COLORADO RIVER ENVIRONMENTAL MODELS
PHASE 4: LAKE BUCHANAN

Prepared for

LCRA
THE POWER TO MAKE A DIFFERENCE.

3700 Lake Austin Boulevard

Austin, Texas 78703

Prepared by

ANCHOR QEA

901 South Mopac Expressway

Barton Oaks Plaza IV, Suite 280

Austin, Texas 78746

In Conjunction with

PARSONS

8000 Centre Park Drive, Suite 200

Austin, Texas 78754

January 2013
Revised March 2013

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

LIST OF ACRONYMS AND ABBREVIATIONS

AAF	Army Air Force
C	carbon
CBOD	carbonaceous biological oxygen demand
cfs	cubic feet per second
Chl-a	chlorophyll-a
cms	cubic meters per second
CREMs	Colorado River Environmental Models
DMR	Discharge Monitoring Report
DO	dissolved oxygen
gN/gOM	gram nitrogen per gram organic matter
GOF	goodness of fit
ha	hectare
HLWO	Highland Lakes Watershed Ordinance
HRU	hydrologic response unit
kg	kilogram
km	kilometer
km²	square kilometer
LBJ	Lyndon Baines Johnson
LCRA	Lower Colorado River Authority
LOADEST	LOAD ESTimator
LTI	LimnoTech, Inc.
µg/L	micrograms per liter
m	meter
m³	cubic meter
MAE	mean absolute error
MDL	method detection limit
ME	mean error
MGD	million gallons per day
mg/L	milligram per Liter
mm	millimeter
msl	mean sea level

N	nitrogen
NCDC	National Climatic Data Center
NED	National Elevation Dataset
NGVD 29	National Geodetic Vertical Datum of 1929
NH3	ammonia, as nitrogen
NH4	ammonium, as nitrogen
NLCD	National Land Cover Dataset
NO3	nitrate, as nitrogen
NOX	nitrate+nitrite, as nitrogen
NPS	non-point source
NRCS	National Resource Conservation Service
NTU	Nephelometric Turbidity Unit
NS	Nash-Sutcliffe model efficiency coefficient
NWS	National Weather Service
P	phosphorus
OM	organic matter
OrgN	organic nitrogen
OrgP	organic phosphorus
PO4	orthophosphate, as phosphorus (also referred to as orthophosphorus)
POR	period of record
R^2	coefficient of determination
RI	reliability index
RSS	Reservoir and Stream Sampling
SI	sensitivity index
SOD	sediment oxygen demand
SSURGO	Soil Survey Geographic Database
STATSGO	State Soil Geographic Database
SWAT	Soil and Water Assessment Tool
TCEQ	Texas Commission on Environmental Quality
TDS	total dissolved solids
TKN	Total Kjeldahl Nitrogen
TN	total nitrogen
TOC	total organic carbon

TP	total phosphorus
TSS	total suspended solids
TWDB	Texas Water Development Board
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

ACKNOWLEDGEMENTS

1   INTRODUCTION

This report documents the development and calibration of the Lake Buchanan watershed and lake water quality models developed during Phase 4 of the Colorado River Environmental Models (CREMs) project. The development and calibration of the Lake Buchanan models largely followed the methodologies used during Phases 2 and 3 of the CREMs project for modeling the other lakes, with a few exceptions due to Lake Buchanan's geographic location and subsequent sensitivity to watershed loadings. Lake Buchanan is first in the series of Highland Lakes and receives and settles out sediment and nutrient loadings from a large upland watershed. Modifications to the modeling methodology used in previous CREMs phases were required in order to capture these changes in nutrients and algal production over time and are documented throughout this report.

1.1   Background

The LCRA initiated development of mathematical models to support water quality management of the lower Colorado River system in 2001 with the CREMs Master Plan (CH2M Hill 2002). The CREMs project was designed to help diagnose existing water quality problems and issues, discern water quality trends, and predict the consequences of various management decisions and associated actions on the water quality of the Highland Lakes, lower Colorado River, and associated tributaries. The modeling tools are being designed to provide the information needed by LCRA staff and management to support policy decisions that proactively and effectively protect the integrity of water resources in the lower Colorado River basin.

The CREMs project has been developed through four phases. Phases 1 and 2 focused on Lake Travis, which was selected during the prioritization process described in the CREMs Master Plan (CH2M Hill 2002). Phase 3 focused on Inks Lake, Lake Lyndon Baines Johnson (LBJ), and Lake Marble Falls. Phase 4, which commenced in 2011, focuses on Lake Buchanan.

The selection of Lake Travis for Phases 1 and 2 was based on the need to support the evaluation of the LCRA Lake Travis Non-point Source (NPS) Pollution Control Ordinance and the Upper Highland NPS Control Ordinance, which in 2006 were combined and renamed the Highland Lakes Watershed Ordinance (HLWO), and to address community

questions regarding the effectiveness of the Texas Commission on Environmental Quality's (TCEQ's) wastewater discharge ban (also known as the point source discharge ban or the Highland Lakes discharge ban). Phase 1 assessed Lake Travis water quality using existing data to develop a simplified model of the reservoir and watershed. Details on the Phase 1 work can be found in the Phase 1 Lake Travis Model (LCRA 2004).

Phase 2 involved acquisition of additional water quality data and development of refined watershed and lake models of Lake Travis. Details on the Phase 2 work can be found in the CREMs Phase 2: Lake Travis Final Report (Anchor QEA and Parsons 2009a).

The Phase 3 and Phase 4 lakes are also included in the TCEQ point source discharge ban. Additionally, portions of their watersheds fall within the boundaries of the HLWO. The discharge ban and HLWO are described in Section 1.1.2 of this report. Details on the Phase 3 work can be found in the CREMs Phase 3: Final Report (Parsons and Anchor QEA 2011). This Phase 4 report describes the development, calibration, and sensitivity analysis of watershed and lake models for Lake Buchanan.

1.1.1 Lake Buchanan System

Lake Buchanan is the first in a series of six reservoirs on the lower Colorado River known as the Highland Lakes (Figure 1-1). By surface area, it is the largest of the Highland Lakes, and by volume, it is second largest after Lake Travis. Lake Buchanan was created by the construction of the Buchanan Dam, which has been in operation since 1938.

Lake Buchanan is considered full at a water surface elevation of 1,020.5 feet (311.05 meters [m]) National Geodetic Vertical Datum of 1929 (NGVD 29), and its normal operating water surface elevation range is at or below 1,018 feet above mean sea level (msl) from May to October and at or below 1,020 feet above msl from November to April (LCRA 2011). Lake Buchanan holds 886,626 acre-feet (1.09×10^9 cubic meters [m^3]) of water when full and covers an area of 22,137 acres (89.6 square kilometers [km^2]). The main body of the lake winds roughly 23 river miles (7 km) through the Central Texas Hill Country, from near the confluence of Deer Creek and the lower Colorado River to Buchanan Dam. The reservoir is less than 0.1 mile (161 m) wide in the upper reaches of the lake, and widens to more than 4.2

miles (6,760 m) at the lake center near Rocky Point. When the lake is full, the deepest point is more than 108 feet (33 m) below the water surface.

The total watershed area of Lake Buchanan covers approximately 20 million acres (31,250 mi^2; Breeding 2012). The spatial extent of the watershed considered for CREMs Phase 4 is limited to the drainage basin of the Colorado River from Buchanan Dam upstream to S.W. Freese Dam in Coleman and Concho counties, and to Lake Brownwood Dam in Brown County. Most flows from the watershed enter the lake via the Colorado River from the north. Major tributaries of the Colorado River in the watershed include the San Saba River (including Brady Creek) and Pecan Bayou. Average annual precipitation in the watershed ranges from approximately 22 to 30 inches (TWDB 2012).

1.1.2 Relevant Ordinances

One of the primary missions of the LCRA is to ensure that water quality of the lower Colorado River tributaries and reservoirs will support recreation, aquatic life, and public water supply uses through monitoring, assessment, advocacy, and regulatory oversight to protect against degradation of the lower Colorado River, its reservoirs, and tributaries. Reservoir and watershed management approaches to protecting Highland Lake water quality include TCEQ's ban on point source discharges and LCRA's implementation of the HLWO. Water quality modeling is critical to understanding processes in the Highland Lakes that are relevant to protection of water quality and to evaluating the benefits provided by the TCEQ Highland Lakes discharge ban and HLWO.

1.1.2.1 Texas Commission on Environmental Quality Highland Lakes Discharge Ban

In order to protect and maintain the existing water quality of the Highland Lakes, the Texas Water Commission (a predecessor to TCEQ) adopted regulations in October 1986 prohibiting new or expanded discharges of wastewater treatment plant (WWTP) effluent into the Highland Lakes or their tributaries within 10 stream miles of the lakes. Details of the discharge ban to Lake Buchanan can be found in Chapter 311, Subchapter B of the Texas Administrative Code.

1.1.2.2   Highland Lakes Watershed Ordinance

LCRA responded to the threat of pollution resulting from a construction boom around the Highland Lakes in the early 1990s with two NPS pollution control ordinances: the Lake Travis NPS Pollution Control Ordinance and the Upper Highland Lakes NPS Control Ordinance. In 2006, the two ordinances were revised into one, the HLWO. The HLWO addresses pollution of surface water and stormwater and targets three key pollutants: total suspended solids (TSS), total phosphorus (TP), and oil and grease. This ordinance applies to development in portions of Travis, Burnet, and Llano counties that drain to the Highland Lakes. The HLWO is a performance-based ordinance, which means that developers and landowners must show that the standards will be met before proceeding with a project. The HLWO applies to all new construction; property that was platted before the ordinance went into effect is exempt from the permitting process but must comply with erosion and sedimentation requirements of the ordinance.

1.2   Summary of the Phase 1 Effort

The principal objective of the Phase 1 Lake Travis modeling effort was to develop a tool to project long-term and large-scale water quality impacts associated with changes in watershed land use. The watershed model was a derivative of PLOAD (see BASINS documentation for an explanation of PLOAD; USEPA 2001) and used simplified approaches to estimate watershed hydrologic and pollutant loadings. The reservoir model consisted of a custom nine-segment model that simulated nitrogen (N), phosphorus (P), and chlorophyll-a (Chl-a) dynamics in a simplified kinetic framework (LCRA 2004).

The Phase 1 data analysis and modeling effort provided the following insights into the Lake Travis system with regards to:

- Data:

  – The Phase 1 dataset had limitations with regard to model development (e.g., lack of storm event data; on-lake wind information; light attenuation measurements; phytoplankton speciation; phytoplankton photosynthesis and respiration data; and cove, metalimnion, and phytoplankton bloom data).

- Low concentrations of nutrients and phytoplankton (many below the method detection limit [MDL]) complicated the discernment of spatial and temporal trends.
- Certain land use types and areas disproportionately contributed to NPS loadings.
- Additional monitoring data were necessary to support the Phase 2 modeling effort.

- Model:

  - Upstream source loads were shown to be important water quality drivers.
  - The Phase 1 model was not sufficiently refined to detect temporally and spatially localized water quality impacts of existing nutrient loads.
  - Nutrient limitations to phytoplankton growth were shown to be important.
  - Lake Travis experiences both nitrogen and phosphorus limitations, as well as co-limitation.

The Phase 1 model can be used to predict long-term, system-wide changes in phytoplankton concentration as a result of changes in land use. However, it cannot be used to predict changes in the duration, extent, and severity of phytoplankton blooms, nor can the Phase 1 model discern what is occurring in the coves of Lake Travis. Algal blooms within the coves are potentially more important to stakeholders than overall average phytoplankton concentrations, as the public strongly associates blooms with degradation of water quality and impairment of recreational opportunities. Hence, while the Phase 1 modeling effort provided valuable insights into the relationships between watershed land use changes and Lake Travis water quality, as well as preliminary quantification of hydrologic and nutrient budgets, it lacked the spatial resolution to define localized water quality impacts of potential watershed land use changes. The Phase 2, 3, and 4 modeling efforts were designed to address these shortcomings.

1.3   Objectives of the CREMs and the Phase 2, 3, and 4 Efforts

The principal goal of the Phase 2 modeling effort was to develop a comprehensive, linked watershed and lake modeling tool of the Lake Travis system. The principal goal of the Phase 3 modeling effort was to develop comprehensive, linked watershed and lake modeling tools for Inks Lake, Lake LBJ, and Lake Marble Falls. The principal goal of the Phase 4 modeling

effort was to develop comprehensive linked watershed and lake modeling tools for Lake Buchanan. The models will ultimately be applied to investigate system responses (both lake and watershed) to projected growth and/or proposed water quality management practices. Specifically, the Phase 2, 3, and 4 models were developed to:

- Evaluate the effectiveness of the HLWO in protecting water quality in the Highland Lakes
- Assess the effectiveness of the TCEQ point source discharge ban in protecting water quality in the Highland Lakes
- Identify and quantify trends in specific water quality indicators (long-term, seasonal, and short-term)
- Quantify differences in water quality between the main body of lakes and their coves
- Evaluate the impacts of land use changes on the quality and quantity of runoff and resulting impacts on the lakes and watersheds
- Assess the impacts of existing point source discharges on the water quality of the Highland Lakes
- Evaluate the relative contribution of anthropogenic and natural background sources of nutrients to observed water quality trends
- Predict the impacts of various basin-wide best management practice implementation strategies
- Identify tributaries with the highest nutrient loadings
- Evaluate water quality trends with respect to drinking water source issues
- Assist in discussions with TCEQ on further development of site-specific nutrient standards for the lakes
- Expand competency of internal LCRA staff with respect to watershed and water quality management and modeling issues
- Identify and guide potential future water quality protection and restoration projects on the Highland Lakes

Various LCRA business units have established many of these objectives as high priority items, as documented in the CREMs Master Plan (CH2M Hill 2002). As such, the Phase 2, 3, and 4 models are valuable tools for providing information to guide management decisions that are central to LCRA's mission statement and operational goals. In the short term, the priority application of the models was to understand the effects of the HLWO and TCEQ's

Highland Lakes discharge ban on water quality (see Anchor QEA and Parsons 2009b, 2011 for discussions of the predicted water quality impacts should these two policies change), although the other long-term objectives were considered throughout model development and application.

1.4   Overview of the Phase 4 Report

The purpose of this report is to provide a detailed description of the Phase 4 program, including monitoring, model development, and calibration. The ultimate goal of the Phase 4 CREMs effort is to develop tools that LCRA can use to aid in the management of Lake Buchanan and address many of the specific objectives outlined in Section 1.3. To reach that goal, steps undertaken in this Phase 4 effort included:

- Conducting increased sampling to aid in the development and calibration of the modeling tools and in the understanding of the Lake Buchanan system
- Developing comprehensive, linked watershed and lake modeling tools of the Lake Buchanan system
- Evaluating the sensitivity of water quality in Lake Buchanan to watershed changes, including the impact of land use changes and possible point source discharges (to be discussed in a separate scenario memorandum to be submitted at a later date.)

This report is divided into five additional sections. Section 2 provides an overview of the Phase 4 sampling efforts, including sampling conducted by LCRA. Sections 3 and 4 discuss model development, calibration, and sensitivity analysis for the watershed and lake models, respectively. Section 5 summarizes the peer review of the models. Section 6 provides a summary of the work.

2   MONITORING PROGRAM

2.1   Overview

The purpose of the Phase 4 monitoring effort was to develop a more complete dataset for supporting the development and calibration of the Lake Buchanan watershed and lake models. For Phase 4, four monitoring programs were designed and implemented: 1) expanded routine monitoring; 2) storm event monitoring; 3) special remote monitoring studies; and 4) special manual sampling studies. These programs started in 2010 and had varying durations. Details of each monitoring program are presented in this section. It should be noted that these monitoring programs were conducted in extreme drought conditions. Tributary flows and lake levels were well below normal levels for the entirety of Phase 4 monitoring.

2.2   Program 1: Expanded Routine Monitoring

Since 1982, LCRA has implemented a Reservoir and Stream Sampling (RSS) program that satisfies State requirements for water quality monitoring. From 1982 to the early 1990s, data were collected monthly; from the early 1990s to the present, data have been collected every other month. This program includes collection of water samples and field data at five stations in Lake Buchanan. In addition, field parameters are measured at an additional station in the lake. Water samples and field data are collected at the Colorado River at Red Bluff, the headwaters of Inks Lake, and at four tributary stations in the watershed of Lake Buchanan.

For CREMs Phase 4, this routine sampling program was enhanced for 18 months to add greater spatial and temporal resolution. Specific components included measuring additional parameters, increasing the sampling temporal resolution at the boundaries (biweekly) and in the lake (monthly), and sampling additional stations in the lake and tributaries. The expanded RSS program started in July 2010 and ended in December 2011, after which the existing RSS program resumed.

Figure 2-1 shows and Table 2-1 lists sampling stations that were monitored during Phase 4. As part of the expanded monitoring program, data were collected at an additional site within

Lake Buchanan (Lake Buchanan at Golden Beach). This additional site is discussed in Section 2.2.4.

Table 2-1
Program 1 – RSS and Expanded RSS Monitoring Locations

Monitoring Site	Station ID	RSS	Expanded RSS	Number of Sampling Events (during the Phase 4 monitoring period: 2010 – 2011)
Lake				
Lake Buchanan at Buchanan Dam	12344	x		18
Lake Buchanan at Golden Beach	12346		x	18
Lake Buchanan at Rocky Point	12347	x		18
Lake Buchanan at the confluence of Council and Morgan Creeks	12349	x		18
Lake Buchanan 0.75 mile south of Garrett Island	12350	x[a]	x	18
Lake Buchanan near Beaver Creek	12352	x		18
Lake Buchanan at Headwaters	12353	x		18
Boundary				
Inks Lake at Headwaters[b]	12343	x		36
Colorado River at Red Bluff[c]	12355	x		56
Tributary				
Cherokee Creek	12274	x		19
Colorado River at Winchell	12358	x		4
Pecan Bayou at Mullin	12394	x		19
San Saba River at San Saba	12392	x		19

Notes:
Lake and tributary sites sampled monthly; boundary sites sampled biweekly
See Figure 2-1 for map of monitoring locations
a – Field parameters measured only
b – Data were not used in the Phase 4 modeling because the site is outside the model domain
c – This site was considered both a tributary and boundary location; for water quality monitoring, this site is the same as U.S. Geological Survey gage 08147000 Colorado River near San Saba, Texas
RSS – Reservoir and Stream Sampling

Throughout this monitoring program, the reservoir stations were sampled at the top (0.3 meters [m] below the water surface) and bottom (1 m above the sediment-water interface) of the water column, consistent with the existing LCRA protocols. Starting in

October 2010, based on knowledge gained during the Phase 3 modeling work, the bottom sample collection depth was changed to 2 m above the sediments to avoid possible entrainment of sediment in the sample. In addition, when a defined thermocline[1] was present, an additional water quality sample was collected at that location (Section 2.2.5). Tributary stations were sampled once at mid-depth.

2.2.1 Expanded List of Parameters

2.2.1.1 Laboratory and Calculated Parameters

Two laboratory parameters, dissolved organic carbon (C) and dissolved phosphorus, were added to the suite of parameters already being analyzed under the routine RSS monitoring program (Table 2-2). These were added so that the dynamics between the particulate and dissolved forms of organic matter could be defined better within the lake model. Ideally, particulate organic carbon and particulate nitrogen would also be measured directly (particulate phosphorus is difficult to measure directly), but due to limited resources, their concentrations were calculated as the difference between the measured total and measured dissolved concentrations. For the measurement of dissolved constituents, filtration followed the procedures outlined in Standard Methods (APHA et al. 1998). The data were reported as low as the MDL, which varies for each laboratory calibration of the analytical instrument (Table 2-2).

---

[1] Metalimnion field data were collected by first identifying the depth at which a 0.5˚C or greater temperature change was measured over a 1-m depth interval. A sample of the water in the metalimnion was collected 1 meter below this point.

Table 2-2

Program 1 – List of Parameters for Expanded River and Stream Sampling

Parameter[a,b]	STORET Code	Units	Detection Limit[c]/ Instrument Precision
Measured in Field			
Irradiance	L1001	$\mu mol\ s^{-1}\ m^{-2}$	0.4%
Oxygen, dissolved	00300	mg/L	0.20
Oxygen, % saturation	00301	%	-
pH	00400	SU	0.20
Secchi depth	00078	m	-
Solar radiation (total)	-	Wm^{-2}	-
Specific conductance	00094	µS/cm	1%
Temperature, air	00020	°C	0.20
Temperature, water	00010	°C	0.05
Turbidity	82078	NTU	1%
Wind direction	L1003	° from North	-
Wind speed	L1002	mph	-
Measured in Laboratory			
Alkalinity, total	00410	mg/L	0.32
Chloride	00940	mg/L	0.08
Chlorophyll-a	70953	µg/L	0.02
Ammonia, nitrogen	00610	mg/L	0.005
Nitrite+nitrate, nitrogen	00630	mg/L	0.008
Organic carbon, dissolved	00681	mg/L	0.03
Organic carbon, total	00680	mg/L	0.03
Pheophytin	32113	µg/L	0.5
Kjeldahl nitrogen, dissolved	00623	mg/L	0.006
Kjeldahl nitrogen, total	00625	mg/L	0.006
Phosphorus, dissolved	00666	mg/L	0.005
Phosphorus, ortho	00671	mg/L	0.005
Phosphorus, total	00665	mg/L	0.005
Sulfate	00945	mg/L	0.02
Suspended solids, total	00530	mg/L	0.5
Calculated			
Dissolved solids, total	70952	mg/L	-
Nitrogen, particulate	-	mg/L	-

Parameter[a,b]	STORET Code	Units	Detection Limit[c]/ Instrument Precision
Organic carbon, particulate	-	mg/L	-
Phosphorus, particulate	-	mg/L	-

Notes:
a – Parameters added in expanded RSS are shown in *italics*.
b – Bacteria were collected only in even months to support routine RSS monitoring.
c – The MDL for each laboratory analyte may vary each time the analytical instrument is calibrated.
°C – degrees Celsius
μg/L – micrograms per liter
μmol s-1 m-2 – micromols per second per square meter
μS/cm – microsiemens per centimeter
m – meter
mg/L – milligram per liter
mph – miles per hour
NTU – nephelometric turbidity unit
SU – standard units
Wm-2 – watts per square meter

2.2.1.2   Field Parameters

Three field parameters—solar radiation, wind direction, and wind speed—were added to the suite of field parameters already being measured under the routine RSS monitoring program (Table 2-2).

Solar radiation controls photosynthesis and the temperature cycle of the lake and is a forcing function for the hydrodynamic and water quality calculations in the lake model. Light penetration must also be known and is described by two factors: 1) the fraction of light absorbed/reflected in the surface layer; and 2) the light extinction through the water column. Both of these were measured using a light probe (e.g., LCRA's Li-Cor LI-189 probe). Light was measured above the water surface, immediately below the water surface (at 0.33 m depth), and at 1-m intervals through the water column down to 10 m concurrently with samples collected in the reservoir (solar radiation data were not needed in the tributaries).

Due to the importance of wind speed and direction on mixing in the lakes, wind data were obtained concurrently with all field samples. This allowed for a point estimate of wind conditions at the time of sampling. These measurements provided information on spatial wind patterns and sheltering over the reservoirs and helped to decrease the uncertainty in

specifying wind energy at the lake surface. Wind data were collected with a portable field sensor at 2 m above the water surface concurrently with all water samples collected in the reservoir (collection of wind data in the tributaries was not needed).

2.2.2   Higher Resolution Sampling at Boundaries

Biweekly sampling was implemented at both boundary locations (Table 2-1).

2.2.3   Higher Resolution Sampling in the Lake

To improve the characterization of water quality in the lake, the sampling frequency was increased from bimonthly to monthly at all non-boundary stations. This allowed for a more complete understanding of seasonal trends in water quality throughout the lake.

2.2.4   Additional Lake Stations

One new location, Lake Buchanan at Golden Beach, was established for Phase 4. Data from this station facilitated the quantification of water quality in a previously unsampled area of the lake and improved the resolution for calibration of the lake model. Water samples were collected and analyzed for the expanded suite of water quality parameters (Table 2-2) on a monthly basis, in tandem with the other sampling on Lake Buchanan.

2.2.5   Expanded Vertical Sampling

The routine monitoring program was expanded to include metalimnion sampling. The metalimnion field data were collected by first identifying the depth at which a 0.5 °C or greater temperature change was measured over a 1-m depth interval. A sample of the water in the metalimnion was collected 1 m below this point.

2.2.6   Lower Detection Limits

For a number of water quality parameters, lower MDLs were applied to the Phase 4 monitoring programs compared to those used historically. This was done to facilitate temporal and spatial trend analysis and to support lake model calibration. Table 2-2 contains the parameter-specific MDLs.

2.3 Program 2: Storm Event Monitoring

Storm loadings in flood prone areas such as central Texas can account for a large percentage of the total annual loading to a waterbody. Such loadings are difficult to quantify due to their transient nature and the level of effort required for collecting samples. Table 2-3 lists the storm monitoring locations and the number of monitoring events.

Table 2-3
Program 2 - Storm Monitoring Locations and Number of Monitoring Events

Site	Site ID	Number of Storm Monitoring Events
Lake		
Lake Buchanan at Buchanan Dam	12344	0
Lake Buchanan at Golden Beach	12346	0
Lake Buchanan at Rocky Point	12347	0
Lake Buchanan at the confluence of Council and Morgan Creeks	12349	0
Lake Buchanan 0.75 mile south of Garrett Island	12350	0
Lake Buchanan near Beaver Creek	12352	0
Lake Buchanan at Headwaters	12353	0
Boundary		
Inks Lake at Headwaters	12343	0
Colorado River at Red Bluff	12355	2
Tributary		
Cherokee Creek	12274	1
Colorado River at Goldthwaite	12356	1
Pecan Bayou at Mullin	12394	2
San Saba River at San Saba	12392	1

Notes:
See Figure 2-1 for map of monitoring locations.

2.3.1 Storm Types and Sampling Frequency

From July 2010 to December 2011, storm event monitoring captured two storms (Table 2-4). Severe drought, coupled with the size of the watershed, made storms that would create a significant change to water quality rare. Both storm events that occurred during this

timeframe were small events that produced localized runoff over a small time scale; therefore, only affected tributaries were sampled because no lake-wide impacts were expected.

Table 2-4

Program 2 – Summary of Storm Sampling

Storm Start Date	Storm Duration (hours)	Approximate Total Rainfall (inches)	Number of Stations Monitored		Number of Samples Collected Over All Stations [a]
			Tributary	Lake	
September 8, 2010[b]	6	1.3	5	0	5
May 11, 2011[c]	4	2.9	2	0	4

Notes:
a – These totals include daily sampling until flows returned to baseline conditions.
b – The September 8, 2010, storm affected all four tributary monitoring sites; these sites were sampled on the day of the storm. An additional sample was collected at Station 12355 the next morning because increased river flow due to the storm did not reach Station 12355 until then.
c – Pecan Bayou received most of the rain during this storm and was sampled on May 11, 12, and 13. An additional sample was collected at Station 12355 on May 13 because the increased river flow due to the storm did not reach Station 12355 until then.

Sampling of each storm followed a different protocol because they were spatially isolated events that had varying degrees of impact. Tributary sampling was initiated based on a prescribed change from base flow that is characteristic of storm events. Once stream gauges reacted to the storm, a sampling crew was dispatched as soon as possible. Samples were collected daily during and after the storm until flows returned to baseline conditions.

2.3.2   Tributary and Lake Stations

Tributary sampling stations for the storm event monitoring program were co-located with the four tributary monitoring locations in the expanded routine monitoring program described in Section 2.2.

2.4   Program 3: Special Remote Monitoring Studies

Remote monitoring using automatic sampling devices collected data on a continuous basis over time, which is otherwise difficult to accomplish by field teams. The objective of this sampling program was to provide detailed data for both the watershed and lake model

calibrations. Remote data collection equipment was deployed at selected locations to serve a number of purposes including helping in the calibration of the Phase 4 models; quantifying the short-circuiting of flood flows and plunging of inflows; and measuring stratification and mixing.

2.4.1 Thermistors and Thermistor Chains

Thermistors measure water temperature and were deployed at several locations in Lake Buchanan, tributaries within the watershed of Lake Buchanan, and Inks Lake. One thermistor or thermistor chain was installed at each of the stations listed in Table 2-5. Most of the devices were installed at the beginning of Phase 4 sampling and were left in place until October 2011. Thermistor chains were designed to measure temperature every 2 m. At stations with one thermistor, only surface temperature was measured. The chains measured temperature each hour. Thermistors below 10 m at Rocky Point were lost due to entanglement with lake debris; therefore, no data were collected at those depths for the duration of the thermistor monitoring.

Table 2-5
Program 3 – Summary of Remote Sampling

Site	Site ID [a]	Vertical Spacing (m)	Average Water Depth at Site (m)	Number of Thermistors per Chain
Inks Lake at the Headwaters	12343	-	2	1
Lake Buchanan at Rocky Point	12347	2	30	16 [c]
Colorado River at Red Bluff	12355	-	1	1
San Saba River at San Saba	12392	-	1	1
Cherokee Creek at FM 501	12274	-	1	1
Pecan Bayou near Mullin	12394	-	1	1

Notes:
a – See Figure 2-1 for map of monitoring locations.
b – Data at Rocky Point were only collected through September 2011.
c – Thermistors located below 10 m were lost due to entanglement with lake debris.
m – meter

2.5   Program 4: Special Manual Sampling Studies

Phase 4 special manual monitoring consisted of monthly phytoplankton enumeration. From September 2010 through December 2011, phytoplankton were collected monthly from surface waters at one location, Lake Buchanan at Buchanan Dam. One liter of raw water was collected and preserved with formalin. Phytoplankton were identified and enumerated into one of three groups: green, blue-green, or diatom. Density and relative abundance of each group were reported.

3 WATERSHED MODEL

This section describes the watershed model developed during Phase 4 of the CREMs project for the Lake Buchanan watershed (Figure 3-1). Section 3.1 presents a general outline of the Soil and Water Assessment Tool (SWAT) watershed modeling software (Arnold et al. 1998), the model state variables of concern, the model input and development, and the model calibration procedures. The following subsections describe the spatial domain, data considerations, model development, and model calibration procedures and results.

3.1   Introduction

The reservoir management tool developed during Phase 4 of the CREMs project consists of hydrodynamic and lake models of Lake Buchanan based on the U.S. Army Corps of Engineers (USACE) CE-QUAL-W2 model. To effectively apply the lake model for the current and future management of the basin, loadings needed to be predicted from upstream, tributaries, and direct runoff under potential watershed scenarios. This was accomplished through the development and calibration of a mathematical model of the Lake Buchanan watershed. The watershed modeling software selected for the CREMs project was SWAT2009 (Neitsch et al. 2011), which is an updated version of the SWAT model. SWAT simulates watershed hydrology and constituent loads and accounts for various land-cover types, land uses, and management practices. The watershed model can predict changes in constituent loads to the lake due to changes in land use and practices within the watershed, and thereby provides a mechanism to tie activities in the watershed to resultant water quality in the lake.

A full description of SWAT and its simulated processes can be found in Neitsch et al. (2011). Selection of SWAT as the modeling platform for the Lake Travis watershed as well as a description of SWAT model theory, structure, and operation as they pertain to the CREMs project are described in the CREMs Phase 2: Lake Travis Final Report (Anchor QEA and Parsons 2009a). Due to success in application of this software for modeling the watersheds of the other Highland Lakes, the same software was applied in Phase 4. The SWAT executable file developed for ArcSWAT 2009 (build 481) was used. ArcSWAT, an ArcGIS extension, is a graphical user input interface for SWAT (Di Luzio et al. 2002).

3.2   Model Development and Inputs

This section generally describes the state variables of concern simulated; model time period and spatial domain; various datasets used to develop the Lake Buchanan watershed model; and the applicable regulations for the watershed.

3.2.1   State Variables of Concern Simulated

The primary purpose of the SWAT models developed for CREMs is the calculation of watershed loads to be applied to the receiving lake models, in this case, the CE-QUAL-W2-based models. As a result, the state variables chosen for simulation in SWAT reflect the needs of the lake models. State variables simulated in SWAT to be passed to the Lake Buchanan model were as follows:

- Flow
- TSS
- Organic phosphorus (OrgP)
- Orthophosphate phosphorus (PO4 [approximated as mineralized phosphorus or minP in SWAT])
- Organic nitrogen (OrgN)
- Ammonia nitrogen[2] (NH3)
- Nitrate+nitrite nitrogen (NOX)

3.2.2   Model Time Period

A daily time step was employed with SWAT over the modeling period extending from January 1, 1984 through December 31, 2011, which was the period that was chosen to simulate water quality for the lake model. SWAT was run for an additional 4-year period from January 1, 1980, through December 31, 1983, to provide a "spin-up" time for the model to equilibrate initial model conditions.

---

[2] In this report, NH3 and NH4 are used interchangeably to refer to total ammonia. The dominant form of ammonia in environmental samples is the protonated ammonium ion (NH4). Measurements represent the sum of both NH3 and NH4. Following the conventions of the respective model documentation reports, NH3 is the abbreviation used primarily in this document when discussing SWAT and NH4 is the abbreviation used when discussing CE-QUAL-W2.

3.2.3 Model Spatial Domain

The total watershed area of Lake Buchanan (i.e., including upstream of O.H. Ivie Reservoir and Lake Brownwood) is approximately 20 million acres (31,250 mi^2; Breeding 2012). The spatial extent of the Lake Buchanan SWAT model is limited to an approximately 4 million acre (6,307 mi^2) drainage basin of the Colorado River from Buchanan Dam upstream to S.W. Freese Dam (which impounds O.H. Ivie Reservoir) in Coleman and Concho Counties, and to Lake Brownwood Dam in Brown County. This drainage area is hereafter referred to as the Lake Buchanan watershed (see Figure 3-1). O.H. Ivie Reservoir and Lake Brownwood have hydraulic residence times of greater than 300 days (RPS et al. 2012), and the flow released from these reservoirs is typically only a minor component of flow into Lake Buchanan. Thus, the impact of the watershed upstream of these reservoirs on Lake Buchanan's water quality is much less than that from the portion of the watershed below these reservoirs.

Figure 3-2 shows the watershed stream network, based on the U.S. Geological Survey (USGS) National Hydrographic Dataset. As shown on Figure 3-1, the Colorado River enters Lake Buchanan from the north; the river and its adjacent watershed comprise 97% of the modeled Lake Buchanan watershed area. The remaining 3% of the modeled Lake Buchanan watershed area drains directly to Lake Buchanan. Major tributaries of the Colorado River in the watershed include the San Saba River (including Brady Creek) and Lower Pecan Bayou.

3.2.4 Topography

The Lake Buchanan watershed topography ranges from near-level plains to gently rolling hills, with some relatively steep terrain and escarpments near the larger watercourses. Watershed elevation ranges from 274 to 751 m above msl (Figure 3-3) based on the 10-m USGS National Elevation Dataset (NED) for 2002 to 2004. Land slopes in the watershed ranged from 0 to 60% with more than 96% of the slopes in the 0 to 10% range, 3.5% in the 10 to 20% range, and only 0.2% with greater than 20% slope (Table 3-1).

Table 3-1

Land Slope Categories in the Lake Buchanan Watershed

Slope (%)	Area (acre)	Percent of Total Watershed Area
0 – 10	3,885,681	96.26

Slope (%)	Area (acre)	Percent of Total Watershed Area
10 – 20	142,707	3.54
20 – 30	6,982	0.17
30 – 60	1,312	0.03
>60	64	<0.01

3.2.5   Land Cover

The Lake Buchanan watershed is predominantly rural. Based on the 2006 Multi-Resolution Land Characteristics Consortium National Land Cover Dataset (NLCD), almost 80% of the watershed land cover is brush and grassland and 10.9% is forest (Figure 3-4, Table 3-2). Approximately 4% of the watershed is developed and another 4% is cultivated row crops. Development is more intense near Brownwood. Development around Lake Buchanan is not extensive, but may be noteworthy because runoff from direct drainage sub-watersheds can deliver urban pollution directly to the lake with minimal attenuation through the basin. Vegetation formation within the watershed is likely attributed to variations in both soil type and precipitation.

Table 3-2
Land Cover Categorization of the Lake Buchanan Watershed

Name	Land Use Code *	Area (acres)	Percent of Total Watershed Area
Open Water	WATR	20,222	0.50
Developed, Low Density	URLD	151,376	3.75
Developed, Medium Density	URMD	7,522	0.19
Developed, High Density	URHD	2,487	0.06
Developed, Industrial/Utilities	UIDU	1,313	0.03
Deciduous Forest	FRSD	98,853	2.45
Evergreen Forest	FRSE	342,142	8.48
Rangeland, Brush/Scrub/Shrub	RNGB	2,714,016	67.23
Grassland/Herbaceous	RNGE	511,264	12.67
Pasture/Hay	HAY	24,351	0.60
Cultivated Crops	AGRR	163,200	4.04

Notes:
* Land Use Codes are as defined in the National Land Cover Dataset.

3.2.6   Geology and Soils

Geological features in the Lake Buchanan watershed directly and indirectly impact watershed hydrology and constituent loading due to soil formation, type, and distribution, which are derived from the regional parent rocks. The Lake Buchanan watershed encompasses a significant portion of the Edwards Plateau and is composed primarily of limestone.

In addition, soil type and climate determine the vegetative cover of a region, which directly impacts watershed hydrology and constituent loads.

The major soil map units in the Lake Buchanan watershed and their primary soil members were taken from the National Resource Conservation Service (NRCS) State Soil Geographic (STATSGO) Database (NRCS 2009). These soil map units are listed in Table 3-3 and shown on Figure 3-5. The soil hydrologic group indicates the rate of infiltration into water-saturated soil, and thus, the tendency of a soil type to generate surface runoff. In the Lake Buchanan watershed, the soil hydrologic groups range from B to D.

As part of Phase 2 of the CREMs project, LimnoTech, Inc. (LTI) examined the extent and characterization of Tarrant-series soil in the Pedernales River watershed. LTI reviewed available STATSGO and the Soil Survey Geographic Database (SSURGO) datasets to identify the extent of Tarrant-series soil, and also reviewed descriptions of the various soil series in these areas. Their evaluation concluded that the hydrologic soil group used in SWAT for the Tarrant series should be changed from D to C, which increases the permeability of the soil. This change was also applied to the Tarrant-series soil in the Lake Buchanan watershed. The LTI soil evaluation is described in Appendix C of the CREMs Phase 2: Lake Travis Final Report (Anchor QEA and Parsons 2009a).

Vertisols, including the Leeray and Tobosa clay soils, are also present in the Lake Buchanan watershed. These are characterized by a strong tendency to shrink and form deep (greater than 50 cm) and wide (2 to 7 cm) cracks when dry, and then swell shut when wet (Neitsch et al. 2011). The volume changes upon drying profoundly alter the soil's water storage and transmission properties. Water enters the soil very rapidly when it is dry, and very slowly when it is wet. Vertisols are abundant in soil map units TX284, TX287, TX288, TX289, TX290, TX483, and TX565. Other non-vertisol soils with high crack formation potential are

also abundant in the watershed and compose the majority of soil map units TX526, TX485, TX554, TX484, and TX369.

Table 3-3

Major Soil Types in the Lake Buchanan Watershed

Soil Map Unit	Primary Soil Component	Hydrologic Group	Area (acres)	Percent of Total Watershed Area
TX544	Tarrant	C	1,044,518	25.88
TX481	Roughcreek	D	436,459	10.81
TX526	Speck	D	222,742	5.52
TX146	Doudle	B	165,068	4.09
TX488	Rumple	C	139,517	3.46
TX361	Nocken	C	124,903	3.09
TX485	Rowena	C	115,004	2.85
TX289	Leeray	D	115,062	2.85
TX284	Leeray	D	111,363	2.76
TX062	Bonti	C	107,030	2.65
TX554	Throck	C	105,560	2.61
TX483	Rowena	C	99,997	2.48
TX064	Bonti	C	88,650	2.20
TX484	Rowena	C	80,727	2.00
TX369	Nuvalde	B	80,890	2.00
TX061	Bolar	C	80,636	2.00
TX617	Winters	C	63,846	1.58
TX360	Nebgen	D	63,648	1.58
TX290	Leeray	D	51,996	1.29
TX252	Talpa	D	51,747	1.28
TX565	Tobosa	D	50,208	1.24
TX151	Eckert	D	47,249	1.17
TX095	Cho	C	42,123	1.04

3.2.7   Aquifers and Springs

Several aquifers underlie the Lake Buchanan watershed. The Ellenberger-San Saba Aquifer underlies portions of Mason, McCullough, San Saba, Lampasas, Burnet, and Llano counties. The Marble Falls Aquifer underlies portions of San Saba, McCullough, and Lampasas counties, and may be hydrologically interconnected with the Ellenberger-San Saba Aquifer. The Hickory Aquifer underlies portions of Mason, Menard, McCulloch, San Saba, Concho, Coleman, Brown, Lampasas, Burnet, and Llano counties. The Edwards–Trinity Plateau Aquifer underlies Schleicher and Menard counties.

The aquifers exhibit a pronounced effect on watershed hydrology. Numerous springs occur along the down-dip extent of these aquifers and dot the landscape of the Lake Buchanan watershed (Figure 3-6). Flow from these springs supports the base flow in the San Saba River and the Colorado River below the confluence with the San Saba River. However, in addition to springs, the San Saba River is reported to lose stream flow to the aquifers in areas where the river flows over the outcrop of the aquifer strata (Black 1988). The largest springs are found at Fort McKavett and near San Saba. Most of the rest are found in the San Saba River watershed or the sub-watersheds that flow directly to Lake Buchanan (Table 3-4). Spring locations and discharge were estimated based on *Database of Historically Documented Springs and Spring Flow Measurements in Texas* (Heitmuller and Reece 2003) and *Major and Historical Springs of Texas: Texas Water Development Board Report 189* (Brune 1975).

Table 3-4
Discharges from Springs in the Lake Buchanan Watershed

Model Sub-basin	Average Median Spring Discharge (cfs)	Names of Major Springs
23	6.5	San Saba Springs
25	3.9	Richland Springs
26	23.6	Sloan Springs, Bogarte Spring, Baker Spring, Maxwell Ranch Springs, Hart Spring
37	5.6	Deep Creek Spring, Sycamore Spring
38	1.2	Parker Springs
39	6.5	Indian Mound Springs, Hudson Pipe Springs, Otte Springs
40	2.2	Heck Springs
42	12.8	Sulphur Spring, Gorman Springs
43	0.3	WAS Springs
44	21.5	Springs at Fort McKavett, Wilkinson Springs
51	4.5	Boiling Springs, Garrett Springs
54	0.3	Jennings Creek Springs

Notes:
cfs – cubic feet per second

Because these springs discharge from regional aquifers rather than the shallow groundwater simulated in SWAT, they were included in the model as point sources. Where time-series of

measured discharge from springs were available, they were used in the model. However, flow measurements at most springs have been infrequent and in these cases, the median reported flow was used for all times. Because flow from these springs varies with regional drought conditions, use of a constant flow and constituent concentrations in the model tends to cause a "leveling" of the predicted flow and loads. This reduces the model fit statistics, particularly at low flow levels.

Reported water quality constituent measurements in these springs are few, particularly for nutrient constituents. The constituent concentrations used were averages for wells in the aquifer from which the springs emanate (Preston et al. 1996; Hopkins 1995).

3.2.8   Watershed Ordinance

A portion of the Lake Buchanan watershed is covered by the HLWO (Figure 3-7). The HLWO controls stormwater runoff and enforces erosion controls to reduce pollution to the Highland Lakes (Section 1.1.2.2; LCRA 2007). The Lake Buchanan sub-watershed delineation, which is described in Section 3.2.9, was constructed to mimic the geographic extent of the HLWO so that if changes to HLWO regulations are considered in the future, model scenario runs can accommodate these changes.

3.2.9   Watershed Sub-Basin Delineation and Hydrologic Response Unit Generation

In SWAT, a watershed is divided into multiple sub-watersheds, which are then further subdivided into hydrologic response units (HRUs) that consist of areas with generally homogeneous slope, land cover, and soil characteristics.

Watershed delineation techniques in ArcSWAT utilizing the NED were applied to delineate the lake's drainage basin. Seventy-three sub-watersheds were delineated using the NED and user-specified sub-watershed outlet points on the stream network (pour points), as illustrated in Figure 3-8. The Lake Buchanan sub-watershed delineation considered the location of watershed calibration stations, the HLWO, and the Lake Buchanan CE-QUAL-W2 model segmentation. Pour points were co-located with hydrologic and water quality calibration stations so that model output at these points could be compared directly to calibration

records. An attempt was made to locate pour points so that the majority of a defined sub-watershed area was either contained within or outside of the HLWO. As a result, specific sub-watersheds can be targeted in future scenario simulations that may involve changes to the HLWO. Also, pour points were added adjacent to Lake Buchanan in order to facilitate the spatial linkage between output from the watershed model and input to the lake model (Figure 3-8). Finally, additional pour points were added, as needed, in order to break larger sub-watersheds into more manageable parcels of similar size. The sub-watershed delineation resulted in 73 sub-watersheds with an average area of 55,298 acres (Figure 3-8).

The NED was also used to calculate slopes and determine the stream network incorporated into SWAT (Figure 3-2). Slopes were divided into five categories: 0 to 10, 10 to 20, 20 to 30, 30 to 60, and greater than 60% (Table 3-1). HRUs were generated for each sub-watershed based upon the spatial intersection of the slope categories with the 2006 NLCD land cover categories and the STATSGO soil map units. To limit the number of very small HRUs, and thus shorten model run time, minimum thresholds for HRU generation were set at 3% of the individual sub-basin area for each land cover category and 5% for soil map unit and slope category. This process resulted in generation of 2,105 HRUs in the 73 sub-watersheds. The average HRU area was approximately 1,900 acres.

3.2.10   Boundary Conditions

The modeled watershed was clipped to the domain downstream of O.H. Ivie Reservoir and Lake Brownwood for reasons stated in Section 3.2.3. In other words, the watershed above these reservoirs was not simulated by the SWAT model. Instead, boundary conditions were specified based on flow and nutrient concentrations released from these reservoirs.

Water releases from O.H. Ivie Reservoir into the modeled domain of the Colorado River were based on measured flows at USGS gage 08136700 (Colorado River near Stacy, Texas), which is approximately 5 miles downstream of O.H. Ivie Reservoir (Figure 3-9).

Water releases from Lake Brownwood into the modeled domain of Pecan Bayou were based on measured daily lake elevations (USGS gage 08143000) and a LCRA-provided rating curve between water release and lake elevation relative to the spillway elevation.

Water quality constituent concentrations in these boundary inflows were estimated based on typical concentrations measured during the simulation period at the lake water quality monitoring station nearest each dam (Stations 12511 and 12395 for O.H. Ivie Reservoir and Lake Brownwood, respectively [Figure 3-9]). A constant boundary concentration estimate was used because insufficient water quality data were available to develop a time series of boundary concentrations. The boundary concentrations are listed in Table 3-5.

Table 3-5
Boundary Concentrations of Simulated Water Quality Constituents at Reservoir Outlets

Parameter	Boundary Concentration (mg/L)	
	Ivie Reservoir	Lake Brownwood
TSS	10	2
OrgP	0.02	0.04
PO4	0.03	0.04
OrgN	0.77	0.6
NH3	0.04	0.1
NOX	0.04	0.2

Notes:
mg/L – milligram per liter
NH3 – ammonia
NOX – nitrate+nitrite, as nitrogen
OrgN – organic nitrogen, as nitrogen
OrgP – organic phosphorus, as phosphorus
PO4 – orthophosphate, as phosphorus
TSS – total suspended solids

3.2.11   Point Source Discharges

There are 22 currently permitted wastewater and stormwater treatment facilities in the Lake Buchanan watershed, as shown in Figure 3-10. Permitted discharge flow rates range from 0.004 to 4.54 million gallons per day (MGD) (Table 3-6). Model inputs for point sources existing within each watershed were developed from the TCEQ's Discharge Monitoring Report (DMR) records for permitted dischargers, to the extent that the parameters were reported. DMR data vary by month, and their availability varies from permit to permit. If DMR data were not available, pollutant concentrations were based on wastewater treatment facility outfall water quality data collected as part of the 2004 and 2005 LCRA San Antonio Water System Water Project low flow surveys (QEA 2004, 2005). Some of the treatment

facilities do not discharge wastewater to streams, but instead hold permits to apply effluents and/or sludge to land; these no-discharge facilities were not incorporated in the SWAT model.

Table 3-6
Wastewater Treatment Facility Flows and Concentrations in the SWAT Model

Model	Type	Permit Number	Permittee	Permitted Flow [a] (MGD)	Average Flow [b] (MGD)	CBOD (mg/L)	TSS (mg/L)	NH3 (mg/L)	TP (mg/L)	DO (mg/L)	PO4 (mg/L)	NOX (mg/L)	OrgN (mg/L)	OrgP (mg/L)
--- [d]	D/C	11394-001	Silver Creek Lodge, Marina, and Yacht Club	0.004	0.00099	2.4 [b]	1.8 [b]	2	3.2	4	3	20	0.5	0.2
SWAT	D/C	11982-001	LCRA (Kirby Creek WWTF)	0.100	0.065	3.77 [b]	6.81 [b]	2	3.2	4	3	20	0.5	0.2
SWAT	D/C	14296-001	LCRA (Lometa WTP)	0.230	0.04	5	4.3 [b]	2	3.2	4	3	20	0.5	0.2
--- [c]	Beneficial sludge	04522-000	City of Goldthwaite	4.92 dry tons/ac/yr-30 ac	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]
SWAT	D/C	10122-001	City of Bangs	0.300	0.100	2.62 [b]	4.68 [b]	2	3.2	4	3	20	0.5	0.2
SWAT	D/C	10150-003	City of Coleman (Hords Creek WTP)	0.050	0.024	5	9.11 [b]	2	3.2	4	3	20	0.5	0.2
--- [c]	TLAP	10274-001	City of Santa Anna	0.141	0.046	5	10	2	3.2	4	3	20	0.5	0.2
SWAT	D/C	10459-001	City of Goldthwaite	0.254	0.100	3.6 [b]	8.1 [b]	2	3.2	4	3	20	0.5	0.2
SWAT	D/C	10459-003	City of Goldthwaite (WTP)	0.022	0.013	5	4.29 [b]	2	3.2	4	3	20	0.5	0.2
--- [c]	Indust No-D/C (Evap)	01297-000	Roddie Wool Scouring	0.143	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]
SWAT	D/C	03911-000	Unimin Corp	Intermittent/flow variable	0.000	5	18.5 [b]	2	3.2	4	3	20	0.5	0.2
SWAT	Indust D/C + Evap	04712-000	City of Brady (WTP)	0.075	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]
SWAT	D/C	10081-001	City of Eden	0.440	0.209	19 [b]	38 [b]	6 [b]	3.2	4	3	20	0.5	0.2
SWAT	D/C	10132-001	City of Brady	1.103	0.359	2.8 [b]	3.1 [b]	0.36 [b]	3.2	4	3	20	0.5	0.2
SWAT	D/C	10345-001	City of Menard	0.220	0.048	10 [b]	30 [b]	2	3.2	4	3	20	0.5	0.2
SWAT	D/C	10345-002	City of Menard (WTP)	0.094	0.003	5	2.7 [b]	2	3.2	4	3	20	0.5	0.2
SWAT	D/C	10665-001	City of Richland Springs	0.050	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]	--- [c]
SWAT	Dual TLAP-D/C	10687-001	City of San Saba	0.310	0.000	5	71 [b]	2	3.2	4	3	20	0.5	0.2
--- [c]	TLAP	12759-001	New Horizons Ranch and Center	0.018	0.009	20 [b]	10 [b]	2	3.2	4	3	20	0.5	0.2
SWAT	D/C	13758-001	City of Mullin	0.040	0.004	9.7 [b]	15.8 [b]	2	3.2	4	3	20	0.5	0.2
SWAT	D/C	14618-001	City of Blanket	0.035	0.009	5 [b]	7 [b]	0.2 [b]	3.2	4	3	20	0.5	0.2
SWAT	Indust TLAP-D/C	02995-000	Kohler Co (cancelled July 2009)	0.432	0.037	27	23	2	3.2	4	3	20	0.5	0.2
SWAT	Indust TLAP-D/C	03781-000	Kohler Co (cancelled July 2009)	0.020	0.0034	12	43	2	3.2	4	3	20	0.5	0.2
SWAT	D/C	10565-001	City of Brownwood	4.540	2.425	2.2 [b]	1.1 [b]	0.37 [b]	3.2	4	3	20	0.5	0.2

Notes:

a – Permit limits provided by the LCRA (Wedig 2011)

b – Average of available self-reported monthly average concentrations from Discharge Monitoring Report (DMR) records for the period of January 2000 to September 2011; the DMR periods of record, however, varied from permit to permit. All other values estimated based on low flow survey data (QEA 2004, 2005) discussed in Section 3.2.11.

c – No-discharge facilities are not included in the model; these treatment facilities do not discharge wastewater to streams, but instead apply effluent and/or sludge to land.

d – Not included because its WWTF has been dismantled in recent years. Loads would have been minor due to the low flow limit.

CBOD – carbonaceous biological oxygen demand	NOX – nitrate + nitrite, as nitrogen	TP – total phosphorus
D/C – direct discharge	OrgN – organic nitrogen, as nitrogen	TSS – total suspended solids
DO – dissolved oxygen	OrgP – organic phosphorus, as phosphorus	WTP – water treatment plant
MGD – million gallons per day	PO4 – orthophosphate, as phosphorus	WWTF – wastewater treatment facility
mg/L – milligrams per literNH3 – ammonia	TLAP – Texas Land Application Permit (no-discharge)	

3.2.12   Climate

The Lake Buchanan watershed is in a semi-arid environment that increases in precipitation from west to east. Average annual precipitation ranges from approximately 22 inches in the western reaches of the watershed to approximately 30 inches in the east (TWDB 2012) (Figure 3-11). The precipitation distribution directly affects vegetative cover formation as water-conserving brush and grasses dominate the western portion of the watershed and forest density gradually increases to the east.

Rainfall in the region generally occurs as intense convective or frontal thunderstorms followed by extended dry periods (Asquith et al. 2006). These thunderstorms result in 'flashy' hydrographs including many ephemeral streams that only flow in response to storm events (Asquith et al. 2006).

Climatic inputs used in SWAT include measured and generated records of precipitation, maximum and minimum temperature, solar radiation, relative humidity, and wind speed. Precipitation, relative humidity, and temperature data were available for the watershed model from proximal weather stations from LCRA's Hydromet network and the National Weather Service (NWS) cooperative observer network (Table 3-7, Figure 3-11). Precipitation data from 32 meteorological stations (17 NWS cooperative stations and 15 LCRA Hydromet stations) were input to the Lake Buchanan SWAT model. Temperature data were derived from nine NWS stations. For days or periods when precipitation or temperature data were not available at a meteorological station, observations from a nearby meteorological station were substituted. Relative humidity data were available for ten LCRA Hydromet stations since 2002; for earlier dates, relative humidity records were generated by SWAT, as discussed below. The time-series of precipitation, relative humidity, and temperature data were imported into the SWAT model along with the station coordinates, and SWAT subsequently spatially distributed them to model sub-basins throughout the modeled watershed (Neitsch et al. 2005).

Solar radiation, relative humidity (prior to 2002), and wind speed records were created using the SWAT U.S. database weather generator as needed (Neitsch et al. 2011).

Table 3-7

Meteorological Stations Used for the Lake Buchanan SWAT Modeling

Station ID	Station Name	Source	Data Types[a]
411017	Brady	NWS	P, T
411138	Brownwood	NWS	P, T
1993	Buchanan Dam 2 miles west-northwest	LCRA	P, RH
411250	Burnet	NWS	T
1984	Burnet 5 miles north-northwest	LCRA	P
1927	Cherokee 4 miles east	LCRA	P, RH
1929	Cherokee Creek at Bend	LCRA	RH
411875	Coleman	NWS	P, T
411934	Concho Peak/Ivie Reservoir	NWS	P
412809	Eldorado	NWS	P
413257	Fort McKavett	NWS	P
413614	Goldthwaite 1 mile west-southwest	NWS	P, T
1964	Lampasas 10 miles west-southwest	LCRA	P
1940	Lampasas 13 miles west-northwest	LCRA	P
415272	Llano	NWS	P, T
415650	Mason	NWS	P, T
1540	Mason 13 miles west-northwest	LCRA	P
1578	Mason 15 miles north-northeast	LCRA	P, RH
415822	Menard	NWS	P, T
2348	Menard 12 miles south-southeast	LCRA	P
416140	Mullin	NWS	P
416747	Paint Rock	NWS	T
1390	Pecan Bayou near Mullin	LCRA	RH
417480	Red Bluff Crossing	NWS	P
417593	Richland Springs	NWS	P
417992	San Saba	NWS	P
1936	San Saba 15 miles east-southeast	LCRA	P, RH
1707	San Saba 15 miles southwest	LCRA	P
1777	San Saba 6 miles south	LCRA	P
417994	San Saba 7 miles northwest	NWS	P
1742	San Saba 8 miles west	LCRA	P
1563	San Saba River near Brady	LCRA	RH
1499	San Saba River near Menard	LCRA	RH
1769	San Saba River near San Saba	LCRA	RH
418863	Taylor Ranch	NWS	P
1983	Tow 10 miles east-southeast	LCRA	P

Station ID	Station Name	Source	Data Types[a]
1966	Tow 10 miles north-northwest	LCRA	P
419099	Tow 3 miles southeast	NWS	P
1199	Winchell	LCRA	P, RH

Notes:

LCRA – Lower Colorado River Authority

NWS – National Weather Service

a –Data Types:

P – precipitation

RH – relative humidity

T – temperature

3.2.13 Watershed Operations

Watershed operations were added to the model in order to address land uses that can significantly impact watershed nutrient loads. Based on conversations with Dr. Raghavan Srinivasan, a professor at Texas A&M University and one of the developers of ArcSWAT, cattle grazing operations were added to grasslands of 0 to 10 slope (heat units = 0.45; consecutive grazing days = 180; consumed biomass = 5 kilograms per hectare per day [kg/ha/day]; and dry weight of daily deposited manure = 2 kg/ha/day) (Srinivasan 2009).

3.2.14 On-Site Sewage Facilities

On-site sewage facilities, including septic tank systems and aerobic systems, were not simulated in the SWAT model, as in previous phases of CREMS models. Although these systems may be a source of nutrients to surface waters when malfunctioning, their impacts were considered to be negligible because of the low population density in the Lake Buchanan watershed. Out of the more than 21,800 septic systems on the Highland Lakes within 2,200 feet of the shoreline, 3,300 of those are around Buchanan. There is no indication these systems contribute nutrients to surface waters (LCRA On-site Sewage Facilities Department 2012).

3.3 Lake Buchanan SWAT Model Calibration

Calibration of a model consists of adjusting input parameters so that the model accurately reproduces trends in data. While the model calibration time period was from the start of 1984 through the end of 2011, model-to-data comparison at any particular location depended on data availability during this time period. A three-step calibration process was performed:

watershed hydrology calibration, then sediment load calibration, and finally, nutrient load calibration. Calibration progressed in this stepwise manner because watershed hydrology drives constituent loading and sediment transport can impact nutrient loading.

For each of the three steps, final calibration parameter values were derived through iterative runs of the model while implementing small model parameter changes based on graphical and statistical evaluations of the model's agreement with monthly data. Graphical evaluations were used in initial stages to approximate model fit for each calibration parameter. The predictive power of the model was evaluated based on calculated coefficient of determination values (R^2) and Nash-Sutcliffe model efficiency coefficient (NS) values (Nash and Sutcliffe 1970). NS measures how much better a model predicts observed values than the average of the observed values. A value of 1 indicates a perfect match, whereas a value of 0 or negative indicates that the model performs no better at predicting observed values than the average of the observed values. The NS is given more weight in model evaluation than the R^2 because NS describes the variability of the model output versus the data (accuracy), whereas R^2 describes the variability of the model output versus a regression line (precision). Finally, the percent difference in mass (for water quality constituents) or volume (for flow) between the sum of model output and the sum of the observed data over the calibration period was also compared to evaluate model goodness of fit (GOF). This last statistic is perhaps most important, as the performance of the Lake Buchanan model will rely on an accurate representation of the total long-term loading of water, sediment, and nutrients transported into the lake.

Flow gages and water quality measurement stations with available data were grouped into three categories based on quantity and representativeness of available data. Primary calibration stations and gages (Figure 3-9) are considered key representatives of a major reach of the Colorado River or a major tributary, and had the greatest number of flow and water quality data available covering the majority of the calibration period. Secondary flow calibration gages had significantly less data, often covering only part of the calibration period, but could be useful to identify appropriate calibration parameters for localized areas within the model or to provide additional verification of model performance. Finally, gages and stations with very little data or very short periods of record (PORs) were not utilized in the model.

As mentioned previously, a stepwise approach was used for the calibration of the Lake Buchanan SWAT model starting with hydrology, then sediment loading, and finally, nutrient loading. All three calibration steps, unless noted otherwise, followed a "basin-wide" approach. In other words, identical flow and water quality calibration parameters were applied to identical HRUs (i.e., areas of the same soil type, land cover, and slope), regardless of the sub-watershed in which they were located.

3.3.1   Hydrology Calibration Data

Average daily flow data from six USGS stream flow gages and three additional LCRA Hydromet stream flow gages were available for the Lake Buchanan watershed model hydrology calibration (Figure 3-9, Table 3-8). The flow data PORs varied by station but, generally, the USGS flow gage PORs spanned the calibration period of 1984 through 2011. Most of the Hydromet flow gages came online between 2002 and 2004, with the earliest in the Lake Buchanan watershed online in 1998. At many gages, both USGS and LCRA report flows based on a common stage sensor, but often using different rating curves. In the case when different flows were reported for the same gage, the USGS value was used for consistency with the longer POR.

The four primary hydrology calibration stations were the Colorado River at US 190 near San Saba (USGS 08147000), San Saba River near San Saba (USGS 08146000), Colorado River at Winchell (USGS 08138000), and Pecan Bayou near Mullin (USGS 08143600). Given that the primary purpose of the model is to provide inflows and water quality constituent loads for the Lake Buchanan lake model, the gage station on the Colorado River near San Saba (in sub-basin 28) was given highest priority in calibration.

Any data gap periods at the calibration stations were not used to calculate model calibration metrics. For example, the USGS gage at Winchell was offline from April 1993 to October 1997 and thus no data were available for evaluating model fit at that gage during that period.

Table 3-8

Lake Buchanan Watershed Hydrologic Calibration Stations

Station Name	Station Number	Source	SWAT Sub-watershed Number	Contributing Area to Modeled Lake Buchanan Watershed Area (%)	POR during Model Simulation Period	Average Monthly Flow Rate (cfs)
Colorado River at Winchell	**08138000**	**USGS**	**14**	**18.1**	**1984 – 1993 1997 – 2011**	**186**
Colorado River near Goldthwaite	1277	LCRA Hydromet	20	36.7	2004 – 2011	279
Colorado River at US 190 near San Saba	**08147000**	**USGS**	**28**	**87.4**	**1984 – 2011**	**633**
Colorado River near Bend	1925	LCRA Hydromet	38	89.5	2002 – 2011	467
Pecan Bayou near Mullin	**08143600**	**USGS**	**18**	**8.1**	**1984 – 2011**	**182**
San Saba River at Menard	08144500	USGS	44	16.3	1984 – 1993 1997 – 2011	46.8
San Saba River near Brady	08144600	USGS	43	24.3	1984 – 1993 1997 – 2011	68.1
San Saba River near San Saba	**08146000**	**USGS**	**29**	**46.6**	**1984 – 1993 1997 – 2011**	**146**
Cherokee Creek near Bend	1929	LCRA Hydromet	40	2.5	1998 – 2011	20.0

Notes:

Station names in **bold** indicate primary hydrology calibration stations.

cfs – cubic feet per second

LCRA – Lower Colorado River Authority

POR – period of record

SWAT – Soil and Water Assessment Tool

USGS – U.S. Geological Survey

3.3.2　Hydrology Calibration Approach

During calibration, a substantial reduction was noted in the amount of stream flow generated in response to rainfall in the mid-1990s. It was possible to obtain a satisfactory model fit to the measured flows for the period 1984 to 1997, or from 1997 to 2011, but not to both periods. When calibrated to post-1997 conditions, the model under-predicted measured flows for the period 1984 to 1997 by approximately 15% on average. Substantial effort was

devoted to resolving this discrepancy, to no avail. Two of the four primary calibration stations were offline from October 1993 to September 1997. The observation could possibly be explained by changes in the gage rating curves or flow measurement methods. Increases in surface water or groundwater use for domestic or agricultural purposes may also explain this observation. Other potential contributing factors—including regional groundwater level changes, new impoundments, or new diversions—do not appear sufficient to explain the observation. As a result, the calibration focused on the period from October 1, 1997, through December 31, 2011, and model fit statistics are based on that period. However, annual flow calibration plots will include the period from 1984 to 1997.

Table 3-9 lists the model parameters that were adjusted to calibrate the watershed hydrology in SWAT. The table briefly describes each parameter; identifies the major soil map units, land use, or sub-basins in which the parameter was changed; indicates the parameter location in the SWAT input files; and provides both the default and calibrated values. These values were derived through iterative runs of the model while implementing small changes in this suite of model parameters, based on both the graphical and statistical evaluations of the model's agreement with data.

Table 3-9
Lake Buchanan SWAT Hydrologic Parameters Adjusted During Calibration

Parameter	Units	Description	Location in SWAT Input	Region or Sub-watershed	Calibrated Value	Default Value
CN2*	--	SCS curve number for moisture condition 2	**.mgt	Soils TX544, TX545	-60%	*
				Soils TX253, TX369, TX565	-40%	*
				Soils TX151, TX227, TX483, TX484, TX488	-30%	*
				Soil TX146	-10%	*
				Soils TX284, TX288, TX290, TX485, TX526	+10%	*
ICRK	--	Model soil cracking	basins.bsn	All	active	inactive

Parameter	Units	Description	Location in SWAT Input	Region or Sub-watershed	Calibrated Value	Default Value
SOL_CRK	m^3/m^3	Crack volume potential of soil	**.sol	All	0 – 0.686 (see text)	0.5
GW_DELAY	day	Amount of time groundwater spends in the vadose zone	**.gw	All	180	31
RCHRG_DP	--	Percent of infiltrated water lost to a regional deep aquifer	**.gw	All	0.7	0.05
ALPHA_BF	day	Baseflow recession constant	**.gw	All	0.058	1
SOL_AWC*	mmH2O/ mmSoil	Soil available water content for plant uptake	**.sol	All	+0.05	*
GWQMIN	mm	Minimum depth of shallow groundwater for discharge	*.gw	All	50	1
ESCO	--	Soil evaporation compensation factor	**.hru	All	0.3	1
SURLAG	days	Surface flow lag time	basins.bsn	All	5	4
CH_K2	mm/hour	Main channel effective hydraulic conductivity	**.rte	Reaches 40, 43, 44, 45, 46, 48, 49, 50, 52, 53, 55, 56, 57, 60, 68	50	0
				Reaches 1 – 20, 22	0.5	0
				All other reaches	1.5	0
CH_N1	unitless	Tributary channel roughness coefficient	**.sub	All	0.10	-
CH_N2	unitless	Main channel roughness coefficient	**.rte	All	0.05	-

Parameter	Units	Description	Location in SWAT Input	Region or Sub-watershed	Calibrated Value	Default Value
OV_N	unitless	Overland flow roughness coefficient	**.hru	All	0.5	-

Notes:
* Indicates that the value varies by HRU and was therefore increased or decreased by a percent or constant value
** Represents variable sub-watershed or HRU number contained in input file name
mm – millimeter
SWAT – Soil and Water Assessment Tool

Several SWAT model groundwater calibration parameters proved particularly useful to improving model performance. Reductions in curve numbers and increases in soil water capacity were performed to approximately match the peak and 99th percentile of flow. Although modifications to curve numbers for Tarrant series soils (TX544 and TX545) were substantial, no other calibration parameter allowed reasonable simulation of the very small amounts of surface runoff produced after rains.

Based on the presence of crack-forming soils in the watershed, the SWAT model algorithms for crack flow were activated, and they improved model fit significantly. SWAT models the formation and volumes of soil cracks. On days when surface runoff is generated, a volume of runoff equal to the crack volume is allowed to enter the cracks. The maximum crack potential (SOLCRK) was set for each soil map unit according to the following formula:

$$SOLCRK = 0.75 * A + 0.375 * B \qquad (3\text{-}1)$$

where:

A	=	percentage of soil map unit comprised of soils with "very high" crack-formation potential (vertisols)
B	=	percentage of soil map unit comprised of soils with "high" crack formation potential

Losses of shallow groundwater (RCHRG_DP) and streamflow (CH_K2) to deep aquifers together with enhanced evapotranspiration parameters (ESCO; GW_REVAP) allowed a reasonable model fit at most flow gages. Of particular note, the channel of the upper San Saba River (from south of Brady to the west) flows through a very permeable geologic unit;

the Dev-Rioconcho soils in this formation have saturated hydraulic permeabilities of 50 to 151 millimeters (mm) per hour, according to the STATSGO database. A value of 50 mm/hour provided a reasonable fit in the SWAT model. Adjustments to GW_DELAY, ALPHA_BF, and SURLAG provided additional improvement in matching observed flows.

3.3.3   Hydrology Calibration Results

Figures 3-12 through 3-20 show the results of the flow calibration by station. Each figure includes a plot for average annual flows, one for average monthly flows, and a third for daily flow duration curves[3]. The calibration was primarily focused on matching the monthly flows from October 1997 through 2011. The model performed well based on the graphical and statistical calibration metrics, particularly at the Colorado River near San Saba gage. The drainage area associated with this gage accounts for 87% of the modeled Lake Buchanan watershed area. The San Saba River watershed hydrology calibration provided a good fit to data as well, but the model tended to under-predict low flows in the westernmost portion of the watershed. This minor shortcoming of the model hydrology is of little consequence considering how little of the total flow volume these low flows represent and considering that most sediment and nutrient transport to the lake does not occur during low flow.

Table 3-10 includes statistical descriptors of the monthly hydrologic calibration for the primary calibration locations (NS, R^2, and volume percent difference). The model performance is good based on the NS values ranging from 0.68 to 0.95 for the primary calibration stations. A percent difference comparison of the sum of the measured flow volumes to the sum of the simulated flow volumes also indicates the hydrology of the model is performing well with differences at the primary calibration stations ranging from -15.2% at the Colorado River at Winchell gage to +6.6% at the Pecan Bayou gage.

---

[3] Flow duration curves are based on the period from October 1997 through December 2011.

Table 3-10

Lake Buchanan SWAT Monthly Hydrologic Calibration Metrics for

Primary Calibration Locations

Station ID and Name	Contributing Area to Modeled Watershed Area (%)	Period of Record Used in Calibration	Monthly NS	Monthly R²	Volume Percent Difference	Average Measured Flow (cfs)	Average Simulated Flow (cfs)
08147000 Colorado River at US 190 near San Saba	87.4	October 1997–2011	0.92	0.92	+2.8	434	446
08138000 Colorado River at Winchell	18.1	October 1997–2011	0.68	0.71	-15.2	71.2	60.4
08146000 San Saba River near San Saba	46.6	October 1997–2011	0.89	0.89	+3.6	136	140
08143600 Pecan Bayou near Mullin	8.1	October 1997–2011	0.95	0.95	+6.6	134	143

Notes:

cfs – cubic feet per second

NS – Nash-Sutcliffe model efficiency coefficient

R^2 – coefficient of determination

Table 3-11 includes statistical descriptors of the monthly hydrologic calibration at the secondary calibration smaller tributary locations. These locations are either on smaller tributaries or have relatively short PORs. Traditionally, modeling small sub-watersheds is difficult when model adjustments are made at a basin-wide scale (Benaman et al. 2005). In this case, parameters were varied across the basin to fit data at primary stations, which have relatively large contributing areas. Consequently, the performance of the model at secondary stations is not as consistently good as at primary calibration stations.

Table 3-11
Lake Buchanan SWAT Monthly Hydrologic Calibration Metrics for
Secondary Calibration Locations

Station ID and Name	Source	Contributing Area to Modeled Watershed Area (%)	Period of Record Used in Calibration	Monthly NS	Monthly R^2	Volume Percent Difference	Average Measured Flow (cfs)	Average Simulated Flow (cfs)
08144500 San Saba River at Menard	USGS	16.3	October 1997–2011	0.22	0.26	-11.2	35.8	31.7
08144600 San Saba River near Brady	USGS	24.3	October 1997–2011	0.17	0.18	-19.8	48.4	38.8
1929 Cherokee Creek near Bend	Hydro-met	2.5	October 1997–2011	0.45	0.49	-11.2	20.0	17.7
1277 Colorado River near Goldthwaite	Hydro-met	36.7	May 2004–2011	0.91	0.92	+5.4	277	292
1925 Colorado River near Bend	Hydro-met	89.5	November 2002–2011	0.90	0.90	+2.9	467	480

Notes:
cfs – cubic feet per second
NS – Nash-Sutcliffe model efficiency coefficient
R^2 – coefficient of determination

The Lake Buchanan watershed SWAT hydrology calibration results compare favorably to
other SWAT applications, including the recent applications of SWAT to the Lake Travis and
Lake LBJ watersheds (Anchor QEA and Parsons 2009a), which both reported monthly NS
values of 0.82 at the most downstream primary calibration gages on the largest tributaries. In
one study, Cho et al. (1995) reported monthly NS values ranging from 0.57 to 0.83 for a small
forested watershed in the Delaware River basin. A previous study in the Trinity River
watershed in Texas (Srinivasan et al. 1998) obtained monthly NS values of 0.87 and 0.84. A

modeling effort completed in the Bosque River watershed in Texas obtained flow volume monthly NS values of 0.80 and 0.89 for two sub-watersheds of 926 and 2,997 km^2, respectively (Santhi et al. 2001). A second Texas effort in the West Fork watershed of the Trinity River basin obtained NS values of 0.12 and 0.72 for two USGS flow stations in a 4,552 km^2 watershed (Santhi et al. 2006). A recent review of many SWAT applications throughout the world, including many in Texas, show monthly NS values ranging from 0.3 to above 0.95 (Gassman et al. 2007). The Santhi et al. (2001) study assumed an "acceptable calibration" for hydrology as a monthly NS greater than 0.6. The NS values for Lake Buchanan watershed primary calibration stations were all greater than 0.6 and, therefore, based on these NS values and the other calibration metrics, the hydrology calibration was deemed acceptable.

3.3.4   Water Quality Calibration Data

Water quality data collected from the early 1980s through 2011 near the hydrology calibration gages were used for sediment and nutrient load calibrations (Figure 3-9). The stations, along with the nearby flow stations, are listed in Table 3-12. Water quality data collected as part of the LCRA CREMs and RSS programs were used for watershed constituent load calibrations (see Section 2 for a description of the CREMs sampling programs). The following constituent data were used for watershed sediment and nutrient calibrations:

- TSS
- OrgP (calculated as TP minus PO4)
- PO4
- TP
- OrgN (calculated as total Kjeldahl nitrogen [TKN] minus NH3)
- NH3
- NOX
- TN (total nitrogen, calculated as TKN plus NOX)

Table 3-12

Lake Buchanan Watershed Water Quality Calibration Stations

Station ID	Station Description	Proximal Flow Gage ID	Period Of Record	Number of Days Sampled for Water Quality
12355	Colorado River at US 190 near San Saba	08147000	1990 – 2011	165
12358	Colorado River at Winchell	08138000	1990 – 2011	122
12392	San Saba River near San Saba	08146000	1984 – 2011	204
12394	Pecan Bayou near Mullin	08143600	1990 – 2011	138

Because water quality data are not collected daily and a continuous daily record is needed for SWAT model calibration, an empirical model was developed to produce a continuous time-series to which the SWAT-simulated time-series was compared for calibration. The USGS LOAD ESTimator (LOADEST; Runkel et al. 2004), a program for estimating constituent loads in streams and rivers, was used to develop watershed-specific constituent regression models (i.e., rating curves) for those tributaries where sufficient stream flow and constituent concentrations were available. Given paired stream flow and constituent concentration data, LOADEST develops a regression model for the estimation of the constituent loads. LOADEST provides several optional regression models; the simplest model was applied, as follows:

$$ln(Load) = a_0 + a_1 * ln\ Q \tag{3-2}$$

where:

Q	=	measured stream flow in cubic meters per second (cms)
$Load$	=	constituent concentration in kg/day (or tons/day for sediment)
a_0	=	intercept
a_1	=	slope

The values of the constants a_0 and a_1 were estimated by LOADEST using adjusted maximum likelihood estimation. This equation was used to generate a time-series of daily estimated loads based on the regressed coefficients for each constituent and daily flow data.

Ideally, a watershed model is calibrated to a long-term record of daily water quality measurements. However, it is impracticable to collect such data on a system the size of the

Lake Buchanan watershed; hence, the necessity of the LOADEST model. A discussion of the limitations of using a model to calibrate a model can be found in the CREMs Phase 2: Lake Travis Final Report (Anchor QEA and Parsons 2009a). In general, the number of water quality constituent measurements under high flow conditions was limited, lending considerable uncertainty to the LOADEST estimated total loads. Despite these limitations, the use of a regression model (e.g., rating curve) like that produced by LOADEST for water quality calibration is a viable, and often used, option when continuous time-series water quality data are not available (Gassman et al. 2007).

Daily loads for each of the constituents were estimated for each of the locations using daily average flow data and the LOADEST rating curves (Figure 3-21a through d). Table 3-13 presents the standard errors associated with the rating curve predictions for each station and constituent. These values are calculated in LOADEST and are provided in the LOADEST output file.

Table 3-13
Uncertainty Associated with Lake Buchanan Watershed Rating Curve Predictions

Station Name (Station ID)	Parameter	Mean Load (kg/day)	Standard Error (kg/day)
Colorado River at US 190 near San Saba (12355)	TSS	265,890	50,010
	OrgN	1540	224
	OrgP	663	280
	NOX	7,642	2,306
	NH3	218	80
	PO4	264	208
	TP	496	145
Colorado River at Winchell (12358)	TSS	52,570	10,810
	OrgN	382	50
	OrgP	83.2	34.6
	NOX	971	615
	NH3	46.6	25.6
	PO4	12.9	11.2
	TP	83.1	26.8
Pecan Bayou near Mullin (12394)	TSS	78,970	14,900
	OrgN	473	60.8
	OrgP	61.1	13.1

Station Name (Station ID)	Parameter	Mean Load (kg/day)	Standard Error (kg/day)
	NOX	18,800	16,656
	NH3	41.8	14.4
	PO4	61.9	23.6
	TP	170	32
San Saba River near San Saba (12392)	TSS	33,080	4,780
	OrgN	256	30
	OrgP	34.6	7.5
	NOX	634	119
	NH3	14	2.5
	PO4	9.0	2.2
	TP	54.1	11.1

Notes:

Mean load is the average daily load for each day of the calibration period 1984 – 2011.

kg/day – kilograms per day

NH3 – ammonia

NOX – nitrate+nitrite, as nitrogen

OrgN – organic nitrogen, as nitrogen

OrgP – organic phosphorus, as phosphorus

PO4 – orthophosphate, as phosphorus

TP – total phosphorus

TSS – total suspended solids

3.3.5 *Water Quality Calibration Approach*

Table 3-14 lists the model parameters that were adjusted to calibrate the sediment and nutrient loads in SWAT. As with the flow calibration, the water quality calibration focused on the period from October 1, 1997, through December 31, 2011, and model fit statistics are based on that period. However, annual flow calibration plots also display the period from 1984 to 1997. Mineral P model output was used for PO4 calibration because the majority of mineral phosphorus is in the form of PO4; nitrate (NO3)+ nitrite model output was used for NOX calibration; and the appropriate model species output were added together for TN (OrgN, NOX, and NH3) and TP (OrgP and PO4) calibrations. OrgP, OrgN, and NH3 are directly output from the model.

Table 3-14

Lake Buchanan SWAT Water Quality Parameters Adjusted During Calibration

Calibration Type	Parameter	Units	Description	Location in SWAT Input	Sub-watershed	Calibration Value	Default Value
Sediment	SPCON	--	Sediment transport linear factor	basin.bsn	All	0.0003	0.0001
	SPEXP	--	Sediment transport exponent	basin.bsn	All	1.05	1
	PRF	--	Peak rate adjustment factor	basin.bsn	All	1.1	1
	LAT_SED	mg/L	Groundwater TSS concentration	**.hru	All	1	0
	CH_COV1	--	Channel erodibility factor	**.rte	3, 6, 8, 9, 11 – 15, 19	0.2	0
					21, 25 – 26, 29 – 31, 37, 39, 43	0.5	
					10, 16 – 18, 20, 22 – 23, 28, 38, 42, 51, 54	0.6	
					All others	0	
	CH_COV2	--	Channel cover factor	**.rte	3, 6, 8, 9, 11 – 15, 19	0.2	0
					21, 25 – 26, 29 – 31, 37, 39, 43	0.5	
					10, 16 – 18, 20, 22 – 23, 28, 38, 41 – 42, 47, 51, 54, 58	1	
					All others	0	
Nutrients	N_UPDIS	--	Nitrogen uptake distribution factor	basins.bsn	All	1	20
	P_UPDIS	--	Phosphorus uptake distribution factor	basins.bsn	All	1	20
	NPERCO	--	Nitrate percolation coefficient	basins.bsn	All	1	0.2
	PSP	--	Phosphorus availability index	basins.bsn	All	0.1	0.4

Notes:

** Represents the variable sub-watershed or HRU number contained in input file name

TSS – total suspended solids

SWAT allows for instream transformations and kinetics of algae growth, nitrogen and phosphorus cycling, carbonaceous biological oxygen demand (CBOD), and dissolved oxygen (DO) to be performed on the basis of routines developed for the QUAL2E model (Brown and Barnwell 1987). This function can be turned on or off. Both options were tested, and turning off the instream processes provided the most appropriate model results for nearly all of the key parameters. Accordingly, for the calibration, instream water quality kinetics were turned off (i.e., ISUBWQ = 0 and IWQ = 0).

3.3.6   Sediment Calibration Results

Figures 3-22 to 3-25 show annual sediment calibration results along with cross-plots of monthly average sediment load calibration results by station for October 1997 through 2011. Time series plots by calibration station are included in Appendix A. Table 3-15 includes statistical descriptors of the monthly sediment load calibration. The calibration was based on the average monthly values.

Table 3-15
Lake Buchanan SWAT Monthly Sediment (TSS) Calibration Metrics

Station Name	Station Number	Contributing Area to Modeled Watershed Area (%)	Monthly NS	Monthly R^2	Mass Percent Difference	Average LOADEST Monthly Load (metric tons/day)	Average Simulated Monthly Load (metric tons/day)
Colorado River at US 190 near San Saba	12355	87.4	0.80	0.81	-2	167	163
San Saba River near San Saba	12392	46.6	0.41	0.70	7	29	31
Colorado River at Winchell	12358	18.1	0.41	0.47	13	20	23
Pecan Bayou near Mullin	12394	8.1	0.35	0.56	40	49	69

Notes:
October 1997 to December 2011
NS – Nash-Sutcliffe model efficiency coefficient
R^2 – coefficient of determination

NS values for TSS range from 0.35 to 0.80, with the best fit at the key downstream calibration station (Colorado River near San Saba). The model comes within a factor of 2 of the observed TSS, which is considered good performance for this constituent in watershed modeling (Benaman et al. 2005). The Lake Buchanan SWAT model produces percent differences for TSS ranging from -2 to +40%. Santhi et al. (2001) considered SWAT's simulations of sediment loading acceptable with percent differences of -16 and -20%. Srinivasan et al. (1998) also performed a sediment calibration in Texas and came within 2% of the measured annual sediment loads. Although the review of 37 different SWAT applications across many different basins does not report percent differences in their summary, they indicate NS values that are negative up to above 0.8 (Gassman et al. 2007). Gassman et al. (2007) and Benaman et al. (2005) also document weaknesses in sediment erosion and transport simulations that make it difficult to simulate sediments in SWAT. The NS values for the Lake Buchanan watershed calibration stations are good given the uncertainty in the TSS calibration record estimated by LOADEST.

3.3.7 Nutrient Calibration Results

Figures 3-26 to 3-53 show annual nutrient calibration results along with cross-plots of monthly average nutrient load calibration results by station and by constituent for October 1997 through 2011. Constituents include OrgP, PO4, TP, OrgN, NOX, NH3, and TN. TP and TN time series plots by calibration station are included in Appendix A. Table 3-16 includes statistical descriptors (NS, R^2, and mass percent difference) of the monthly nutrient load calibration. The calibration was based on the average monthly loads, and thus incorporates inaccuracies in flow predictions as well as nutrient concentrations.

Table 3-16
Lake Buchanan SWAT Monthly Nutrient Calibration Metrics

Parameter	Station Name	Station Number	Contributing Area to Total Lake Buchanan Watershed Area (%)	NS	R^2	Mass Percent Difference	Average LOADEST Monthly Load (kg/day)	Average Simulated Monthly Load (kg/day)
OrgP	Colorado River at US 190 near San Saba	12355	87	0.67	0.69	-25	406	302
	Colorado River at Winchell	12358	18	0.51	0.49	74	33	58
	Pecan Bayou near Mullin	12394	8	0.18	0.48	140	40	97
	San Saba River near San Saba	12392	47	-0.82	0.54	47	31	45
PO4	Colorado River at US 190 near San Saba	12355	87	0.27	0.78	-49	158	80
	Colorado River at Winchell	12358	18	0.15	0.35	128	5	12
	Pecan Bayou near Mullin	12394	8	0.29	0.68	-15	42	36
	San Saba River near San Saba	12392	47	-0.12	0.60	125	8	18
TP	Colorado River at US 190 near San Saba	12355	87	0.62	0.74	23	312	383
	Colorado River at Winchell	12358	18	0.41	0.43	109	33	70
	Pecan Bayou near Mullin	12394	8	0.27	0.55	19	111	133
	San Saba River near San Saba	12392	47	0.19	0.62	34	47	63

Parameter	Station Name	Station Number	Contributing Area to Total Lake Buchanan Watershed Area (%)	NS	R^2	Mass Percent Difference	Average LOADEST Monthly Load (kg/day)	Average Simulated Monthly Load (kg/day)
OrgN	Colorado River at US 190 near San Saba	12355	87	0.50	0.74	-25	1,004	751
	Colorado River at Winchell	12358	18	0.42	0.44	1	163	164
	Pecan Bayou near Mullin	12394	8	0.33	0.50	-6	316	299
	San Saba River near San Saba	12392	47	-2.38	0.55	-56	230	101
NOX	Colorado River at US 190 near San Saba	12355	87	0.53	0.74	-54	4,554	2,096
	Colorado River at Winchell	12358	18	-0.06	0.30	36	336	458
	Pecan Bayou near Mullin	12394	8	0.48	0.51	-95	11,303	581
	San Saba River near San Saba	12392	47	0.46	0.62	-4	530	508
NH3	Colorado River at US 190 near San Saba	12355	87	0.49	0.63	-82	135	24
	Colorado River at Winchell	12358	18	0.20	0.24	-94	19	1
	Pecan Bayou near Mullin	12394	8	0.50	0.50	-25	27	20
	San Saba River near San Saba	12392	47	-4.24	0.29	-86	13	2
TN	Colorado River at US 190 near San Saba	12355	87	0.72	0.75	-50	5,694	2,871

Parameter	Station Name	Station Number	Contributing Area to Total Lake Buchanan Watershed Area (%)	NS	R^2	Mass Percent Difference	Average LOADEST Monthly Load (kg/day)	Average Simulated Monthly Load (kg/day)
	Colorado River at Winchell	12358	18	0.37	0.43	20	517	623
	Pecan Bayou near Mullin	12394	8	0.52	0.55	-92	11,647	900
	San Saba River near San Saba	12392	47	0.43	0.63	-21	773	612

Notes:

LOADEST uncertainty is illustrated by average monthly LOADEST TP values that are less than the sum of the average monthly LOADEST PO4 + OrgP values.

Time period considered: October 1997 through December 2011

kg/day – kilograms per day

NH3 – ammonia

NOX – nitrate+nitrite, as nitrogen

NS – Nash-Sutcliffe model efficiency coefficient

OrgN – organic nitrogen, as nitrogen

OrgP – organic phosphorus, as phosphorus

PO4 – orthophosphate, as phosphorus

R^2 – coefficient of determination

TN – total nitrogen

TP – total phosphorus

For the nutrient series, the model fits are fair to good for all nutrient species. Generally, the model tends to slightly under-estimate nutrient loads relative to LOADEST output. In-stream water quality kinetics were turned off in the SWAT model due to substantial uncertainty regarding the kinetic parameters, which may explain the model's under-estimation of NH4 loads.

The nutrient under-estimates were most notable under high flow conditions. Very few ambient water quality measurements were made under high flow conditions; thus, the LOADEST estimates under high flows have considerable uncertainty. Crucially, LOADEST assumes a log-linear increase in loads as flows increase. Because of the paucity of data under high flow conditions, it is difficult to judge the veracity of this assumption for each constituent. Some indication of river water quality under high flow conditions can be ascertained by examining Lake Buchanan data shortly after high flow events, as discussed in Section 4. Ultimately, in cases where constituent loads do not increase log-linearly with flow in the real world, the SWAT underprediction of LOADEST loads may better represent the actual watershed than the LOADEST calibration targets themselves. The model fit is often best at the key calibration station, Colorado River near San Saba, which is most relevant to the loads entering Lake Buchanan.

Of particular note, the high and extremely variable nitrate levels in Pecan Bayou could not be supported by existing known sources. This may be influenced by high nitrate loads from point sources, which do not report nitrate concentrations in effluent (and therefore, nitrate concentration from these sources have to be estimated), or by row crop agriculture. The measured nitrate nitrogen levels and those predicted by the model range from below detection to more than 10 milligrams per Liter (mg/L), with highest levels observed from December through February. However, note that the LOADEST fit to ambient data for NOX in Pecan Bayou is poor at high flows (Figure 3-21c).

Calibration metrics for the Lake Buchanan watershed model at the Colorado River near San Saba are compared to those for the Lake Travis and Lake LBJ watershed models in Table 3-17.

Table 3-17

Comparison of Lake Buchanan (Colorado River at US 190 east of San Saba) to Lake Travis and Lake LBJ SWAT Monthly Nutrient Calibration Metrics

Parameter	Lake Buchanan		Lake Travis [a]		Lake LBJ [b]	
	Monthly NS	Mass Percent Difference	Monthly NS	Mass Percent Difference	Monthly NS	Mass Percent Difference
OrgP	0.67	-25	0.31	-18	0.17	-34
PO4	0.27	-49	0.53	-45	0.77	35
TP	0.62	23	0.35	3	0.58	11
OrgN	0.50	-25	0.06	-69	0.5	-5
NOX	0.53	-54	-20.17	640	-165	-78
TN	0.72	-50	NA	NA	0.64	7

Notes:

a – As reported in the CREMs Phase 2: Lake Travis Final Report (Anchor QEA and Parsons 2009a) for Hammett's Crossing station

b – As reported in the CREMs Phase 3: Final Report (Parsons and Anchor QEA 2011) for Llano River near Llano station

NOX – nitrate+nitrite, as nitrogen

NS – Nash-Sutcliffe model efficiency coefficient

OrgN – organic nitrogen, as nitrogen

OrgP – organic phosphorus, as phosphorus

PO4 – orthophosphate, as phosphorus

TN – total nitrogen

TP – total phosphorus

Modeling the nutrient series in SWAT is challenging. Gassman et al. (2007) summarized SWAT model performance in nutrient simulations for various studies and found that SWAT performed "acceptably" to "poorly" in general. LOADEST rating curve uncertainties, which are illustrated by average monthly LOADEST TP values that are less than the sum of the average monthly LOADEST PO4 + OrgP values, are propagated to the SWAT model calibration. Adjustment of multiple parameters that describe land-side processes (including erosion and plant uptake) are required, and in-stream kinetics are ignored. Little site-specific data are available to guide the modeler as to which parameters should be adjusted and, consequently, literature values and professional judgment are used to guide the calibration. Despite these limitations, the nutrient calibration of the Lake Buchanan SWAT model, when compared to other nutrient calibration efforts, is considered acceptable. Santhi et al. (2001) and Santhi et al. (2006) show percent differences for the phosphorus series of -18 and -3% for PO4, on average. Santhi et al. (2001) also reported a 7% over-prediction in OrgP. In both studies, the mineral nitrogen (i.e., NH3 plus NOX) was over-predicted by about 45%.

Another study in upstate New York showed TP percent differences of about 6 to 41% (Tolson and Shoemaker 2007).

3.4   Sensitivity Analysis

Sensitivity analysis relates to how the variation (uncertainty) in the output of a mathematical model can be apportioned, qualitatively or quantitatively, to different sources of variation in both model input data and, more commonly, the various parameters in the model that affect the performance or calibration of the model. In general, both uncertainty and sensitivity analyses investigate the robustness of a model. While uncertainty analysis is an evaluation of the overall uncertainty in the conclusions of the model, sensitivity analysis is an attempt to identify what source of uncertainty weighs more on the model output or conclusions.

Choosing the appropriate uncertainty analysis/sensitivity analysis method is often a matter of trading off between the amount of information one wants from the analyses and the computational difficulties of the analyses. These computational difficulties are often inversely related to the number of assumptions one is willing or able to make about the shape of a model's response surface (Pascual et al. 2003).

Considering the computational difficulty of running the SWAT models in an iterative or Monte Carlo fashion to facilitate uncertainty analysis, a one-at-a-time sensitivity analysis was performed in three steps. The initial step was to select the parameters and their ranges to test in the one-at-a-time sensitivity analysis. Table 3-18 lists the eight parameters chosen for sensitivity analysis. These parameters were identified during calibration as strongly influencing model predictions of nitrogen and phosphorus loads. The table shows the calibrated value for the parameter and the range evaluated in the sensitivity analysis. Ranges were developed using professional judgment, taking into account information available in the literature pertaining to the ranges for these parameters where possible.

Table 3-18

SWAT Parameters Selected for Sensitivity Analysis

Parameter	Description	Location in SWAT Input	Calibrated Value	Sensitivity Range
ESCO	Soil evaporation compensation factor	**.hru	0.3	0.01 to 1
CH_K2	Main channel effective hydraulic conductivity	**.rte	*	-50% to +50%
SPCON	Linear parameter to determine maximum amount of sediment re-entrainment	basins.bsn	0.0003	0.0001 to 0.001
PRF	Peak rate adjustment factor for sediment routing	basins.bsn	1.1	0.5 to 2
PSP	Phosphorus availability index	basins.bsn	0.1	0.07 to 0.7
P_UPDIS	Phosphorus uptake distribution factor	basins.bsn	1	1 to 100
NPERCO	Nitrate percolation coefficient	basins.bsn	1	0.05 to 1
N_UPDIS	Nitrogen uptake distribution factor	basins.bsn	1	1 to 100

Notes:

* Indicates that the value is variable by HRU and was therefore increased or decreased by a percent or constant value

** Represents the variable sub-watershed or HRU number contained in input file name

For each parameter selected, the second step of the procedure involved changing the model input to the low value of the range specified in Table 3-18 and running the model. This was repeated using the high value of the range. In this one-at-a-time manner, the two results are used in the third step in the presentation and evaluation of the sensitivity analysis for the following four key state variables of the model:

- Flows
- TSS
- TP
- TN

Changing parameters one-at-a-time ignores correlations between parameters and, consequently, introduces a limitation of this approach. However, given the desired study outcomes and the restricted time and resources, a one-at-a-time sensitivity approach aided in

narrowing down the list of parameters efficiently. Results from this approach should not supersede professional judgment or previous analyses.

To evaluate the sensitivity of the SWAT models to the selected variables, a sensitivity index (SI) was computed in step 3, using the following equation:

$$SI = \max\left(\left|\frac{\overline{Param}_{low} - \overline{Param}_{base}}{P_{low}}\right|, \left|\frac{\overline{Param}_{high} - \overline{Param}_{base}}{P_{high}}\right|\right) \tag{3-3}$$

where:

$Param$	=	average flow or load for a given state variable
P_{low}	=	percent reduction from base parameter value
P_{high}	=	percent increase from base parameter value

The main function of the SWAT model is to generate nutrient loadings for the CE-QUAL-W2 lake model. As a result, the focus of the sensitivity analyses was the nitrogen and phosphorus series. Results of the sensitivity analyses are summarized in Table 3-19. The table shows the difference between the high run and the low run for each parameter for each state variable along with the sensitivity index. The sensitivity indices are sorted in descending order so that the most sensitive parameter for a given state variable is listed first.

Table 3-19

Sensitivity Results for the Lake Buchanan Watershed SWAT Model

Output Variable	Parameter	Sensitivity Index	Parameter Values			Results for Output Variable of Concern [a]		
			Base	Minimum	Maximum	Base	Minimum Parameter	Maximum Parameter
Flow (m³/s)	ESCO	0.046	0.3	0.1	1	12.64	12.15	23.29
	CH_K2	0.0038	*	-50%	+50%	12.64	12.45	12.72
	N_UPDIS	0.0011	20	1	100	12.54	12.64	12.50
	NPERCO	0.0003	0.2	0.05	1	12.75	12.75	12.64
	PSP	0.0000	0.1	0.07	0.7	12.64	12.64	12.63
	P_UPDIS	0	20	1	100	12.64	12.64	12.64
	SPCON	0	0.0003	0.0001	0.001	12.64	12.64	12.64
	PRF	0	1.1	0.5	2.0	12.64	12.64	12.64
TSS (tons/day)	PRF	1.47	1.1	0.5	2	163	83	238
	SPCON	1.38	0.0003	0.0001	0.001	163	71	443
	ESCO	1.09	0.3	0.1	1	163	153	417
	N_UPDIS	0.021	20	1	100	161	163	164
	CH_K2	0.020	*	-50%	+50%	163	164	163
	PSP	0.002	0.1	0.07	0.7	163	163	164
	NPERCO	0.002	0.2	0.05	1	164	163	163
	P_UPDIS	0	20	1	100	163	163	163

Output Variable	Parameter	Sensitivity Index	Parameter Values			Results for Output Variable of Concern [a]		
			Base	Minimum	Maximum	Base	Minimum Parameter	Maximum Parameter
Total Phosphorus (kilograms/day)	ESCO	3.09	0.3	0.1	1	383	355	1104
	PSP	2.27	0.1	0.07	0.7	383	451	374
	P_UPDIS	0.49	20	1	100	336	383	296
	N_UPDIS	0.14	20	1	100	370	383	384
	CH_K2	0.06	*	-50%	+50%	383	380	385
	NPERCO	0.002	0.2	0.05	1	384	384	383
	SPCON	0	0.0003	0.0001	0.001	383	383	383
	PRF	0	1.1	0.5	2.0	383	383	383
Total Nitrogen (kilograms/day)	ESCO	13.62	0.3	0.1	1	2,871	2,664	6,050
	NPERCO	3.95	0.2	0.05	1	1,613	1,317	2,871
	N_UPDIS	3.41	20	1	100	2,547	2,871	1,613
	CH_K2	0.32	*	-50%	+50%	2,871	2,855	2,882
	PSP	0.067	0.1	0.07	0.7	2,871	2,869	2,863
	P_UPDIS	0.074	20	1	100	2,864	2,871	2,863
	PRF	0	1.1	0.5	2	2,871	2,871	2,871
	SPCON	0	0.0003	0.0001	0.001	2,871	2,871	2,871

Notes:
a – Flow and loads at reach 28 – Colorado River near San Saba
* Spatially variable
m^3/s – cubic meters per second

Phosphorus concentrations are most sensitive to ESCO, PSP, and P_UPDIS. The ESCO coefficient modifies the depth distribution used to meet the soil evaporative demand to account for the effect of capillary action, crusting, and cracks, and is related to soil nutrient availability. It strongly influences the soil moisture and the amount of runoff generated. PSP, the phosphorus availability coefficient, controls the relationship between concentrations of phosphorus in soil solution and active mineral phosphorus in soils. P_UPDIS controls the depth distribution of plant uptake of phosphorus from soil; higher values of P_UPDIS withdraw most phosphorus from soils close to the surface, while lower values of P_UPDIS entail a more even depth distribution of phosphorus uptake.

Nitrogen concentrations are sensitive to ESCO, NPERCO, and N_UPDIS. NPERCO is the ratio of nitrate concentration in runoff to that in water percolating through soil. N_UPDIS is the nitrogen analog to P_UPDIS, and controls the depth distribution of plant uptake of nitrogen from soil. As explained above, ESCO is related to soil moisture and runoff generation.

Sediment concentrations are most sensitive to PRF, SPCON, and ESCO. SPCON is the linear parameter for calculating the maximum amount of sediment that can be transported at a given water velocity during channel sediment routing. PRF is the peak rate adjustment factor, the ratio of peak flow to average flow, which impacts sediment routing in the main channel.

4 LAKE MODEL

This section describes the lake model developed during Phase 4 of the CREMs project for Lake Buchanan. The following subsections describe an overview of the modeling software selected; overall calibration approach, metrics, and goals; general model development; hydrodynamic model development and calibration; lake model development and calibration; sensitivity analyses; and bounding calibration.

4.1   Introduction

The watershed model was coupled to the lake model through the usage of flows and loads predicted by the calibrated SWAT model (Section 3). In preparation for simulating potential conditions in the future, this linkage was implemented to create a way to quantitatively understand the impact of watershed changes to the receiving lake's water quality.

The watershed model was also linked to the lake model for the previous phases of the CREMs project. Lake Buchanan, however, differs from the other modeled lakes in that it is the first in the series of the Highland Lakes and subsequently receives loadings from a very large upland watershed; the upstream sub-basins (i.e., those that do not directly drain into Lake Buchanan) comprise approximately 97% of the Lake Buchanan watershed (Figure 3-8). Consequently, watershed model results more greatly impact the lake model for Lake Buchanan; the upstream end of Lake Buchanan is not bounded by a dam, unlike the other modeled lakes, and subsequently no data collected at a dam could be used for upstream loading characterization. This difference made the Phase 4 lake model calibration challenging and resulted in necessary accommodations in the water balance.

In addition, the calibration for water quality required focused data analyses; these analyses focused on areas where the model performed poorly during initial simulations. Results from these analyses then guided the calibration.

As part of the model development, spatial and temporal trends of the ambient water quality of Lake Buchanan were reviewed. A short summary of these trends and accompanying figures are in Appendix B.

4.2   Model Overview and Performance Metrics

4.2.1   Model Selection

The lake model selected for Phase 4 of CREMs is CE-QUAL-W2 version 3.6[4], a two-dimensional, laterally averaged hydrodynamic and lake model developed and maintained by the USACE Waterways Experiment Station. Model selection was based on the model evaluation in the CREMs Master Plan (CH2M Hill 2002), results from the Phase 1 work, and internal discussions. Selection of CE-QUAL-W2 version 3.6 also maintains compatibility with the model used for CREMs Phase 2 modeling (CE-QUAL-W2 version 3.5), while incorporating recent improvements to the model code. Version 3.6 was also used for CREMs Phase 3. In addition, the SWAT and CE-QUAL-W2 models have been successfully linked for other sites such as the Cedar Creek Reservoir (Debele et al. 2006) and Lake Waco (White et al. 2010), both in Texas.

CE-QUAL-W2 is best suited for relatively long and narrow waterbodies, such as Lakes Travis, LBJ, Inks, Marble Falls, and Buchanan, that exhibit longitudinal and vertical water quality gradients. The model has been applied to rivers, lakes, reservoirs, and estuaries across the United States (Cole and Wells 2008).

4.2.2   General Processes Modeled

The Lake Buchanan lake model represents the major hydrodynamic, water column nutrient cycling, and sediment processes controlling water quality in the lake (Figure 4-1). The hydrodynamic component simulates temperature as well as vertical and horizontal mixing processes. The water column component describes the major water column processes affecting lake water quality, including nitrification, organic matter decomposition, algal photosynthesis, respiration, and nutrient uptake as well as particle settling to the sediment bed. The sediment component represents the conversion of particulate organic matter to dissolved nutrients and the concurrent consumption of oxidized compounds from the overlying water column. These sediment fluxes are approximated by zero-order equations in the model.

---

[4] The lake model calibration was done using CE-QUAL-W2 version 3.6. However, during the course of Phase 4 work, an updated version (3.7) of the code became available. The calibration presented herein was tested using the updated code and the results looked similar.

For hydrodynamics and associated constituent transport, CE-QUAL-W2 uses laterally averaged equations of fluid motion, namely equations for continuity and for conservation of momentum. Included in these equations are velocity, acceleration, gravity, pressure, and turbulent shear stresses. Additional governing equations include the equation of state, which relates density to temperature and concentration of dissolved substances, and the equation of free water surface, which integrates continuity over the depth of the water column. For details on the hydrodynamic and constituent transport processes that CE-QUAL-W2 simulates, see Appendix A of the CE-QUAL-W2 user manual (Cole and Wells 2008).

For water quality, CE-QUAL-W2 computes the concentrations of user-specified state variables such as algae, DO, organic matter, and forms of nutrients for each model segment and each time step using constituent-specific rate equations that account for sources and sinks associated with biological and chemical processes. The user can specify any number of generic constituents, suspended solids groups, CBOD groups, algal groups, macrophyte groups, zooplankton groups, and epiphyton groups. Numerous processes are associated with these variables (e.g., algal dynamics include photosynthesis, respiration, settling, mortality, and excretion). For detailed descriptions of all water quality processes simulated by CE-QUALW2, see Appendix B of the CE-QUAL-W2 user manual (Cole and Wells 2008).

4.2.3   *Overall Calibration Approach*

Lake model calibration is typically performed in two distinct steps. First, the hydrodynamics are calibrated to predict water transport including flows, dispersion, depths, velocities, water surface elevations, temperature, and conservative constituents such as specific conductance. After satisfactory completion of the hydrodynamic calibration, water quality is calibrated to simulate the major processes of eutrophication kinetics. After water quality calibration, the hydrodynamic calibration is checked again because parameters such as suspended solids affect light penetration and therefore potentially affect water temperature, density, and movement.

For Lake Buchanan, the lake model calibration followed these two steps. However, the calibration for water quality required additional focused data analyses; these analyses focused

on areas where the model performed poorly during initial simulations. Results from these analyses then guided the calibration.

4.2.4   *Calibration Metrics and Goals*

The CE-QUAL-W2 model was calibrated to observed hydrodynamic and water quality measurements from January 1, 1984, through December 31, 2011. Although data were considered for the entire 28-year period, the calibration focused on October 1, 1997 through December 31, 2011, which is the watershed model calibration period (Sections 3.3.2 and 3.3.5). To evaluate model GOF to data, one typically identifies quantitative calibration metrics that compare predictions of simulated constituents to data. GOF measures should quantify absolute error, model bias, and relative error.

Three GOF measures were considered for the lake model: 1) mean absolute error[5] (MAE); 2) mean error (ME); and 3) reliability index (RI). As a gauge of model accuracy, the MAE is the primary indicator of model GOF, as recommended by Cole and Wells (2008). The MAE is calculated simply and is directly interpretable (i.e., its units are the same as the units of the observations). A disadvantage of the MAE is that because it is not normalized by the magnitude of the values, a given MAE target may be easy to achieve when concentrations are very low and much harder to achieve when concentrations are high, even when the overall fit to the high data looks good. The ME is used as a measure of the bias of model predictions. The RI of Leggett and Williams (1981) is applied as a measure of relative error. The RI indicates the average factor by which model predictions differ from observations. A RI of 1 indicates a perfect fit. If all predicted values are one-half order of magnitude apart, a RI of 5 will result. RI values of less than 3 are generally considered to be acceptable for most parameters. RI values that are greater than 10 usually indicate extremely low values near detection limits (often found with some nutrient species) or highly variable parameters, such as algae biomass. One weakness of the RI is that the values are difficult to interpret since they are unitless and their range is expected to vary by parameter. GOF metrics are described in detail in Appendix C. In Sections 4.4.5 and 4.5.5, various model-to-data GOF measures are provided with the calibration results.

---

[5] MAE is identical to the AME statistic used in the CREMs Phase 3 report. While AME is the acronym used in the CE-QUAL-W2 manual, MAE is more common in the literature and is accordingly used herein.

Cole and Wells (2008) do not provide guidelines regarding a priori acceptable levels of error for CE-QUAL-W2. Ultimately, acceptable levels of error should be based on model uncertainty versus water quality prediction requirements of lake managers. However, based on a review of reported model calibration metrics in other systems, calibration goals for MAE were identified for several parameters; these goals were optimistically considered to be potentially achievable (Table 4-1). These calibration goals were not considered strict criteria, but rather as guidelines or objectives. It is worth noting that most of the other systems may have had shorter data collection periods for calibration data and had fewer monitoring sites.

By calibrating to longer periods of data, a lake model can address a broad range of environmental conditions, enhancing its utility for predicting future water quality. However, in addition to natural variation, calibration to a dataset collected over longer periods incorporates concomitant data uncertainty due to changes in analytical methods, sampling procedures, and data quality objectives that may contribute to inflation of the overall MAE metric relative to that reported in short-term modeling efforts. In addition, an artificial contribution to MAE inflation occurs for parameters that sometimes occur below analytical detection limits. As an example, if a PO4 concentration was reported as less than a detection limit of 0.040 mg/L and assumed to contain levels at half the detection limit, and the model predicted a concentration of 0.001 mg/L, the MAE would be calculated as 0.019 mg/L, though the error may have been 0. For these reasons, the MAE calibration goals were applied only as objectives and guidelines, not as strict criteria. The ultimate determination of model calibration is better judged based on the spatial-temporal calibration plots.

Table 4-1
Calibration Goals for Mean Absolute Error

Parameter	Units	Mean Absolute Error
Water level	Meters	0.2
Water temperature	˚C	1
TOC	mg/L	0.6
Chl-a	µg/L	4
TKN	mg/L	0.4
NH4	µg/L	30

Parameter	Units	Mean Absolute Error
NOX	mg/L	0.1
TP	µg/L	20
PO4	µg/L	10

Notes:
These are average mean absolute error goals for the system as a whole.
˚C – degrees Celsius
µg/L – micrograms per liter
Chl-a – chlorophyll-a
mg/L – milligrams per liter
NH4 – ammonium, as nitrogen
NOX – nitrate + nitrite, as nitrogen
PO4 – orthophosphorus, as phosphorus
TKN – total Kjeldahl nitrogen
TOC – total organic carbon
TP – total phosphorus

4.3   General Model Development

This subsection describes the state variables of concern, model time period, and development of the model segmentation.

4.3.1   Selection of State Variables of Concern

The CE-QUAL-W2 model includes a variety of optional state variables to simulate aquatic systems; the user chooses which state variable to include and thereby can control some of the model's complexity. The state variables chosen for water quality simulation for Lake Buchanan are listed in Table 4-2.

Table 4-2
Water Quality State Variables Selected for Simulation

Constituent Name[a]	Include in Phase 4 Model?	Comments
Generic constituents	Yes	Included chloride, specific conductivity, total dissolved solids, water age
Inorganic suspended solids	Yes	One class included
Algae[b]	Yes	Three groups included

Constituent Name[a]	Include in Phase 4 Model?	Comments
Epiphyton	No	Not expected to have a significant impact on the state variables of concern
CBOD	No	Modeled as organic matter groups
NH4	Yes	
NOX	Yes	
PO4	Yes	
Labile dissolved organic matter	Yes	
Refractory dissolved organic matter	Yes	
Labile particulate organic matter	Yes	
Refractory particulate organic matter	Yes	
Dissolved silica	No	Not expected to have a significant impact on the state variables of concern
Particulate biogenic silica	No	Not expected to have a significant impact on the state variables of concern
Total inorganic carbon	No	Total inorganic carbon is not an issue of management concern and does not significantly impact other state variables
Alkalinity	No	Alkalinity is not an issue of management concern and does not significantly impact other state variables
Total iron	No	Iron is included in CE-QUAL-W2 primarily as a sorption site for PO4; this mechanism is not expected to be significant in the Highland Lakes; thus it was not simulated
Dissolved oxygen	Yes	
Organic sediments	No	Organic sediments were not specified because the method selected for simulation uses a constant release and demand instead of using a sediment compartment to accumulate organic sediments and allow their decay
Macrophytes	No	Not expected to have a significant impact on the state variables of concern

Notes:
a – State variables are available in CE-QUAL-W2 Version 3.6.

b – CE-QUAL-W2 simulates algal biomass. However, SWAT outputs Chl-a and the lake calibration data are Chl-a
concentrations. As discussed below, SWAT Chl-a outputs are converted to algal biomass for input to
 CE-QUAL-W2. CE-QUAL-W2 outputs both algal biomass and Chl-a, the latter of which was compared to
monitoring data.
NH4 – ammonium, as nitrogen
NOX – nitrate + nitrite, as nitrogen
PO4 – orthophosphorus, as phosphorus

4.3.2   Model Time Period

The lake model was developed and calibrated using data from January 1, 1984, through
December 31, 2011, matching the time period of output from the watershed model
calibration (Section 3). CE-QUAL-W2 internally calculates the time step necessary for the
model to maintain hydrodynamic numerical stability. The minimum time step specified was
1 second and the maximum time step allowed was set to 3,600 seconds. The model was
specified to output values at noon for each day simulated.

4.3.3   Model Segmentation

Lakes are modeled in CE-QUAL-W2 in two dimensions: 1) the longitudinal direction,
divided (i.e., in the direction of flow) into multiple segments of varying length; and 2) the
vertical direction (i.e., at depth), divided into layers of fixed height. Each longitudinal
segment extends from "bank to bank"; therefore, the model predicts average concentrations
for each segment in the direction transverse to flow as well as for each vertical model layer.
During a model simulation, the number and thickness of vertical layers remain fixed and the
vertical segments become variably wet (i.e., active) or dry (i.e., inactive) depending on the
water surface elevation of the lake.

The main body of the lake is considered to be one "branch." Tributaries and coves adjacent
to the main body are included as additional branches, which must be composed of two or
more initially wet segments. The lake model domain consists of the main body of Lake
Buchanan and its major branches (i.e., coves downstream of Morgan Creek, Campground
Creek, and Redrock Creek, as illustrated in Figure 4-2).

The longitudinal segmentation for the main body of the lake begins at Station 12353 and
ends at Buchanan Dam. Table 4-3 summarizes the longitudinal segmentation and
dimensions of the CE-QUAL-W2 model representing the lake. The entire model domain

consists of 28 longitudinal segments in 4 branches, although 8 of the longitudinal segments are inactive segments required at the upstream and downstream boundaries of each branch. The lake model was segmented vertically into 39 layers of 1-m thickness, including inactive layers on the top and bottom. The computational grid in the longitudinal/vertical plane is shown in Figure 4-3.

Table 4-3
Summary of Longitudinal Segmentation for CE-QUAL-W2 Model

Branch	Number of Active Longitudinal Model Segments	Average Length (km)	Average Width (km) at Various Surface Elevations Above msl		
			301 m	309 m	311 m
Lake Buchanan (Main Branch)	12	1.95	1.84	2.96	3.12
Morgan Creek	3	1.11	0.29	0.66	0.75
Campground Creek	2	1.11	0.45	1.65	1.94
Redrock Creek	3	1.12	0.38	1.23	1.44

Notes:
301 m – minimum elevation measured from 1984 to 2011
309 m – average elevation measured from 1984 to 2011
311 m – elevation at which lake is considered full
km – kilometer
m – meter
msl – mean sea level

The widths of each of the model's computational elements, formed by the longitudinal and vertical segmentation of the model domain, were determined from a bathymetric survey performed by the Texas Water Development Board (TWDB) in March and April 2006 and high-resolution LIDAR data collected by LCRA on December 31, 2006, and January 1, 2007 (TWDB 2007). The raster provided by TWDB was geo-processed using ArcGIS and Interactive Data Language to obtain the widths of each longitudinal segment at elevations corresponding to the top and bottom of each vertical layer.

ArcGIS was also used to determine the lengths and orientations of each longitudinal segment. For each segment, the length was computed by measuring an imaginary line connecting the mid-point of its upstream border to the mid-point of its downstream border at normal pool elevation. Orientations of each longitudinal segment were determined using

ArcGIS and confirmed using the Graphic User Interface program provided by the CE-QUAL-W2 model developers.

The adequacy of the model bathymetry was evaluated by comparing its elevation-volume relationship to that measured during the bathymetric survey. Figure 4-4 compares the measured and modeled elevation-volume relationship. The percent difference in volume was less than or equal to 1% for all elevations except for the bottom four layers, which constitute less than 0.4% of the lake volume at normal pool elevation.

To check that model predictions were independent of the resolution of the computational grid, tests on the longitudinal and vertical grid spacing were performed. Three higher resolution grids were assessed: 1) double the number of vertical segments; 2) double the number of longitudinal segments; and 3) double both the number of vertical and longitudinal segments. For each of these grids, a conservative tracer (i.e., chloride) test was performed by running the model through the entire simulation period with zero tracer for the first year (1984), a constant 1,000 mg/L at the upstream boundary for 2 months (January and February 1985), zero tracer for several years, another constant 1,000 mg/L at the upstream boundary for 2 months (June and July 2002), and zero tracer thereafter. Two time periods for the constant chloride release were selected in order to examine model predictions at different inflow rates; the average upstream flows for January to February 1985 and for June to July 2002 were 32 and 85 cms, respectively. Vertical profiles of predicted chloride and water temperature at the most downstream segment of the lake were reviewed for each month of each simulation year. Model predictions using the higher resolution grids were similar to those using the original grid; larger differences were relatively limited in space and time and were within the uncertainty of the model. These tests confirmed the usage of the original model grid resolution.

4.4   Hydrodynamics Model Development and Calibration

The subsections that follow describe the input development as well as the calibration approach, data, and results for the hydrodynamics portion of the lake model.

4.4.1 Model Inputs

Hydrodynamic inputs to the lake model include initial water temperature, flows, boundary temperatures, boundary concentrations of generic constituents, and meteorological data. Each of these is described in more detail below.

4.4.1.1 Initial Water Temperature

For each model element, the initial water temperature on January 1, 1984, was set to 9.7°C. This temperature was estimated based on interpolation between average temperatures in the lake (all depths and locations with available data) on December 7, 1983, and January 25, 1984. The lake was not thermally stratified at that time.

4.4.1.2 Flows

4.4.1.2.1 Water Balance

CE-QUAL-W2 is highly sensitive to the daily balance of water in the lake. Given the model requirement for mass balance, an imbalance between inflows and outflows would result in changes in lake volume; consequently, water surface elevations predicted by the model may be unrealistic compared to measured elevations. Because of this, a water balance was developed externally and its resulting adjusted flows were then input into the model. The water balance is described in detail in Appendix D.

A water balance was developed for Lake Buchanan from Station 12353 to Buchanan Dam. Review of inflow, release, and elevation data[6] on a daily basis indicated that some adjustments would be necessary to one or more of the water balance components. Inflows included river flows at the upstream boundary of the model from the calibrated SWAT model, runoff from the local watershed and ungaged tributaries (also from the SWAT model), and direct precipitation to the lake surface. Losses included evaporation and releases via turbines and floodgates.

The goal of the adjustments was to provide a good fit of calculated water surface elevations to observed elevations on a daily basis, while minimizing the number of days requiring changes

---

[6] Elevation data provided by the LCRA were converted to NGVD 29 by adding 0.01 feet to elevations measured relative to LCRA's site-specific datum. This was necessary in order to use the volume-elevation tables in NGVD 29 provided by the TWDB for Lake Buchanan (TWDB 2007).

to flows. The adjustment methodology allowed daily deviations from reported elevations to occur as long as they were predicted to self-correct in the near future (i.e., 7 days). For days requiring adjustment, outflows were adjusted first so that the SWAT-predicted flows (and consequently, SWAT-predicted loads) remained unchanged as often as possible. If the new outflow was negative, then outflow was set to zero and the remainder of the adjustment was added to the SWAT results of all upstream, tributary, and runoff flows based on a prorated fraction of total inflow for the day.

4.4.1.2.2 Application of Adjusted Flows to Lake Model

Table 4-4 describes the data sources and locations of inflows to and outflows from the lake model. All inflows to the lake model were derived from the output of the calibrated SWAT model. These inflows were used in development of the water balance (Appendix D), and the resulting adjusted inflows were set as the boundary conditions to the lake model; see Appendix E for details on how adjusted inflows were prorated to each lake segment.

As described in Appendix D, outflows were included as the sum of turbine and floodgate release data and required adjustments during the water balance process. Following the water balance, daily outflows were split into turbine and flood flows by honoring the original turbine data, with excess being assigned to flood flows. During days when the water balance outflow was less than the turbine data, the turbine flow was set to the water balance outflow and flood flow was set to zero.

Outflows were withdrawn from the model through two outlet structures at Buchanan Dam. For turbine flows, one outlet structure was set to 943 feet (287.4 m) above msl, the elevation of the penstock invert plus half of the 12-foot pipe diameter. For flood flows, a second structure was specified at 1,005.37 feet (306.4 m) above msl, the elevation of the 14- and 16- gate spillway crests. During flood gate operation, the smaller 14- and 16-gate sections are typically opened first; rarely is the larger 7-gate section opened (Thomas 2012).

Table 4-4

Lake Model Flows: Tributaries, Outflows, and Directly Connected Watersheds

Branch	Lake Segment [a]	Inflow/Outflow Name
1	2	Upstream (Colorado River): SWAT reach 54
1	2, 3, 4	SWAT sub-basin 59
1	3	SWAT reach 58
1	5, 6, 7, 8	SWAT sub-basin 66
1	6	SWAT reaches 61 and 62
1	8, 9, 10, 11, 16, 17, 18, 21, 22	SWAT sub-basin 71
1	11, 12, 13	SWAT sub-basin 73
1	13	Outflow (Buchanan Dam)
2	16	SWAT reaches 63 and 64
2	17	SWAT reaches 65 and 70
3	21	SWAT reach 67
4	25	SWAT reach 69
4	25, 26, 27	SWAT sub-basin 72

Notes:

See Figure E-1 in Appendix E for a map showing the relationship between watershed and lake model segmentation.

a – Flow from sub-basins listed with multiple lake model segments were apportioned to each segment by drainage area proration.

SWAT - Soil and Water Assessment Tool

4.4.1.3 Boundary Temperatures

Boundary water temperatures for flows from upstream and tributaries, as well as the temperature of the sediment bed, were needed as model inputs. Boundary temperatures were estimated as described below.

4.4.1.3.1 Upstream Water Temperatures

Daily water temperatures for flow to the lake from upstream were linearly interpolated from depth-averaged measurements typically taken on a monthly basis at Station 12355 (Colorado River at Red Bluff). Because temperature data were not available at this site until June 19, 1986, monthly averages were assigned to mid-month and interpolated to obtain daily values from January 1, 1984, to June 18, 1986.

4.4.1.3.2   Tributary Water Temperatures

Water temperature data for tributaries to Lake Buchanan were limited. Morgan Creek data were usually measured monthly or every other month between 1984 and 1990 and then monthly or every other month from 2007 to 2011. No data were available for Campground Creek. Temperature data were only available for one date (June 12, 1996) for Redrock Creek. As a substitute, daily water temperatures for Morgan, Campground, and Redrock Creeks were linearly interpolated from depth-averaged measurements typically taken monthly or every other month at Station 12392 (San Saba River at SH 16 north of San Saba).

4.4.1.3.3   Sediment Bed Temperature

The temperature of the sediment bed was initially set to 14.2 °C, the average water temperature measured at the lake bottom at Station 12344 for the calibration period. As discussed in Section 4.4.5, the sediment bed temperature was changed during calibration to 18 °C.

4.4.1.4   Boundary Concentrations

4.4.1.4.1   Generic Constituents

Specific conductance and chloride concentrations in flow to the lake from upstream were linearly interpolated from depth-averaged measurements at Station 12355 (Colorado River at Red Bluff). Measurements at Station 12355 were taken monthly from June 1986 through January 1990, every other month from April 1990 through June 2010, and weekly from July 2010 through December 2011 for specific conductance; chloride at this location was measured every other month from August 1990 to June 2010 and weekly from July 2010 through December 2011. These conservative tracers are useful in helping to understand and constrain the lake's overall water balance and retention time.

Chloride data were unavailable from January 1, 1984, through August 22, 1990; specific conductance data were unavailable from January 1, 1984, through June 19, 1986. For these time periods, data from Station 12353 (Lake Buchanan at Headwaters) were used. Chloride and specific conductance data at Station 12353 were collected monthly from January 1984 through June 1989, every other month from August 1989 to June 2010, and monthly from August 2010 through December 2011.

For flows from tributaries and runoff, daily concentrations for the generic constituents were linearly interpolated from depth-averaged measurements at Station 12392 (San Saba River at SH 16). Chloride and specific conductance measurements at Station 12392 were taken monthly from January 1984 through June 1989, every other month from August 1989 to June 2010, and monthly or twice a month from July 2010 through December 2011.

4.4.1.5 Meteorological Data

Model inputs were created using hourly values. The hourly cloud cover, wind speed and direction, and air and dew point temperature data were obtained from the National Climatic Data Center (NCDC) for Burnet Municipal Airport and Robert Gray Army Air Force (AAF) station, located approximately 18 km southeast and 60 km northeast of Lake Buchanan, respectively. Data at both locations compared well to the limited wind speed and wind direction data collected around the Highland Lakes during the CREMs expanded monitoring program. Because records at Burnet Municipal Airport do not begin until 1997, data from the Robert Gray AAF station were used for the earlier model time period, January 1, 1984, to December 31, 1996. Additionally, cloud cover data at the Robert Gray AAF station were used for 2007 to 2010 when cloud cover was not measured at Burnet Municipal Airport.

Smaller gaps in various meteorological data were filled differently. Missing records of wind data (wind speed and direction) were replaced using historical averages for a specific hour collected at the same station (e.g., if no data were measured at the Robert Gray AAF station on January 1, 1996, at 2pm, the average of data measured at 2pm from 1984 to 1996 at the Robert Gray AAF station was applied). Smaller gaps of temperature data (air and dew point temperature) were filled with historical averages for a specific hour of a specific day at the same station (e.g., if no data were measured at Burnet Municipal Airport on January 1, 1999, at 2pm, the average of data measured on January 1 at 2pm from 1997 to 2011 at Burnet Municipal Airport was applied). Gaps in cloud cover data were filled using the same approach as the wind data except for the missing data from 1997 to 2010. For cloud cover data measured from 1997 to 2010 at Burnet Municipal Airport, the missing value was replaced if there is a cloud cover data measured at the same time at the Robert Gray AAF station. Otherwise, the missing value was replaced using the historical averages for a specific hour collected at Burnet Municipal Airport.

For cloud cover, the values in the NCDC dataset range from 0 to 8 oktas, representing eighths of the total celestial dome covered by clouds (i.e., 0 oktas for clear to 8 oktas for fully overcast). The input to the lake model required cloud cover on a scale of 0 to 10 rather than 0 to 8; therefore, each NCDC value was multiplied by 1.25. NCDC values of 9 or 10 were reported to represent partial but indeterminate obscuration; model values for these times were set to 5. Daily solar radiation was computed internally in the model based on cloud cover for Lake Buchanan and position on the earth (latitude: 30.82 °North and longitude: 98.40 °West).

4.4.2   Hydrodynamic Calibration Approach

The calibration of the hydrodynamics portion of the lake model involved comparison of model-predicted water surface elevation to data collected at the dam and of model-predicted temperature to data collected at various stations throughout the lake from January 1, 1984, to December 31, 2011.

The calibration objective for the model water surface elevation was to be within 0.2 m of the measured water surface elevation at the dam. This calibration objective was based on the observed intra-day variation in water surface elevation, the variation in lake elevation from upstream to downstream, and uncertainty in the timing of daily inflows and outflows. The calibration objective for water temperature was a MAE of 1.0 °C.

Although the hydrodynamics calibration was evaluated and fine-tuned primarily through comparison of model predictions to water surface elevation and temperature data, model predictions of generic constituents were also compared to data to corroborate the movement of water within the lake. The comparisons were considered qualitative since no MAE objectives existed for specific conductance and chloride.

4.4.3   Calibration Data

Temperature, specific conductance, and chloride data from eight LCRA monitoring sites were used for the Lake Buchanan lake model hydrodynamics calibration (Table 4-5). Special attention was paid to model-to-data comparisons at Lake Buchanan near Buchanan Dam

(station 12344) because it is the deepest and most downstream location and best represents in-lake hydrodynamic processes.

Table 4-5

Lake Model Hydrodynamics Calibration Stations and Sampling Frequency

Station ID	Station Description	Model Segment	Period Of Record for Calibration	Number of Days with Measurements		
				Water Temperature	Specific Conductance	Chloride
12344	Lake Buchanan near Buchanan Dam	13	1984 – 2011	226	226	217
12353	Lake Buchanan at Headwaters	2	1984 – 2011	216	216	205
12352	Lake Buchanan near Beaver Creek Cove	6	1990 – 2011	211	211	136
12351	Lake Buchanan at Buchanan Village	6	1984 – 1990	72	72	72
12350	Lake Buchanan approximately 0.75 miles south of Garret Island	7	2010 – 2011	208	208	17
12347	Lake Buchanan at Rocky Point	9	1984 – 2011	218	218	206
12349	Lake Buchanan at the confluence of Council and Morgan Creeks	18	1984 – 1990, 2007 – 2011	112	112	113
12346	Lake Buchanan at Golden Beach	26	1984 – 1990, 2010 – 2011	87	87	88

Notes:
See Figure 4-2 for locations. Stations on the figure but not listed in the table had very infrequent data.

Water temperatures were measured by LCRA at several locations in the lake from 1984 to 2011. From January 1984 through June 1989 and from June 2010 through 2011, temperatures were recorded every month. During other time periods, water temperatures were measured every other month. For each sampling event, measurements were taken at the surface (approximately 0.3 m below the surface) and at generally 1- to 1.5-m intervals for the entire depth of the water column. From October 2010 through September 2011, these measurements were supplemented with hourly temperature data measured every 2 m for the top 10 m by a thermistor chain at Rocky Point (Station 12347).

Specific conductance and chloride were also measured by LCRA at several locations in the lake from 1984 to 2011. From January 1984 through June 1989 and from June 2010 through 2011, temperatures were recorded every month. During other time periods, water temperatures were measured every other month. For specific conductance, measurements were taken at the surface (approximately 0.3 m below the surface) and at generally 1- to 1.5-m intervals for the entire depth of the water column. For chloride, measurements were generally taken at the surface and near the bottom of the water column.

Water surface elevations were recorded daily at midnight (i.e., midnight the morning of a given day) by the LCRA River Operations Center at Buchanan Dam for the entire simulation period.

4.4.4   Model Parameterization

Model parameter values considered during the hydrodynamic calibration process were primarily set to the default recommended values cited in the CE-QUAL-W2 manual (Cole and Wells 2008), as shown in Table 4-6. As was done for the CREMs Phase 2 and Phase 3 models, the explicit treatment of the vertical eddy viscosity in the longitudinal momentum equation was selected in lieu of the default implicit solution technique and the Manning equation for bottom surface roughness was used instead of the default Chezy formulation. Changes to other parameter values during calibration are discussed in Section 4.4.5.

Table 4-6
CE-QUAL-W2 Hydrodynamic Parameters Adjusted During Calibration

Parameter	Calibration Value	Default Value	Units	Description
SLHTC	TERM	TERM	---	Specifies either ET or term-by-term surface heat exchange calculations
AFW	9.2	9.2	---	Coefficients in wind speed effects on heat exchange
BFW	0.46	0.46	---	
CFW	2.0	2.0	---	
SLTRC	ULTIMATE	ULTIMATE	---	Transport solution scheme, ULTIMATE, QUICKEST, or UPWIND
THETA	0.55	0.55	---	Time weighting for vertical advection scheme
AX	1.0	1.0	$m^2\,sec^{-1}$	Longitudinal eddy viscosity
DX	1.0	1.0	$m^2\,sec^{-1}$	Longitudinal eddy diffusivity

Parameter	Calibration Value	Default Value	Units	Description
CBHE	1.2	0.3	watts m^2 sec^{-1}	Coefficient of bottom heat exchange
TSED	18.0	---	˚C	Sediment temperature
FI	0.01	0.01	---	Interfacial friction factor
TSEDF	1.0	1.0	---	Heat lost to sediments that is added back to water column
FRICC	MANN	CHEZY	---	Bottom friction solution, MANNING or CHEZY
FRICT	0.035	---	---	Manning's n coefficient for bottom friction
Z0	0.001	0.001	M	Water surface roughness height
AZC	W2	W2	---	Form of vertical turbulence closure algorithm, NIC, PARAB, RNG, W2, W2N, or TKE
AZSLC	EXP	IMP	---	Specified either implicit, IMP, or explicit, EXP, treatment of the vertical eddy viscosity in the longitudinal momentum equation
AZMAX[a]	1.0E-3	1.0	m^2 sec^{-1}	Maximum value for vertical eddy viscosity
WSC	1.0	---	---	Wind sheltering coefficient
EXH2O	0.45	0.25 or 0.45	m^{-1}	Extinction coefficient for pure water
EXSS	0.01	0.01	m^{-1} / g m^{-3}	Extinction coefficient for inorganic solids
EXOM	0.2	0.2	m^{-1} / g m^{-3}	Extinction coefficient for organic solids
EXA[b]	0.2 / 0.3 / 0.2	0.2	m^{-1} / g m^{-3}	Extinction coefficient for algae
BETA	0.45	0.45		Fraction of incident solar radiation absorbed at the water surface

Notes:
a – The default value listed in the CE-QUAL-W2 manual is 1.0 m^2 sec^{-1}. The model developer recommends a value of 1.0E-3 m^2 sec^{-1} if AZSLC was set to EXP (see Appendix E of the CREMs Phase 2: Lake Travis Final Report [Anchor QEA and Parsons 2009a]).
b – The calibration values reflect values used for the three algal groups modeled and were determined during water quality calibration.
ET – equilibrium temperature
M – meter

4.4.5   Calibration Results

The calibration of predicted water surface elevation to data at Buchanan Dam (Segment 13) is shown in Figure 4-5. By design of the water balance (see Appendix D), the model-predicted elevation tracks the data very well. Comparing the modeled daily water surface elevation to measured elevations, the MAE was 0.05 m, well below the MAE target of 0.2 m. Flow inputs were taken from the water balance and not adjusted during calibration.

Figure 4-6a shows temporal plots of average predicted water temperatures and data in the top third, middle third, and bottom third of the water column near Buchanan Dam (Segment 13). Temperature plots for other stations are shown in Figures 4-6b through 4-6h. Figure G-1 of Appendix G shows predicted temperature depth profiles and data for each month of each simulation year near Buchanan Dam; temperature depth profiles for the seven other calibration stations are included in Figures G-2 through G-8; and additional depth profiles of thermistor data at Rocky Point are shown in Figure G-9. The model predictions agree well with data both seasonally and at depth. Starting in the spring and continuing into the summer and early fall, the lake becomes thermally stratified with the top-most layer (epilimnion) having higher temperatures than the deeper hypolimnion, typically by about 10 to 15 degrees. During late fall and early winter, the lake "turns over" as surface water cooled by lower air temperatures becomes more dense and sinks. This exchange of surface and bottom waters is enhanced by wind-induced mixing, which maintains generally uniform water temperatures during the winter over the entire water depth.

To evaluate the model performance numerically, MAE was calculated across three water depths and compared to the calibration goal of 1 °C. MAE and other model fit statistics are summarized in Table 4-7. The metrics show that on average, the model does a good job of reproducing temperature observations; MAE ranged from 0.68 to 0.73 °C at the main calibration station and frequently was below the target at the other calibration stations. The calibration performance for system-wide water temperature is on target with applications of CE-QUAL-W2 on other systems (see Table 2 of Appendix D).

Table 4-7
Lake Model Performance Metrics for Water Temperature

Station ID (Lake Model Segment)	Depth	Mean Error (˚C)	Mean Absolute Error (˚C) **	Reliability Index	Number of Samples
12344 (13)	Top Third	-0.28	0.68	1.05	224
	Middle Third	0.05	0.73	1.06	223
	Bottom Third	0.00	0.73	1.07	222
12353 (2)	All Depths *	0.14	1.06	1.10	186
12352 (6)	Top Third	0.17	0.67	1.05	210
	Middle Third	0.13	0.59	1.04	209

Station ID (Lake Model Segment)	Depth	Mean Error (°C)	Mean Absolute Error (°C) **	Reliability Index	Number of Samples
	Bottom Third	0.29	0.95	1.07	205
12351 (6)	Top Third	0.01	0.71	1.05	72
	Middle Third	-0.19	0.61	1.05	69
	Bottom Third	1.48	1.80	1.13	69
12350 (7)	Top Third	-0.13	0.64	1.04	207
	Middle Third	0.05	0.62	1.04	206
	Bottom Third	-0.75	1.08	1.10	19
12347 (9)	Top Third	-0.25	0.66	1.05	216
	Middle Third	0.12	0.69	1.05	214
	Bottom Third	0.31	0.74	1.06	195
12349 (18)	Top Third	-0.24	0.71	1.05	111
	Middle Third	-0.19	0.64	1.05	111
	Bottom Third	2.57	2.77	1.22	111
12346 (26)	Top 2 Meters	-0.15	0.65	1.05	87
	Middle Third	-0.11	0.57	1.05	67
	Bottom 2 Meters	-0.84	0.84	1.14	3

Notes:

* Statistics for all layers combined due to shallowness of lake at this station

** System-wide average mean absolute error target = 1 °C

°C - degrees Celsius

Several parameters were adjusted during temperature calibration of the model, particularly to improve the model fit to vertical patterns in temperature data at the dam site throughout the year (Table 4-5). The wind sheltering coefficient was set to 1.0 for every longitudinal segment, which effectively means that the wind on Lake Buchanan is equal to the wind at the meteorological station. For an improved fit to hypolimnetic water temperature data and depth of the thermocline, the temperature of the sediment bed was adjusted to 18 °C and the coefficient of bottom heat exchange was increased from 0.3 to 1.2. The annual average temperature for Burnet[7] is 18 °C; the CE-QUAL-W2 manual suggests using the local annual average air temperature as the sediment temperature.

As mentioned in Section 4.4.4, two hydrodynamic formulations differed from default values. The treatment of the vertical eddy viscosity in the longitudinal momentum equation was

---

[7] http://www.usclimatedata.com/climate.php?location=USTX0186

treated as explicit as recommended by the CE-QUAL-W2 manual for reservoirs. The maximum recommended value for the vertical eddy viscosity for the explicit scheme is 0.001 (See Appendix E of the CREMs Phase 2: Lake Travis Final Report [Anchor QEA and Parsons 2009a]). The Manning equation for bottom surface roughness was used instead of the default Chezy formulation.

Figures 4-7a and 4-8a show the temporal plots of specific conductance and chloride in the upper, middle, and lower third of the water column at Station 12344. Overall, the model does a good job in reproducing specific conductance and chloride concentrations. It accurately tracks lake response to a large salt pulse that occurred from 1987 to 1990 due to saline water release from the Natural Dam Salt Lake in 1987 to 1989 (Raines and Rast 1999), as well as other peaks and dips in concentration. Figures 4-7b through 4-7h and 4-8b through 4-8h show other locations for specific conductance and chloride, respectively. Model performance metrics are provided in Tables 4-8 and 4-9. Vertical depth profiles of specific conductance and chloride are provided in Appendix G.

Table 4-8
Lake Model Performance Metrics for Specific Conductance

Station ID (Lake Model Segment)	Depth	Mean Error (µS/cm)	Mean Absolute Error (µS/cm)	Reliability Index	Number of Samples
12344 (13)	Top Third	-102.84	113.19	1.22	225
	Middle Third	-97.53	110.96	1.21	224
	Bottom Third	-74.42	106.31	1.20	223
12353 (2)	All Depths *	-33.11	130.61	1.23	186
12352 (6)	Top Third	-99.06	110.10	1.21	210
	Middle Third	-91.55	113.48	1.21	209
	Bottom Third	-42.01	141.47	1.25	205
12351 (6)	Top Third	-66.52	95.07	1.18	72
	Middle Third	-69.50	102.53	1.18	69
	Bottom Third	-81.83	122.41	1.21	69
12350 (7)	Top Third	-100.91	110.14	1.21	207
	Middle Third	-89.20	113.74	1.21	207
	Bottom Third	-62.63	137.21	1.21	19

Station ID (Lake Model Segment)	Depth	Mean Error (µS/cm)	Mean Absolute Error (µS/cm)	Reliability Index	Number of Samples
12347 (9)	Top Third	-101.59	112.47	1.22	217
	Middle Third	-92.88	109.81	1.21	215
	Bottom Third	-69.07	101.12	1.19	196
12349 (18)	Top Third	-63.35	82.08	1.16	111
	Middle Third	-56.94	78.61	1.15	111
	Bottom Third	-61.35	89.82	1.17	111
12346 (26)	Top 2 Meters	-52.68	77.95	1.14	87
	Middle Third	-54.57	84.48	1.15	67
	Bottom 2 Meters	-2.01	9.00	1.01	3

Notes:

* Statistics for all layers combined due to shallowness of lake at this station.

µS/cm – microsiemens per centimeter

Table 4-9

Lake Model Performance Metrics for Chloride

Station ID (Lake Model Segment)	Depth	Mean Error (mg/L)	Mean Absolute Error (mg/L)	Reliability Index	Number of Samples
12344 (13)	Top 2 Meters	25.56	31.25	1.72	217
	Middle Third	40.84	45.66	2.13	43
	Bottom 2 Meters	26.84	32.80	1.76	216
12353 (2)	All Depths *	19.78	26.75	1.42	175
12352 (6)	Top 2 Meters	5.16	12.50	1.30	136
	Middle Third	10.41	10.41	1.29	3
	Bottom 2 Meters	5.85	13.41	1.31	130
12351 (6)	Top 2 Meters	59.77	66.56	2.30	72
	Middle Third	58.50	65.41	2.29	72
	Bottom 2 Meters	56.06	63.70	2.29	72
12350 (7)	Top 2 Meters	12.94	15.68	1.54	17
	Middle Third	10.33	16.98	1.71	7
	Bottom 2 Meters	10.63	17.28	1.72	7
12347 (9)	Top 2 Meters	26.67	31.93	1.73	207
	Middle Third	43.30	48.46	2.28	33
	Bottom 2 Meters	26.86	32.43	1.66	186
12349 (18)	Top 2 Meters	46.68	47.95	2.06	113
	Middle Third	43.89	43.89	2.56	30
	Bottom 2 Meters	45.29	45.29	2.60	30

Station ID (Lake Model Segment)	Depth	Mean Error (mg/L)	Mean Absolute Error (mg/L)	Reliability Index	Number of Samples
12346 (26)	Top 2 Meters	58.79	60.27	2.30	88
	Middle Third	13.83	13.83	1.39	10
	Bottom 2 Meters	13.82	13.82	1.39	10

Notes:
* Statistics for all layers combined due to shallowness of lake at this station.
mg/L – milligram per liter

4.5   Water Quality Model Development and Calibration

A discussed in Section 4.1, the water quality calibration for the lake model proved to be challenging because Lake Buchanan is first in a series of lakes and subsequently receives loadings from a very large upland watershed.

The subsections that follow describe the water quality inputs; loading summaries; calibration approach, data, and results; sensitivity analyses; and bounding calibration of the lake model. Additional discussion is included on the focused data analyses and consequent influence on water quality calibration.

4.5.1   Model Inputs

Water quality inputs to the lake model include upstream boundary, tributary, and runoff concentrations, as well as initial conditions. Each of these is described below.

4.5.1.1   Upstream Boundary, Tributary, and Runoff Concentrations

Water quality constituent concentrations in lake inflows from upstream, tributaries, and runoff (direct drainage) were derived from flows and loadings predicted by the calibrated daily SWAT model. SWAT output was processed into input to CE-QUAL-W2 by:
1) spatially relating each lake model segment to the appropriate watershed model subbasin to determine the appropriate SWAT output file type to use; 2) deconvoluting SWAT state variables to CE-QUAL-W2 state variables to determine daily loads; and 3) incorporating deconvoluted variables into the lake model through the calculation of daily concentrations. Appendix E provides more detail.

4.5.1.2   Initial Conditions

Initial conditions for CE-QUAL-W2 state variables were estimated from ambient data from the first sampling event of 1984, which occurred on January 25. Measurements from all depths at the Station 12344 (Lake Buchanan near Buchanan Dam) were averaged. Values for some water quality parameters could be used directly. Other measured water quality parameters needed to be deconvoluted into state variables because the measured parameters did not directly correspond to the input variables required by the model.

The input variables of organic matter, inorganic suspended solids, and algae required deconvolution of data. Deconvolution follows data-based equations used for CREMs Phase 2 (Section 4.5.1.2 of the CREMs Phase 2: Lake Travis Final Report [Anchor QEA and Parsons 2009a]). For organic matter, average percentages of dissolved organic matter were computed based on data measured in 2010 and 2011 at Station 12344 as part of the CREMs expanded monitoring program; the averages were 99% for C, 79% for N, and 28% for P. No measured information was available for the labile/refractory split; each organic matter group was assumed to be 100% refractory. For inorganic suspended solids, the deconvolution required C to algal biomass and C to detrital organic matter ratios; these were both set to 0.45, the recommended CE-QUAL-W2 values. For algae, the deconvolution needed the stoichiometric ratio between algal biomass and Chl-a; a value of 0.1 mg algae/µg Chl-a was used, identical to the calibrated value from the CREMs Phase 3 models. Algal concentrations were divided by three for the three algal groups modeled.

4.5.2   Loading Summaries

Figure 4-9 illustrates the proportion of overall loads to the lake of major water quality parameters during the period 1984 to 2011. These sources are grouped as follows: 1) inflows from upstream watershed (i.e., the Colorado River); and 2) the sum of runoff inflows from the local watershed plus modeled tributaries to Lake Buchanan. Inflows from upstream constitute 96 to 100% of loads of all water quality constituents except for PO4, which has an 88% contribution from upstream.

Contrary to the other lakes modeled during the CREMs project, the watershed contributes the vast majority of loads to Lake Buchanan since the upstream boundary of the model

receives loadings from the watershed. See Figure 4-12 of the CREMs Phase 2: Lake Travis Final Report (Anchor QEA and Parsons 2009a) and Figures 4-28 through 4-30 of the CREMs Phase 3: Final Report (Parsons and Anchor QEA 2011) for loading summaries for the other lakes.

4.5.3   *Water Quality Calibration Approach*

The calibration of the water quality portion of the lake model involved fitting model predictions of nutrients, total organic carbon, Chl-a, and DO to data collected near Buchanan Dam from January 1, 1984, through December 31, 2011. Model parameters were adjusted to match the following observed water quality constituents:

- NH4, TKN, and NOX
- PO4 and TP
- Total organic carbon (TOC)
- DO
- Chl-a

Calibration required adjusting model parameters to optimize the model's fit to data. The majority of water quality parameters were measured at the surface and at one additional hypolimnion depth. For these parameters, calibration focused on matching temporal trends in surface concentrations (top 2 m; top one-third of the water column for DO) and in bottom concentrations (bottom 2 m; bottom one-third of water column for DO).[8] Secondary consideration was given to model to data comparisons for the middle of the water column where limited data were collected; in such instances, model results for the middle third of the water column (not the middle 2 m) were compared to data collected at the thermocline. For DO, measurements were available at multiple depths throughout the water column, so calibration for this parameter also focused on matching observed vertical profiles. Chl-a is most meaningful near the surface[9]; as a result, model to data comparisons were made only for the top 2 m of the water column.

---

[8] For DO, the top one-third and bottom one-third of the water column were used to maximize the use of the vertical profile data.

[9] Chl-a pigments degrade at various rates under various conditions (Wetzel 2001), so the measured Chl-a concentration below the photic zone is more a reflection of degradation rates, which CE-QUAL-W2 does not simulate, than it is of algal biomass or productivity.

The calibration for water quality required additional focused data analyses; these analyses focused on areas where the model performed poorly during initial model simulations. Results from these analyses guided the calibration.

In the sections below, the focus is on Station 12344 (Lake Buchanan near Buchanan Dam; model segment 13) because this station has a long POR and best represents the overall character of Lake Buchanan. Stations exhibiting different behaviors, trends (i.e., long-term shifts in concentration), and patterns (i.e., short-term shifts such as seasonal changes in concentration) from those observed at Station 12344 are noted and discussed.

The lake model performance needs to be considered in light of the complexities of the Lake Buchanan system and the magnitudes of the calibration targets (which are relatively small values, based on data from downstream lakes) relative to ambient concentrations (which are sometimes relatively high in Lake Buchanan relative to downstream lakes).

4.5.4   Calibration Data

Water quality data from eight LCRA monitoring sites were used for the Lake Buchanan lake model water quality calibration (Table 4-10, Figure 4-2). Special attention was paid to model to data comparisons at Lake Buchanan near Buchanan Dam (Station 12344) because it is the deepest and most downstream location and best represents in-lake processes..

Table 4-10

Lake Model Water Quality Calibration Stations and Sampling Frequency

Station ID	Station Description	Model Segment	Period Of Record for Calibration	Number of Days with Measurements							
				NH4	TKN	NOX	PO4	TP	TOC	DO	Chl-a
12344	Lake Buchanan near Buchanan Dam	13	1984 – 2011	218	217	204	207	218	226	216	217
12353	Lake Buchanan at Headwaters	2	1984 – 2011	203	205	195	195	205	205	216	203
12352	Lake Buchanan near Beaver Creek Cove	6	1990 – 2011	136	135	126	124	135	136	211	134
12351	Lake Buchanan at Buchanan Village	6	1984 – 1990	72	72	72	72	72	72	72	72
12350	Lake Buchanan approximately 0.75 miles south of Garret Island	7	2010 – 2011	17	17	17	9	17	17	16	16
12347	Lake Buchanan at Rocky Point	9	1984 – 2011	204	203	196	195	203	205	218	204
12349	Lake Buchanan at the confluence of Council and Morgan Creeks	18	1984 – 1990, 2007 – 2011	113	113	113	101	113	113	112	112
12346	Lake Buchanan at Golden Beach	26	1984 – 1990, 2010 – 2011	88	88	88	81	88	88	87	87

Notes:

See Figure 4-2 for locations. (Note: there are stations in Figure 4-2 that are not listed in the table because they had infrequent data.)

Chl-a – chlorophyll-a

DO – dissolved oxygen

NH4 – ammonium, as nitrogen

NOX – nitrate+nitrite, as nitrogen

PO4 – orphophosphate, as phosphorus

TKN – total Kjeldahl nitrogen

TOC – total organic carbon

TP – total phosphorus

4.5.4.1   Lake Complexities and Calibration Expectations

The Lake Buchanan calibration effort faced several complexities that were not encountered (or not encountered to the same degree) in previous phases of CREMs. As discussed in Section 4.5.4.2, the robust 28-year data record for Lake Buchanan clearly shows an increasing trend in summertime hypolimnetic concentrations of nutrients.[10] This trend could not be satisfactorily represented using the time invariant zero-order sediment release capabilities of CE-QUAL-W2. In addition, recent algal blooms, particularly in dry late summers, could not be adequately characterized by the model using traditional stoichiometric requirements. Both trends could not be reproduced in the initial model runs, which had a more traditional water quality calibration approach.

Another complexity of Phase 4 is that Lake Buchanan is the first in the series of Highland Lakes. For the other CREMs lake models, a large percentage of each lake's inflows was defined using an interpolation (to fill in gaps in data) of data at an upstream boundary condition defined by a dam inflow. For Lake Buchanan, the upstream boundary was defined through predictions from the SWAT model. While interpolated data are subject to missing extreme events, SWAT is subject to potentially exaggerating extreme events, largely because of a lack of calibration data at high flows. Additionally, Lake Buchanan appears to be experiencing more dramatic temporal changes in water quality than the other Highland Lakes. For all of these reasons, the Lake Buchanan model proved to be difficult to calibrate and the results presented in Section 4.5.6 represent the culmination of more than 100 model runs.

For the Lake Buchanan model, the calibration targets were set to the same values as the MAE targets used in CREMs Phase 3 (and Phase 2; see Section 4.2.4 of this document). However, Lake Buchanan has characteristics that are distinct from the downstream Highland Lakes. Several water quality constituents (e.g., NH4 and PO4 in the hypolimnion and Chl-a in the epilimnion) often occur in Lake Buchanan at greater concentrations than in the other Highland Lakes, so a MAE target based on modeling results of CE-QUAL-W2 in other systems is harder to achieve in Lake Buchanan. In other words, to achieve the Phase 3 MAE

---

[10] The term "nutrients" is used in this document to generically refer to bioavailable forms of nitrogen and phosphorus, which are the most common nutrients limiting algal growth in freshwater systems.

targets in Lake Buchanan, the relative error of the Lake Buchanan model must be less than in the Phase 3 models. For example, achieving a MAE goal for PO4 of 0.01 mg/L in the hypolimnion of Lake LBJ (which typically has concentrations of less than 0.01 to 0.03 mg/L) is easier than achieving the same MAE goal in the hypolimnion of Lake Buchanan, which in recent years has PO4 concentrations ranging from less than 0.01 mg/L in the winter to more than 0.2 mg/L in the summer.

4.5.4.2   Focused Data Analyses

The calibration for water quality required additional focused data analyses that were formulated and performed while the model was being calibrated; these analyses focused on areas where the model performed poorly during initial calibration attempts. Results from these analyses then guided the rest of the calibration. This section describes the data-based evidence for the following:

- Increasing sediment nutrient release rates, and consequently hypolimnetic nutrient concentrations, with time
- Increased frequency and magnitude of late summer algal blooms, particularly in dry years
- Steady but very low concentrations of epilimnetic nutrients throughout time

Hypolimnetic Nutrients

Figure 4-10 illustrates the 28-year record of annual maximum hypolimnetic PO4 and NH4 concentrations near Buchanan Dam (Station 12344, segment 13 of the model). This figure also illustrates several characteristics of Lake Buchanan. First and foremost, the hypolimnetic concentrations of these nutrients have increased over time. Maximal nutrient concentrations in the hypolimnion of Lake Buchanan in recent years are approximately six times the measured levels in the mid-1980s. Second, PO4 and NH4 concentrations accumulate in tandem, with a high concentration of one nutrient generally matched by a high concentration of the other, and similarly with low concentrations. Third, the average mass ratio of concentrations (N:P) predicted by the regressions is 8.4:1, which is very similar to that commonly assumed for marine and freshwater plankton (i.e., the Redfield ratio, which is a N:P molar ratio of 16:1, or 7.2:1 by mass; Wetzel 2001).

One hypothetical explanation for the increase in hypolimnetic nutrients is that of episodic large-scale enrichment of the sediments. However, this is not supported by the results shown in Figure 4-10. For example, the so-called "Christmas Flood" of 1991, which was followed by a very wet spring in 1992, is not followed by a clear enrichment of the sediments; both 1992 and 1993 were relatively low years for hypolimnetic nutrient concentrations. One source of complexity when looking at these data on an individual year basis is that the theoretical maximum nutrient concentration in any given year should occur on the last day before turnover. Because both the exact sampling dates and the date of turnover vary by year,[11] some data points may represent conditions immediately before turnover, and some may represent conditions several weeks prior to turnover. Additionally, the summertime duration of anoxia in the hypolimnion, as well as the volume of the hypolimnion, vary somewhat from year to year and both would be expected to impact the hypolimnetic concentrations of nutrients. These variations do not decrease the validity of the overall trends, but do suggest that one should not over-interpret the data from any single year.

Nutrients in the hypolimnion, in and of themselves, do not constitute a direct water quality concern. The importance of accumulation of nutrients in the hypolimnion is that greater concentrations in the hypolimnion result in greater concentration driving forces across the thermocline and, consequently, greater fluxes of nutrients to the epilimnion. These nutrients may then promote algal growth in the epilimnion.

This observed increase in hypolimnetic nutrient concentrations in Lake Buchanan is substantially greater than that observed in the other Highland Lakes. Data at their respective dams suggest that Lake Travis hypolimnetic nutrient concentrations (CREMs Phase 2: Lake Travis Final Report [Anchor QEA and Parsons 2009a], Figures 4-44 and 4-59) have increased by about three times (from 1984 to 2007), whereas Lake Marble Falls, Lake LBJ, and Inks Lake do not appear to have increased at all (CREMs Phase 3: Final Report [Parsons and Anchor QEA 2011], Figures 4-36, 4-39, 4-88, 4-112, 4-145, and 4-151).

---

[11] In the early portion of the POR, LCRA staff typically collected October samples in late October, with sampling occasionally occurring after lake turnover. In later years, LCRA staff typically collected samples earlier in the month. Because lake turnover occurs at different times in the fall of each year, this subtle shift is important to understand when scrutinizing October data.

Epilimnetic Chlorophyll-a

In most freshwater systems, increasing nutrient concentrations generally lead to increasing algal growth. Figure 4-11 shows the 28-year record of individual Chl-a measurements in the epilimnion near Buchanan Dam. This figure shows a trend of increasing Chl-a concentrations over the POR. The linear regression for this plot indicates that, on average, the Chl-a concentrations in recent years are approximately four times those in the mid-1980s.

Of particular interest is evidence supporting a linkage between increasing hypolimnetic concentrations of nutrients with increasing epilimnetic concentrations of Chl-a. The highest hypolimnetic nutrient concentrations are observed from August to October of each year and would consequently be expected to have the largest influence on the epilimnion in these months. Figure 4-12 shows the average Chl-a concentration for August to October versus the antecedent 12-month average upstream inflows as predicted by SWAT. At low flows, an interesting temporal pattern exists. Low flow periods in the 1980s and 1990s were followed by relatively low Chl-a concentrations (commensurate with, or lower than, high flow years in those decades). Low flow periods in the 2000s were followed by substantially higher Chl-a concentrations.

Dry years exhibited generally higher Chl-a concentrations than wet years in the 2000s. Dry years have the lowest inflows and thus the least opportunity for nutrient loads from the watershed. Indeed, in the very dry years of 2006, 2008, 2009, and 2011, many inflows to Lake Buchanan dried up completely and lake levels dropped dramatically (Figure 4-5). This suggests that recent watershed inflows are not always the primary source of the nutrients that fuel algal growth in the summer. Rather, the data suggest that cumulative inflows and/or other loads over the course of many years have enriched the sediments, leading to increased nutrient release during anoxic conditions and higher flux of nutrients to the epilimnion to fuel late summer algal growth.

Epilimnetic Nutrients

While increases in hypolimnetic nutrient and epilimnetic Chl-a concentrations are clear in the data, the same cannot be said for epilimnetic nutrient concentrations. Figure 4-13 illustrates individual PO4 and NH4 data, and associated linear regressions, for the 28-year

POR. In the epilimnion, many samples were reported as below the detection limit, both early and late in the POR. Samples above the detection limits exhibit no meaningful pattern and regressions indicate no trends in the data. These data suggest that Lake Buchanan remains a nutrient-limited system, where the increasing nutrients fluxing across the thermocline in recent years continue to be quickly taken up by algae, keeping ambient dissolved nutrient concentrations very low.

4.5.5   Model Parameterization

Model parameters adjusted during the water quality calibration are shown in Table 4-11. Results from the focused data analyses guided the water quality calibration. The major changes during calibration were to the sediment nutrient release rates and algal parameterization. This subsection describes these two changes as well as other adjustments to model parameters.

Table 4-11

CE-QUAL-W2 Water Quality Parameters Adjusted During Calibration

Parameter	Description	Default Value	Calibration Value *	Units	Basis
AG	Maximum algal growth rate	2.0	2.0 / 1.1 / 2.0	day^{-1}	calibration parameter
AR	Maximum algal respiration rate	0.04	0.04 / 0.03 / 0.04	day^{-1}	calibration parameter
AE	Maximum algal excretion	0.04	0.04 / 0.02 / 0.04	day^{-1}	calibration parameter
AM	Maximum algal mortality	0.1	0.12 / 0.06 / 0.12	day^{-1}	calibration parameter
AS	Algal settling rate	0.1	0.08 (all groups)	m day^{-1}	calibration parameter
AHSP	Algal half-saturation for phosphorus-limited growth	0.003	0.003 / 0.002 / 0.003	g m^{-3}	calibration parameter
AHSN	Algal half-saturation for nitrogen-limited growth	0.014	0.014 / 0.0 / 0.014	g m^{-3}	calibration parameter
ASAT	Light saturation intensity at maximum photosynthetic rate	75	70 (all groups)	W m^{-2}	calibration parameter
AT1	Lower temperature for algal growth	5	7 / 23/ 10	˚C	calibration parameter
AT2	Lower temperature for maximum algal growth	25	14 / 28 / 20	˚C	calibration parameter
AT3	Upper temperature for maximum algal growth	35	20 / 35 / 25	˚C	calibration parameter
AT4	Upper temperature for algal growth	40	25 / 40 / 35	˚C	calibration parameter
AK1	Fraction of algal growth at AT1	0.1	0.1 (all groups)	---	model default
AK2	Fraction of maximum algal growth at AT2	0.99	0.99 (all groups)	---	model default
AK3	Fraction of maximum algal growth at AT3	0.99	0.99 (all groups)	---	model default
AK4	Fraction of algal growth at AT4	0.1	0.1 (all groups)	---	model default
ALGP	Stoichiometric equivalent between algal biomass and phosphorus	0.005	0.007 / 0.002 / 0.007	---	calibration parameter
ALGN	Stoichiometric equivalent between algal biomass and nitrogen	0.08	0.07 / 0.02 / 0.07	---	calibration parameter
ALGC	Stoichiometric equivalent between algal biomass and carbon	0.45	0.45 (all groups)	---	model default
ACHLA	Stoichiometric ration between algal biomass and chlorophyll-a	0.05	0.1 (all groups)	---	calibration parameter
ALPOM	Fraction of algal biomass that is converted to POM when algae die	0.8	0.8 (all groups)	---	model default
ANEQN	Equation number for algal ammonia preference	2	2 (all groups)	---	model default
ANPR	Algal half-saturation constant for ammonia preference	0.001	0.03 (all groups)	g m^{-3}	calibration parameter

Parameter	Description	Default Value	Calibration Value *	Units	Basis
LDOMDK	Labile dissolved organic matter decay rate	0.1	0.05	day^{-1}	calibration parameter
RDOMDK	Refractory dissolved organic matter decay rate	0.001	0.008	day^{-1}	calibration parameter
LRDDK	Labile to refractory conversion rate	0.01	0.01	day^{-1}	model default
LPOMDK	Labile particulate organic matter decay rate	0.08	0.04	day^{-1}	calibration parameter
RPOMDK	Refractory particulate organic matter decay rate	0.001	0.001	day^{-1}	model default
LRPDK	Labile to refractory conversion rate	0.01	0.01	day^{-1}	model default
POMS	Particulate organic matter settling rate	0.1	0.4	m day^{-1}	calibration parameter
OMT1	Lower temperature for organic matter decay	4	15	˚C	calibration parameter
OMT2	Upper temperature for organic matter decay	25	25	˚C	model default
OMK1	Fraction of organic matter decay at OMT1	0.1	0.1	---	model default
OMK2	Fraction of organic matter decay at OMT2	0.99	0.99	---	model default
ORGP	Stoichiometric equivalent between organic matter and phosphorus	0.005	0.007	---	calibration parameter
ORGN	Stoichiometric equivalent between organic matter and nitrogen	0.08	0.07	---	calibration parameter
ORGC	Stoichiometric equivalent between organic matter and carbon	0.45	0.45	---	model default
PO4R	Sediment release rate of phosphorus	0.001	0.0012†	Fraction of SOD as g m^{-2} day^{-1}	calibration parameter
PARTP	Phosphorus partitioning coefficient for suspended solids	0.0	0.0	---	model default
NH4R	Sediment release rate of ammonium	0.001	0.01†	Fraction of SOD as g m^{-2} day^{-1}	calibration parameter
NH4DK	Ammonium decay rate	0.12	0.12	day^{-1}	model default
NH4T1	Lower temperature for ammonia decay	5	10	˚C	calibration parameter
NH4T2	Lower temperature for maximum ammonia decay	25	25	˚C	model default
NH4K1	Fraction of nitrification rate at NH4T1	0.1	0.1	---	model default
NH4K2	Fraction of nitrification rate at NH4T2	0.99	0.99	---	model default
NO3DK	Nitrate decay rate	0.03	0.03	day^{-1}	model default
NO3S	Denitrification rate from sediments	0.001	0.15	m day^{-1}	calibration parameter

Parameter	Description	Default Value	Calibration Value *	Units	Basis
FNO3SED	Fraction of NO3 diffused into the sediments that becomes part of organic nitrogen in the sediments	0.0	0.0	---	model default
NO3T1	Lower temperature for nitrate decay	5	10	°C	calibration parameter
NO3T2	Lower temperature for maximum nitrate decay	25	25	°C	model default
NO3K1	Fraction of denitrification at NO3T1	0.1	0.1	---	model default
NO3K2	Fraction of denitrification at NO3T2	0.99	0.99	---	model default
O2NH4	Oxygen stoichiometry for nitrification	4.57	4.57	---	model default
O2OM	Oxygen stoichiometry for organic matter decay	1.4	1.4 (all groups)	---	model default
O2AR	Oxygen stoichiometry for algal respiration	1.1	1.1 (all groups)	---	model default
KDO	Dissolved oxygen half-saturation constant	0.1	0.1	$g\ m^{-3}$	model default
SOD	Sediment oxygen demand, zero-order	---	0.8 except 1.6 for one segment	$g\ O_2\ m^{-2}\ day^{-1}$	calibration parameter
SODT1	Lower temperature for zero-order SOD or first-order sediment decay	4	4	°C	model default
SODT2	Upper temperature for zero-order SOD or first-order sediment decay	25	25	°C	model default
SODK1	Fraction of SOD at SODT1	0.1	0.1	---	model default
SODK2	Fraction of SOD at SODT2	0.99	0.99	---	model default
FSOD	Fraction of the zero-order SOD used	1	1	---	model default

Notes:

* For parameters with three numbers, the values are listed in the order of the algal groups modeled: ALG1, ALG2, and ALG3 (nominally diatoms, blue-greens, and greens, respectively).

† The phosphorus and ammonia sediment release rates in this table are the base rates used in 1984. In subsequent years, these rates are incremented to match the data, as discussed in Section 4.5.5.1.

°C – degrees Celsius

day^{-1} – per day

$g\ O_2\ m^{-3}$ – grams oxygen per cubic meter

$g\ m^{-3}$ – grams per cubic meter

$W\ m^{-2}$ – watts per square meter

$m\ day^{-1}$ – meters per day

4.5.5.1   Sediment Nutrient Release Rates

The increasing trend in hypolimnetic nutrients observed in data over time necessitated a modest recoding of the CE-QUAL-W2 model. CE-QUAL-W2 has limited functionality to represent the release of dissolved nutrients from sediments under anaerobic conditions; namely, the model is limited to spatially variable but temporally constant zero-order maximal release rates for PO4 and NH4. To specify a linearly increasing sediment release rate that matched the data, the model was recoded so that each year had incrementally higher release rates than the previous year (Appendix F). In the first year of the simulation, PO4R and NH4R were set to 0.0012 and 0.01, respectively. These fractional rates were incrementally increased by an equal amount each year such that for the last year of the simulation (2011, i.e., year 28), the fractional rates were 0.007 and 0.058, respectively. At Buchanan Dam, as at most stations, the epilimnion model fit is within the MAE target of 0.03 mg/L.

Specifying a time variable nutrient release rate from the sediments resulted in a good calibration fit to the hypolimnetic nutrient concentrations (Section 4.5.6). While sediment release is very likely the source of the observed increases in hypolimnetic nutrient concentrations, it is not entirely clear that the corresponding increase in nutrient flux across the thermocline could account for the observed increases in summertime algal concentrations. Nutrient flux across the thermocline is controlled by the concentration gradient between the hypolimnion and epilimnion and the resistance caused by the strong density gradients of the thermocline. The resistance to mass transfer created by the density gradients of the thermocline is largely controlled by the temperature calibration. As discussed in Section 4.4.5, the temperature calibration is well within the calibration target and suggests that the overall mass transfer rate across the thermocline is adequately quantified. Preliminary model runs demonstrated that with the temperature and hypolimnetic nutrient concentrations calibrated, adequate algae could not be grown to match the Chl-a data using CREMs Phase 3 stoichiometric ratios because there were not enough nutrients in the epilimnion. Accordingly, changes to algal parameterization were required.

4.5.5.2   Algal Parameterization

To promote summertime algal growth in the model to reasonably match Chl-a data in the later years, several parameters in the second (of three) algal group (ALG2; nominally blue-green algae) were modified. Changes to algal parameterization were implemented to provide an adequate fit the observed and repeatable patterns in Chl-a data. These changes should not be construed as definitive support of the underlying mechanisms; rather, they were the most practicable means of fitting the data within the limitations of the CE-QUAL-W2 model.

4.5.5.2.1   Nitrogen Fixation

The Michaelis-Menten half-saturation coefficient for nitrogen was set to zero for the second algal group. This change activates nitrogen fixation. Nitrogen fixation is a mechanism by which certain species of blue-green algae acquire their nitrogen resources from the atmosphere instead of water (Wetzel 2001). Nitrogen fixation is known to be energetically unfavorable relative to taking up nitrogen from water, so algae only fix nitrogen when aqueous sources are largely unavailable (Ferber et al. 2004). Unfortunately, the model does not adjust the extent of nitrogen fixation based on the availability of aqueous nitrogen. Rather, the modeled algal group fixes nitrogen whenever it grows. Because nitrogen fixation is effectively a source of nitrogen to the waterbody, this framework could lead to substantial overestimation of dissolved nitrogen compounds.

To ameliorate this potential overprediction, three changes were made to the nitrogen fixing algal group (ALG2). The temperature rate coefficients for this group were set to allow growth only during the summertime. The lower temperature rate coefficient was set to 23 °C, which means that the growth rate for this algal group at 23 °C is only 10% of maximum. Maximal growth was set to be achieved at 28 °C for this algal group. These settings constrain growth (as well as respiration, excretion, and mortality, as these three sink mechanisms are tied to identical temperature coefficients) to the warmest temperatures only. Additionally, the nitrogen stoichiometric requirement for ALG2 was reduced from 0.07 gN/gOM ([gram nitrogen per gram organic matter] as used in the other algal groups and in the CREMs Phase 3 models) to 0.02 gN/gOM so that when algal growth occurs, the model adds less nitrogen to the water body. By having a lower stoichiometric requirement than is likely to be accurate, the model is effectively, albeit approximately, simulating an algal

assemblage that fixes nitrogen part of the time and/or an algal assemblage that has variable stoichiometry (in the model, stoichiometry is time invariant; in actuality, algae have some ability to adjust cellular quotas to reflect ambient concentrations; Sterner and Elser 2002). Finally, the growth rate of ALG2 was set to a relatively low value (1.1 day^{-1}) and the loss rates were also set to relatively low values (0.03, 0.02, and 0.06 day^{-1} for respiration, excretion, and mortality, respectively). Collectively, these changes significantly reduce nitrogen growth limitations without excessively impacting the NH4 and NOX calibrations.

4.5.5.2.2   Phosphorus Stoichiometry

PO4 also limits algal growth in Lake Buchanan and there is no corollary to nitrogen fixation for phosphorus. To provide an adequate model fit to the observed summertime algal growth, the phosphorus stoichiometric requirement of ALG2 was reduced from 0.007 gP/gOM (as used in the other algal groups and in the CREMs Phase 3 models) to 0.002 gP/gOM. This allows more algae, and hence more Chl-a, to accumulate per unit of phosphorus. Different algal species have different phosphorus requirements and algae are known to adjust their cellular quota of phosphorus based on phosphorus availability in the water column. Essentially, through a mechanism often called "luxury" uptake (Sterner and Elser 2002; Reynolds 1984), some algal species can accumulate excess phosphorus during times of plenty and leverage those resources to fuel additional growth when other factors are ideal (e.g., sunlight and temperature). The use of a diminished phosphorus stoichiometric requirement does not provide definitive evidence that either a summertime algal species with low phosphorus requirements or luxury uptake occurs. However, given the combination of a good hypolimnetic nutrient calibration, a good temperature calibration, and very low inflows, no other way was found to calibrate the model to data. Other possible mechanisms that may contribute essential nutrients to algae in the epilimnion are discussed in Section 4.5.6.2.

4.5.5.2.3   Algal Stoichiometry

Because algal stoichiometric ratios are an important part of any lake model and exhibit a high degree of variability, the changes in algal stoichiometry described in the previous section are important to understand in context of observed ranges in the literature.

CE-QUAL-W2 does not directly simulate Chl-a; rather, the model simulates algal organic matter. The model default stoichiometric values are AN = 0.08 gN/gOM, AP = 0.005 gP/gOM, and ACHLA = 0.05 mgOM/µgChl-a. Combined, these values result in N:Chl-a and P:Chl-a ratios of 4 and 0.25, respectively. These ratios mean that for every unit of Chl-a grown in the model, using default stoichiometry, four units of N are required and 0.25 units of P are required. For comparison, a common benchmark for algal stoichiometry is the Redfield ratio, which is a C:N:P mass ratio of approximately 41:7.2:1 (Sterner and Elser 2002). Algal biomass is often considered to consist of 45% carbon; and a carbon:Chl-a ratio of 100 is a reasonable middle value (Sterner and Elser 2002). Combined, these values give N:Chl-a and P:Chl-a ratios of 17.6 and 2.4, respectively. These values are several times higher than the model defaults; however, this range is within of the range of values observed in the literature (Wetzel 2001; Reynolds 1984; Sterner and Elser 2002; Bowie et al. 1985).

In the calibrated model, the (nominally) diatoms group (ALG1) and the (nominally) greens group (ALG3) have N:Chl-a and P:Chl-a ratios of 7 and 0.7, respectively. These values are between the CE-QUAL-W2 defaults and Redfield-based estimations. The (nominally) blue-greens algal group (ALG2) has N:Chl-a and P:Chl-a ratios of 2 and 0.2, respectively. These values are somewhat below the CE-QUAL-W2 default values. In a nutrient limited system such as Lake Buchanan, it is not unreasonable to expect low N and low P requirements for some or all of the algal groups. Additionally, low stoichiometric ratios specified for ALG2 is the only practicable method of mimicking the possible effects of nitrogen fixation and variable stoichiometry.

4.5.5.3   Additional Model Parameterization

Additional model parameters were modified during the water quality calibration. Key parameter changes are detailed in this subsection. Several lower temperature thresholds (e.g., algal growth and chemical reactions) were increased to allow for greater seasonal variability in these kinetics in the relatively warm (i.e., relative to many other applications of CE-QUAL-W2) Lake Buchanan. To reduce nitrate concentrations, the sediment denitrification rate (0.15 m/day) was increased relative to CREMs Phase 3 models and the CE-QUAL-W2 default (all 0.001 m/day), but remained lower than the value used in CREMs Phase 2 (Lake Travis, 0.35 m/day).

To calibrate the model not only to TOC but to TKN and TP as well, the detrital settling rate was increased relative to the CE-QUAL-W2 default (0.4 versus 0.1 m/day). The labile decay rates (for dissolved and particulate) were decreased relative to the defaults and earlier phases of CREMs. This was done to reduce the rate of oxygen demand (and PO4 and NH4 spikes) when large storm events enter the lake. The DO data rarely, if ever, exhibit the large drops that can occur in the model when large loads of organic matter enter the lake and decay rapidly. By decreasing the labile decay rate, reaeration is better able to balance the oxygen loss during decomposition, resulting in good fit to the DO data. To provide a small amount of additional nutrients to fuel algal growth in the summertime, the maximum refractory dissolved decay rate was increased relative to the defaults and earlier phases of CREMs (excepting Lake Marble Falls, which used a higher rate) and the temperature rate coefficients were adjusted so that the decay would achieve this rate in the epilimnion in the summertime but be closer to the default rate in the winter and the in the hypolimnion.

4.5.6   Calibration Results and Discussion

The Lake Buchanan model produced a reasonable fit to the overall trends and patterns in data. This subsection presents the calibration results[12] and ends with calibration discussion.

As with any long-term dataset, several high outliers exist in the data. These outliers are often caused by large inflows that quickly and dramatically change concentrations of a portion of, or occasionally all of, the lake. In a minority of cases, the high outliers may have

---

[12] The calibration results presented include those at model segment 2, which is the most upstream active segment in the model grid. This segment is shallow (approximately 5 meters deep at the average water elevation from 1984 through 2011) and goes dry when lake water levels are low. Accordingly, statistics for this segment are calculated using the results for all active layers; temporal plots show gaps when this lake model segment goes dry. While this model segment (which approximates true bathymetry using stacked rectangular boxes) goes dry when lake levels are low, in reality, the field crew will sample from the incised river channel as far as it is possible to navigate if the river is truly dry. Accordingly, water quality measurements are always collected and assigned to Station 12353, regardless of lake levels. Having no model results to compare to data could possibly be remedied by increasing the resolution of the model grid throughout the model domain. The addition of such resolution, however, would not be expected to change model results much and would be detrimental to the model numerical stability and simulation time; see Section 4.3.3 for a discussion on grid resolution testing.

been caused by field sampling and analytical problems. It is often not possible to calibrate a lake model to outliers without substantial degradation of the model calibration fit to more typical data values. Accordingly, high outliers are often the most difficult for lake models to match and it is notable that the Lake Buchanan model matches some of these events.

4.5.6.1 Calibration Results

4.5.6.1.1 Nitrogen

Figures 4-14 through 4-16 illustrate the model-predicted and measured temporal profiles of NH4, TKN, and NOX at all calibration stations. Calibration metrics are provided in Tables 4-12 through 4-14.

Ammonium, as Nitrogen

In the epilimnion, concentrations of NH4 in many samples are below the detection limit and the model is generally within the range of the data. Neither the data nor the model exhibit a long-term NH4 trend (see Figure 4-14). The data also exhibit no clear patterns, although there is some suggestion of higher NH4 in the winter than other seasons. The model shows fairly regular increases in NH4 from late winter through the spring, followed by a tapering after turnover. While turnover introduces significant NH4 to the epilimnion, the DO in the epilimnion promotes significant nitrification, resulting in rapid decreases in NH4 throughout the water column. At Buchanan Dam, as at most other stations, the model fit is within the calibration MAE target of 30 µg/L (micrograms per liter).

Table 4-12
Lake Model Performance Metrics for Ammonia

Station ID (Segment)	Depth	Mean Error (µg/L)	Mean Absolute Error (µg/L) **	Reliability Index	Number of Samples
12344 (13)	Top 2 Meters	15.53	25.28	2.96	218
	Middle Third	-9.44	57.08	3.31	43
	Bottom 2 Meters	24.06	148.50	3.22	215
12353 (2)	All Depths *	35.04	43.00	3.28	173
12352 (6)	Top 2 Meters	28.80	39.58	3.70	136
	Middle Third	-7.31	41.91	7.32	3
	Bottom 2 Meters	36.04	73.52	4.02	130

Station ID (Segment)	Depth	Mean Error (µg/L)	Mean Absolute Error (µg/L) **	Reliability Index	Number of Samples
12351 (6)	Top 2 Meters	17.87	27.11	3.10	72
	Middle Third	14.43	28.43	3.12	72
	Bottom 2 Meters	7.30	33.19	3.28	72
12350 (7)	Top 2 Meters	-4.88	19.79	5.16	17
	Middle Third	21.34	64.24	3.72	7
	Bottom 2 Meters	-138.65	148.22	4.40	7
12347 (9)	Top 2 Meters	17.64	27.91	3.07	205
	Middle Third	2.30	54.25	3.26	34
	Bottom 2 Meters	83.20	152.48	3.44	184
12349 (18)	Top 2 Meters	13.87	27.49	3.56	113
	Middle Third	8.23	46.85	4.23	30
	Bottom 2 Meters	-97.80	143.31	5.32	30
12346 (26)	Top 2 Meters	4.61	16.97	2.86	88
	Middle Third	-12.12	13.66	3.64	10
	Bottom 2 Meters	-28.47	29.28	4.09	10

Notes:
* Statistics for all layers combined due to shallowness of lake at this station
** System-wide average mean absolute error target = 30 µg/L
µg/L – micrograms per liter

In the hypolimnion, the NH4 data show an increasing trend (see Figure 4-14) and seasonal patterns. Soon after the onset of stratification, DO resources in the hypolimnion are consumed, anaerobic conditions develop, nitrification ceases, and NH4 is released from the sediments. This pattern in the data is strong and repeatable. The model, using the specified time variable sediment release rates, reasonably matches the overall patterns and trends of NH4 in the hypolimnion. Because of the high magnitude of the values, the model does not achieve the original calibration MAE goal for NH4 (all goals were set based on modeling results in other systems). However, despite the relatively high MAE, the reliability index (which is scaled relative to the magnitude of the data) is nearly as good for the hypolimnion model fit as for the epilimnion.

Total Kjeldahl Nitrogen

TKN is a combination of NH4 and organic nitrogen, which in turn is composed of dissolved and particulate fractions. At Station 12344 (Lake Buchanan Near Buchanan Dam), as

predicted by the model, the majority of organic nitrogen is in the dissolved form. This makes sense, as most particulates settle before reaching the dam. In the epilimnion, where NH4 concentrations are fairly consistently low in both the model and data, the TKN model fit is reasonable, but often underpredicts the data (Figure 4-15). This underprediction is difficult to correct, because the model often overpredicts TP and it is difficult in the model to increase TKN without increasing TP, and vice versa (see Section 4.5.6.1.2). The major loss mechanisms for TKN are settling of the particulate fraction and decay of the organic fraction to NH4 combined with nitrification of NH4 to NO3. The settling and decay rates of organic nitrogen are, by definition in the model, equal to the rates for organic phosphorus. Accordingly, it is difficult to provide a better fit to TKN without making the TP fit worse. In the hypolimnion, the patterns and trends of NH4 are evident in the TKN data, and the model provides a reasonable fit to the data.

Table 4-13
Lake Model Performance For Total Kjeldahl Nitrogen

Station ID (Lake Model Segment)	Depth	Mean Error (mg/L)	Mean Absolute Error (mg/L) **	Reliability Index	Number of Samples
12344 (13)	Top 2 Meters	0.31	0.34	2.54	217
	Middle Third	0.28	0.32	2.49	43
	Bottom 2 Meters	0.26	0.37	2.17	216
12353 (2)	All Depths *	0.48	0.53	2.59	175
12352 (6)	Top 2 Meters	0.31	0.34	2.53	135
	Middle Third	0.15	0.16	1.71	3
	Bottom 2 Meters	0.29	0.36	2.57	129
12351 (6)	Top 2 Meters	0.36	0.38	2.58	72
	Middle Third	0.36	0.38	2.52	72
	Bottom 2 Meters	0.35	0.38	2.53	72
12350 (7)	Top 2 Meters	0.32	0.32	2.52	17
	Middle Third	0.40	0.40	3.03	7
	Bottom 2 Meters	0.21	0.42	2.79	7
12347 (9)	Top 2 Meters	0.26	0.29	2.47	204
	Middle Third	0.32	0.34	2.33	33
	Bottom 2 Meters	0.34	0.40	2.27	183

Station ID (Lake Model Segment)	Depth	Mean Error (mg/L)	Mean Absolute Error (mg/L) **	Reliability Index	Number of Samples
12349 (18)	Top 2 Meters	0.28	0.31	2.52	113
	Middle Third	0.31	0.33	2.49	30
	Bottom 2 Meters	0.18	0.34	2.30	30
12346 (26)	Top 2 Meters	0.30	0.32	2.51	88
	Middle Third	0.26	0.26	2.20	10
	Bottom 2 Meters	0.26	0.26	2.23	10

Notes:
* Statistics for all layers combined due to shallowness of lake at this station.
** System-wide average mean absolute error target = 0.4 mg/L
mg/L – milligram per liter

Nitrate +Nitrite, as Nitrogen

Occasional large NOX spikes are seen in the model results (Figure 4-16). These are based on SWAT-predicted loads entering the lake from the watershed and upstream. In the epilimnion, the model exhibits some spikes that are not seen in the data (e.g., spring of 1990), but other spikes in the model are seen in the data (e.g., late fall of 2000). Seasonally, the data are generally below the detection limit in the summer and higher in the winter. The model shows modest increases in nitrate during the late summer due to NH4 flux from the hypolimnion and subsequent nitrification. These late summer increases are also a result of nitrogen fixation by ALG2 and subsequent release and nitrification in the water column. In the model, concentrations tend to decrease in the spring because of algal uptake and flux of NOX to the sediments due to denitrification in the sediments.

In the hypolimnion, the data exhibit a fairly regular pattern of concentrations above the detection limit in the winter and spring (when the water column is mixed and oxic), with rapid declines in the spring following the onset of stratification (as oxygen resources are exhausted and bacteria turn to NOX as their preferred electron acceptor). This pattern is matched by the model, although the model typically predicts lower concentrations than measured. Numerous tests were conducted at different denitrification rates, but algal growth in the epilimnion was often sensitive to these rates (i.e., other denitrification rates resulted in a poorer fit to Chl-a). Regardless, the model fit to NOX is close to the statistical calibration MAE target of 0.1 mg/L.

Table 4-14

Lake Model Performance Metrics for Nitrate+Nitrite

Station ID (Lake Model Segment)	Depth	Mean Error (mg/L)	Mean Absolute Error (mg/L) **	Reliability Index	Number of Samples
12344 (13)	Top 2 Meters	-0.08	0.12	4.36	203
	Middle Third	-0.06	0.10	4.44	42
	Bottom 2 Meters	0.02	0.11	3.51	202
12353 (2)	All Depths *	-0.48	0.62	7.35	166
12352 (6)	Top 2 Meters	-0.13	0.16	5.82	126
	Middle Third	-0.18	0.18	43.10	3
	Bottom 2 Meters	-0.11	0.16	4.91	121
12351 (6)	Top 2 Meters	-0.08	0.17	3.91	72
	Middle Third	-0.11	0.19	4.02	72
	Bottom 2 Meters	-0.08	0.16	3.59	72
12350 (7)	Top 2 Meters	-0.14	0.14	13.96	17
	Middle Third	-0.19	0.19	21.89	7
	Bottom 2 Meters	-0.15	0.15	13.31	7
12347 (9)	Top 2 Meters	-0.09	0.13	4.57	197
	Middle Third	-0.12	0.12	4.69	32
	Bottom 2 Meters	-0.01	0.12	3.60	177
12349 (18)	Top 2 Meters	-0.11	0.15	4.63	113
	Middle Third	-0.14	0.14	6.16	30
	Bottom 2 Meters	-0.09	0.09	4.48	30
12346 (26)	Top 2 Meters	-0.09	0.12	4.02	88
	Middle Third	-0.09	0.09	6.02	10
	Bottom 2 Meters	-0.10	0.10	6.39	10

Notes:

* Statistics for all layers combined due to shallowness of lake at this station.

** System-wide average mean absolute error target = 0.1 mg/L

mg/L – milligram per liter

4.5.6.1.2   Phosphorus

Figures 4-17 through 4-18 illustrate the model-predicted and measured temporal profiles of PO4 and TP at all calibration stations. Calibration metrics are provided in Tables 4-15 and 4-16.

Orthophosphorus

The epilimnetic PO4 data are dominated by non-detects at a variety of detection limits. No trends are evident in the data (Figure 4-17). There is some evidence that samples above the detection limit occur most frequently after turnover in the late fall and early winter. This is supported conceptually, because when the large mass of hypolimnetic PO4 mixes with the epilimnion, the concentration in the epilimnion will increase. Following fall turnover, the primary PO4 loss mechanism of algal growth exists, but is hampered by suboptimal temperatures and sunlight. Accordingly, the removal of PO4 from the water column is somewhat limited and samples above the detection limit are theoretically expected and occasionally observed. The statistical MAE of the model in the epilimnion is within the calibration target, but is of questionable value due to the frequency of non-detects in the data.

In the hypolimnion, the pattern is very similar to that observed for NH4 and the model fit, using time variable sediment release, is reasonable. Because the magnitudes of these values far exceed the calibration MAE goal of 10 μg/L, the model does not achieve the MAE goal, but has a reliability index better than that of the epilimnion (Table 4-15).

Table 4-15
Lake Model Performance Metrics for Orthophosphorus

Station ID (Lake Model Segment)	Depth	Mean Error (µg/L)	Mean Absolute Error (µg/L) **	Reliability Index	Number of Samples
12344 (13)	Top 2 Meters	-1.65	8.72	3.23	207
	Middle Third	-11.45	14.00	2.92	39
	Bottom 2 Meters	-7.52	24.55	2.66	205
12353 (2)	All Depths *	-5.09	25.78	3.91	171
12352 (6)	Top 2 Meters	0.23	10.75	4.04	124
	Middle Third	-6.29	6.29	4.21	3
	Bottom 2 Meters	-6.69	19.39	3.76	118
12351 (6)	Top 2 Meters	2.50	6.10	3.36	72
	Middle Third	0.41	6.24	2.67	72
	Bottom 2 Meters	-3.21	8.18	2.76	72
12350 (7)	Top 2 Meters	-14.13	14.15	5.57	9
	Middle Third	-27.22	27.22	6.43	2
	Bottom 2 Meters	-97.65	97.65	15.71	2

Station ID (Lake Model Segment)	Depth	Mean Error (µg/L)	Mean Absolute Error (µg/L) **	Reliability Index	Number of Samples
12347 (9)	Top 2 Meters	-1.15	8.05	3.30	195
	Middle Third	-10.93	12.02	3.06	30
	Bottom 2 Meters	-8.55	22.59	2.98	174
12349 (18)	Top 2 Meters	18.51	26.11	3.31	101
	Middle Third	-8.06	10.69	4.45	20
	Bottom 2 Meters	-28.81	30.03	4.60	20
12346 (26)	Top 2 Meters	-1.45	5.62	3.21	81
	Middle Third	-17.76	17.83	6.07	7
	Bottom 2 Meters	-26.15	26.15	11.92	7

Notes:

* Statistics for all layers combined due to shallowness of lake at this station.

** System-wide average mean absolute error target = 10 µg/L

µg/L – micrograms per liter

Total Phosphorus

For TP, the data exhibit no trends or patterns and are characterized by a large fraction of non-detects (Figure 4-18). The model has spikes from the watershed that are sometimes supported by the data (e.g., late 2000) and sometimes not (e.g., mid-2007). One complexity for all organic inputs (nitrogen, phosphorus, and carbon) is that common sense suggests that larger storm events mobilize more particulates and that the fraction of particulates (and possibly refractory particulates) in large storms is probably greater than in small storms. However, dissolved, particulate, refractory, and labile forms cannot be output from SWAT and the monitoring data are, at this time, insufficient to generate functional relationships between flow and the percentage of these forms. To develop such relationships, a robust dataset of concentrations of dissolved and particulate organics, as well as degradation studies for refractory versus labile, would need to be developed across a range of flow rates. Currently, the RSS program does not differentiate dissolved and particulate fractions, and the Phase 4 CREMs monitoring program (which does) is dominated by low flow measurements. If concentration data were collected that demonstrated a usable relationship between dissolved/particulate fractions and flow, these data could be used to improve the model inputs and likely the model fit. Similarly, if laboratory studies were implemented to evaluate refractory and labile fractions, such information could also be used to improve the model inputs and model fit. Overall, the model generally overpredicts TP in the epilimnion and is outside of the MAE calibration target (Table 4-16), but increasing the organic matter settling rate or decay rate (and subsequent uptake and settling of algae) would further compromise the TKN and TOC model fits. The final calibration was considered to be a reasonable compromise between these organic species. In the hypolimnion, the TP data and model largely reflect the patterns in PO4 and the model MAE is, like for PO4, somewhat greater than the target.

Table 4-16
Lake Model Performance Metrics for Total Phosphorus

Station ID (Lake Model Segment)	Depth	Mean Error (µg/L)	Mean Absolute Error (µg/L) **	Reliability Index	Number of Samples
12344 (13)	Top 2 Meters	-3.60	37.82	2.90	218
	Middle Third	-29.32	37.27	4.10	43
	Bottom 2 Meters	-12.89	49.42	2.63	216
12353 (2)	All Depths *	-6.71	72.66	2.55	175
12352 (6)	Top 2 Meters	-1.43	41.24	2.55	135
	Middle Third	-29.22	29.22	5.81	3
	Bottom 2 Meters	-1.87	55.86	2.54	129
12351 (6)	Top 2 Meters	-10.06	27.48	2.66	72
	Middle Third	-13.65	29.72	2.67	72
	Bottom 2 Meters	-20.69	34.55	2.77	72
12350 (7)	Top 2 Meters	-15.15	23.73	2.70	17
	Middle Third	-8.05	28.10	2.63	7
	Bottom 2 Meters	-41.26	51.79	2.88	7
12347 (9)	Top 2 Meters	-9.93	32.14	2.86	204
	Middle Third	-28.78	30.72	3.37	33
	Bottom 2 Meters	-0.39	59.19	2.71	183
12349 (18)	Top 2 Meters	-18.21	24.19	2.86	113
	Middle Third	-15.52	30.24	3.28	30
	Bottom 2 Meters	-39.34	50.64	3.71	30
12346 (26)	Top 2 Meters	-18.39	23.21	2.98	88
	Middle Third	-20.23	31.34	3.31	10
	Bottom 2 Meters	-26.13	36.33	3.48	10

Notes:
* Statistics for all layers combined due to shallowness of lake at this station.
** System-wide average mean absolute error target = 20 µg/L
µg/L – micrograms per liter

4.5.6.1.3   Total Organic Carbon

The TOC data exhibit no trends, no patterns, and essentially no variability (Figure 4-19). Nearly all of the data at Buchanan Dam are between 3 and 6 mg/L. Even at the Lake Buchanan headwaters site, the data are rarely outside of this range, suggesting that particulate organics settle out quickly and the remaining organics decay slowly.

Overall, the model fit is weaker for TOC than for the other state variables (Table 4-17). Fortunately, TOC has little impact on the calibration of the other state variables; it only affects DO, which has a robust calibration.

Table 4-17

Lake Model Performance Metrics for Total Organic Carbon

Station ID (Lake Model Segment)	Depth	Mean Error (mg/L)	Mean Absolute Error (mg/L) **	Reliability Index	Number of Samples
12344 (13)	Top 2 Meters	1.49	2.00	2.04	217
	Middle Third	1.31	1.80	2.04	43
	Bottom 2 Meters	1.06	1.88	1.99	216
12353 (2)	All Depths *	0.29	1.90	1.71	175
12352 (6)	Top 2 Meters	1.36	1.91	1.89	136
	Middle Third	1.81	1.81	1.65	3
	Bottom 2 Meters	1.23	1.95	1.92	130
12351 (6)	Top 2 Meters	0.73	1.53	1.75	72
	Middle Third	0.72	1.48	1.71	72
	Bottom 2 Meters	0.78	1.65	1.81	72
12350 (7)	Top 2 Meters	2.44	2.44	2.00	17
	Middle Third	2.67	2.67	2.14	7
	Bottom 2 Meters	2.27	2.40	2.23	7
12347 (9)	Top 2 Meters	1.32	1.85	1.93	207
	Middle Third	1.27	1.55	1.79	33
	Bottom 2 Meters	1.11	1.88	1.97	185
12349 (18)	Top 2 Meters	1.35	1.86	1.90	113
	Middle Third	1.62	1.91	1.88	30
	Bottom 2 Meters	1.34	2.00	2.02	30
12346 (26)	Top 2 Meters	1.27	1.69	1.88	88
	Middle Third	2.23	2.23	1.91	10
	Bottom 2 Meters	2.38	2.38	2.03	10

Notes:

* Statistics for all layers combined due to shallowness of lake at this station.

** System-wide average mean absolute error target = 0.6 mg/L

mg/L – milligram per liter

4.5.6.1.4 Dissolved Oxygen

The DO data exhibit no obvious long-term trends (Figure 4-20). The data do, however, exhibit strong seasonal patterns. The pattern in the epilimnion is largely caused by the dependence of DO saturation on temperature coupled with significant reaeration caused by wind. The pattern in the hypolimnion is largely caused by nitrification, organic matter decay, and sediment oxygen demand (SOD), which collectively consume oxygen faster than

the rate at which oxygen is supplied from the epilimnion. Both the epilimnetic and hypolimnetic datasets are well fit by the model (Table 4-18).

Table 4-18
Lake Model Performance Metrics for Dissolved Oxygen

Station ID (Lake Model Segment)	Depth	Mean Error (mg/L)	Mean Absolute Error (mg/L)	Reliability Index	Number of Samples
12344 (13)	Top Third	0.16	0.60	1.13	225
	Middle Third	-0.13	0.88	1.60	224
	Bottom Third	-0.40	0.86	1.78	224
12353 (2)	All Depths *	-0.54	0.95	1.18	186
12352 (6)	Top Third	0.05	0.71	1.12	210
	Middle Third	-0.62	0.88	1.22	209
	Bottom Third	-1.45	1.81	2.06	205
12351 (6)	Top Third	0.32	0.87	1.15	72
	Middle Third	-0.57	0.83	1.19	69
	Bottom Third	0.94	1.58	1.44	69
12350 (7)	Top Third	0.15	0.62	1.10	207
	Middle Third	-0.51	0.94	1.34	207
	Bottom Third	-1.91	1.94	1.79	19
12347 (9)	Top Third	0.21	0.57	1.09	217
	Middle Third	-0.20	0.83	1.52	215
	Bottom Third	-0.50	1.06	2.00	196
12349 (18)	Top Third	-0.13	0.89	1.12	111
	Middle Third	-1.14	1.31	1.50	111
	Bottom Third	-1.38	1.64	2.10	79
12346 (26)	Top Third	0.36	0.58	1.09	87
	Middle Third	0.16	0.73	1.18	67
	Bottom Third	-0.14	0.77	1.10	3

Notes:
* Statistics for all layers combined due to shallowness of the lake at this station.
mg/L – milligram per liter

The decline of DO in the hypolimnion in the springtime following stratification is fairly well fit by the model across all 28 years of data, even though the SOD was set to a constant maximal value (i.e., SOD was not increased annually like NH4 and PO4 releases were). In

reality, SOD has probably increased over the years[13] and the model could probably have been calibrated equally well with such an increase. However, since this increase was not necessary to calibrate the model adequately, it was not implemented.

The duration of anoxia in the hypolimnion does not appear to have changed over the 28-year POR, nor is there clear evidence for a long-term trend in the depth of the thermocline (see DO and temperature profiles in Figures F-26 through F-33 and F1 through F-9, respectively). These observations suggest that the increase in hypolimnetic concentrations of nutrients over the 28-year period is caused by an increase in the sediment release rate, as opposed to an increase in the release duration or a decrease in the hypolimnetic volume.

4.5.6.1.5 Chlorophyll-a

Algae in the model respond to a variety of factors including mixing, temperature, light, nitrogen, phosphorus, competition, and the balance between growth and loss rates. In reality, algae respond to even more forces, including cyclic predator-prey relationships with zooplankton, variable stoichiometry, additional (e.g., trace) nutrient requirements, buoyancy regulation, and competition between a much wider array of species. Accordingly, Chl-a calibration in lake models can be challenging. For the Lake Buchanan model, a combination of model parameters that provided an adequate fit to the trends and patterns in the data could not be found without both an increasing sediment release rate for nutrients and an algal group that fixes nitrogen and has low phosphorus requirements. Figures 4-21a through 4-21h illustrate the data and model fit following implementation of these changes.

In the 1980s, the model generally overpredicts the data, but the overprediction is modest. This occurs because ALG2 efficiently consumes the phosphorus fluxing across the thermocline or is input from the watershed. The same algal group also fixes nitrogen, resulting in late summer growth a little higher than the data.

---

[13] While the model calibration to the data does not require SOD to increase with time like nutrient releases, it is unlikely that nutrient enrichment of the sediments would occur without an accompanying enrichment of organic carbon.

The Chl-a data for the 1990s are higher, but the model predictions are also higher as a result of the increased sediment release and hence flux across the thermocline to the epilimnion. Again, the model generally overpredicts the data by a modest amount.

The Chl-a data for the 2000s are higher still and the model matches the data well. Most importantly, in the dry late summers (2003, 2006, 2008, 2009, and 2011) when inflows are very low, Chl-a concentrations increase in the data and the model matches these patterns (as a direct result of the higher sediment release rates and low stoichiometric requirements of ALG2). In the winter, the Chl-a data tends to decrease and the model matches that pattern as well.

In general, the Chl-a data increase over the 28-year POR and show seasonal patterns of increasing in the summer and decreasing in the winter. The model matches these trends and patterns well. For the entire POR, the model fit is very close to the calibration goal, despite the complex trends and patterns in the data (Table 4-19). In the model, the long-term increase is directly tied to the increase in sediment release. In reality, changes in other loads, algal assemblages, and other forcing functions cannot be ruled out and are discussed in greater detail in the discussion section below.

To achieve this model fit, all algal groups were assigned a settling rate of 0.08 m/day. This value is somewhat lower than the CE-QUAL-W2 default value of 0.1 m/day. While it might make physiological sense to assign the ALG2 group an even lower settling rate, due to the observed lower settling rate of many species of blue-green algae, this is not necessarily practicable in CE-QUAL-W2. There are five possible loss mechanisms for algae in the model. One (zooplankton grazing) is not enabled in the Lake Buchanan model, or in any phase of CREMs, primarily because of a lack of data with which to calibrate. Three mechanisms (respiration, excretion, and mortality) all have the same temperature function as growth, so during suboptimal temperature periods when growth is slow, these loss rates are also slow. The fifth and last mechanism is settling. Accordingly, if settling is very low, no algal loss mechanisms exceed growth and algae persist through the winter at unrealistically high values. For this reason, algal settling was set to the same value for all groups at 20% below the default for ALG2.

Table 4-19
Lake Model Performance Metrics for Chlorophyll-a

Station ID (Lake Model Segment)	Depth	Mean Error (µg/L)	Mean Absolute Error (µg/L) **	Reliability Index	Number of Samples
12344 (13)	Top 2 Meters	-2.02	4.88	2.30	217
	Middle Third	1.22	2.43	2.56	34
	Bottom 2 Meters	-1.48	2.90	2.46	36
12353 (2)	All Depths *	9.94	18.88	2.76	173
12352 (6)	Top 2 Meters	-0.54	6.74	2.00	134
	Middle Third	1.29	6.23	2.00	134
	Bottom 2 Meters	3.64	6.97	2.74	7
12351 (6)	Top 2 Meters	-1.33	6.36	2.37	72
	Middle Third	-0.03	6.04	2.36	72
	Bottom 2 Meters	2.17	6.53	3.02	72
12350 (7)	Top 2 Meters	0.19	7.55	1.74	16
	Middle Third	3.82	6.73	1.81	16
	Bottom 2 Meters	9.52	9.53	3.55	16
12347 (9)	Top 2 Meters	-2.96	5.53	2.33	205
	Middle Third	1.50	3.74	2.43	27
	Bottom 2 Meters	-1.39	3.70	2.70	36
12349 (18)	Top 2 Meters	-1.36	5.94	2.28	112
	Middle Third	3.30	6.80	2.76	13
	Bottom 2 Meters	5.68	7.79	5.39	13
12346 (26)	Top 2 Meters	-3.89	5.39	2.61	87
	Middle Third	-3.19	4.74	2.48	87
	Bottom 2 Meters	-1.25	3.46	2.25	87

Notes:
* Statistics for all layers combined due to shallowness of lake at this station.
** System-wide average mean absolute error target = 4 µg/L
µg/L – micrograms per liter

The algal groups in the lake model nominally correspond to diatoms (ALG1), blue-greens (also referred to as cyanobacteria, ALG2), and greens (ALG3). These model algal groups cannot be considered direct representations of the algal classes, because each class represents a range of species with some common, but many distinct, characteristics. ALG1 (diatoms) were simulated using relatively cold temperature rate coefficients (i.e., growth is maximized at lower temperatures), ALG3 (greens) were simulated using moderate temperature

coefficients, and ALG2 (blue-greens) were simulated using very warm temperature coefficients. This allows for seasonal succession of the algal groups that mimics common patterns. As a result, in the model, diatoms are most abundant in the spring, followed by greens in the early summer, and blue-greens in the summer and fall (Figure 4-22).

Figure 4-22 illustrates an estimate of percent biomass from Lake Buchanan algal count data (Section 2.5). To generate these data-based biomass percentages, calculations identical to those described in Parsons and Anchor QEA (2011) were performed. Briefly, the count data were multiplied by estimates of cell biovolume (2,826 μm^3/cell for diatoms, 395 μm^3/cell for blue-greens, and 1766 μm^3/cell for greens; Table 4-15 of Parsons and Anchor QEA 2011) to obtain biovolume estimates by group, which were then assumed to equal biomass estimates (i.e., all groups were assumed to have the same density and water content). The model compares reasonably well with the data and exhibits similar seasonal patterns. An exception is that the modeled diatoms taper off too rapidly in the spring, maintain concentrations that are too low through the summer, and do not exhibit a fall bloom; rather blue-greens remain dominant in the model through the winter. Because of the limitations of the model (with respect to assigning specific algal taxa to modeled algal groups) and the data (high variability in a limited dataset, in addition to assumptions regarding biovolume, density, and water content), this comparison cannot be considered more than semi-quantitative. Given these limitations, the model fairly represents the available data.

Figures 4-23a to 4-23c illustrate algal growth limiting factors by year and Figures 4-24a to 4-24c illustrate the growth limiting factors by month. All figures are shown for the top 1-m depth. Light limitation is difficult to interpret, because some days may have a combination of low incident solar radiation and/or high Chl-a biomass and accordingly not enough light is available to maximize growth. More frequently however, algal growth in the top 1 m is likely limited by photoinhibition, whereby too much light decreases the growth rate. With respect to nutrients, phosphorus is more frequently limiting than nitrogen. Nitrogen is never limiting for ALG2 (because this group fixes nitrogen in the model), and is rarely limiting for ALG1 and ALG3 in the late summer when ALG2 is growing rapidly. This latter effect occurs for two reasons. Firstly, because ALG2 does not take up aqueous nitrogen sources, there is more for the other two groups. Secondly, respiration, excretion, and mortality of ALG2 provide a source of nitrogen to the two other groups. Nitrogen sometimes limits groups

ALG1 and ALG3 in the spring, when the temperature is optimized for these groups, but not for ALG2. Nutrients limit algal growth more frequently in recent years, likely as a result of higher Chl-a and consequently lower photoinhibition. The pattern of more frequent nitrogen limitation in recent years was also observed in the Lake LBJ model output (see Figure 4-129 of the CREMs Phase 3: Final Report [Parsons and Anchor QEA, 2011]).

4.5.6.2 Calibration Discussion

To provide an adequate fit to the data, the lake model was modified or parameterized in two fundamentally different ways relative to previous phases of CREMs:

- The CE-QUAL-W2 code was changed to specify a time-variable zero-order sediment release rate, as opposed to the time invariant zero-order release allowed in the original code.
- An algal group was parameterized to have the following characteristics:
  - Very narrow temperature range, which allows substantial growth only in the summer
  - Nitrogen fixation, which decouples algal growth from ambient nitrogen concentrations
  - Low nitrogen and phosphorus stoichiometry, which reduce the source of nitrogen during nitrogen fixation and allow for more growth using less phosphorus
  - Low growth, respiration, excretion, and mortality rates, which reduce the source of nitrogen during nitrogen fixation

The first modification is fundamentally supported by the data. There is clear evidence that summertime hypolimnetic nutrient concentrations have increased over the past 28 years and there is little evidence of a possible source of these nutrients other than sediment release during anoxic conditions. To put the trends in context, Lake Buchanan was impounded in 1937. In the mid-1980s (50 years later), the hypolimnetic concentrations of NH4 and PO4 were approximately 300 μg/L and 40 μg/L respectively (Figure 4-10). In the late 2000s (75 years later), these concentrations were about 1,800 μg/L and 200 μg/L, respectively.

