1968	20,976	19,469	6,495	3,574	94,756	145,270	49,857	42,717	1,550	21,472	30,378	145,974	-704	-0.48	51,481,863	51,485,421	-3,558	-0.01
Feb. 1968	23,753	20,003	6,975	8,306	89,918	148,954	62,465	43,987	1,826	19,616	21,092	148,986	-32	-0.02	51,630,817	51,634,406	-3,590	-0.01
Mar. 1968	22,283	18,086	8,676	8,750	90,010	147,806	51,003	44,281	2,059	22,633	28,124	148,100	-294	-0.20	51,778,623	51,782,506	-3,883	-0.01
Apr. 1968	22,228	13,066	14,462	34,856	89,757	174,368	76,950	48,495	3,562	26,594	18,390	173,992	377	0.22	51,952,991	51,956,498	-3,507	-0.01
May 1968	86,574	13,286	12,811	40,475	106,784	259,930	152,314	56,751	5,728	28,505	13,287	256,585	3,345	1.30	52,212,921	52,213,083	-162	0.00
Jun. 1968	188,859	50,455	18,685	18,014	111,882	387,896	249,735	98,363	1,544	24,766	7,160	381,567	6,329	1.64	52,600,817	52,594,650	6,167	0.01
Jul. 1968	111,912	24,425	32,347	31,079	125,055	324,817	233,134	47,515	1,620	29,902	14,278	326,449	-1,632	-0.50	52,925,634	52,921,099	4,535	0.01
Aug. 1968	86,764	19,277	25,025	47,073	126,160	304,300	216,166	41,308	1,917	29,473	16,756	305,620	-1,320	-0.43	53,229,934	53,226,719	3,215	0.01
Sep. 1968	40,950	19,085	15,762	9,122	122,600	207,519	153,279	37,968	1,143	18,809	730	211,929	-4,410	-2.10	53,437,453	53,438,648	-1,195	0.00
Oct. 1968	26,098	21,665	10,476	14,425	118,926	191,590	125,264	44,036	1,255	20,983	1,481	193,019	-1,430	-0.74	53,629,043	53,631,668	-2,625	0.00
Nov. 1968	14,616	18,161	7,378	9,188	103,519	152,862	79,772	42,889	1,411	20,585	9,674	154,329	-1,467	-0.96	53,781,904	53,785,997	-4,092	-0.01
Dec. 1968	14,386	15,274	7,544	4,342	99,487	141,033	57,176	39,506	1,289	21,523	22,807	142,302	-1,269	-0.90	53,922,938	53,928,299	-5,361	-0.01
Jan. 1969	16,138	15,483	6,874	2,217	99,403	140,116	65,016	38,297	1,174	19,990	16,251	140,727	-611	-0.44	54,063,054	54,069,026	-5,973	-0.01
Feb. 1969	15,496	12,150	6,452	3,436	88,003	125,537	58,093	35,291	1,131	18,447	12,828	125,789	-252	-0.20	54,188,591	54,194,816	-6,225	-0.01
Mar. 1969	15,597	14,142	6,677	9,634	89,183	135,233	52,975	38,640	1,547	23,132	19,480	135,773	-540	-0.40	54,323,824	54,330,589	-6,765	-0.01
Apr. 1969	21,650	9,709	9,062	25,986	90,628	157,036	76,151	41,624	2,748	25,276	10,468	156,268	768	0.49	54,480,860	54,486,856	-5,997	-0.01
May 1969	332,177	116,879	12,935	108,310	77,496	647,798	217,262	183,113	22,380	63,230	152,967	638,953	8,845	1.37	55,128,657	55,125,809	2,848	0.01
Jun. 1969	356,968	207,990	15,289	62,361	84,760	727,368	220,725	226,068	6,734	54,679	216,226	724,432	2,935	0.40	55,856,025	55,850,241	5,784	0.01
Jul. 1969	143,110	36,807	34,409	38,909	150,827	404,062	305,065	58,308	2,685	28,580	11,933	406,572	-2,510	-0.62	56,260,087	56,256,813	3,274	0.01
Aug. 1969	77,152	18,006	38,219	29,420	135,643	298,440	229,033	32,944	1,849	26,986	10,257	301,069	-2,628	-0.88	56,558,528	56,557,882	646	0.00
Sep. 1969	48,058	16,796	14,452	23,726	125,087	228,120	157,226	43,598	1,365	23,863	2,289	228,341	-221	-0.10	56,786,647	56,786,223	425	0.00
Oct. 1969	51,902	40,665	16,299	91,421	111,568	311,855	170,399	86,571	3,841	37,271	12,731	310,813	1,042	0.33	57,098,502	57,097,036	1,466	0.00
Nov. 1969	59,091	43,226	15,343	7,329	104,042	229,031	109,150	59,833	4,570	22,046	35,341	230,940	-1,908	-0.83	57,327,533	57,327,975	-442	0.00
Dec. 1969	36,085	36,332	15,384	3,943	99,131	190,875	54,195	53,639	3,298	23,622	57,157	191,911	-1,036	-0.54	57,518,408	57,519,886	-1,478	0.00

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jan. 1970	29,666	31,351	15,169	944	96,260	173,389	23,833	49,672	2,650	23,397	74,502	174,054	-664	-0.38	57,691,798	57,693,940	-2,142	0.00
Feb. 1970	22,619	24,596	11,779	512	86,443	145,949	26,342	40,387	2,100	19,933	57,852	146,613	-664	-0.45	57,837,746	57,840,553	-2,807	0.00
Mar. 1970	28,281	23,719	13,330	25,970	93,707	185,007	55,392	55,202	3,265	24,552	46,453	184,864	143	0.08	58,022,753	58,025,417	-2,663	0.00
Apr. 1970	98,919	52,122	15,997	23,835	74,791	265,665	23,796	71,356	7,022	37,793	124,626	264,592	1,073	0.40	58,288,418	58,290,009	-1,591	0.00
May 1970	291,605	44,204	15,651	28,323	88,464	468,248	206,577	100,984	8,270	35,466	111,732	463,029	5,218	1.12	58,756,666	58,753,038	3,627	0.01
Jun. 1970	364,277	196,864	17,206	66,086	88,633	733,066	237,704	201,935	3,944	51,345	232,633	727,561	5,505	0.75	59,489,732	59,480,599	9,132	0.02
Jul. 1970	185,639	52,267	22,660	36,212	153,233	450,011	344,236	71,205	2,442	24,479	9,279	451,641	-1,630	-0.36	59,939,743	59,932,241	7,502	0.01
Aug. 1970	91,706	26,644	31,471	17,756	150,571	318,147	262,369	35,151	1,665	23,395	2,353	324,933	-6,786	-2.11	60,257,890	60,257,174	716	0.00
Sep. 1970	44,376	23,126	23,194	44,197	126,031	260,924	171,289	56,596	1,940	25,050	5,473	260,348	576	0.22	60,518,814	60,517,522	1,292	0.00
Oct. 1970	36,649	30,699	15,786	21,004	118,853	222,990	119,910	60,966	2,126	23,629	18,392	225,022	-2,032	-0.91	60,741,804	60,742,544	-740	0.00
Nov. 1970	35,828	39,345	14,059	10,541	105,100	204,873	85,786	62,327	2,253	21,431	33,840	205,638	-765	-0.37	60,946,677	60,948,182	-1,504	0.00
Dec. 1970	30,730	33,601	15,998	1,809	105,502	187,640	68,036	54,920	2,173	20,646	42,944	188,719	-1,079	-0.57	61,134,317	61,136,901	-2,584	0.00
Jan. 1971	24,367	27,906	15,246	5,751	99,036	172,305	41,675	49,650	2,031	22,713	57,150	173,219	-913	-0.53	61,306,623	61,310,120	-3,497	-0.01
Feb. 1971	19,703	22,933	13,360	10,513	89,378	155,887	40,835	42,687	1,815	20,775	50,439	156,551	-664	-0.42	61,462,510	61,466,671	-4,161	-0.01
Mar. 1971	27,022	22,017	13,671	7,783	95,543	166,035	49,875	43,865	2,397	22,384	47,924	166,444	-408	-0.25	61,628,545	61,633,114	-4,569	-0.01
Apr. 1971	68,124	58,739	15,075	66,167	81,556	289,662	58,432	89,150	5,617	38,340	94,887	286,427	3,235	1.12	61,918,206	61,919,541	-1,334	0.00
May 1971	160,470	164,002	17,013	39,544	83,611	464,639	116,432	129,571	10,844	41,151	163,668	461,666	2,973	0.64	62,382,846	62,381,207	1,638	0.00
Jun. 1971	303,281	122,023	16,122	16,784	123,292	581,501	358,956	168,731	3,212	23,244	21,594	575,736	5,765	1.00	62,964,347	62,956,943	7,404	0.01
Jul. 1971	158,831	45,512	32,742	21,032	146,967	405,083	323,826	58,122	1,524	21,834	4,365	409,670	-4,587	-1.13	63,369,430	63,366,613	2,817	0.00
Aug. 1971	79,374	26,438	38,793	17,369	136,705	298,679	236,548	31,724	1,238	25,516	6,701	301,728	-3,049	-1.02	63,668,109	63,668,342	-232	0.00
Sep. 1971	60,892	32,599	25,111	64,462	112,423	295,486	149,462	76,833	2,324	33,160	32,058	293,837	1,649	0.56	63,963,595	63,962,179	1,417	0.00
Oct. 1971	21,313	28,662	15,687	13,676	118,124	197,462	108,037	56,219	1,458	20,444	14,205	200,363	-2,901	-1.46	64,161,057	64,162,542	-1,485	0.00
Nov. 1971	21,200	32,777	16,860	2,512	114,693	188,042	104,159	50,377	1,452	17,757	15,485	189,230	-1,189	-0.63	64,349,099	64,351,772	-2,673	0.00
Dec. 1971	19,932	27,765	16,514	3,051	103,654	170,916	61,801	48,325	1,575	21,472	38,844	172,017	-1,101	-0.64	64,520,015	64,523,789	-3,774	-0.01
Jan. 1972	19,897	25,750	17,117	5,984	96,742	165,490	37,239	47,717	1,472	23,226	56,436	166,090	-600	-0.36	64,685,505	64,689,879	-4,374	-0.01
Feb. 1972	18,324	24,814	12,503	4,350	94,364	154,355	53,138	42,819	1,211	19,440	38,317	154,925	-570	-0.37	64,839,859	64,844,804	-4,945	-0.01
Mar. 1972	15,572	17,945	9,459	6,504	98,788	148,267	59,340	39,963	1,593	20,889	27,264	149,049	-782	-0.53	64,988,126	64,993,853	-5,727	-0.01
Apr. 1972	21,229	17,371	14,254	41,153	98,115	192,122	99,177	46,061	1,923	26,977	17,321	191,459	663	0.35	65,180,248	65,185,312	-5,064	-0.01
May 1972	85,193	14,091	16,807	21,841	116,325	254,257	169,989	47,298	2,134	25,203	6,027	250,652	3,606	1.43	65,434,505	65,435,964	-1,458	0.00
Jun. 1972	190,664	67,021	15,567	53,199	109,016	435,466	276,640	105,940	2,430	33,183	11,845	430,037	5,429	1.25	65,869,972	65,866,001	3,971	0.01

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jul. 1972	80,397	17,557	37,008	24,521	133,033	292,516	226,659	34,635	1,334	25,545	7,654	295,826	-3,310	-1.13	66,162,488	66,161,827	661	0.00
Aug. 1972	53,388	21,295	32,737	57,667	122,455	287,542	194,185	41,866	1,785	33,279	17,101	288,215	-673	-0.23	66,450,030	66,450,042	-12	0.00
Sep. 1972	32,127	20,438	16,719	31,100	114,078	214,461	136,011	50,079	1,206	26,392	2,381	216,069	-1,608	-0.75	66,664,491	66,666,111	-1,620	0.00
Oct. 1972	33,893	17,631	16,192	15,156	110,797	193,669	120,556	44,871	1,127	21,679	6,840	195,072	-1,403	-0.72	66,858,160	66,861,183	-3,023	0.00
Nov. 1972	23,987	23,935	10,024	25,254	104,898	188,097	101,504	55,025	1,774	22,605	7,776	188,684	-587	-0.31	67,046,257	67,049,867	-3,610	-0.01
Dec. 1972	22,711	23,058	9,676	8,209	96,972	160,626	53,540	49,482	1,626	23,305	33,741	161,695	-1,068	-0.66	67,206,883	67,211,562	-4,678	-0.01
Jan. 1973	24,190	26,087	13,878	12,599	91,485	168,239	39,439	51,996	1,476	24,975	50,734	168,621	-381	-0.23	67,375,123	67,380,183	-5,060	-0.01
Feb. 1973	17,122	21,789	14,115	1,344	84,812	139,181	44,150	37,661	1,455	19,129	37,695	140,090	-909	-0.65	67,514,304	67,520,273	-5,969	-0.01
Mar. 1973	21,955	20,886	15,536	22,620	92,837	173,835	65,585	46,765	2,569	24,682	34,426	174,027	-192	-0.11	67,688,139	67,694,300	-6,161	-0.01
Apr. 1973	57,571	24,720	17,505	64,450	78,253	242,499	47,211	68,440	9,051	38,083	78,232	241,016	1,483	0.61	67,930,638	67,935,316	-4,678	-0.01
May 1973	530,725	234,658	22,776	83,418	64,032	935,608	85,552	226,138	58,817	89,892	467,244	927,642	7,967	0.86	68,866,246	68,862,957	3,289	0.00
Jun. 1973	383,070	114,125	20,589	20,743	109,066	647,593	327,854	162,093	12,806	28,168	113,572	644,493	3,100	0.48	69,513,840	69,507,450	6,389	0.01
Jul. 1973	191,144	49,623	21,376	50,395	150,460	462,998	353,659	66,985	4,080	25,660	13,771	464,154	-1,156	-0.25	69,976,838	69,971,604	5,233	0.01
Aug. 1973	87,137	23,742	38,142	14,484	150,792	314,297	269,445	29,578	2,948	20,635	1,592	324,198	-9,901	-3.10	70,291,135	70,295,802	-4,667	-0.01
Sep. 1973	43,693	29,626	22,899	60,905	112,874	269,997	118,465	54,716	2,520	35,890	58,039	269,630	366	0.14	70,561,132	70,565,433	-4,301	-0.01
Oct. 1973	25,648	32,825	19,902	11,784	106,197	196,356	55,352	50,292	3,089	24,322	65,499	198,553	-2,196	-1.11	70,757,488	70,763,985	-6,497	-0.01
Nov. 1973	24,292	34,535	14,991	13,093	103,427	190,337	73,364	52,663	2,740	20,519	41,910	191,197	-860	-0.45	70,947,825	70,955,182	-7,357	-0.01
Dec. 1973	20,656	29,447	17,656	20,762	105,989	194,510	71,034	53,584	3,113	22,765	45,039	195,534	-1,024	-0.53	71,142,335	71,150,716	-8,381	-0.01
Jan. 1974	24,966	27,813	17,893	10,799	97,995	179,466	40,088	51,578	2,565	22,860	62,954	180,046	-580	-0.32	71,321,801	71,330,762	-8,961	-0.01
Feb. 1974	24,021	26,190	16,630	7,450	90,080	164,372	51,221	44,635	3,164	19,685	46,056	164,761	-389	-0.24	71,486,173	71,495,523	-9,350	-0.01
Mar. 1974	41,826	27,309	16,907	15,101	98,144	199,287	77,529	55,820	6,706	23,846	35,519	199,420	-133	-0.07	71,685,460	71,694,943	-9,483	-0.01
Apr. 1974	62,226	24,724	16,435	38,703	86,090	228,178	69,134	64,227	12,623	31,624	49,642	227,250	928	0.41	71,913,638	71,922,193	-8,555	-0.01
May 1974	168,814	32,588	21,989	2,998	117,692	344,080	236,863	76,226	11,308	18,935	1,170	344,501	-421	-0.12	72,257,719	72,266,694	-8,976	-0.01
Jun. 1974	208,466	87,788	18,505	56,720	117,818	489,296	311,574	133,834	3,043	30,432	1,935	480,819	8,478	1.75	72,747,015	72,747,513	-498	0.00
Jul. 1974	120,817	28,993	35,748	37,457	136,948	359,962	281,116	43,180	2,301	30,732	4,919	362,248	-2,286	-0.63	73,106,977	73,109,761	-2,784	0.00
Aug. 1974	69,751	28,568	37,906	11,951	137,550	285,726	236,441	27,107	1,508	22,675	953	288,683	-2,957	-1.03	73,392,704	73,398,444	-5,741	-0.01
Sep. 1974	34,966	23,489	30,472	18,490	115,476	222,893	144,433	47,644	1,702	23,180	5,766	222,725	168	0.08	73,615,596	73,621,169	-5,573	-0.01
Oct. 1974	30,542	28,422	18,111	29,979	117,073	224,126	129,237	62,017	2,458	23,776	7,275	224,763	-637	-0.28	73,839,723	73,845,932	-6,210	-0.01
Nov. 1974	19,460	25,730	14,232	11,042	110,500	180,964	99,725	51,229	2,135	19,982	9,877	182,948	-1,983	-1.09	74,020,687	74,028,880	-8,193	-0.01
Dec. 1974	16,650	23,655	9,795	3,912	107,314	161,327	70,172	46,444	1,987	20,605	23,131	162,338	-1,012	-0.63	74,182,014	74,191,218	-9,205	-0.01

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jan. 1975	19,749	23,711	9,254	2,732	101,809	157,255	59,685	47,234	1,758	21,017	28,084	157,778	-523	-0.33	74,339,269	74,348,996	-9,728	-0.01
Feb. 1975	16,192	18,689	13,326	5,136	90,775	144,116	54,517	40,764	1,725	19,577	28,027	144,611	-495	-0.34	74,483,385	74,493,608	-10,223	-0.01
Mar. 1975	17,968	18,096	12,656	10,923	101,090	160,732	77,767	44,655	2,818	21,257	14,784	161,281	-548	-0.34	74,644,117	74,654,888	-10,771	-0.01
Apr. 1975	22,760	20,019	15,164	32,562	94,624	185,129	83,735	47,954	3,972	27,540	21,585	184,786	343	0.19	74,829,246	74,839,674	-10,428	-0.01
May 1975	61,440	23,737	18,290	94,986	113,082	311,535	184,670	50,932	7,147	40,066	25,760	308,575	2,960	0.95	75,140,782	75,148,249	-7,467	-0.01
Jun. 1975	203,195	115,049	19,466	38,502	102,722	478,934	262,908	117,967	7,495	34,110	50,307	472,786	6,147	1.29	75,619,715	75,621,035	-1,320	0.00
Jul. 1975	188,273	55,881	27,586	55,039	143,868	470,647	368,308	59,828	2,212	29,375	10,176	469,899	748	0.16	76,090,362	76,090,934	-572	0.00
Aug. 1975	92,875	32,656	36,179	36,868	152,492	351,070	281,970	37,017	2,126	24,120	6,801	352,034	-964	-0.27	76,441,432	76,442,968	-1,536	0.00
Sep. 1975	49,350	25,415	32,643	9,236	142,614	259,258	202,022	35,735	1,263	18,628	3,110	260,758	-1,501	-0.58	76,700,690	76,703,727	-3,037	0.00
Oct. 1975	16,590	23,278	12,965	8,008	132,929	193,770	122,047	51,248	1,405	18,731	2,678	196,109	-2,339	-1.20	76,894,460	76,899,835	-5,376	-0.01
Nov. 1975	17,566	24,409	11,590	18,695	115,797	188,057	92,765	56,385	1,895	21,701	16,377	189,123	-1,067	-0.57	77,082,516	77,088,959	-6,442	-0.01
Dec. 1975	21,448	21,914	10,864	5,986	113,465	173,677	76,606	51,442	1,803	21,146	23,613	174,611	-934	-0.54	77,256,193	77,263,570	-7,377	-0.01
Jan. 1976	17,165	19,624	16,417	4,366	108,578	166,150	64,316	45,833	1,481	21,730	34,009	167,370	-1,220	-0.73	77,422,343	77,430,939	-8,596	-0.01
Feb. 1976	13,000	17,159	14,402	4,387	104,618	153,566	76,677	39,241	1,491	19,123	17,861	154,394	-828	-0.54	77,575,909	77,585,333	-9,424	-0.01
Mar. 1976	12,571	16,227	14,894	11,662	105,522	160,877	74,143	42,519	1,883	22,516	20,260	161,322	-445	-0.28	77,736,786	77,746,655	-9,869	-0.01
Apr. 1976	16,405	12,312	13,901	34,548	102,907	180,073	91,686	45,945	2,753	26,359	12,818	179,562	511	0.28	77,916,859	77,926,217	-9,358	-0.01
May 1976	49,958	15,520	18,351	43,291	120,387	247,507	171,252	36,744	3,162	29,619	5,487	246,264	1,243	0.50	78,164,366	78,172,481	-8,114	-0.01
Jun. 1976	104,270	18,367	26,034	22,468	125,035	296,174	239,739	28,455	1,402	22,804	1,106	293,507	2,667	0.90	78,460,540	78,465,987	-5,447	-0.01
Jul. 1976	101,917	18,416	37,623	37,346	131,345	326,647	257,496	29,166	1,623	31,981	5,173	325,439	1,209	0.37	78,787,187	78,791,426	-4,239	-0.01
Aug. 1976	100,792	36,830	33,288	32,597	131,676	335,183	255,928	40,248	1,769	29,863	6,152	333,958	1,225	0.37	79,122,371	79,125,384	-3,014	0.00
Sep. 1976	36,151	29,400	20,809	59,135	120,671	266,165	165,930	54,584	1,878	32,158	11,953	266,502	-337	-0.13	79,388,536	79,391,887	-3,351	0.00
Oct. 1976	15,724	21,238	16,138	15,372	125,539	194,010	117,474	51,491	1,578	21,812	4,059	196,415	-2,405	-1.23	79,582,546	79,588,302	-5,756	-0.01
Nov. 1976	14,000	19,928	8,498	2,252	114,503	159,181	88,200	45,267	1,659	19,841	5,656	160,623	-1,441	-0.90	79,741,727	79,748,924	-7,197	-0.01
Dec. 1976	14,219	21,813	9,916	2,539	110,129	158,616	85,655	43,933	1,492	21,097	7,404	159,583	-967	-0.61	79,900,343	79,908,507	-8,164	-0.01
Jan. 1977	11,590	16,911	9,501	1,507	105,078	144,588	65,898	40,540	1,396	21,942	15,690	145,466	-878	-0.61	80,044,931	80,053,973	-9,042	-0.01
Feb. 1977	12,682	15,535	9,823	2,885	96,949	137,874	71,389	38,305	1,181	18,503	8,713	138,092	-218	-0.16	80,182,805	80,192,065	-9,260	-0.01
Mar. 1977	16,452	14,612	13,381	10,576	100,816	155,836	66,549	43,742	2,187	24,119	19,690	156,288	-451	-0.29	80,338,641	80,348,352	-9,711	-0.01
Apr. 1977	36,112	12,476	13,417	55,177	100,985	218,166	109,502	50,586	9,406	31,722	16,199	217,415	751	0.34	80,556,807	80,565,767	-8,960	-0.01
May 1977	49,655	7,672	18,253	28,886	116,096	220,562	156,200	27,056	4,077	26,748	6,028	220,109	454	0.21	80,777,370	80,785,876	-8,506	-0.01
Jun. 1977	92,709	13,390	29,584	30,075	113,535	279,293	211,903	26,557	1,356	28,932	8,558	277,305	1,988	0.71	81,056,663	81,063,181	-6,519	-0.01

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jul. 1977	60,448	26,980	27,105	60,545	111,363	286,440	193,998	42,014	2,782	39,423	7,204	285,422	1,018	0.36	81,343,102	81,348,603	-5,500	-0.01
Aug. 1977	62,611	20,826	32,764	28,855	117,523	262,579	202,100	27,009	2,149	29,939	2,500	263,696	-1,117	-0.42	81,605,681	81,612,299	-6,617	-0.01
Sep. 1977	24,209	9,560	19,869	3,292	114,775	171,705	125,265	26,513	976	20,632	388	173,775	-2,070	-1.20	81,777,386	81,786,074	-8,688	-0.01
Oct. 1977	11,788	13,375	14,347	3,652	113,925	157,087	101,447	35,456	1,001	20,099	180	158,181	-1,094	-0.69	81,934,473	81,944,255	-9,782	-0.01
Nov. 1977	10,322	14,927	9,472	7,391	99,947	142,058	75,291	39,333	1,372	22,547	3,885	142,428	-370	-0.26	82,076,531	82,086,683	-10,152	-0.01
Dec. 1977	13,227	16,434	12,219	1,494	104,776	148,150	85,986	39,956	1,196	20,079	2,132	149,349	-1,199	-0.81	82,224,681	82,236,032	-11,351	-0.01
Jan. 1978	14,126	16,286	10,976	4,730	98,043	144,161	72,654	40,637	1,207	22,061	7,961	144,521	-359	-0.25	82,368,842	82,380,552	-11,710	-0.01
Feb. 1978	10,789	14,007	10,980	3,537	90,034	129,346	71,071	33,549	1,301	19,058	5,704	130,683	-1,336	-1.03	82,498,188	82,511,235	-13,047	-0.02
Mar. 1978	11,904	14,891	12,120	8,586	96,257	143,759	79,319	37,928	1,323	21,793	3,953	144,316	-558	-0.39	82,641,947	82,655,551	-13,604	-0.02
Apr. 1978	15,609	13,719	16,739	31,672	90,593	168,331	93,605	42,685	1,944	26,608	2,875	167,716	615	0.37	82,810,278	82,823,267	-12,989	-0.02
May 1978	86,080	53,390	15,903	103,092	98,328	356,793	195,005	102,959	5,366	40,239	7,979	351,550	5,243	1.48	83,167,071	83,174,817	-7,746	-0.01
Jun. 1978	235,996	113,787	16,622	36,266	108,372	511,044	325,506	139,476	2,450	31,892	5,600	504,923	6,121	1.20	83,678,115	83,679,740	-1,625	0.00
Jul. 1978	130,837	33,720	41,065	18,520	136,636	360,778	303,055	32,637	1,360	24,917	1,250	363,218	-2,441	-0.67	84,038,893	84,042,958	-4,065	0.00
Aug. 1978	82,629	24,867	38,452	18,785	136,368	301,100	240,617	27,096	1,384	27,925	5,033	302,054	-954	-0.32	84,339,993	84,345,012	-5,019	-0.01
Sep. 1978	25,274	16,868	18,991	2,307	124,313	187,753	142,629	30,567	1,056	18,420	200	192,871	-5,118	-2.69	84,527,746	84,537,883	-10,137	-0.01
Oct. 1978	13,850	22,408	16,545	31,319	117,306	201,427	118,405	54,711	1,560	25,071	178	199,926	1,501	0.75	84,729,174	84,737,809	-8,635	-0.01
Nov. 1978	15,106	24,043	12,892	4,178	106,726	162,945	90,099	50,204	932	20,852	2,200	164,287	-1,342	-0.82	84,892,118	84,902,096	-9,978	-0.01
Dec. 1978	16,021	22,314	13,591	9,634	105,113	166,673	85,349	52,920	1,149	22,266	5,647	167,331	-659	-0.39	85,058,791	85,069,428	-10,637	-0.01
Jan. 1979	15,705	21,014	13,895	4,645	100,257	155,516	68,090	49,825	1,075	22,207	15,101	156,298	-782	-0.50	85,214,307	85,225,726	-11,419	-0.01
Feb. 1979	13,606	21,284	12,111	3,838	88,360	139,199	56,680	42,980	1,214	20,289	18,529	139,692	-493	-0.35	85,353,506	85,365,418	-11,912	-0.01
Mar. 1979	16,683	23,504	14,041	22,172	101,223	177,623	92,935	50,000	3,031	24,228	7,588	177,782	-158	-0.09	85,531,129	85,543,199	-12,071	-0.01
Apr. 1979	49,044	27,450	16,498	33,561	96,041	222,594	112,371	59,403	13,027	28,235	7,939	220,974	1,619	0.73	85,753,723	85,764,174	-10,451	-0.01
May 1979	150,334	125,012	20,477	83,227	87,392	466,442	166,890	161,541	14,276	45,885	71,957	460,548	5,894	1.27	86,220,165	86,224,722	-4,557	-0.01
Jun. 1979	320,527	277,684	22,052	67,196	83,196	770,654	208,915	251,410	5,934	60,816	238,688	765,764	4,891	0.64	86,990,819	86,990,486	333	0.00
Jul. 1979	152,425	41,669	29,123	23,403	161,142	407,762	343,395	39,802	1,527	22,223	4,736	411,683	-3,921	-0.96	87,398,582	87,402,169	-3,588	0.00
Aug. 1979	88,082	56,959	28,035	87,354	128,958	389,387	237,440	72,139	2,134	37,210	39,857	388,780	607	0.16	87,787,969	87,790,949	-2,981	0.00
Sep. 1979	35,620	24,618	26,707	13,861	131,945	232,752	173,518	40,604	1,198	20,033	1,922	237,276	-4,525	-1.93	88,020,720	88,028,226	-7,506	-0.01
Oct. 1979	18,590	30,886	20,499	22,077	128,475	220,528	138,297	54,434	1,178	22,409	5,618	221,936	-1,409	-0.64	88,241,248	88,250,162	-8,914	-0.01
Nov. 1979	21,226	33,249	15,390	20,364	106,456	196,685	78,646	59,141	1,690	25,009	32,663	197,149	-464	-0.24	88,437,933	88,447,311	-9,378	-0.01
Dec. 1979	25,979	35,193	16,804	13,964	102,656	194,597	45,200	61,570	1,459	25,704	61,283	195,215	-618	-0.32	88,632,530	88,642,525	-9,996	-0.01

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jan. 1980	31,972	39,355	18,016	9,848	98,822	198,013	34,210	67,164	1,416	25,207	70,043	198,040	-28	-0.01	88,830,542	88,840,566	-10,023	-0.01
Feb. 1980	33,131	50,051	16,499	6,717	89,969	196,366	37,871	64,018	3,025	23,360	68,373	196,647	-281	-0.14	89,026,908	89,037,213	-10,304	-0.01
Mar. 1980	39,121	63,827	18,373	16,874	96,297	234,491	64,681	75,312	2,704	26,057	65,623	234,377	114	0.05	89,261,400	89,271,590	-10,190	-0.01
Apr. 1980	118,689	129,387	19,010	40,806	78,903	386,794	52,143	138,015	8,599	40,793	143,672	383,222	3,572	0.93	89,648,194	89,654,812	-6,618	-0.01
May 1980	639,559	594,683	23,759	71,959	69,672	1,399,632	134,080	528,946	32,173	88,847	605,873	1,389,919	9,712	0.70	91,047,826	91,044,732	3,094	0.00
Jun. 1980	427,974	211,936	22,017	11,043	118,305	791,274	375,522	210,607	4,353	27,898	173,740	792,119	-845	-0.11	91,839,099	91,836,851	2,249	0.00
Jul. 1980	161,274	49,669	27,486	42,802	171,060	452,291	364,599	50,991	3,159	25,392	12,725	456,866	-4,575	-1.01	92,291,390	92,293,717	-2,327	0.00
Aug. 1980	87,762	32,827	36,207	24,500	158,440	339,737	274,639	35,142	1,308	23,132	6,818	341,039	-1,302	-0.38	92,631,127	92,634,756	-3,629	0.00
Sep. 1980	37,354	27,480	27,703	15,598	139,781	247,917	190,753	36,460	1,172	21,733	1,228	251,346	-3,430	-1.37	92,879,044	92,886,102	-7,058	-0.01
Oct. 1980	17,108	24,159	18,081	5,791	134,996	200,135	139,331	42,839	1,383	18,349	1,327	203,229	-3,093	-1.53	93,079,179	93,089,330	-10,151	-0.01
Nov. 1980	20,179	27,693	13,181	8,094	113,231	182,379	89,958	51,556	2,529	20,755	18,115	182,914	-535	-0.29	93,261,558	93,272,244	-10,687	-0.01
Dec. 1980	18,358	25,359	13,887	1,554	112,616	171,774	73,390	49,252	1,590	20,160	28,442	172,833	-1,059	-0.61	93,433,332	93,445,078	-11,746	-0.01
Jan. 1981	15,847	22,433	13,781	3,108	109,142	164,310	56,187	47,711	1,234	21,162	38,664	164,957	-647	-0.39	93,597,642	93,610,035	-12,393	-0.01
Feb. 1981	12,388	19,446	12,089	3,396	102,151	149,470	74,006	38,724	1,435	17,777	18,197	150,138	-668	-0.45	93,747,112	93,760,173	-13,062	-0.01
Mar. 1981	14,173	21,350	16,457	28,287	106,007	186,274	84,302	49,813	2,933	25,440	23,875	186,363	-90	-0.05	93,933,385	93,946,537	-13,151	-0.01
Apr. 1981	20,416	14,735	17,037	24,277	103,665	180,131	93,762	40,565	5,181	25,364	15,623	180,496	-365	-0.20	94,113,516	94,127,032	-13,516	-0.01
May 1981	39,987	22,247	19,089	89,447	111,391	282,161	149,399	59,594	6,564	37,625	26,422	279,604	2,557	0.91	94,395,677	94,406,636	-10,959	-0.01
Jun. 1981	89,413	35,452	26,839	24,153	112,774	288,630	196,157	40,283	3,384	27,202	20,430	287,455	1,175	0.41	94,684,307	94,694,091	-9,784	-0.01
Jul. 1981	83,855	20,182	35,126	47,048	131,251	317,462	245,224	29,906	1,655	30,374	9,412	316,572	890	0.28	95,001,769	95,010,663	-8,894	-0.01
Aug. 1981	70,134	23,775	35,198	27,024	133,298	289,429	229,516	32,226	1,504	26,027	1,166	290,438	-1,009	-0.35	95,291,198	95,301,101	-9,903	-0.01
Sep. 1981	30,647	14,400	20,907	11,046	126,205	203,205	154,207	31,355	1,200	20,022	542	207,326	-4,121	-2.01	95,494,404	95,508,428	-14,024	-0.01
Oct. 1981	20,492	20,839	18,546	15,148	122,788	197,813	128,656	42,082	1,220	23,232	2,824	198,014	-201	-0.10	95,692,217	95,706,442	-14,225	-0.01
Nov. 1981	10,793	17,589	13,811	3,148	109,613	154,955	84,130	41,688	1,272	19,790	9,305	156,187	-1,232	-0.79	95,847,172	95,862,628	-15,457	-0.02
Dec. 1981	13,262	17,254	13,418	8,304	105,177	157,414	81,003	37,433	1,539	21,607	16,236	157,817	-403	-0.26	96,004,585	96,020,445	-15,860	-0.02
Jan. 1982	14,688	20,931	13,199	3,524	101,216	153,558	69,887	36,694	1,323	21,237	24,832	153,973	-416	-0.27	96,158,143	96,174,419	-16,276	-0.02
Feb. 1982	15,378	16,076	11,819	1,635	93,495	138,403	70,075	32,197	1,255	18,277	16,769	138,573	-170	-0.12	96,296,545	96,312,991	-16,446	-0.02
Mar. 1982	13,288	15,783	15,354	8,489	101,954	154,868	77,798	42,168	1,941	20,273	13,152	155,332	-464	-0.30	96,451,414	96,468,323	-16,910	-0.02
Apr. 1982	14,209	7,969	17,183	6,655	103,889	149,905	90,306	30,781	1,693	19,540	7,931	150,251	-346	-0.23	96,601,318	96,618,574	-17,256	-0.02
May 1982	46,253	20,158	18,697	78,954	106,275	270,338	162,544	53,296	4,087	35,549	11,976	267,453	2,885	1.07	96,871,656	96,886,027	-14,371	-0.01
Jun. 1982	145,156	61,498	17,892	65,708	110,740	400,995	242,931	96,507	3,022	32,888	20,206	395,554	5,441	1.37	97,272,651	97,281,581	-8,930	-0.01

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jul. 1982	164,065	82,961	23,248	53,142	127,985	451,400	319,569	80,058	2,761	30,422	15,963	448,773	2,628	0.58	97,724,051	97,730,354	-6,302	-0.01
Aug. 1982	119,434	32,821	33,821	34,916	148,546	369,538	304,339	42,755	2,139	24,868	1,106	375,207	-5,668	-1.52	98,093,590	98,105,560	-11,971	-0.01
Sep. 1982	70,472	43,537	27,931	46,743	128,262	316,944	210,130	72,680	3,967	26,876	2,566	316,219	725	0.23	98,410,534	98,421,779	-11,245	-0.01
Oct. 1982	38,701	36,436	18,842	23,063	130,777	247,818	155,139	68,025	1,893	21,978	3,172	250,207	-2,388	-0.96	98,658,352	98,671,986	-13,634	-0.01
Nov. 1982	20,158	32,702	13,998	6,395	115,071	188,324	103,277	58,512	1,726	19,847	6,396	189,758	-1,434	-0.76	98,846,677	98,861,745	-15,068	-0.02
Dec. 1982	17,898	36,326	17,614	11,133	103,202	186,173	35,867	57,581	1,571	26,865	65,125	187,008	-835	-0.45	99,032,850	99,048,753	-15,903	-0.02
Jan. 1983	18,393	32,196	20,263	1,090	101,450	173,393	20,748	51,172	1,296	23,700	77,430	174,345	-952	-0.55	99,206,242	99,223,098	-16,856	-0.02
Feb. 1983	18,024	27,147	16,104	1,697	92,175	155,147	25,207	47,396	2,213	19,974	60,746	155,535	-388	-0.25	99,361,389	99,378,633	-17,244	-0.02
Mar. 1983	45,417	58,727	19,371	46,878	93,440	263,833	64,627	84,861	5,087	30,760	77,522	262,857	976	0.37	99,625,222	99,641,490	-16,268	-0.02
Apr. 1983	159,584	132,492	20,390	53,979	78,200	444,644	39,995	147,374	18,012	47,471	188,218	441,070	3,574	0.81	100,069,867	100,082,561	-12,694	-0.01
May 1983	415,853	325,814	23,503	83,463	76,399	925,032	82,270	315,762	36,251	69,664	415,520	919,466	5,566	0.60	100,994,898	101,002,026	-7,128	-0.01
Jun. 1983	737,986	649,969	23,013	74,905	81,526	1,567,399	141,544	616,197	19,405	80,726	701,911	1,559,783	7,616	0.49	102,562,297	102,561,809	488	0.00
Jul. 1983	406,561	253,969	23,432	48,100	138,077	870,139	384,937	240,215	9,767	31,901	204,731	871,552	-1,412	-0.16	103,432,436	103,433,361	-924	0.00
Aug. 1983	180,179	87,126	26,710	36,031	166,025	496,071	333,139	78,729	6,261	26,174	56,065	500,369	-4,297	-0.86	103,928,508	103,933,729	-5,221	-0.01
Sep. 1983	60,044	34,246	33,775	6,418	149,120	283,602	175,718	49,219	2,268	17,895	41,720	286,819	-3,217	-1.13	104,212,110	104,220,549	-8,438	-0.01
Oct. 1983	28,479	30,709	22,214	6,097	137,225	224,725	102,842	55,313	2,158	19,216	47,357	226,886	-2,162	-0.96	104,436,835	104,447,435	-10,600	-0.01
Nov. 1983	26,430	35,509	14,057	28,689	118,332	223,017	63,920	71,434	3,112	22,581	62,542	223,589	-572	-0.26	104,659,851	104,671,023	-11,172	-0.01
Dec. 1983	33,655	36,903	17,821	7,108	111,912	207,398	32,688	65,393	2,322	22,219	85,824	208,447	-1,048	-0.50	104,867,250	104,879,470	-12,220	-0.01
Jan. 1984	34,105	38,170	19,563	3,565	105,548	200,952	18,273	66,931	2,350	22,266	91,463	201,284	-332	-0.17	105,068,202	105,080,754	-12,553	-0.01
Feb. 1984	32,434	45,543	16,635	10,991	96,061	201,663	31,485	63,210	3,482	21,881	82,125	202,183	-520	-0.26	105,269,865	105,282,937	-13,073	-0.01
Mar. 1984	37,614	46,033	18,682	18,881	109,441	230,651	83,604	68,189	4,131	22,709	52,565	231,198	-547	-0.24	105,500,515	105,514,135	-13,620	-0.01
Apr. 1984	131,095	80,135	32,969	53,250	85,606	383,055	67,632	111,782	20,859	41,098	139,473	380,844	2,211	0.58	105,883,570	105,894,979	-11,409	-0.01
May 1984	394,201	215,830	21,827	26,552	84,899	743,310	162,750	224,028	48,788	47,154	254,799	737,520	5,790	0.78	106,626,880	106,632,499	-5,619	-0.01
Jun. 1984	278,285	183,573	21,714	44,700	114,458	642,730	292,357	185,469	9,657	30,507	122,766	640,756	1,974	0.31	107,269,610	107,273,256	-3,646	0.00
Jul. 1984	228,715	102,695	27,430	36,202	166,716	561,758	417,593	110,697	4,695	22,744	5,339	561,069	689	0.12	107,831,368	107,834,325	-2,957	0.00
Aug. 1984	201,062	61,942	39,302	48,753	138,522	489,581	317,266	66,633	5,489	36,208	66,487	492,083	-2,503	-0.51	108,320,949	108,326,408	-5,459	-0.01
Sep. 1984	88,802	40,035	37,979	12,670	132,519	312,005	161,726	60,144	3,246	22,823	65,544	313,483	-1,478	-0.47	108,632,954	108,639,892	-6,937	-0.01
Oct. 1984	88,609	72,785	22,694	70,371	115,771	370,228	84,812	110,701	6,381	37,855	130,861	370,609	-381	-0.10	109,003,183	109,010,501	-7,318	-0.01
Nov. 1984	70,264	56,175	19,749	1,523	116,345	264,055	60,242	78,627	5,512	21,003	100,315	265,699	-1,645	-0.62	109,267,237	109,276,200	-8,963	-0.01
Dec. 1984	39,168	44,651	15,497	4,877	123,954	228,147	71,462	68,679	3,782	19,527	66,509	229,959	-1,812	-0.79	109,495,384	109,506,160	-10,775	-0.01

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jan. 1985	33,603	38,589	15,952	8,292	113,648	210,085	42,315	67,096	2,939	21,568	76,976	210,893	-808	-0.38	109,705,469	109,717,053	-11,584	-0.01
Feb. 1985	27,862	35,721	15,898	7,016	98,170	184,667	34,370	58,750	2,394	19,733	70,052	185,300	-632	-0.34	109,890,137	109,902,353	-12,216	-0.01
Mar. 1985	31,024	32,680	18,321	8,713	122,342	213,081	110,175	57,685	4,010	19,384	22,884	214,137	-1,056	-0.49	110,103,218	110,116,490	-13,272	-0.01
Apr. 1985	70,448	34,733	18,622	46,331	107,145	277,279	139,524	70,957	8,772	27,937	28,856	276,047	1,232	0.45	110,380,497	110,392,537	-12,040	-0.01
May 1985	180,426	38,411	21,295	35,267	100,790	376,189	178,398	56,437	14,049	36,680	89,898	375,462	726	0.19	110,756,685	110,767,999	-11,314	-0.01
Jun. 1985	212,480	88,448	25,687	40,770	126,276	493,660	321,171	94,536	5,239	27,299	39,238	487,482	6,178	1.26	111,250,345	111,255,482	-5,136	0.00
Jul. 1985	110,731	43,974	27,031	70,832	154,655	407,224	307,292	57,181	3,812	32,438	7,869	408,592	-1,368	-0.34	111,657,569	111,664,074	-6,505	-0.01
Aug. 1985	76,000	26,757	36,512	8,320	161,208	308,797	265,376	28,675	2,992	19,533	1,002	317,579	-8,782	-2.80	111,966,366	111,981,652	-15,287	-0.01
Sep. 1985	34,651	26,370	24,687	41,164	130,477	257,349	154,188	56,691	2,605	28,432	14,785	256,701	648	0.25	112,223,715	112,238,353	-14,639	-0.01
Oct. 1985	26,185	29,752	20,293	15,425	124,481	216,137	96,321	57,344	2,846	23,755	37,778	218,044	-1,907	-0.88	112,439,851	112,456,398	-16,546	-0.01
Nov. 1985	28,770	32,728	17,968	20,217	113,273	212,956	76,816	61,769	2,875	23,053	49,062	213,575	-620	-0.29	112,652,807	112,669,973	-17,166	-0.02
Dec. 1985	24,743	34,439	18,961	9,658	107,585	195,387	33,670	60,367	2,669	24,138	75,169	196,012	-624	-0.32	112,848,195	112,865,985	-17,790	-0.02
Jan. 1986	23,874	31,448	19,840	2,341	106,785	184,288	34,076	55,299	2,708	22,015	70,981	185,079	-791	-0.43	113,032,483	113,051,064	-18,581	-0.02
Feb. 1986	19,572	28,406	17,669	5,898	100,859	172,405	66,800	48,550	1,892	18,586	36,998	172,826	-422	-0.24	113,204,887	113,223,890	-19,003	-0.02
Mar. 1986	26,379	31,057	18,550	6,528	116,773	199,287	100,249	52,020	2,349	20,078	24,568	199,264	24	0.01	113,404,175	113,423,154	-18,979	-0.02
Apr. 1986	67,483	67,346	20,611	54,020	89,958	299,417	65,140	94,177	4,662	36,818	96,388	297,185	2,232	0.75	113,703,592	113,720,339	-16,747	-0.01
May 1986	106,258	52,900	22,062	40,209	134,197	355,625	244,399	73,532	3,531	24,944	7,379	353,784	1,841	0.52	114,059,218	114,074,124	-14,906	-0.01
Jun. 1986	283,515	212,893	22,044	36,770	104,098	659,320	273,999	212,335	3,288	40,843	121,464	651,929	7,391	1.13	114,718,537	114,726,052	-7,515	-0.01
Jul. 1986	151,256	76,621	25,612	32,803	166,199	452,491	361,706	78,115	1,992	23,332	1,712	466,857	-14,367	-3.13	115,171,028	115,192,910	-21,882	-0.02
Aug. 1986	74,154	34,177	32,091	19,396	156,098	315,915	255,581	38,523	1,678	23,081	1,031	319,895	-3,980	-1.25	115,486,943	115,512,805	-25,862	-0.02
Sep. 1986	40,606	26,611	30,356	15,292	131,349	244,215	147,153	42,823	1,420	25,004	28,850	245,250	-1,036	-0.42	115,731,158	115,758,056	-26,897	-0.02
Oct. 1986	22,946	35,978	21,467	35,869	124,360	240,619	108,242	63,630	2,589	27,803	39,339	241,603	-984	-0.41	115,971,777	115,999,659	-27,881	-0.02
Nov. 1986	30,804	37,454	18,554	19,914	115,918	222,645	104,444	68,025	2,096	21,389	27,384	223,338	-693	-0.31	116,194,422	116,222,996	-28,574	-0.02
Dec. 1986	21,237	36,530	19,958	6,118	113,436	197,279	62,344	59,653	1,874	22,654	52,245	198,770	-1,492	-0.75	116,391,701	116,421,767	-30,066	-0.03
Jan. 1987	19,178	28,961	19,859	8,282	109,828	186,108	51,051	57,214	1,633	22,432	54,432	186,763	-655	-0.35	116,577,808	116,608,529	-30,721	-0.03
Feb. 1987	16,304	28,562	18,211	15,123	99,059	177,258	60,129	52,445	2,271	21,442	41,375	177,662	-404	-0.23	116,755,066	116,786,191	-31,125	-0.03
Mar. 1987	31,252	43,800	19,929	16,423	101,443	212,846	36,251	63,719	3,872	27,301	81,812	212,955	-108	-0.05	116,967,912	116,999,146	-31,233	-0.03
Apr. 1987	83,434	50,963	20,296	19,211	101,005	274,908	104,060	69,399	8,382	26,207	66,293	274,341	568	0.21	117,242,821	117,273,487	-30,666	-0.03
May 1987	283,157	98,577	22,537	98,915	94,524	597,710	171,240	125,173	28,876	57,005	210,772	593,065	4,646	0.78	117,840,531	117,866,551	-26,020	-0.02
Jun. 1987	179,822	77,880	22,935	65,227	120,442	466,307	254,373	81,175	6,365	31,833	92,042	465,789	518	0.11	118,306,838	118,332,340	-25,502	-0.02

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jul. 1987	88,994	26,734	32,123	26,331	156,779	330,962	279,900	30,349	2,550	23,296	2,888	338,983	-8,021	-2.39	118,637,800	118,671,323	-33,523	-0.03
Aug. 1987	65,447	29,269	35,140	44,160	139,853	313,869	233,354	37,892	2,264	28,666	11,576	313,752	117	0.04	118,951,669	118,985,075	-33,406	-0.03
Sep. 1987	31,347	20,685	25,325	15,532	130,673	223,563	148,049	37,383	1,736	22,219	15,224	224,611	-1,048	-0.47	119,175,232	119,209,686	-34,454	-0.03
Oct. 1987	24,815	21,688	21,049	21,781	131,256	220,589	142,111	53,111	2,014	21,553	3,880	222,668	-2,080	-0.94	119,395,821	119,432,355	-36,534	-0.03
Nov. 1987	19,066	27,612	16,142	20,793	118,986	202,599	106,737	57,817	2,648	21,843	14,147	203,192	-593	-0.29	119,598,420	119,635,547	-37,127	-0.03
Dec. 1987	15,731	26,549	18,803	15,997	108,175	185,255	62,130	56,168	2,097	24,368	41,281	186,044	-789	-0.43	119,783,675	119,821,591	-37,916	-0.03
Jan. 1988	14,660	21,435	21,170	5,509	99,705	162,479	12,765	48,088	1,943	25,349	75,144	163,289	-810	-0.50	119,946,155	119,984,881	-38,726	-0.03
Feb. 1988	19,490	27,136	19,732	6,915	91,986	165,260	20,188	45,305	3,246	23,122	73,732	165,594	-334	-0.20	120,111,415	120,150,475	-39,060	-0.03
Mar. 1988	28,928	30,143	19,793	18,013	108,291	205,167	83,959	52,161	5,030	23,218	40,962	205,329	-162	-0.08	120,316,582	120,355,804	-39,222	-0.03
Apr. 1988	40,792	24,769	19,697	17,683	108,558	211,499	117,525	44,932	7,295	22,082	19,785	211,619	-120	-0.06	120,528,081	120,567,423	-39,342	-0.03
May 1988	101,646	34,369	22,698	87,399	111,432	357,545	194,191	62,465	11,193	38,006	48,637	354,492	3,052	0.86	120,885,626	120,921,916	-36,290	-0.03
Jun. 1988	164,516	63,938	24,123	32,023	124,827	409,428	299,147	65,594	5,929	24,904	10,440	406,013	3,415	0.84	121,295,053	121,327,928	-32,875	-0.03
Jul. 1988	97,448	30,033	32,577	31,119	140,216	331,394	272,553	33,195	2,754	25,263	2,290	336,055	-4,661	-1.40	121,626,447	121,663,983	-37,536	-0.03
Aug. 1988	77,363	30,789	37,237	39,098	138,927	323,414	251,719	42,490	2,047	25,116	1,247	322,619	795	0.25	121,949,862	121,986,603	-36,741	-0.03
Sep. 1988	26,580	19,044	24,198	28,330	135,321	233,473	170,252	41,534	1,771	23,568	970	238,094	-4,621	-1.96	122,183,335	122,224,697	-41,362	-0.03
Oct. 1988	17,668	19,938	16,641	1,739	129,586	185,571	126,058	41,181	1,439	19,073	1,403	189,155	-3,584	-1.91	122,368,905	122,413,851	-44,946	-0.04
Nov. 1988	19,279	23,674	12,139	4,604	110,508	170,204	92,283	48,891	1,305	20,912	6,767	170,157	46	0.03	122,539,109	122,584,009	-44,900	-0.04
Dec. 1988	17,328	26,625	21,114	12,210	103,905	181,182	58,606	54,210	1,506	25,689	41,523	181,535	-353	-0.19	122,720,291	122,765,543	-45,252	-0.04
Jan. 1989	15,738	23,713	14,456	11,756	102,670	168,332	45,851	48,529	1,509	24,583	48,692	169,164	-831	-0.49	122,888,623	122,934,707	-46,084	-0.04
Feb. 1989	14,392	26,496	13,535	7,245	92,619	154,287	52,026	39,733	1,306	20,926	40,775	154,767	-479	-0.31	123,042,910	123,089,473	-46,563	-0.04
Mar. 1989	21,263	25,873	14,505	6,405	108,570	176,615	93,694	40,874	1,949	20,552	20,147	177,216	-600	-0.34	123,219,526	123,266,689	-47,163	-0.04
Apr. 1989	21,768	16,432	13,463	21,342	108,087	181,092	107,921	37,814	2,379	22,234	10,704	181,052	41	0.02	123,400,618	123,447,741	-47,123	-0.04
May 1989	68,777	18,893	18,646	47,372	118,755	272,444	193,520	42,214	1,995	27,406	1,858	266,993	5,451	2.02	123,673,062	123,714,734	-41,672	-0.03
Jun. 1989	101,958	46,508	16,108	62,386	121,548	348,507	246,563	67,473	1,910	29,971	1,186	347,104	1,403	0.40	124,021,569	124,061,838	-40,269	-0.03
Jul. 1989	103,807	25,123	41,360	44,446	131,423	346,160	262,500	35,576	1,387	32,828	13,055	345,345	815	0.24	124,367,730	124,407,183	-39,453	-0.03
Aug. 1989	72,906	29,080	19,212	37,858	141,995	301,051	237,865	37,771	1,380	26,217	1,412	304,646	-3,595	-1.19	124,668,780	124,711,829	-43,048	-0.03
Sep. 1989	28,513	26,517	13,159	44,941	128,309	241,440	163,659	50,823	1,518	25,970	1,161	243,130	-1,690	-0.70	124,910,221	124,954,959	-44,739	-0.04
Oct. 1989	22,910	24,617	10,232	12,617	121,342	191,718	112,334	48,660	1,145	23,087	8,027	193,253	-1,534	-0.80	125,101,939	125,148,212	-46,273	-0.04
Nov. 1989	18,671	23,045	9,061	2,371	115,389	168,537	99,384	46,224	1,133	18,632	4,259	169,632	-1,095	-0.65	125,270,476	125,317,844	-47,369	-0.04
Dec. 1989	18,803	21,933	9,915	7,827	107,537	166,016	73,412	47,166	1,347	22,379	22,265	166,569	-554	-0.33	125,436,492	125,484,414	-47,922	-0.04

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Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jan. 1990	14,587	23,308	18,564	9,199	104,978	170,636	62,640	48,950	1,228	23,585	34,678	171,081	-446	-0.26	125,607,127	125,655,495	-48,368	-0.04
Feb. 1990	11,361	22,161	15,380	5,288	91,369	145,559	45,962	41,512	1,047	20,857	36,656	146,034	-474	-0.33	125,752,687	125,801,529	-48,842	-0.04
Mar. 1990	27,712	42,526	19,945	41,778	98,074	230,035	70,634	67,325	3,157	30,197	57,820	229,132	904	0.39	125,982,722	126,030,661	-47,939	-0.04
Apr. 1990	46,740	48,401	19,103	25,742	97,338	237,324	94,058	68,678	2,844	25,828	45,160	236,568	756	0.32	126,220,046	126,267,229	-47,183	-0.04
May 1990	68,467	25,064	21,006	43,422	122,060	280,020	191,589	47,054	4,937	26,434	9,402	279,418	602	0.22	126,500,066	126,546,646	-46,581	-0.04
Jun. 1990	155,324	63,935	25,166	10,187	123,850	378,462	287,760	66,562	1,395	20,845	976	377,537	925	0.24	126,878,528	126,924,183	-45,656	-0.04
Jul. 1990	91,481	35,796	29,647	68,115	131,261	356,300	264,891	48,418	2,380	33,223	7,052	355,964	336	0.09	127,234,827	127,280,147	-45,320	-0.04
Aug. 1990	64,225	29,649	32,838	41,827	141,949	310,488	242,524	35,433	2,420	28,443	1,913	310,732	-244	-0.08	127,545,315	127,590,879	-45,564	-0.04
Sep. 1990	36,203	29,696	25,129	31,427	132,495	254,949	186,028	44,904	1,279	24,231	687	257,129	-2,180	-0.85	127,800,265	127,848,009	-47,744	-0.04
Oct. 1990	20,752	24,062	19,854	18,516	126,808	209,991	131,673	48,121	1,268	23,112	6,844	211,018	-1,027	-0.49	128,010,256	128,059,027	-48,771	-0.04
Nov. 1990	22,789	23,552	13,326	14,037	114,850	188,553	104,631	48,640	1,531	21,163	13,303	189,268	-714	-0.38	128,198,809	128,248,294	-49,485	-0.04
Dec. 1990	15,757	19,387	14,090	2,866	108,918	161,017	64,471	42,952	1,234	21,238	32,205	162,100	-1,083	-0.67	128,359,826	128,410,395	-50,569	-0.04
Jan. 1991	13,263	21,005	18,743	6,987	100,978	160,976	48,150	42,415	1,150	22,791	47,006	161,511	-535	-0.33	128,520,802	128,571,906	-51,104	-0.04
Feb. 1991	10,946	19,829	16,172	626	97,484	145,056	59,850	35,020	1,030	18,123	31,558	145,581	-525	-0.36	128,665,859	128,717,487	-51,629	-0.04
Mar. 1991	13,718	16,680	15,165	8,329	108,695	162,587	72,313	39,338	1,908	21,163	28,241	162,962	-375	-0.23	128,828,446	128,880,449	-52,004	-0.04
Apr. 1991	19,260	10,247	17,795	30,327	105,150	182,780	101,744	42,072	2,615	23,312	12,970	182,713	67	0.04	129,011,226	129,063,163	-51,937	-0.04
May 1991	77,737	17,049	21,593	54,632	114,985	285,997	197,668	46,510	4,541	28,351	6,729	283,798	2,198	0.77	129,297,223	129,346,961	-49,739	-0.04
Jun. 1991	208,949	109,910	21,966	58,730	106,947	506,501	292,243	134,804	4,846	34,688	33,130	499,712	6,790	1.35	129,803,724	129,846,673	-42,949	-0.03
Jul. 1991	96,328	42,106	38,965	60,521	140,267	378,187	287,467	53,555	1,794	34,058	3,290	380,164	-1,977	-0.52	130,181,911	130,226,837	-44,926	-0.03
Aug. 1991	81,594	35,755	30,014	51,395	144,411	343,169	269,434	44,392	2,219	27,160	724	343,929	-760	-0.22	130,525,080	130,570,765	-45,686	-0.03
Sep. 1991	41,276	22,842	22,403	21,120	131,450	239,092	163,683	44,021	1,177	23,047	8,338	240,265	-1,174	-0.49	130,764,171	130,811,031	-46,859	-0.04
Oct. 1991	16,338	22,087	19,639	15,238	125,050	198,352	113,172	53,200	1,132	21,584	10,985	200,074	-1,722	-0.86	130,962,524	131,011,105	-48,581	-0.04
Nov. 1991	20,475	31,754	15,490	28,569	117,600	213,887	122,034	64,358	1,773	21,694	4,388	214,247	-360	-0.17	131,176,411	131,225,352	-48,941	-0.04
Dec. 1991	16,926	26,197	18,906	1,297	115,963	179,289	96,092	50,207	1,578	19,553	13,407	180,837	-1,548	-0.86	131,355,699	131,406,188	-50,489	-0.04
Jan. 1992	16,832	24,536	19,845	11,326	101,693	174,232	45,941	50,442	1,497	25,142	51,780	174,802	-570	-0.33	131,529,932	131,580,991	-51,059	-0.04
Feb. 1992	15,848	23,180	19,230	789	96,221	155,268	42,702	41,466	2,288	20,544	48,949	155,949	-680	-0.44	131,685,200	131,736,939	-51,739	-0.04
Mar. 1992	35,501	52,879	21,361	46,666	97,154	253,561	67,741	76,915	4,534	30,930	72,153	252,274	1,288	0.51	131,938,761	131,989,213	-50,452	-0.04
Apr. 1992	47,105	36,625	20,833	14,829	107,012	226,405	117,319	56,034	6,617	21,661	25,265	226,896	-491	-0.22	132,165,166	132,216,109	-50,943	-0.04
May 1992	106,472	26,575	25,553	23,730	126,437	308,767	228,129	50,122	2,705	21,199	3,535	305,690	3,078	1.00	132,473,934	132,521,799	-47,865	-0.04
Jun. 1992	120,508	54,779	21,879	67,344	125,904	390,415	260,650	85,886	4,372	28,888	7,732	387,528	2,886	0.74	132,864,348	132,909,327	-44,979	-0.03

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jul. 1992	85,548	39,769	28,111	44,813	140,434	338,675	258,492	50,437	2,292	27,859	1,948	341,028	-2,353	-0.69	133,203,023	133,250,355	-47,332	-0.04
Aug. 1992	66,236	43,326	31,132	66,865	133,811	341,371	227,487	66,056	2,549	32,616	10,867	339,575	1,796	0.53	133,544,394	133,589,929	-45,536	-0.03
Sep. 1992	26,853	23,796	22,469	3,550	132,991	209,659	147,553	40,732	1,164	18,083	5,960	213,492	-3,833	-1.81	133,754,053	133,803,422	-49,369	-0.04
Oct. 1992	17,091	27,257	20,373	9,553	128,545	202,819	122,036	49,199	1,335	20,856	10,112	203,539	-720	-0.35	133,956,872	134,006,960	-50,089	-0.04
Nov. 1992	19,421	25,948	15,307	20,976	115,140	196,792	105,076	58,794	2,263	20,718	10,333	197,184	-392	-0.20	134,153,664	134,204,144	-50,481	-0.04
Dec. 1992	15,521	25,433	18,608	7,256	104,282	171,099	50,014	50,171	1,797	23,250	47,141	172,373	-1,274	-0.74	134,324,763	134,376,518	-51,755	-0.04
Jan. 1993	17,810	23,947	17,936	2,941	100,627	163,260	40,878	46,396	1,930	22,066	52,635	163,904	-644	-0.39	134,488,023	134,540,422	-52,398	-0.04
Feb. 1993	16,469	22,911	16,438	11,351	92,078	159,248	55,576	45,396	1,695	19,990	36,733	159,389	-141	-0.09	134,647,271	134,699,811	-52,540	-0.04
Mar. 1993	17,971	29,314	19,096	13,858	100,753	180,993	62,116	51,193	1,926	22,036	43,976	181,247	-254	-0.14	134,828,264	134,881,057	-52,794	-0.04
Apr. 1993	25,168	30,776	19,852	40,952	101,585	218,333	89,819	58,252	4,032	28,806	36,783	217,692	641	0.29	135,046,597	135,098,750	-52,152	-0.04
May 1993	86,440	30,867	21,439	32,899	122,159	293,804	211,100	45,828	3,189	23,896	7,249	291,261	2,542	0.87	135,340,401	135,390,011	-49,610	-0.04
Jun. 1993	175,950	89,984	22,222	49,844	121,339	459,339	294,292	123,897	2,201	29,206	2,319	451,914	7,425	1.63	135,799,740	135,841,925	-42,185	-0.03
Jul. 1993	130,841	54,866	31,768	28,765	143,542	389,782	300,039	62,617	1,514	26,633	772	391,576	-1,794	-0.46	136,189,522	136,233,501	-43,979	-0.03
Aug. 1993	73,246	36,274	31,839	27,879	146,097	315,335	242,161	45,938	1,455	24,975	1,449	315,978	-642	-0.20	136,504,857	136,549,478	-44,621	-0.03
Sep. 1993	39,620	36,201	22,496	41,353	123,903	263,573	141,373	70,157	1,657	28,669	22,344	264,199	-627	-0.24	136,768,430	136,813,678	-45,248	-0.03
Oct. 1993	19,290	32,917	20,211	40,724	121,511	234,652	99,782	73,800	1,670	28,517	32,641	236,410	-1,758	-0.75	137,003,082	137,050,088	-47,006	-0.03
Nov. 1993	23,191	35,550	14,512	15,787	115,602	204,643	102,749	64,505	1,569	20,859	16,254	205,935	-1,292	-0.63	137,207,725	137,256,023	-48,298	-0.04
Dec. 1993	17,225	33,412	14,316	4,151	115,768	184,871	84,798	53,418	1,468	20,022	26,661	186,366	-1,495	-0.81	137,392,596	137,442,388	-49,793	-0.04
Jan. 1994	15,336	27,620	18,491	7,453	108,066	176,966	62,686	52,649	1,615	22,153	38,412	177,516	-550	-0.31	137,569,562	137,619,904	-50,342	-0.04
Feb. 1994	14,856	24,119	14,958	7,088	93,951	154,971	47,115	46,354	1,539	20,303	40,088	155,399	-427	-0.28	137,724,533	137,775,303	-50,770	-0.04
Mar. 1994	19,681	30,367	18,273	11,936	108,642	188,899	84,221	54,297	2,046	20,986	27,449	188,998	-99	-0.05	137,913,432	137,964,301	-50,869	-0.04
Apr. 1994	37,088	31,379	17,125	40,037	105,410	231,039	115,690	63,283	4,887	27,267	19,124	230,251	788	0.34	138,144,471	138,194,552	-50,081	-0.04
May 1994	118,342	45,752	25,971	23,670	121,721	335,456	240,357	61,249	4,549	23,783	2,436	332,374	3,082	0.92	138,479,927	138,526,925	-46,998	-0.03
Jun. 1994	125,726	56,470	41,893	32,647	121,835	378,571	280,706	63,980	3,480	24,797	3,420	376,383	2,188	0.58	138,858,498	138,903,308	-44,810	-0.03
Jul. 1994	71,697	24,114	28,886	27,744	139,101	291,541	231,722	38,335	1,456	23,851	1,109	296,474	-4,933	-1.68	139,150,039	139,199,782	-49,744	-0.04
Aug. 1994	58,114	28,490	26,350	33,411	128,877	275,242	199,347	46,863	1,452	27,256	575	275,494	-252	-0.09	139,425,280	139,475,277	-49,996	-0.04
Sep. 1994	27,930	19,701	23,646	11,749	120,840	203,865	139,676	43,795	995	21,413	411	206,290	-2,425	-1.18	139,629,146	139,681,567	-52,421	-0.04
Oct. 1994	15,137	24,656	19,620	40,258	115,079	214,750	105,348	56,308	1,233	33,532	18,959	215,379	-629	-0.29	139,843,896	139,896,946	-53,050	-0.04
Nov. 1994	20,008	25,316	17,898	11,060	110,627	184,909	101,249	57,247	1,038	20,121	5,883	185,537	-628	-0.34	140,028,805	140,082,483	-53,678	-0.04
Dec. 1994	14,309	23,369	13,164	3,719	112,173	166,735	85,767	50,662	1,243	20,055	10,135	167,863	-1,128	-0.67	140,195,540	140,250,346	-54,806	-0.04

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jan. 1995	13,675	21,859	13,852	3,182	106,089	158,658	80,691	46,301	1,287	20,434	10,681	159,395	-737	-0.46	140,354,198	140,409,741	-55,543	-0.04
Feb. 1995	11,895	18,053	12,640	10,252	92,817	145,657	68,813	44,067	1,190	19,705	12,081	145,856	-199	-0.14	140,499,855	140,555,597	-55,742	-0.04
Mar. 1995	13,117	19,855	14,251	6,686	101,040	154,949	81,287	43,696	1,209	20,833	8,497	155,523	-574	-0.37	140,654,804	140,711,120	-56,316	-0.04
Apr. 1995	20,923	24,322	17,339	55,180	100,171	217,935	99,599	59,706	3,208	31,467	22,435	216,414	1,521	0.70	140,872,738	140,927,534	-54,796	-0.04
May 1995	229,214	179,002	23,687	110,137	86,507	628,547	181,995	215,679	15,217	58,674	149,141	620,707	7,840	1.26	141,501,285	141,548,241	-46,956	-0.03
Jun. 1995	583,758	539,865	24,860	93,631	76,457	1,318,570	118,863	504,319	7,851	93,759	585,012	1,309,803	8,767	0.67	142,819,855	142,858,044	-38,189	-0.03
Jul. 1995	395,304	201,455	25,478	27,174	121,493	770,904	350,002	195,248	5,167	34,557	189,068	774,043	-3,138	-0.41	143,590,760	143,632,087	-41,327	-0.03
Aug. 1995	113,444	41,234	30,788	14,481	180,623	380,570	319,115	44,770	1,289	19,330	4,768	389,272	-8,703	-2.26	143,971,330	144,021,359	-50,029	-0.03
Sep. 1995	57,069	39,659	24,871	49,194	141,885	312,678	194,889	64,652	1,837	27,995	22,934	312,308	370	0.12	144,284,007	144,333,667	-49,660	-0.03
Oct. 1995	21,098	30,532	23,188	9,162	131,186	215,165	110,509	58,518	1,391	21,159	26,624	218,201	-3,036	-1.40	144,499,173	144,551,868	-52,695	-0.04
Nov. 1995	22,493	29,887	15,215	7,174	124,580	199,349	102,894	54,174	1,602	19,036	22,853	200,559	-1,210	-0.61	144,698,522	144,752,427	-53,905	-0.04
Dec. 1995	19,477	30,617	15,389	1,072	117,024	183,579	82,087	50,707	1,068	19,889	30,813	184,564	-985	-0.54	144,882,101	144,936,991	-54,890	-0.04
Jan. 1996	17,000	28,675	19,058	9,920	105,311	179,964	51,660	54,086	1,364	23,035	50,022	180,167	-203	-0.11	145,062,065	145,117,159	-55,094	-0.04
Feb. 1996	18,334	29,710	17,757	2,095	97,052	164,949	46,819	49,338	1,122	20,369	47,668	165,317	-368	-0.22	145,227,014	145,282,475	-55,462	-0.04
Mar. 1996	21,133	30,814	18,929	16,460	107,957	195,293	72,577	56,990	1,744	23,469	40,596	195,377	-85	-0.04	145,422,306	145,477,853	-55,546	-0.04
Apr. 1996	37,939	30,646	17,659	15,953	114,220	216,417	127,700	51,743	2,054	21,367	13,136	216,000	417	0.19	145,638,723	145,693,852	-55,129	-0.04
May 1996	150,858	70,701	22,199	70,488	122,844	437,091	268,468	106,947	2,912	32,359	19,209	429,894	7,197	1.66	146,075,814	146,123,746	-47,932	-0.03
Jun. 1996	236,103	169,756	20,344	42,098	122,683	590,983	346,097	192,437	2,178	29,547	16,132	586,392	4,591	0.78	146,666,797	146,710,138	-43,341	-0.03
Jul. 1996	133,918	65,495	29,294	42,535	155,533	426,775	317,990	82,621	1,675	30,156	1,202	433,645	-6,870	-1.60	147,093,572	147,143,783	-50,211	-0.03
Aug. 1996	69,370	32,124	37,300	27,785	154,736	321,315	254,677	42,805	1,295	24,533	1,915	325,224	-3,909	-1.21	147,414,888	147,469,008	-54,120	-0.04
Sep. 1996	41,854	42,535	33,600	56,505	124,414	298,908	127,923	72,984	1,465	36,139	60,560	299,070	-163	-0.05	147,713,795	147,768,078	-54,283	-0.04
Oct. 1996	29,774	33,398	22,349	7,738	129,951	223,209	108,880	66,358	1,086	21,527	27,703	225,554	-2,345	-1.05	147,937,004	147,993,632	-56,628	-0.04
Nov. 1996	23,030	33,847	16,349	6,895	126,158	206,278	118,747	58,584	1,238	18,357	10,586	207,512	-1,234	-0.60	148,143,282	148,201,144	-57,862	-0.04
Dec. 1996	17,439	29,829	17,678	2,256	112,719	179,920	66,543	53,820	1,144	21,726	38,029	181,262	-1,342	-0.74	148,323,202	148,382,406	-59,204	-0.04
Jan. 1997	16,110	28,569	18,787	6,299	106,089	175,854	48,739	52,584	1,273	23,174	50,775	176,545	-691	-0.39	148,499,056	148,558,951	-59,895	-0.04
Feb. 1997	16,254	25,143	17,404	9,402	97,261	165,465	60,647	48,851	1,185	19,842	35,230	165,755	-290	-0.18	148,664,521	148,724,706	-60,185	-0.04
Mar. 1997	19,671	26,383	17,658	5,230	109,706	178,649	70,453	49,908	1,808	21,814	35,230	179,213	-564	-0.32	148,843,169	148,903,919	-60,750	-0.04
Apr. 1997	37,124	43,500	19,903	48,150	109,650	258,327	125,470	80,226	3,134	25,927	21,582	256,339	1,988	0.77	149,101,496	149,160,257	-58,762	-0.04
May 1997	158,015	80,588	22,480	36,666	130,335	428,084	290,101	98,620	4,059	26,521	3,687	422,988	5,096	1.20	149,529,580	149,583,245	-53,666	-0.04
Jun. 1997	433,135	375,302	23,194	64,179	92,015	987,825	208,060	419,803	3,837	65,067	281,016	977,783	10,042	1.02	150,517,405	150,561,028	-43,624	-0.03

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jul. 1997	133,541	53,350	32,605	76,466	165,053	461,015	321,533	87,052	2,611	30,744	23,056	464,997	-3,982	-0.86	150,978,420	151,026,025	-47,605	-0.03
Aug. 1997	114,907	75,145	25,456	81,865	140,654	438,027	248,648	106,006	3,584	37,087	43,201	438,526	-499	-0.11	151,416,447	151,464,551	-48,104	-0.03
Sep. 1997	68,374	45,443	24,343	28,936	138,087	305,182	187,775	72,902	1,827	23,029	21,828	307,361	-2,179	-0.71	151,721,629	151,771,912	-50,283	-0.03
Oct. 1997	44,523	54,269	22,185	42,671	128,204	291,851	118,308	89,564	2,650	30,544	51,970	293,036	-1,186	-0.41	152,013,480	152,064,948	-51,468	-0.03
Nov. 1997	41,925	56,280	20,985	10,205	115,410	244,805	77,662	80,511	2,725	22,818	62,568	246,284	-1,480	-0.60	152,258,284	152,311,232	-52,948	-0.03
Dec. 1997	33,437	44,462	21,048	8,525	114,833	222,306	59,421	69,609	3,098	23,184	68,606	223,919	-1,613	-0.72	152,480,590	152,535,151	-54,561	-0.04
Jan. 1998	31,398	38,002	20,748	2,298	105,751	198,196	19,020	62,171	2,755	23,781	91,333	199,060	-864	-0.43	152,678,786	152,734,211	-55,425	-0.04
Feb. 1998	28,568	33,420	18,250	4,091	100,747	185,076	53,030	54,473	2,416	19,532	56,184	185,634	-558	-0.30	152,863,862	152,919,846	-55,984	-0.04
Mar. 1998	41,205	45,331	20,635	20,726	106,862	234,759	64,981	73,450	3,505	24,536	67,960	234,432	327	0.14	153,098,621	153,154,278	-55,657	-0.04
Apr. 1998	119,926	93,645	22,946	44,847	99,838	381,201	129,858	121,200	12,071	31,369	84,347	378,846	2,356	0.62	153,479,822	153,533,123	-53,301	-0.03
May 1998	226,265	85,223	25,039	41,163	121,227	498,917	291,200	102,766	21,245	28,615	52,925	496,751	2,166	0.44	153,978,739	154,029,874	-51,135	-0.03
Jun. 1998	166,277	67,913	25,404	29,052	138,977	427,623	282,650	85,915	4,250	23,915	28,684	425,414	2,210	0.52	154,406,362	154,455,287	-48,925	-0.03
Jul. 1998	153,575	56,578	29,940	95,318	152,629	488,040	332,925	83,980	3,838	34,784	31,006	486,533	1,506	0.31	154,894,402	154,941,821	-47,419	-0.03
Aug. 1998	101,212	38,940	34,600	25,814	163,229	363,795	287,205	50,667	4,895	21,495	2,386	366,648	-2,853	-0.78	155,258,197	155,308,469	-50,272	-0.03
Sep. 1998	41,596	26,356	32,385	18,668	143,020	262,025	191,119	46,106	1,342	22,041	2,677	263,285	-1,260	-0.48	155,520,222	155,571,754	-51,532	-0.03
Oct. 1998	33,535	29,597	22,403	38,019	128,090	251,644	93,736	69,181	1,989	30,982	56,575	252,463	-819	-0.33	155,771,866	155,824,217	-52,351	-0.03
Nov. 1998	23,158	39,115	19,714	11,498	126,627	220,112	110,301	63,396	1,903	19,680	26,131	221,410	-1,298	-0.59	155,991,978	156,045,627	-53,649	-0.03
Dec. 1998	20,917	33,107	20,042	7,574	117,308	198,947	73,457	59,330	1,644	21,644	43,865	199,941	-994	-0.50	156,190,925	156,245,568	-54,643	-0.03
Jan. 1999	21,532	32,059	19,237	5,478	112,144	190,450	64,597	56,074	1,685	21,543	47,265	191,164	-714	-0.37	156,381,375	156,436,732	-55,357	-0.04
Feb. 1999	17,734	23,794	16,789	2,461	98,838	159,616	55,083	45,783	1,589	18,794	39,204	160,452	-836	-0.52	156,540,991	156,597,185	-56,194	-0.04
Mar. 1999	20,406	23,854	19,530	4,936	119,835	188,562	88,257	49,747	1,780	19,986	29,119	188,889	-327	-0.17	156,729,552	156,786,073	-56,521	-0.04
Apr. 1999	72,552	58,308	22,395	127,911	104,677	385,843	132,427	131,379	12,373	41,499	62,739	380,417	5,425	1.42	157,115,395	157,166,491	-51,096	-0.03
May 1999	299,220	252,226	26,107	53,188	90,532	721,272	167,703	240,252	26,391	54,136	228,270	716,753	4,519	0.63	157,836,667	157,883,243	-46,577	-0.03
Jun. 1999	357,999	225,948	25,244	39,327	102,850	751,368	279,924	230,232	8,689	39,987	190,283	749,116	2,253	0.30	158,588,035	158,632,359	-44,324	-0.03
Jul. 1999	164,636	53,692	27,323	45,397	170,253	461,301	350,062	75,487	3,596	24,196	10,952	464,292	-2,992	-0.65	159,049,336	159,096,652	-47,316	-0.03
Aug. 1999	144,185	85,842	27,319	68,258	139,066	464,671	237,649	112,564	4,740	34,693	74,006	463,652	1,019	0.22	159,514,007	159,560,303	-46,296	-0.03
Sep. 1999	50,200	43,694	28,985	44,987	133,566	301,432	131,599	79,054	2,247	27,773	62,636	303,308	-1,877	-0.62	159,815,439	159,863,611	-48,173	-0.03
Oct. 1999	34,286	39,755	27,148	9,903	134,262	245,354	112,580	73,297	1,885	20,300	39,445	247,506	-2,152	-0.87	160,060,792	160,111,117	-50,325	-0.03
Nov. 1999	29,626	38,299	21,206	6,006	121,458	216,596	87,352	67,248	2,006	19,429	42,079	218,114	-1,518	-0.70	160,277,389	160,329,232	-51,843	-0.03
Dec. 1999	28,640	36,726	19,058	5,308	113,443	203,175	38,310	64,479	2,050	22,217	77,210	204,266	-1,090	-0.54	160,480,564	160,533,497	-52,933	-0.03

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jan. 2000	28,609	37,573	21,531	5,473	111,481	204,667	45,307	60,557	2,138	21,726	75,666	205,394	-727	-0.35	160,685,231	160,738,891	-53,660	-0.03
Feb. 2000	25,509	34,664	19,281	3,863	102,146	185,463	40,937	54,519	1,907	20,069	68,479	185,911	-447	-0.24	160,870,695	160,924,802	-54,107	-0.03
Mar. 2000	24,256	29,529	21,132	20,142	113,282	208,341	66,114	57,703	2,701	23,841	58,611	208,970	-628	-0.30	161,079,036	161,133,772	-54,736	-0.03
Apr. 2000	43,842	22,620	21,852	22,067	119,232	229,613	126,252	49,035	4,786	23,344	26,388	229,806	-193	-0.08	161,308,649	161,363,578	-54,929	-0.03
May 2000	117,486	43,953	23,948	36,808	127,521	349,716	243,117	68,369	4,785	26,773	3,389	346,434	3,283	0.94	161,658,365	161,710,011	-51,646	-0.03
Jun. 2000	118,150	43,754	31,334	21,481	129,651	344,370	255,963	64,648	1,818	22,659	881	345,970	-1,600	-0.46	162,002,735	162,055,981	-53,246	-0.03
Jul. 2000	74,627	29,585	39,327	30,406	131,075	305,020	228,912	48,182	1,239	28,169	593	307,094	-2,074	-0.68	162,307,755	162,363,076	-55,320	-0.03
Aug. 2000	69,664	23,457	43,634	46,064	125,782	308,601	221,683	50,766	1,592	33,084	838	307,963	638	0.21	162,616,356	162,671,038	-54,682	-0.03
Sep. 2000	42,233	23,066	26,917	37,393	120,551	250,161	162,511	57,691	2,252	26,537	1,063	250,054	106	0.04	162,866,517	162,921,093	-54,576	-0.03
Oct. 2000	29,745	26,789	20,131	16,236	120,235	213,136	128,746	57,693	1,571	24,088	2,613	214,710	-1,575	-0.74	163,079,653	163,135,803	-56,150	-0.03
Nov. 2000	20,953	27,271	15,959	6,424	108,390	178,997	95,362	54,643	1,753	20,930	7,686	180,373	-1,375	-0.77	163,258,650	163,316,176	-57,526	-0.04
Dec. 2000	18,053	24,606	17,271	4,424	106,763	171,117	84,132	51,079	1,492	21,044	14,247	171,995	-878	-0.51	163,429,767	163,488,171	-58,404	-0.04
Jan. 2001	17,732	22,677	21,488	8,832	101,411	172,140	68,489	50,989	1,438	23,228	28,435	172,578	-438	-0.25	163,601,907	163,660,749	-58,842	-0.04
Feb. 2001	16,202	21,645	19,377	8,388	89,500	155,112	55,715	44,532	1,337	21,440	32,485	155,510	-398	-0.26	163,757,019	163,816,259	-59,240	-0.04
Mar. 2001	18,396	24,552	21,401	12,901	108,178	185,428	97,774	50,171	1,952	22,459	13,331	185,687	-260	-0.14	163,942,446	164,001,946	-59,500	-0.04
Apr. 2001	24,303	27,130	22,074	46,255	106,539	226,301	91,345	60,363	3,560	31,159	38,864	225,290	1,011	0.45	164,168,747	164,227,236	-58,489	-0.04
May 2001	94,146	51,886	25,831	79,890	108,567	360,320	199,753	83,871	6,534	38,468	28,631	357,258	3,063	0.85	164,529,068	164,584,494	-55,426	-0.03
Jun. 2001	110,476	42,229	28,558	20,318	122,686	324,267	244,178	55,867	2,401	23,897	1,743	328,086	-3,819	-1.17	164,853,335	164,912,580	-59,245	-0.04
Jul. 2001	82,303	45,082	39,597	69,701	123,905	360,589	251,613	64,829	1,437	36,488	3,748	358,115	2,474	0.69	165,213,924	165,270,695	-56,771	-0.03
Aug. 2001	67,600	25,645	46,925	28,759	131,931	300,860	230,265	48,923	1,164	24,877	847	306,076	-5,216	-1.72	165,514,784	165,576,771	-61,987	-0.04
Sep. 2001	37,327	20,607	25,443	26,282	121,548	231,206	156,274	47,781	1,059	25,145	1,191	231,451	-245	-0.11	165,745,990	165,808,222	-62,232	-0.04
Oct. 2001	17,958	17,160	23,327	6,350	125,985	190,780	123,338	46,416	987	20,439	1,105	192,284	-1,504	-0.79	165,936,771	166,000,506	-63,736	-0.04
Nov. 2001	14,747	17,103	16,555	11,315	110,340	170,060	88,834	51,100	1,661	21,509	7,781	170,885	-825	-0.48	166,106,830	166,171,391	-64,561	-0.04
Dec. 2001	15,492	21,142	16,013	2,808	109,329	164,784	81,779	48,607	1,370	20,066	13,754	165,576	-791	-0.48	166,271,615	166,336,967	-65,352	-0.04
Jan. 2002	13,945	20,361	15,784	9,050	107,776	166,915	84,715	49,066	1,524	20,123	11,852	167,280	-365	-0.22	166,438,530	166,504,247	-65,717	-0.04
Feb. 2002	12,971	16,405	17,137	3,811	93,897	144,221	69,079	39,869	1,444	18,794	15,531	144,718	-497	-0.34	166,582,751	166,648,964	-66,214	-0.04
Mar. 2002	16,376	20,346	19,326	11,530	101,088	168,666	84,218	47,394	1,773	21,889	13,554	168,828	-162	-0.10	166,751,417	166,817,792	-66,375	-0.04
Apr. 2002	14,409	9,945	21,333	3,563	106,642	155,893	98,721	30,070	1,190	19,179	7,336	156,496	-604	-0.39	166,907,310	166,974,288	-66,979	-0.04
May 2002	36,870	14,005	35,161	33,055	109,845	228,936	156,099	42,025	1,704	25,208	1,574	226,610	2,326	1.02	167,136,245	167,200,898	-64,653	-0.04
Jun. 2002	54,619	11,562	29,818	31,231	104,077	231,307	163,162	36,115	1,215	29,712	1,157	231,361	-54	-0.02	167,367,553	167,432,260	-64,707	-0.04

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jul. 2002	38,892	7,743	40,195	13,751	100,523	201,105	145,425	26,790	846	27,459	1,898	202,418	-1,313	-0.65	167,568,657	167,634,678	-66,020	-0.04
Aug. 2002	26,052	6,679	27,697	26,534	92,945	179,908	108,718	31,014	859	33,588	5,869	180,048	-141	-0.08	167,748,565	167,814,726	-66,161	-0.04
Sep. 2002	16,076	9,314	23,986	26,372	89,198	164,947	98,202	38,560	1,012	26,639	984	165,396	-450	-0.27	167,913,512	167,980,123	-66,611	-0.04
Oct. 2002	14,352	15,295	21,633	24,561	92,998	168,838	94,156	43,480	964	26,948	2,210	167,758	1,081	0.64	168,082,350	168,147,880	-65,530	-0.04
Nov. 2002	8,788	14,564	15,954	7,794	89,122	136,222	72,496	40,917	912	20,442	2,356	137,123	-901	-0.66	168,218,572	168,285,003	-66,432	-0.04
Dec. 2002	9,231	13,562	13,922	159	94,411	131,284	70,228	36,574	965	19,136	5,117	132,020	-736	-0.56	168,349,856	168,417,023	-67,167	-0.04
Jan. 2003	8,680	13,412	18,052	610	91,676	132,430	66,719	36,055	904	19,724	9,426	132,827	-397	-0.30	168,482,285	168,549,850	-67,565	-0.04
Feb. 2003	6,946	12,802	18,411	9,295	80,404	127,858	59,869	35,122	1,036	19,528	12,394	127,949	-91	-0.07	168,610,144	168,677,799	-67,656	-0.04
Mar. 2003	17,544	29,862	21,048	51,824	86,580	206,859	98,296	63,493	3,210	26,583	14,027	205,609	1,249	0.61	168,817,002	168,883,409	-66,406	-0.04
Apr. 2003	54,517	38,242	21,458	54,094	88,087	256,398	138,999	62,449	10,078	29,094	14,731	255,352	1,046	0.41	169,073,400	169,138,760	-65,360	-0.04
May 2003	113,703	69,796	23,972	46,765	95,979	350,215	214,683	88,602	6,061	31,496	6,618	347,461	2,754	0.79	169,423,615	169,486,221	-62,606	-0.04
Jun. 2003	191,416	117,780	23,023	40,843	107,931	480,994	323,690	118,482	1,994	29,923	1,790	475,879	5,115	1.07	169,904,609	169,962,100	-57,491	-0.03
Jul. 2003	69,336	32,248	43,451	16,285	120,251	281,571	225,054	37,598	1,152	23,944	754	288,502	-6,931	-2.43	170,186,180	170,250,602	-64,422	-0.04
Aug. 2003	46,847	20,929	43,781	56,963	114,422	282,941	195,810	48,238	1,739	33,762	615	280,164	2,777	0.99	170,469,121	170,530,766	-61,645	-0.04
Sep. 2003	31,560	20,671	25,312	10,271	113,633	201,448	146,597	34,730	826	20,747	1,001	203,901	-2,454	-1.21	170,670,569	170,734,667	-64,099	-0.04
Oct. 2003	18,108	16,884	21,282	4,219	116,477	176,971	116,541	40,212	855	19,249	556	177,413	-443	-0.25	170,847,539	170,912,081	-64,542	-0.04
Nov. 2003	17,309	23,097	14,228	3,920	100,058	158,613	91,689	46,102	1,049	19,339	760	158,938	-325	-0.20	171,006,153	171,071,019	-64,866	-0.04
Dec. 2003	13,058	14,880	14,428	5,561	99,530	147,457	80,115	41,546	1,274	20,431	5,158	148,525	-1,068	-0.72	171,153,609	171,219,544	-65,935	-0.04
Jan. 2004	13,306	17,619	15,370	6,099	100,847	153,241	79,523	42,278	1,323	19,892	10,597	153,613	-372	-0.24	171,306,850	171,373,157	-66,307	-0.04
Feb. 2004	15,048	17,741	16,882	10,079	94,001	153,752	83,029	41,251	1,572	18,806	9,296	153,954	-202	-0.13	171,460,602	171,527,111	-66,509	-0.04
Mar. 2004	14,031	20,270	19,743	4,916	91,386	150,346	72,930	41,143	1,325	20,480	14,833	150,711	-365	-0.24	171,610,948	171,677,822	-66,874	-0.04
Apr. 2004	31,102	28,413	21,132	50,856	92,600	224,102	123,363	59,985	2,371	27,202	9,320	222,241	1,861	0.83	171,835,050	171,900,063	-65,013	-0.04
May 2004	70,923	27,641	25,037	34,688	108,833	267,122	184,336	46,810	5,033	27,222	2,327	265,728	1,394	0.52	172,102,172	172,165,791	-63,619	-0.04
Jun. 2004	85,710	41,282	23,693	58,304	104,868	313,857	208,274	67,814	2,346	30,537	2,087	311,058	2,799	0.90	172,416,028	172,476,848	-60,820	-0.04
Jul. 2004	95,034	38,876	31,811	42,856	116,453	325,030	230,473	63,664	2,825	28,406	976	326,343	-1,314	-0.40	172,741,058	172,803,192	-62,134	-0.04
Aug. 2004	69,680	33,274	32,797	61,794	119,227	316,772	223,570	59,538	3,229	28,536	665	315,539	1,233	0.39	173,057,830	173,118,731	-60,901	-0.04
Sep. 2004	41,858	27,339	24,120	37,078	121,523	251,918	172,884	54,252	1,507	24,532	700	253,875	-1,956	-0.77	173,309,748	173,372,606	-62,857	-0.04
Oct. 2004	55,494	51,512	26,826	23,291	118,005	275,128	161,773	84,760	1,799	22,981	1,008	272,321	2,808	1.03	173,584,876	173,644,926	-60,050	-0.03
Nov. 2004	20,797	31,185	14,923	15,682	109,171	191,757	105,830	60,481	1,822	19,995	6,551	194,679	-2,921	-1.51	173,776,634	173,839,605	-62,971	-0.04
Dec. 2004	18,463	28,378	16,458	2,366	106,094	171,758	87,613	51,450	1,796	19,463	12,881	173,203	-1,445	-0.84	173,948,392	174,012,807	-64,416	-0.04

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jan. 2005	14,739	26,488	14,485	11,678	103,436	170,826	85,038	50,437	2,057	20,268	13,811	171,612	-785	-0.46	174,119,218	174,184,419	-65,201	-0.04
Feb. 2005	12,288	22,935	15,074	1,893	93,356	145,546	75,263	39,709	1,674	17,262	12,278	146,186	-640	-0.44	174,264,764	174,330,605	-65,841	-0.04
Mar. 2005	15,284	25,294	16,984	12,393	100,476	170,431	91,578	47,150	2,168	20,644	9,048	170,588	-158	-0.09	174,435,194	174,501,193	-65,999	-0.04
Apr. 2005	57,830	36,469	21,471	54,248	98,866	268,884	124,749	65,405	14,846	32,536	29,488	267,024	1,860	0.69	174,704,079	174,768,217	-64,138	-0.04
May 2005	157,135	75,028	23,120	37,008	113,233	405,525	251,980	101,576	12,806	27,207	8,128	401,696	3,829	0.95	175,109,604	175,169,913	-60,309	-0.03
Jun. 2005	205,078	150,509	23,424	75,681	111,830	566,522	269,033	165,043	7,290	42,962	77,500	561,828	4,694	0.83	175,676,126	175,731,741	-55,615	-0.03
Jul. 2005	78,689	27,157	38,963	20,011	144,028	308,848	245,675	40,207	1,291	22,360	3,731	313,263	-4,416	-1.42	175,984,974	176,045,004	-60,031	-0.03
Aug. 2005	62,937	22,275	32,350	41,200	135,473	294,235	220,257	44,855	2,487	26,395	1,555	295,550	-1,315	-0.45	176,279,209	176,340,554	-61,345	-0.03
Sep. 2005	31,193	13,714	28,068	8,712	126,417	208,104	154,757	32,864	894	20,007	1,124	209,645	-1,541	-0.74	176,487,313	176,550,199	-62,886	-0.04
Oct. 2005	37,435	38,807	21,980	60,816	124,598	283,636	152,007	79,641	2,484	32,989	14,552	281,673	1,963	0.69	176,770,949	176,831,872	-60,923	-0.03
Nov. 2005	17,680	25,204	25,556	3,774	116,202	188,415	106,414	51,121	1,854	18,444	13,738	191,571	-3,156	-1.66	176,959,363	177,023,443	-64,079	-0.04
Dec. 2005	13,908	24,073	14,025	4,009	111,807	167,822	78,128	46,853	1,606	19,398	23,009	168,995	-1,173	-0.70	177,127,185	177,192,437	-65,252	-0.04
Jan. 2006	13,269	21,077	14,054	3,618	113,376	165,394	92,807	44,160	1,693	18,172	9,298	166,130	-736	-0.44	177,292,579	177,358,567	-65,988	-0.04
Feb. 2006	11,589	18,792	15,839	4,007	97,136	147,362	81,500	39,117	1,508	17,250	8,313	147,688	-326	-0.22	177,439,942	177,506,255	-66,314	-0.04
Mar. 2006	15,161	23,991	20,724	14,898	100,245	175,019	79,042	47,634	1,832	23,468	23,063	175,040	-21	-0.01	177,614,961	177,681,295	-66,335	-0.04
Apr. 2006	17,627	15,030	21,698	11,723	110,529	176,608	111,399	35,615	1,717	19,912	8,184	176,827	-219	-0.12	177,791,569	177,858,122	-66,553	-0.04
May 2006	74,481	18,536	27,518	18,227	111,530	250,293	183,384	38,367	1,418	23,239	1,385	247,793	2,499	1.00	178,041,861	178,105,915	-64,054	-0.04
Jun. 2006	103,088	34,127	27,556	12,314	107,318	284,403	212,078	48,675	877	22,643	1,158	285,430	-1,027	-0.36	178,326,265	178,391,346	-65,081	-0.04
Jul. 2006	98,345	36,181	28,055	48,159	108,598	319,338	218,382	60,648	3,101	33,316	1,251	316,697	2,641	0.83	178,645,603	178,708,043	-62,440	-0.03
Aug. 2006	58,691	19,219	47,762	38,553	111,362	275,587	196,618	40,538	1,550	32,181	5,758	276,646	-1,058	-0.38	178,921,190	178,984,688	-63,498	-0.04
Sep. 2006	32,936	16,740	22,731	20,398	114,512	207,317	145,216	38,559	1,240	23,403	1,040	209,458	-2,141	-1.03	179,128,507	179,194,146	-65,639	-0.04
Oct. 2006	30,170	27,155	21,704	38,212	113,097	230,337	136,366	61,943	2,005	25,971	1,279	227,565	2,772	1.21	179,358,844	179,421,711	-62,866	-0.04
Nov. 2006	16,444	22,951	17,025	5,246	106,730	168,397	98,834	50,525	3,269	18,465	1,139	172,232	-3,835	-2.25	179,527,241	179,593,943	-66,701	-0.04
Dec. 2006	15,950	23,550	16,190	28,341	99,513	183,544	88,346	59,399	2,609	24,631	8,618	183,604	-59	-0.03	179,710,786	179,777,546	-66,761	-0.04
Jan. 2007	17,697	22,878	16,100	11,312	98,079	166,067	73,431	48,620	2,217	25,637	17,179	167,084	-1,017	-0.61	179,876,853	179,944,630	-67,778	-0.04
Feb. 2007	21,689	31,796	17,136	5,047	90,492	166,160	87,847	45,160	2,370	21,913	9,013	166,303	-143	-0.09	180,043,013	180,110,934	-67,921	-0.04
Mar. 2007	57,689	41,997	18,633	16,552	101,038	235,909	143,918	56,151	7,375	23,299	2,096	232,839	3,070	1.31	180,278,922	180,343,772	-64,851	-0.04
Apr. 2007	79,347	45,222	21,417	48,386	102,715	297,087	168,577	61,946	14,295	33,268	18,340	296,427	660	0.22	180,576,008	180,640,199	-64,191	-0.04
May 2007	248,228	77,462	23,498	63,235	106,522	518,945	278,511	91,087	17,748	48,945	79,716	516,008	2,938	0.57	181,094,954	181,156,207	-61,253	-0.03
Jun. 2007	197,597	75,652	22,956	20,357	130,773	447,334	328,296	73,115	4,719	25,488	15,070	446,687	647	0.14	181,542,288	181,602,894	-60,606	-0.03

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jul. 2007	97,725	25,220	34,681	37,065	135,793	330,483	247,049	44,437	2,094	27,994	9,079	330,653	-170	-0.05	181,872,772	181,933,547	-60,776	-0.03
Aug. 2007	74,974	23,097	22,411	59,463	138,064	318,009	239,046	45,651	2,500	32,089	1,796	321,081	-3,072	-0.96	182,190,780	182,254,628	-63,848	-0.04
Sep. 2007	36,171	20,303	30,551	22,222	129,917	239,164	175,187	38,449	1,543	22,500	2,496	240,175	-1,011	-0.42	182,429,944	182,494,803	-64,859	-0.04
Oct. 2007	33,238	28,415	21,071	21,466	126,187	230,377	149,485	53,505	1,987	22,767	1,709	229,453	923	0.40	182,660,321	182,724,256	-63,936	-0.03
Nov. 2007	15,969	24,225	19,283	3,211	113,584	176,271	104,417	48,109	1,756	19,103	4,529	177,914	-1,644	-0.93	182,836,591	182,902,171	-65,579	-0.04
Dec. 2007	15,299	23,106	14,725	15,759	114,463	183,352	90,340	49,523	2,350	23,970	17,908	184,091	-739	-0.40	183,019,943	183,086,262	-66,319	-0.04
Jan. 2008	15,078	20,937	16,109	3,550	114,064	169,738	88,766	41,786	2,206	22,778	15,225	170,761	-1,023	-0.60	183,189,681	183,257,022	-67,341	-0.04
Feb. 2008	18,107	21,148	18,198	5,671	104,647	167,771	84,034	39,888	2,353	22,463	19,357	168,095	-324	-0.19	183,357,452	183,425,117	-67,665	-0.04
Mar. 2008	23,457	22,098	19,562	7,837	105,953	178,907	94,312	42,001	2,791	22,101	18,007	179,212	-305	-0.17	183,536,359	183,604,329	-67,970	-0.04
Apr. 2008	27,665	16,305	19,813	16,019	112,265	192,067	113,450	35,326	3,263	22,536	17,474	192,049	18	0.01	183,728,427	183,796,378	-67,952	-0.04
May 2008	81,368	21,220	24,150	36,146	118,991	281,875	196,384	44,117	3,817	24,922	9,937	279,177	2,697	0.96	184,010,301	184,075,556	-65,254	-0.04
Jun. 2008	168,871	55,767	21,175	28,929	117,953	392,694	275,845	79,416	1,836	25,289	5,391	387,778	4,916	1.26	184,402,996	184,463,334	-60,338	-0.03
Jul. 2008	106,755	28,058	34,396	24,819	127,091	321,119	233,972	43,385	1,141	26,777	17,725	323,001	-1,882	-0.58	184,724,114	184,786,335	-62,220	-0.03
Aug. 2008	60,737	42,260	24,001	94,686	127,737	349,420	209,899	67,150	3,169	42,802	24,356	347,375	2,045	0.59	185,073,534	185,133,710	-60,176	-0.03
Sep. 2008	37,847	27,180	24,081	30,933	133,455	253,496	178,112	50,446	1,503	22,205	2,893	255,159	-1,663	-0.65	185,327,030	185,388,869	-61,839	-0.03
Oct. 2008	24,095	27,193	23,209	18,385	132,002	224,884	143,543	51,908	1,501	21,710	7,619	226,281	-1,397	-0.62	185,551,915	185,615,150	-63,236	-0.03
Nov. 2008	14,790	23,689	21,006	4,501	115,737	179,722	104,079	45,534	1,497	18,777	11,502	181,388	-1,666	-0.92	185,731,637	185,796,539	-64,902	-0.03
Dec. 2008	15,493	24,770	18,507	8,572	113,726	181,068	89,965	47,674	2,057	22,124	19,922	181,740	-672	-0.37	185,912,705	185,978,279	-65,574	-0.04
Jan. 2009	16,722	23,798	19,074	5,862	112,457	177,913	94,155	45,421	1,770	21,775	15,467	178,588	-674	-0.38	186,090,619	186,156,867	-66,248	-0.04
Feb. 2009	13,117	21,693	16,804	2,040	98,809	152,463	82,158	37,357	1,633	19,121	12,735	153,003	-540	-0.35	186,243,082	186,309,870	-66,788	-0.04
Mar. 2009	12,757	20,980	18,607	12,531	109,275	174,150	84,616	41,585	1,861	22,873	23,461	174,396	-245	-0.14	186,417,232	186,484,266	-67,033	-0.04
Apr. 2009	37,181	43,453	21,095	73,683	115,539	290,950	125,008	69,663	6,415	37,487	49,912	288,485	2,465	0.85	186,708,183	186,772,751	-64,568	-0.03
May 2009	120,731	66,996	22,229	48,978	128,749	387,683	242,027	84,885	6,832	28,865	22,288	384,896	2,788	0.72	187,095,866	187,157,646	-61,781	-0.03
Jun. 2009	232,688	182,942	22,725	88,485	117,137	643,977	197,888	198,712	7,776	49,357	184,360	638,093	5,884	0.92	187,739,843	187,795,740	-55,896	-0.03
Jul. 2009	109,893	52,495	25,377	69,795	155,934	413,494	276,426	73,578	4,375	30,739	30,917	416,035	-2,541	-0.61	188,153,337	188,211,774	-58,437	-0.03
Aug. 2009	56,146	24,218	25,881	28,101	155,011	289,357	216,664	36,884	1,744	23,523	12,368	291,183	-1,826	-0.63	188,442,694	188,502,957	-60,263	-0.03
Sep. 2009	39,436	23,340	23,971	24,687	143,551	254,985	175,919	39,308	1,572	23,210	15,246	255,255	-270	-0.11	188,697,678	188,758,212	-60,534	-0.03
Oct. 2009	37,357	32,545	22,068	45,711	152,472	290,154	144,158	64,557	2,445	27,844	50,895	289,899	254	0.09	188,987,832	189,048,112	-60,279	-0.03
Nov. 2009	21,993	34,019	20,253	9,756	126,390	212,411	102,309	54,929	3,156	20,224	33,658	214,276	-1,865	-0.87	189,200,243	189,262,388	-62,144	-0.03
Dec. 2009	21,996	27,692	20,422	10,207	118,595	198,912	64,060	52,672	2,773	23,244	57,211	199,960	-1,047	-0.53	189,399,156	189,462,347	-63,192	-0.03

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)

Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jan. 2010	19,836	29,439	14,741	2,062	124,008	190,087	89,753	46,104	2,224	20,993	31,780	190,854	-767	-0.40	189,589,243	189,653,202	-63,959	-0.03
Feb. 2010	16,538	23,782	15,932	8,908	112,036	177,197	92,367	40,575	2,072	19,615	23,116	177,746	-549	-0.31	189,766,440	189,830,948	-64,508	-0.03
Mar. 2010	22,956	33,579	20,946	19,176	119,620	216,277	106,277	48,508	3,436	24,023	34,163	216,408	-131	-0.06	189,982,717	190,047,355	-64,638	-0.03
Apr. 2010	78,737	63,124	22,115	61,076	107,928	332,980	120,296	80,036	15,746	36,211	77,938	330,227	2,753	0.83	190,315,697	190,377,582	-61,886	-0.03
May 2010	170,760	132,436	23,692	40,831	111,846	479,566	175,836	138,841	15,386	33,884	111,161	475,108	4,458	0.93	190,795,263	190,852,690	-57,428	-0.03
Jun. 2010	297,607	252,377	21,606	61,141	108,887	741,618	246,374	260,982	4,755	41,659	181,728	735,499	6,119	0.83	191,536,881	191,588,189	-51,308	-0.03
Jul. 2010	90,479	39,470	26,930	36,670	170,283	363,832	281,888	54,439	2,663	24,877	6,686	370,552	-6,720	-1.83	191,900,713	191,958,742	-58,028	-0.03
Aug. 2010	91,268	27,932	24,568	32,063	156,177	332,008	256,143	45,062	1,886	24,882	4,289	332,262	-254	-0.08	192,232,721	192,291,003	-58,283	-0.03
Sep. 2010	36,644	17,044	24,978	2,964	145,691	227,321	181,507	30,857	1,001	16,855	2,299	232,519	-5,198	-2.26	192,460,041	192,523,523	-63,481	-0.03
Oct. 2010	35,774	24,908	22,299	12,624	138,351	233,956	160,217	46,411	1,509	19,843	5,377	233,357	598	0.26	192,693,997	192,756,880	-62,883	-0.03
Nov. 2010	17,130	26,164	19,961	6,068	128,081	197,404	123,387	47,999	1,707	17,961	8,359	199,413	-2,009	-1.01	192,891,401	192,956,293	-64,892	-0.03
Dec. 2010	16,317	23,643	18,544	3,242	124,138	185,883	106,028	43,978	1,758	19,566	15,530	186,860	-976	-0.52	193,077,284	193,143,152	-65,868	-0.03
Jan. 2011	16,338	23,729	15,964	6,060	111,658	173,748	73,026	43,736	1,782	22,984	32,767	174,296	-548	-0.31	193,251,033	193,317,448	-66,416	-0.03
Feb. 2011	13,771	22,245	12,726	9,391	100,232	158,365	59,374	40,095	1,761	21,488	36,015	158,733	-368	-0.23	193,409,397	193,476,181	-66,784	-0.03
Mar. 2011	14,421	23,728	17,288	3,518	121,658	180,614	100,144	40,299	1,668	19,963	18,955	181,028	-414	-0.23	193,590,011	193,657,210	-67,198	-0.03
Apr. 2011	24,943	17,685	18,349	31,135	121,595	213,707	128,715	38,205	2,101	25,169	18,985	213,175	532	0.25	193,803,719	193,870,385	-66,666	-0.03
May 2011	80,847	61,363	21,666	90,081	124,244	378,201	195,987	90,332	3,126	36,986	46,542	372,974	5,227	1.39	194,181,920	194,243,359	-61,439	-0.03
Jun. 2011	284,309	200,863	20,700	35,042	114,162	655,076	310,215	235,493	1,954	30,179	70,192	648,033	7,043	1.08	194,836,996	194,891,392	-54,396	-0.03
Jul. 2011	292,266	216,449	23,994	75,833	125,538	734,080	363,943	232,580	1,804	38,297	95,623	732,247	1,833	0.25	195,571,076	195,623,639	-52,563	-0.03
Aug. 2011	101,737	33,410	28,330	14,710	168,400	346,586	282,462	44,694	1,108	18,683	6,165	353,110	-6,524	-1.86	195,917,662	195,976,749	-59,087	-0.03
Sep. 2011	49,620	32,723	23,060	29,834	144,009	279,247	195,927	53,404	1,451	21,549	7,149	279,481	-234	-0.08	196,196,909	196,256,230	-59,321	-0.03
Oct. 2011	35,153	32,364	21,895	38,365	141,391	269,168	169,870	61,847	1,645	25,010	11,692	270,065	-897	-0.33	196,466,077	196,526,295	-60,218	-0.03
Nov. 2011	19,219	33,070	19,041	6,551	129,907	207,788	123,276	52,478	1,458	18,456	14,056	209,723	-1,935	-0.93	196,673,865	196,736,018	-62,153	-0.03
Dec. 2011	19,279	31,508	16,029	9,968	113,801	190,584	56,688	52,311	1,791	23,599	57,061	191,451	-867	-0.45	196,864,449	196,927,469	-63,019	-0.03
Jan. 2012	20,383	30,020	16,790	3,002	113,285	183,480	46,115	49,118	1,799	23,006	64,122	184,160	-680	-0.37	197,047,929	197,111,629	-63,700	-0.03
Feb. 2012	16,659	32,143	17,002	15,511	103,086	184,401	43,164	48,500	1,777	24,671	66,675	184,787	-386	-0.21	197,232,331	197,296,416	-64,085	-0.03
Mar. 2012	18,826	24,120	19,451	582	120,983	183,961	90,979	41,240	1,684	20,156	30,905	184,965	-1,004	-0.54	197,416,292	197,481,381	-65,089	-0.03
Apr. 2012	27,629	18,513	18,628	25,166	122,191	212,127	130,404	37,037	2,561	24,236	17,428	211,665	461	0.22	197,628,418	197,693,046	-64,628	-0.03
May 2012	56,793	16,895	22,405	31,967	127,045	255,105	183,564	36,230	2,060	22,605	9,013	253,473	1,632	0.64	197,883,523	197,946,519	-62,996	-0.03
Jun. 2012	62,388	14,531	35,310	18,412	118,591	249,232	194,938	28,172	1,658	22,360	3,277	250,405	-1,173	-0.47	198,132,755	198,196,924	-64,169	-0.03

Table D-1. Simulated Monthly Surface Water Budgets (ac-ft)																		
Month/Year	Inflows						Outflows						Mass Balance					
	Gaged Surface Water Inflows	Gaged Surface Water Inflows at Selected Tributary Mouth Gages	Return Flow and Discharge Inflows	Ungaged Surface Water Inflows	Stream Gain from Aquifer	Total Inflows	Physical Diversions	Flows Removed above Selected Tributary Mouth Gages	Ungaged Diversions	Stream Loss to Aquifer	Streamflow Out Below Julesburg	Total Outflows	In Minus Out	% Mass Balance Error	Cumulative In	Cumulative Out	Cumulative In Minus Out	Cumulative % Mass Balance Error
Jul. 2012	71,291	25,385	33,030	49,245	117,257	296,207	217,832	43,993	1,764	30,214	1,459	295,263	944	0.32	198,428,962	198,492,186	-63,225	-0.03
Aug. 2012	60,528	13,738	28,156	8,818	114,922	226,161	180,332	26,785	872	20,666	1,155	229,810	-3,649	-1.60	198,655,123	198,721,996	-66,873	-0.03
Sep. 2012	26,679	15,727	20,301	40,393	108,530	211,631	137,150	42,807	1,553	27,109	905	209,525	2,106	1.00	198,866,754	198,931,521	-64,767	-0.03
Oct. 2012	34,012	23,481	19,183	18,581	117,323	212,580	143,068	46,118	1,259	21,364	1,406	213,215	-636	-0.30	199,079,334	199,144,737	-65,403	-0.03
Nov. 2012	10,544	20,886	17,639	3,342	99,240	151,651	76,357	41,076	1,031	19,820	15,419	153,703	-2,052	-1.34	199,230,985	199,298,439	-67,454	-0.03
Dec. 2012	8,856	18,452	17,859	5,440	97,971	148,579	55,550	39,265	1,053	22,550	30,920	149,338	-759	-0.51	199,379,564	199,447,777	-68,213	-0.03

Appendix E: Calibration Hydrographs at Observation Wells

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Groundwater-Level Calibration Observation Well Locations ..... Plate E-1
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402321104371200 USGS E-20
402359104375200 DWR E-21
402538103242001 USGS NAWQA 14 ..... E-22
402658104400001 USGS NAWQA 15 ..... E-23
402758103184400 USGS E-24
LSP-61 06N6517BBC E-25
403121103181200 USGS E-26
403317103170700 USGS E-27
403453103140700 USGS E-28
404105103092600 USGS E-29
LSP-91 05S6618CDA E-30
394418104203301 DWR (KB-37) E-31
394537104183001 DWR (KB-36) E-32
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395727104071701 DWR (KB-22) E-44
395807104491900 USGS E-45
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395904104252901 DWR (GS-6) E-47
395908104174601 DWR (KB-23) E-48
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400054104255601 DWR E-52
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400146104273501 DWR (GS-5) E-55
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401304103495500 USGS E-82
401315104490101 DWR E-83
401357103494600 USGS E-84
401515103432900 USGS E-85
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401634103541700 USGS E-89
401701104451400 DWR E-90
401724104484000 USGS E-91
401727104133000 USGS E-92
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401752103541000 USGS E-94
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37081 ARSENAL E-124
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WT-14 CDOW 2006 ..... E-167
HAYNES STOCK WL Julesburg E-168
HAYNES MON. WL Julesburg E-169
LEEF Julesburg E-170
MW-10 Julesburg E-171

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MW-4 Julesburg E-174
MW-1 Julesburg E-175
MW-2 Julesburg E-176
MW-3 Julesburg E-177
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WHITE Julesburg E-186
HODGES Julesburg E-187
OLD MIDDLE WELL Julesburg E-188
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COLLINS Julesburg E-190
SPILLMAN WELL EAST Julesburg E-191
SPILLMAN WELL WEST Julesburg E-192
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BEAVER Julesburg E-194
MANN SOUTH Julesburg E-195
JULIUS Julesburg E-196
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WELL ID 320;CSU WP 103 CSU E-246
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N-7 DWR E-260
S-23A DWR E-261
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S-26A DWR E-263
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Well ID 341;CSU WP 119 CSU E-299

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83-1 Thorn 2005 ..... E-390
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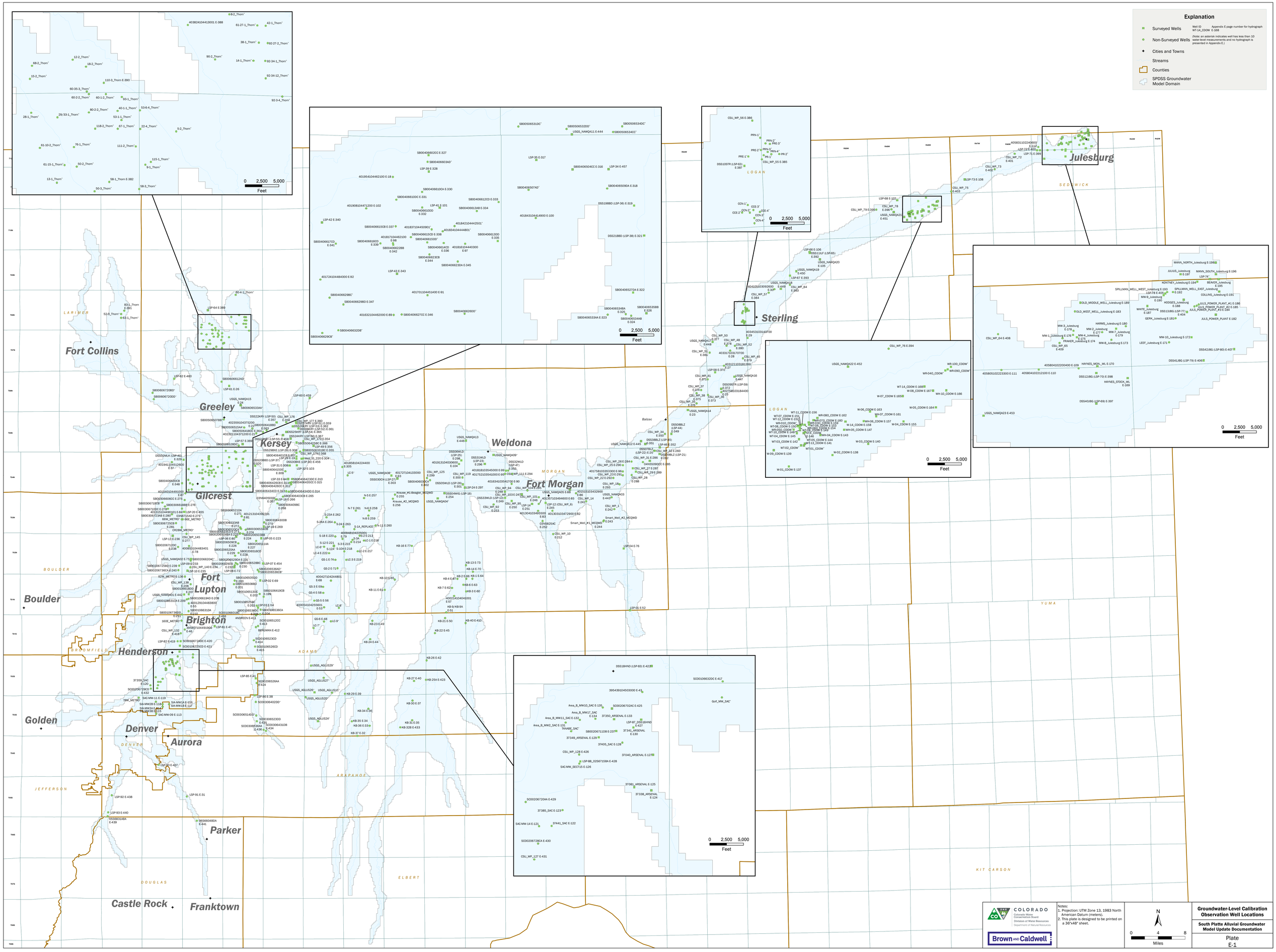

COLORADO
Colorado Water Conservation Board
Division of Water Resources
Department of Natural Resources

Brown AND Caldwell

Notes:
1. Projection: UTM Zone 13, 1983 North American Datum (meters).
2. This plate is designed to be printed on a 36"x48" sheet.

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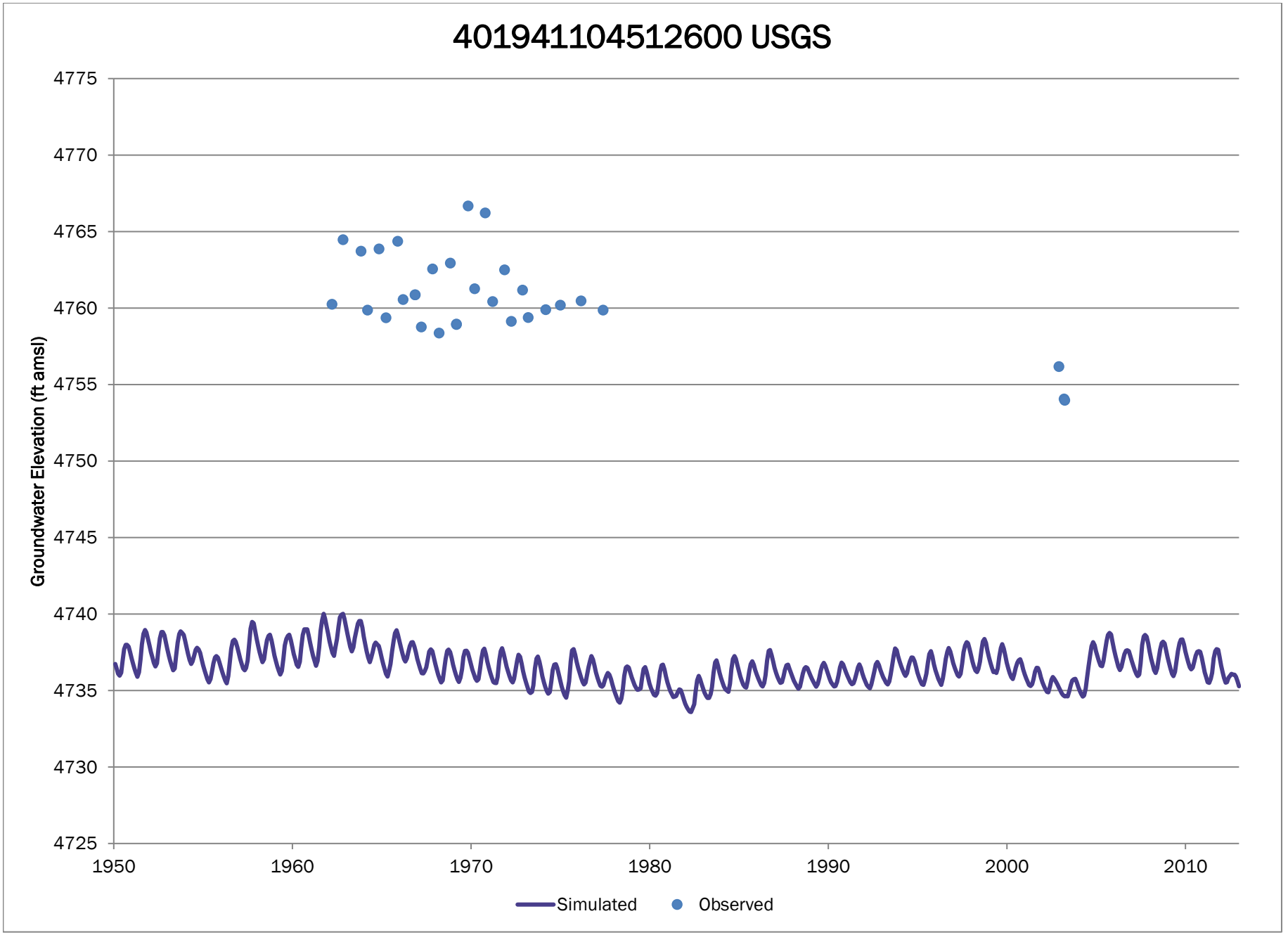
Groundwater-Level Calibration Observation Well Locations

South Platte Alluvial Groundwater Model Update Documentation

Plate
E-1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Groundwater Elevation (ft amsl)
4775
4770
4765
4760
4755
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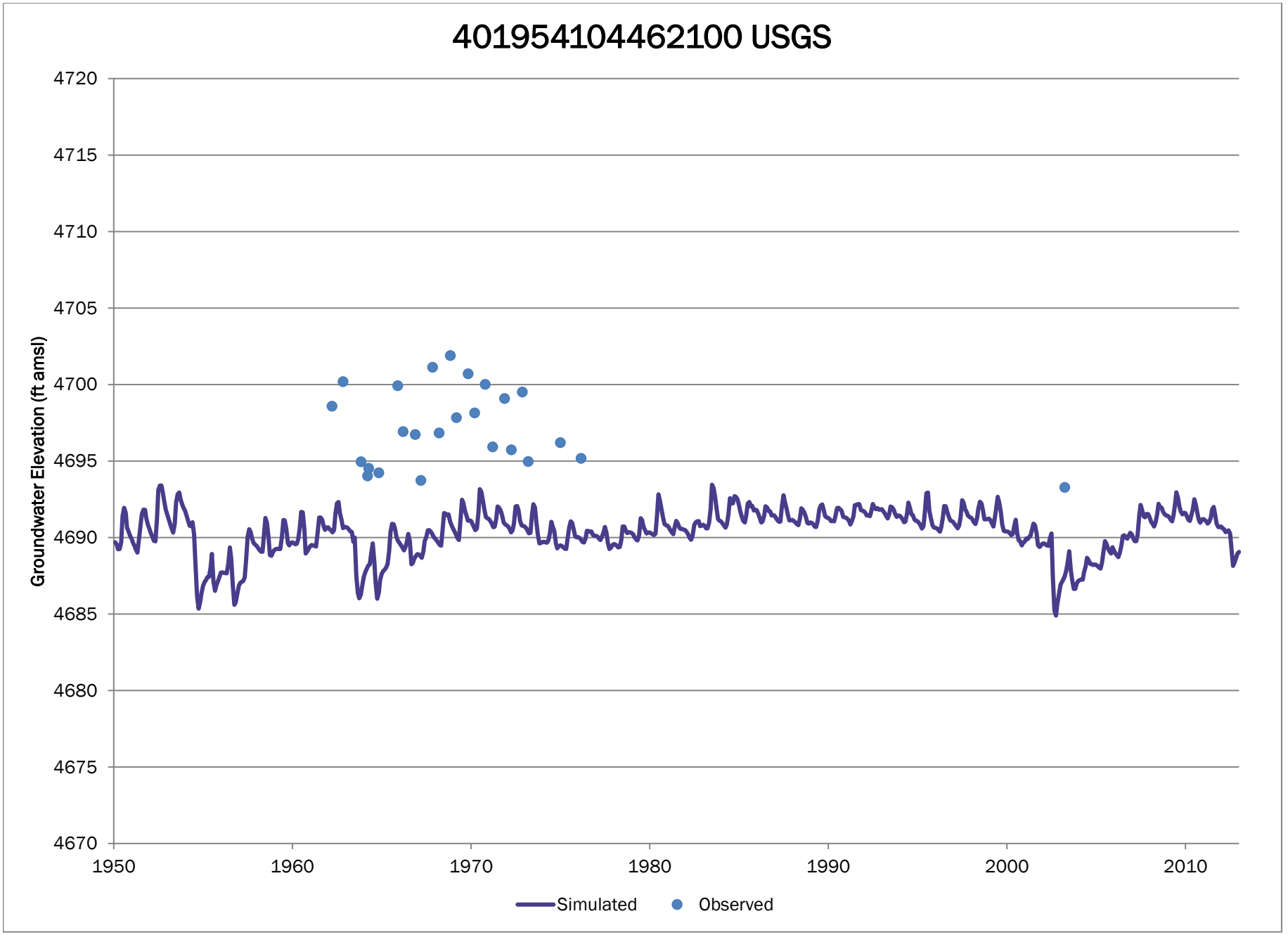
4745
4740
4735
4730
4725
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed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Groundwater Elevation (ft amsl)
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4715
4710
4705
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4690
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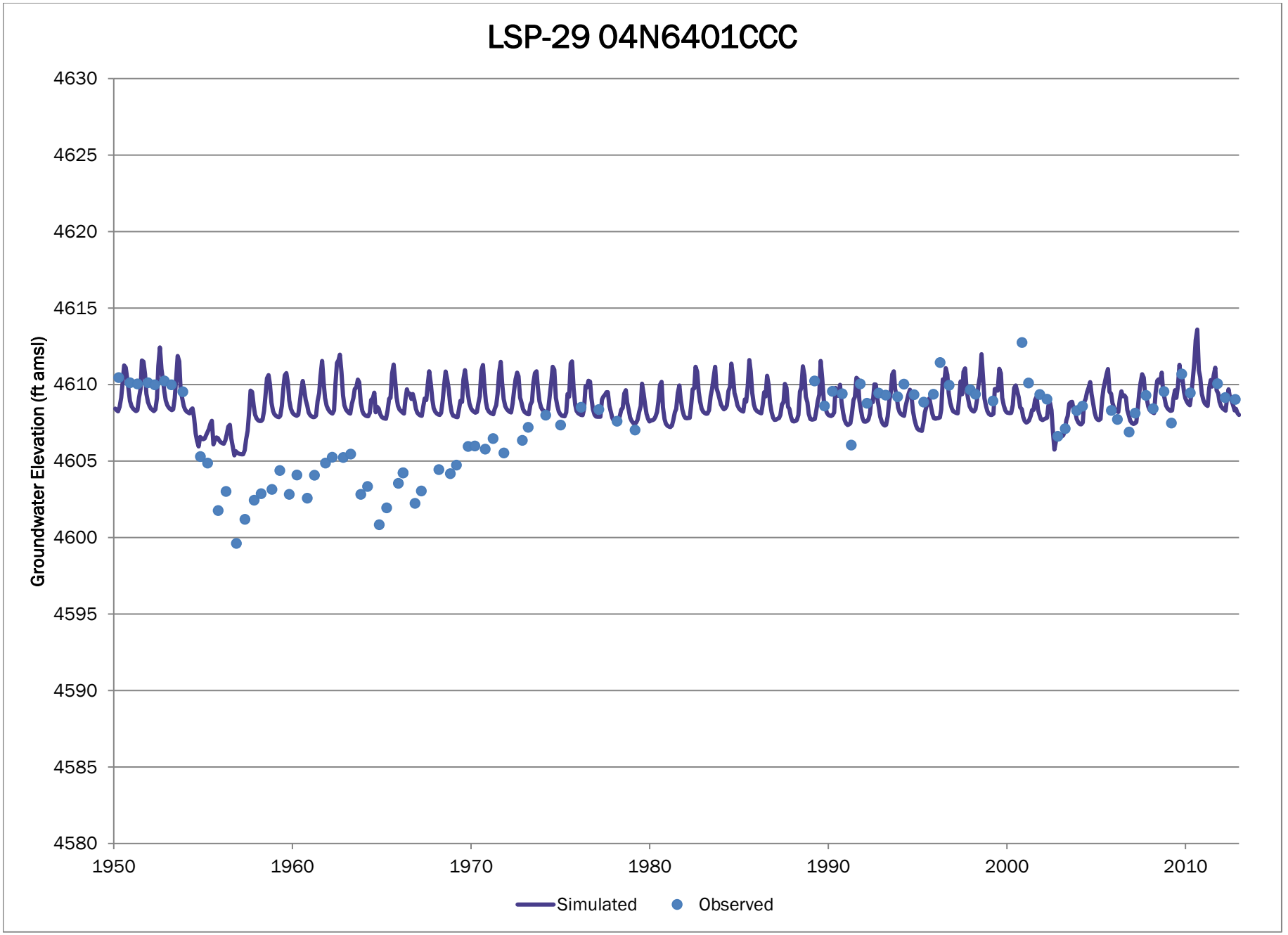
4675
4670
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed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Groundwater Elevation (ft amsl)
4630
4625
4620
4615
4610
4605
4600
4595
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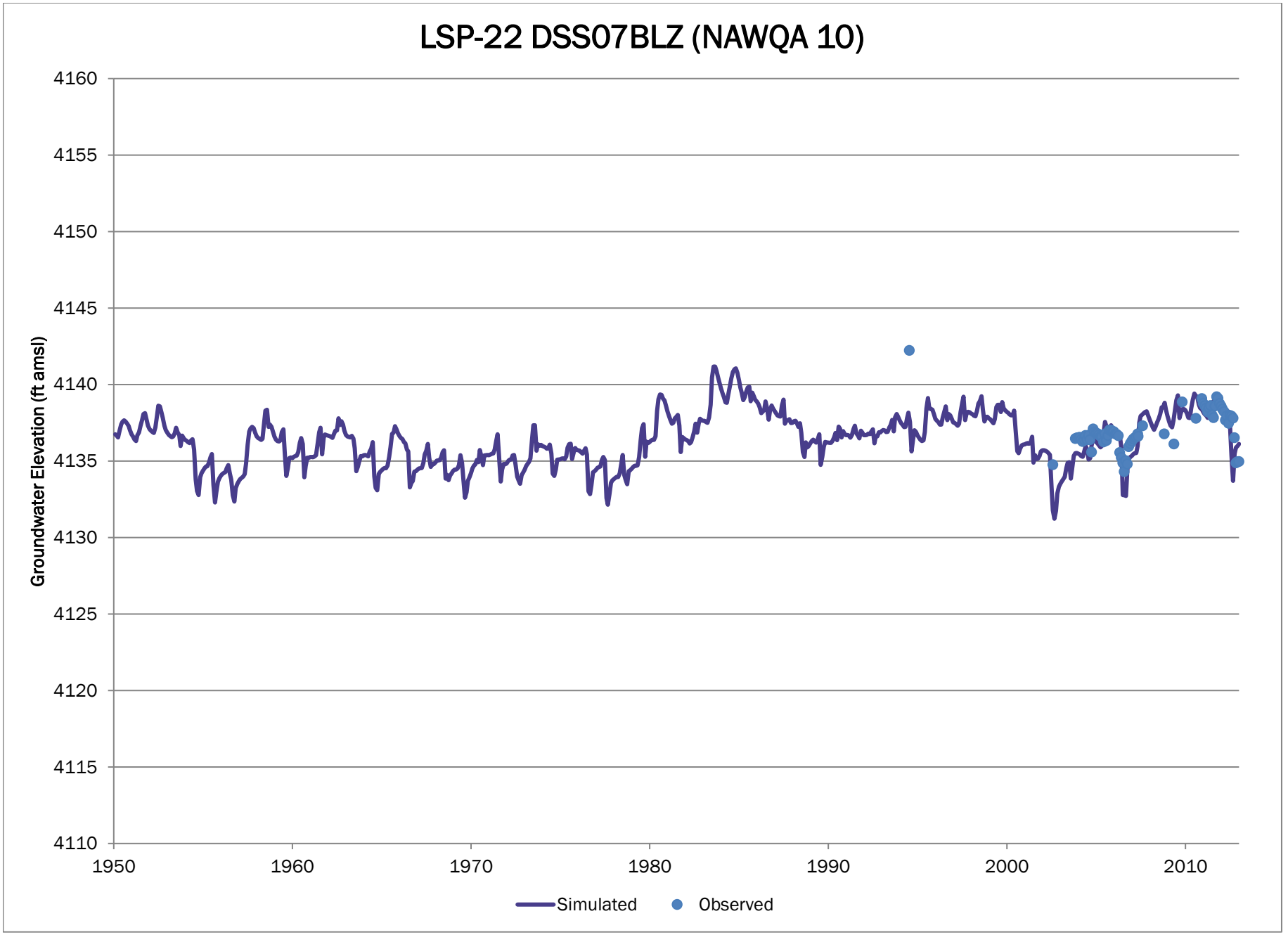
4585
4580
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed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Groundwater Elevation (ft amsl)
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4155
4150
4145
4140
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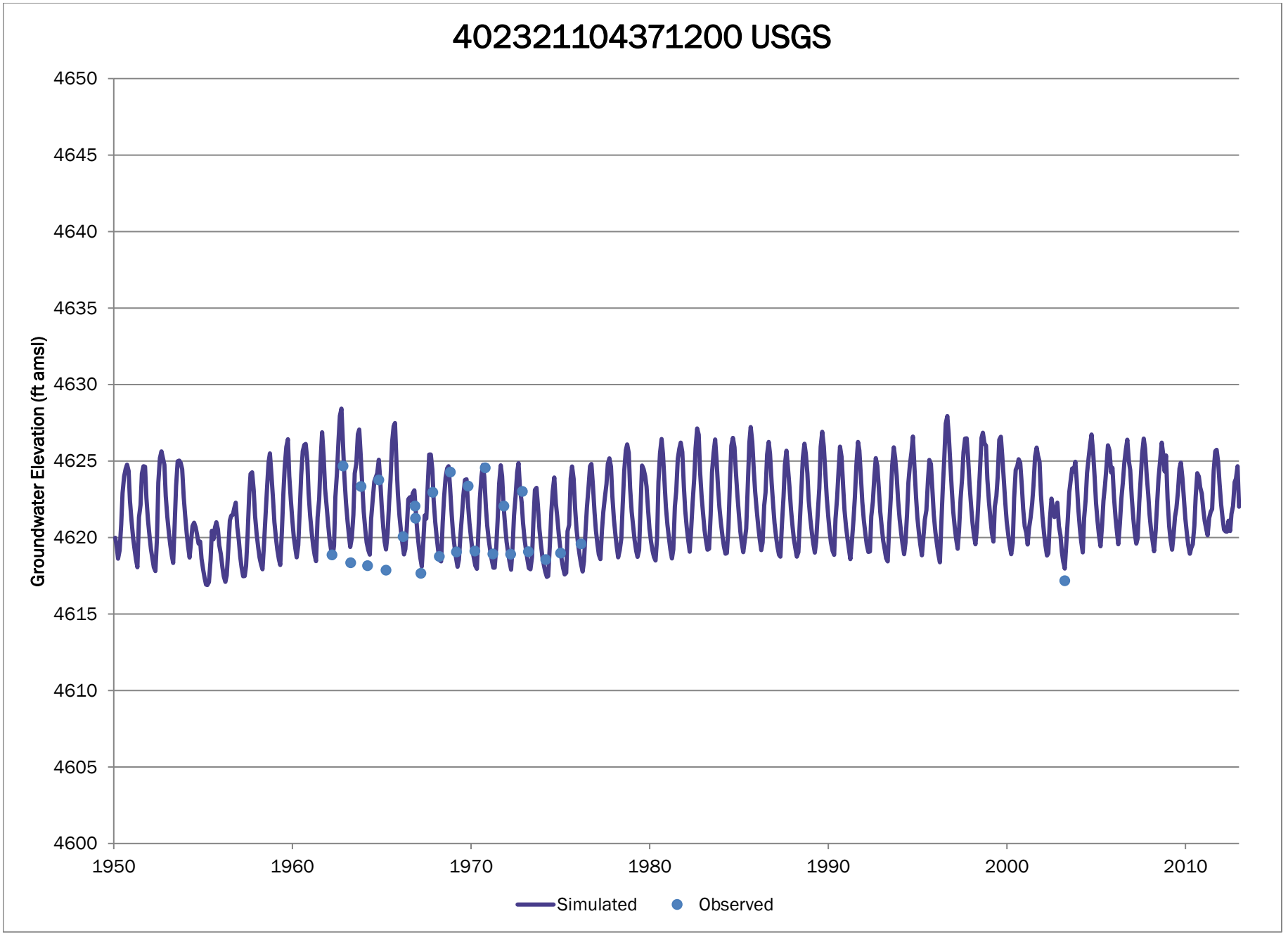
4130
4125
4120
4115
4110
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed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4645
4640
4635
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4620
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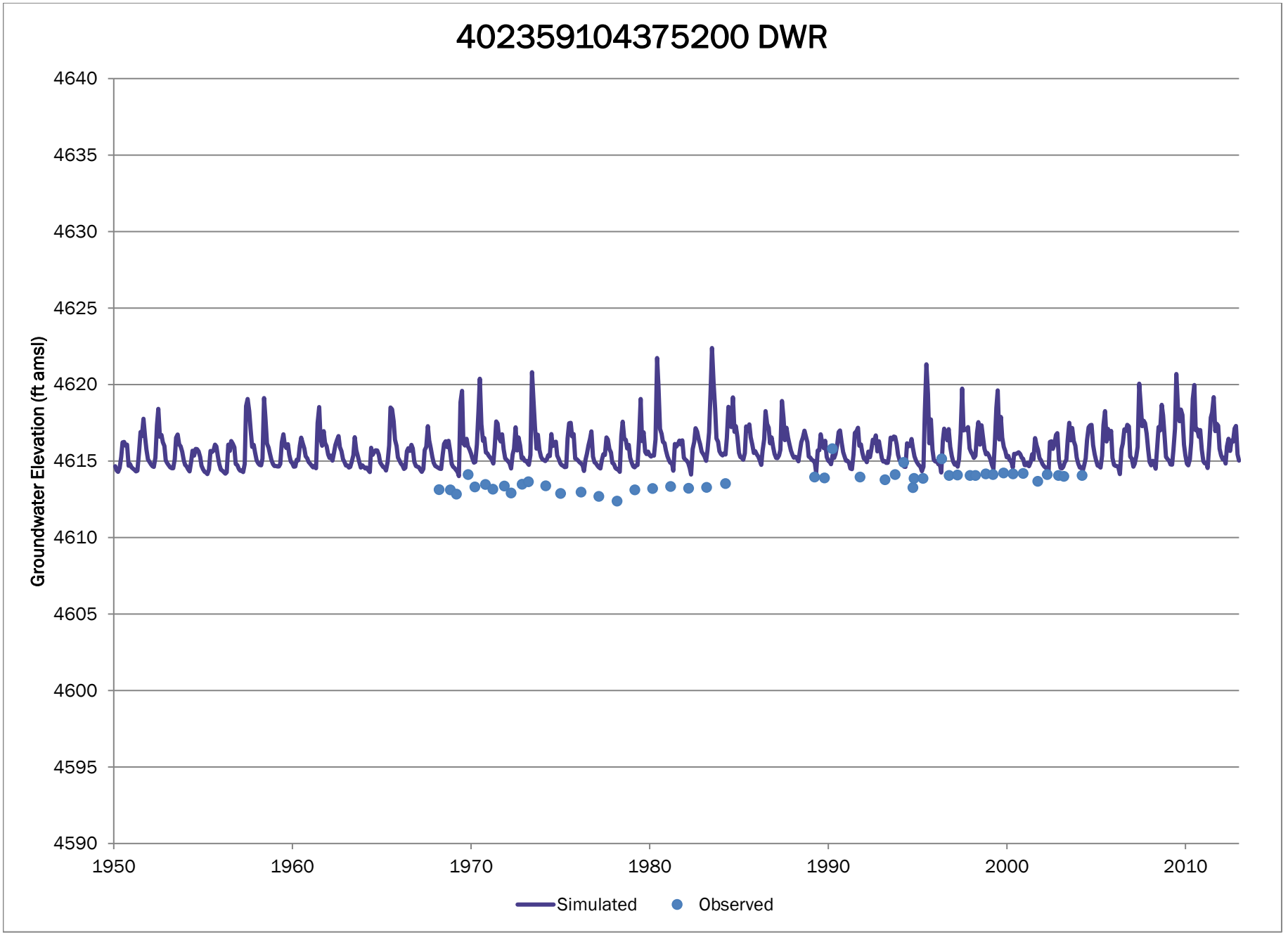
4610
4605
4600
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed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Groundwater Elevation (ft amsl)
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4635
4630
4625
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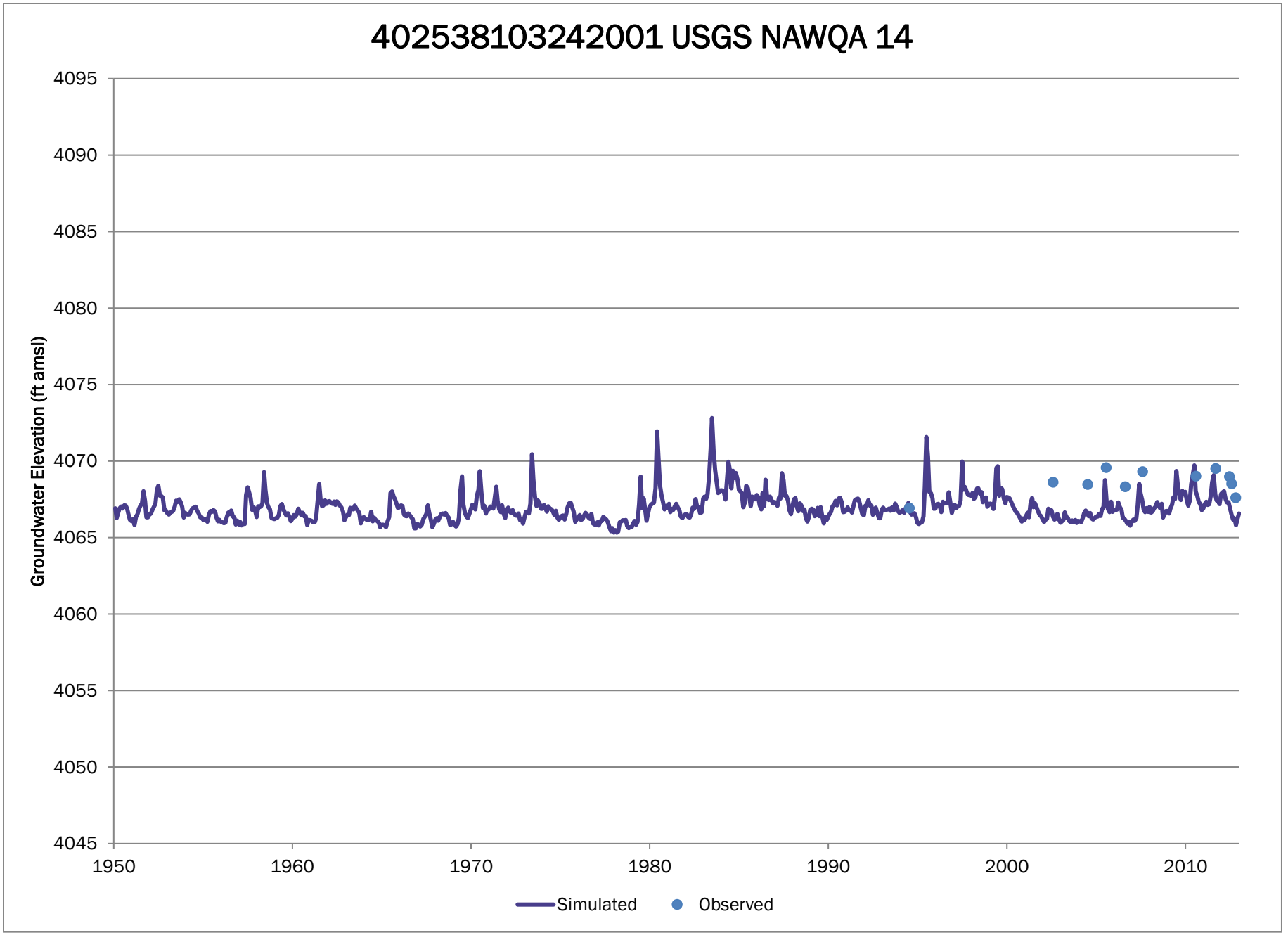
4595
4590
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed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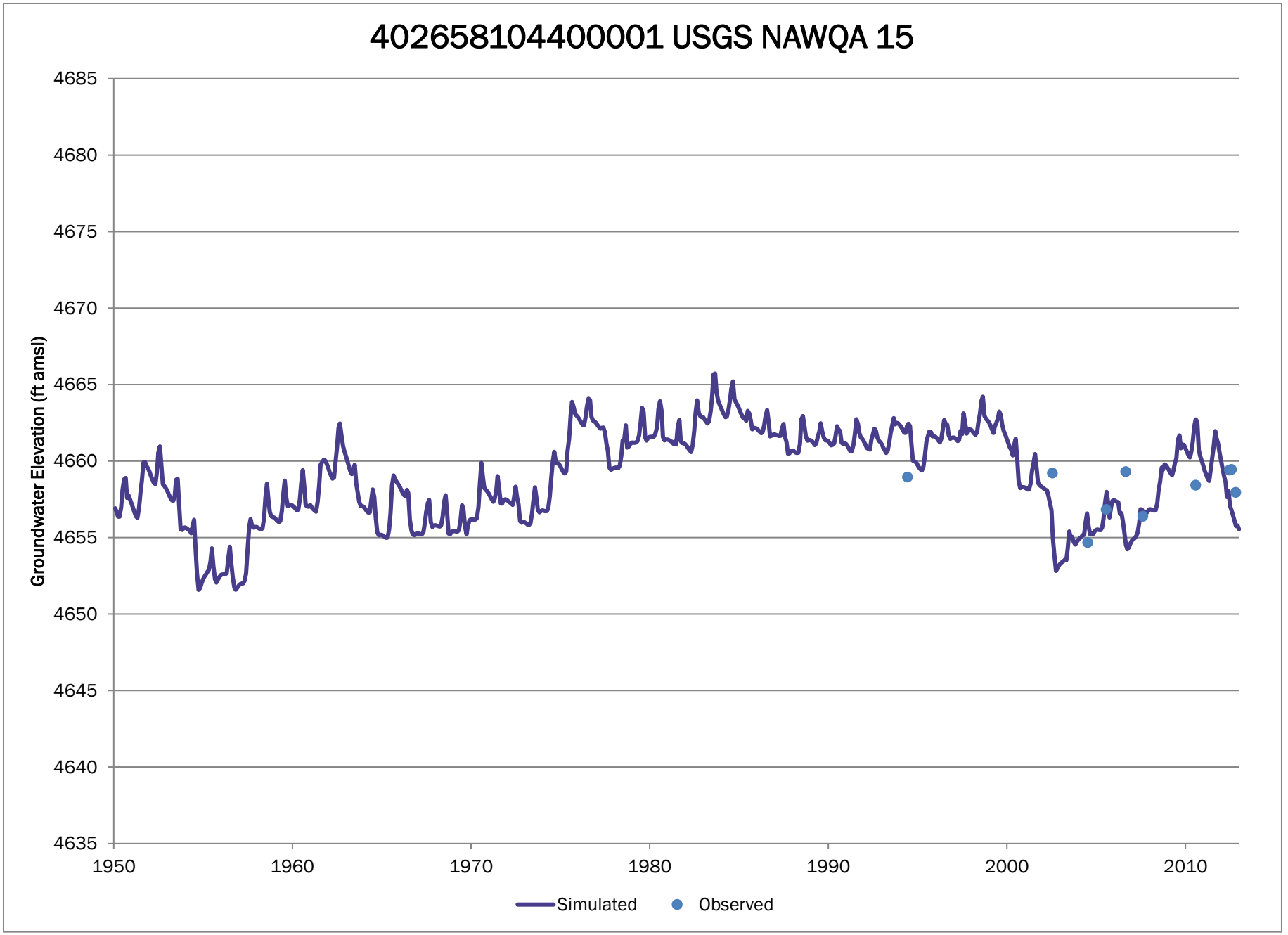
4090
4085
4080
4075
4070
4065
4060
4055
4050
4045
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed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Groundwater Elevation (ft amsl)
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4680
4675
4670
4665
4660
4655
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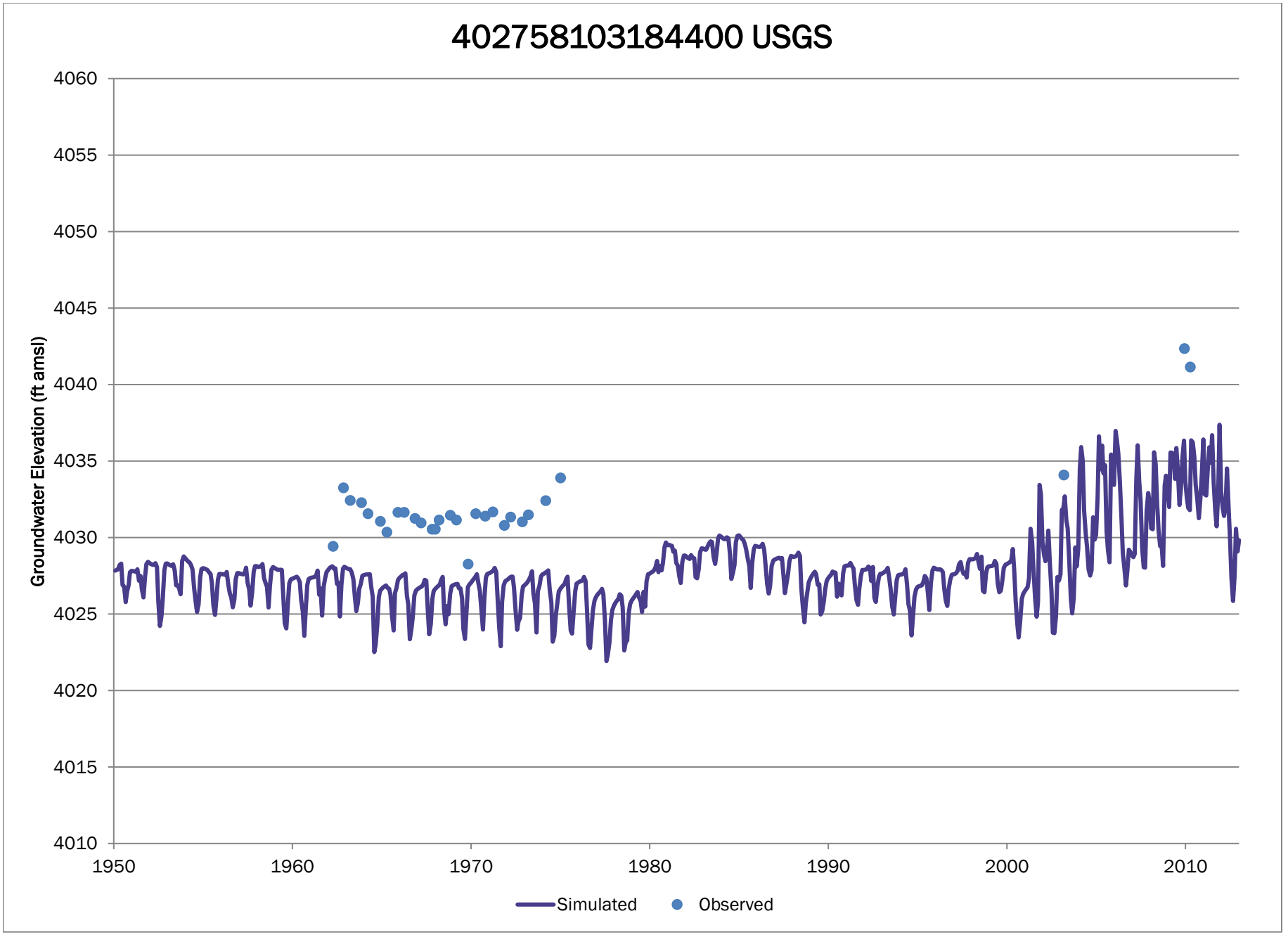
4645
4640
4635
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed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Groundwater Elevation (ft amsl)
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4055
4050
4045
4040
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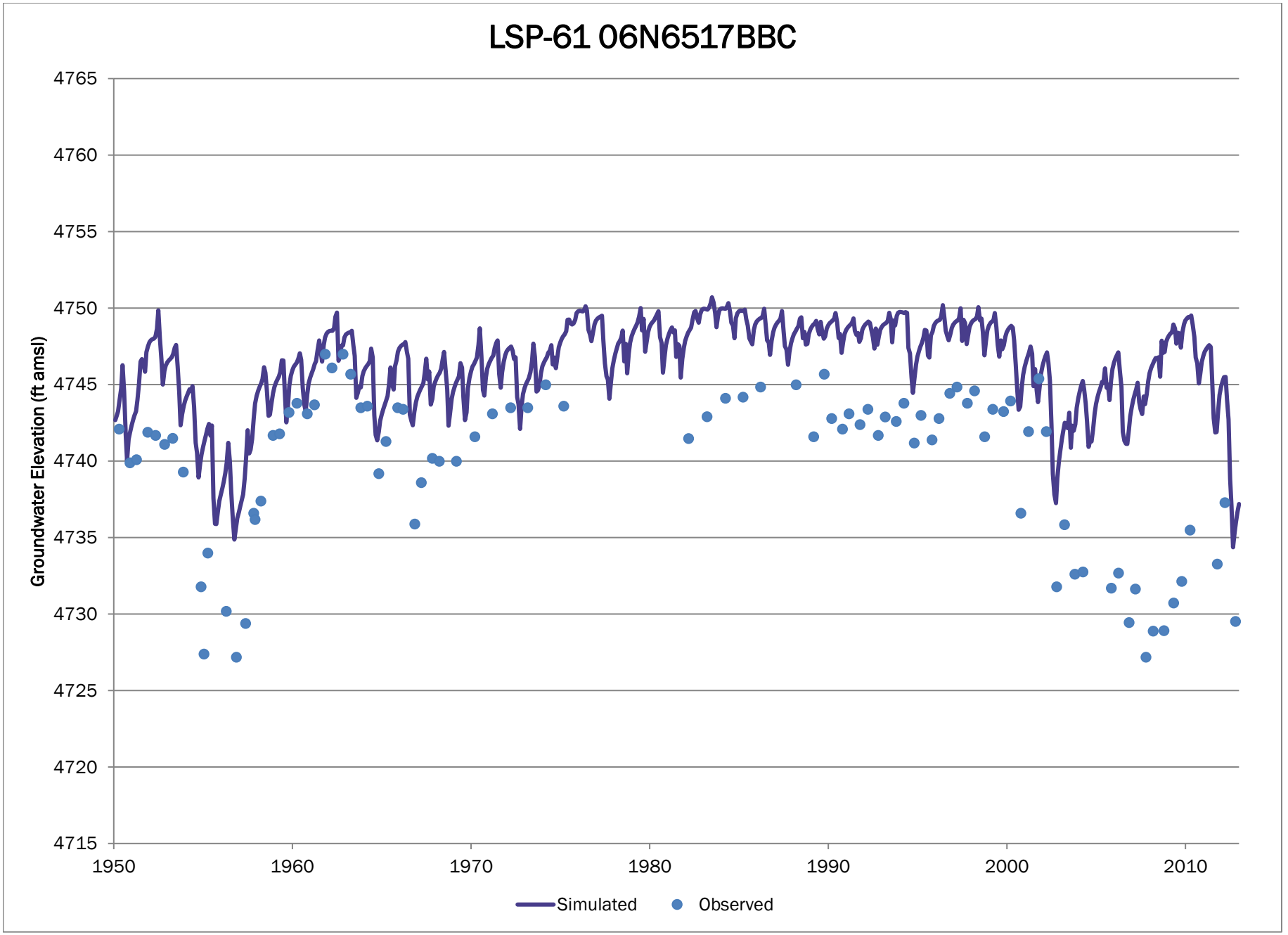
4030
4025
4020
4015
4010
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed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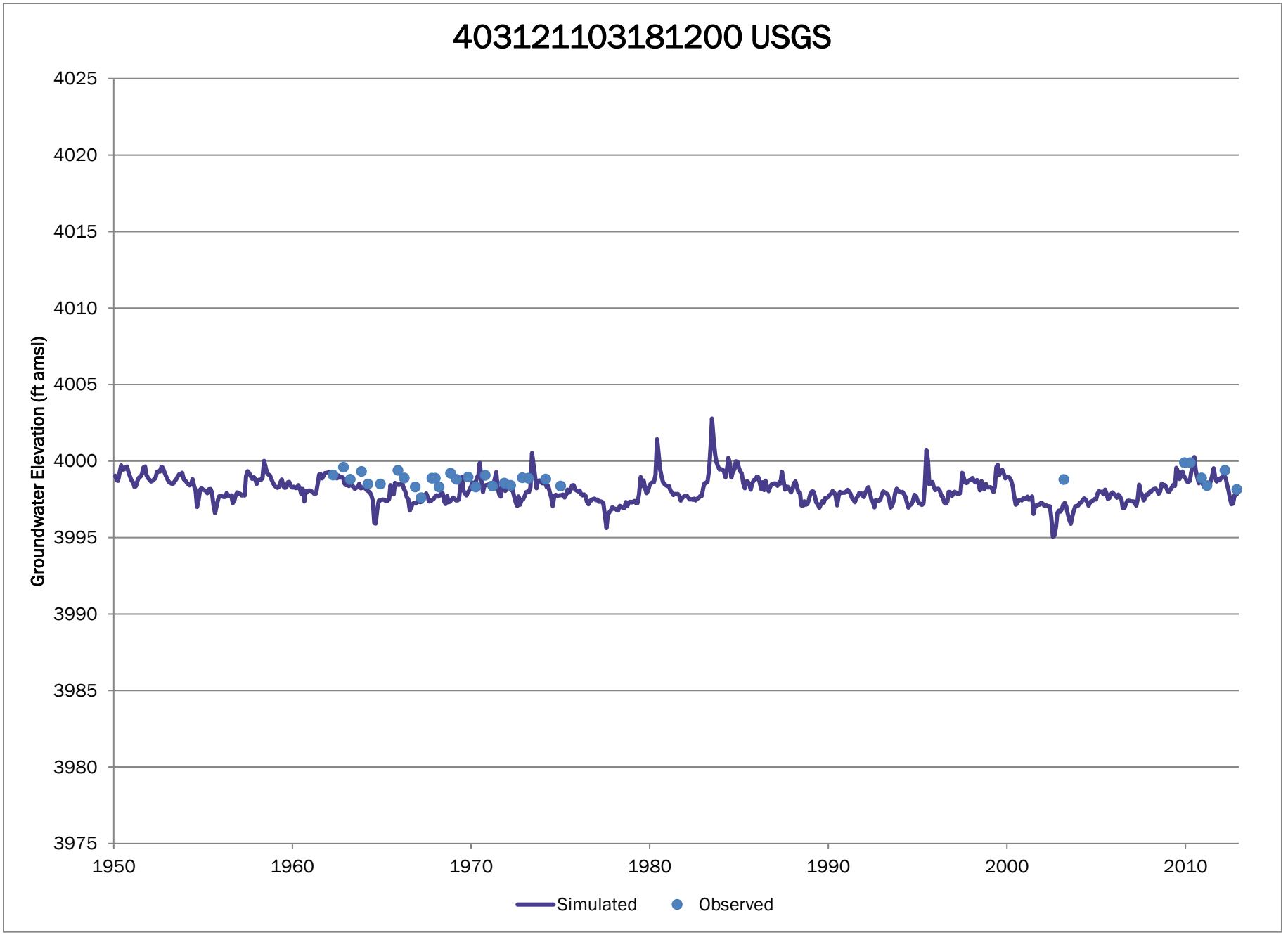
Groundwater Elevation (ft amsl)
4765
4760
4755
4750
4745
4740
4735
4730
4725
4720
4715
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed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4020
4015
4010
4005
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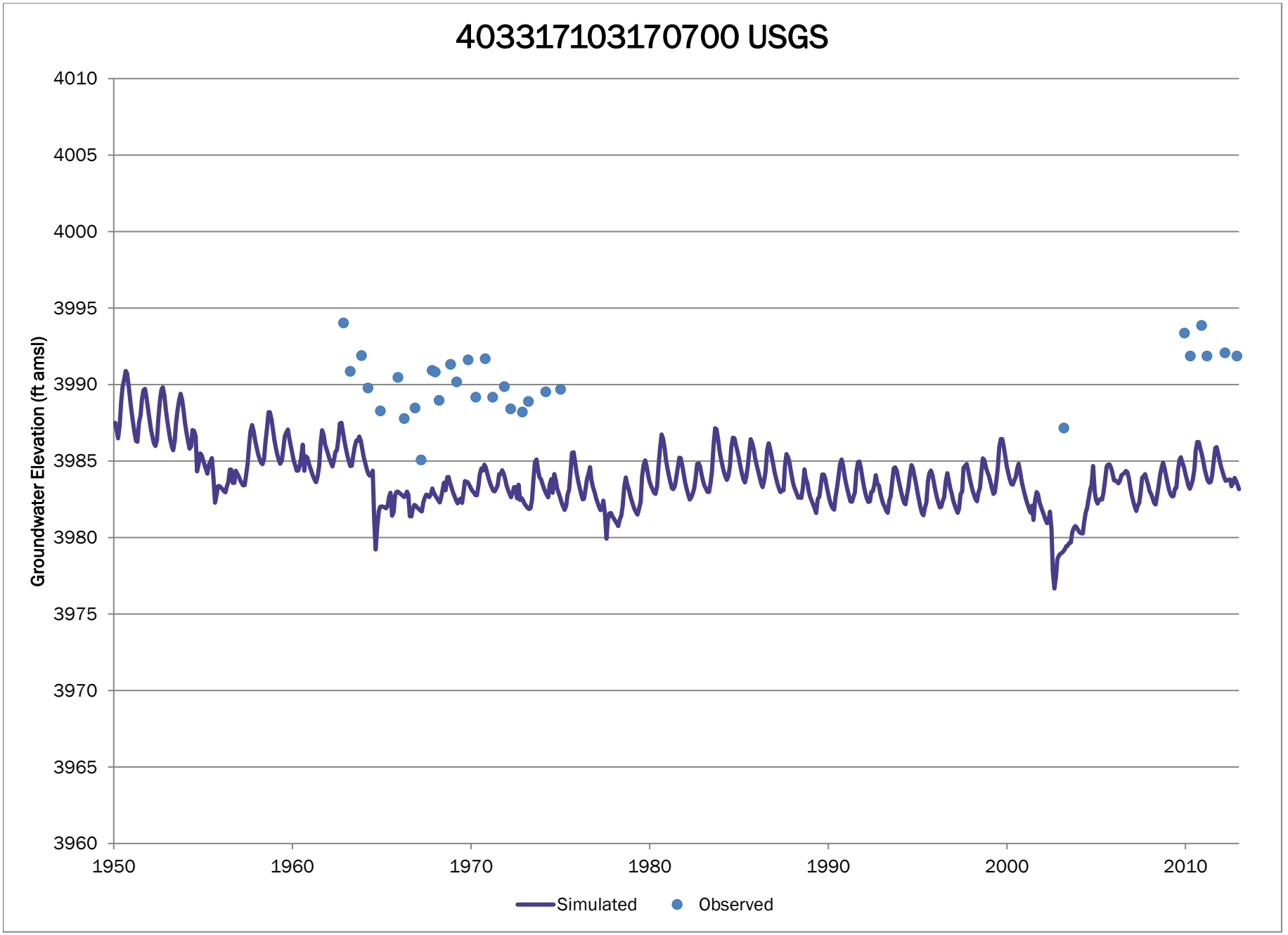
3995
3990
3985
3980
3975
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed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Groundwater Elevation (ft amsl)
4010
4005
4000
3995
3990
3985
3980
3975
3970
3965
3960
1950
1960
1970
1980
1990
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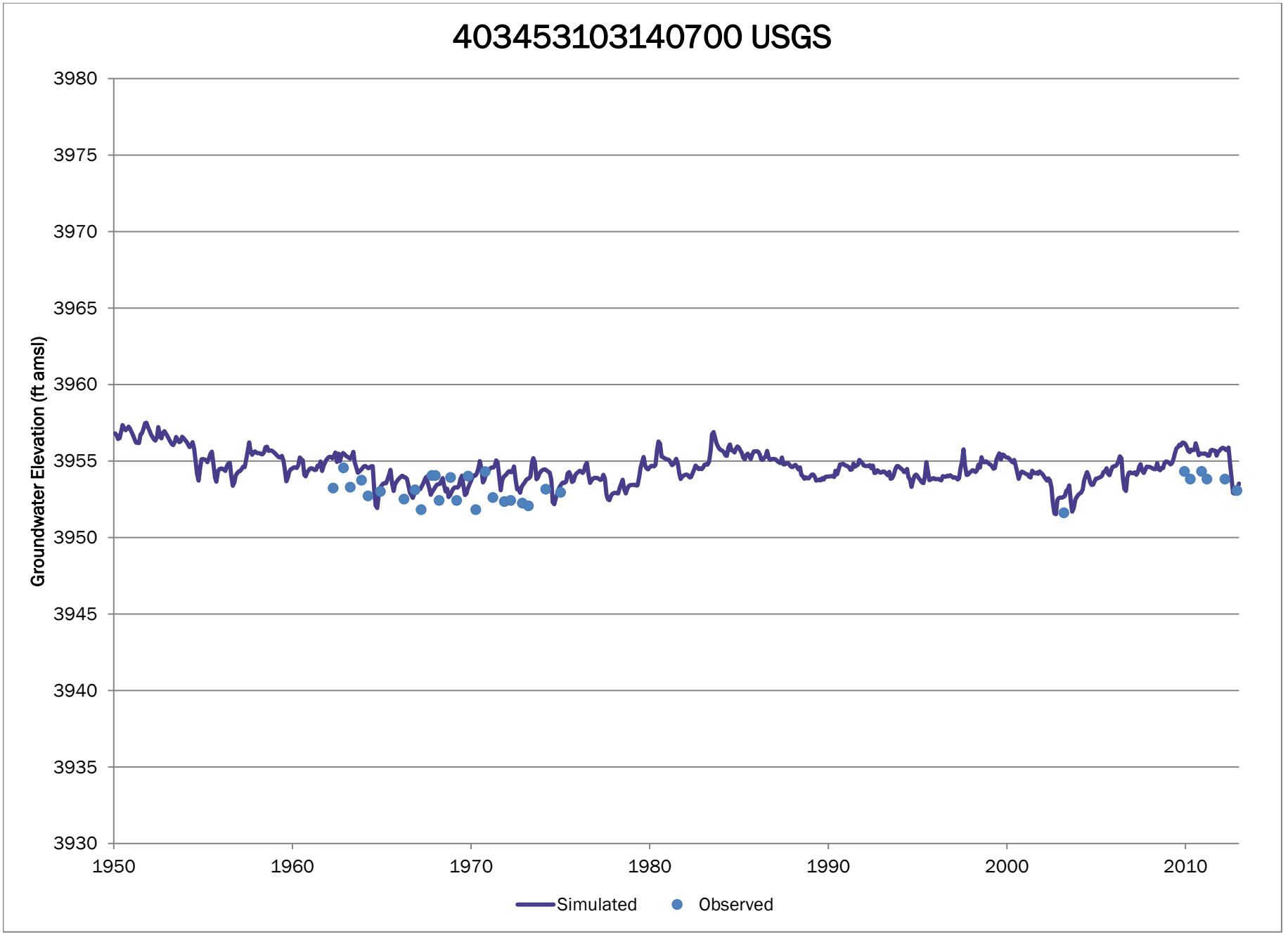
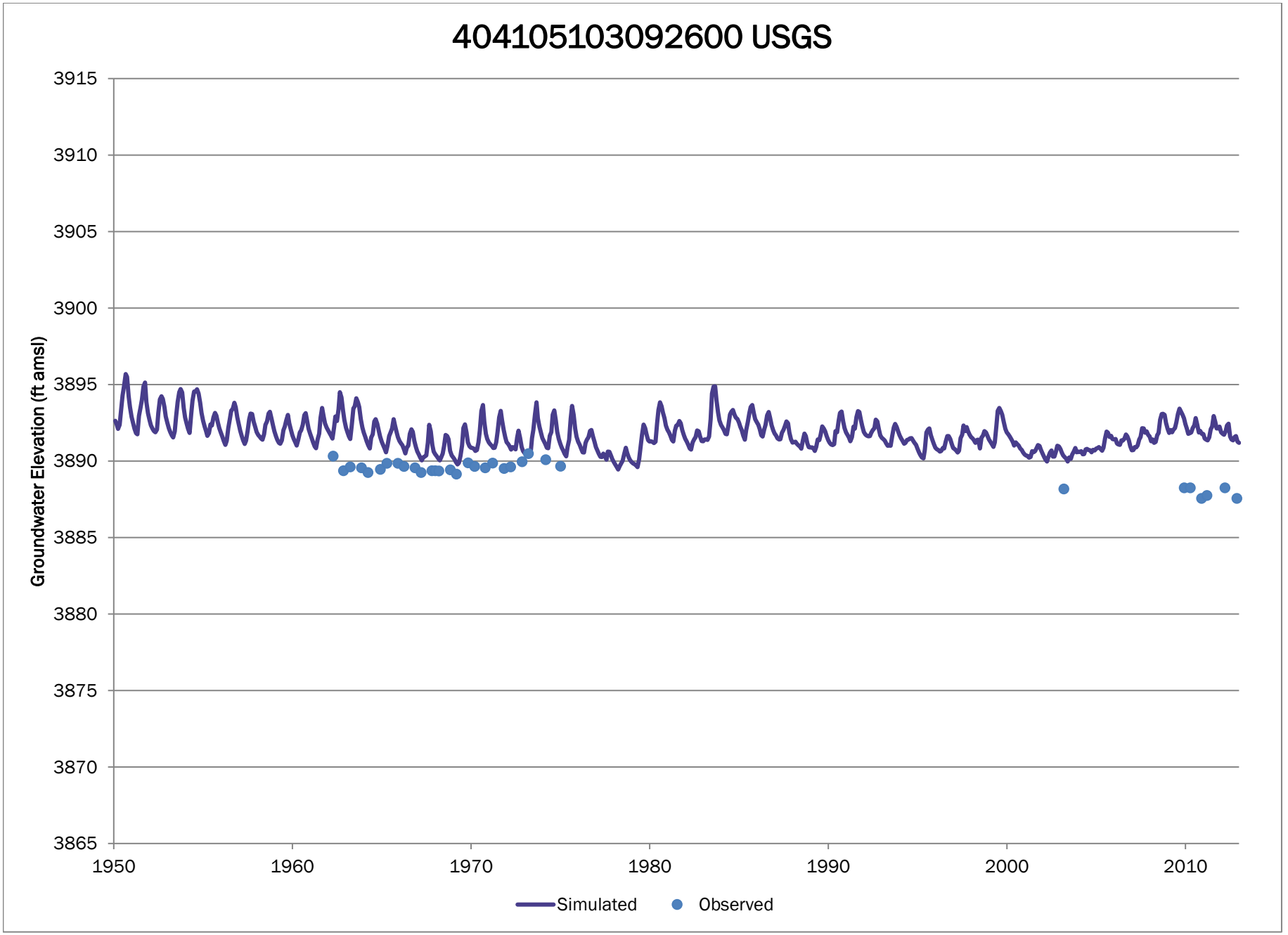
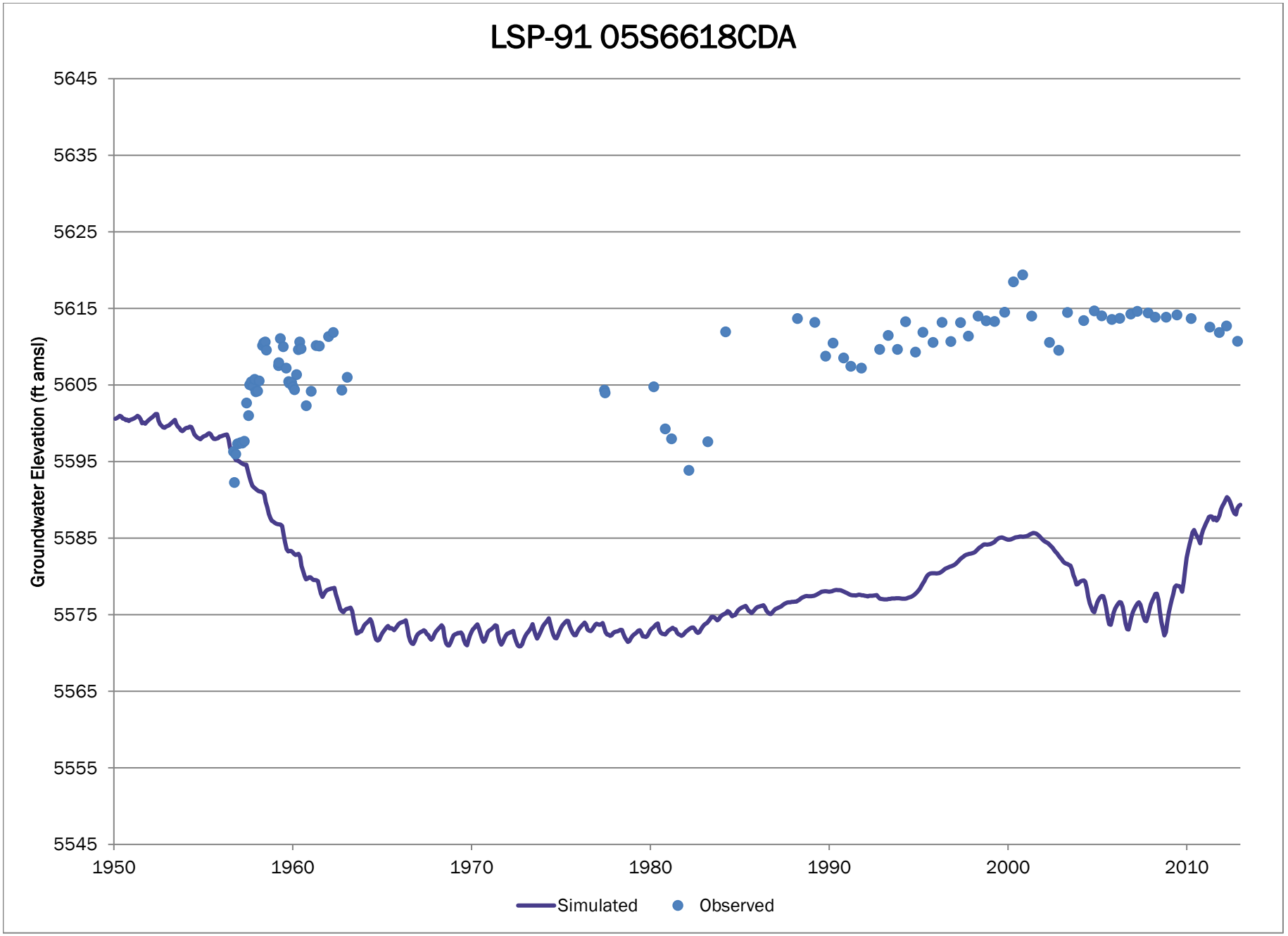
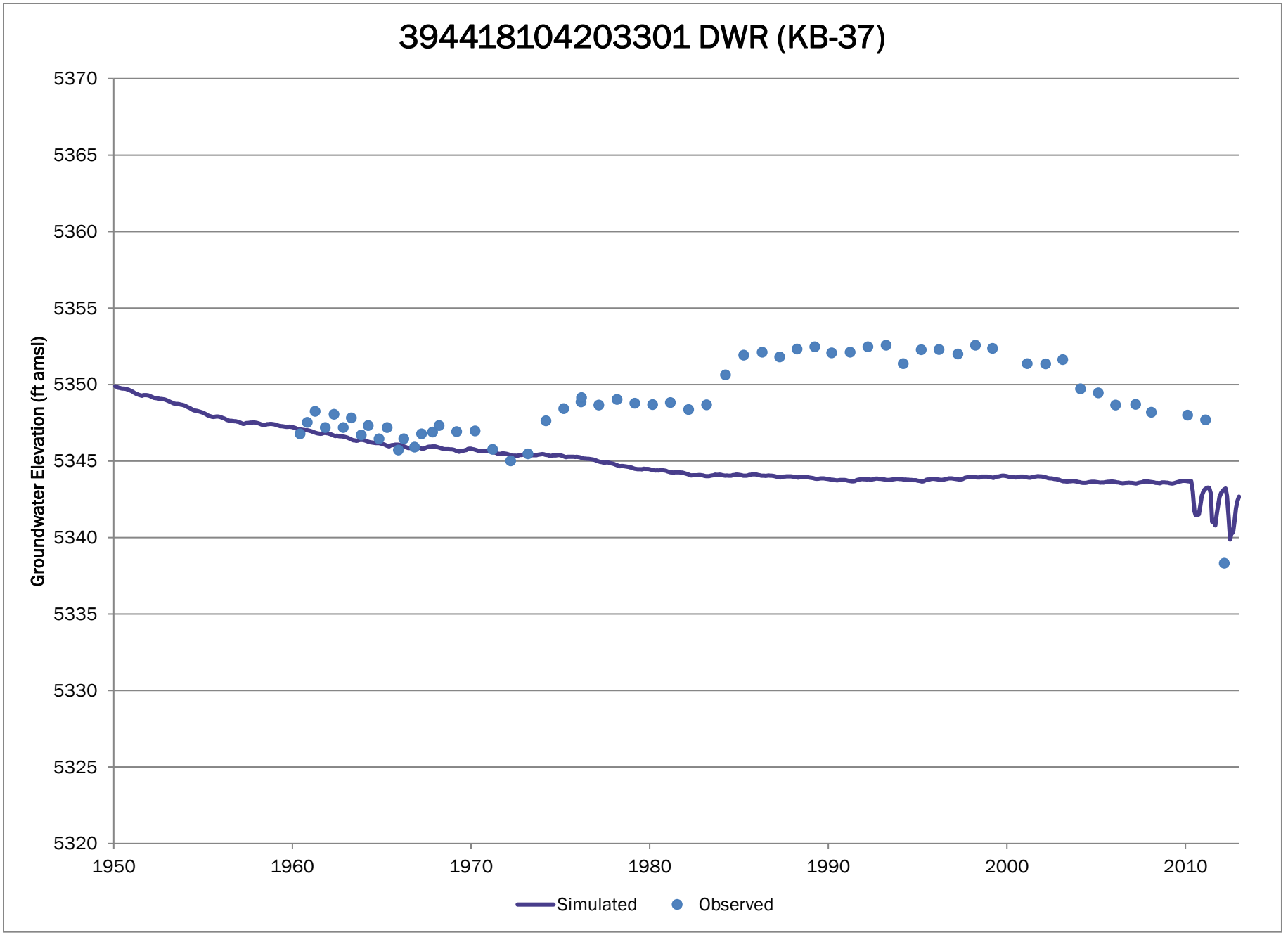
2010
Simulated
Observed

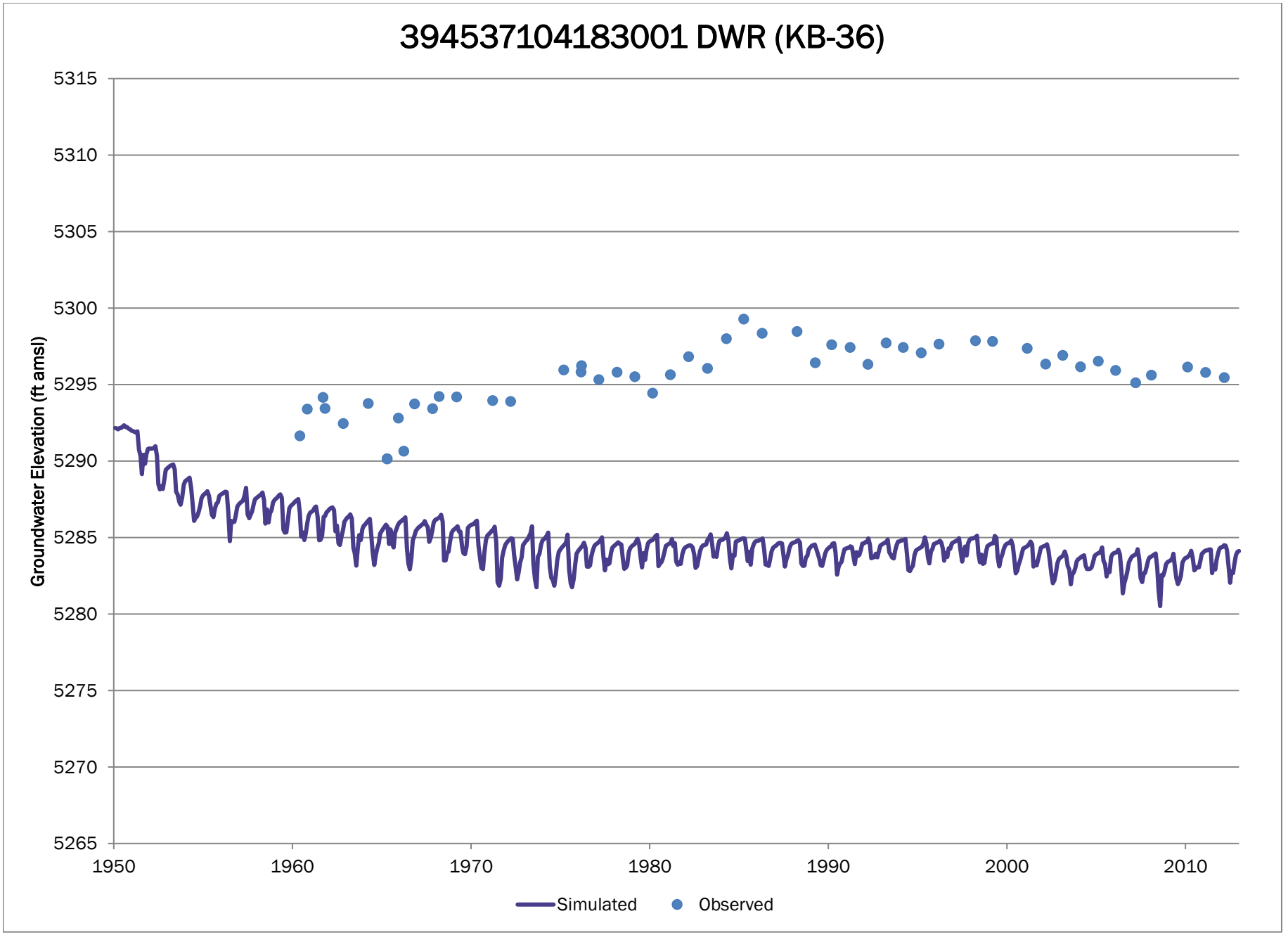

403453103140700 USGS
Groundwater Elevation (ft amsl)
3980
3975
3970
3965
3960
3955
3950
3945
3940
3935
3930
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

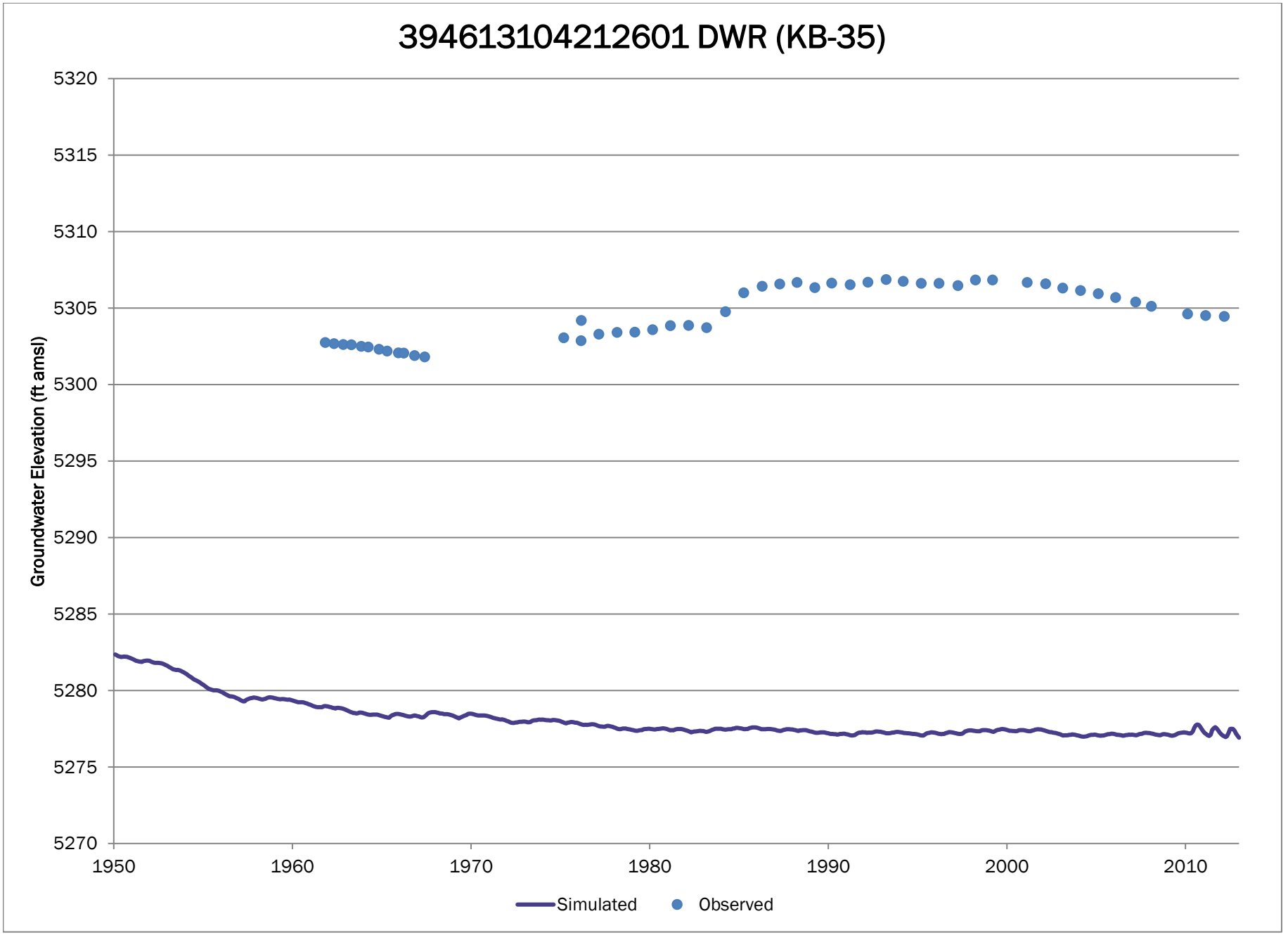

404105103092600 USGS
Groundwater Elevation (ft amsl)
3915
3910
3905
3900
3895
3890
3885
3880
3875
3870
3865
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

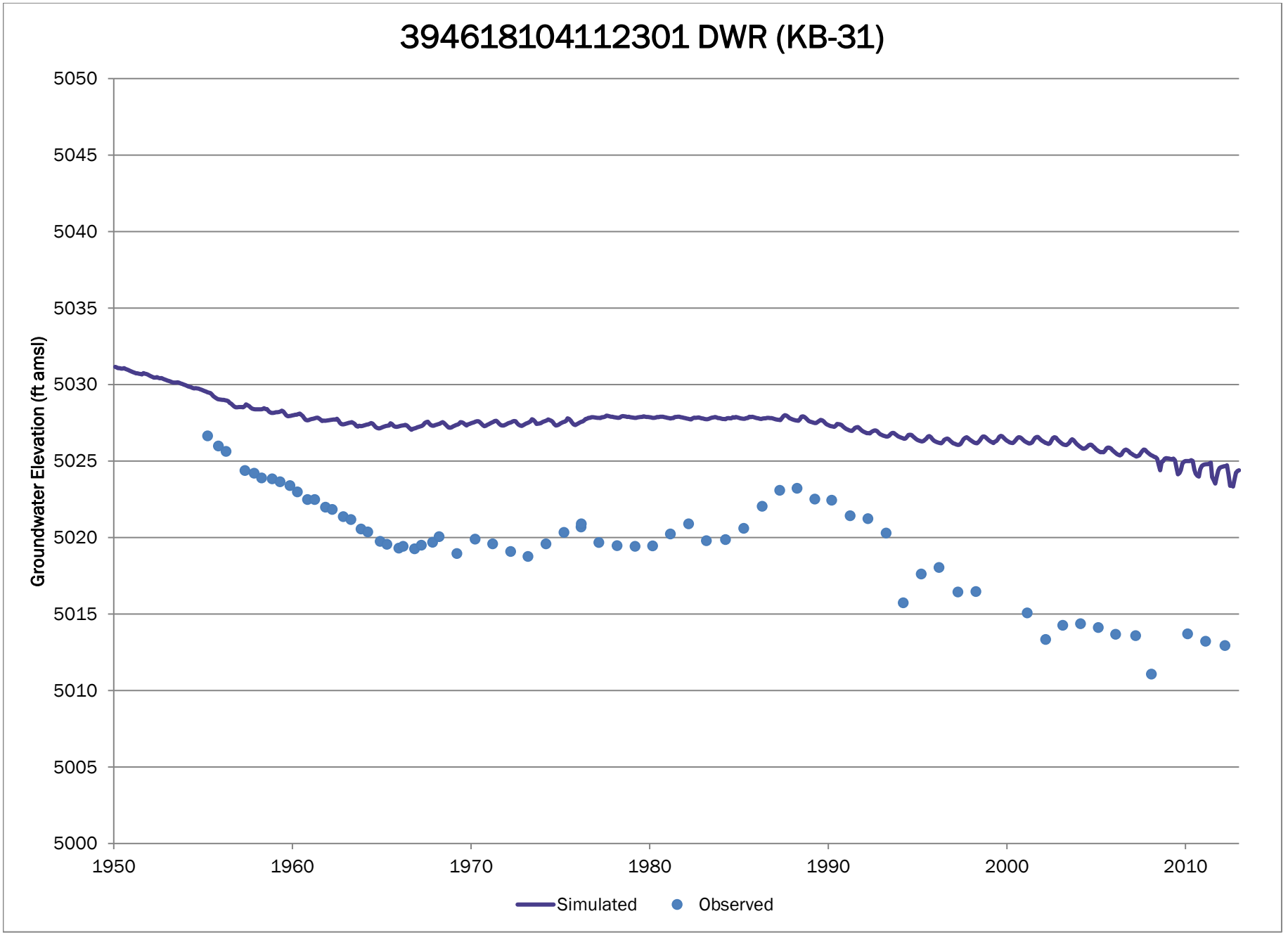
Note elevation axis range of 100 feet.

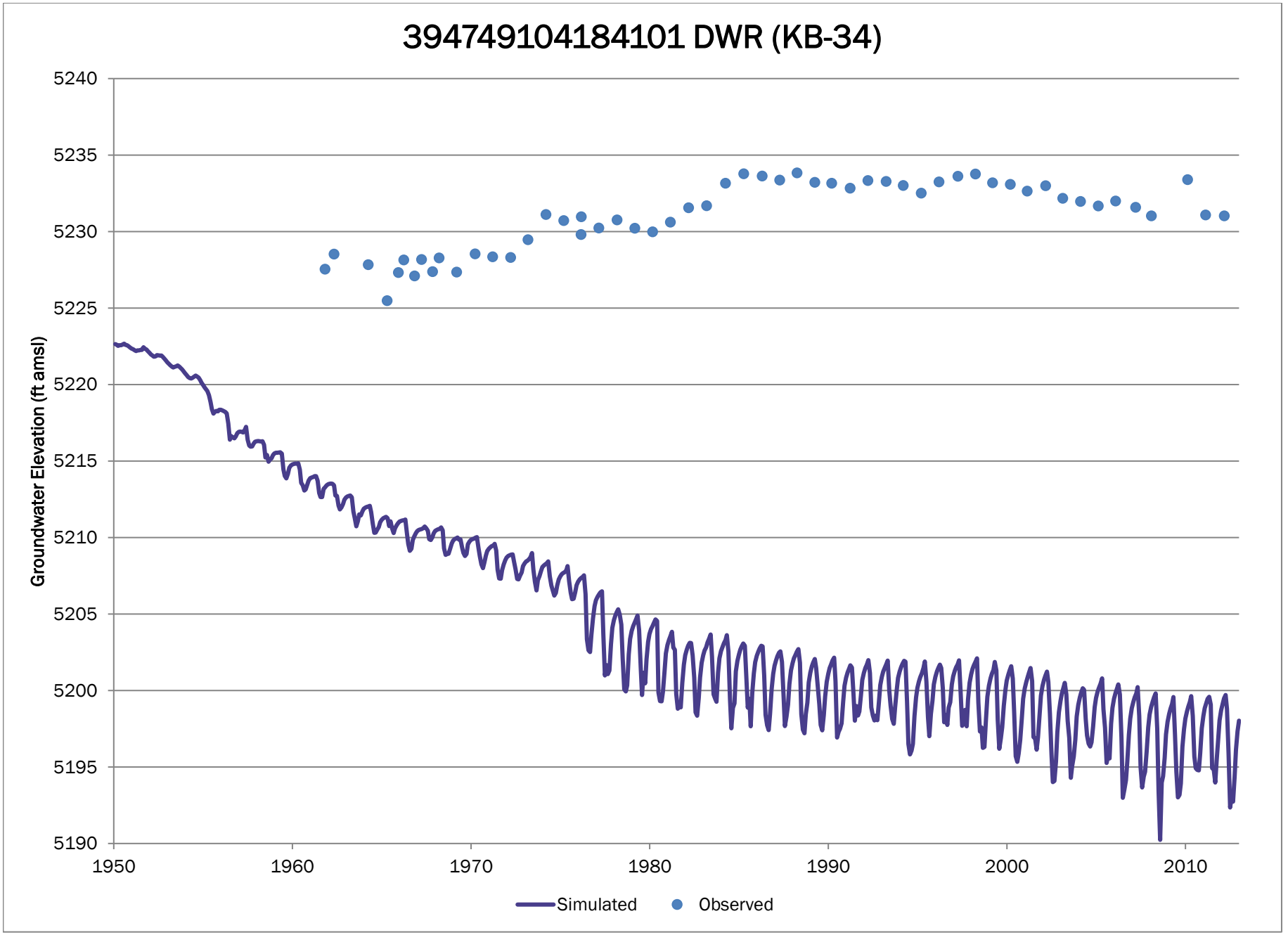



394418104203301 DWR (KB-37)
Groundwater Elevation (ft amsl)
5370
5365
5360
5355
5350
5345
5340
5335
5330
5325
5320
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

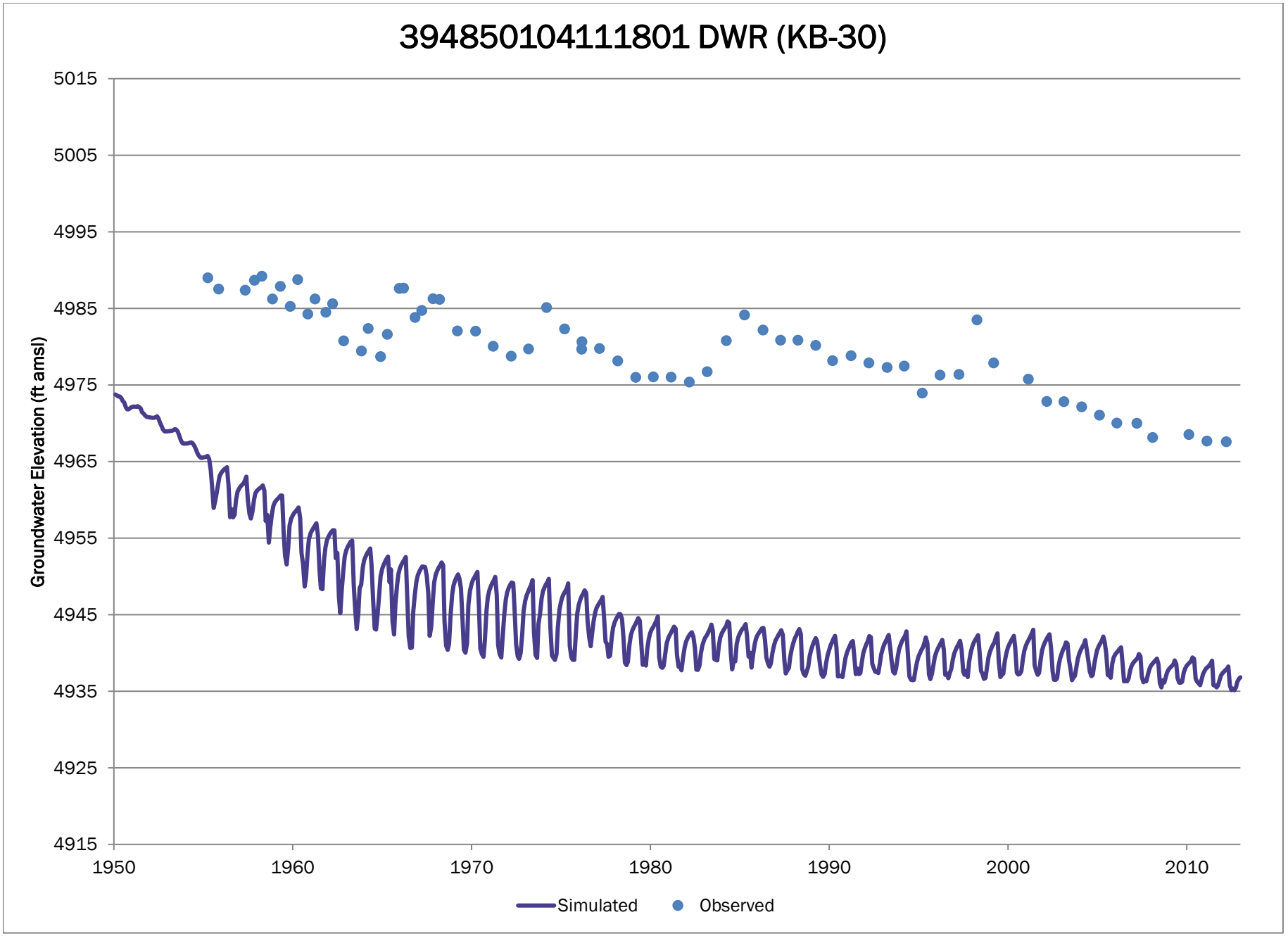

394537104183001 DWR (KB-36)
Groundwater Elevation (ft amsl)
5315
5310
5305
5300
5295
5290
5285
5280
5275
5270
5265
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

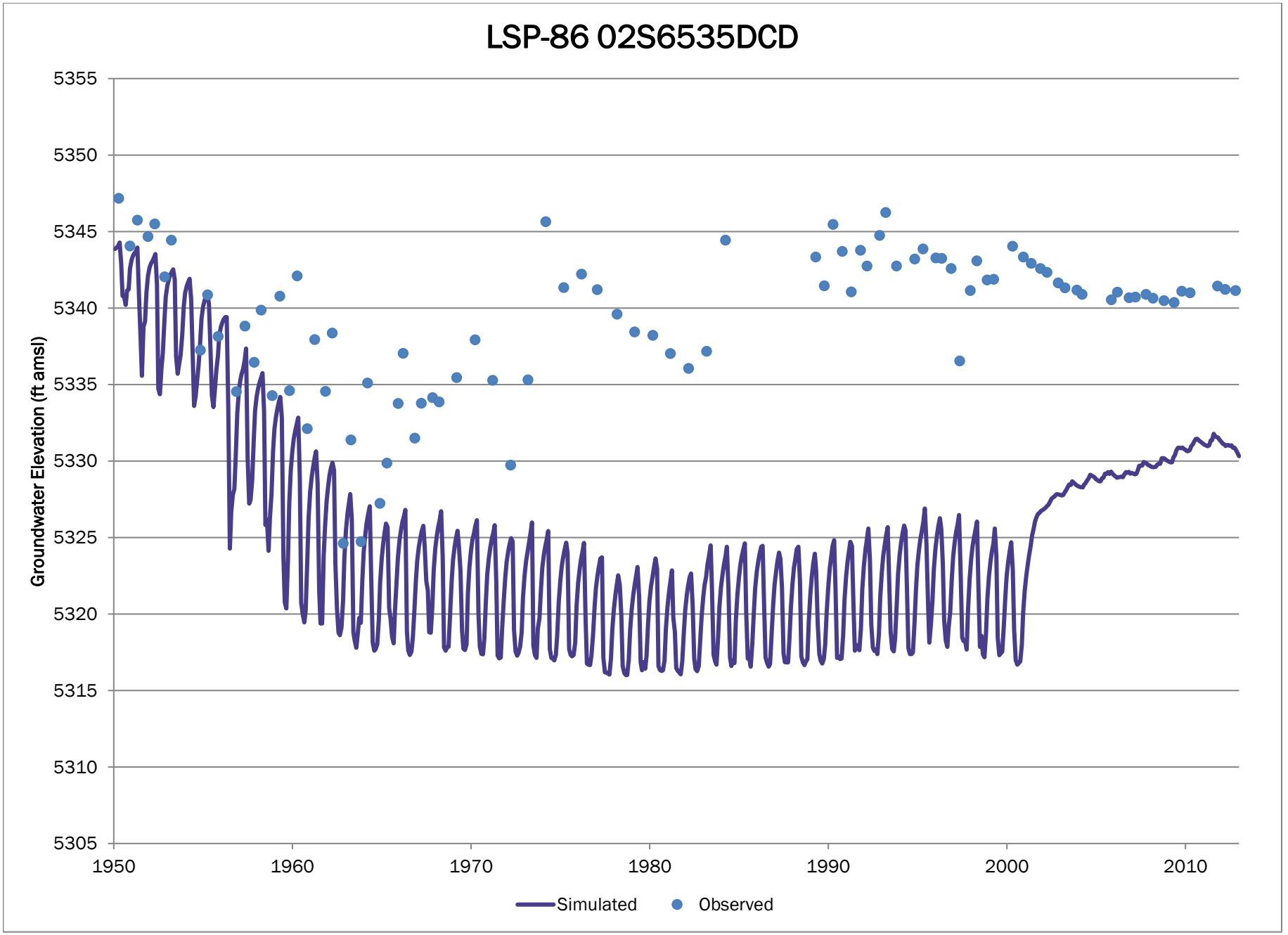

394613104212601 DWR (KB-35)
Groundwater Elevation (ft amsl)
5320
5315
5310
5305
5300
5295
5290
5285
5280
5275
5270
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

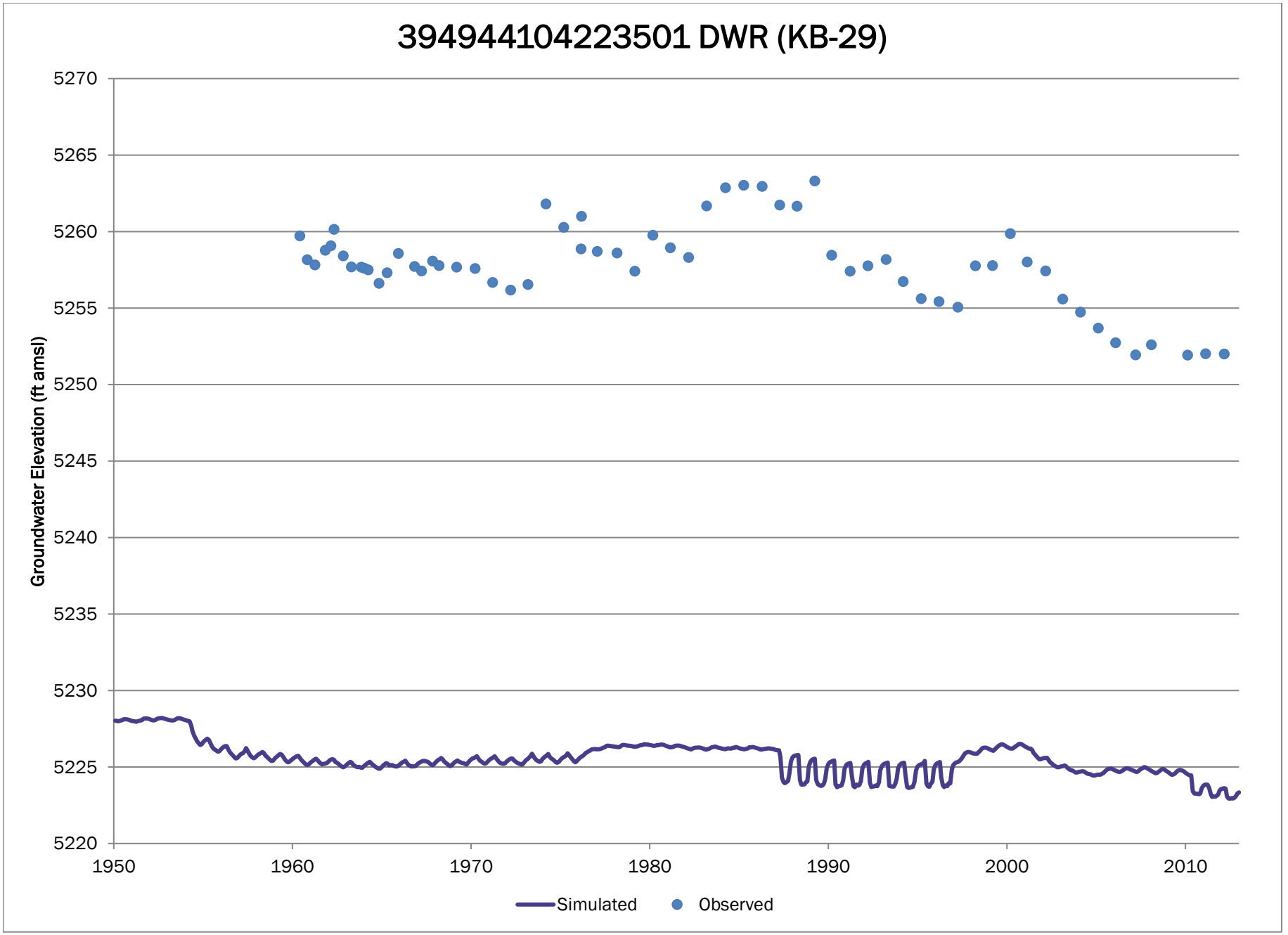

394618104112301 DWR (KB-31)
Groundwater Elevation (ft amsl)
5050
5045
5040
5035
5030
5025
5020
5015
5010
5005
5000
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


394749104184101 DWR (KB-34)
Groundwater Elevation (ft amsl)
5240
5235
5230
5225
5220
5215
5210
5205
5200
5195
5190
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

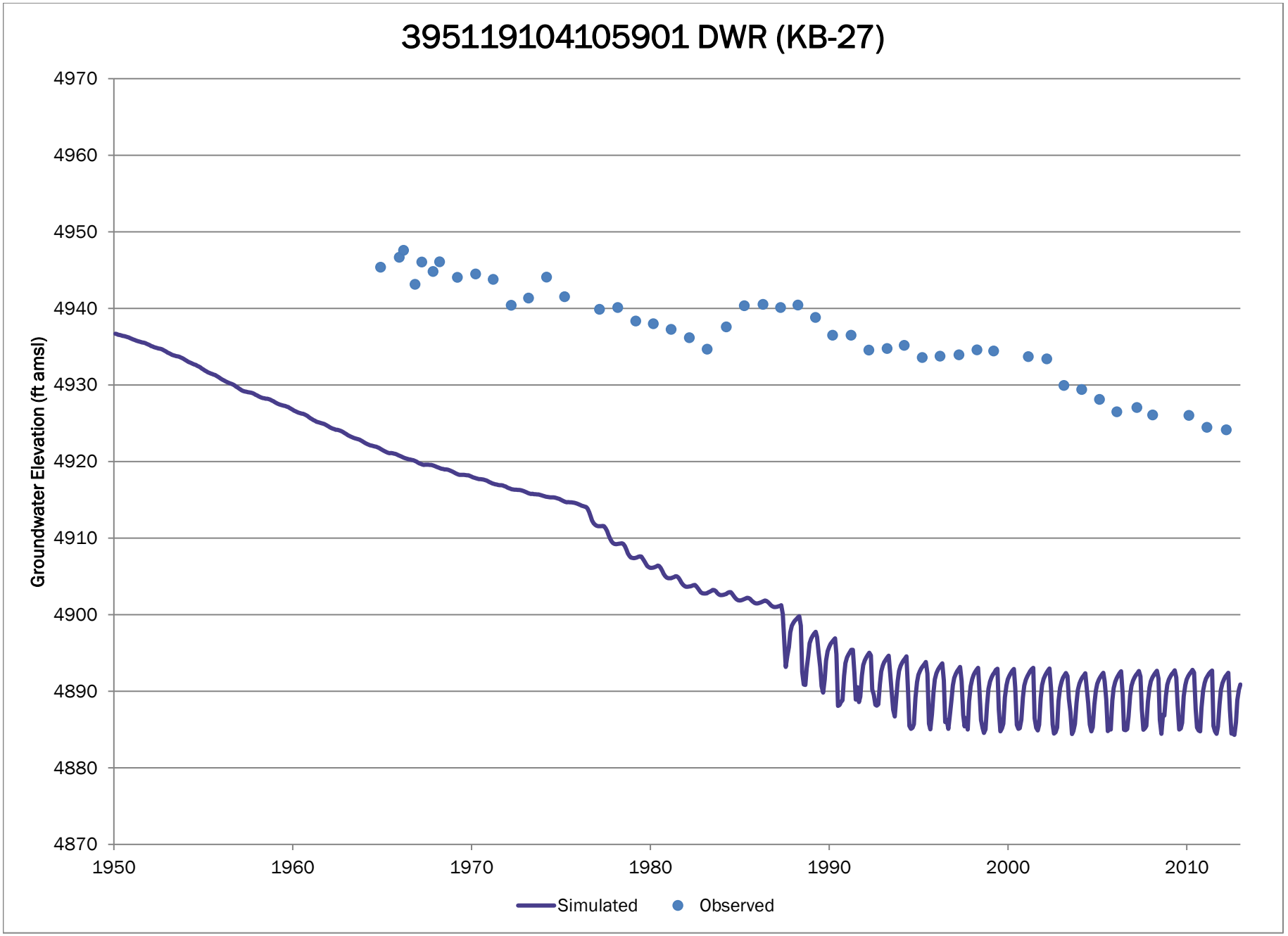
Note elevation axis range of 100 feet.

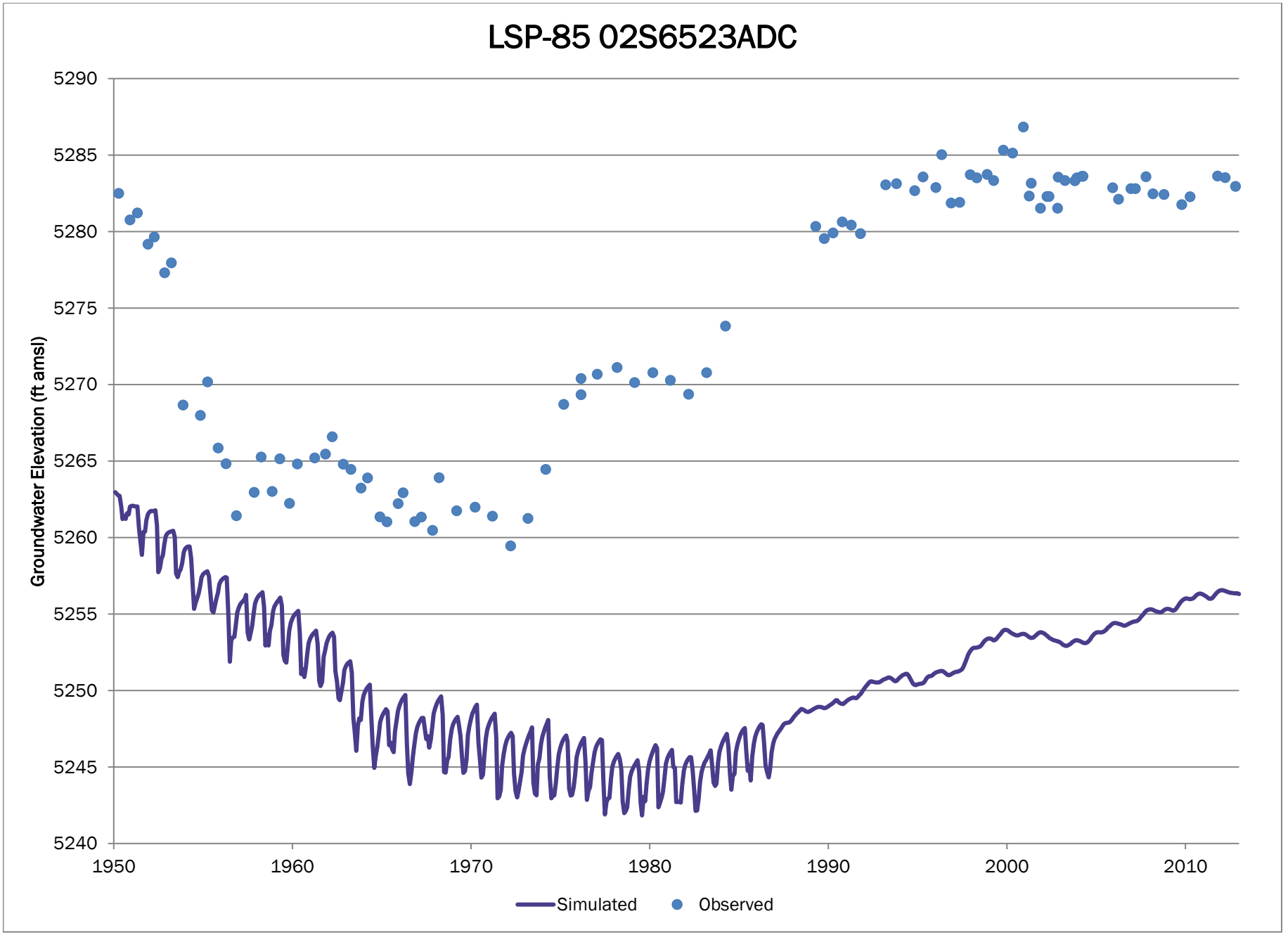



LSP-86 02S6535DCD
Groundwater Elevation (ft amsl)
5355
5350
5345
5340
5335
5330
5325
5320
5315
5310
5305
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

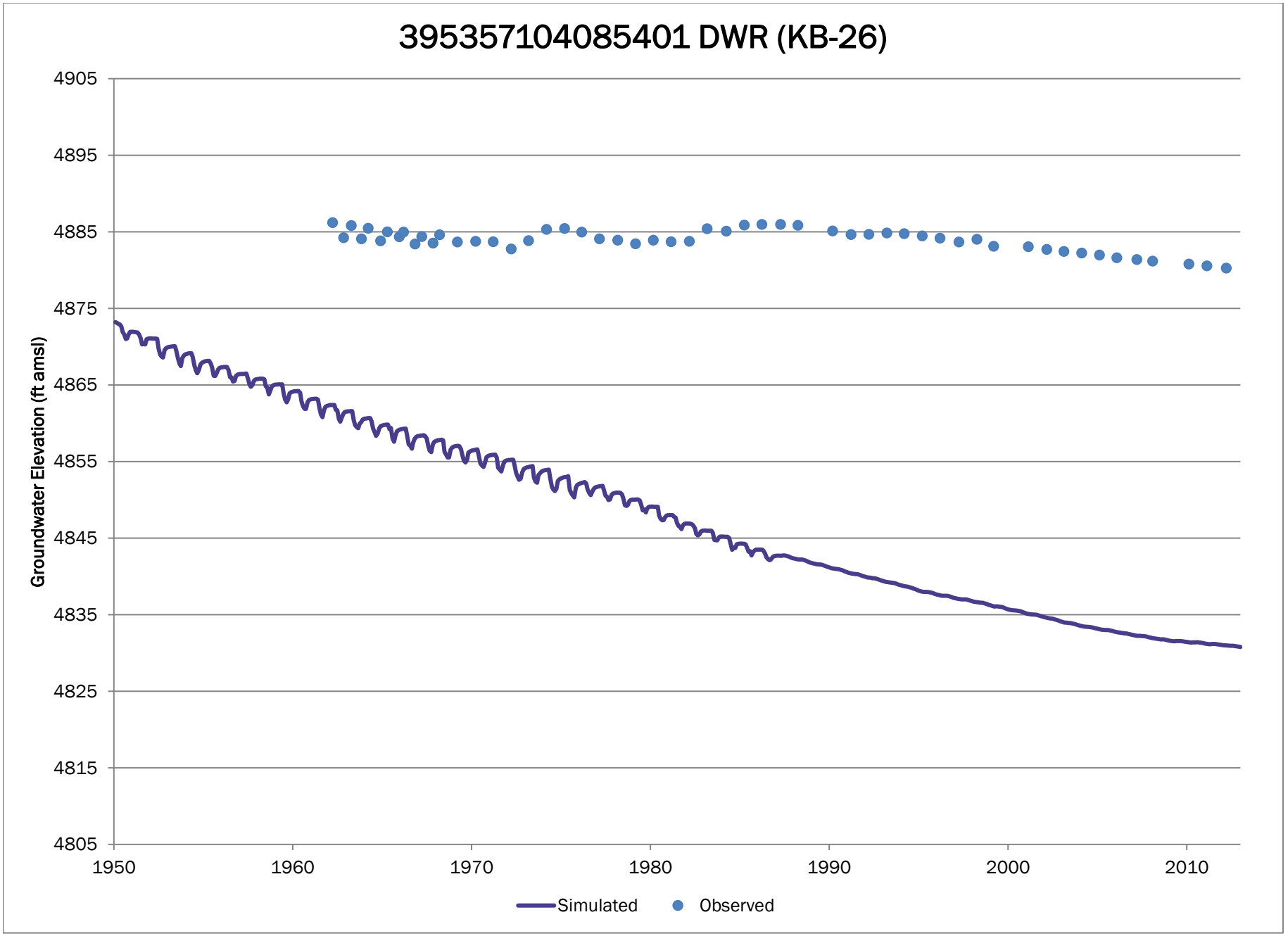

394944104223501 DWR (KB-29)
Groundwater Elevation (ft amsl)
5270
5265
5260
5255
5250
5245
5240
5235
5230
5225
5220
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

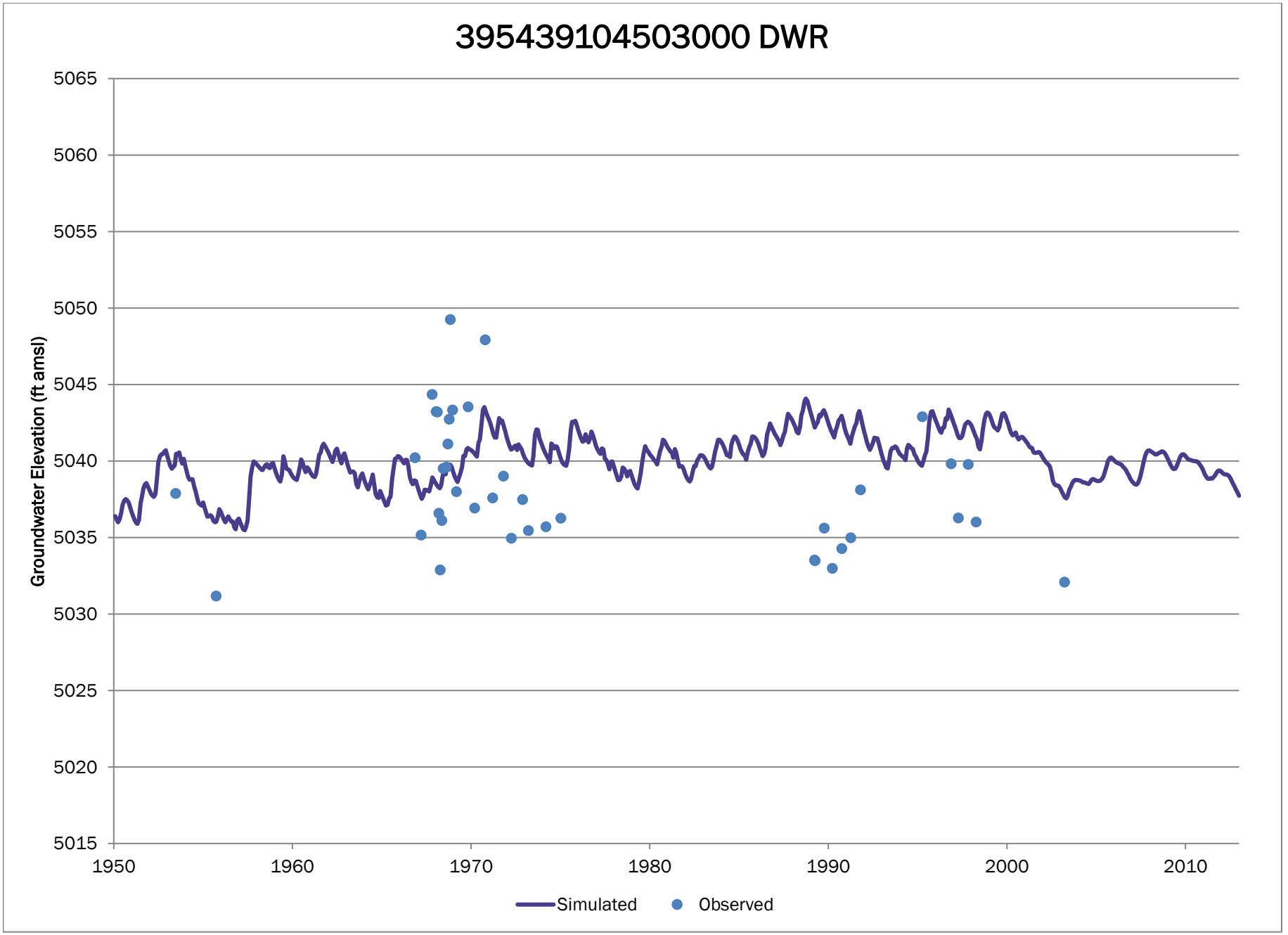
Note elevation axis range of 100 feet.



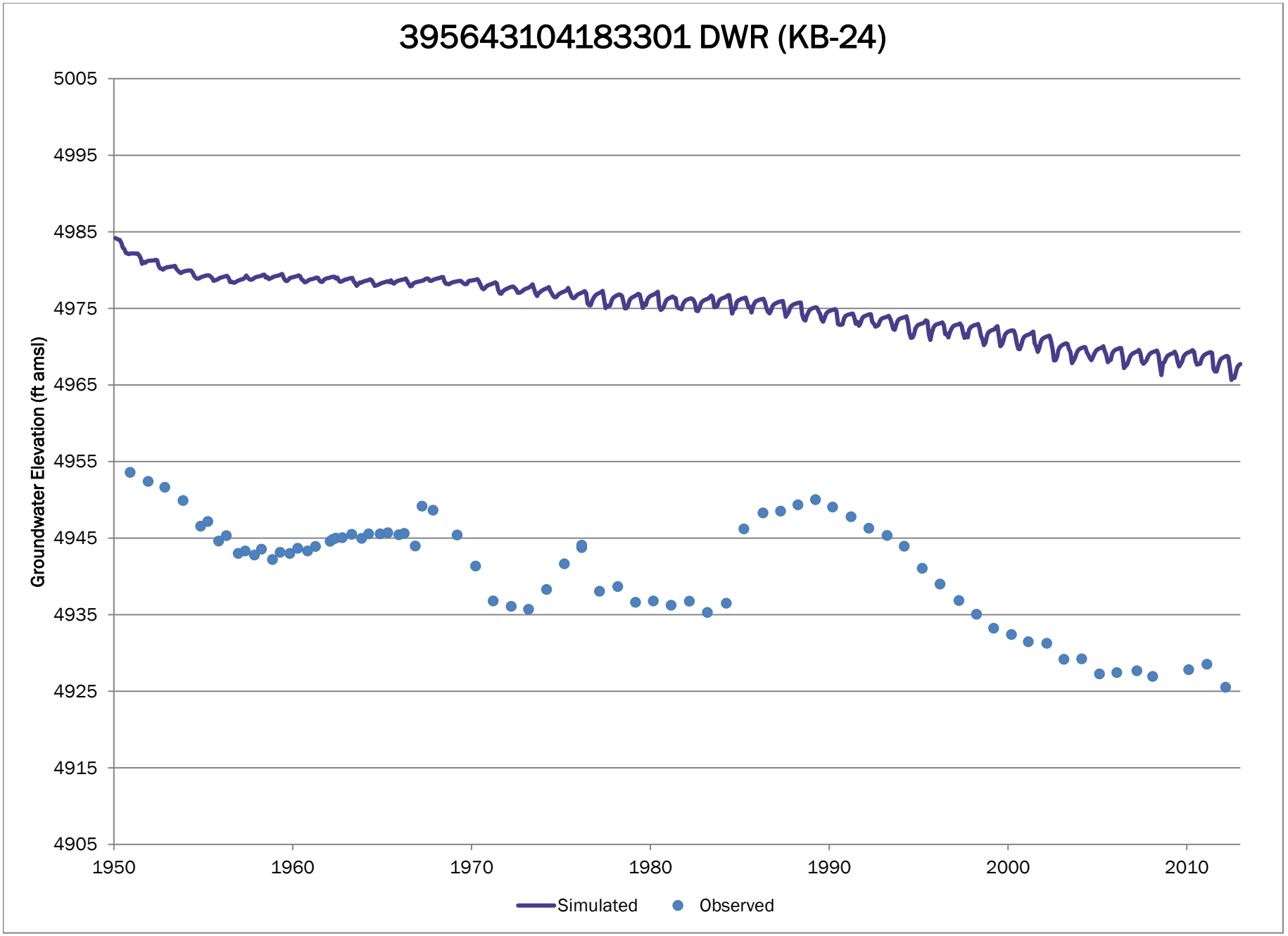

LSP-85 02S6523ADC
Groundwater Elevation (ft amsl)
5290
5285
5280
5275
5270
5265
5260
5255
5250
5245
5240
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

Note elevation axis range of 100 feet.

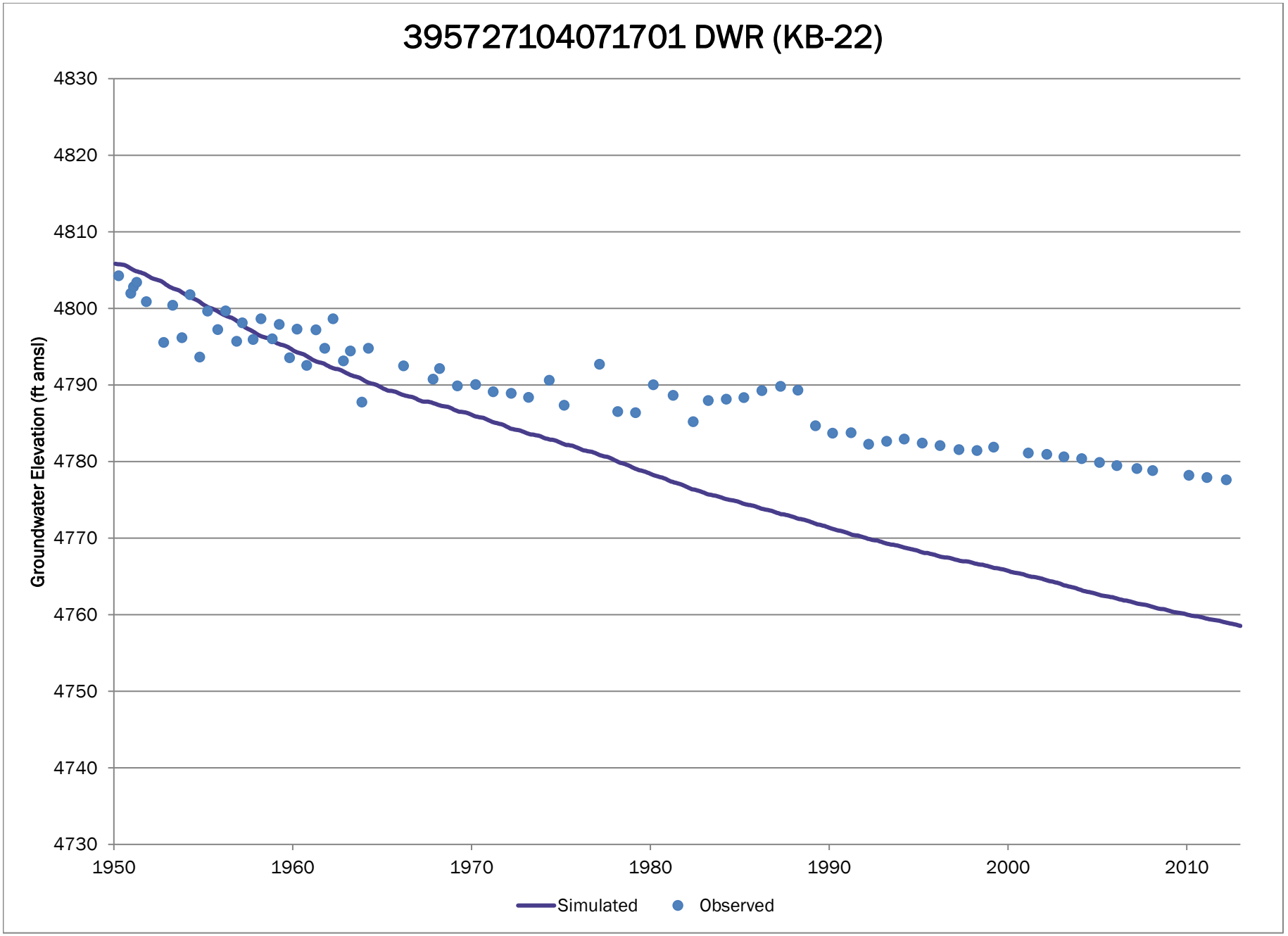


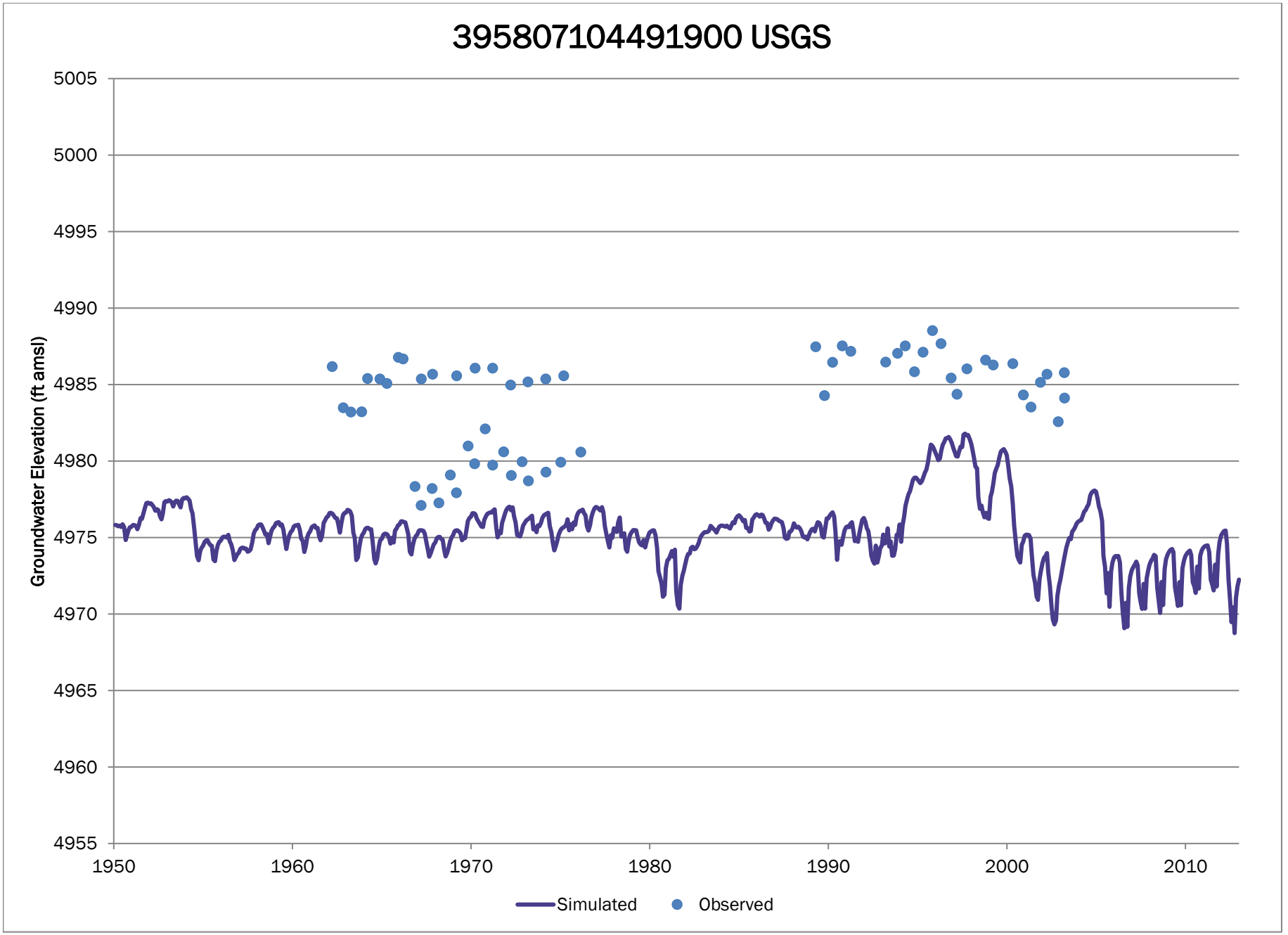

395439104503000 DWR
Groundwater Elevation (ft amsl)
5065
5060
5055
5050
5045
5040
5035
5030
5025
5020
5015
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

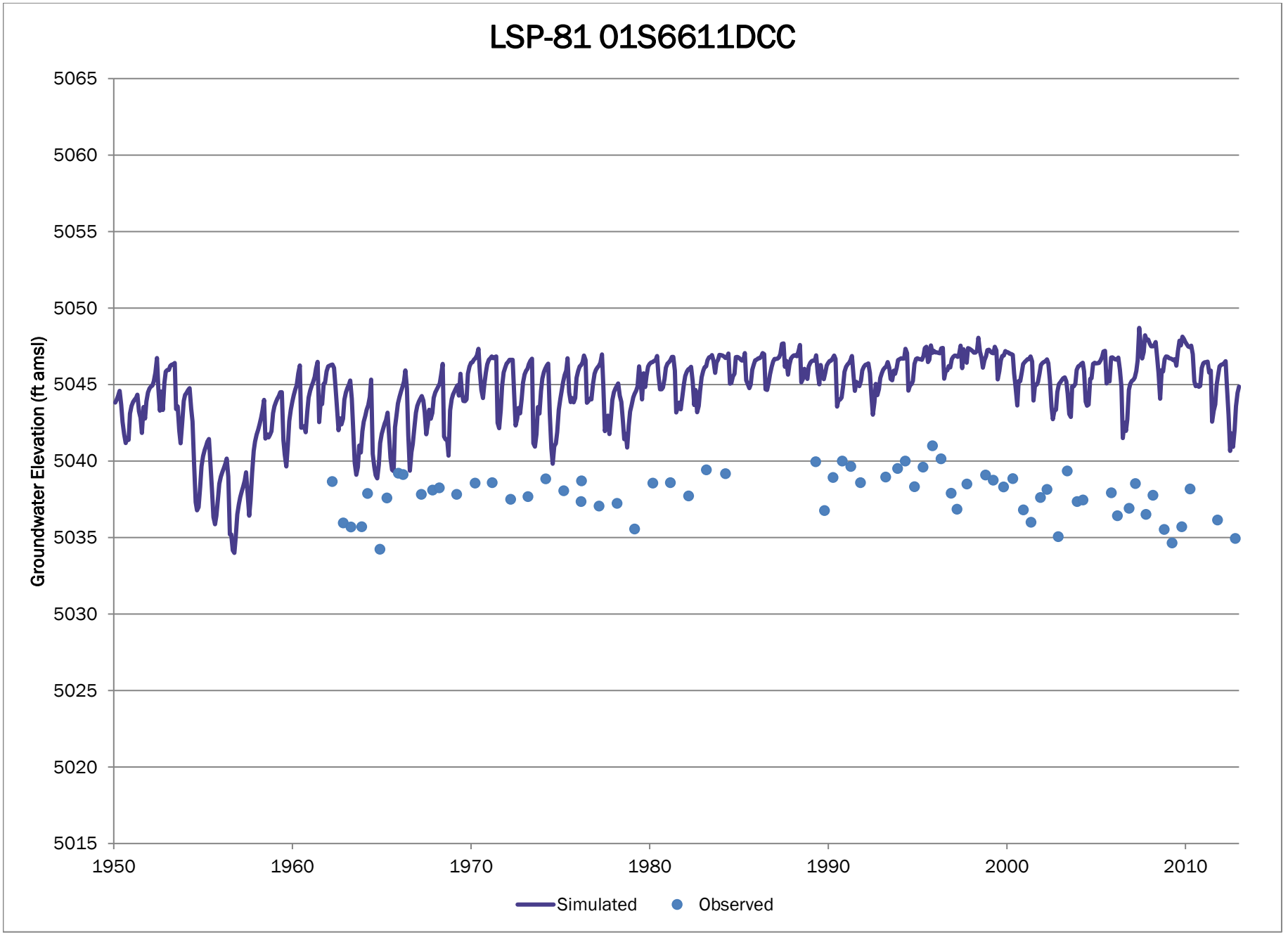
Note elevation axis range of 100 feet.



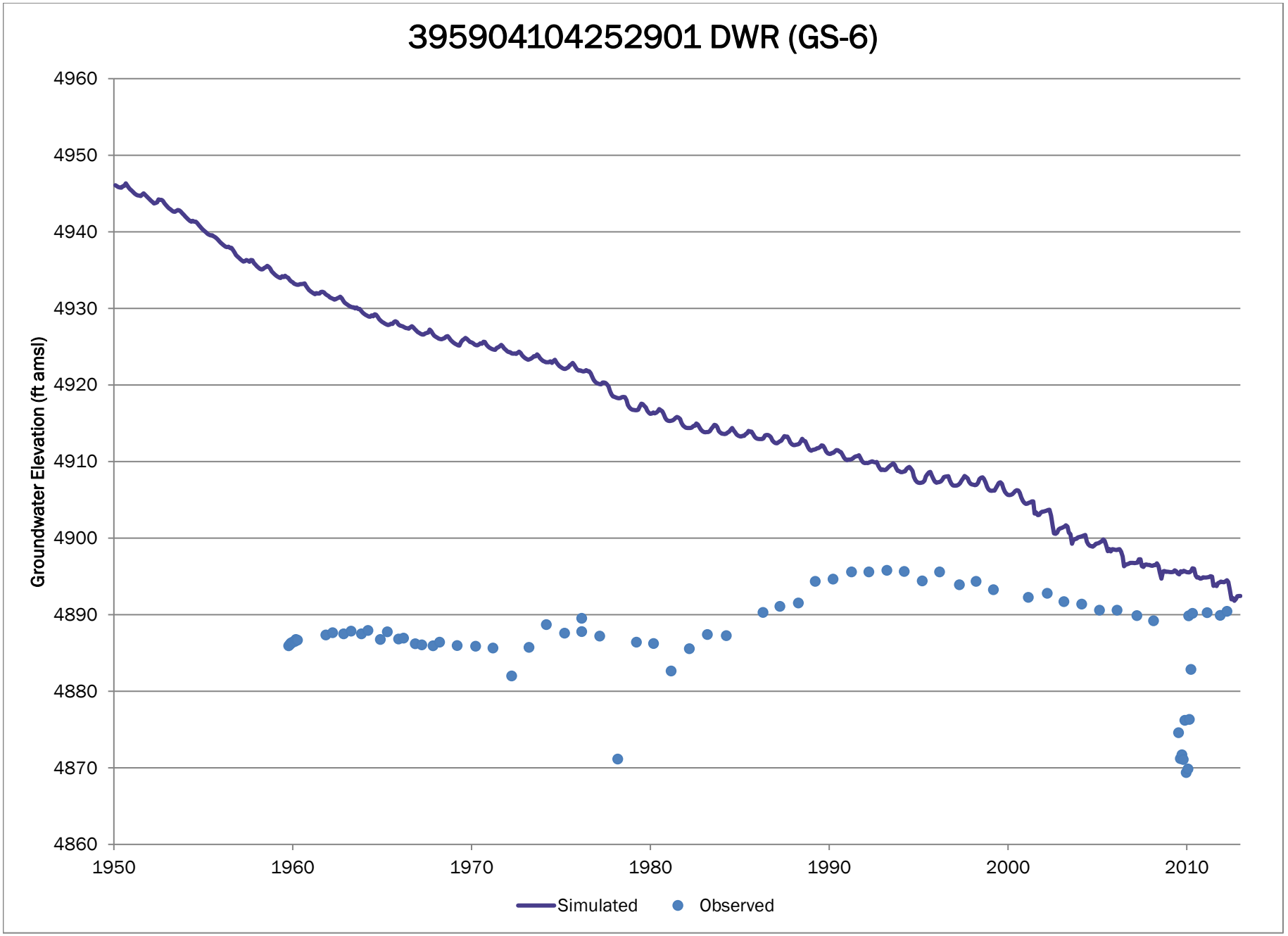
Note elevation axis range of 100 feet.



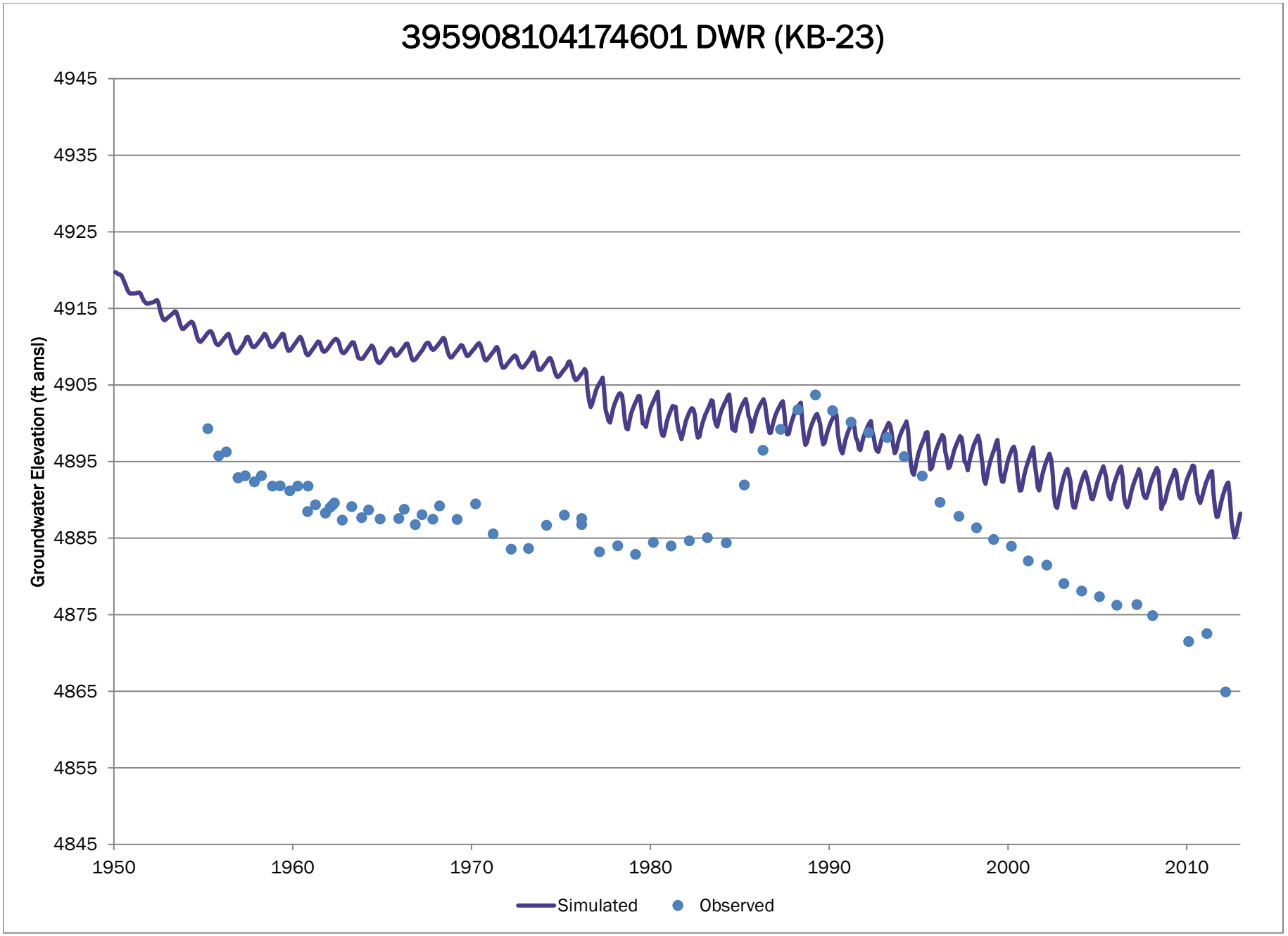

395807104491900 USGS
Groundwater Elevation (ft amsl)
5005
5000
4995
4990
4985
4980
4975
4970
4965
4960
4955
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


LSP-81 01S6611DCC
Groundwater Elevation (ft amsl)
5065
5060
5055
5050
5045
5040
5035
5030
5025
5020
5015
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

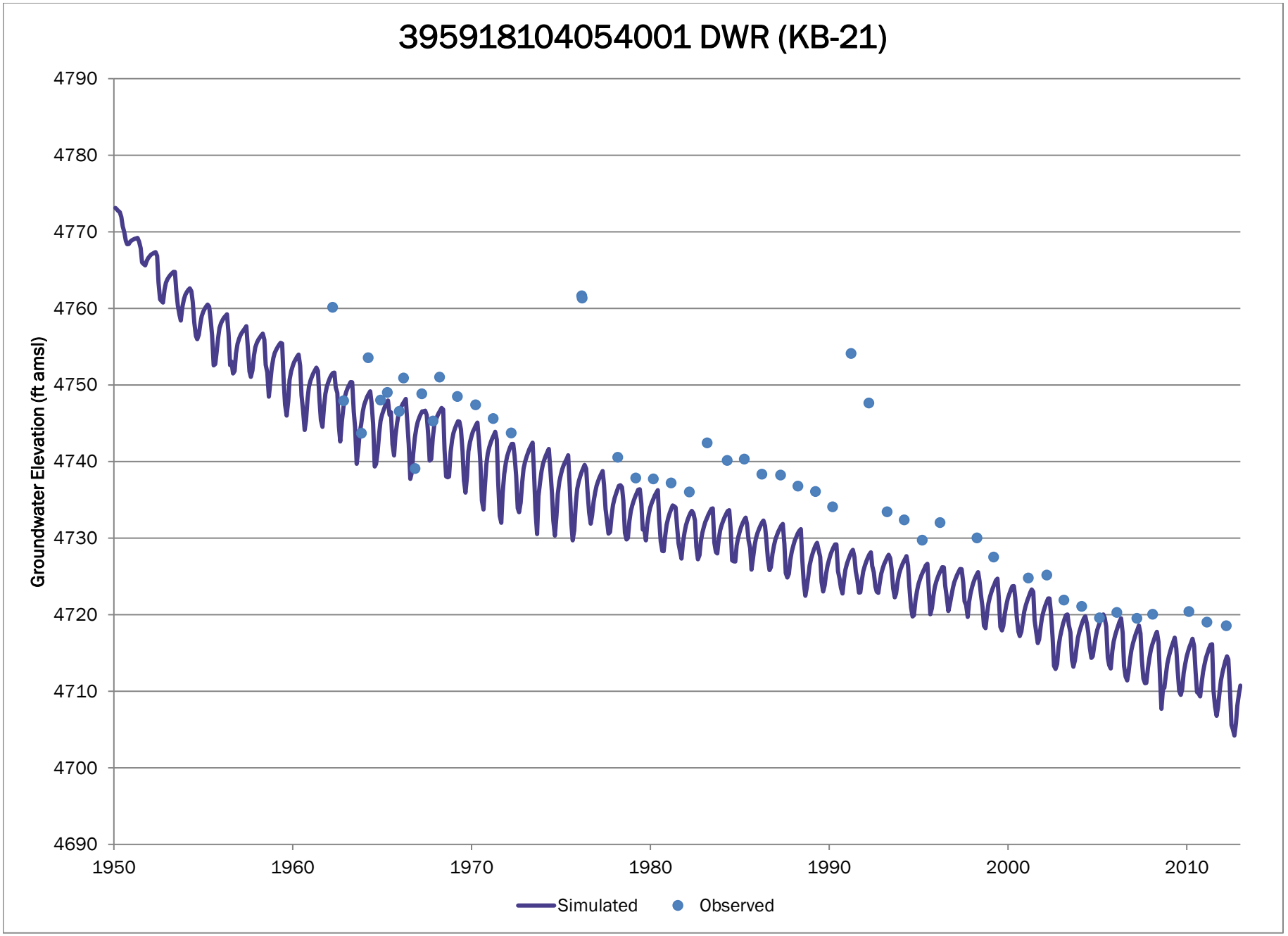
Note elevation axis range of 100 feet.



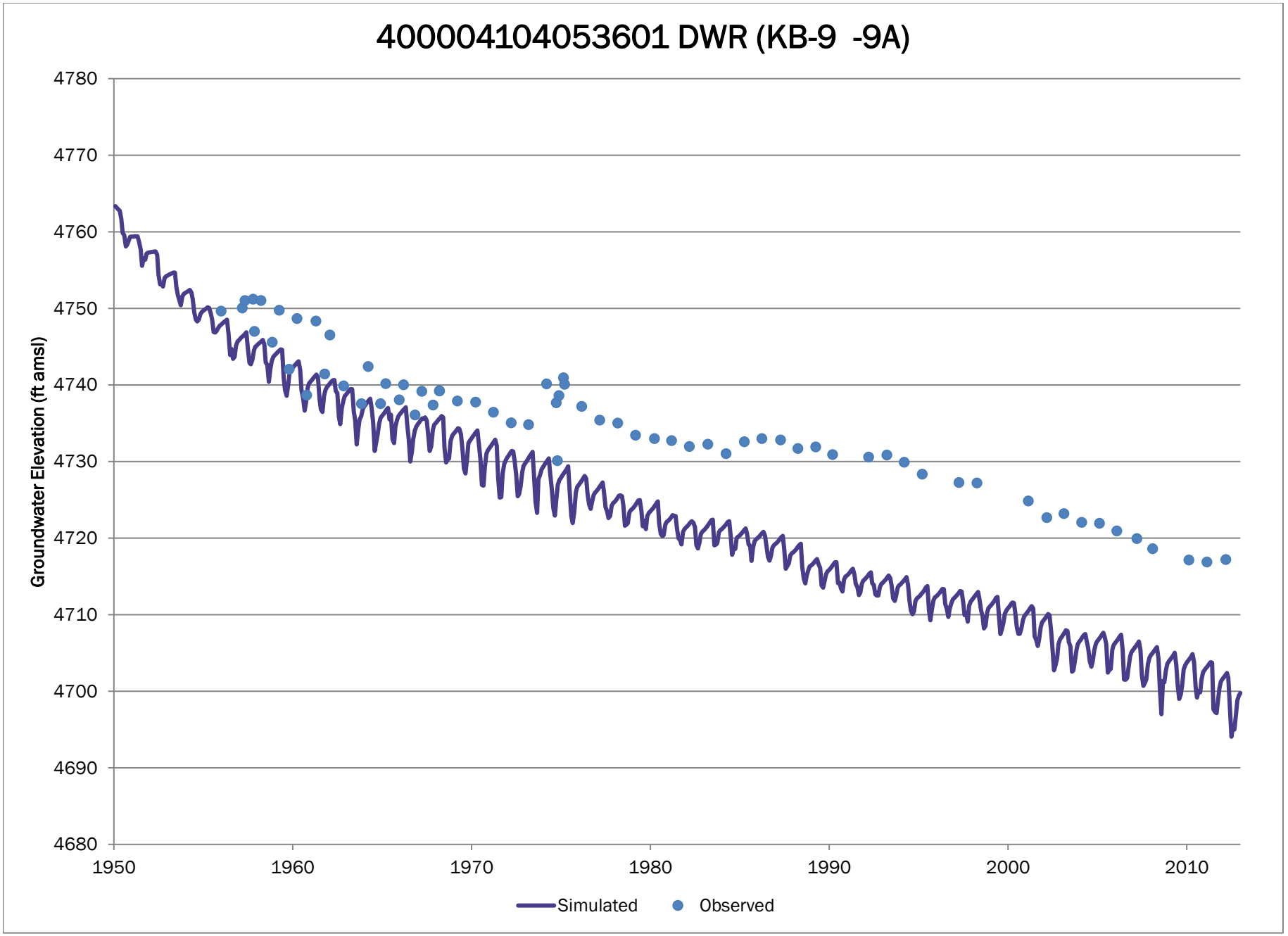
Note elevation axis range of 100 feet.

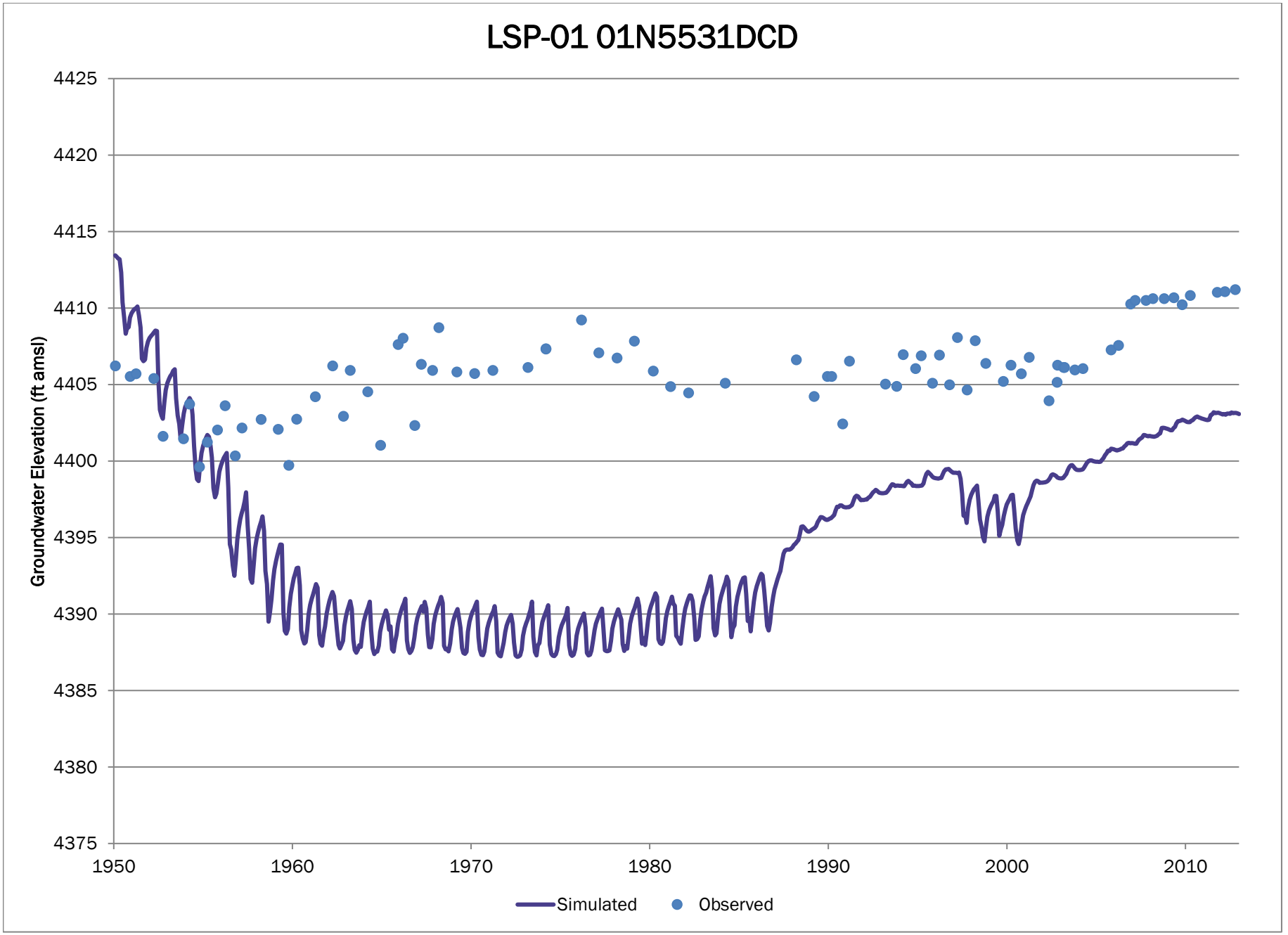


Note elevation axis range of 100 feet.

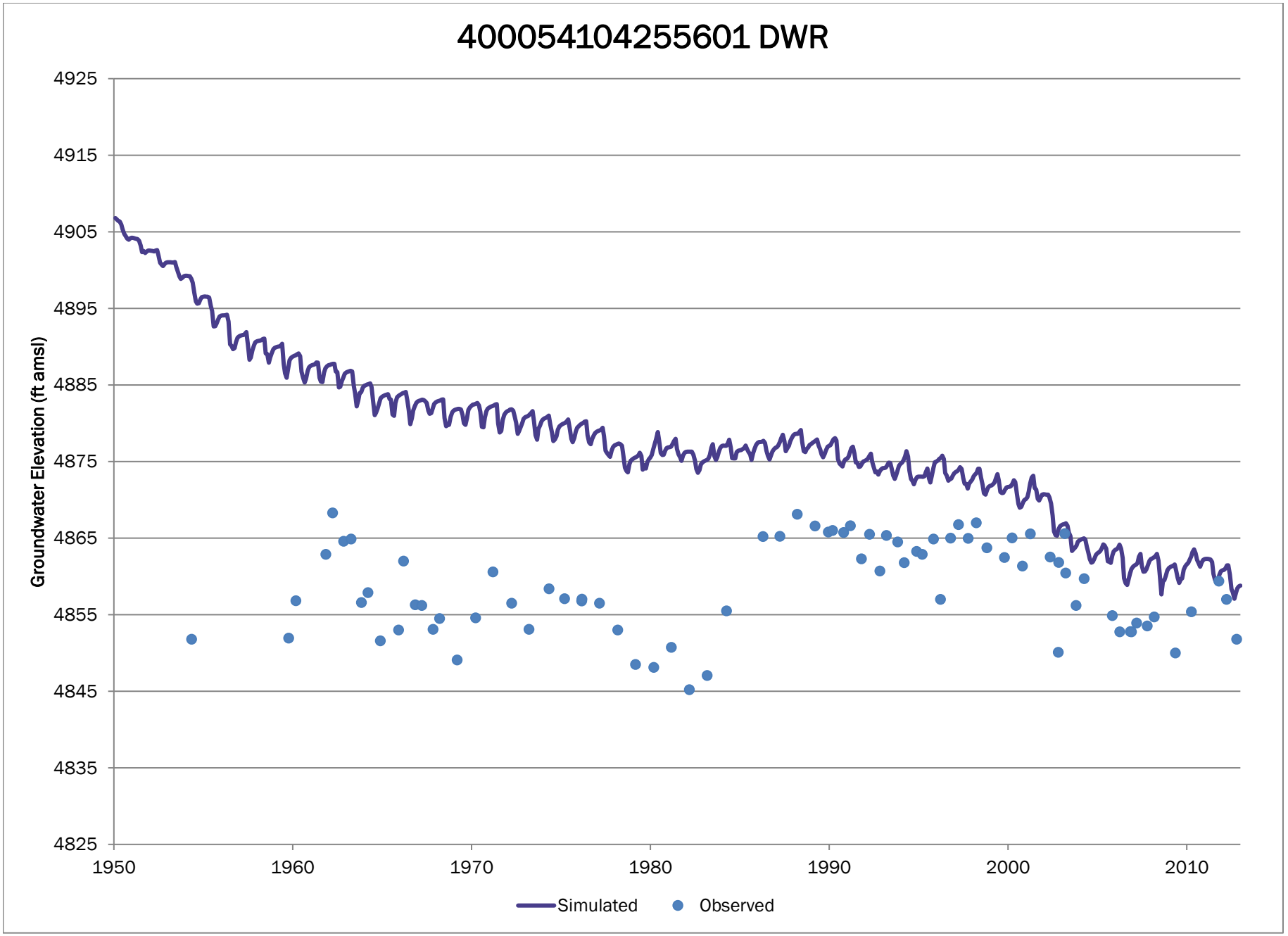


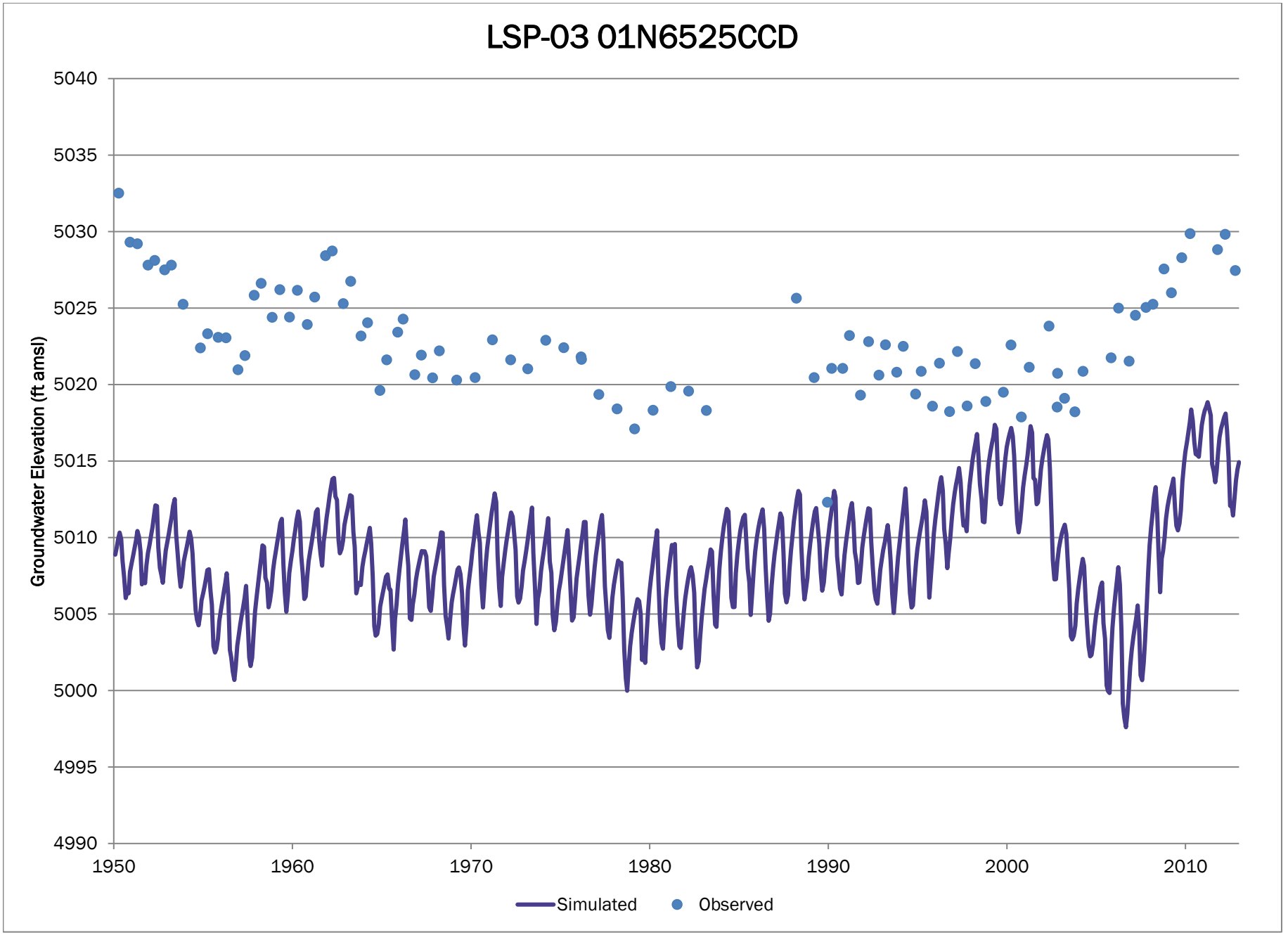
Note elevation axis range of 100 feet.

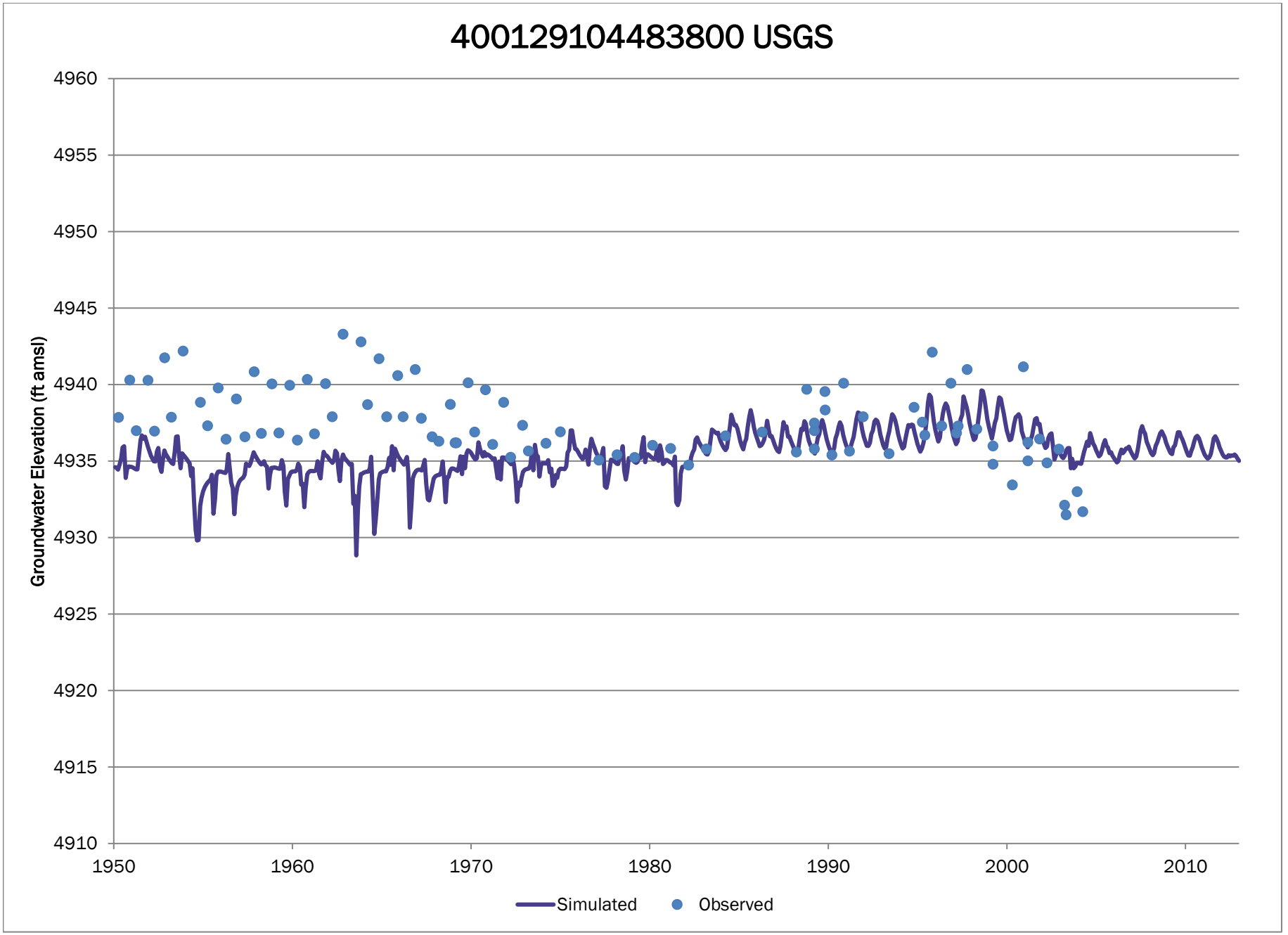


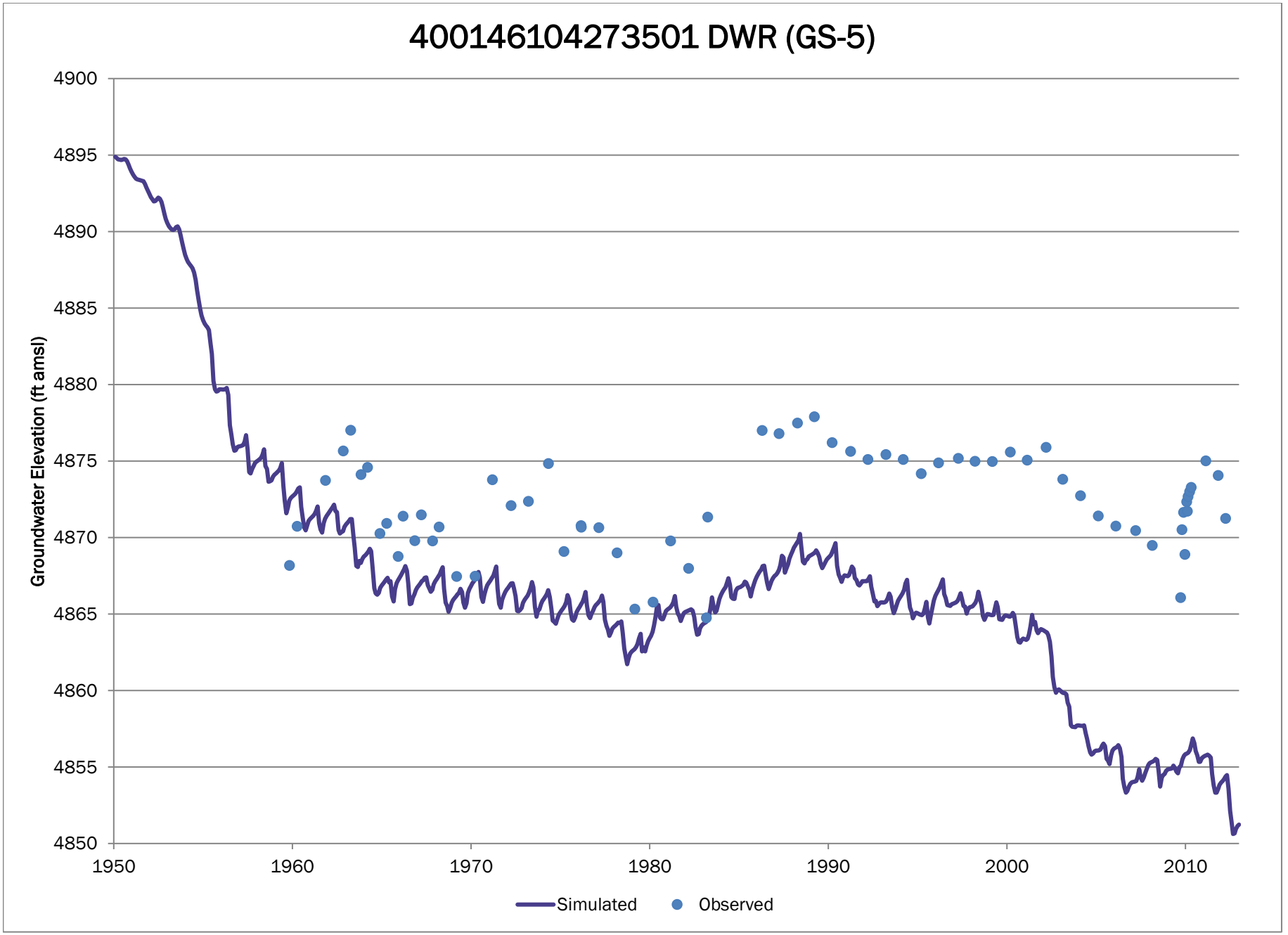

LSP-01 01N5531DCD
Groundwater Elevation (ft amsl)
4425
4420
4415
4410
4405
4400
4395
4390
4385
4380
4375
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

Note elevation axis range of 100 feet.

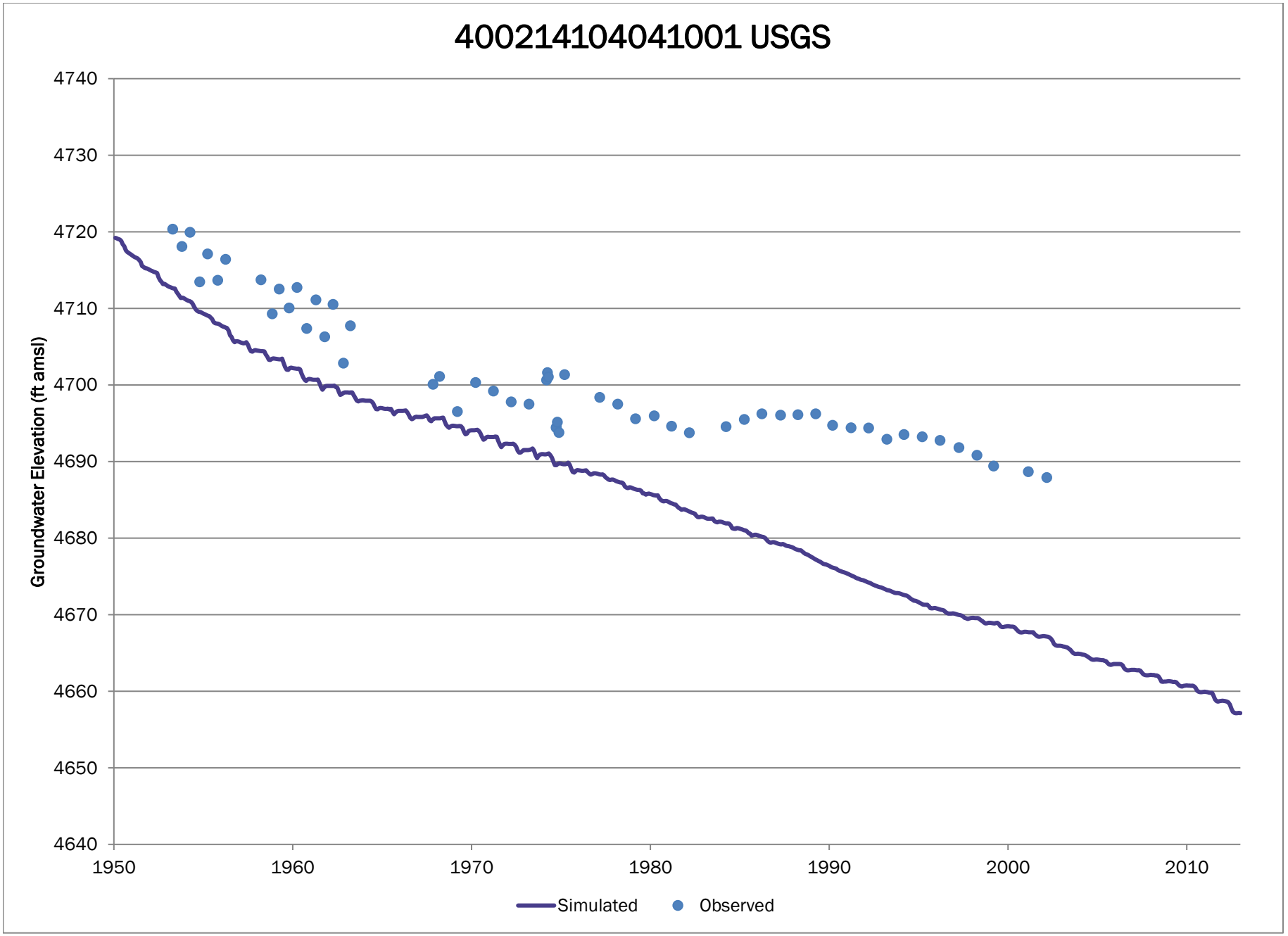



LSP-03 01N6525CCD
Groundwater Elevation (ft amsl)
5040
5035
5030
5025
5020
5015
5010
5005
5000
4995
4990
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

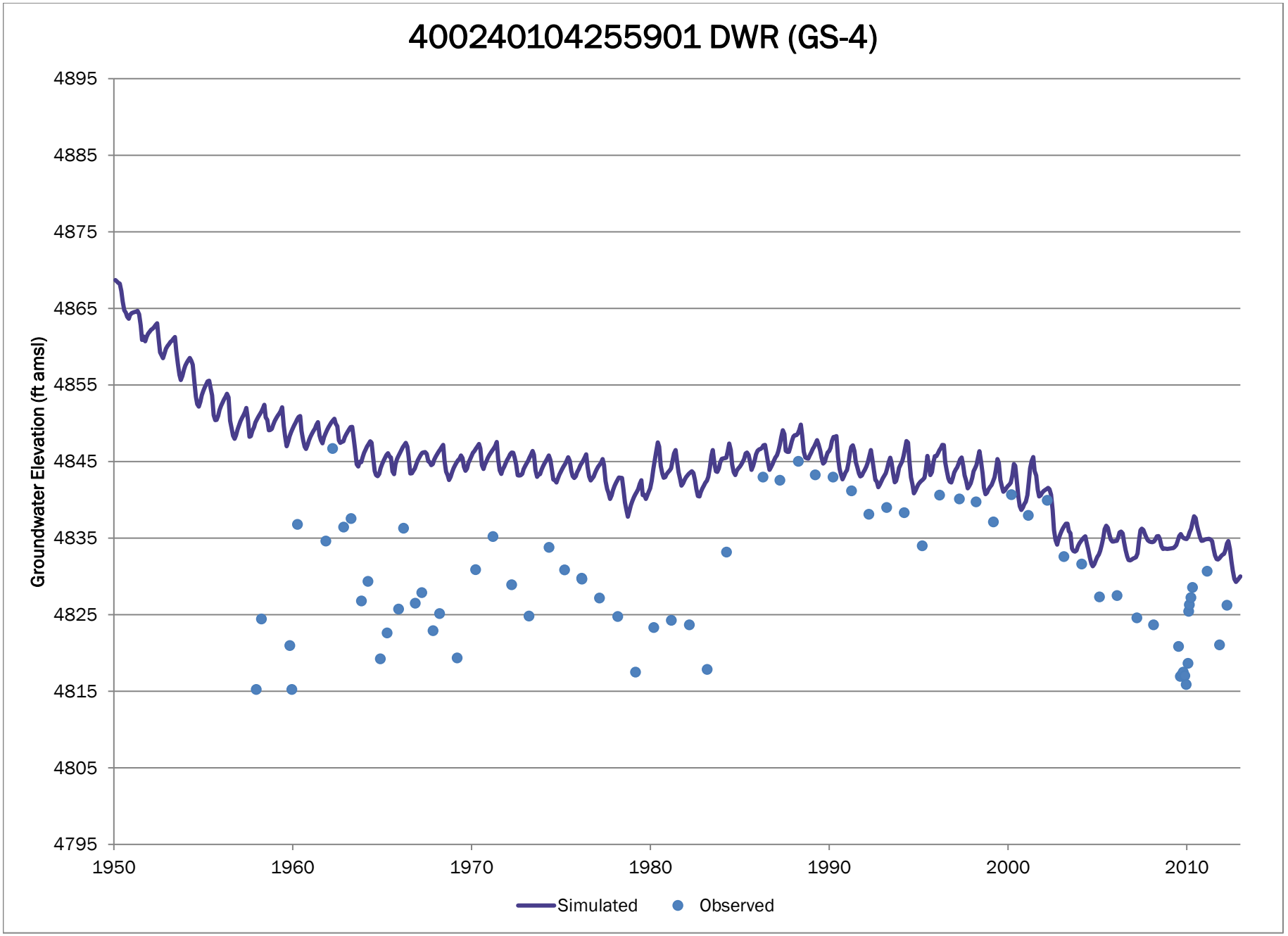

400129104483800 USGS
Groundwater Elevation (ft amsl)
4960
4955
4950
4945
4940
4935
4930
4925
4920
4915
4910
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


400146104273501 DWR (GS-5)
Groundwater Elevation (ft amsl)
4900
4895
4890
4885
4880
4875
4870
4865
4860
4855
4850
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

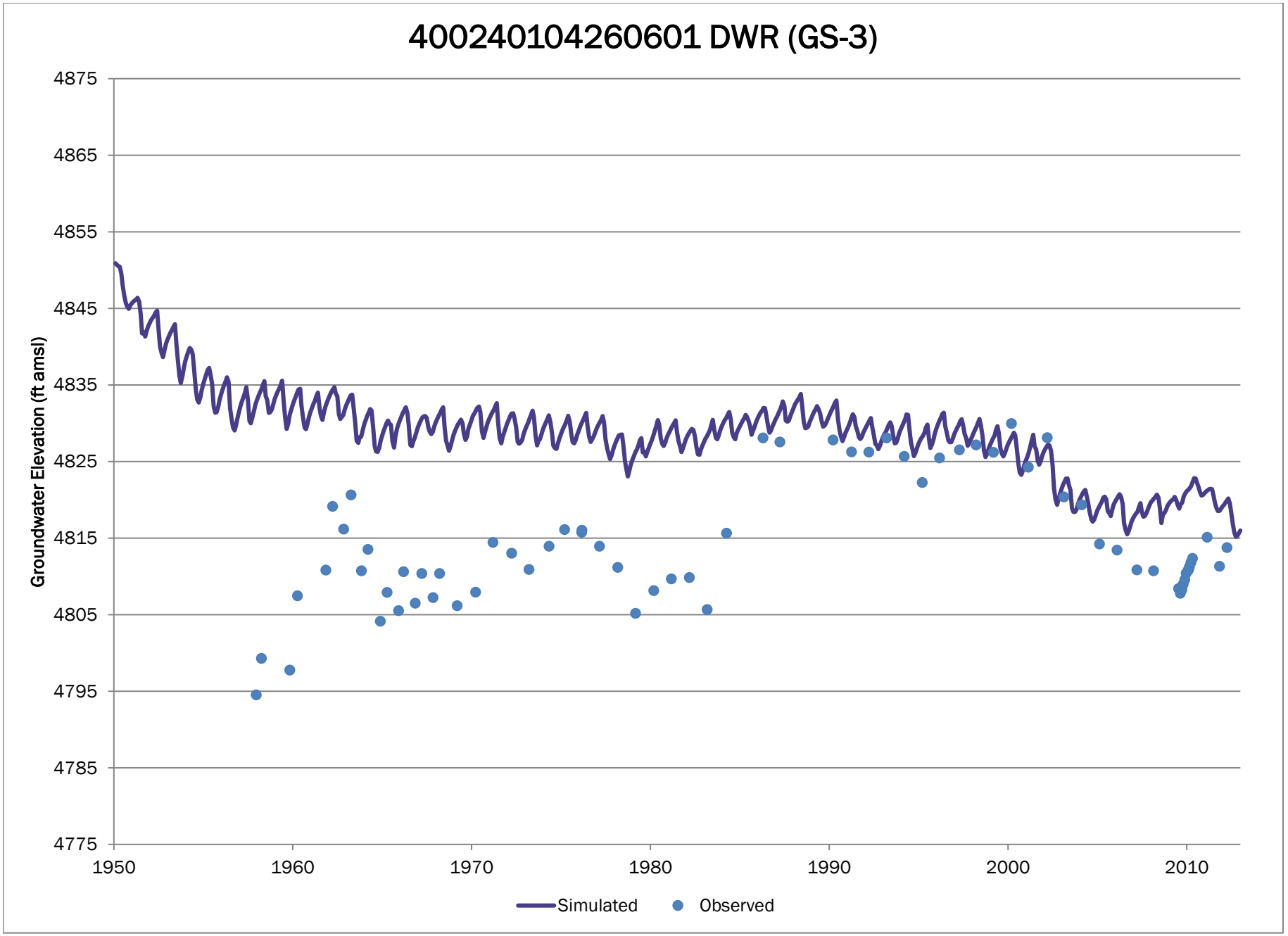
Note elevation axis range of 100 feet.



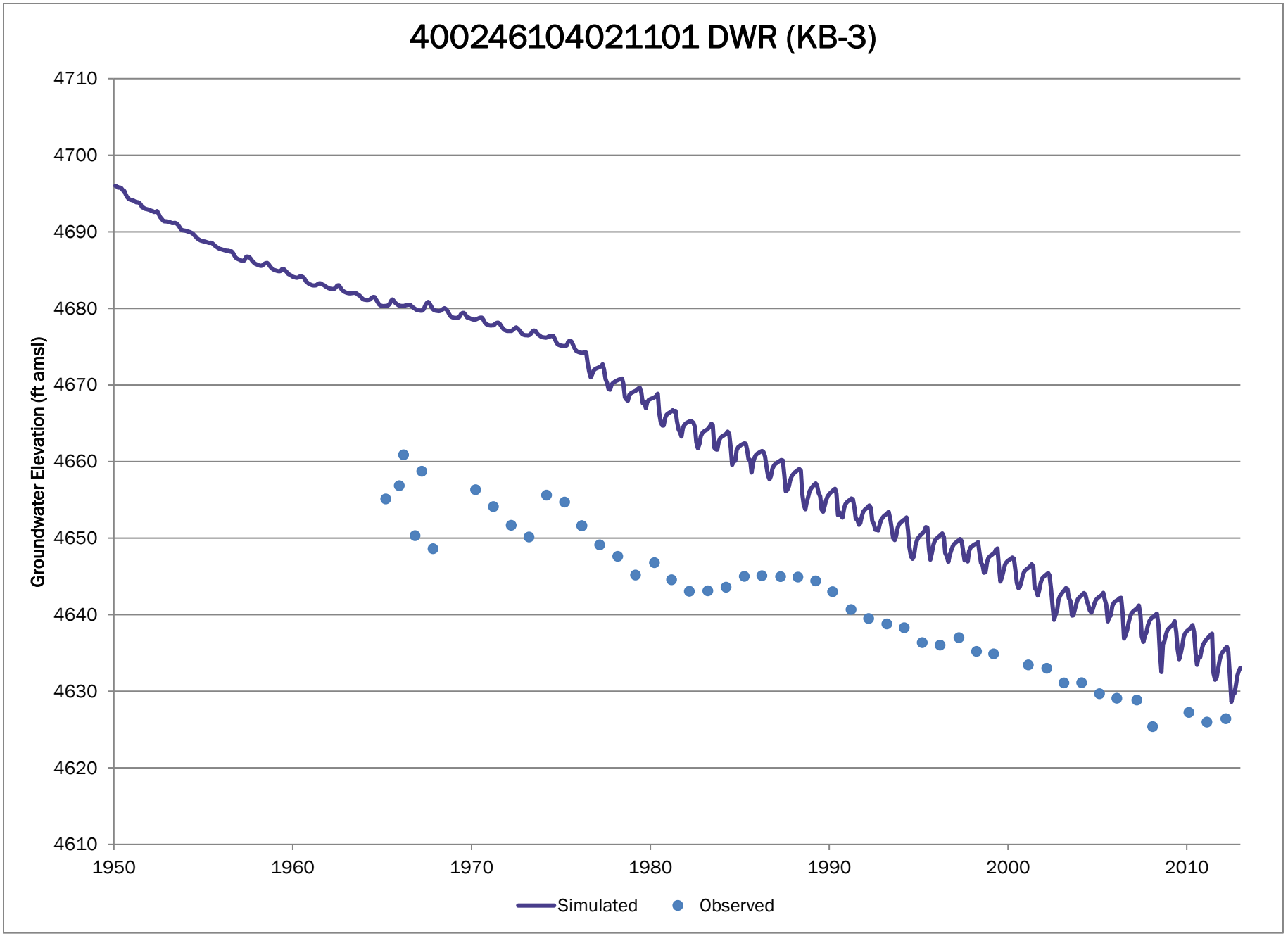
Note elevation axis range of 100 feet.

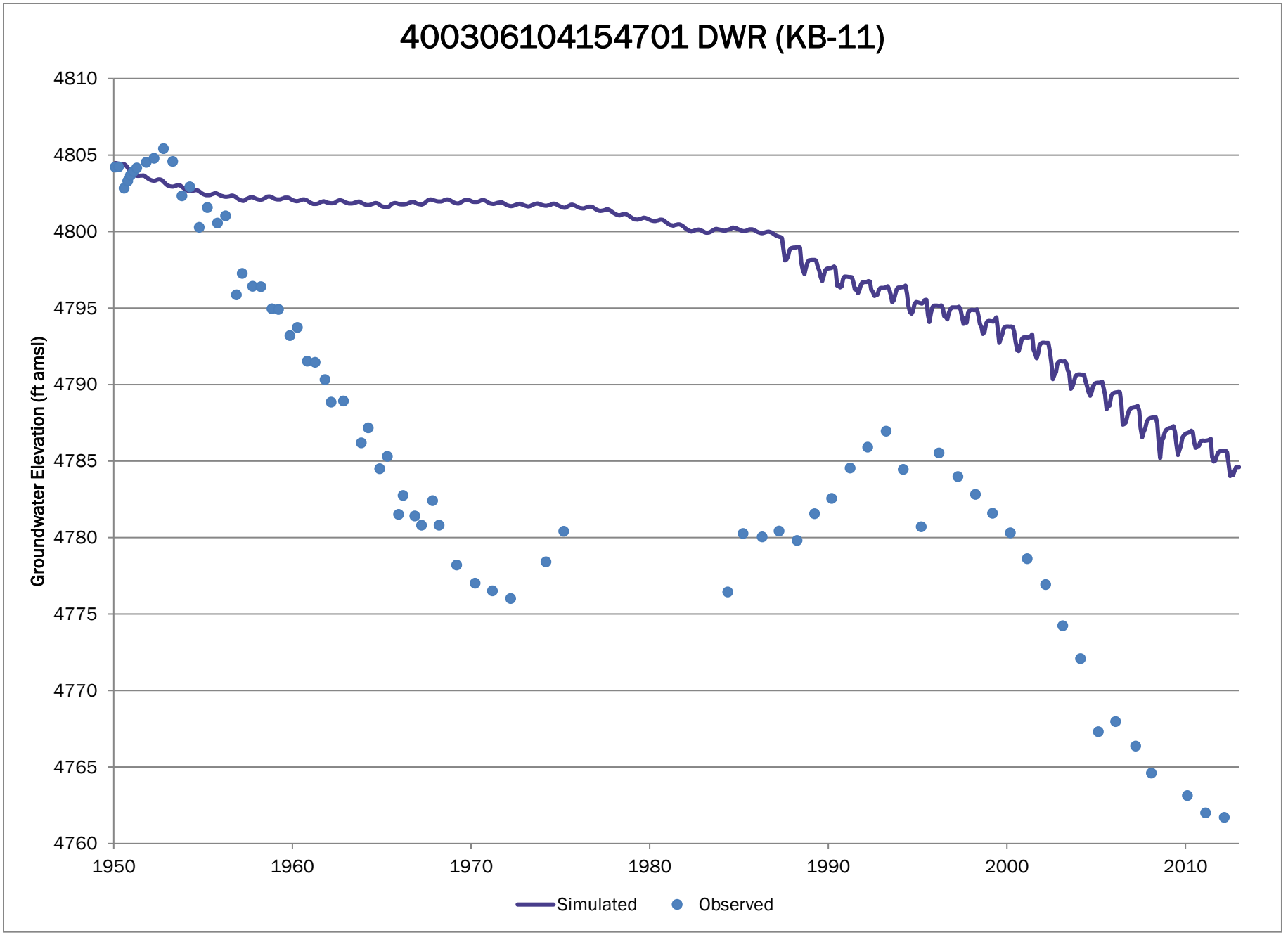


Note elevation axis range of 100 feet.

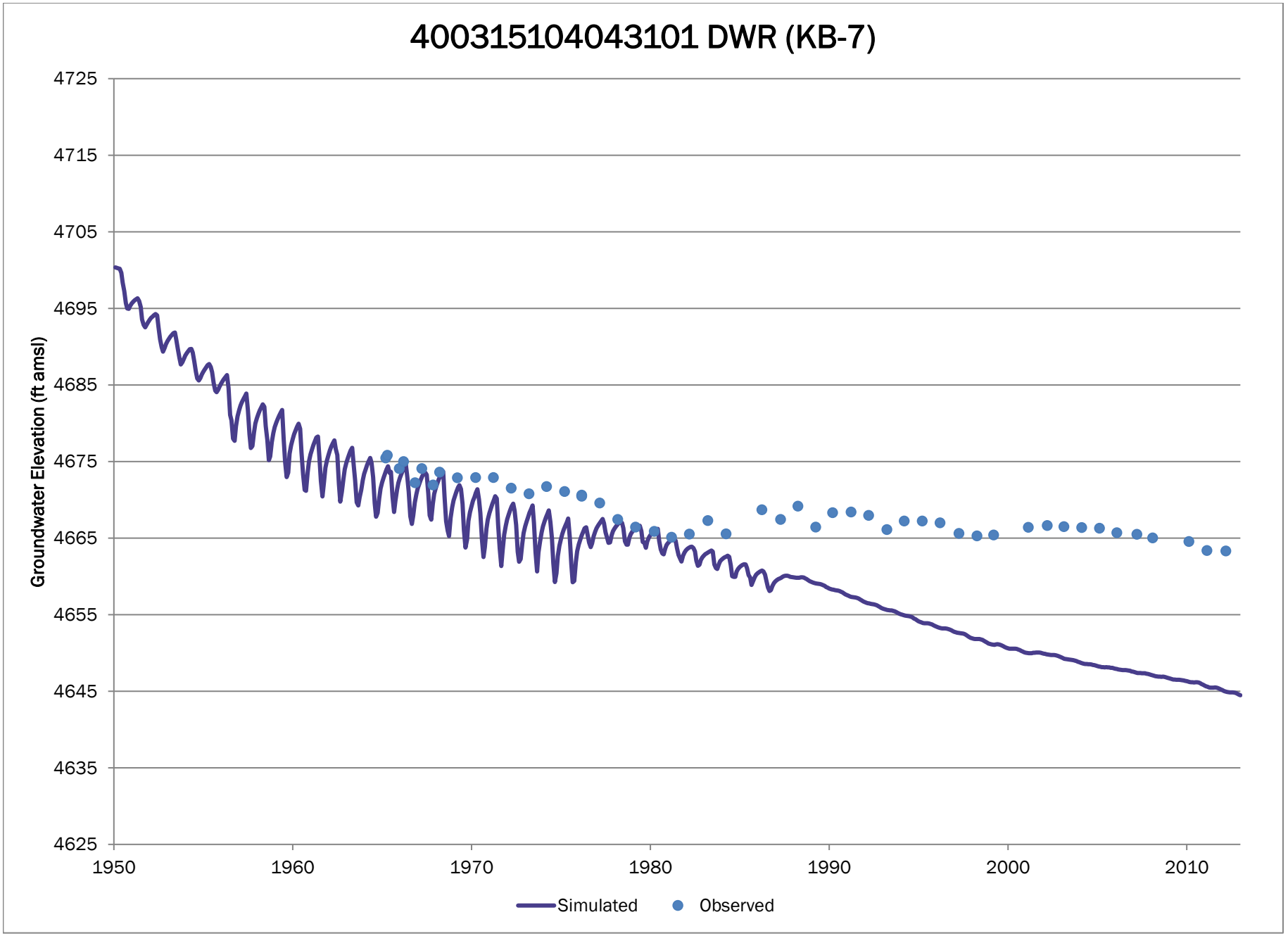


Note elevation axis range of 100 feet.

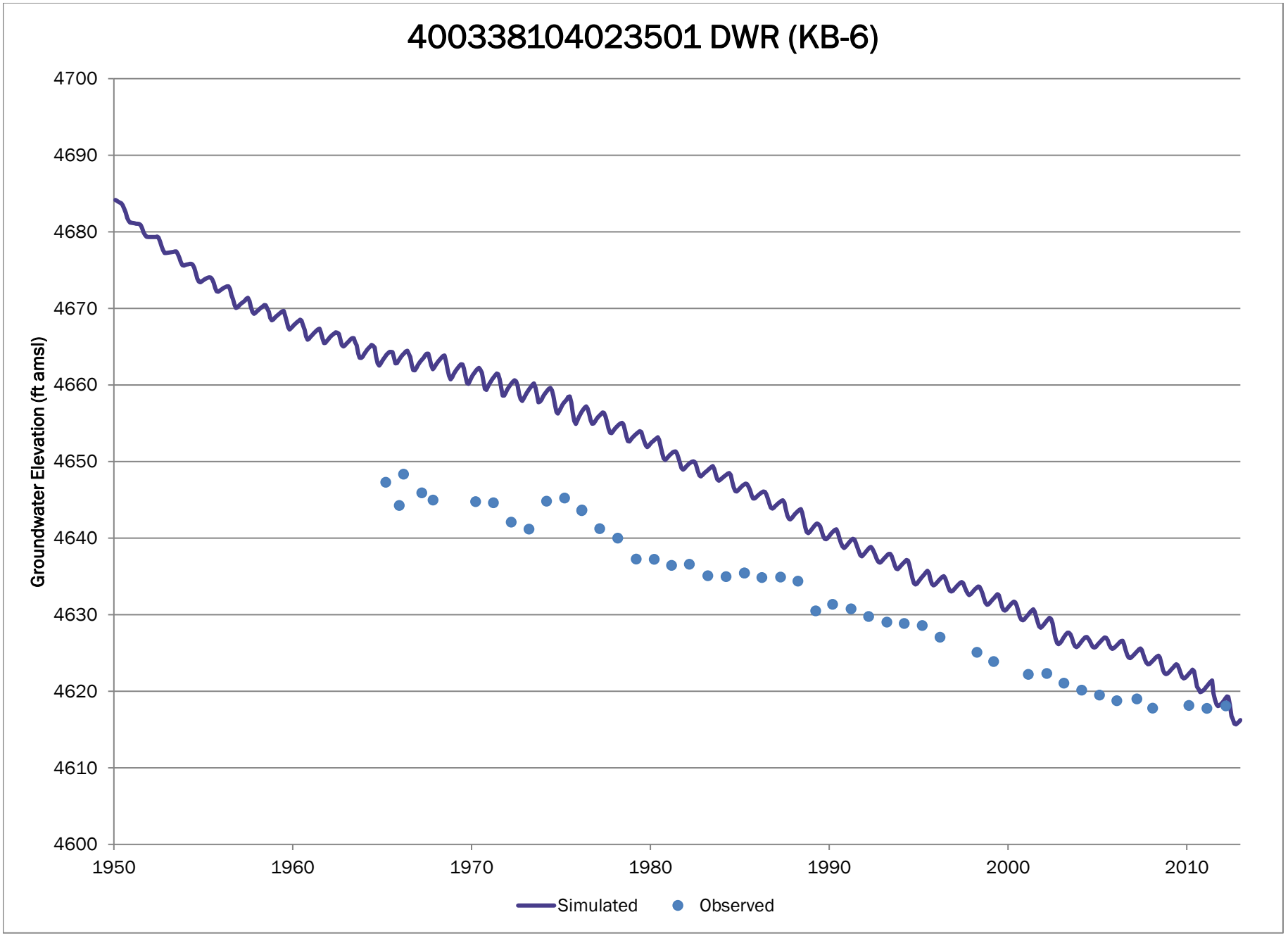



400306104154701 DWR (KB-11)
Groundwater Elevation (ft amsl)
4810
4805
4800
4795
4790
4785
4780
4775
4770
4765
4760
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

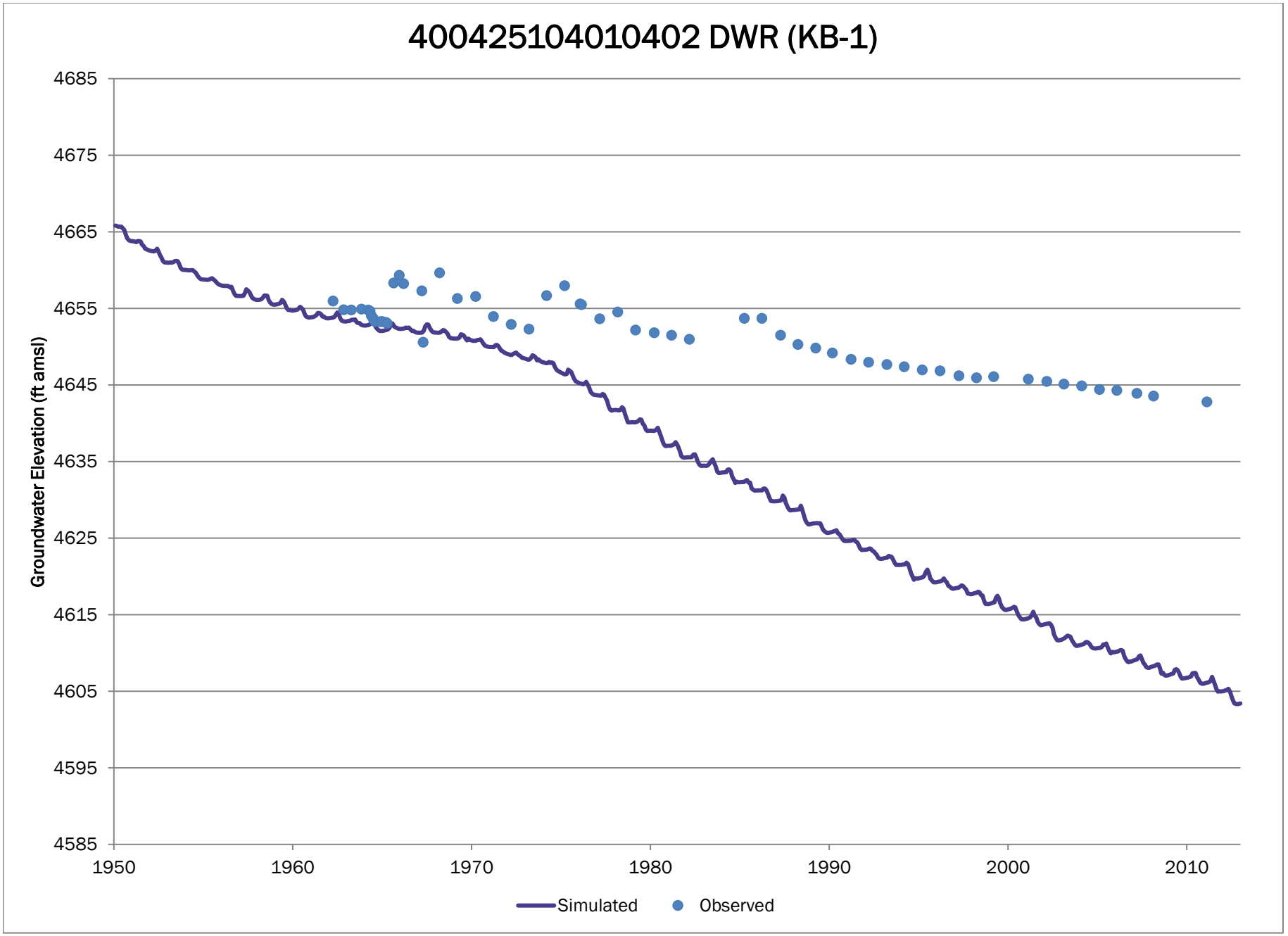
Note elevation axis range of 100 feet.



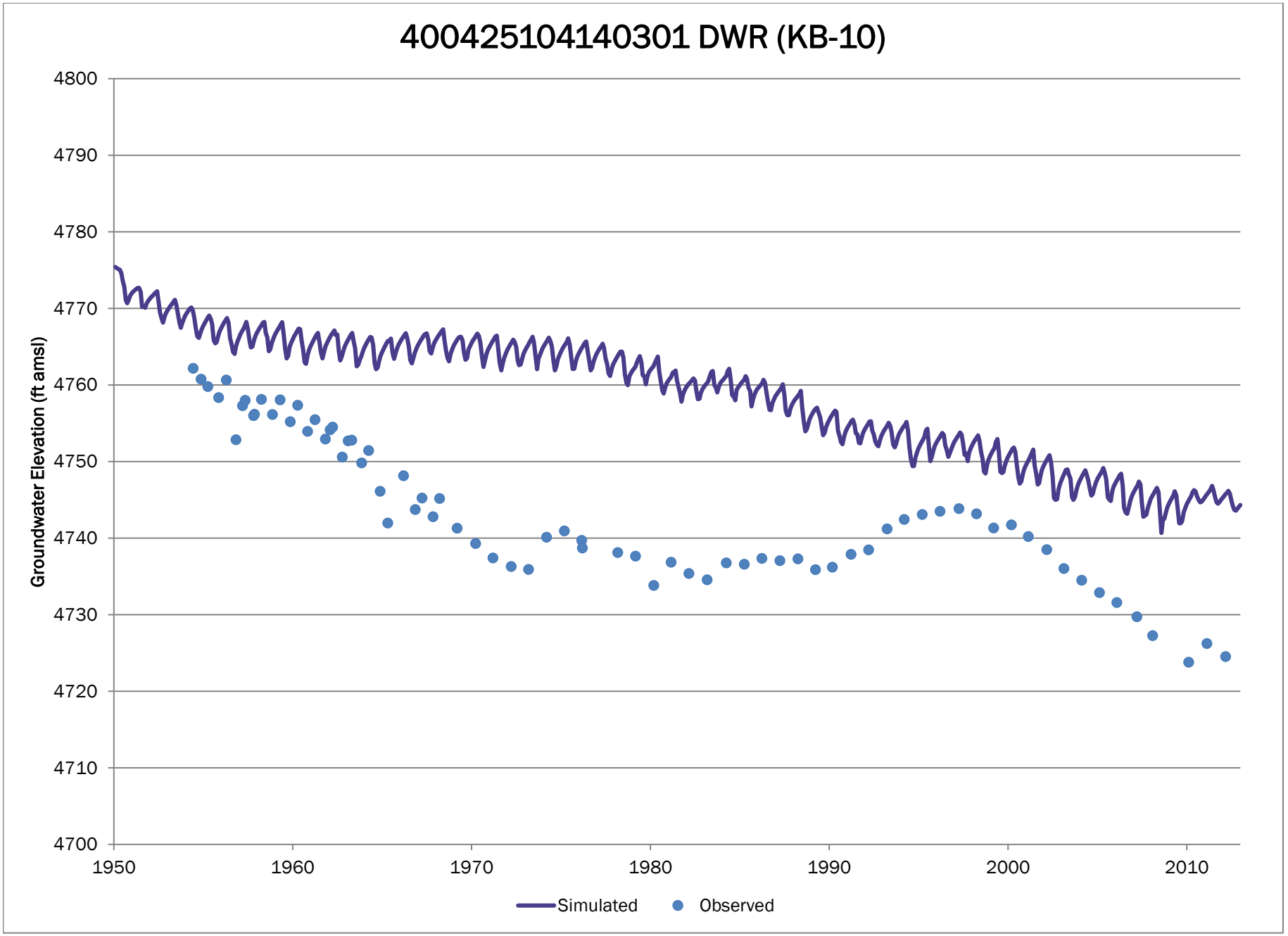
Note elevation axis range of 100 feet.



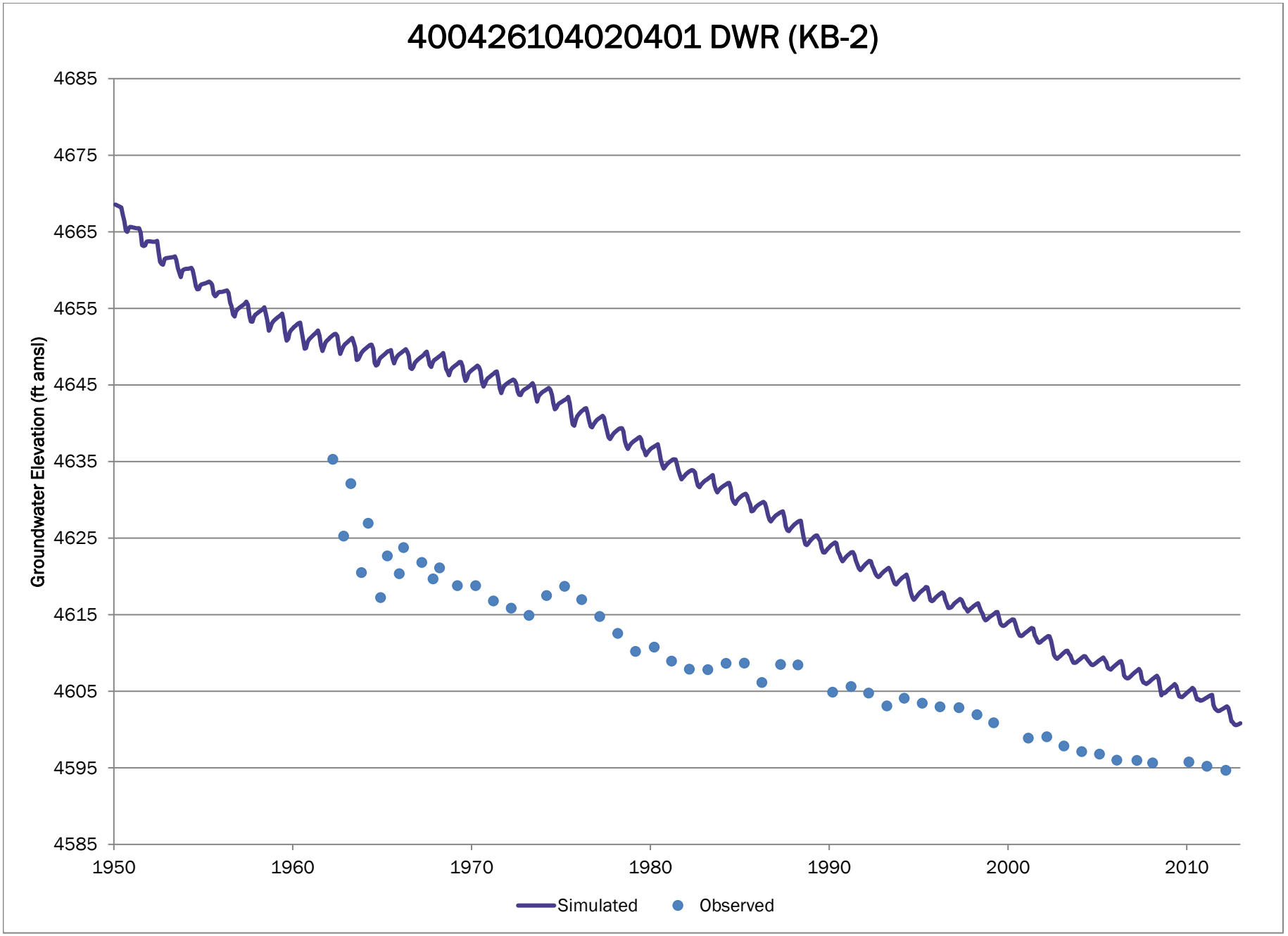
Note elevation axis range of 100 feet.



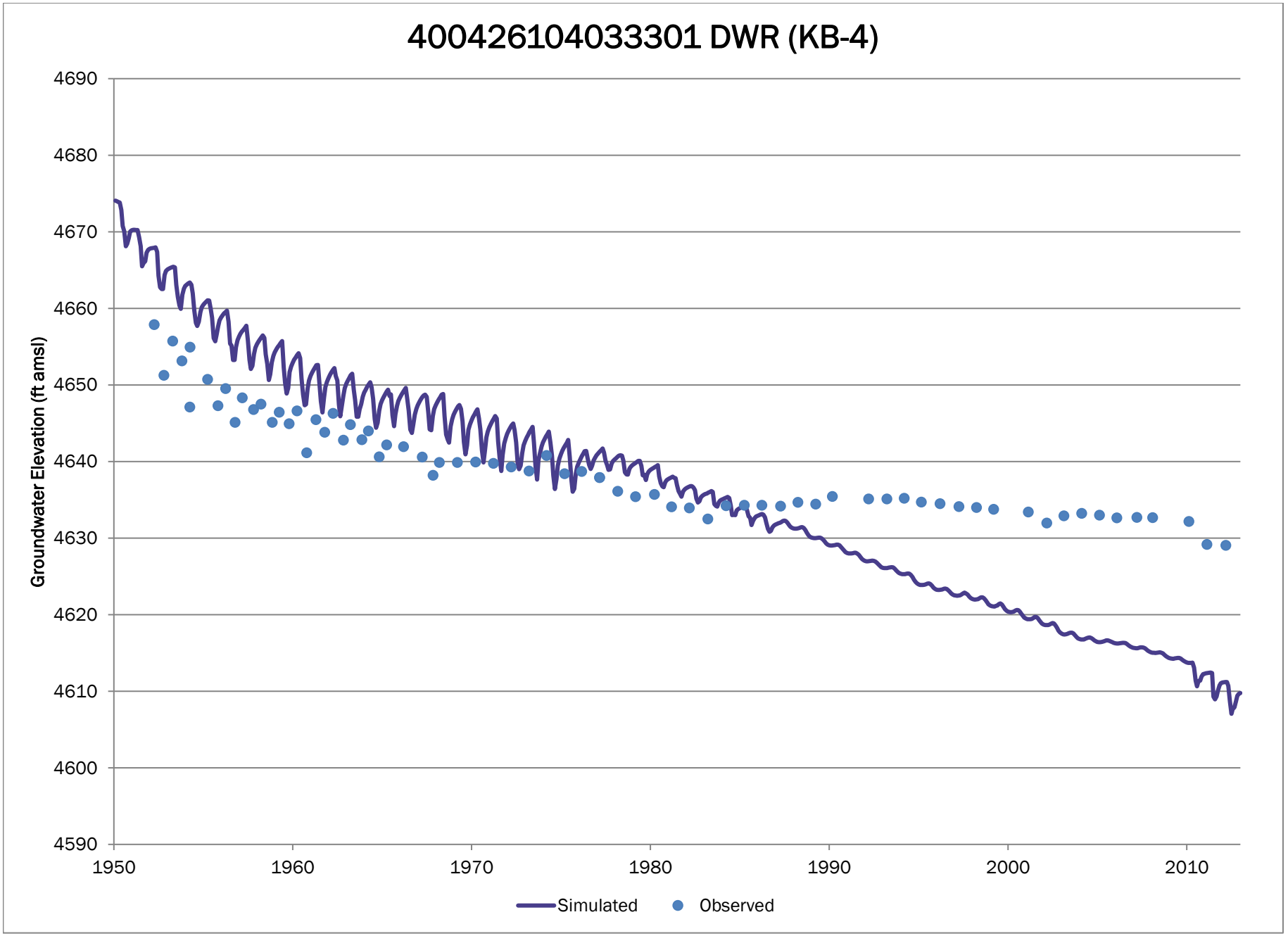
Note elevation axis range of 100 feet.



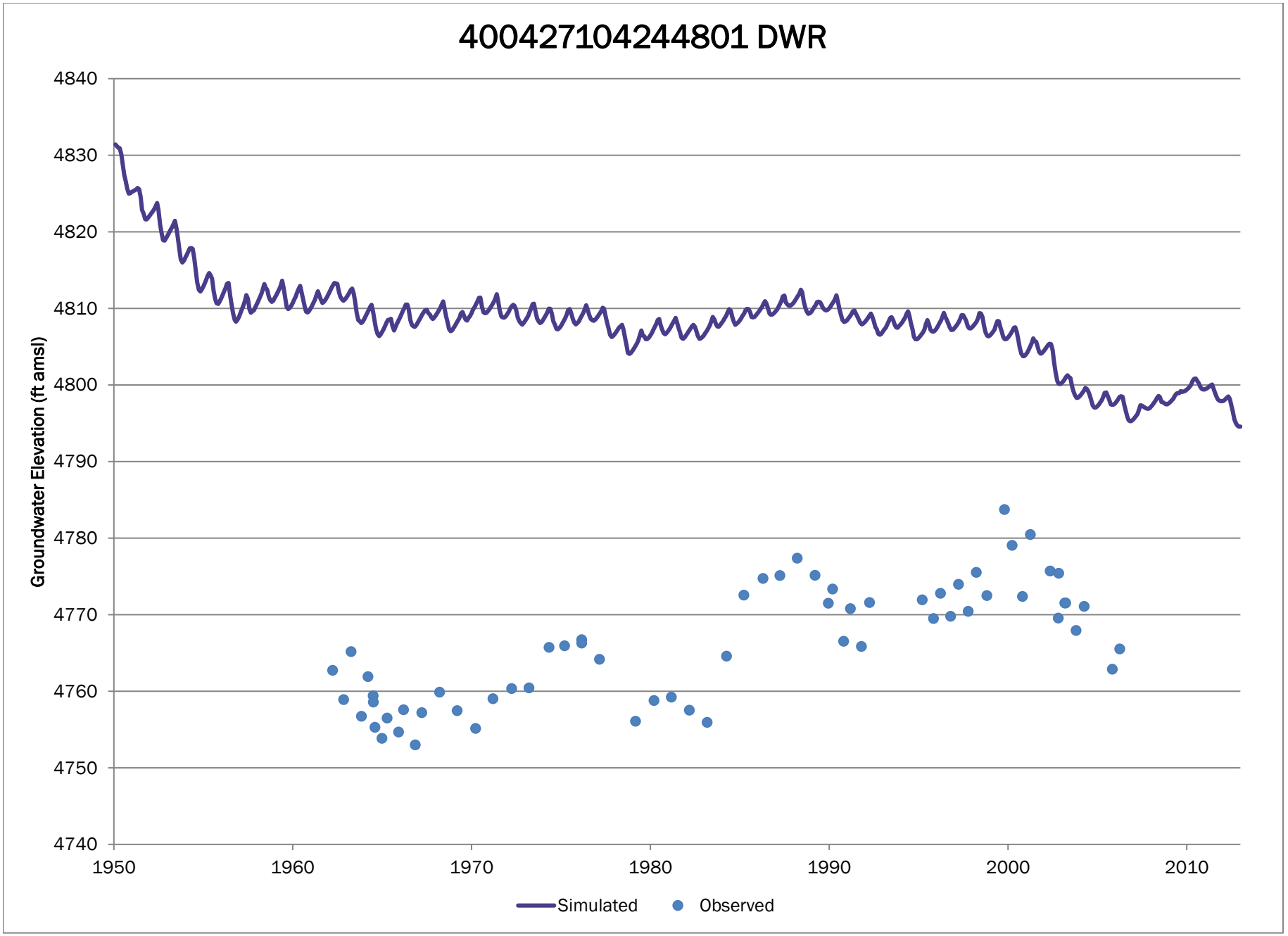
Note elevation axis range of 100 feet.

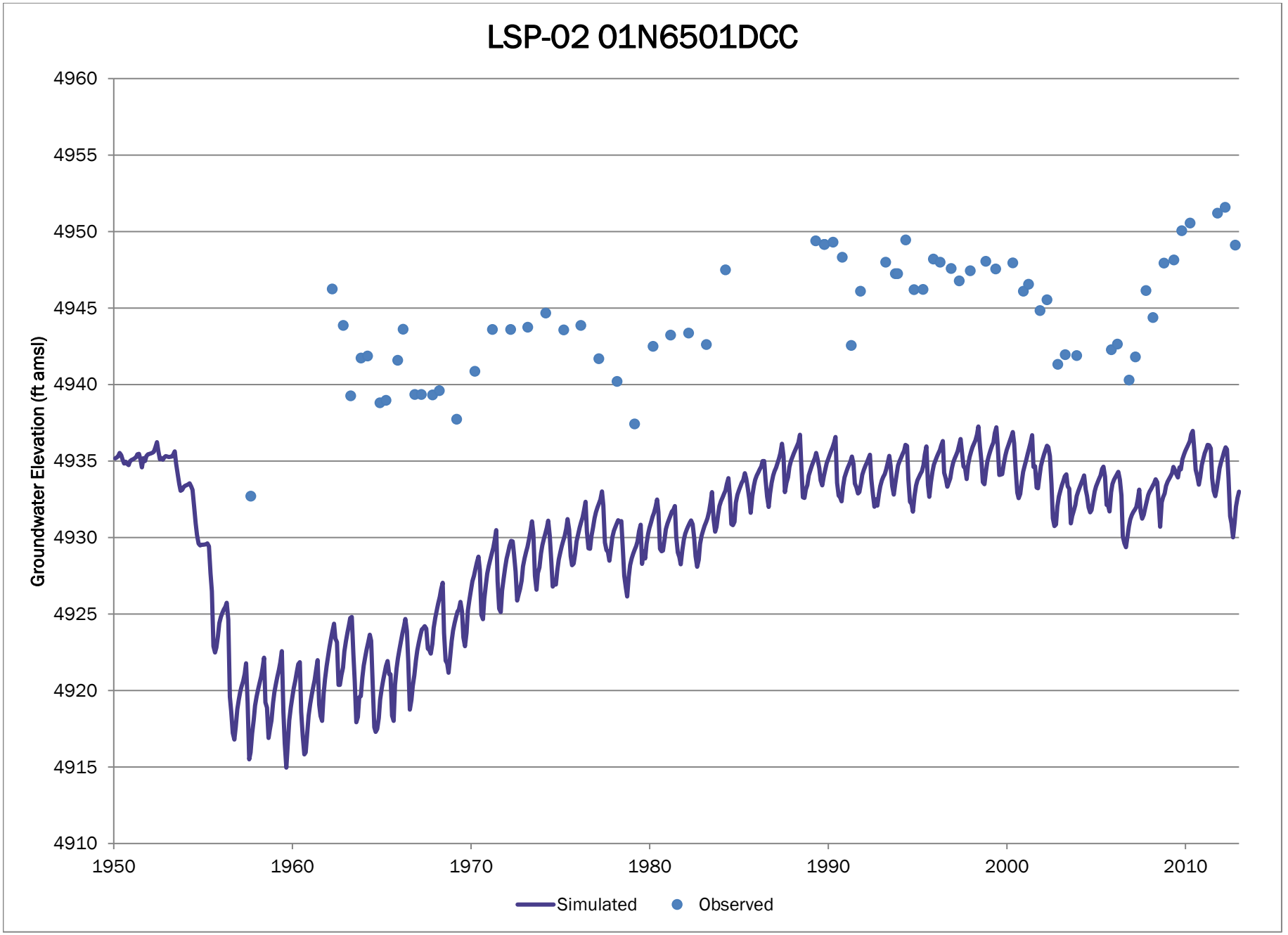


Note elevation axis range of 100 feet.

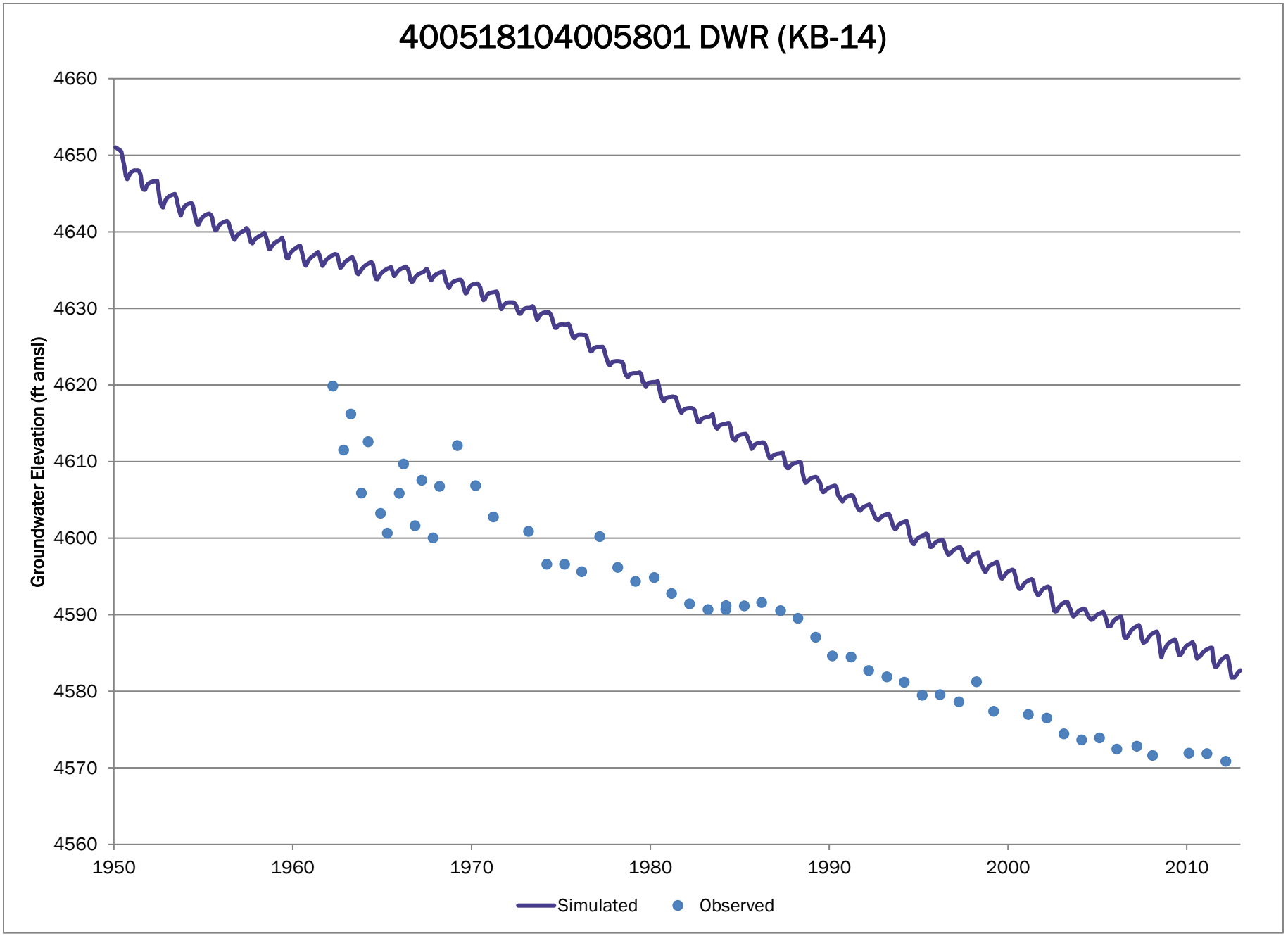


Note elevation axis range of 100 feet.

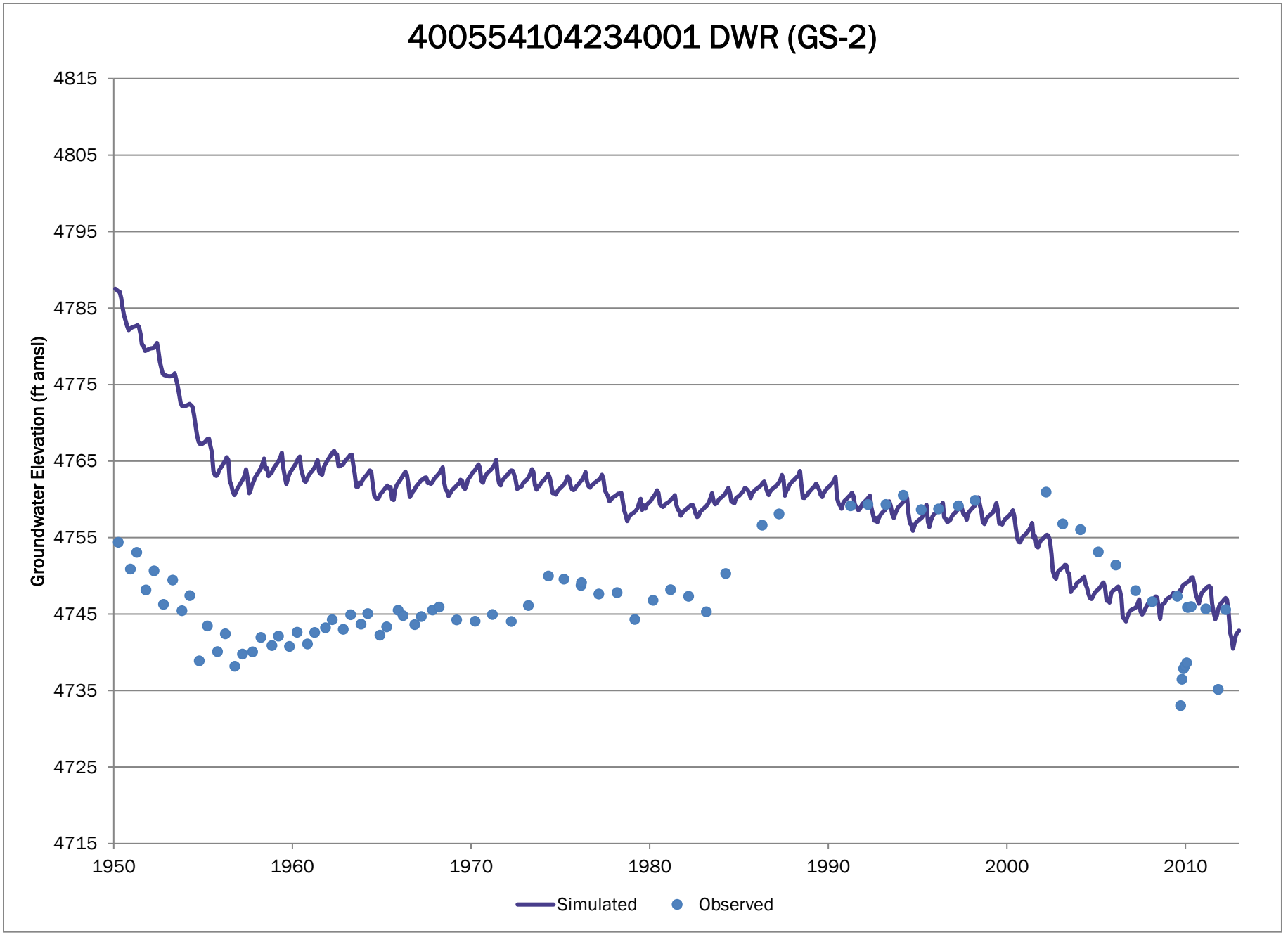


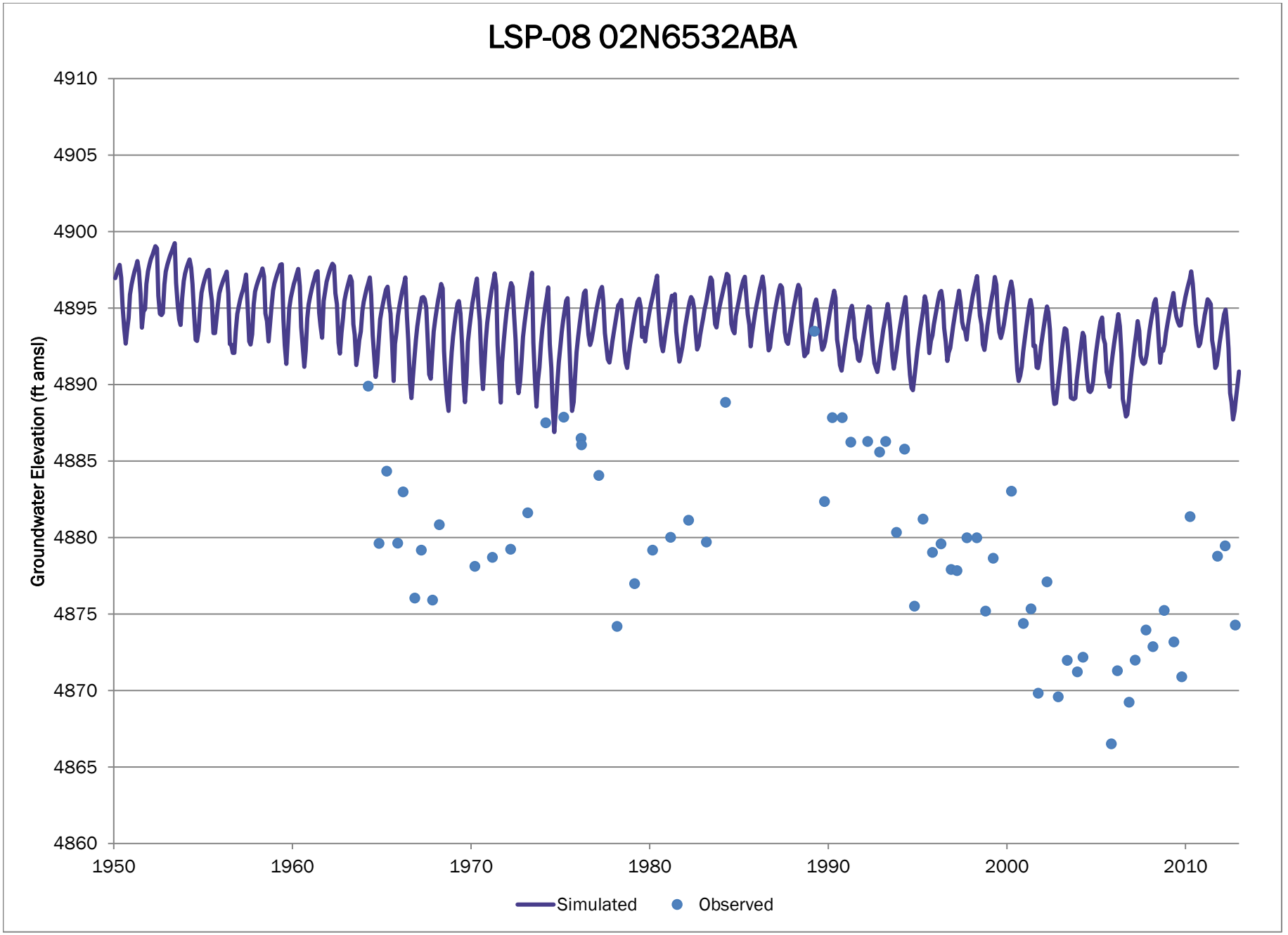

LSP-02 01N6501DCC
Groundwater Elevation (ft amsl)
4960
4955
4950
4945
4940
4935
4930
4925
4920
4915
4910
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

Note elevation axis range of 100 feet.

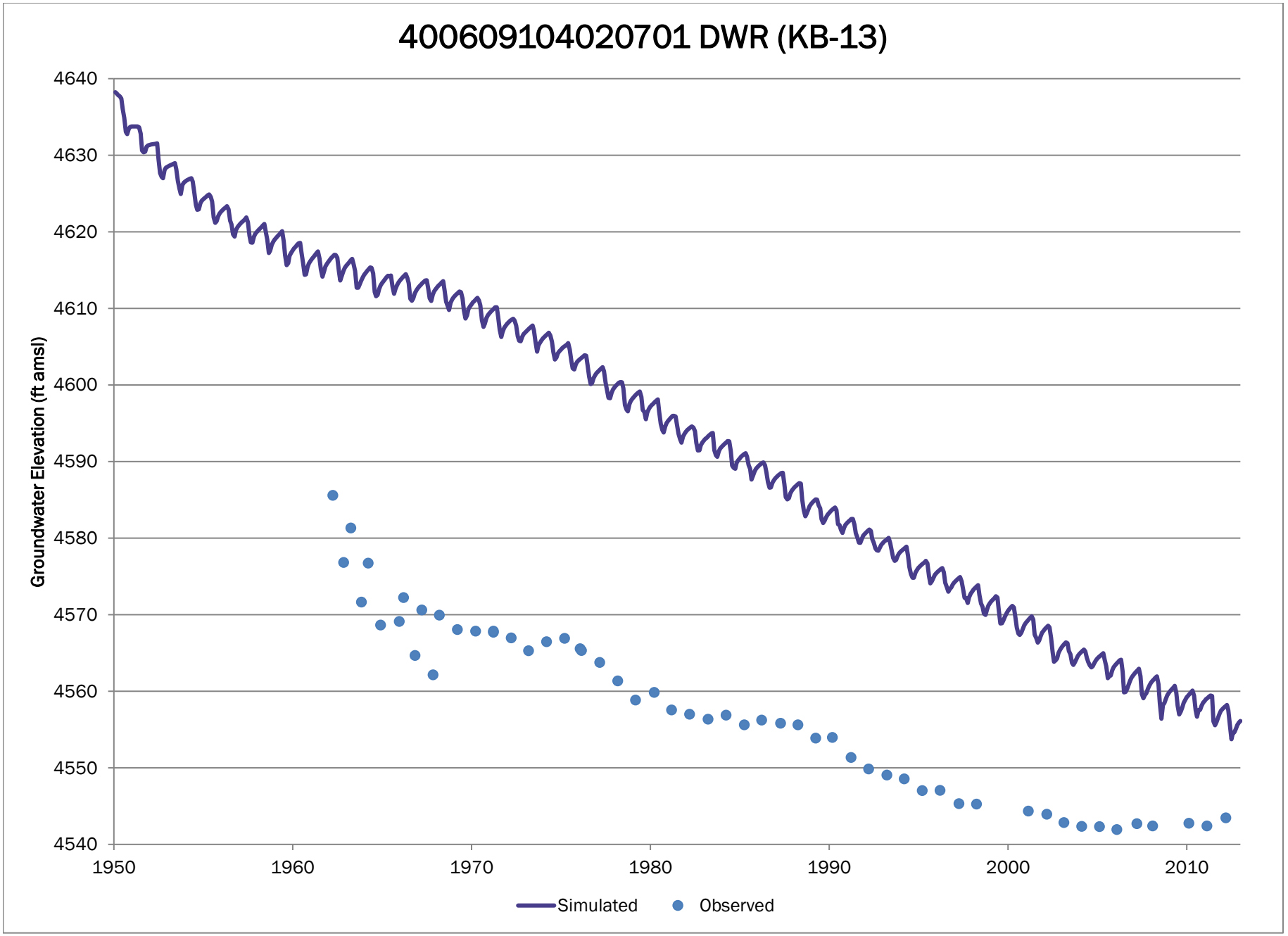


Note elevation axis range of 100 feet.

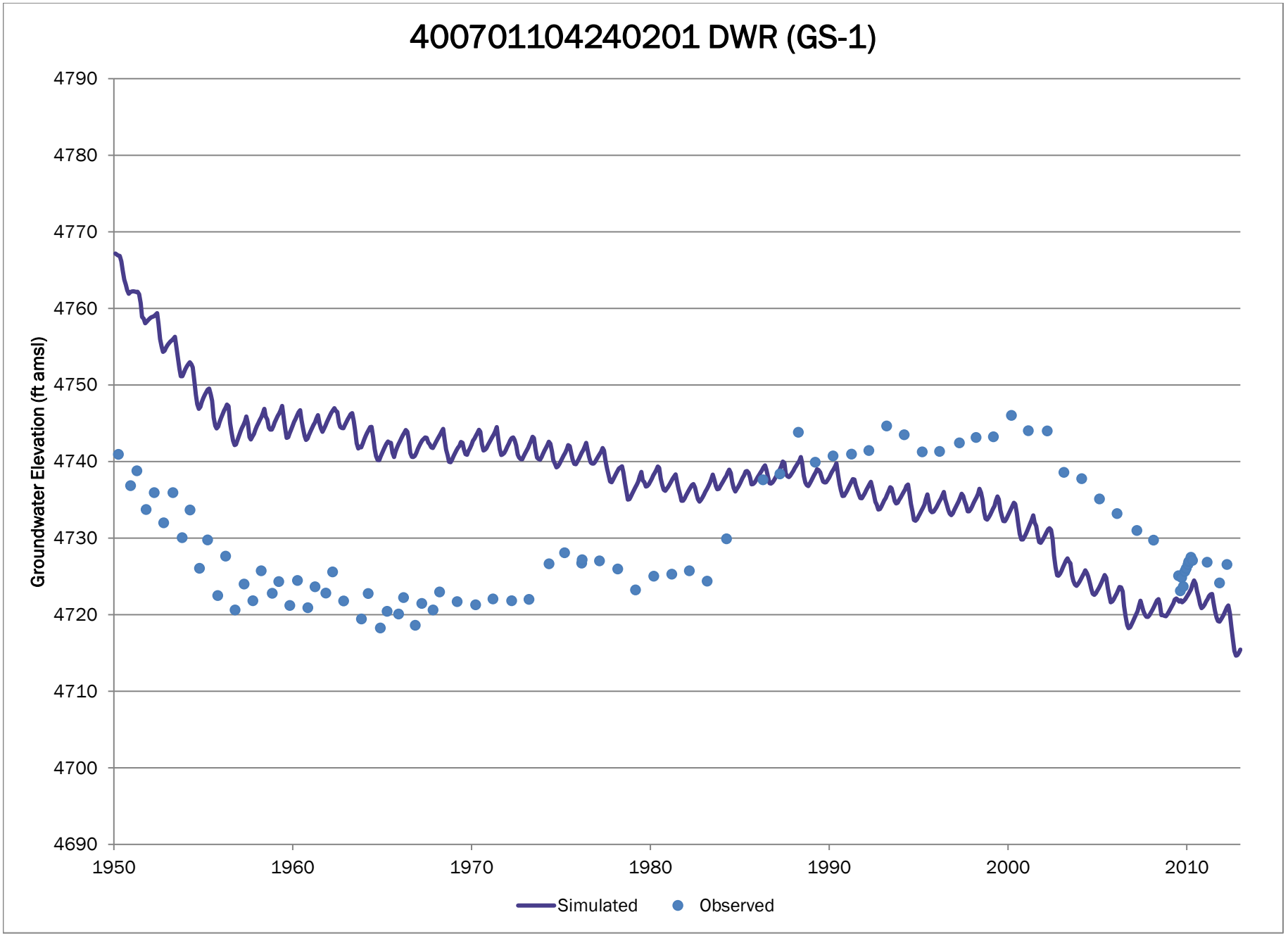


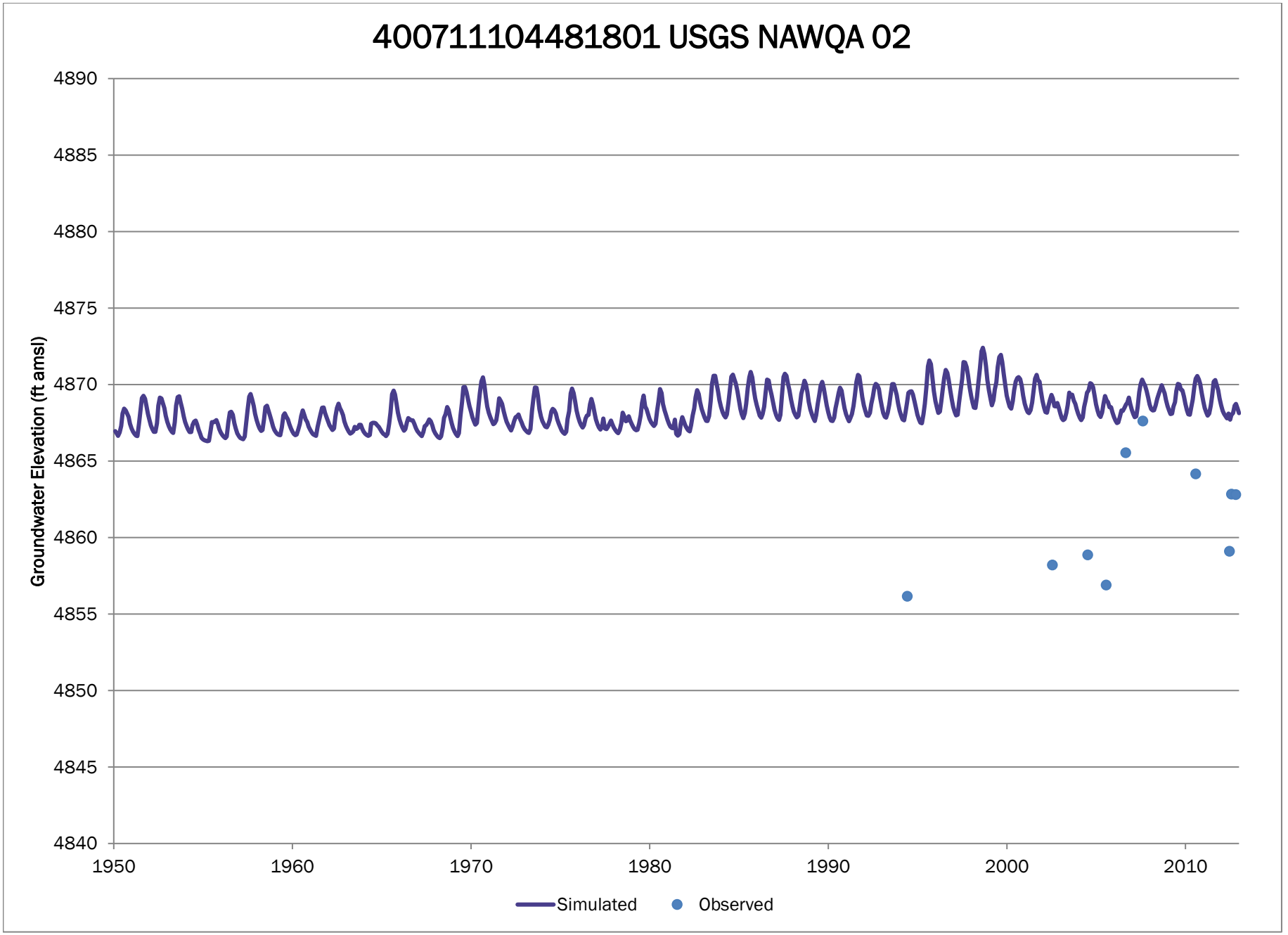

LSP-08 02N6532ABA
Groundwater Elevation (ft amsl)
4910
4905
4900
4895
4890
4885
4880
4875
4870
4865
4860
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

Note elevation axis range of 100 feet.

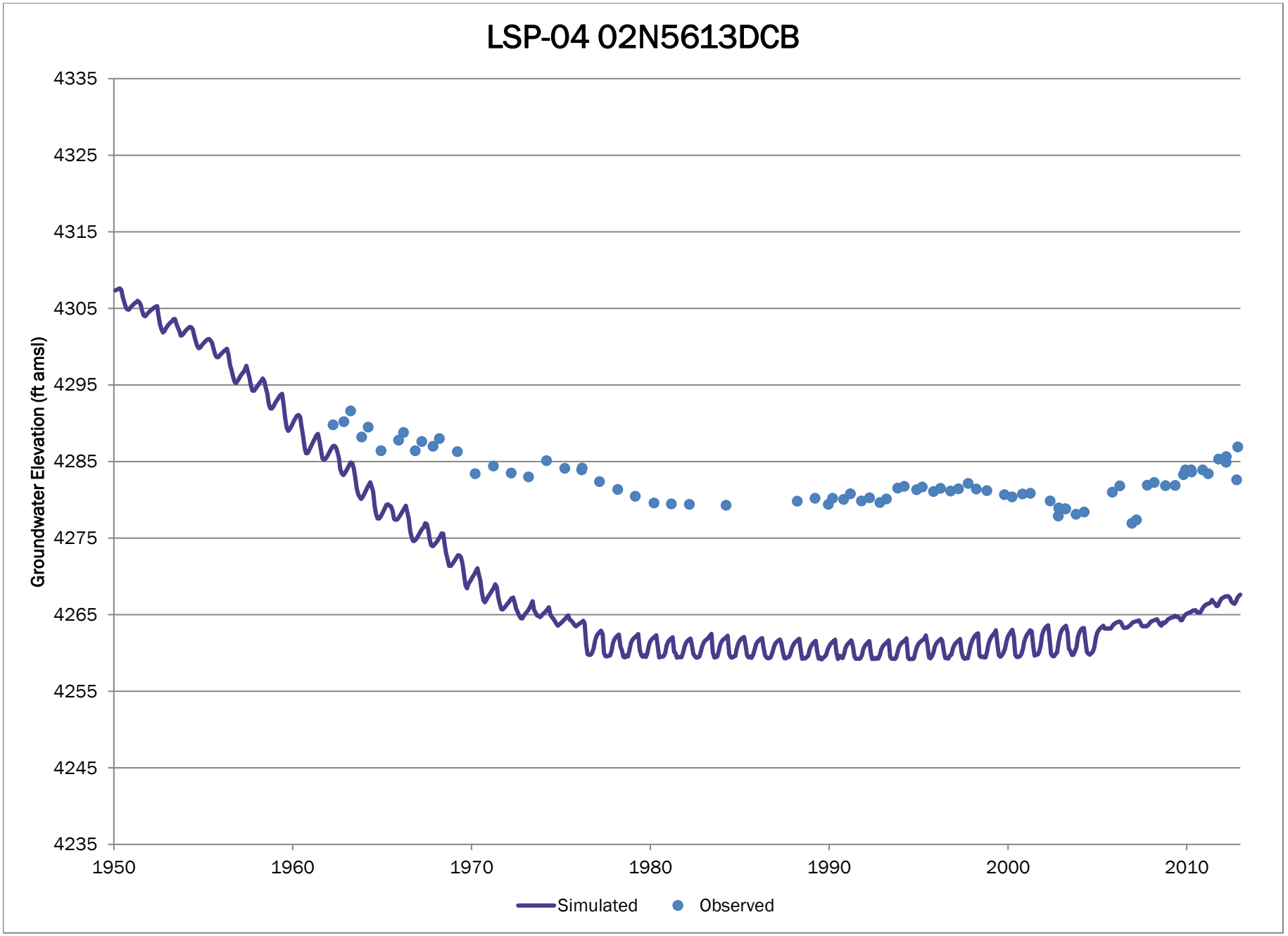


Note elevation axis range of 100 feet.

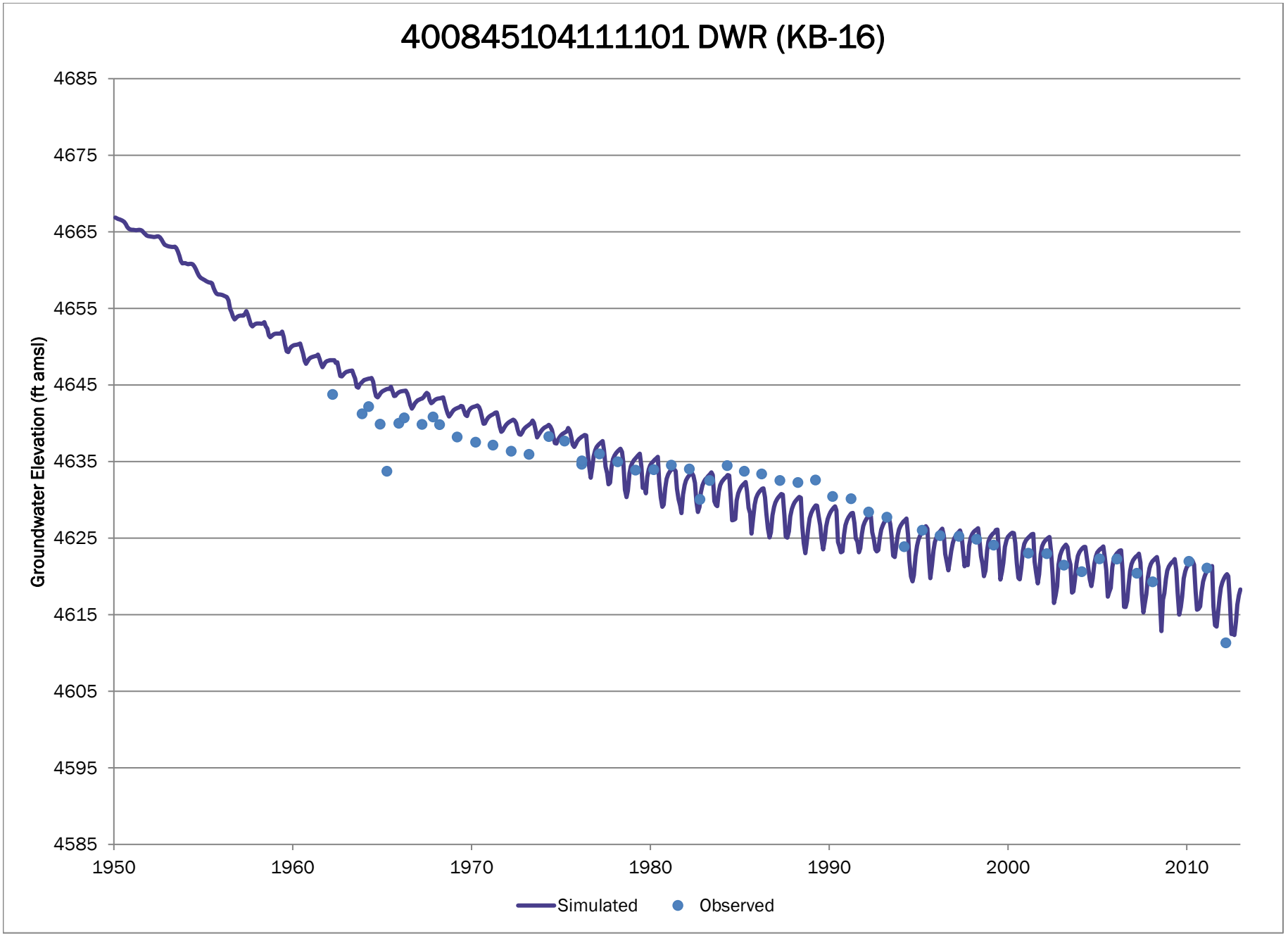


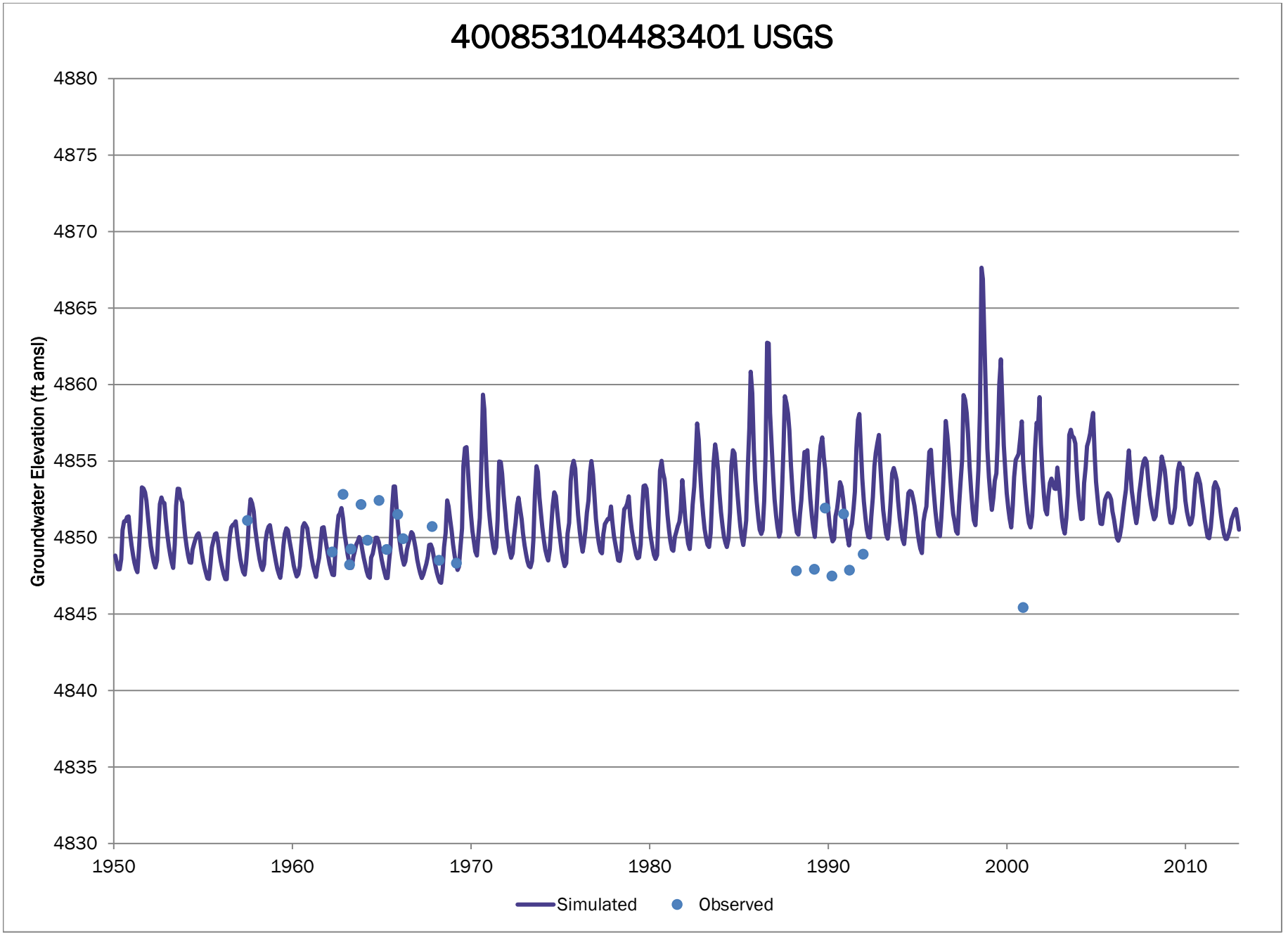

400711104481801 USGS NAWQA 02
Groundwater Elevation (ft amsl)
4890
4885
4880
4875
4870
4865
4860
4855
4850
4845
4840
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

Note elevation axis range of 100 feet.

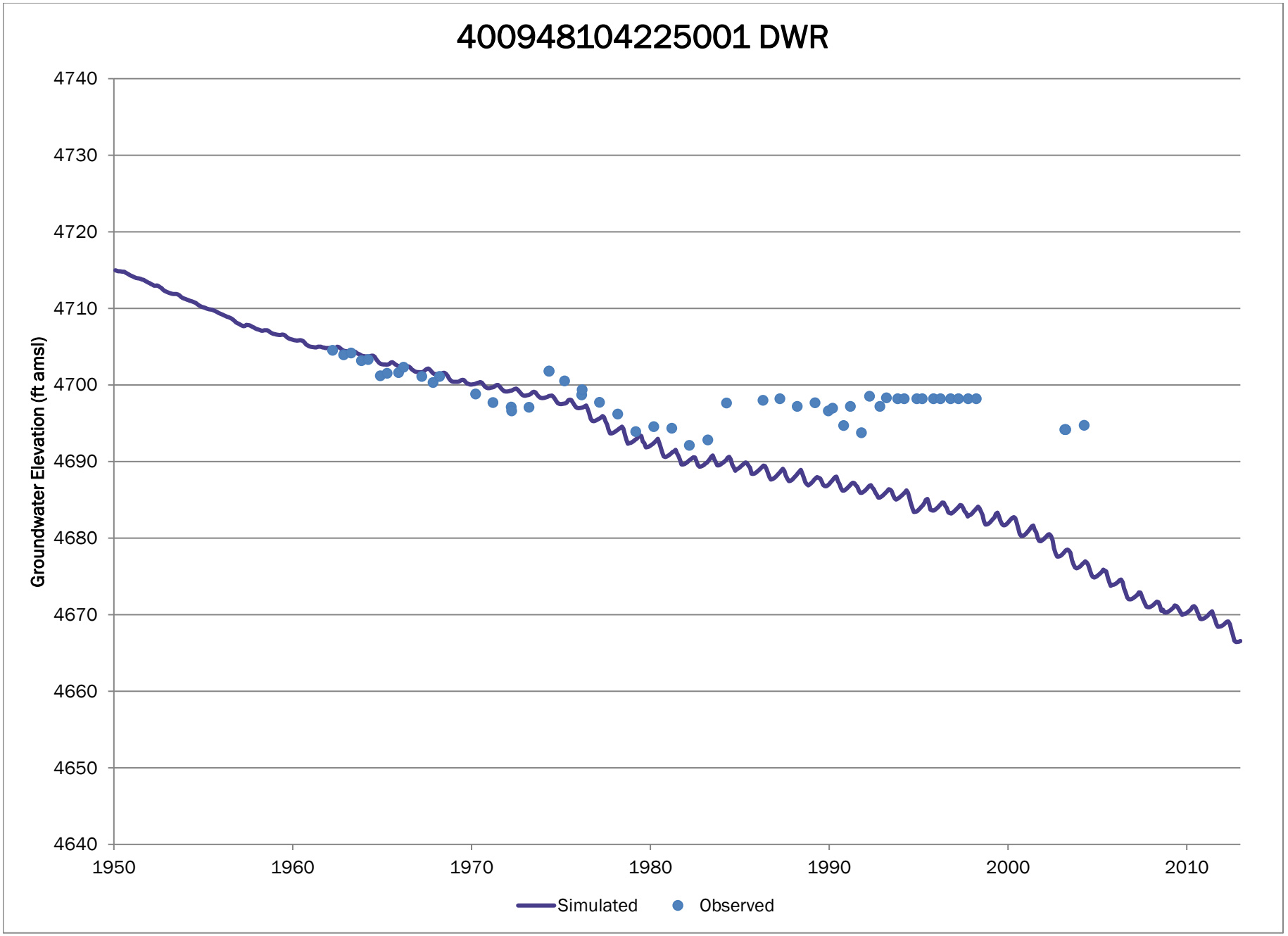


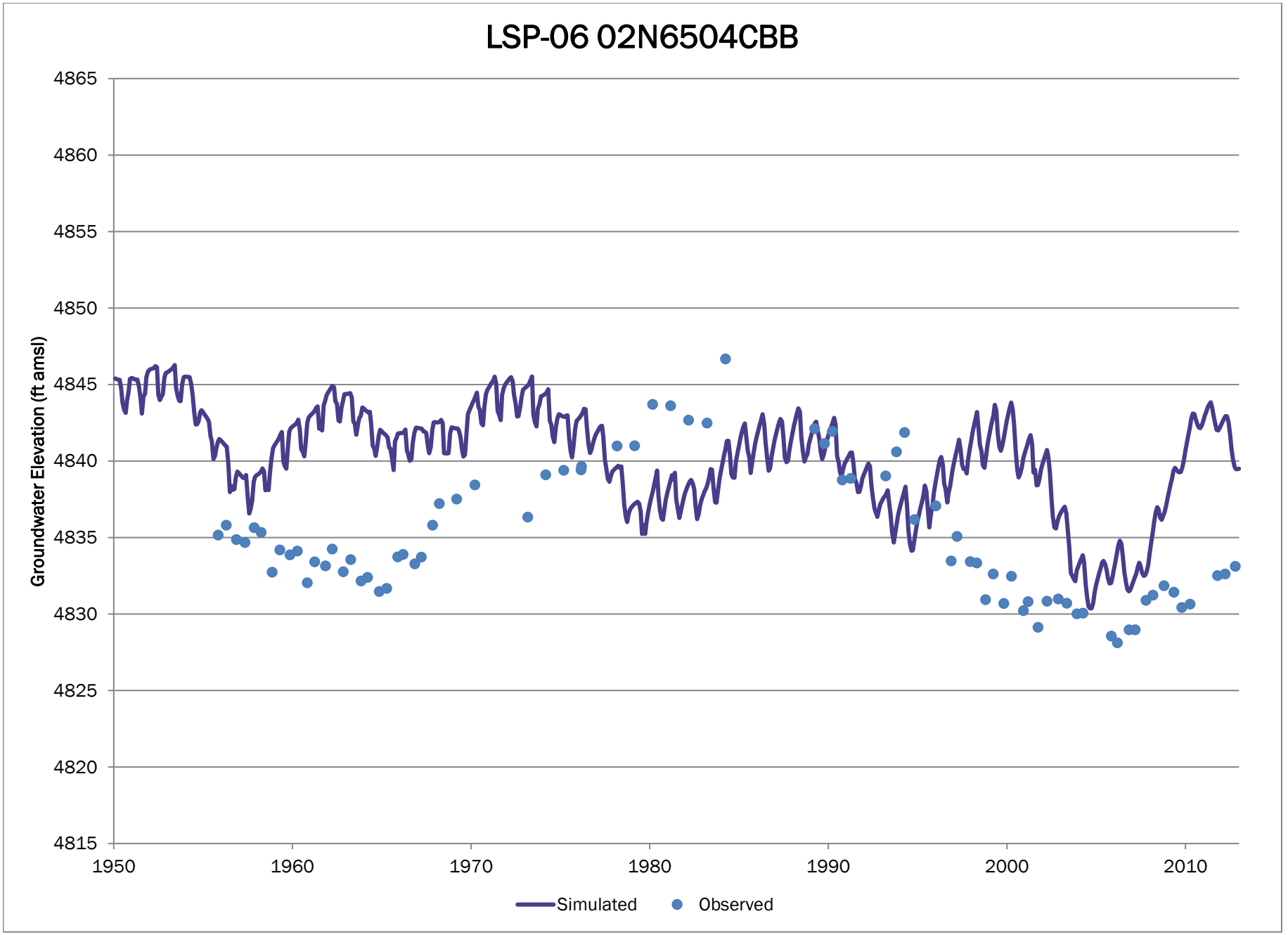
Note elevation axis range of 100 feet.

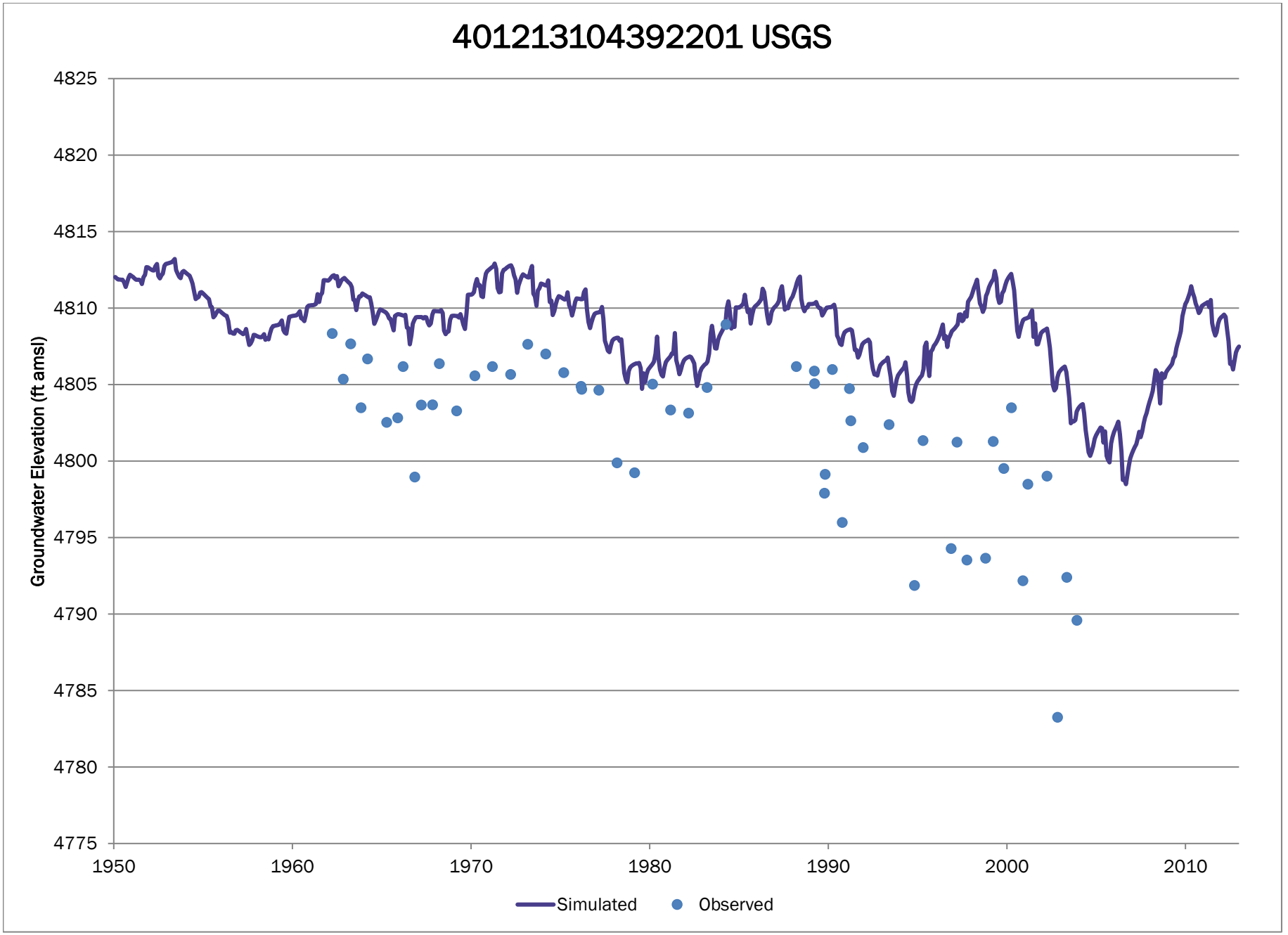


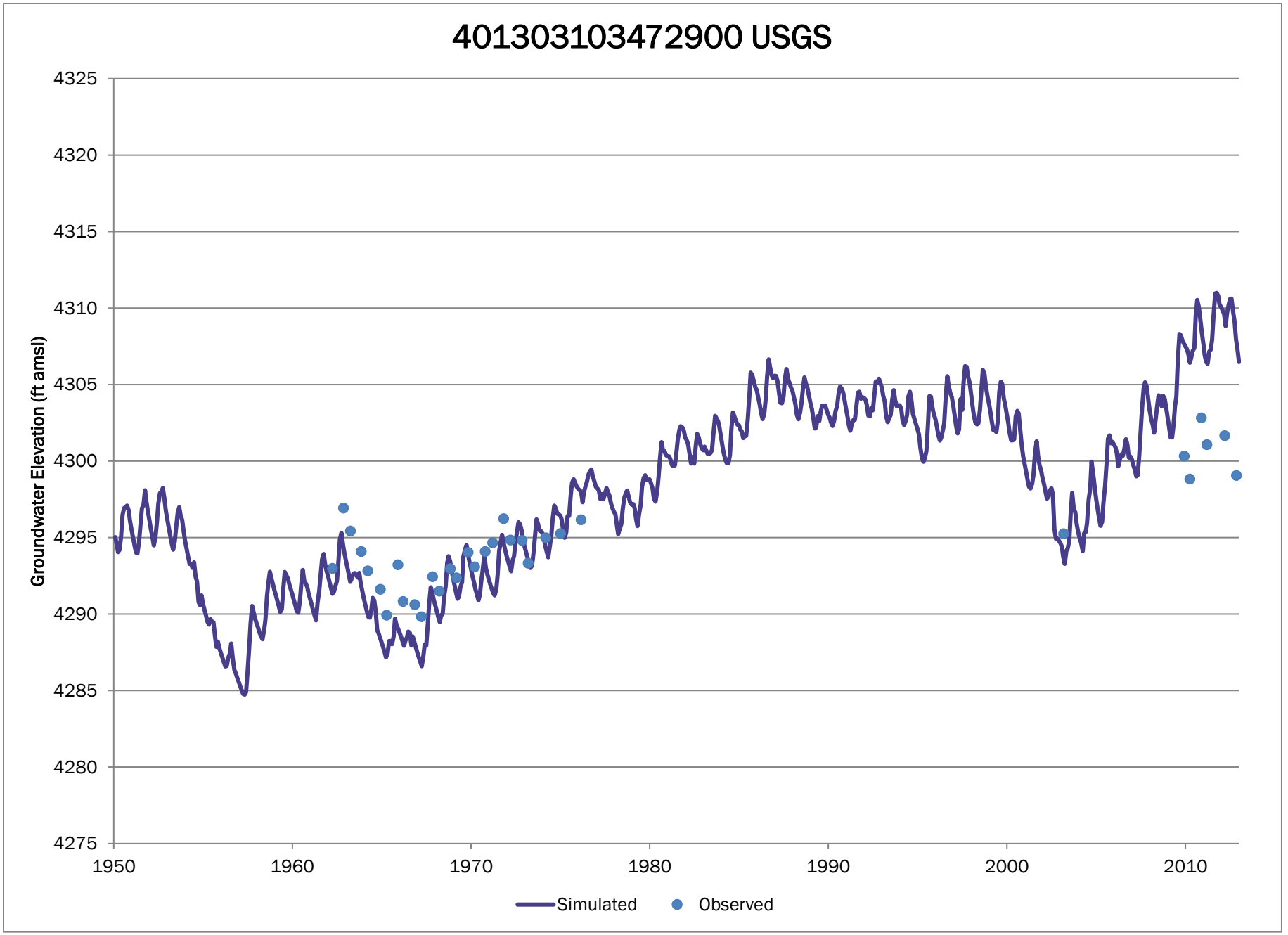

400853104483401 USGS
Groundwater Elevation (ft amsl)
4880
4875
4870
4865
4860
4855
4850
4845
4840
4835
4830
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

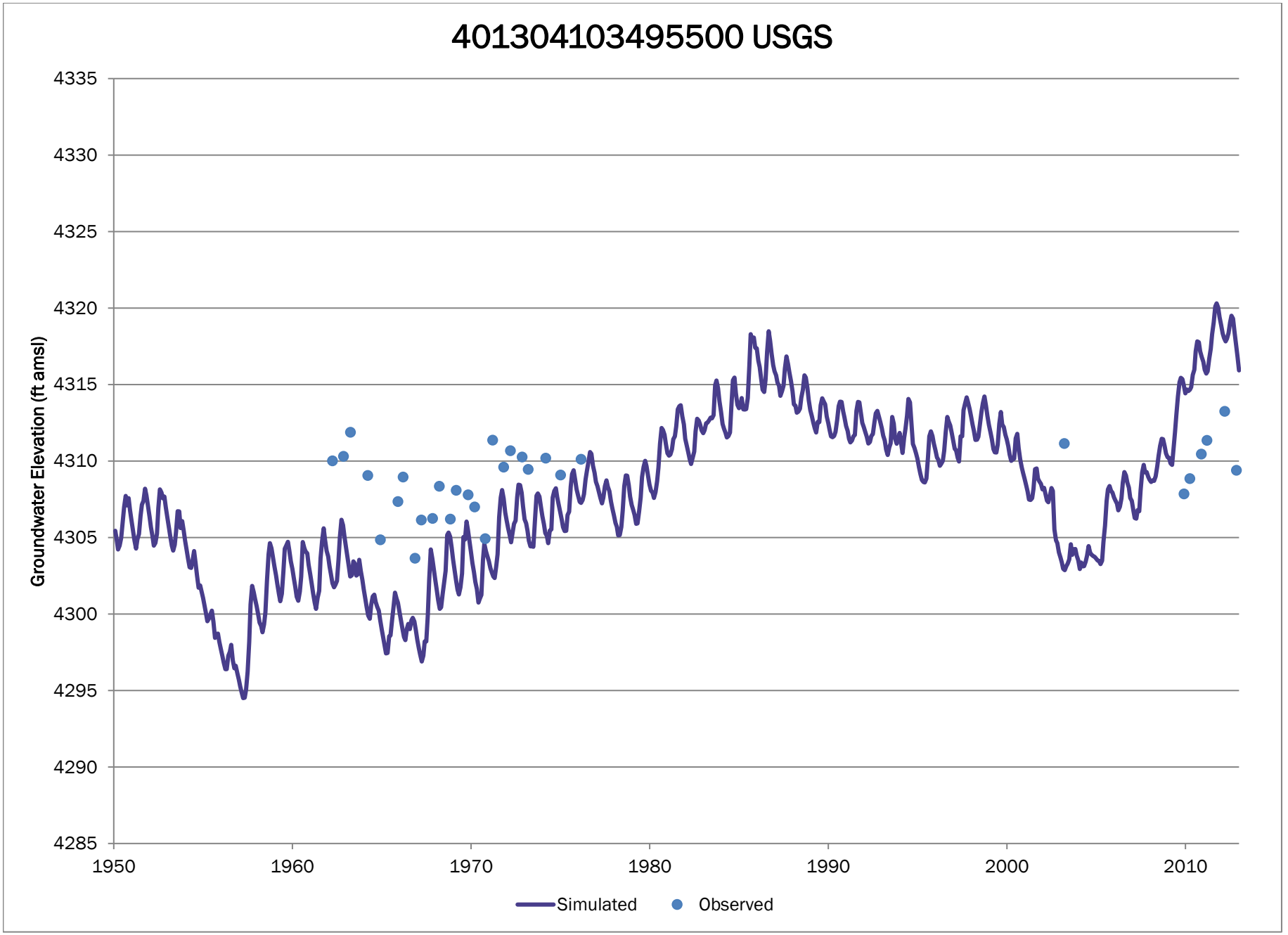
Note elevation axis range of 100 feet.

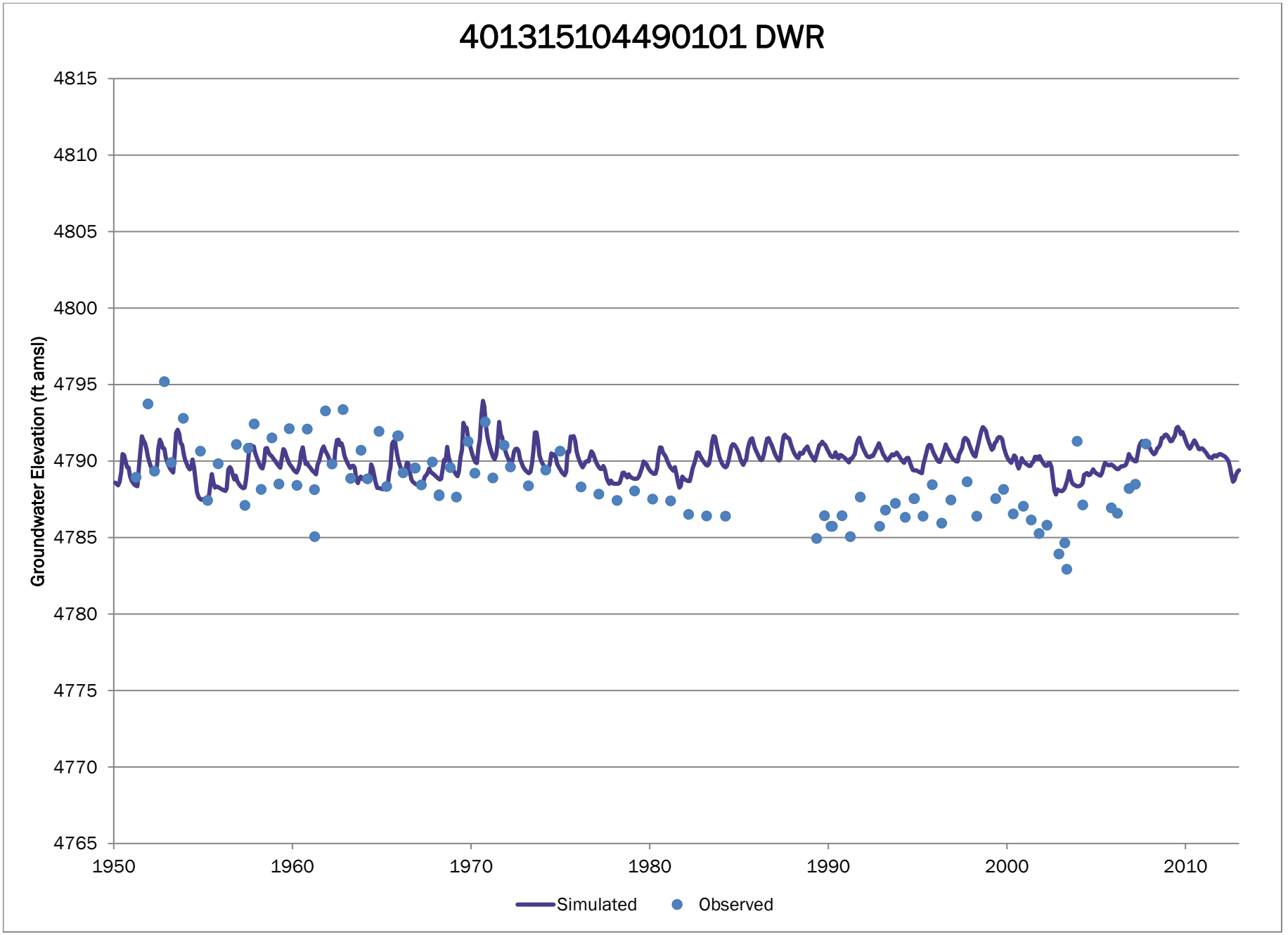


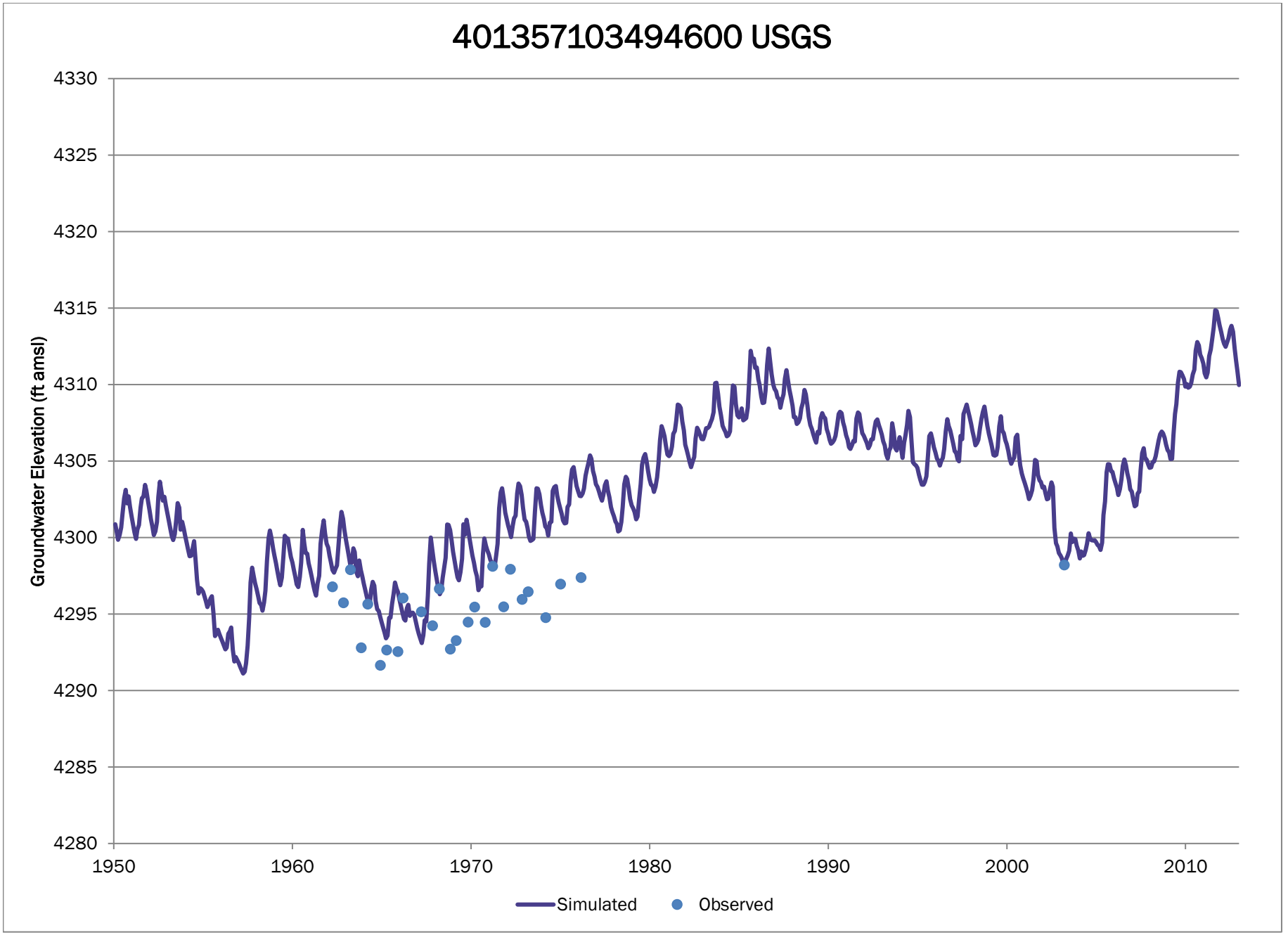

LSP-06 02N6504CBB
Groundwater Elevation (ft amsl)
4865
4860
4855
4850
4845
4840
4835
4830
4825
4820
4815
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

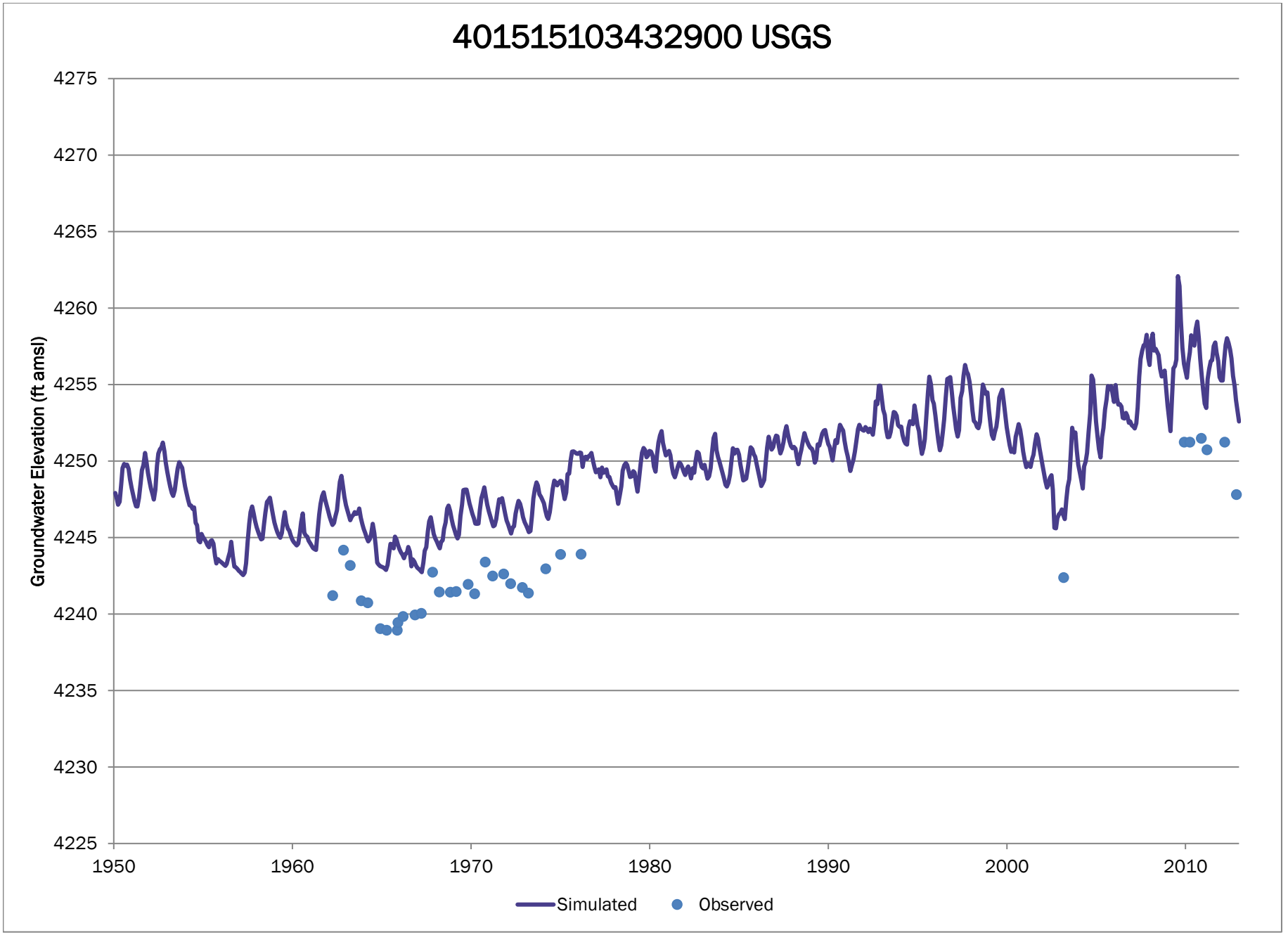

401213104392201 USGS
Groundwater Elevation (ft amsl)
4825
4820
4815
4810
4805
4800
4795
4790
4785
4780
4775
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

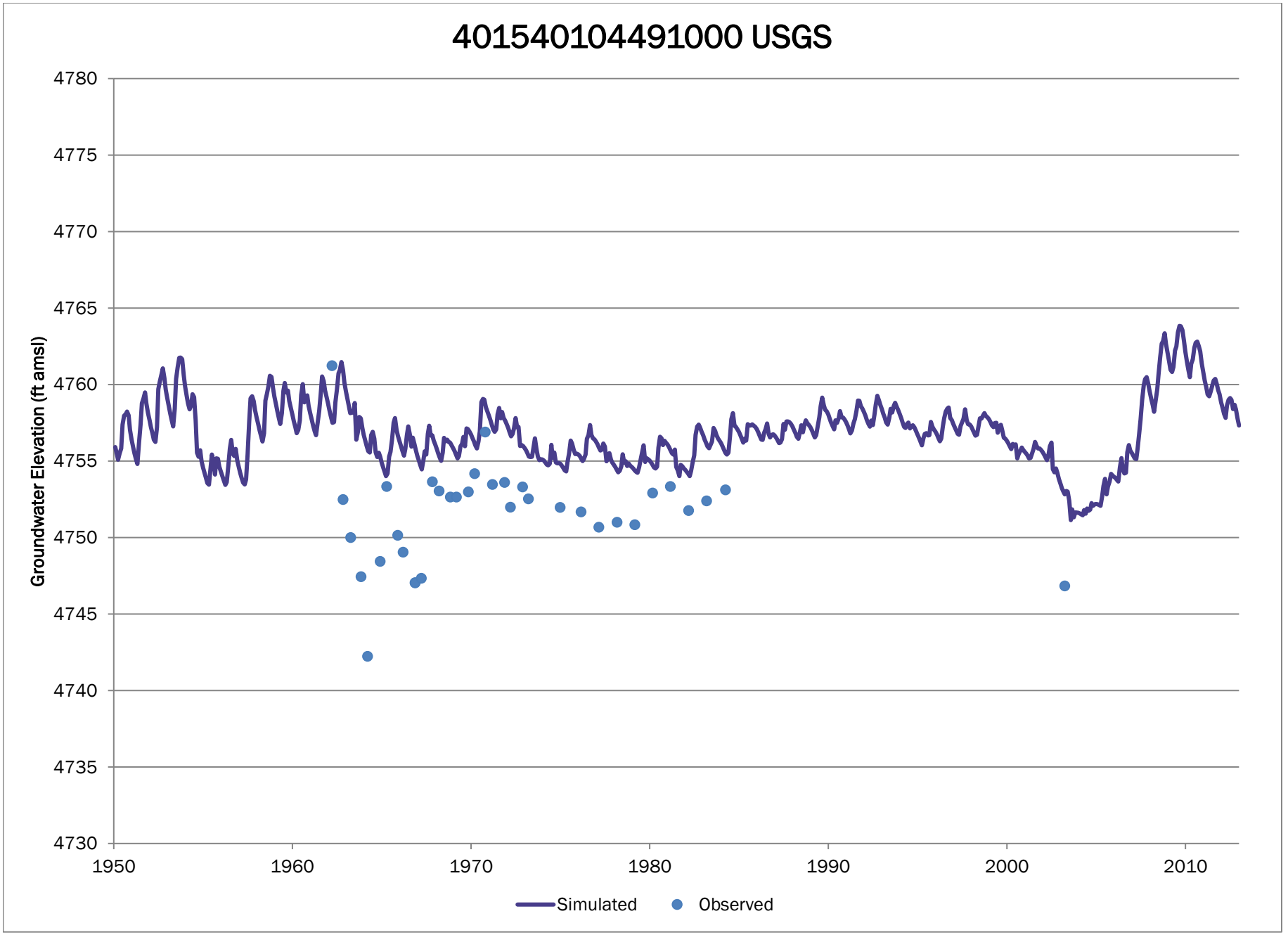

401303103472900 USGS
Groundwater Elevation (ft amsl)
4325
4320
4315
4310
4305
4300
4295
4290
4285
4280
4275
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

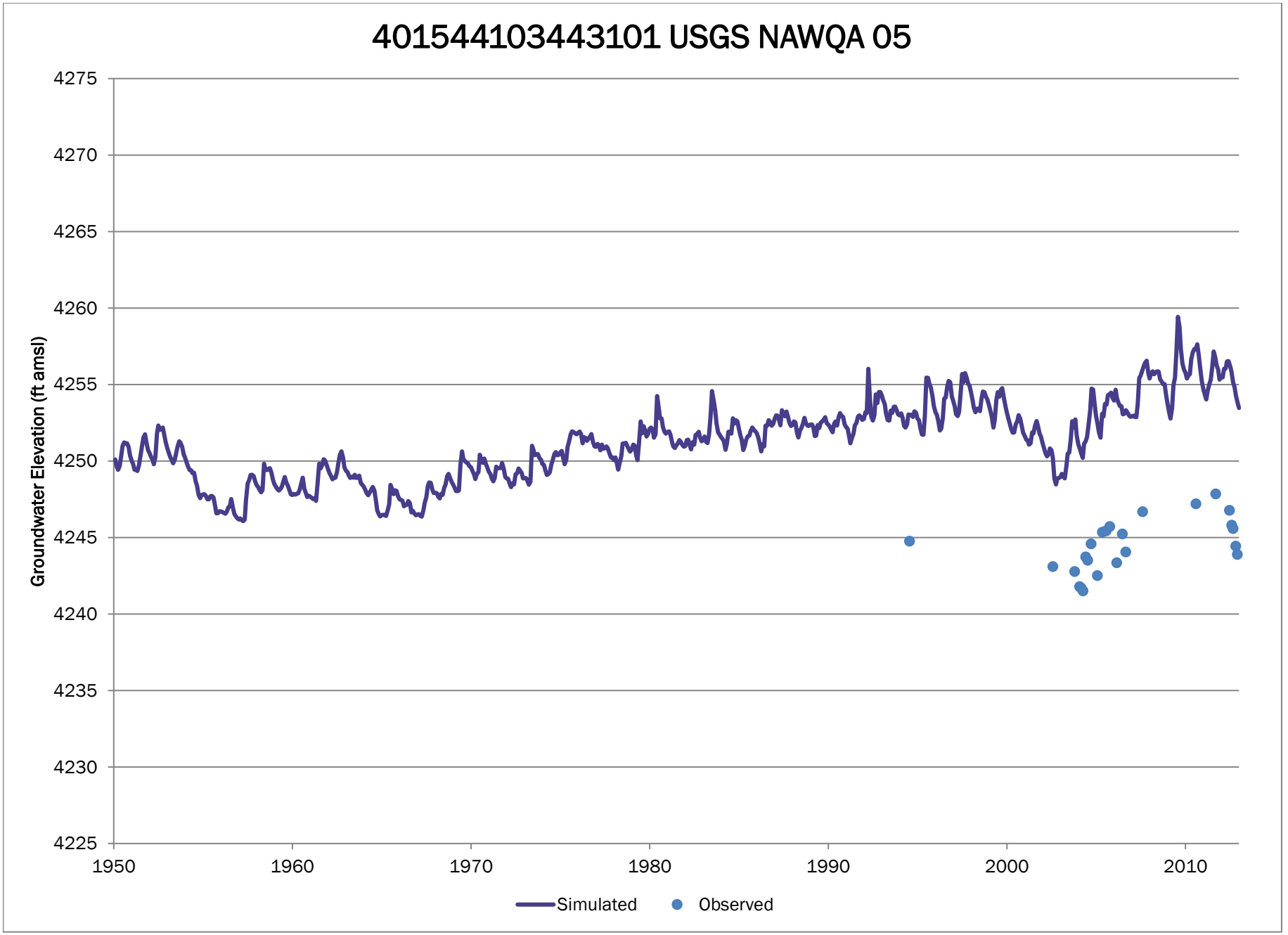

401304103495500 USGS
Groundwater Elevation (ft amsl)
4335
4330
4325
4320
4315
4310
4305
4300
4295
4290
4285
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

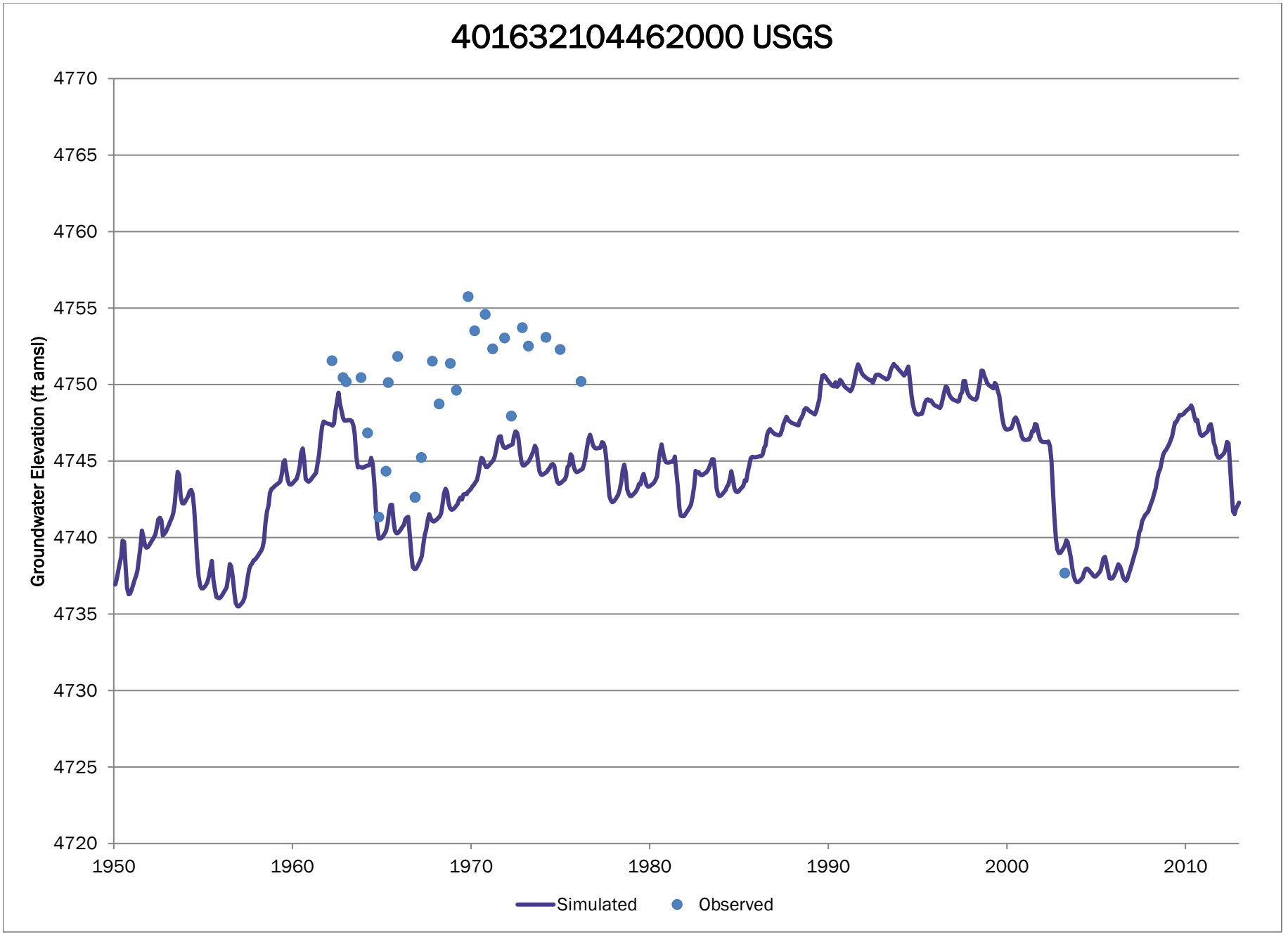

401315104490101 DWR
Groundwater Elevation (ft amsl)
4815
4810
4805
4800
4795
4790
4785
4780
4775
4770
4765
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

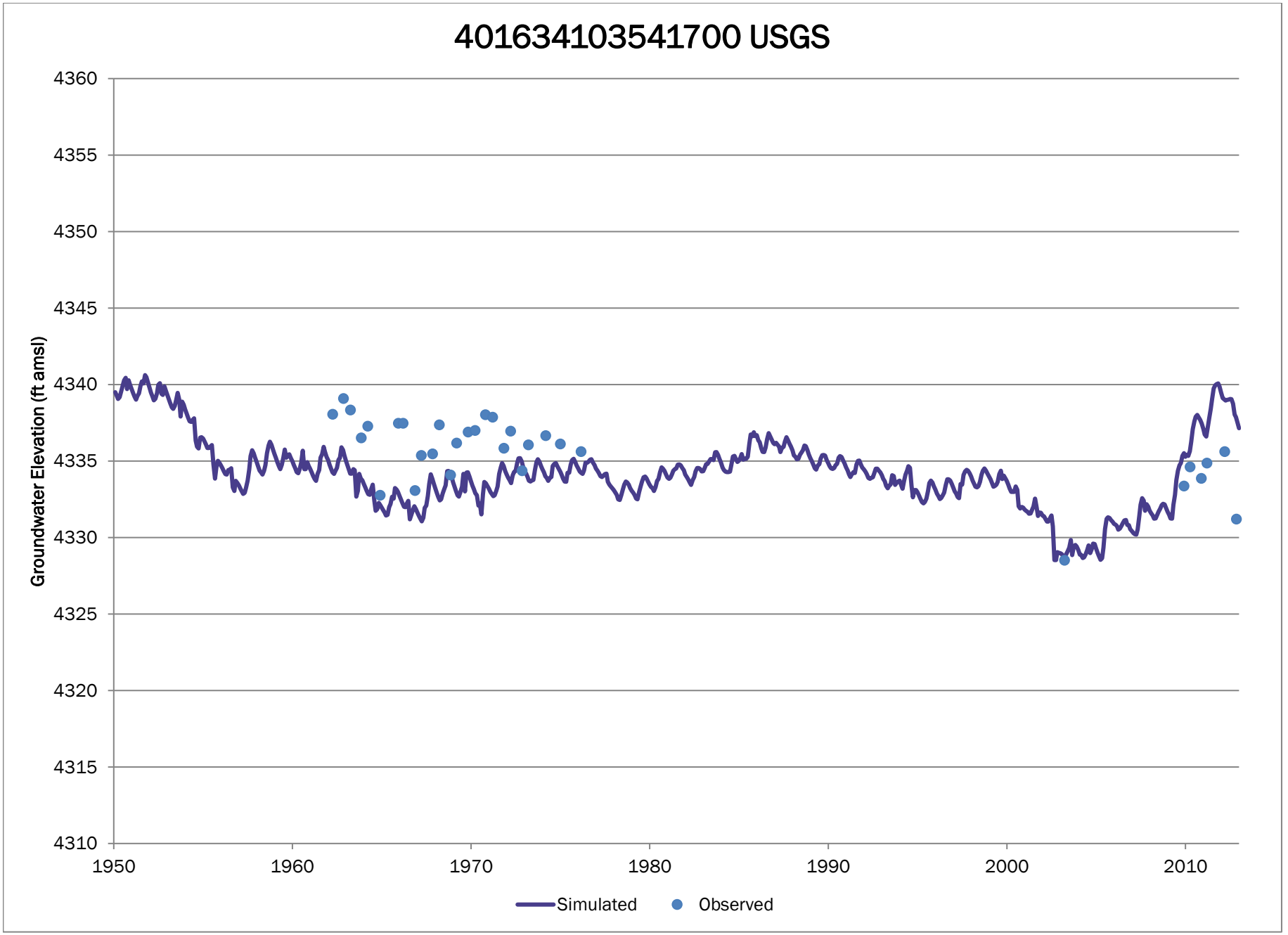

401357103494600 USGS
Groundwater Elevation (ft amsl)
4330
4325
4320
4315
4310
4305
4300
4295
4290
4285
4280
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

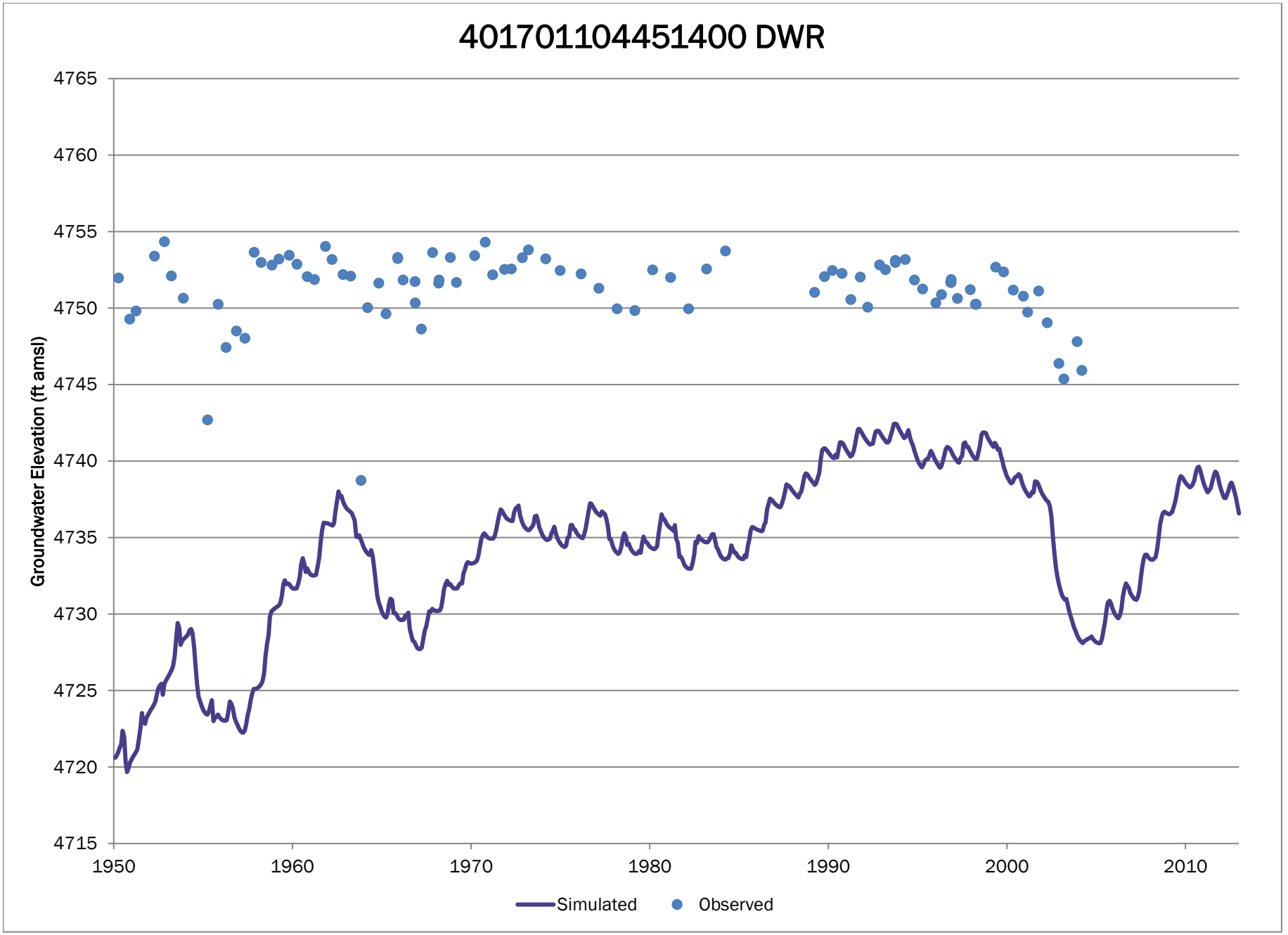

401515103432900 USGS
Groundwater Elevation (ft amsl)
4275
4270
4265
4260
4255
4250
4245
4240
4235
4230
4225
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

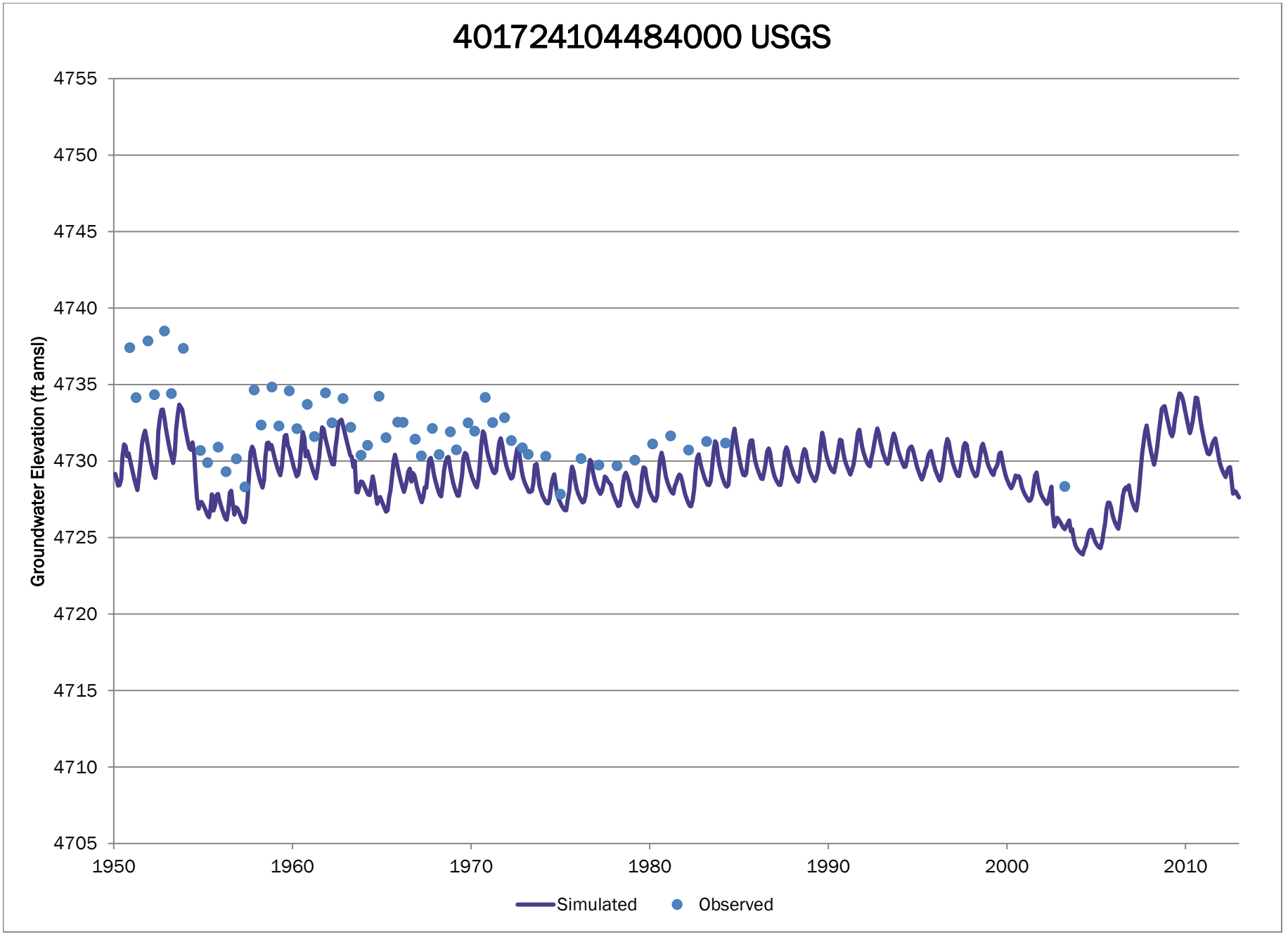

401540104491000 USGS
Groundwater Elevation (ft amsl)
4780
4775
4770
4765
4760
4755
4750
4745
4740
4735
4730
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

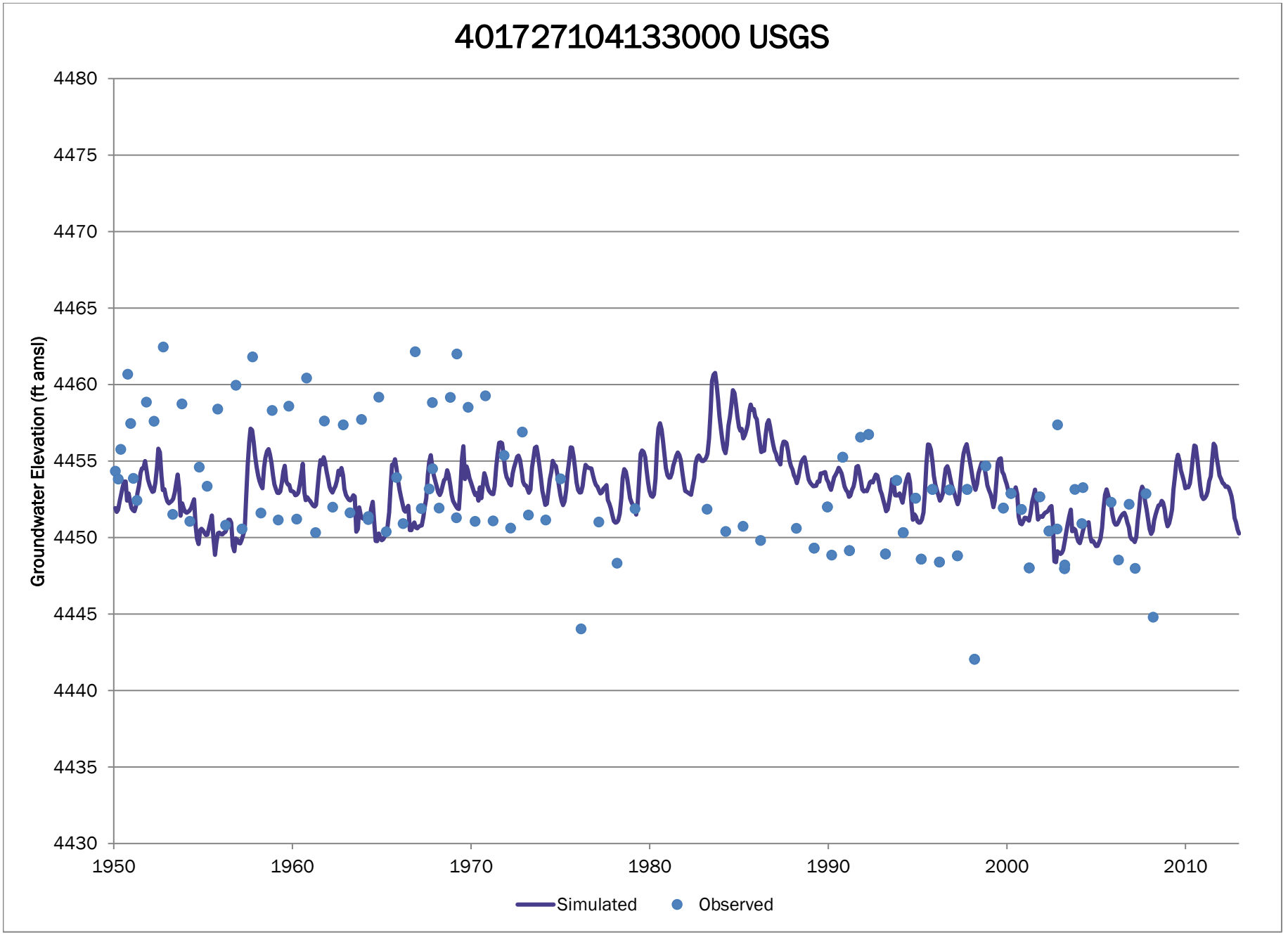

40154410344310 1 USGS NAWQA 05
Groundwater Elevation (ft amsl)
4275
4270
4265
4260
4255
4250
4245
4240
4235
4230
4225
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

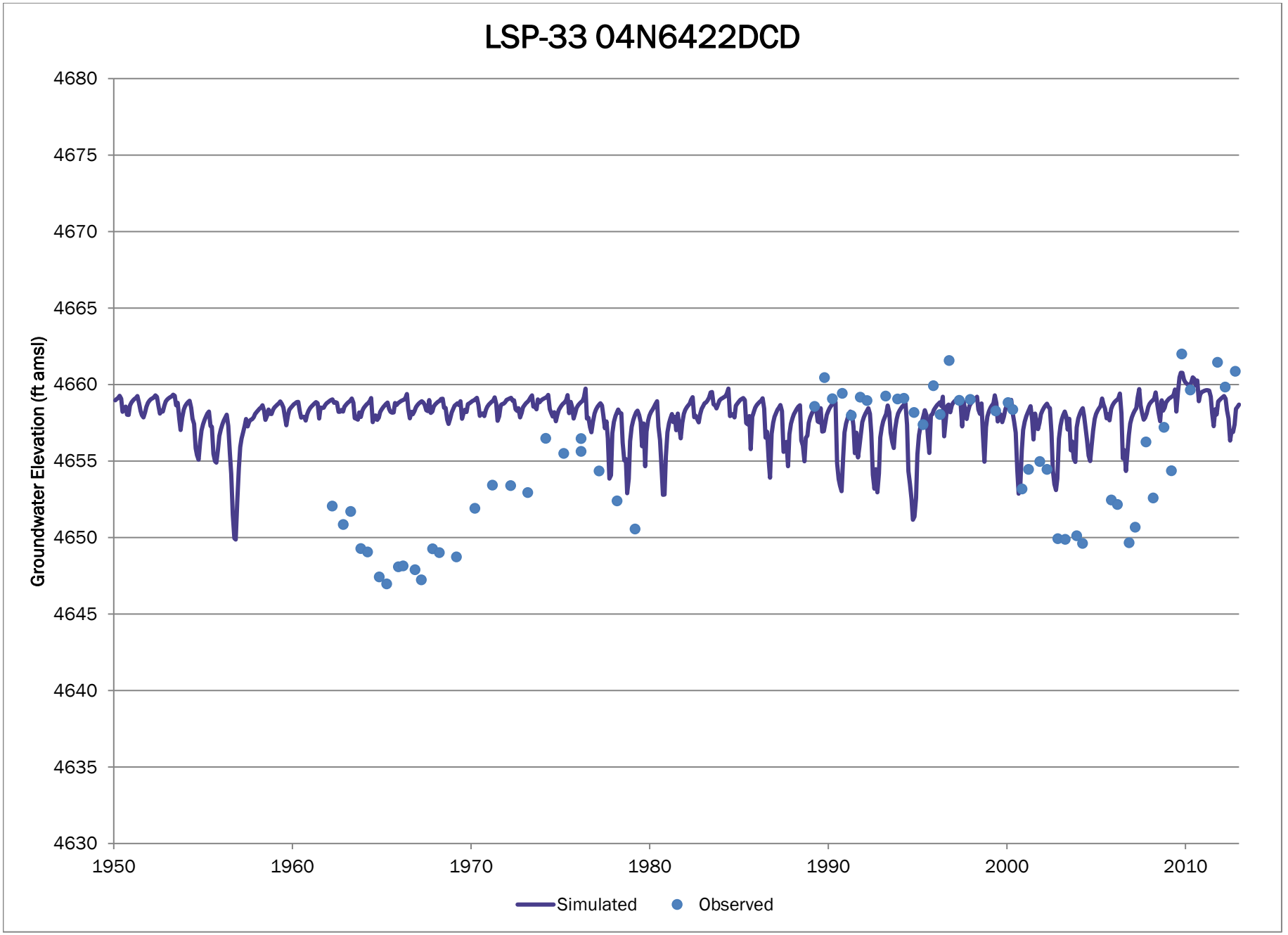

401632104462000 USGS
Groundwater Elevation (ft amsl)
4770
4765
4760
4755
4750
4745
4740
4735
4730
4725
4720
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

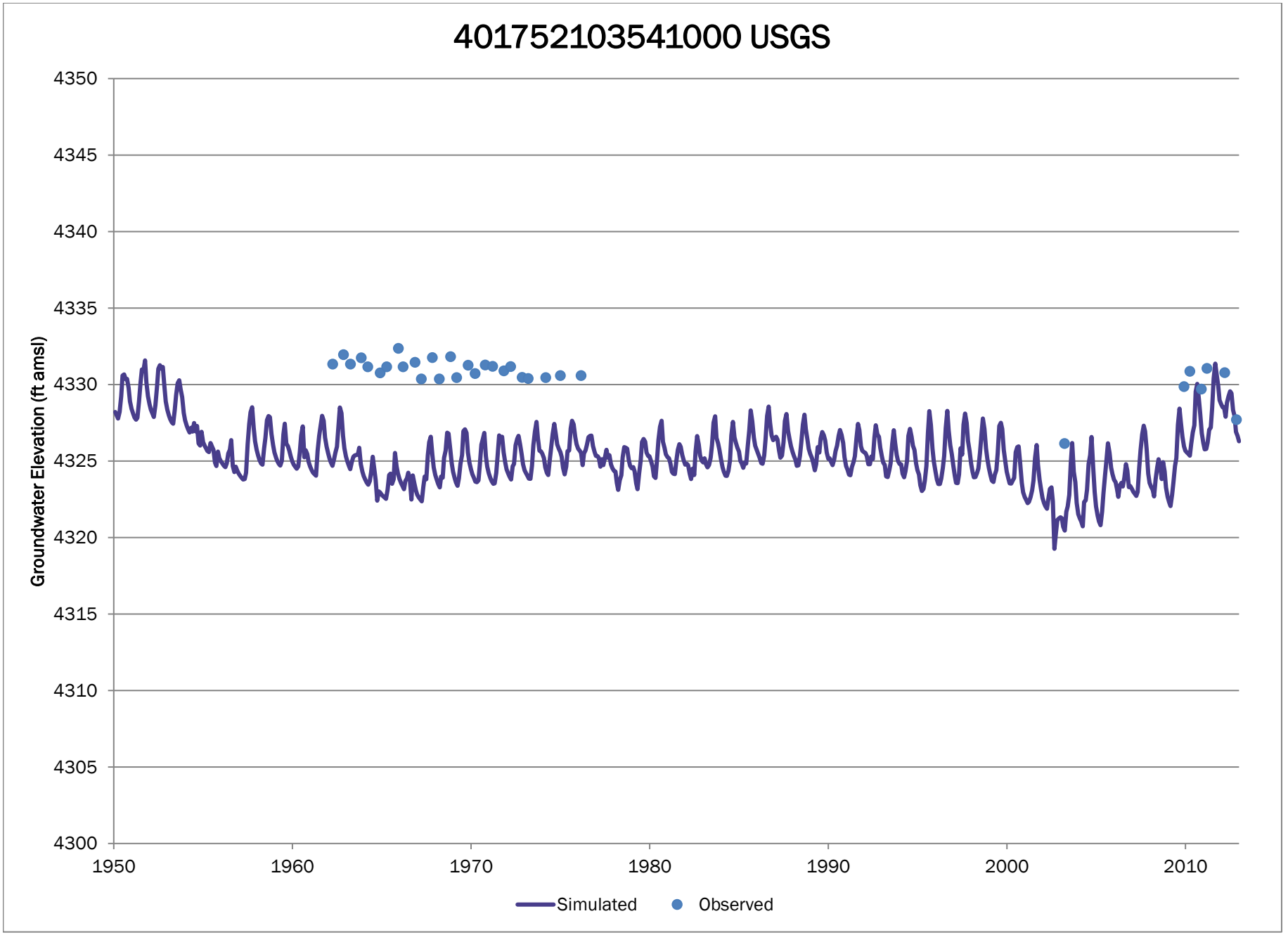

401634103541700 USGS
Groundwater Elevation (ft amsl)
4360
4355
4350
4345
4340
4335
4330
4325
4320
4315
4310
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

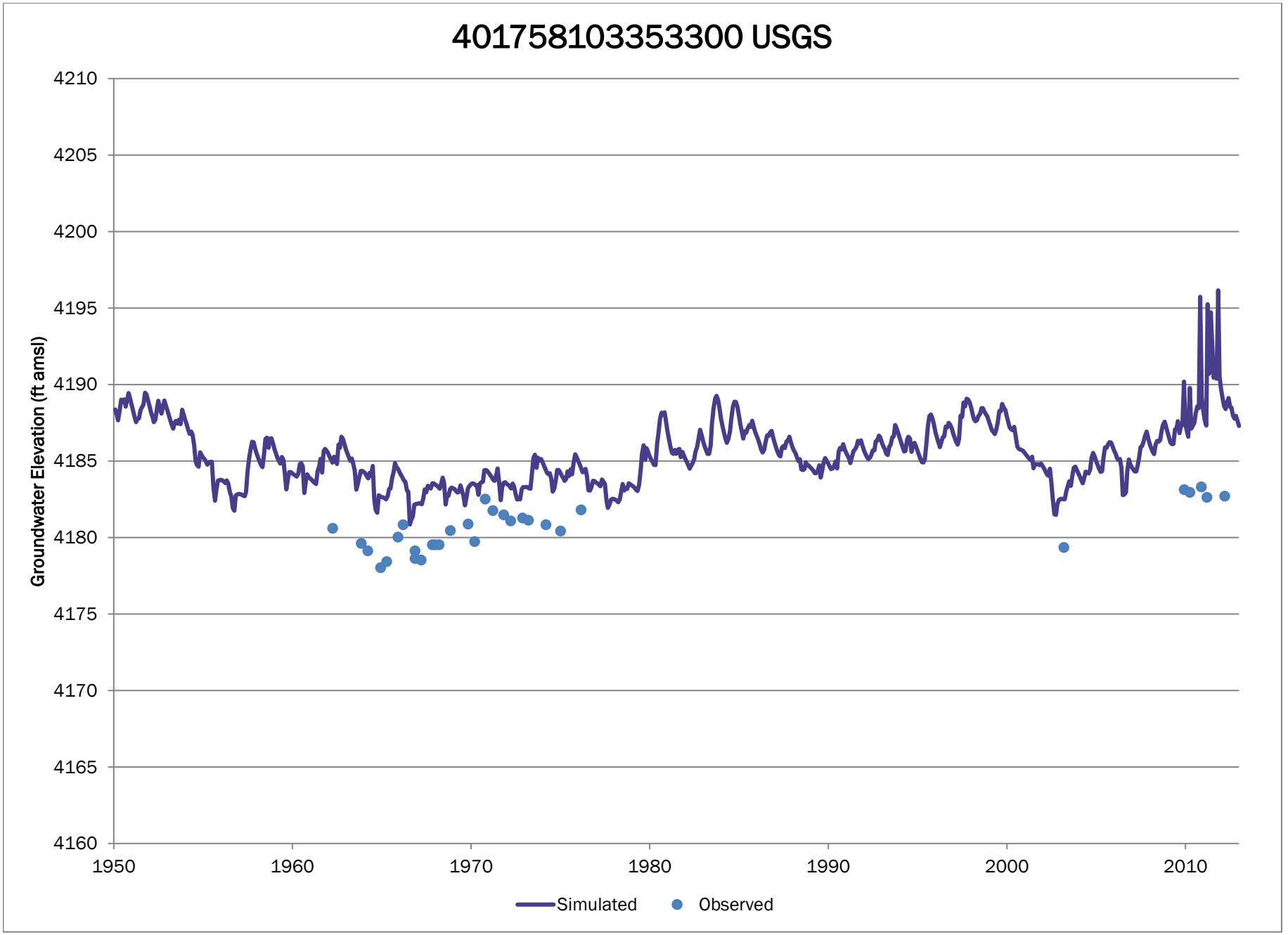

401701104451400 DWR
Groundwater Elevation (ft amsl)
4765
4760
4755
4750
4745
4740
4735
4730
4725
4720
4715
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

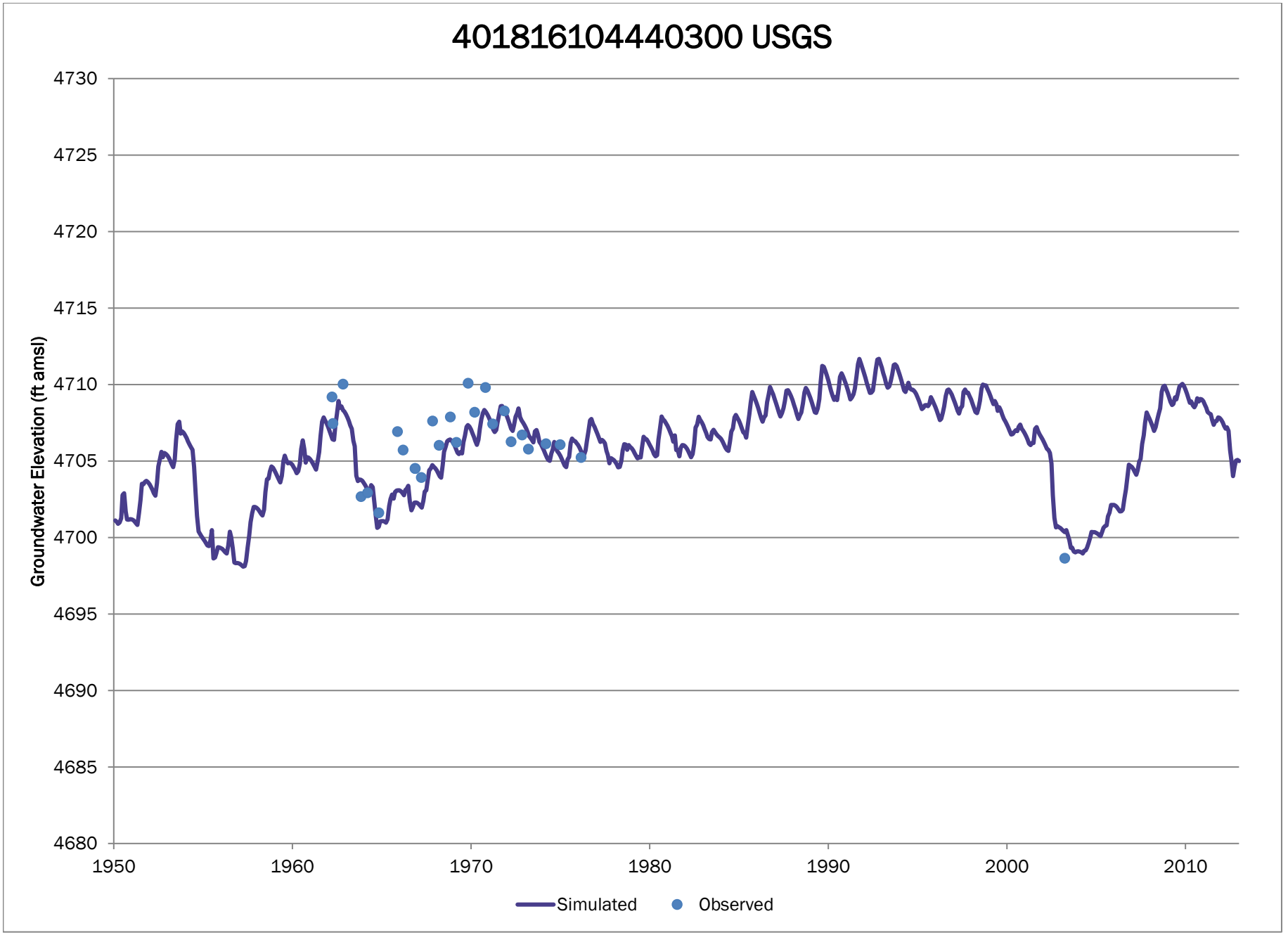

401724104484000 USGS
Groundwater Elevation (ft amsl)
4755
4750
4745
4740
4735
4730
4725
4720
4715
4710
4705
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

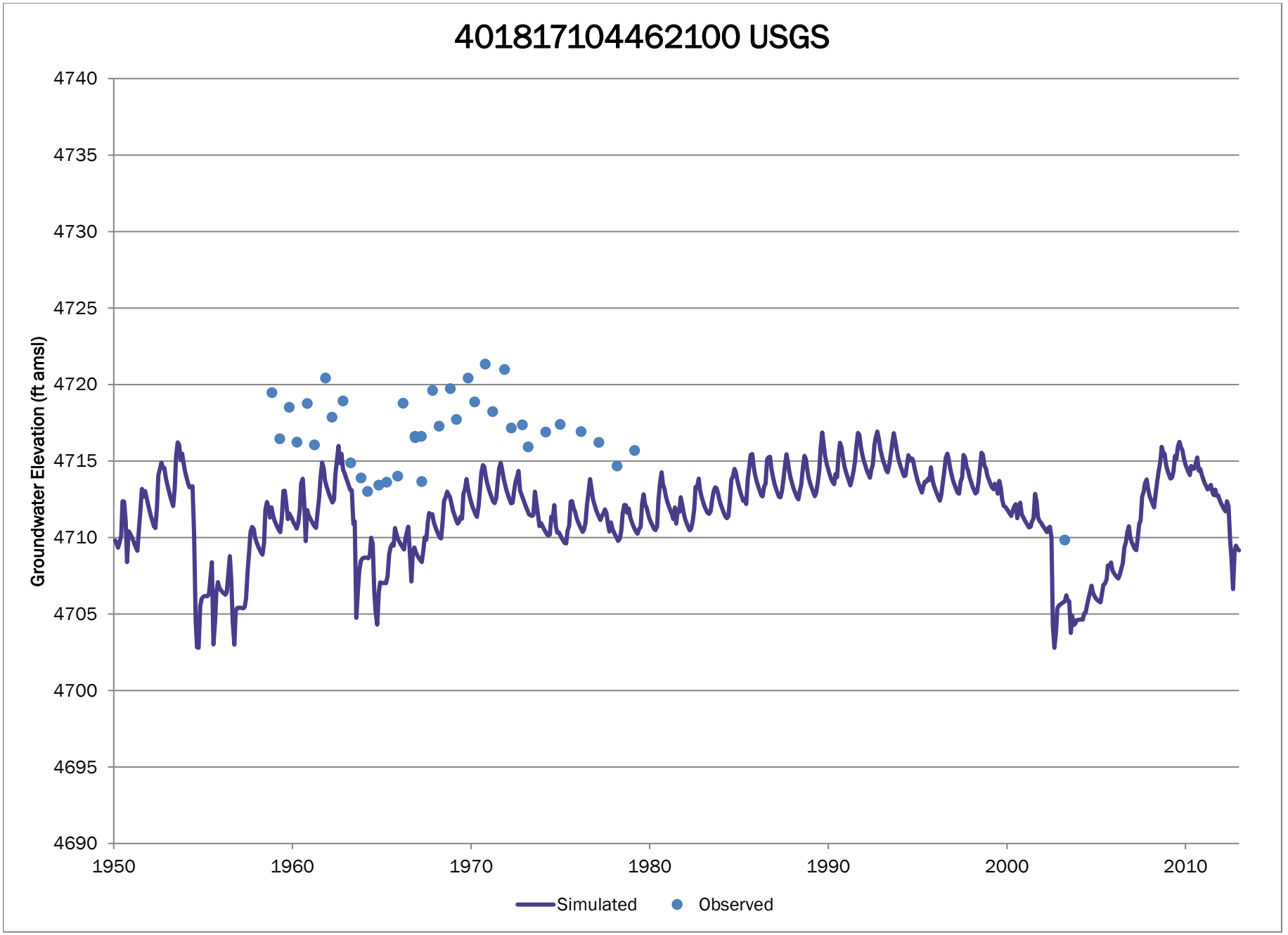

401727104133000 USGS
Groundwater Elevation (ft amsl)
4480
4475
4470
4465
4460
4455
4450
4445
4440
4435
4430
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

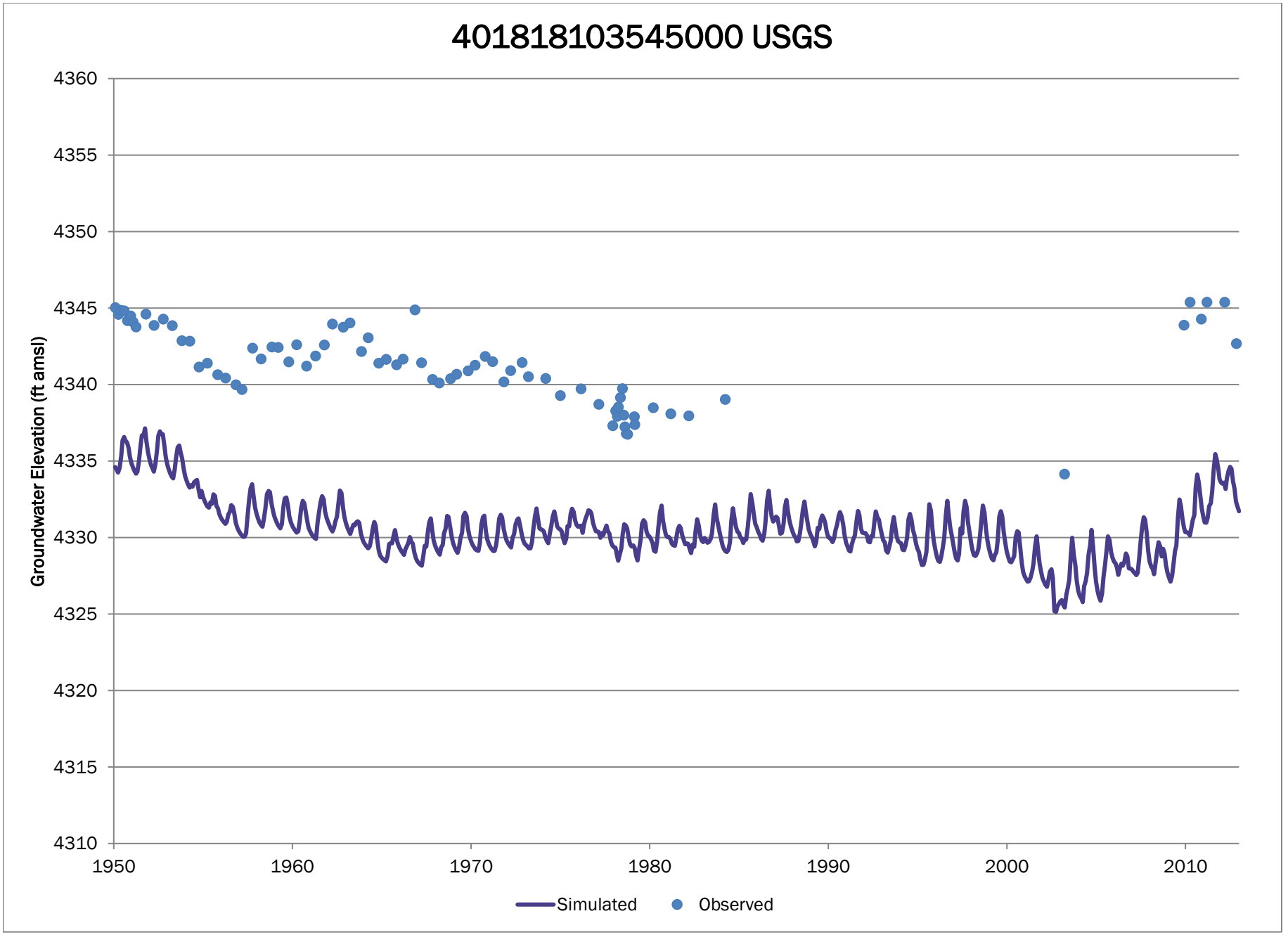

LSP-33 04N6422DCD
Groundwater Elevation (ft amsl)
4680
4675
4670
4665
4660
4655
4650
4645
4640
4635
4630
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

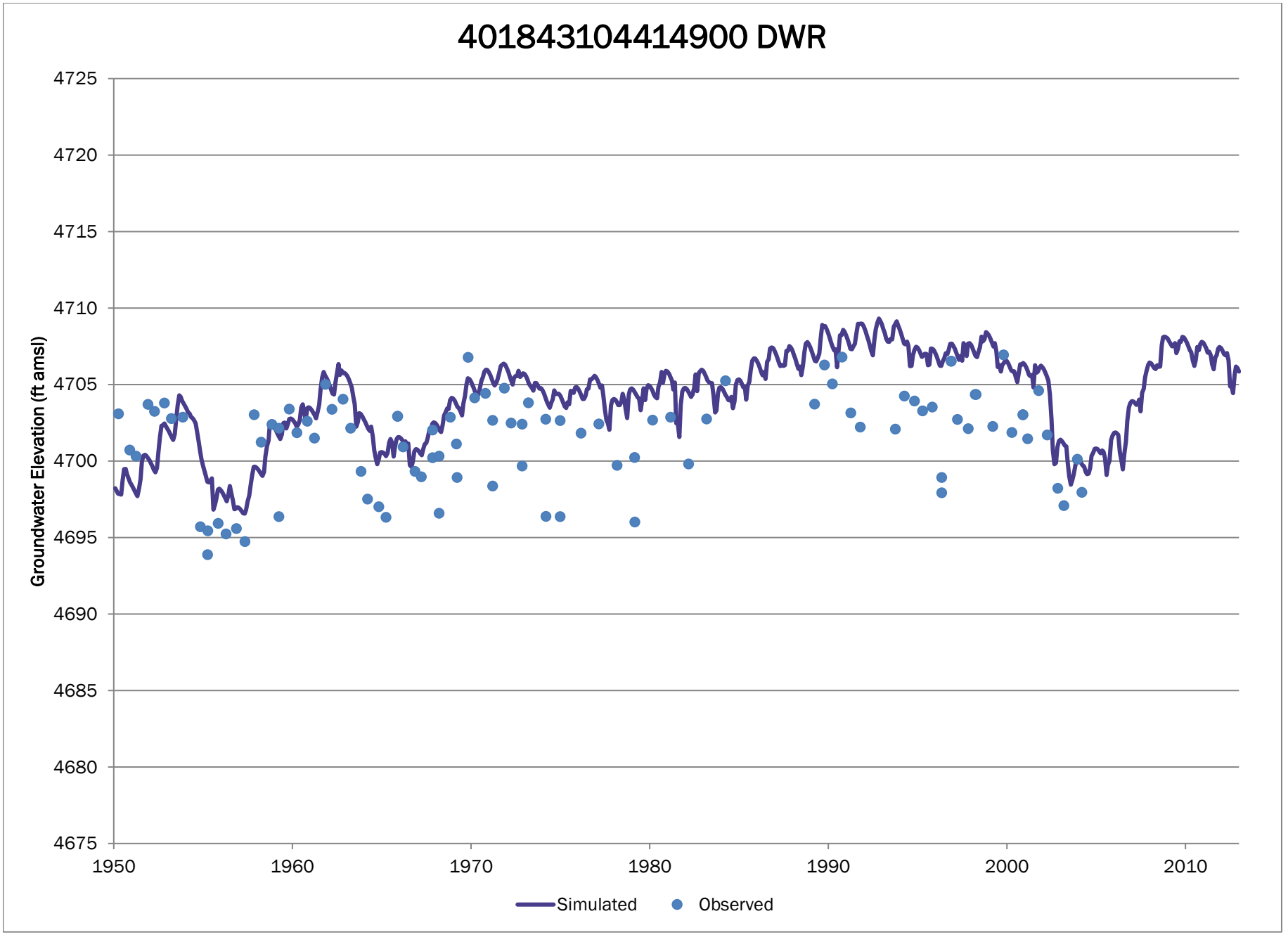

401752103541000 USGS
Groundwater Elevation (ft amsl)
4350
4345
4340
4335
4330
4325
4320
4315
4310
4305
4300
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

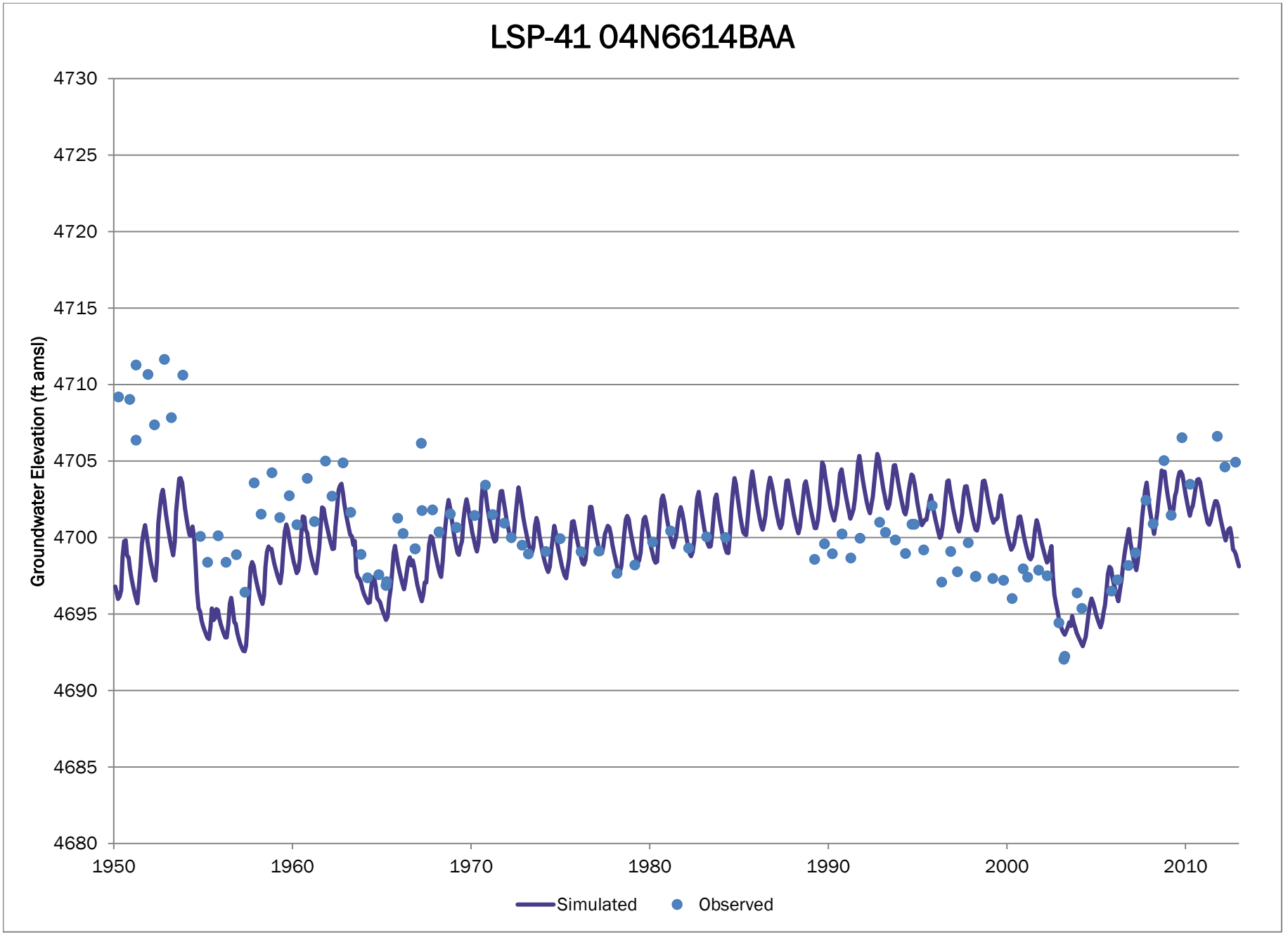

401758103353300 USGS
Groundwater Elevation (ft amsl)
4210
4205
4200
4195
4190
4185
4180
4175
4170
4165
4160
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

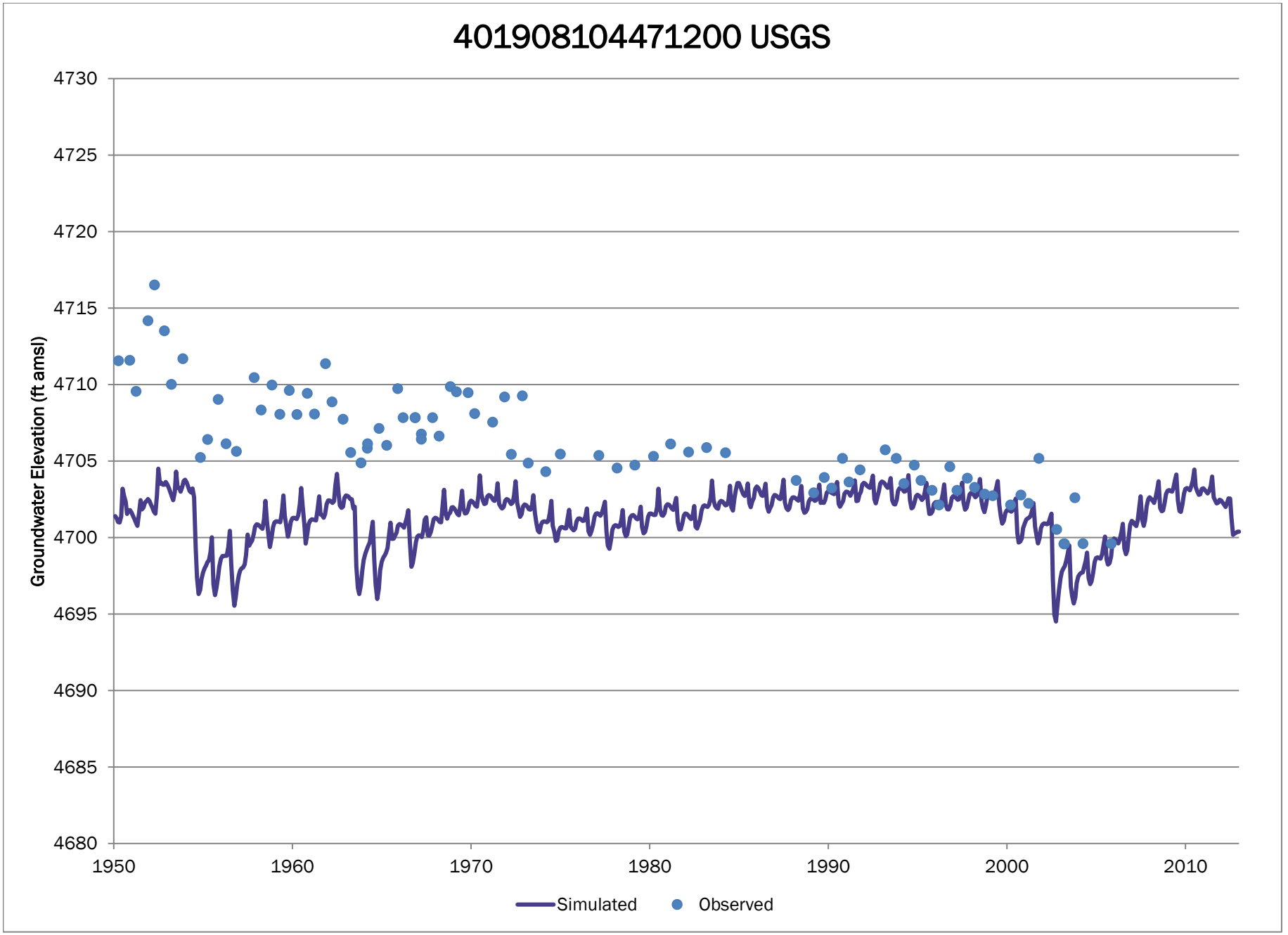

401816104440300 USGS
Groundwater Elevation (ft amsl)
4730
4725
4720
4715
4710
4705
4700
4695
4690
4685
4680
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

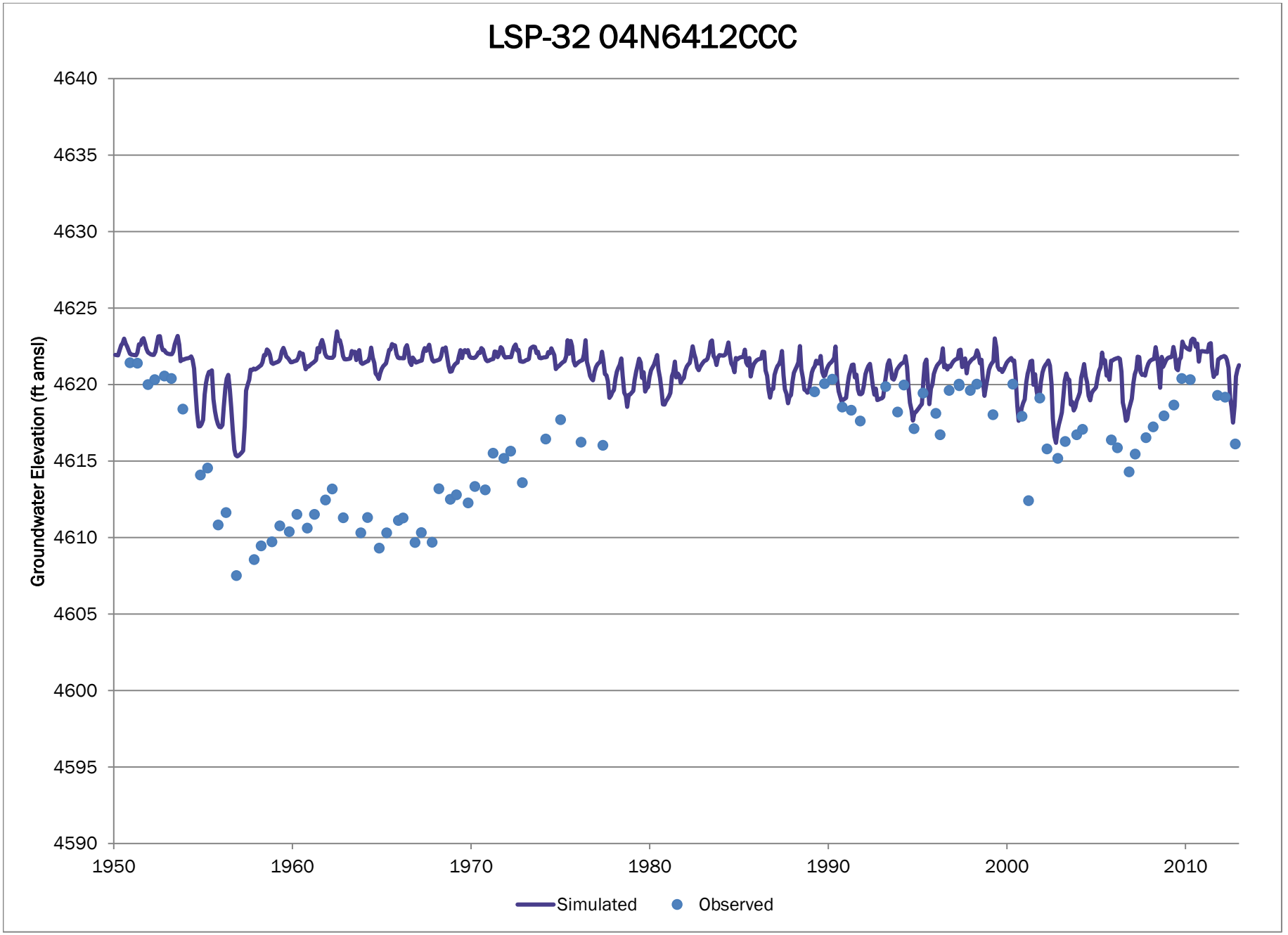

401817104462100 USGS
Groundwater Elevation (ft amsl)
4740
4735
4730
4725
4720
4715
4710
4705
4700
4695
4690
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

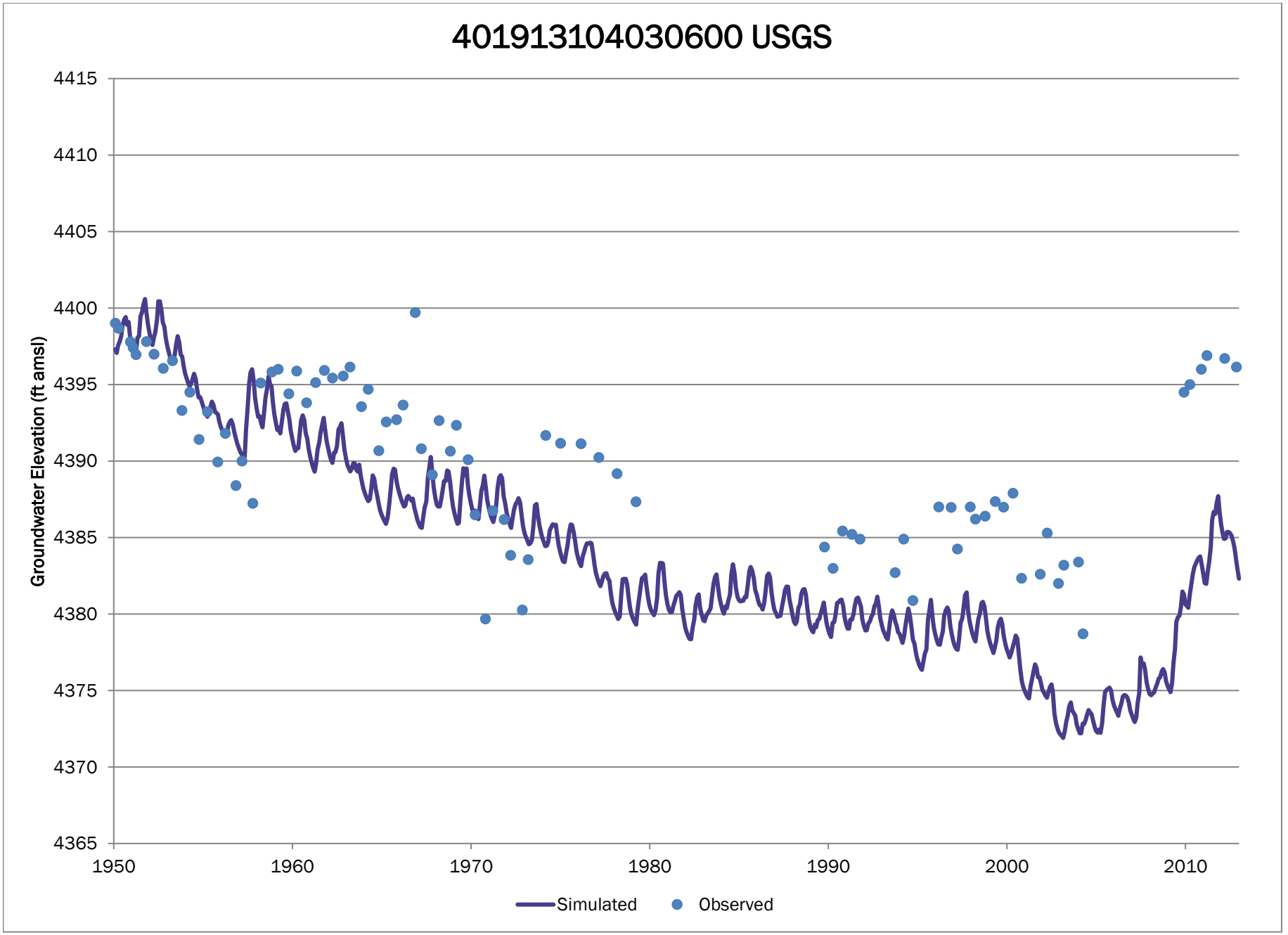

401818103545000 USGS
Groundwater Elevation (ft amsl)
4360
4355
4350
4345
4340
4335
4330
4325
4320
4315
4310
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

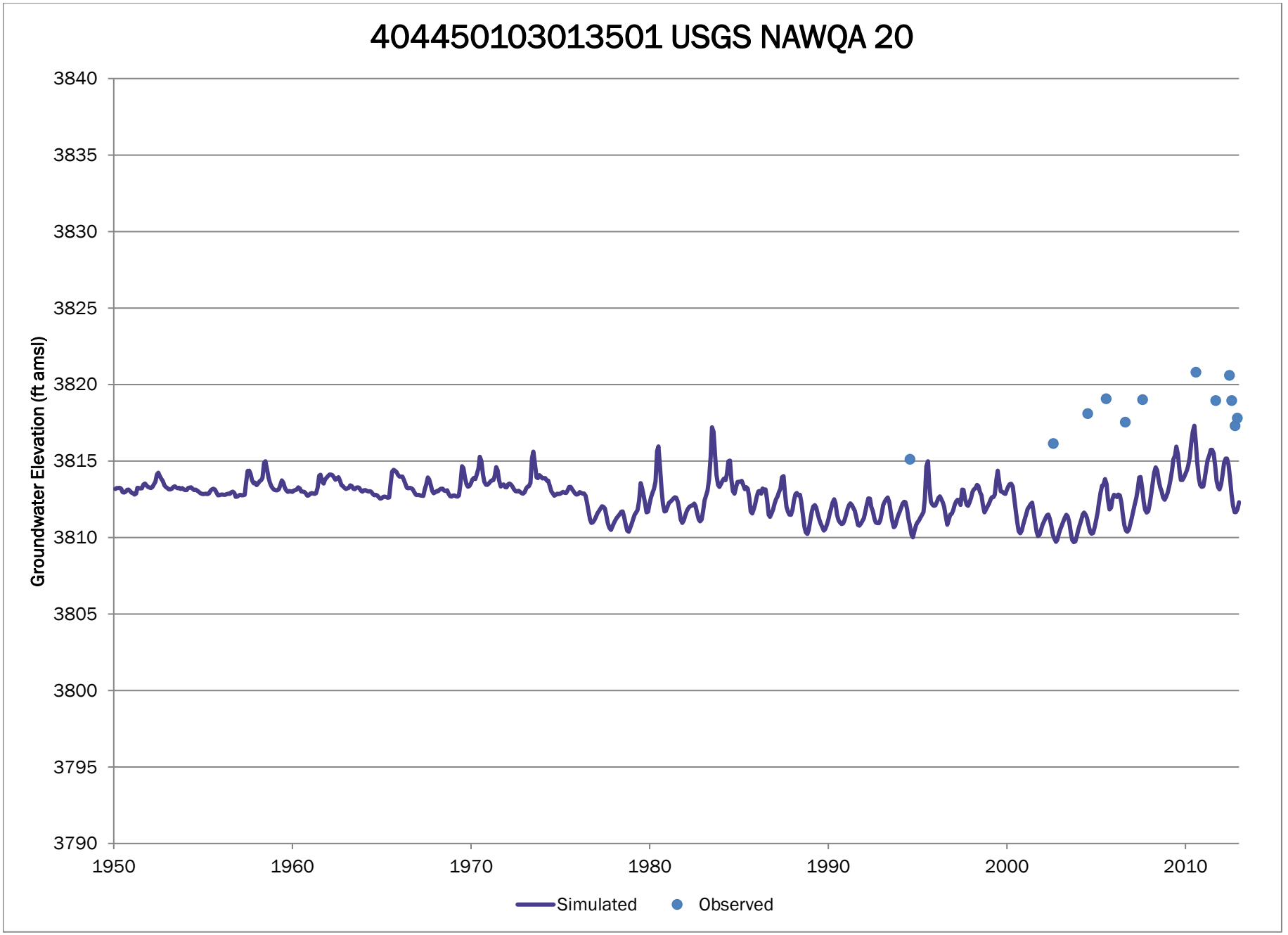

401843104414900 DWR
Groundwater Elevation (ft amsl)
4725
4720
4715
4710
4705
4700
4695
4690
4685
4680
4675
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