The second modification to the modeling approach in Phase 4 is the inclusion of a specialized algal group. Matching measured algal growth during nominally nutrient-limited conditions

is a known challenge of lake models, as noted in the CE-QUAL-W2 manual (Cole and Wells 2008):

> *The problem is that if the model is correctly predicting very low nutrient levels during these times (typically at detection levels), then there are insufficient nutrients in the water column to support the observed levels of primary production indicated by supersaturated conditions. This is a shortcoming of all currently used water quality models and indicates insufficient understanding of phytoplankton/nutrient dynamics in the photic zone.*

Several mechanisms exist by which algae can obtain nutrients or maximize their use of limited nutrients. First and foremost, certain species of blue-green algae can fix nitrogen from the atmosphere. The model was parameterized to allow this, although it is not possible using the current model to scale nitrogen fixation based on dissolved NH4 and NOX concentrations, as very likely happens in reality. Some species of blue-green algae also have the ability to regulate their buoyancy and have been reported in literature to settle to nutrient rich waters below the photic zone and then rise back up in the morning to take advantage of sunlight (e.g., Ferber et al. 2004 report blue-green algae taking diurnal advantage of nutrients at a mean depth of 3.4 m). Several possible, but indefinite, mechanisms for unmeasured nutrient loads to the epilimnion exist. Mass transfer across the thermocline is controlled by temperature (and hence density) gradients. While these gradients are well represented in the model, internal seiches or other sources of turbulence are possibly under-represented in the model and mass transfer possibly exceeds that suggested by the temperature gradients. In addition, epilimnetic sediment resuspension, (e.g., as caused by wind or boats) could entrain nutrients into the epilimnion, especially during dry periods if the ratio of littoral sediment area to water column volume increases. Nutrient recycling in the epilimnion may be underrepresented in the model. Detrital settling, including algal settling, is specified using a fixed velocity that is independent of density gradients. In the real world, the strong density gradient at the thermocline may hinder settling, allowing additional time for decay and recycling of dissolved nutrients to the photic zone for uptake by living algae. Finally, algae are known to exhibit nonhomeostatic cellular concentrations, that is, their cellular quotas of nutrients can adjust, within bounds, based on the nutrient concentrations in the surrounding water (Sterner and Elser 2002). In a

practical sense, this means that some algal species can prosper with less nitrogen and phosphorus resources than others. Perhaps more importantly, some algal species can store a limited quantity of excess nitrogen and phosphorus and use those cellular stores to support growth, even in the absence of external nutrients. Reynolds (1984) cites an earlier study (Mackereth 1953) where *Asterionella* (a species of diatoms) was able to store 24 times the absolute cellular minimum of phosphorus, allowing four full divisions in a phosphorus-free medium. This mechanism, sometimes termed luxury uptake or luxury consumption, cannot be confirmed in Lake Buchanan using the available data, but is theoretically possible.

Ultimately, a combination of several of these mechanisms may be contributing to the nutrient dynamics of algae in Lake Buchanan. However, many of the mechanisms cannot be simulated, or even approximated, in CE-QUAL-W2 without substantial code changes. Time-variable nitrogen fixation, buoyancy regulation, increased mass transfer across the thermocline, resuspension of sediment nutrients, density gradient dependent settling of detritus, and variable algal stoichiometry are all examples of possible real-world mechanisms that cannot be directly simulated in the model. Fortunately, the model provides a satisfactory fit to the data even without these capabilities. This was accomplished through parameter changes that approximate nitrogen fixation and variable stoichiometry, while recognizing that these modifications cannot be used to conclusively establish these, or any other mechanisms, as the primary sources of nutrients for summertime algal blooms.

4.6   Sensitivity Analysis

To identify the key factors responsible for predictions of Chl-a concentration by the CE-QUAL-W2 model, a model sensitivity analysis was performed. The sensitivity analysis was conducted by varying the values (one at a time from the base, i.e., calibration, simulation) of 17 individual parameters and loads, and examining the resulting predicted Chl-a concentration at a depth of 0 to 2 m. These 17 parameters were selected based on experience calibrating the model, professional judgment, and the results of the sensitivity analyses of CREMs Phase 2 and Phase 3 (Anchor QEA and Parsons 2009a; Parsons and Anchor QEA 2011). Because of long run times with the full 28-year model, the sensitivity analysis was run for a 6-year period (2006 to 2011). This period includes years with low and

high inflows and uses the same sediment release rates as in the calibration simulation for 2006 through 2011.

Two model runs were performed for each parameter: one used the base value minus 50% ("low" run) and the other used the base value plus 50% ("high" run). For parameters with a maximum acceptable value (e.g., 1.0 for fractions or 100% for percentages), if the base value plus 50% exceeded the maximum acceptable value, the "high" simulation used the maximum acceptable value. For algal parameters, each run included simultaneous changes for all three modeled groups.

A SI was computed using the following equation:

$$SI_{chla} = \max\left(\left|\frac{\overline{Chla}_{low} - \overline{Chla}_{base}}{P_{low}}\right|, \left|\frac{\overline{Chla}_{high} - \overline{Chla}_{base}}{P_{high}}\right|\right) \qquad (4\text{-}1)$$

where:

$Chla$ =   Chl-a concentration in µg/L

P_{low} =   percent reduction from base parameter value in low run

P_{high} =   percent increase from base parameter value in high run

The results of sensitivity analysis are displayed in Table 4-20 and Figures 4-25 and 4-26. The model exhibited greatest sensitivity to the Chl-a content of algae (ACHLA), the maximum algal growth rate (AG), and the algal phosphorus content (AGLP). The most sensitive three parameters were prominent, with SI values greater than 10, whereas more than half the parameters had SI values less than 5. ACHLA is a sensitive model parameter because the model actually simulates algal biomass (also referred to as algal organic matter), not Chl-a. Chl-a is only output from the model as a derived constituent. Accordingly, any change in ACHLA creates a direct corresponding change in Chl-a outputs. The maximum algal growth rate is often an important parameter in lake models, because it is the limiting constraint on growth when nutrients are available, e.g., after storm events. In a nutrient limited system such as Lake Buchanan, increasing the maximum algal growth rate allows algae to grow faster in response to episodic nutrient sources. Finally, ALGP is important because Lake Buchanan is often phosophorus limited; as ALGP decreases, additional algae (and hence Chl-a) growth occurs per unit of phosphorus, leading to increases in the biomass of algae.

Sources of phosphorus (e.g., sediment release (PO4R) and "Orthophosphorus inflows from SWAT") are also sensitive inputs to the model because of the frequency of phosphorus limitation on algal growth. This sensitivity analysis suggests that overall, the Lake Buchanan model Chl-a predictions are most sensitive to algal stoichiometry, algal growth, and phosphorus loading and utilization by algae.

Table 4-20
CE-QUAL-W2 Parameter Selection and Results for Sensitivity Analysis

Parameter	Description	Base Value	Low	High	SI
AG	Maximum algal growth rate	2.0 / 1.1 / 2.0	1.0 / 0.55 / 1.0	3.0 / 1.65 / 3.0	16.54
AM	Maximum algal mortality rate	0.12 / 0.06 / 0.12	0.06 / 0.03 / 0.06	0.18 / 0.09 / 0.18	7.05
AS	Algal settling rate	0.08	0.04	0.12	6.70
ASAT	Light saturation intensity at maximum photosynthetic rate	70	35	105	0.86
ALGP	Stoichiometric equivalent between algal biomass and phosphorus	0.007 / 0.002 / 0.007	0.0035 / 0.001 / 0.0035	0.0105 / 0.003 / 0.0105	10.83
ALGN	Stoichiometric equivalent between algal biomass and nitrogen	0.07 / 0.02 / 0.07	0.035 / 0.01 / 0.035	0.105 / 0.03 / 0.105	3.88
ACHLA	Stoichiometric ratio between algal biomass and Chl-a	0.10	0.05	0.15	21.03
RPOMDK	Refractory particulate organic matter decay rate	0.0010	0.0005	0.0015	0.19
POMS	Particulate organic matter settling rate	0.40	0.20	0.60	1.84
ALPOM	Fraction of algal biomass that is converted to POM when algae die	0.80	0.40	1.00	8.65
PO4R	Sediment release rate of phosphorus†	0.0012	0.0006	0.0018	2.63
NH4R	Sediment release rate of ammonia†	0.010	0.005	0.015	0.60
NO3S	Denitrification rate from sediments	0.15	0.08	0.23	1.93
Fraction of dissolved CNP in inflows*		Base	Base-50%	Base+50%	3.02
Refractory percentage in inflows		75.0	37.5	100.0	1.49
Orthophosphorus inflows from SWAT*		Base	Base-50%	Base+50%	4.21
Ammonia inflows from SWAT*		Base	Base-50%	Base+50%	0.17

Notes:
For parameters with three numbers, the values are listed in the order of the algal groups modeled: ALG1, ALG2, and ALG3 (nominally diatoms, blue-greens, and greens, respectively).

† The "low" and "high" runs were subject to the same incremental increase in PO4R and NH4R as the base case, i.e., the 2011 values were approximately 6 times the initial values (shown in the table).
* For parameters with a maximum acceptable value (e.g., 1.0 for fractions or 100% for percentages), if the base value plus 50% exceeded the maximum acceptable value, the "high" simulation used the maximum acceptable value.
CNP – carbon, nitrogen, and phosphorus
POM – particulate organic matter
SWAT – Soil and Water Assessment Tool

4.7   Bounding Calibration

Model uncertainty was addressed with a bounding calibration (QEA 1999). In this approach, an upper-bound, but still reasonable, calibration of Chl-a was generated to yield insight into the uncertainty associated with the model predictions. The upper bound of Chl-a was selected because high Chl-a concentrations are relevant to management decisions. The upper bound approach was implemented because long model run times precluded iterative model runs such as those performed in a Monte Carlo simulation.

Based on the sensitivity analysis, the three most sensitive calibration parameters were adjusted to achieve an upper-bound calibration for surface Chl-a levels over the full calibration period in the lake model. These parameters were the Chl-a content of algae, the maximum algal growth rate, and the algal phosphorus content. The maximum algal growth rate was increased by 20% to increase Chl-a, while the algal phosphorus content and Chl-a content of were reduced by the same percentage.

A 20% change in the values of these three most influential calibration parameters was observed to maintain a reasonable upper-bound calibration, with moderate increase in the MAE calibration metric. With these changes, the parameter values were still considered reasonable in light of values reported by other investigators using CE-QUAL-W2. Figures 4-27 to 4-36 show temporal plots comparing measured data, the original model calibration, and the bounding calibration for water quality parameters in the lake. Calibration statistics for the original and bounding calibrations are compared in Table 4-21.

The bounding calibration may be used when evaluating future scenarios (e.g., changes in land use and point sources) to generate reasonable, upper-bound predictions of future Chl-a.

Table 4-21

Model Performance Metrics for Original and Bounding Calibration

Parameter	Depth	MAE of Original Calibration	MAE of Bounding Calibration
Dissolved Oxygen (mg/L)	Top Third	0.601	0.598
	Middle Third	0.883	0.899
	Bottom Third	0.858	0.875
Total Organic Carbon (mg/L)	Top 2 Meters	1.999	1.899
	Middle Third	1.796	1.769
	Bottom 2 Meters	1.881	1.821
Orthophosphorus (µg/L)	Top 2 Meters	8.716	7.899
	Middle Third	14.001	12.916
	Bottom 2 Meters	24.551	23.312
Total Phosphorus (µg/L)	Top 2 Meters	37.823	36.635
	Middle Third	37.27	35.651
	Bottom 2 Meters	49.416	48.105
Ammonium Nitrogen (µg/L)	Top 2 Meters	25.283	25.418
	Middle Third	57.076	57.021
	Bottom 2 Meters	148.503	148.254
Nitrate + Nitrite Nitrogen (mg/L)	Top 2 Meters	0.12	0.119
	Middle Third	0.103	0.103
	Bottom 2 Meters	0.105	0.104
Total Kjeldahl Nitrogen (mg/L)	Top 2 Meters	0.341	0.333
	Middle Third	0.322	0.319
	Bottom 2 Meters	0.37	0.361
Chlorophyll-a (µg/L)	Top 2 Meters	4.883	7.817

Notes:
µg/L – micrograms per liter
MAE – mean absolute error
mg/L – milligrams per liter

5 PEER REVIEW

A consulting firm wellversed in water quality modeling externally peer-reviewed the Phase 4 models and found them to be consistent with proper modeling practices (LTI 2012). The peer review memorandum states that additional modifications to the models are not expected to be of significant benefit unless additional data collection is performed.

The peer review recommended that the models "best be used as part of a 'weight of evidence' approach in supporting management decisions, rather than a primary decision-making tool" due to the nature of the available data to support model calibration (LTI 2012). The primary issues, which are caused by unresolvable features of the available data, are identified during the peer review as follows (LTI 2012):

- *Insufficient wet weather monitoring data to rigorously define watershed model coefficients, due to drought conditions occurring during the recent field monitoring period conducted to support the study.*
- *Observed late summer algal blooms that could not be adequately simulated using typical parameterization of the water quality model.*
- *Phosphorus concentrations in the deeper waters of Lake Buchanan appearing to indicate that sediment phosphorus release has significantly increased over time.*

LCRA agrees with the "weight of evidence" approach in supporting management decisions. No model should be used in isolation for decision making; auxiliary information may include institutional knowledge of the Highland Lakes system, observations by field staff, and established water quality principles and mechanisms. Additional stormwater monitoring would be beneficial for the watershed model; it is unfortunate that the expanded monitoring conducted specifically to support this project occurred during drought conditions. This report describes and explains the adjustments to model parameters and model code that were necessary to match late summer algal and hypolimnetic nutrient data (Sections 4.5.4.2, 4.5.5, and 4.5.6.2) and states that these changes should not be construed as definitive support of any underlying mechanisms but rather as the most practicable means of fitting the data within the limitations of the CE-QUAL-W2 model.

Ultimately, the peer review concluded that "all reasonable attempts have been made to make this the best management tool possible." Future improvements to the data and model in response to all peer review comments will be considered by LCRA.

6 SUMMARY

Phase 4 of the CREMs project focuses on Lake Buchanan, the first in a series of six reservoirs on the lower Colorado River known as the Highland Lakes.   This phase of the CREMs project included:

- An expanded monitoring program to acquire a more complete dataset for supporting the development of the Lake Buchanan watershed and lake model
- Development and calibration of linked watershed and lake models for Lake Buchanan
- Evaluation of the sensitivity of Lake Buchanan to changes in the watershed, including the impact of land use changes and potential increases in runoff and discharges to the lake (to be discussed in a separate scenario memorandum).

The CREMs Phase 4 monitoring program conducted by LCRA included expanding routine monitoring, conducting storm event monitoring, incorporating special remote monitoring studies, and performing manual sampling studies (see Section 2). These programs were initiated in 2010 and were similar to monitoring programs conducted in previous phases of the CREMs project. Data from these programs and special studies supported the development and calibration of the watershed and lake models.

The outcome of CREMs Phase 4 is a reservoir management tool consisting of linked watershed and lake models of Lake Buchanan. Together, these models can be used to predict lake responses to changes in consitutent loads due to changes in land use, point sources, and land management practices within the watershed.   The Lake Buchanan watershed model was developed and calibrated using SWAT2009 and is an update of SWAT2005 that was used for CREMs Phases 2 and 3. The hydrodynamic and lake model of Lake Buchanan was developed and calibrated using USACE's CE-QUAL-W2, version 3.6. This is the same version that was used in Phase 3 of the CREMs project and is an update of version 3.5 that was used for CREMs Phase 2.

The modeled Lake Buchanan watershed is approximately 4.0 million acres with only 3% of the watershed area draining directly to Lake Buchanan. The remaining 97% of the watershed drains to the Colorado River, which enters Lake Buchanan from the north. The spatial extent of the Lake Buchanan SWAT model is the drainage basin of the Colorado River

from Buchanan Dam to S.W. Freese Dam (which impounds O.H. Ivie Reservoir) in Coleman and Concho counties, and to Lake Brownwood Dam in Brown County. The simulation period is January 1, 1984,[14] through December 31, 2011.

During the SWAT model hydrology calibration, a substantial reduction was noted in the amount of stream flow generated in response to rainfall in the mid-1990s. It was possible to achieve a satisfactory model fit to measured flows from 1984 to 1997 or from 1997 to 2011, but not both periods. Therefore, the watershed calibration focused on the period from October 1, 1997 through December 31, 2011 and model fit statistics are based on that period. The model performed well based on graphical and statistical calibration metrics, particularly at the Colorado River near San Saba gage. A good model fit at this most downstream calibration station is important given that the primary purpose of the watershed model is to provide inflows and water quality constituent loads for the Lake Buchanan lake model. NS model efficiency values for monthly flows ranged from 0.68 to 0.96 for the primary calibration stations. A percent difference comparison of the simulated flow volumes also indicated the model was performing well with differences at the primary calibration gages ranging from -15.2% at the Colorado River at Winchell gage to +6.6% at the Pecan Bayou gage.

Calibration of the SWAT model for sediment and nutrient loadings was based on model-to-model comparisions. Due to limited data, daily loads for each constituent were estimated for each location using daily average flow data and LOADEST rating curves; these loads were compared to model output. The water quality calibration focused on the period from October 1, 1997, through December 31, 2011 (matching the time period of the SWAT hydrology calibration). For TSS, the NS values range from 0.35 to 0.80 and the percent differences range from -2 to +40%. For both metrics, the best fit occurred at the key downstream calibration station (Colorado River near San Saba). Model fits for the nutrient series are fair to good for all nutrient species and generally best at the Colorado River near San Saba. Generally, the model tends to slightly under-estimate nutrient loads relative to LOADEST estimates, particularly under high flow conditions. Monthly NS values for the nutrients ranged from 0.27 (for PO4) to 0.72 (for TN). Mass percent differences ranged from

---

[14] The watershed model was run for an additional 4-year period prior to January 1, 1984, to provide a "spin-up" time for the model to equilibrate initial model conditions.

-54% (for NOX) to +23% (for TP). Overall, the nutrient calibration is considered acceptable, given the limitations of modeling the nutrient series in SWAT and the uncertainties in the LOADEST rating curve.

The Lake Buchanan lake model covers the main body of Lake Buchanan and its major branches (coves downstream of Morgan Creek, Campground Creek, and Redrock Creek). The model segmentation and bathymetry were developed based on surveys performed by TWDB in 2006 and high-resolution LIDAR data collected by LCRA in 2006 and 2007. The lake model was developed and calibrated using data from January 1, 1984, through December 31, 2011, matching the time period of output from the watershed model.

The lake model calibration was performed in two steps consisting of a hydrodynamic calibration followed by water quality calibration. Hydrodynamics in the model were calibrated to predict water transport including flows, dispersion, depths, velocities, water surface elevations, water temperature, and conservative constituents. Water quality was calibrated to simulate the major processes of eutrophication kinetics.

Model development for the hydrodynamics calibration required the creation of an external water balance. The goal of the adjustments to flow records was to provide a good fit of calculated water surface elevations to observed elevations on a daily basis, while minimizing the number of days requiring changes to flows. Given the adjusted flows from the water balance, the water surface elevations predicted by the model followed measurements at the dam well; the MAE was 0.05 m, well below the target MAE of 0.2 m. These final water balanced flows were not changed during the hydrodynamics calibration.

The hydrodynamic calibration focused on matching model-predicted temperature to data collected at various stations throughout the lake. The model predictions agree well with data both seasonally and at depth. The MAE ranged from 0.68 to 0.73 °C at the main calibration station, below the temperature target of 1 °C.

Model to data comparisons were performed at a number of sites at different depths through the water column. For the Lake Buchanan model, the water quality calibration targets (MAE, ME, and RI) were set as the same targets used in CREMs Phases 2 and 3 to evaluate

model GOF. However, due to the long POR reflecting a broad range of environmental conditions and changing sampling and analysis techniques over the years, the target metrics were applied as objectives and guidelines, not strict criteria. The ultimate determination of model calibration was based upon close review of temporal model-to-data plots.

Two changes from previous CREMs lake models were made in CREMs Phase 4 to improve the calibration of the model. First, to address the increasing trend in summertime hypolimnetic concentrations of nutrients observed over the 28-year data record for Lake Buchanan, a modficiation of the CE-QUAL-W2 code was made to allow for a time variable zero-order sediment release rate. Second, the algal blooms in recent years, particularly in dry late summers, could not be adequately characterized by the model using traditional stoichiometric requirements for algae. To mimic algal nutrient uptake mechanisms and to match recent observed algal blooms, several parameter adjustments were made to one of the three algal groups simulated, including nitrogen fixation; lower stoichiometric ratios; a narrow temperature range for growth; and lower growth, respiration, excretion, and mortality rates.

The calibration of the Lake Buchanan model focused on matching patterns in the hypolimnetic nutrients and epilimnetic Chl-a while striving to meet calibration goals for other constituents. In the epilimnion, model-predicted concentrations of NH4 in many samples are below the detection limit and the model is generally within the range of the data. Neither the data nor the model exhibit a long-term NH4 trend. In the hypolimnion, the NH4 data show a clear increasing trend and seasonal patterns. The model, using the specified time variable sediment release rates, reasonably matches the overall patterns and trends. For TKN, the model fit in the eplimnion is reasonable, but often underpredicts the data. In the hypolimnion, the patterns and trends of NH4 are evident in the TKN data, and the model provides a reasonable fit to the data. The model results for NOX show occasional large spikes, which are due to SWAT predicted loads entering the lake from the watershed and upstream. In the hypolimnion, the pattern in the data is matched by the model, although the model typically predicts lower concentrations.

In the phosphorus series, the epilimnetic PO4 data are dominated by non-detects. No trends are evident in the data. In the hypolimnion, the patterns are very similar to that observed

for NH4. For TP in the epilimnion, the data exhibit no trends or patterns and are characterized by a large fraction of non-detects. Overall, the model generally overpredicts TP in the epilimnion. In the hypolimnion, the TP data and model largely reflect the patterns in PO4.

In general, the Chl-a data increase over the 28-year period of record and show seasonal patterns of increasing in the summer and decreasing in the winter. The model matches these trends and patterns well. For the earlier years (1980s and 1990s), the model results for Chl-a concentrations are higher than the data. For the 2000s, the Chl-a concentrations in the lake are higher than those measured in the 1980s and 1990s and for this period, the model matches the data well, even in the dry late summers when inflows are low. For the winter, the Chl-a data tends to decrease and the model matches the pattern well for all periods.

The model provides a satisfactory fit to the water quality data, which was accomplished through modifying the CE-QUAL-W2 code to specify a time-variable zero-order sediment release rate and changes to parameters that approximate nitrogen fixation and variable stoichiometry for one algal group as well as other model parameter changes.

Sensitivity analyses were performed for both the watershed and lake models to identify the key input parameters with the largest impacts on model predictions. For the watershed model, a sensitivity analysis was performed by varying eight parameters and examining their effects on predicted flows and loads of solids and nutrients, with the focus on the nitrogen and phosphorus series. Phosphorus concentrations were most sensitive to the soil evaporation compensation factor (ESCO), phosphorus availability index (PSP), and phosphorus uptake distribution (P_UPDIS). Nitrogen concentrations were most sensitive to ESCO, nitrogen percolation coefficient (NPERCO), and nitrogen update distribution (N_UPDIS), while sediment concentrations were most sensitive to peak rate adjustment factor (PRF), specific conductivity (SPCON), and ESCO.

For the lake model, model sensitivity analysis focused on predictions of Chl-a concentrations by CE-QUAL-W2 for the 0 to 2 m depth. The sensitivity analysis was conducted by varying the values (one at a time from the base [i.e. calibration] simulation) of 17 individual

parameters and loads. The model exhibited the greatest sensitivity to the Chl-a concentration of algae, the maximum algal growth rate, and the algal phosphorus content.

Water quality model uncertainty was addressed with a bounding calibration in which an upper-bound calibration of Chl-a was generated and compared to the original calibration. Based on the sensitivity analysis, the three most sensitive calibration parameters were adjusted to acheive the upper-bound calibration for surface Chl-a concentrations. A 20% change in the values of these parameters was observed to maintain a reasonable upper-bound calibration with a moderate increase in the MAE calibration metrics. This measure of uncertainty was considered reasonable in comparison to other values reported in CE-QUAL-W2 applications. The bounding calibration may be used when evaluating future scenarios (e.g., changes in land use and point sources) to generate reasonable, upper-bound predictions of future Chl-a.

The Lake Buchanan watershed and lake models developed through Phase 4 of the CREMs project provide predictive management tools for LCRA to facilitate watershed and reservoir management decisions. These models can be used to evaluate the water quality and quantity effects of a wide range of management policies, such as the HLWO, the TCEQ point source discharge ban, and land use change. In addition, the studies and investigations conducted within Phase 4 have increased LCRA's understanding of Lake Buchanan's unique characteristics and changing conditions.

7 REFERENCES

APHA et al. (American Public Health Association, American Water Works Association, and Water Environment Federation), 1998. *Standard Methods for the Examination of Water and Wastewater*, 20th Edition. Washington, D.C.: American Public Health Association.

Anchor QEA and Parsons (Anchor QEA, LLC, and Parsons Water and Infrastructure, Inc.), 2009a. *Colorado River Environmental Models Phase 2: Lake Travis Final Report.* Final draft submitted to LCRA on March 18, 2009; revised on May 11, 2009. Prepared for Lower Colorado River Authority.

Anchor QEA and Parsons, 2009b. *Final Scenario Memo.* March 18, 2009, revised May 11, 2009. Prepared for Lower Colorado River Authority.

Anchor QEA and Parsons, 2011. *Final Phase 3 Scenario Memo.* July 21, 2011. Prepared for Lower Colorado River Authority.

Arnold, J.G., R. Srinivasan, R.S. Muttiah, and J.R. Williams, 1998. Large area hydrologic modeling and assessment part I: model development. *J. of American Water Resources Assn.* 34(1):73-89.

Asquith, W.H., M.C. Roussel, T.G. Cleveland, X. Fang, and D.B. Thompson, 2006. *Statistical Characteristics of Storm Interevent Time, Depth, and Duration for Eastern New Mexico, Oklahoma, and Texas*: U.S. Geological Survey Professional Paper 1725.

Benaman, J., C.A. Shoemaker, and D.A. Haith, 2005. Calibration and validation of soil and water assessment tools on an agricultural watershed in Upstate New York. *Hydrologic Enginr.* 10(5):363-374.

Black, C.W., 1988. Hydrogeology of the Hickory Sandstone Aquifer, Upper Cambrian, Riley Formation, Mason and McCulloch Counties, Texas. Master's Thesis, Department, University of Texas at Austin, Austin, Texas.

Bowie, G.L., W.B. Mills, D.B. Porcella, C.L. Campbell, J.R. Pagenkopt, G.L. Rupp, K.M. Johnson, P.W.H. Chan, and S.A. Gherini, 1985. *Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling (Second Edition)*. EPA/600/3-25/040.

Breeding, S.D. 2012. *Lake Buchanan.* Texas State Historical Association, Denton, Texas. Cited on October 31, 2012. Available from: http://www.tshaonline.org/handbook/online/articles/rol20

Brown, L.C., and T.O. Barnwell, 1987. *The Enhanced Stream Water Quality Models QUAL2E and QUAL2E-UNCAS: Documentation and User Manual.* USEPA, Office of Research and Development, Athens, Georgia. EPA 600-3-87-007. May 1987.

Brune, G., 1975. Major and historical springs of Texas, Report 189. Prepared for Texas Water Development Board. March 1975.

CH2M Hill, 2002. *Master Plan for the Colorado River Environmental Models Program.* Lower Colorado River Authority, Austin, Texas.

Cho, S., G.D. Jennings, C. Stallings, and H.A. Devine, 1995. GIS-based water quality model calibration in the Delaware River Basin. Presented at American Society of Agricultural Engineers Meeting. Microfiche No. 95-2404.

Cole, T.M. and S.A. Wells, 2008. *CE-QUAL-W2: A Two-Dimensional, Laterally Averaged, Hydrodynamic and Water Quality Model, Version 3.6.* United States Army Corps of Engineers. Instruction Report EL-08-1.

Debele, B., R. Srinivasan, and J.Y. Parlange, 2006. Coupling upland watershed and downstream waterbody hydrodynamic and water quality models (Soil Water Assessment Tool [SWAT] and CE-QUAL-W2) for better water resources management in complex river basins. *Environ. Model Assess.* DOI 10.2007/s10666-006-9075-1.

Di Luzio, M., R. Srinivasan, J.G. Arnold , and S.L. Neitsch, 2002. *Soil and Water Assessment Tool. ArcView GIS Interface Manual: Version 2000.* GSWRL Report 02-03, BRC Report 02-07. College Station, Texas: Texas Water Resources Institute.

Ferber, L.R., Levine, S.N., Lini, A., and Livingston, G.P., 2004. Do Cyanobacteria Dominate in Eutrophic Lakes because they Fix Atmospheric Nitrogen? *Freshwater Biology*. 49: 690-708.

Gassman, P.W., M.R. Reyes, C.H. Green, and J.G. Arnold, 2007. The soil and water assessment tool: historical development, applications, and future research directions. *Transactions of the ASABE* 50(4):1211-1250.

Heitmuller, F.T., and B.D. Reece, 2003. *Database of Historically Documented Springs and Spring Flow Measurements in Texas*. Open File Report 03-315. U.S. Geological Survey, Austin, Texas.

Hopkins, J. 1995. *Water Quality in the Edwards-Trinity (Plateau) Aquifer, Edwards Plateau and Trans-Pecos, Texas.Hydrologic Atlas No. 3.* Prepared for Texas Water Development Board. Austin, Texas.

LCRA (Lower Colorado River Authority), 2004. Phase 1 Lake Travis Model. LCRA, Austin, Texas.

LCRA, 2007. *Highland Lakes Watershed Ordinance Regulations Handbook.* Lower Colorado River Authority, Austin, Texas. Cited: June 12, 2012. Available from: http://www.lcra.org/library/media/public/docs/water/quality/HighlandLakesOrdinanceHandbook.pdf.

LCRA, 2011. *LCRA Dams and Lakes*. Lower Colorado River Authority, Austin, Texas. Cited on: December 5, 2011. Available from: http://www.lcra.org/water/dams/index.html..

LCRA On-Site Sewage Facilities Department, 2012. Personal communication with L. Hatzenbuehler. Austin, Texas. November 29, 2012.

Leggett, R.W.and L.R. Williams, 1981. A Reliability Index for Models. *Ecological Modeling* 13:303-312.

LTI (LimnoTech), 2012. *Draft Memo: Peer Review of CREMS Phase 4 November 2012 Draft Report*. Prepared for Lower Colorado River Authority. December 2012.

RPS, Espey, Parsons, Crespo Consulting Services, Inc., and Watearth, 2012. *Watershed Protection for Texas Reservoirs: Addressing Sedimentation and Water Quality Risks*. Prepared for the Texas Water Development Board, Austin, Texas. January 2012.

Nash, J. E., and J. V. Sutcliffe, 1970. River flow forecasting through conceptual models part I—A discussion of principles. *J. of Hydrology* 10(3):282–290.

NRCS (Natural Resources Conservation Service), United States Department of Agriculture. Official Soil Series Descriptions. Cited: December 2009. Available from: http://soils.usda.gov/technical/classification/osd/index.html.

Neitsch, S.L., J.G. Arnold, J.R. Kiniry, and J.R. Williams, 2005. *Soil and Water Assessment Tool Theoretical Documentation: Version 2005.* United States Department of Agriculture Agricultural Research Center and Texas A&M University Agricultural Experiment Station.

Neitsch, S.L., J.G. Arnold, J.R. Kiniry, and J.R. Williams, 2011. *Soil and Water Assessment Tool Theoretical Documentation: Version 2009.* Texas Water Resources Institute Technical Report No. 406. Texas A&M University System. College Station, Texas.

Parsons and Anchor QEA (Parsons Water and Infrastructure, Inc. and Anchor QEA, LLC), 2011. *Colorado River Environmental Models Phase 3: Inks Lake, Lake LBJ, Lake Marble Falls Final Report.* Prepared for Lower Colorado River Authority. March 2011.

Pascual, P., N. Stiber, and E. Sunderland, 2003. *Draft Guidance on the Development, Evaluation, and Application of Regulatory Environmental Models.* Prepared for USEPA Office of Science Policy, Council for Regulatory Environmental Modeling, Washington, D.C. November 2003.

Preston, R.D., D.J. Pavilcek, R.L. Bluntzer, and J. Derton, 1996. *The Paleozoic and Related Aquifers of Central Texas.* Report 346. Prepared for Texas Water Development Board.

QEA, 1999. *PCBs in the Upper Hudson River: Volume 2, A Model of PCB Fate, Transport and Bioaccumulation.* Prepared for General Electric. Montvale, New Jersey. June 1999.

QEA, 2004. Summary of low flow survey, November 9-12, 2004. Memo; Austin, Texas: Lower Colorado River Authority; December 2004.

QEA, 2005. Calibration of QUAL-TX. Austin, Texas: Lower Colorado River Authority; August 2005.Raines, T.H. and W. Rast, 1999. *Characterization and Simulation of the Quantity and Quality of Water in the Highland Lakes, Texas, 1983-1992.* USGS Report 99-4087.

Reynolds, C.S., 1984. *The Ecology of Freshwater Phytoplankton.* Cambridge University Press: New York, New York.

Runkel, R.L., C.G. Crawford, and T.A. Cohn, 2004. *Load Estimator (LOADEST): A FORTRAN Program for Estimating Constituent Loads in Streams and Rivers.* USGS Techniques and Methods Book 4, Chapter A5. Reston, Virginia.

Santhi, C., J.G. Arnold, J.R. Williams, W.A. Dugas, R. Srinivasan, and L.M. Hauck, 2001. Validation of the SWAT model on a large river basin with point and nonpoint sources. *J. of American Water Resources Assn.* 37(5):1169-1188.

Santhi, C., R. Srinivasan, J.G. Arnold, and J.R. Williams, 2006. A modeling approach to evaluate the impacts of water quality management plans implemented in a watershed in Texas. *Environmental Modeling and Software* 21:1141-1157.

Srinivasan, R., T.S. Ramanarayanan, J.G. Arnold, and S.T. Bednarz, 1998. Large area hydrologic modeling and assessment, Part II: Model application. *J. of American Water Resources Assn.* 34(1):91-101.

Srinivasan, R., 2009. Personal communication with Johnathan Bumgarner of Anchor QEA. June 16, 2009.

Sterner, R.W. and Elser, J.J., 2002. *Ecological Stoichiometry: The Biology of Elements from Molecules to the Biosphere.* Princeton University Press: Princeton, New Jersey.

Thomas, D., 2012. Personal communication with Emily Chen of Anchor QEA. August 6, 2012.

Tolson, B.A., and C.A. Shoemaker, 2007. Cannonsville reservoir watershed SWAT2000 model development, calibration and validation. *J. of Hydrology* 337:68-86.

TWDB (Texas Water Development Board), 2007. *Volumetric and Sedimentation Survey of Lake Buchanan: March-April 2006 Survey.* Prepared for the Lower Colorado River Authority, Austin, Texas. August 2007.

TWDB, 2012. Annual Texas Precipitation (Average monthly and annual precipitation for the climatological period 1961-90). Geographical Information Systems (GIS) dataset. Cited: May 25, 2012. Available from: http://www.twdb.state.tx.us/mapping/gisdata.asp.

USEPA (U.S. Environmental Protection Agency), 2001. *PLOAD version 3.0, An ArcView GIS Tool to Calculate Nonpoint Sources of Pollution in Watershed and Stormwater Projects*, User's Manual. January 2001.

Wedig, J., 2011. Personal communication with Emily Chen of Anchor QEA regarding Susan Meckel's compilation of TCEQ permit information. January 24, 2011.

Wetzel, R.G., 2001. *Limnology*, Third Edition. Academic Press: San Diego, California.

White, J.D., S.J. Prochnow, C.T. Filstrup, J.T. Scott, B.W. Byars, and L. Zygo-Flynn, 2010. A combined watershed-water quality modeling analysis of the Lake Waco reservoir: I. Calibration and confirmation of predicted water quality. *Lake Reserv Manage*. 26:147-158.

NOTES:
ESRI Data and Maps [DVD]. (2009). Redlands, CA:
Environmental Systems Research Institute.

Miles
0   10   20

Figure 1-1
Site Map
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

R:\Jobs\110577-01.01_LCRA_CREMS_Phase4\Maps\Lake_Buchanan_Site_Map_ZoomedOut.mxd lhudson 1/28/2013 8:30:19 AM

LEGEND
- RSS (yellow)
- Expanded RSS (green)

12394
12358
Colorado River
12356
283
377
183
190
12392
12355
Brady
San Saba
San Saba River
12274
190
87
12353
12352
12350   12349
12346   12347
Llano
Burnet
12344
Mason
12343

TEXAS

R:\Jobs\110577-01.01_LCRA_CREMS_Phase4\Maps\Lake_Buchanan_Site_Map.mxd lhudson 1/28/2013 8:32:48 AM

ANCHOR QEA
PARSONS

NOTES:
ESRI Data and Maps [DVD]. (2009). Redlands, CA:
Environmental Systems Research Institute.

Miles
0   5   10

Figure 2-1
Sampling Stations
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 3-1
Lake Buchanan Model Watershed
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Legend
- ■ Cities
- Counties
- Lakes
- NHD Streams
- Lake Buchanan Watershed

Figure 3-2
Lake Buchanan Watershed and Stream Network
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS
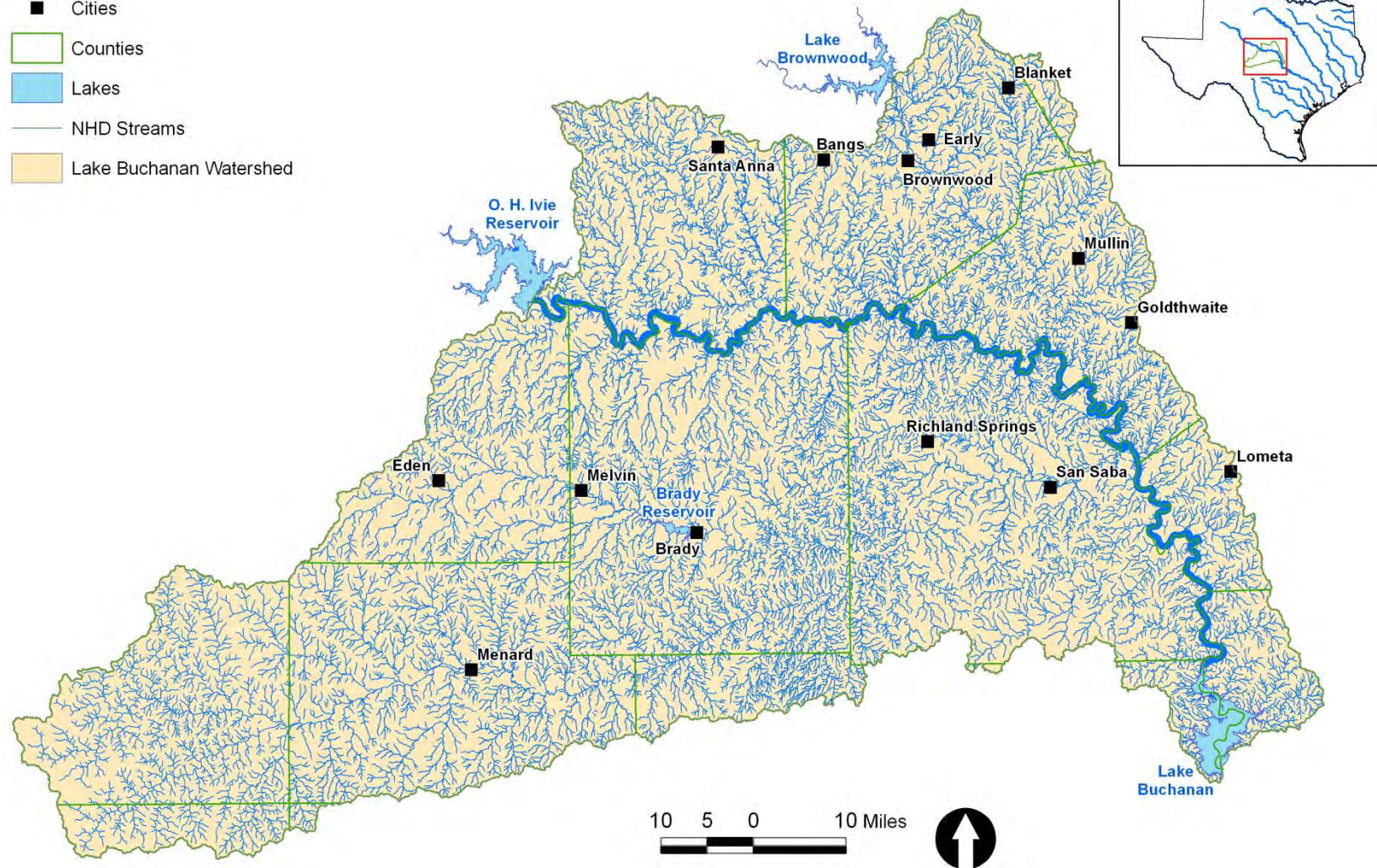
Legend

Streams

Lakes

Elevation (m above msl)
High : 751

Low : 274

10 5 0   10 Miles

Figure 3-3
Lake Buchanan Watershed with Digital Elevation Model
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority
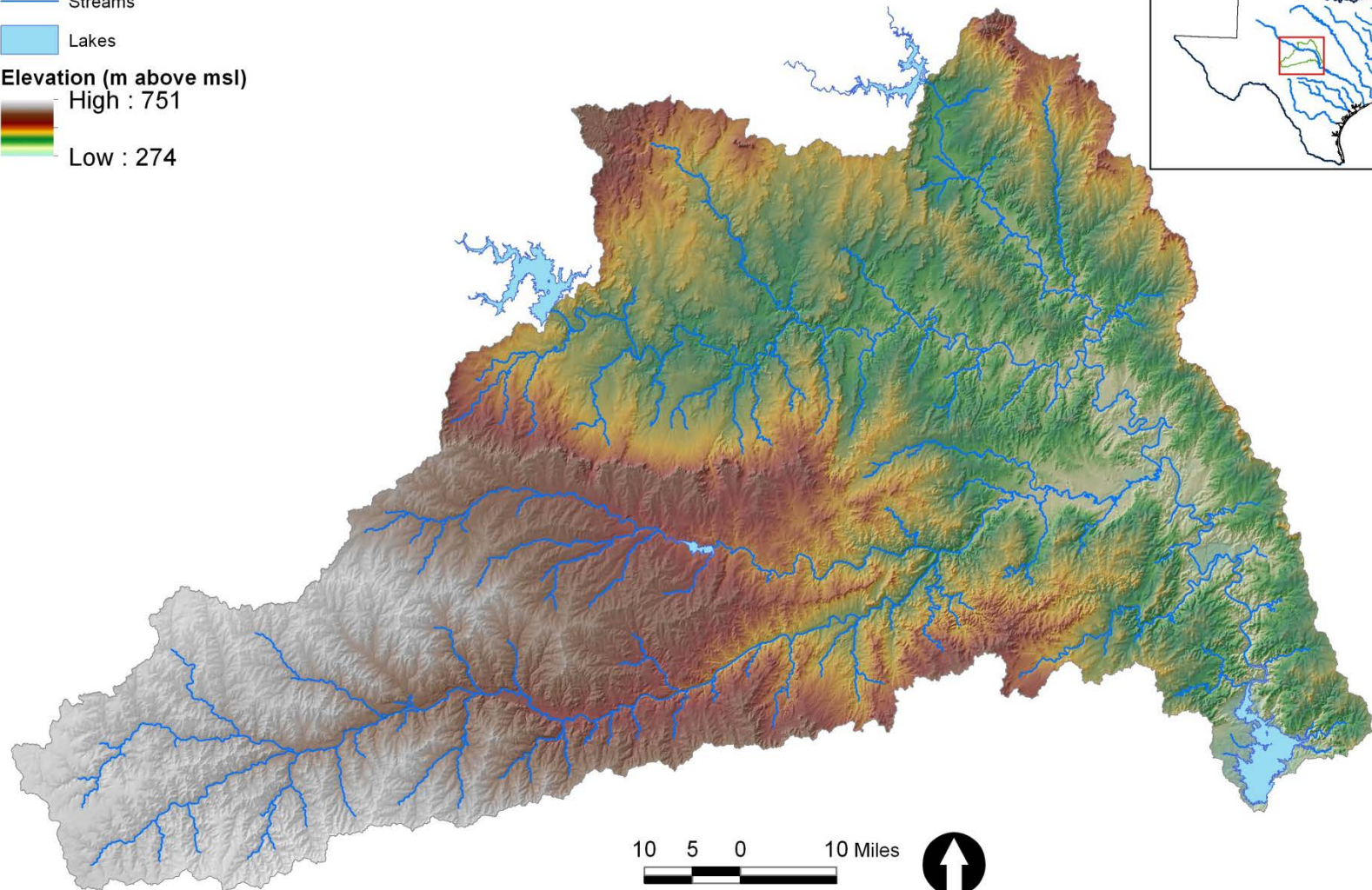
Legend

- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub/Scrub
- Grassland/Herbaceous
- Pasture Hay
- Cultivated Crops
- Woody Wetlands

Lake Brownwood

O. H. Ivie Reservoir

Brady Reservoir

Lake Buchanan

10 5 0   10 Miles

Figure 3-4
Lake Buchanan Watershed Land Cover
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority
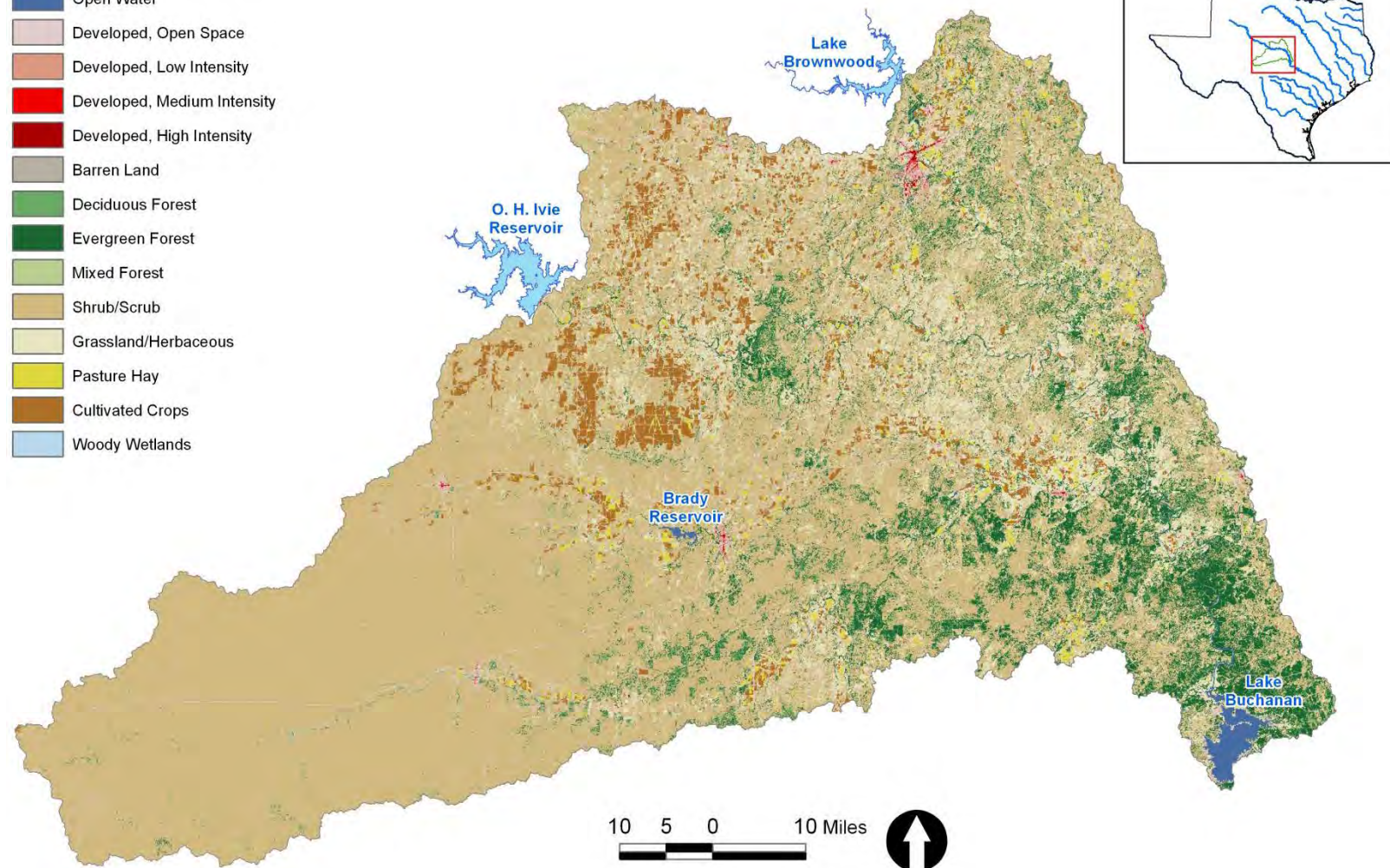
Legend
- Cities
- Streams
- Lakes
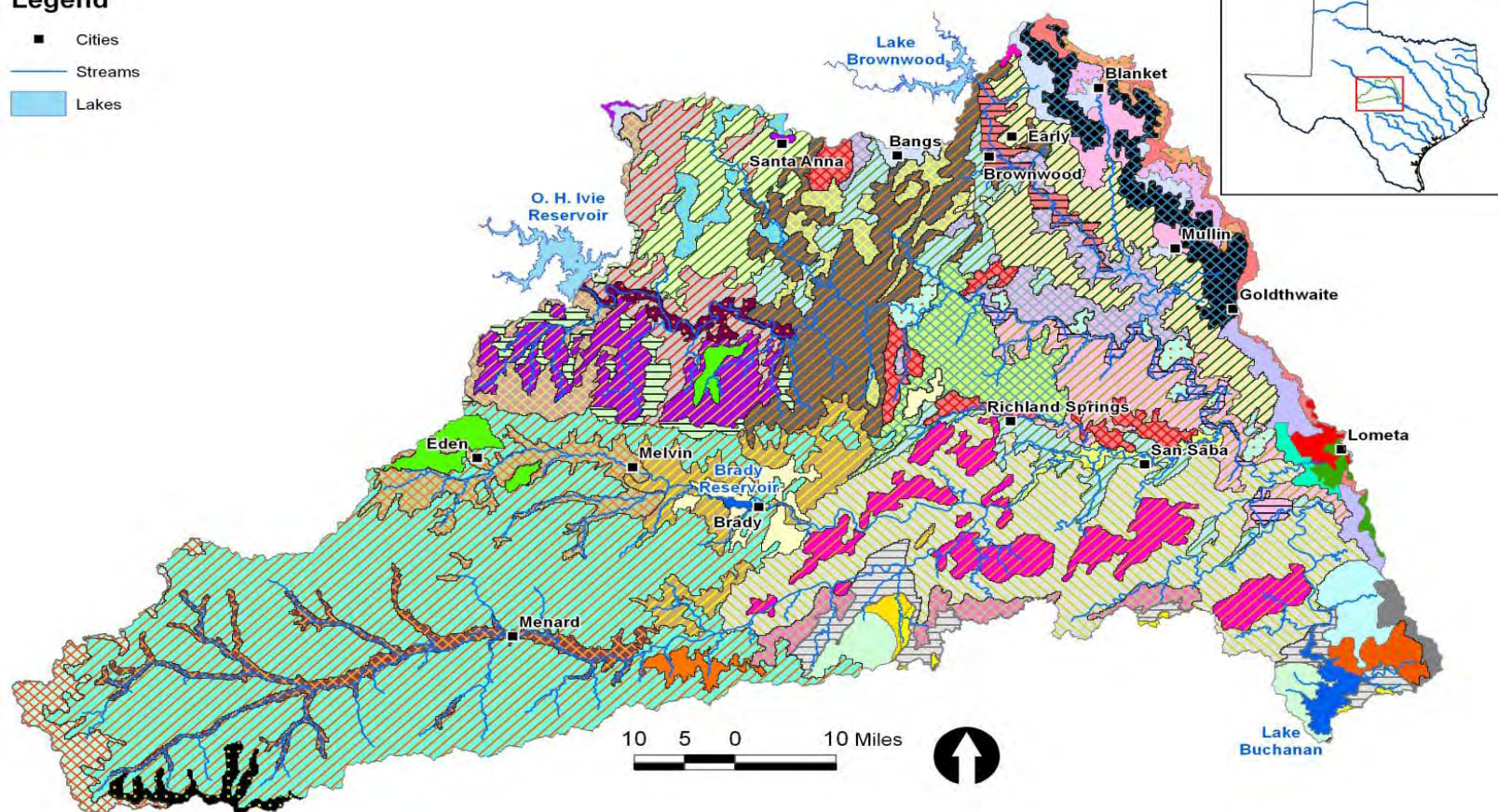
Soil ID

TX483	TX061	TX360	TX095	TX408	TX155	TX344	TX071	TX302
TX146	TX485	TX062	TX369	TX192	TX543	TX169	TX545	TX089	TX327
TX284	TX488	TX064	TX484	TX227	TX592	TX191	TX615	TX094	TX380
TX289	TX526	TX151	TX565	TX273	TX598	TX253	TXW	TX287	TX521
TX361	TX544	TX252	TX617	TX329	TX137	TX288	TX070	TX295
TX481	TX554	TX290	TX069					

Figure 3-5
Lake Buchanan Watershed STATSGO Classification
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA

PARSONS

Figure 3-6
Lake Buchanan Watershed and Springs
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Legend

— NHD Streams

☐ Counties

■ Lake Buchanan

☐ Lake Buchanan Watershed

Highland Lakes Watershed Ordinance

■ Region A

2 1 0 — 2 Miles

Figure 3-7
Lake Buchanan Watershed within the HLWO
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA

PARSONS

Figure 3-8
Lake Buchanan Watershed Model Segmentation and Pour Points
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 3-9
Lake Buchanan Watershed Calibration Stations
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 3-10
Lake Buchanan Watershed Wastewater and Stormwater Treatment Facilities
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 3-11
Lake Buchanan Watershed Average Annual Precipitation and Meteorological Stations Used in SWAT Modeling
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 3-12
Flow Calibration Results for USGS Gage 08147000-Colorado River at US 190 near San Saba
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 3-13
Flow Calibration Results for USGS Gage 08138000-Colorado River at Winchell
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 3-14
Flow Calibration Results for USGS Gage 08146000-San Saba River near San Saba
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 3-15
Flow Calibration Results for USGS Gage 08143600-Pecan Bayou near Mullin
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 3-16
Flow Calibration Results for LCRA Station 1925-Colorado River near Bend
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 3-17
Flow Calibration Results for LCRA Station 1277-Colorado River near Goldthwaite
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 3-18
Flow Calibration Results for USGS Gage 08144600-San Saba River at US187 near Brady
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 3-21a
LOADEST Fit Plots for Station 12355-Colorado River at US 190 near San Saba
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 3-21c
LOADEST Fit Plots for Station 12394-Pecan Bayou at FM 573 southwest of Mullin
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 3-22a Annual Sediment Load Calibration Results for Station 12355-Colorado River at US 190 near San Saba

Figure 3-22b Monthly Average Sediment Load Calibration Results for Station 12355-Colorado River at US 190 near San Saba
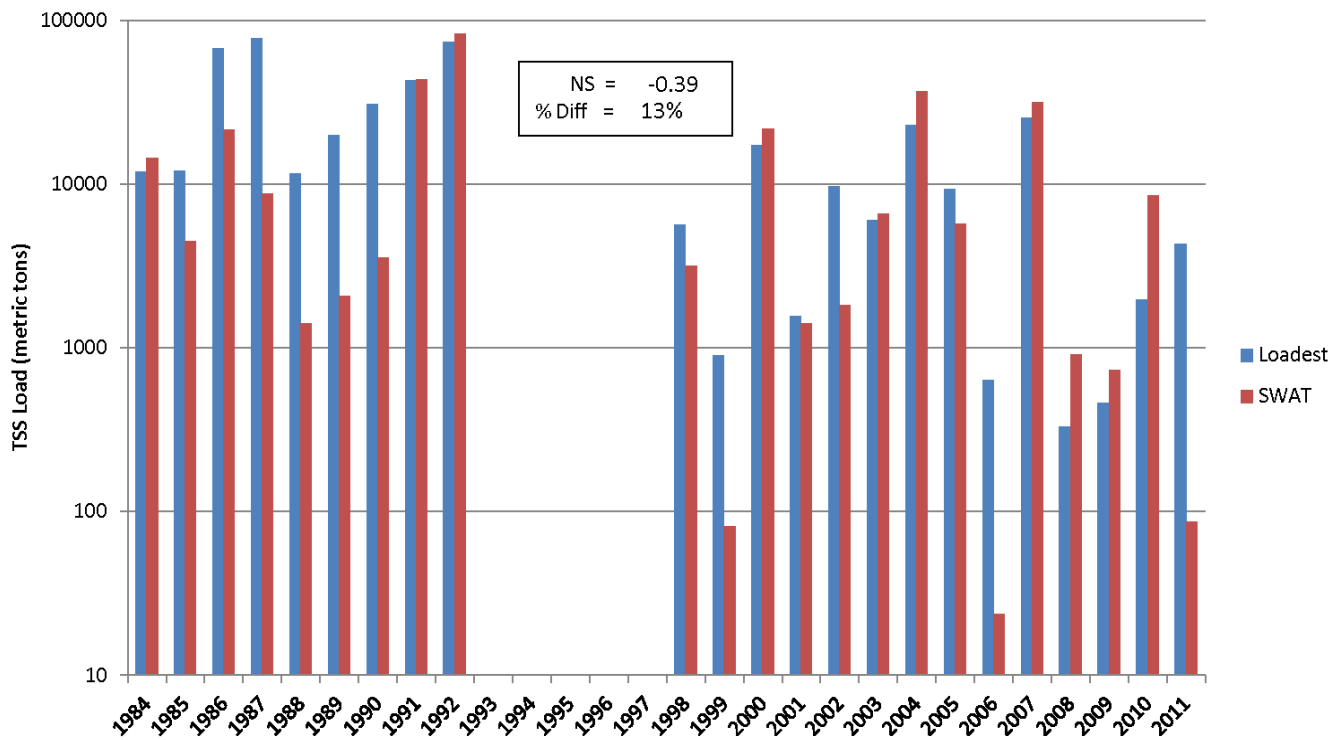
Figure 3-23a Annual Sediment Load Calibration Results for Station 12358-
Colorado River at Highway 377 in Winchell
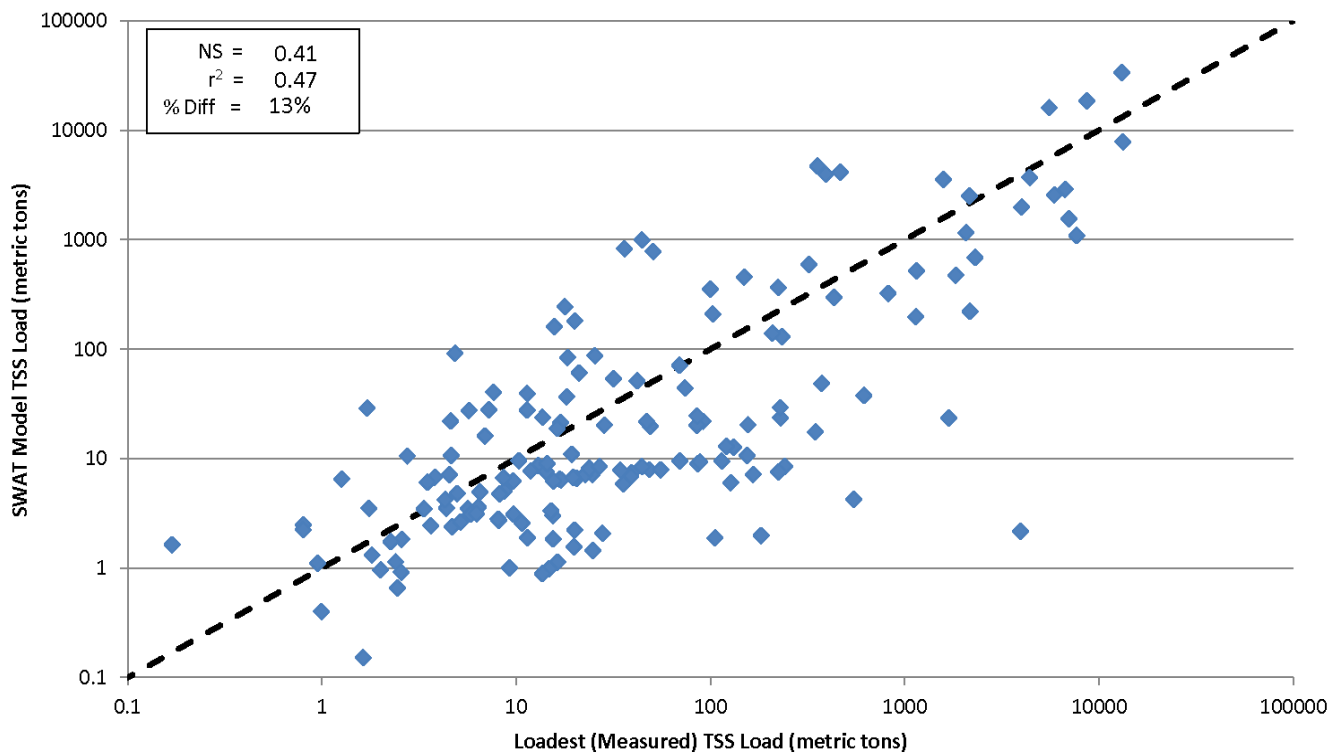
Figure 3-23b Monthly Average Sediment Load Calibration Results for Station 12358-
Colorado River at Highway 377 in Winchell

Figures 3-23a and b
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority
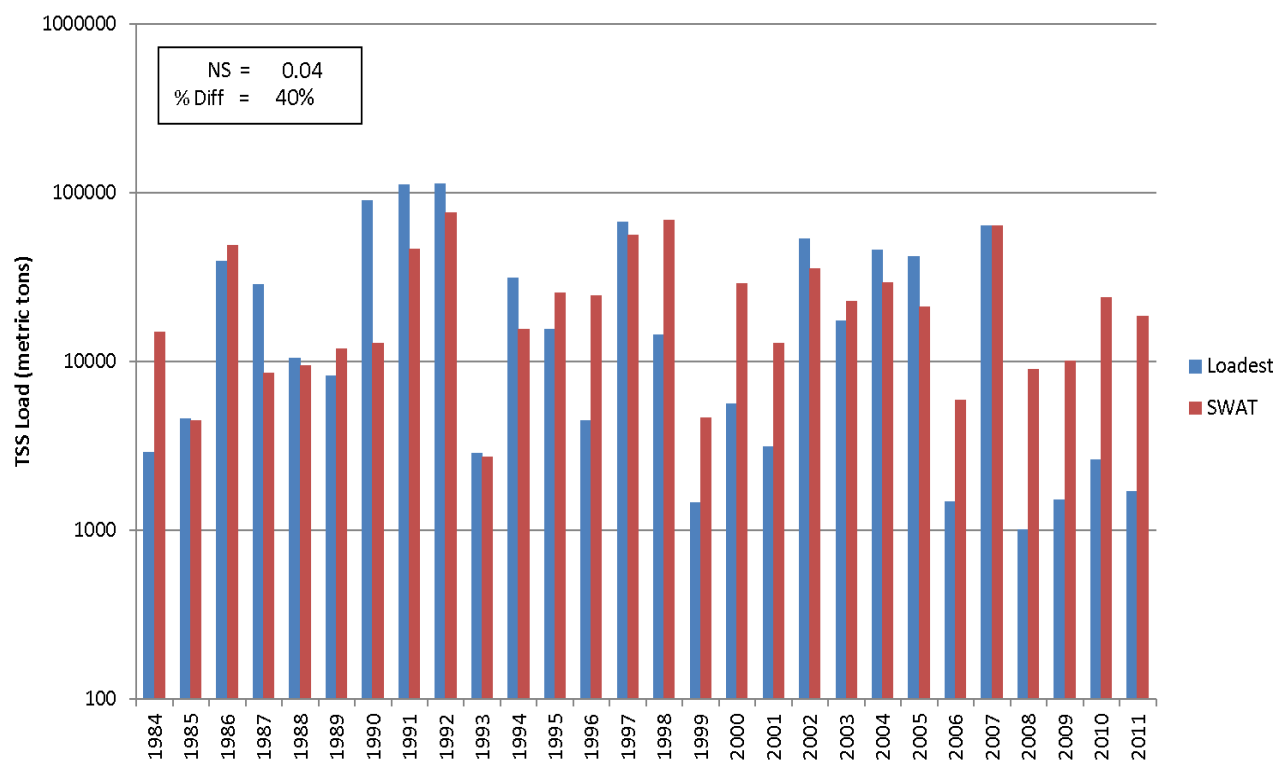
Figure 3-24a Annual Sediment Load Calibration Results for Station 12394-Pecan Bayou at FM 573 southwest of Mullin
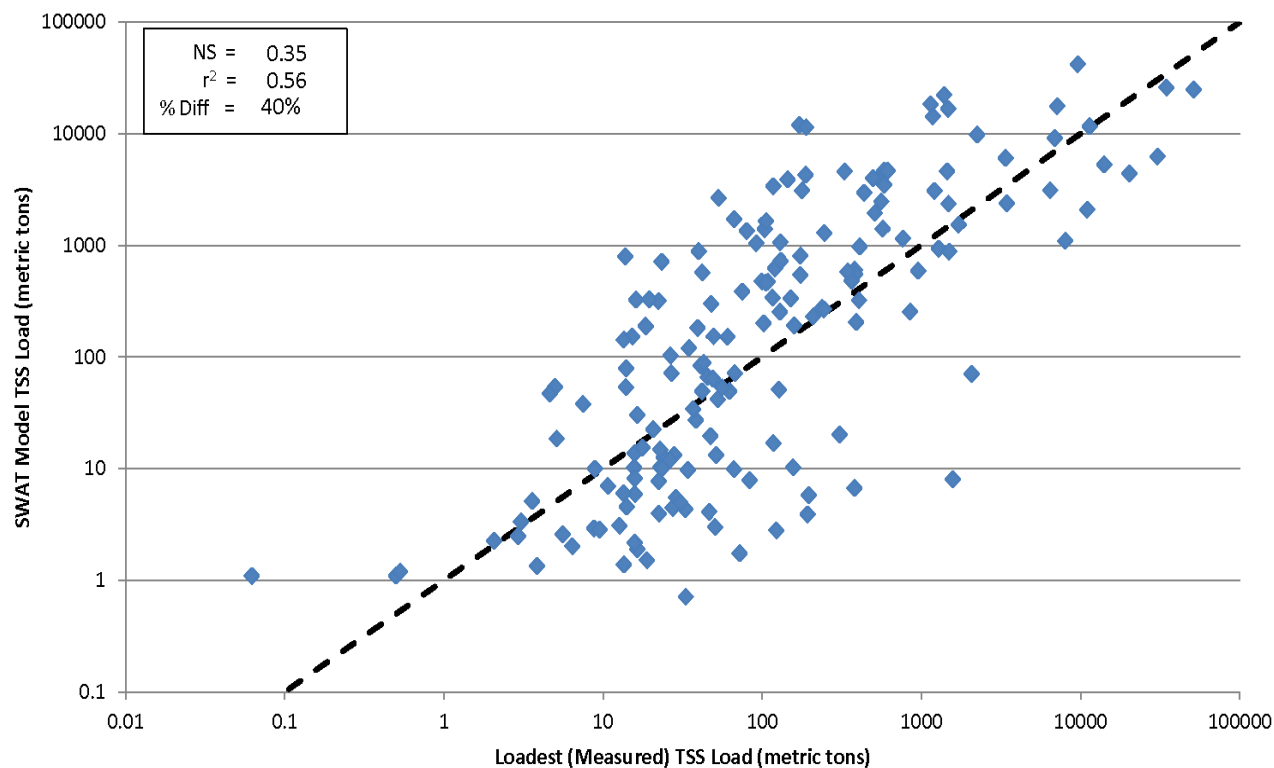
Figure 3-24b Monthly Average Sediment Load Calibration Results for Station 12394-Pecan Bayou at FM 573 southwest of Mullin
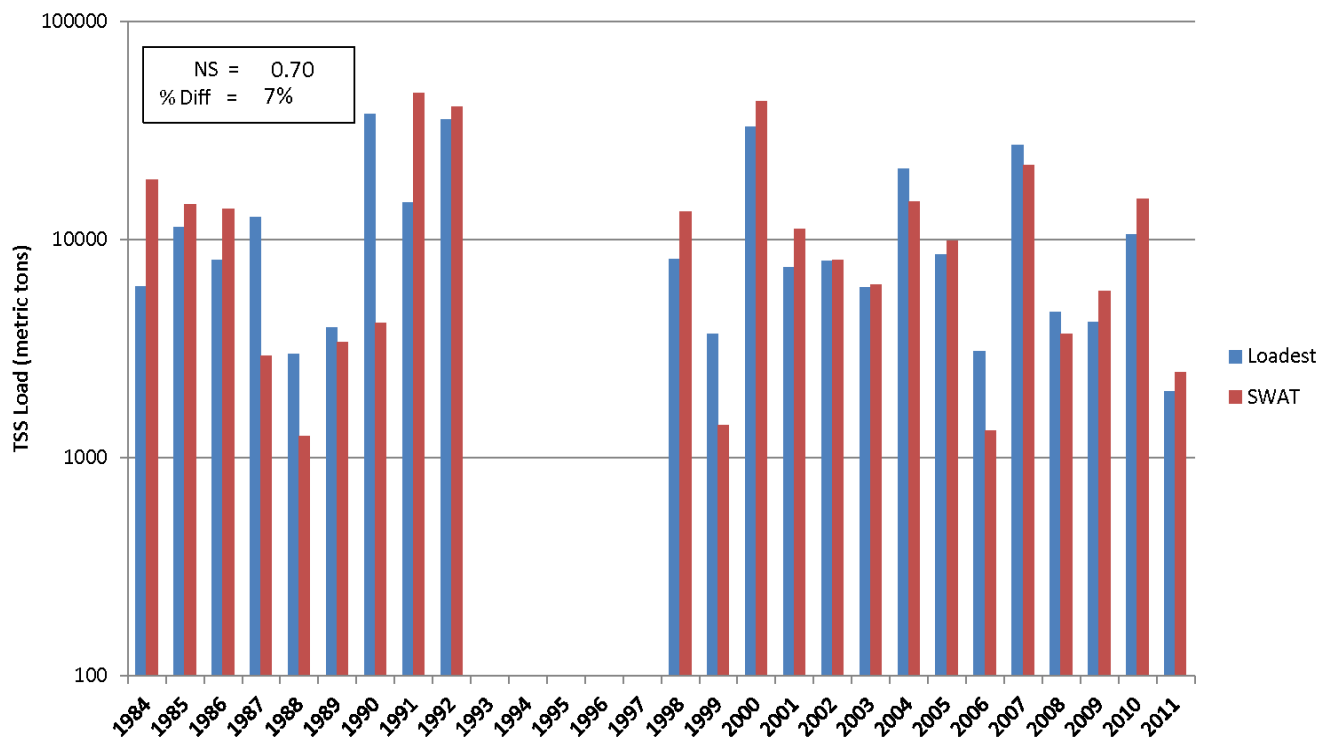
Figure 3-25a Annual Sediment Load Calibration Results for Station 12392-
San Saba River at SH 16 near San Saba
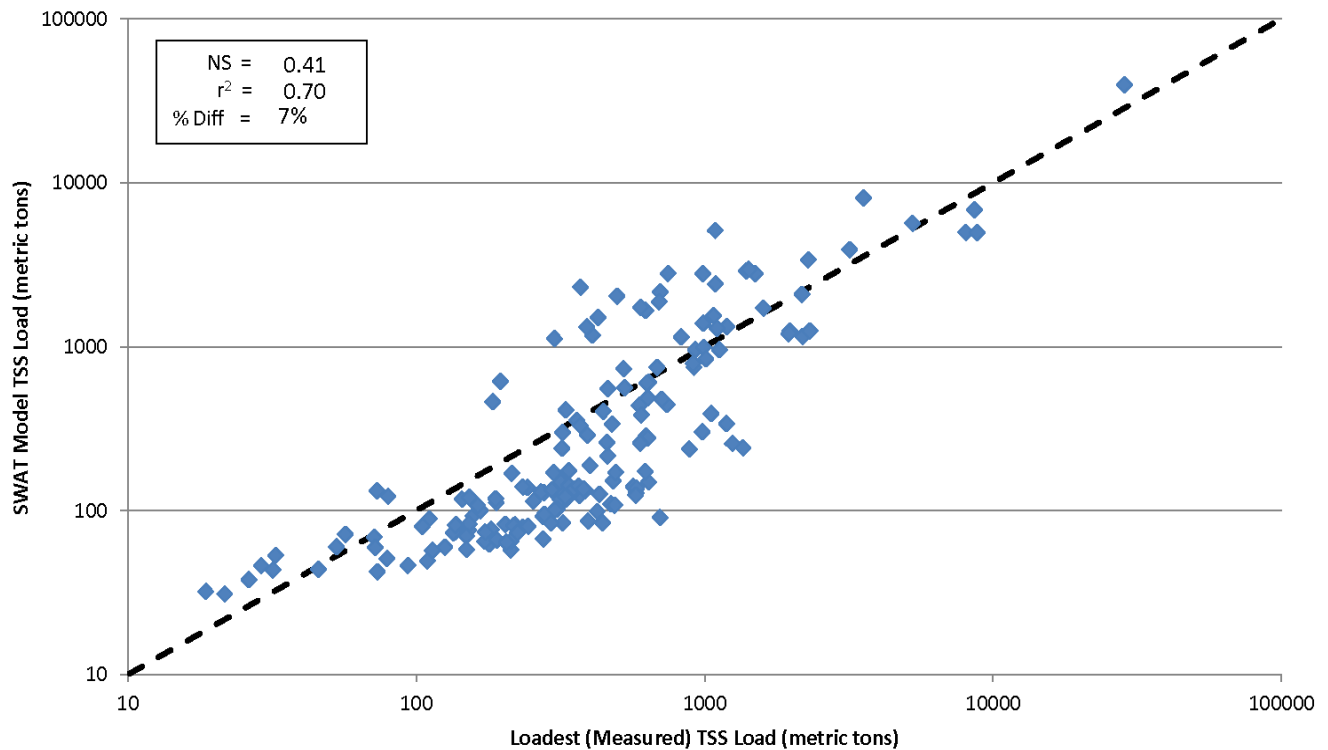
Figure 3-25b Monthly Average Sediment Load Calibration Results for Station 12392-
San Saba River at SH 16 near San Saba
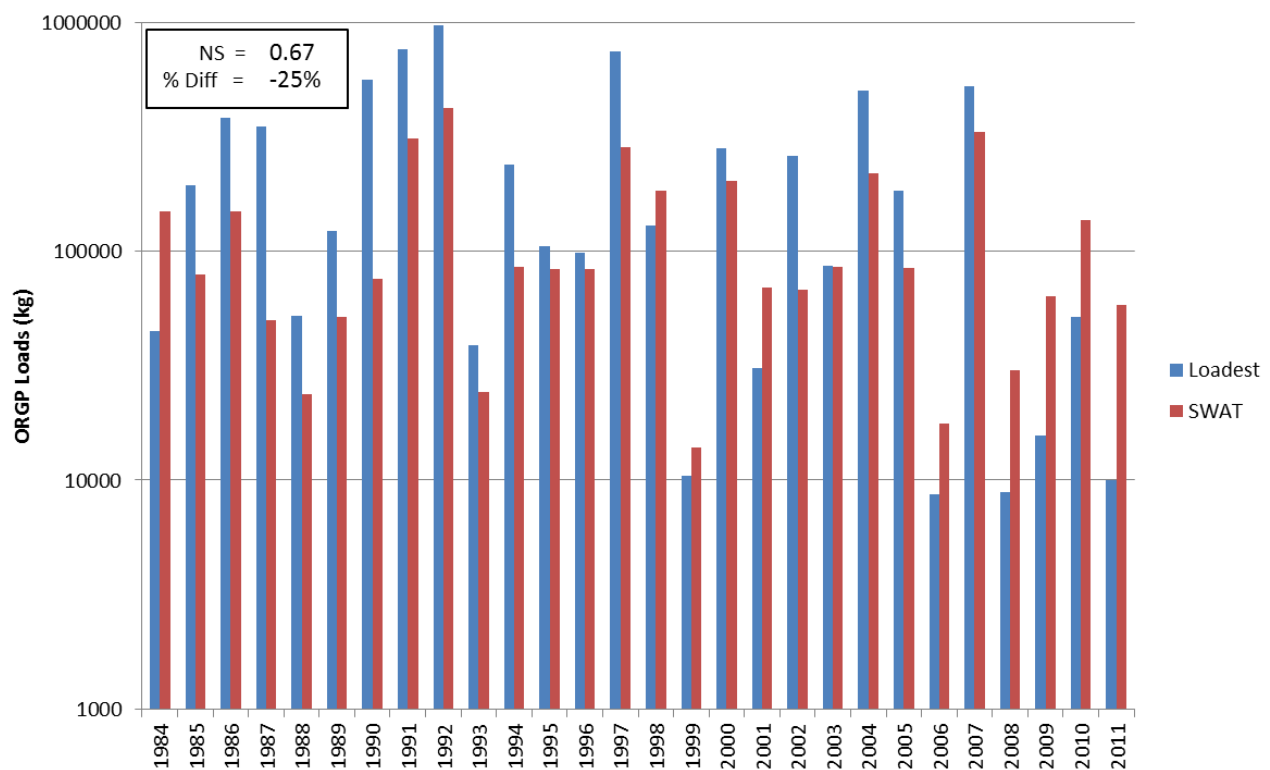
Figure 3-26a Annual Organic Phosphorus Load Calibration Results for Station 12355-Colorado River at US 190 near San Saba
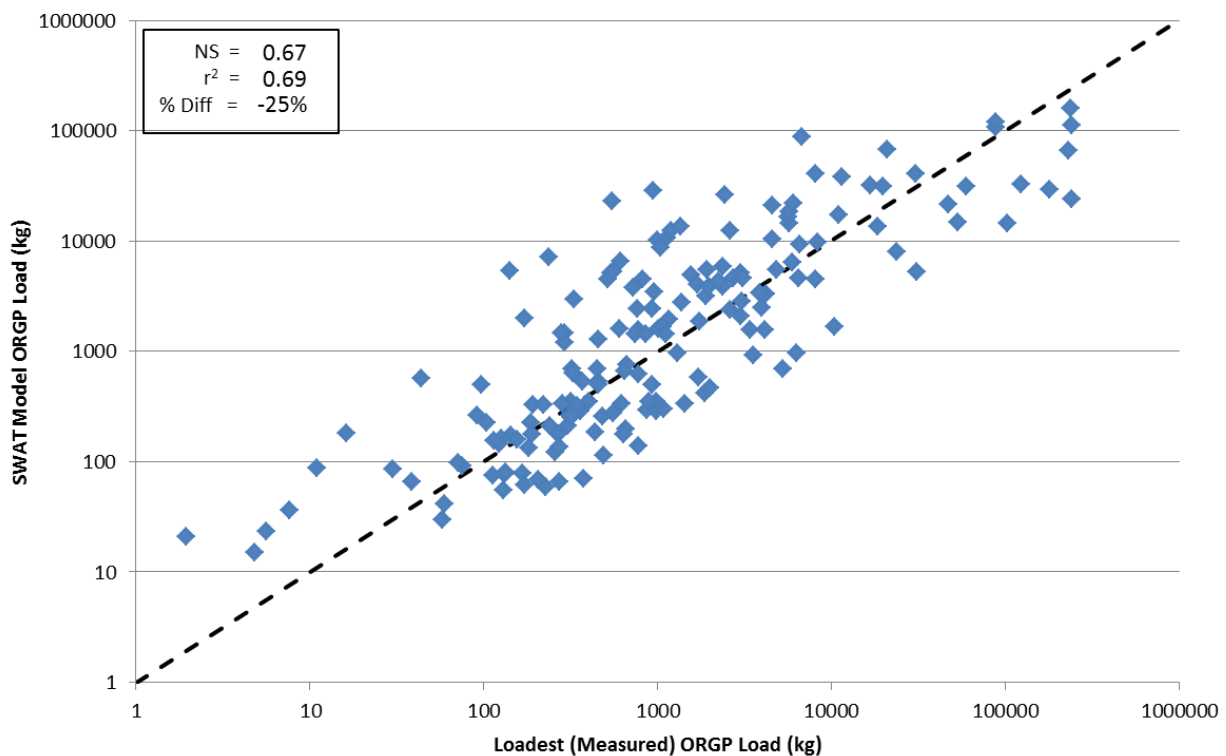
Figure 3-26b Monthly Average Organic Phosphorus Load Calibration Results for Station 12355-Colorado River at US 190 near San Saba
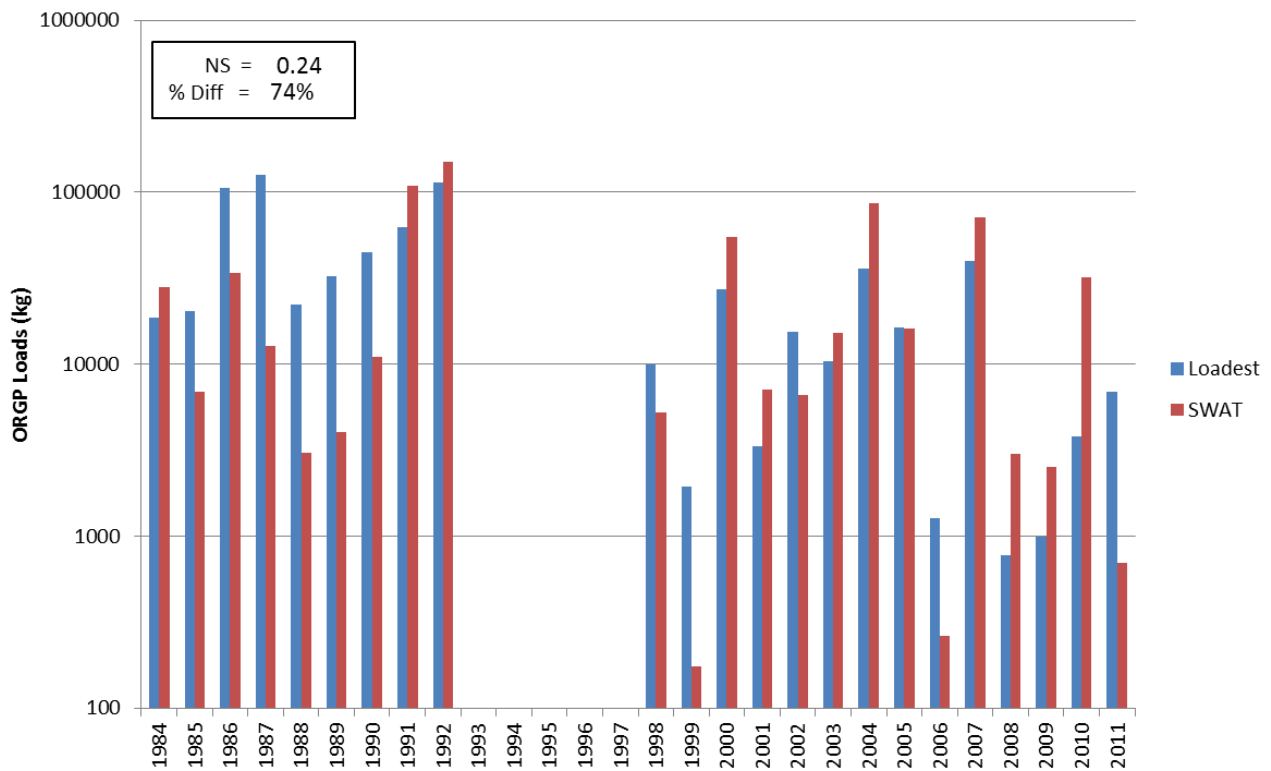
Figure 3-27a Annual Organic Phosphorus Load Calibration Results for Station 12358-Colorado River at Highway 377 in Winchell
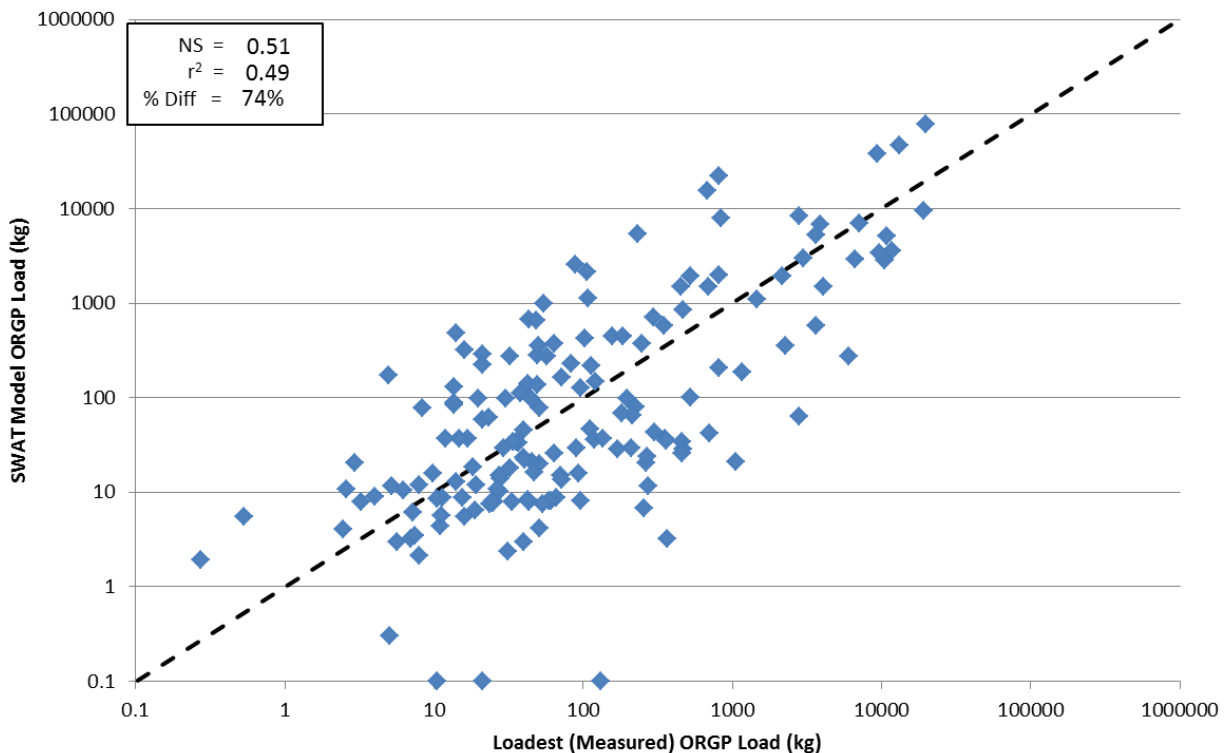
Figure 3-27b Monthly Average Organic Phosphorus Load Calibration Results for Station 12358-Colorado River at Highway 377 in Winchell
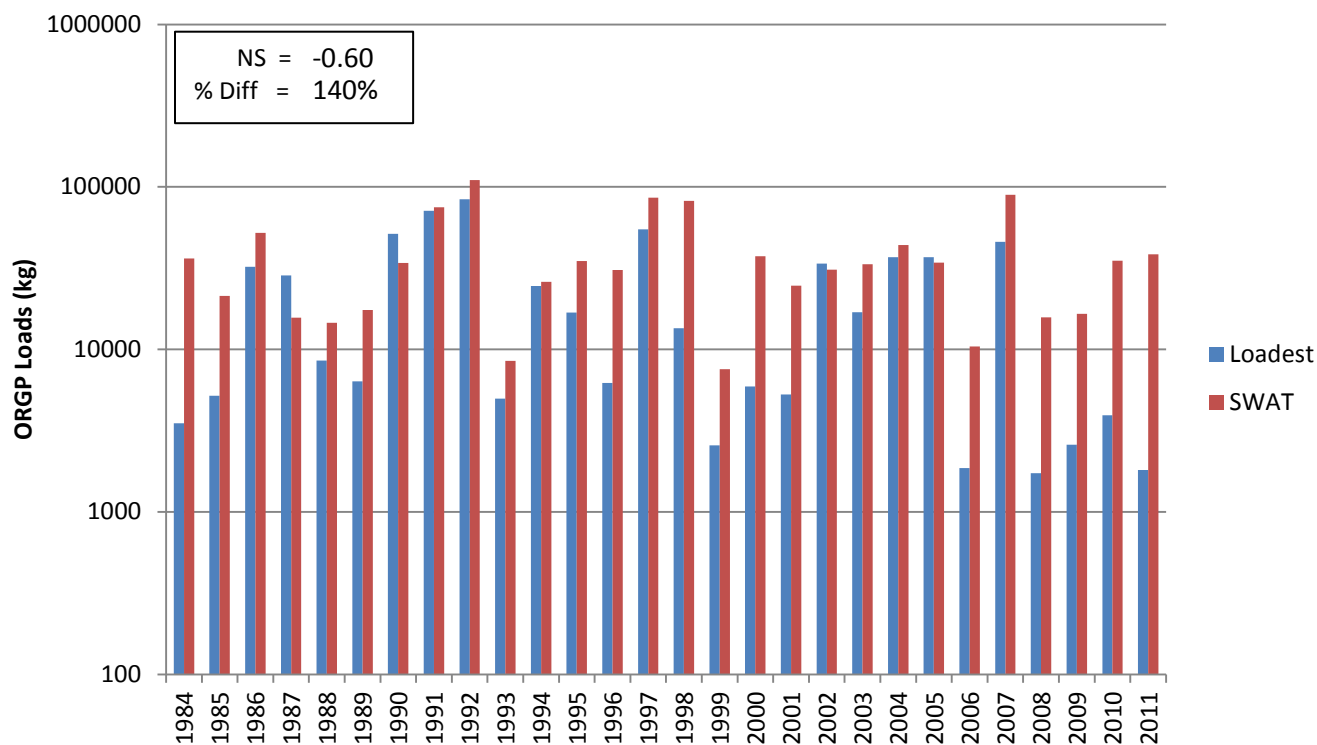
Figure 3-28a Annual Organic Phosphorus Load Calibration Results for Station 12394-
Pecan Bayou at FM 573 southwest of Mullin
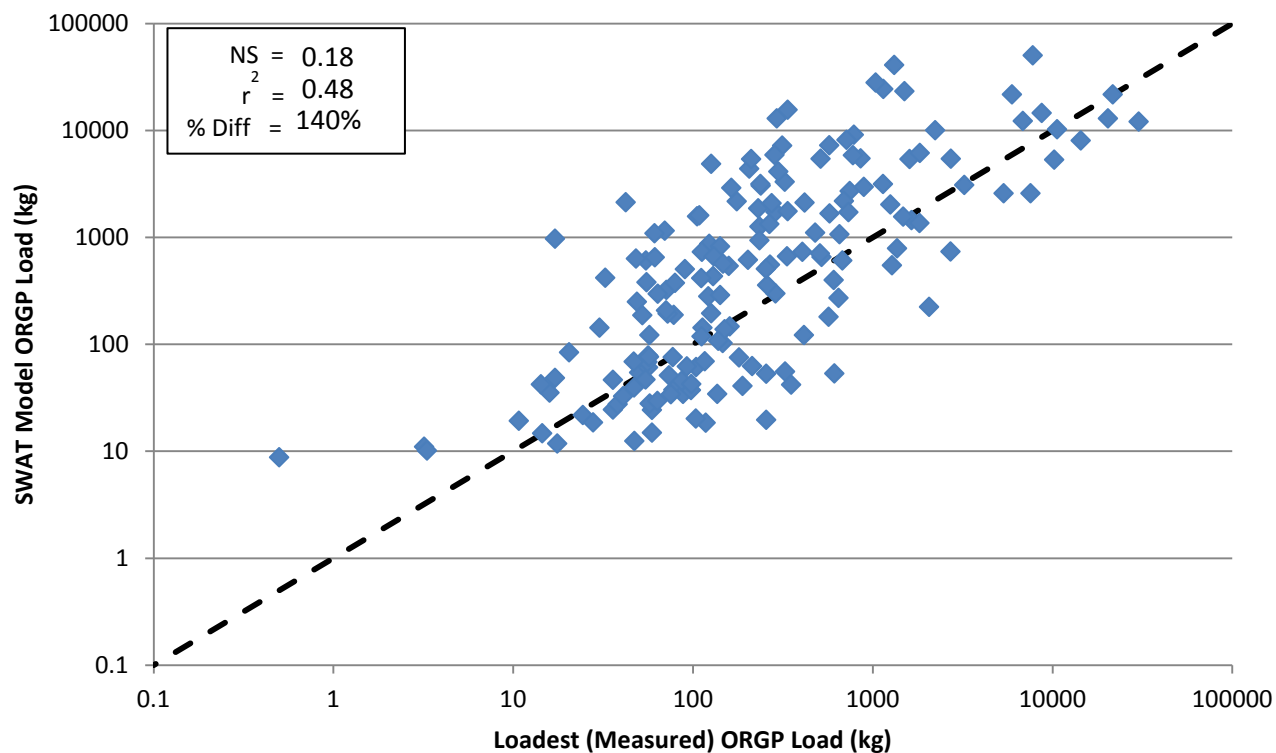
Figure 3-28b Monthly Average Organic Phosphorus Load Calibration Results for Station 12394-
Pecan Bayou at FM 573 southwest of Mullin
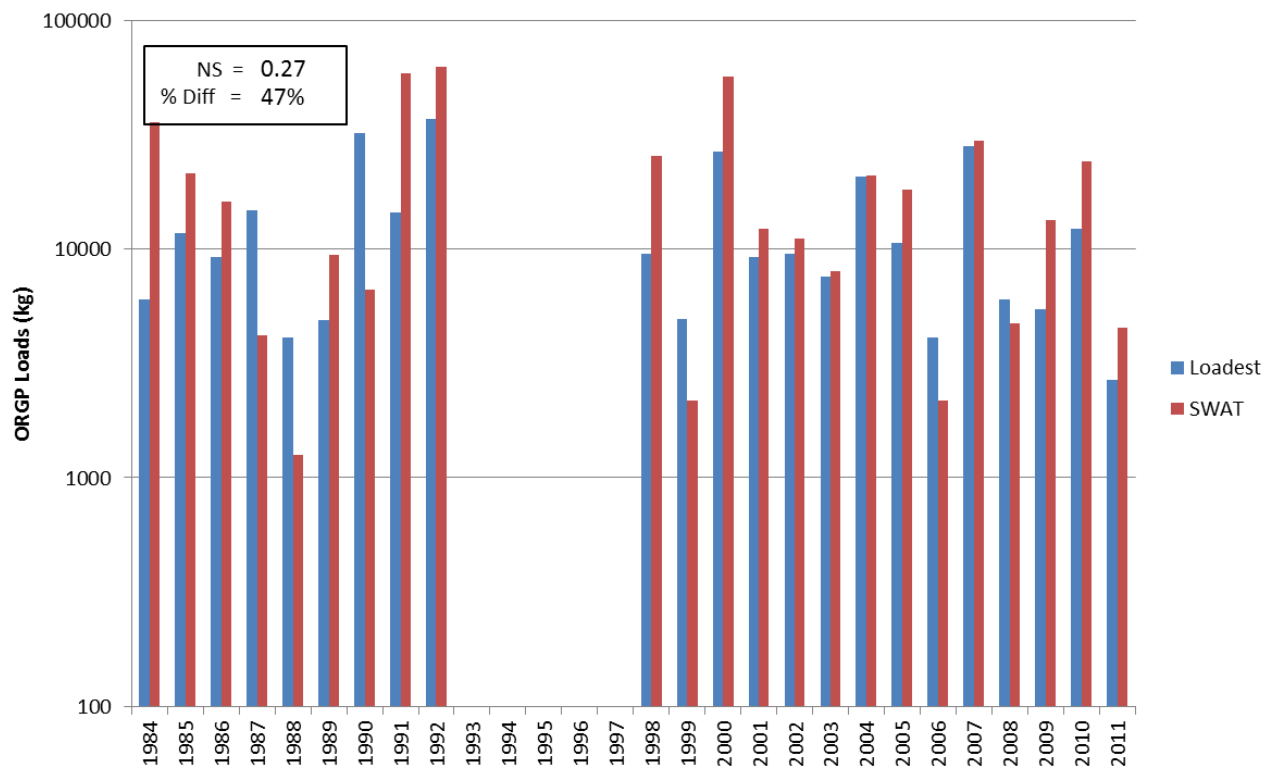
Figure 3-29a Annual Organic Phosphorus Load Calibration Results for Station 12392-San Saba River at SH 16 near San Saba
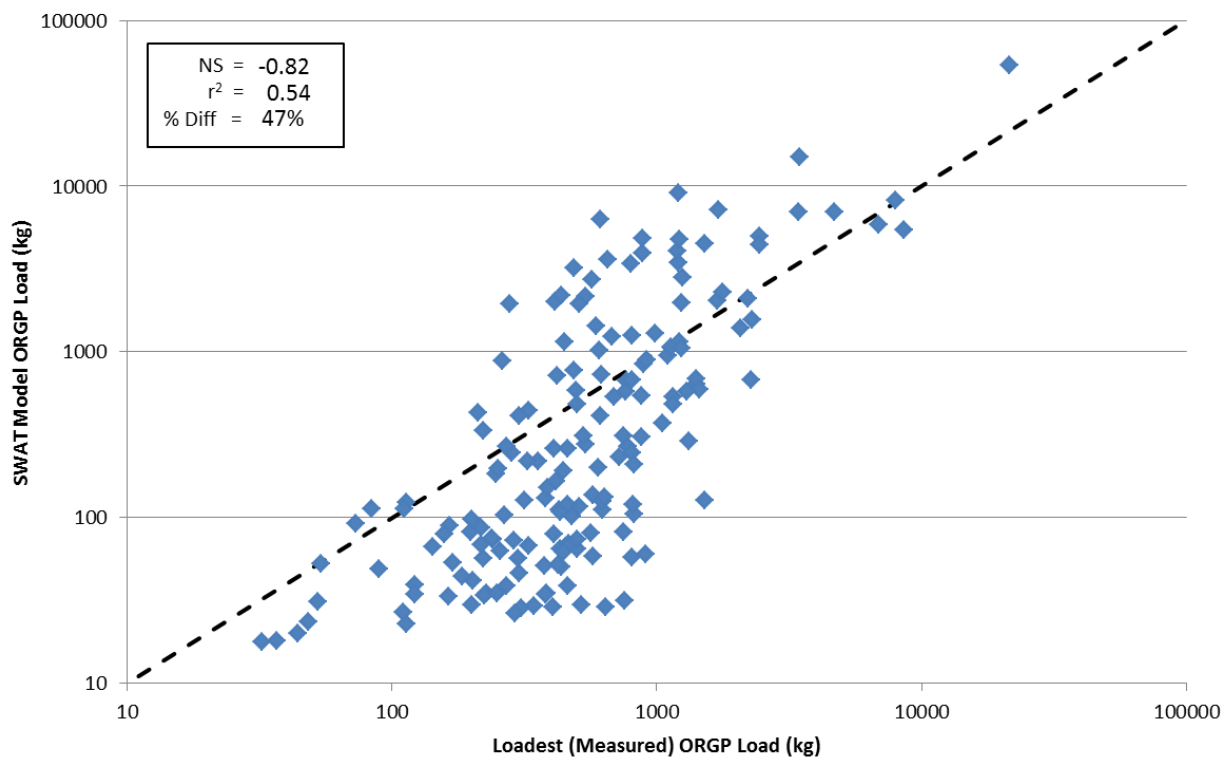
Figure 3-29b Monthly Average Organic Phosphorus Load Calibration Results for Station 12392-San Saba River at SH 16 near San Saba
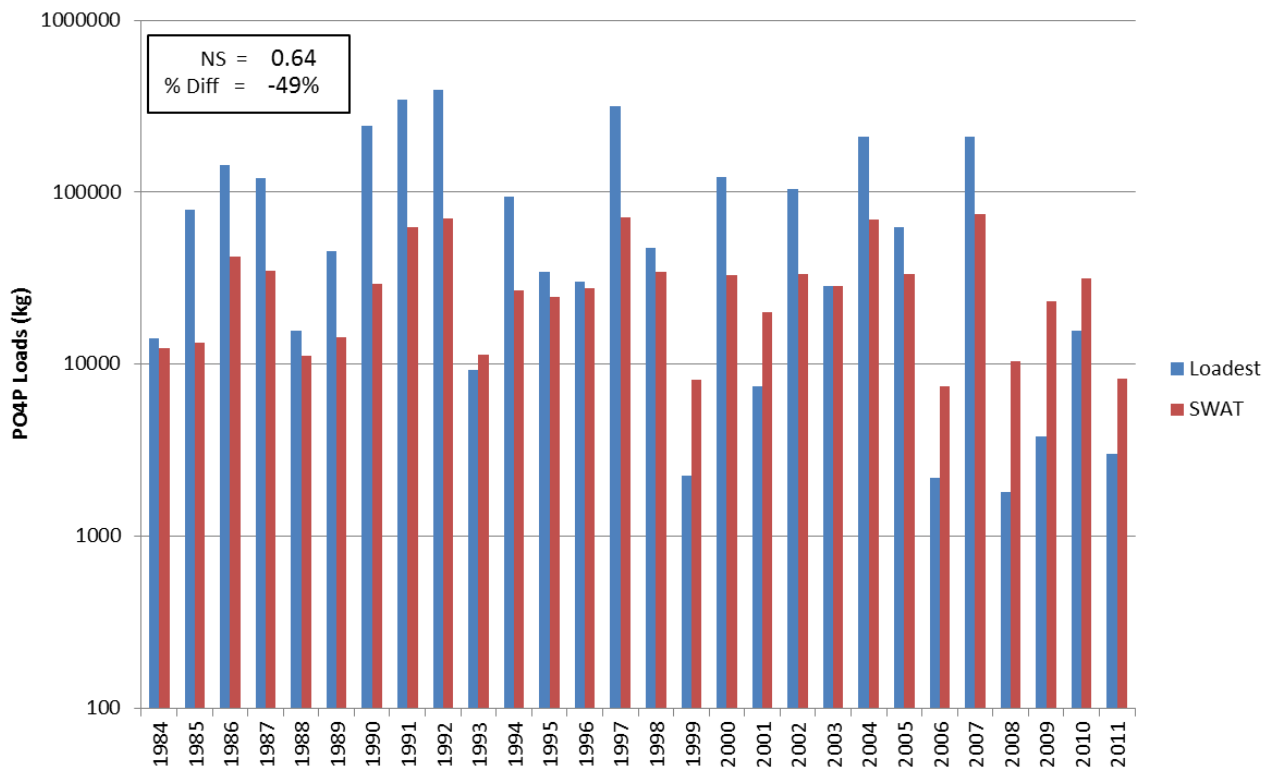
Figure 3-30a Annual Orthophosphate Load Calibration Results for Station 12355-Colorado River at US 190 near San Saba
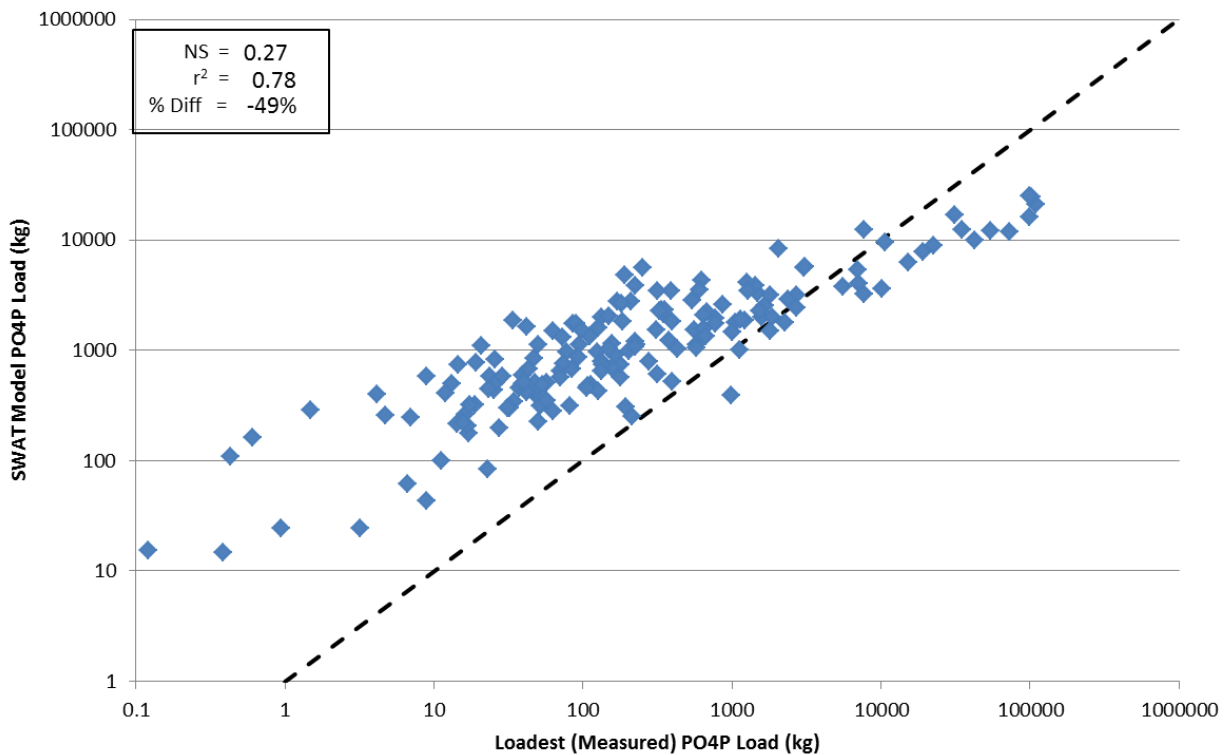
Figure 3-30b Monthly Average Orthophosphate Load Calibration Results for Station 12355-Colorado River at US 190 near San Saba
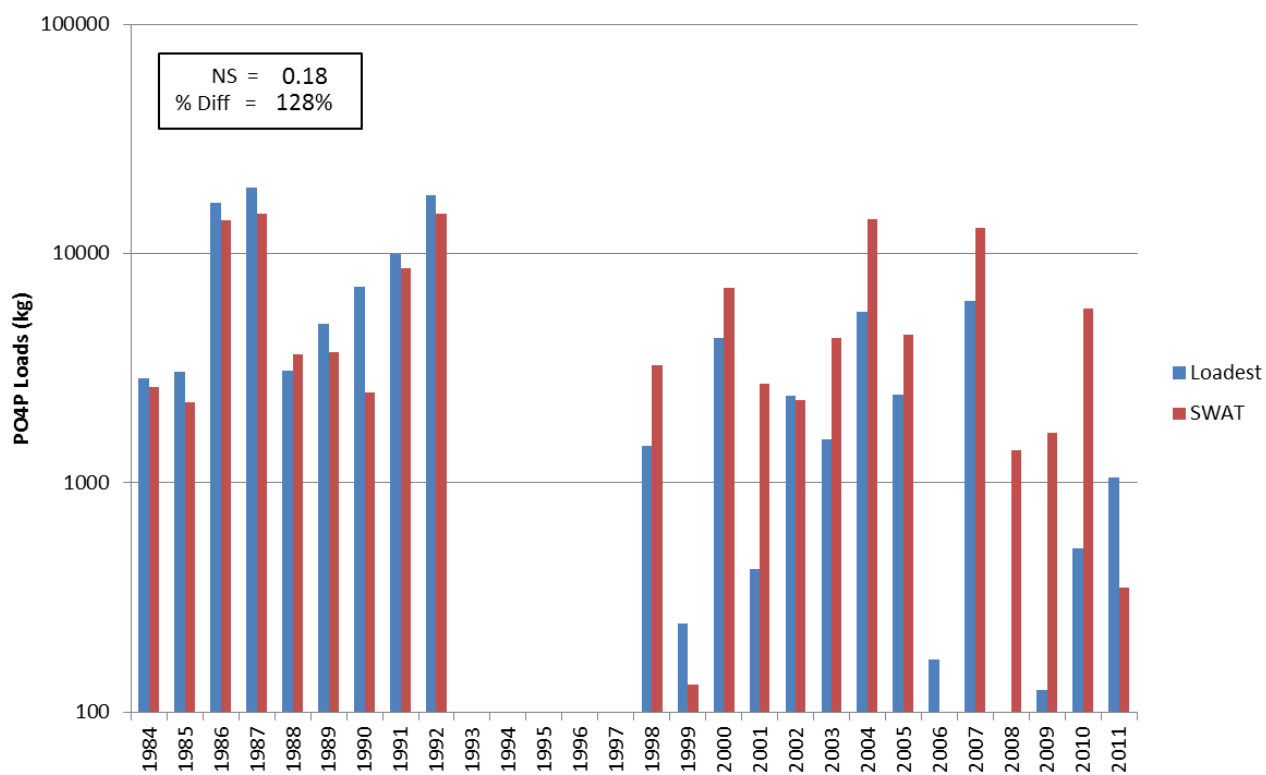
Figure 3-31a Annual Orthophosphate Load Calibration Results for Station 12358-Colorado River at Highway 377 in Winchell
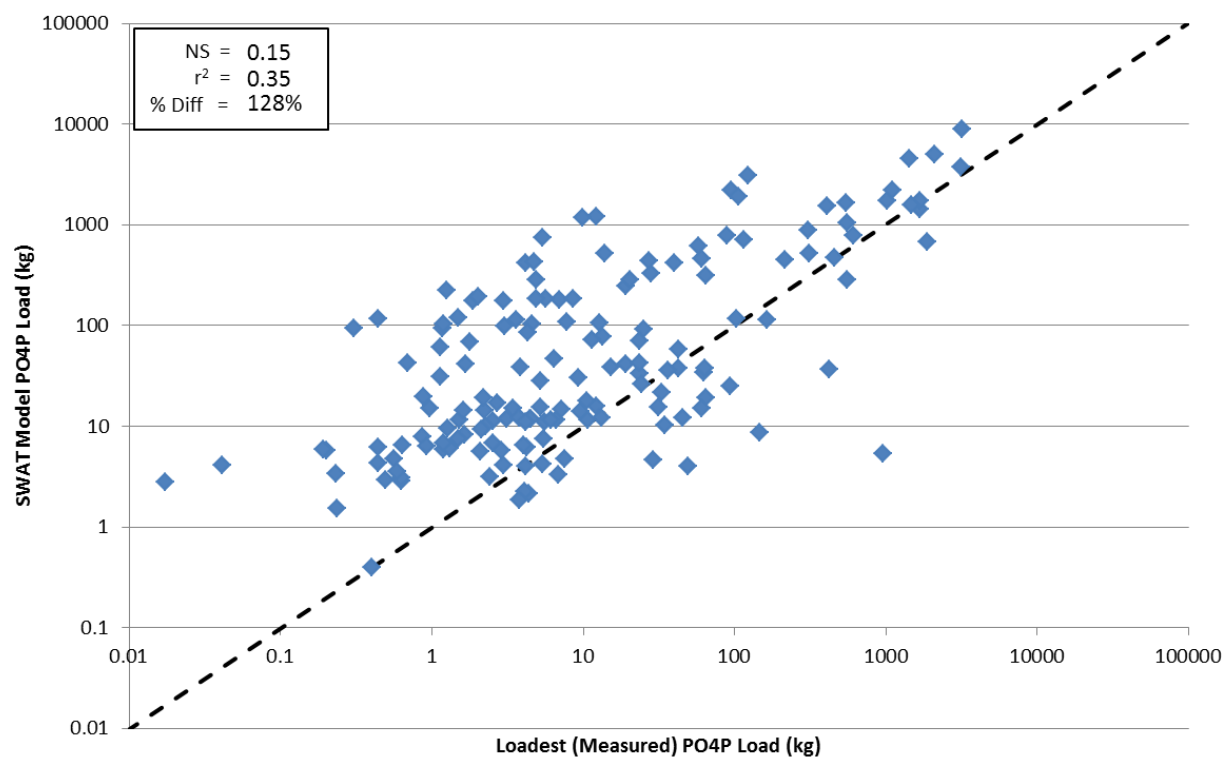
Figure 3-31b Monthly Average Orthophosphate Load Calibration Results for Station 12358-Colorado River at Highway 377 in Winchell
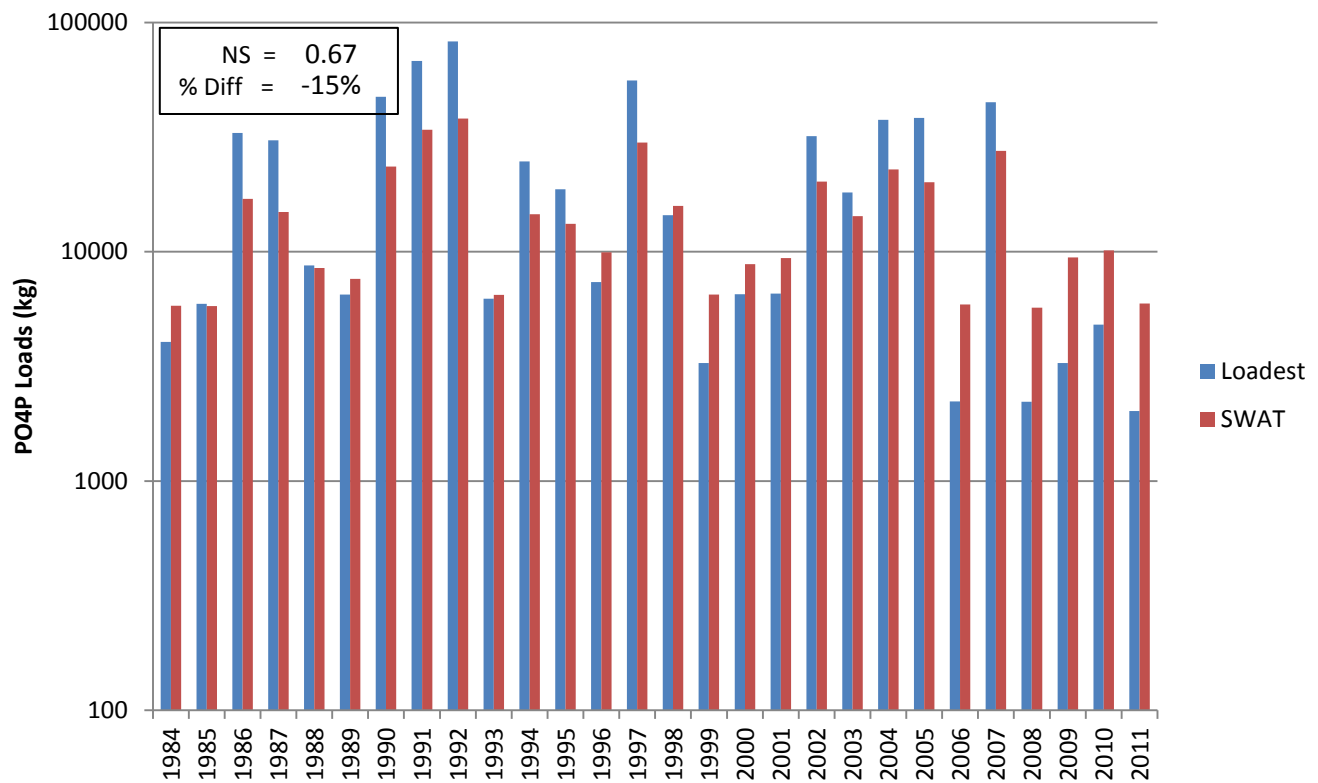
Figure 3-32a Annual Orthophosphate Load Calibration Results for Station 12394-Pecan Bayou at FM 573 southwest of Mullin
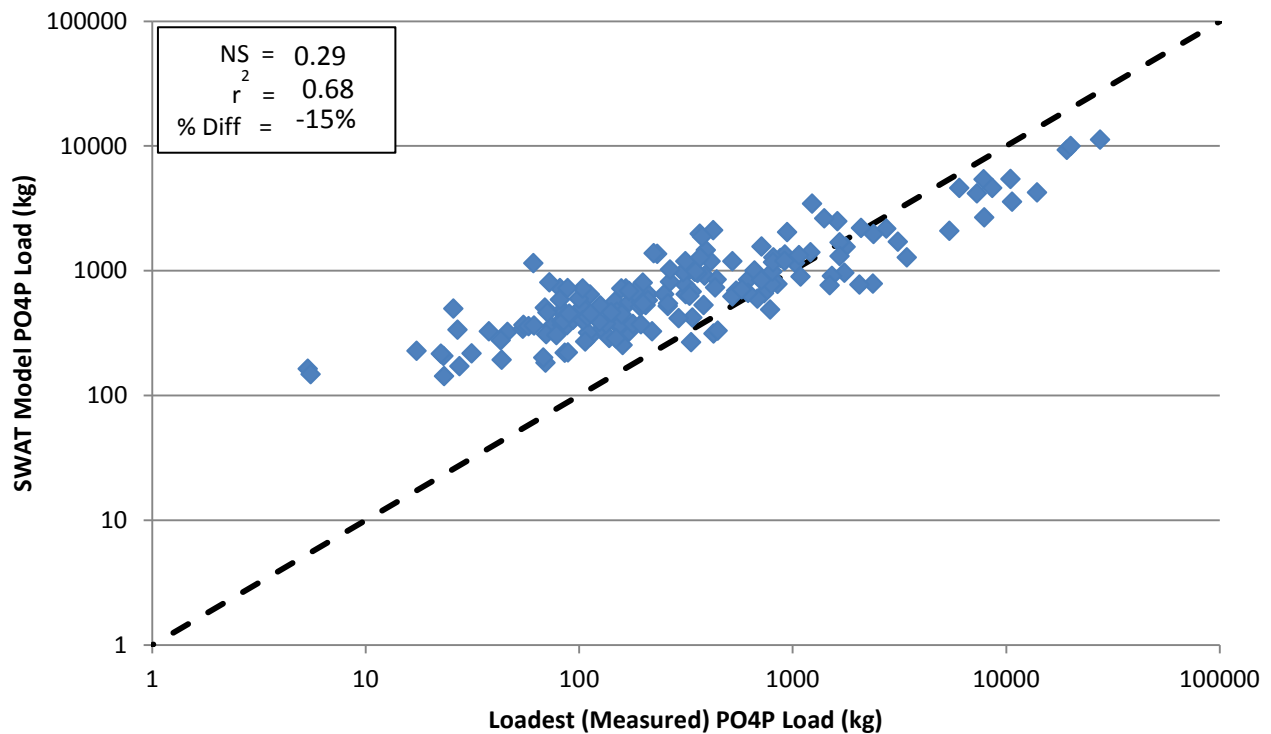
Figure 3-32b Monthly Average Orthophosphate Load Calibration Results for Station 12394-Pecan Bayou at FM 573 southwest of Mullin
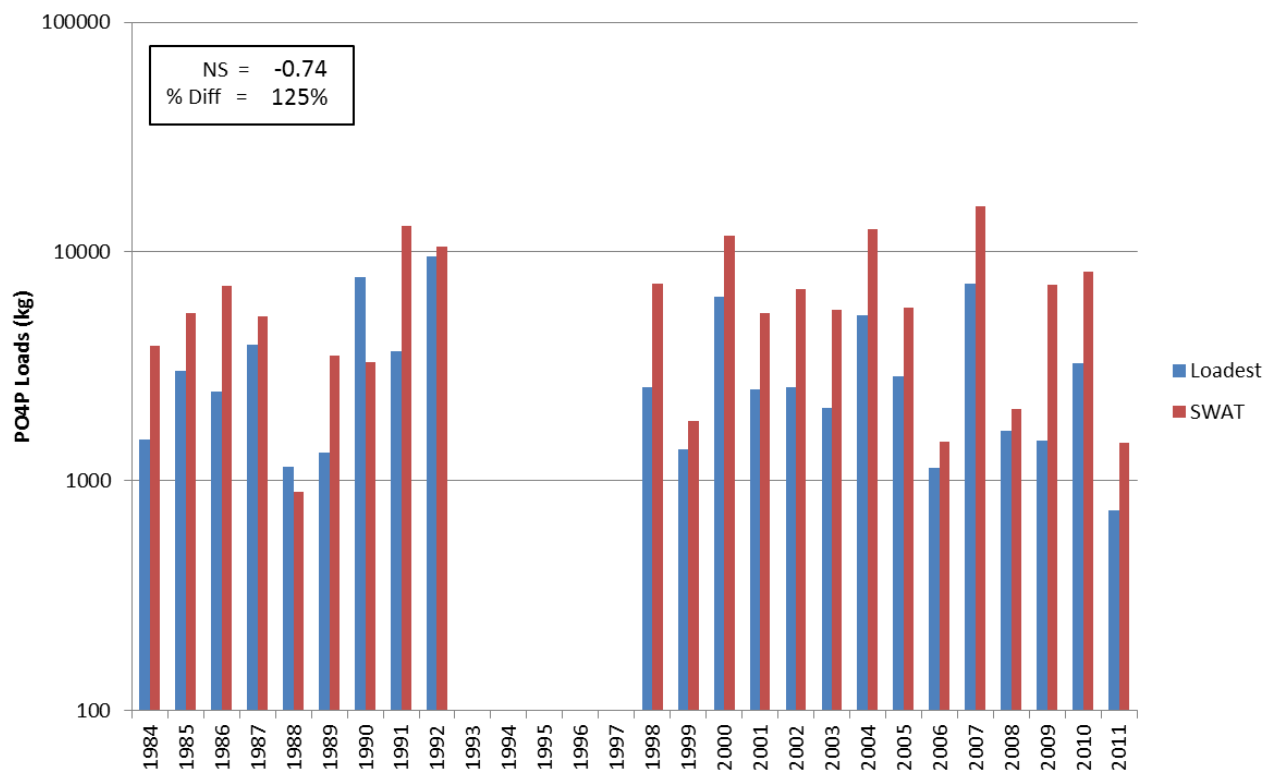
Figure 3-33a Annual Orthophosphate Load Calibration Results for Station 12392-San Saba River at SH 16 near San Saba
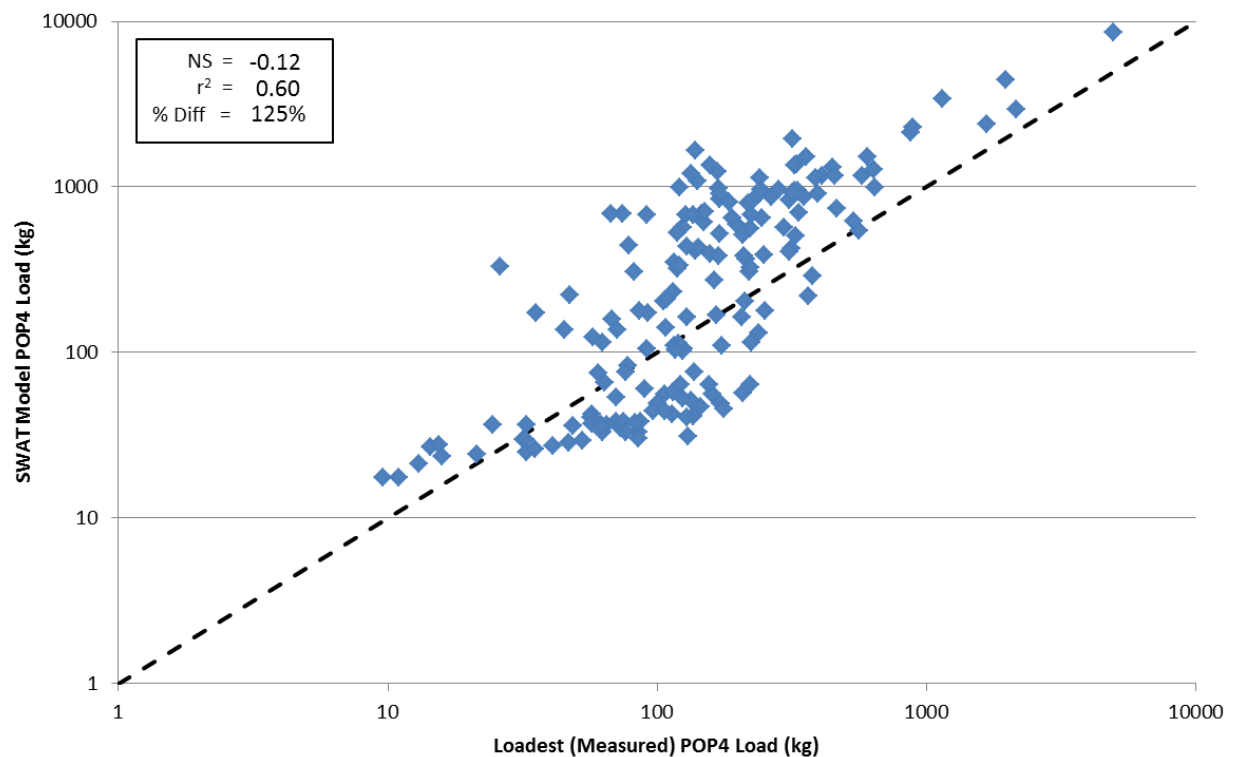
Figure 3-33b Monthly Average Orthophosphate Load Calibration Results for Station 12392-San Saba River at SH 16 near San Saba
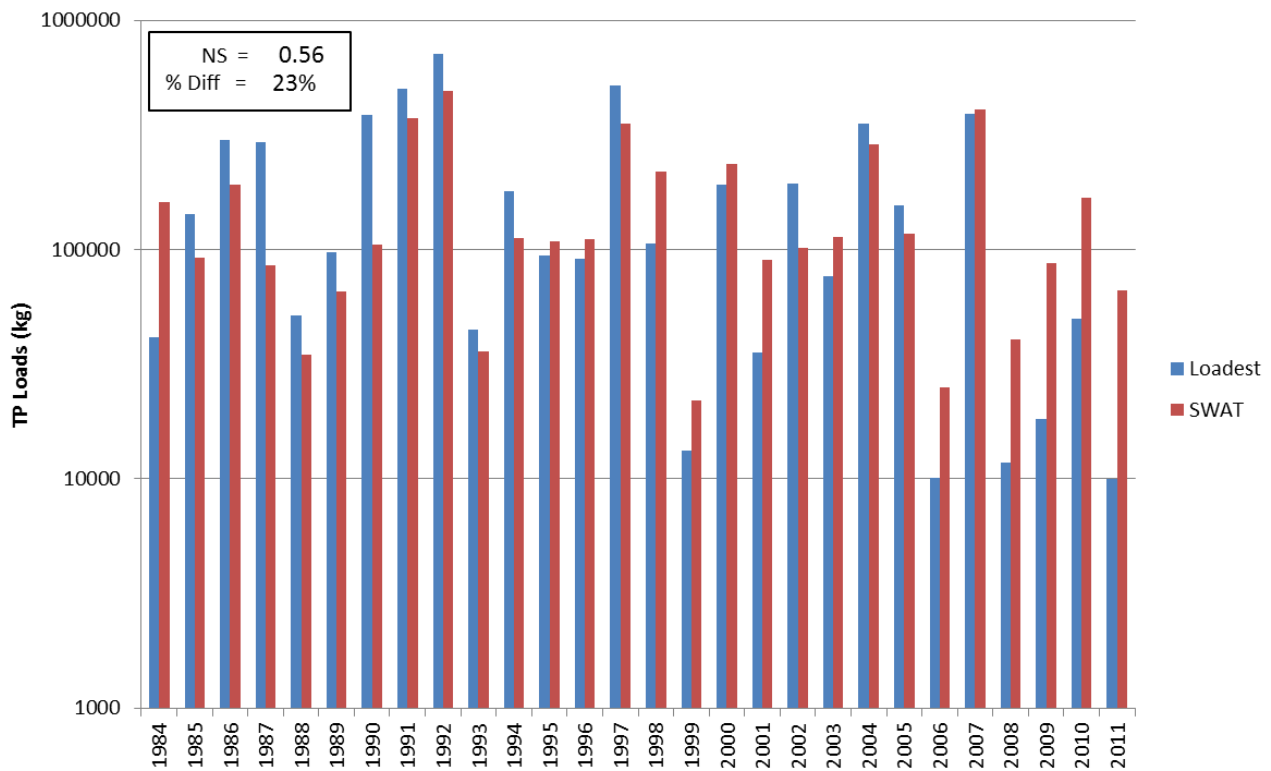
Figure 3-34a Annual Total Phosphorus Load Calibration Results for Station 12355-Colorado River at US 190 near San Saba
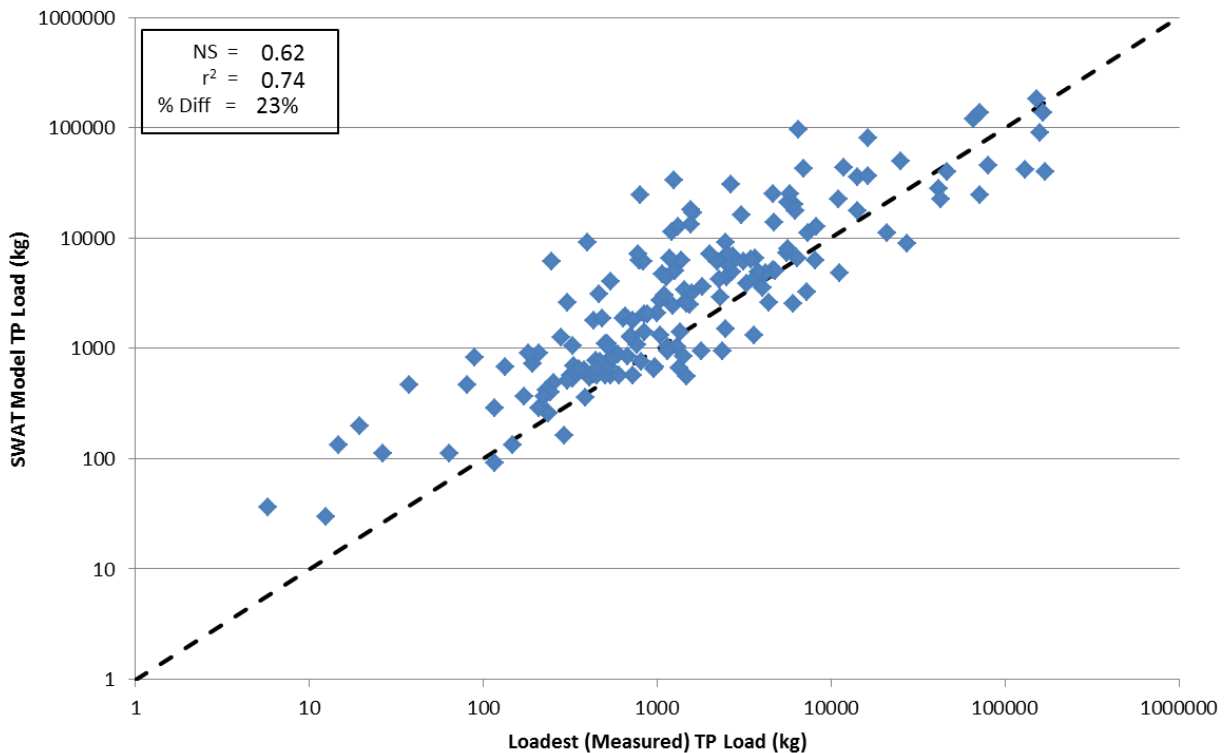
Figure 3-34b Monthly Average Total Phosphorus Load Calibration Results for Station 12355-Colorado River at US 190 near San Saba
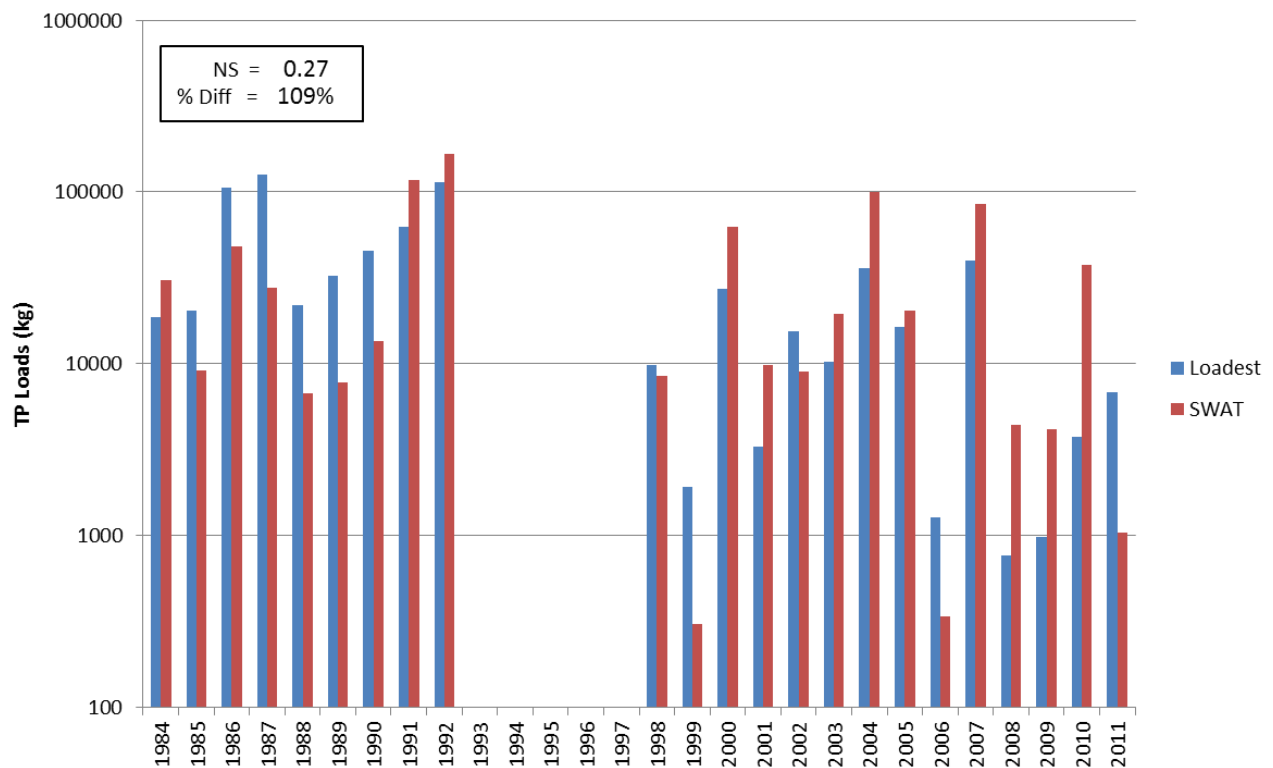
Figure 3-35a Annual Total Phosphorus Load Calibration Results for Station 12358-Colorado River at Highway 377 in Winchell
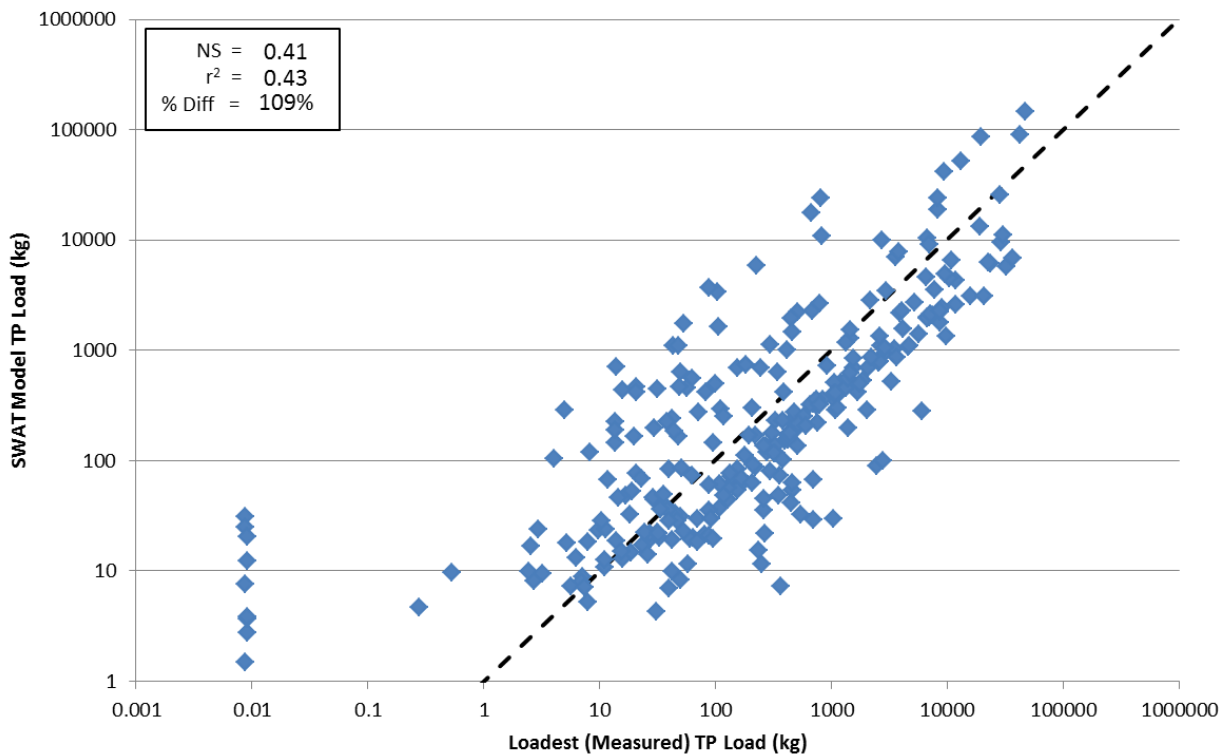
Figure 3-35b Annual Total Phosphorus Load Calibration Results for Station 12358-Colorado River at Highway 377 in Winchell
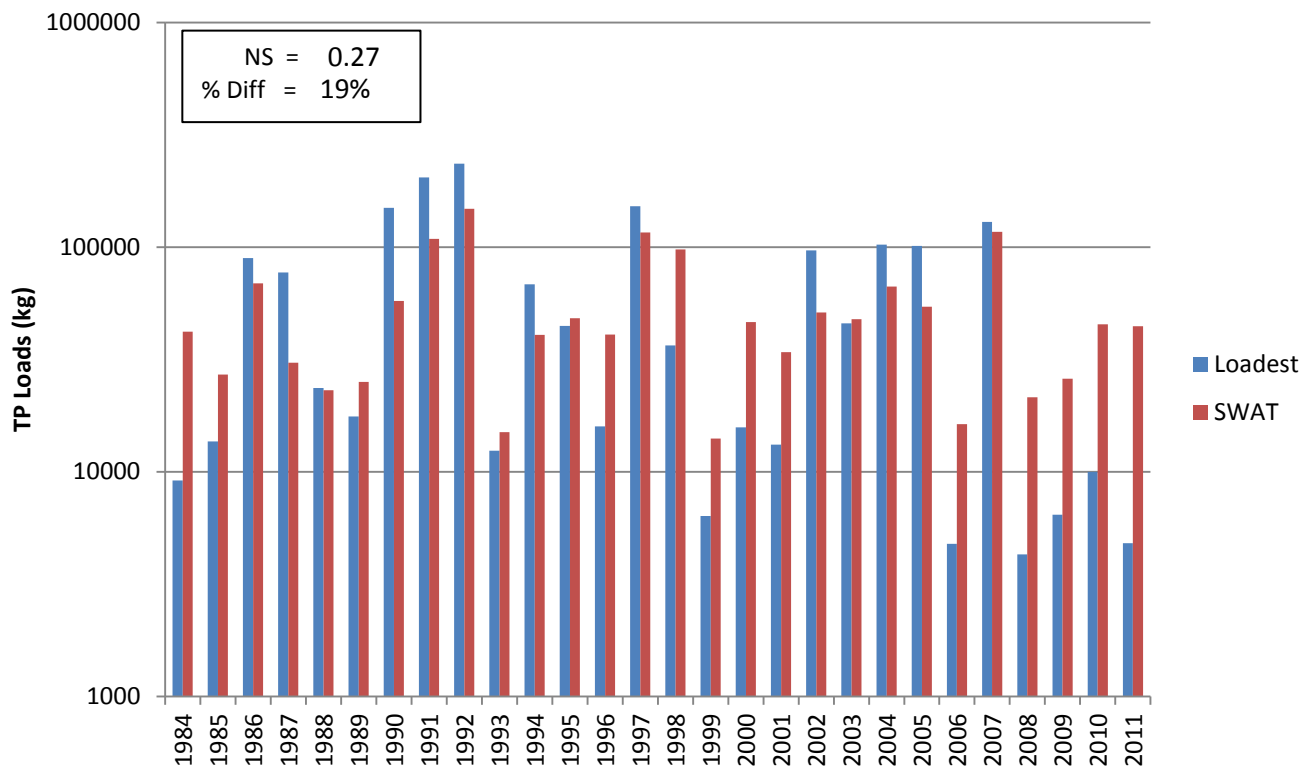
Figure 3-36a Annual Total Phosphorus Load Calibration Results for Station 12394-Pecan Bayou at FM 573 southwest of Mullin
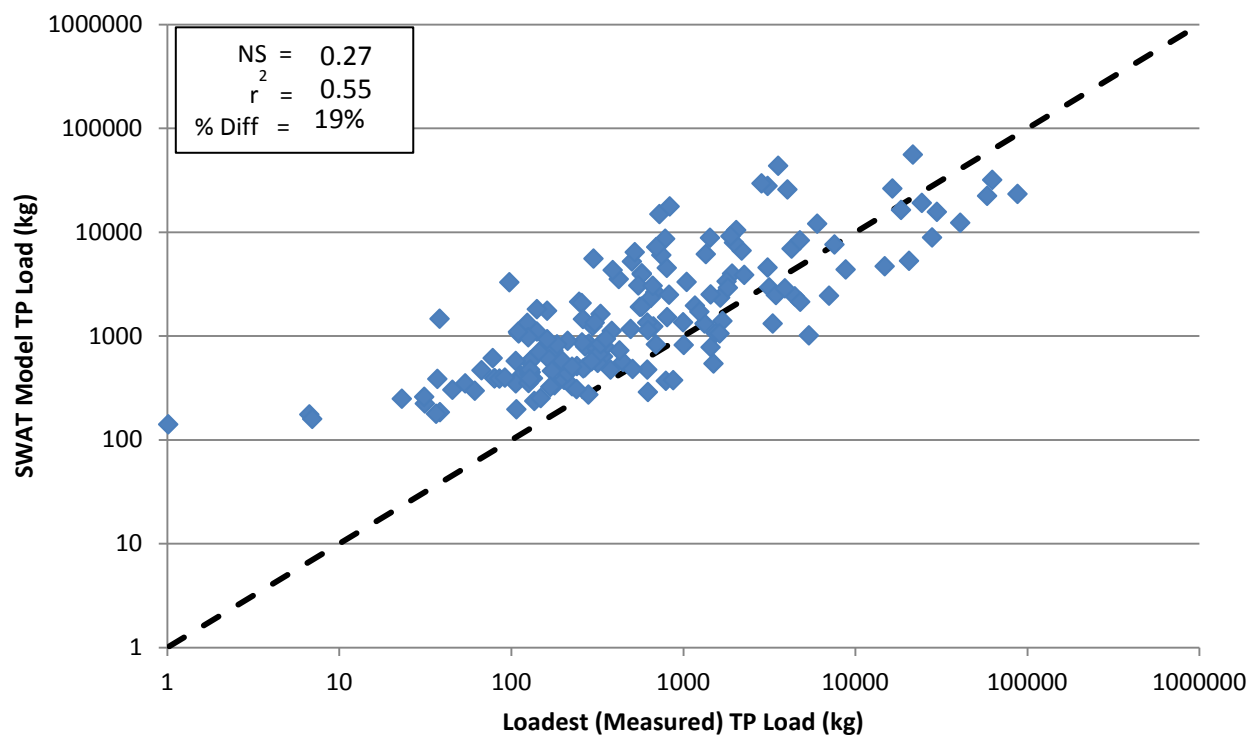
Figure 3-36b Monthly Average Total Phosphorus Load Calibration Results for Station 12394-Pecan Bayou at FM 573 southwest of Mullin
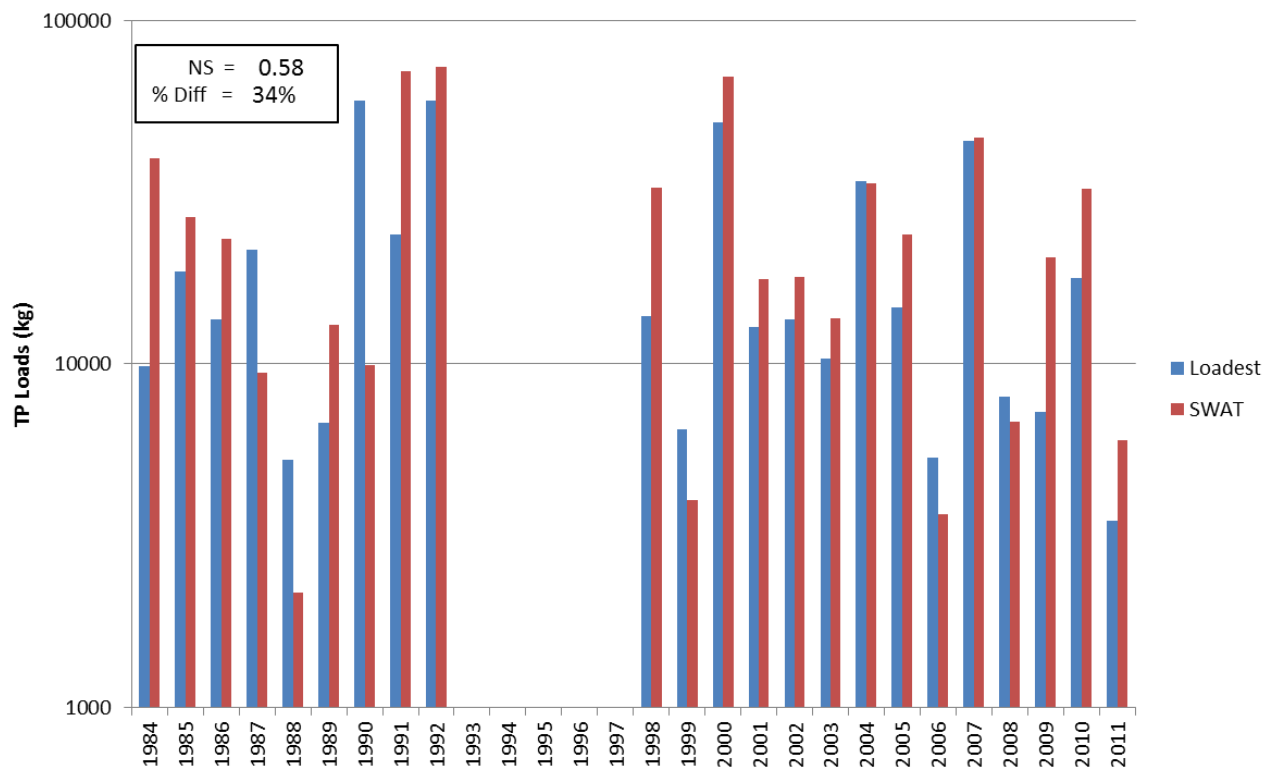
Figure 3-37a Annual Total Phosphorus Load Calibration Results for Station 12392-San Saba River at SH 16 near San Saba
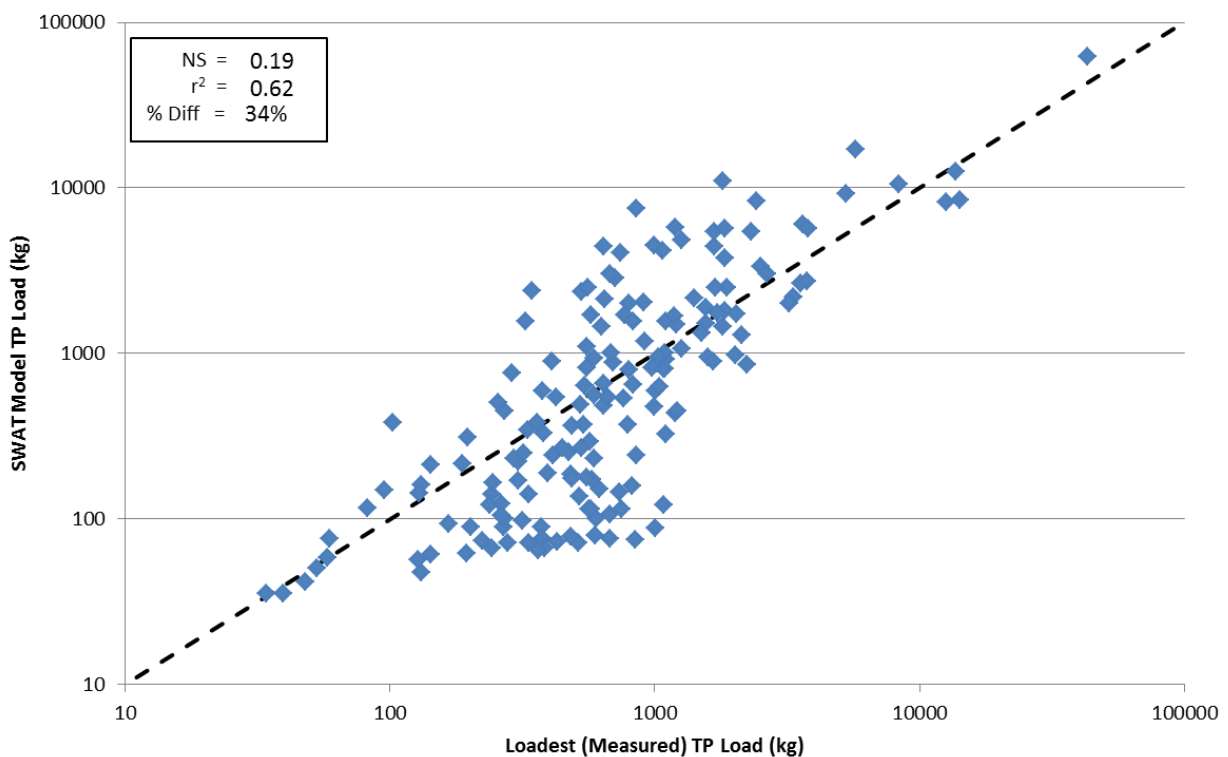
Figure 3-37b Monthly Average Total Phosphorus Load Calibration Results for Station 12392-San Saba River at SH 16 near San Saba
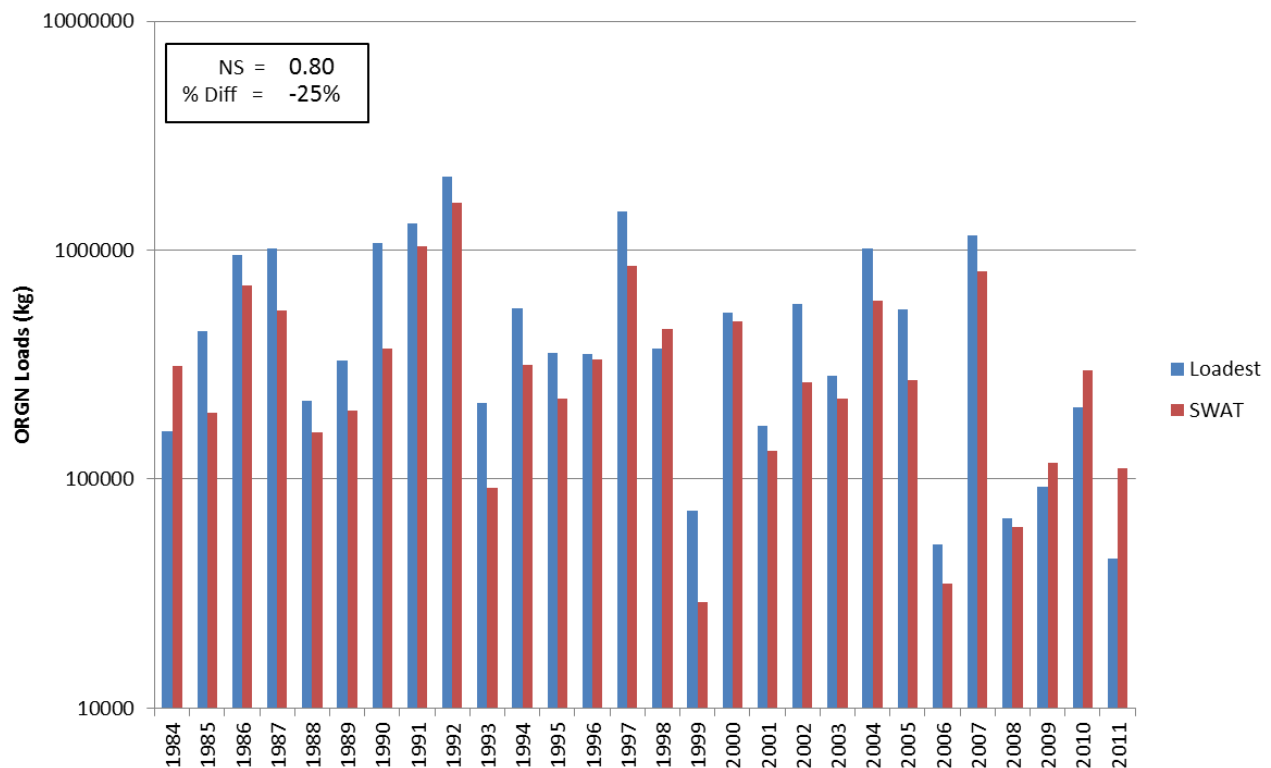
Figure 3-38a Annual Organic Nitrogen Load Calibration Results for Station 12355-Colorado River at US 190 near San Saba
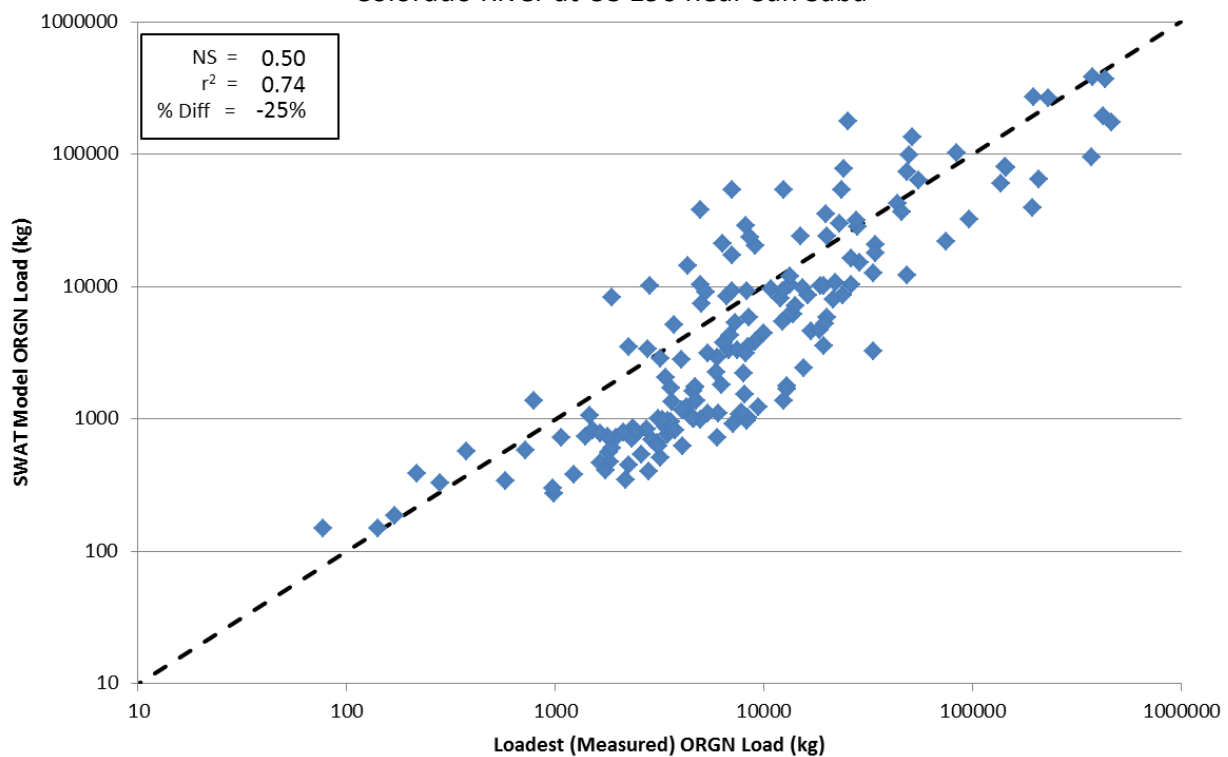
Figure 3-38b Monthly Average Organic Nitrogen Load Calibration Results for Station 12355-Colorado River at US 190 near San Saba
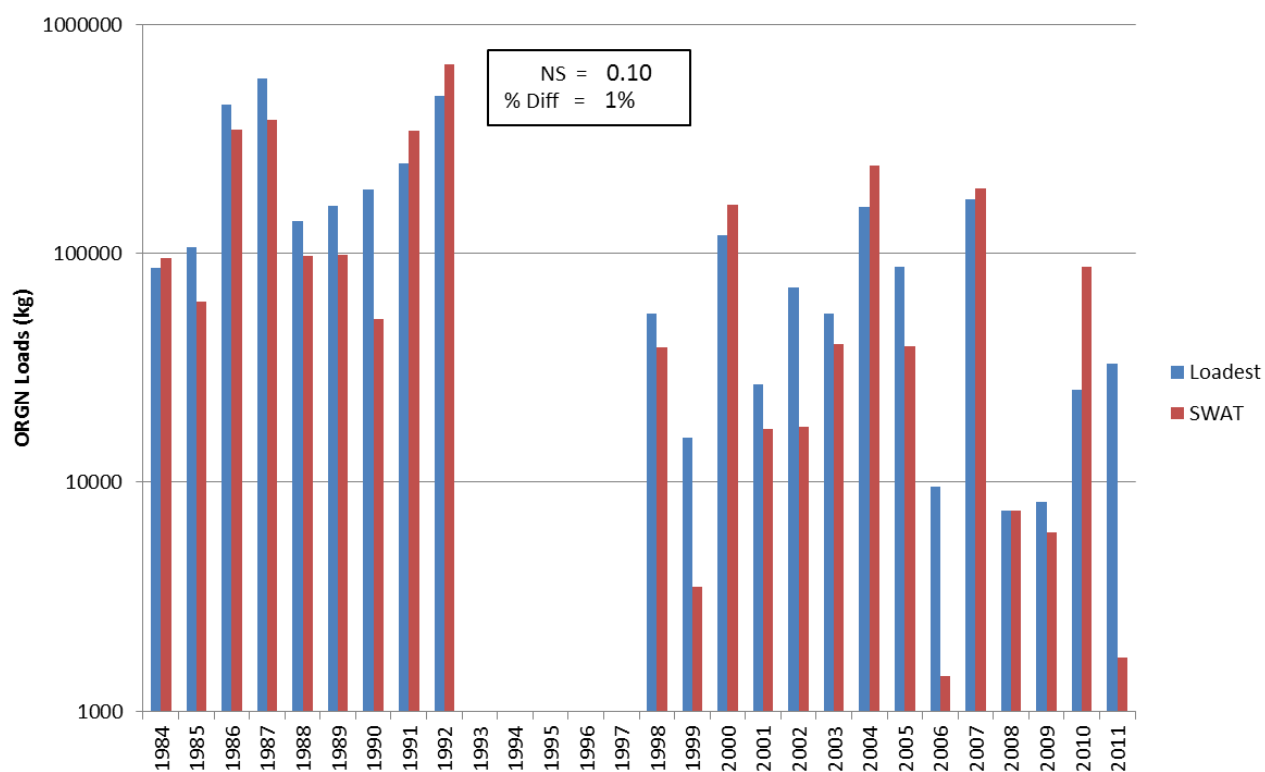
Figure 3-39a Annual Organic Nitrogen Load Calibration Results for Station 12358-Colorado River at Highway 377 in Winchell
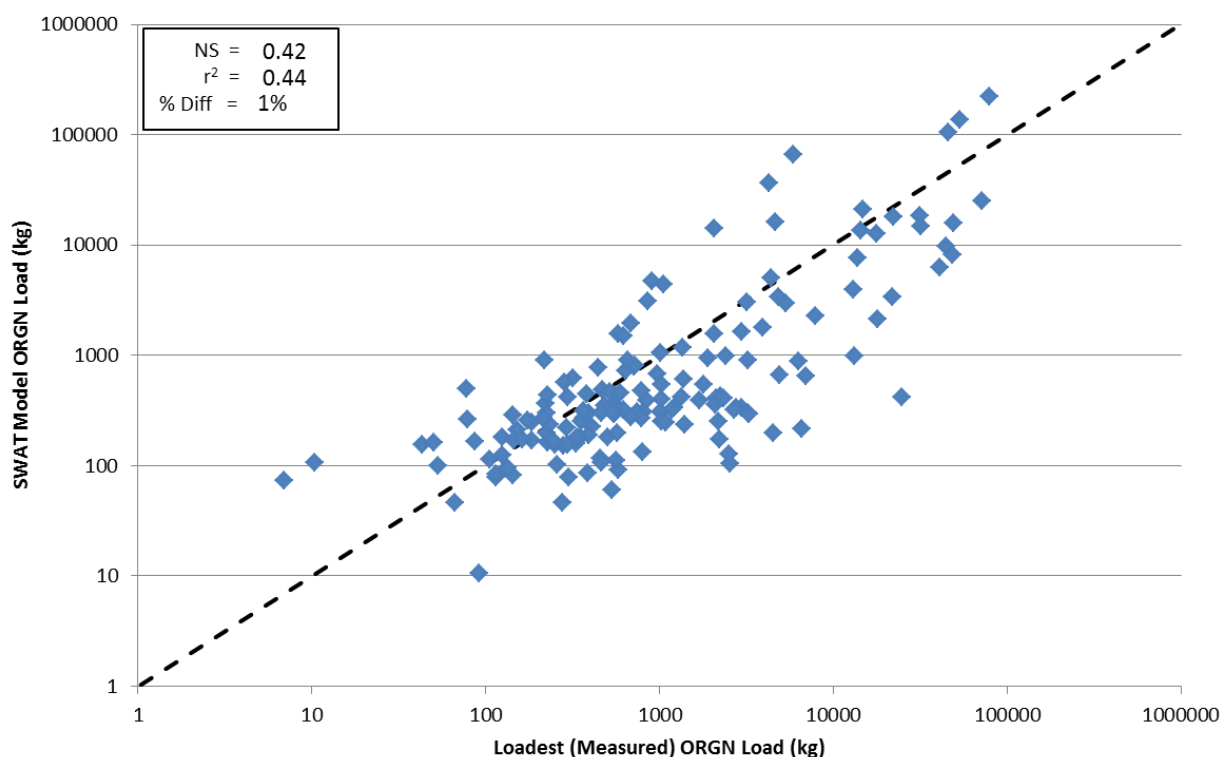
Figure 3-39b Monthly Average Organic Nitrogen Load Calibration Results for Station 12358-Colorado River at Highway 377 in Winchell
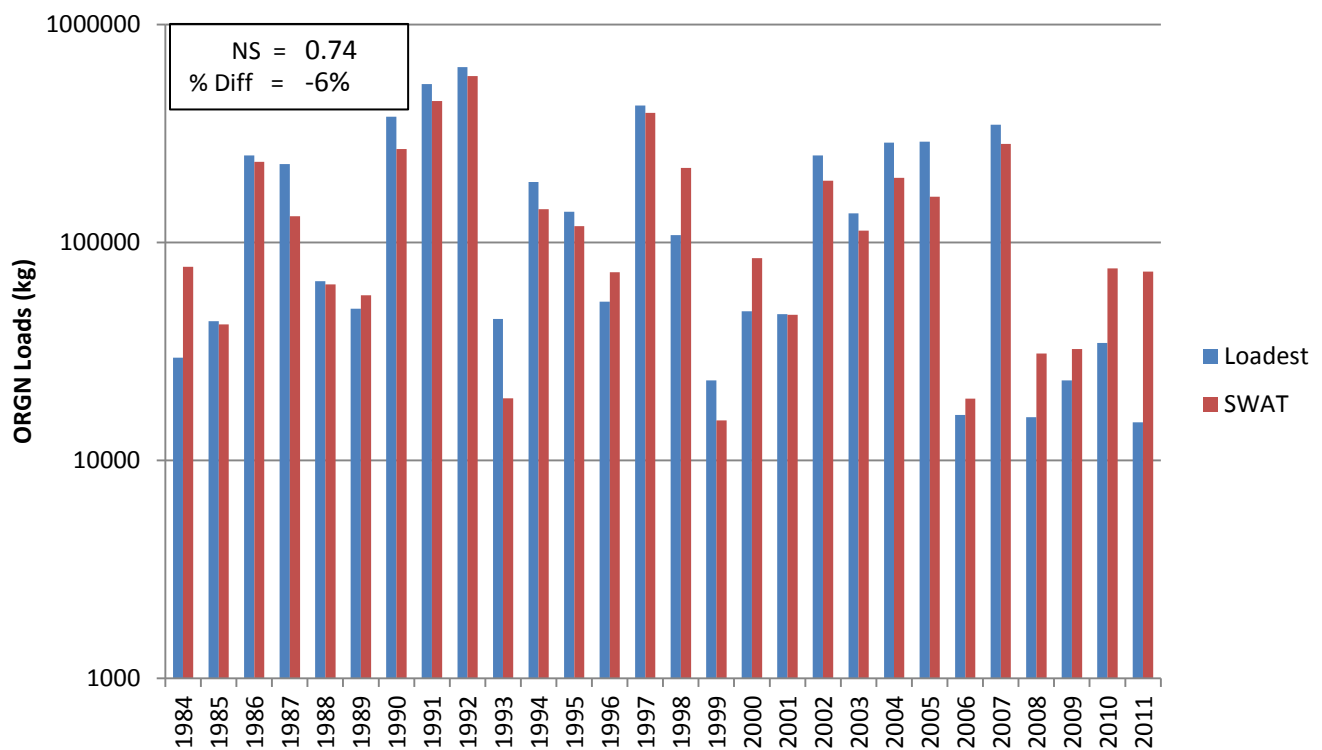
Figure 3-40a Annual Organic Nitrogen Load Calibration Results for Station 12394-Pecan Bayou at FM 573 southwest of Mullin
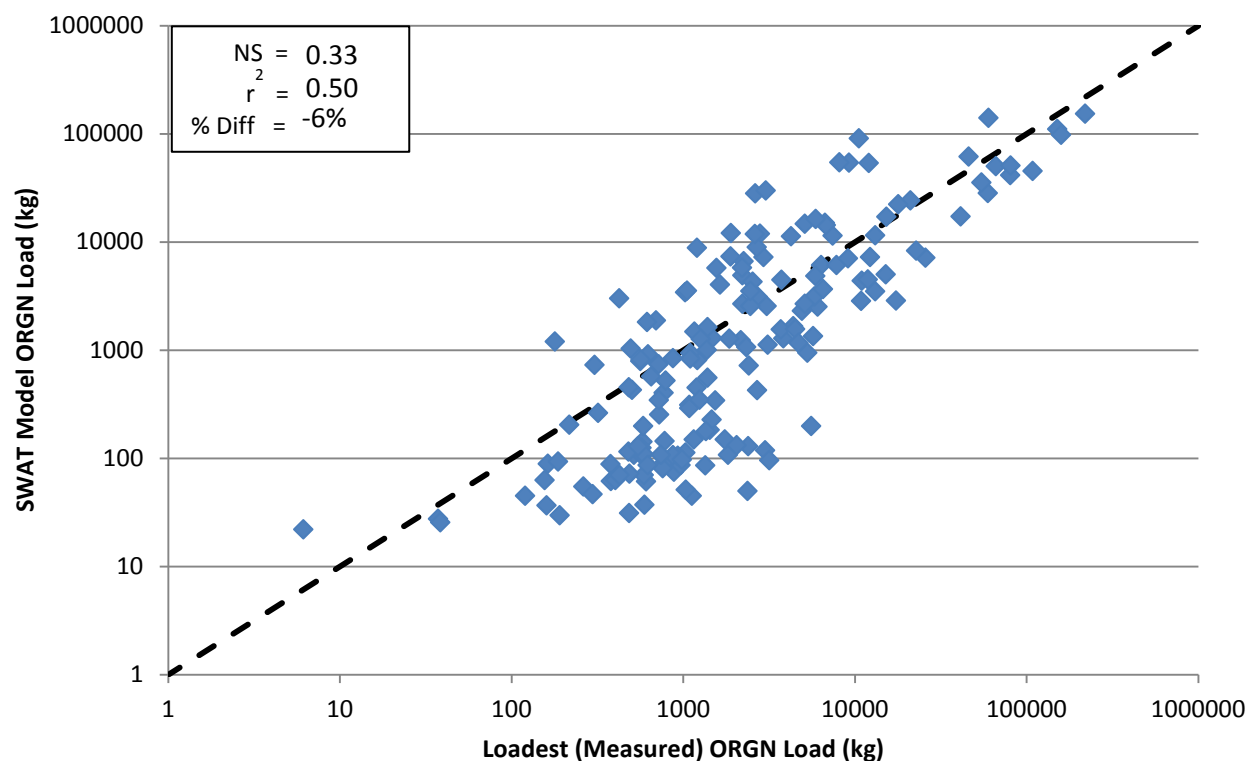
Figure 3-40b Monthly Average Organic Nitrogen Load Calibration Results for Station 12394-Pecan Bayou at FM 573 southwest of Mullin
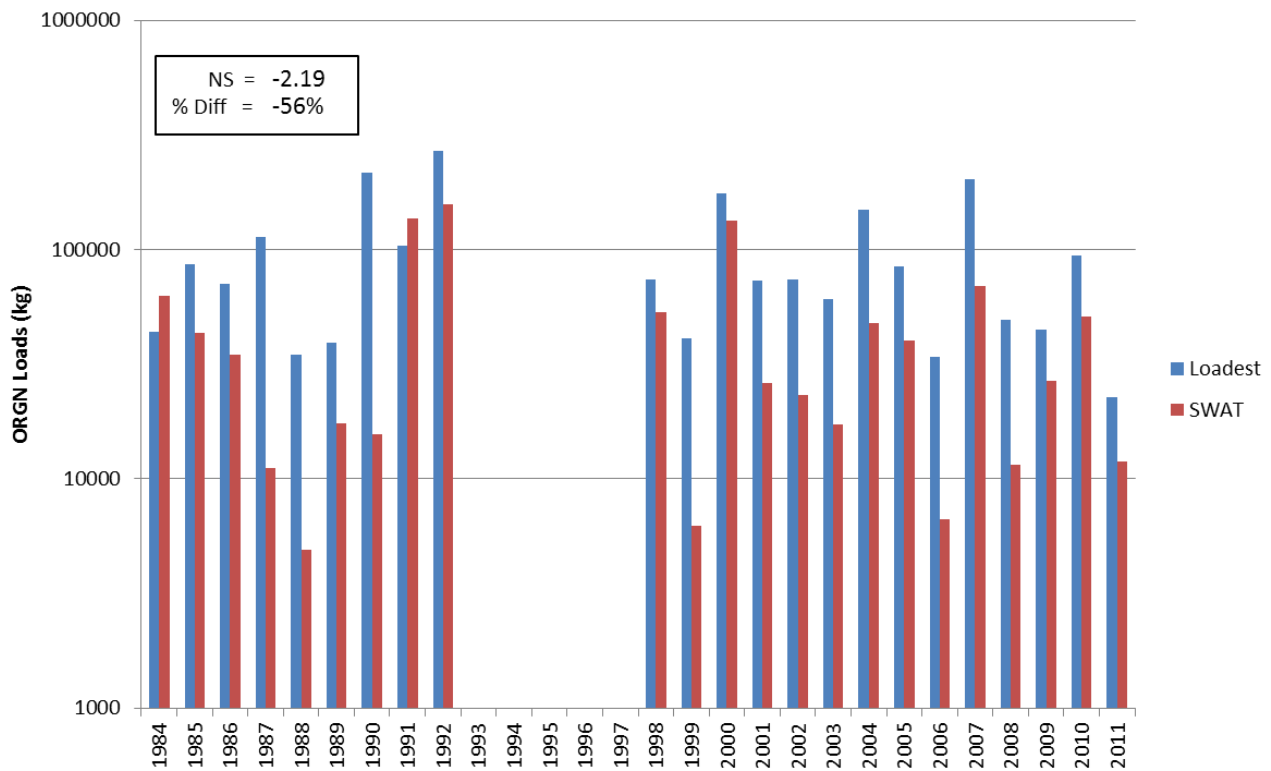
Figure 3-41a Annual Organic Nitrogen Load Calibration Results for Station 12392-San Saba River at SH 16 near San Saba
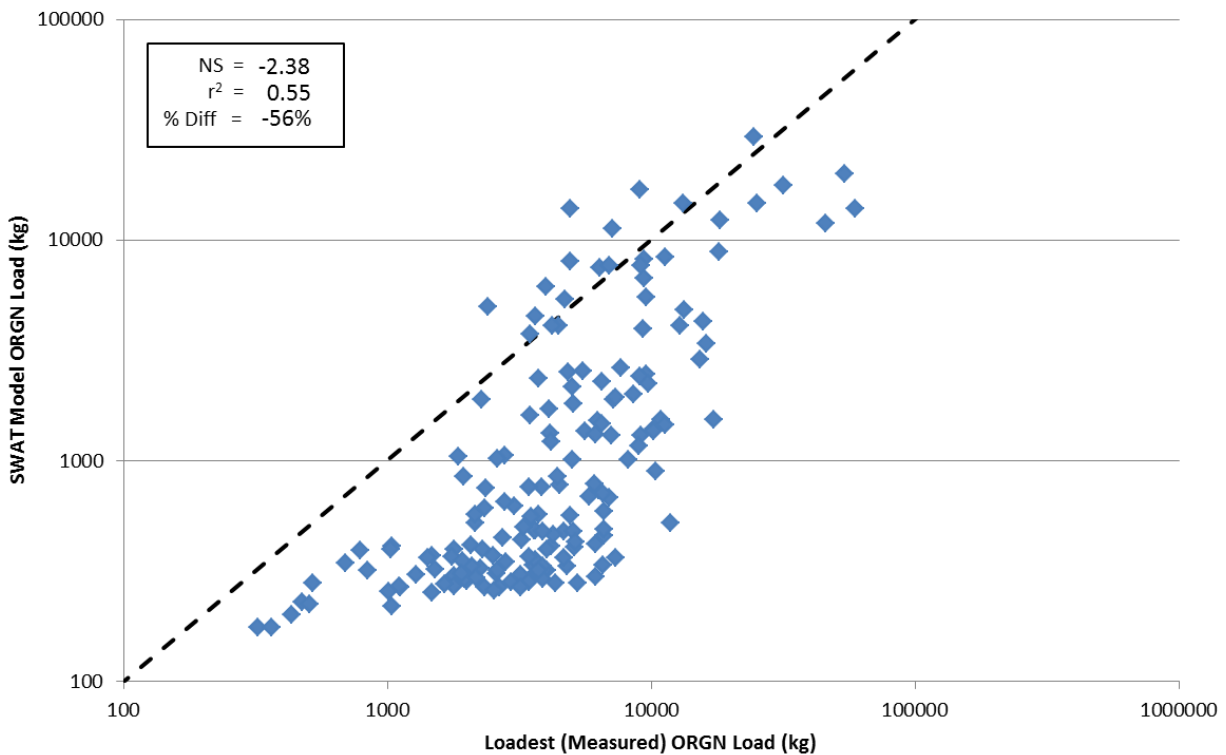
Figure 3-41b Monthly Average Organic Nitrogen Load Calibration Results for Station 12392-San Saba River at SH 16 near San Saba
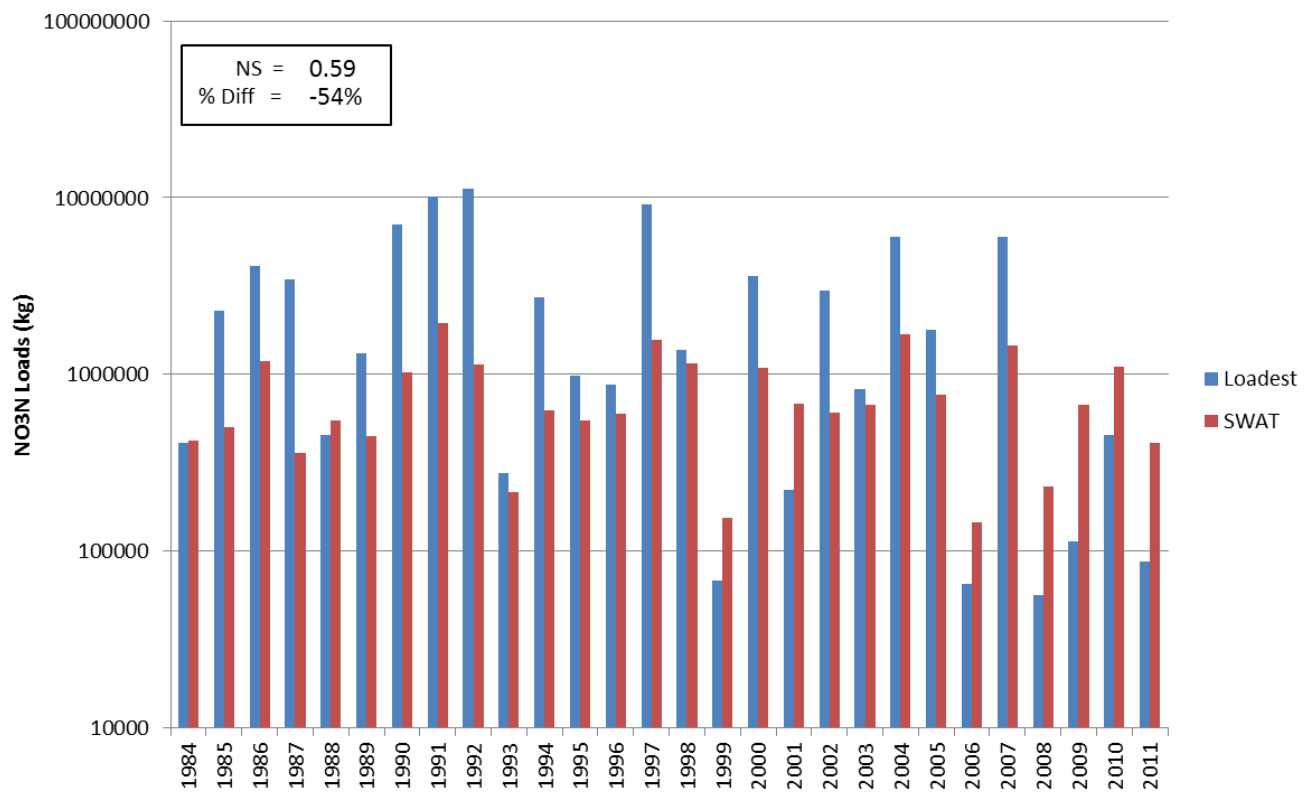
Figure 3-42a Annual Nitrate+Nitrite Load Calibration Results for Station 12355-
Colorado River at US 190 near San Saba
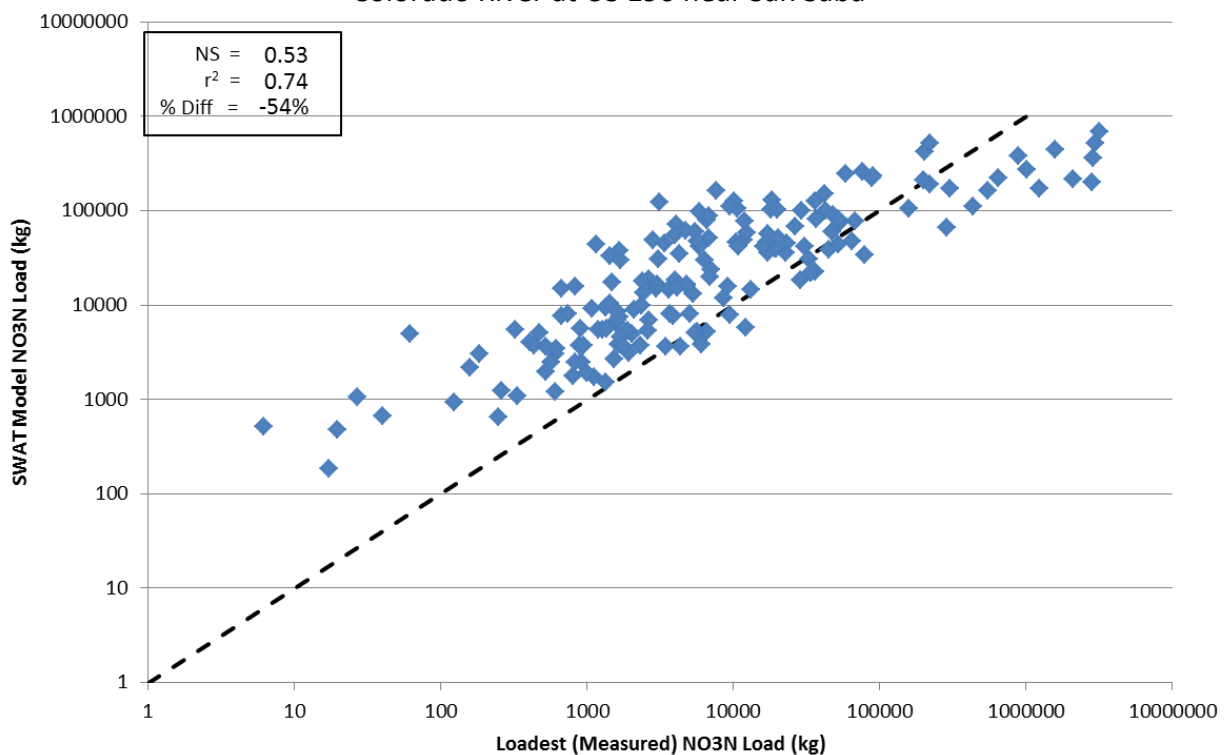
Figure 3-42b Monthly Average Nitrate+Nitrite Load Calibration Results for Station 12355-
Colorado River at US 190 near San Saba
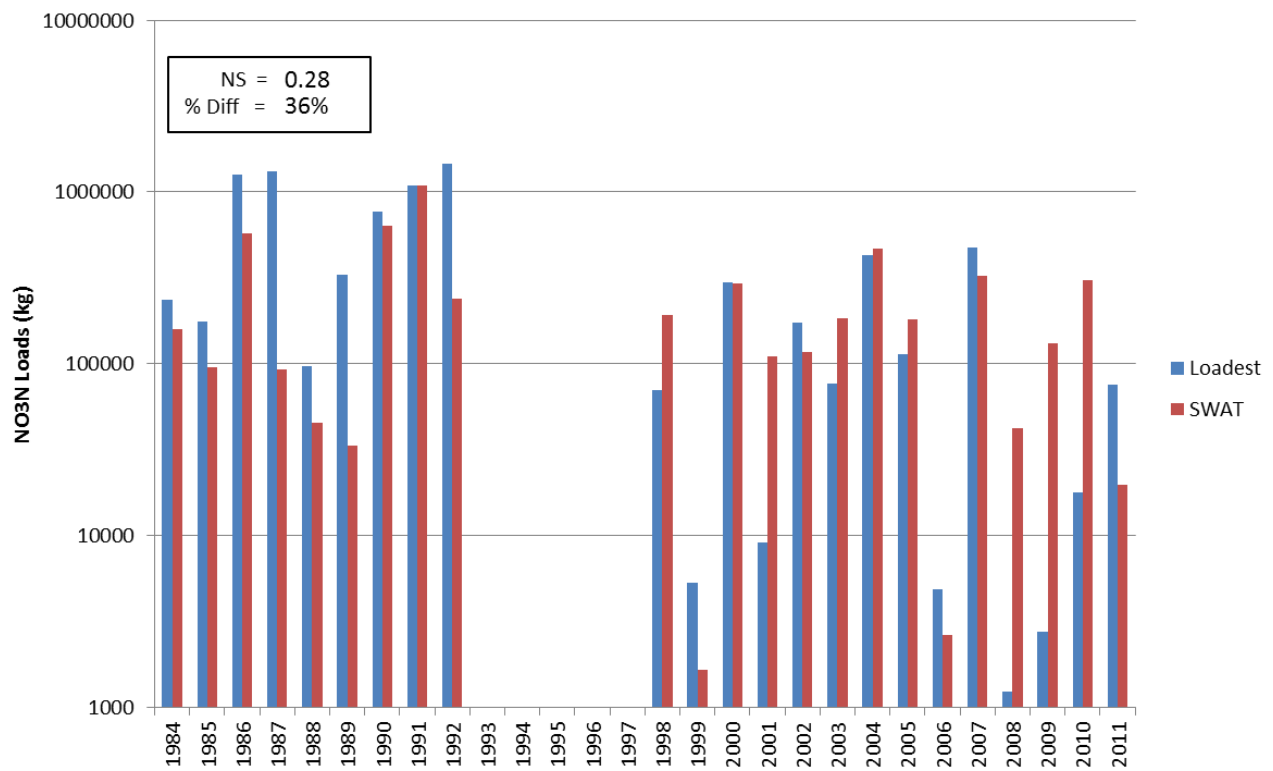
Figure 3-43a Annual Nitrate+Nitrite Load Calibration Results for Station 12358-Colorado River at Highway 377 in Winchell
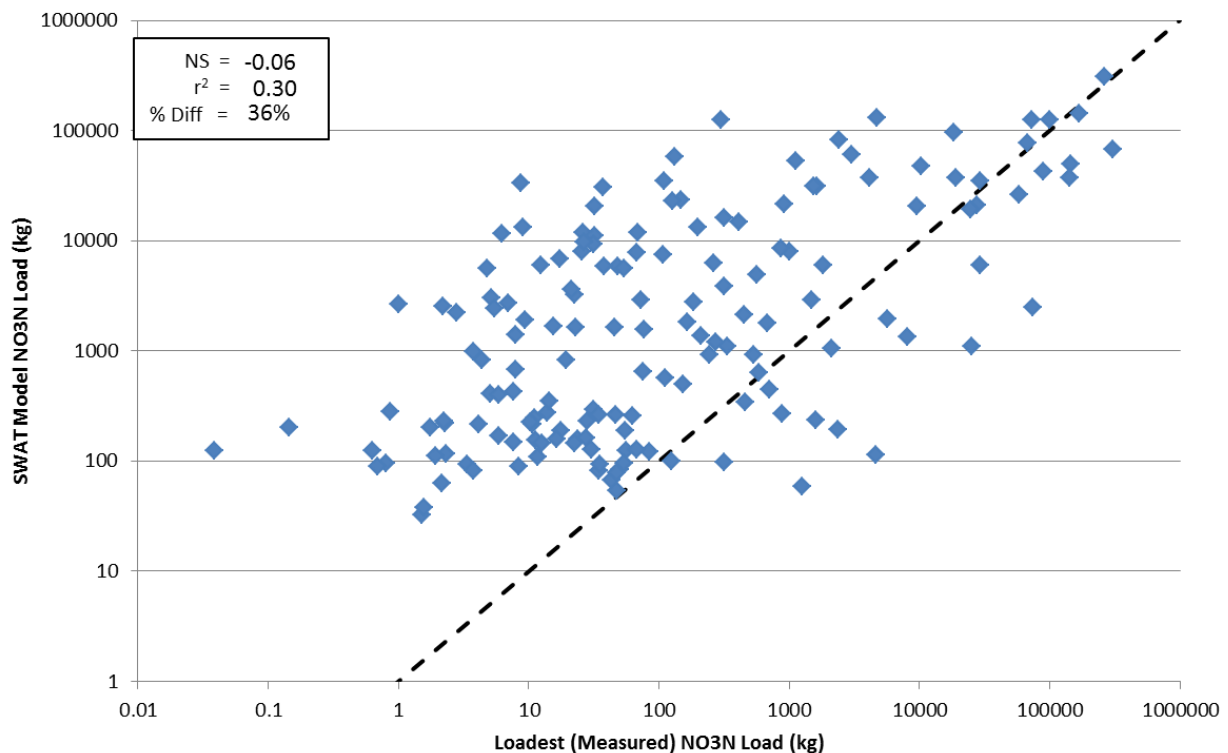
Figure 3-43b Monthly Average Nitrate+Nitrite Load Calibration Results for Station 12358-Colorado River at Highway 377 in Winchell
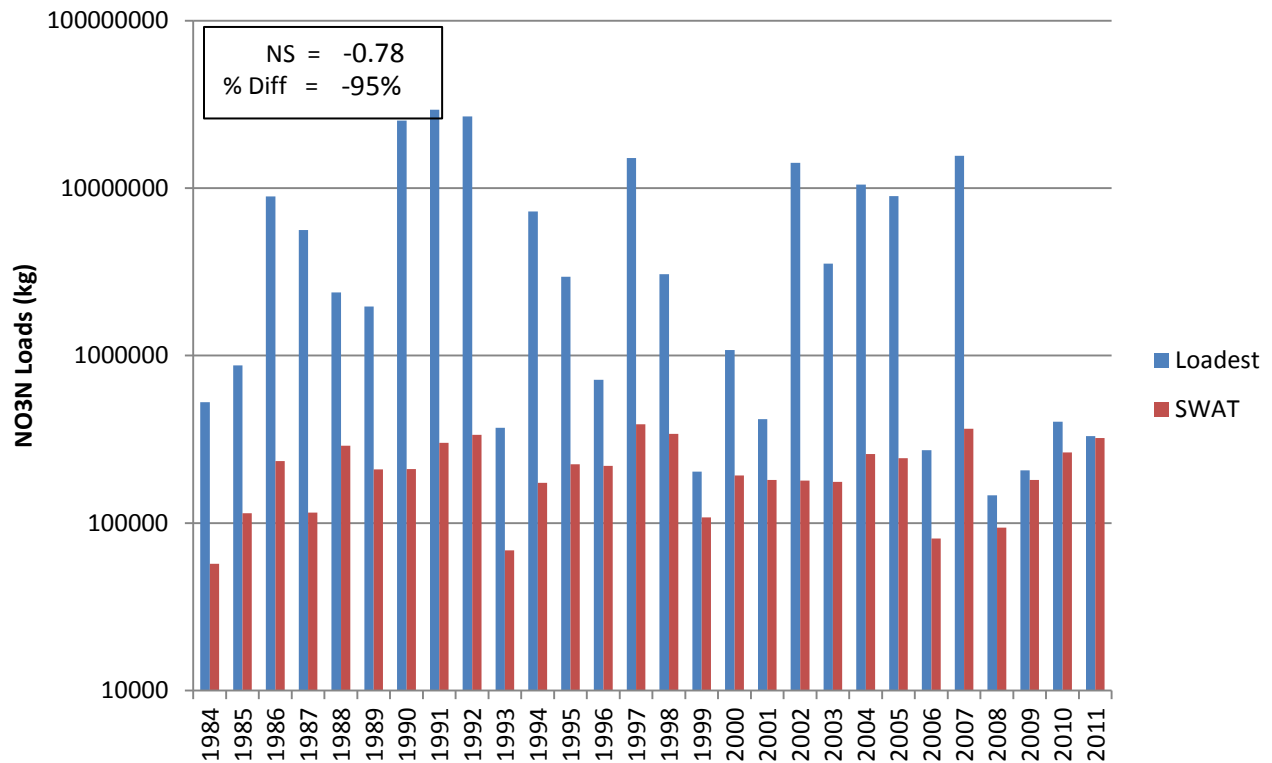
Figure 3-44a Annual Nitrate+Nitrite Load Calibration Results for Station 12394-Pecan Bayou at FM 573 southwest of Mullin
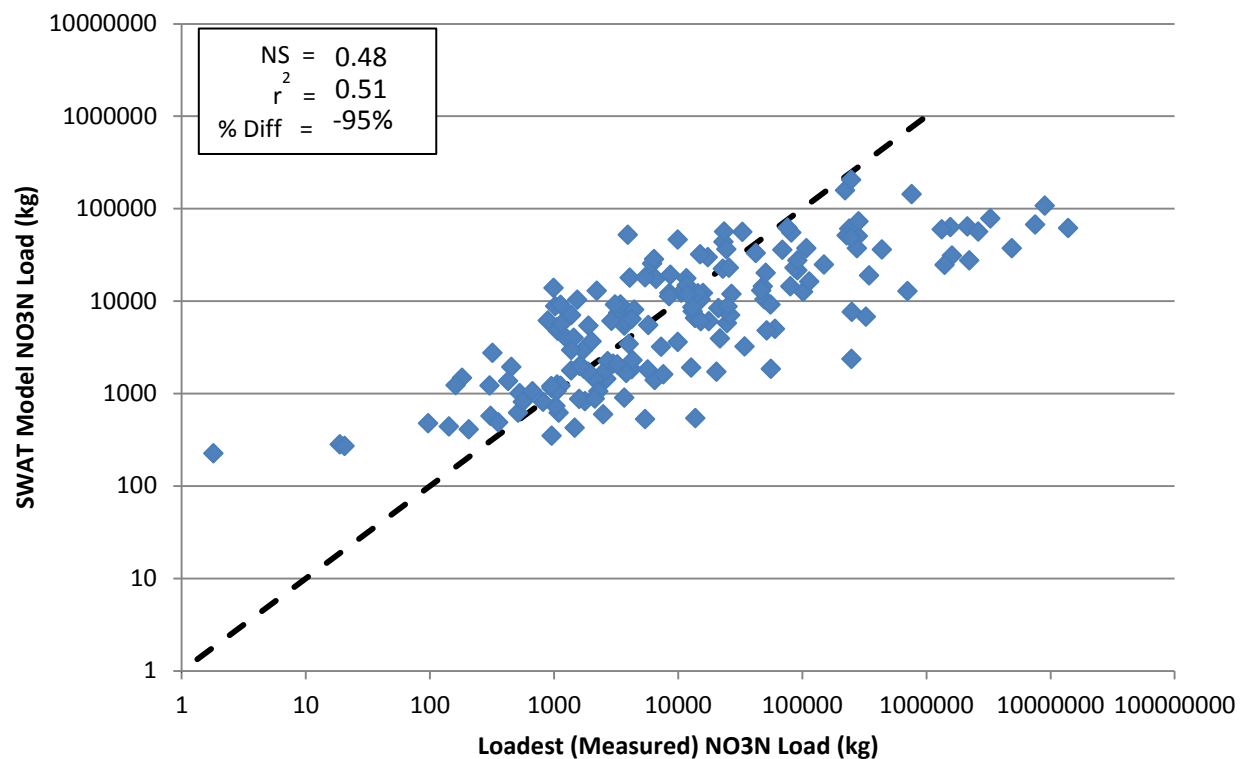
Figure 3-44b Monthly Average Nitrate+Nitrite Load Calibration Results for Station 12394-Pecan Bayou at FM 573 southwest of Mullin

Figures 3-44a and b
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority
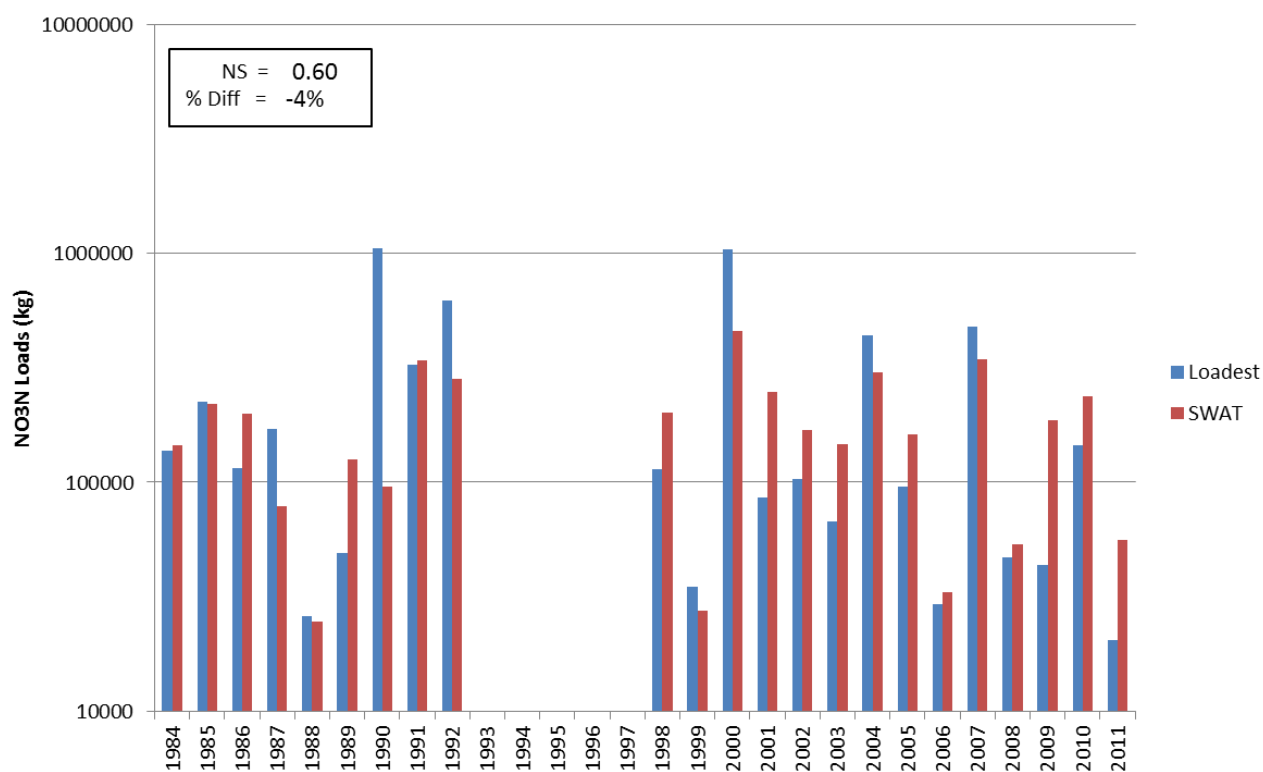
Figure 3-45a Annual Nitrate+Nitrite Load Calibration Results for Station 12392-
San Saba River at SH 16 near San Saba
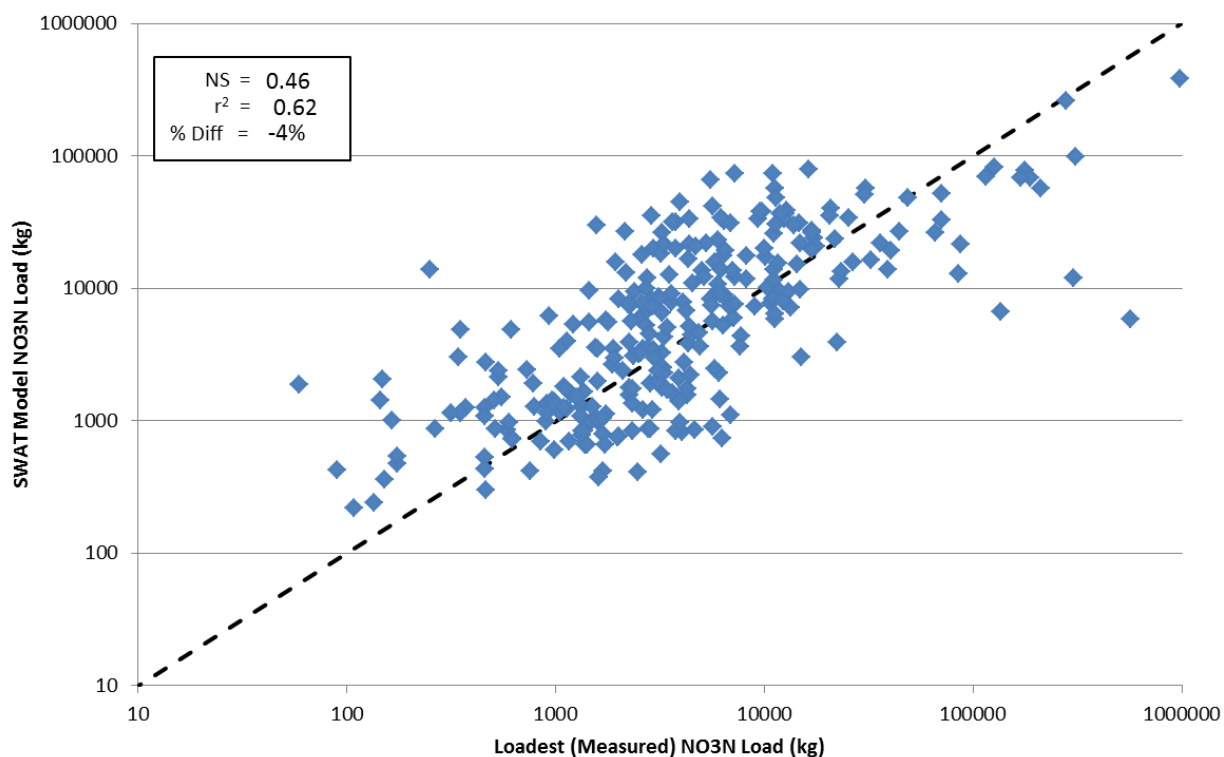
Figure 3-45b Monthly Average Nitrate+Nitrite Load Calibration Results for Station 12392-
San Saba River at SH 16 near San Saba
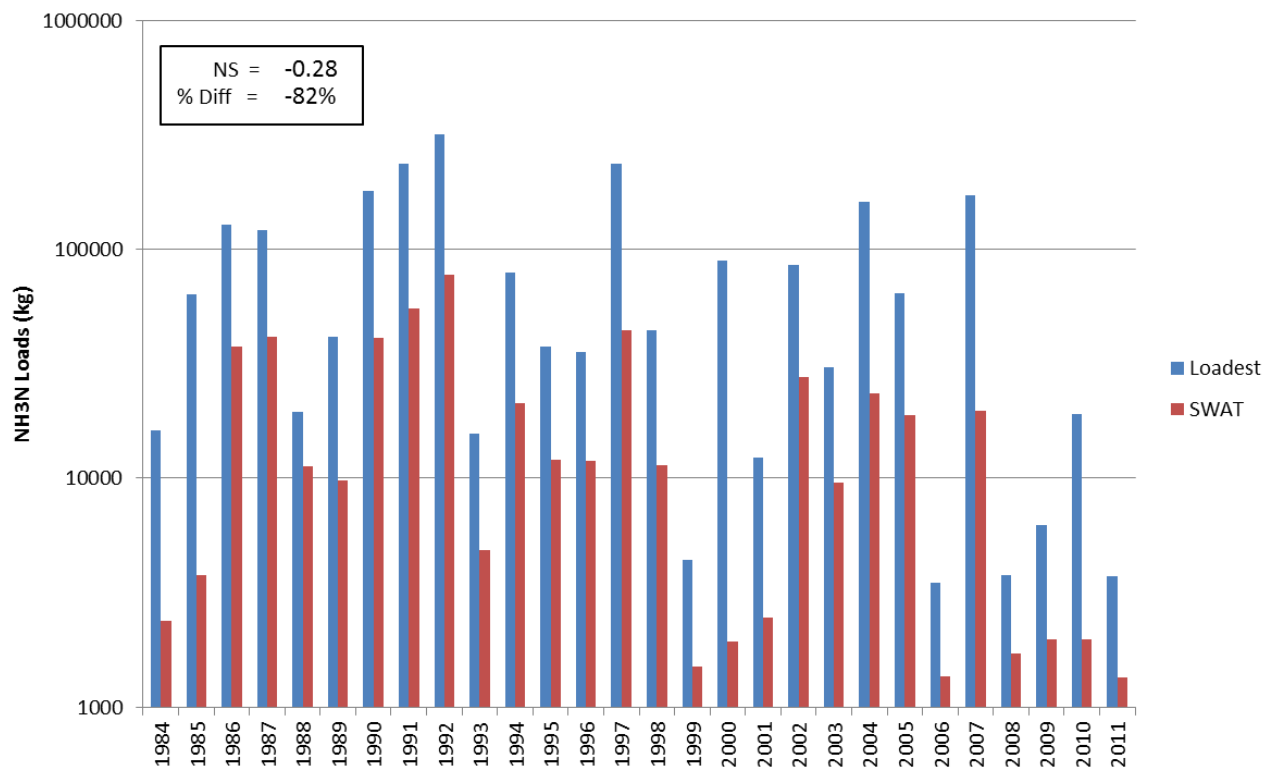
Figure 3-46a Annual Ammonium Nitrogen Load Calibration Results for Station 12355-Colorado River at US 190 near San Saba
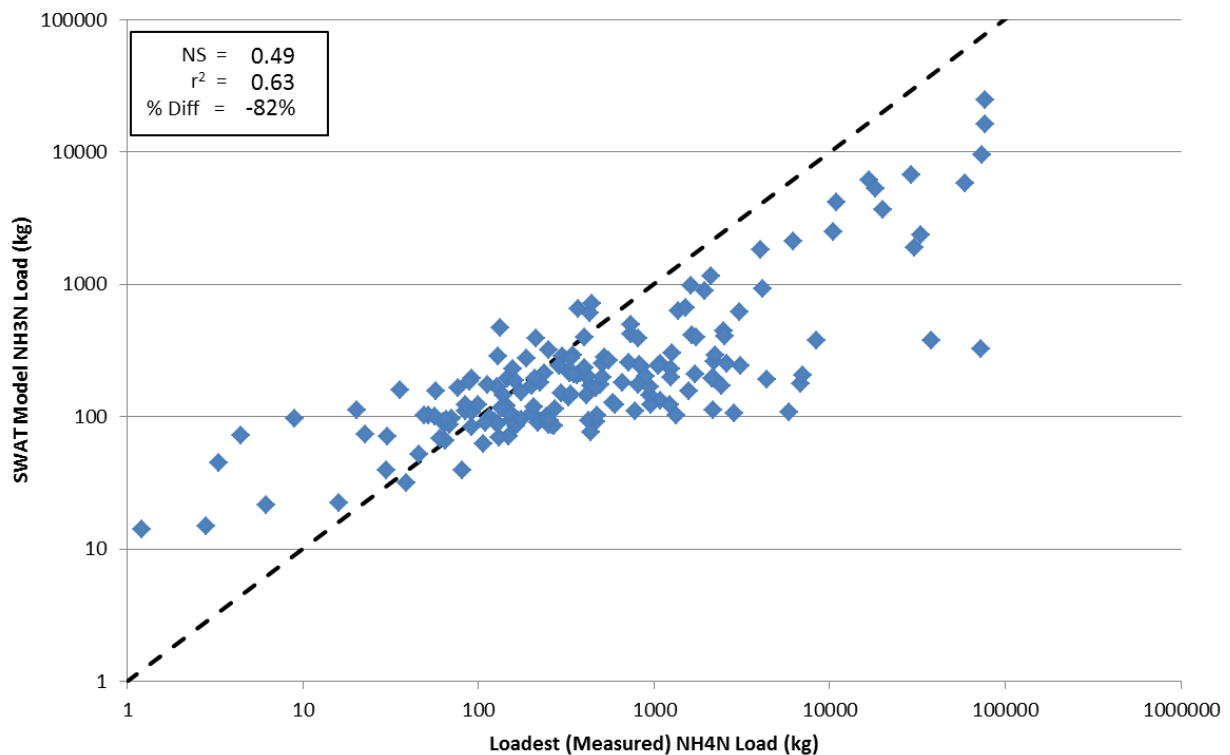
Figure 3-46b Monthly Average Ammonium Nitrogen Load Calibration Results for Station 12355-Colorado River at US 190 near San Saba
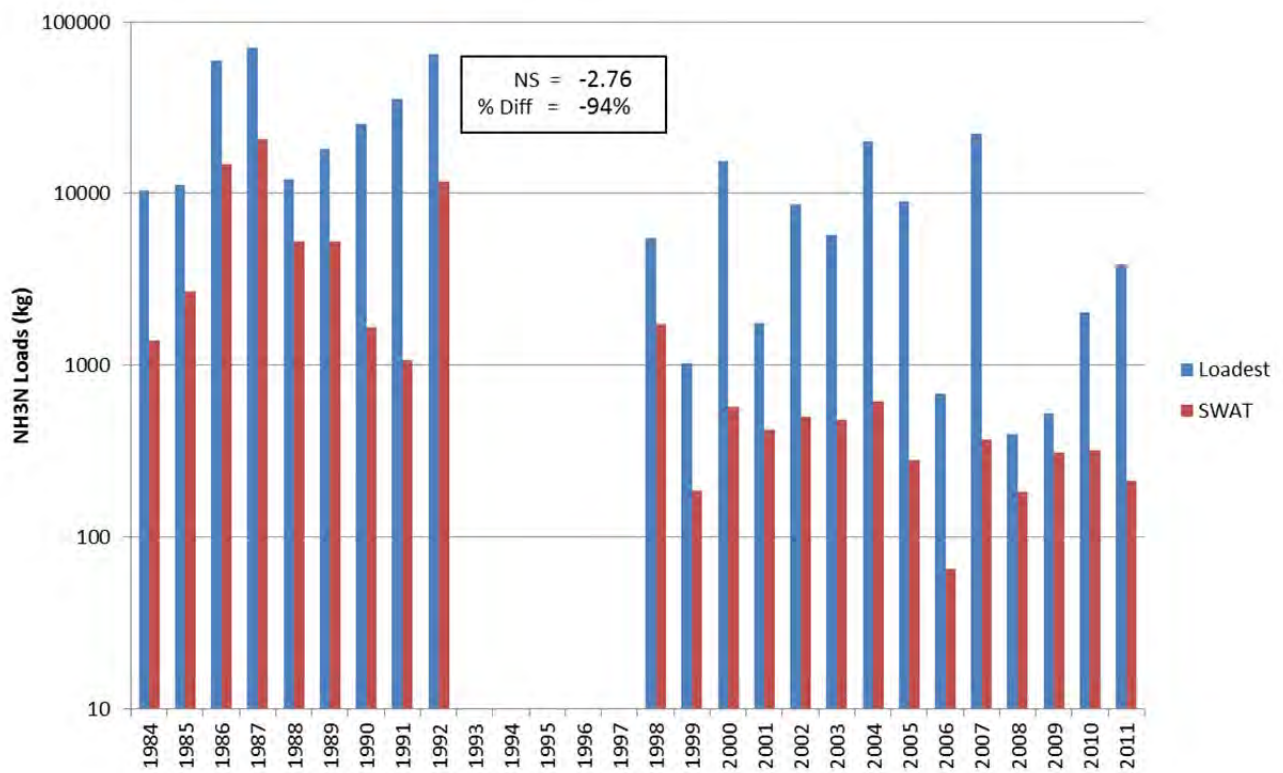
Figure 3-47a Annual Ammonium Nitrogen Load Calibration Results for Station 12358-Colorado River at Highway 377 in Winchell
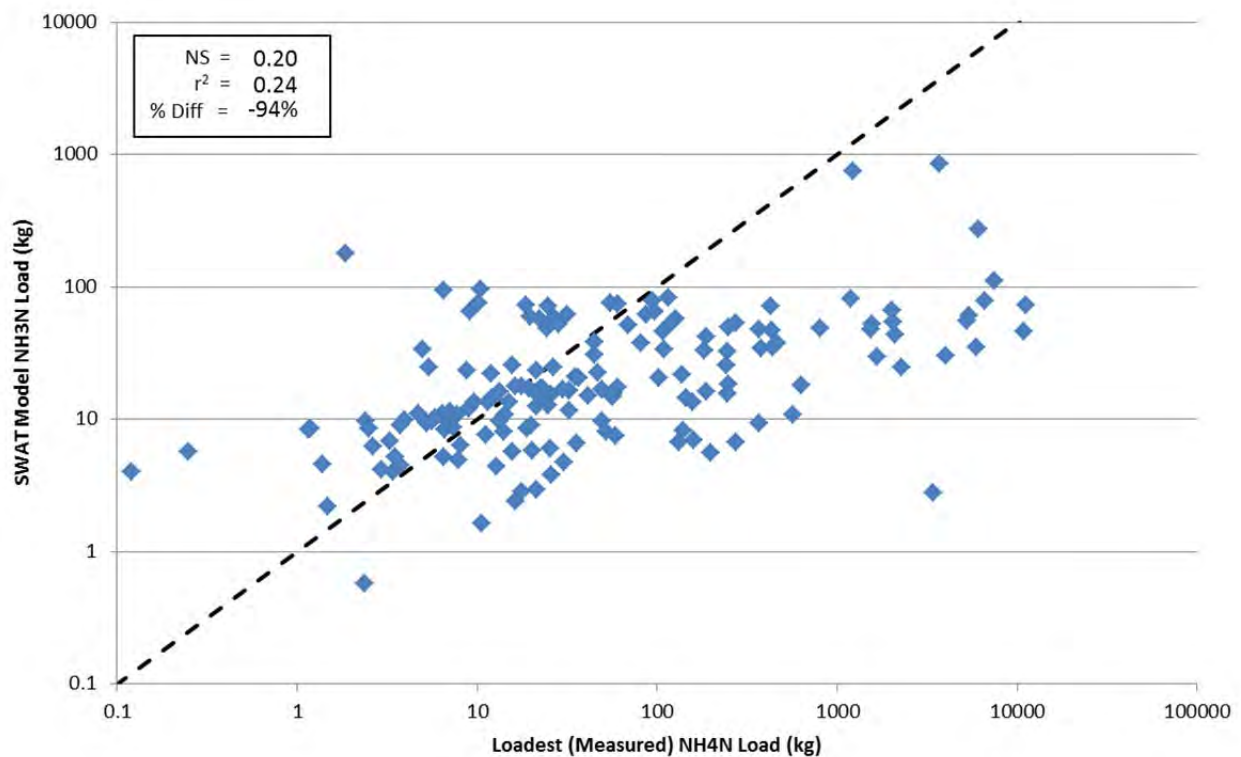
Figure 3-47b Monthly Average Ammonium Nitrogen Load Calibration Results for Station 12358-Colorado River at Highway 377 in Winchell
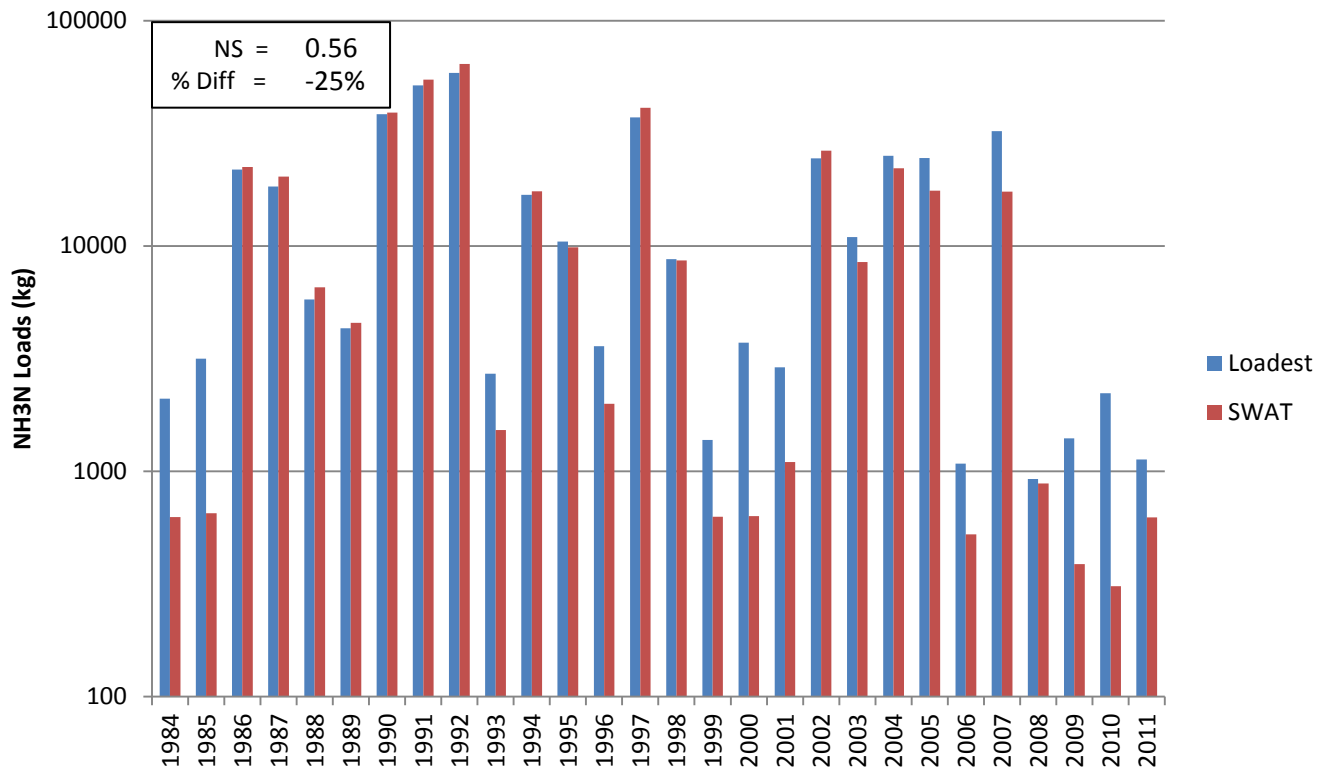
Figure 3-48a Annual Ammonium Nitrogen Load Calibration Results for Station 12394-Pecan Bayou at FM 573 southwest of Mullin
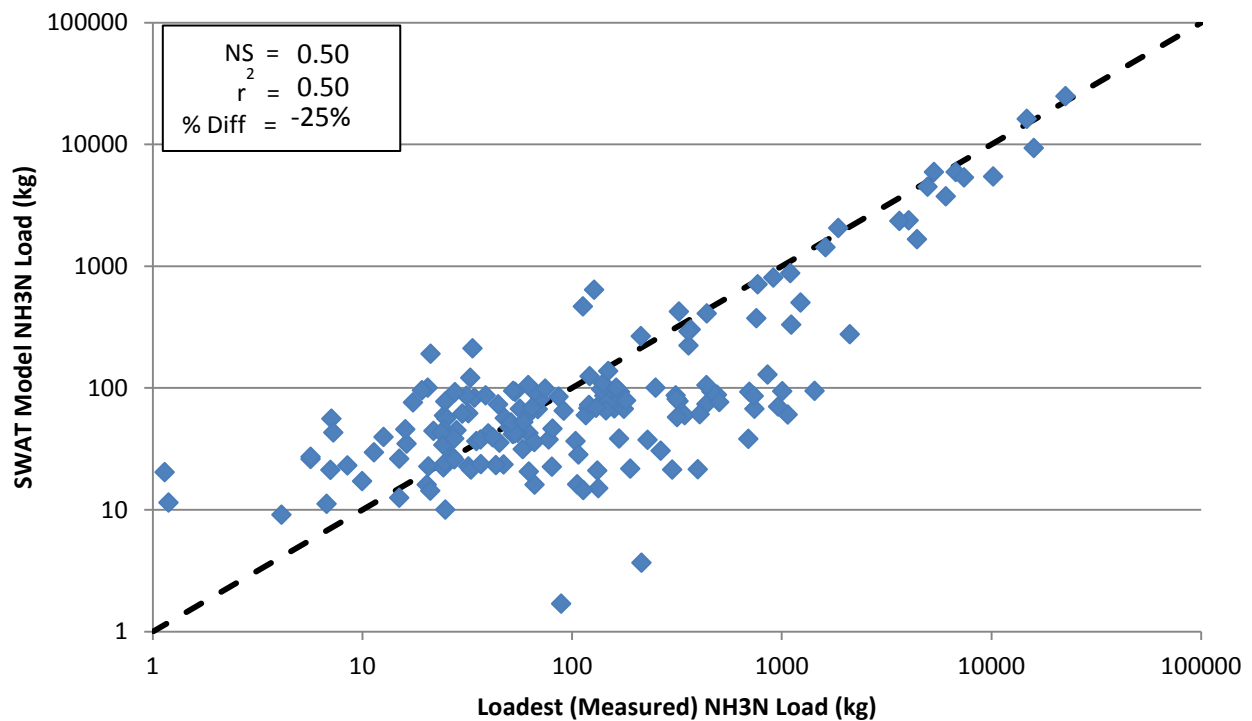
Figure 3-48b Monthly Average Ammonium Nitrogen Load Calibration Results for Station 12394-Pecan Bayou at FM 573 southwest of Mullin
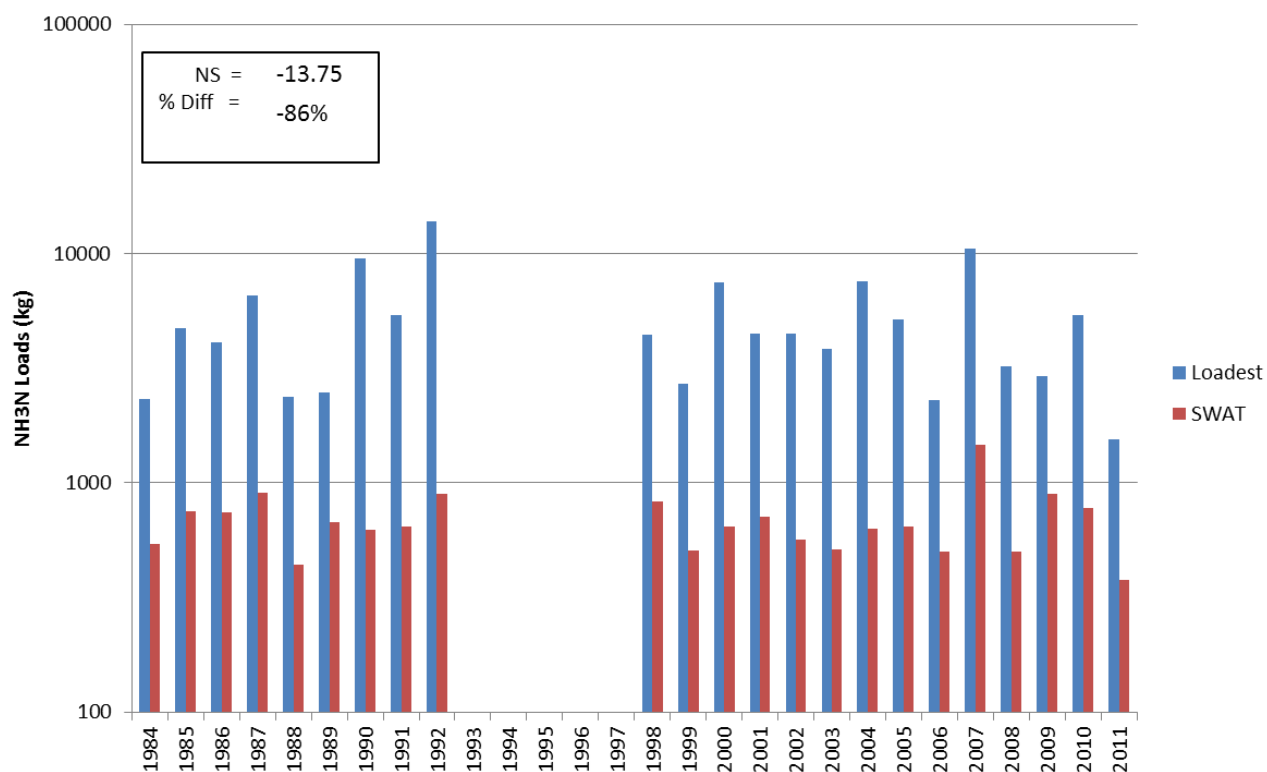
Figure 3-49a Annual Ammonium Nitrogen Load Calibration Results for Station 12392-San Saba River at SH 16 near San Saba
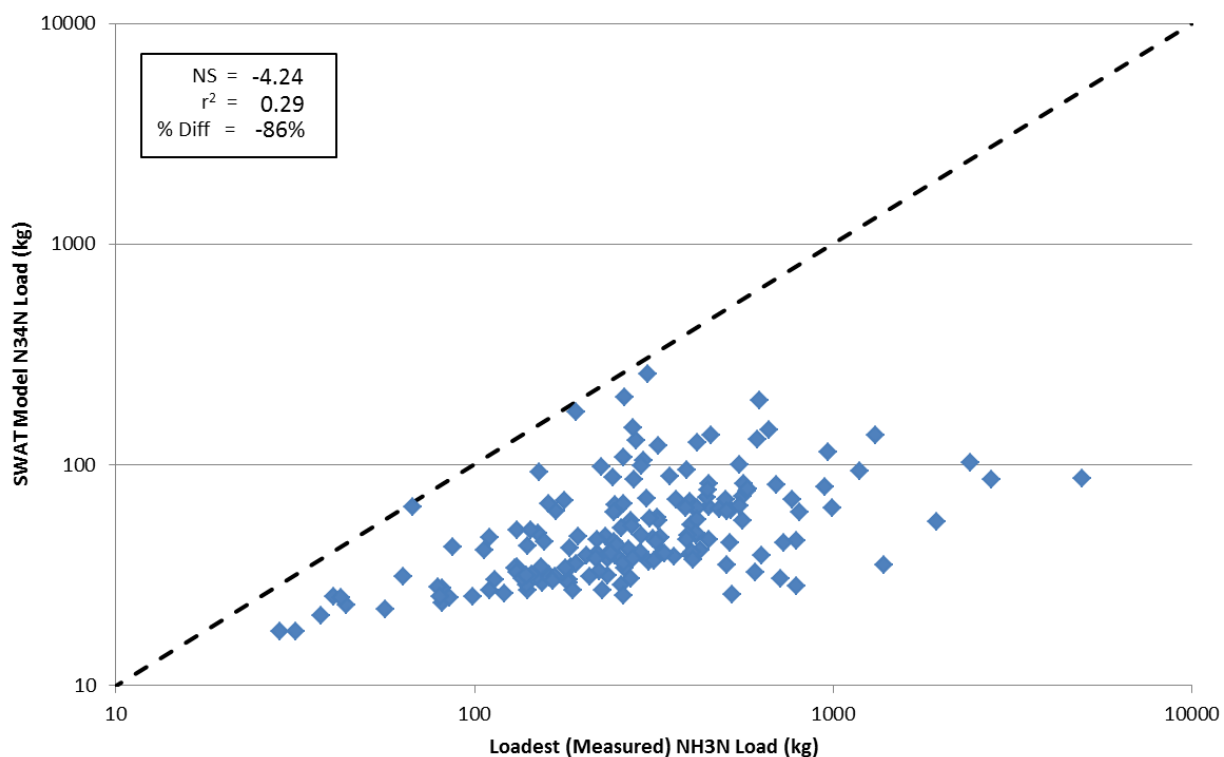
Figure 3-49b Monthly Average Ammonium Nitrogen Load Calibration Results for Station 12392-San Saba River at SH 16 near San Saba
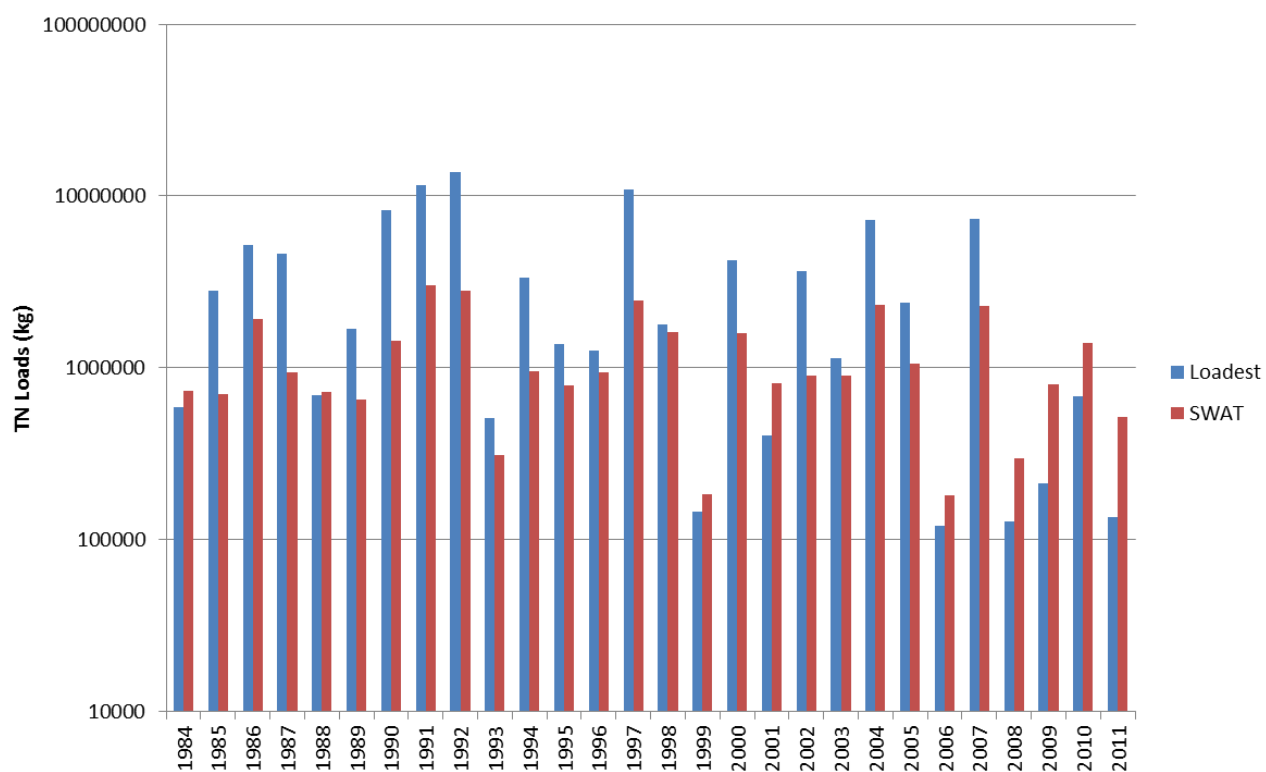
Figure 3-50a Annual Total Nitrogen Load Calibration Results for Station 12355-Colorado River at US 190 near San Saba
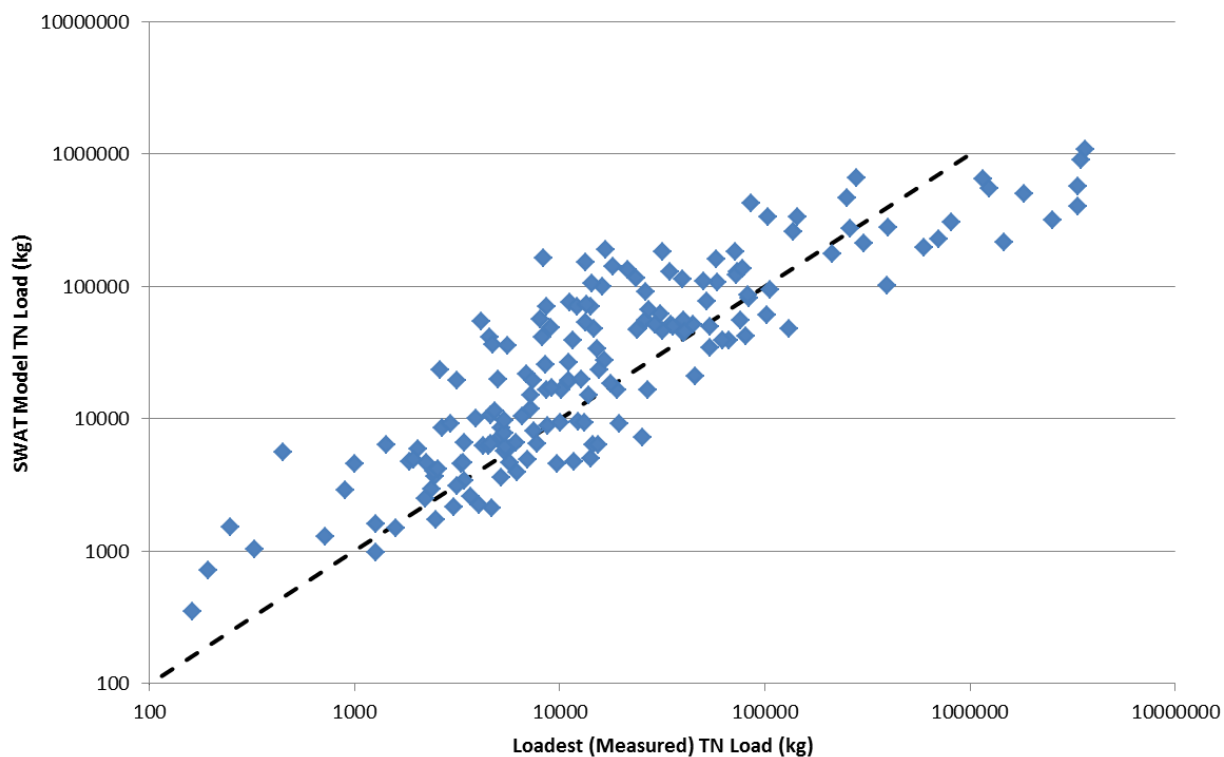
Figure 3-50b Monthly Average Total Nitrogen Load Calibration Results for Station 12355-Colorado River at US 190 near San Saba
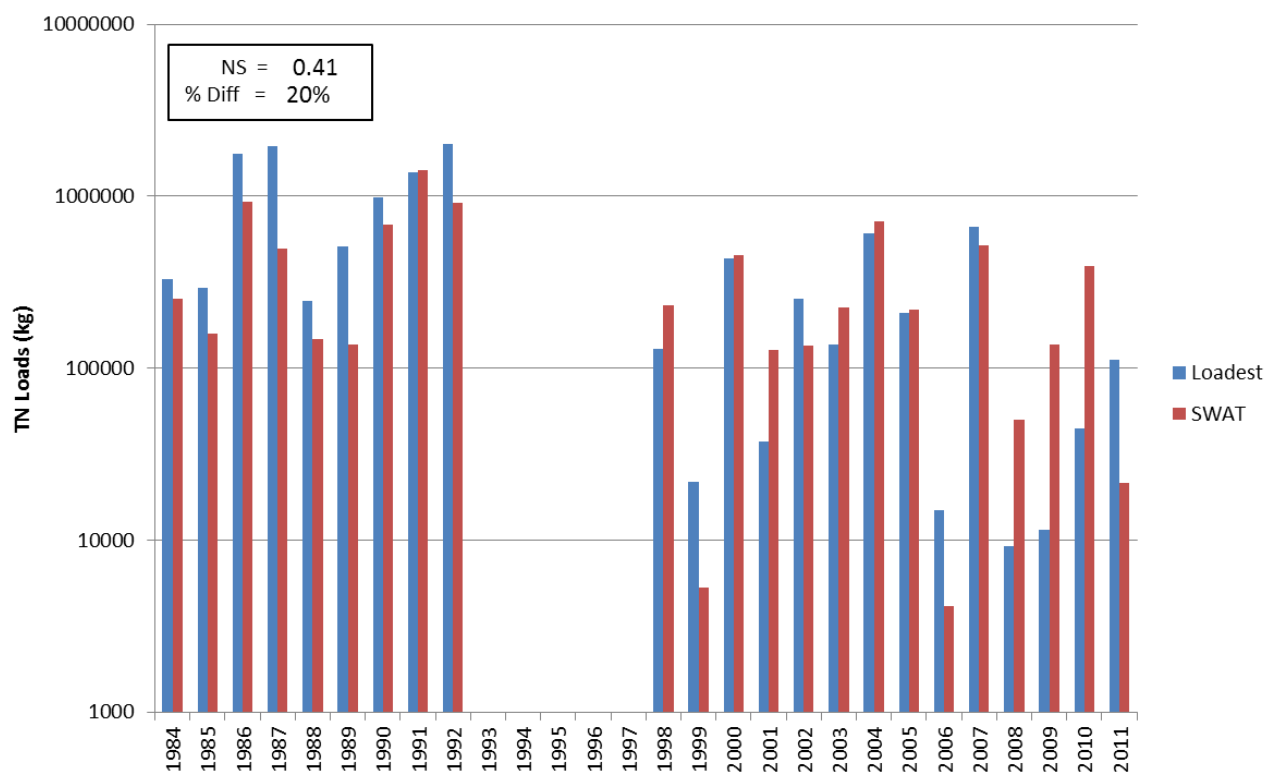
Figure 3-51a Annual Total Nitrogen Load Calibration Results for Station 12358-Colorado River at Highway 377 in Winchell
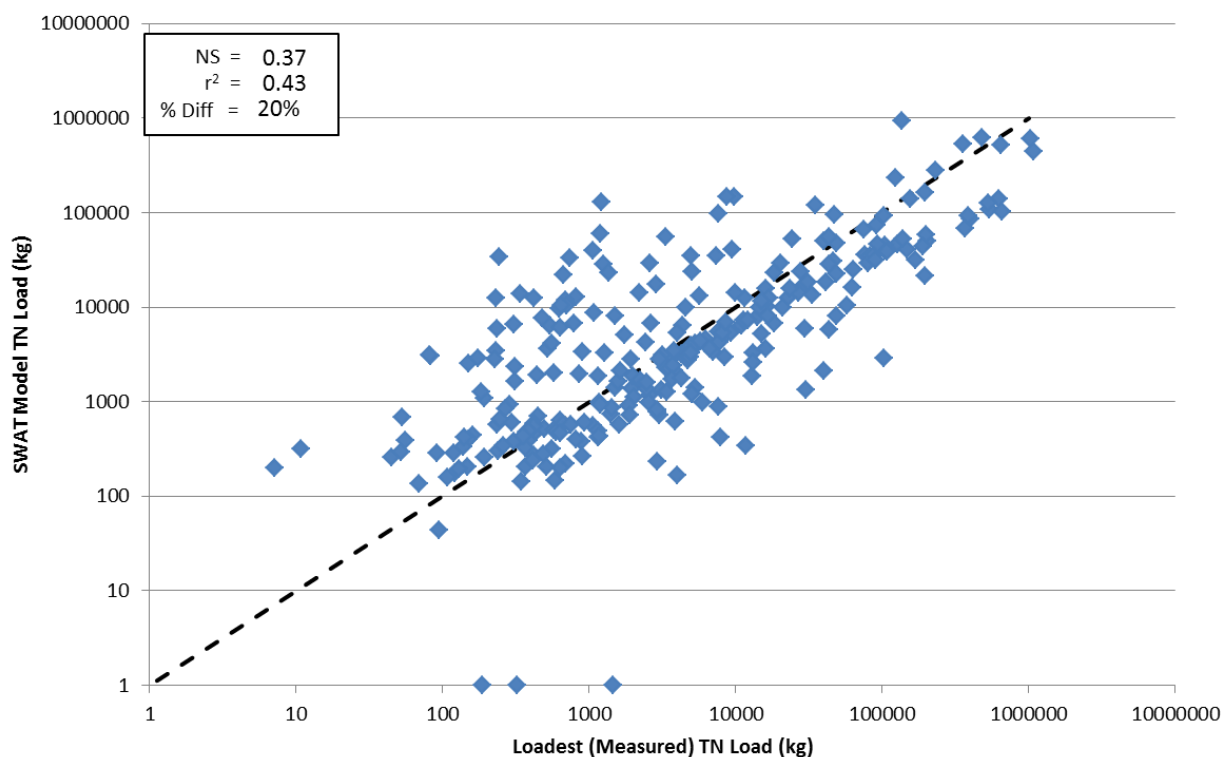
Figure 3-51b Monthly Average Total Nitrogen Load Calibration Results for Station 12358-Colorado River at Highway 377 in Winchell
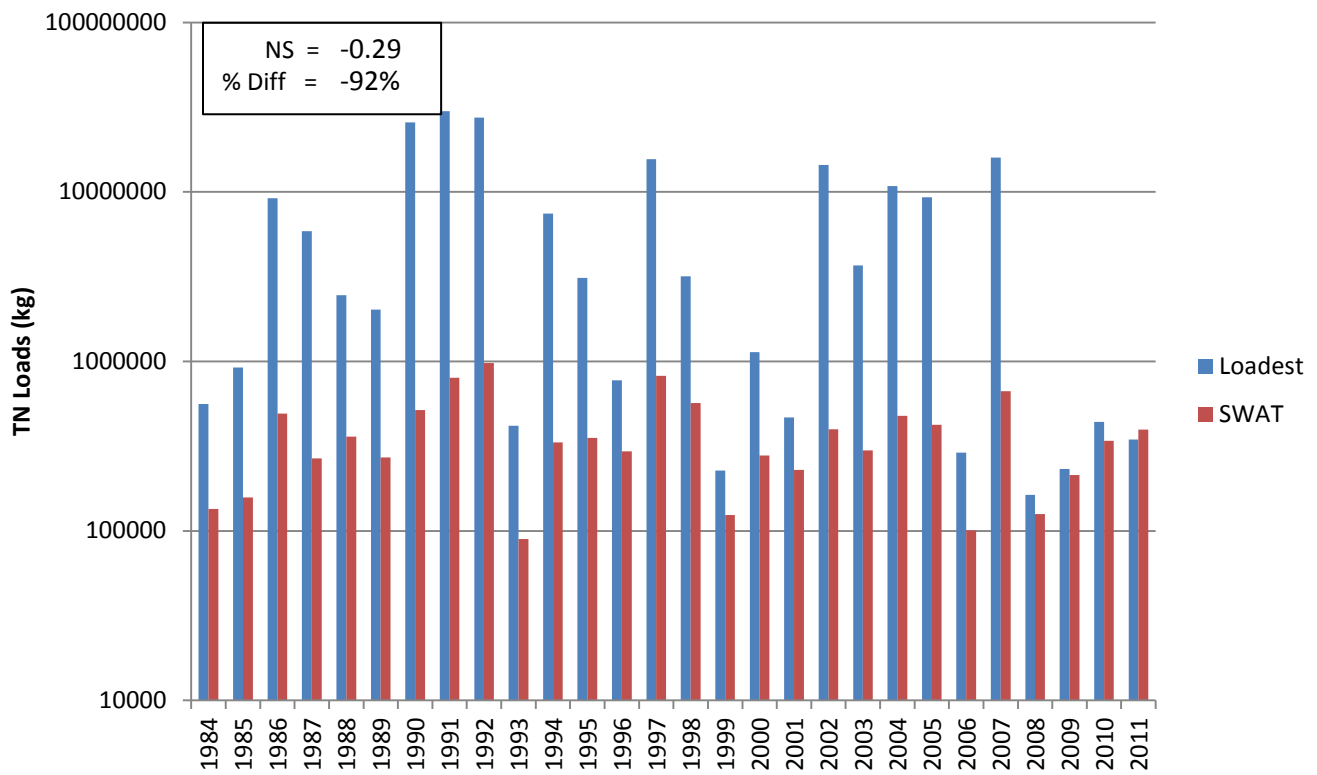
Figure 3-52a Annual Total Nitrogen Load Calibration Results for Station 12394-Pecan Bayou at FM 573 southwest of Mullin
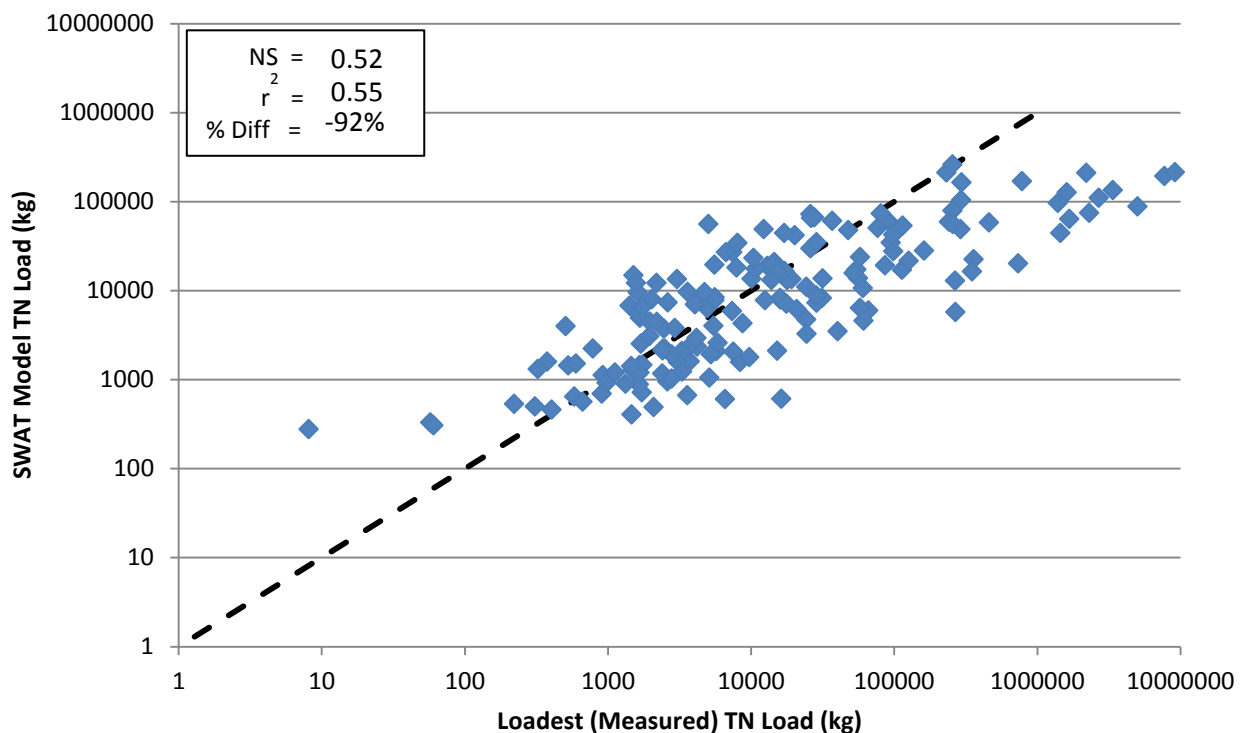
Figure 3-52b Monthly Average Total Nitrogen Load Calibration Results for Station 12394-Pecan Bayou at FM 573 southwest of Mullin
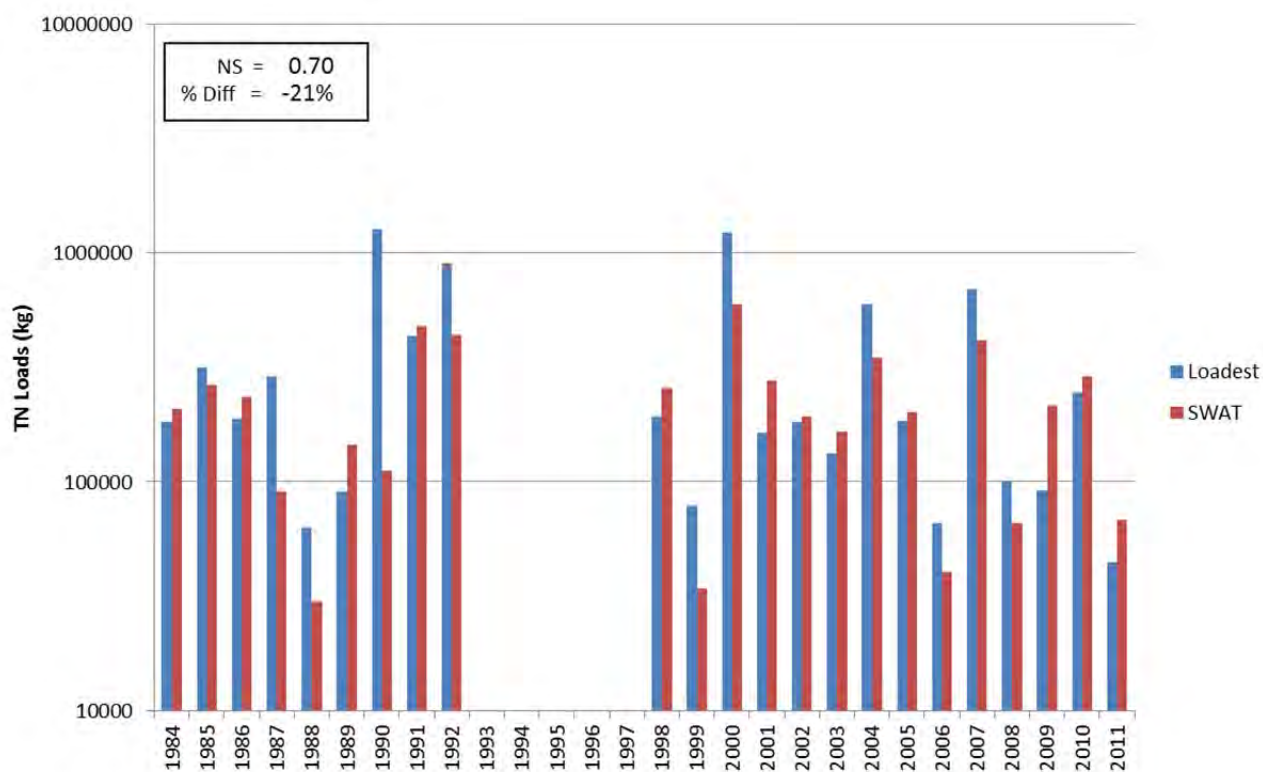
Figure 3-53a Annual Total Nitrogen Load Calibration Results for Station 12392-San Saba River at SH 16 near San Saba
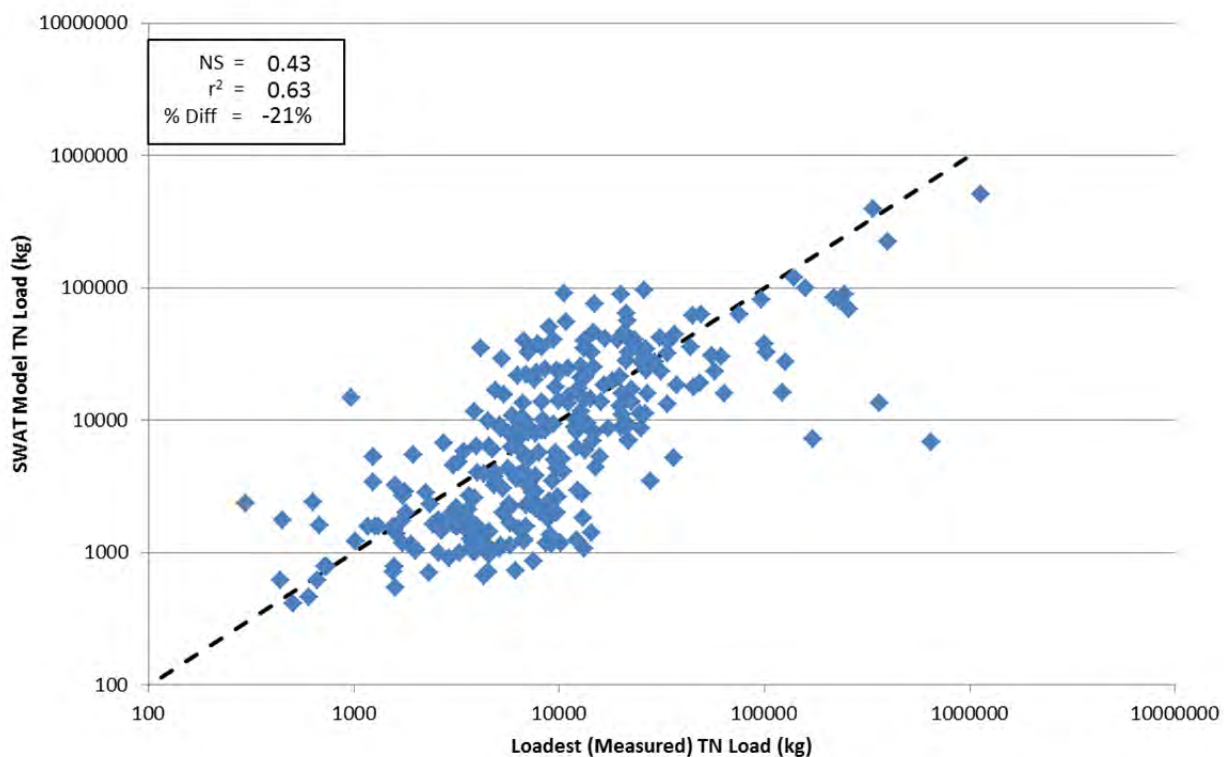
Figure 3-53b Monthly Average Total Nitrogen Load Calibration Results for Station 12392-San Saba River at SH 16 near San Saba

Figure 4-2
Lake Longitudinal Segmentation and Calibration Stations
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority
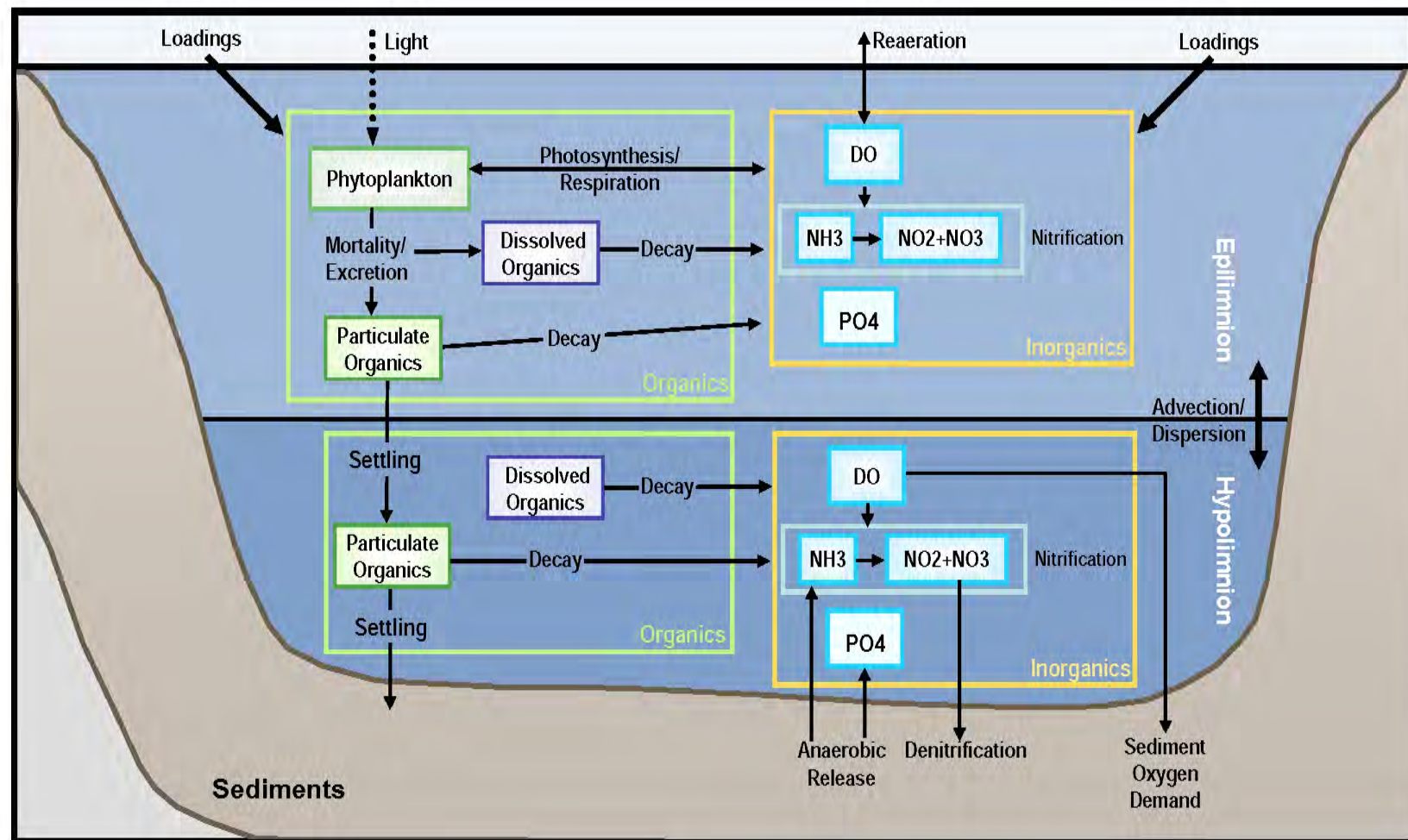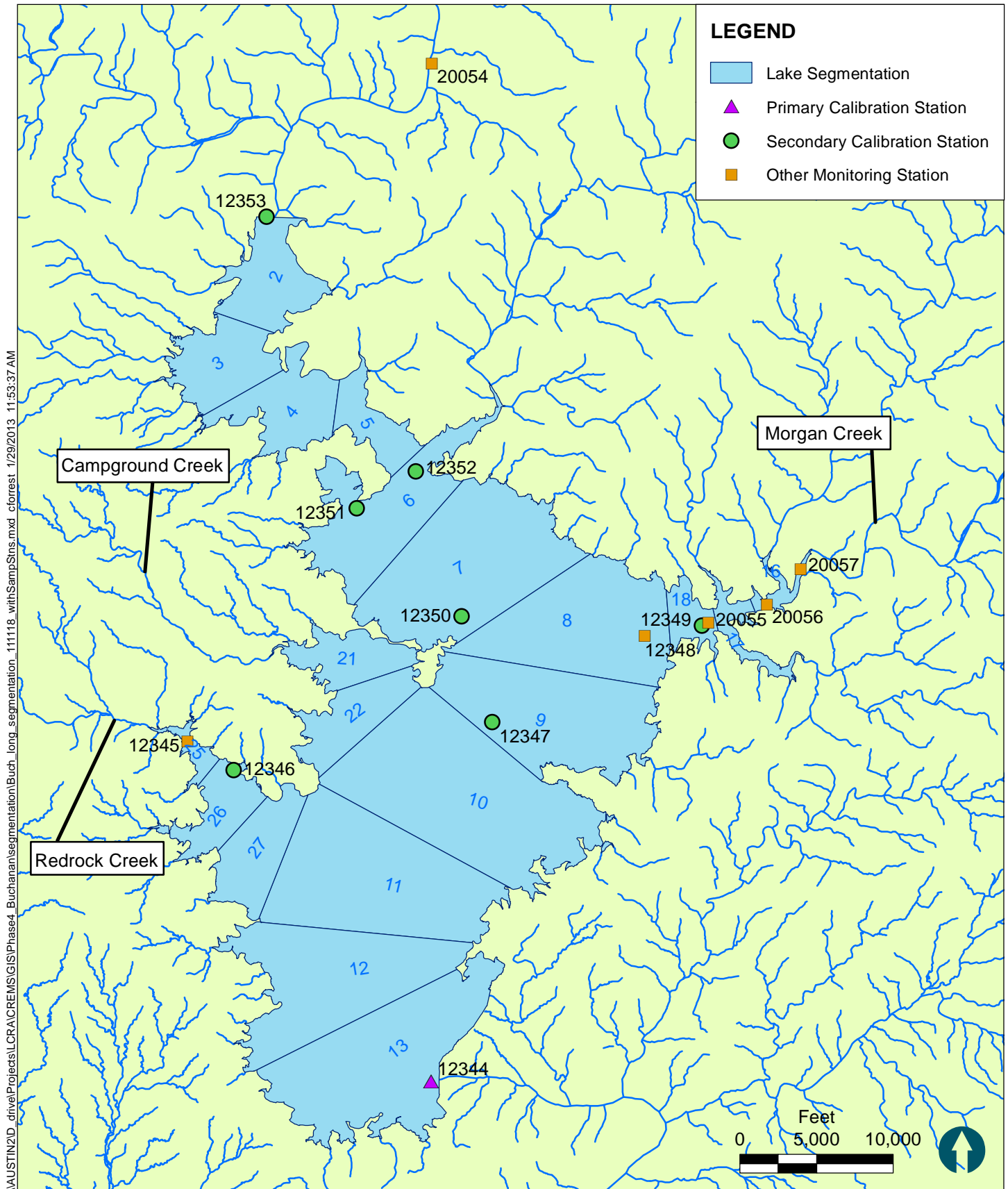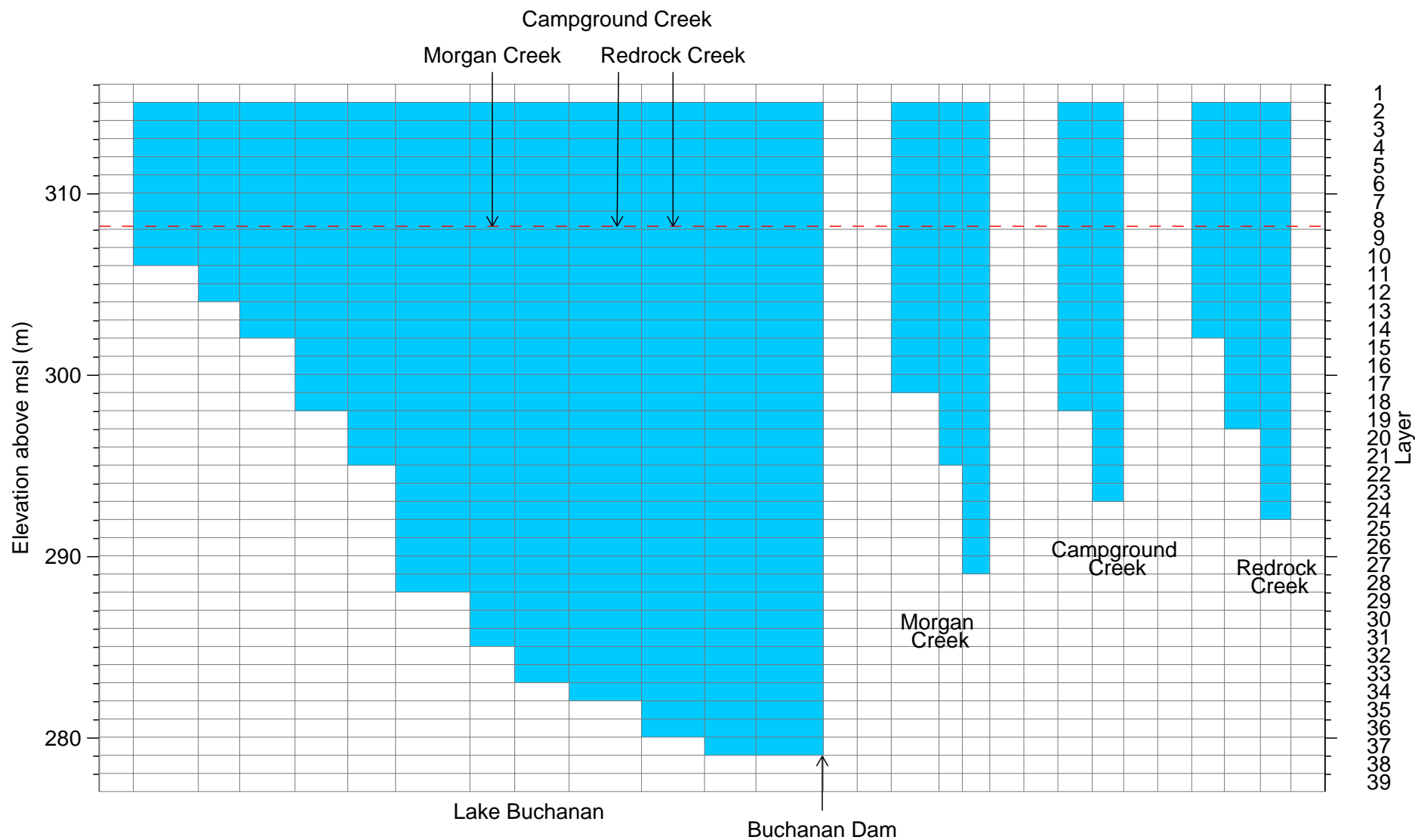
Figure 4-3

Computational Grid in the X-Z Plane Showing Active and Inactive Cells

Notes: Locations where modeled tributaries enter lake indicated above figure.
Red horizontal dashed line = normal pool elevation

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-4
Elevation-volume Relationship for Lake Buchanan
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority
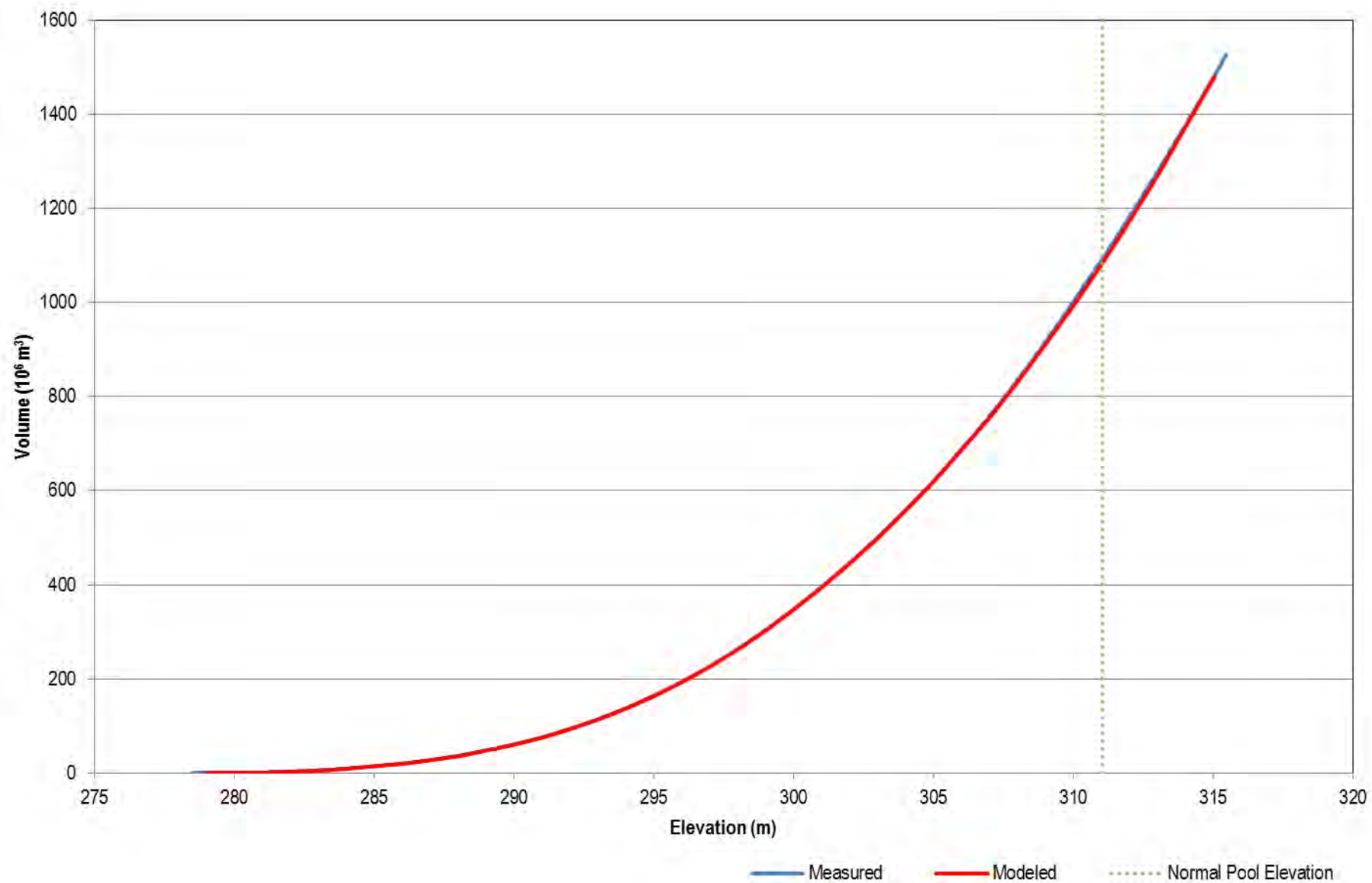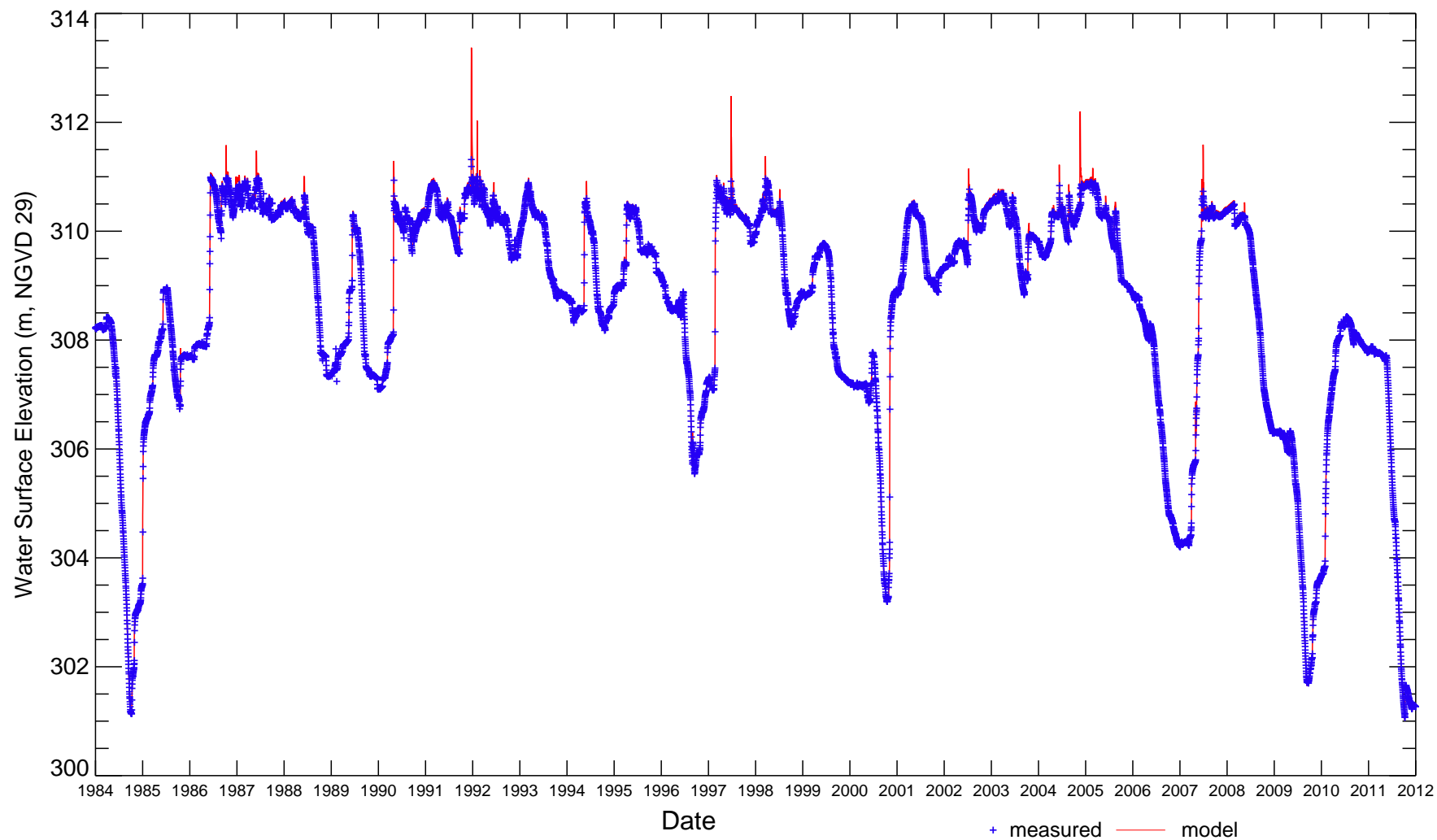
Figure 4-5

Daily Predicted and Measured Water Surface Elevations at Buchanan Dam

Measured elevations were increased by 0.01 ft to convert from LCRA datum to NGVD 29
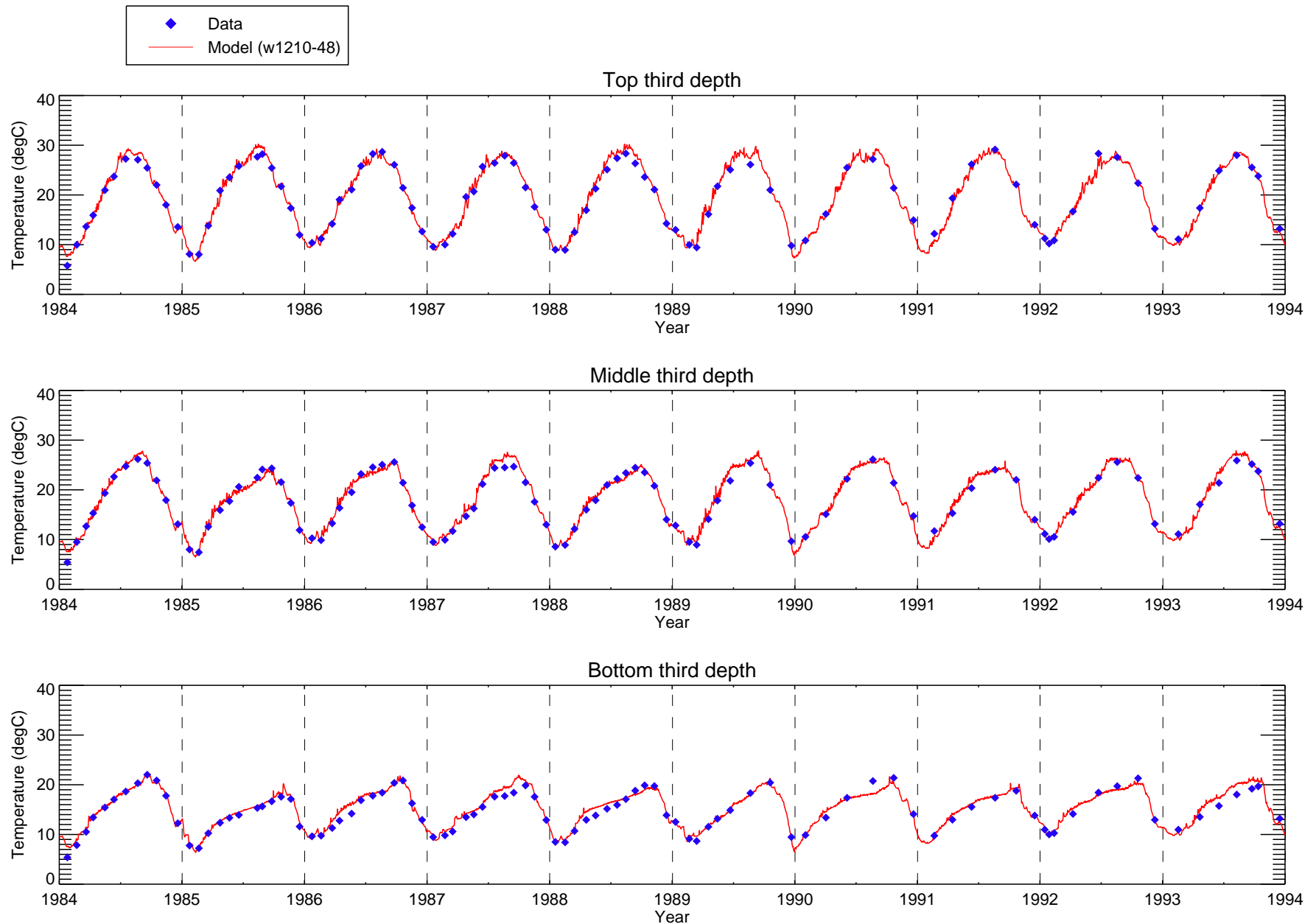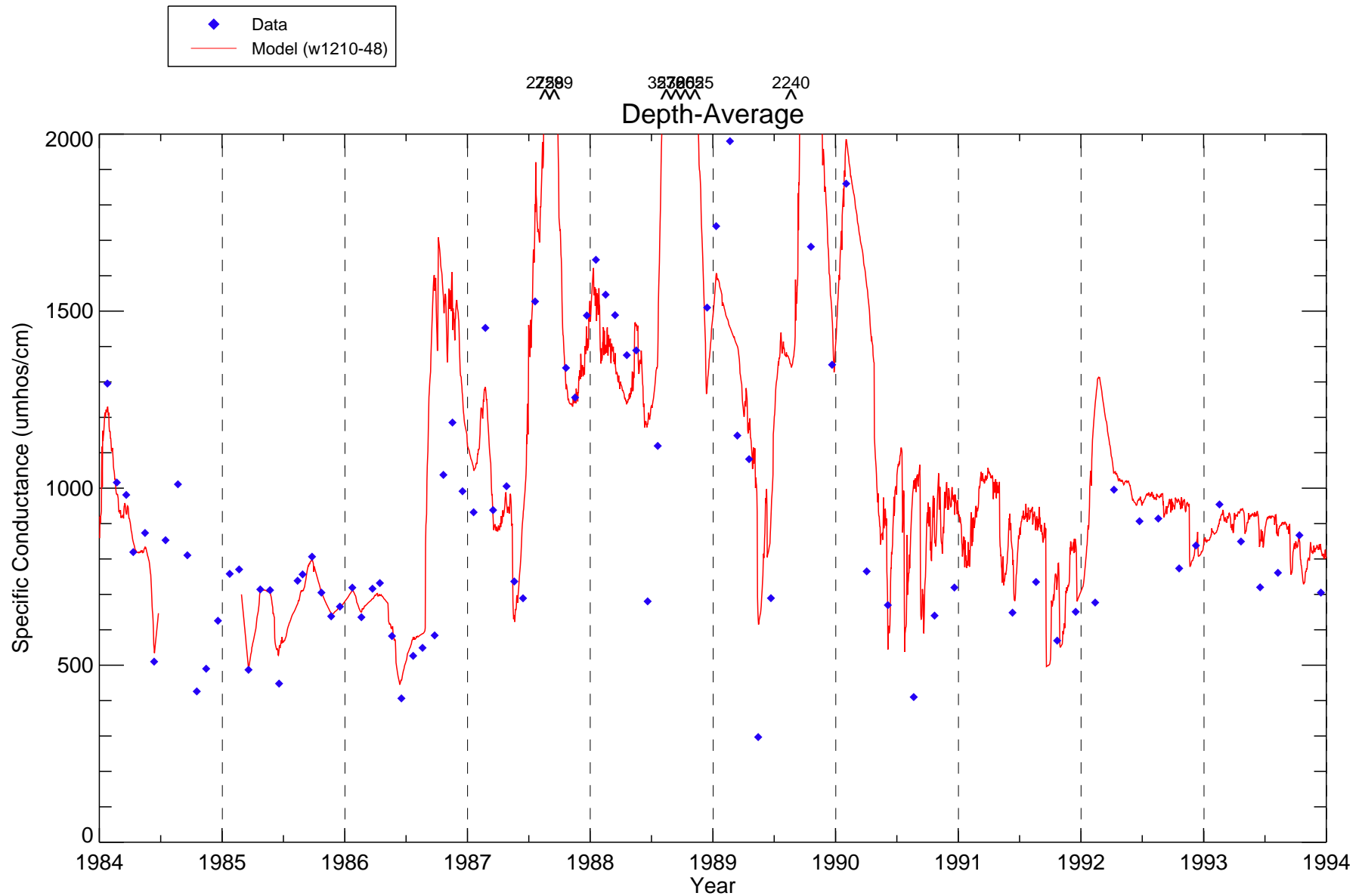
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-6a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

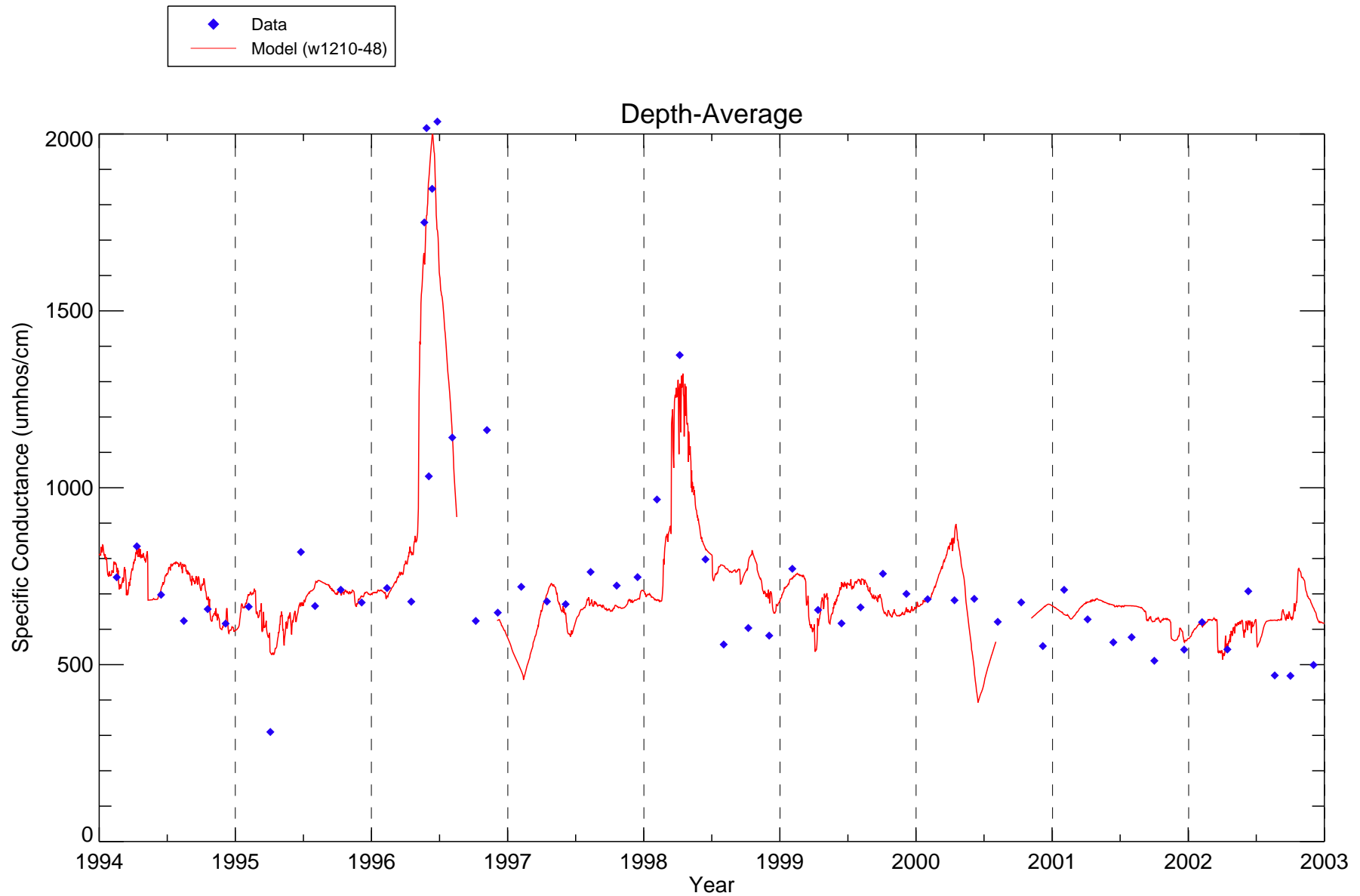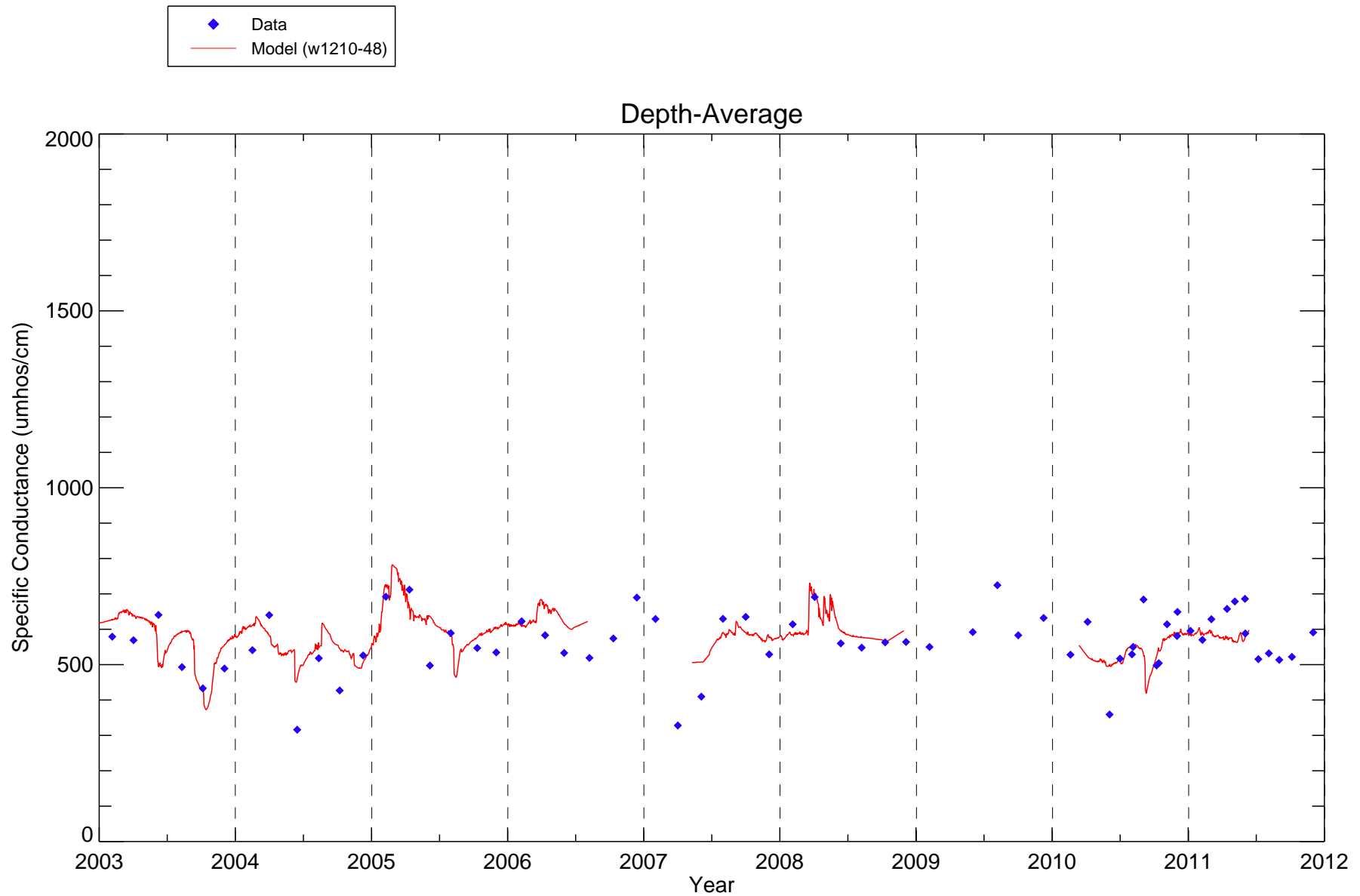CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:02:11 2013

Figure 4-6a

Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

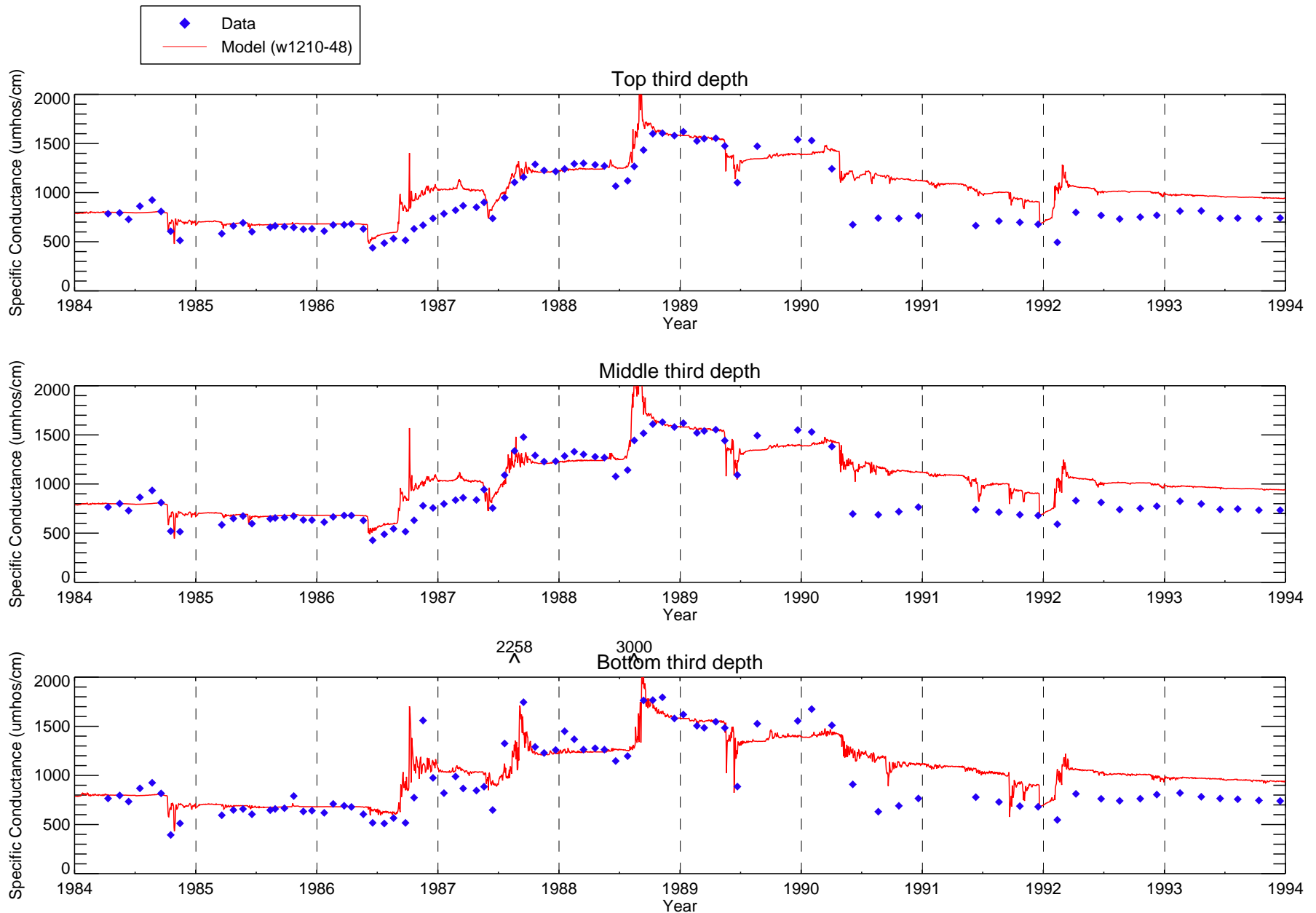CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:04:26 2013

Figure 4-6a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
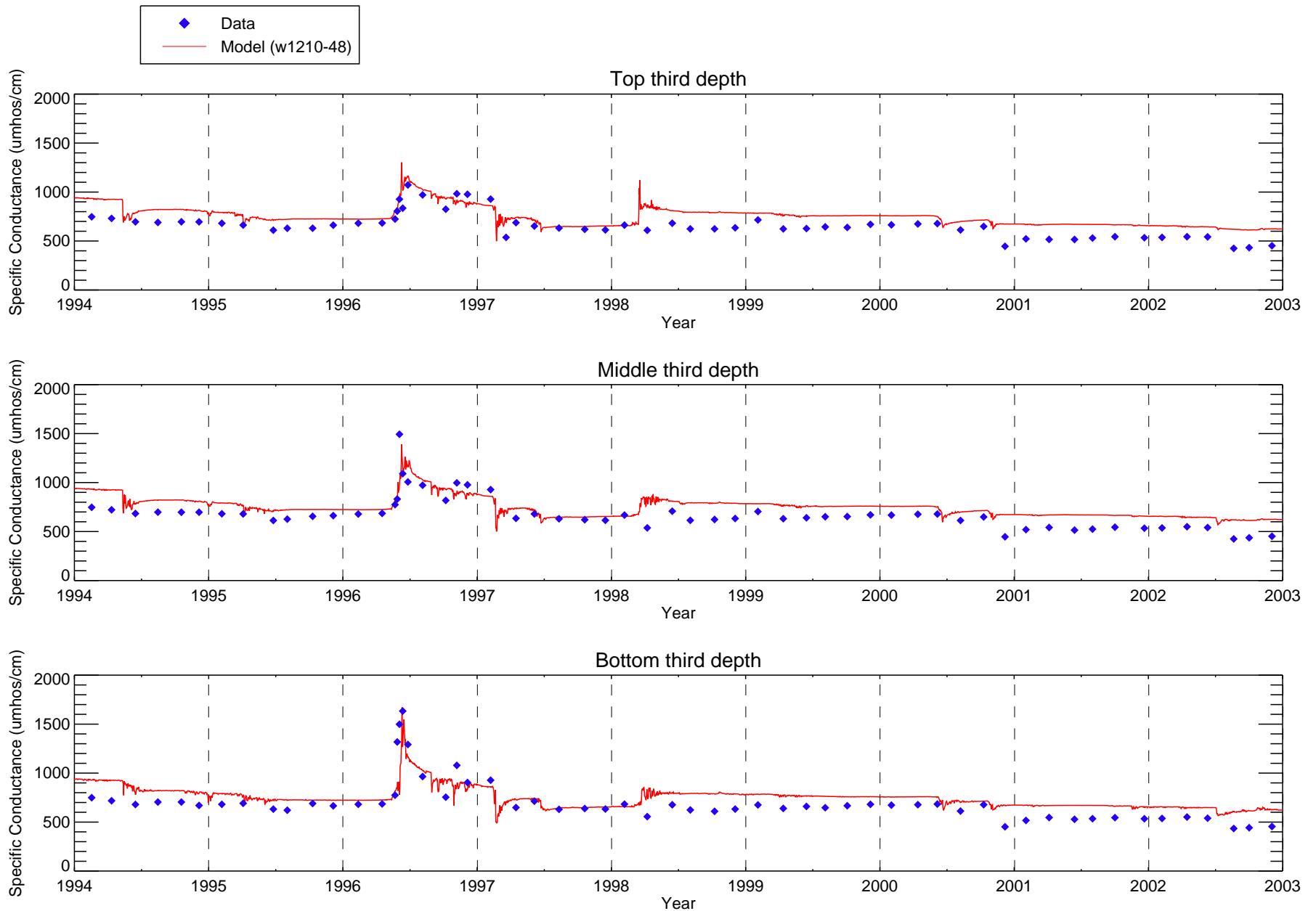
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:06:42 2013

Figure 4-6b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Temperature

Notes: Data are averaged over water column depths shown.
Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
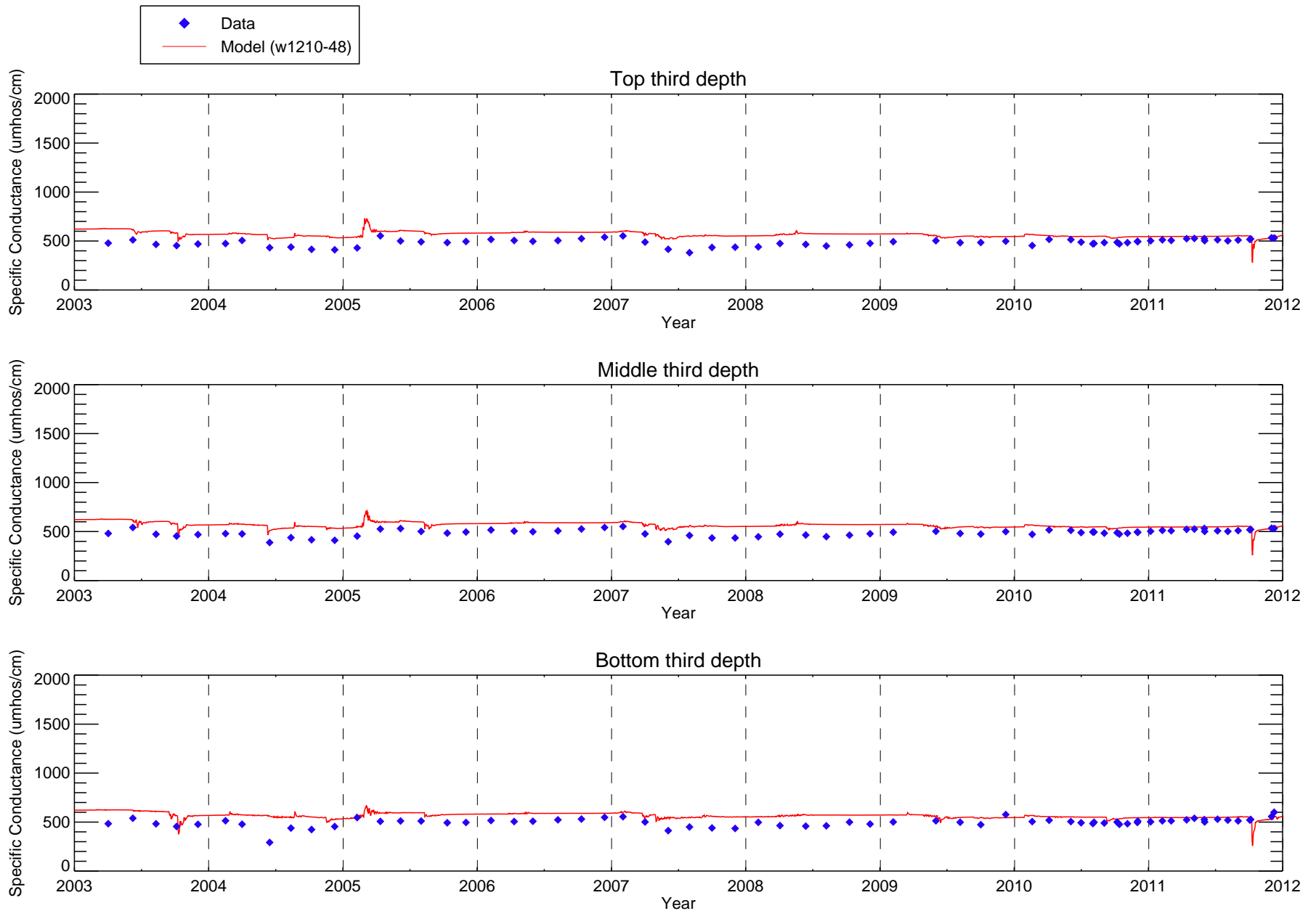
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:13:45 2013

Figure 4-6b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Temperature

Notes: Data are averaged over water column depths shown.
Model output is averaged over water column depths shown.Data greater than y-range are indicated by caret above axis.
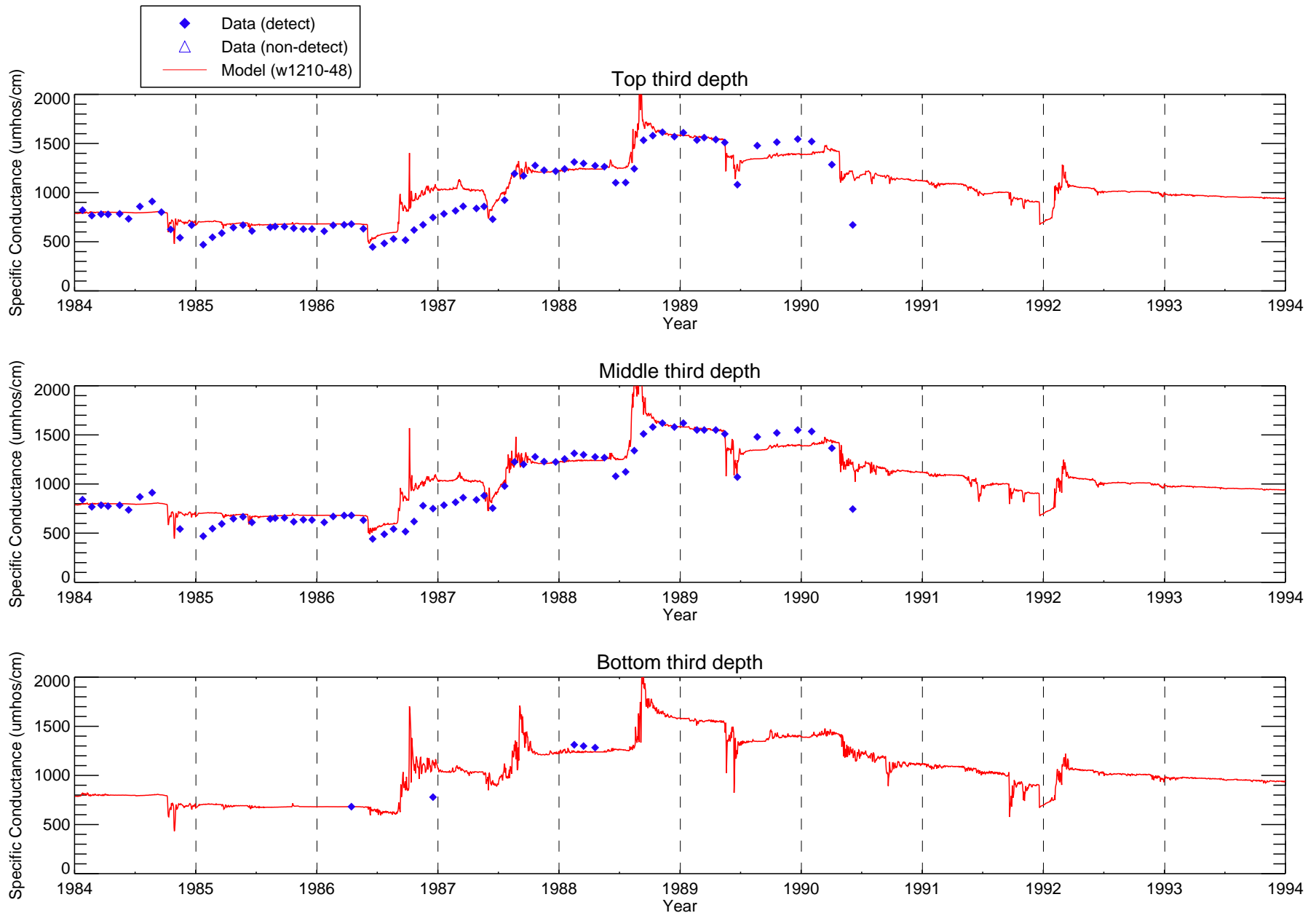
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-6b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Temperature

Notes: Data are averaged over water column depths shown.
Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
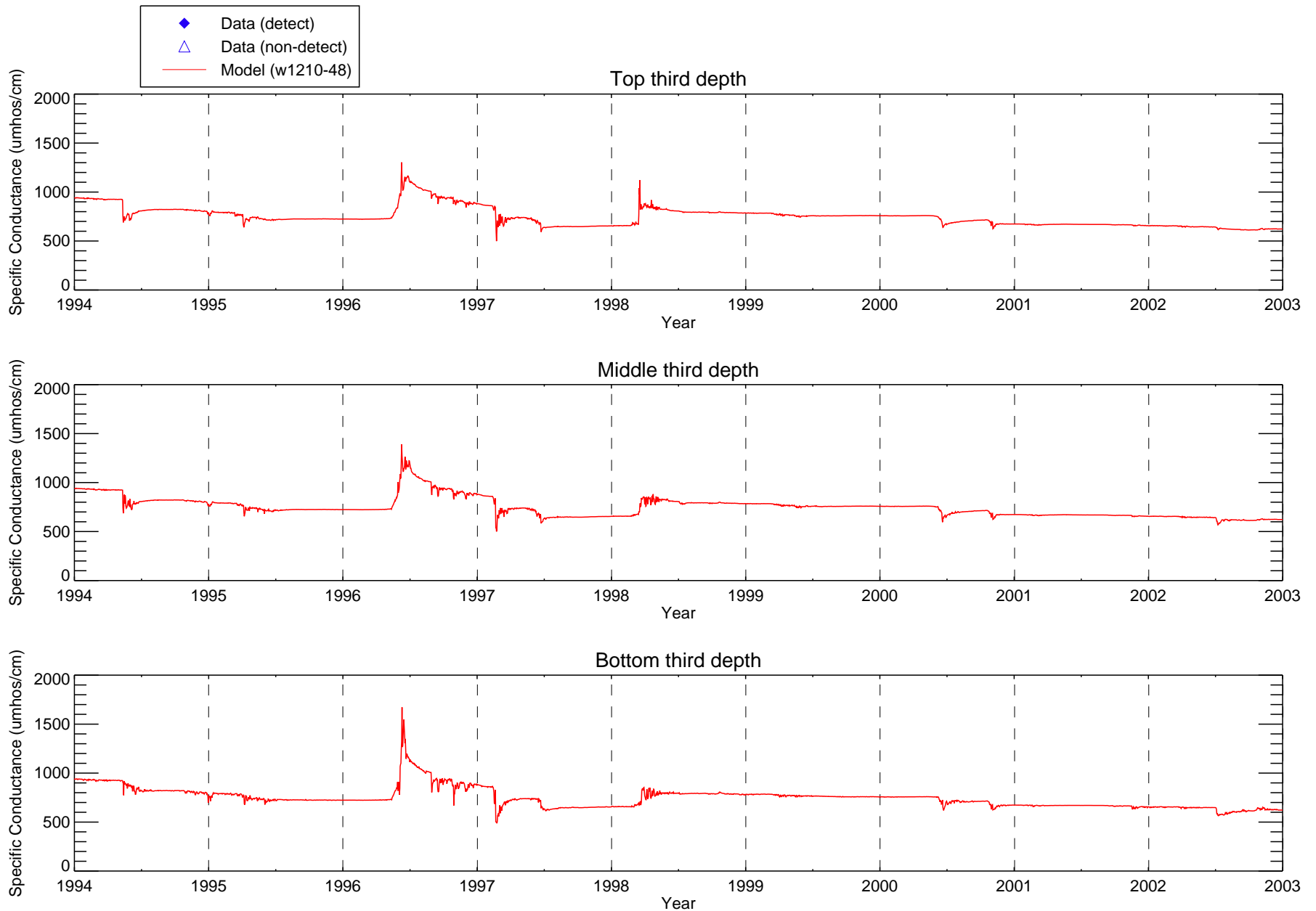
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:13:56 2013

Figure 4-6c

Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
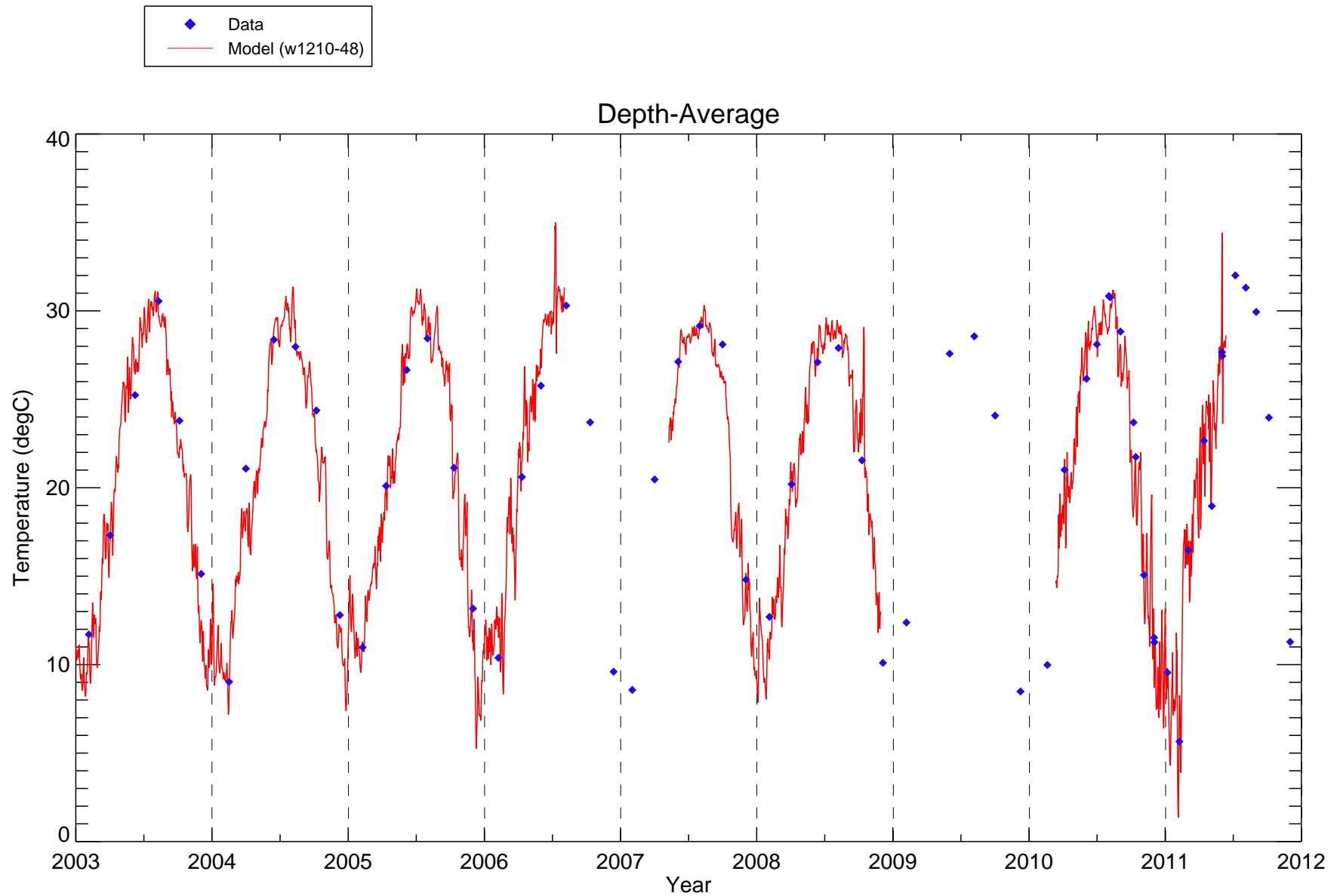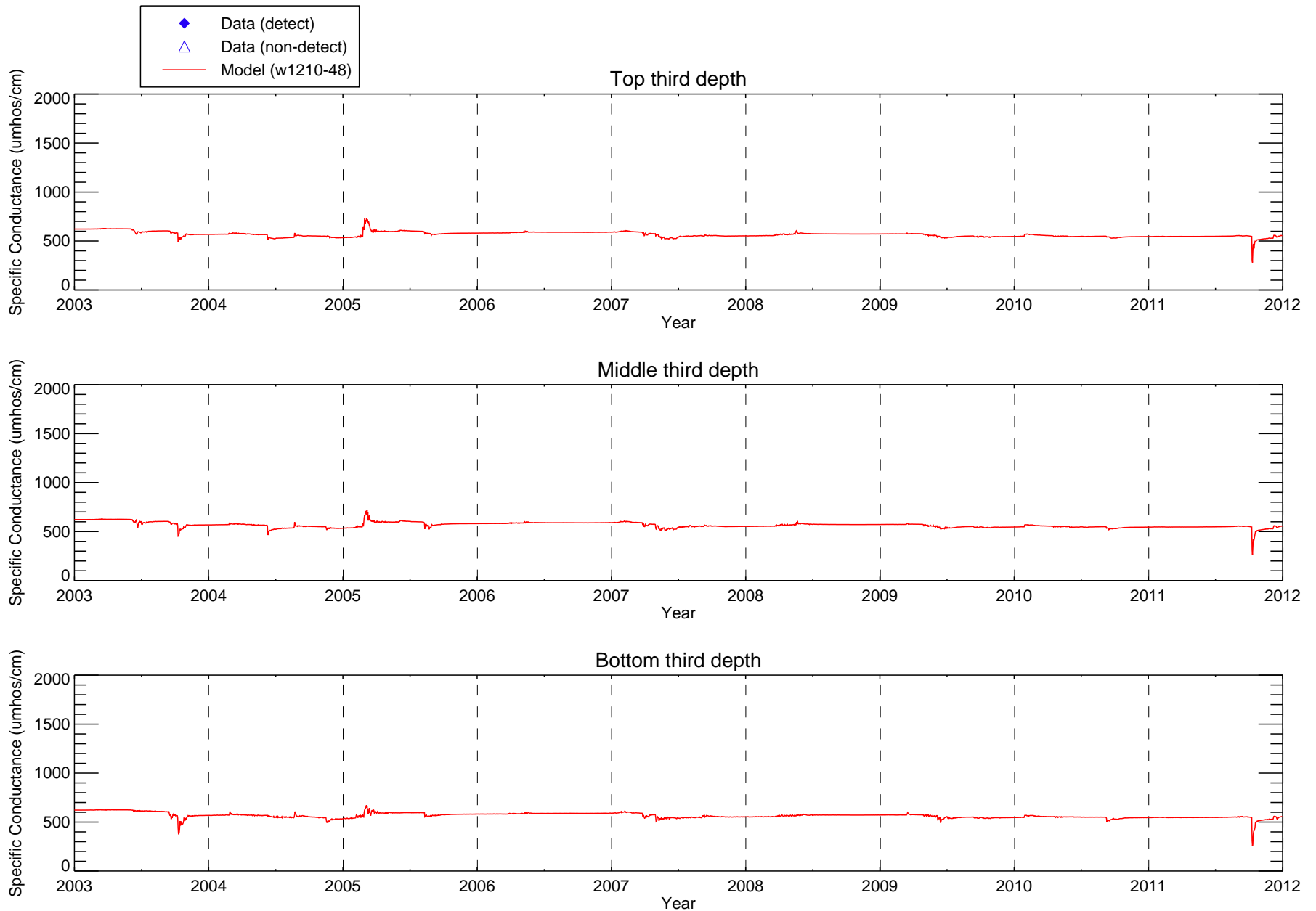
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-6c

Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
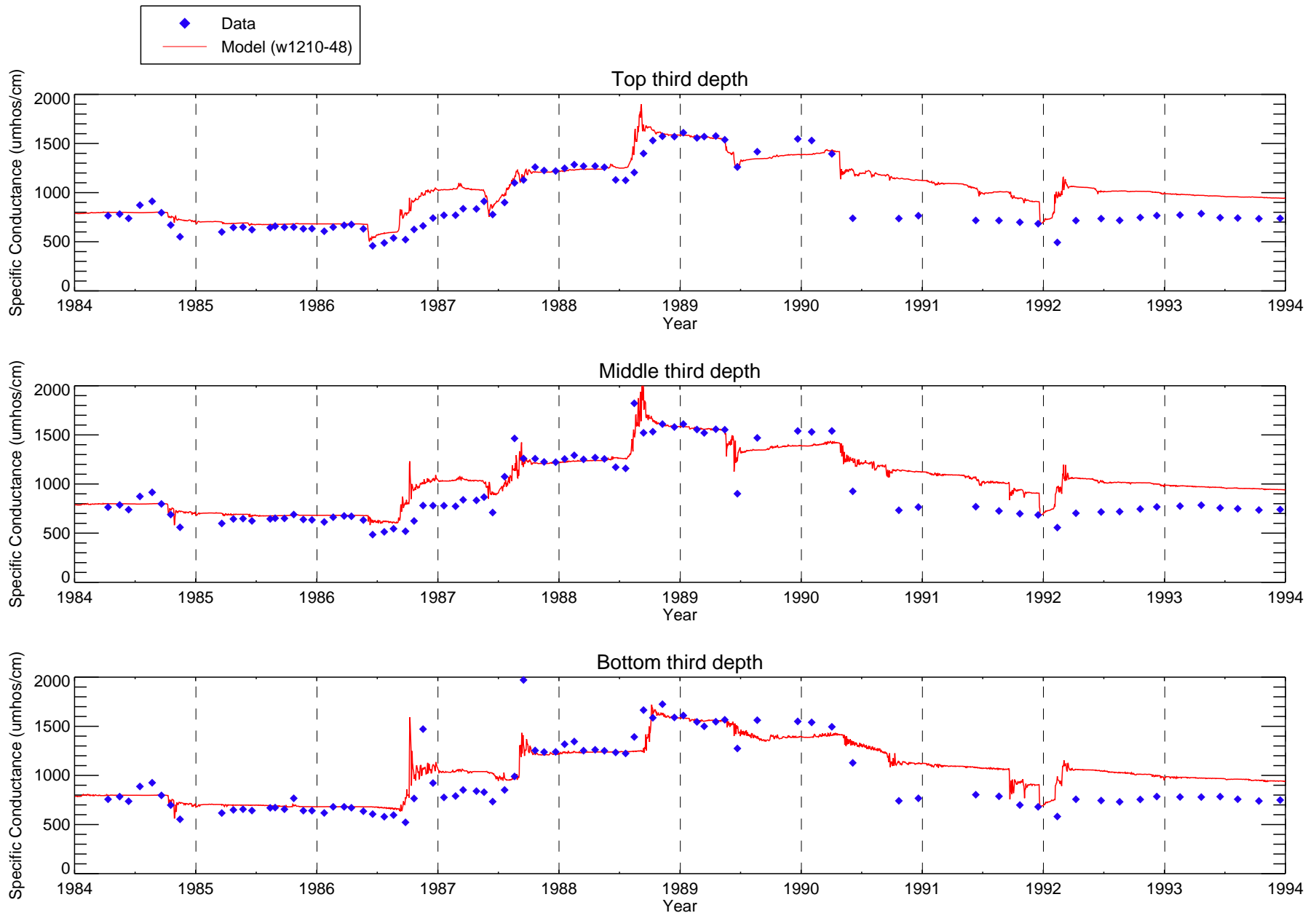
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-6d

Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
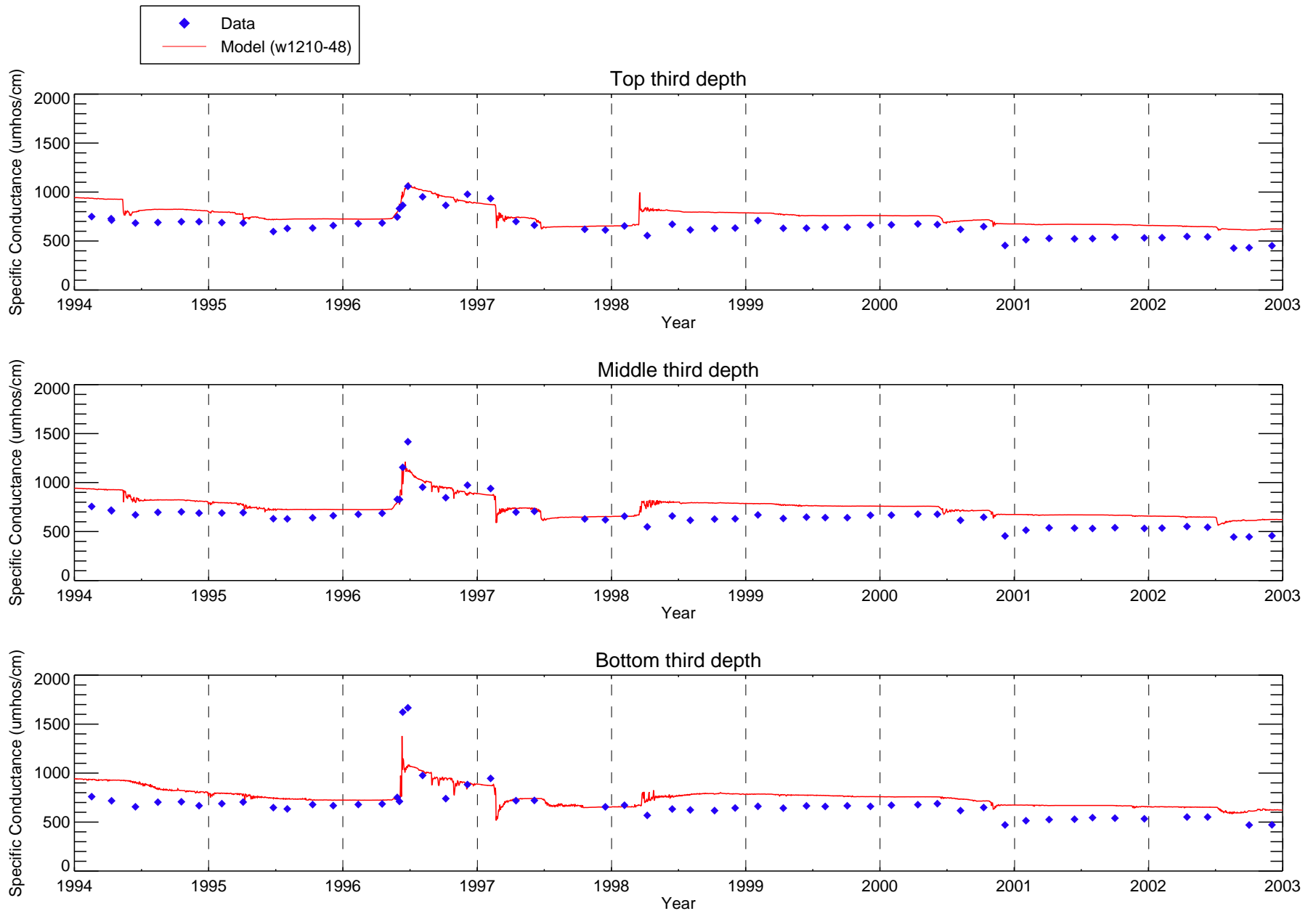
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-6d

Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

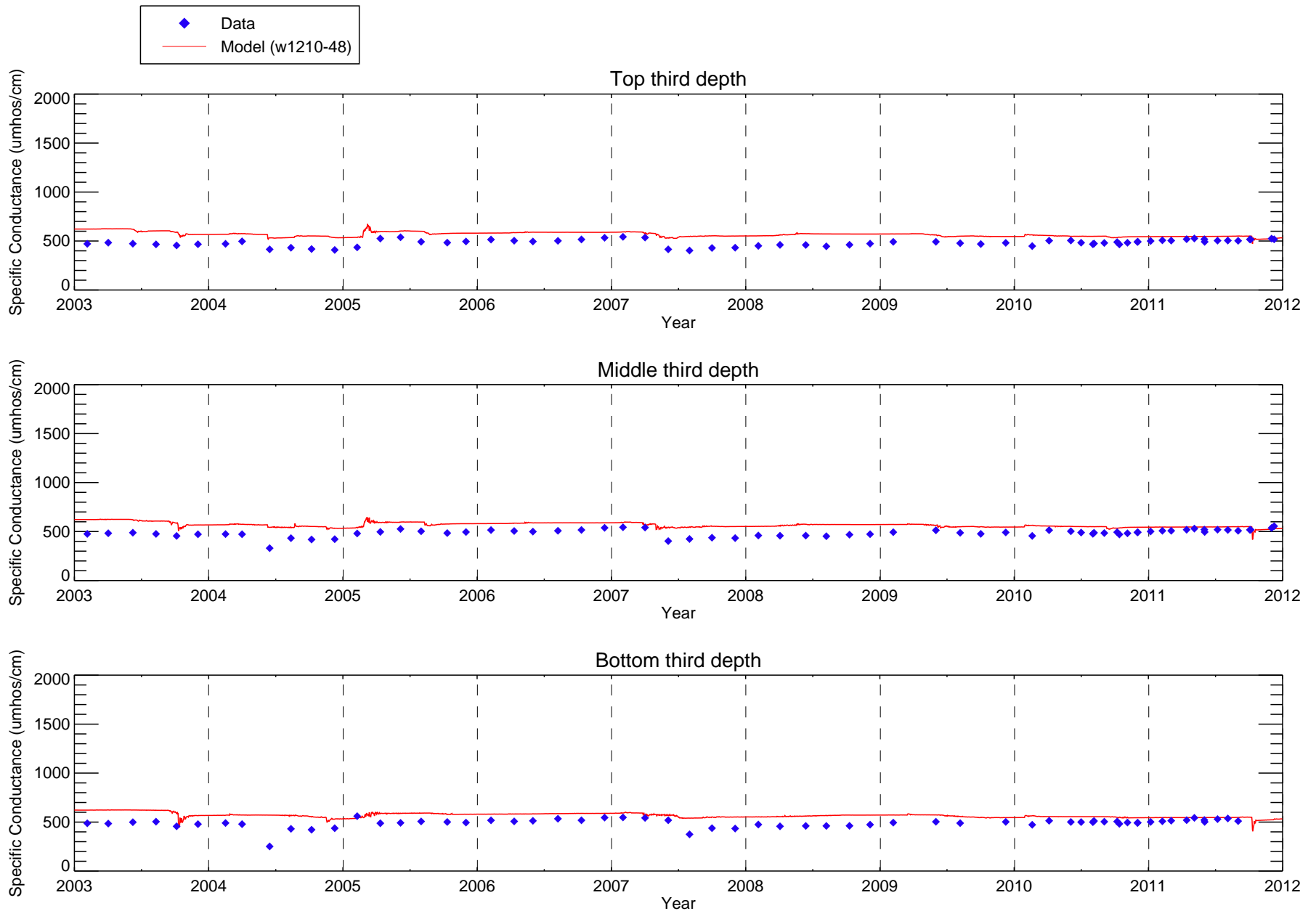CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - \\austin2\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 09:45:13 2013

Top third depth

Middle third depth

Bottom third depth

Figure 4-6d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

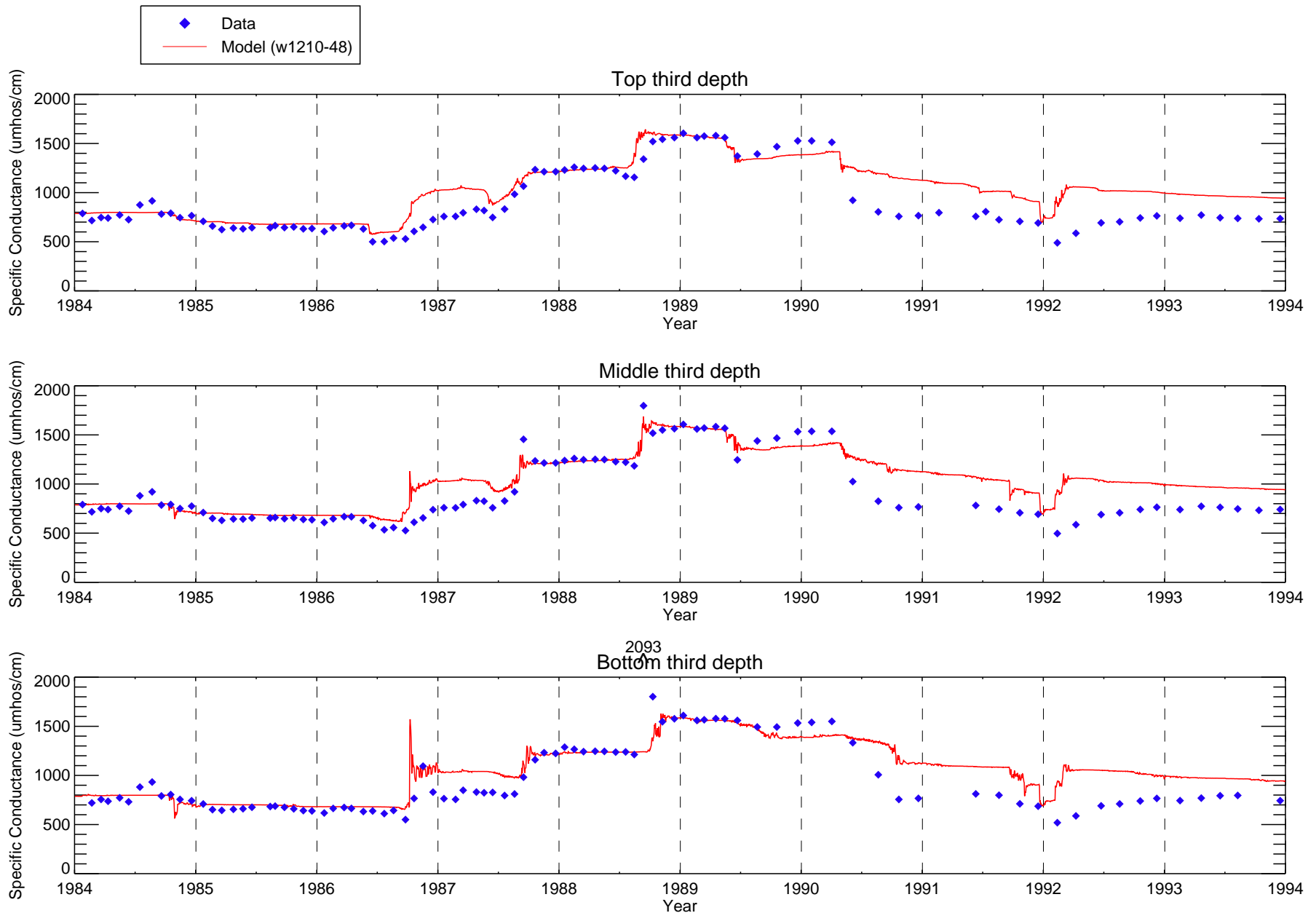CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - \\austin2\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 09:49:25 2013

Figure 4-6e

Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
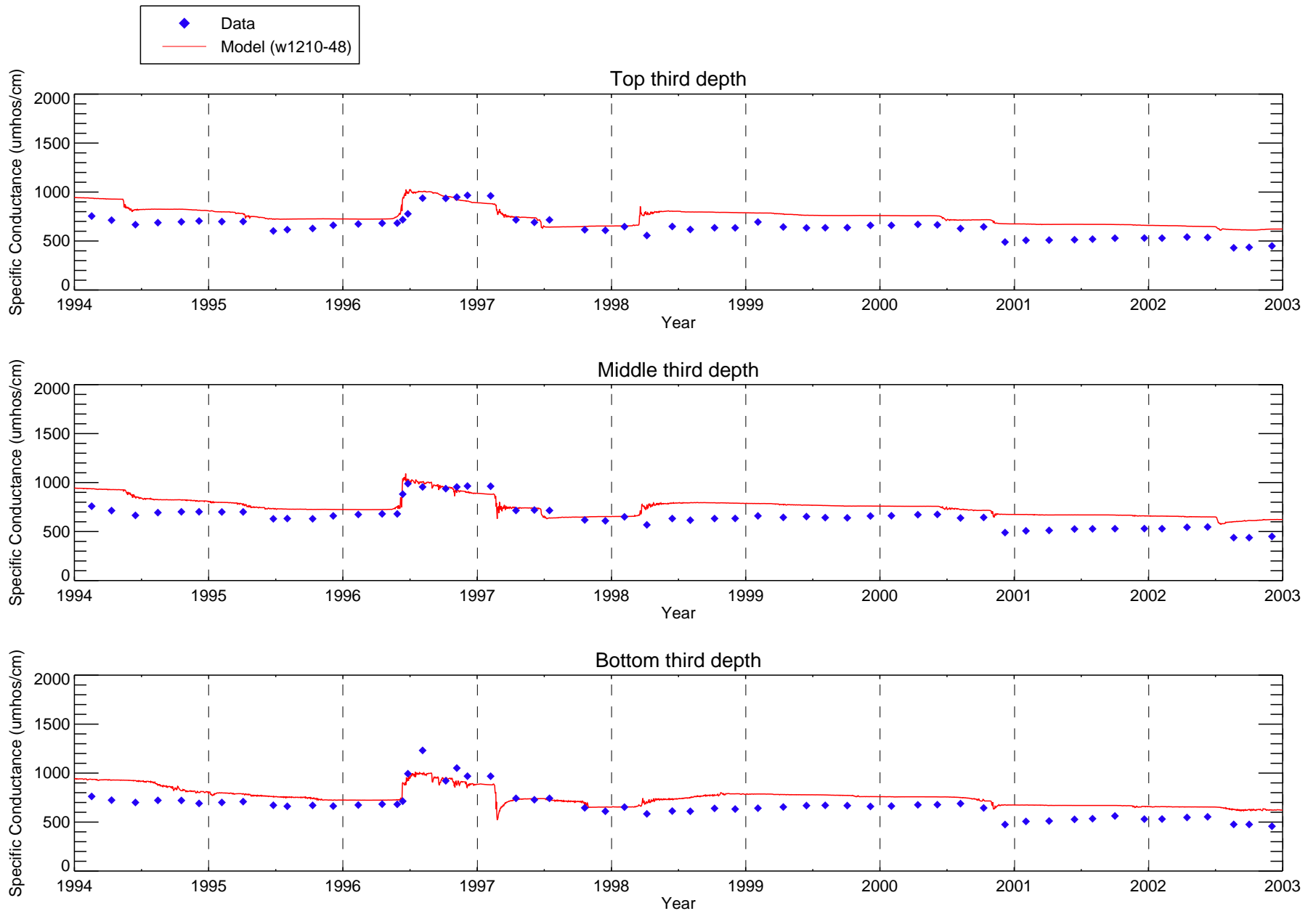Lower Colorado River Authority

Figure 4-6e

Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
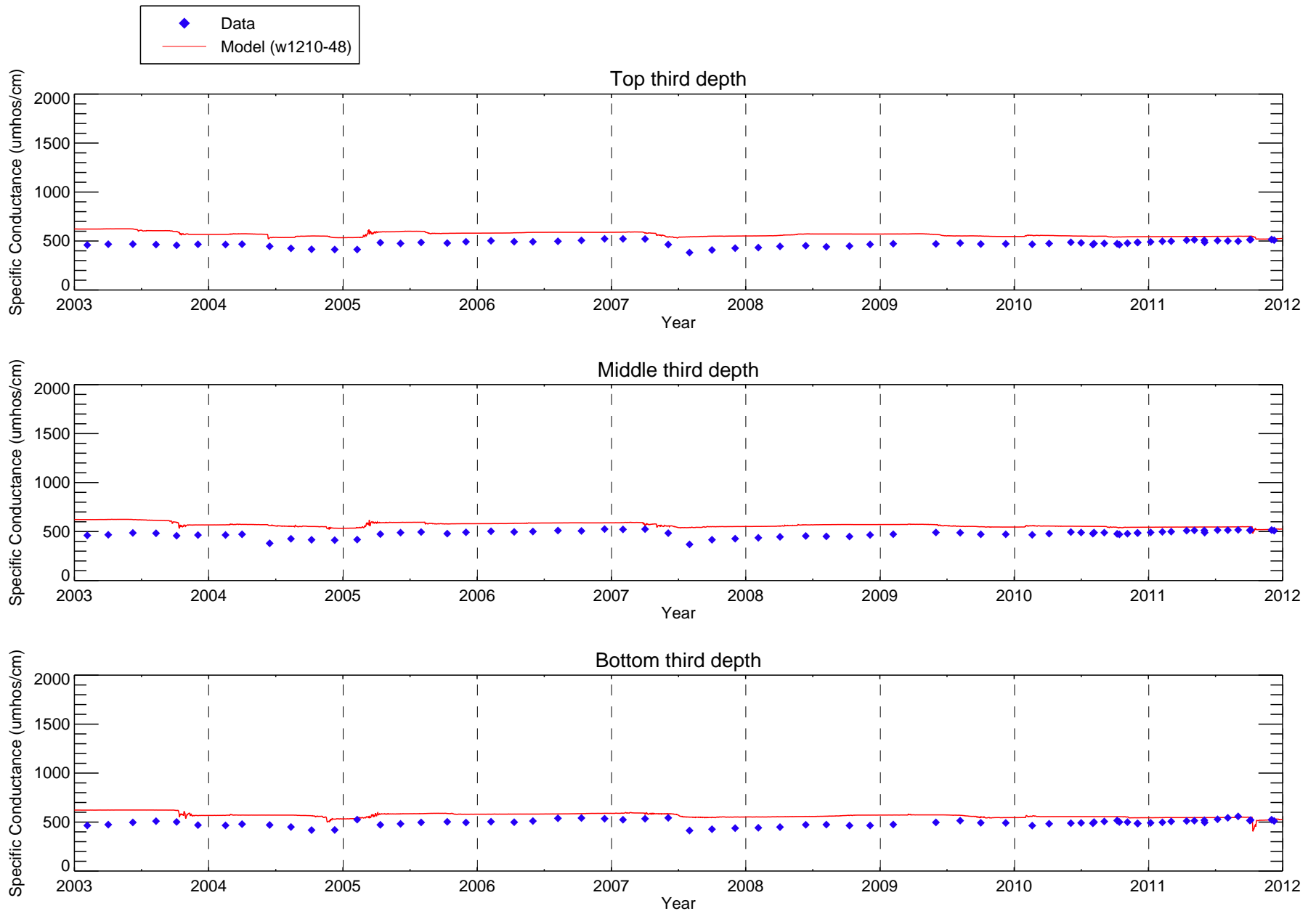Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 14:52:19 2013

Figure 4-6e

Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Temperature
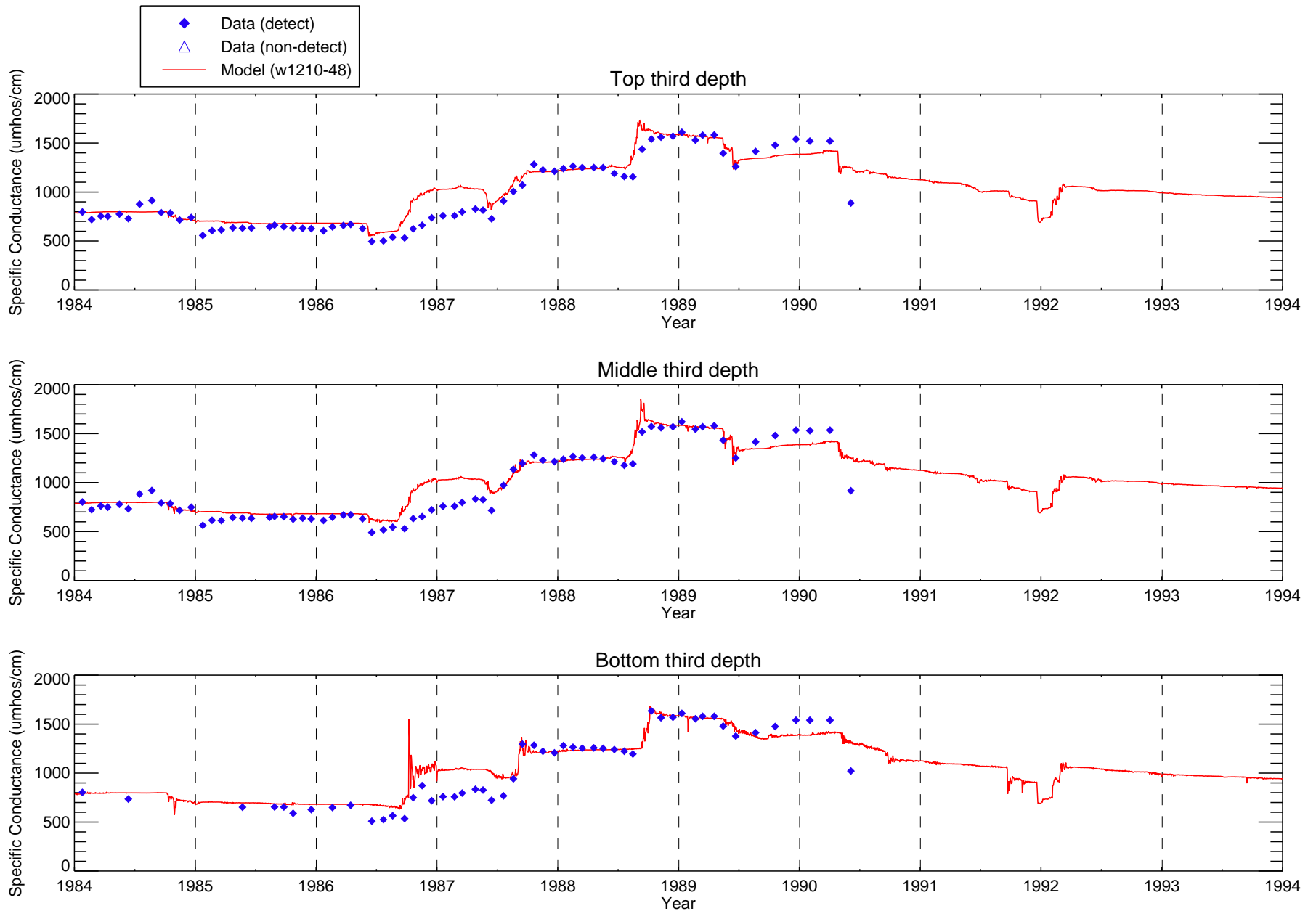
Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 14:53:45 2013

Figure 4-6f

Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

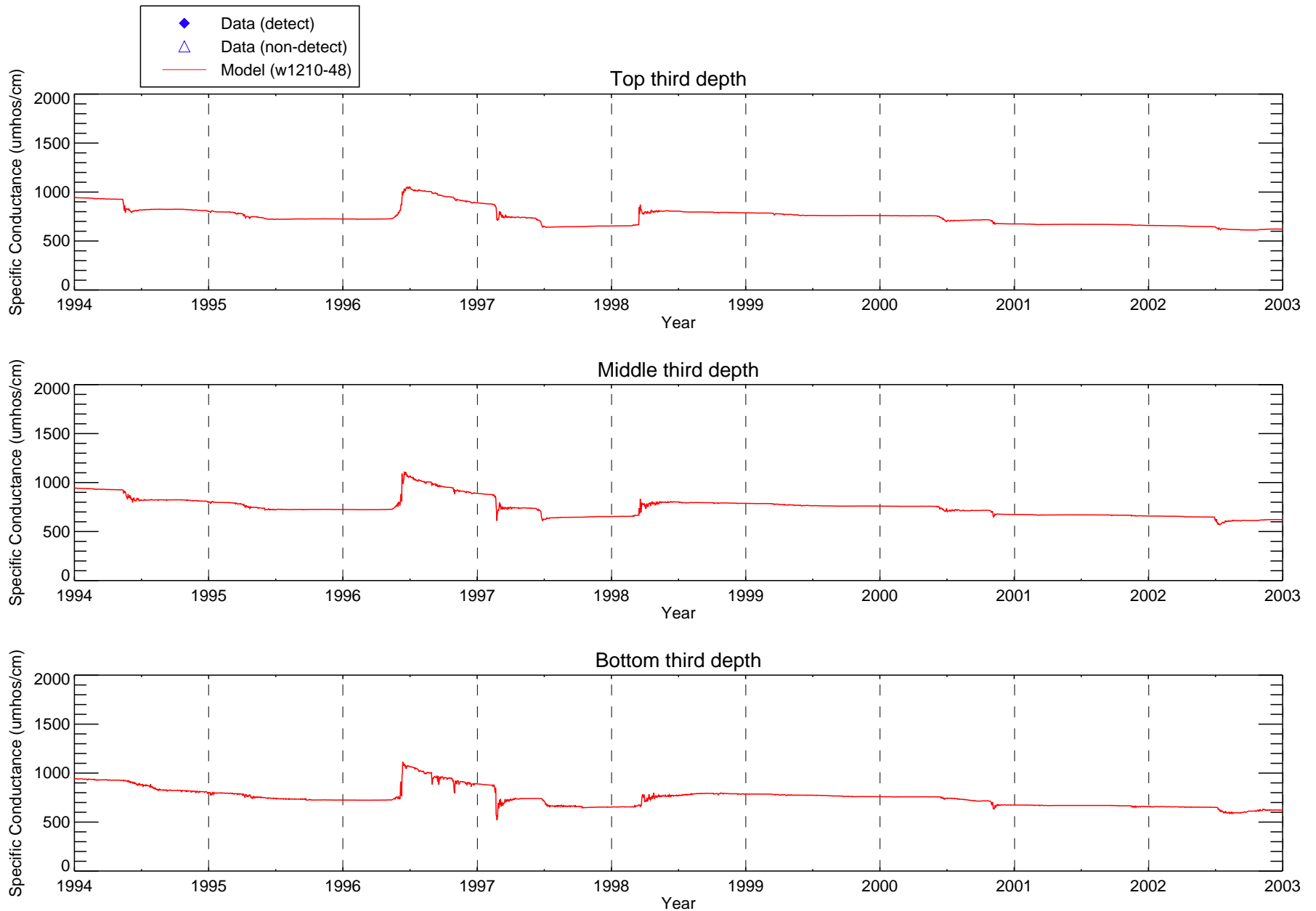CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-6f
Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

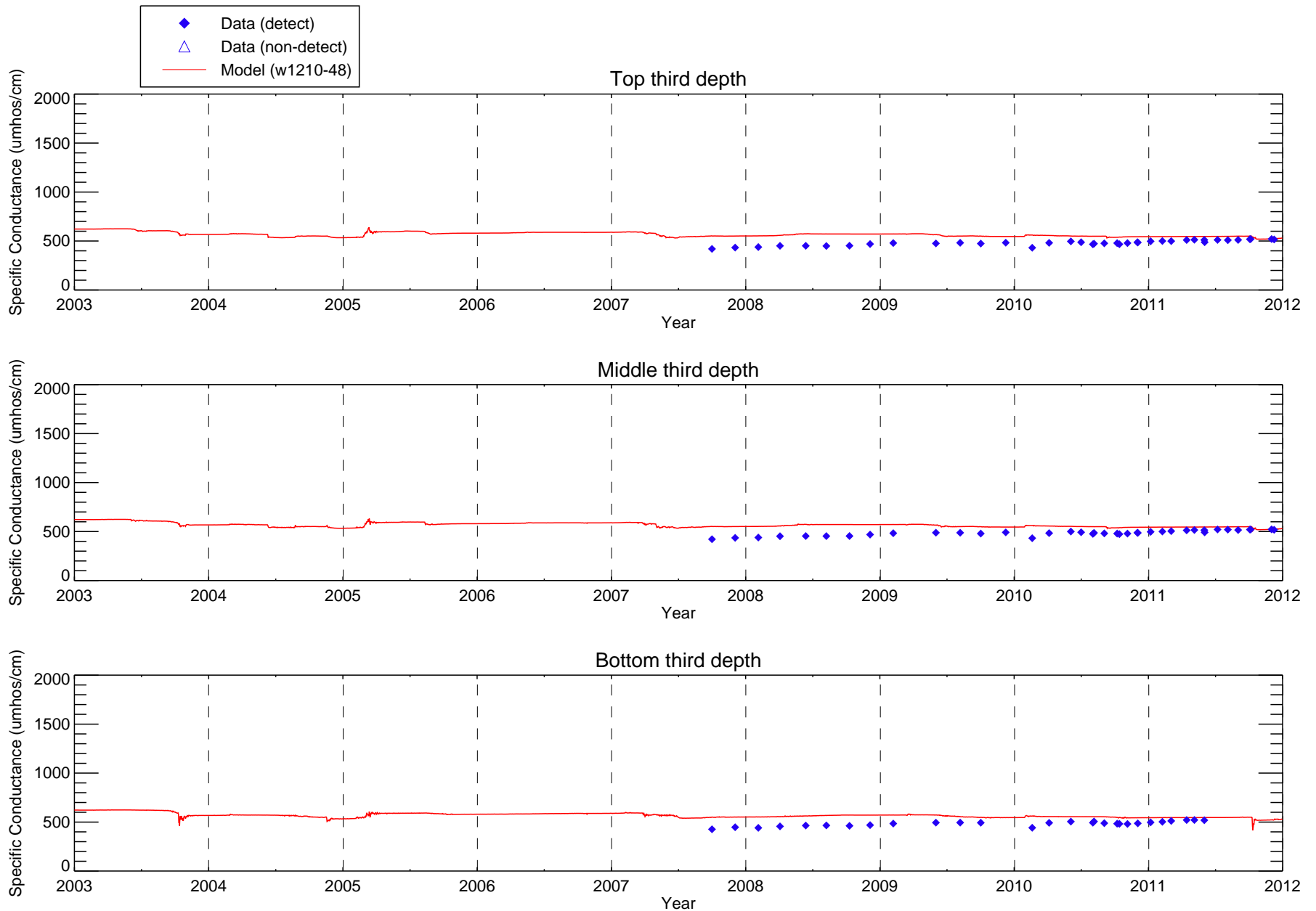CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 14:57:52 2013

Figure 4-6f

Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

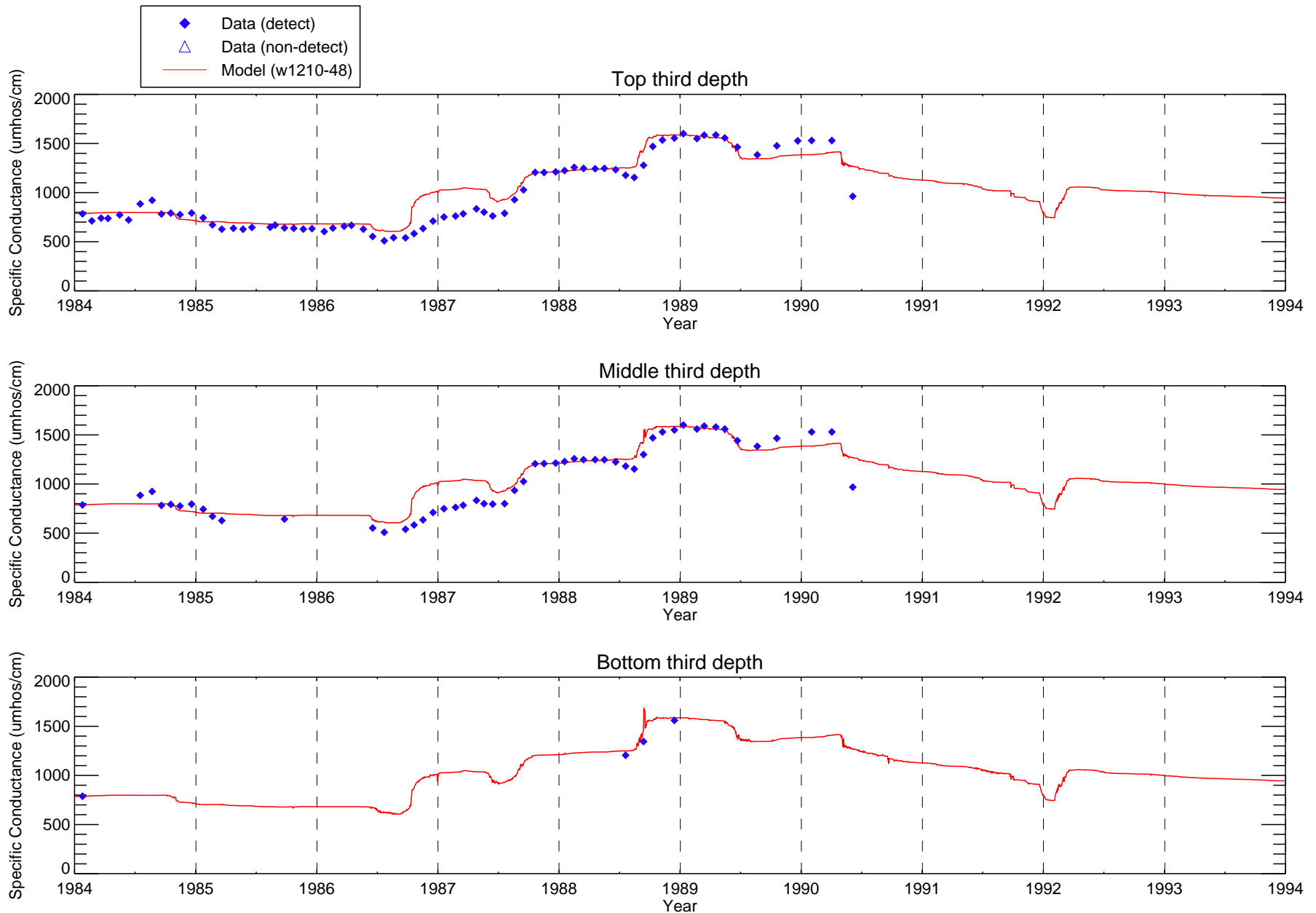CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-6g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

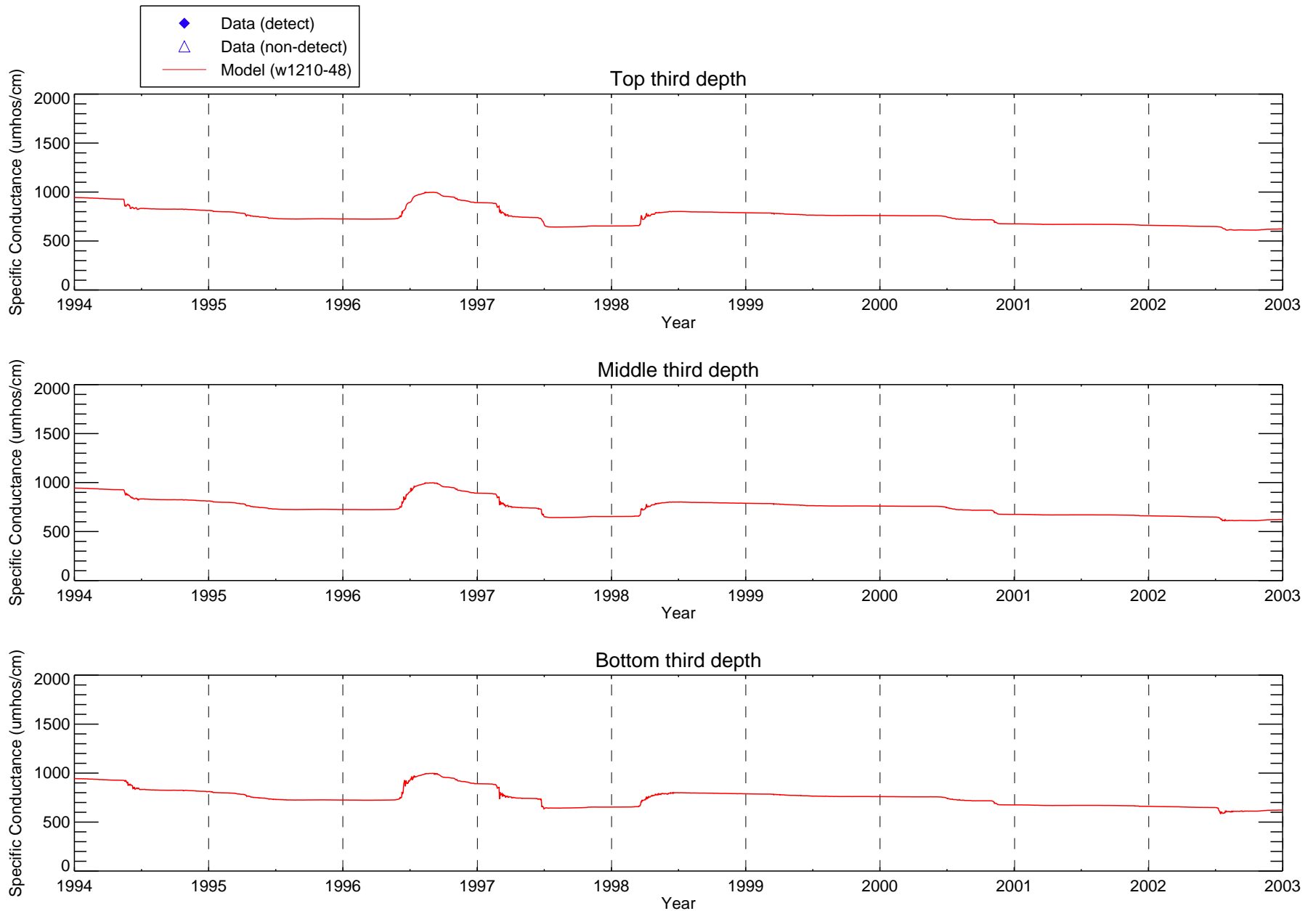CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-6g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

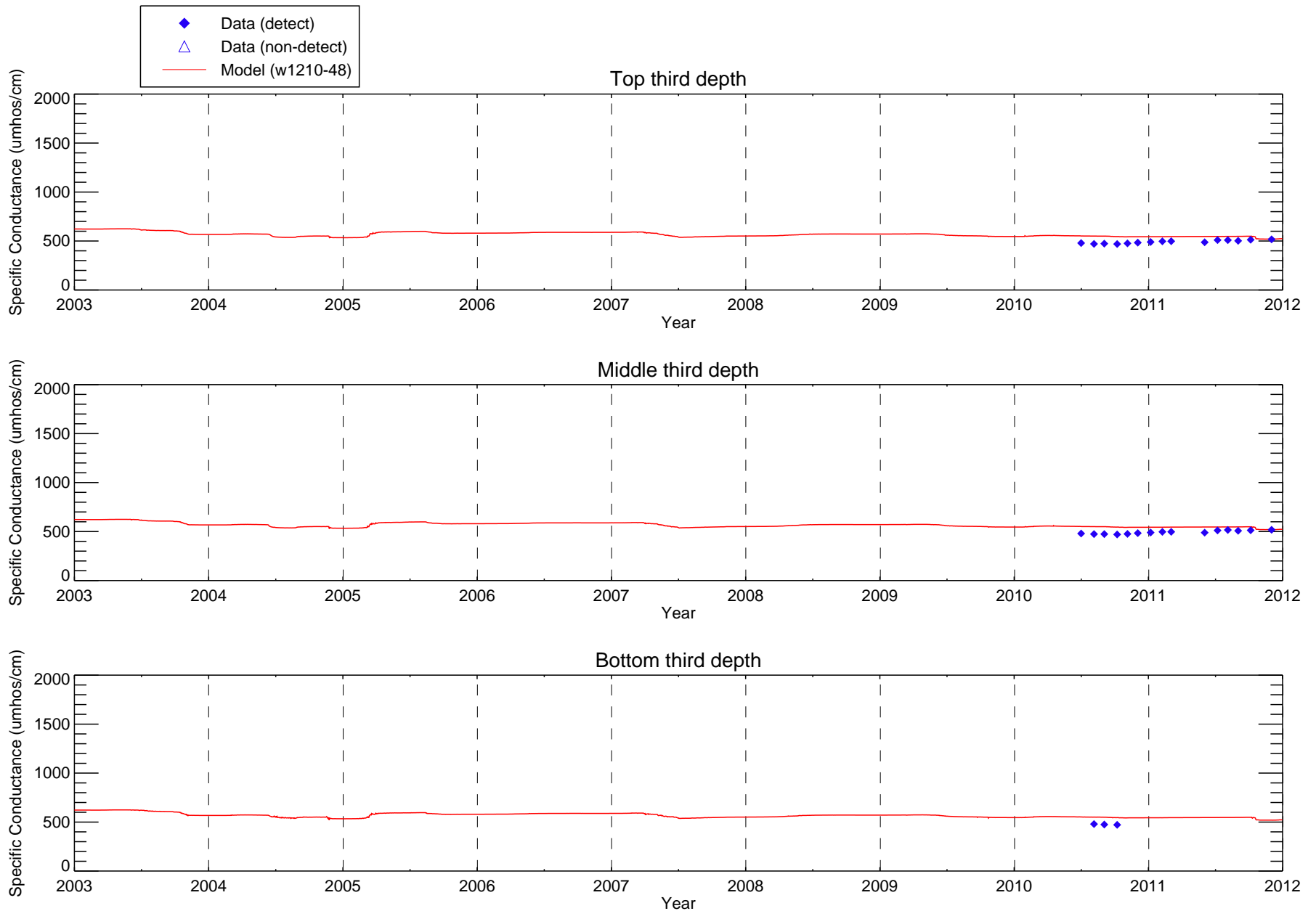CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-6g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

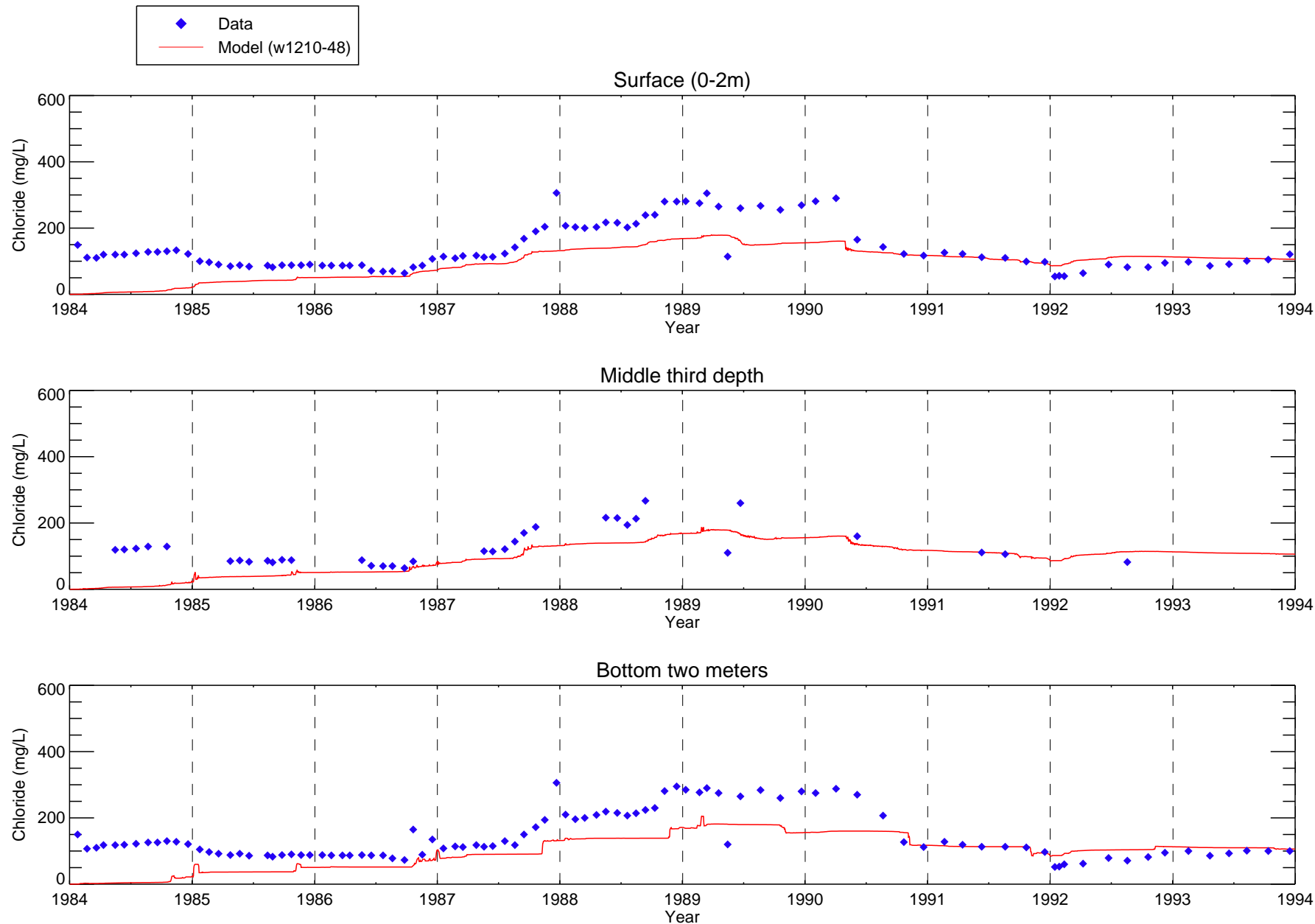CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:10:50 2013

Figure 4-6h

Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

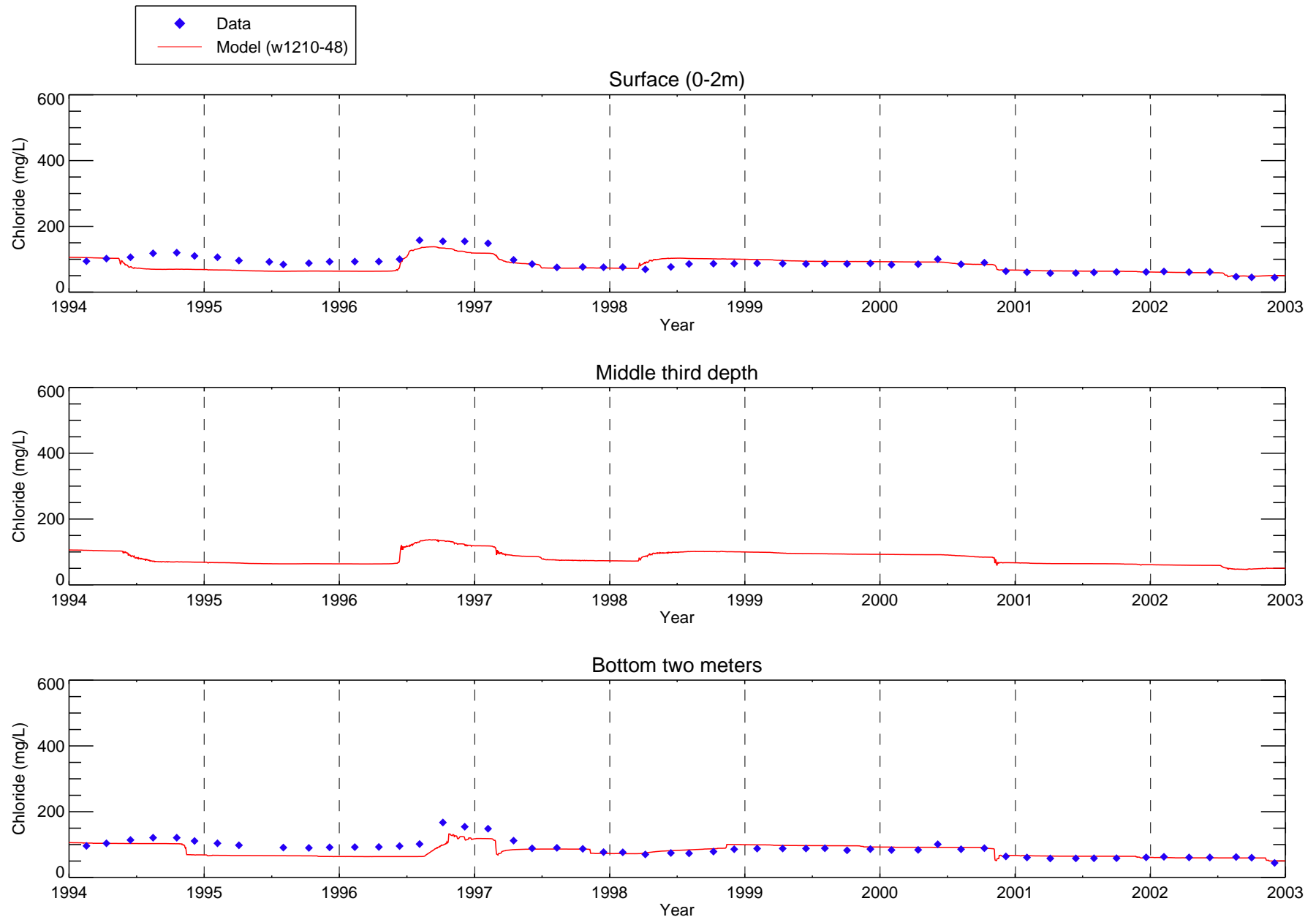CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:11:47 2013

Figure 4-6h

Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

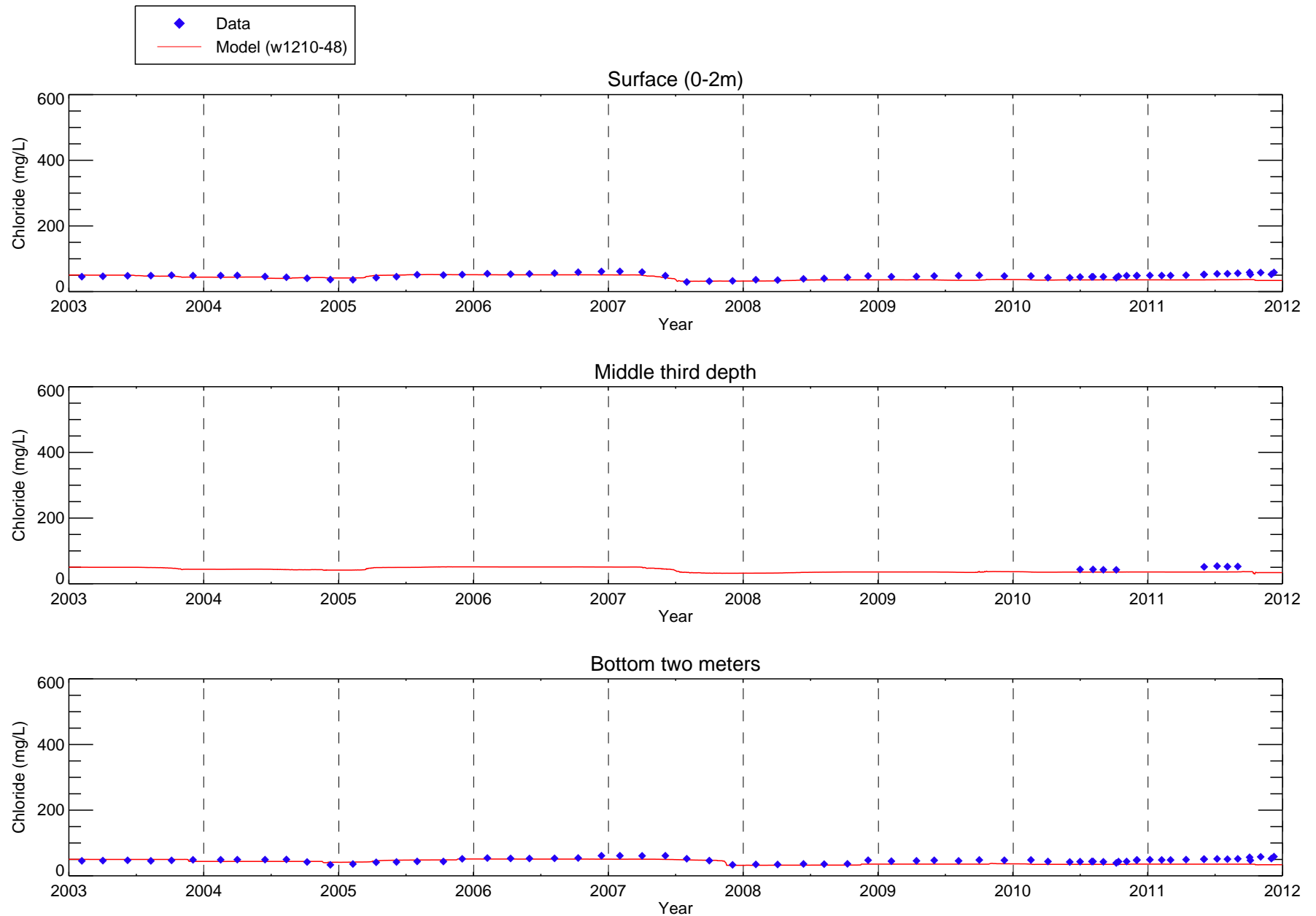CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-6h

Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Temperature

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

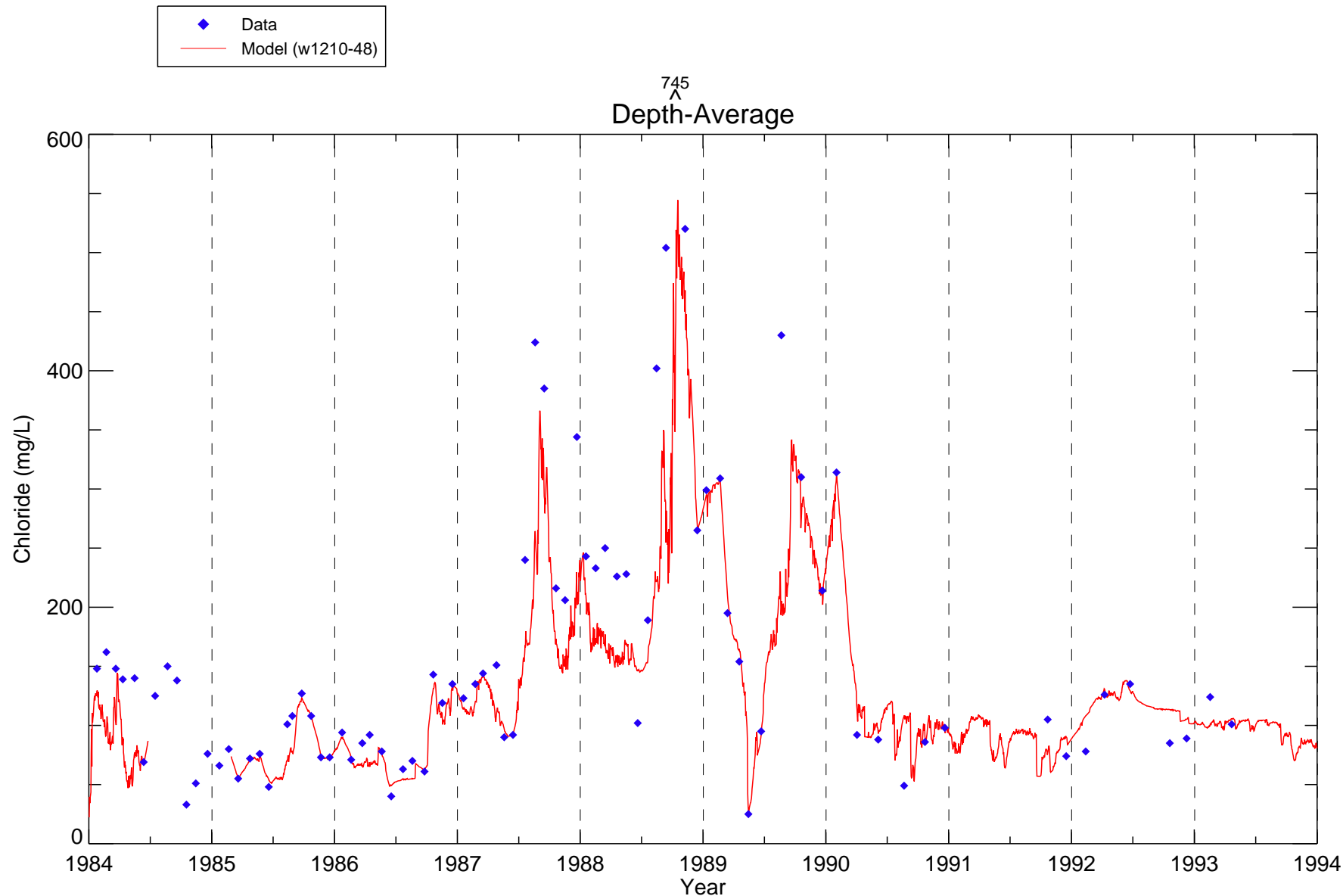CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:13:39 2013

Figure 4-7a

Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-7a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
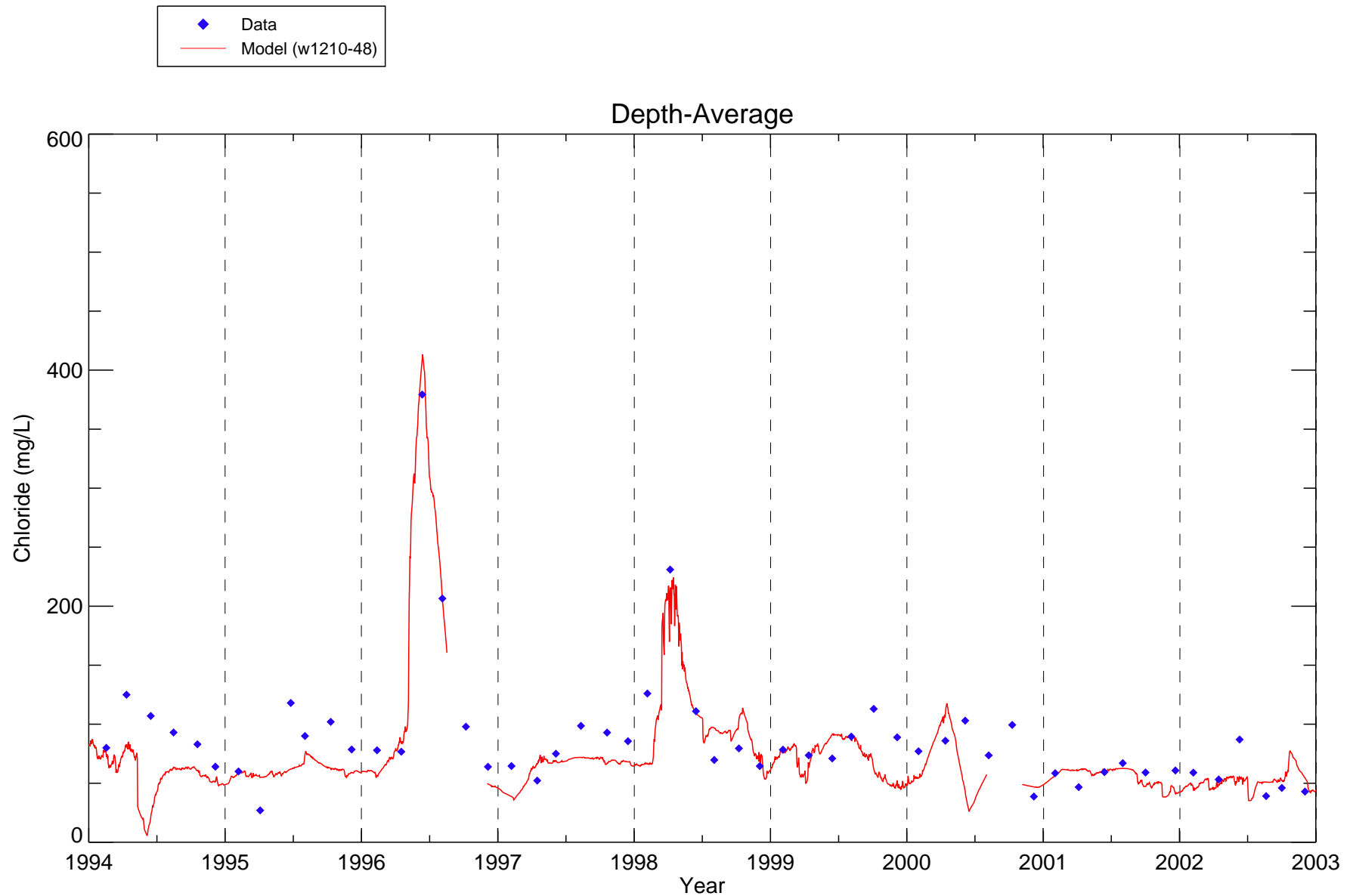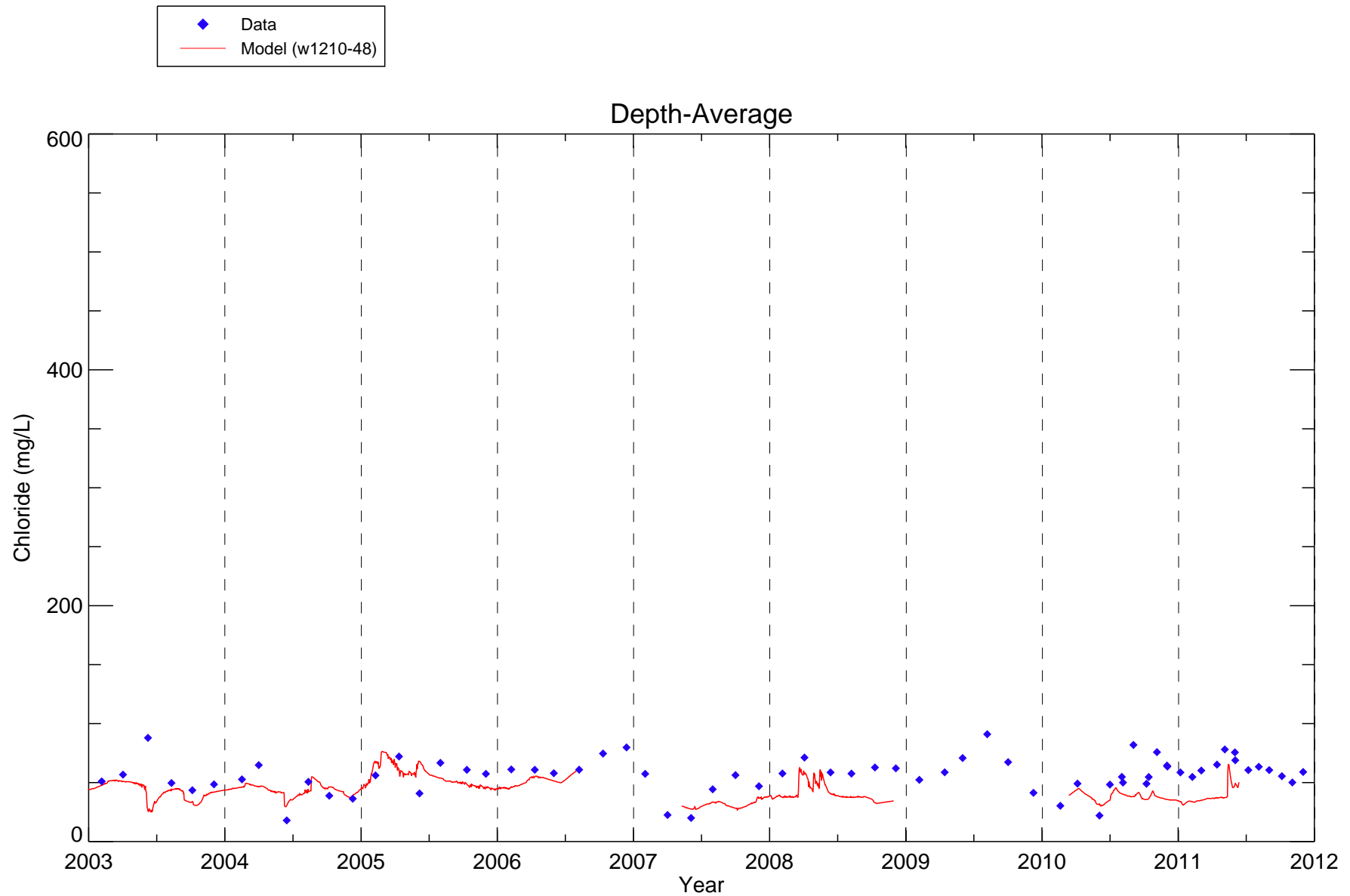Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:28:44 2013

Figure 4-7a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown.Data greater than y-range are indicated by caret above axis.

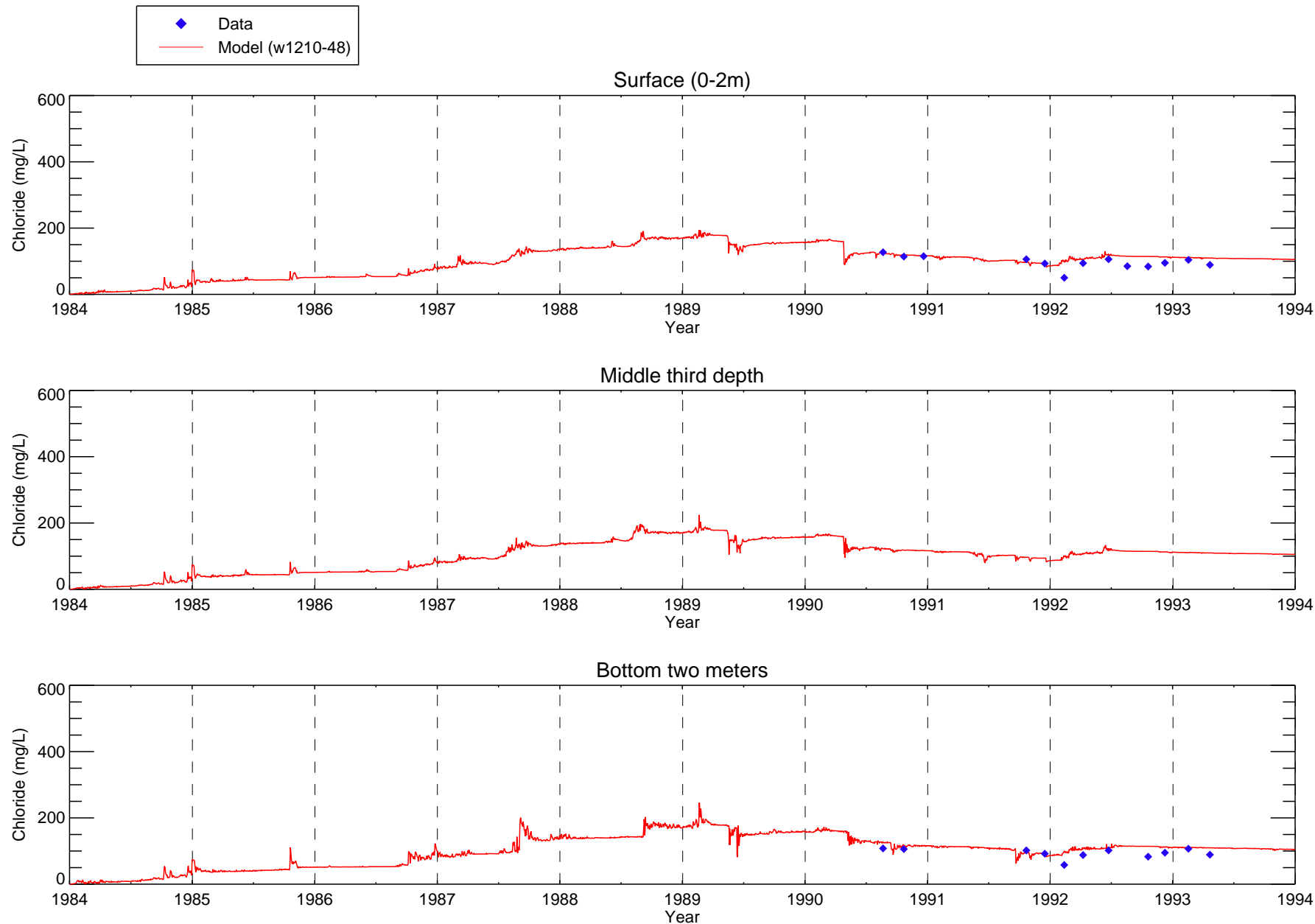CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-7b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Specific Conductance

Notes: Data are averaged over water column depths shown.
Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-7b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Specific Conductance

Notes: Data are averaged over water column depths shown.
Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
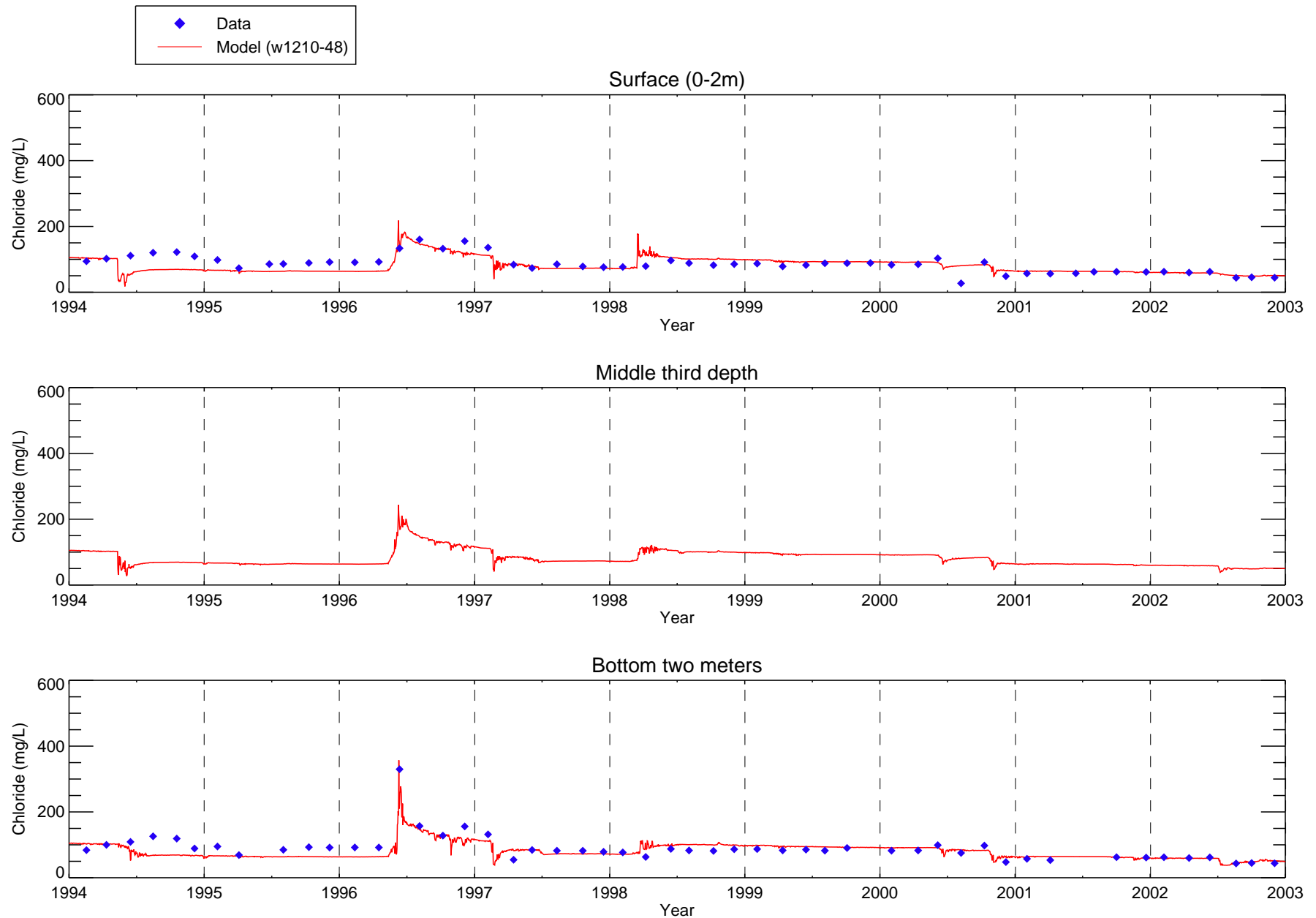Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:38:09 2013

Figure 4-7b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Specific Conductance

Notes: Data are averaged over water column depths shown.
Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
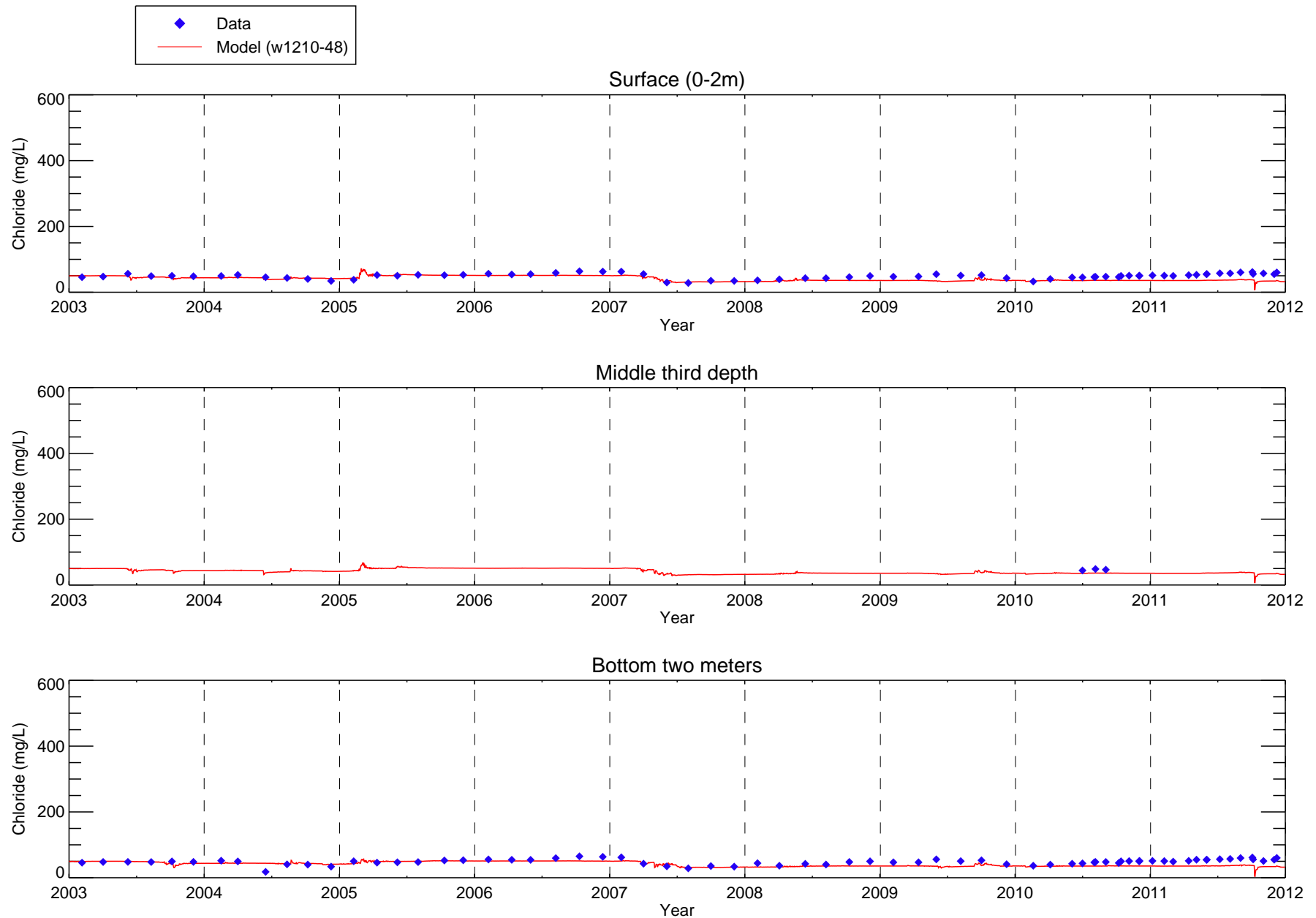Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:38:14 2013

Figure 4-7c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
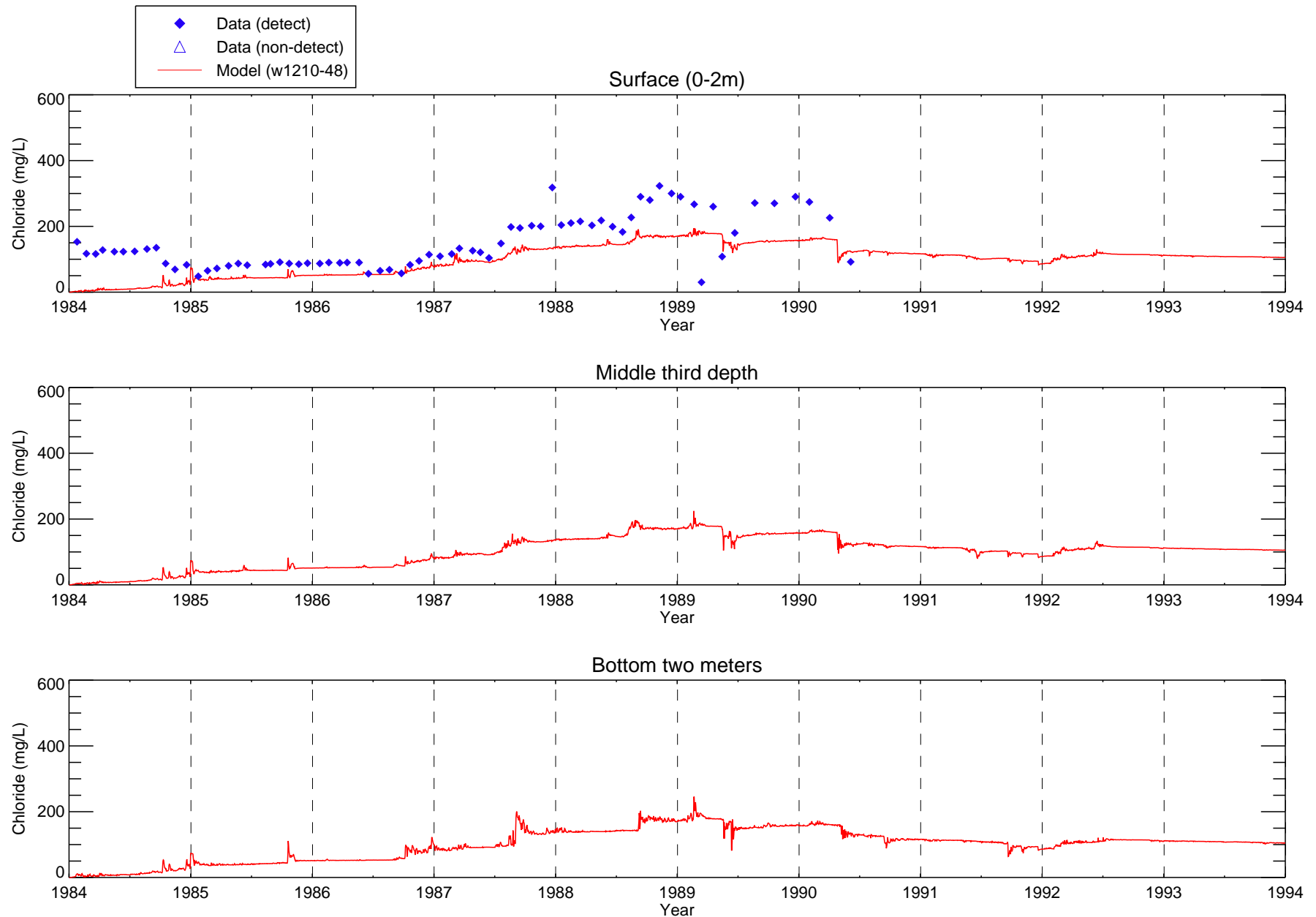Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 13:02:29 2013

Figure 4-7c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
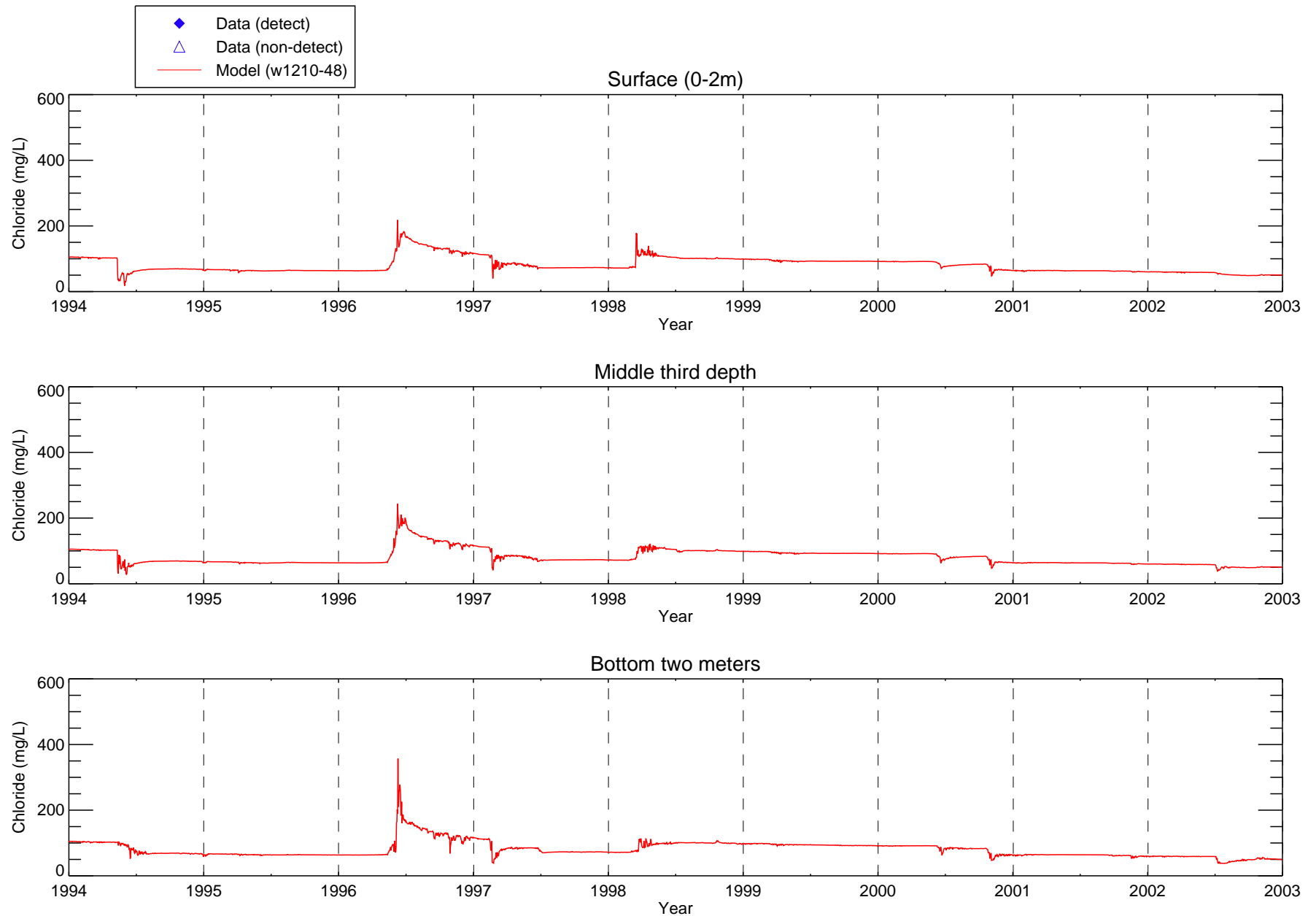Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 13:03:38 2013

Figure 4-7c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

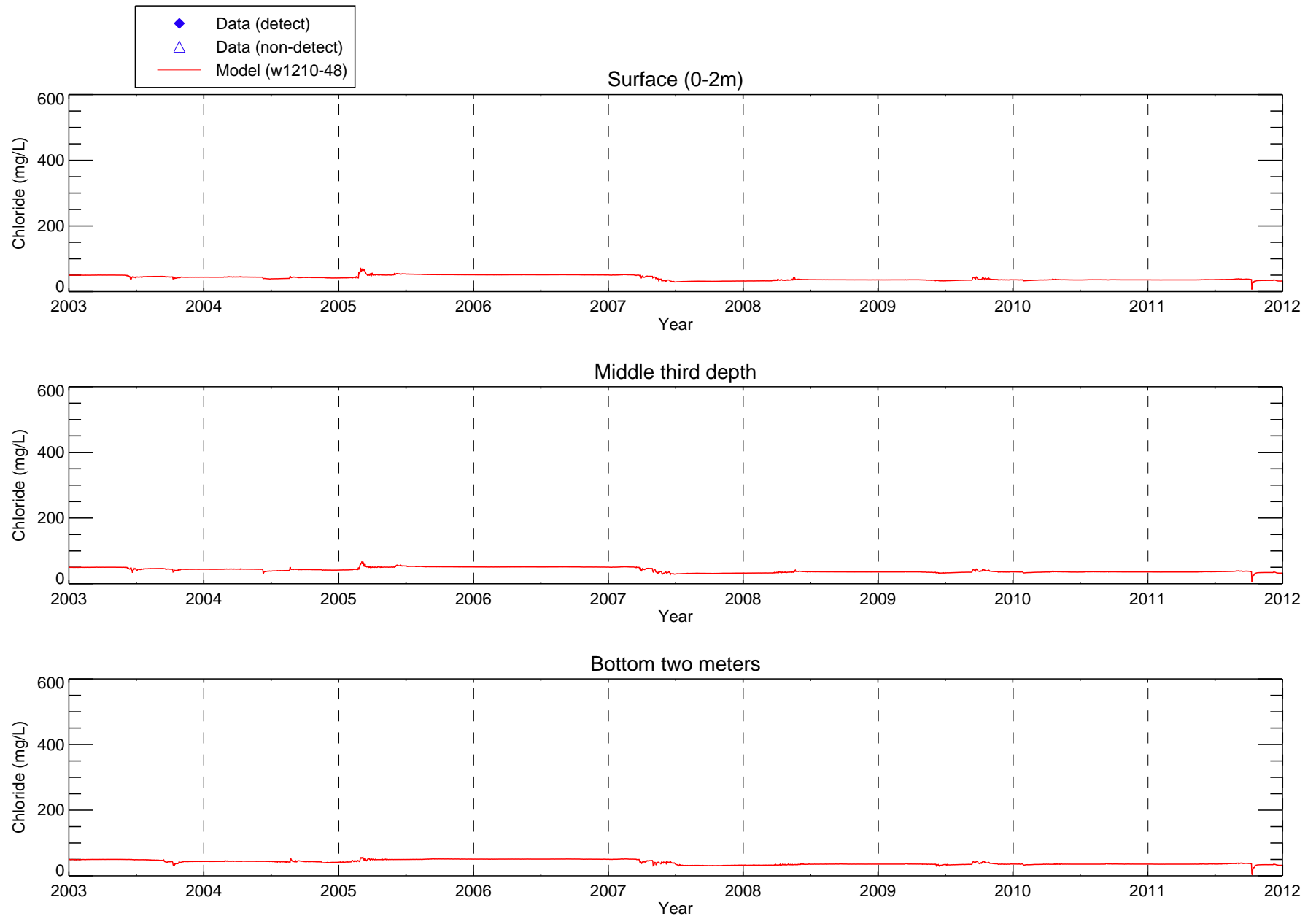CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 13:04:48 2013

Figure 4-7d

Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
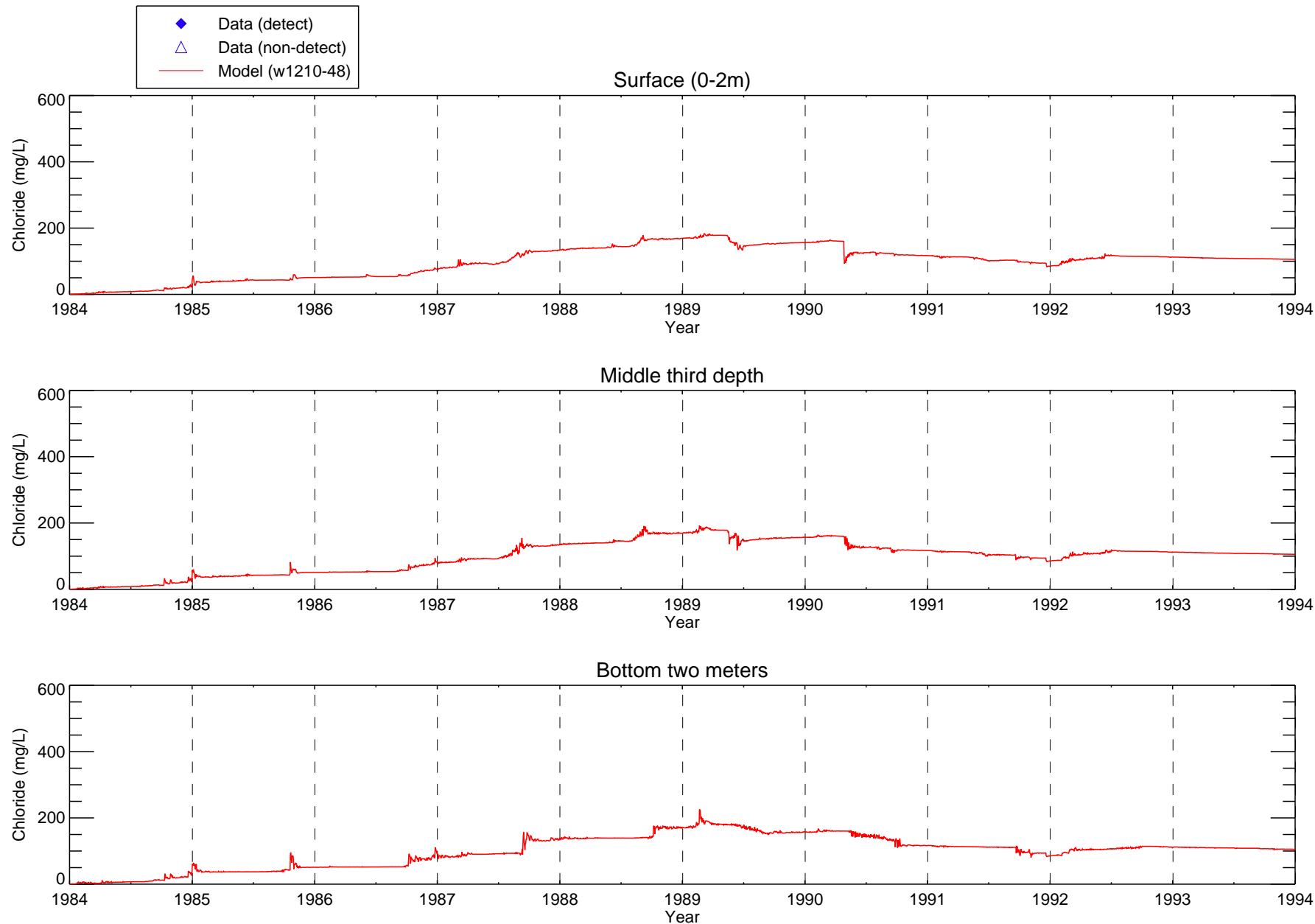Lower Colorado River Authority

Figure 4-7d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
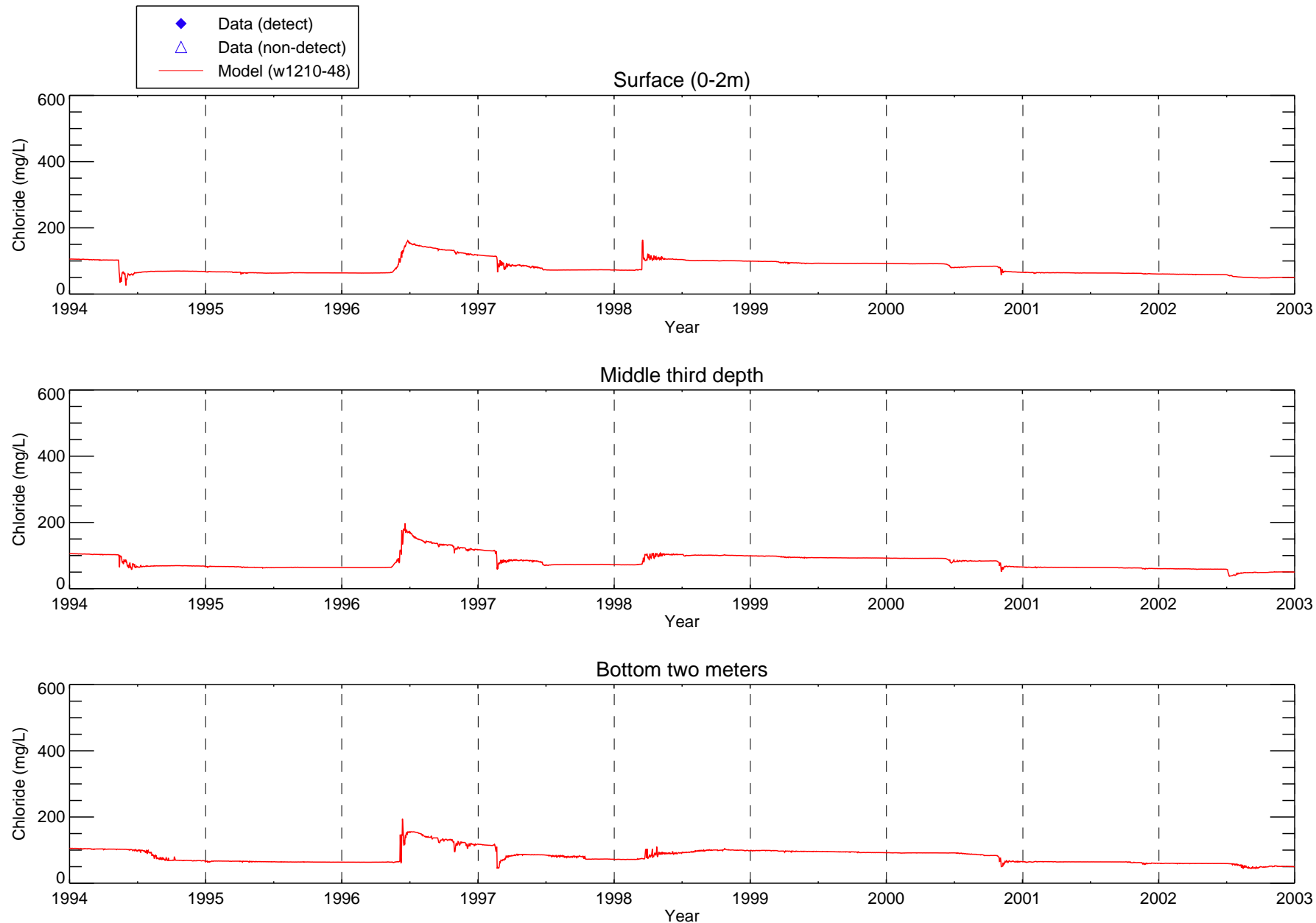Lower Colorado River Authority

Figure 4-7d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - \\austin2\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 08:44:51 2013

Figure 4-7e

Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

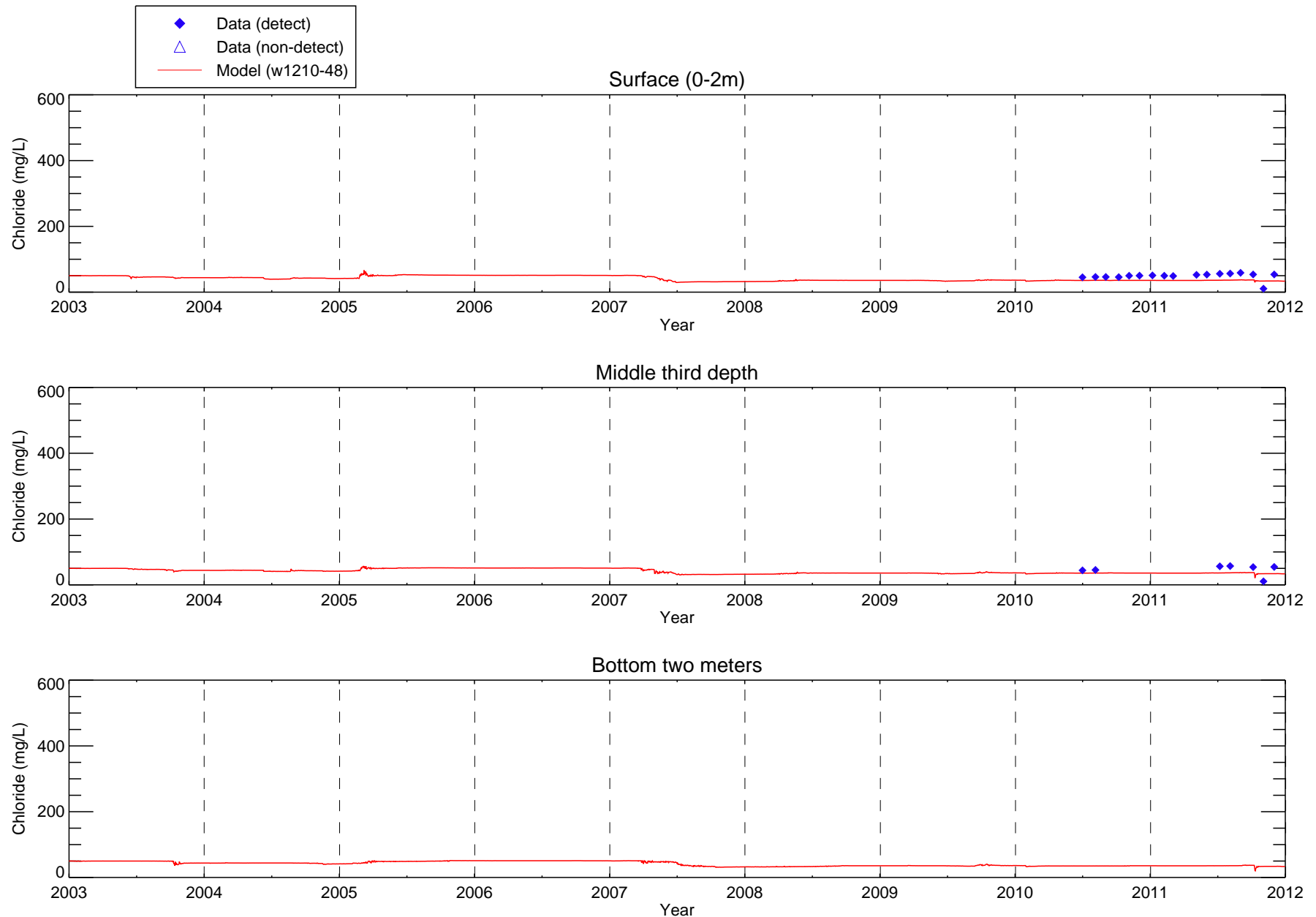EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:15:23 2013

Figure 4-7e
Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

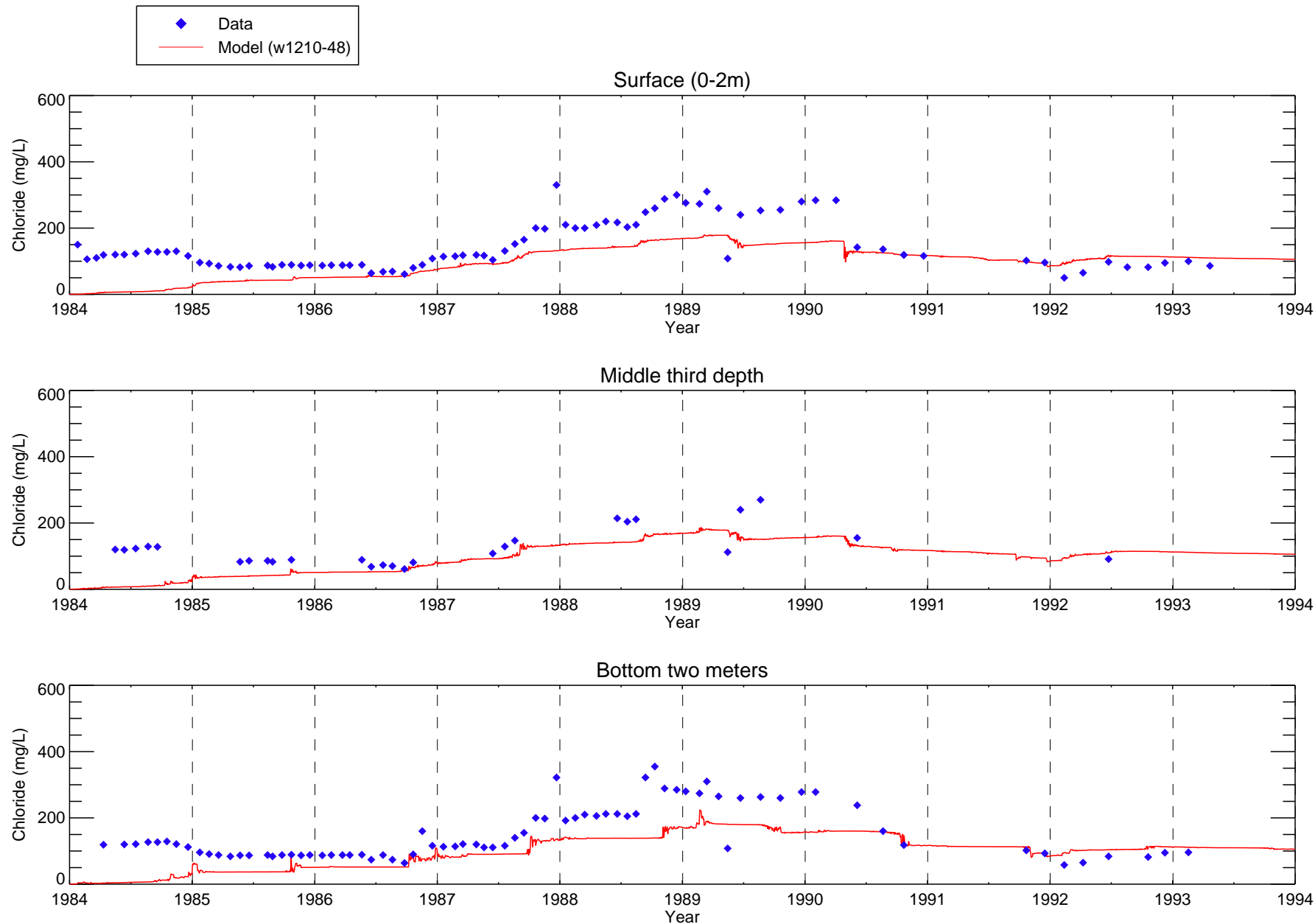CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:16:50 2013

Figure 4-7e

Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown.Data greater than y-range are indicated by caret above axis.