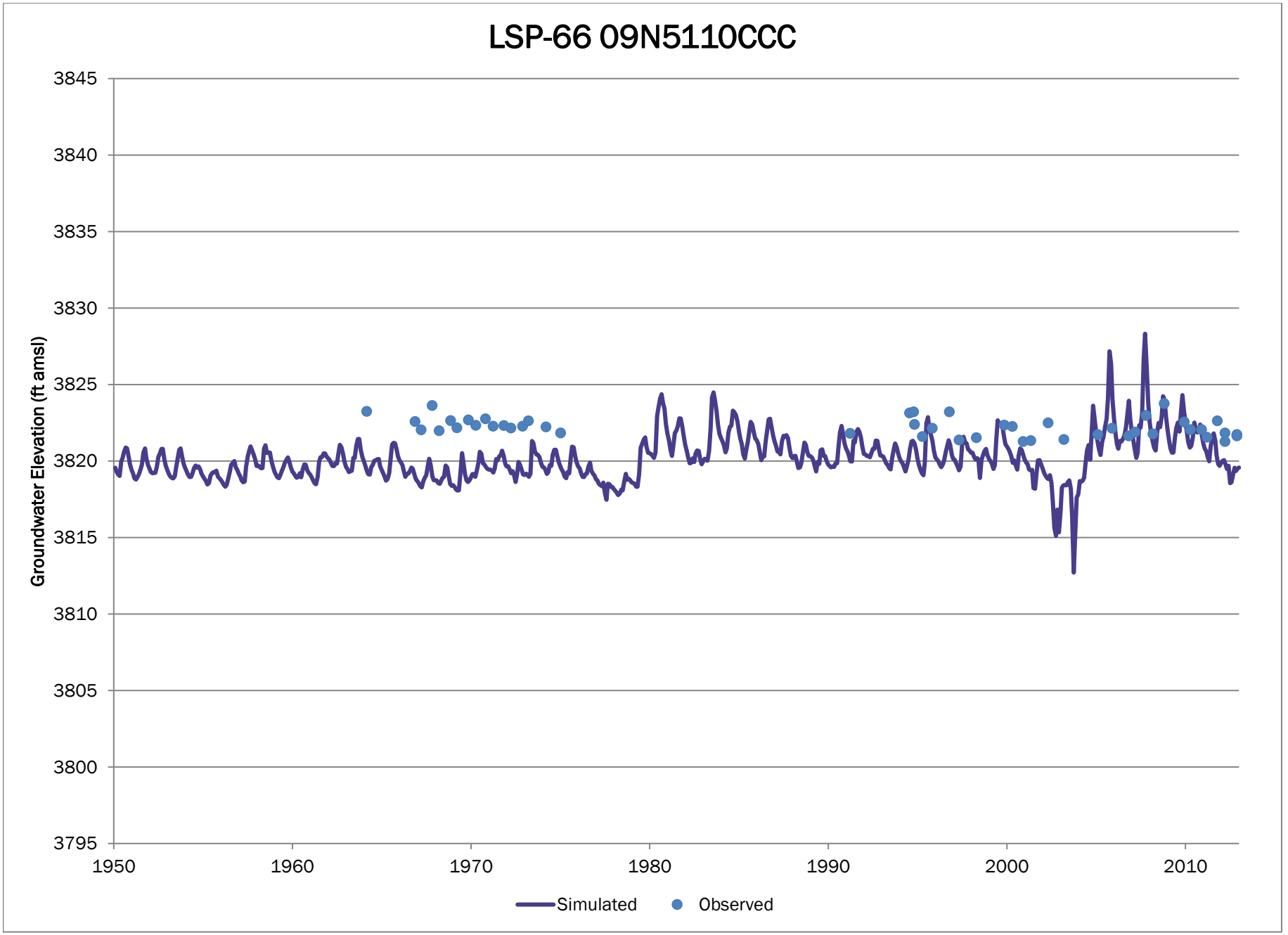

LSP-41 04N6614BAA
Groundwater Elevation (ft amsl)
4730
4725
4720
4715
4710
4705
4700
4695
4690
4685
4680
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

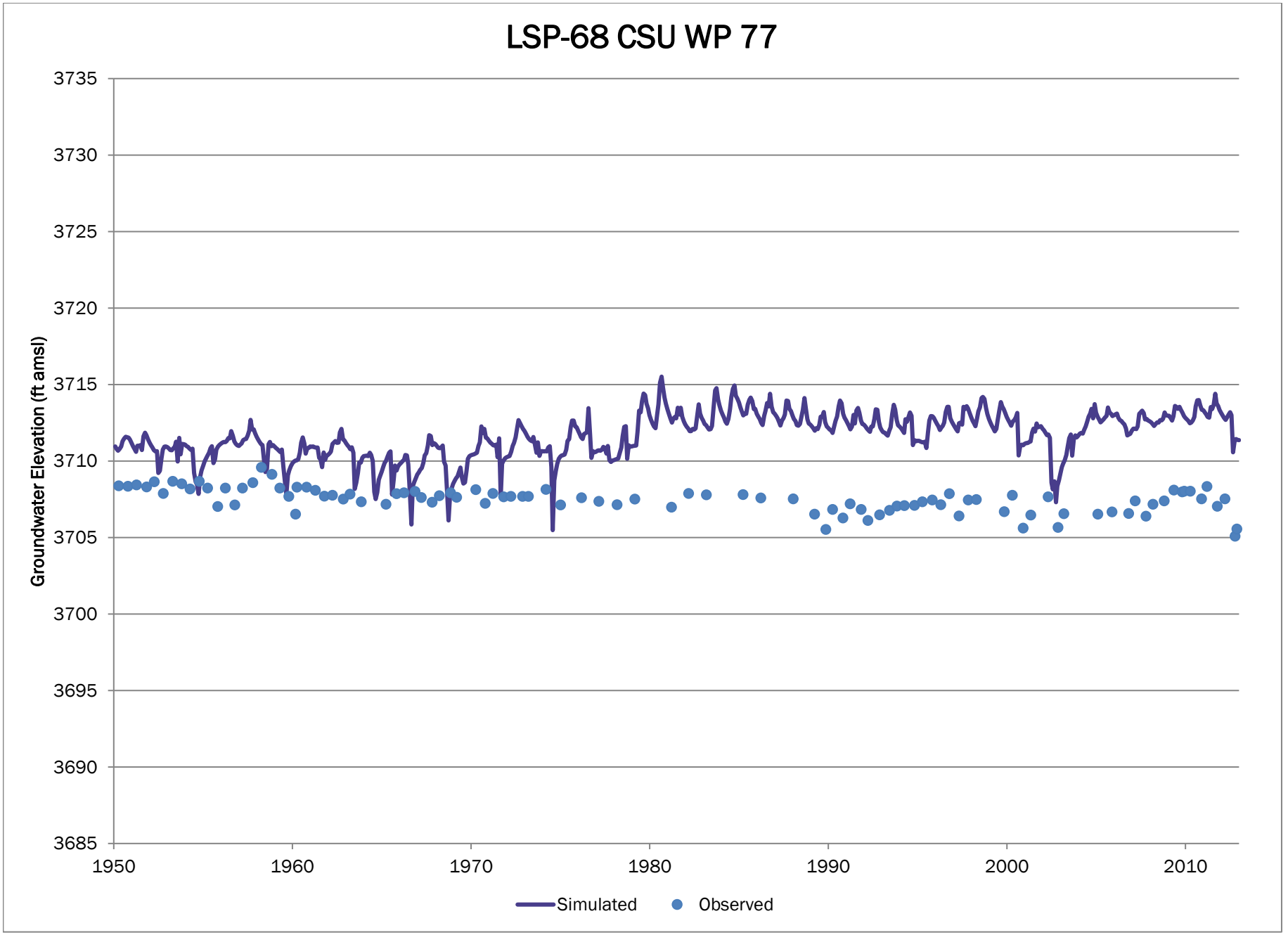

401908104471200 USGS
Groundwater Elevation (ft amsl)
4730
4725
4720
4715
4710
4705
4700
4695
4690
4685
4680
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

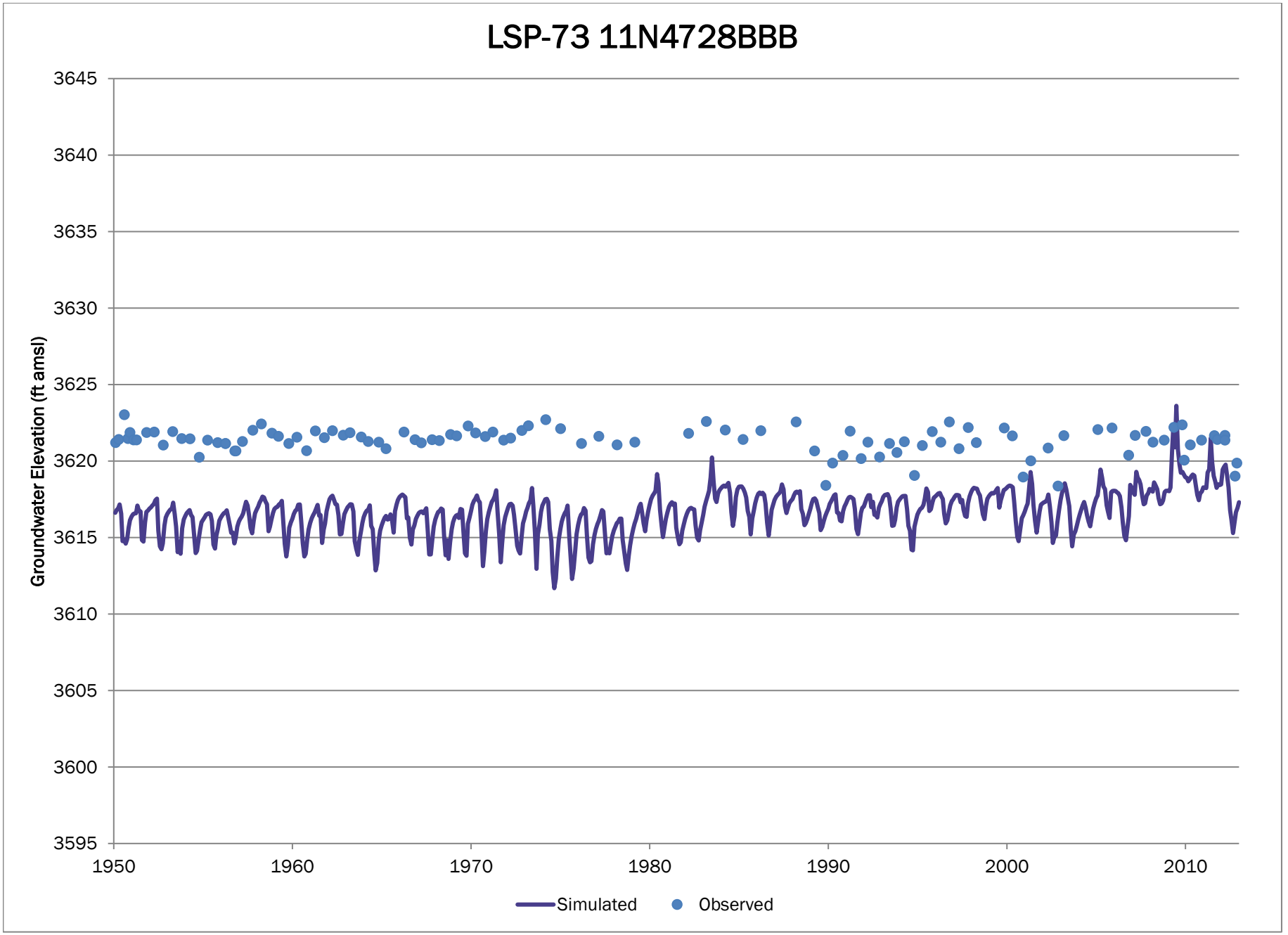

LSP-32 04N6412CCC
Groundwater Elevation (ft amsl)
4640
4635
4630
4625
4620
4615
4610
4605
4600
4595
4590
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

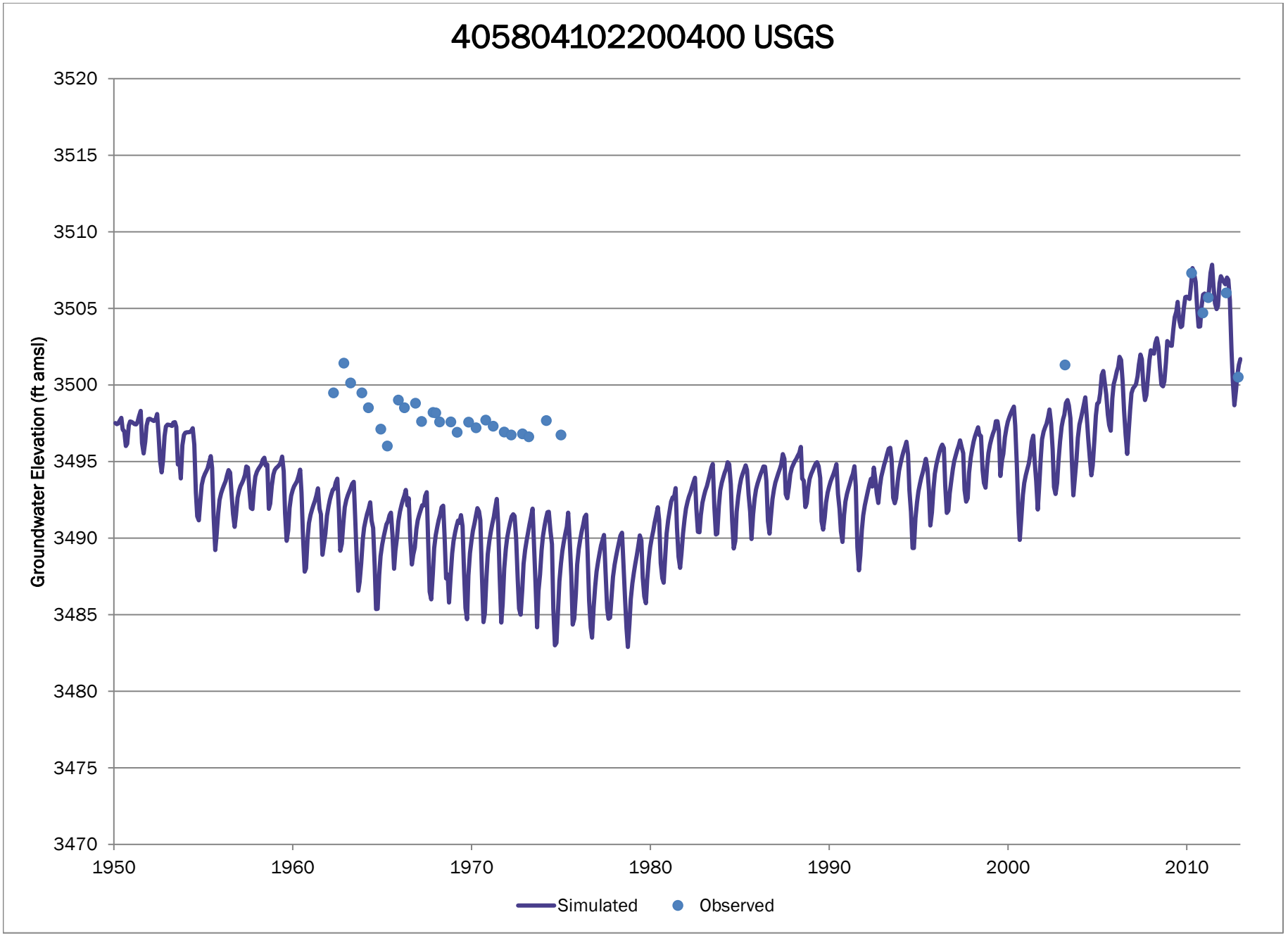

401913104030600 USGS
Groundwater Elevation (ft amsl)
4415
4410
4405
4400
4395
4390
4385
4380
4375
4370
4365
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

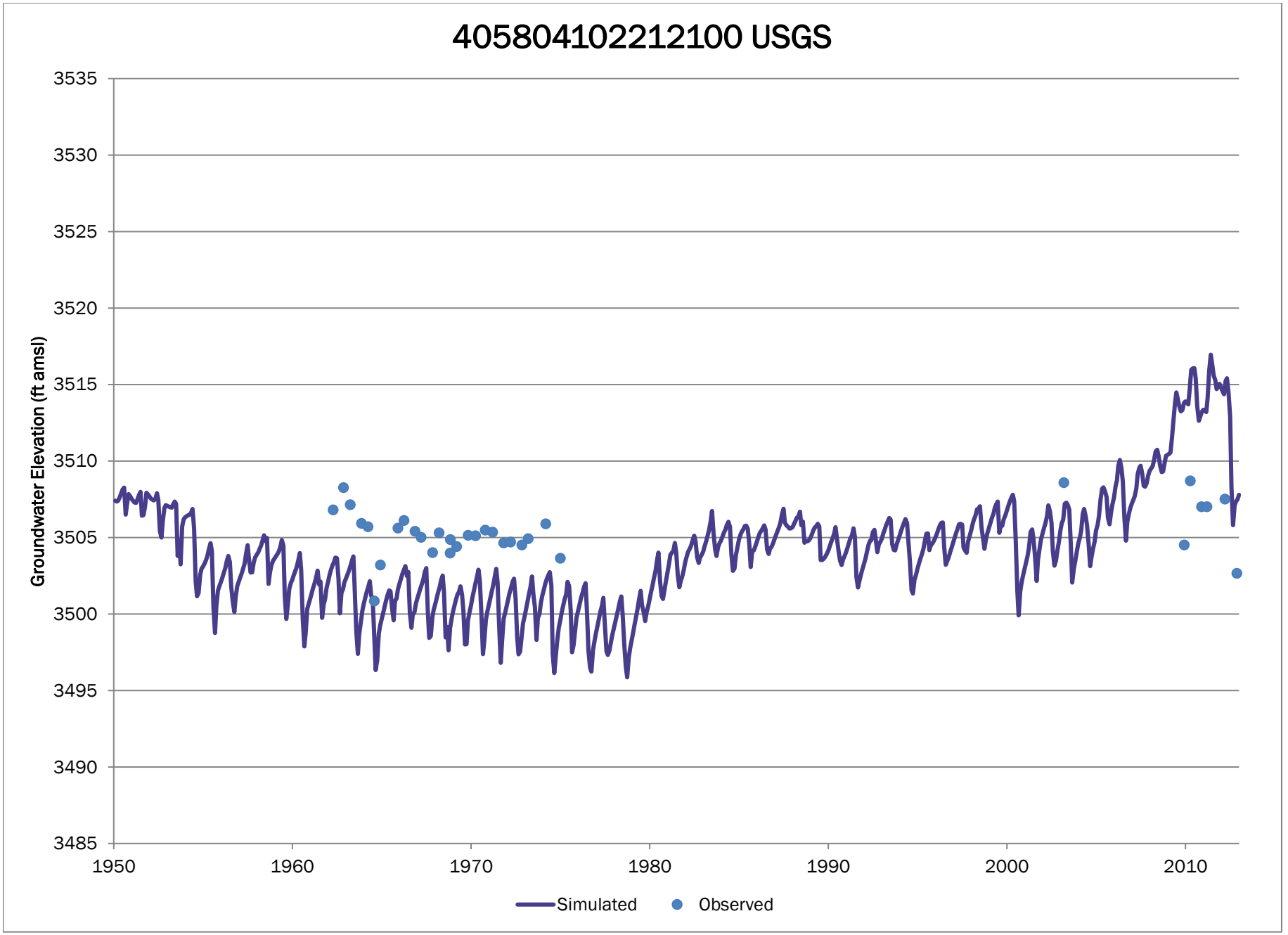

404450103013501 USGS NAWQA 20
Groundwater Elevation (ft amsl)
3840
3835
3830
3825
3820
3815
3810
3805
3800
3795
3790
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

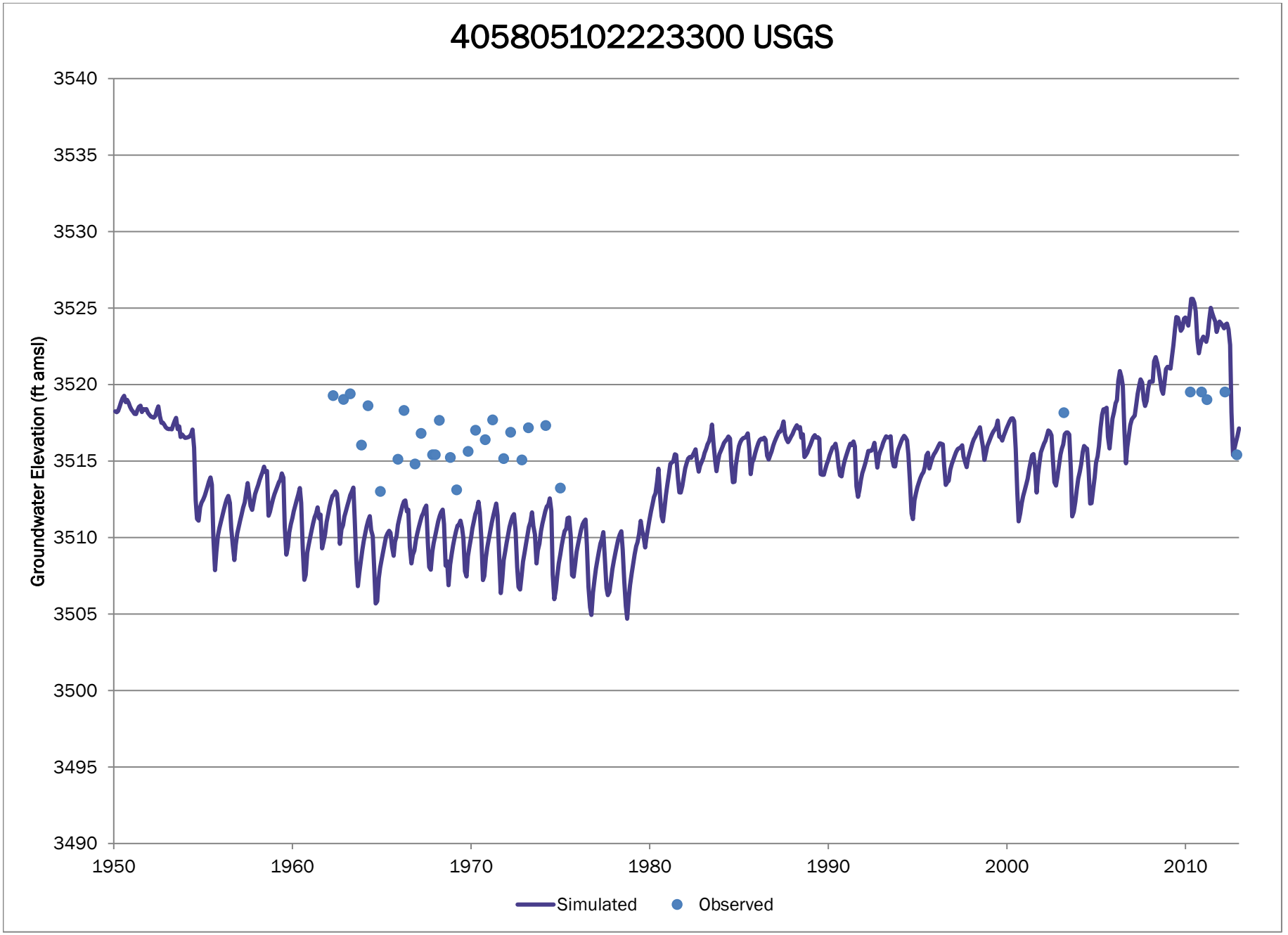

LSP-66 09N5110CCC
Groundwater Elevation (ft amsl)
3845
3840
3835
3830
3825
3820
3815
3810
3805
3800
3795
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

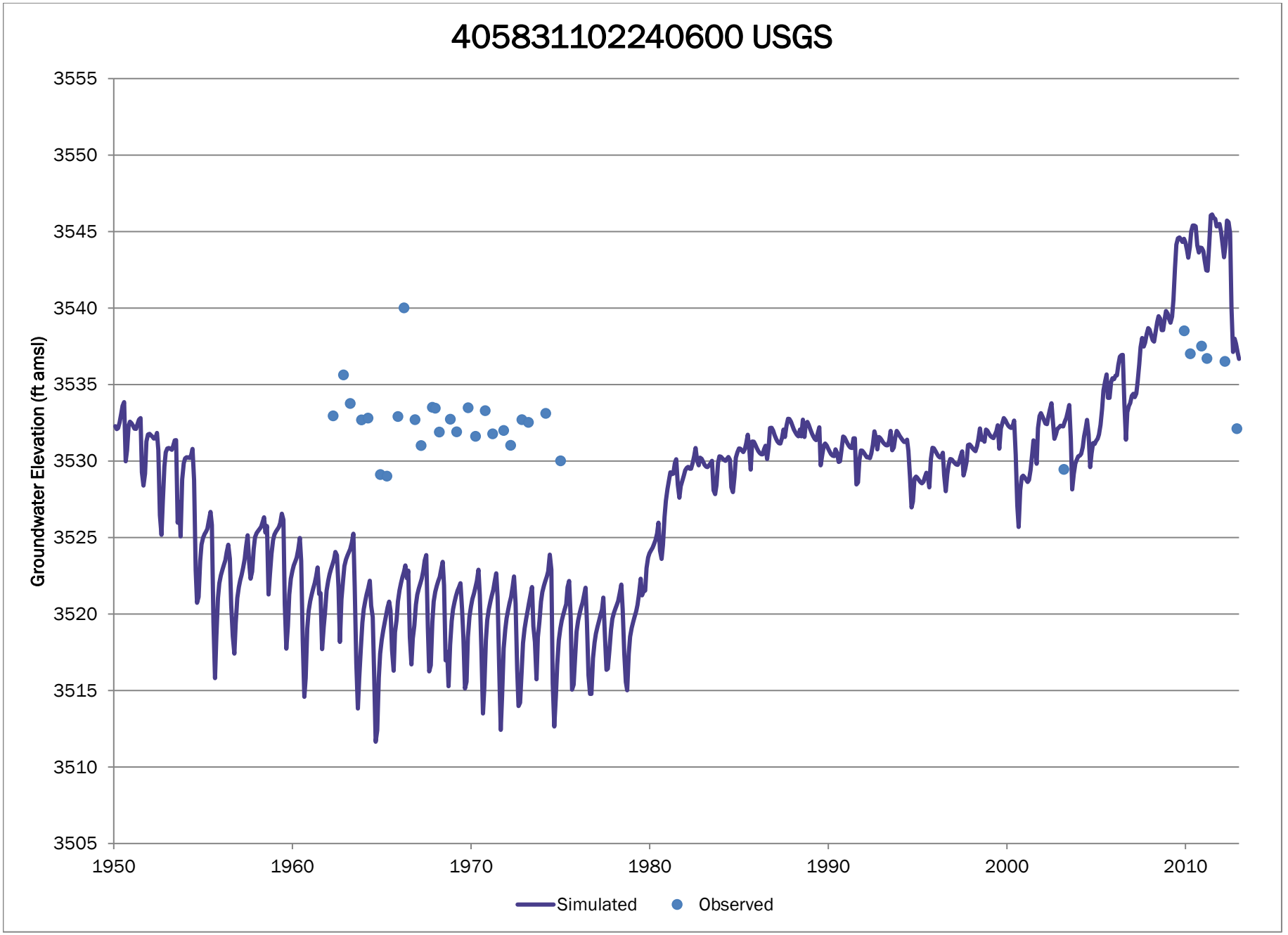

LSP-68 CSU WP 77
Groundwater Elevation (ft amsl)
3735
3730
3725
3720
3715
3710
3705
3700
3695
3690
3685
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

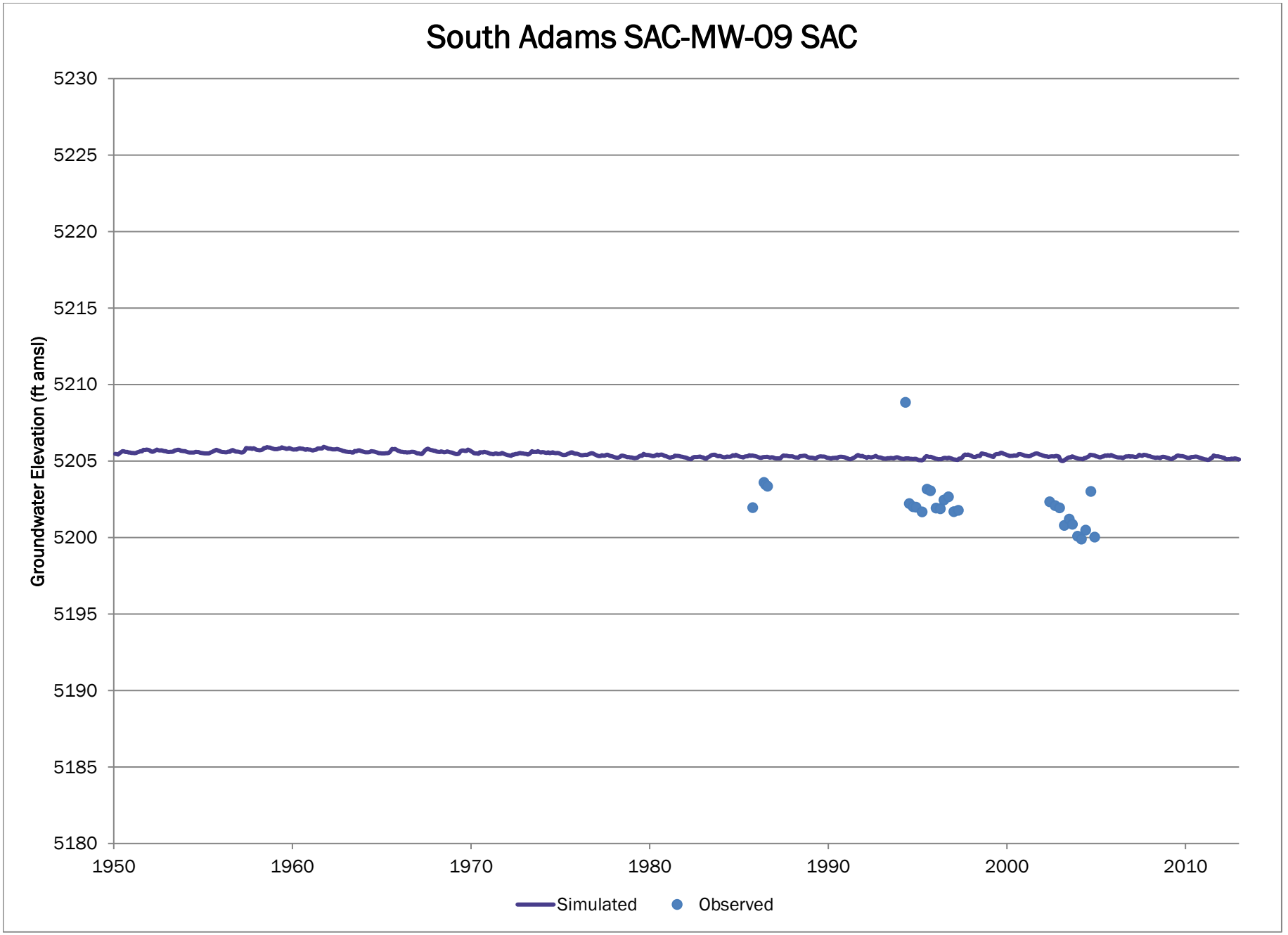

LSP-73 11N4728BBB
Groundwater Elevation (ft amsl)
3645
3640
3635
3630
3625
3620
3615
3610
3605
3600
3595
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

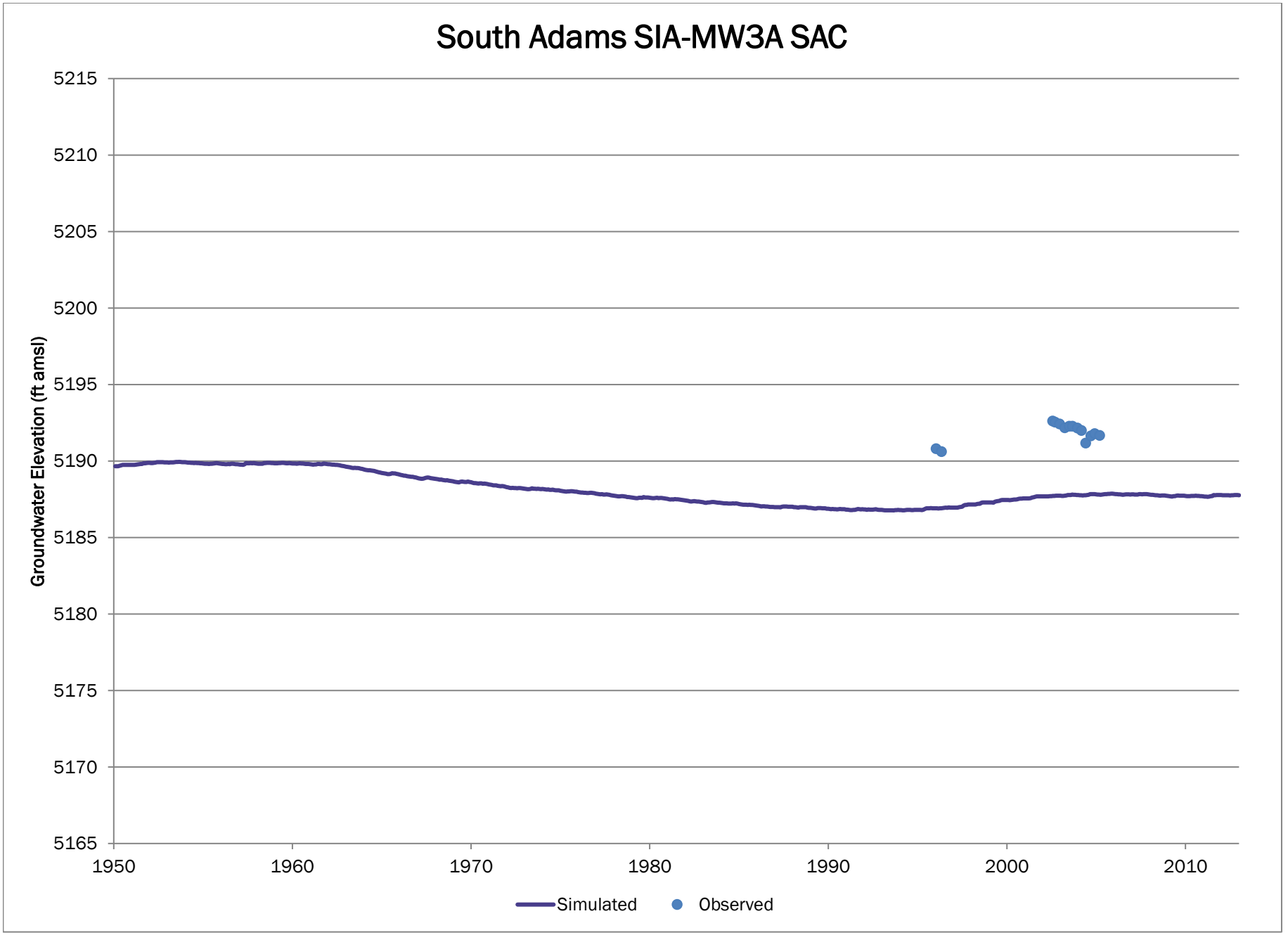

405804102200400 USGS
Groundwater Elevation (ft amsl)
3520
3515
3510
3505
3500
3495
3490
3485
3480
3475
3470
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

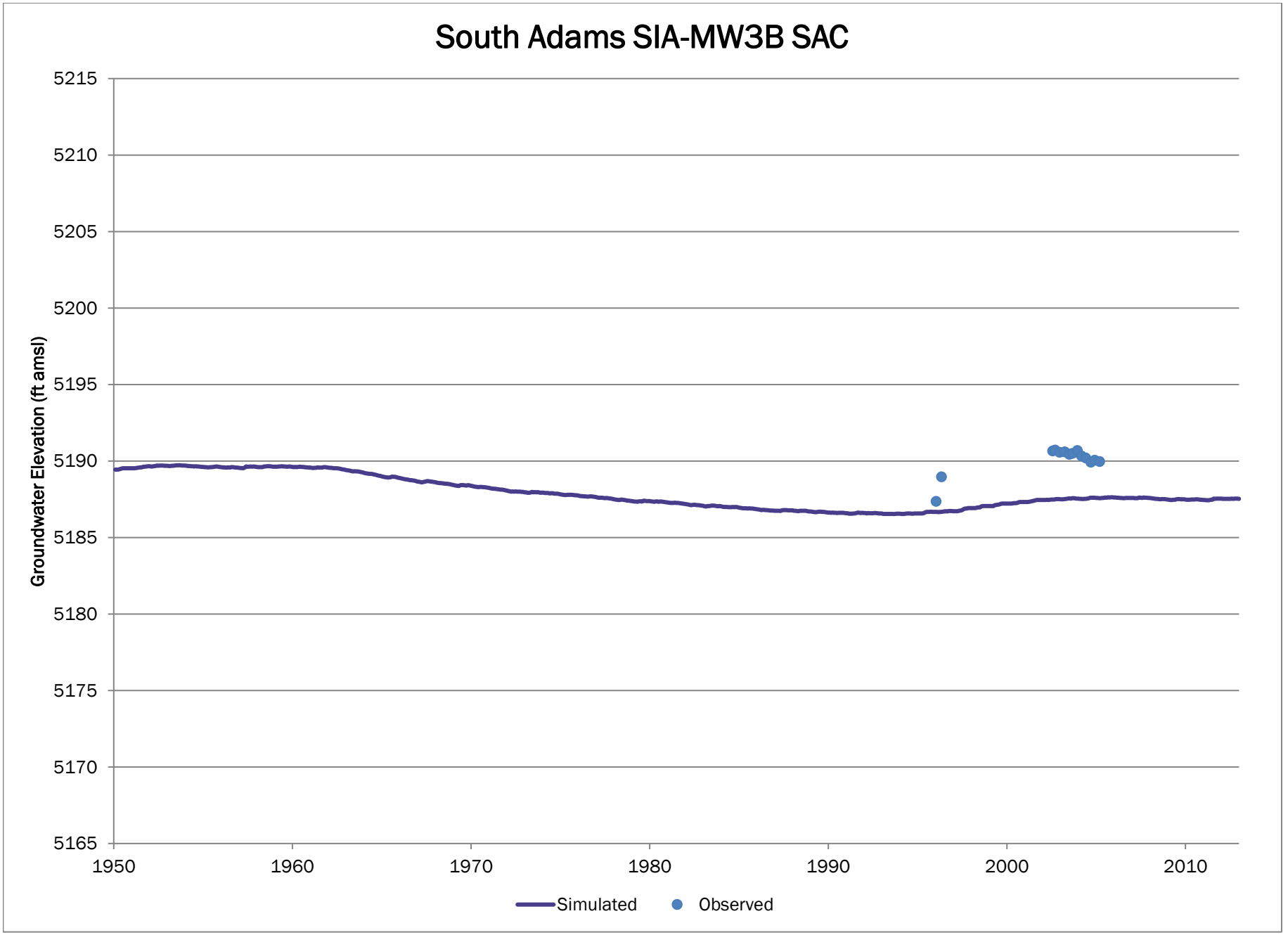

405804102212100 USGS
Groundwater Elevation (ft amsl)
3535
3530
3525
3520
3515
3510
3505
3500
3495
3490
3485
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

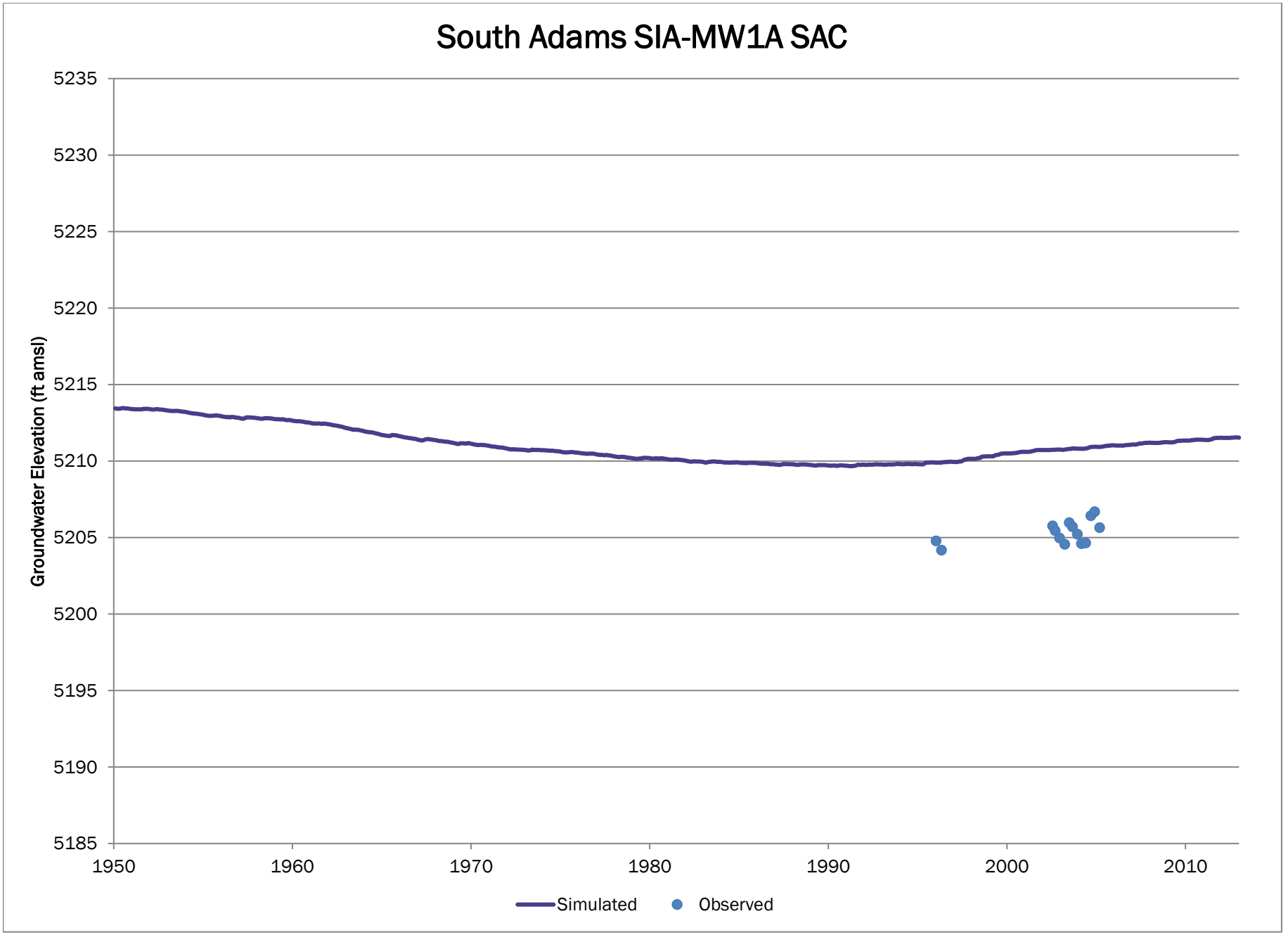

405805102223300 USGS
Groundwater Elevation (ft amsl)
3540
3535
3530
3525
3520
3515
3510
3505
3500
3495
3490
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

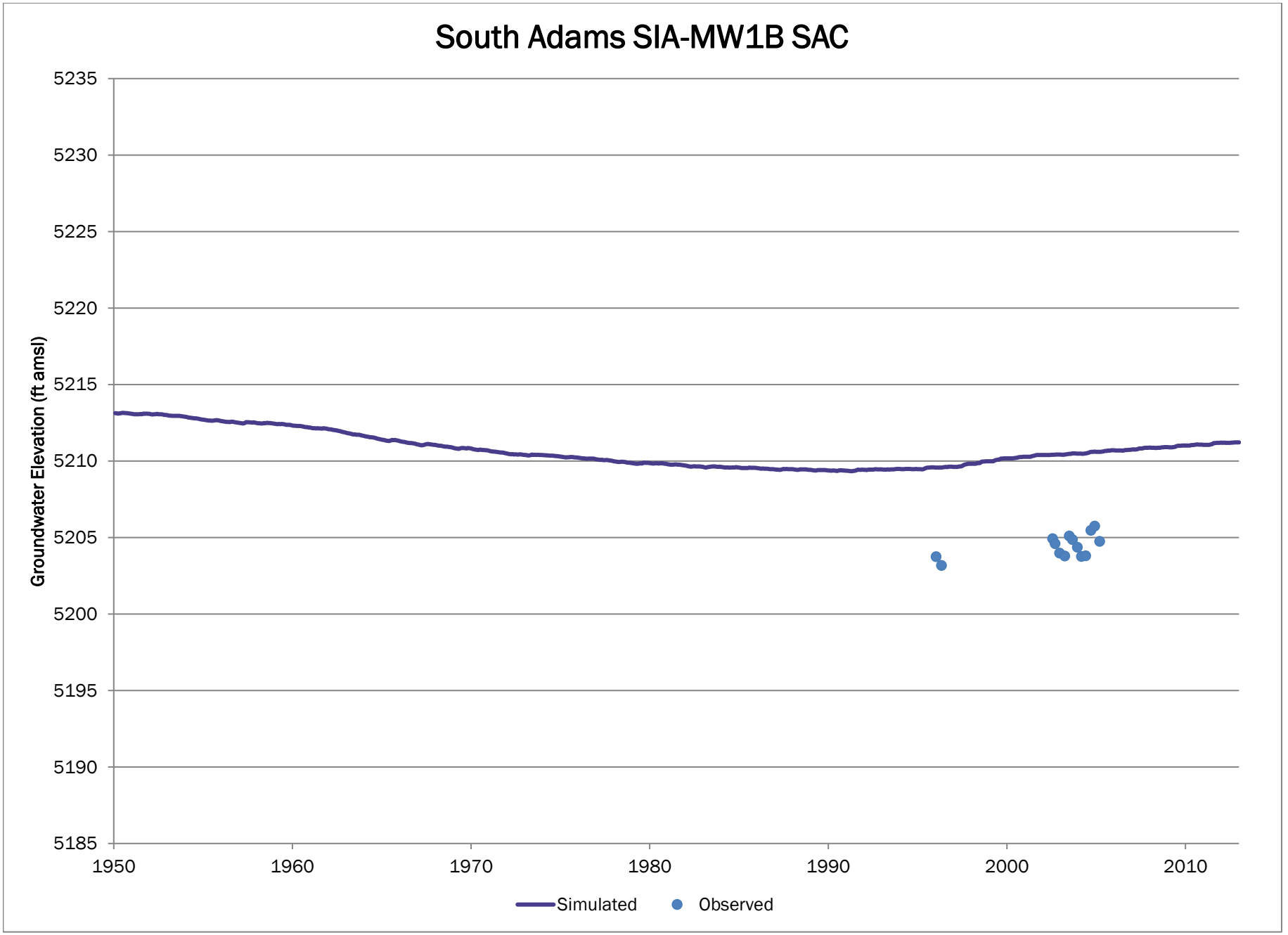

405831102240600 USGS
Groundwater Elevation (ft amsl)
3555
3550
3545
3540
3535
3530
3525
3520
3515
3510
3505
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

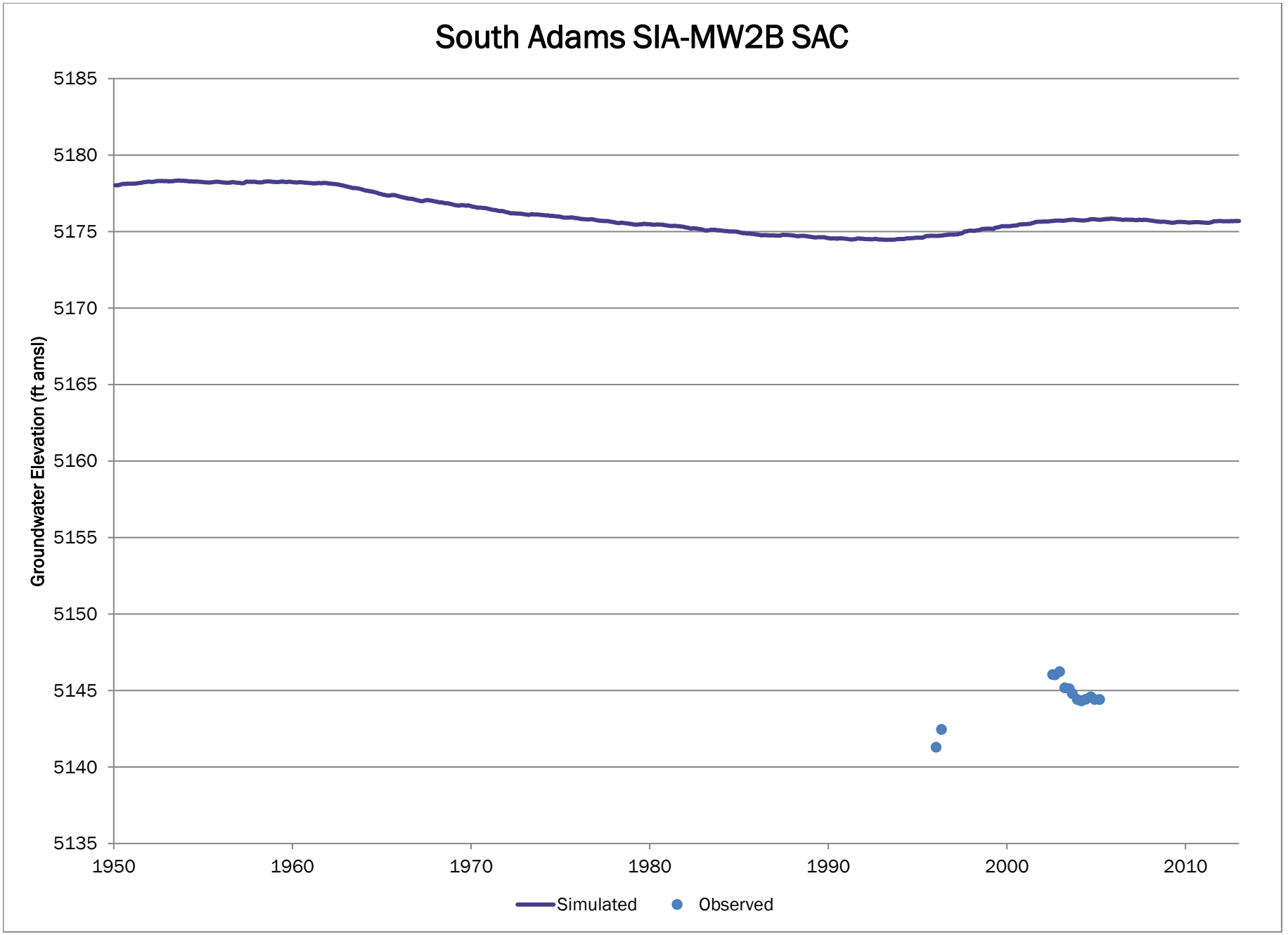

South Adams SAC-MW-09 SAC
Groundwater Elevation (ft amsl)
5230
5225
5220
5215
5210
5205
5200
5195
5190
5185
5180
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

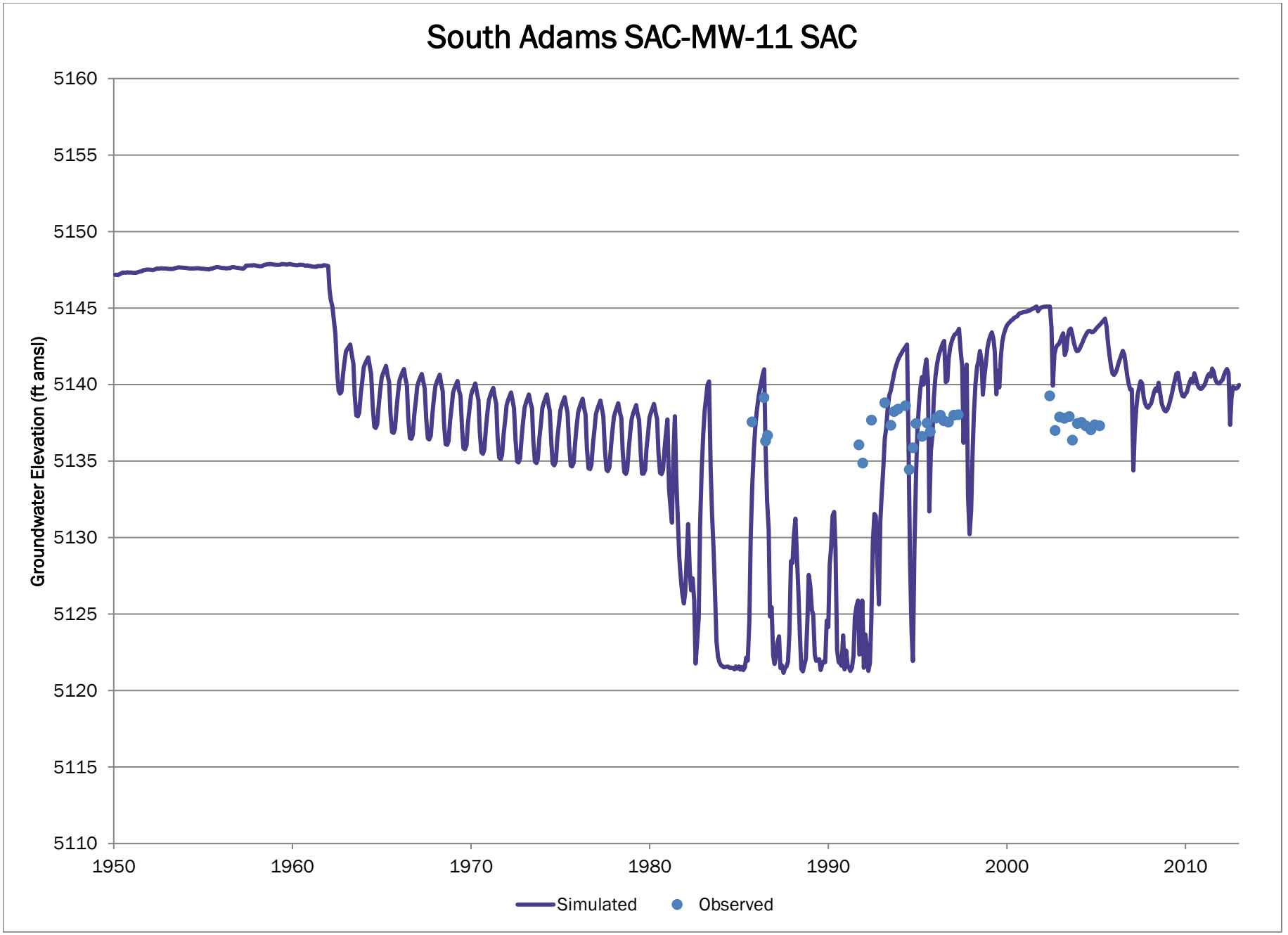

South Adams SIA-MW3A SAC
Groundwater Elevation (ft amsl)
5215
5210
5205
5200
5195
5190
5185
5180
5175
5170
5165
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

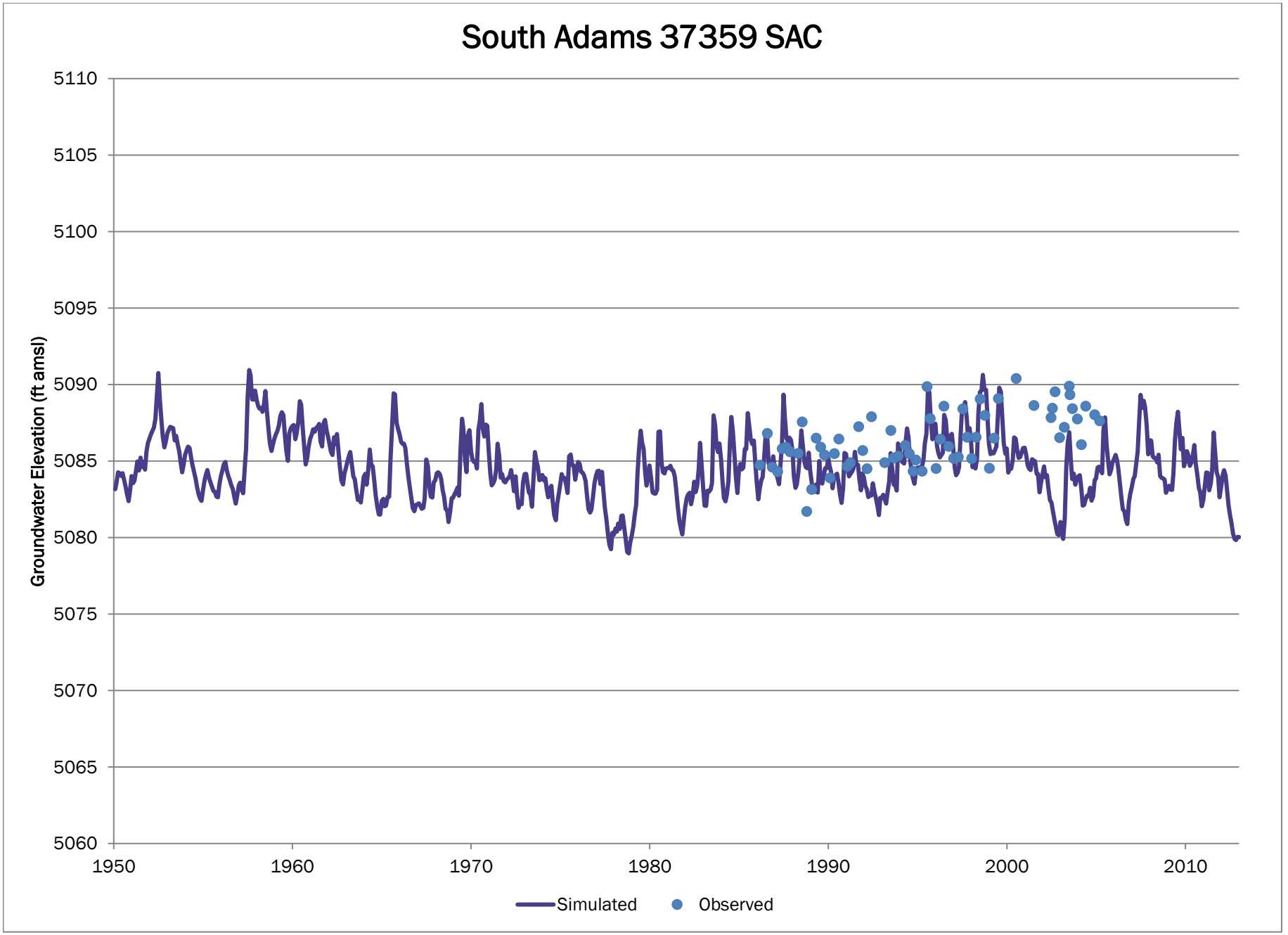

South Adams SIA-MW3B SAC
Groundwater Elevation (ft amsl)
5215
5210
5205
5200
5195
5190
5185
5180
5175
5170
5165
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

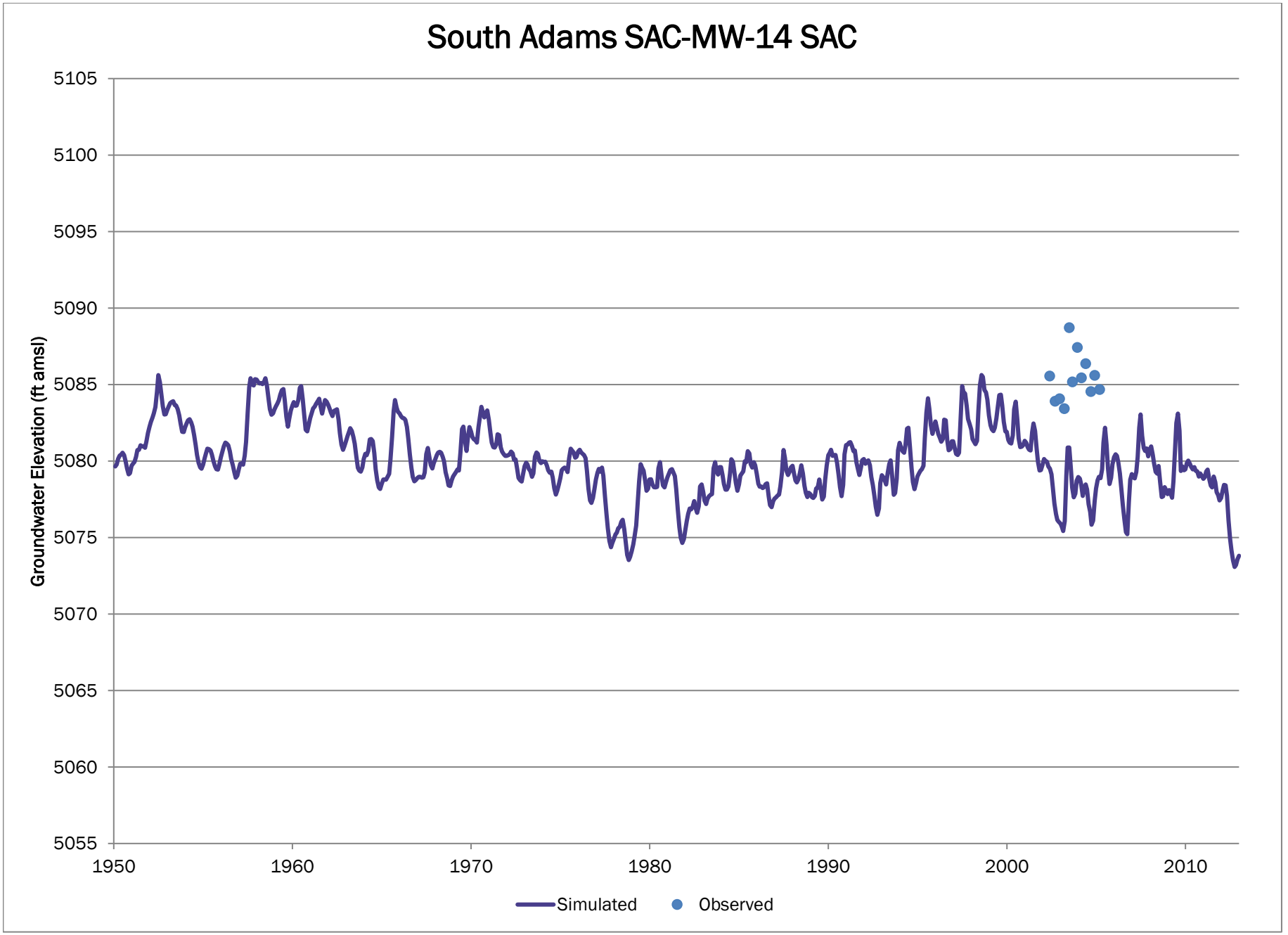

South Adams SIA-MW1A SAC
Groundwater Elevation (ft amsl)
5235
5230
5225
5220
5215
5210
5205
5200
5195
5190
5185
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

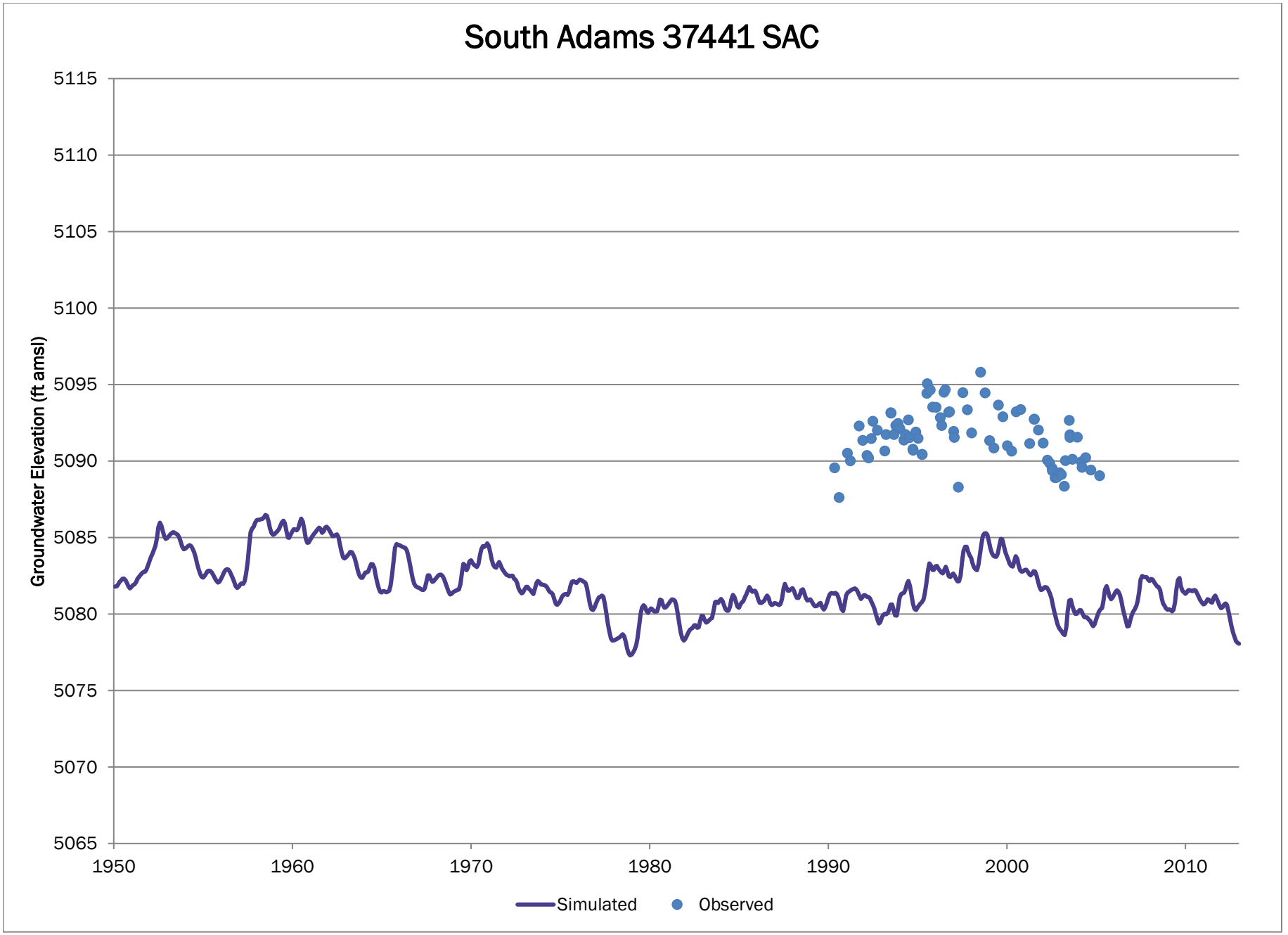

South Adams SIA-MW1B SAC
Groundwater Elevation (ft amsl)
5235
5230
5225
5220
5215
5210
5205
5200
5195
5190
5185
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

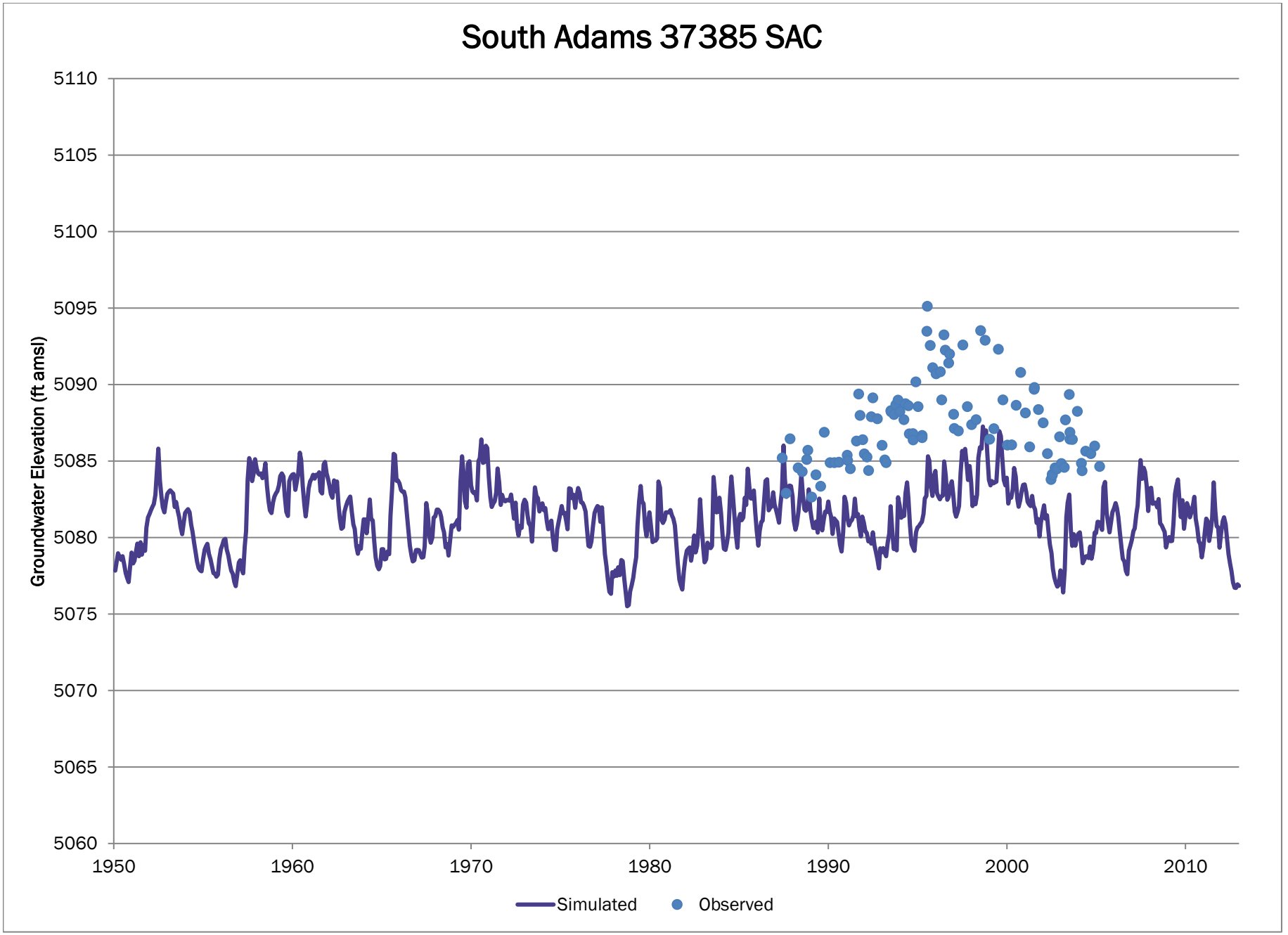

South Adams SIA-MW2B SAC
Groundwater Elevation (ft amsl)
5185
5180
5175
5170
5165
5160
5155
5150
5145
5140
5135
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

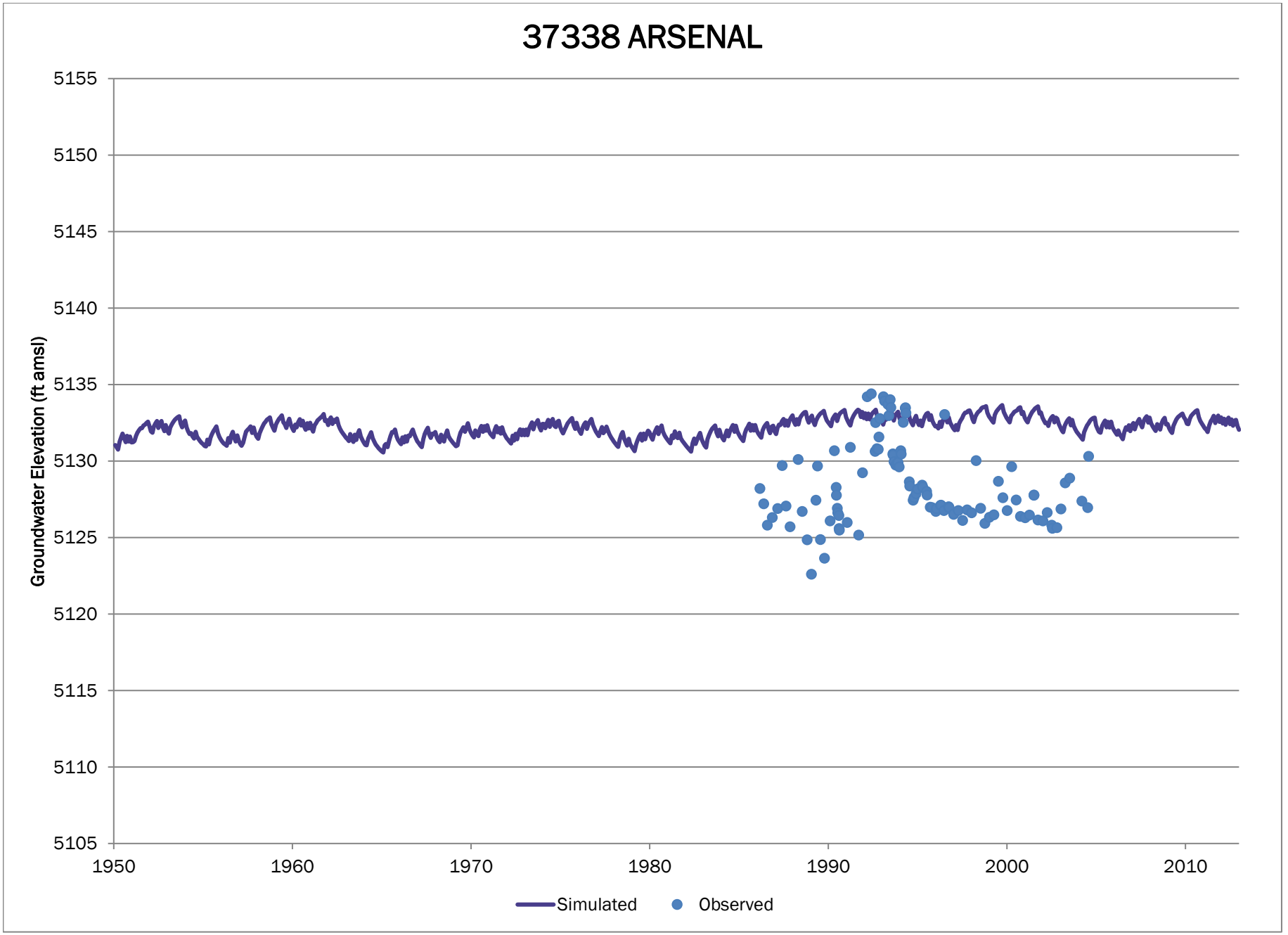

South Adams SAC-MW-11 SAC
Groundwater Elevation (ft amsl)
5160
5155
5150
5145
5140
5135
5130
5125
5120
5115
5110
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

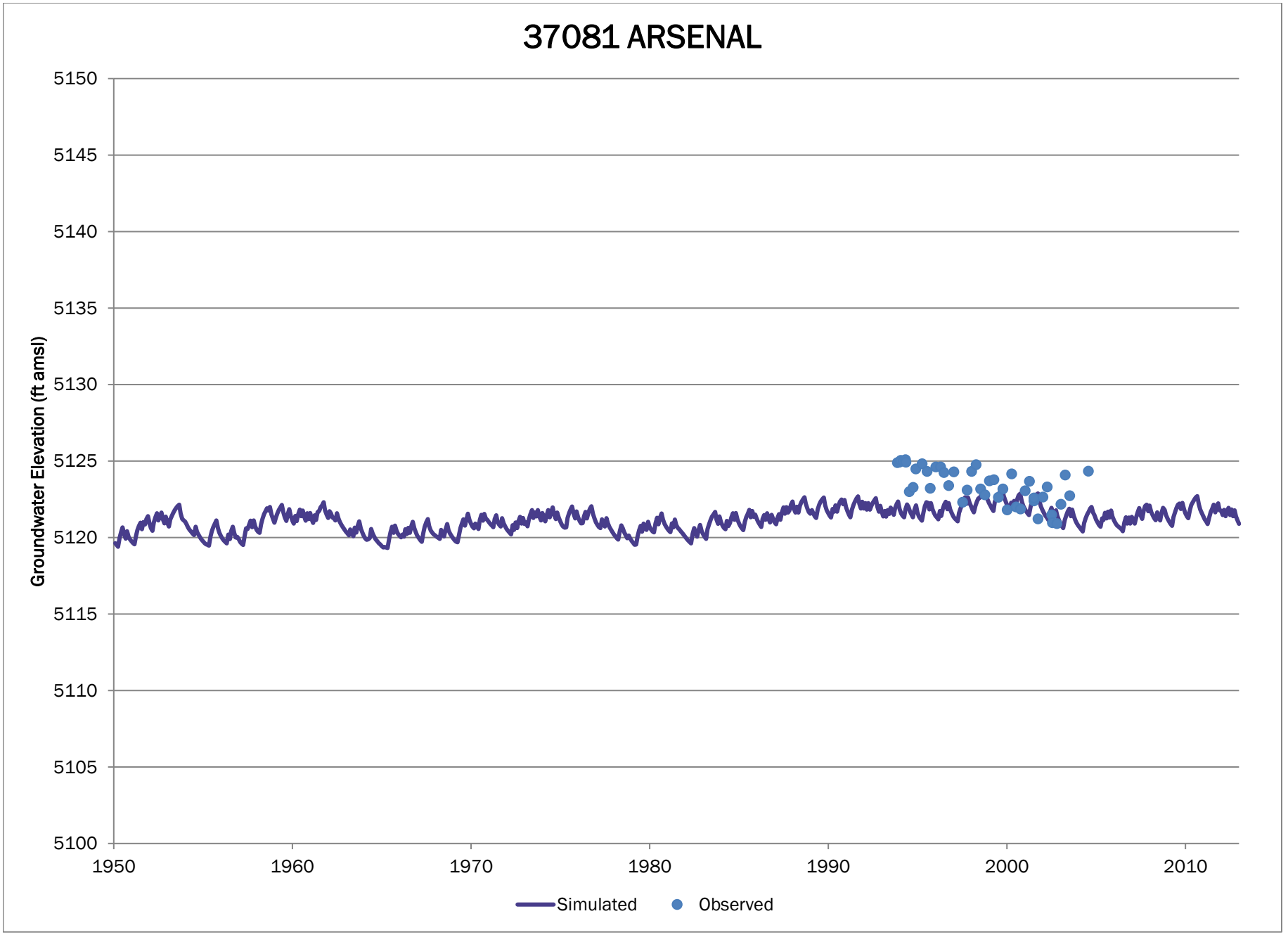

South Adams 37359 SAC
Groundwater Elevation (ft amsl)
5110
5105
5100
5095
5090
5085
5080
5075
5070
5065
5060
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

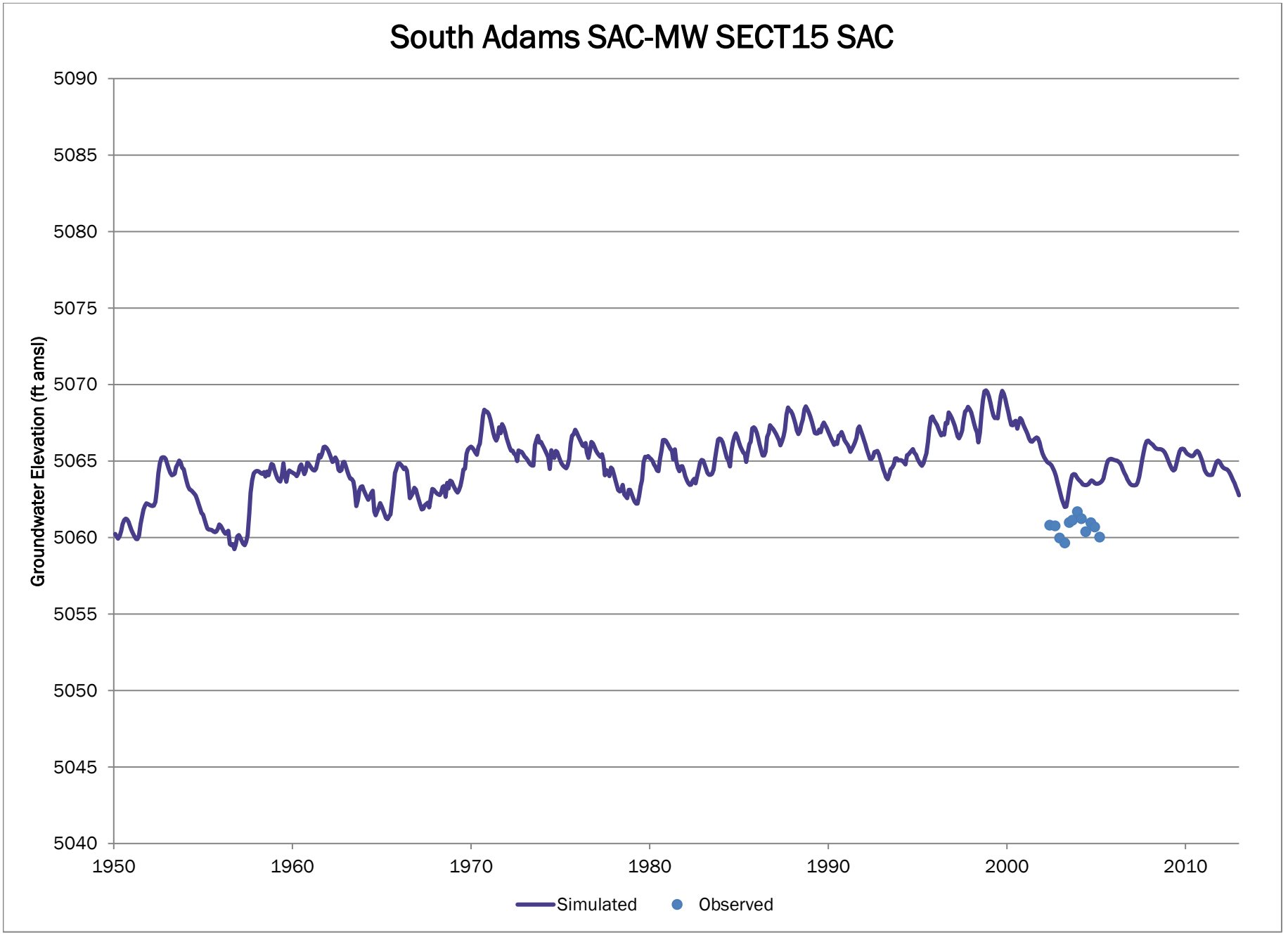

South Adams SAC-MW-14 SAC
Groundwater Elevation (ft amsl)
5105
5100
5095
5090
5085
5080
5075
5070
5065
5060
5055
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

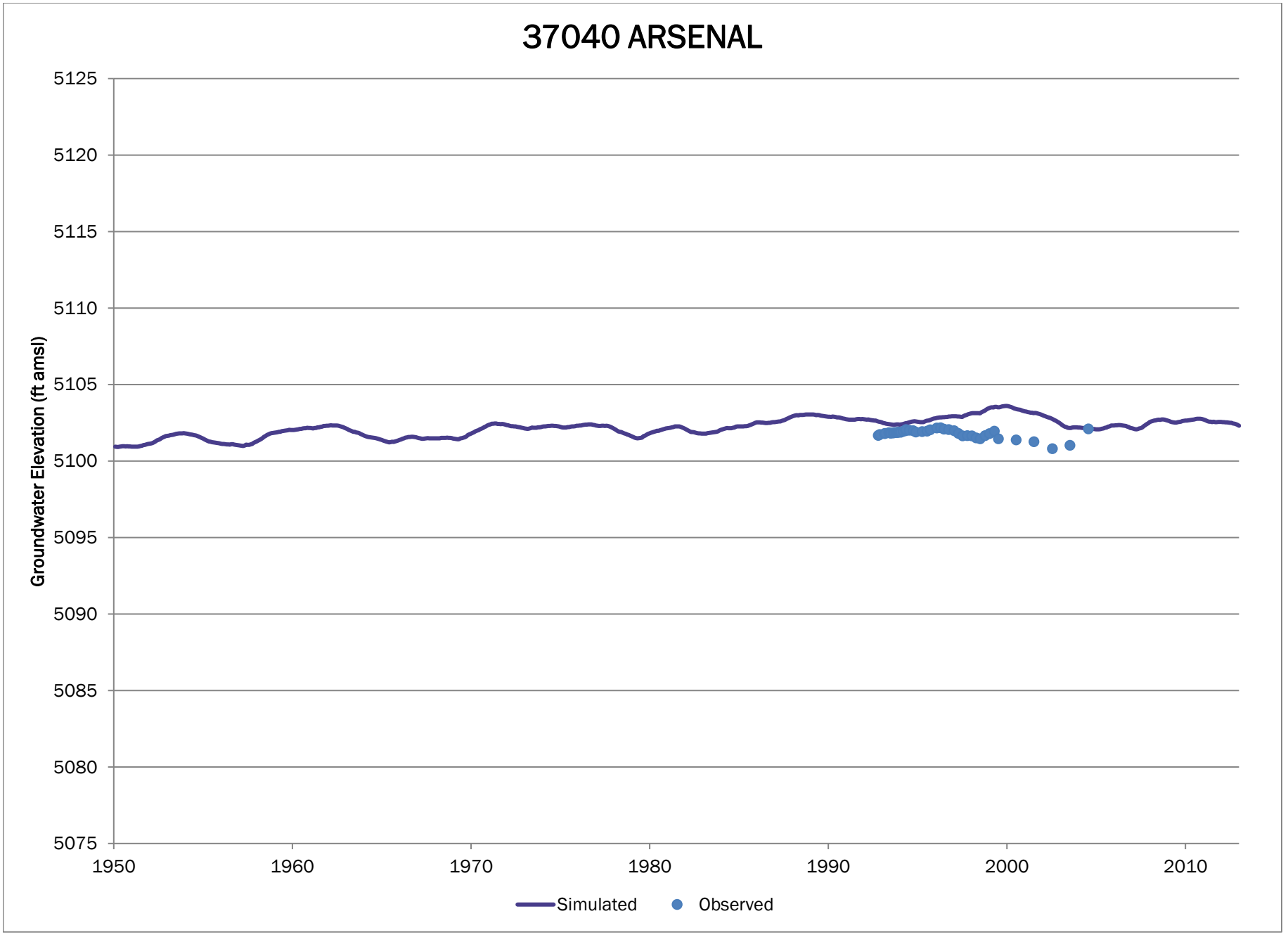

South Adams 37441 SAC
Groundwater Elevation (ft amsl)
5115
5110
5105
5100
5095
5090
5085
5080
5075
5070
5065
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

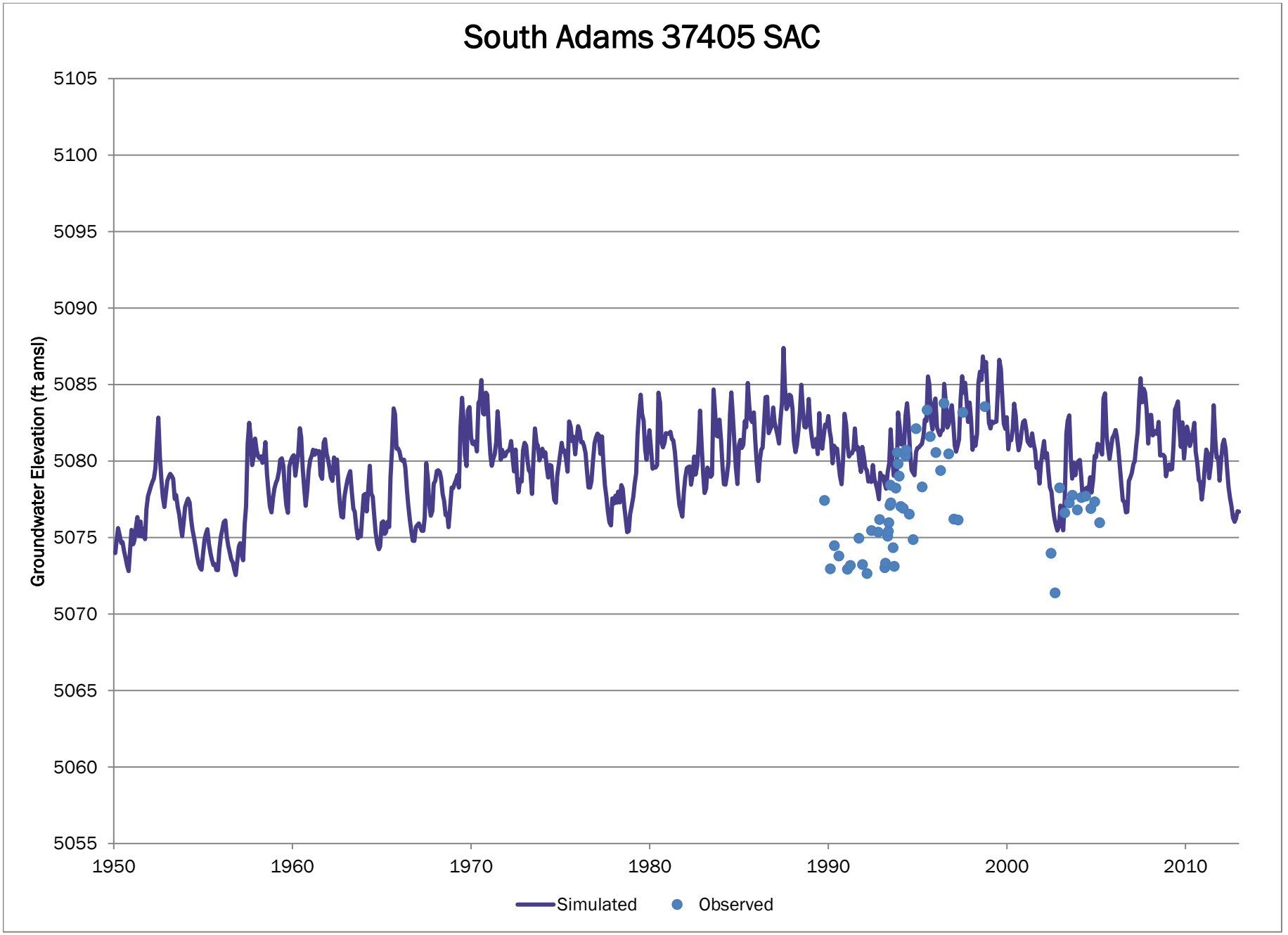

South Adams 37385 SAC
Groundwater Elevation (ft amsl)
5110
5105
5100
5095
5090
5085
5080
5075
5070
5065
5060
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

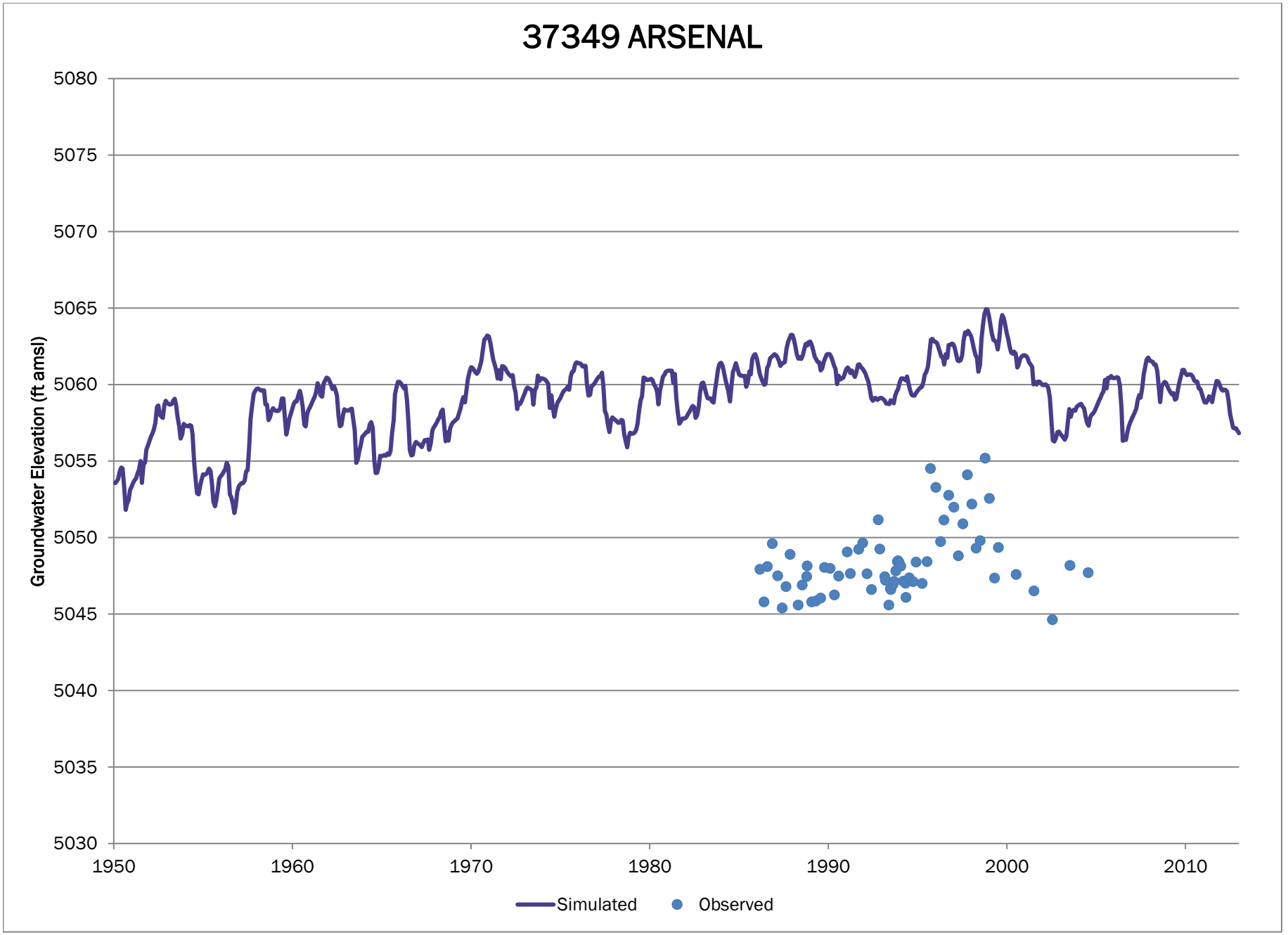

37338 ARSENAL
Groundwater Elevation (ft amsl)
5155
5150
5145
5140
5135
5130
5125
5120
5115
5110
5105
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

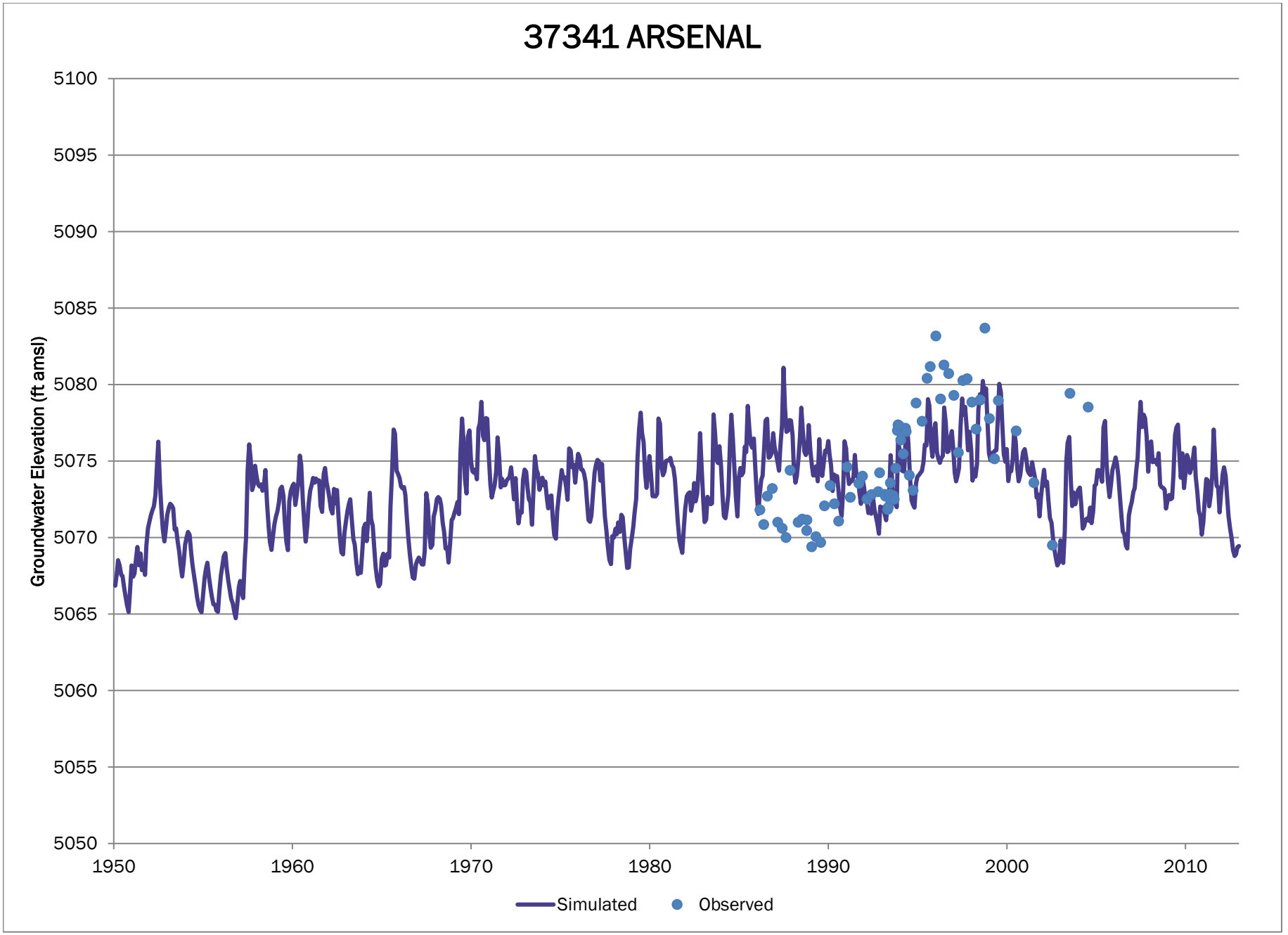

37081 ARSENAL
Groundwater Elevation (ft amsl)
5150
5145
5140
5135
5130
5125
5120
5115
5110
5105
5100
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

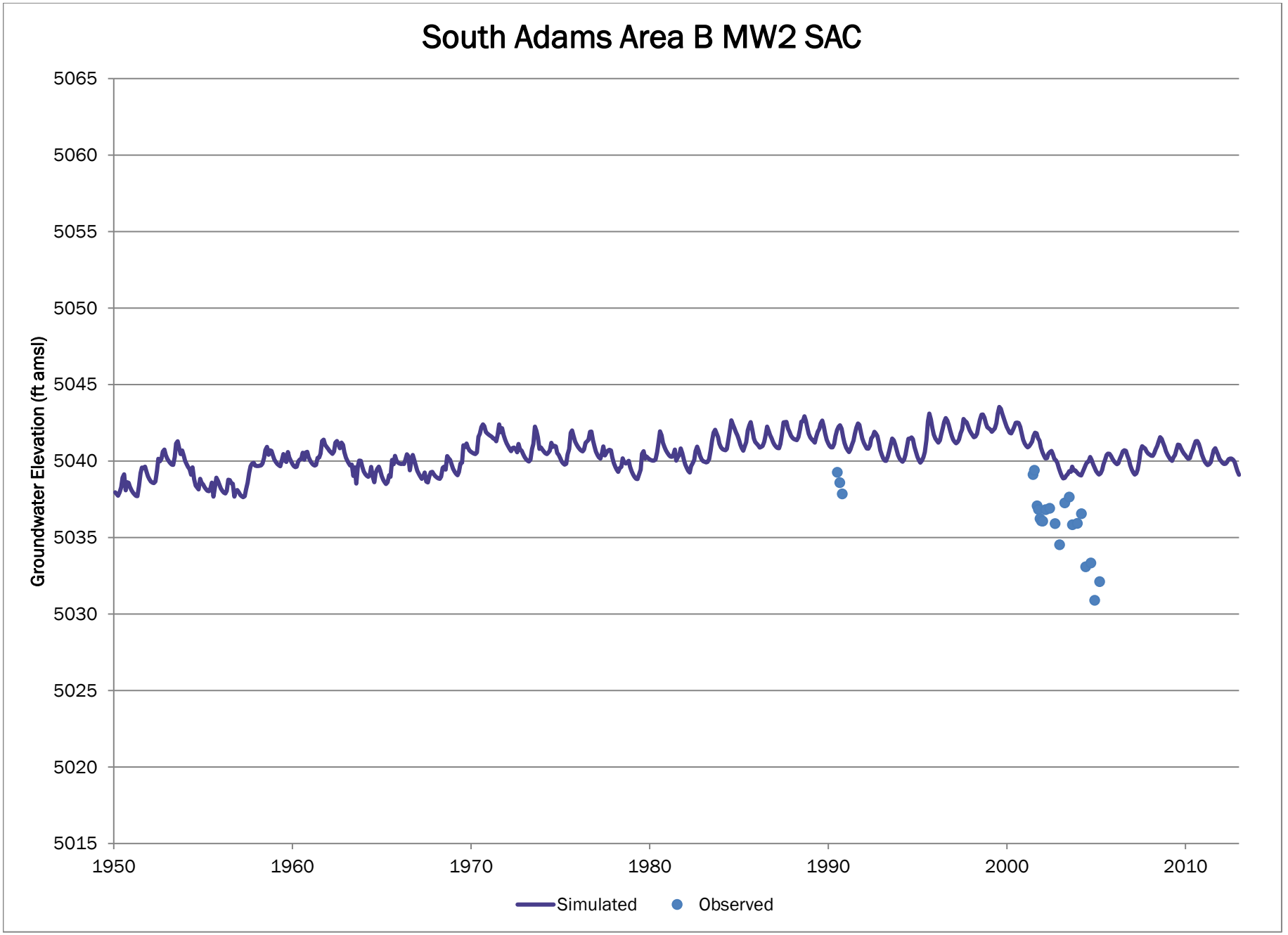

South Adams SAC-MW SECT15 SAC
Groundwater Elevation (ft amsl)
5090
5085
5080
5075
5070
5065
5060
5055
5050
5045
5040
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

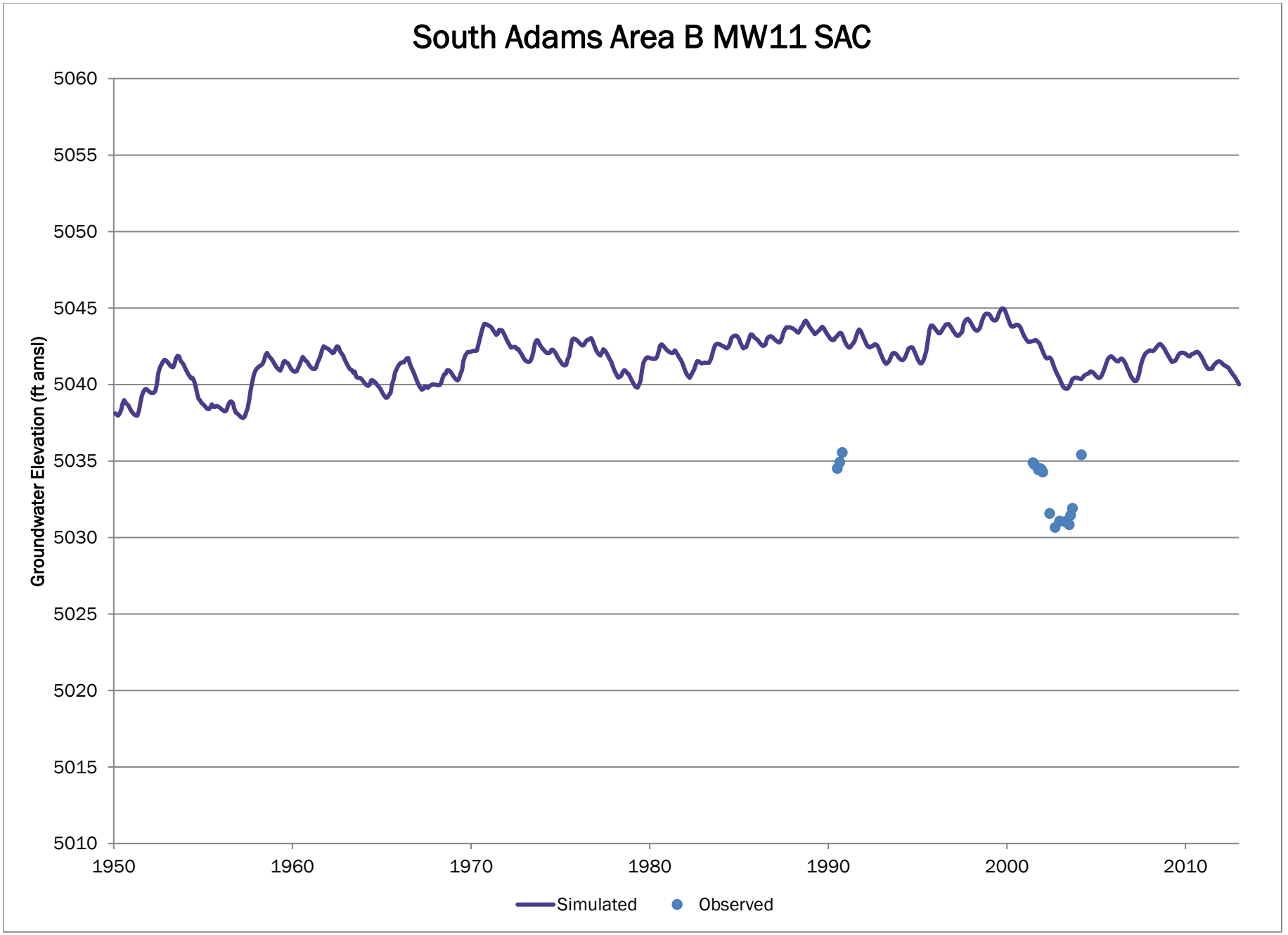

37040 ARSENAL
Groundwater Elevation (ft amsl)
5125
5120
5115
5110
5105
5100
5095
5090
5085
5080
5075
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

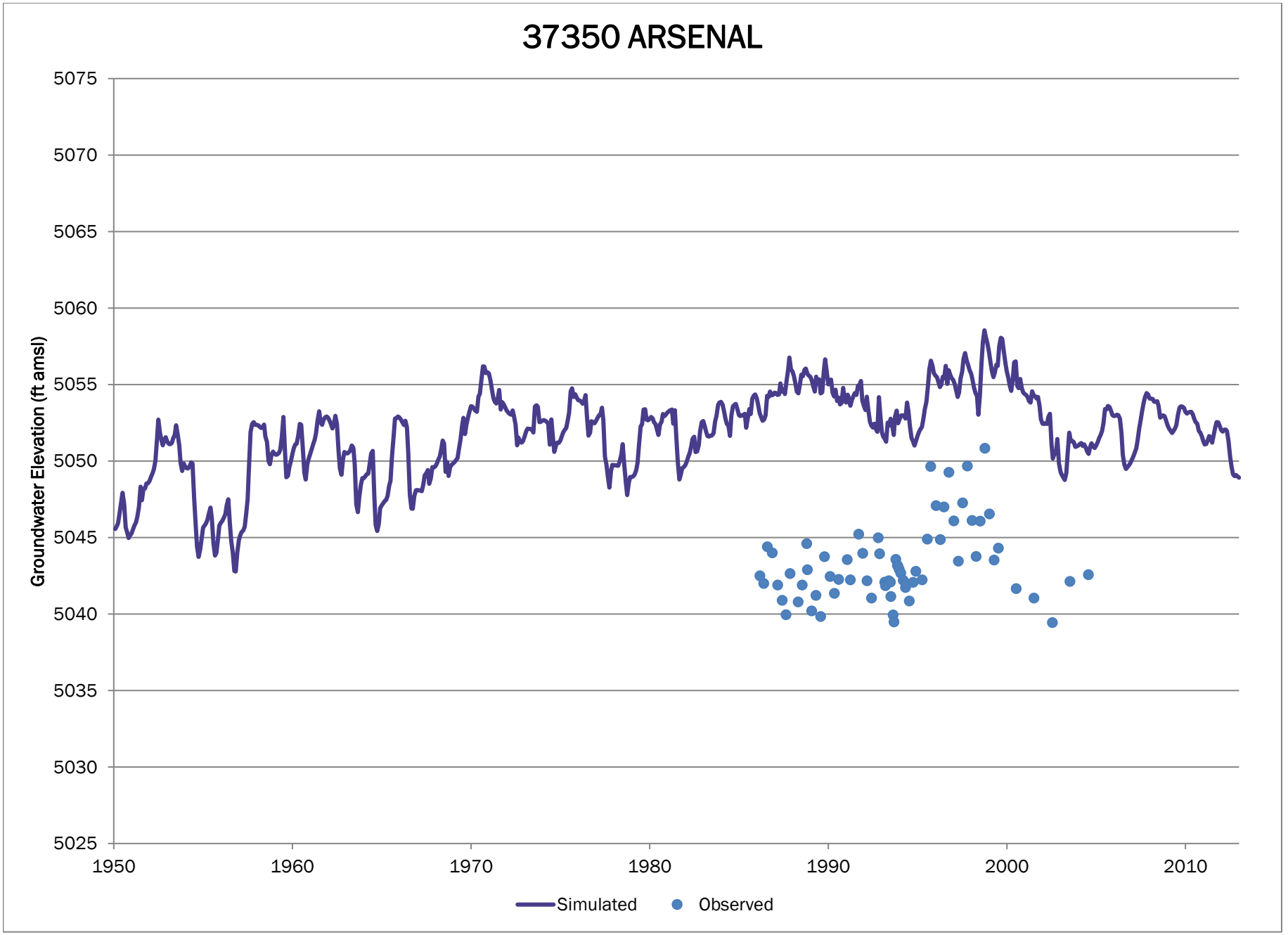

South Adams 37405 SAC
Groundwater Elevation (ft amsl)
5105
5100
5095
5090
5085
5080
5075
5070
5065
5060
5055
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

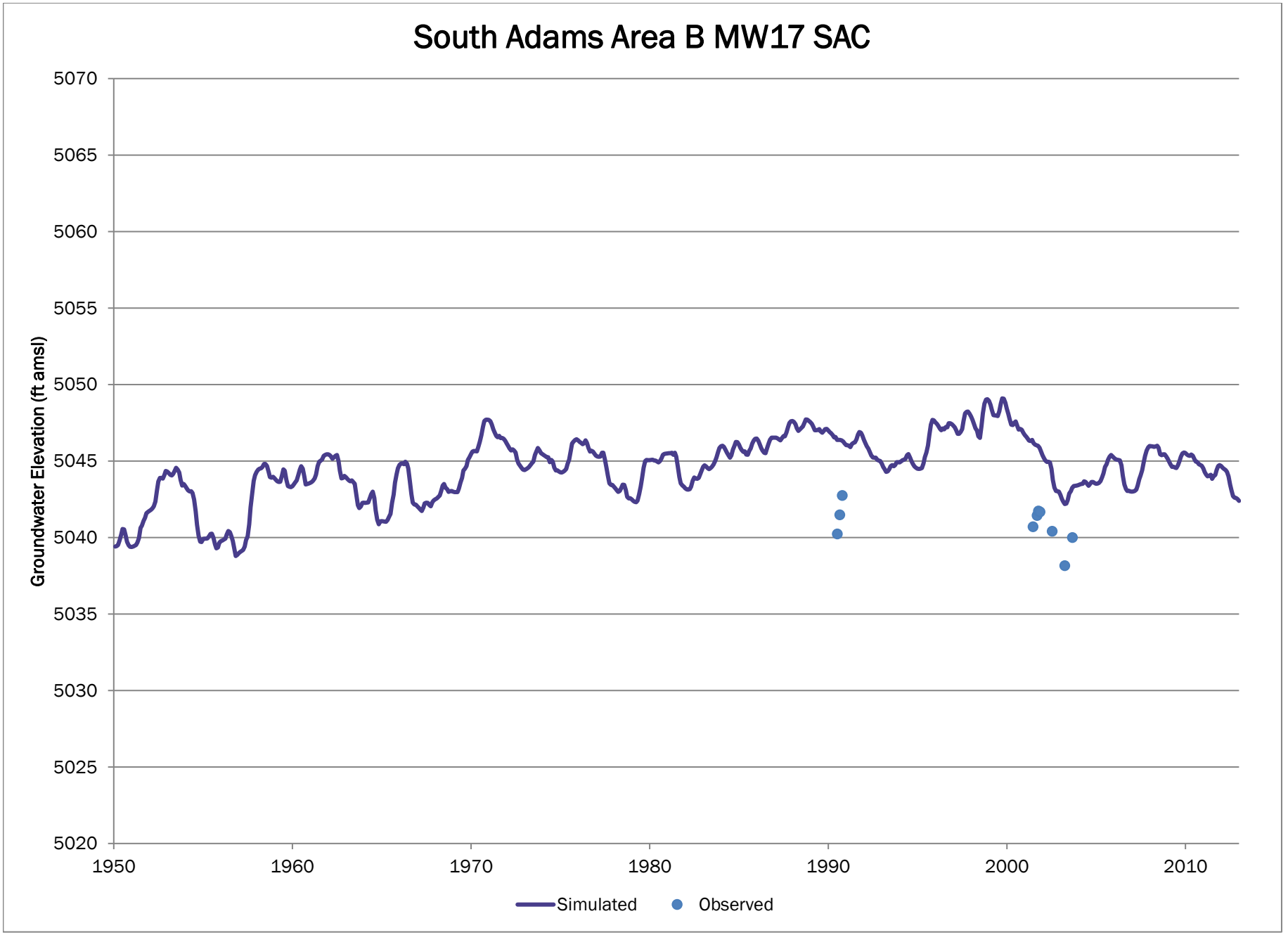

37349 ARSENAL
Groundwater Elevation (ft amsl)
5080
5075
5070
5065
5060
5055
5050
5045
5040
5035
5030
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

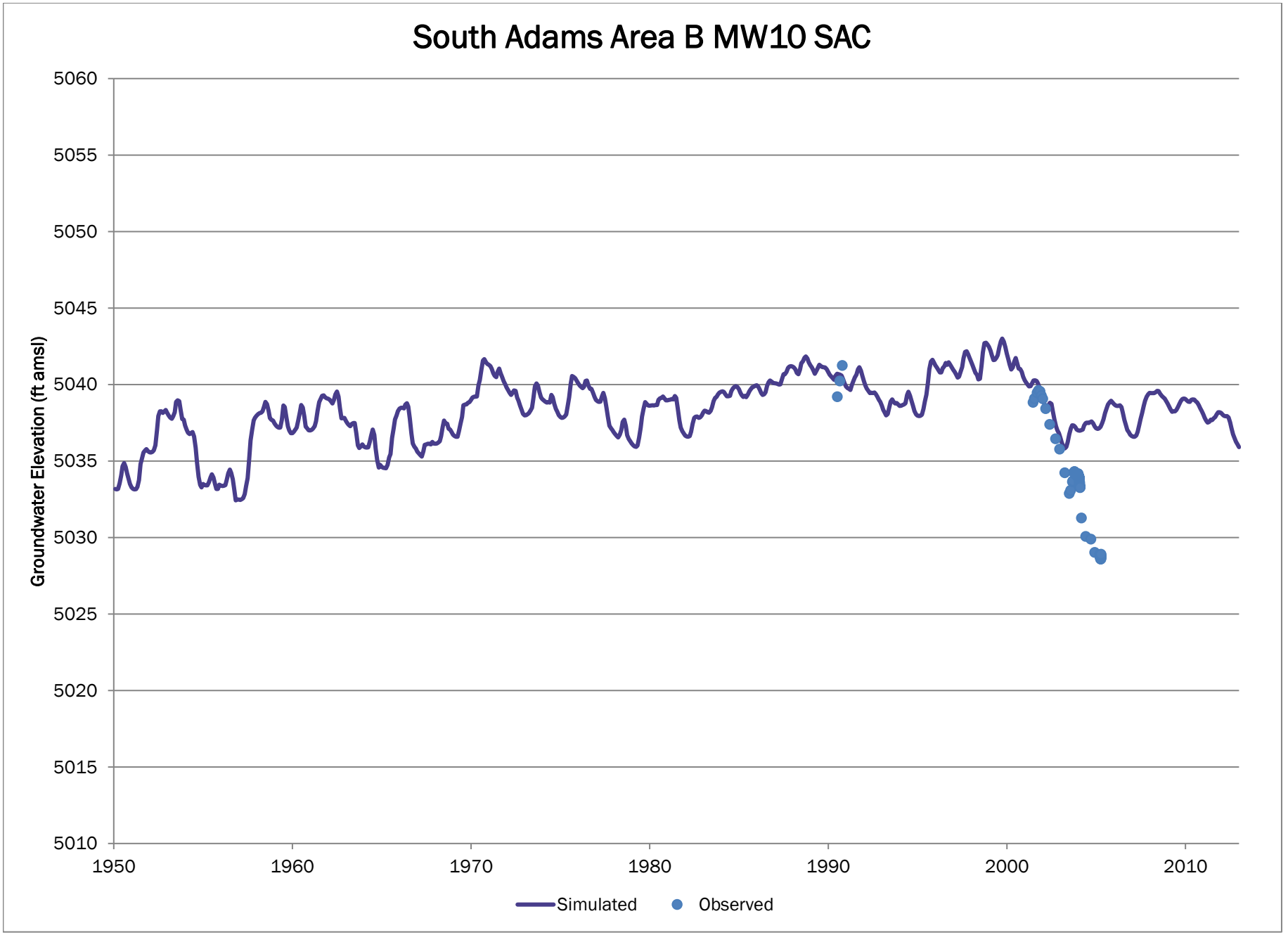

37341 ARSENAL
Groundwater Elevation (ft amsl)
5100
5095
5090
5085
5080
5075
5070
5065
5060
5055
5050
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

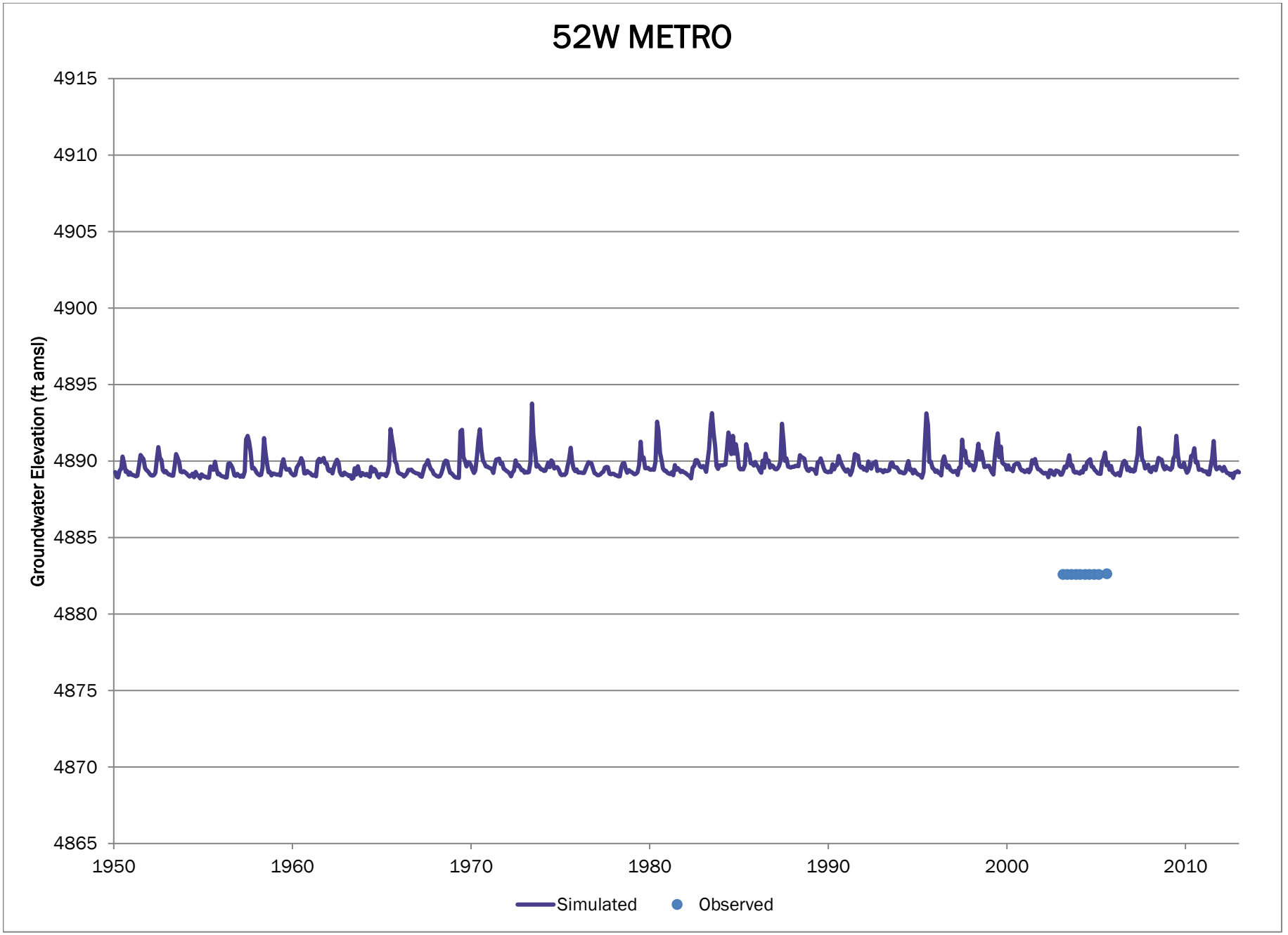

South Adams Area B MW2 SAC
Groundwater Elevation (ft amsl)
5065
5060
5055
5050
5045
5040
5035
5030
5025
5020
5015
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

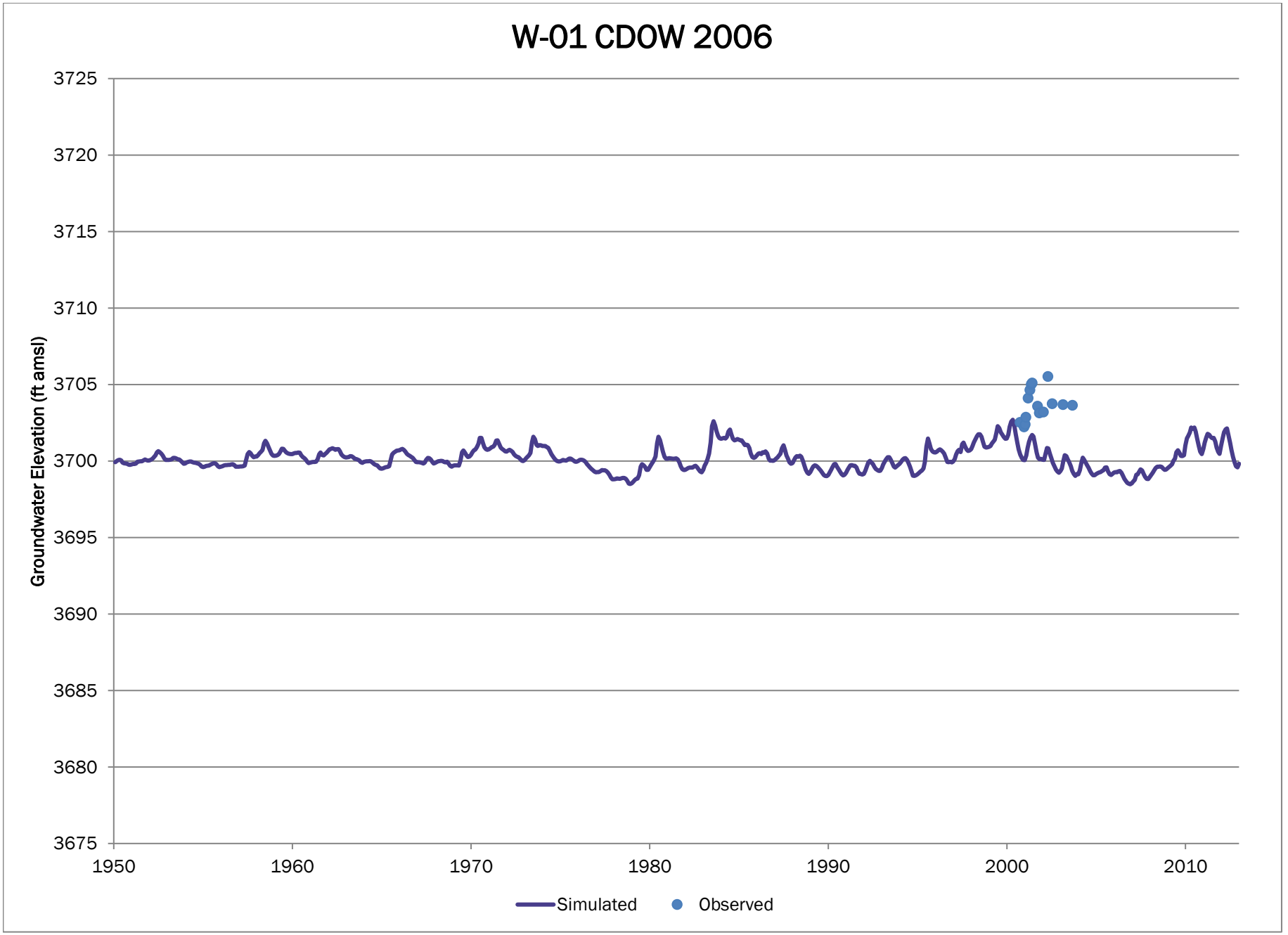

South Adams Area B MW11 SAC
Groundwater Elevation (ft amsl)
5060
5055
5050
5045
5040
5035
5030
5025
5020
5015
5010
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

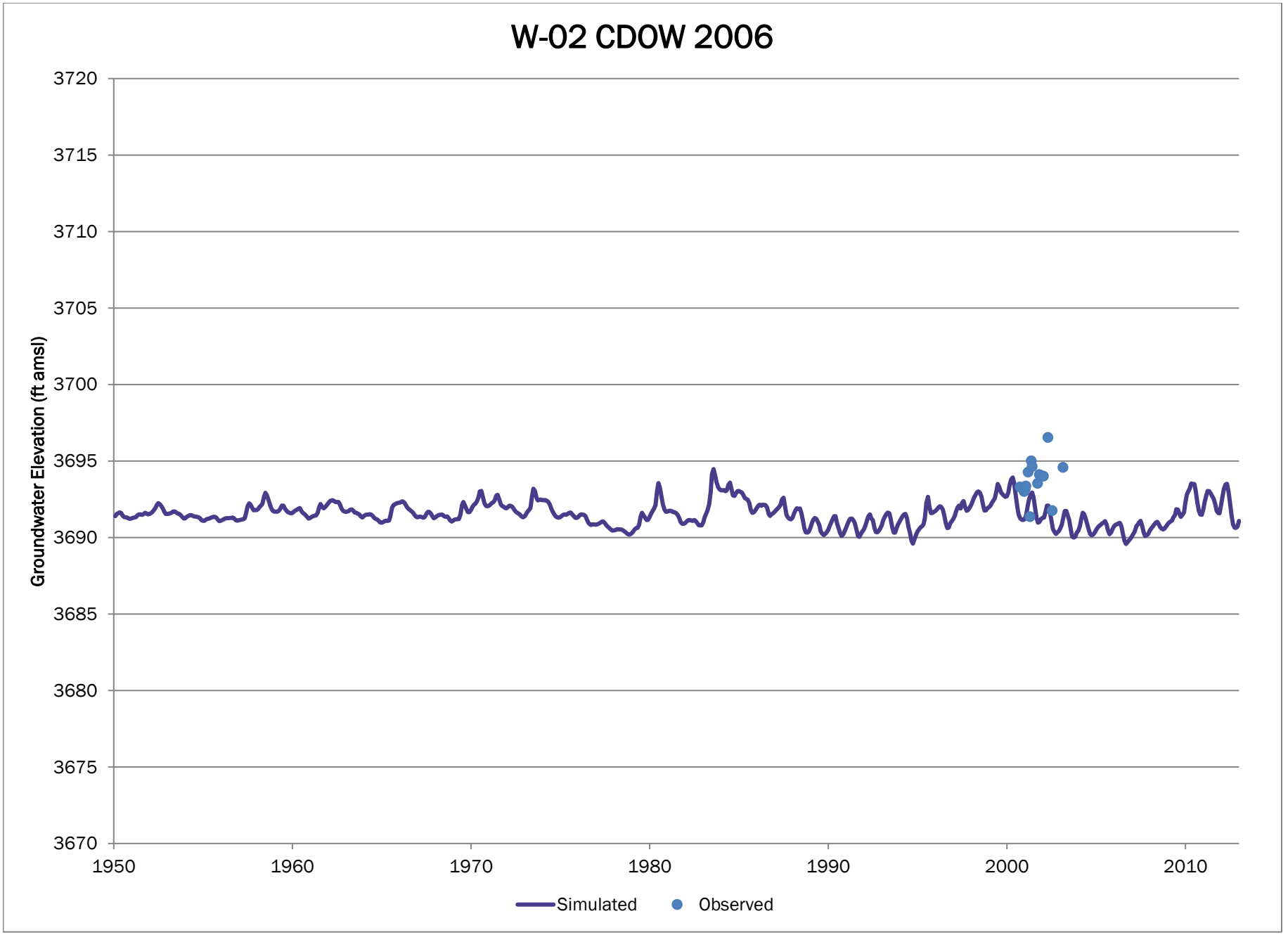

37350 ARSENAL
Groundwater Elevation (ft amsl)
5075
5070
5065
5060
5055
5050
5045
5040
5035
5030
5025
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

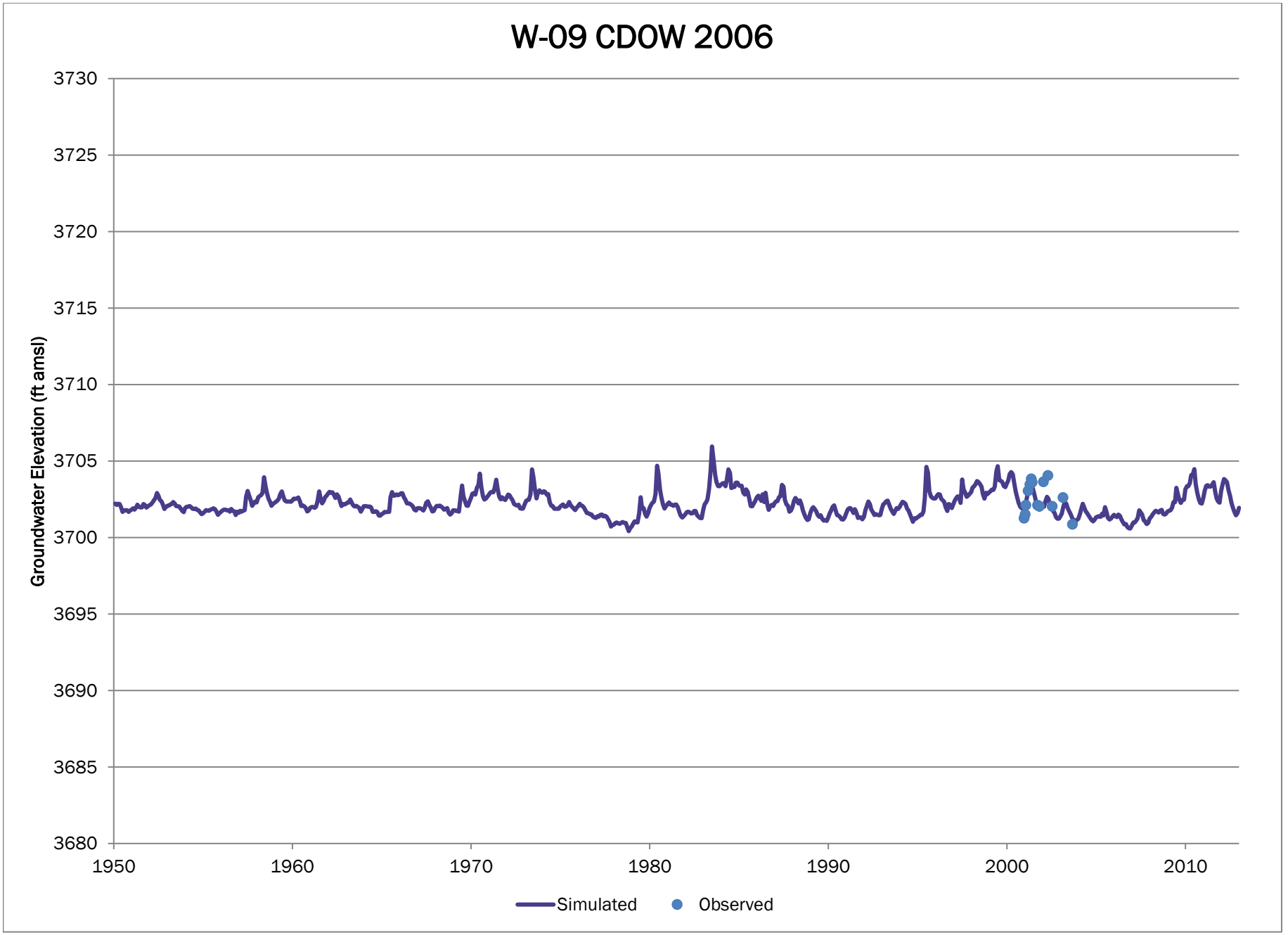

South Adams Area B MW17 SAC
Groundwater Elevation (ft amsl)
5070
5065
5060
5055
5050
5045
5040
5035
5030
5025
5020
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

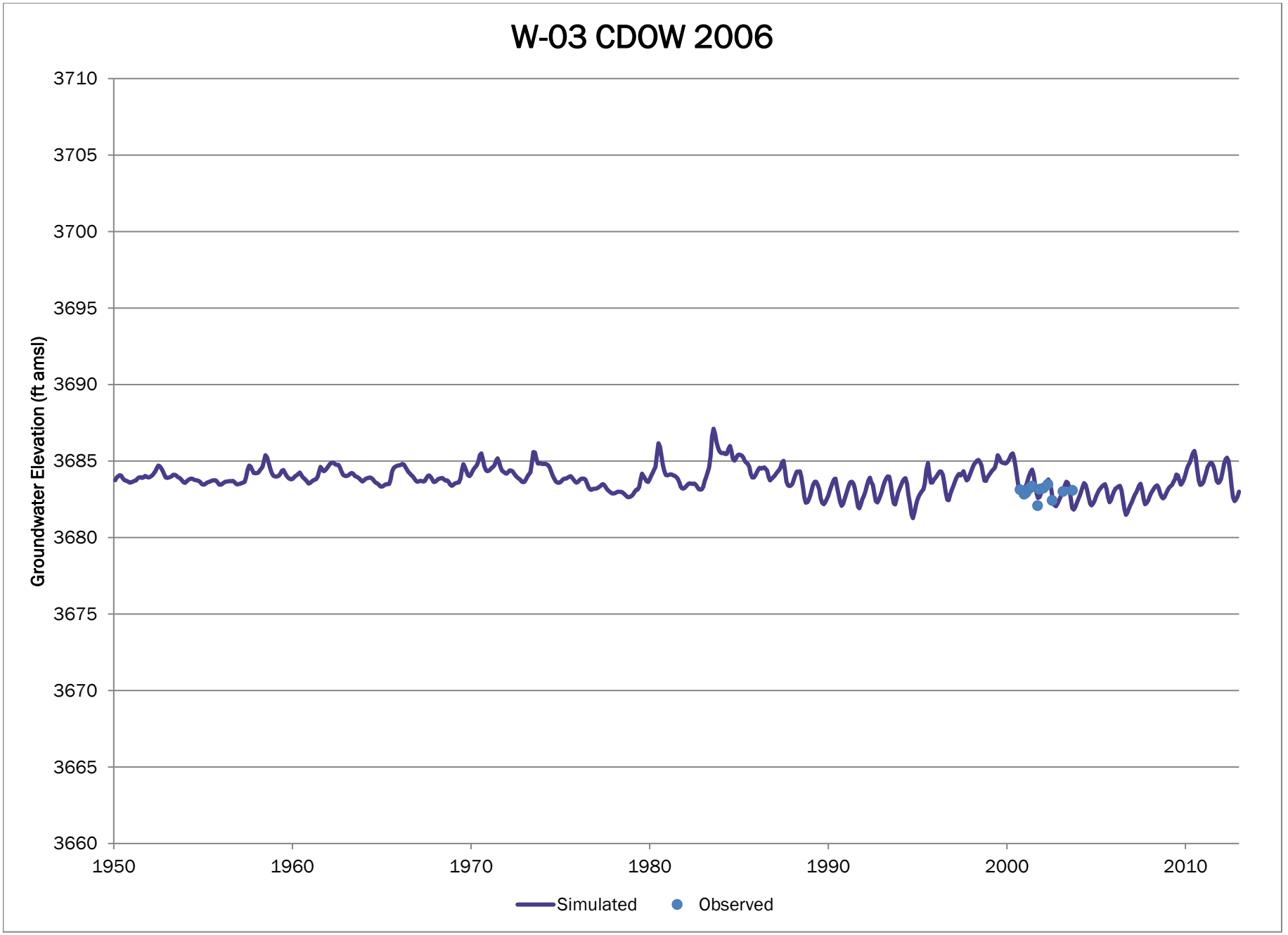

South Adams Area B MW10 SAC
Groundwater Elevation (ft amsl)
5060
5055
5050
5045
5040
5035
5030
5025
5020
5015
5010
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

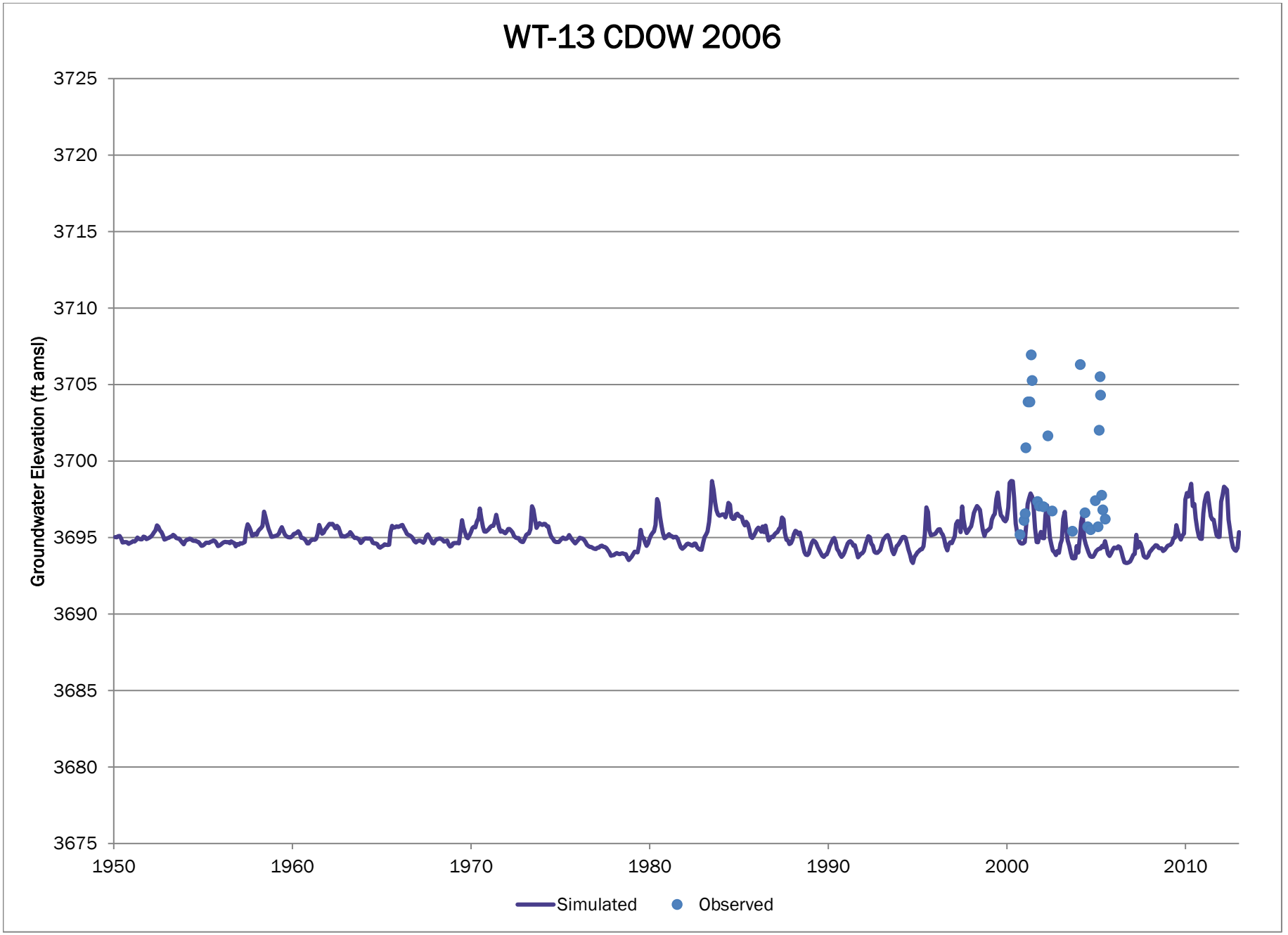

52W METRO
Groundwater Elevation (ft amsl)
4915
4910
4905
4900
4895
4890
4885
4880
4875
4870
4865
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

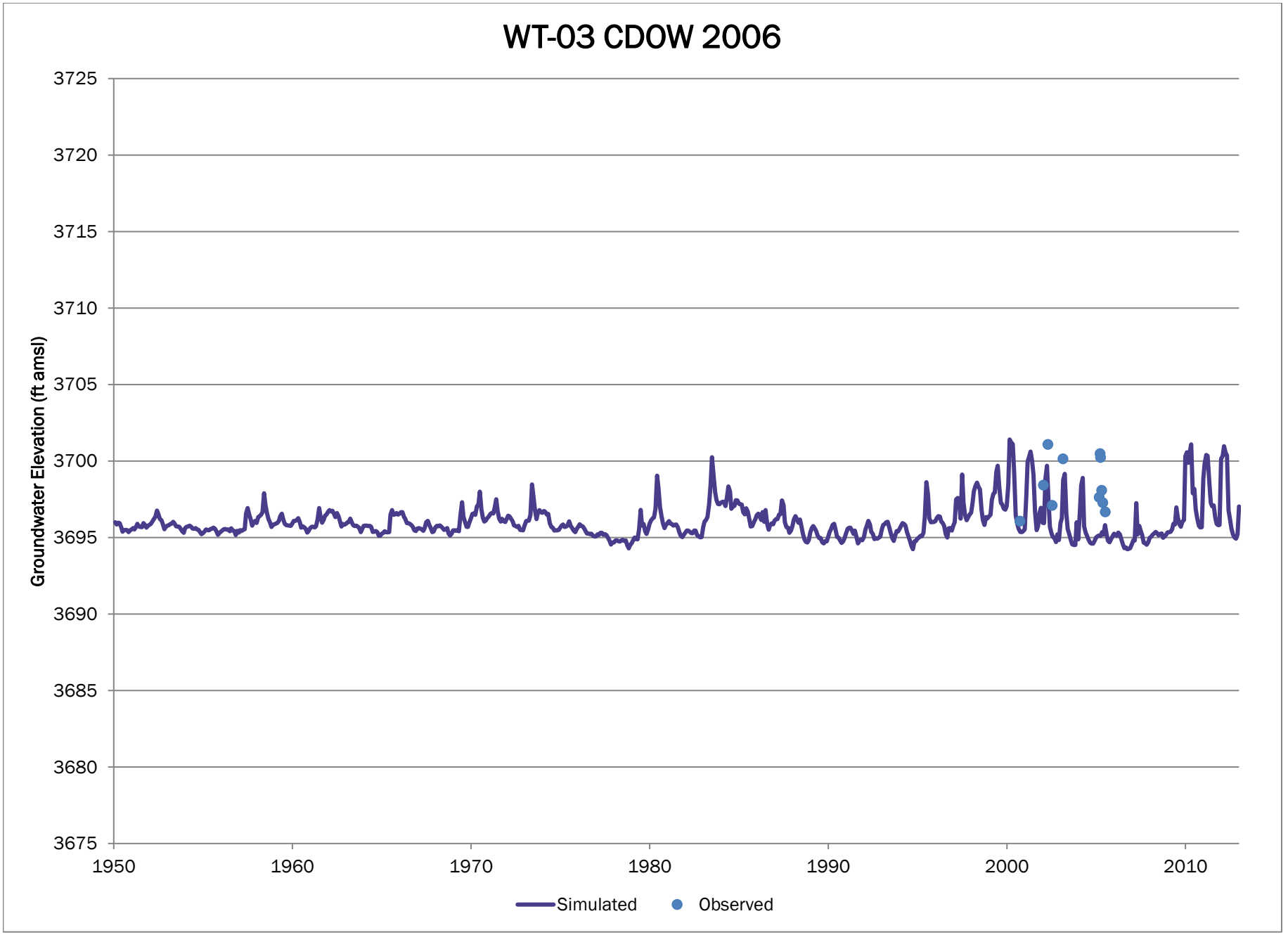

W-01 CDOW 2006
Groundwater Elevation (ft amsl)
3725
3720
3715
3710
3705
3700
3695
3690
3685
3680
3675
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

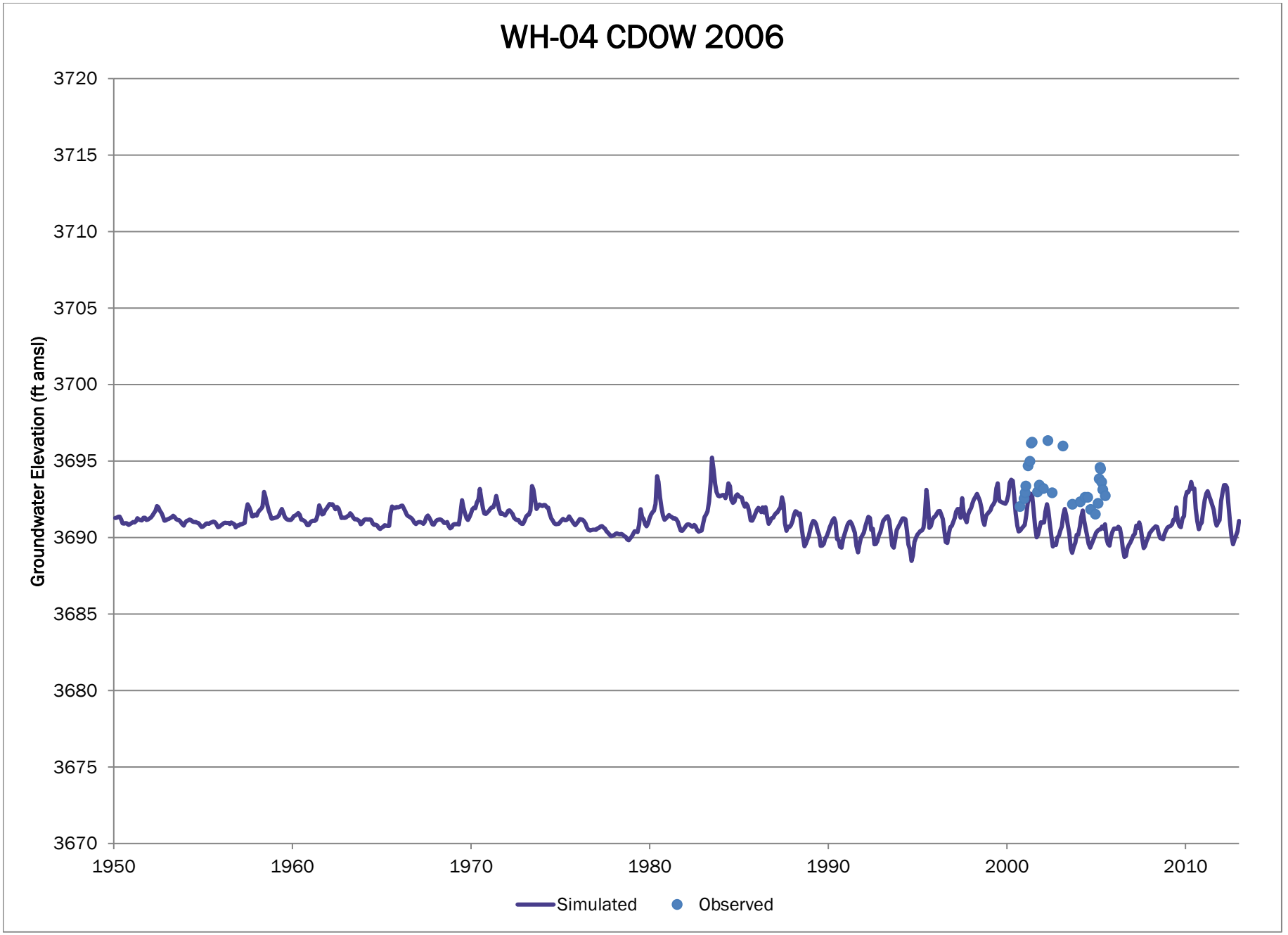

W-02 CDOW 2006
Groundwater Elevation (ft amsl)
3720
3715
3710
3705
3700
3695
3690
3685
3680
3675
3670
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

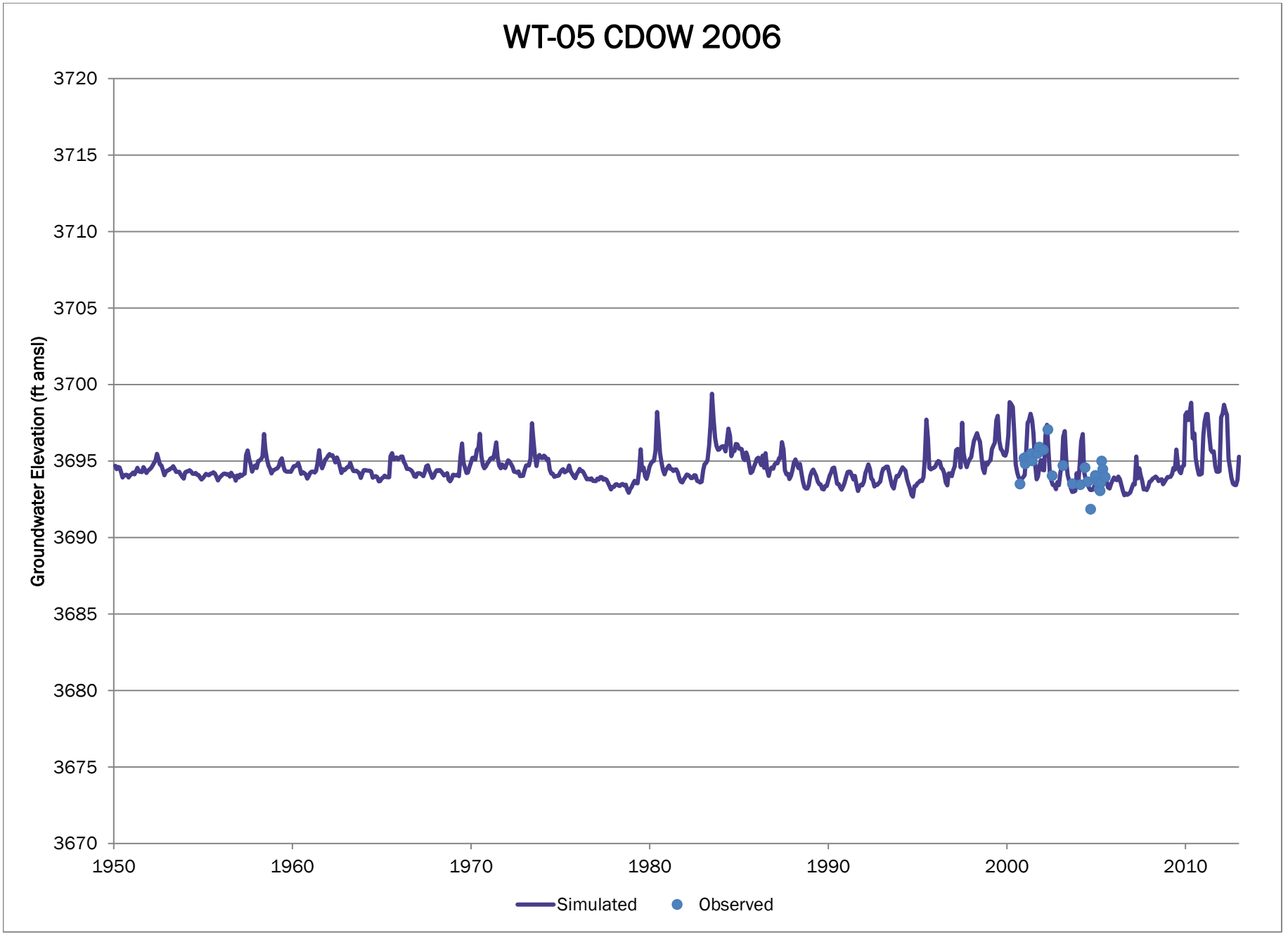

W-09 CDOW 2006
Groundwater Elevation (ft amsl)
3730
3725
3720
3715
3710
3705
3700
3695
3690
3685
3680
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

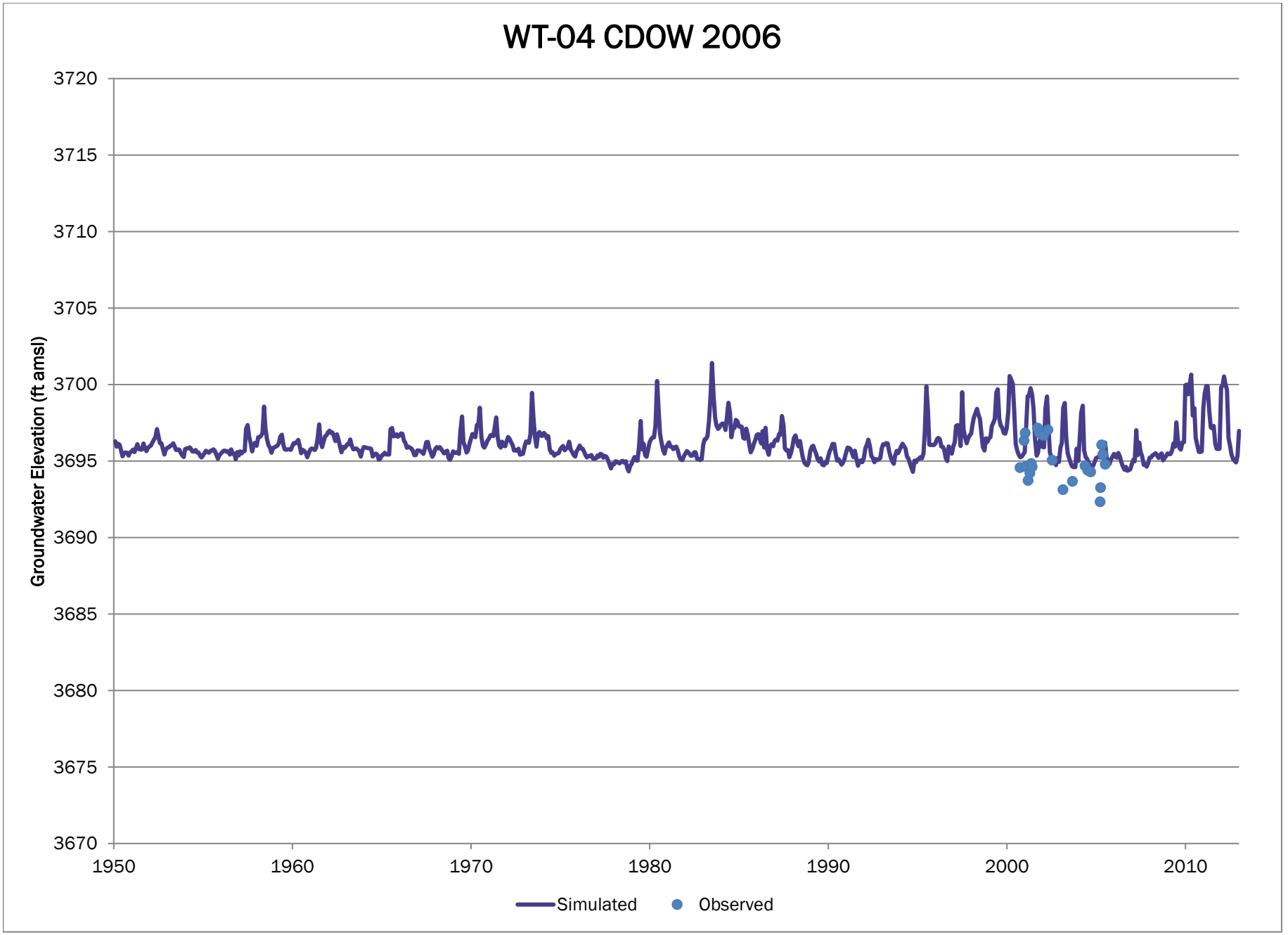

W-03 CDOW 2006
Groundwater Elevation (ft amsl)
3710
3705
3700
3695
3690
3685
3680
3675
3670
3665
3660
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

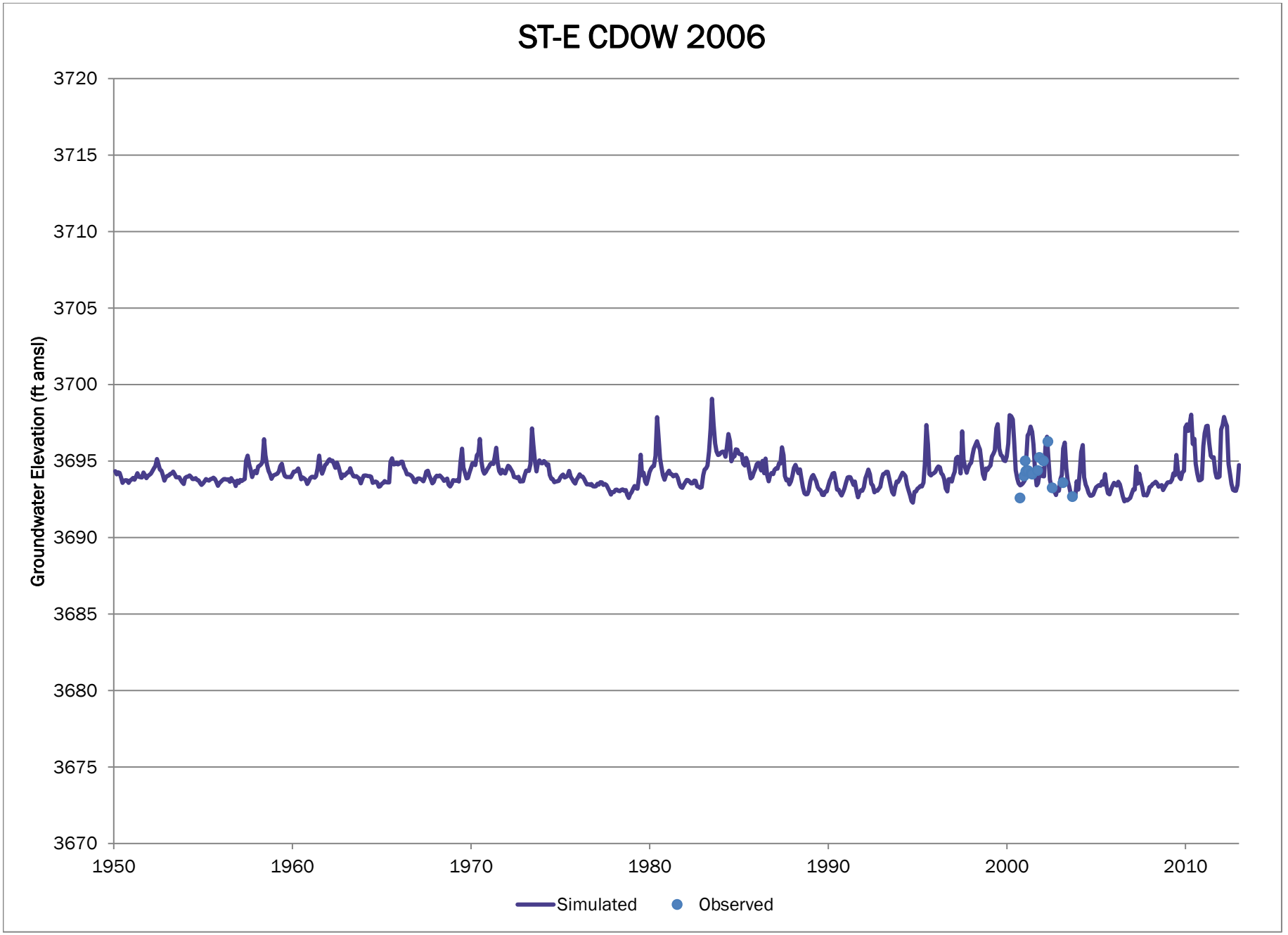

WT-13 CDOW 2006
Groundwater Elevation (ft amsl)
3725
3720
3715
3710
3705
3700
3695
3690
3685
3680
3675
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

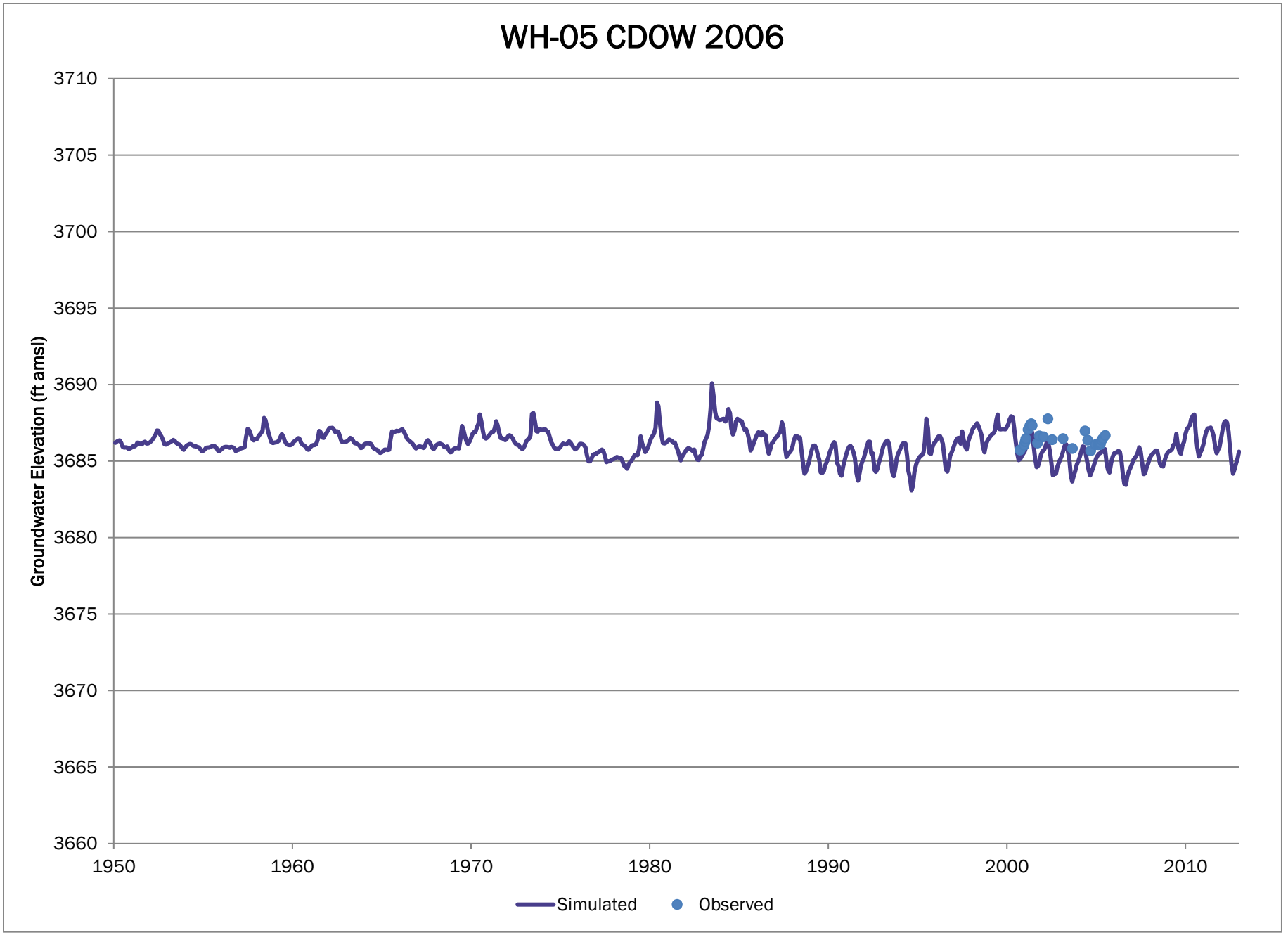

WT-03 CDOW 2006
Groundwater Elevation (ft amsl)
3725
3720
3715
3710
3705
3700
3695
3690
3685
3680
3675
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

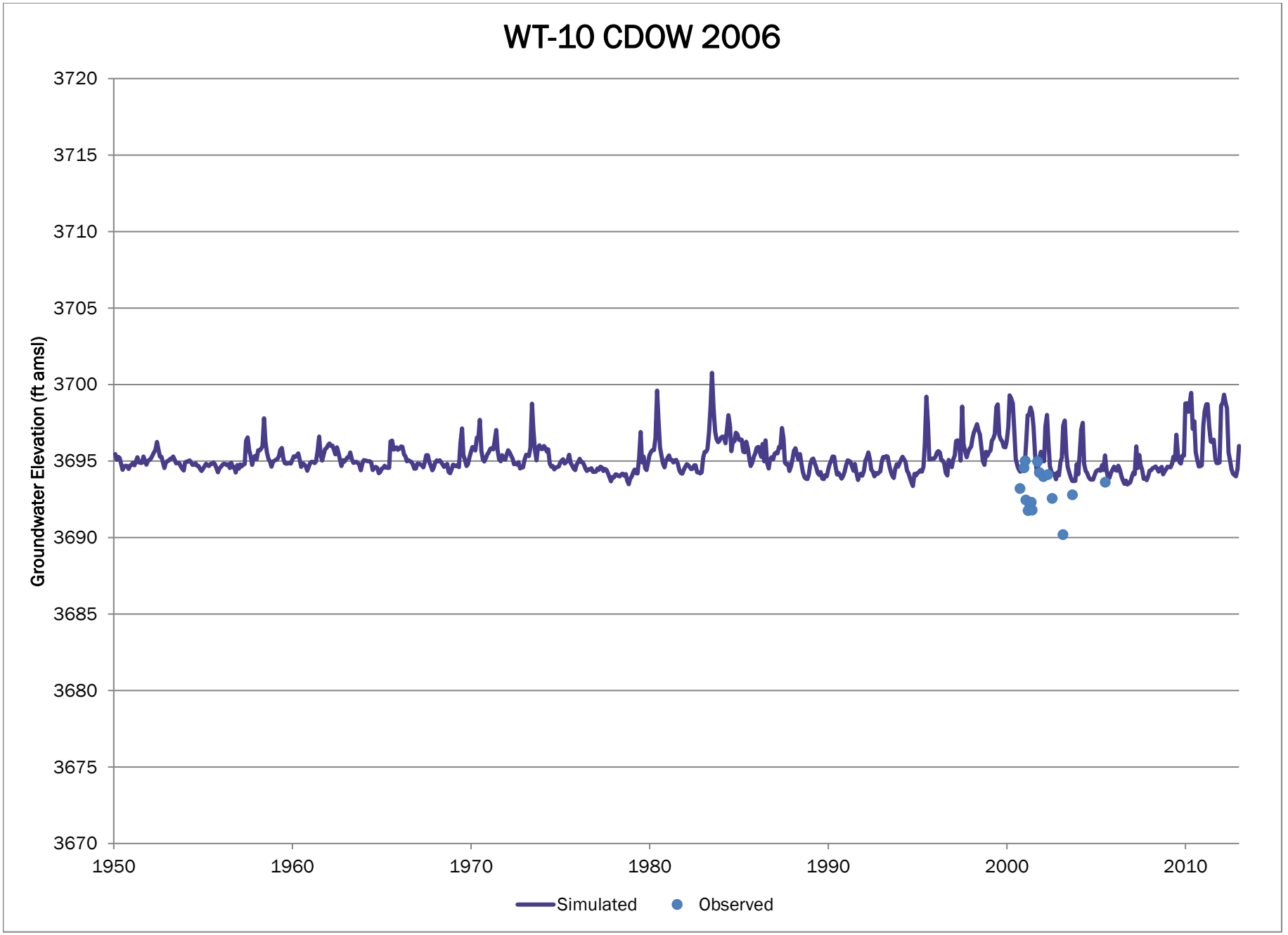

WH-04 CDOW 2006
Groundwater Elevation (ft amsl)
3720
3715
3710
3705
3700
3695
3690
3685
3680
3675
3670
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

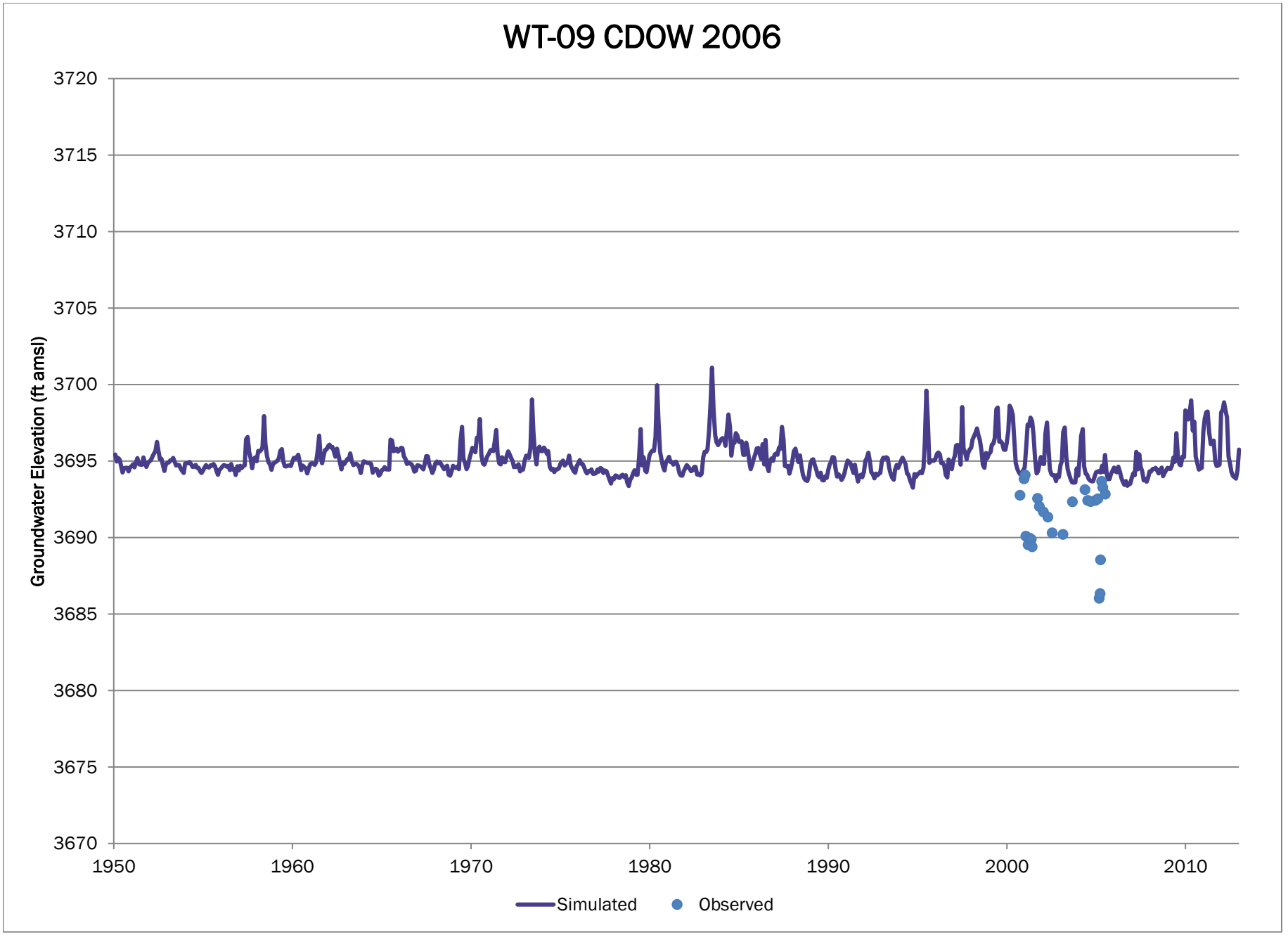

WT-05 CDOW 2006
Groundwater Elevation (ft amsl)
3720
3715
3710
3705
3700
3695
3690
3685
3680
3675
3670
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

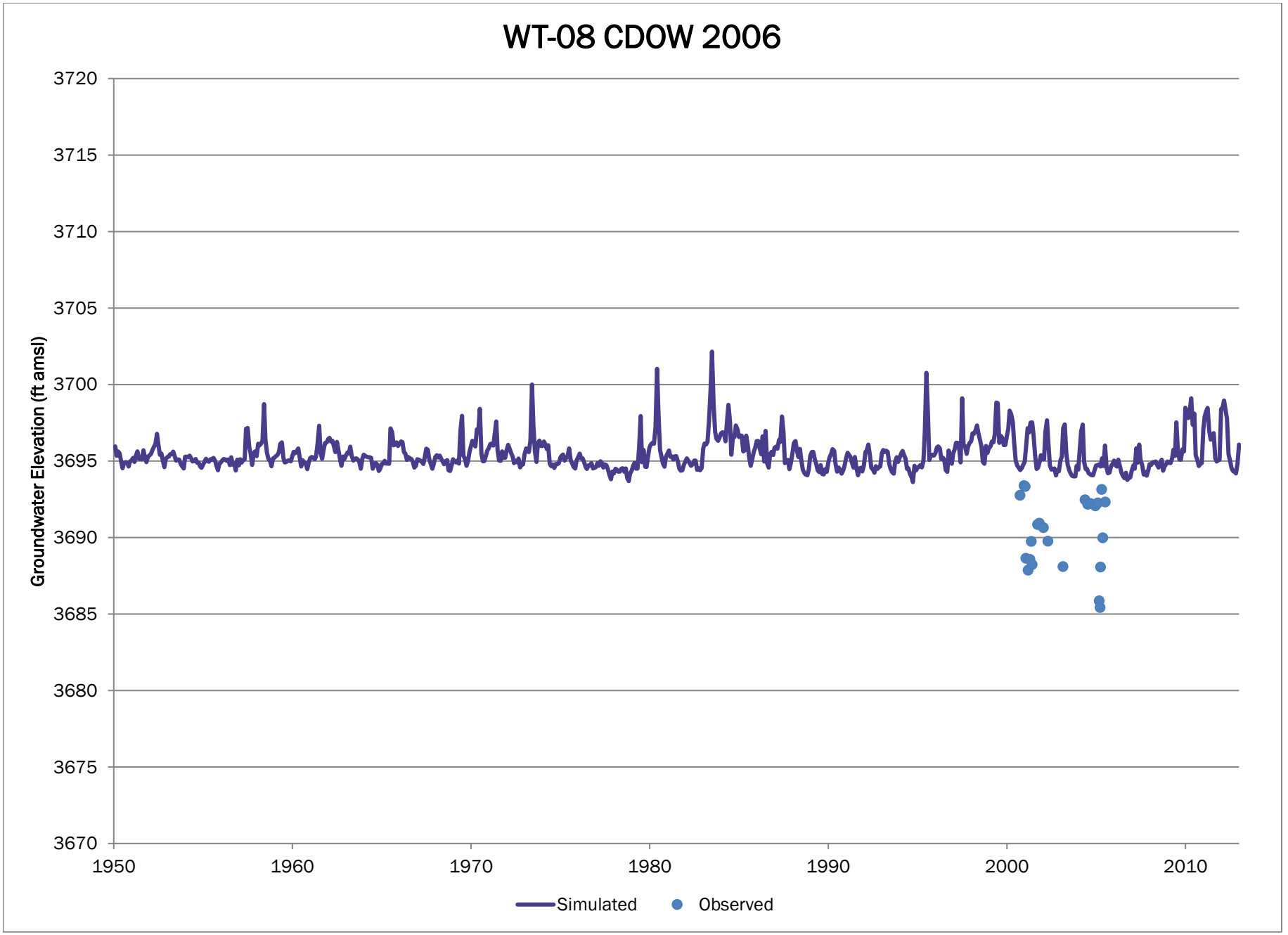

WT-04 CDOW 2006
Groundwater Elevation (ft amsl)
3720
3715
3710
3705
3700
3695
3690
3685
3680
3675
3670
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

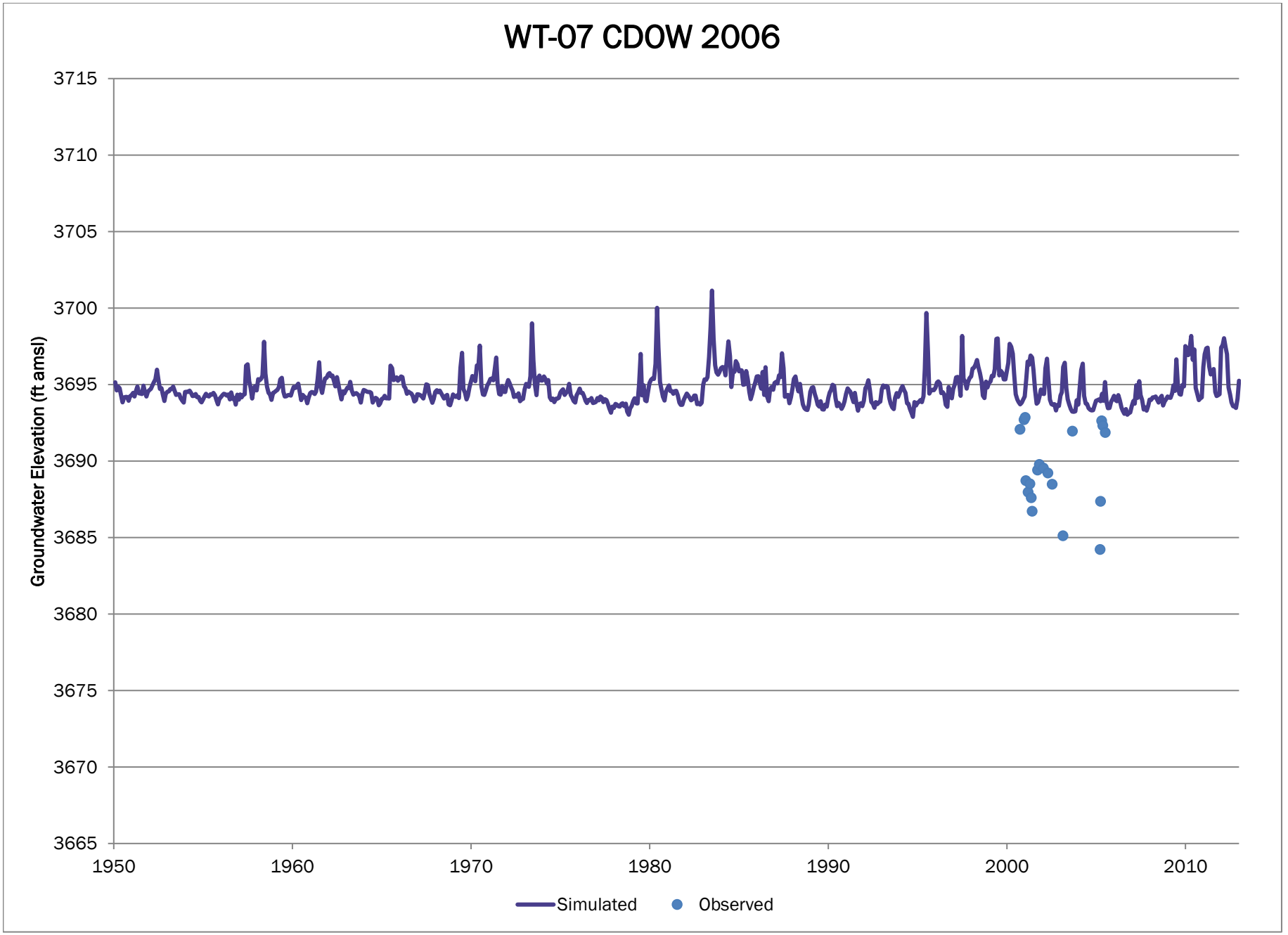

ST-E CDOW 2006
Groundwater Elevation (ft amsl)
3720
3715
3710
3705
3700
3695
3690
3685
3680
3675
3670
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

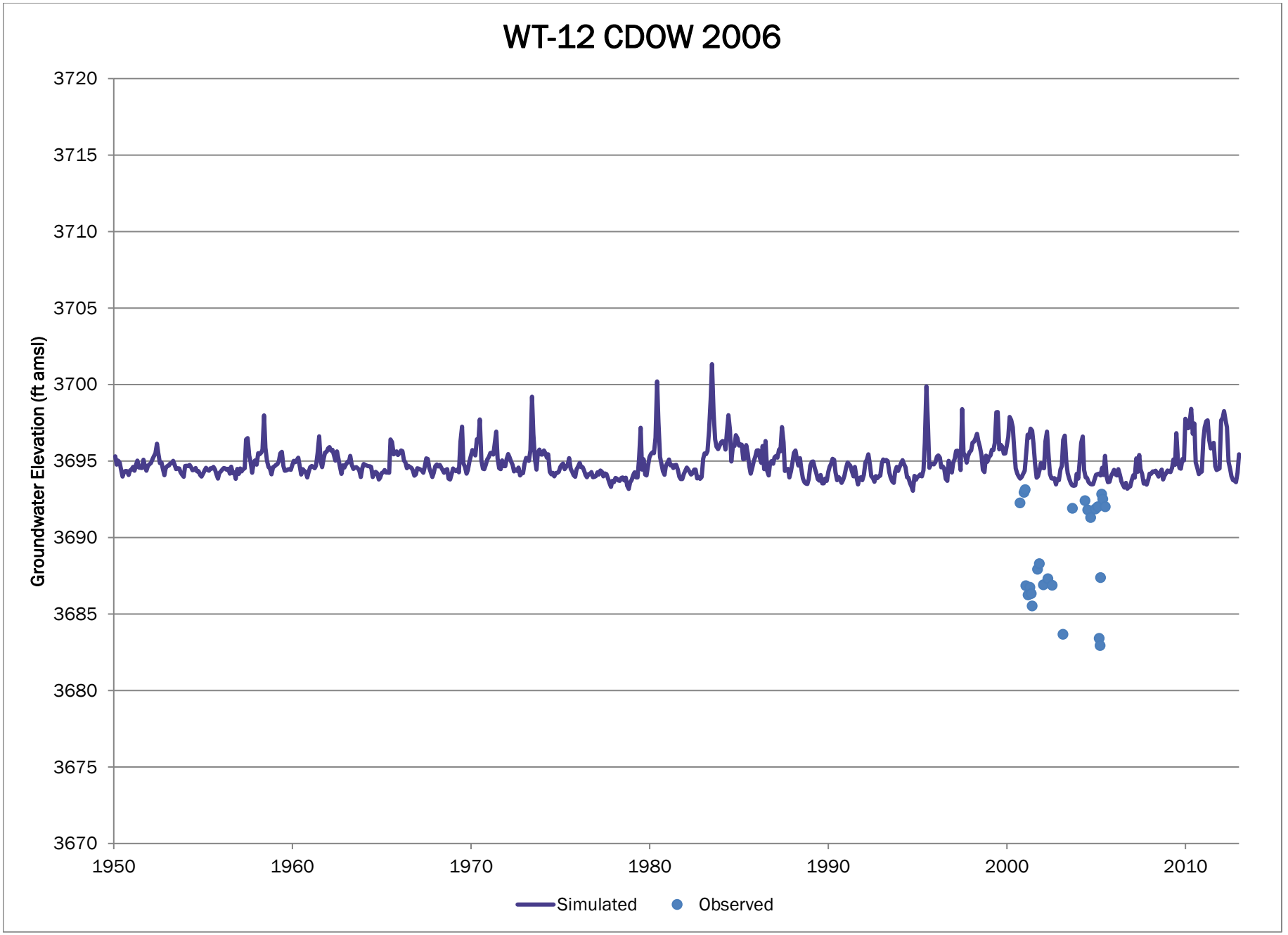

WH-05 CDOW 2006
Groundwater Elevation (ft amsl)
3710
3705
3700
3695
3690
3685
3680
3675
3670
3665
3660
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

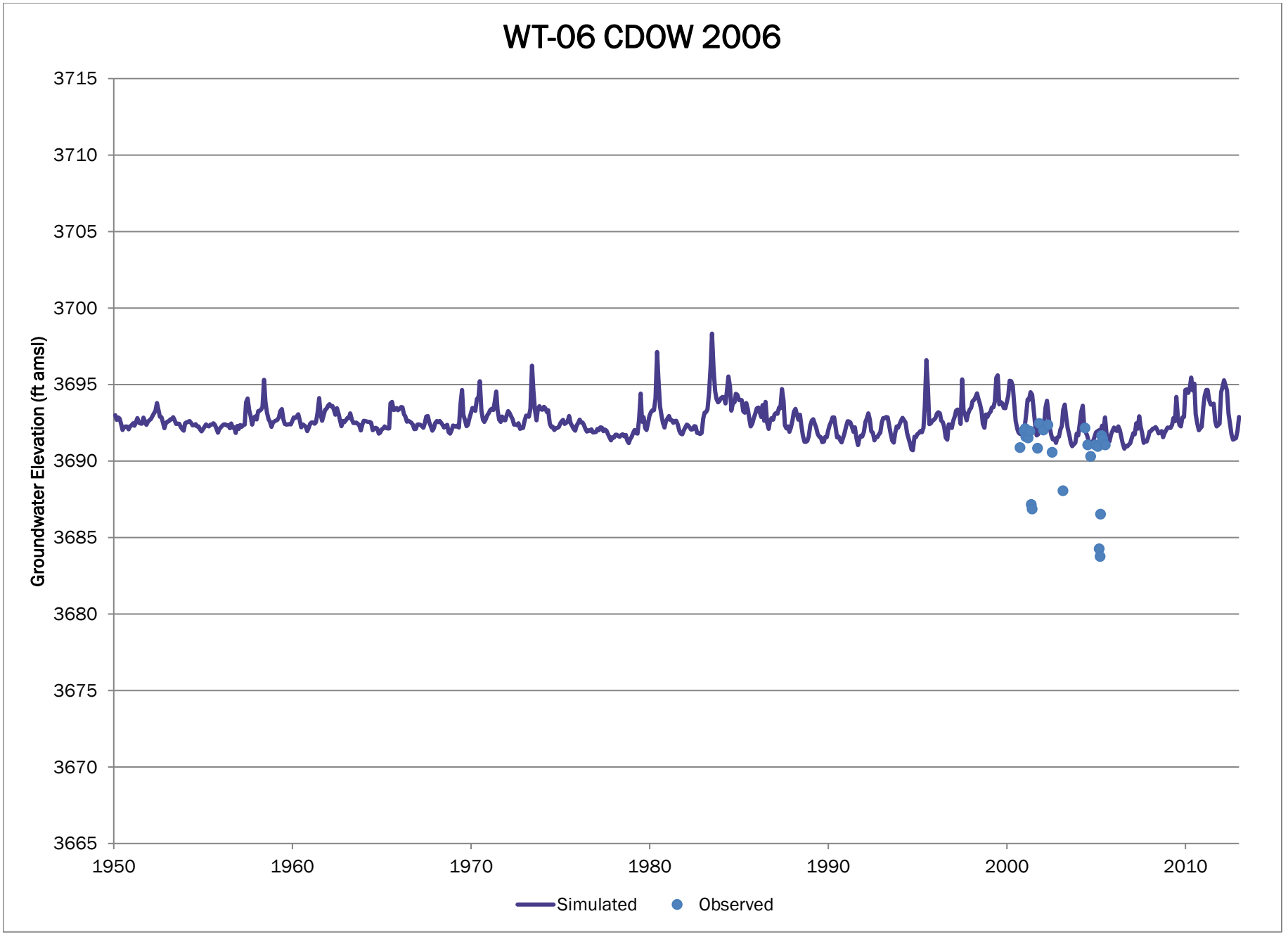

WT-10 CDOW 2006
Groundwater Elevation (ft amsl)
3720
3715
3710
3705
3700
3695
3690
3685
3680
3675
3670
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

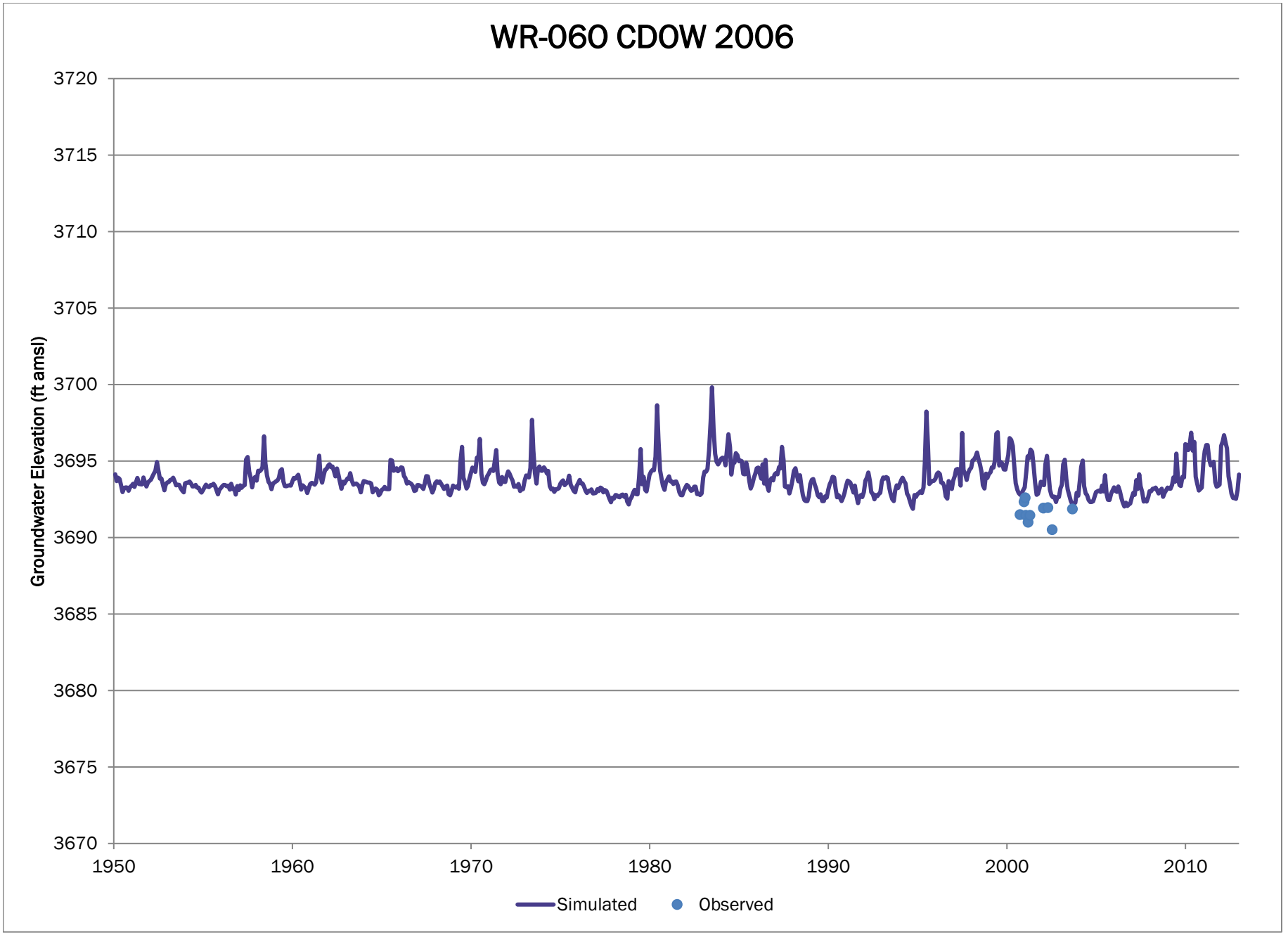

WT-09 CDOW 2006
Groundwater Elevation (ft amsl)
3720
3715
3710
3705
3700
3695
3690
3685
3680
3675
3670
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

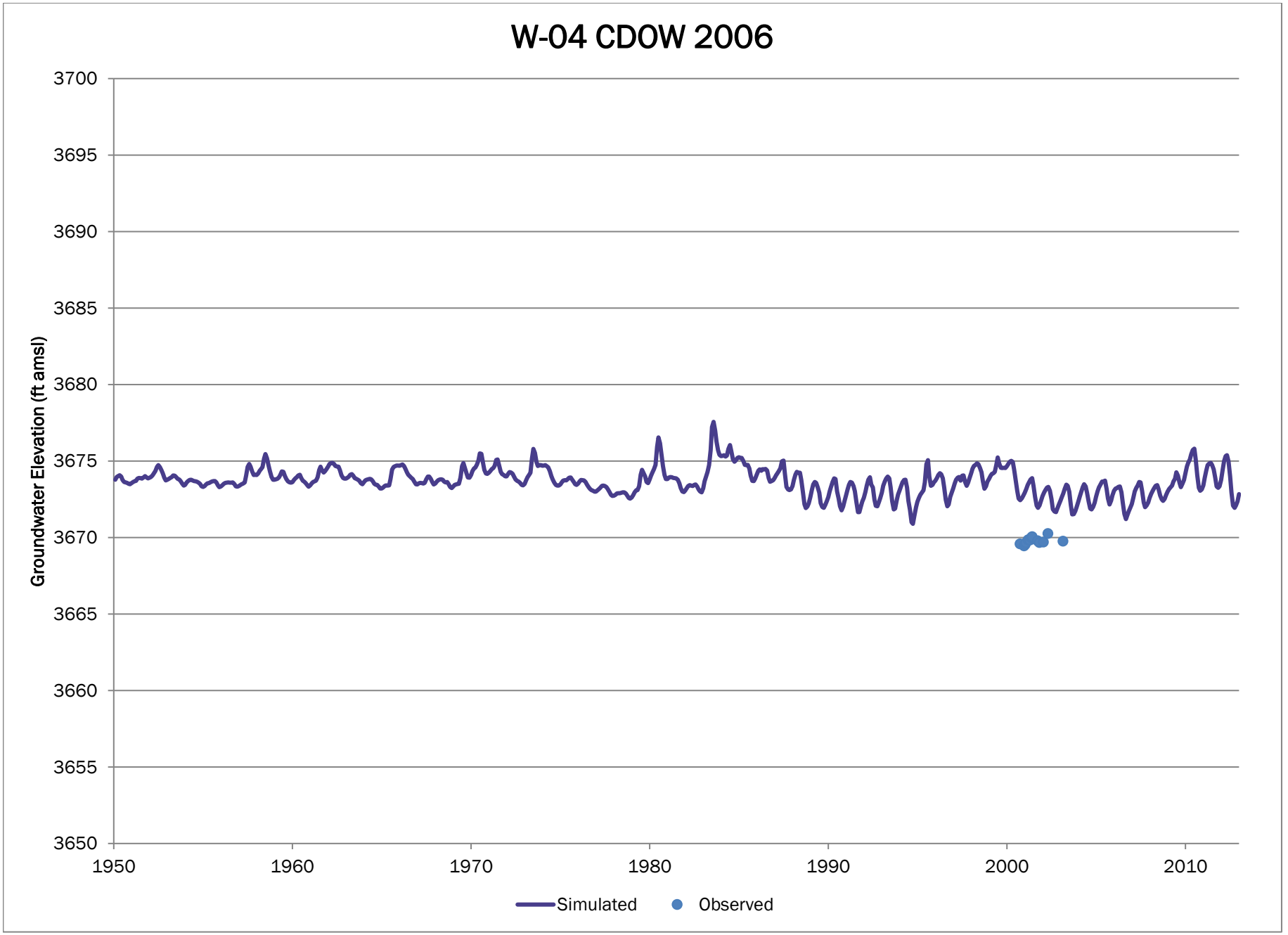

WT-08 CDOW 2006
Groundwater Elevation (ft amsl)
3720
3715
3710
3705
3700
3695
3690
3685
3680
3675
3670
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

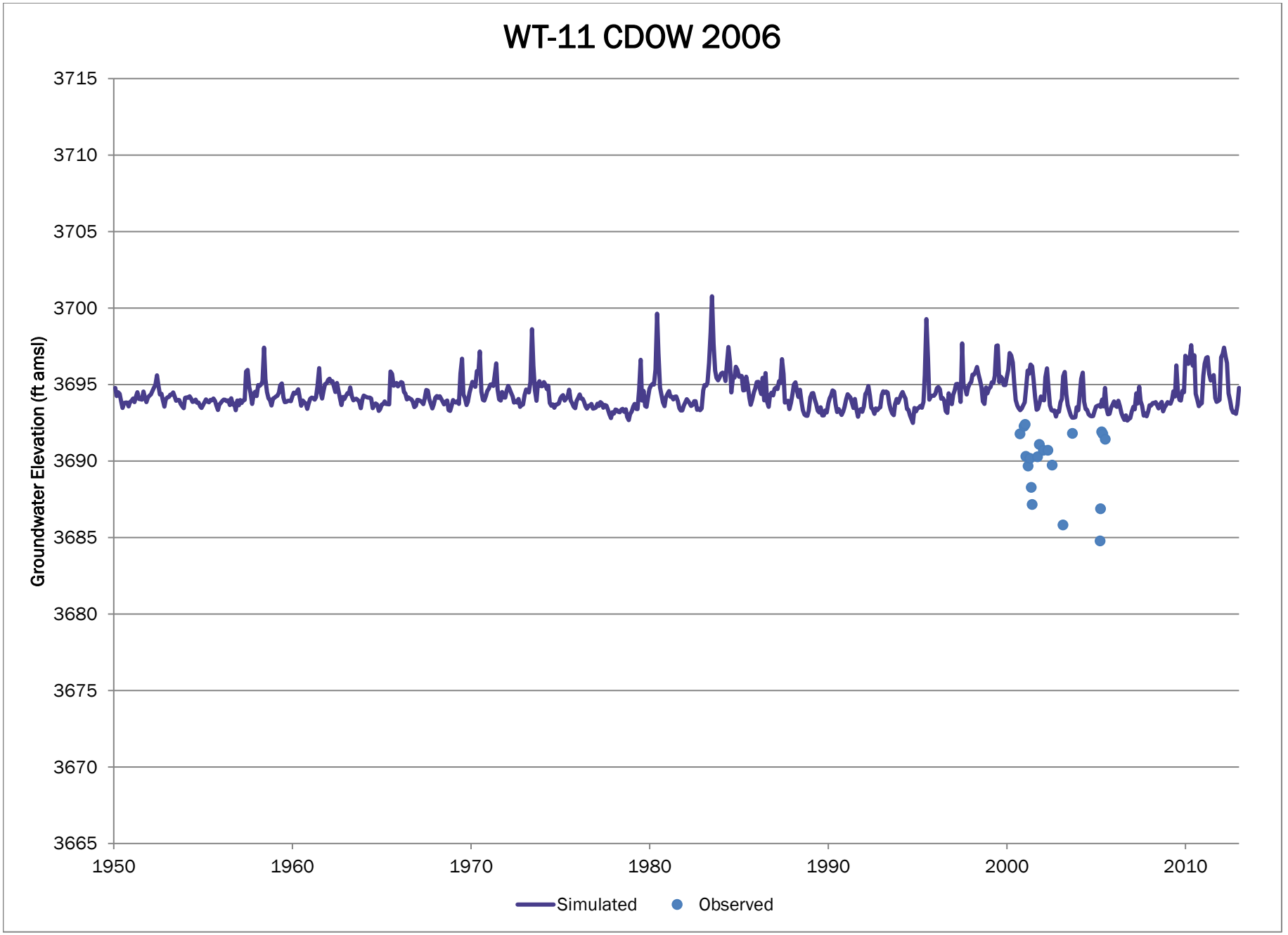

WT-07 CDOW 2006
Groundwater Elevation (ft amsl)
3715
3710
3705
3700
3695
3690
3685
3680
3675
3670
3665
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

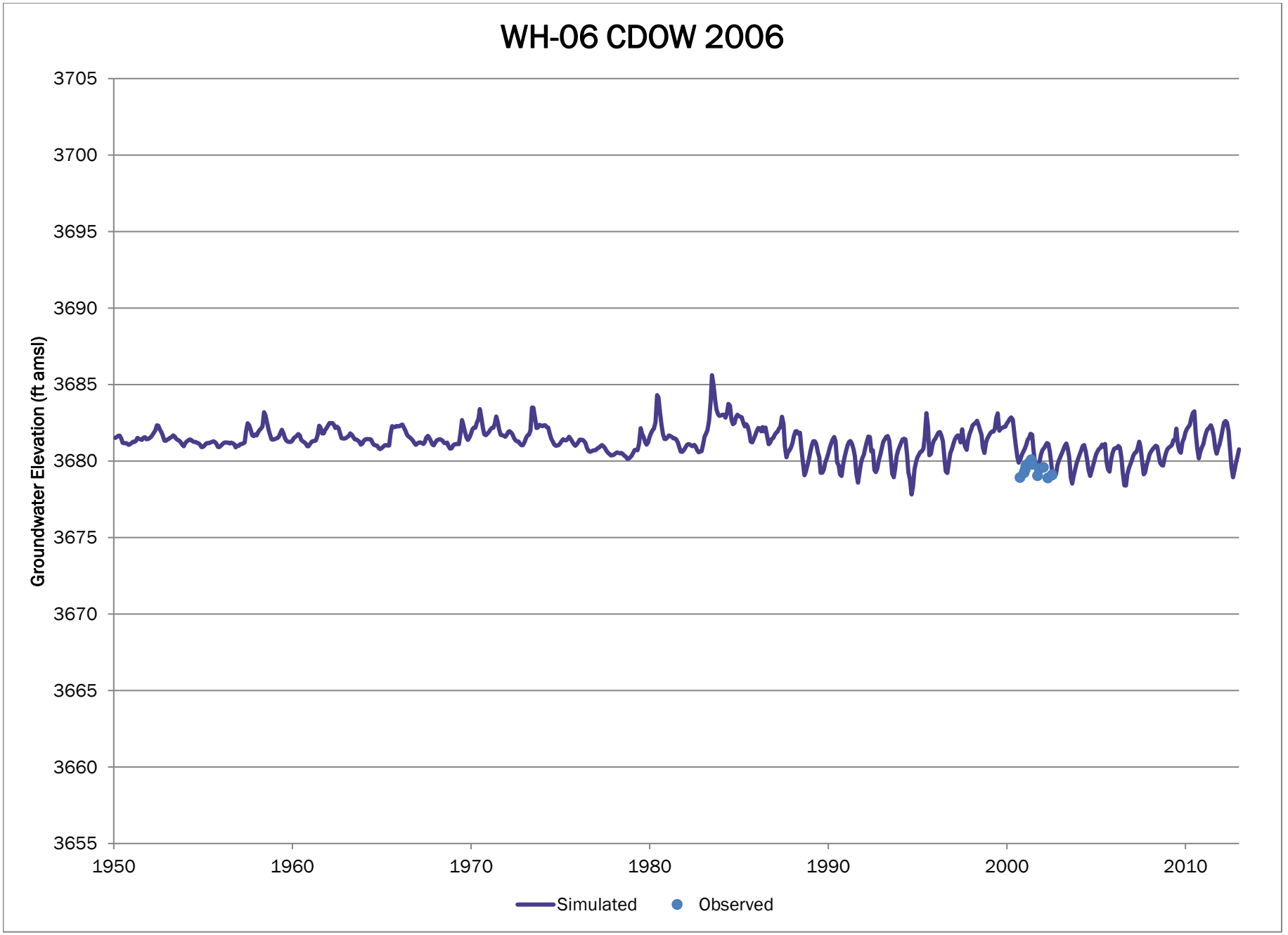

WT-12 CDOW 2006
Groundwater Elevation (ft amsl)
3720
3715
3710
3705
3700
3695
3690
3685
3680
3675
3670
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

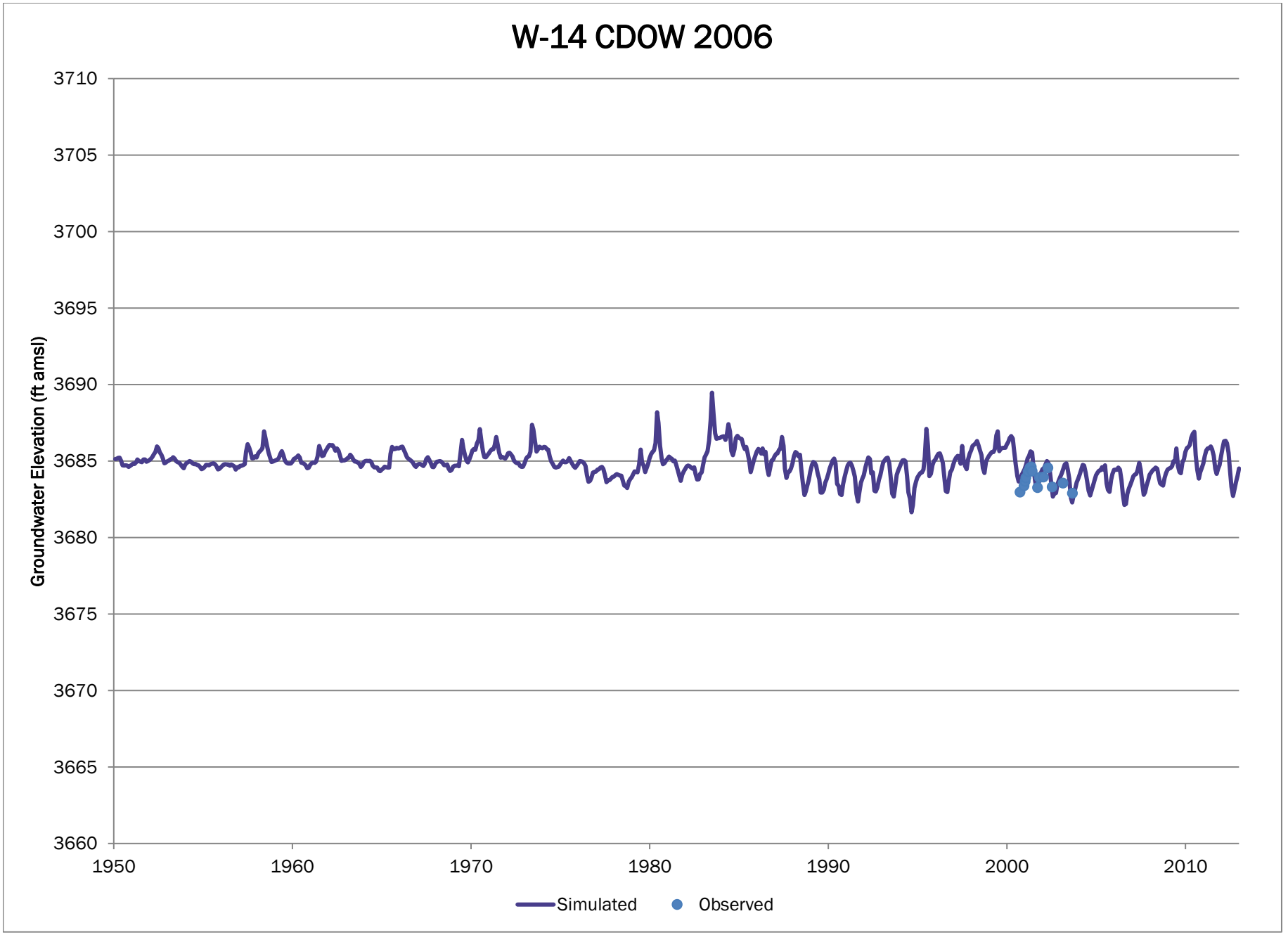

WT-06 CDOW 2006
Groundwater Elevation (ft amsl)
3715
3710
3705
3700
3695
3690
3685
3680
3675
3670
3665
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

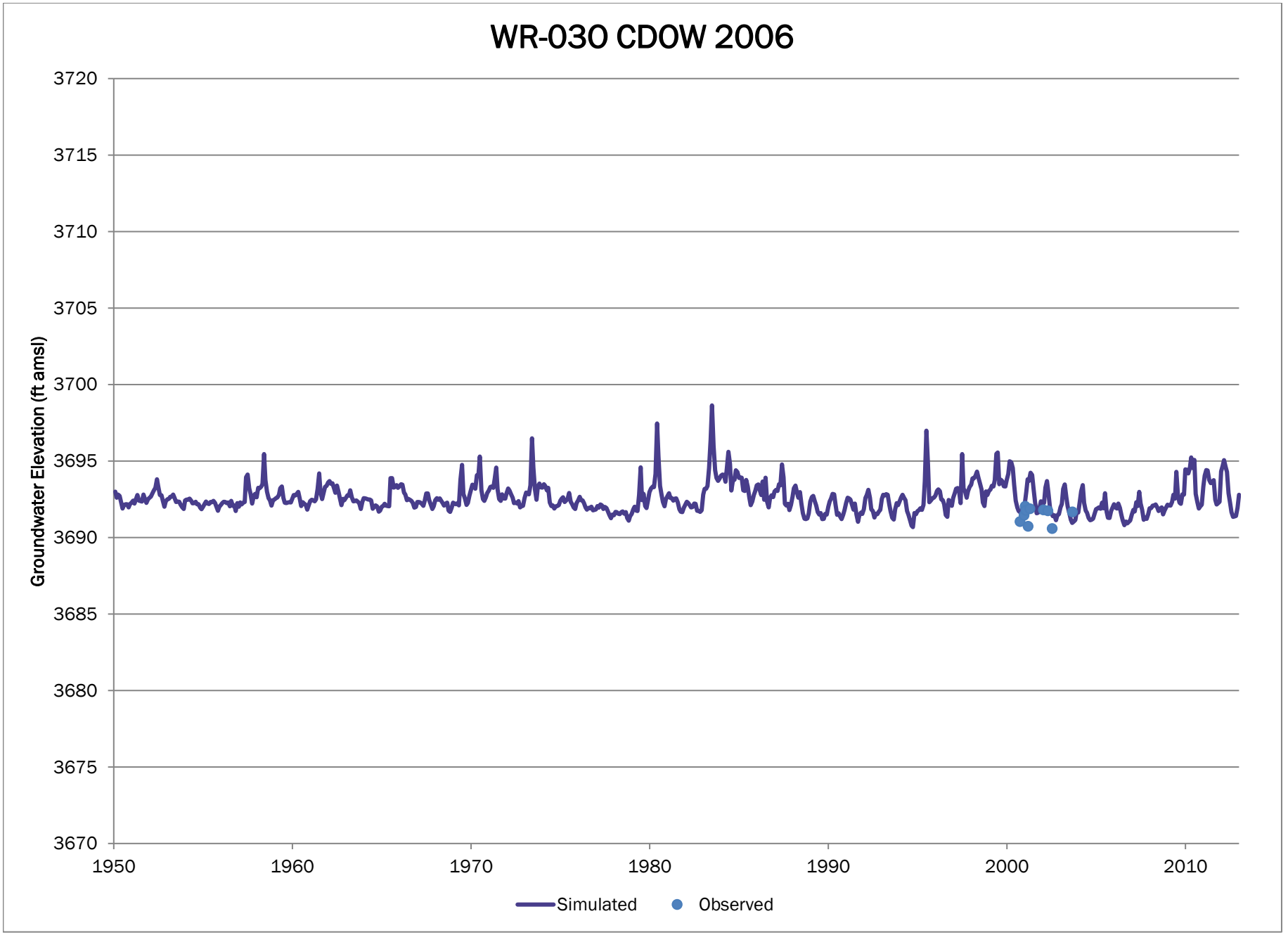

WR-060 CDOW 2006
Groundwater Elevation (ft amsl)
3720
3715
3710
3705
3700
3695
3690
3685
3680
3675
3670
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

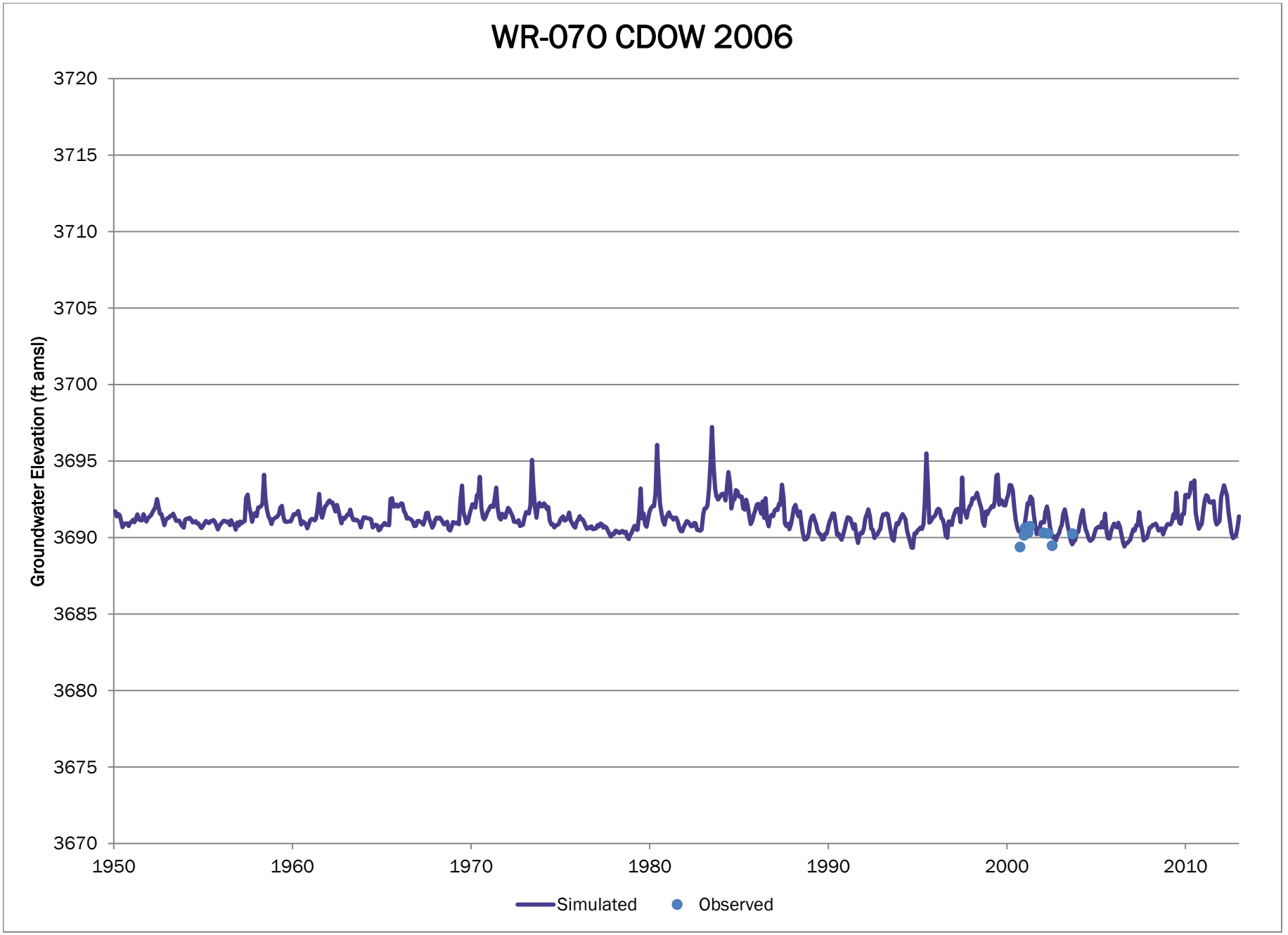

W-04 CDOW 2006
Groundwater Elevation (ft amsl)
3700
3695
3690
3685
3680
3675
3670
3665
3660
3655
3650
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

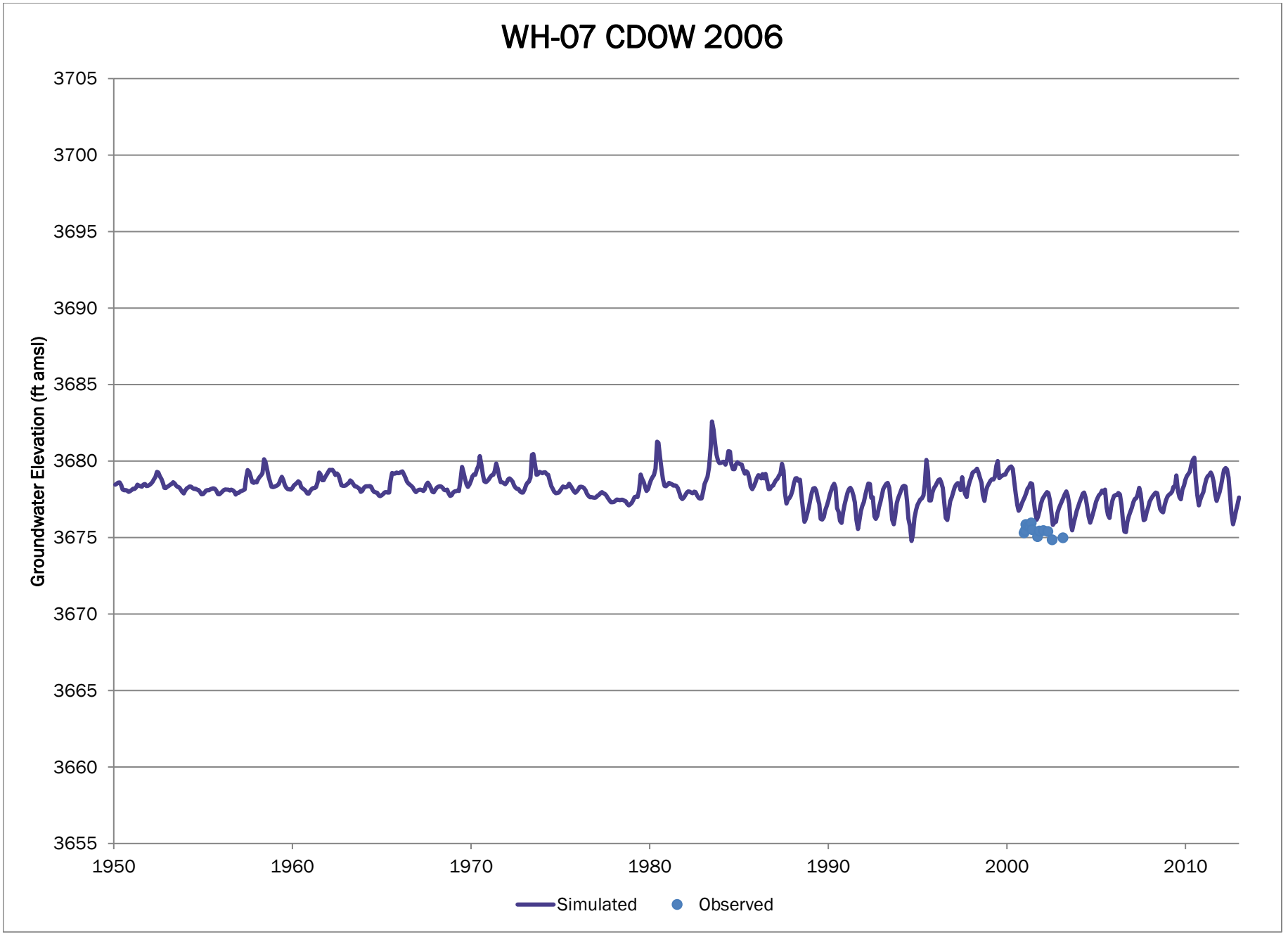

WT-11 CDOW 2006
Groundwater Elevation (ft amsl)
3715
3710
3705
3700
3695
3690
3685
3680
3675
3670
3665
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

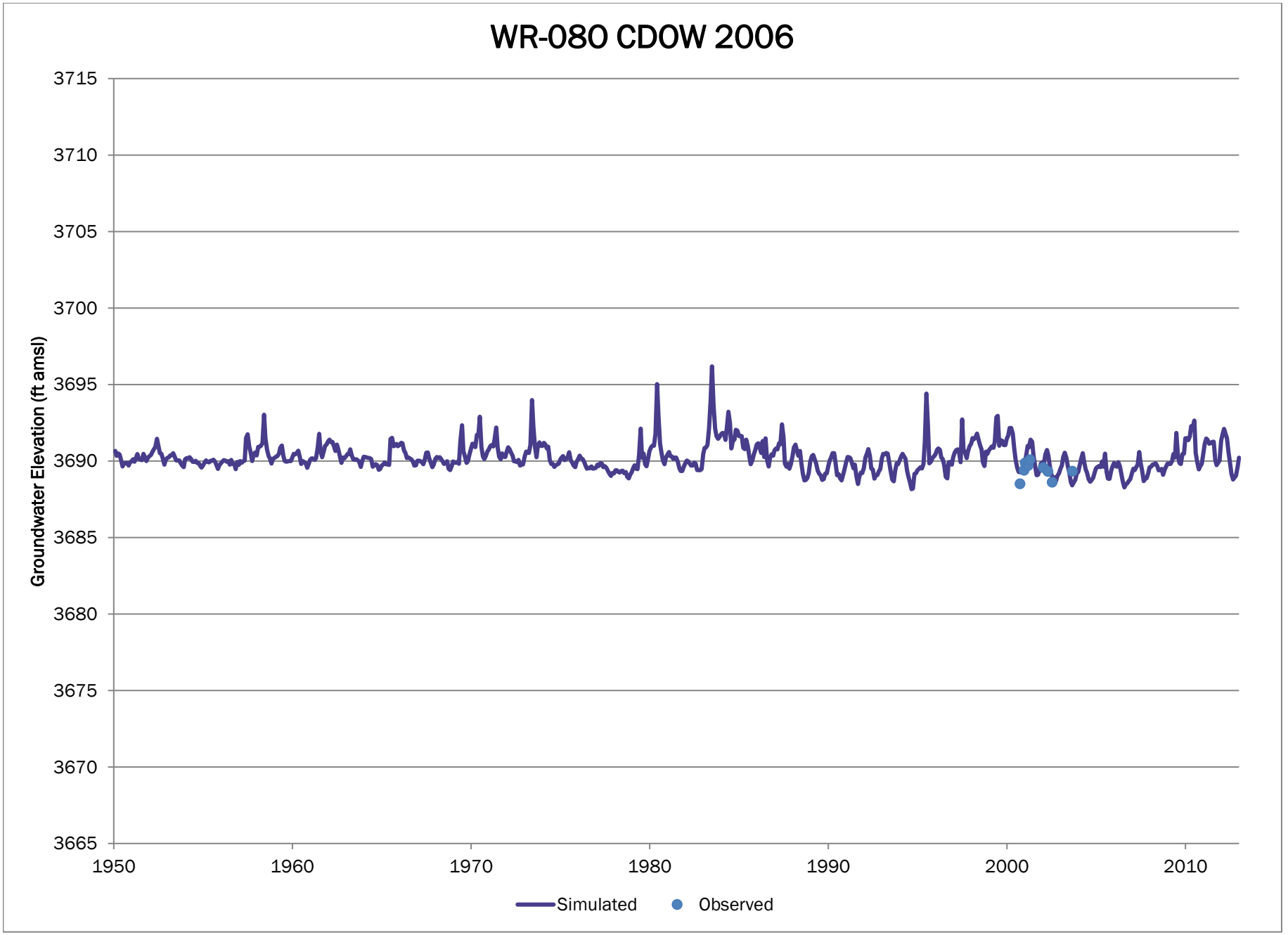

WH-06 CDOW 2006
Groundwater Elevation (ft amsl)
3705
3700
3695
3690
3685
3680
3675
3670
3665
3660
3655
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

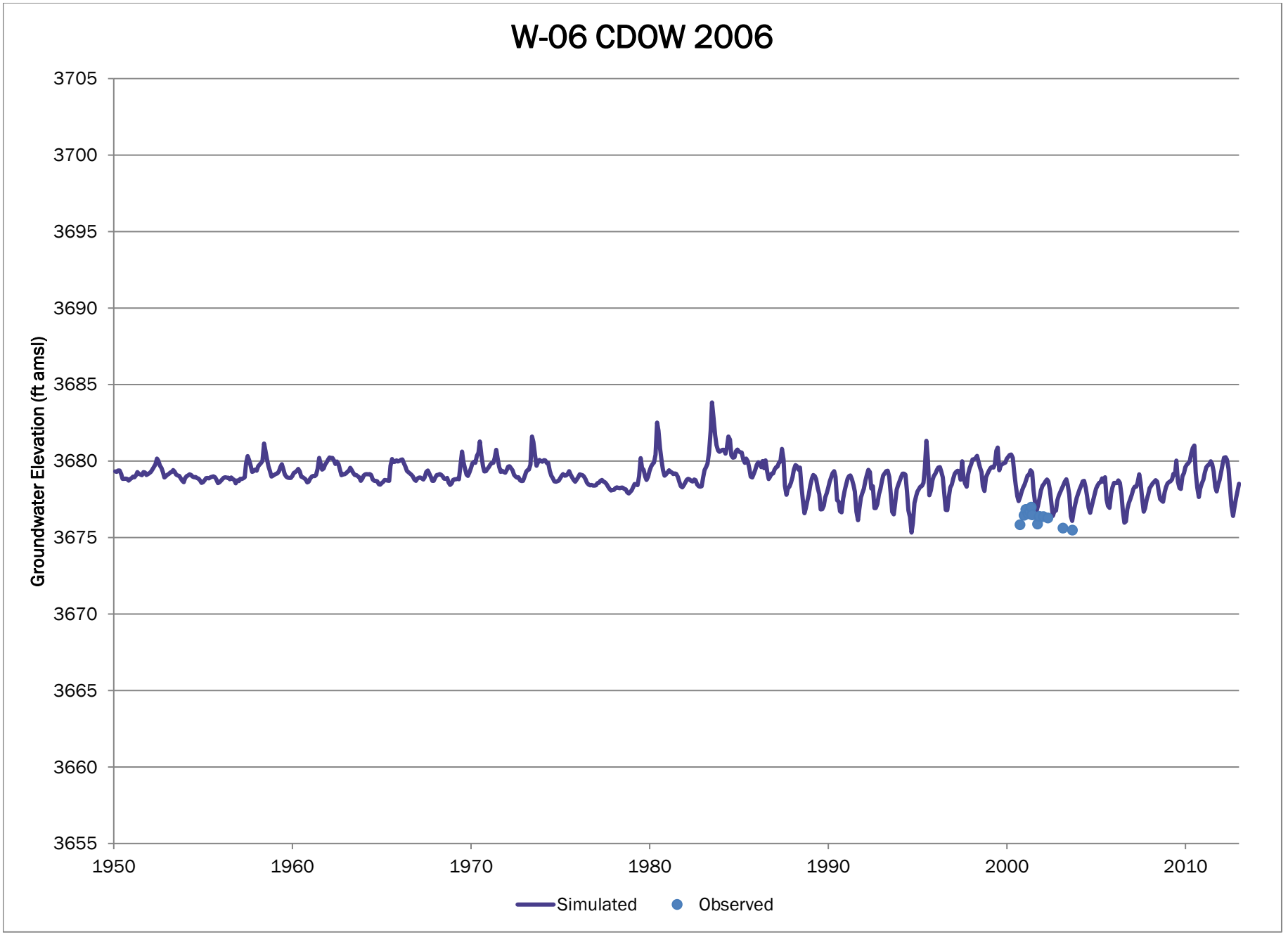

W-14 CDOW 2006
Groundwater Elevation (ft amsl)
3710
3705
3700
3695
3690
3685
3680
3675
3670
3665
3660
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

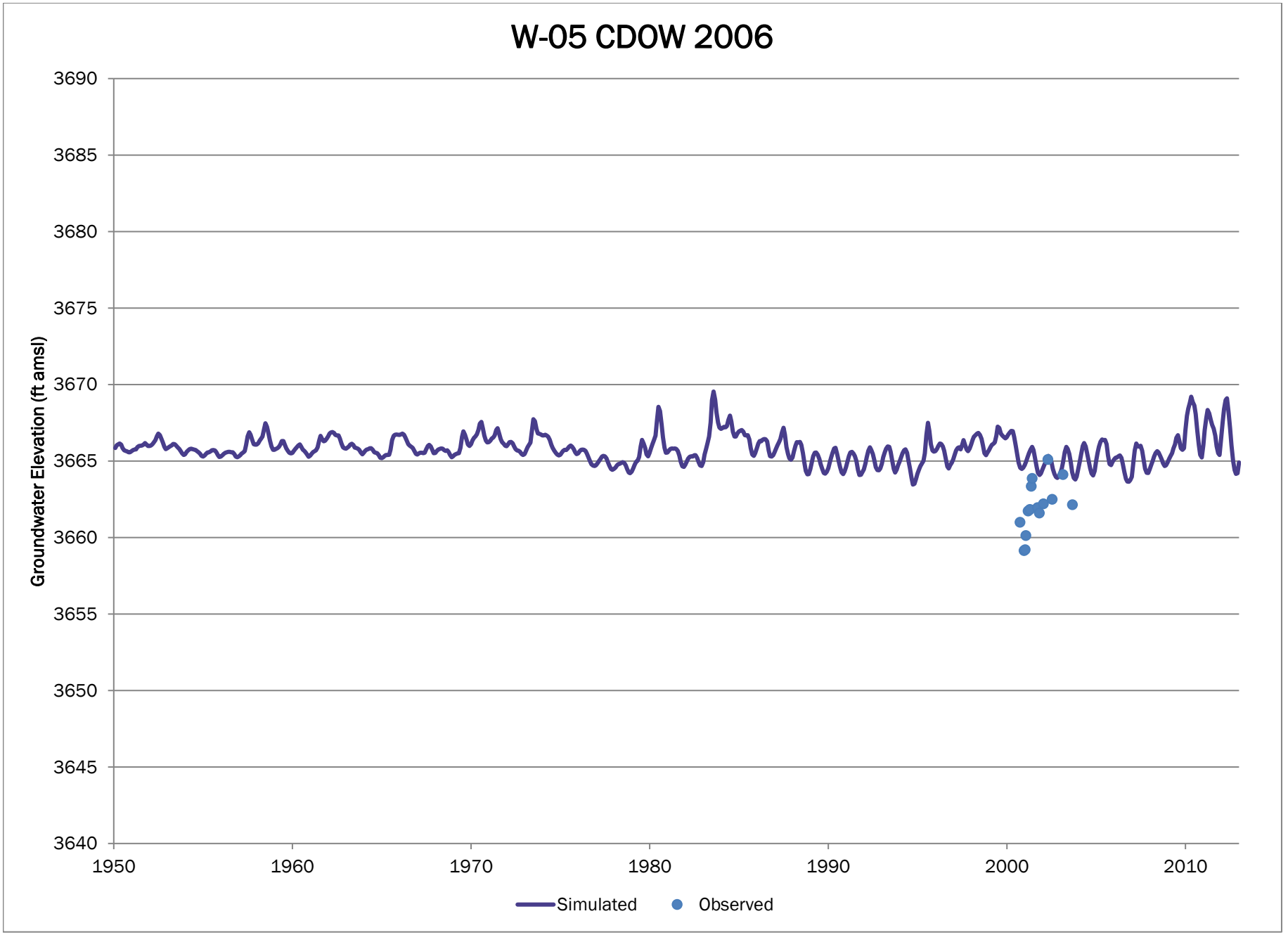

WR-030 CDOW 2006
Groundwater Elevation (ft amsl)
3720
3715
3710
3705
3700
3695
3690
3685
3680
3675
3670
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