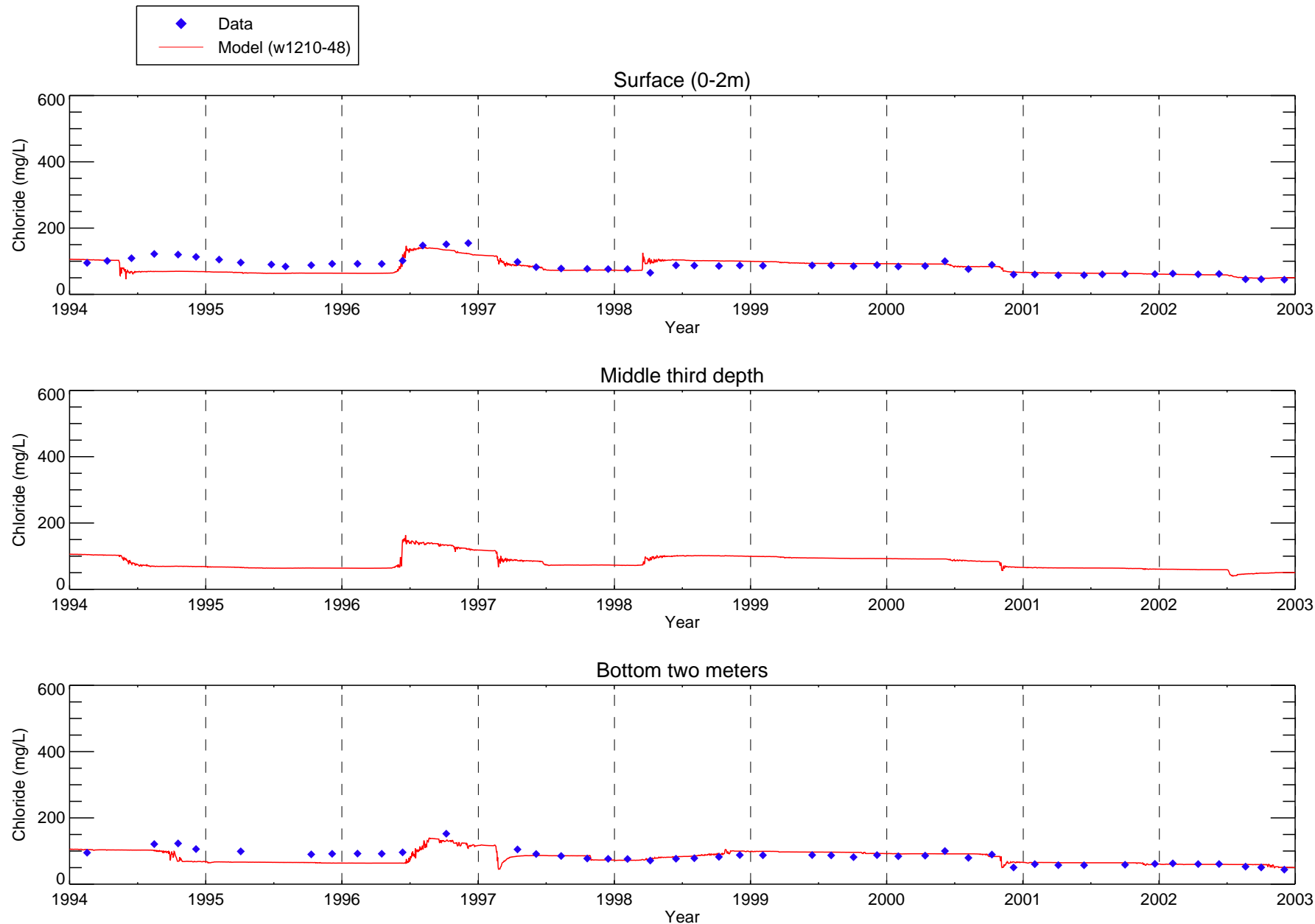CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-7f
Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

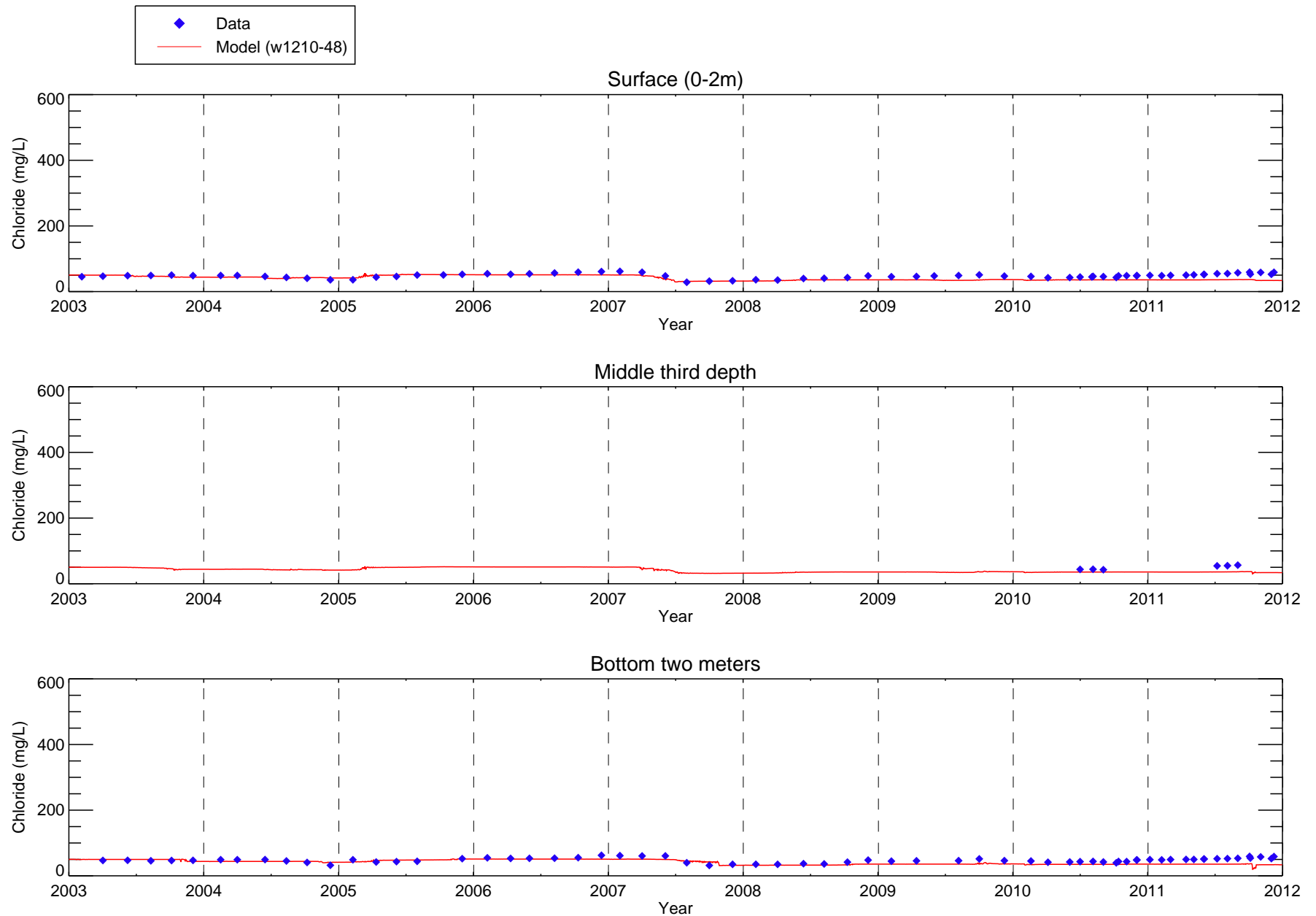CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-7f

Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown.Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
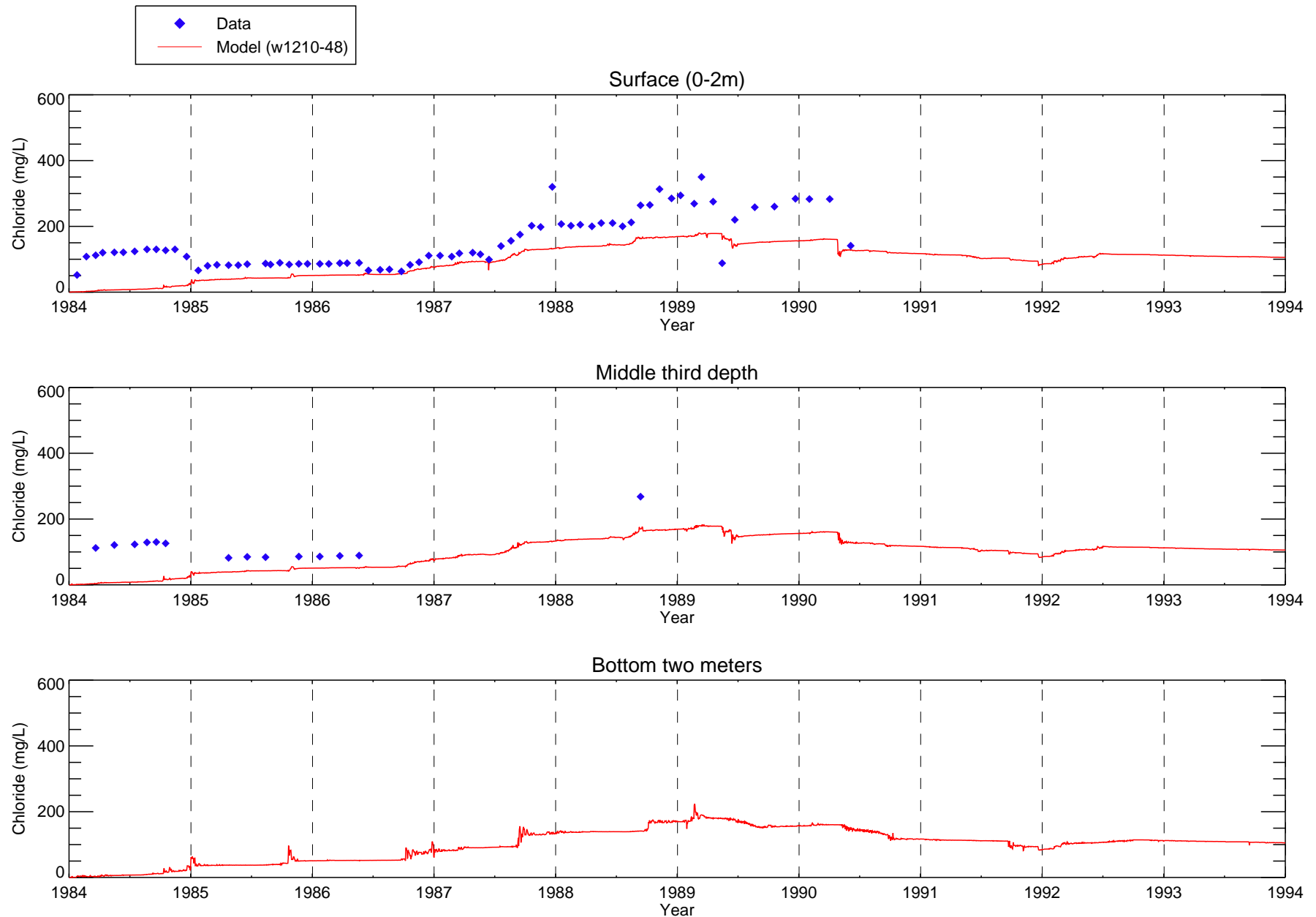Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:22:08 2013

Figure 4-7f
Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

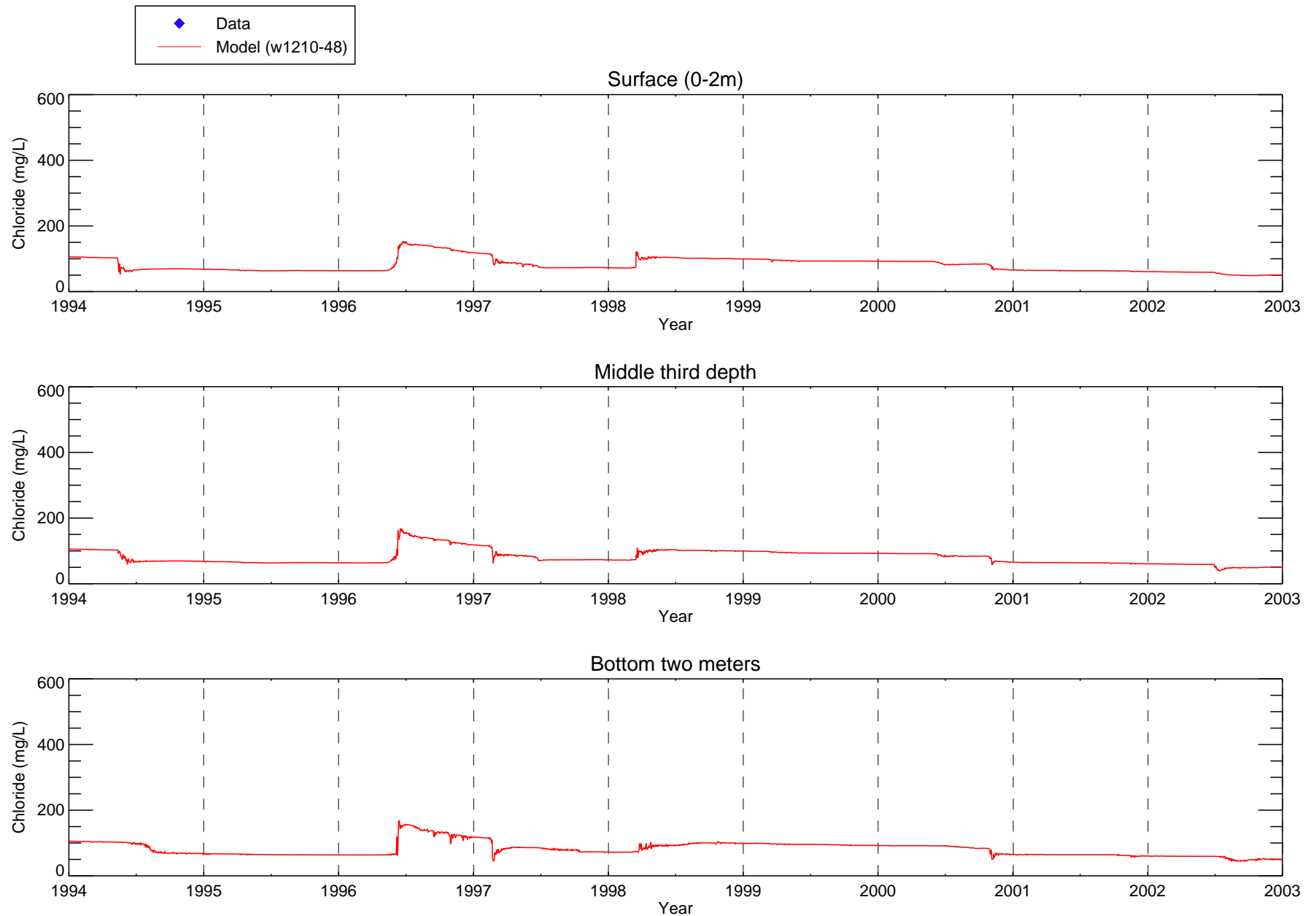CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:24:11 2013

Figure 4-7g
Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

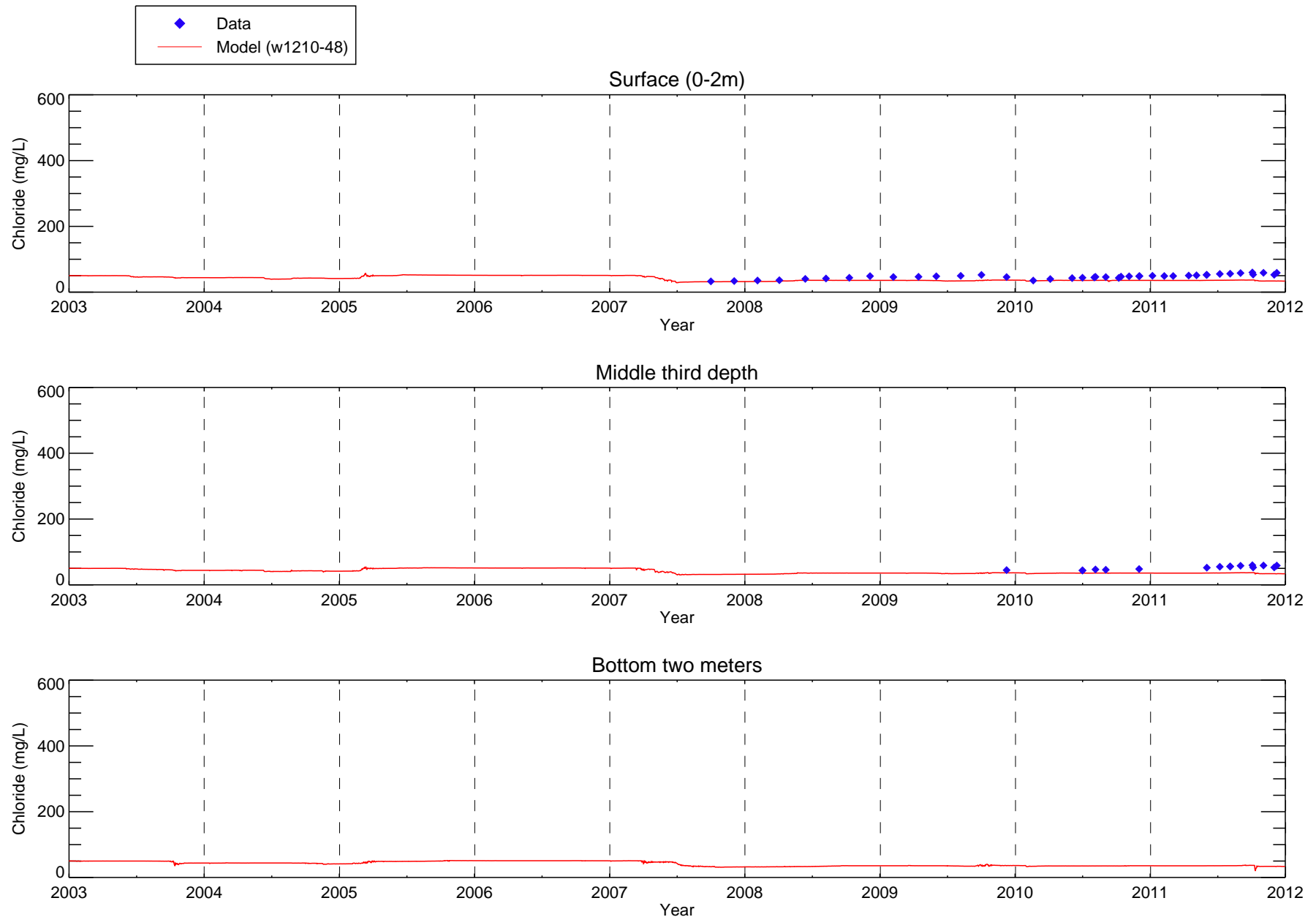CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:32:23 2013

Figure 4-7g
Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
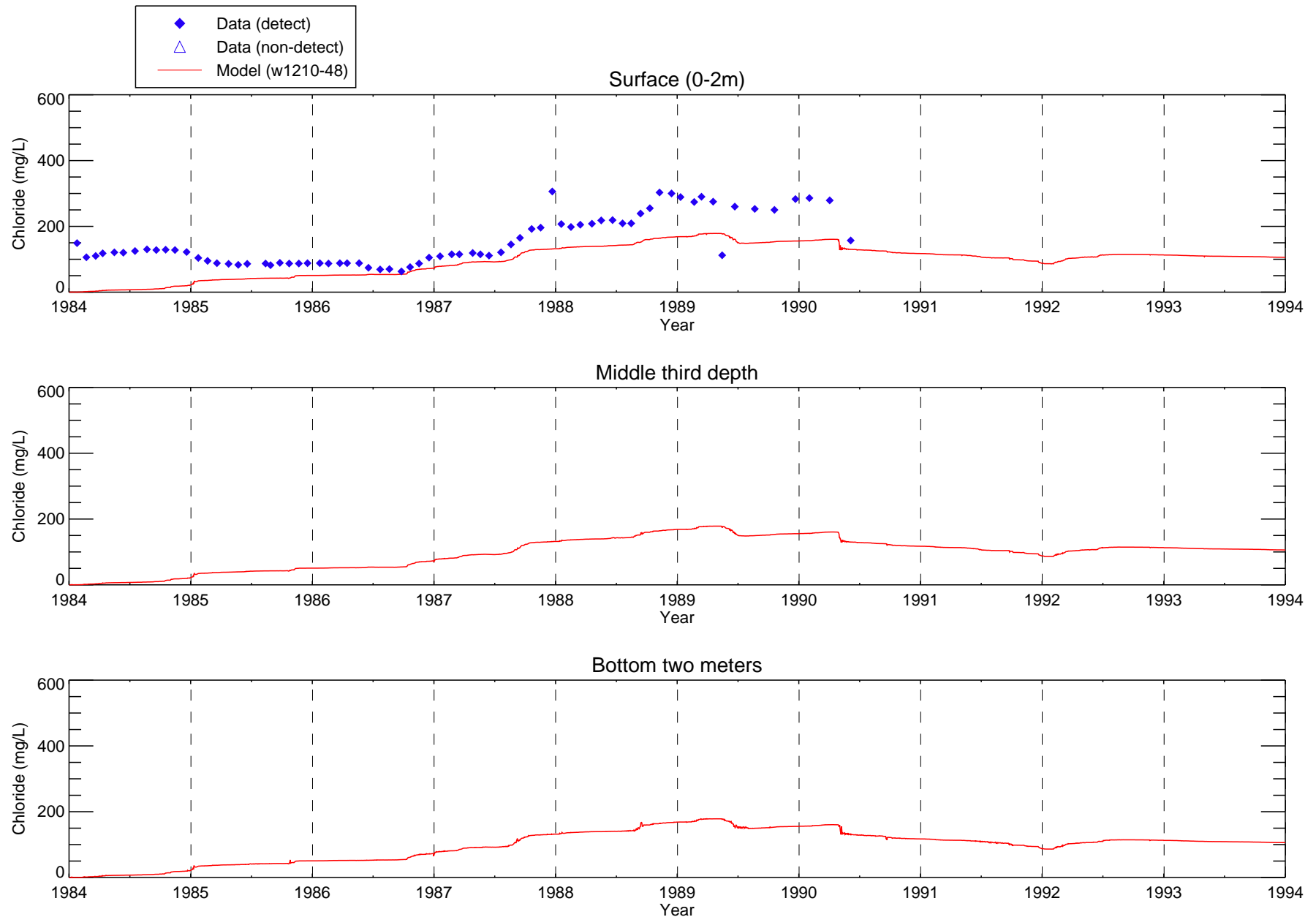
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:33:45 2013

Figure 4-7g
Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

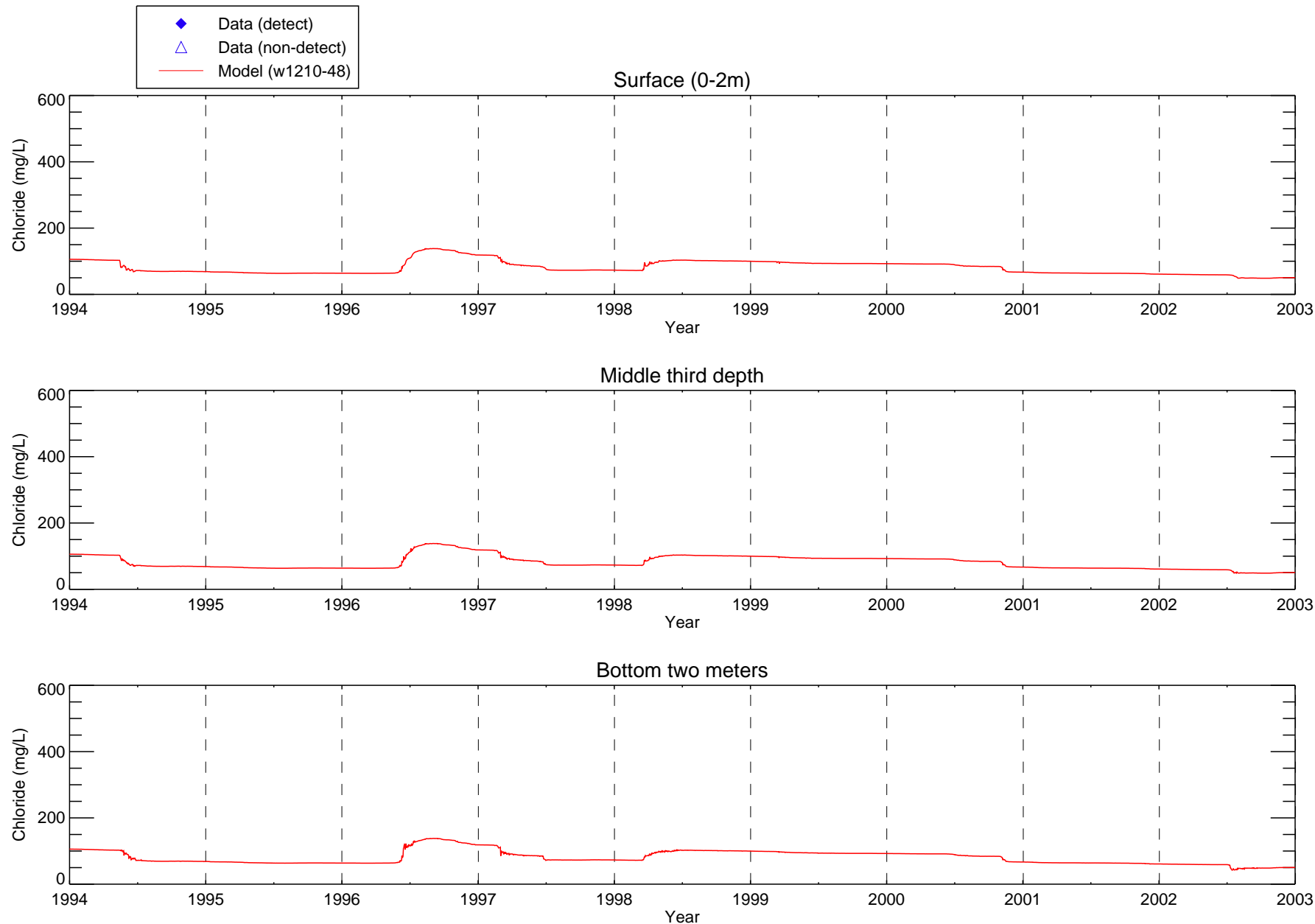CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:35:08 2013

Figure 4-7h

Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
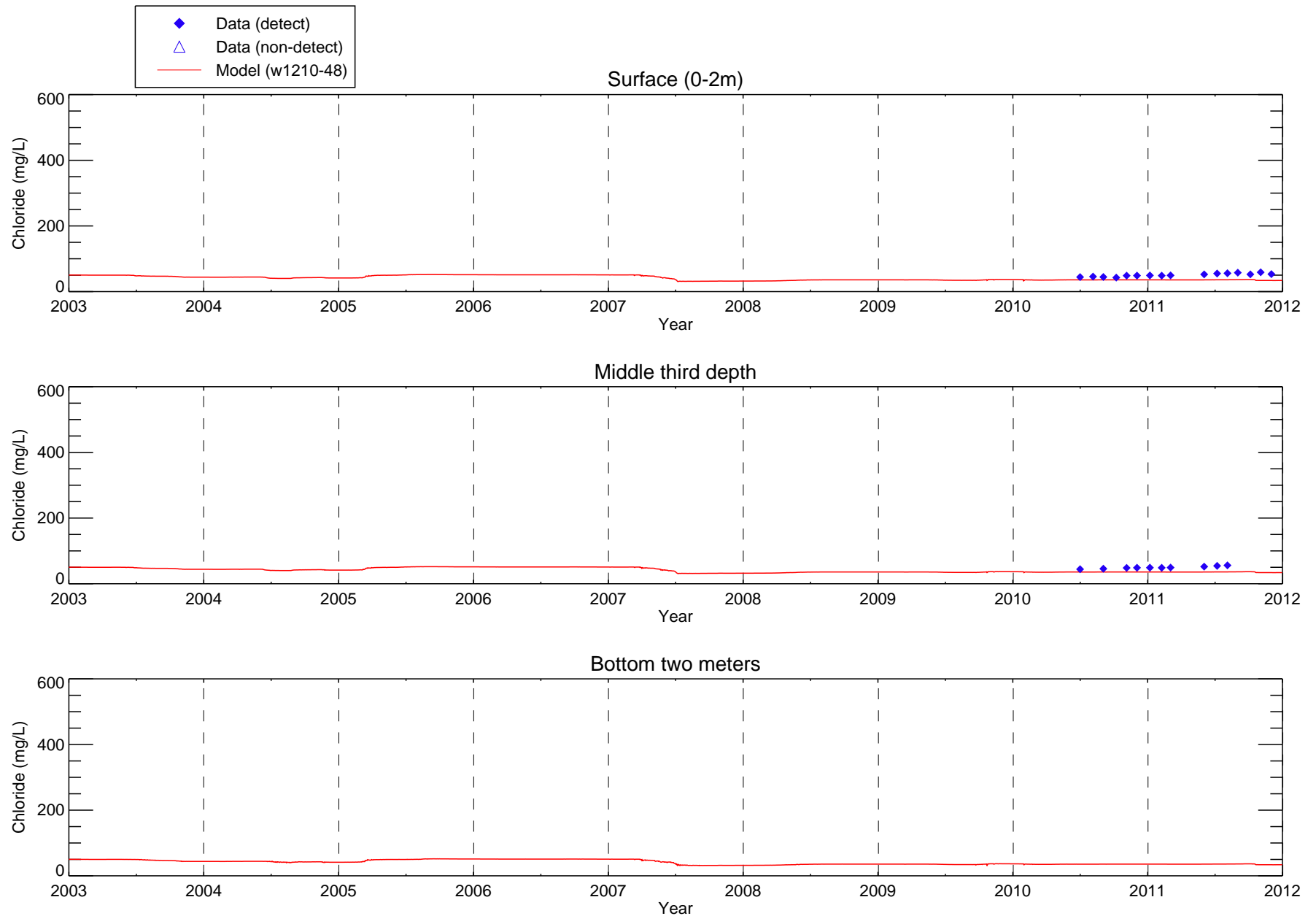Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:36:05 2013

Figure 4-7h

Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
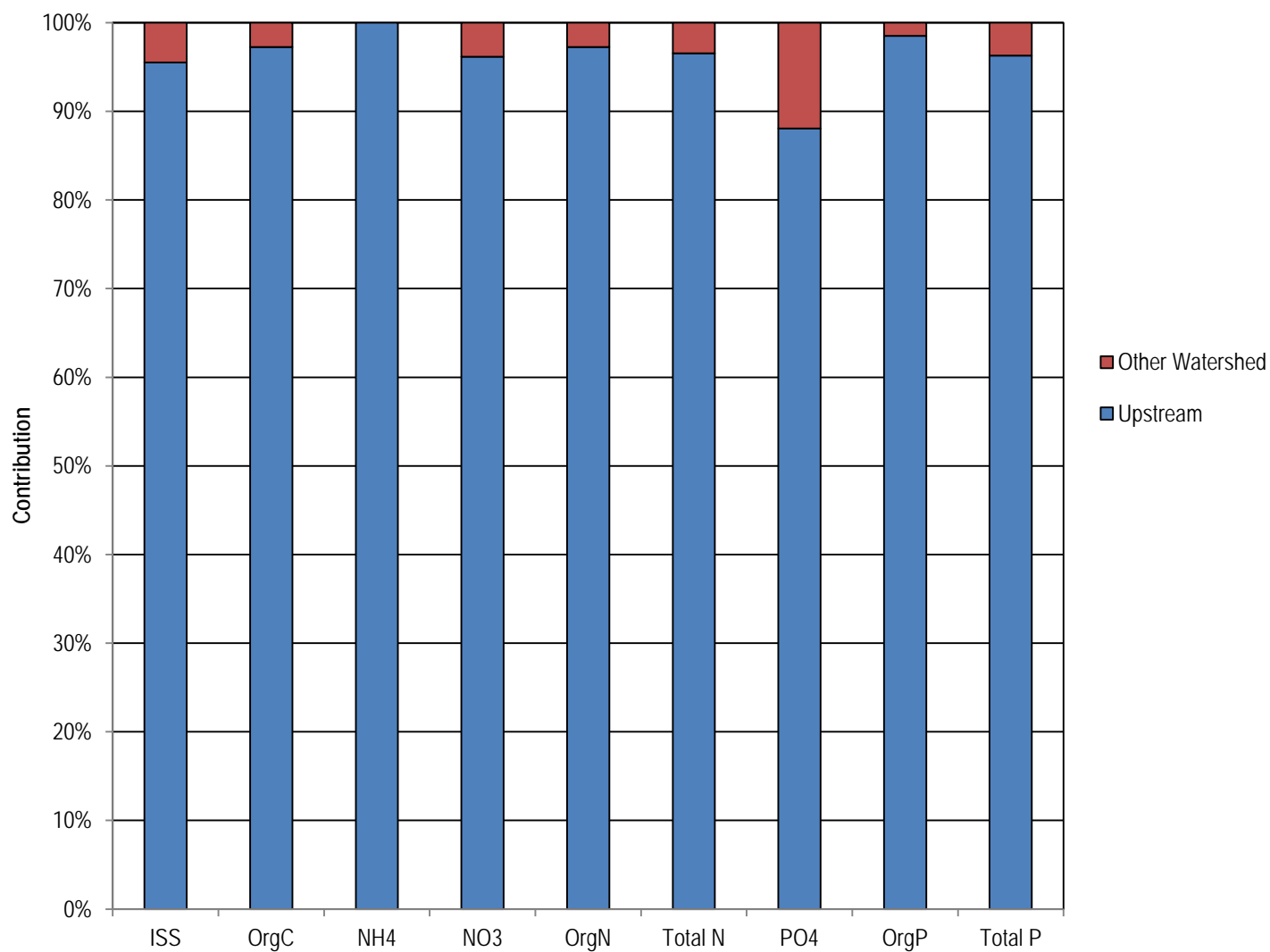Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:37:01 2013

Figure 4-7h
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 15:37:57 2013

Figure 4-8a

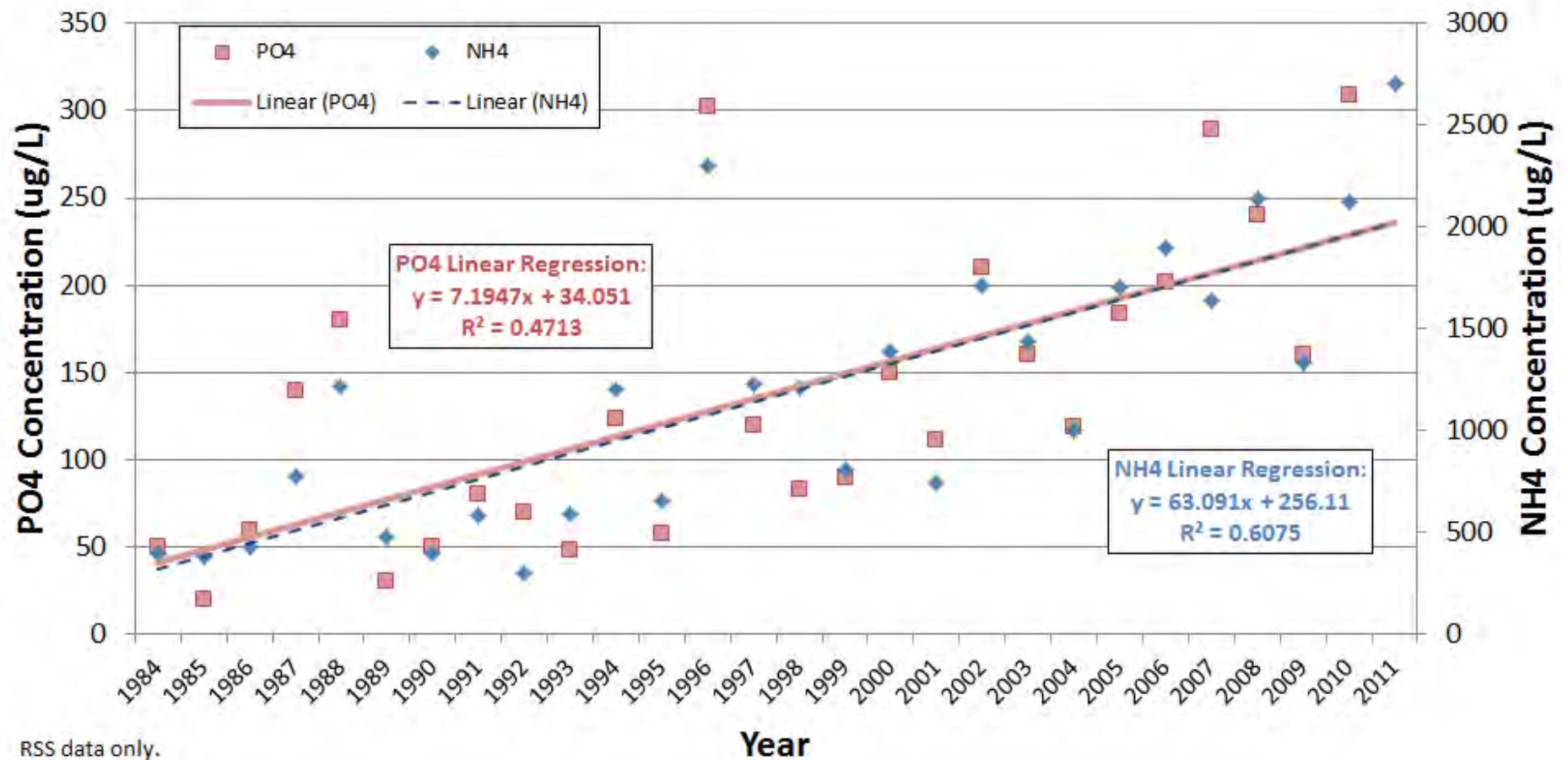**Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Chloride**

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
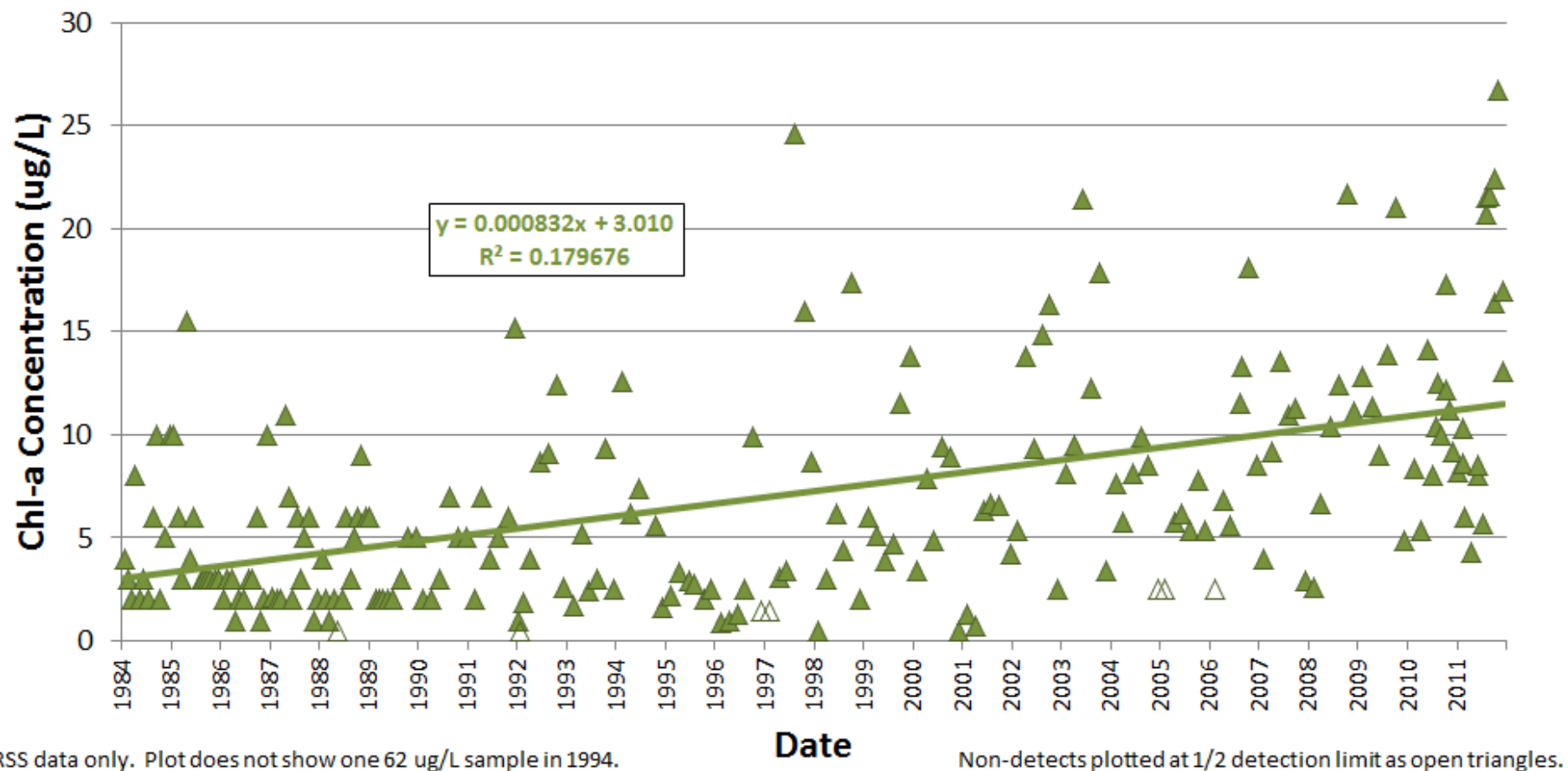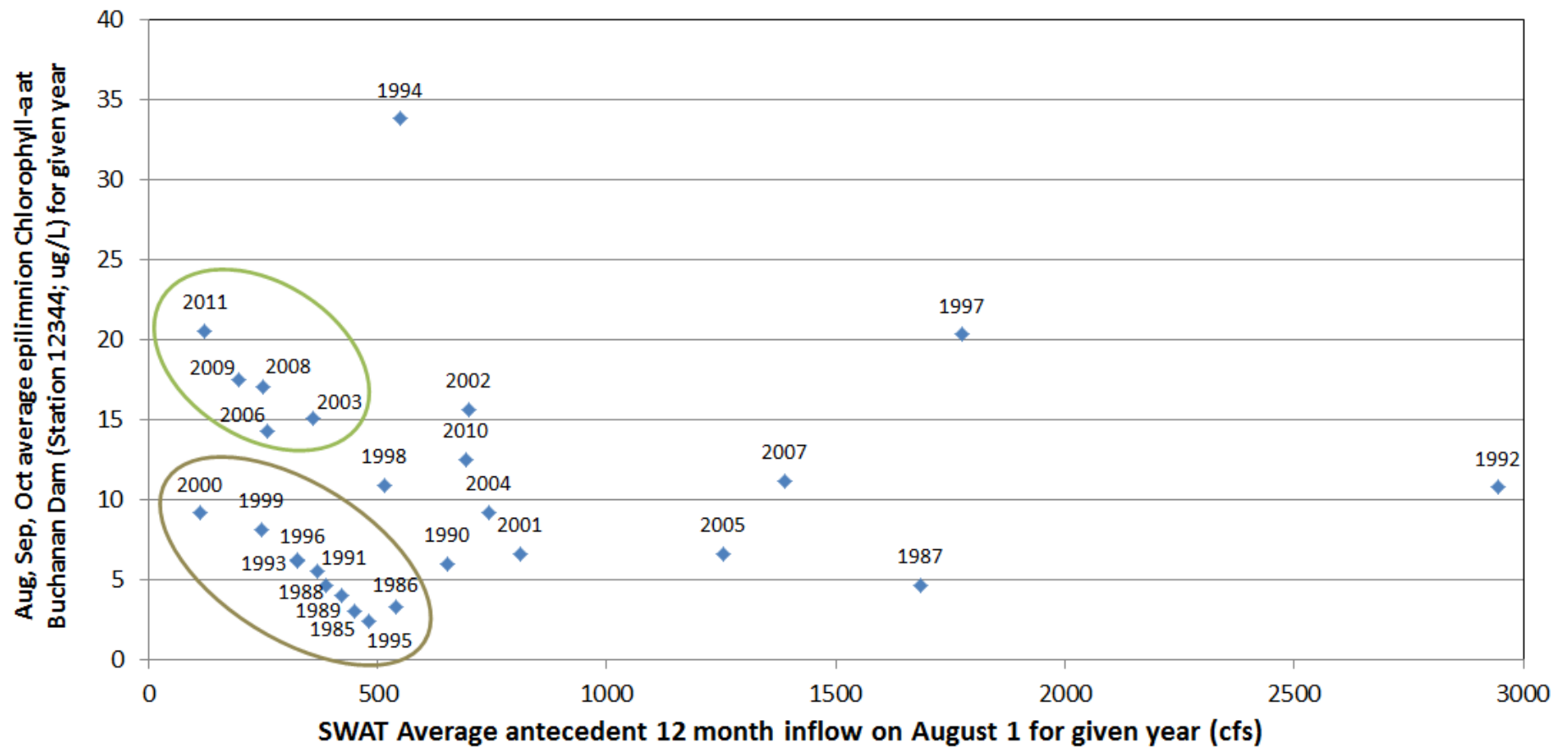Lower Colorado River Authority

Figure 4-8a

Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
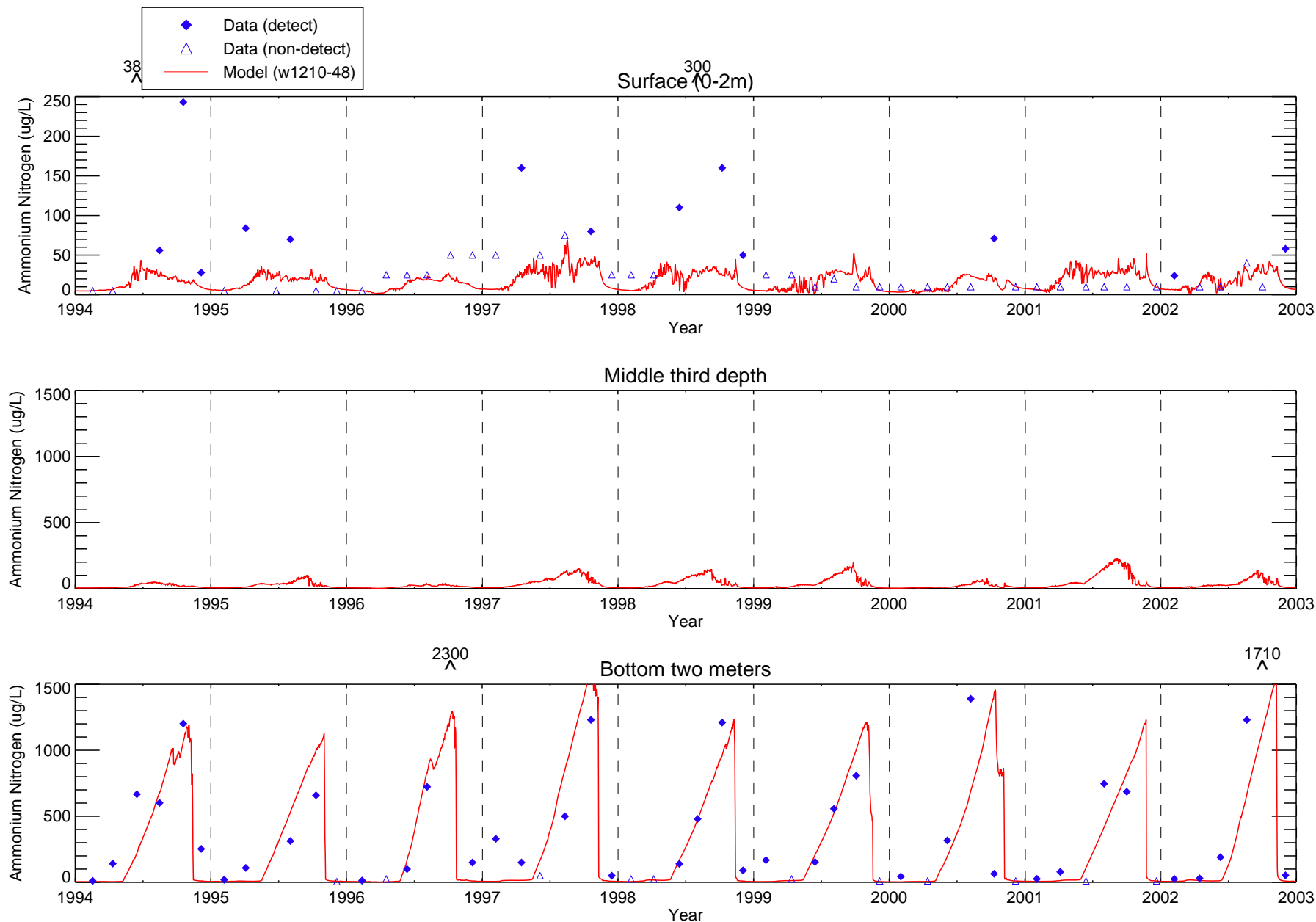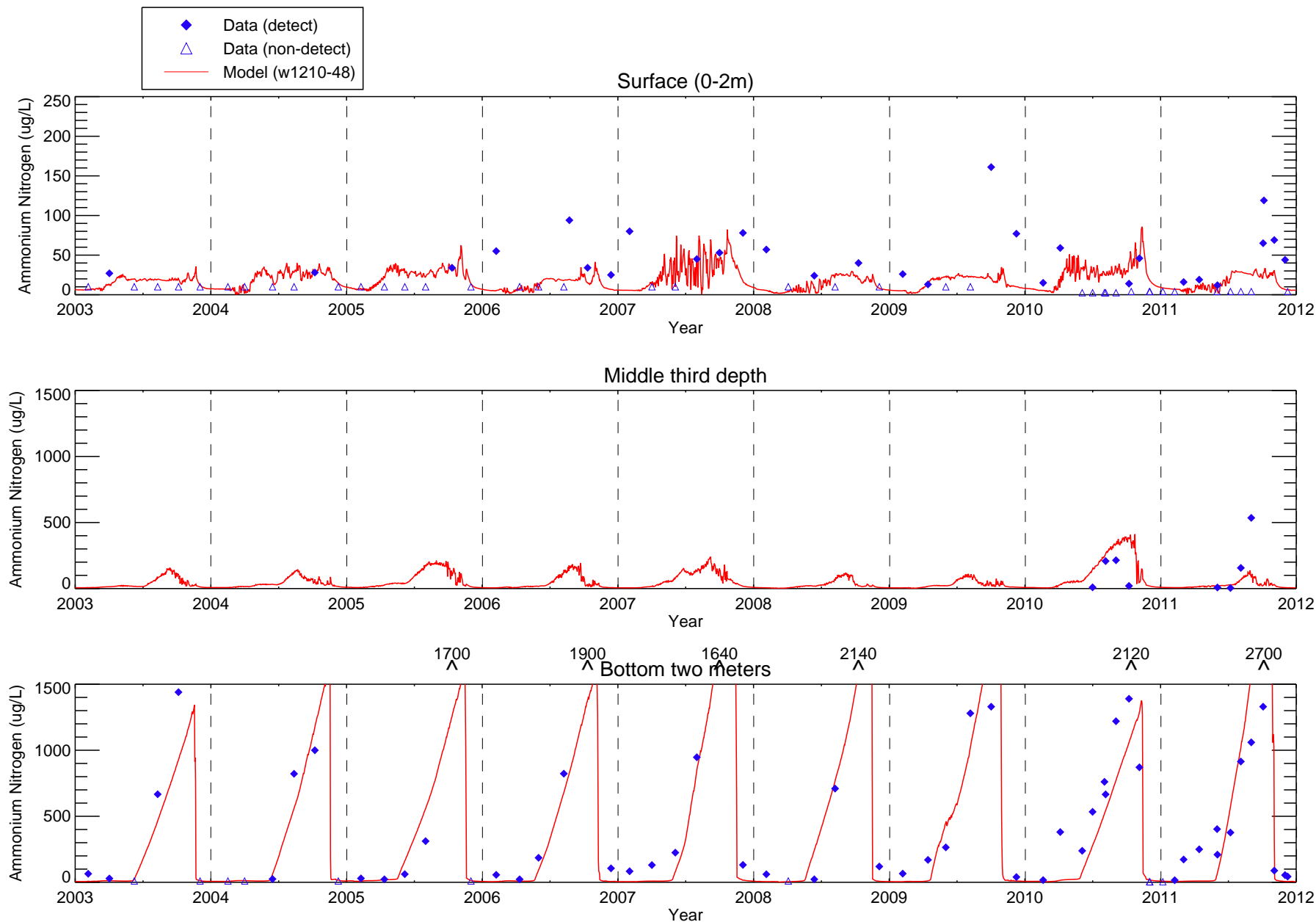
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-8a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 16:27:30 2013

Figure 4-8b

Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Chloride

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
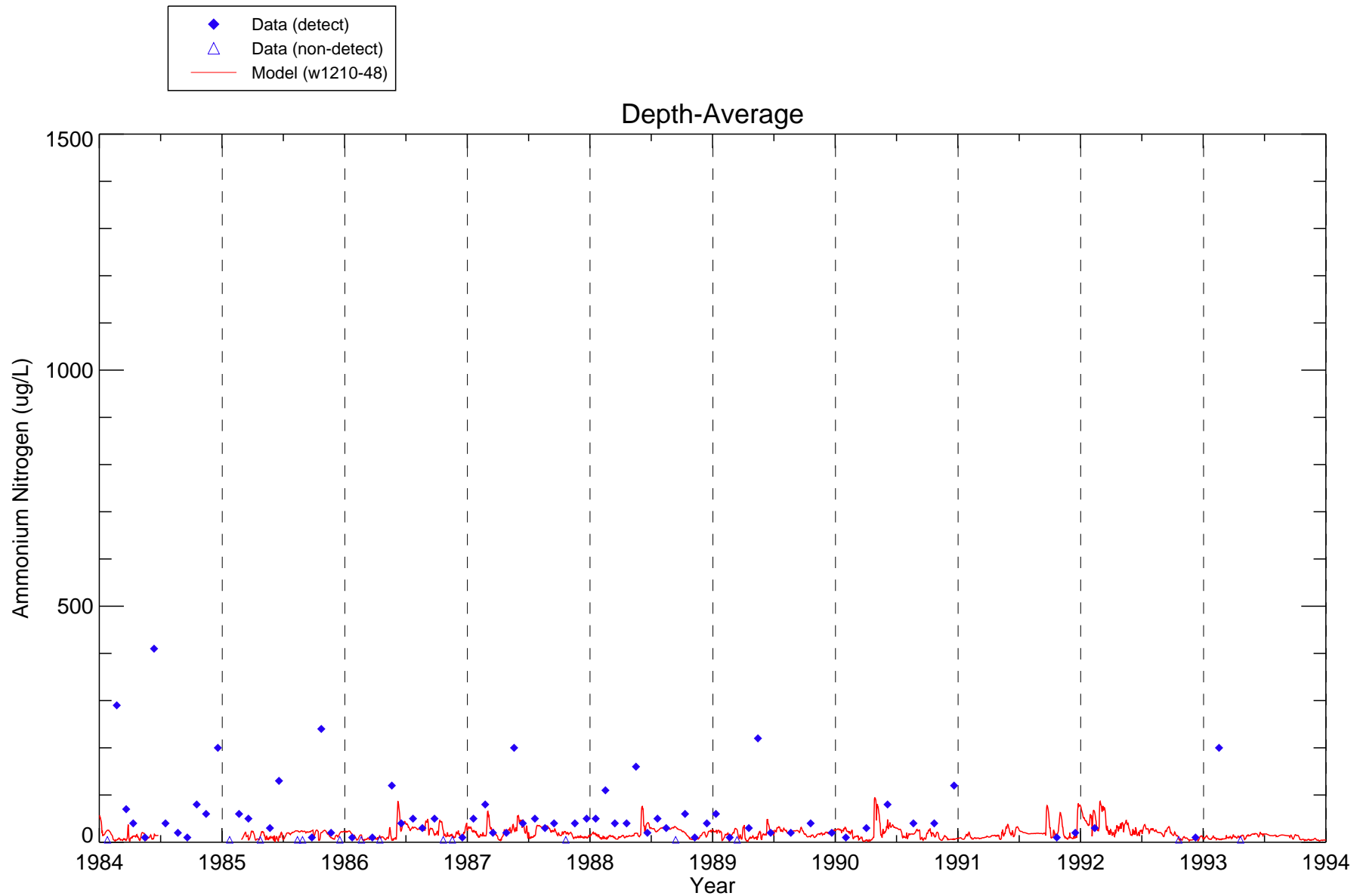
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-8b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Chloride

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 16:32:29 2013

Figure 4-8b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Chloride

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 16:32:34 2013

Figure 4-8c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-8c

Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority
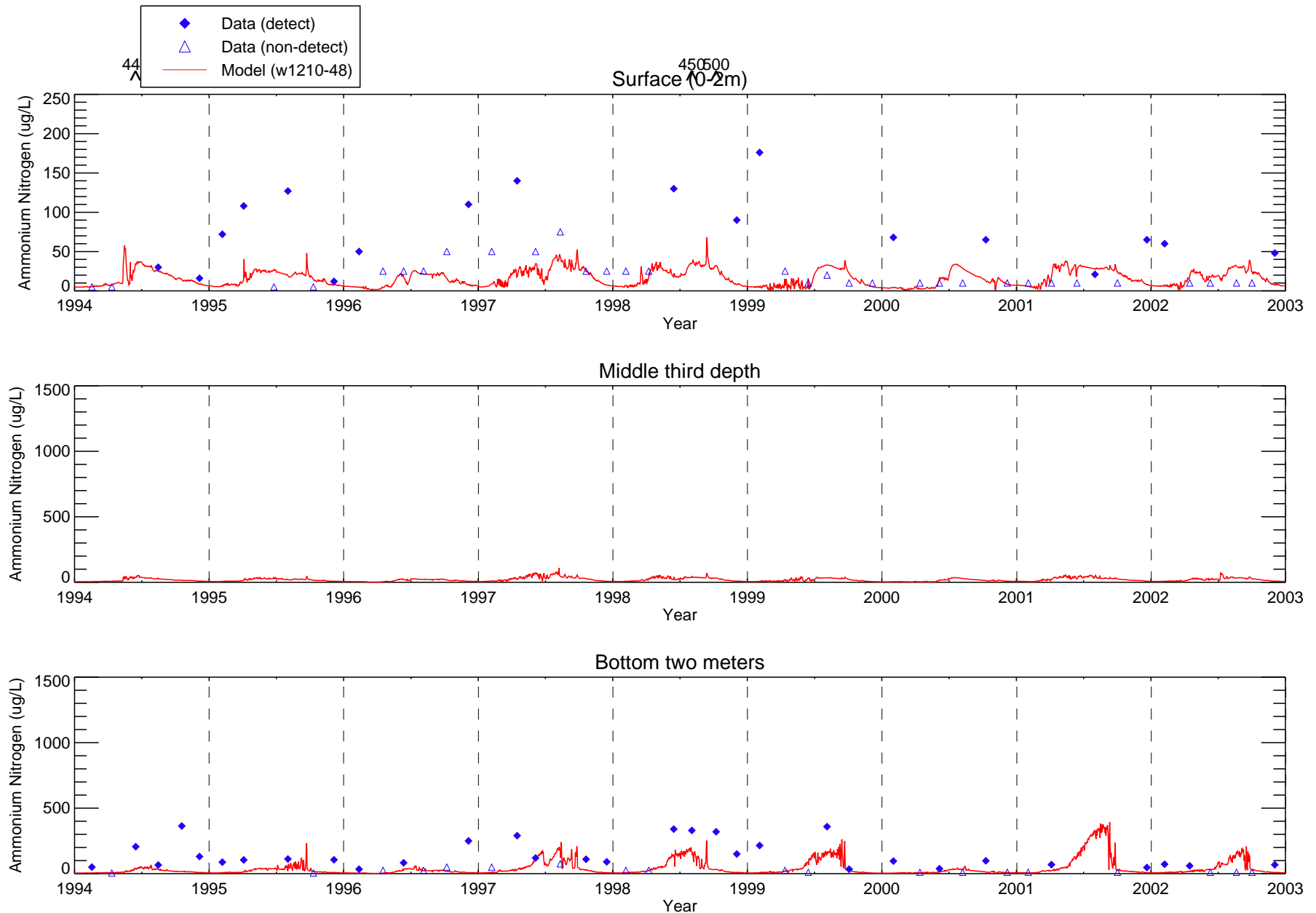
Figure 4-8c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-8d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS
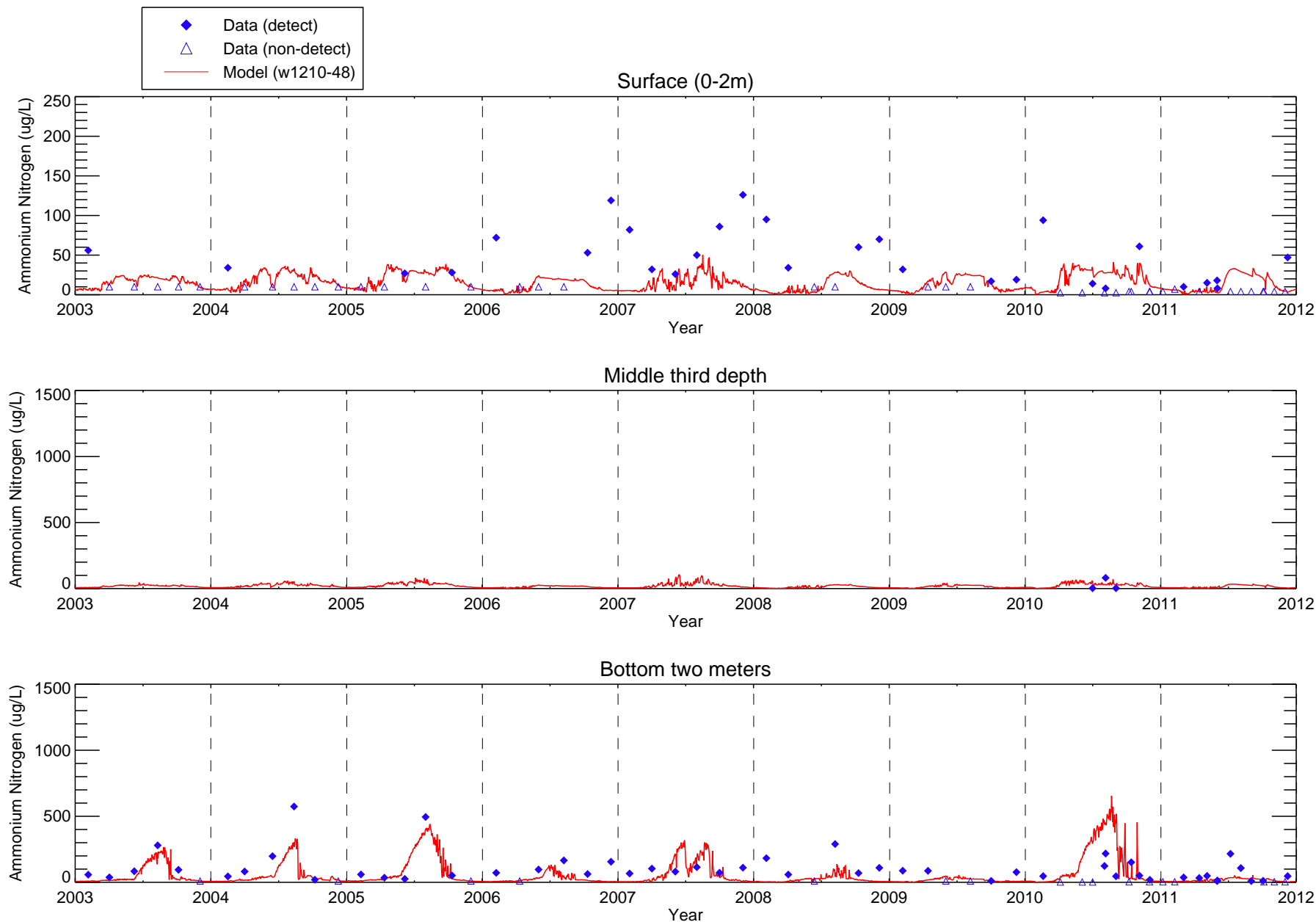
EC - \\austin2\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 08:48:16 2013

Figure 4-8d

Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-8d
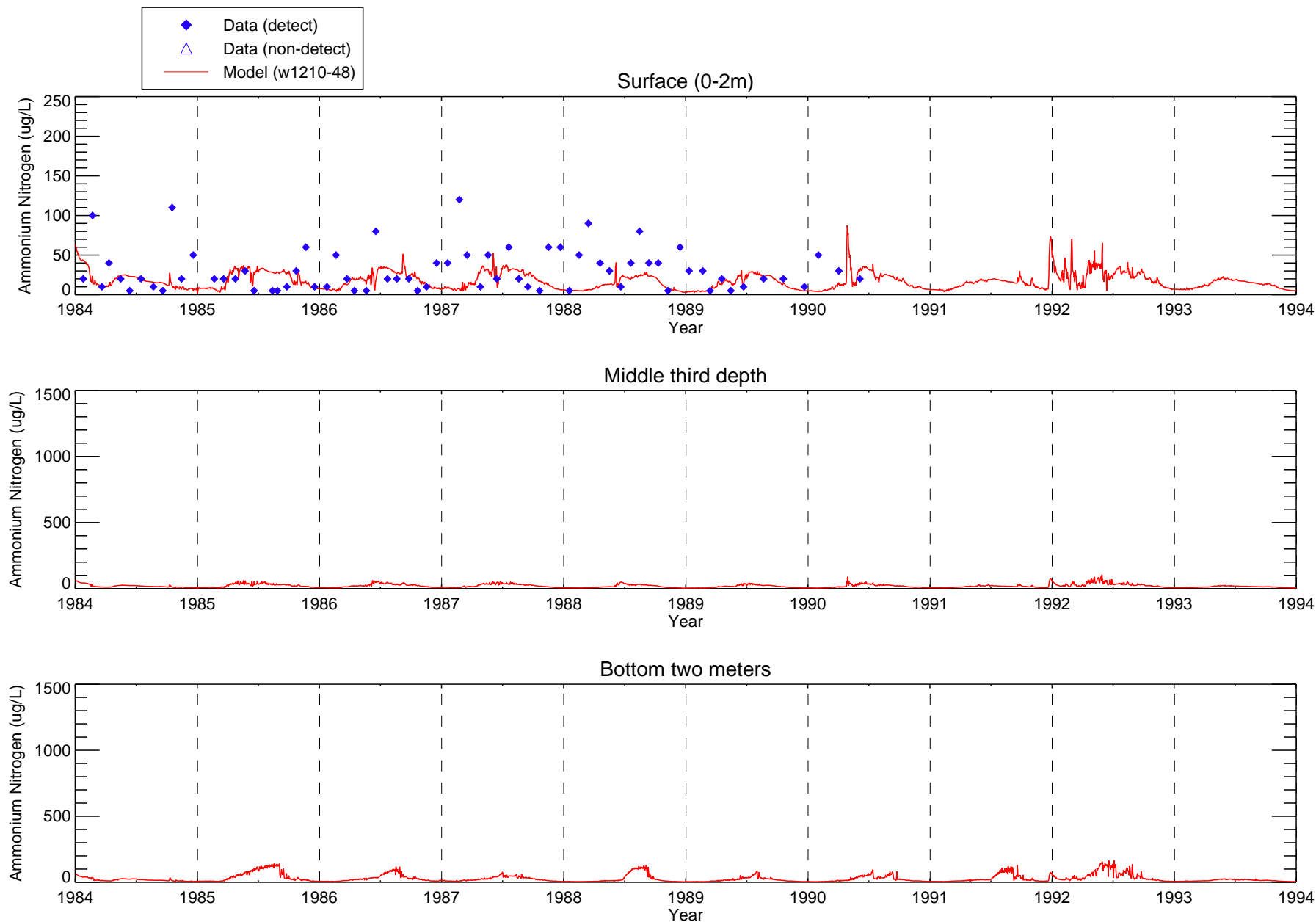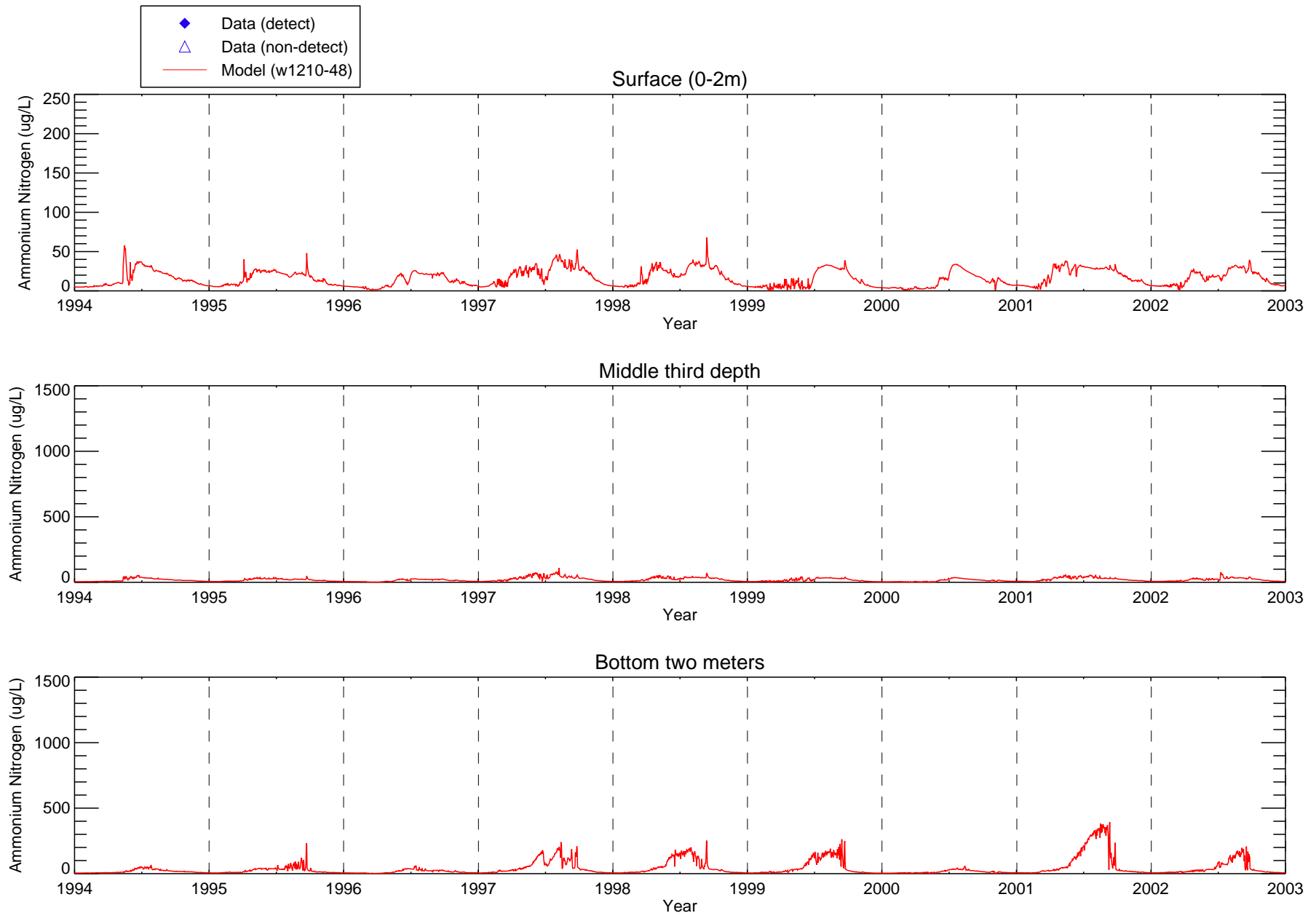**Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Chloride**

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-8e

Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

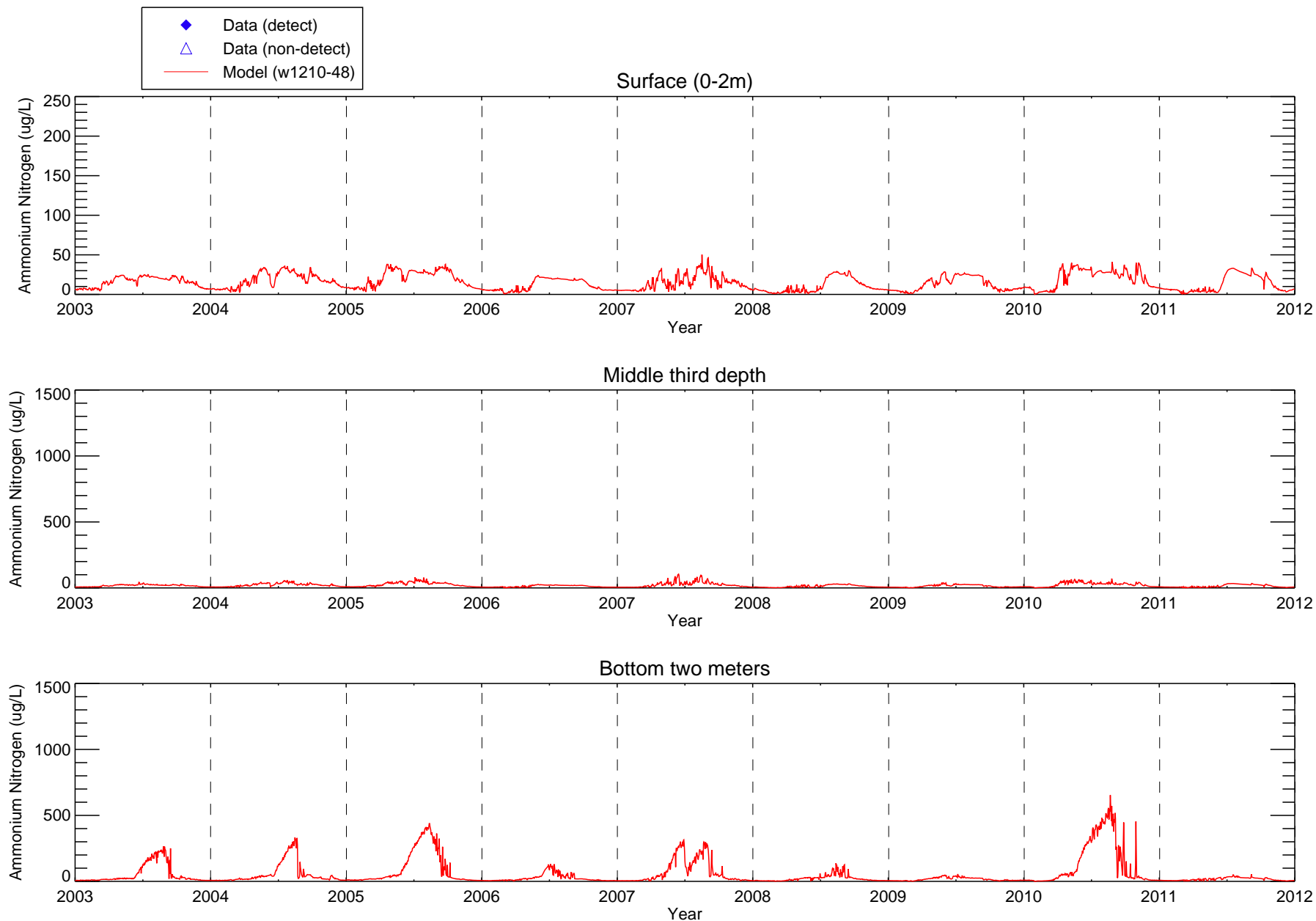CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Surface (0-2m)

Middle third depth

Bottom two meters

Legend:
- ◆ Data (detect)
- △ Data (non-detect)
- —— Model (w1210-48)

Y-axis (all panels): Chloride (mg/L)
X-axis (all panels): Year

Figure 4-8e

Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
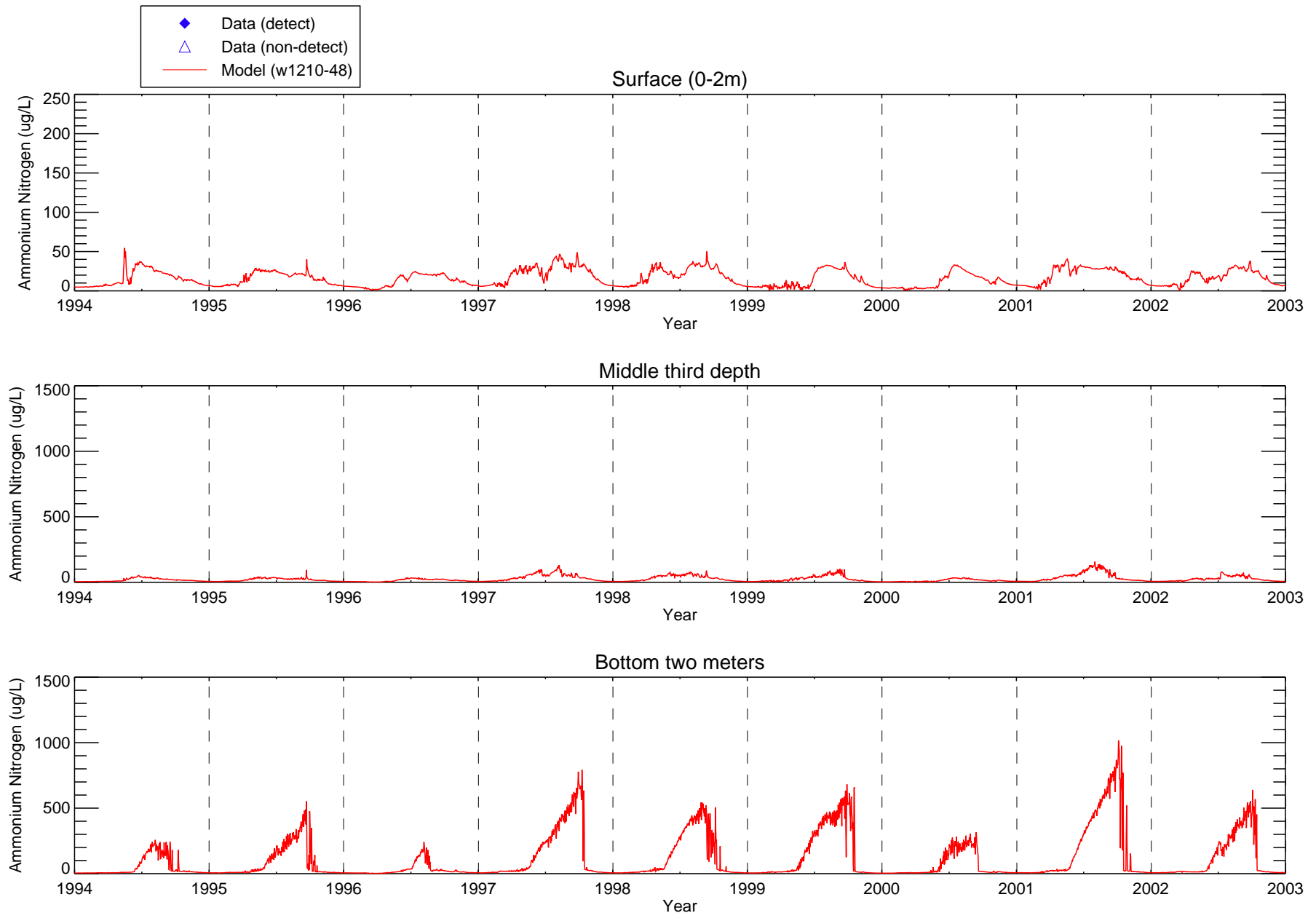Tue Jan 29 16:16:42 2013

Figure 4-8e

Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 16:17:46 2013

Figure 4-8f
Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

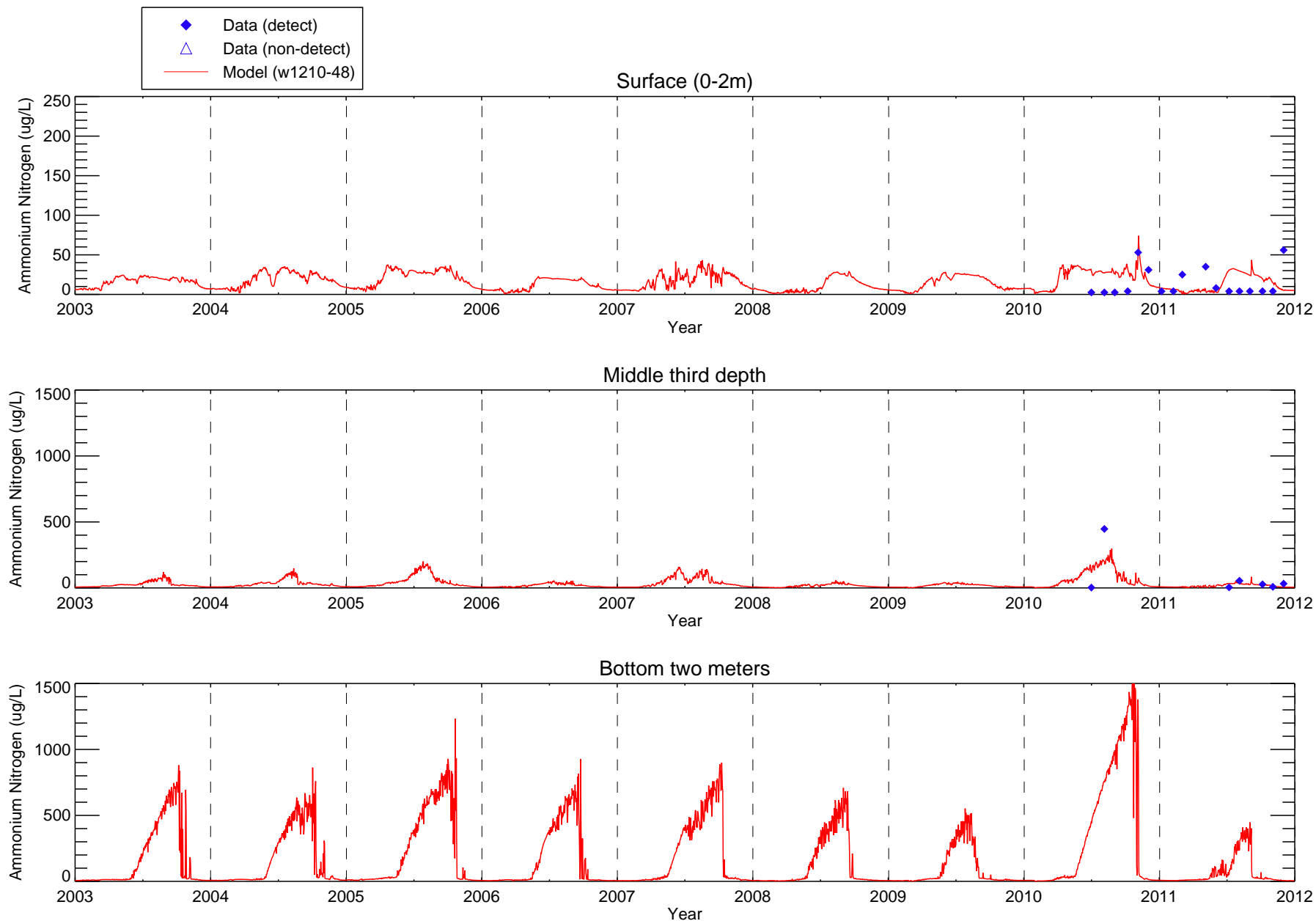EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 16:19:17 2013

Surface (0-2m)

Middle third depth

Bottom two meters

Figure 4-8f
Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS
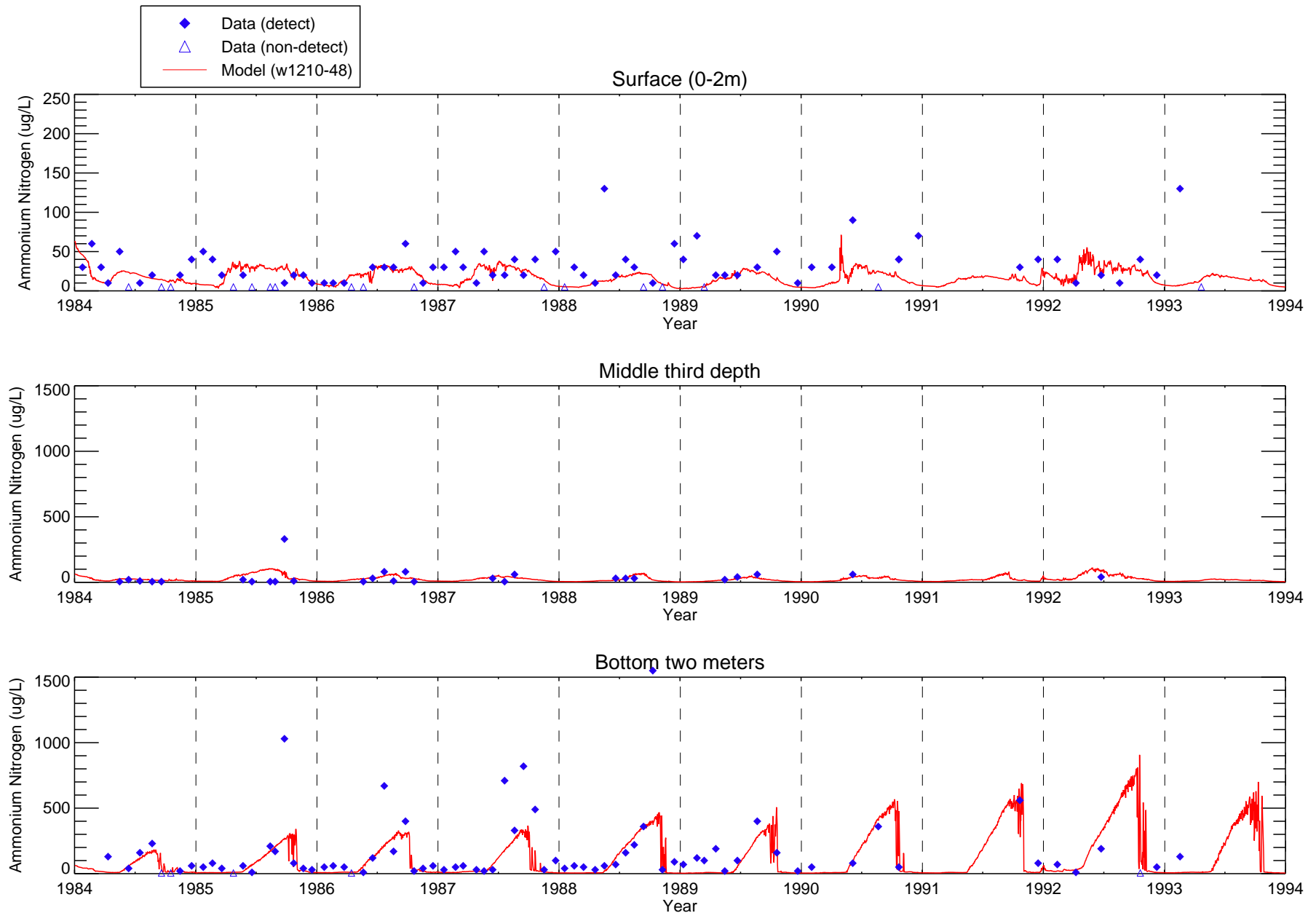
EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
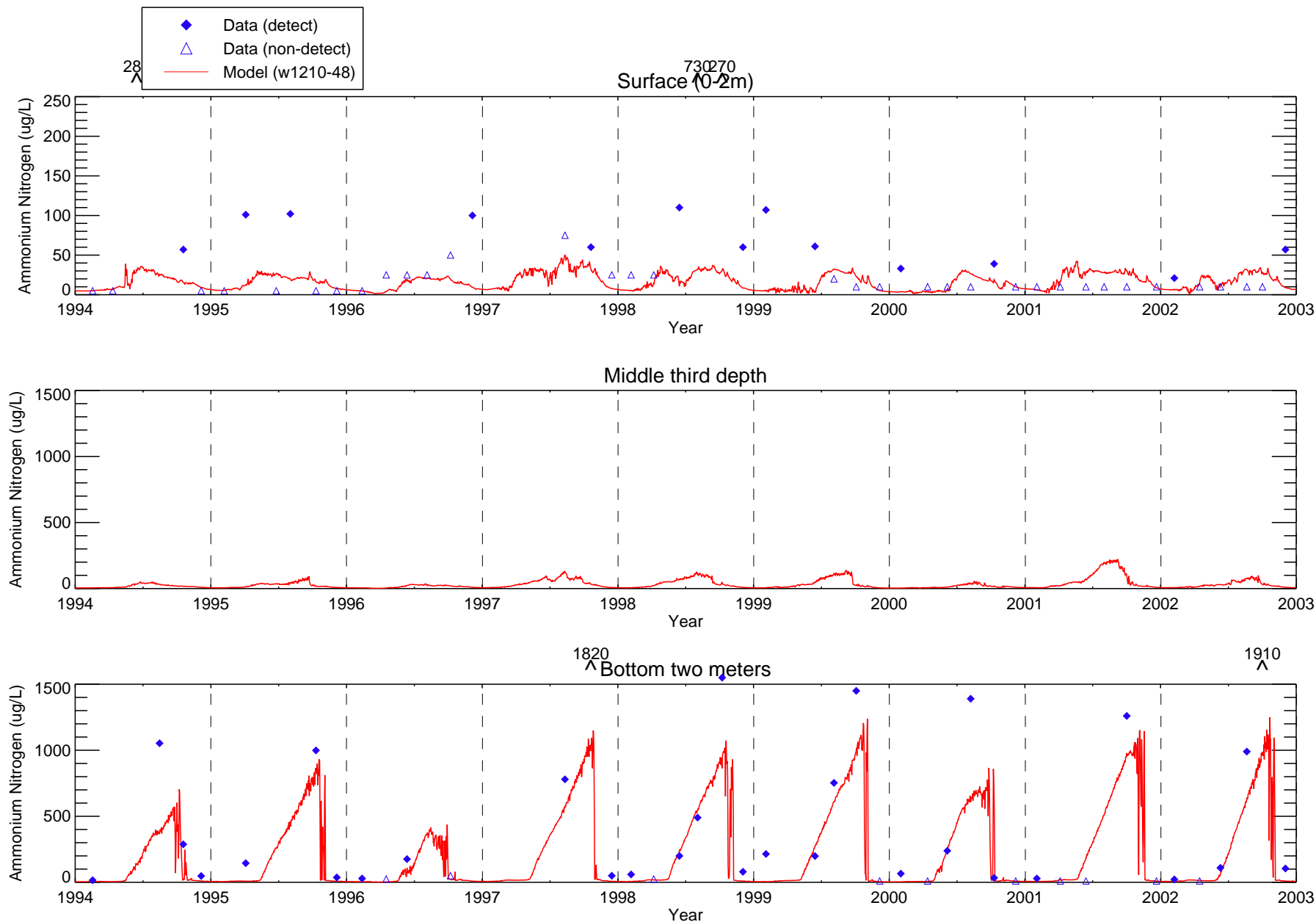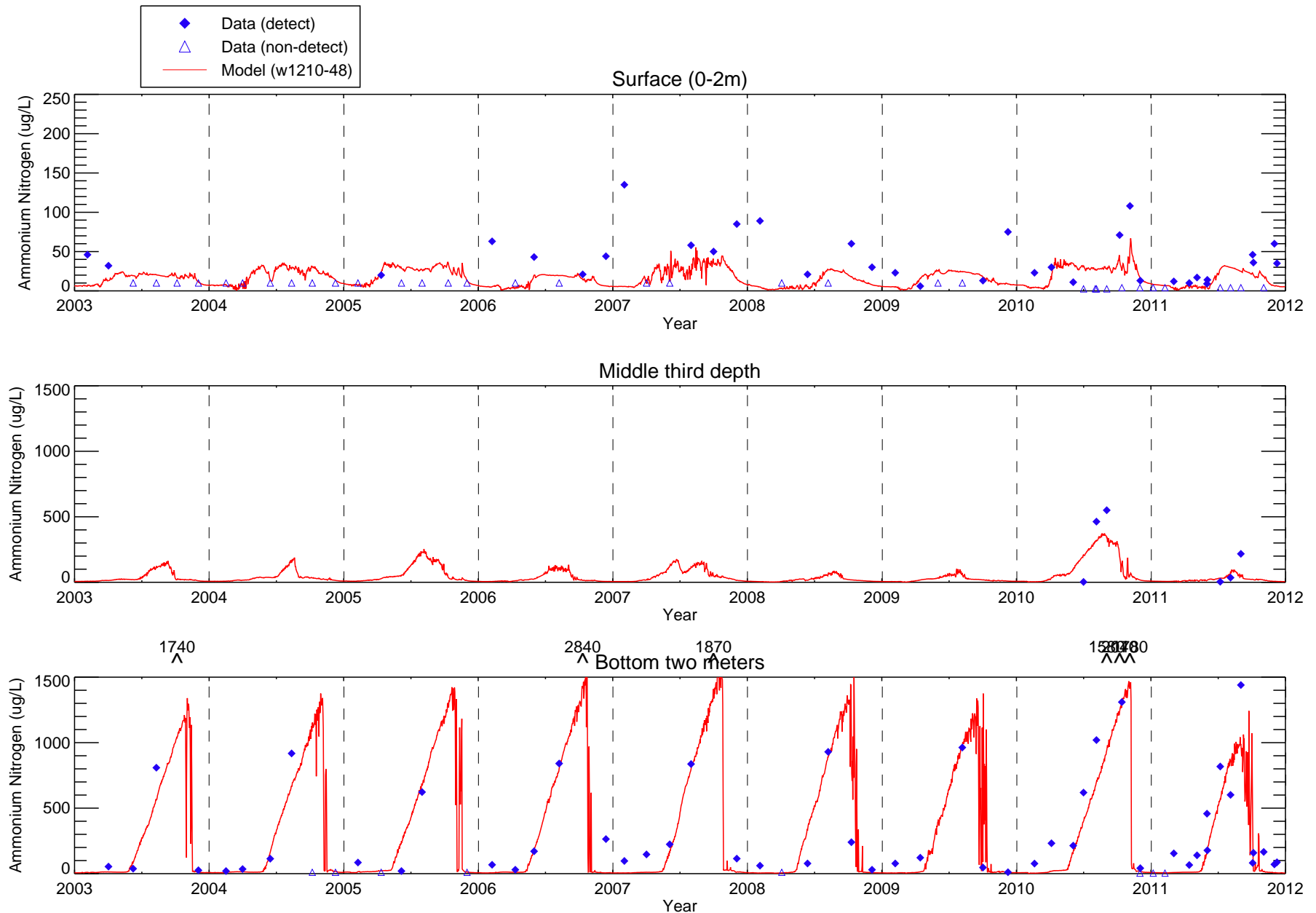Tue Jan 29 16:20:49 2013

Figure 4-8f
Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 16:22:19 2013

Figure 4-8g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
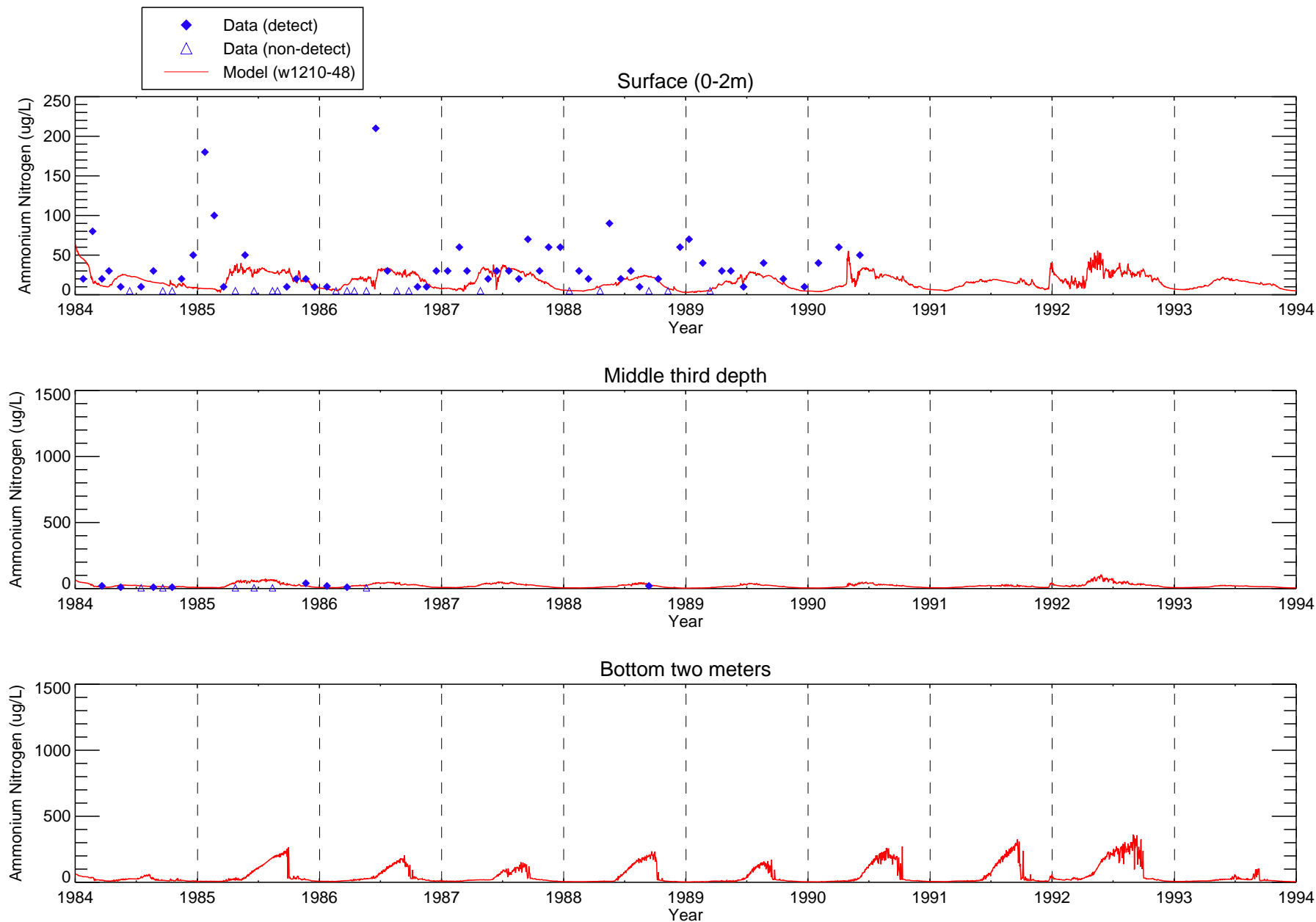
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-8g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
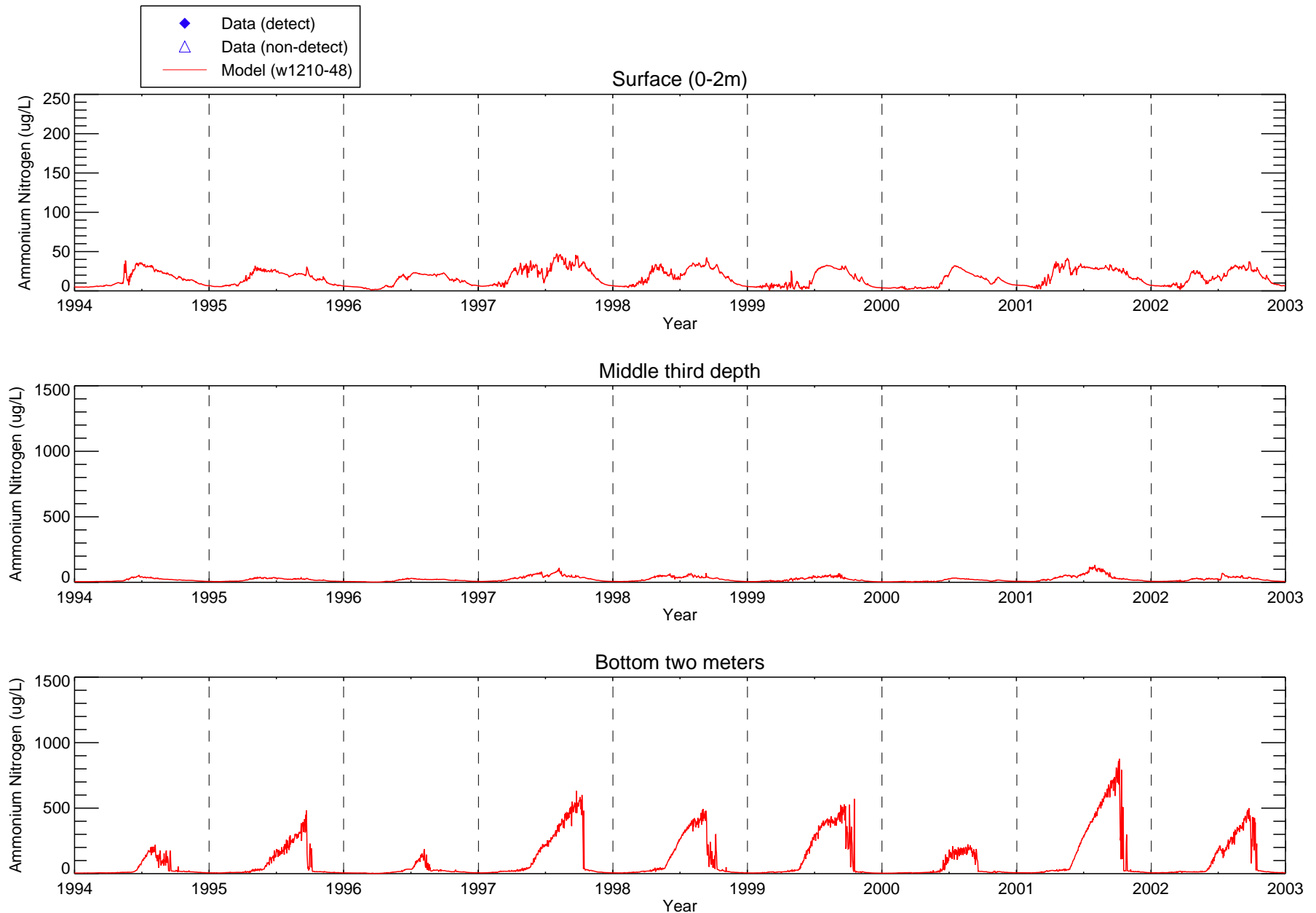Tue Jan 29 16:29:33 2013

Figure 4-8g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-8h
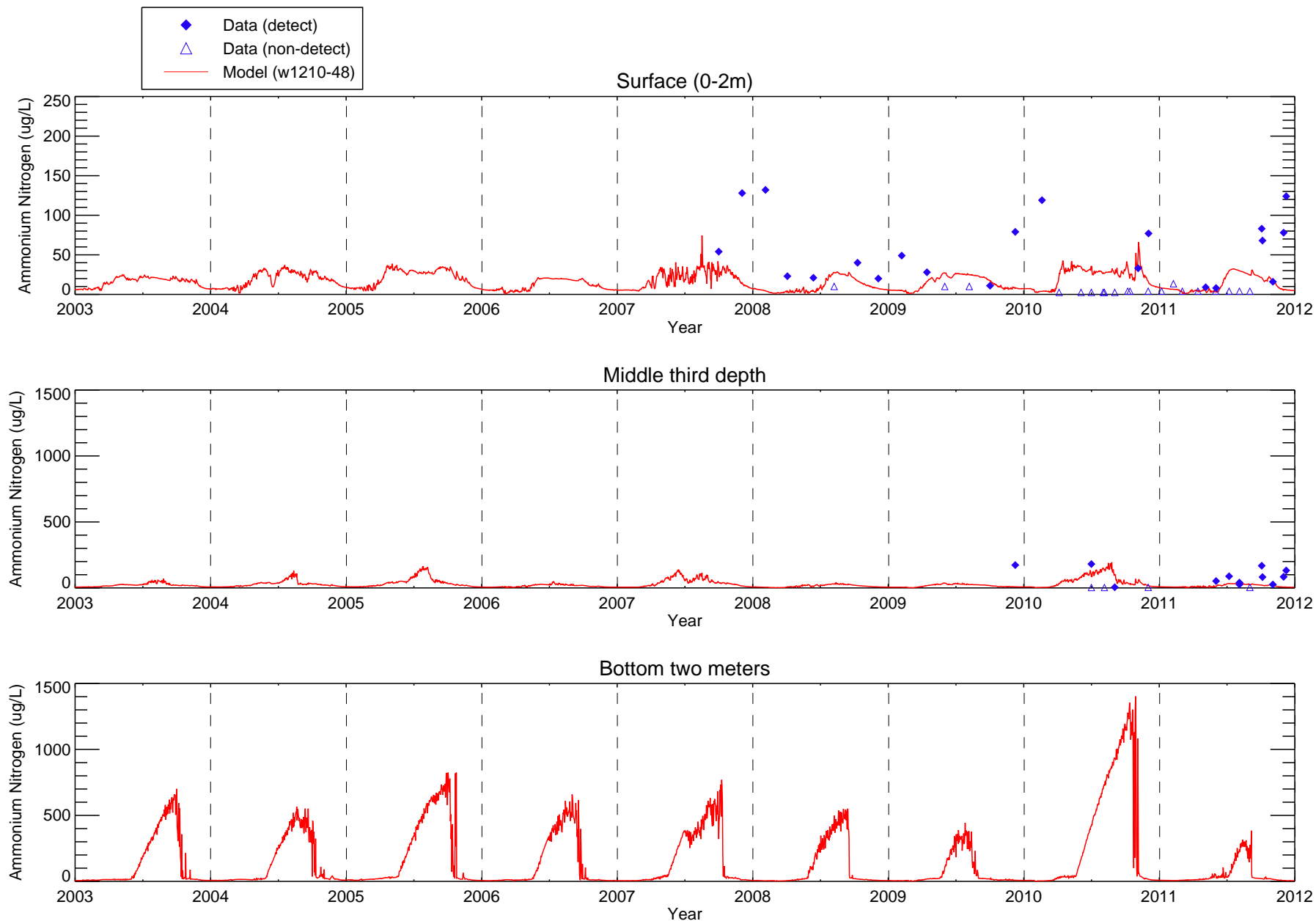
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

Figure 4-8h

Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-8h
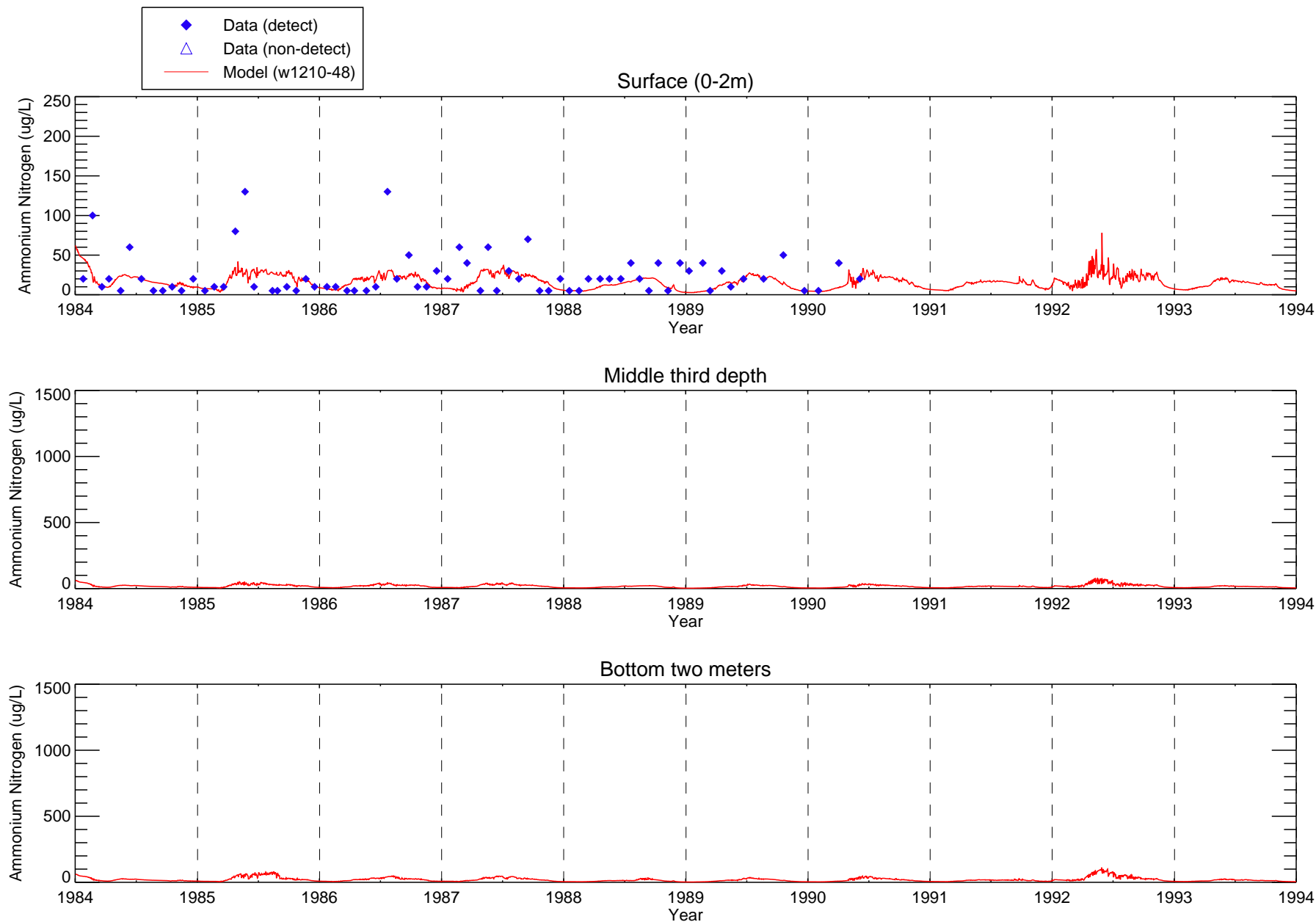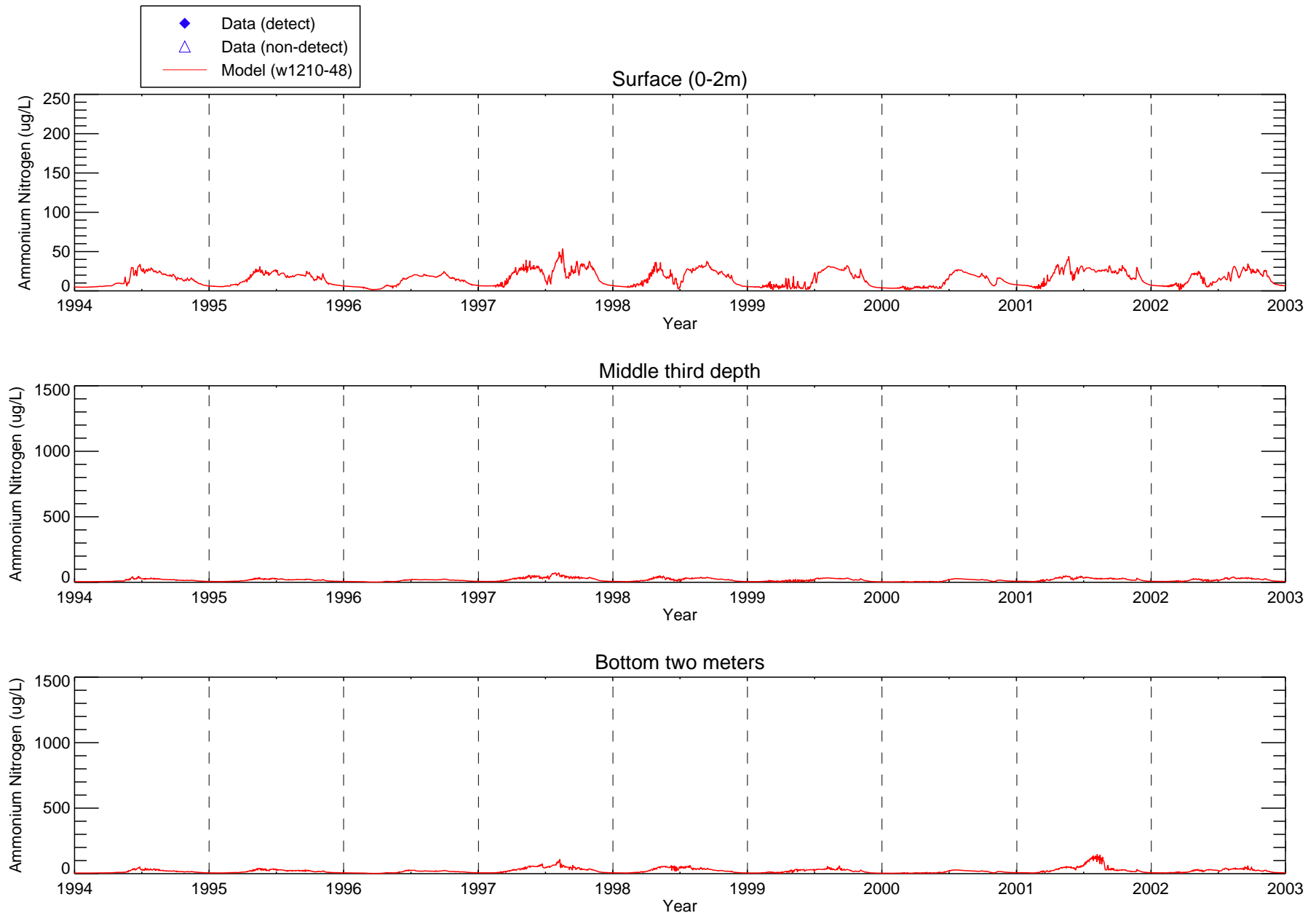**Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Chloride**

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 16:32:18 2013

Notes: 'Other Watershed' includes runoff inflows from the local watershed and modeled tributaries

Figure 4-9
Percentage Contribution to Lake Buchanan by Source Type for Input Constituent Mass
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

RSS data only.

Note: In the regression equations, the "x" variable takes the value 1 for the year 1984, 2 for the year 1985, etc.

Figure 4-10
Annual Hypolimnetic Maximum PO4 and NH4 Concentrations at Buchanan Dam
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

RSS data only. Plot does not show one 62 ug/L sample in 1994.

Non-detects plotted at 1/2 detection limit as open triangles.

Note: The "x" variable takes on the value of the number of days since 12/31/1983, so 1/1/1984 has an "x" value of 1, 1/1/1985 has an "x" value of 367 due to the leap year of 1984, etc.

The plotted trend line equation is $y = 0.000832x + 3.010$ with $R^2 = 0.179676$.

Figure 4-11
Epilimnetic Chl-a Data at Buchanan Dam
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority
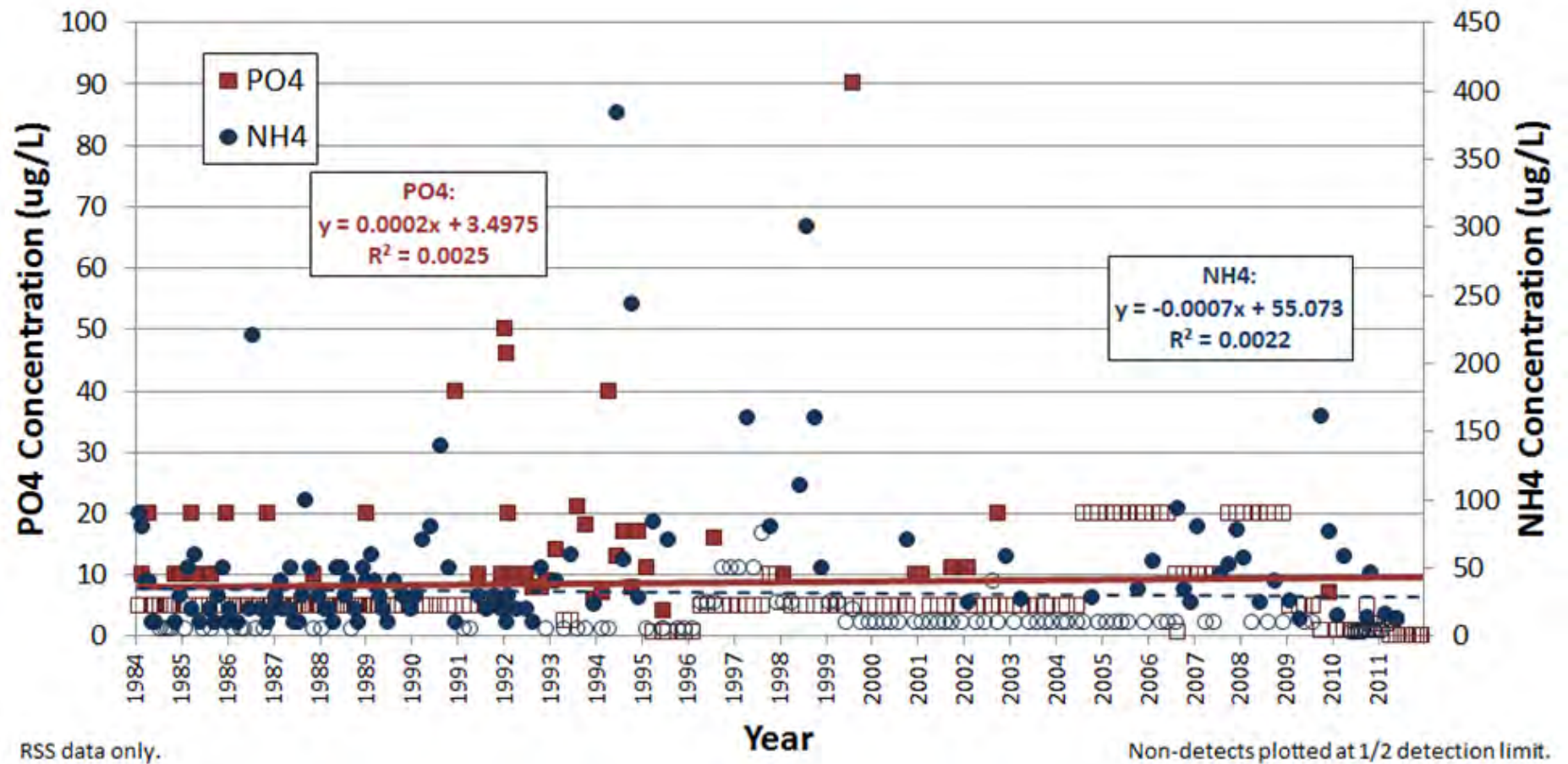
Figure 4-13
Epilimnetic PO4 and NH4 Data at Buchanan Dam
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority
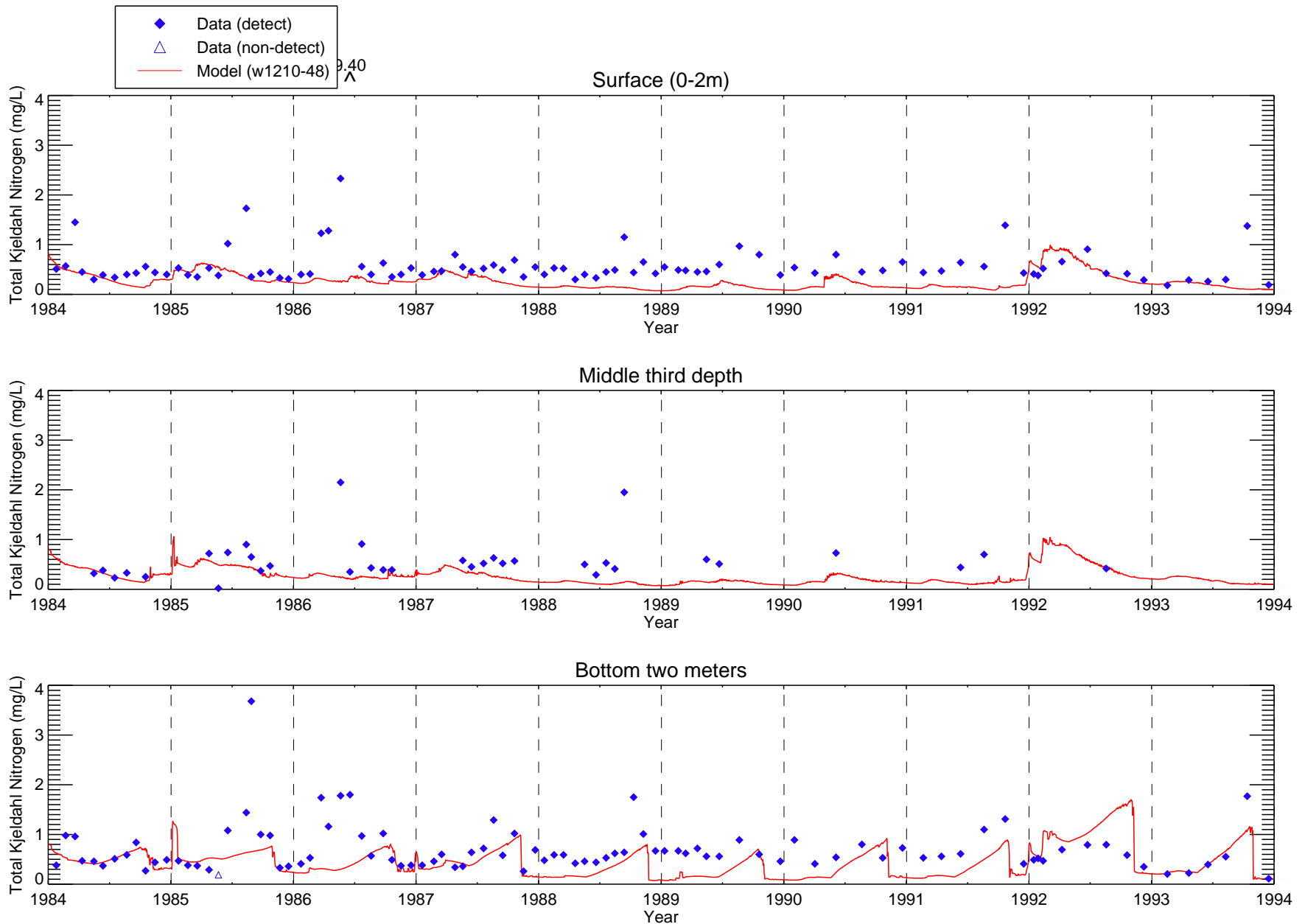
Figure 4-14a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
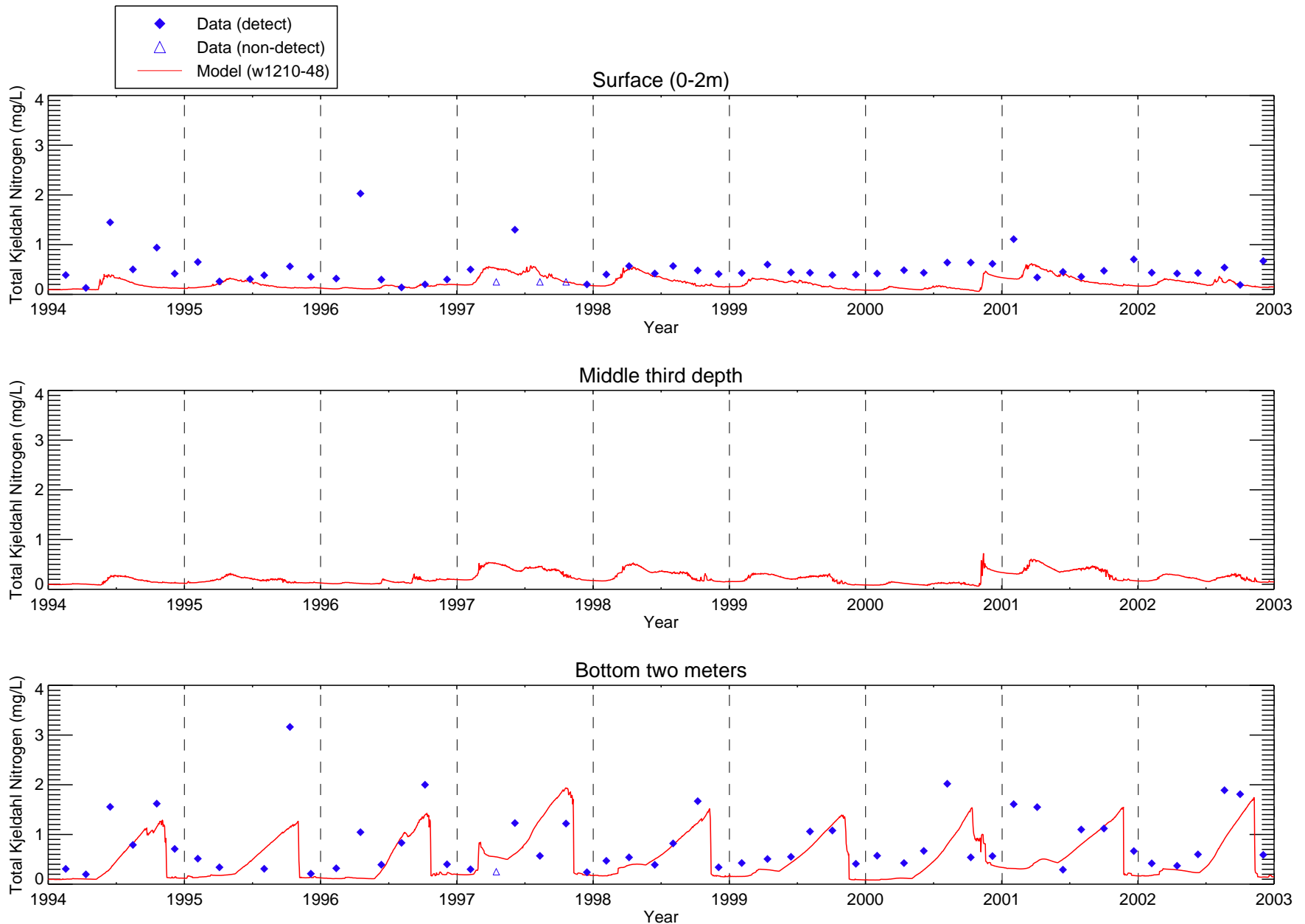Lower Colorado River Authority

Figure 4-14a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
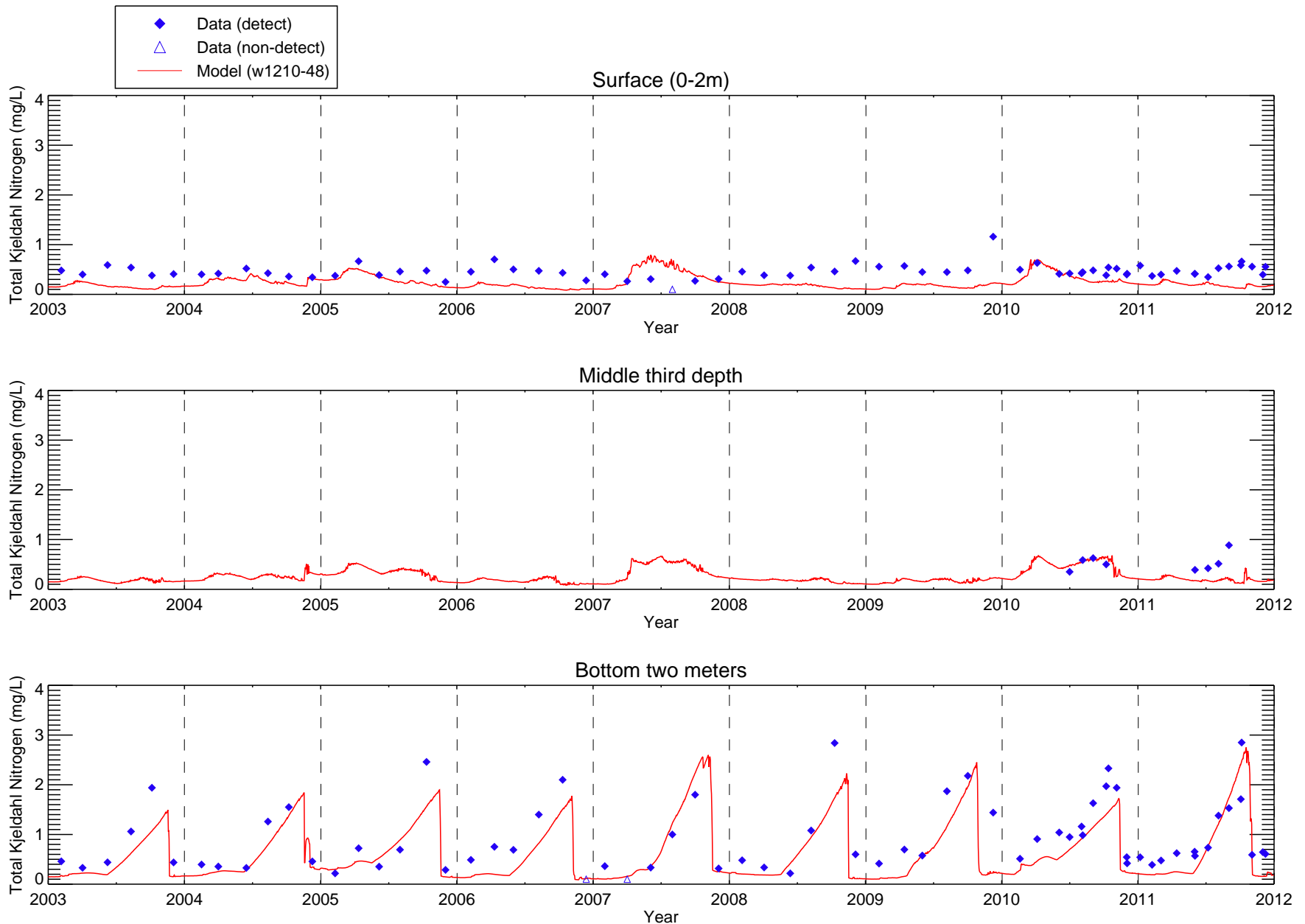
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-14a

Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
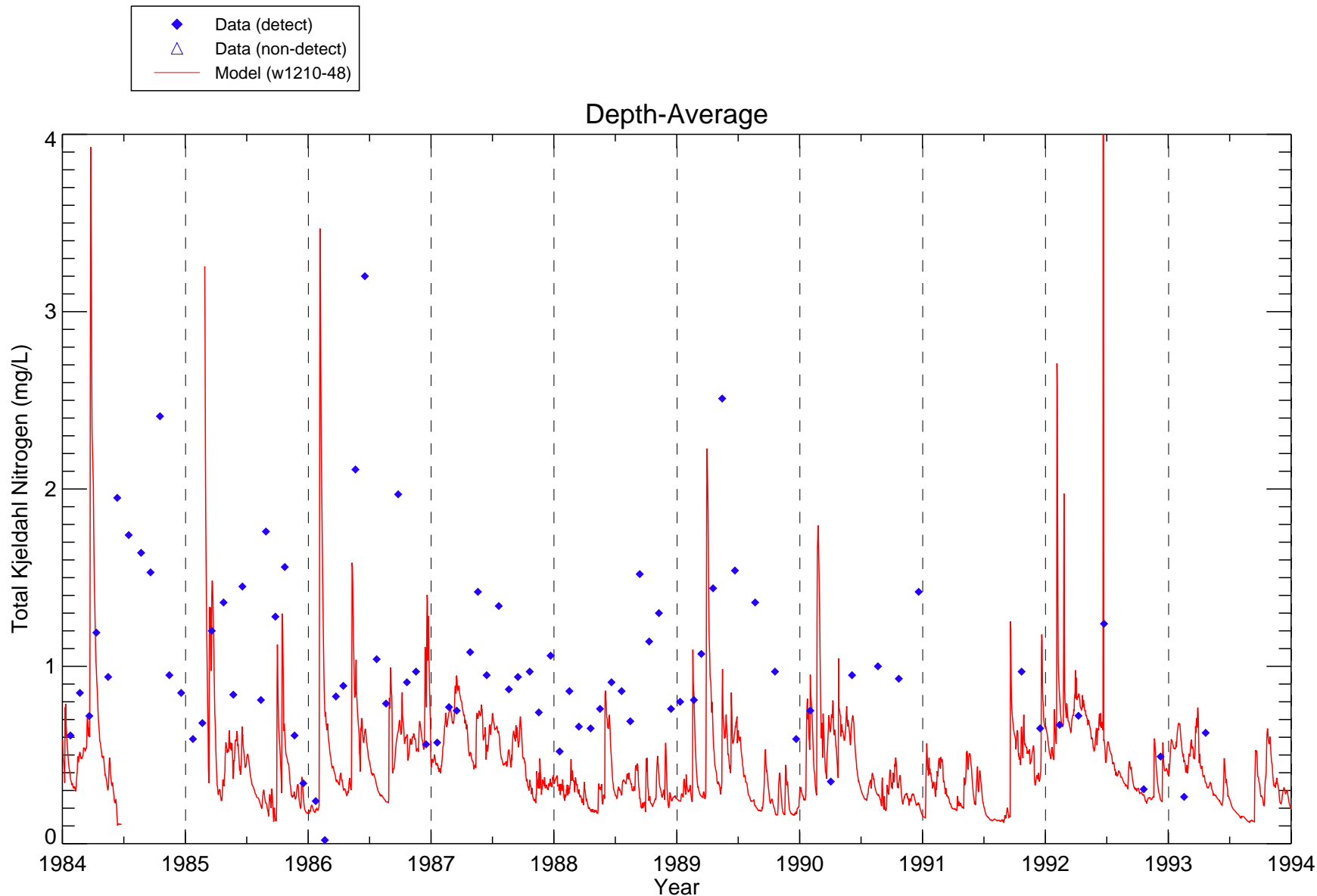
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 20:13:22 2013

Figure 4-14b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Ammonium Nitrogen

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Depth-Average

Figure 4-14b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Ammonium Nitrogen

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
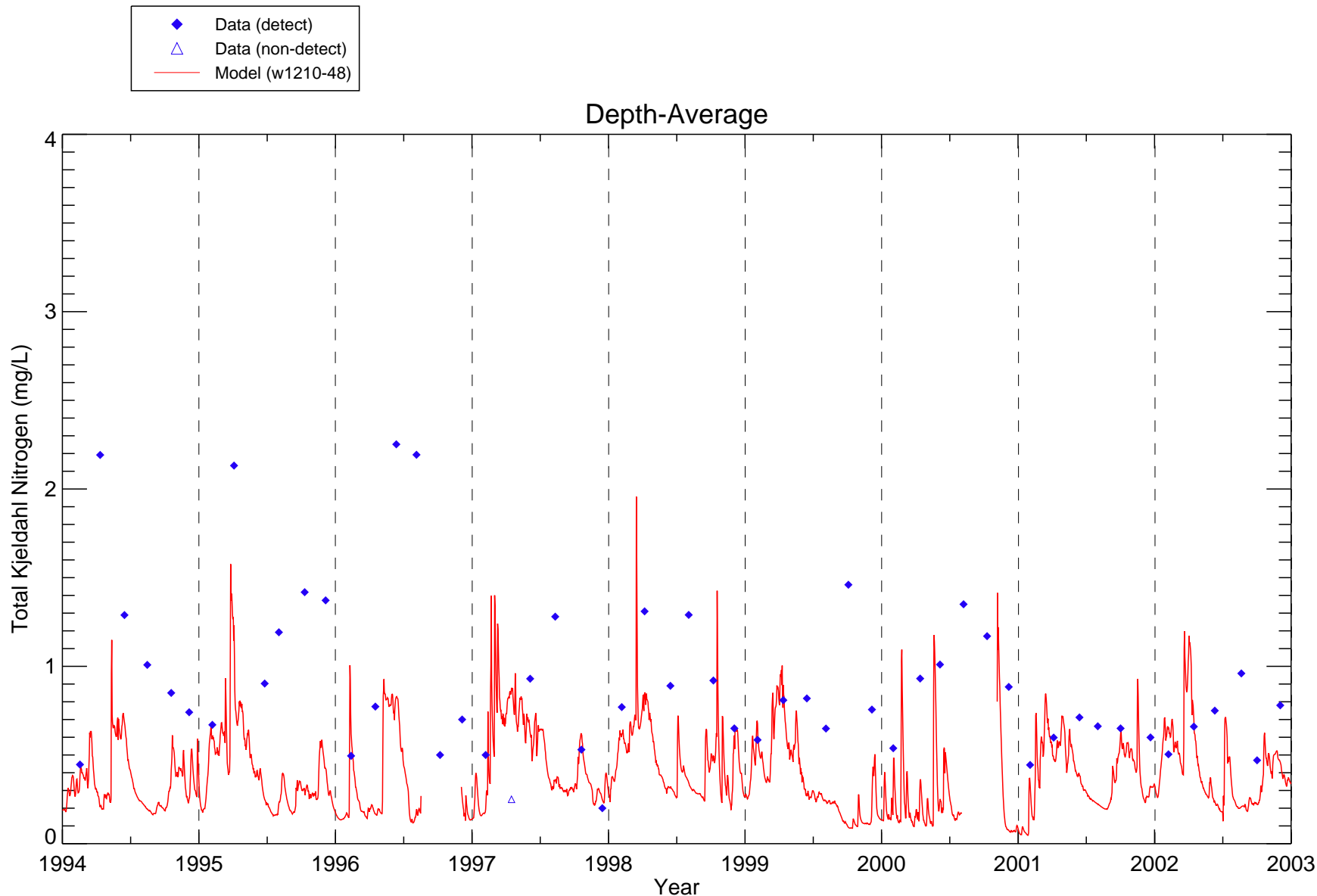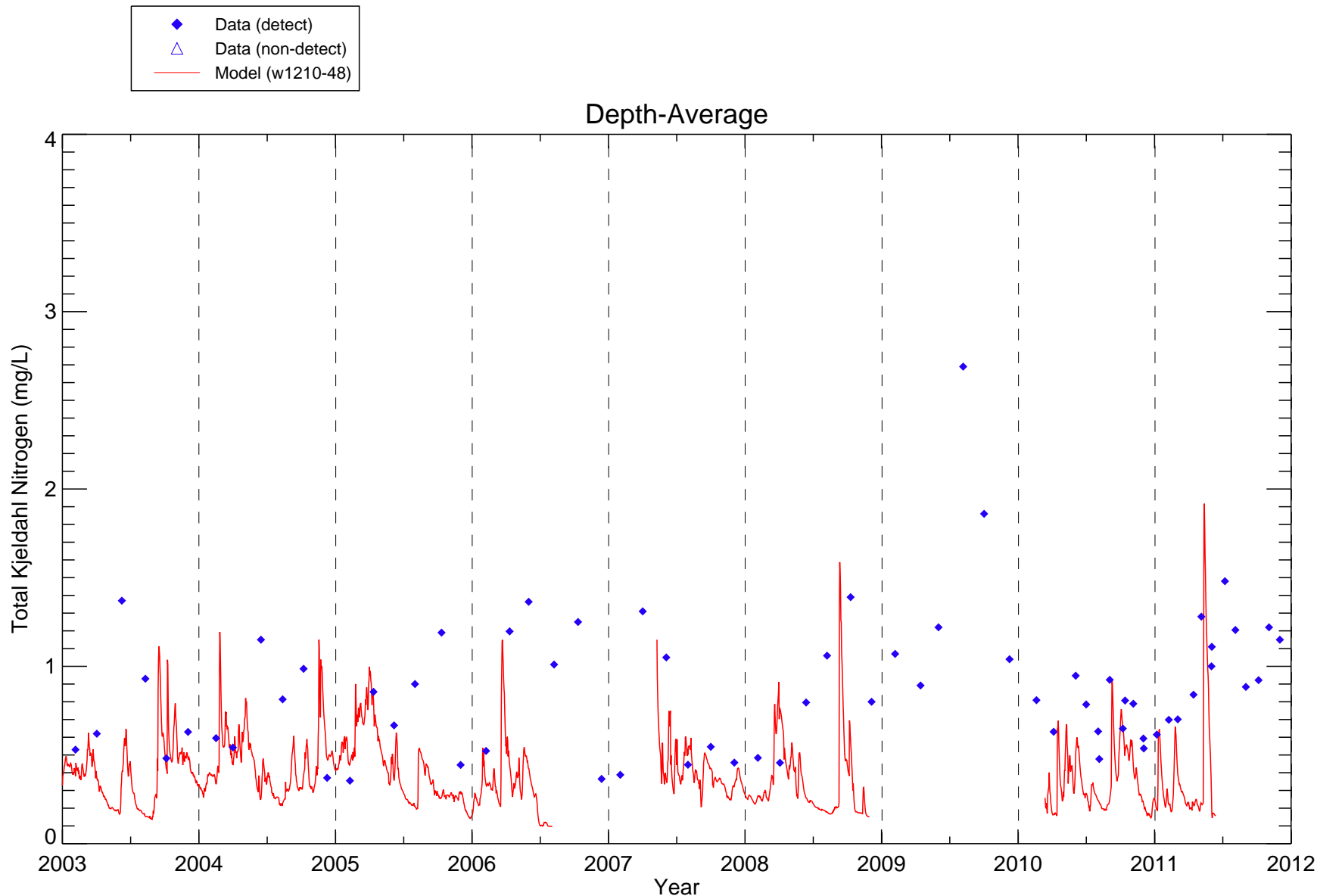
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 20:18:25 2013

Figure 4-14b

Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Ammonium Nitrogen

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
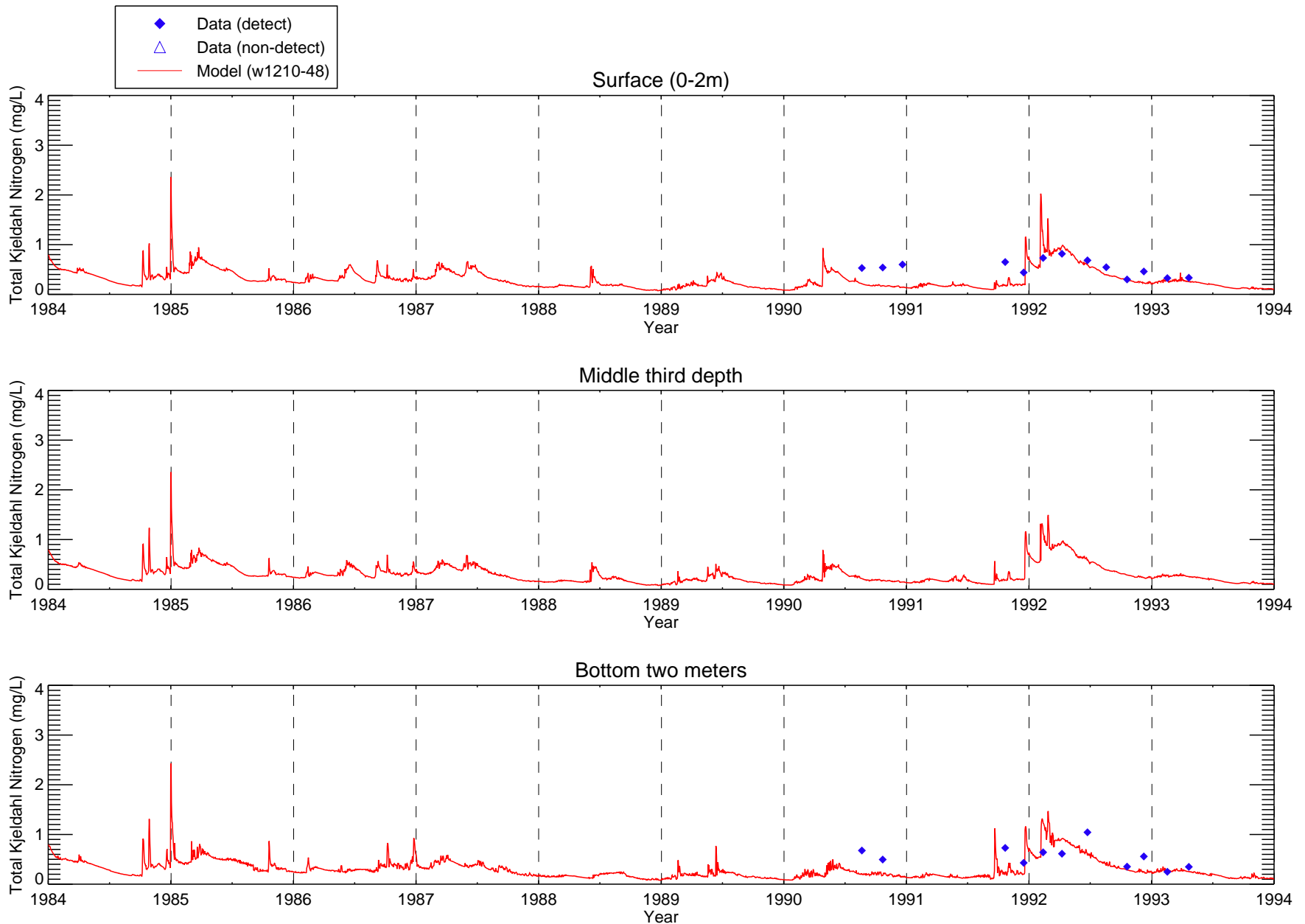
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-14c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
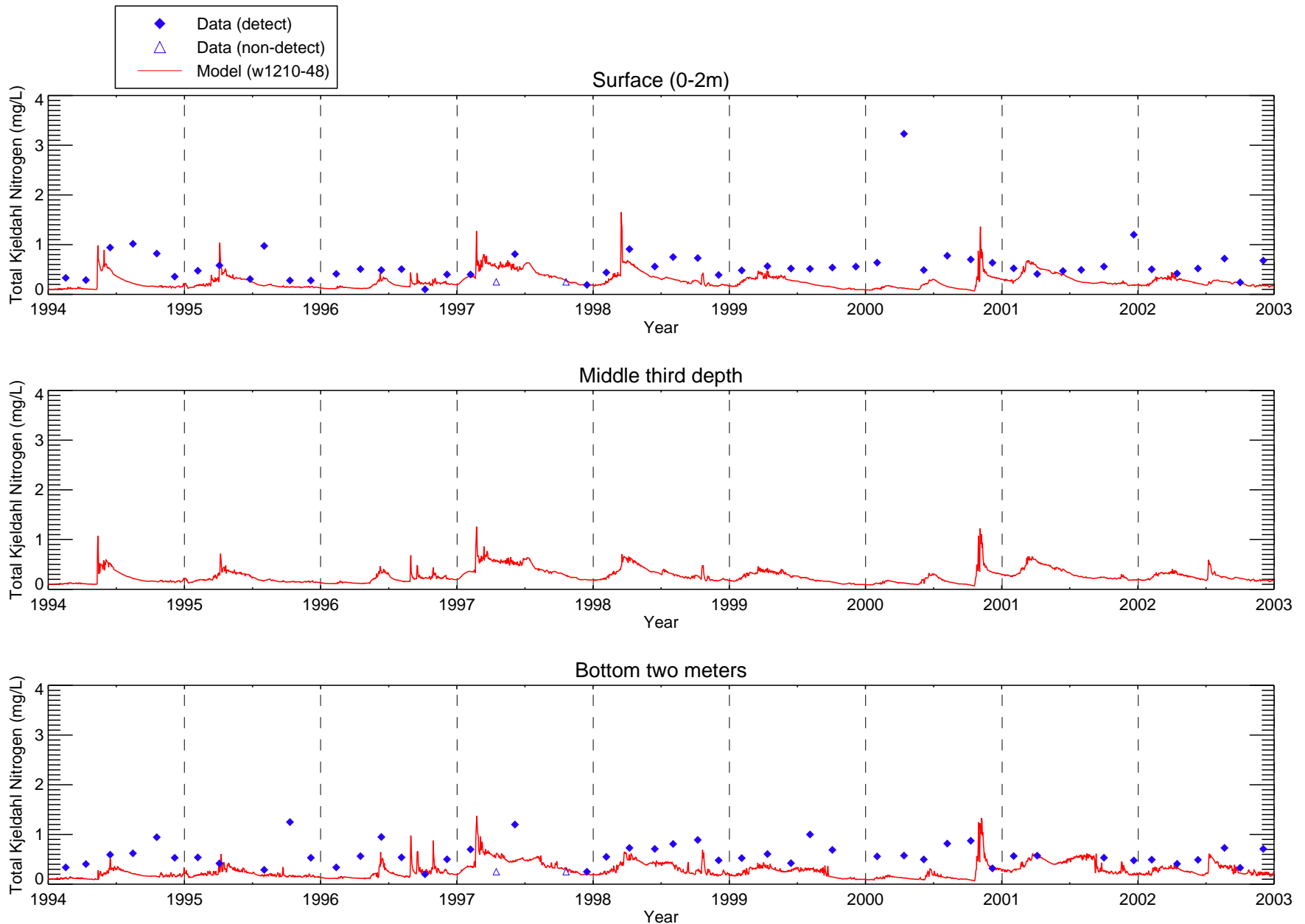
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 13:24:44 2013

Figure 4-14c

Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
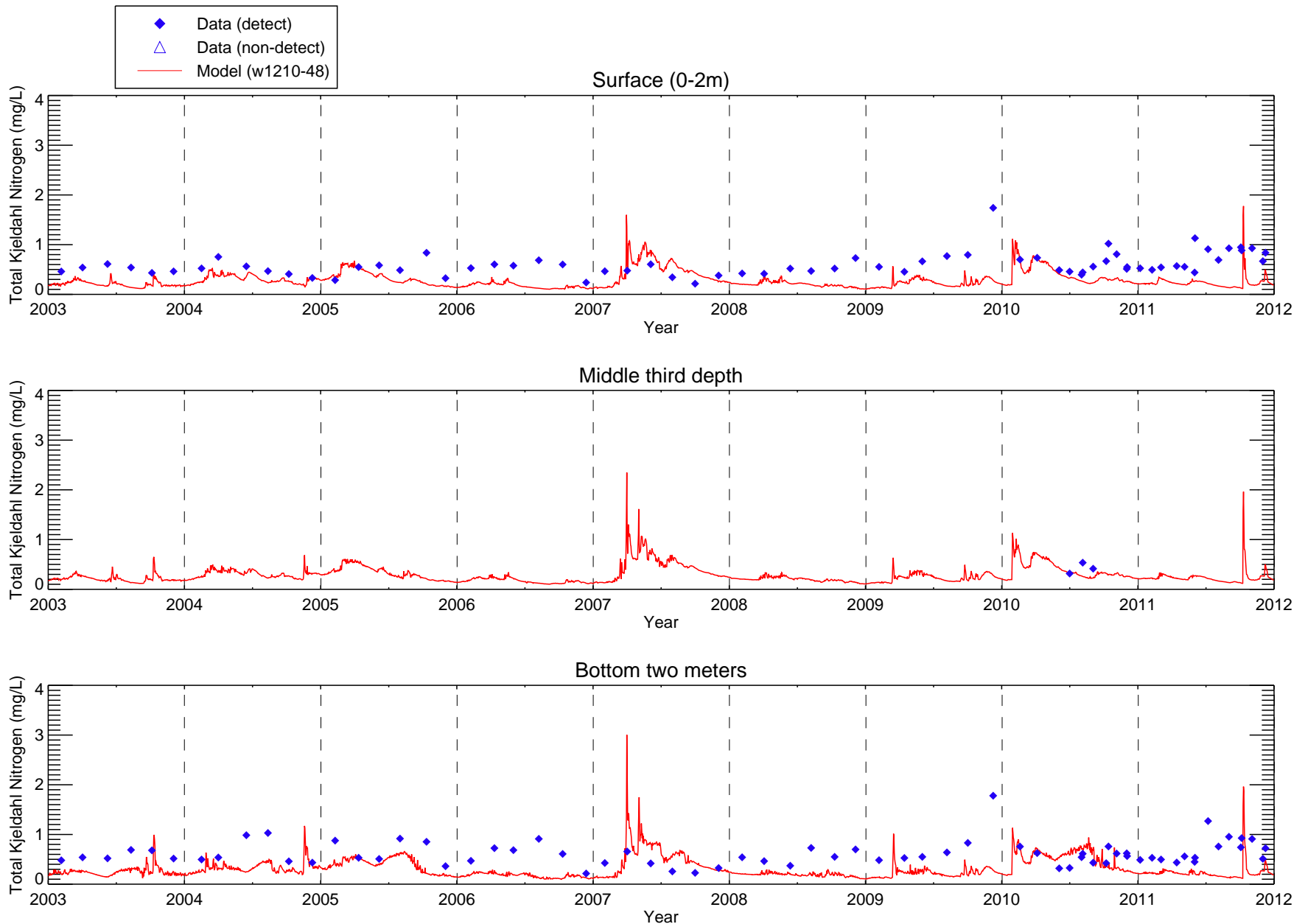Lower Colorado River Authority

Figure 4-14c

Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
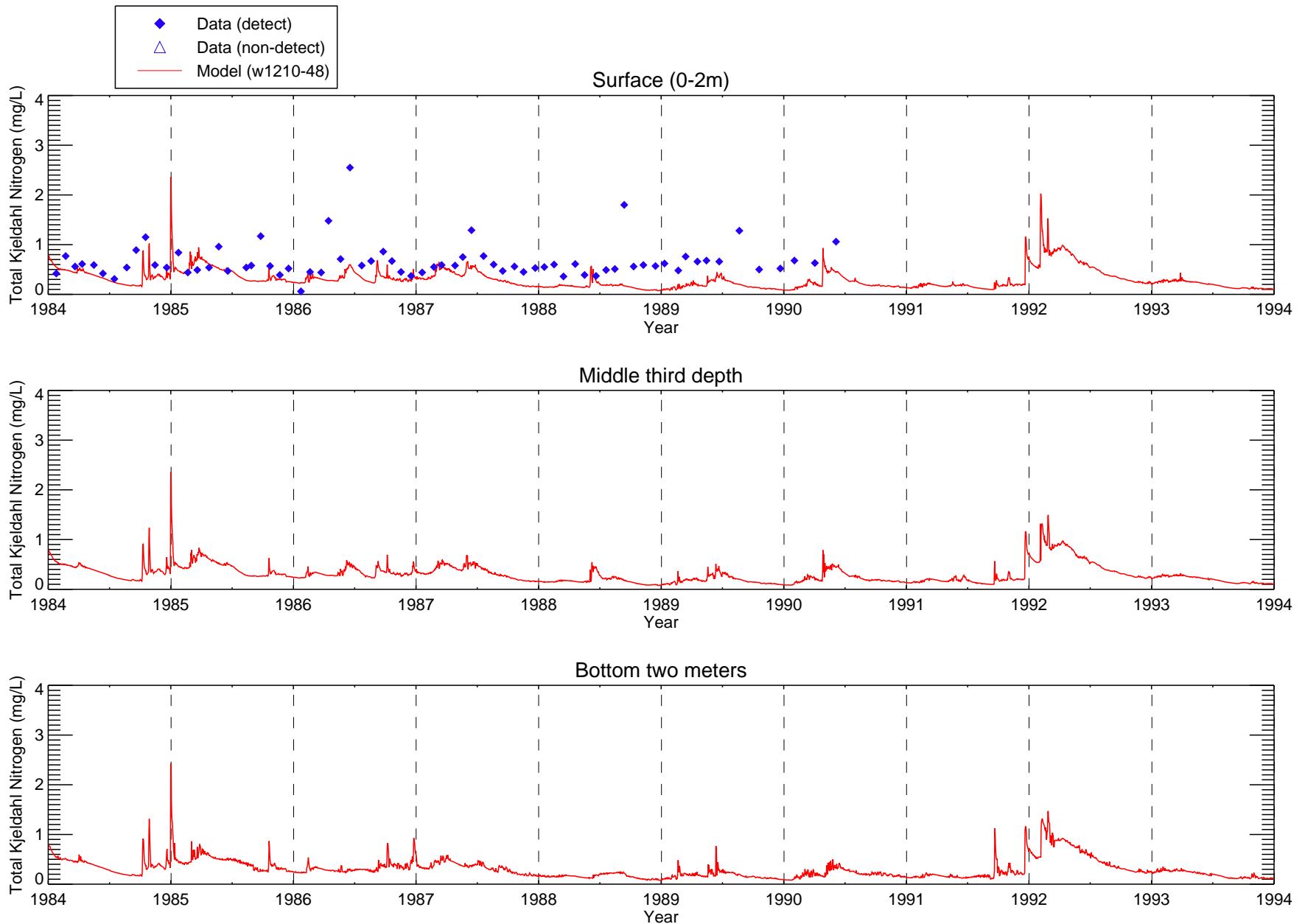Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 13:26:26 2013

Figure 4-14d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
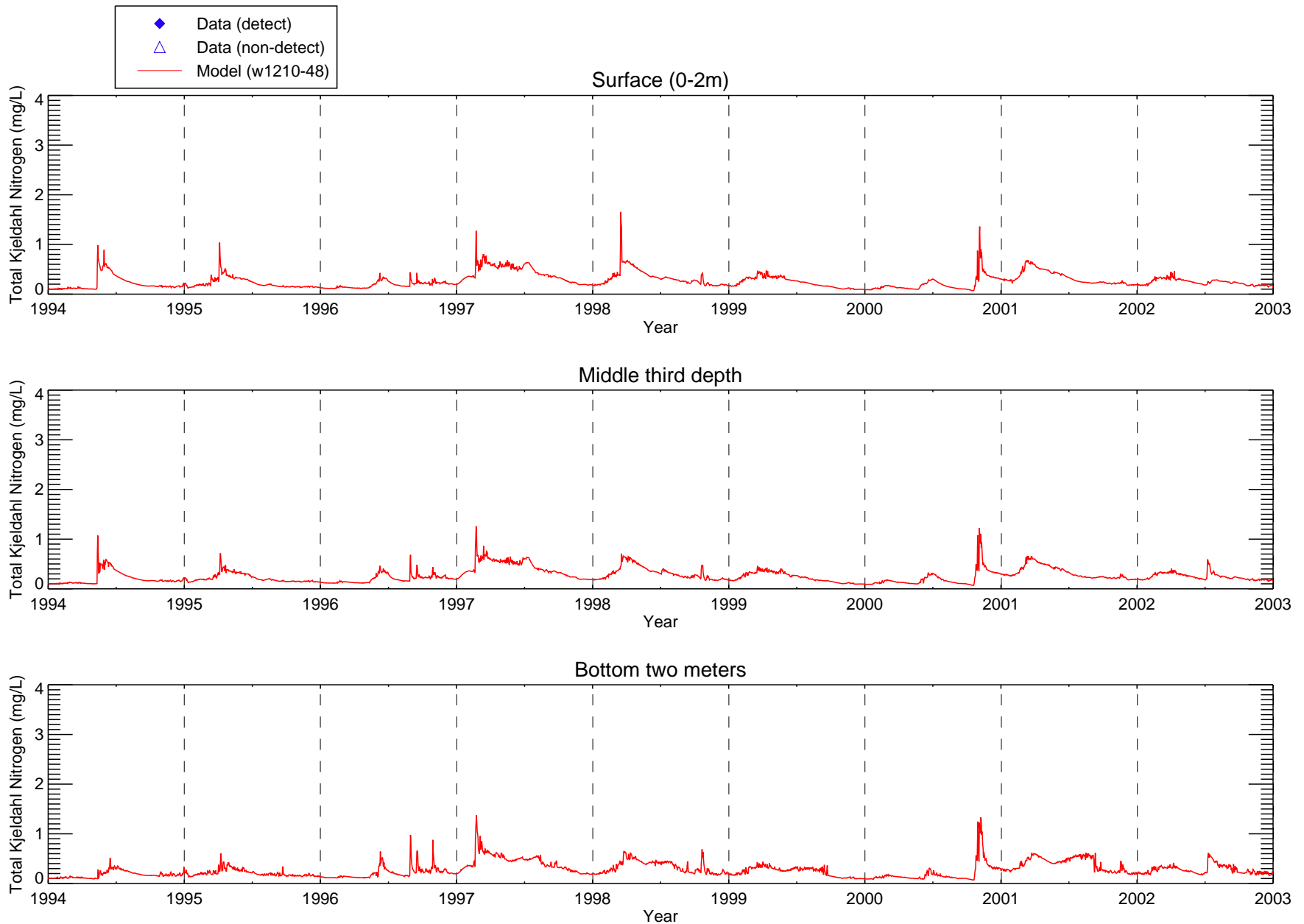Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 20:19:09 2013

Figure 4-14d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
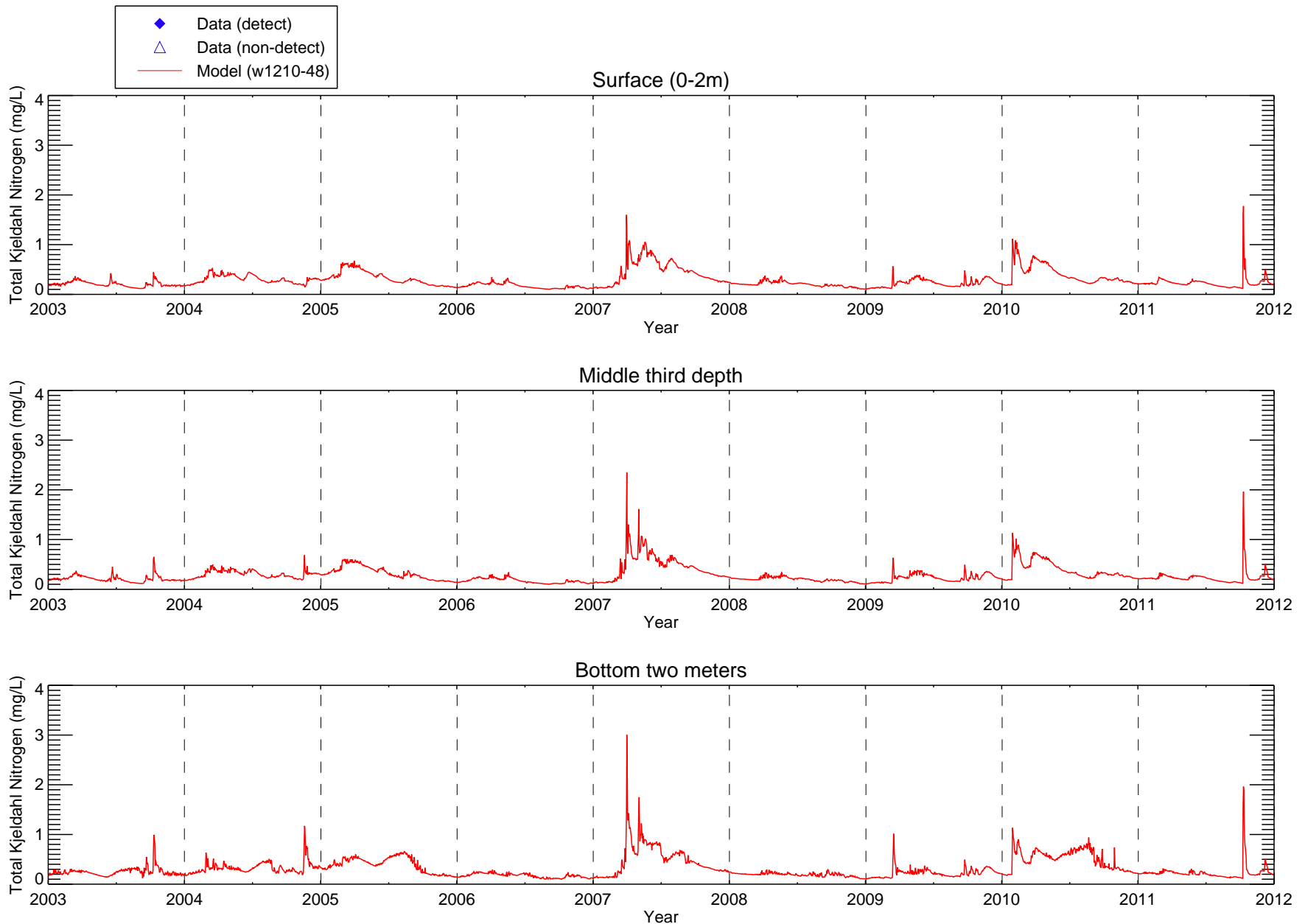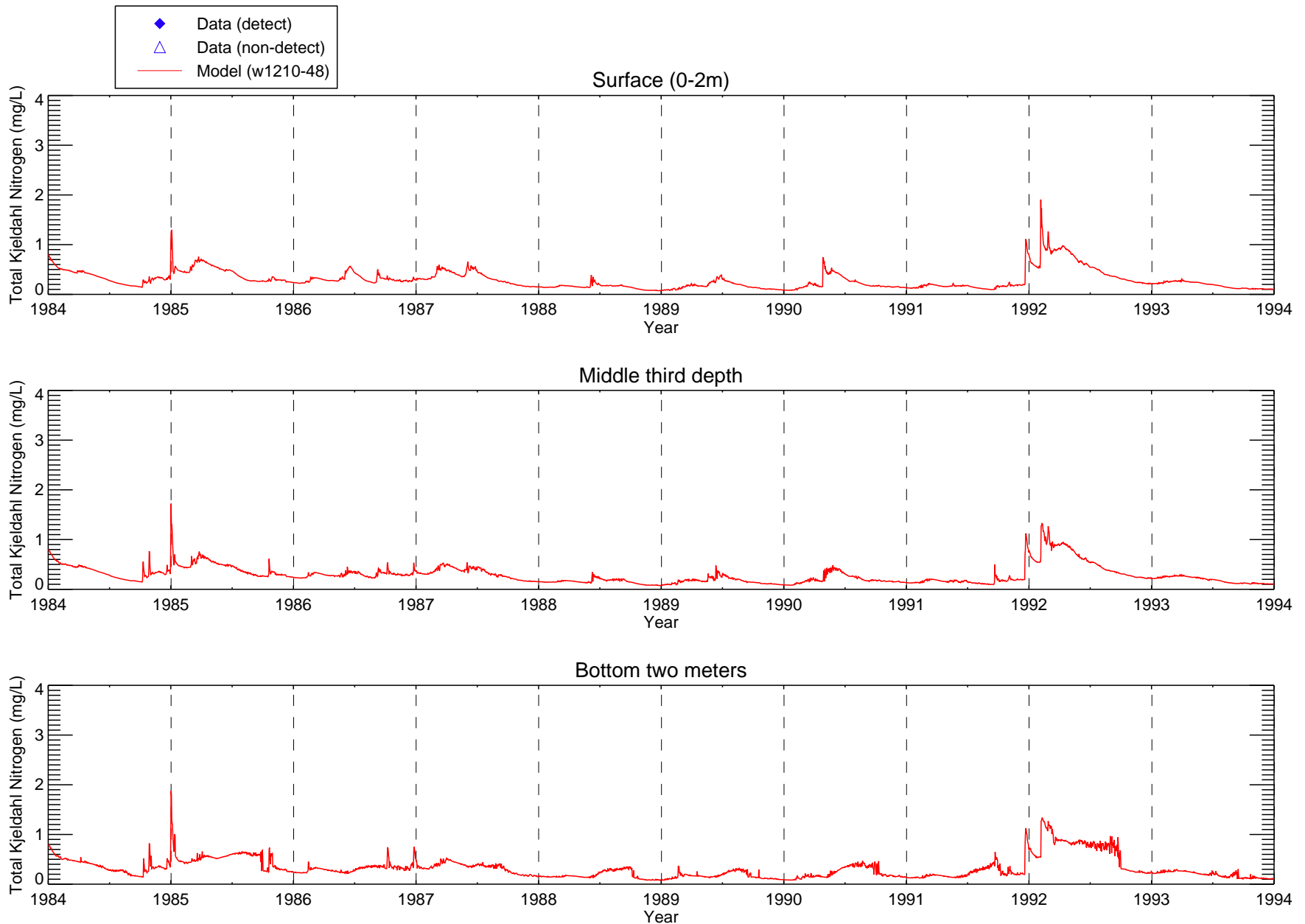
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-14d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
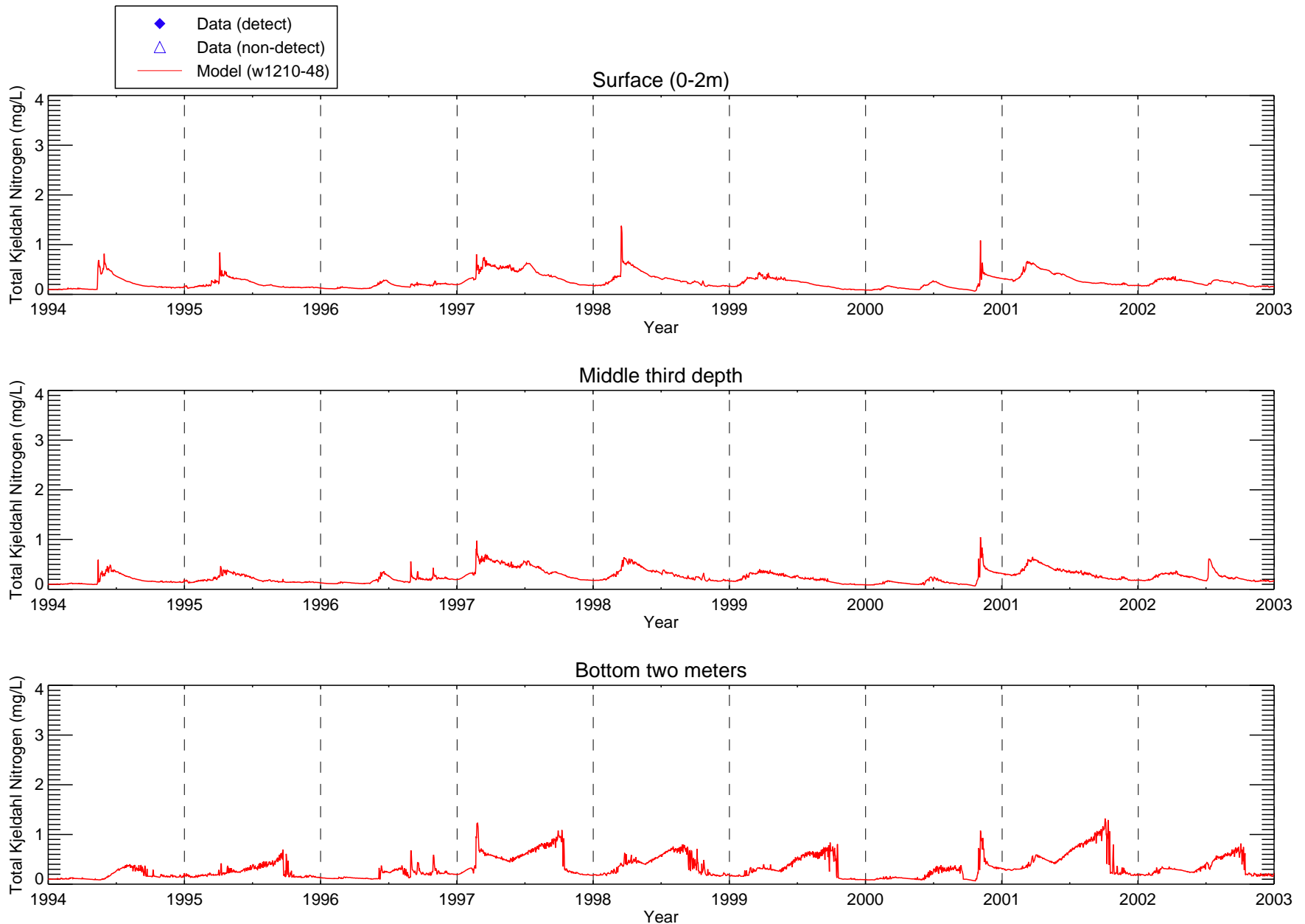
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-14e
Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
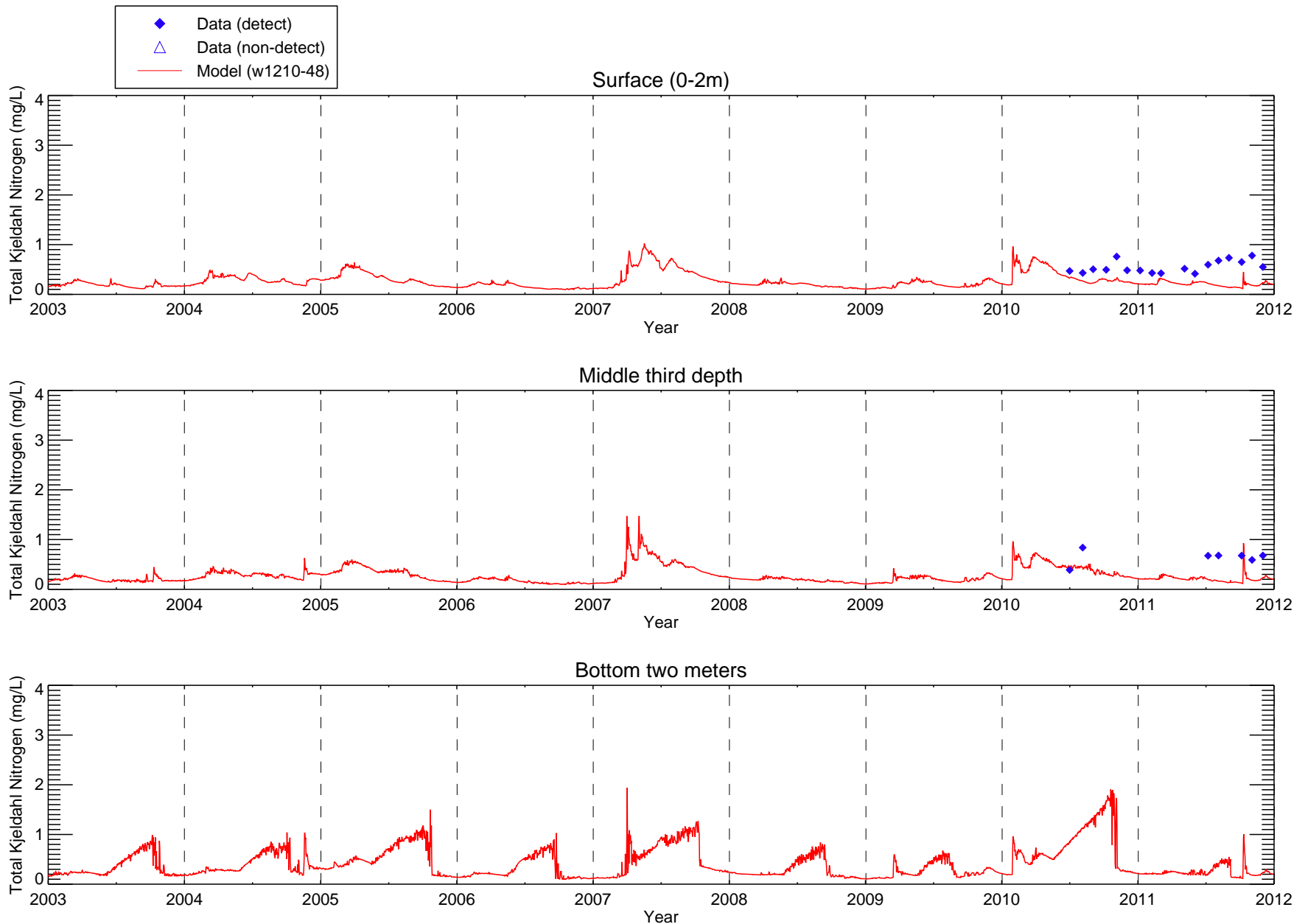
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-14e
Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
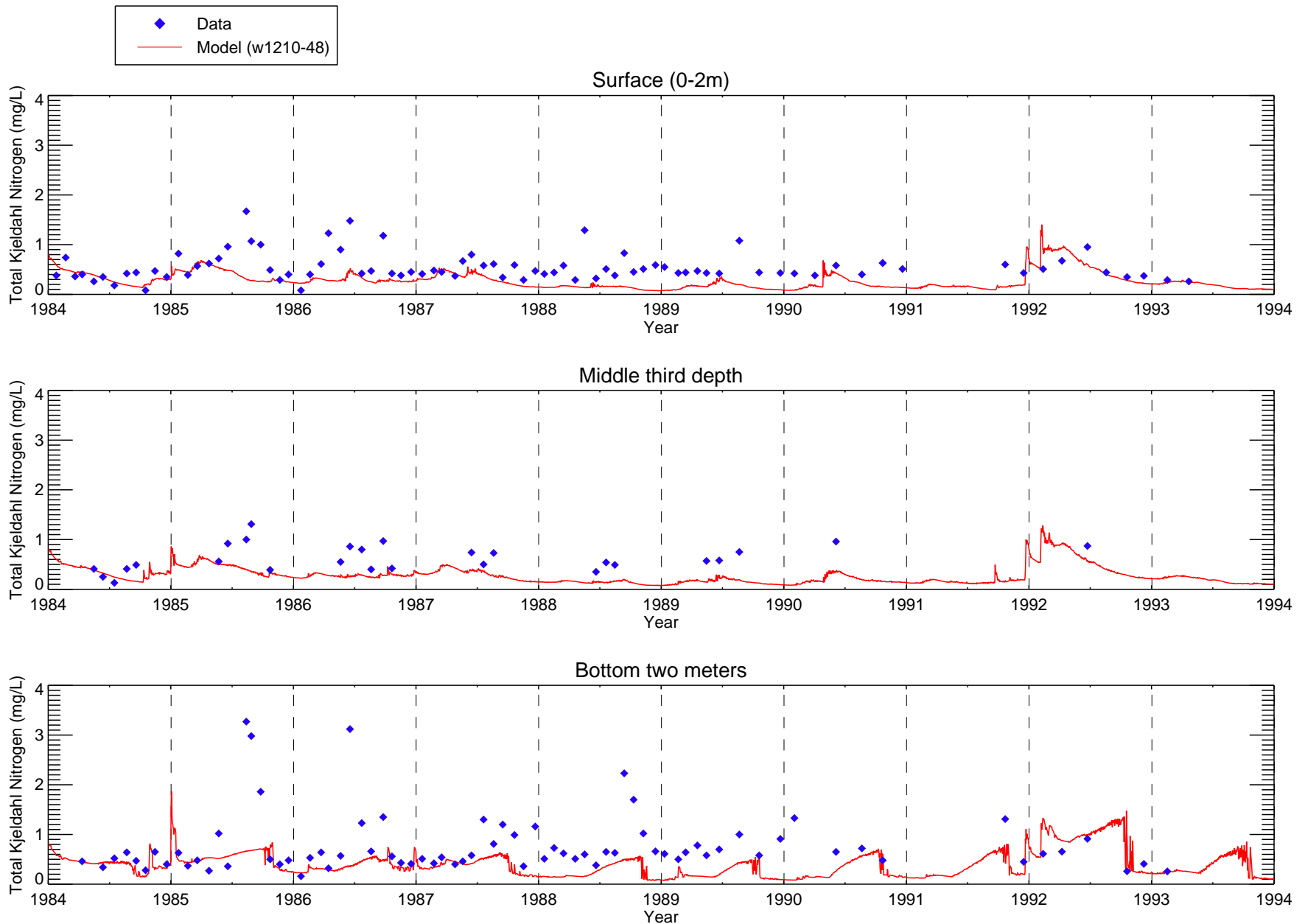CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-14e

Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
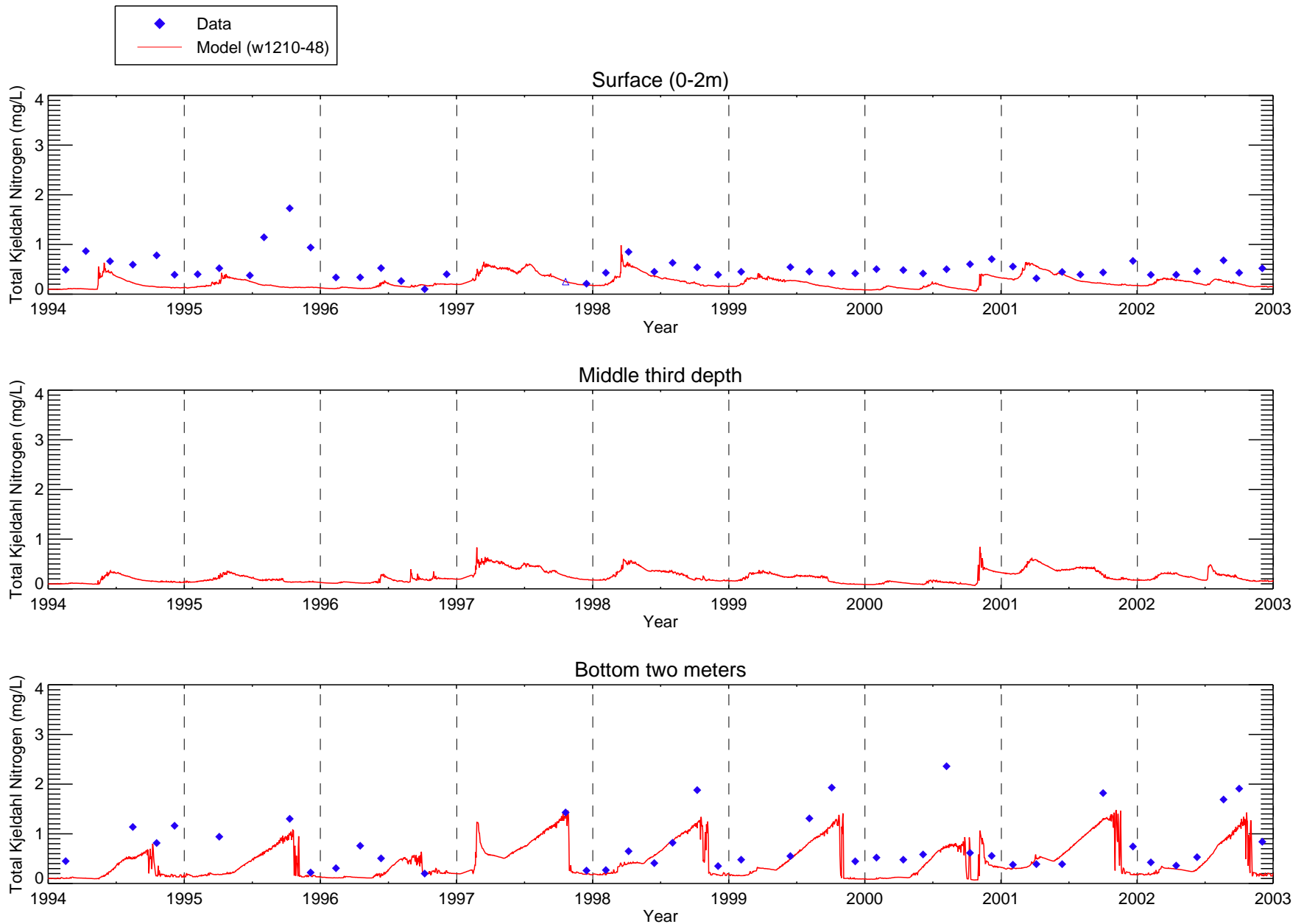
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-14f

Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-14f

Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
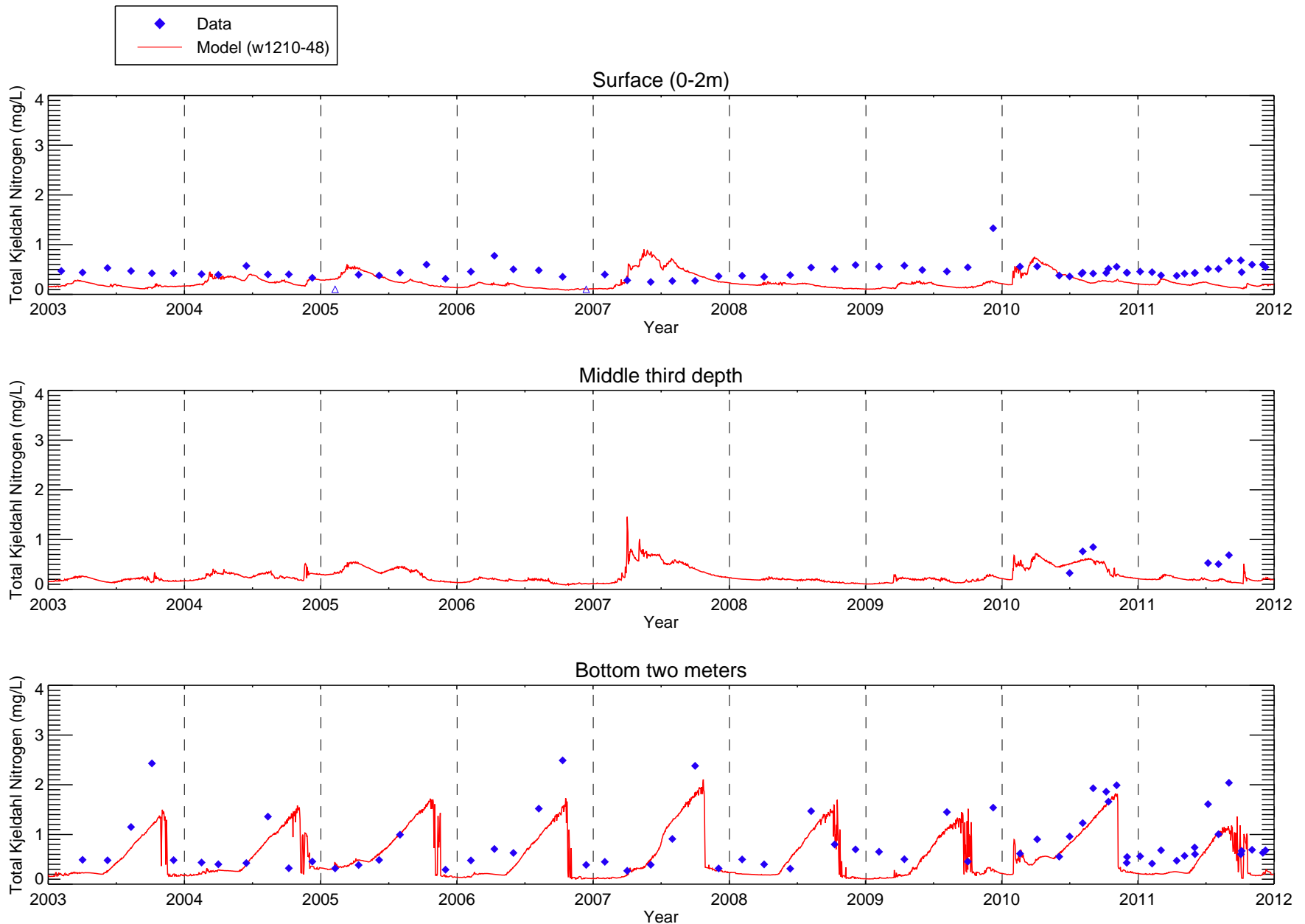Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 20:06:37 2013

Figure 4-14f
Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
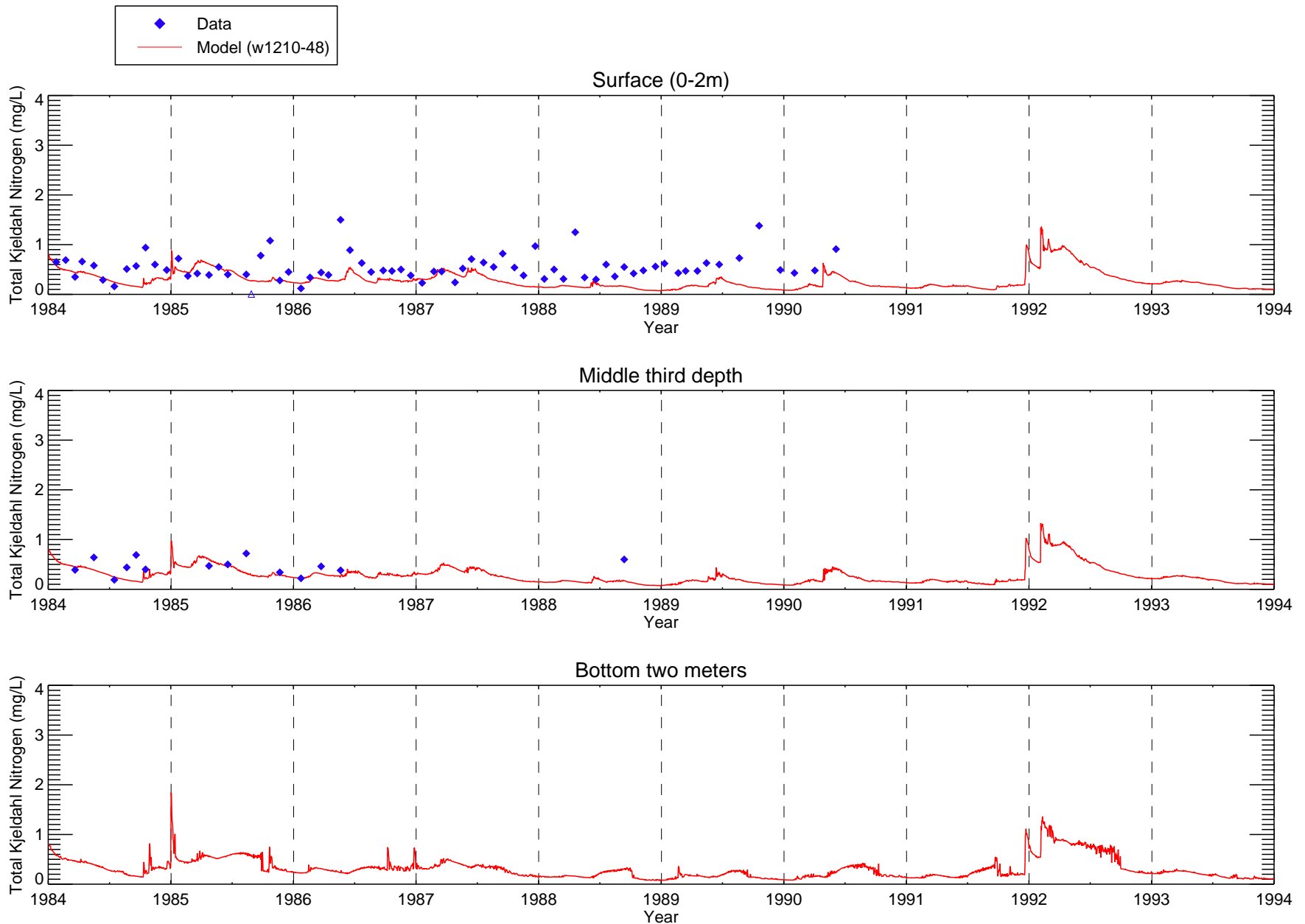Lower Colorado River Authority

Figure 4-14g
Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
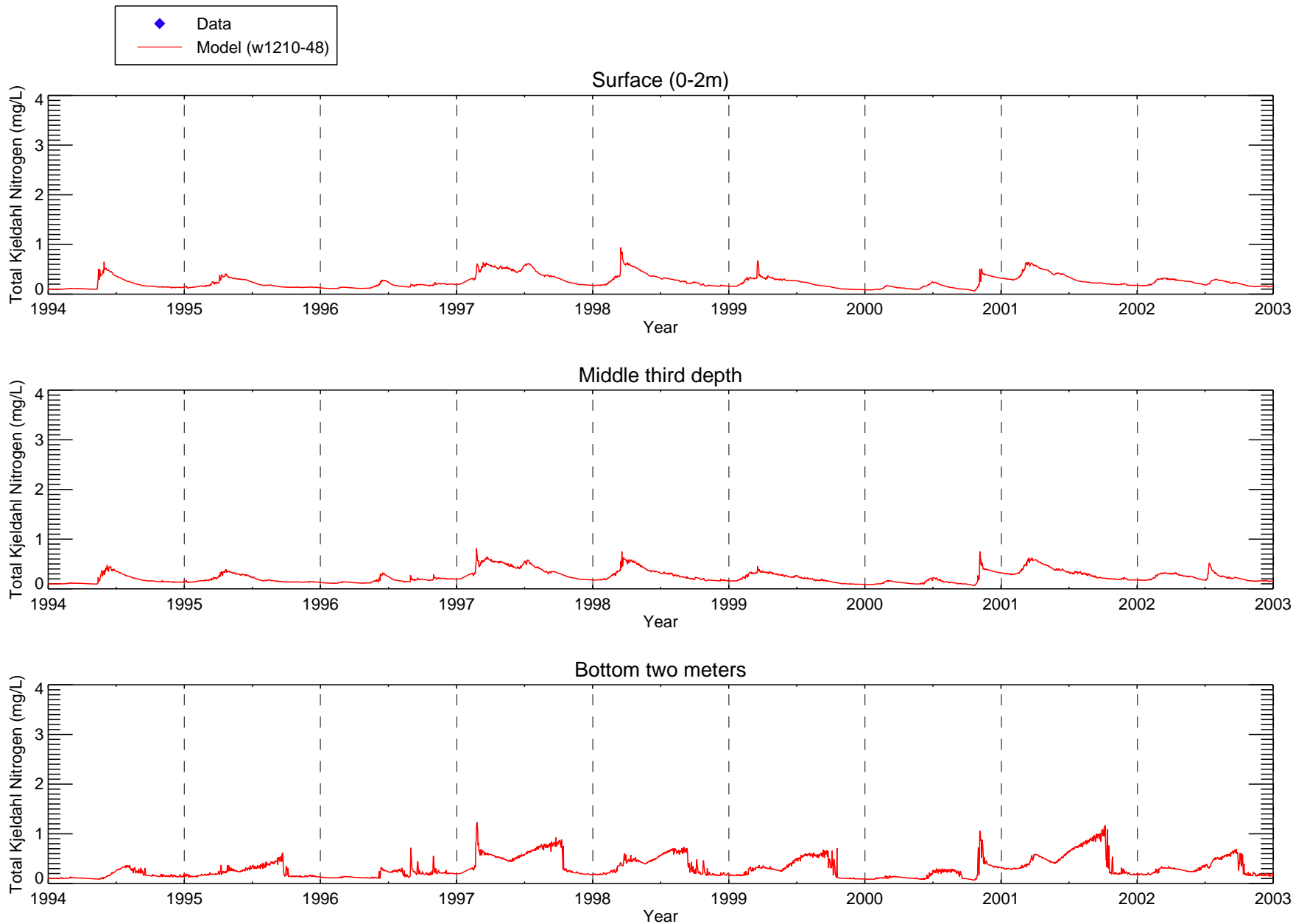Lower Colorado River Authority

Figure 4-14g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
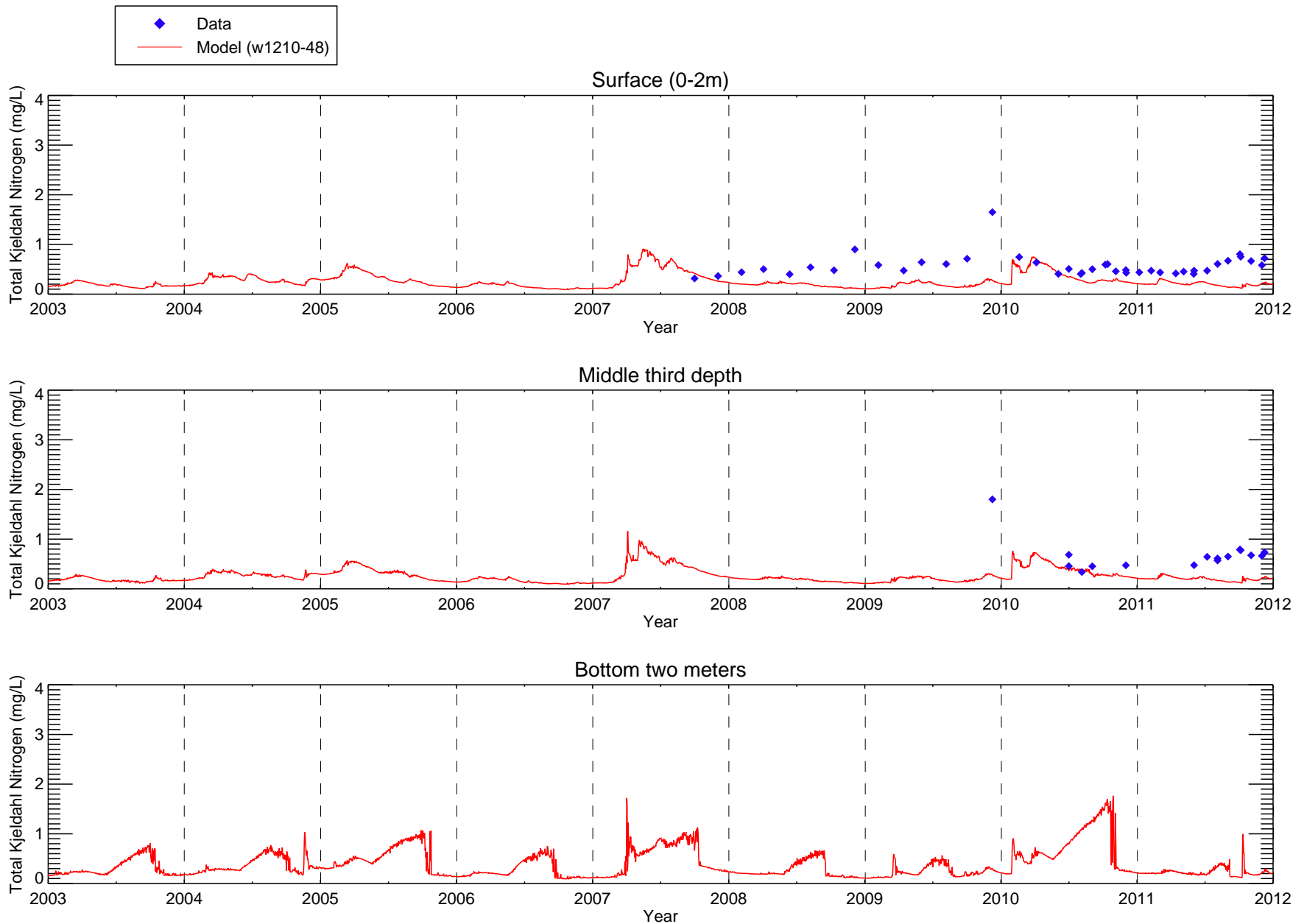Lower Colorado River Authority

Figure 4-14g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
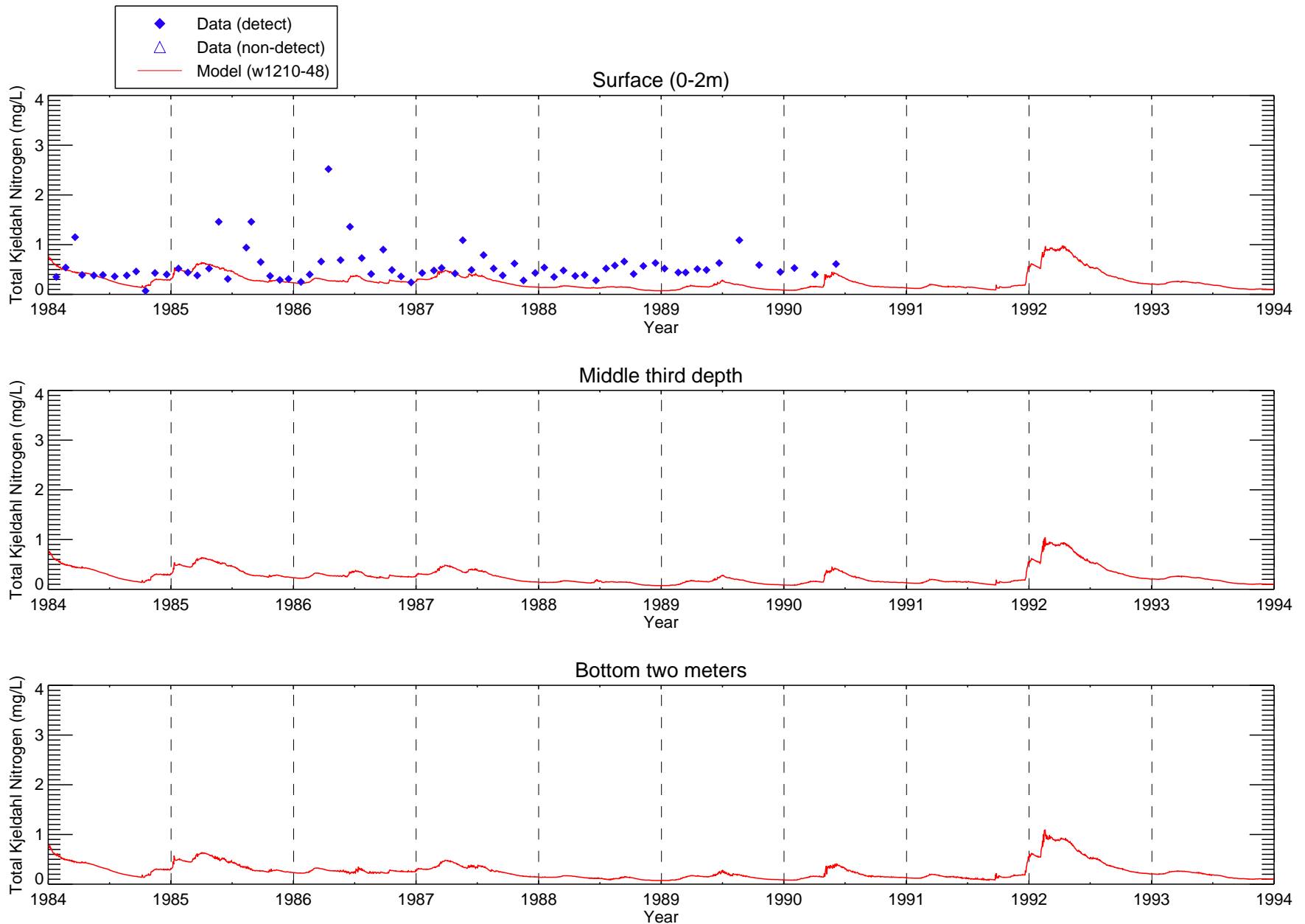Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 20:16:30 2013

Figure 4-14h
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
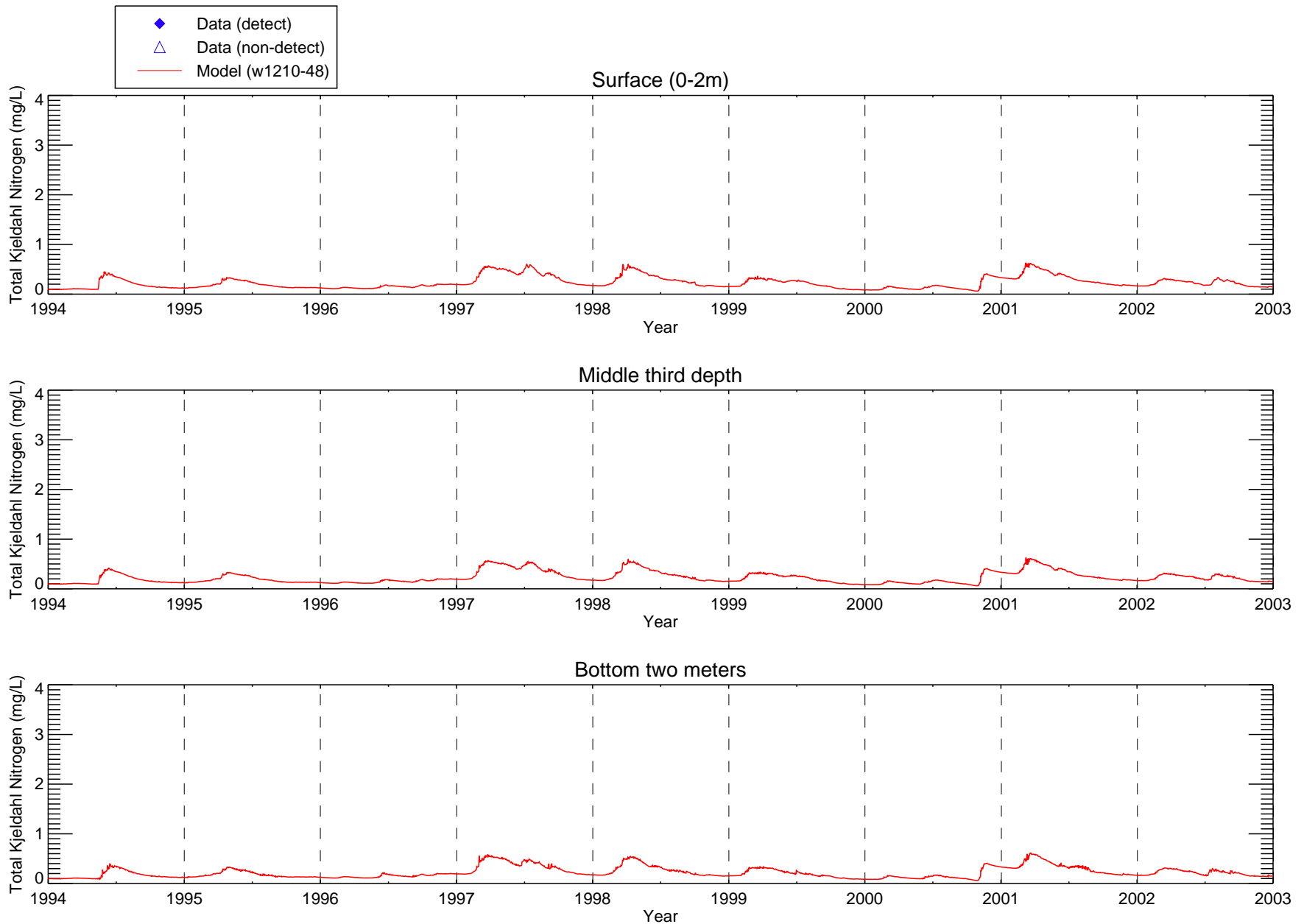
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 20:17:06 2013

Figure 4-14h
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
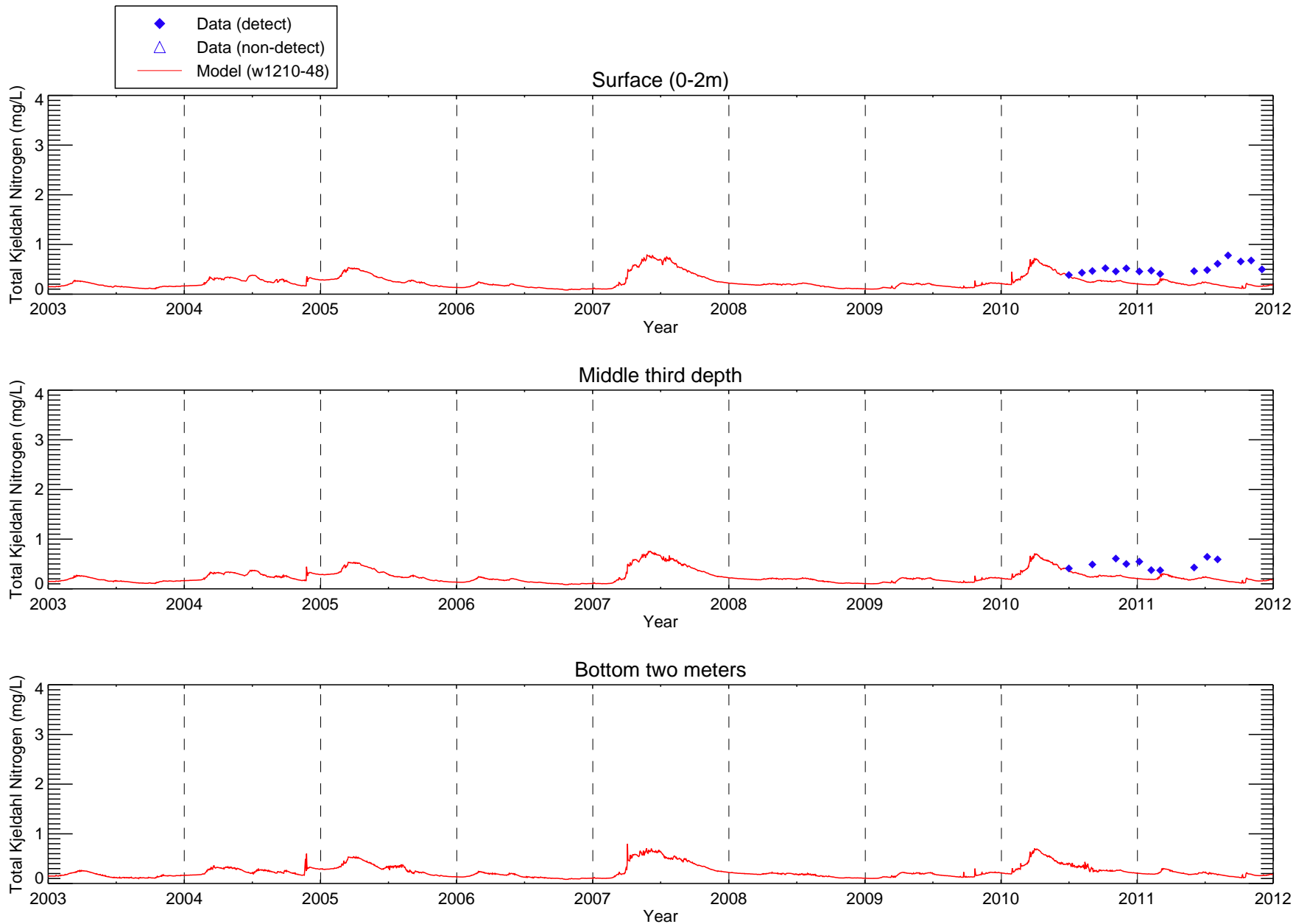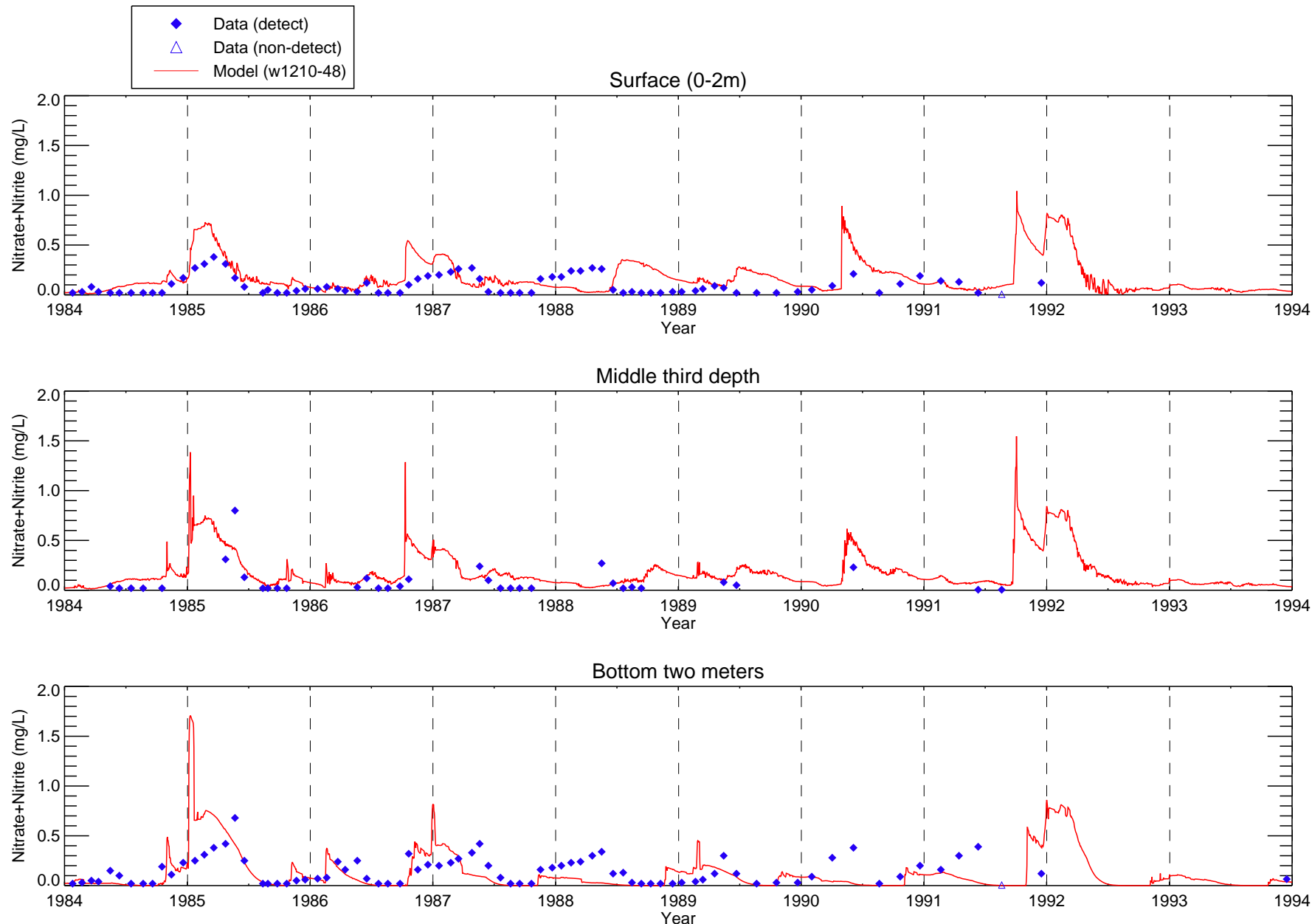
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-14h

Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
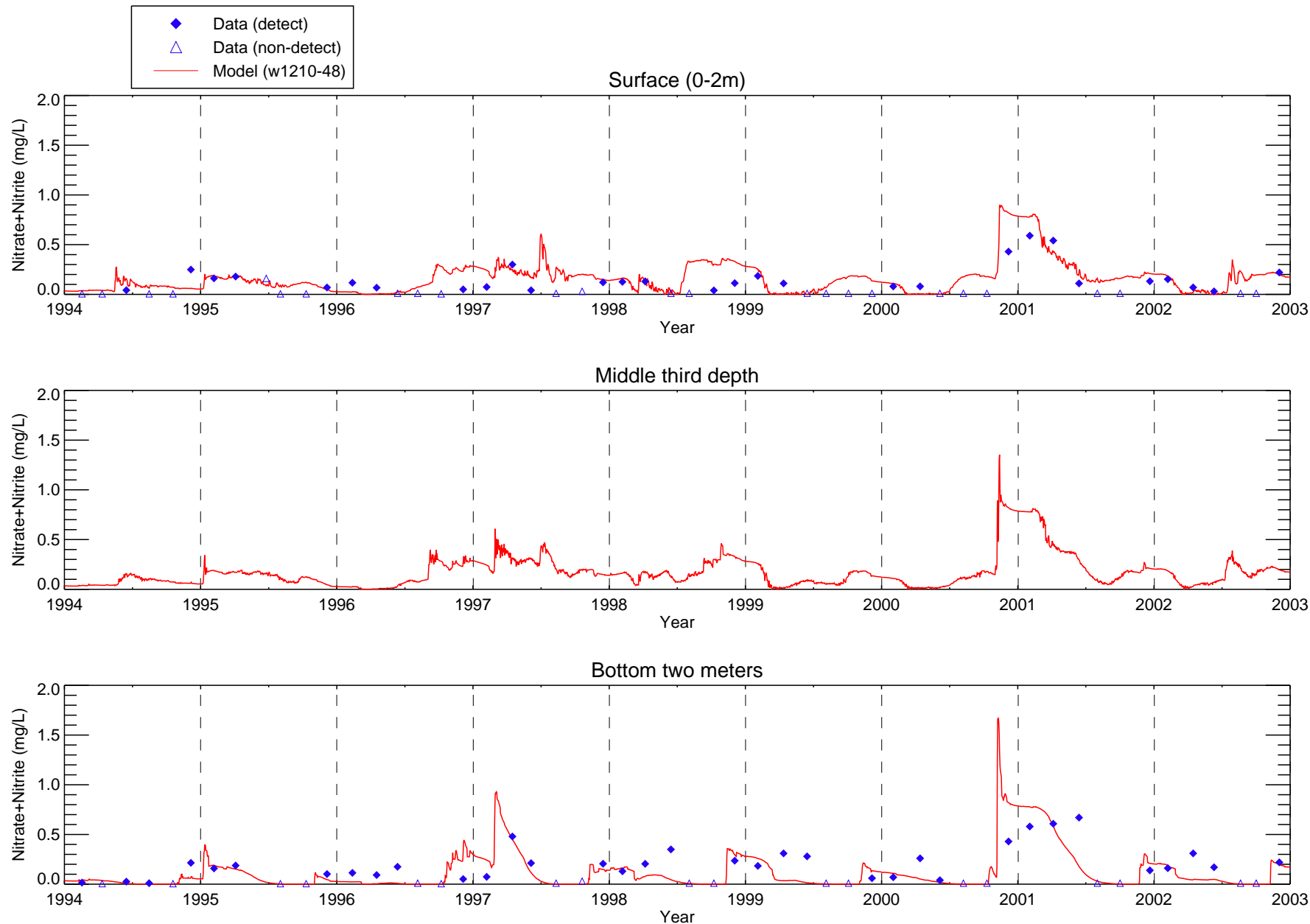PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 20:18:14 2013

Figure 4-15a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
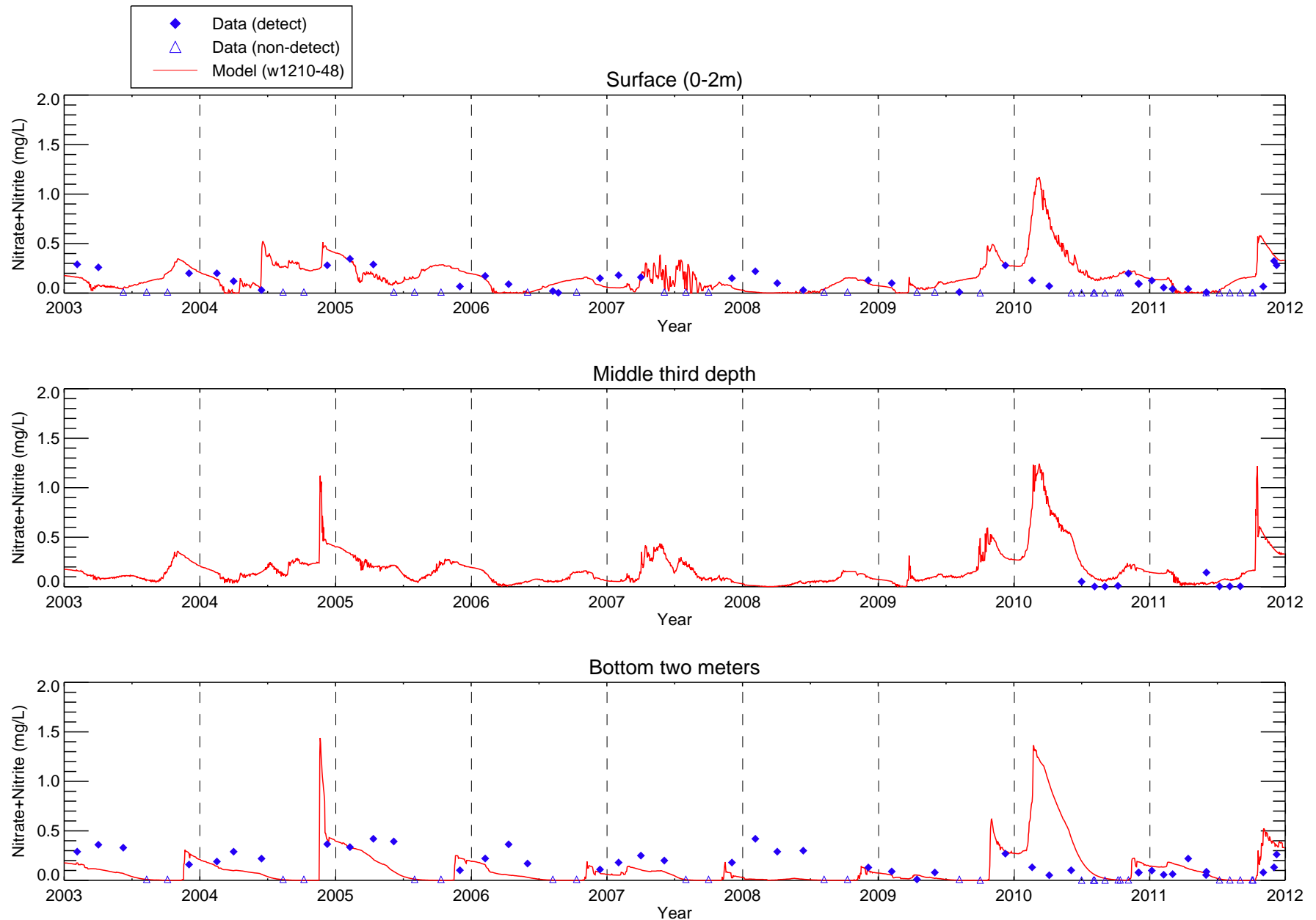
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-15a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
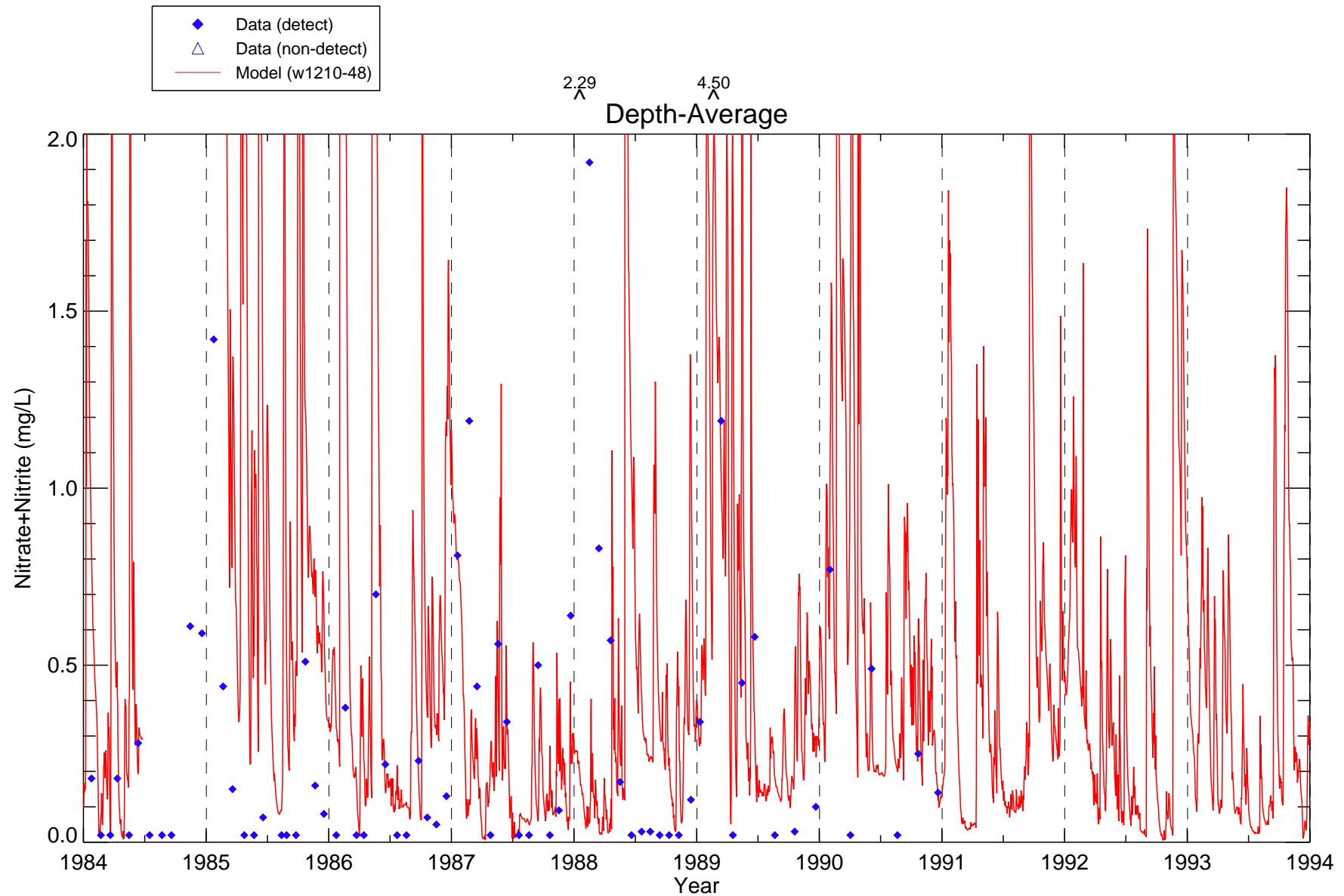
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-15a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-15b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Total Kjeldahl Nitrogen

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
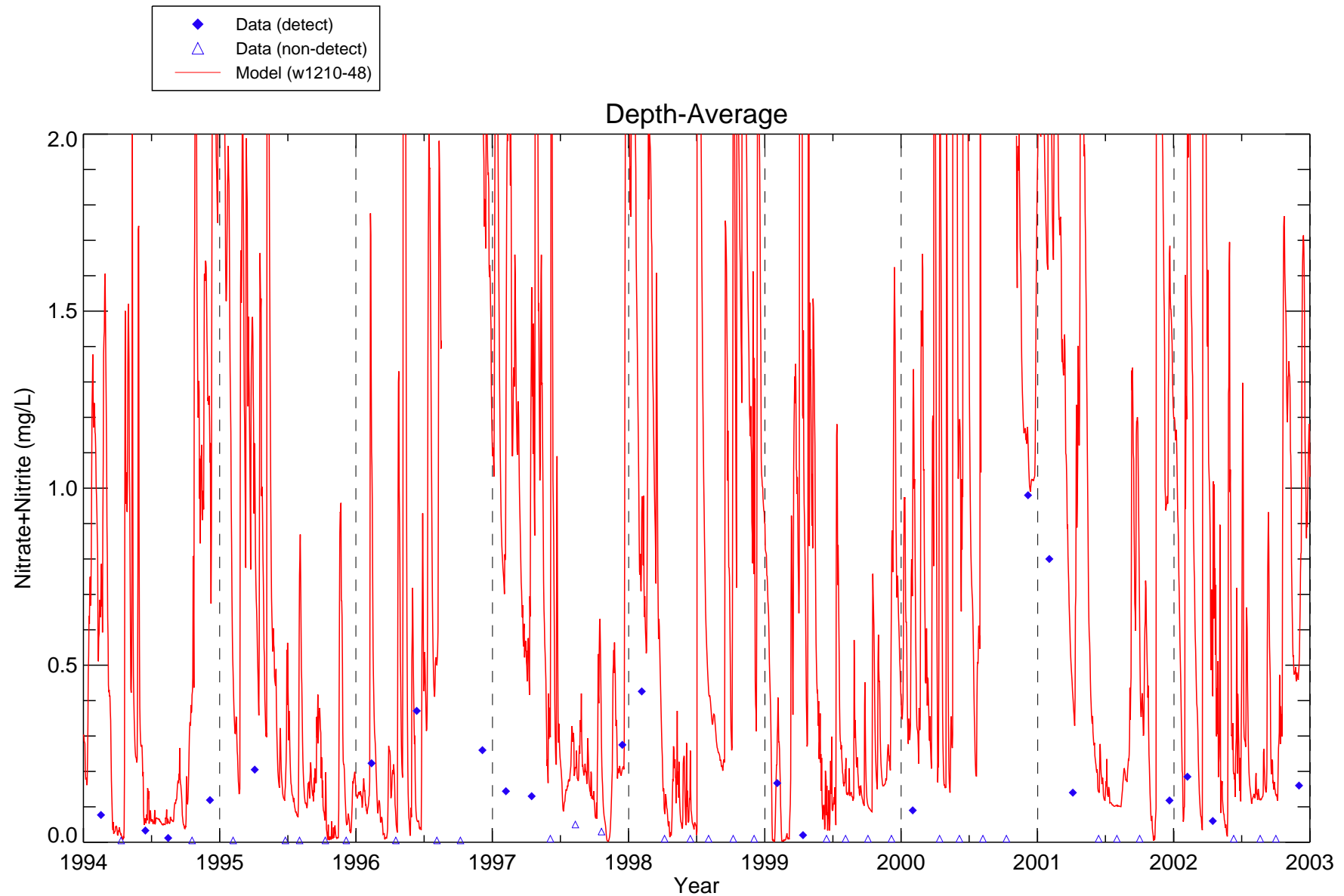
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-15b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Total Kjeldahl Nitrogen

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
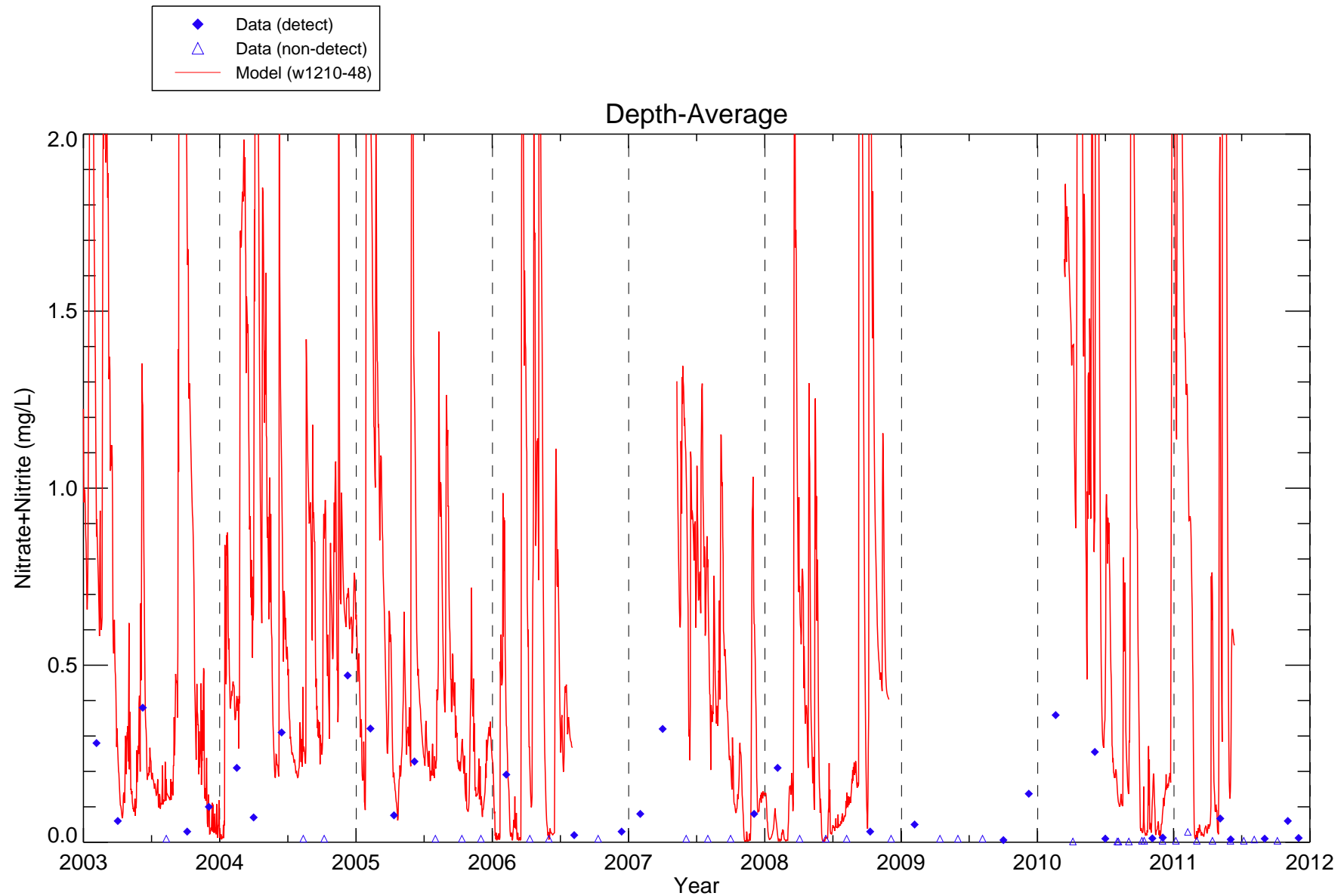
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:33:59 2013

Figure 4-15b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Total Kjeldahl Nitrogen

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
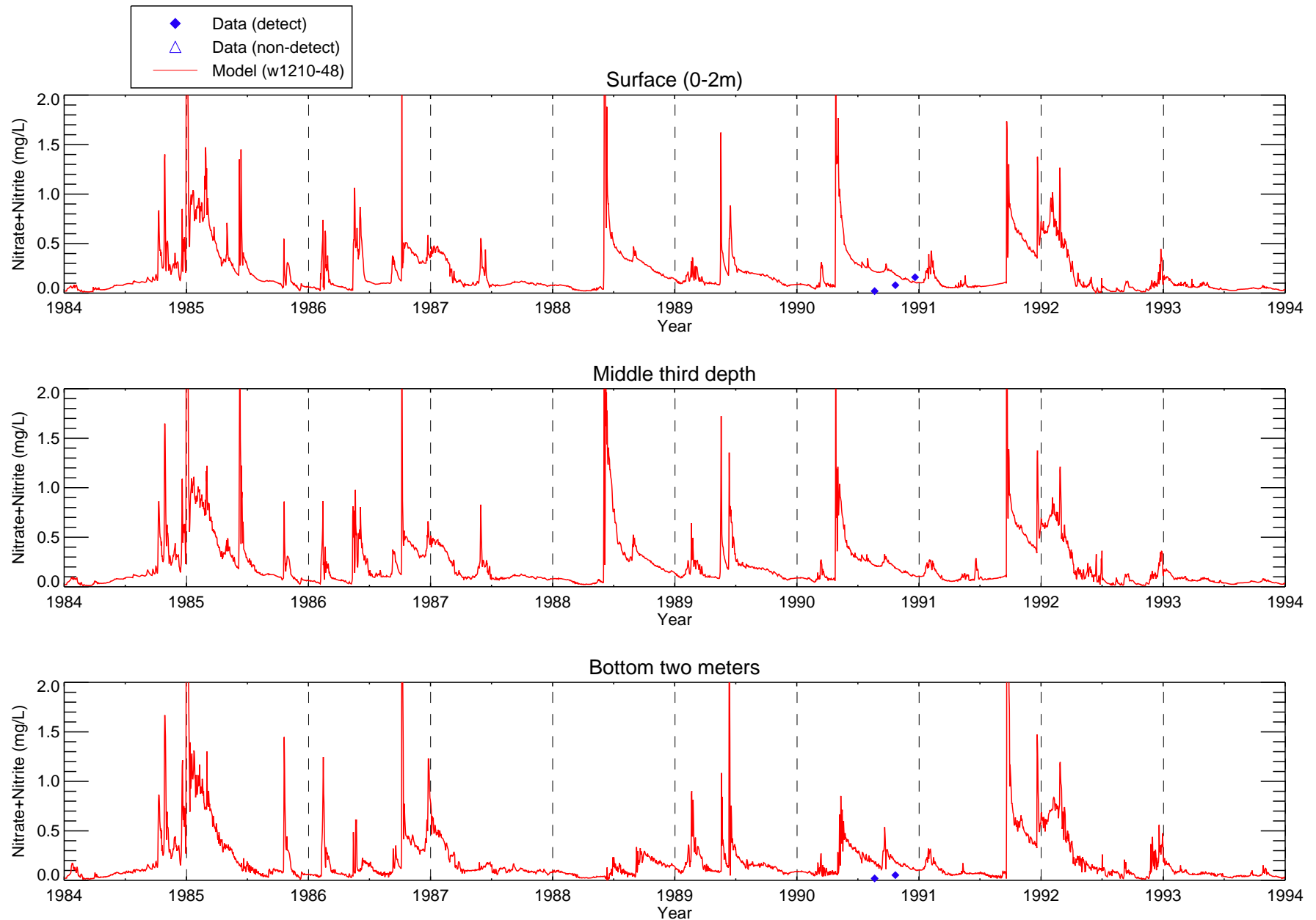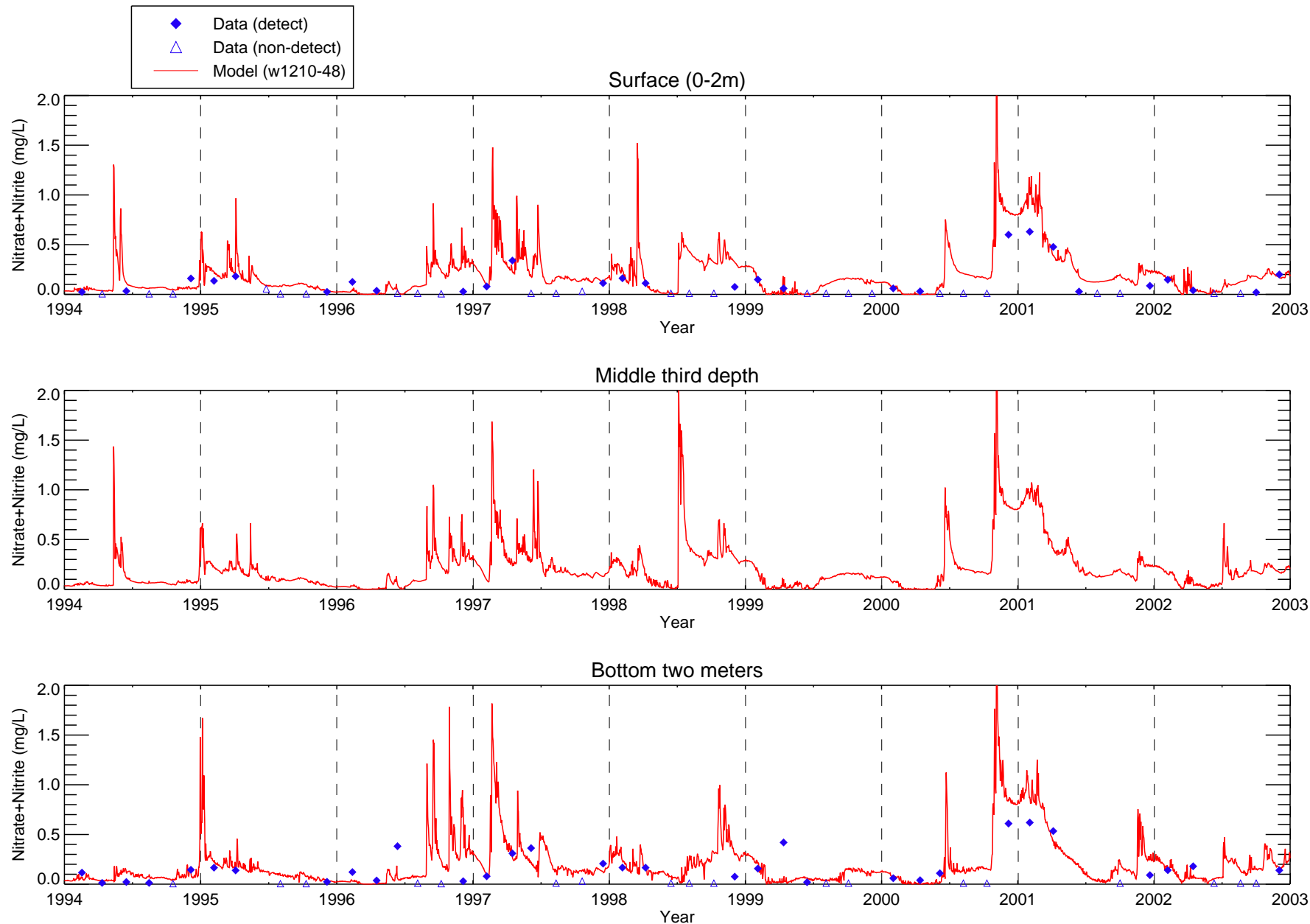
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:34:04 2013

ANCHOR
QEA
PARSONS

Figure 4-15c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

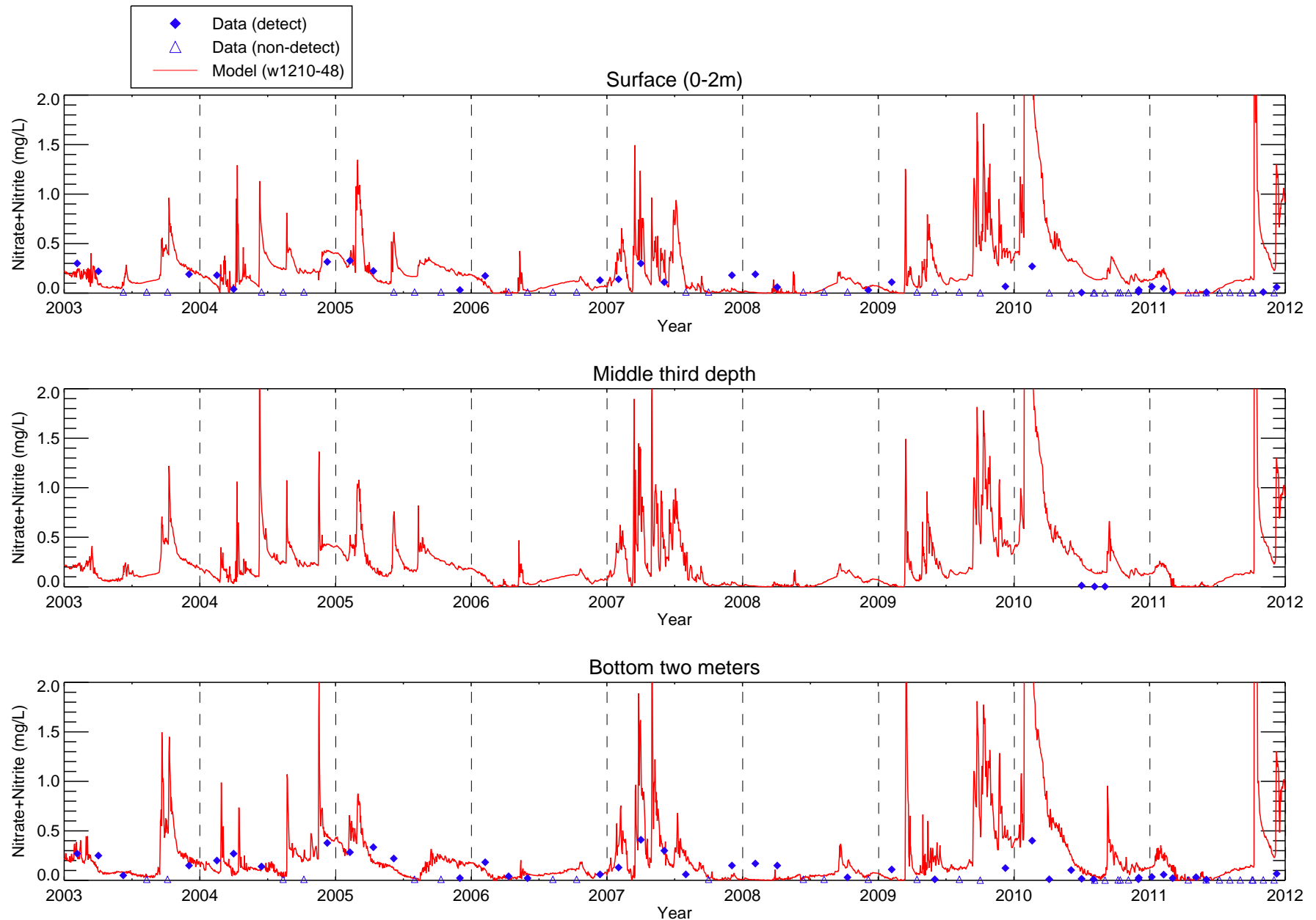CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 13:11:42 2013

Figure 4-15c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

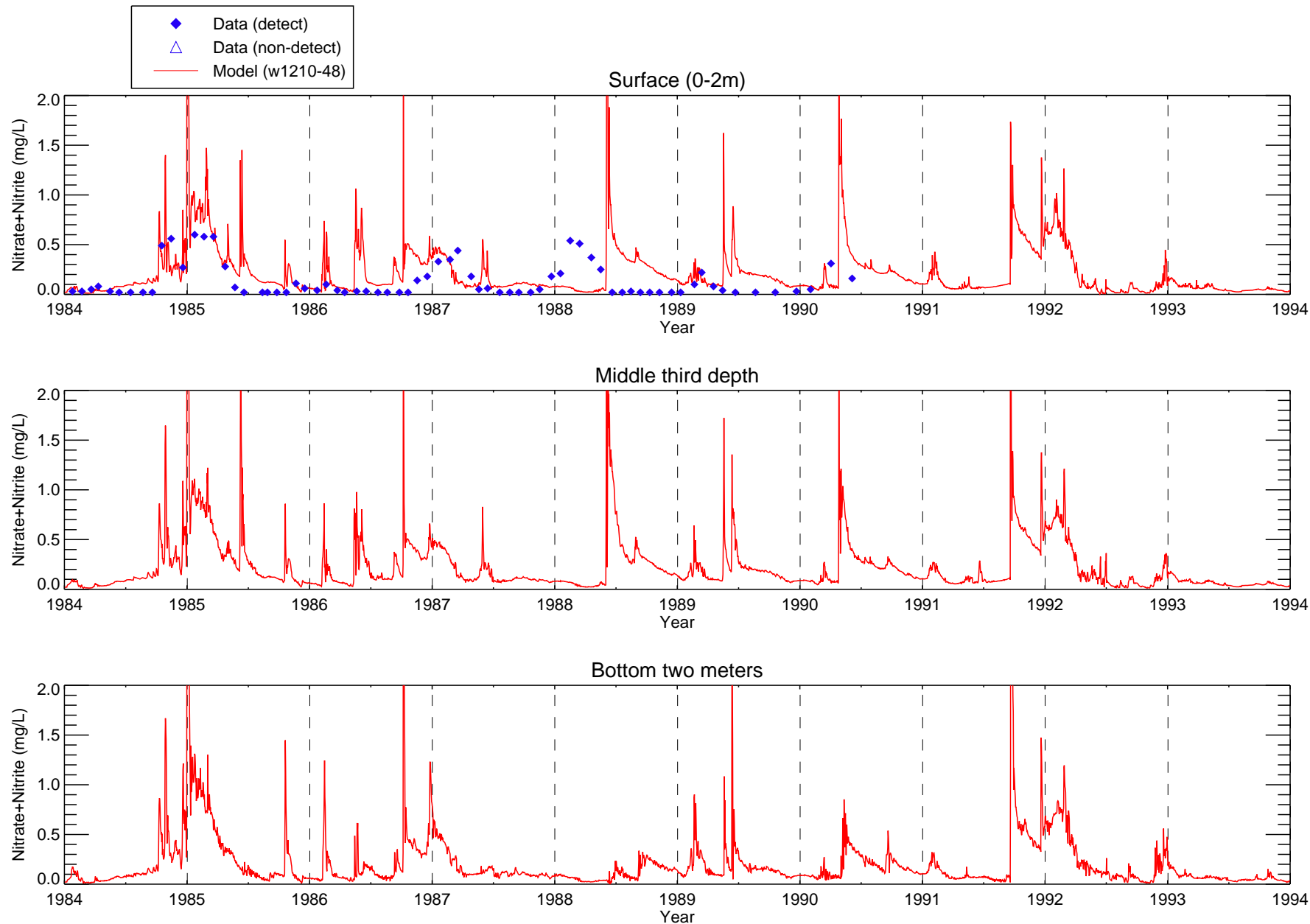CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-15c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
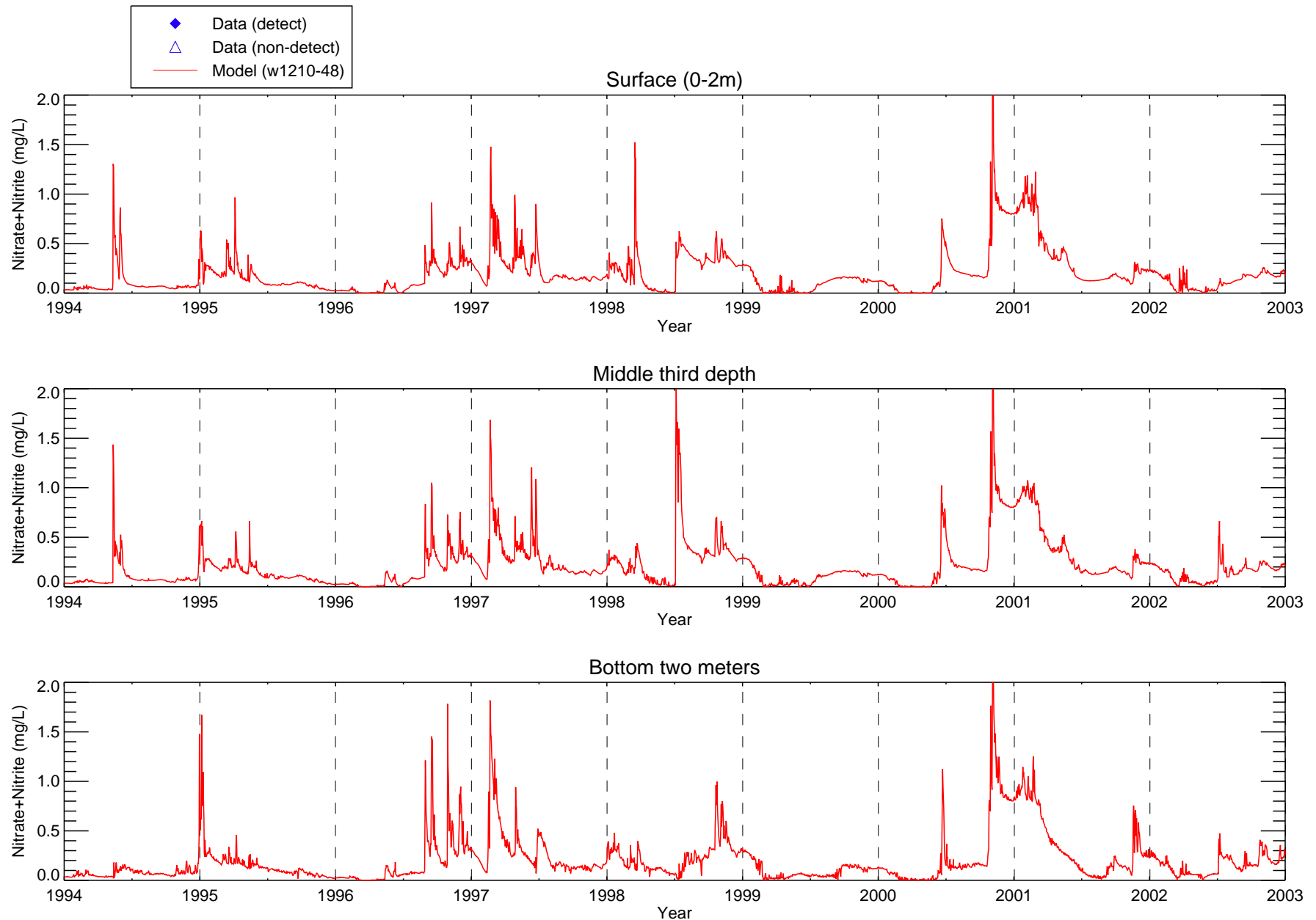
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-15d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
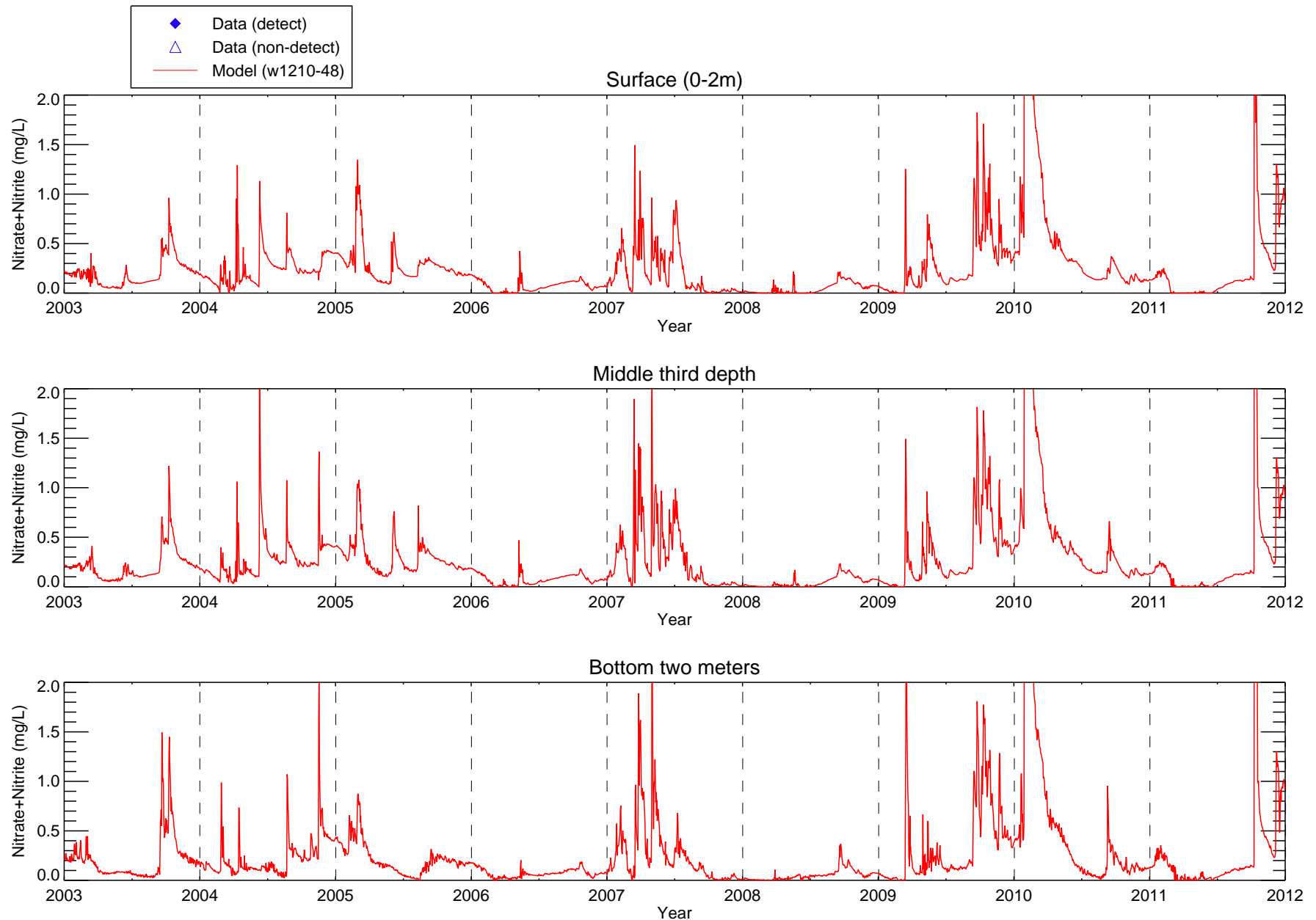
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - \\austin2\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 09:10:41 2013

Figure 4-15d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
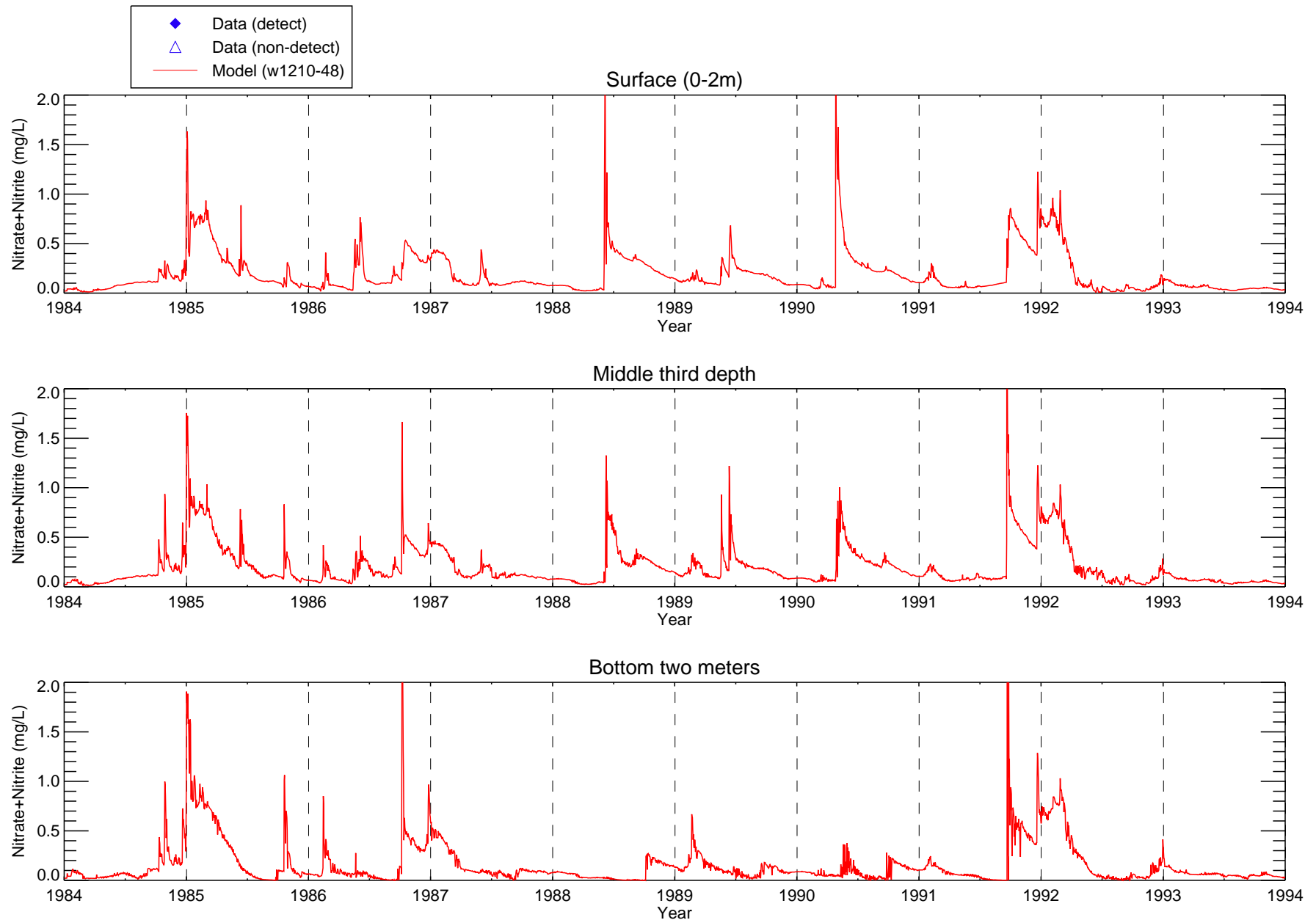
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-15d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
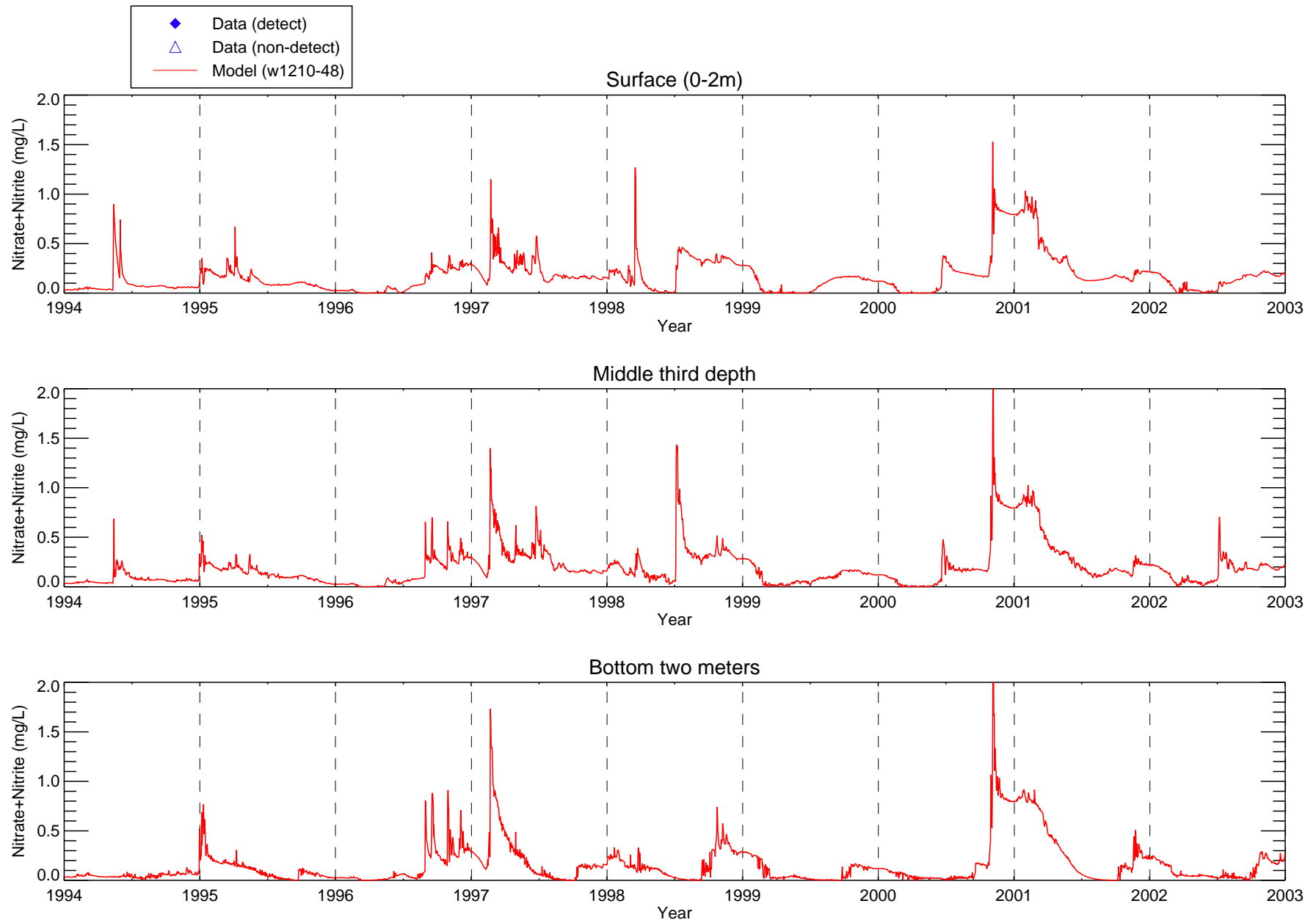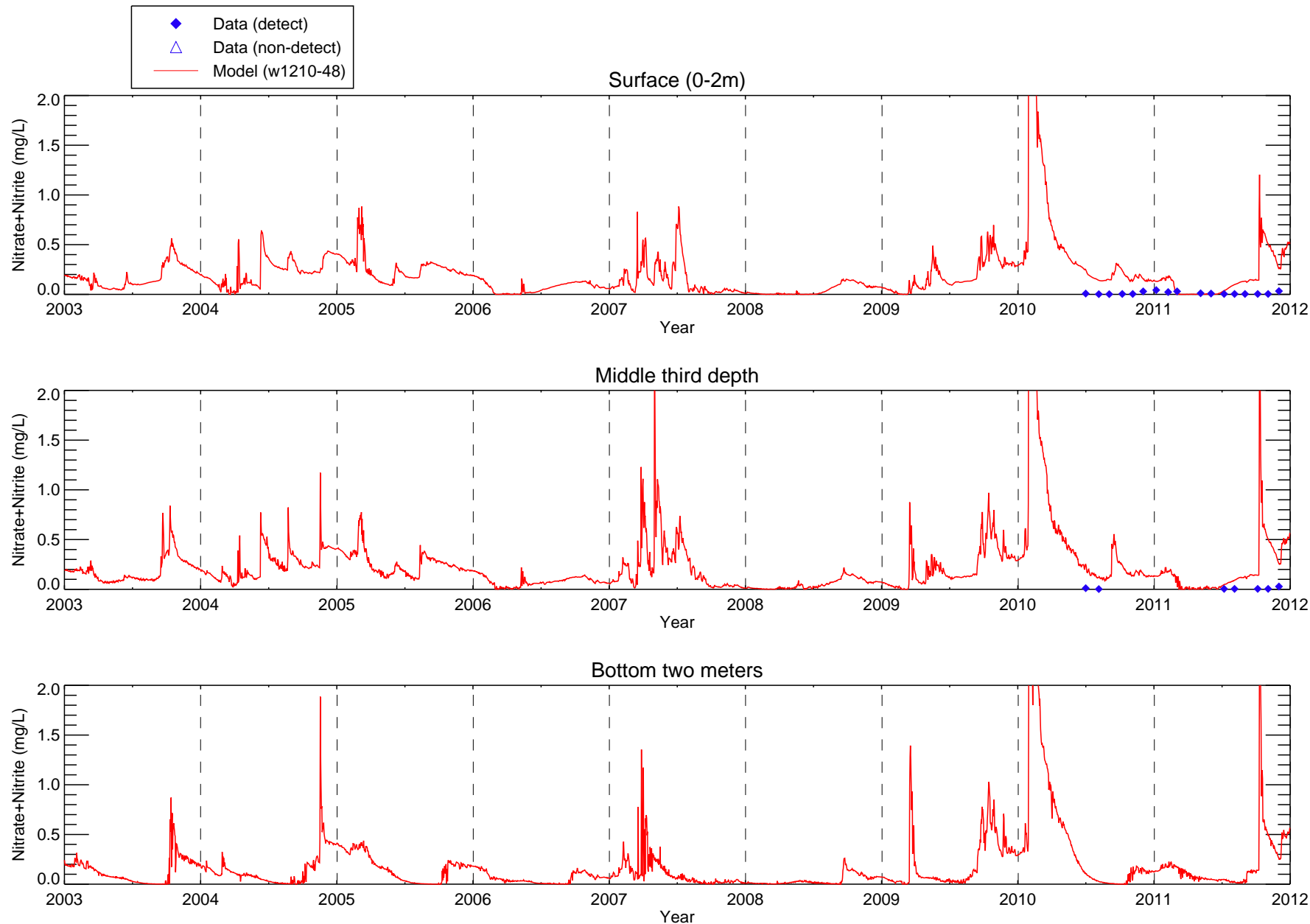
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-15e

Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

Figure 4-15e

Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
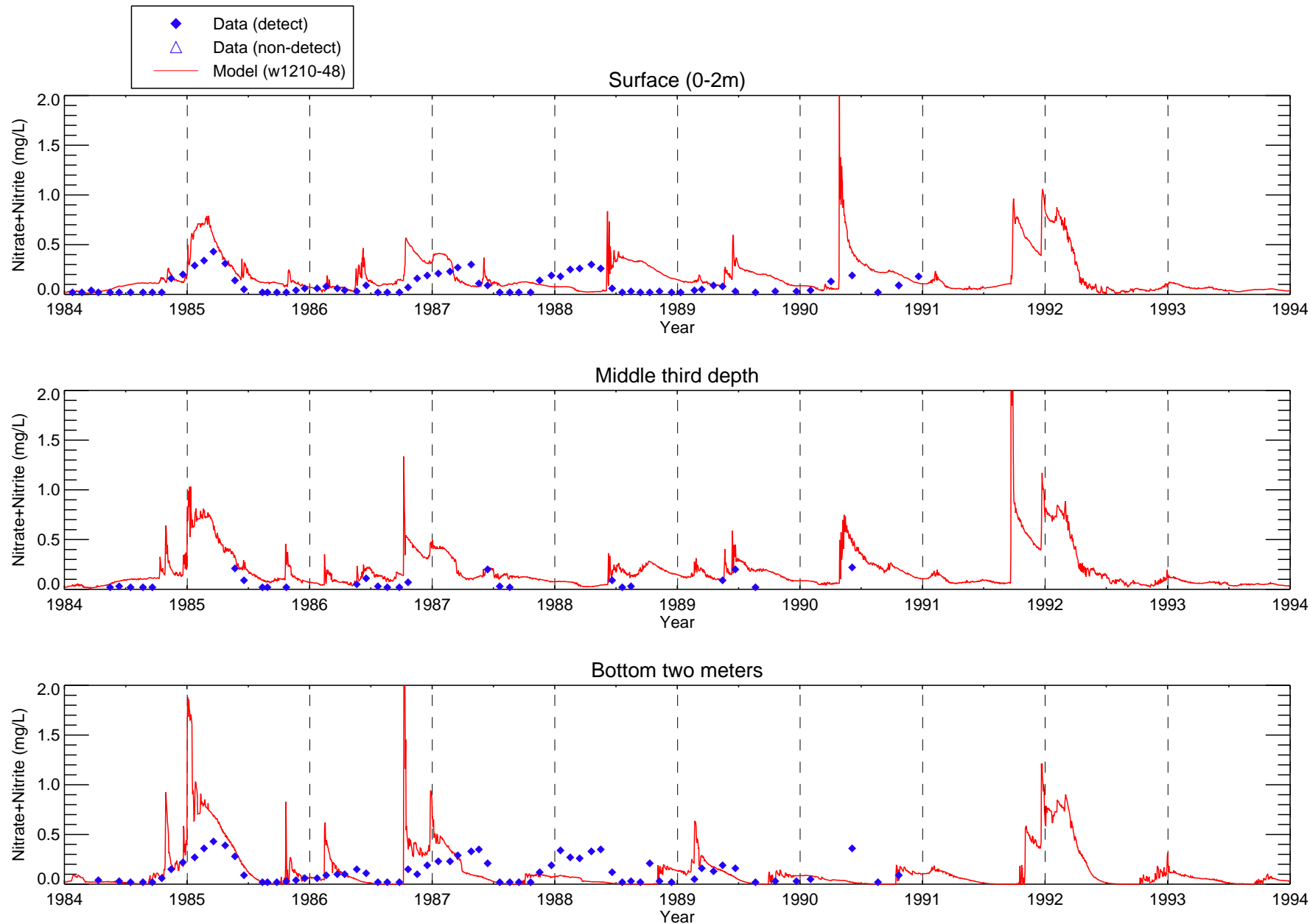
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-15e

Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-1) f
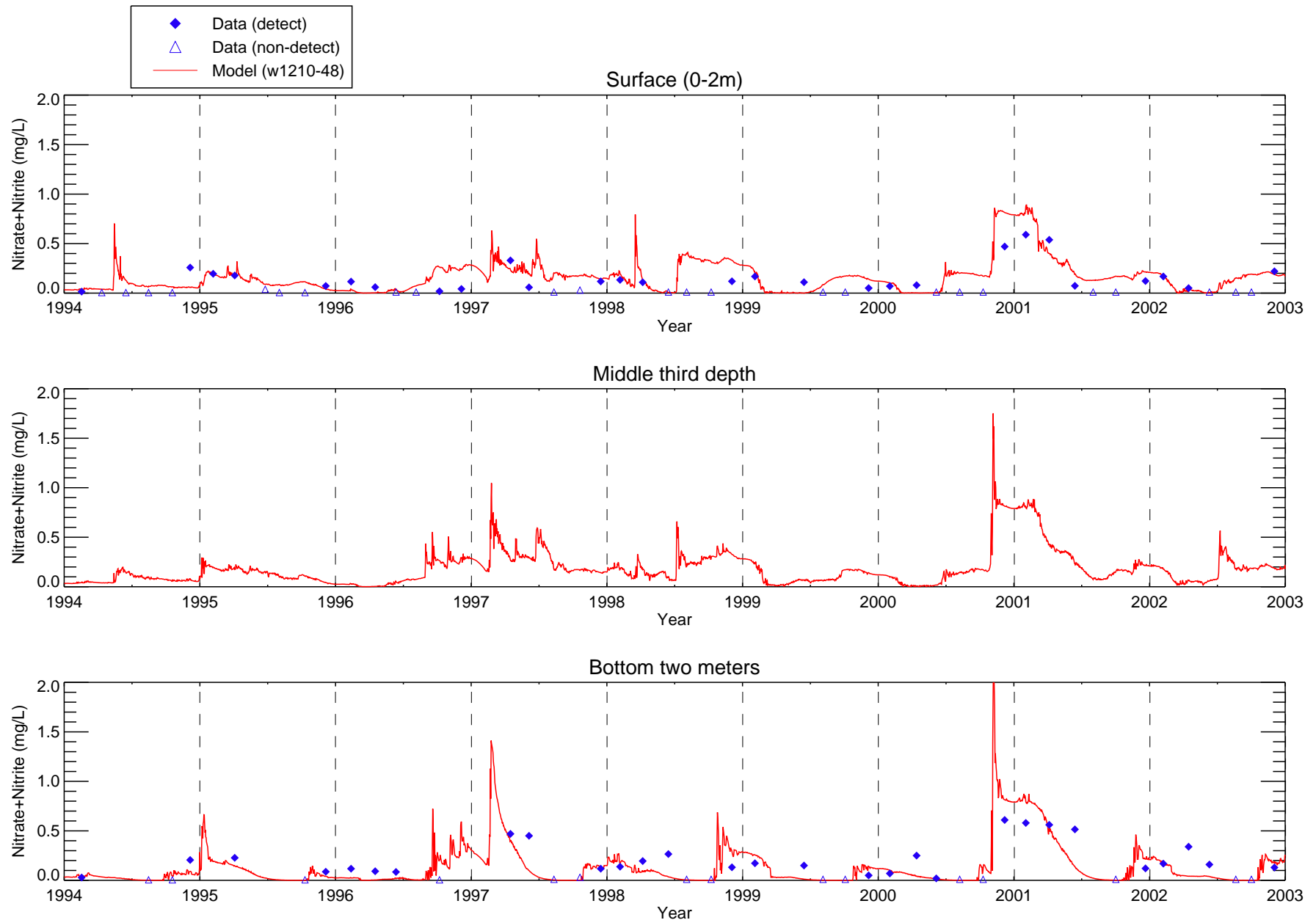**Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Total Kjeldahl Nitrogen**

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
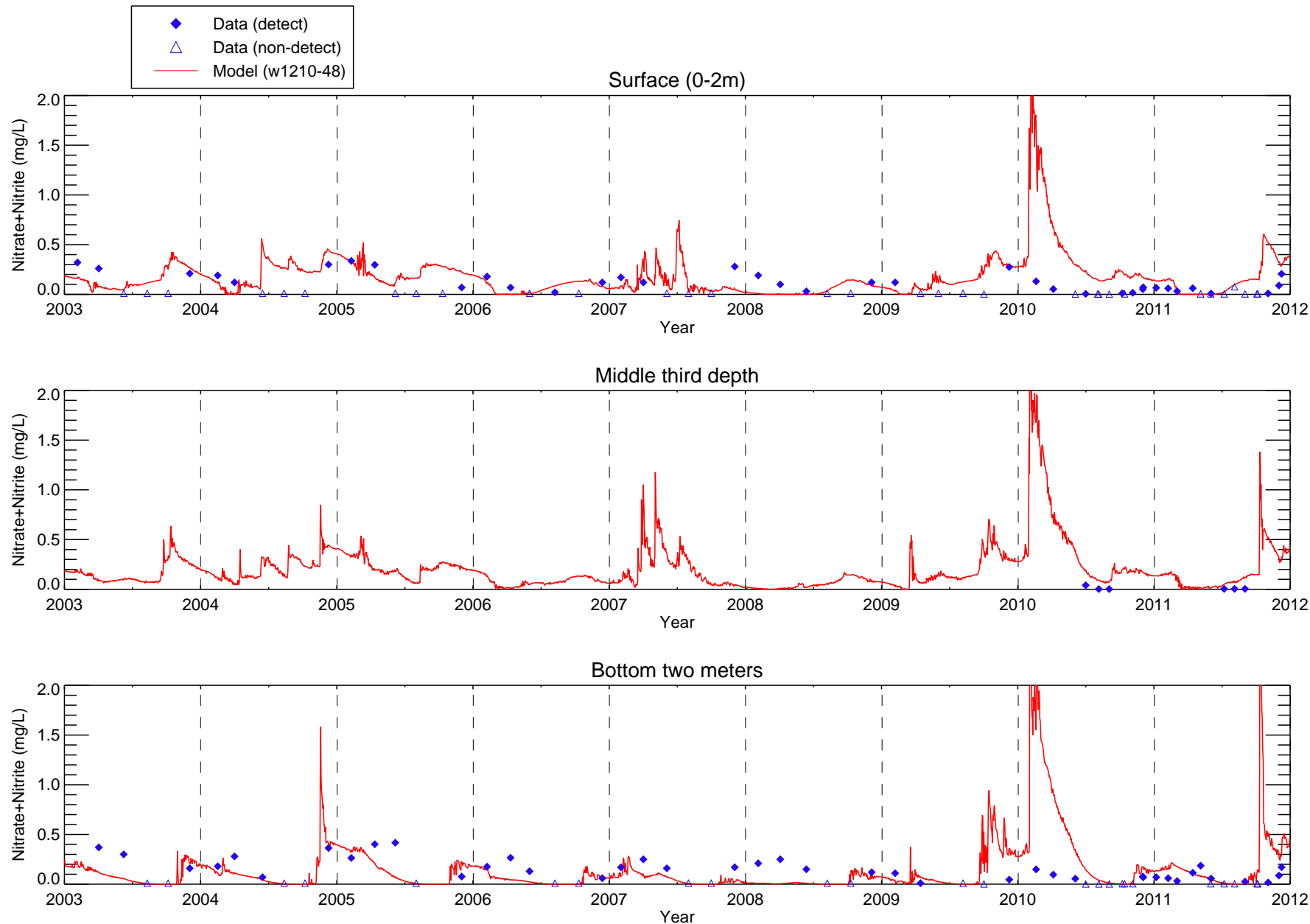Lower Colorado River Authority

Figure 4-15f
Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
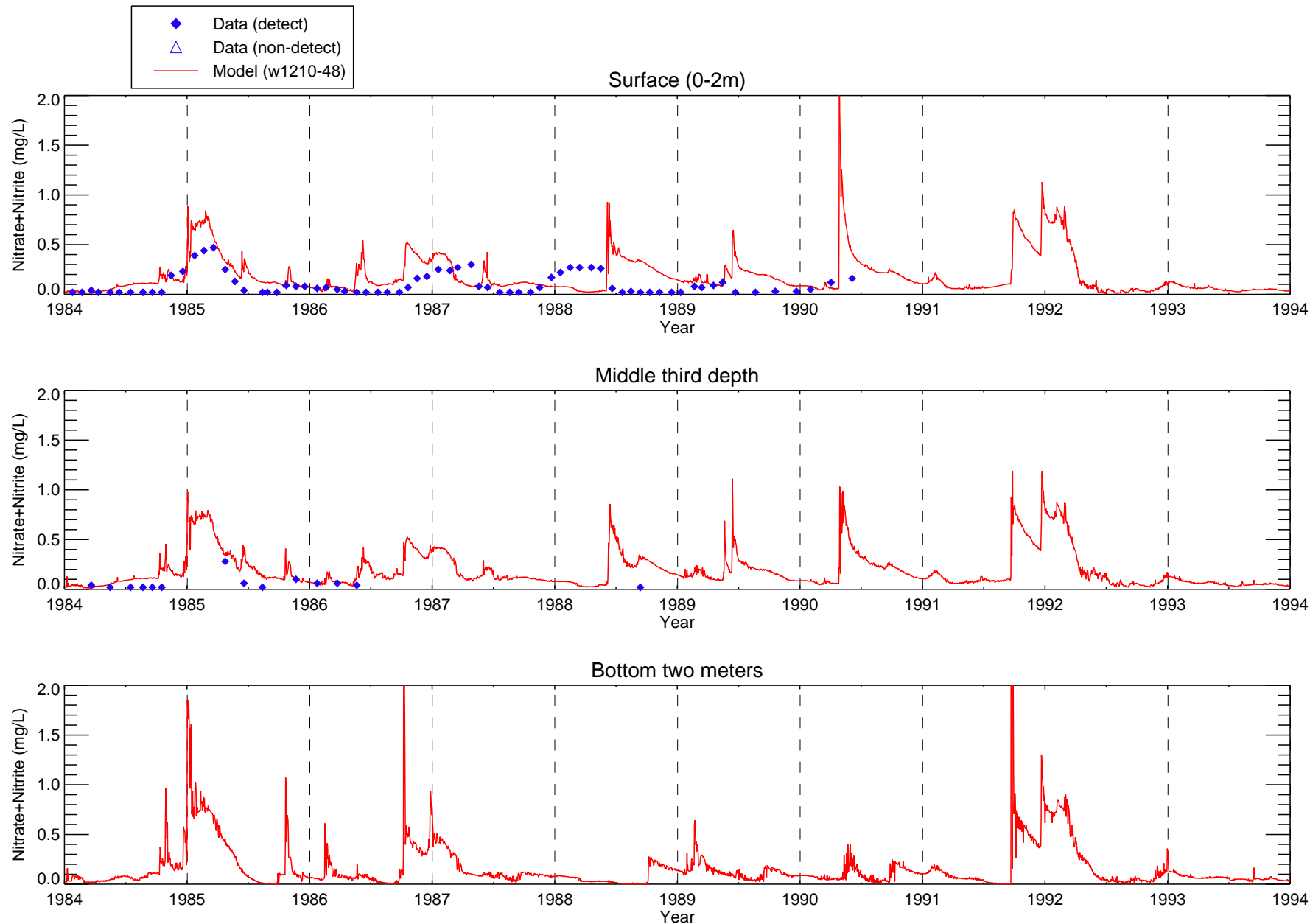
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:22:12 2013

Figure 4-15f

Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
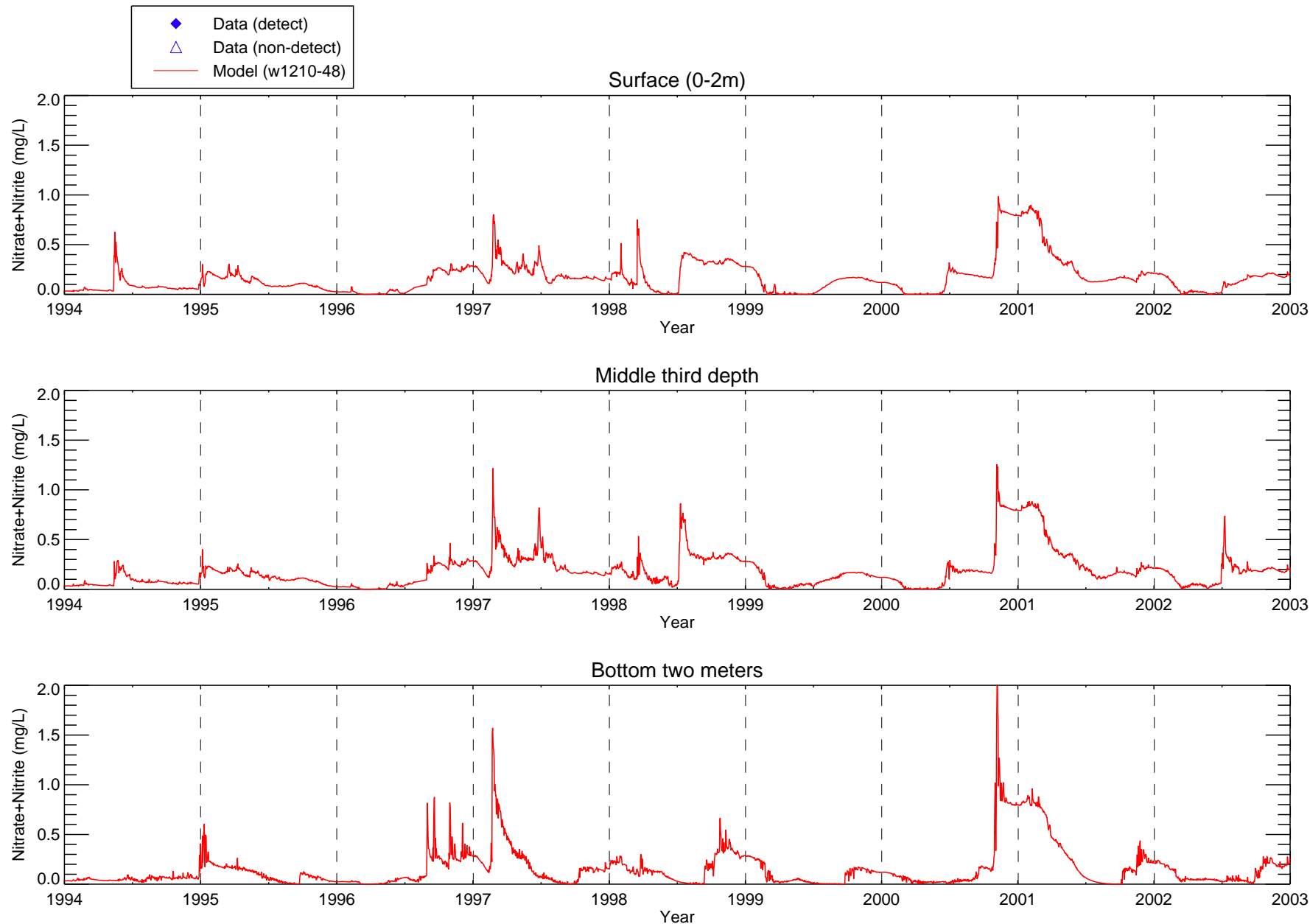
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:23:43 2013

Figure 4-15g
Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
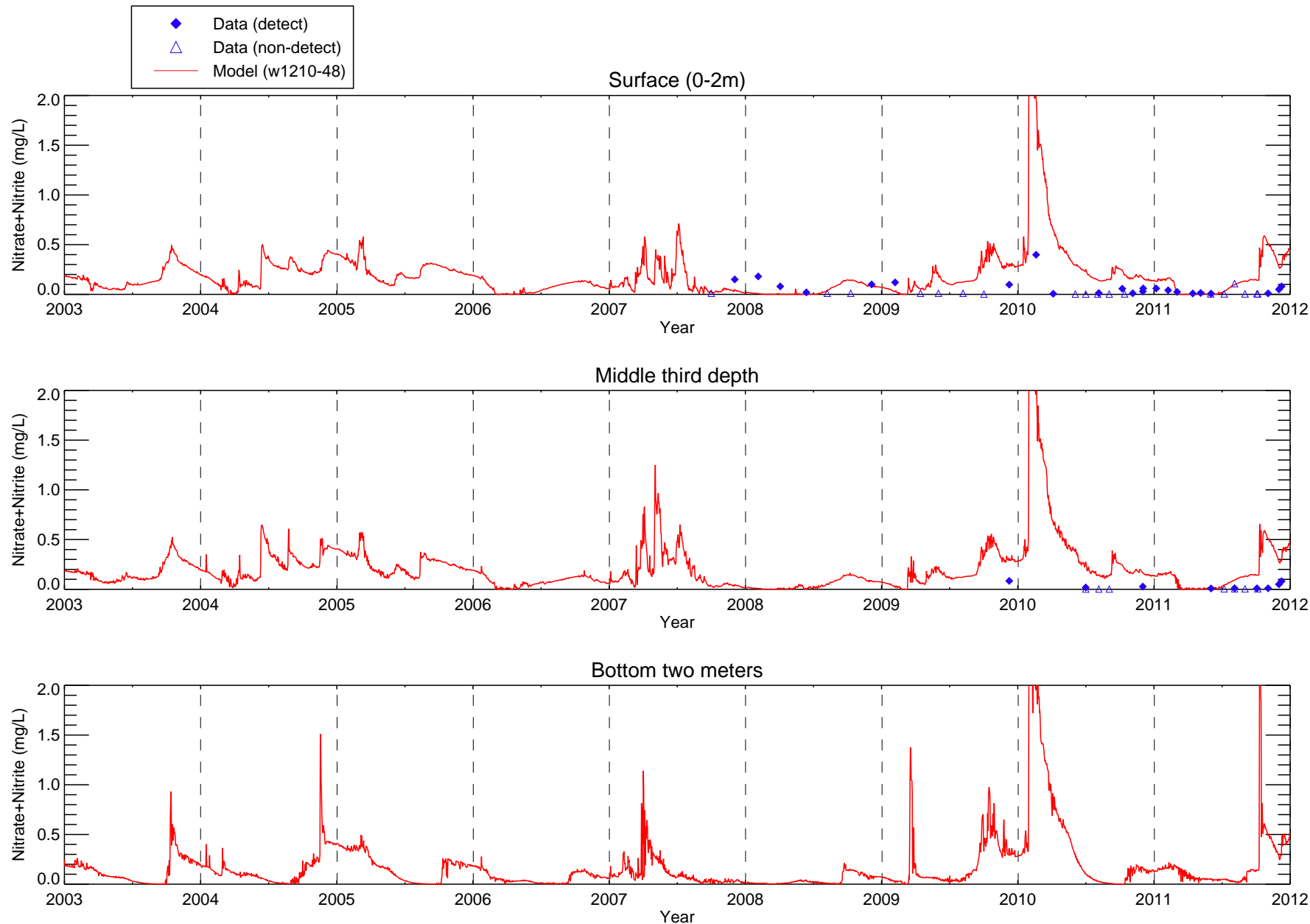
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:30:00 2013

Figure 4-15g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
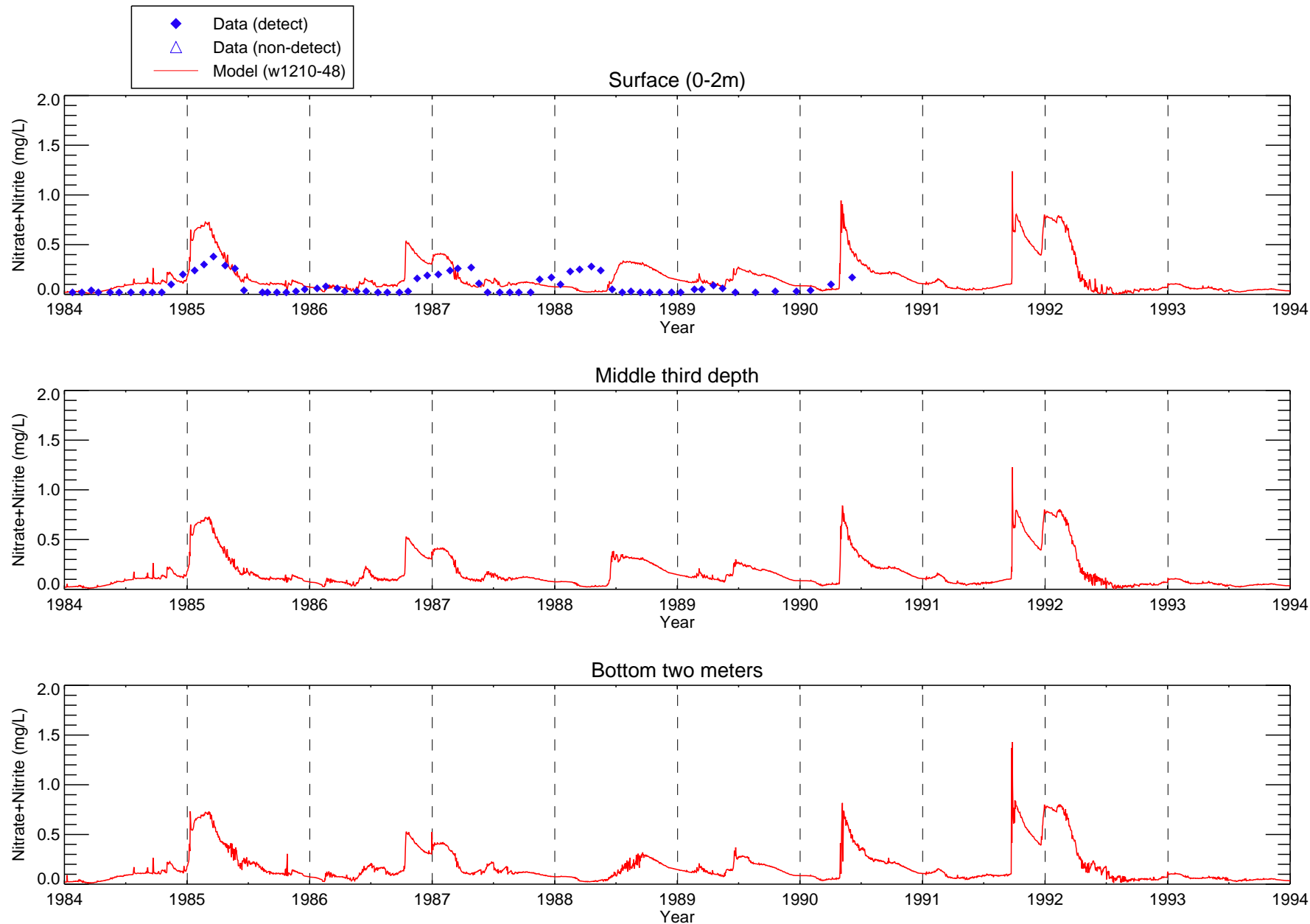
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-15g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
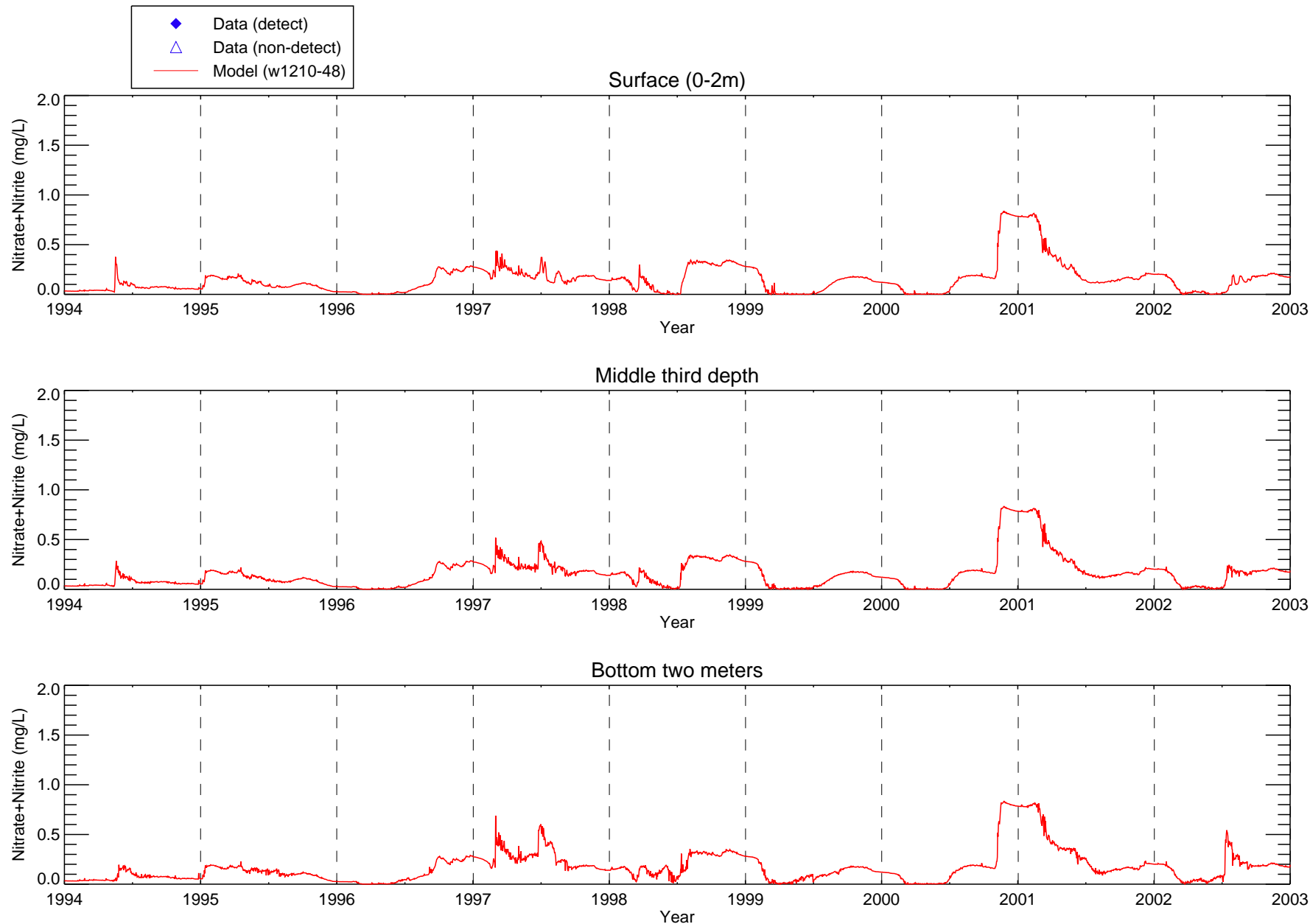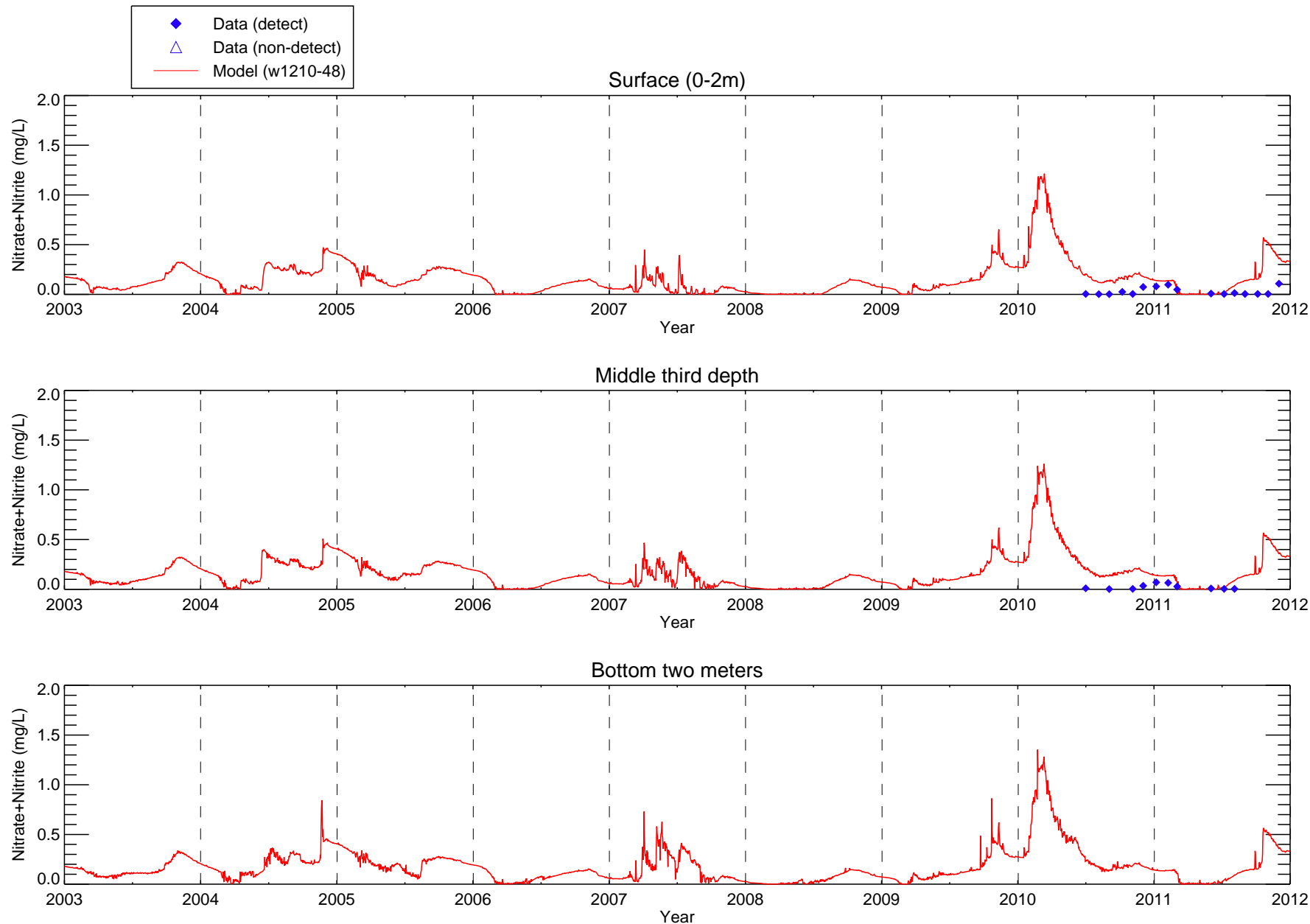
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-15h
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:32:39 2013

Figure 4-15h
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

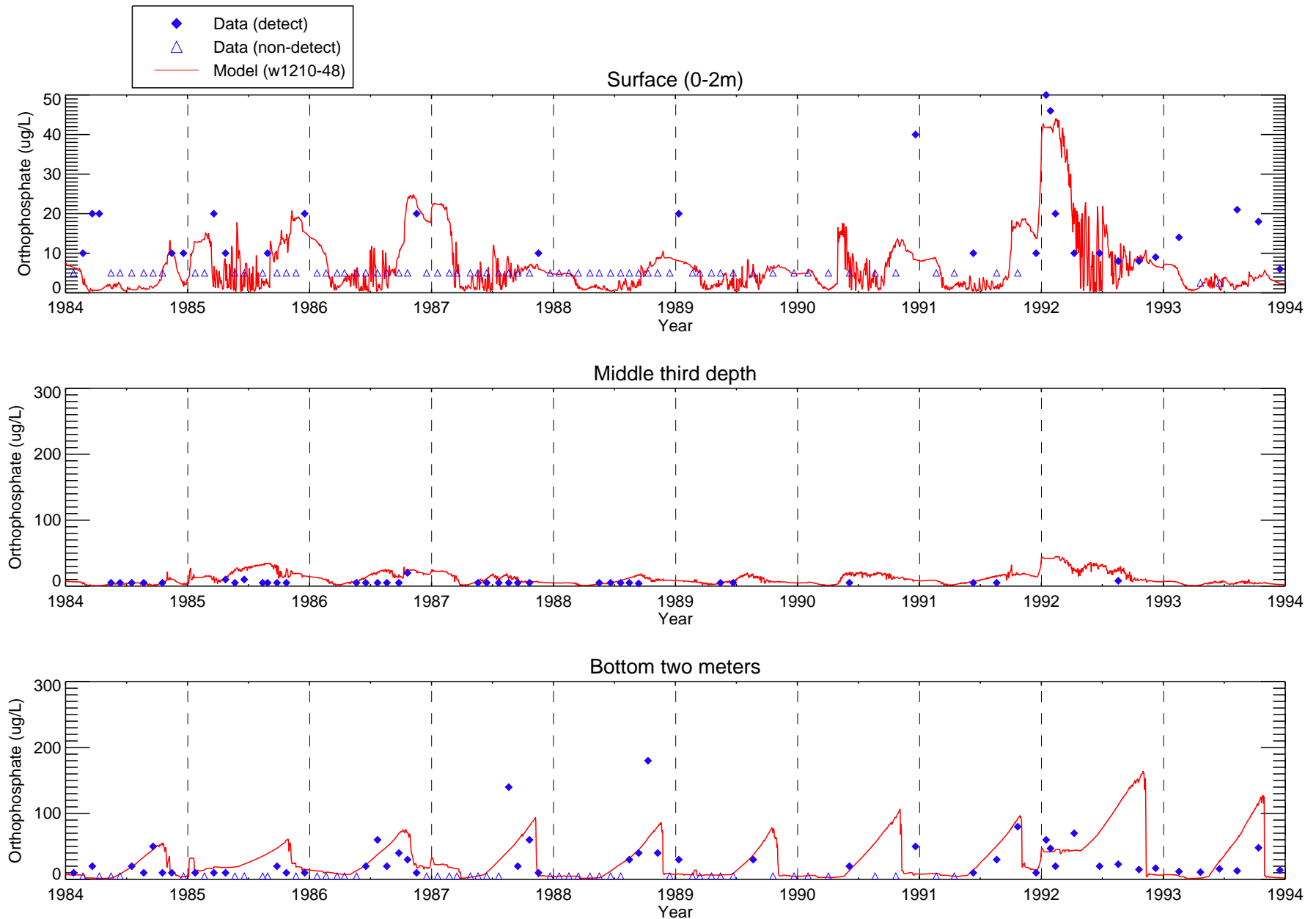CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:33:14 2013

Figure 4-15h
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
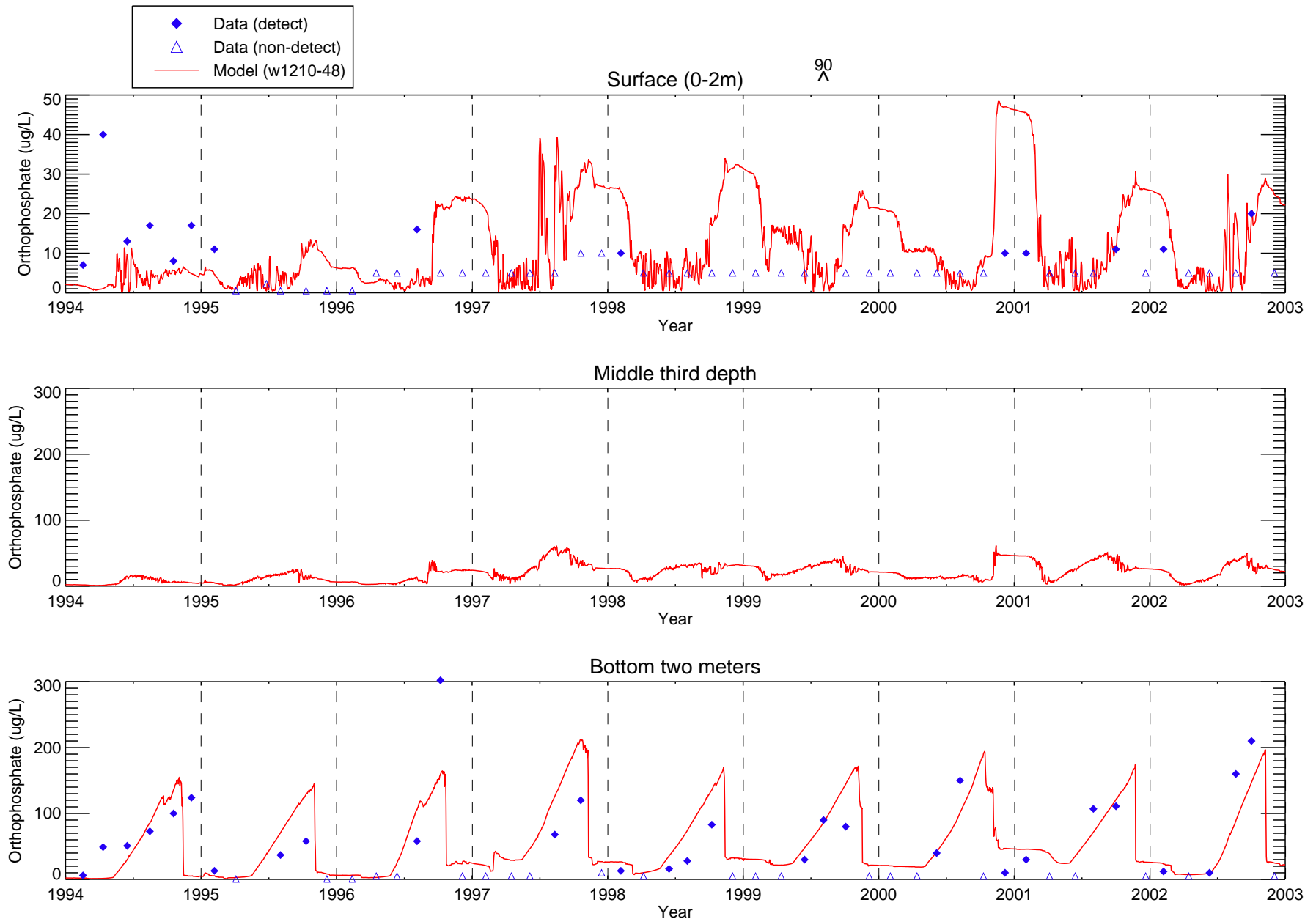Tue Jan 29 18:33:48 2013

Figure 4-16a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
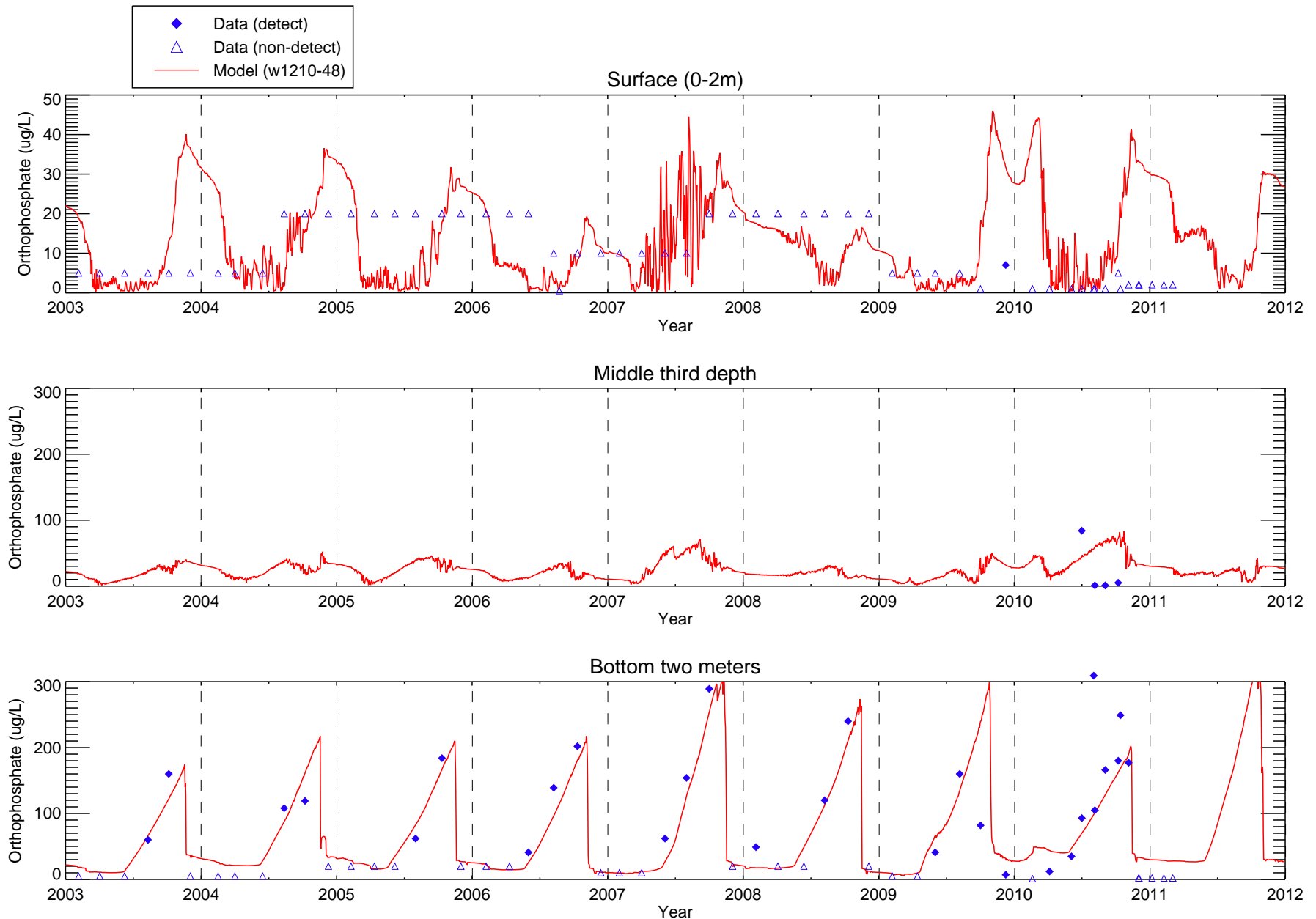
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-16a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
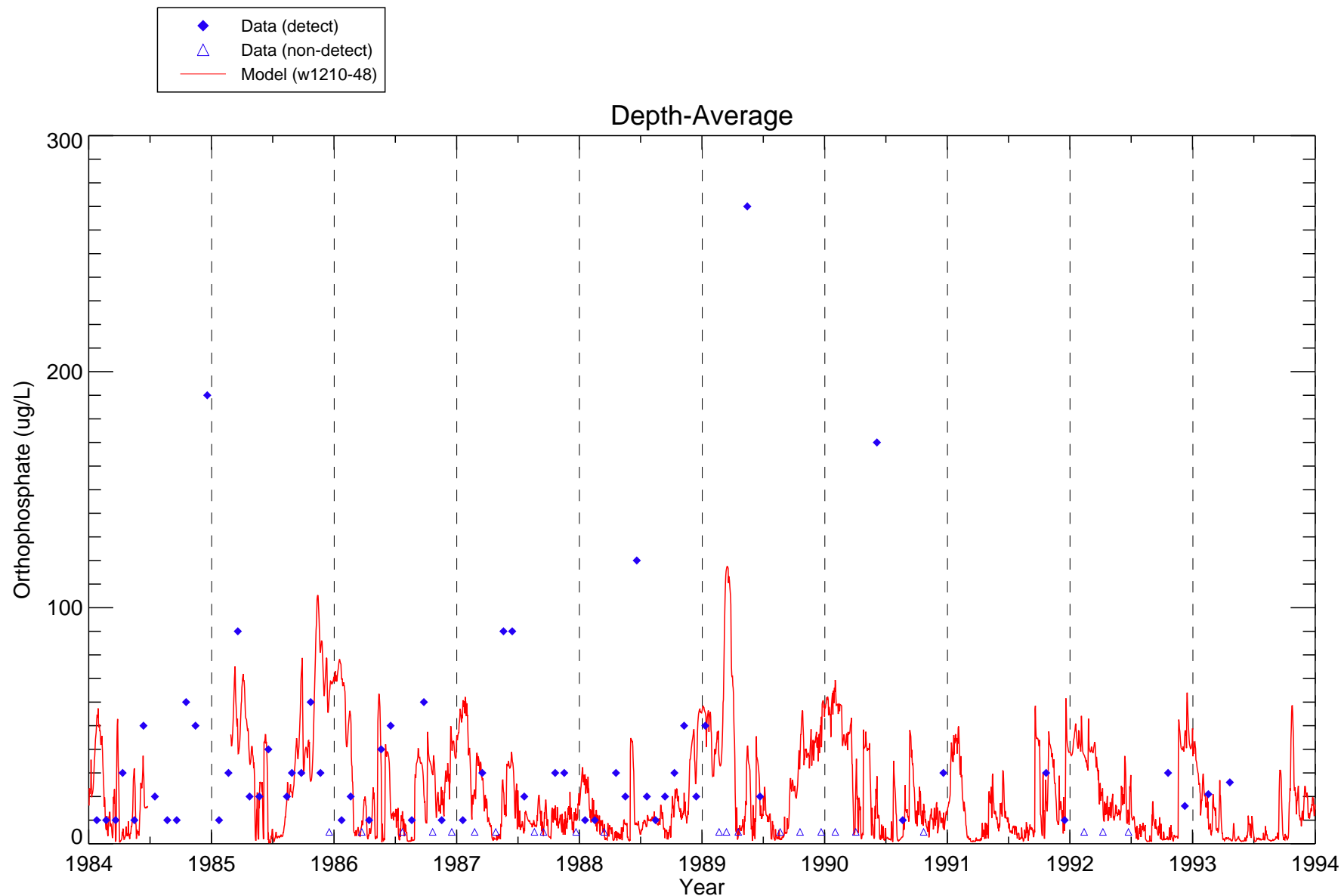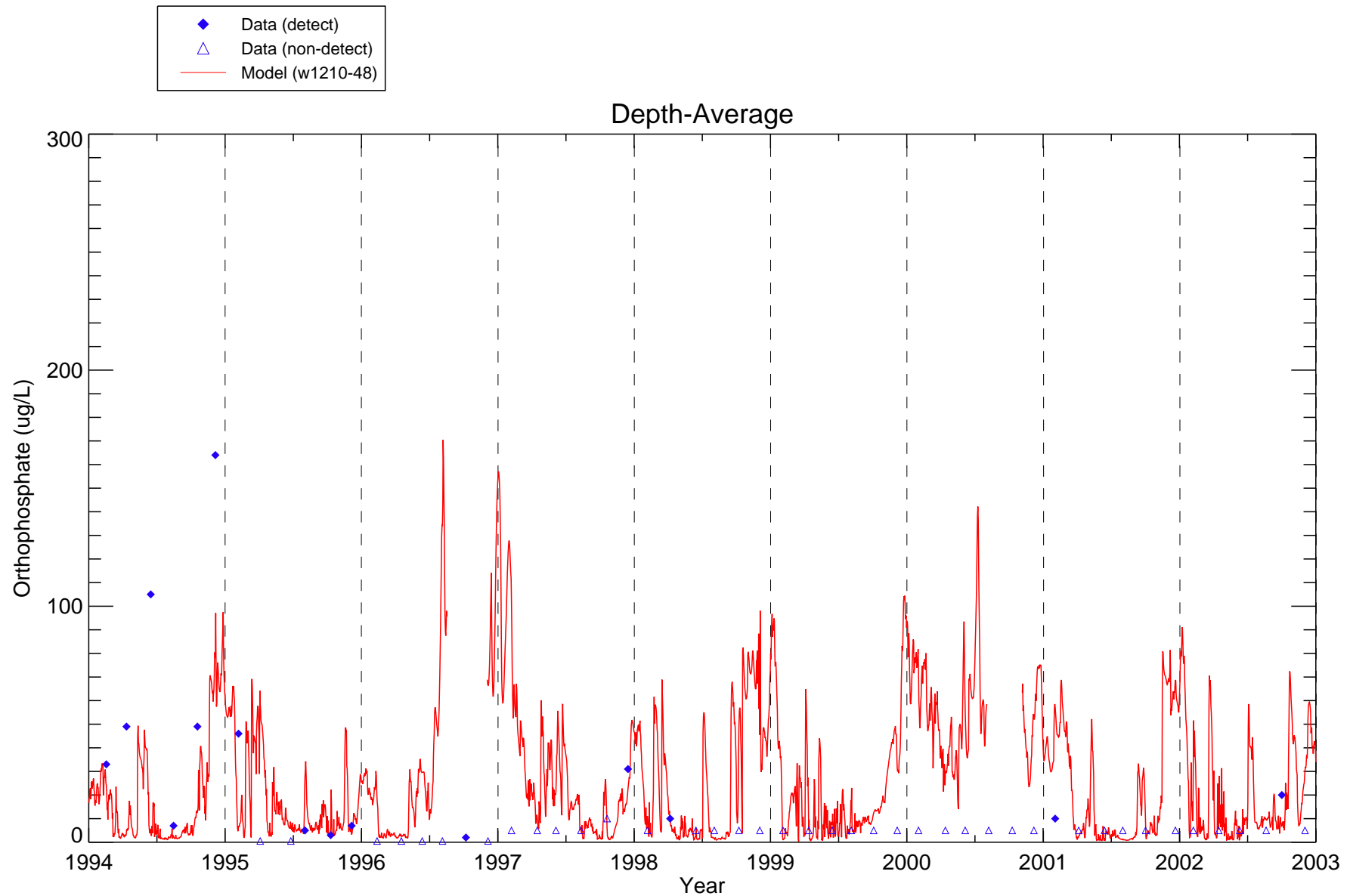Lower Colorado River Authority

Figure 4-16a

Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
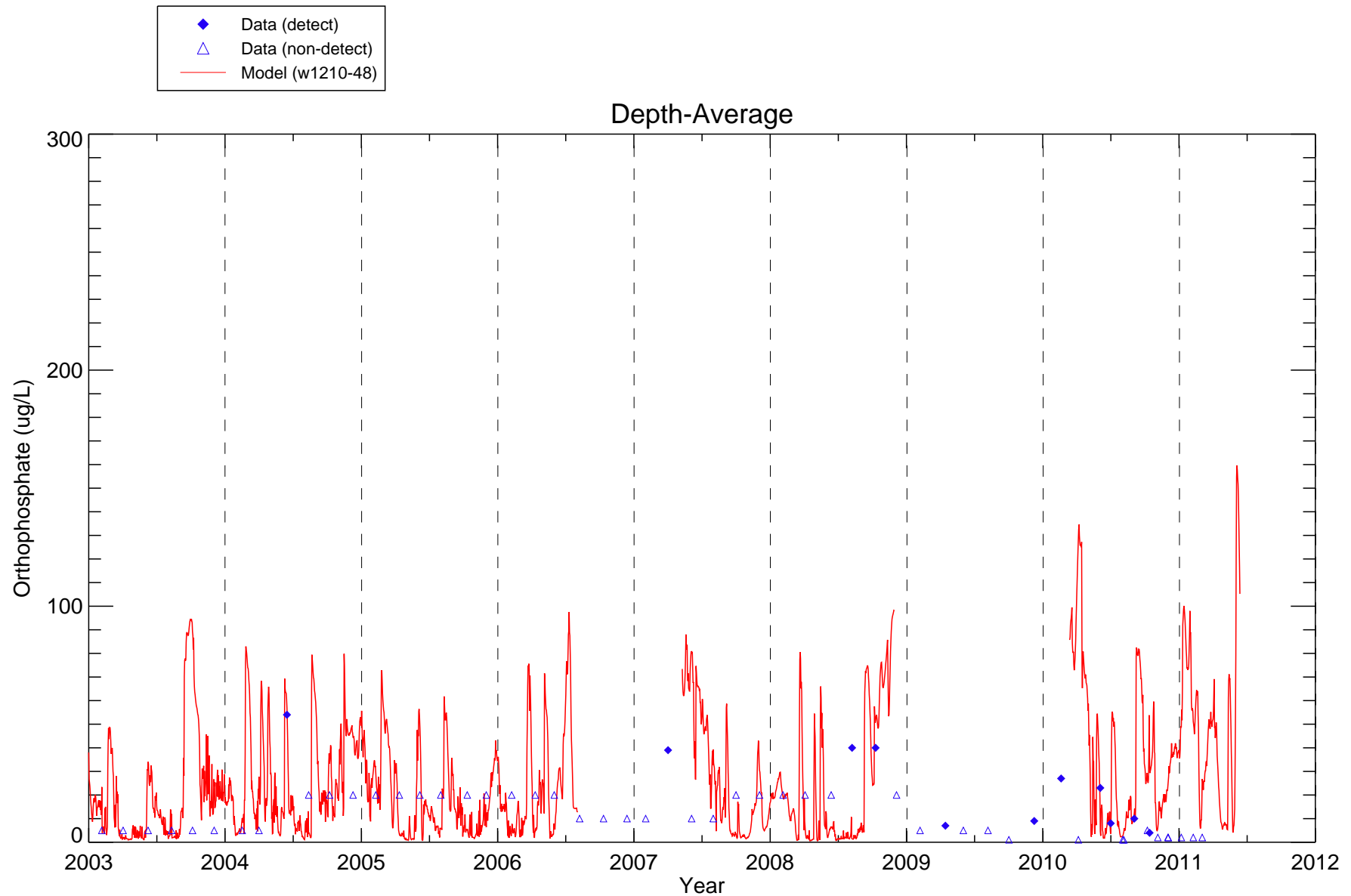
CREMs Phase 4: Lake Buchanan
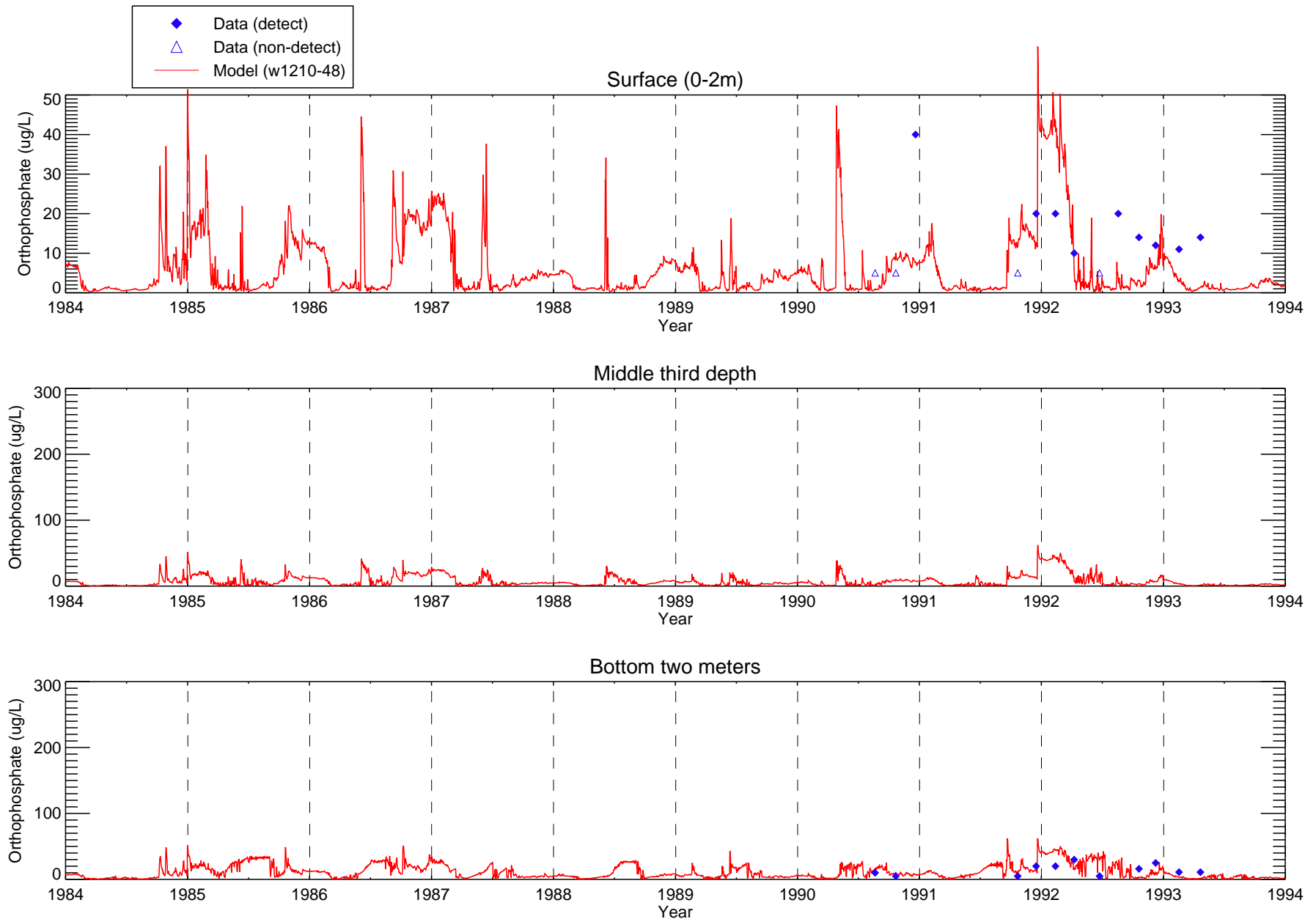Lower Colorado River Authority

Figure 4-16b

Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Nitrate+Nitrite

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:36:38 2013

Depth-Average

Legend:
- ◆ Data (detect)
- △ Data (non-detect)
- — Model (w1210-48)

Y-axis: Nitrate+Nitrite (mg/L)

X-axis: Year (1994–2003)

Figure 4-16b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Nitrate+Nitrite

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
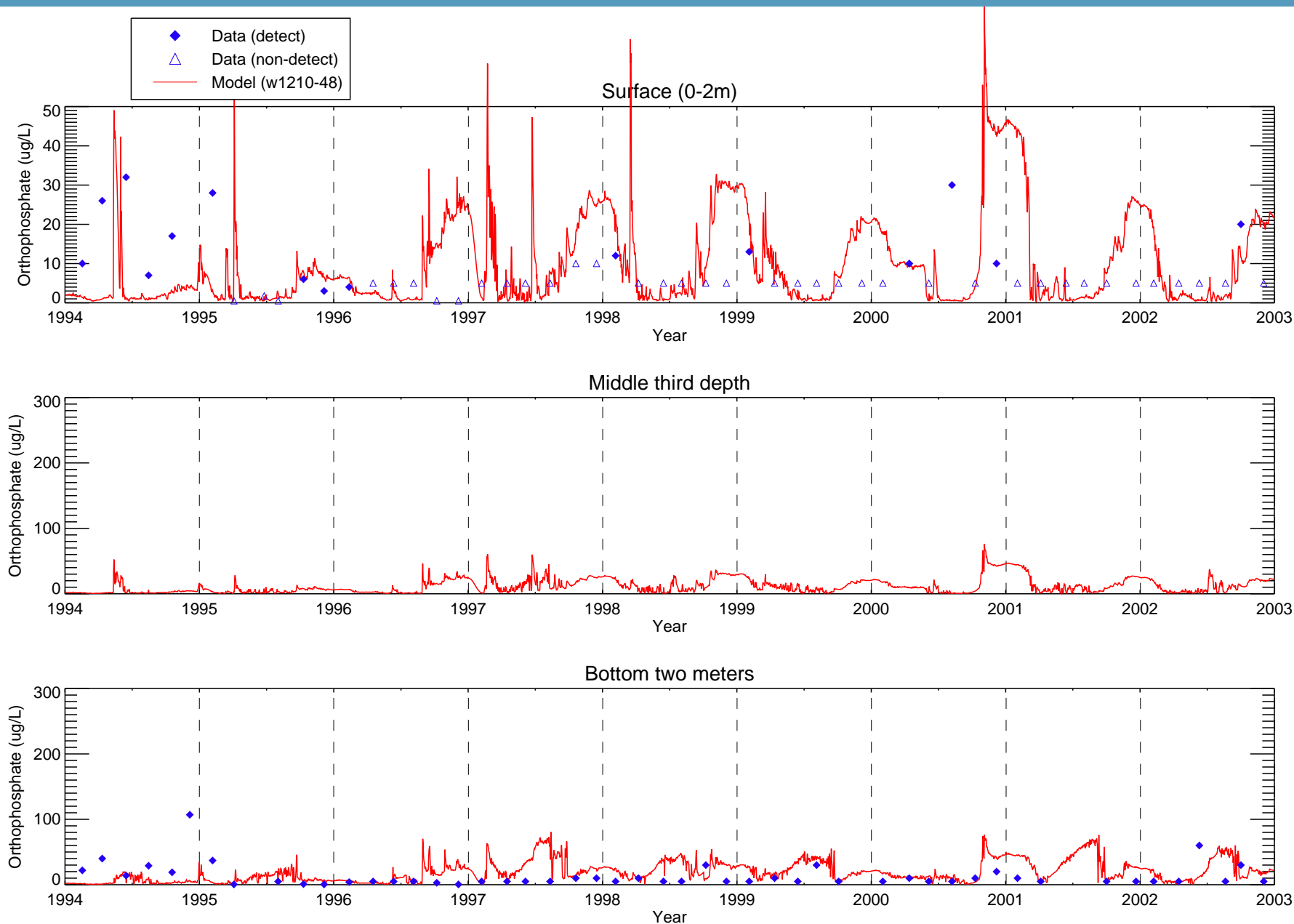
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:36:43 2013

Figure 4-16b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Nitrate+Nitrite

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
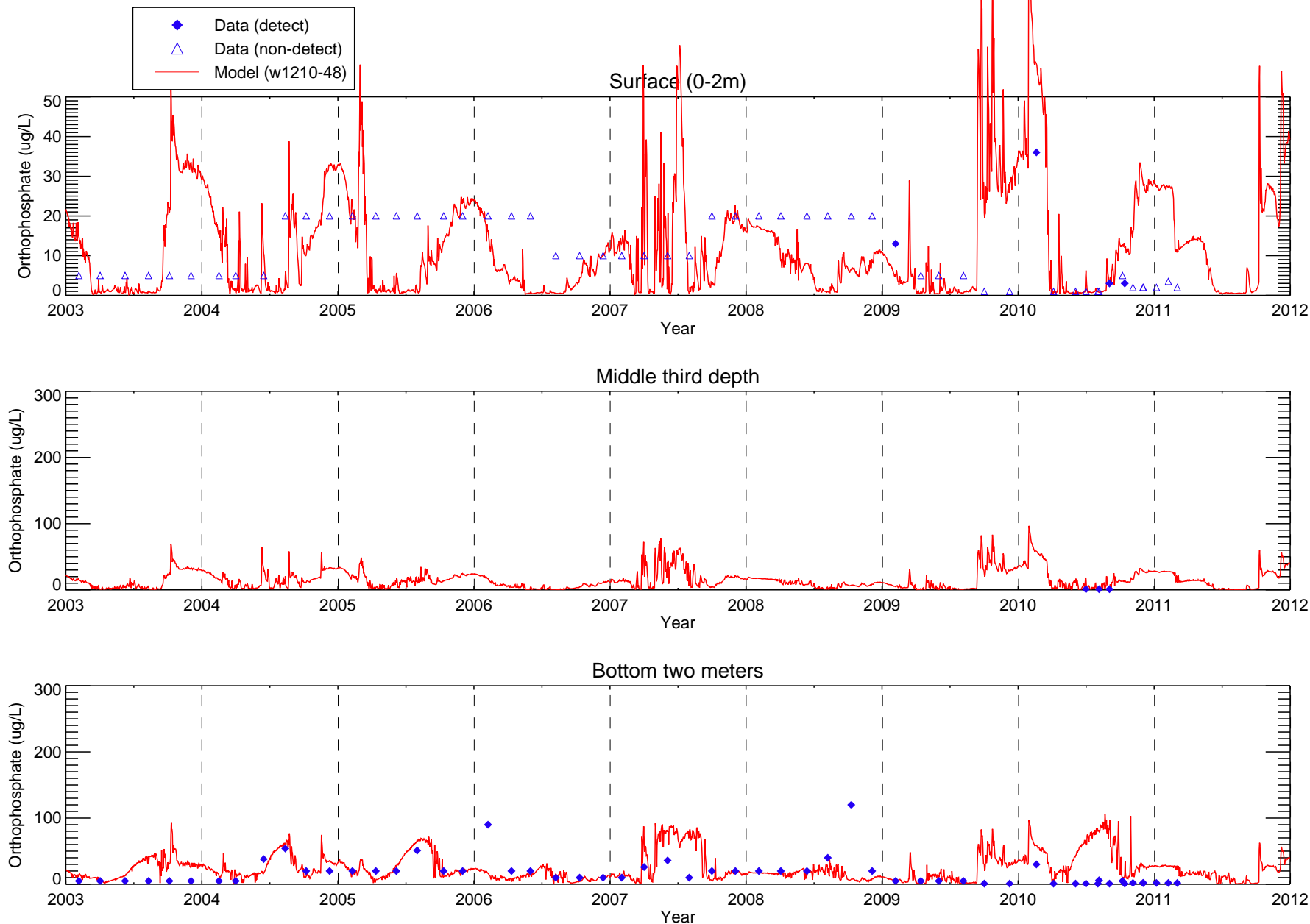Lower Colorado River Authority

Figure 4-16c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
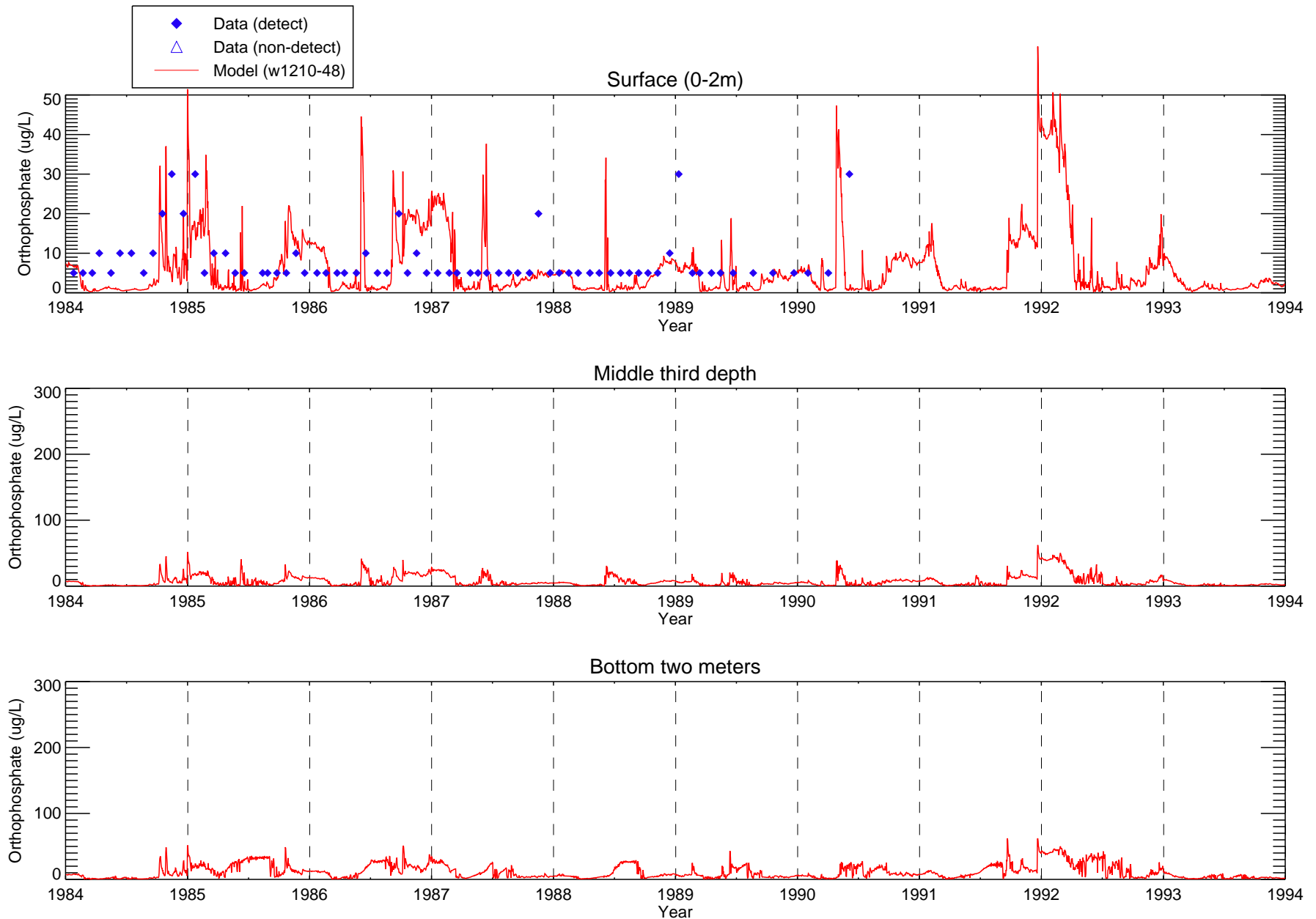Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 13:19:24 2013

Figure 4-16c

Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
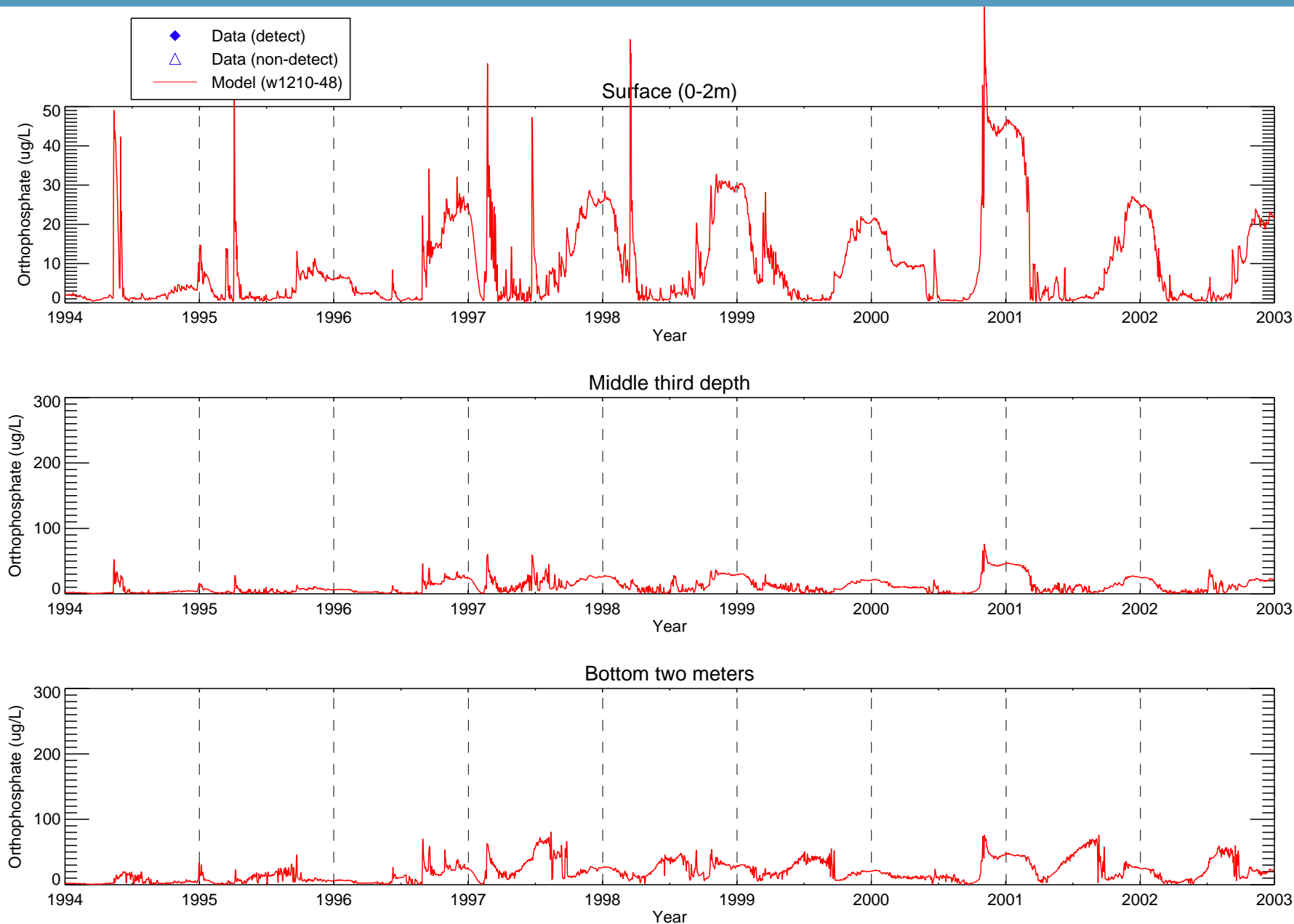
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-16c

Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
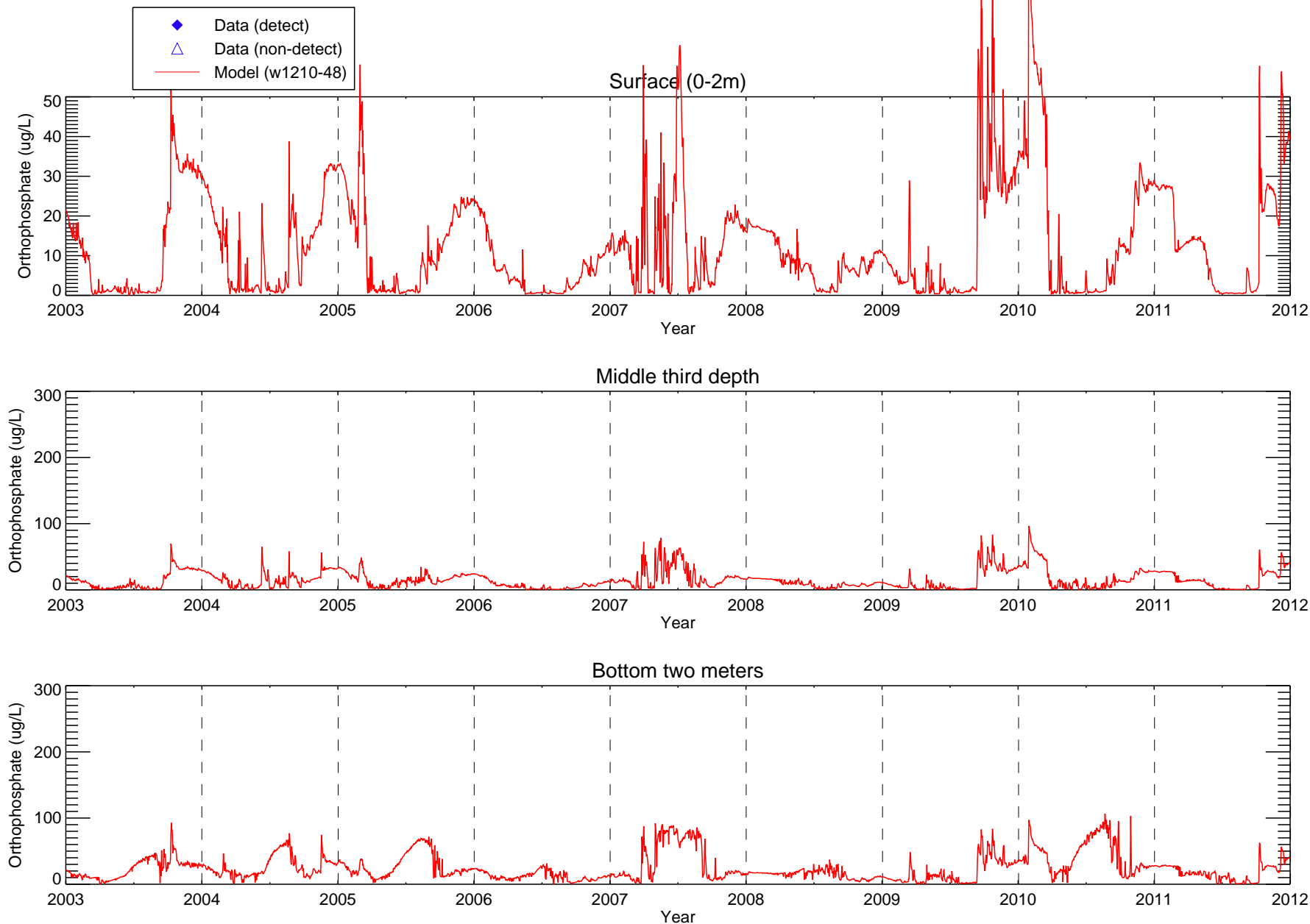
CREMs Phase 4: Lake Buchanan
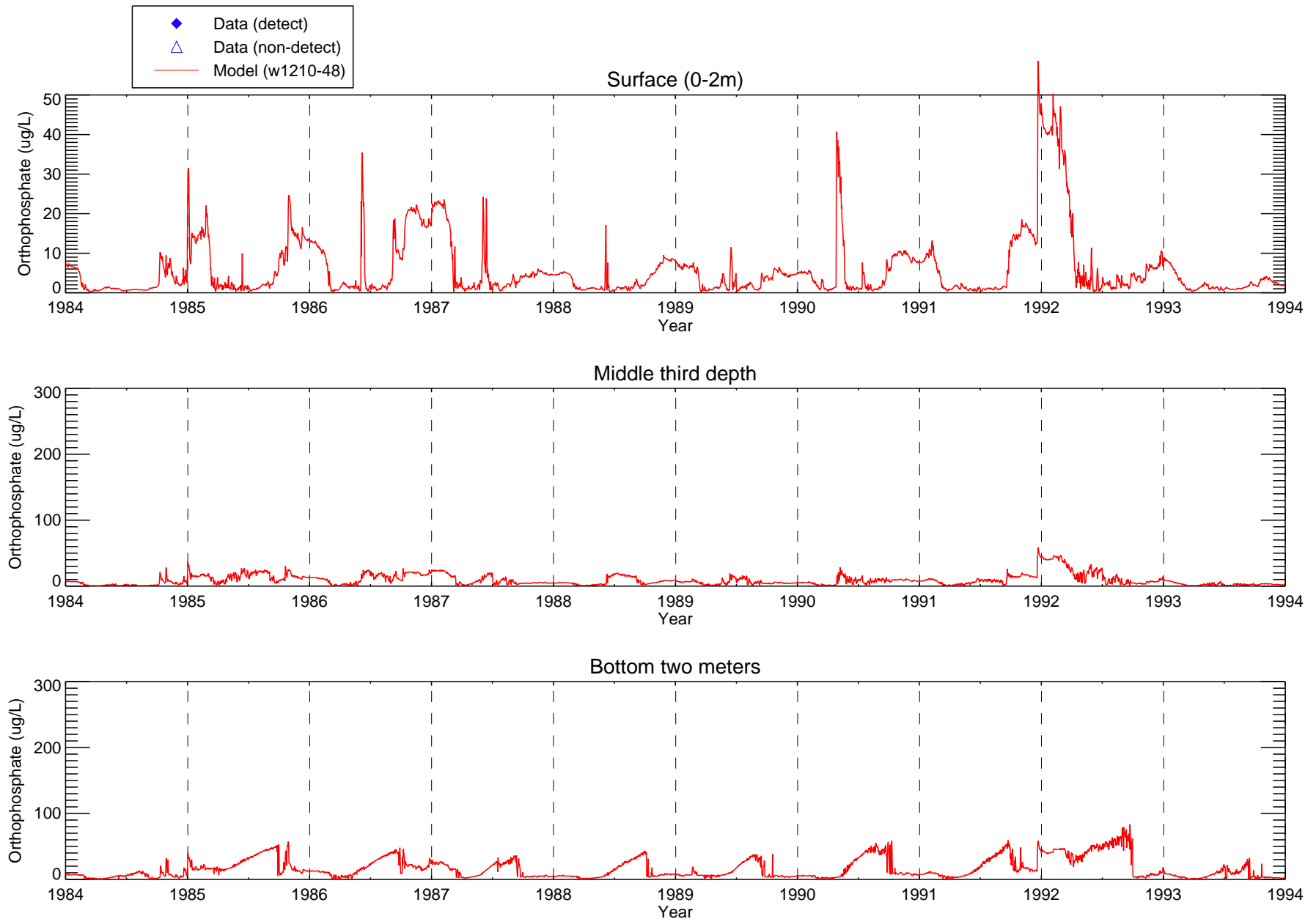Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 13:21:07 2013

Figure 4-16d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:37:33 2013

Figure 4-16d

Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-16d
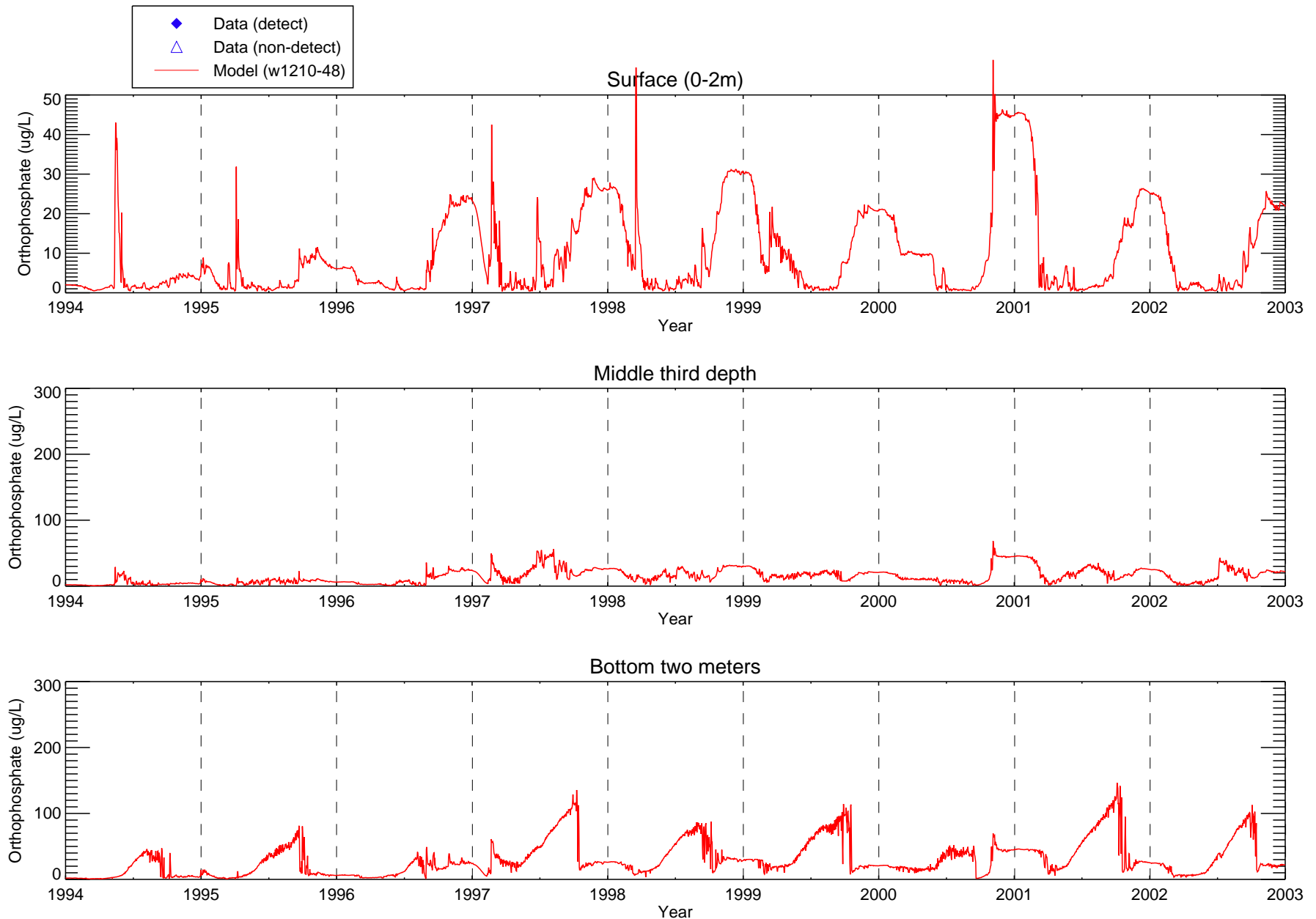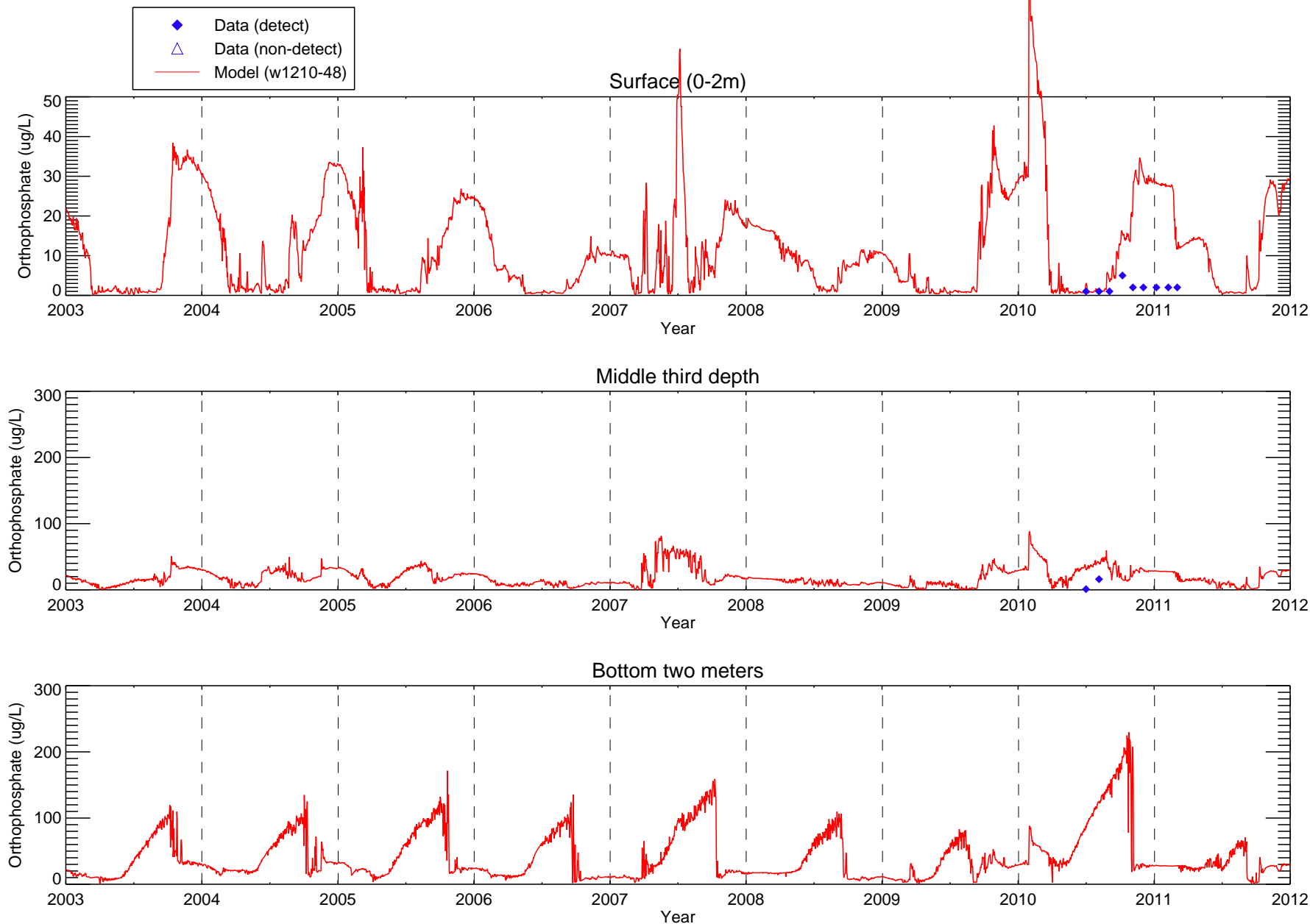**Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Nitrate+Nitrite**

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:39:01 2013

Figure 4-16e
Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
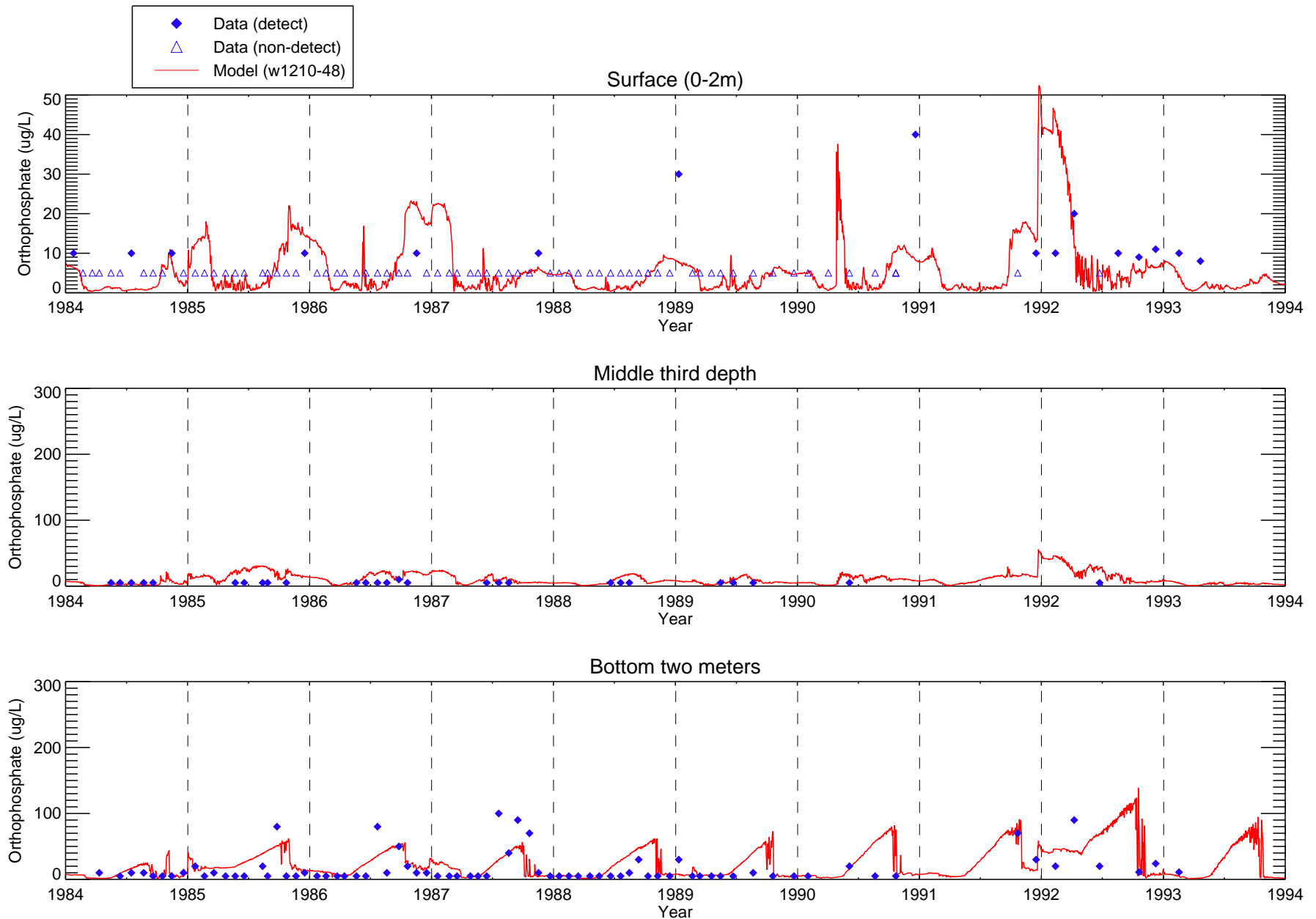
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:20:00 2013

Figure 4-16e
Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

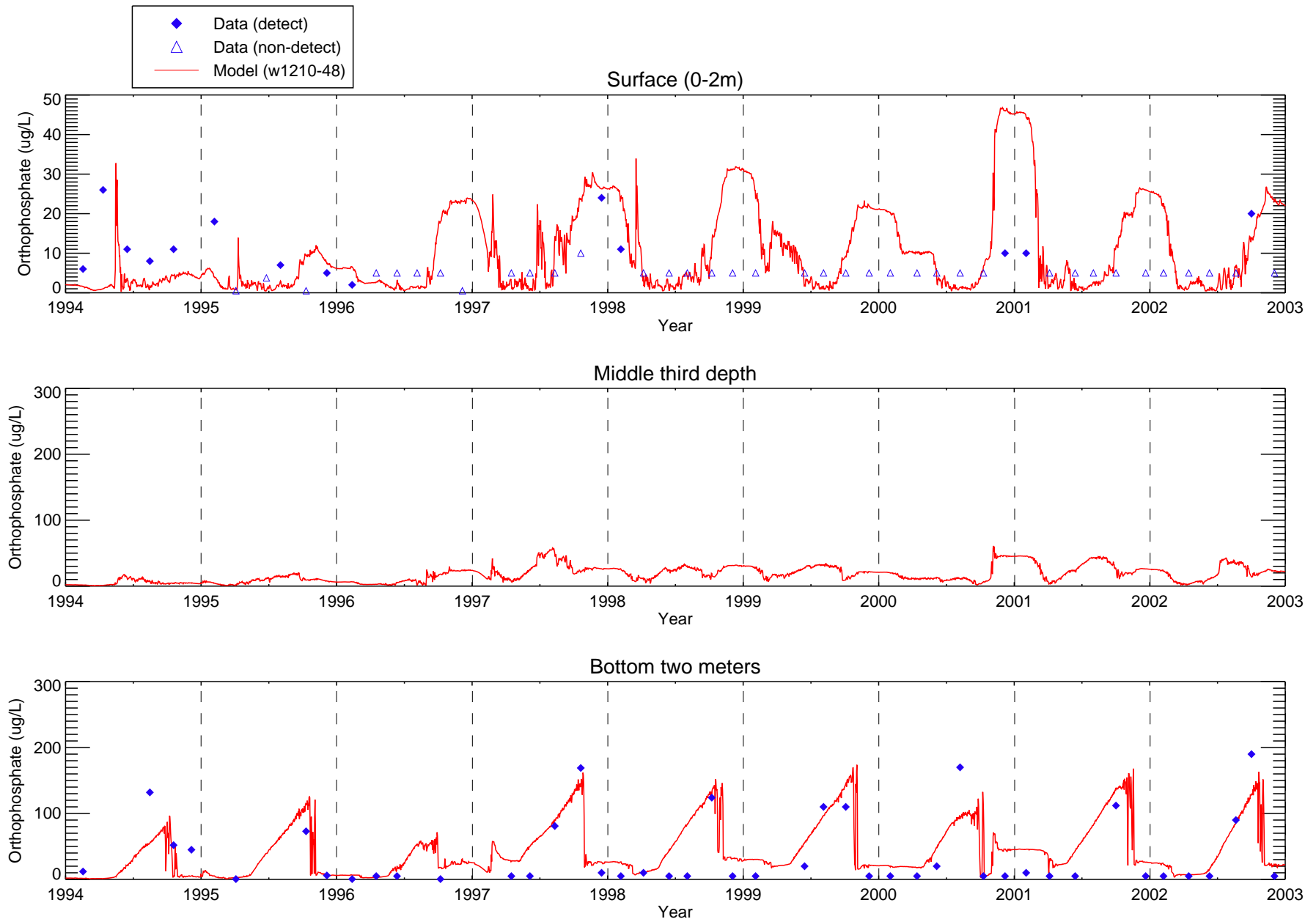CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:21:03 2013

Figure 4-16e
Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

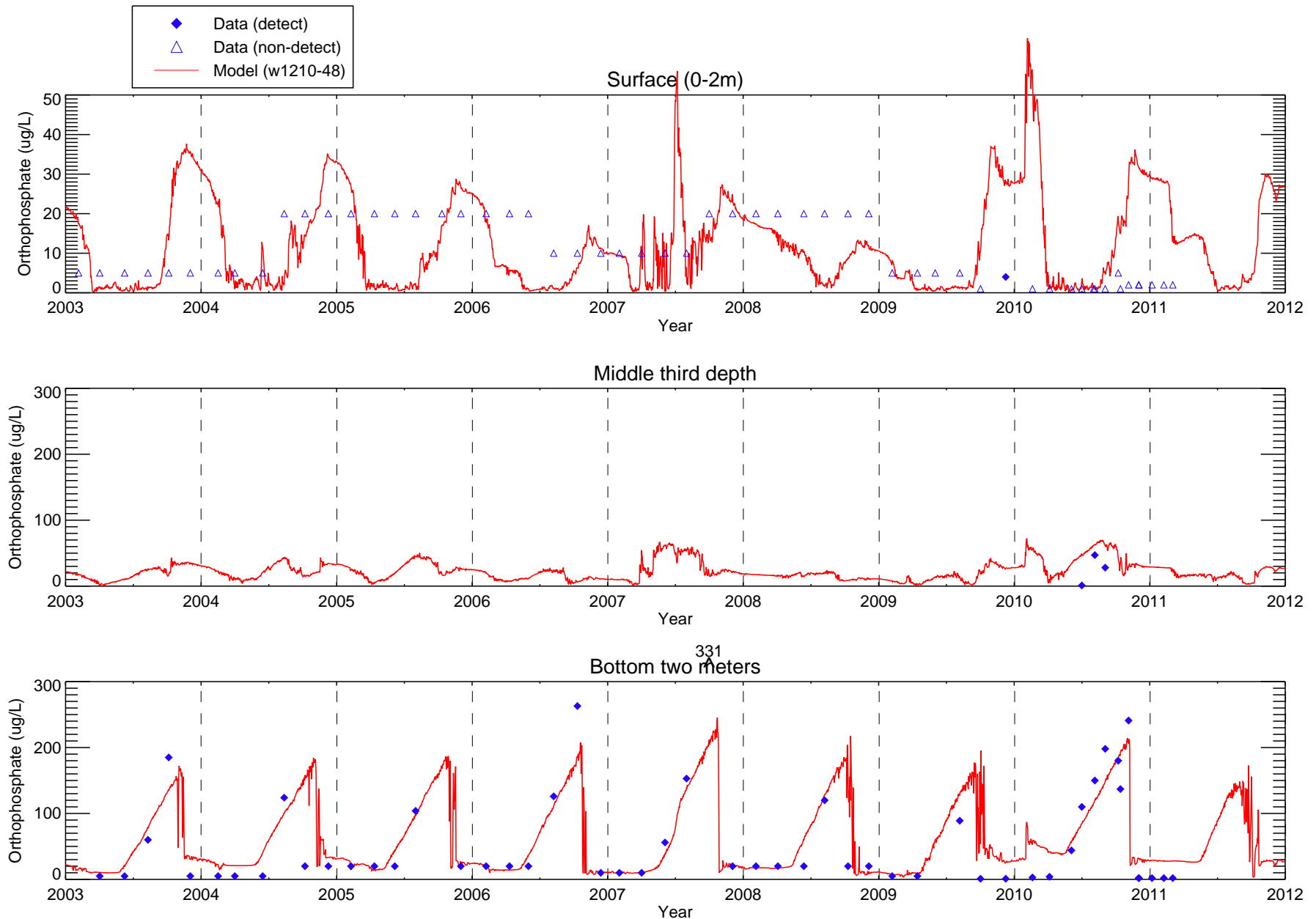CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:22:06 2013

Figure 4-16f
Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
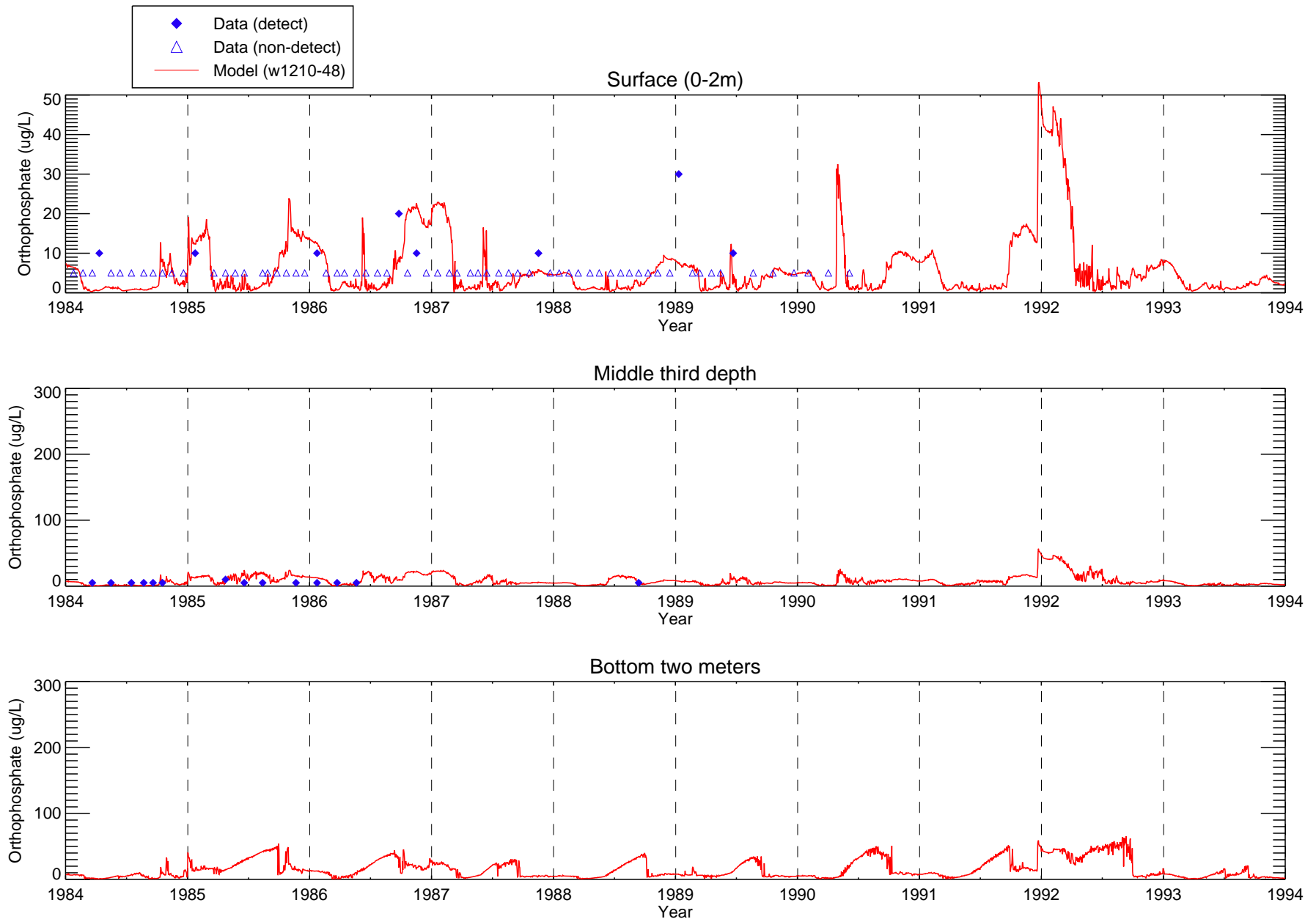
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-16f

Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
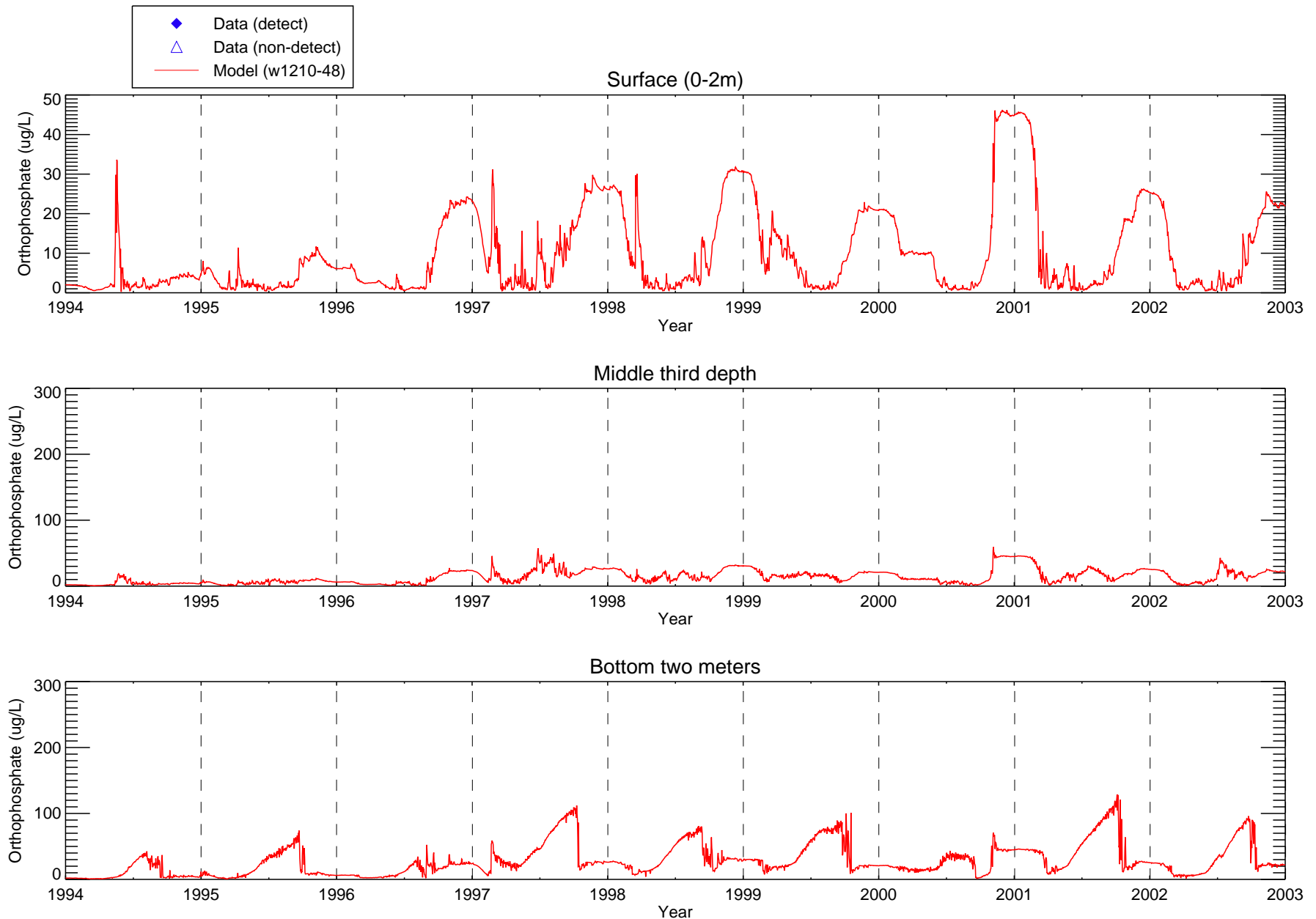
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-16f

Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
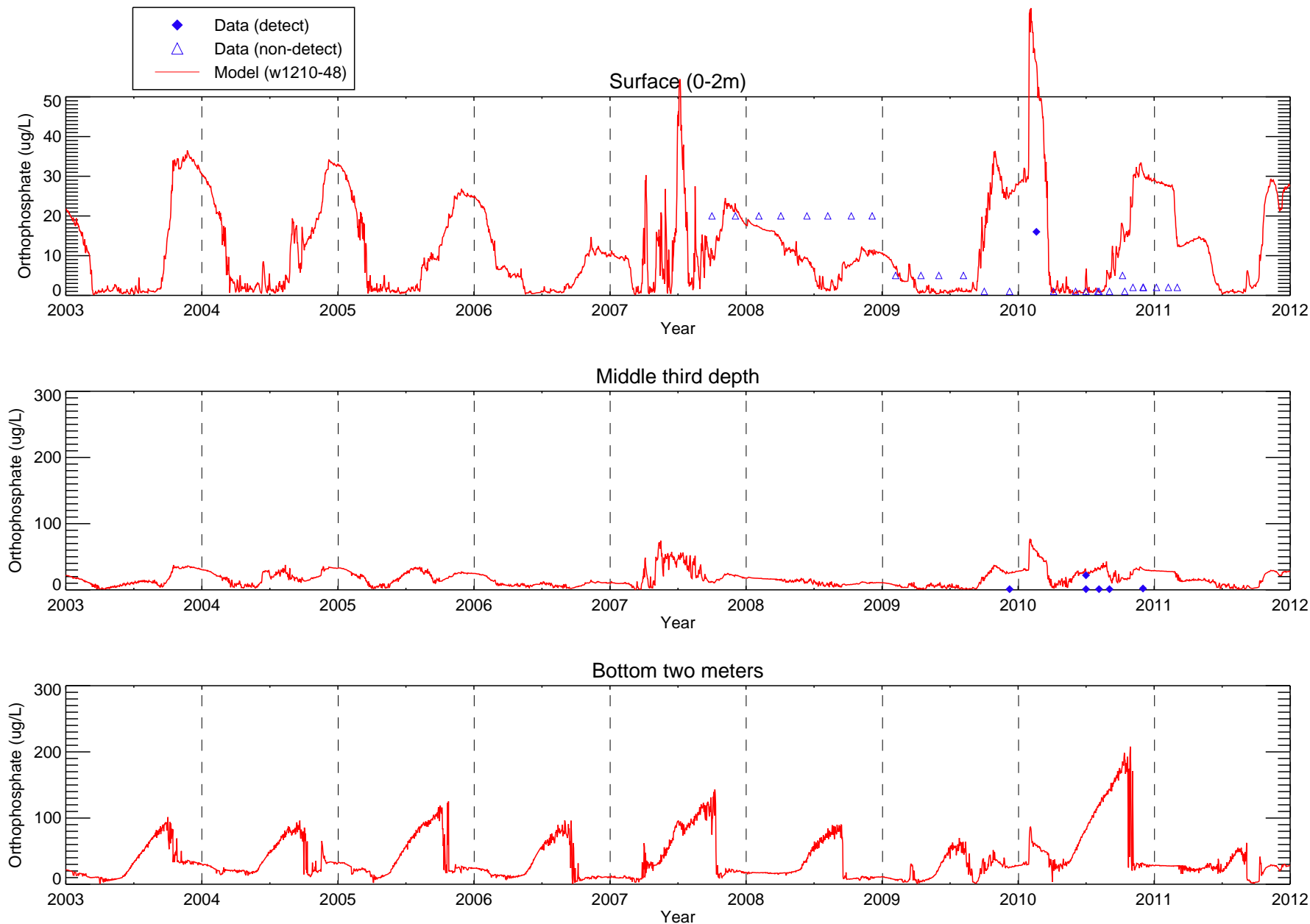
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-16g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
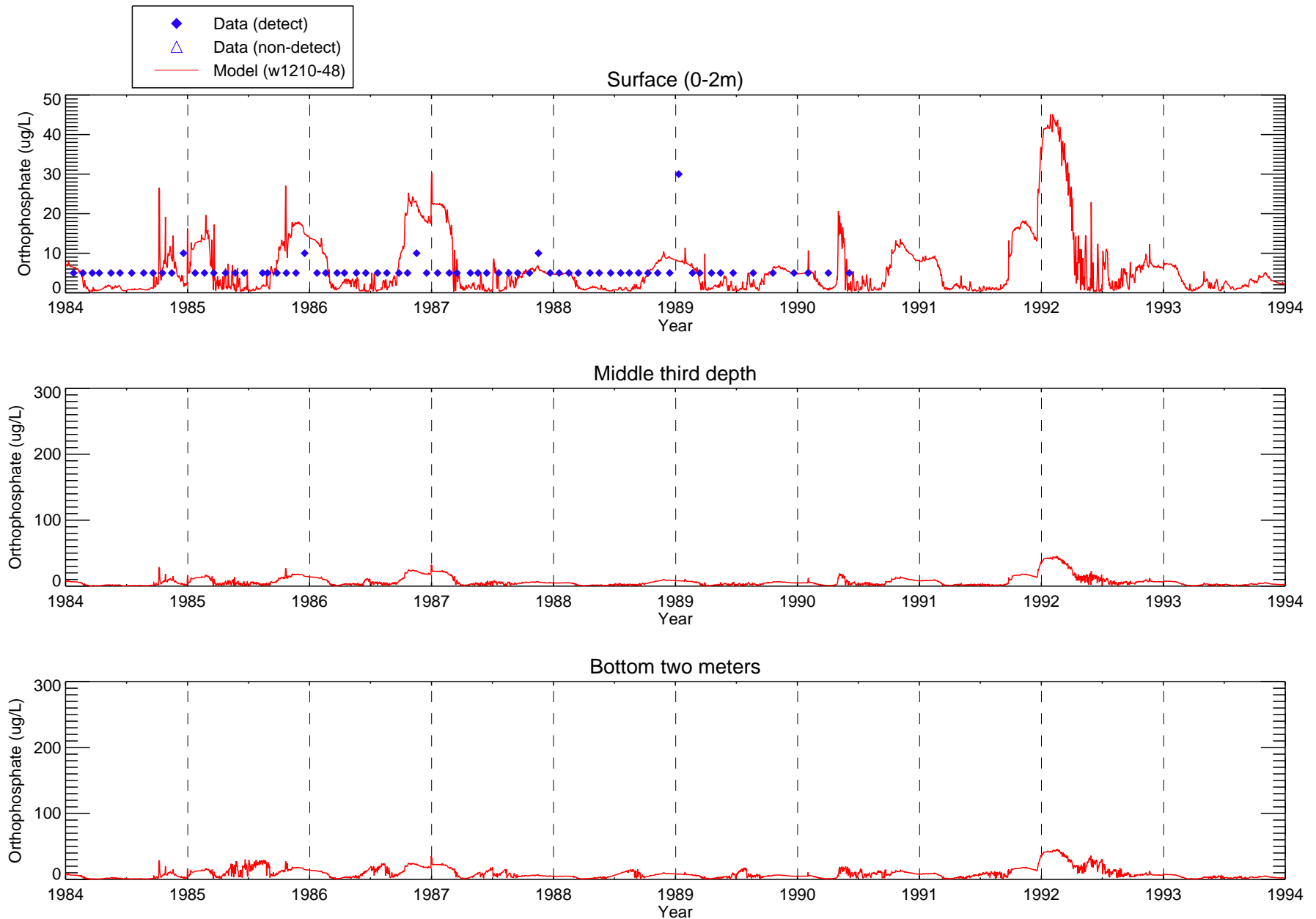
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-16g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
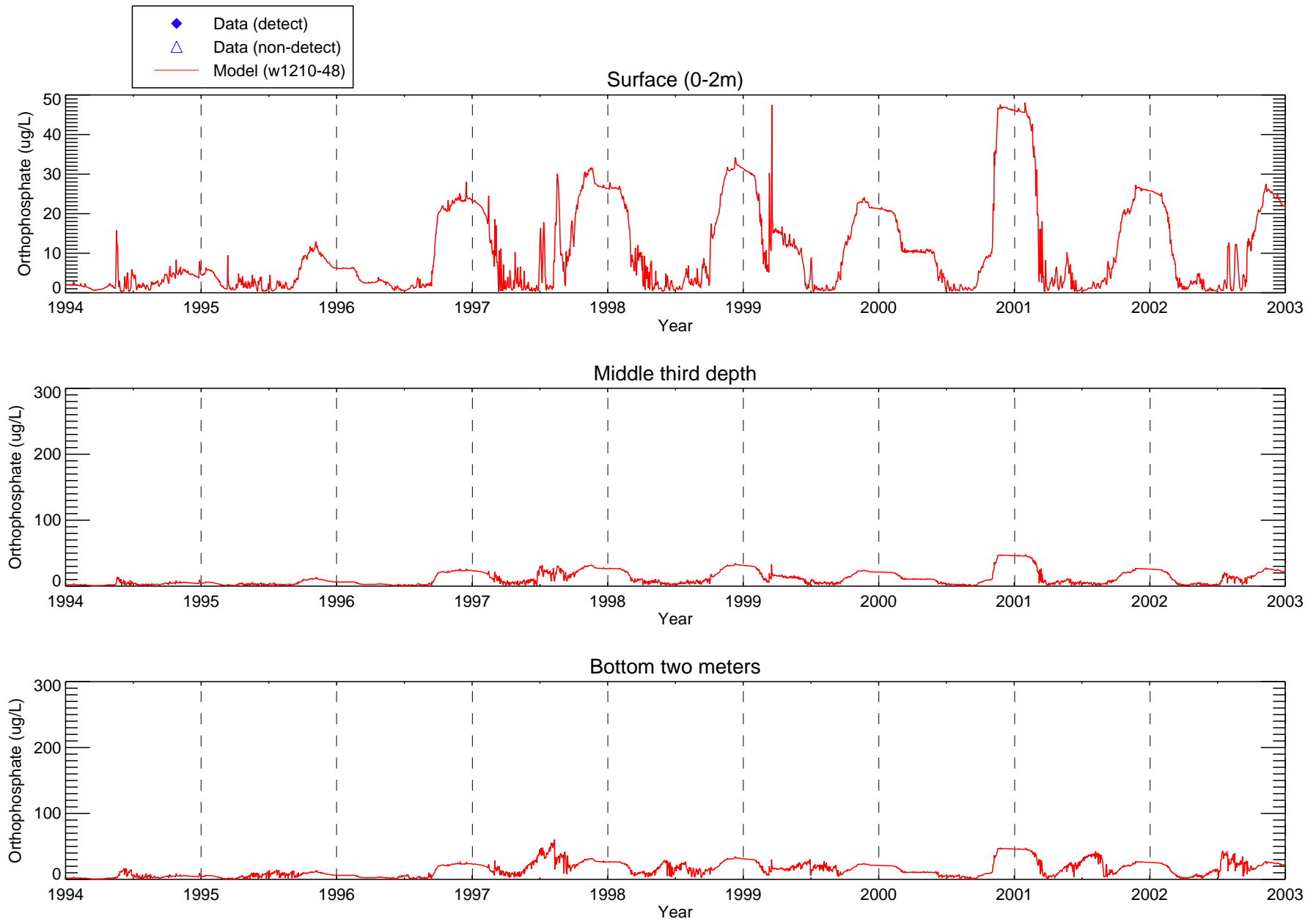
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:33:47 2013

Figure 4-16g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
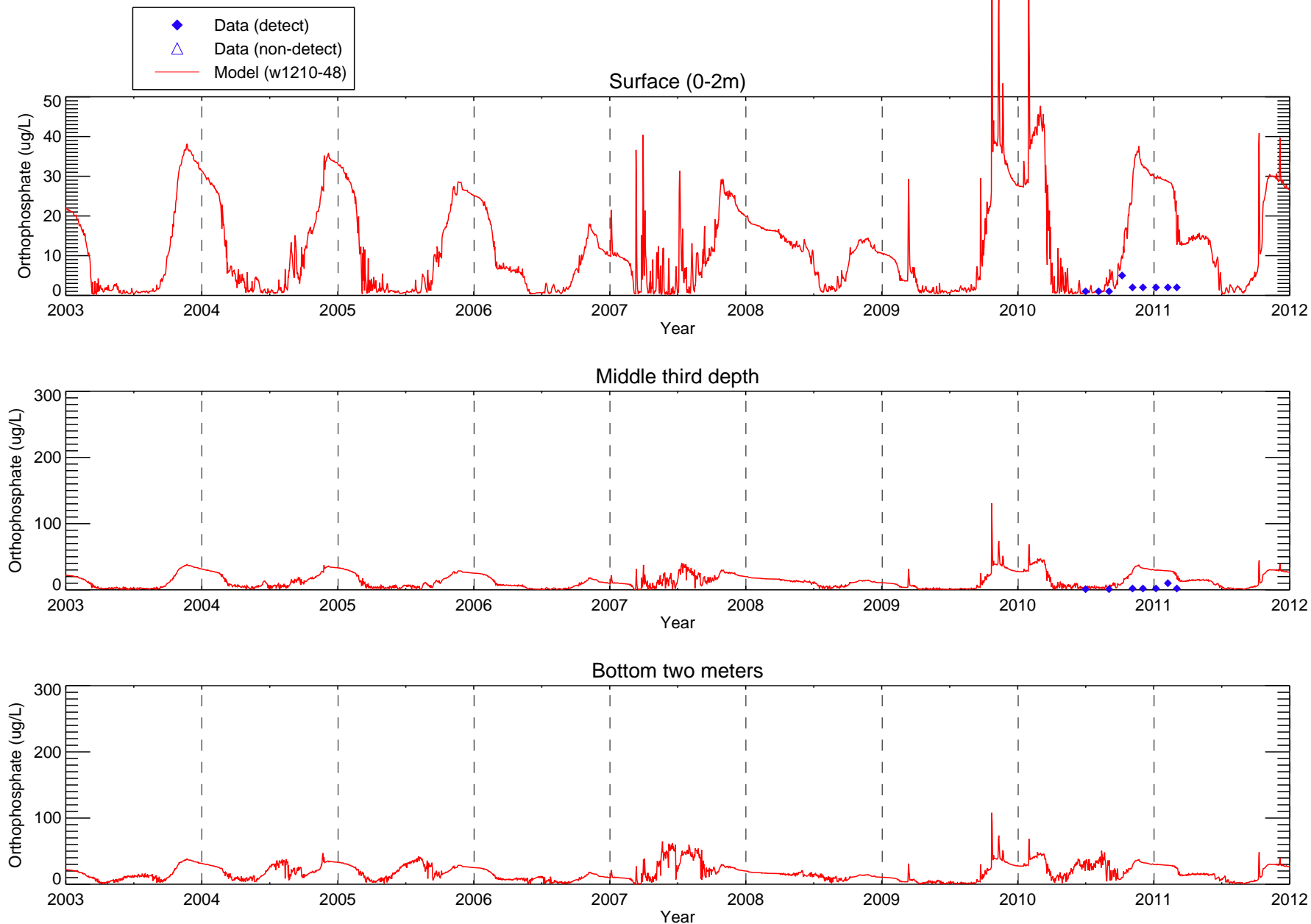
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-16h

Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
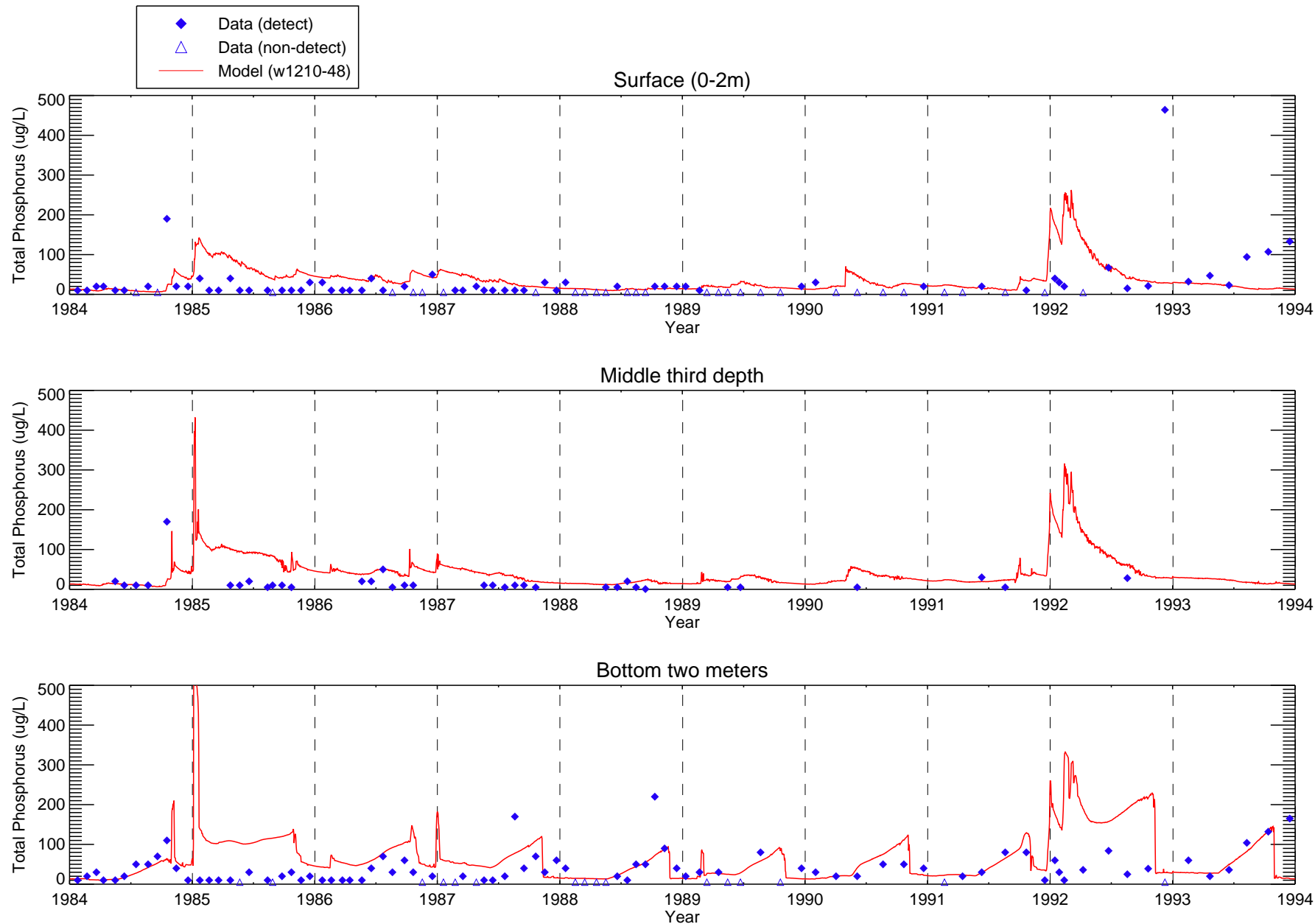Lower Colorado River Authority

Figure 4-16h
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
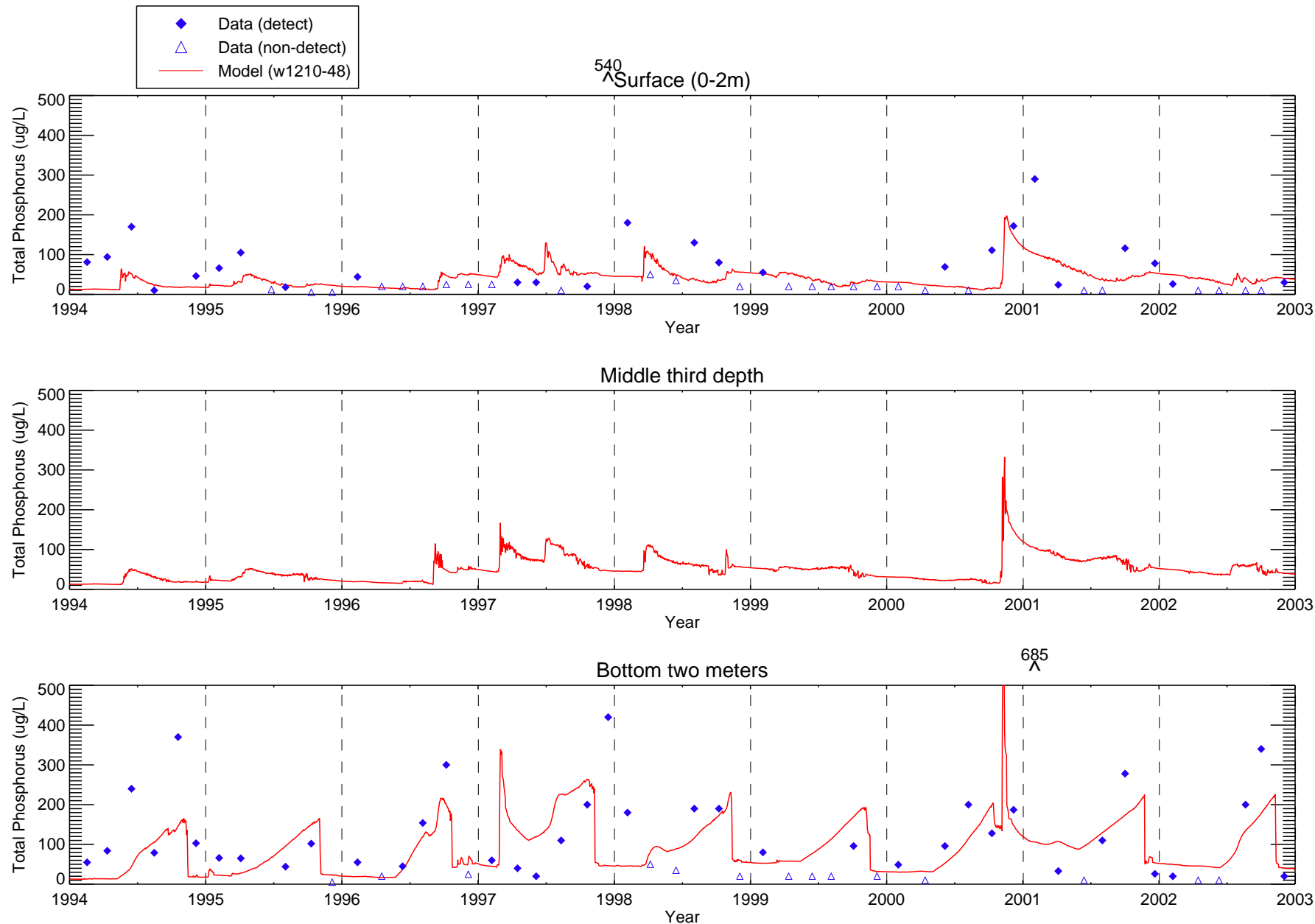Lower Colorado River Authority

Figure 4-16h
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
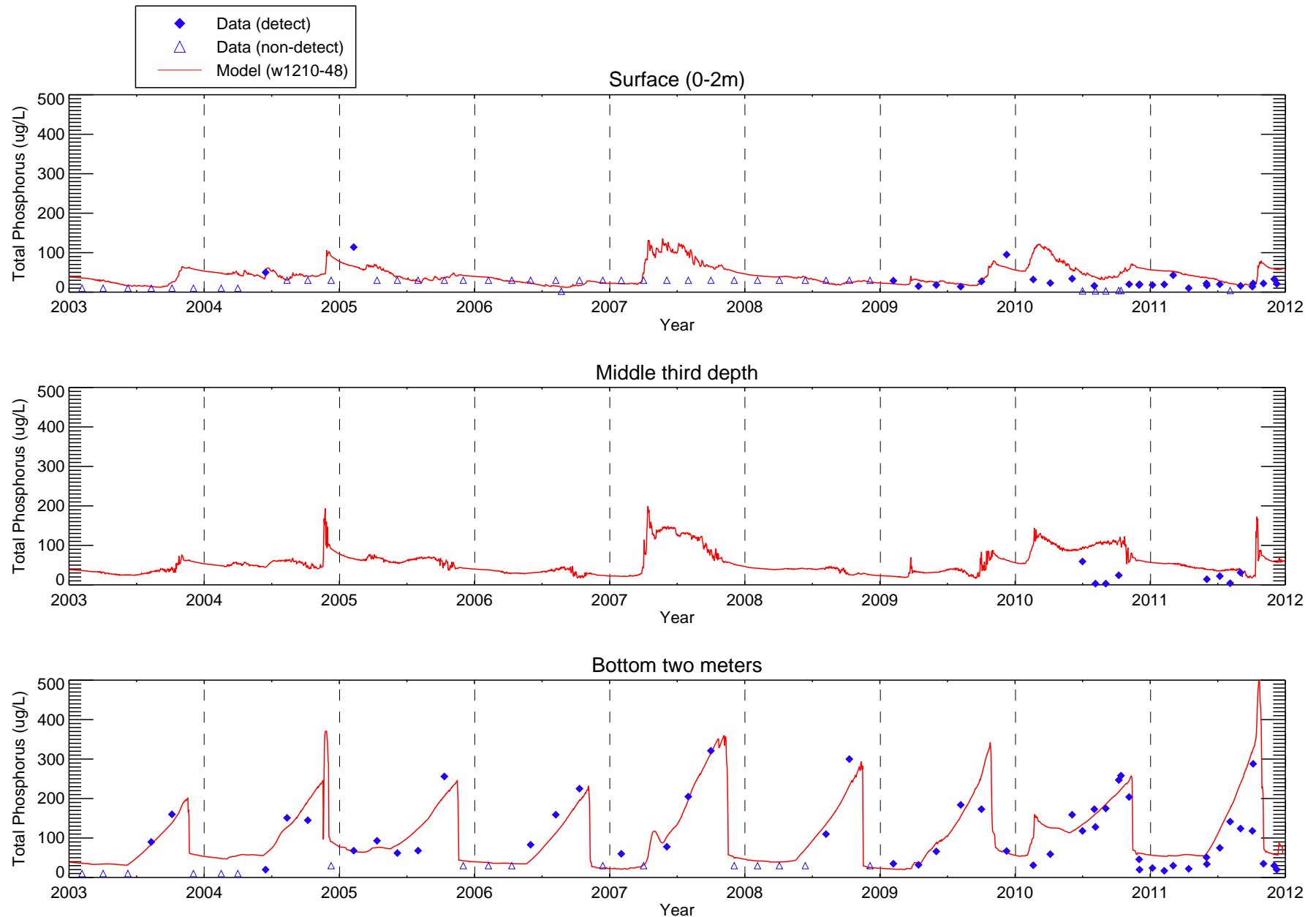
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:36:31 2013

Figure 4-17a

Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
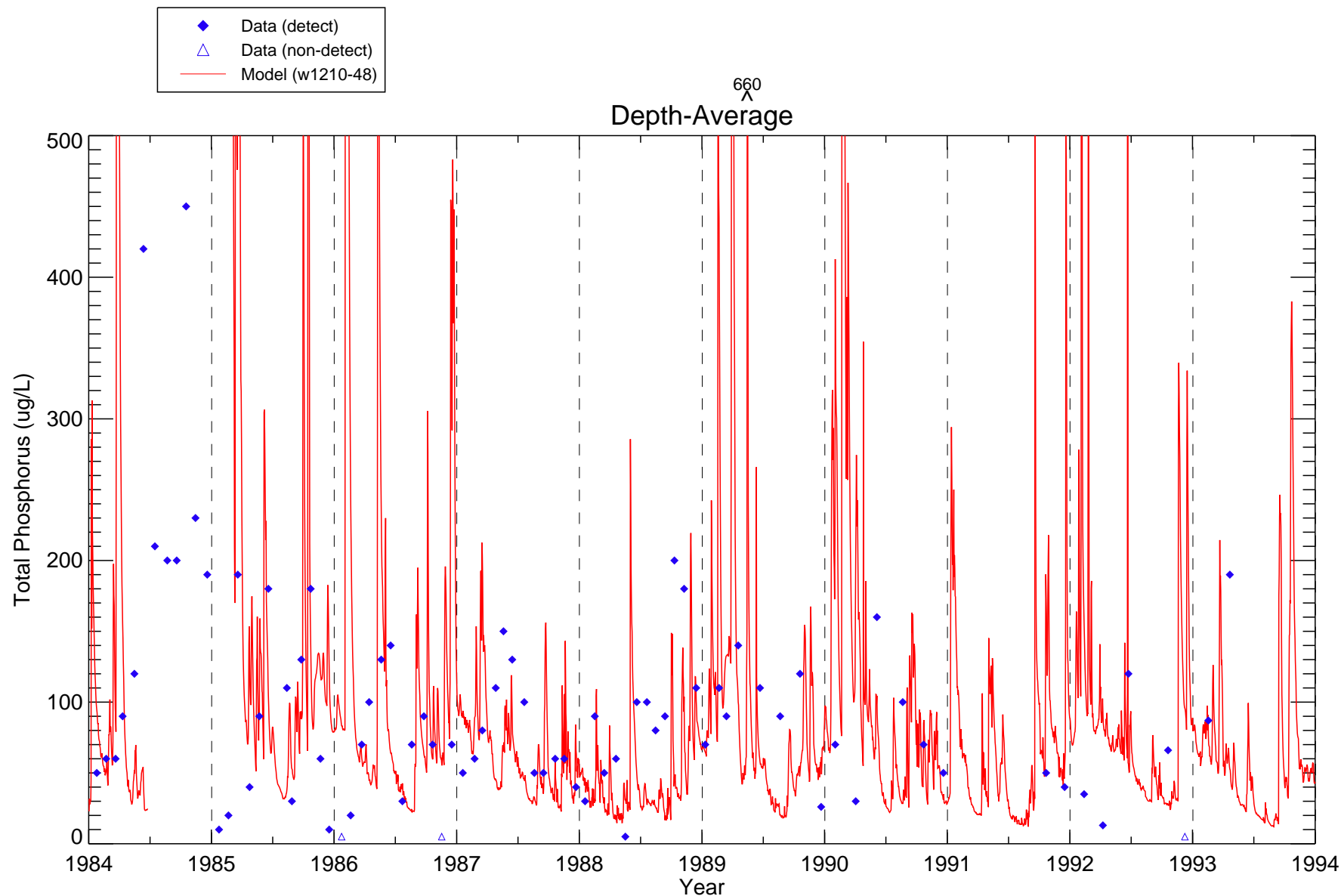
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:43:33 2013

Figure 4-17a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
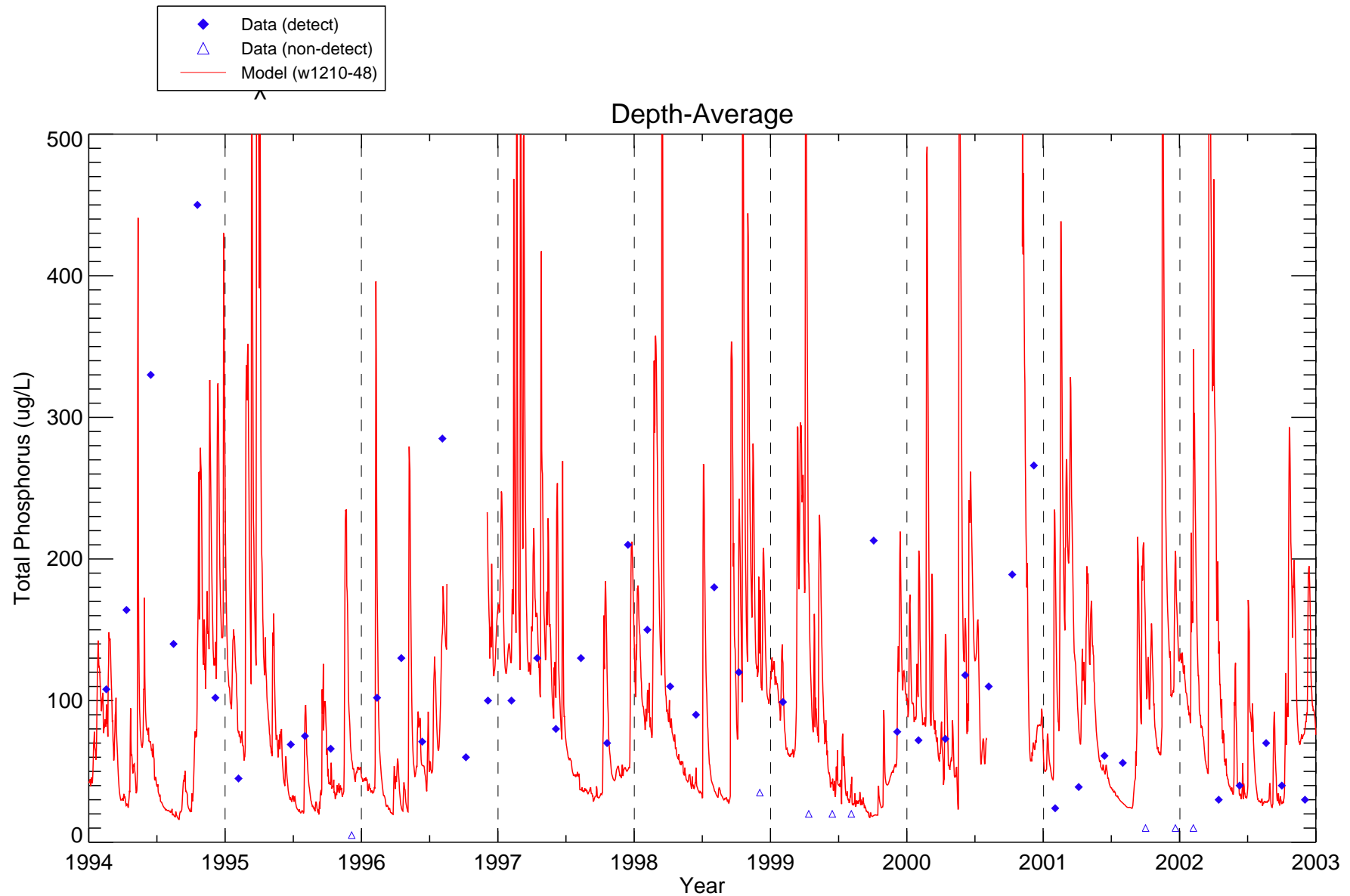
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

Figure 4-17a

Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
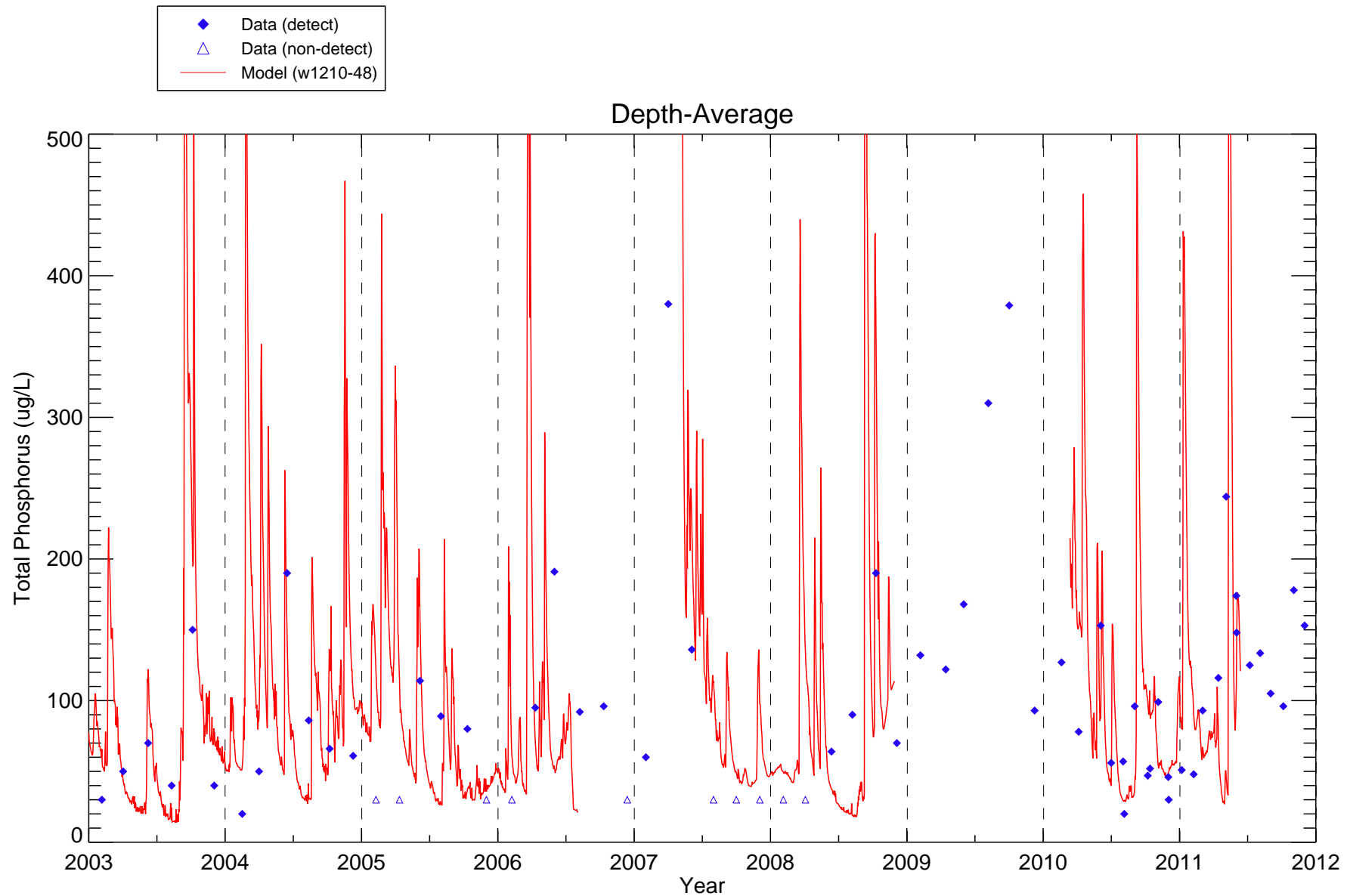
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-17b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Orthophosphate

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
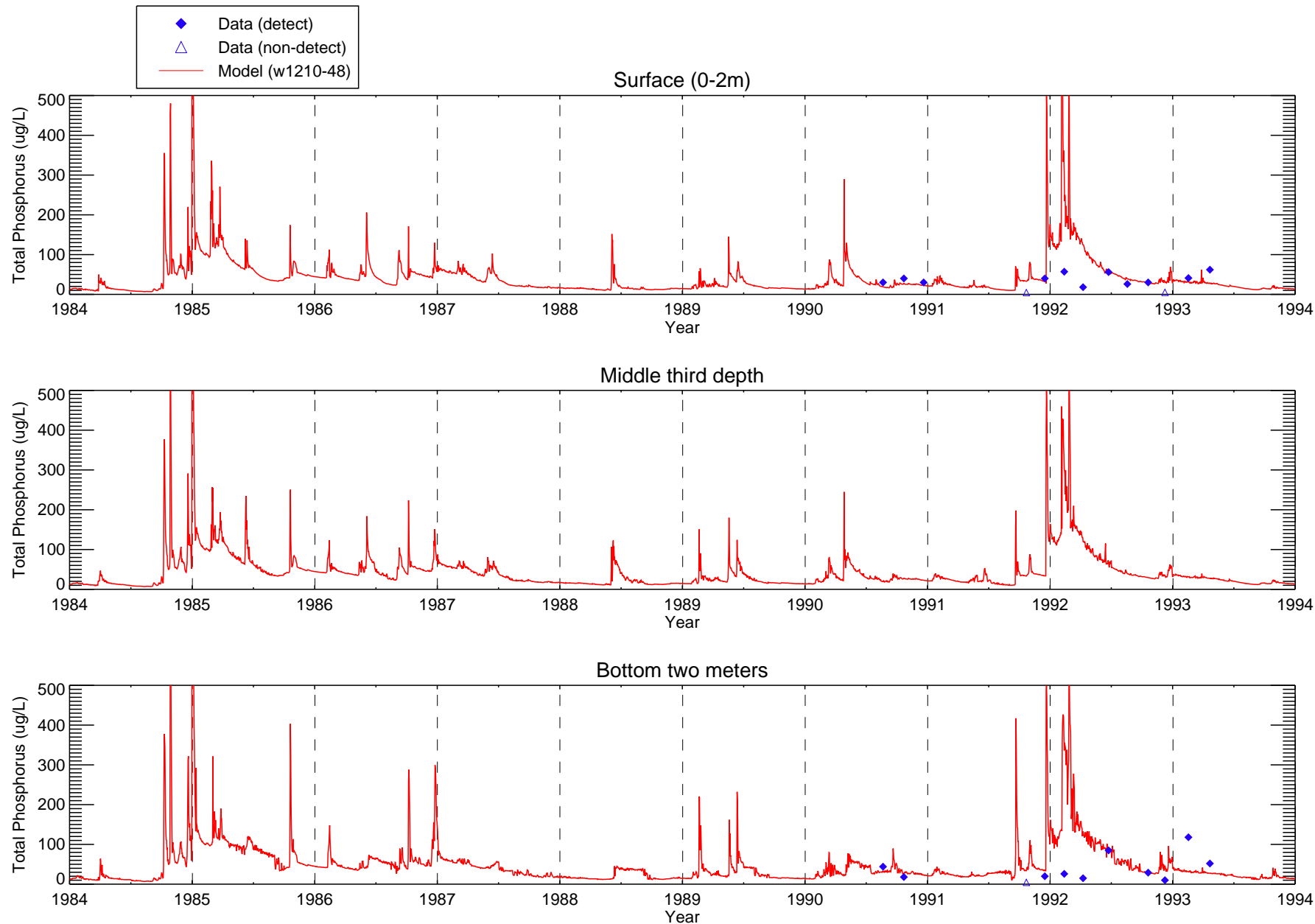
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:51:59 2013