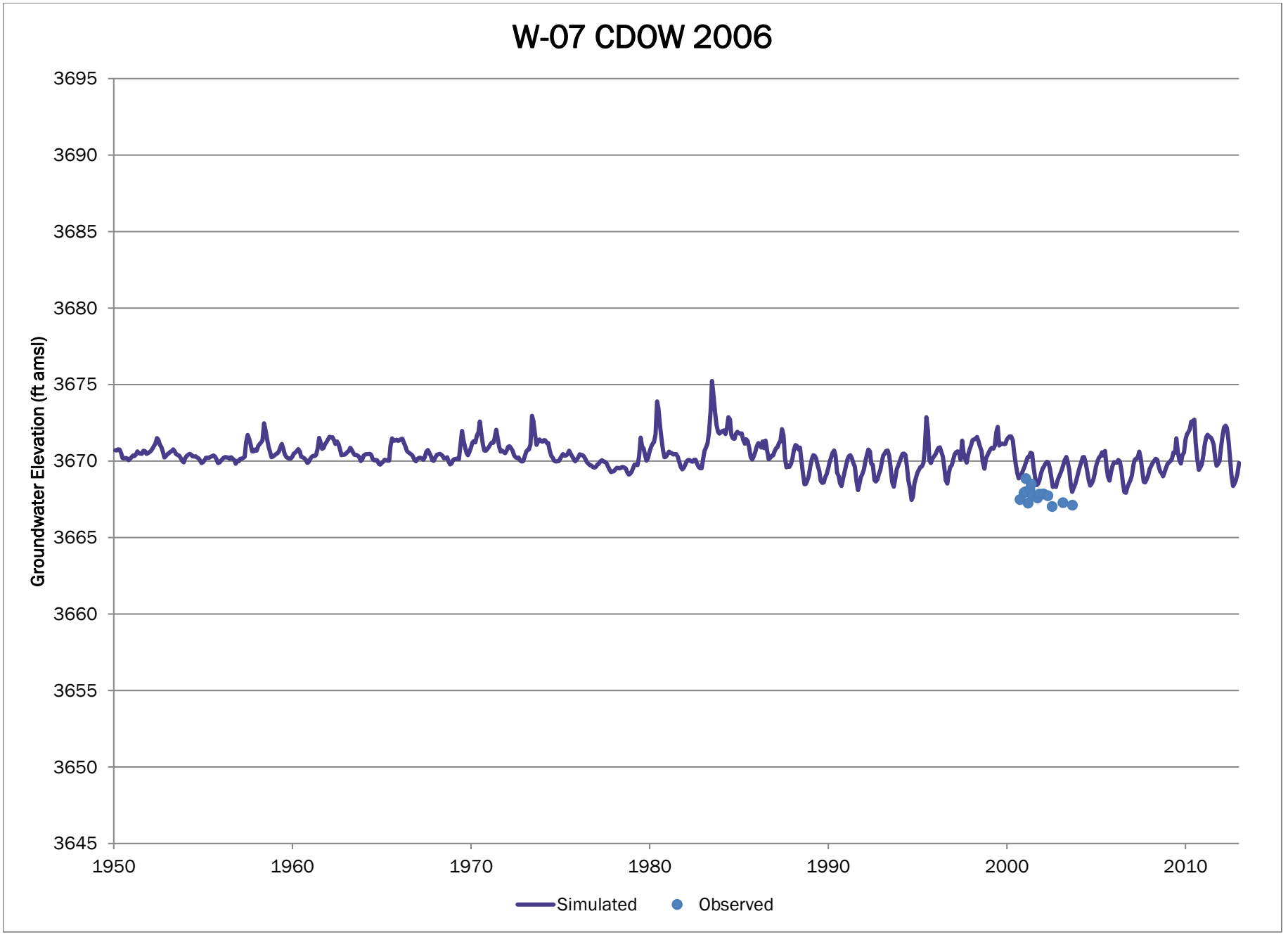

WR-070 CDOW 2006
Groundwater Elevation (ft amsl)
3720
3715
3710
3705
3700
3695
3690
3685
3680
3675
3670
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

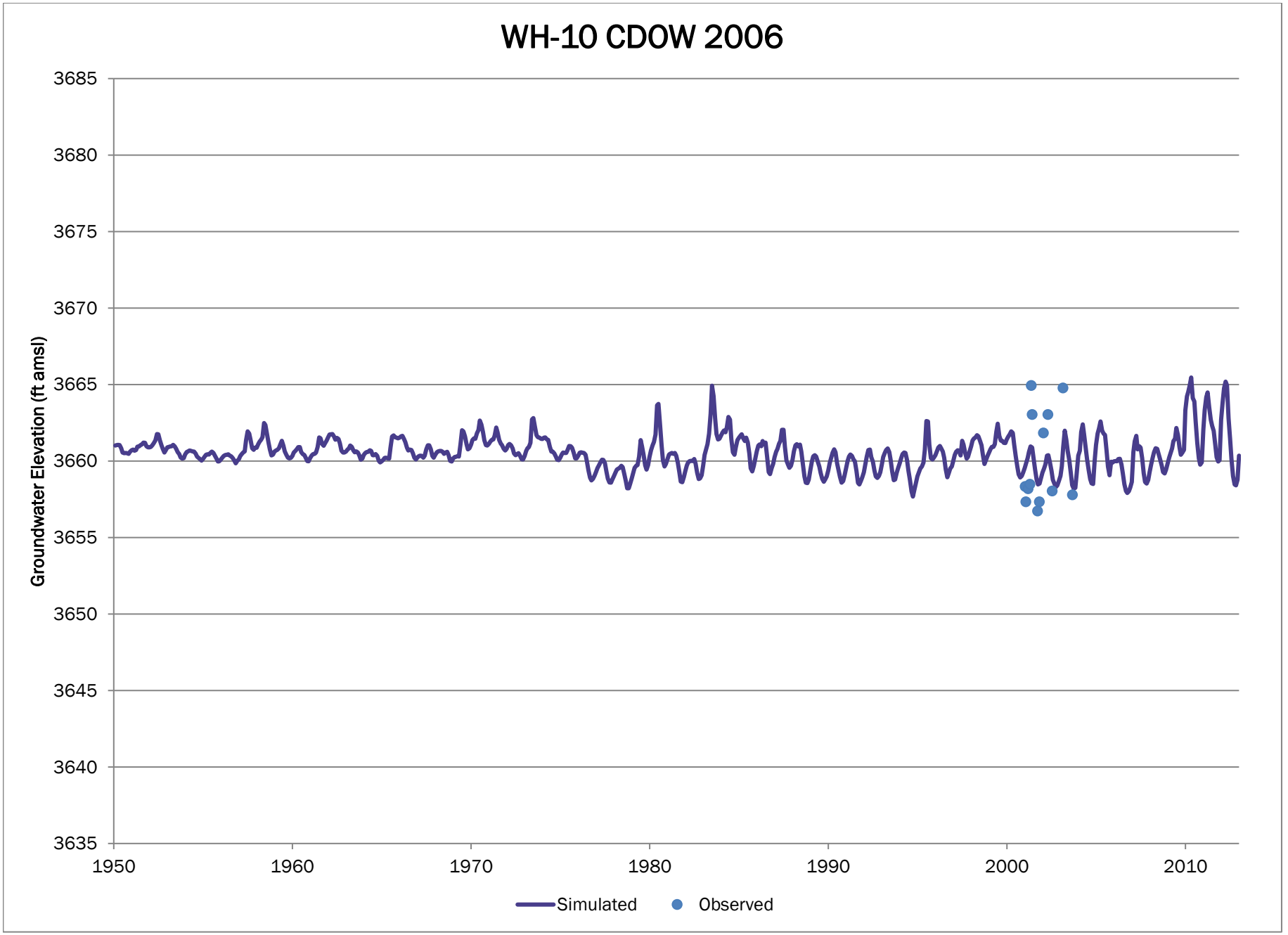

WH-07 CDOW 2006
Groundwater Elevation (ft amsl)
3705
3700
3695
3690
3685
3680
3675
3670
3665
3660
3655
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

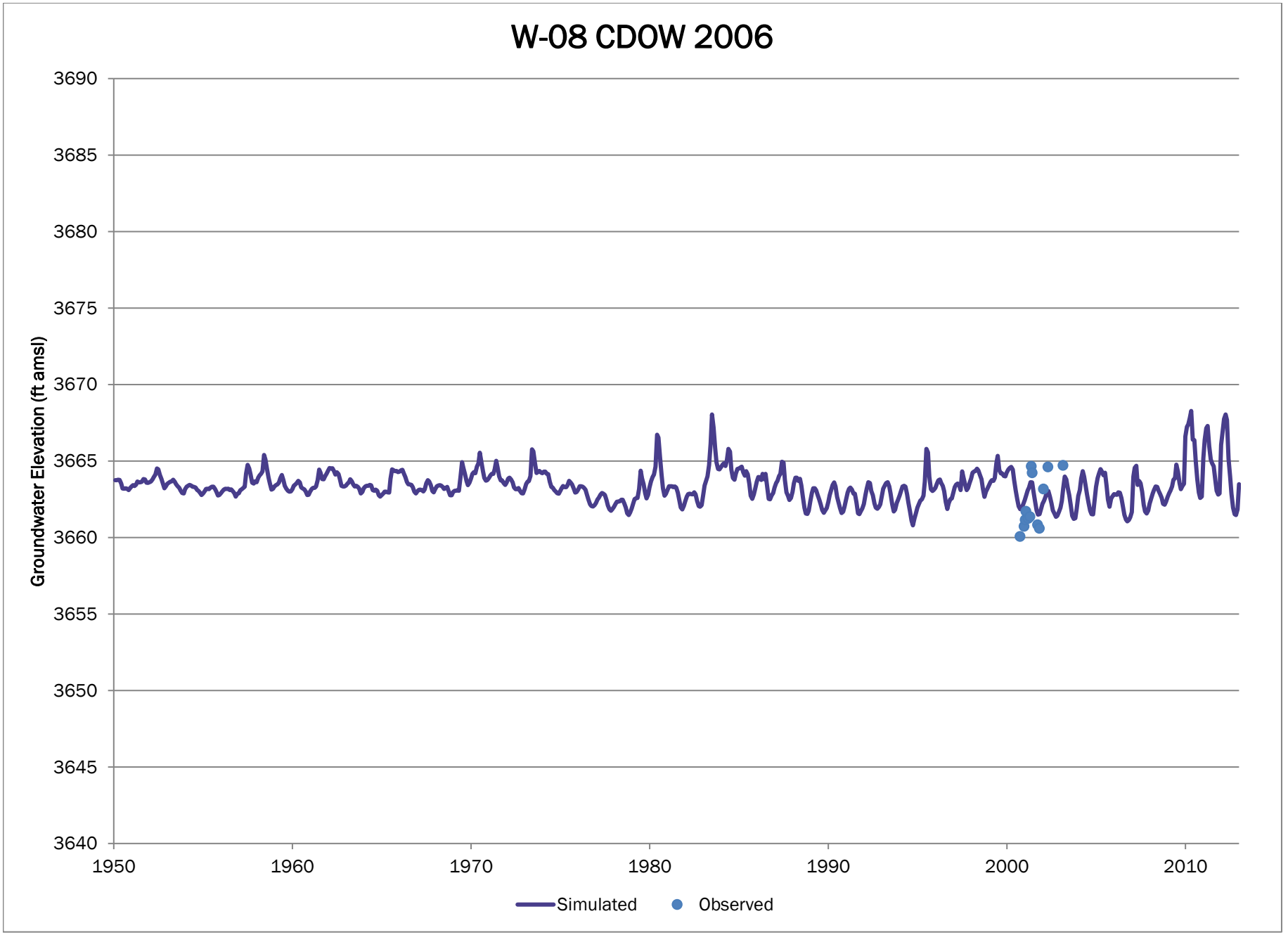

WR-080 CDOW 2006
Groundwater Elevation (ft amsl)
3715
3710
3705
3700
3695
3690
3685
3680
3675
3670
3665
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

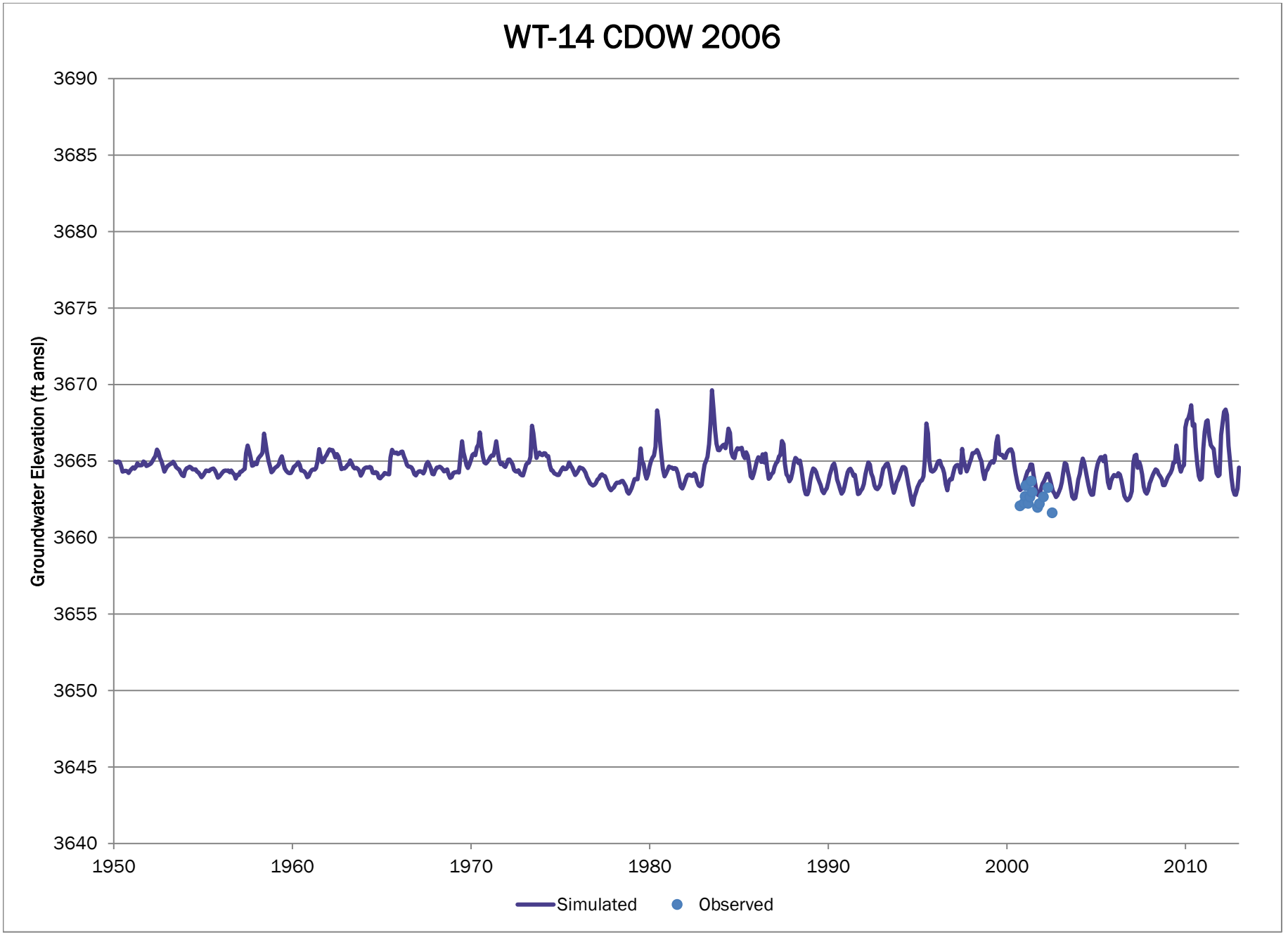

W-06 CDOW 2006
Groundwater Elevation (ft amsl)
3705
3700
3695
3690
3685
3680
3675
3670
3665
3660
3655
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

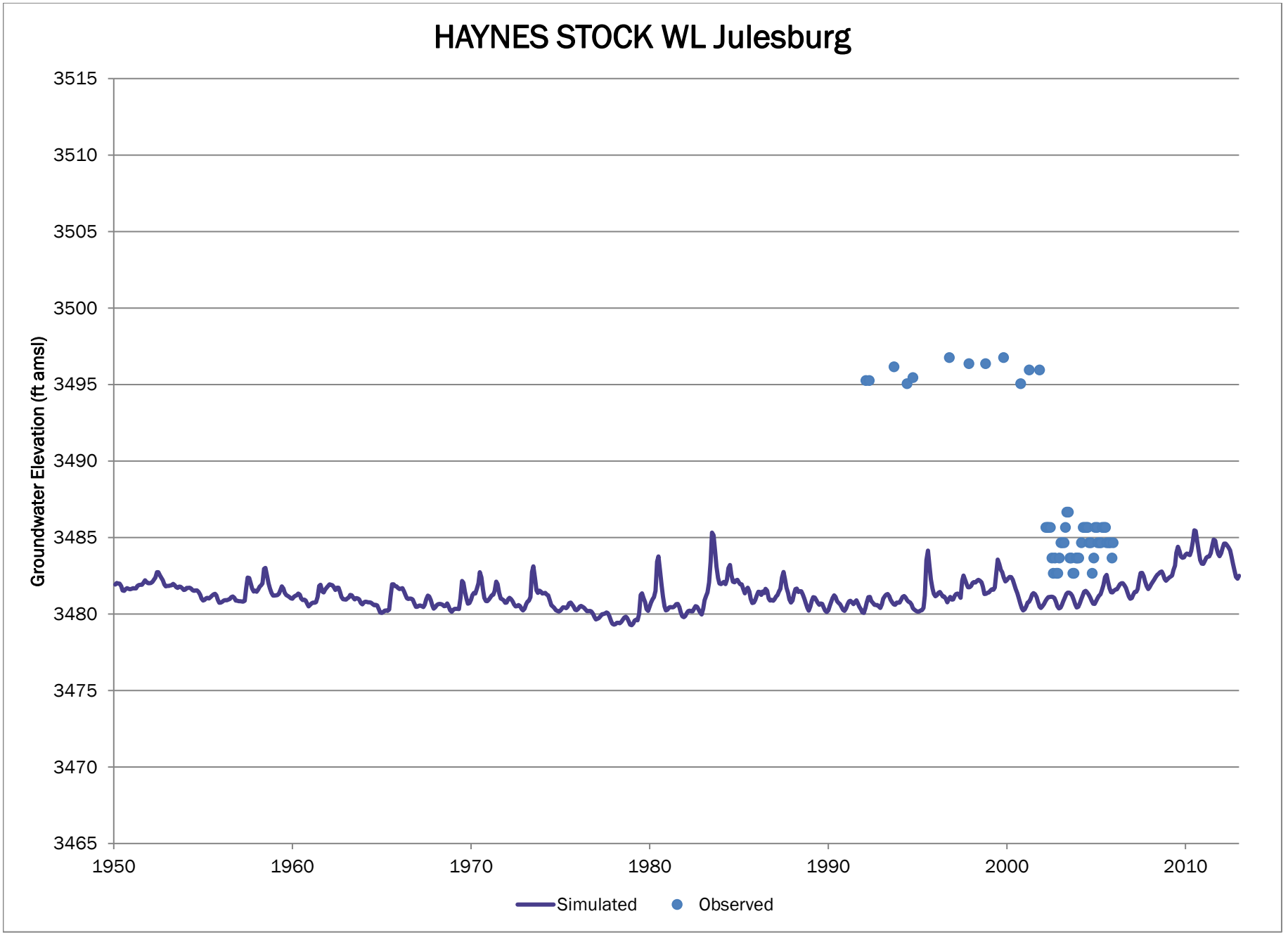

W-05 CDOW 2006
Groundwater Elevation (ft amsl)
3690
3685
3680
3675
3670
3665
3660
3655
3650
3645
3640
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

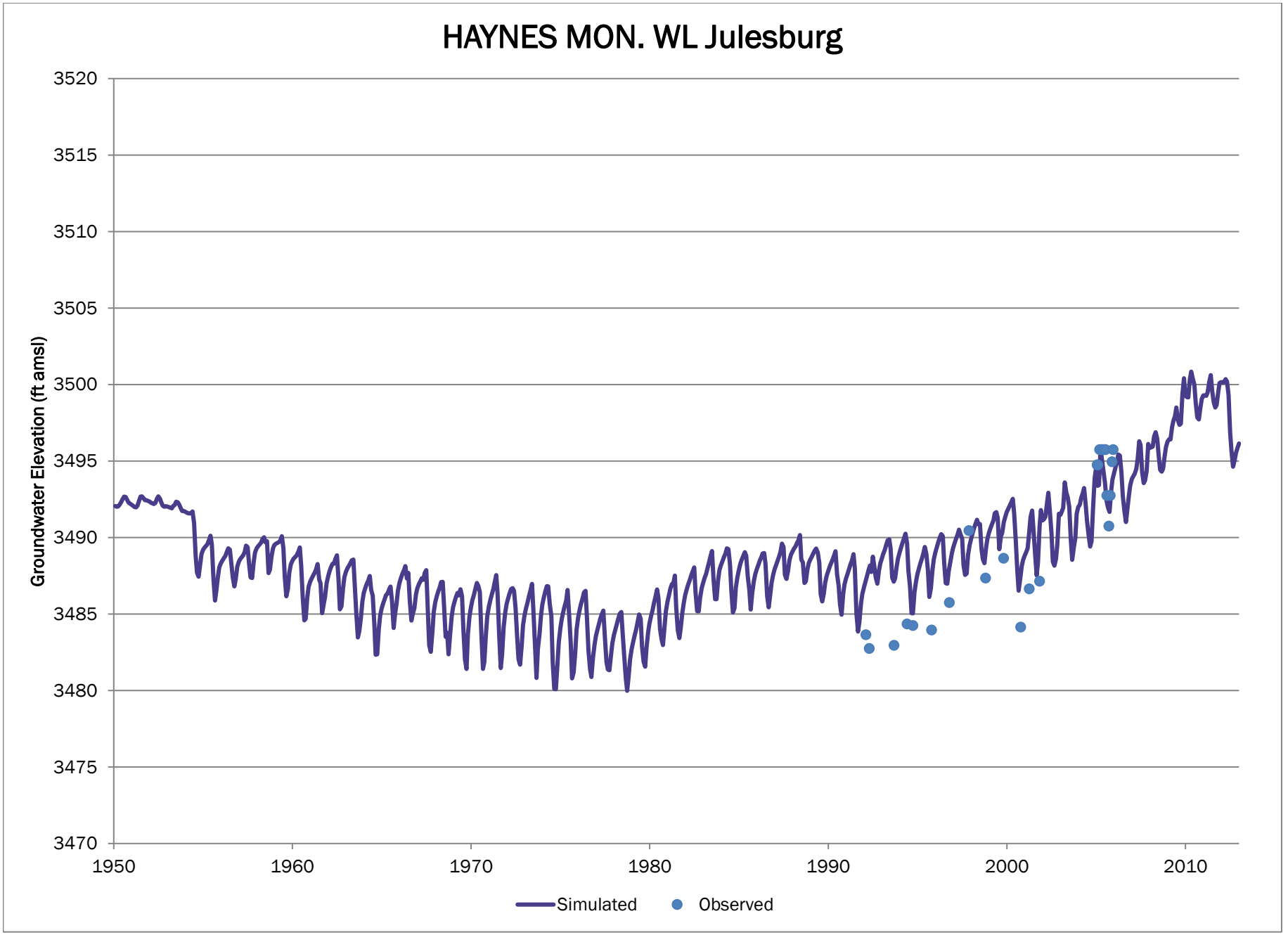

W-07 CDOW 2006
Groundwater Elevation (ft amsl)
3695
3690
3685
3680
3675
3670
3665
3660
3655
3650
3645
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

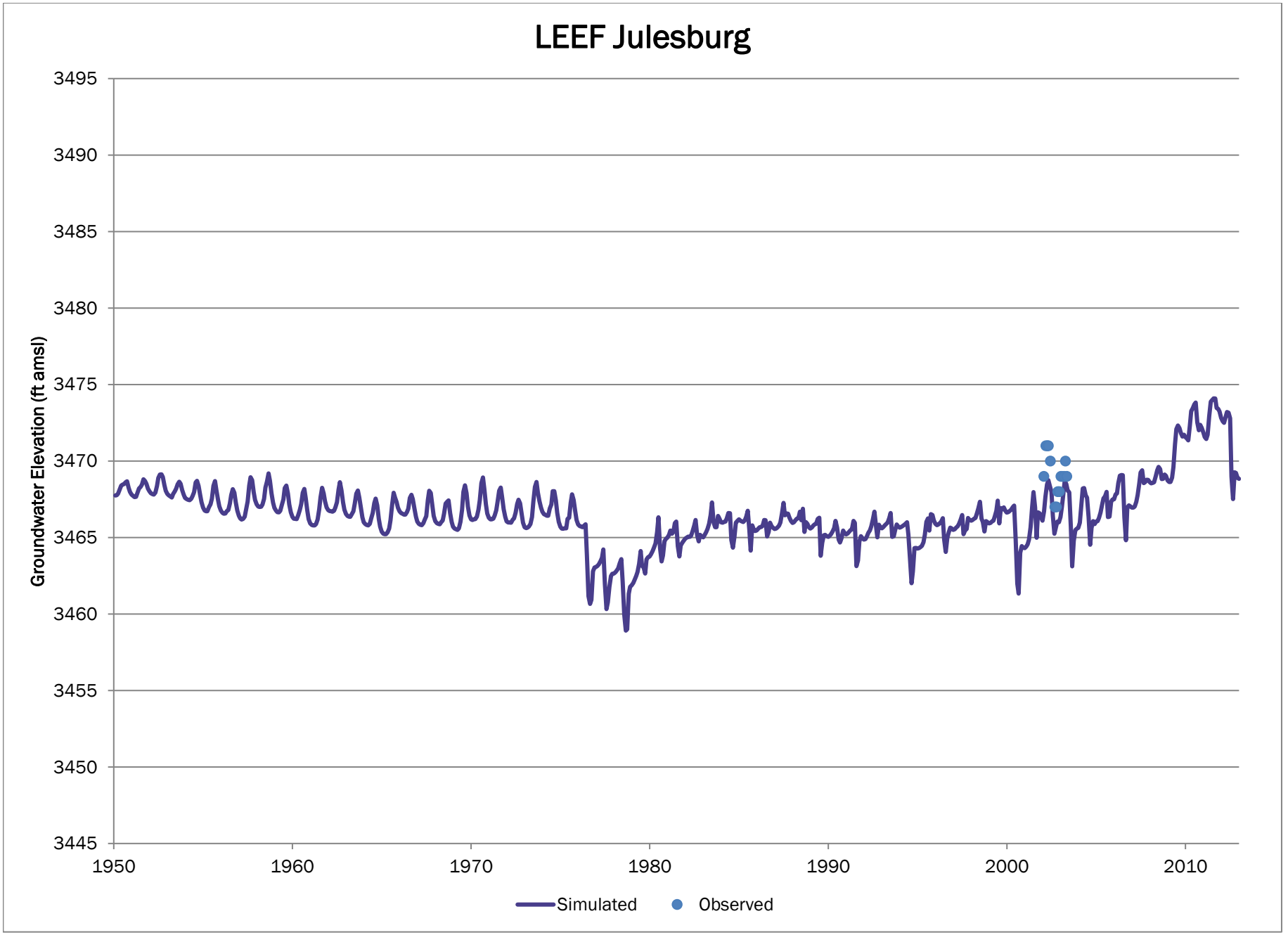

WH-10 CDOW 2006
Groundwater Elevation (ft amsl)
3685
3680
3675
3670
3665
3660
3655
3650
3645
3640
3635
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

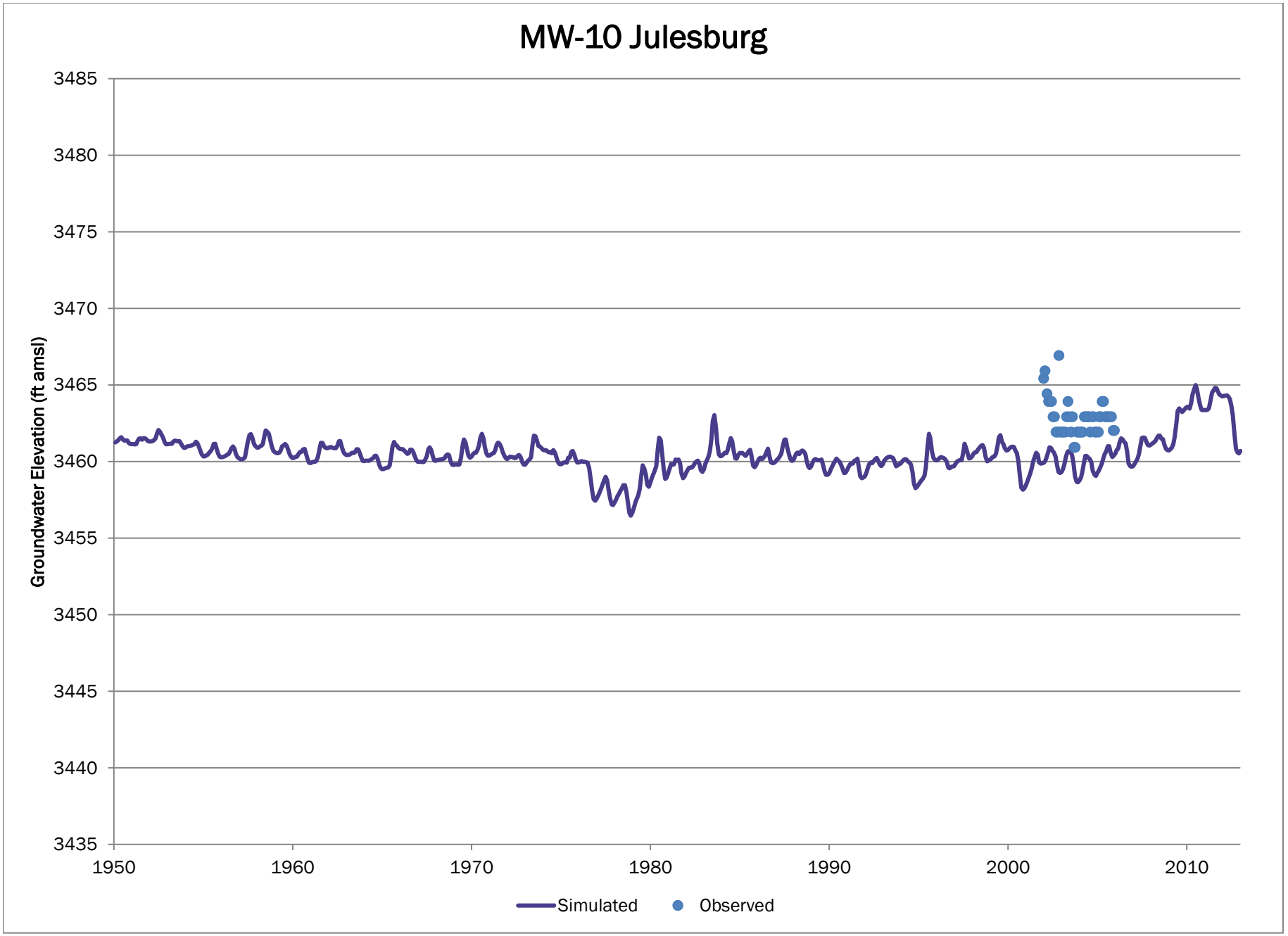

W-08 CDOW 2006
Groundwater Elevation (ft amsl)
3690
3685
3680
3675
3670
3665
3660
3655
3650
3645
3640
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

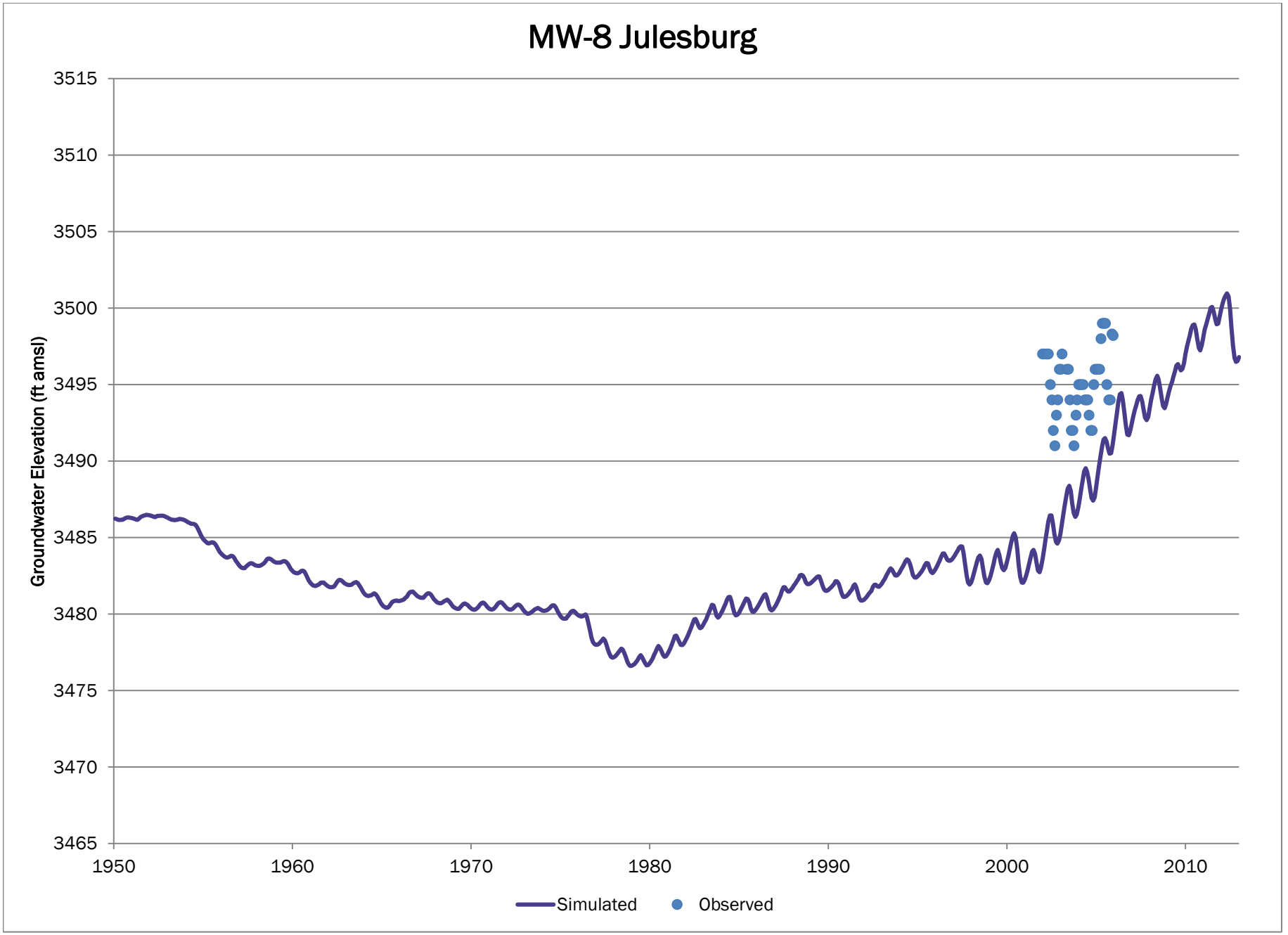

WT-14 CDOW 2006
Groundwater Elevation (ft amsl)
3690
3685
3680
3675
3670
3665
3660
3655
3650
3645
3640
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


HAYNES STOCK WL Julesburg
Groundwater Elevation (ft amsl)
3515
3510
3505
3500
3495
3490
3485
3480
3475
3470
3465
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

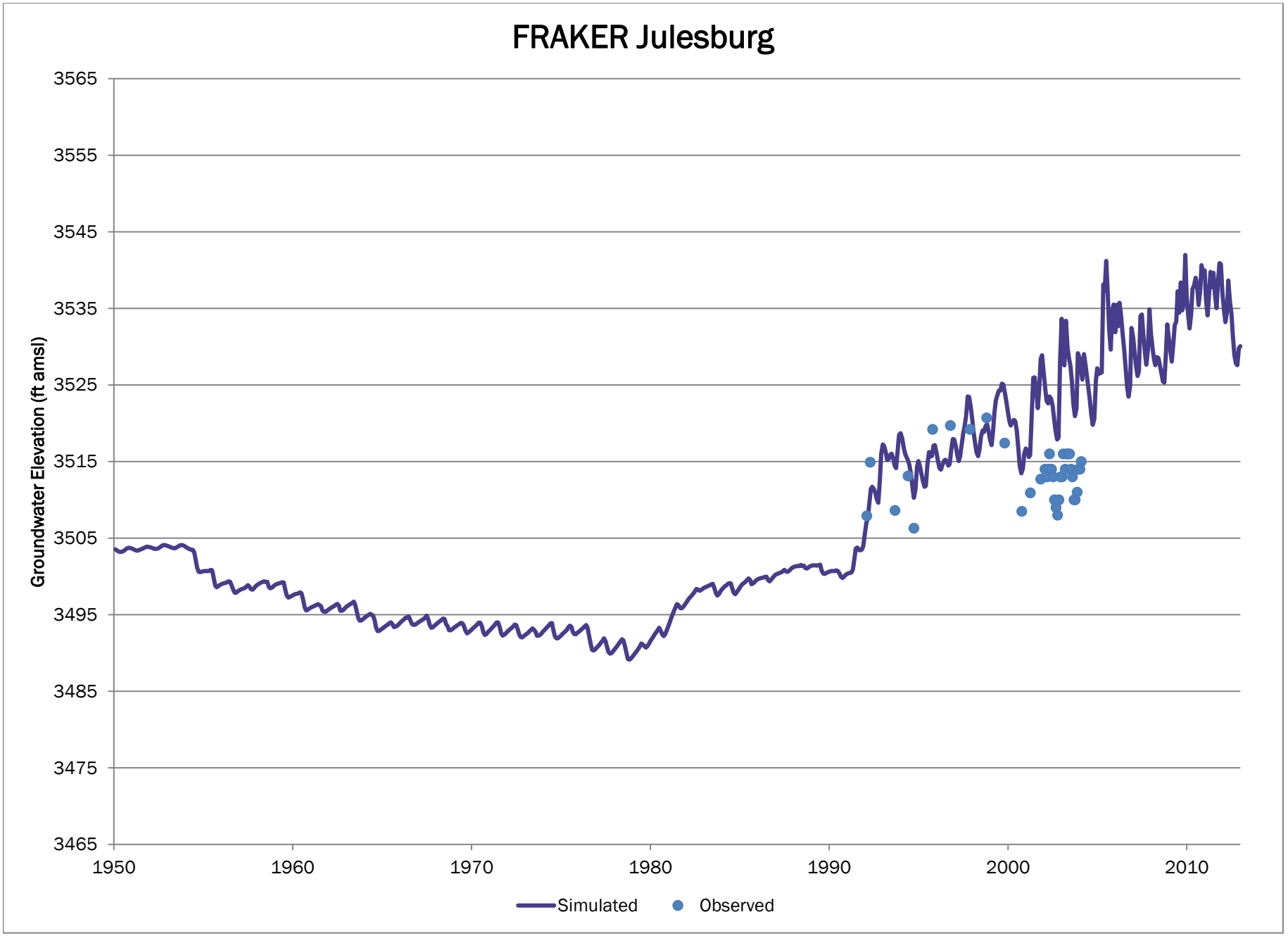

HAYNES MON. WL Julesburg
Groundwater Elevation (ft amsl)
3520
3515
3510
3505
3500
3495
3490
3485
3480
3475
3470
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

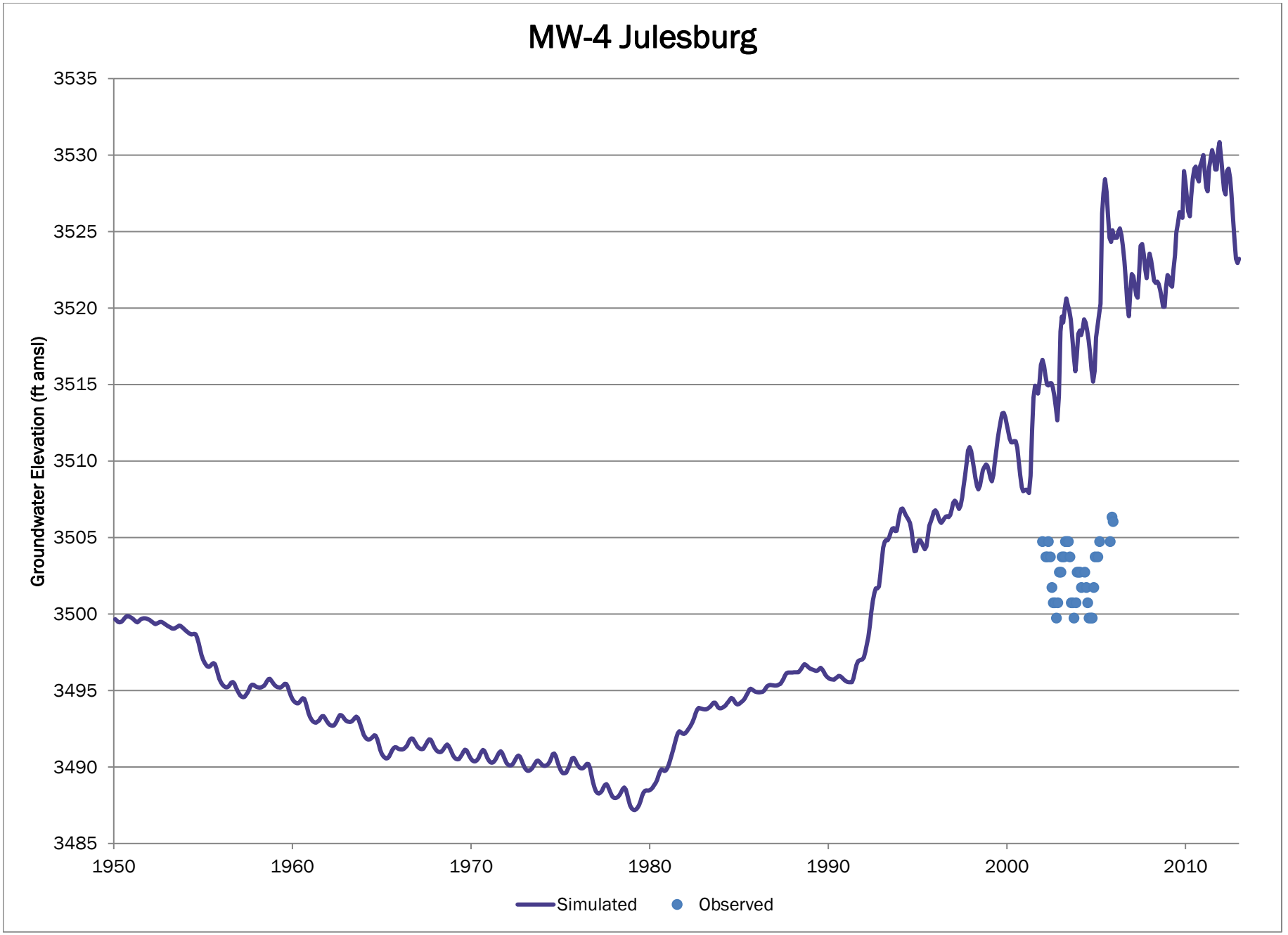

LEEF Julesburg
Groundwater Elevation (ft amsl)
3495
3490
3485
3480
3475
3470
3465
3460
3455
3450
3445
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


MW-10 Julesburg
Groundwater Elevation (ft amsl)
3485
3480
3475
3470
3465
3460
3455
3450
3445
3440
3435
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

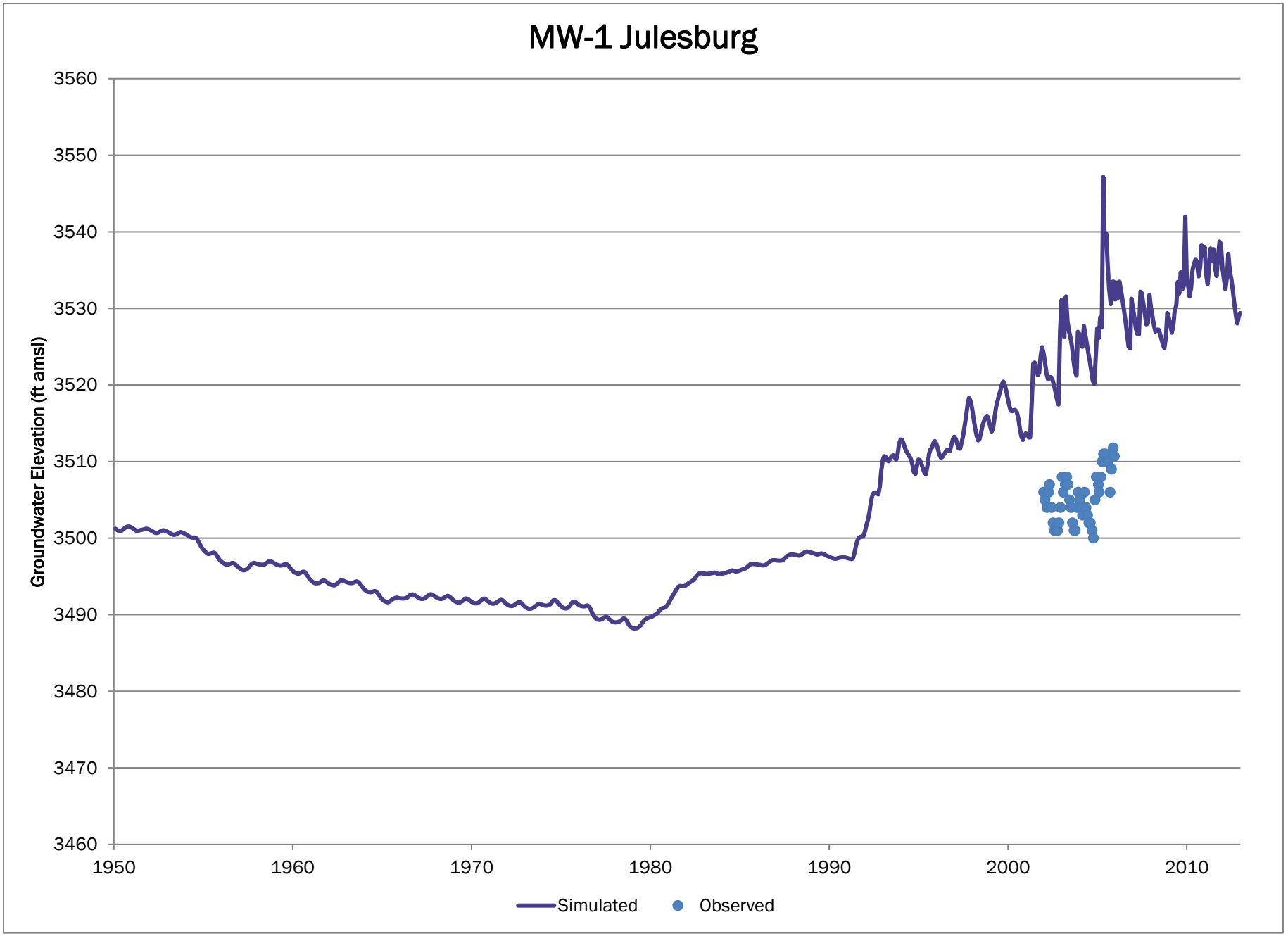

MW-8 Julesburg
Groundwater Elevation (ft amsl)
3515
3510
3505
3500
3495
3490
3485
3480
3475
3470
3465
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

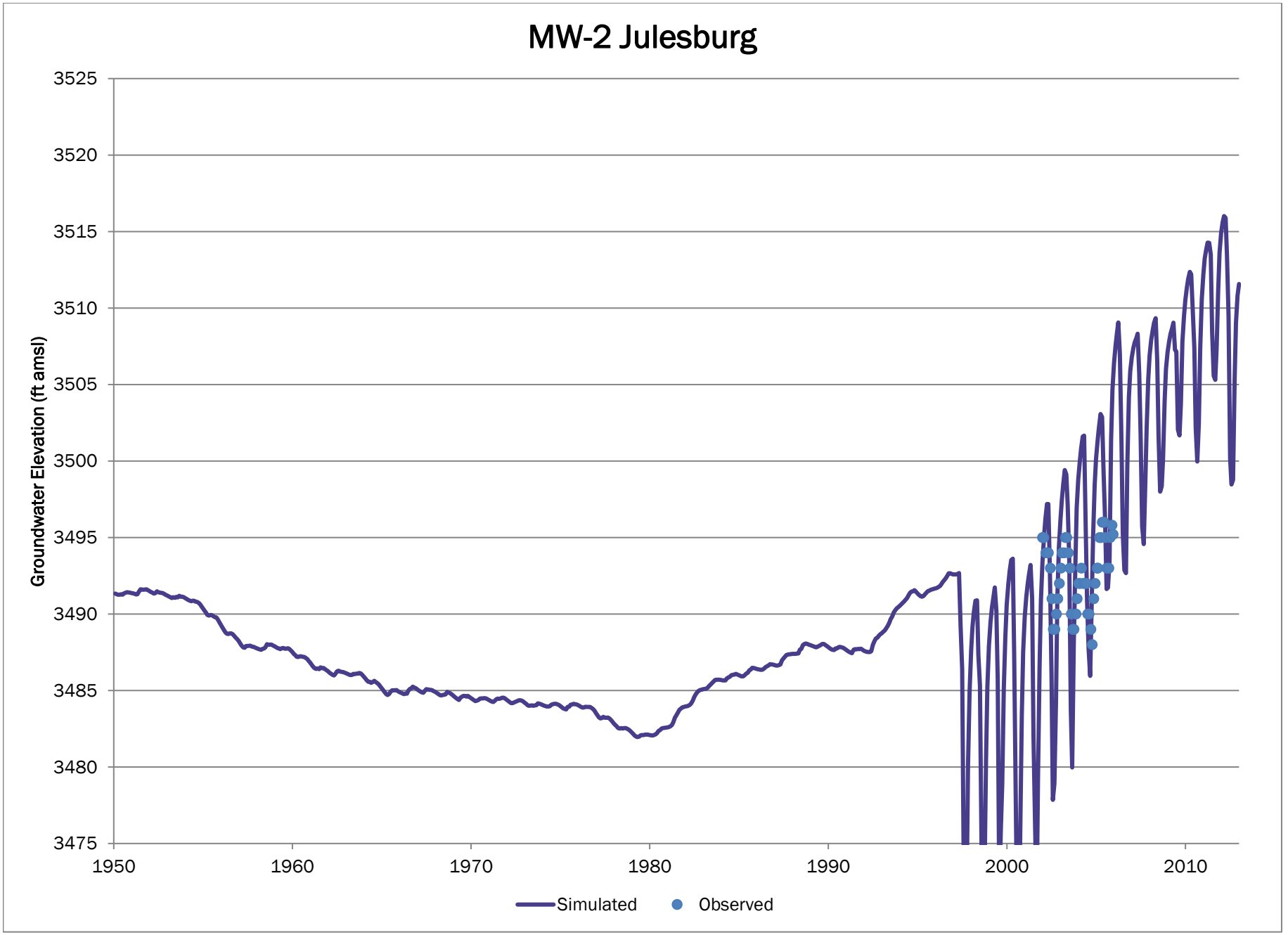
Note elevation axis range of 100 feet.



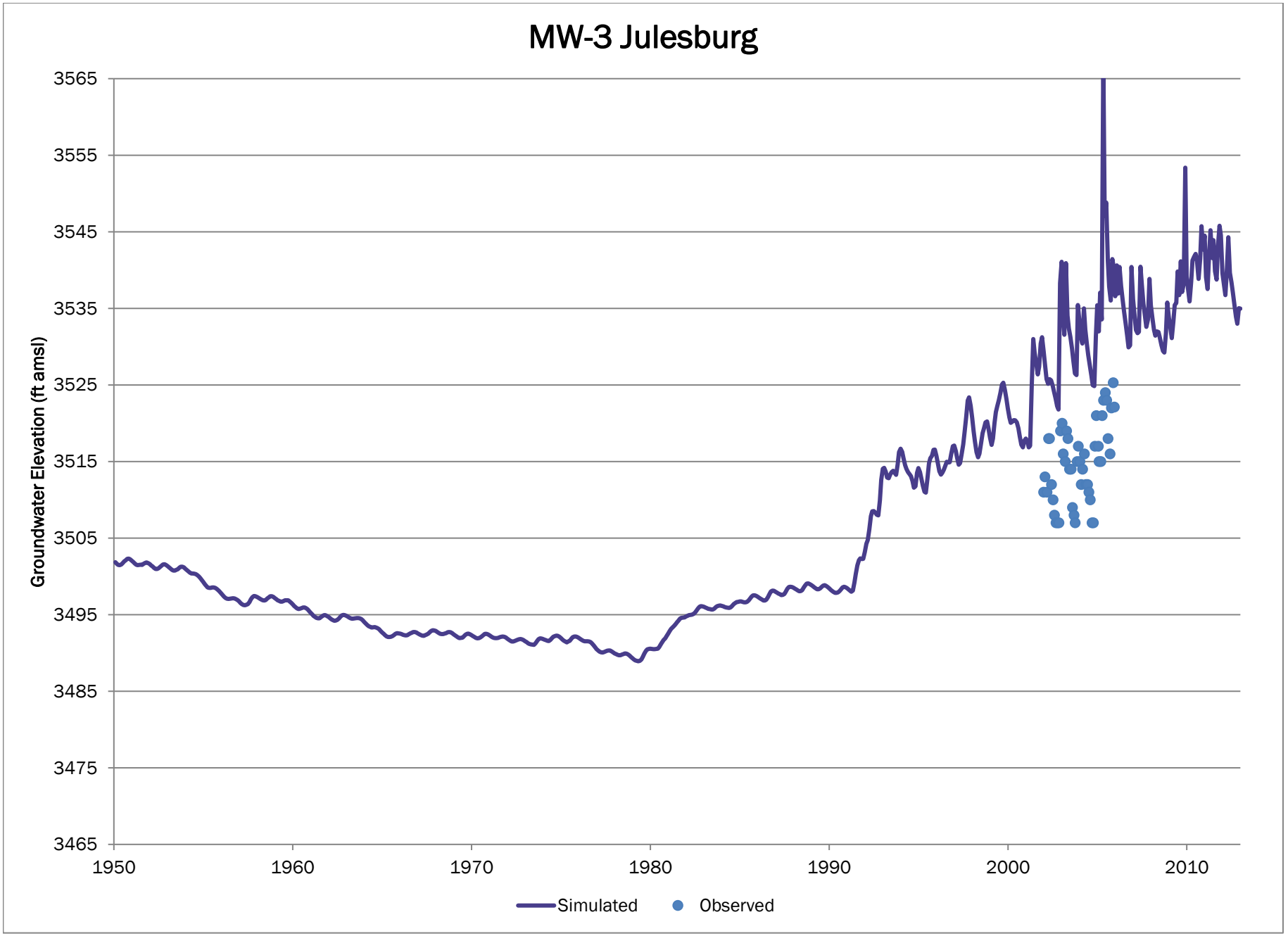

MW-4 Julesburg
Groundwater Elevation (ft amsl)
3535
3530
3525
3520
3515
3510
3505
3500
3495
3490
3485
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

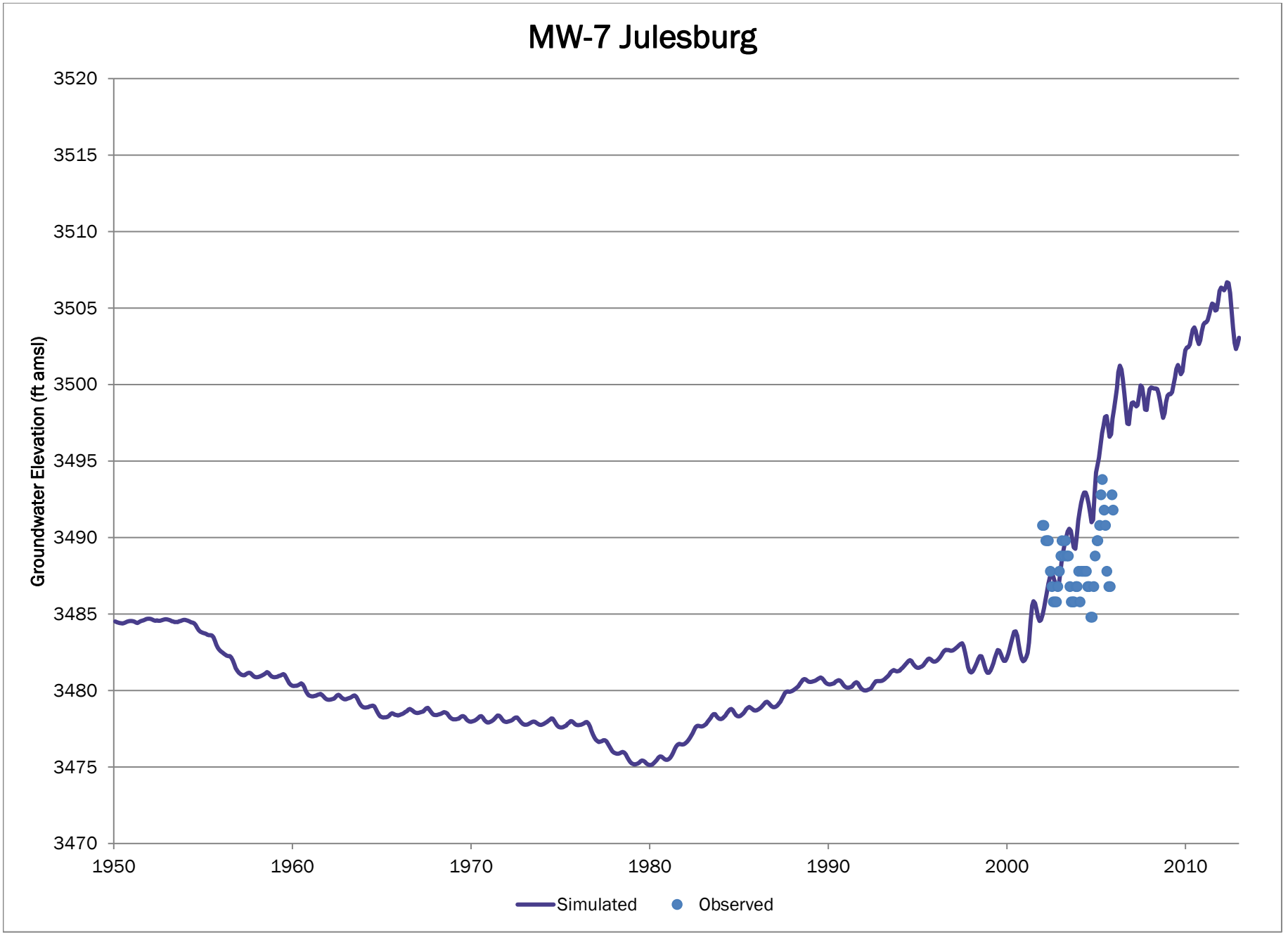
Note elevation axis range of 100 feet.

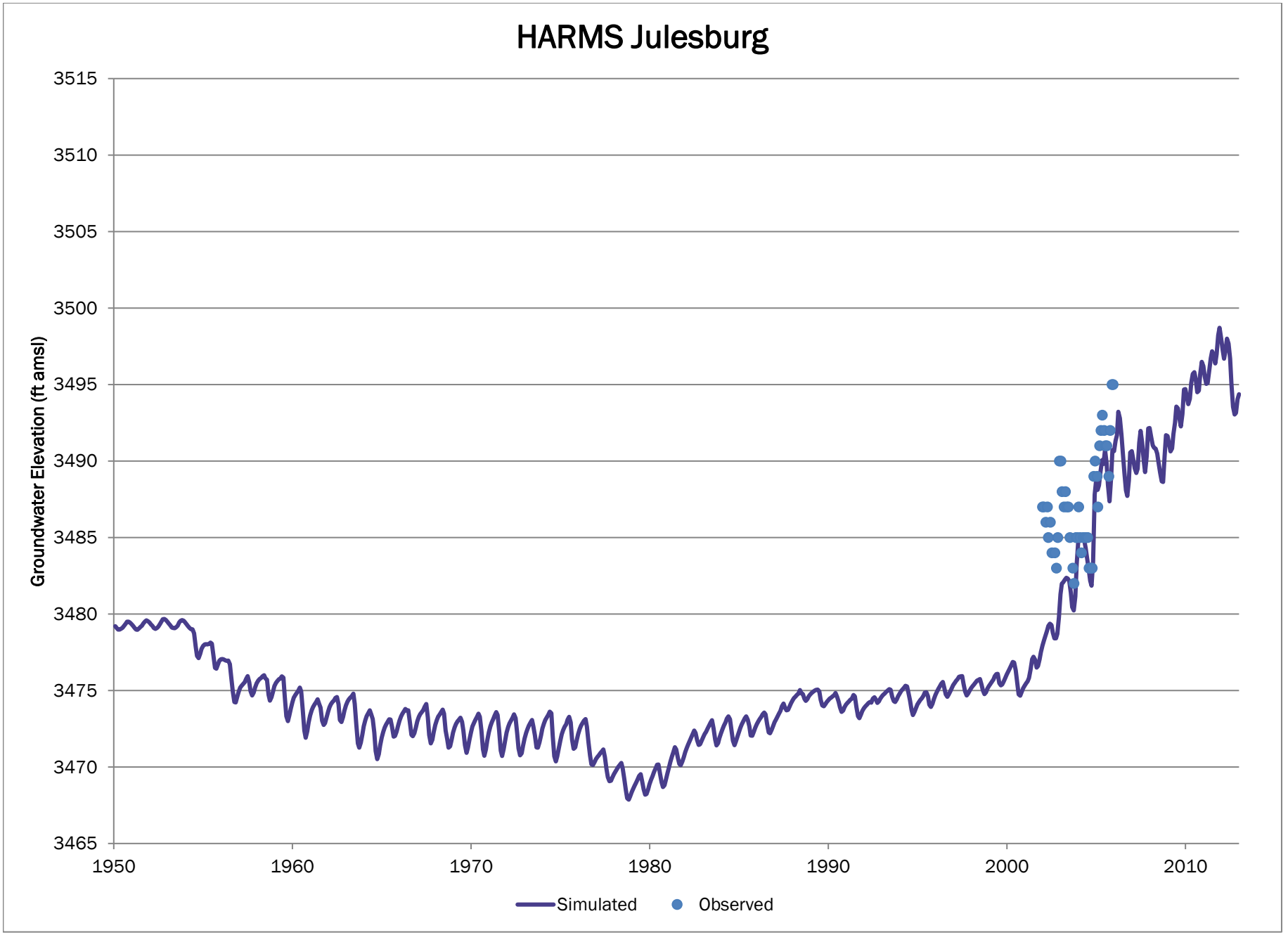


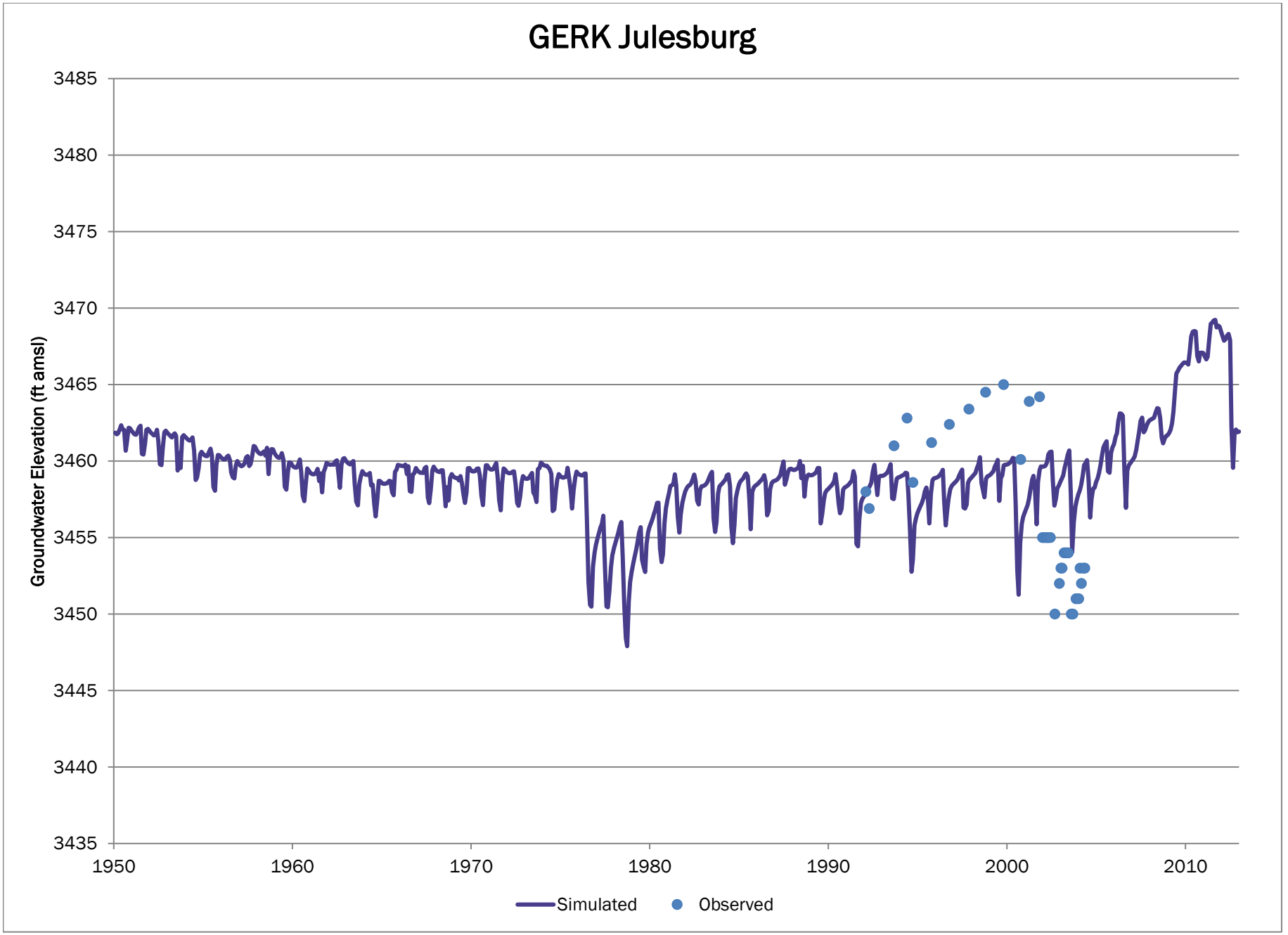

MW-2 Julesburg
Groundwater Elevation (ft amsl)
3525
3520
3515
3510
3505
3500
3495
3490
3485
3480
3475
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

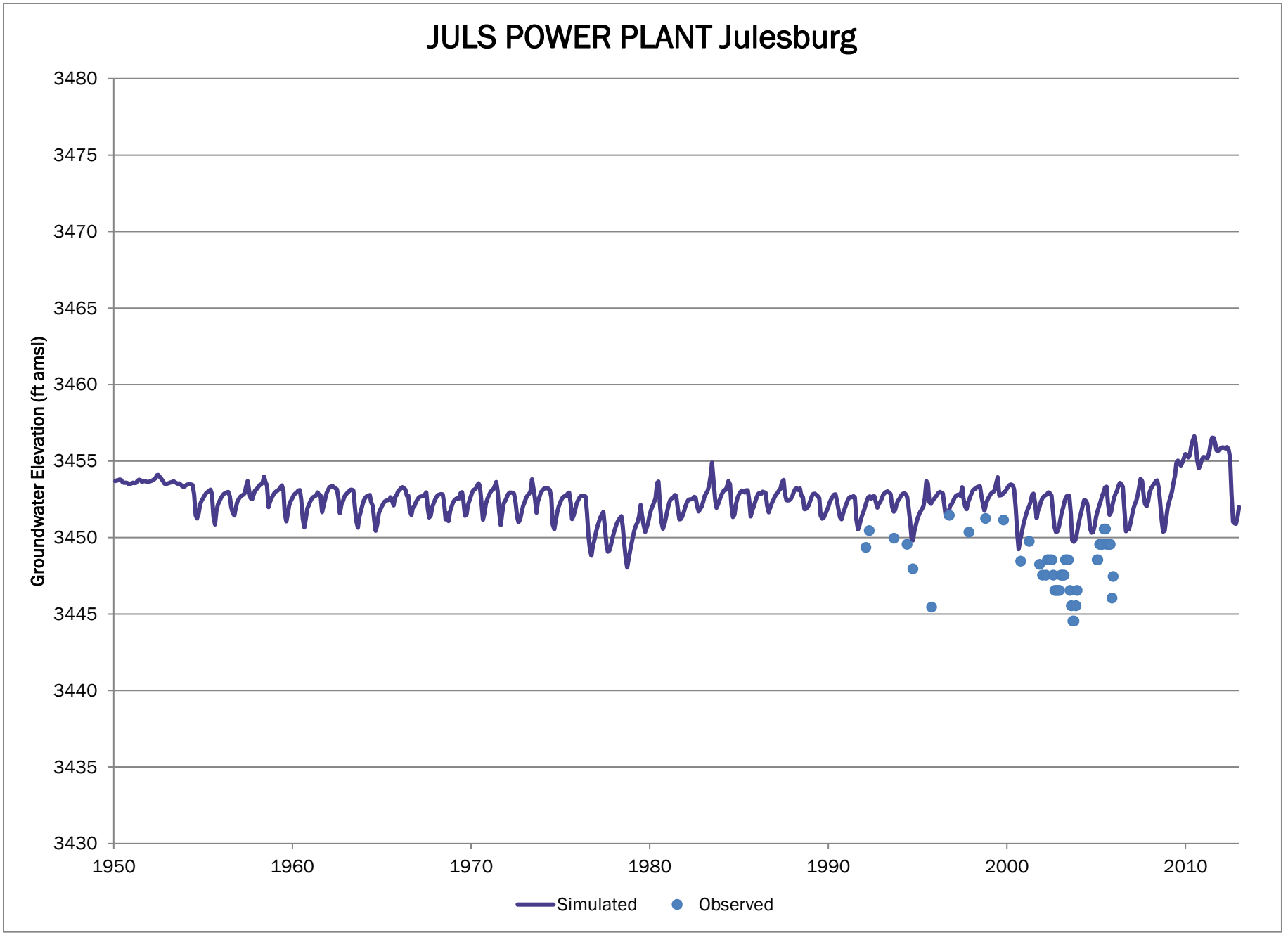
Note elevation axis range of 100 feet.



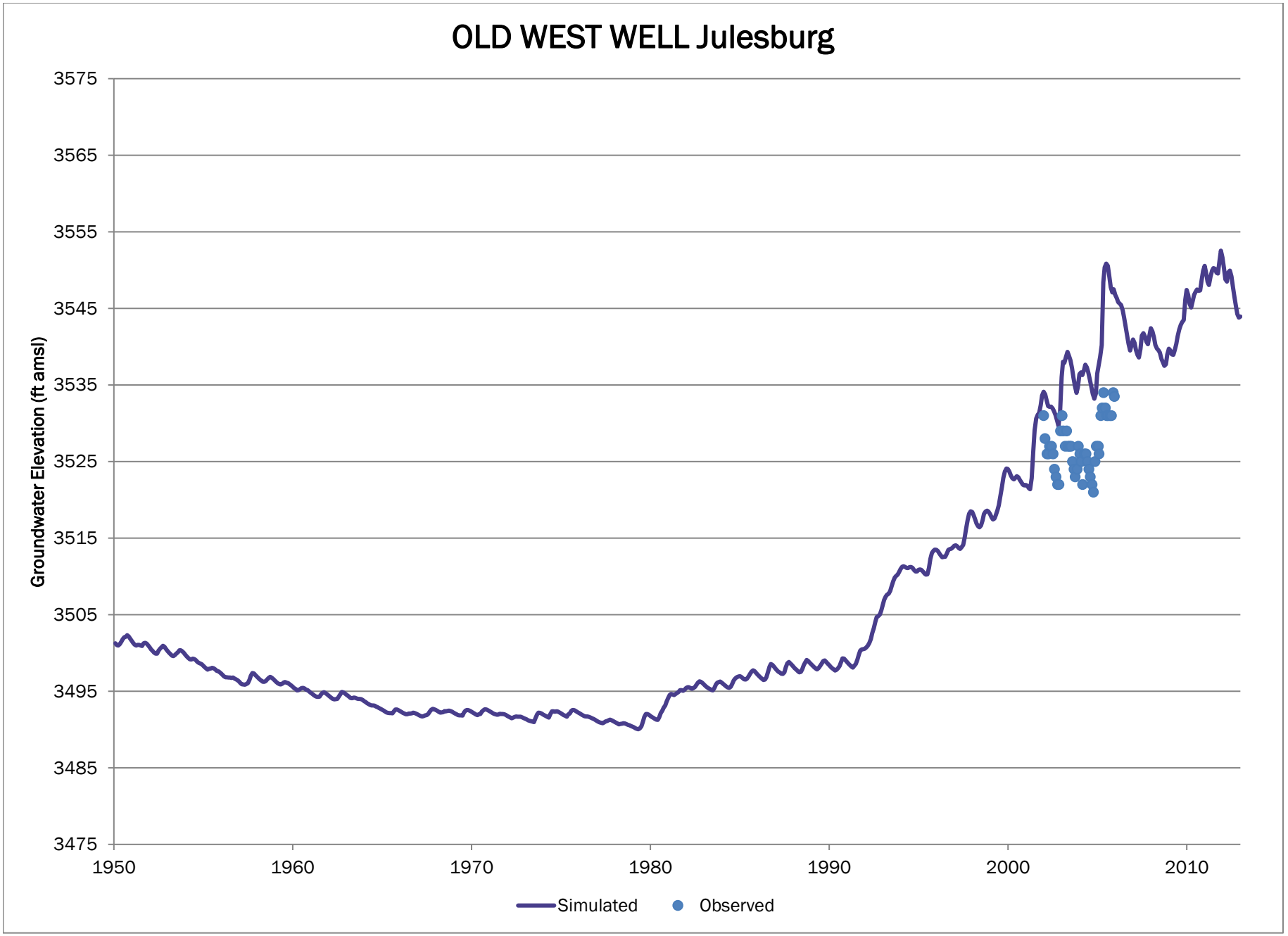

MW-7 Julesburg
Groundwater Elevation (ft amsl)
3520
3515
3510
3505
3500
3495
3490
3485
3480
3475
3470
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

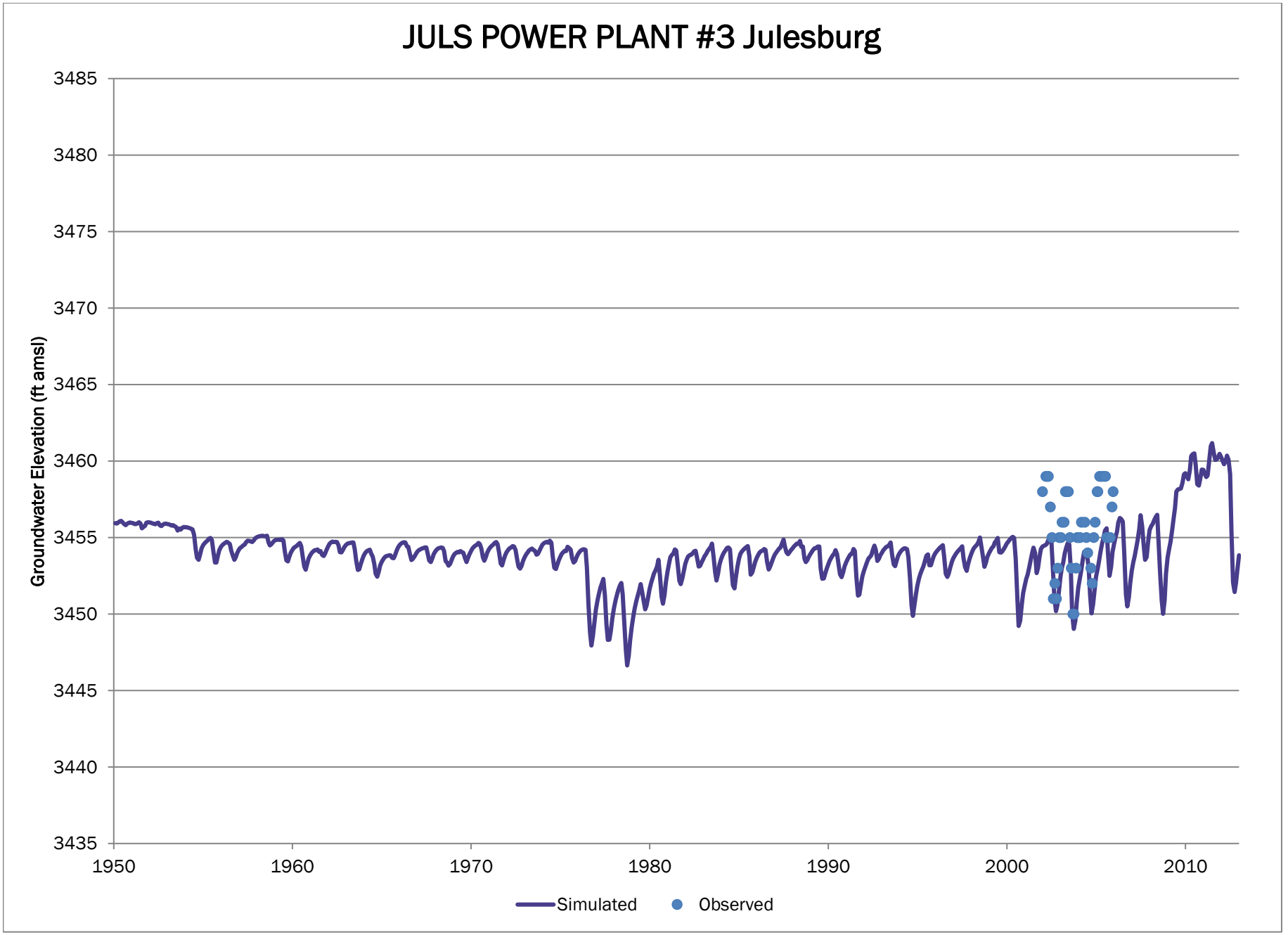

HARMS Julesburg
Groundwater Elevation (ft amsl)
3515
3510
3505
3500
3495
3490
3485
3480
3475
3470
3465
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

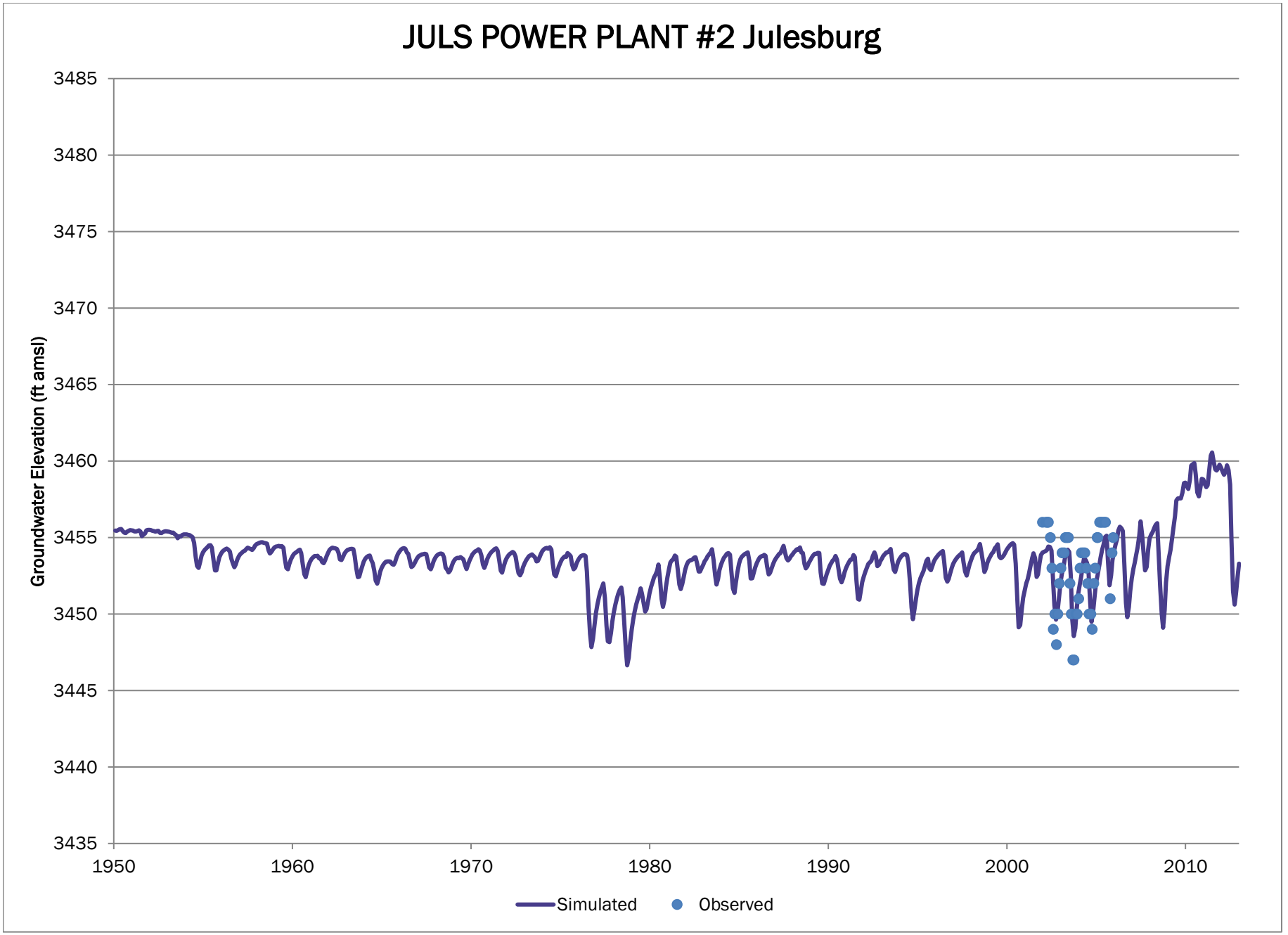

GERK Julesburg
Groundwater Elevation (ft amsl)
3485
3480
3475
3470
3465
3460
3455
3450
3445
3440
3435
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

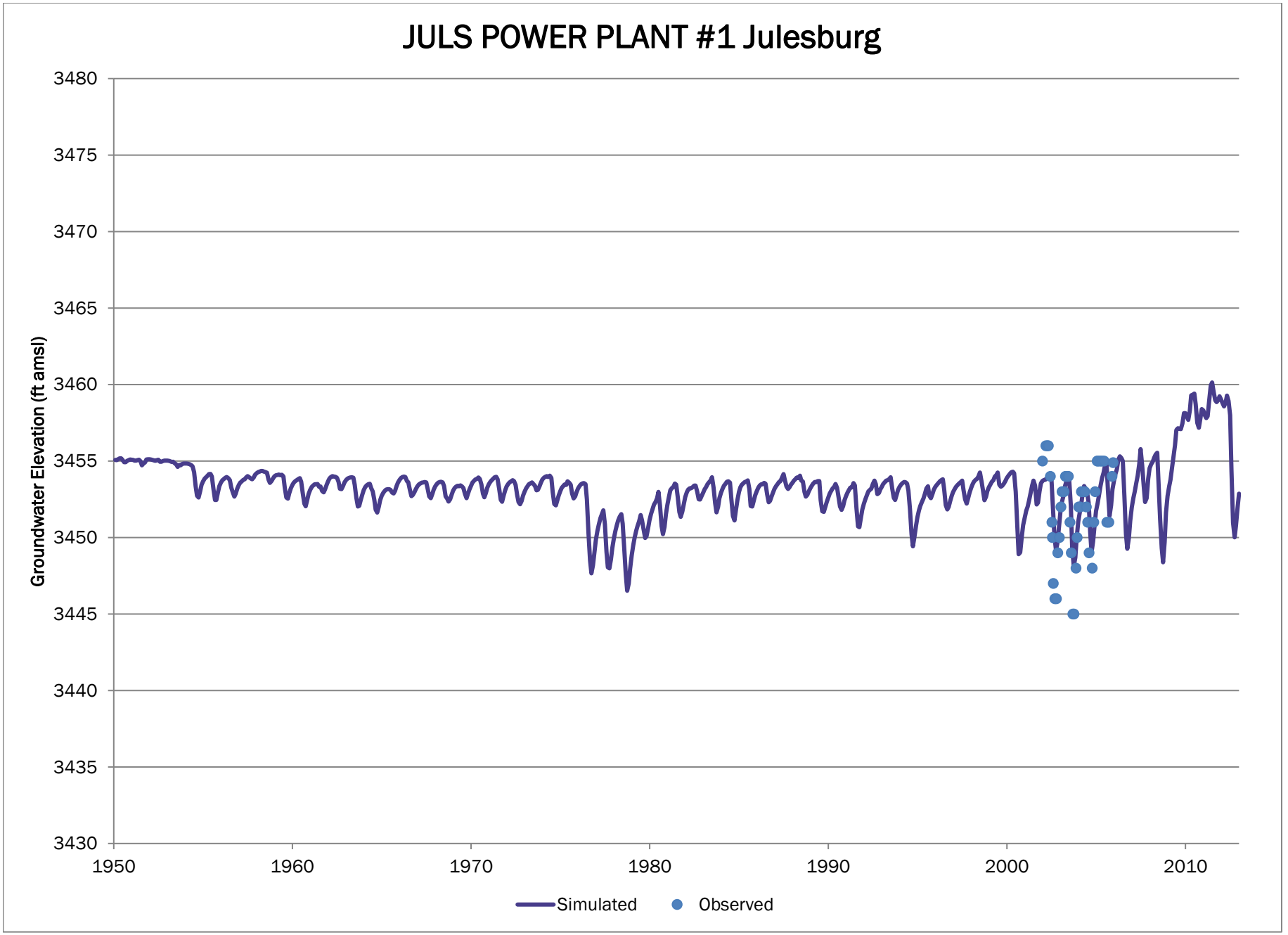

JULS POWER PLANT Julesburg
Groundwater Elevation (ft amsl)
3480
3475
3470
3465
3460
3455
3450
3445
3440
3435
3430
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

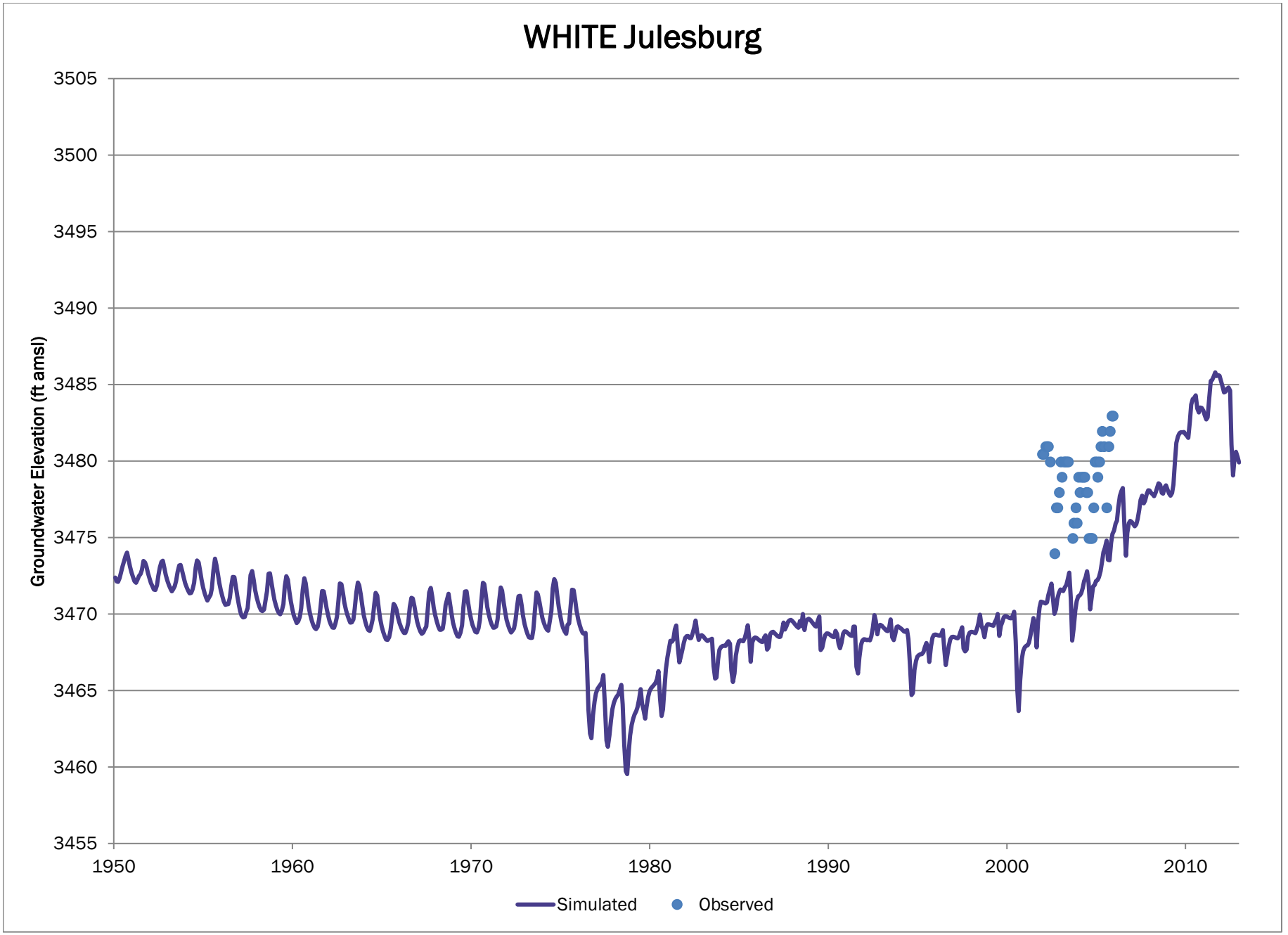
Note elevation axis range of 100 feet.

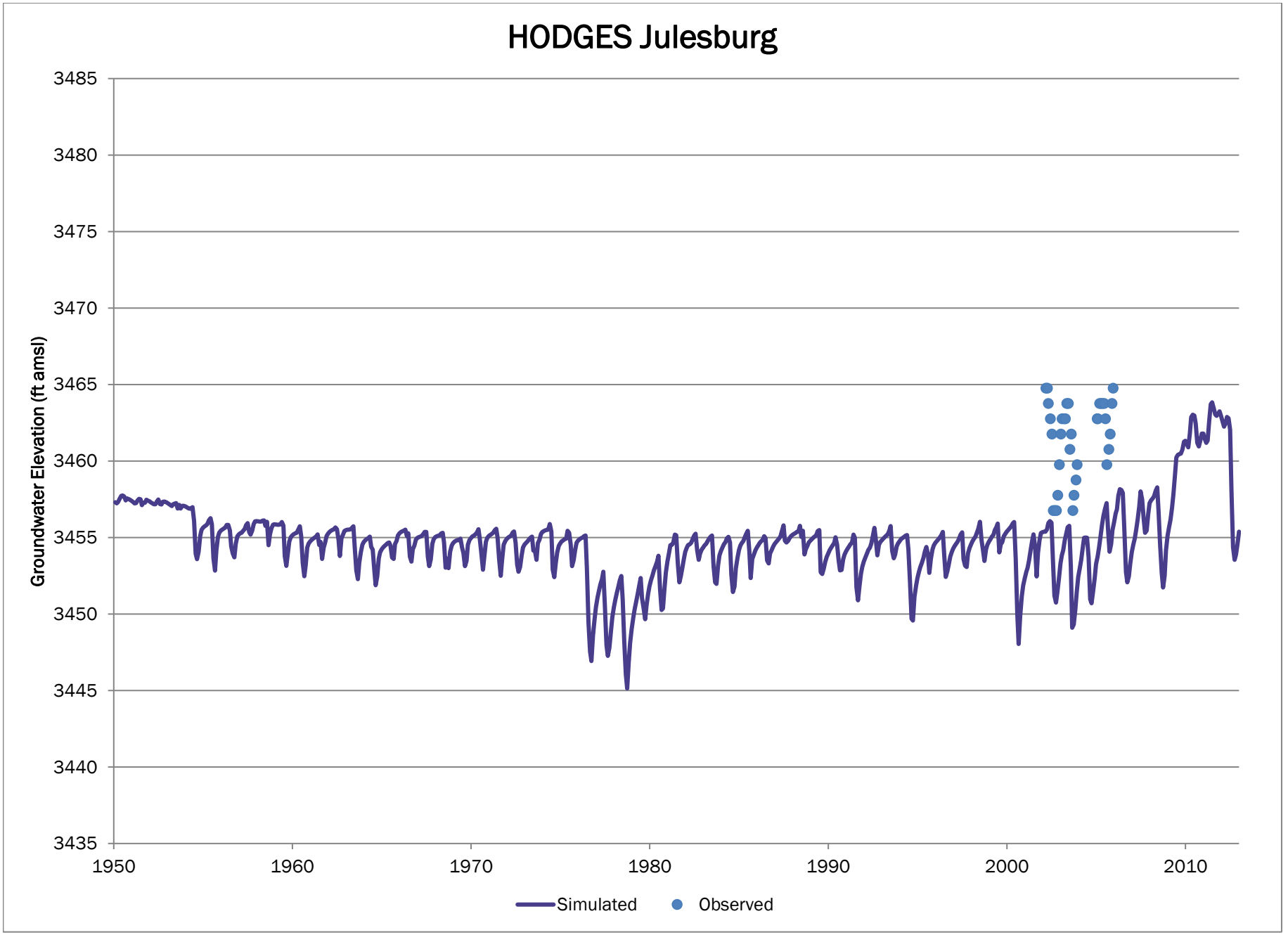



JULS POWER PLANT #3 Julesburg
Groundwater Elevation (ft amsl)
3485
3480
3475
3470
3465
3460
3455
3450
3445
3440
3435
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

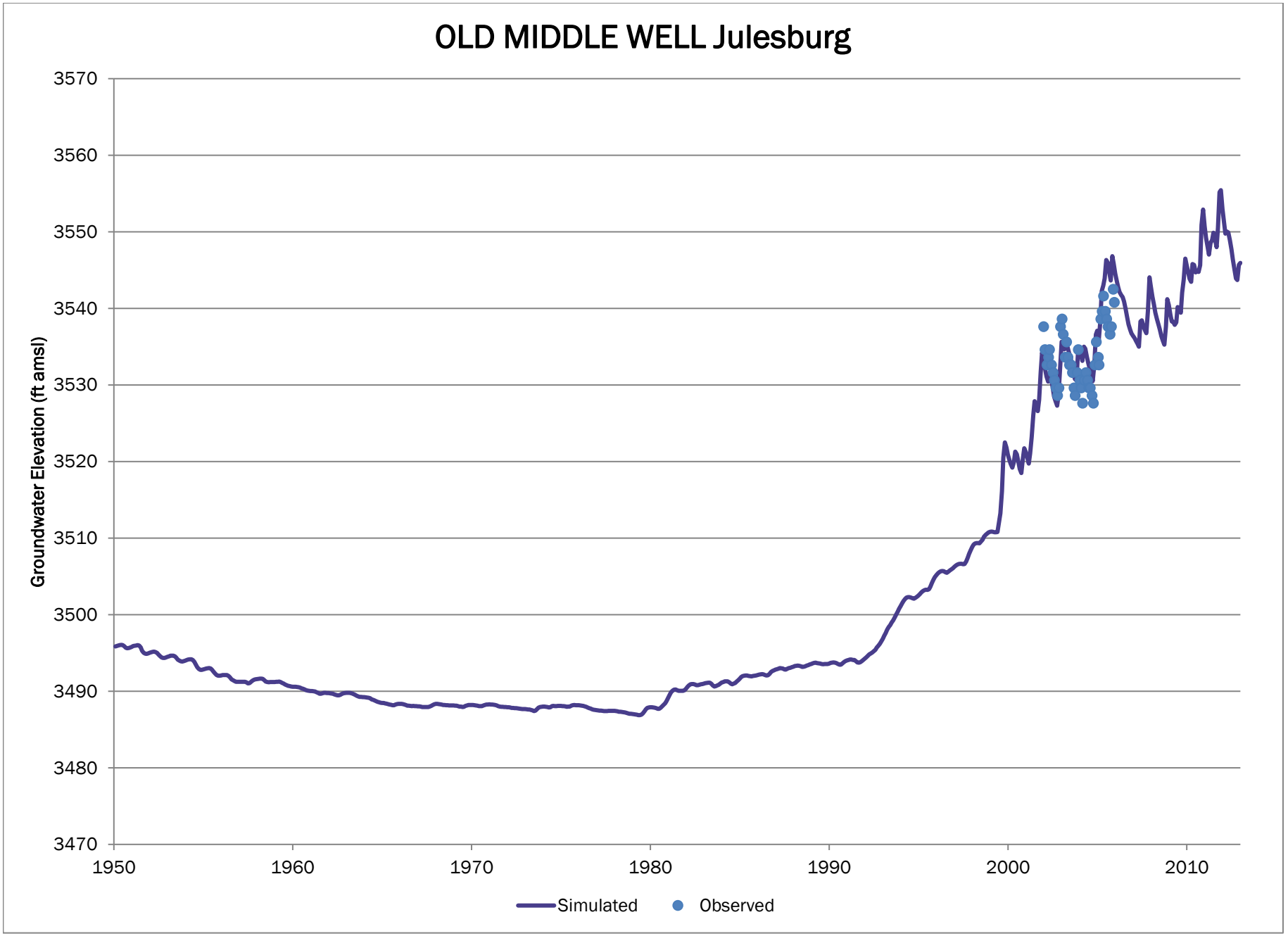

JULS POWER PLANT #2 Julesburg
Groundwater Elevation (ft amsl)
3485
3480
3475
3470
3465
3460
3455
3450
3445
3440
3435
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

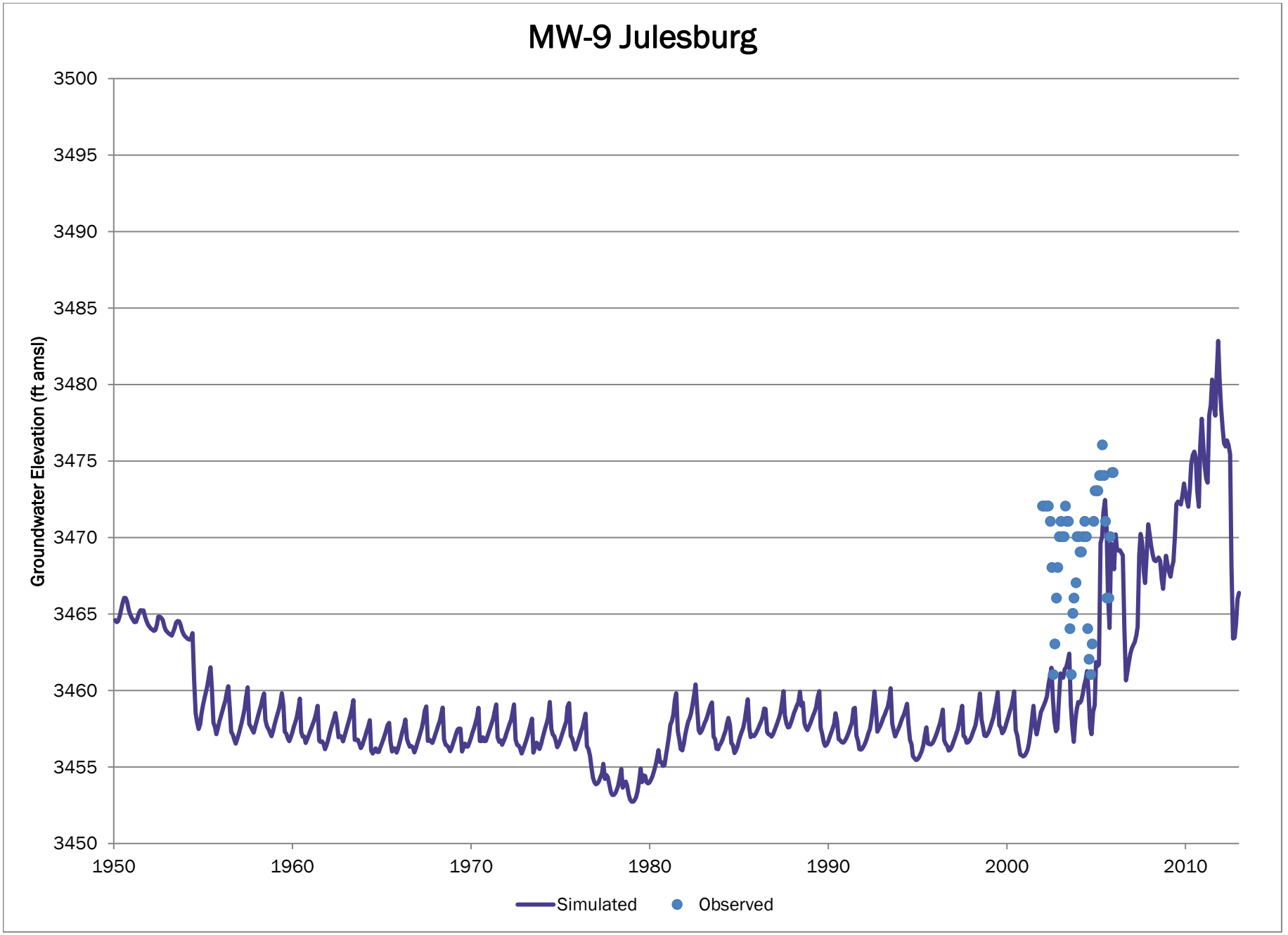

JULS POWER PLANT #1 Julesburg
Groundwater Elevation (ft amsl)
3480
3475
3470
3465
3460
3455
3450
3445
3440
3435
3430
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

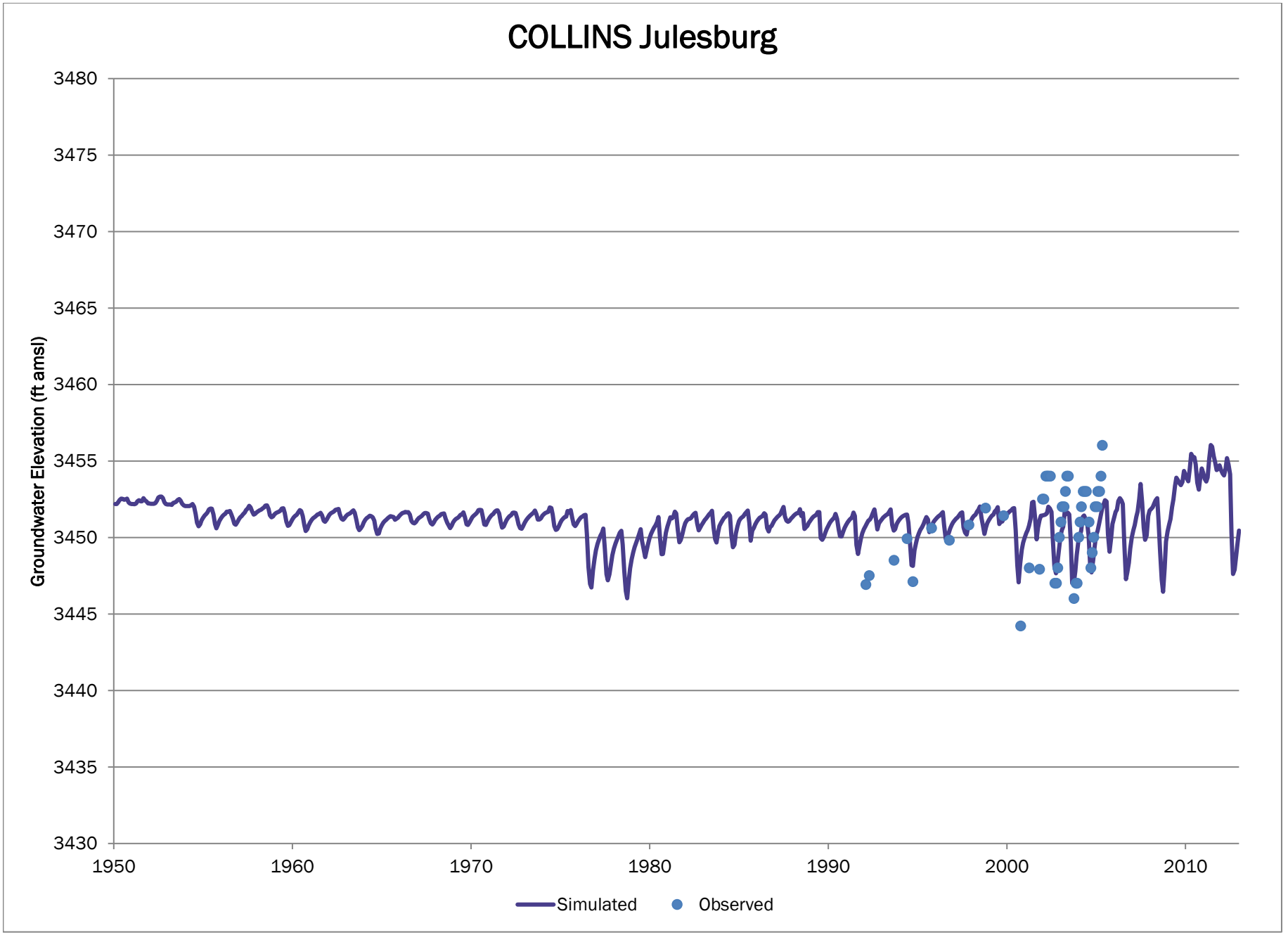

WHITE Julesburg
Groundwater Elevation (ft amsl)
3505
3500
3495
3490
3485
3480
3475
3470
3465
3460
3455
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

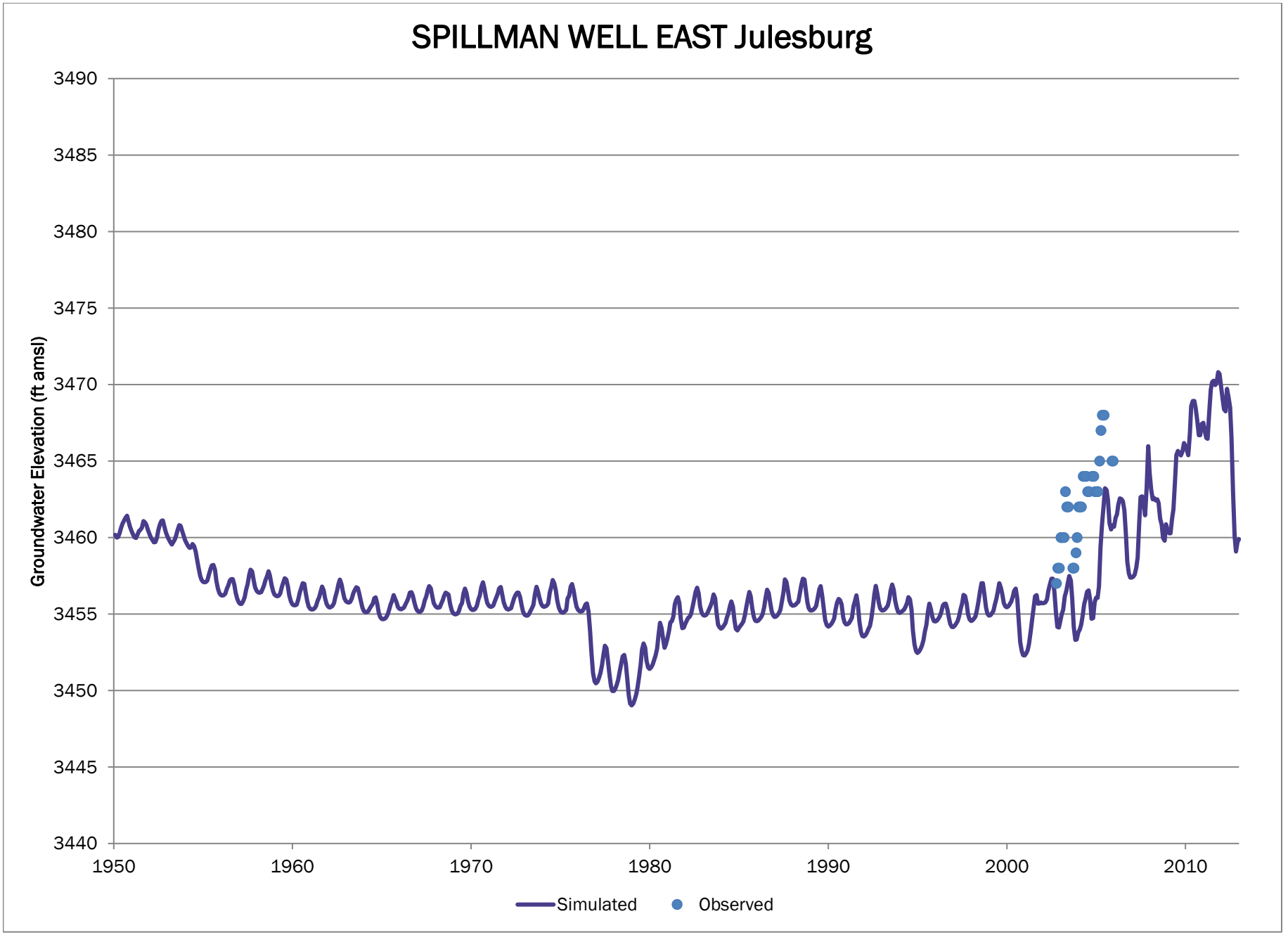

HODGES Julesburg
Groundwater Elevation (ft amsl)
3485
3480
3475
3470
3465
3460
3455
3450
3445
3440
3435
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

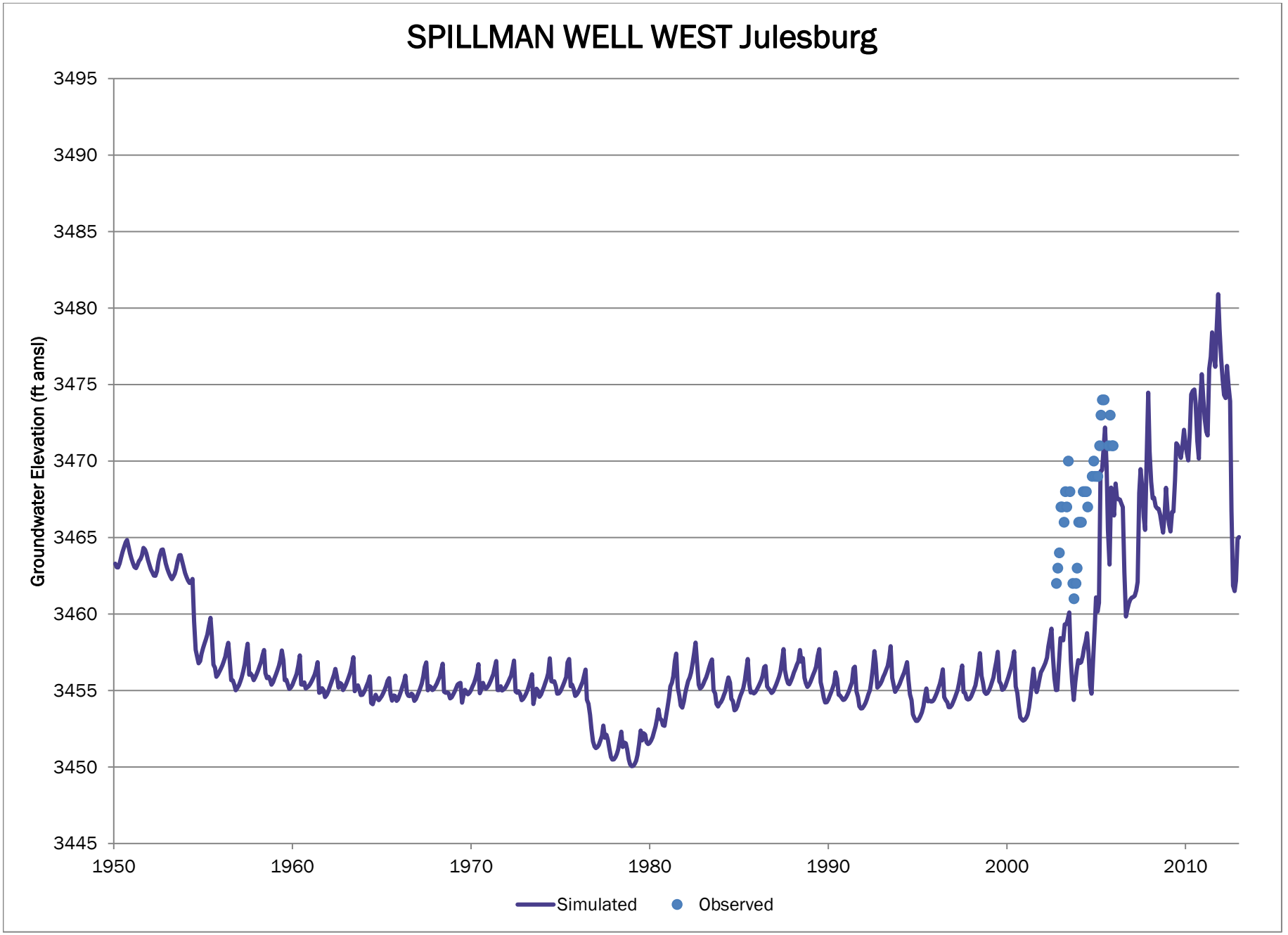
Note elevation axis range of 100 feet.

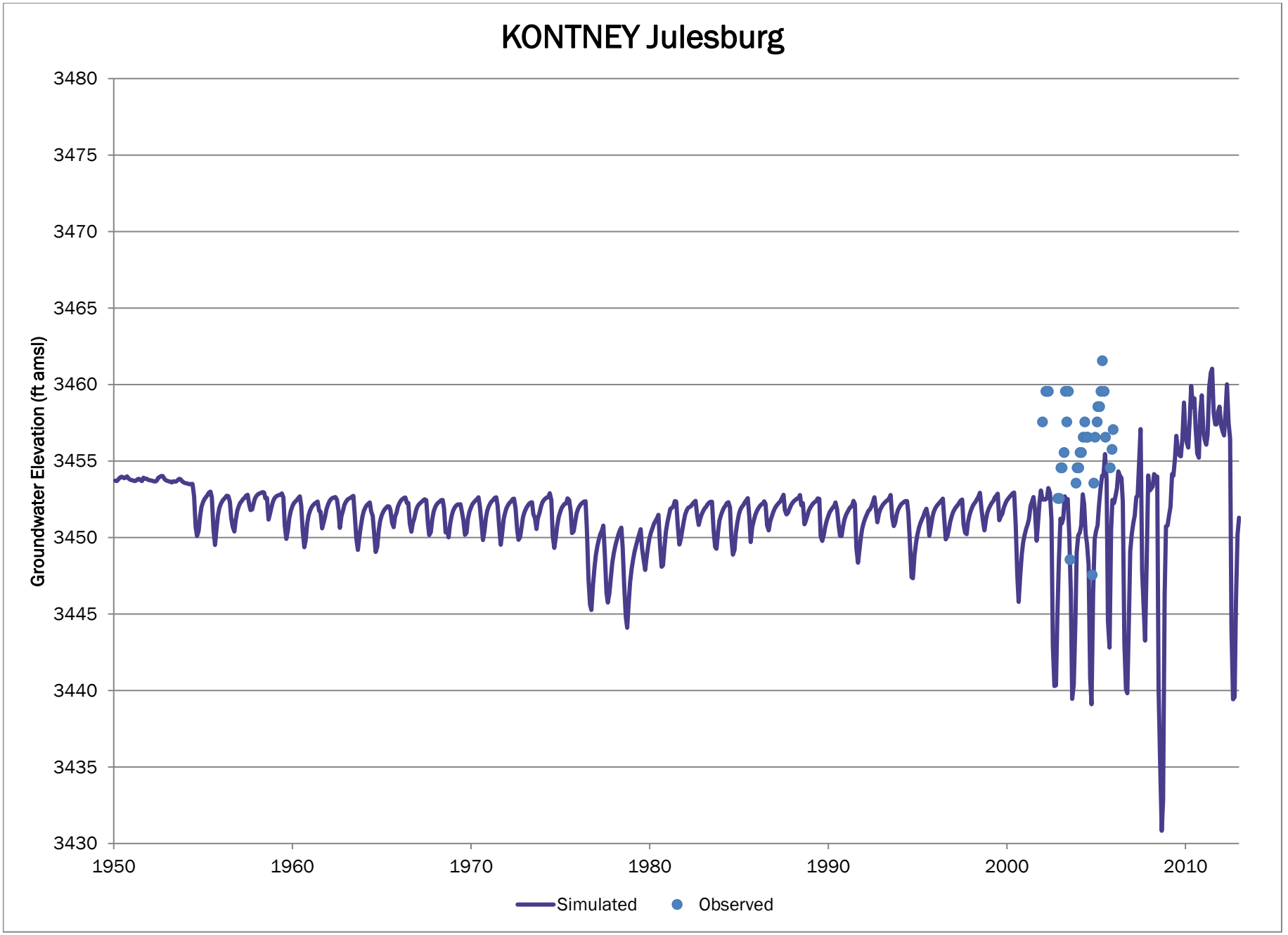


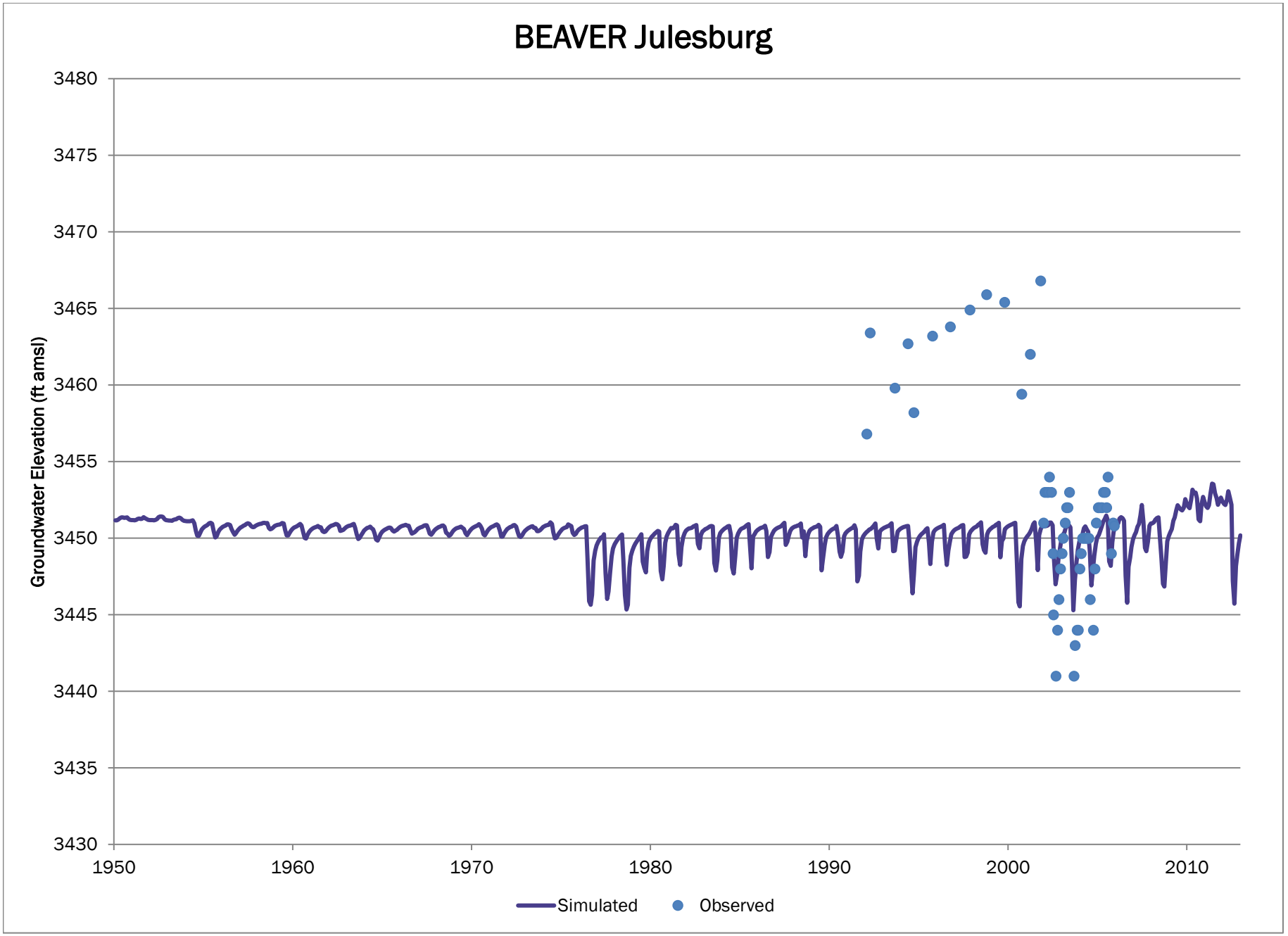

MW-9 Julesburg
Groundwater Elevation (ft amsl)
3500
3495
3490
3485
3480
3475
3470
3465
3460
3455
3450
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

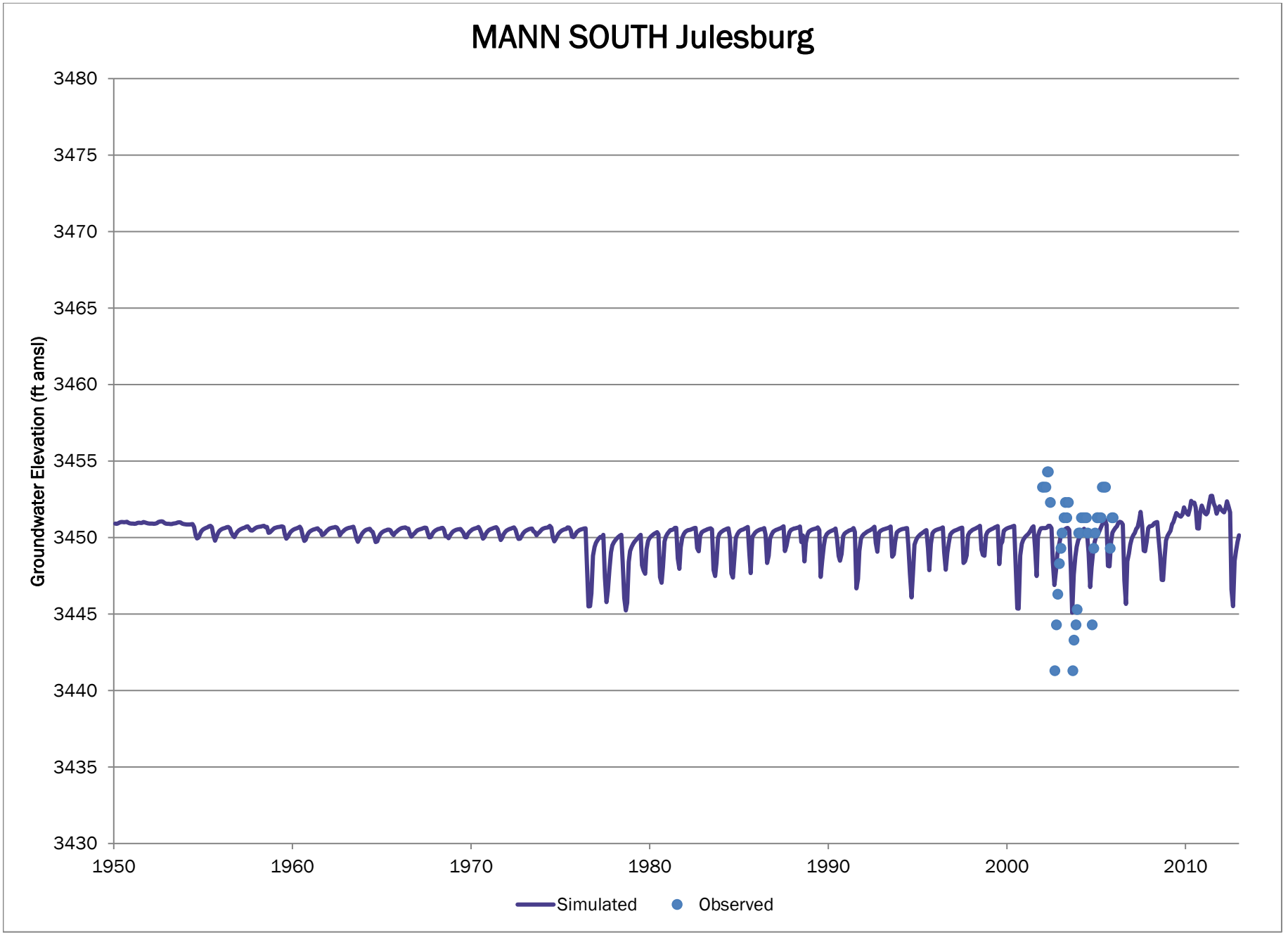

COLLINS Julesburg
Groundwater Elevation (ft amsl)
3480
3475
3470
3465
3460
3455
3450
3445
3440
3435
3430
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

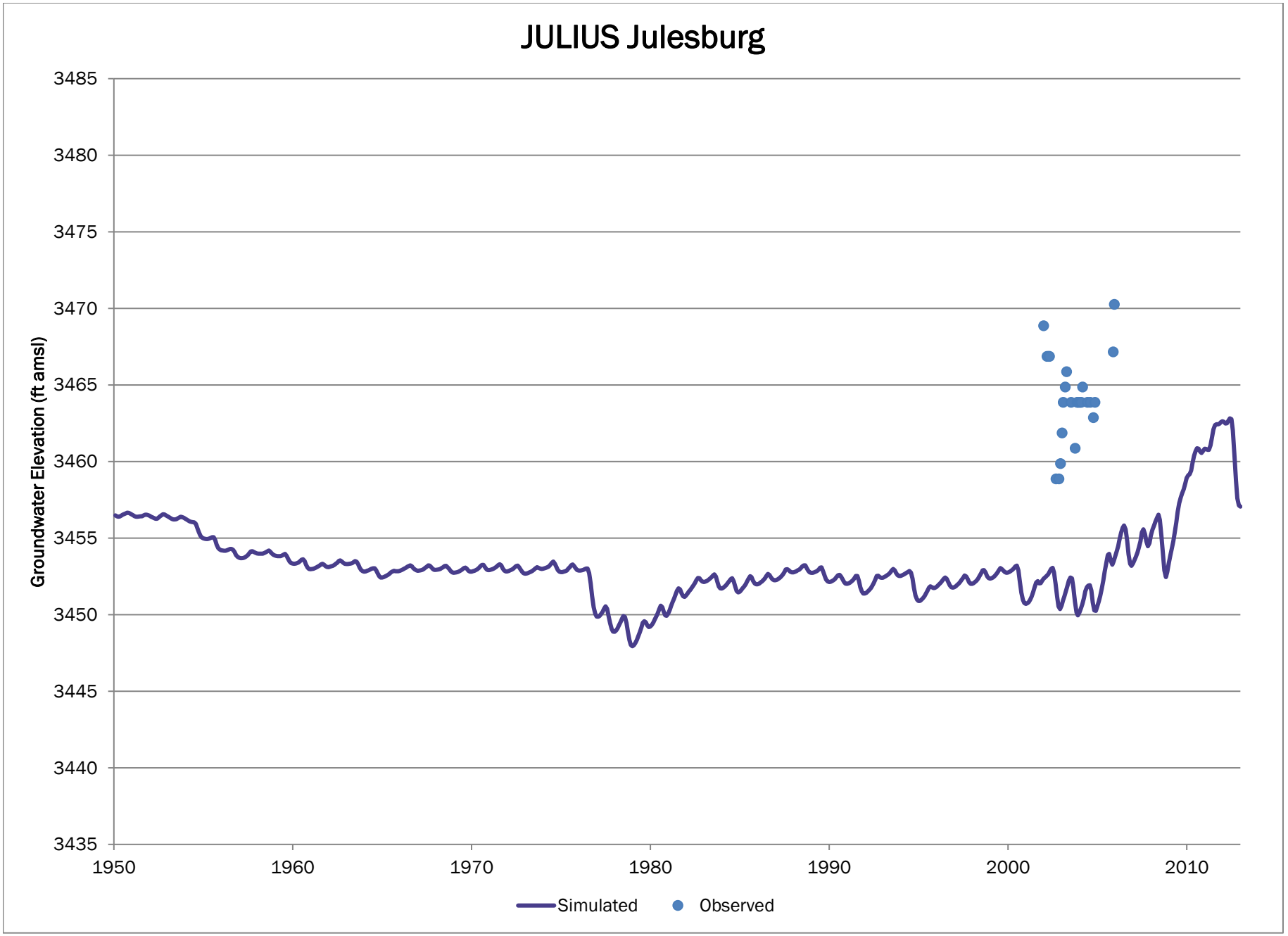

SPILLMAN WELL EAST Julesburg
Groundwater Elevation (ft amsl)
3490
3485
3480
3475
3470
3465
3460
3455
3450
3445
3440
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

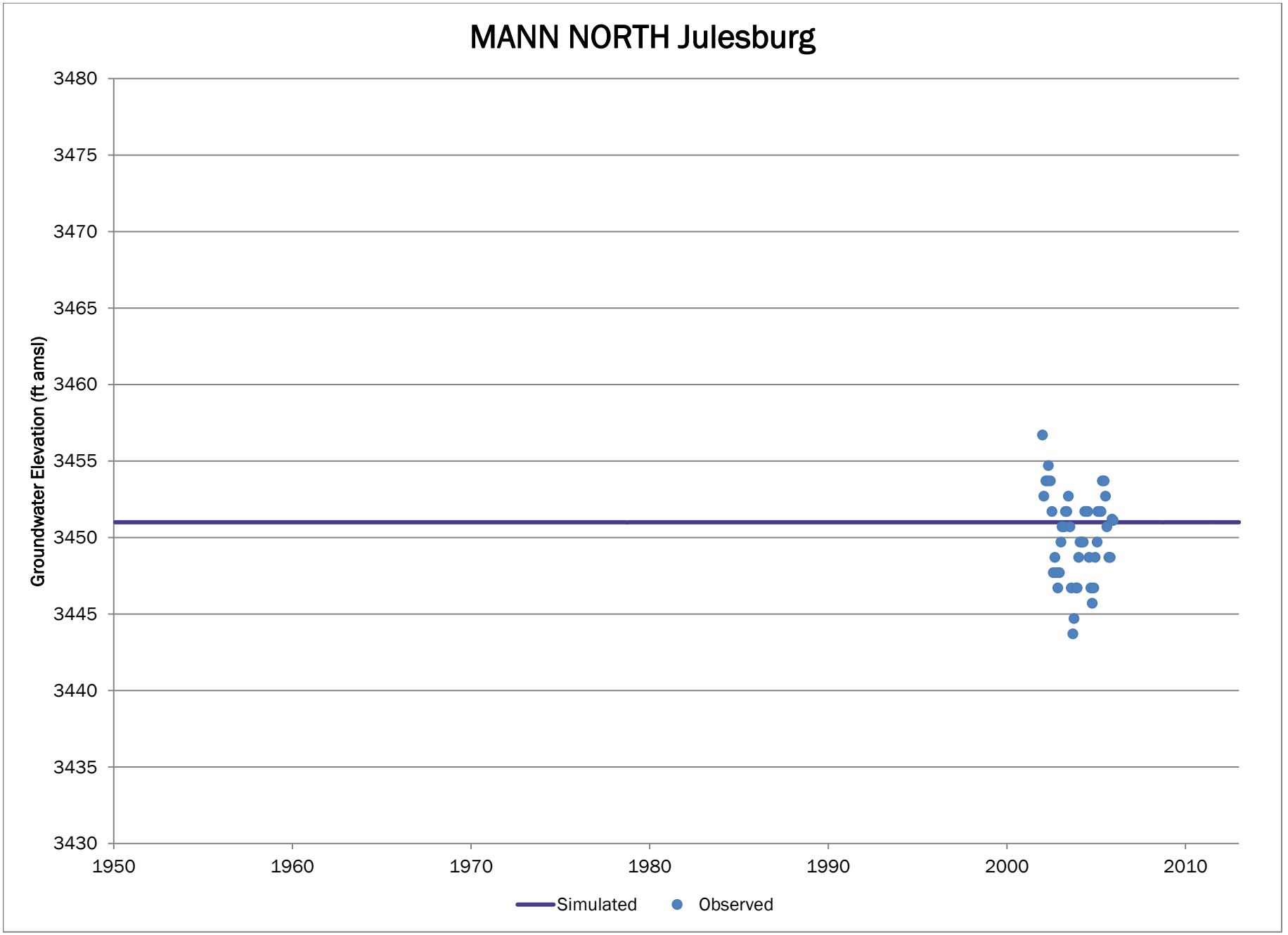

SPILLMAN WELL WEST Julesburg
Groundwater Elevation (ft amsl)
3495
3490
3485
3480
3475
3470
3465
3460
3455
3450
3445
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

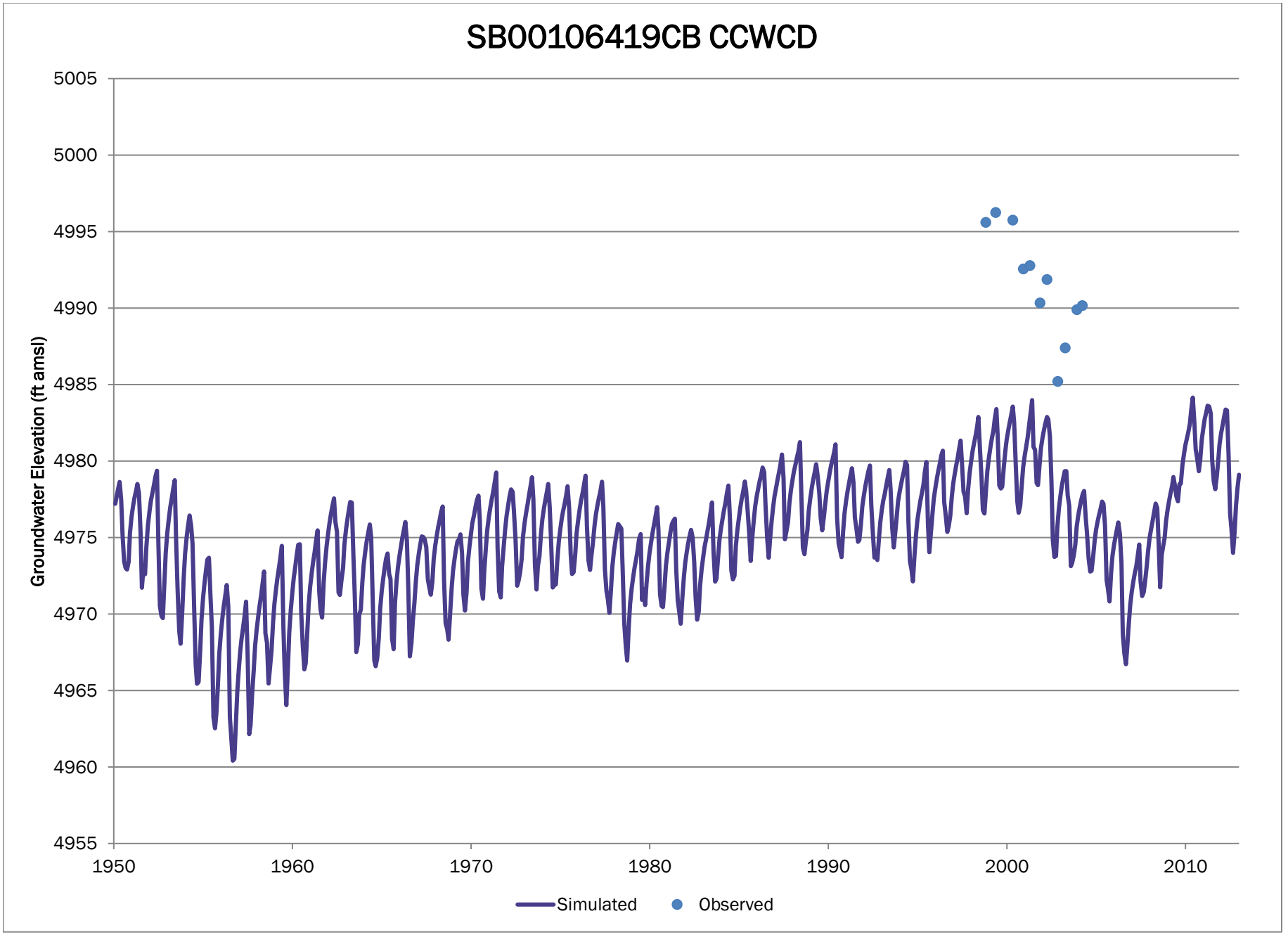

KONTNEY Julesburg
Groundwater Elevation (ft amsl)
3480
3475
3470
3465
3460
3455
3450
3445
3440
3435
3430
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

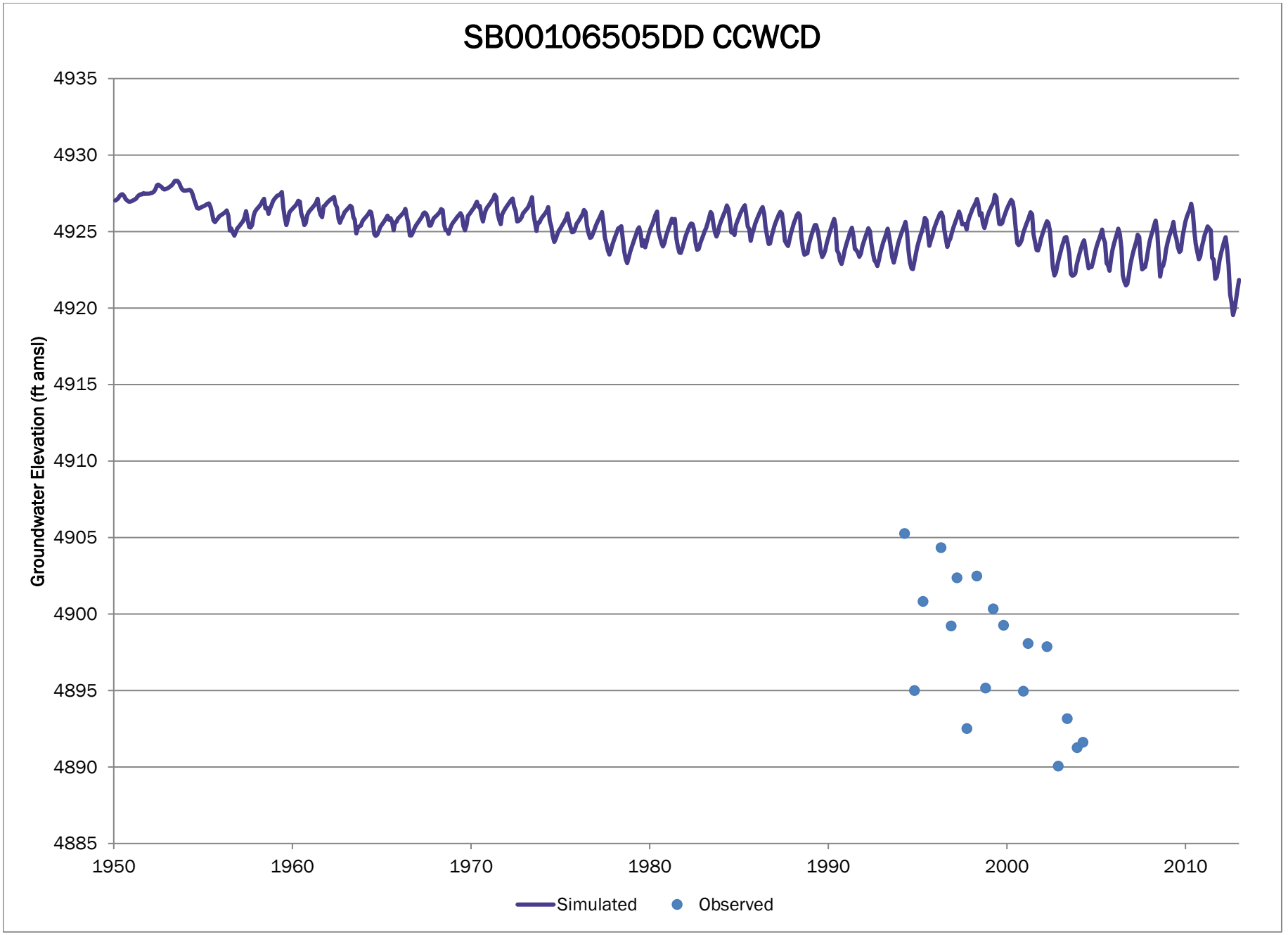

BEAVER Julesburg
Groundwater Elevation (ft amsl)
3480
3475
3470
3465
3460
3455
3450
3445
3440
3435
3430
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

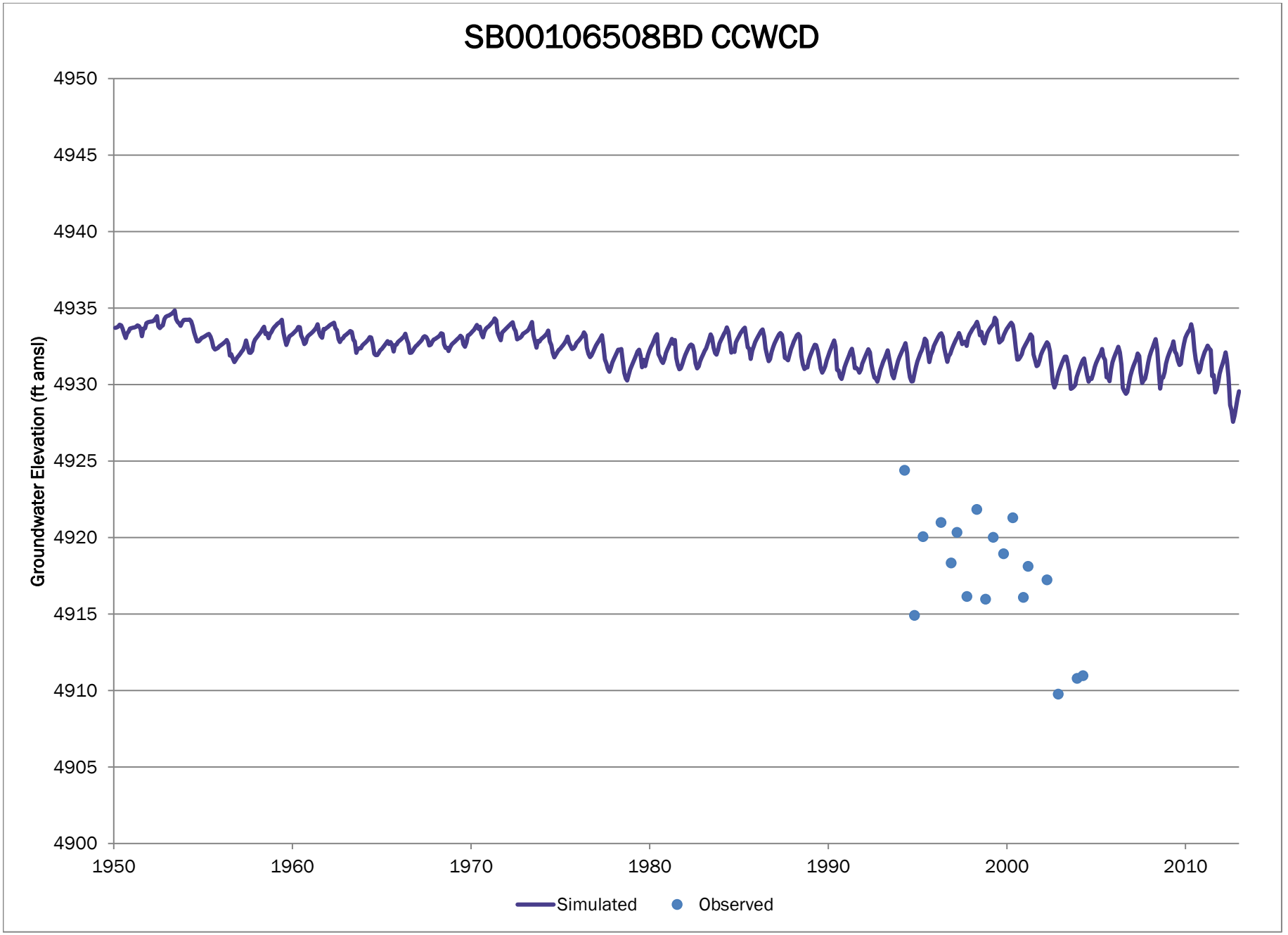

MANN SOUTH Julesburg
Groundwater Elevation (ft amsl)
3480
3475
3470
3465
3460
3455
3450
3445
3440
3435
3430
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


JULIUS Julesburg
Groundwater Elevation (ft amsl)
3485
3480
3475
3470
3465
3460
3455
3450
3445
3440
3435
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

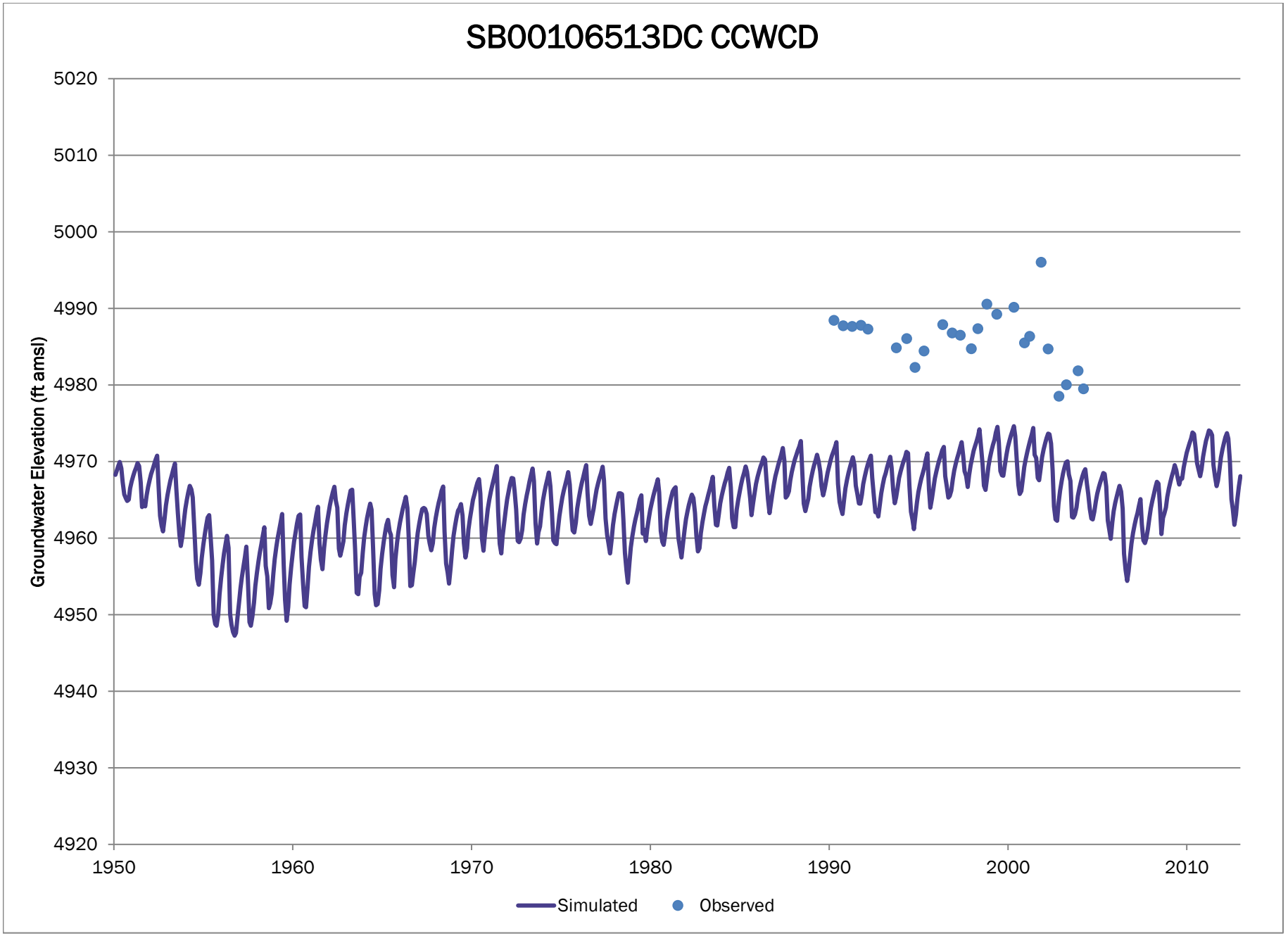

MANN NORTH Julesburg
Groundwater Elevation (ft amsl)
3480
3475
3470
3465
3460
3455
3450
3445
3440
3435
3430
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

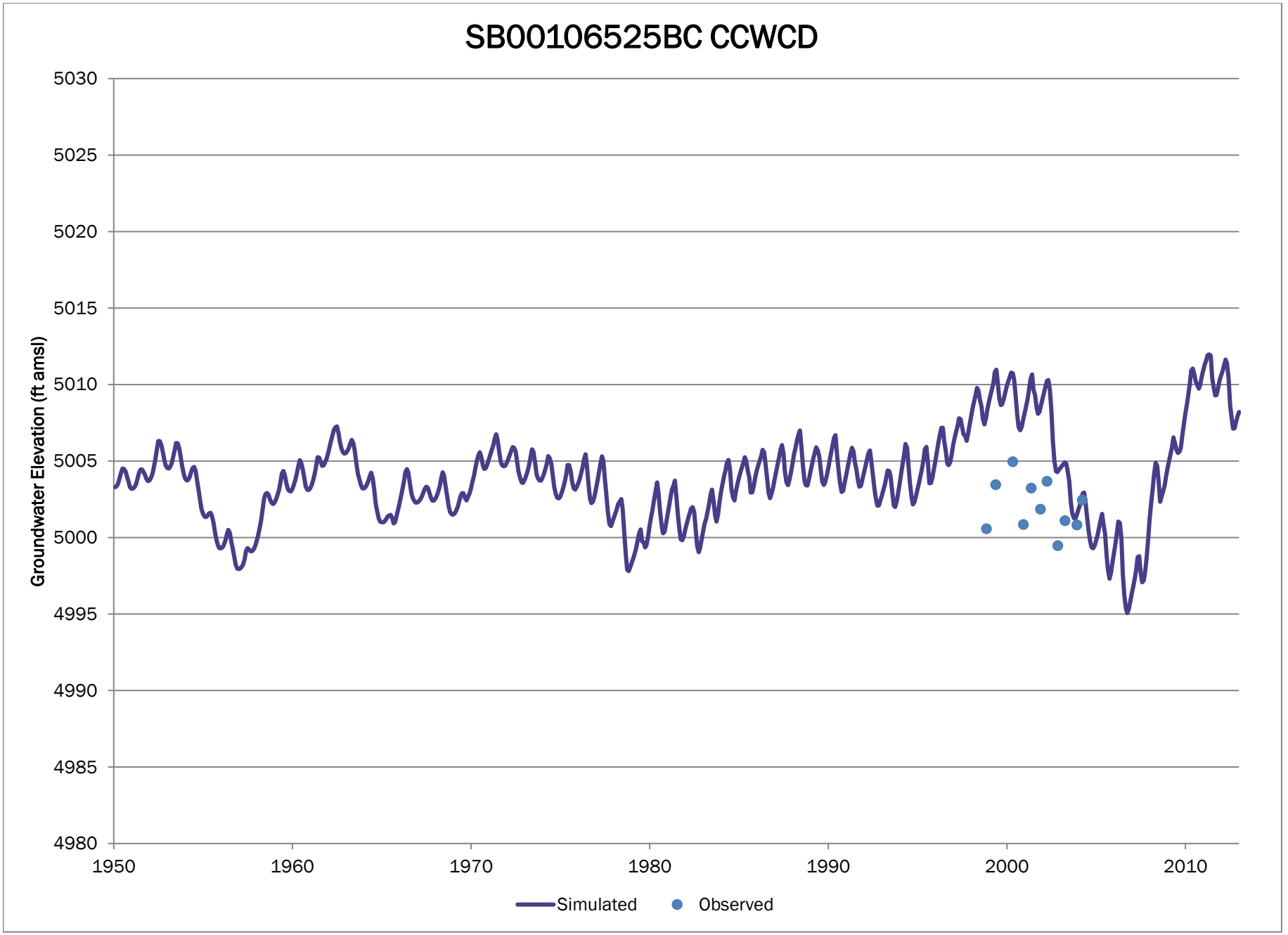

SB00106419CB CCWCD
Groundwater Elevation (ft amsl)
5005
5000
4995
4990
4985
4980
4975
4970
4965
4960
4955
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

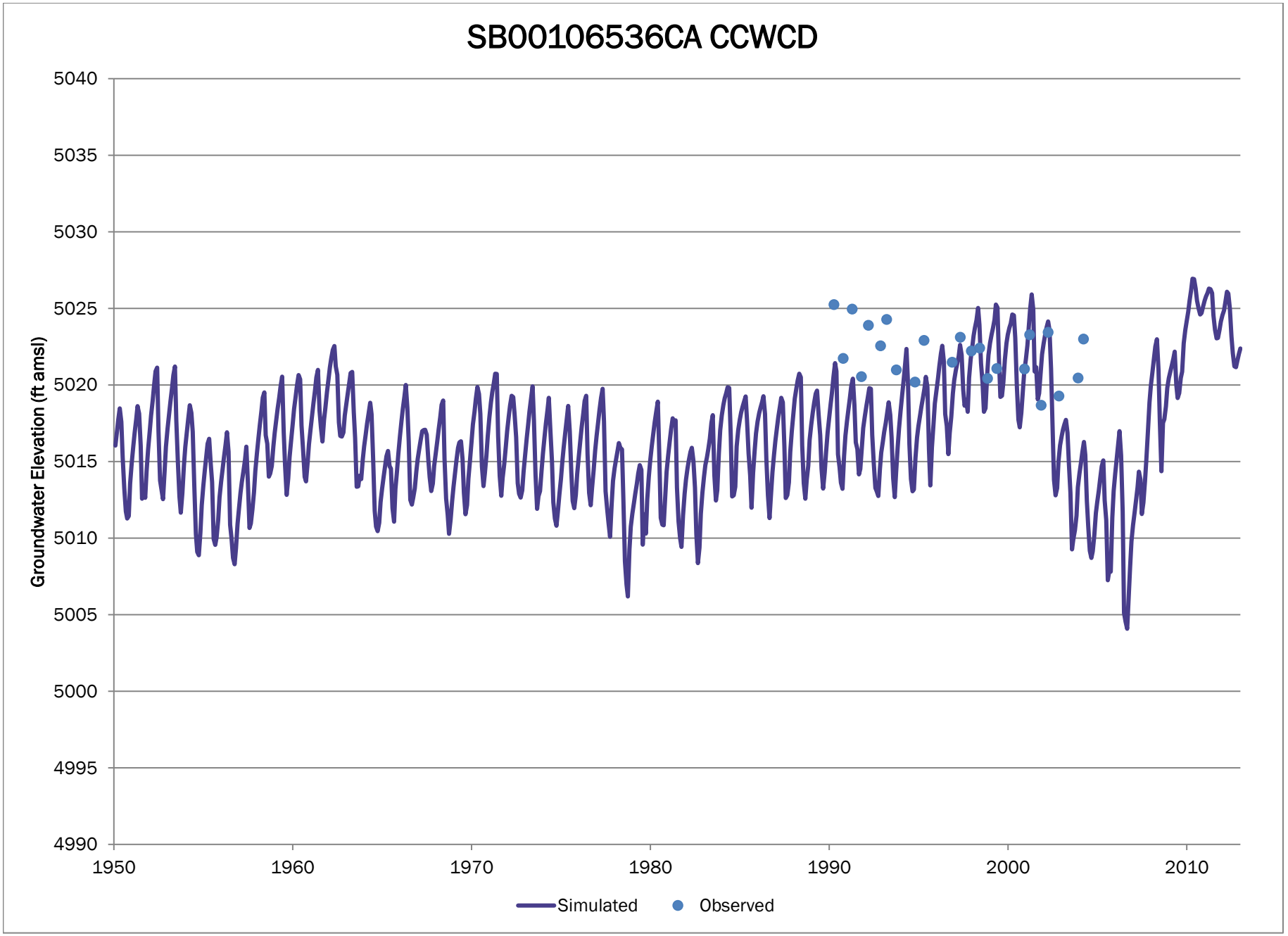

SB00106505DD CCWCD
Groundwater Elevation (ft amsl)
4935
4930
4925
4920
4915
4910
4905
4900
4895
4890
4885
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

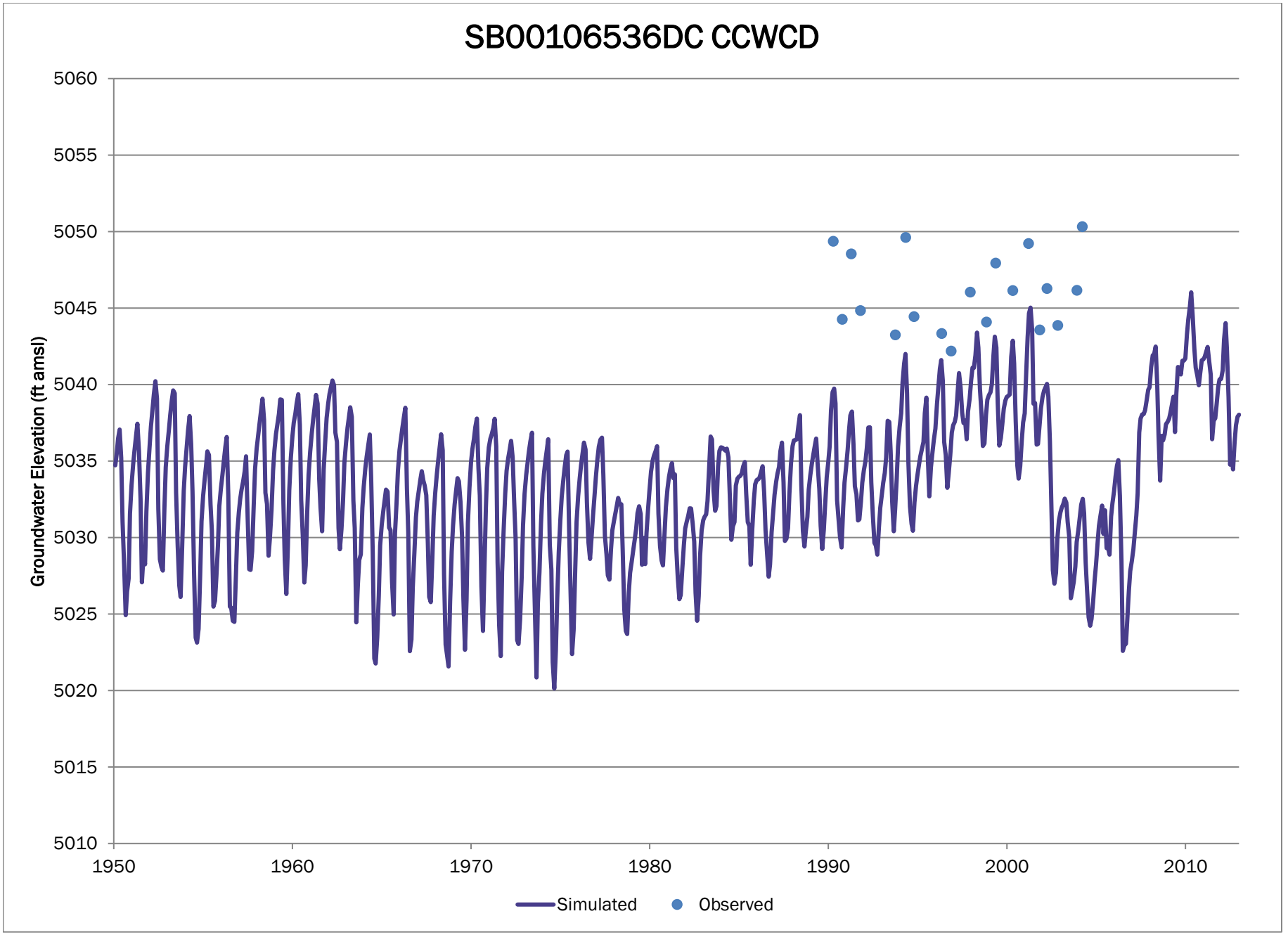

SB00106508BD CCWCD
Groundwater Elevation (ft amsl)
4950
4945
4940
4935
4930
4925
4920
4915
4910
4905
4900
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

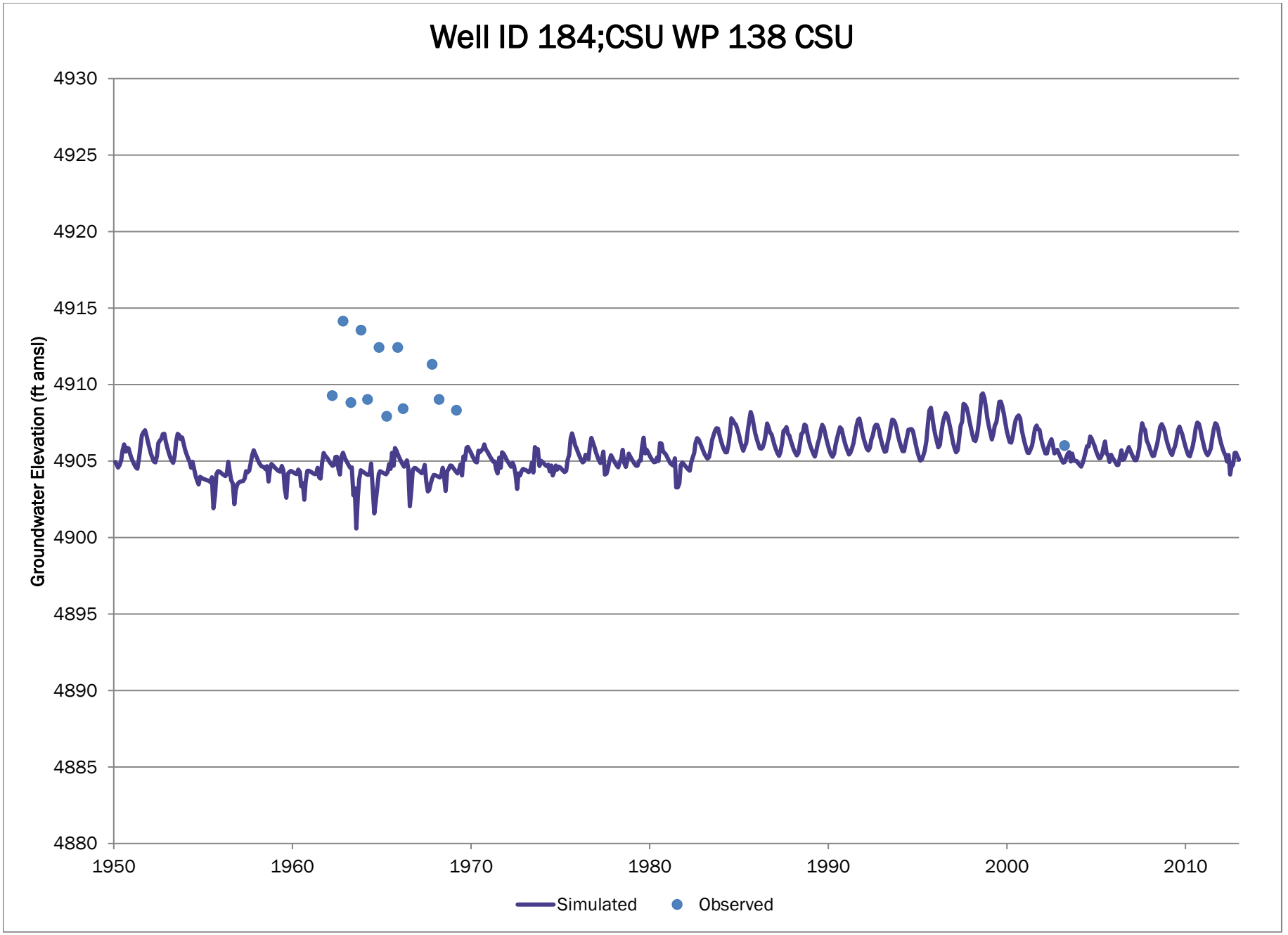
Note elevation axis range of 100 feet.

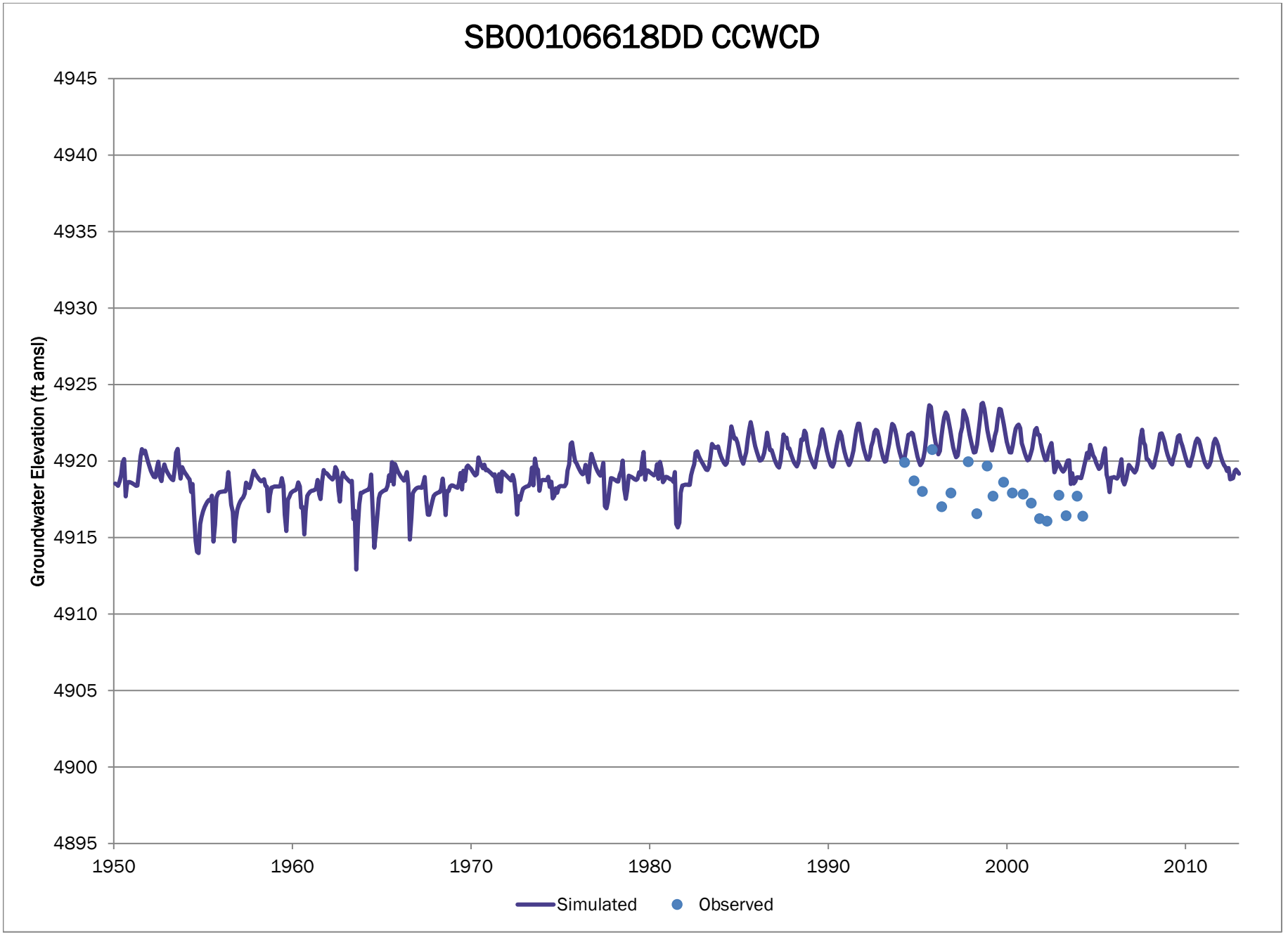


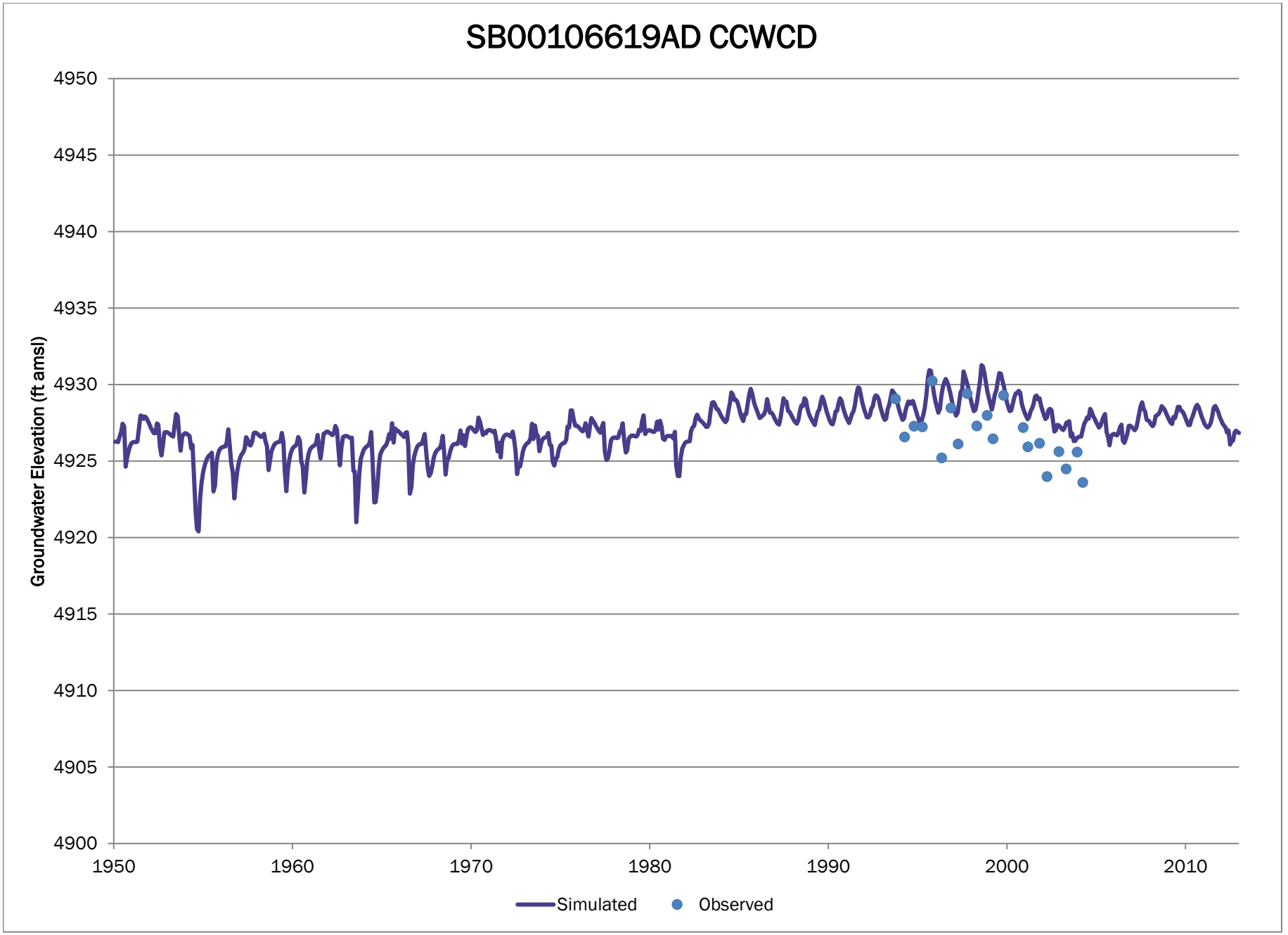

SB00106525BC CCWCD
Groundwater Elevation (ft amsl)
5030
5025
5020
5015
5010
5005
5000
4995
4990
4985
4980
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

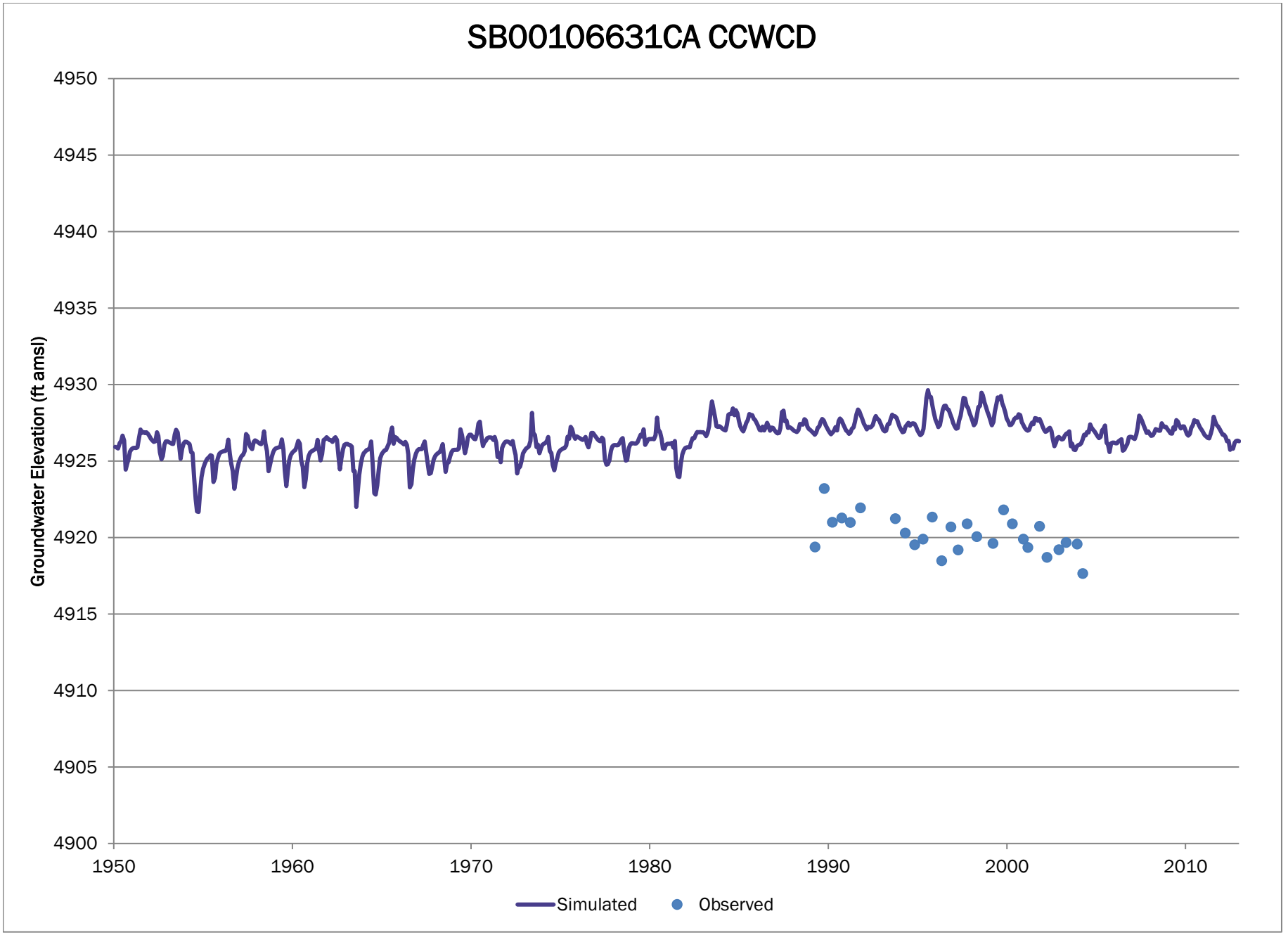

SB00106536CA CCWCD
Groundwater Elevation (ft amsl)
5040
5035
5030
5025
5020
5015
5010
5005
5000
4995
4990
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

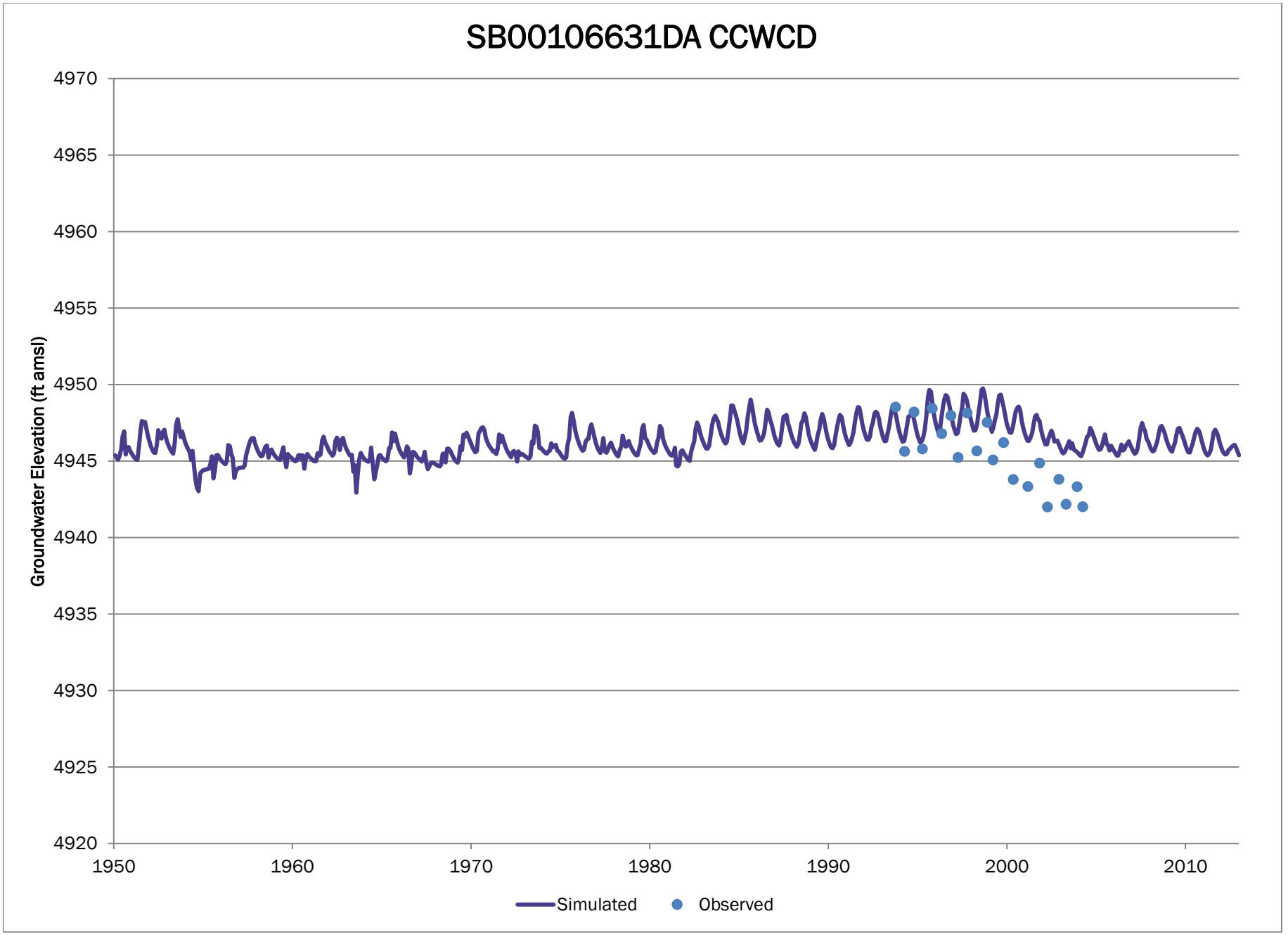

SB00106536DC CCWCD
Groundwater Elevation (ft amsl)
5060
5055
5050
5045
5040
5035
5030
5025
5020
5015
5010
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

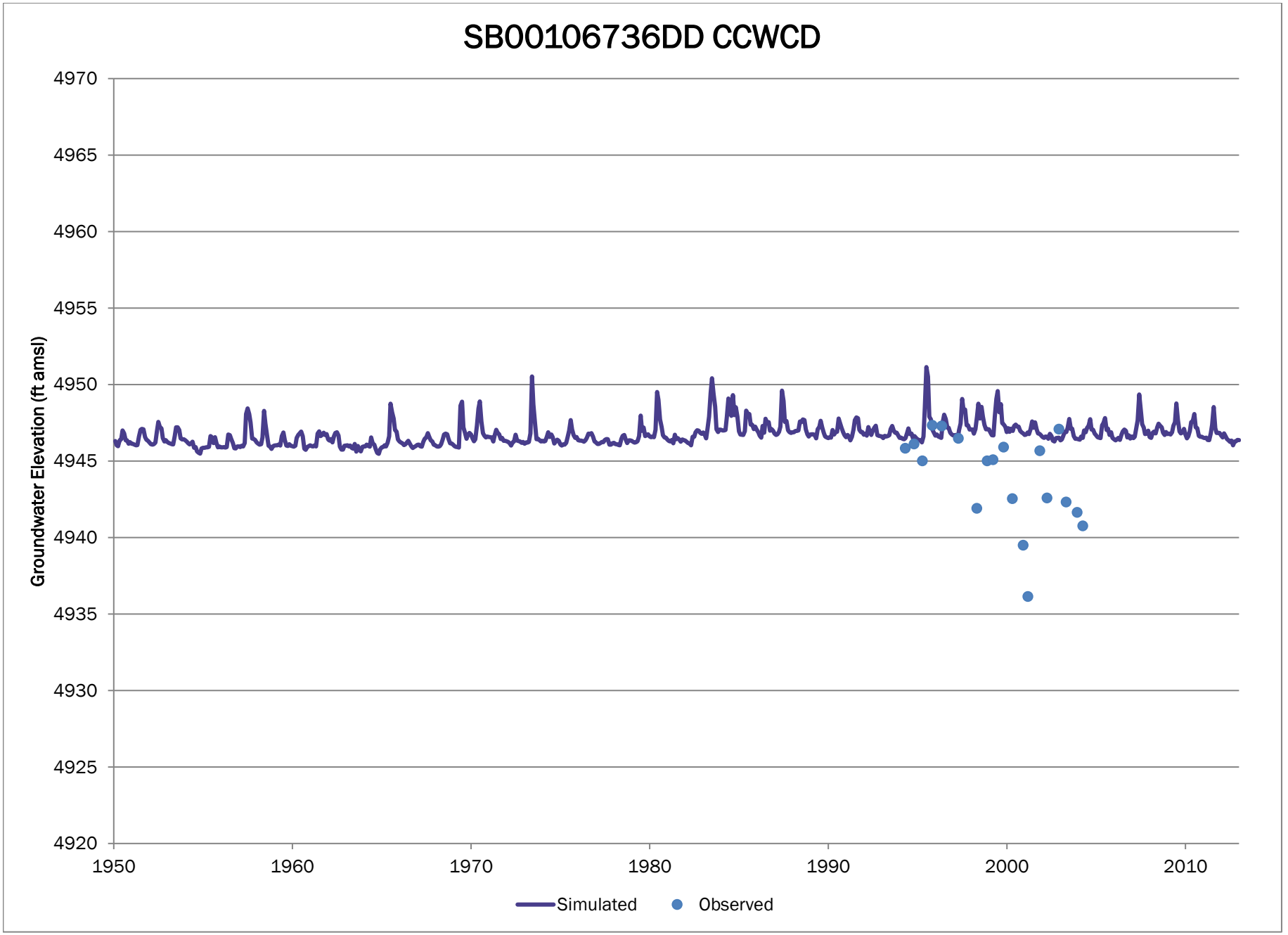

Well ID 184;CSU WP 138 CSU
Groundwater Elevation (ft amsl)
4930
4925
4920
4915
4910
4905
4900
4895
4890
4885
4880
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


SB00106618DD CCWCD
Groundwater Elevation (ft amsl)
4945
4940
4935
4930
4925
4920
4915
4910
4905
4900
4895
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

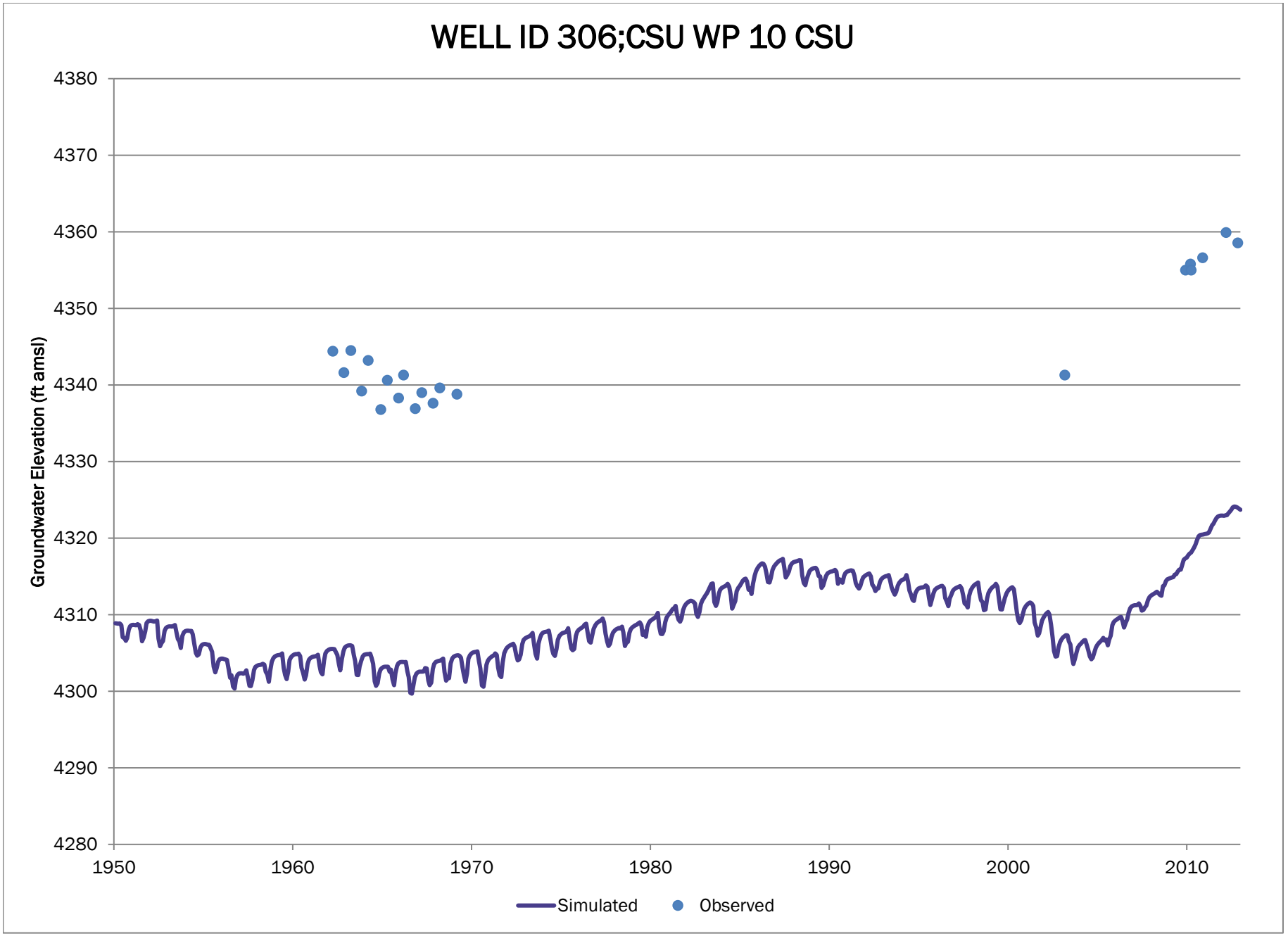

SB00106619AD CCWCD
Groundwater Elevation (ft amsl)
4950
4945
4940
4935
4930
4925
4920
4915
4910
4905
4900
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

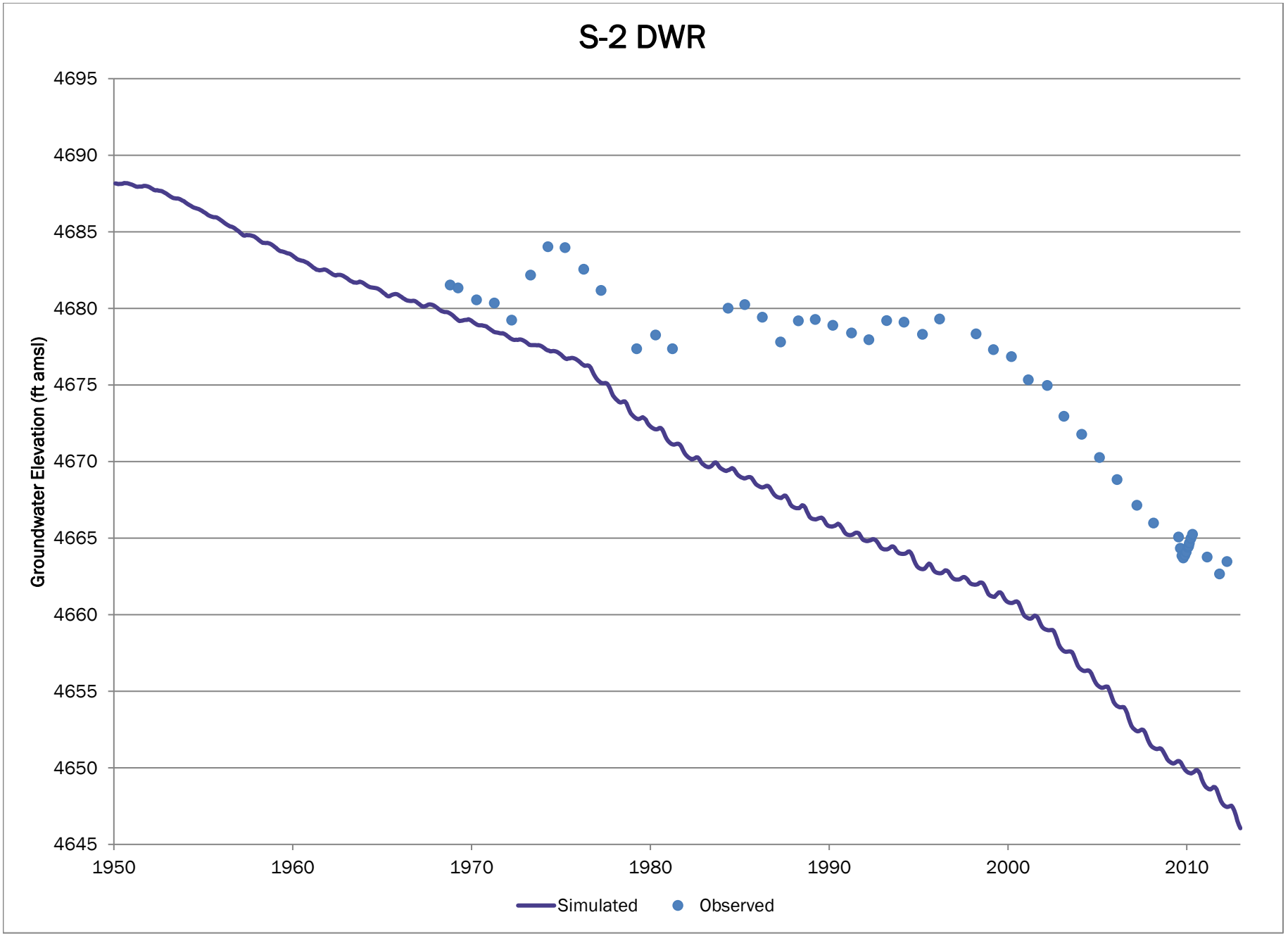

SB00106631CA CCWCD
Groundwater Elevation (ft amsl)
4950
4945
4940
4935
4930
4925
4920
4915
4910
4905
4900
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


SB00106631DA CCWCD
Groundwater Elevation (ft amsl)
4970
4965
4960
4955
4950
4945
4940
4935
4930
4925
4920
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

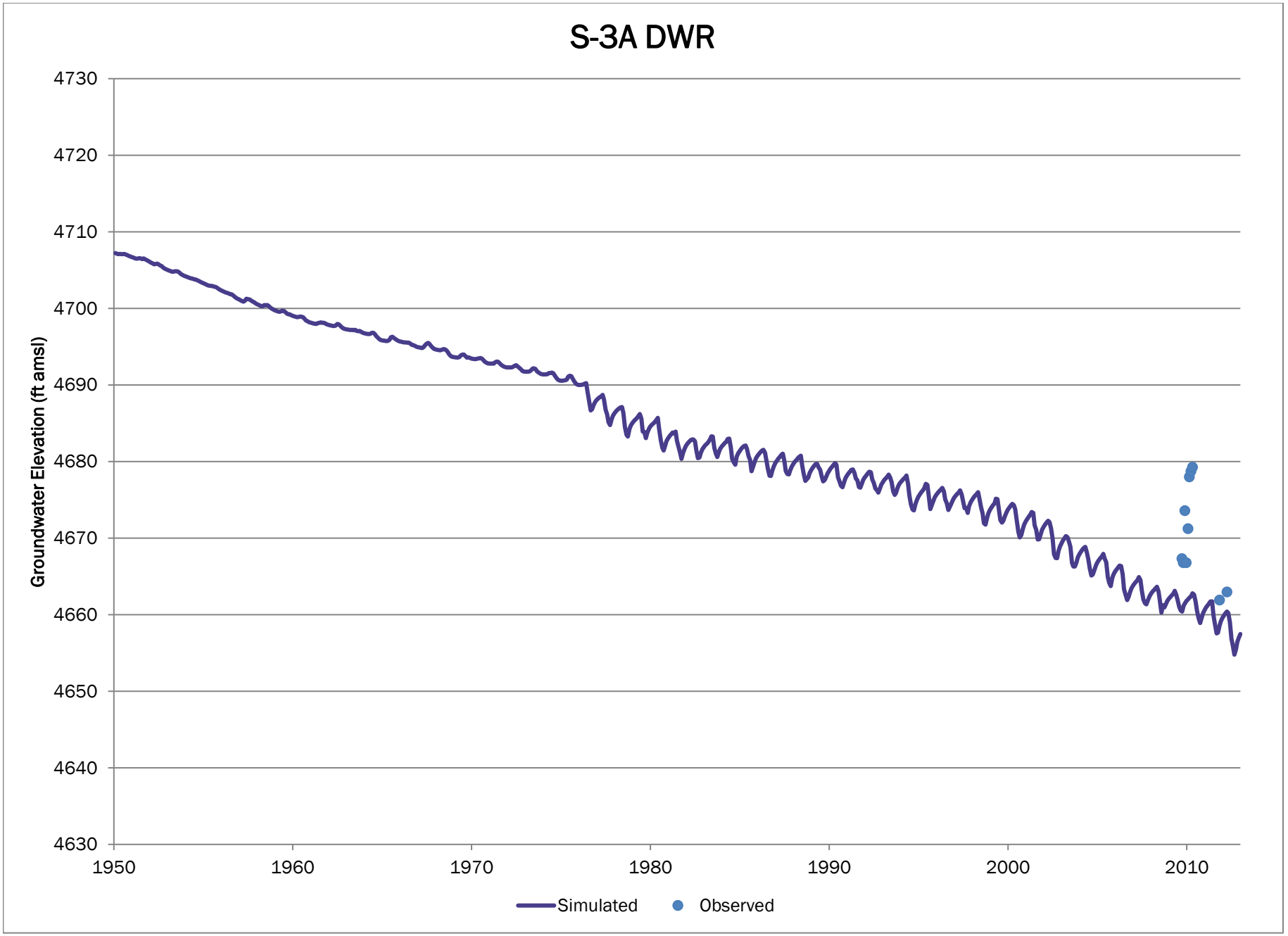

SB00106736DD CCWCD
Groundwater Elevation (ft amsl)
4970
4965
4960
4955
4950
4945
4940
4935
4930
4925
4920
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

Note elevation axis range of 100 feet.

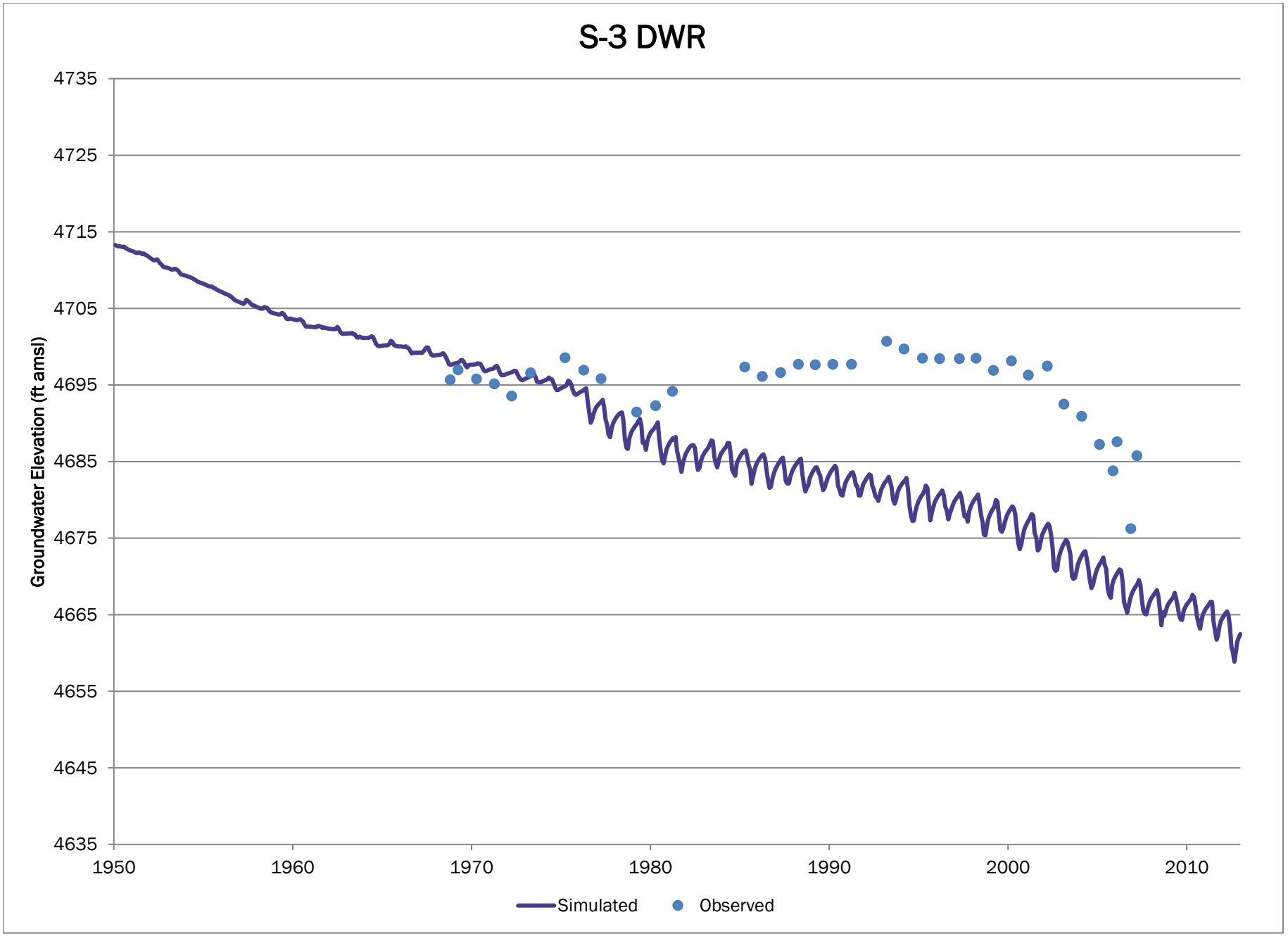


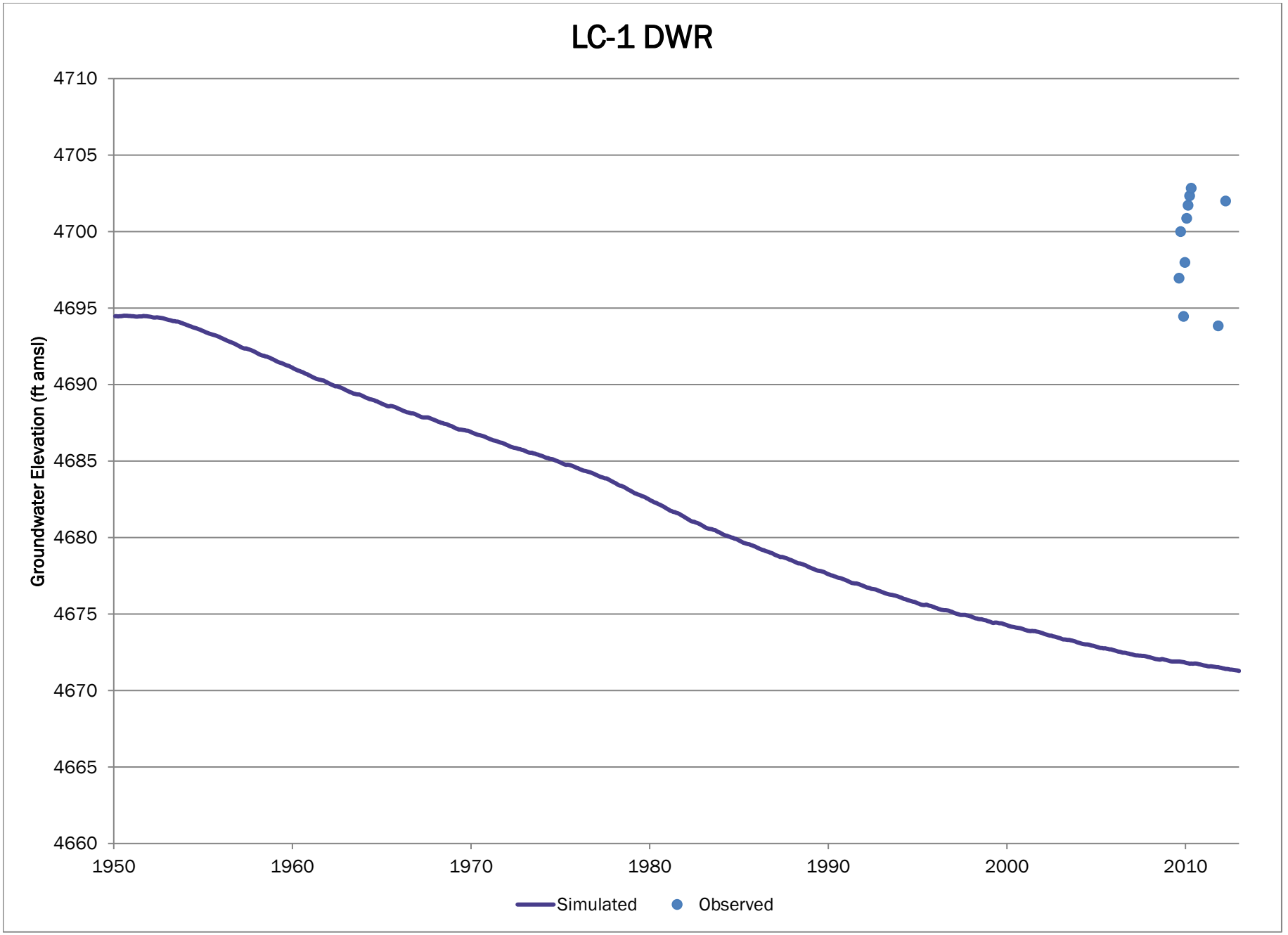

S-2 DWR
Groundwater Elevation (ft amsl)
4695
4690
4685
4680
4675
4670
4665
4660
4655
4650
4645
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

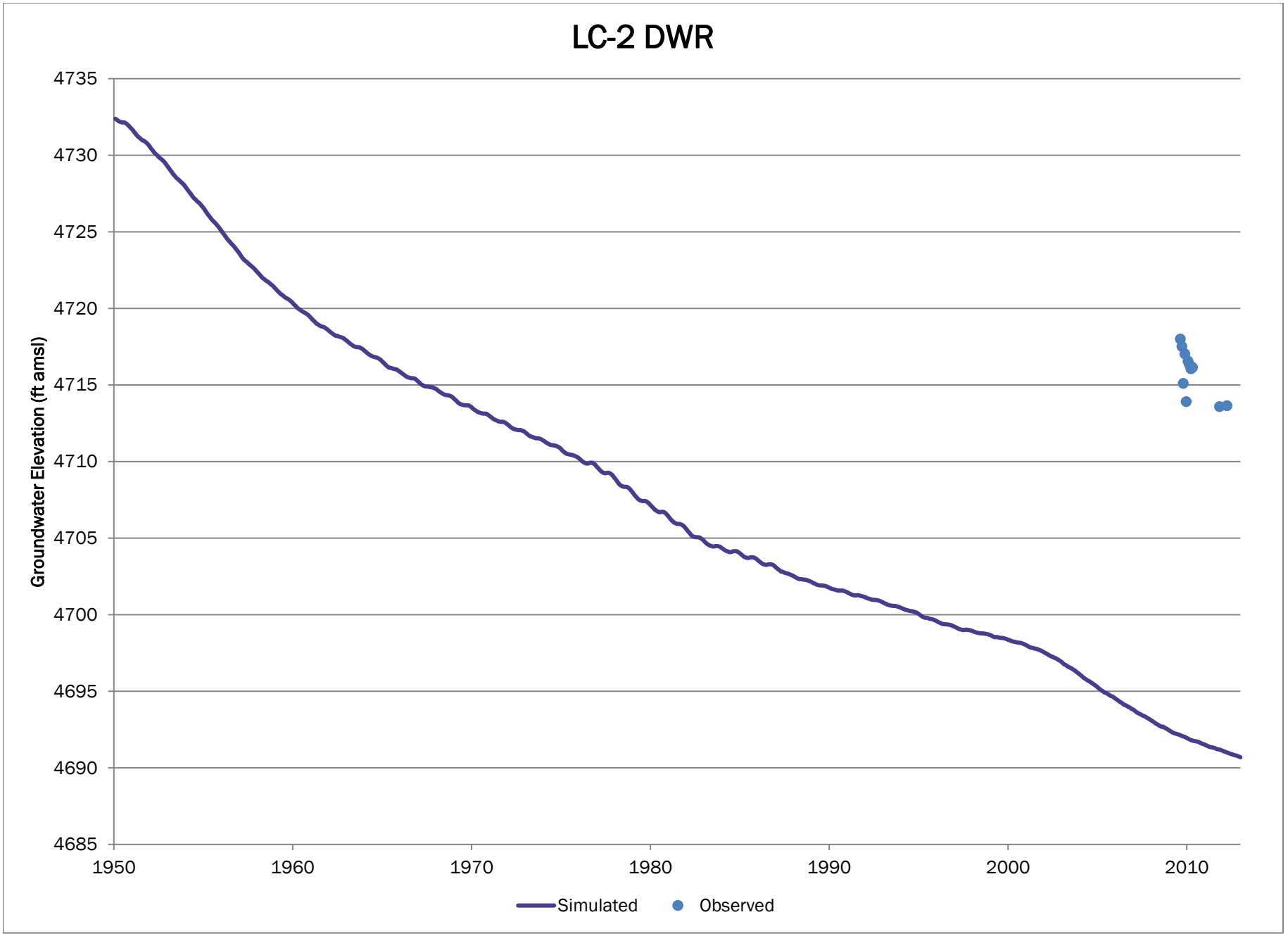
Note elevation axis range of 100 feet.



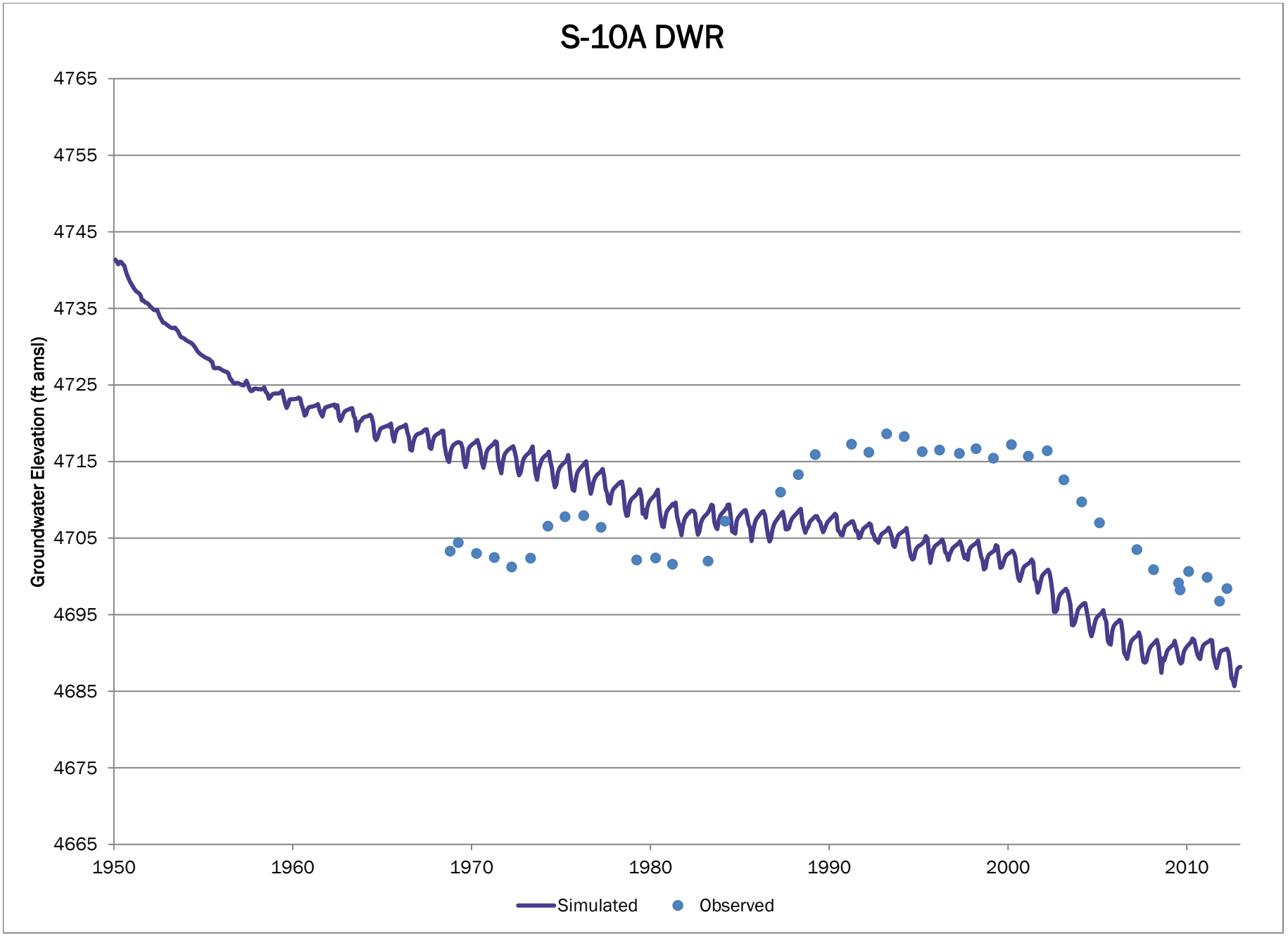
Note elevation axis range of 100 feet.



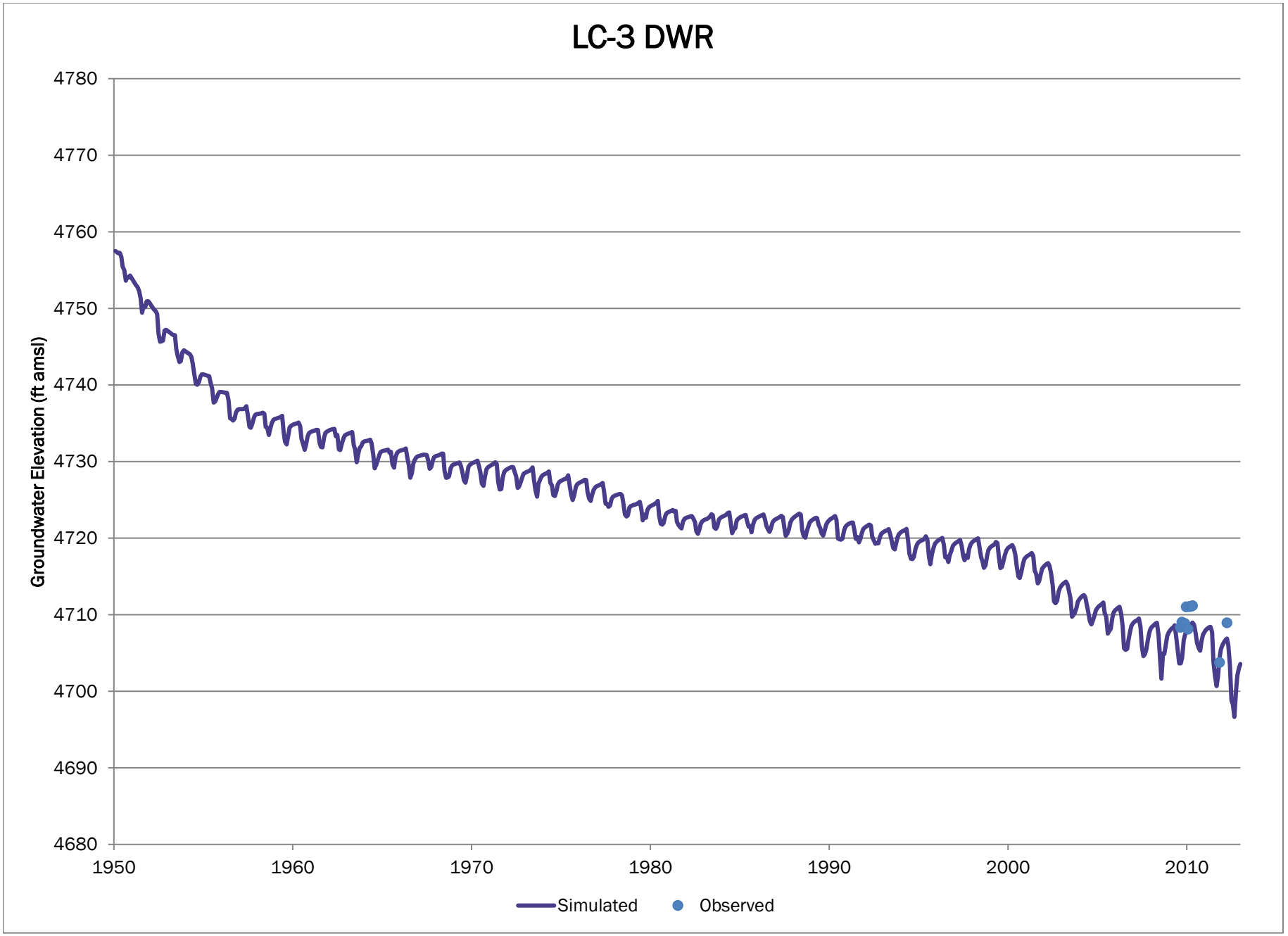

LC-1 DWR
Groundwater Elevation (ft amsl)
4710
4705
4700
4695
4690
4685
4680
4675
4670
4665
4660
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


LC-2 DWR
Groundwater Elevation (ft amsl)
4735
4730
4725
4720
4715
4710
4705
4700
4695
4690
4685
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

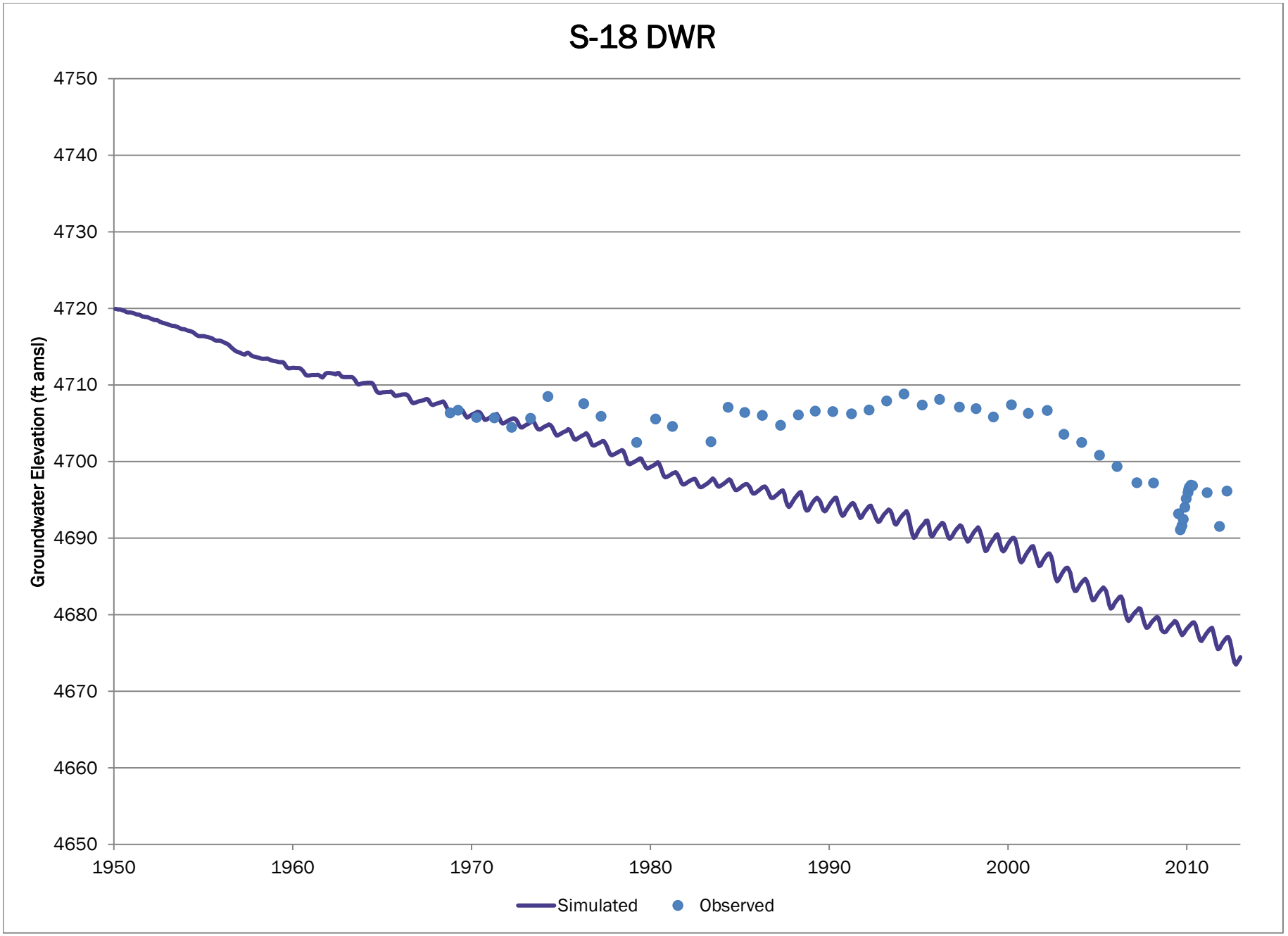
Note elevation axis range of 100 feet.



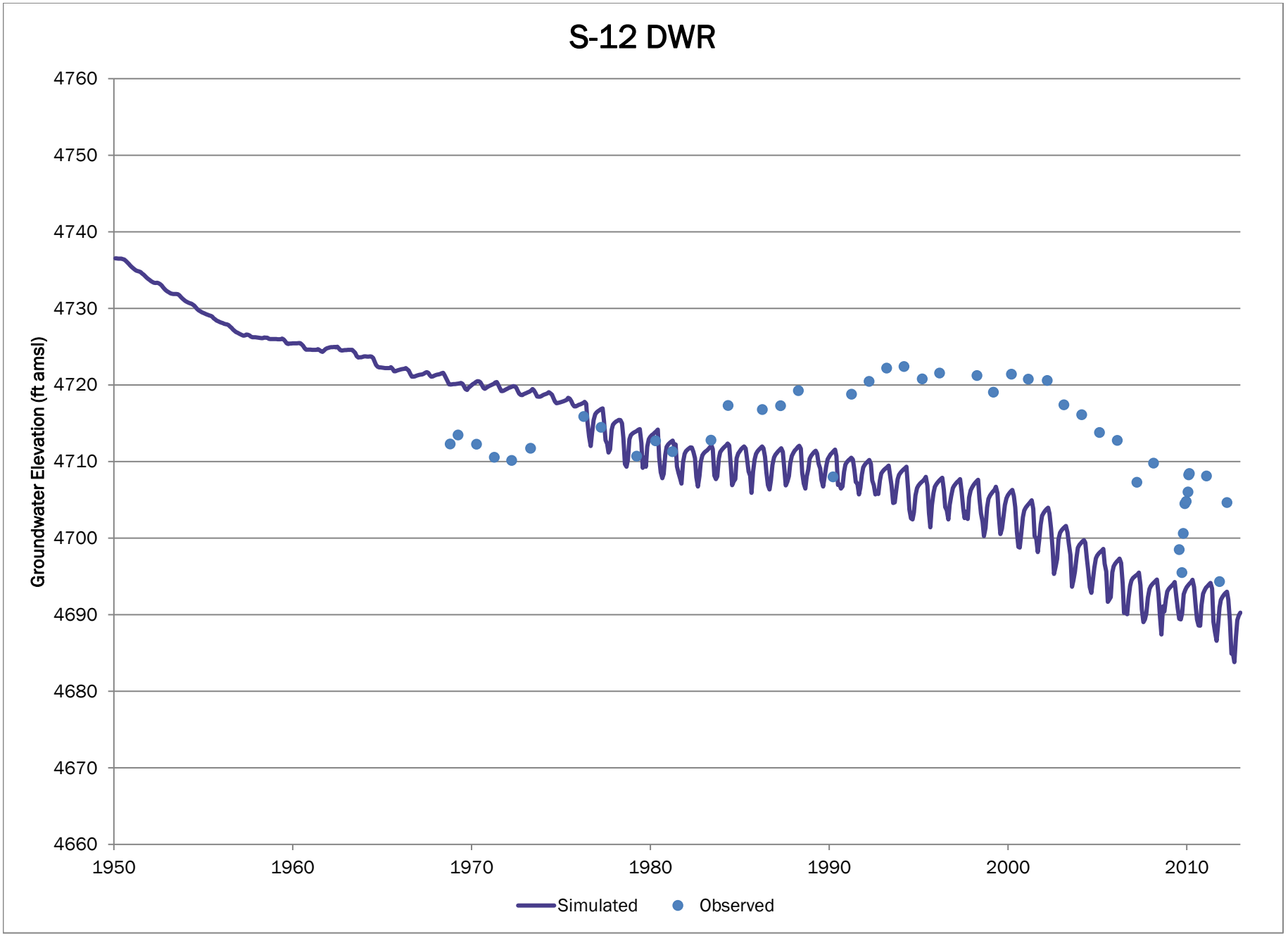
Note elevation axis range of 100 feet.



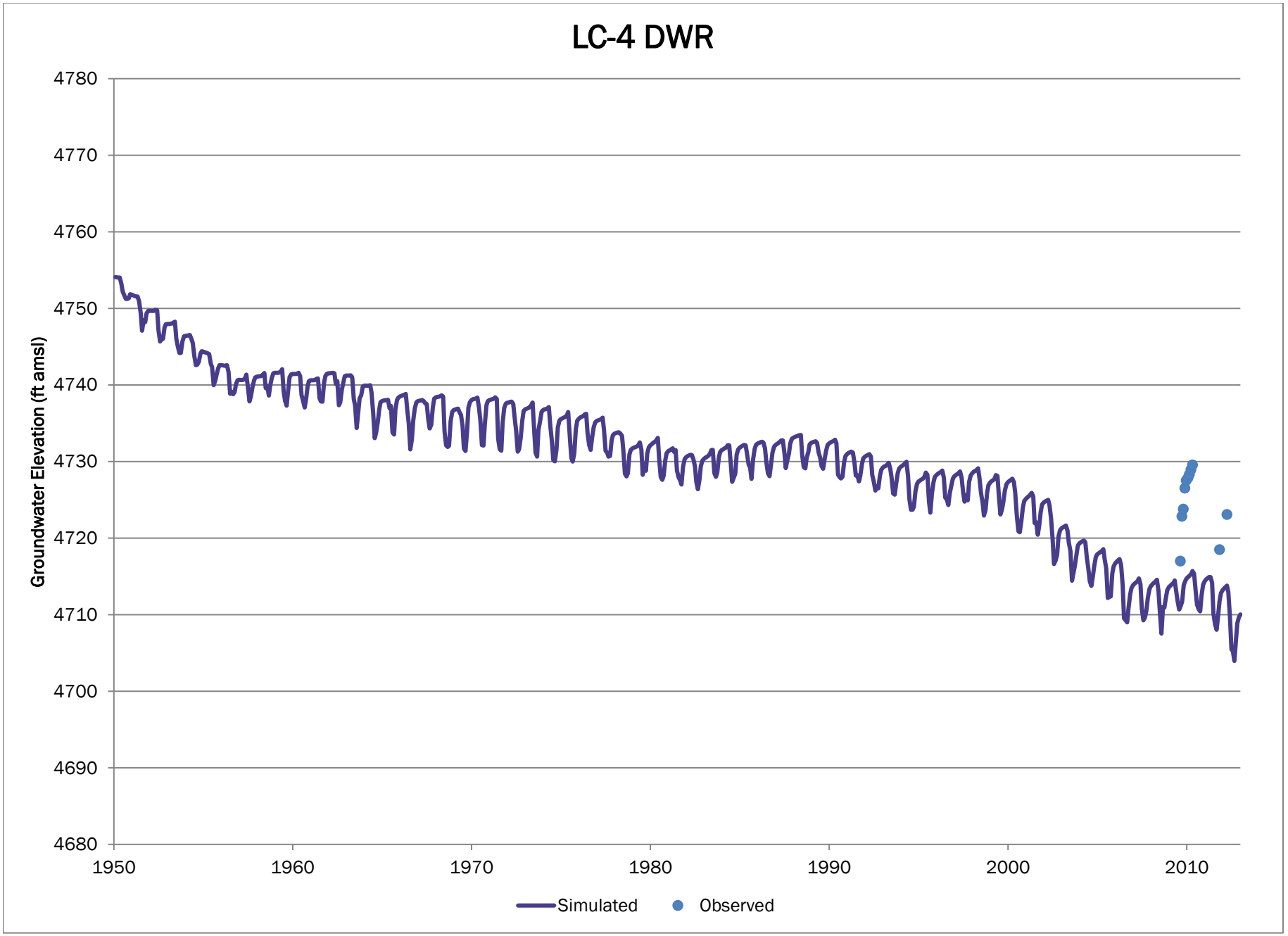
Note elevation axis range of 100 feet.

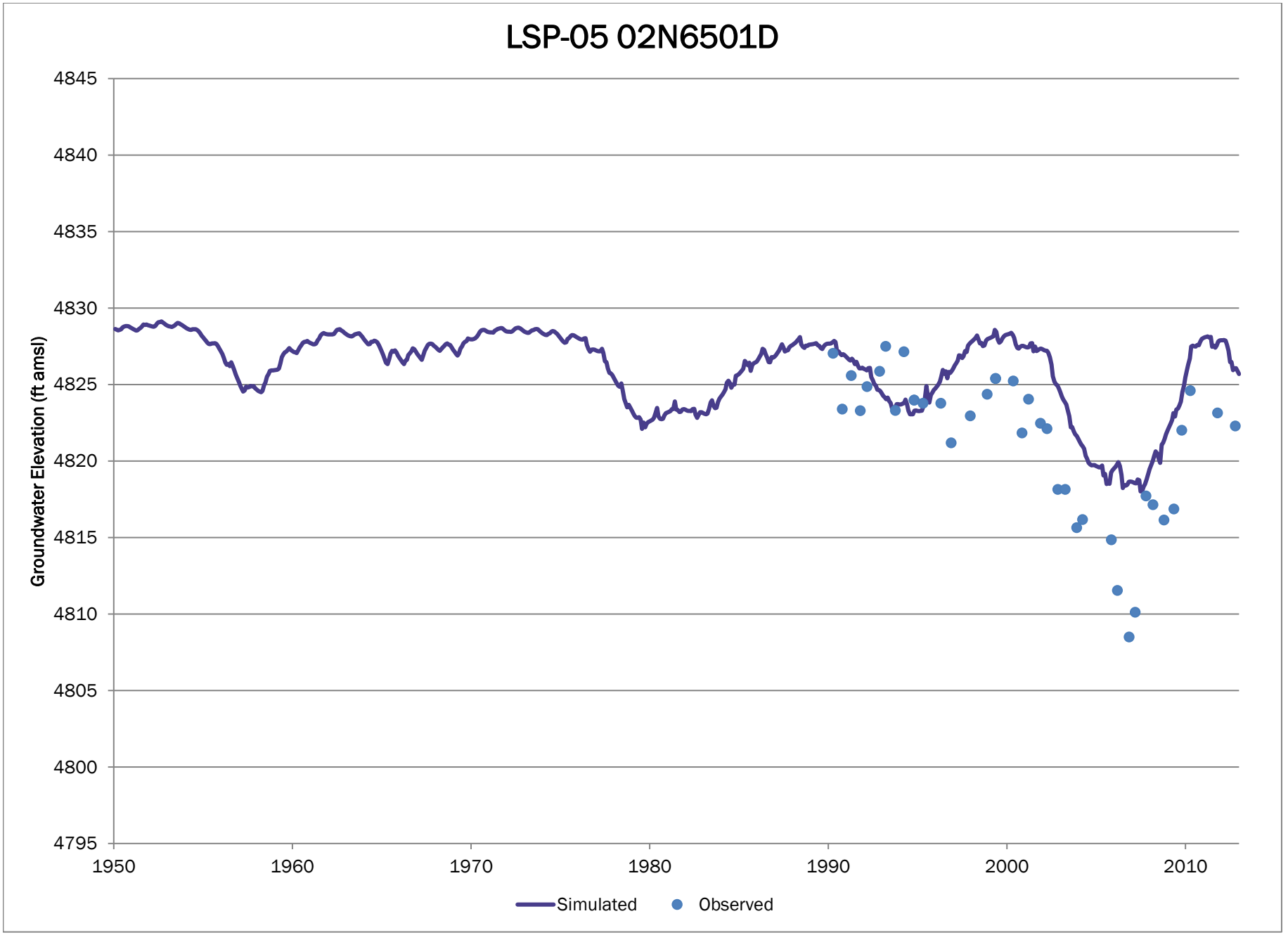


Note elevation axis range of 100 feet.

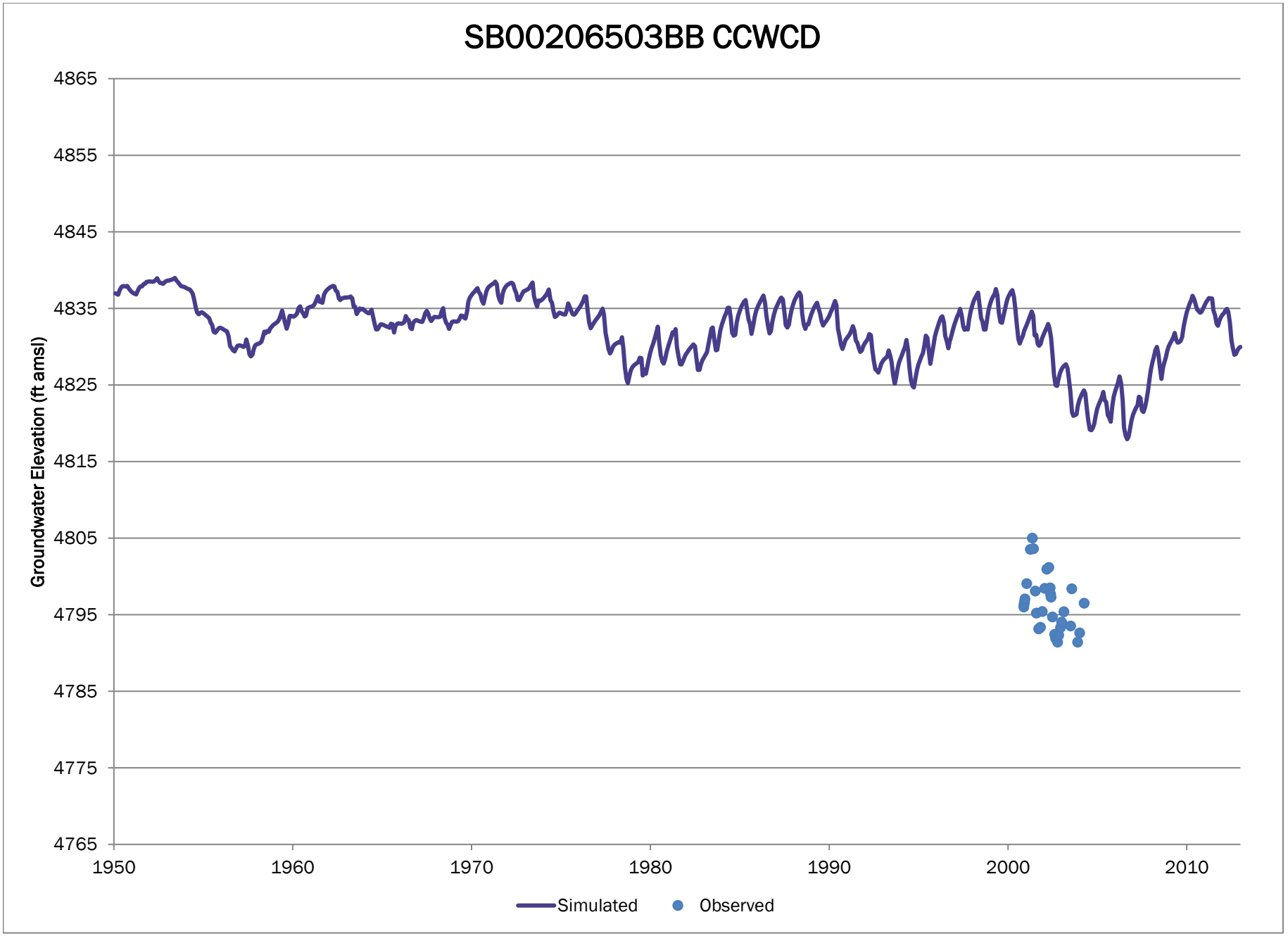


Note elevation axis range of 100 feet.