Figure 4-17b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Orthophosphate
Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
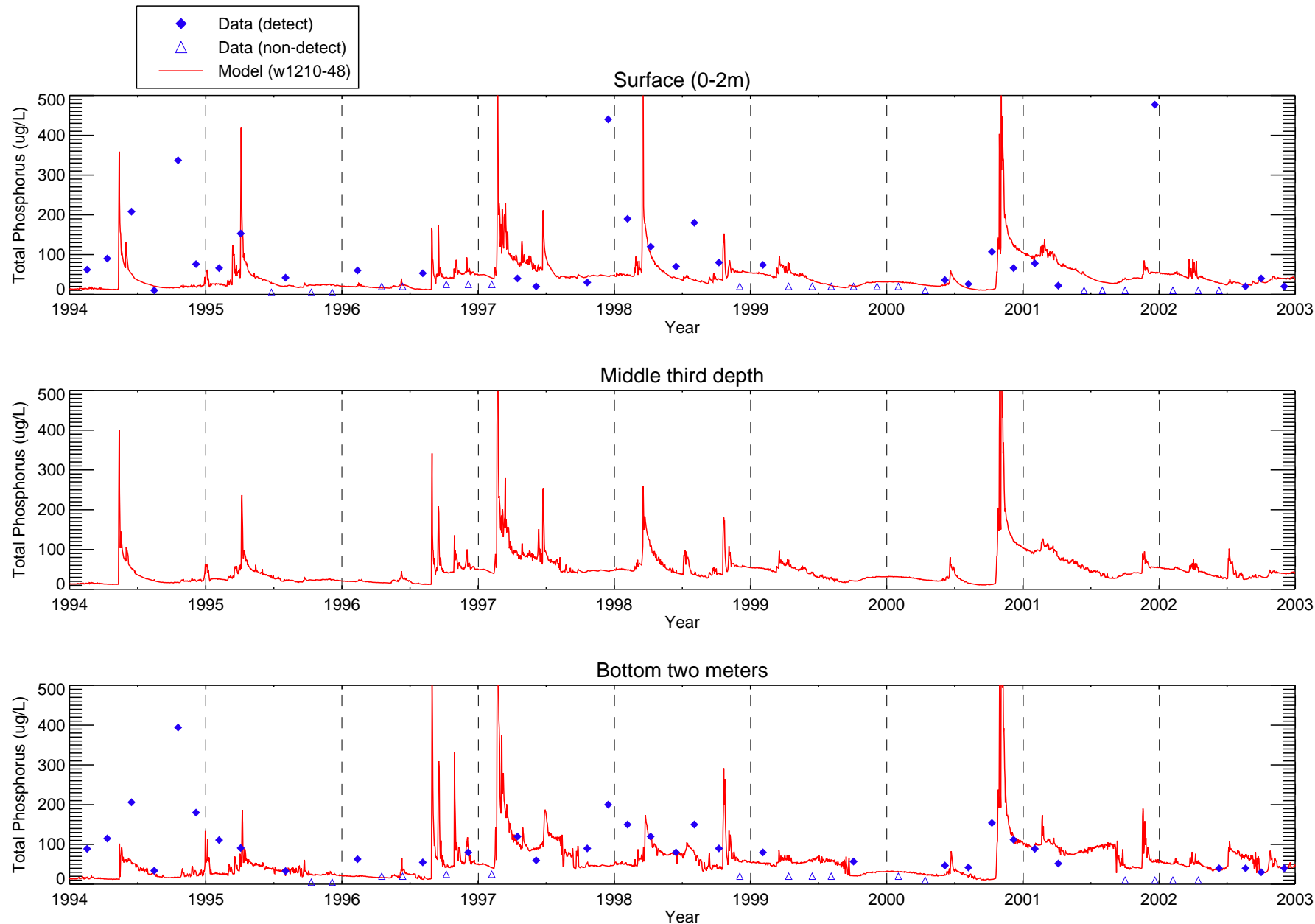
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:52:04 2013

Figure 4-17b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Orthophosphate

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

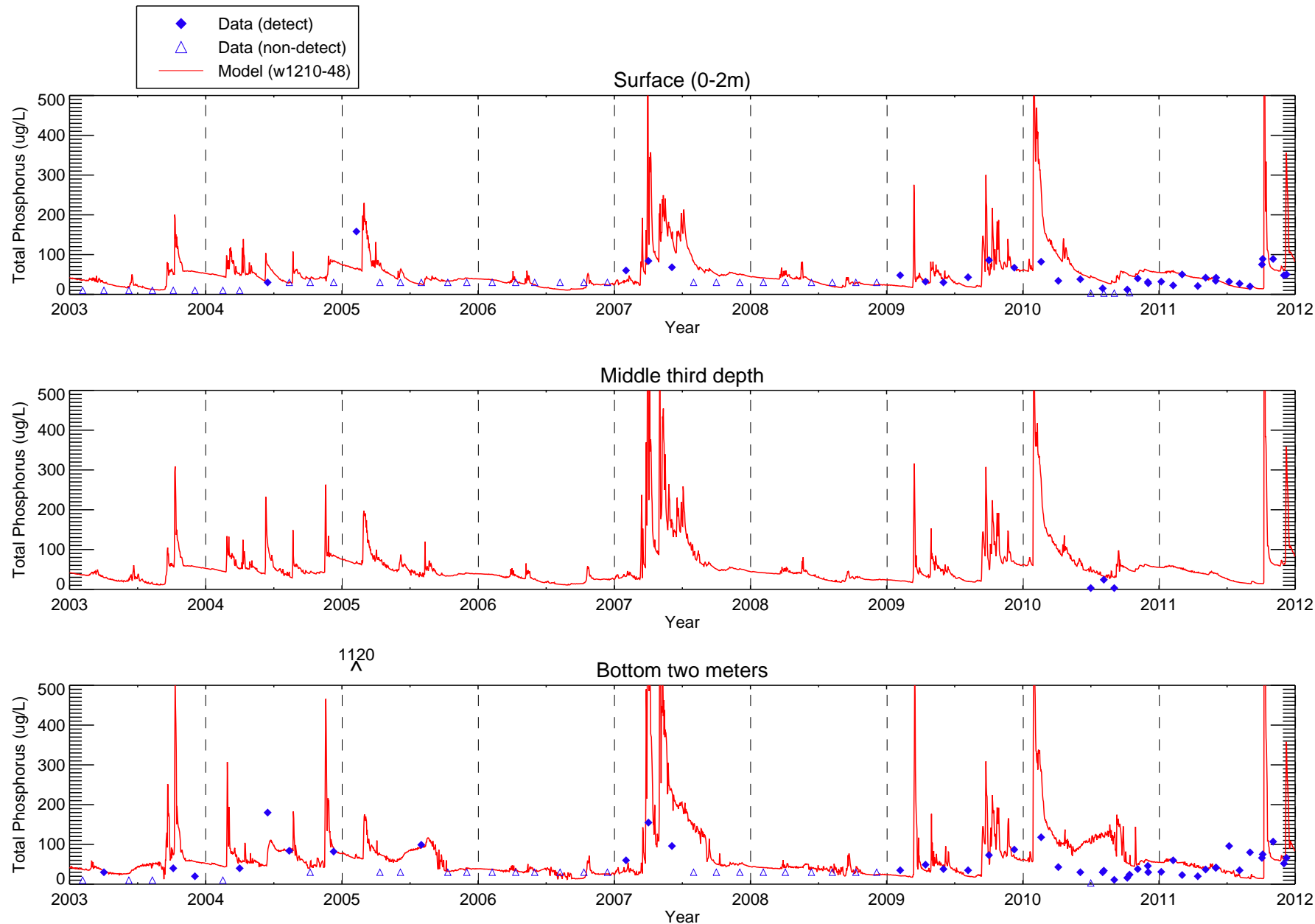CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:52:09 2013

Figure 4-17c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
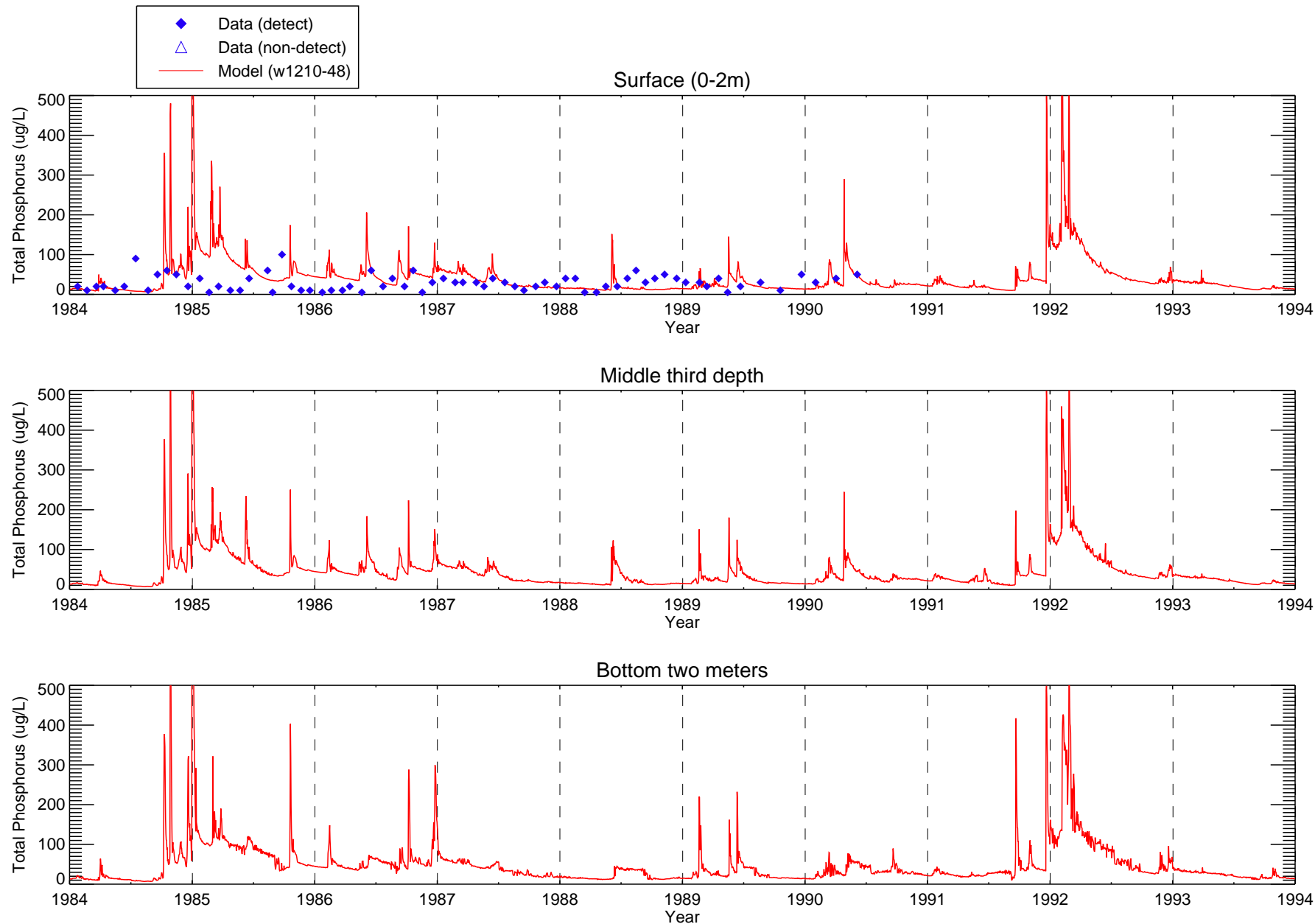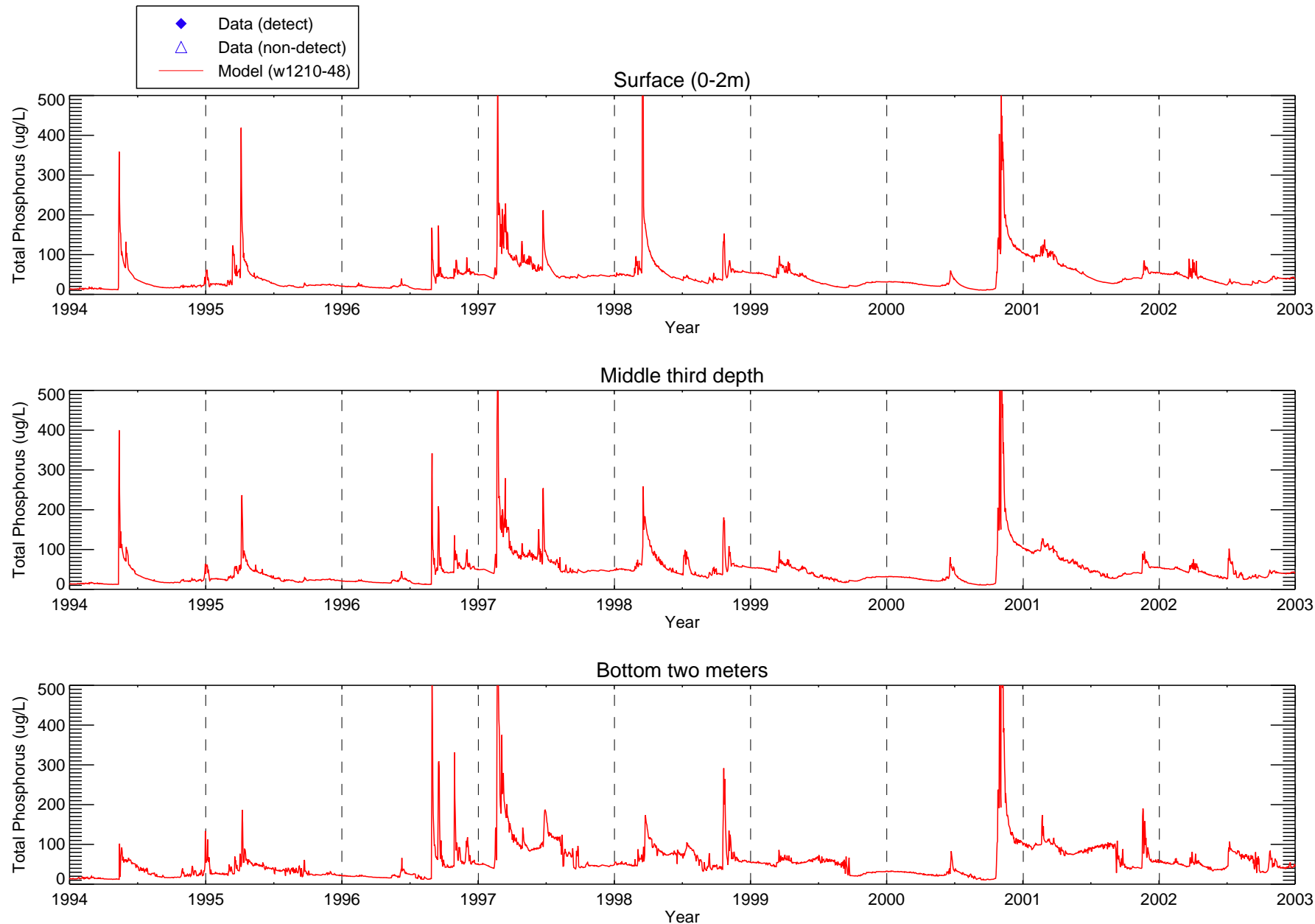Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 13:14:15 2013

Figure 4-17c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
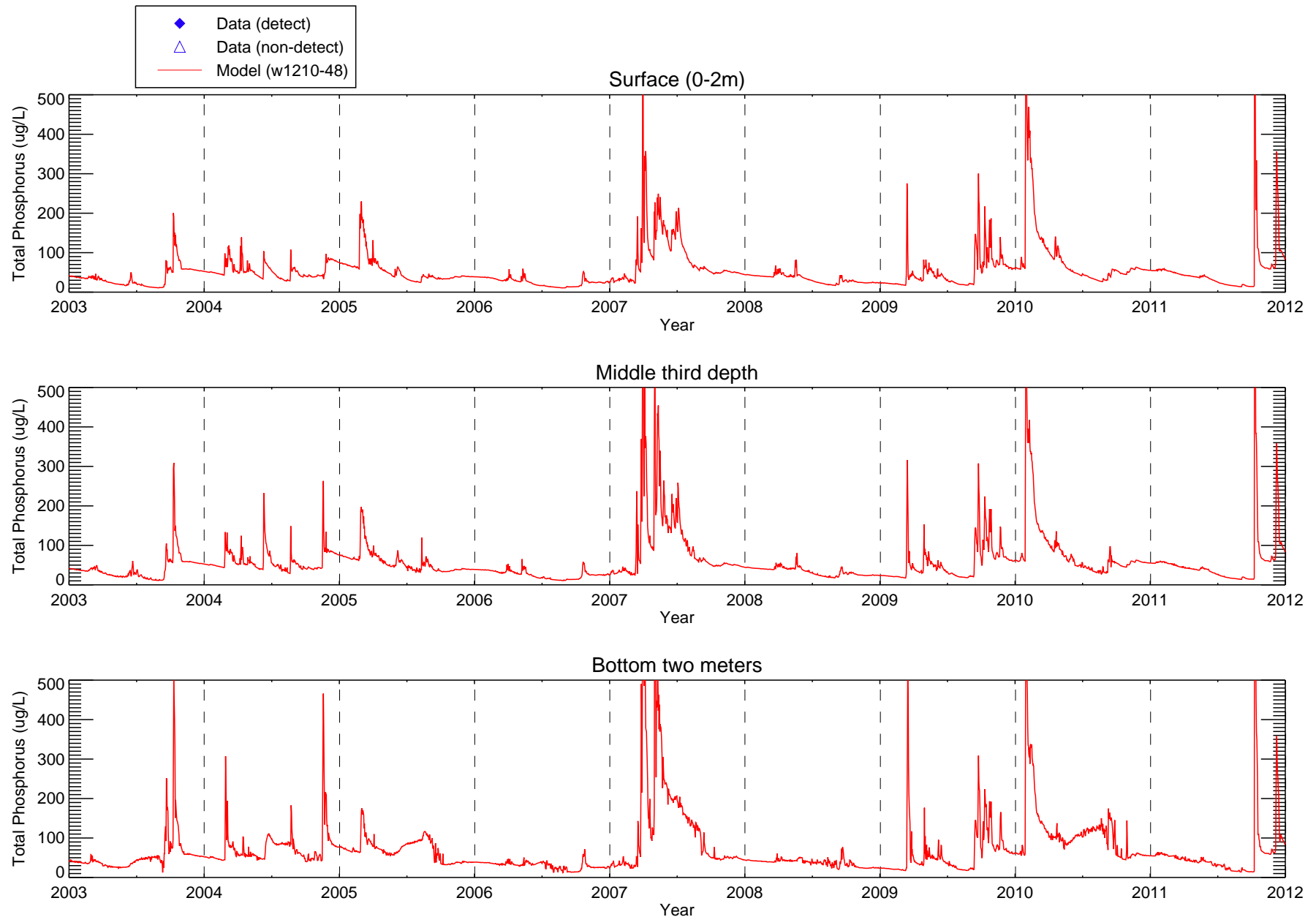Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 13:15:07 2013

Figure 4-17c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
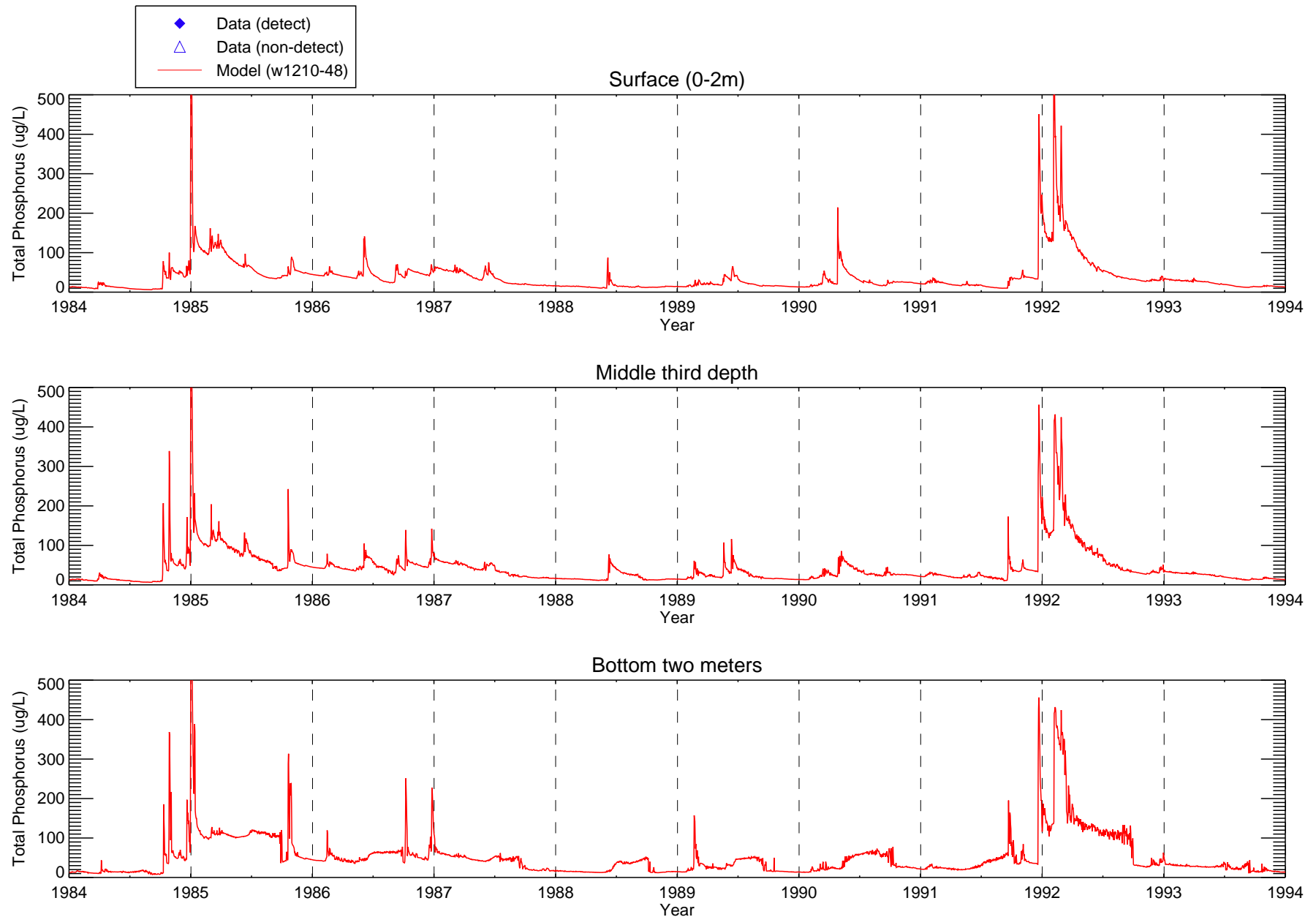Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 13:15:57 2013

Figure 4-17d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
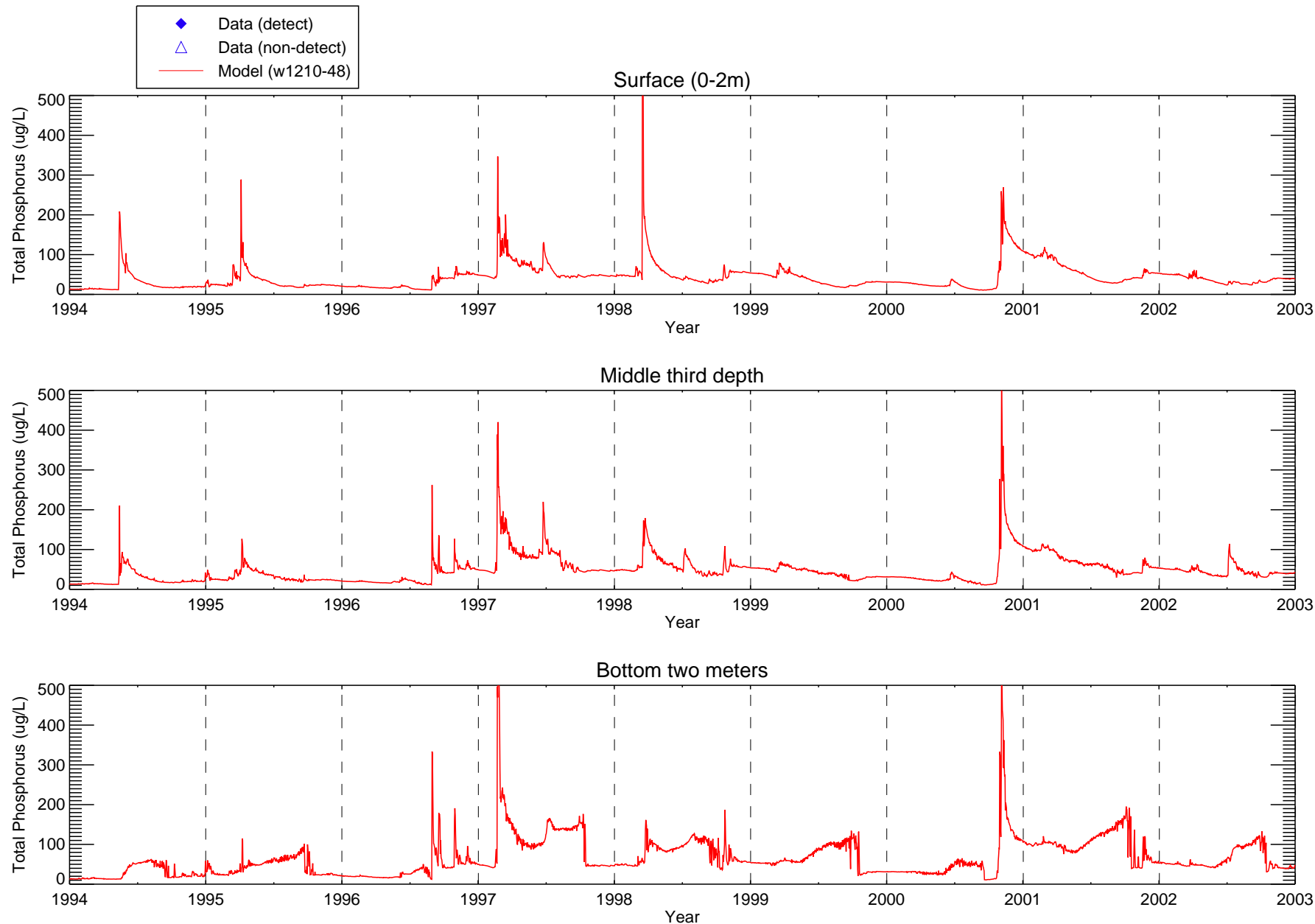
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-17d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
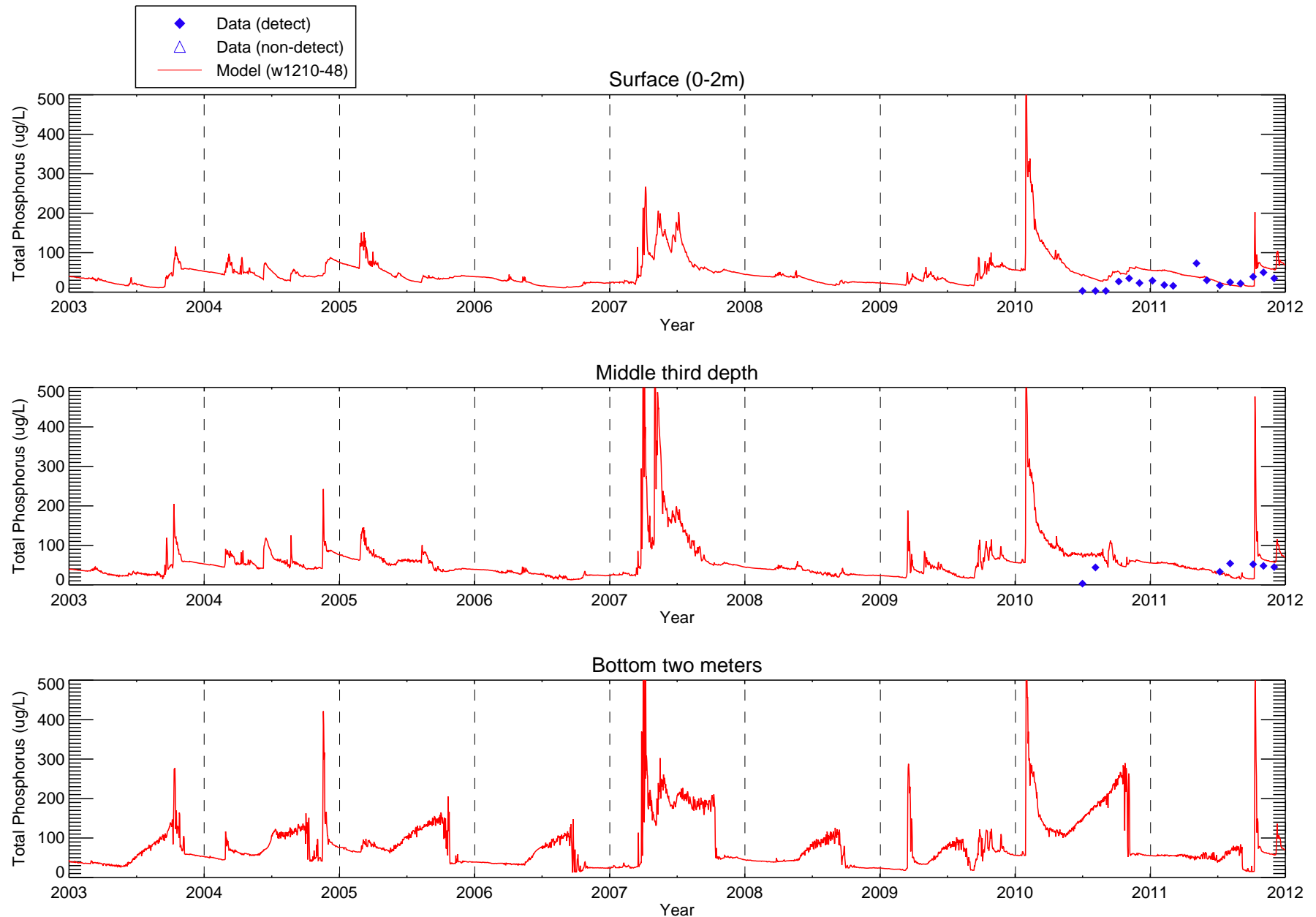
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - \\austin2\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 09:23:07 2013

Figure 4-17d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
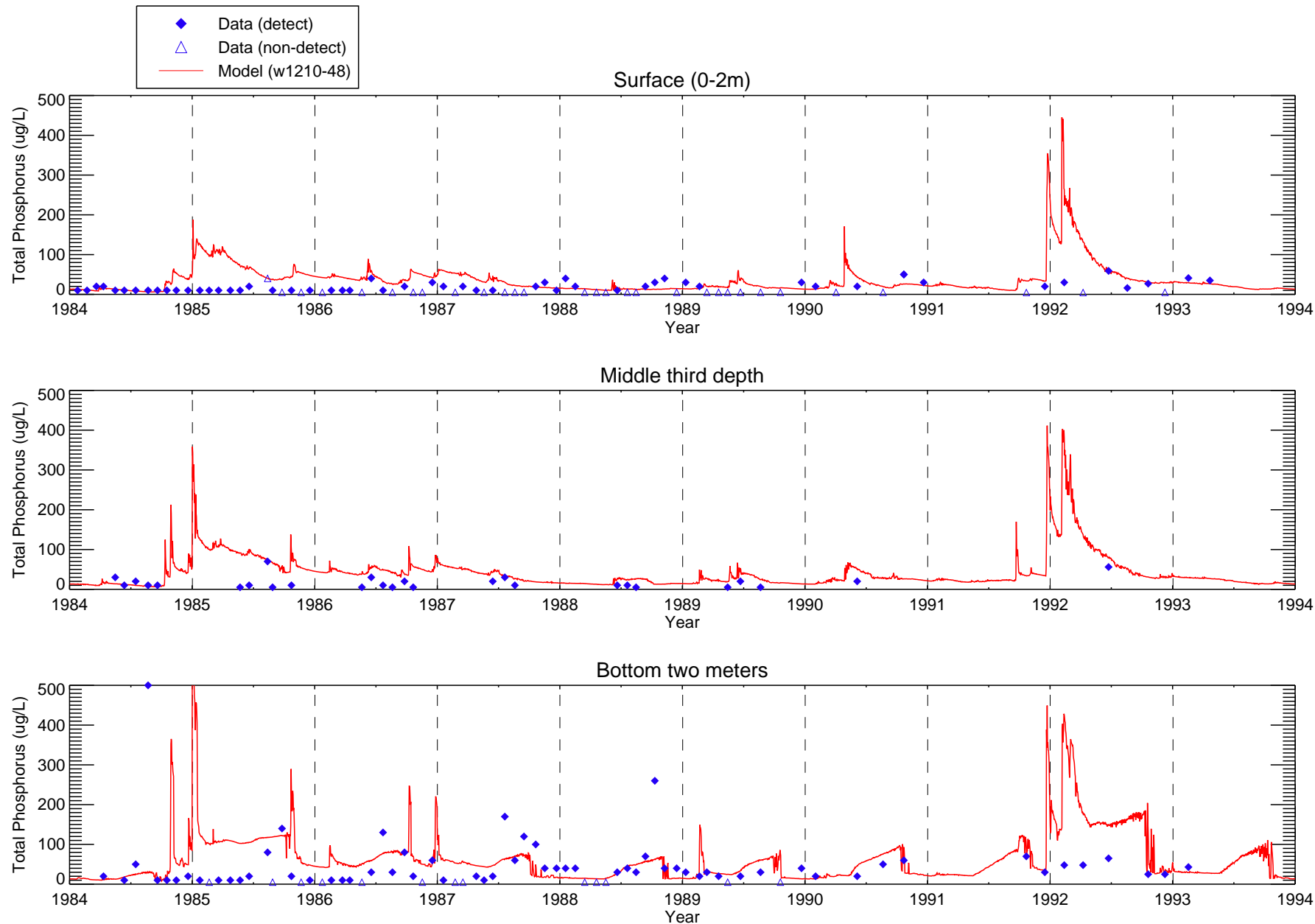
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - \\austin2\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 09:26:12 2013

Figure 4-17e
Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

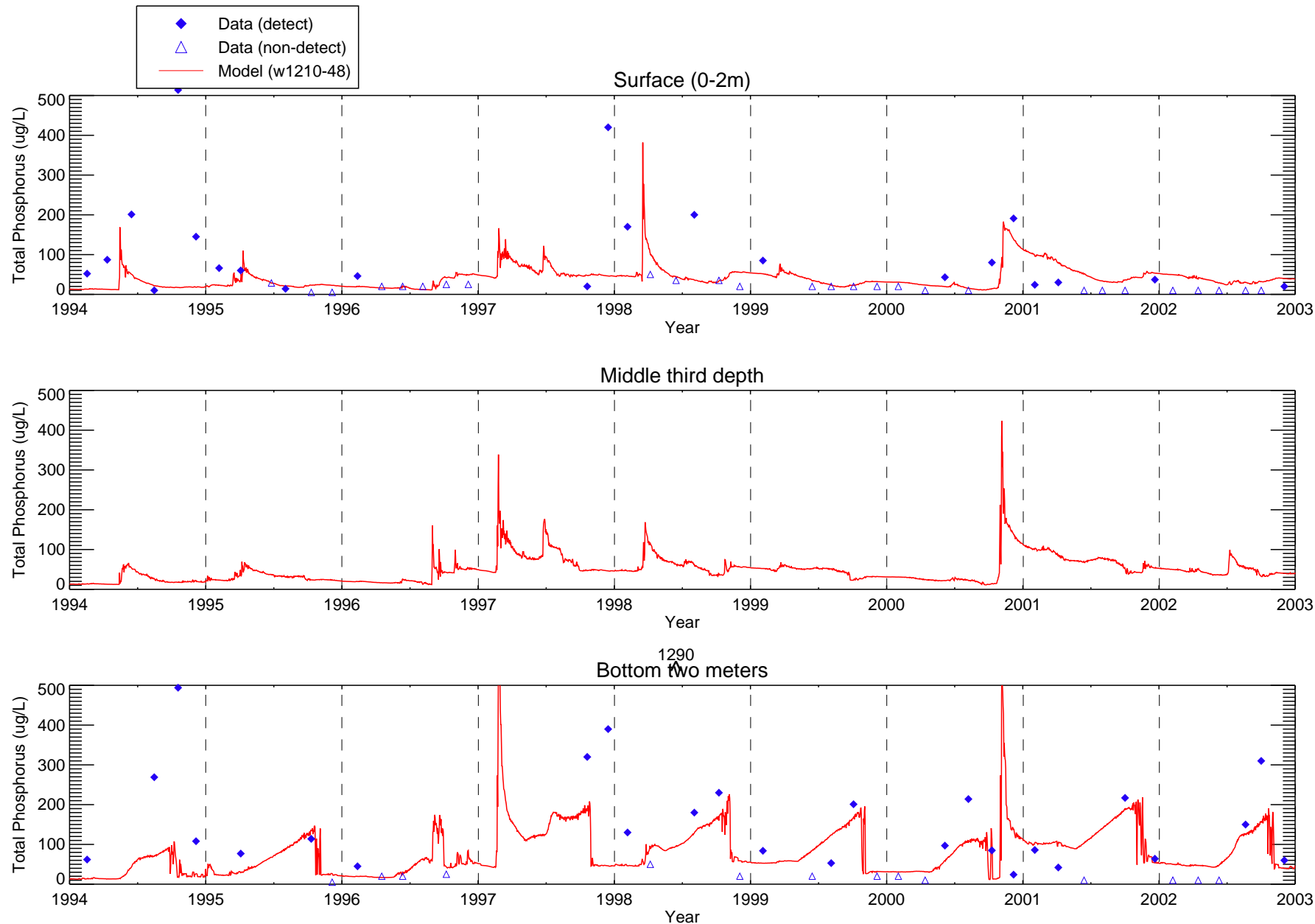CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-17e
Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

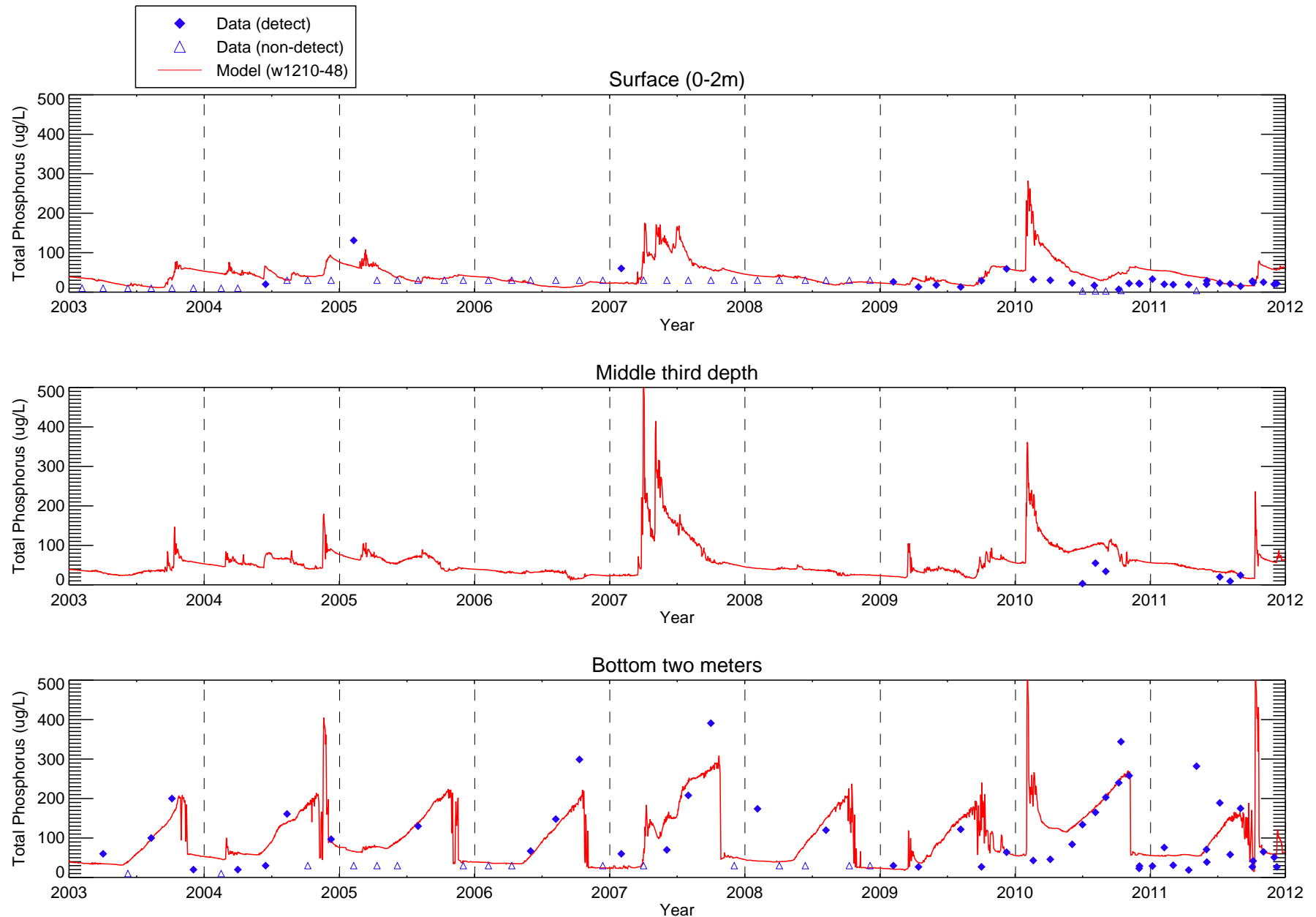CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

Figure 4-17e

Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

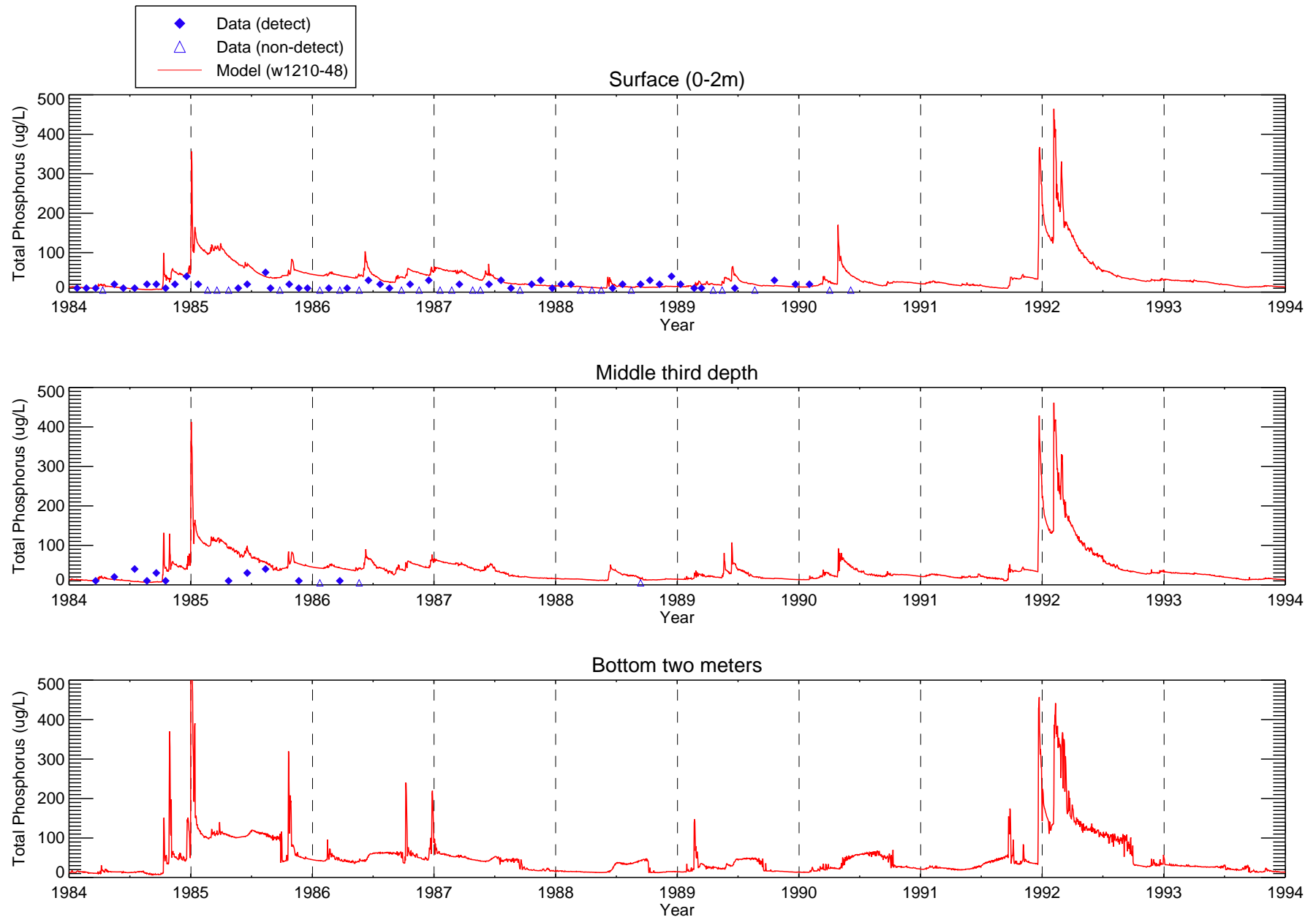CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-17f

Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
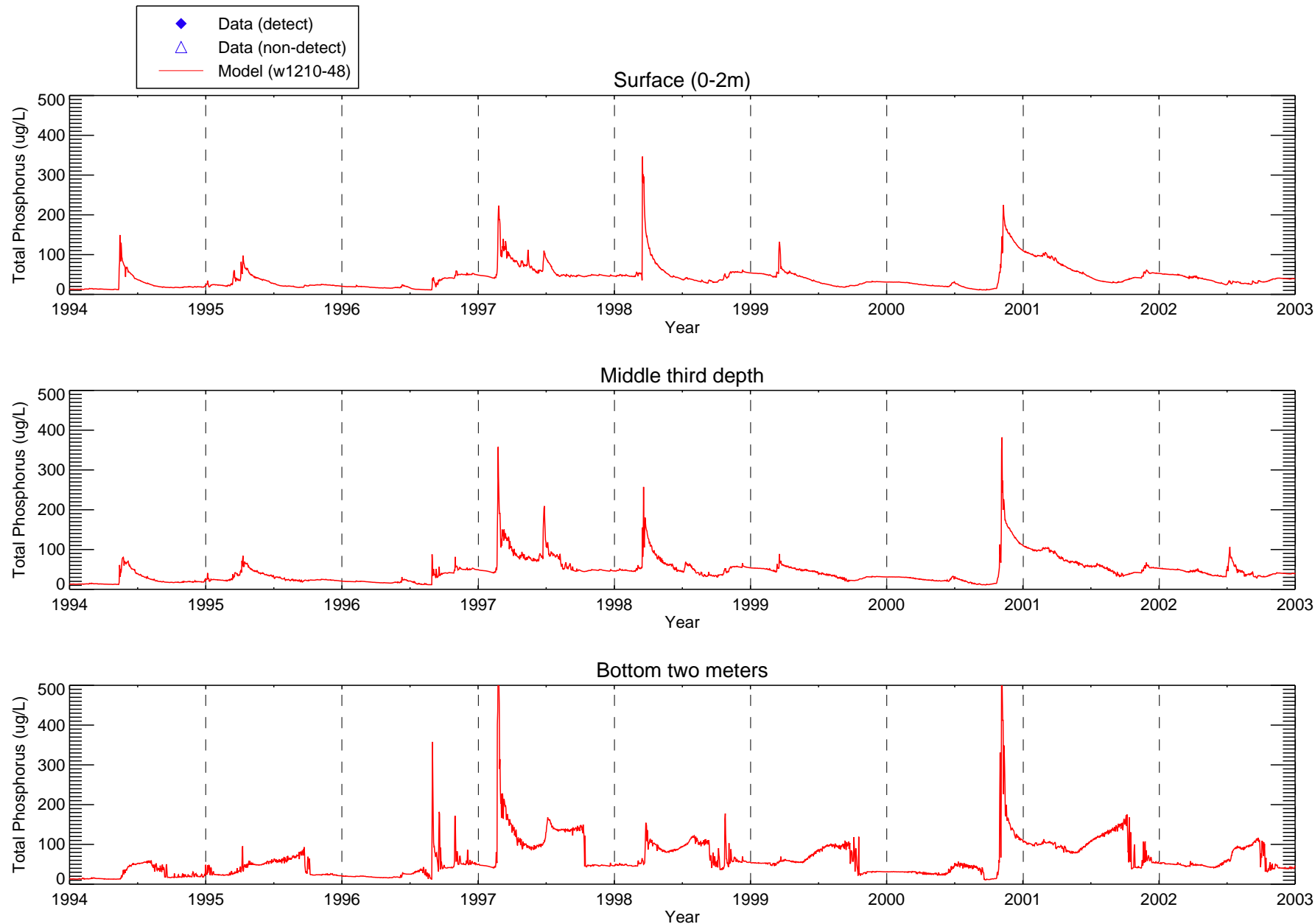
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-17f
Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
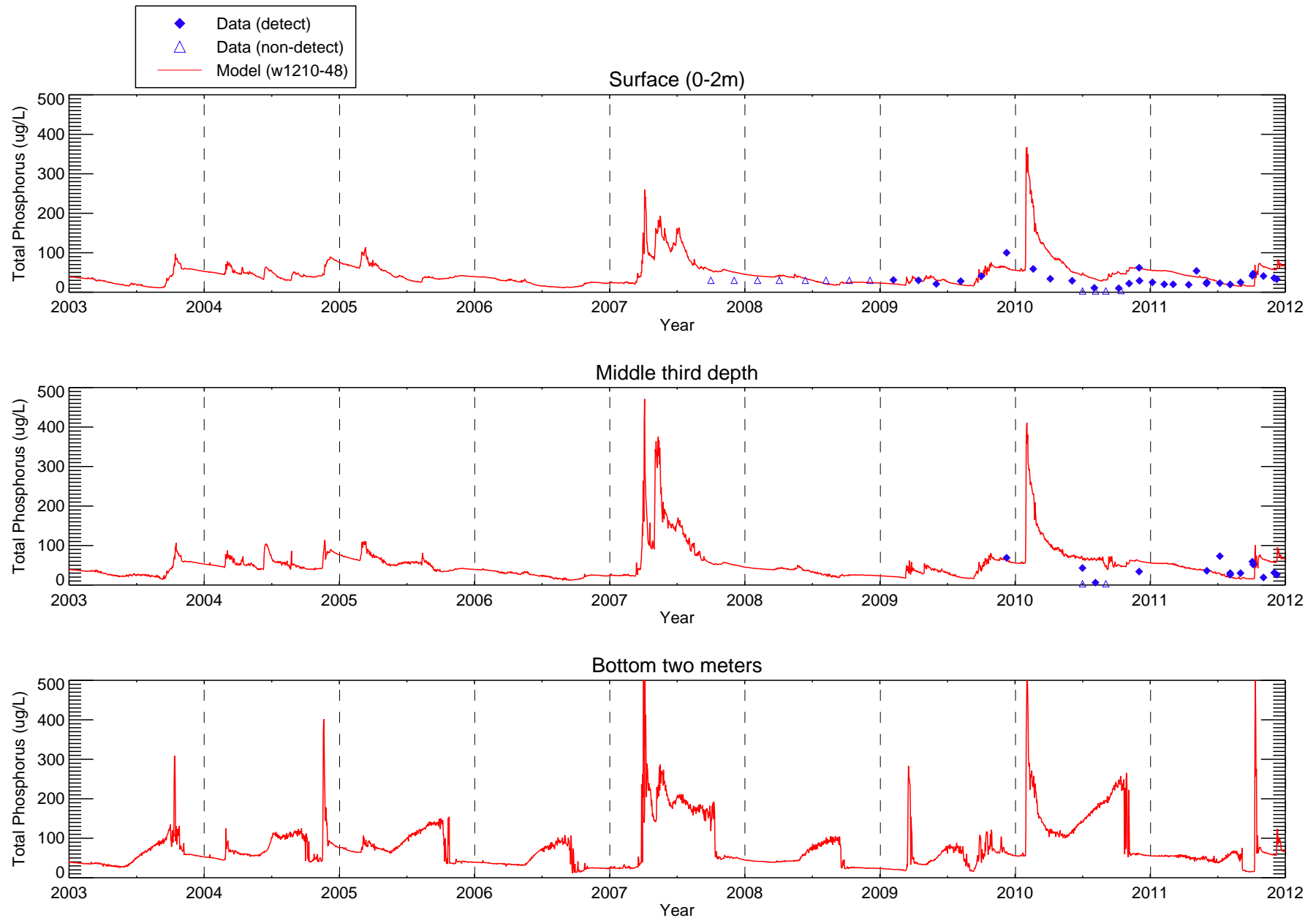
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-17f
Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
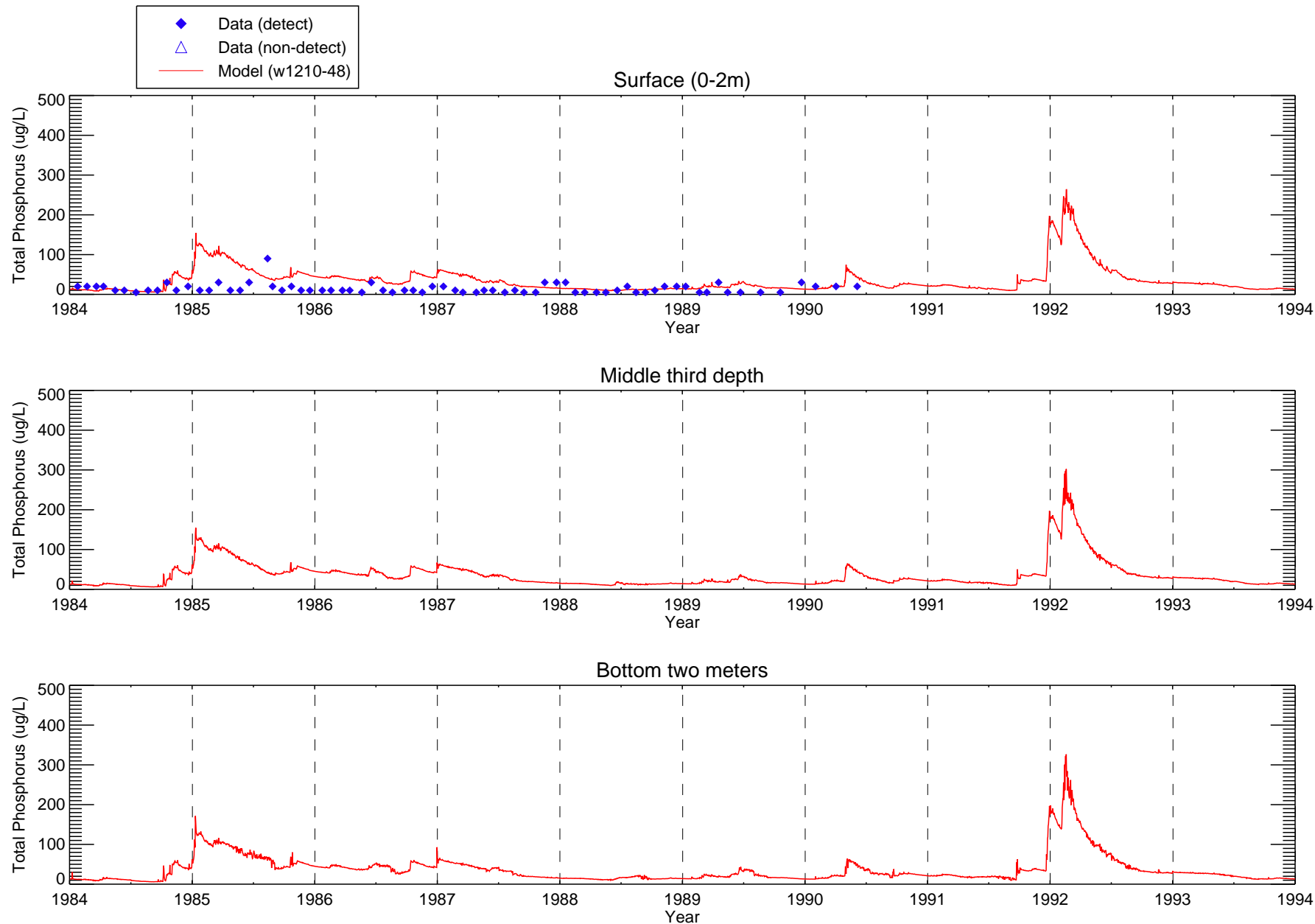
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-17g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
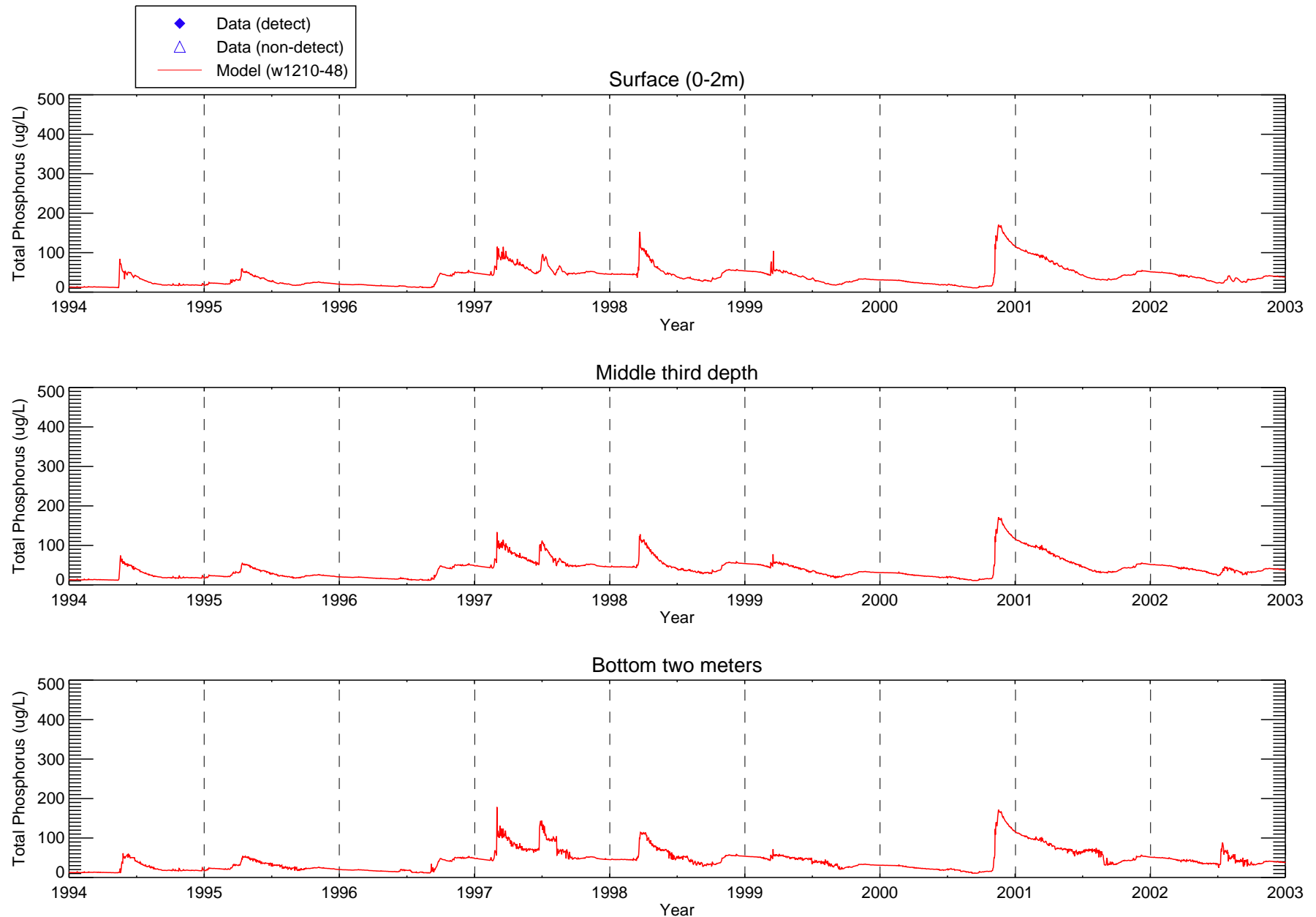Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:48:04 2013

Figure 4-17g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
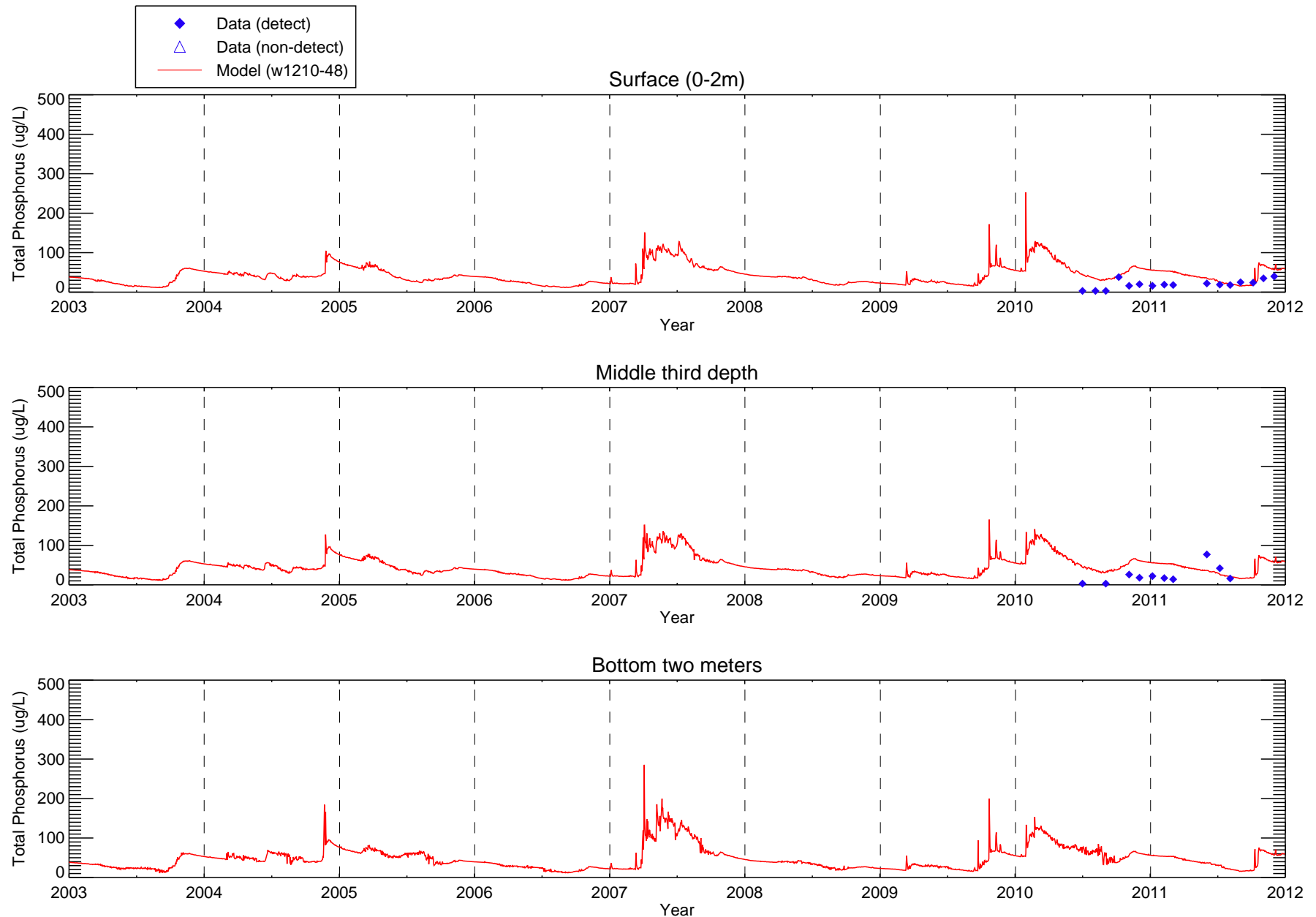Lower Colorado River Authority

Figure 4-17g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
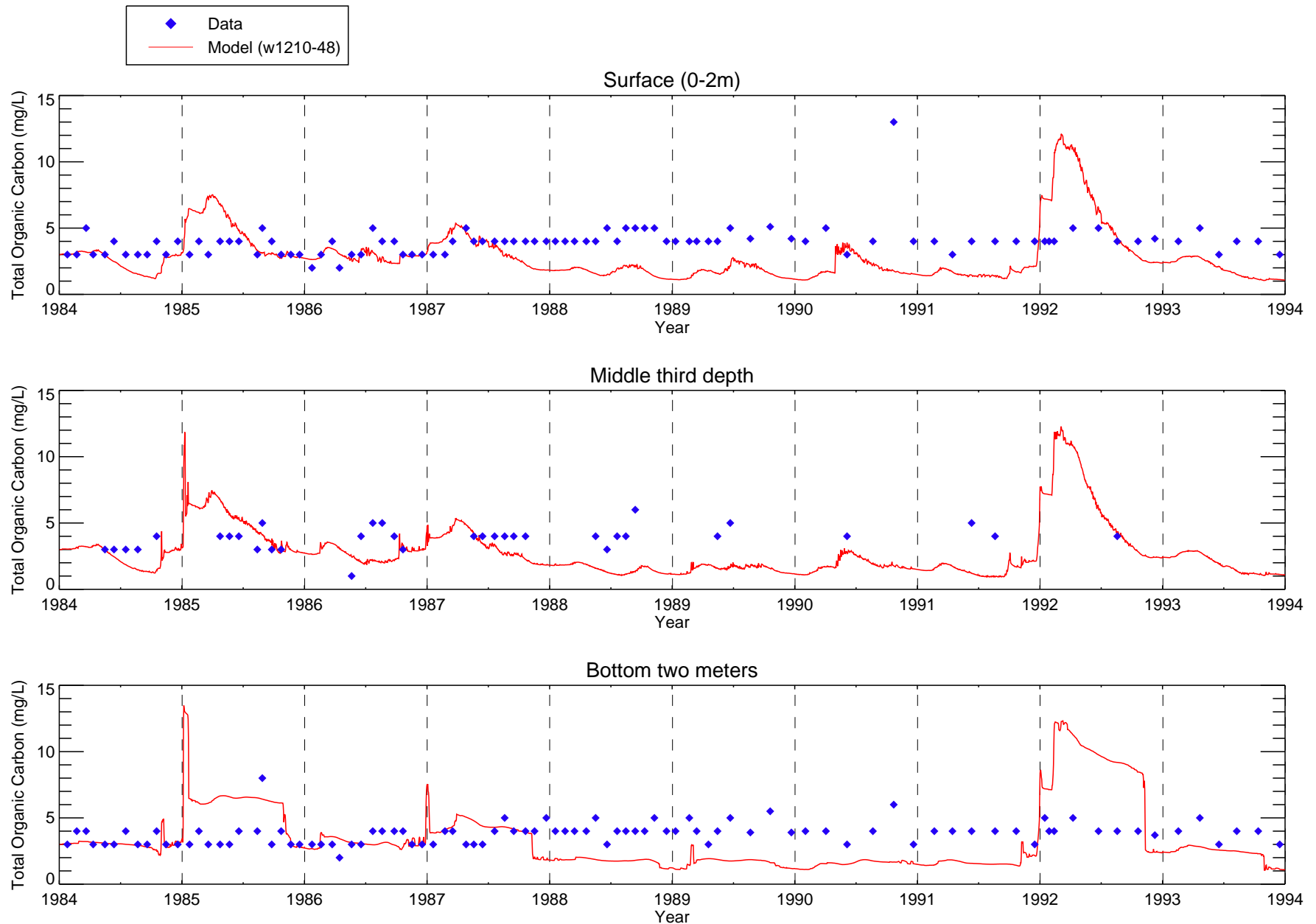Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:50:08 2013

Figure 4-17h
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
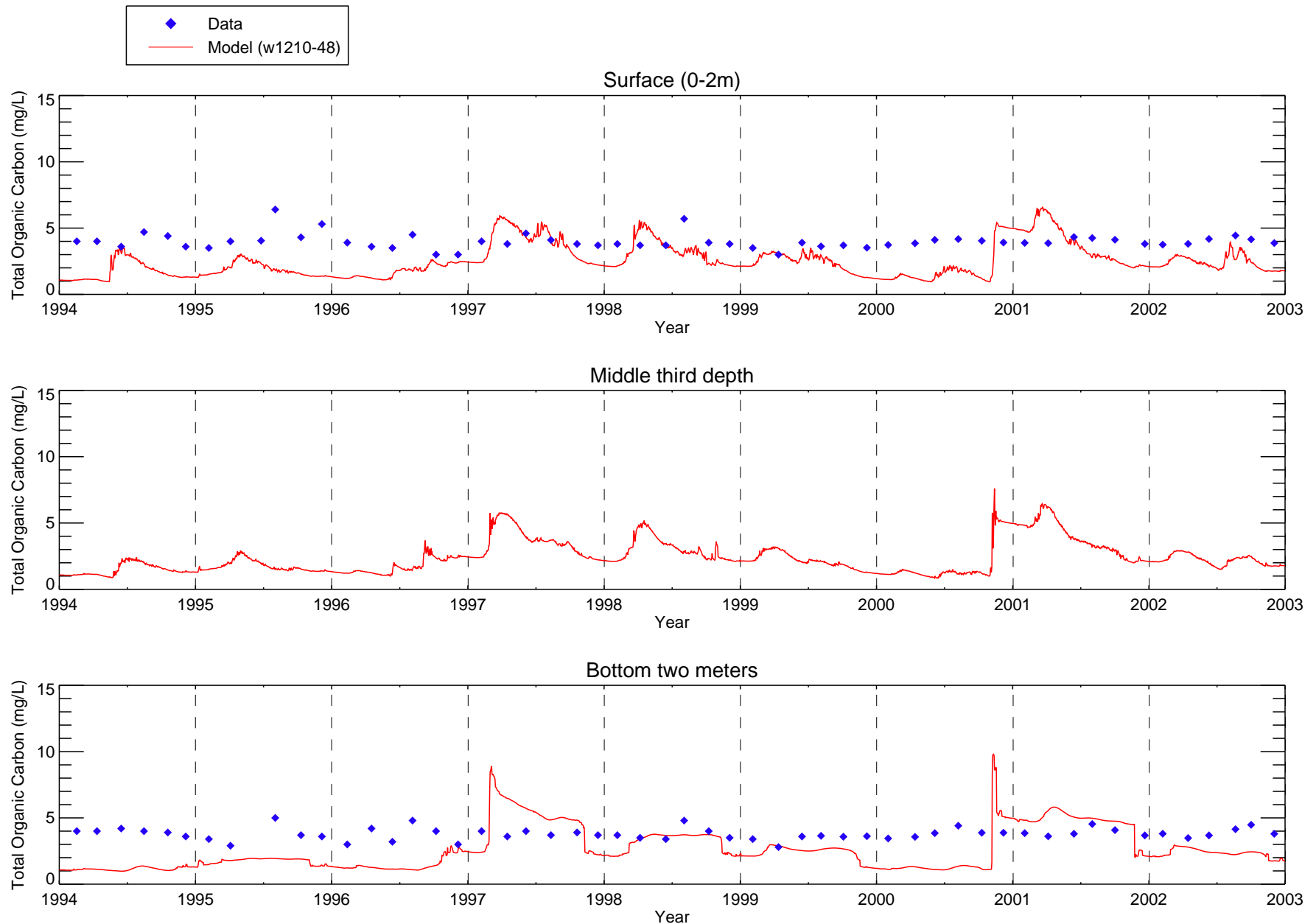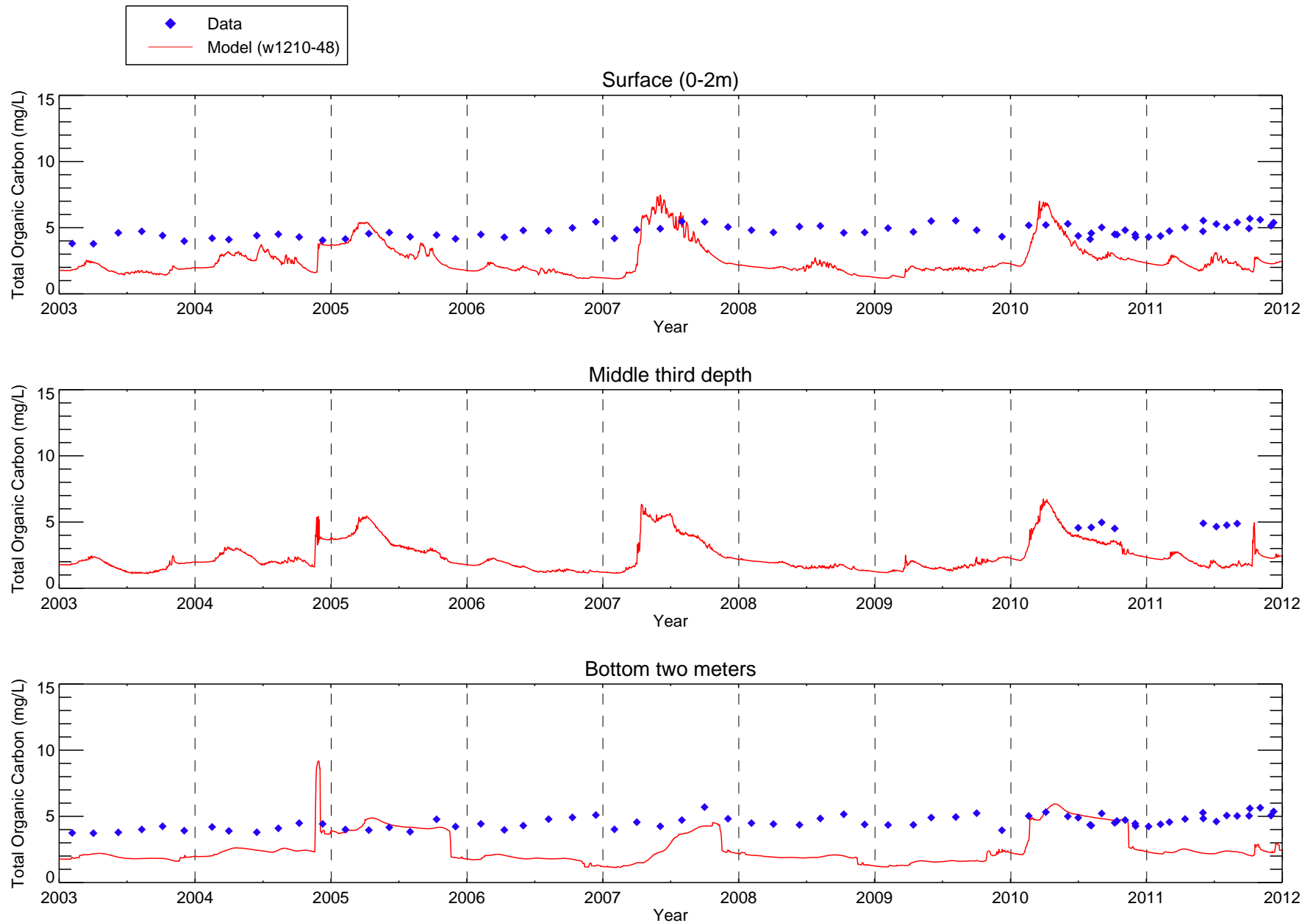Lower Colorado River Authority

Figure 4-17h
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA PARSONS

Figure 4-17h
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
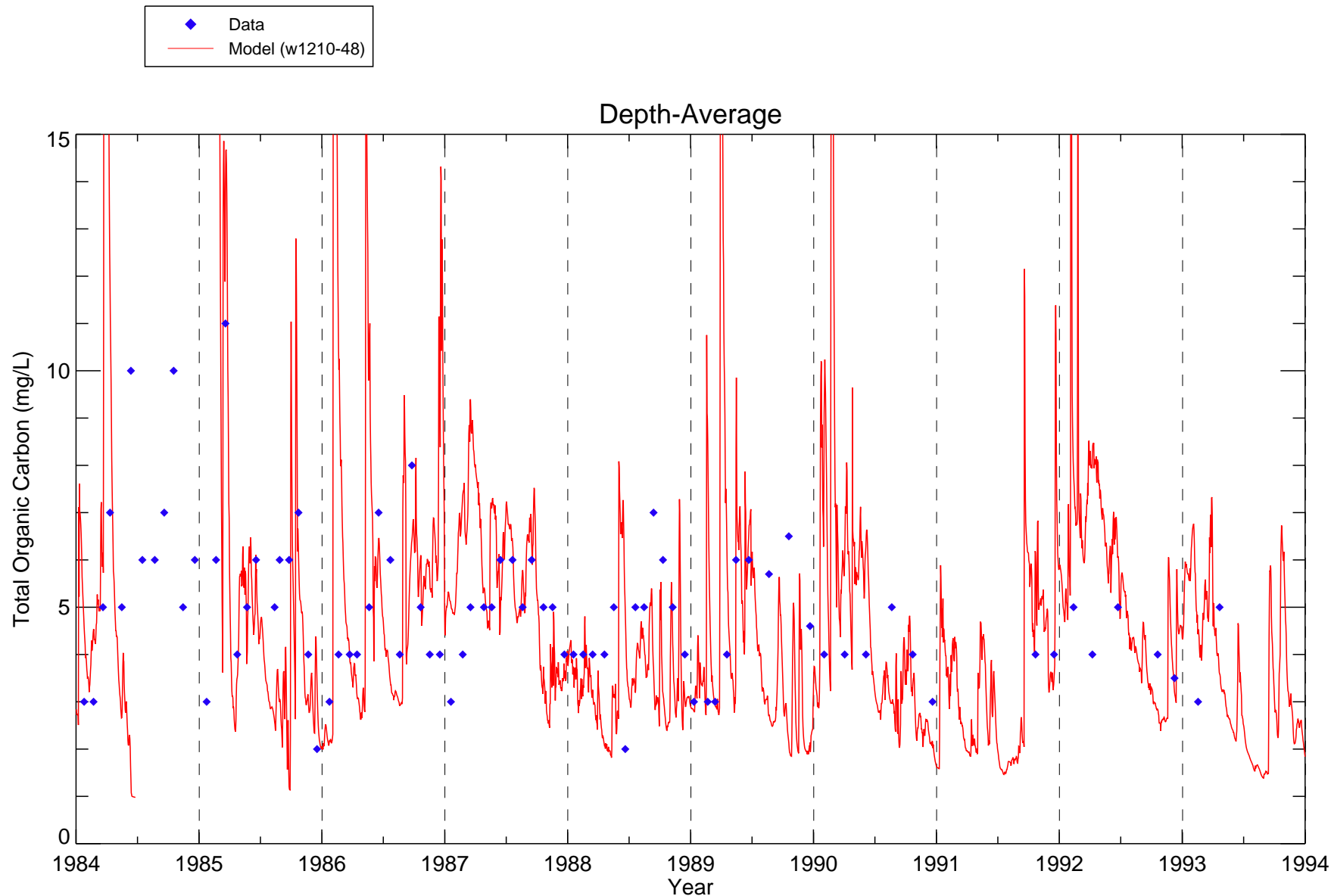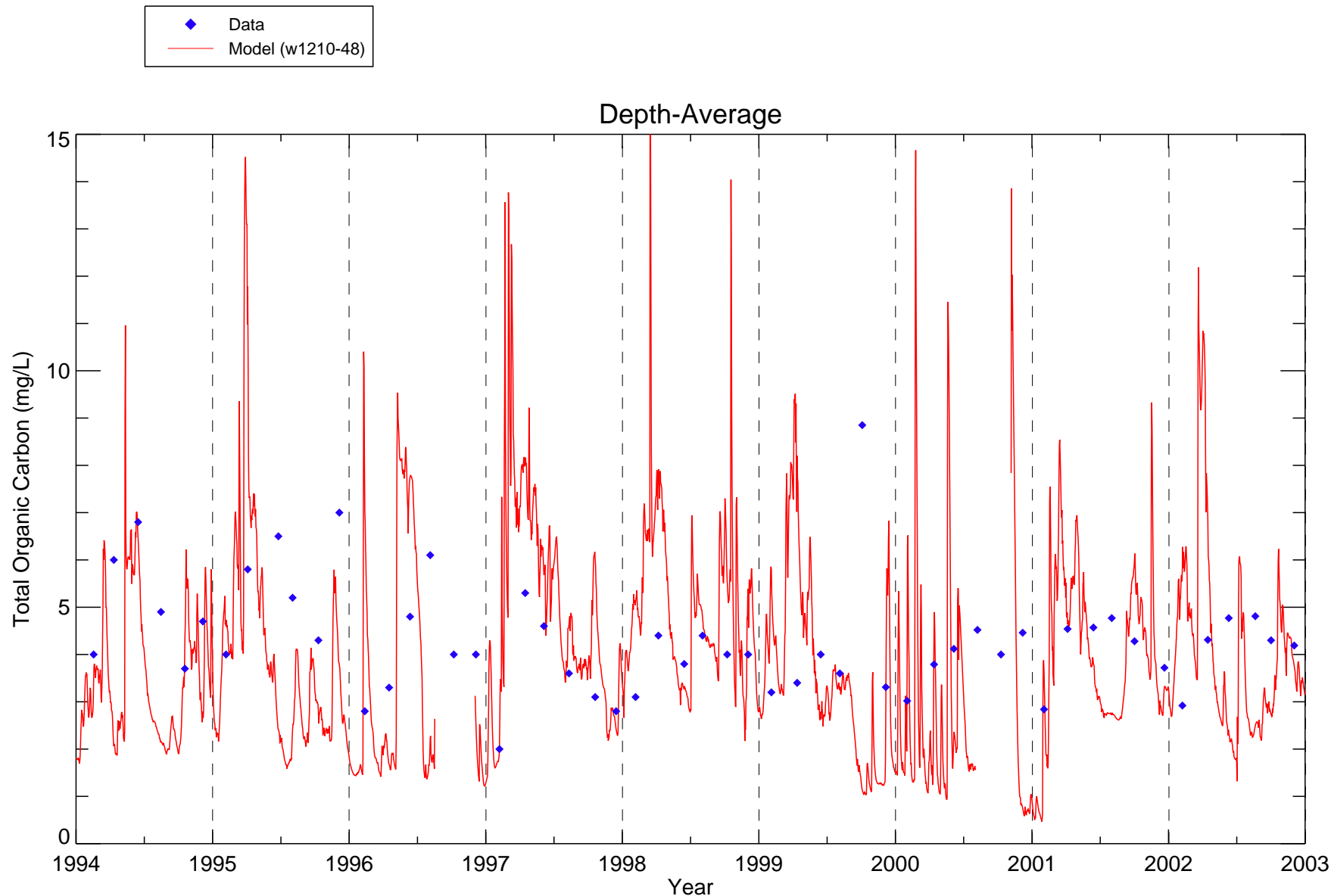
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-18a

Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Total Phosphorus

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:01:41 2013

Figure 4-18a

Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Total Phosphorus

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-18a

Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Total Phosphorus

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
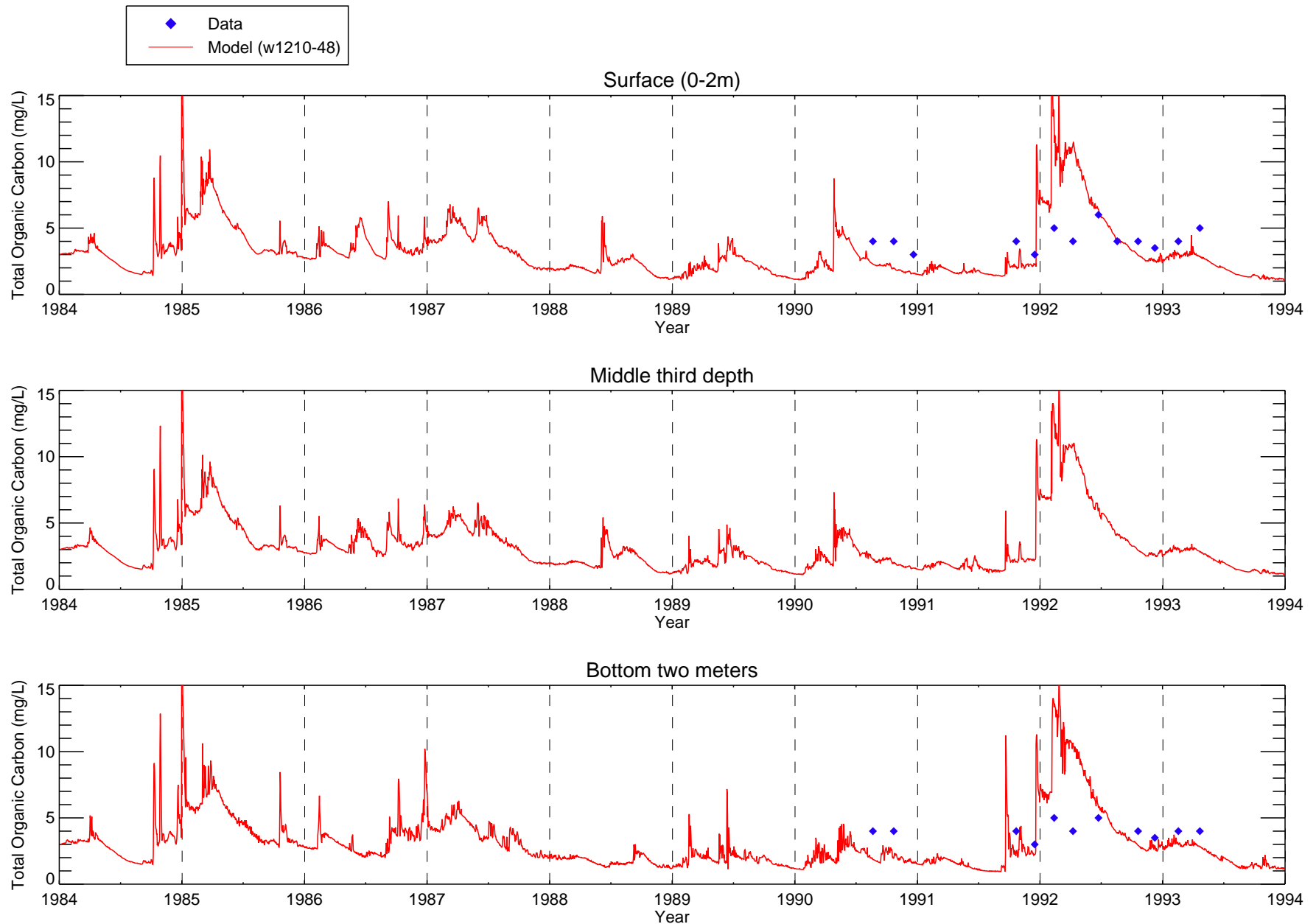
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-18b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Total Phosphorus
Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-18b
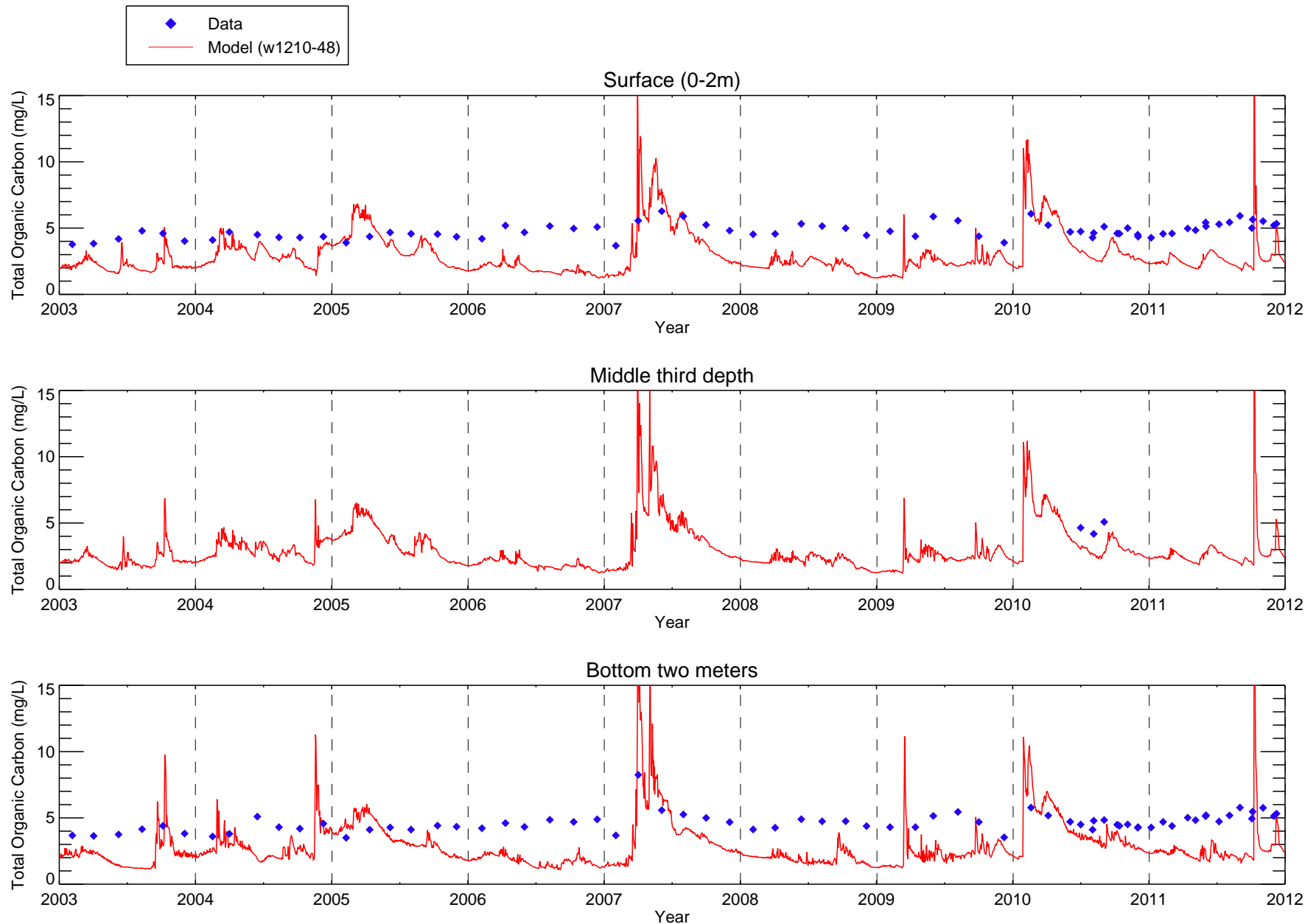**Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Total Phosphorus**

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Depth-Average

Figure 4-18b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Total Phosphorus

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
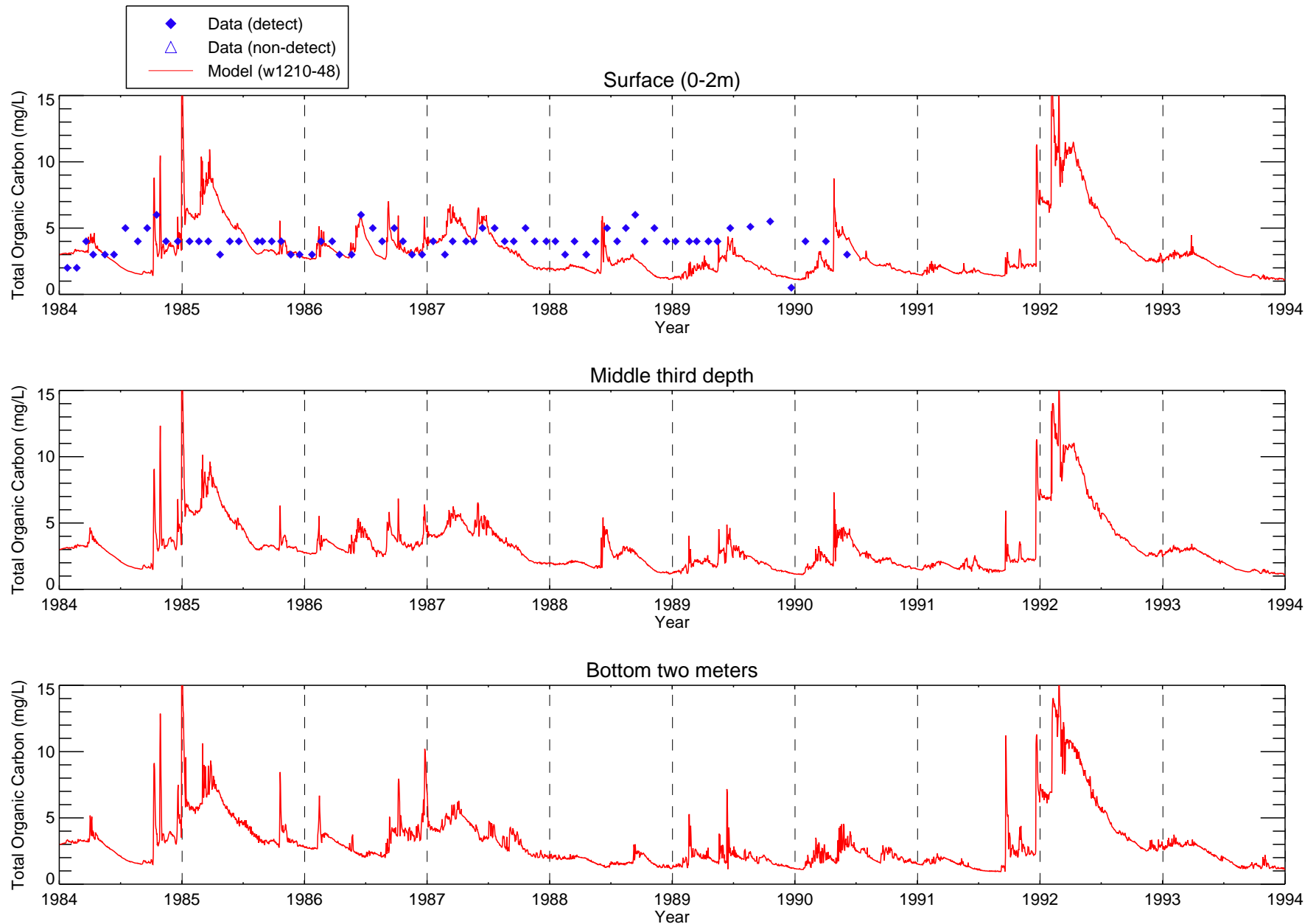Tue Jan 29 19:10:15 2013

Figure 4-18c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Total Phosphorus

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
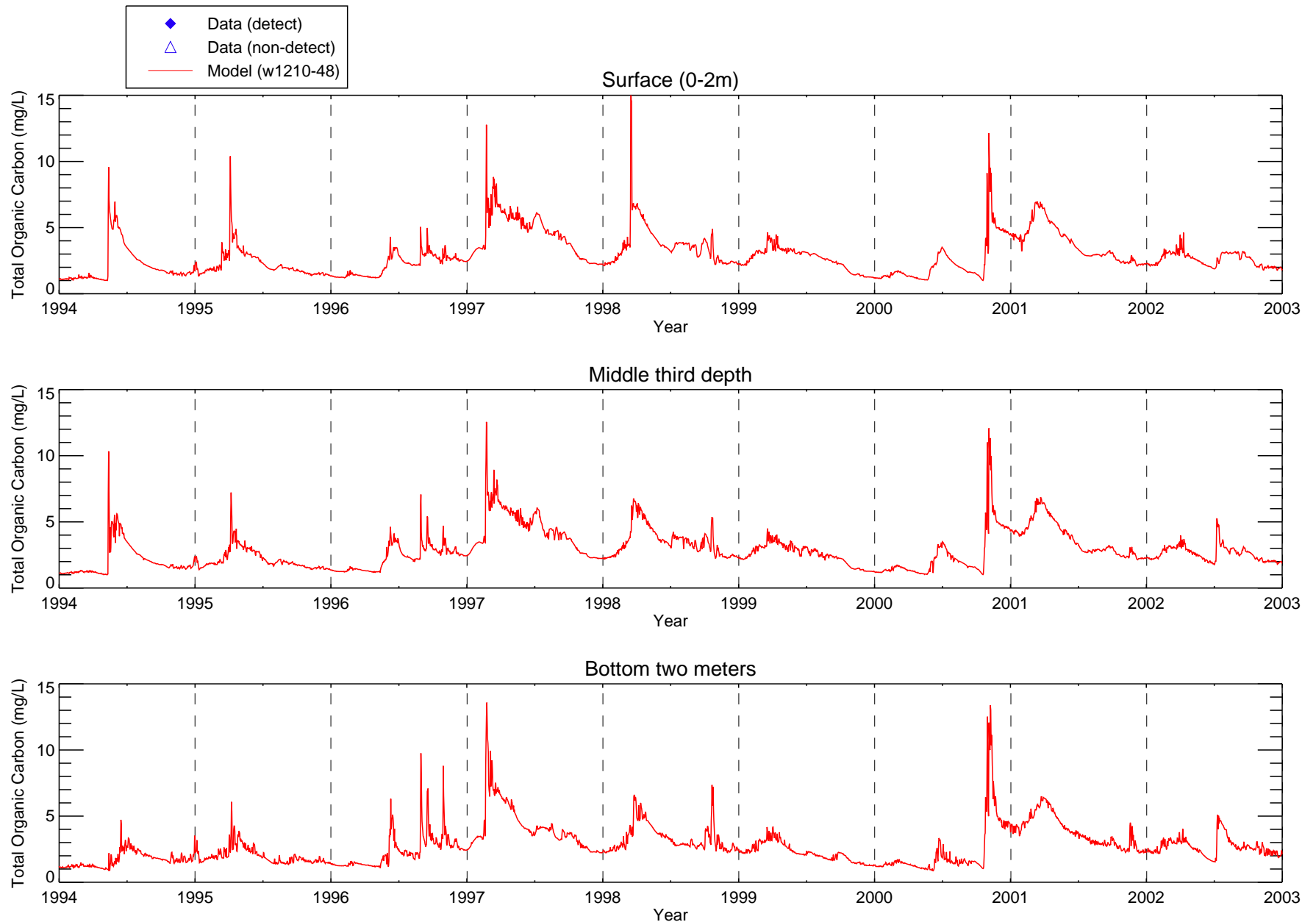
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-18c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Total Phosphorus

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
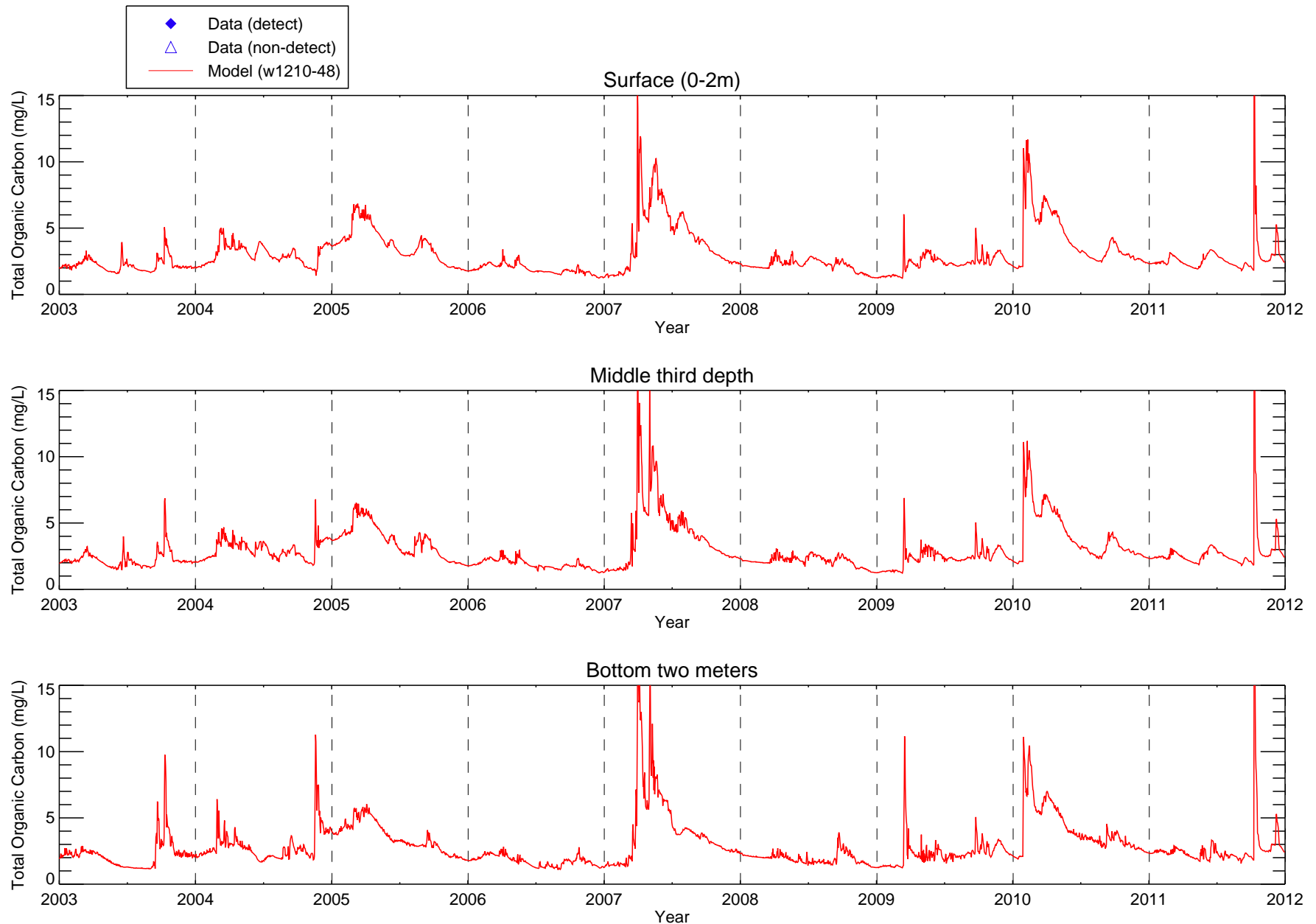
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 13:17:41 2013

Figure 4-18c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Total Phosphorus

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
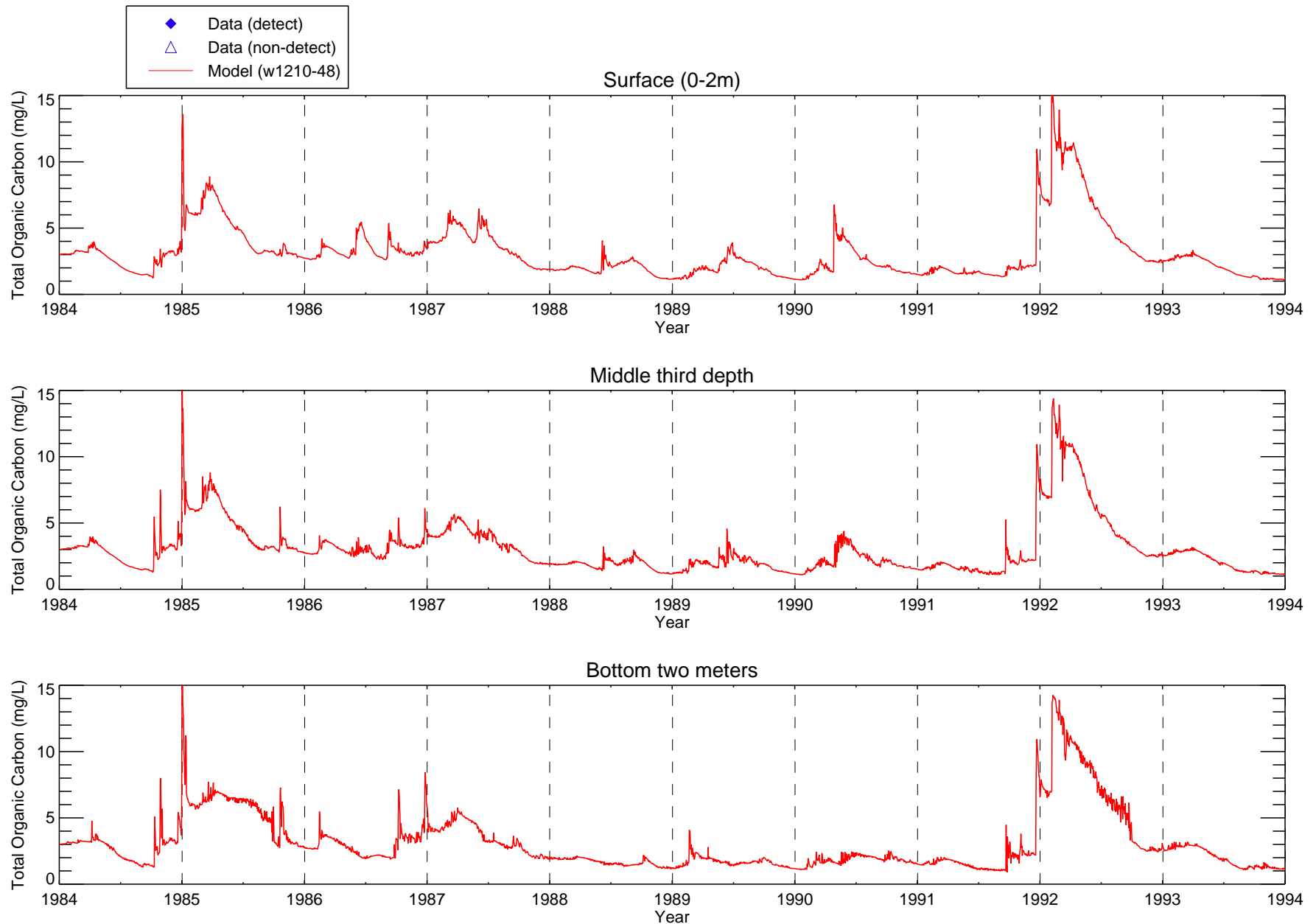
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 13:18:32 2013

Figure 4-18d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Total Phosphorus

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
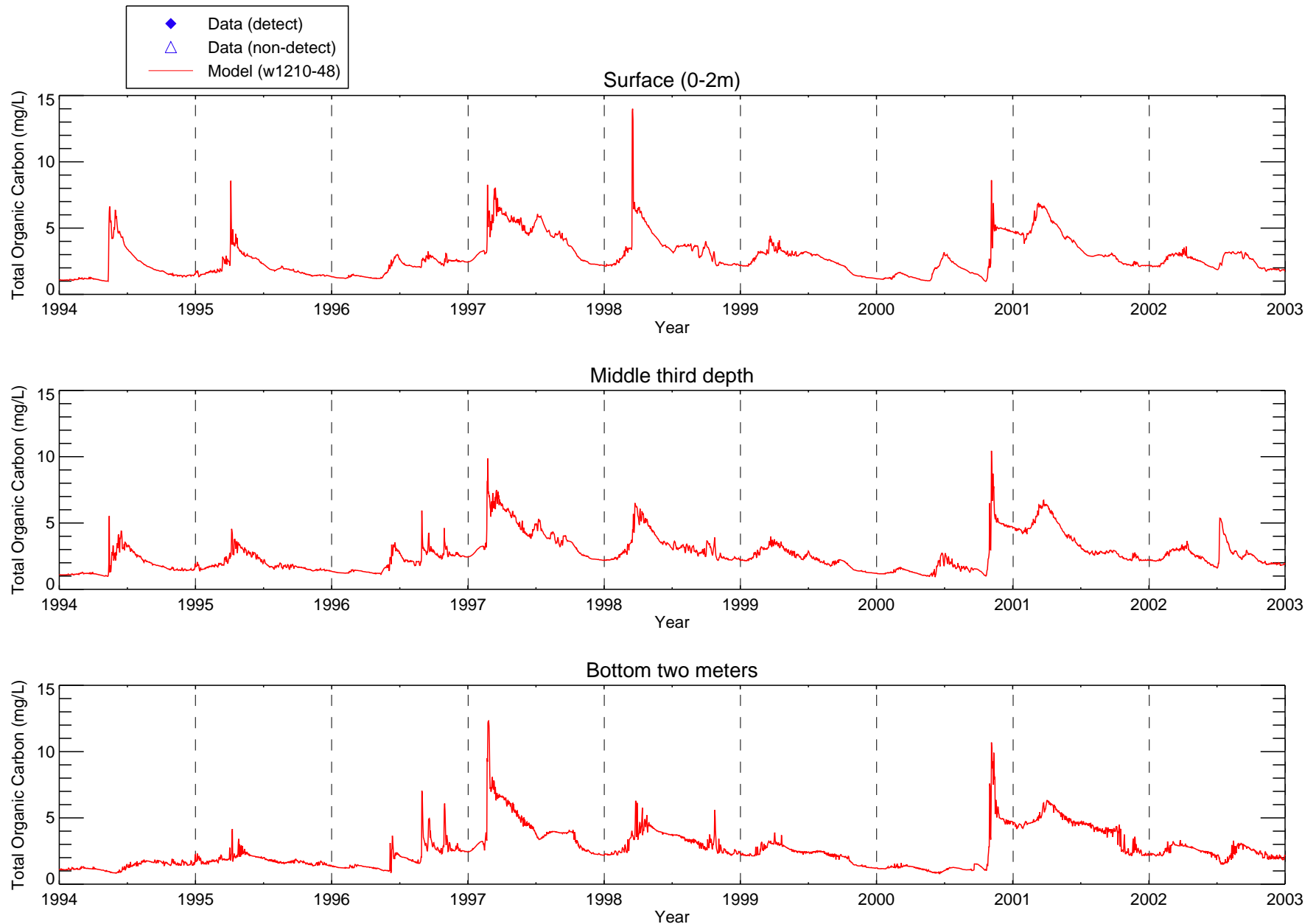
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-18d
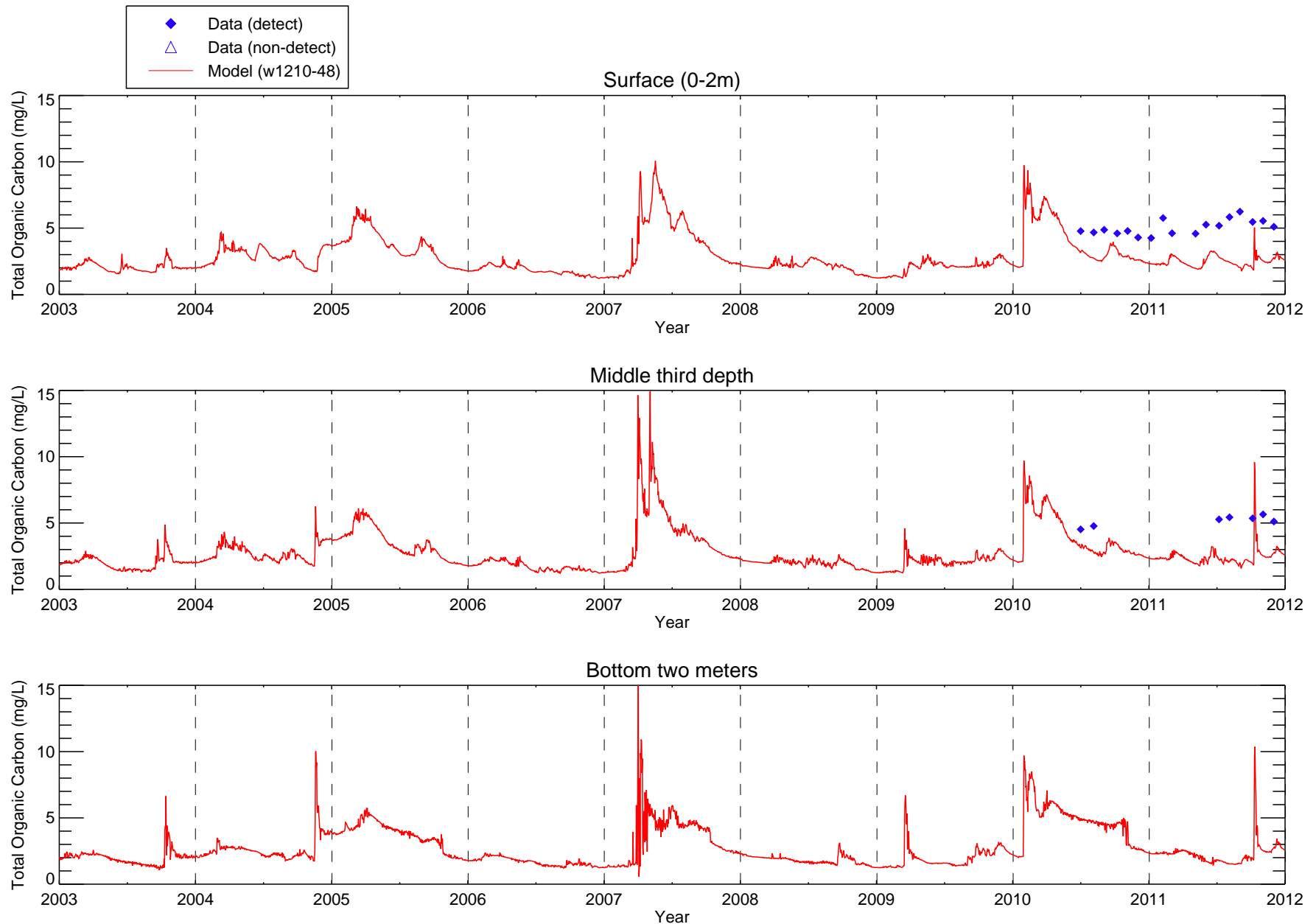
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Total Phosphorus

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-18d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Total Phosphorus

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
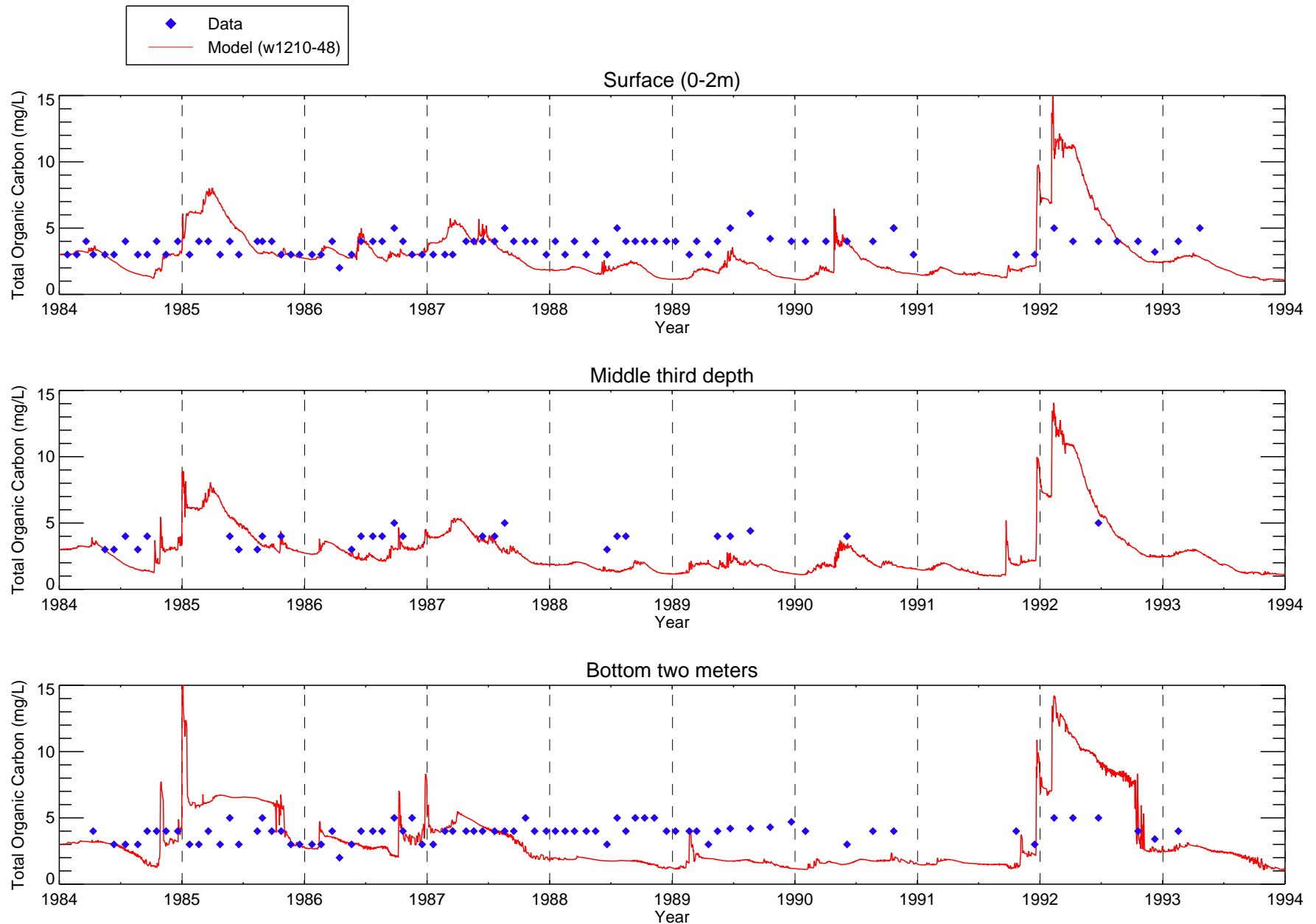
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-18e
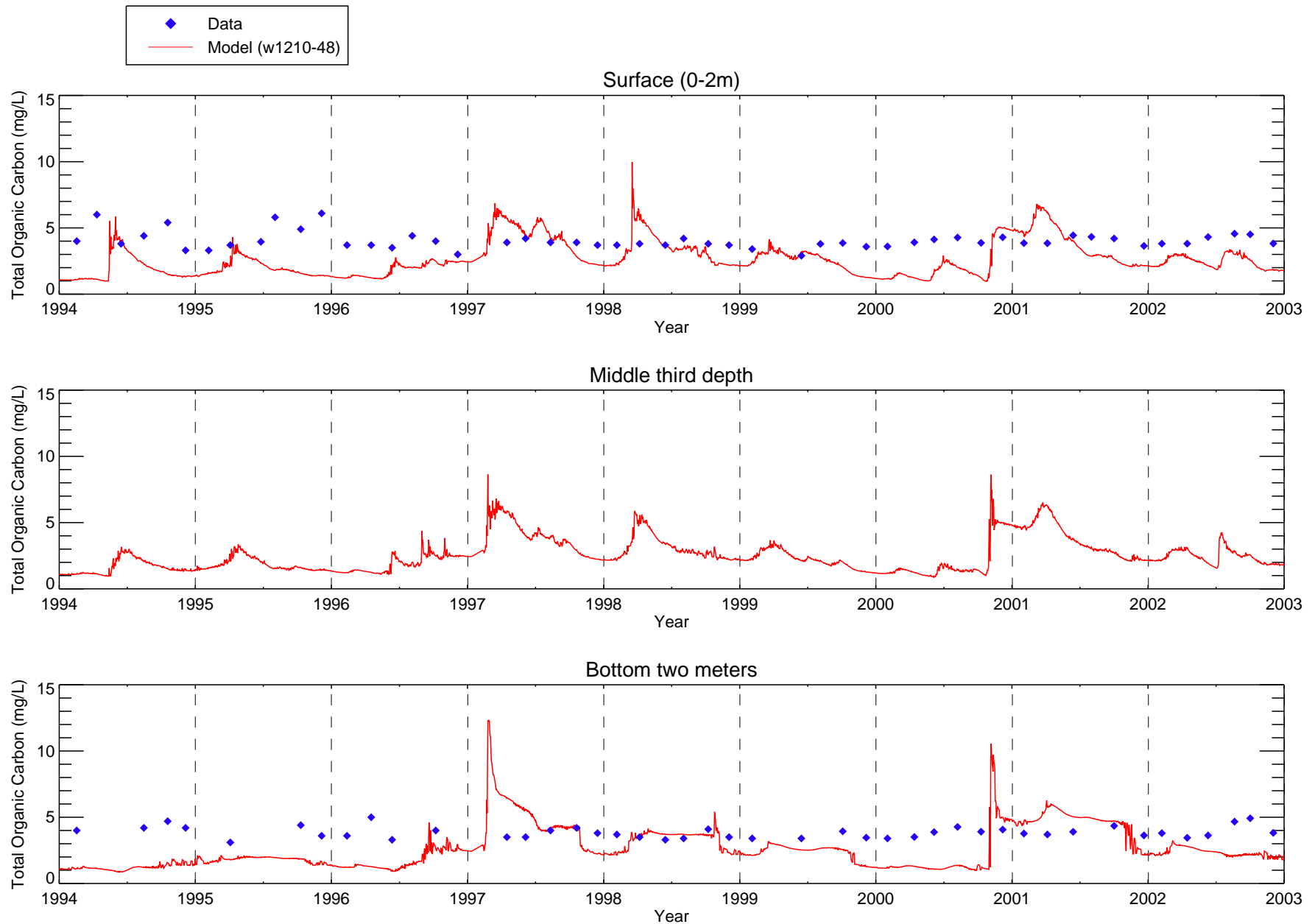**Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Total Phosphorus**

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:53:14 2013

Figure 4-18e

Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Total Phosphorus

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
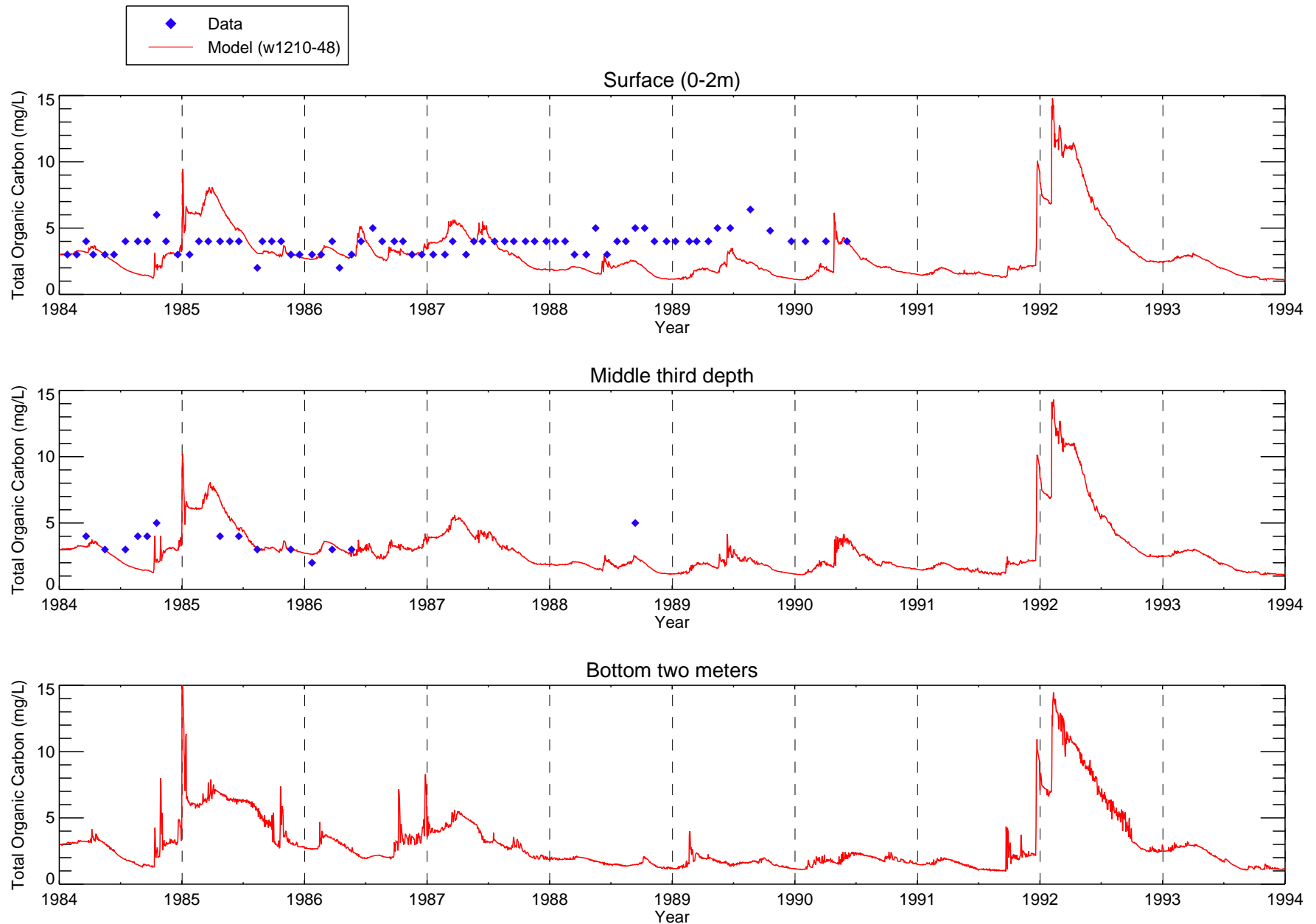PARSONS

Figure 4-18e

Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Total Phosphorus

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-18f
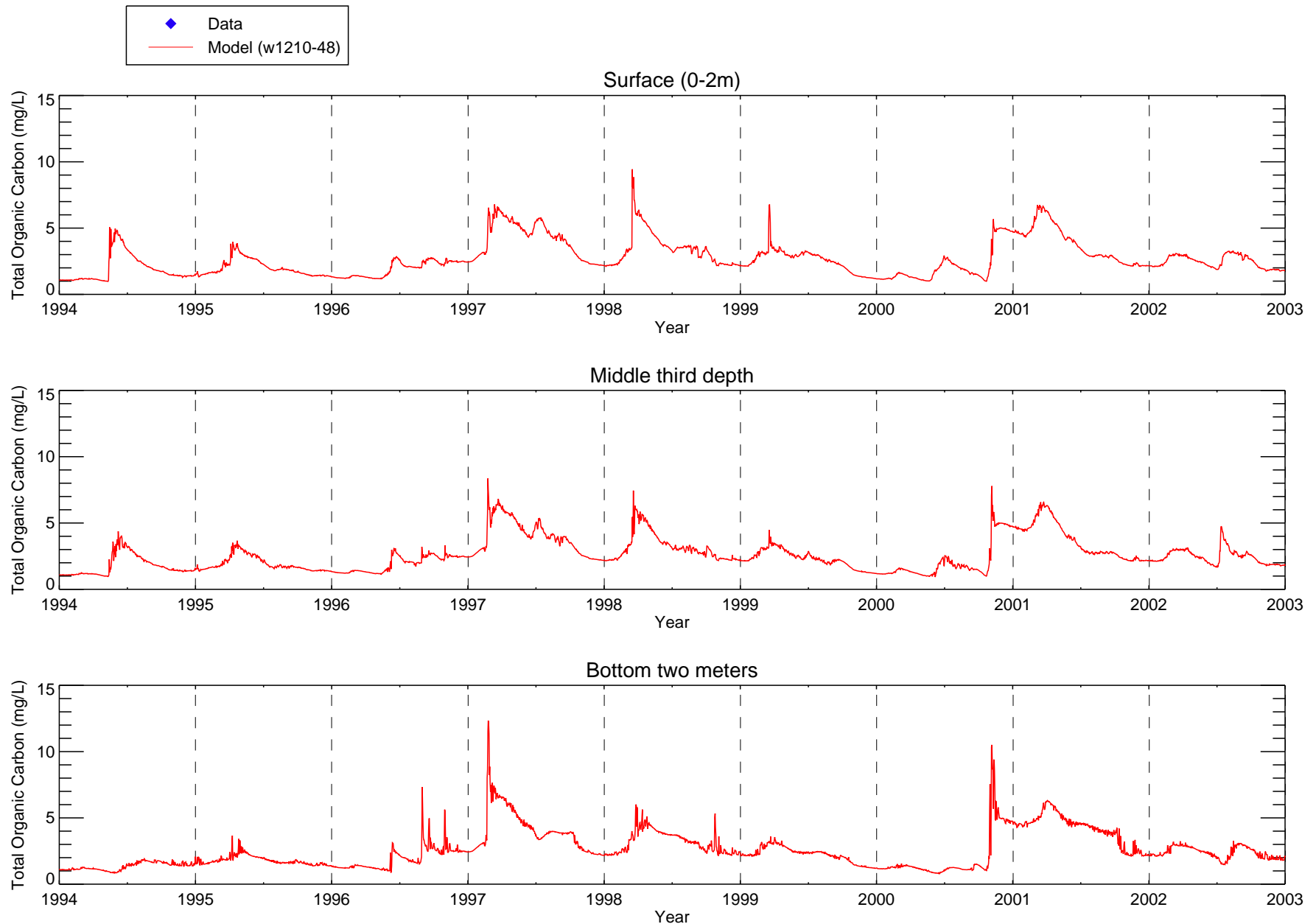**Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Total Phosphorus**

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
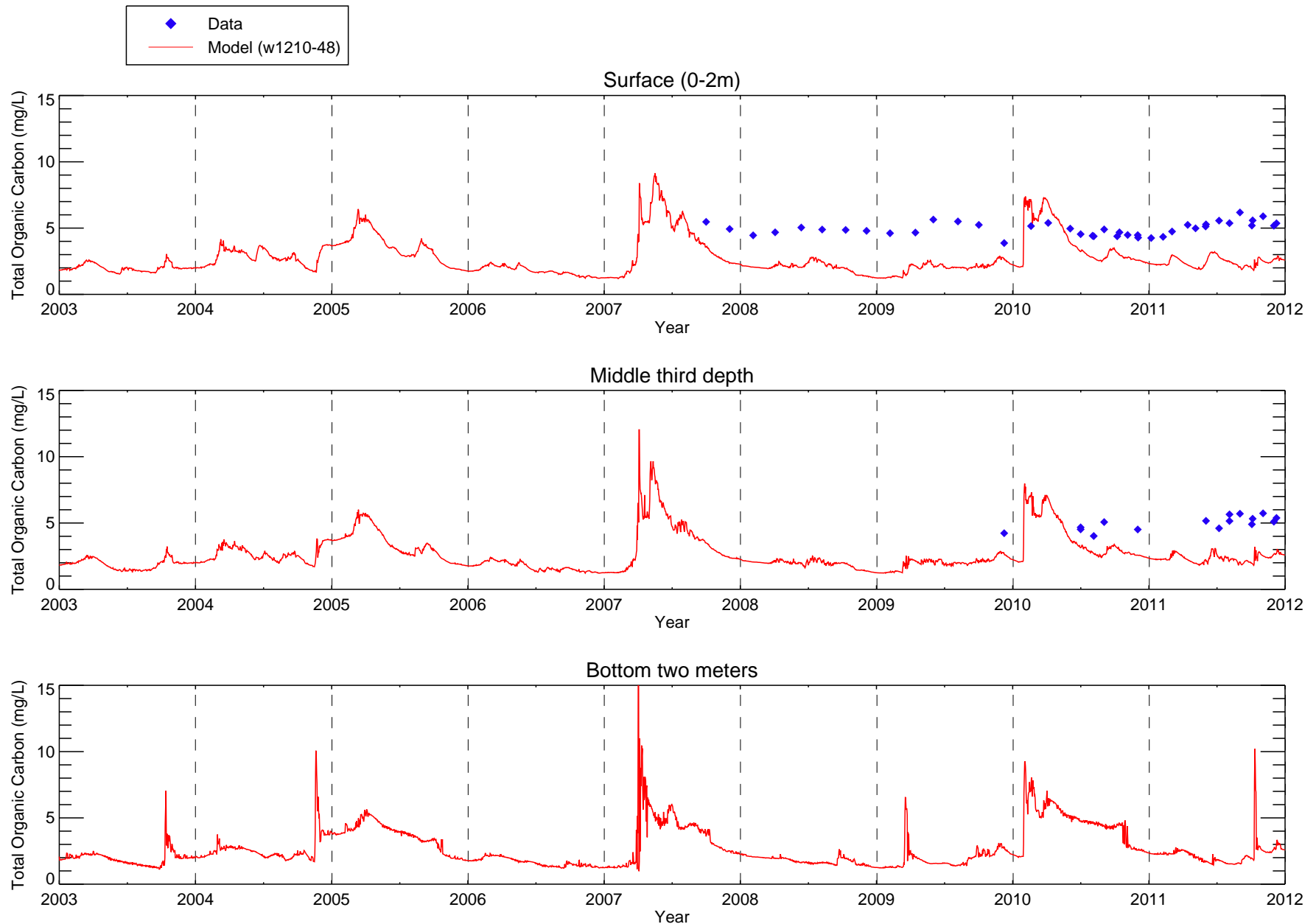
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-18f
Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Total Phosphorus

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

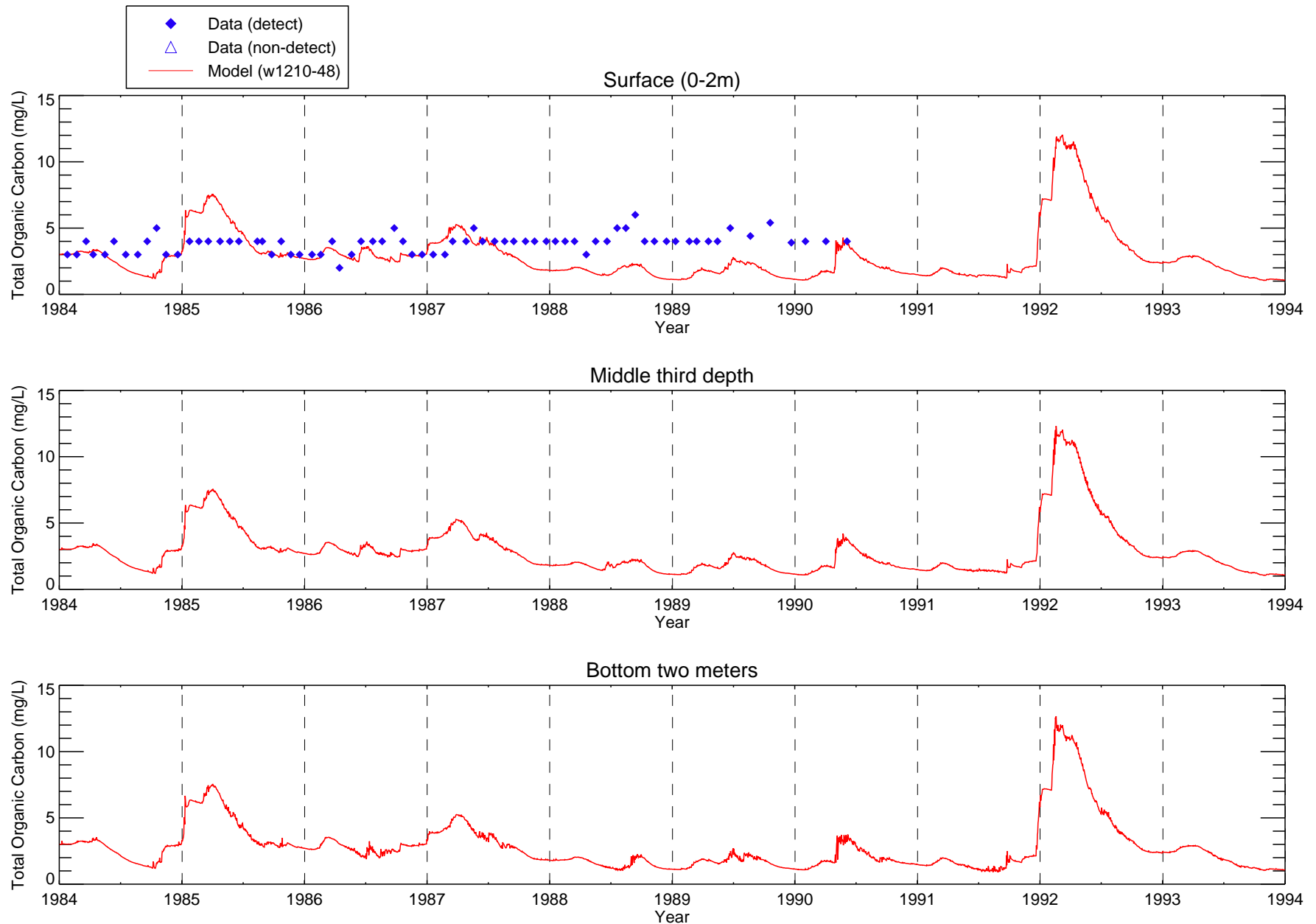EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:58:25 2013

Figure 4-18f
Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Total Phosphorus

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:59:56 2013

Figure 4-18g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Total Phosphorus

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
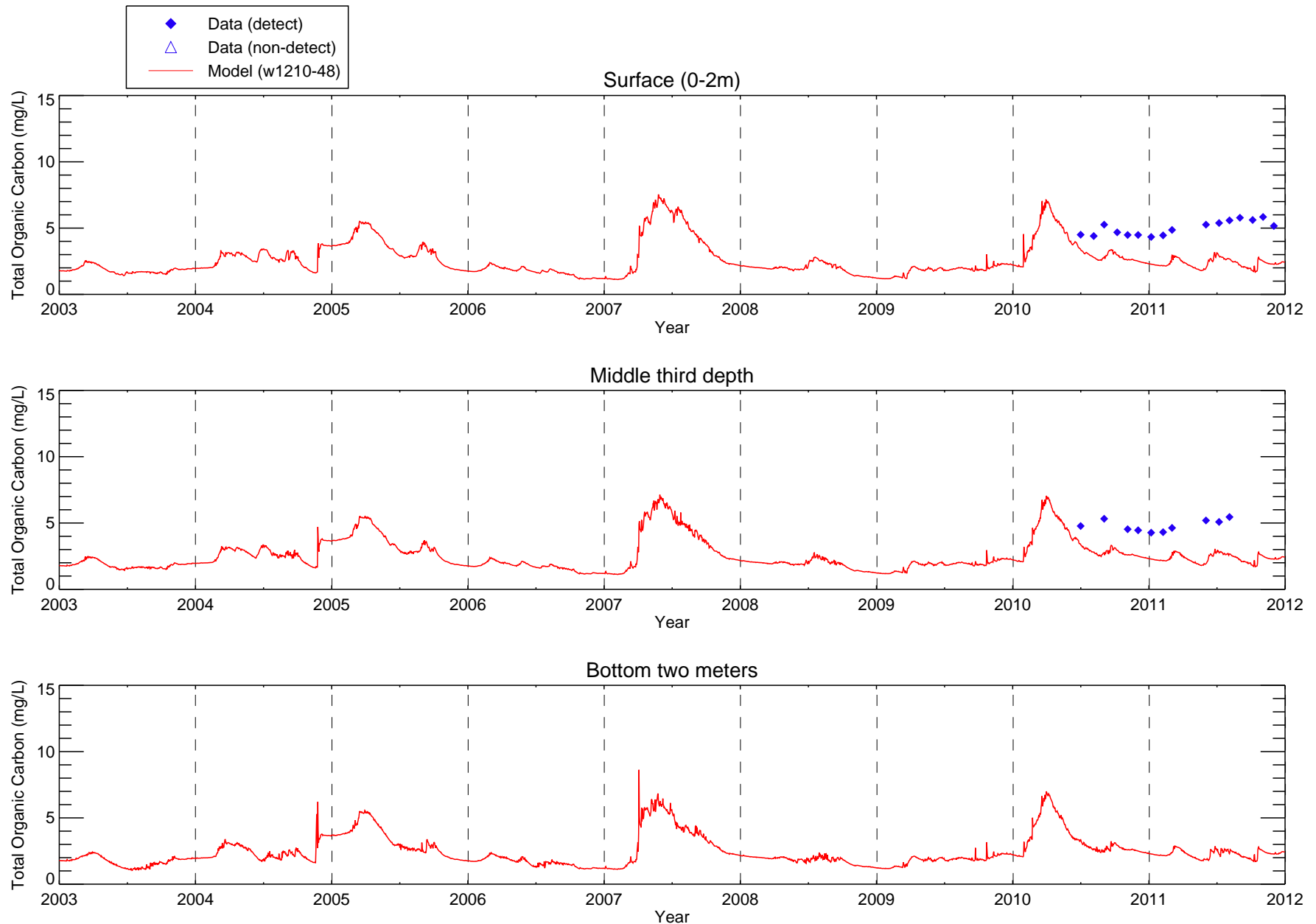
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-18g
Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Total Phosphorus

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-18g
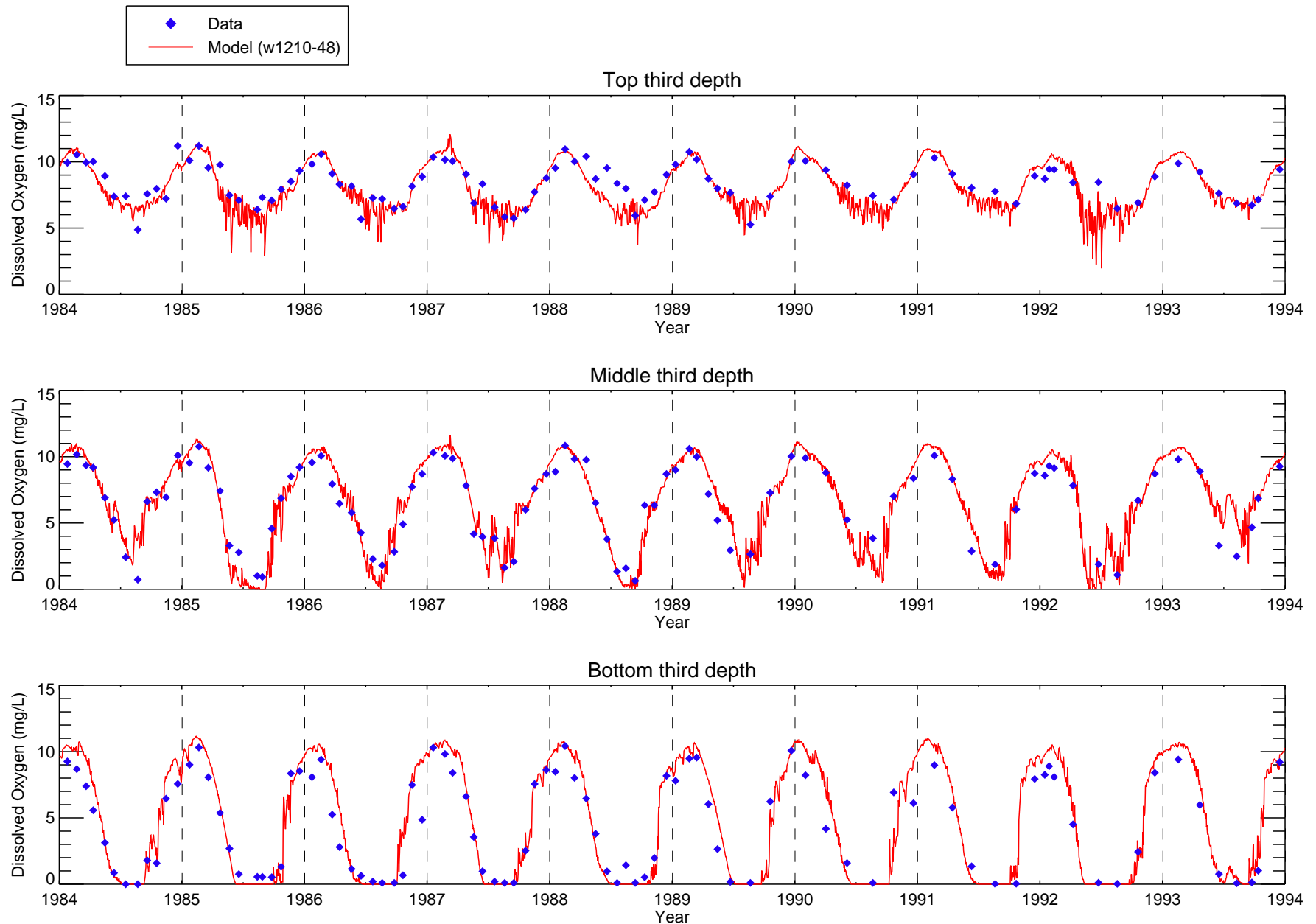**Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Total Phosphorus**

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-18h
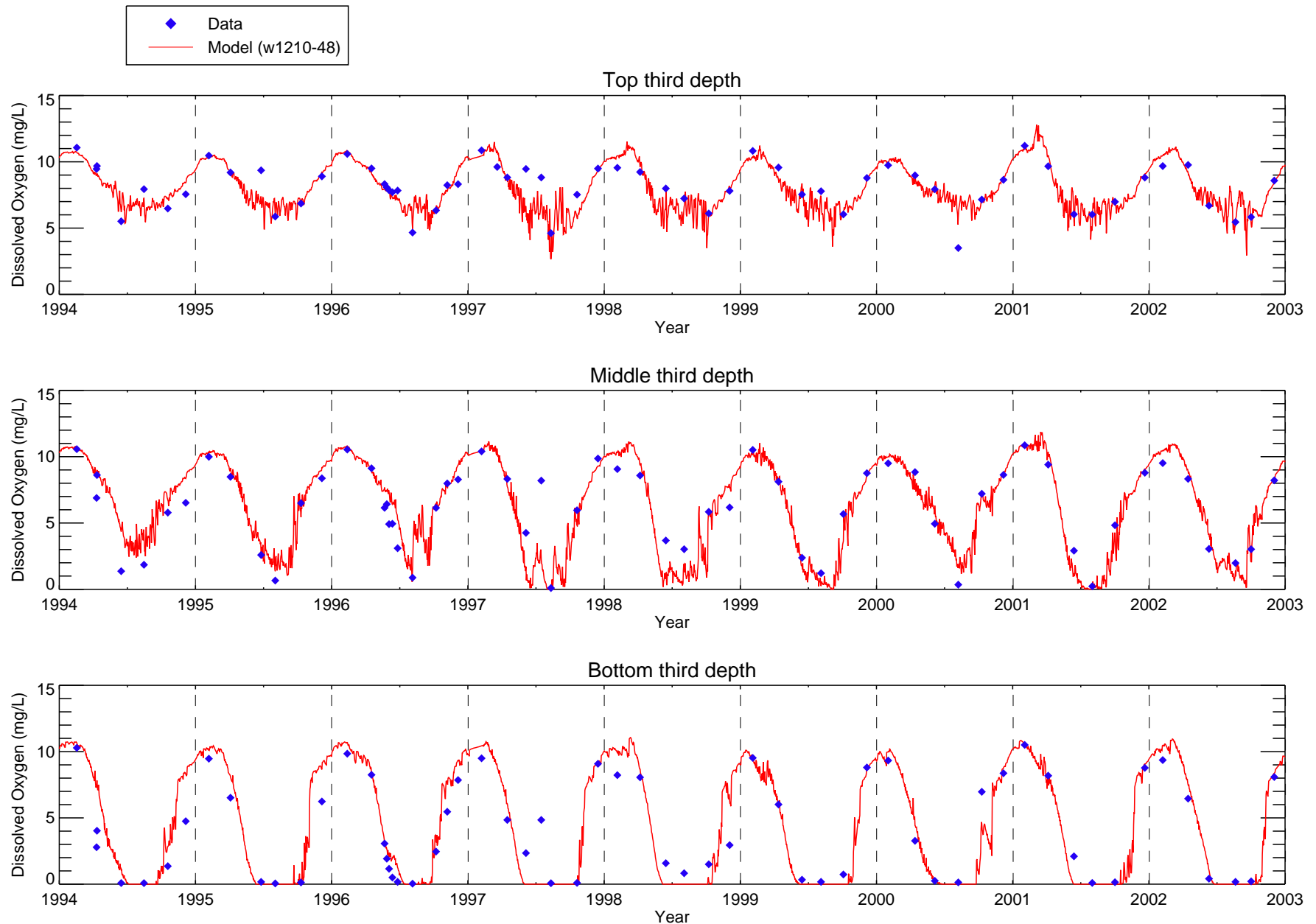**Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Total Phosphorus**

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-18h
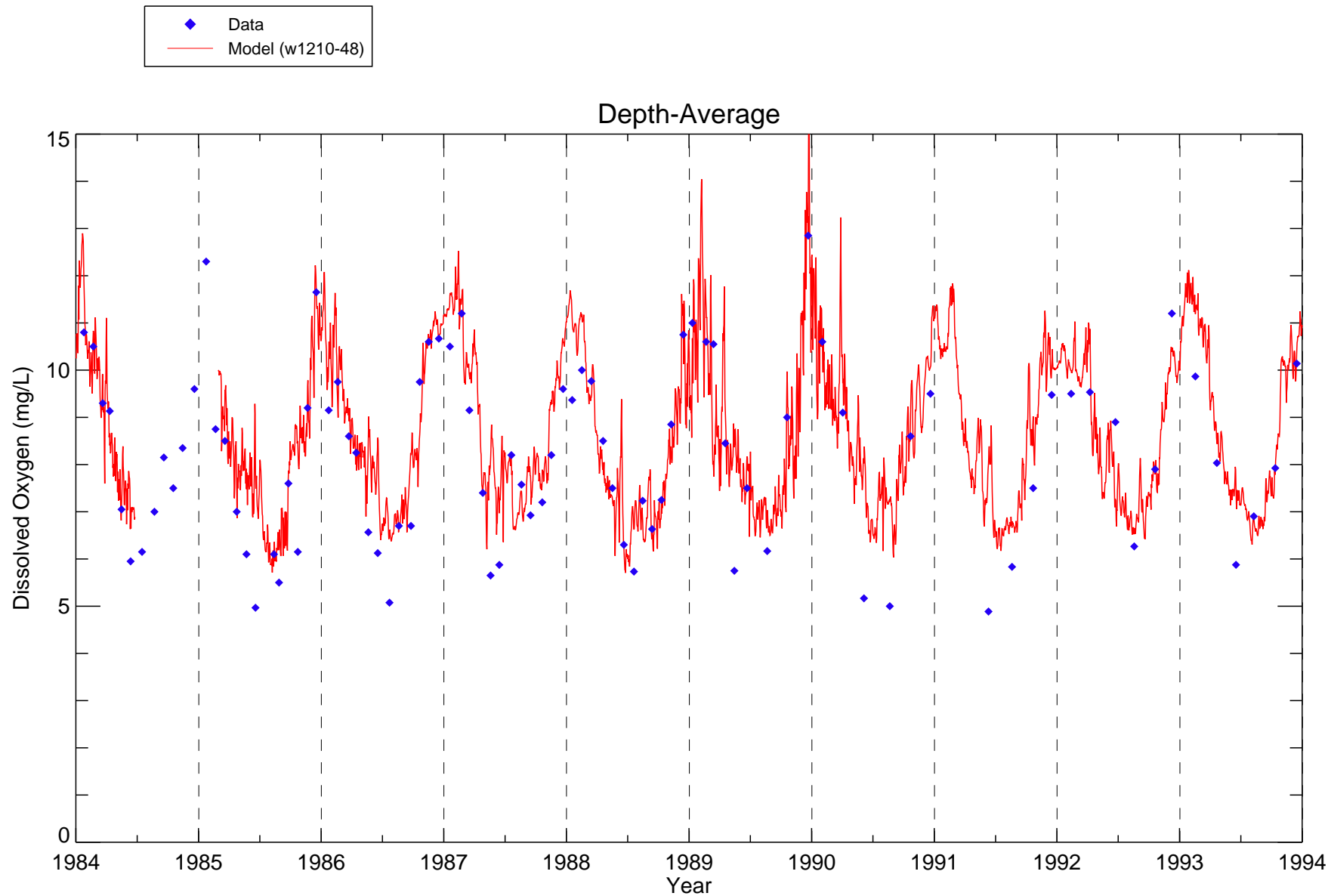**Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Total Phosphorus**
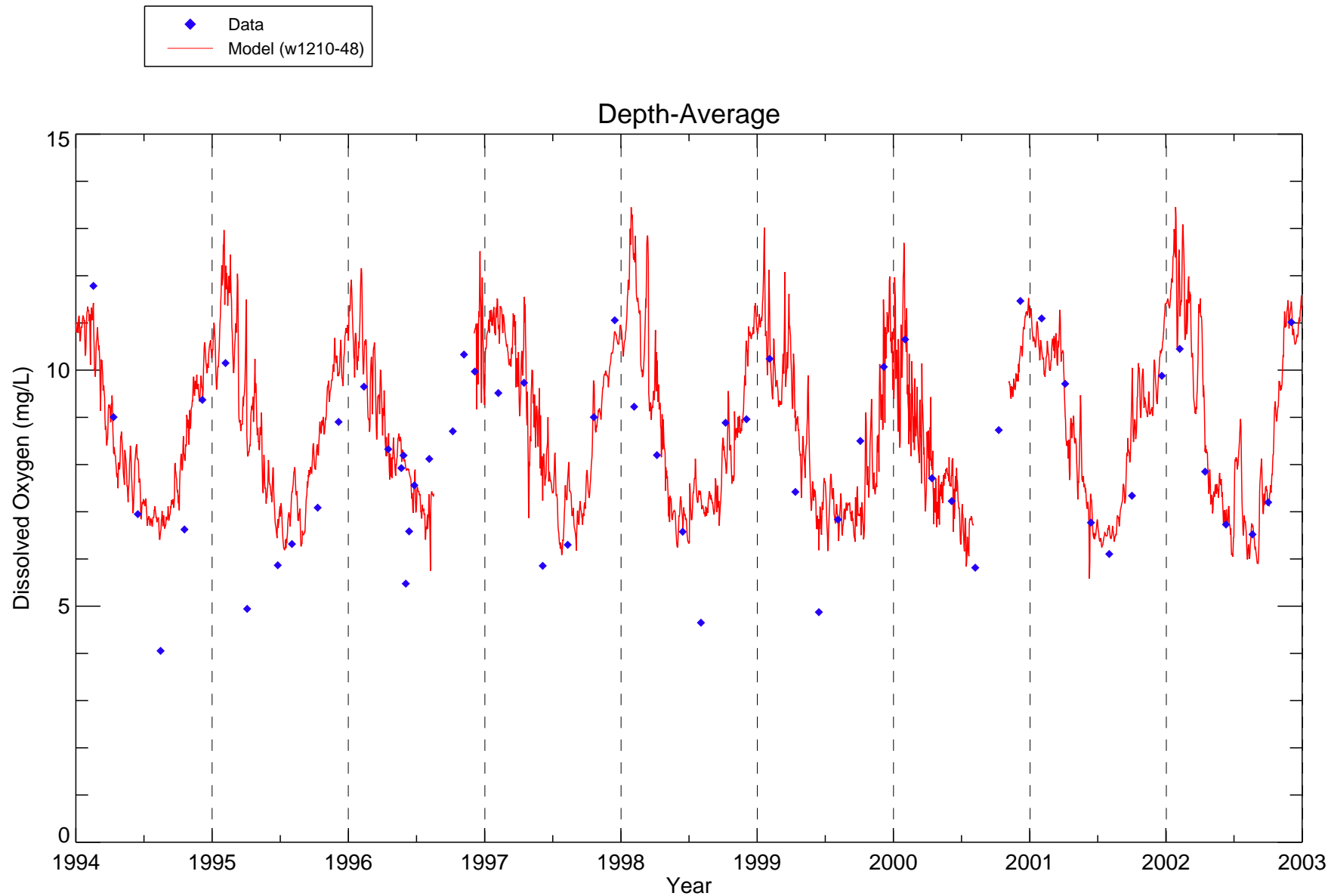
Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-18h
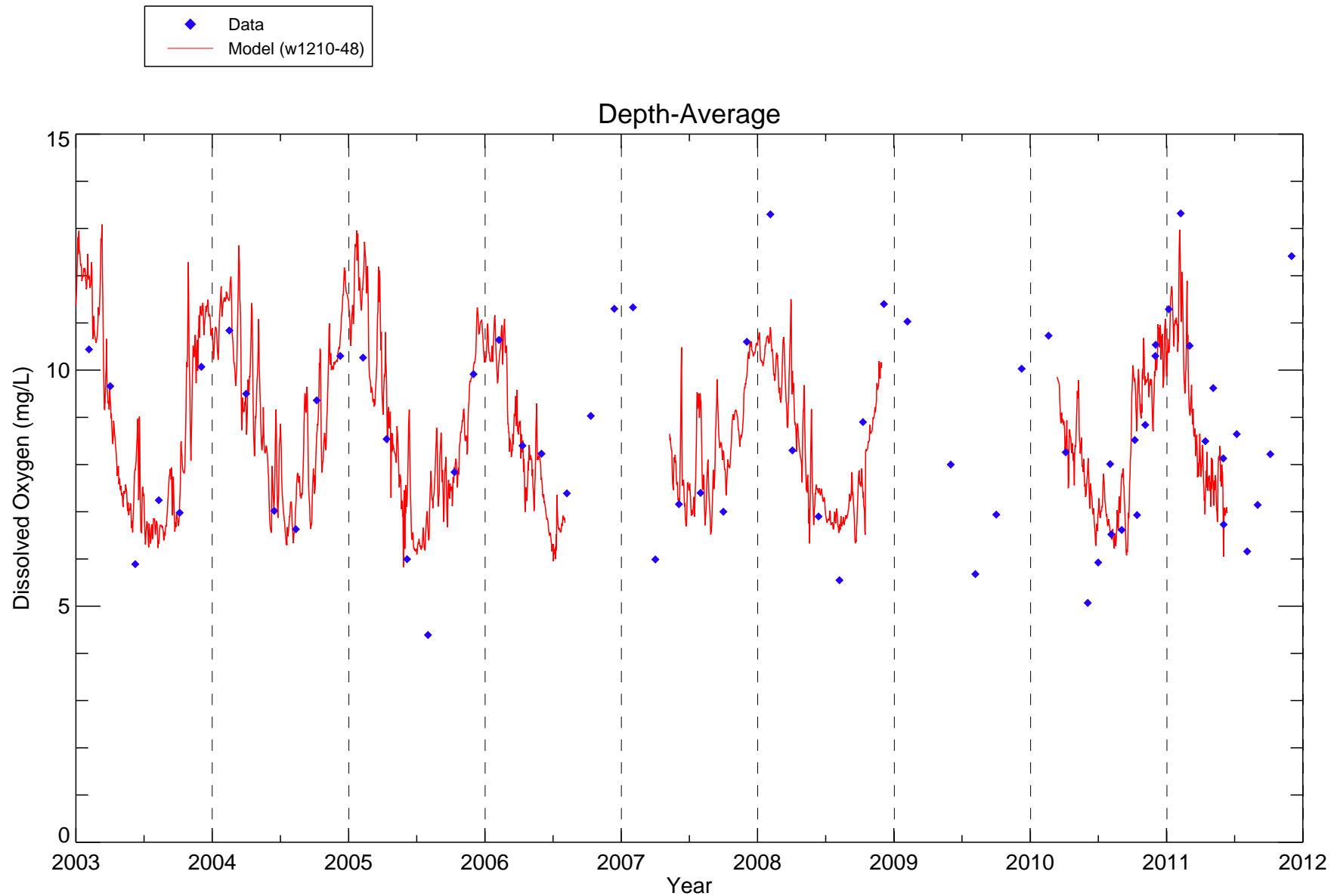**Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Total Phosphorus**

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-19a
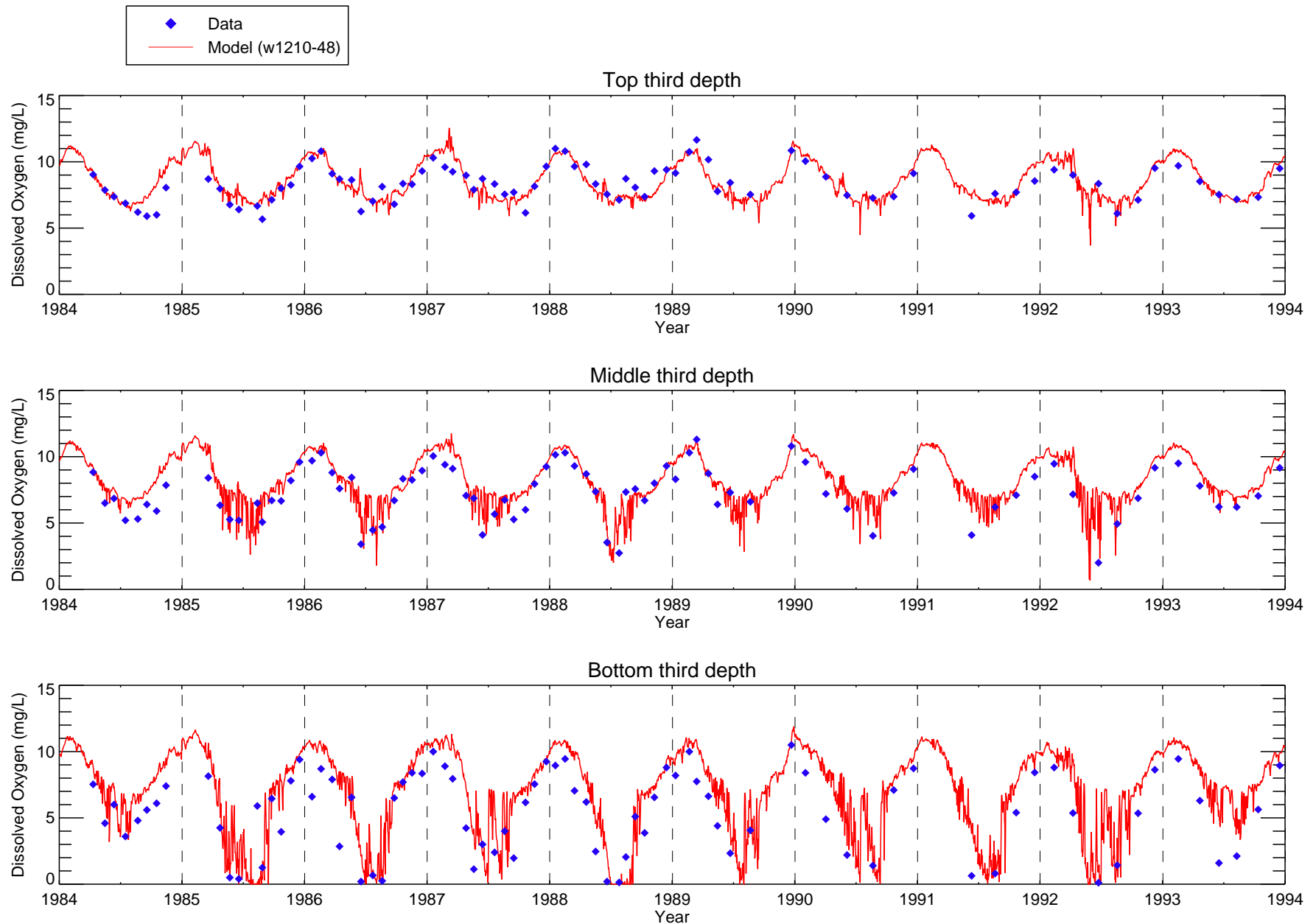
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
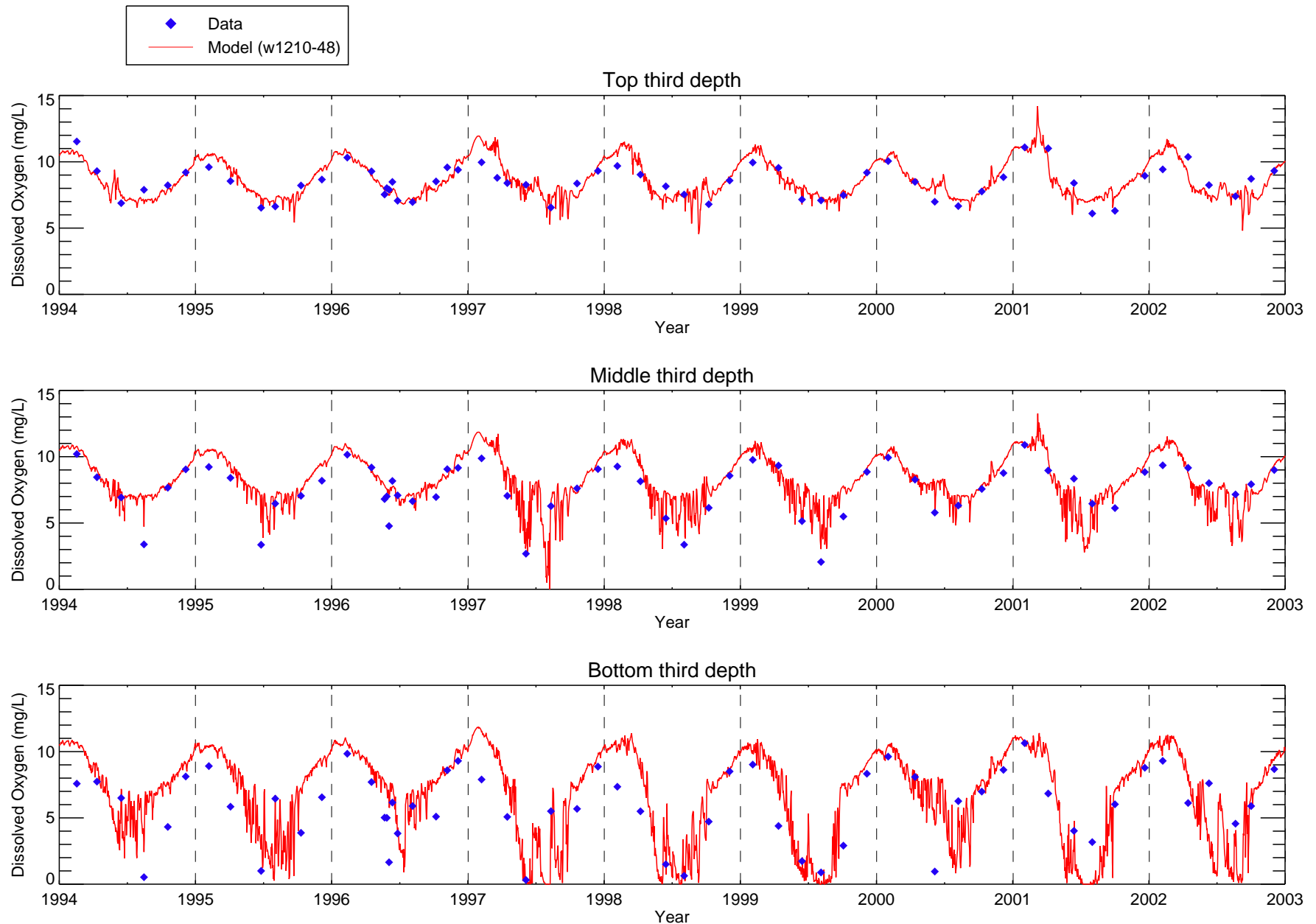
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:48:34 2013

Figure 4-19a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
CREMs Phase 4: Lake Buchanan
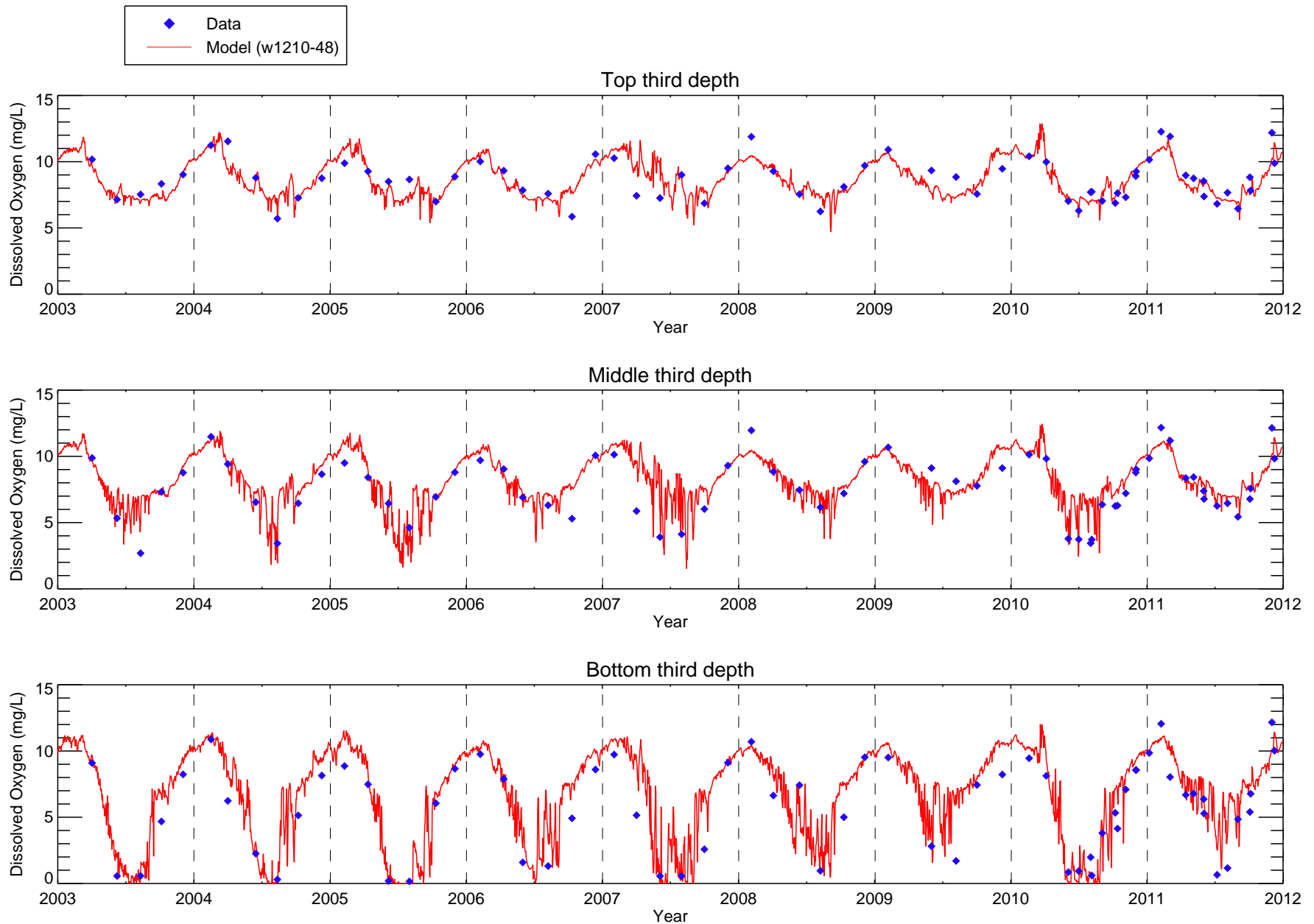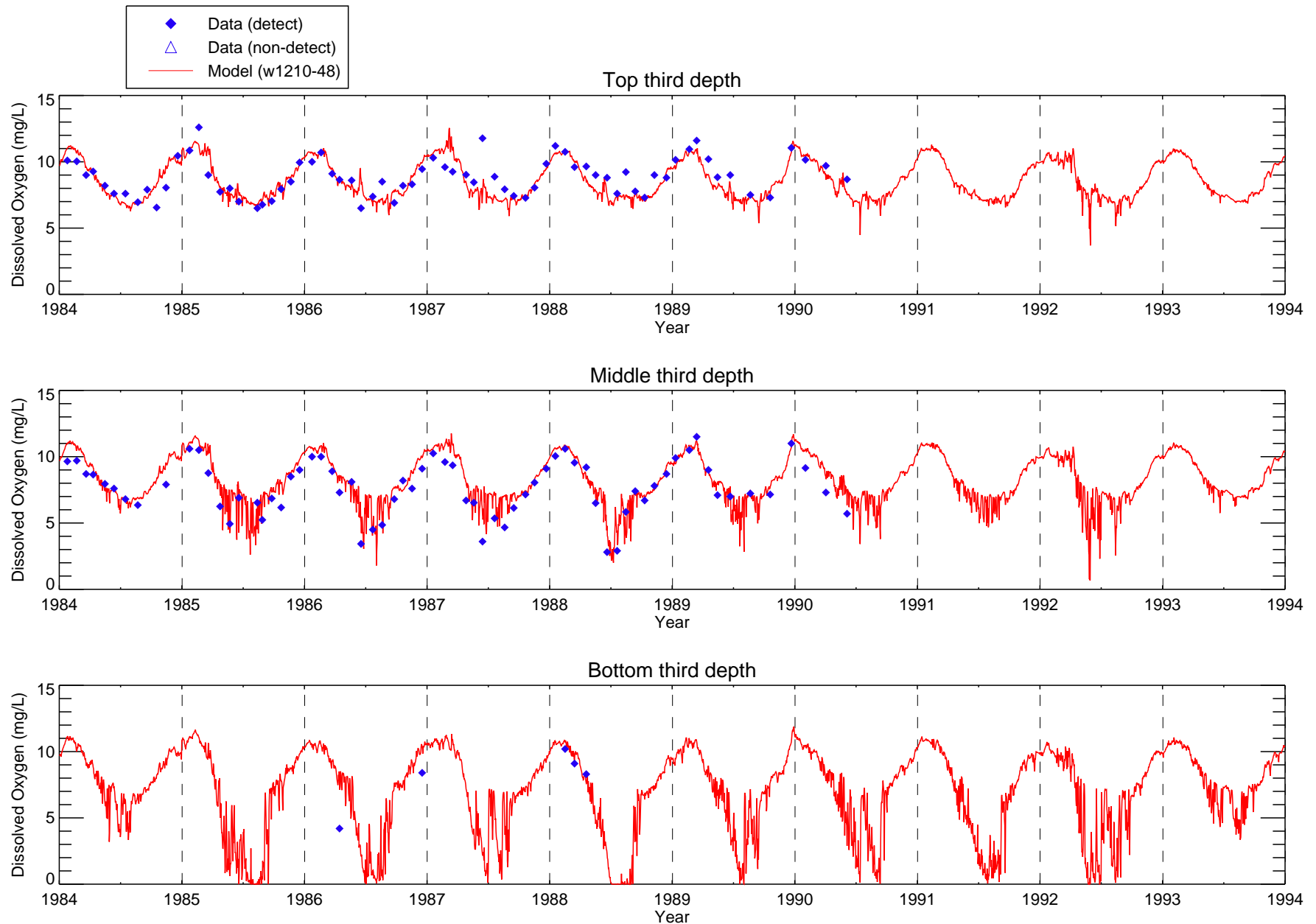Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:50:18 2013

Figure 4-19a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Total Organic Carbon
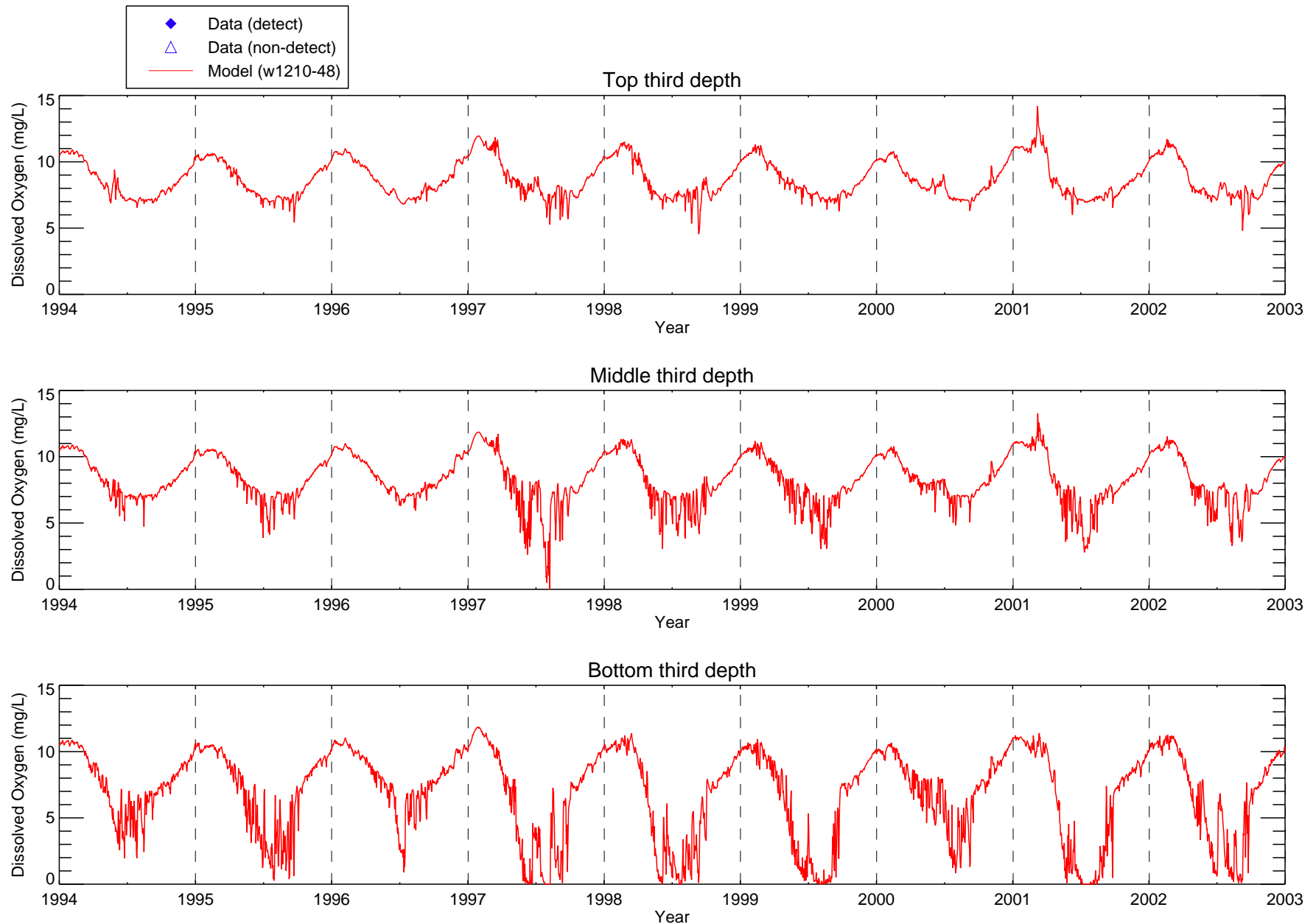
Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
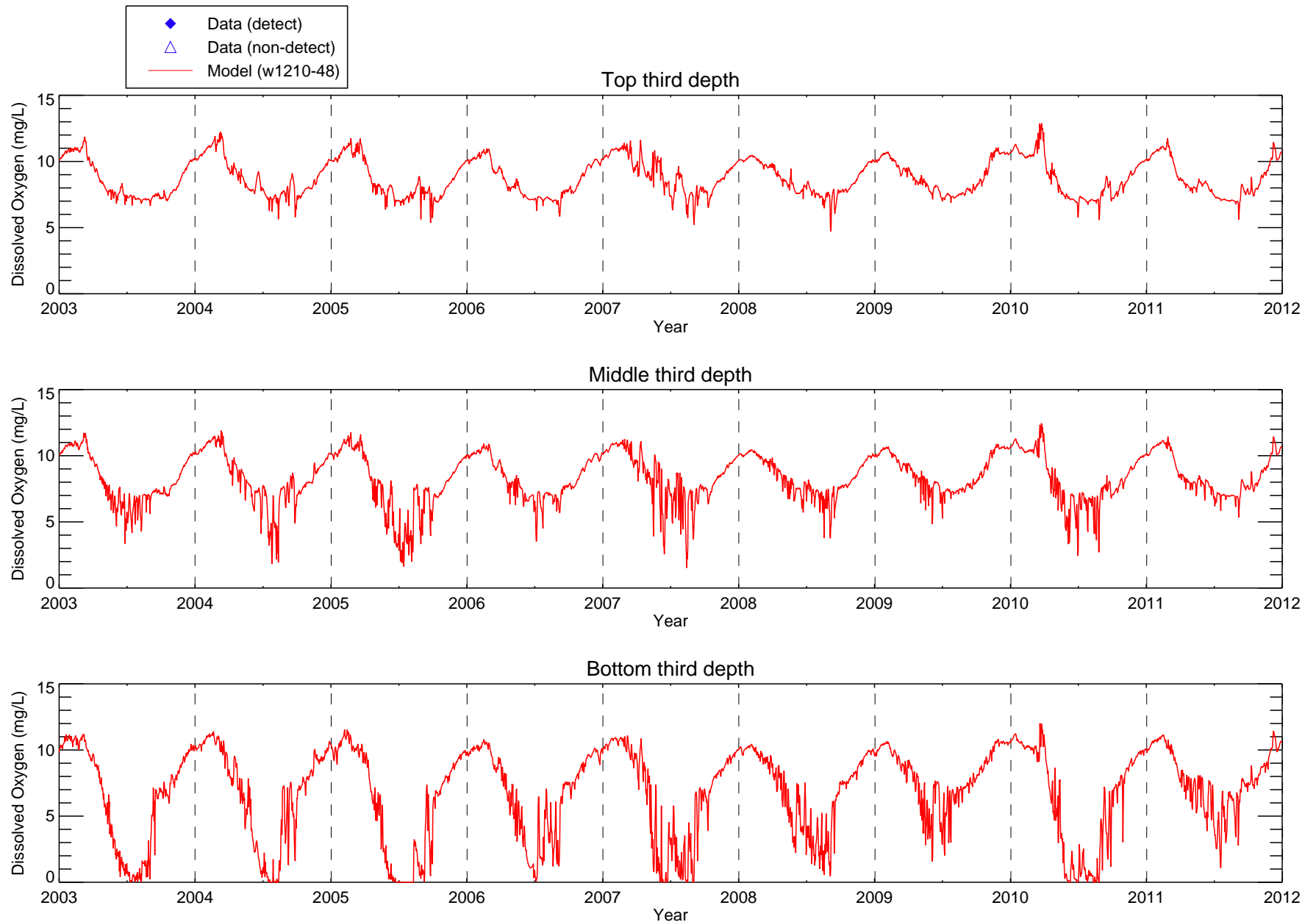Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:52:02 2013

Figure 4-19b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Total Organic Carbon

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:56:59 2013

Figure 4-19b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Total Organic Carbon

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
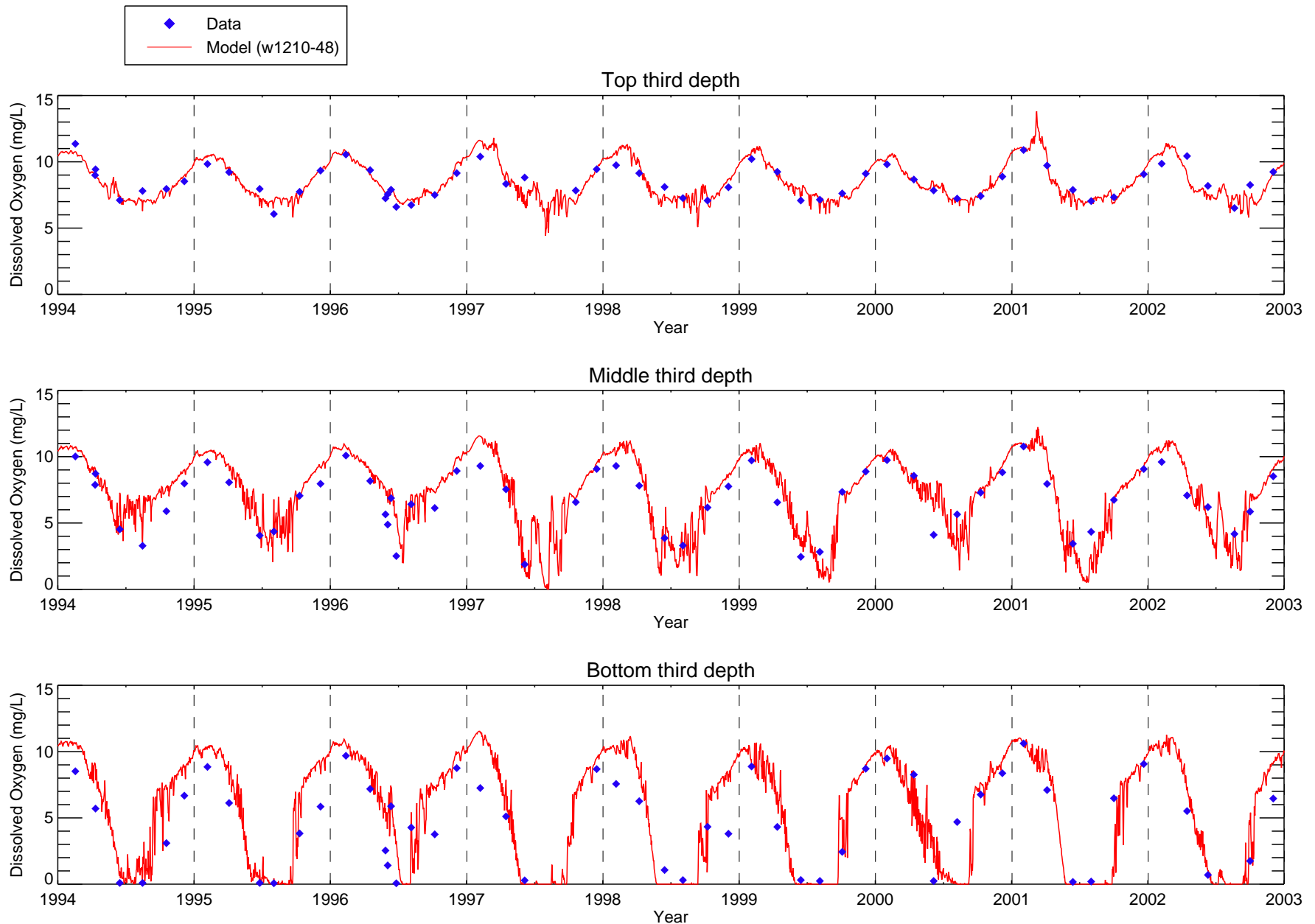Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:57:04 2013

Figure 4-19b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Total Organic Carbon

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-19c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
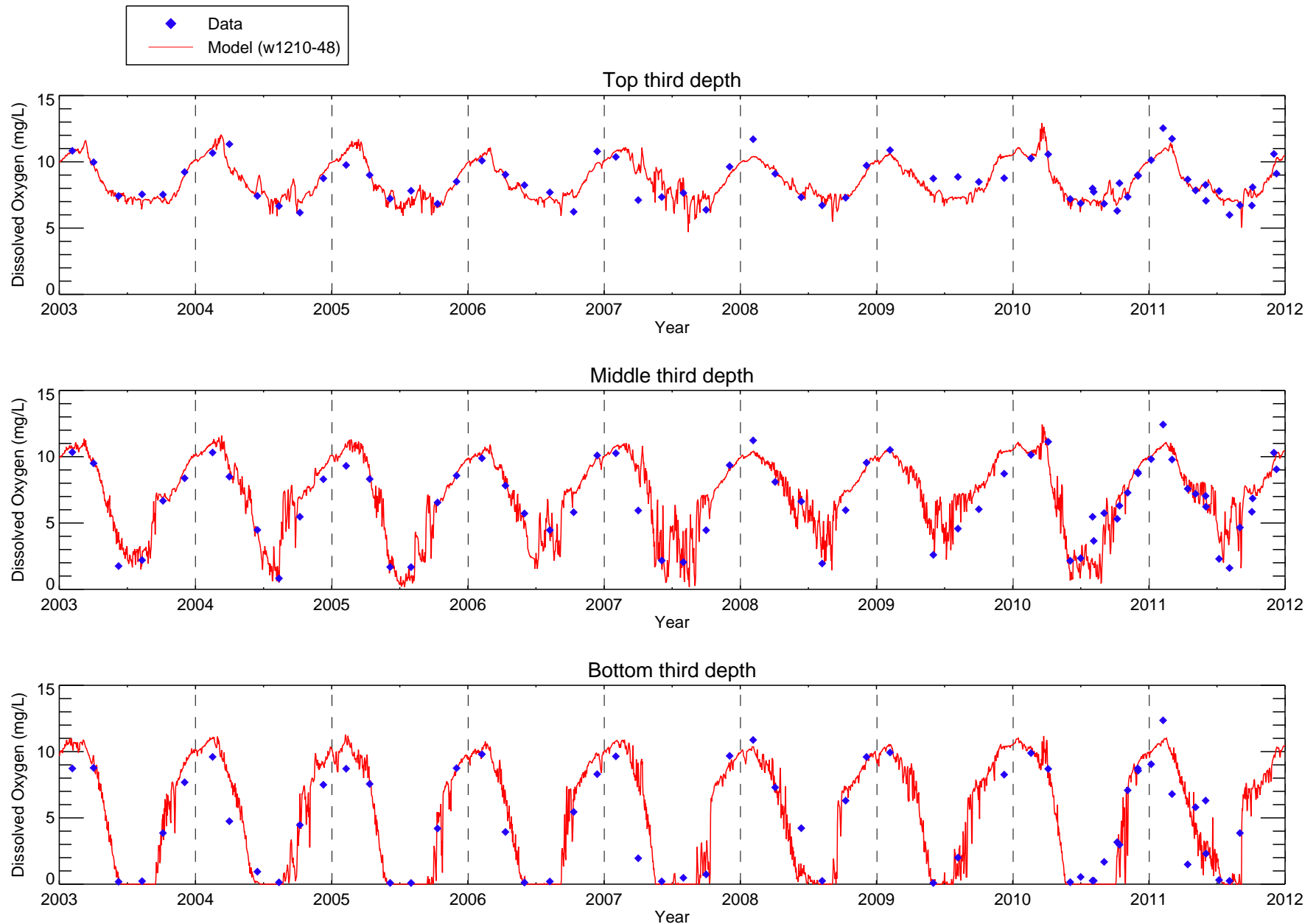
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-19c

Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
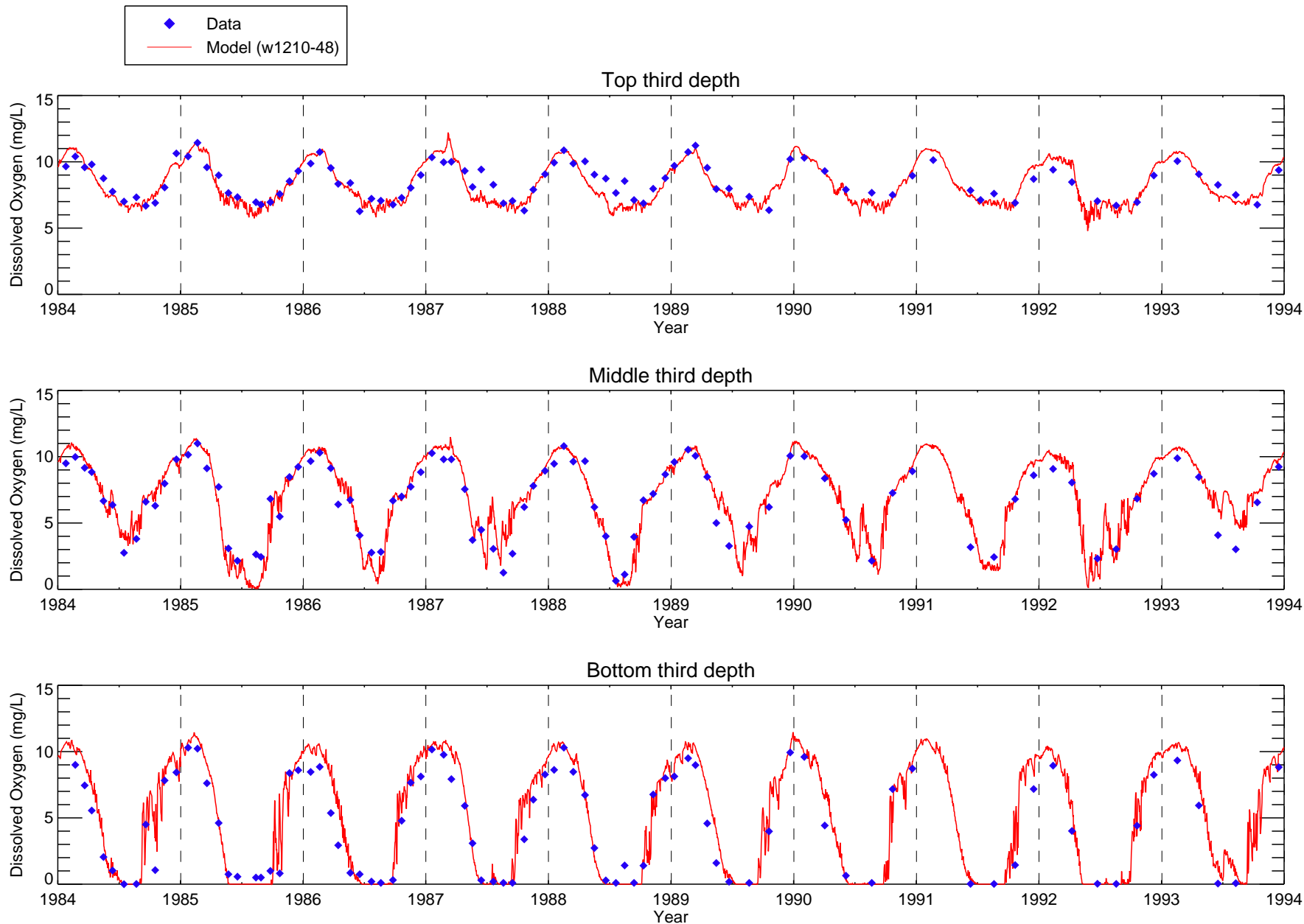
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 13:22:50 2013

Figure 4-19c

Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
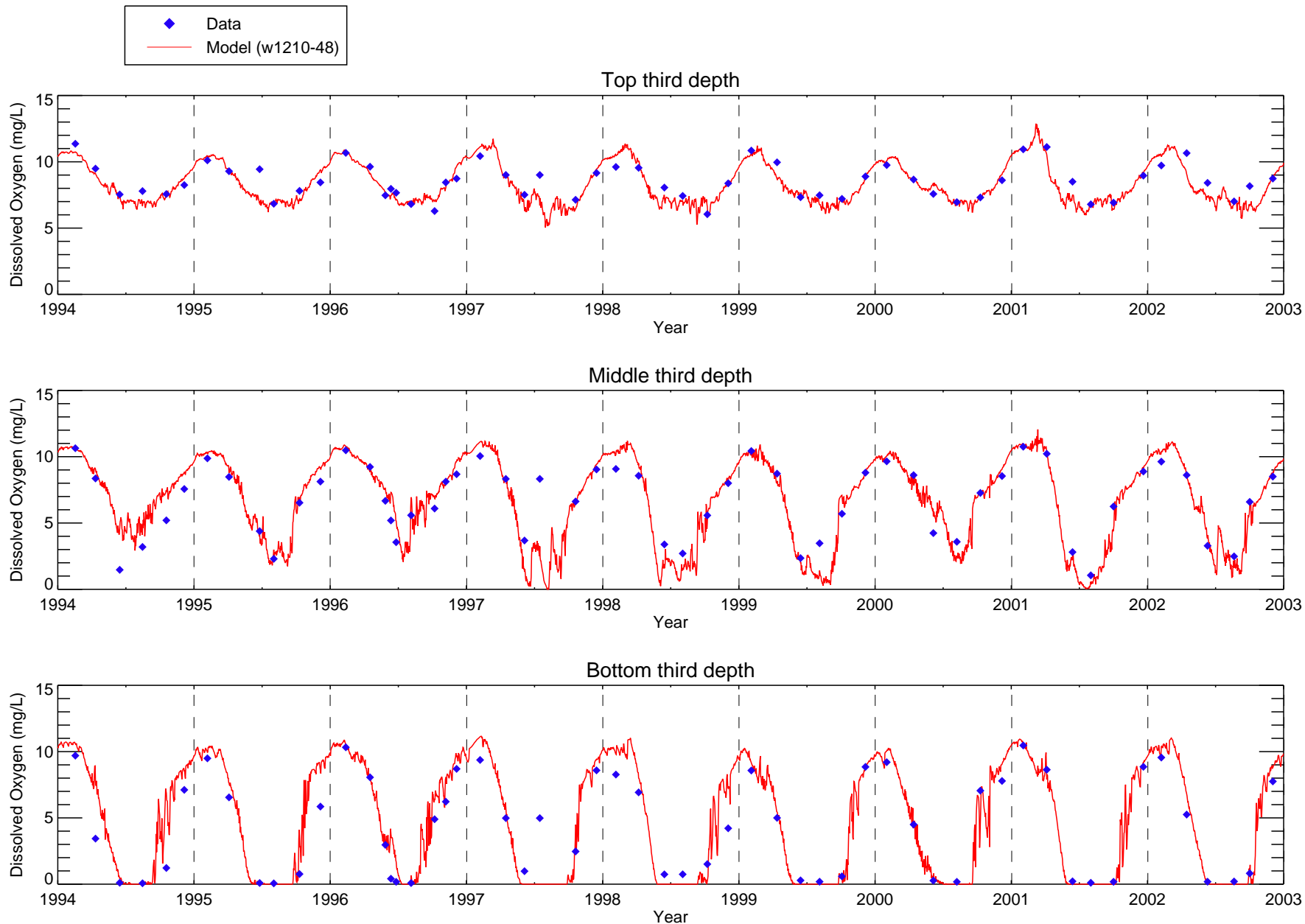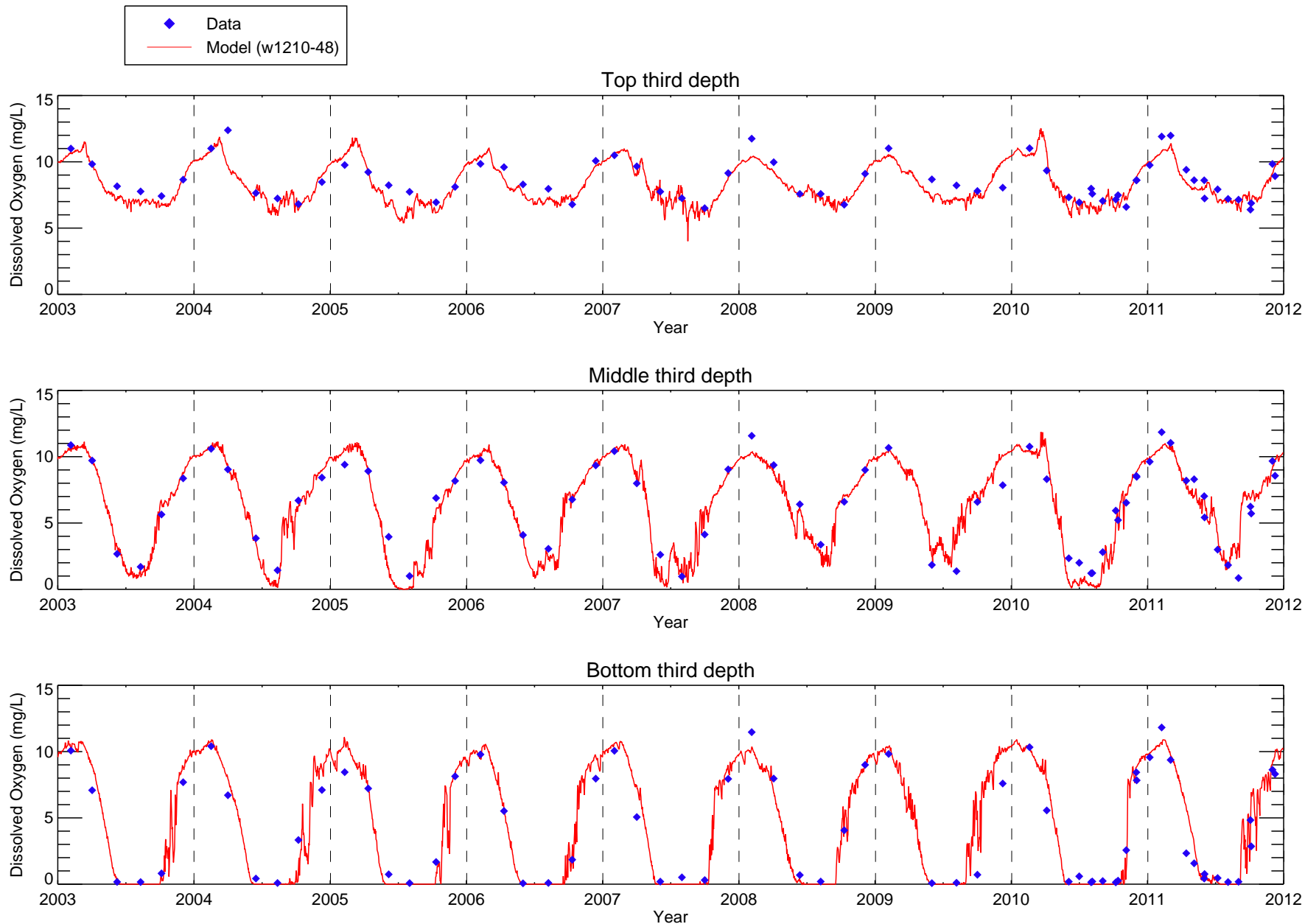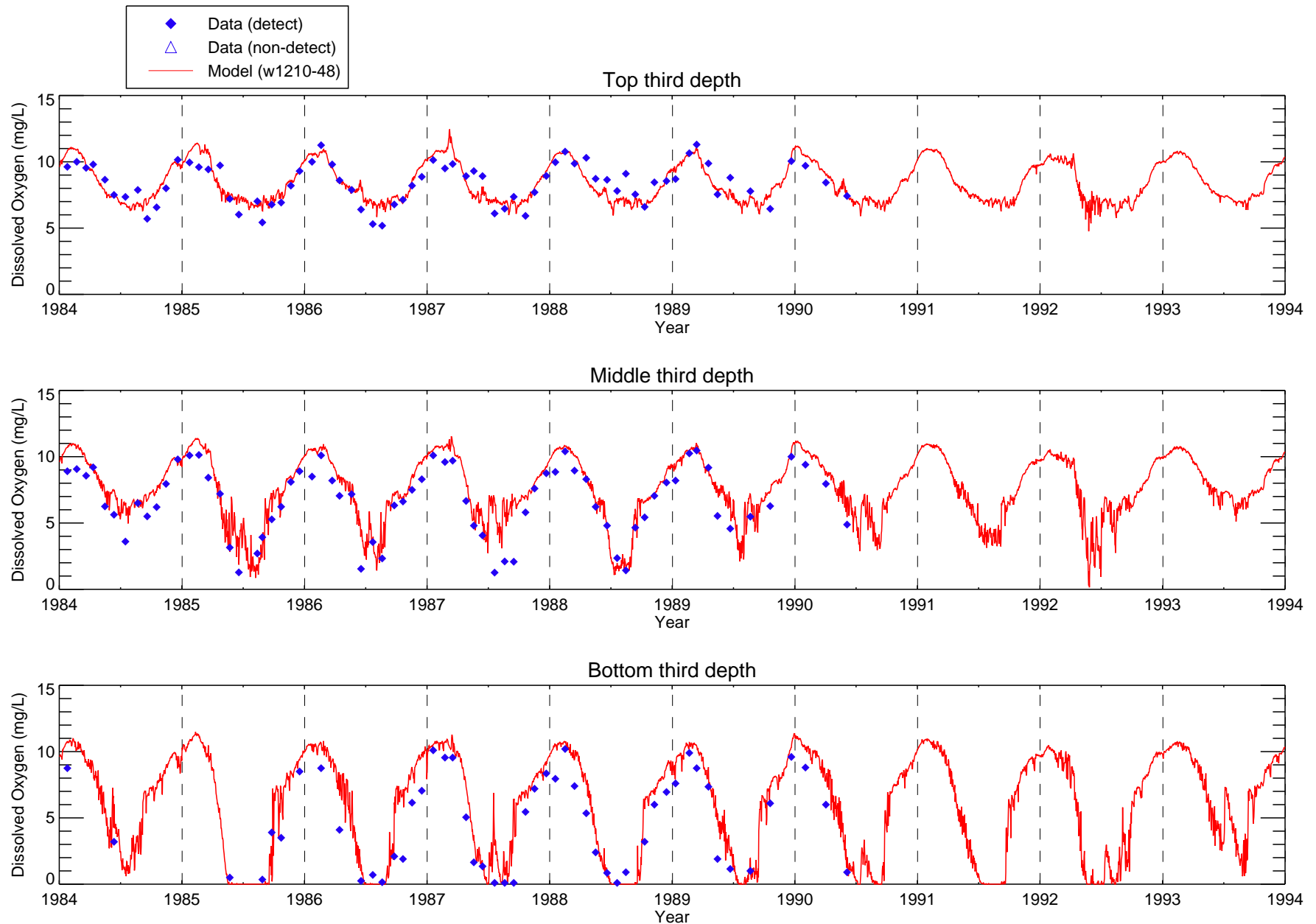
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 13:23:41 2013