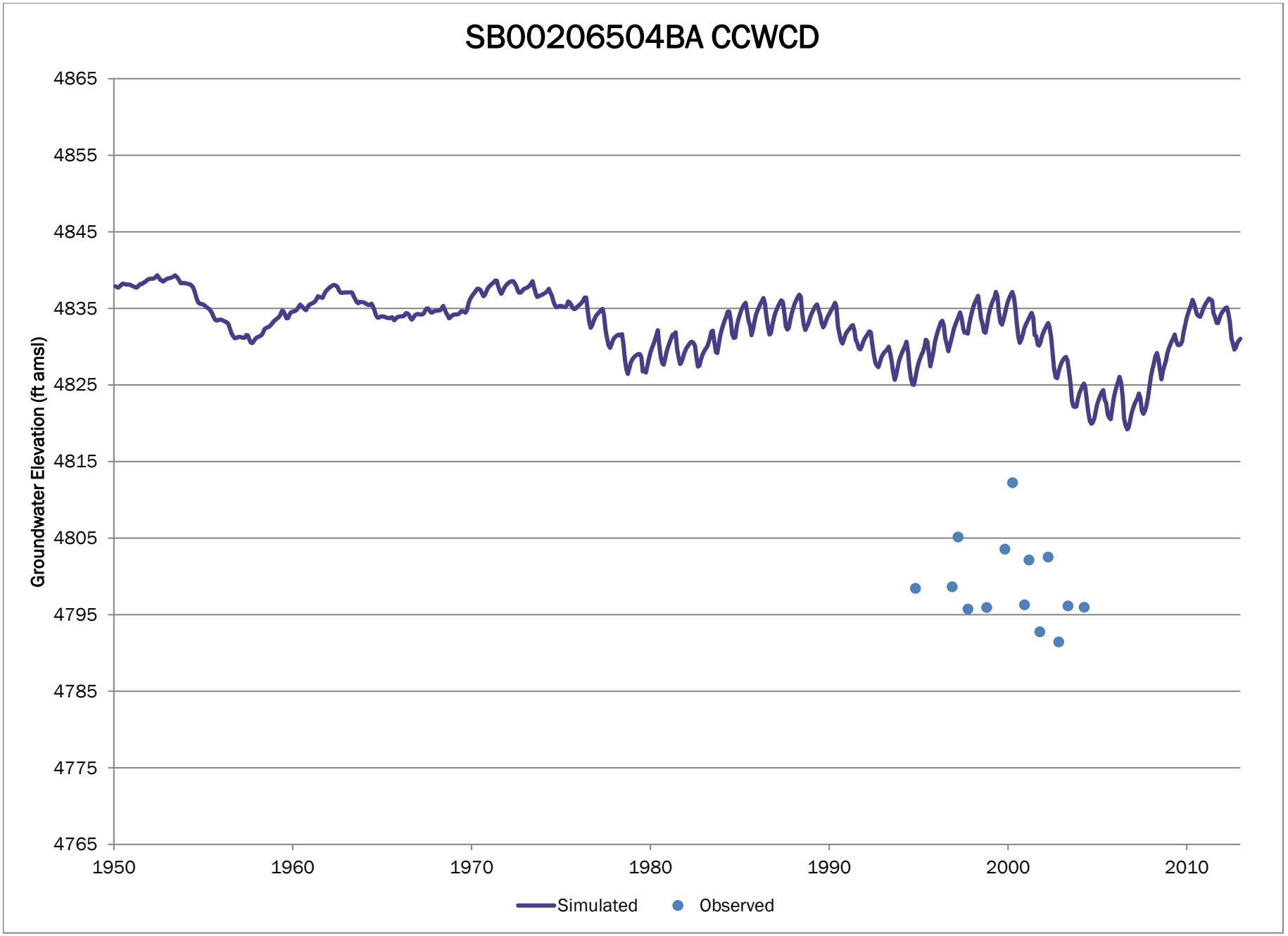


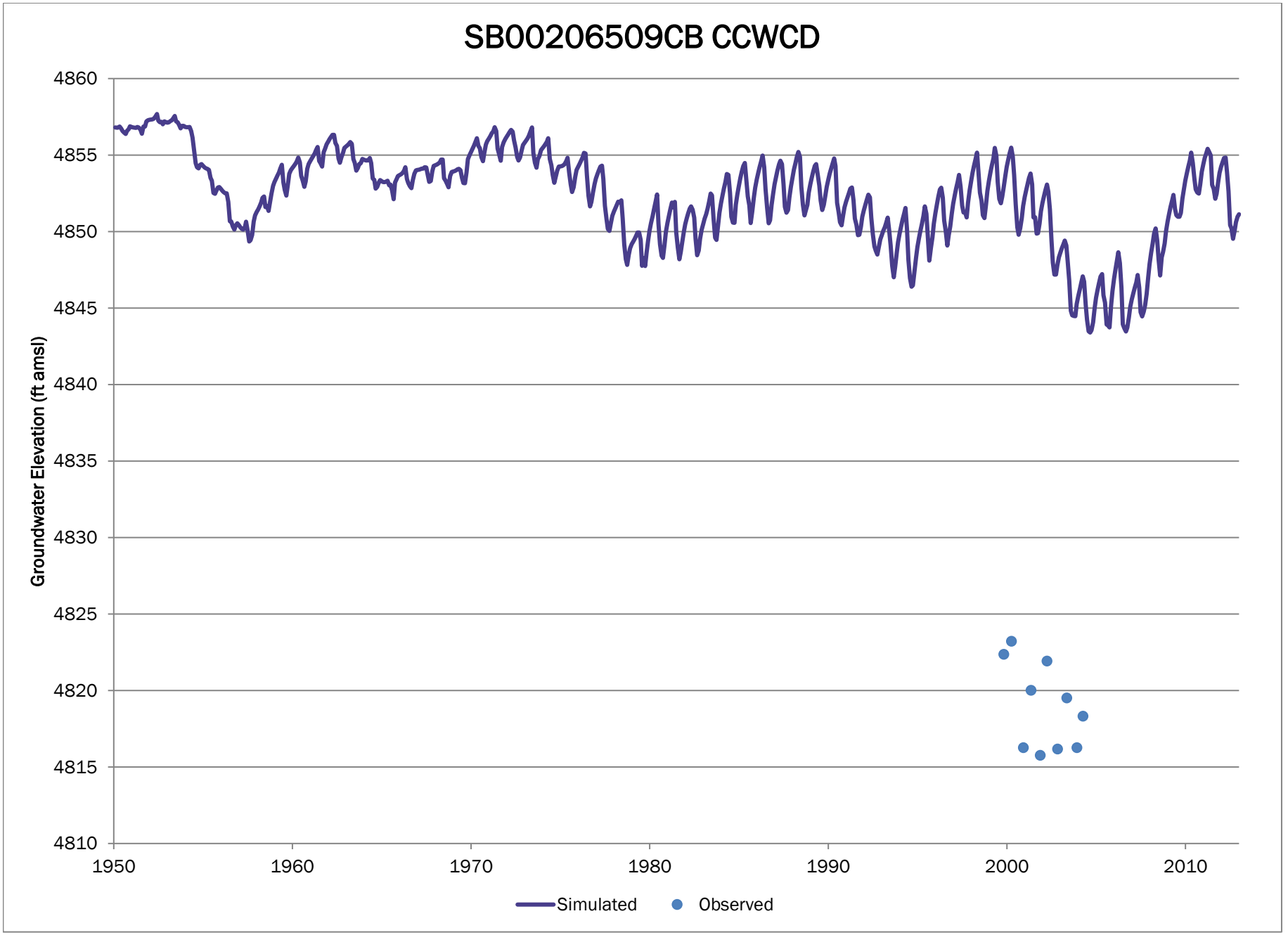

LSP-05 02N6501D
Groundwater Elevation (ft amsl)
4845
4840
4835
4830
4825
4820
4815
4810
4805
4800
4795
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

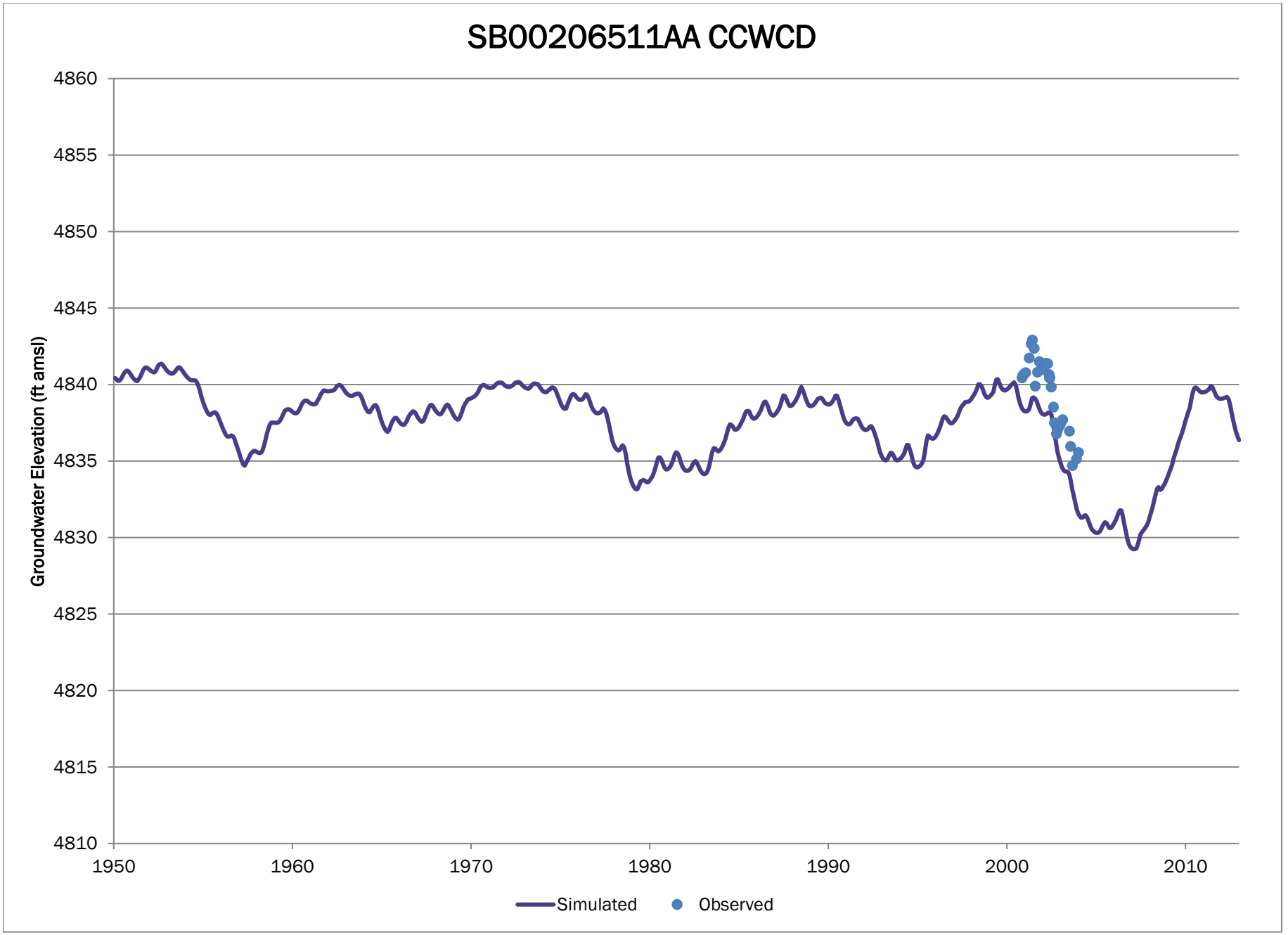
Note elevation axis range of 100 feet.

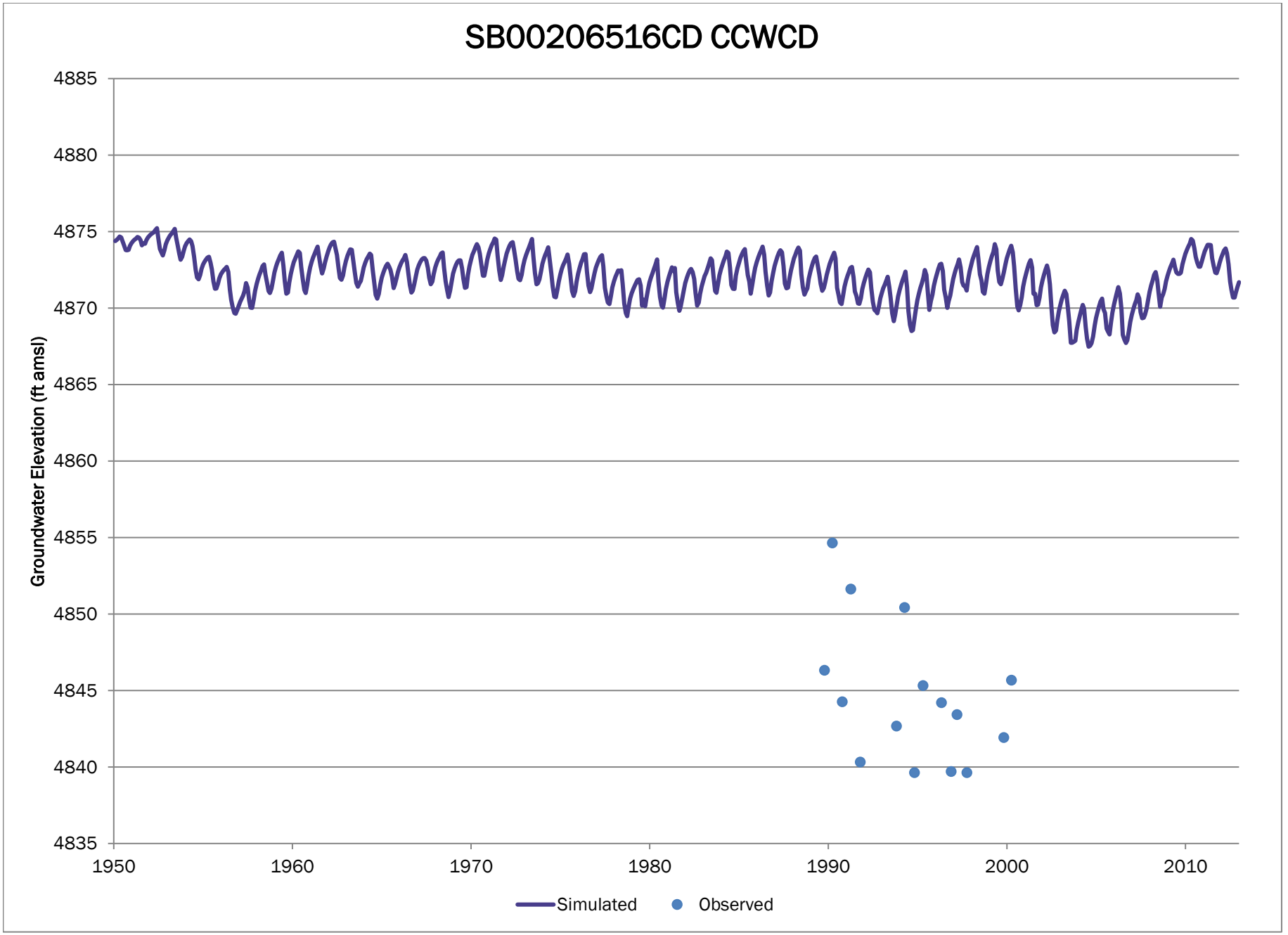


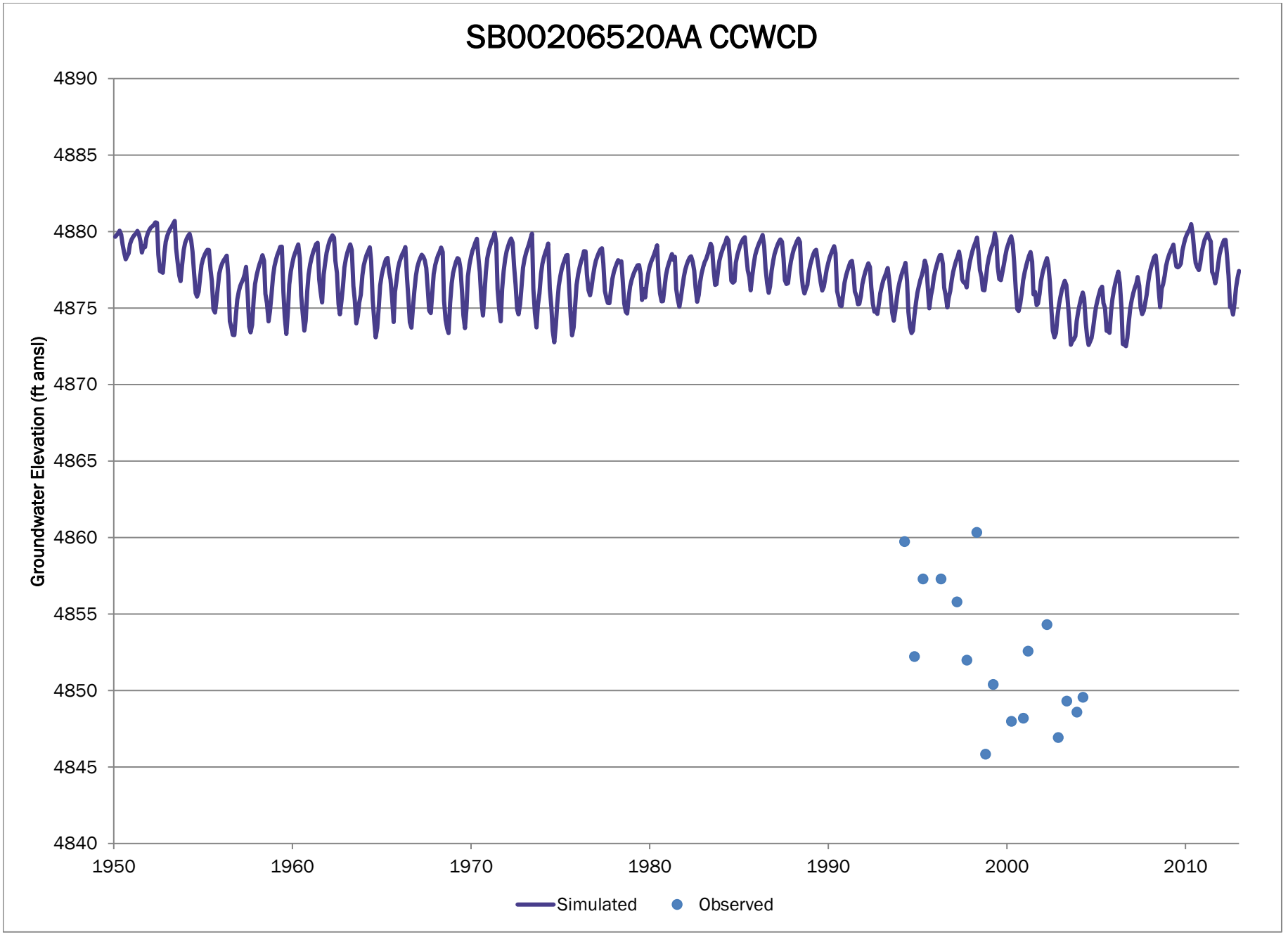
Note elevation axis range of 100 feet.

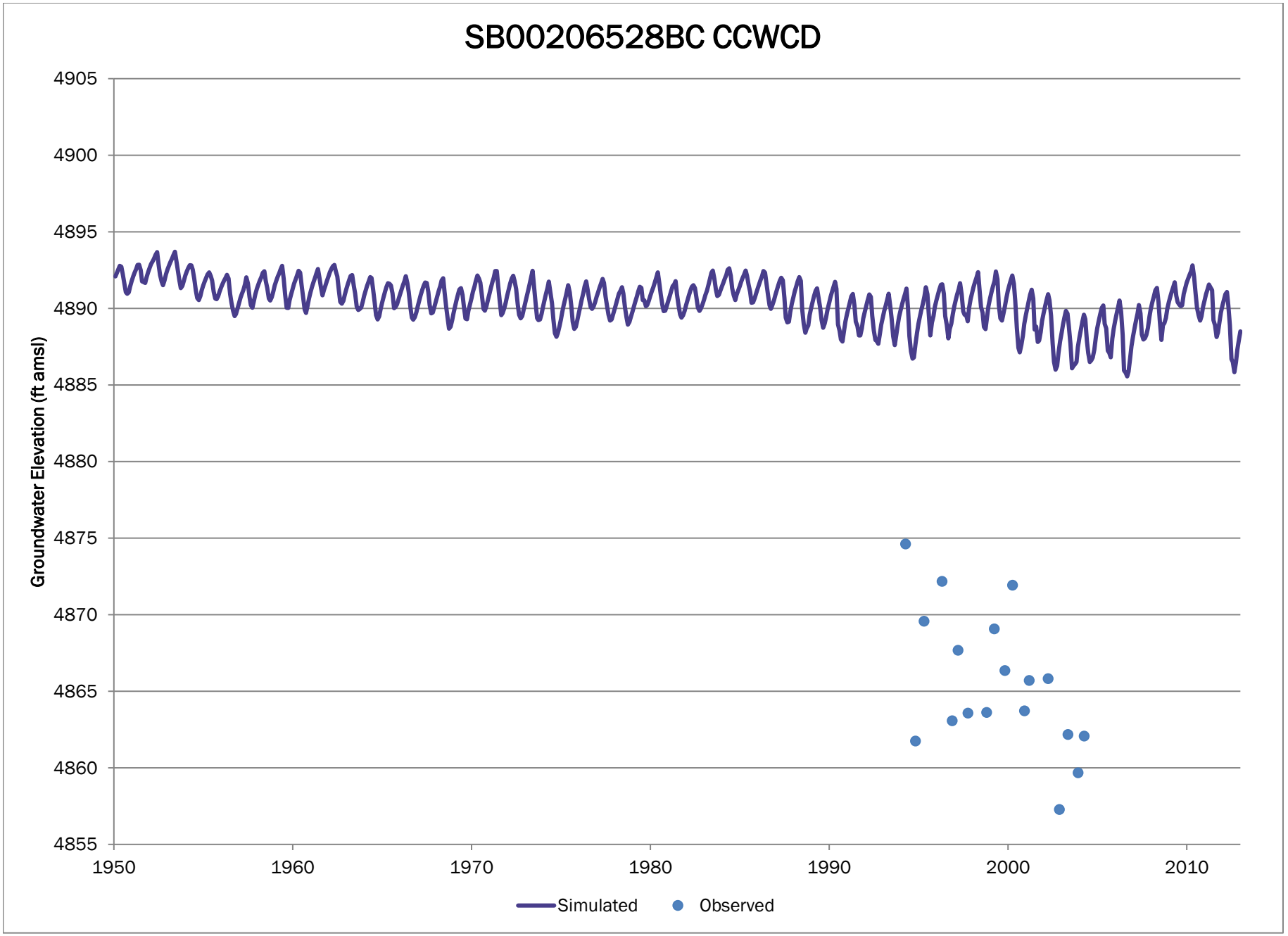


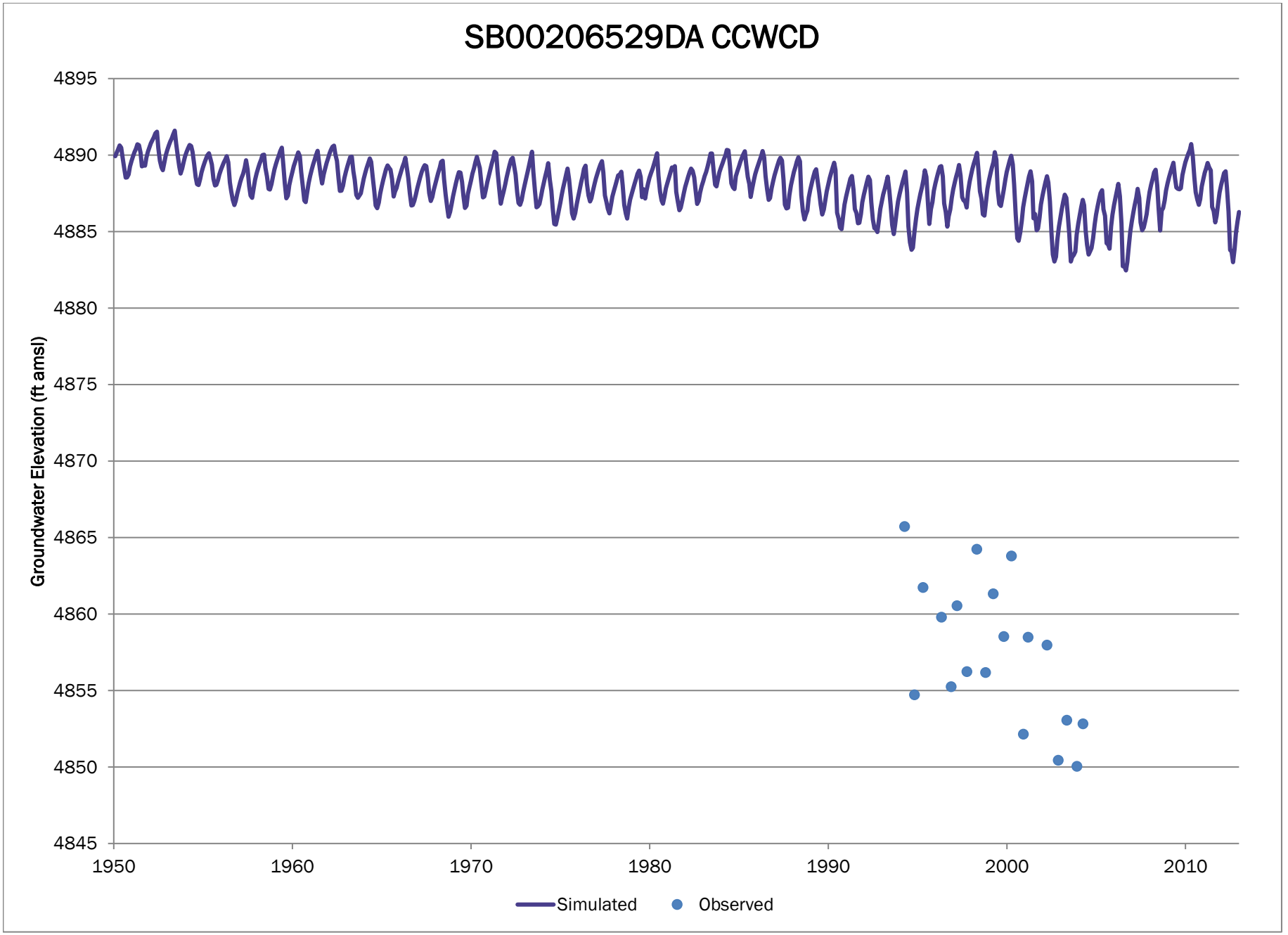

SB00206509CB CCWCD
Groundwater Elevation (ft amsl)
4860
4855
4850
4845
4840
4835
4830
4825
4820
4815
4810
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

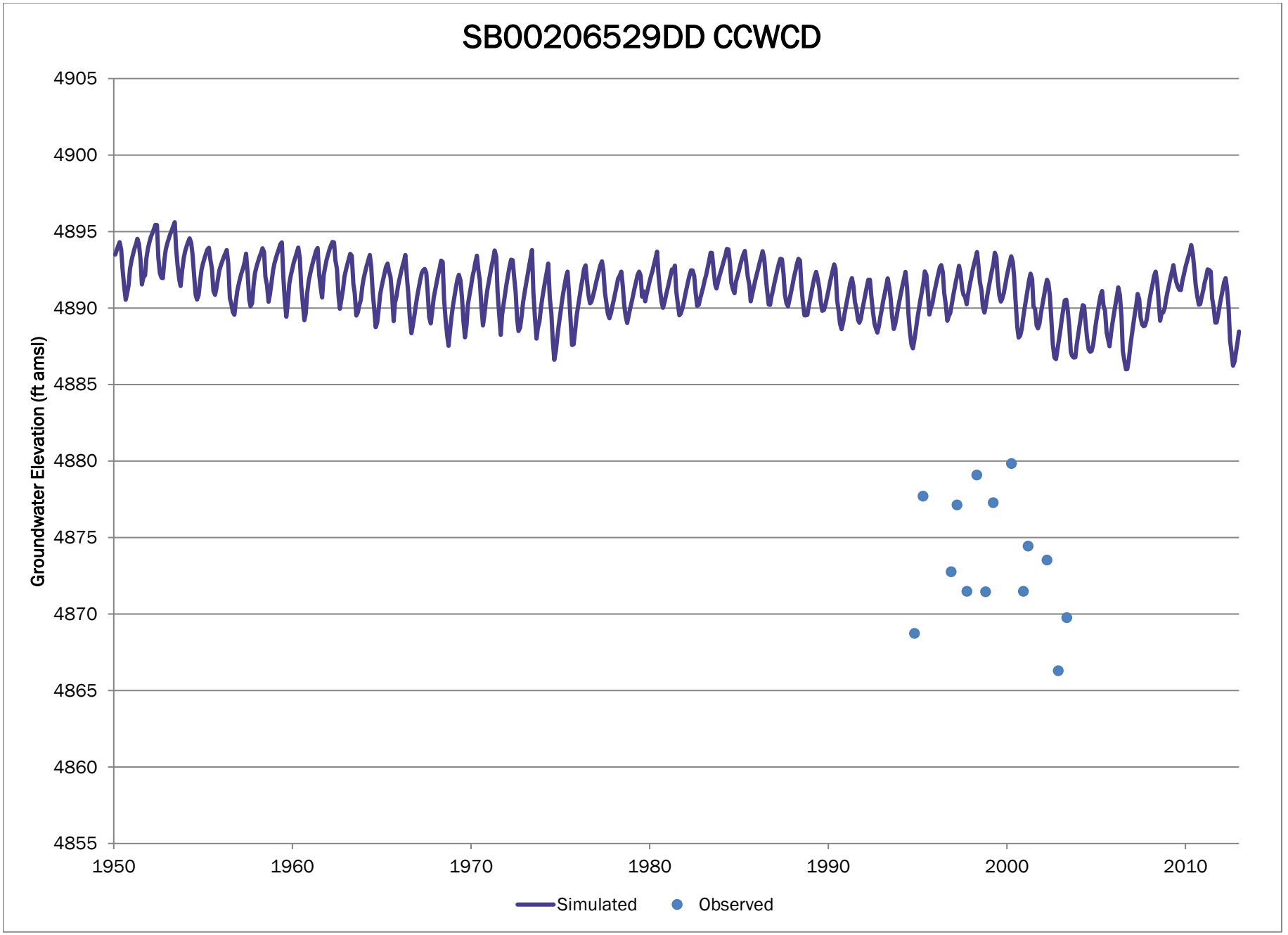

SB00206511AA CCWCD
Groundwater Elevation (ft amsl)
4860
4855
4850
4845
4840
4835
4830
4825
4820
4815
4810
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

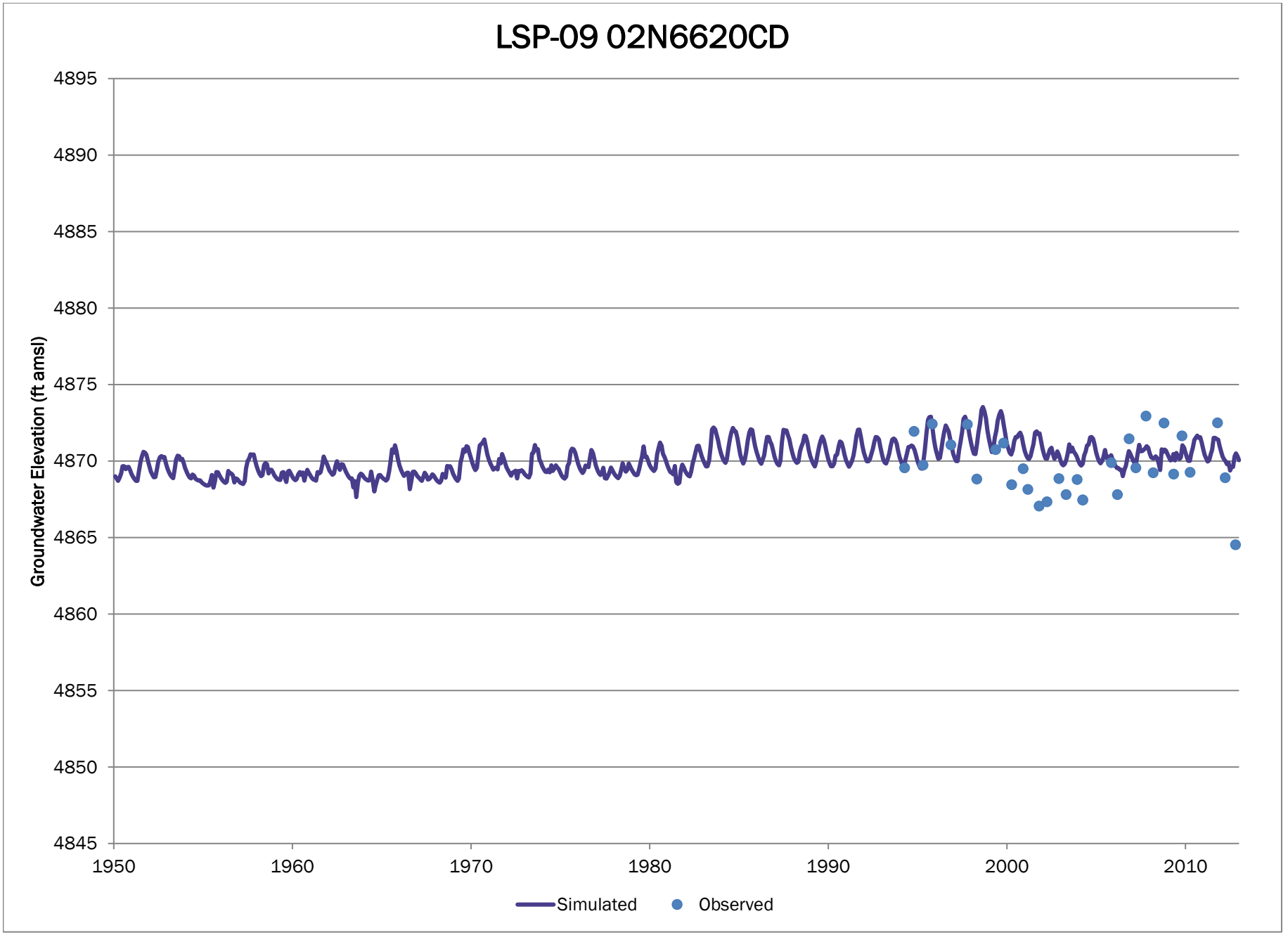

SB00206516CD CCWCD
Groundwater Elevation (ft amsl)
4885
4880
4875
4870
4865
4860
4855
4850
4845
4840
4835
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

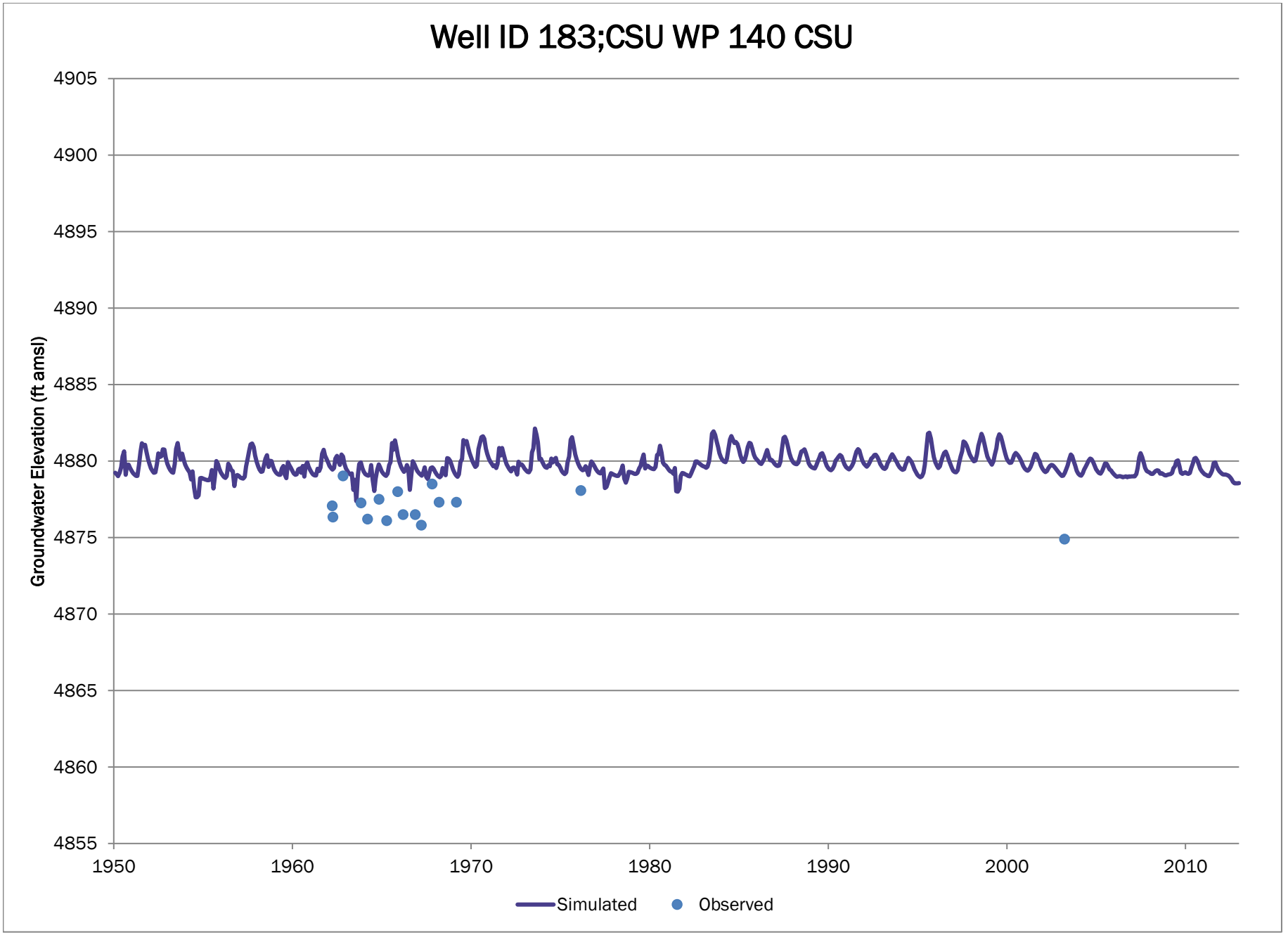

SB00206520AA CCWCD
Groundwater Elevation (ft amsl)
4890
4885
4880
4875
4870
4865
4860
4855
4850
4845
4840
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

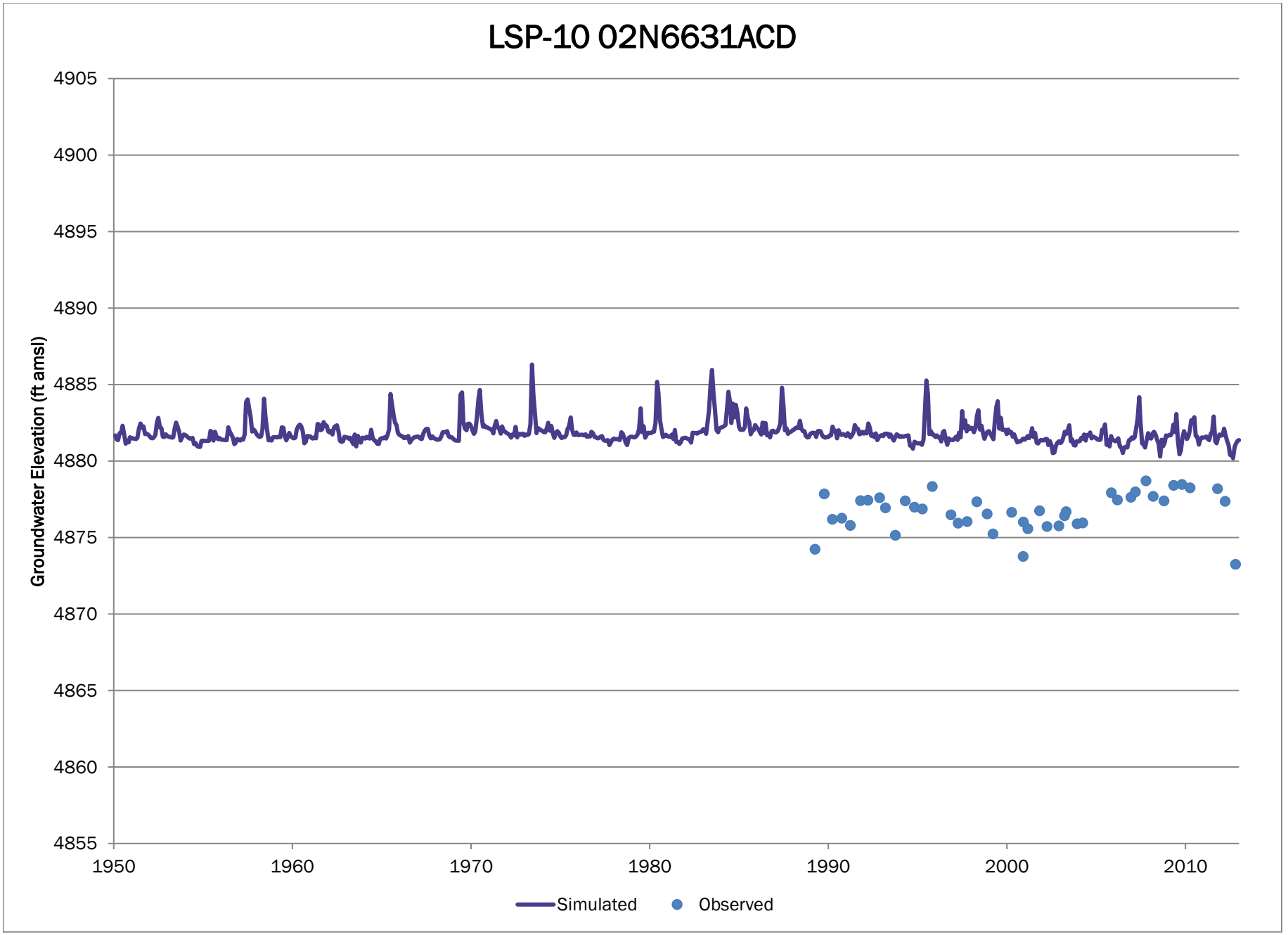

SB00206528BC CCWCD
Groundwater Elevation (ft amsl)
4905
4900
4895
4890
4885
4880
4875
4870
4865
4860
4855
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

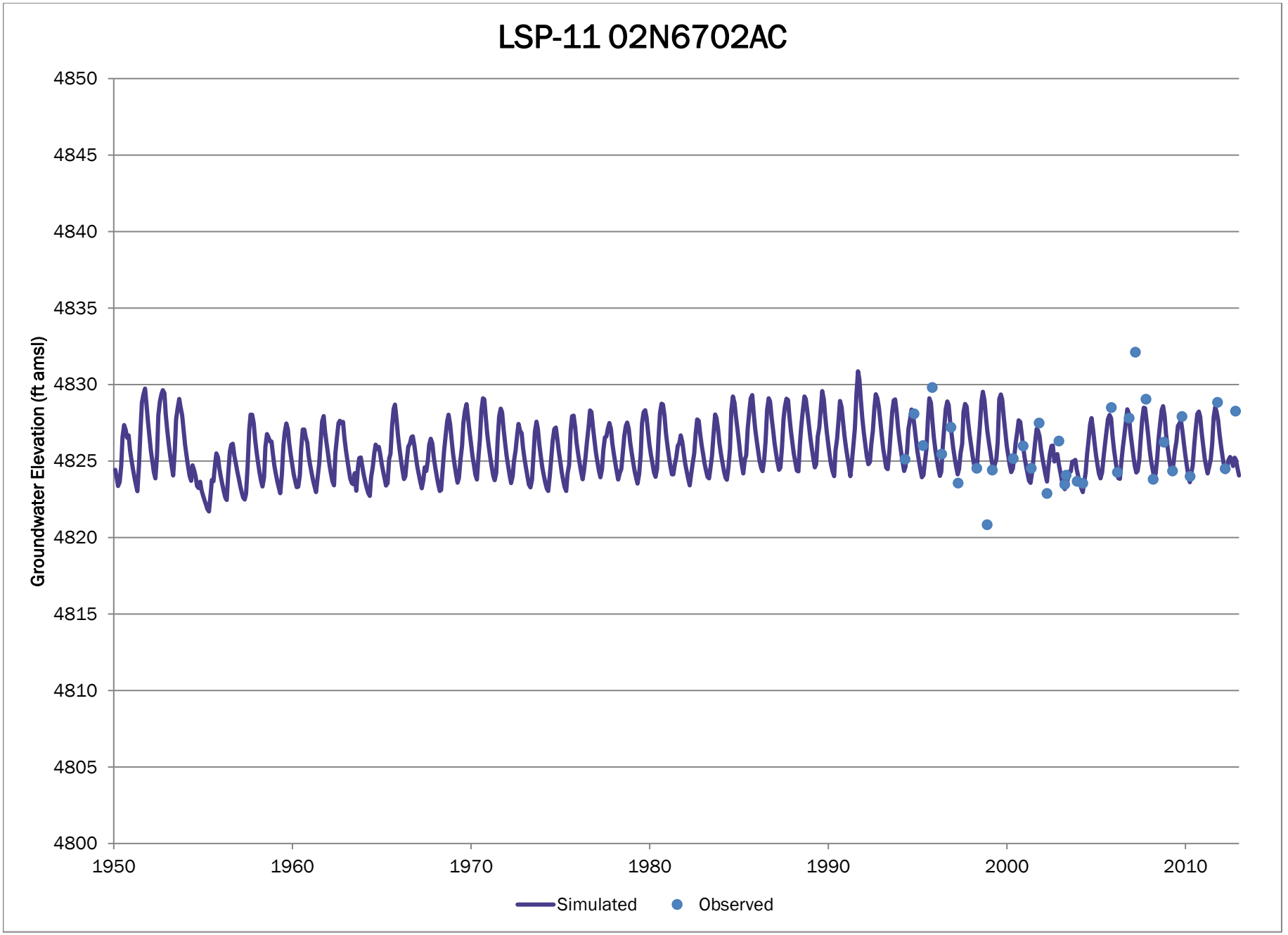

SB00206529DA CCWCD
Groundwater Elevation (ft amsl)
4895
4890
4885
4880
4875
4870
4865
4860
4855
4850
4845
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

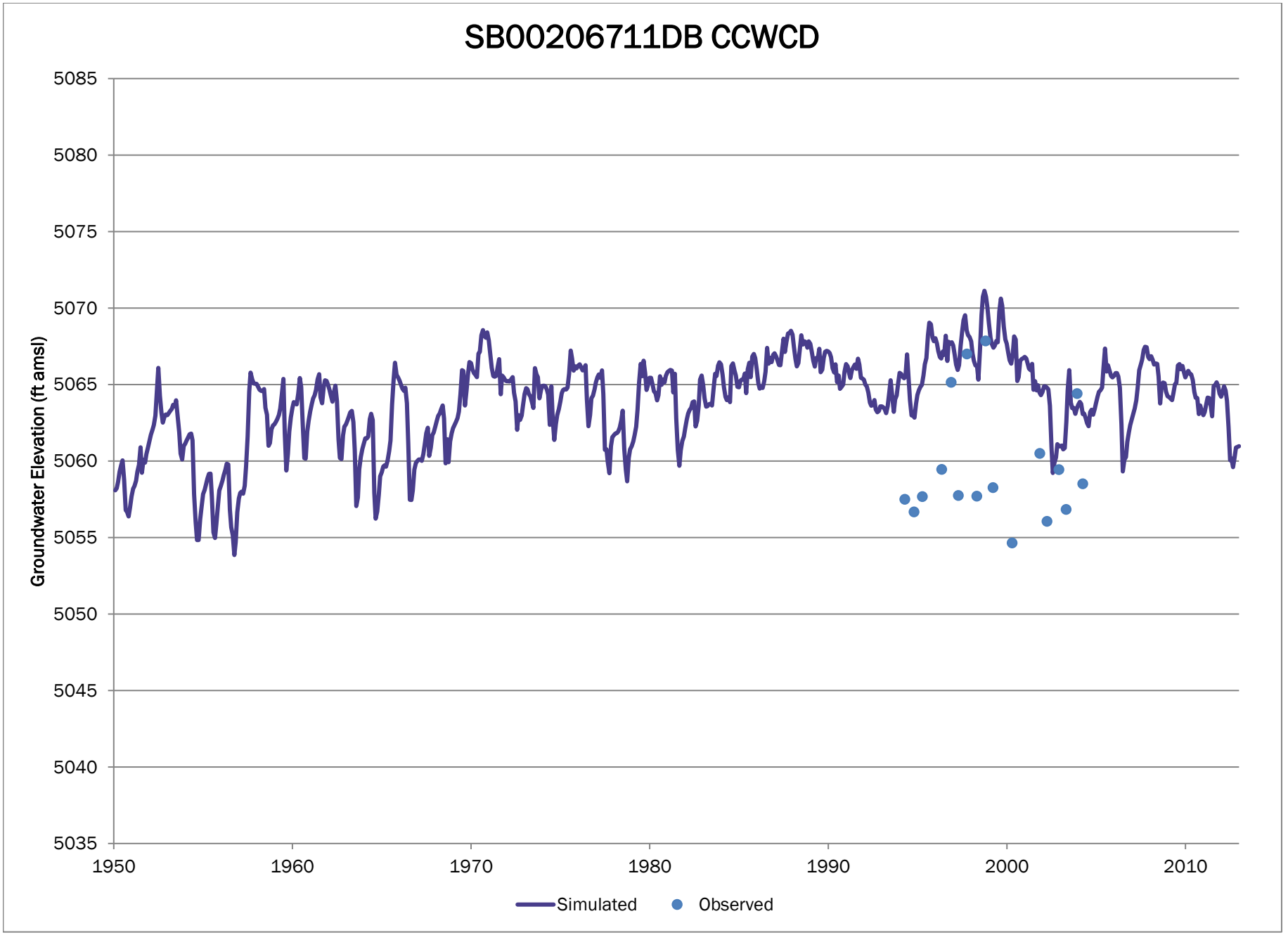

SB00206529DD CCWCD
Groundwater Elevation (ft amsl)
4905
4900
4895
4890
4885
4880
4875
4870
4865
4860
4855
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

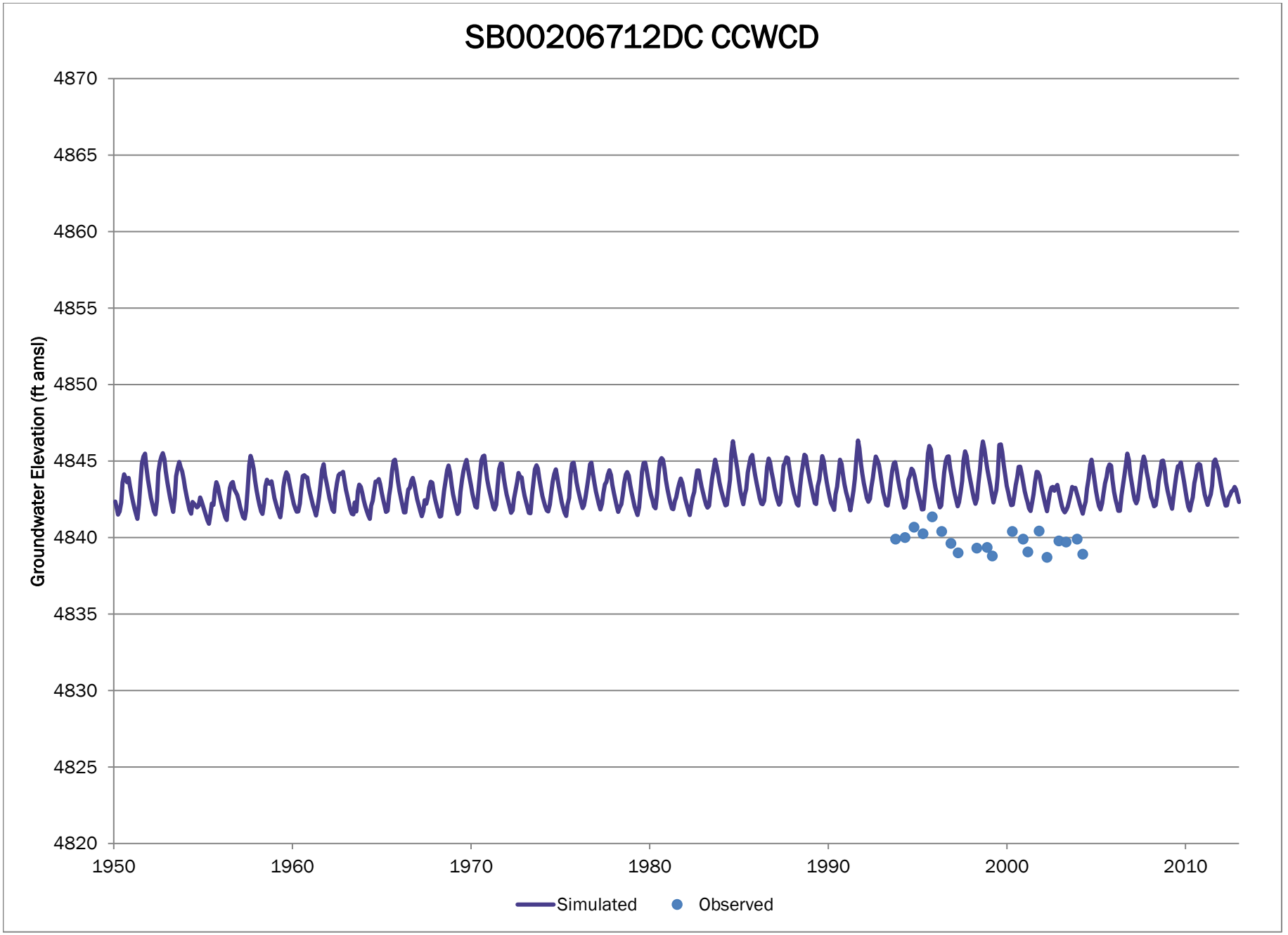

LSP-09 02N6620CD
Groundwater Elevation (ft amsl)
4895
4890
4885
4880
4875
4870
4865
4860
4855
4850
4845
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

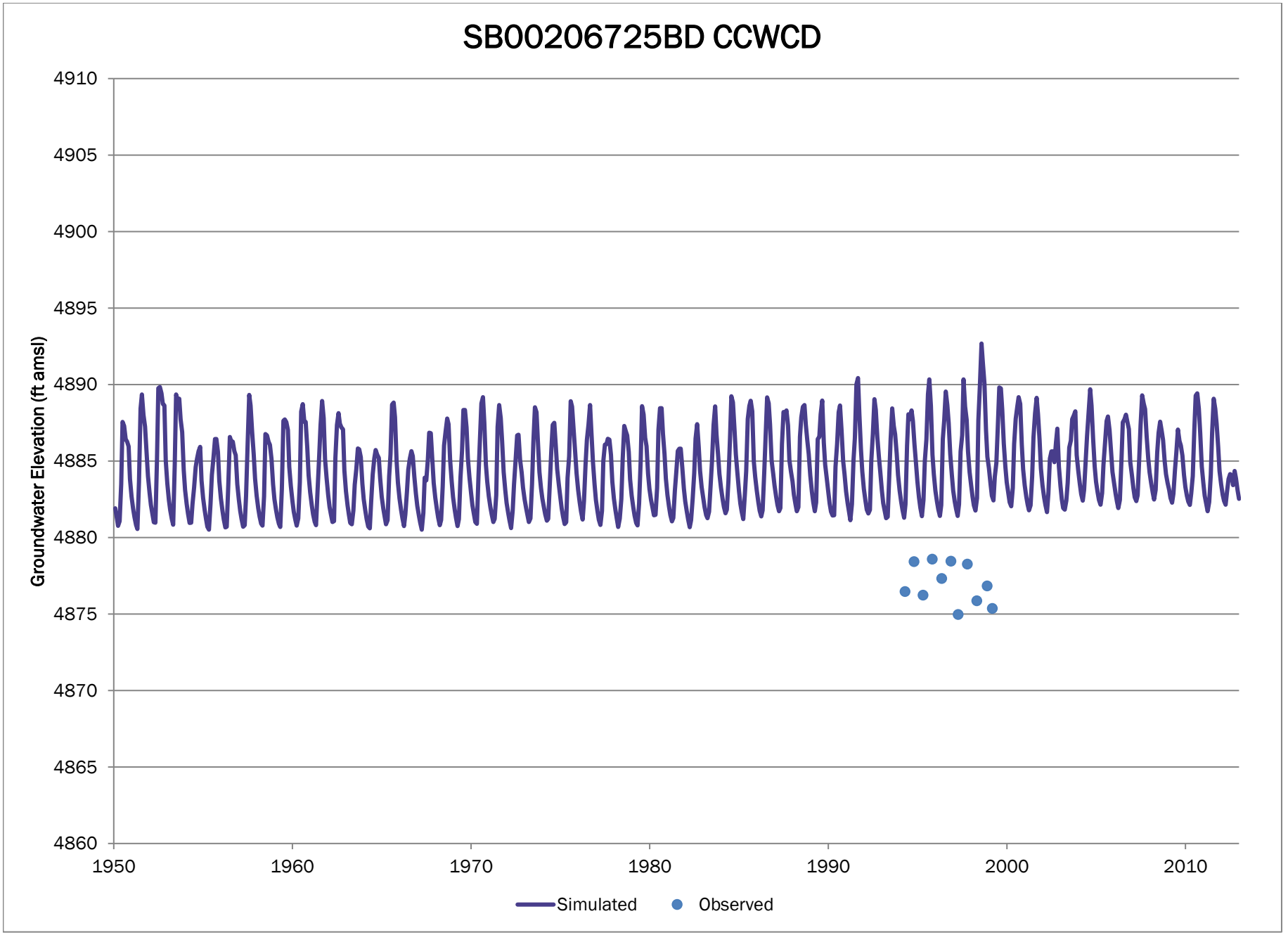

Well ID 183;CSU WP 140 CSU
Groundwater Elevation (ft amsl)
4905
4900
4895
4890
4885
4880
4875
4870
4865
4860
4855
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

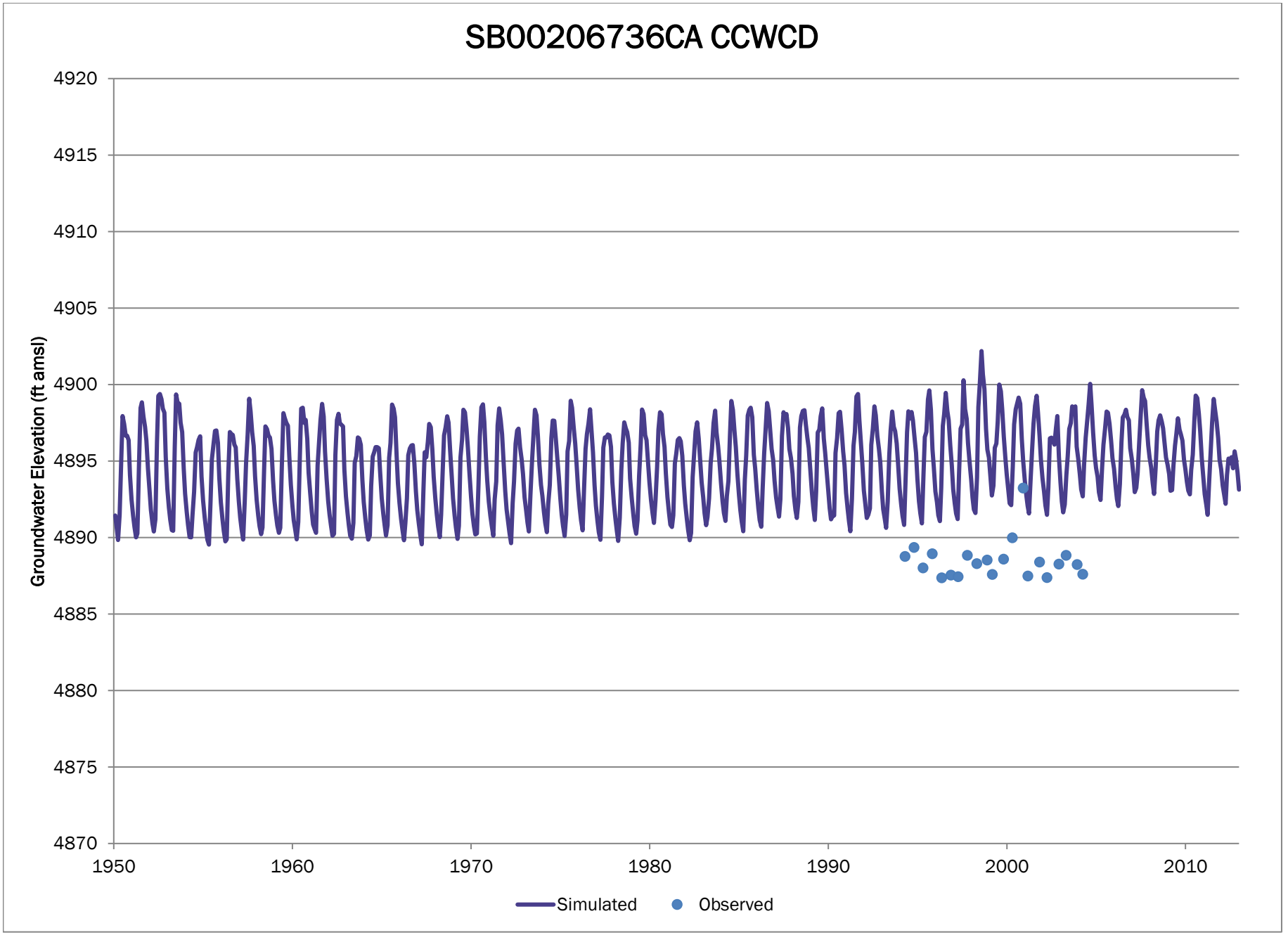

LSP-10 02N6631ACD
Groundwater Elevation (ft amsl)
4905
4900
4895
4890
4885
4880
4875
4870
4865
4860
4855
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

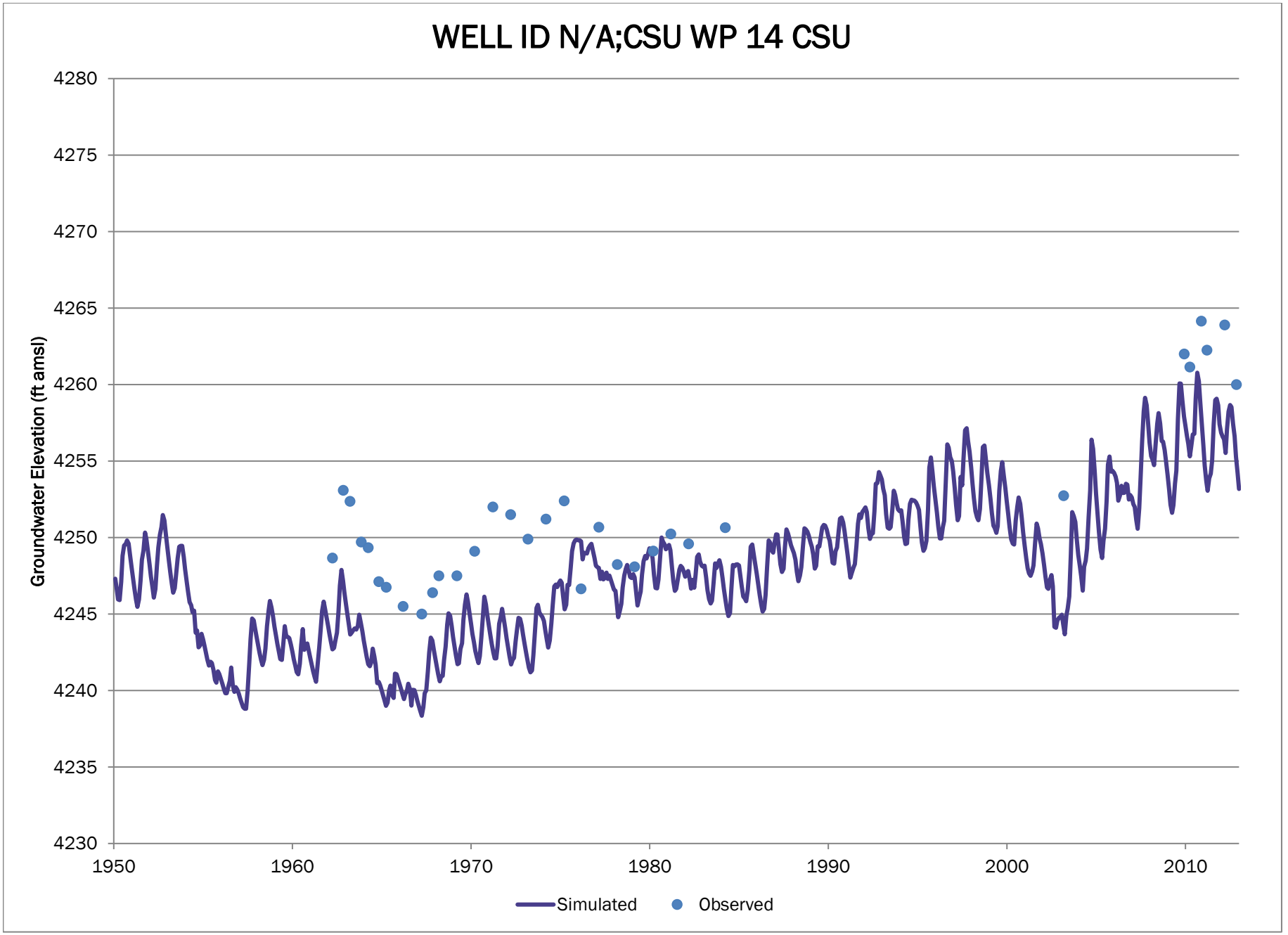

LSP-11 02N6702AC
Groundwater Elevation (ft amsl)
4850
4845
4840
4835
4830
4825
4820
4815
4810
4805
4800
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

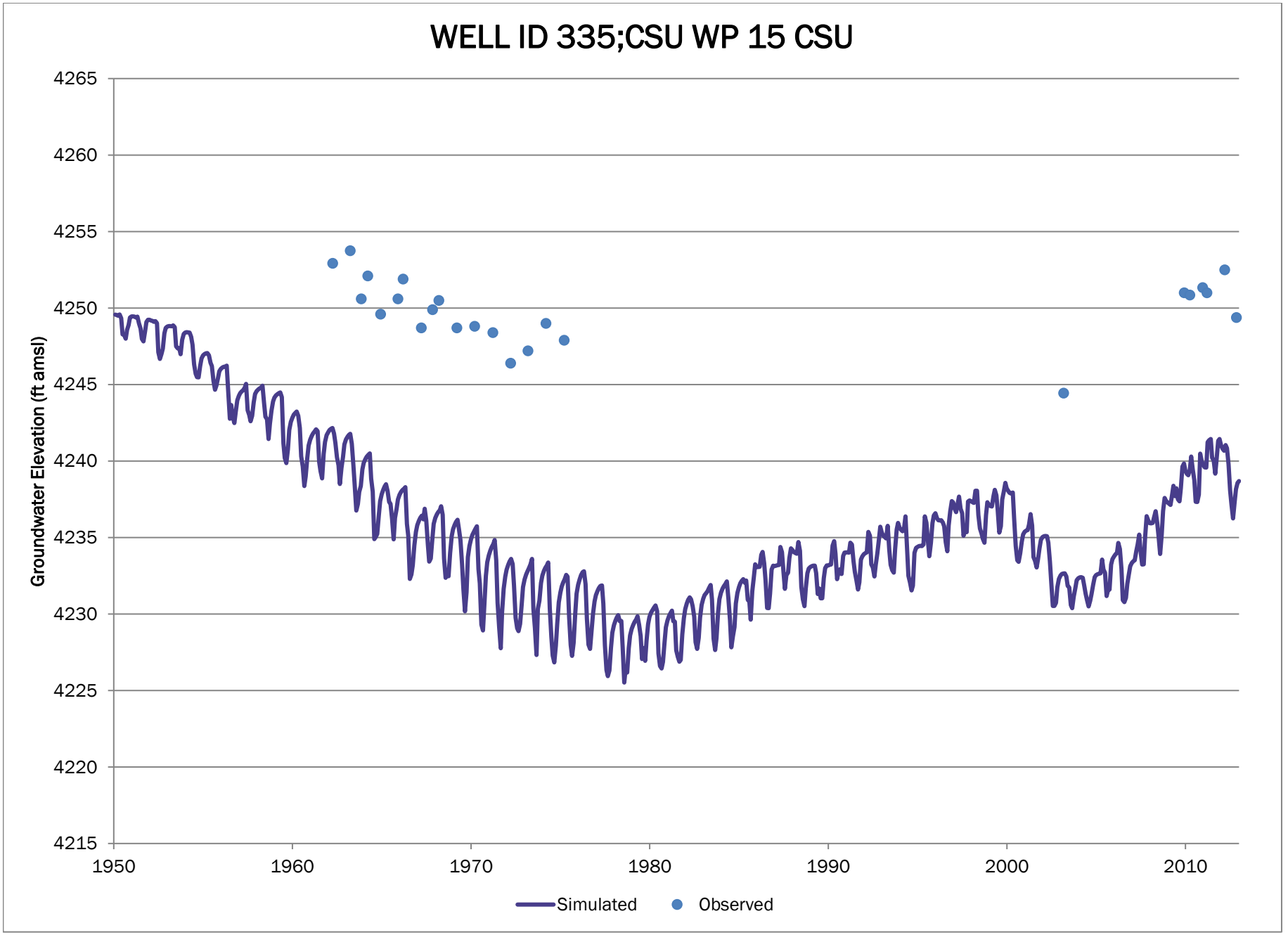

SB00206711DB CCWCD
Groundwater Elevation (ft amsl)
5085
5080
5075
5070
5065
5060
5055
5050
5045
5040
5035
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

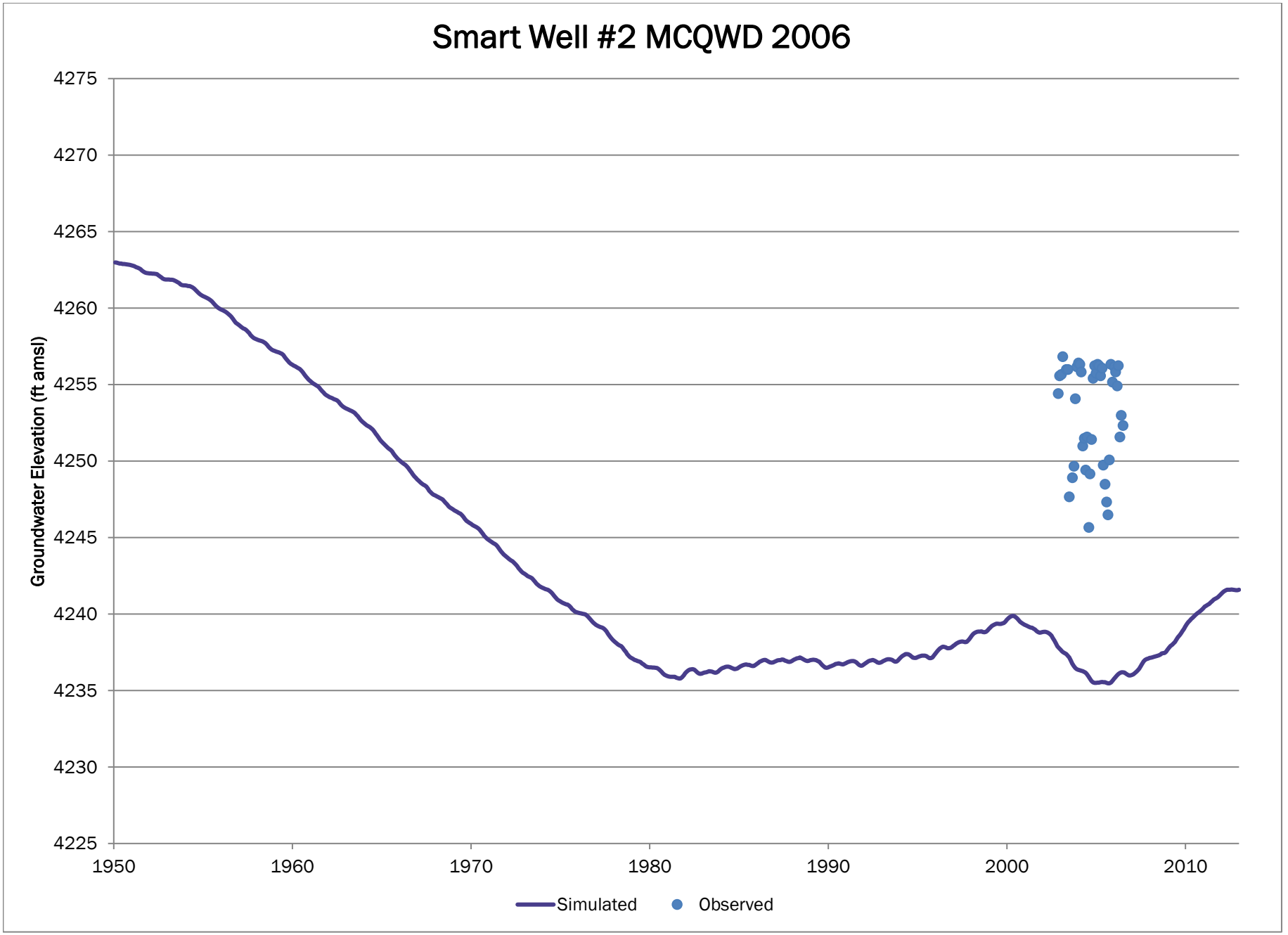

SB00206712DC CCWCD
Groundwater Elevation (ft amsl)
4870
4865
4860
4855
4850
4845
4840
4835
4830
4825
4820
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

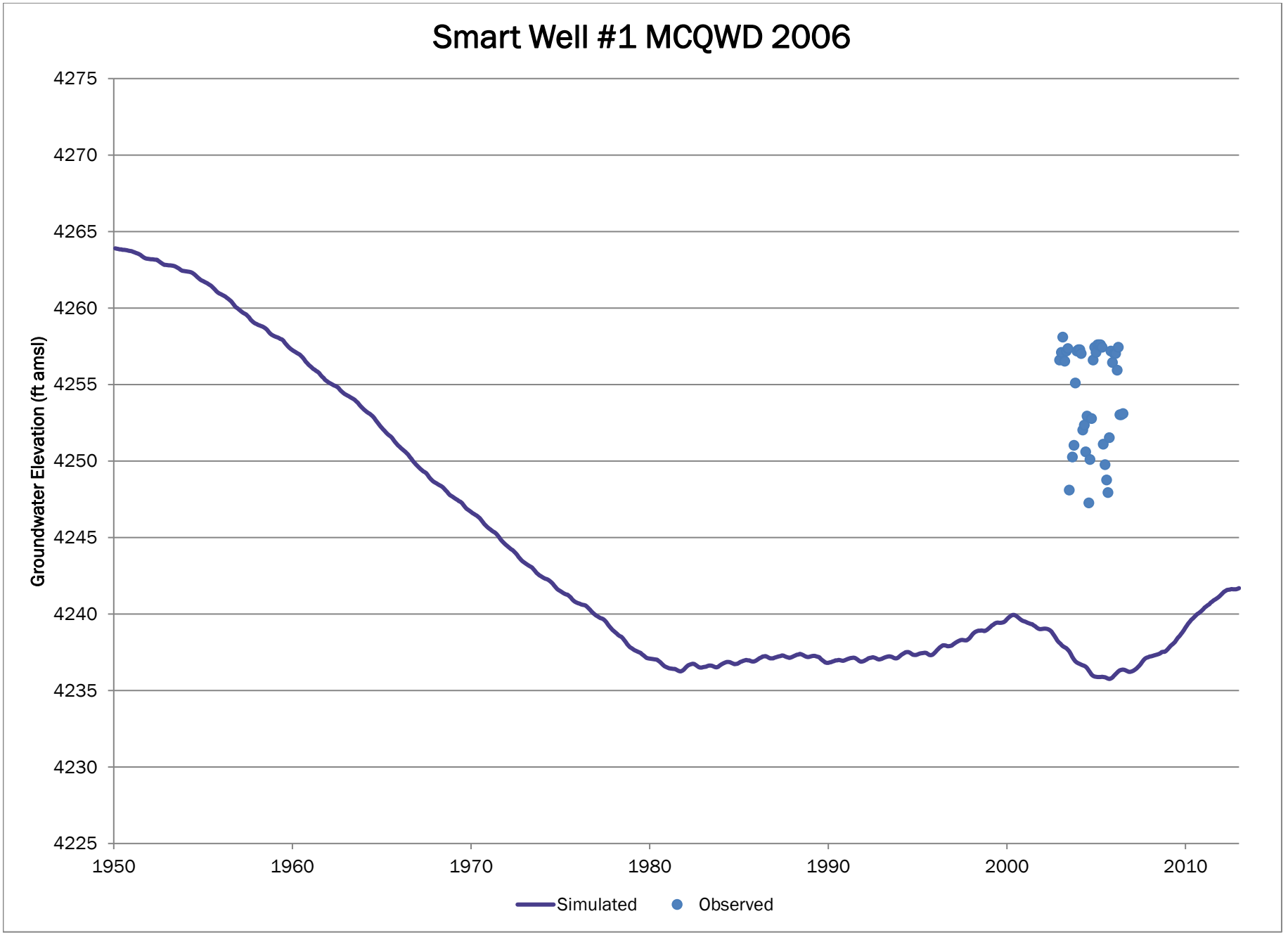

SB00206725BD CCWCD
Groundwater Elevation (ft amsl)
4910
4905
4900
4895
4890
4885
4880
4875
4870
4865
4860
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

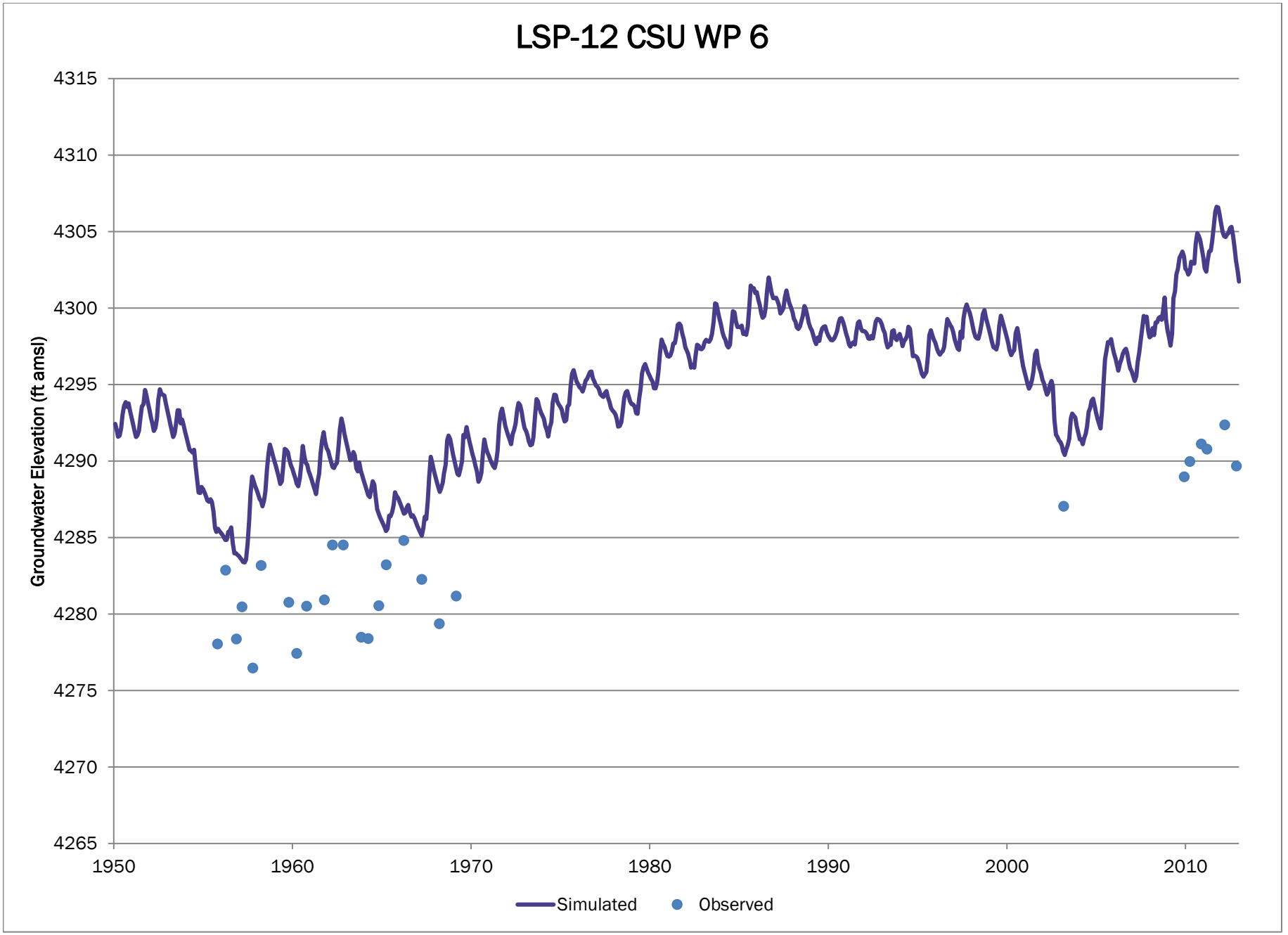

SB00206736CA CCWCD
Groundwater Elevation (ft amsl)
4920
4915
4910
4905
4900
4895
4890
4885
4880
4875
4870
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

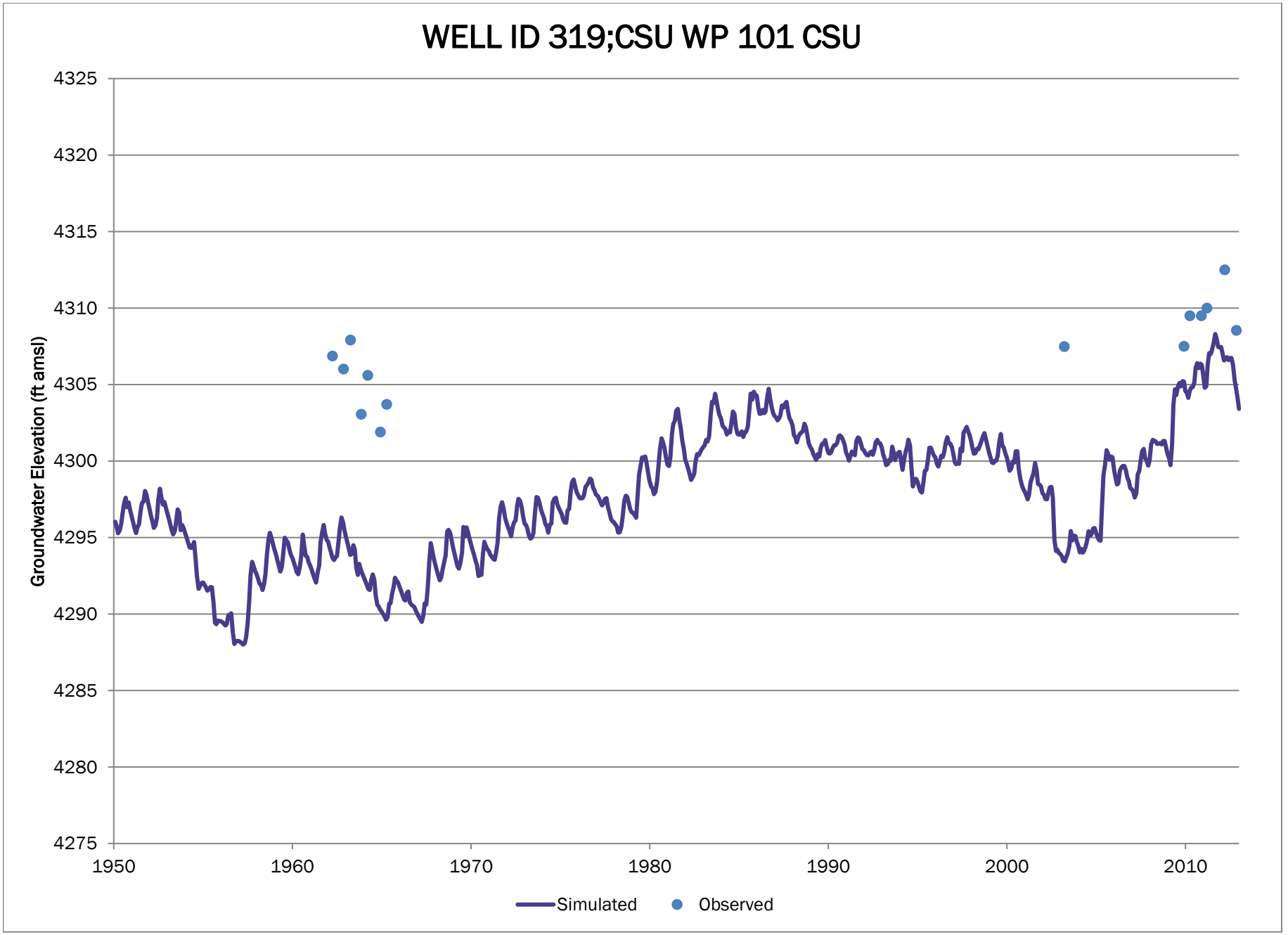

WELL ID N/A;CSU WP 14 CSU
Groundwater Elevation (ft amsl)
4280
4275
4270
4265
4260
4255
4250
4245
4240
4235
4230
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

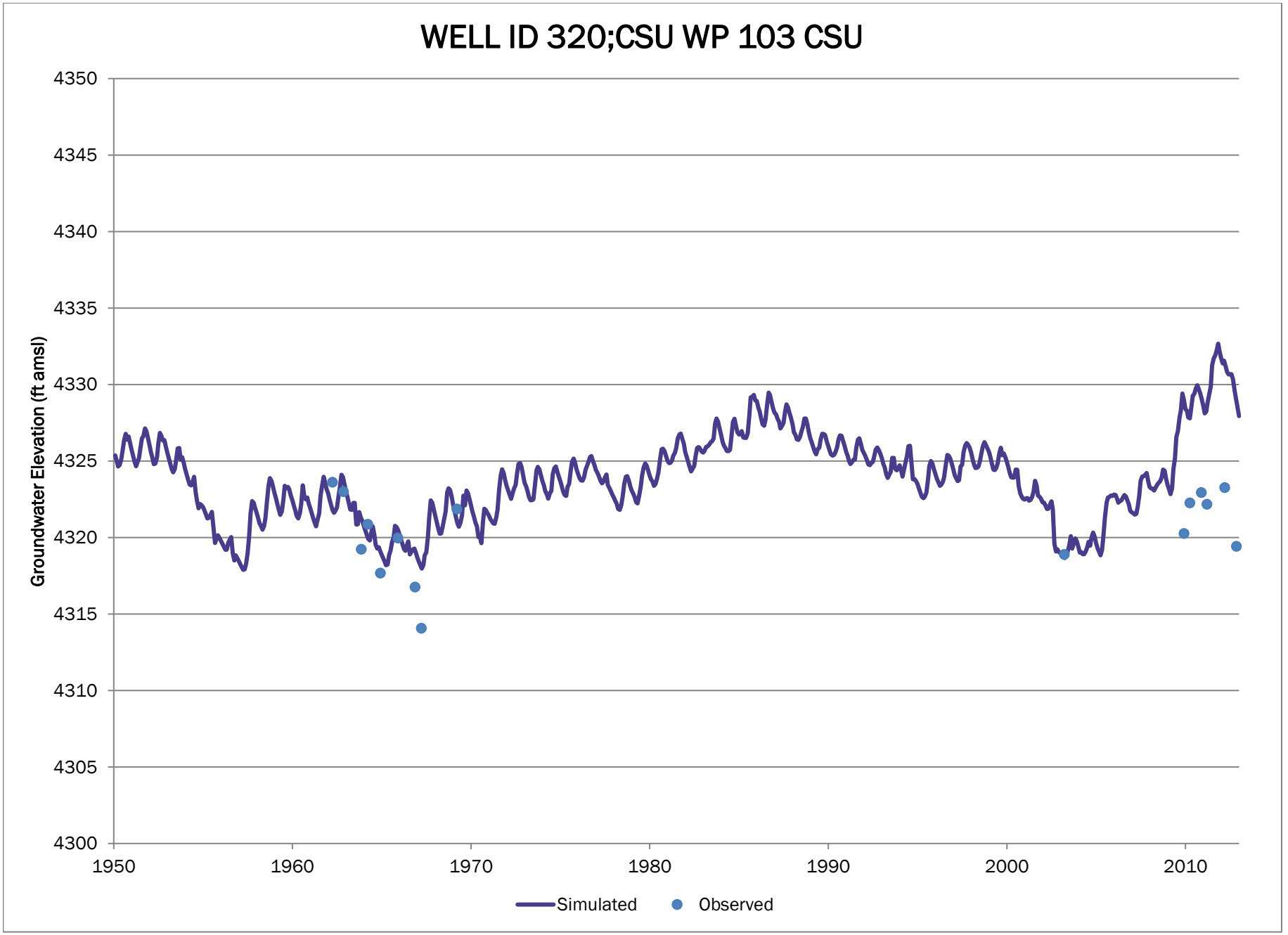

WELL ID 335;CSU WP 15 CSU
Groundwater Elevation (ft amsl)
4265
4260
4255
4250
4245
4240
4235
4230
4225
4220
4215
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

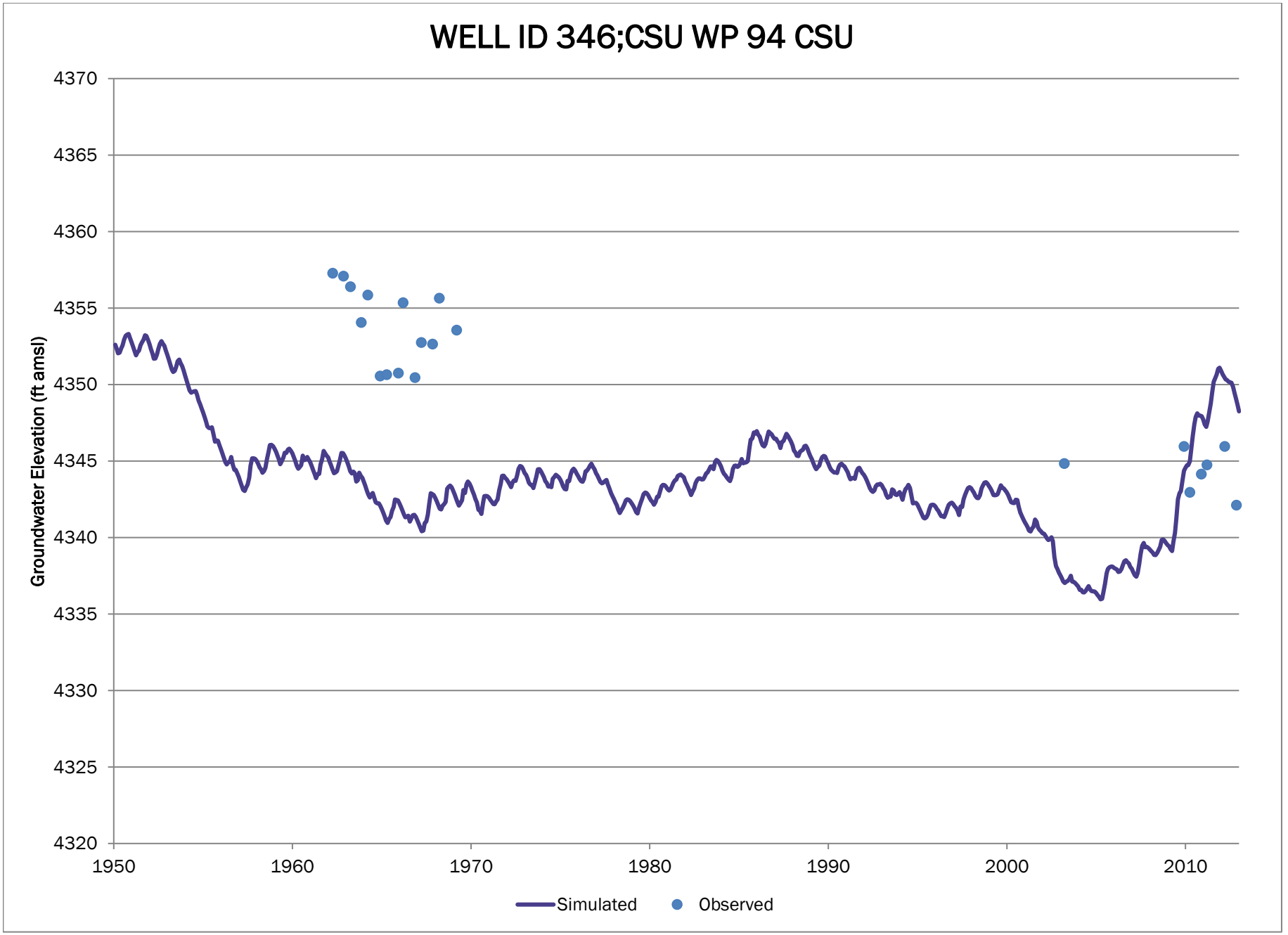

Smart Well #2 MCQWD 2006
Groundwater Elevation (ft amsl)
4275
4270
4265
4260
4255
4250
4245
4240
4235
4230
4225
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

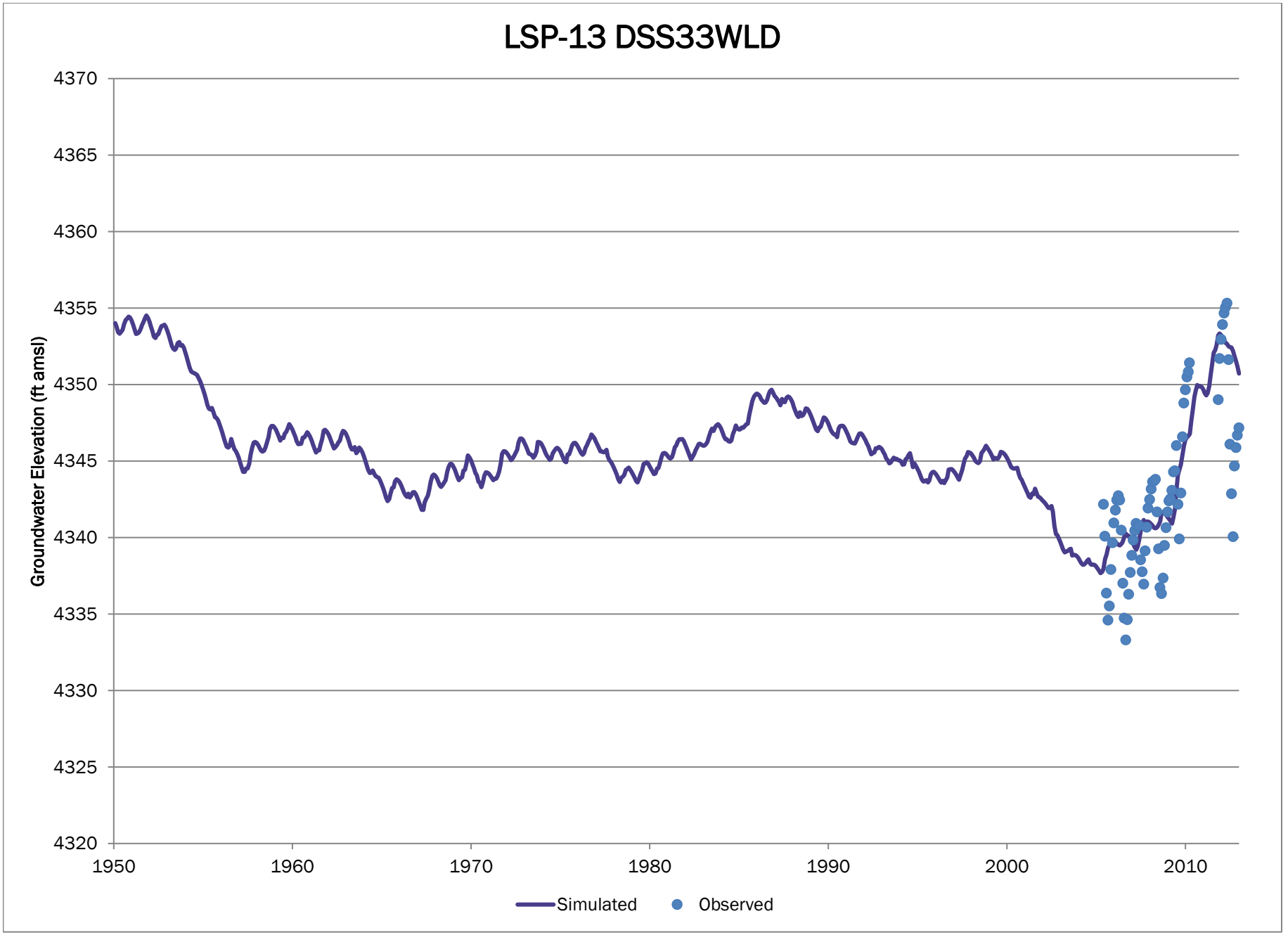

Smart Well #1 MCQWD 2006
Groundwater Elevation (ft amsl)
4275
4270
4265
4260
4255
4250
4245
4240
4235
4230
4225
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

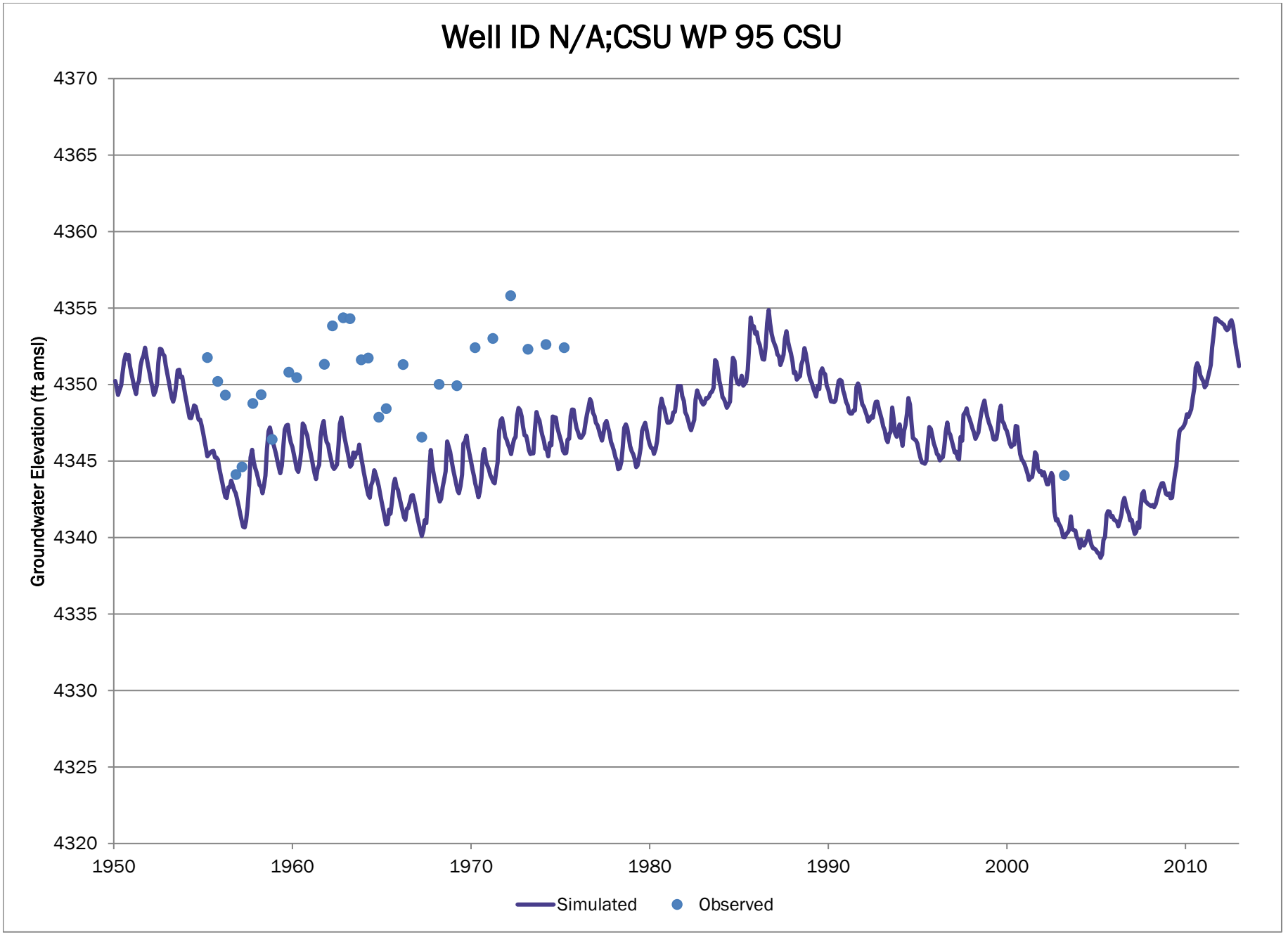

LSP-12 CSU WP 6
Groundwater Elevation (ft amsl)
4315
4310
4305
4300
4295
4290
4285
4280
4275
4270
4265
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

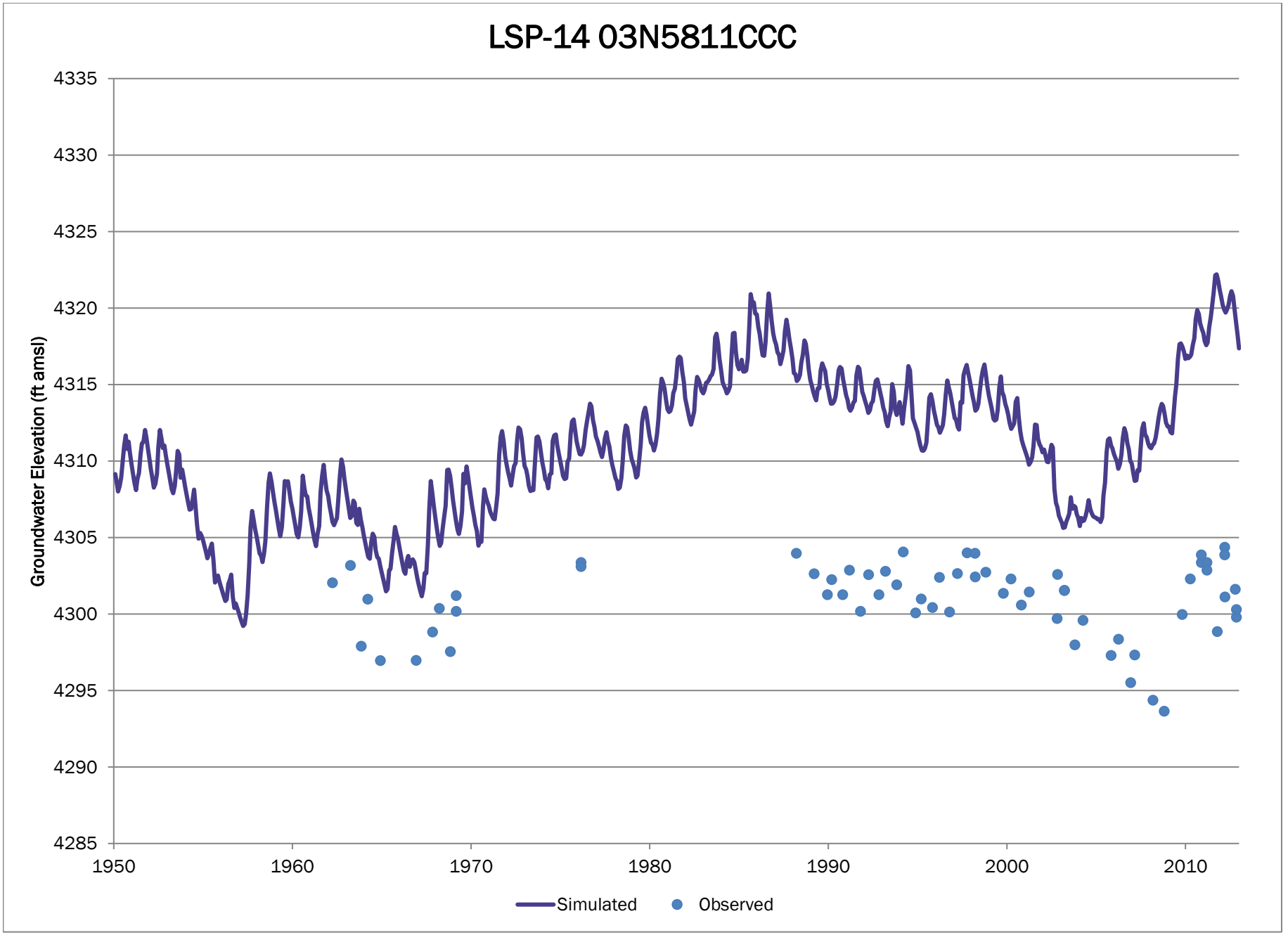

WELL ID 319;CSU WP 101 CSU
Groundwater Elevation (ft amsl)
4325
4320
4315
4310
4305
4300
4295
4290
4285
4280
4275
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

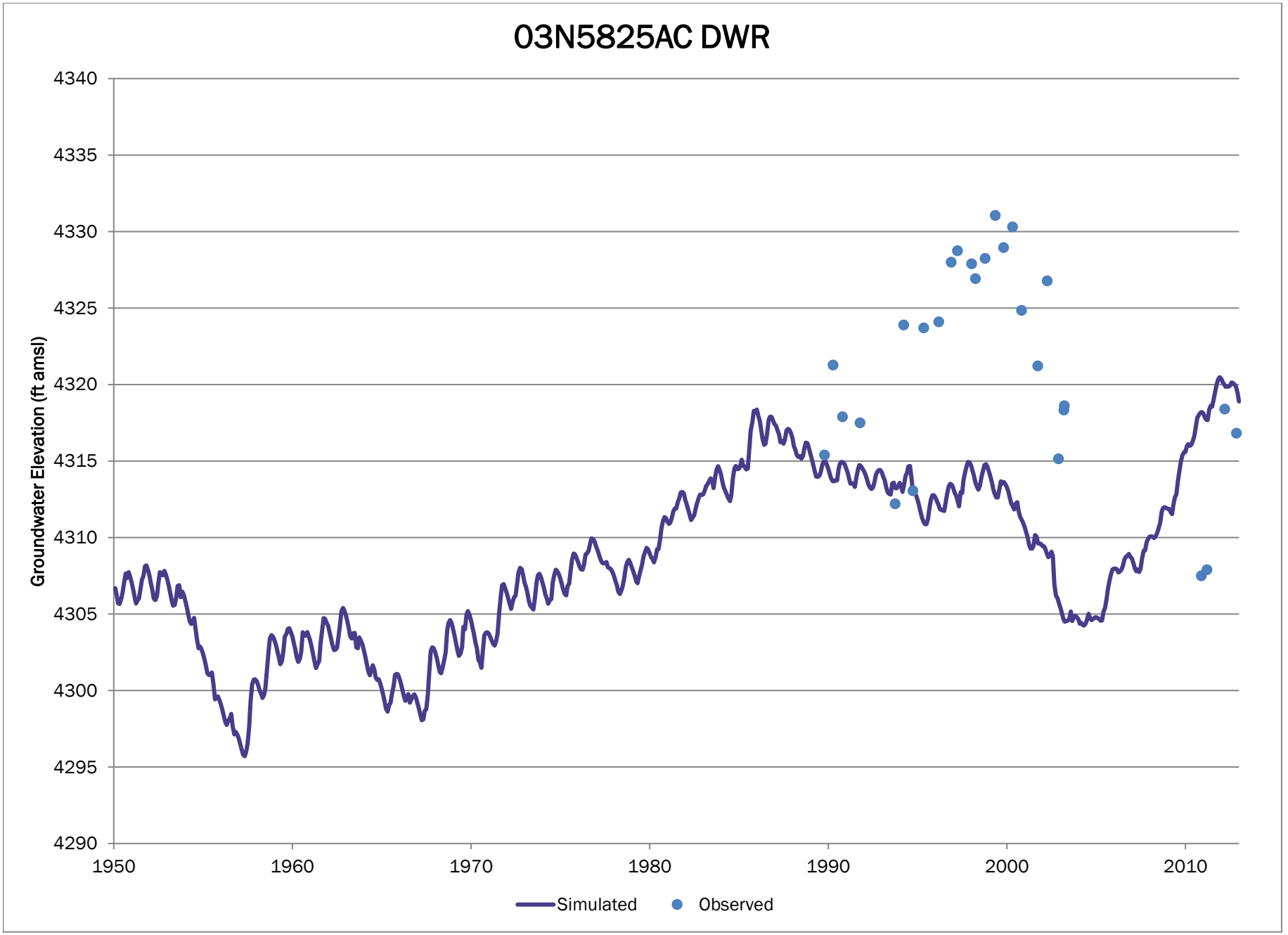

WELL ID 320;CSU WP 103 CSU
Groundwater Elevation (ft amsl)
4350
4345
4340
4335
4330
4325
4320
4315
4310
4305
4300
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

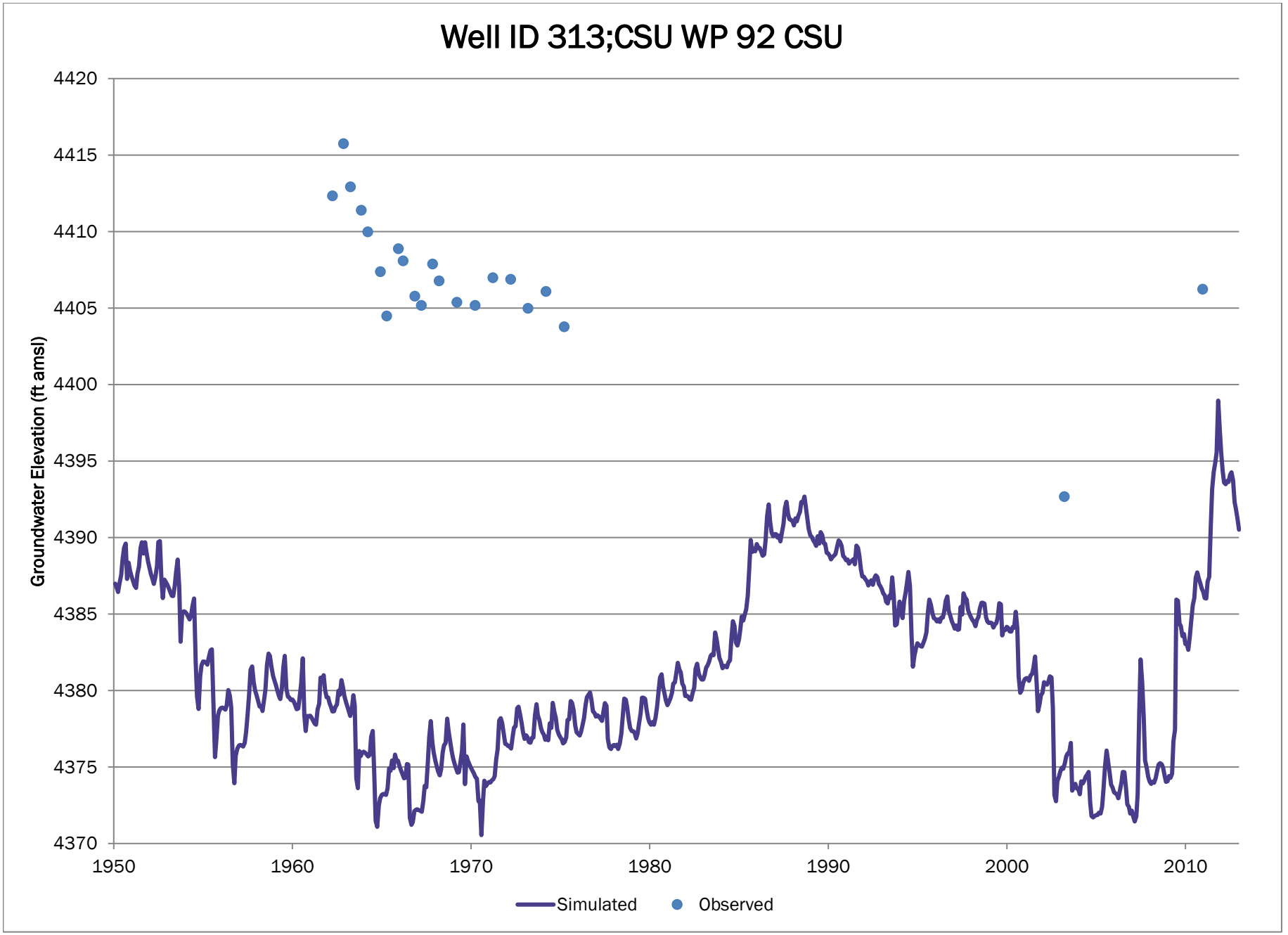

WELL ID 346;CSU WP 94 CSU
Groundwater Elevation (ft amsl)
4370
4365
4360
4355
4350
4345
4340
4335
4330
4325
4320
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


LSP-13 DSS33WLD
Groundwater Elevation (ft amsl)
4370
4365
4360
4355
4350
4345
4340
4335
4330
4325
4320
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

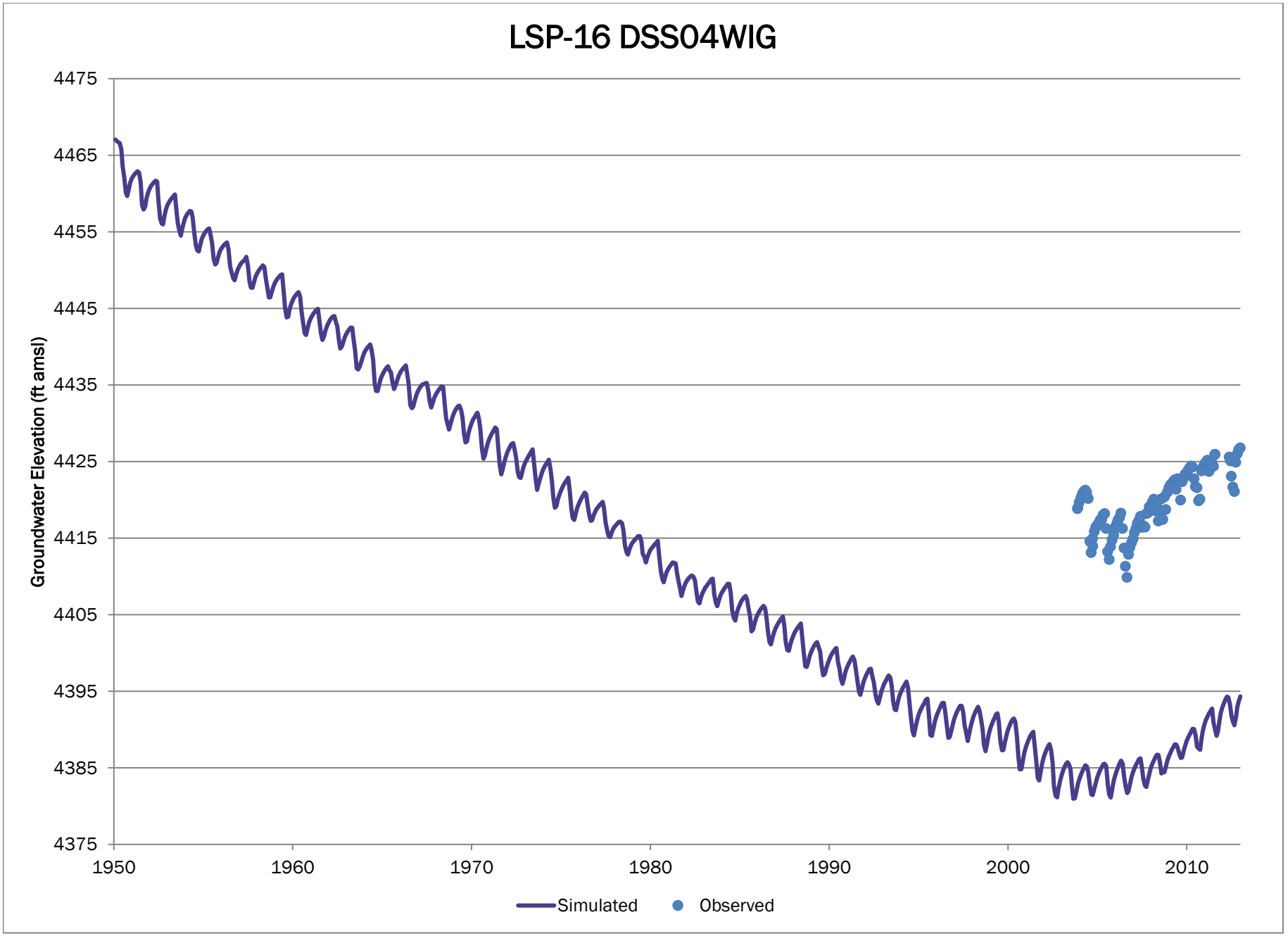

Well ID N/A;CSU WP 95 CSU
Groundwater Elevation (ft amsl)
4370
4365
4360
4355
4350
4345
4340
4335
4330
4325
4320
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

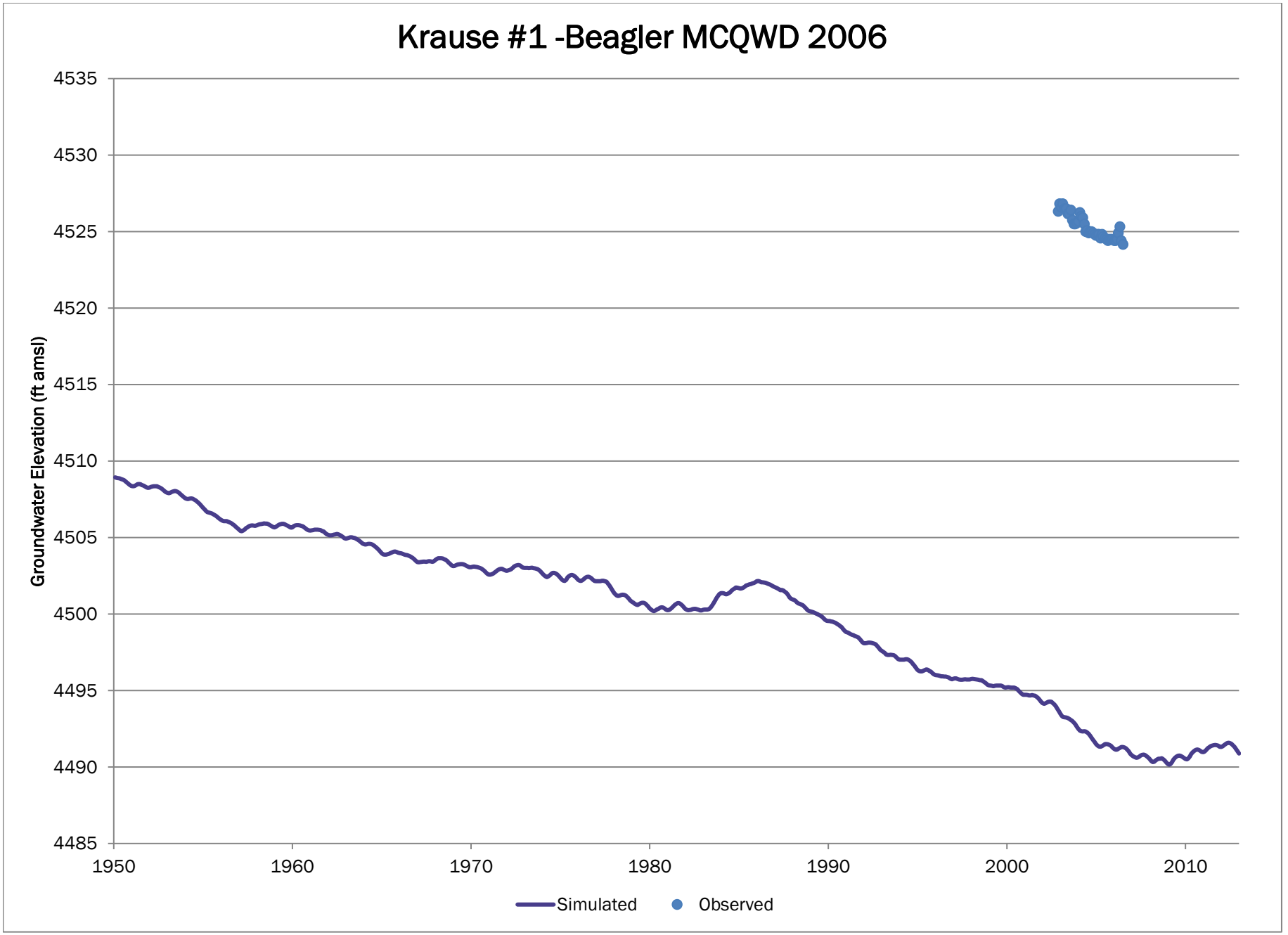

LSP-14 03N5811CCC
Groundwater Elevation (ft amsl)
4335
4330
4325
4320
4315
4310
4305
4300
4295
4290
4285
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


03N5825AC DWR
Groundwater Elevation (ft amsl)
4340
4335
4330
4325
4320
4315
4310
4305
4300
4295
4290
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

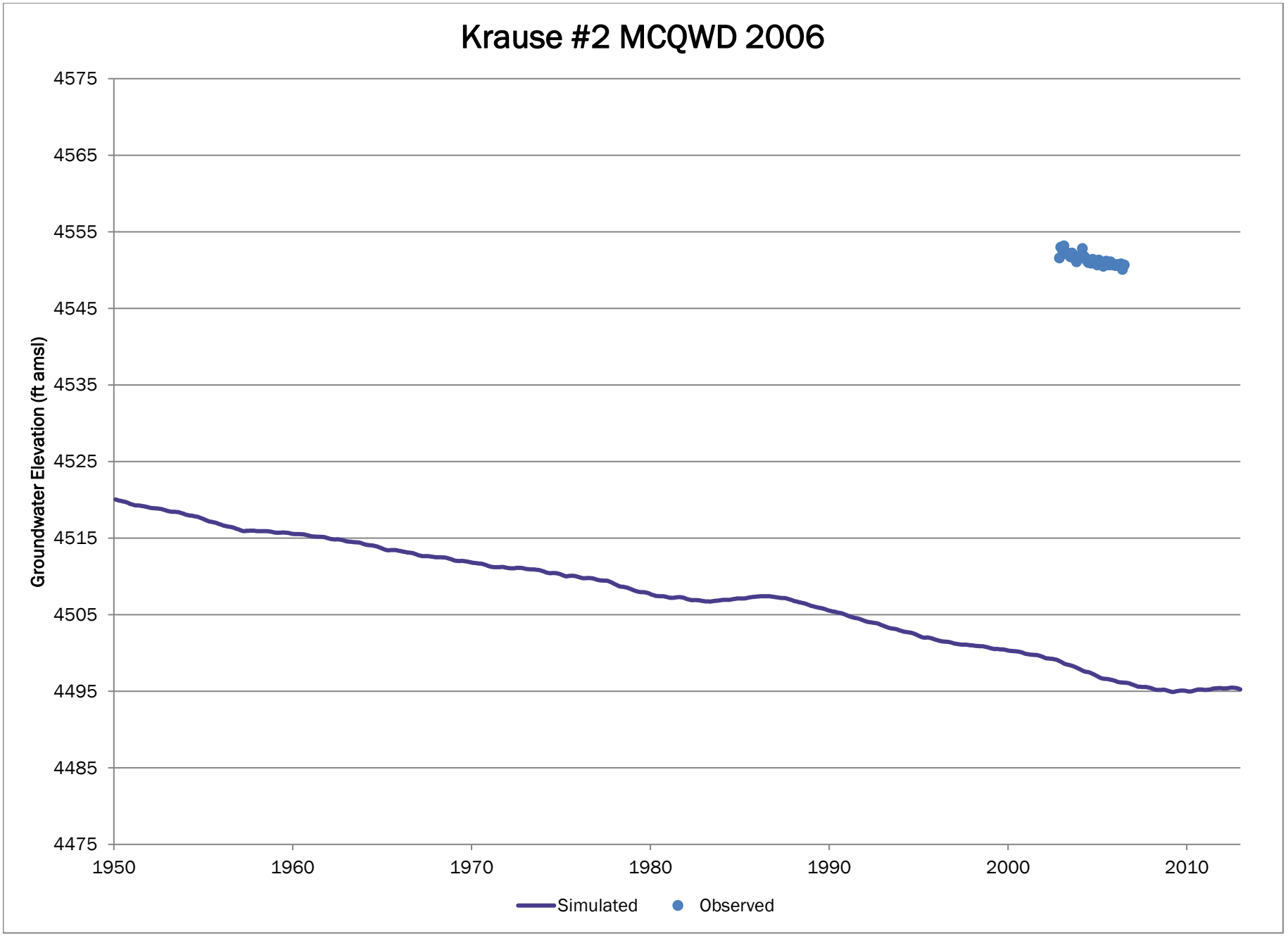

Well ID 313;CSU WP 92 CSU
Groundwater Elevation (ft amsl)
4420
4415
4410
4405
4400
4395
4390
4385
4380
4375
4370
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

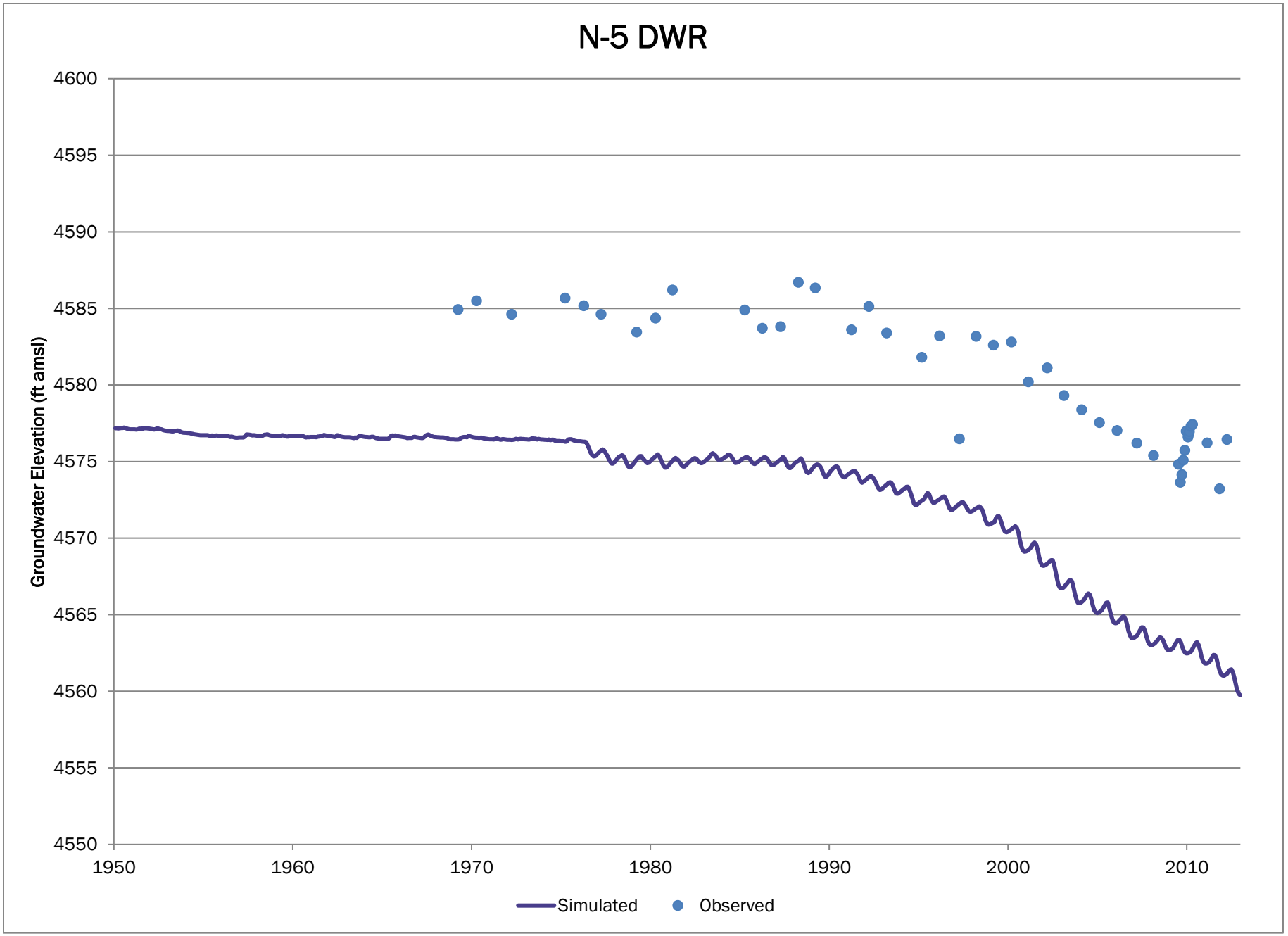
Note elevation axis range of 100 feet.

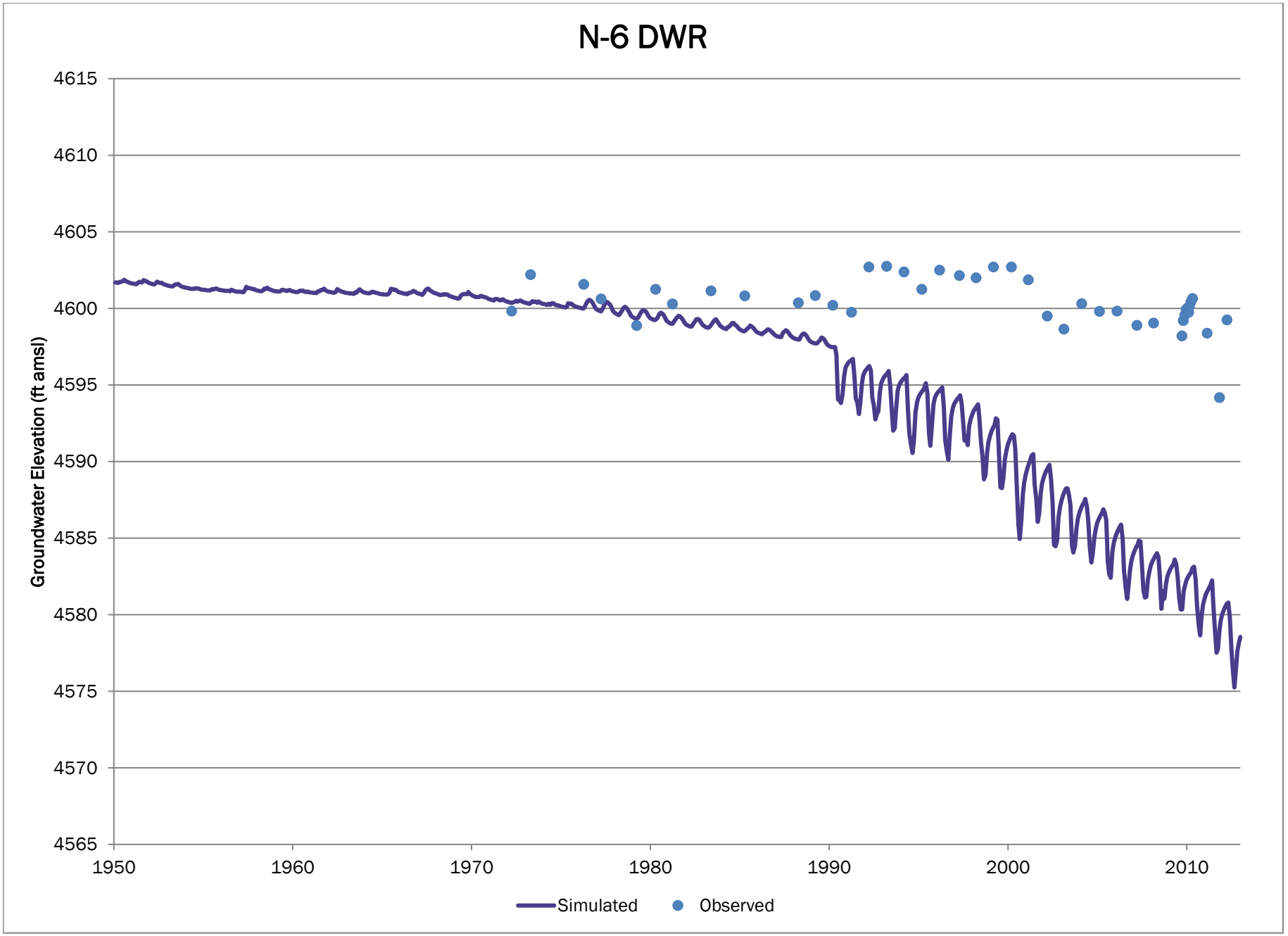


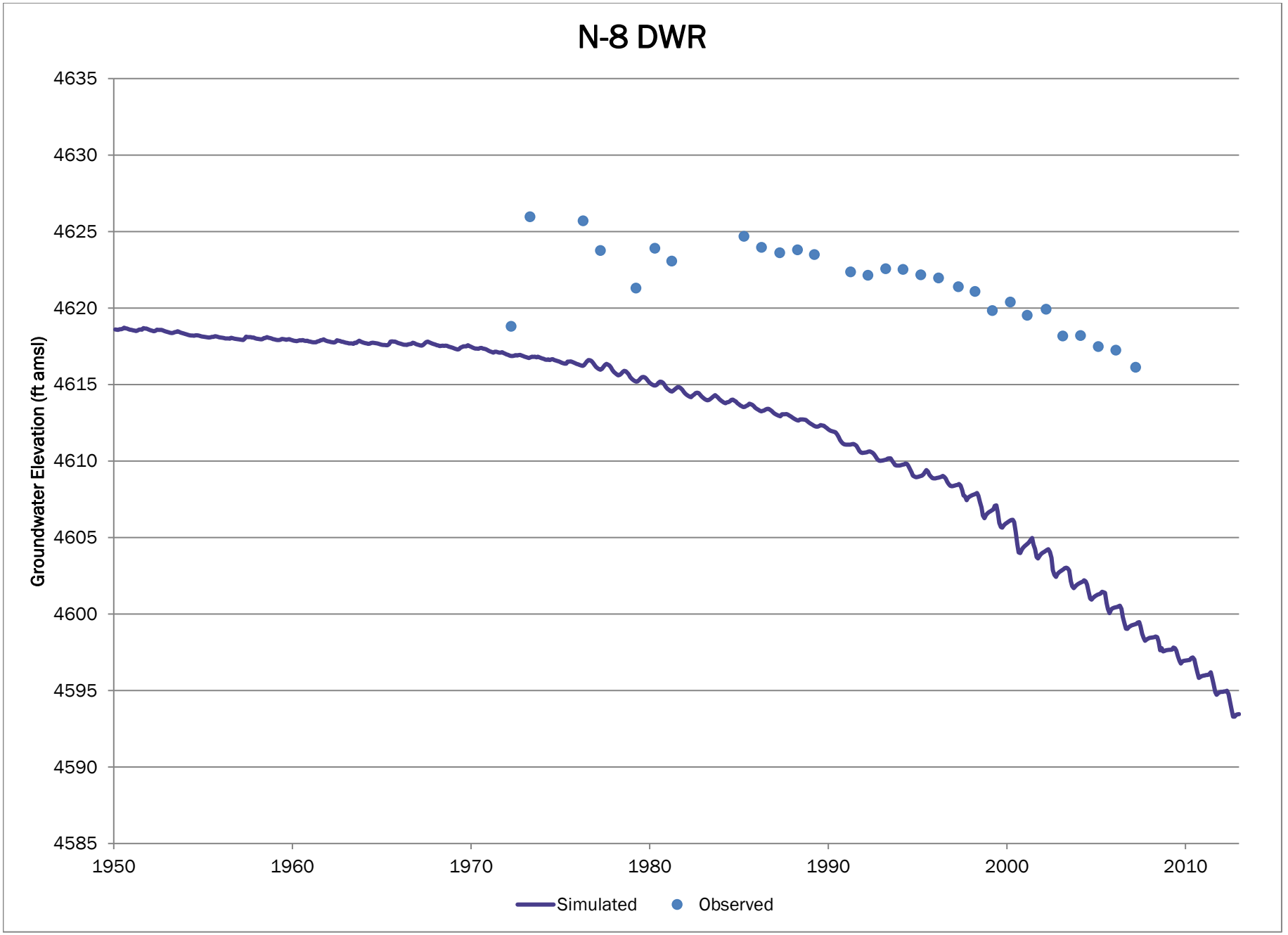

Krause #1 -Beagler MCQWD 2006
Groundwater Elevation (ft amsl)
4535
4530
4525
4520
4515
4510
4505
4500
4495
4490
4485
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

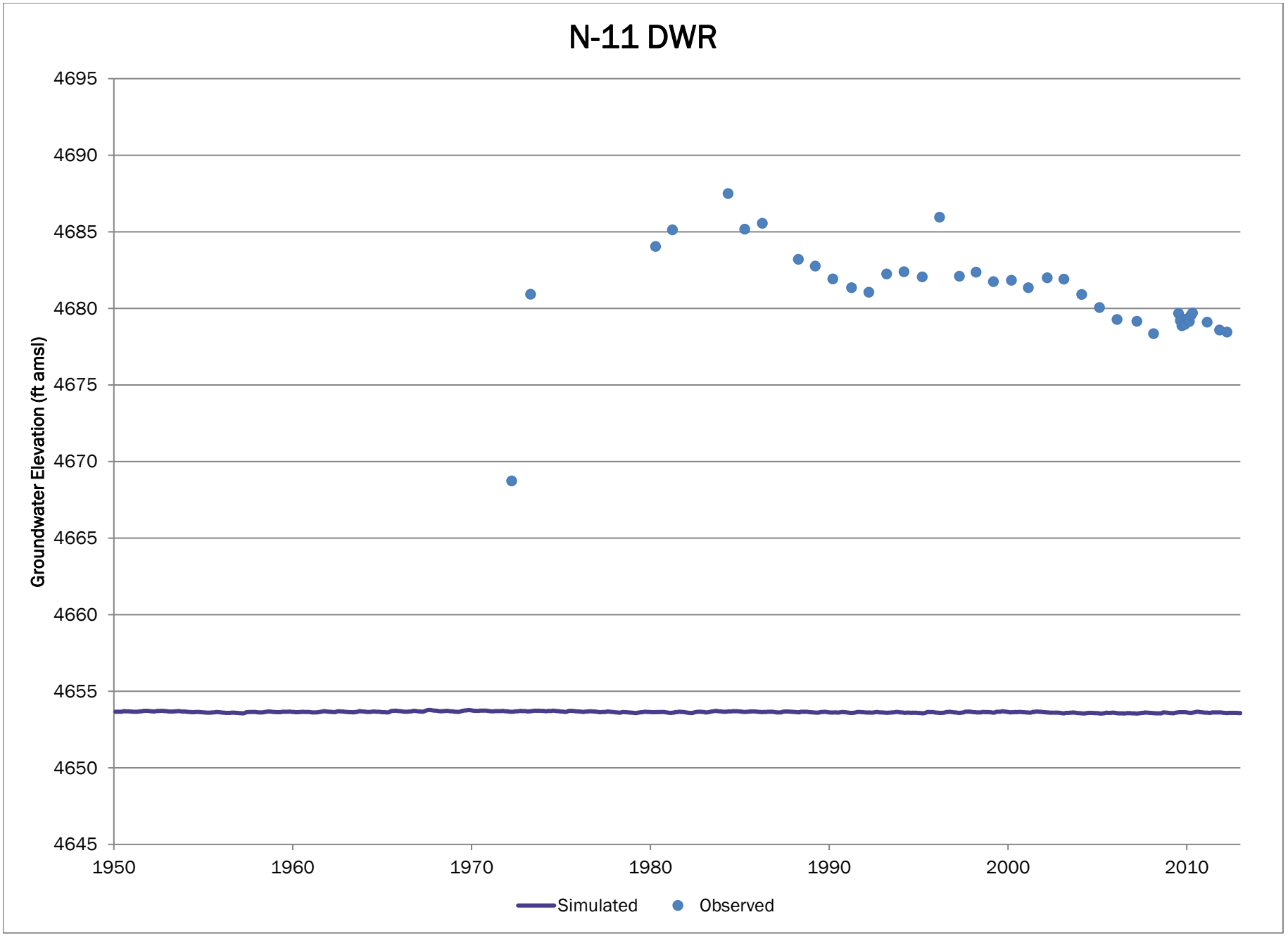
Note elevation axis range of 100 feet.

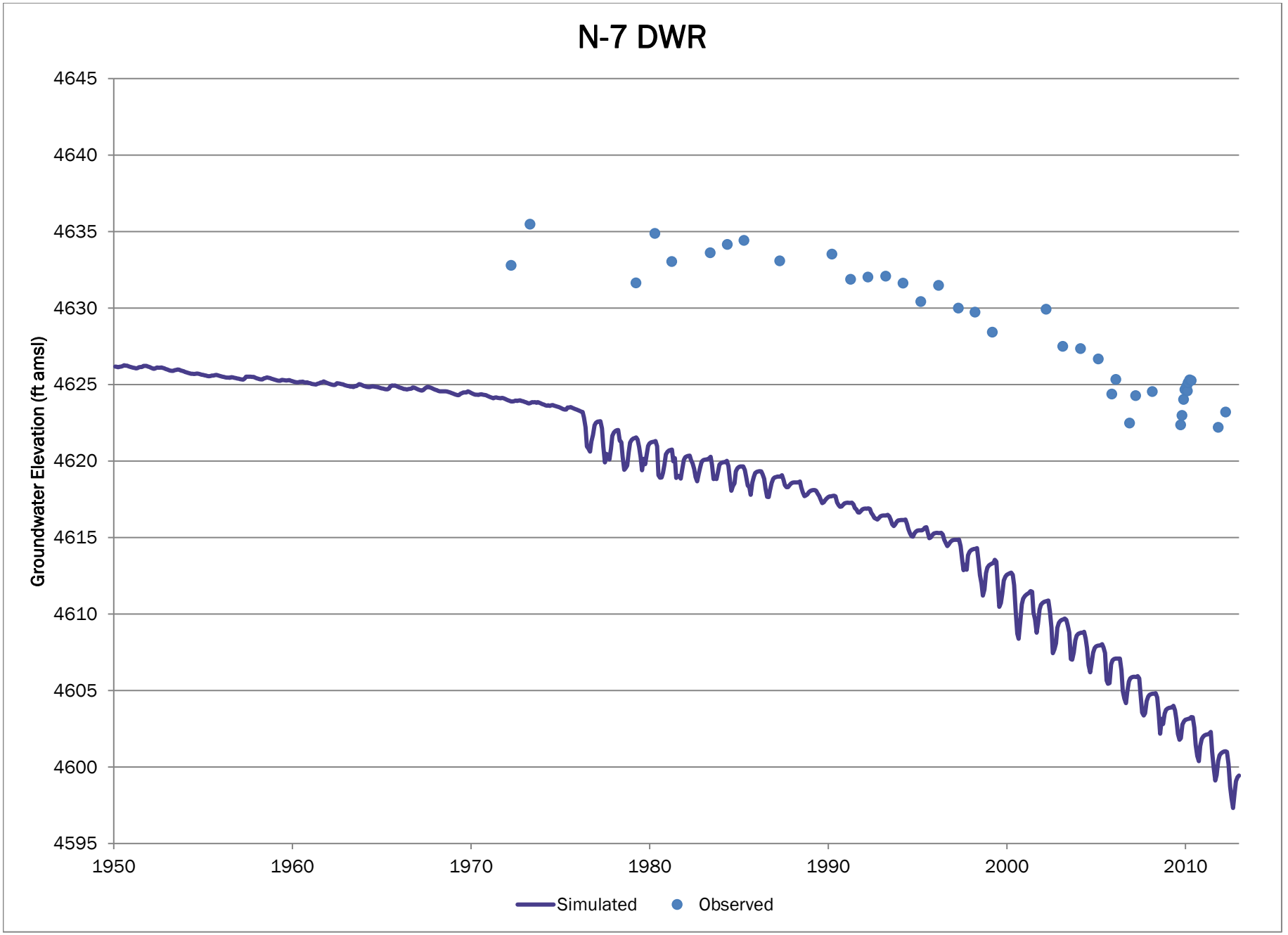



N-5 DWR
Groundwater Elevation (ft amsl)
4600
4595
4590
4585
4580
4575
4570
4565
4560
4555
4550
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

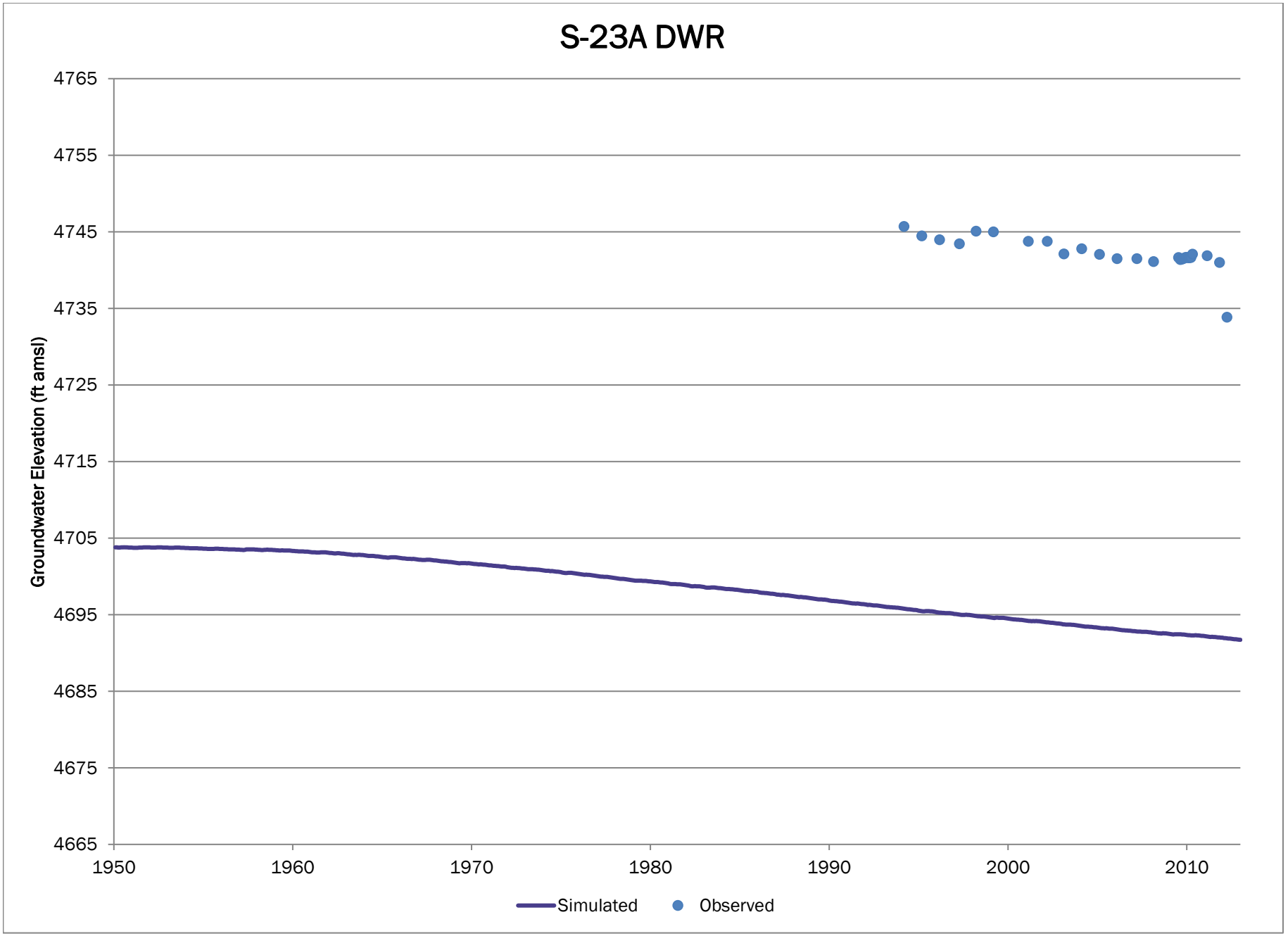

N-6 DWR
Groundwater Elevation (ft amsl)
4615
4610
4605
4600
4595
4590
4585
4580
4575
4570
4565
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

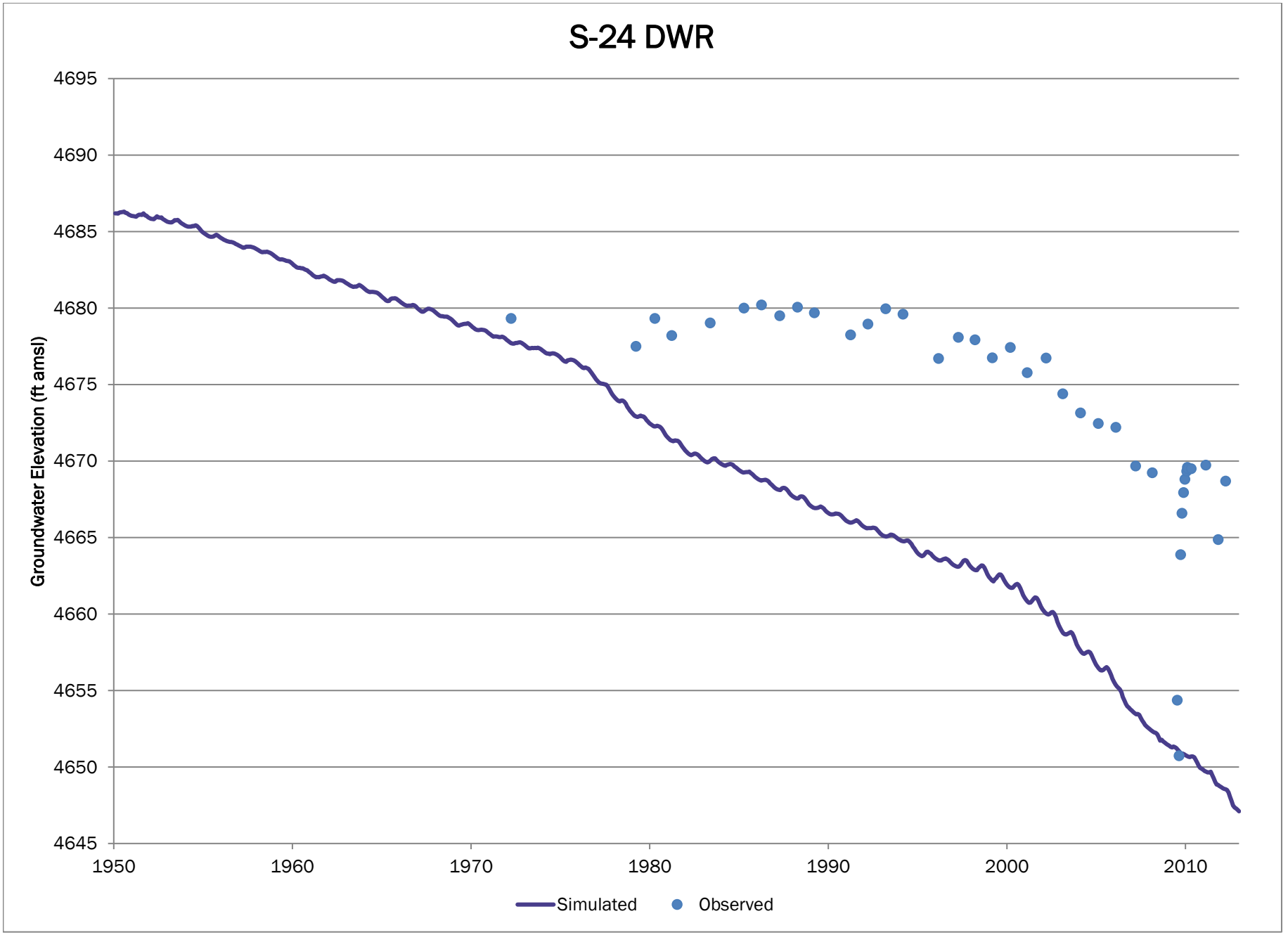

N-8 DWR
Groundwater Elevation (ft amsl)
4635
4630
4625
4620
4615
4610
4605
4600
4595
4590
4585
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

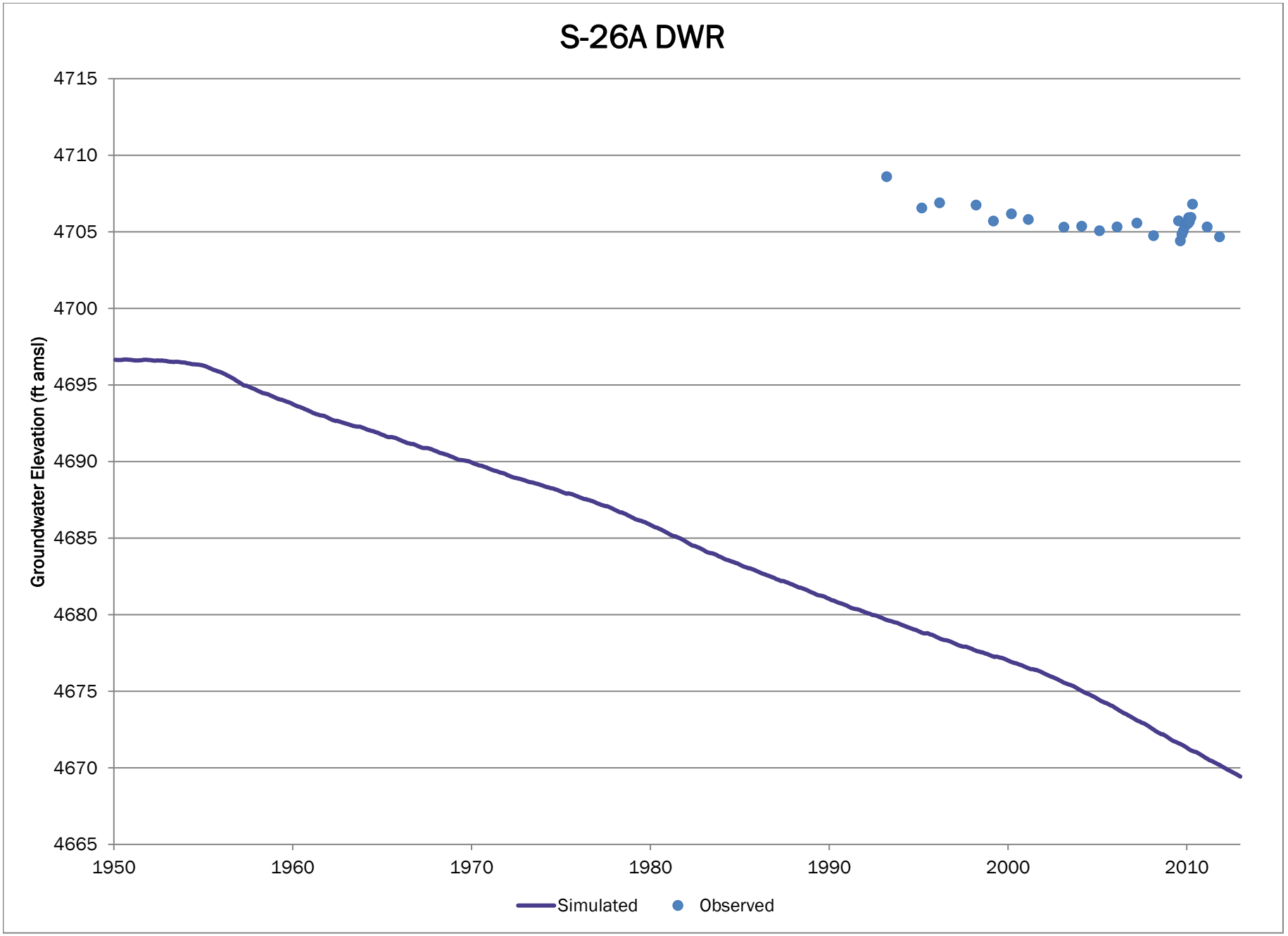

N-11 DWR
Groundwater Elevation (ft amsl)
4695
4690
4685
4680
4675
4670
4665
4660
4655
4650
4645
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

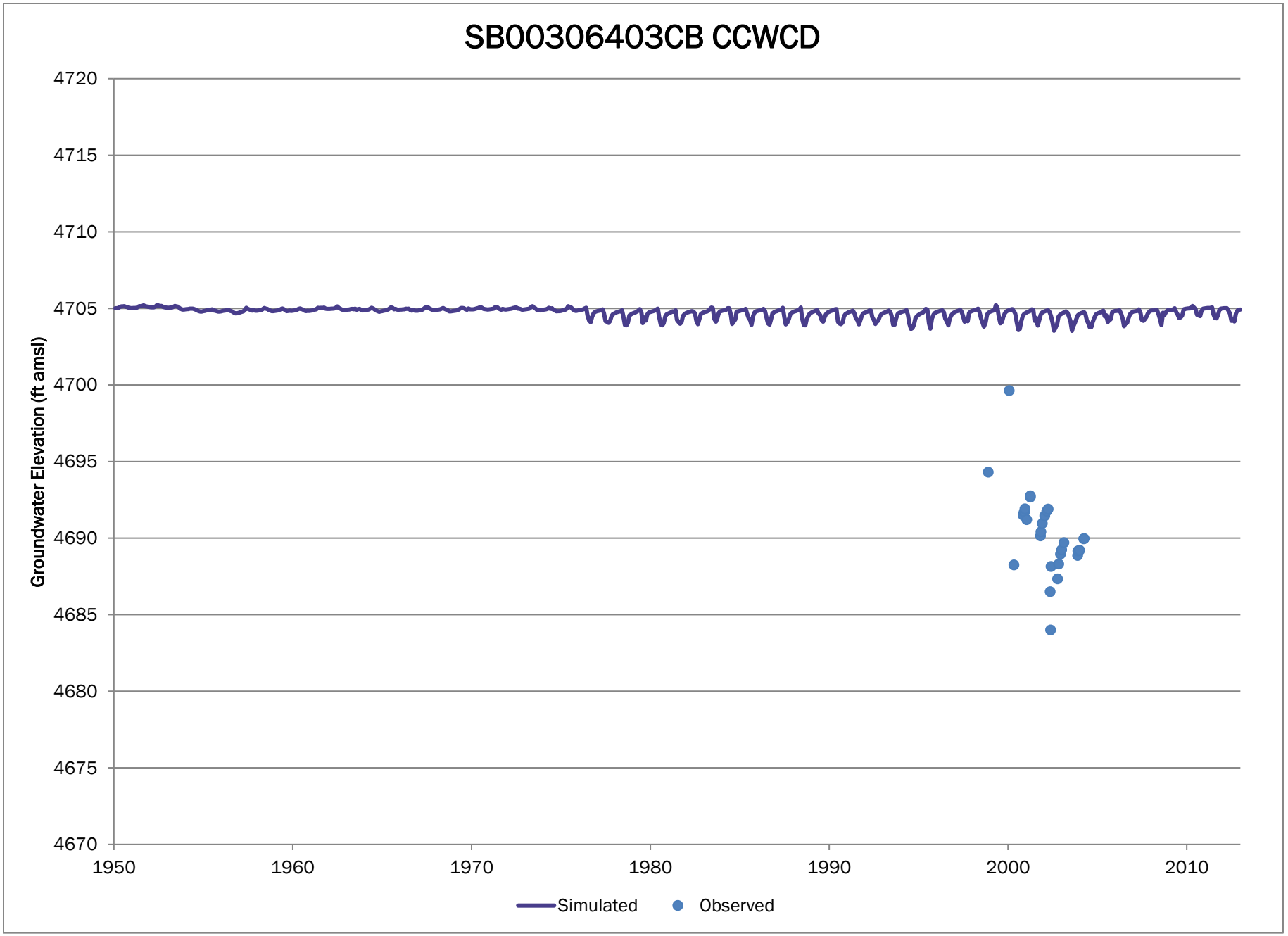

N-7 DWR
Groundwater Elevation (ft amsl)
4645
4640
4635
4630
4625
4620
4615
4610
4605
4600
4595
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

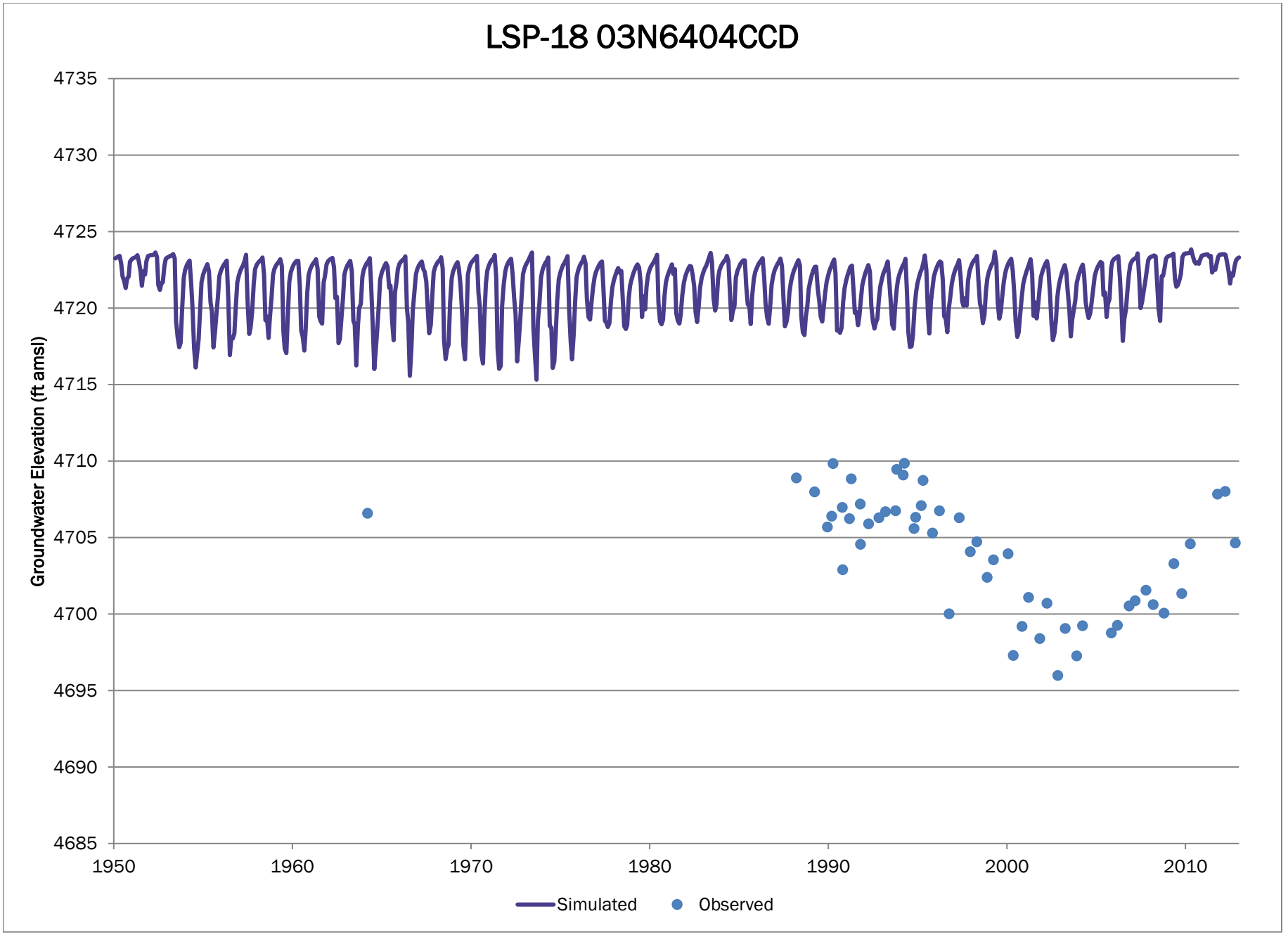
Note elevation axis range of 100 feet.

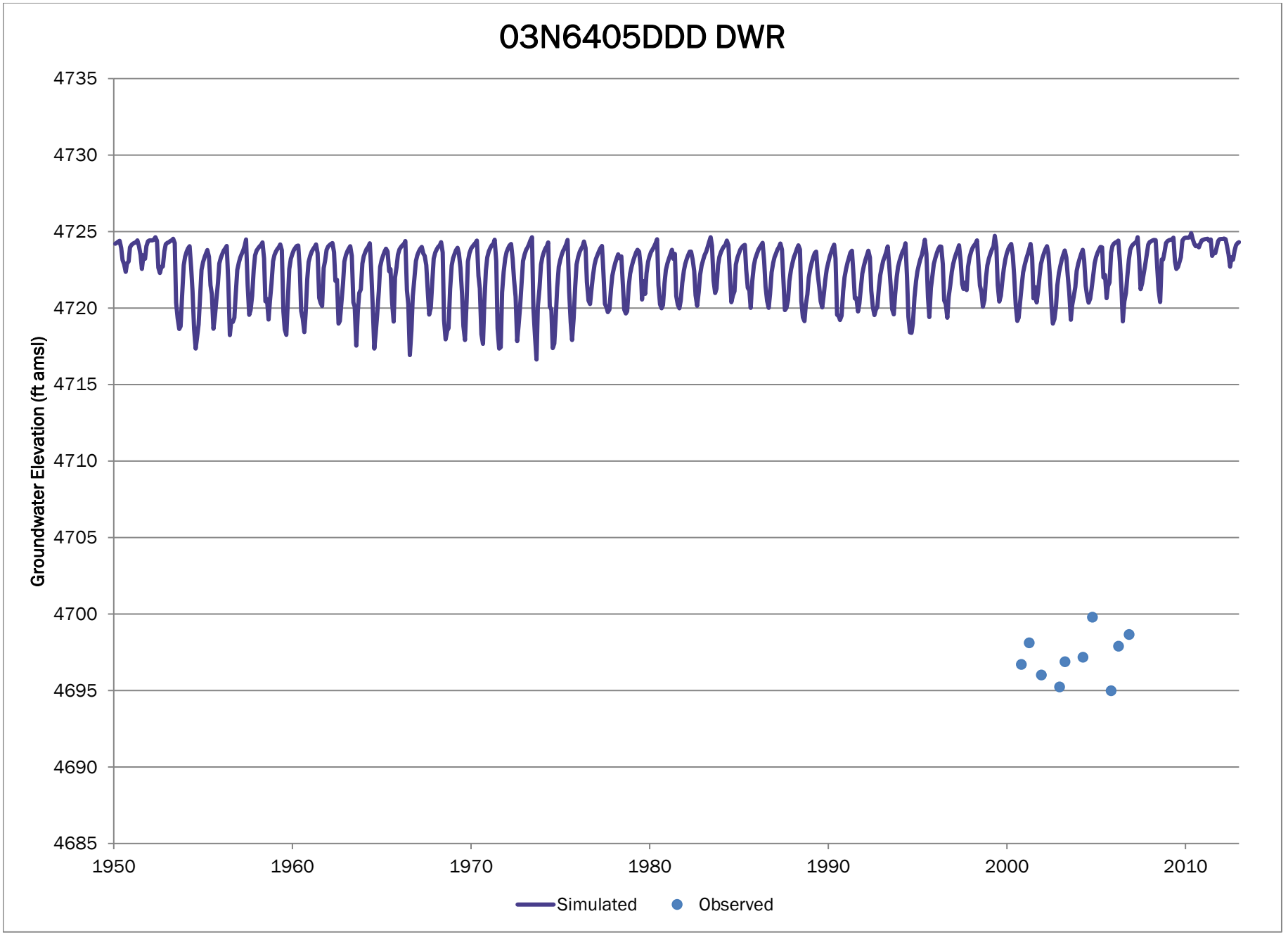


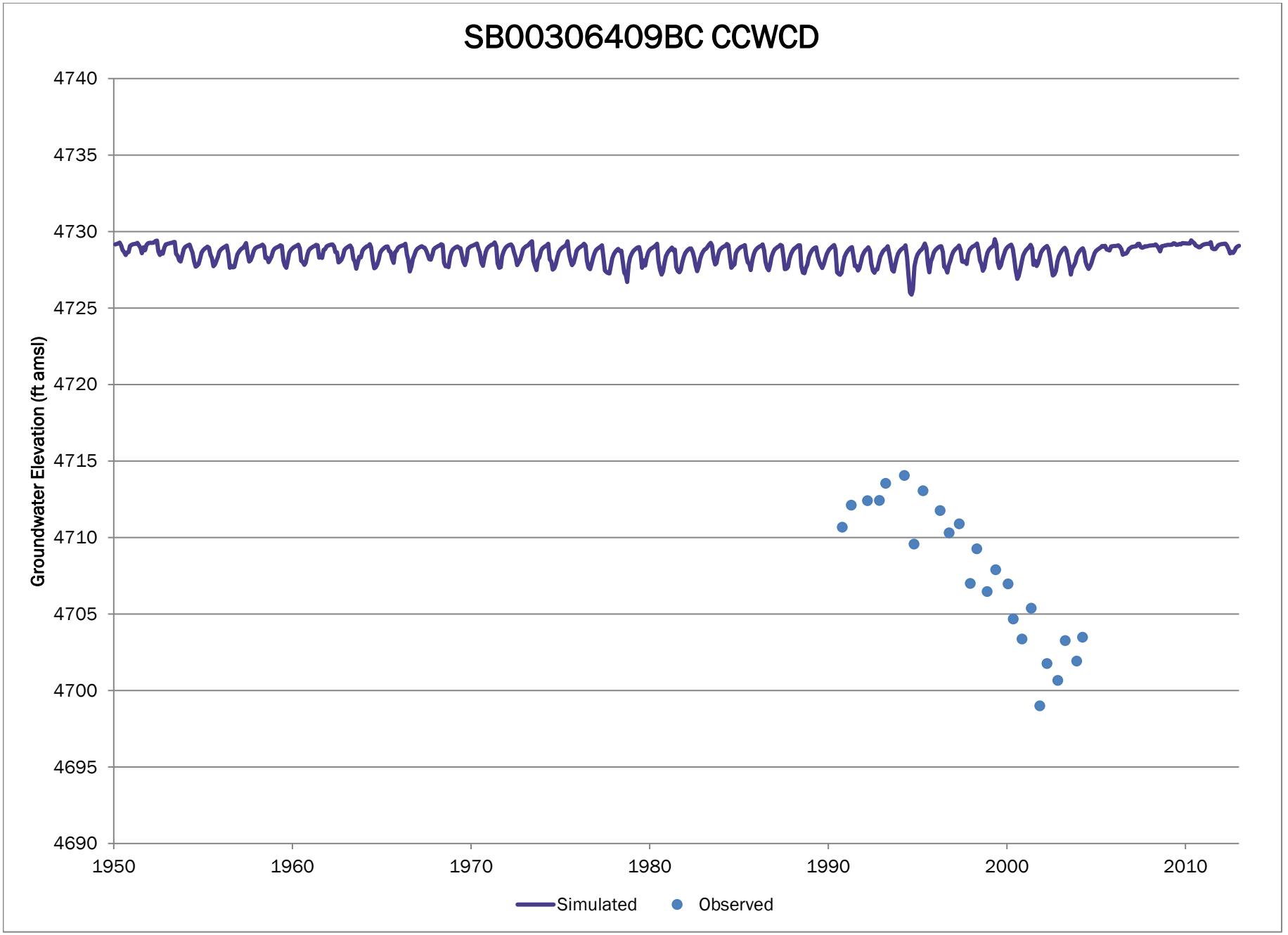

S-24 DWR
Groundwater Elevation (ft amsl)
4695
4690
4685
4680
4675
4670
4665
4660
4655
4650
4645
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

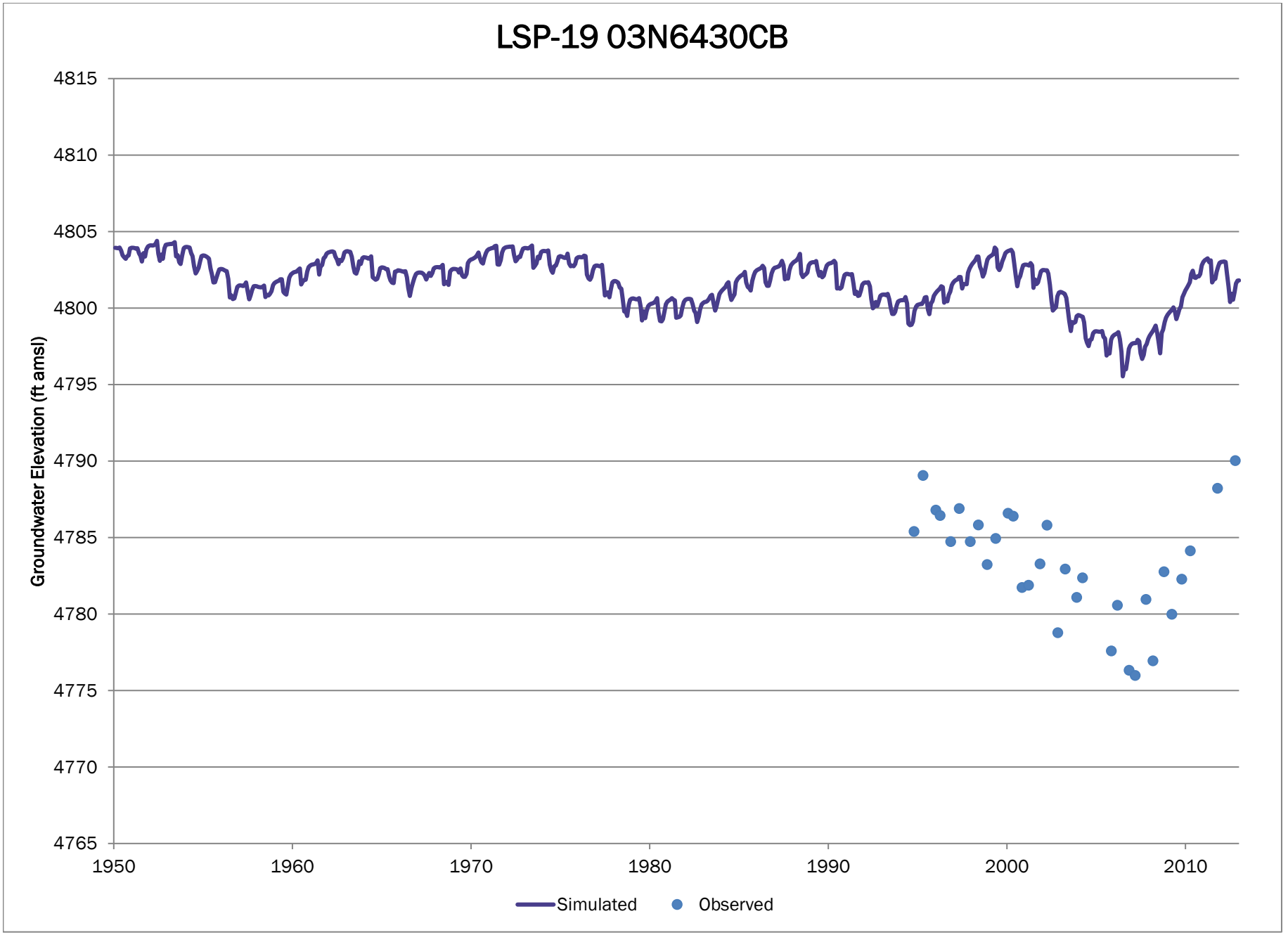

S-26A DWR
Groundwater Elevation (ft amsl)
4715
4710
4705
4700
4695
4690
4685
4680
4675
4670
4665
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

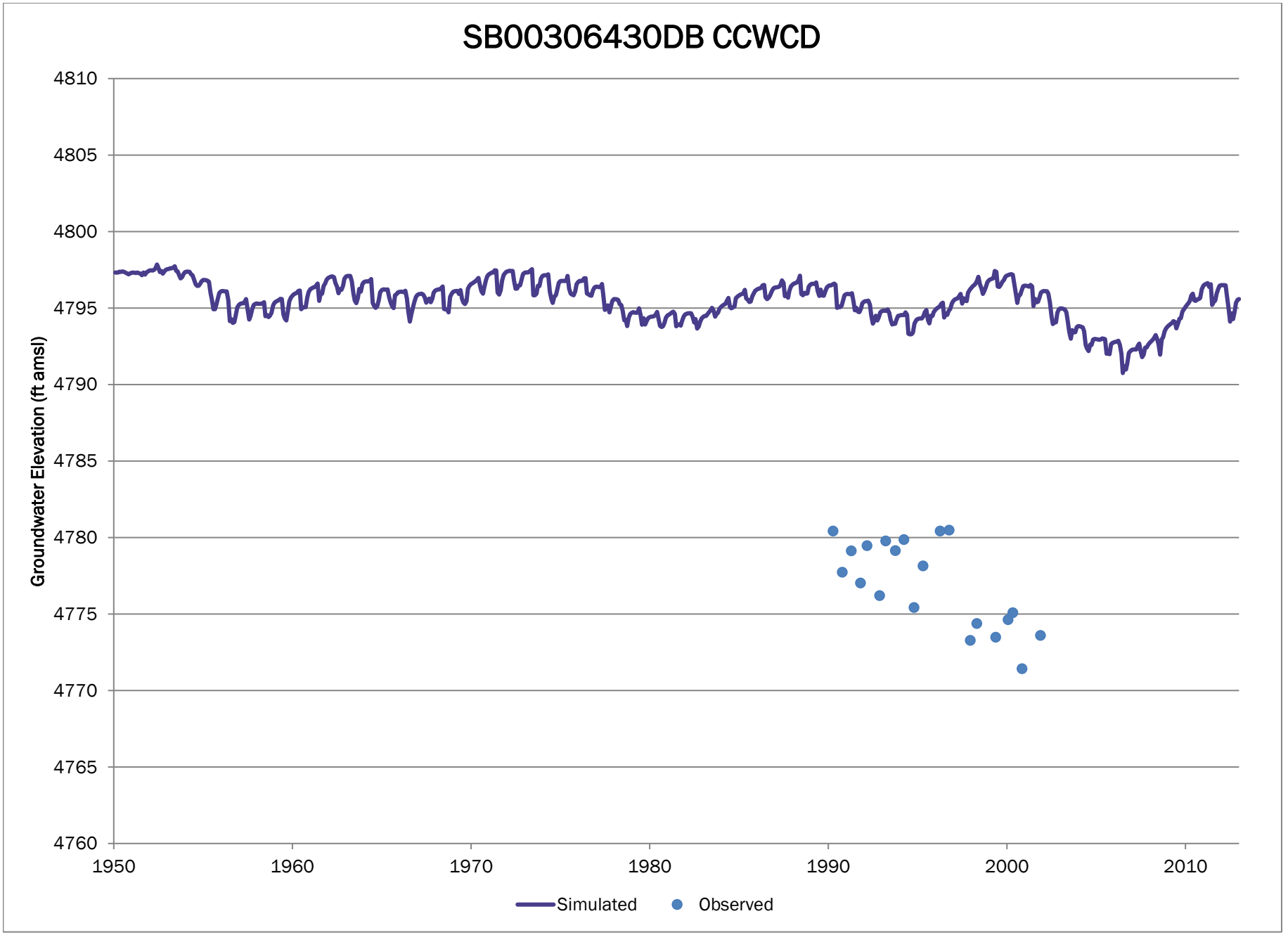

SB00306403CB CCWCD
Groundwater Elevation (ft amsl)
4720
4715
4710
4705
4700
4695
4690
4685
4680
4675
4670
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

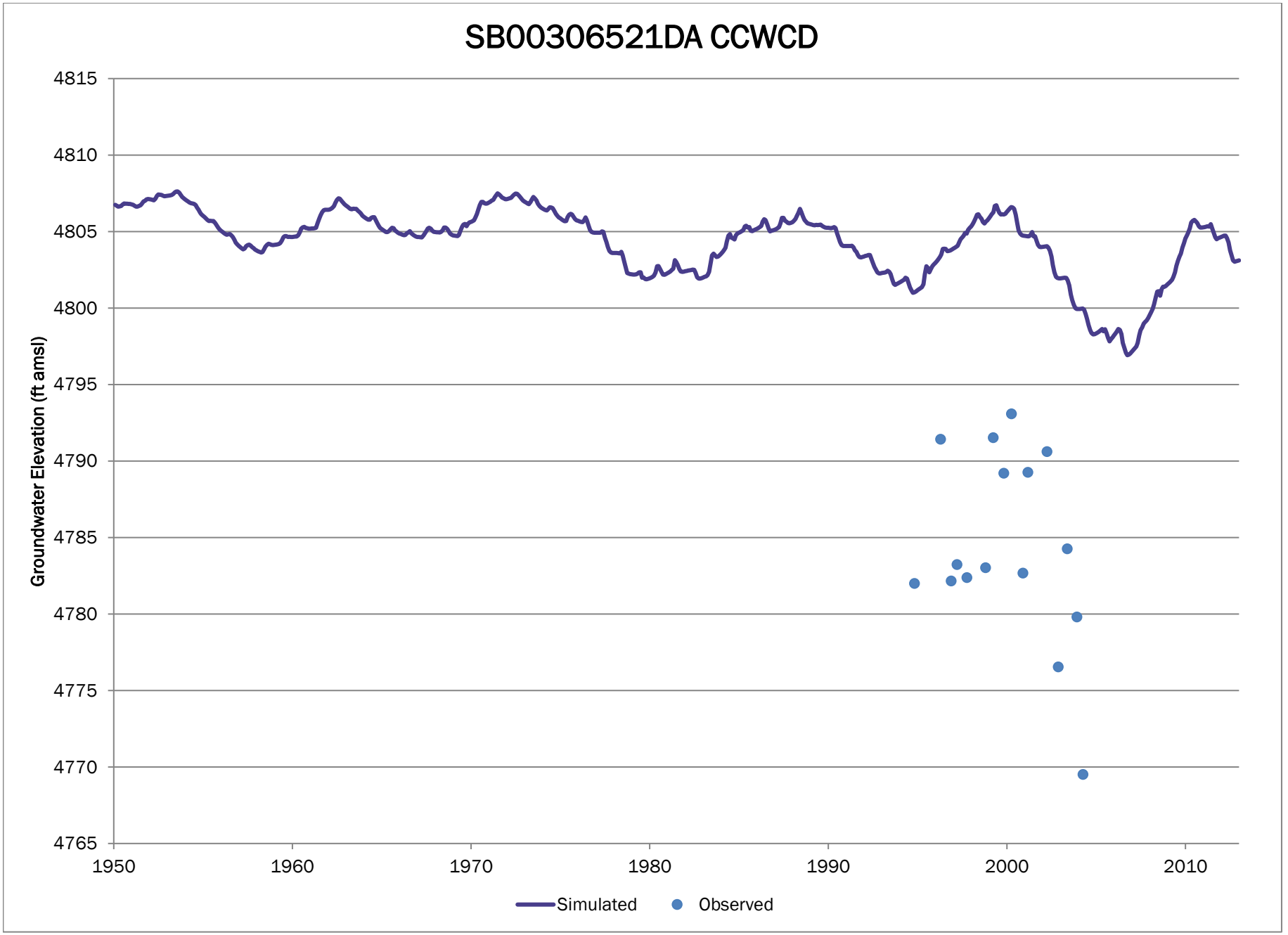

LSP-18 03N6404CCD
Groundwater Elevation (ft amsl)
4735
4730
4725
4720
4715
4710
4705
4700
4695
4690
4685
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


03N6405DDD DWR
Groundwater Elevation (ft amsl)
4735
4730
4725
4720
4715
4710
4705
4700
4695
4690
4685
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

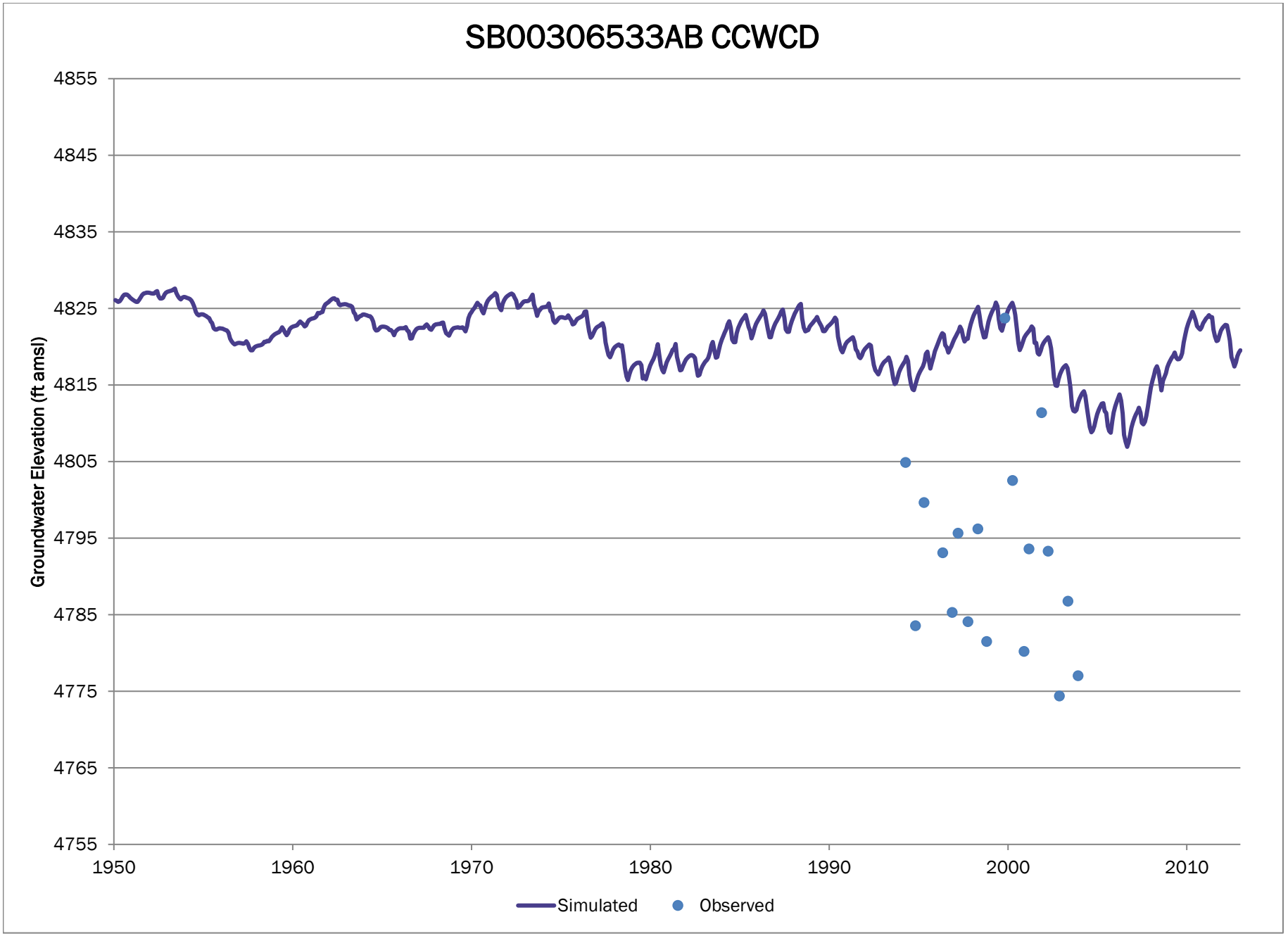

SB00306409BC CCWCD
Groundwater Elevation (ft amsl)
4740
4735
4730
4725
4720
4715
4710
4705
4700
4695
4690
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

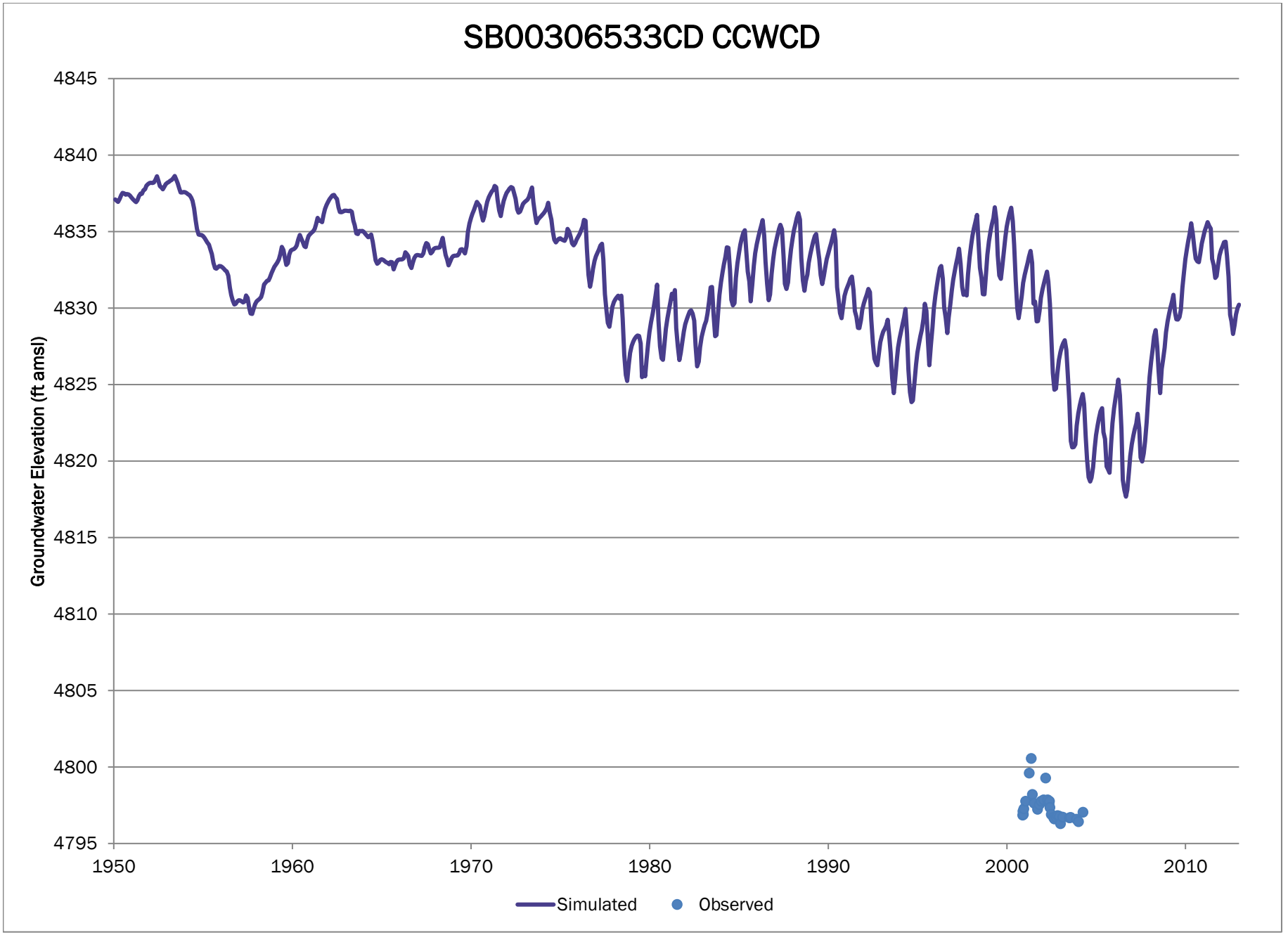

LSP-19 03N6430CB
Groundwater Elevation (ft amsl)
4815
4810
4805
4800
4795
4790
4785
4780
4775
4770
4765
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


SB00306430DB CCWCD
Groundwater Elevation (ft amsl)
4810
4805
4800
4795
4790
4785
4780
4775
4770
4765
4760
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

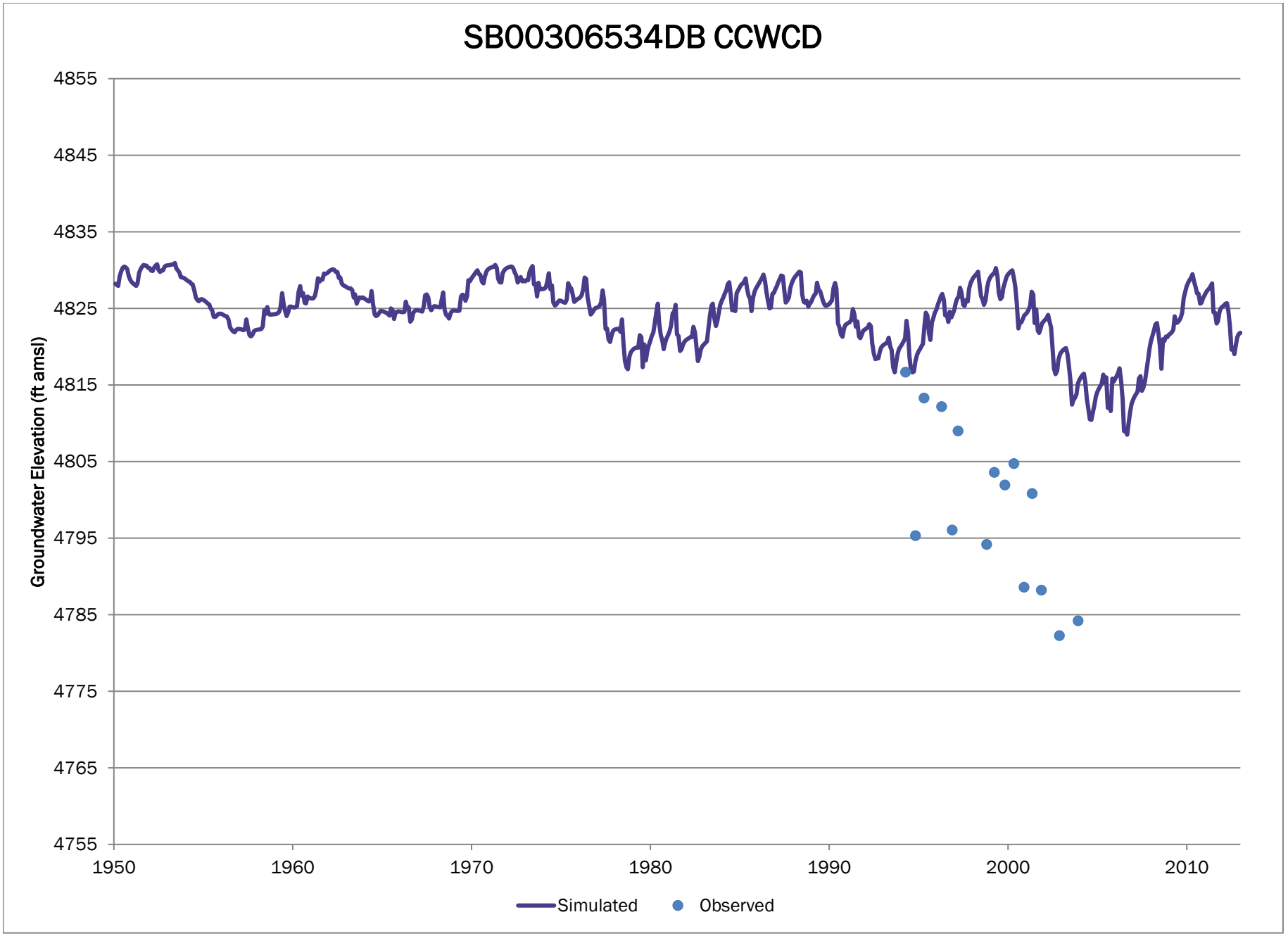

SB00306521DA CCWCD
Groundwater Elevation (ft amsl)
4815
4810
4805
4800
4795
4790
4785
4780
4775
4770
4765
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

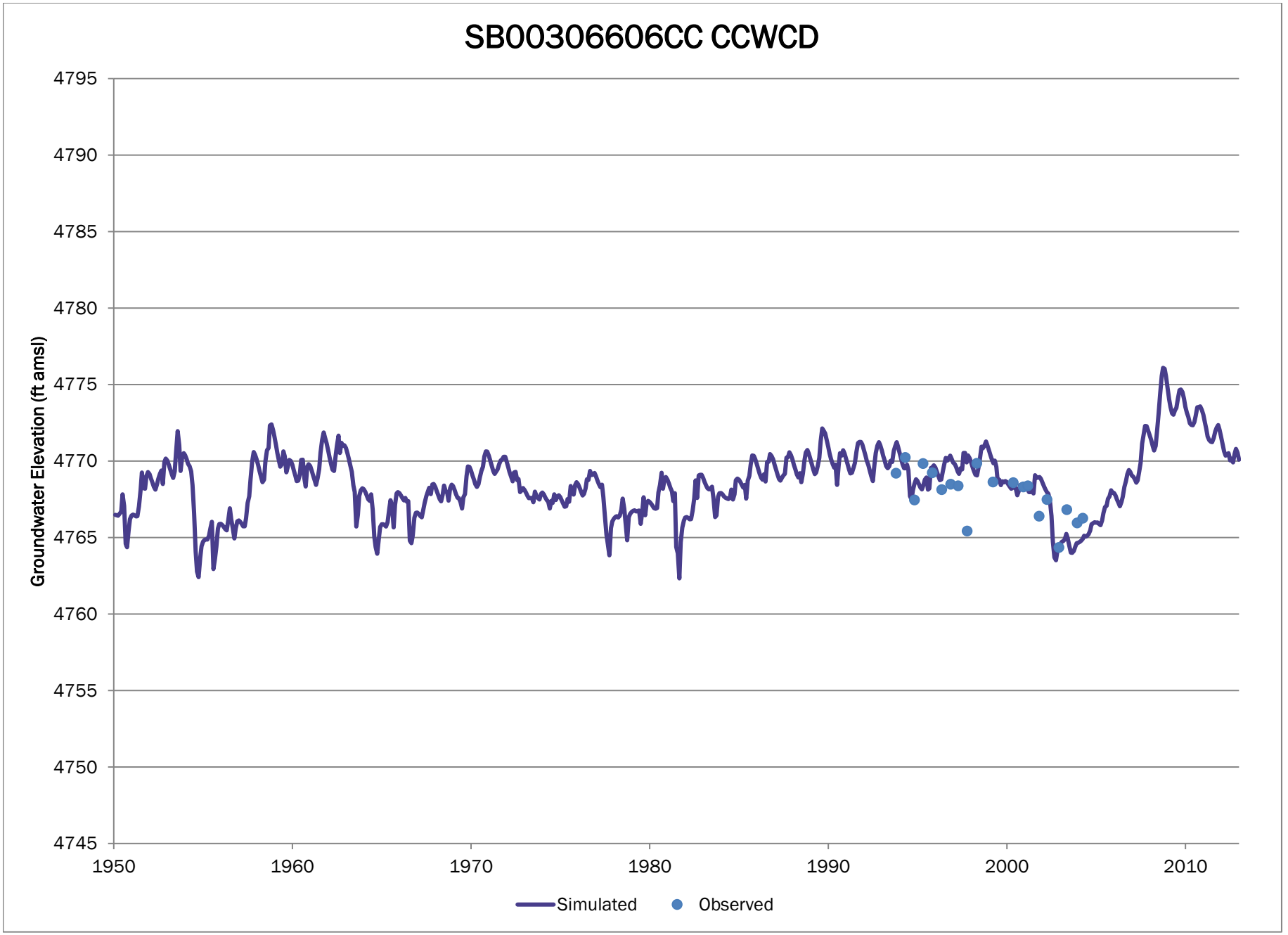
Note elevation axis range of 100 feet.

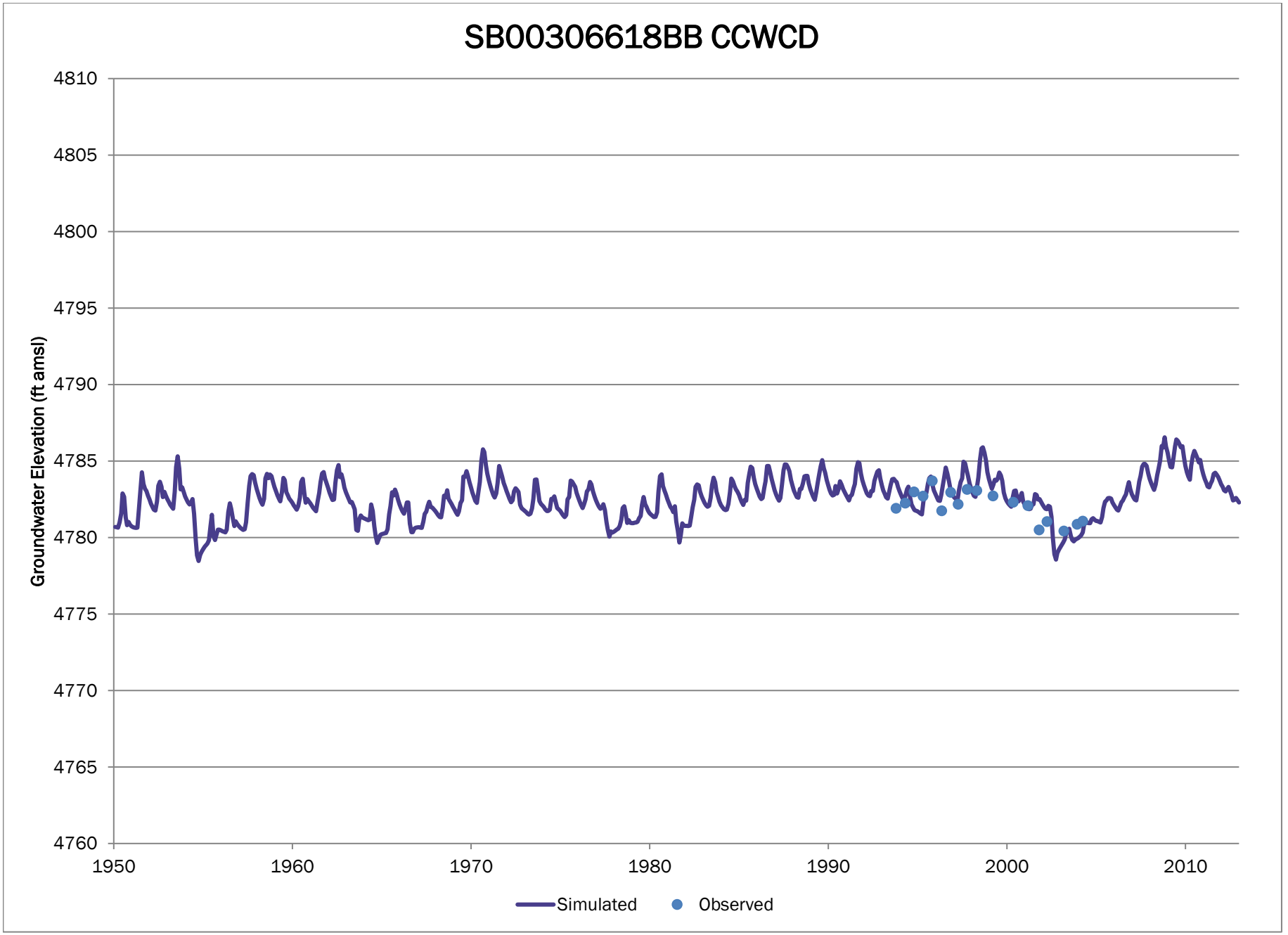


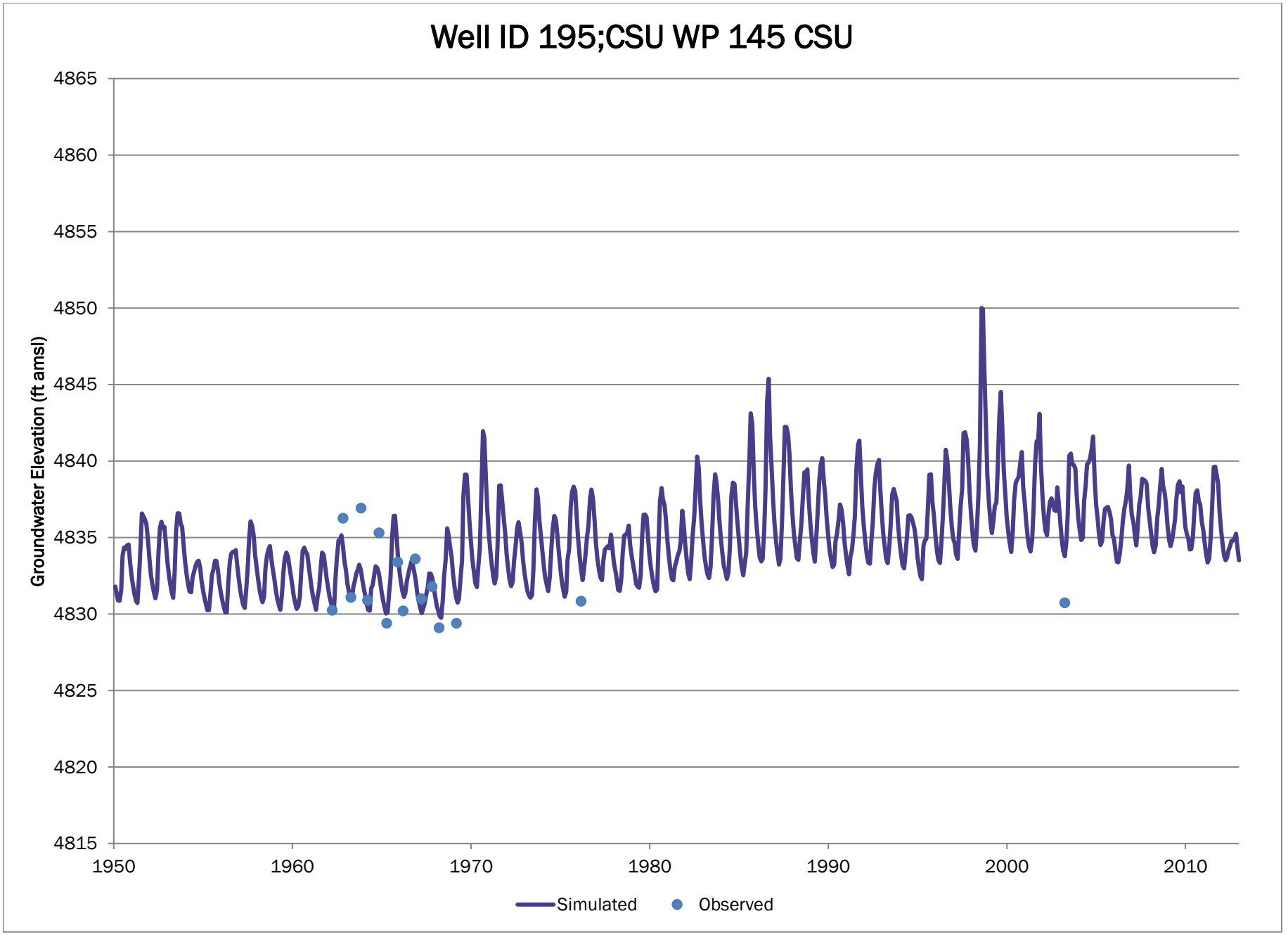

SB00306533CD CCWCD
Groundwater Elevation (ft amsl)
4845
4840
4835
4830
4825
4820
4815
4810
4805
4800
4795
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

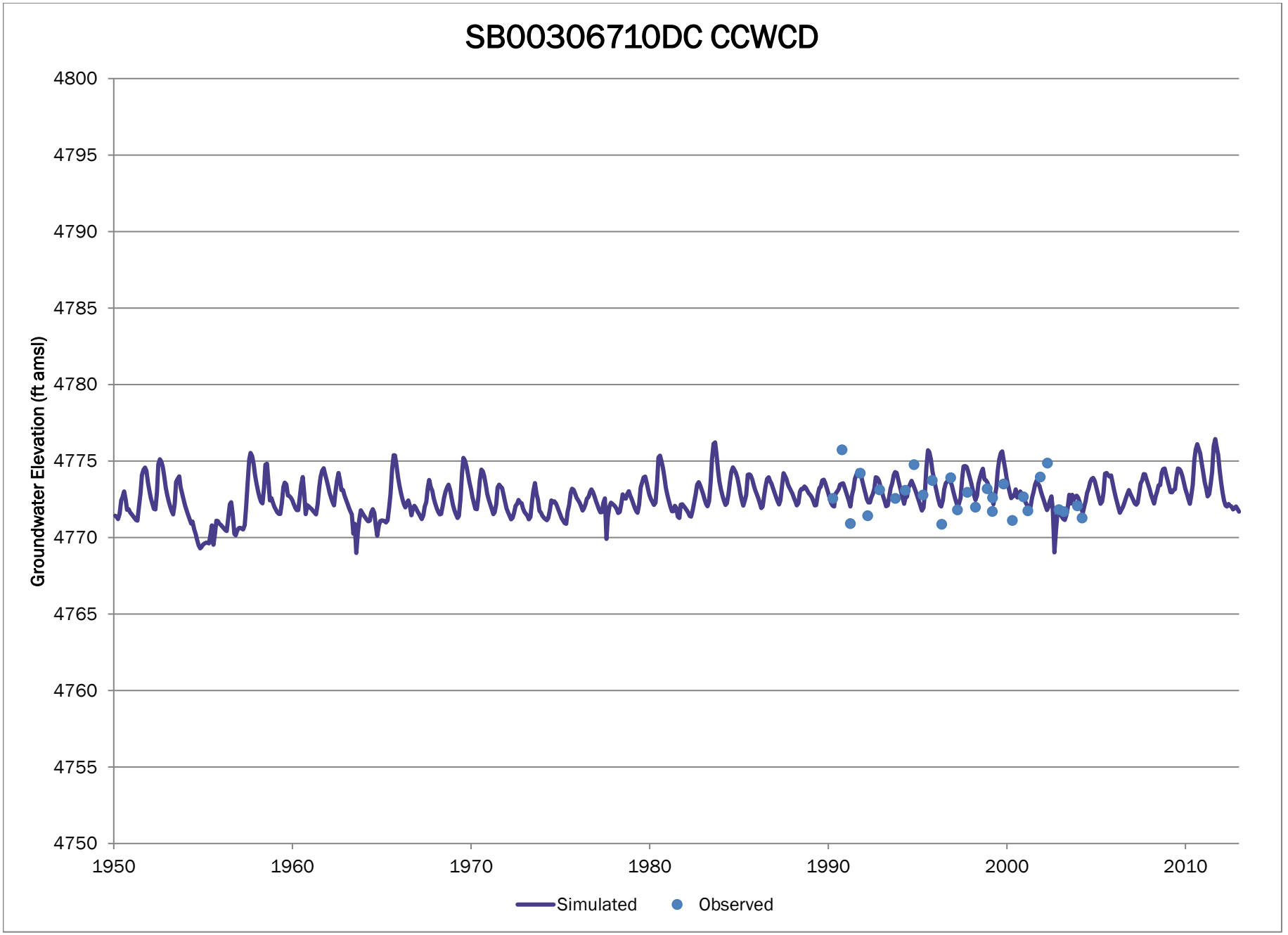
Note elevation axis range of 100 feet.