Figure 4-19d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-19d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
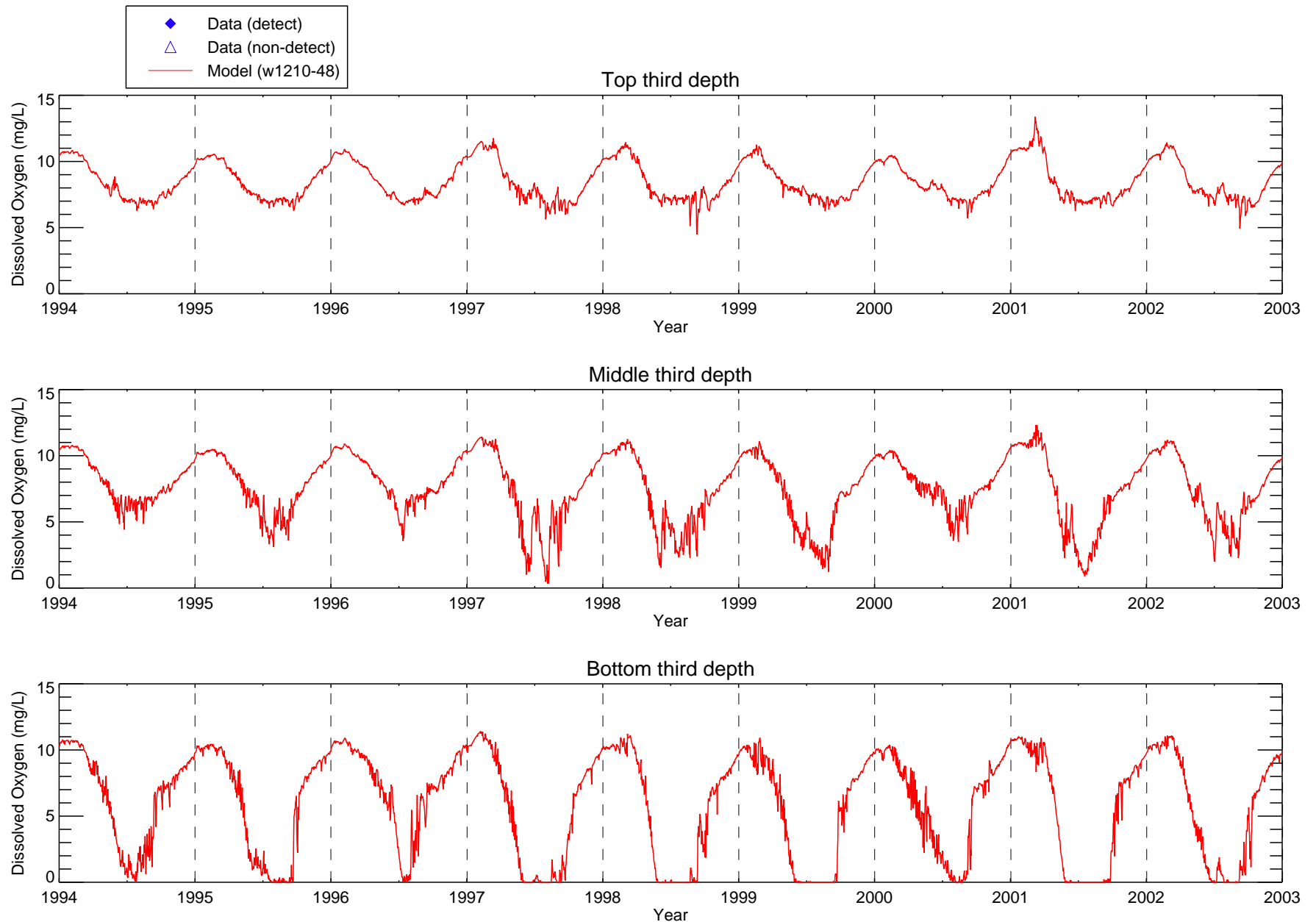
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-19d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-19e
Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
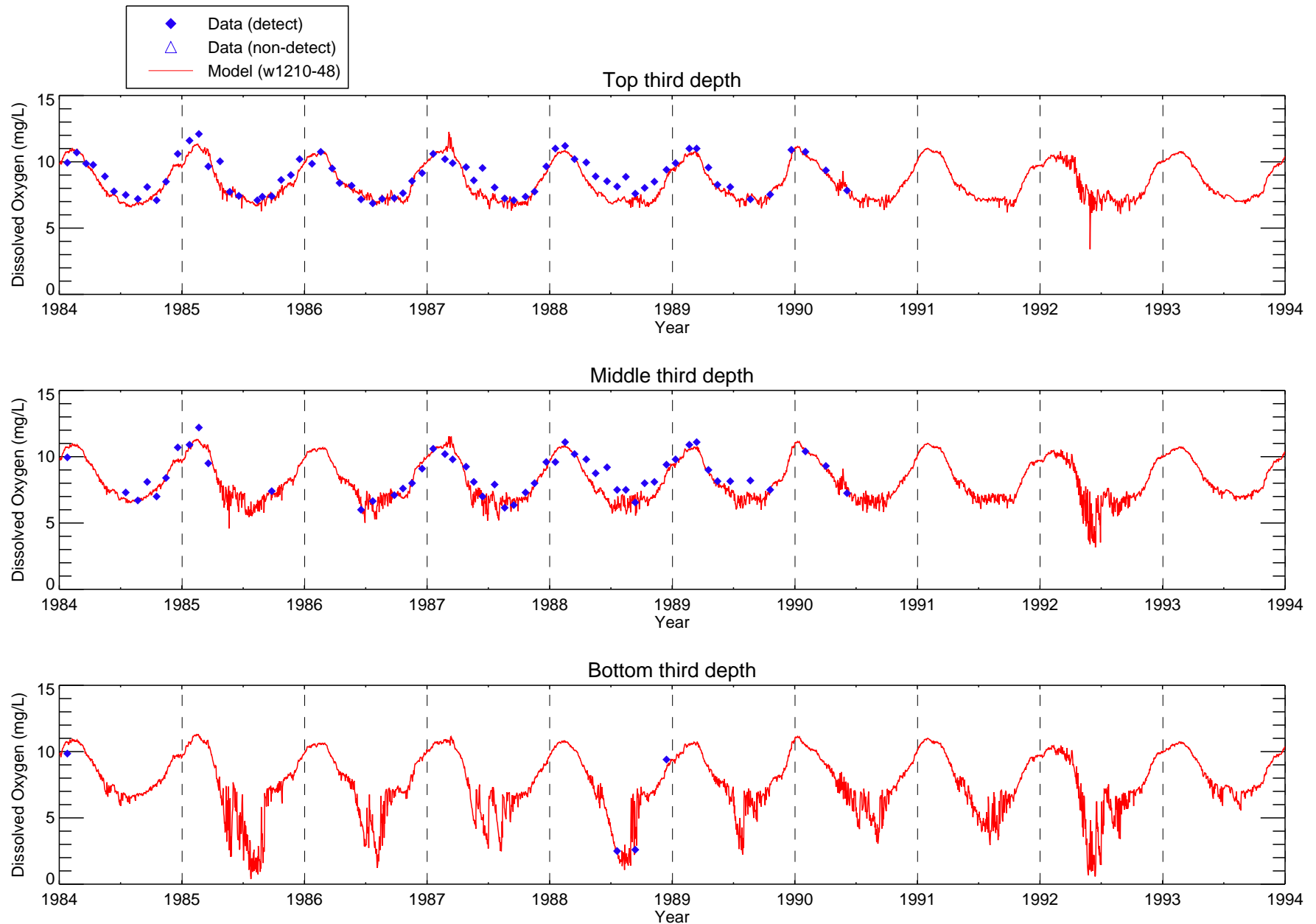
CREMs Phase 4: Lake Buchanan
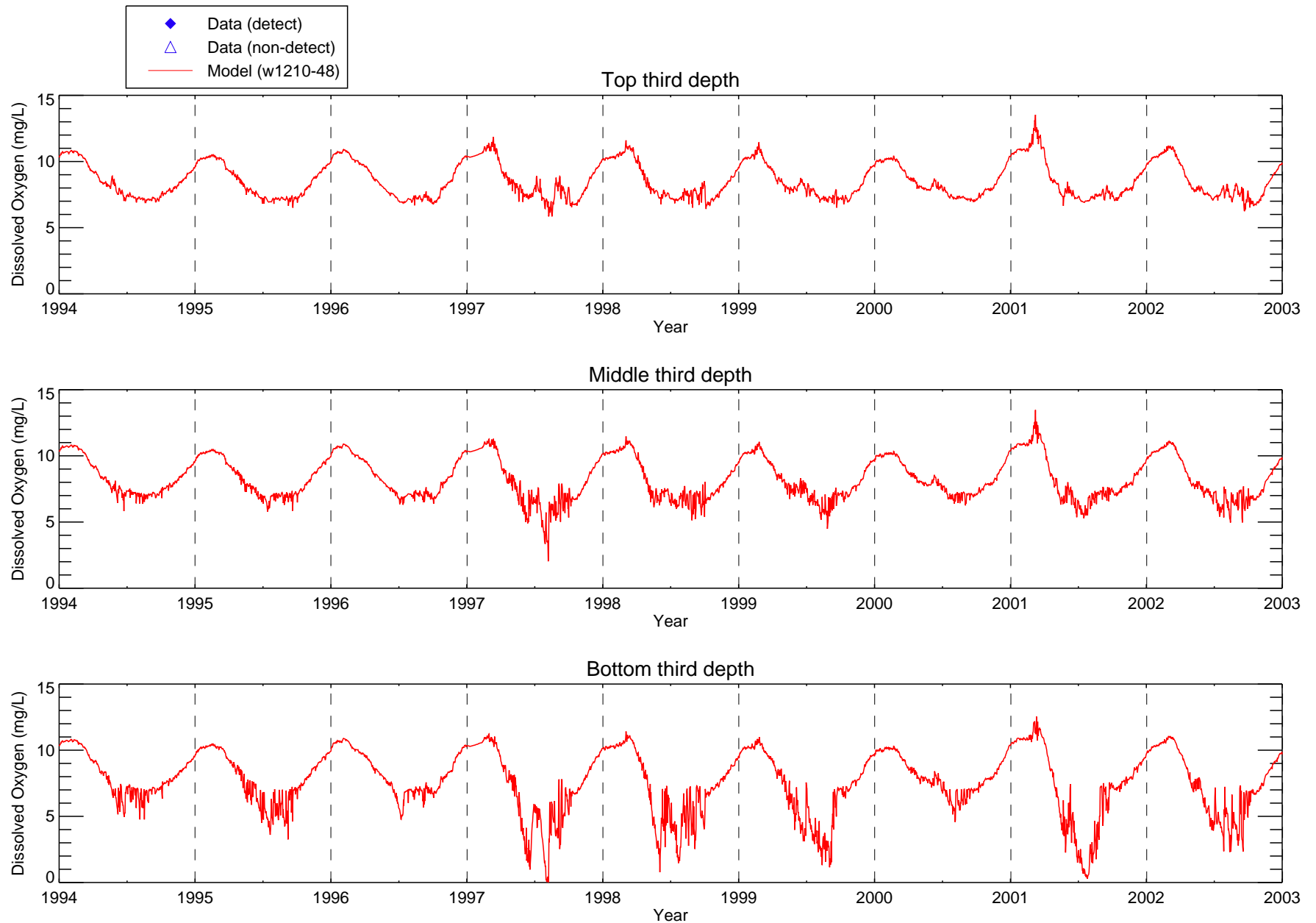Lower Colorado River Authority

Figure 4-19e
Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
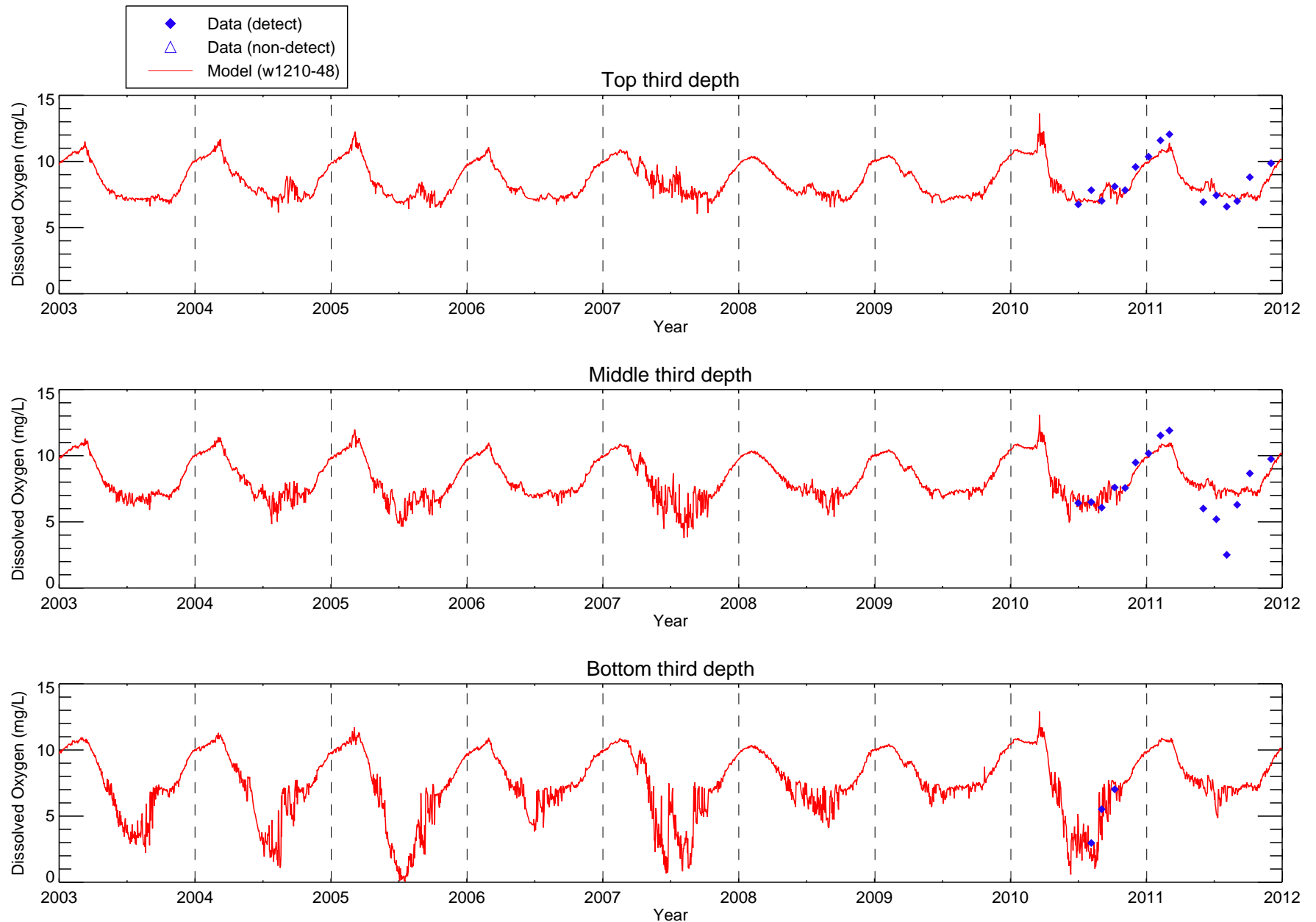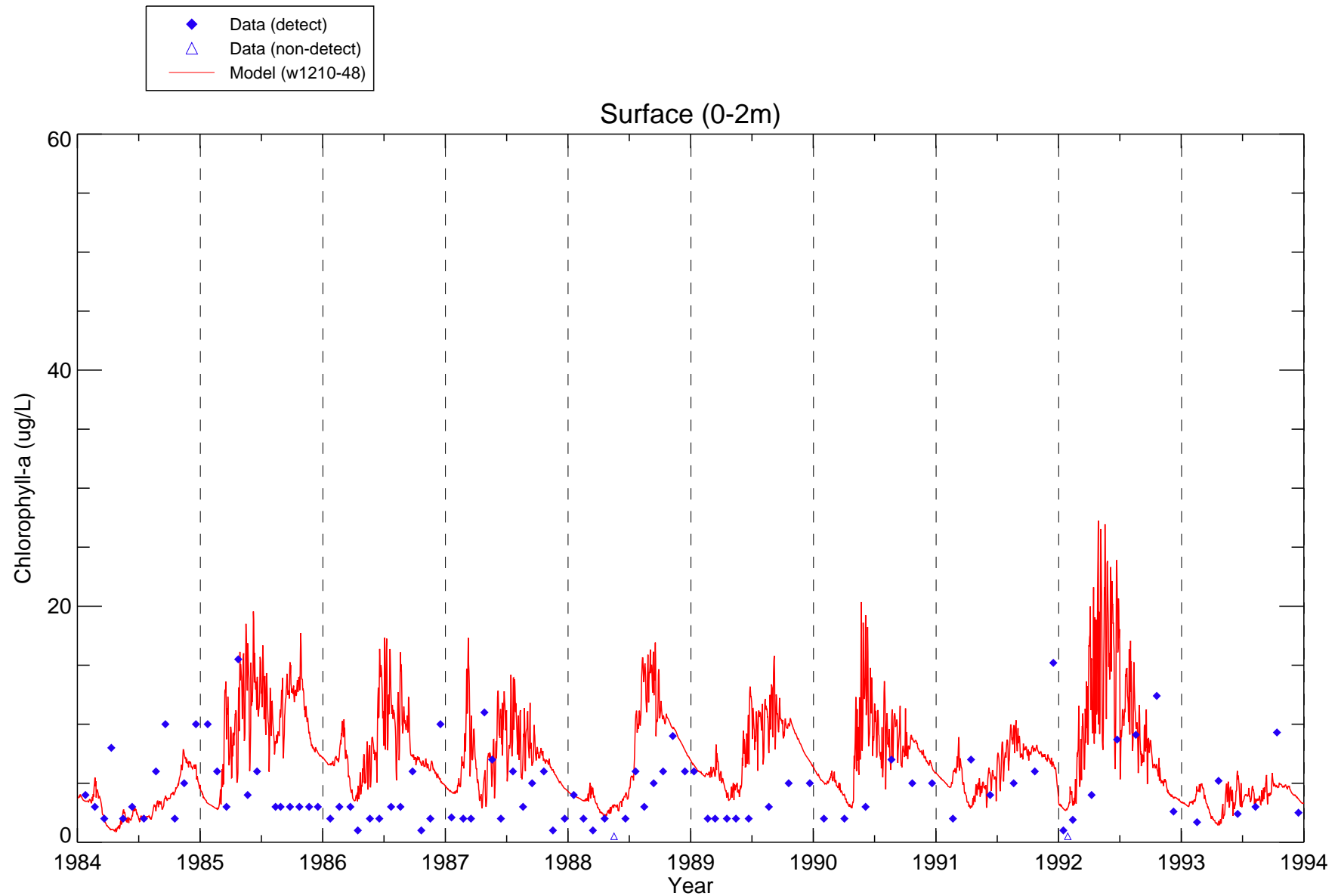
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-19e
Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:42:16 2013

Figure 4-19f
Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
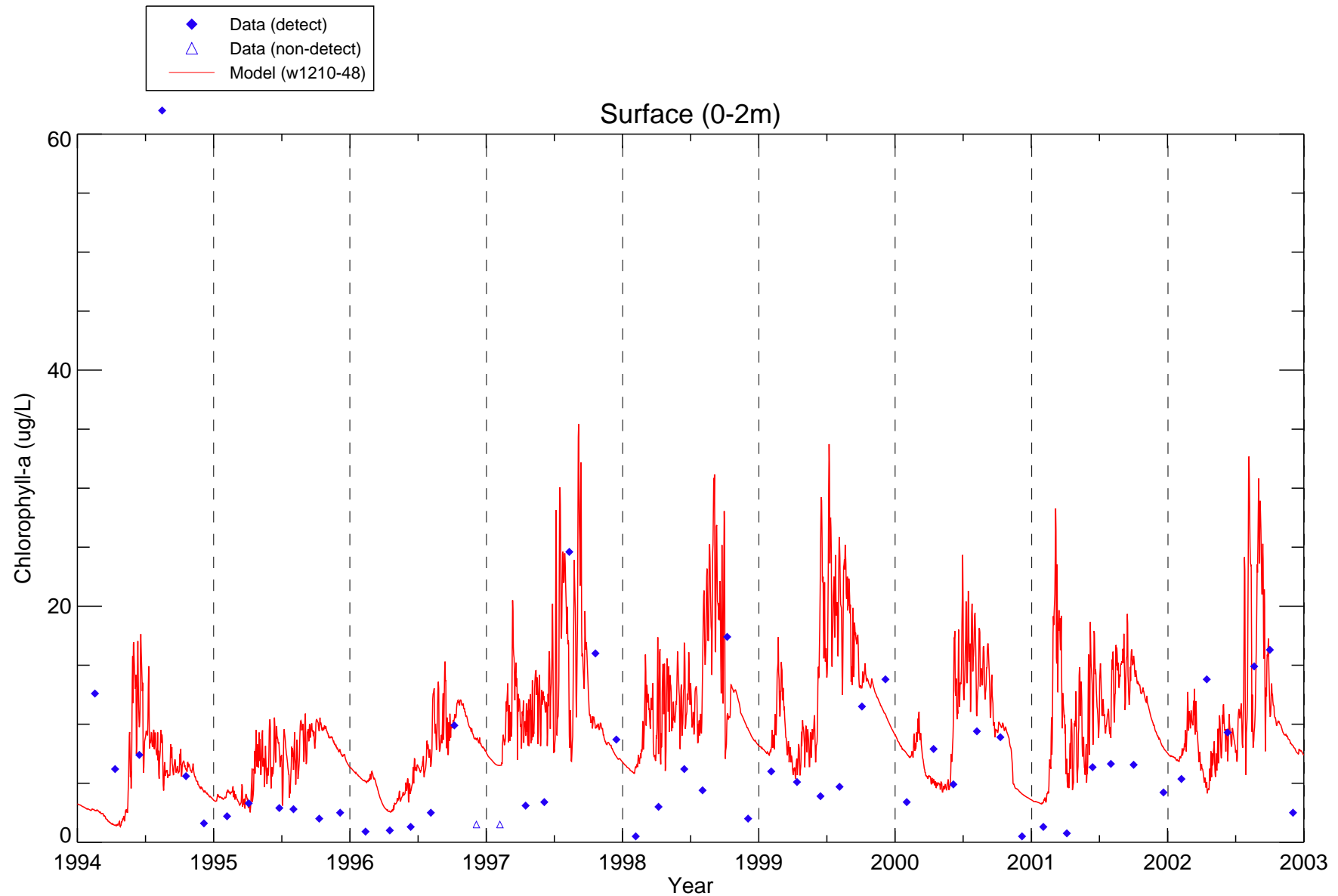
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-19f
Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-19f

Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:46:49 2013

Figure 4-19g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-19g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-19g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-19h
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-19h

Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-19h
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:56:53 2013

Figure 4-20a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 17:58:26 2013

Figure 4-20a

Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
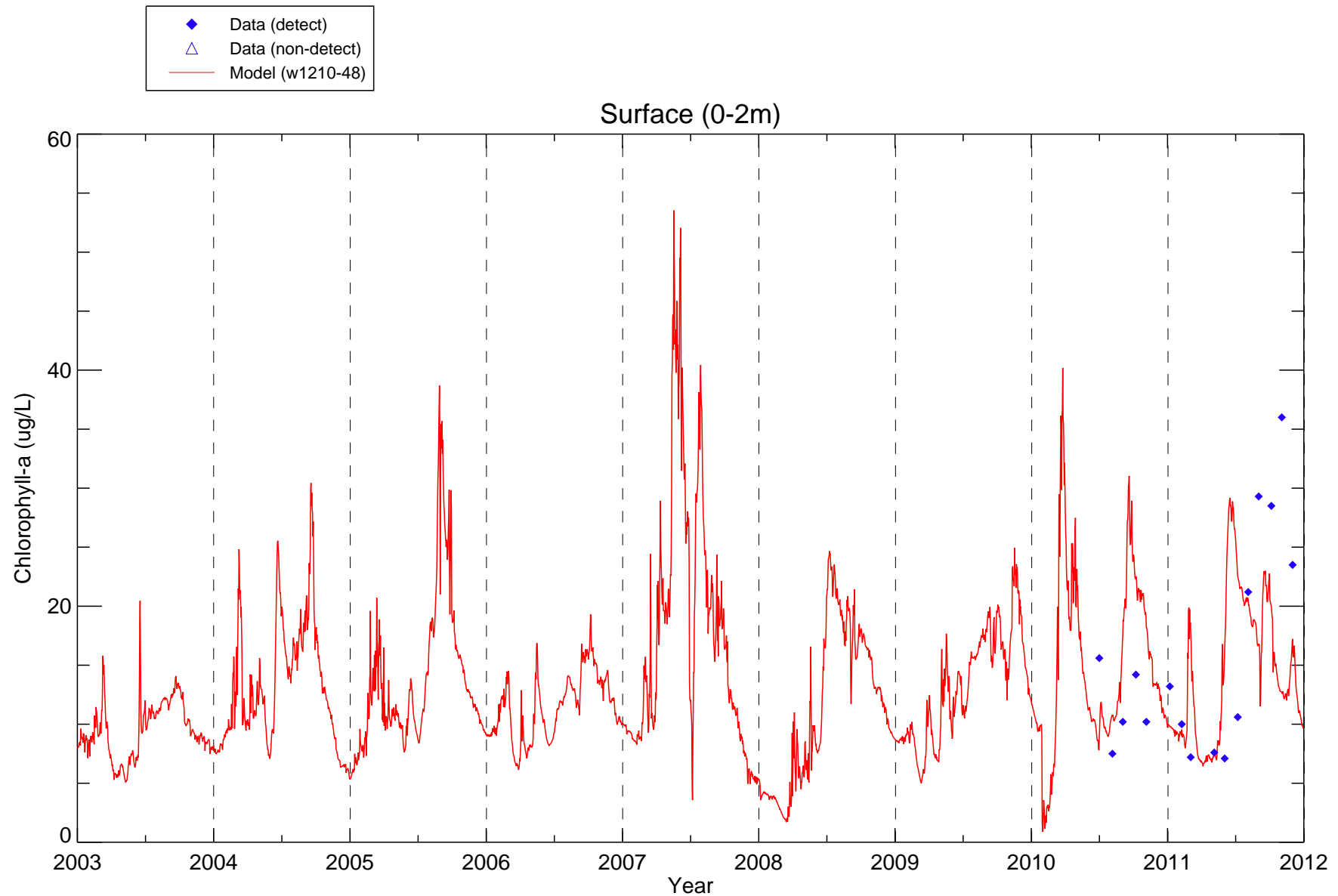
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:00:42 2013

Figure 4-20b

Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Dissolved Oxygen

Notes: Data are averaged over water column depths shown.
Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

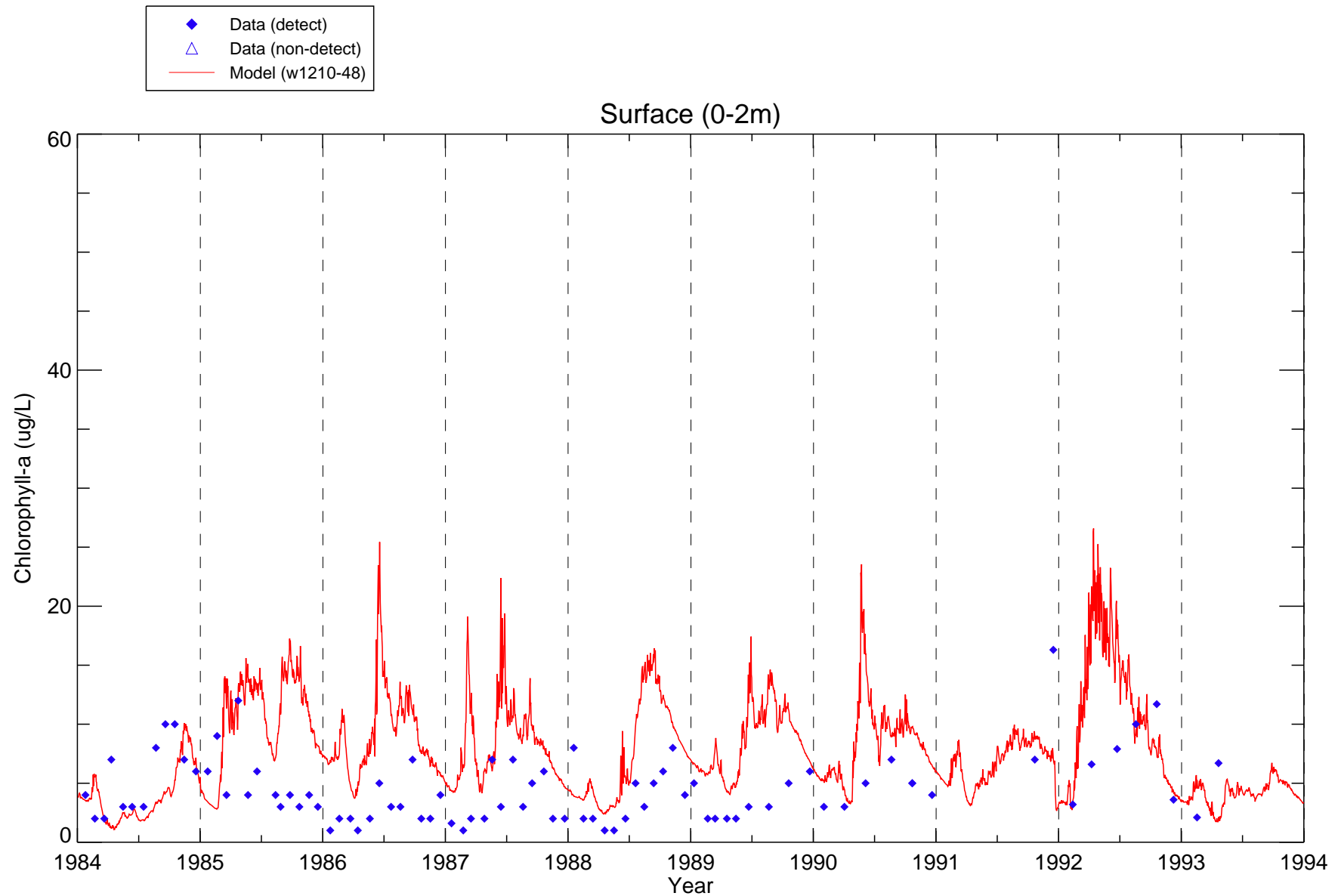CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:07:43 2013

Figure 4-20b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Dissolved Oxygen

Notes: Data are averaged over water column depths shown.
Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

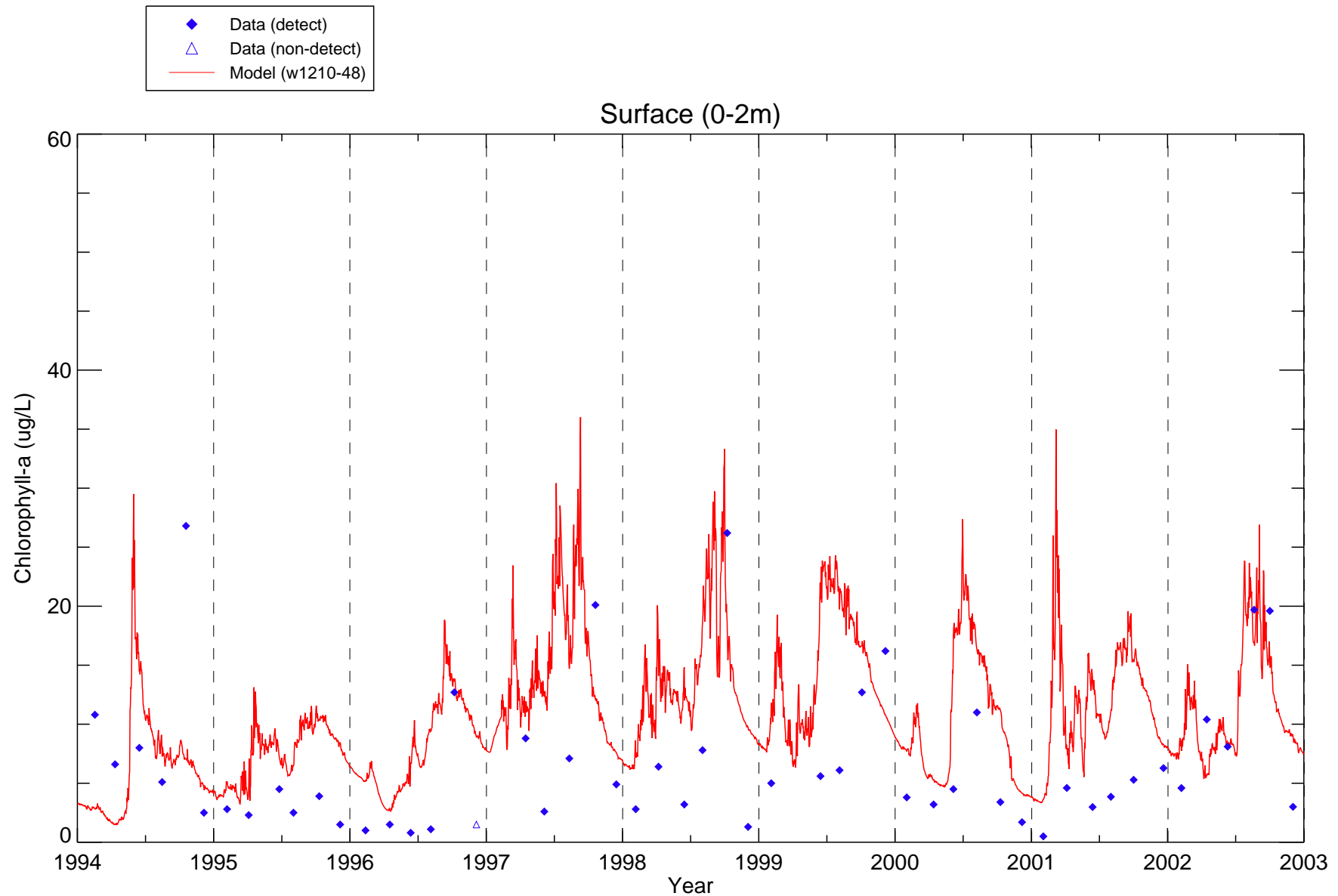CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:07:49 2013

Figure 4-20b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Dissolved Oxygen

Notes: Data are averaged over water column depths shown.
Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-20c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-20c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-20c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-20d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-20d

Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - \\austin2\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Wed Jan 30 09:03:08 2013

Figure 4-20d

Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-20e
Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 17:45:20 2013

Figure 4-20e
Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 17:46:51 2013

Figure 4-20e
Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 17:48:21 2013

Figure 4-20f

Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-20f

Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-20f
Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 17:53:54 2013

Figure 4-20g
Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:02:04 2013

Figure 4-20g
Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
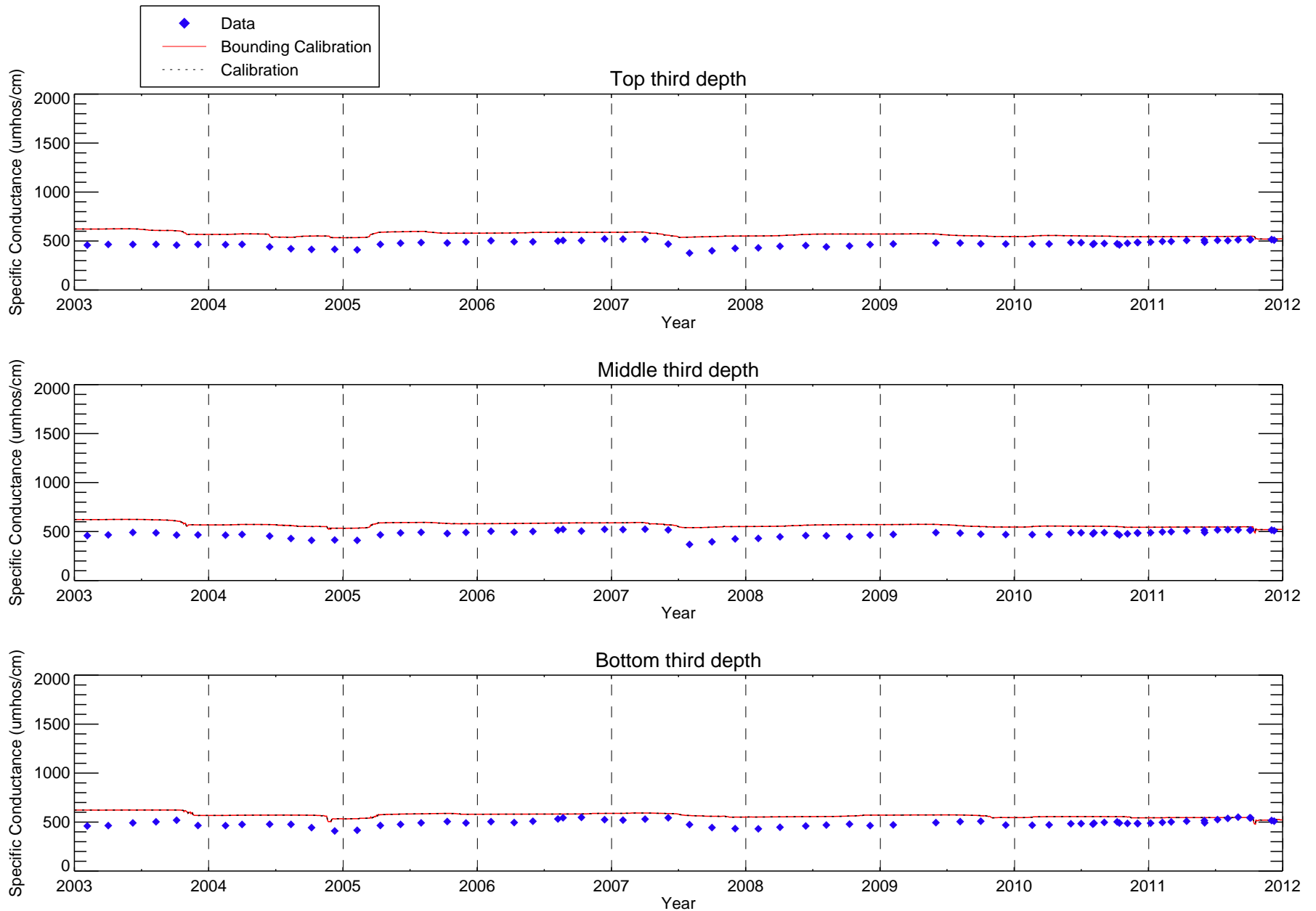
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-20g
Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
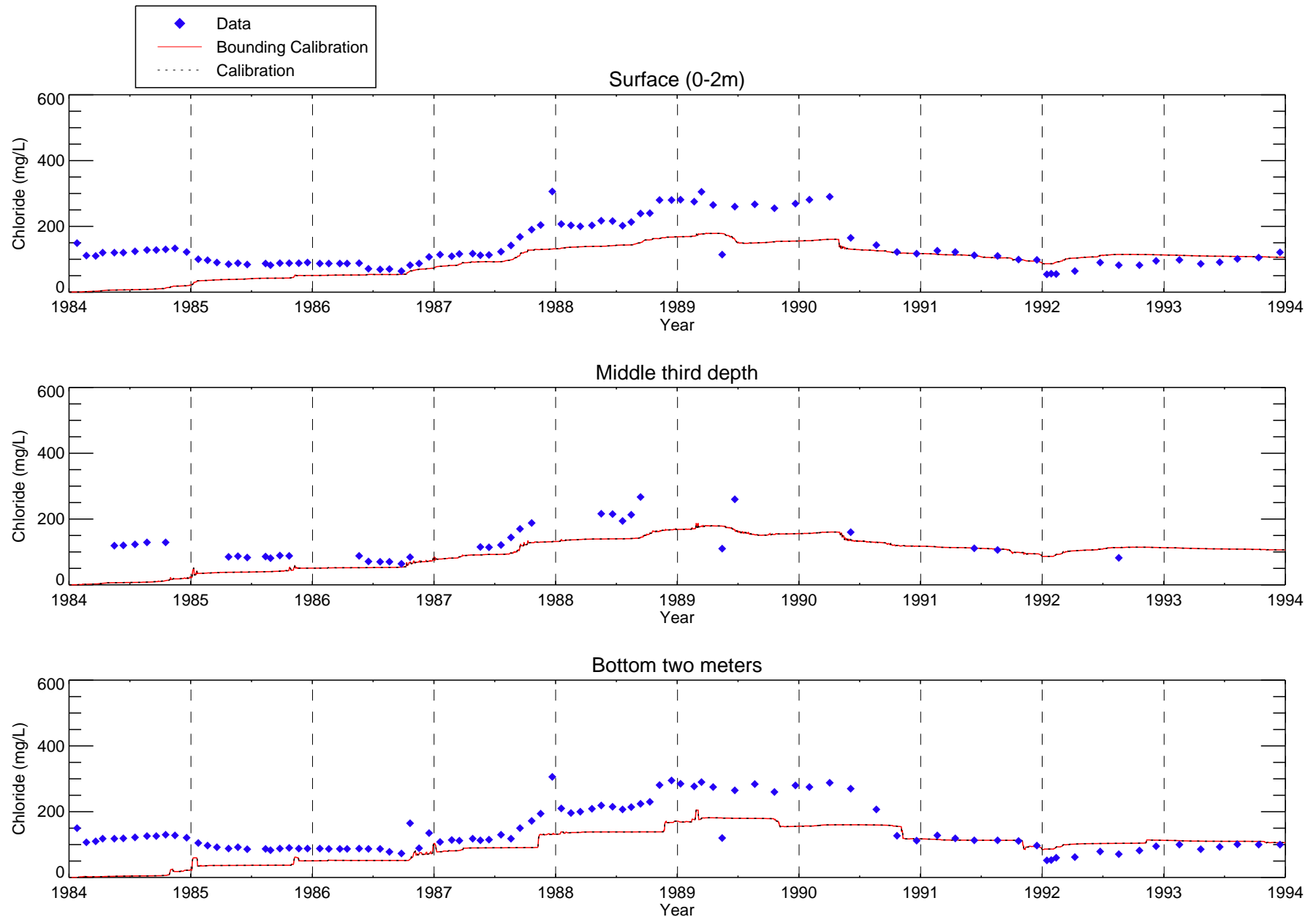
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-20h
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
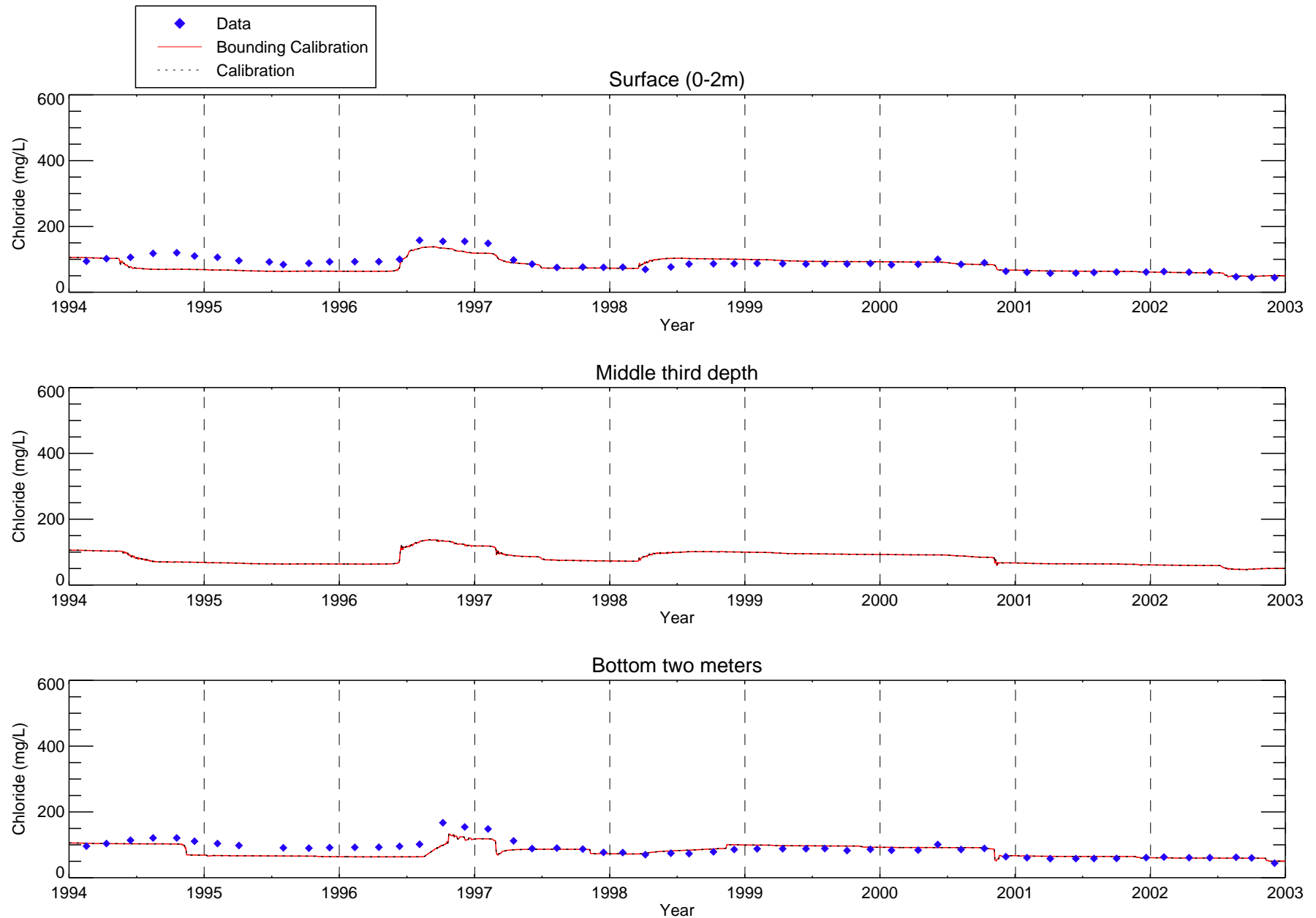
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 18:05:45 2013

Figure 4-20h
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
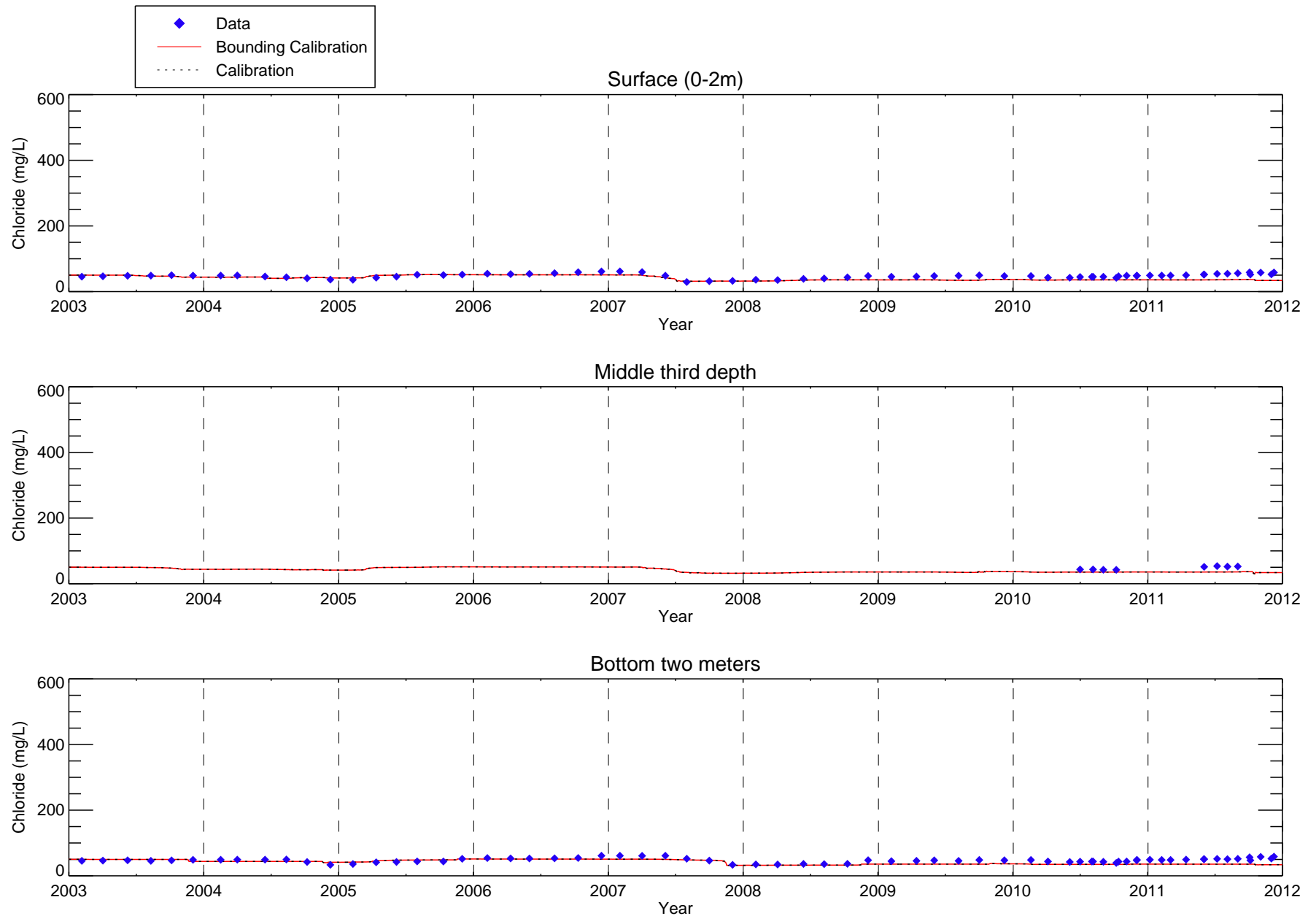
CREMs Phase 4: Lake Buchanan
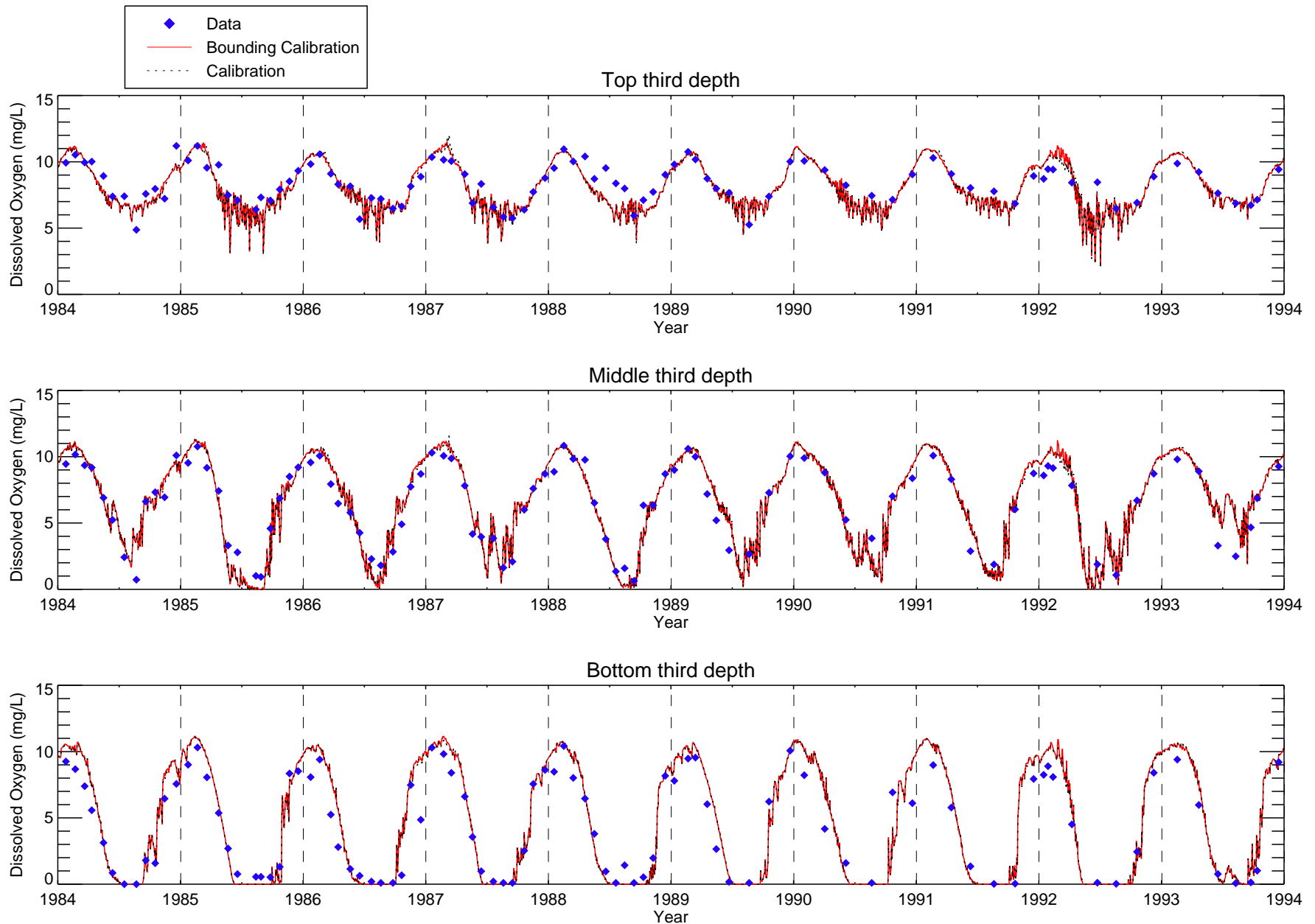Lower Colorado River Authority

Figure 4-20h
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

Figure 4-21a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

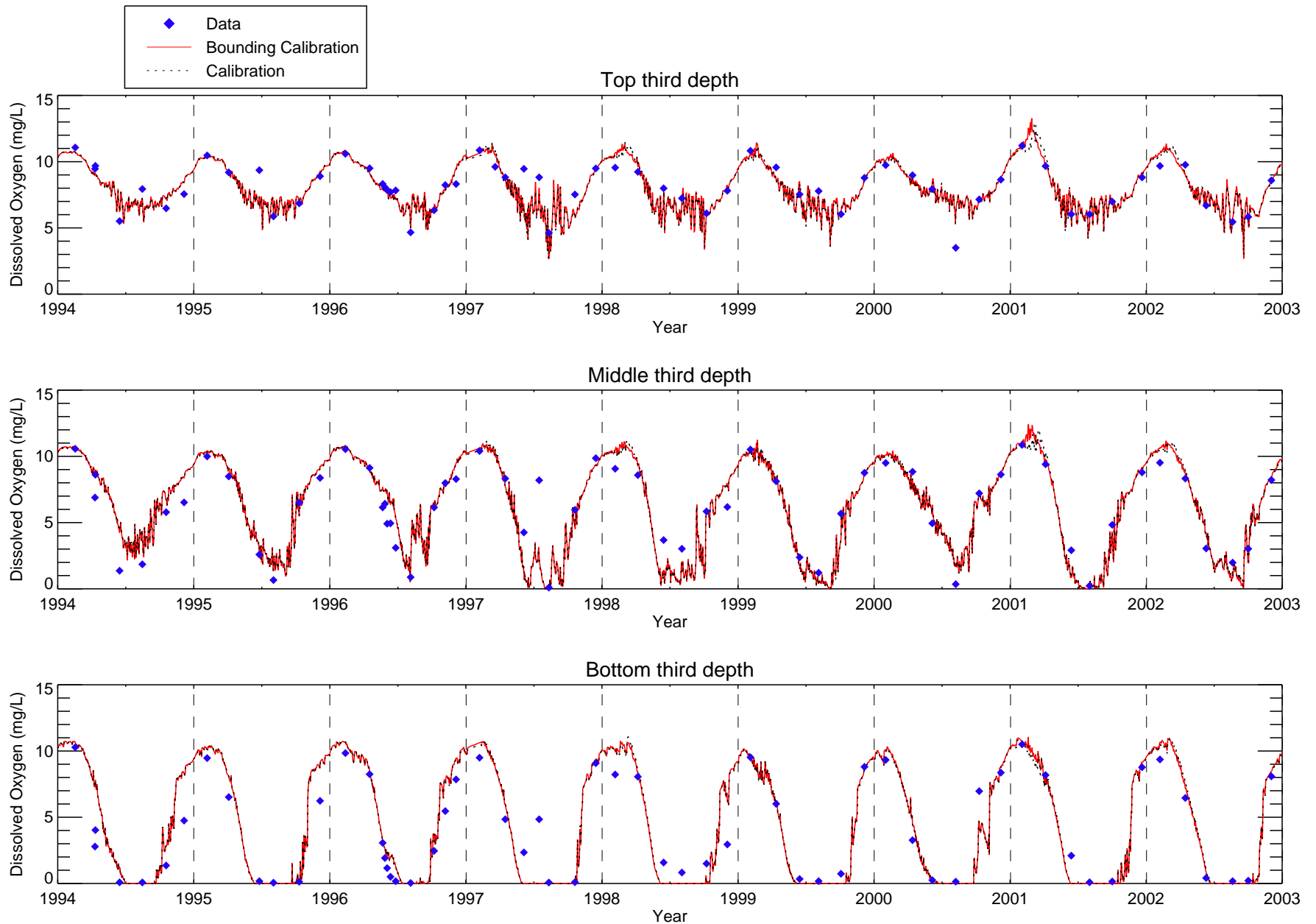EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:59:54 2013

Figure 4-21a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:59:59 2013

Figure 4-21a
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
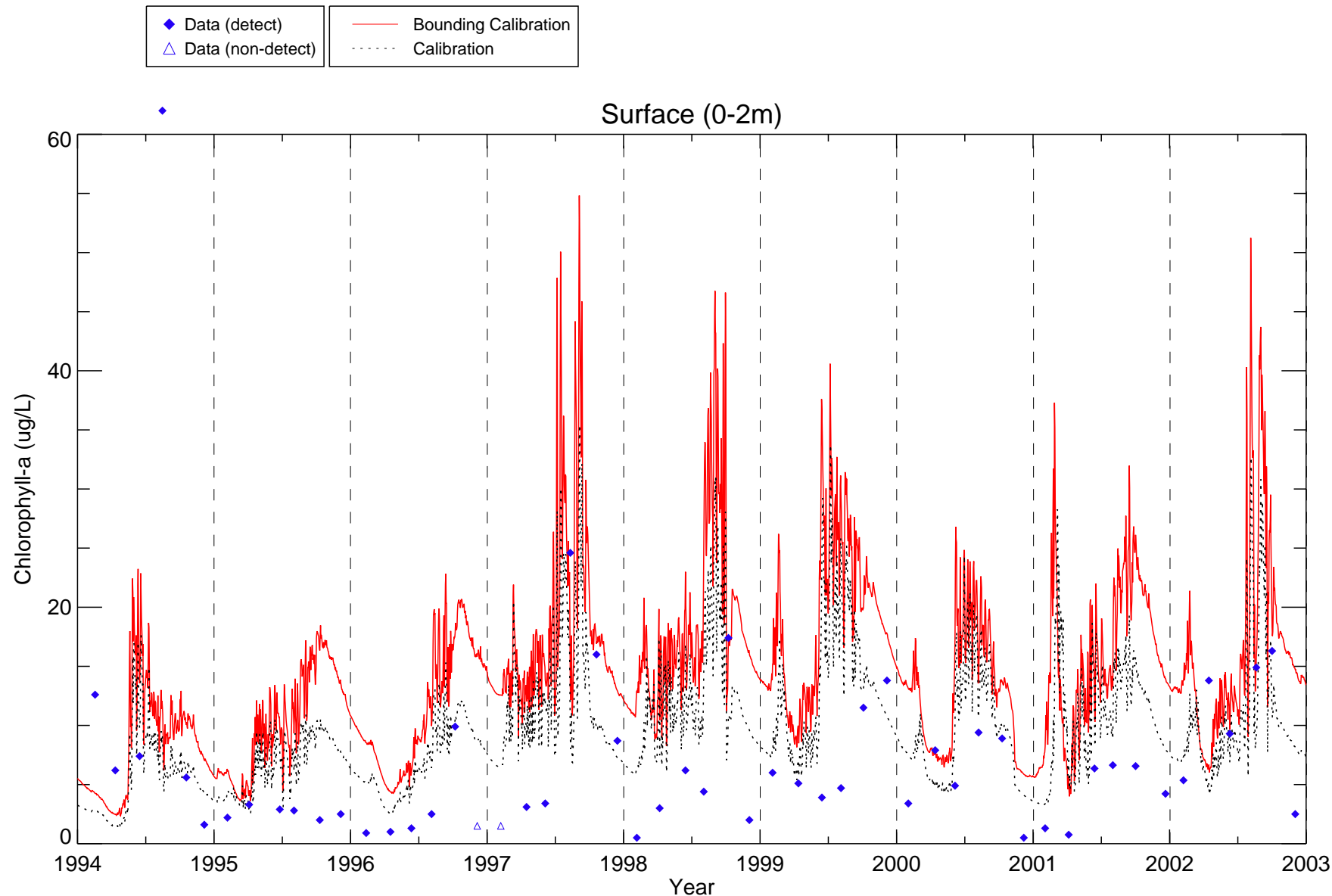Tue Jan 29 20:00:03 2013

Figure 4-21b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 20:00:24 2013

ANCHOR
QEA
PARSONS

Figure 4-21b
Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
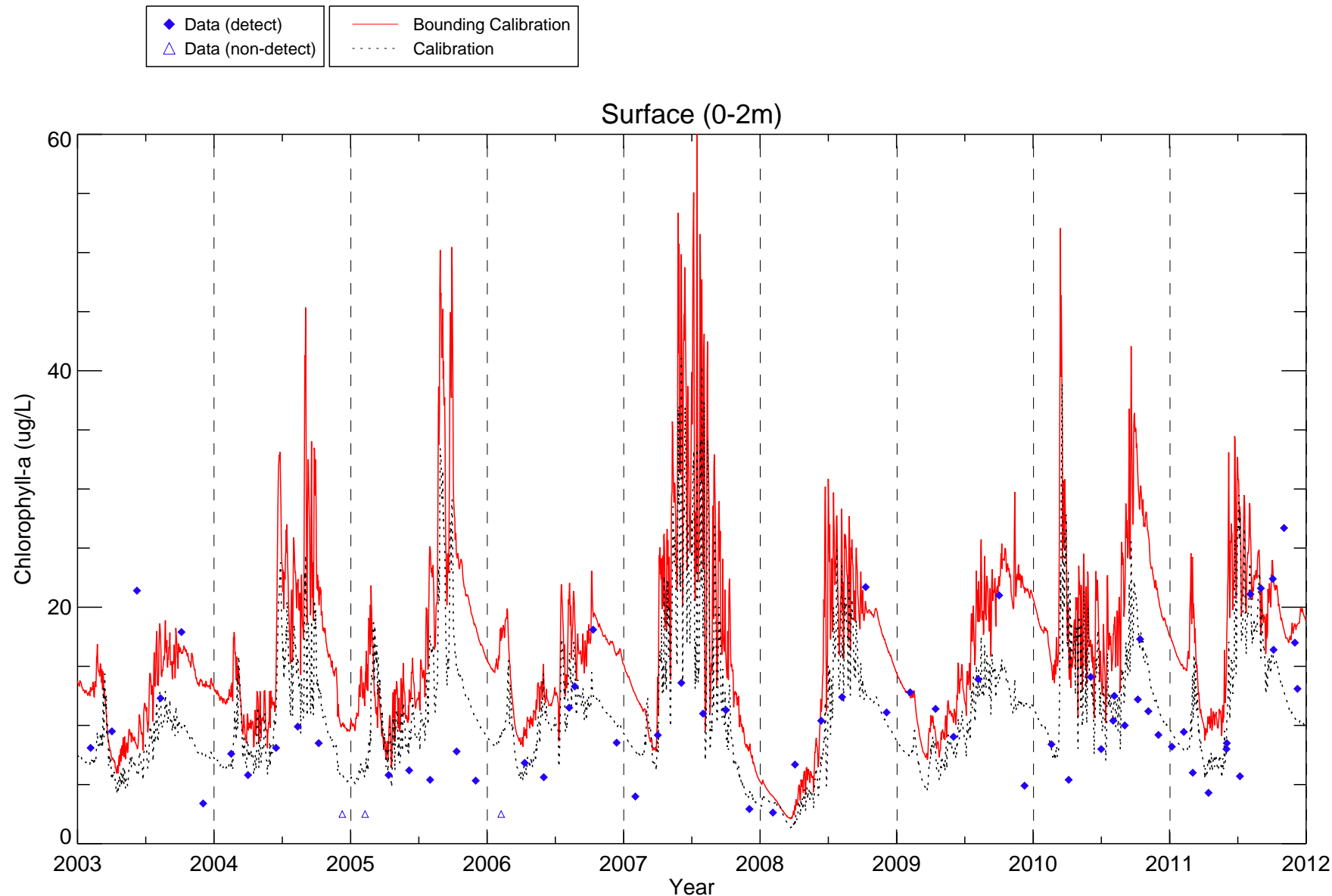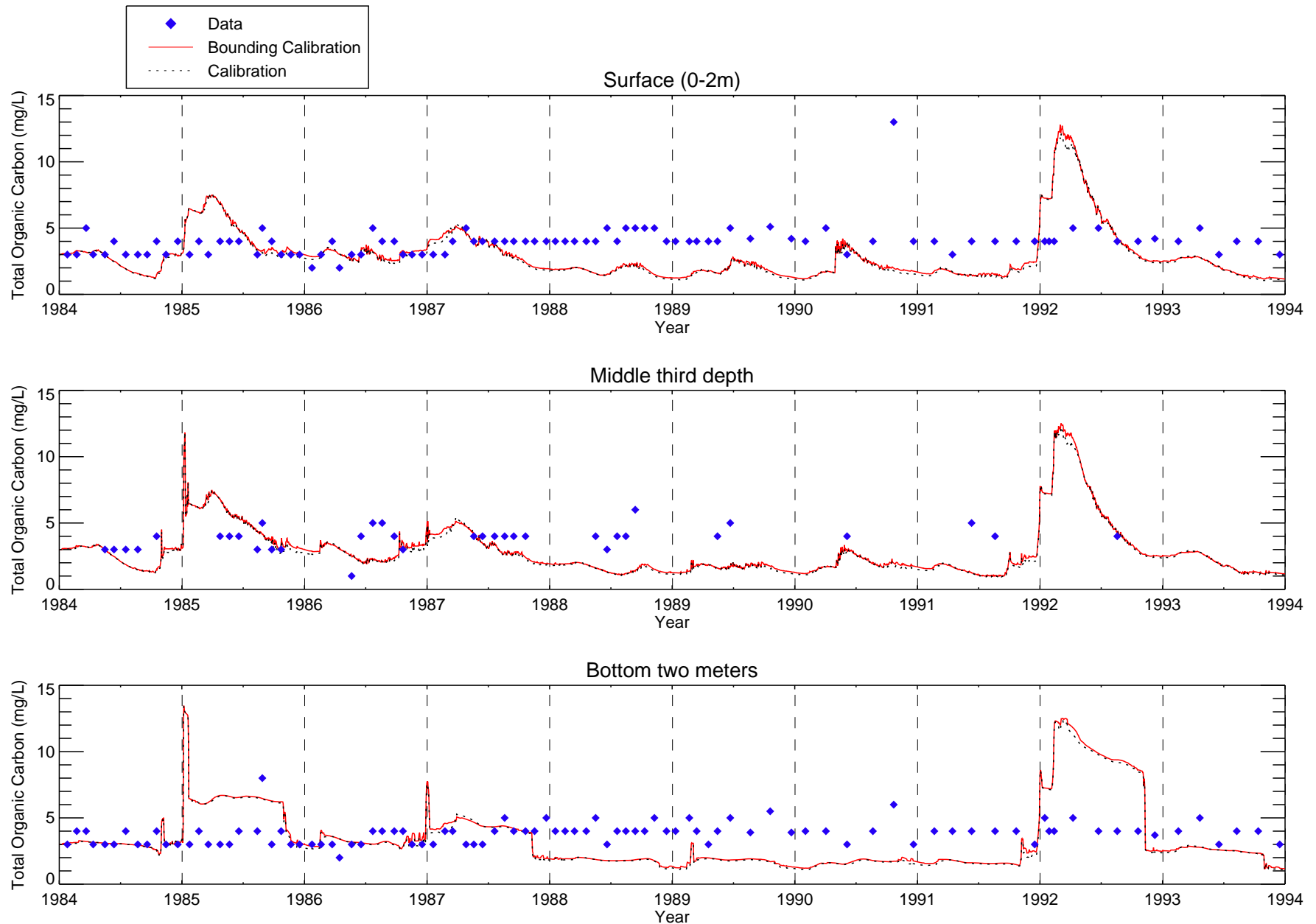
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 20:00:25 2013

ANCHOR QEA
PARSONS

Figure 4-21b

Temporal of Model versus Data for Lake Buchanan Near Lake Headwater (Segment 2) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
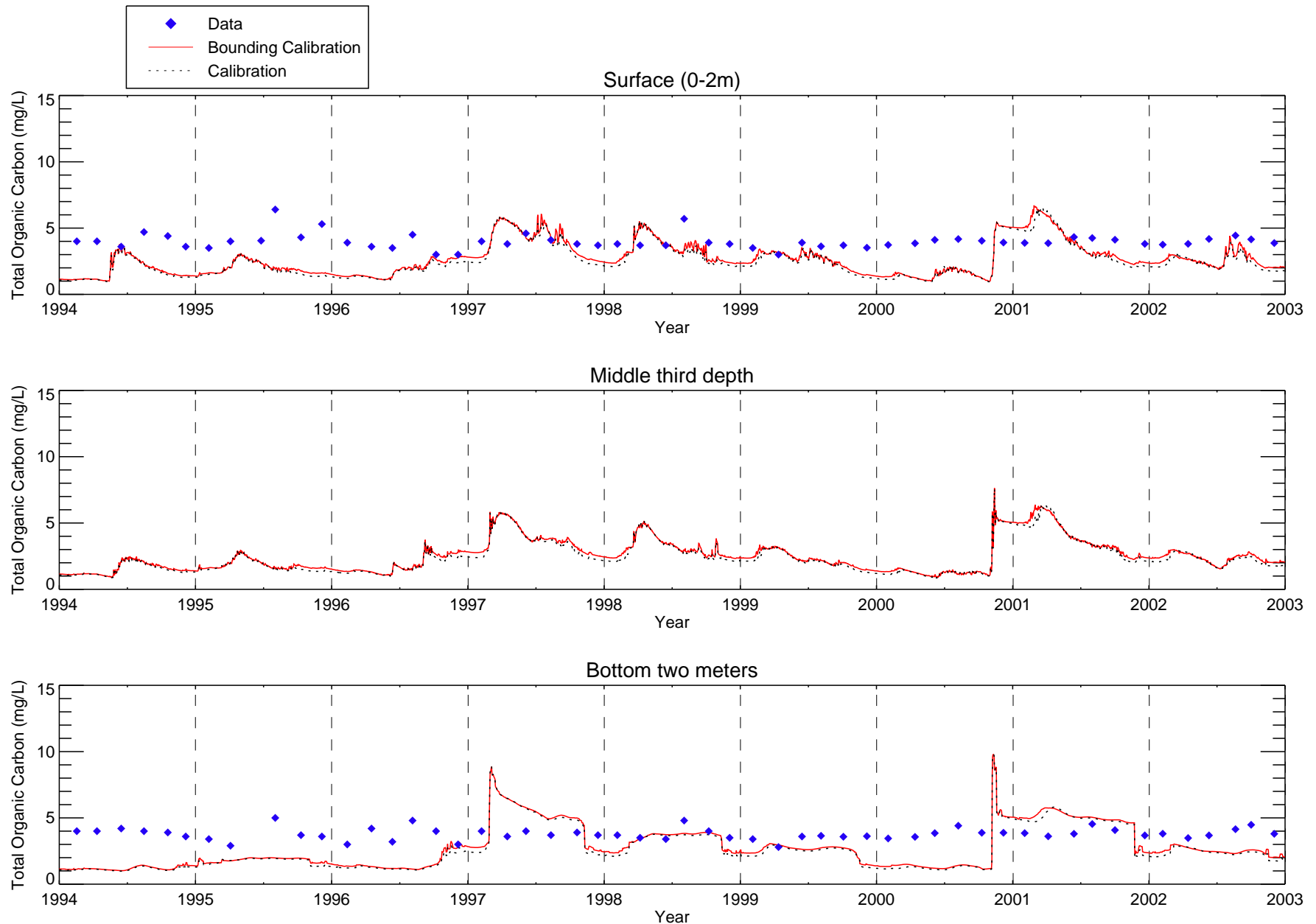
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-21c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

Figure 4-21c
Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
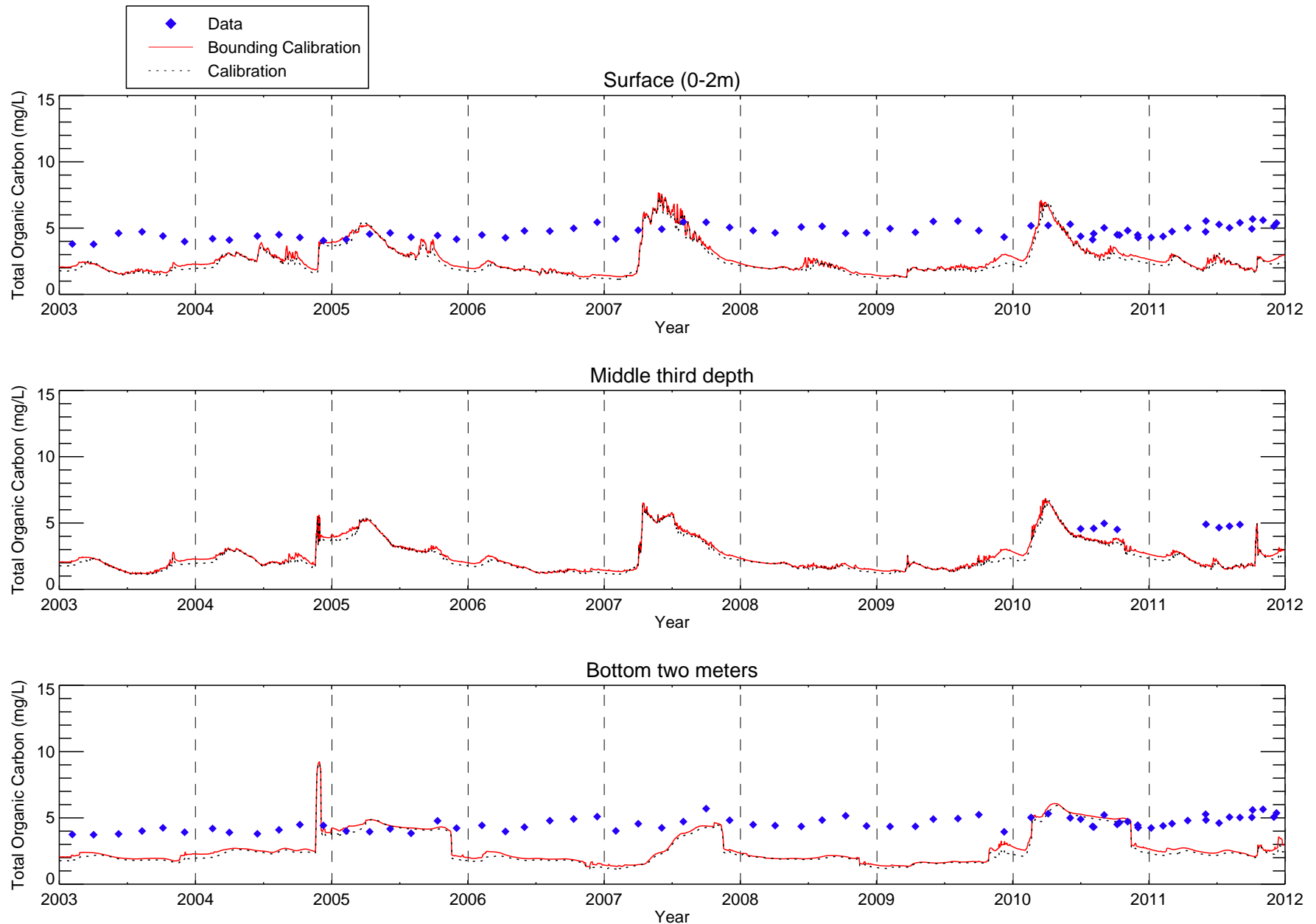
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-21c

Temporal of Model versus Data for Lake Buchanan Near Beaver Creek Cove (Segment 6) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

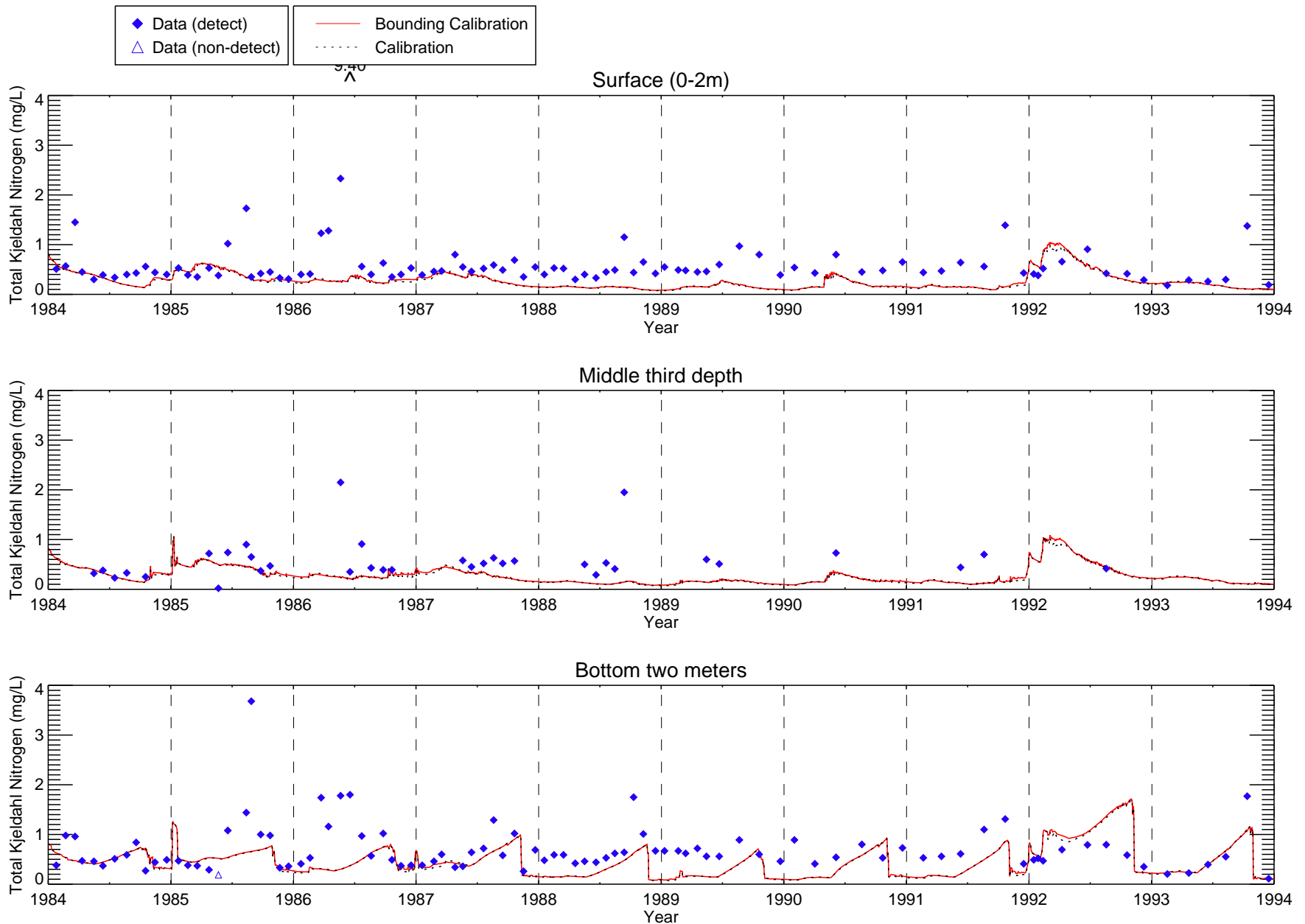CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

Surface (0-2m)

Legend:
- ◆ Data (detect)
- △ Data (non-detect)
- — Model (w1210-48)

Y-axis: Chlorophyll-a (ug/L)
X-axis: Year

Figure 4-21d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Surface (0-2m)
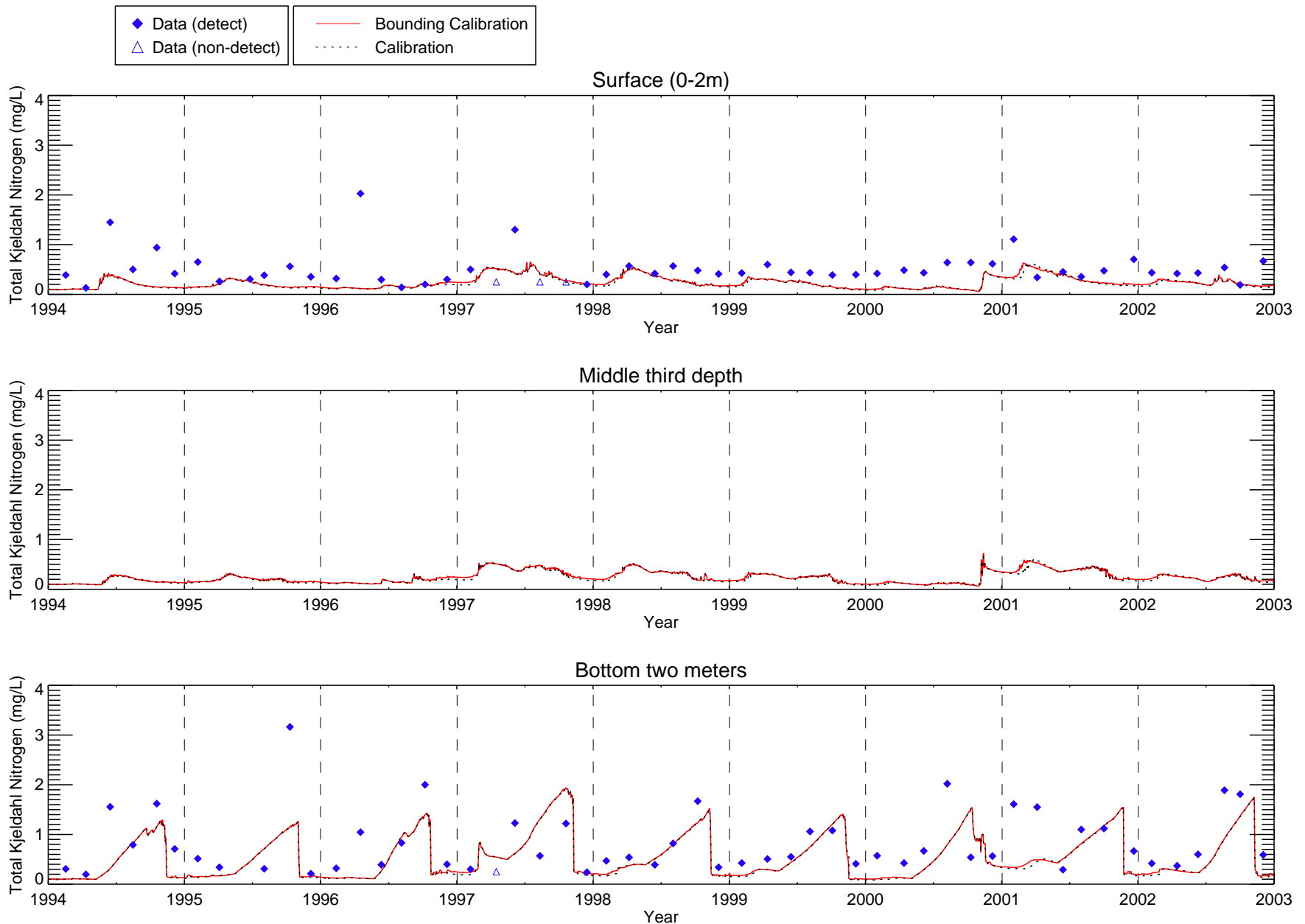
Legend:
- ◆ Data (detect)
- △ Data (non-detect)
- —— Model (w1210-48)

Y-axis: Chlorophyll-a (ug/L)

X-axis: Year

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 20:00:32 2013

Figure 4-21d
Temporal of Model versus Data for Lake Buchanan at Buchanan Village (Segment 6) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
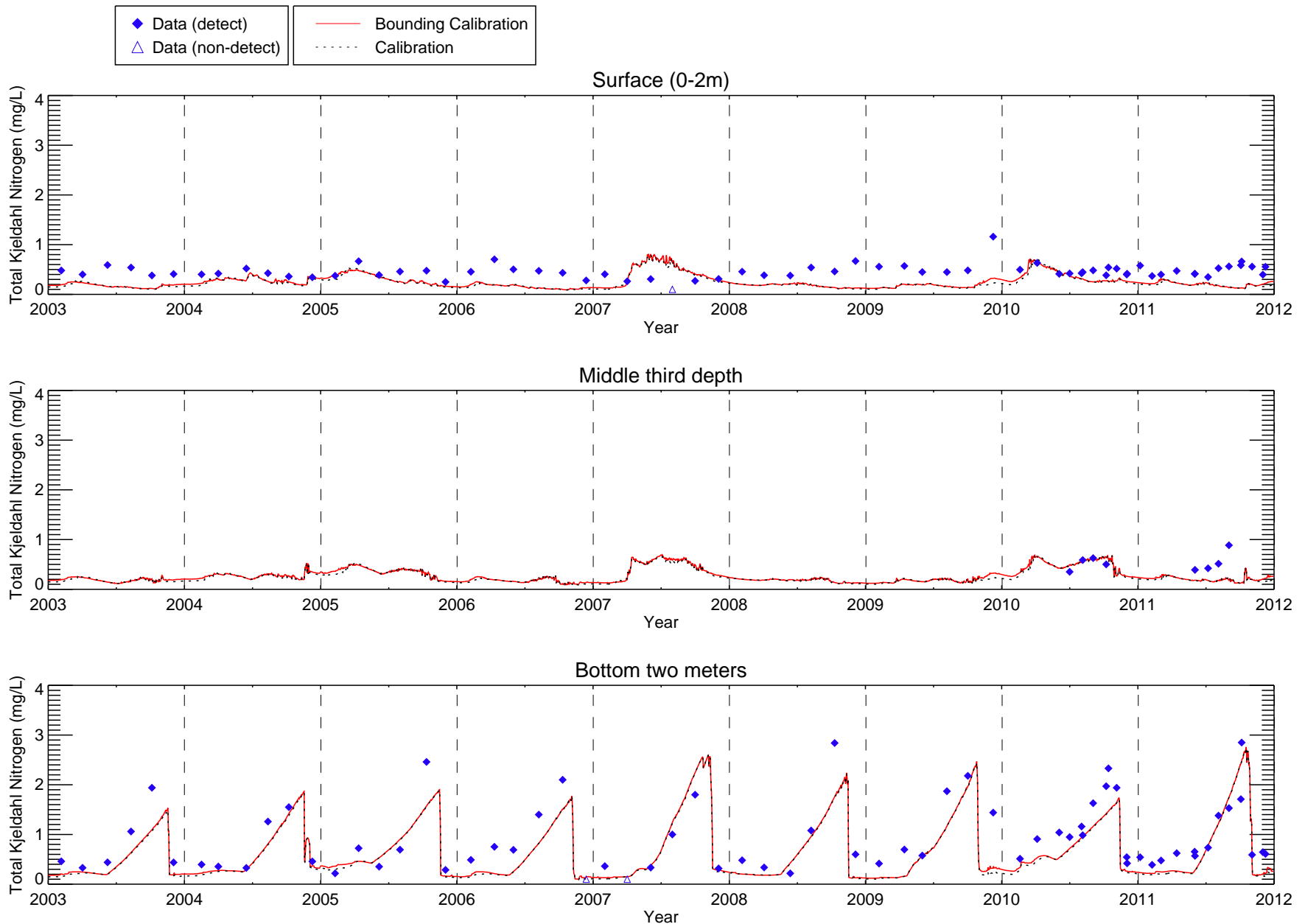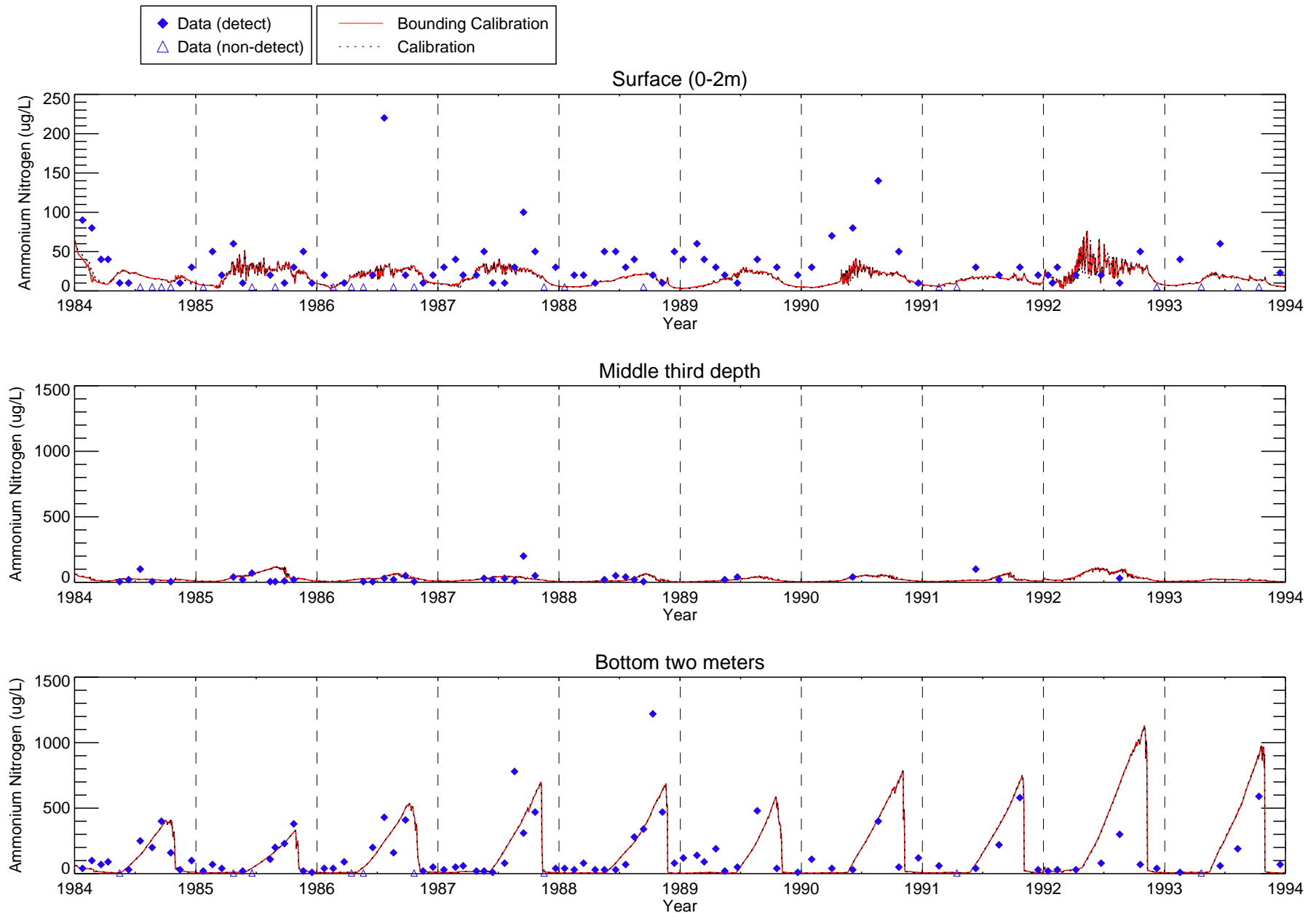
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 20:00:35 2013

Figure 4-21e
Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:59:27 2013

Surface (0-2m)

Legend:
- ◆ Data (detect)
- △ Data (non-detect)
- — Model (w1210-48)

Figure 4-21e
Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
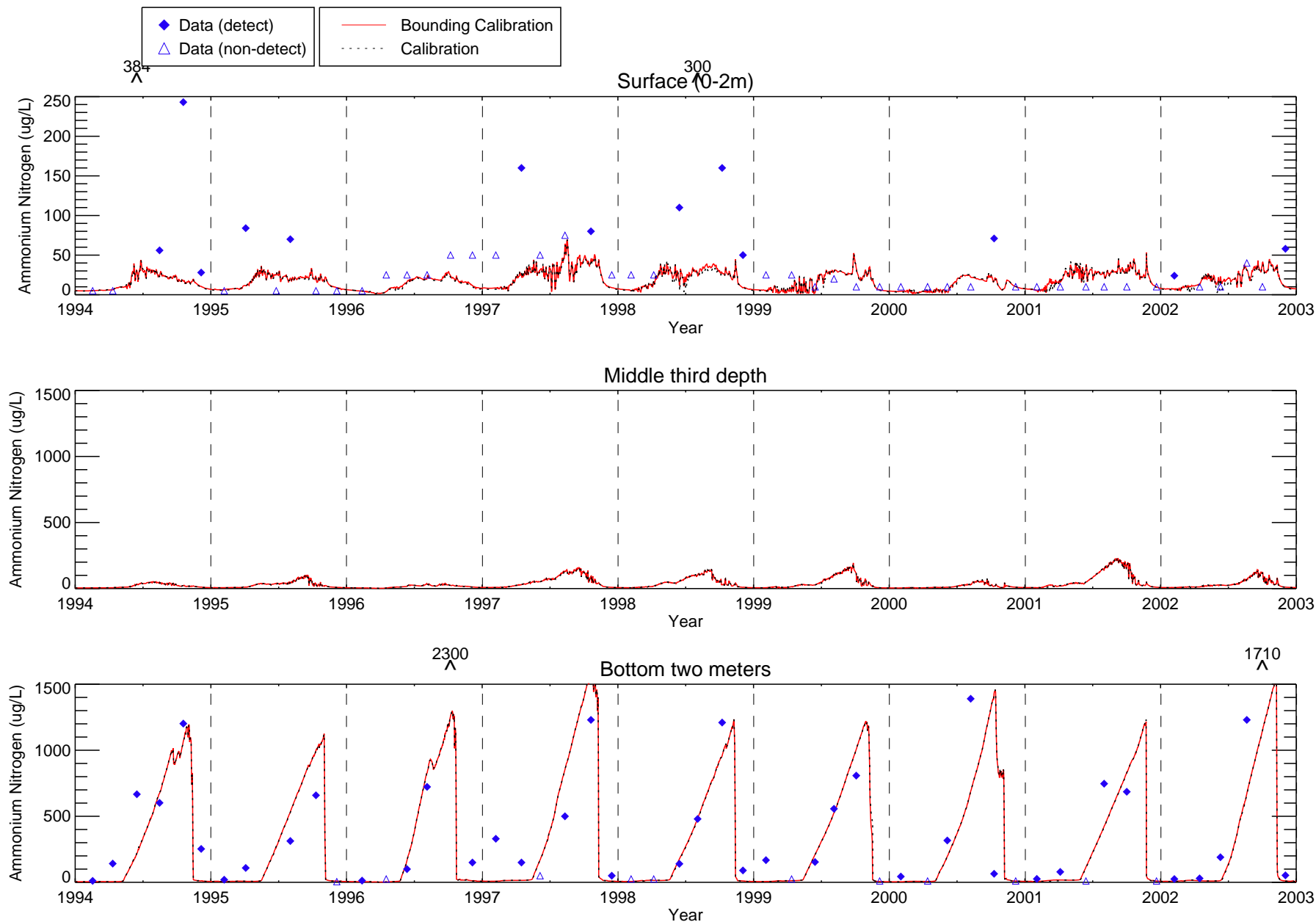
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-21e
Temporal of Model versus Data for Lake Buchanan ~3/4 mi south of Garret Island (Segment 7) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 19:59:34 2013

Figure 4-21f
Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
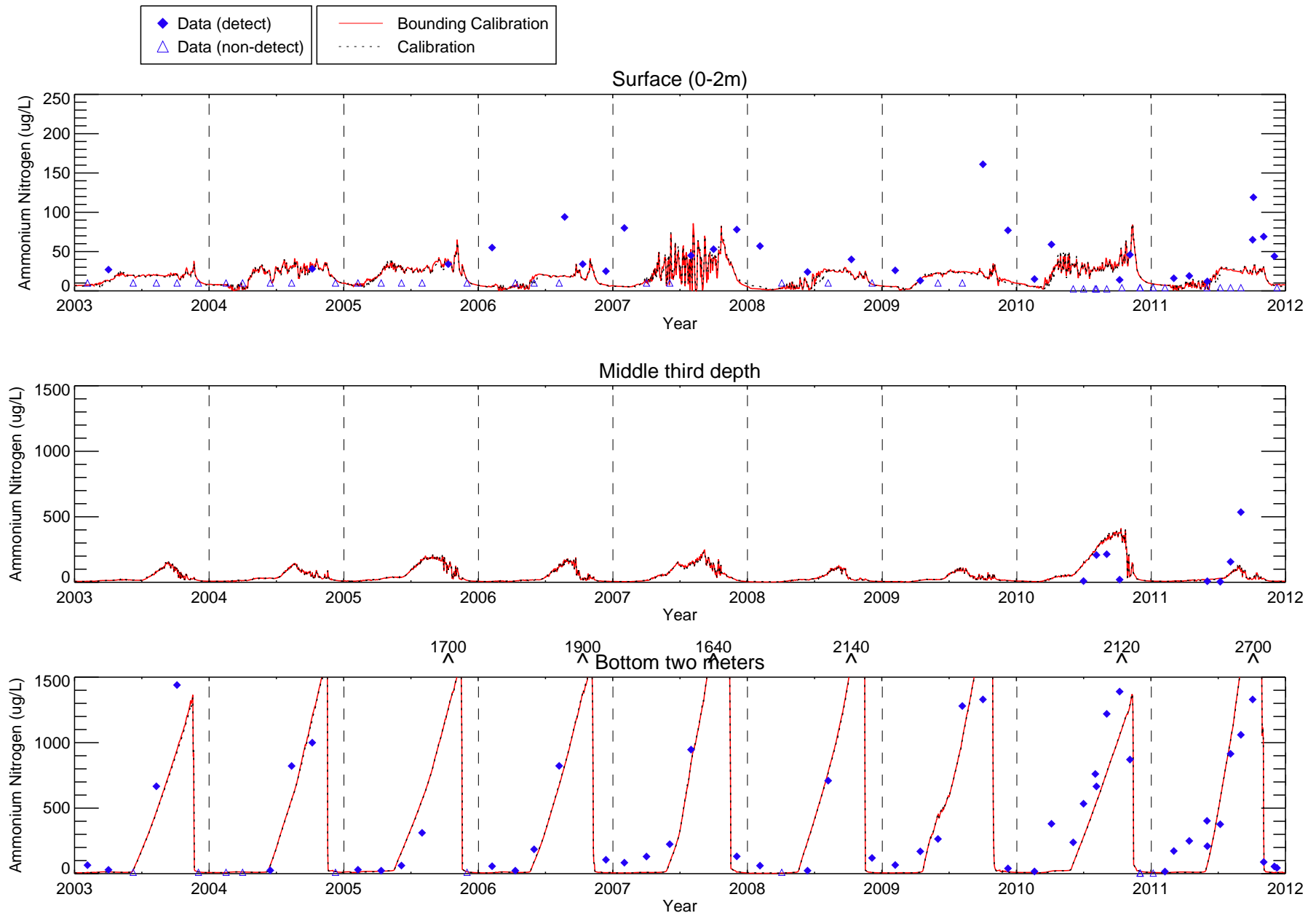
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-21f

Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
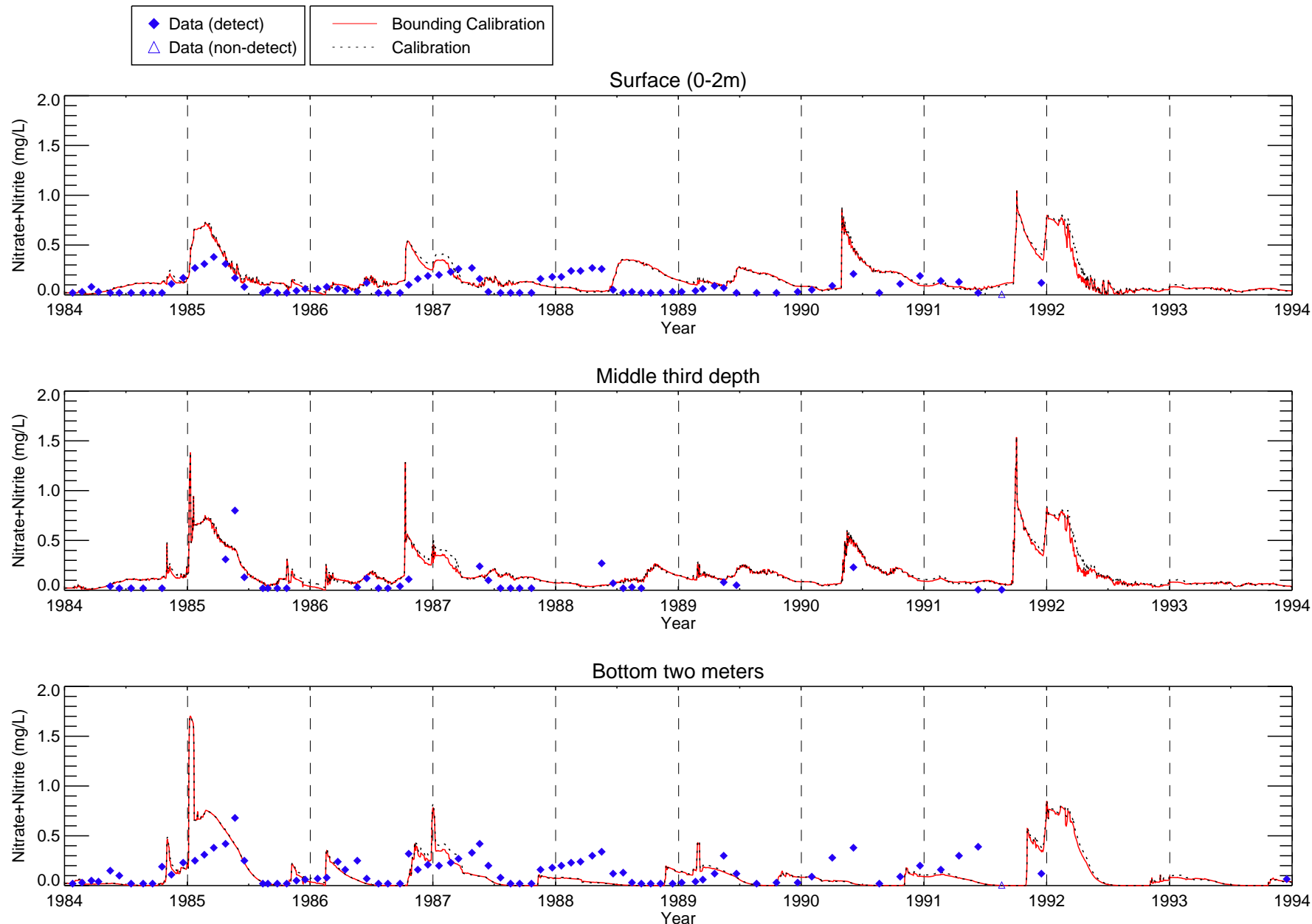
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-21f

Temporal of Model versus Data for Lake Buchanan at Rocky Point (Segment 9) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
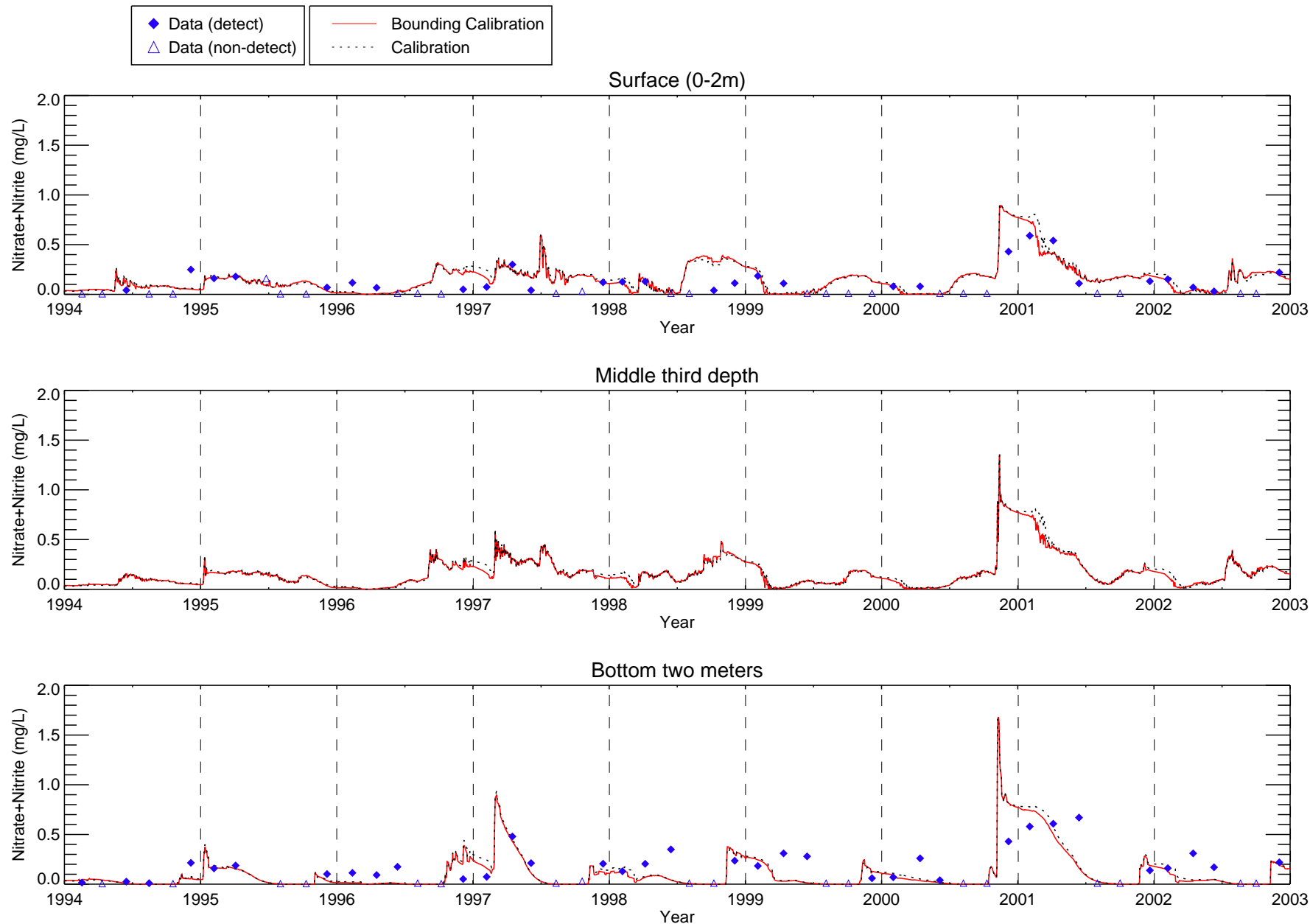
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-21g
Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
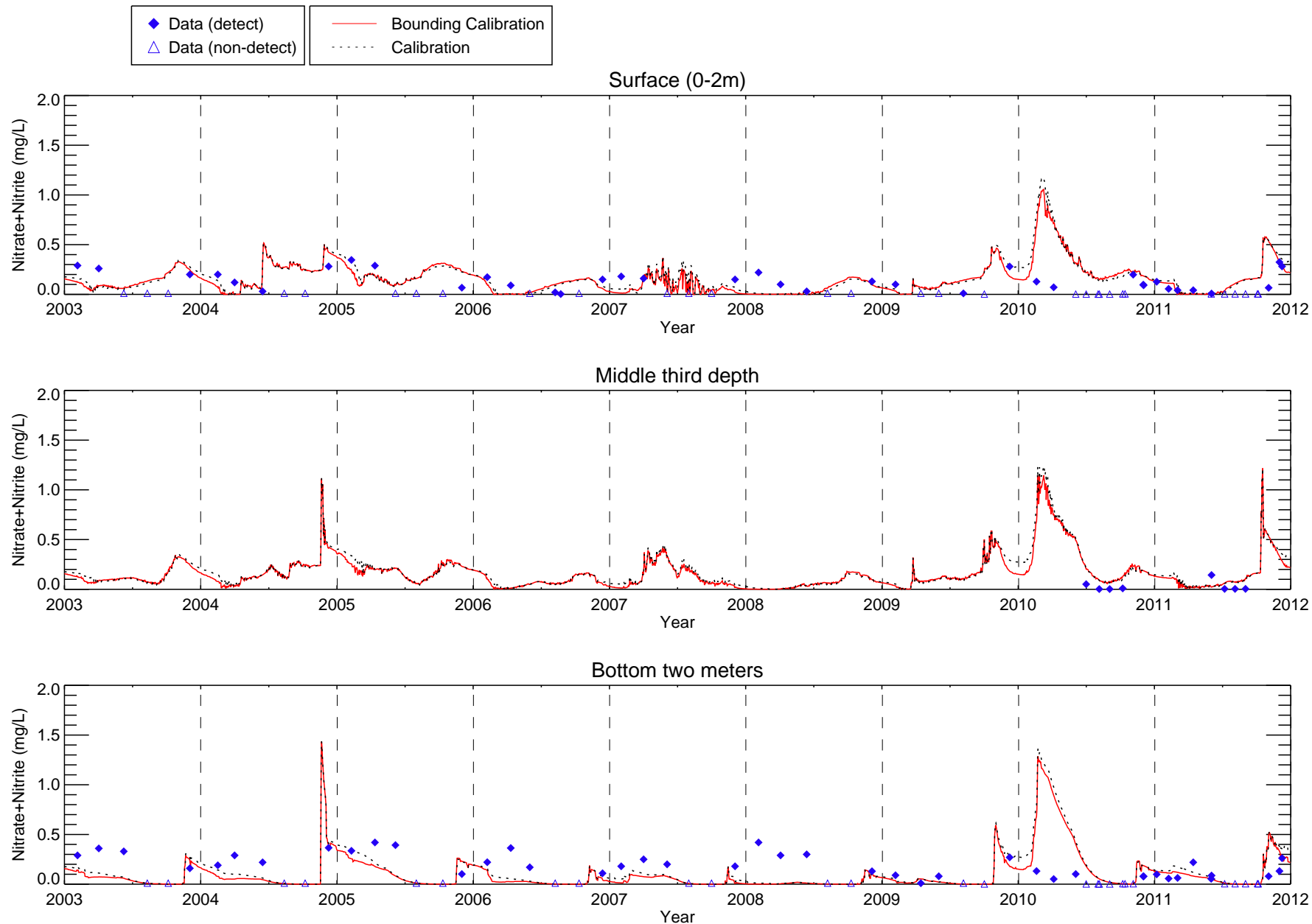Lower Colorado River Authority

Surface (0-2m)

Legend:
- ◆ Data (detect)
- △ Data (non-detect)
- — Model (w1210-48)

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 20:00:11 2013

Figure 4-21g

Temporal of Model versus Data for Lake Buchanan at Confluence of Council and Morgan Creeks (Segment 18) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

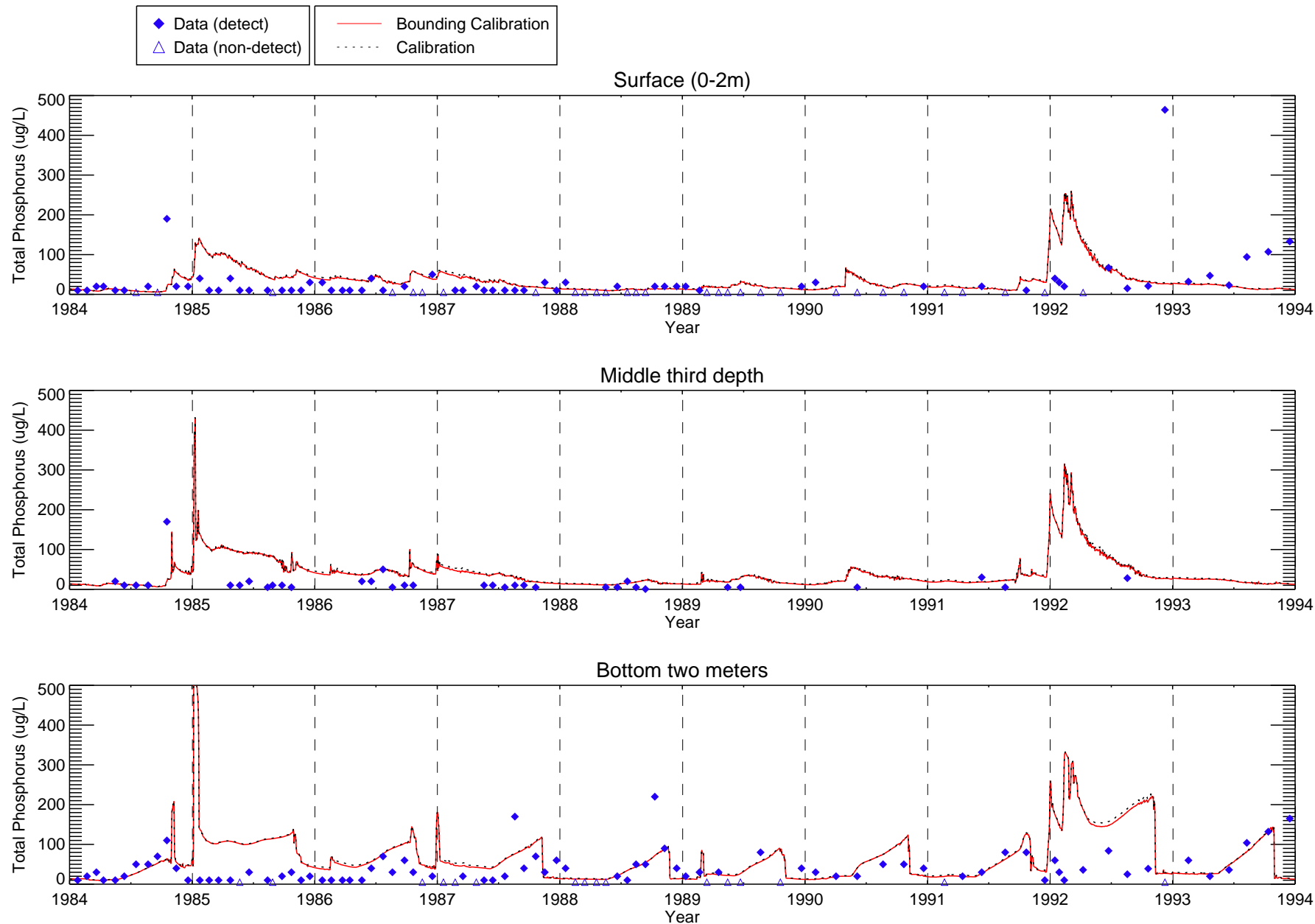CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Tue Jan 29 20:00:15 2013

Figure 4-21h

Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Surface (0-2m)

Legend:
- ◆ Data (detect)
- △ Data (non-detect)
- — Model (w1210-48)

Figure 4-21h
Temporal of Model versus Data for Lake Buchanan at Golden Beach (Segment 26) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
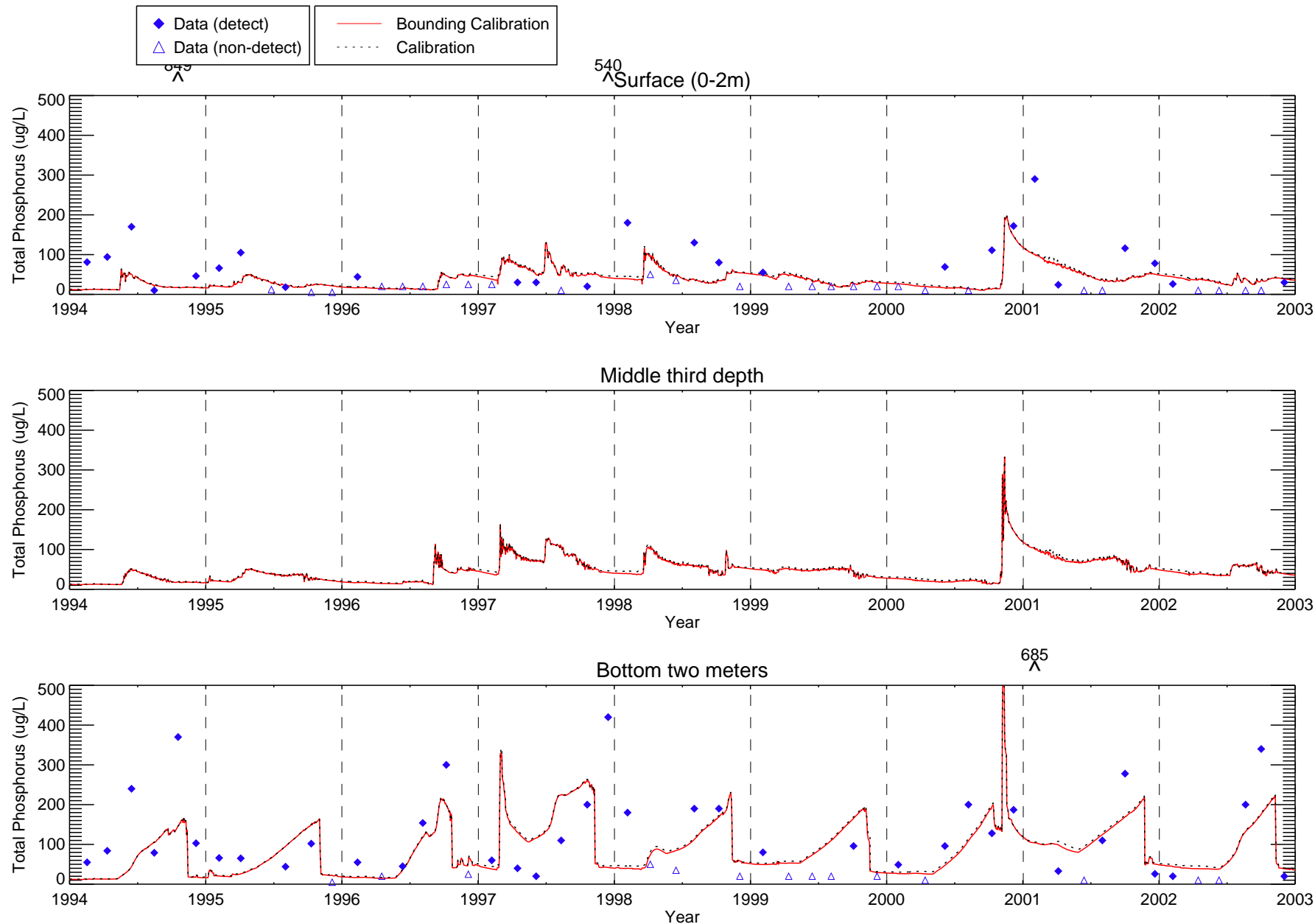
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority
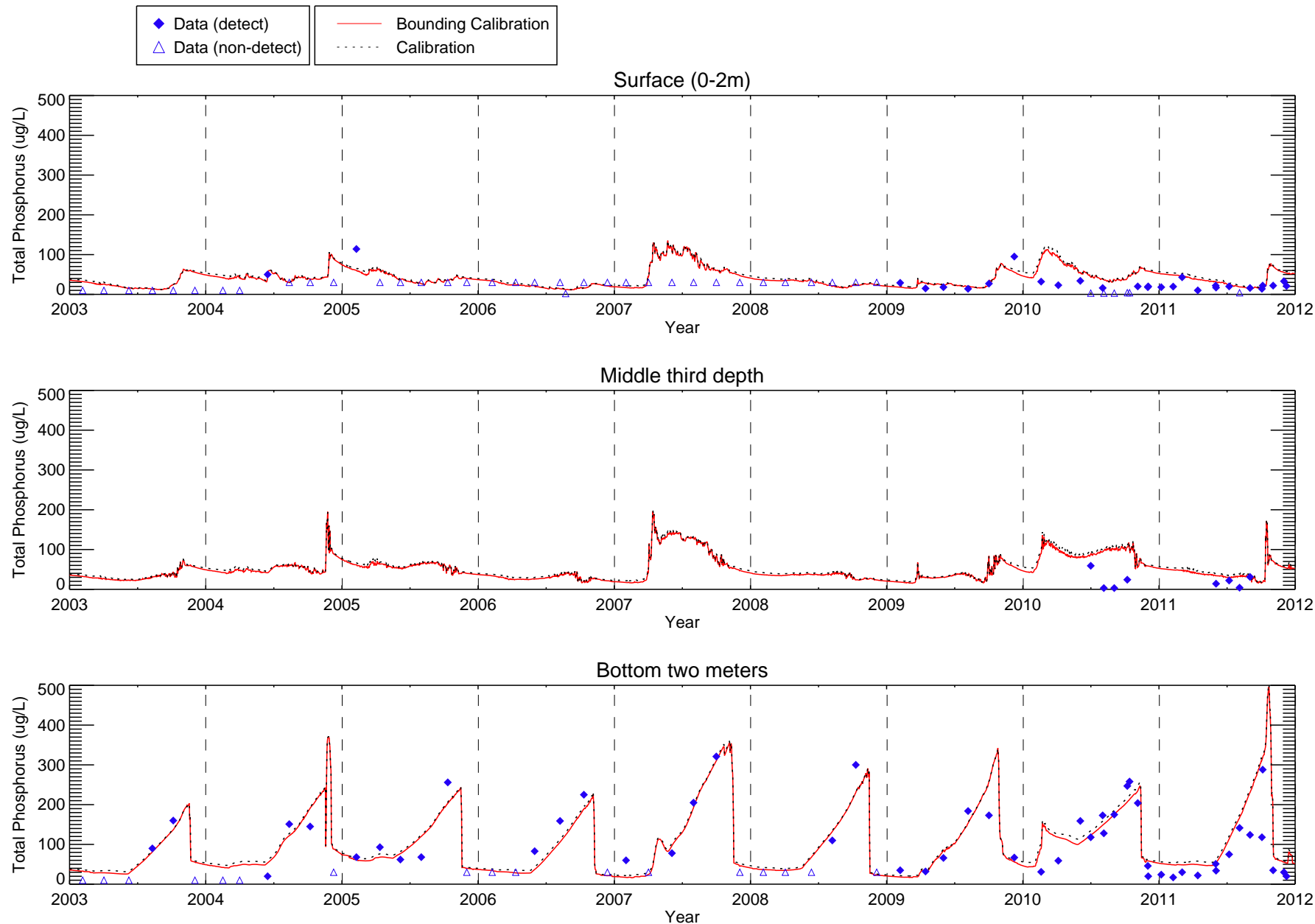
ANCHOR QEA
PARSONS

Left bar: Model Percent Biomass
Right bar: Data-based Percent Biomass

Figure 4-22
Predicted Seasonal Abundances of Major Algal Groups in Lake Buchanan
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-23a
Algal Group 1 Limiting Factors By Year in Lake Buchanan Near Buchanan Dam
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority
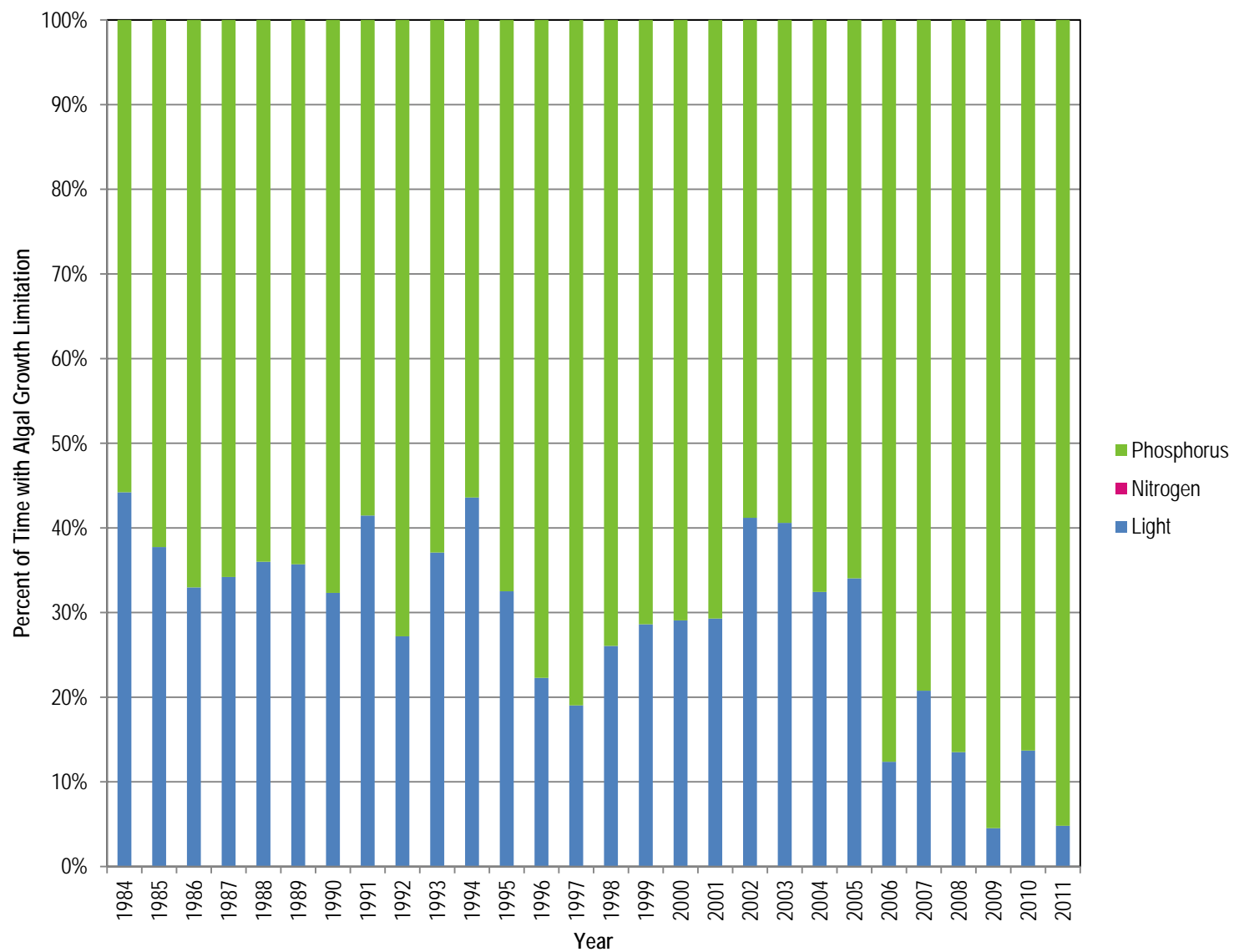
Figure 4-23b
Algal Group 2 Limiting Factors By Year in Lake Buchanan Near Buchanan Dam
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority
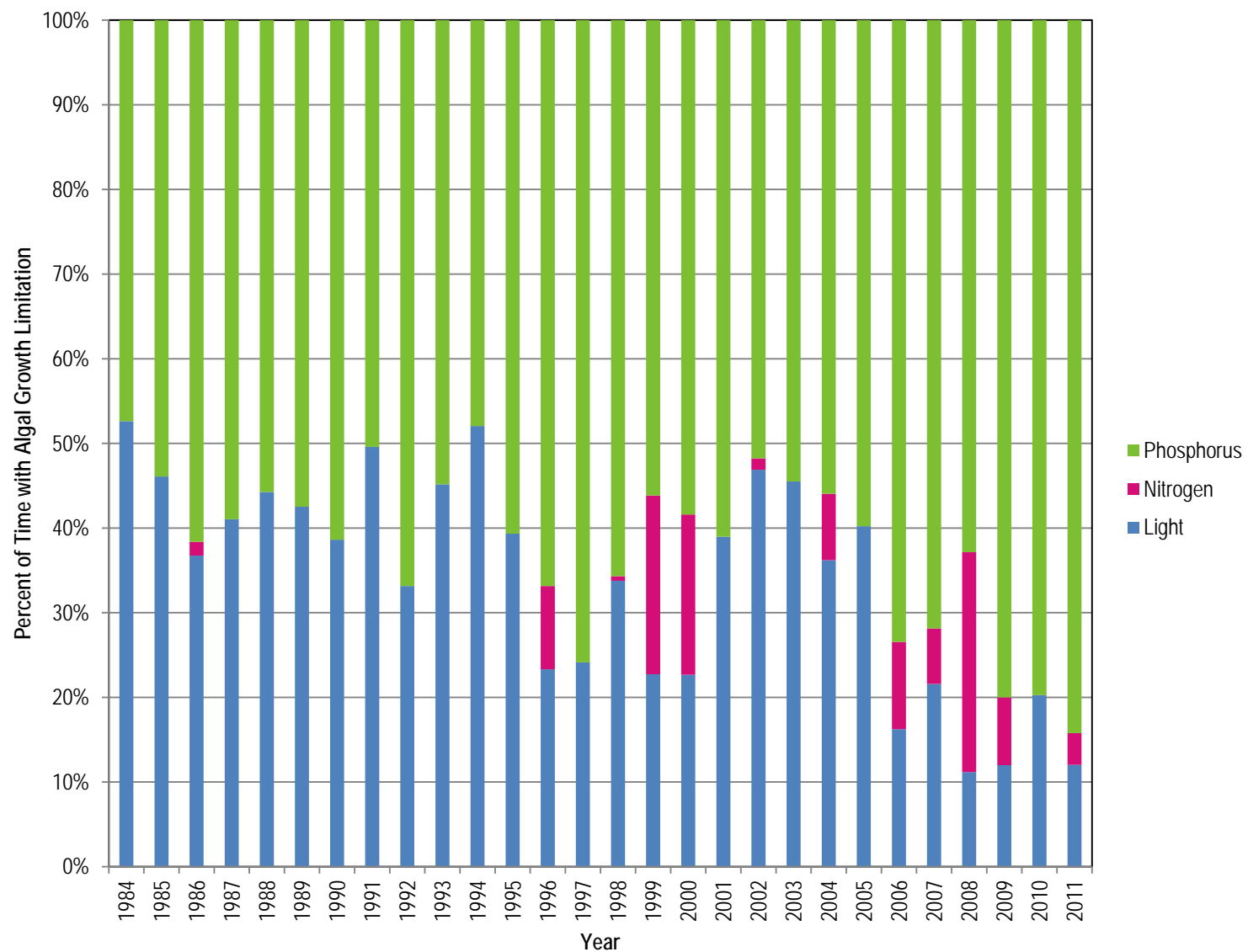
Figure 4-23c
Algal Group 3 Limiting Factors By Year in Lake Buchanan Near Buchanan Dam
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-24a
Algal Group 1 Limiting Factors By Month in Lake Buchanan Near Buchanan Dam
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-24c
Algal Group 3 Limiting Factors By Month in Lake Buchanan Near Buchanan Dam
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority
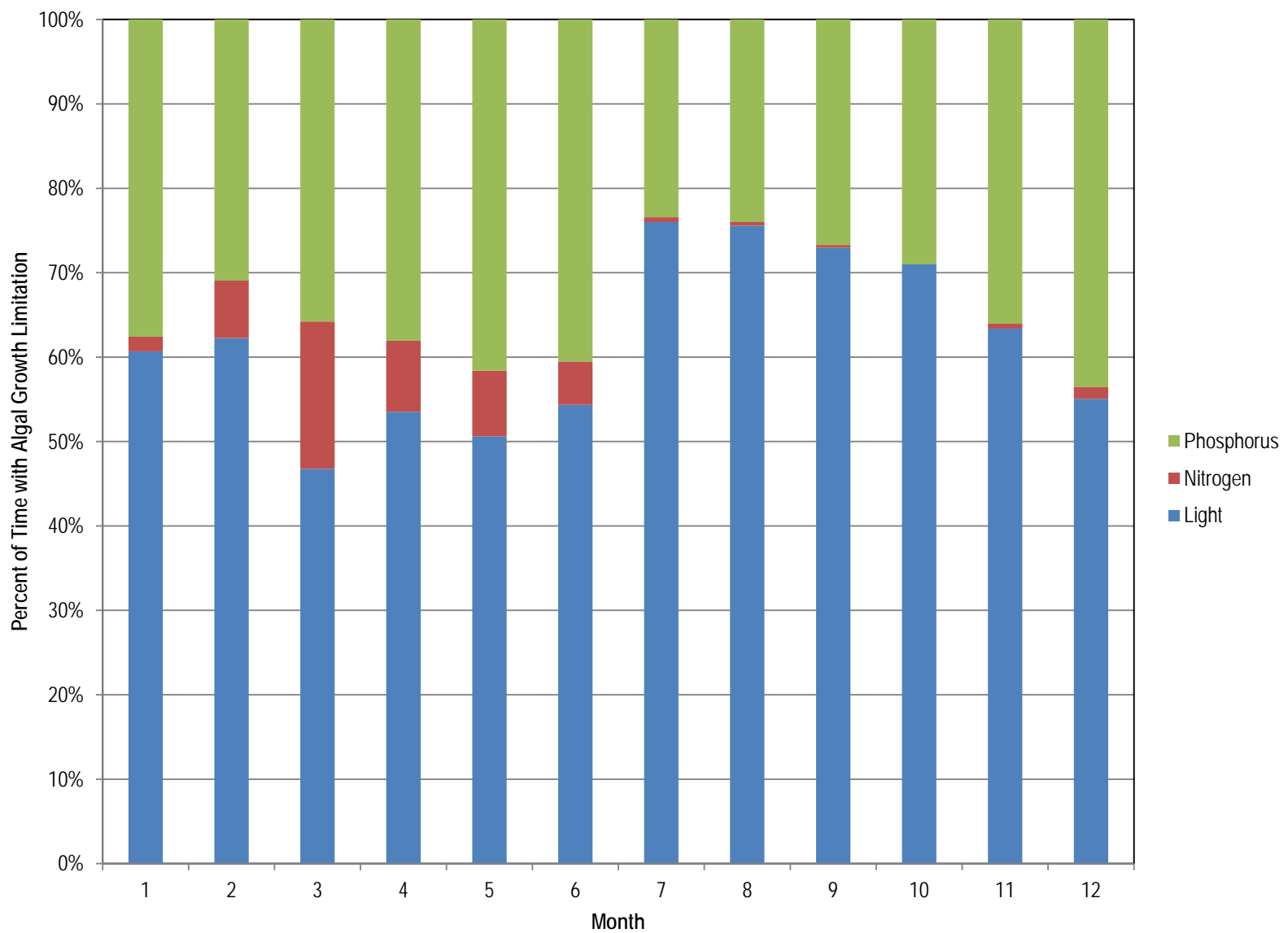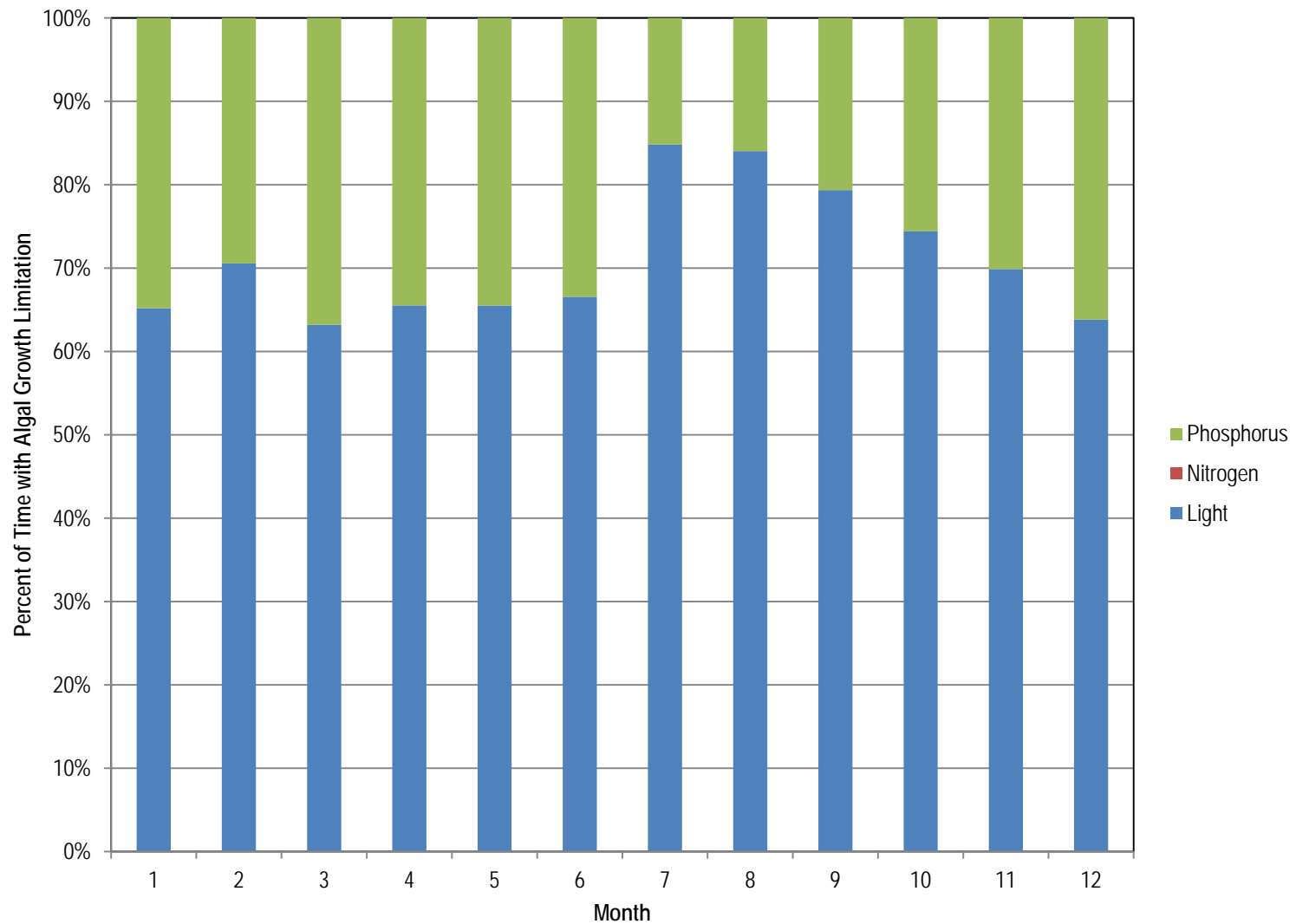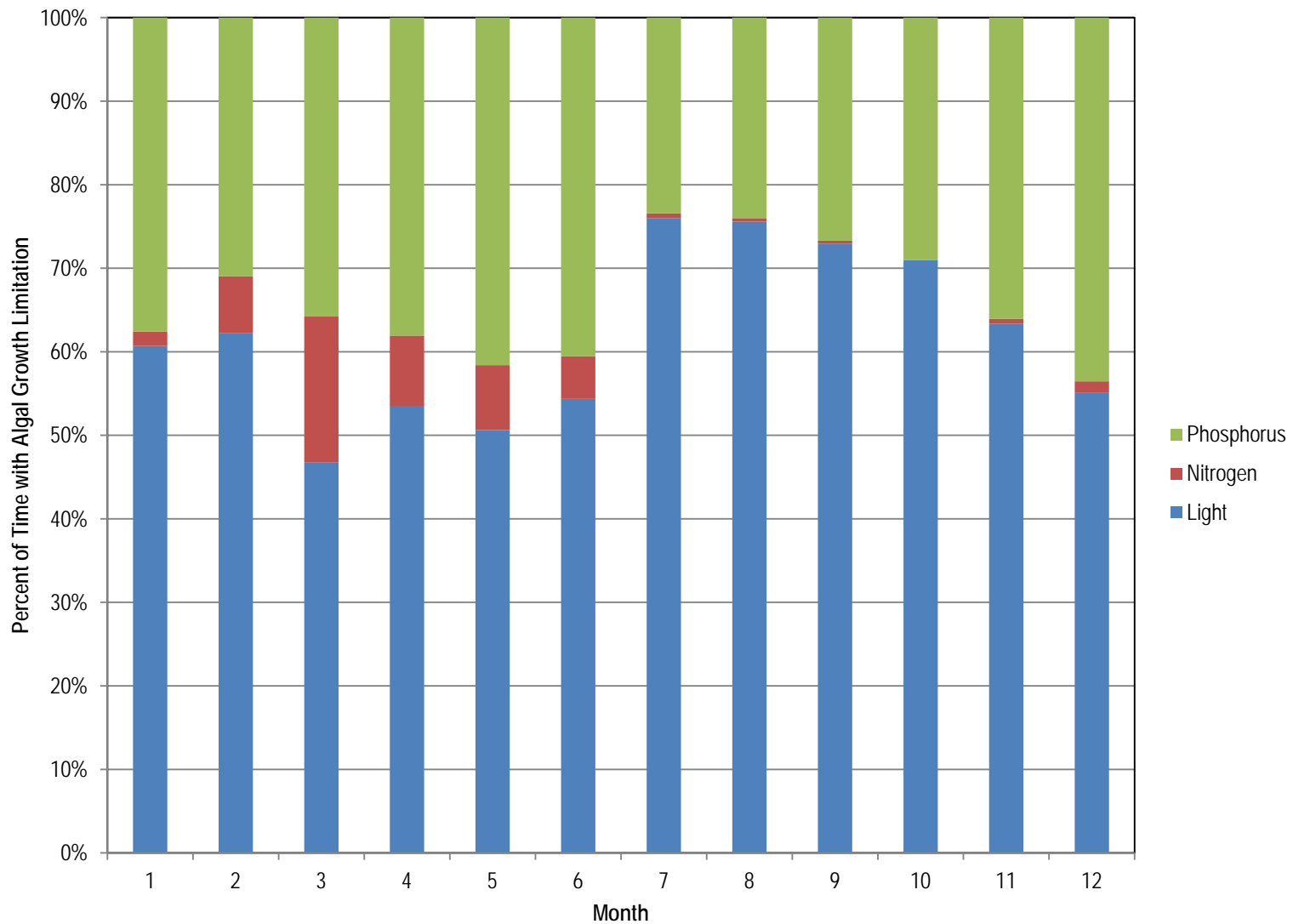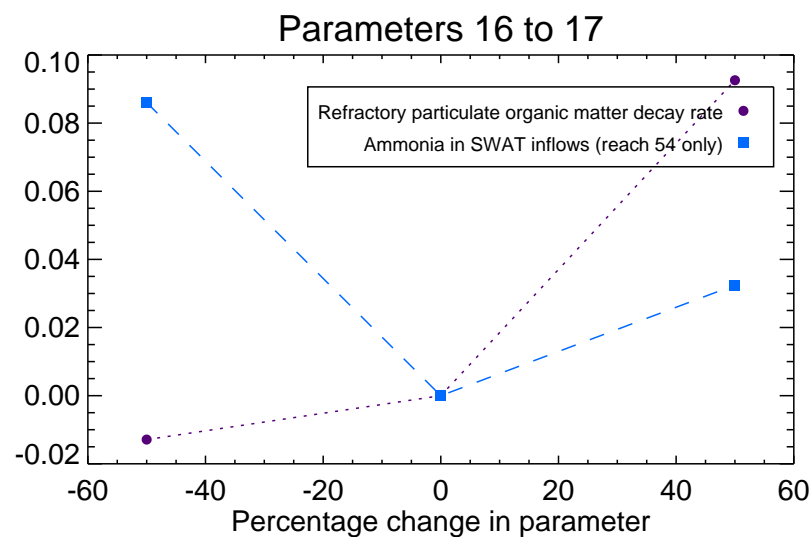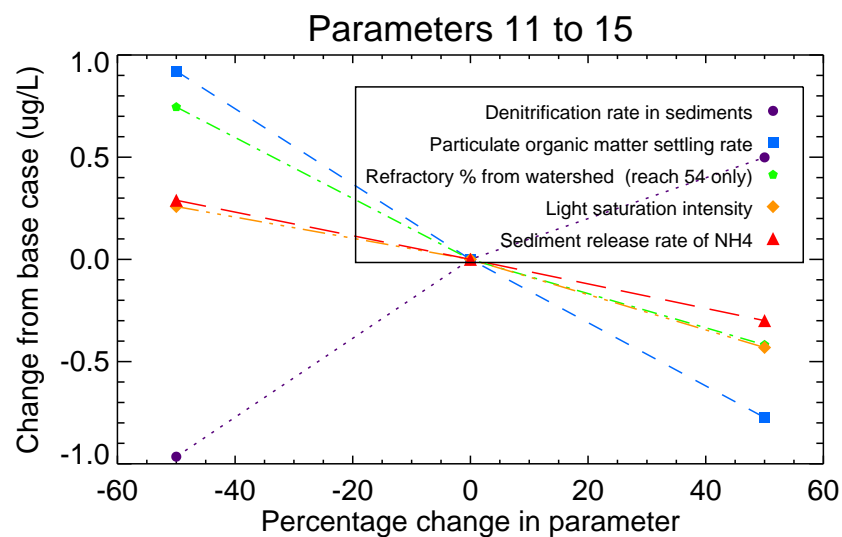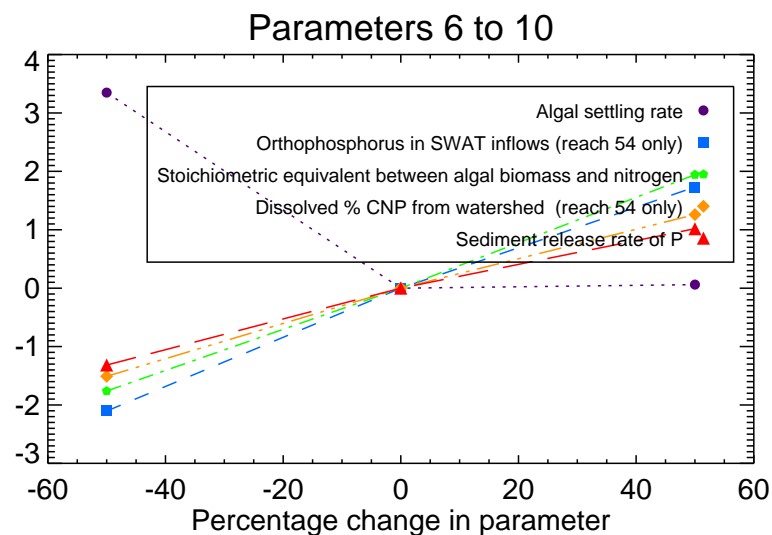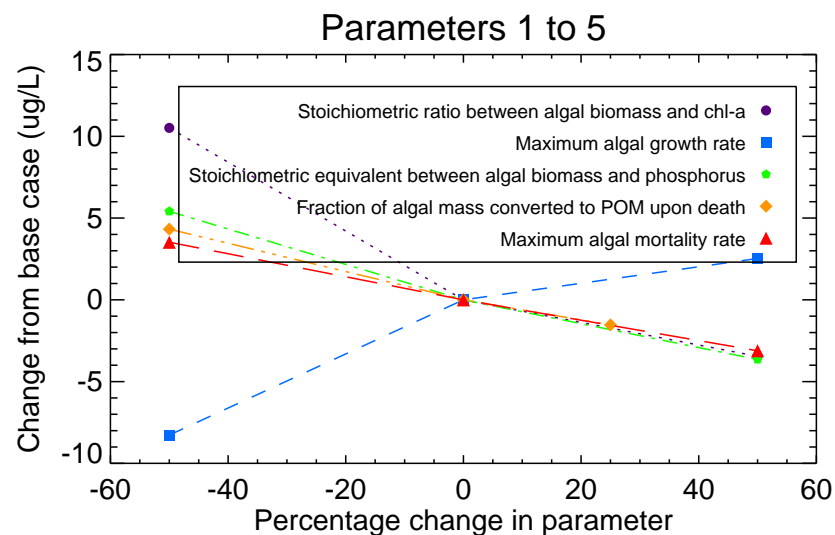
Figure 4-25
Sensitivity of chlorophyll-a Predictions near Buchanan Dam, Lake Buchanan to 17 Input Parameters of the CE-QUAL-W2 Model year-round in Surface Waters

Notes: Surface = 0.00 to 2.00 m; year-round = months 1 through 12. Parameters plotted by highest ranking index (maximum of absolute slope differences between two sensitivity cases and base case). Parameters changed one-at-a-time except for algal growth (mortality kept at 10% of growth) and dissolved % of carbon, nitrogen, and phosphorus (CNP; all varied at once). For high case, value changed to +40% due to model instability with +50%. ^Only tested for high case because base case value is same as low value.

CREMs Phase 4: Lake Buchanan
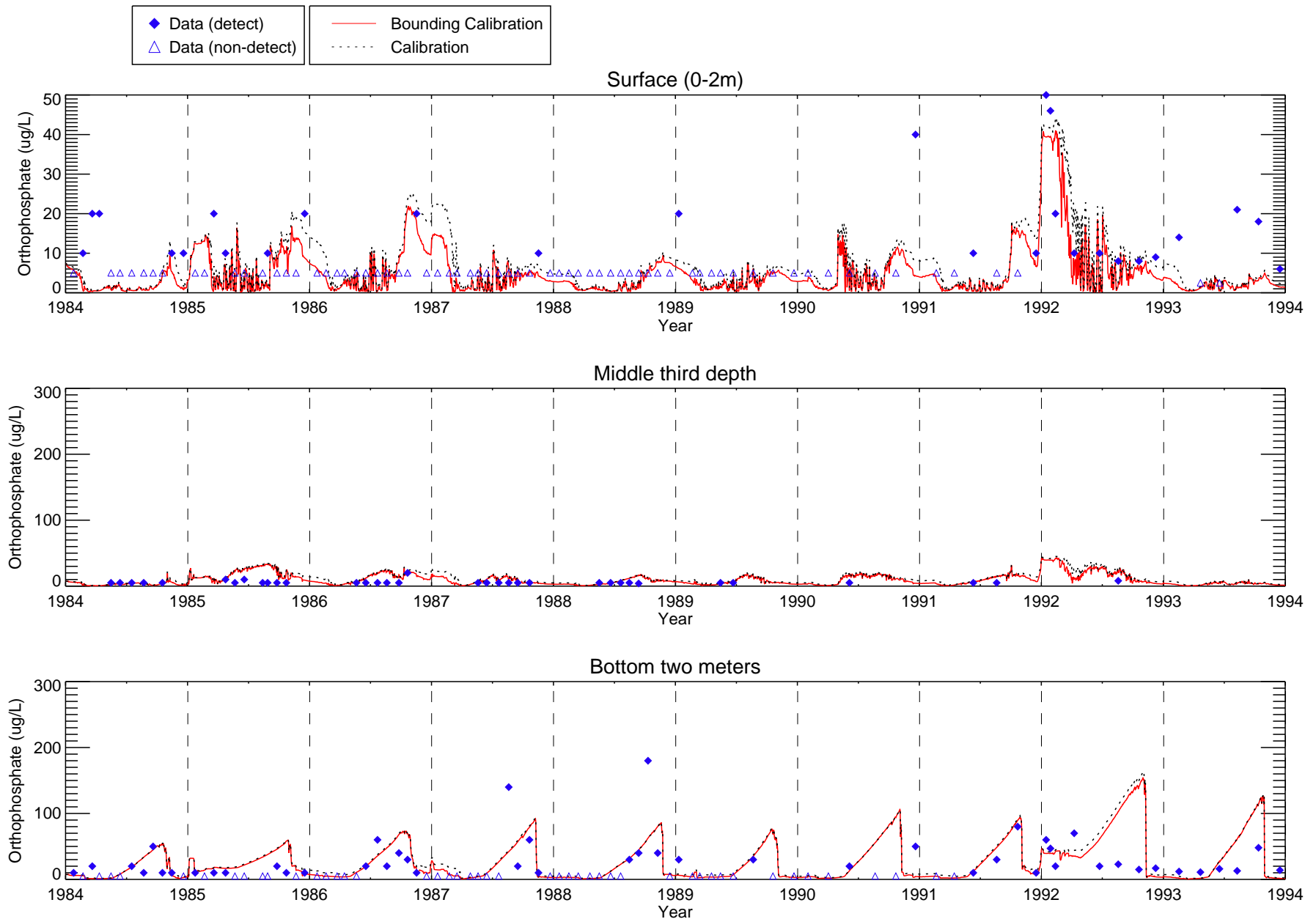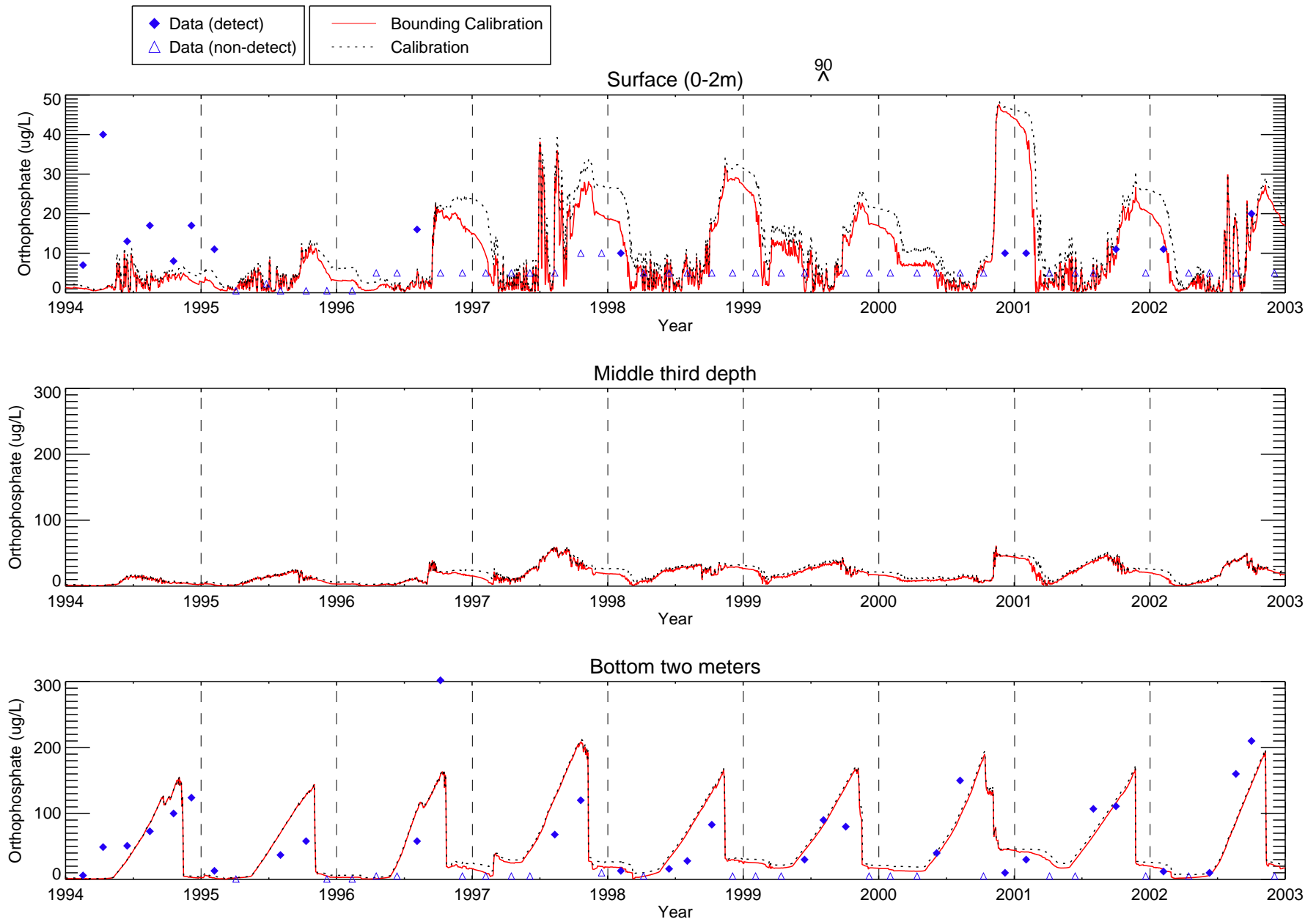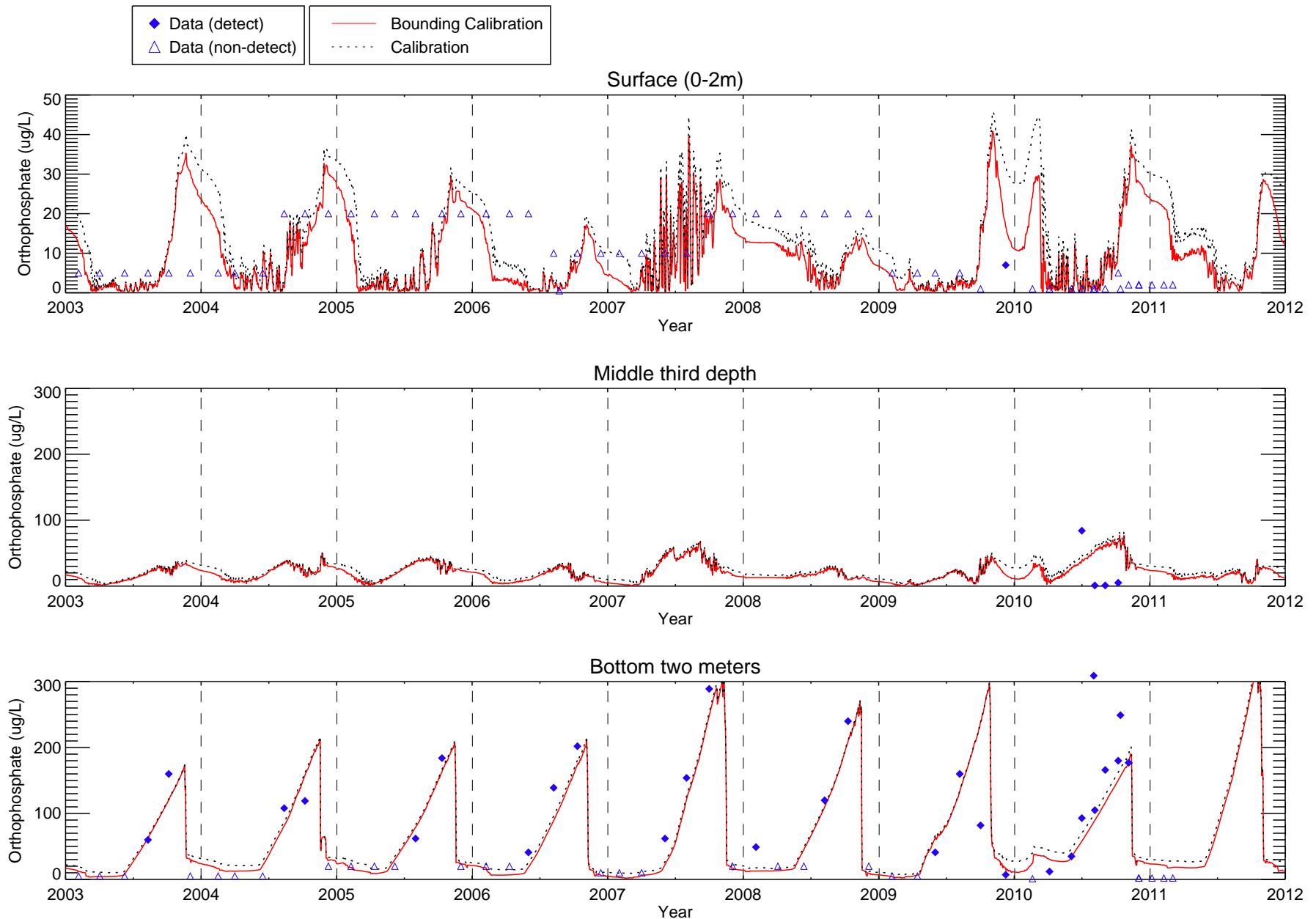Lower Colorado River Authority

Figure 4-27
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown.Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Fri Mar 08 10:20:14 2013

Figure 4-27
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Specific Conductance

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Fri Mar 08 10:24:39 2013

ANCHOR
QEA
PARSONS

Figure 4-28
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-28
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Chloride

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-28
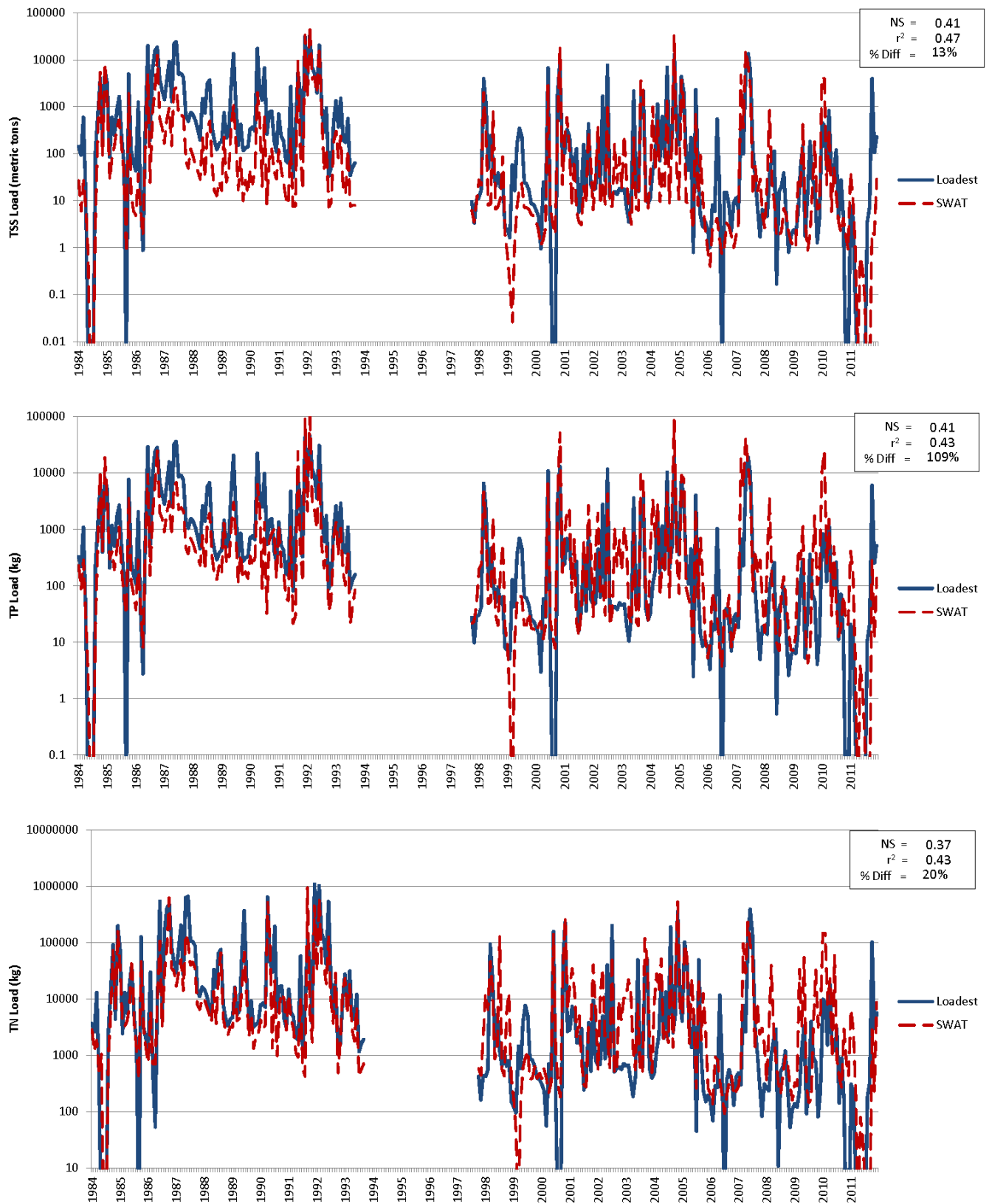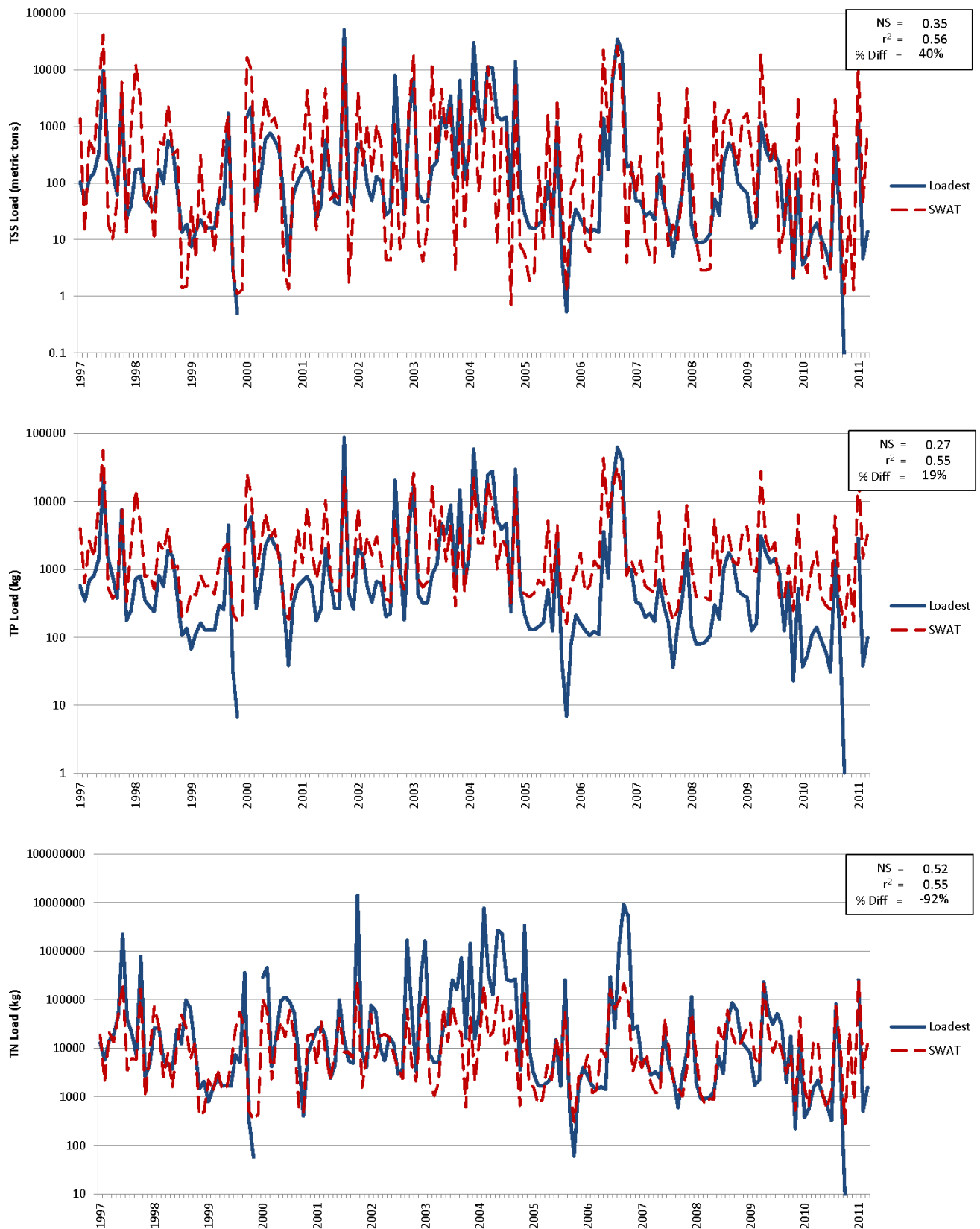**Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Chloride**

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown.
Data greater than y-range are indicated by caret above axis.
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Fri Mar 08 10:34:42 2013

Figure 4-29
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-29
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-29
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Dissolved Oxygen

Notes: Model depths used to divide water column into thirds; if data were collected below maximum model depth, they were included in the bottom section. Data are averaged over water column depths shown. Model output is averaged over water column depths shown.Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Fri Mar 08 10:48:04 2013

Figure 4-30
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Fri Mar 08 10:11:13 2013

Figure 4-30
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Fri Mar 08 10:11:20 2013

Figure 4-30
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Chlorophyll-a

Notes: Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Fri Mar 08 10:11:26 2013

Figure 4-31
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Fri Mar 08 11:31:40 2013

Figure 4-31
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-31
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Total Organic Carbon

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-32
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-32
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Fri Mar 08 10:54:46 2013

Figure 4-32
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Total Kjeldahl Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - F:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_temporal.pro
Fri Mar 08 10:58:07 2013

Figure 4-33
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-33

Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-33
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Ammonium Nitrogen

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-34
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Surface (0-2m)

Middle third depth

Bottom two meters

Figure 4-34
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-34
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Nitrate+Nitrite

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-35

Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Total Phosphorus

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-35
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Total Phosphorus

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-36
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Orthophosphate
Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA PARSONS

Figure 4-36
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure 4-36
Temporal of Model versus Data for Lake Buchanan Near Buchanan Dam (Segment 13) - Orthophosphate

Notes: Model depths used to divide water column into thirds for top two panels; if data were collected below maximum model depth, they were included in the bottom section. Each data point is a discrete measurement except when multiple measurements were taken on the same day at the same depth (average shown). Model output is averaged over water column depths shown. Non-detects plotted at half the detection limit. Data greater than y-range are indicated by caret above axis.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

APPENDIX A
TEMPORAL PLOTS OF MODEL VERSUS DATA - WATERSHED MODEL

Figure A-1
Temporal of Model versus Data for Station 12355-
Colorado River at US 190 near San Saba
CREMs Phase 4: Lake Buchanan - Lower Colorado River Authority

Figure A-2
Temporal of Model versus Data for Station 12358-
Colorado River at Highway 377 in Winchell
CREMs Phase 4: Lake Buchanan - Lower Colorado River Authority

Figure A-3
Temporal of Model versus Data for Station 12394-
Pecan Bayou at FM 573 southwest of Mullin
CREMs Phase 4: Lake Buchanan - Lower Colorado River Authority

Figure A-4
Temporal of Model versus Data for Station 12392-
San Saba River at SH 16 near San Saba
CREMs Phase 4: Lake Buchanan - Lower Colorado River Authority

APPENDIX B
CREMS PHASE 4: DATA ANALYSIS MEMO

901 S. Mopac Expressway
Barton Oaks Plaza IV, Suite 280
Austin, Texas 78746
Phone 512.306.9221
Fax 512.306.9202
www.anchorqea.com

MEMORANDUM

To:	Lisa Hatzenbuehler, LCRA	**Date:**	November 1, 2012
	Bryan Cook, LCRA		
	Dean Thomas, LCRA		
	Jerry Guajardo, LCRA		
	Dave Bass, LCRA		
From:	Dan Opdyke, Anchor QEA, LLC	**Project:**	110577.01.01
	Brad Hamer, AmaTerra Environmental, Inc		
Cc:	Elaine Darby, Anchor QEA, LLC		
	Emily Chen, Anchor QEA, LLC		
	Kirk Dean, Parsons		
Re:	Qualitative evaluation of Lake Buchanan water quality to assist CREMs modeling		

Introduction

Ambient water quality data from Lake Buchanan were evaluated to provide insight into major trends and patterns. This evaluation was performed to supplement the development of a CE-QUAL-W2 model of Lake Buchanan as part of the Colorado River Environmental Models (CREMs) project.

Methods

Water quality data were compiled from the Lower Colorado River Authority Reservoir and Stream Sampling (RSS) Program ambient water quality monitoring and the CREMs project databases. Data from 1982 through 2011 are presented in a series of box and whisker plots in Figures 1a through 17e. In these plots, the blue rectangle represents the inter-quartile range (IQR; i.e., first to third quartiles). The horizontal black line within the blue rectangle denotes the median. The lower whisker represents the smallest data point that is greater than the first quartile minus 1.5 times the IQR. The upper whisker represents the highest data point that is less than the third quartile plus 1.5 times the IQR. Individual values outside the whiskers are plotted as black circles.

Concentration data are presented relative to:

- Longitudinal distance along the reservoir
- Cove versus thalweg sites
- Depth
- Time of day
- Month
- Year

Results

Table 1 summarizes the qualitative identification of trends and patterns found in the data evaluation as well as comments regarding possible mechanisms contributing to the trend or pattern observed.

Table 1
Qualitative Trends and Patterns Observed in Lake Buchanan Data

Parameter		Trends							Comments
		Distance (upstream to downstream)	Cove vs. Thalweg	Depth (shallow to deep)	Time of Day (morning to evening)	Month	Year (older to newer)	Miscellaneous	
Chlorophyll-a		↘ (in reservoirs, Chl-a often higher near headwaters)	N/A	↘ (light limits Chl-a at depth)	↗	Late summer and early fall are highest	↗ (possible eutrophication)		Typical pattern for reservoir undergoing eutrophication.
Dissolved Oxygen	All Depths	↘ (probably due to increased hypolimnion)	N/A	↘ (reduced re-aeration at depth)	↗ (weak but possible diel pattern of primary productivity)	Lowest in summer (temperature and hypolimnion impacts)	↔		Individual year chart suggests recent dry years have higher dissolved oxygen than recent wet years.
	Surface (<5m)	↔	↔	N/A	↔	Lowest in summer (temperature impacts)	↔ (perhaps very slight ↗?)		Most low concentration values are at headwaters site, 2-5m depth.
	Benthic (>20m)	NED	N/A	N/A	NED	Lowest in summer (hypolimnion impacts)	↔		
Ammonia		↔	N/A	↗ (reduced nitrification, reduced algal uptake, and sediment release of NH_4 under anoxic conditions)	↔	↔ for median, highest outliers in late summer (at depth)	↔ for median, higher outliers in later years (at depth)		Data suggest hypolimnetic enrichment.
NO_2+NO_3		↗ (slight)	↔	↗	↔	Lowest in summer (hypolimnion impacts)	↔ (although lowest in recent 5 years)		
TKN		↘ (likely settling of particulate fraction, algal uptake of ammonia)	N/A	↗ (slight increase, sediment release of NH_4 under anoxic conditions)	↔	Slightly higher in summer (sediment release of NH_4)	↔		
DKN:TKN		N/A	N/A	↗ (probably increasing NH_4 at depth)	N/A	N/A	N/A	↘ as TSS ↗	DKN approximately 75% of TKN
TP		↘ (likely settling of particulate fraction)	N/A	↗ (slight, probably sediment release of PO_4 under anoxic conditions)	↗	↔	↗ (slight, possible eutrophication)		
PO_4		↔		↗ (sediment release under anoxic conditions)	↔	↔	↔ (but ↗ in hypolimnion)		If real trends existed, they would probably be obscured by prevalence of samples below detection limit
DP:TP (Note multiple samples >1)		↗ (slight, probably particulates settling out)	↔	↘	N/A	N/A	N/A	No meaningful trend with TSS	Highly variable, but DP often less than 50% of TP. Note that TP fraction can include algae.
$DissPO_4$:DP		N/A	↔	N/A	N/A	N/A	N/A		
$DissPO_4$:TP		N/A	Thalweg lower	N/A	N/A	N/A	N/A	No meaningful trend with TDS	
pH		↔	N/A	↘ (increased CO_2 at depth?)	↔	↔	↔		

Parameter	Trends							Comments
	Distance (upstream to downstream)	Cove vs. Thalweg	Depth (shallow to deep)	Time of Day (morning to evening)	Month	Year (older to newer)	Miscellaneous	
Secchi Depth	↗ (particulates settling out, less algae downstream)	N/A	N/A	↘	↔	↘ (slight)		
TOC	↔	N/A	↔	↔	↔	↗ (slight)		
DOC:TOC (some > 1)	N/A	Thalweg slightly lower	N/A	N/A	N/A	N/A		DOC > TOC generally > 0.95
TSS	↘	N (higher outliers in thalweg)	↔	↗	↔	↔		
Turbidity	↘	N/A	↘	↗	Lower in summer, higher in winter	↗ (slight)		

Notes:
↔ = no discernible trend
↗ = discernible increasing trend
↘ = discernible decreasing trend
CO_2 = carbon dioxide
DKN = dissolved Kjeldahl nitrogen
DOC = dissolved organic carbon
DP = dissolved phosphorus
N = no visible trend
N/A = not analyzed
NED = not enough data (to make an informed judgment)
NH_4 = ammonium, as nitrogen
NO_2+NO_3 = nitrite plus nitrate, as nitrogen
PO_4 = orthophosphate, as phosphorus
TDS = total dissolved solids
TKN = total Kjeldahl nitrogen
TOC = total organic carbon
TP = total phosphorus
TSS = total suspended solid

Discussion

Common signatures of increased eutrophication are apparent in Lake Buchanan data. Chlorophyll-a (Chl-a) and total phosphorus concentrations appear to increase with time (Figures 1e and 7e). The increasing trend in Chl-a is most visible in the minimum and median values and is not as strong for the highest values. For example, from 1982 to 1986, the minimum Chl-a concentration was 0.2 micrograms per liter (μg/L), whereas from 2007 to 2011, the minimum was 3.9 μg/L. The median value increased from 5 to 12 μg/L between these time periods. Late summer hypolimnetic concentrations of orthophosphate and ammonia (which fuel algal growth as they transport across the thermocline) also exhibit a long-term increasing trend (See *Colorado River Environmental Models Phase 4: Lake Buchanan*, Figure 4-10). Secchi depth measurements exhibit a slight long-term decreasing trend, while turbidity exhibits a slight increasing trend (Figures 13d and 17e), both of which are likely a reflection of the increase in Chl-a concentrations.

Concentrations of Chl-a are often higher near the headwaters of Lake Buchanan (Station 12353) than near the dam (Station 12344; Figure 1a). This feature is common for reservoirs because headwaters are frequently the primary source of nutrients. Moreover, in the summertime, with prevailing southerly winds, surface water containing algae will tend to be pushed north towards the headwaters of Lake Buchanan. Also, Chl-concentrations tend to increase with time of day, which may be a reflection of growth over the course of the day (Figure 1c).

Most particulates show substantial settling out between the headwaters site (Station 12353) and the next downstream site (Station 12352; Figures 5a, 7a, and 16a).

Total suspended solids (TSS) and turbidity patterns are consistent with each other; however, the trends appear stronger with turbidity. Accordingly, some were labeled as "↔" for TSS and "↗" or "↘" for turbidity (Figures 16a-f and 17a-f).

Time of day trends are difficult to identify because monitoring programs are not evenly distributed over the diel cycle and most data are collected in a narrow window (all Figures ending with 'b').

FIGURES

Source: AmaTerra Environmental, Inc

Figure 1b
Chlorophyll-a - Depth (shallow to deep)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Chlorophyll-a (ug/l)

Time of day

| 0.00 to 0.35 | 0.36 to 0.40 | 0.40 to 0.49 | 0.50 to 0.99 |
| n = 16 | n = 183 | n = 733 | n = 233 |

Source: AmaTerra Environmental, Inc

Figure 1c
Chlorophyll-a - Time of Day (morning to evening)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

ANCHOR
QEA

Figure 1d
Chlorophyll-a - Month
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 1e
Chlorophyll-a - Year (older to newer)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

ANCHOR
QEA

Source: AmaTerra Environmental, Inc

Source: AmaTerra Environmental, Inc

Figure 2b
Dissolved Oxygen (all depths) - Depth (shallow to deep)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 2c
Dissolved Oxygen (all depths) - Time of Day (morning to evening)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 2d
Dissolved Oxygen (all depths) - Month
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Surface Dissolved Oxygen (mg/l) versus Kilometers upstream from Buchanan Dam

= Thalweg locations
= Cove locations

Source: AmaTerra Environmental, Inc

Figure 2f
Dissolved Oxygen (surface) - Distance (upstream to downstream)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 2g
Dissolved Oxygen-Surface - Cove vs. Thalweg
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 2h
Dissolved Oxygen-Surface - Time of Day (morning to evening)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 2i
Dissolved Oxygen (Surface) - Month
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 2j
Dissolved Oxygen (Surface) - Year (older to newer)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 2k
Dissolved Oxygen (Benthic) - Distance (upstream to downstream)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 2I
Dissolved Oxygen (Benthic) - Time of Day (morning to evening)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 2m
Dissolved Oxygen (Benthic) - Month
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 2n
Dissolved Oxygen (Benthic) - Year (older to newer)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 3a
Ammonia - Distance (upstream to downstream)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 3b
Ammonia - Depth (shallow to deep)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Ammonia Nitrogen (mg/l)

10
1
0.1
0.01
0.001

| 0.00 to 0.35 | 0.36 to 0.40 | 0.40 to 0.49 | 0.50 to 0.99 |
| n = 41 | n = 352 | n = 1366 | n = 359 |

Time of day

Source: AmaTerra Environmental, Inc

Figure 3c
Ammonia - Time of Day (morning to evening)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 3d
Ammonia - Month
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 3e
Ammonia - Year (older to newer)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 4a
NO₂+NO₃ - Distance (upstream to downstream)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 4b
NO$_2$+NO$_3$ - Cove vs. Thalweg
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 4c
NO$_2$+NO$_3$ - Depth (shallow to deep)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 4d

NO$_2$+NO$_3$ - Time of Day (morning to evening)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 4e
NO$_2$+NO$_3$ - Month
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 4f
NO$_2$+NO$_3$ - Year (older to newer)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 5a
TKN - Distance (upstream to downstream)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Source: AmaTerra Environmental, Inc

Figure 5d
TKN - Month
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 6a
DKN:TKN - Depth (shallow to deep)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 7a
TP - Distance (upstream to downstream)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 7b
TP - Depth (shallow to deep)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 7d
TP - Month
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Source: AmaTerra Environmental, Inc

Source: AmaTerra Environmental, Inc

Figure 8c
PO_4 - Time of Day (morning to evening)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 8d
PO$_4$ - Month
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Source: AmaTerra Environmental, Inc

Figure 8e
PO$_4$ - Year (older to newer)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 9a
DP:TP - Distance (upstream to downstream)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 9b
DP:TP - Cove vs. Thalweg
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 9c
DP:TP - Depth (shallow to deep)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 9d

Source: AmaTerra Environmental, Inc

Figure 10
DissPO4:DP - Cove vs. Thalweg
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Dissolved o-Phosphate:Total P ratio

Total Dissolved Solids (mg/l)

| 126-300 | 301-400 | 401-600 | 601-2360 |
| n = 178 | n = 318 | n = 422 | n = 268 |

Figure 12b
pH - Depth (shallow to deep)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 12c
pH - Time of Day (morning to evening)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 12d
pH - Month
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 12e
pH - Year (older to newer)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 13b
Secchi - Time of Day (morning to evening)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 13d
Secchi - Year (older to newer)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 14a
TOC - Distance (upstream to downstream)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Source: AmaTerra Environmental, Inc

Figure 14c
TOC - Time of Day (morning to evening)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 14d
TOC - Month
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Total Organic Carbon (mg/l) versus Year

| | 1982-1986 n = 612 | 1987-1991 n = 406 | 1992-1996 n = 193 | 1997-2001 n = 205 | 2002-2006 n = 210 | 2007-2011 n = 502 |

ANCHOR QEA

Source: AmaTerra Environmental, Inc

Total Suspended Solids (mg/l)

Cove
n = 512

Thalweg
n = 1527

Site type

Figure 16b
TSS - Cove vs. Thalweg
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

ANCHOR
QEA

Figure 16c
TSS - Depth (shallow to deep)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Total Suspended Solids (mg/l) vs. Time of day

0.00 to 0.35	0.36 to 0.40	0.40 to 0.49	0.50 to 0.99
n = 40	n = 336	n = 1306	n = 354

Figure 16d
TSS - Time of Day (morning to evening)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 16e
TSS - Month
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Source: AmaTerra Environmental, Inc

Source: AmaTerra Environmental, Inc

Figure 17b
Turbidity - Depth (shallow to deep)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Source: AmaTerra Environmental, Inc

Figure 17d
Turbidity - Month
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

Figure 17e
Turbidity - Year (older to newer)
CREMs Phase 4: Data Analysis Memo
Lower Colorado River Authority

APPENDIX C
WATER QUALITY CALIBRATION METRICS FOR THE LAKE TRAVIS CE-QUAL-W2 MODEL

Water Quality Calibration Metrics for the Lake Travis CE-QUAL-W2 Model

ANCHOR QEA

PARSONS

MEMORANDUM

TO: CREMS Lake Travis Team | **DATE:** 4/13/2007

FROM: Kirk Dean, Parsons | **RE:** Water quality calibration metrics for the Lake Travis CE-QUAL-W2 model

CC: | **JOB#:** PARcrm

This memorandum discusses several issues pertinent to the calibration of the Lake Travis water quality model. Recommendations are made regarding the most suitable approaches for the Lake Travis model for CREMS.

Manual Calibration or Numerical Optimization?

One key decision is whether to utilize 1) a formal numerical optimization procedure or 2) statistical and graphical comparisons between model predictions and observations in a manual trial and error approach, with the modeler providing interpretation and judgment as to the optimum calibration. The latter is the more common approach. However, as the number of interacting parameters simulated increases, the model calibration becomes more complex because varying one parameter affects many others. Because a eutrophication model includes multiple biological responses to multiple chemical and physical driving parameters, it can be difficult and time-consuming for a modeler to find the optimum values of model calibration parameters. Thus, a numerical optimization procedure may be recommended. However, numerical optimization procedures should not be considered 'black boxes' that feed out the ultimate answer, but should be used as a tool with statistical and graphical analysis by an experienced modeler.

Formal numerical optimization procedures can be of several types. For a small number of parameters, an optimum numerical solution may be obtained by minimizing an objective function using calculus-based solver algorithms. UCODE uses nonlinear regression, with a modified Gauss-Newton method to adjust parameter values to minimize the weighted least-squares objective function. PEST is a similar program using the Marquardt-Levenburg method of nonlinear parameter estimation. Either of these tools will work with most models. These programs may, however, have problems with numerical instability when fitting functions do not vary smoothly.

Another option would be to run a Monte Carlo analysis. In Monte Carlo analysis, key parameters are varied within a range of potential values; the model is run with each

combination of parameter values, and model goodness of fit is judged with one or more statistics until a best fit is identified.

More recently, genetic algorithms (GAs) have been used commonly in model calibration. They are based on the biological principles of natural selection, with optimal combinations of parameters selected from a "population" of potential values through many "generations" of variations. In each generation, combinations of parameters that improve the model fit tend to be more favored for selection in the next generation. GA's tend to be more stable and robust than calculus-based numerical algorithms, and tend to converge to a solution more efficiently than Monte Carlo analysis. Mulligan and Brown (1998) report use of a genetic algorithm to calibrate Streeter-Phelps and QUAL2E stream models. Pelletier et al. (2006) applied a publicly-available GA (PIKAIA) to calibrate a QUAL2Kw eutrophication model. Ostfeld and Salomons (2005) report application of a hybrid genetic algorithm to calibrate a CE-QUAL-W2 model. In this report, the efficiency of the genetic algorithm was enhanced using hurdle-race and k-nearest neighbor algorithms to eliminate most of the excess computational effort.

Although the numerical optimization methods offer certain advantages, many modelers feel more comfortable with a manual trial-and error approach based on statistical and graphical analysis. Given the time required to develop a numerical optimization program, the manual approach is recommended for the Lake Travis model.

Calibration then Verification or Combined Calibration/Verification?

Typically, it is recommended that models should be calibrated to one dataset, then verified using an independent dataset. Often, this is performed by splitting the available dataset in half, using the first half for calibration and the second half for verification. If the model fits the verification dataset well (without adjusting the calibrated model parameters), it lends confidence in model predictions of future conditions. Cole and Wells (2002) point out, however, that the separation between calibration and verification is a false one, because if the verification run does not fit well, then the model calibration coefficients will inevitably be adjusted until the model fits both calibration and verification periods. Thus, they recommend that the model should be calibrated to all available data continuously, i.e. not broken into separate runs by years or seasons. However, the model should exhibit good fit to all periods, including individual years, droughts, and flood periods. Ideally, the calibration data set should encompass the full range of variations and extreme conditions that might be anticipated in the future.

Measures of Model Goodness of Fit

While some modelers do not use statistical measures of goodness of fit (GOF), choosing to rely instead on graphical illustration of GOF, it is generally recommended (Reckhow et al. 1990) that one or more quantitative measures of GOF be used in calibration and verification/confirmation of models. Numerous statistical measures of model goodness of fit (GOF) are available, and some are listed below and summarized in Table 1. The similarly of most of these measures is readily noticeable when they are expressed using common notation. The table lists the number of times each GOF statistic was used in a brief review of modeling reports.

Several authors recommend that several GOF measures be used, to quantify 1) model bias, 2) absolute error, and 3) relative error. This may lead to situations where different calibrations show improved performance with respect to some GOF statistics, but poorer performance for others. For this reason, it is recommended that acceptable ranges of GOF statistics are decided in advance, as well as a hierarchy of importance of GOF statistics. To facilitate calibration, an automated or semi-automated method should be implemented to calculate and summarize the various GOF statistics, compare them to acceptable ranges, and calculate an overall calibration score.

Cole and Wells (2002) recommend using the absolute mean error (AME) as an indicator of CE-QUAL-W2 model accuracy, since it is simply calculated and directly interpretable, i.e., it is in the same units as the measurement. A similar statistic is the root mean square error (RMSE), with the difference that it provides an extra penalty for the outlying predictions that are very different from observations. The RMSE is commonly used in the objective minimization functions of parameter optimization algorithms. Neither the AME nor RMSE provide information on model bias, as deviations in either direction from observed values are penalized equally. For quantification of the bias of model predictions, the mean error (ME) or mean percent error (M%E) are recommended.

The reliability index (RI) of Leggett and Williams (1981) has been used by many CE-QUAL-W2 modelers to evaluate model performance. Wlosinski (1984) considered the RI to be the best statistic for reporting aggregate model performance for CE-QUAL-R1, the predecessor to CE-QUAL-W2. The RI indicates the average factor by which model predictions differ from observations. A RI of 1.0 indicates a perfect fit. If all predicted values are one-half order of magnitude apart, a RI of 5 will result. RI values of less than 3 are generally considered to be acceptable for most parameters. RI values of greater than 10 usually indicate extremely low values near detection limits, as often found with some nutrient species, or highly variable parameters, such as algae biomass. One of the weaknesses of the RI is that the values are difficult to interpret since they are unitless and their range is expected to vary by parameter. The RI should be used with other measures of absolute and relative error.

The modeling efficiency (MEF) measures how much better a model predicts observed values than the average of the observed values. A value of 1 indicates a perfect match, whereas a value of 0 indicates that the model performs no better at predicting observed values than the average of the observed values.

Theil's inequality coefficient is similar to a correlation coefficient, but is a measure of distance instead of similarity. One advantage of Theil's inequality coefficient is that it can be decomposed into bias, variance, and fit quality components (Smith and Rose, 1995). However, the interpretation of these quantities may not be as straightforward as the more direct measures.

While the modeler has substantial leeway in selecting GOF statistics, we recommend using mean error (ME) to evaluate bias, root mean square error (RMSE) to evaluate absolute error, and Leggett and Williams' (1981) reliability index (RI). These are straightforward to calculate and interpret. Since they have been used in other modeling studies, it will facilitate comparison of model performance with other studies.

Table 1. Summary of model goodness of fit statistics and their characteristics

Statistic	Statistic name	Use[‡]	Measure of?	Penalizes outliers?	Units?	Range[†,*]
ME	mean error	9	absolute bias	N	Same as observation	$-\infty - +\infty$ 0*
M%E	mean percent error	2	relative bias	N	Unitless % of observation	$-\infty - +\infty$ 0*
MSE	mean square error	2	absolute error	Y	Square of observation	$0* - \infty$
MAE	mean absolute error	10	absolute error	N	Same as observation	$0* - \infty$
MA%E	mean absolute percent error	2	relative error	N	Unitless % of observation	$0* - \infty$
RMSE	root mean square error	11	absolute error	Y	Same as observation	$0* - \infty$
RMAE	relative mean absolute error	1	relative error	N	Unitless % of observation	$0* - \infty$
GSD	general standard deviation	1	relative error	Y	Unitless % of observation	$0* - \infty$
U	Theil's inequality coefficient	1	fit quality index	Y	unitless	$0* - 1$
E	Nash-Sutcliffe coefficient of efficiency	1	fit quality index	Y	unitless	$-\infty - 1*$
E′	modified coefficient of efficiency	1	fit quality index	N	unitless	$-\infty - +\infty$ 1*
J	Janus quotient	1	fit quality index	Y	unitless	$0* - \infty$
R^2	coefficient of determination	8	fit quality index	Y	unitless	$0 - 1*$
d	index of agreement	1	fit quality index	Y	unitless	$0 - 1*$
d′	modified index of agreement	1	fit quality index	N	unitless	$0 - 1*$
L_k	likelihood function	1	fit quality index	Y	Square root of observation	$0* - \infty$
k_g or RI	reliability index	6	fit quality index	Y	unitless	$1* - \infty$
d	functional distance	1	fit quality index	N	logarithm of y	$0* - \infty$
MEF	modeling efficiency	1	fit quality index	Y	unitless	$-\infty - 1*$

† assuming observed data are positive numbers   ‡ number of modeling reports and papers using this statistic

*asterisk indicates value for a perfect model fit to observed data

Model Verification and Confirmation

For model confirmation, several authors recommend that statistical hypothesis tests should be used in lieu of, or as a supplement to, descriptive GOF statistics. If model predictions fall within confidence limits of measured data, the model cannot be said to differ from the real system and confidence in model predictions is increased, even in the case of poor GOF statistics commonly observed for highly variable or near-detection limit parameters. To evaluate model predictive capacity, one can test the hypothesis that average prediction errors are, for example, less than 1 mg/l for dissolved oxygen

and less than 10 µg/l for chlorophyll a. Many hypothesis tests, such as the t-test, Wilcoxon-Mann-Witney test, or the Kolmogorov-Smirnov test are capable. All of these tests require independent samples drawn from a population, but water quality model simulations are typically very strongly autocorrelated with respect to time and location. Reckhow et al. (1990) describe methods to adjust for this autocorrelation. The t-test also requires normally distributed values, which is unusual for most environmental parameters but may be achievable through log-transformation.

Cole and Wells (2002) do not provide guidelines regarding a priori acceptable levels of error for CE-QUAL-W2. Ultimately, acceptable levels of error should be based on model uncertainty versus water quality prediction requirements of lake managers. However, based on a review of reported model errors in other systems, we can identify calibration goals for some parameters that may be achievable. These are average absolute mean errors for the system as a whole, and may not be met at all places and times.

Table 2. Calibration goals for system-wide average absolute mean error, based on CE-QUAL-W2 modeling results in other systems

water level	0.2 meters	total Kjeldahl nitrogen	0.4 mg/l
water temperature	1°C	ammonia nitrogen	0.03 mg/l
pH	0.3 su	nitrate nitrogen	0.1 mg/l
total organic carbon	0.6 mg/l	total phosphorus	0.02 mg/l
chlorophyll a	4 µg/l	orthophosphate phosphorus	0.01 mg/l

Model Goodness of Fit Statistic Formulas

In these formulas:
- y_i represents a measured value at point i in time and space
- $\hat{y}_i$ represents a model predicted value at point i in time and space
- i represents a point in time and space
- n represents the number of observations
- $\bar{y}$ represents the average measured value
- $\bar{\hat{y}}$ represents the average predicted value

Mean error
$$ME = \left(\sum_{i=1}^{n} (y_i - \hat{y}_i) \right) / n$$

Mean % error
$$M\%E = 100 \left[\sum_{i=1}^{n} (y_i - \hat{y}_i) / y_i \right] / n$$

Mean square error
$$MSE = \left[\sum_{i=1}^{n} (y_i - \hat{y}_i)^2 \right] / n$$

Mean absolute error

$$MAE = \left(\sum_{i=1}^{n} |y_i - \hat{y}_i| \right) / n$$

Mean absolute % error

$$MA\%E = 100 \left[\sum_{i=1}^{n} (|y_i - \hat{y}_i| / |y_i|) \right] / n$$

Root mean square error

$$RMSE = \left\{ \left[\sum (y_i - \hat{y}_i)^2 \right] / n \right\}^{0.5}$$

Relative mean absolute error

$$RMAE = \left(\sum_{i=1}^{n} |y_i - \hat{y}_i| \right) / (n * \bar{y}) = MAE / \bar{y}$$

General standard deviation

$$GSD = RMSE / \bar{y}$$

Theil's inequality coefficient (Theil, 1966)

$$U = \sqrt{\left[\sum_{i=1}^{n} (y_i - \hat{y}_i)^2 \right] / \sum_{i=1}^{n} y_i^2}$$

$$U_{bias} = \left[\bar{y} - \bar{\hat{y}} \right]^2 / \left[(1/n) \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 \right]$$

$$U_{variance} = \left[s - \hat{s} \right]^2 / \left[(1/n) \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 \right]$$

where $\hat{s} = \sqrt{\dfrac{1}{n} \sum_{i=1}^{n} (\hat{y}_i - \bar{\hat{y}})^2}$ and $s = \sqrt{\dfrac{1}{n} \sum_{i=1}^{n} (y_i - \bar{y})^2}$

$$U_{covariance} = \left[2(1 - r_{y\hat{y}}) * s * \hat{s} \right] / \left[(1/n) \sum (y_i - \hat{y}_i)^2 \right]$$

Nash-Sutcliffe coefficient of efficiency (Nash and Sutcliffe 1970)

$$E = 1 - \sum_{i=1}^{n} (y_i - \hat{y}_i)^2 / \sum_{i=1}^{n} (y_i - \bar{y})^2$$

Modified coefficient of efficiency reduces the impact of outliers:

$$E' = 1 - \sum_{i=1}^{n}(y_i - \hat{y}_i) / \sum_{i=1}^{n}(y_i - \bar{y})$$

Janus quotient (Gadd and Wold, 1964) $\quad J^2 = \left\{ \sum_{i=1}^{m}(y_i - \hat{y}_i)^2 / m \right\} / \left\{ \sum_{i=1}^{n}(y_i - \hat{y}_i)^2 / n \right\}$

Coefficient of determination $\quad r^2 = \left\{ \dfrac{\sum\limits_{i=1}^{n}(y_i - \bar{y})(\hat{y}_i - \bar{\hat{y}})}{\left[\sum\limits_{i=1}^{n}(y_i - \bar{y})^2\right]^{0.5} * \left[\sum\limits_{i=1}^{n}(\hat{y}_i - \bar{\hat{y}})^2\right]^{0.5}} \right\}^2$

Index of Agreement (Willmott et al., 1985) $\quad d = 1 - \dfrac{\sum\limits_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum\limits_{i=1}^{n}(|\hat{y}_i - \bar{y}| + |y_i - \bar{y}|)^2}$

Modified index of agreement $\quad d' = 1 - \dfrac{\sum\limits_{i=1}^{n}(y_i - \hat{y}_i)}{\sum\limits_{i=1}^{n}(|\hat{y}_i - \bar{y}| + |y_i - \bar{y}|)}$

Likelihood function for parameter k $\quad L_k = \sqrt{\dfrac{1}{n_k} * \sum\limits_{i=1}^{n_k} \dfrac{(\hat{y}_{i,k} - y_{i,k})^2}{y_{i,k}}}$

Reliability index (Leggett and Williams 1981) $\quad k_g = \dfrac{1 + \sqrt{\dfrac{1}{n}\sum\limits_{i=1}^{n}\left[\dfrac{1-(y_i/\hat{y}_i)}{1+(y_i/\hat{y}_i)}\right]^2}}{1 - \sqrt{\dfrac{1}{n}\sum\limits_{i=1}^{n}\left[\dfrac{1-(y_i/\hat{y}_i)}{1+(y_i/\hat{y}_i)}\right]^2}}$

Functional distance $\quad d = \sqrt{\sum\limits_{i=1}^{n}(\ln y_i - \ln \hat{y}_i)^2 / n}$

Dean_CREMS_CalibrationMetrics_20070413.doc

Modeling efficiency

$$MEF = \frac{\sum_{i=1}^{n}(y_i - \bar{y})^2 - \sum_{i=1}^{n}(\hat{y}_i - y_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}$$

Autocorrelation coefficient for time lag k

$$r_k = \frac{\text{cov}\,ar[y_i, y_{i+k}]}{s(y_i) * s(y_{i+k})}$$

References

Berger, C.J., R.L. Annear, Jr., and S.A. Wells. 2003. "Upper Spokane River Model: Model Calibration, 2001". Technical Report EWR-1-03, Department of Civil and Environmental Engineering, Portland State University, Portland, OR, 89 pages.
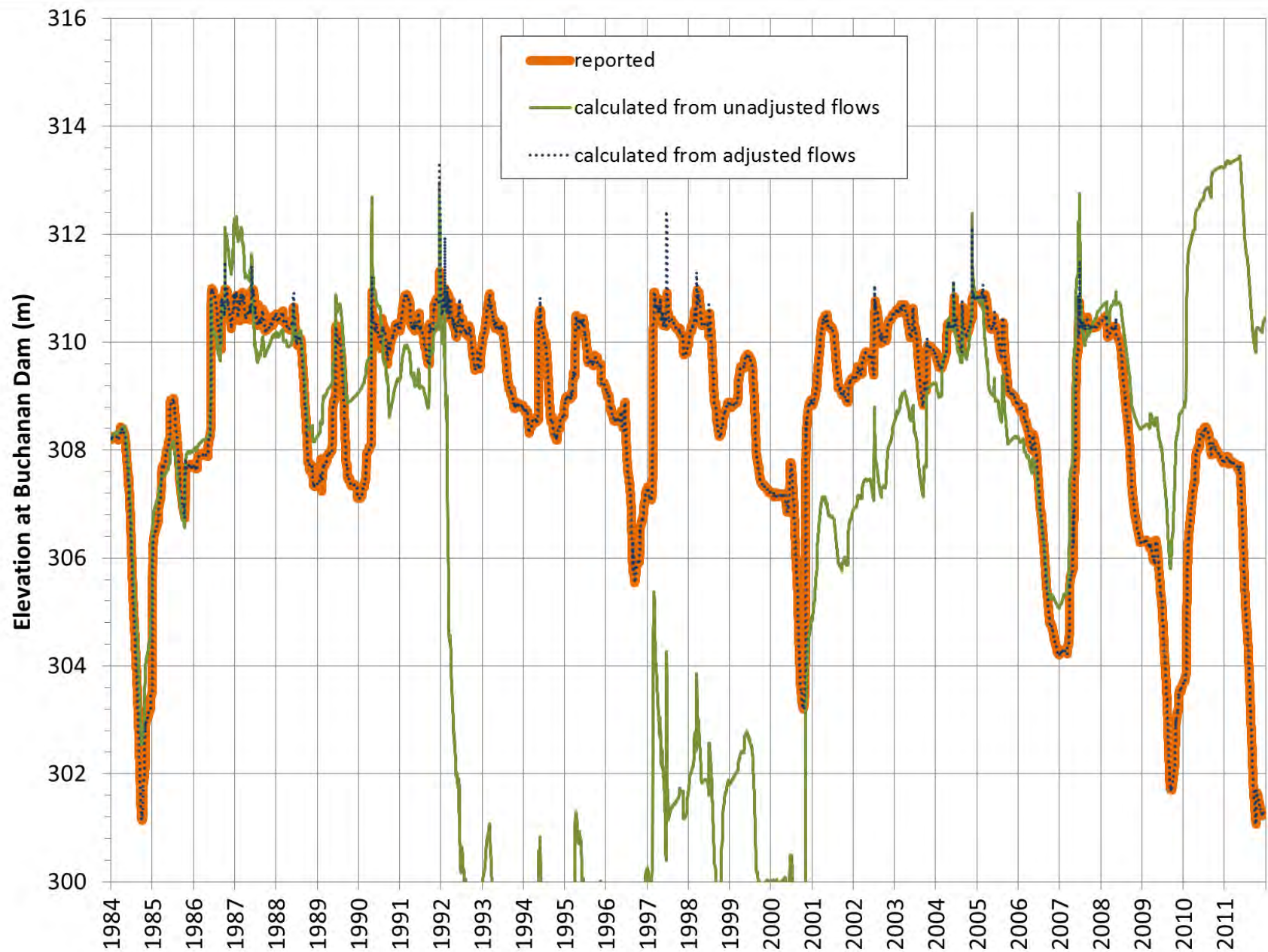
Cole, T.M., and S.A. Wells. 2002. CE-QUAL-W2: A two-dimensional, laterally averaged, hydrodynamic and water quality model, version 3.1: user manual. Instruction report EL-02-1. U.S. Army Corps of Engineers, Washington DC, August 2002.
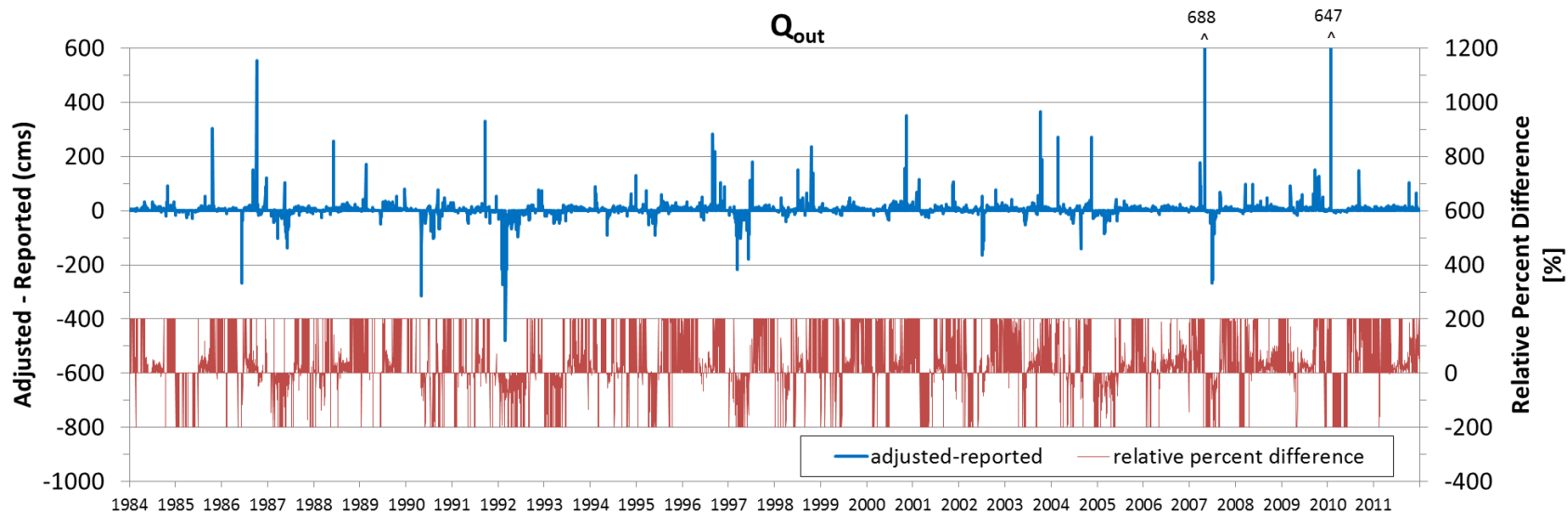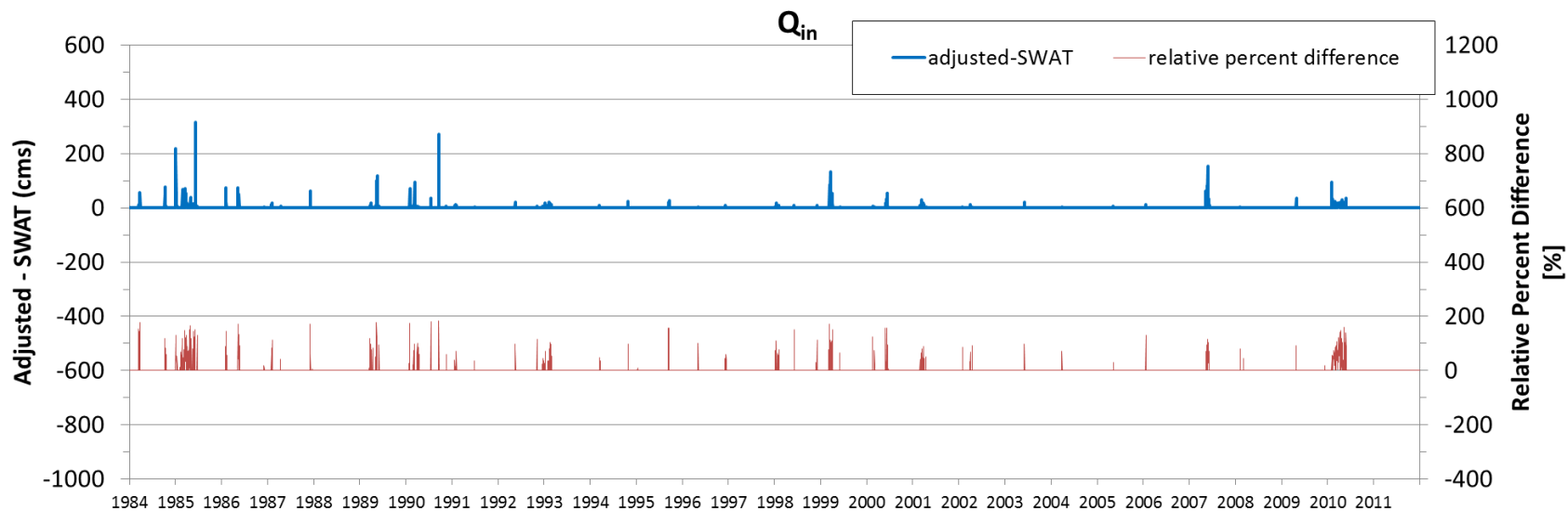
Gadd, A., and H. Wold. 1964. The Janus coefficient: a measure for the accuracy of prediction. In H. Wold (ed.) *Econometric model building: essays on the causal chain approach*. North Holland, Amsterdam, pp. 229-235.

Leggett, R.W., and L.R. Williams. 1981. A reliability index for models. *Ecological Modelling*, 13: 303-312.

Mulligan, A.E., and L.C. Brown. 1998. Genetic algorithms for calibrating water quality models. *Journal of Environmental Engineering*, 124: 202-211.

Nash, J.E., and J.V. Sutcliffe. 1970. River flow forecasting through conceptual models part 1: a discussion of principles. *Journal of Hydrology*, 10: 282-290.

Ostfeld, A. and S. Salomons. 2005. A hybrid genetic-instance based learning algorithm for CE-QUAL-W2 calibration. *Journal of Hydrology*, 310: 122-142.

Pelletier, G.J., S.C. Chapra, and H. Tao. 2006. QUAL2Kw – A framework for modeling water quality in streams and rivers using a genetic algorithm for calibration. *Journal of Environmental Modeling and Software*, 21: 419-425.

Reckhow, K.H., J.T. Clements, and R.C. Dodd. 1990. Statistical evaluation of mechanistic water-quality models. *Journal of Environmental Engineering*, 116: 250-268.

Smith, E.P., and K.A. Rose. 1995. Model goodness-of-fit analysis using regression and related techniques. *Journal of Ecological Modelling*, 77:49-64.

Theil, H. 1966. Applied Econometric Forecasting. North Holland, Amsterdam, 474 pp.

Willmott, C.J., S.G Ackleson, R.E. Davis, J.J. Feddema, K.M. Klink, D.R. Legates, J. O'Donnell, and C.M. Rowe. 1985. Statistics for the evaluation and comparison of models. *Journal of Geophysical Research*, 90: 8995–9005.

Wlosinski, J.H. 1984. Evaluation techniques for CE-QUAL-R1 – a one-dimensional reservoir water quality model. Miscellaneous Paper E-84-1. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

APPENDIX D
LAKE BUCHANAN WATER BALANCE

This appendix describes the methodology used to develop the water balance needed for the CE-QUAL-W2 model of Lake Buchanan as part of Phase 4 of the Colorado River Environmental Models (CREMs). Unlike the lakes modeled during the previous phases of the project, upstream inflows were not measured daily as Lake Buchanan is not bound on the upstream end[1] by a dam. Instead, preliminary inflow estimates were obtained from the calibrated watershed model. Review of the water balance on a daily basis indicated that some adjustments would be necessary to one or more of the water balance components. The goal of the adjustments was to provide a good fit of calculated water surface elevations to observed elevations on a daily basis, while minimizing the number of days requiring changes to flows.