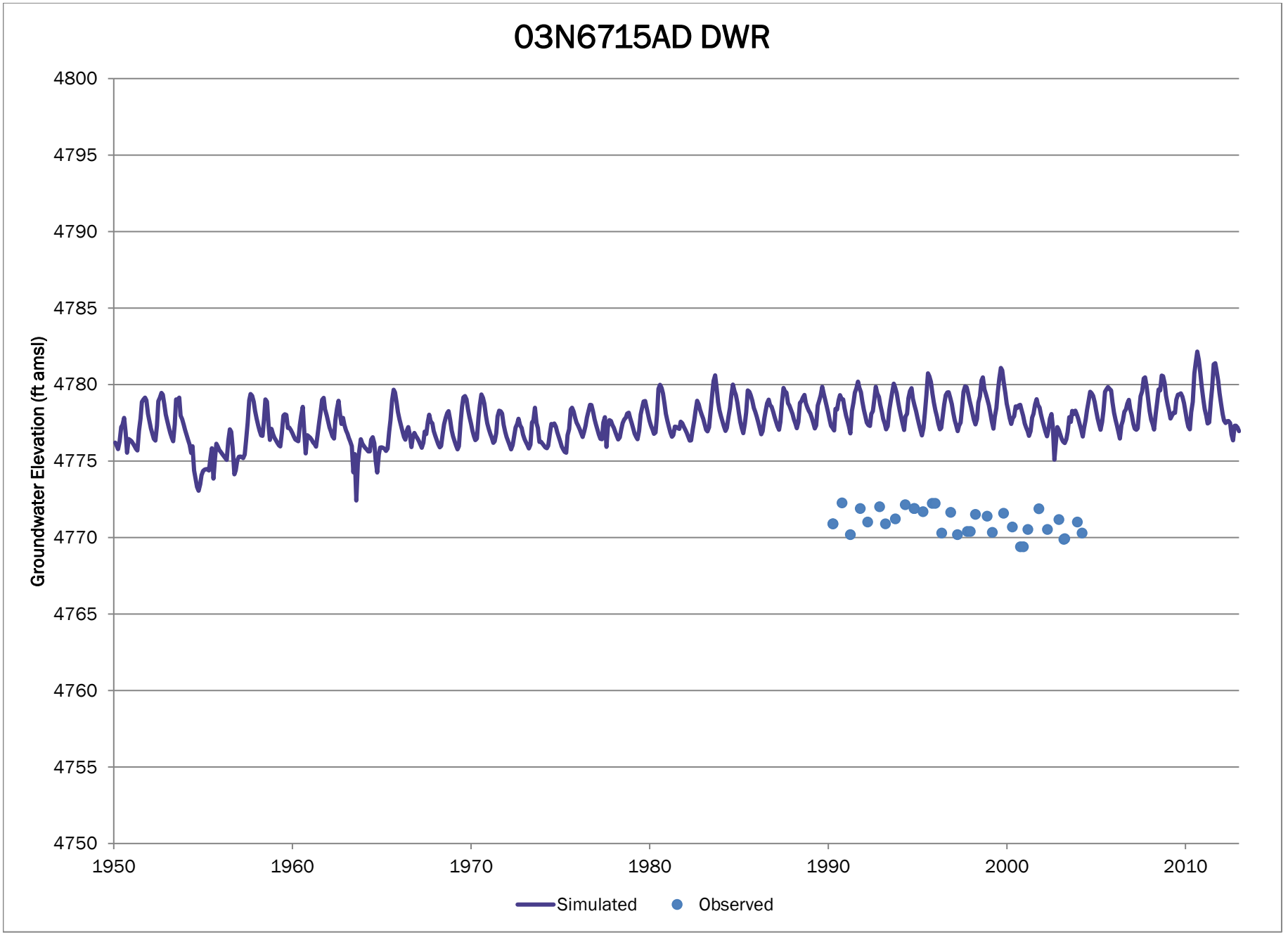


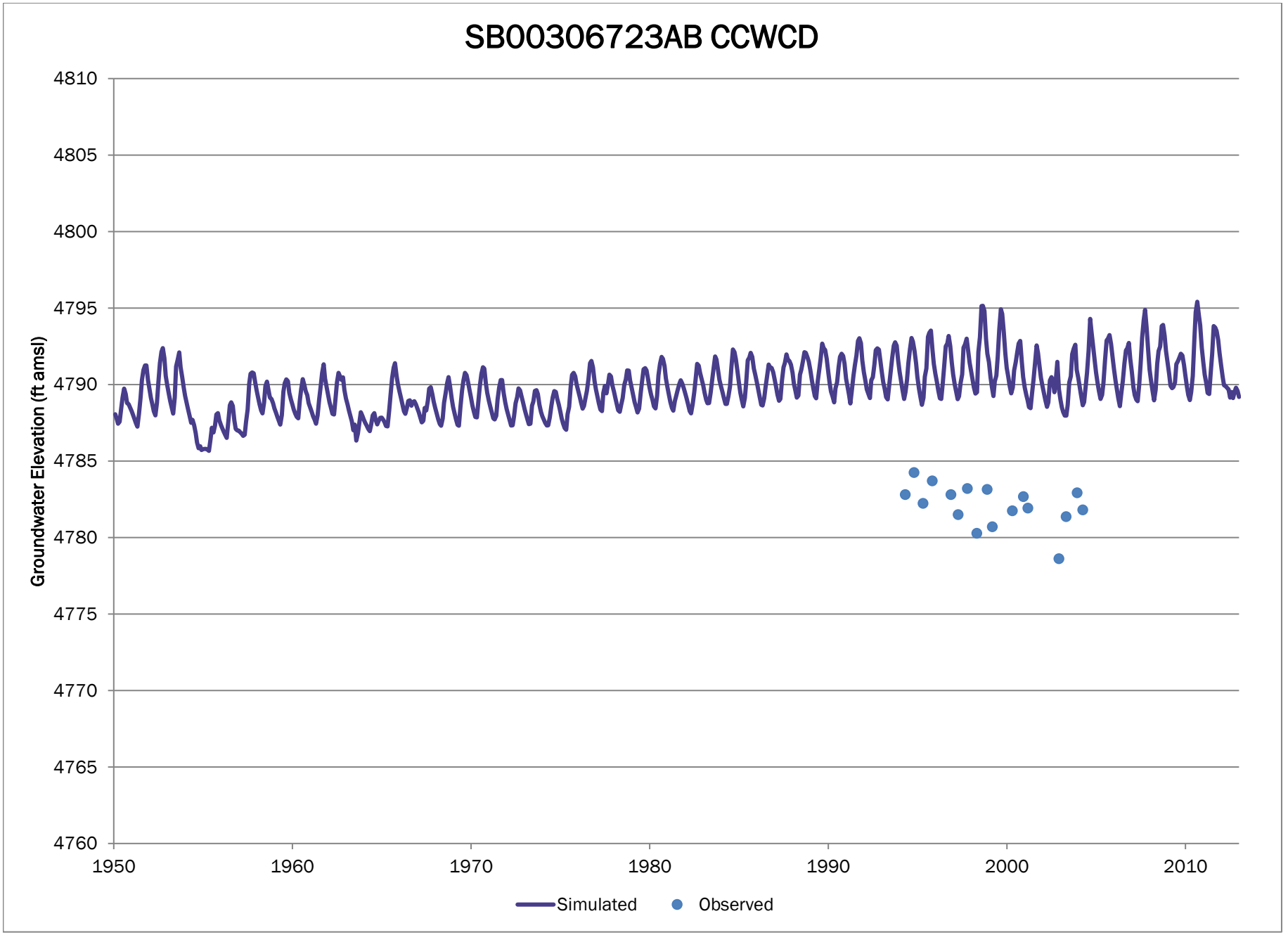

SB00306606CC CCWCD
Groundwater Elevation (ft amsl)
4795
4790
4785
4780
4775
4770
4765
4760
4755
4750
4745
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

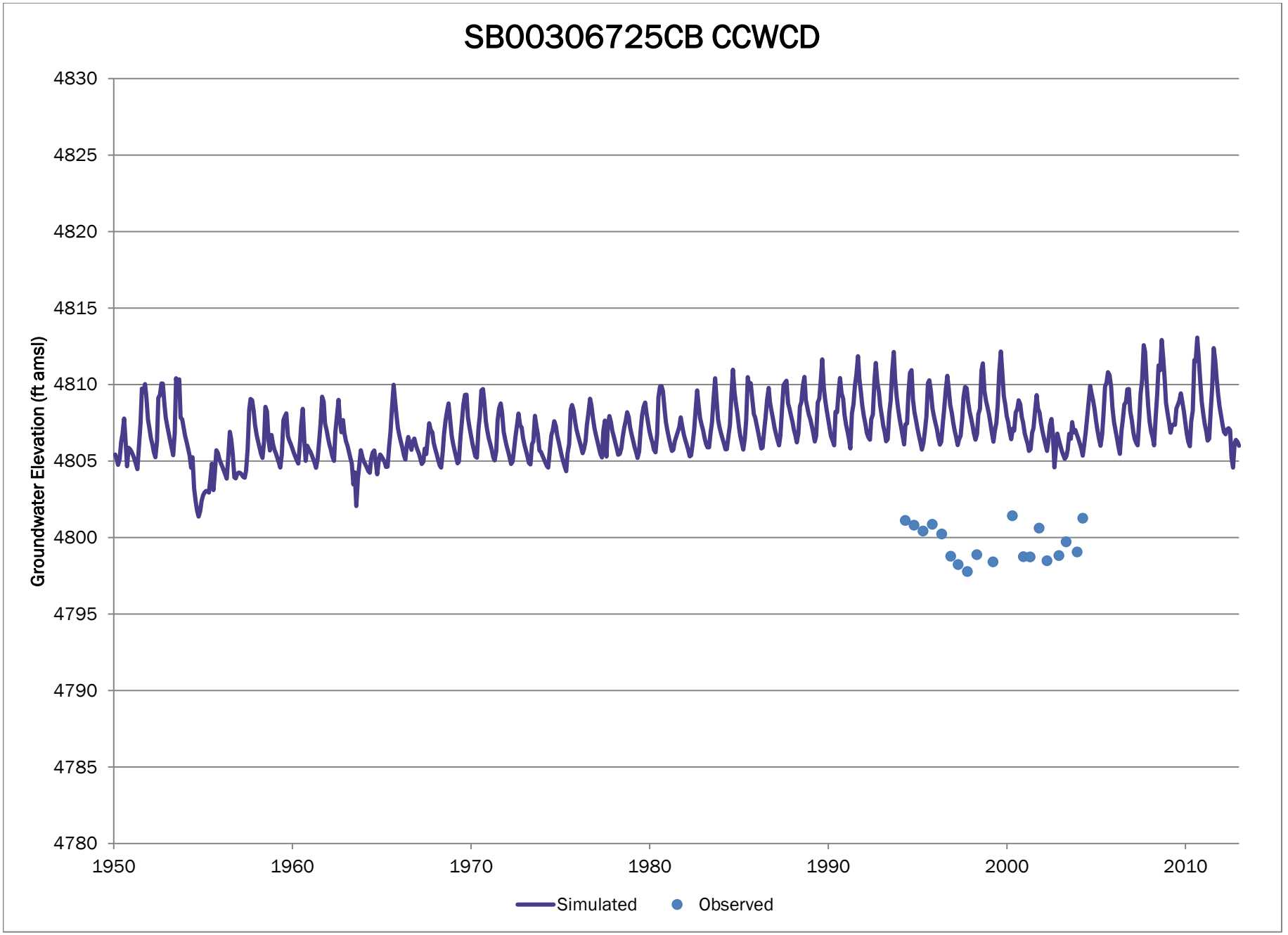

SB00306618BB CCWCD
Groundwater Elevation (ft amsl)
4810
4805
4800
4795
4790
4785
4780
4775
4770
4765
4760
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

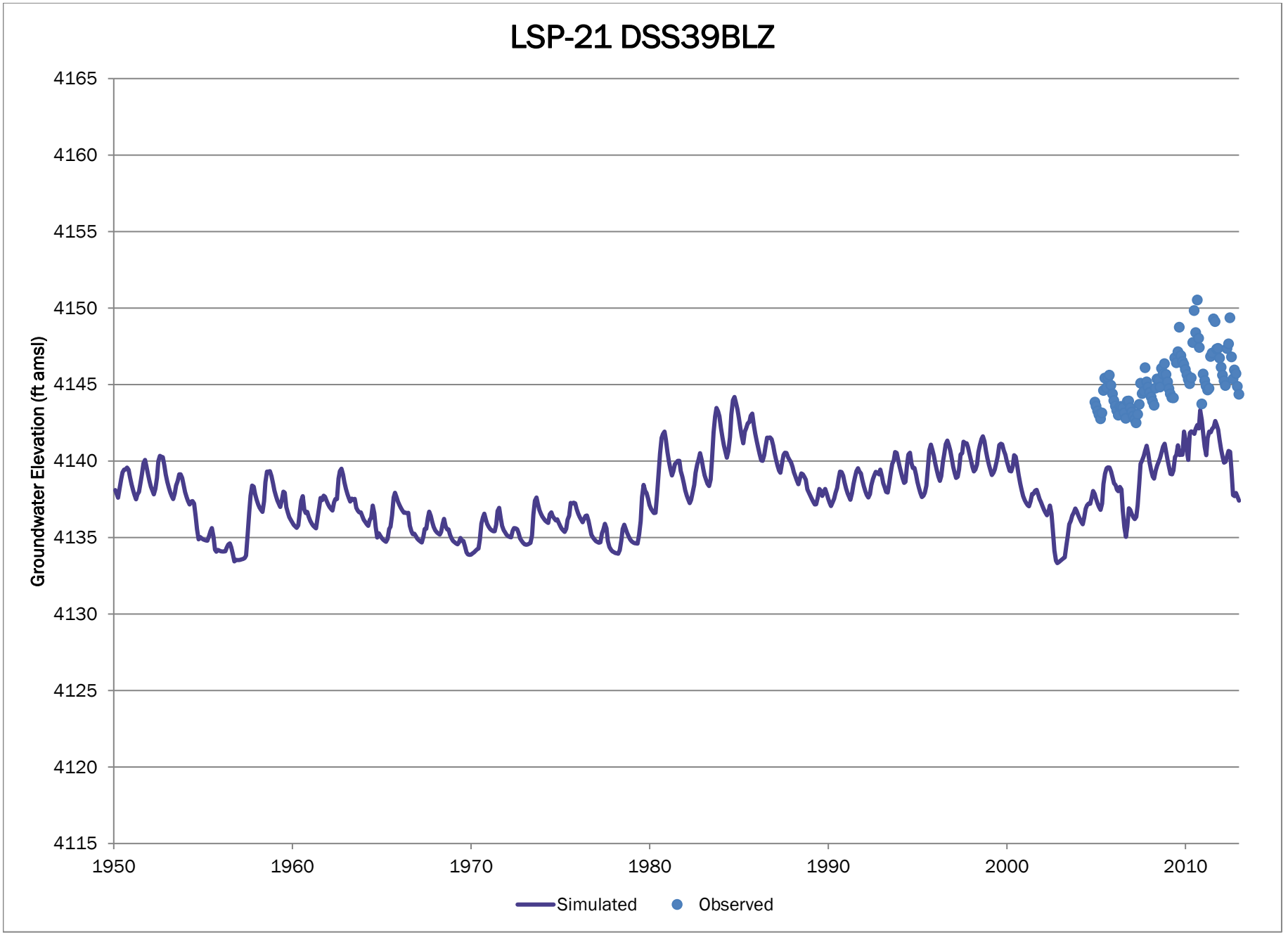

Well ID 195;CSU WP 145 CSU
Groundwater Elevation (ft amsl)
4865
4860
4855
4850
4845
4840
4835
4830
4825
4820
4815
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

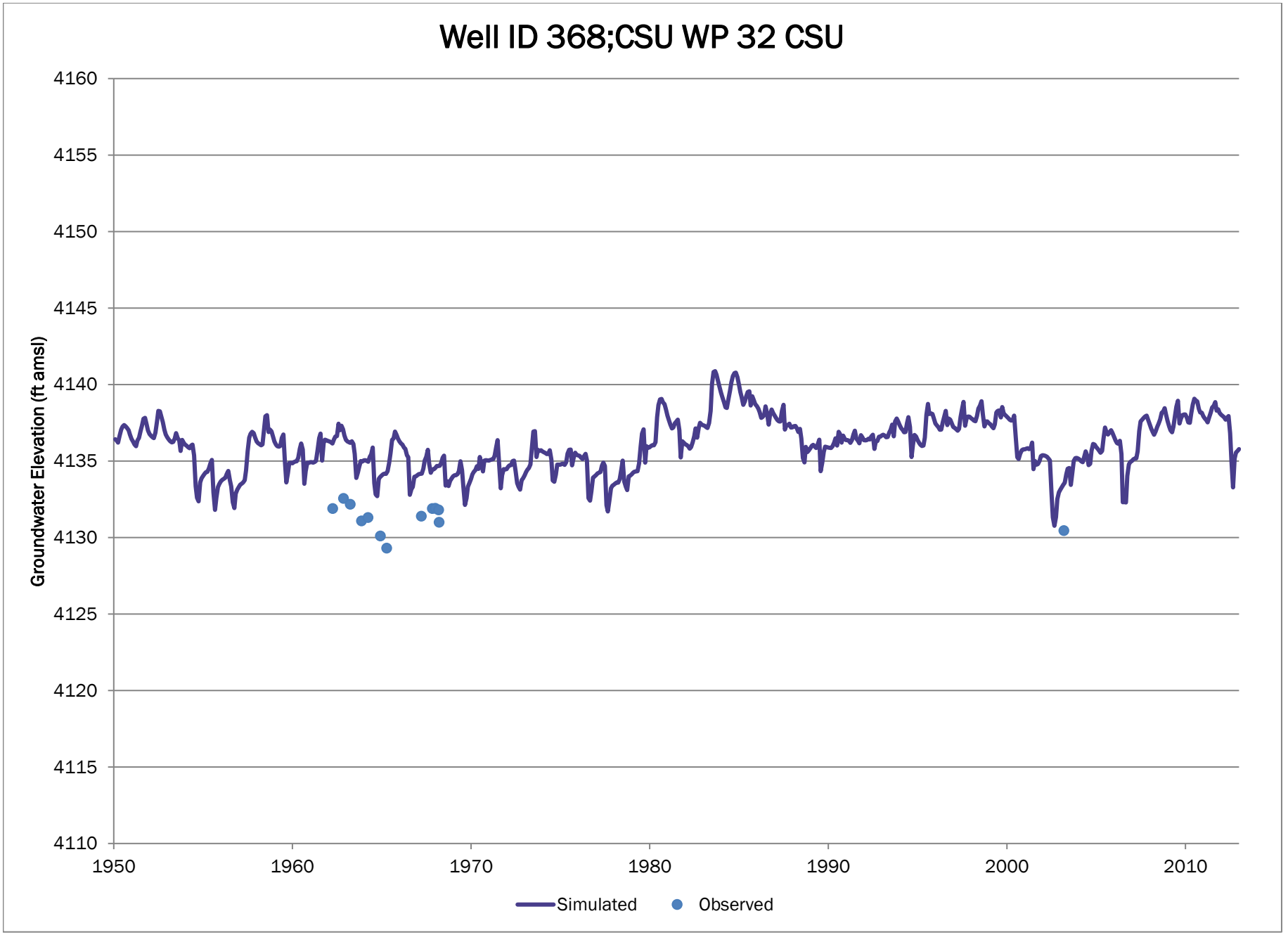

SB00306710DC CCWCD
Groundwater Elevation (ft amsl)
4800
4795
4790
4785
4780
4775
4770
4765
4760
4755
4750
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

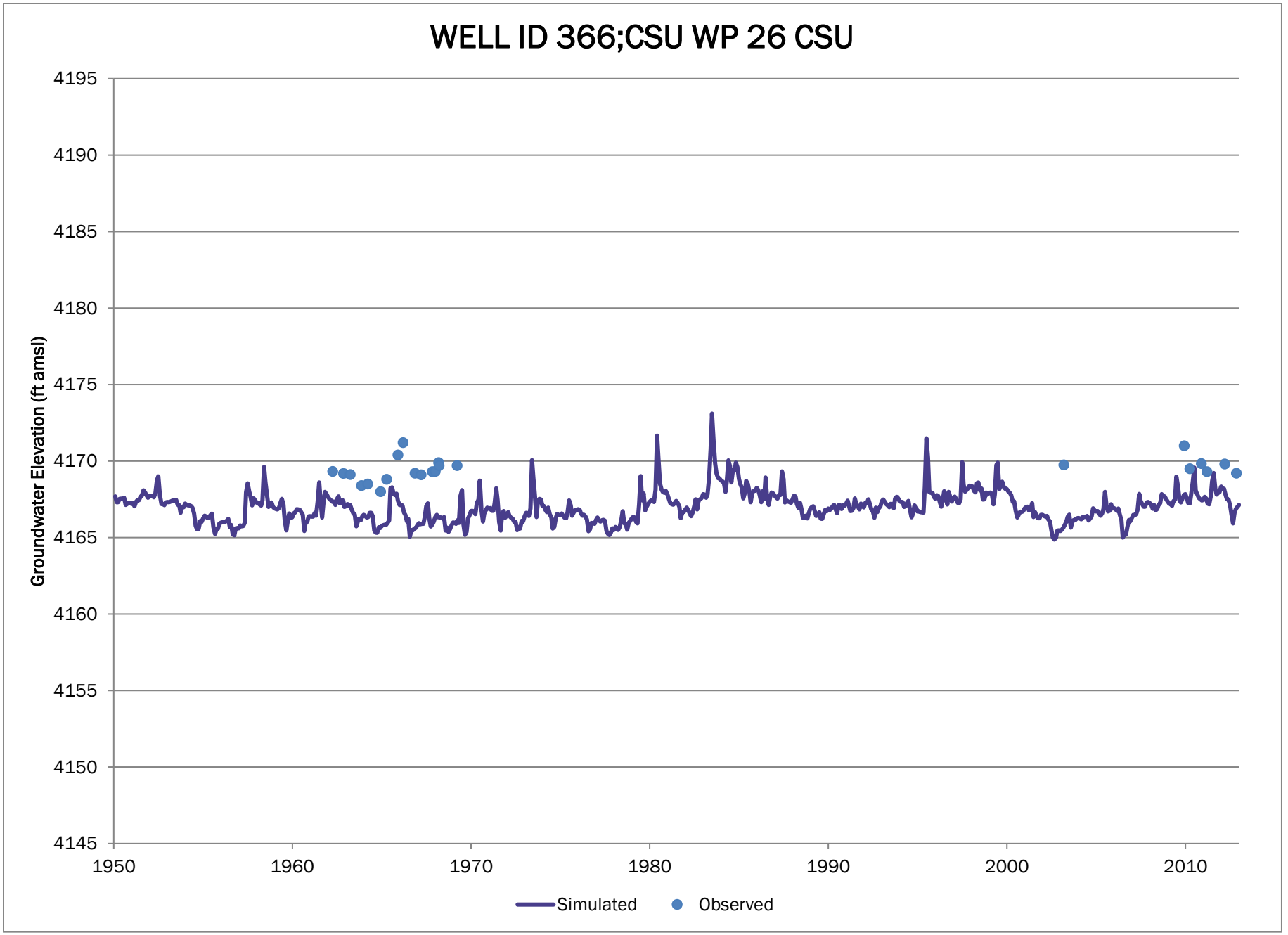

03N6715AD DWR
Groundwater Elevation (ft amsl)
4800
4795
4790
4785
4780
4775
4770
4765
4760
4755
4750
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

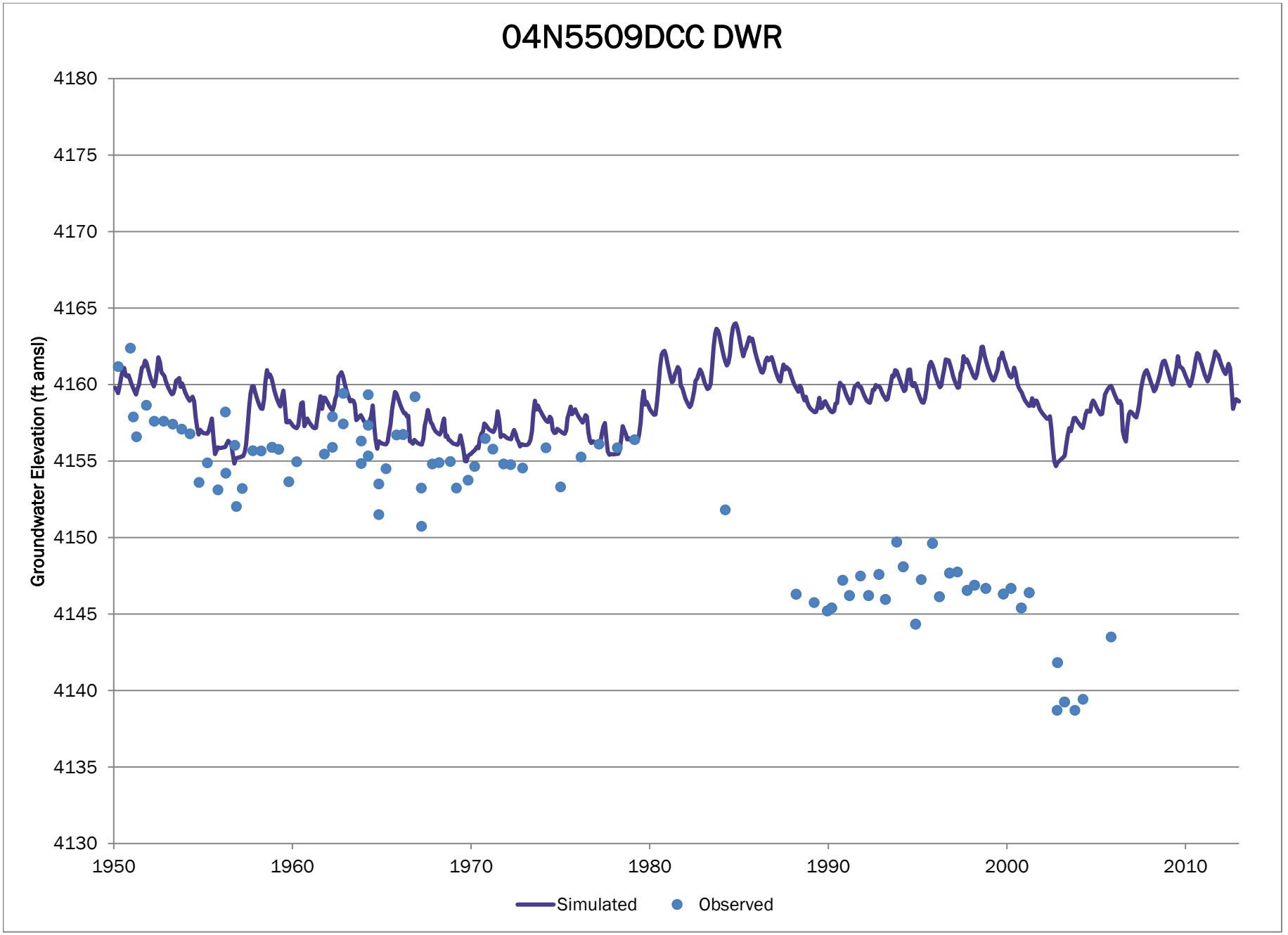

SB00306723AB CCWCD
Groundwater Elevation (ft amsl)
4810
4805
4800
4795
4790
4785
4780
4775
4770
4765
4760
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

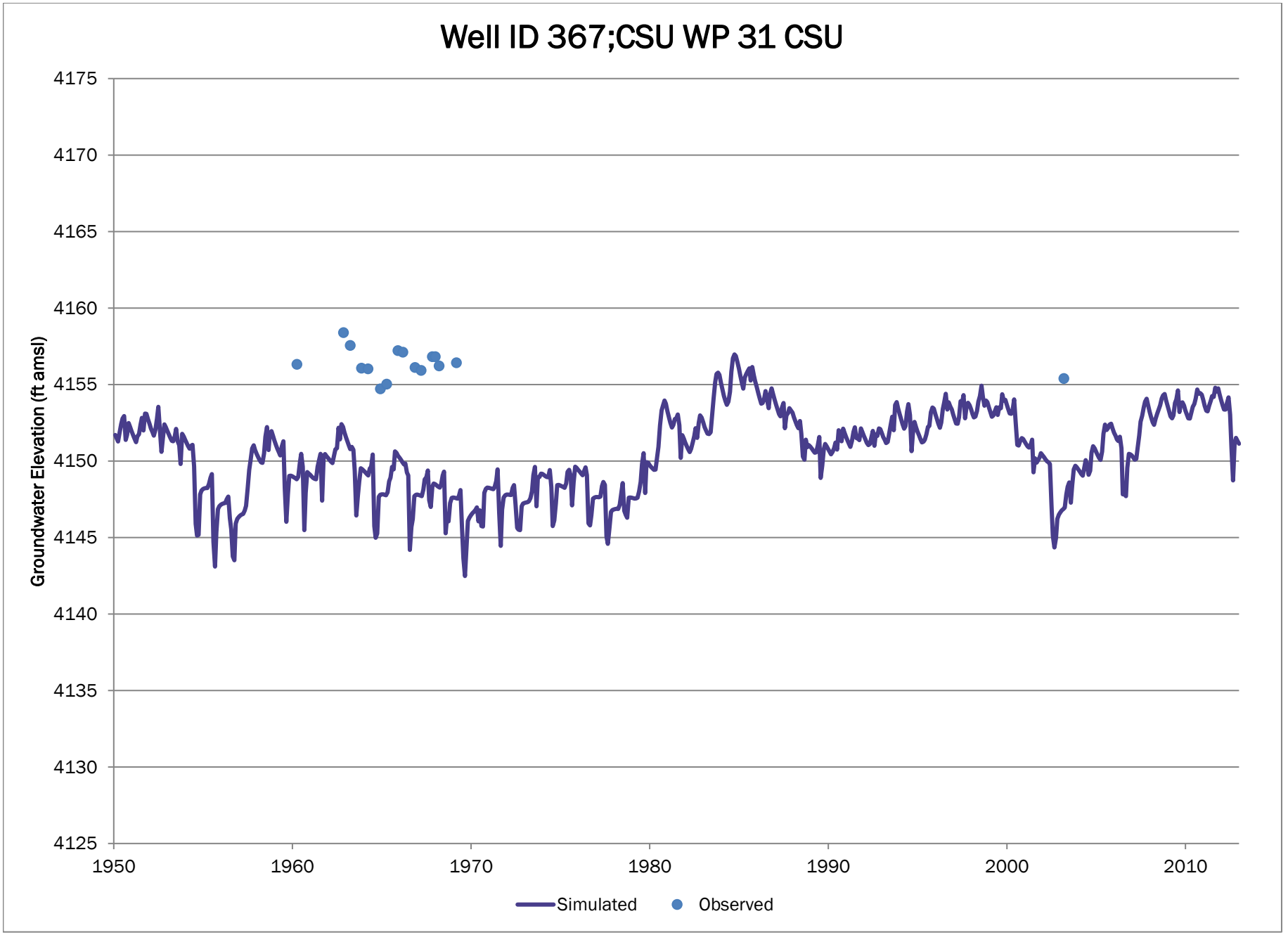

SB00306725CB CCWCD
Groundwater Elevation (ft amsl)
4830
4825
4820
4815
4810
4805
4800
4795
4790
4785
4780
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

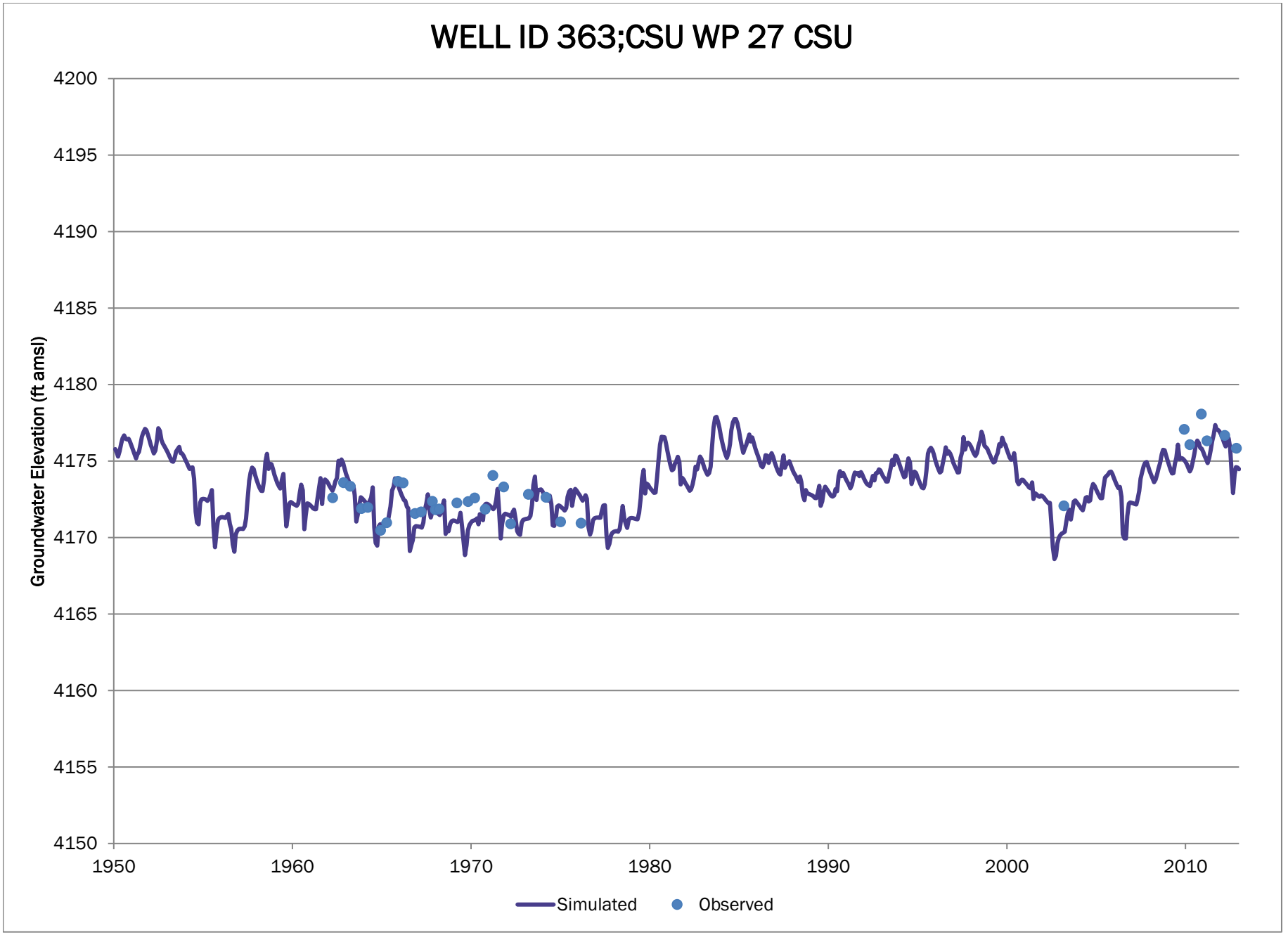

LSP-21 DSS39BLZ
Groundwater Elevation (ft amsl)
4165
4160
4155
4150
4145
4140
4135
4130
4125
4120
4115
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

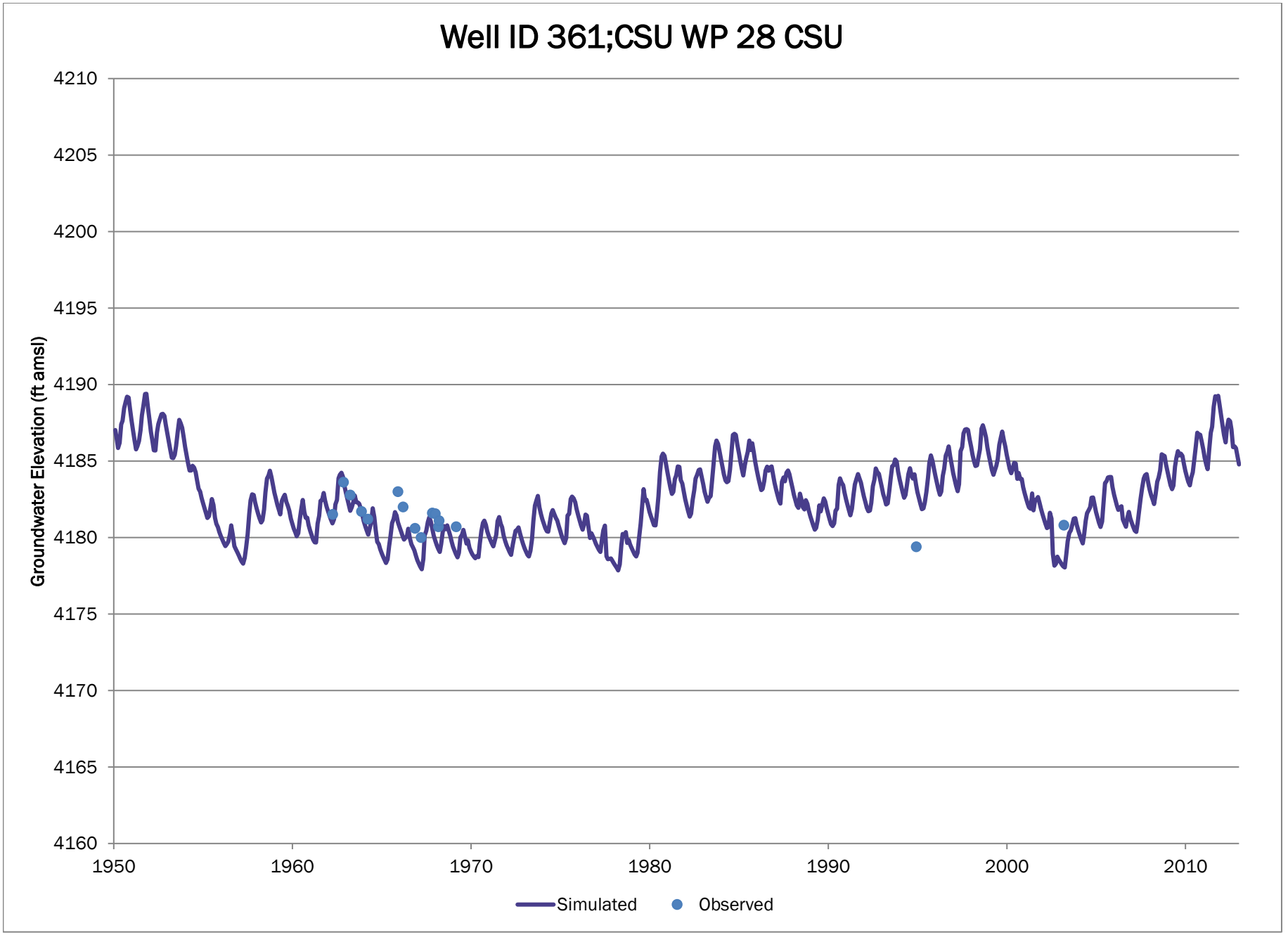

Well ID 368;CSU WP 32 CSU
Groundwater Elevation (ft amsl)
4160
4155
4150
4145
4140
4135
4130
4125
4120
4115
4110
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

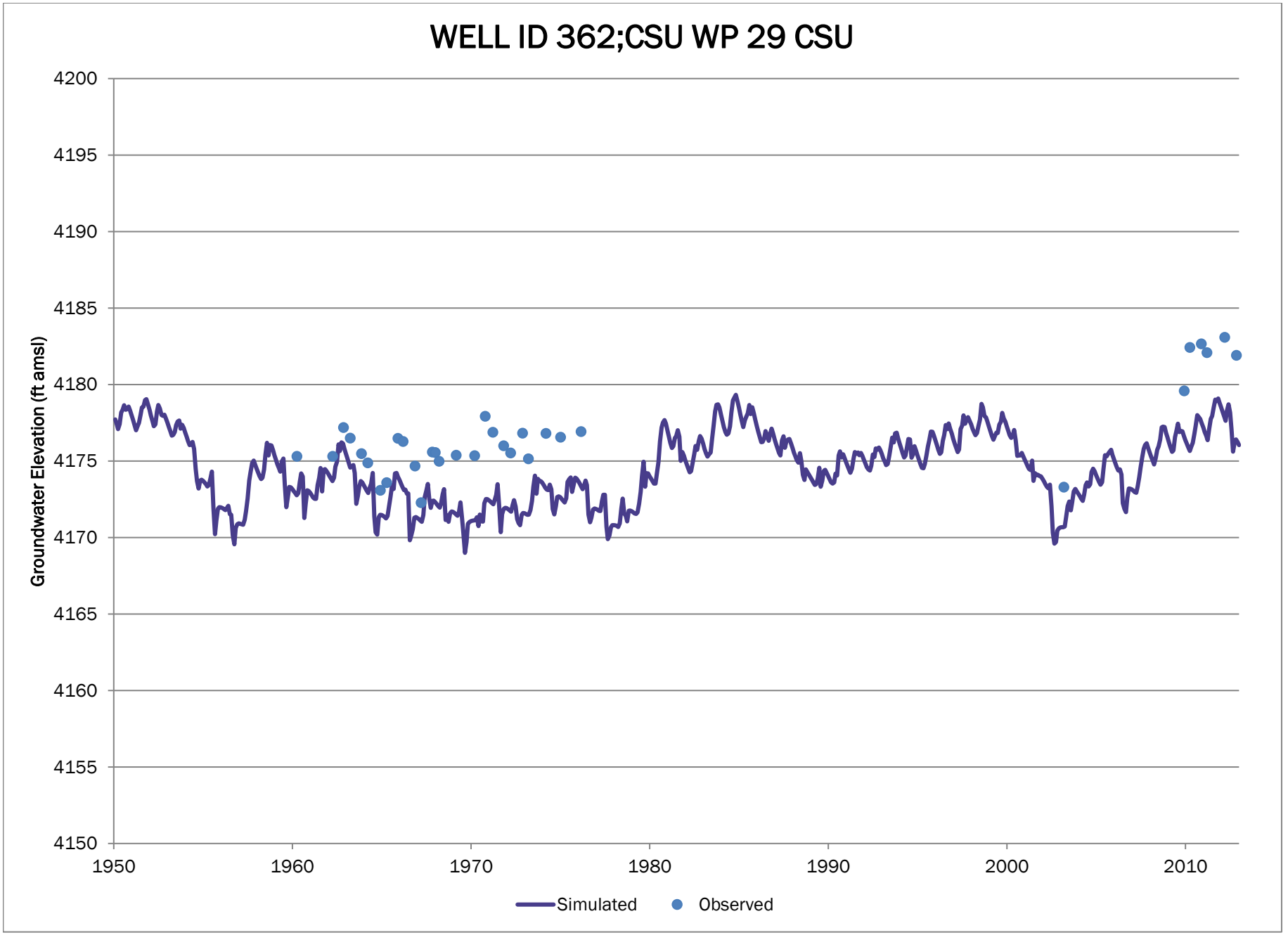

WELL ID 366;CSU WP 26 CSU
Groundwater Elevation (ft amsl)
4195
4190
4185
4180
4175
4170
4165
4160
4155
4150
4145
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

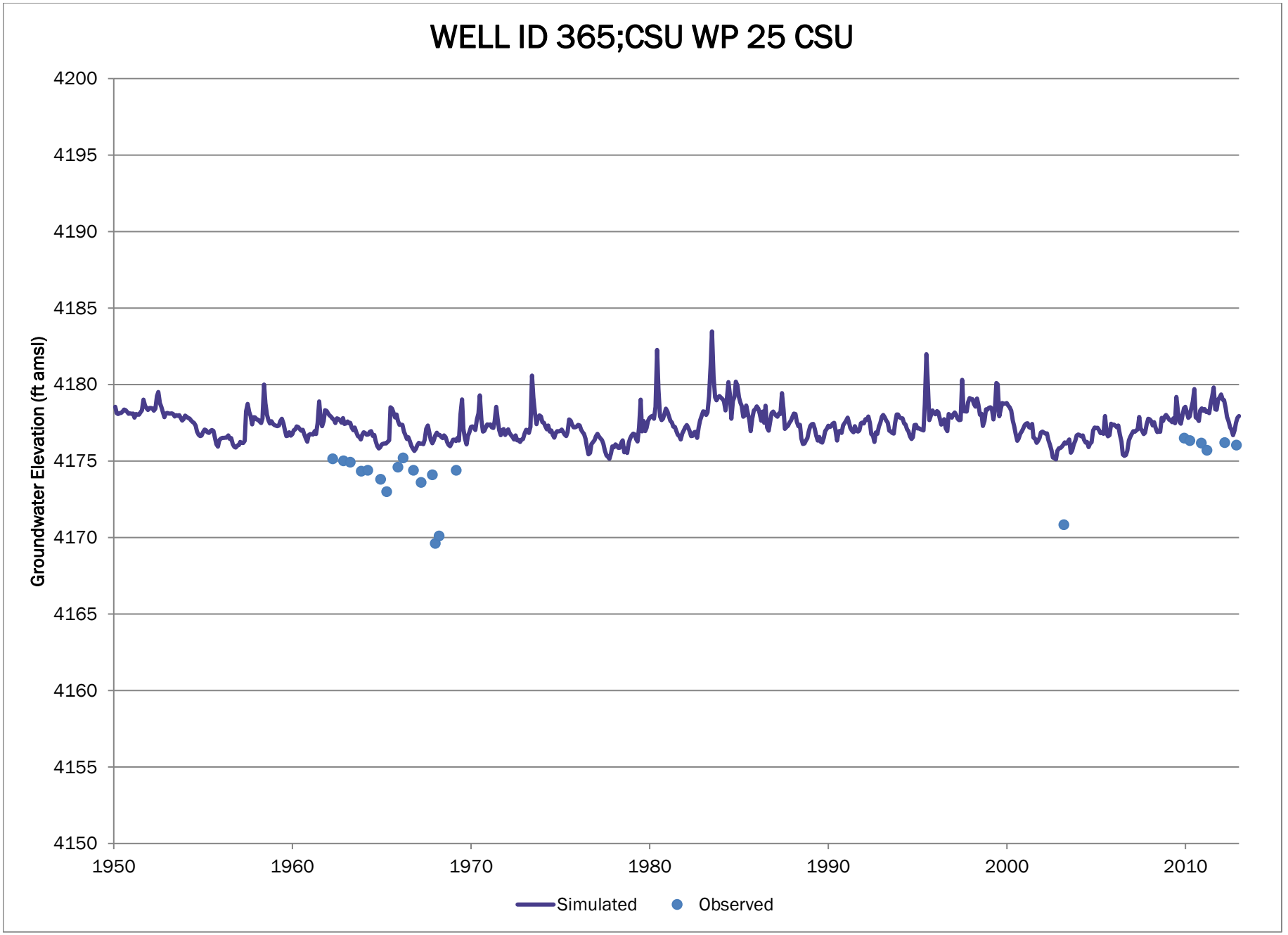

04N5509DCC DWR
Groundwater Elevation (ft amsl)
4180
4175
4170
4165
4160
4155
4150
4145
4140
4135
4130
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

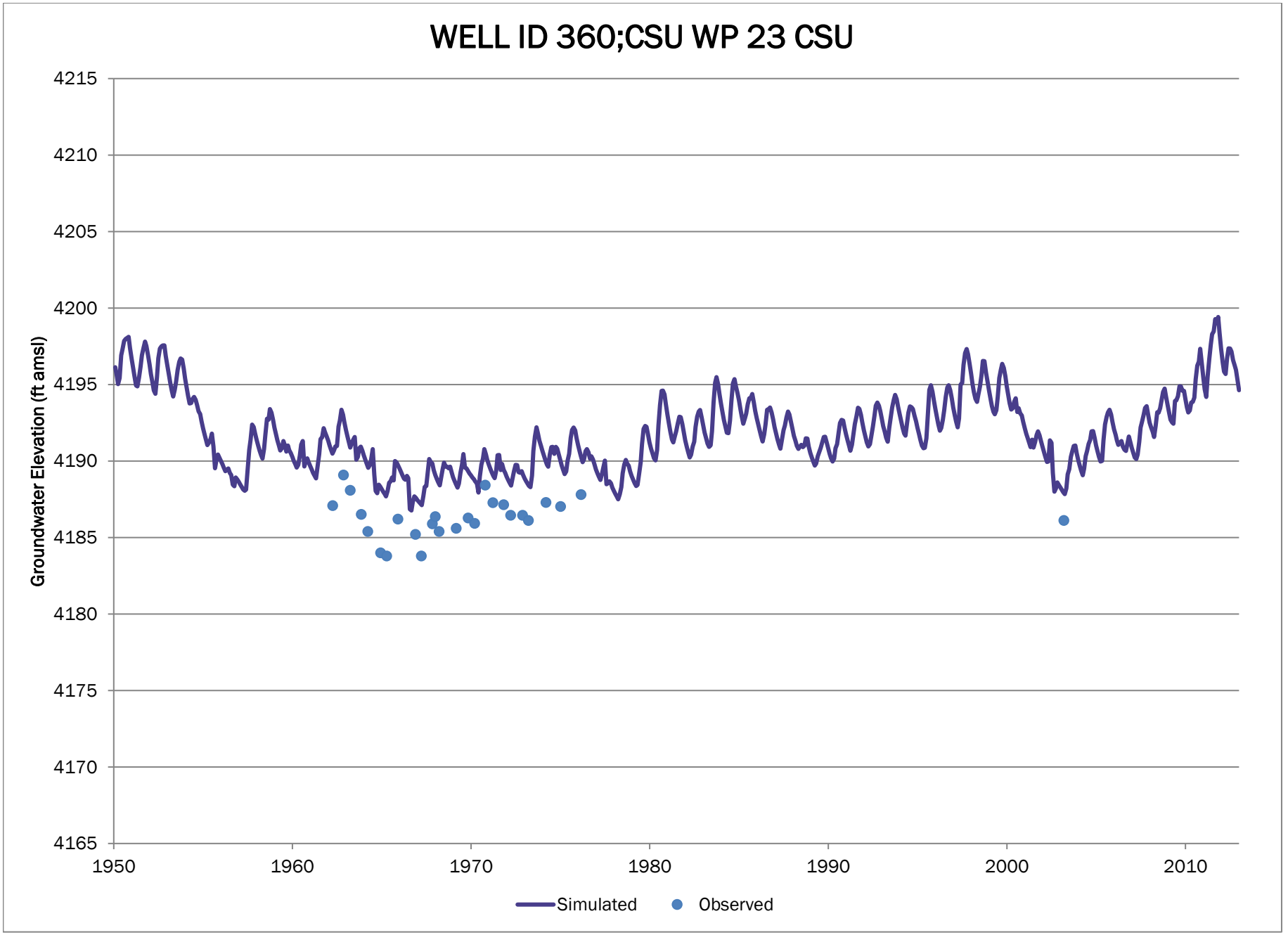

Well ID 367;CSU WP 31 CSU
Groundwater Elevation (ft amsl)
4175
4170
4165
4160
4155
4150
4145
4140
4135
4130
4125
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

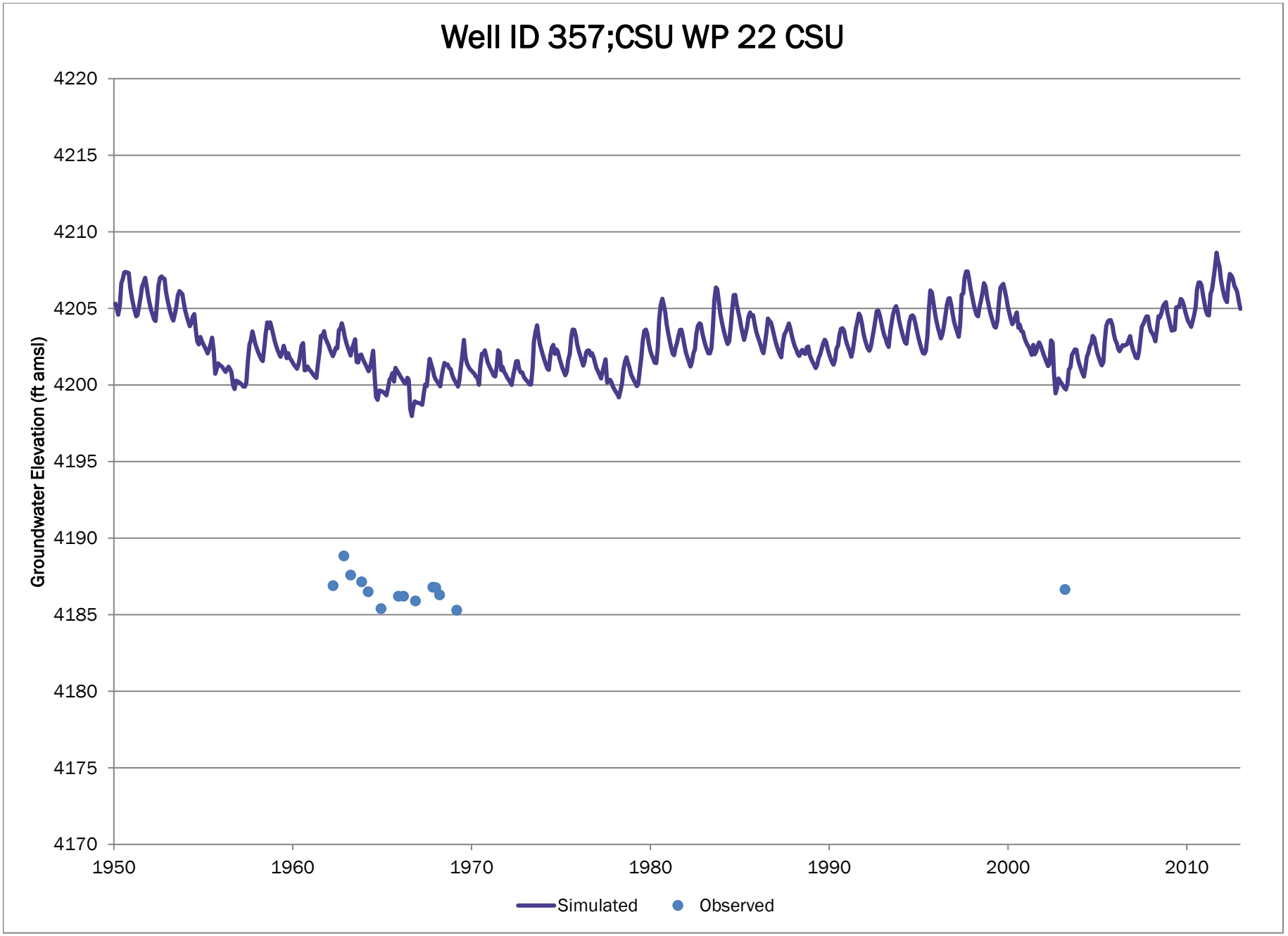

WELL ID 363;CSU WP 27 CSU
Groundwater Elevation (ft amsl)
4200
4195
4190
4185
4180
4175
4170
4165
4160
4155
4150
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

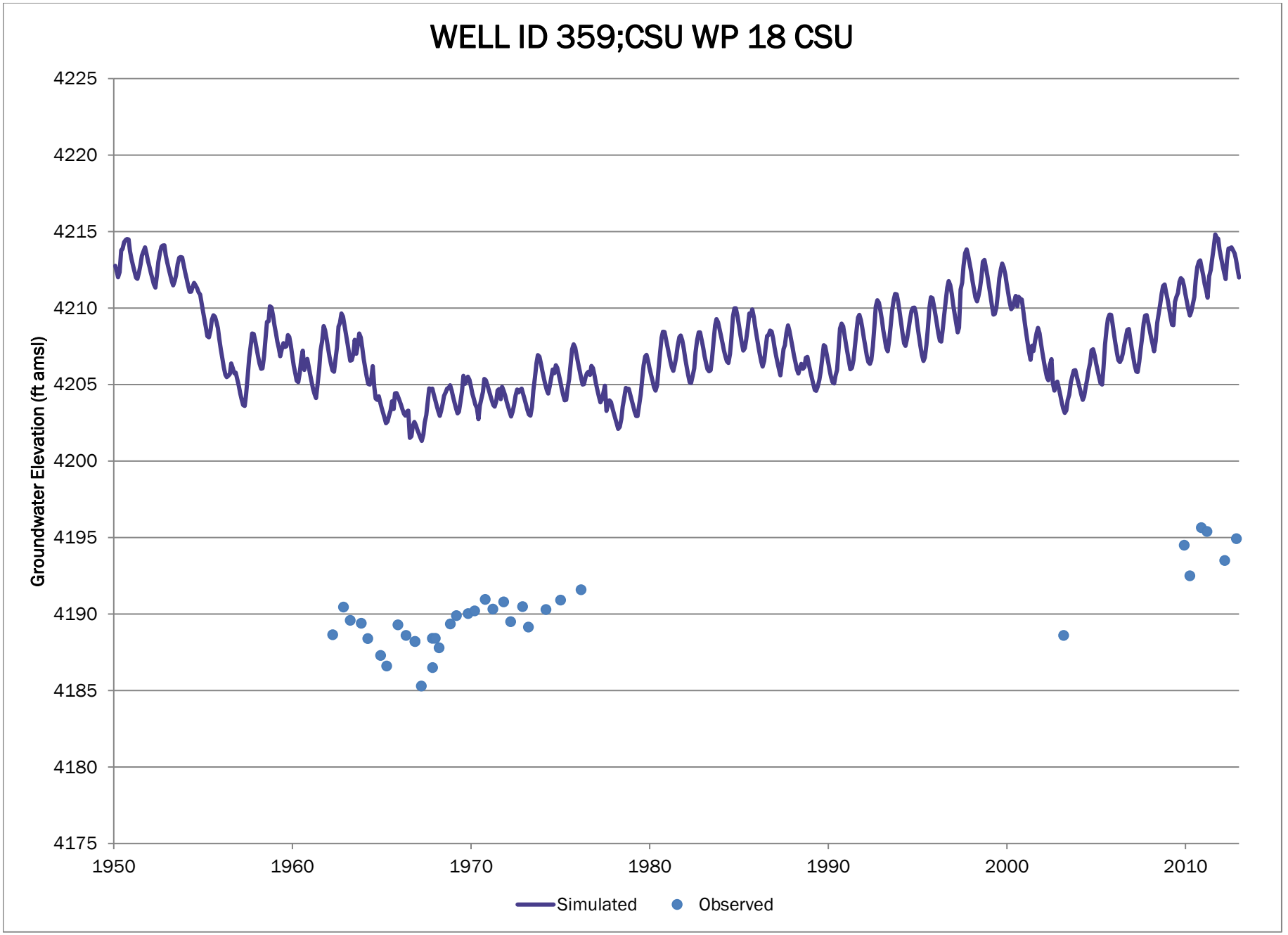

Well ID 361;CSU WP 28 CSU
Groundwater Elevation (ft amsl)
4210
4205
4200
4195
4190
4185
4180
4175
4170
4165
4160
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

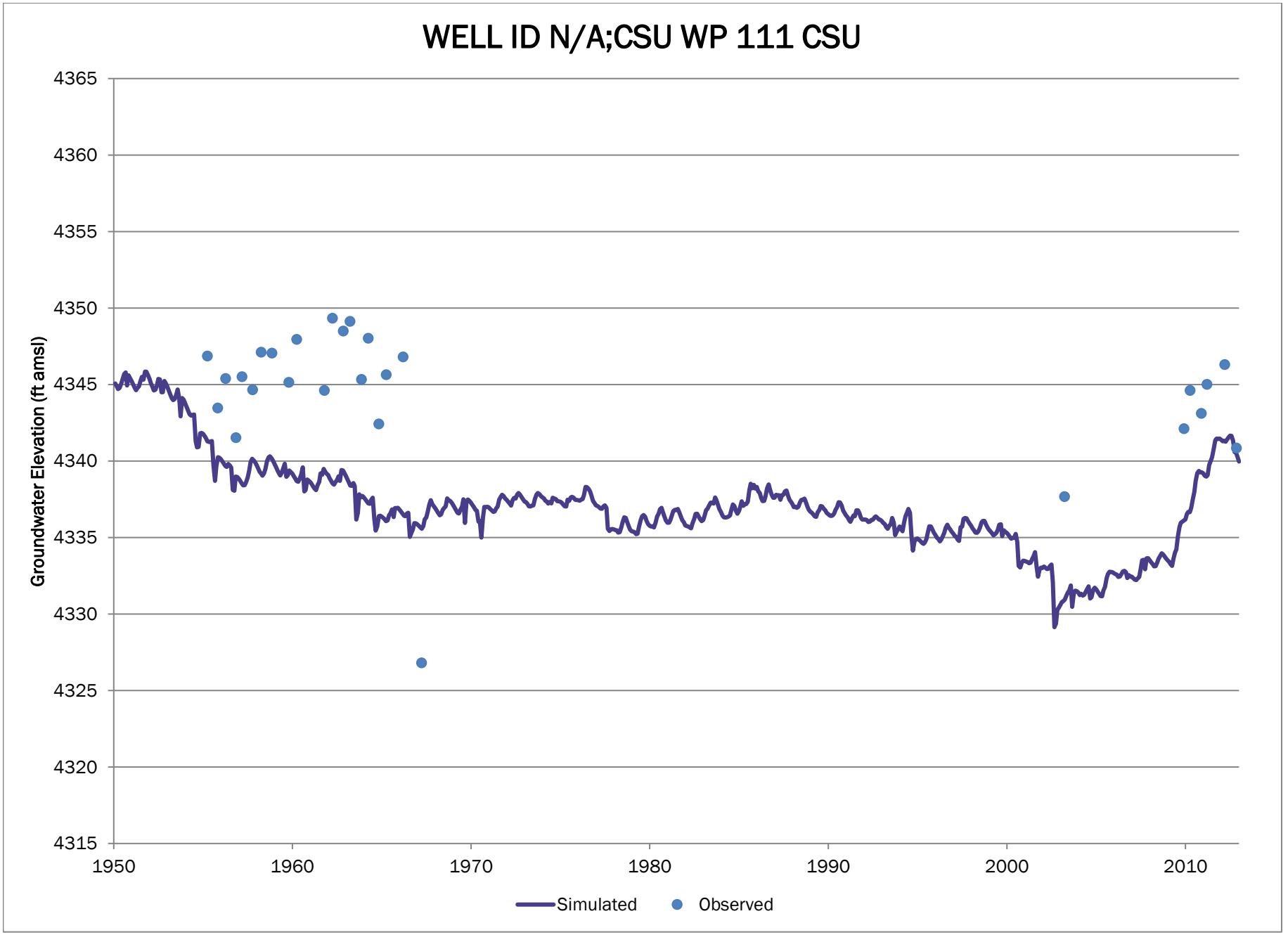

WELL ID 362;CSU WP 29 CSU
Groundwater Elevation (ft amsl)
4200
4195
4190
4185
4180
4175
4170
4165
4160
4155
4150
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

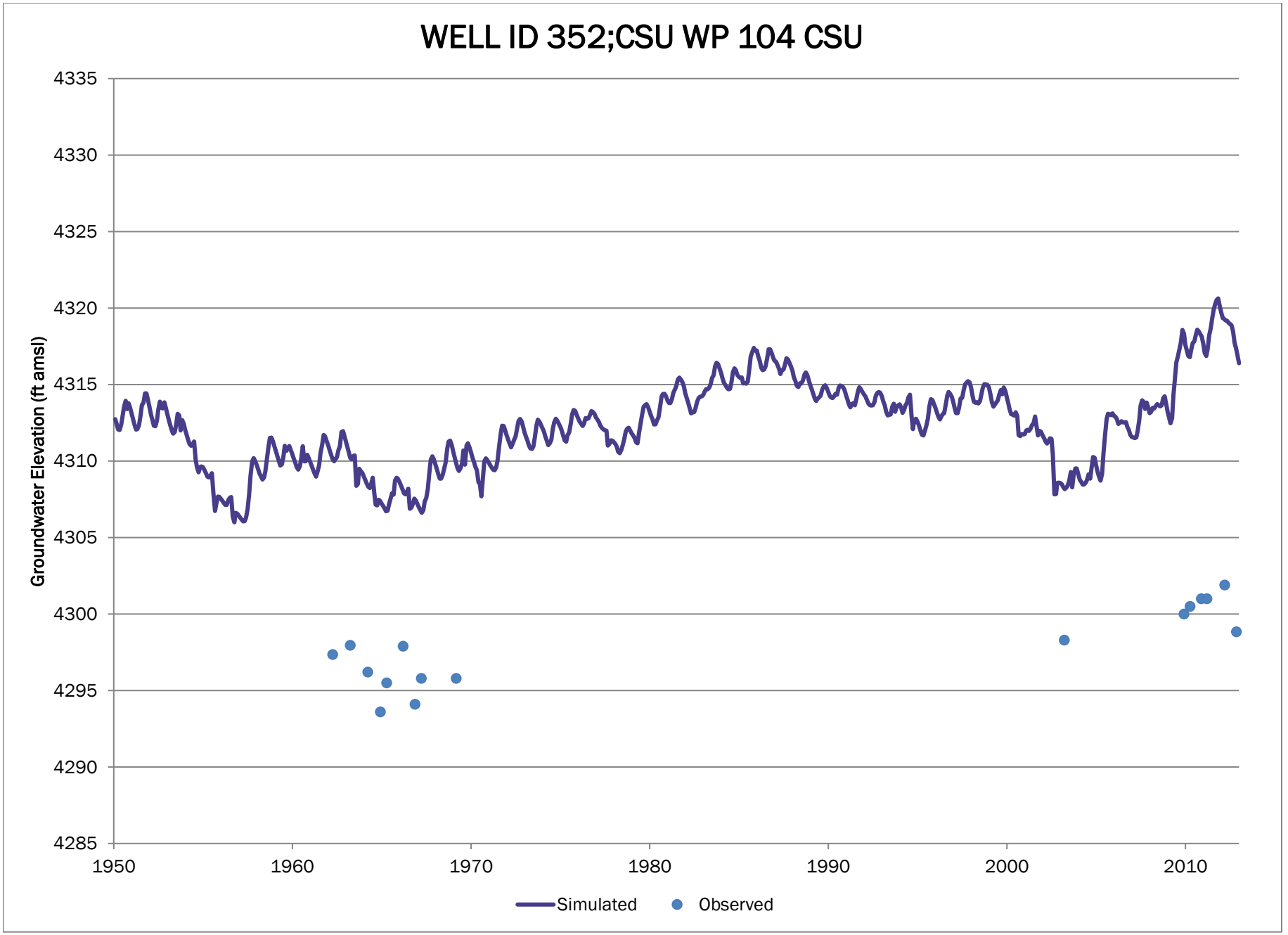

WELL ID 365;CSU WP 25 CSU
Groundwater Elevation (ft amsl)
4200
4195
4190
4185
4180
4175
4170
4165
4160
4155
4150
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

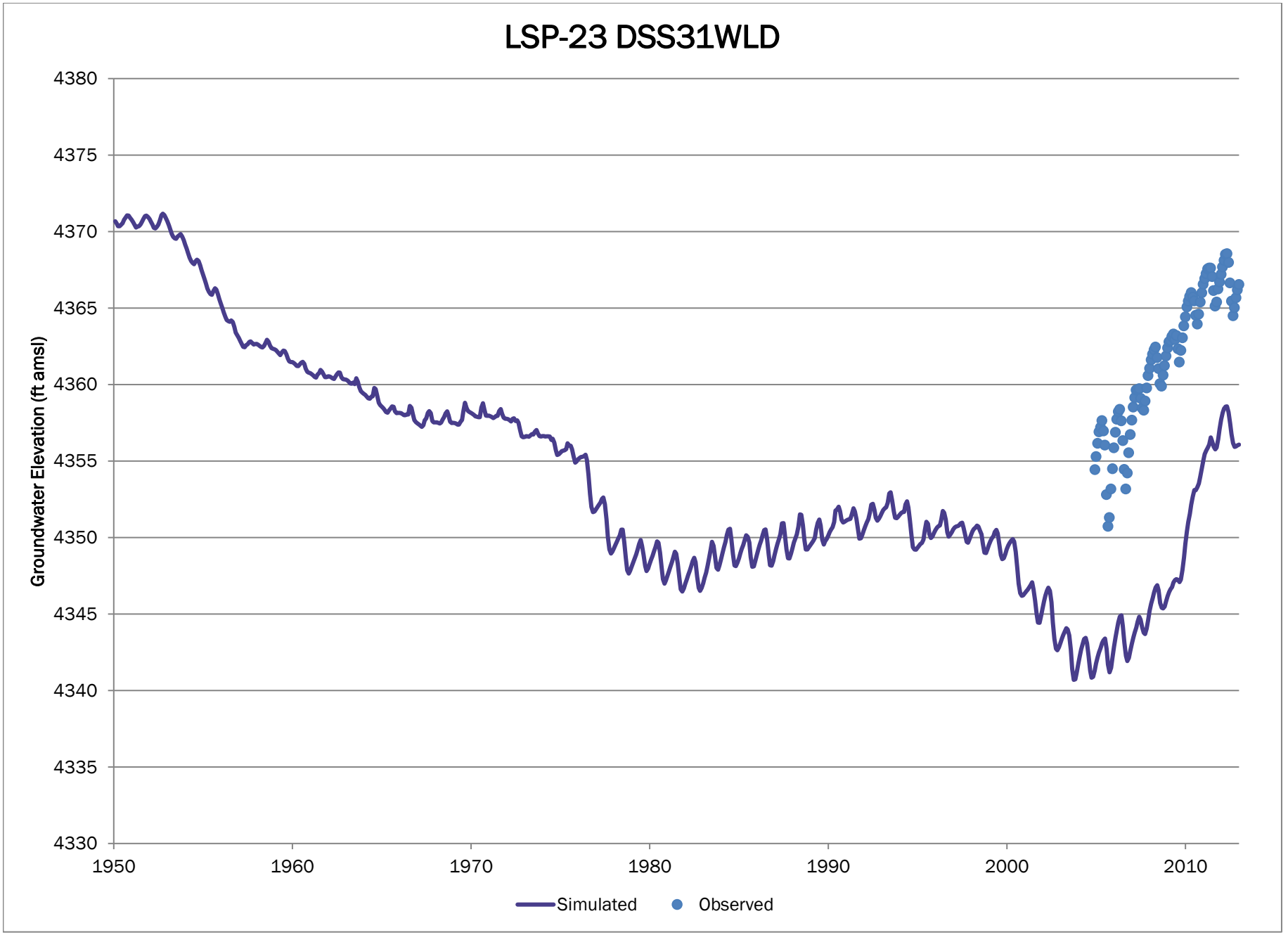

WELL ID 360;CSU WP 23 CSU
Groundwater Elevation (ft amsl)
4215
4210
4205
4200
4195
4190
4185
4180
4175
4170
4165
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


Well ID 357;CSU WP 22 CSU
Groundwater Elevation (ft amsl)
4220
4215
4210
4205
4200
4195
4190
4185
4180
4175
4170
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

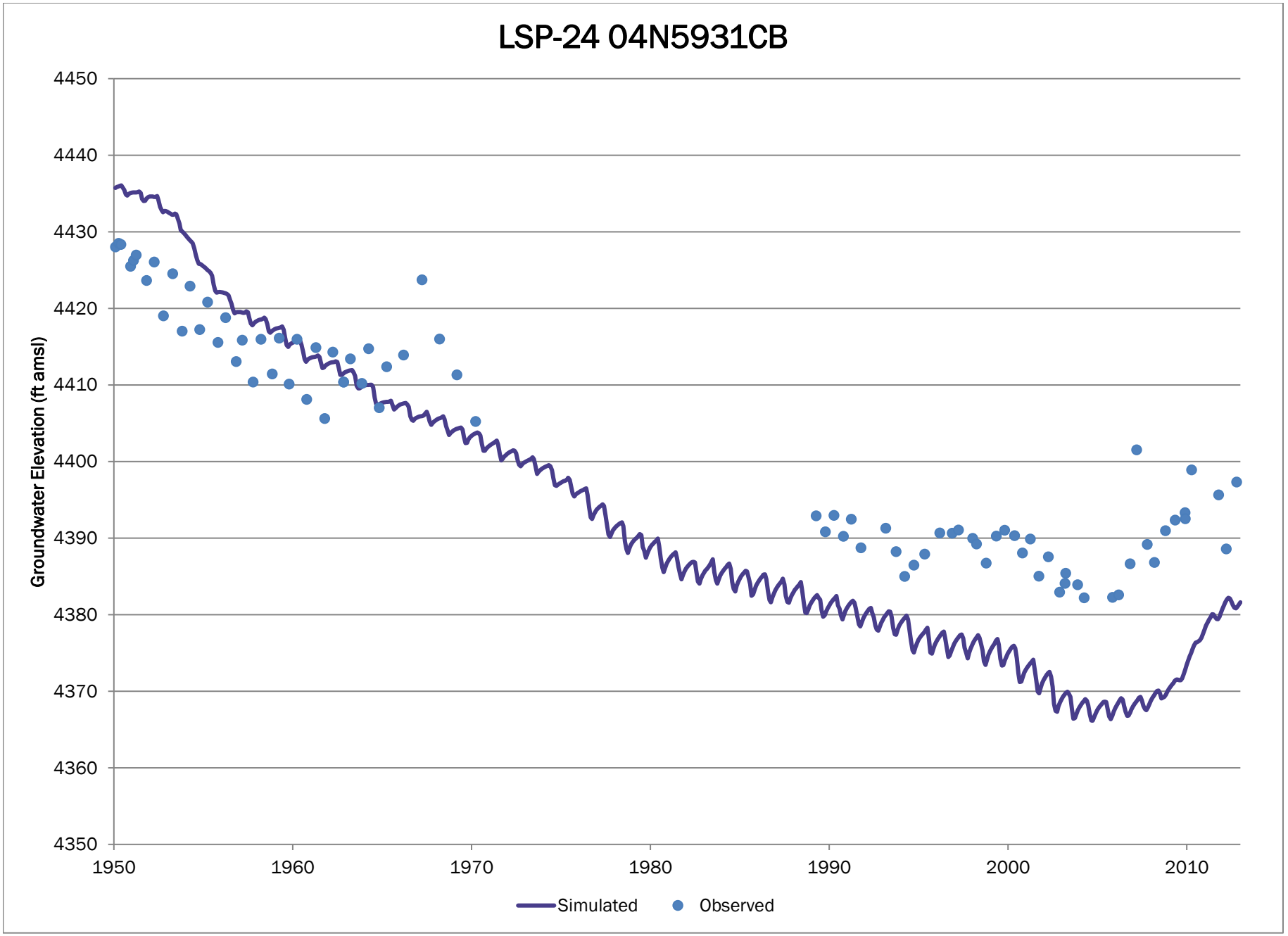

WELL ID 359;CSU WP 18 CSU
Groundwater Elevation (ft amsl)
4225
4220
4215
4210
4205
4200
4195
4190
4185
4180
4175
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

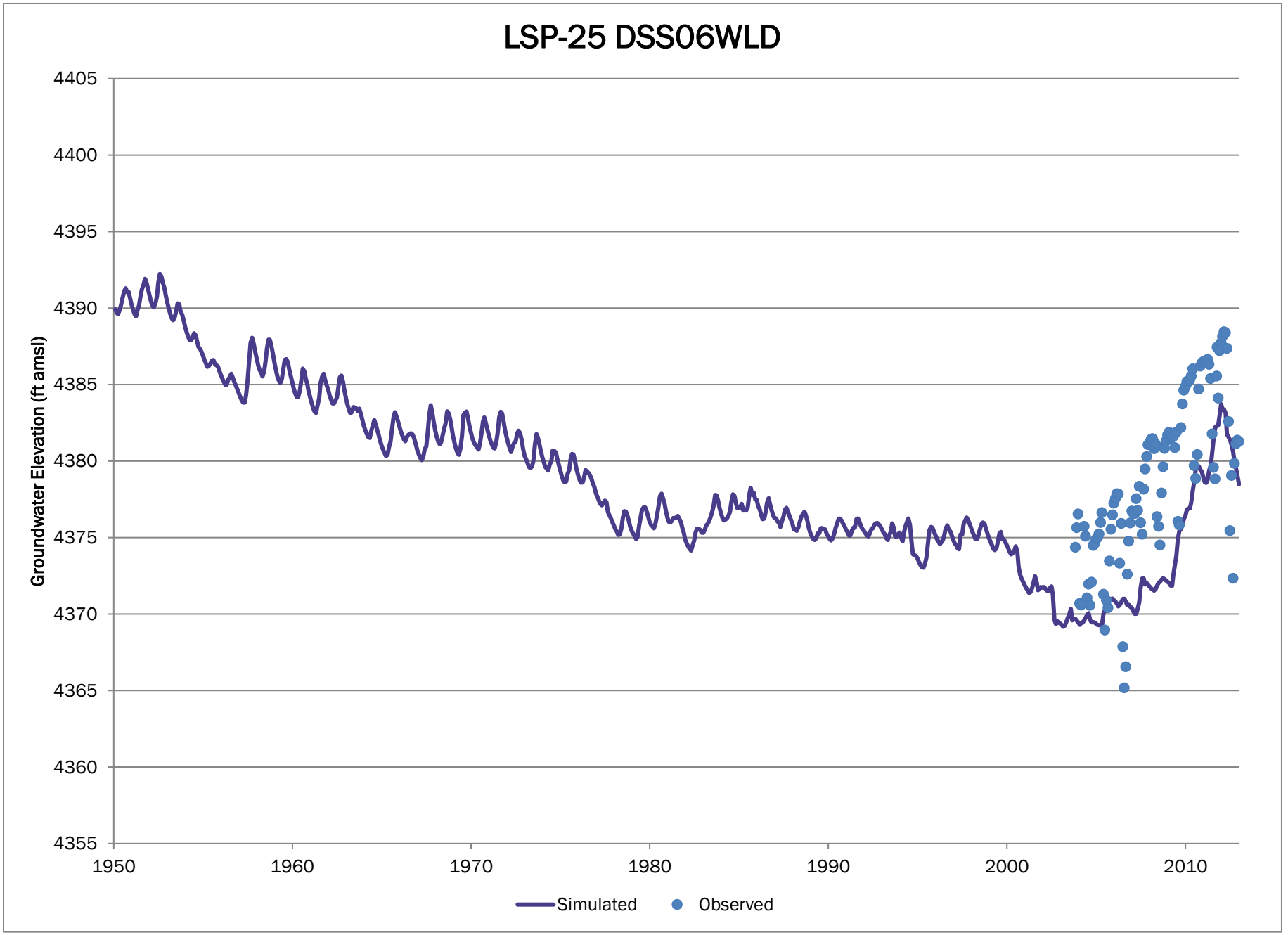

WELL ID N/A;CSU WP 111 CSU
Groundwater Elevation (ft amsl)
4365
4360
4355
4350
4345
4340
4335
4330
4325
4320
4315
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

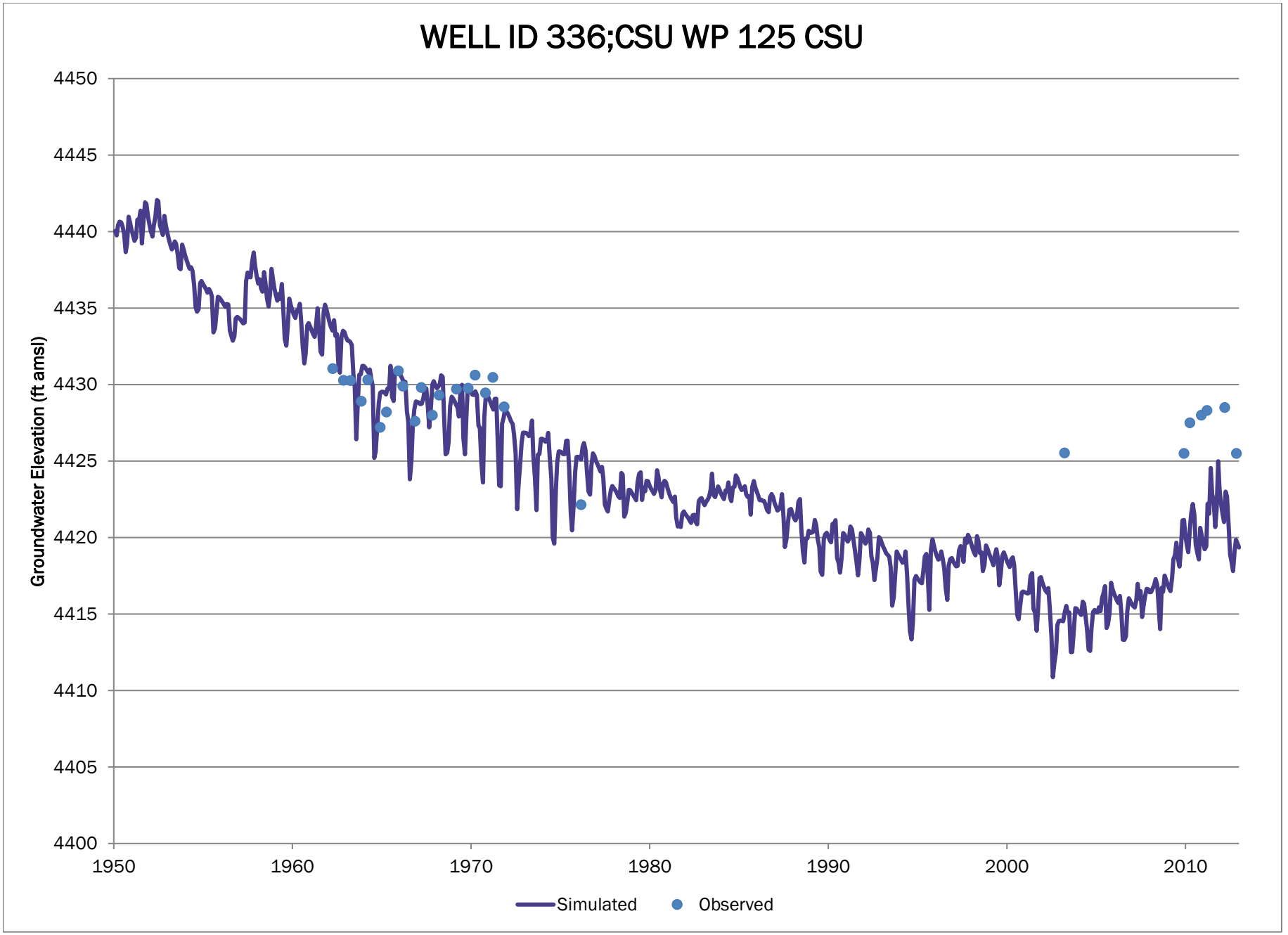

WELL ID 352;CSU WP 104 CSU
Groundwater Elevation (ft amsl)
4335
4330
4325
4320
4315
4310
4305
4300
4295
4290
4285
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


LSP-23 DSS31WLD
Groundwater Elevation (ft amsl)
4380
4375
4370
4365
4360
4355
4350
4345
4340
4335
4330
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

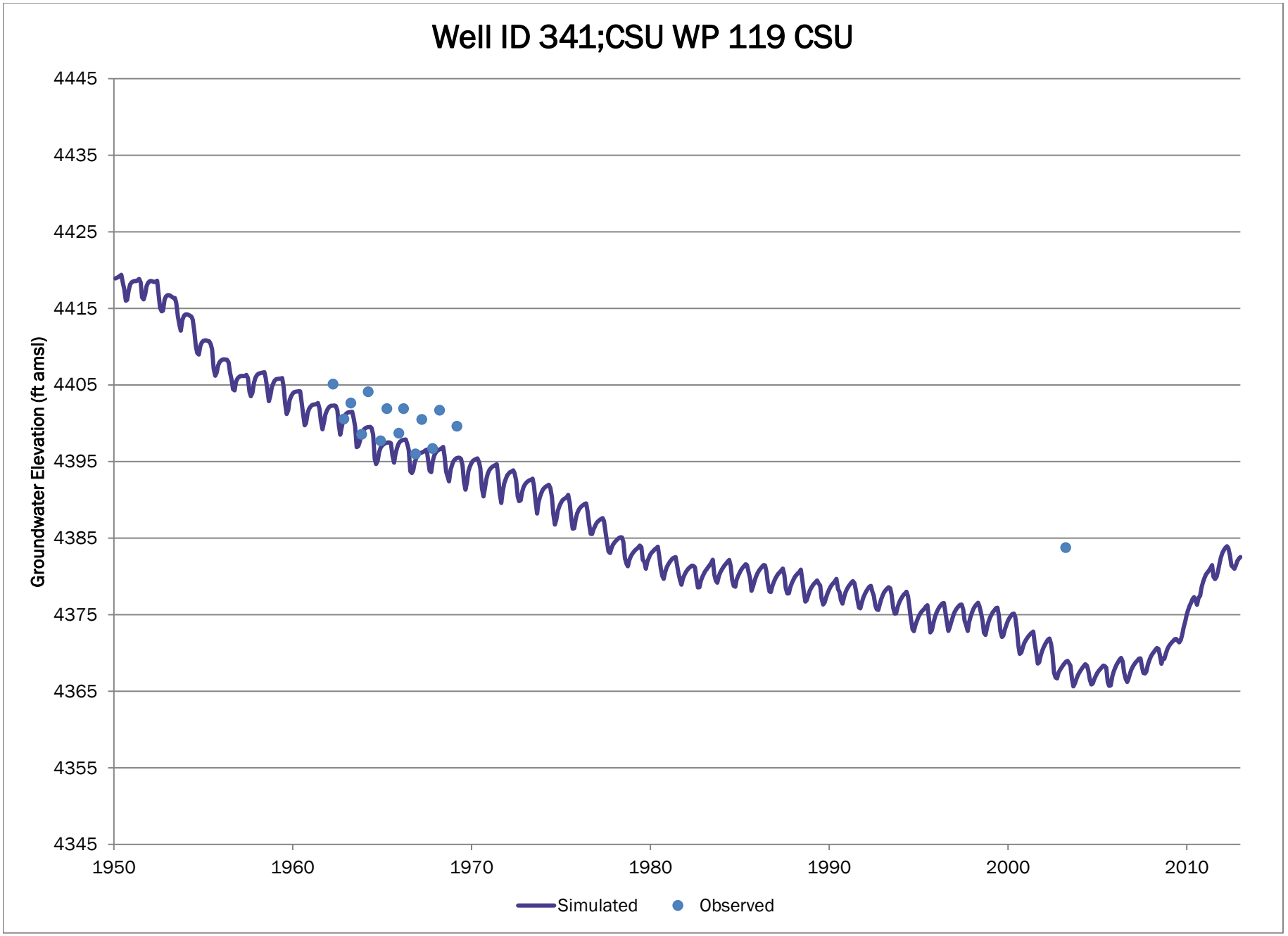
Note elevation axis range of 100 feet.



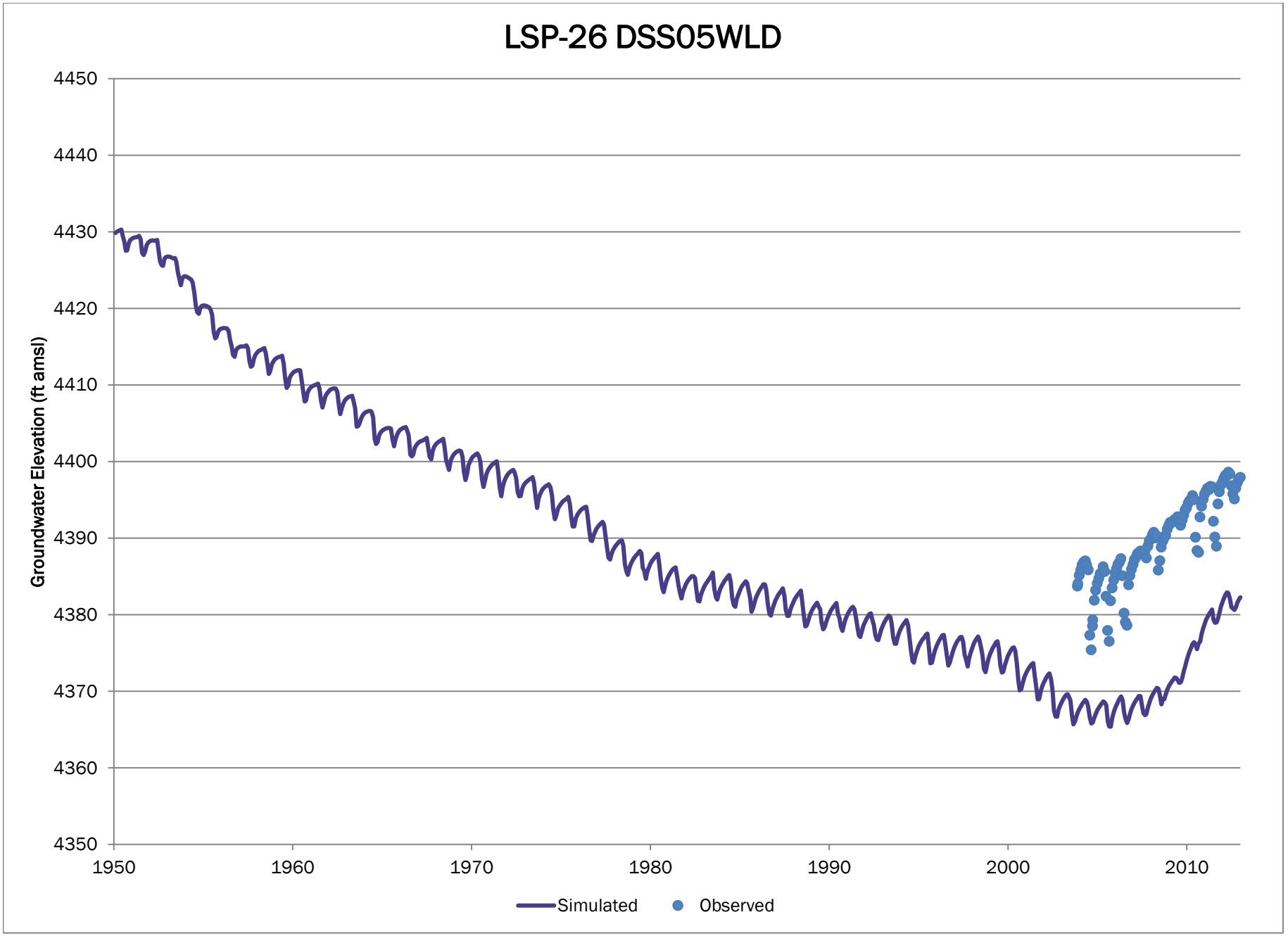

LSP-25 DSS06WLD
Groundwater Elevation (ft amsl)
4405
4400
4395
4390
4385
4380
4375
4370
4365
4360
4355
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

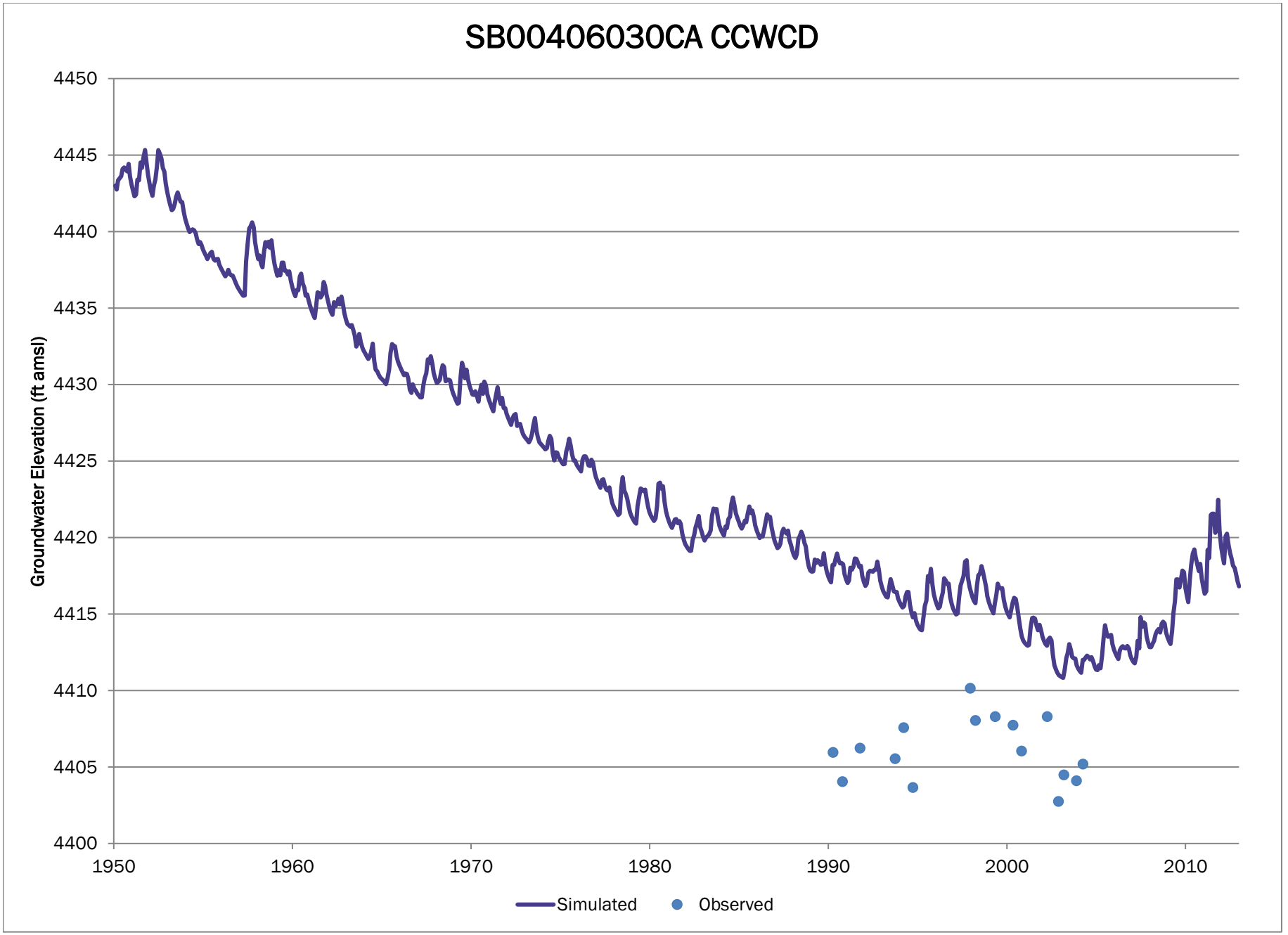

WELL ID 336;CSU WP 125 CSU
Groundwater Elevation (ft amsl)
4450
4445
4440
4435
4430
4425
4420
4415
4410
4405
4400
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

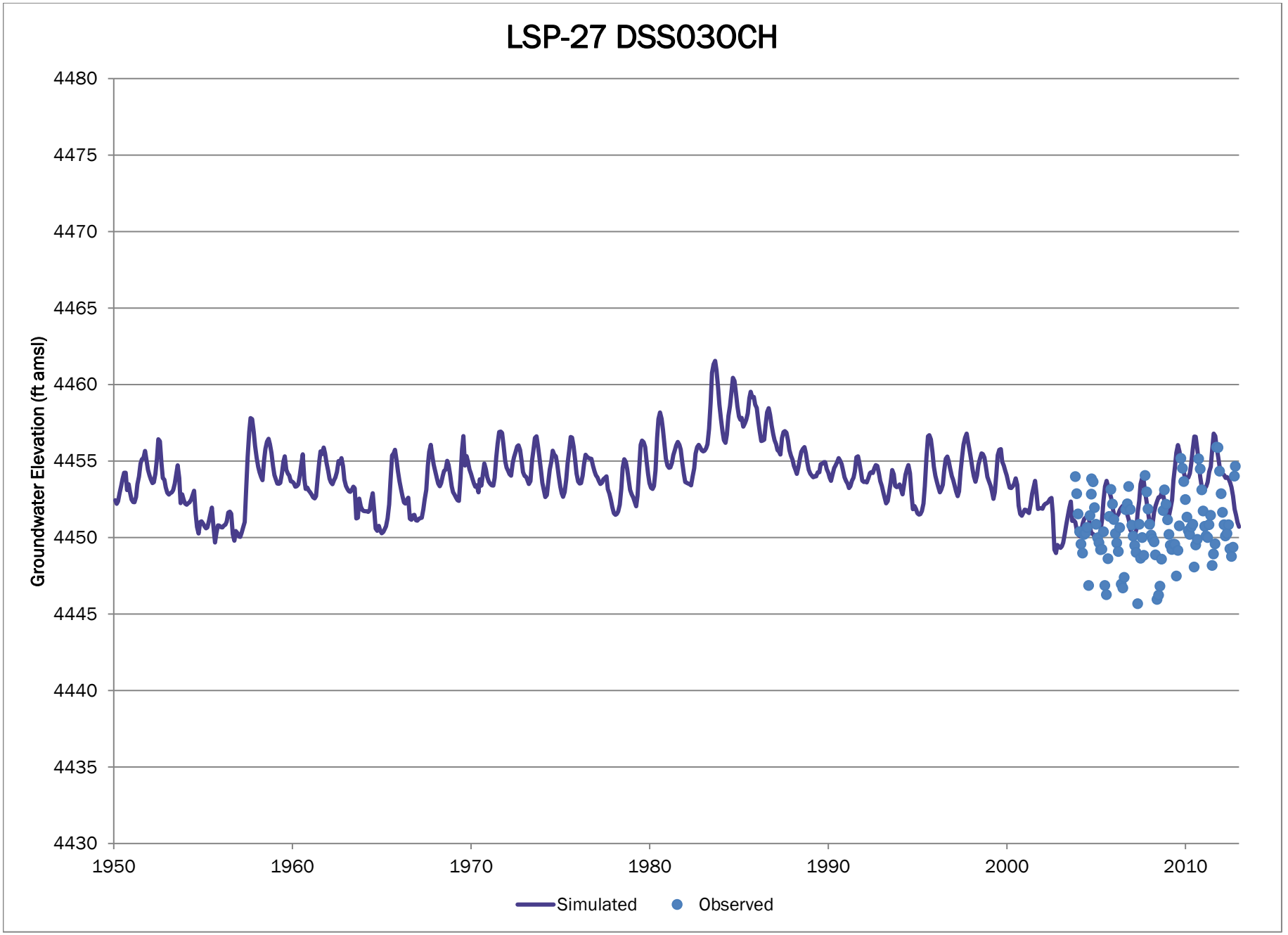
Note elevation axis range of 100 feet.

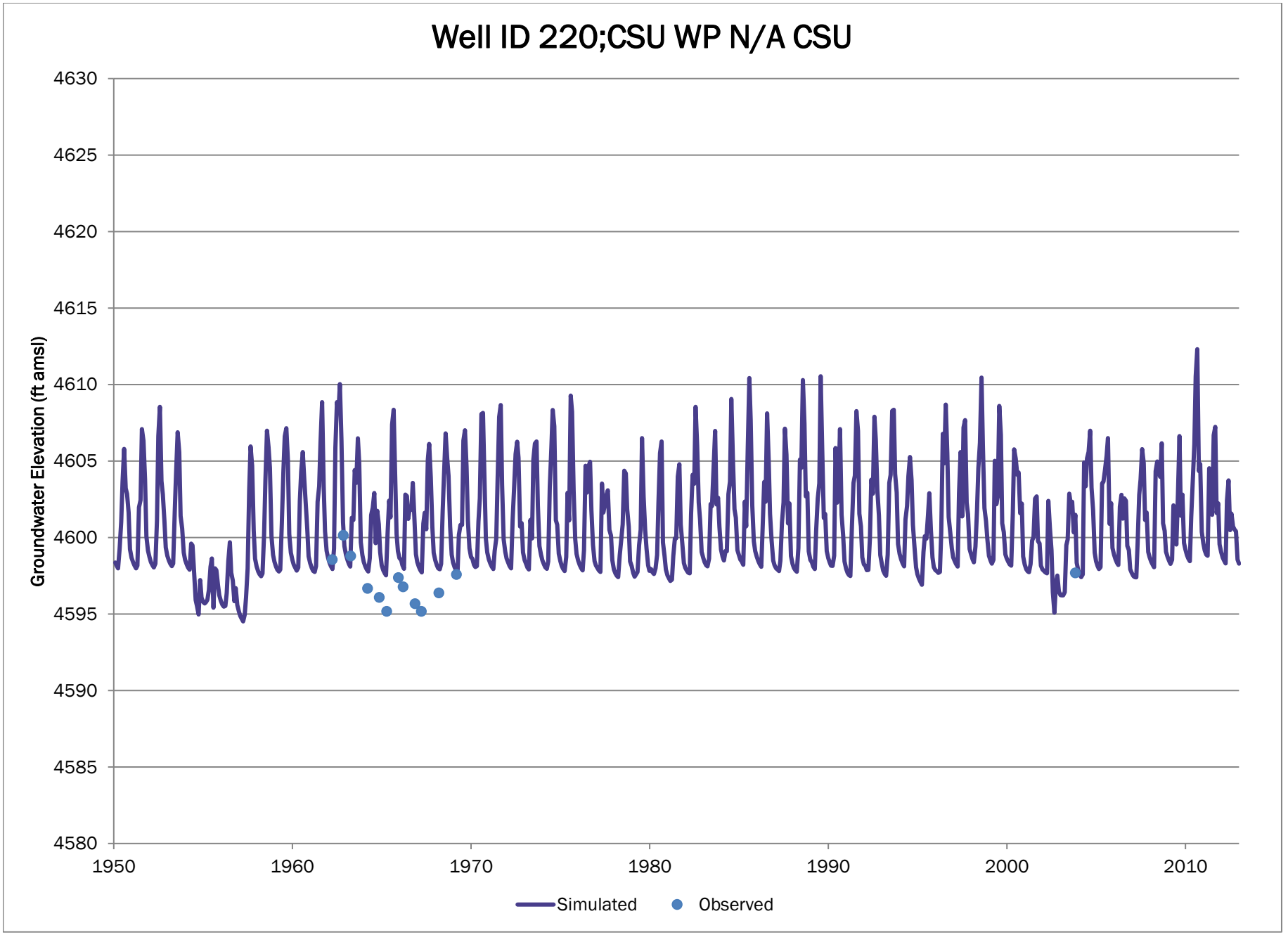


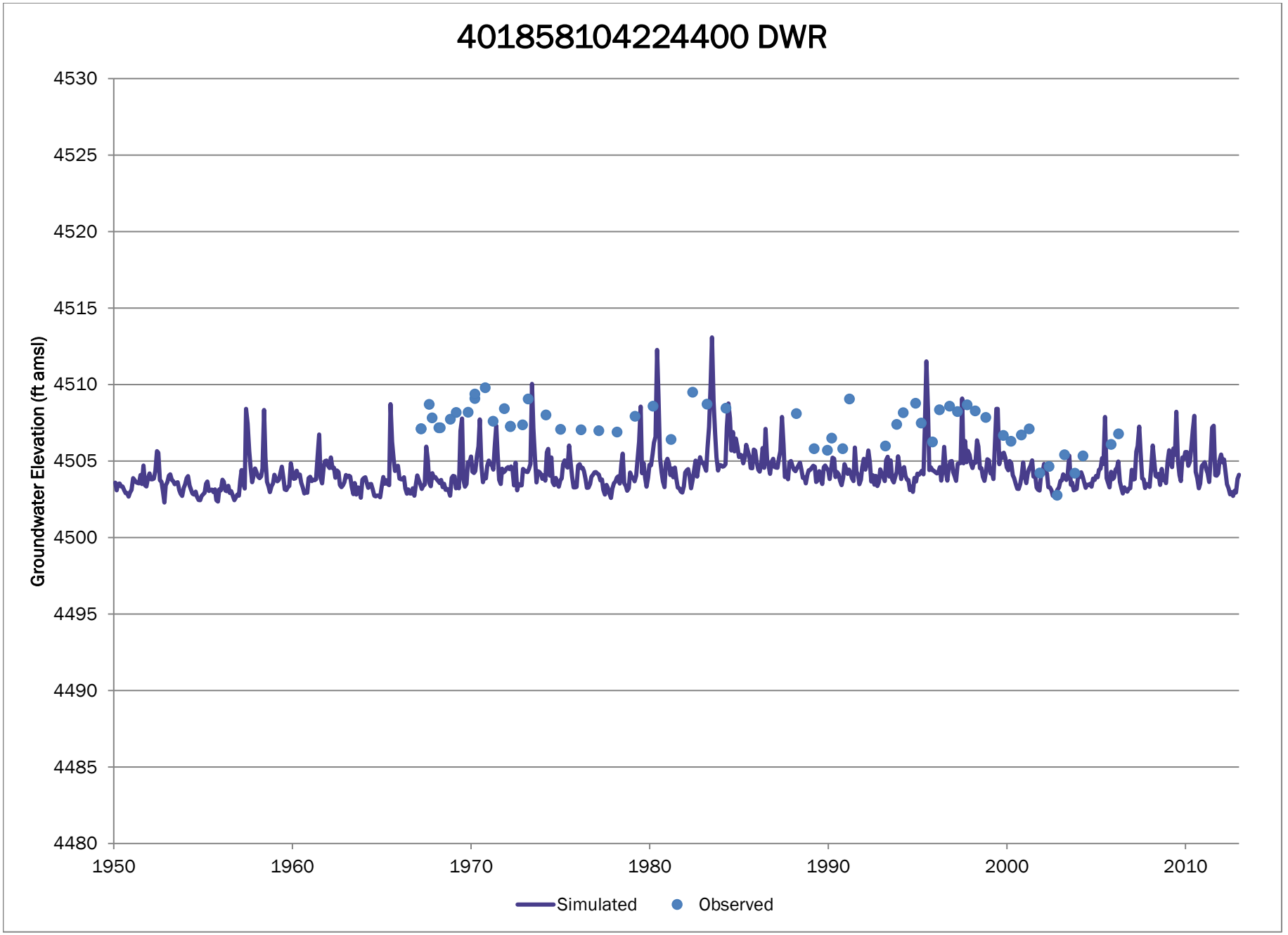
Note elevation axis range of 100 feet.

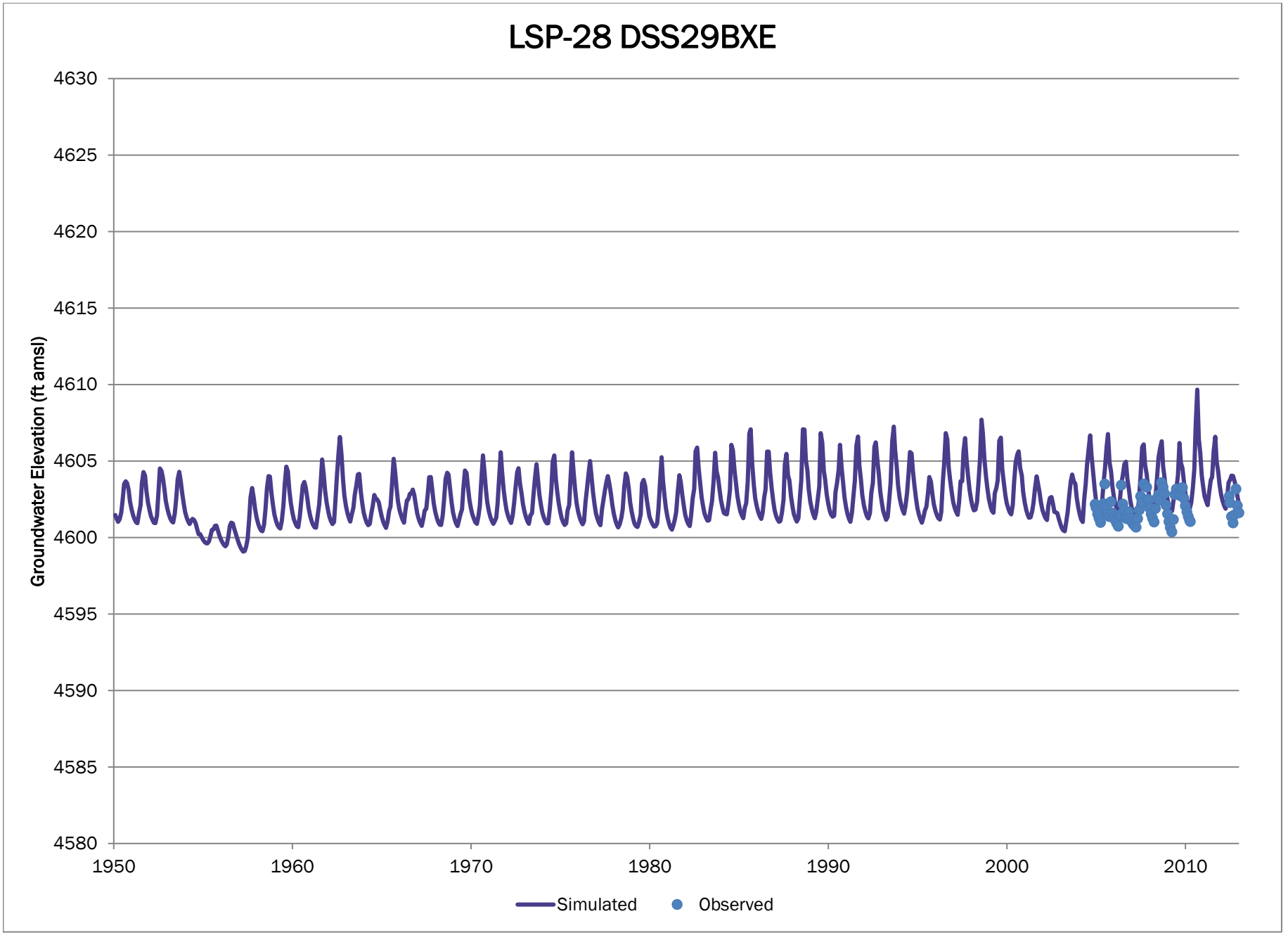


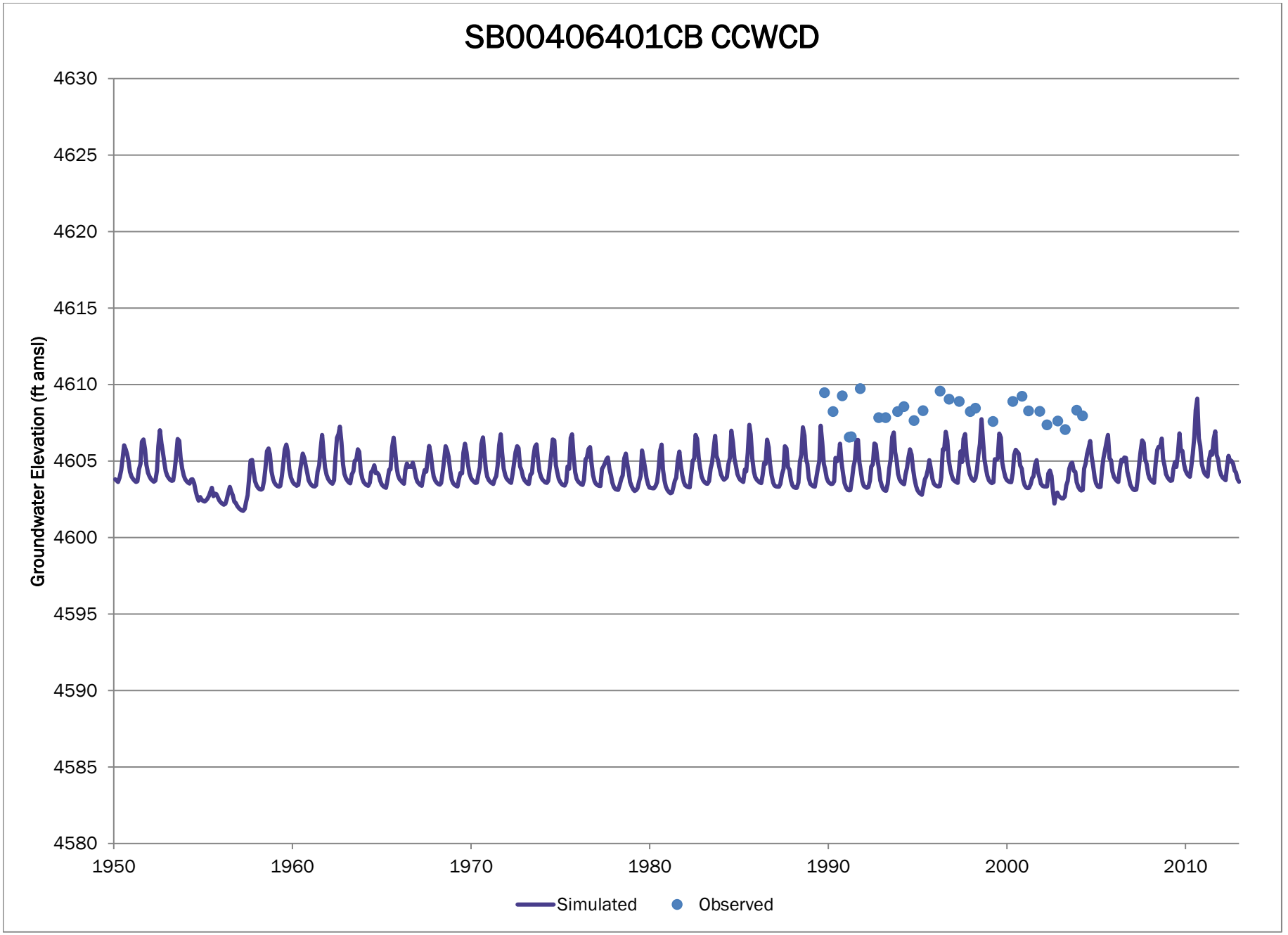

SB00406030CA CCWCD
Groundwater Elevation (ft amsl)
4450
4445
4440
4435
4430
4425
4420
4415
4410
4405
4400
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

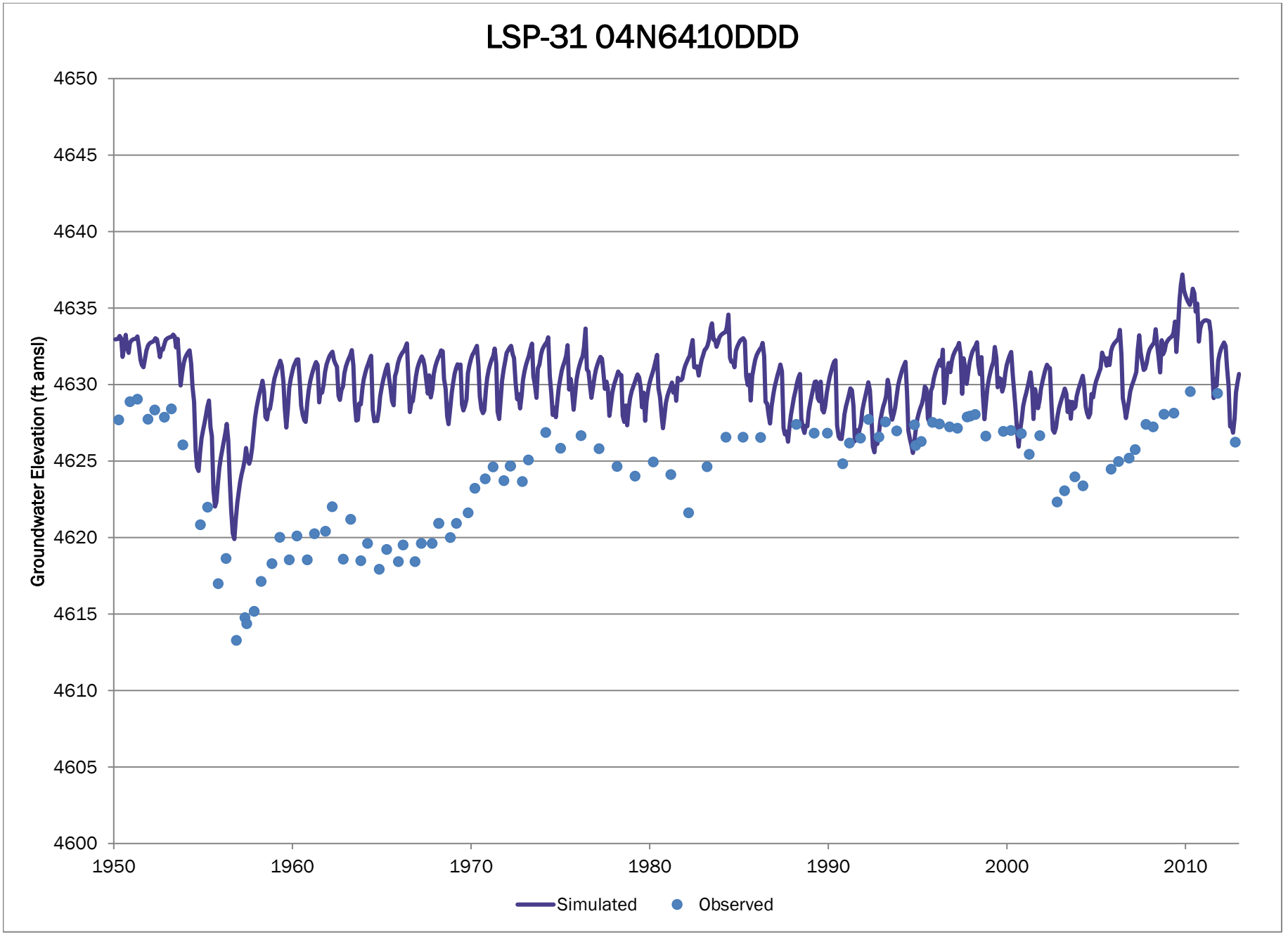

LSP-27 DSS030CH
Groundwater Elevation (ft amsl)
4480
4475
4470
4465
4460
4455
4450
4445
4440
4435
4430
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

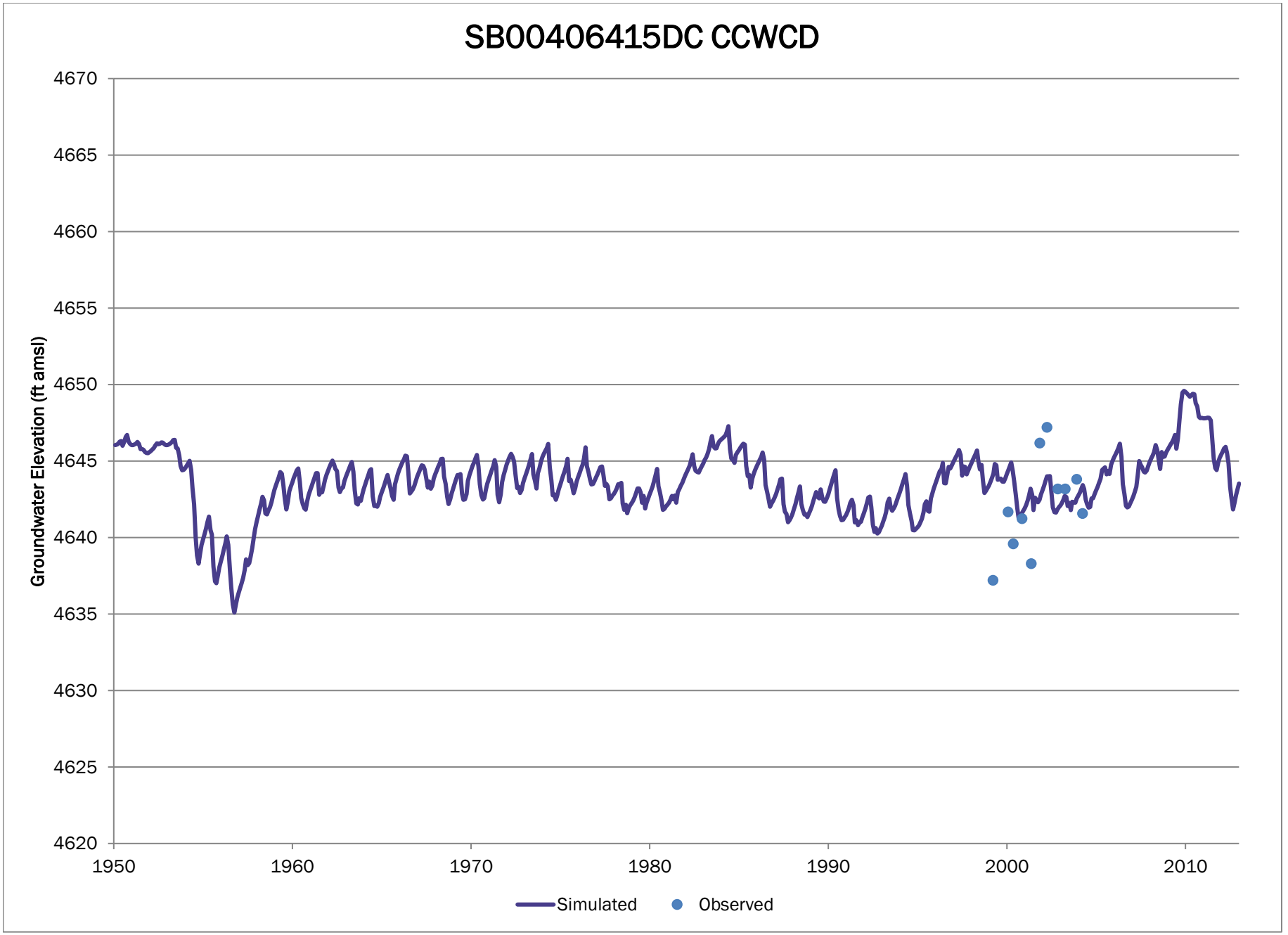

Well ID 220;CSU WP N/A CSU
Groundwater Elevation (ft amsl)
4630
4625
4620
4615
4610
4605
4600
4595
4590
4585
4580
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

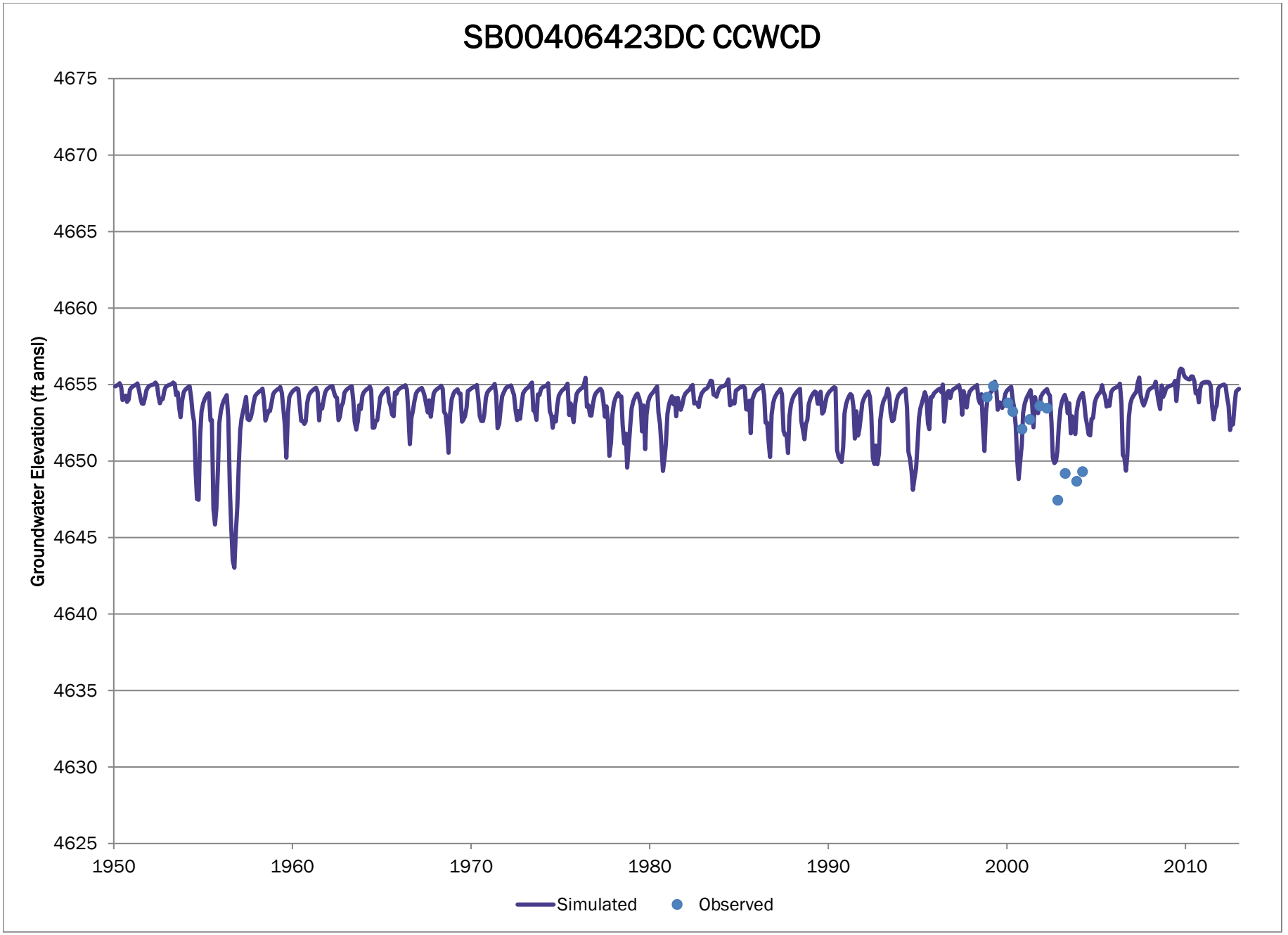

401858104224400 DWR
Groundwater Elevation (ft amsl)
4530
4525
4520
4515
4510
4505
4500
4495
4490
4485
4480
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

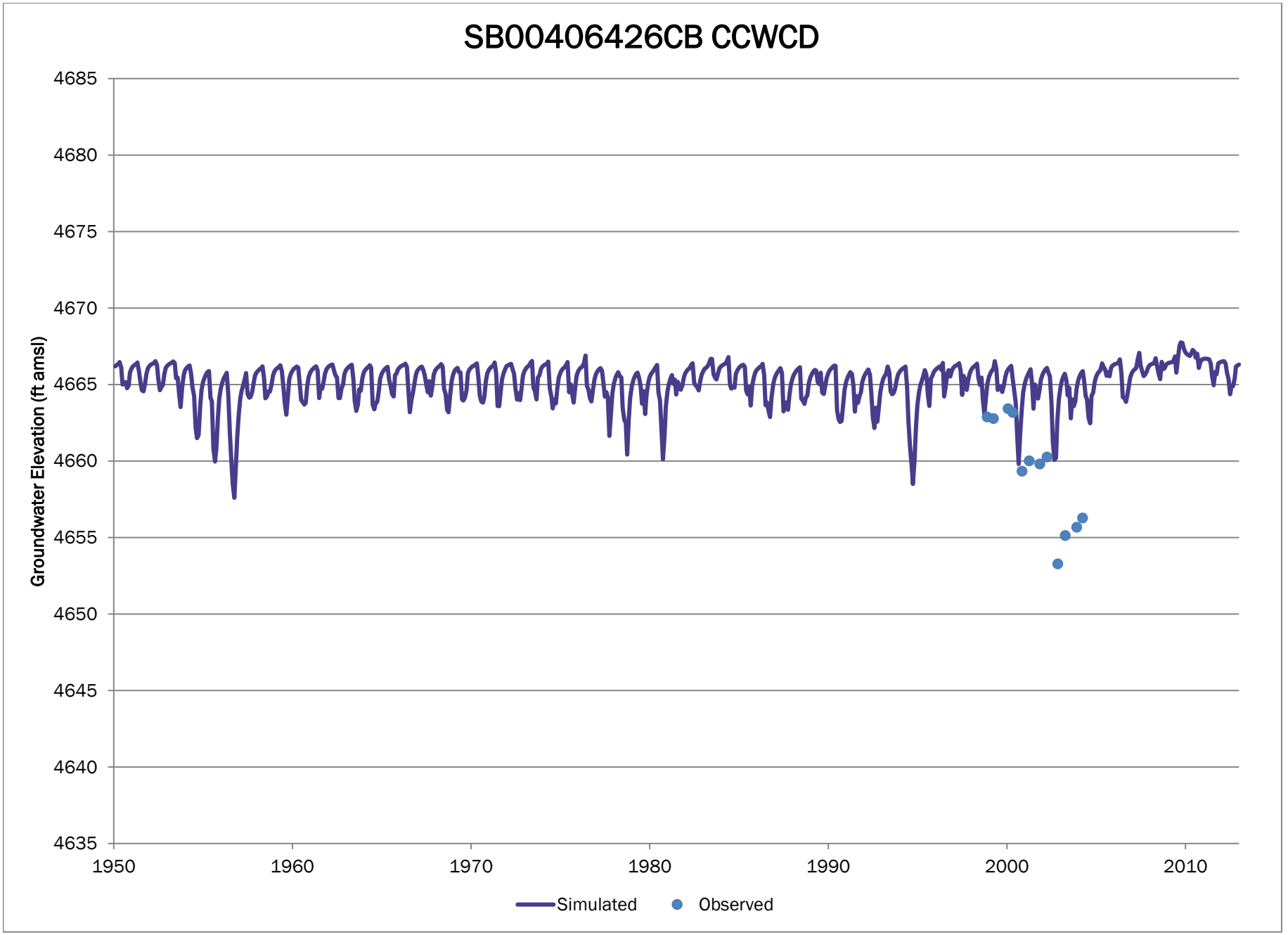

LSP-28 DSS29BXE
Groundwater Elevation (ft amsl)
4630
4625
4620
4615
4610
4605
4600
4595
4590
4585
4580
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

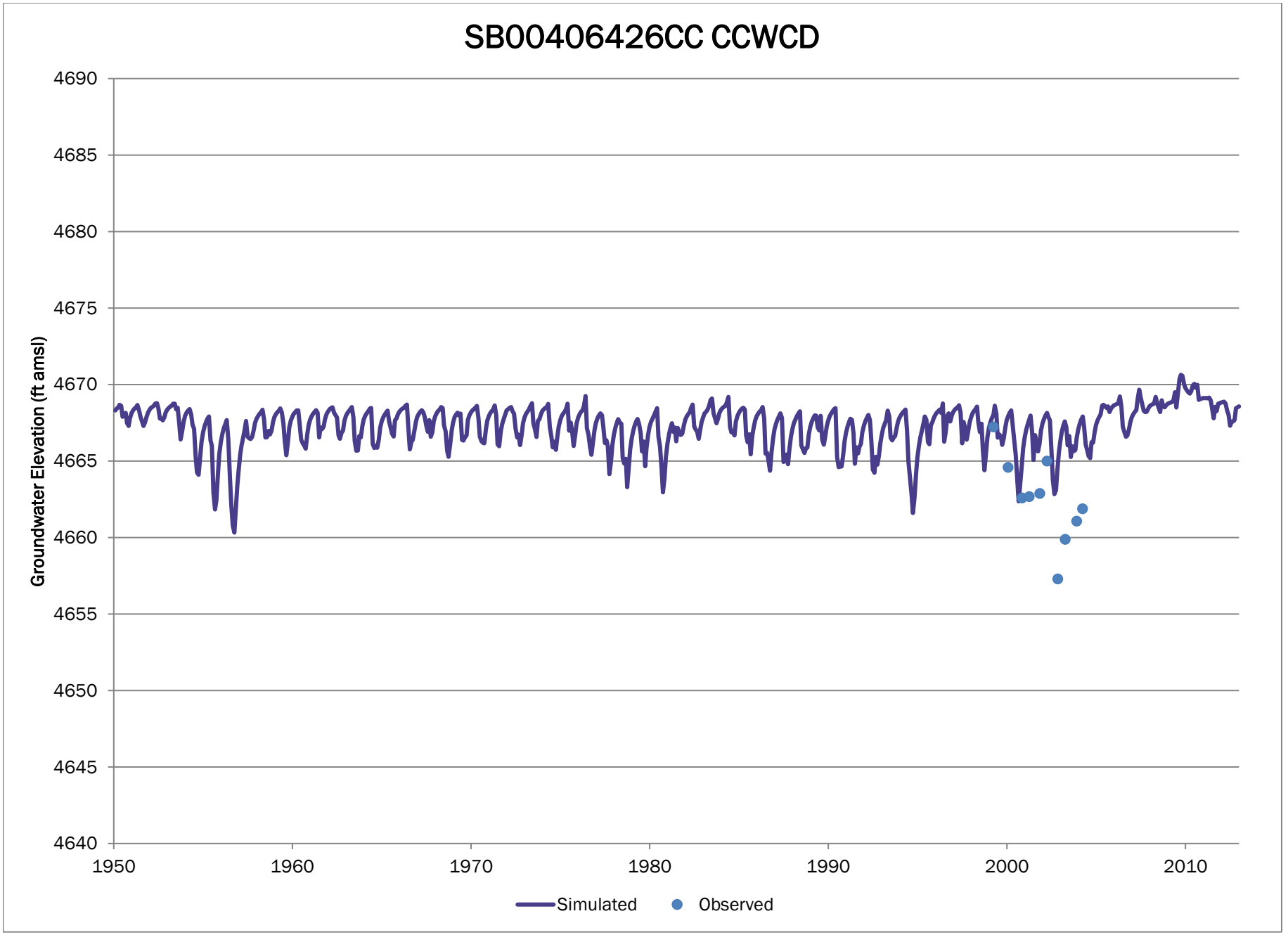

SB00406401CB CCWCD
Groundwater Elevation (ft amsl)
4630
4625
4620
4615
4610
4605
4600
4595
4590
4585
4580
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

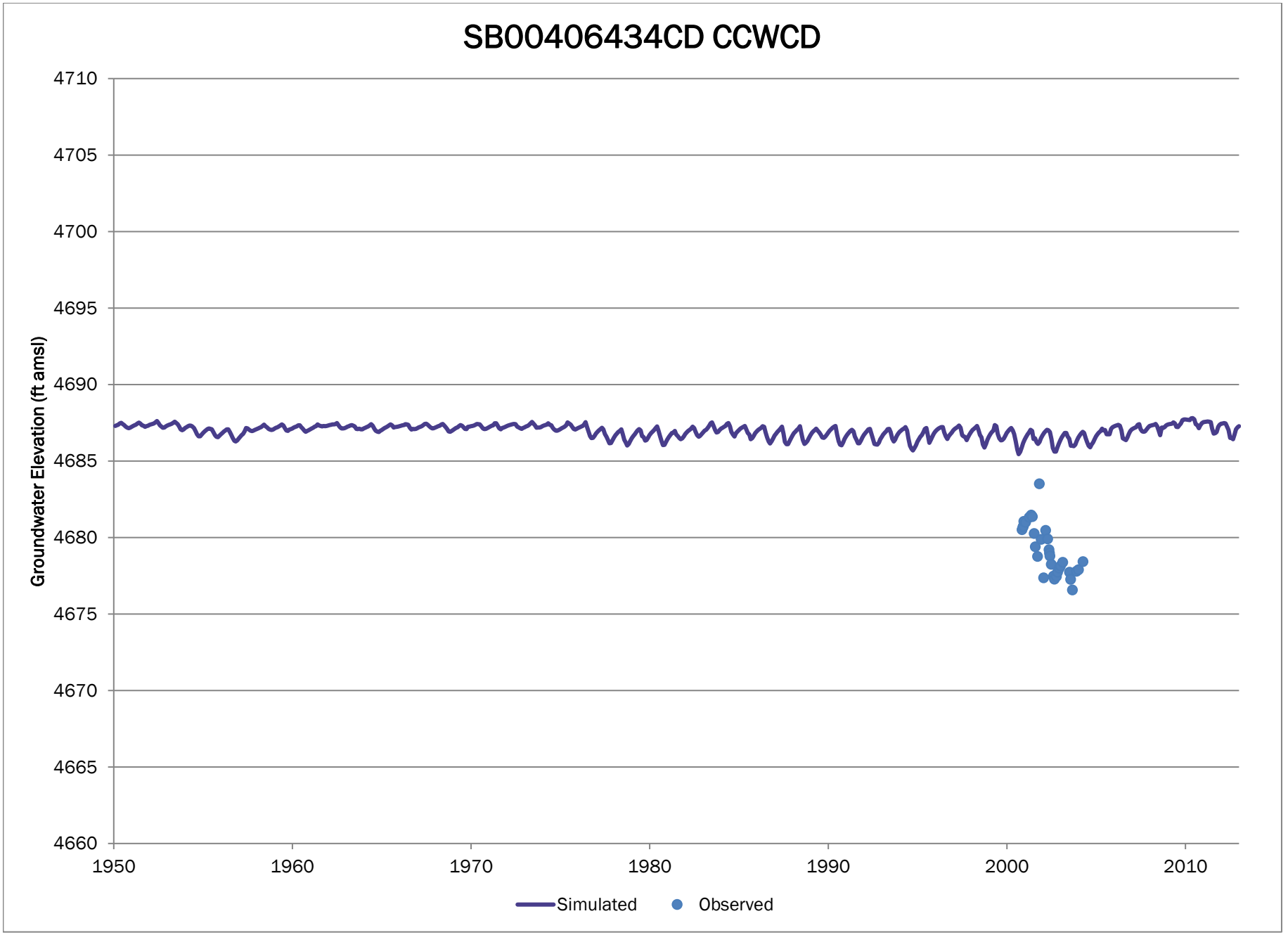

LSP-31 04N6410DDD
Groundwater Elevation (ft amsl)
4650
4645
4640
4635
4630
4625
4620
4615
4610
4605
4600
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

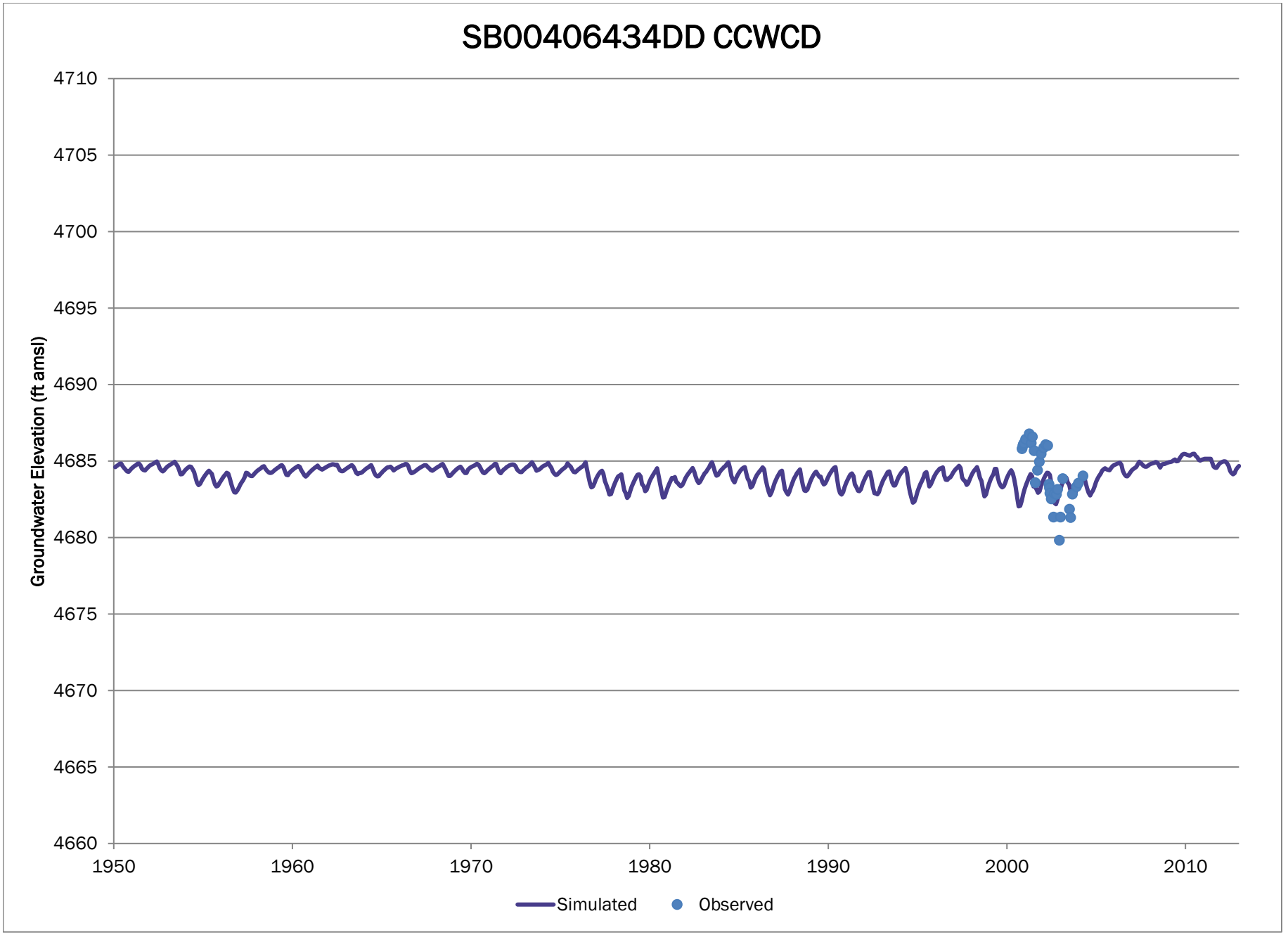

SB00406415DC CCWCD
Groundwater Elevation (ft amsl)
4670
4665
4660
4655
4650
4645
4640
4635
4630
4625
4620
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

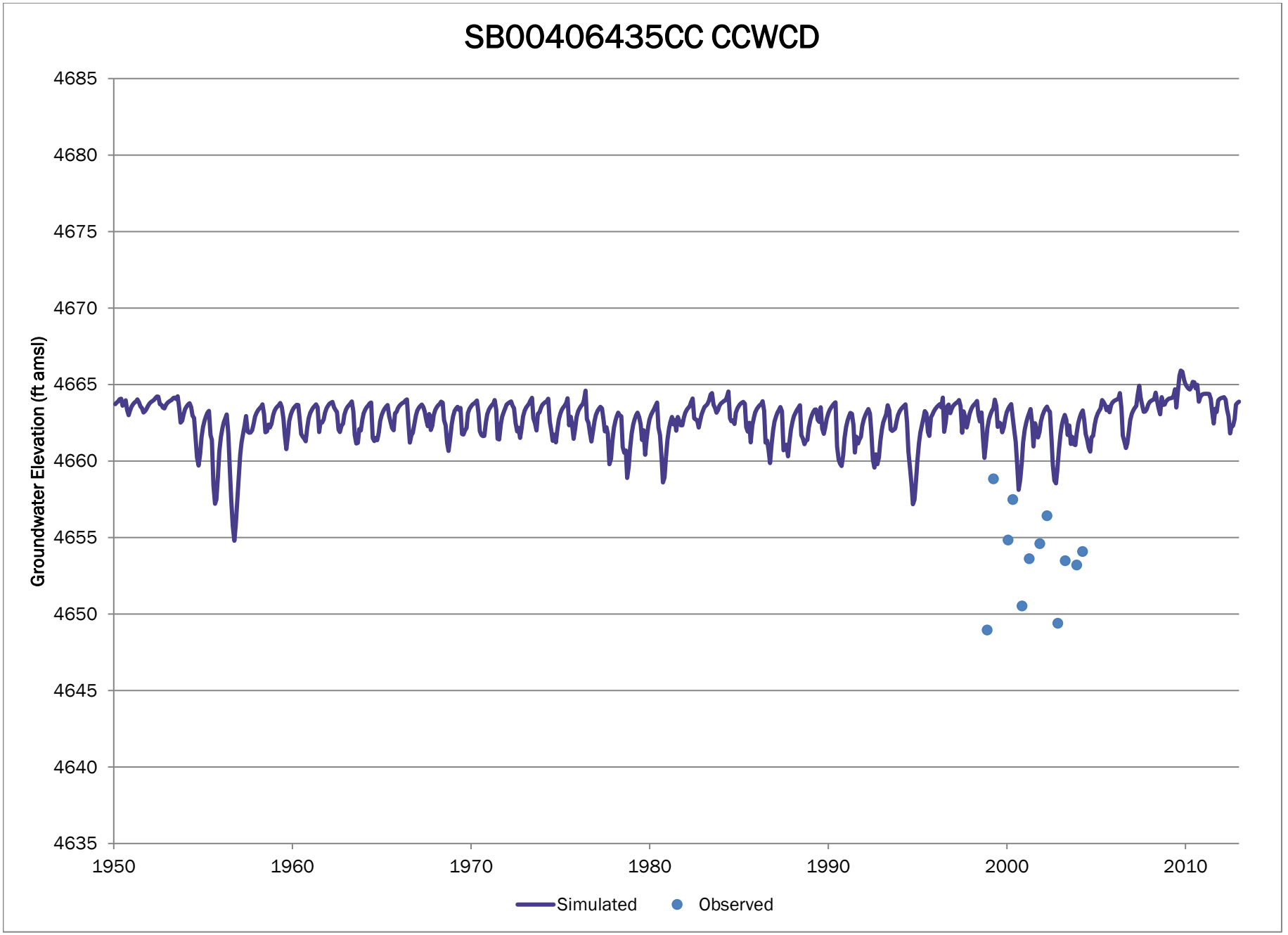

SB00406423DC CCWCD
Groundwater Elevation (ft amsl)
4675
4670
4665
4660
4655
4650
4645
4640
4635
4630
4625
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

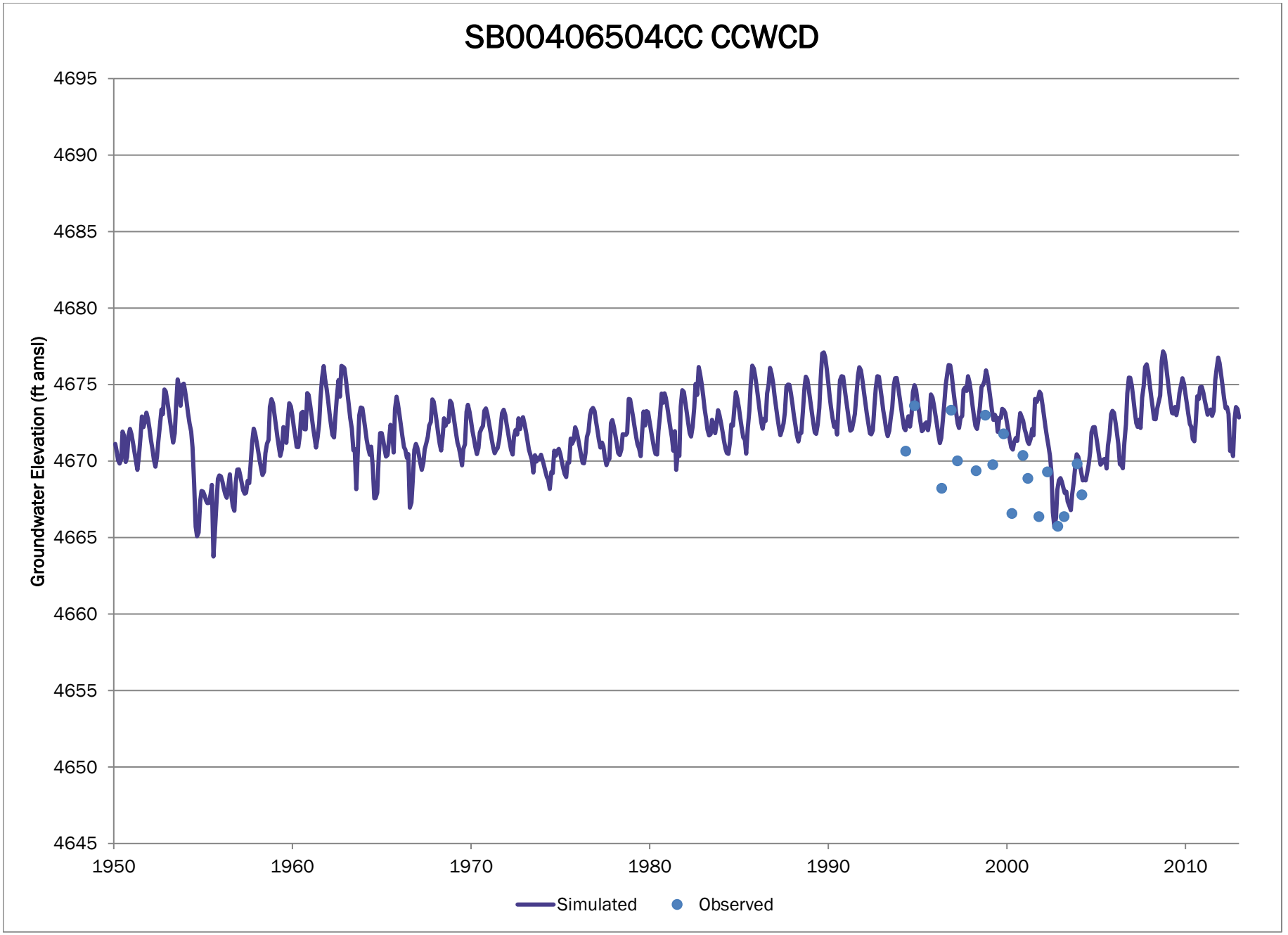

SB00406426CB CCWCD
Groundwater Elevation (ft amsl)
4685
4680
4675
4670
4665
4660
4655
4650
4645
4640
4635
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

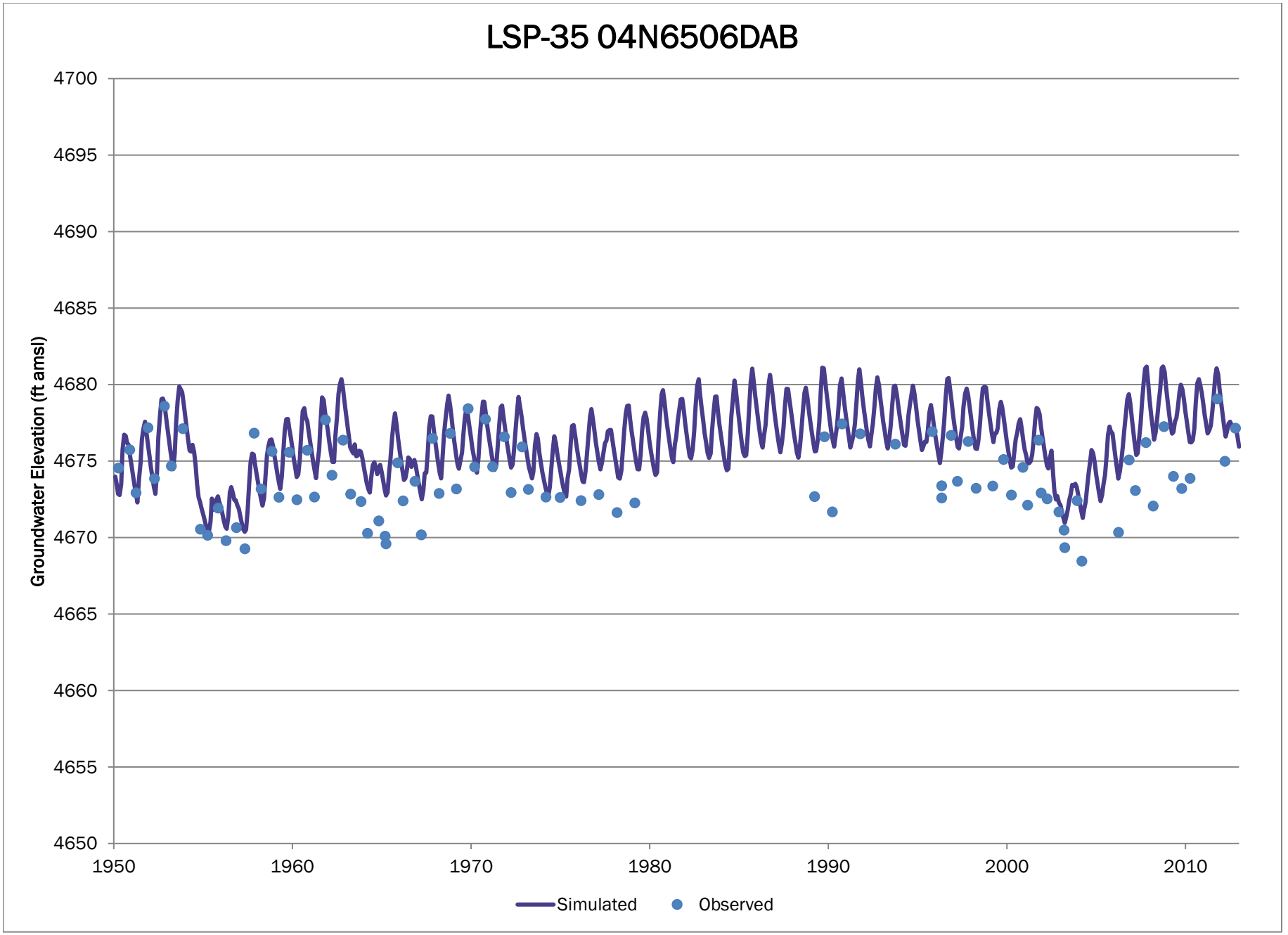

SB00406426CC CCWCD
Groundwater Elevation (ft amsl)
4690
4685
4680
4675
4670
4665
4660
4655
4650
4645
4640
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

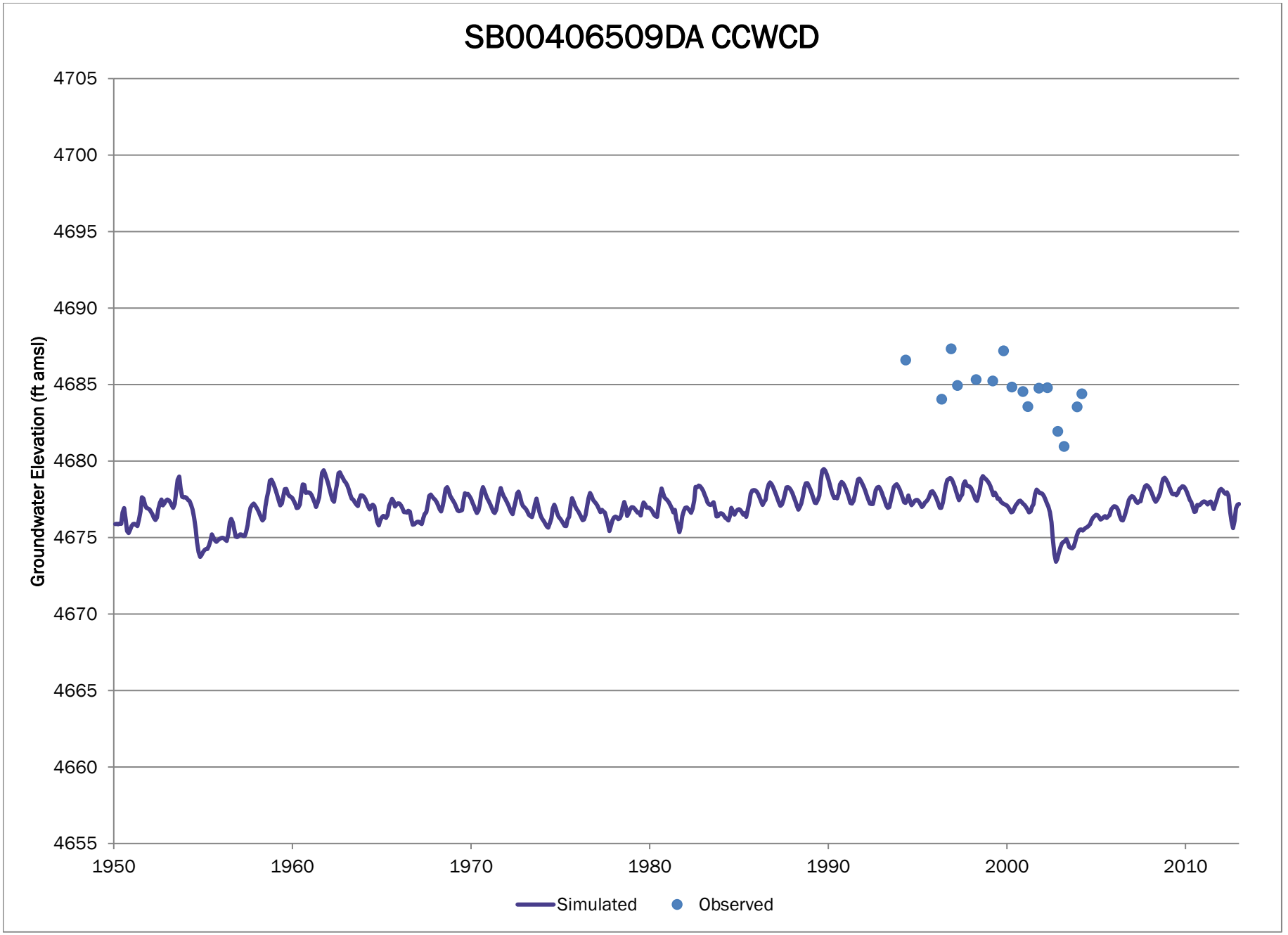

SB00406434CD CCWCD
Groundwater Elevation (ft amsl)
4710
4705
4700
4695
4690
4685
4680
4675
4670
4665
4660
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

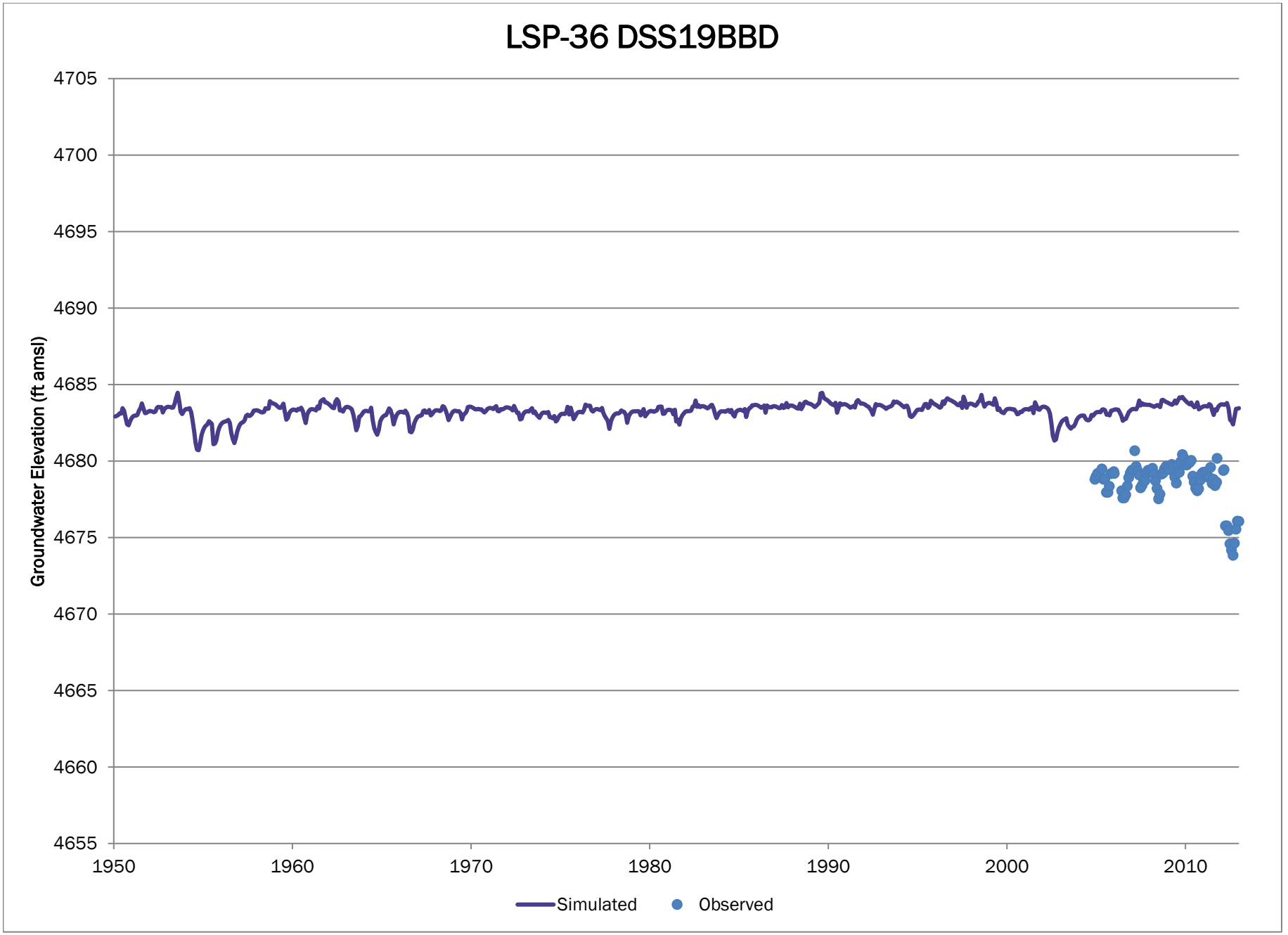

SB00406434DD CCWCD
Groundwater Elevation (ft amsl)
4710
4705
4700
4695
4690
4685
4680
4675
4670
4665
4660
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

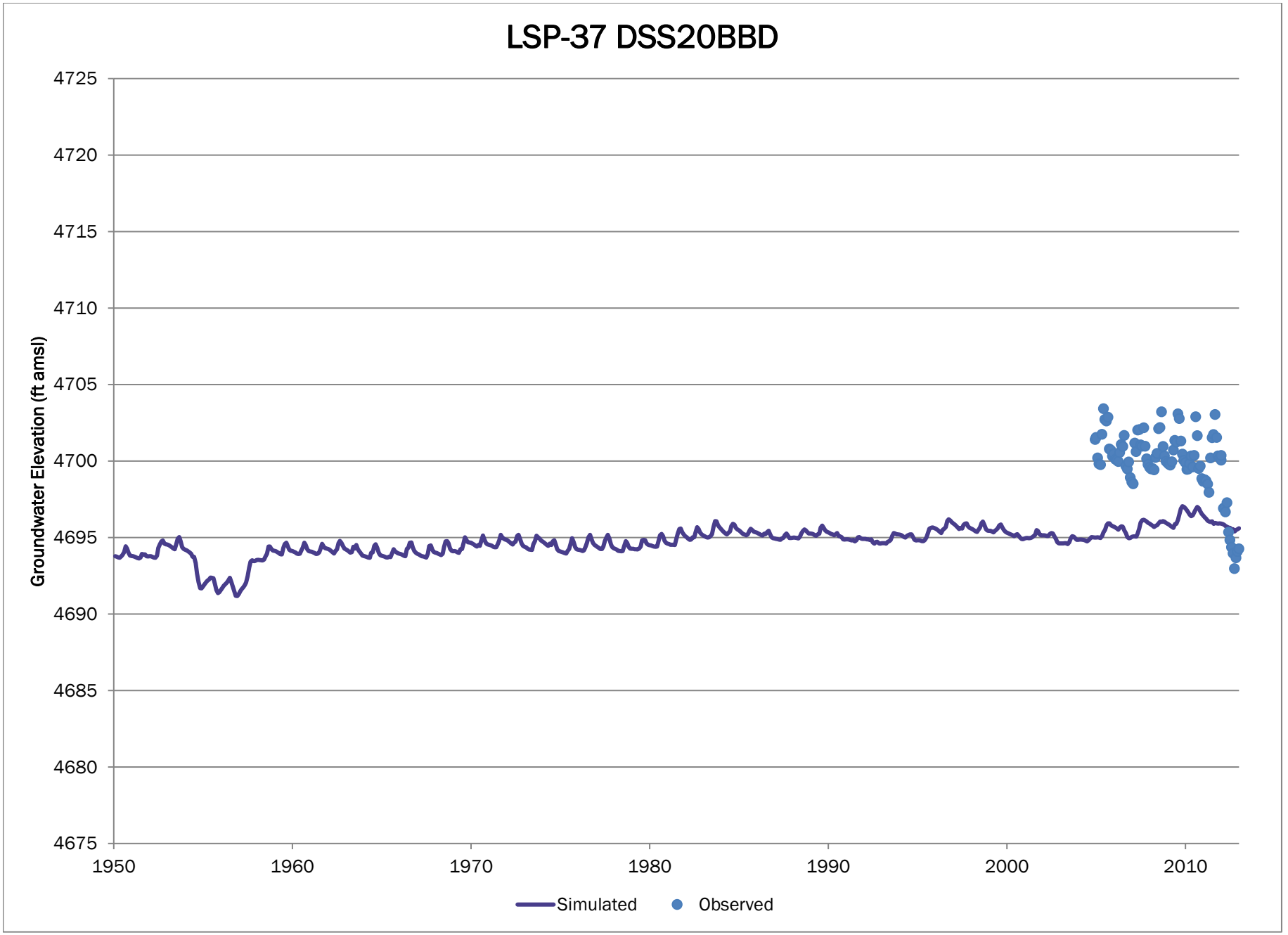

SB00406435CC CCWCD
Groundwater Elevation (ft amsl)
4685
4680
4675
4670
4665
4660
4655
4650
4645
4640
4635
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

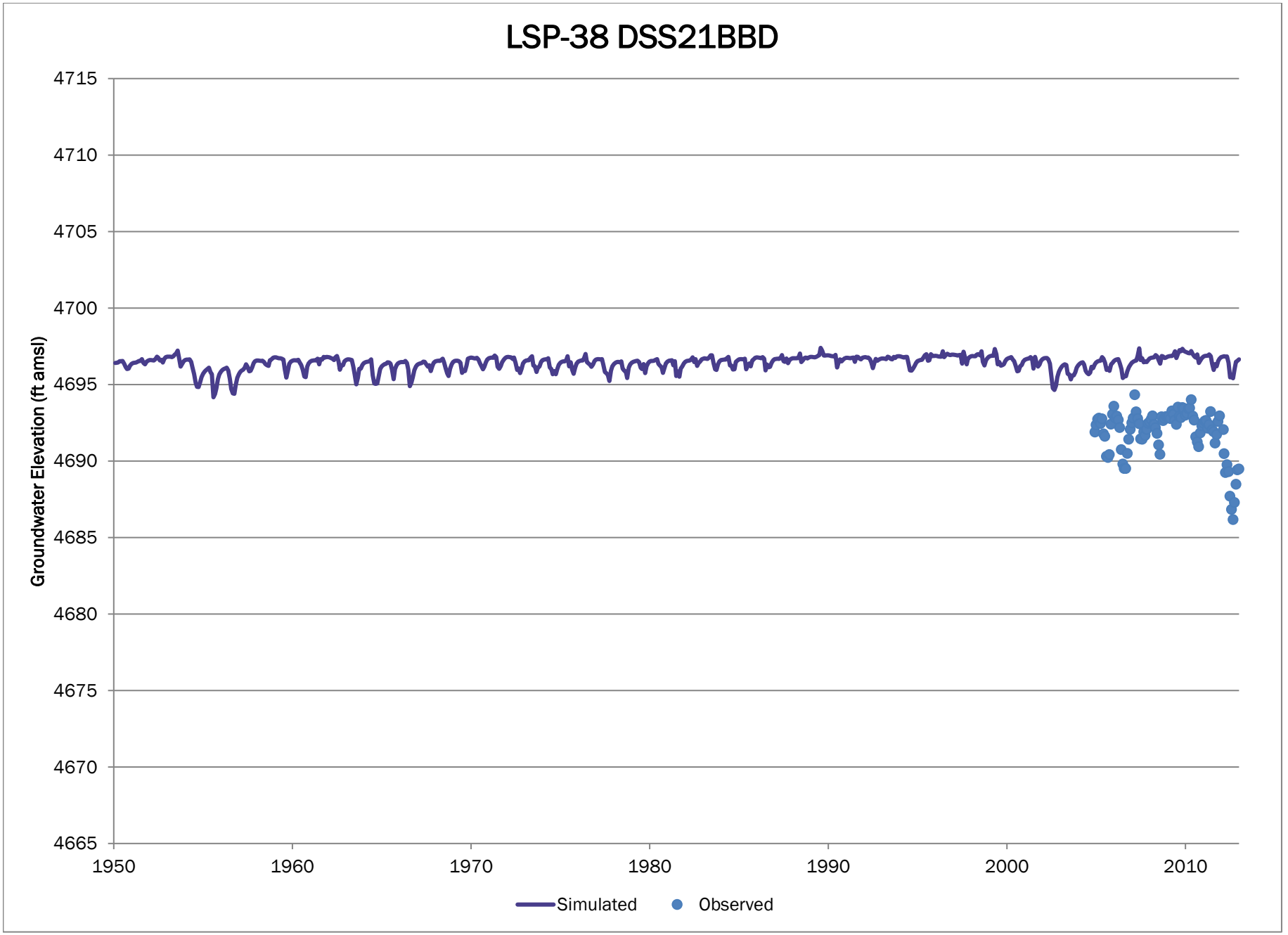

SB00406504CC CCWCD
Groundwater Elevation (ft amsl)
4695
4690
4685
4680
4675
4670
4665
4660
4655
4650
4645
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

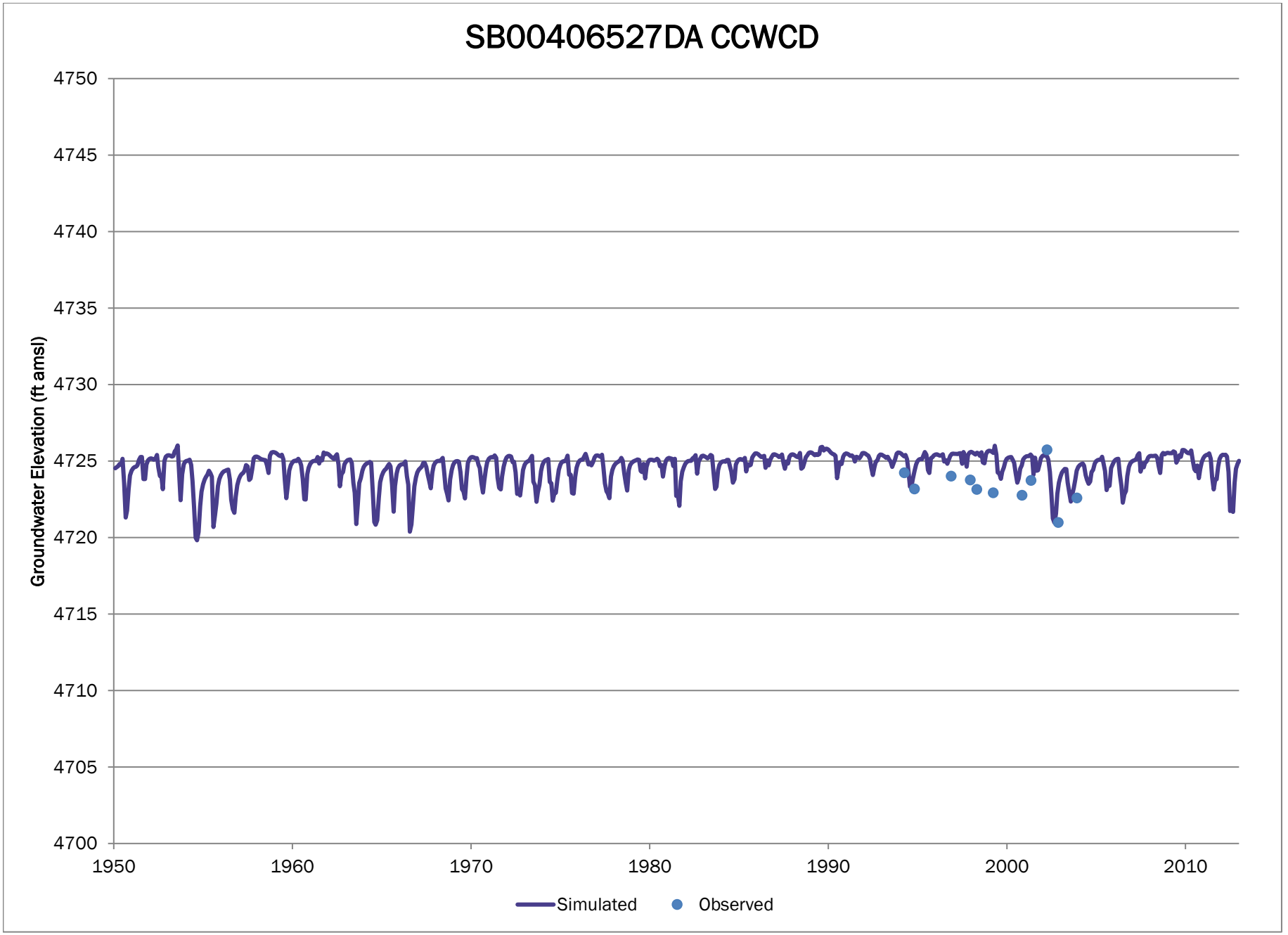

LSP-35 04N6506DAB
Groundwater Elevation (ft amsl)
4700
4695
4690
4685
4680
4675
4670
4665
4660
4655
4650
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

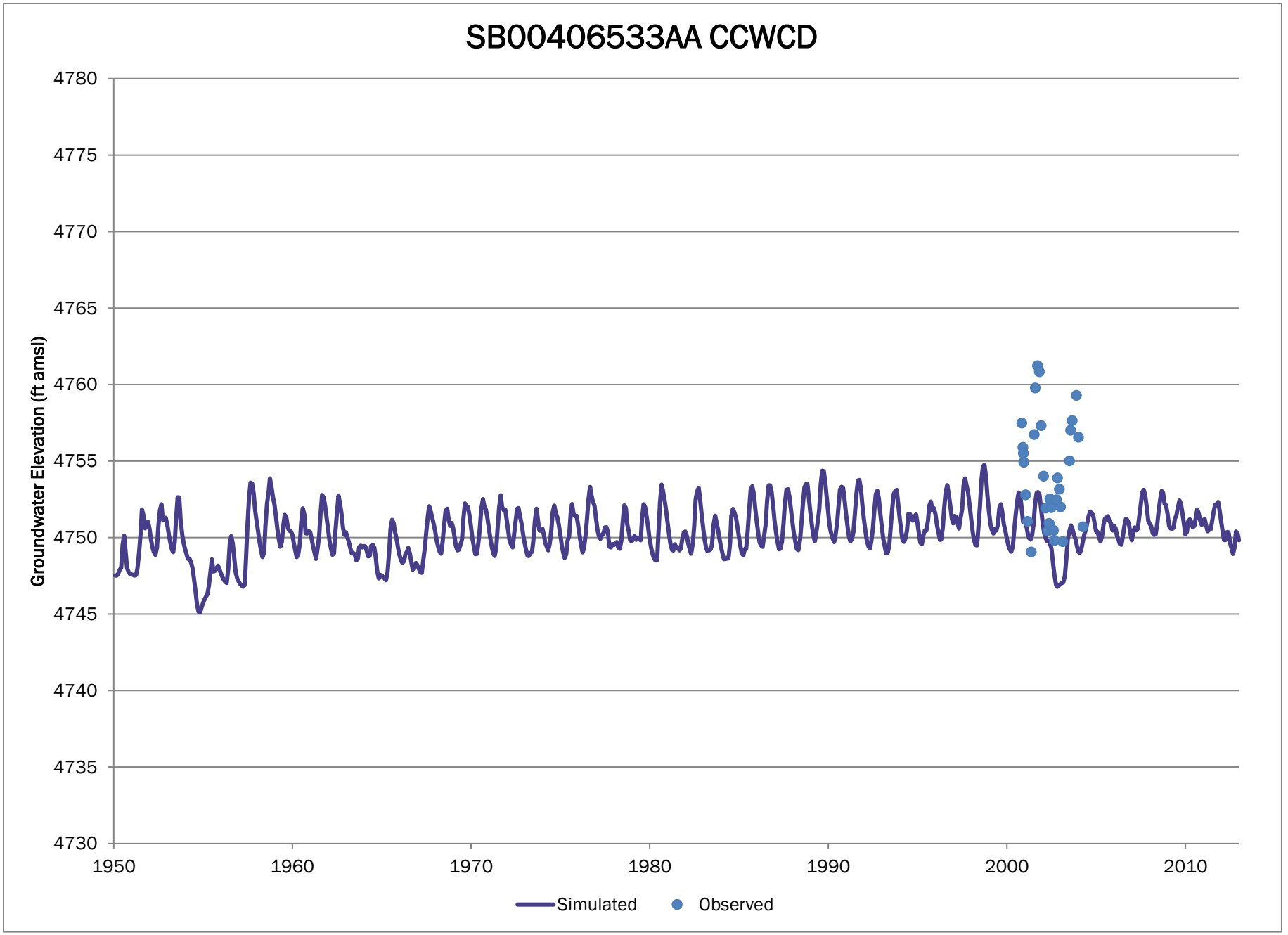

SB00406509DA CCWCD
Groundwater Elevation (ft amsl)
4705
4700
4695
4690
4685
4680
4675
4670
4665
4660
4655
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

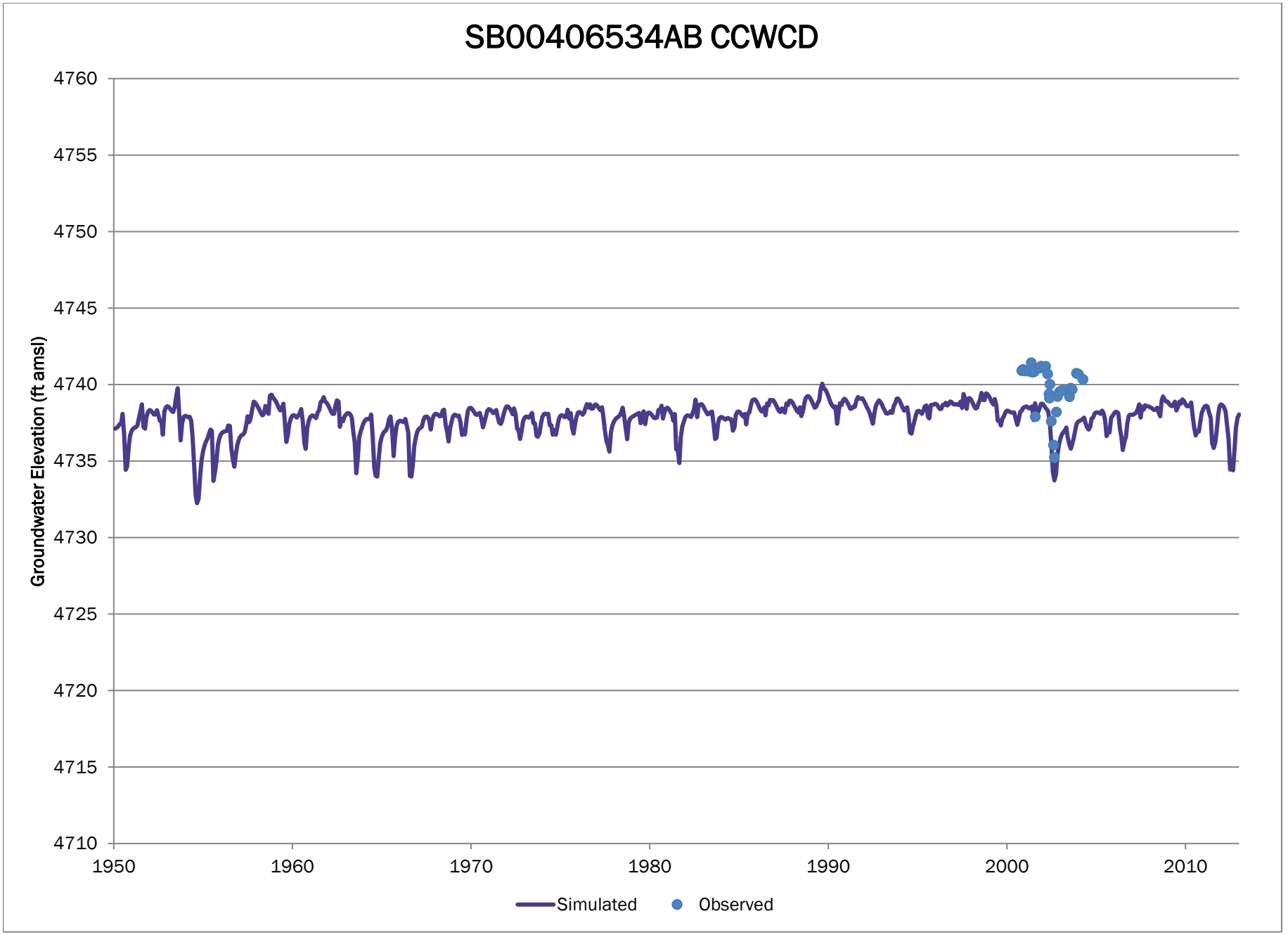

LSP-36 DSS19BBD
Groundwater Elevation (ft amsl)
4705
4700
4695
4690
4685
4680
4675
4670
4665
4660
4655
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

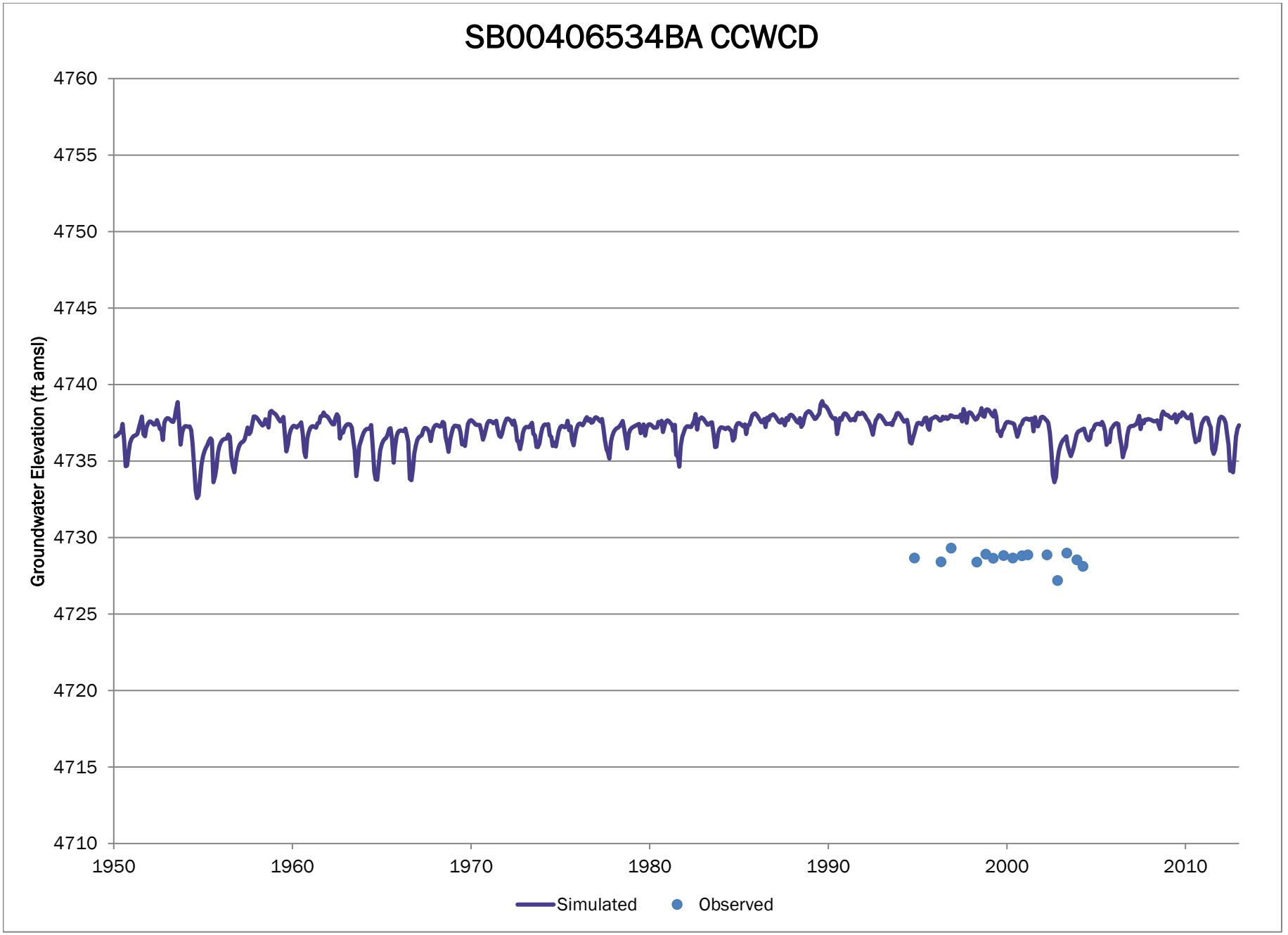

LSP-37 DSS20BBD
Groundwater Elevation (ft amsl)
4725
4720
4715
4710
4705
4700
4695
4690
4685
4680
4675
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

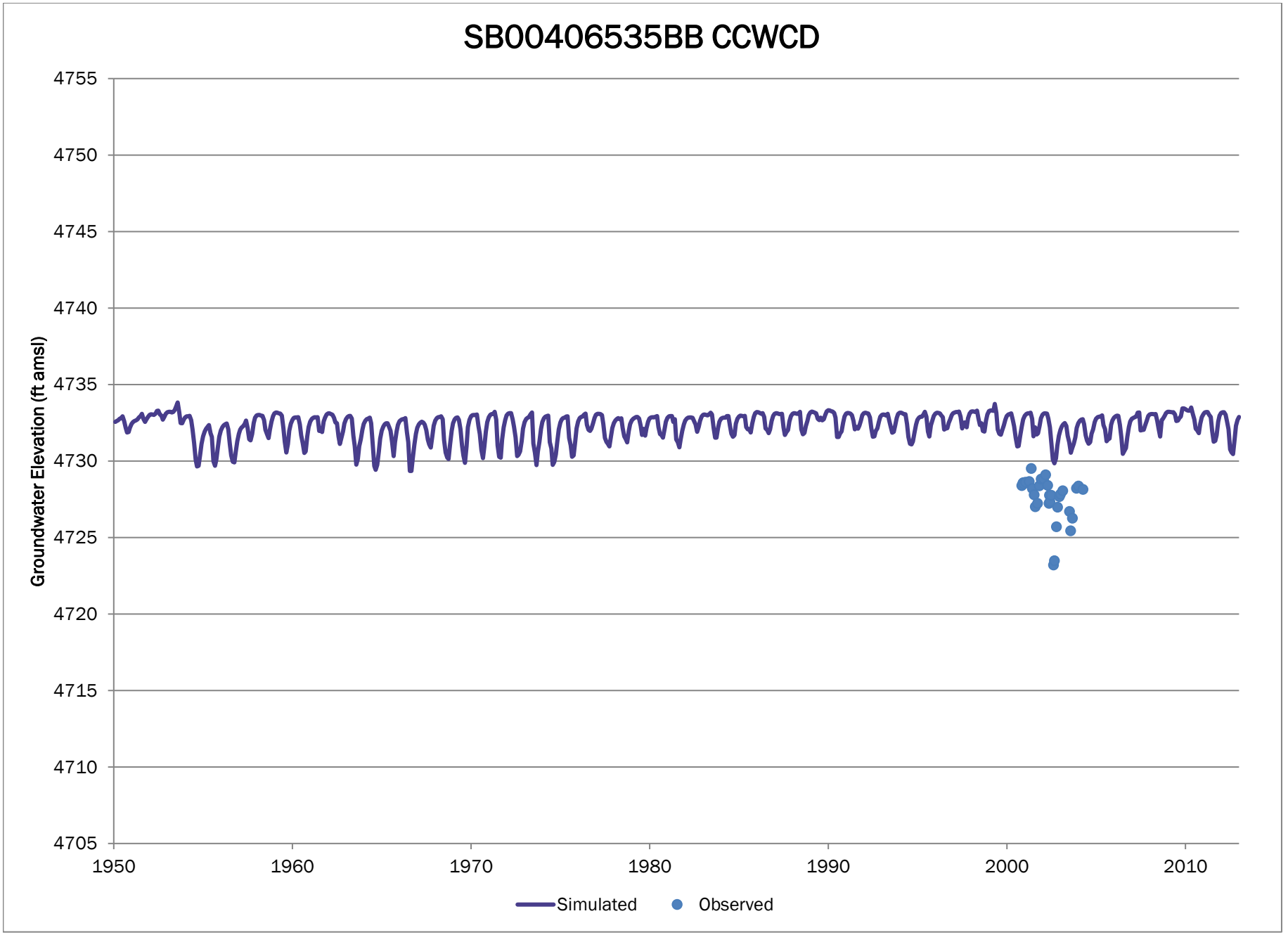

LSP-38 DSS21BBD
Groundwater Elevation (ft amsl)
4715
4710
4705
4700
4695
4690
4685
4680
4675
4670
4665
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

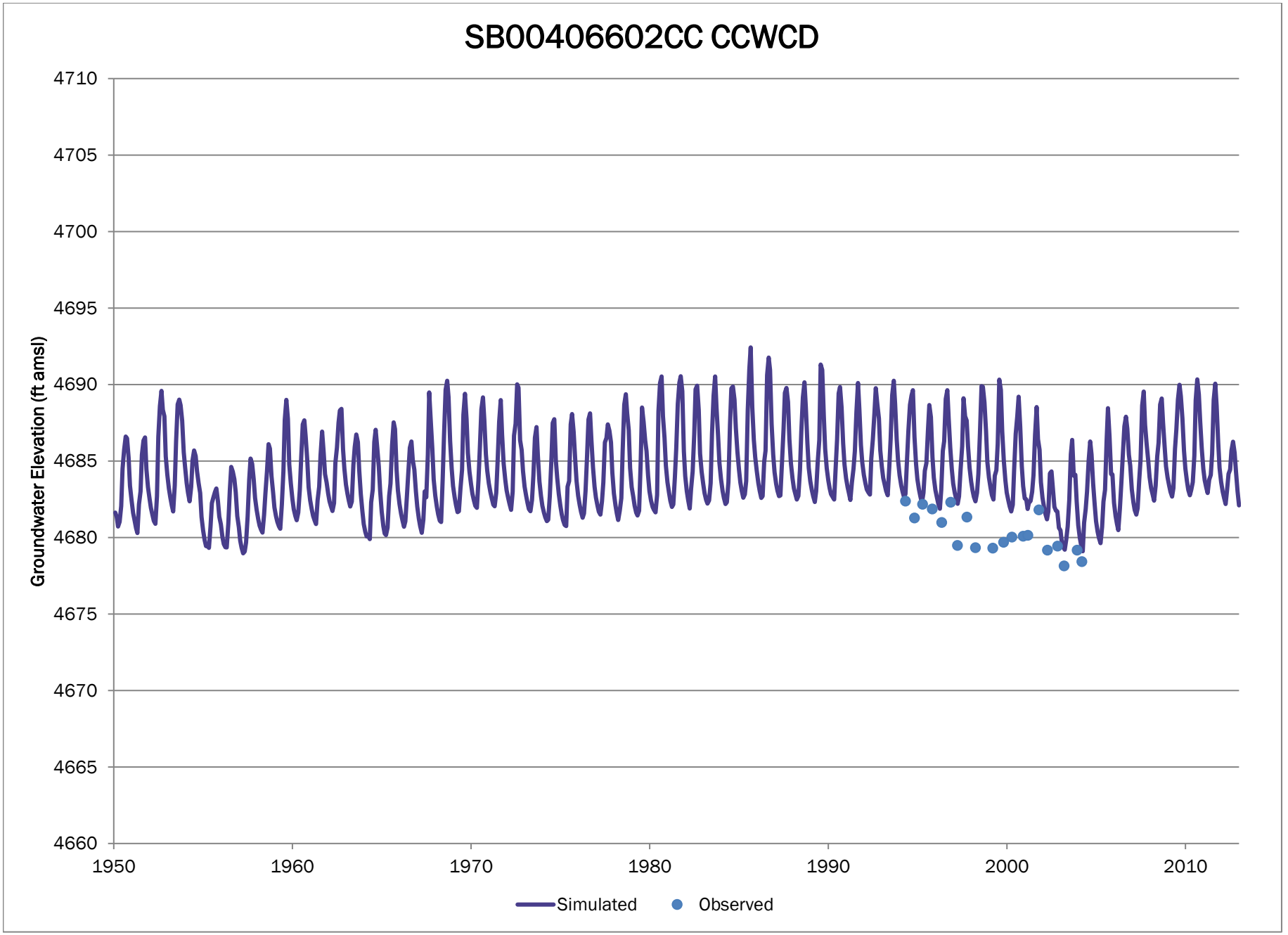

SB00406527DA CCWCD
Groundwater Elevation (ft amsl)
4750
4745
4740
4735
4730
4725
4720
4715
4710
4705
4700
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

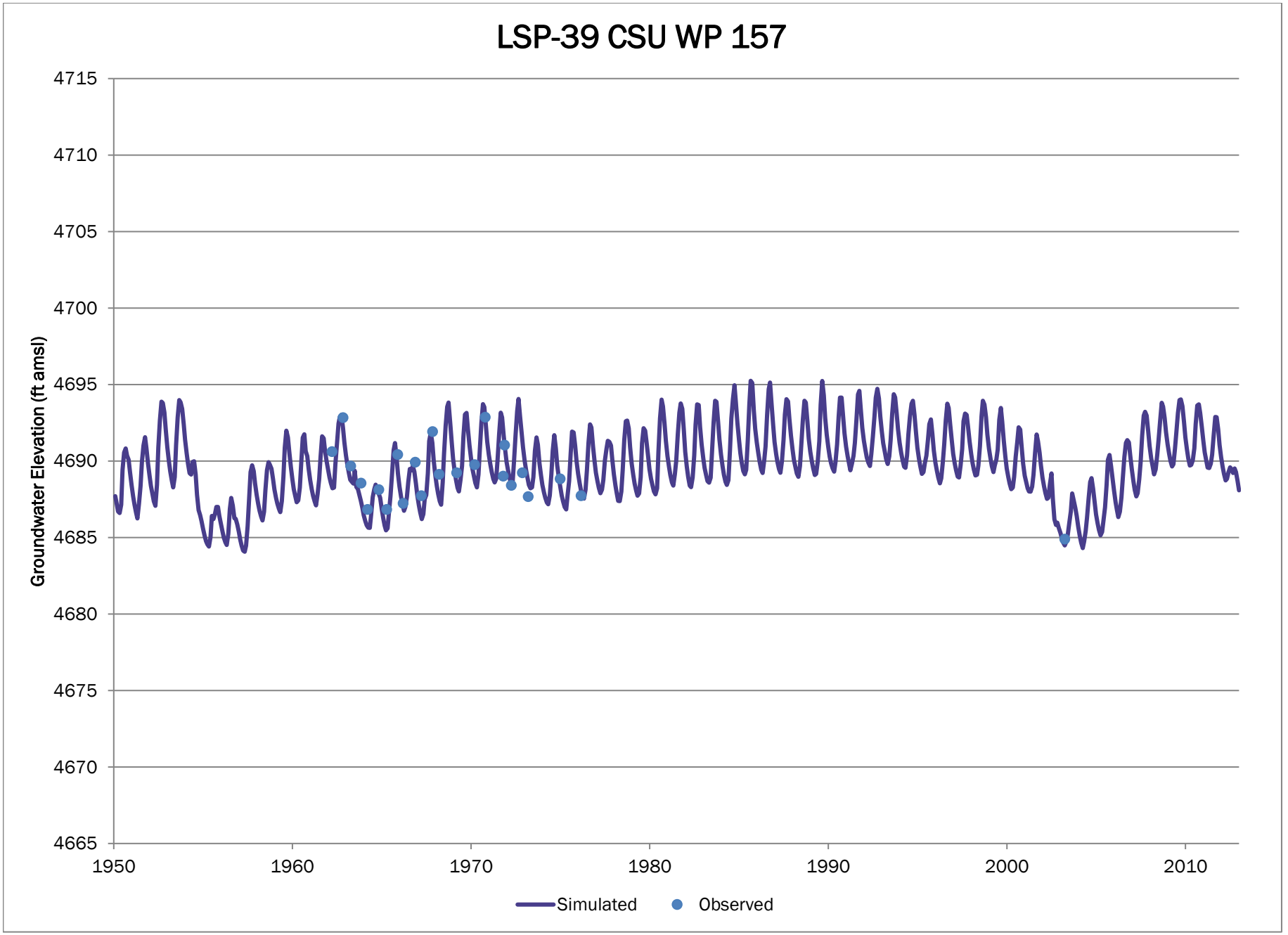

SB00406533AA CCWCD
Groundwater Elevation (ft amsl)
4780
4775
4770
4765
4760
4755
4750
4745
4740
4735
4730
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

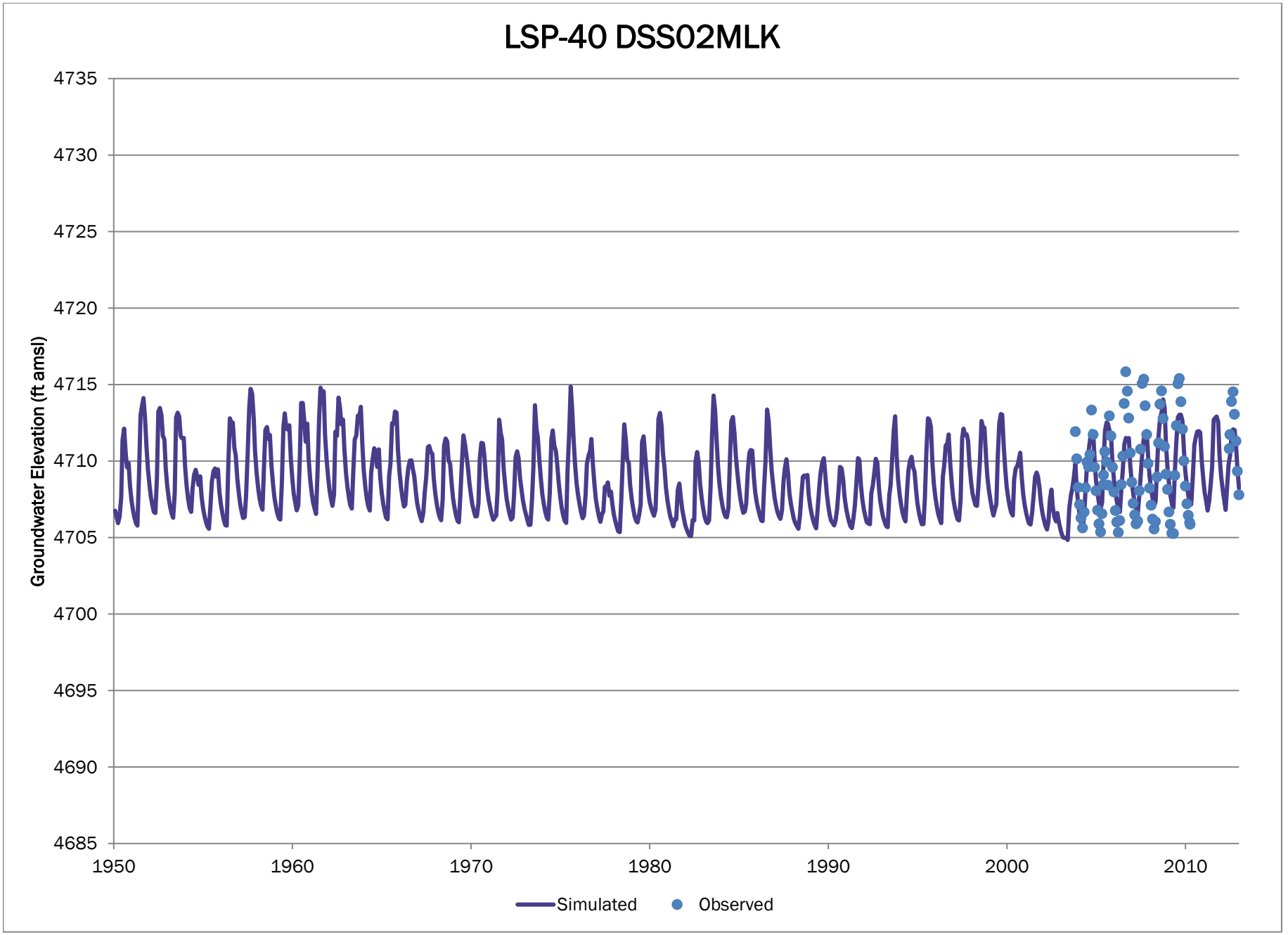

SB00406534AB CCWCD
Groundwater Elevation (ft amsl)
4760
4755
4750
4745
4740
4735
4730
4725
4720
4715
4710
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

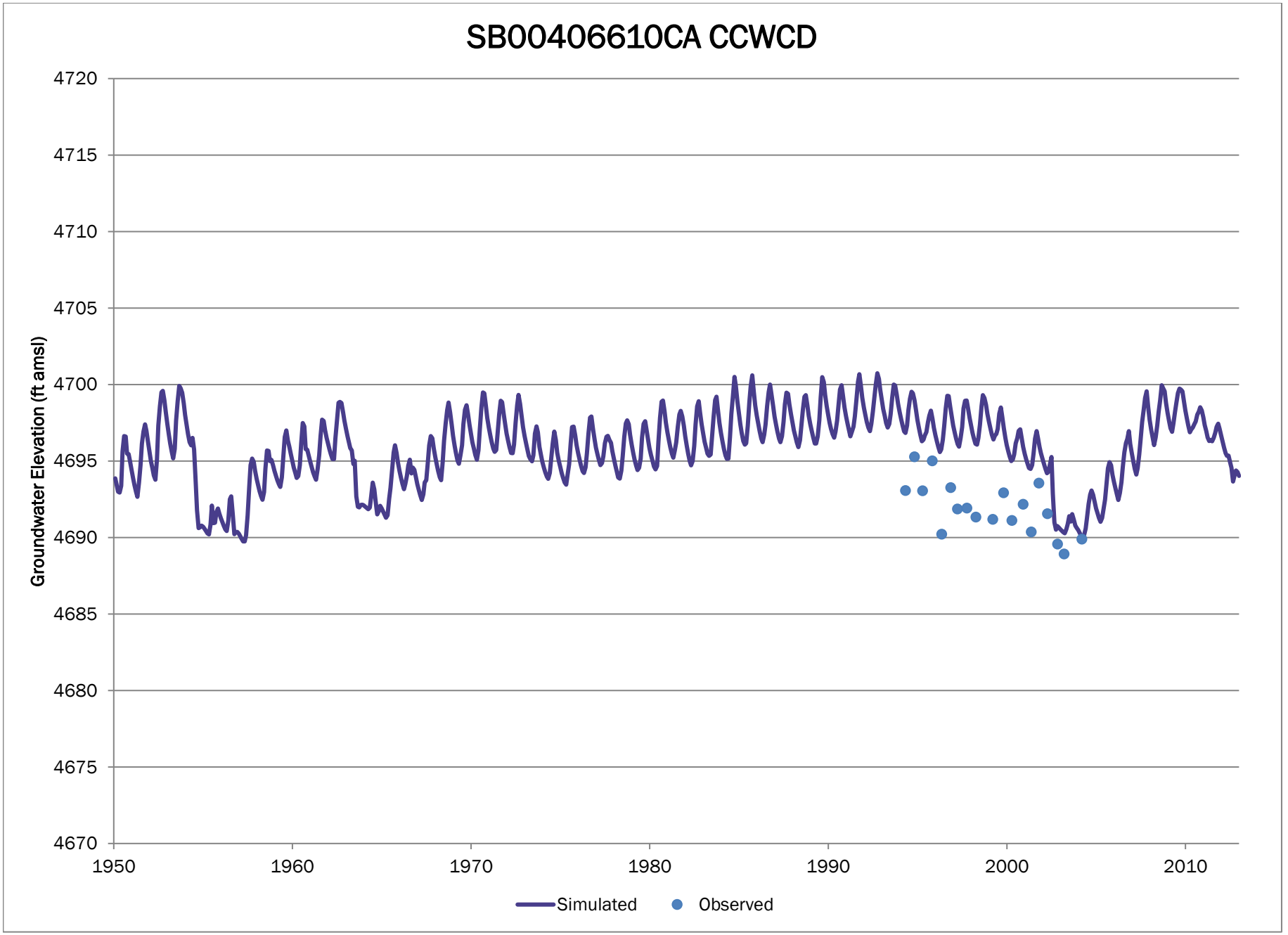

SB00406534BA CCWCD
Groundwater Elevation (ft amsl)
4760
4755
4750
4745
4740
4735
4730
4725
4720
4715
4710
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

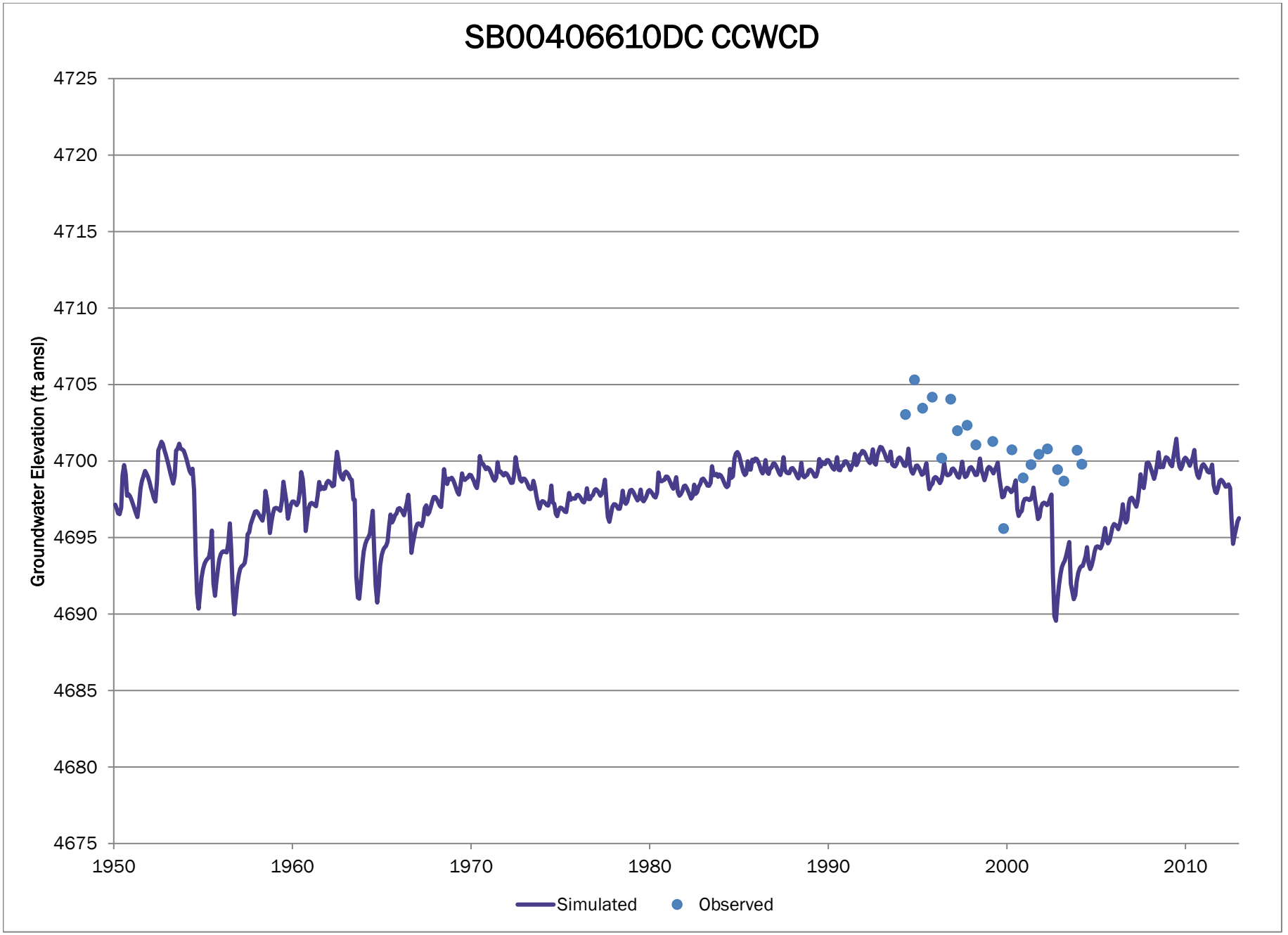

SB00406535BB CCWCD
Groundwater Elevation (ft amsl)
4755
4750
4745
4740
4735
4730
4725
4720
4715
4710
4705
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

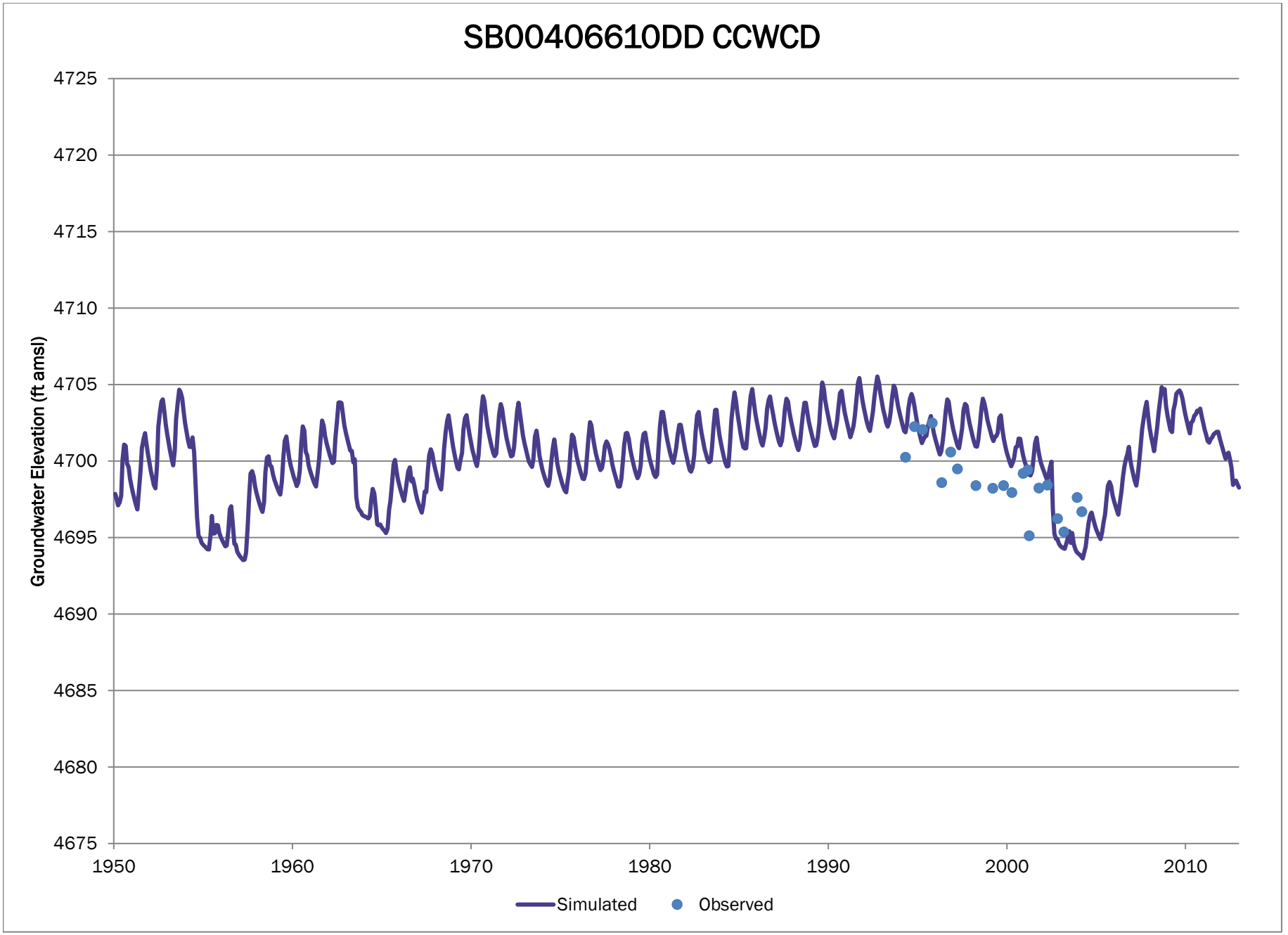

SB00406602CC CCWCD
Groundwater Elevation (ft amsl)
4710
4705
4700
4695
4690
4685
4680
4675
4670
4665
4660
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

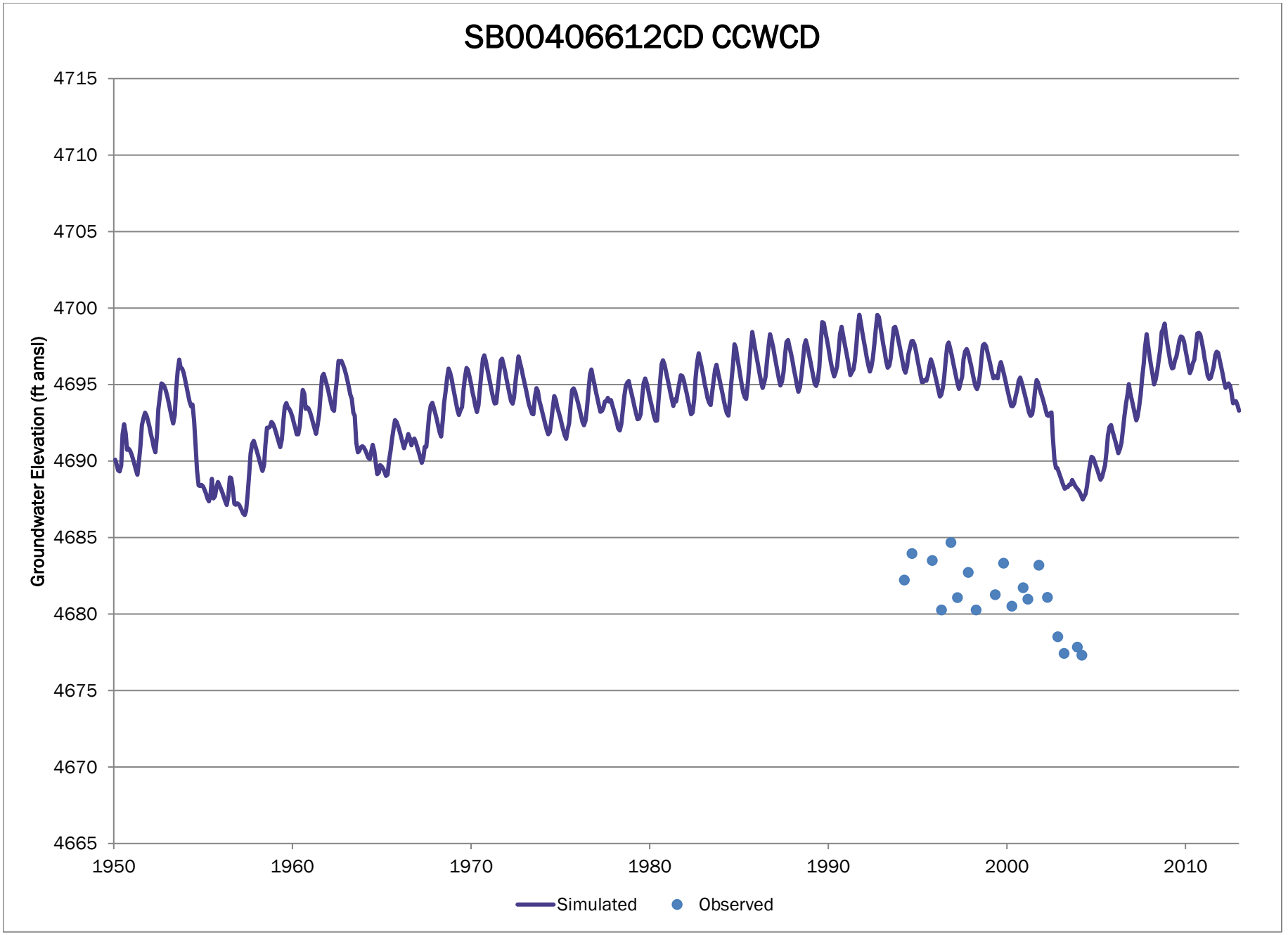

LSP-39 CSU WP 157
Groundwater Elevation (ft amsl)
4715
4710
4705
4700
4695
4690
4685
4680
4675
4670
4665
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

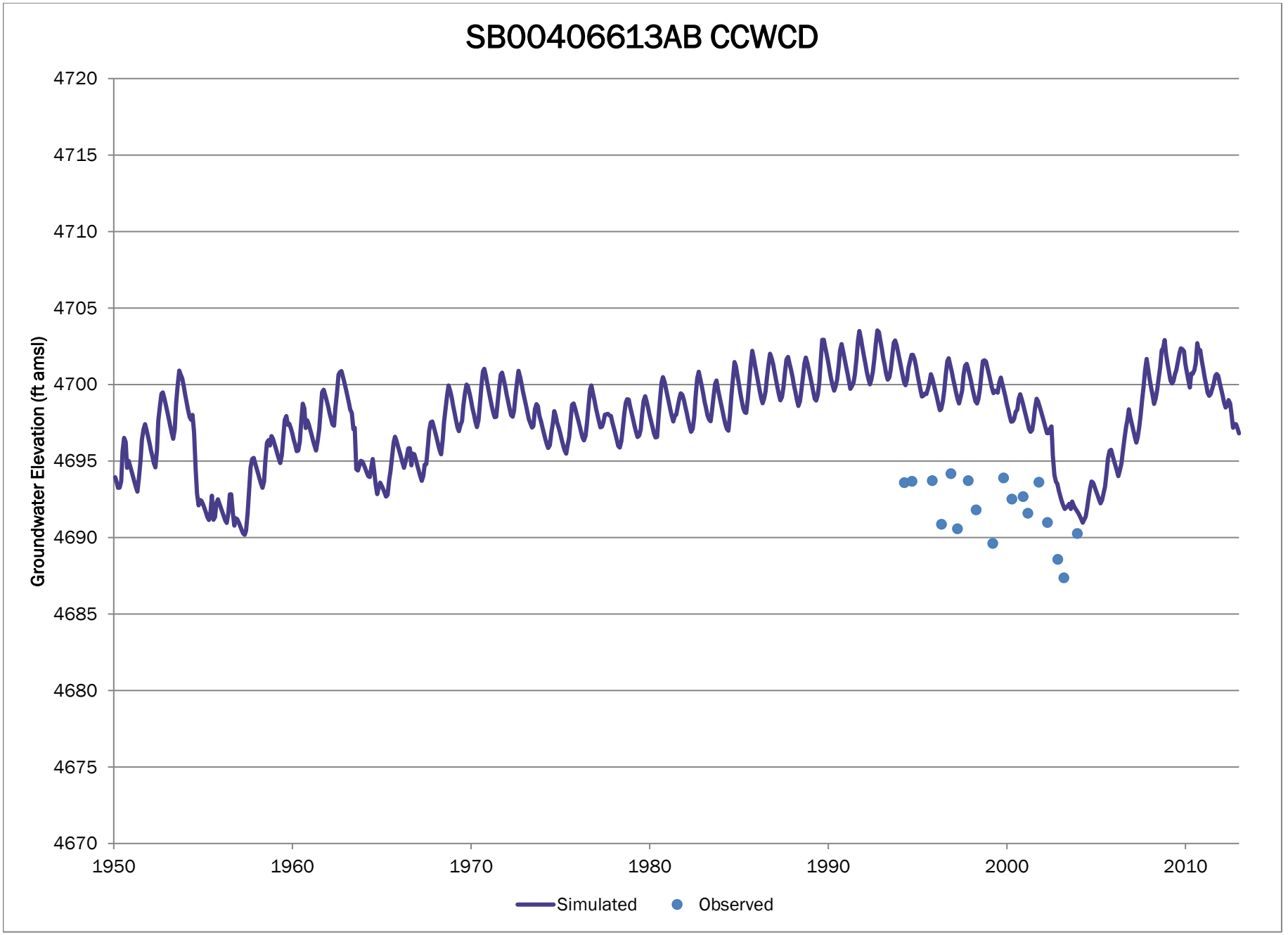

LSP-40 DSS02MLK
Groundwater Elevation (ft amsl)
4735
4730
4725
4720
4715
4710
4705
4700
4695
4690
4685
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

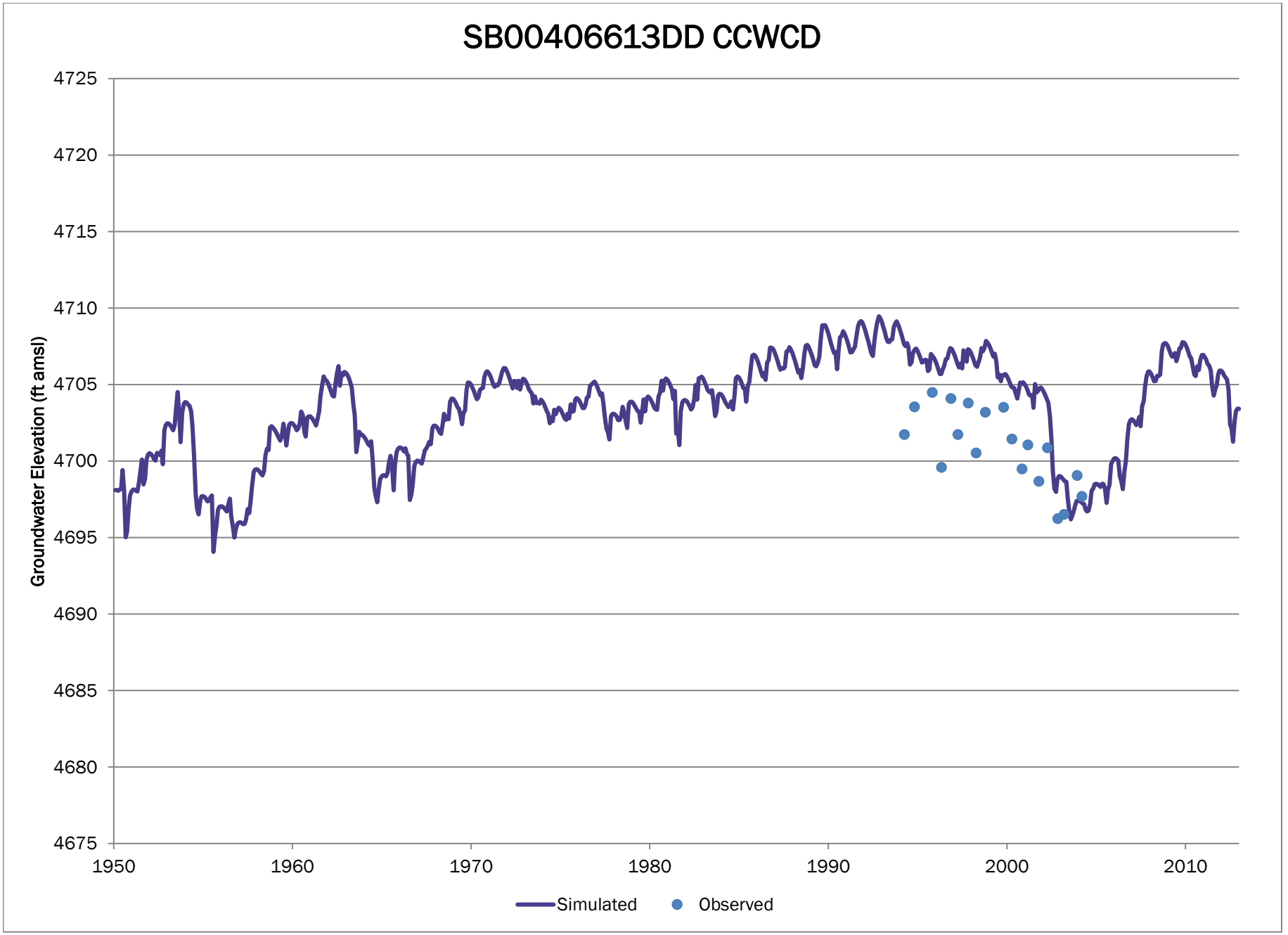

SB00406610CA CCWCD
Groundwater Elevation (ft amsl)
4720
4715
4710
4705
4700
4695
4690
4685
4680
4675
4670
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

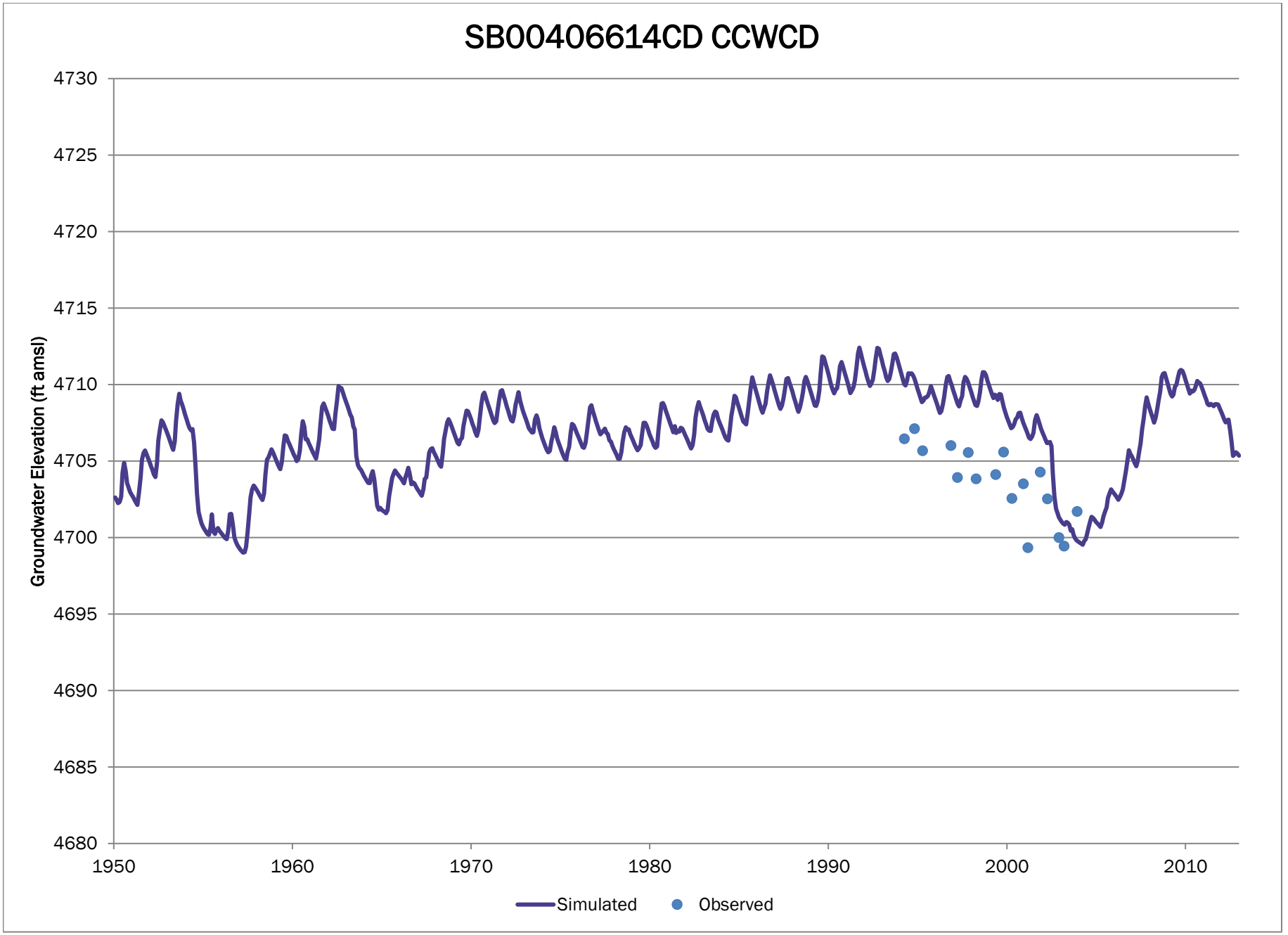

SB00406610DC CCWCD
Groundwater Elevation (ft amsl)
4725
4720
4715
4710
4705
4700
4695
4690
4685
4680
4675
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

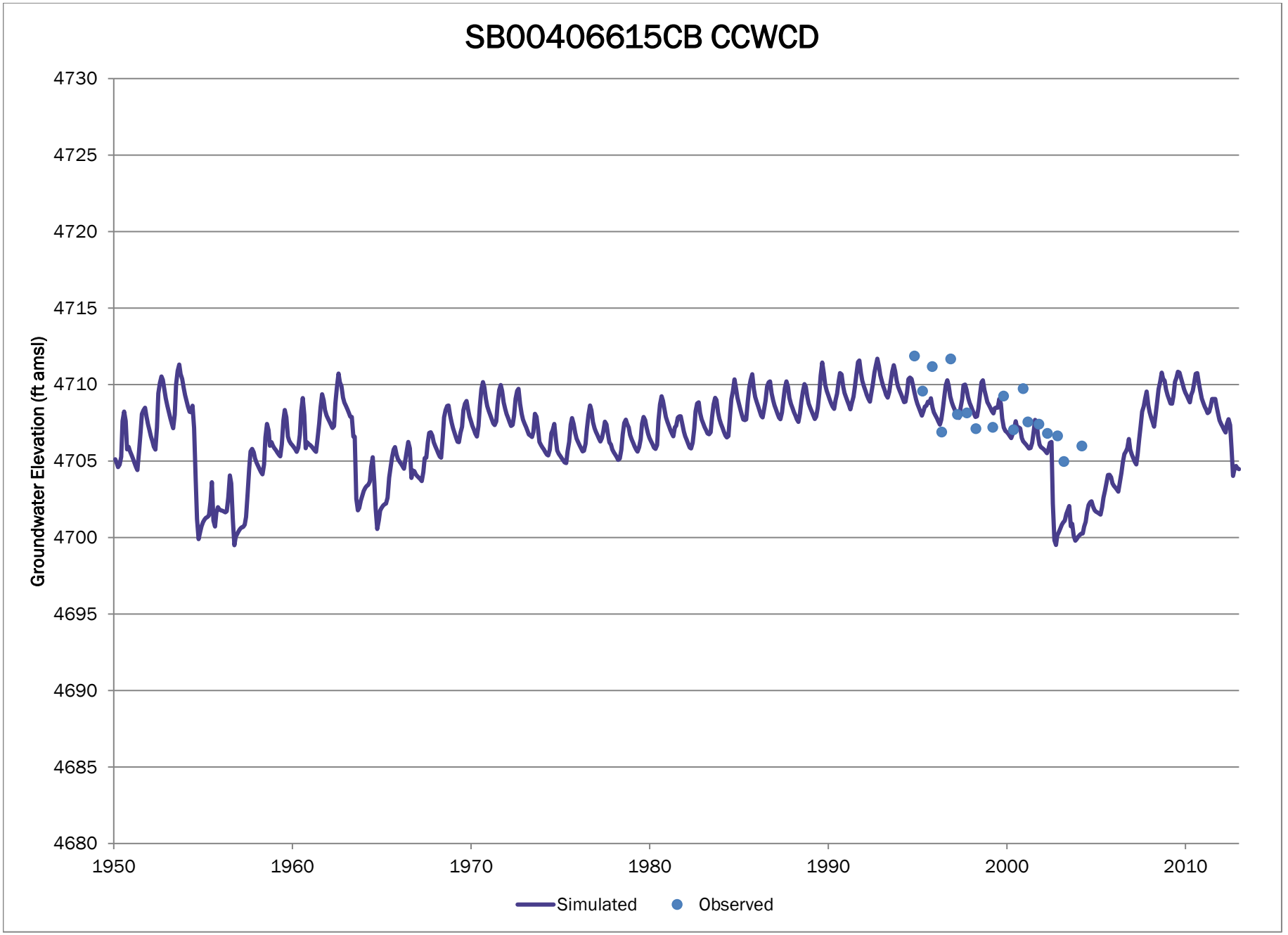

SB00406610DD CCWCD
Groundwater Elevation (ft amsl)
4725
4720
4715
4710
4705
4700
4695
4690
4685
4680
4675
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

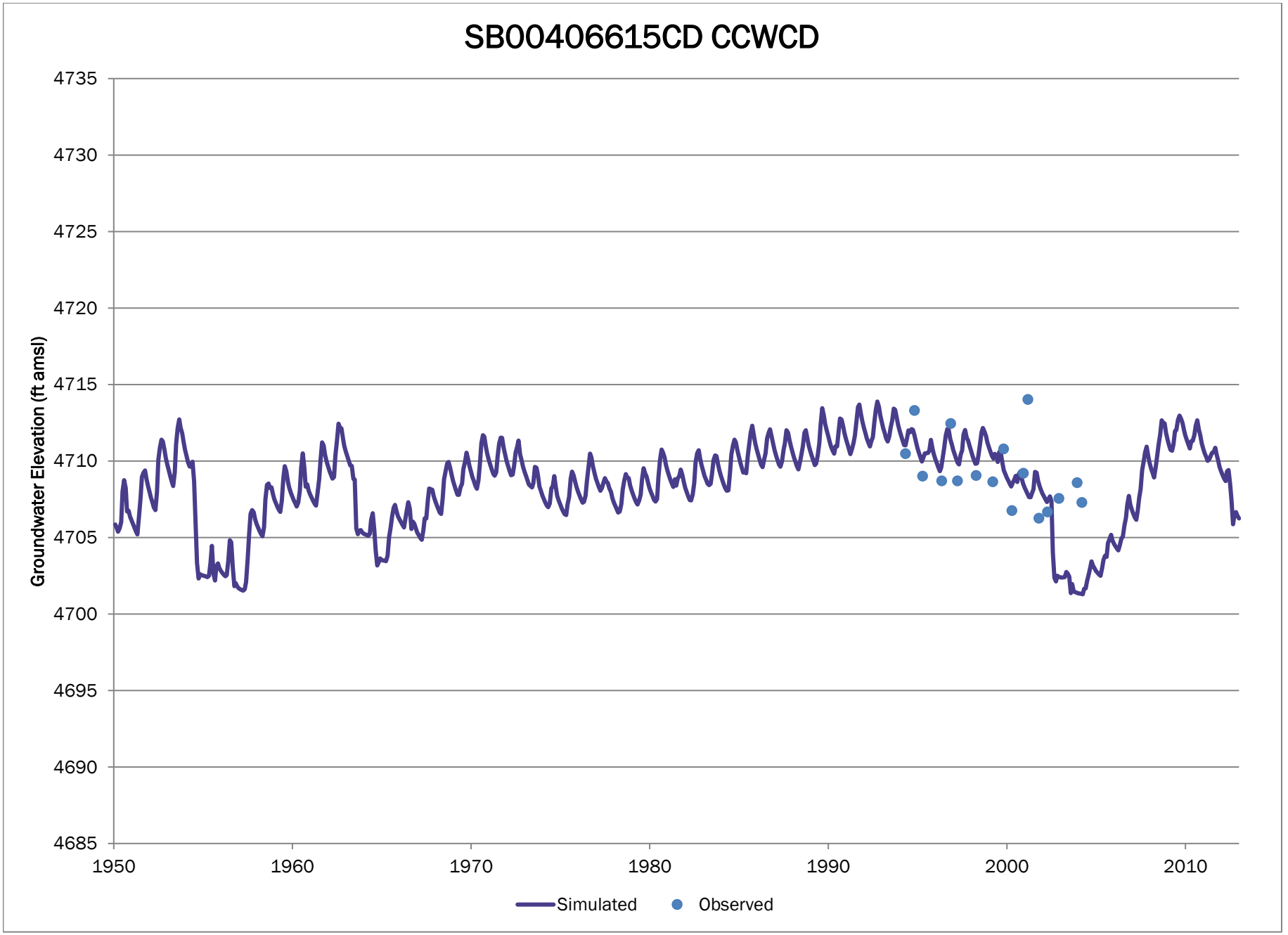

SB00406612CD CCWCD
Groundwater Elevation (ft amsl)
4715
4710
4705
4700
4695
4690
4685
4680
4675
4670
4665
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

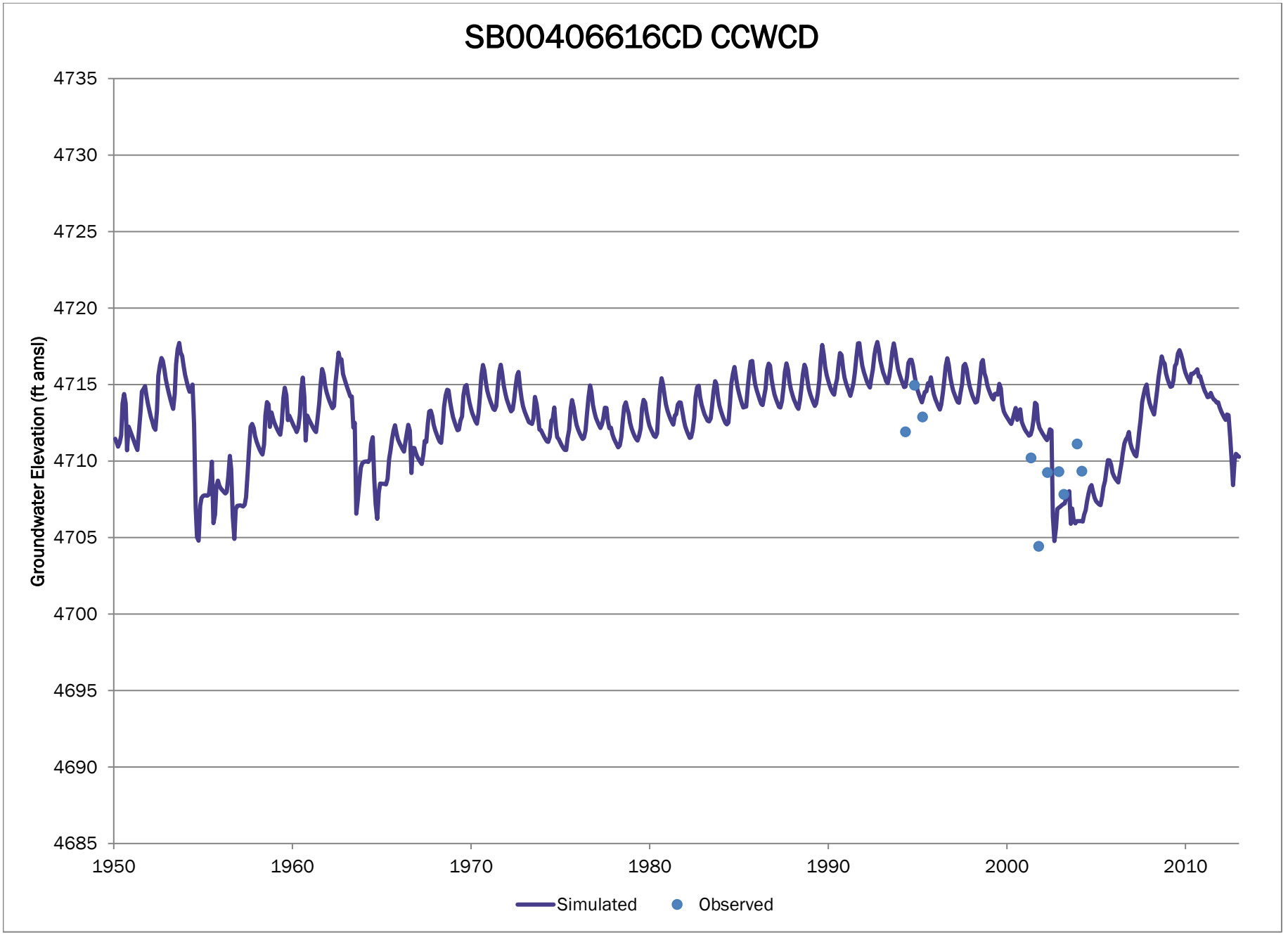

SB00406613AB CCWCD
Groundwater Elevation (ft amsl)
4720
4715
4710
4705
4700
4695
4690
4685
4680
4675
4670
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

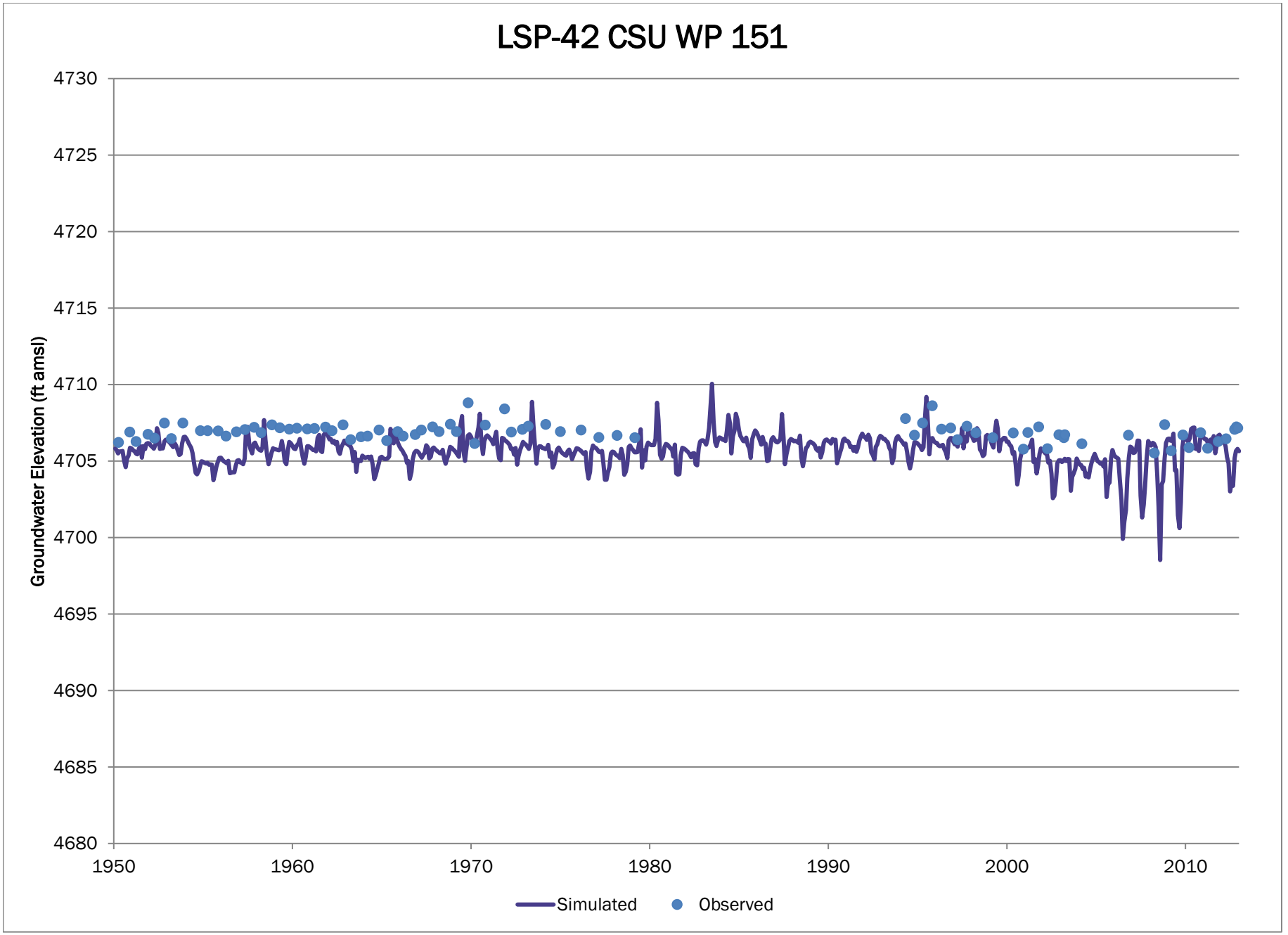

SB00406613DD CCWCD
Groundwater Elevation (ft amsl)
4725
4720
4715
4710
4705
4700
4695
4690
4685
4680
4675
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

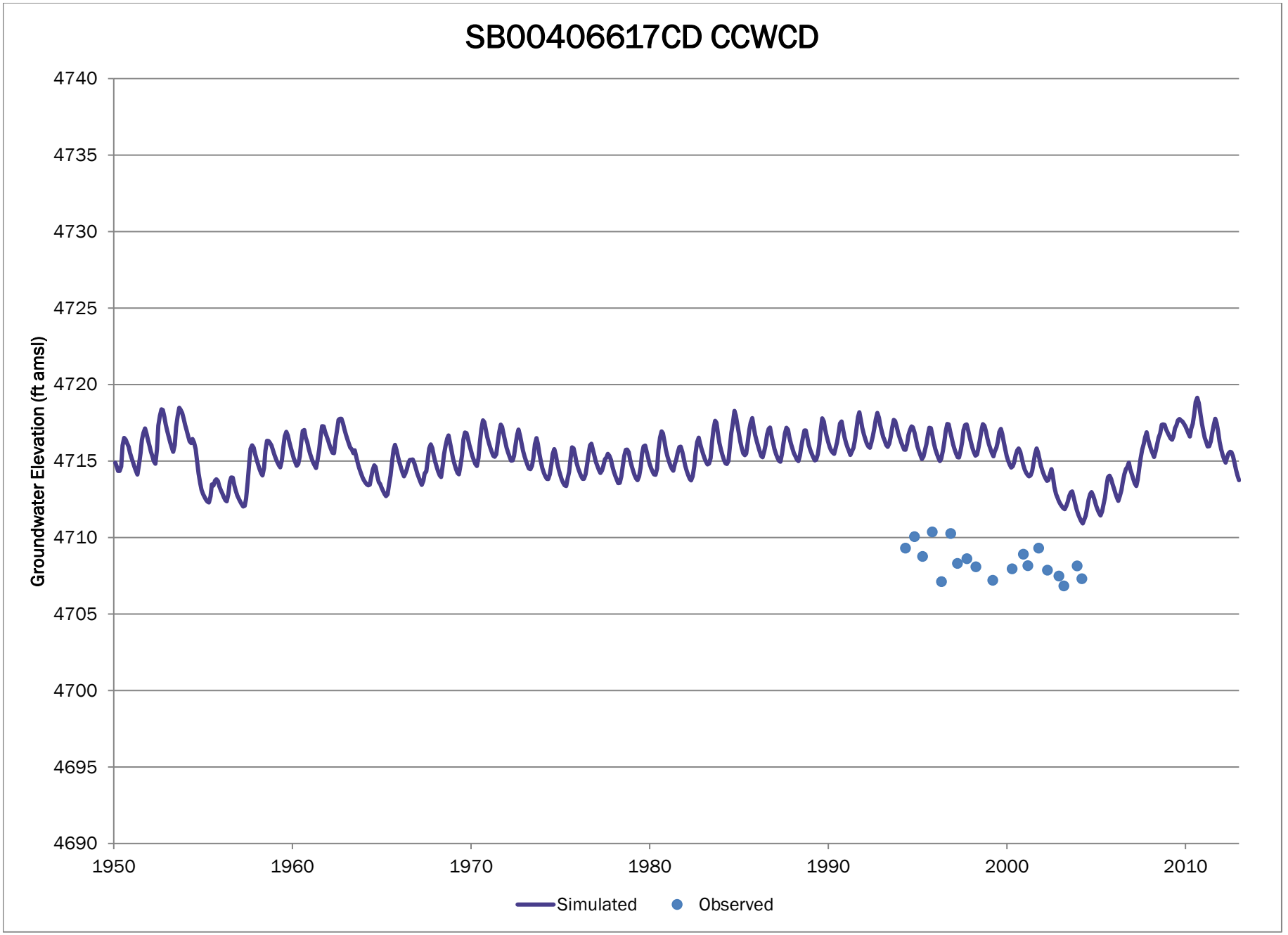

SB00406614CD CCWCD
Groundwater Elevation (ft amsl)
4730
4725
4720
4715
4710
4705
4700
4695
4690
4685
4680
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

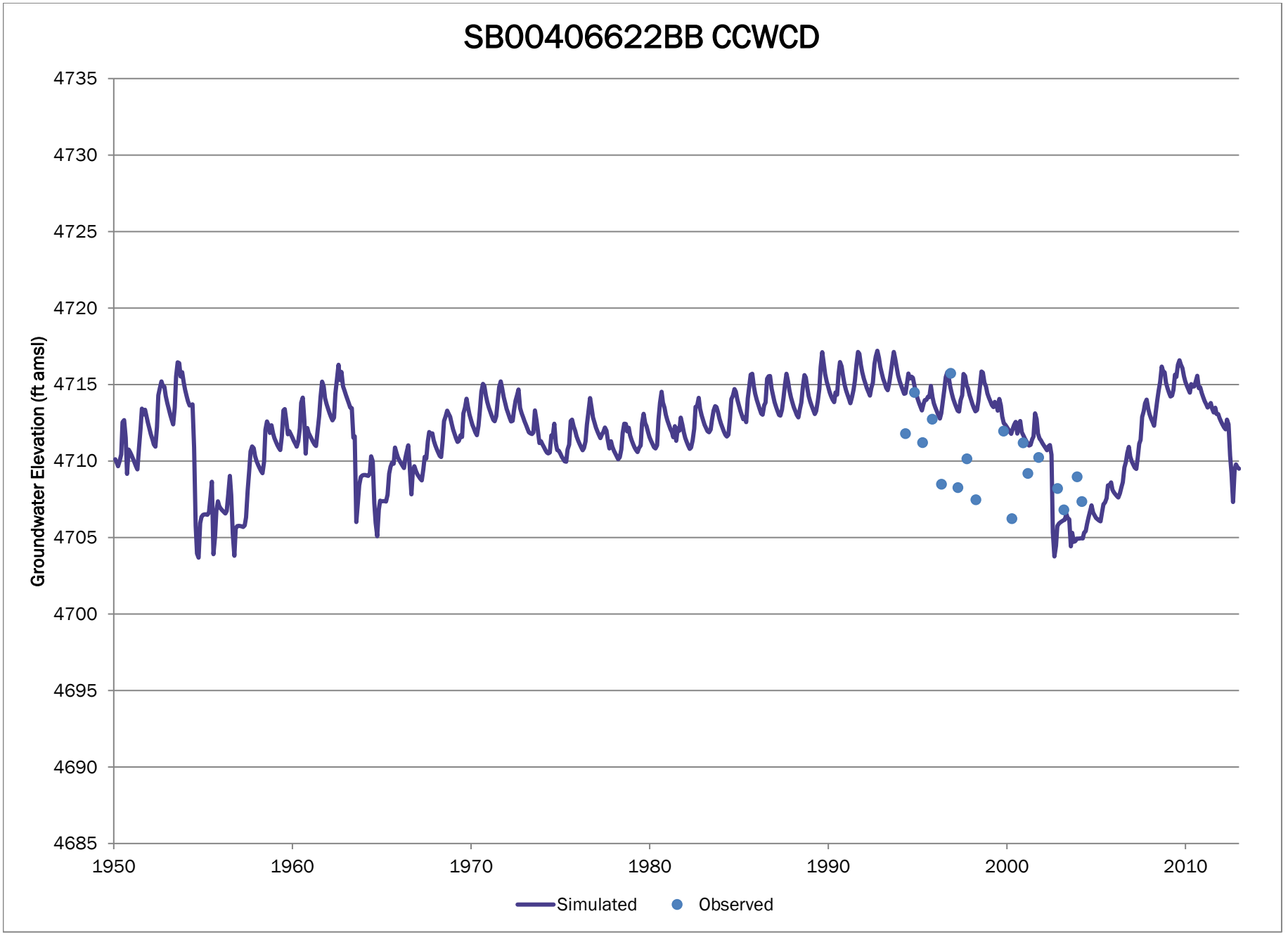

SB00406615CB CCWCD
Groundwater Elevation (ft amsl)
4730
4725
4720
4715
4710
4705
4700
4695
4690
4685
4680
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

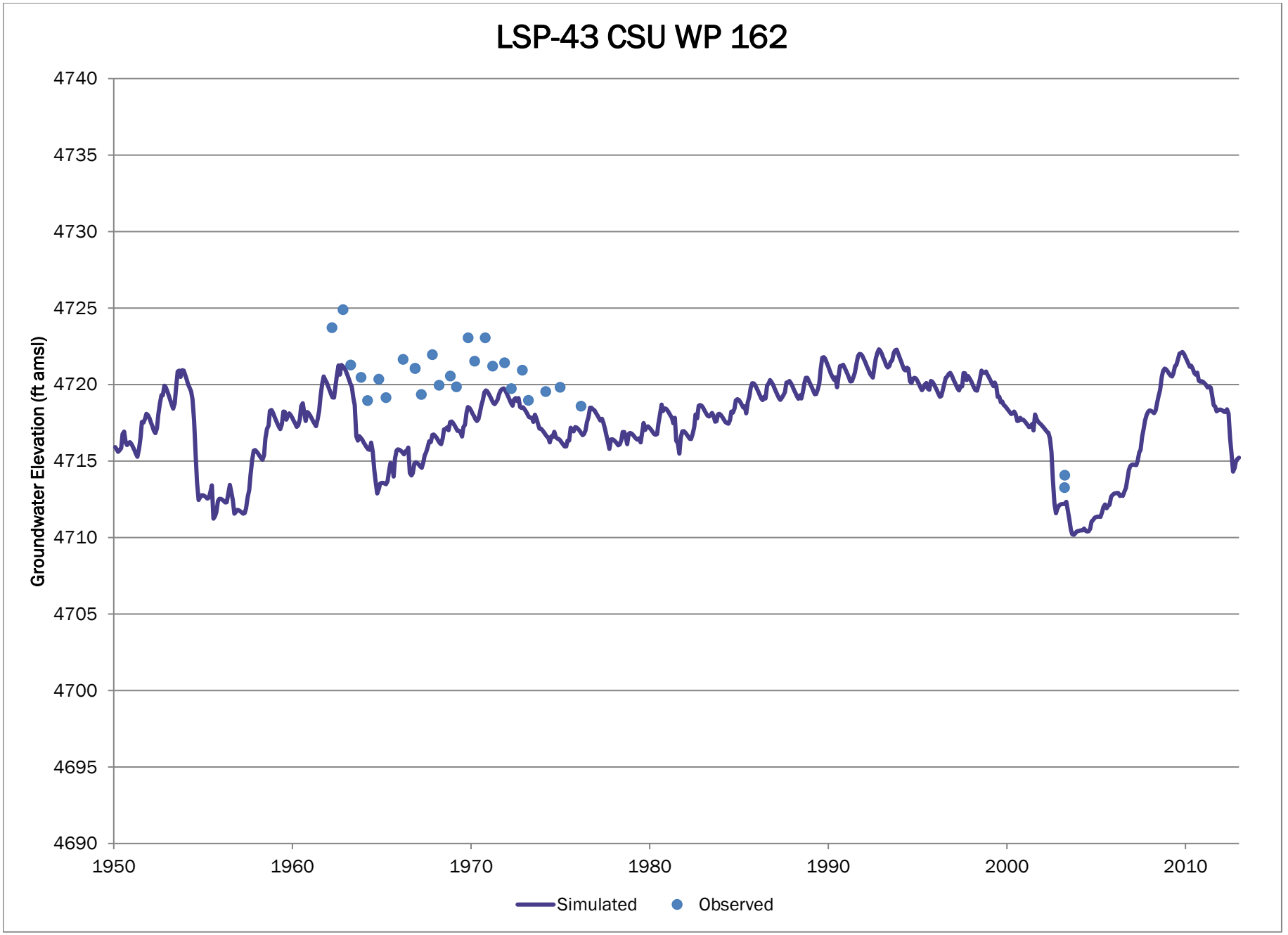

SB00406615CD CCWCD
Groundwater Elevation (ft amsl)
4735
4730
4725
4720
4715
4710
4705
4700
4695
4690
4685
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

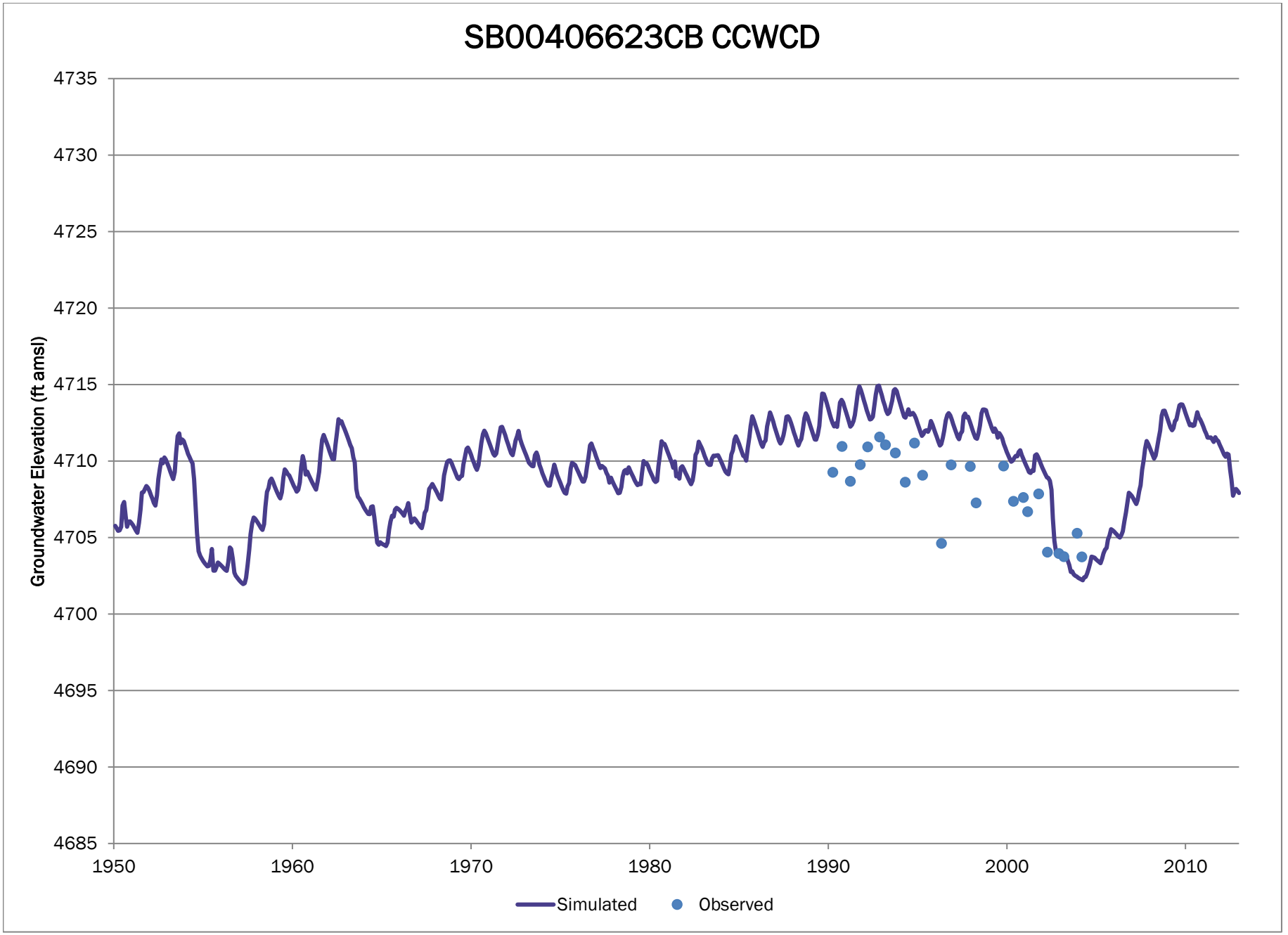

SB00406616CD CCWCD
Groundwater Elevation (ft amsl)
4735
4730
4725
4720
4715
4710
4705
4700
4695
4690
4685
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

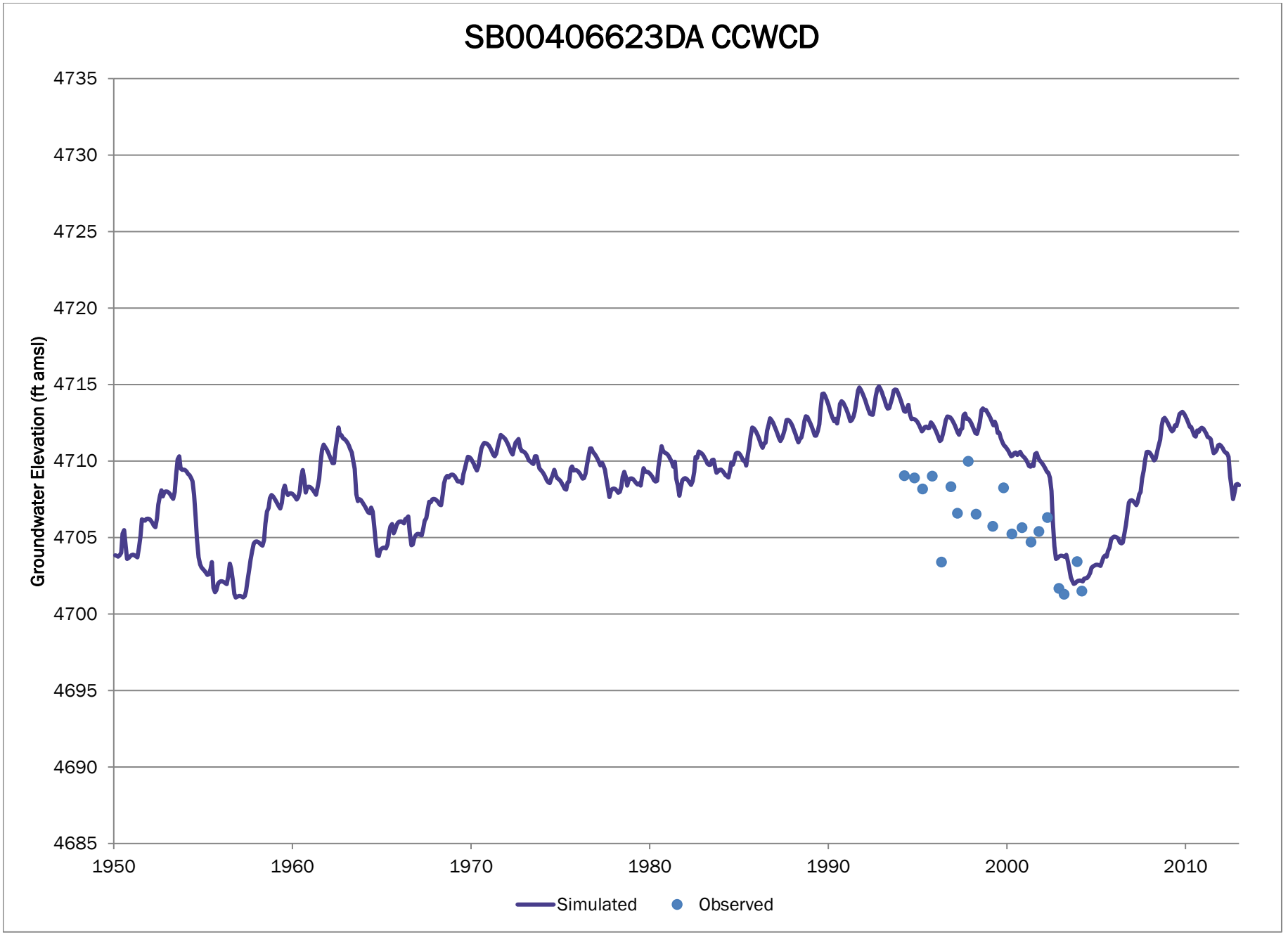

LSP-42 CSU WP 151
Groundwater Elevation (ft amsl)
4730
4725
4720
4715
4710
4705
4700
4695
4690
4685
4680
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

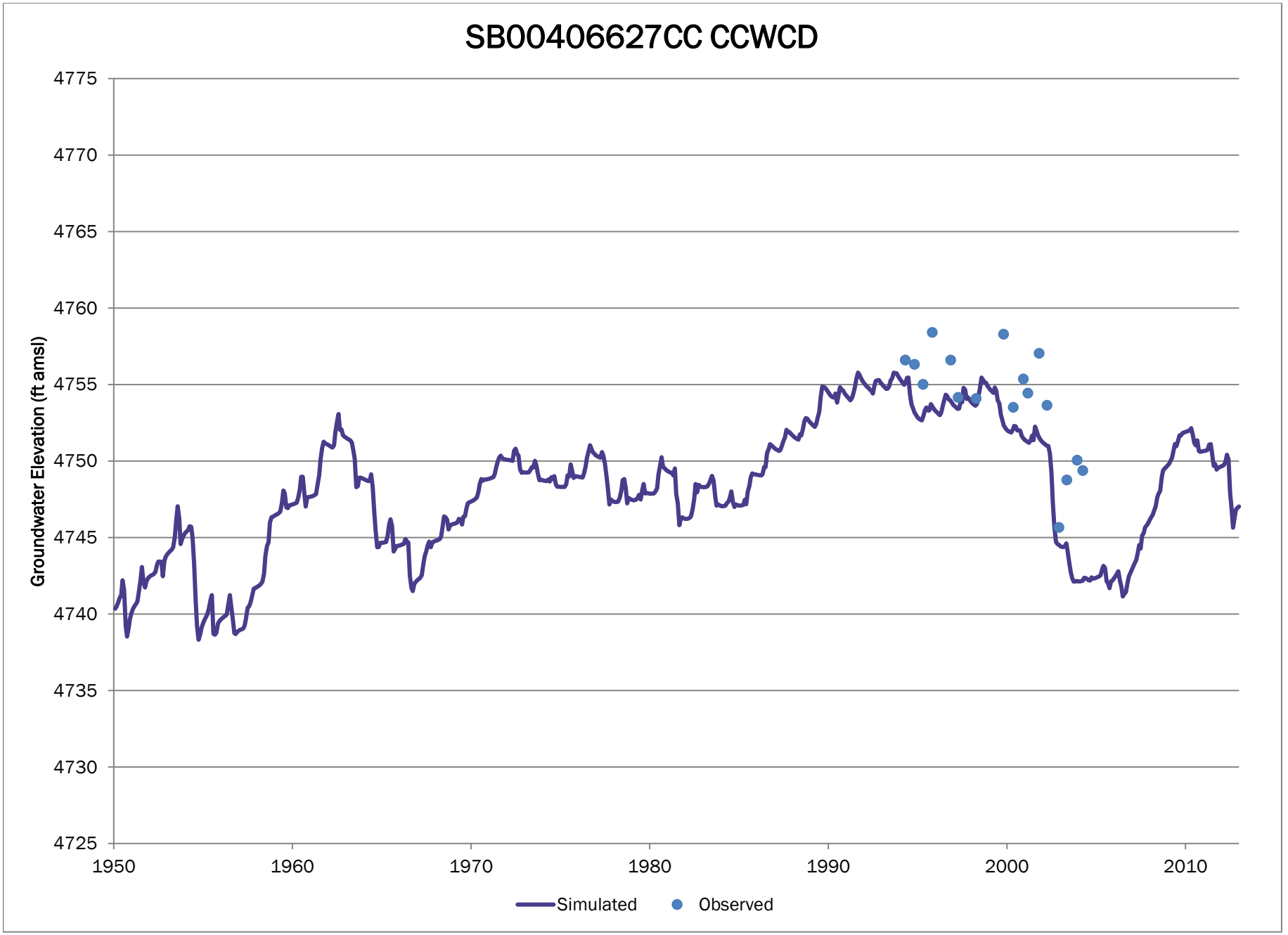

SB00406617CD CCWCD
Groundwater Elevation (ft amsl)
4740
4735
4730
4725
4720
4715
4710
4705
4700
4695
4690
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

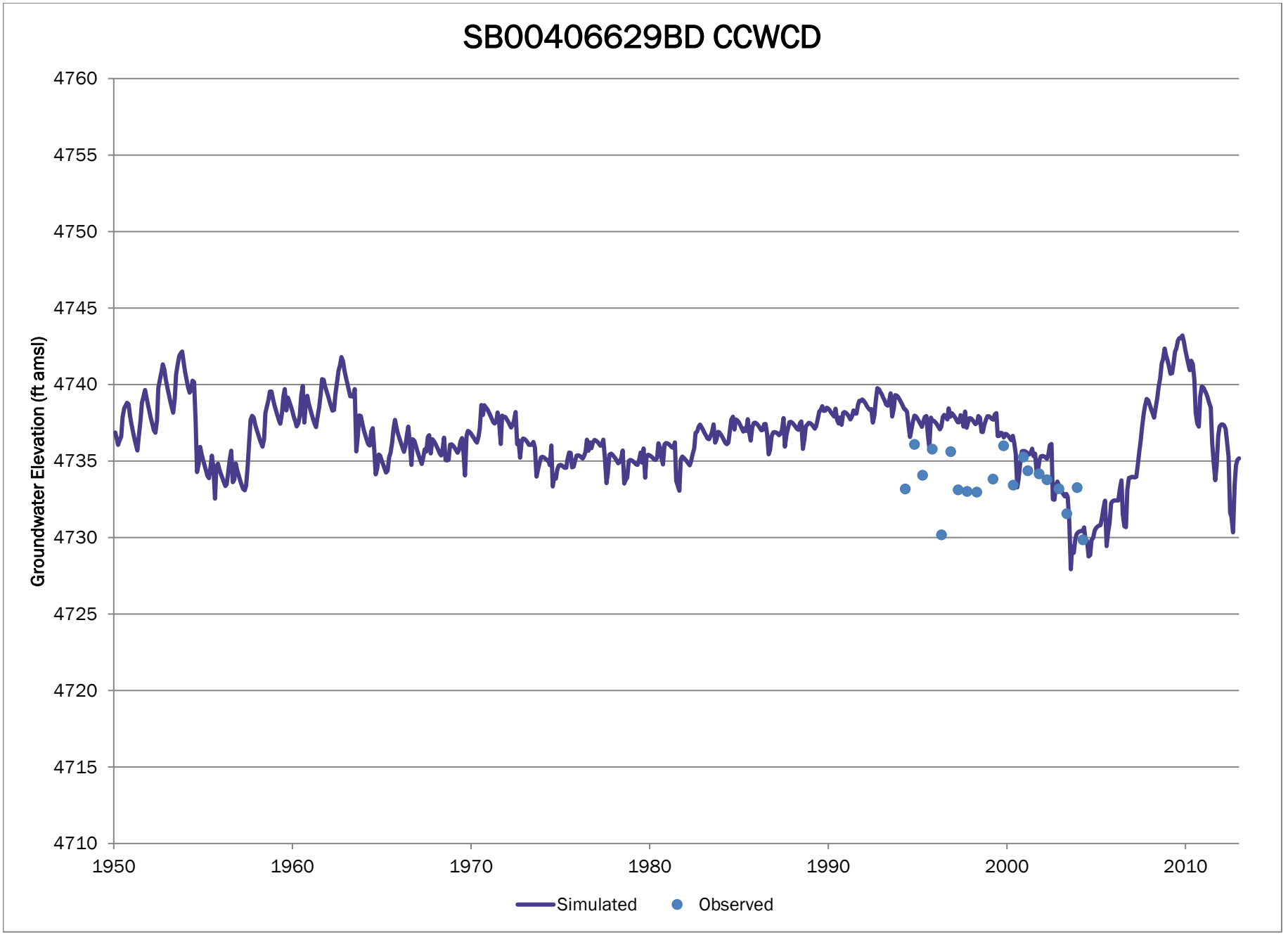

SB00406622BB CCWCD
Groundwater Elevation (ft amsl)
4735
4730
4725
4720
4715
4710
4705
4700
4695
4690
4685
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

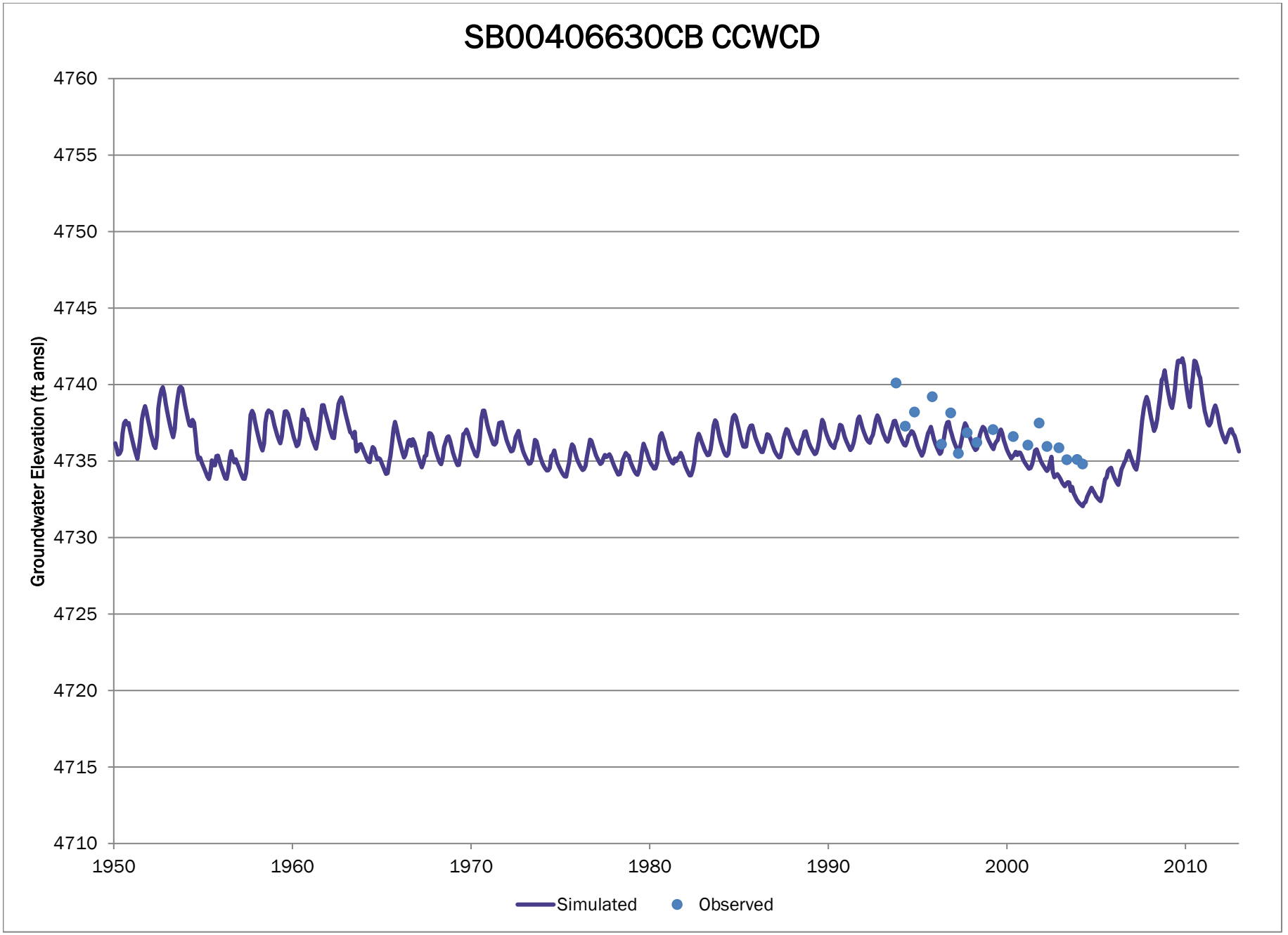

LSP-43 CSU WP 162
Groundwater Elevation (ft amsl)
4740
4735
4730
4725
4720
4715
4710
4705
4700
4695
4690
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

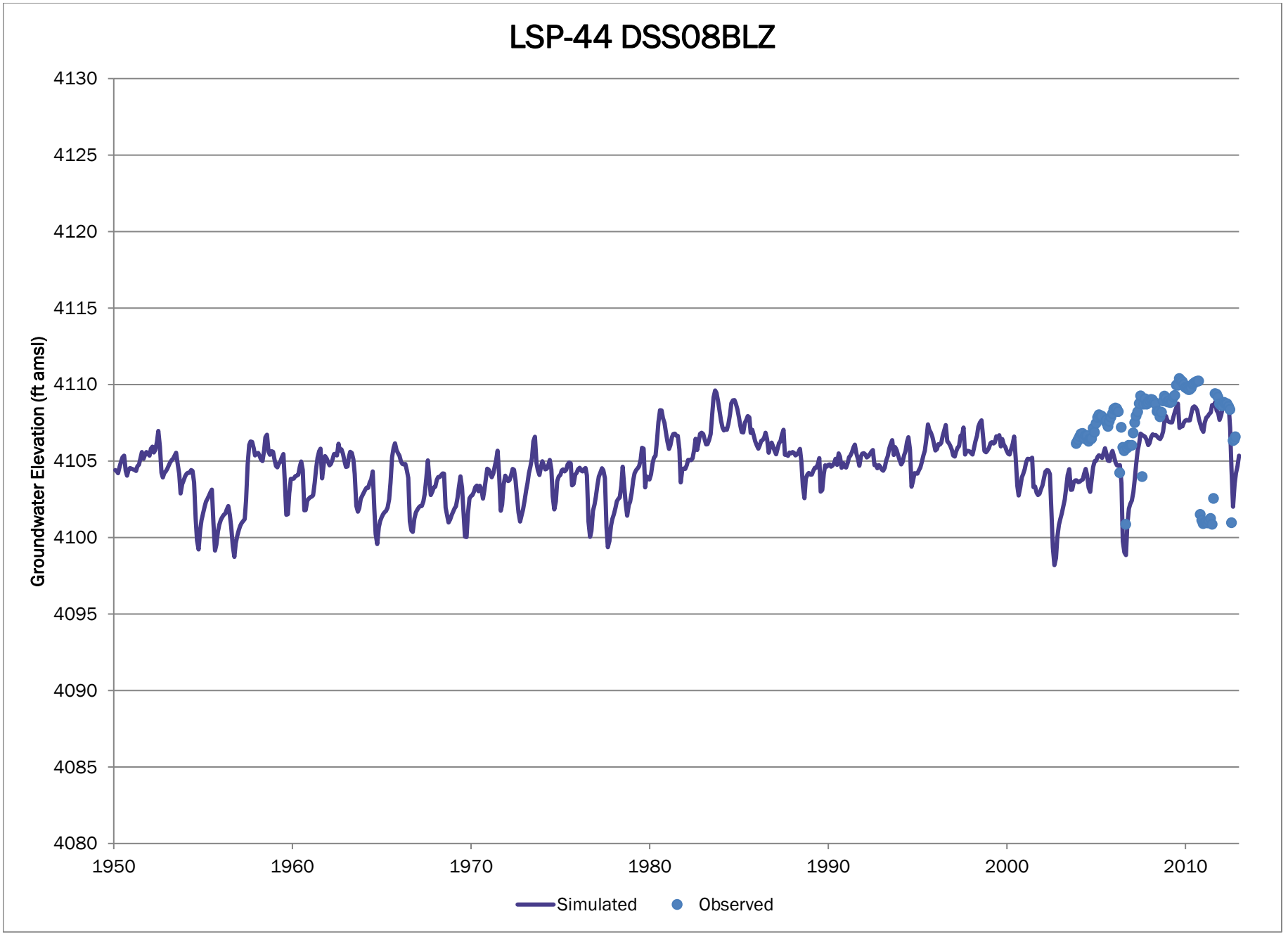

SB00406623CB CCWCD
Groundwater Elevation (ft amsl)
4735
4730
4725
4720
4715
4710
4705
4700
4695
4690
4685
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

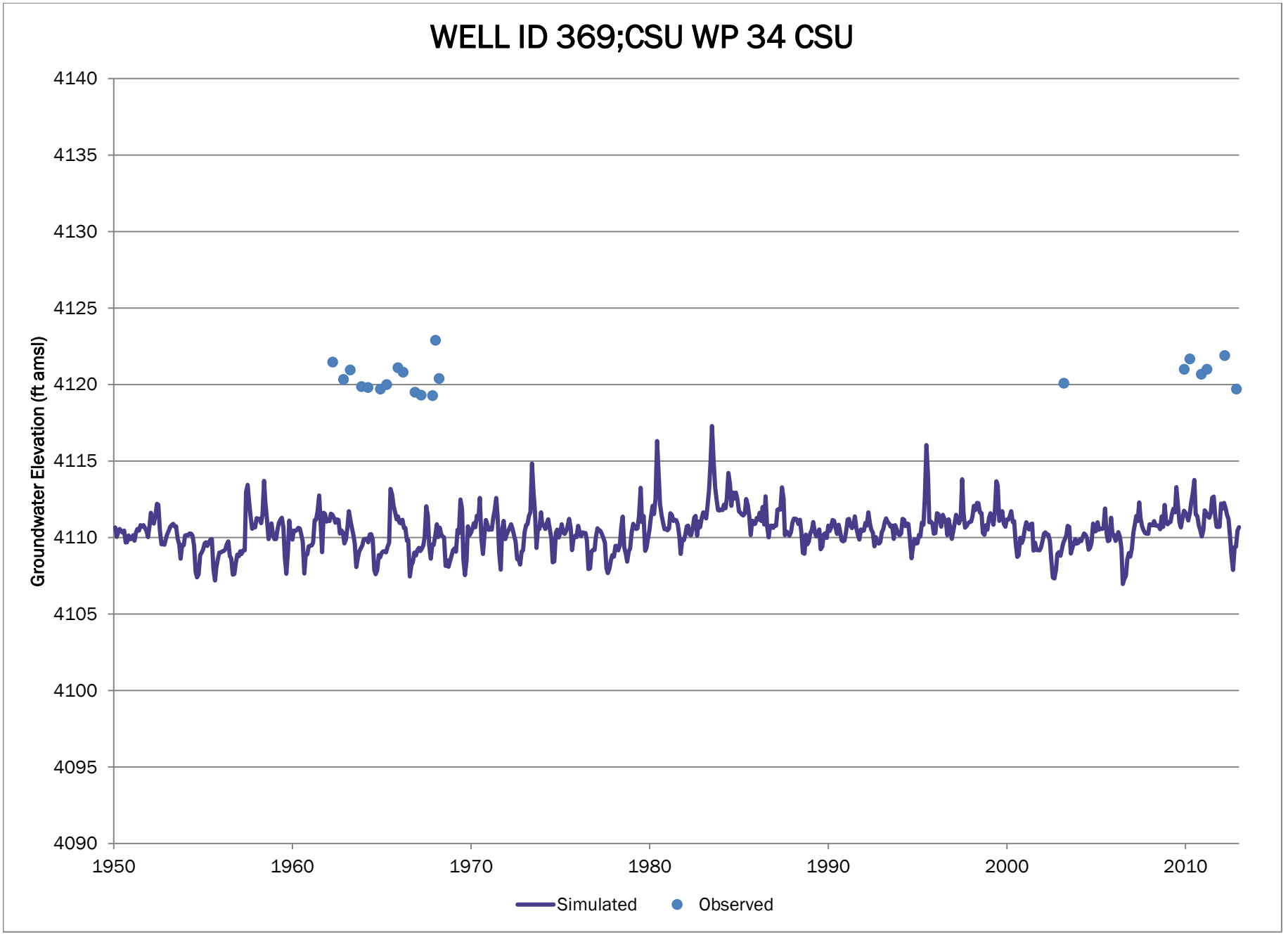

SB00406623DA CCWCD
Groundwater Elevation (ft amsl)
4735
4730
4725
4720
4715
4710
4705
4700
4695
4690
4685
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

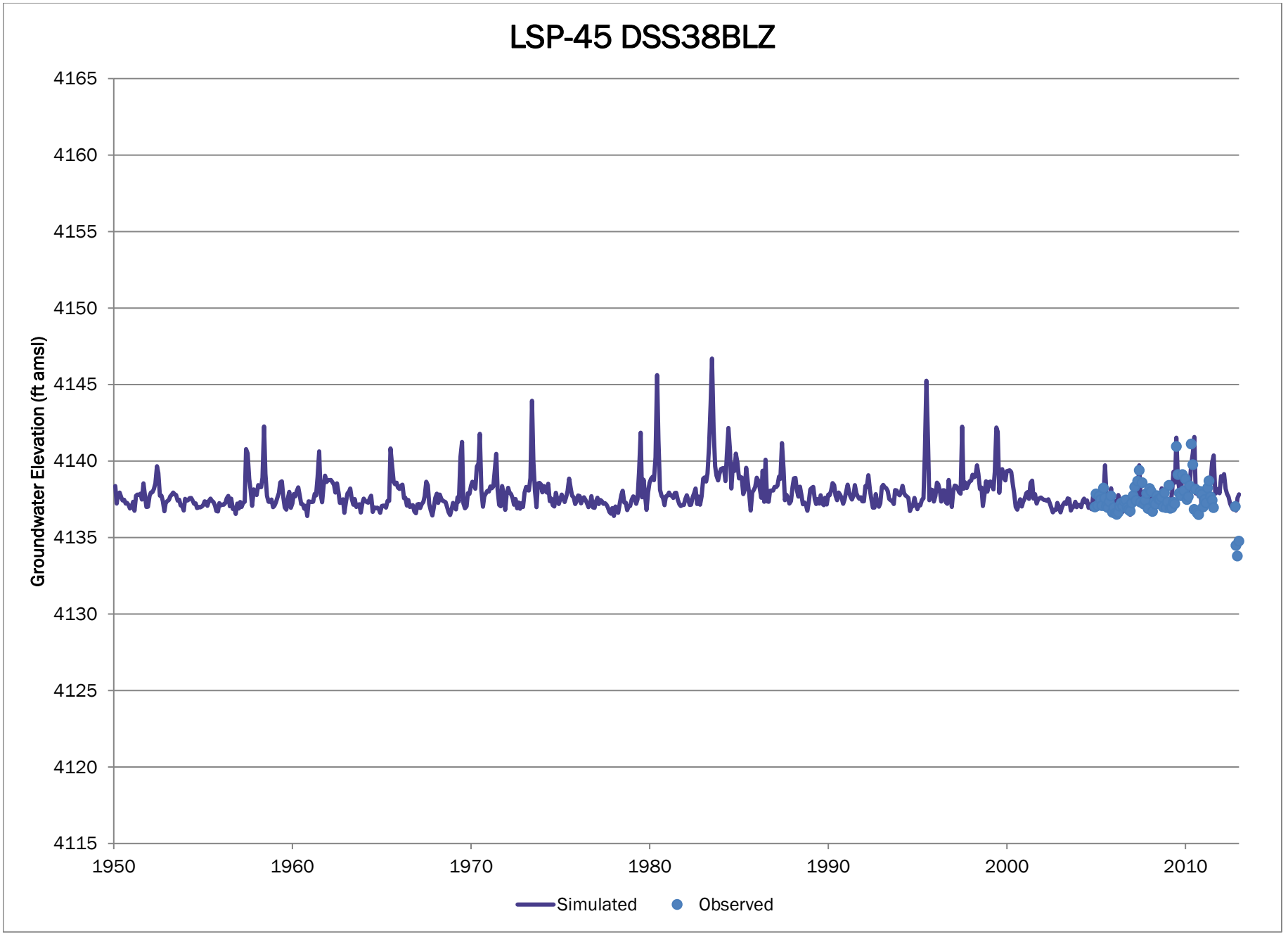

SB00406627CC CCWCD
Groundwater Elevation (ft amsl)
4775
4770
4765
4760
4755
4750
4745
4740
4735
4730
4725
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

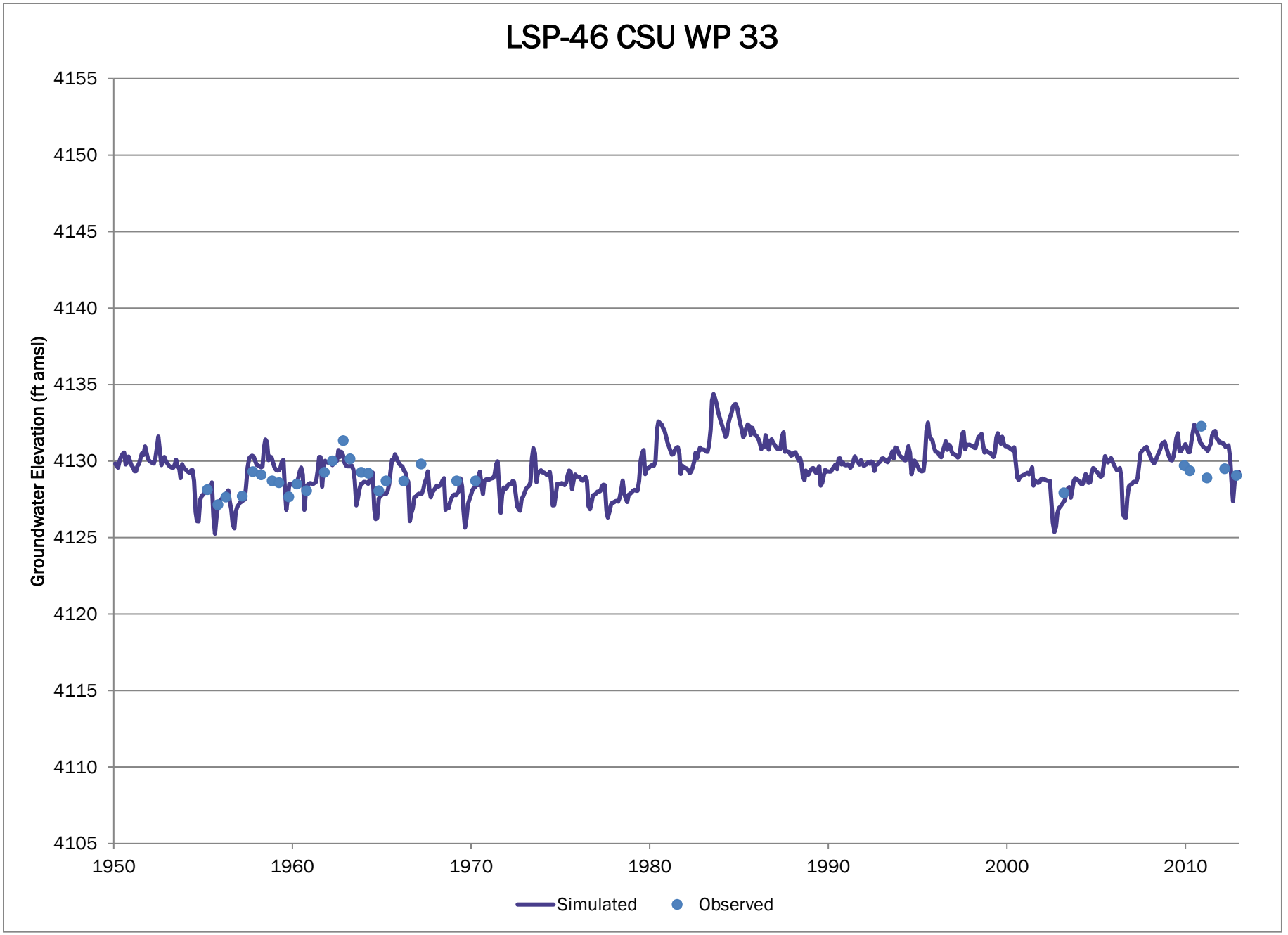

SB00406629BD CCWCD
Groundwater Elevation (ft amsl)
4760
4755
4750
4745
4740
4735
4730
4725
4720
4715
4710
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

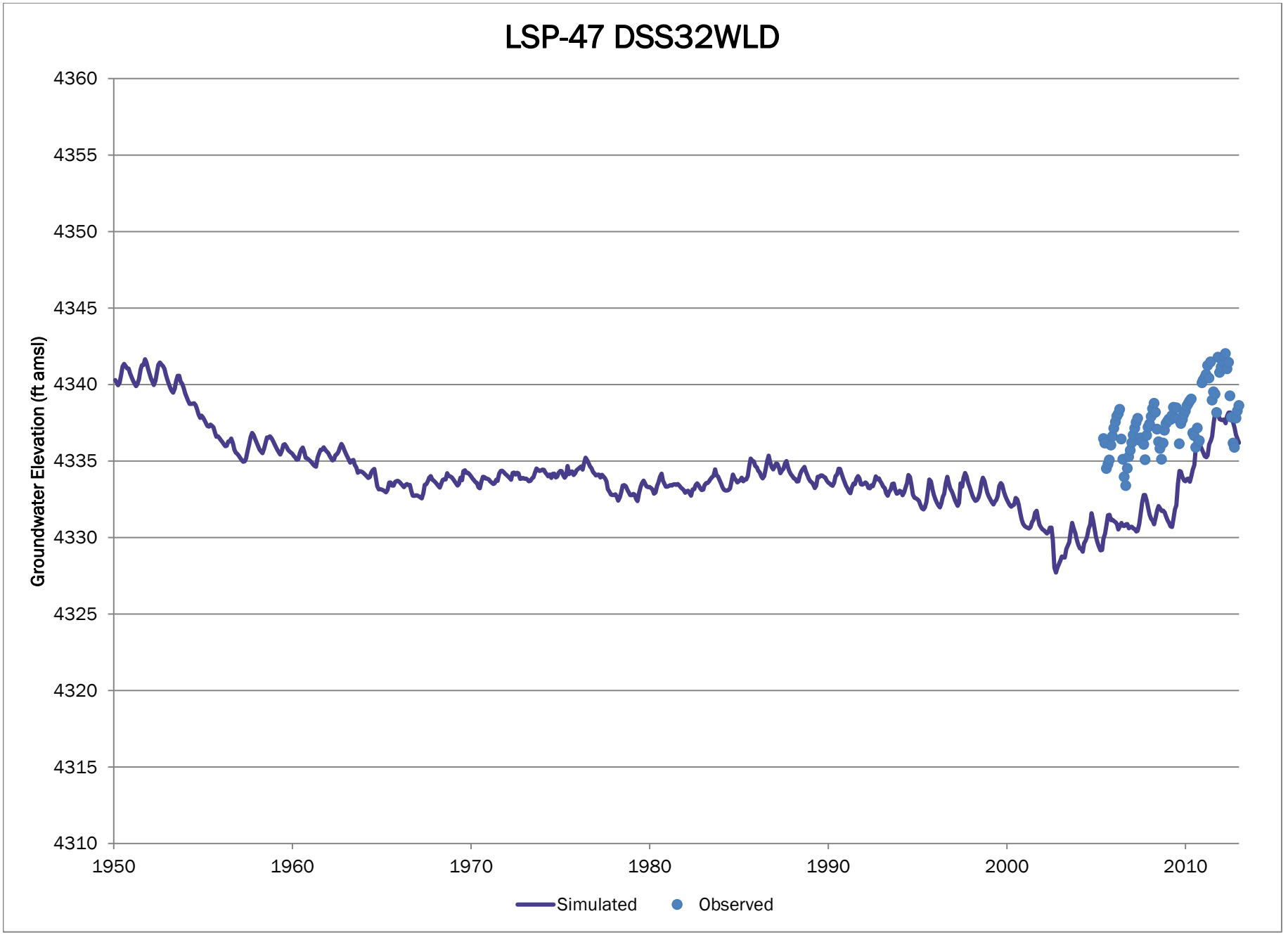

SB00406630CB CCWCD
Groundwater Elevation (ft amsl)
4760
4755
4750
4745
4740
4735
4730
4725
4720
4715
4710
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

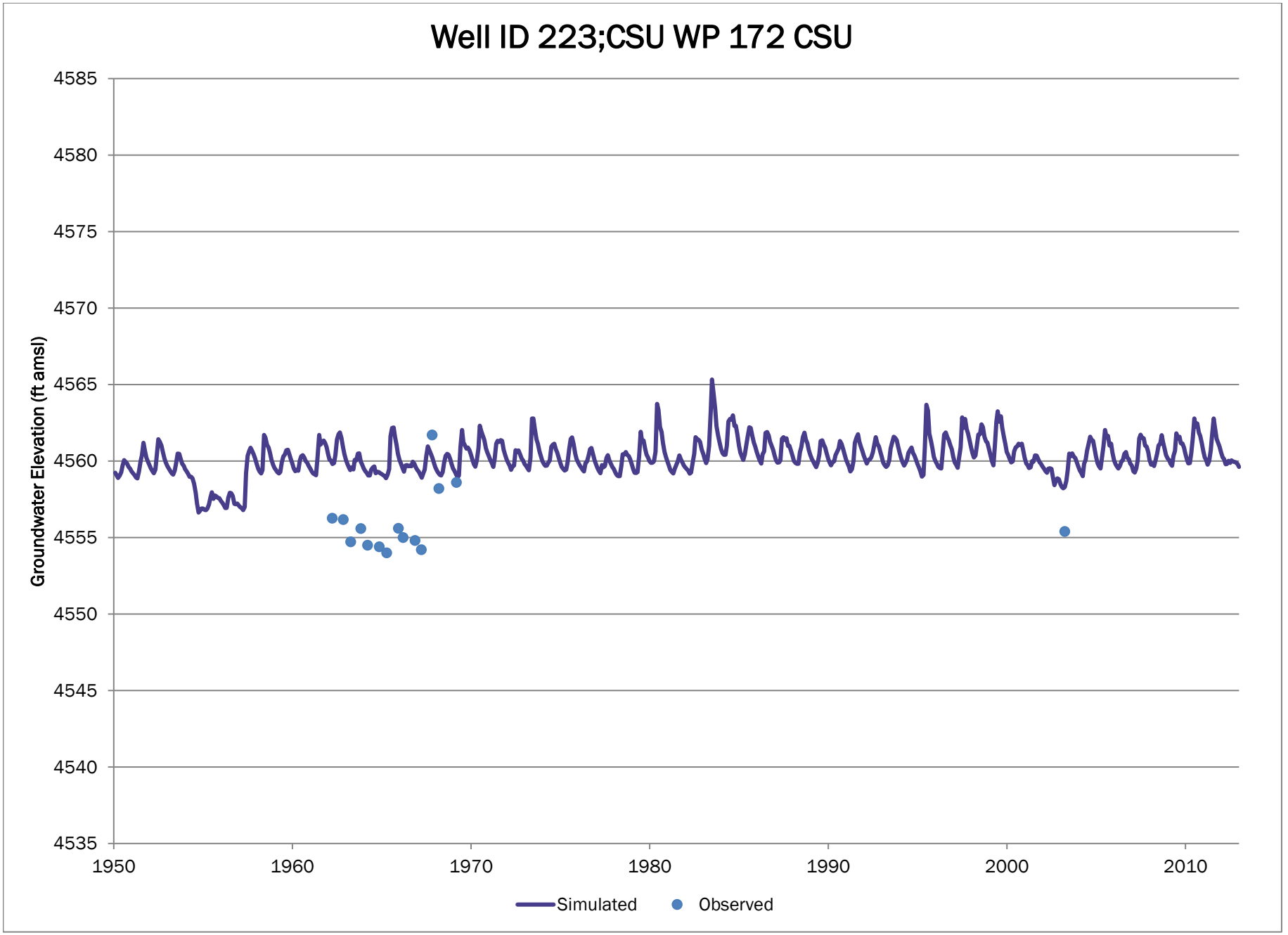

LSP-44 DSS08BLZ
Groundwater Elevation (ft amsl)
4130
4125
4120
4115
4110
4105
4100
4095
4090
4085
4080
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

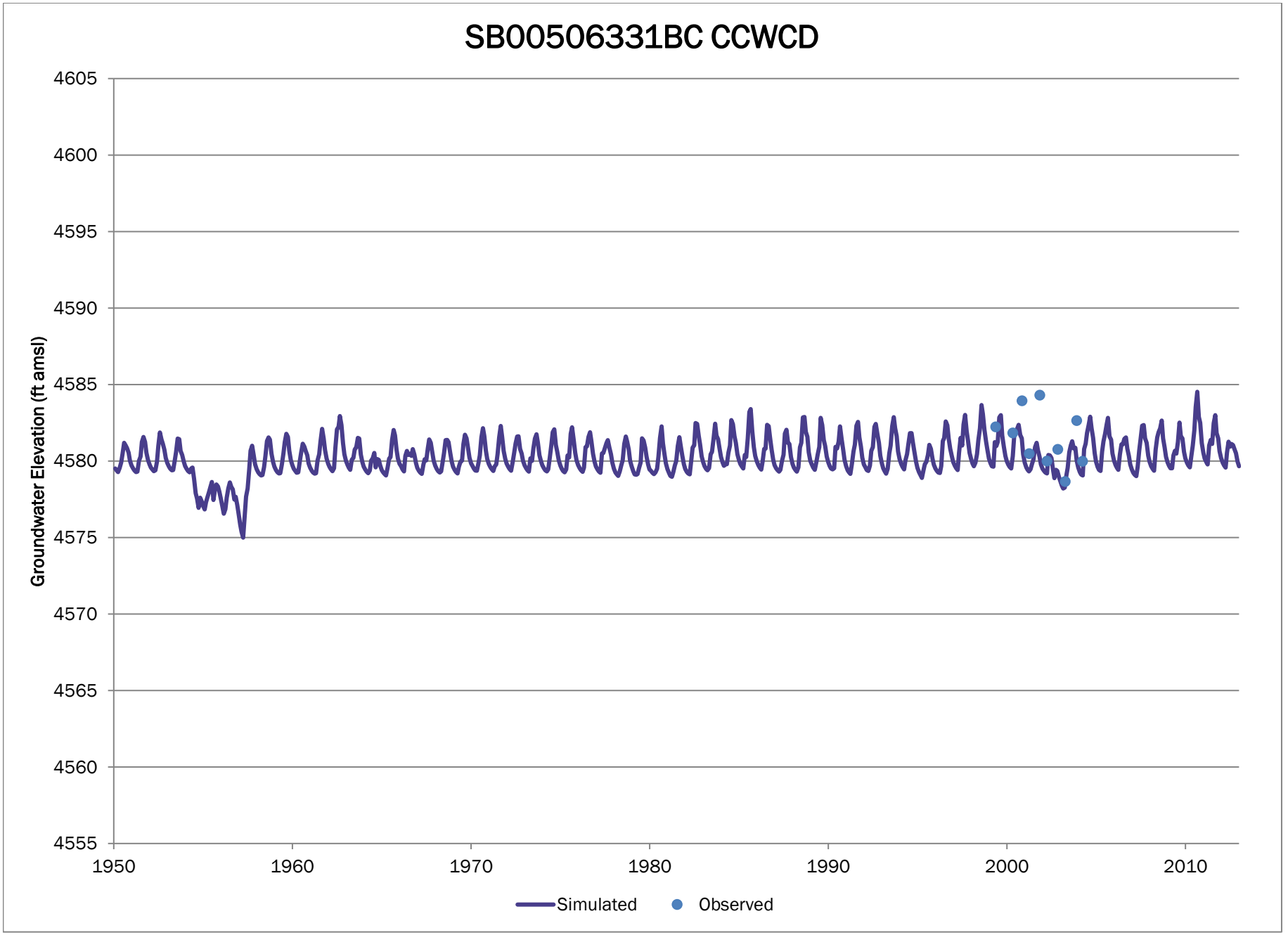

WELL ID 369;CSU WP 34 CSU
Groundwater Elevation (ft amsl)
4140
4135
4130
4125
4120
4115
4110
4105
4100
4095
4090
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

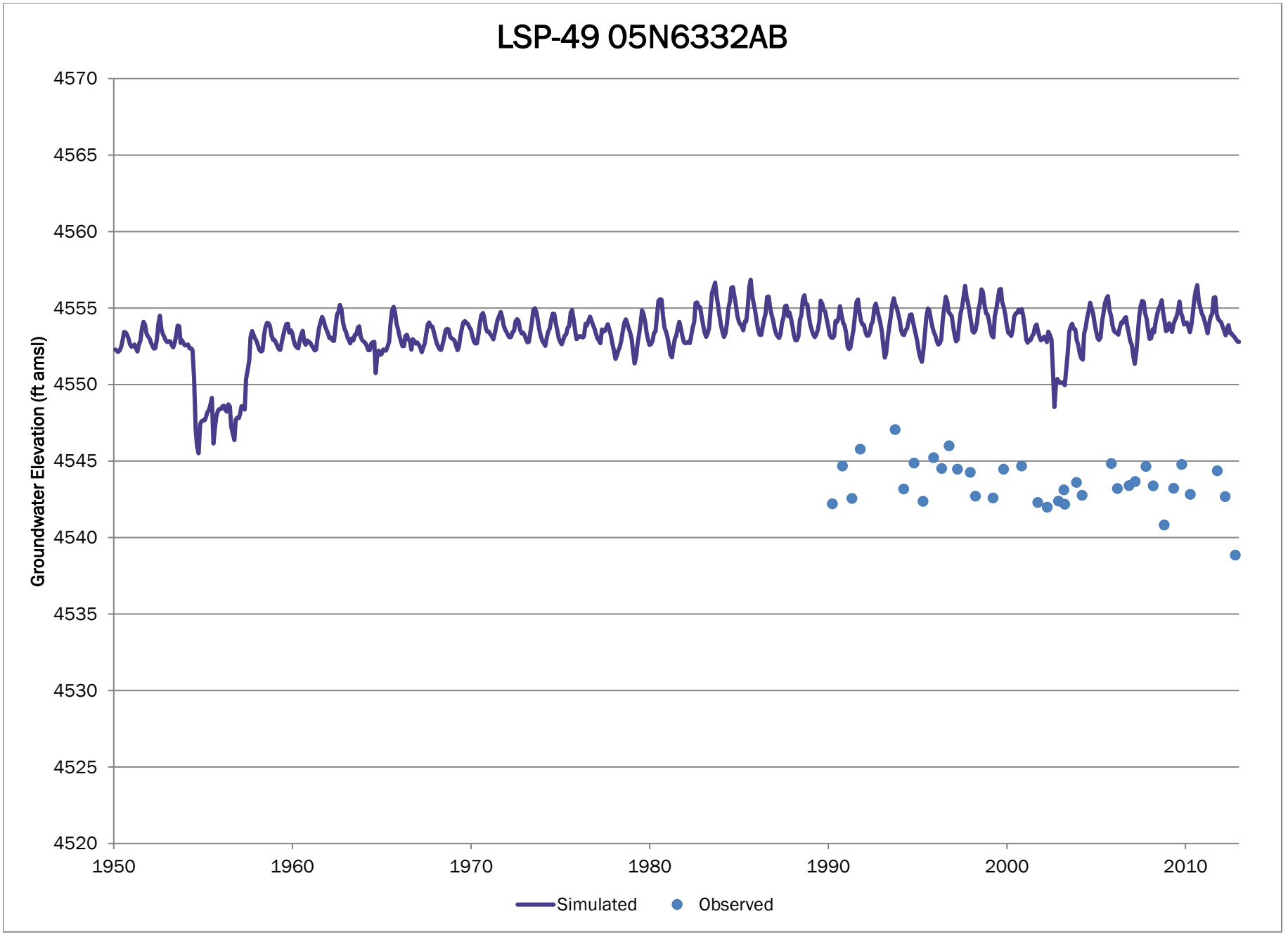

LSP-45 DSS38BLZ
Groundwater Elevation (ft amsl)
4165
4160
4155
4150
4145
4140
4135
4130
4125
4120
4115
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

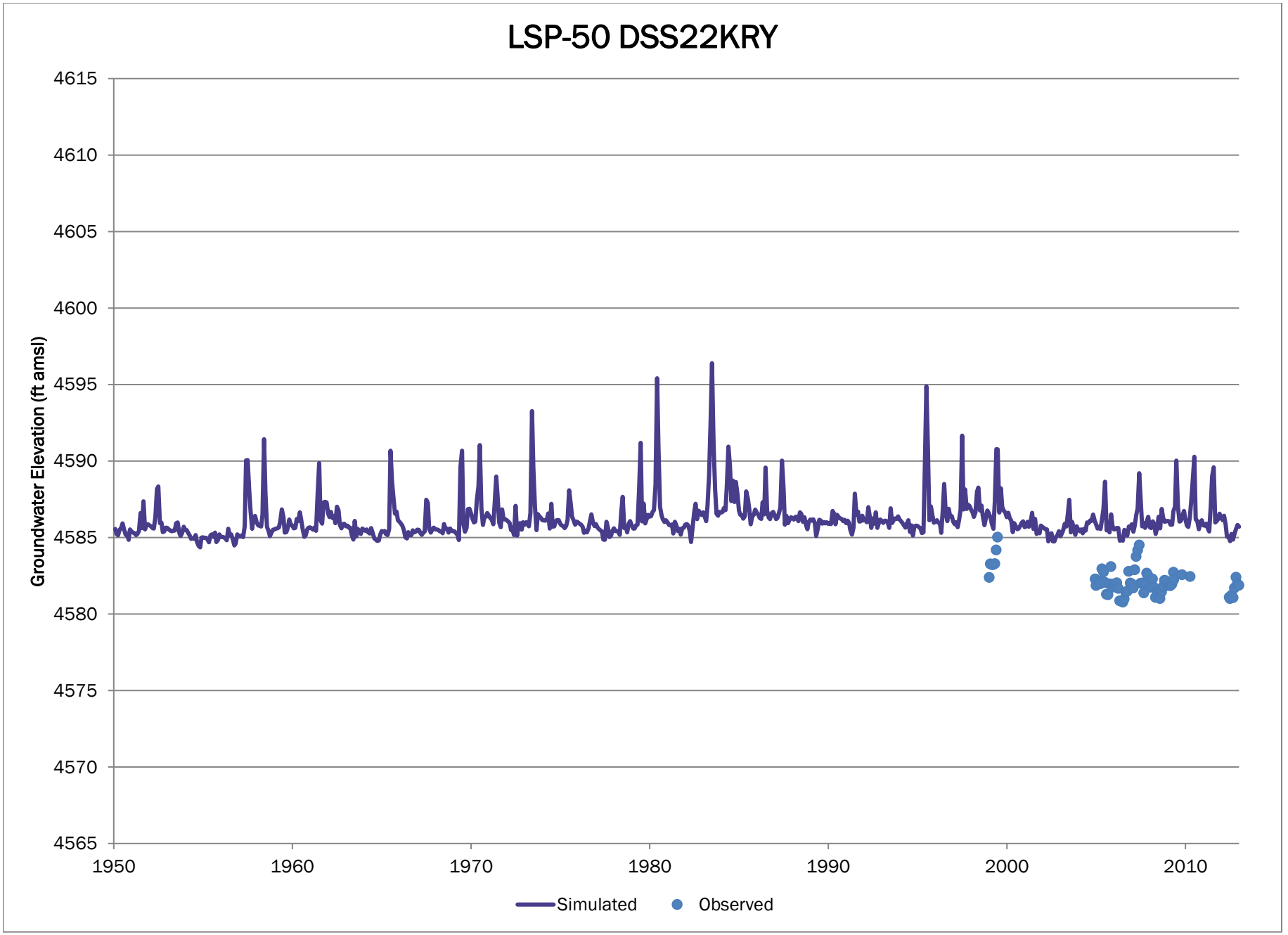

LSP-46 CSU WP 33
Groundwater Elevation (ft amsl)
4155
4150
4145
4140
4135
4130
4125
4120
4115
4110
4105
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

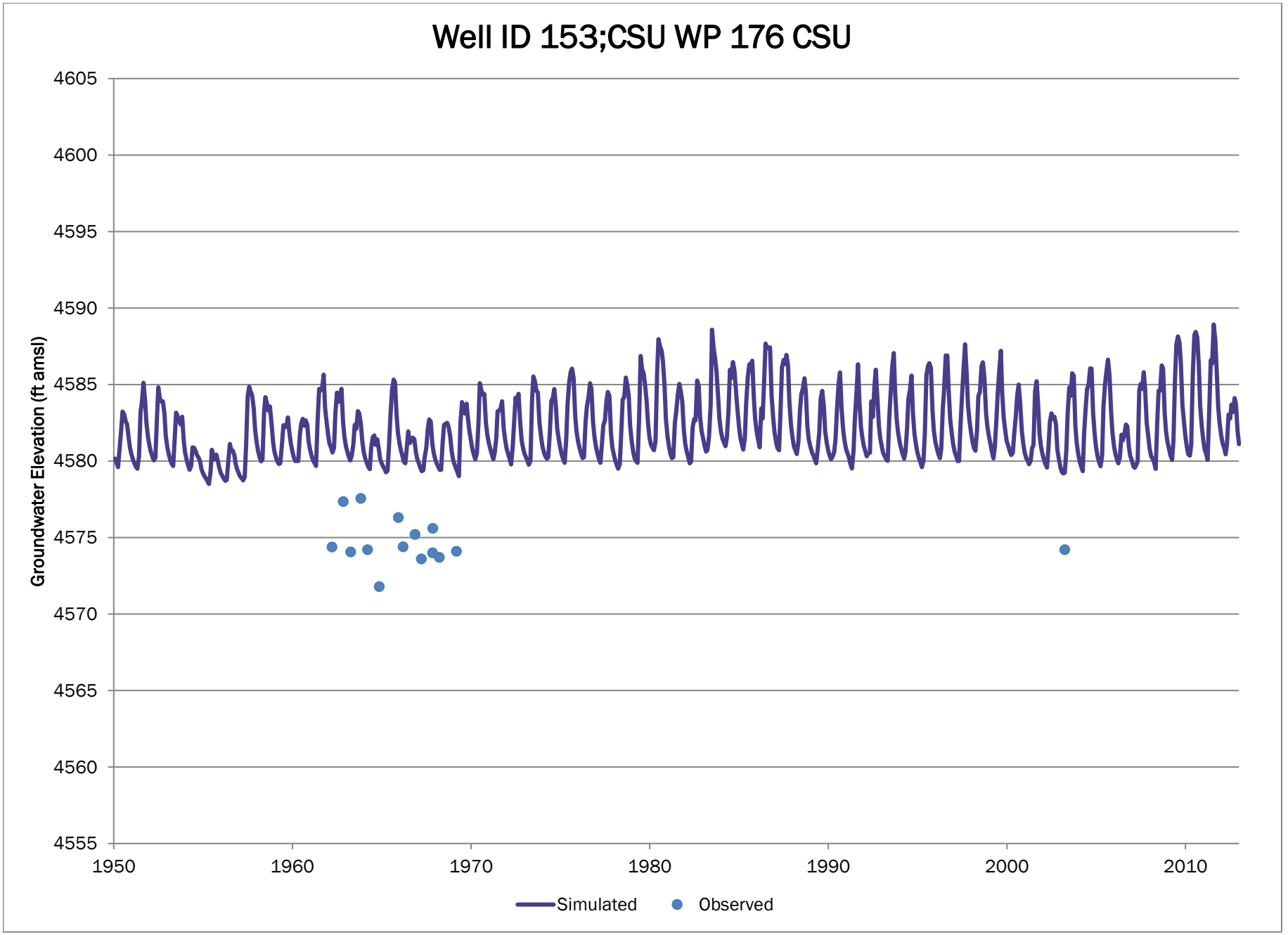

LSP-47 DSS32WLD
Groundwater Elevation (ft amsl)
4360
4355
4350
4345
4340
4335
4330
4325
4320
4315
4310
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

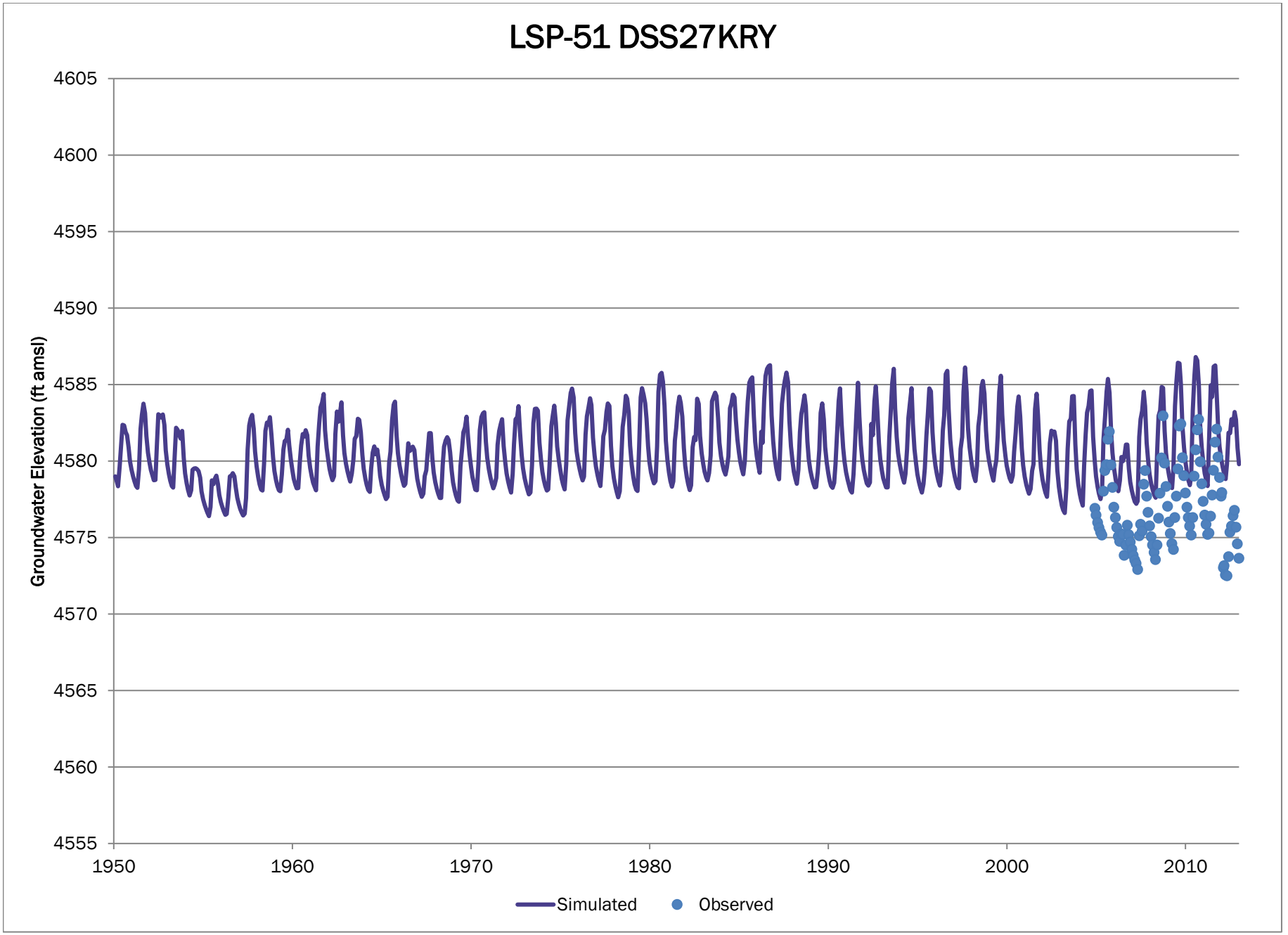

Well ID 223;CSU WP 172 CSU
Groundwater Elevation (ft amsl)
4585
4580
4575
4570
4565
4560
4555
4550
4545
4540
4535
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

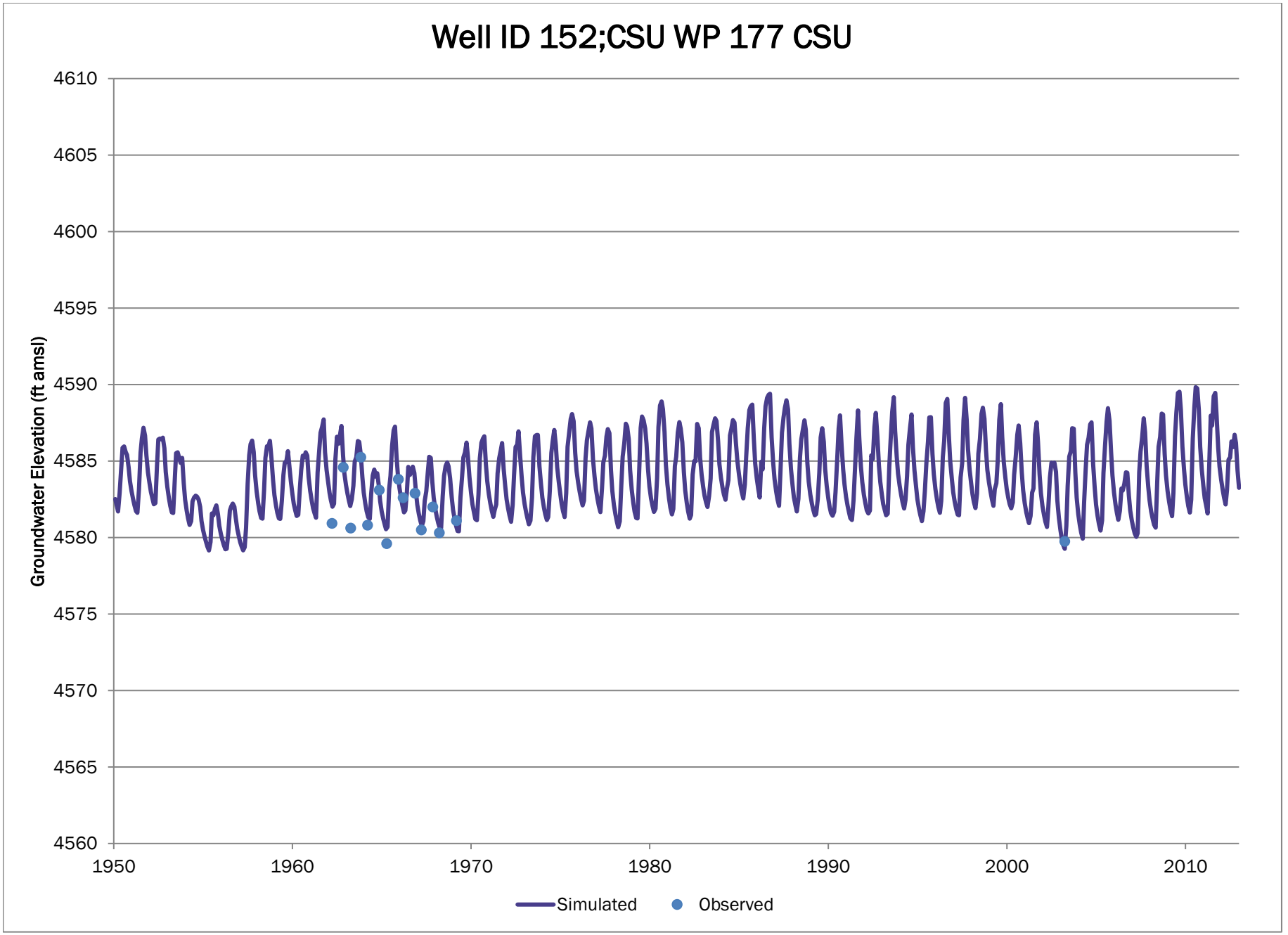

SB00506331BC CCWCD
Groundwater Elevation (ft amsl)
4605
4600
4595
4590
4585
4580
4575
4570
4565
4560
4555
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

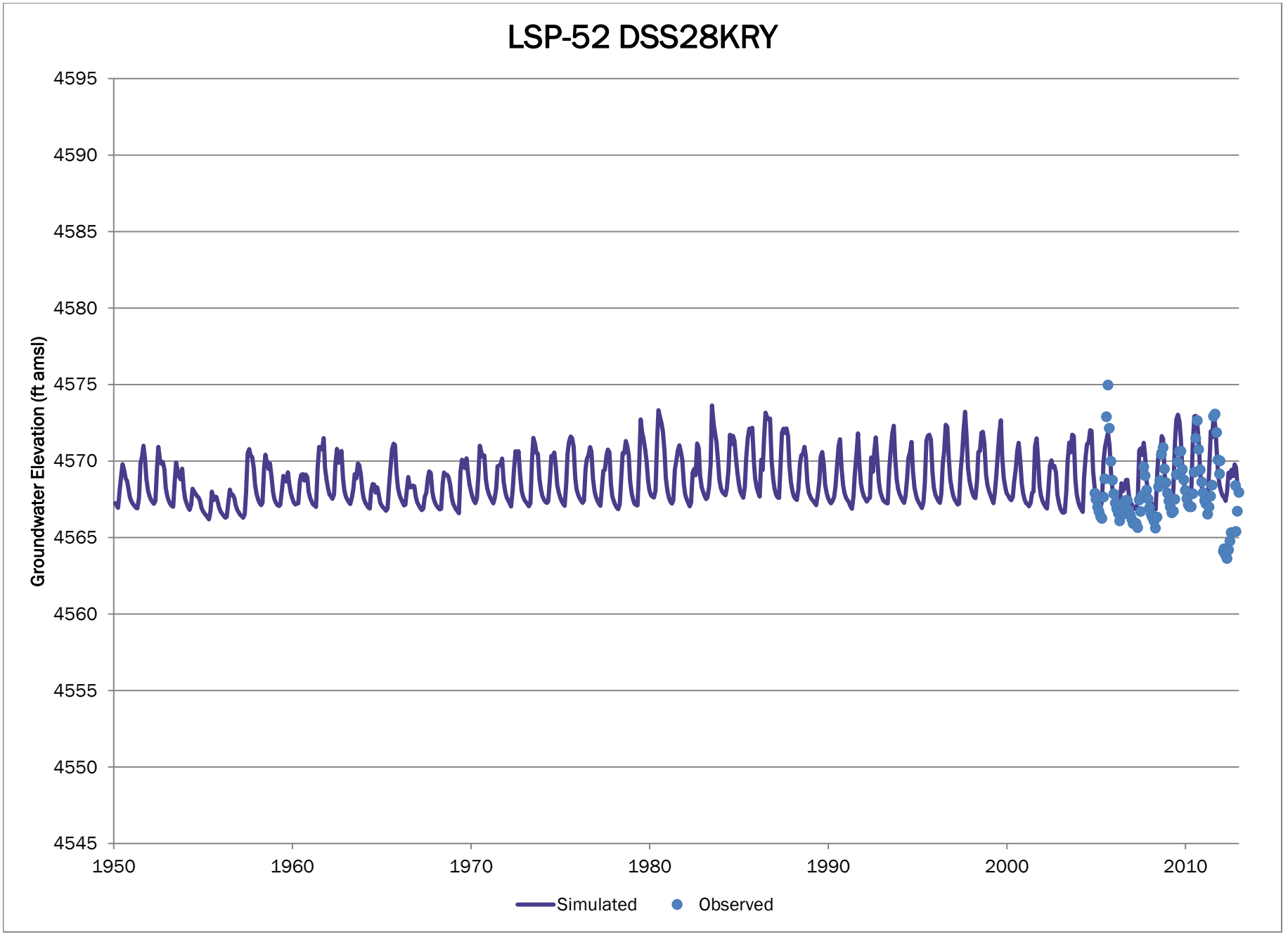

LSP-49 05N6332AB
Groundwater Elevation (ft amsl)
4570
4565
4560
4555
4550
4545
4540
4535
4530
4525
4520
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

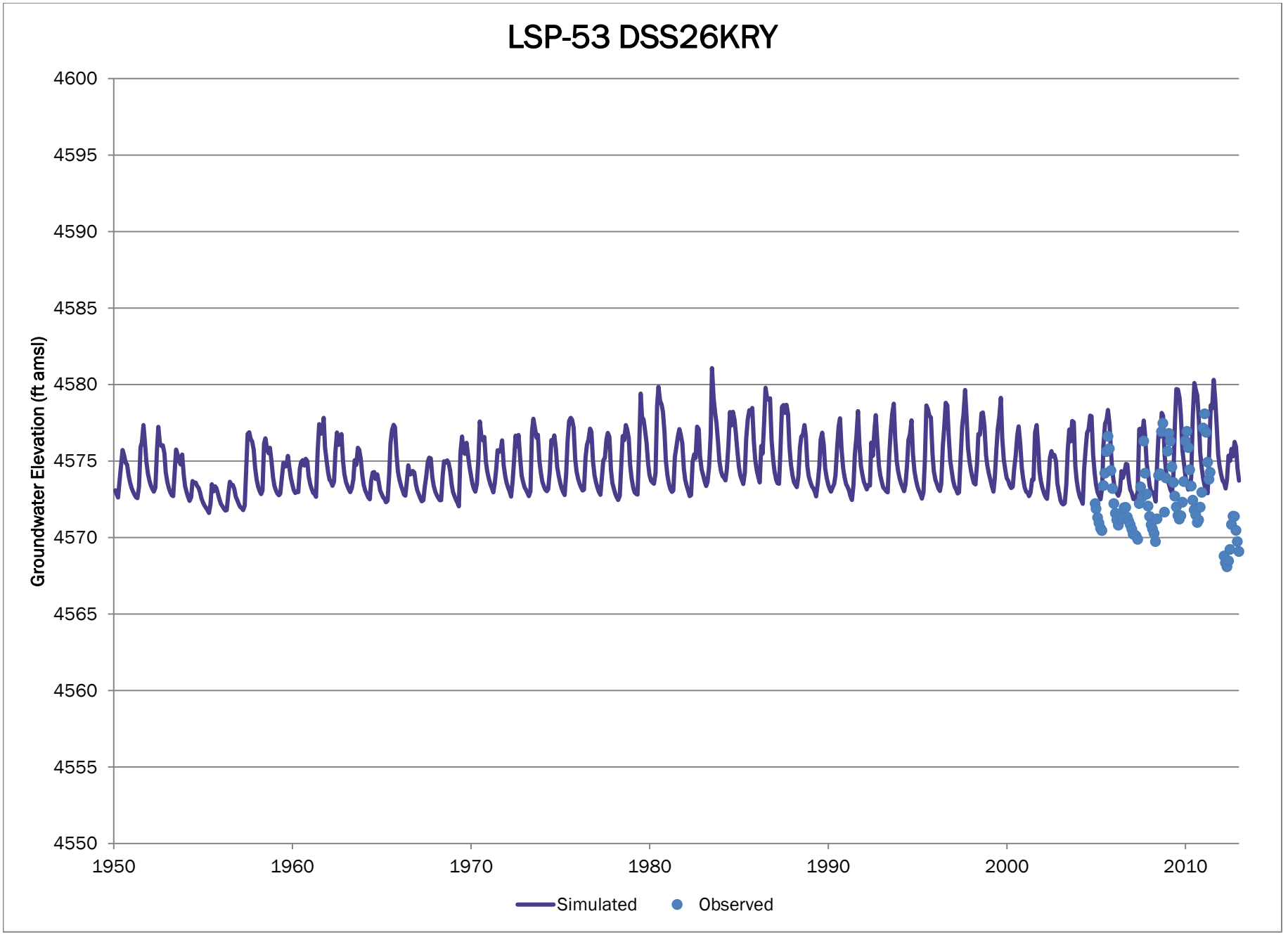

LSP-50 DSS22KRY
Groundwater Elevation (ft amsl)
4615
4610
4605
4600
4595
4590
4585
4580
4575
4570
4565
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

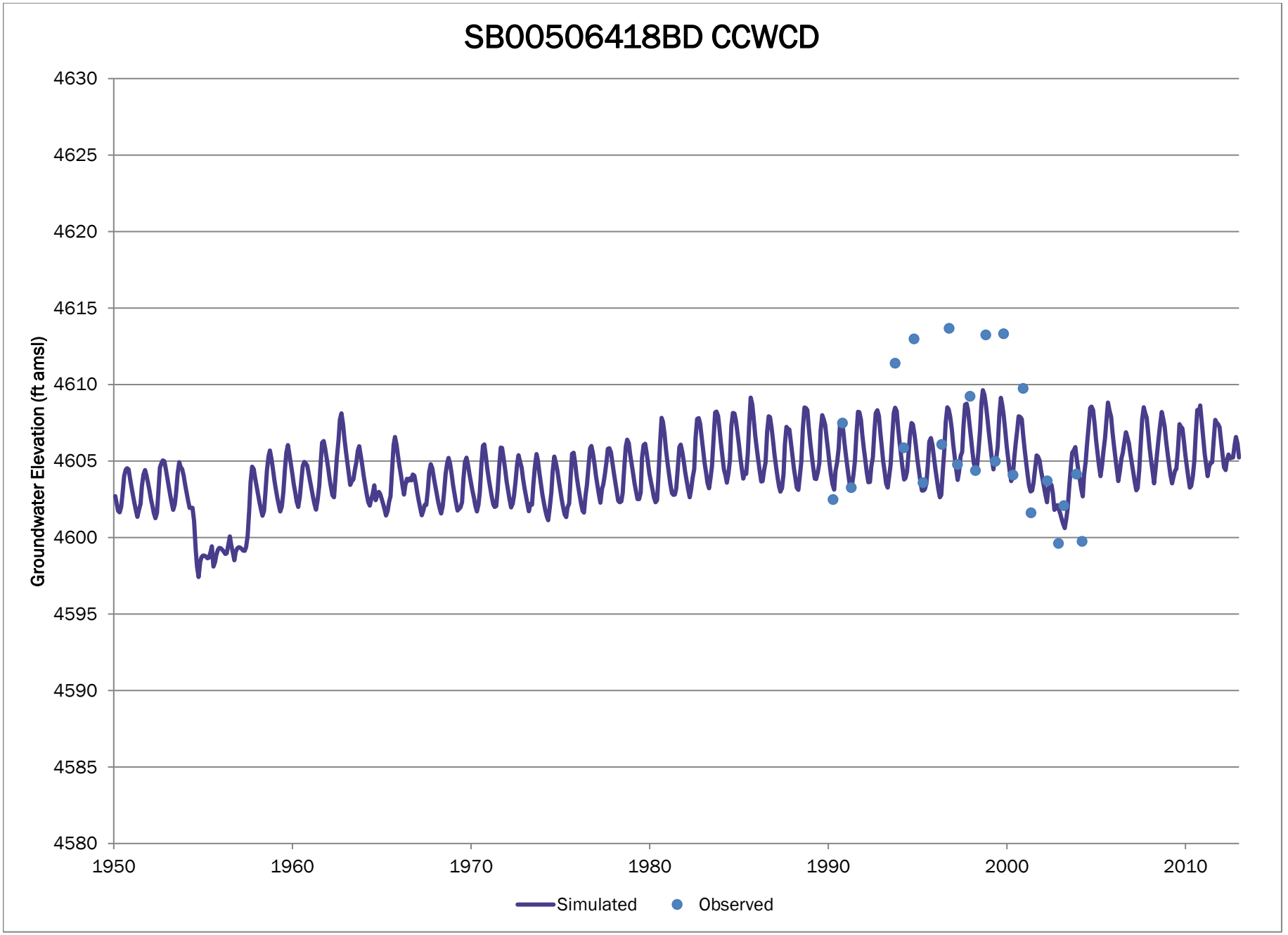

Well ID 153;CSU WP 176 CSU
Groundwater Elevation (ft amsl)
4605
4600
4595
4590
4585
4580
4575
4570
4565
4560
4555
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

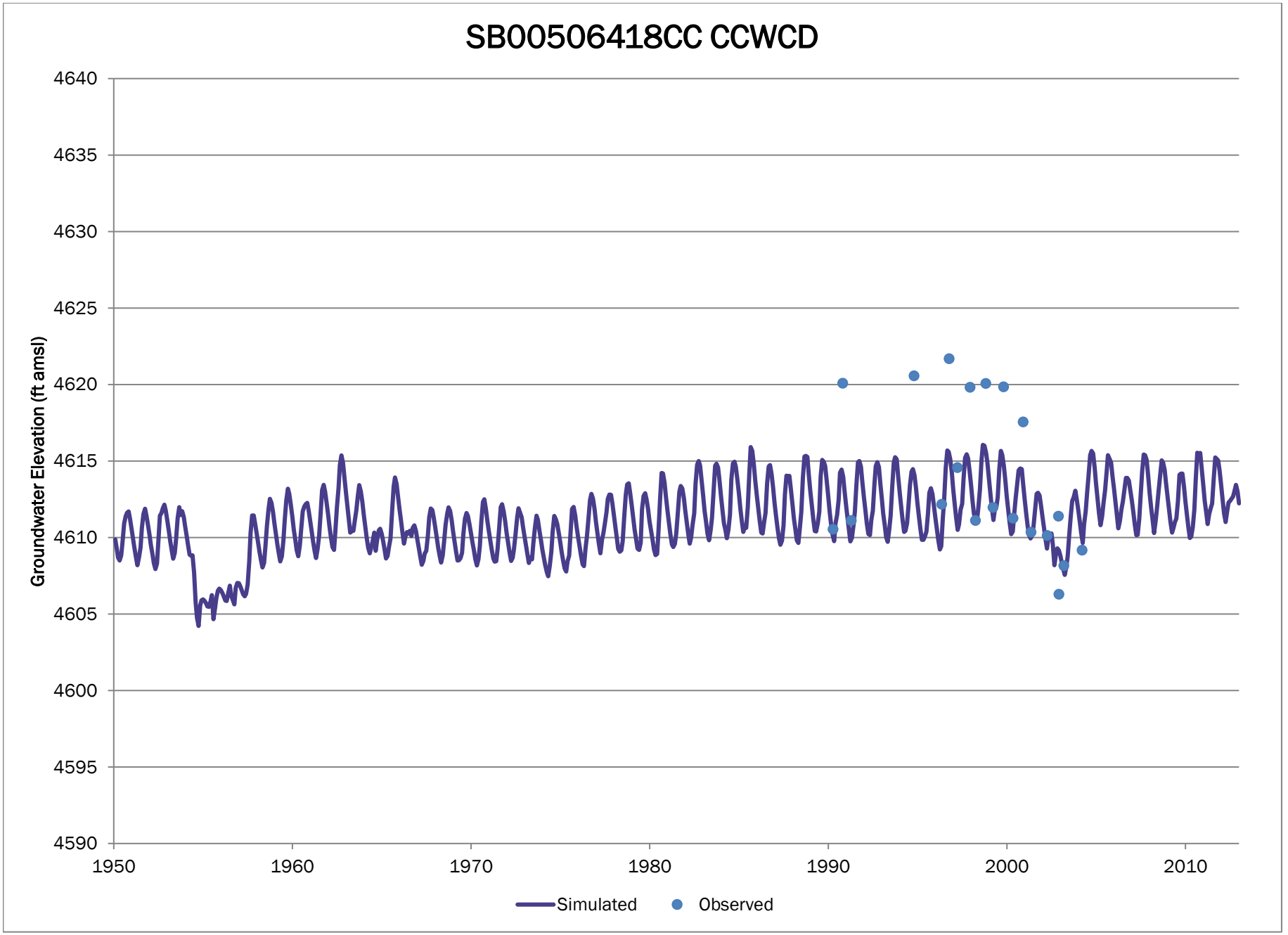

LSP-51 DSS27KRY
Groundwater Elevation (ft amsl)
4605
4600
4595
4590
4585
4580
4575
4570
4565
4560
4555
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

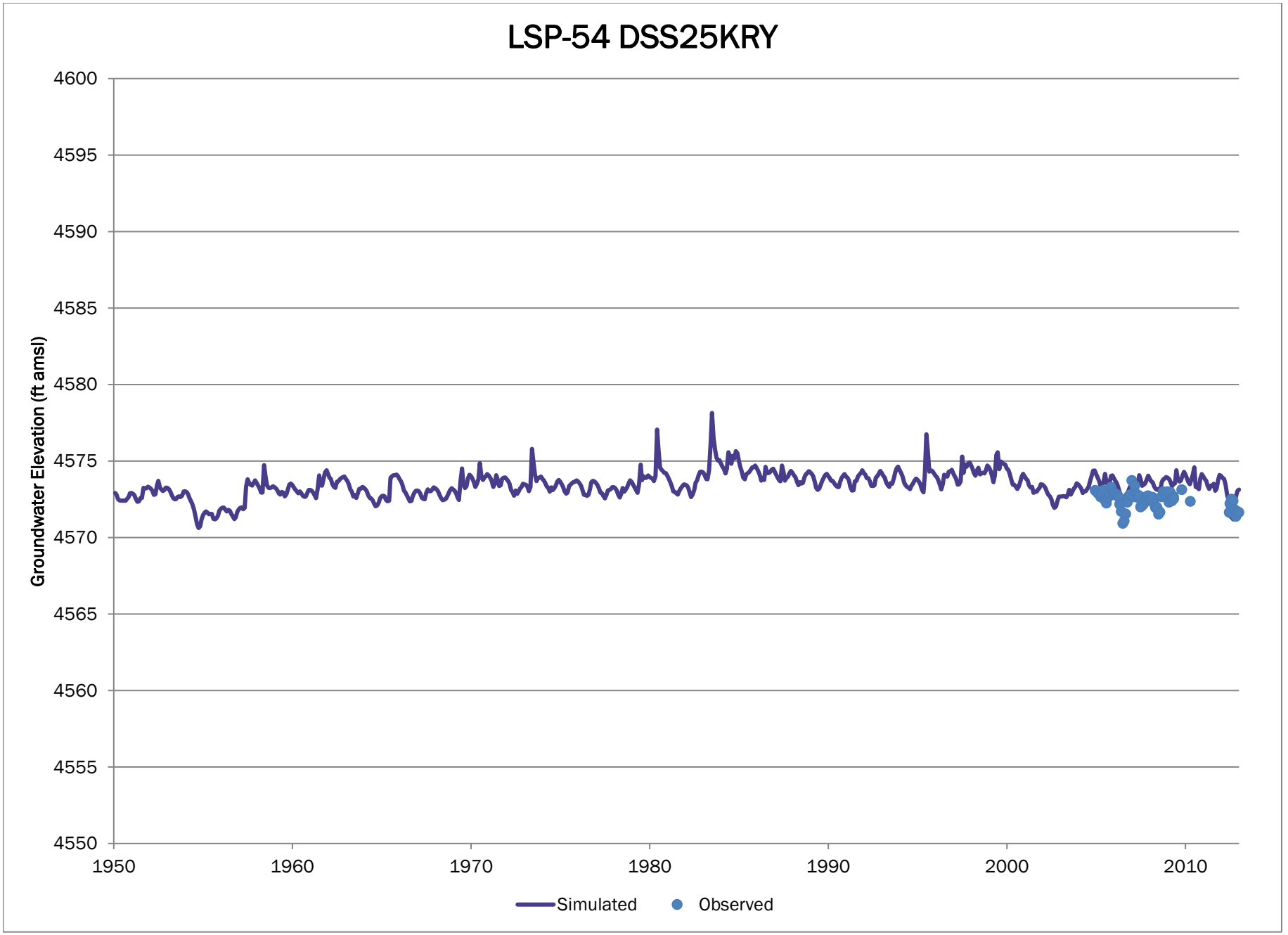

Well ID 152;CSU WP 177 CSU
Groundwater Elevation (ft amsl)
4610
4605
4600
4595
4590
4585
4580
4575
4570
4565
4560
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

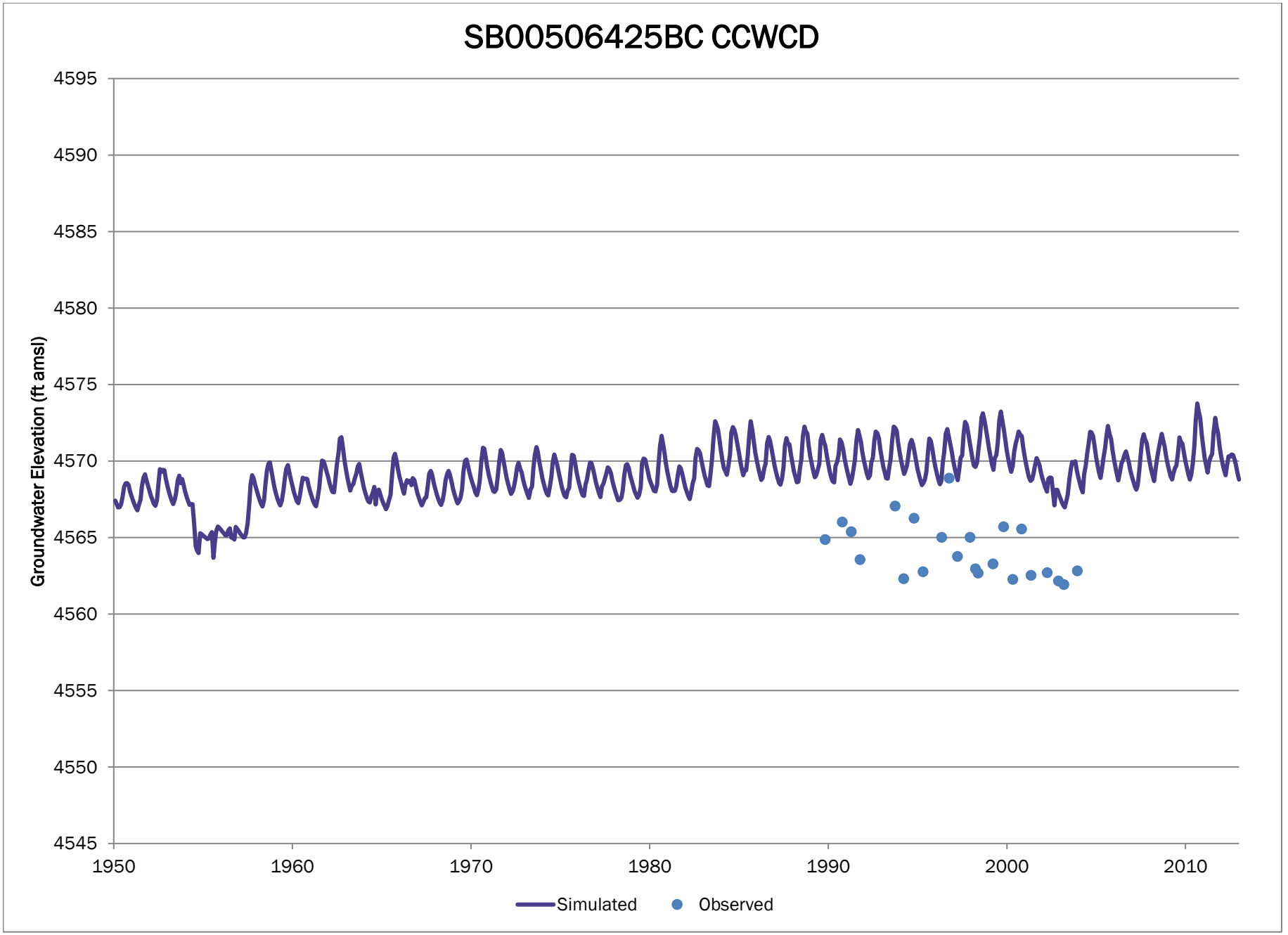

LSP-52 DSS28KRY
Groundwater Elevation (ft amsl)
4595
4590
4585
4580
4575
4570
4565
4560
4555
4550
4545
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

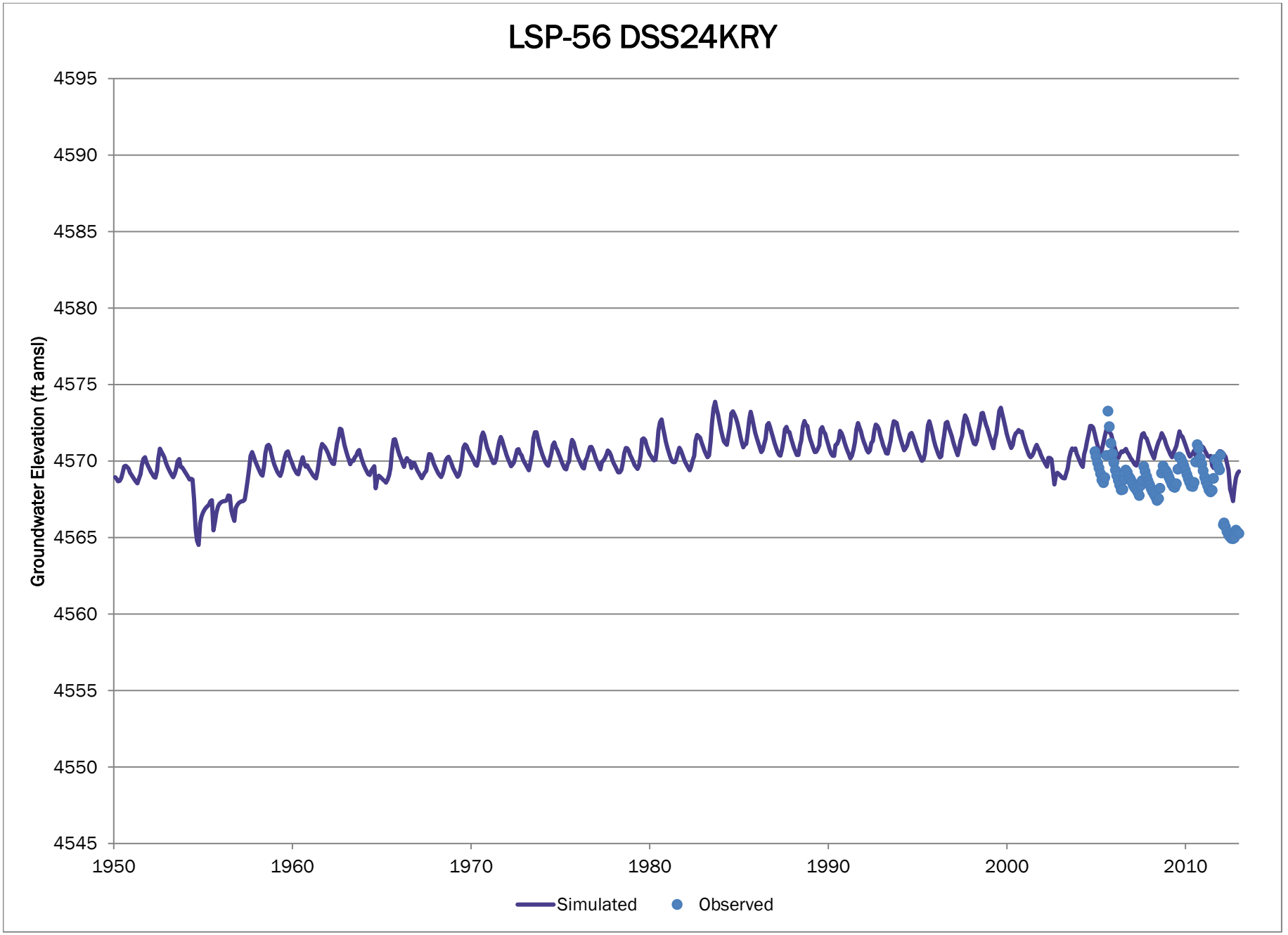

LSP-53 DSS26KRY
Groundwater Elevation (ft amsl)
4600
4595
4590
4585
4580
4575
4570
4565
4560
4555
4550
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

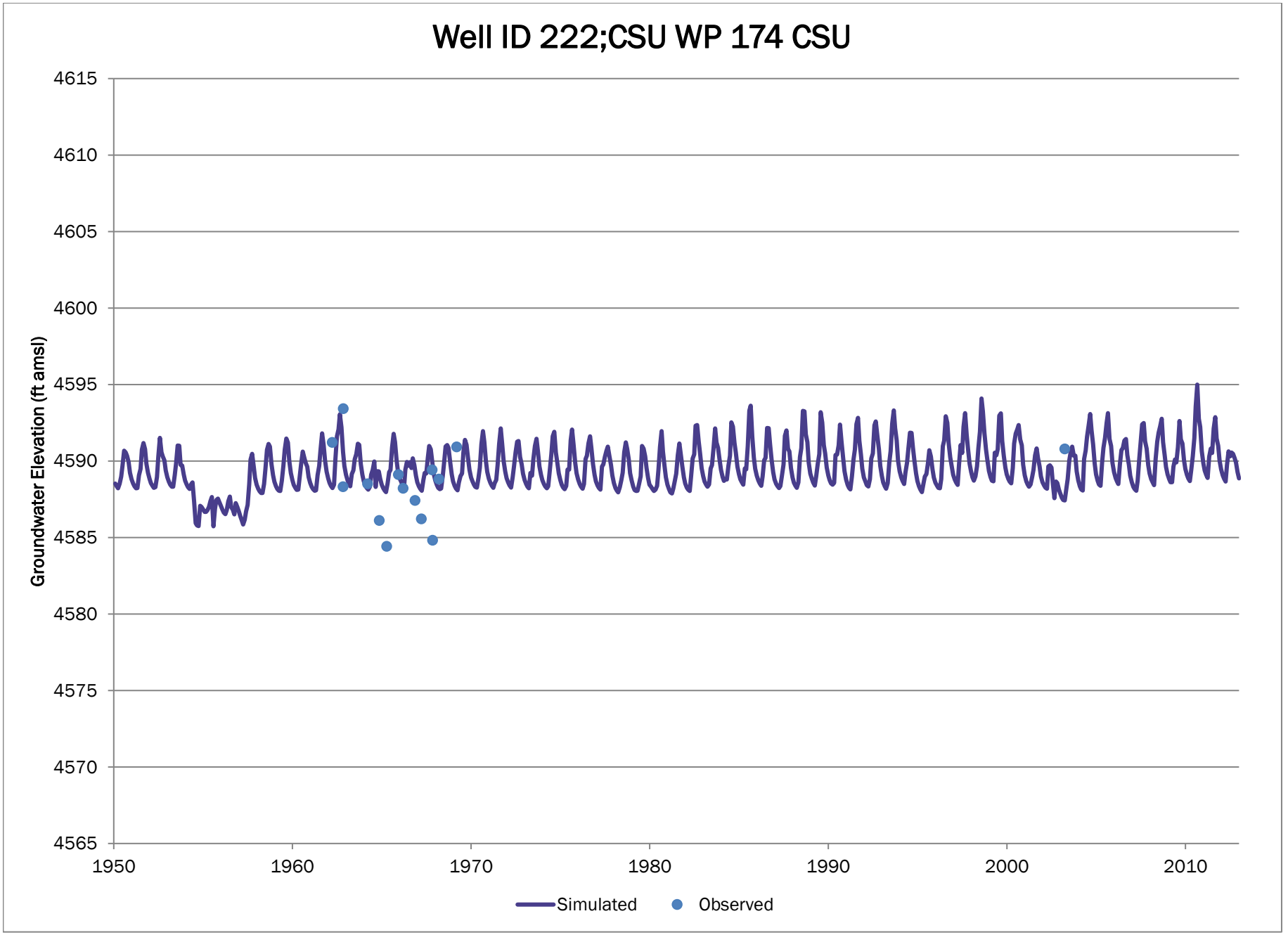

SB00506418BD CCWCD
Groundwater Elevation (ft amsl)
4630
4625
4620
4615
4610
4605
4600
4595
4590
4585
4580
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

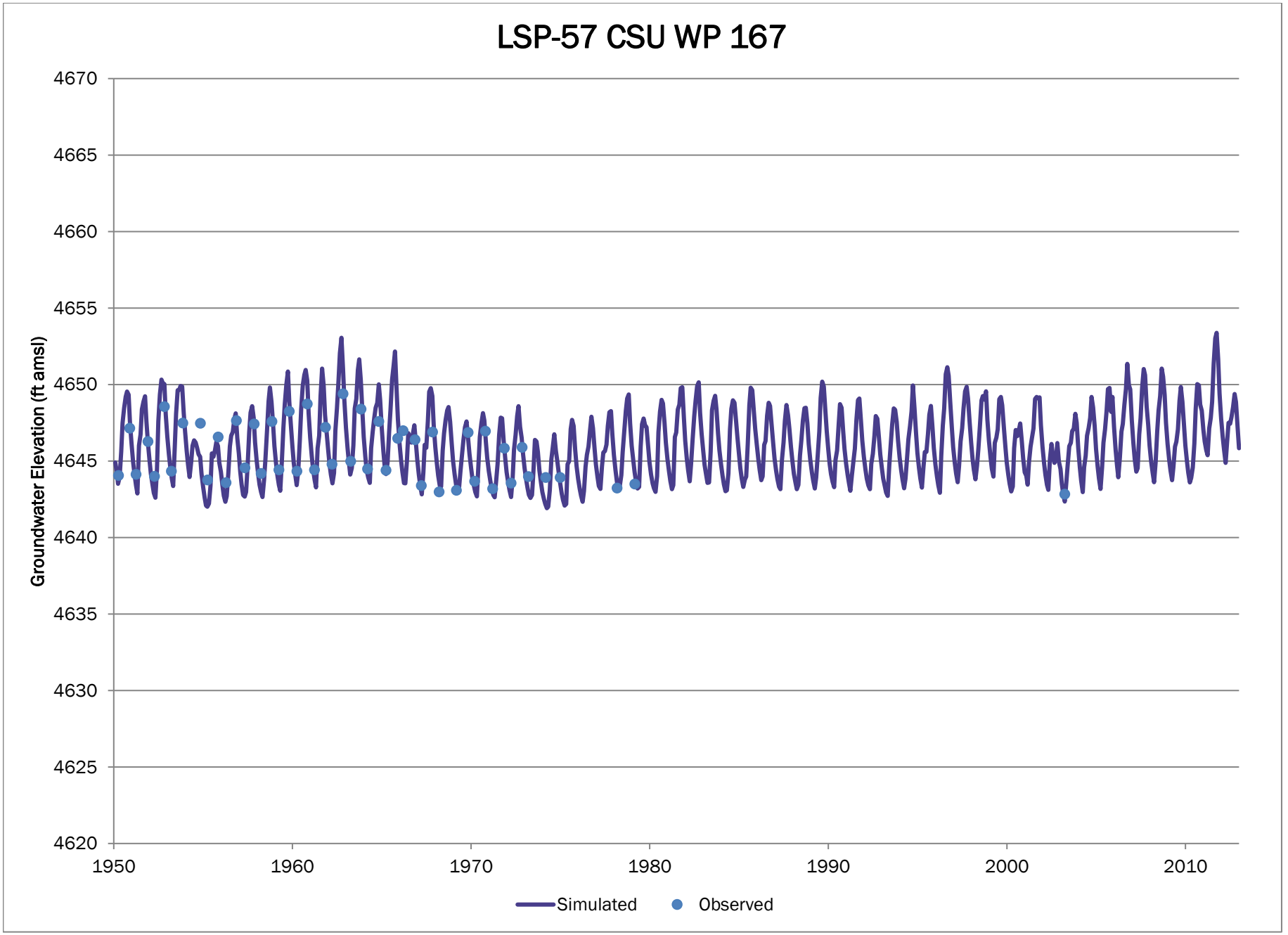

SB00506418CC CCWCD
Groundwater Elevation (ft amsl)
4640
4635
4630
4625
4620
4615
4610
4605
4600
4595
4590
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

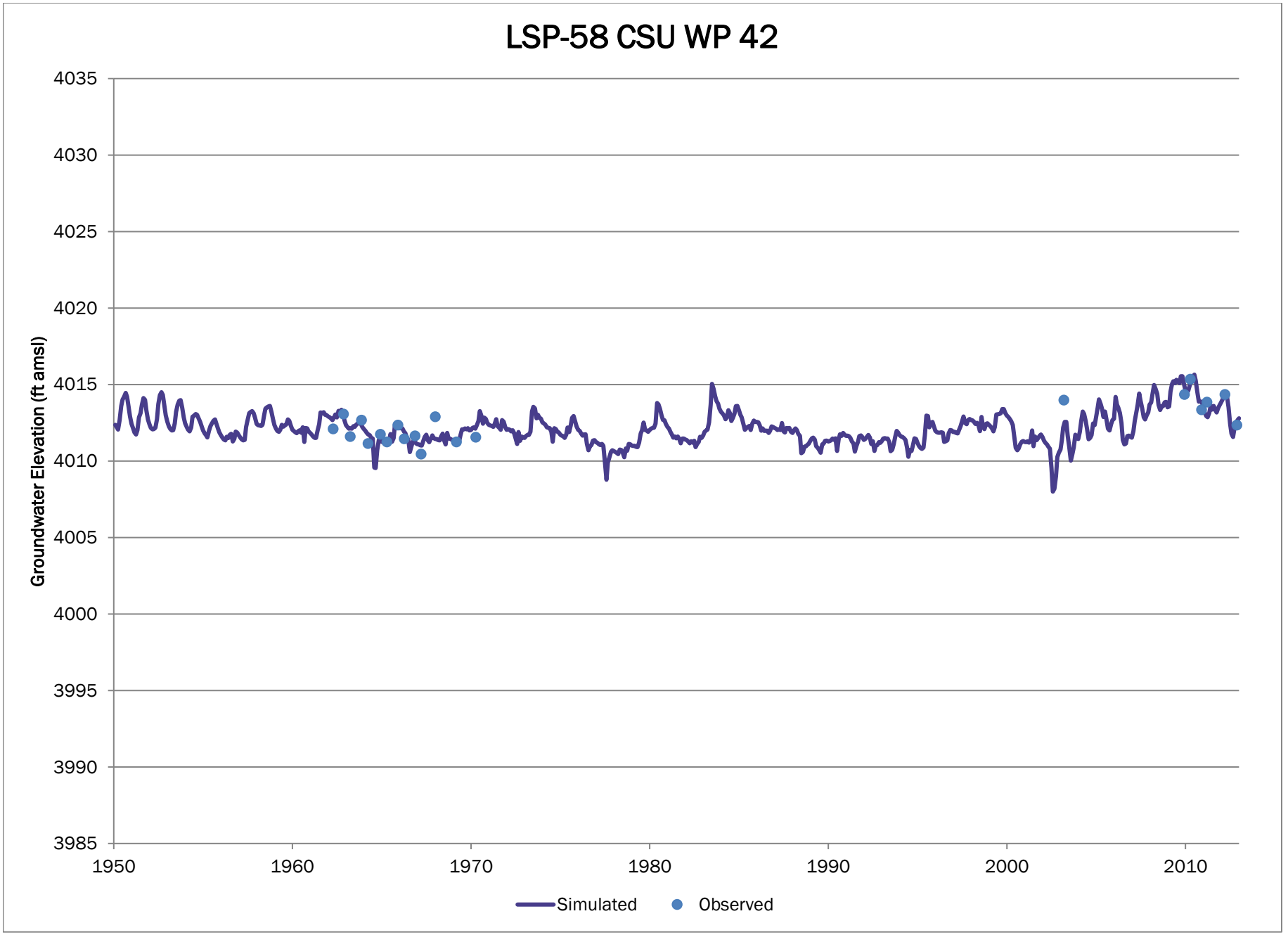

LSP-54 DSS25KRY
Groundwater Elevation (ft amsl)
4600
4595
4590
4585
4580
4575
4570
4565
4560
4555
4550
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

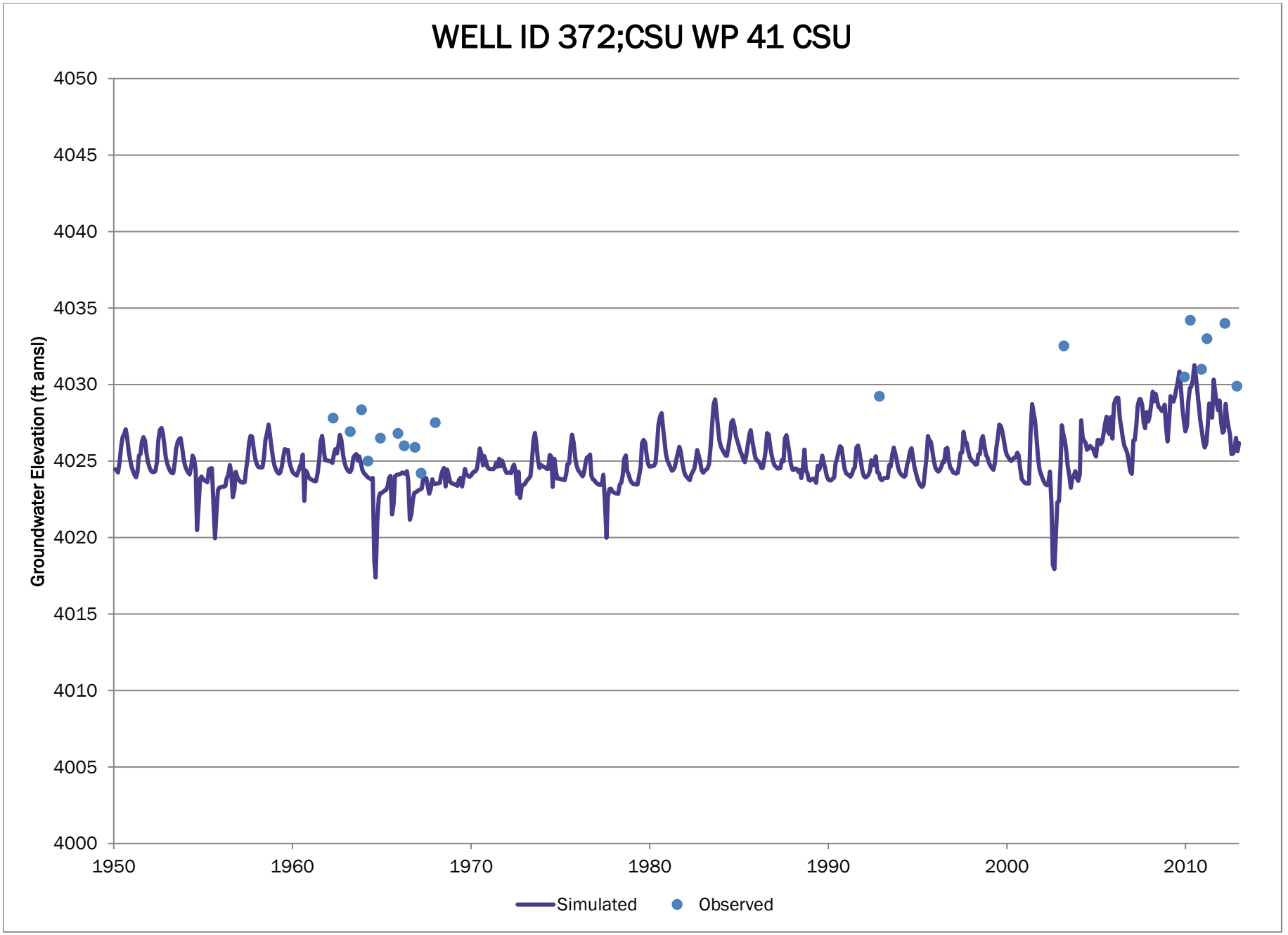

SB00506425BC CCWCD
Groundwater Elevation (ft amsl)
4595
4590
4585
4580
4575
4570
4565
4560
4555
4550
4545
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

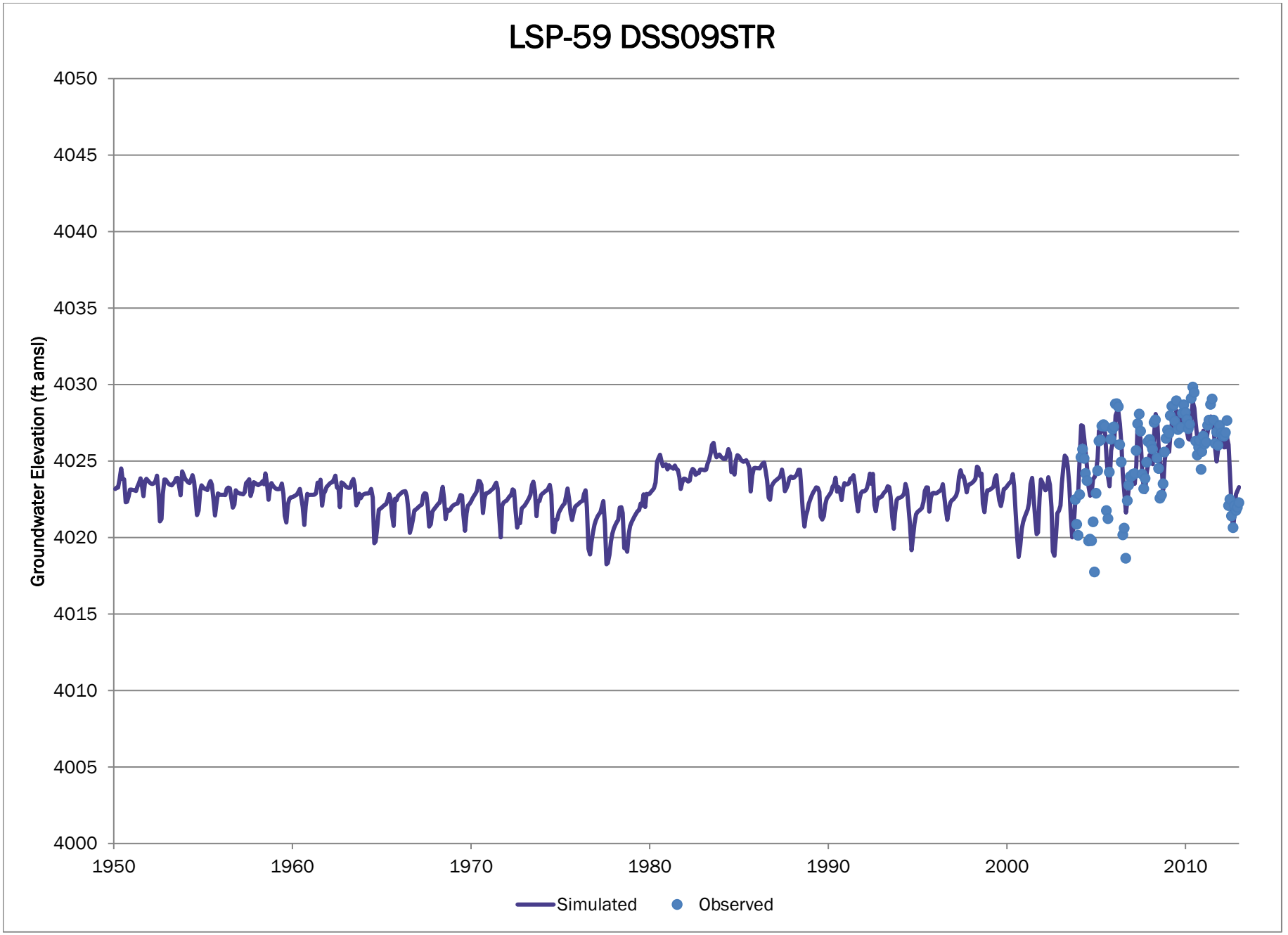

LSP-56 DSS24KRY
Groundwater Elevation (ft amsl)
4595
4590
4585
4580
4575
4570
4565
4560
4555
4550
4545
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

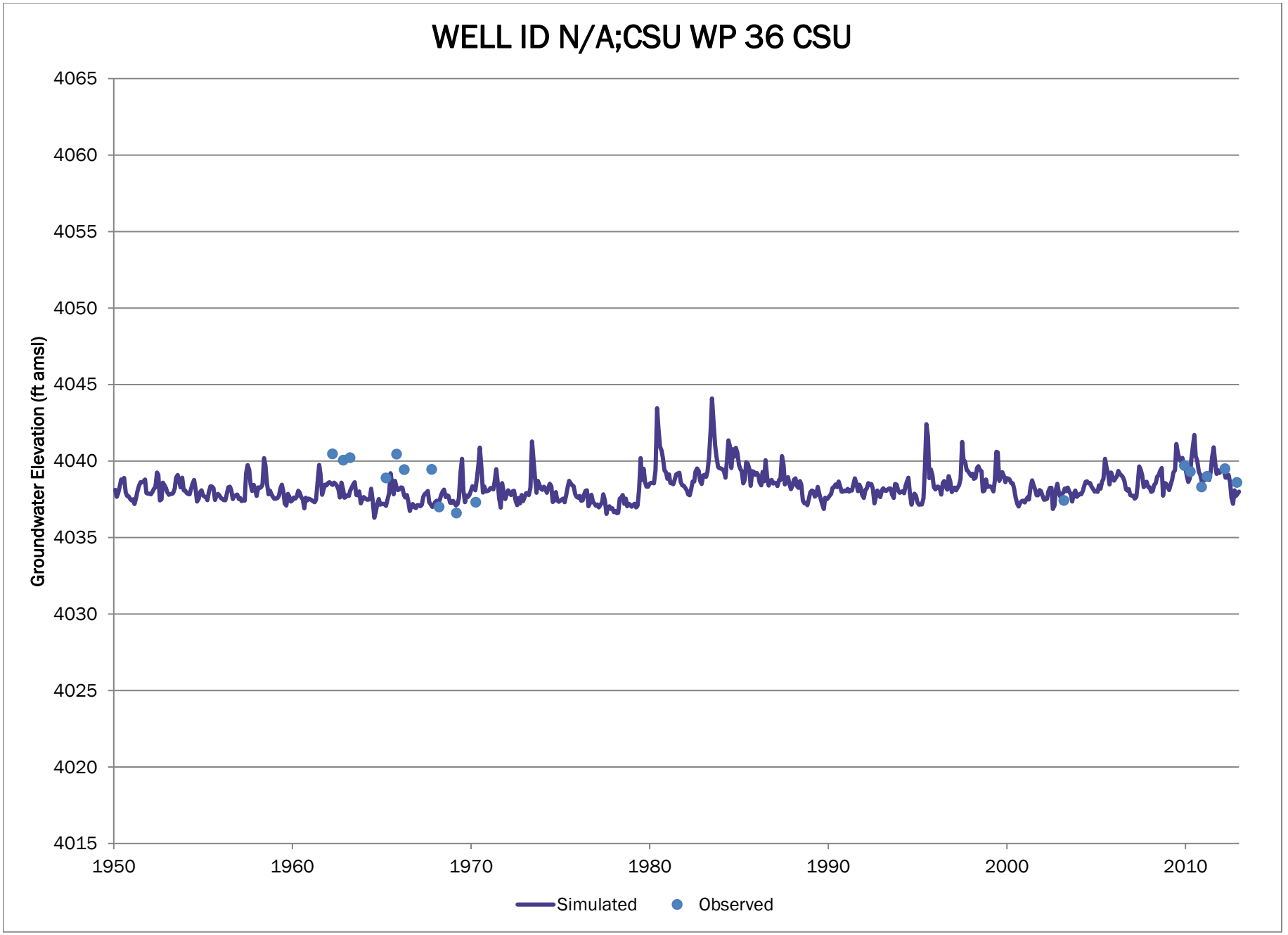

Well ID 222;CSU WP 174 CSU
Groundwater Elevation (ft amsl)
4615
4610
4605
4600
4595
4590
4585
4580
4575
4570
4565
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

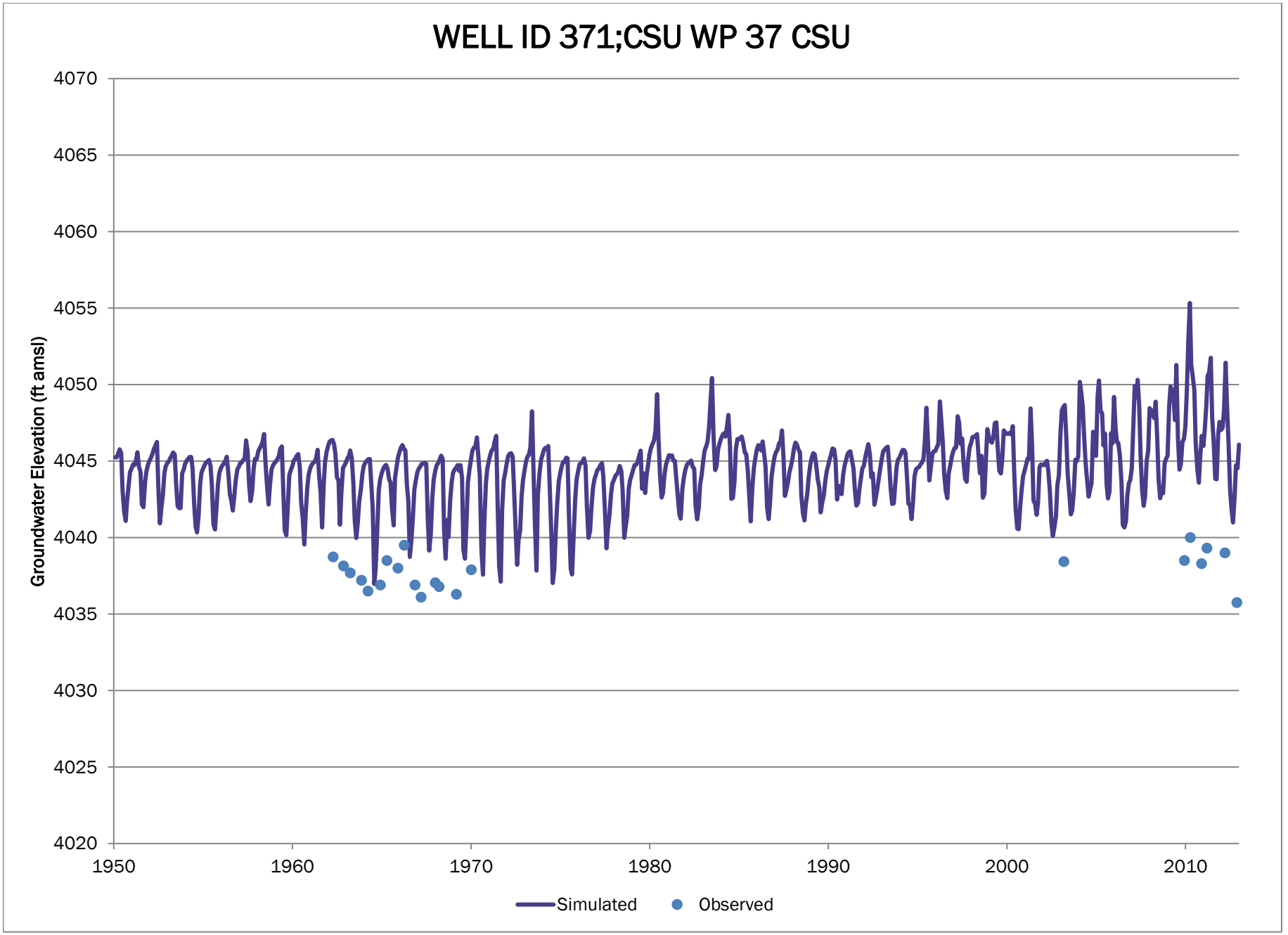

LSP-57 CSU WP 167
Groundwater Elevation (ft amsl)
4670
4665
4660
4655
4650
4645
4640
4635
4630
4625
4620
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

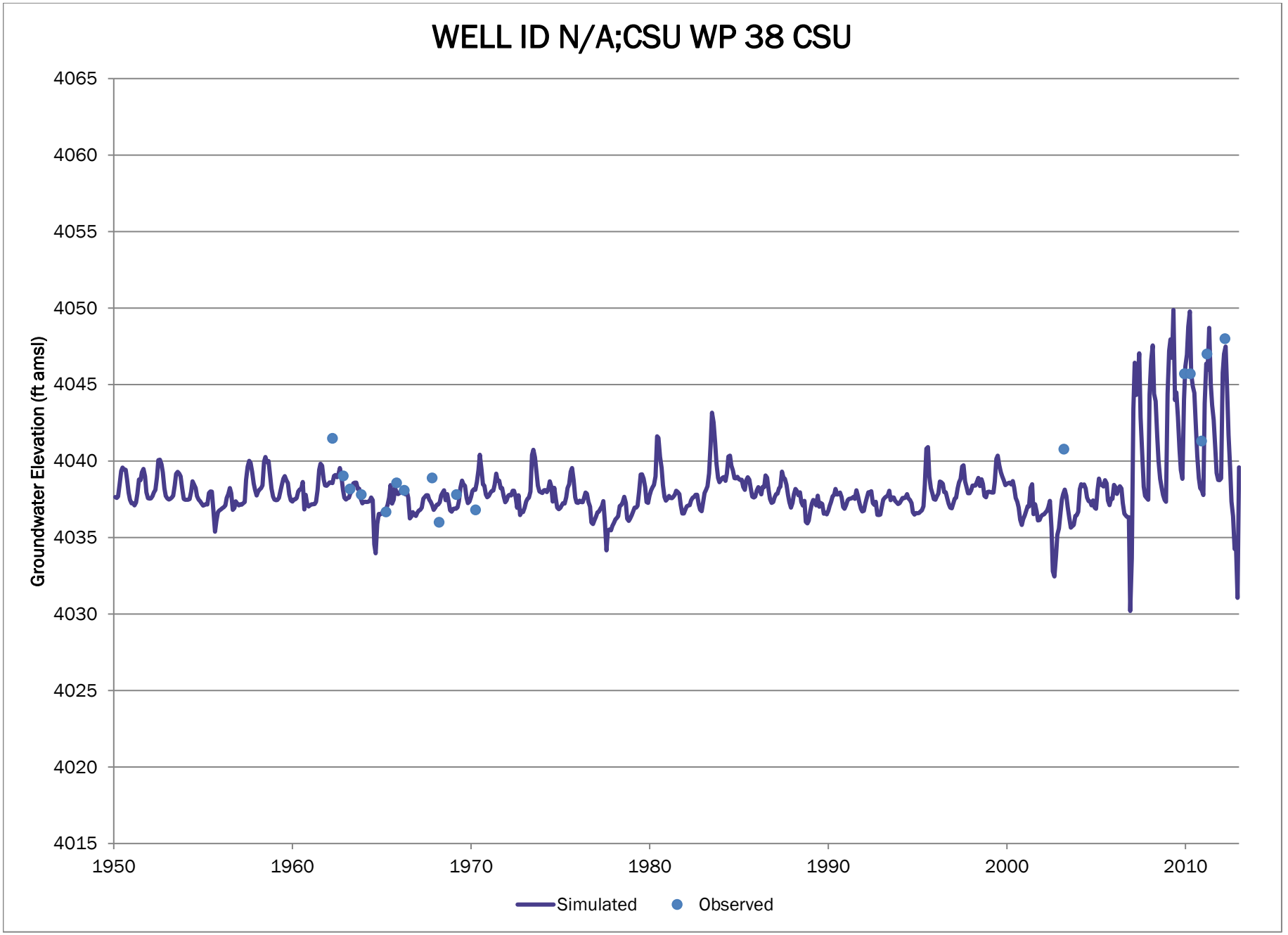

LSP-58 CSU WP 42
Groundwater Elevation (ft amsl)
4035
4030
4025
4020
4015
4010
4005
4000
3995
3990
3985
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

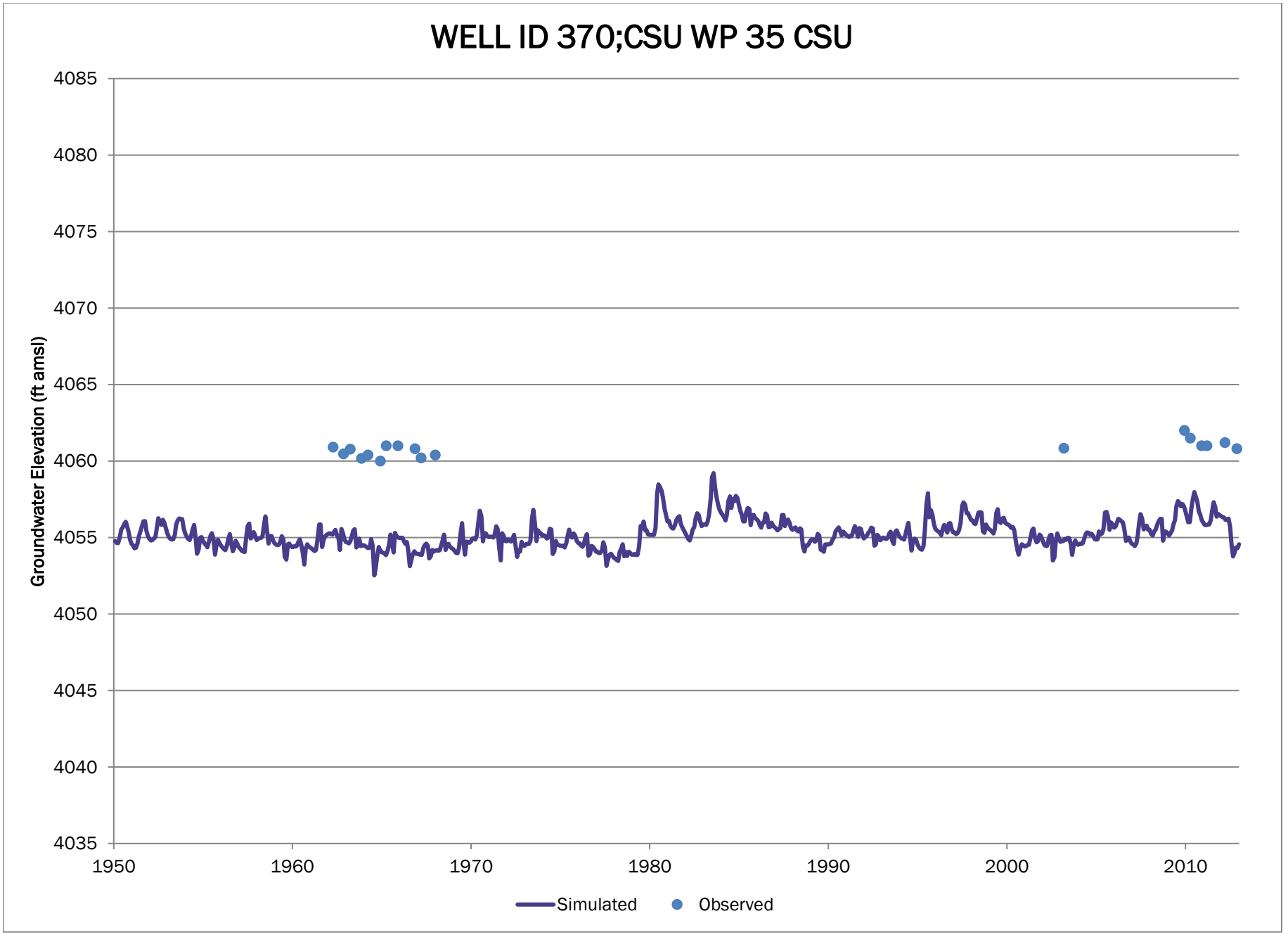

WELL ID 372;CSU WP 41 CSU
Groundwater Elevation (ft amsl)
4050
4045
4040
4035
4030
4025
4020
4015
4010
4005
4000
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

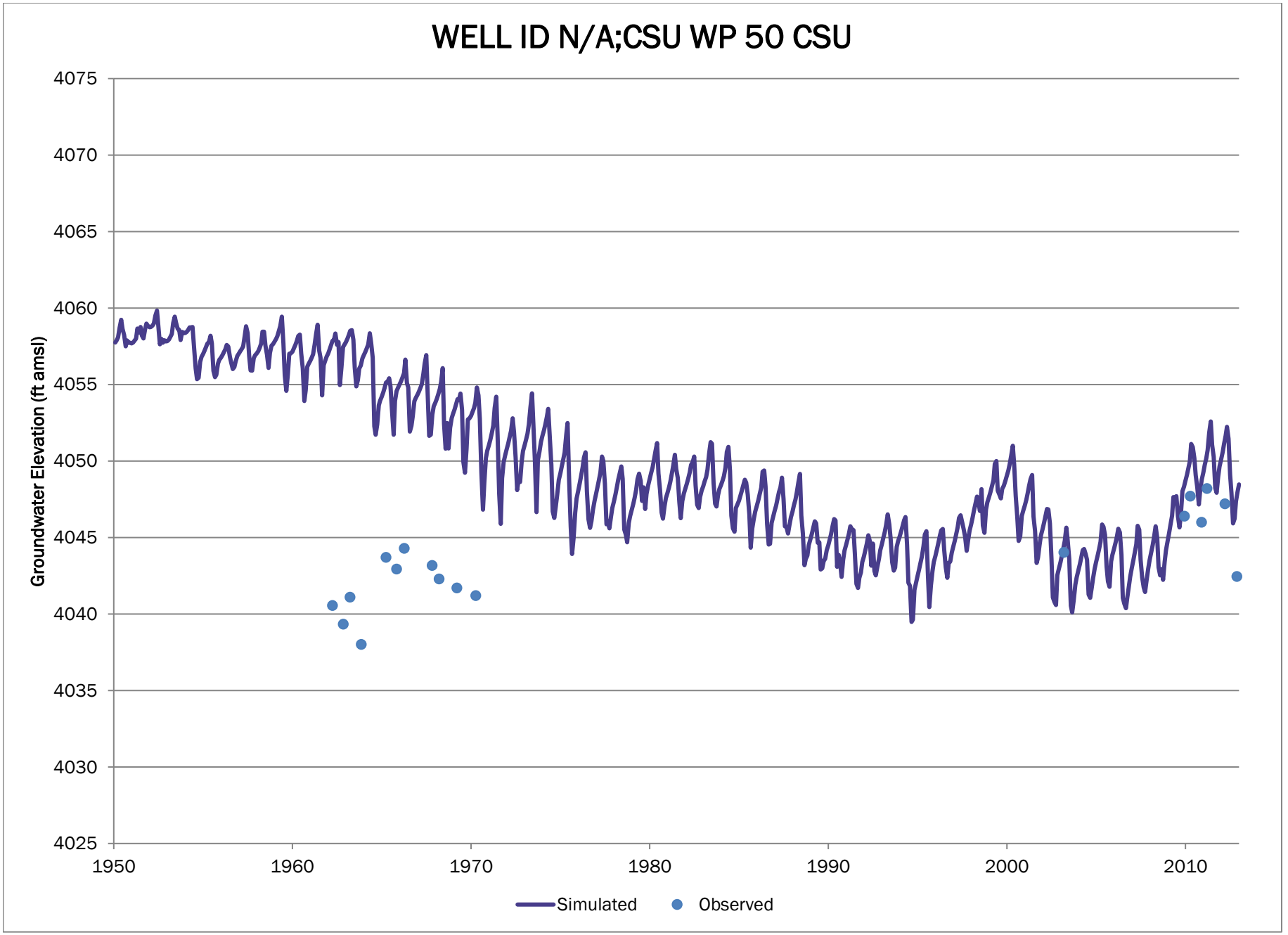

LSP-59 DSS09STR
Groundwater Elevation (ft amsl)
4050
4045
4040
4035
4030
4025
4020
4015
4010
4005
4000
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

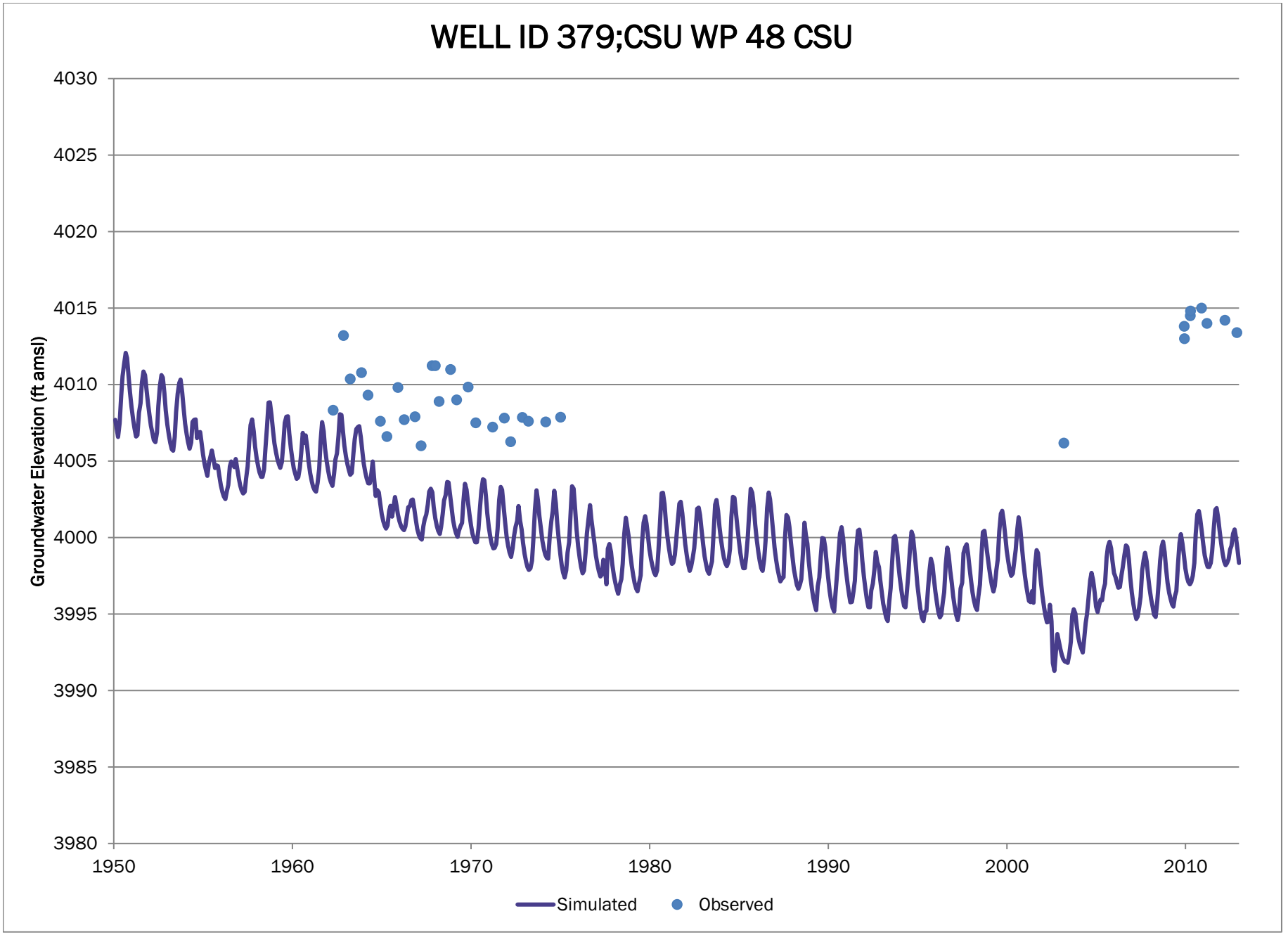

WELL ID N/A;CSU WP 36 CSU
Groundwater Elevation (ft amsl)
4065
4060
4055
4050
4045
4040
4035
4030
4025
4020
4015
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

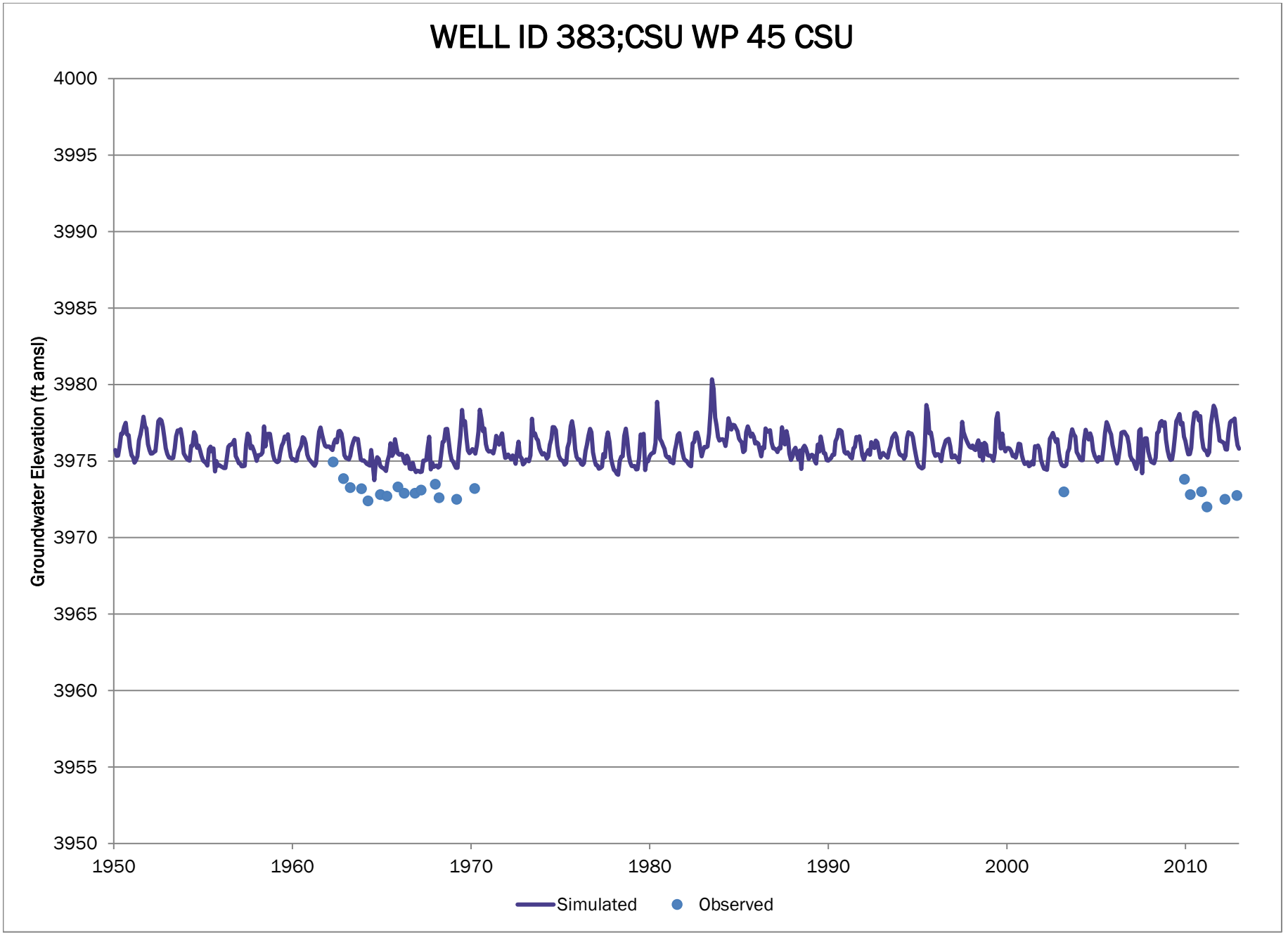

WELL ID 371;CSU WP 37 CSU
Groundwater Elevation (ft amsl)
4070
4065
4060
4055
4050
4045
4040
4035
4030
4025
4020
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

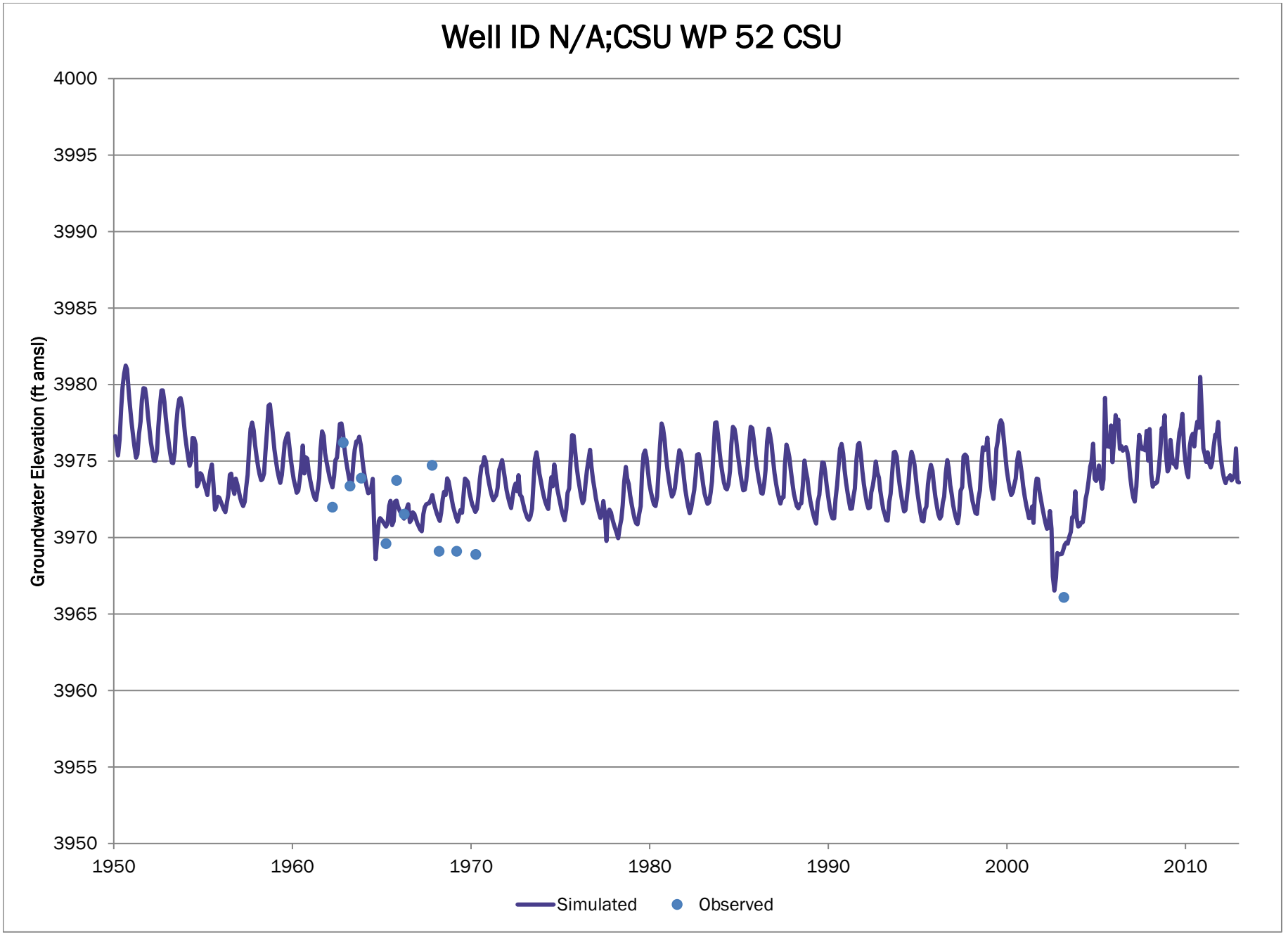

WELL ID N/A;CSU WP 38 CSU
Groundwater Elevation (ft amsl)
4065
4060
4055
4050
4045
4040
4035
4030
4025
4020
4015
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

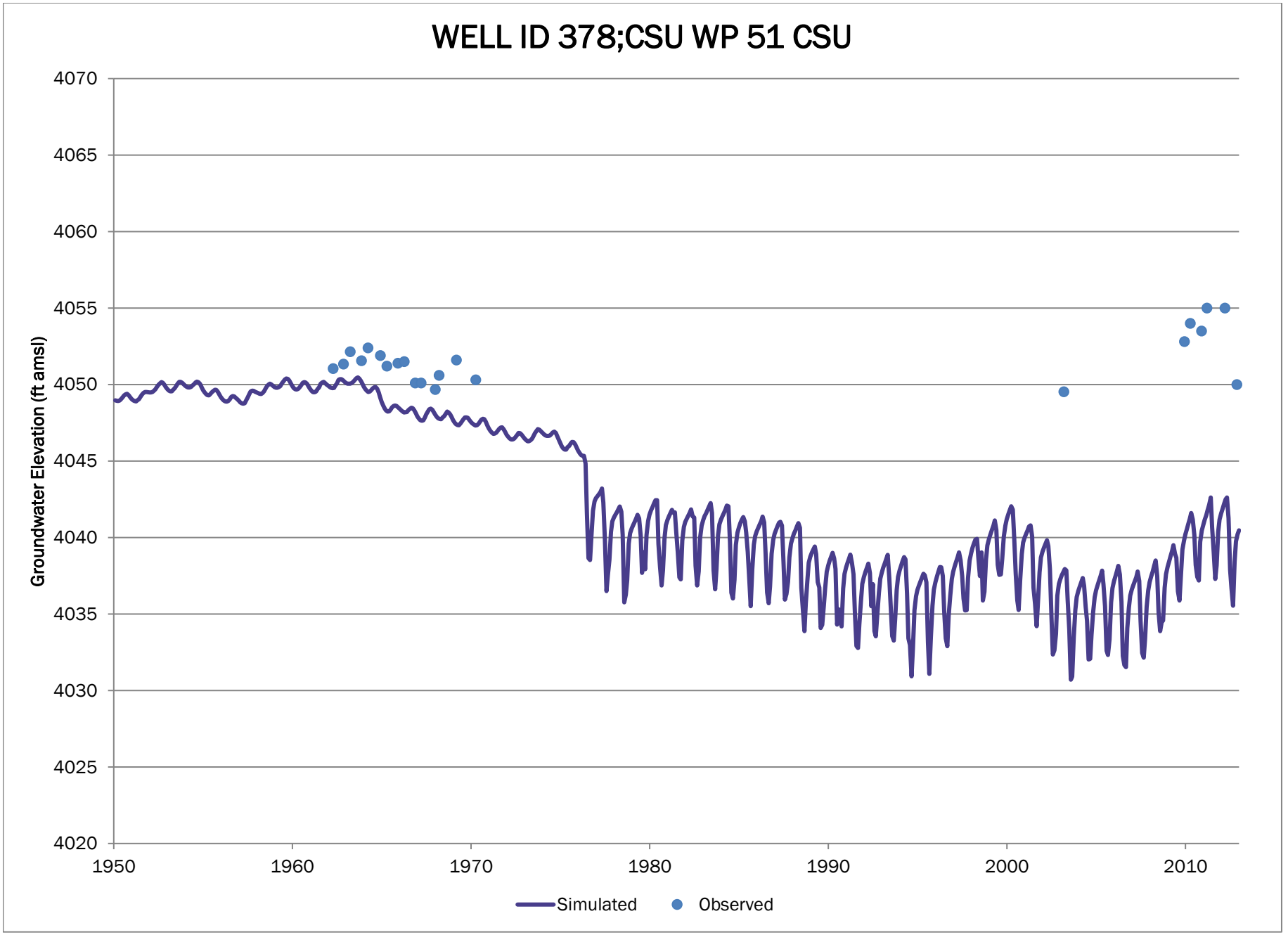

WELL ID 370;CSU WP 35 CSU
Groundwater Elevation (ft amsl)
4085
4080
4075
4070
4065
4060
4055
4050
4045
4040
4035
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

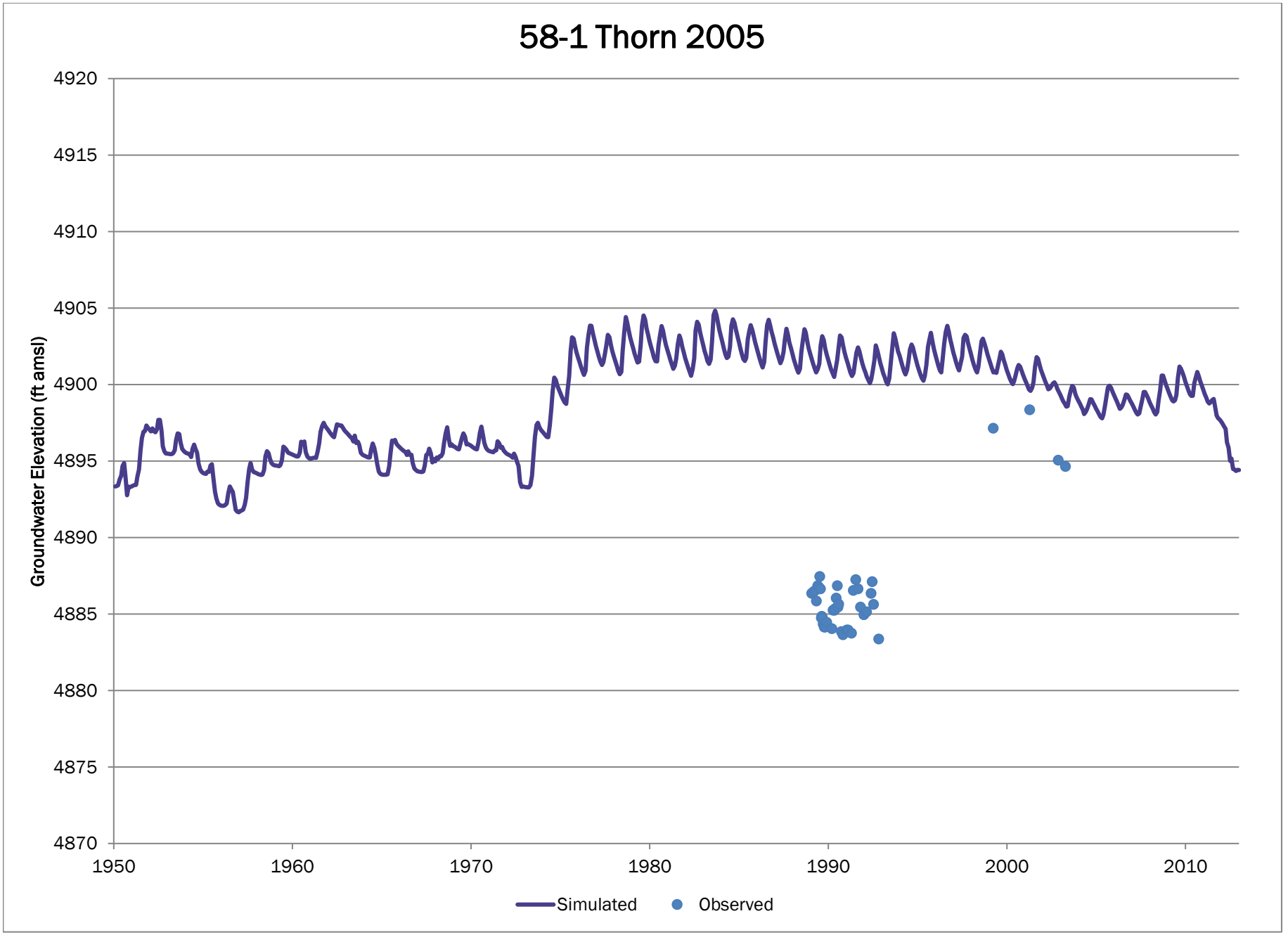

WELL ID N/A;CSU WP 50 CSU
Groundwater Elevation (ft amsl)
4075
4070
4065
4060
4055
4050
4045
4040
4035
4030
4025
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

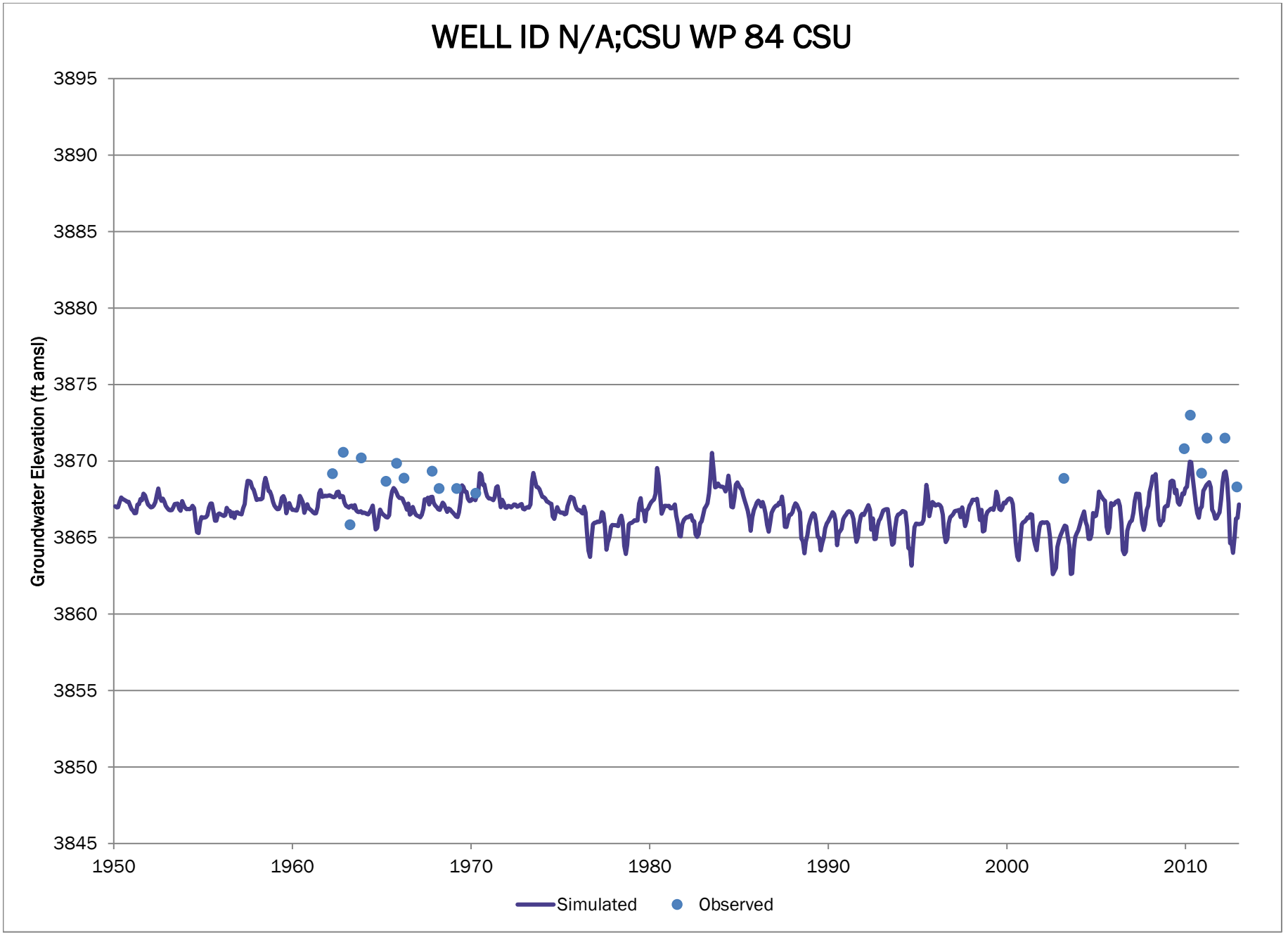

WELL ID 379;CSU WP 48 CSU
Groundwater Elevation (ft amsl)
4030
4025
4020
4015
4010
4005
4000
3995
3990
3985
3980
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

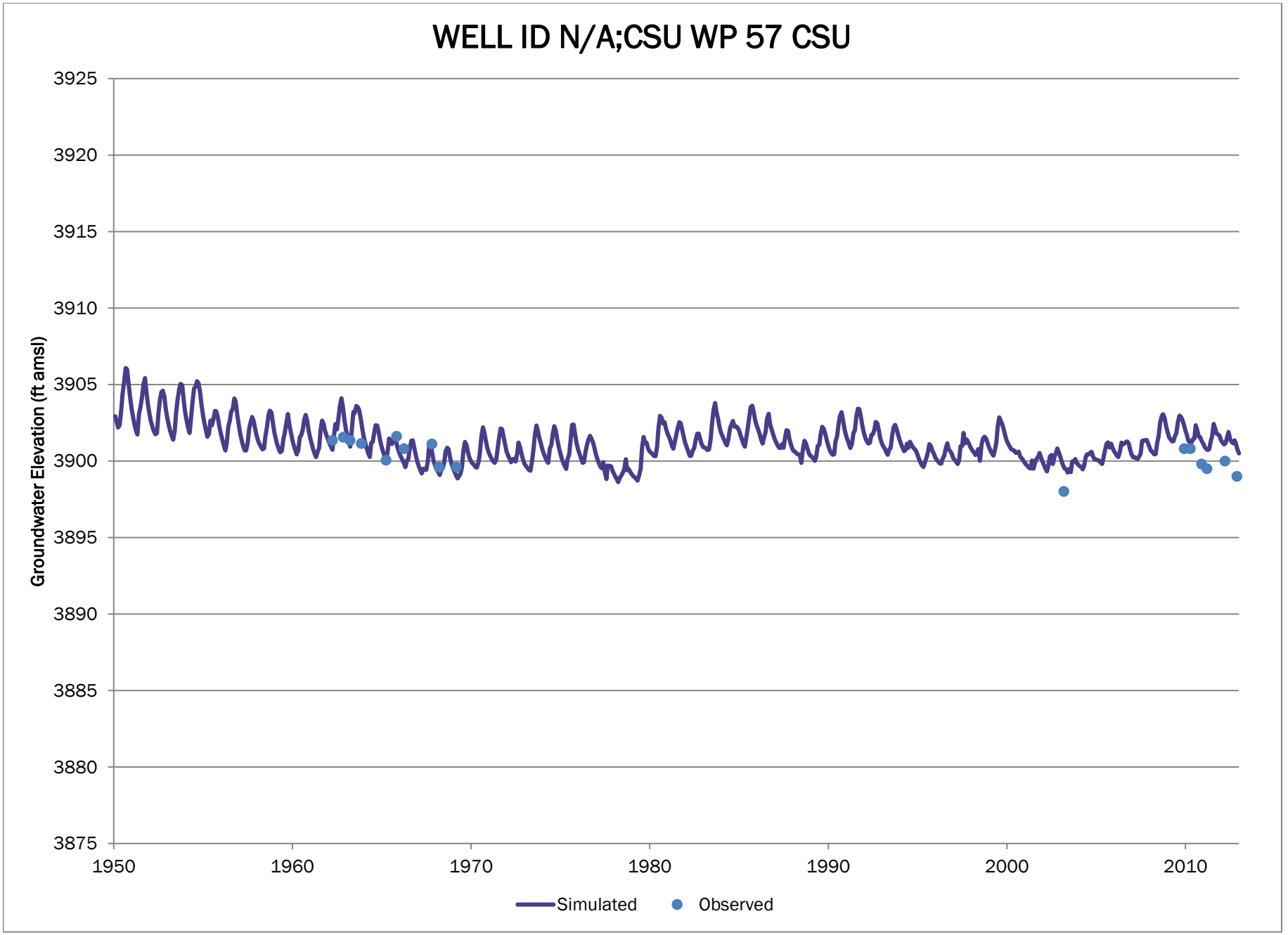

WELL ID 383;CSU WP 45 CSU
Groundwater Elevation (ft amsl)
4000
3995
3990
3985
3980
3975
3970
3965
3960
3955
3950
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

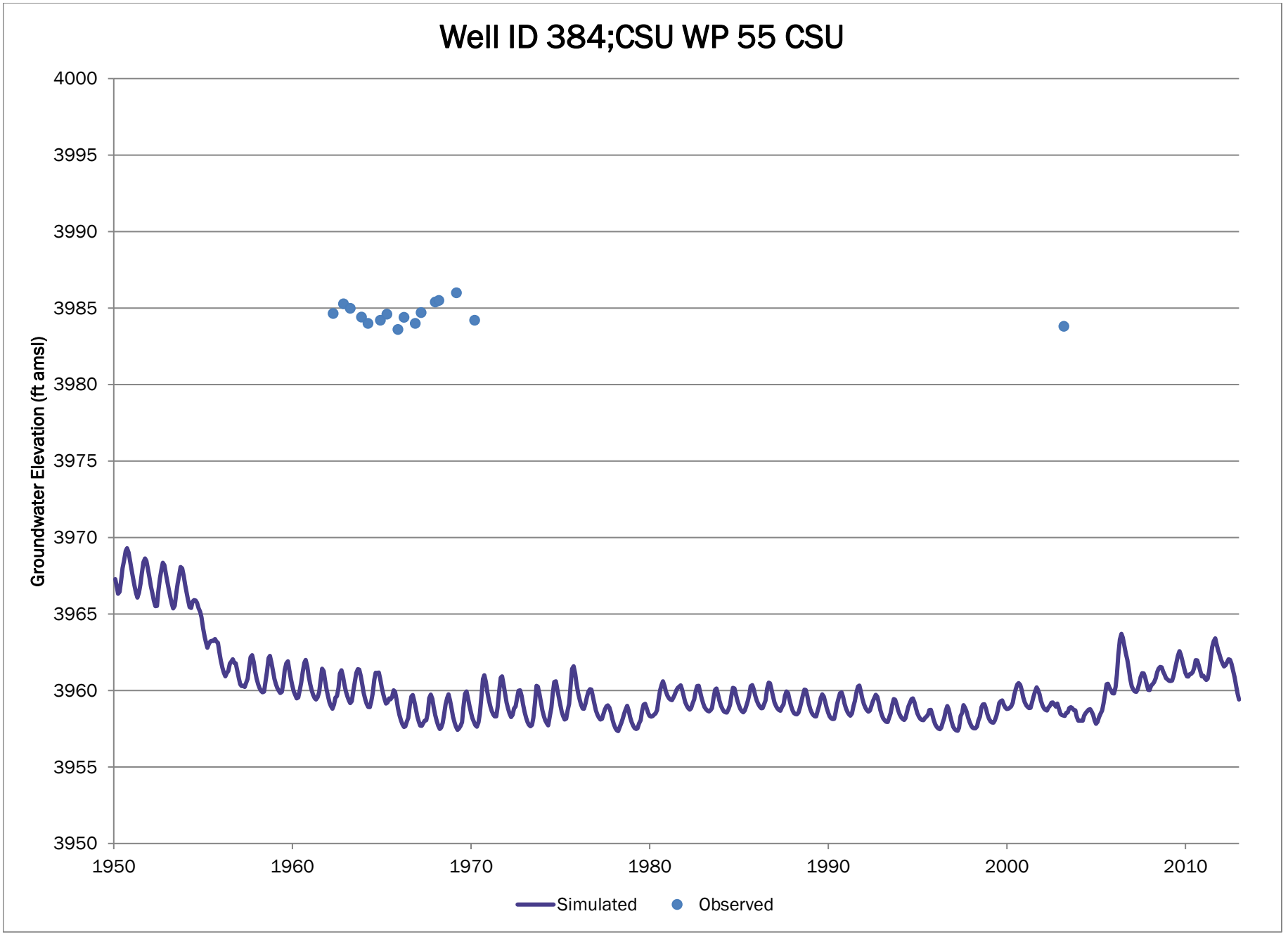

Well ID N/A;CSU WP 52 CSU
Groundwater Elevation (ft amsl)
4000
3995
3990
3985
3980
3975
3970
3965
3960
3955
3950
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

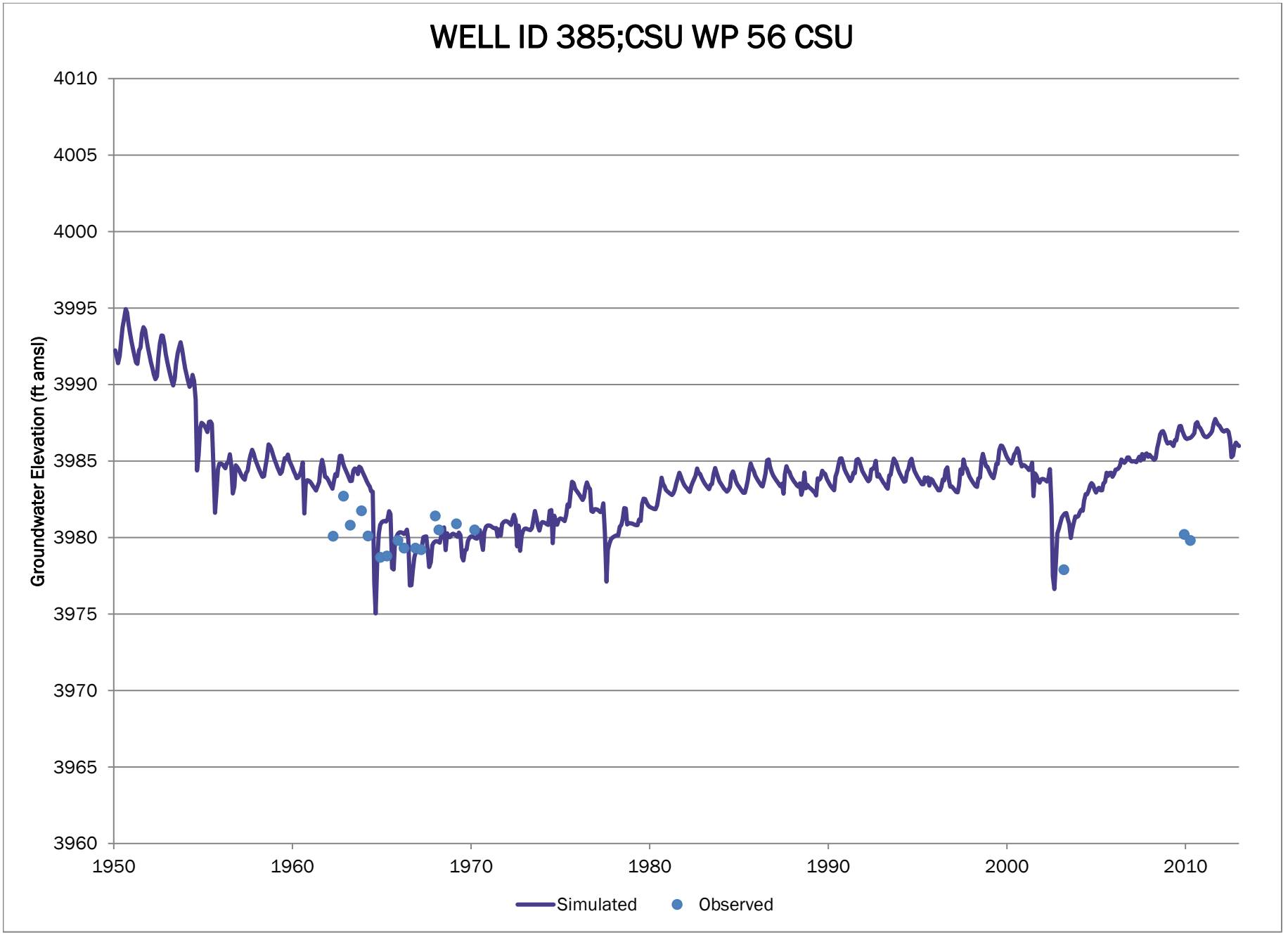

WELL ID 378;CSU WP 51 CSU
Groundwater Elevation (ft amsl)
4070
4065
4060
4055
4050
4045
4040
4035
4030
4025
4020
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

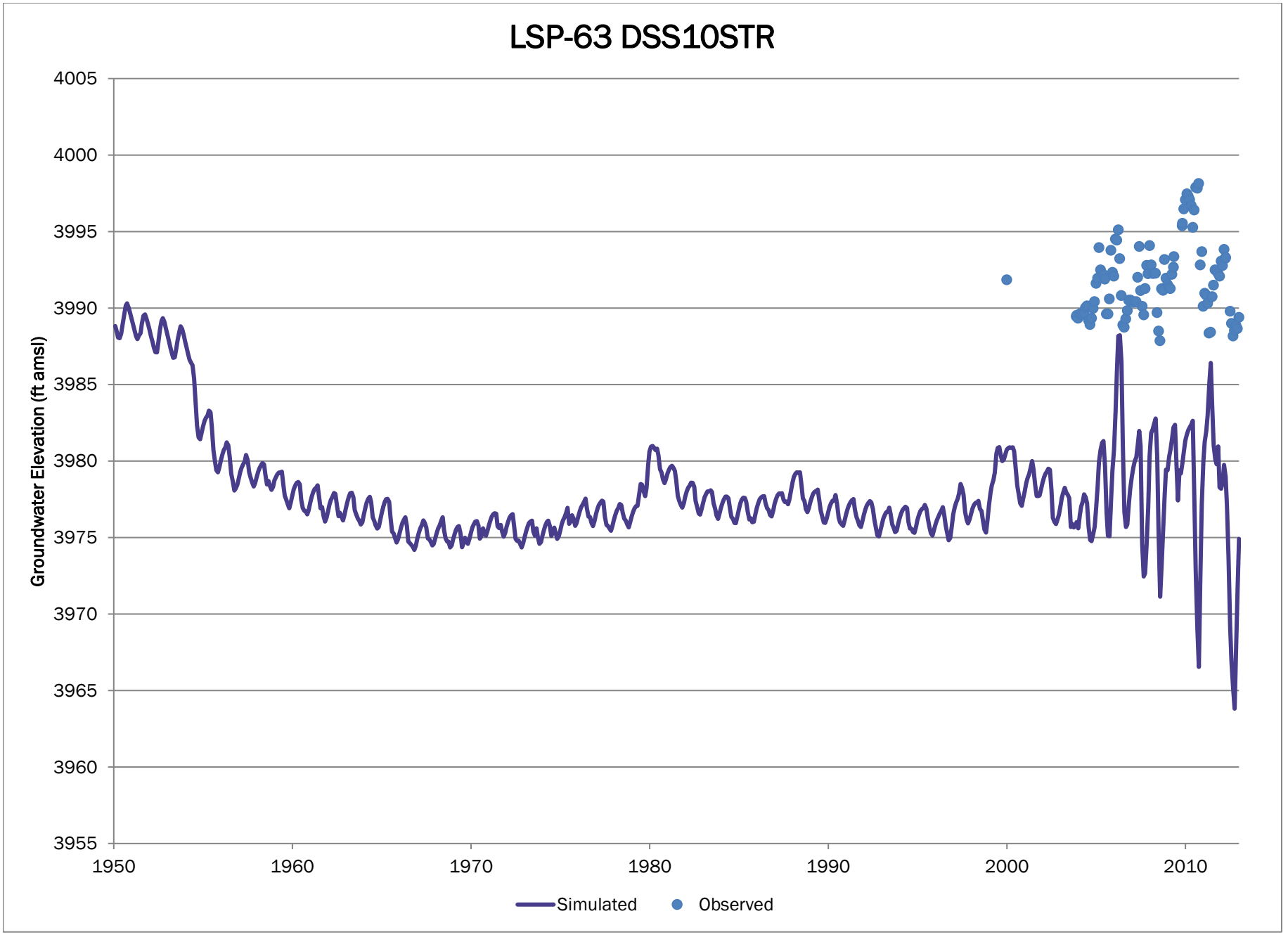

58-1 Thorn 2005
Groundwater Elevation (ft amsl)
4920
4915
4910
4905
4900
4895
4890
4885
4880
4875
4870
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

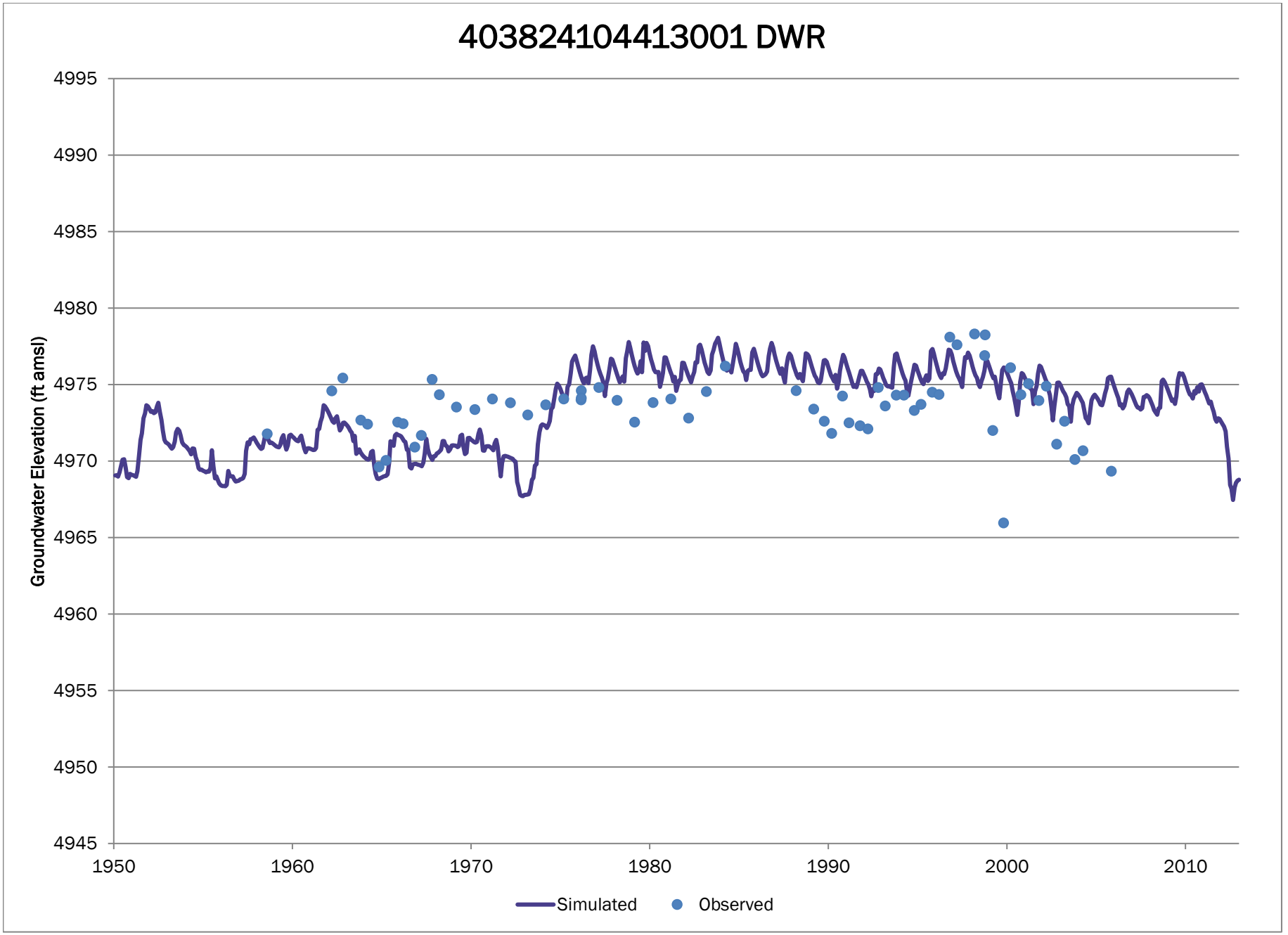

WELL ID N/A;CSU WP 84 CSU
Groundwater Elevation (ft amsl)
3895
3890
3885
3880
3875
3870
3865
3860
3855
3850
3845
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

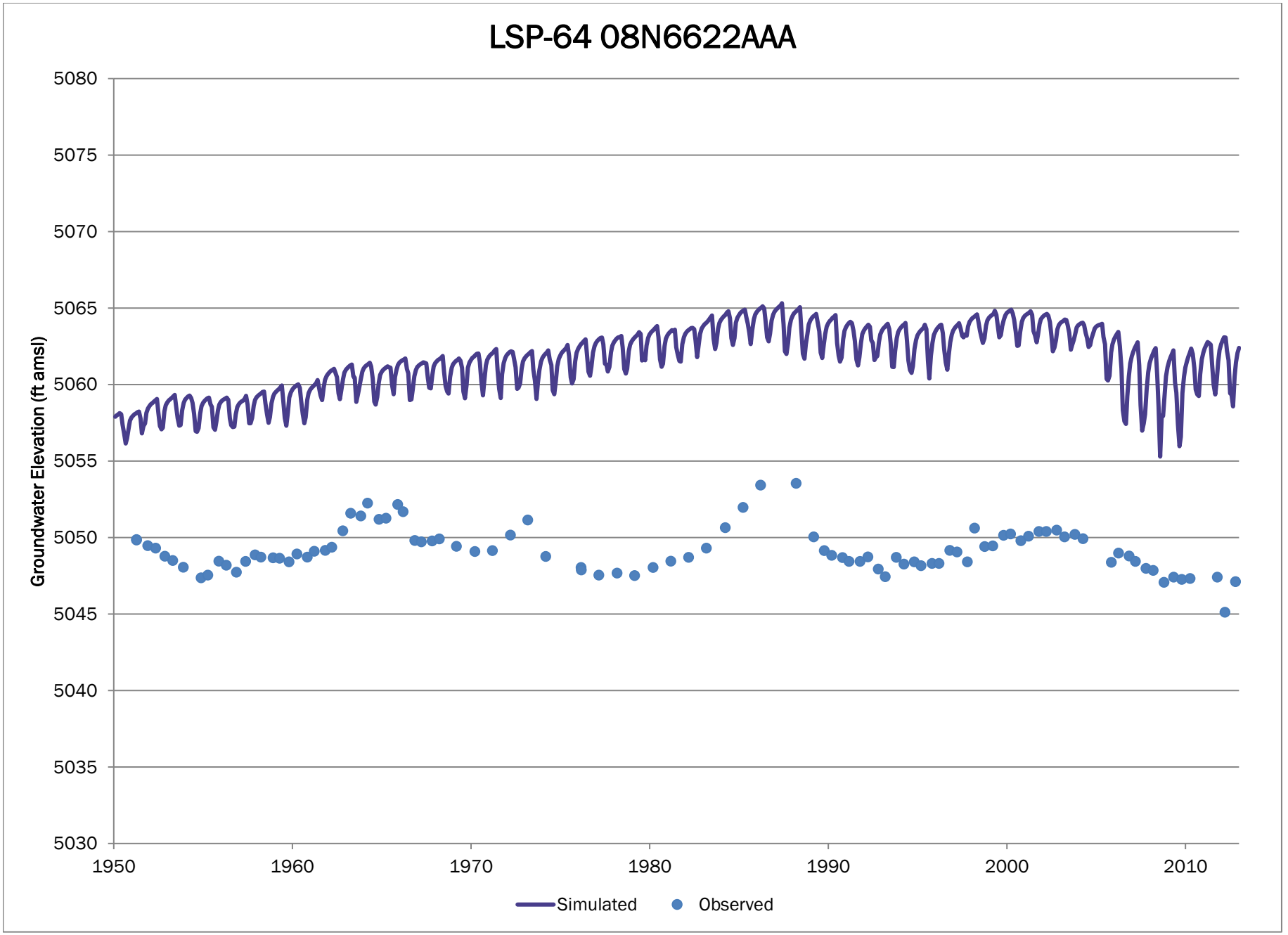

WELL ID N/A;CSU WP 57 CSU
Groundwater Elevation (ft amsl)
3925
3920
3915
3910
3905
3900
3895
3890
3885
3880
3875
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

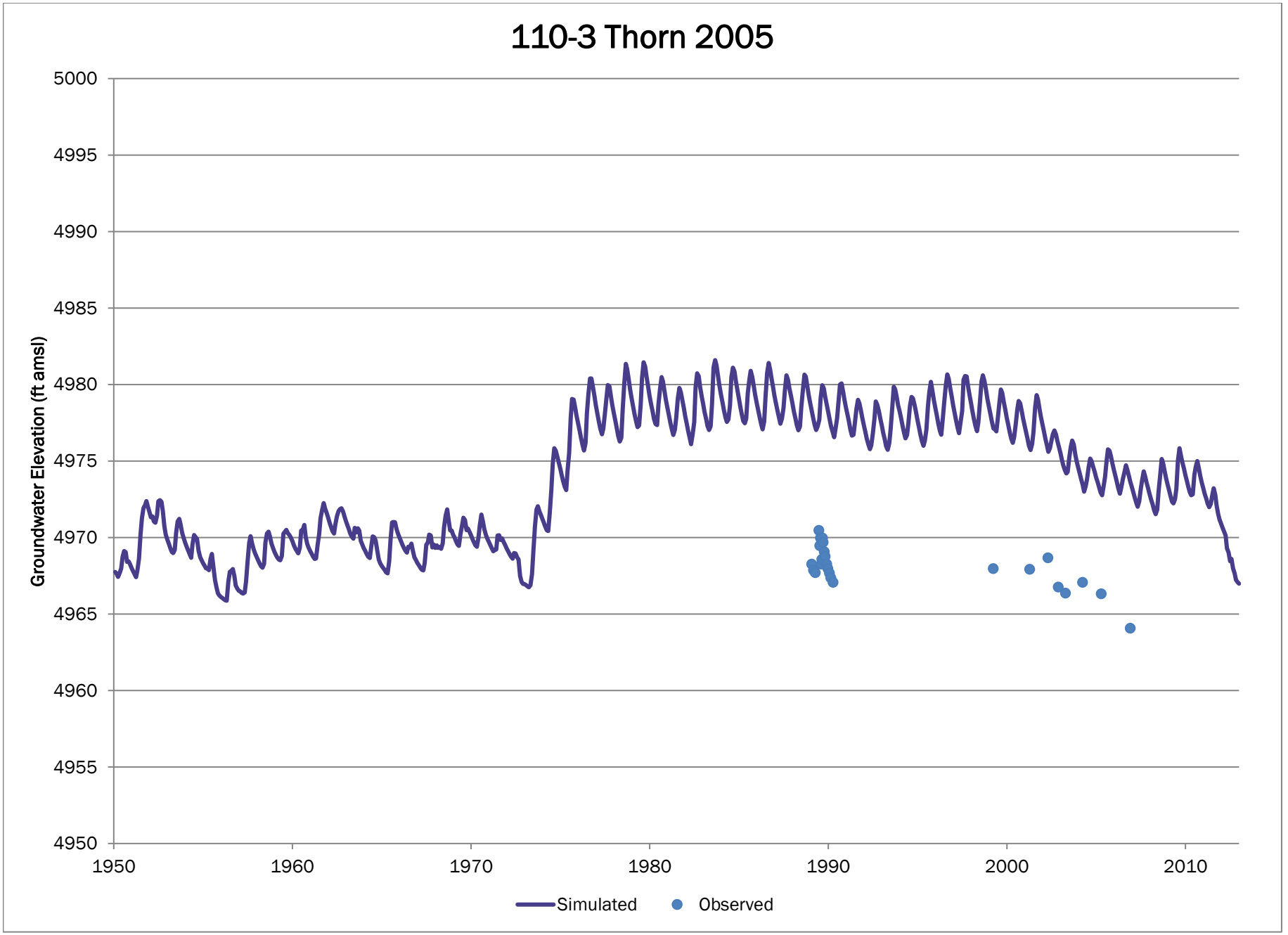

Well ID 384;CSU WP 55 CSU
Groundwater Elevation (ft amsl)
4000
3995
3990
3985
3980
3975
3970
3965
3960
3955
3950
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

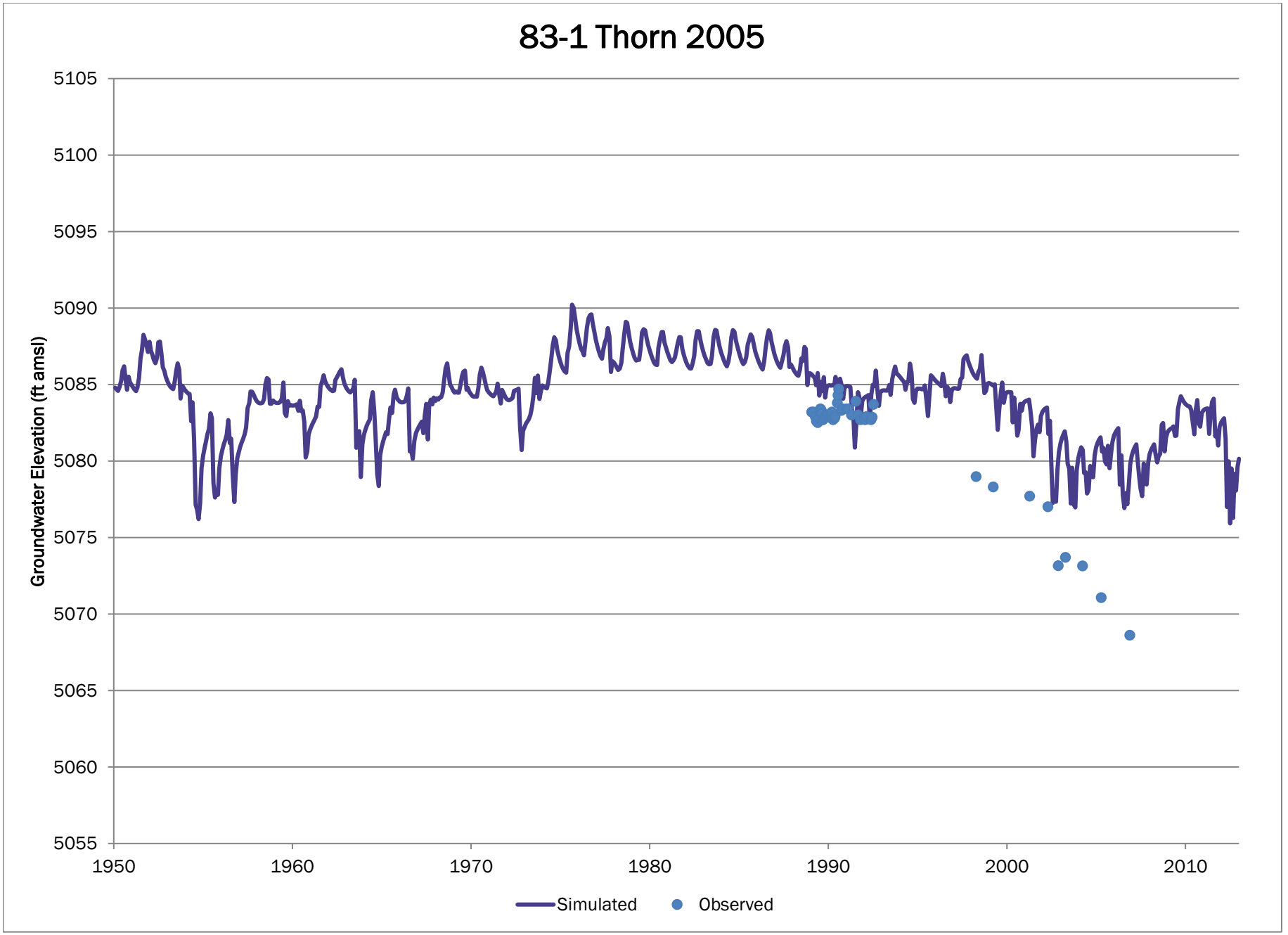

WELL ID 385;CSU WP 56 CSU
Groundwater Elevation (ft amsl)
4010
4005
4000
3995
3990
3985
3980
3975
3970
3965
3960
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

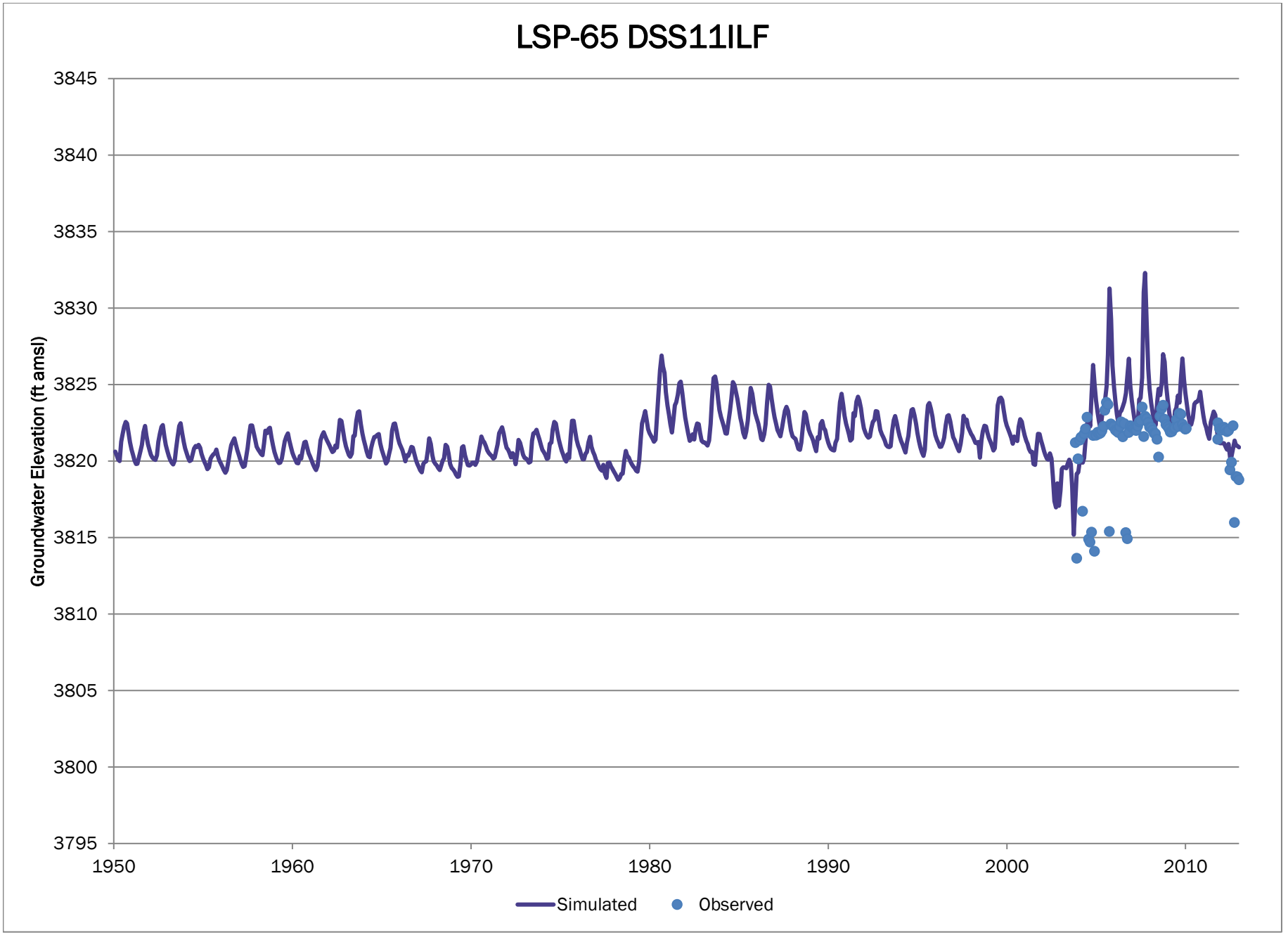

LSP-63 DSS10STR
Groundwater Elevation (ft amsl)
4005
4000
3995
3990
3985
3980
3975
3970
3965
3960
3955
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

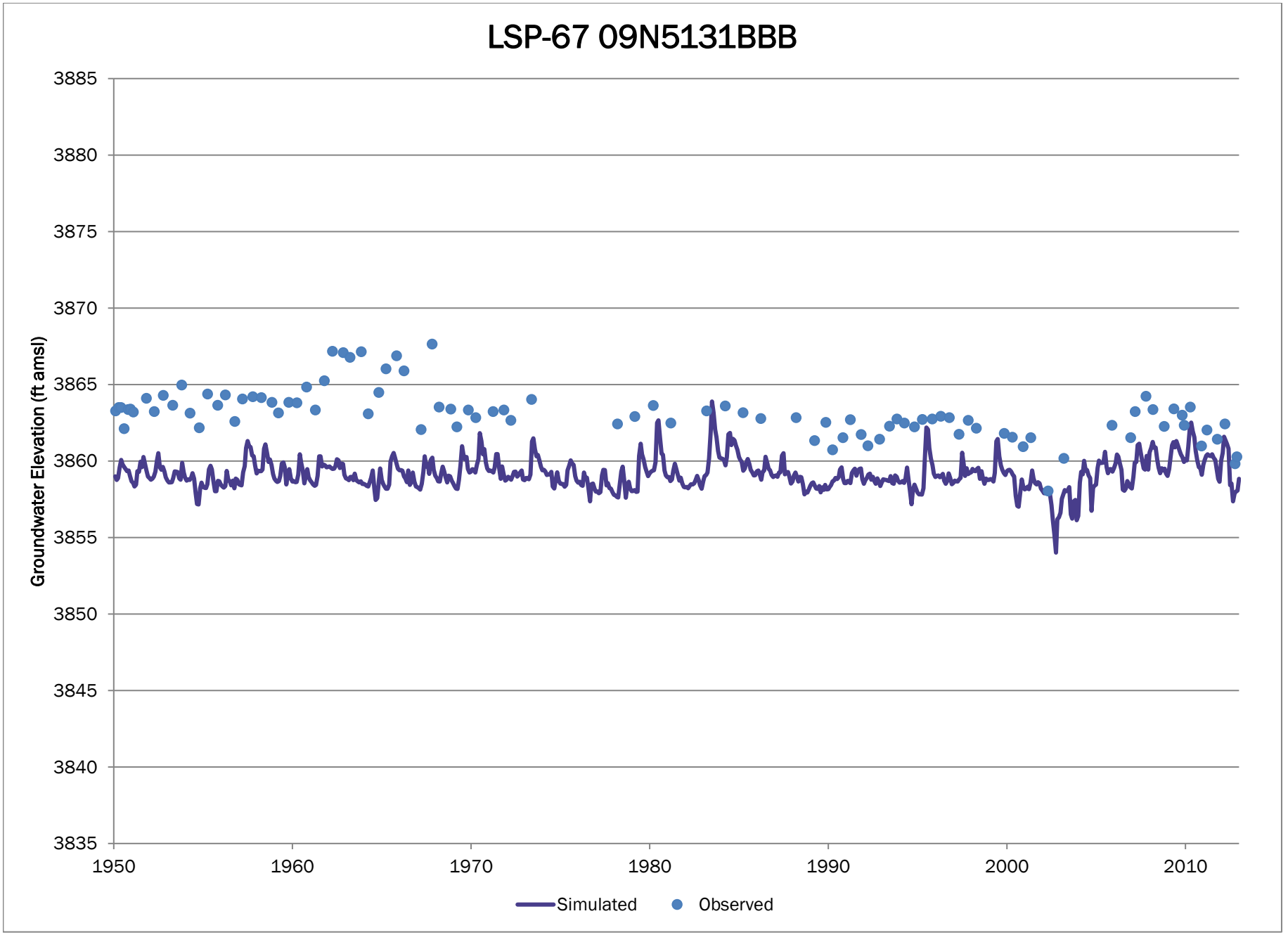

403824104413001 DWR
Groundwater Elevation (ft amsl)
4995
4990
4985
4980
4975
4970
4965
4960
4955
4950
4945
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

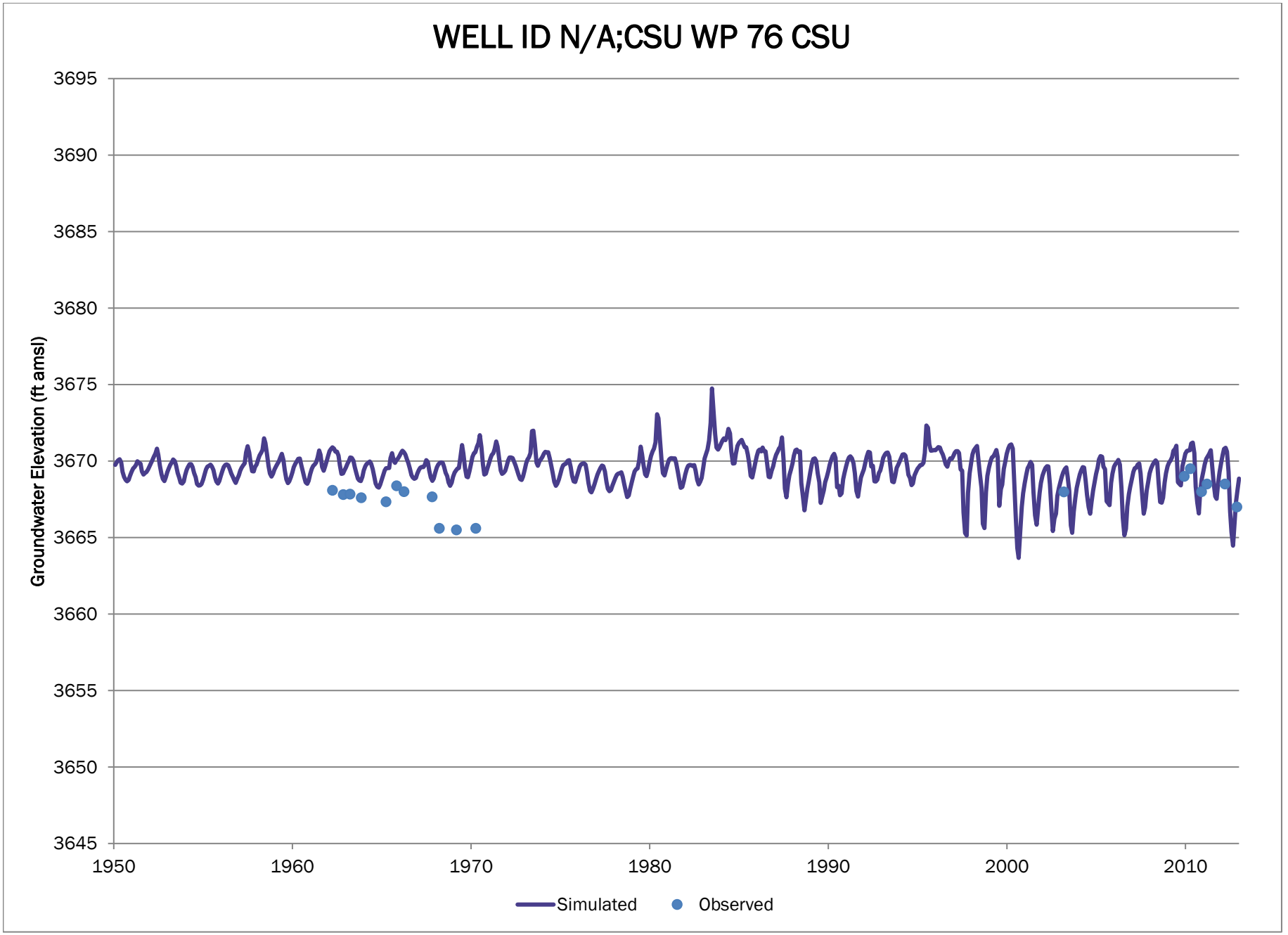

LSP-64 08N6622AAA
Groundwater Elevation (ft amsl)
5080
5075
5070
5065
5060
5055
5050
5045
5040
5035
5030
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

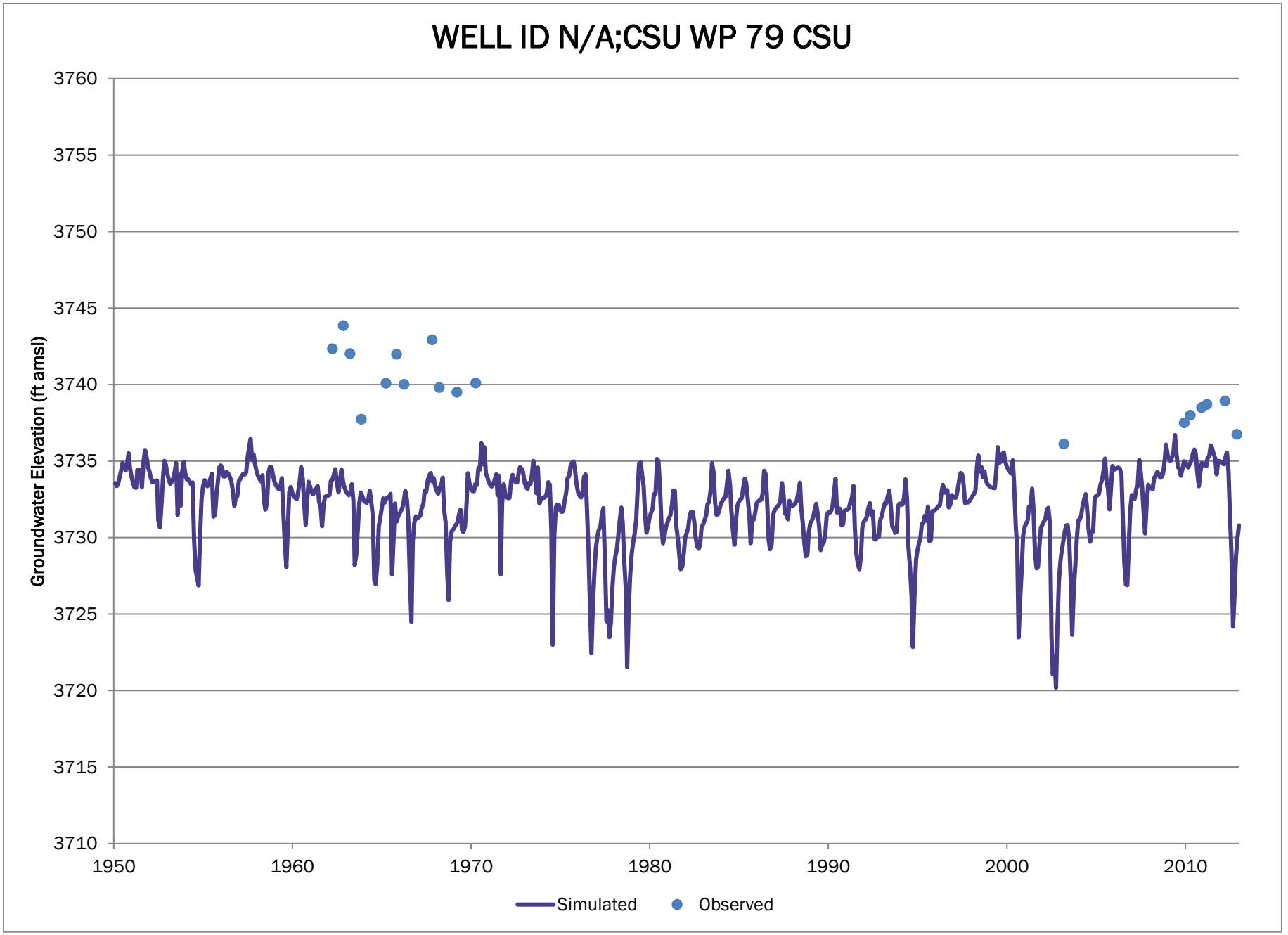

110-3 Thorn 2005
Groundwater Elevation (ft amsl)
5000
4995
4990
4985
4980
4975
4970
4965
4960
4955
4950
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

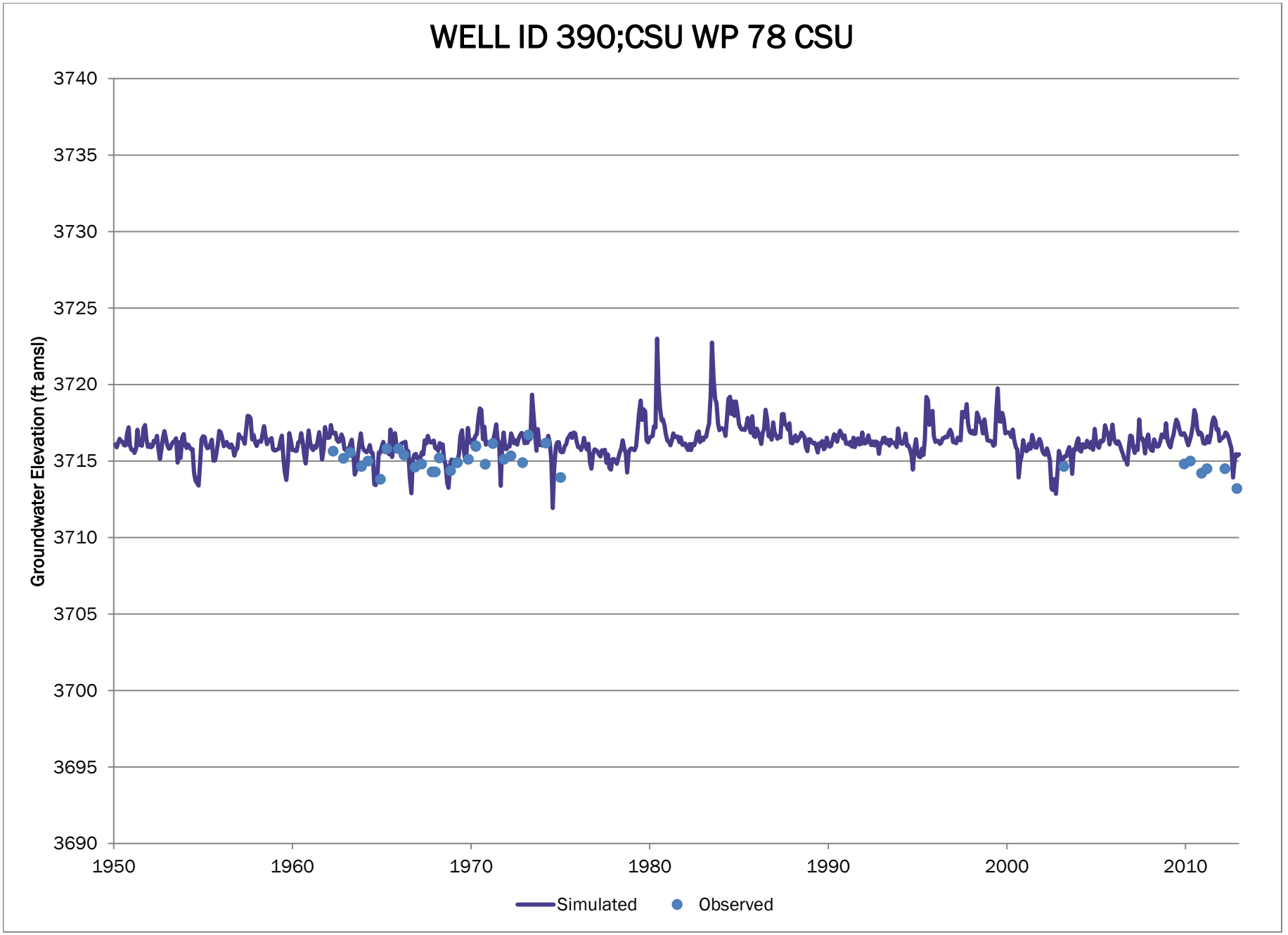

83-1 Thorn 2005
Groundwater Elevation (ft amsl)
5105
5100
5095
5090
5085
5080
5075
5070
5065
5060
5055
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

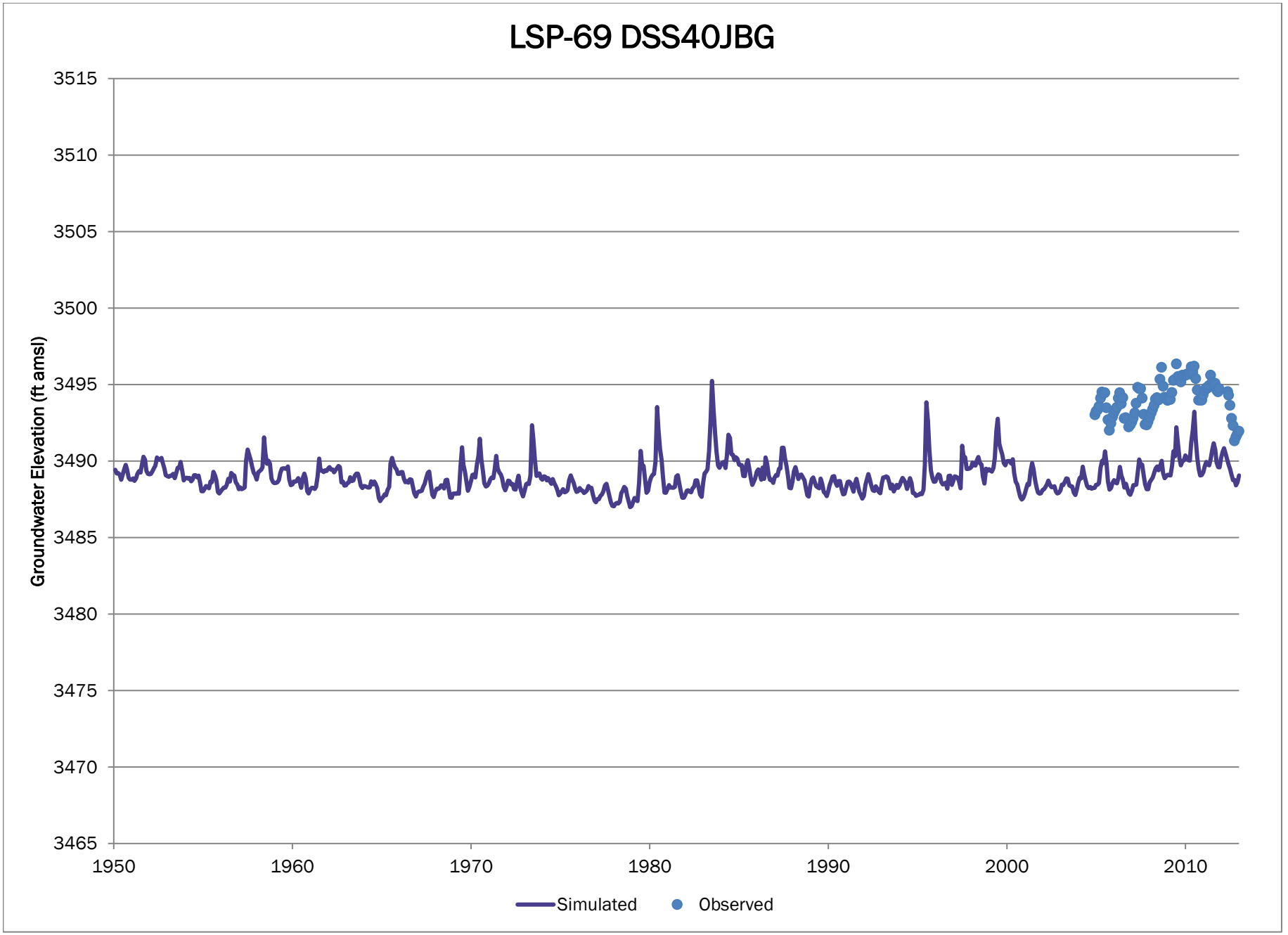

LSP-65 DSS11ILF
Groundwater Elevation (ft amsl)
3845
3840
3835
3830
3825
3820
3815
3810
3805
3800
3795
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

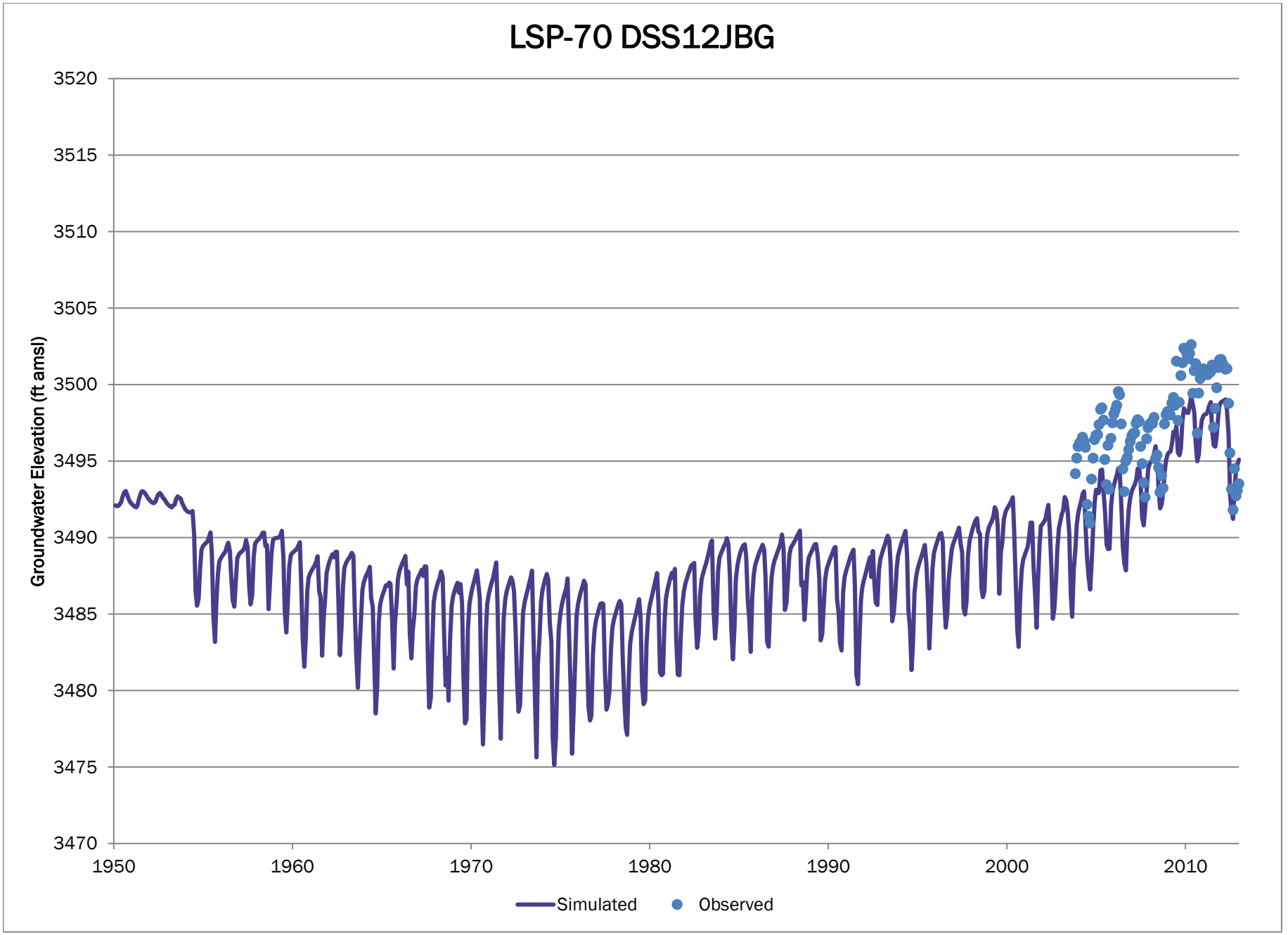

LSP-67 09N5131BBB
Groundwater Elevation (ft amsl)
3885
3880
3875
3870
3865
3860
3855
3850
3845
3840
3835
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

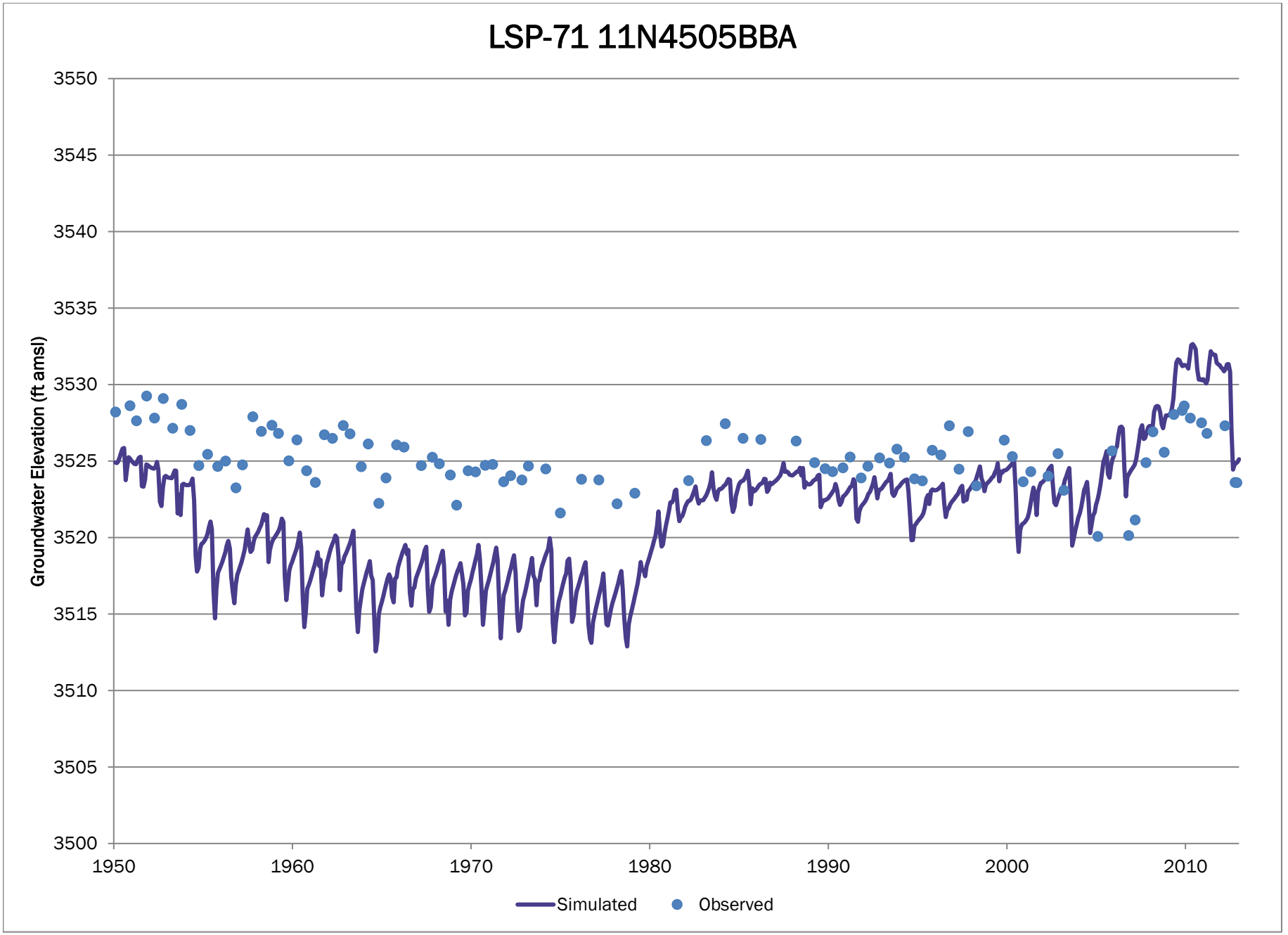

WELL ID N/A;CSU WP 76 CSU
Groundwater Elevation (ft amsl)
3695
3690
3685
3680
3675
3670
3665
3660
3655
3650
3645
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

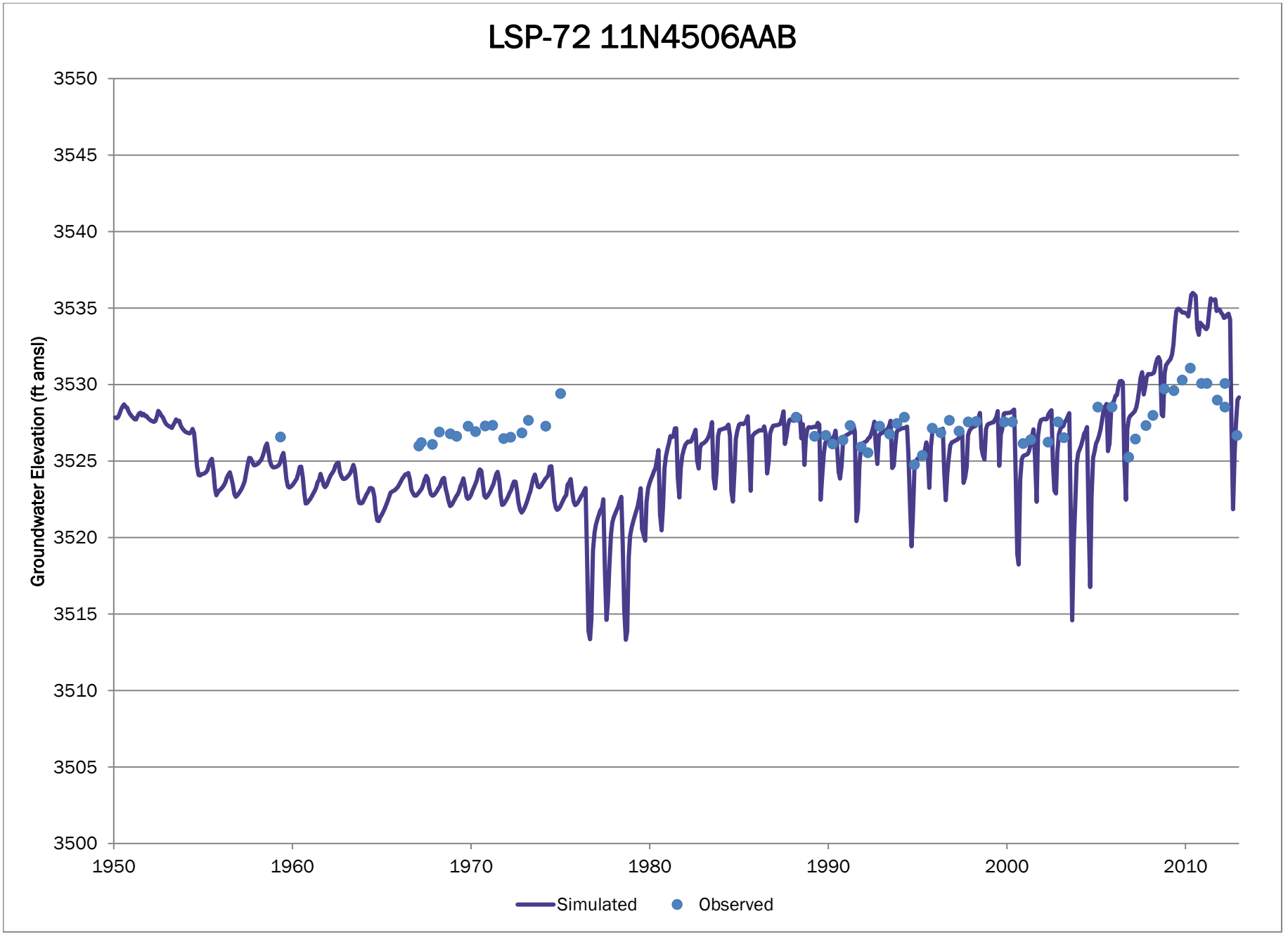

WELL ID N/A;CSU WP 79 CSU
Groundwater Elevation (ft amsl)
3760
3755
3750
3745
3740
3735
3730
3725
3720
3715
3710
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

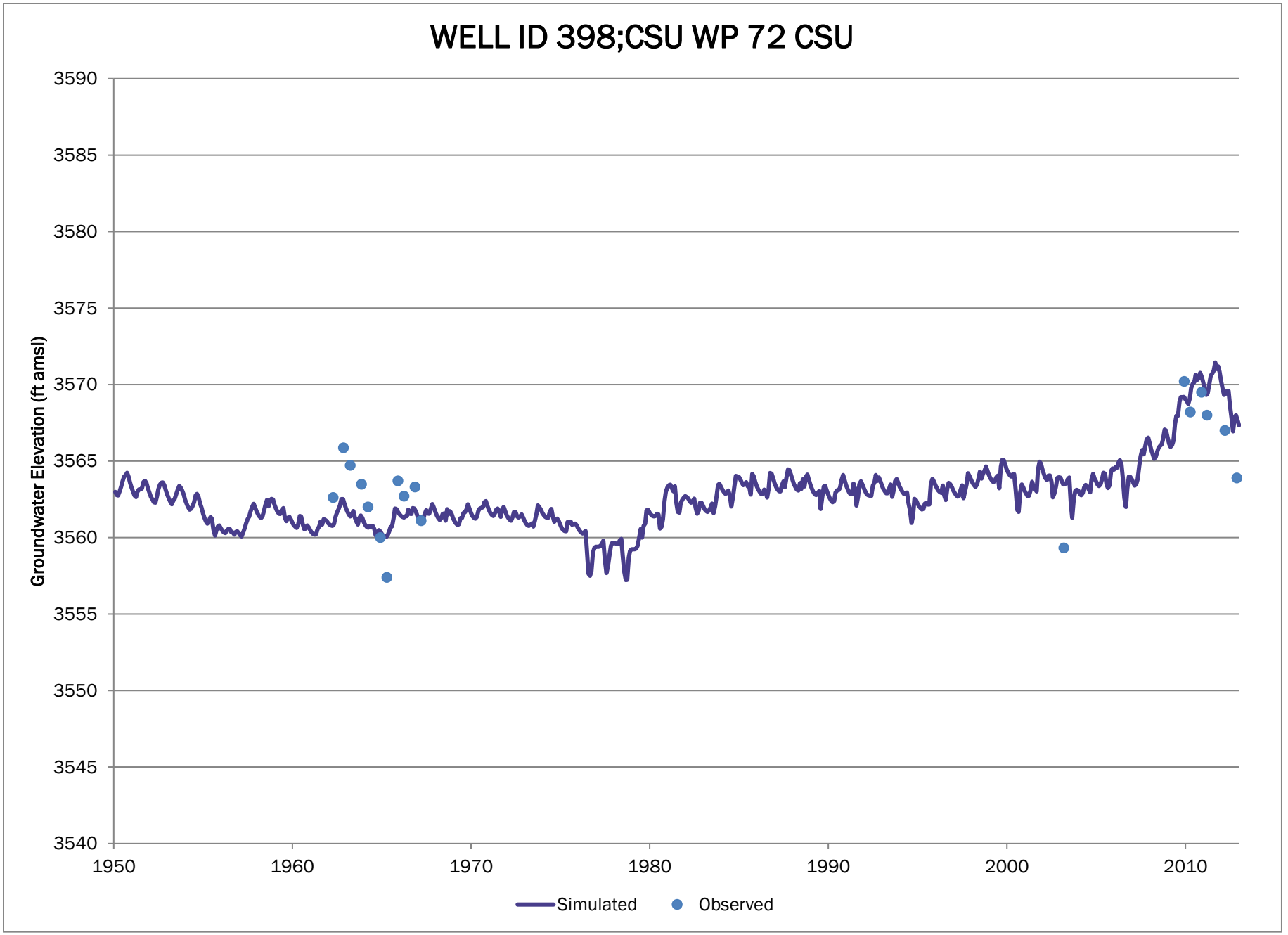

WELL ID 390;CSU WP 78 CSU
Groundwater Elevation (ft amsl)
3740
3735
3730
3725
3720
3715
3710
3705
3700
3695
3690
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

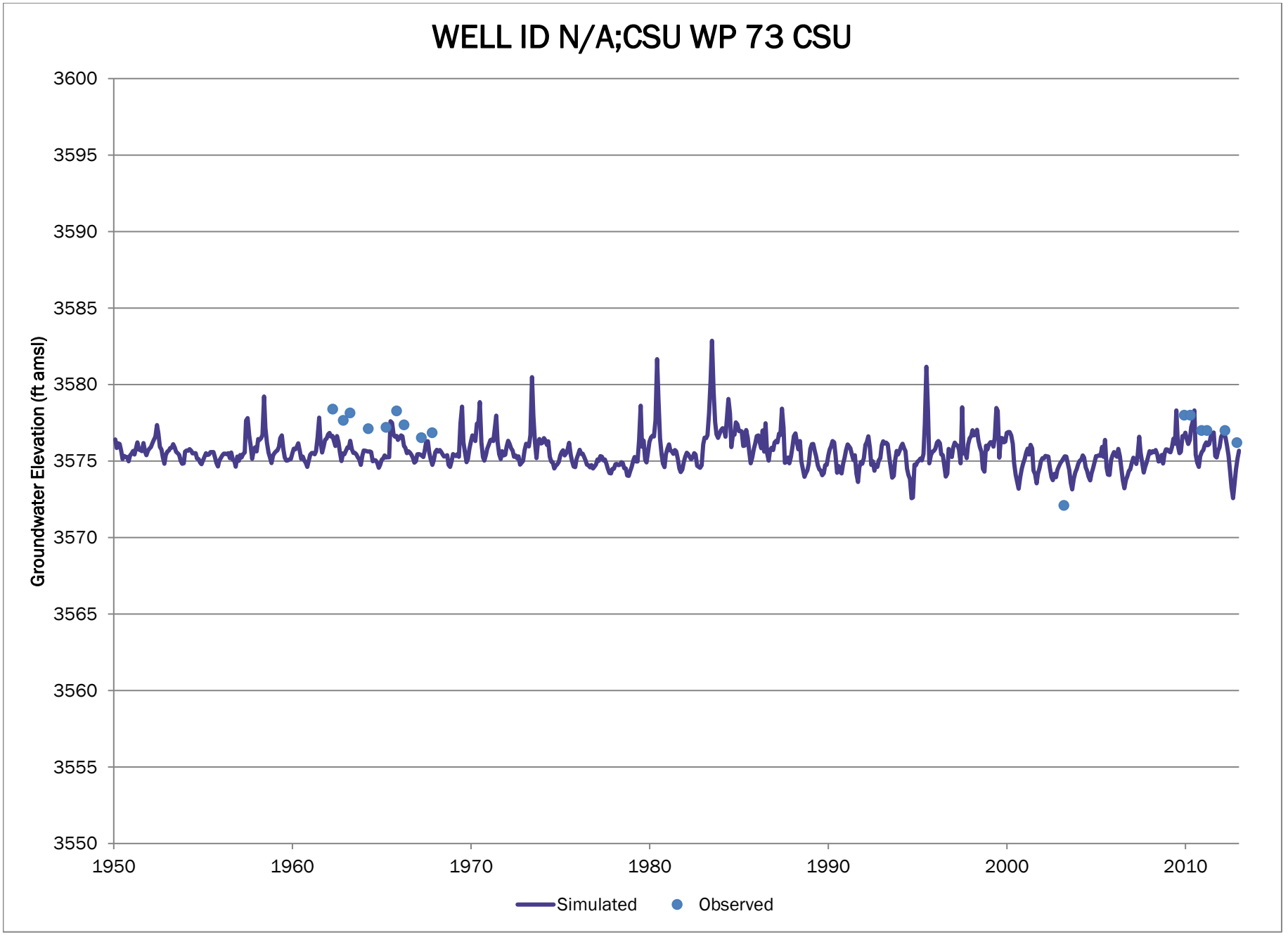

LSP-69 DSS40JBG
Groundwater Elevation (ft amsl)
3515
3510
3505
3500
3495
3490
3485
3480
3475
3470
3465
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

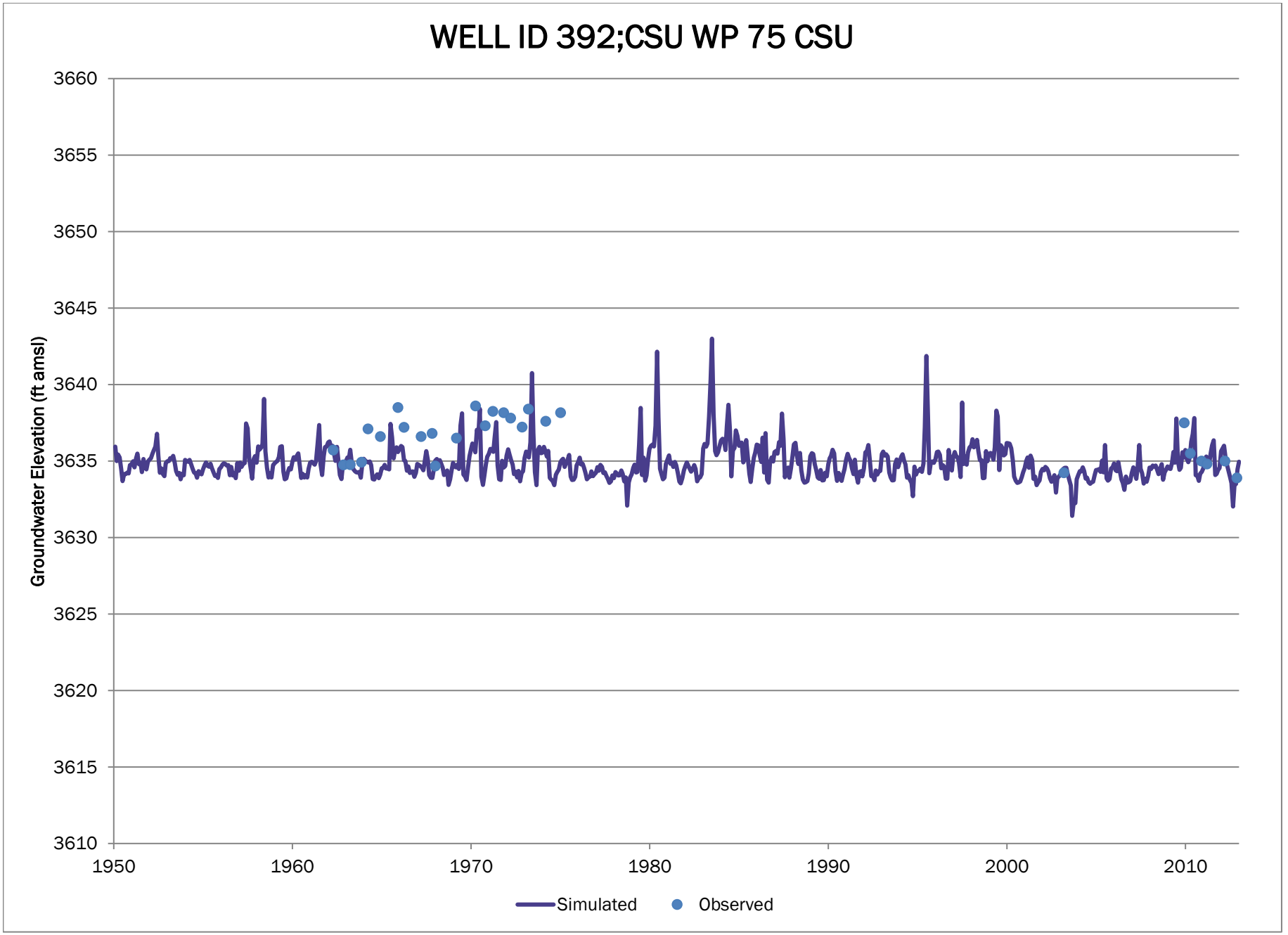

LSP-70 DSS12JBG
Groundwater Elevation (ft amsl)
3520
3515
3510
3505
3500
3495
3490
3485
3480
3475
3470
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

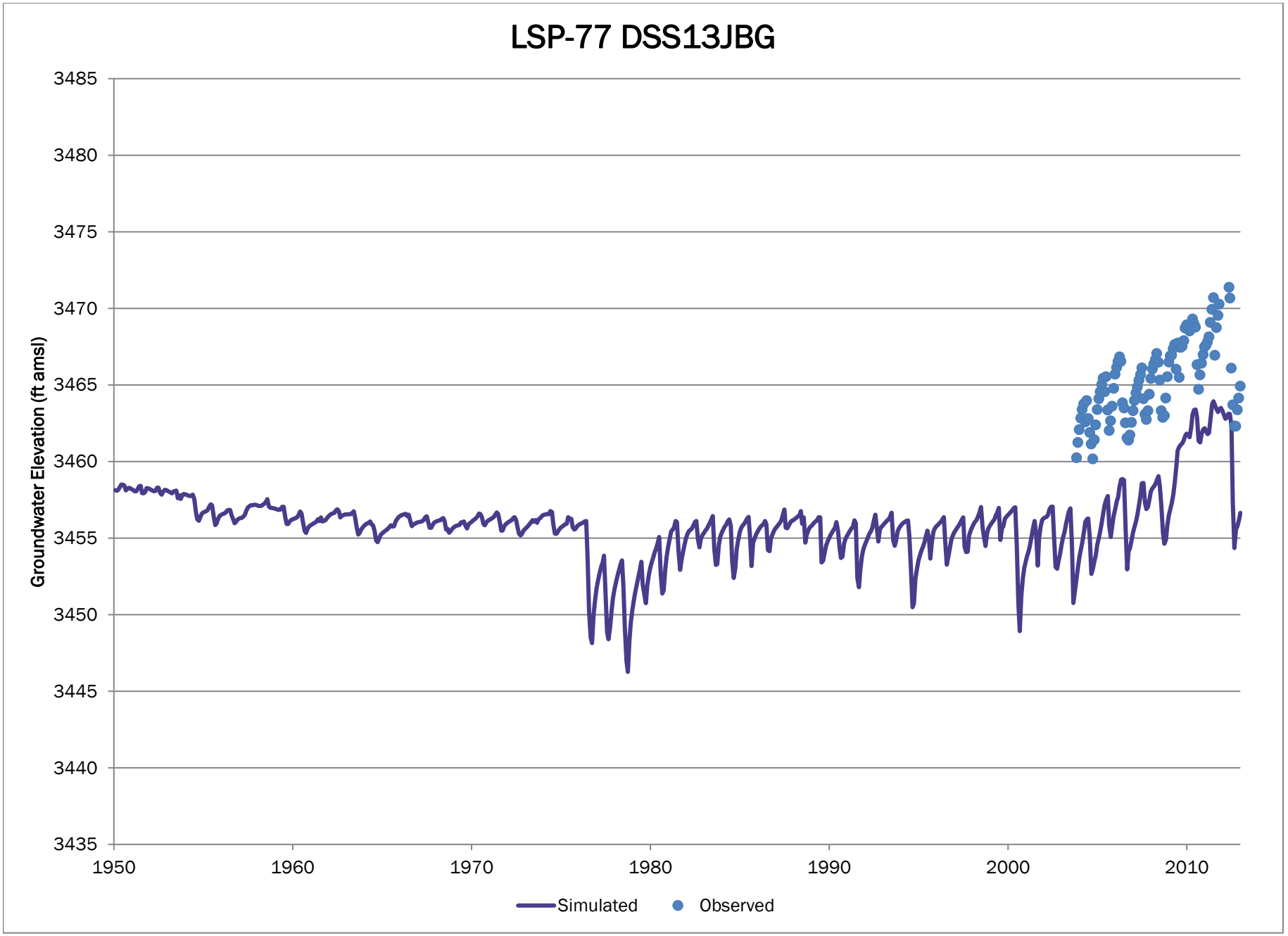

LSP-71 11N4505BBA
Groundwater Elevation (ft amsl)
3550
3545
3540
3535
3530
3525
3520
3515
3510
3505
3500
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

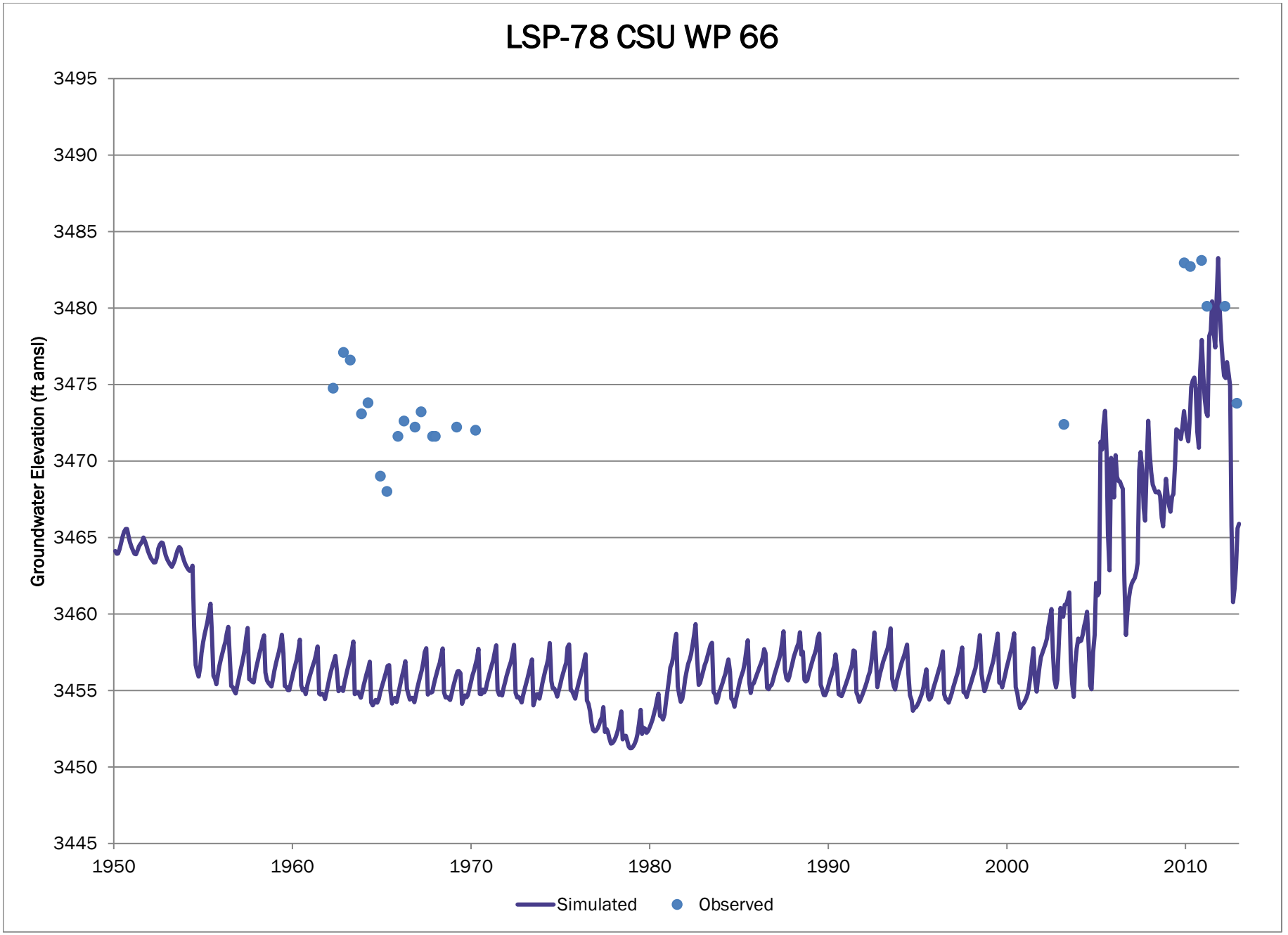

LSP-72 11N4506AAB
Groundwater Elevation (ft amsl)
3550
3545
3540
3535
3530
3525
3520
3515
3510
3505
3500
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

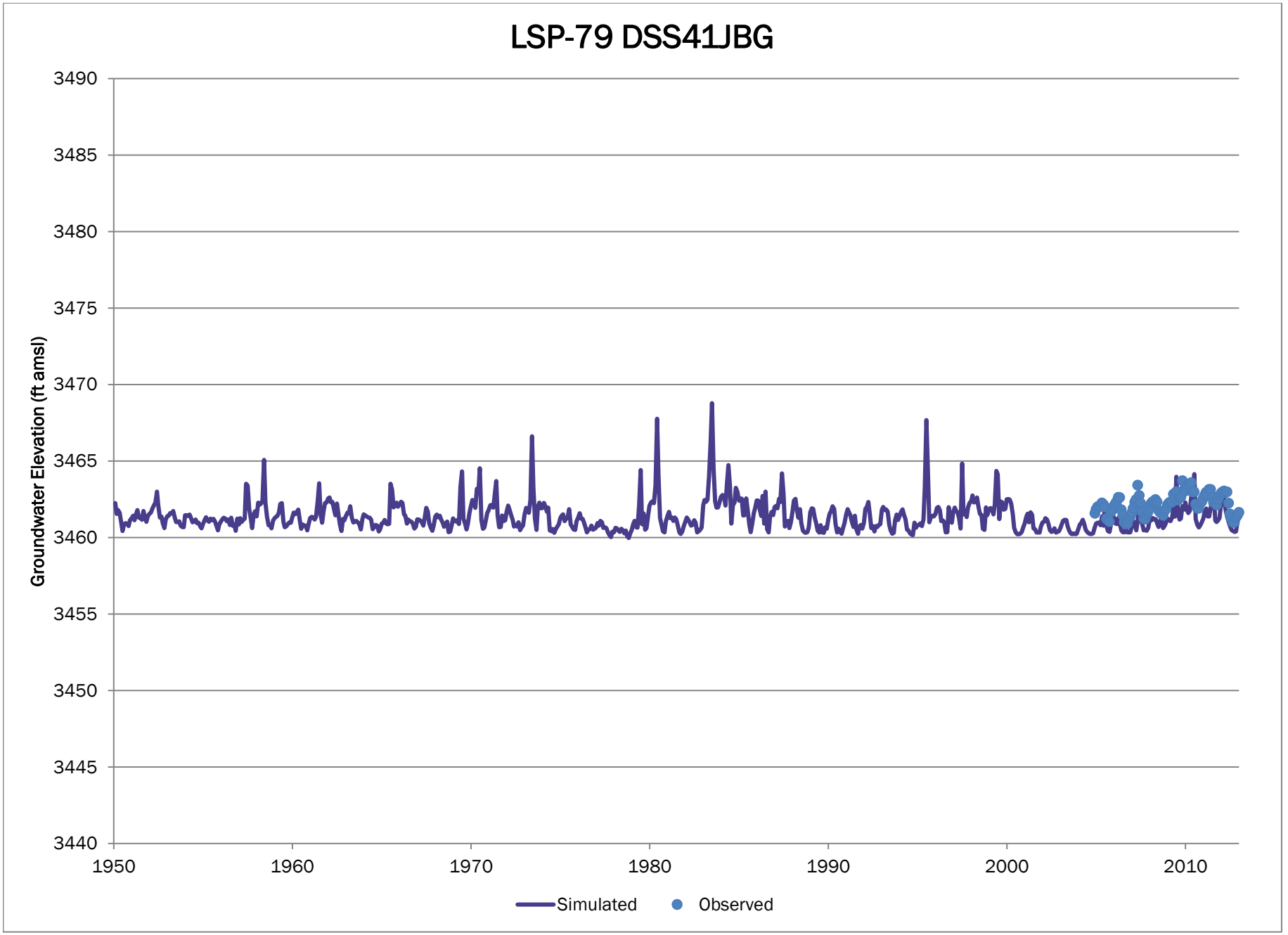

WELL ID 398;CSU WP 72 CSU
Groundwater Elevation (ft amsl)
3590
3585
3580
3575
3570
3565
3560
3555
3550
3545
3540
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

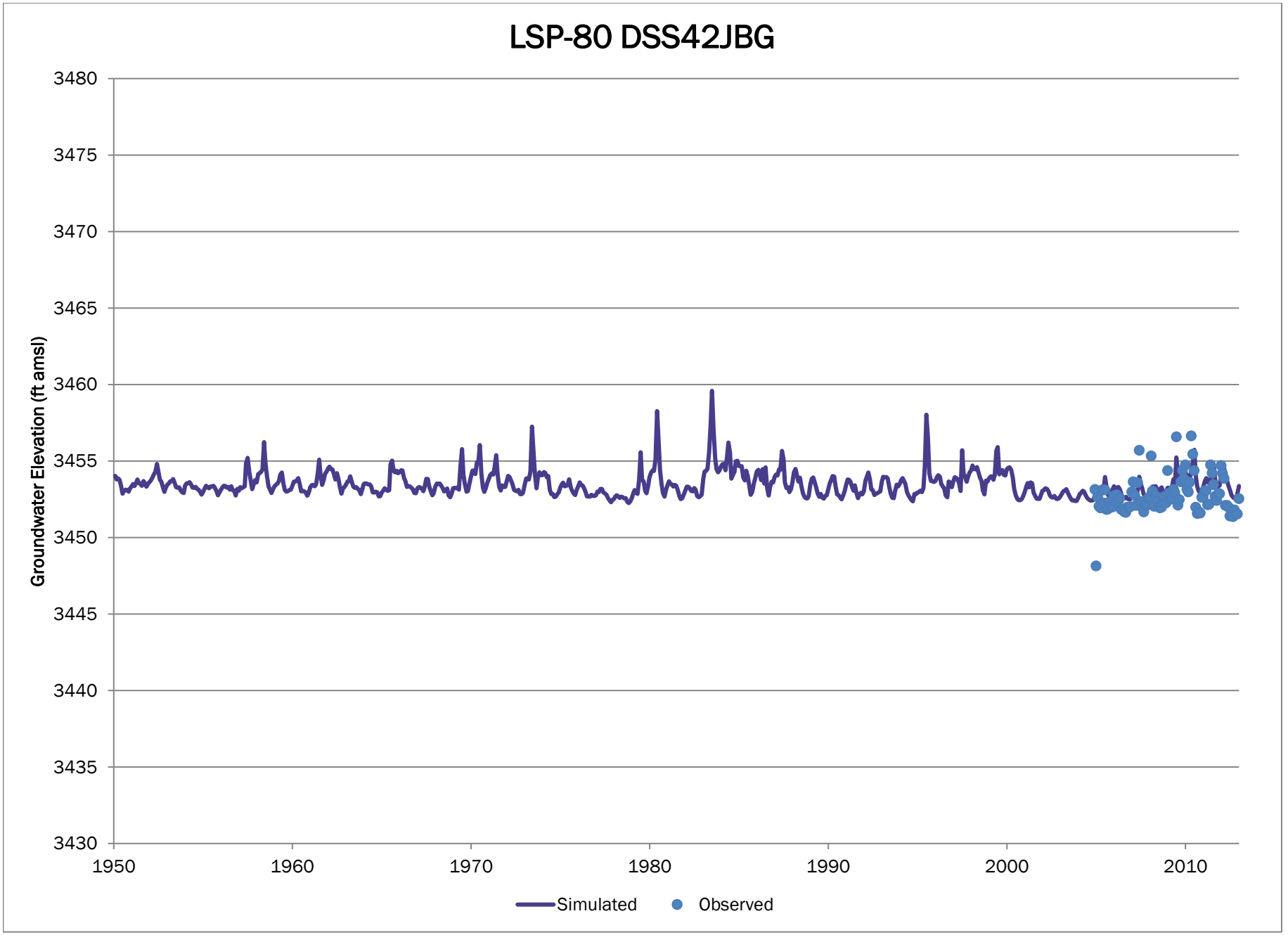

WELL ID N/A;CSU WP 73 CSU
Groundwater Elevation (ft amsl)
3600
3595
3590
3585
3580
3575
3570
3565
3560
3555
3550
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

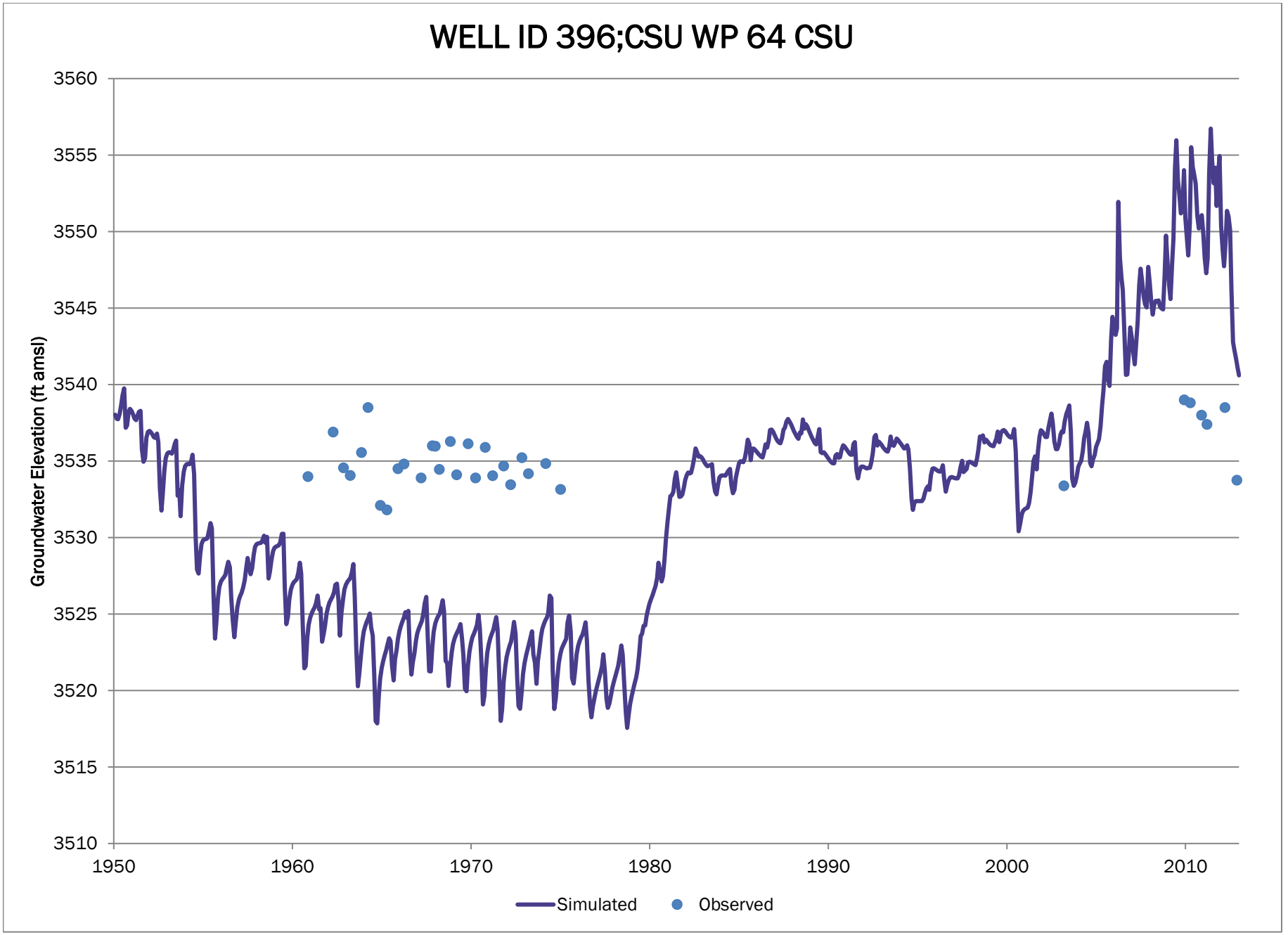

WELL ID 392;CSU WP 75 CSU
Groundwater Elevation (ft amsl)
3660
3655
3650
3645
3640
3635
3630
3625
3620
3615
3610
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

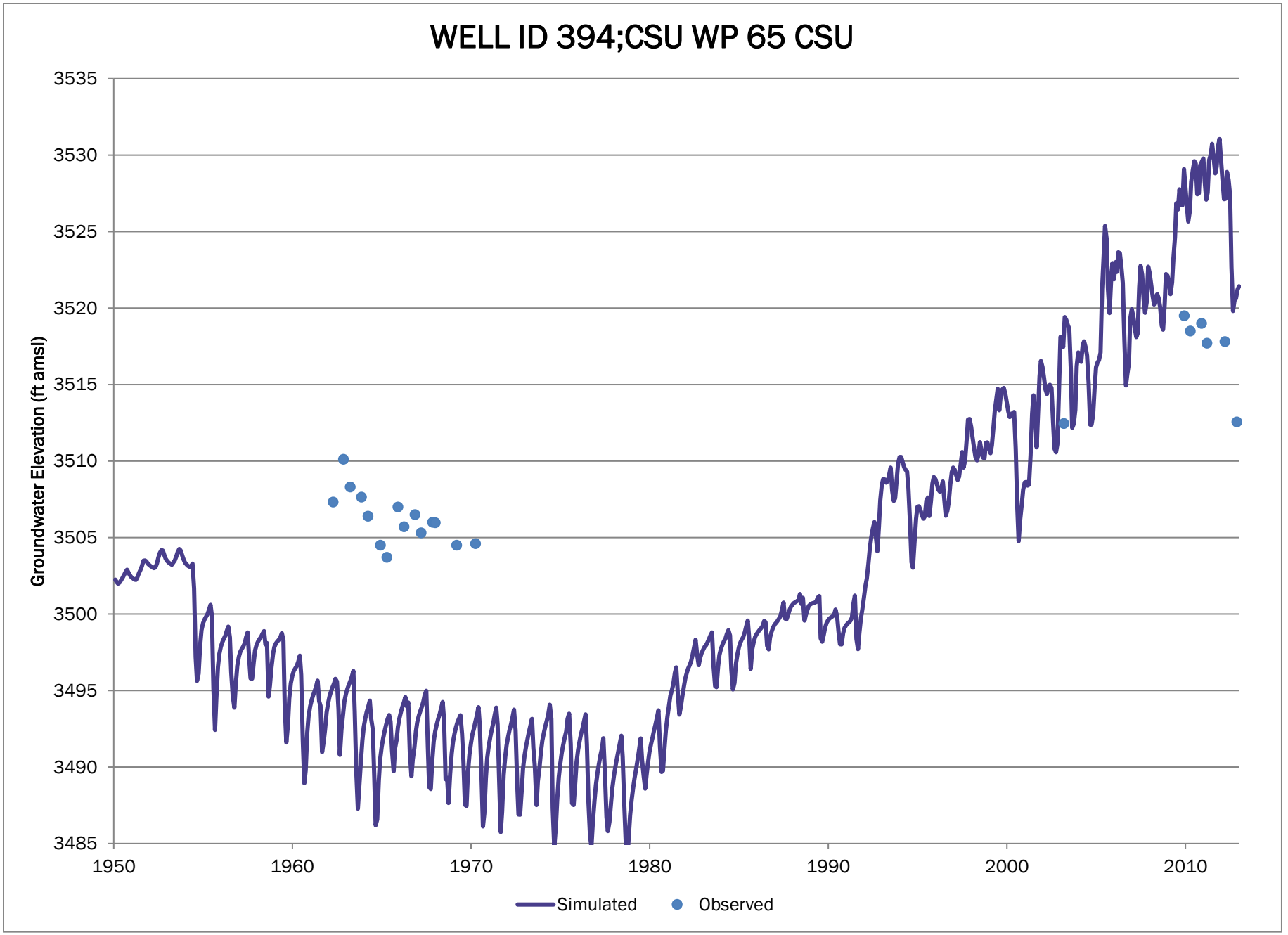

LSP-77 DSS13JBG
Groundwater Elevation (ft amsl)
3485
3480
3475
3470
3465
3460
3455
3450
3445
3440
3435
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

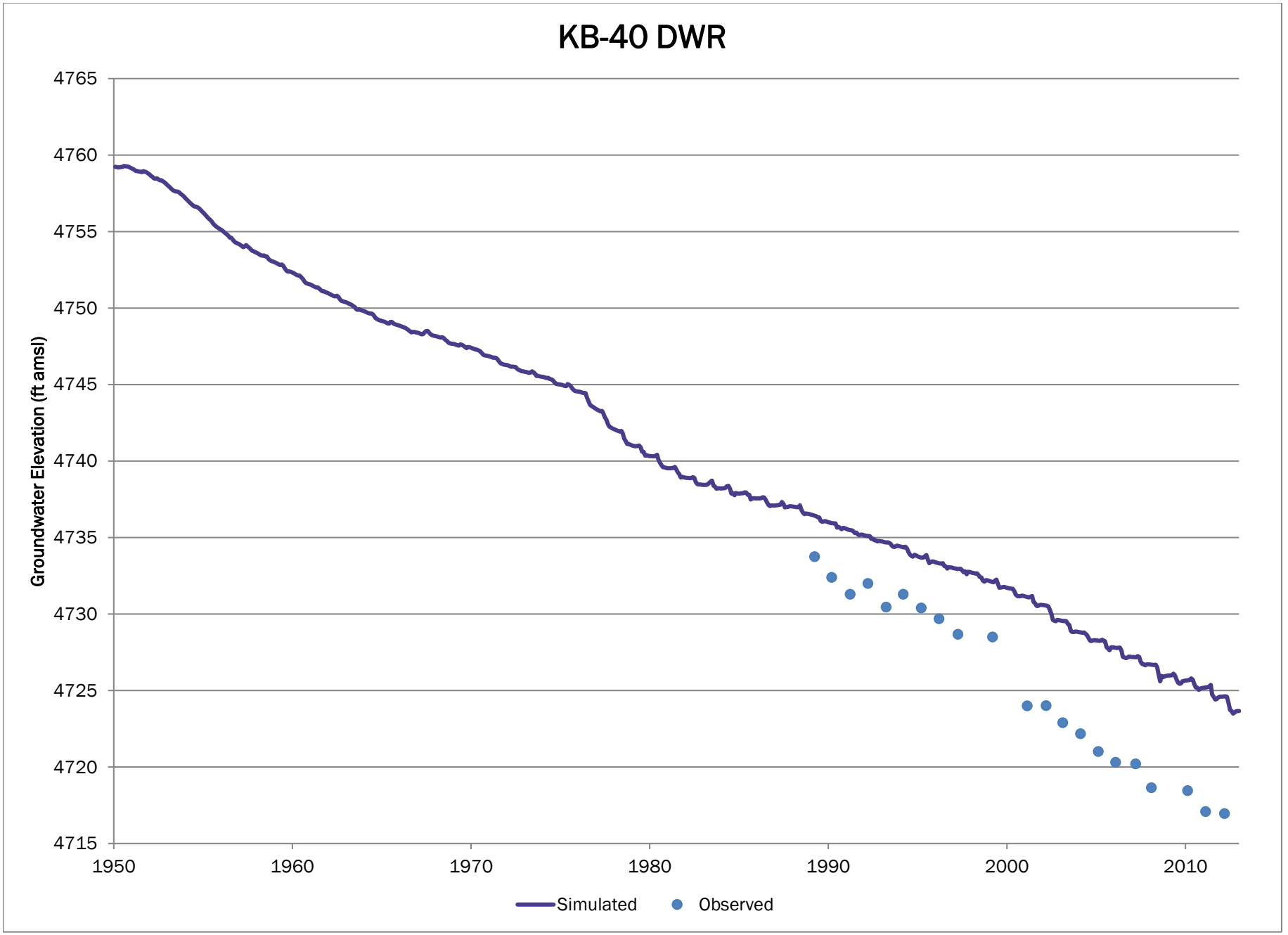

LSP-78 CSU WP 66
Groundwater Elevation (ft amsl)
3495
3490
3485
3480
3475
3470
3465
3460
3455
3450
3445
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

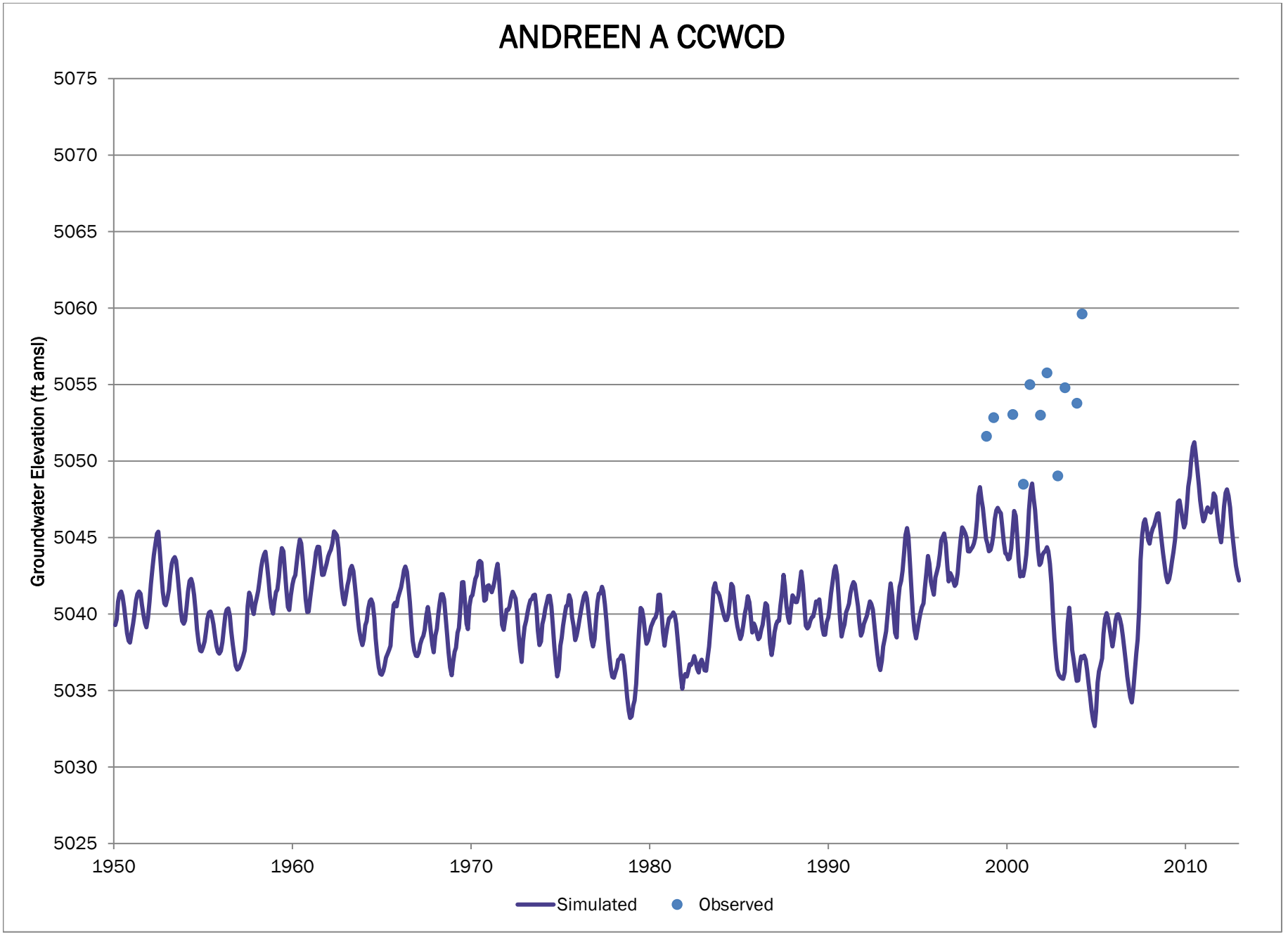

LSP-79 DSS41JBG
Groundwater Elevation (ft amsl)
3490
3485
3480
3475
3470
3465
3460
3455
3450
3445
3440
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

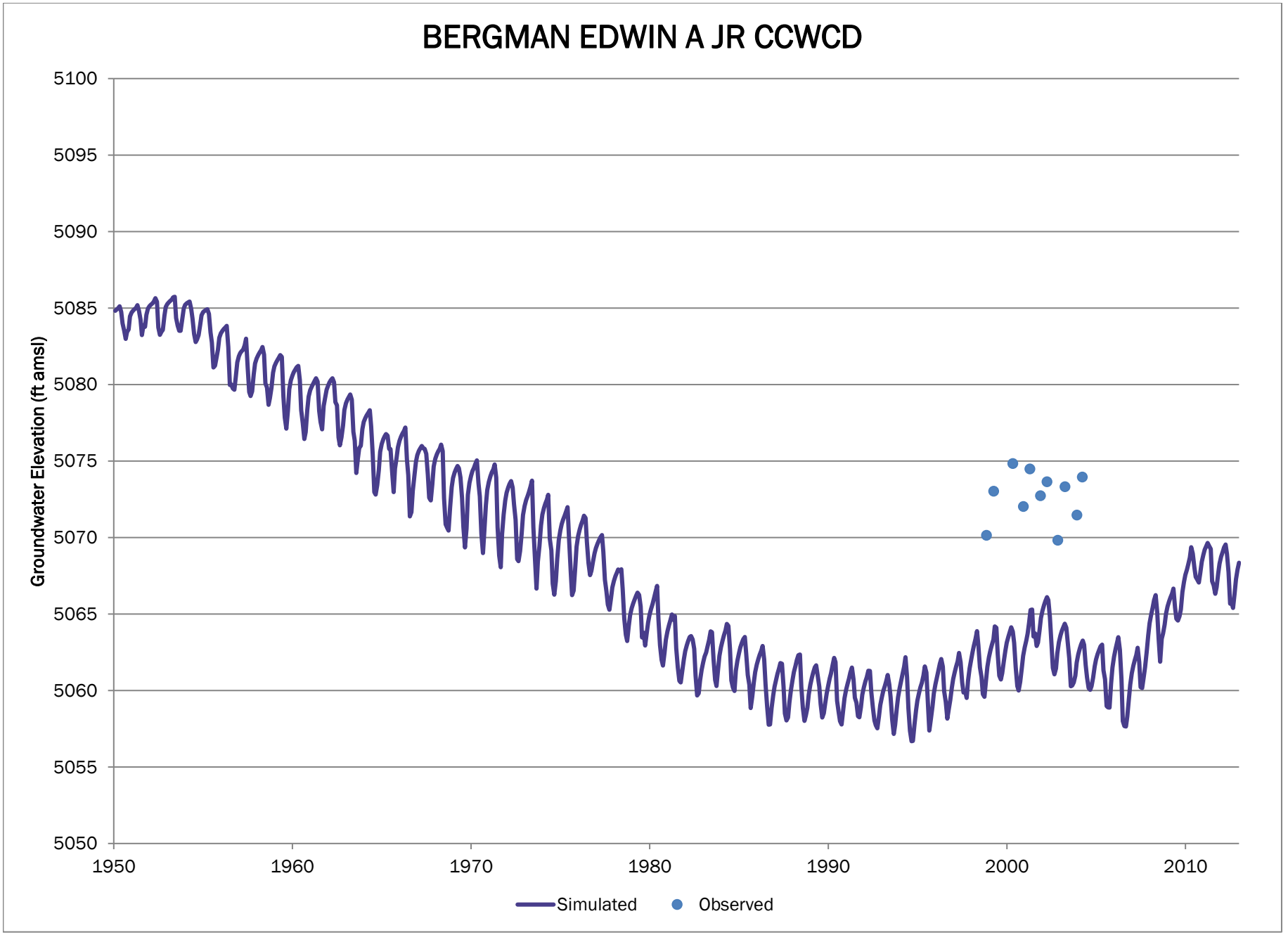

LSP-80 DSS42JBG
Groundwater Elevation (ft amsl)
3480
3475
3470
3465
3460
3455
3450
3445
3440
3435
3430
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

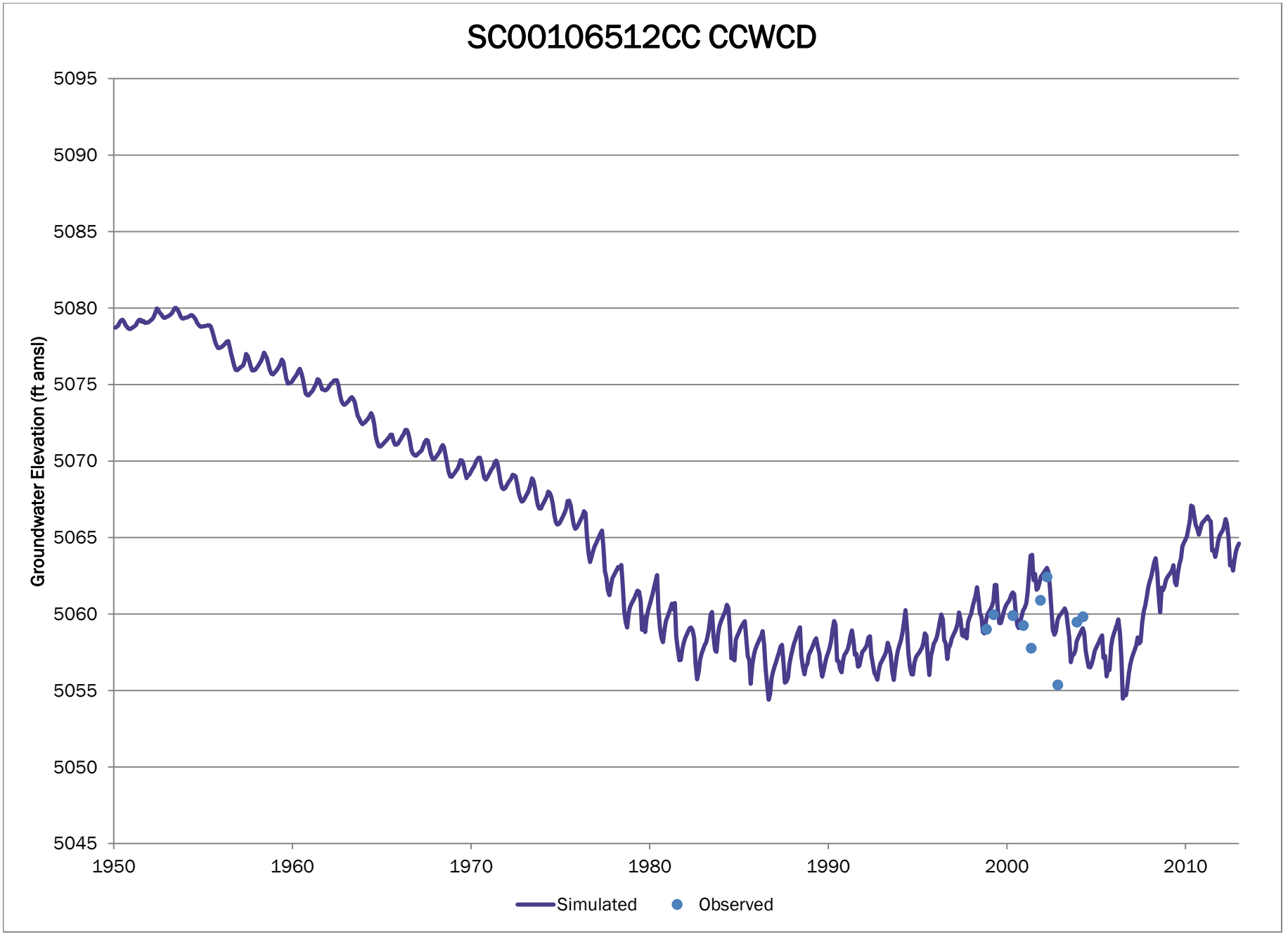

WELL ID 396;CSU WP 64 CSU
Groundwater Elevation (ft amsl)
3560
3555
3550
3545
3540
3535
3530
3525
3520
3515
3510
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

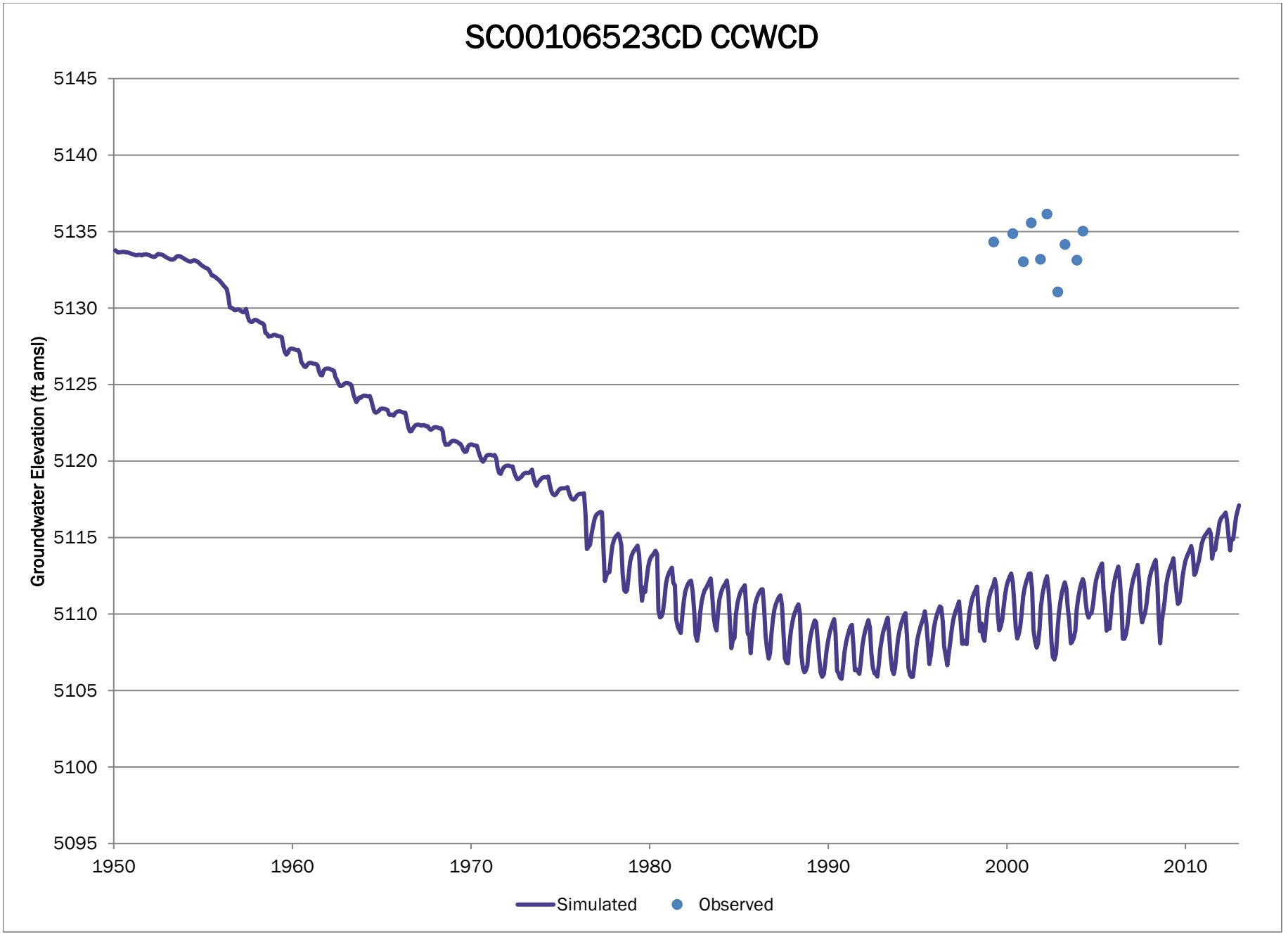

WELL ID 394;CSU WP 65 CSU
Groundwater Elevation (ft amsl)
3535
3530
3525
3520
3515
3510
3505
3500
3495
3490
3485
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

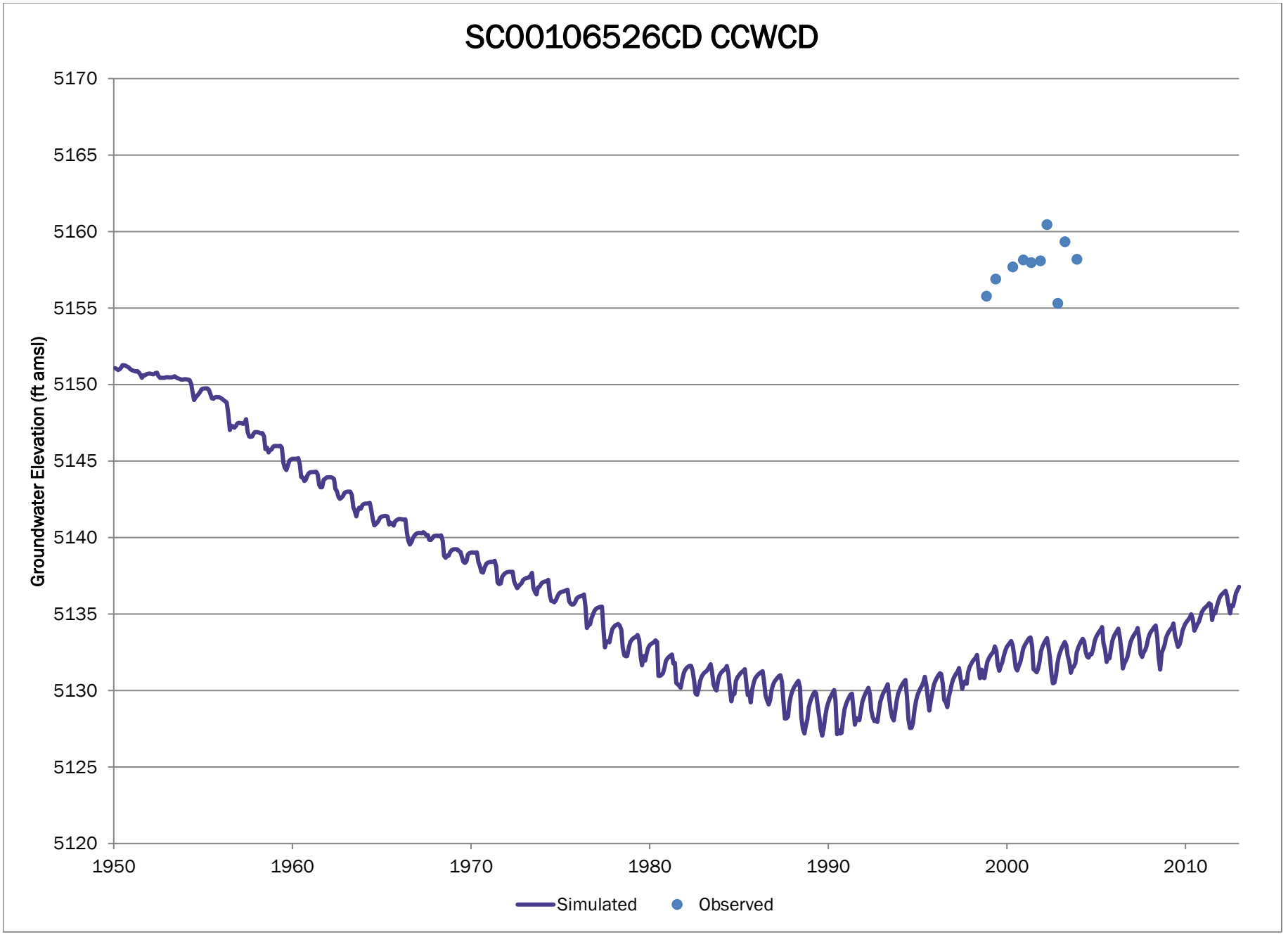

KB-40 DWR
Groundwater Elevation (ft amsl)
4765
4760
4755
4750
4745
4740
4735
4730
4725
4720
4715
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

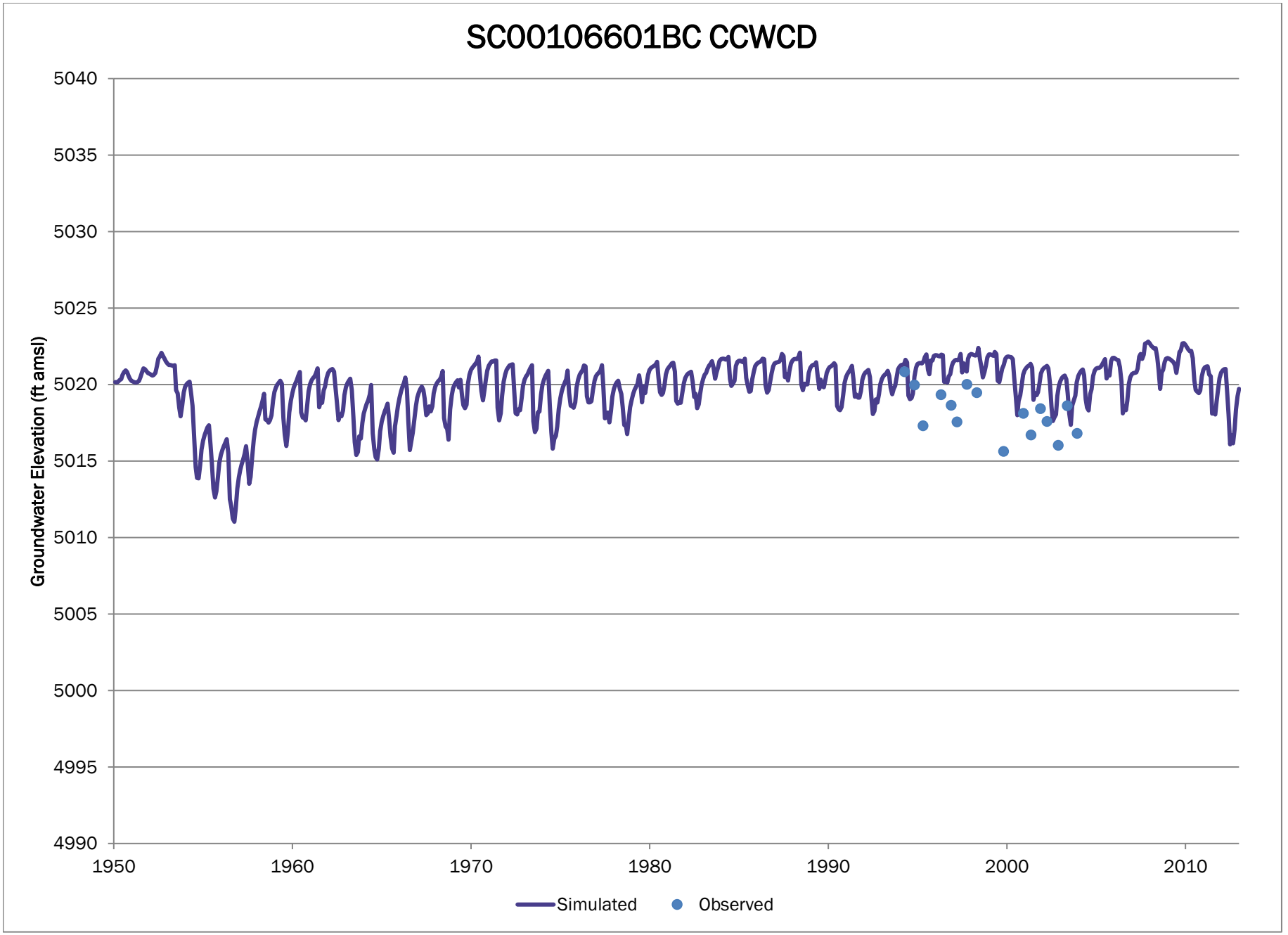

ANDREEN A CCWCD
Groundwater Elevation (ft amsl)
5075
5070
5065
5060
5055
5050
5045
5040
5035
5030
5025
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

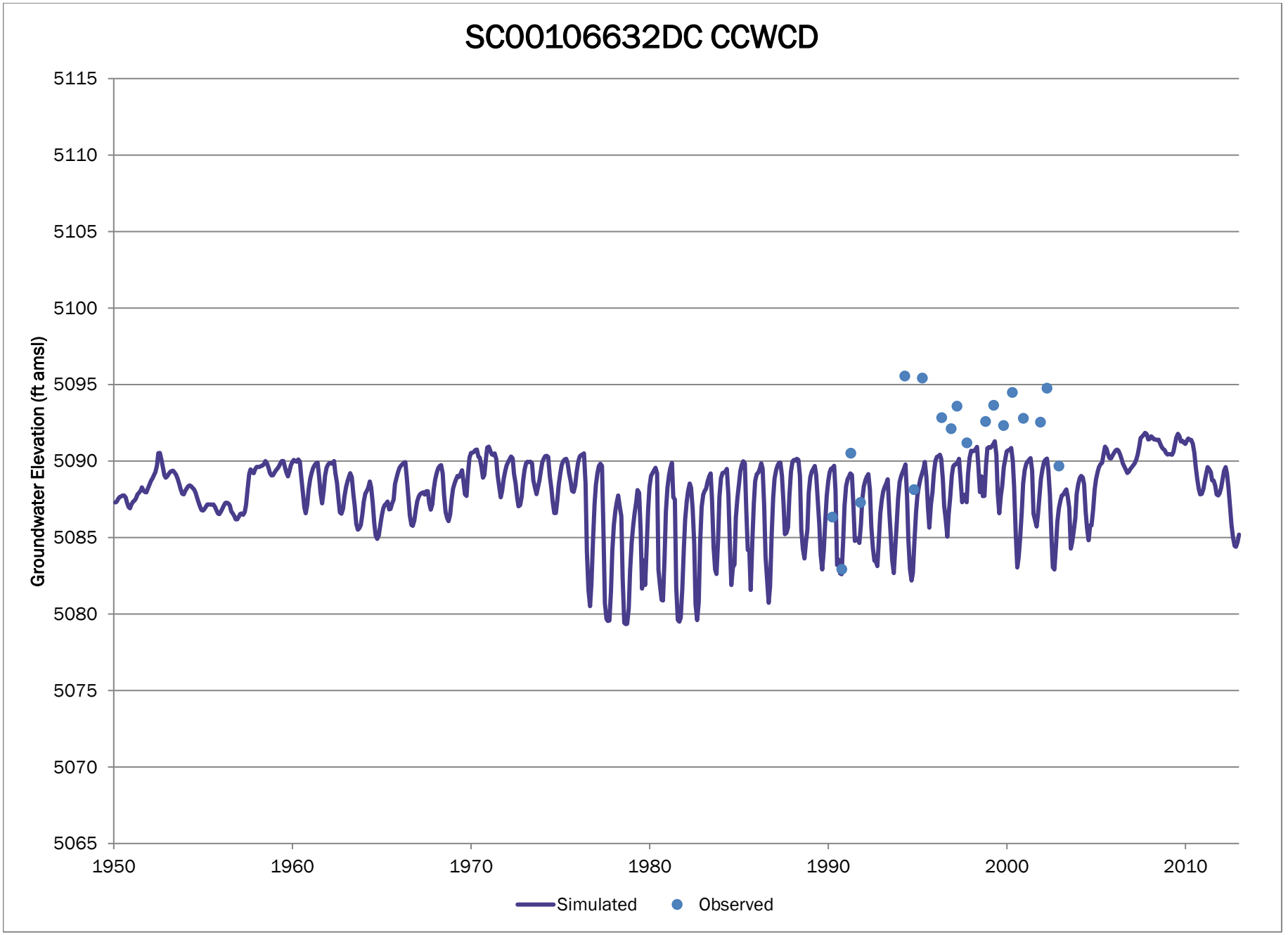

BERGMAN EDWIN A JR CCWCD
Groundwater Elevation (ft amsl)
5100
5095
5090
5085
5080
5075
5070
5065
5060
5055
5050
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

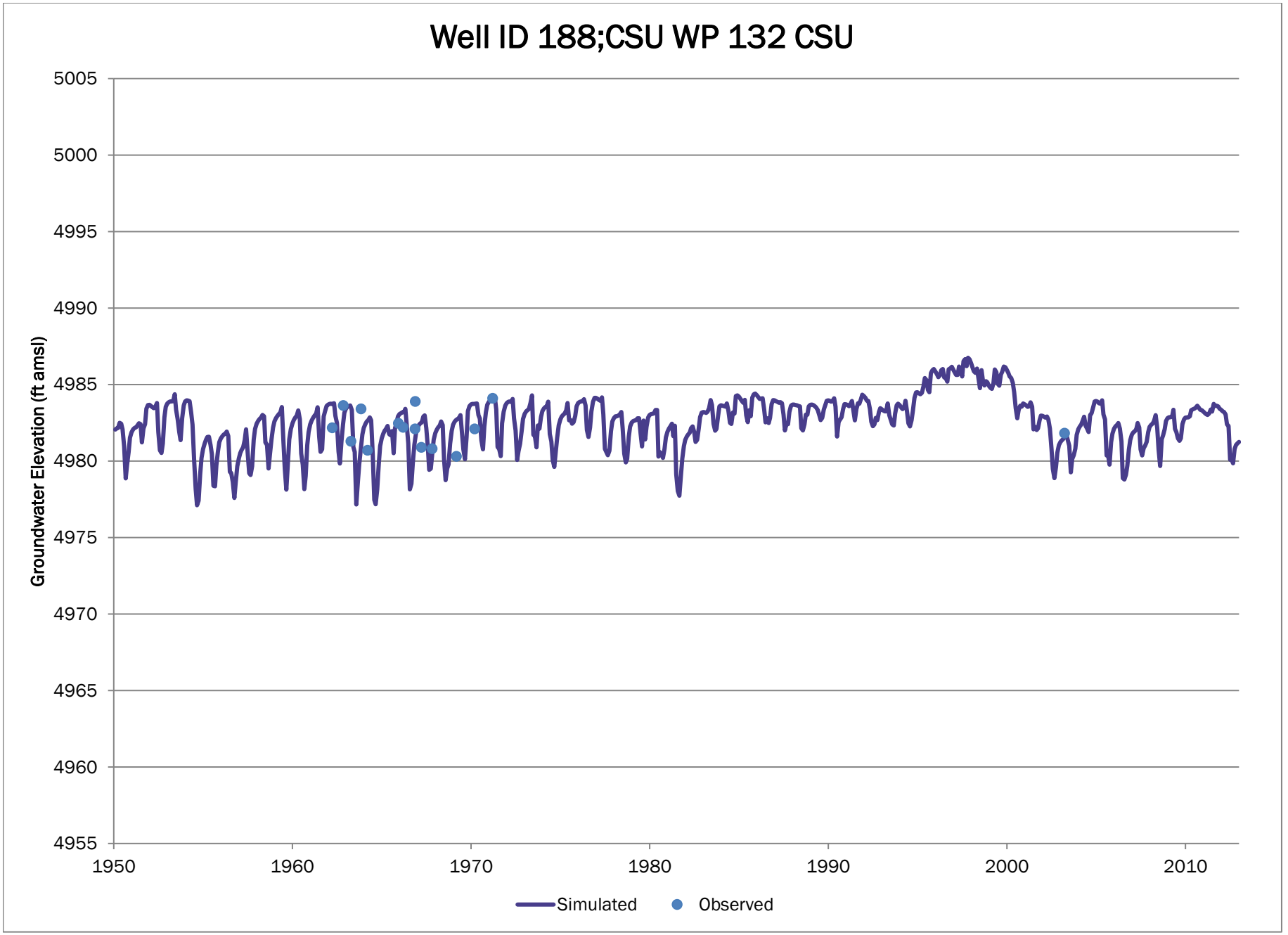

SC00106512CC CCWCD
Groundwater Elevation (ft amsl)
5095
5090
5085
5080
5075
5070
5065
5060
5055
5050
5045
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

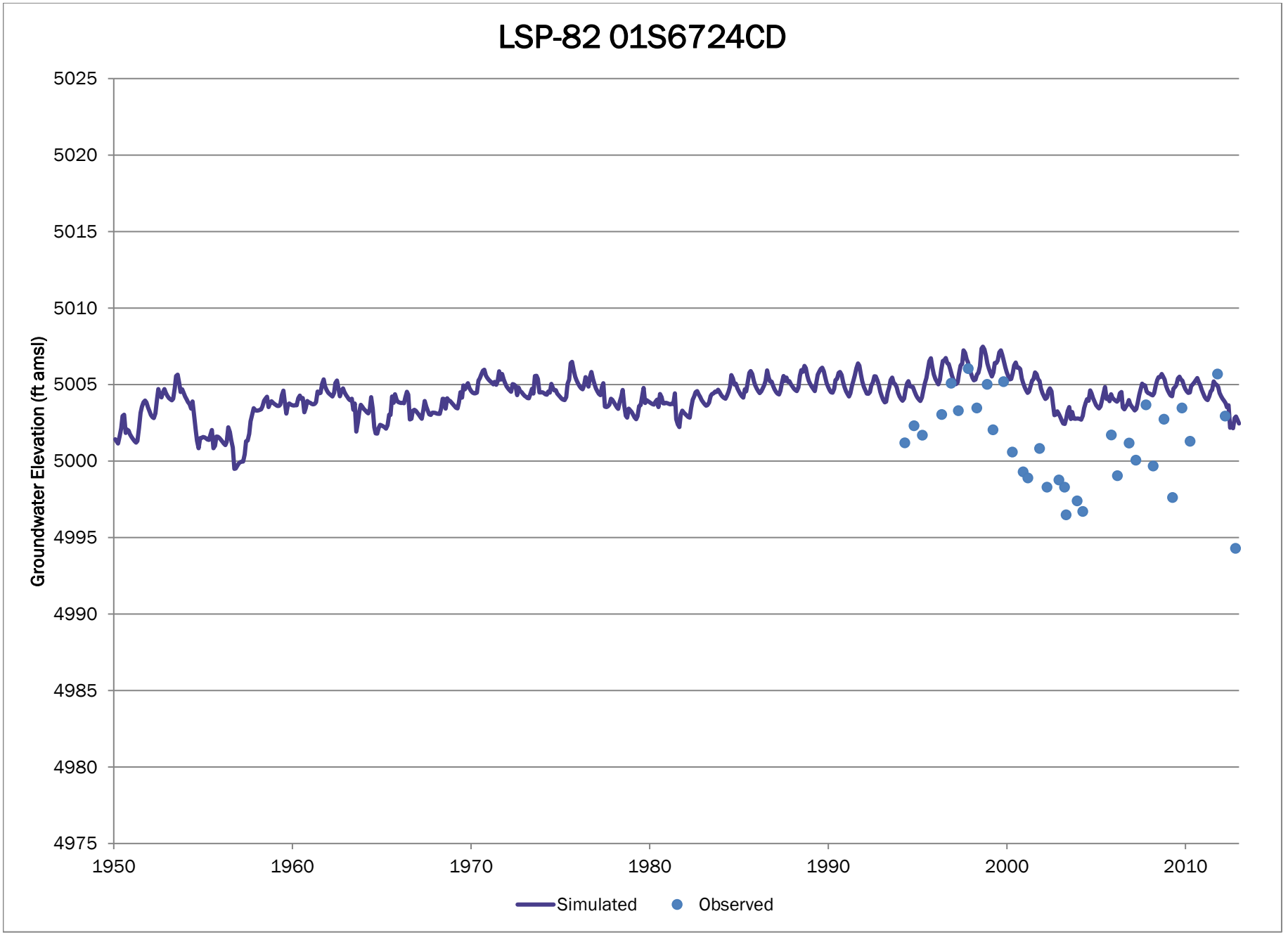

SC00106523CD CCWCD
Groundwater Elevation (ft amsl)
5145
5140
5135
5130
5125
5120
5115
5110
5105
5100
5095
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

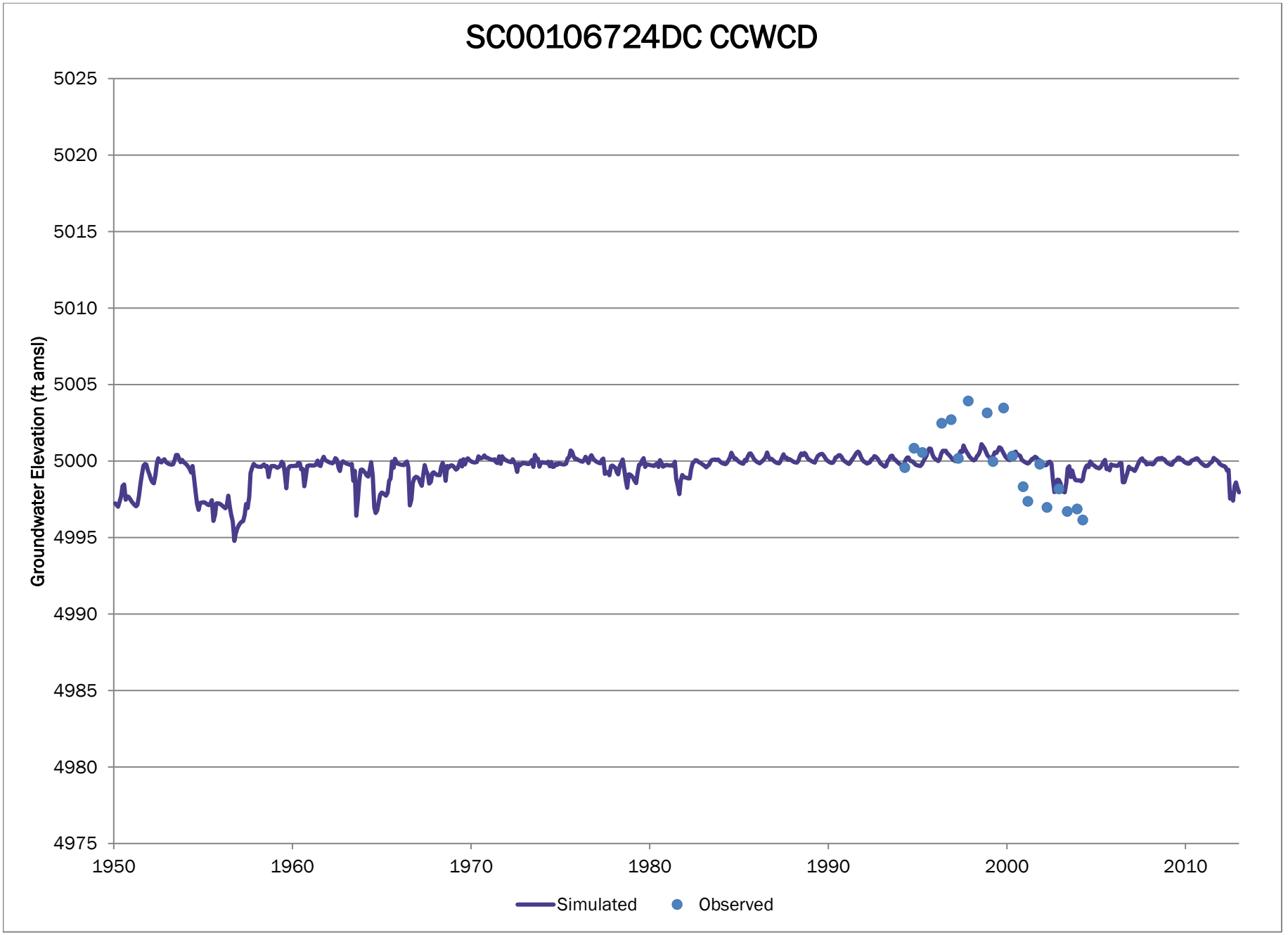

SC00106526CD CCWCD
Groundwater Elevation (ft amsl)
5170
5165
5160
5155
5150
5145
5140
5135
5130
5125
5120
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

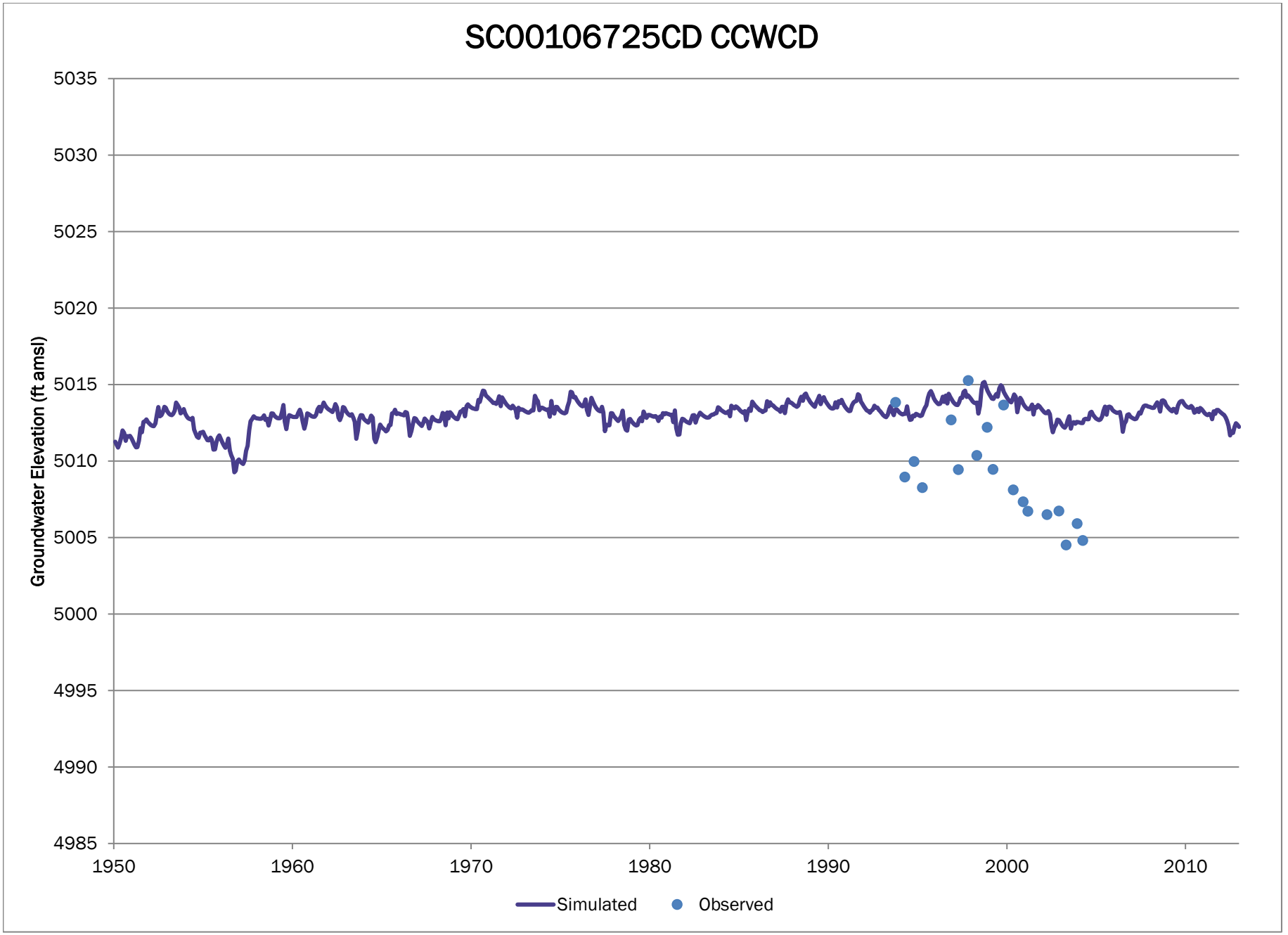

SC00106601BC CCWCD
Groundwater Elevation (ft amsl)
5040
5035
5030
5025
5020
5015
5010
5005
5000
4995
4990
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

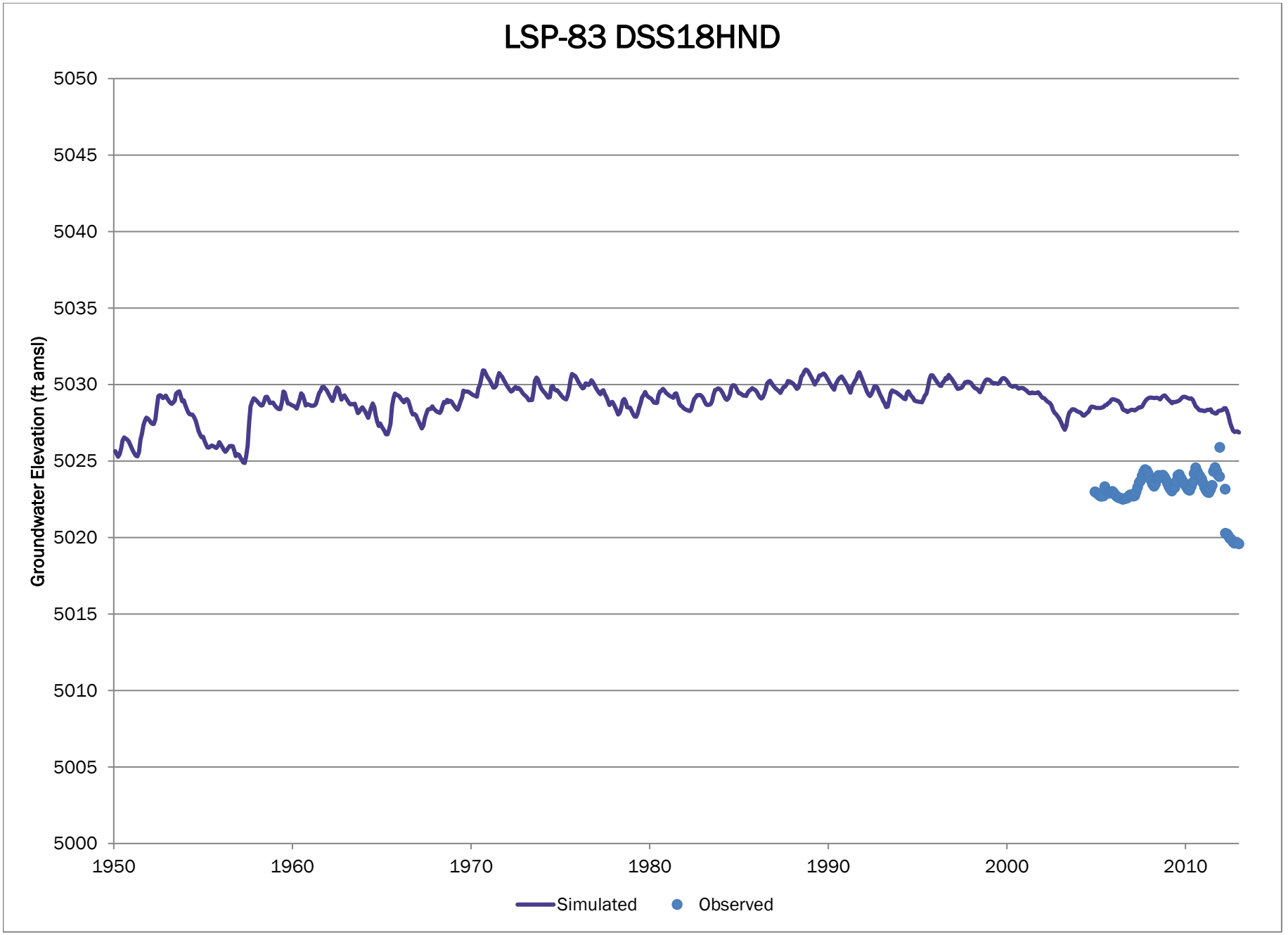

SC00106632DC CCWCD
Groundwater Elevation (ft amsl)
5115
5110
5105
5100
5095
5090
5085
5080
5075
5070
5065
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


Well ID 188;CSU WP 132 CSU
Groundwater Elevation (ft amsl)
5005
5000
4995
4990
4985
4980
4975
4970
4965
4960
4955
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

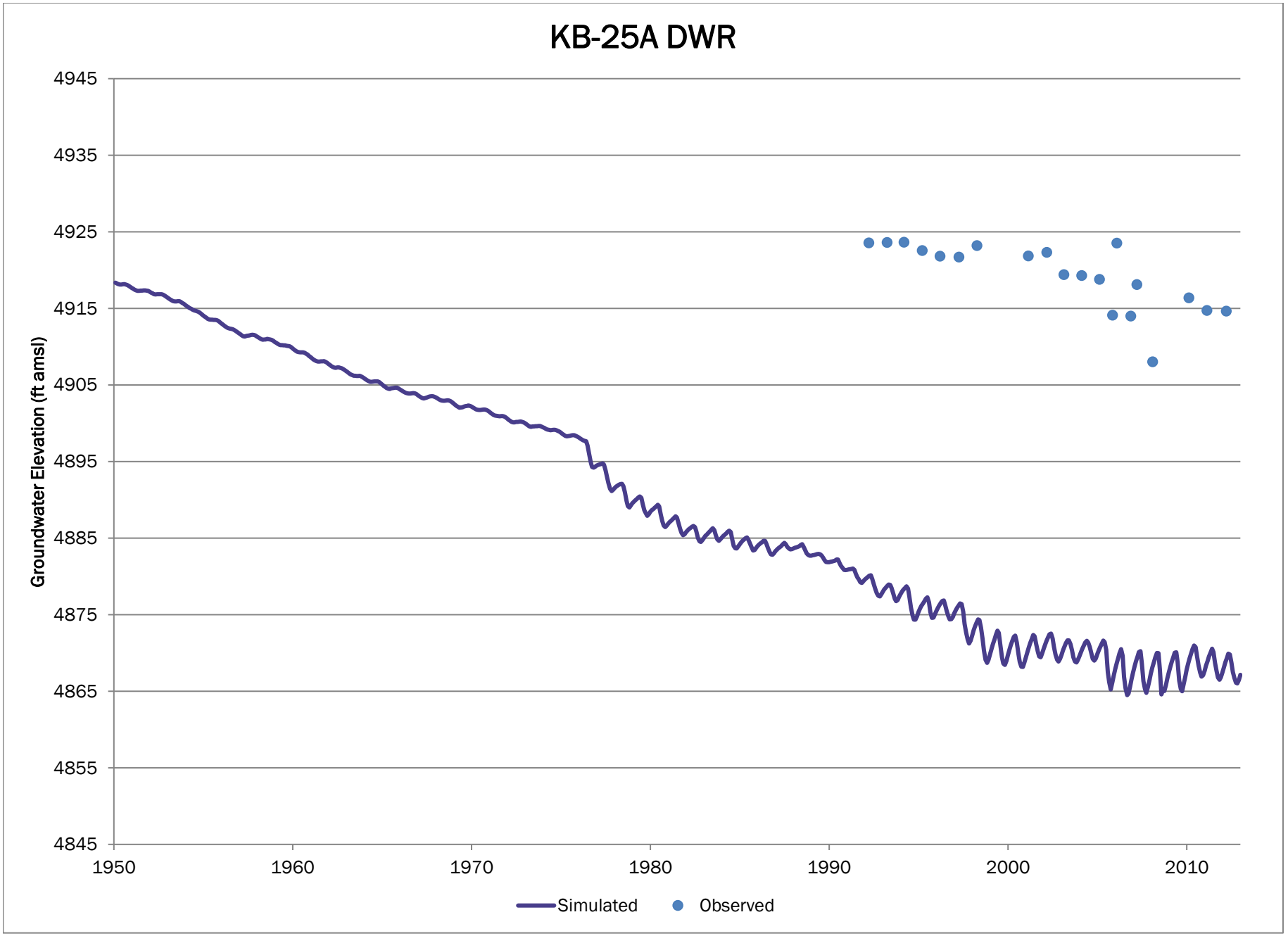

LSP-82 01S6724CD
Groundwater Elevation (ft amsl)
5025
5020
5015
5010
5005
5000
4995
4990
4985
4980
4975
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


SC00106724DC CCWCD
Groundwater Elevation (ft amsl)
5025
5020
5015
5010
5005
5000
4995
4990
4985
4980
4975
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

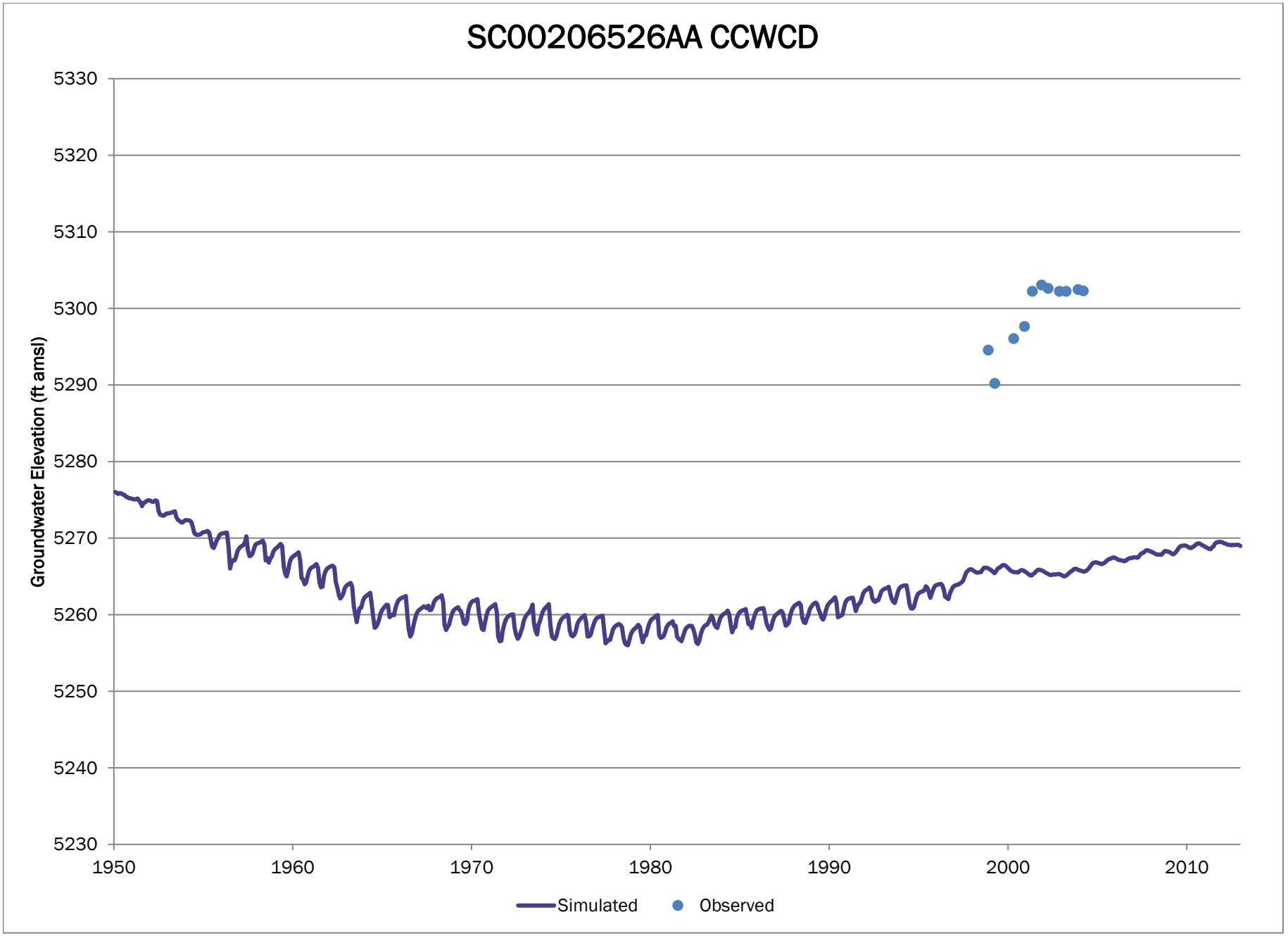

SC00106725CD CCWCD
Groundwater Elevation (ft amsl)
5035
5030
5025
5020
5015
5010
5005
5000
4995
4990
4985
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

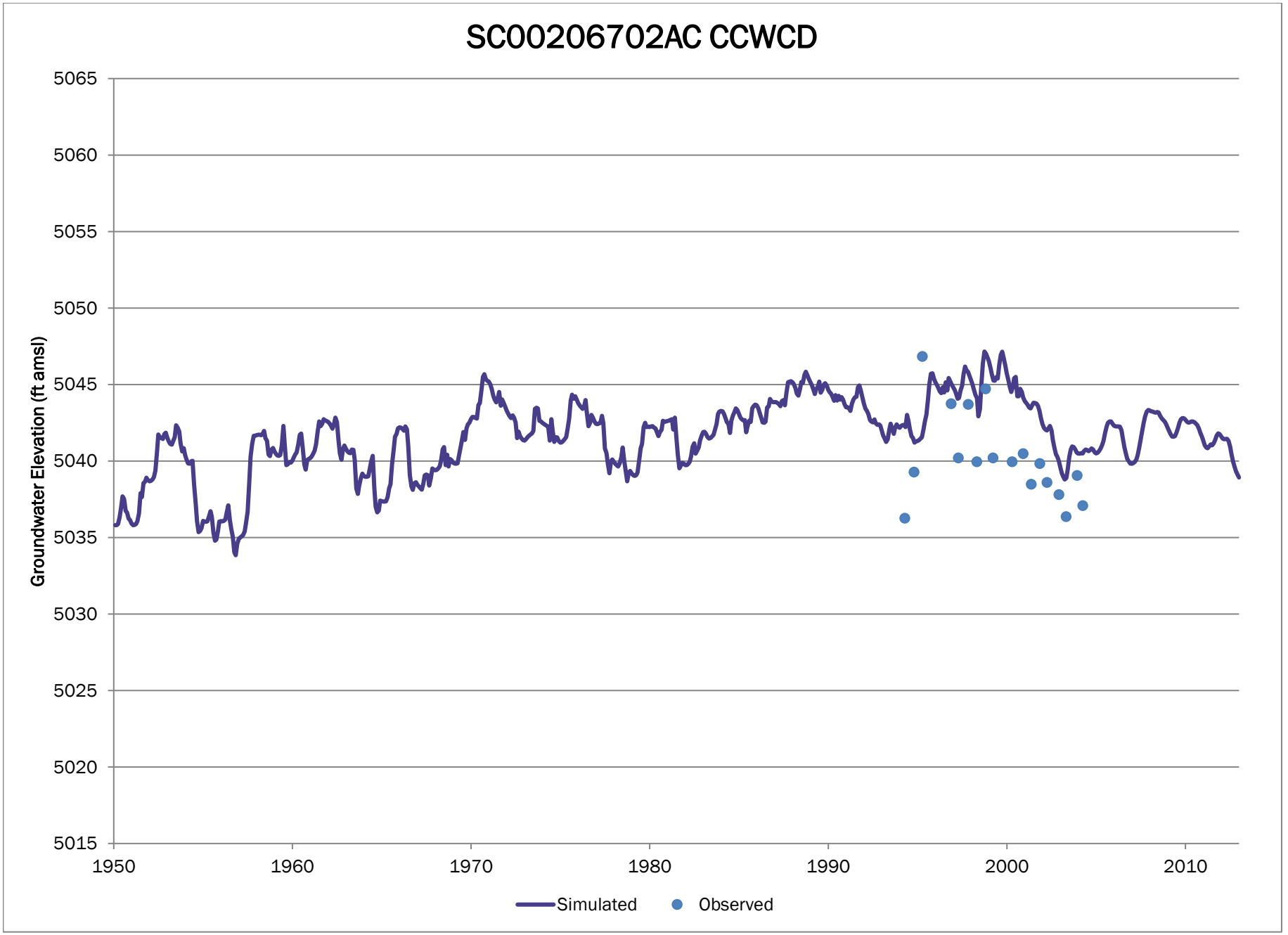

LSP-83 DSS18HND
Groundwater Elevation (ft amsl)
5050
5045
5040
5035
5030
5025
5020
5015
5010
5005
5000
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

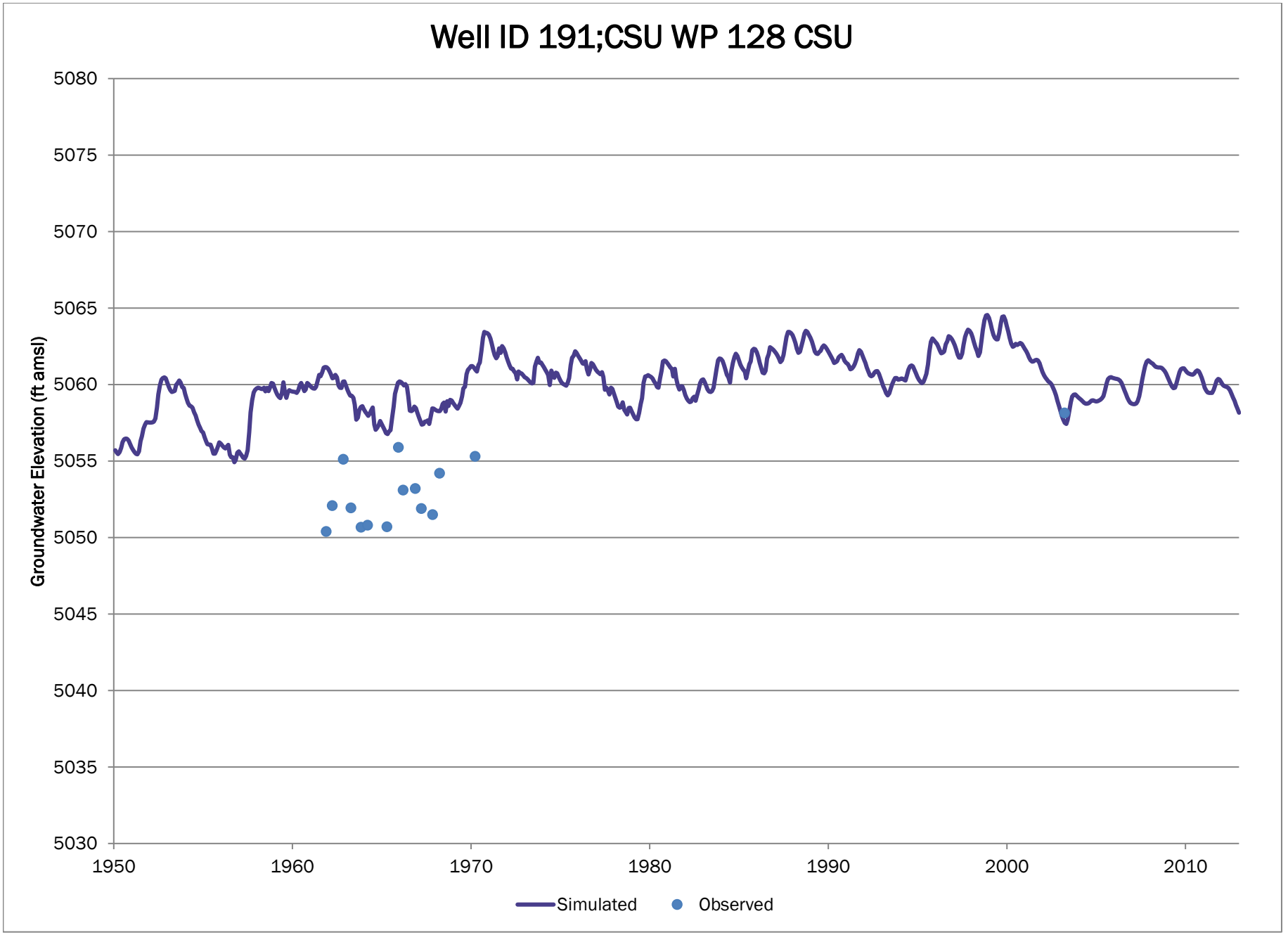
Note elevation axis range of 100 feet.

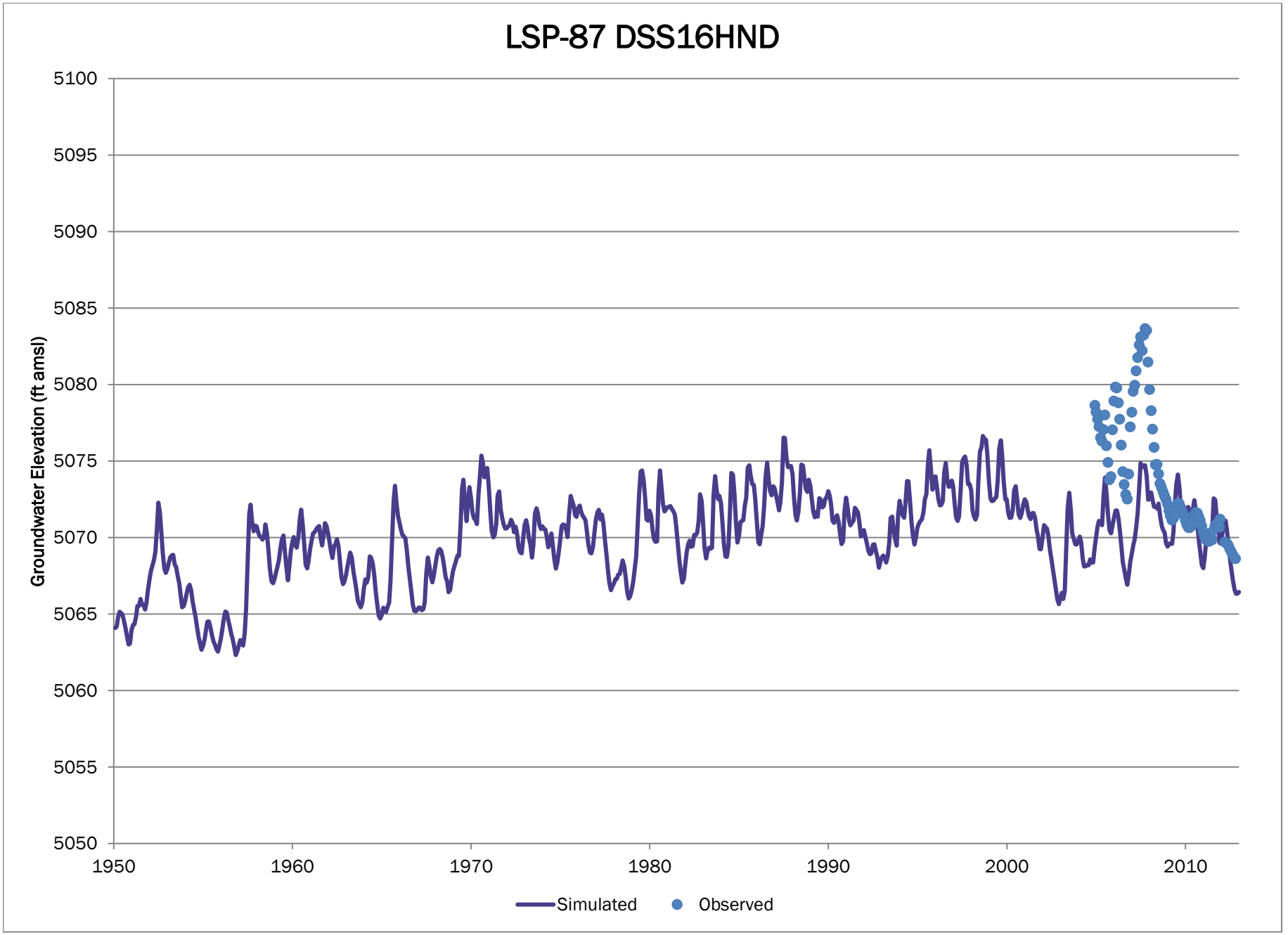


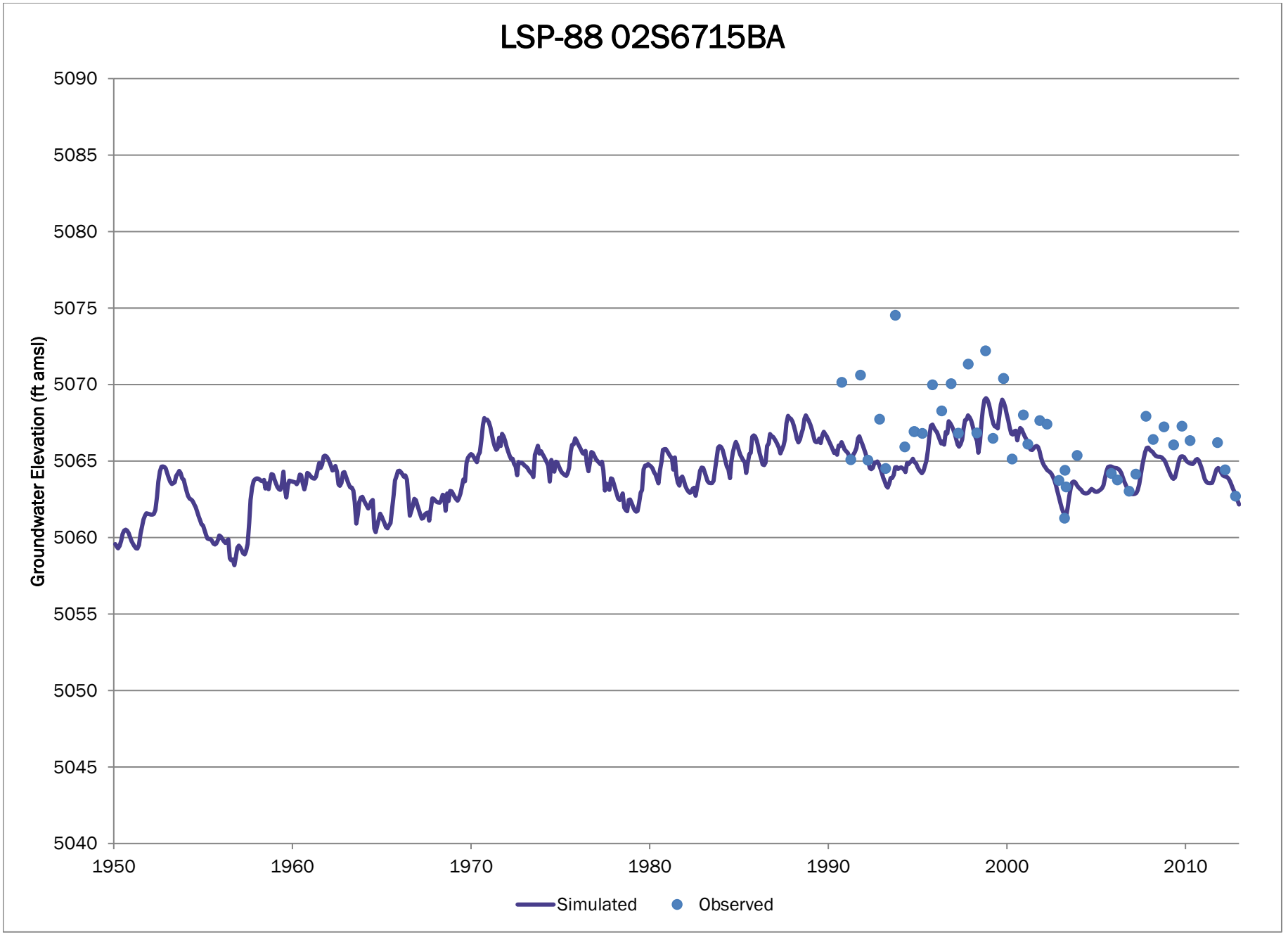
Note elevation axis range of 100 feet.

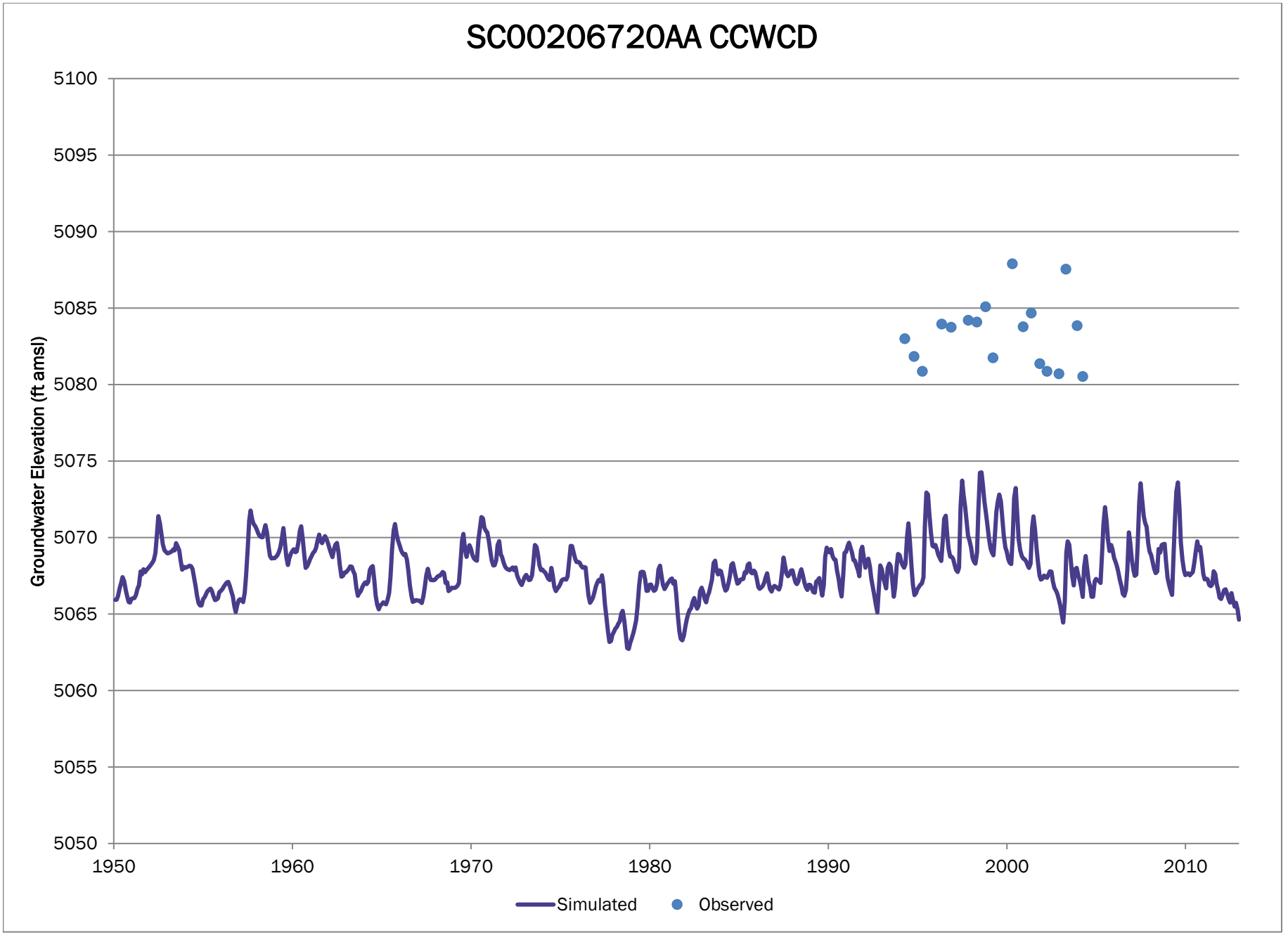


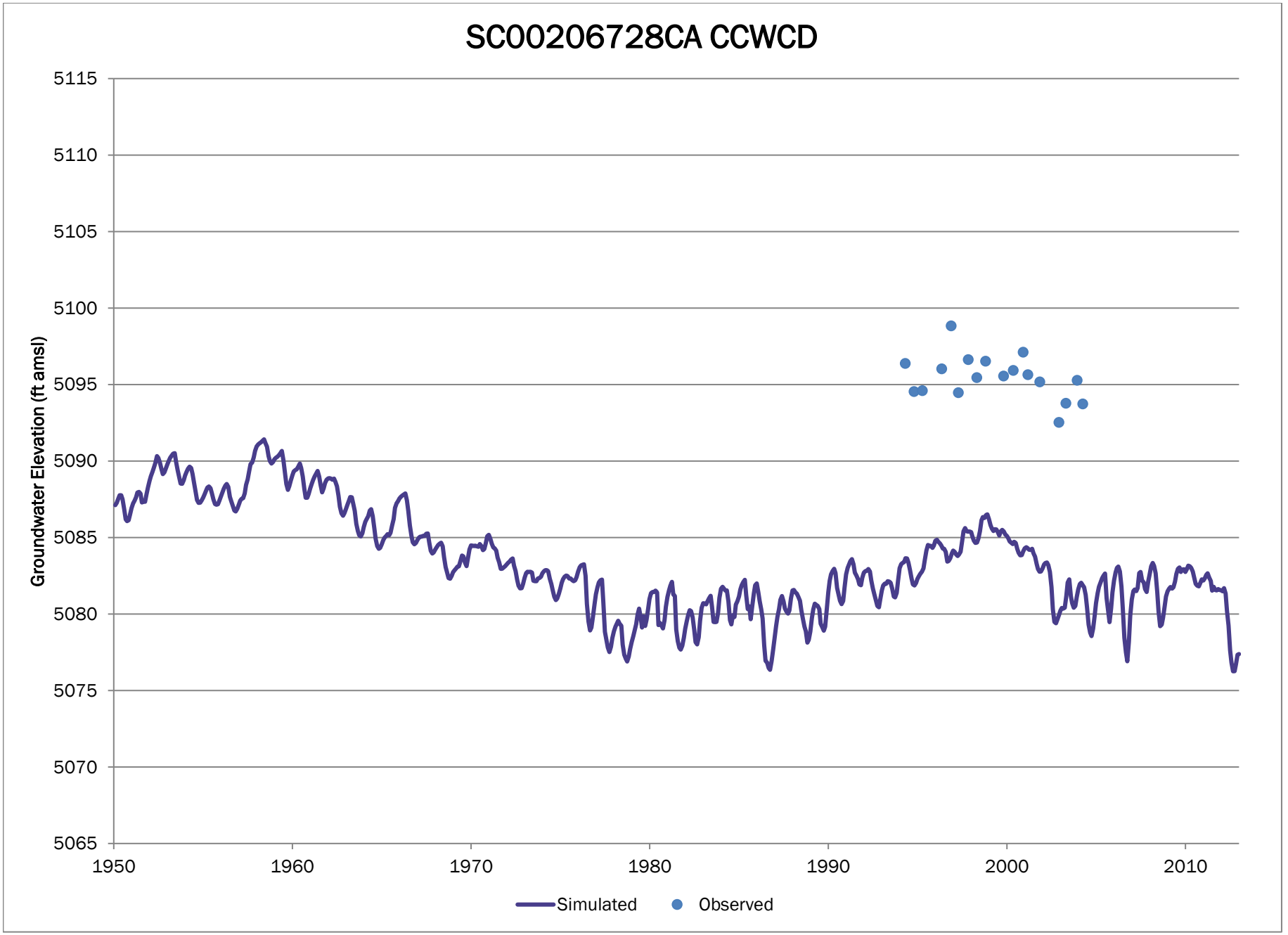

SC00206702AC CCWCD
Groundwater Elevation (ft amsl)
5065
5060
5055
5050
5045
5040
5035
5030
5025
5020
5015
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

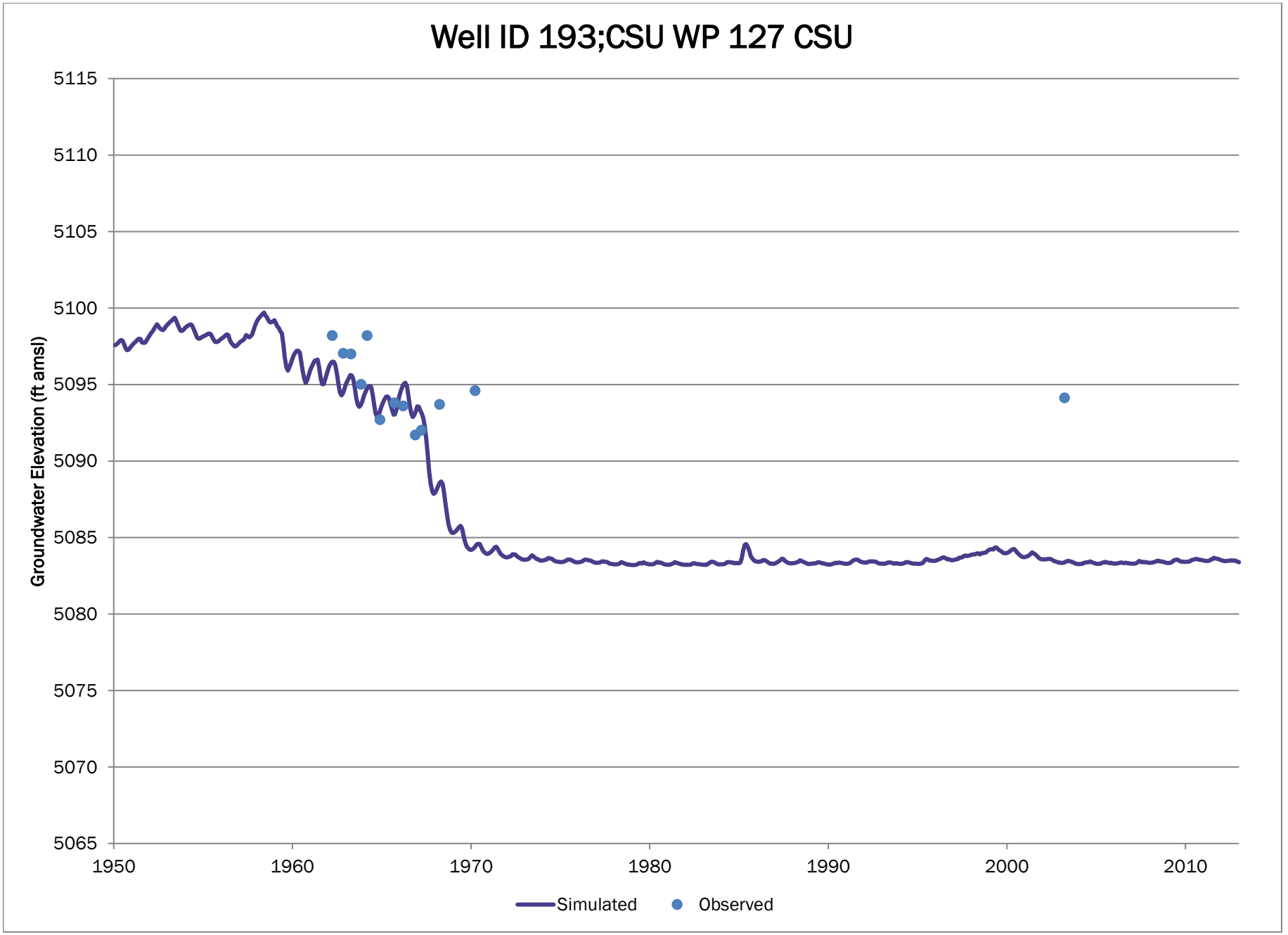

Well ID 191;CSU WP 128 CSU
Groundwater Elevation (ft amsl)
5080
5075
5070
5065
5060
5055
5050
5045
5040
5035
5030
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

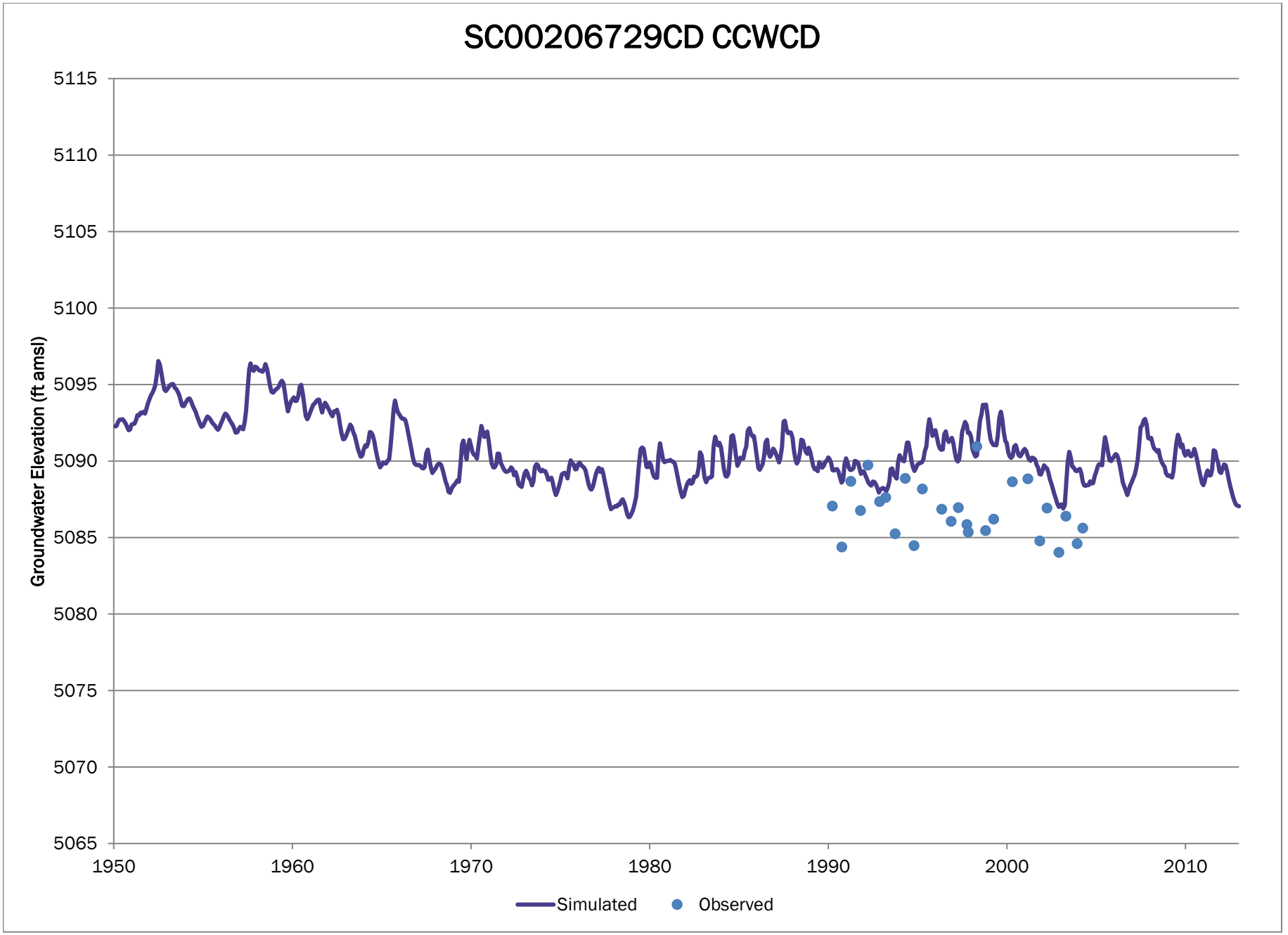

LSP-87 DSS16HND
Groundwater Elevation (ft amsl)
5100
5095
5090
5085
5080
5075
5070
5065
5060
5055
5050
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

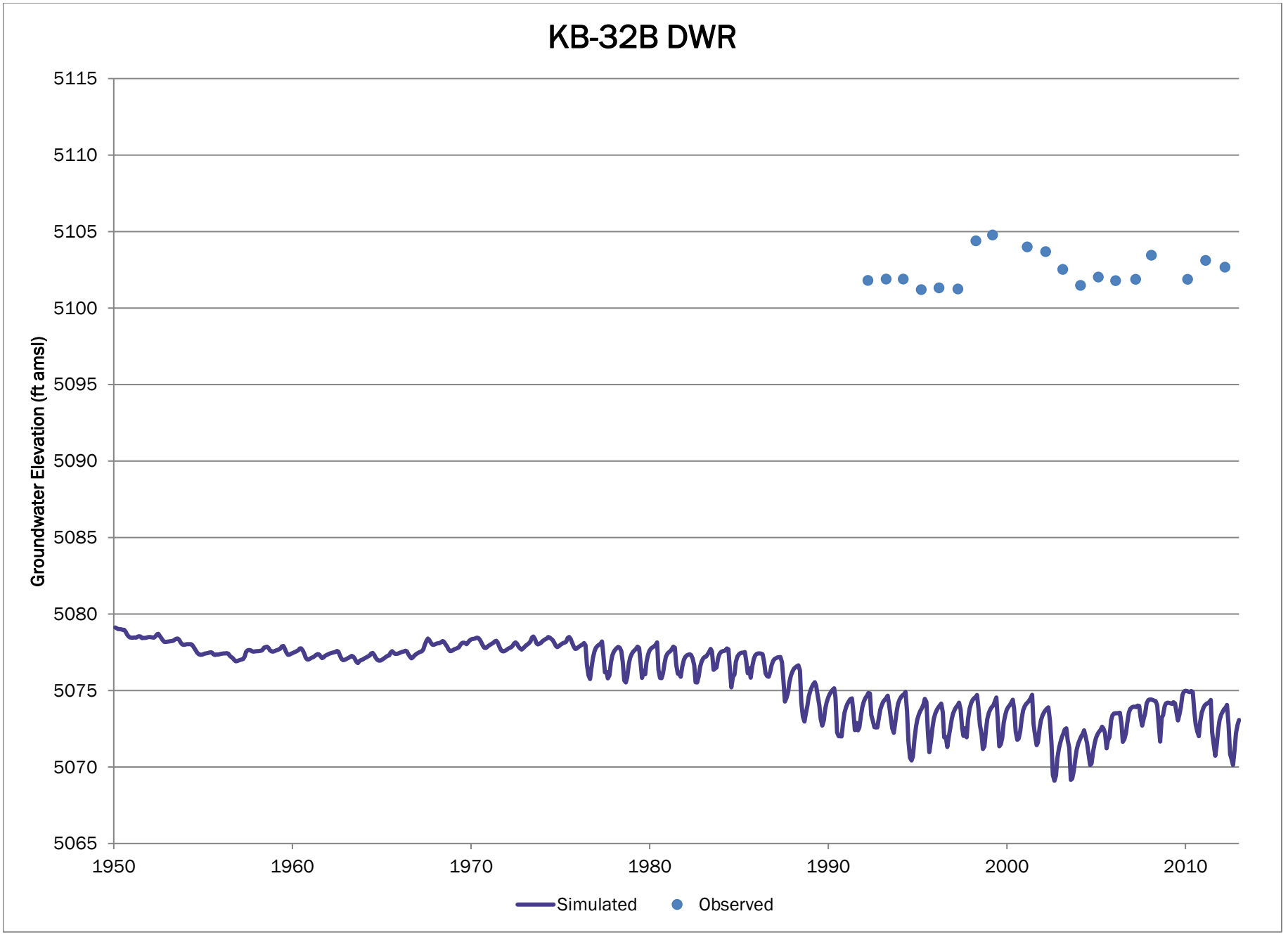

LSP-88 02S6715BA
Groundwater Elevation (ft amsl)
5090
5085
5080
5075
5070
5065
5060
5055
5050
5045
5040
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

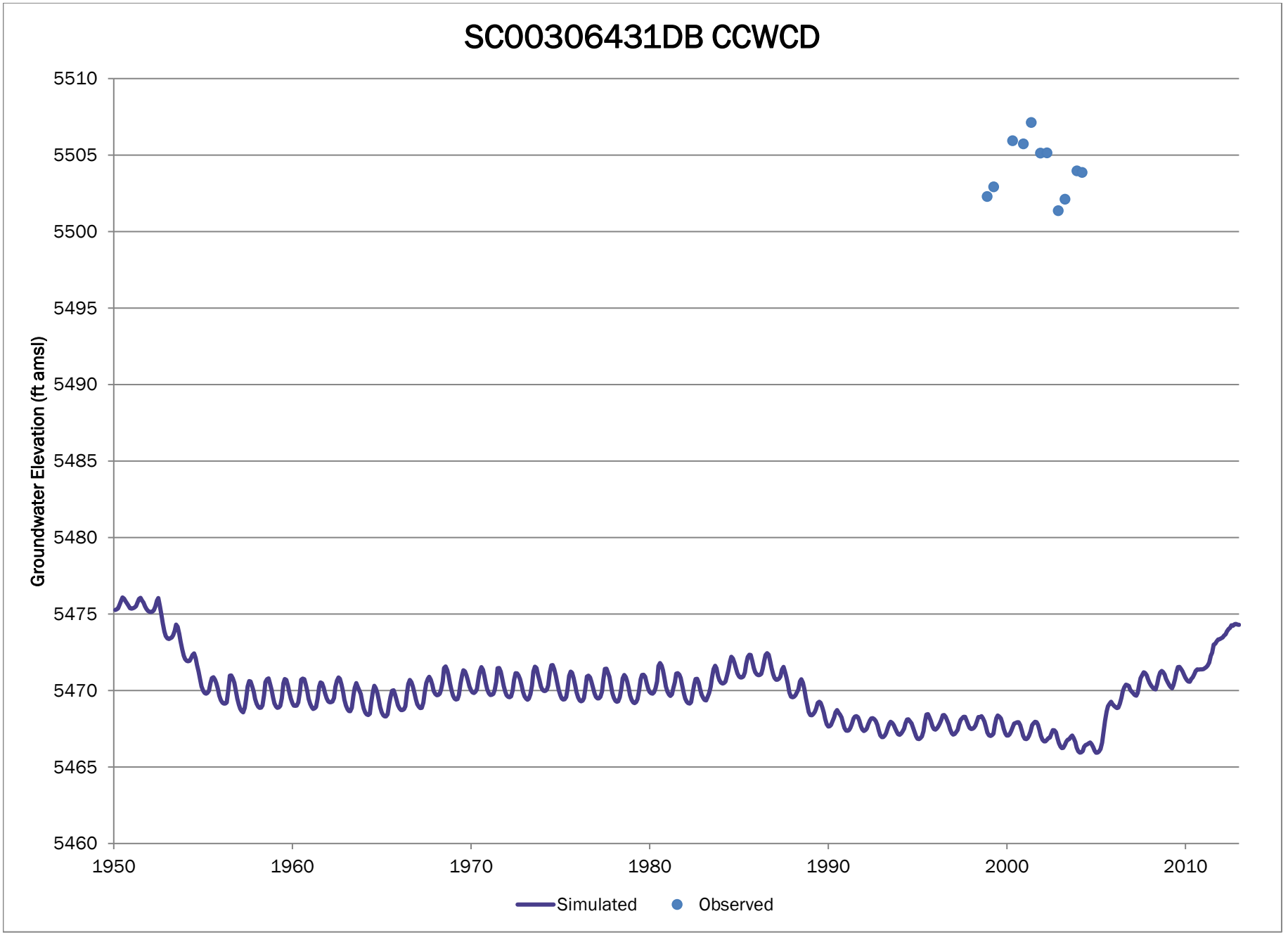

SC00206720AA CCWCD
Groundwater Elevation (ft amsl)
5100
5095
5090
5085
5080
5075
5070
5065
5060
5055
5050
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

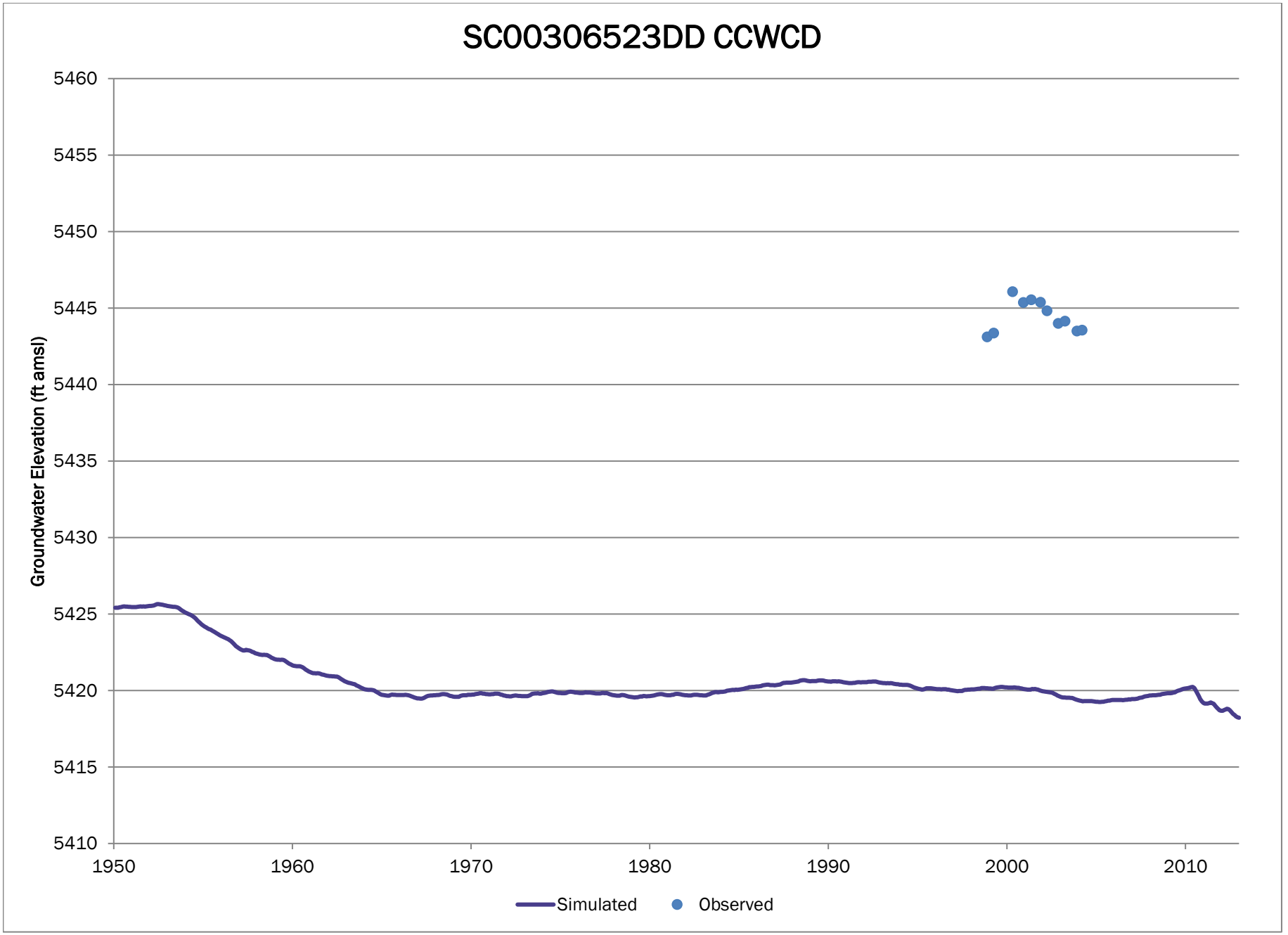

SC00206728CA CCWCD
Groundwater Elevation (ft amsl)
5115
5110
5105
5100
5095
5090
5085
5080
5075
5070
5065
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

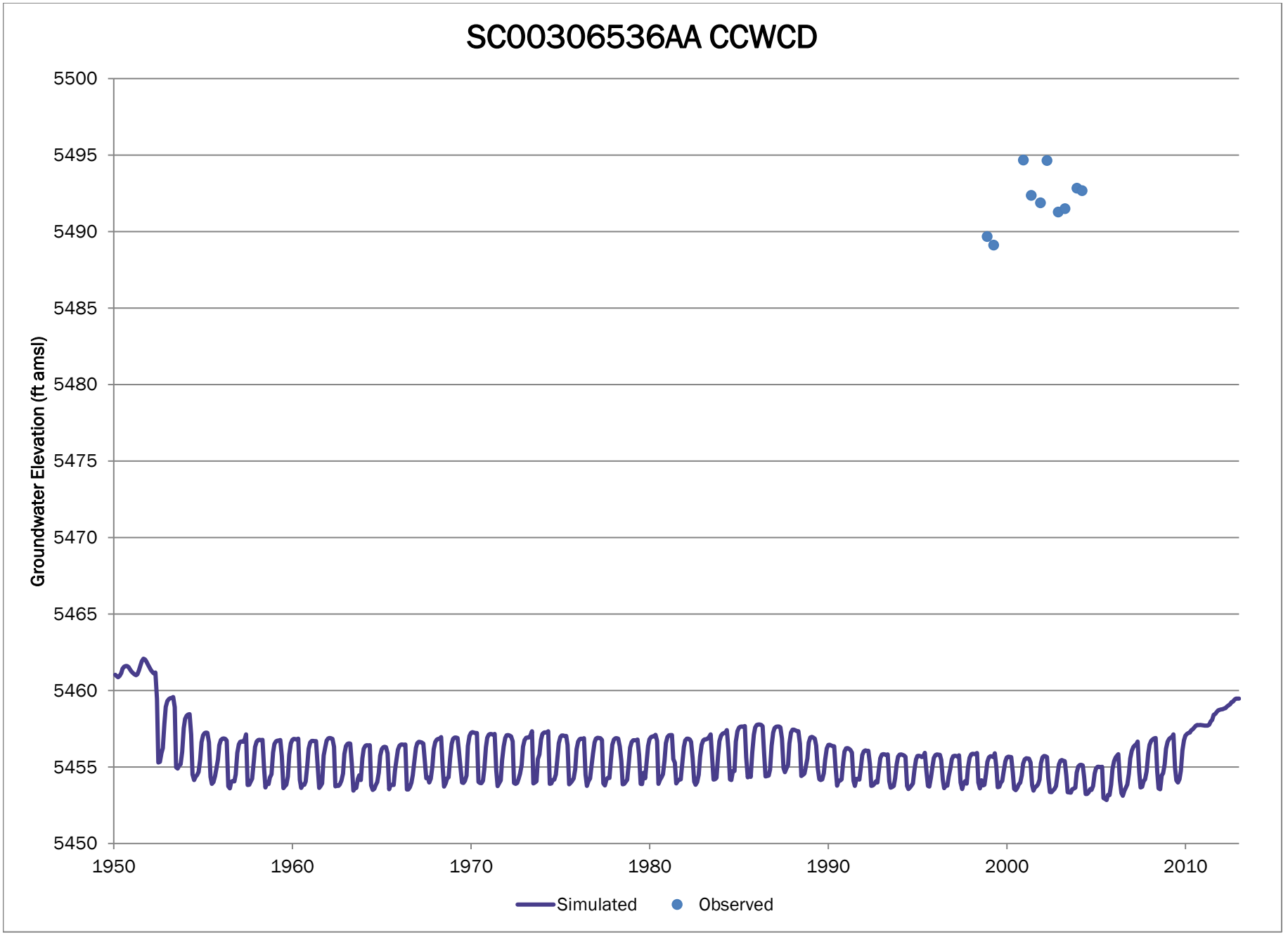

Well ID 193;CSU WP 127 CSU
Groundwater Elevation (ft amsl)
5115
5110
5105
5100
5095
5090
5085
5080
5075
5070
5065
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

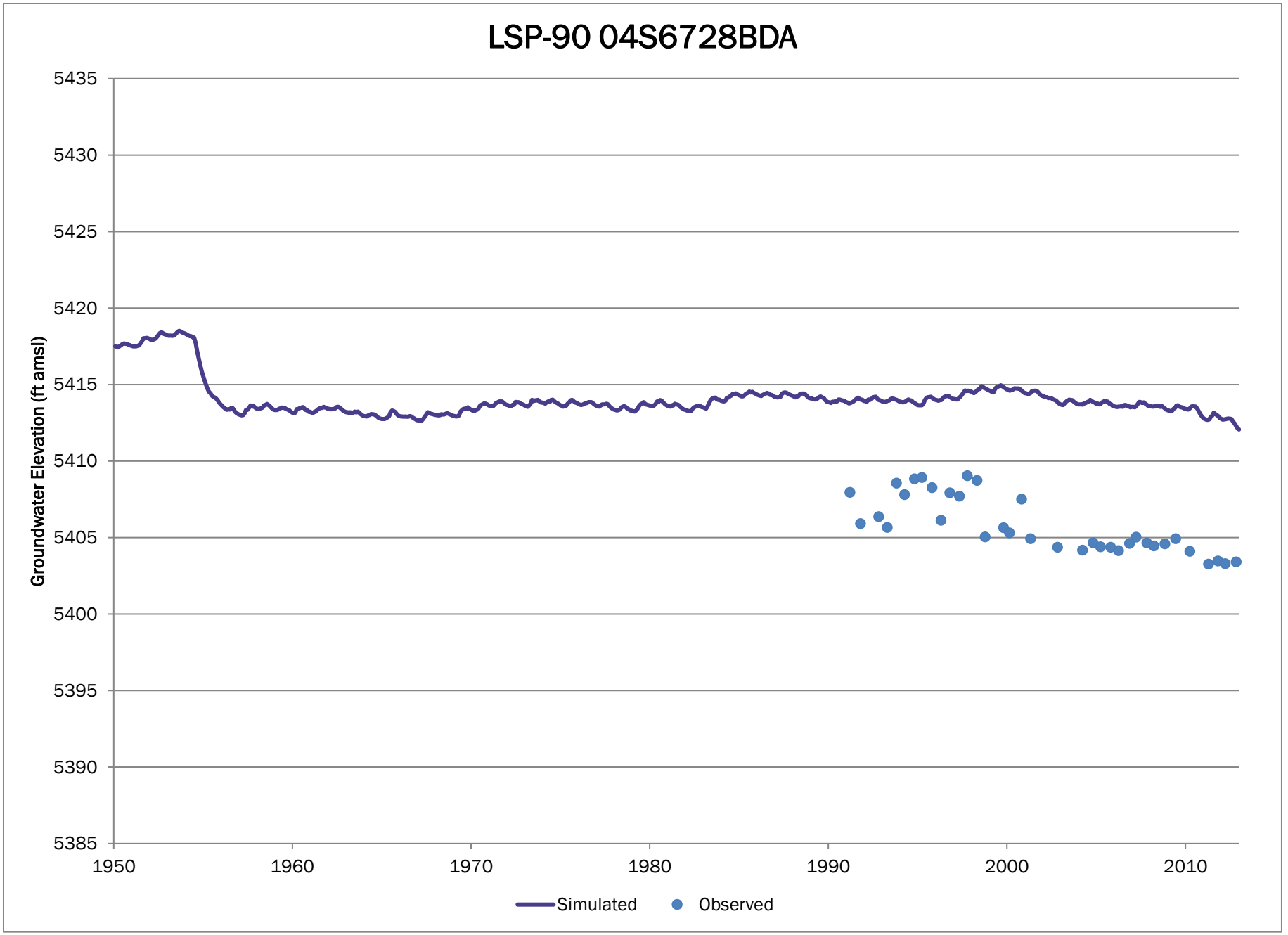

SC00206729CD CCWCD
Groundwater Elevation (ft amsl)
5115
5110
5105
5100
5095
5090
5085
5080
5075
5070
5065
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

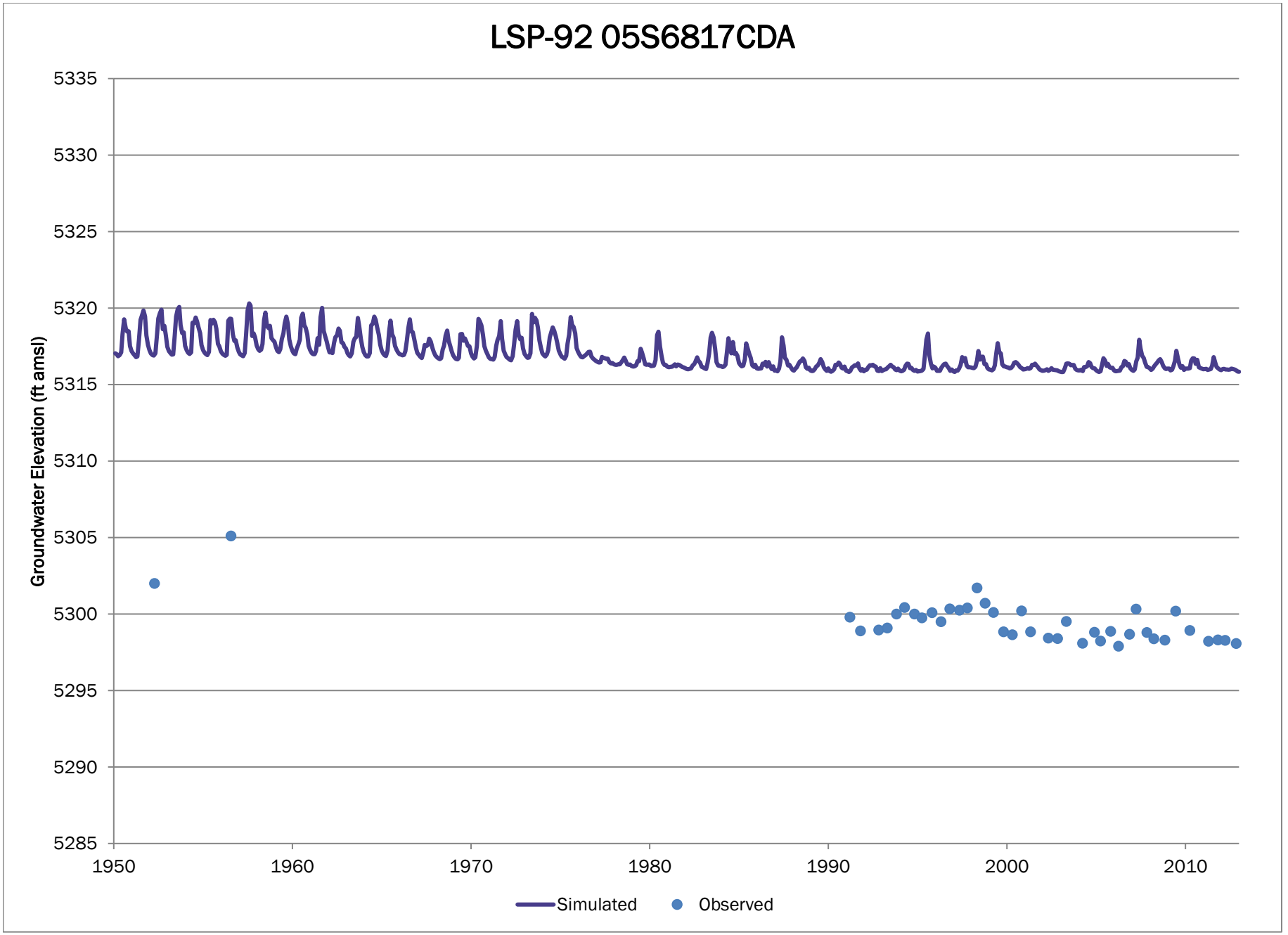

KB-32B DWR
Groundwater Elevation (ft amsl)
5115
5110
5105
5100
5095
5090
5085
5080
5075
5070
5065
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

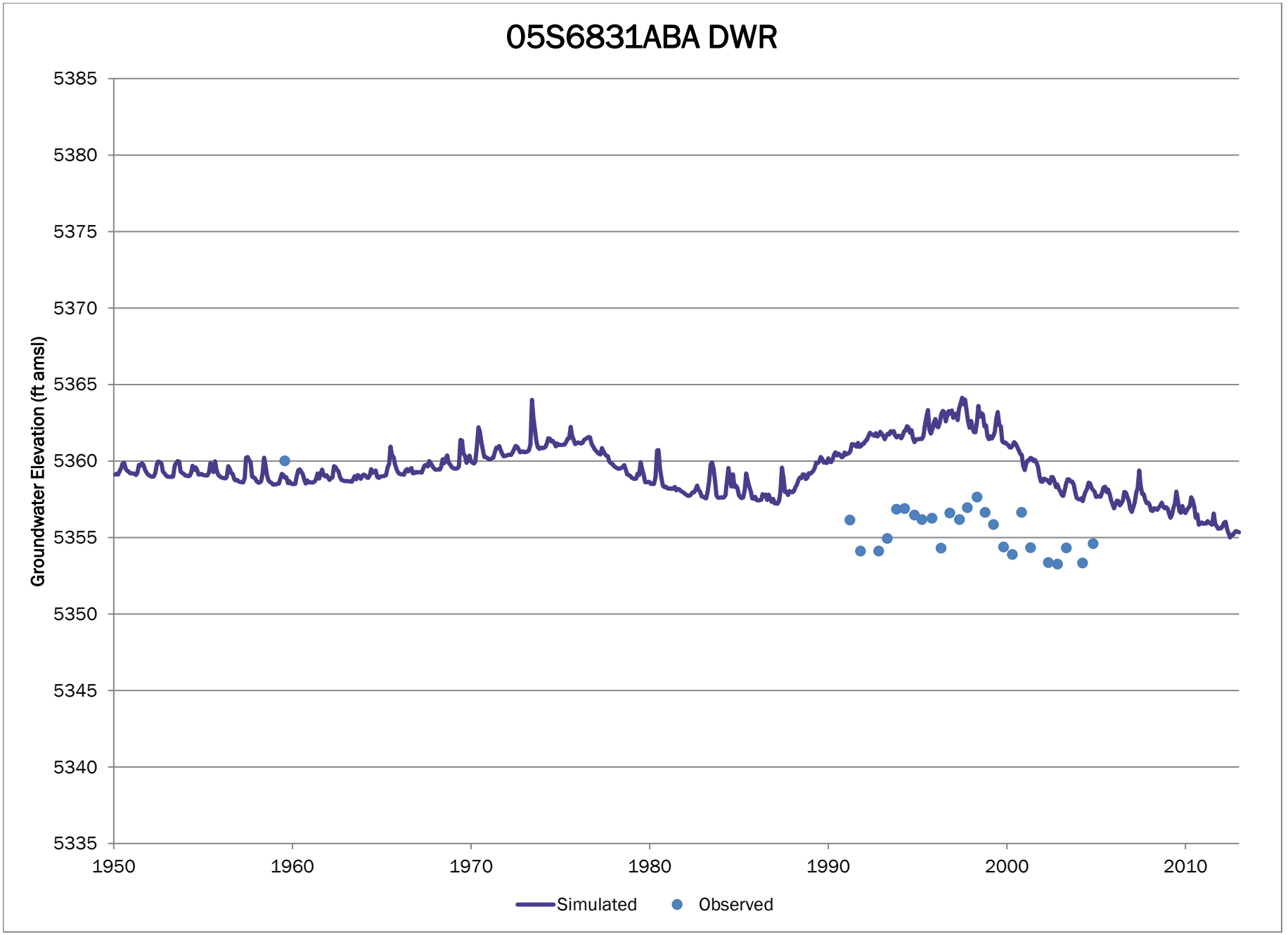

SC00306431DB CCWCD
Groundwater Elevation (ft amsl)
5510
5505
5500
5495
5490
5485
5480
5475
5470
5465
5460
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

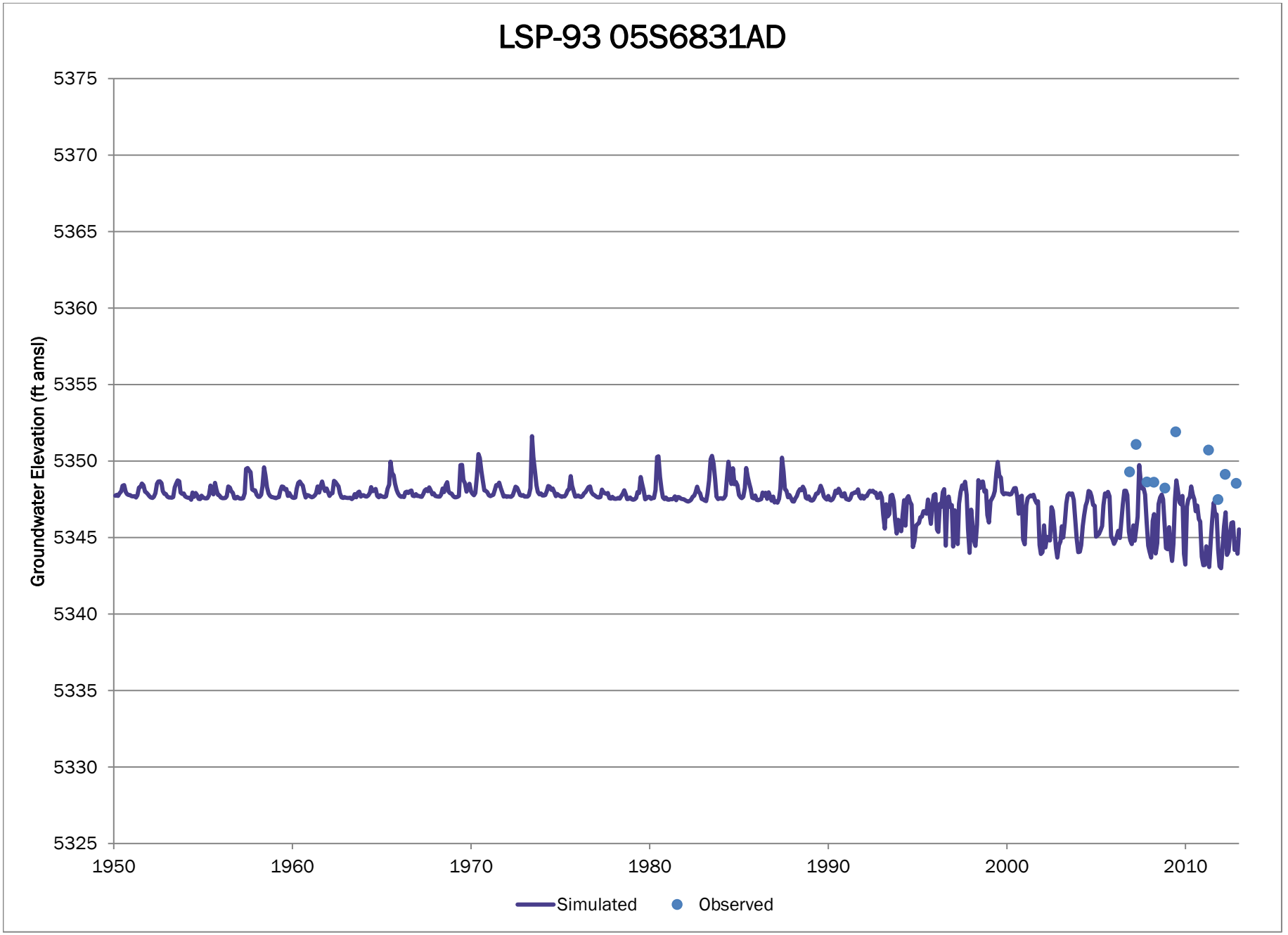

SC00306523DD CCWCD
Groundwater Elevation (ft amsl)
5460
5455
5450
5445
5440
5435
5430
5425
5420
5415
5410
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

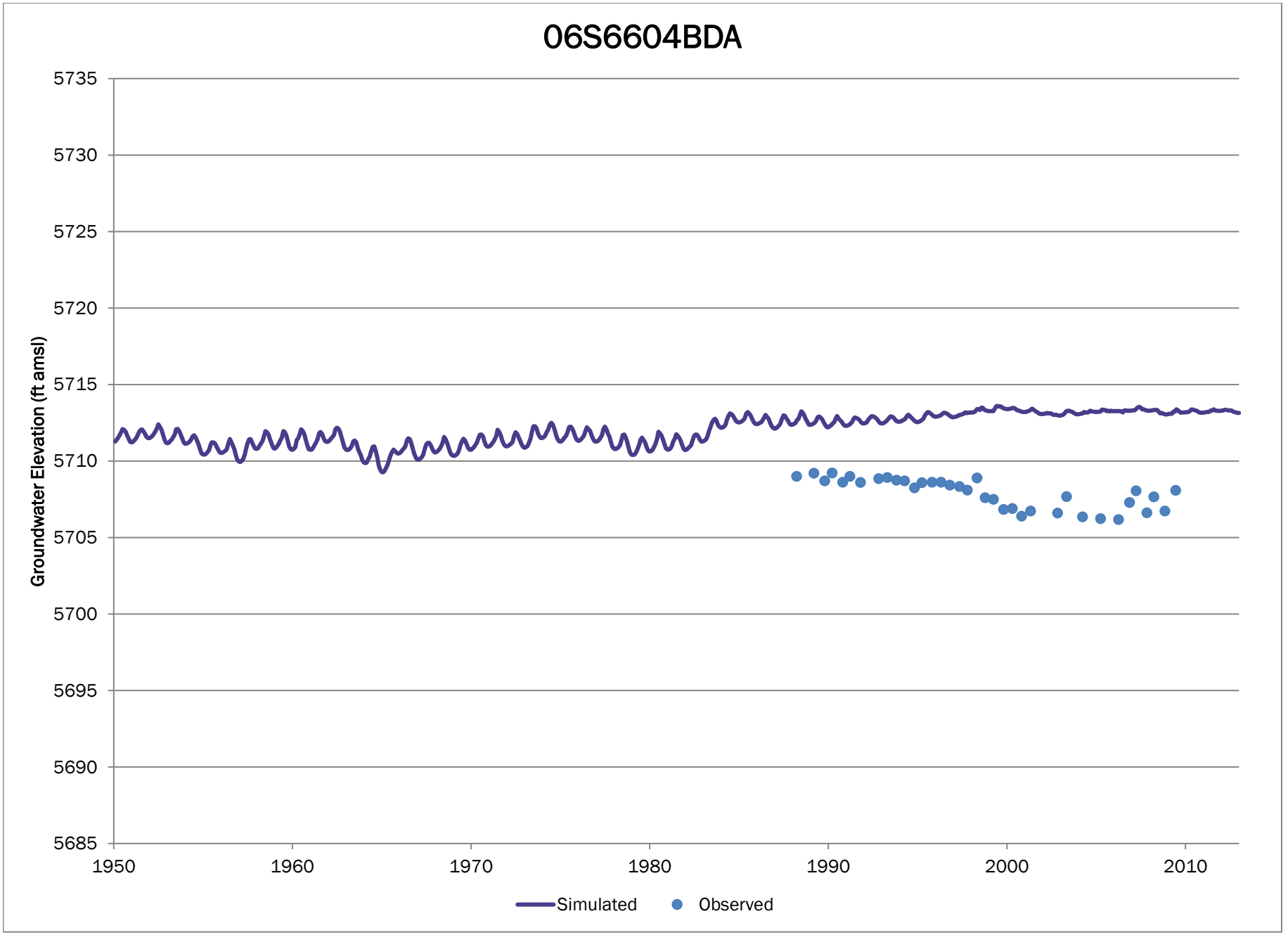

SC00306536AA CCWCD
Groundwater Elevation (ft amsl)
5500
5495
5490
5485
5480
5475
5470
5465
5460
5455
5450
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

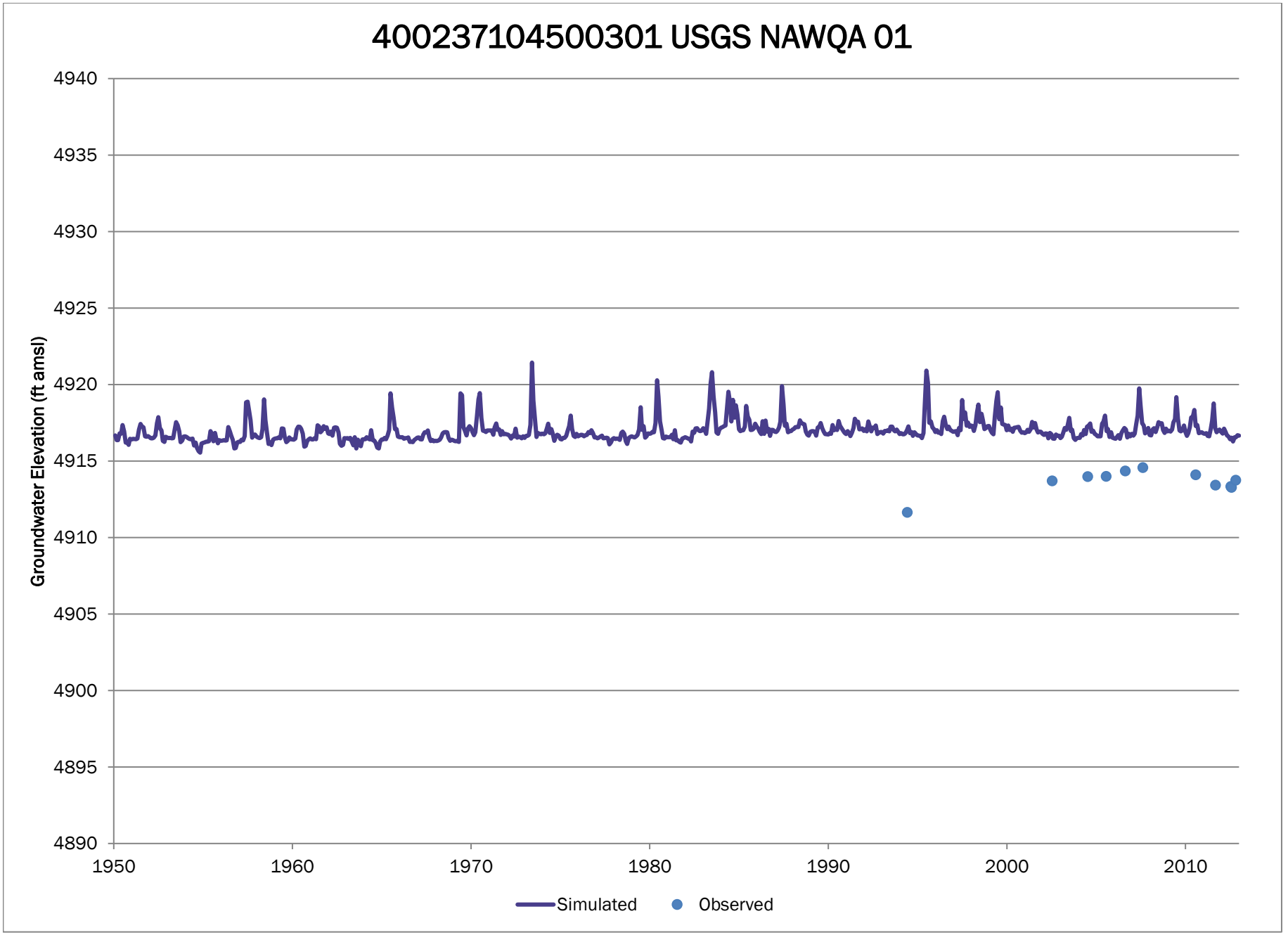

LSP-90 04S6728BDA
Groundwater Elevation (ft amsl)
5435
5430
5425
5420
5415
5410
5405
5400
5395
5390
5385
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

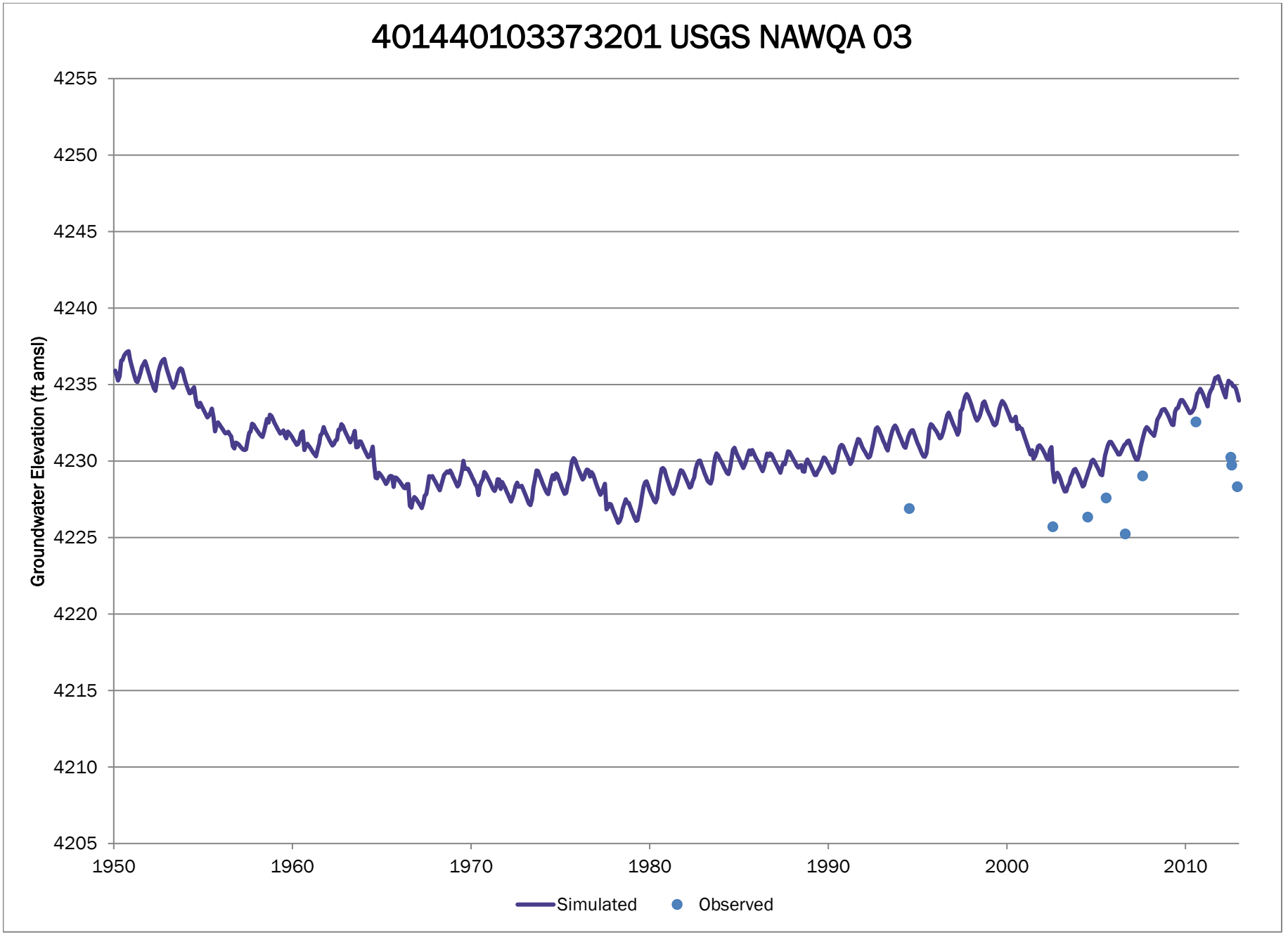

LSP-92 05S6817CDA
Groundwater Elevation (ft amsl)
5335
5330
5325
5320
5315
5310
5305
5300
5295
5290
5285
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

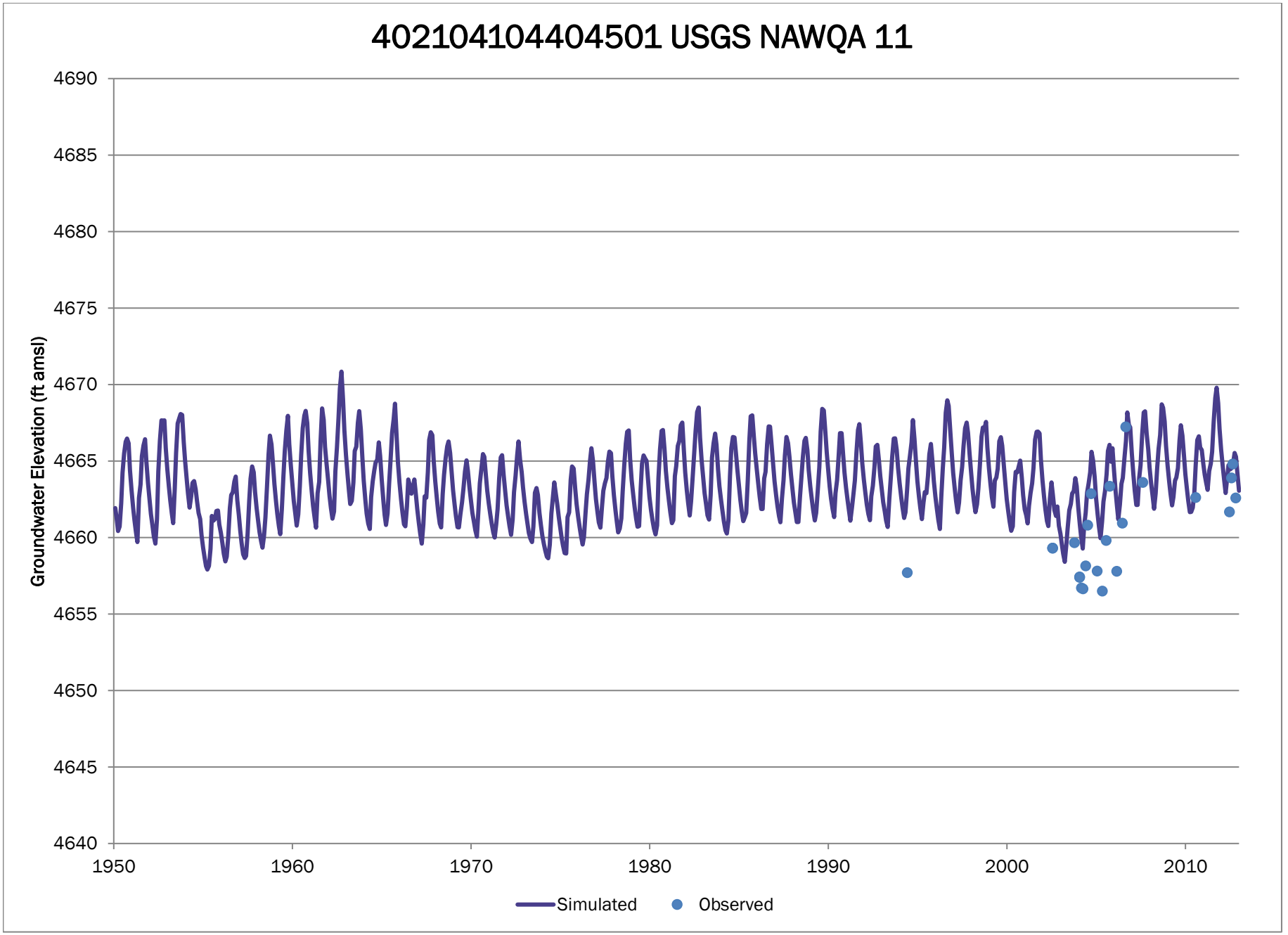

05S6831ABA DWR
Groundwater Elevation (ft amsl)
5385
5380
5375
5370
5365
5360
5355
5350
5345
5340
5335
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

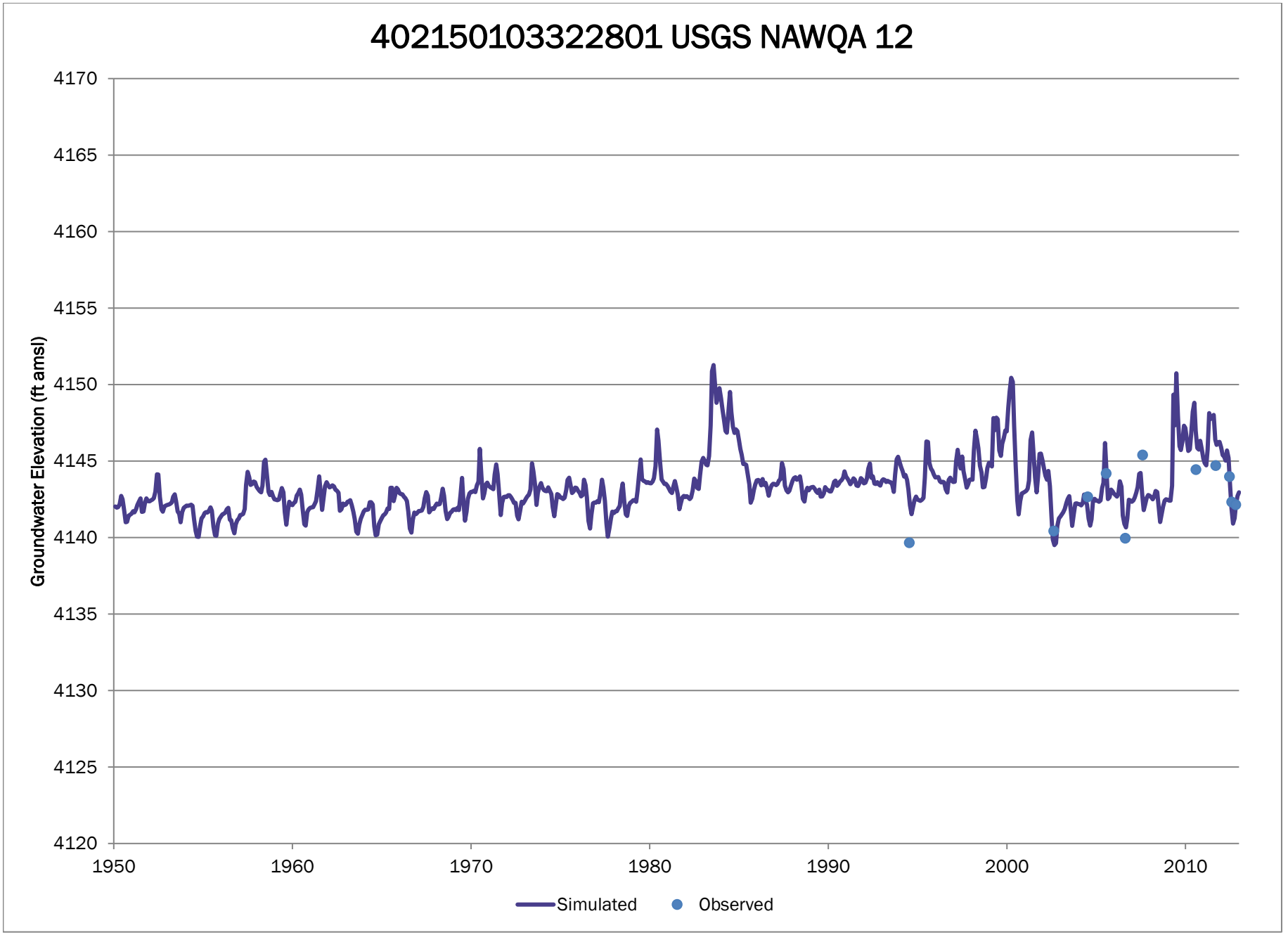

LSP-93 05S6831AD
Groundwater Elevation (ft amsl)
5375
5370
5365
5360
5355
5350
5345
5340
5335
5330
5325
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

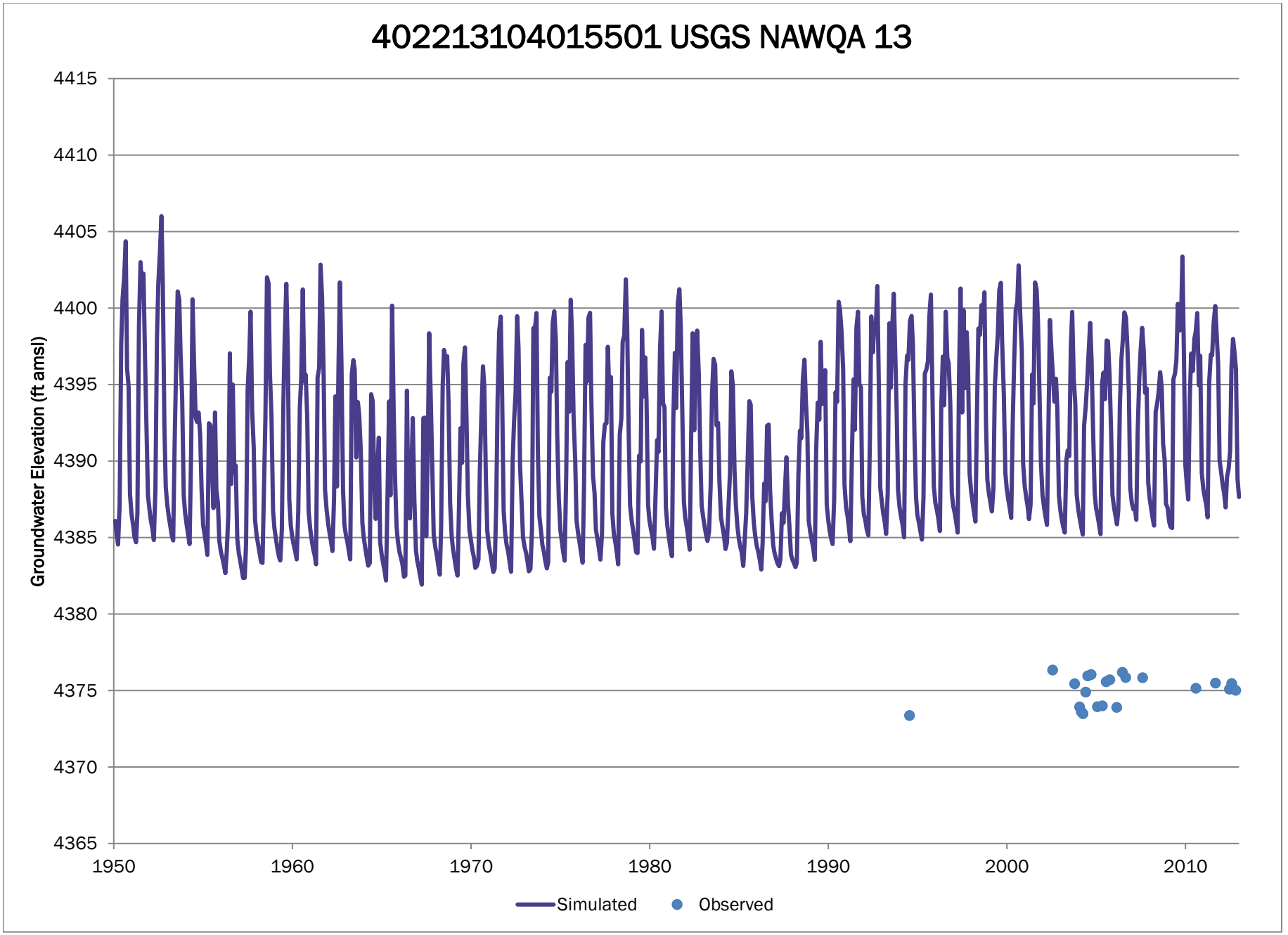

06S6604BDA
Groundwater Elevation (ft amsl)
5735
5730
5725
5720
5715
5710
5705
5700
5695
5690
5685
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

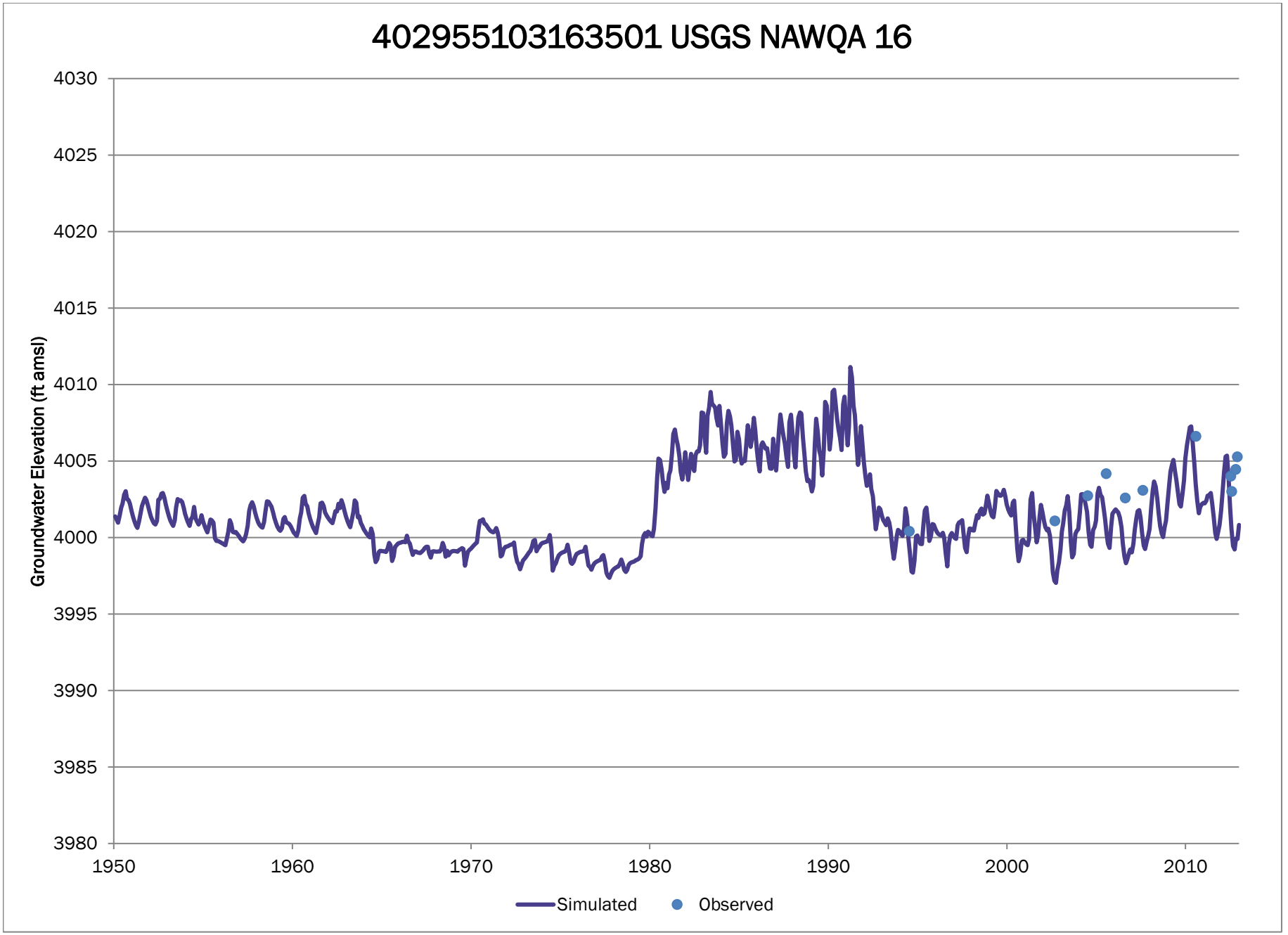

400237104500301 USGS NAWQA 01
Groundwater Elevation (ft amsl)
4940
4935
4930
4925
4920
4915
4910
4905
4900
4895
4890
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

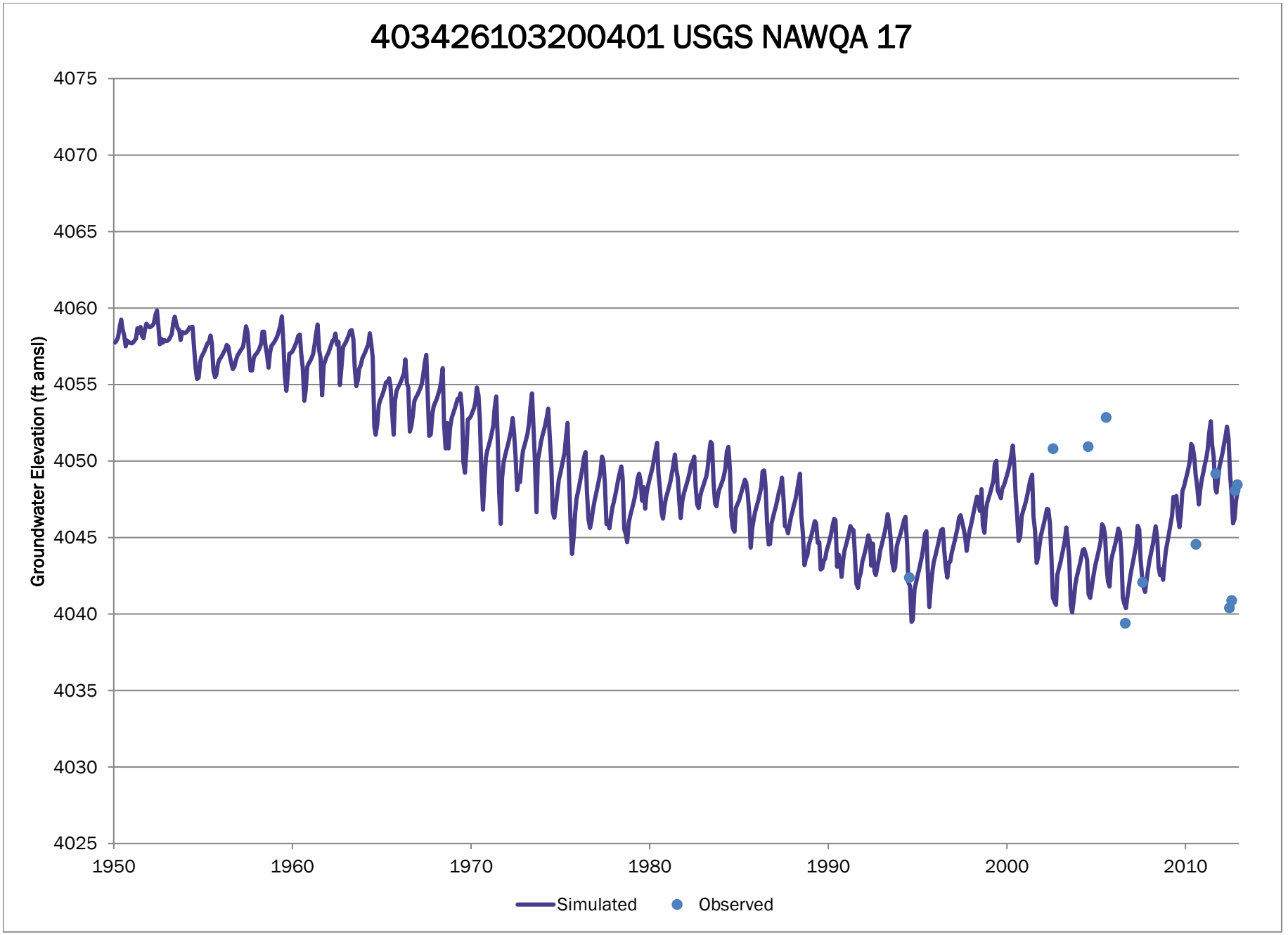

401440103373201 USGS NAWQA 03
Groundwater Elevation (ft amsl)
4255
4250
4245
4240
4235
4230
4225
4220
4215
4210
4205
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

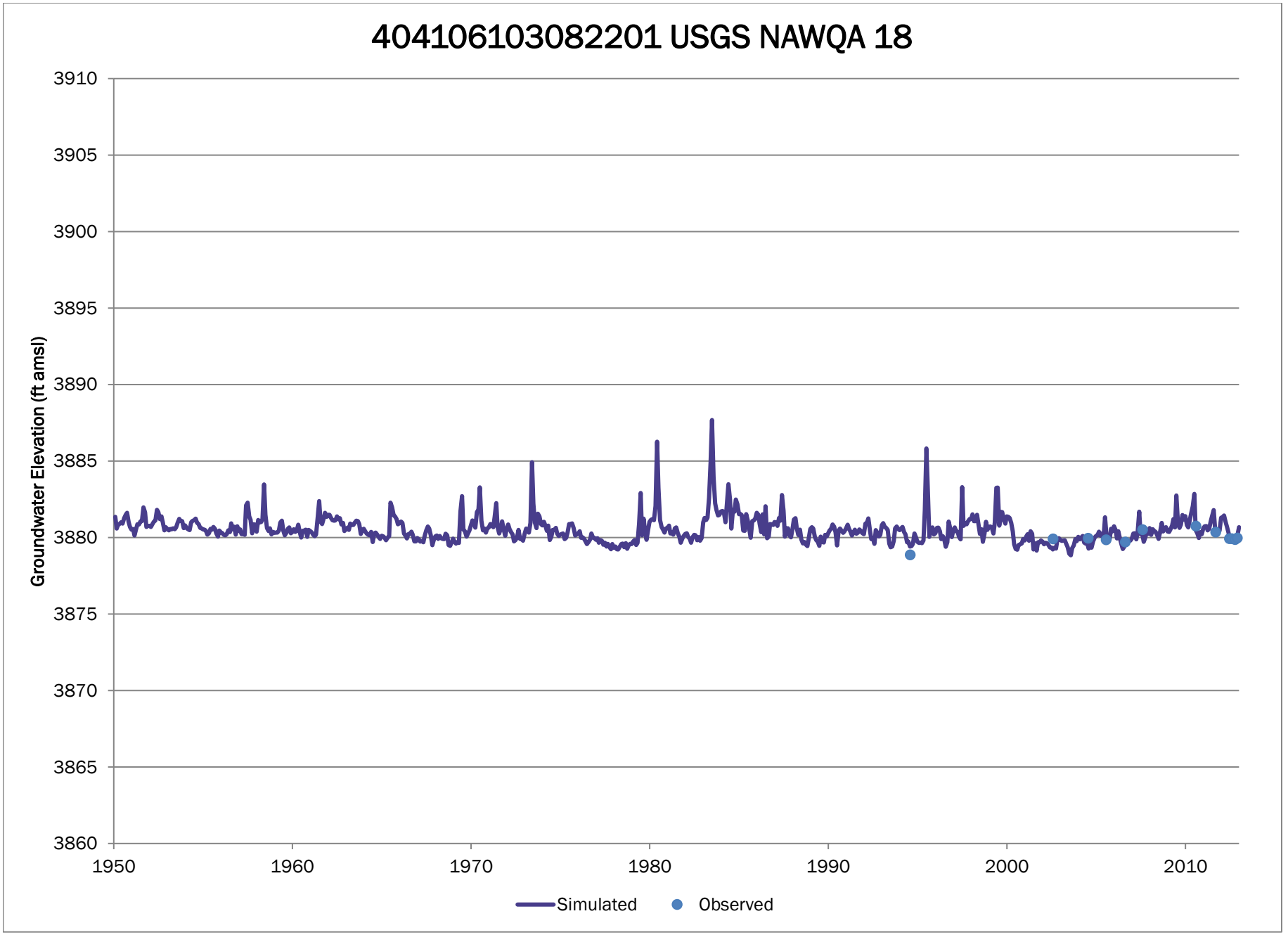

402104104404501 USGS NAWQA 11
Groundwater Elevation (ft amsl)
4690
4685
4680
4675
4670
4665
4660
4655
4650
4645
4640
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

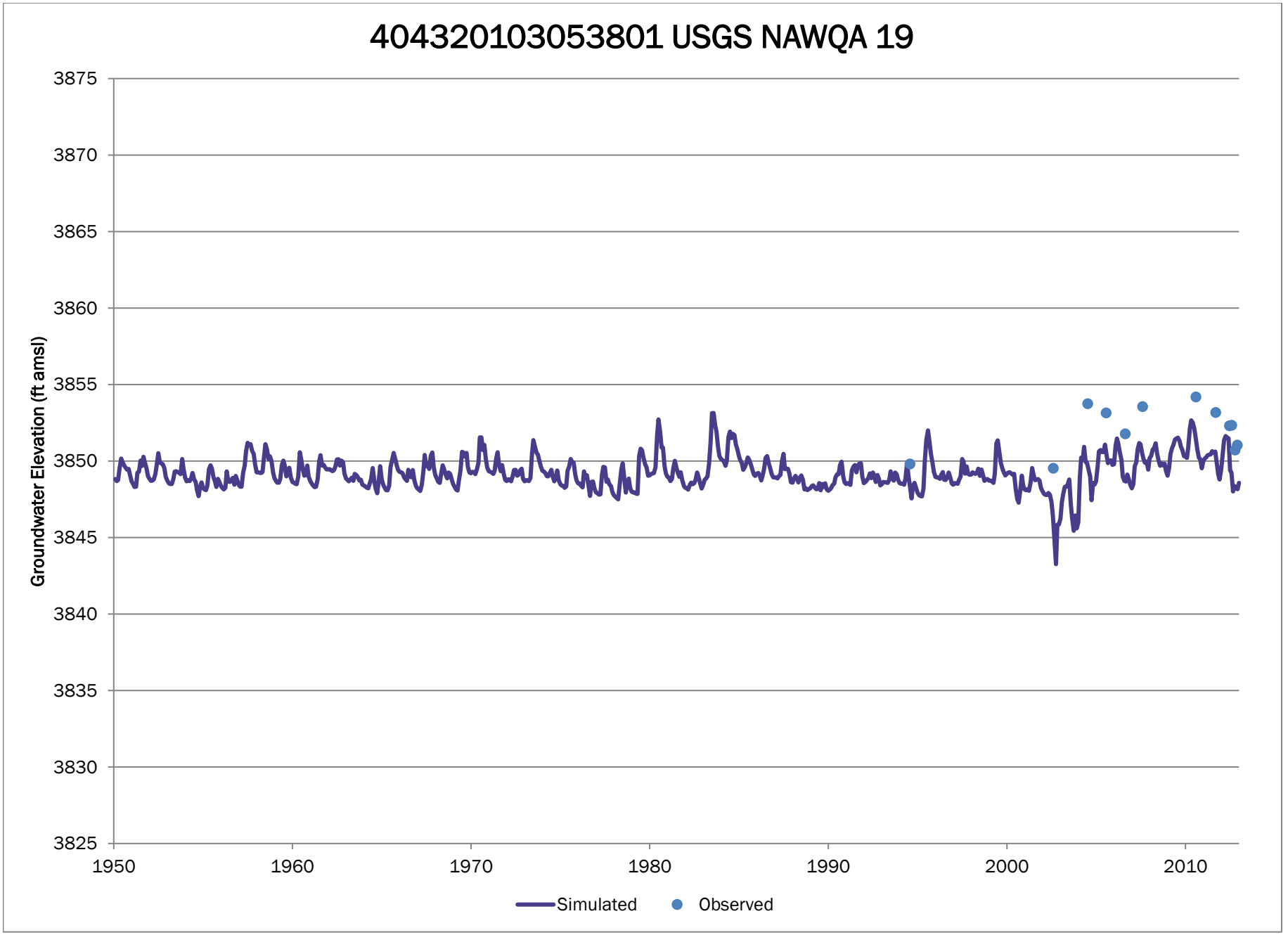

402150103322801 USGS NAWQA 12
Groundwater Elevation (ft amsl)
4170
4165
4160
4155
4150
4145
4140
4135
4130
4125
4120
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

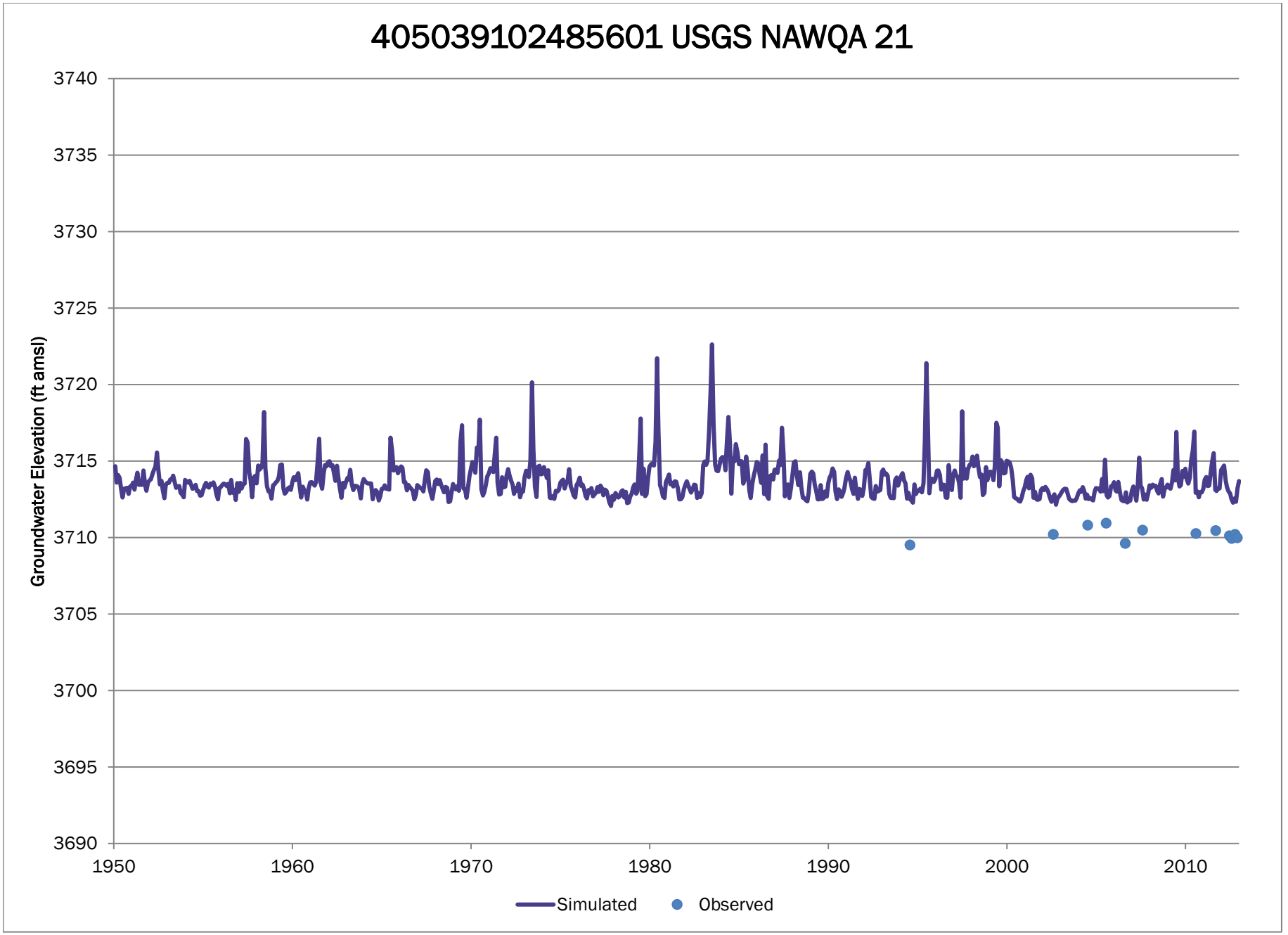

402213104015501 USGS NAWQA 13
Groundwater Elevation (ft amsl)
4415
4410
4405
4400
4395
4390
4385
4380
4375
4370
4365
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

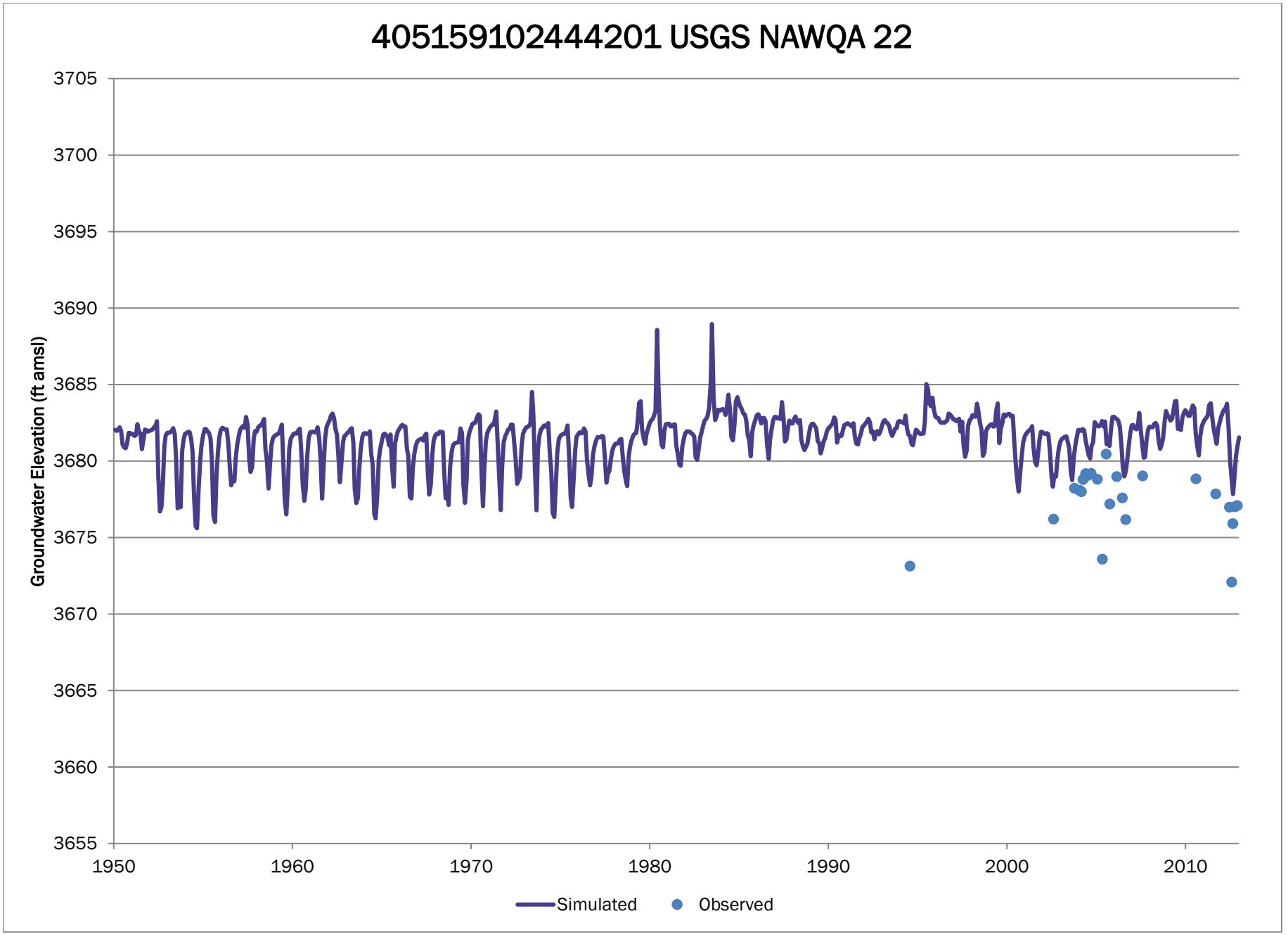

40295103163501 USGS NAWQA 16
Groundwater Elevation (ft amsl)
4030
4025
4020
4015
4010
4005
4000
3995
3990
3985
3980
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

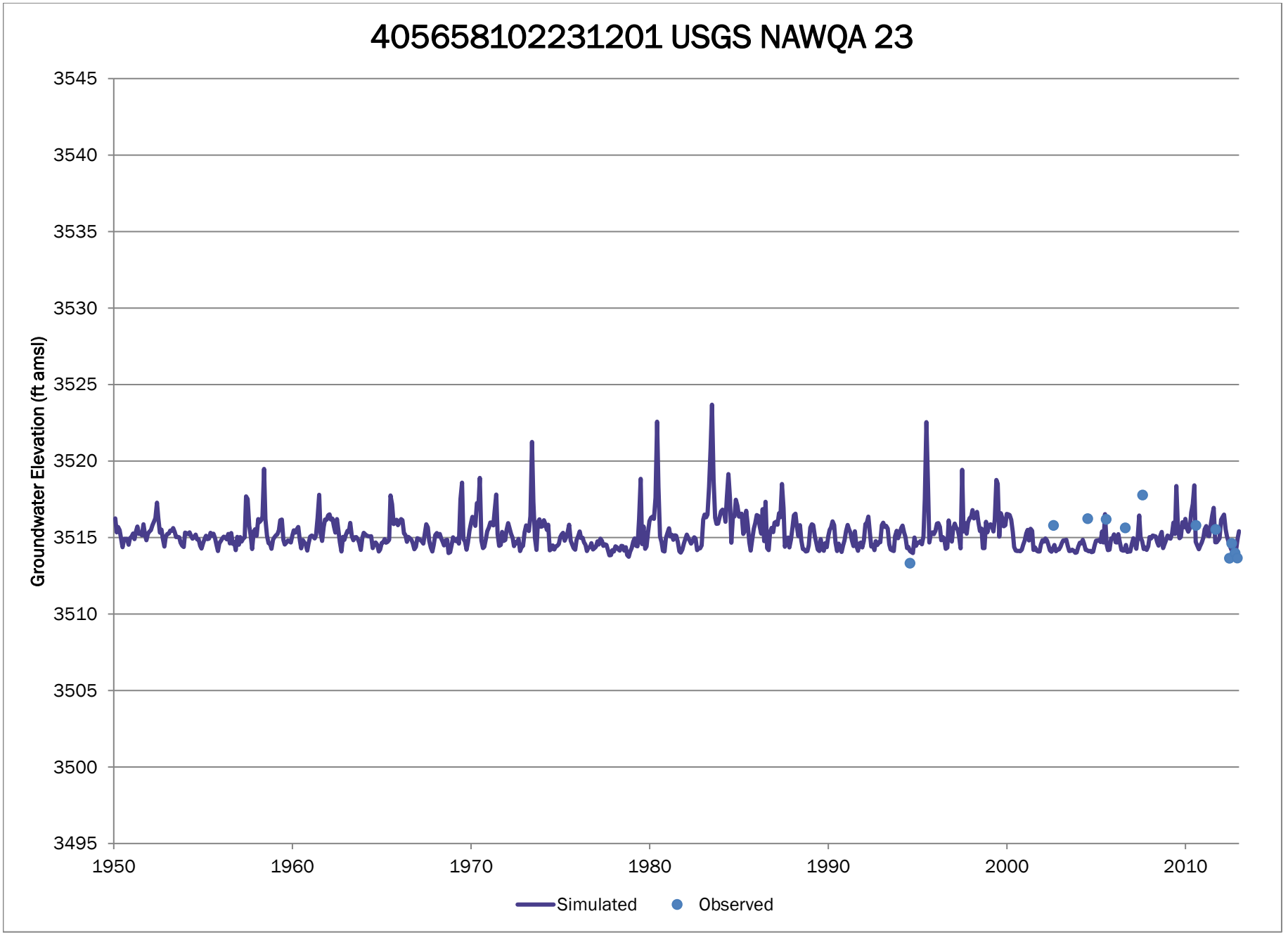

403426103200401 USGS NAWQA 17
Groundwater Elevation (ft amsl)
4075
4070
4065
4060
4055
4050
4045
4040
4035
4030
4025
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

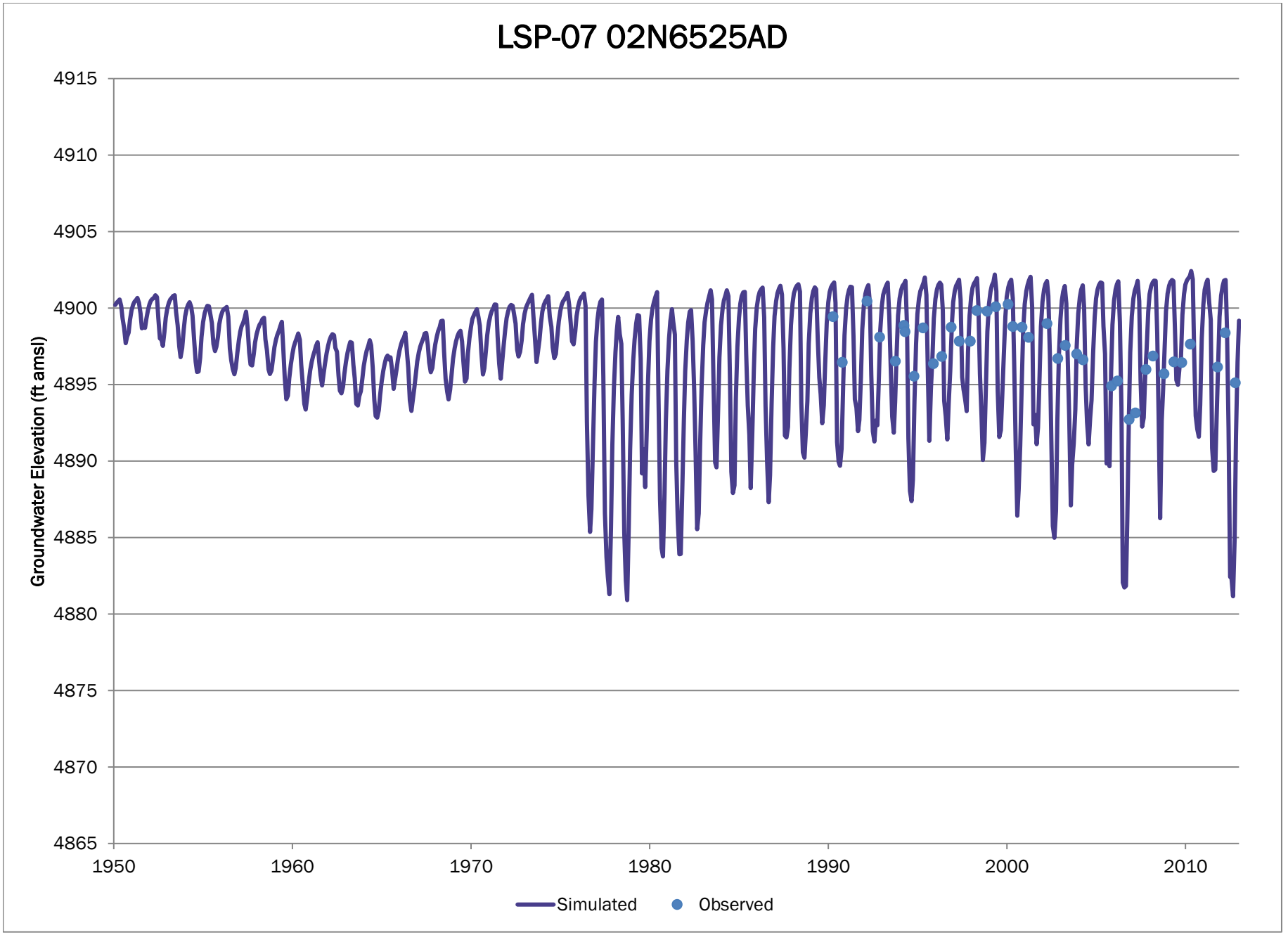

404106103082201 USGS NAWQA 18
Groundwater Elevation (ft amsl)
3910
3905
3900
3895
3890
3885
3880
3875
3870
3865
3860
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

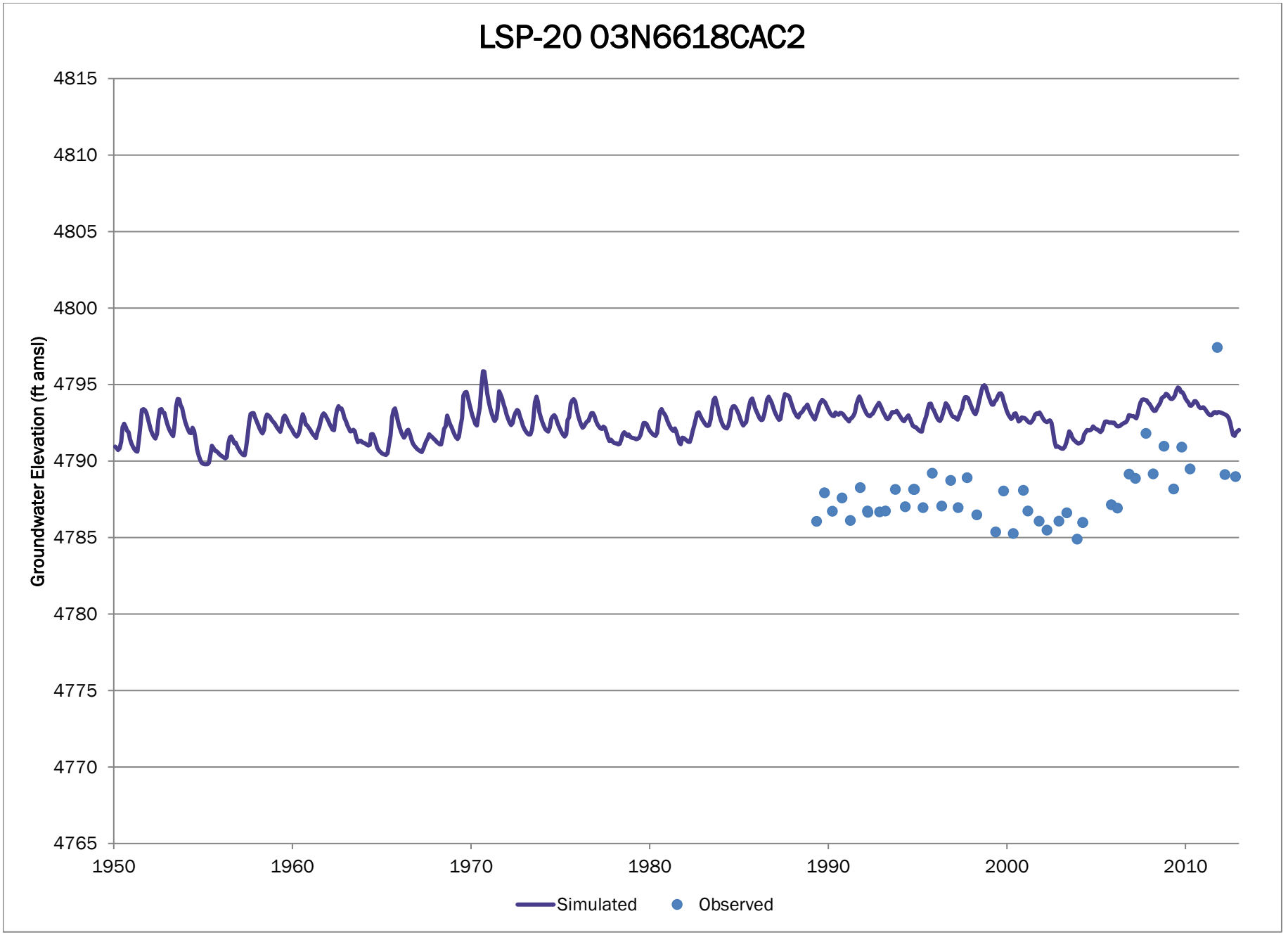

404320103053801 USGS NAWQA 19
Groundwater Elevation (ft amsl)
3875
3870
3865
3860
3855
3850
3845
3840
3835
3830
3825
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

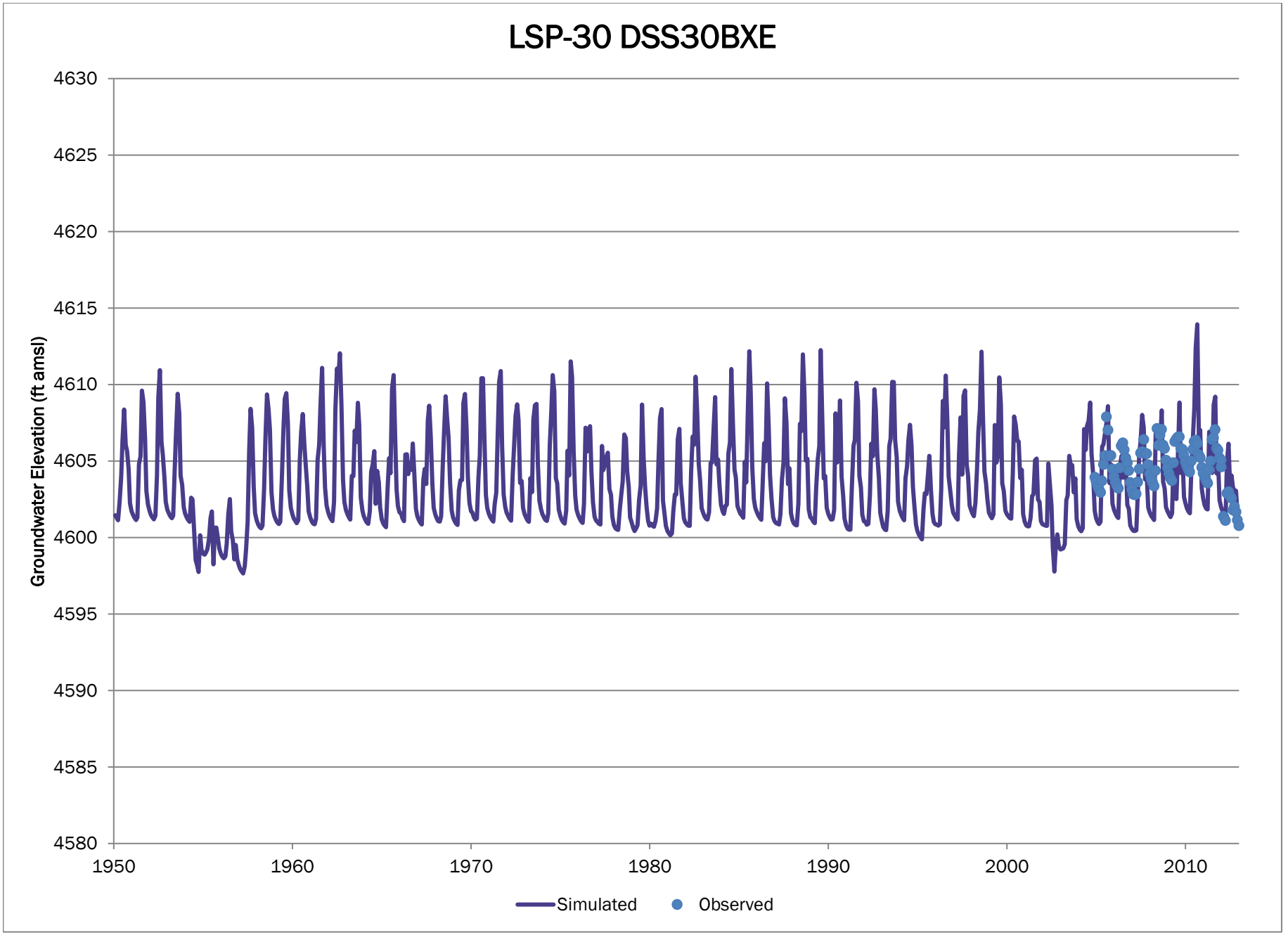

405039102485601 USGS NAWQA 21
Groundwater Elevation (ft amsl)
3740
3735
3730
3725
3720
3715
3710
3705
3700
3695
3690
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

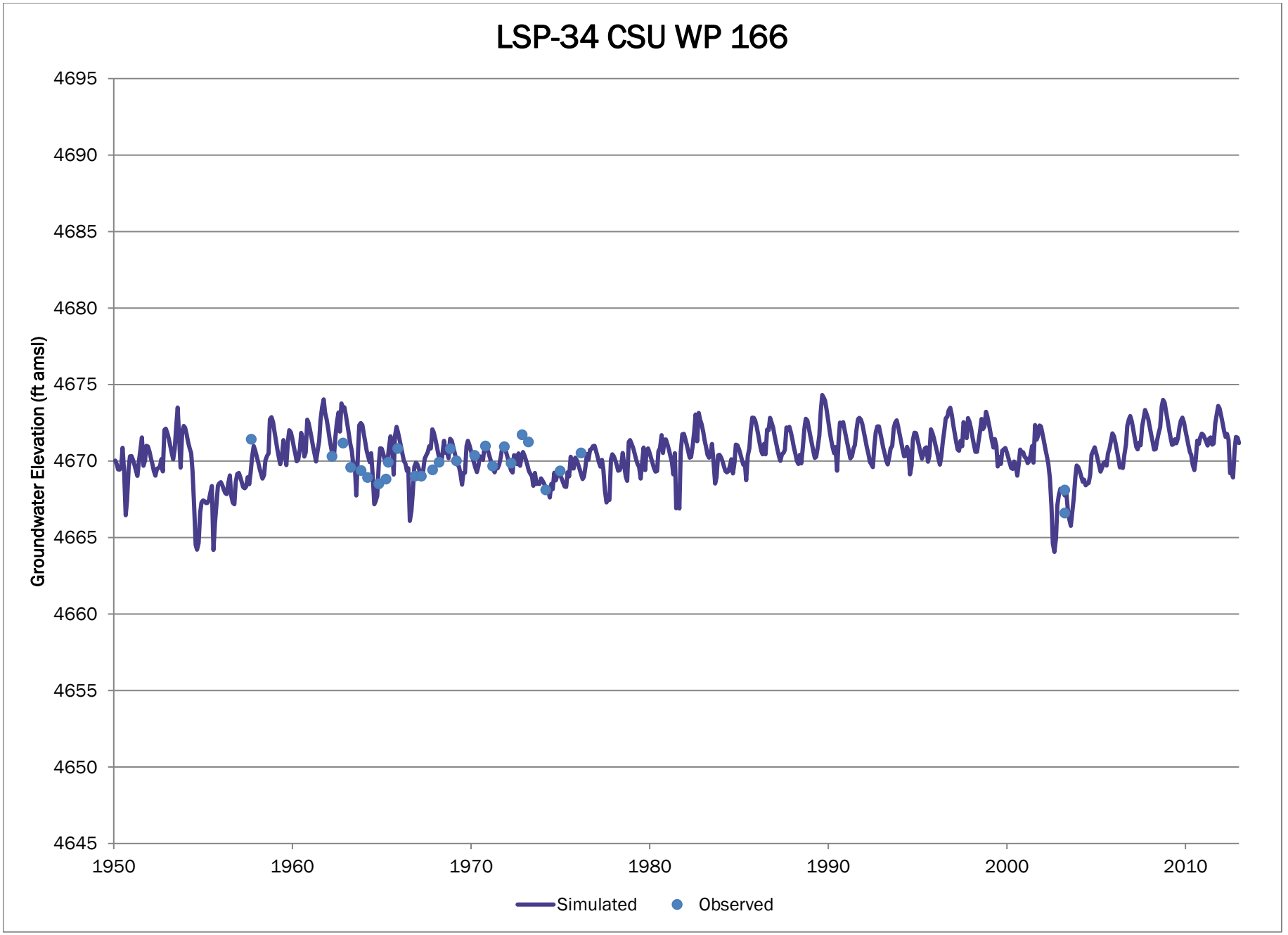

405159102444201 USGS NAWQA 22
Groundwater Elevation (ft amsl)
3705
3700
3695
3690
3685
3680
3675
3670
3665
3660
3655
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

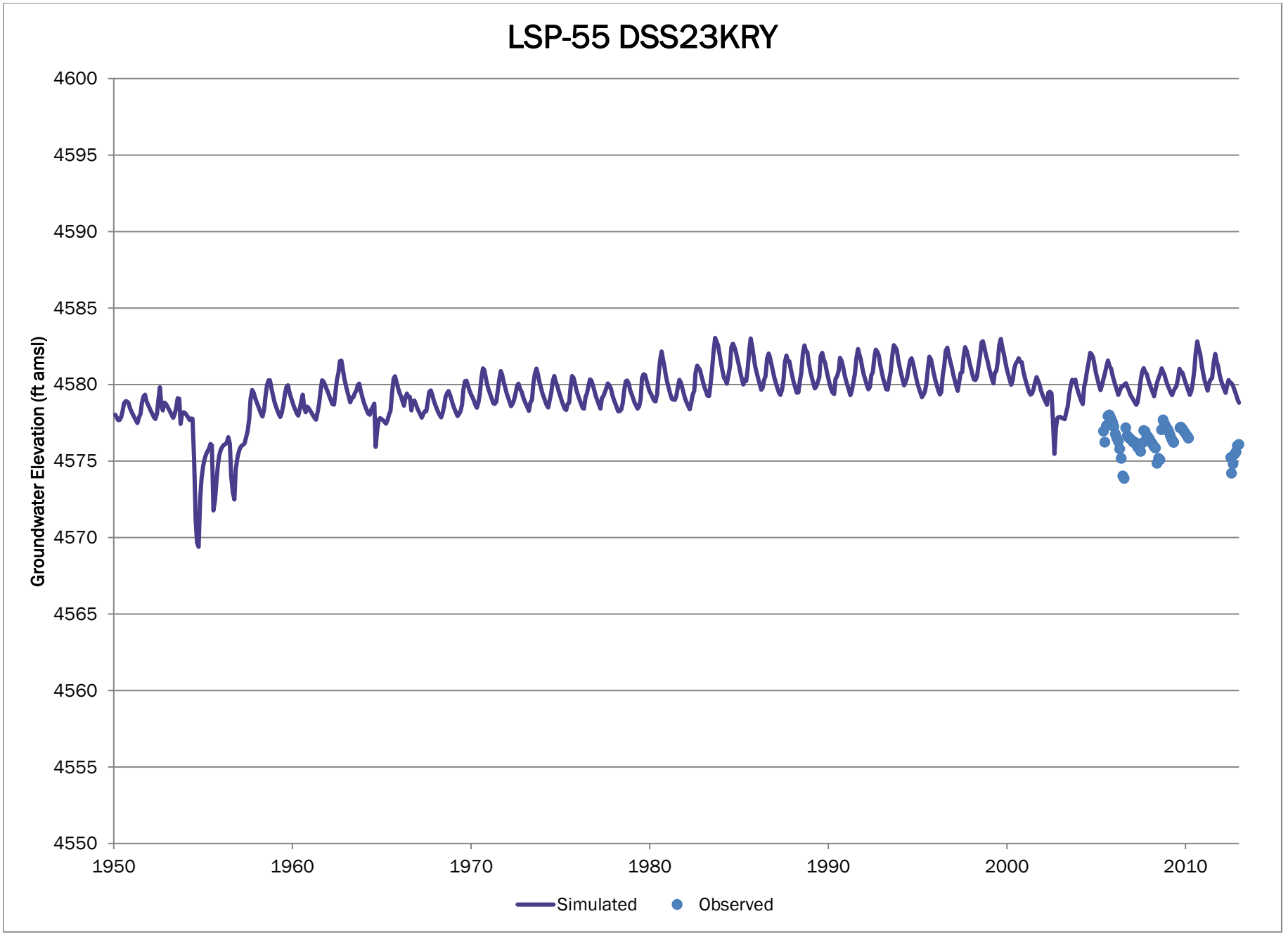

405658102231201 USGS NAWQA 23
Groundwater Elevation (ft amsl)
3545
3540
3535
3530
3525
3520
3515
3510
3505
3500
3495
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

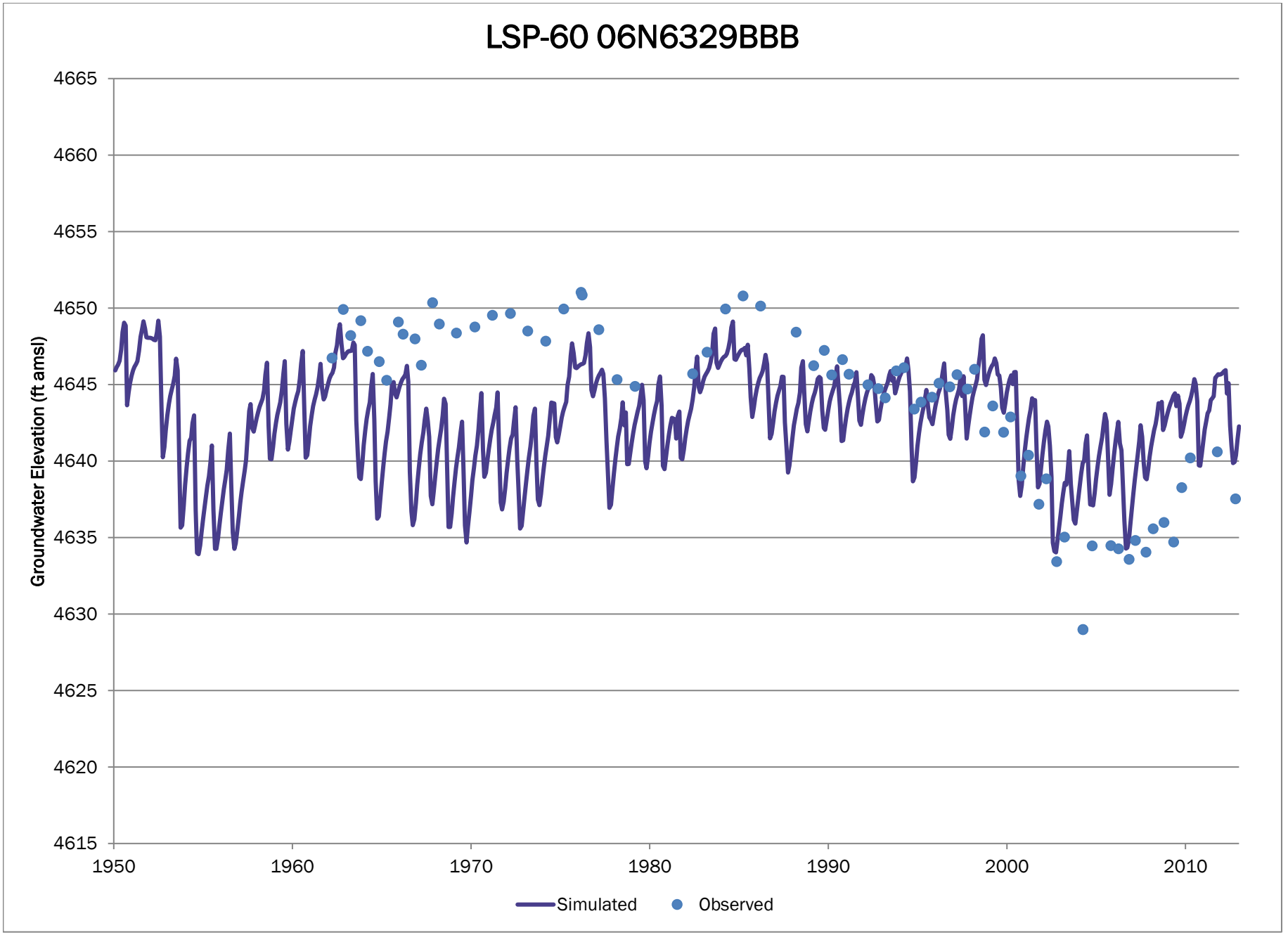

LSP-07 02N6525AD
Groundwater Elevation (ft amsl)
4915
4910
4905
4900
4895
4890
4885
4880
4875
4870
4865
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed

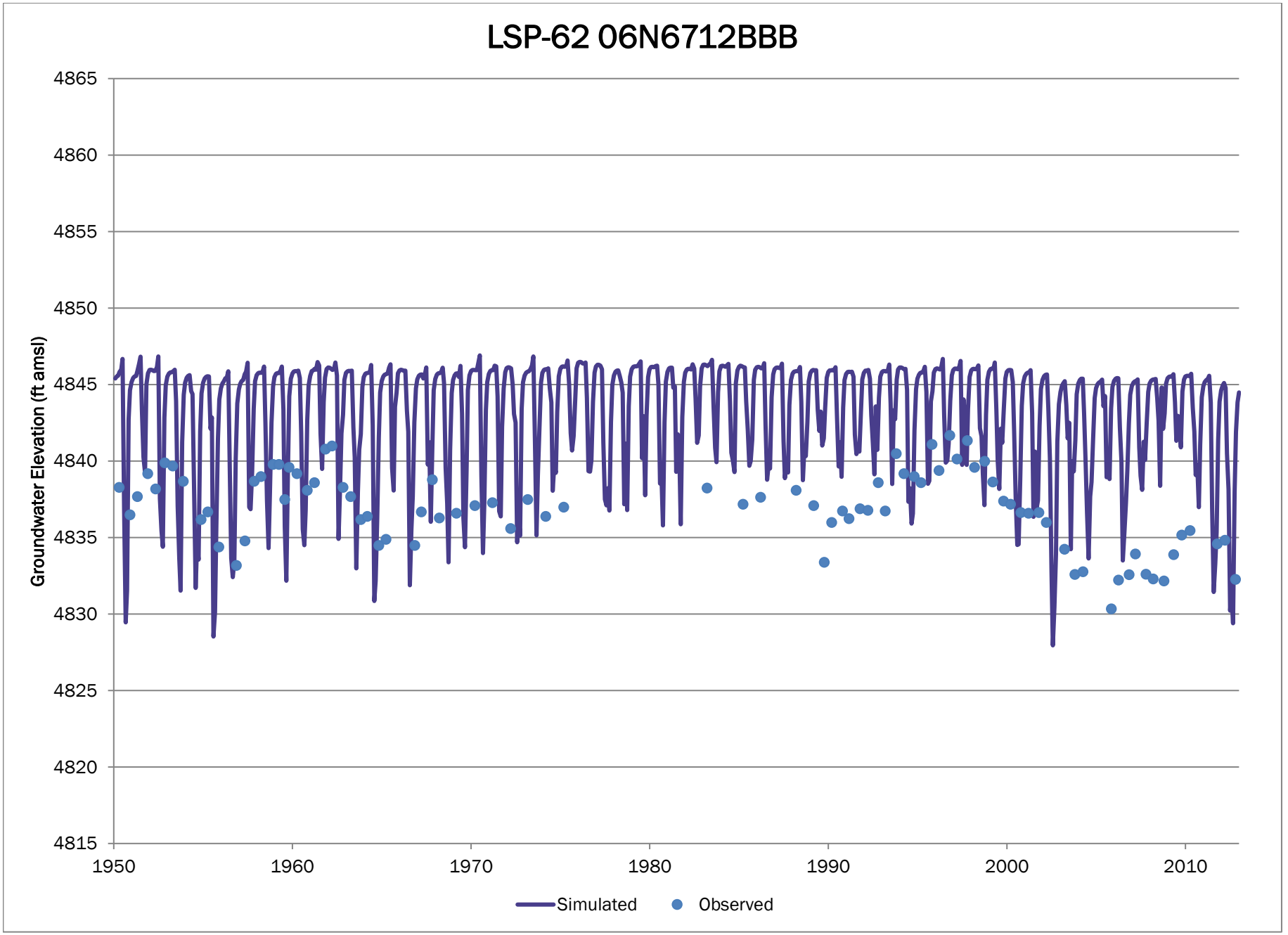

LSP-20 03N6618CAC2
Groundwater Elevation (ft amsl)
4815
4810
4805
4800
4795
4790
4785
4780
4775
4770
4765
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


LSP-30 DSS30BXE
Groundwater Elevation (ft amsl)
4630
4625
4620
4615
4610
4605
4600
4595
4590
4585
4580
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


LSP-34 CSU WP 166
Groundwater Elevation (ft amsl)
4695
4690
4685
4680
4675
4670
4665
4660
4655
4650
4645
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


LSP-55 DSS23KRY
Groundwater Elevation (ft amsl)
4600
4595
4590
4585
4580
4575
4570
4565
4560
4555
4550
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


LSP-60 06N6329BBB
Groundwater Elevation (ft amsl)
4665
4660
4655
4650
4645
4640
4635
4630
4625
4620
4615
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed


LSP-62 06N6712BBB
Groundwater Elevation (ft amsl)
4865
4860
4855
4850
4845
4840
4835
4830
4825
4820
4815
1950
1960
1970
1980
1990
2000
2010
Simulated
Observed



Brown AND Caldwell

Denver Office

1527 Cole Blvd, Suite 300
Lakewood, CO 80401
Tel: 303.239.5400

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