WATER BALANCE

The governing equations of the CE-QUAL-W2 model are based on the conservation of fluid mass and momentum, and assume that water is an incompressible fluid. Thus, water inflows must be balanced by outflows and changes in system volume (reservoir storage). Inflows include river flows at the upstream boundary of the model, runoff from the local watershed and ungaged tributaries, and direct precipitation to the lake surface. Losses include evaporation and releases via turbines and floodgates. Water withdrawals for local irrigation or other purposes, groundwater losses and gains, and seepage through the dam were assumed to be small and were omitted. The datasets used in developing the water balance are described below.

DATA SOURCES

Reservoir Water Surface Elevation and Storage

Daily water surface elevations at Buchanan Dam were provided by the Lower Colorado River Authority (LCRA) River Operations Center (ROC). These elevations were reported each day at midnight (i.e., the beginning of each day). Elevations were converted to National Geodetic Vertical Datum of 1929 (NGVD 29) by adding 0.01 feet to elevations measured relative to LCRA's site-specific datum. Lake storage and surface area were calculated from the water surface elevation using the elevation-area and elevation-volume tables developed

---

[1] The upstream boundary of the lake model was defined as the location of monitoring station 12353, Lake Buchanan at the Headwaters. Daily flow data are not available at this location.

from the March to April 2006 bathymetry survey conducted by the Texas Water Development Board (TWDB, 2007). Because these tables included 1/10th foot vertical resolution while lake surface elevation was reported to 1/100th foot of vertical resolution, the volume and area tables were linearly interpolated to 1/100th foot. The elevation datum used was NGVD 29.

Water Releases at Dams

Releases from Lake Buchanan are the sum of turbine releases (for hydropower generation) and floodgate releases. A dataset of daily release records were provided by the ROC. This is the same dataset used for the Inks Lake water balance prior to running the Phase 3 water balance utility.

Upstream, Tributary, and Runoff Inflows

Upstream, tributary, and runoff inflows were quantified using a Soil and Water Assessment Tool (SWAT) watershed model; see Section 3 of the main CREMs Phase 4 report for details. The upstream inflow is defined as the Colorado River. Daily flows for this inflow were obtained from SWAT subbasin #54, which ends at the upstream boundary of the lake model. Tributary inflows are local tributaries and were taken from the SWAT reach file outputs. Runoff is defined by smaller subbasins that drain directly to the lake without significant concentrated flow and were taken from the SWAT subbasin file outputs.

Evaporation and Precipitation

Watershed subbasins extend to the thalweg (centerline) of the lake and account for direct precipitation to the lake surface and evaporation from the lake surface for the inundated portion of each subbasin. Accordingly, precipitation and evaporation did not need to be included explicitly in the water balance described herein.

APPROACH

The following challenges arose in developing the water balance:

- There is uncertainty in the SWAT-predicted flows.

- – For the period of 1984 through 1997, SWAT under-predicts flows by approximately 15% on average (see Section 3.3.2 of the main CREMs Phase 4 report). Therefore, the upstream inflow to the lake water balance is biased low during this time period.

- – For the period of October 1, 1997 through 2011, the percentage difference between measured and simulated water volume is less than 3% at the Colorado River near San Saba River gage (see Table 3-10 of the main CREMs Phase 4 report). Over- or under-predictions on a daily basis, however, would cause issues in a daily water balance.

- – There is uncertainty associated with the tributary and runoff flows predicted by the watershed model because of very few gaged inflows in the watershed.

- Daily precipitation and evaporation values in the SWAT model were based on measurements from gages within the watershed and may not necessarily represent precipitation and evaporation over the lake surface for localized storms.

- There is uncertainty associated with estimates of water releases at the dams, particularly with floodgate releases. Cole and Wells (2008) state that reservoir outflow measurements have typical errors of 5 to 10%. In the case of floodgate measurements, the uncertainty is likely even higher.

- Water surface elevations vary spatially and fluctuate over a daily cycle, but the elevation measurements used were taken from the dam at midnight.

- There is uncertainty associated with the lake elevation-volume and elevation-area relationships.

For a daily period, the generalized flow balance can be expressed as:

$$V_t = V_y + Q_{up} + Q_{tr} + Q_{ws} - Q_{dd} \qquad \text{(D-1)}$$

where:

V_t = lake storage today, acre-feet

V_y = lake storage yesterday, acre-feet

Q_{up} = inflow from upstream, acre-feet/day

Q_{tr} = inflow from tributaries, acre-feet/day

Q_{ws} = runoff inflow from watershed[2], acre-feet/day

Q_{dd} = outflow over downstream dam, acre-feet/day

The green line on Figure D-1 shows daily water surface elevations obtained from the TWDB volume-elevation table based on calculated water volume using the equation above and unadjusted datasets. Using the unadjusted datasets in the daily water balance leads to large deviations in water surface elevations from reported values.

One way to match the reported elevations is to force a closure every day by adjusting inflows and/or outflows on a daily basis. Sometimes, however, a large adjustment in one direction (positive or negative) might be followed by a large adjustment in the opposite direction in the following days. For these cases, it would be more appropriate to see if the data would correct itself in the near future before making the initial adjustment.

METHODOLOGY

The adjustment methodology allows daily deviations from reported elevations to occur as long as they are predicted to self-correct in the near future. The objective was to minimize deviations from reported water surface elevations and minimize the adjustments to inflows and outflows.

A window of 7 days into the future was chosen based on professional judgment. Seven days allowed for limited deviations between measured and calculated elevations. At least two sources of timing errors exist, both of which operate within a few days, as follows:

1. If a strong wind picks up, the measured elevation and corresponding volume will change, even if the true lake volume does not change. However, the wind will settle out in a couple of days, and/or change direction, so this apparent change in elevation and volume will self-correct over a period of a few days.

2. The timing of SWAT storm inflows is often off by a few days, but never off by weeks or months. So if SWAT anticipates or lags actual inflows, a 7-day window is reasonable to allow the numbers to self-correct.

---

[2] The SWAT model already accounts for precipitation and evaporation from the lake surface.

For each day, on a volume basis, the adjustment that would be needed to close a water balance was calculated and compared to the adjustment that would be needed 7 days from the current day to decide whether or not to make the adjustment for the current day, as follows:

- Adjustment for the current day

    – PV1 = predicted unadjusted volume at the end of the day = $(Q_{in} - Q_{out})$ *time + volume at the beginning of the day based on reported elevation and volume-elevation table

        - Q_{in} = SWAT flows from upstream + SWAT flows from local drainage (cms)
        - Q_{out} = reported releases at Buchanan Dam (cms)
        - Time = 86,400 s (day)

    – MV1 = measured volume at the beginning of the next day = volume based on reported elevation and volume-elevation table
    – Potential adjustment today = PV1 – MV1

- Adjustment 7 days ahead

    – PV7 = cumulative predicted unadjusted volume at the end of the 7th day = (sum of 7 days of Q_{in} – sum of 7 days of Q_{out}) *time + volume at the beginning of the 1st day based on reported elevation and volume-elevation table

        - Time = 86,400 s (1 day)

    – MV7 = measured volume at the beginning of the 8th day = volume based on reported elevation and volume-elevation table
    – Cumulative adjustment 7 days ahead = PV7 – MV7

If the adjustment 7 days ahead was greater than the adjustment for the current day (i.e., the water balance will be getting worse in the future), the flows on the current day were adjusted so that calculated and measured volumes were equal. If the adjustment 7 days ahead was less than the adjustment for the current day (i.e., the water balance will be getting better in the future), no adjustment to the current day's flows were made. A change in adjustment direction (e.g., a positive adjustment today that becomes negative in 7 days) indicated that an

adjustment to the current day's water balance would make the 7-day flow balance worse; accordingly, no adjustment was made on such days.

For days requiring adjustment, it was decided that the ROC-reported outflows would be adjusted first so that the SWAT-predicted flows (and consequently, SWAT-predicted loads) remained unchanged as often as possible. The flow calculated as the "potential adjustment today" was subtracted from the ROC-reported outflow for the day. If the new outflow was negative, then outflow was set to zero and the remainder of the adjustment was added to the SWAT results of all upstream, tributary, and runoff flows based on a prorated fraction of total inflow for the day. This supplementation of inflow, for example, would be necessary when data showed an increase in elevation, the outflow was zero, and SWAT inflows were insufficient to account for the measured elevation increase. Following the methodology above resulted in preliminary supplemented inflows 7.3% of the time; and preliminary supplemented flows equaled 5.9% of the total flows from SWAT.

Additional steps were taken to reduce the number of days with supplemented inflows. For days with preliminary supplemented flows, the adjusted outflows in the next 7 days were reviewed to see if the supplemented flow could be decreased or zeroed out by reducing the upcoming outflows. In other words, the outflows acted like a bank account containing flows available to pay for the supplemented flows based on a running tally of previous account withdrawals. In the end, supplemented flows occurred 3.9% of the time and equaled 3.4% of the total flows from SWAT.

RESULTS

Water Surface Elevations

By methodology design, post-adjustment elevations at Buchanan Dam matched reported elevations well (Figure D-1). The largest exceptions were deviations of about 1 to 2 meters during four time periods. These occurred during or close to high flow events and lasted between 2 days and approximately 1 month each. These deviations were left uncorrected because the 7-day flow calculation showed that the flows and water balance would self-correct over time (although not necessarily completely within 7 days).

Evaluation of Adjustments

Evaluation of the adjustments to inflow and outflow included review of the magnitude (absolute and relative) and frequency of the changes. On a daily basis, these changes were computed as the difference between the adjusted flow and the original flow and as a relative percent difference (RPD).

$$RPD = \frac{(X-Y)}{(\frac{X+Y}{2})} * 100 \qquad \text{(D-2)}$$

Using this equation, the minimum and maximum RPD are -200% and +200%, respectively. A RPD of 200% means that the original value was zero and the adjusted value was greater than zero; a RPD of -200% means that the adjusted value was zero and the original value was greater than zero.

Figure D-2 shows the magnitude change and RPD over time to both inflows and outflows. By methodology design, inflows were changed modestly in the positive direction with the exception of 3 days with adjustments greater than 219 cubic meters per second (cms) (Figures D-2 and D-3, top panels). Typically, but not always, large changes to outflows were associated with high flow events; on infrequent occasions, changes up to 688 cms were made to outflows. However, during extreme high flow events (e.g., flows exceeding 1,000 cms), the adjustment methodology did not change any daily outflow value (Figure D-3, bottom panel). Overall, the magnitudes and RPDs of adjustments were lower than (or less than) those that would have resulted from an adjustment method requiring daily water balance closure, but there were still some significant adjustments.

Another way to visualize the adjustments is via probability plots, as depicted on Figure D-4 for inflow and outflow. Shown as individual symbols, daily values were ranked in ascending order and cumulative probability was plotted on the x-axis. The vertical line at 50 indicates the median; half the values are smaller than and half are larger than this value. These plots can be used to understand the distributions of the values. Table D-1 summarizes select flow adjustment statistics, which can also be seen on the probability plots. Inflows and outflows were not changed 96% and 26% of the time, respectively.

Table D-1

Statistics on Results from the Water Balance Methodology

Evaluation of Magnitude of Change [a]	Criteria	% of Total Time [b]
Inflow (Q_{in} adjusted – SWAT)	= 0 cms	96%
	between 0 and 10 cms	2%
	≥ 10 cms	1%
Outflow (Q_{out} adjusted – reported)	≤ -10 cms	6%
	between -10 and 0 cms	18%
	= 0 cms	26%
	between 0 and 10 cms	41%
	≥ 10 cms	9%

Notes:

a   For reference, 10 cms ~ 353 cfs; Q_{in} adjusted mean = 19.8 cms; Q_{in} adjusted median = 3.9 cms; Q_{out} adjusted mean = 20.3 cms; Q_{out} adjusted median = 6.1 cms.

The Q_{out} adjusted mean is greater than the Q_{in} adjusted mean due to a reduction in water surface elevation of approximately 7 meters between January 1, 1984 and December 31, 2011.

b   Total time = days from 1984 through 2011; the sum of percentages for inflows does not equal 100% due to rounding.

cfs – cubic feet per second

cms – cubic meters per second0

Figure D-5 shows two distributions of flow adjustments for the time periods noted above, 1984 to 1997 and 1998 to 2011. Due to the SWAT model's general under-prediction of flows for 1984 to 1997 at Colorado River at San Saba gage (the closest upstream calibration station), the earlier time period required larger and more frequent adjustments to inflows whereas less frequent and smaller adjustments were needed during the SWAT calibration period (1998 to 2011) for the same station.

RECOMMENDATIONS

Although there were still some considerable changes to flows, this method resulted in fewer days requiring adjustments and smaller magnitudes of adjustments compared to closing the water balance on a daily basis. This methodology is reasonable given the uncertainty in the inflows from SWAT and is appropriate for using for CE-QUAL-W2 for lake model predictions.

REFERENCES

Cole, TM, and SA Wells, 2008. *CE-QUAL-W2: A Two-Dimensional, Laterally Averaged, Hydrodynamic and Water Quality Model, Version 3.6. User Manual.* Instruction Report EL-08-1. U.S. Army Corps of Engineers. Washington, DC.

TWDB (Texas Water Development Board), 2007. *Volumetric and Sedimentation Survey of Lake Buchanan.* Texas Water Development Board. Austin, Texas. August 2007.

FIGURES

Figure D-1
Water Surface Elevation at Buchanan Dam as Measured and Calculated With and Without Flow Adjustments
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Relative percent difference = (adjusted - original)/average of adjusted and original * 100

Figure D-2
Magnitude and Relative Percent Difference Between Adjusted and Unadjusted Inflows and Outflows
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Q_in (cms)

Q_out (cms)
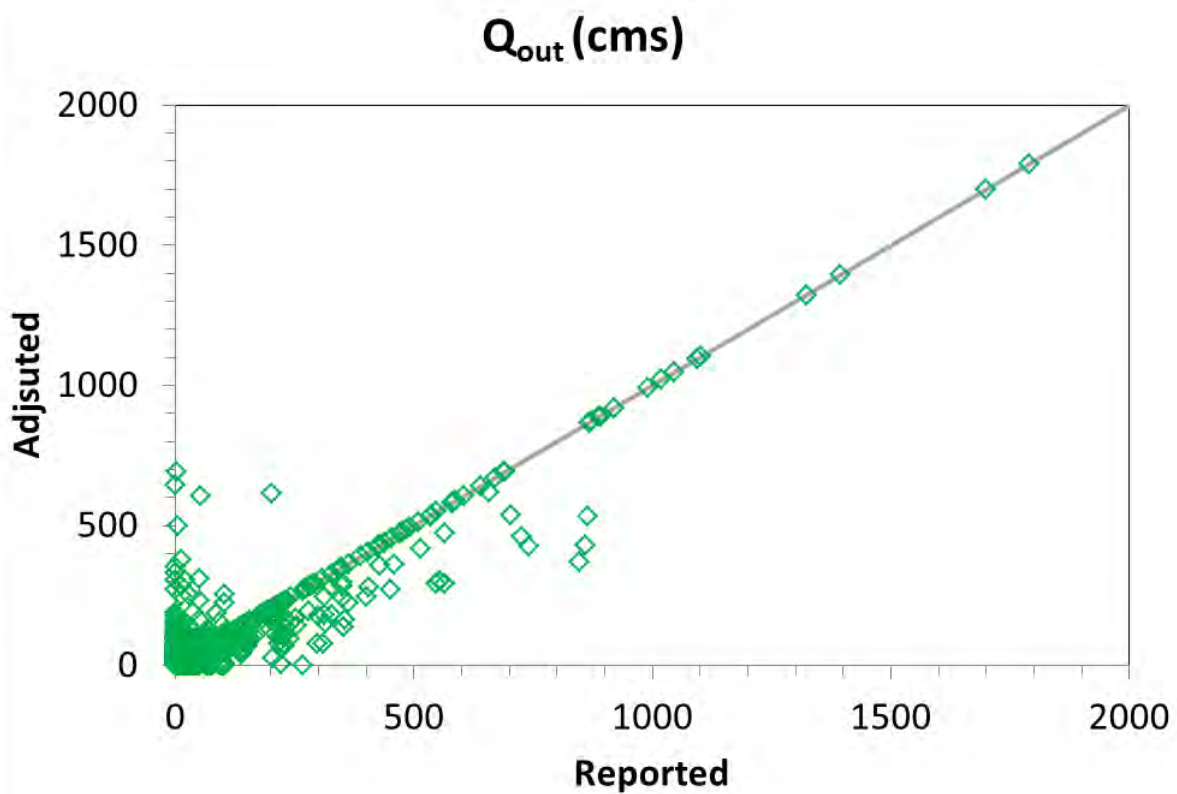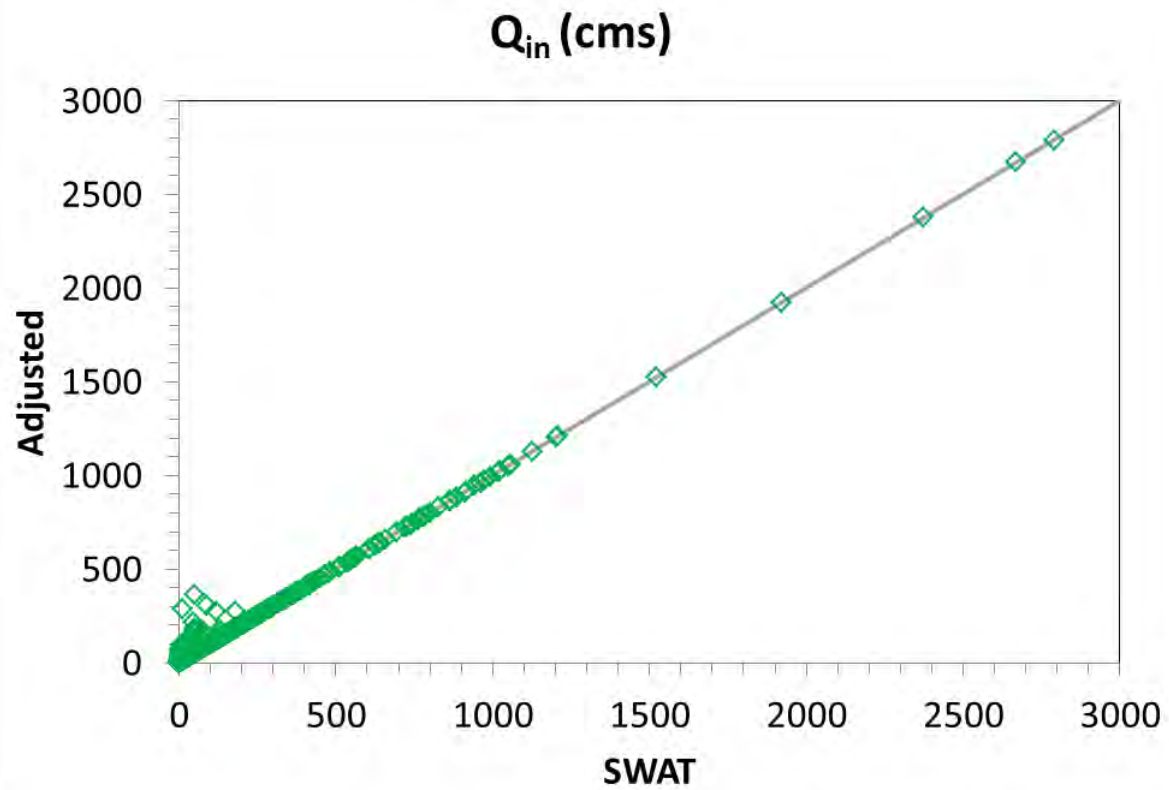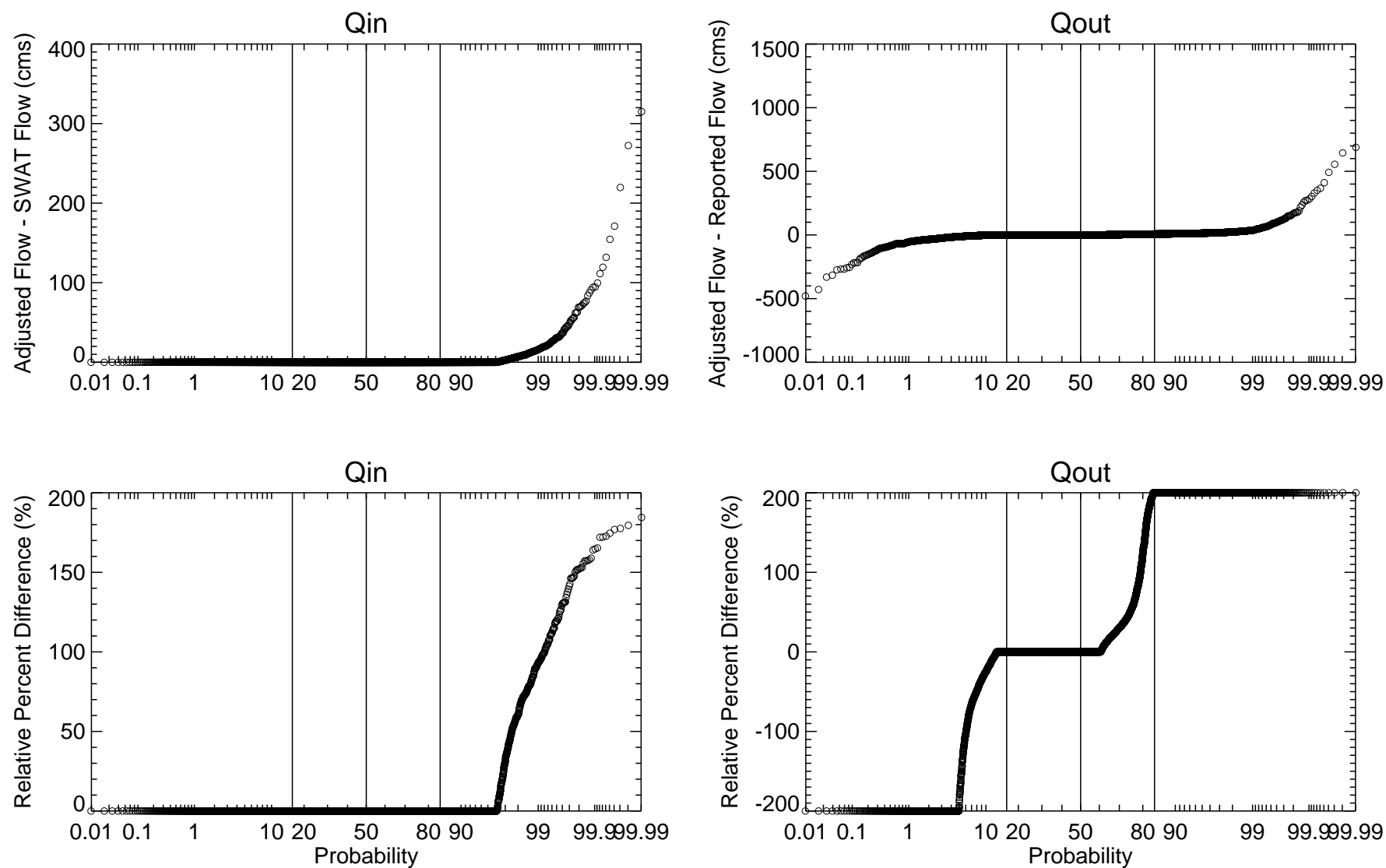
Figure D-4

Probability Plots of Changes to Inflows and Outflows for the Buchanan Water Balance

*Notes: Relative % difference = (adjusted - original)/average of adjusted and original * 100*
Releases are adjusted first, then inflows

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority
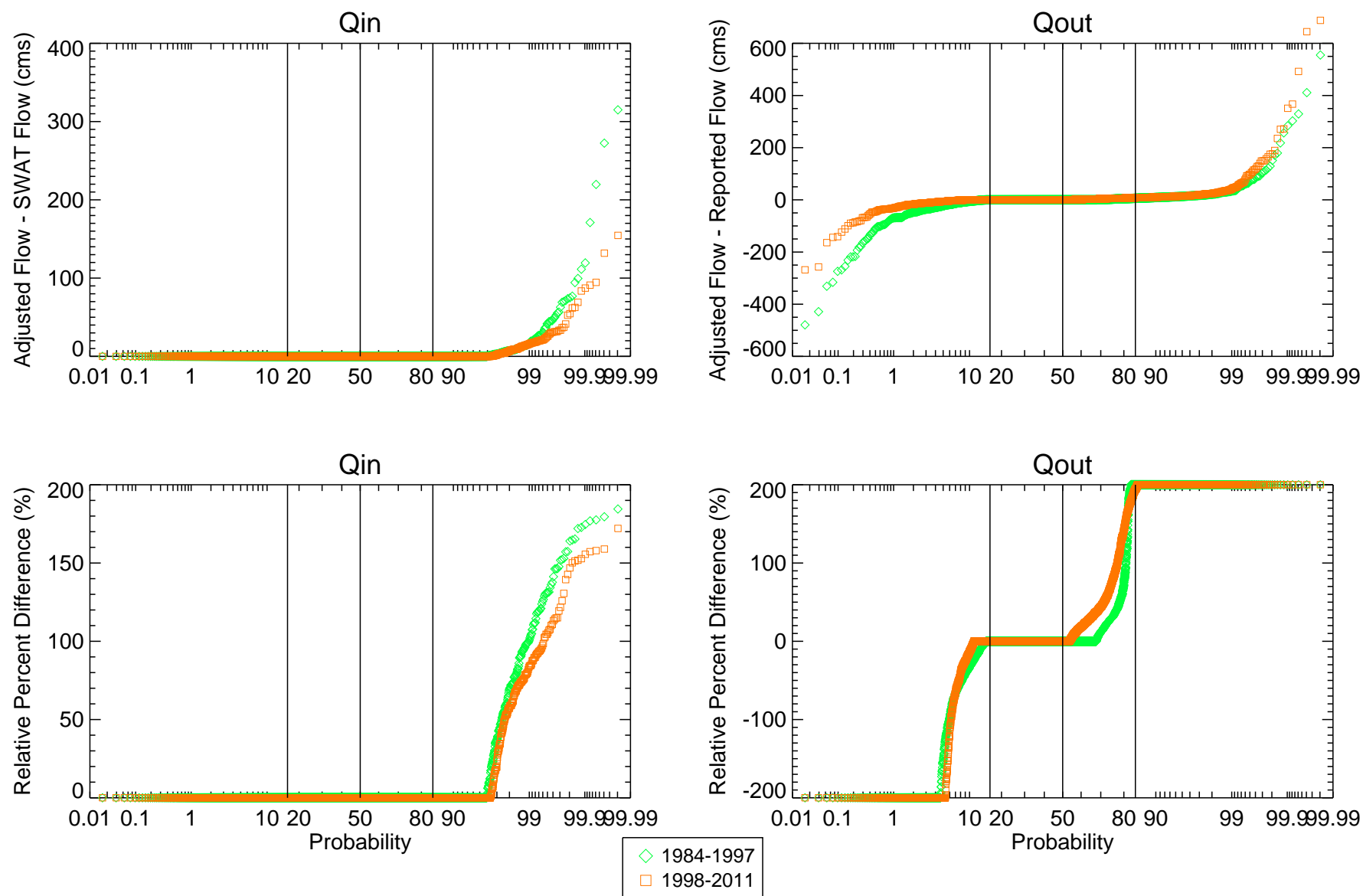
Figure D-5

Probability Plots of Changes to Inflows and Outflows for the Buchanan Water Balance for Two Time Periods

*Notes: Relative % difference = (adjusted - original)/average of adjusted and original * 100*
Releases are adjusted first, then inflows

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

APPENDIX E
WATERSHED AND LAKE MODEL LINKAGE

1 INTRODUCTION

The watershed model was joined to the lake model through the conversion of Soil and Water Assessment Tool (SWAT)-predicted flow and load output into flow and concentration inputs required by CE-QUAL-W2. The linkage was performed in four steps:

1. Spatially relate each lake model segment to the appropriate watershed model subbasin
2. Deconvolute SWAT state variables to CE-QUAL-W2 state variables
3. Incorporate deconvoluted variables into the lake model
4. Incorporate watershed flows into the lake model

The first two steps are described in Sections 2 and 3 below, respectively. Sections 4 and 5 below describe how the SWAT output was incorporated in the lake model.

2 MODEL SPATIAL LINKAGES

Figure E-1 shows the lake model segments and nearby subbasins of the watershed model. Due to the nature of the subbasin delineation, each lake model segment is spatially related to a watershed model subbasin in one of two ways: either it is contained within a watershed subbasin or it is the receiving segment of an adjacent upstream watershed.

Determination of the spatial relationship of each lake model segment to a watershed model subbasin is important because the relationship indicates the proper watershed model output file to use for linkage between the models. The two SWAT model output files used for the linkage were output.sub and output.rch. The output.sub file contains summary information for each subbasin in the watershed (i.e., the loadings coming directly from the land surface into the lake segment). The output.rch file contains summary information for each routing reach in the watershed (i.e., the loadings once SWAT has routed the sediment and nutrients down the stream). If the lake segment is contained within a watershed subbasin, the information from output.sub is used. If the lake segment is the receiving segment of an adjacent upstream watershed, the tributary information from output.rch is used. The output.rch file contains cumulative results from water quality processes within all upstream watershed subbasins at the point where the reach intersects and empties into the lake. Table

E-1 shows the relationship between the lake model segments and watershed model subbasins and indicates the type of output file used.

Table E-1
Relationship Between Lake Model Segments and Watershed Model Subbasins

Branch	Watershed Subbasin Number	SWAT Output Type	Receiving Lake Model Segment Numbers
1	54	RCH	2
1	59	SUB	2, 3, 4
1	58	RCH	3
1	66	SUB	5, 6, 7, 8
1	61	RCH	6
1	62	RCH	6
1	71	SUB	8, 9, 10, 11, 16, 17, 18, 21, 22
1	73	SUB	11, 12, 13
2	63	RCH	16
2	64	RCH	16
2	65	RCH	17
2	70	RCH	17
3	67	RCH	21
4	69	RCH	25
4	72	SUB	25, 26, 27

Notes:
See Figure E-1 for a map showing the relationship between watershed subbasins and lake model segmentation.

3 DECONVOLUTION OF SWAT TO CE-QUAL-W2 STATE VARIABLES

A custom intermediary program was created that connected and converted the output files from the watershed model to appropriate input files for the lake model. It not only needed information for spatially linking the two models, but also required some output processing because several variables output by SWAT were not directly translatable to inputs to CE-QUAL-W2. Post-processors read in the SWAT output files and produced inputs in the format required by CE-QUAL-W2. This transformation required the deconvolution of some SWAT state variables. The state variables used in CE-QUAL-W2 are as follows:

- Inorganics (inorganic suspended solids [ISS], orthophosphate)
- Nitrogen (ammonium, nitrate+nitrite)
- Organic matter (labile and refractory, dissolved and particulate)
- Algae
- Dissolved oxygen

In the following discussions, equations pertaining to the deconvolution of variables in the output.rch file are on the left side of the page; equations using variables in output.sub are on the right side of the page. These equations calculate load, whereas CE-QUAL-W2 requires flow and concentration files as inputs. The conversion of load to concentrations is discussed in Section 4 of the Phase 4 report.

3.1.1 Inorganics

3.1.1.1 Inorganic Suspended Solids

ISS was calculated either by subtracting the particulate portion of organic matter (OM) from the sediment that is transported out of a reach, or by subtracting the particulate portion of OM from the sediment transported into a subbasin. If ISS was negative, it was set to zero.

$$ISS = \frac{SED\_OUT - LPOM - RPOM}{timestep} \qquad ISS = \frac{SYLD \times AREA - LPOM - RPOM}{timestep} \qquad \text{(E-1)}$$

where:

SED_OUT = sediment transported with water out of reach during the timestep (mass); from SWAT output.rch

$LPOM$ = labile particulate OM (see Section 3.3 below)

$RPOM$ = refractory particulate OM (see Section 3.3 below)

$SYLD$ = sediment yield (mass/area); sediment from the subbasin that is transported into the reach during the timestep; from SWAT output.sub

$AREA$ = area of subbasin (length squared); from SWAT output.sub

$timestep$ = watershed model timestep

3.1.1.2　Bioavailable Phosphorus

Orthophosphate is the form of phosphorus that is bioavailable. Except for the conversion to appropriate units, deconvolution of SWAT variables to CE-QUAL-W2 variables was not necessary for orthophosphate.

$$PO4 = \frac{MINP\_OUT}{timestep} \qquad\qquad PO4 = \frac{(SOLP + SEDP) \times AREA}{timestep} \qquad (E\text{-}2)$$

where:

$MINP\_OUT$ = mineral phosphorus transported with water into reach during the timestep (mass); from SWAT output.rch

$SOLP$ = soluble P yield (mass/area); phosphorus that is transported by surface runoff into the reach during the timestep; from SWAT output.sub

$SEDP$ = mineral P yield (mass/area); mineral phosphorus attached to sediment that is transported by surface runoff into the reach during the timestep; from SWAT output.sub

$AREA$ = area of subbasin (area); from SWAT output.sub

$timestep$ = watershed model timestep

3.2　Nitrogen

3.2.1.1　Ammonia

Except for the conversion to appropriate units, deconvolution of SWAT variables to CE-QUAL-W2 variables was not necessary for the model elements receiving ammonia from upstream reaches. Ammonia is not tracked in subbasins and therefore, ammonia levels from the land surface were set to zero in the lake model input file.

$$NH4 = \frac{NH4\_OUT}{timestep} \qquad\qquad NH4 = 0 \qquad (E\text{-}3)$$

where:

$NH4\_OUT$ = ammonium transported with water out of reach during the timestep (mass); from SWAT output.rch

timestep   =   watershed model timestep

3.2.1.2   Nitrate + Nitrite

Except for the conversion to appropriate units, deconvolution of SWAT variables to CE-QUAL-W2 variables was not necessary for nitrate plus nitrite.

$$NOX = \frac{NO3\_OUT + NO2\_OUT}{timestep} \quad NOX = \frac{(LATNO3 + GWNO3 + NSURQ) \times AREA}{timestep} \quad \text{(E-4)}$$

where:

NO3_OUT   =   nitrate transported with water out of reach during the timestep (mass); from SWAT output.rch

NO2_OUT   =   nitrite transported with water out of reach during the timestep (mass); from SWAT output.rch

LATNO3   =   nitrate in lateral flow (mass/area); nitrate transported by lateral flow into the reach during the timestep; from SWAT output.sub

GWNO3   =   nitrate in groundwater (mass/area); nitrate transported by groundwater into the reach during the timestep; from SWAT output.sub

NSURQ   =   nitrate in surface runoff (mass/area); nitrate transported by the surface runoff into the reach during the timestep; from SWAT output.sub

AREA   =   area of subbasin (area); from SWAT output.sub

timestep =   watershed model timestep

3.3   Organic Matter

Organic matter in CE-QUAL-W2 is divided into four categories: 1) labile dissolved (LD); 2) labile particulate (LP); 3) refractory dissolved (RD); and 4) refractory particulate (RP). For each of these categories, the following equations were used to convert the carbon form of OM to the appropriate value for input into CE-QUAL-W2.

$$OM_x = \frac{f_{xOM} \times ORGN\_OUT \times R_{cn}}{timestep \times R_{com}} \qquad OM_x = \frac{f_{xOM} \times ORGN \times AREA \times R_{cn}}{timestep \times R_{com}} \qquad (E-5)$$

where:

fX_{OM} (x = LD, LP, RD, RP)	=	fraction of a particular type of OM
ORGN_OUT	=	organic nitrogen transported with water out of reach during the timestep (mass nitrogen); from SWAT output.rch
R_{cn}	=	stoichiometric equivalent between carbon and nitrogen
R_{com}	=	stoichiometric equivalent between carbon and OM
timestep	=	watershed model timestep
AREA	=	area of subbasin (area); from SWAT output.sub

The OM loads in inflows were estimated from the OrgN load output from SWAT by using a carbon to nitrogen ratio (R_{cn}) in OM of 9.8 and a carbon content of 0.45 in OM (R_{com}). The carbon to nitrogen ratio was identical to that estimated during the CREMs Phase 3 work using almost 900 samples collected in Lake Lyndon B. Johnson tributaries since 1984 (Parsons and Anchor QEA 2011).

The OM loads were partitioned into dissolved to particulate and labile to refractory pools assuming different dissolved to particulate proportions and labile to refractory splits, depending on the whether the values were to be used as the upstream boundary or as tributary and runoff inputs. Table E-2 summarizes the proportions. For upstream loads, dissolved proportions were derived from 11 sets of paired total organic carbon and dissolved organic carbon data at Station 12353, Lake Buchanan, near Headwaters. For tributaries and runoff loads, they were calculated from 46 sets of paired data from Lake Buchanan tributaries. The labile percentage of 25% was based on a similar modeling effort on the Bosque River in Texas (Flowers et al 2001).

Table E-2

Dissolved Content and Decay Characteristics of Organic Matter Groups

Input	Ratio	Organic Carbon	Organic Nitrogen	Organic Phosphorus
Upstream	Dissolved:Particulate	99:1	58:42	25:75
	Labile:Refractory	25:75	25:75	25:75
Tributaries and Runoff	Dissolved:Particulate	98:2	71:29	30:70
	Labile:Refractory	25:75	25:75	25:75

A portion of OM is organic phosphorus and a portion is organic nitrogen. The following equations were used to convert the SWAT output for organic phosphorus and organic nitrogen to inputs to CE-QUAL-W2.

$$OM_x\_P = \frac{f_{xOM} \times ORGP\_OUT}{timestep} \qquad OM_x\_P = \frac{f_{xOM} \times ORGP \times AREA}{timestep} \qquad \text{(E-6)}$$

$$OM_x\_N = \frac{f_{xOM} \times ORGN\_OUT}{timestep} \qquad OM_x\_N = \frac{f_{xOM} \times ORGN \times AREA}{timestep} \qquad \text{(E-7)}$$

where:

f_{xOM} (x = LD, LP, RD, RP)	=	fraction of a particular type of OM
ORGP_OUT	=	organic phosphorus transported with water out of reach during the timestep (mass P); from SWAT output.rch
ORGP	=	organic phosphorus yield (mass/area); organic phosphorus transported with sediment into the reach during the timestep; from SWAT output.sub
ORGN_OUT	=	organic nitrogen transported with water out of reach during the timestep (mass N); from SWAT output.rch
ORGN	=	organic nitrogen yield (mass/area); organic nitrogen transported out of the subbasin and into

the reach during the timestep; from SWAT output.sub

AREA	=	area of subbasin (area); from SWAT output.sub
timestep	=	watershed model timestep

These loads were then partitioned into dissolved and particulate, and labile and refractory pools (Table E-2). Similarly, OrgP loads from SWAT were converted to inflow concentrations and then partitioned into dissolved to particulate and labile to refractory pools (Table E-2). The datasets used for these proportions were the same as the datasets for the dissolved OM calculations except the OrgN calculation used NH4, dissolved Kjeldahl nitrogen (DKN), and total Kjeldahl nitrogen data and the OrgP calculation used dissolved phosphorus, PO4, and total phosphorus data.

3.4   Algae

Values for algal biomass from SWAT reaches needed to be converted from units of mass Chl-a to units of mass OM by using a stoichiometric equivalent between OM and Chl-a: ACHLA. Algae in runoff from the watershed subbasins was assumed to be negligible; therefore, algae from the subbasins was set to zero in the lake model input file. Algal daily loads were divided evenly among the three algal groups (generally presenting diatoms, blue-greens, and greens) included in the lake model.

$$ALG = \frac{CHLA\_OUT \times ACHLA}{timestep} \qquad\qquad ALG = 0 \qquad\qquad\qquad \text{(E-8)}$$

where:

CHLA_OUT	=	algal biomass transported with water out of reach during the timestep (mass Chl-a); from SWAT output.rch
ACHLA	=	stoichiometric equivalent between OM and Chl-a (mass algae/mass Chl-a)
timestep	=	watershed model timestep

Because SWAT in-stream kinetics were not activated for this project, the SWAT-predicted Chl-a concentrations are not reliable. Fortunately, the lake model is not sensitive to these concentrations because in-lake processes control the lake model's Chl-a results.

3.5   Dissolved Oxygen

DO from the SWAT reaches and subbasins was not taken from the SWAT model output but instead was calculated from the temperatures specified in the lake model input (see Section 4.4.1.3.2 of the Phase 4 main report), assuming 100% saturation. Saturation DO was calculated via a temperature-dependent formula provided in Standard Methods 20th Edition (APHA 1998) at an atmospheric pressure of 101.3 kPa and using water temperatures measured at San Saba River at SH 16 (Station 12392).

4   INCORPORATING DECONVOLUTED VARIABLES INTO THE LAKE MODEL

Loadings predicted by the watershed model were input as a daily time series into the lake model through the specification of a flow file and a concentration file for each linked watershed subbasin. Flows were calculated from SWAT output as follows:

$$Flow = FLOW\_OUT \qquad\qquad Flow = \frac{WYLD \times AREA}{timestep} \qquad\qquad (3\text{-}9)$$

where:

$FLOW\_OUT$ = average daily streamflow into reach during the time step (volume/time); from SWAT output.rch

$WYLD$ = net amount of water that leaves the subbasin and contributes to streamflow in the reach during the timestep (length); from SWAT output.sub

$AREA$ = area of subbasin (length squared) for SWAT output.sub or drained by reach (length squared) for SWAT output.sub

$timestep$ = watershed model timestep

The concentrations from spatially appropriate subbasins were then calculated by dividing the deconvoluted loadings from the watershed model by SWAT-predicted flow. In this manner,

the loadings predicted by SWAT were preserved in the lake model with the exception for 3.9% of days when the lake model required additional watershed inflows determined through the lake water balance (see Appendix D and Section 4.5.1.1 of the Phase 4 report for more details). These supplementary inflows were assigned the same concentrations as the SWAT-predicted flow for the day.

5 INCORPORATING WATERSHED FLOWS AND CONCENTRATIONS INTO THE LAKE MODEL

After the water balance, adjusted inflows and calculated concentrations for each subbasin were entered into the lake model differently, depending on the spatial relationship between the watershed and the lake segmentations (Figure E-1). For subbasins described as "RCH" in Table E-1, adjusted flows from the water balance and calculated concentrations were used directly. For subbasins described as "SUB," adjusted inflows from the water balance and calculated concentrations were prorated to appropriate lake segments. For example, portions of subbasin 59 overlap lake segments 2, 3, and 4, while other portions of the subbasin are hydrologically upgradient of each of the three lake segments. Consequently, adjusted flow for subbasin 59 was apportioned to each segment prorated based on drainage area. Calculated concentrations were distributed to each segment prorated based on flow, which, in turn, was based on the drainage area proration.

6 REFERENCES

Anchor QEA and Parsons, 2011. *Final Phase 3 Scenario Memo.* July 21, 2011. Prepared for Lower Colorado River Authority.

APHA et al. (American Public Health Association, American Water Works Association, and Water Environment Federation), 1998. *Standard Methods for the Examination of Water and Wastewater*, 20th Edition. Washington, D.C.: American Public Health Association.

Flowers, J.D., L.M. Hauck, and R.L. Kiesling, 2001. *Water Quality Modeling of Lake Waco using CE-QUAL-W2 for Assessment of Phosphorus Control Strategies. PublicationTR0114.* Texas Institute for Applied Environmental Research, Tarleton State University, Stephenville, Texas. December 2001.

FIGURES

LEGEND

- Lake Segmentation
- SWAT Subbasins
- NHD Streams

ANCHOR QEA
PARSONS
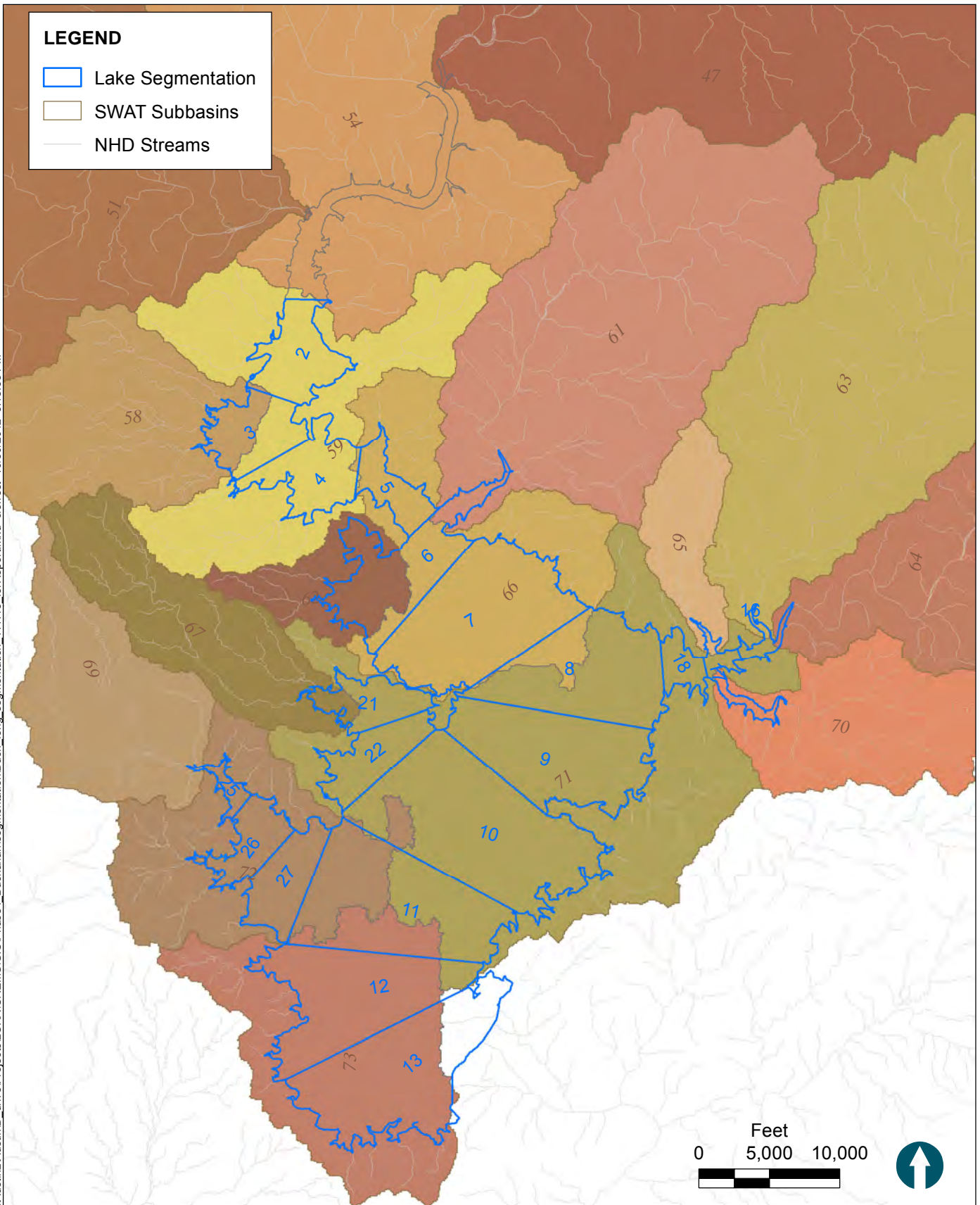
APPENDIX F
CODE MODIFICATIONS TO CE-QUAL-W2

This appendix documents the modifications made to the CE-QUAL-W2 Version 3.6 code used for modeling Lake Buchanan as part of Phase 4 of the Colorado River Environmental Models (CREMs) project. As described in Section 4.5.5.1 of the main report, code modifications were necessary to match the increasing trend in hypolimnetic nutrient data observed over time since the original CE-QUAL-W2 code is limited to spatially variable but temporally constant zero-order maximal release rates for orthophosphate, as phosphorus, (PO4) and ammonium, as nitrogen (NH4).

In file "water-quality.f90", the following code modifications were made:

Original code:
```
PO4SR(K,I)  = PO4R(JW)*SODD(K,I)*DO2(K,I)
```

was changed to:
```
PO4SR(K,I)  =  (PO4R(JW) +
PO4R(JW)*5.0*REAL(INT(JDAY/365.25))/28.0) * SODD(K,I) *
DO2(K,I) !DRO Hardwire 20121015
```

Original code:
```
NH4SR(K,I)  =  NH4R(JW) *SODD(K,I)*DO2(K,I)
```

was changed to:
```
NH4SR(K,I)  =  (NH4R(JW) +
NH4R(JW)*5.0*REAL(INT(JDAY/365.25))/28.0) * SODD(K,I) *
DO2(K,I) !DRO Hardwire 20121015
```

This scales the PO4 and NH4 sediment release rates from a base case (to match 1984 data) to six times the base case (i.e., the base case sediment release rate plus five times the base case rate) to match 2011 data.

APPENDIX G

VERTICAL DEPTH PROFILES OF WATER TEMPERATURE, SPECIFIC CONDUCTIVITY, CHLORIDE, AND DISSOLVED OXYGEN

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 1984

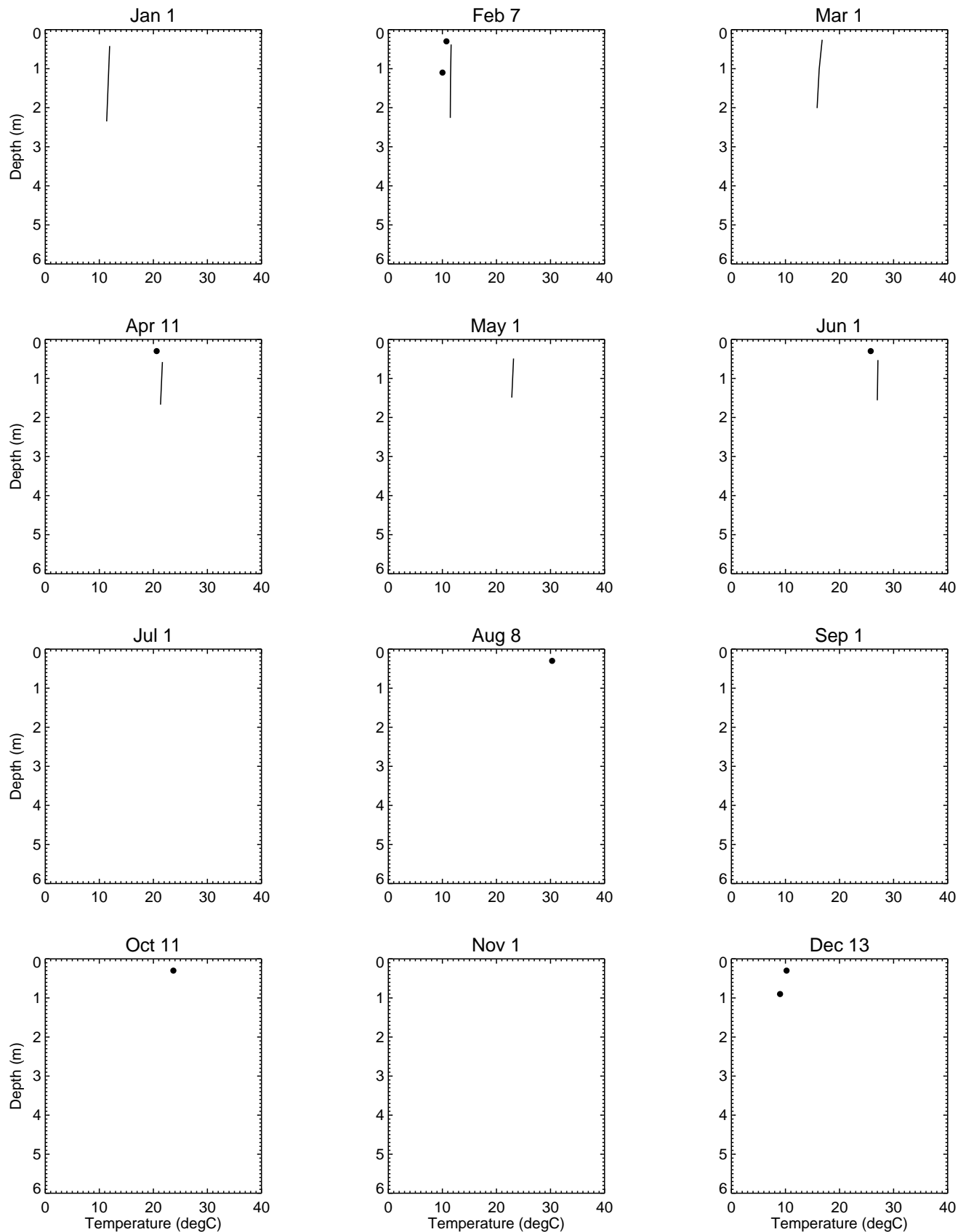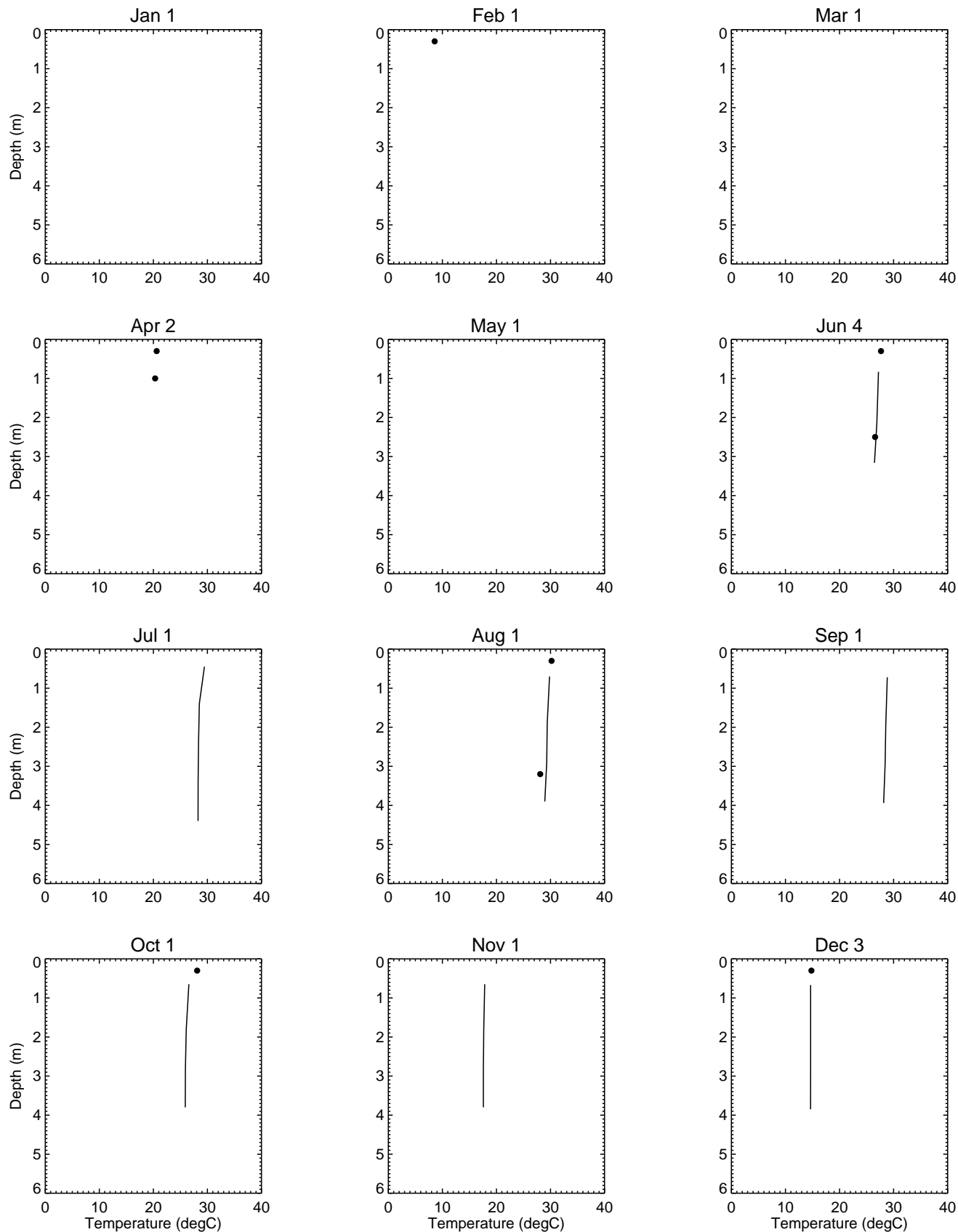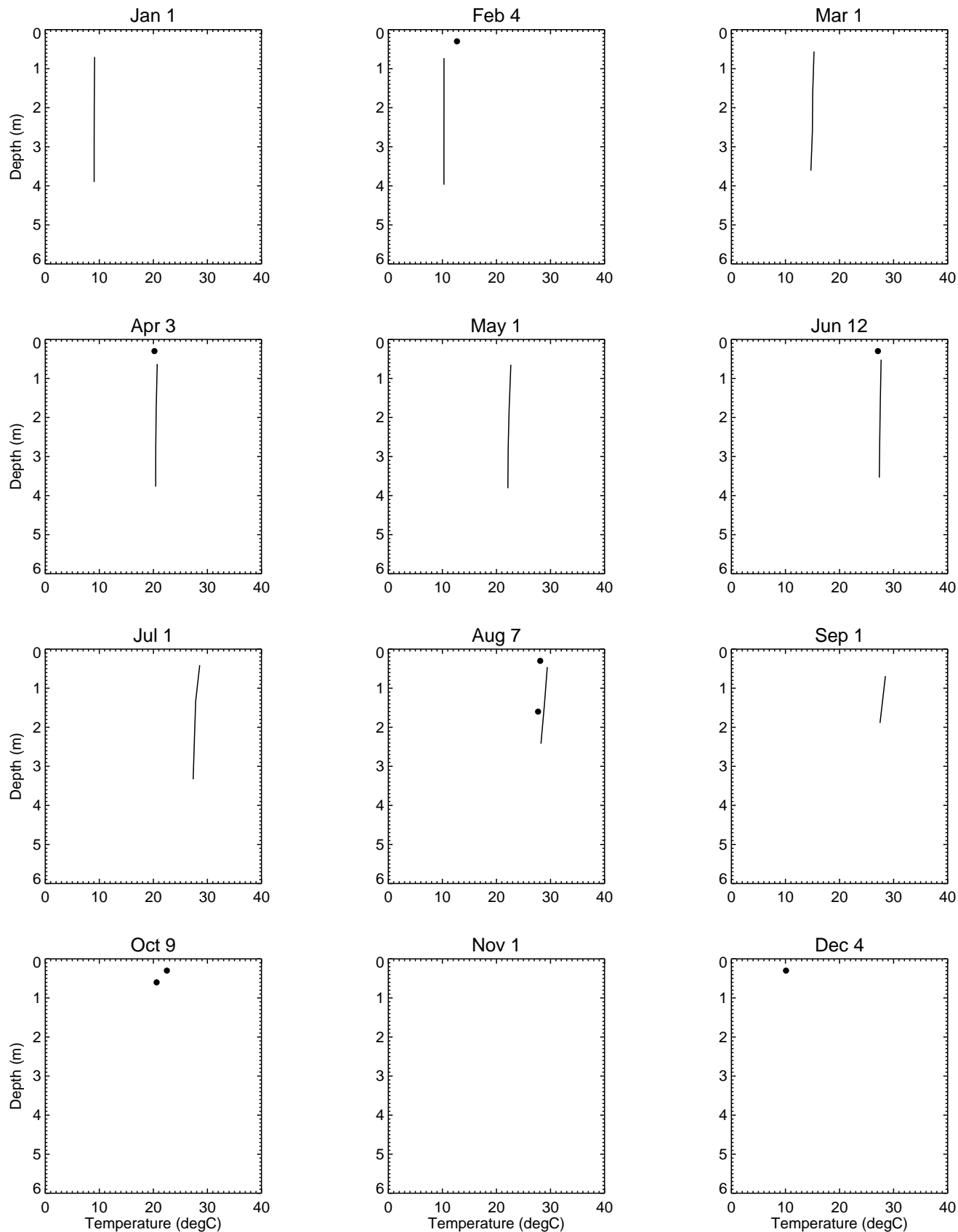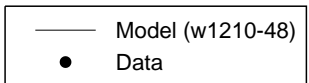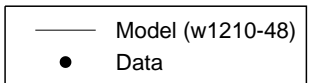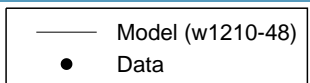*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 1985

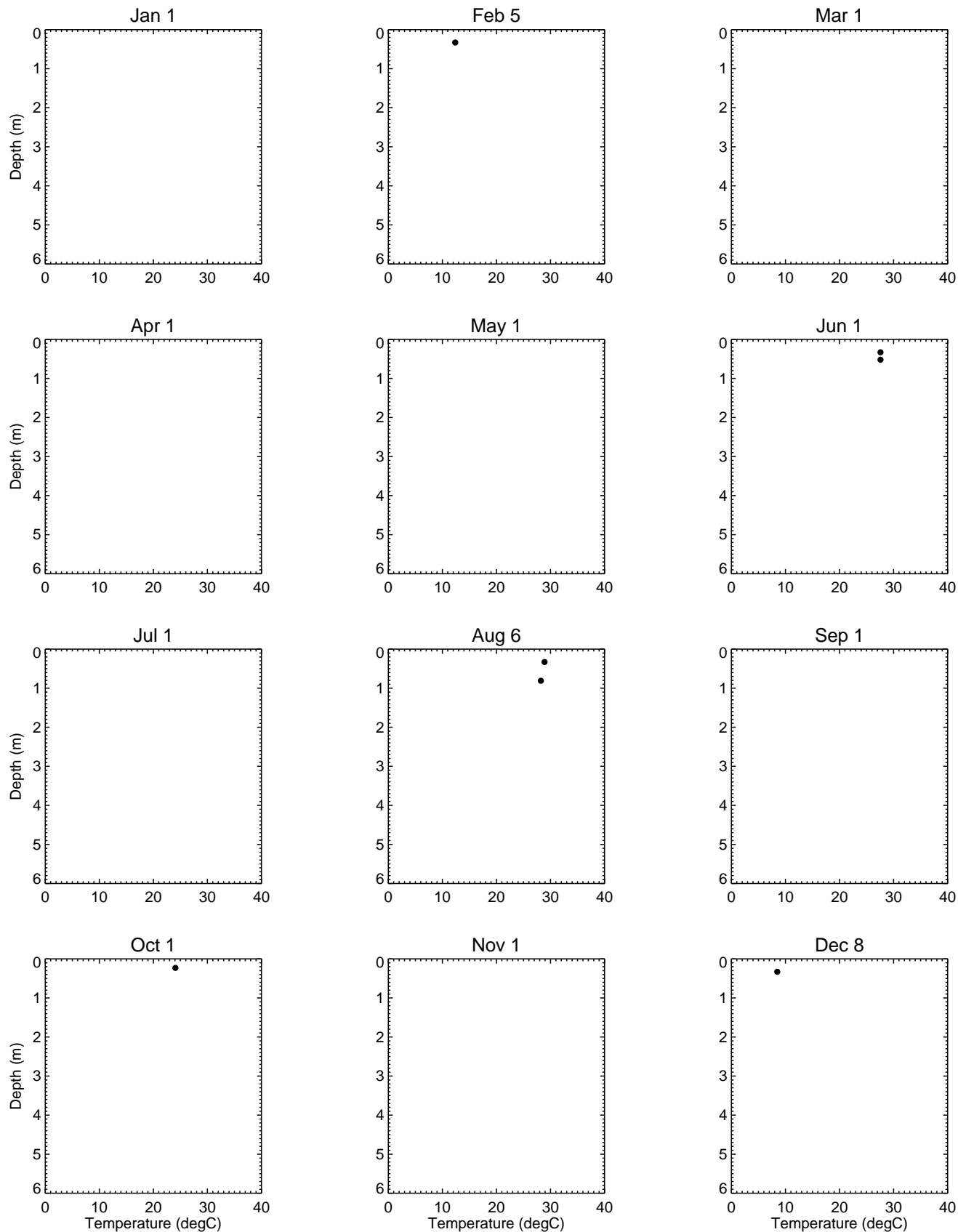*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 1986

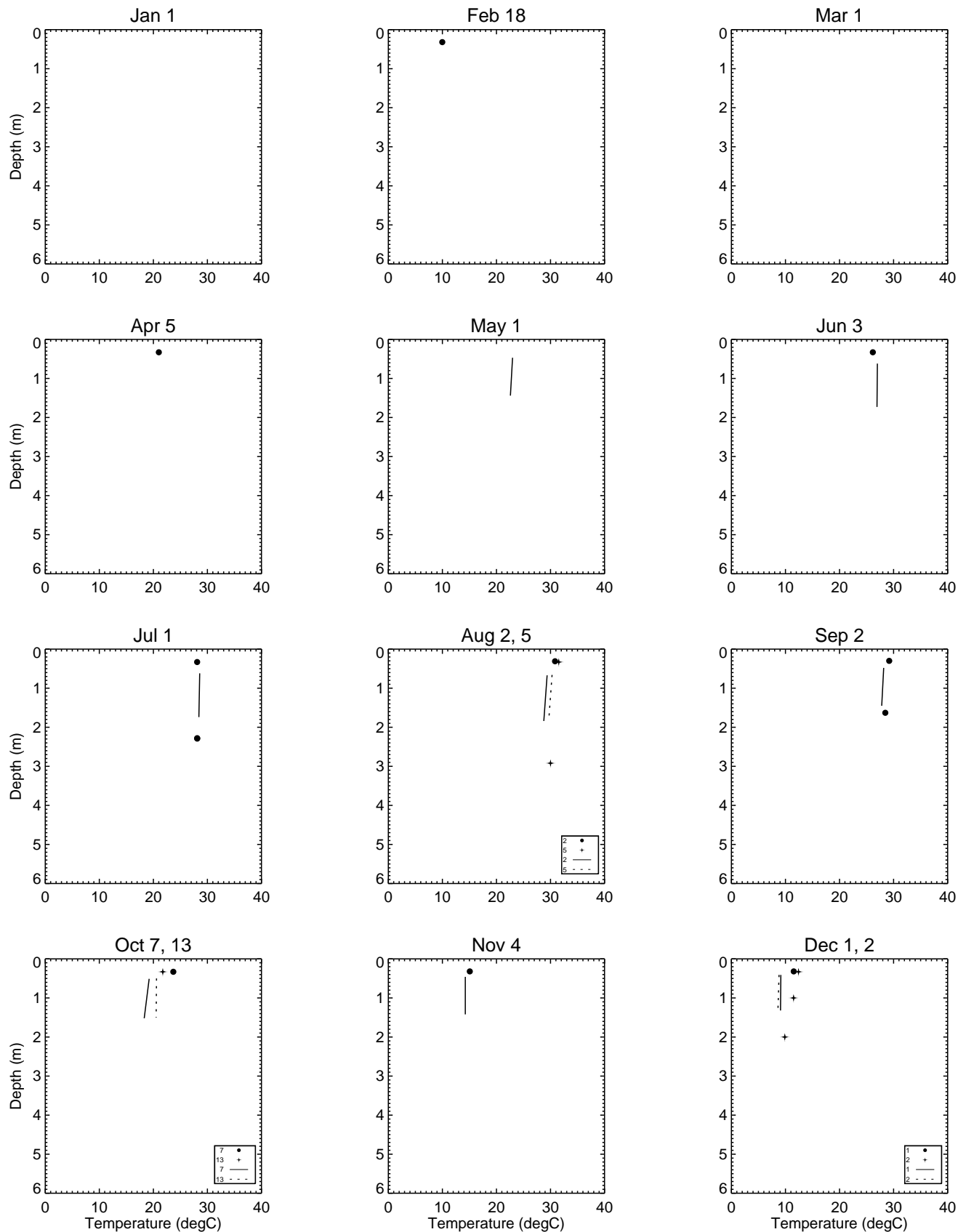*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 1987

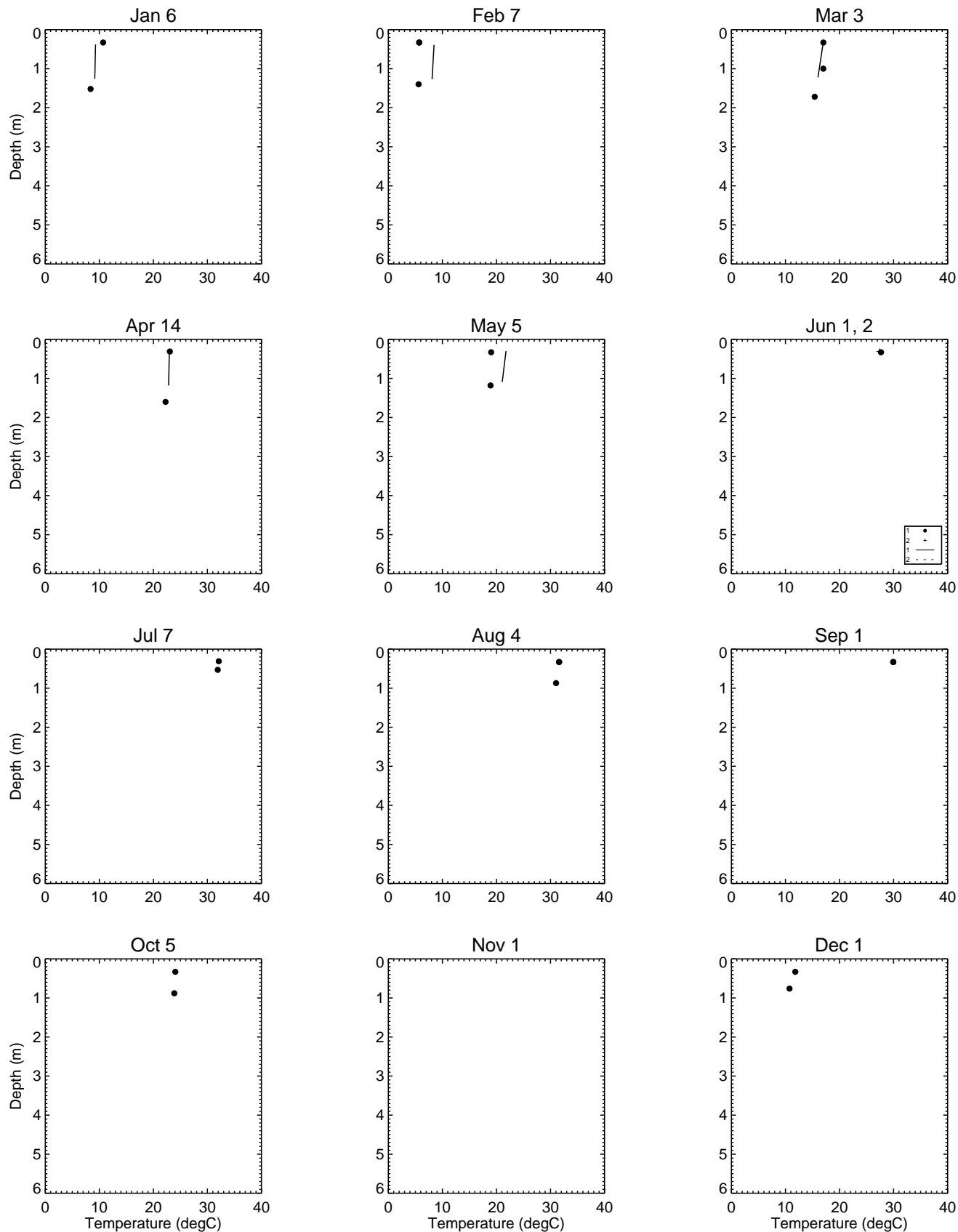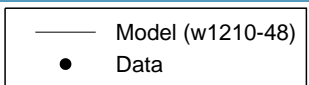*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 1988

Profiles shown for dates with available data else model results for first day of month shown.
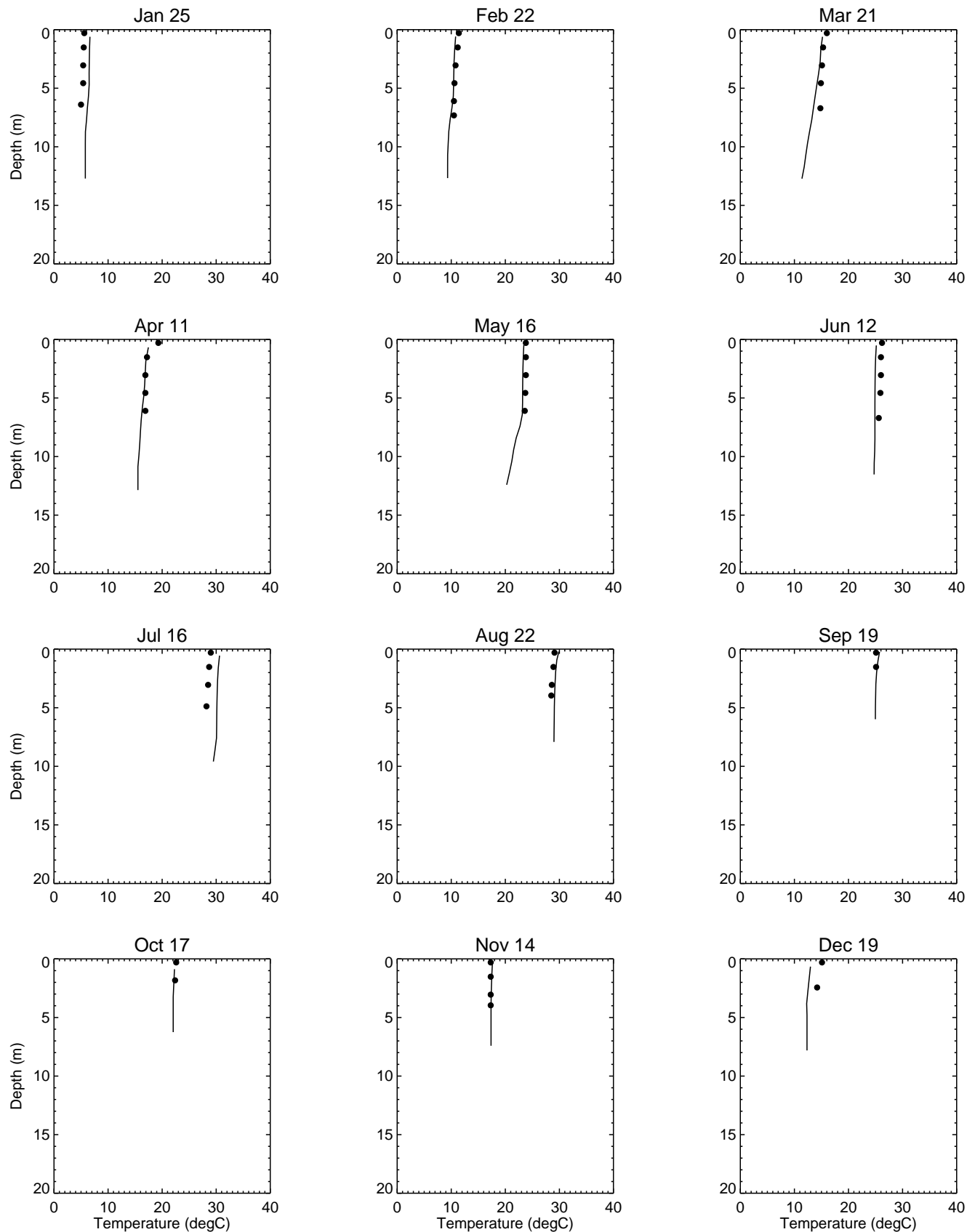
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 10 — Feb 20 — Mar 14 — Apr 18 — May 15 — Jun 22 — Jul 1 — Aug 21 — Sep 1 — Oct 19 — Nov 1 — Dec 21

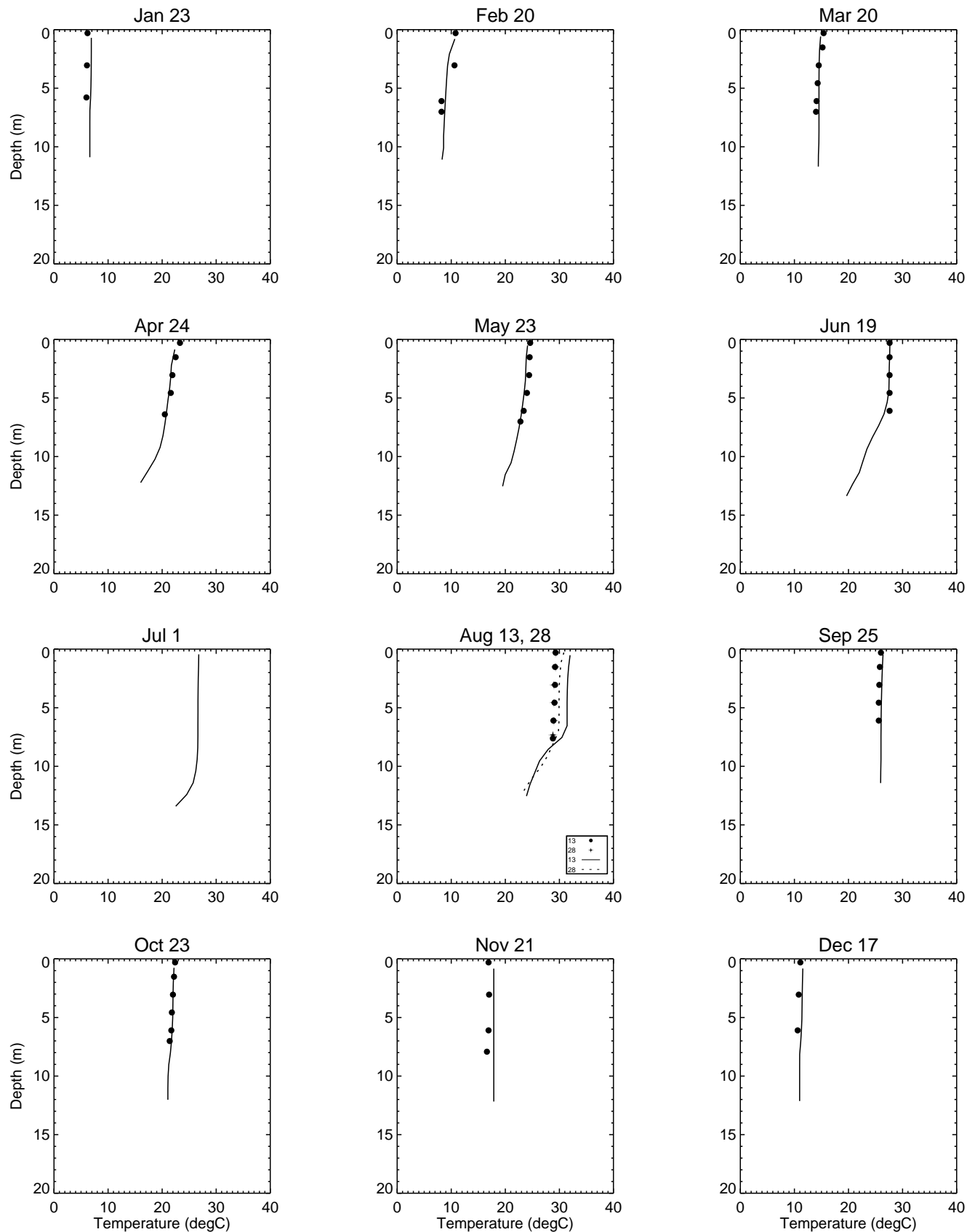Depth (m) vs Temperature (degC)

Model (w1210-48)
• Data

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 1989

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:57 2013

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 1990

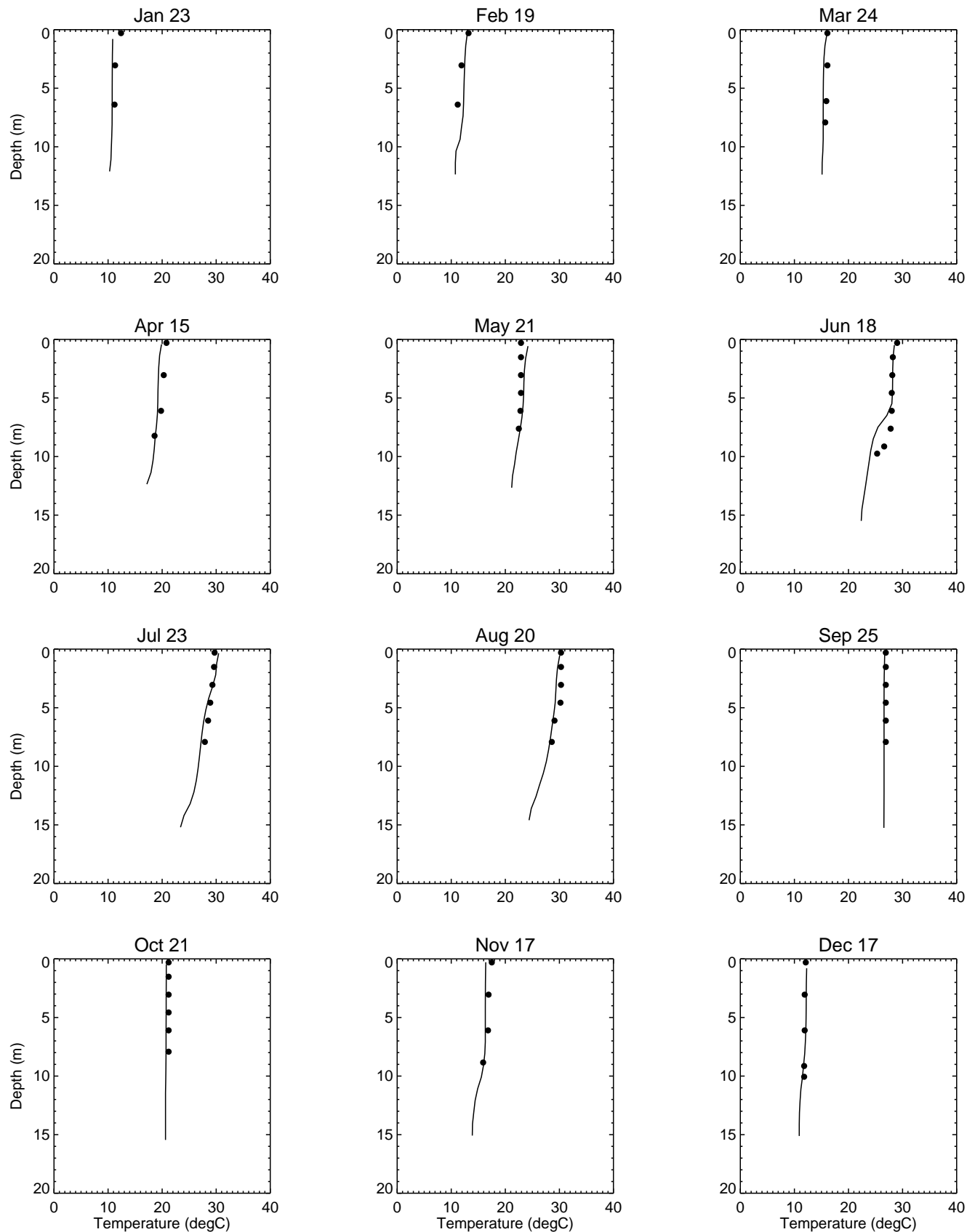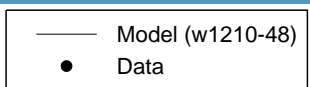*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 1991

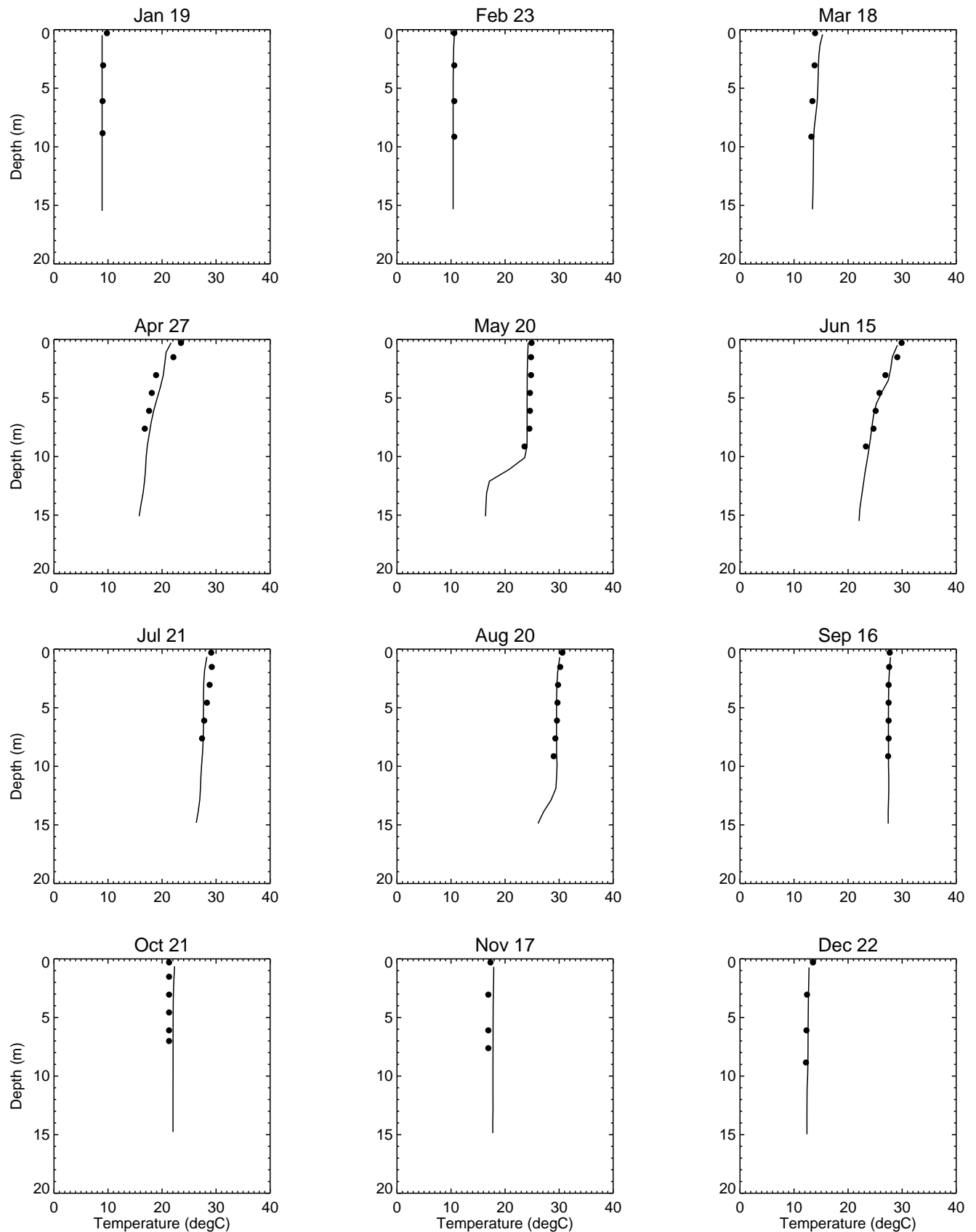*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 1993

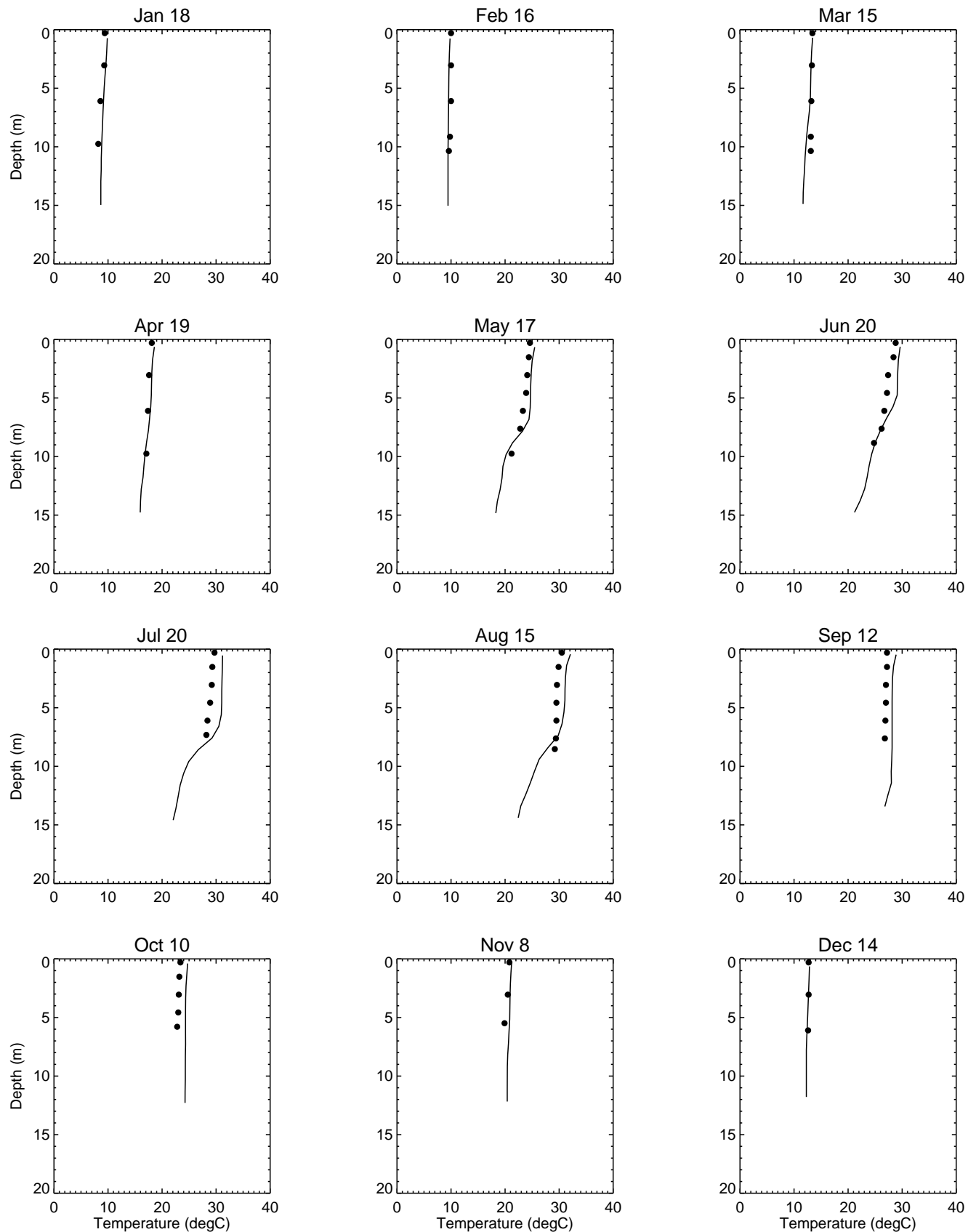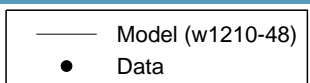*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 1994

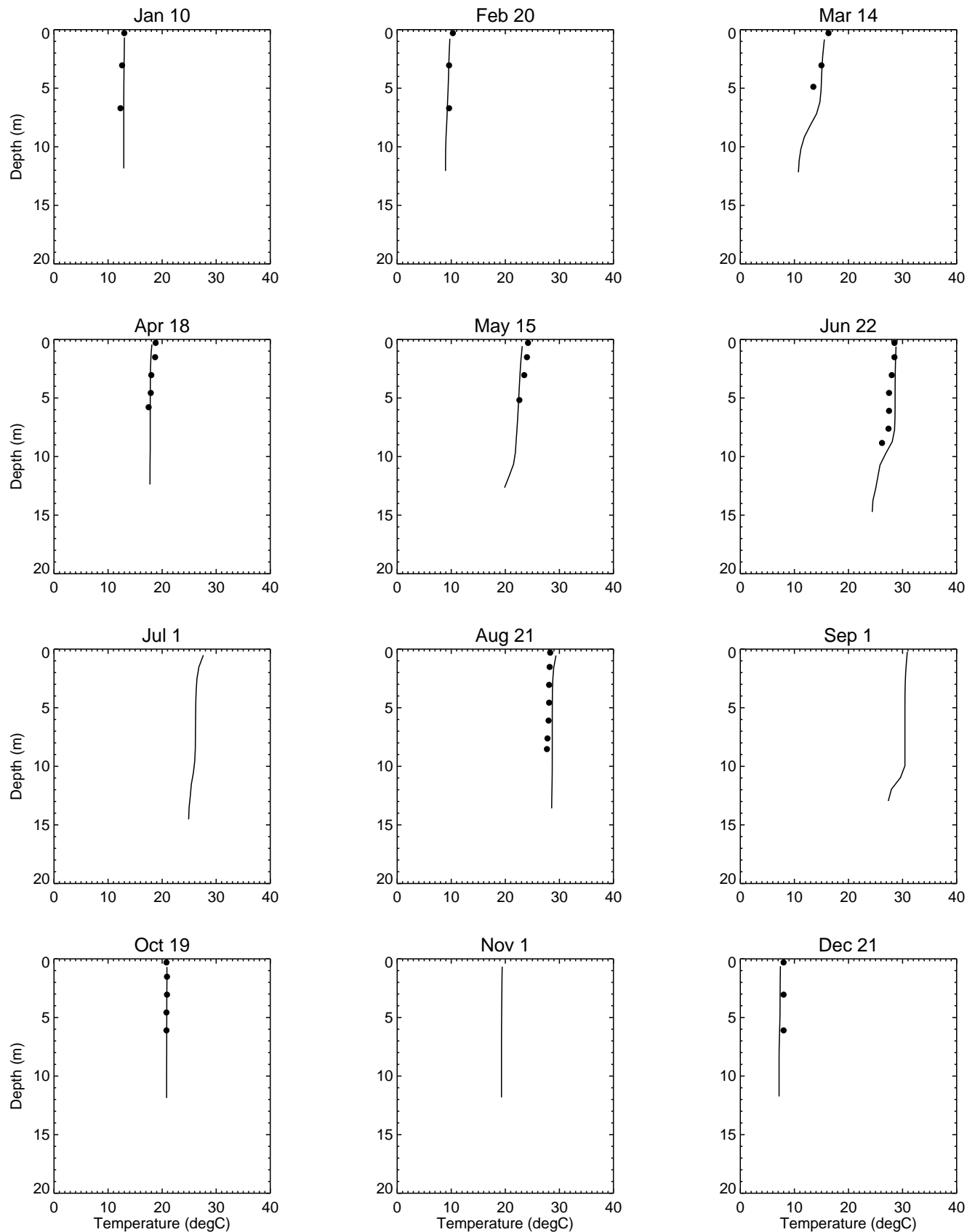*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
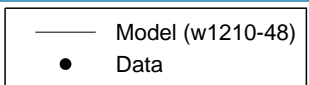Fri Jan 25 18:12:58 2013

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 1995

Profiles shown for dates with available data else model results for first day of month shown.

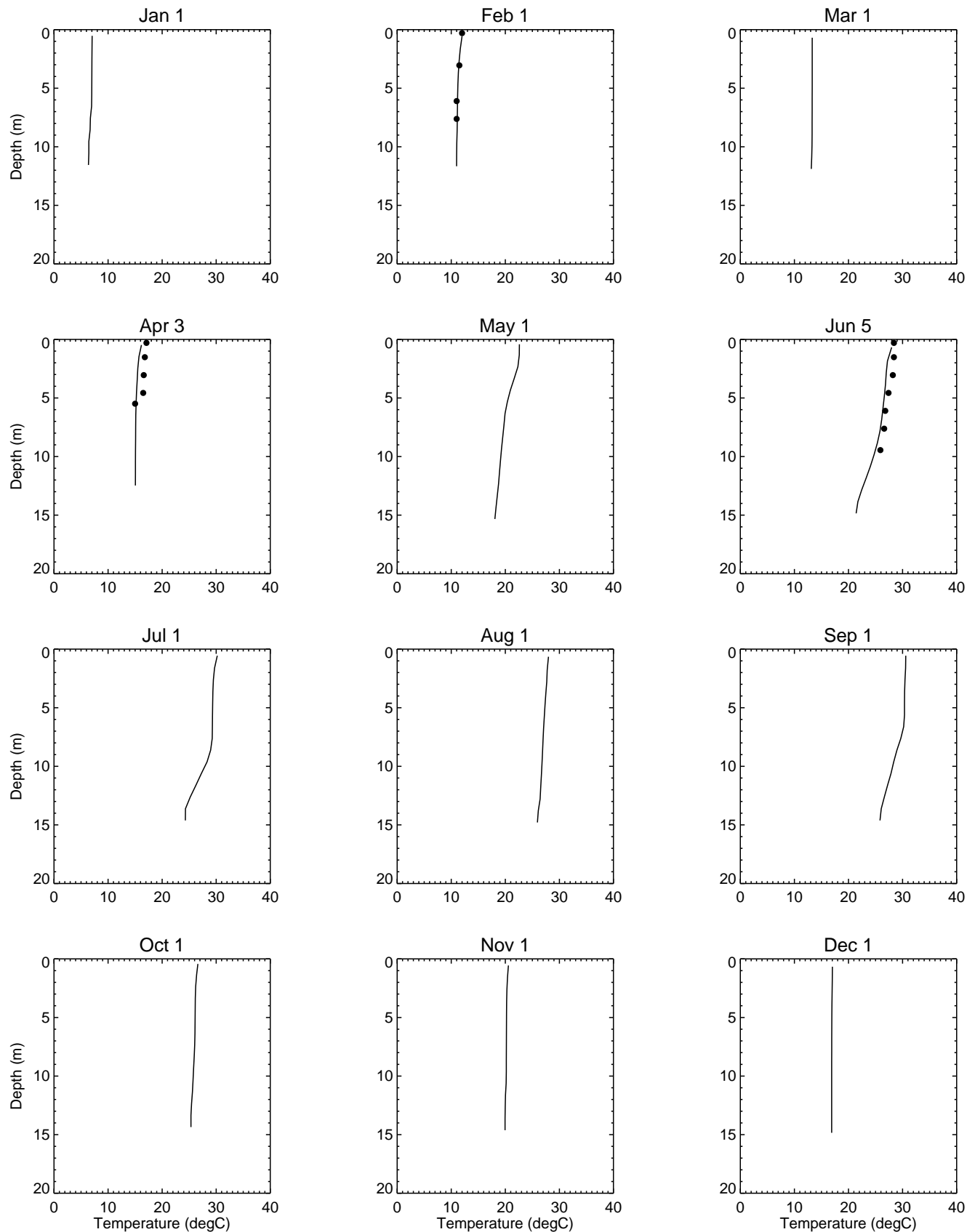CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 1996

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 1997

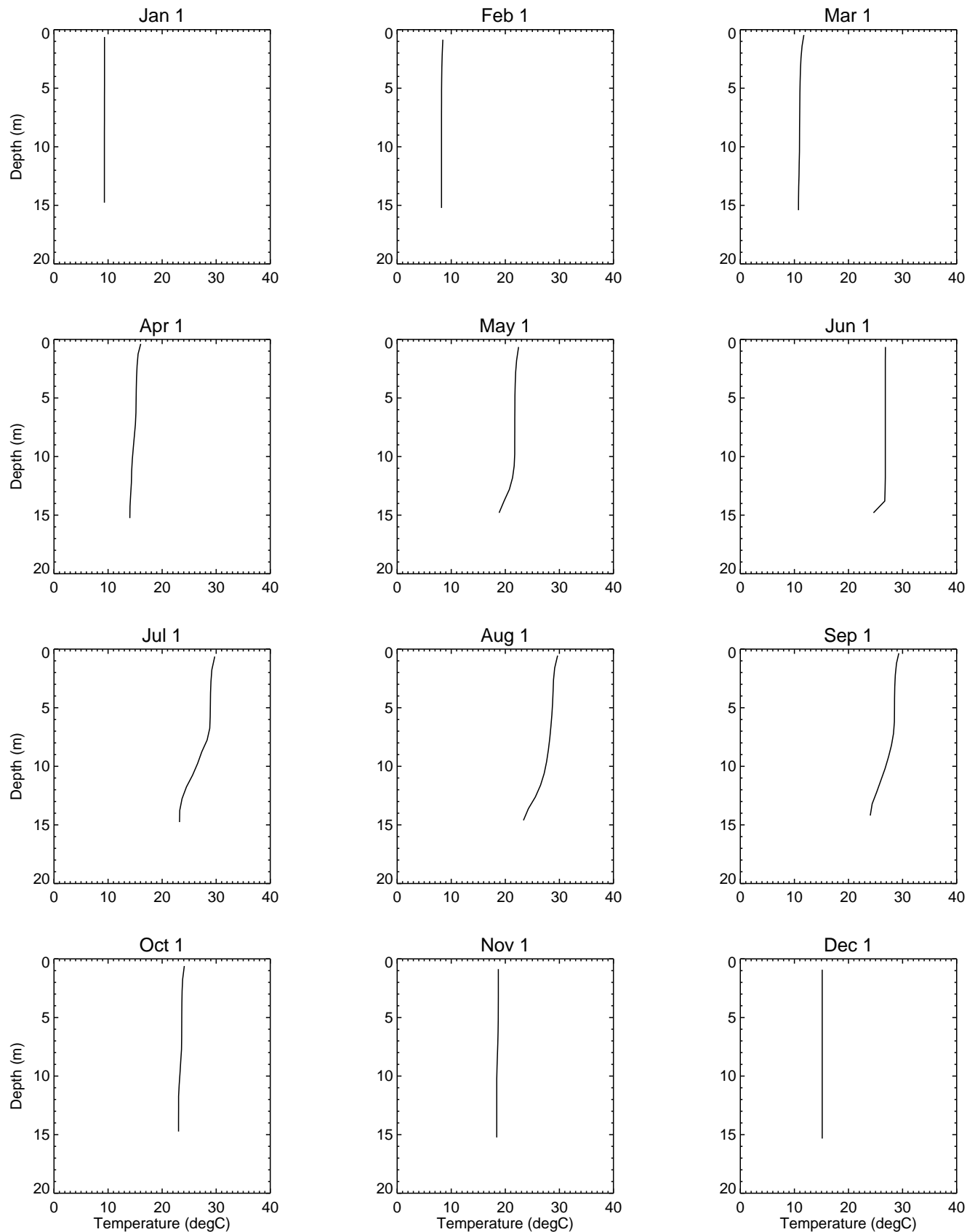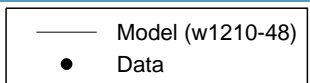*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 1998

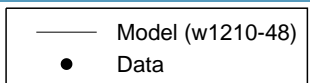*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 1999

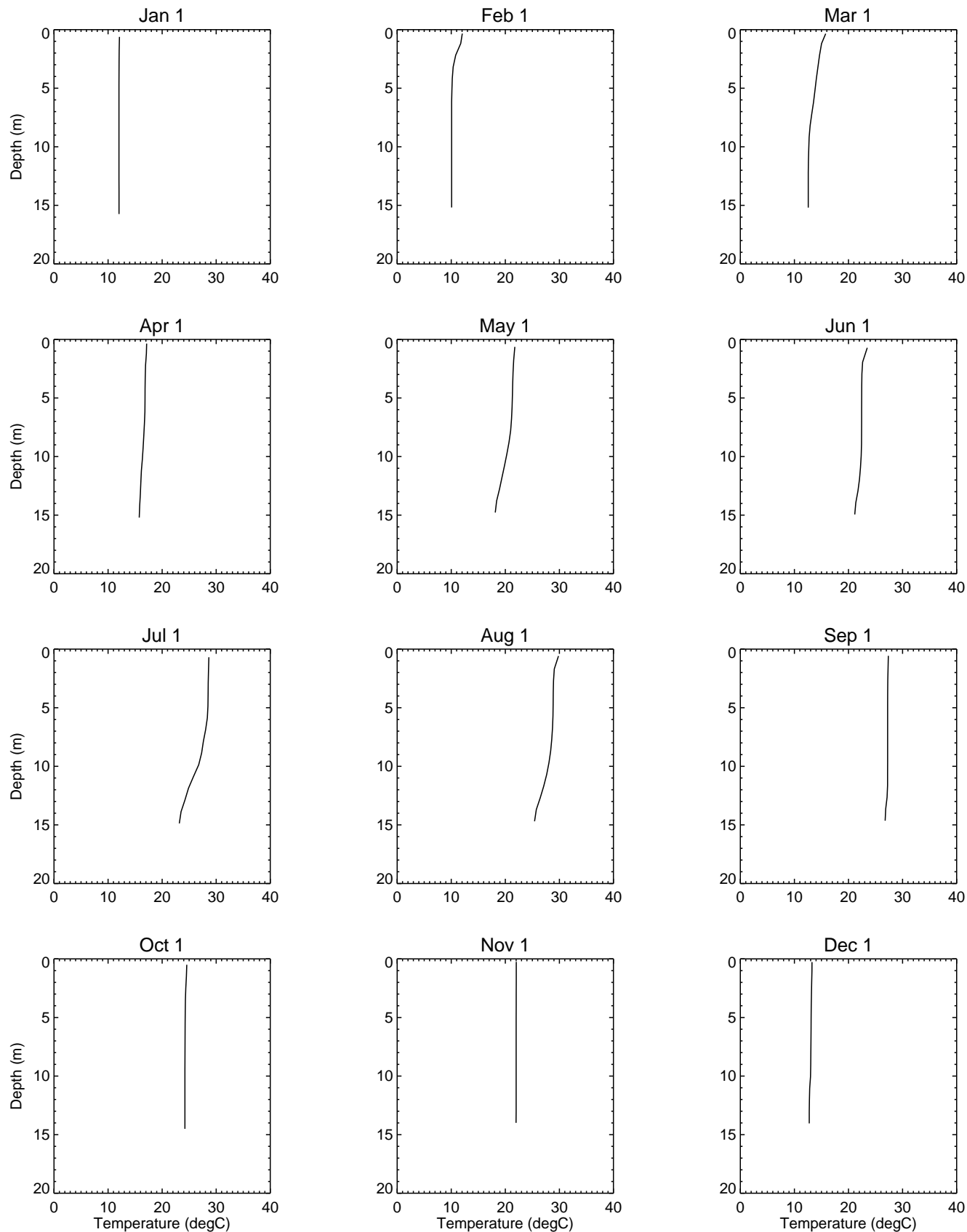*Profiles shown for dates with available data else model results for first day of month shown.*

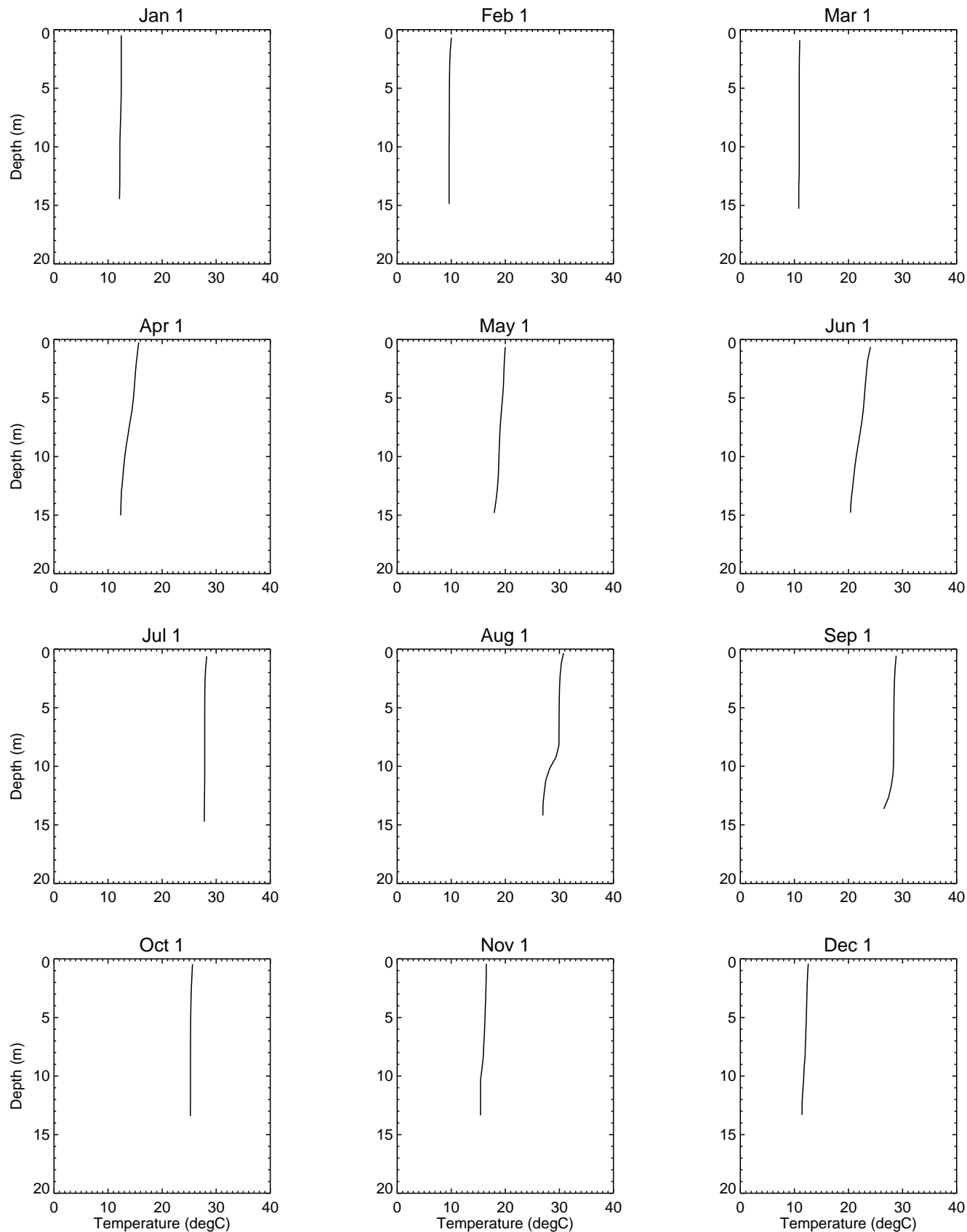CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 2000

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 2001

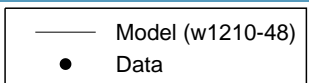*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:58 2013

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 2002

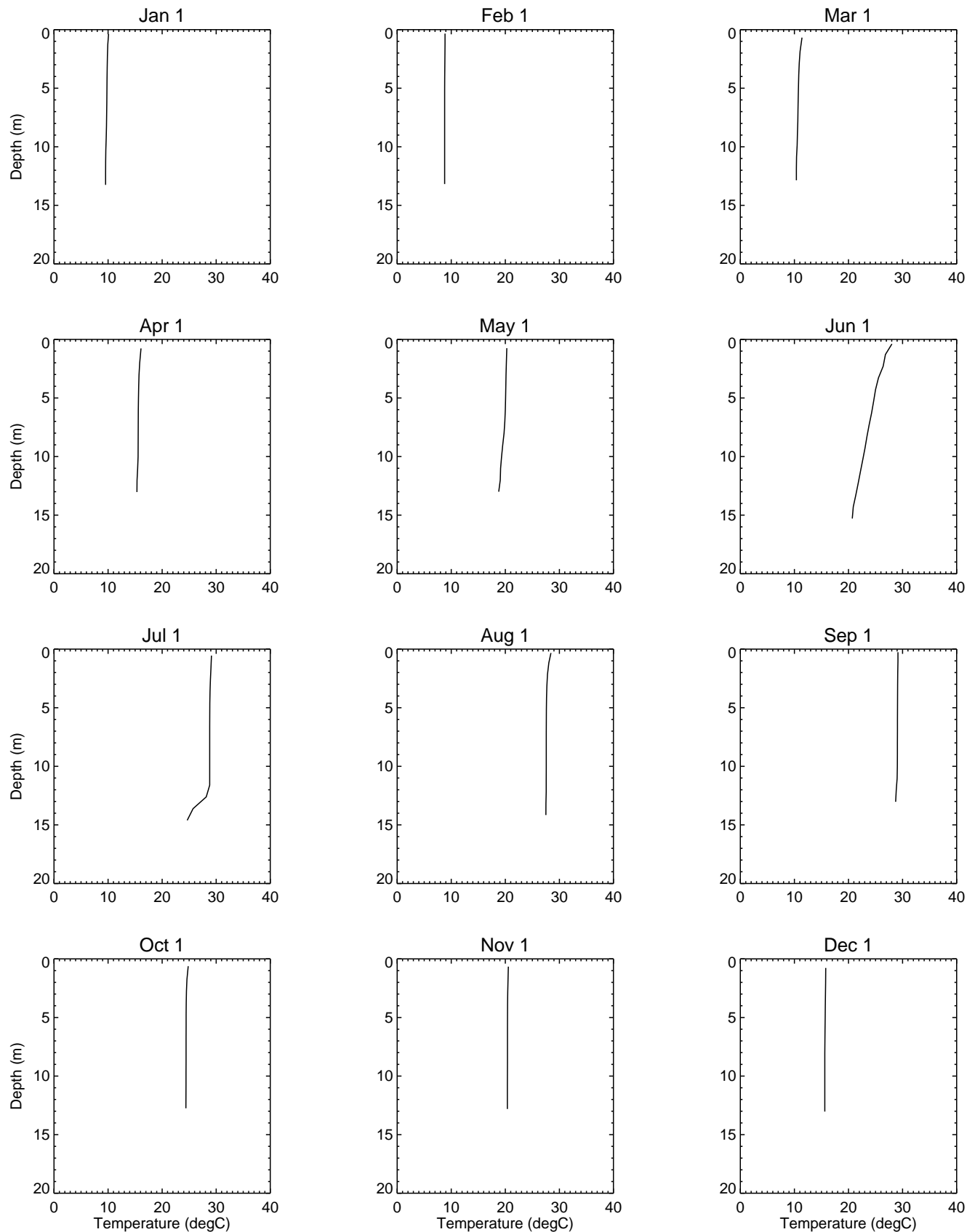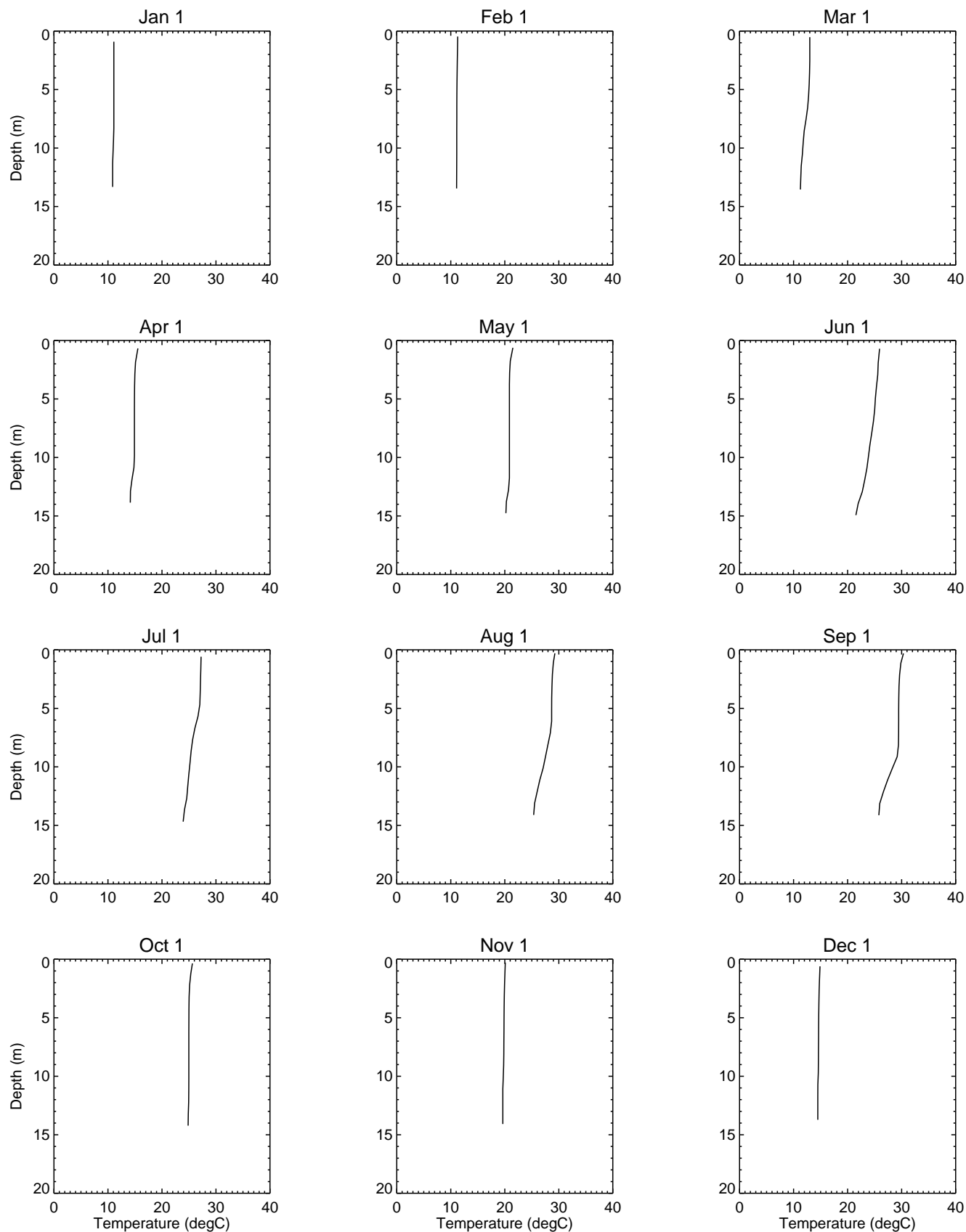*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 2003

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 2004

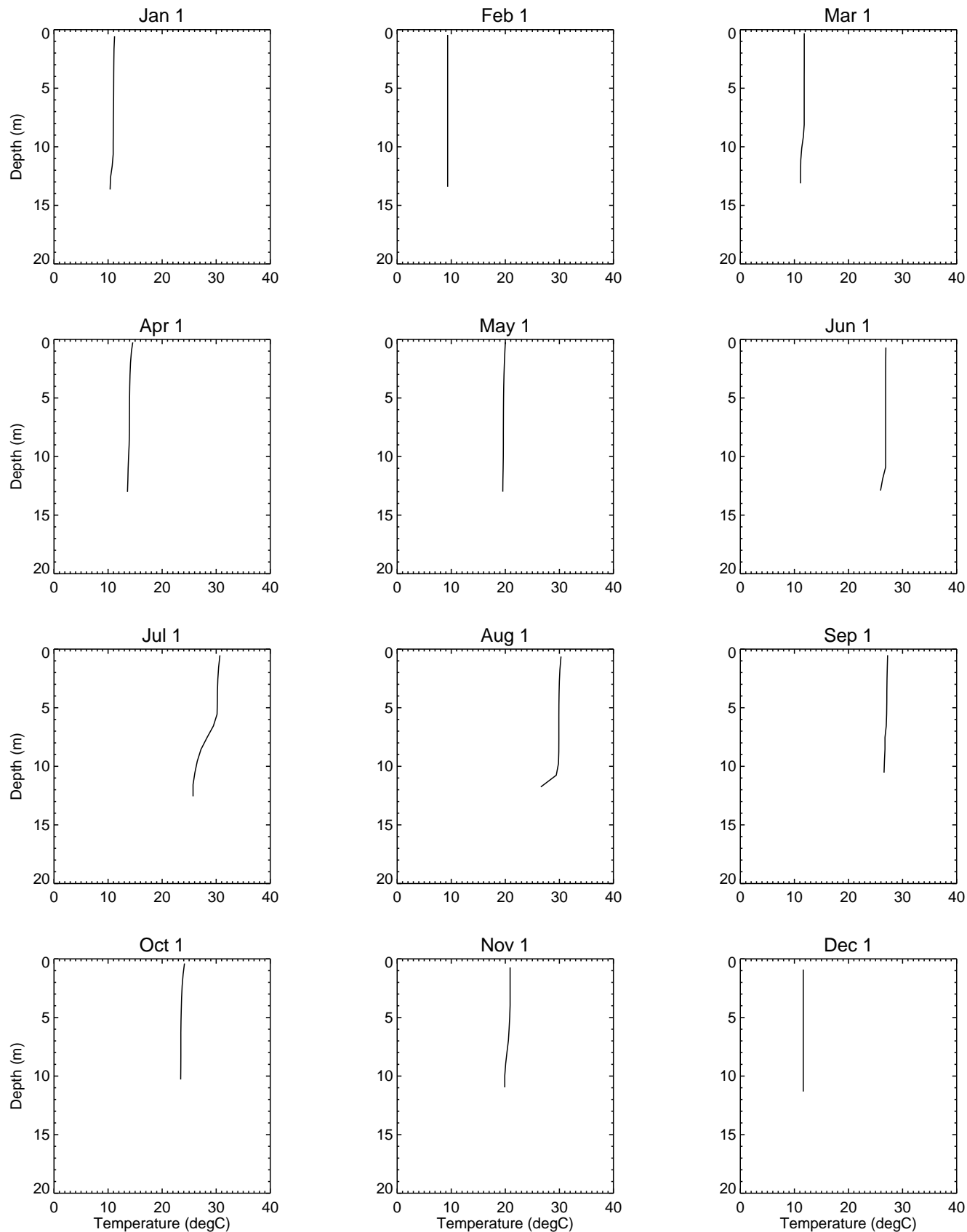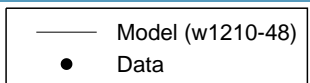*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 2005

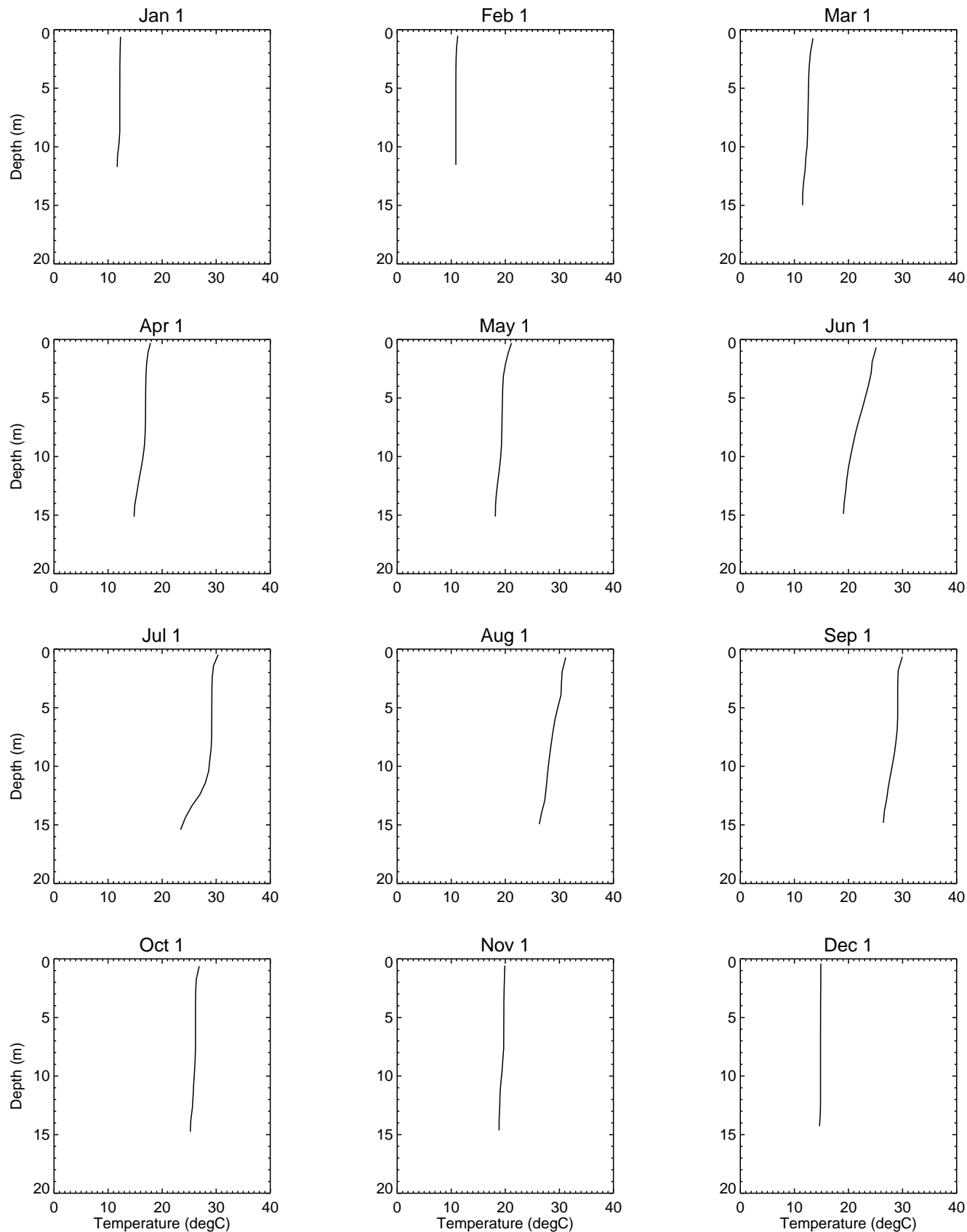*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 2006

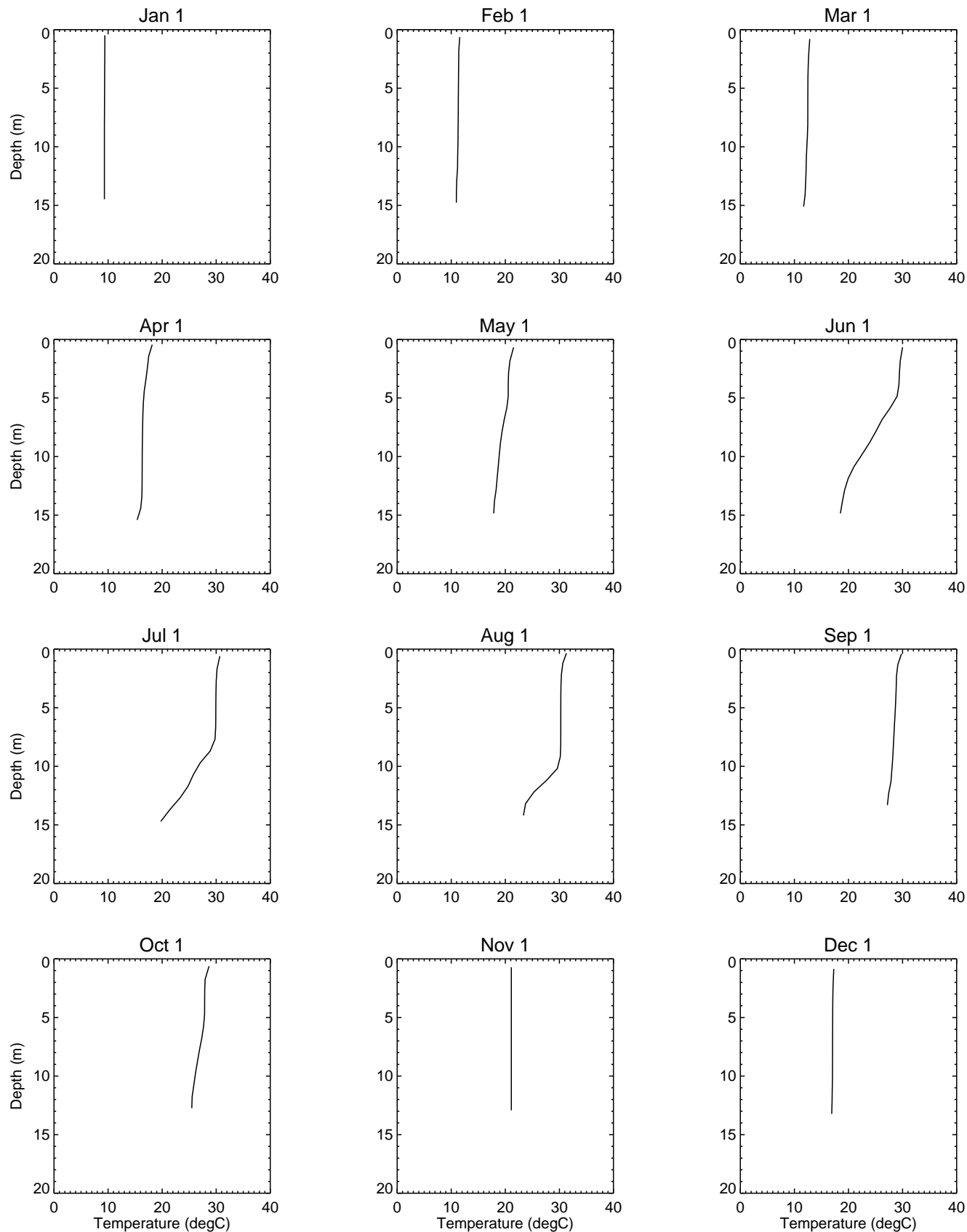*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 2007

Profiles shown for dates with available data else model results for first day of month shown.

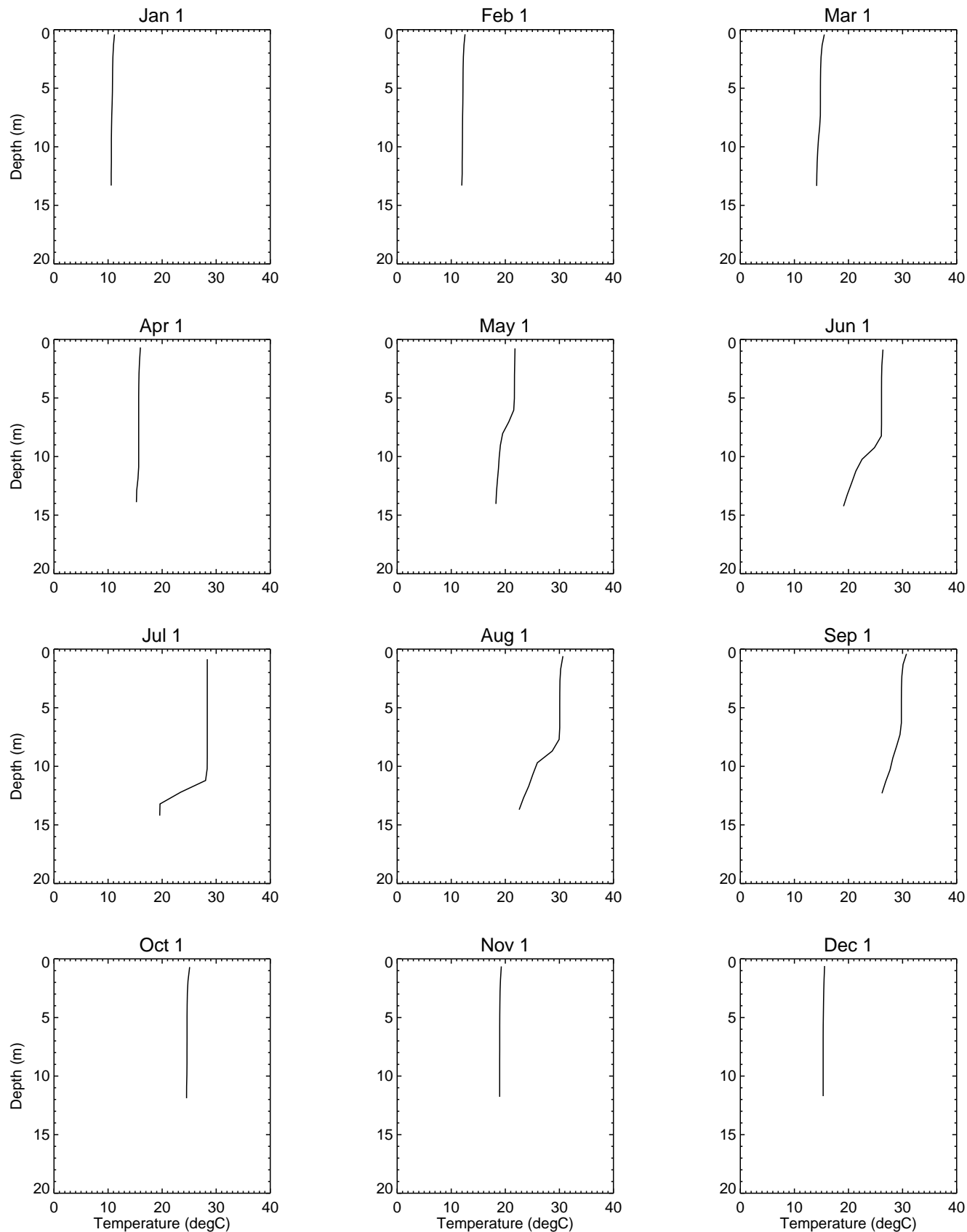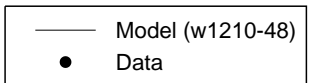CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 2008

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 2009

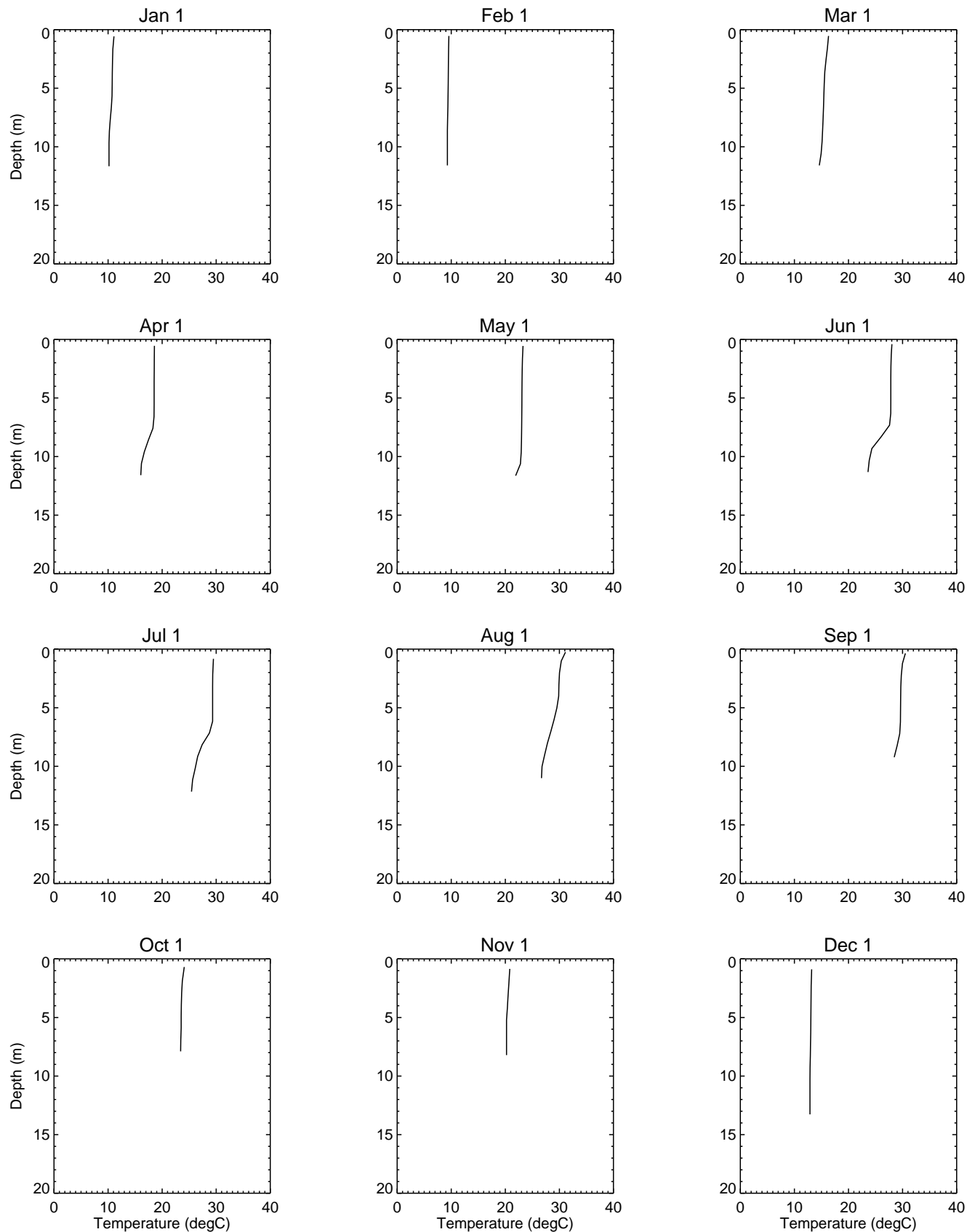*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 2010

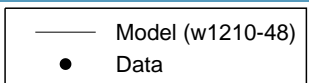*Profiles shown for dates with available data else model results for first day of month shown.*

——— Model (w1210-48)

● Data

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-1

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Temperature - 2011

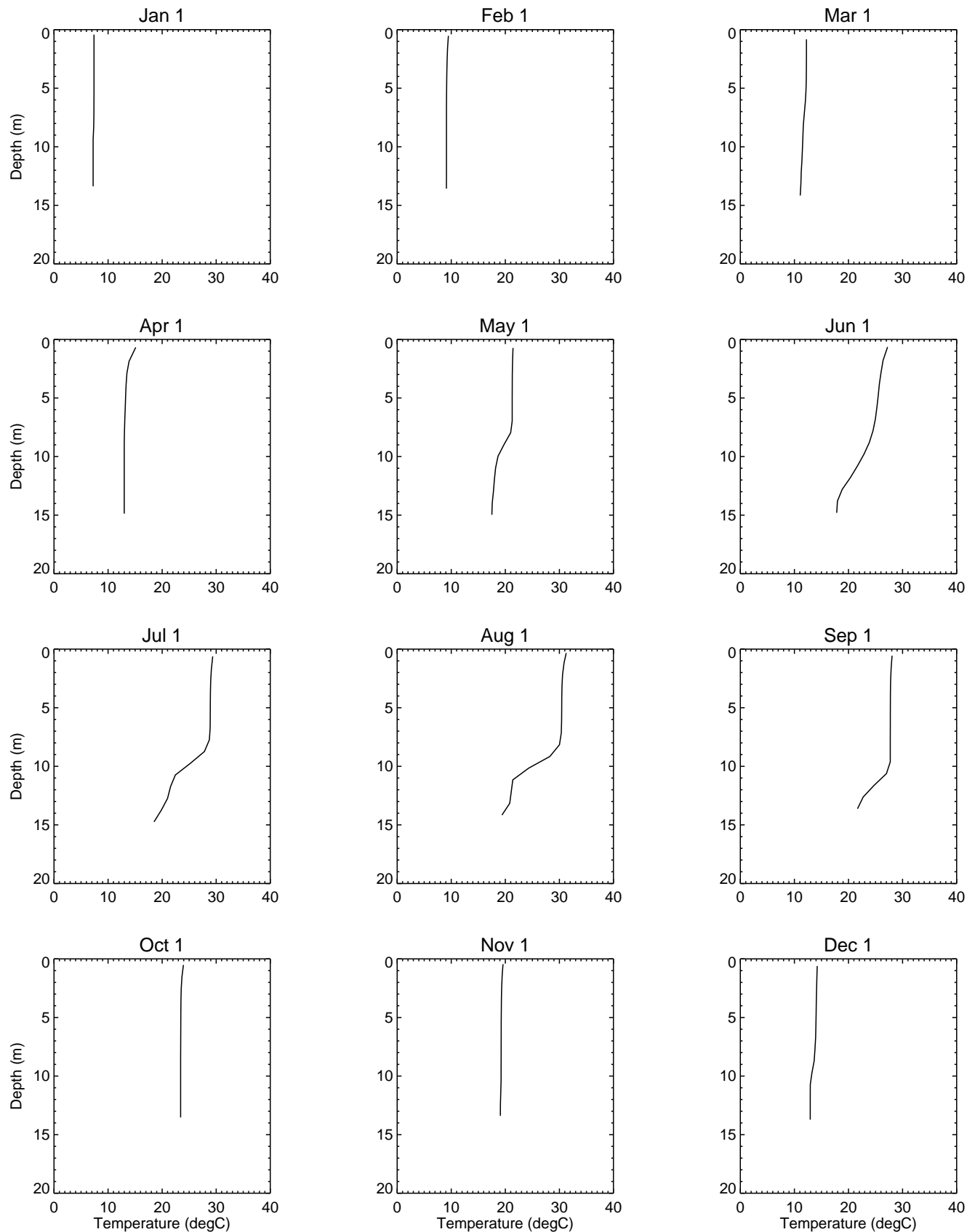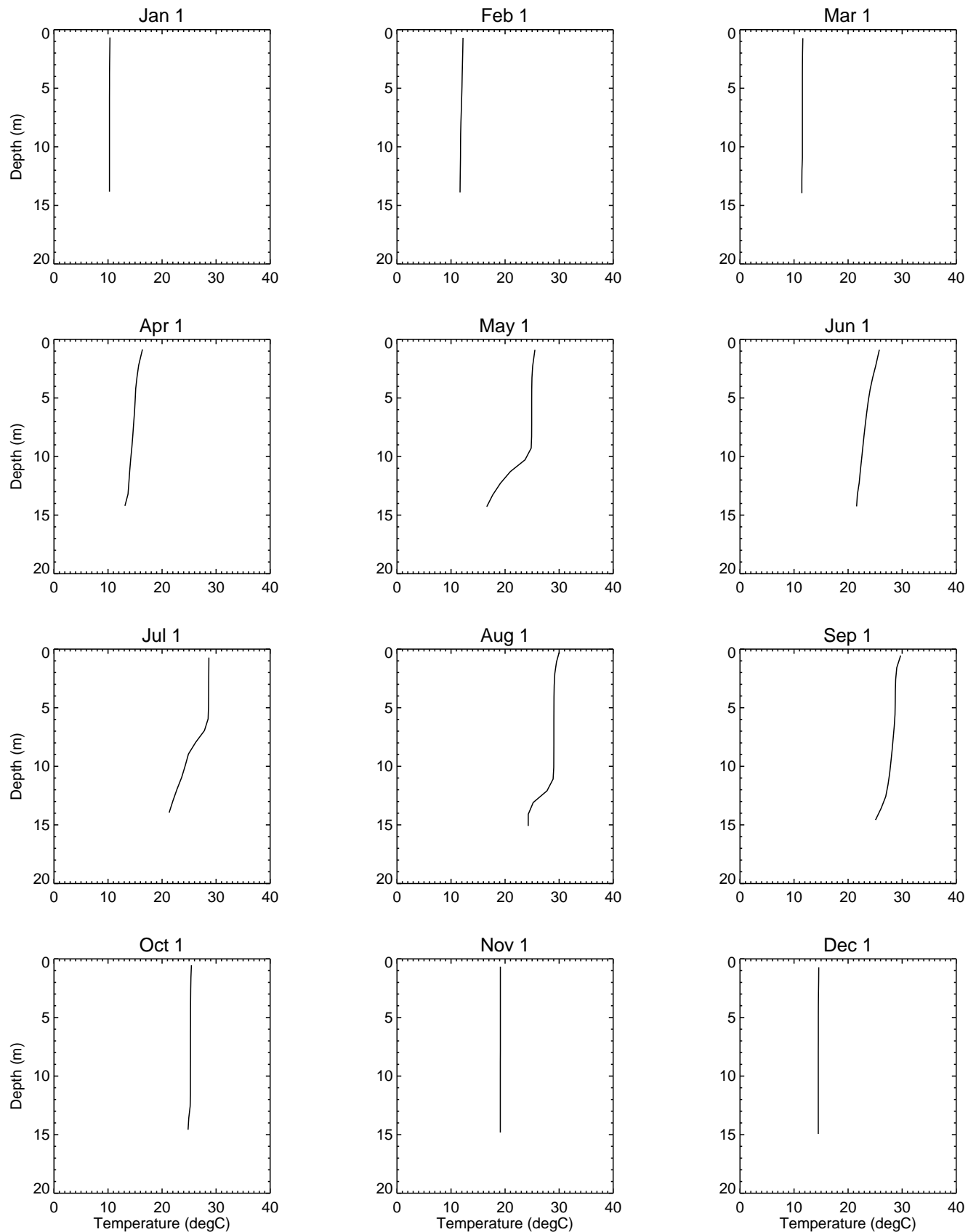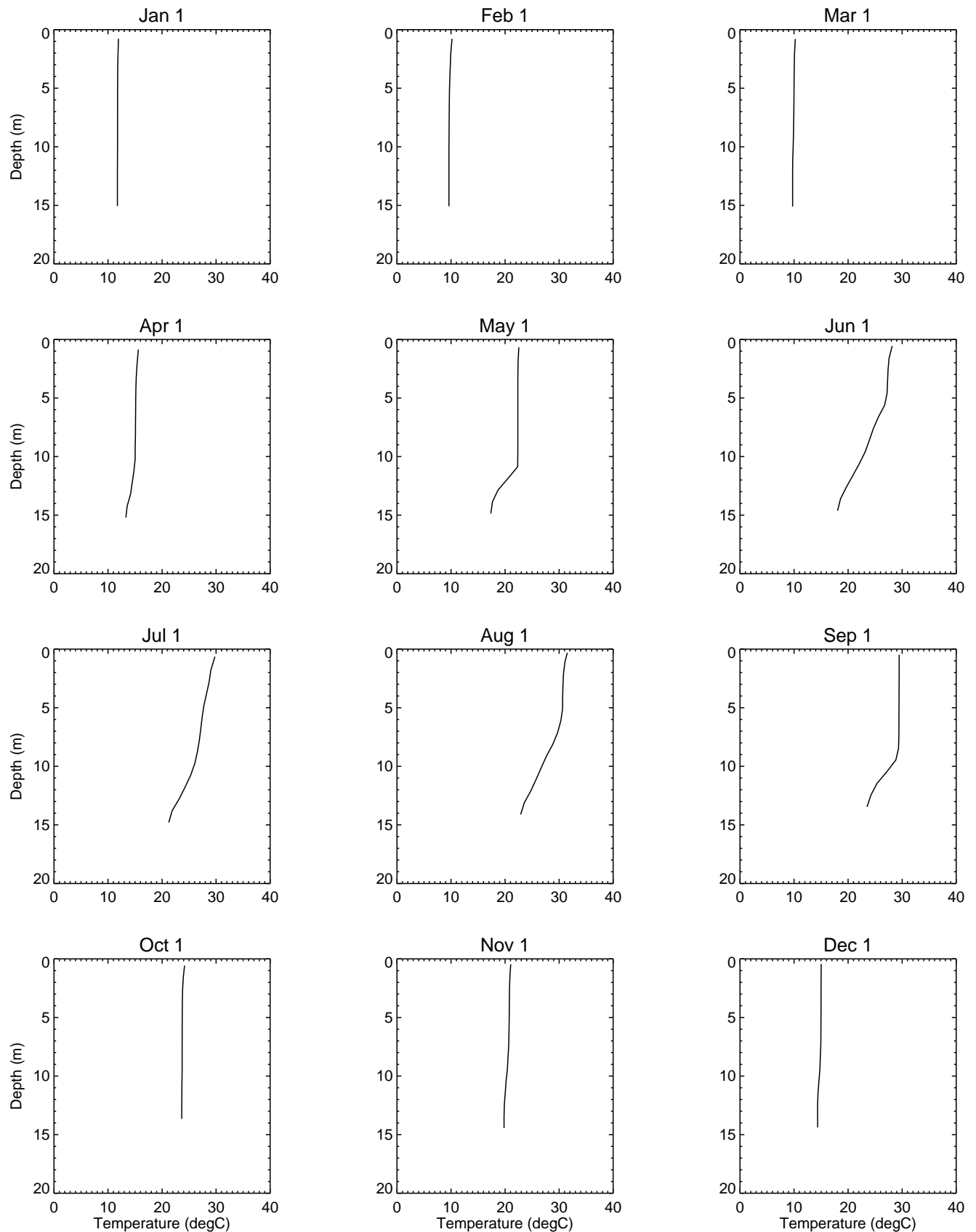*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:58 2013

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 1985

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 1986

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Vertical Profiles of Model Versus Data for Lake Buchanan

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 1987

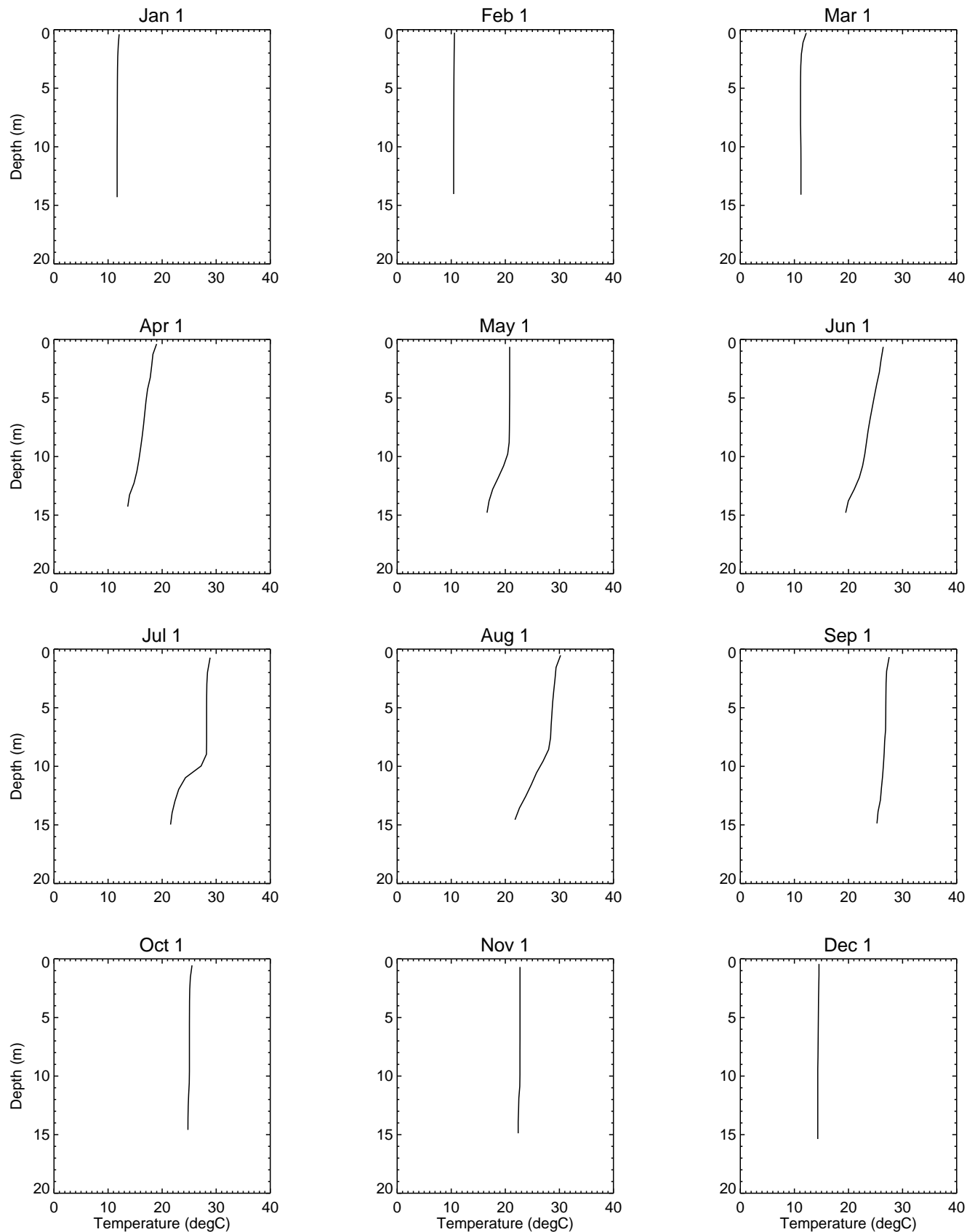*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
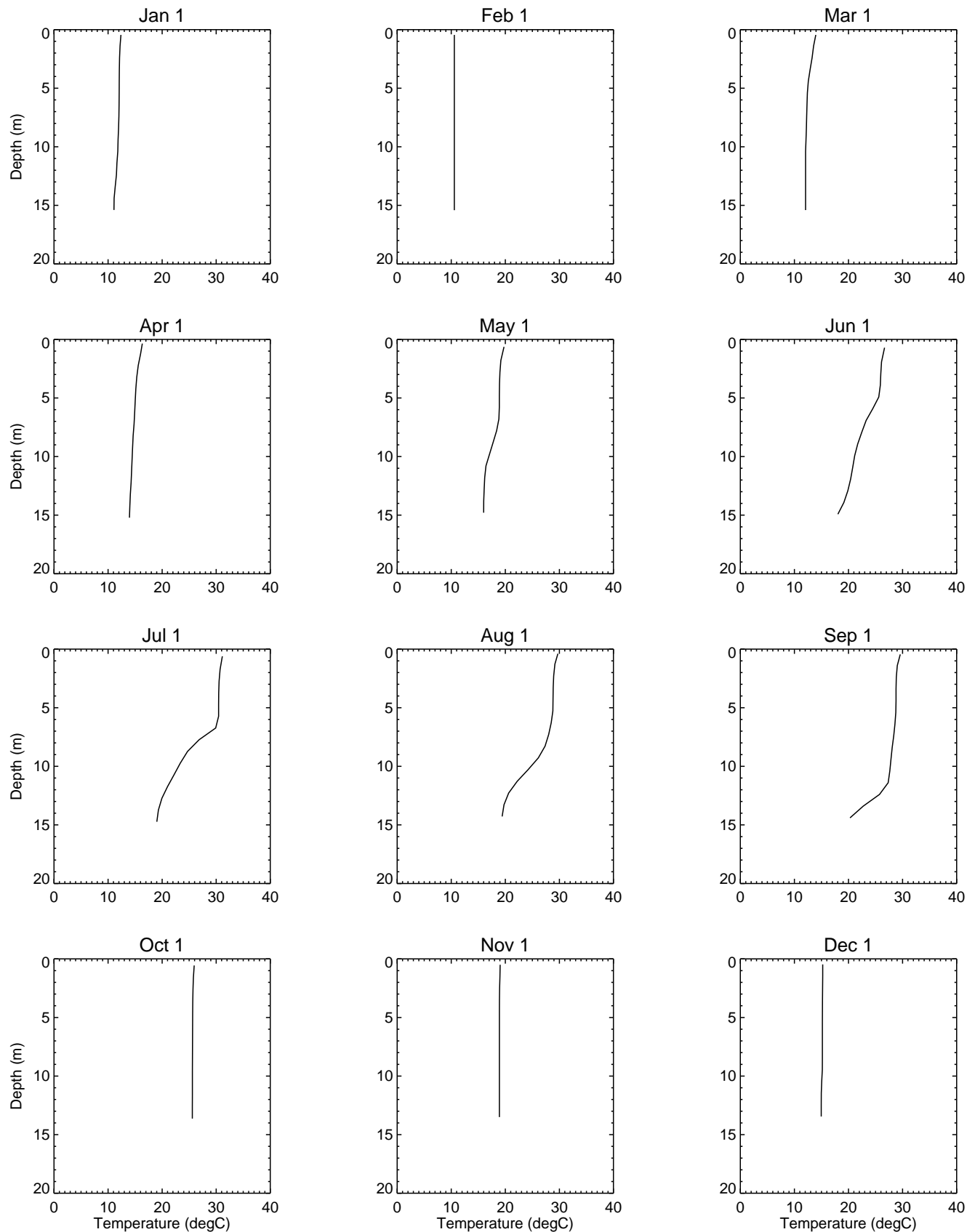Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:01 2013

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 1988

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
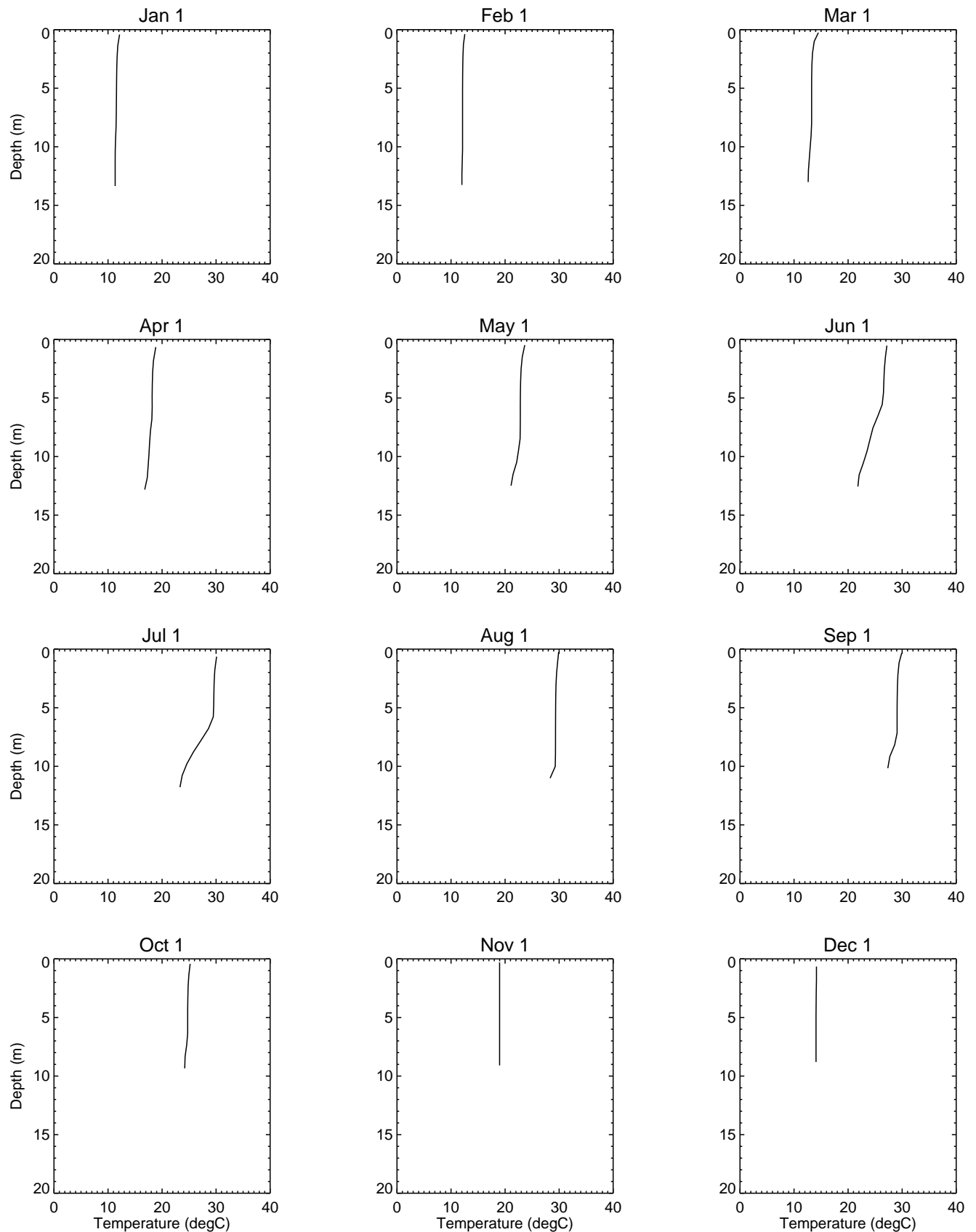
Lower Colorado River Authority

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 1989

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 1990

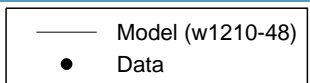*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
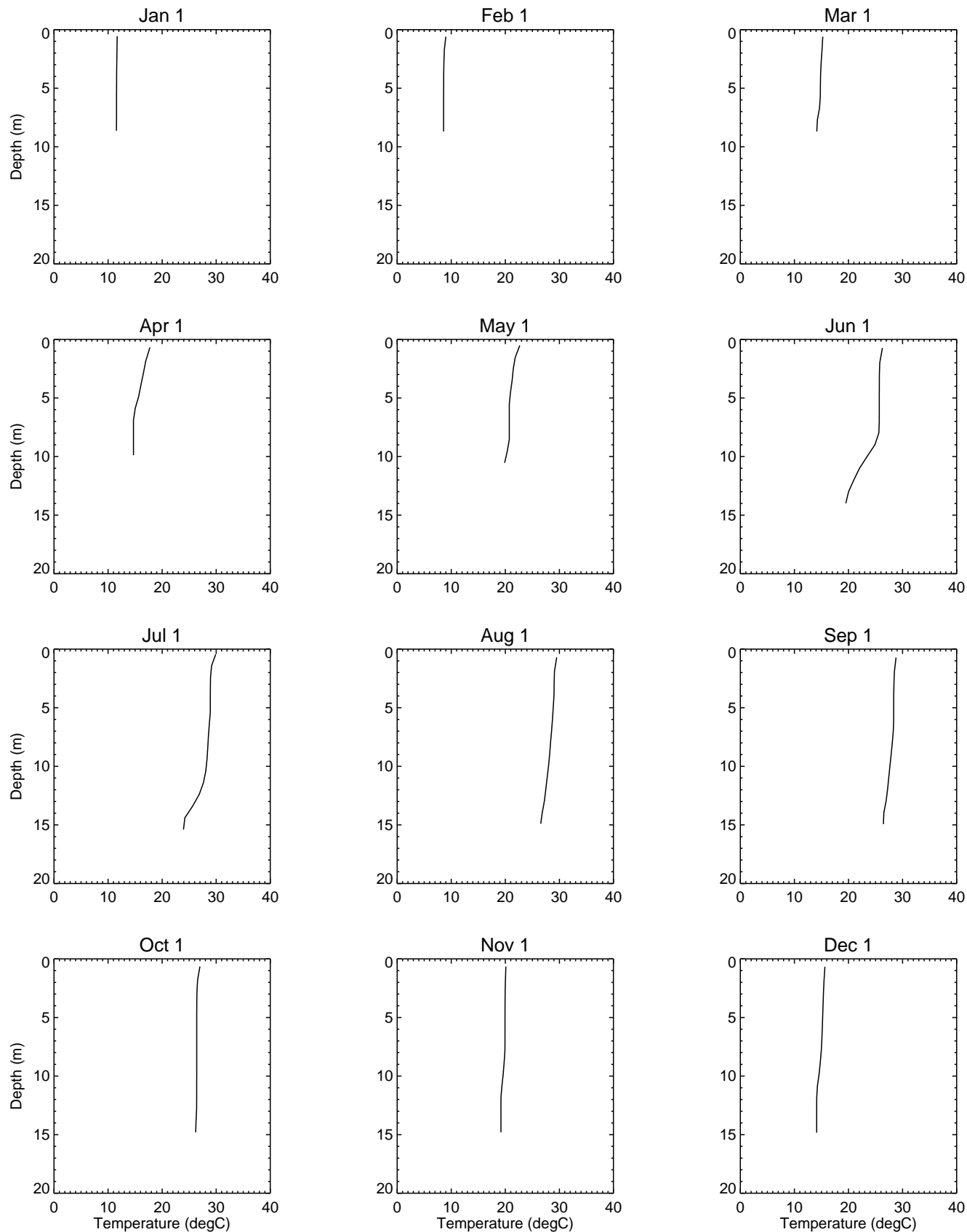
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:01 2013

Model (w1210-48)
● Data

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 1991

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
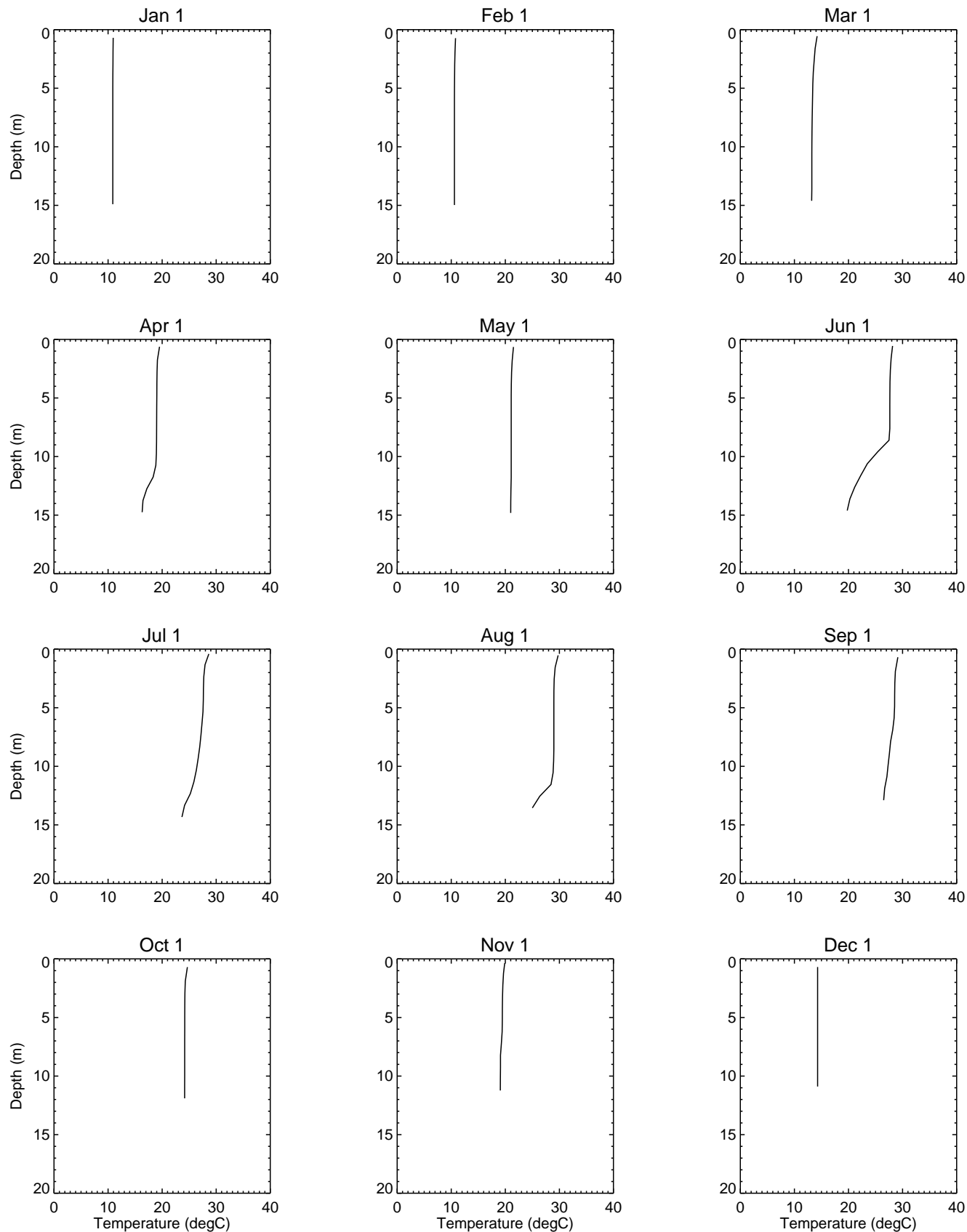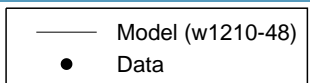
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:01 2013

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
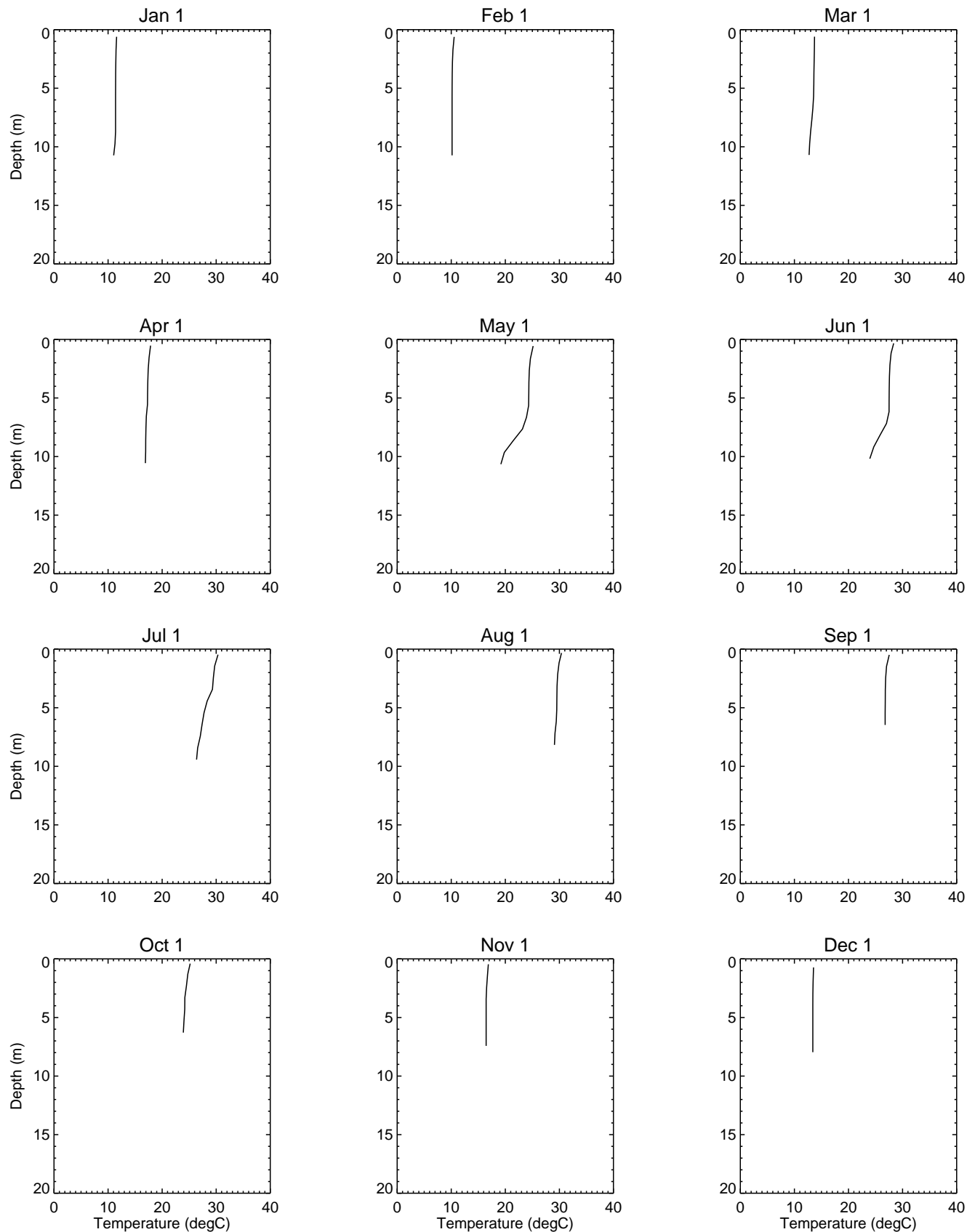Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:01 2013

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 1993

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
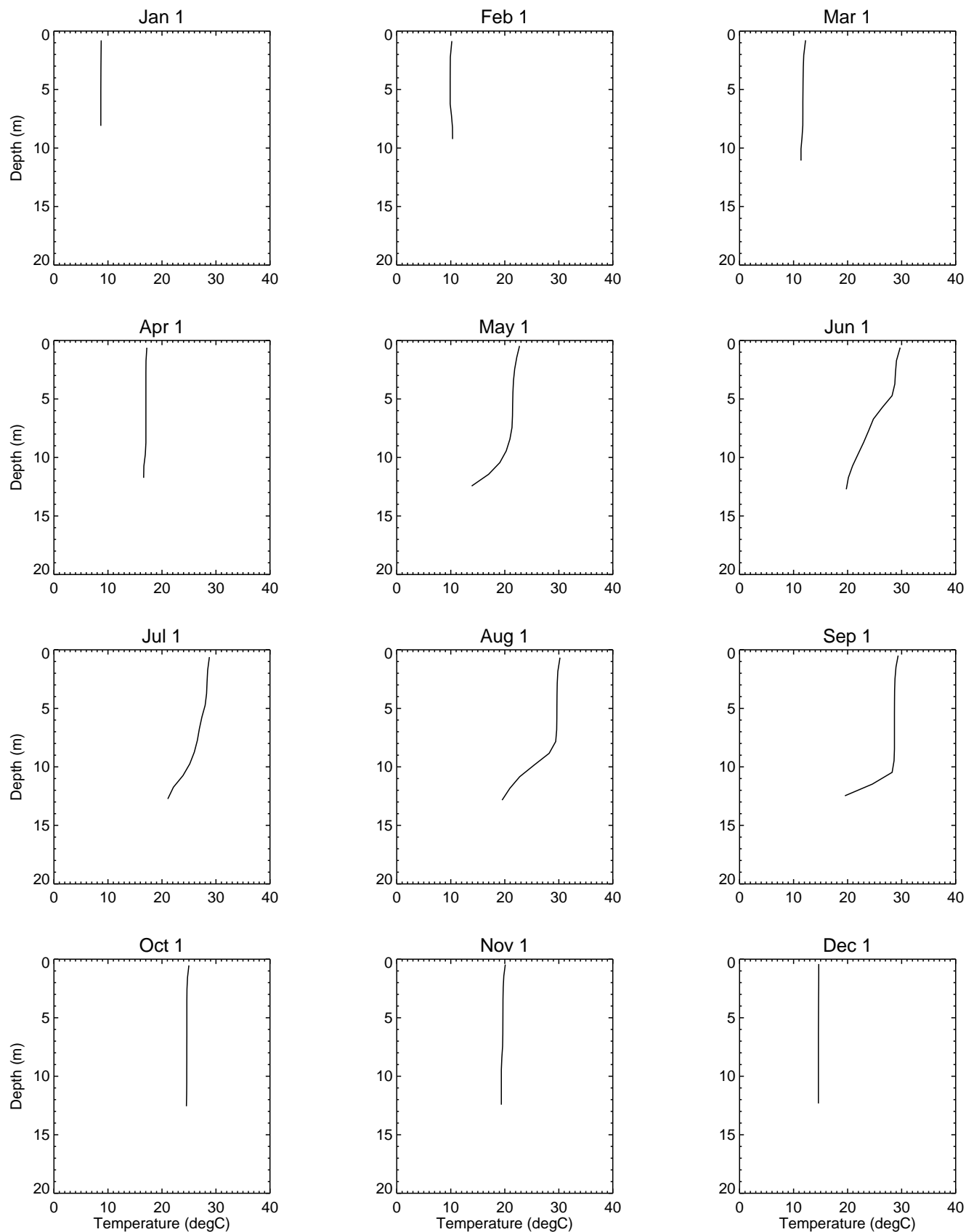
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:01 2013

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 1994

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
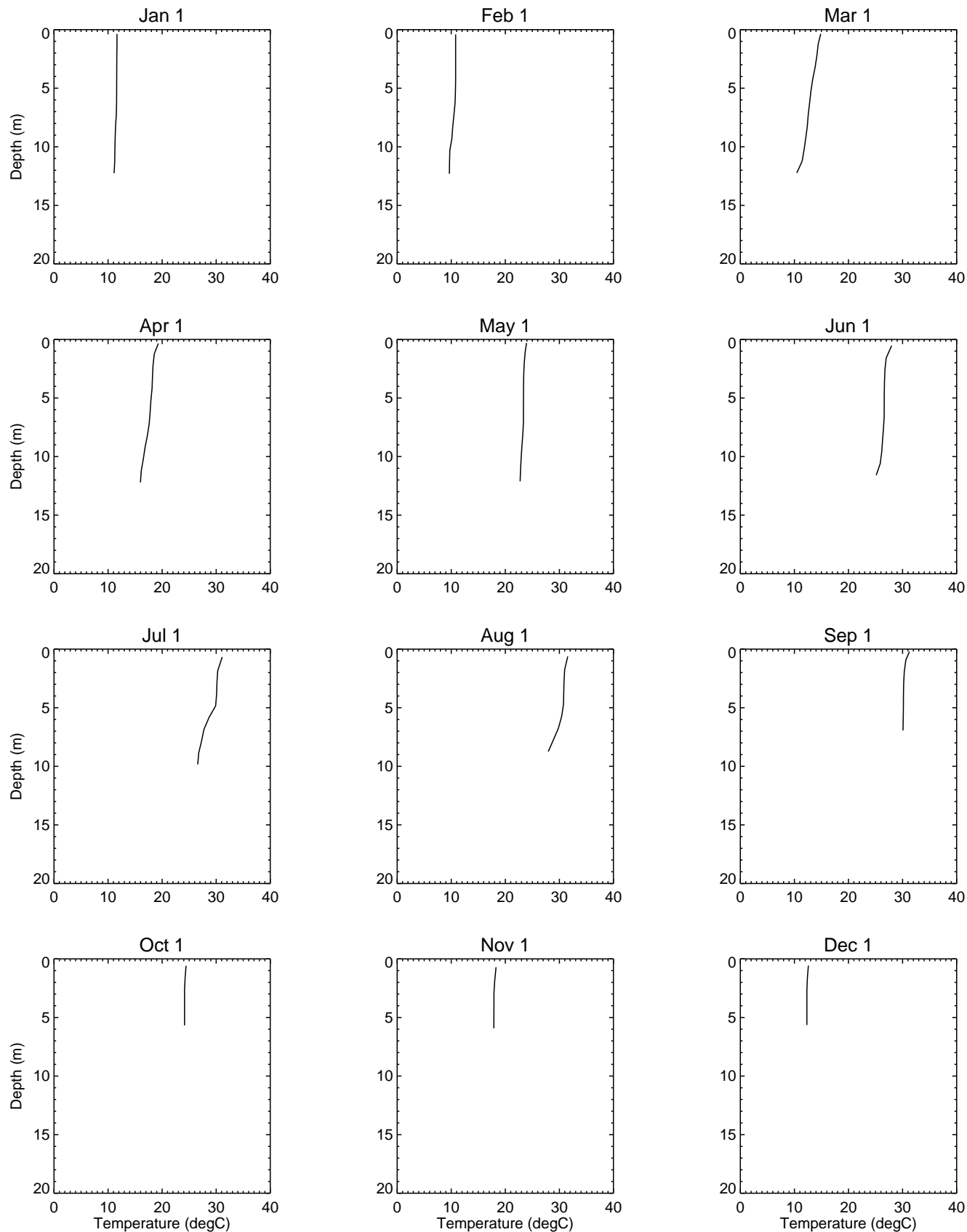
Lower Colorado River Authority

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 1995

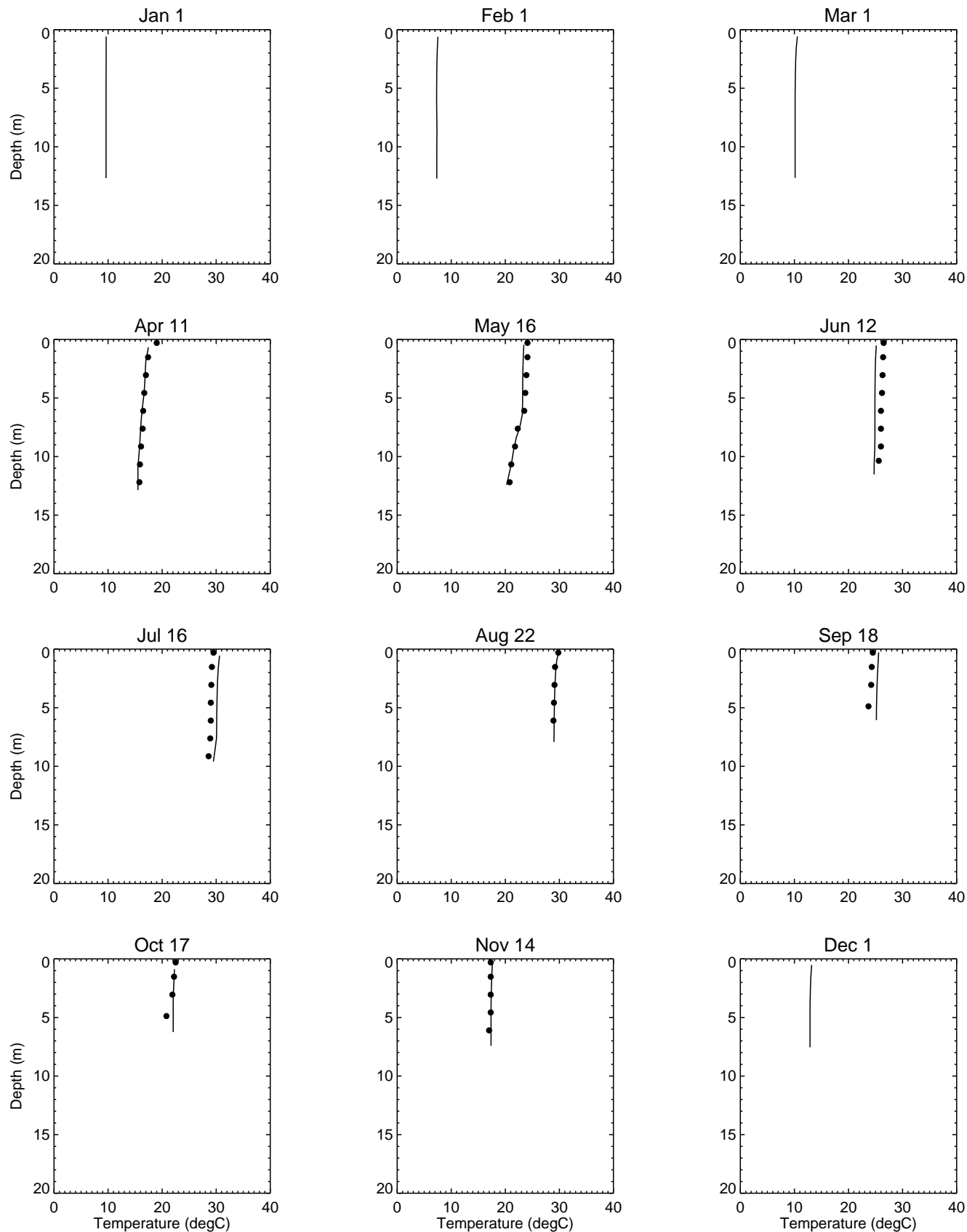*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 1996

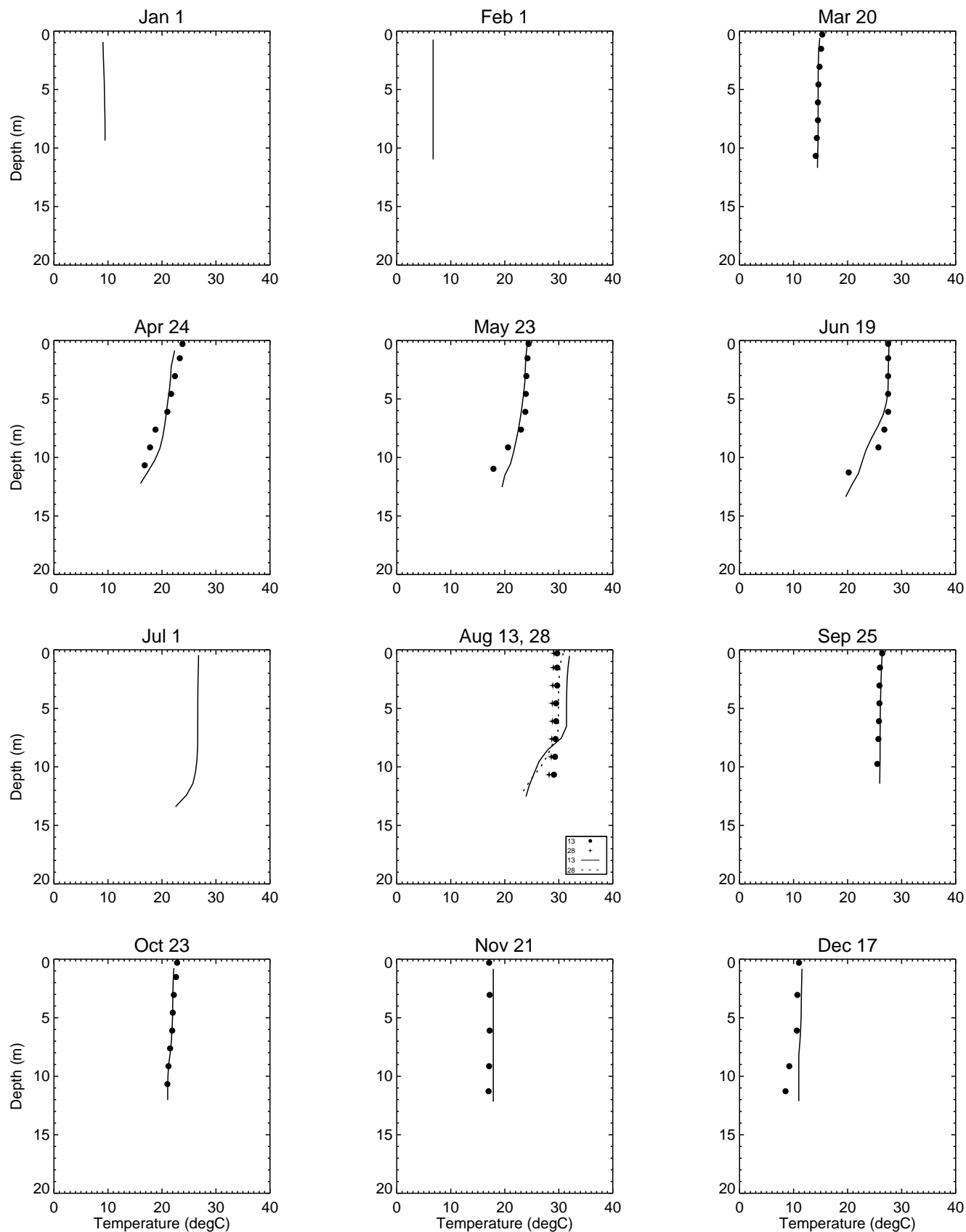*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 1997

Profiles shown for dates with available data else model results for first day of month shown.

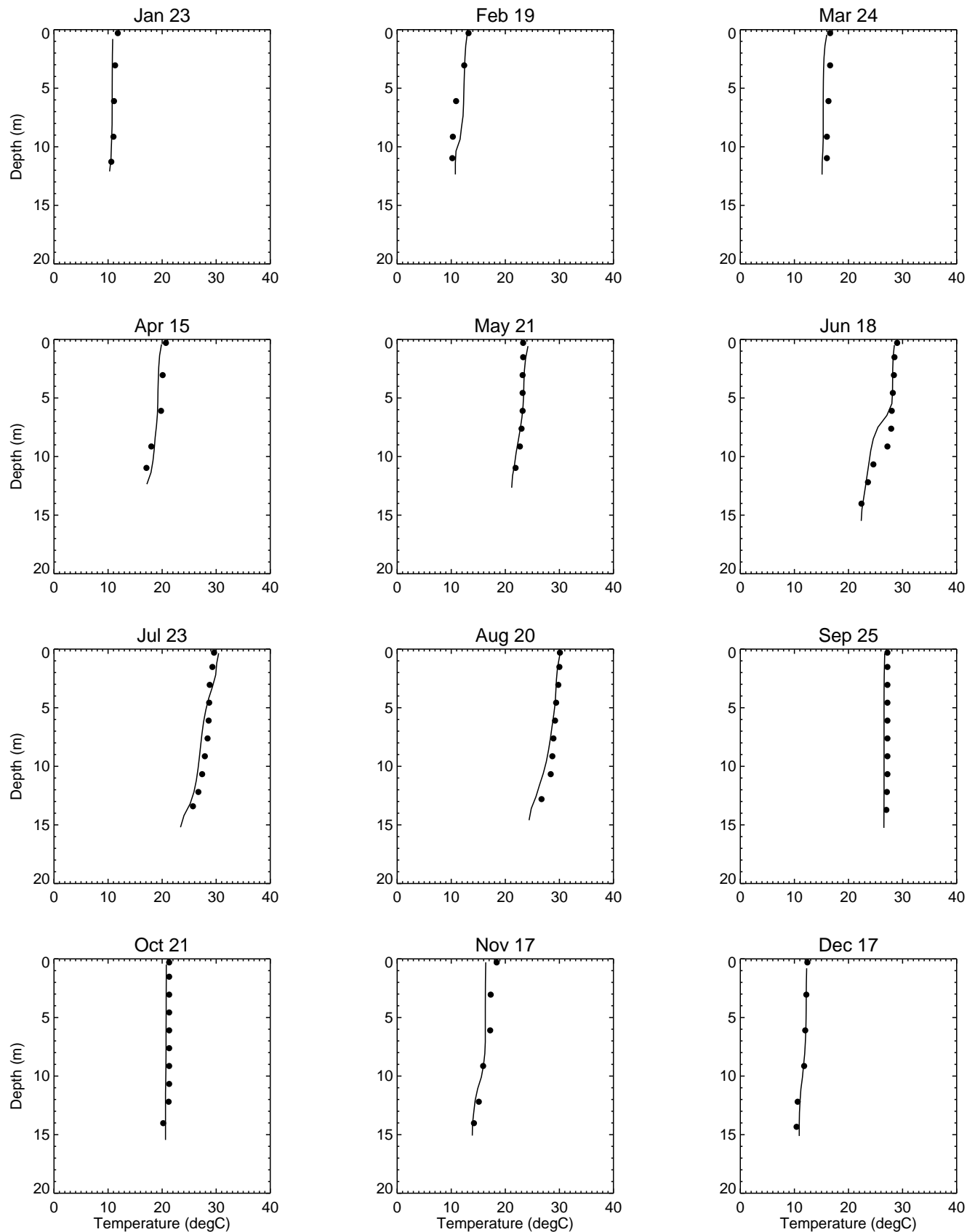CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:01 2013

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 1998

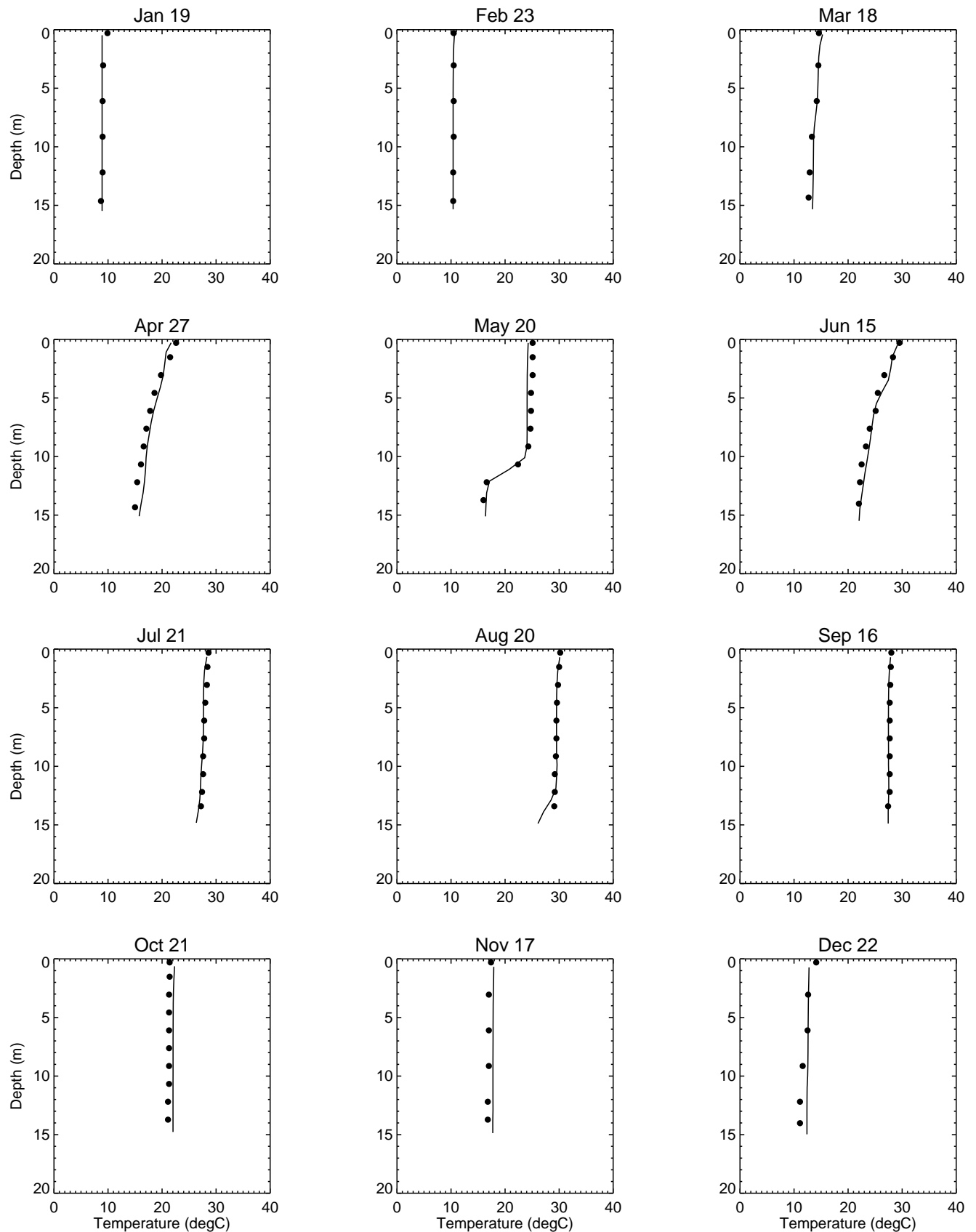*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:01 2013

Model (w1210-48)
● Data

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 1999

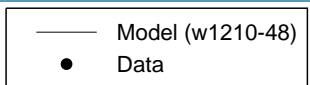*Profiles shown for dates with available data else model results for first day of month shown.*
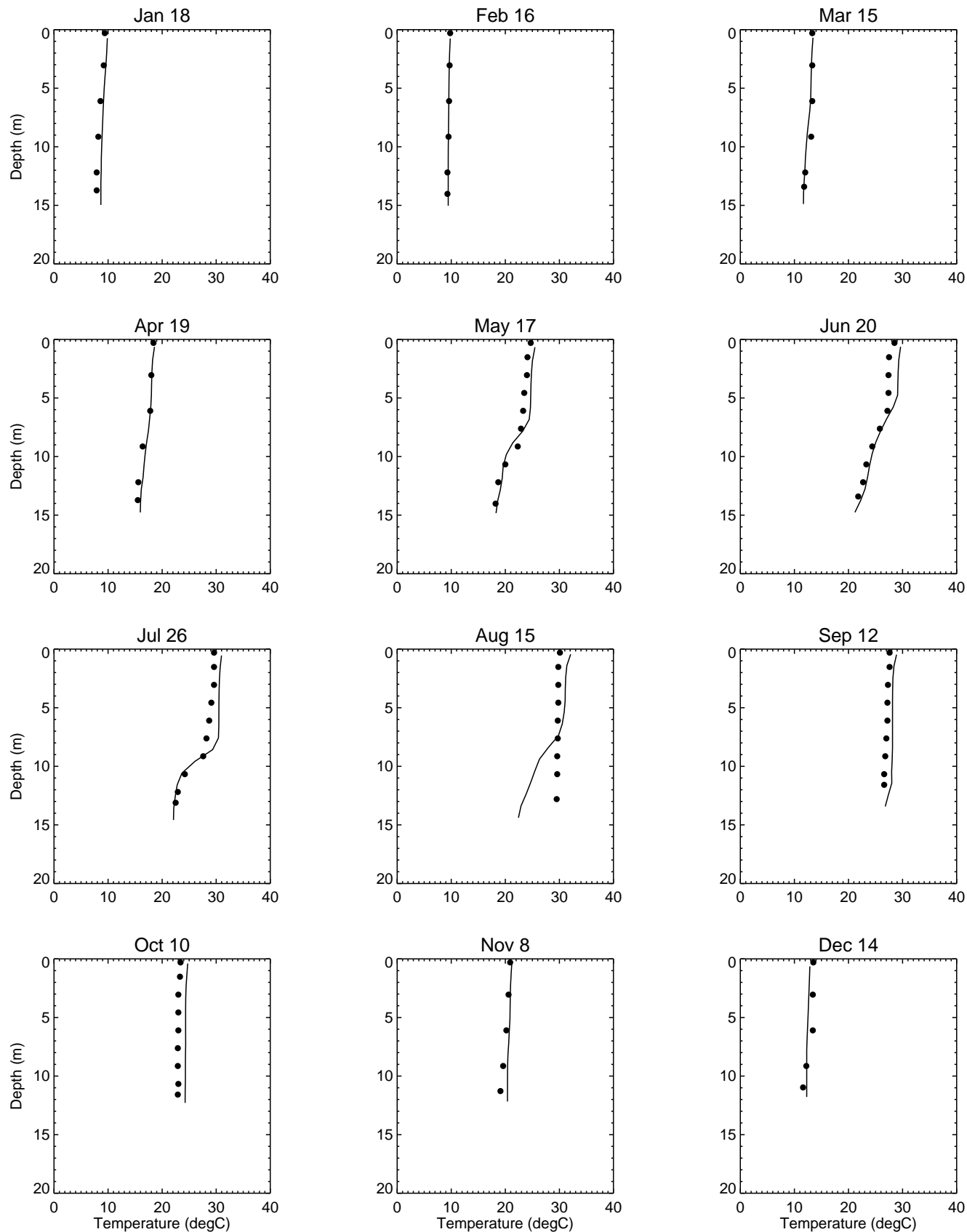
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 2000

Profiles shown for dates with available data else model results for first day of month shown.

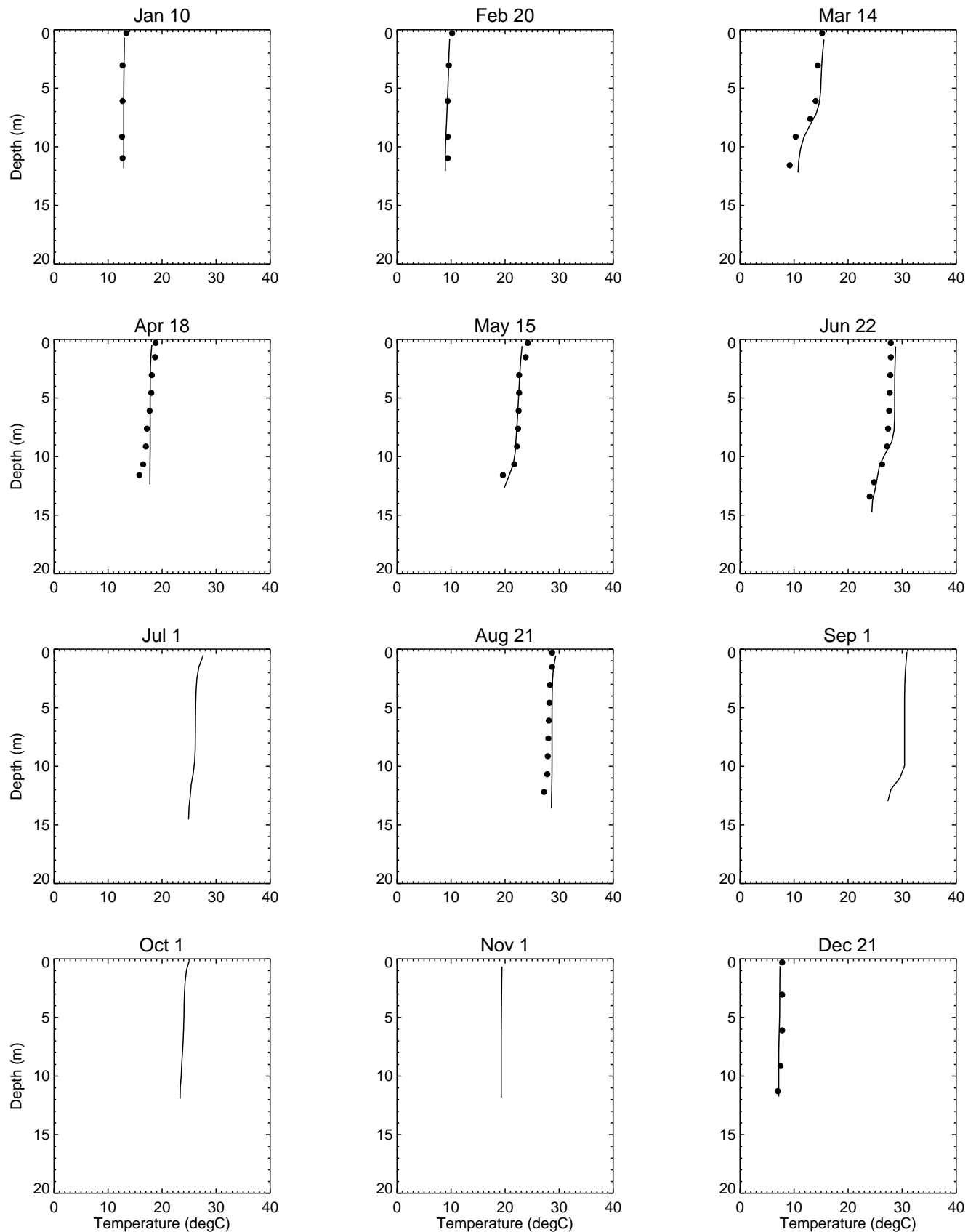CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 2001

Profiles shown for dates with available data else model results for first day of month shown.

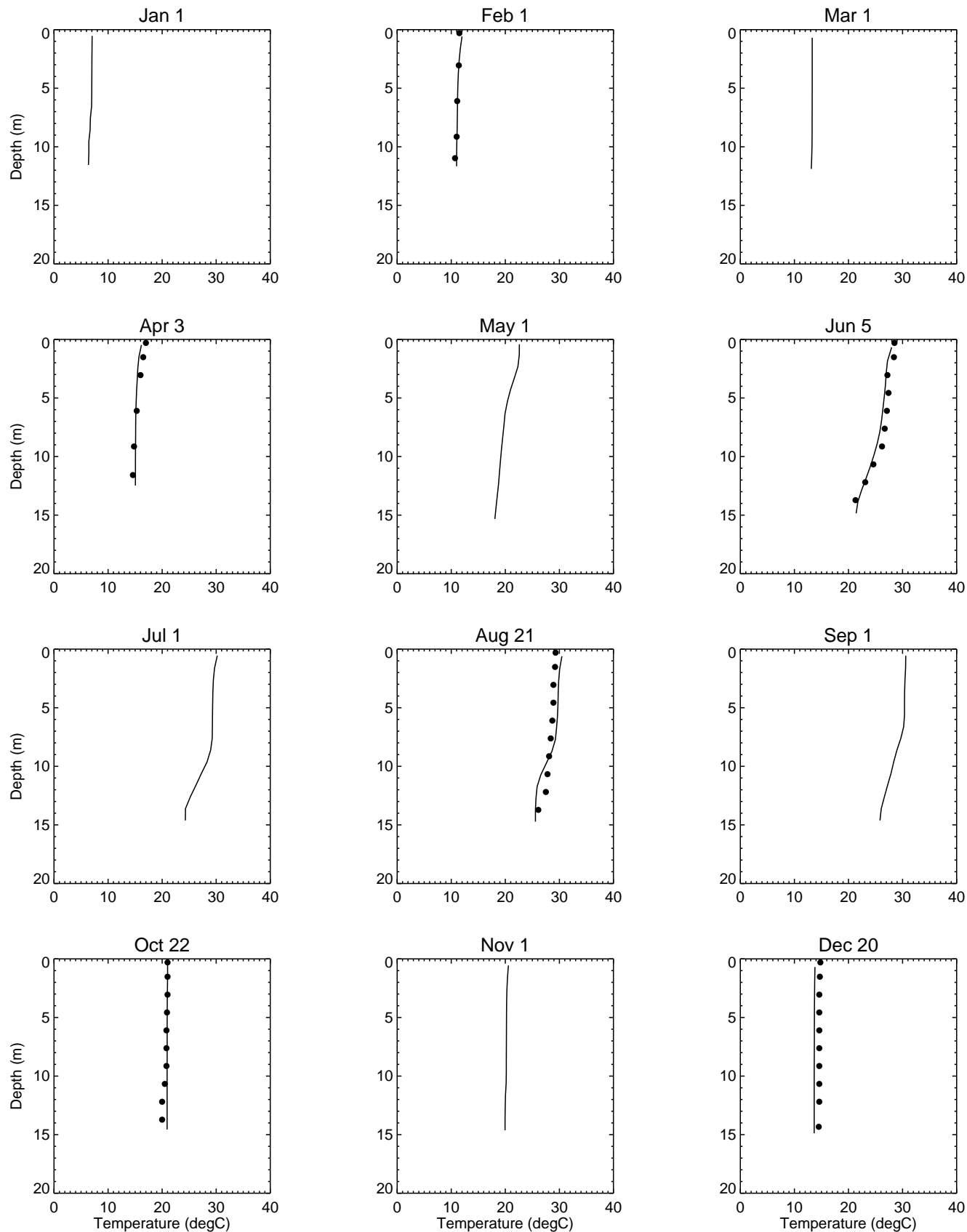CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 2002

Profiles shown for dates with available data else model results for first day of month shown.

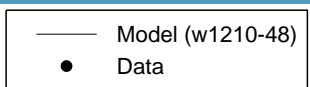CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 2003

Profiles shown for dates with available data else model results for first day of month shown.

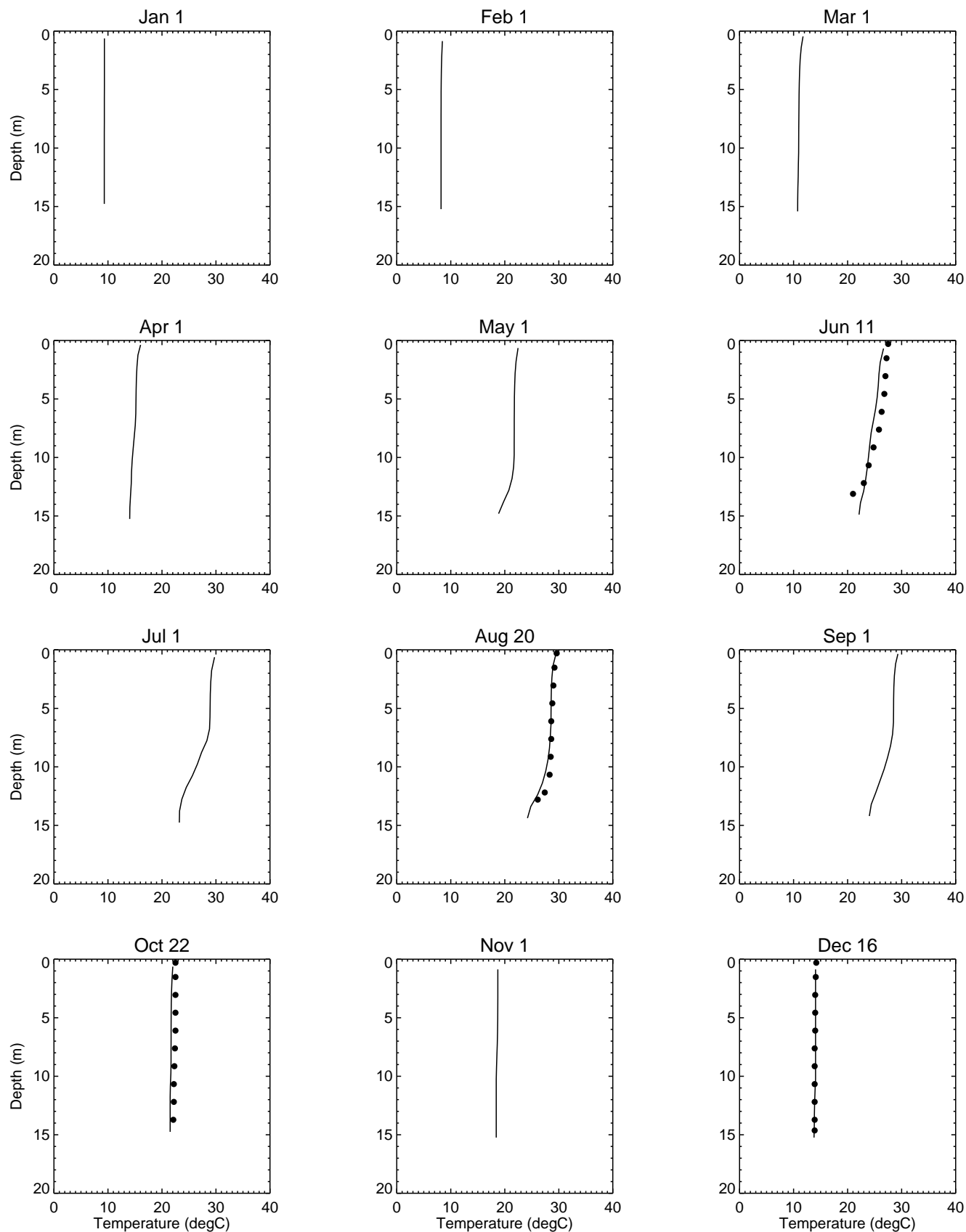CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:01 2013

Model (w1210-48)
● Data

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 2005

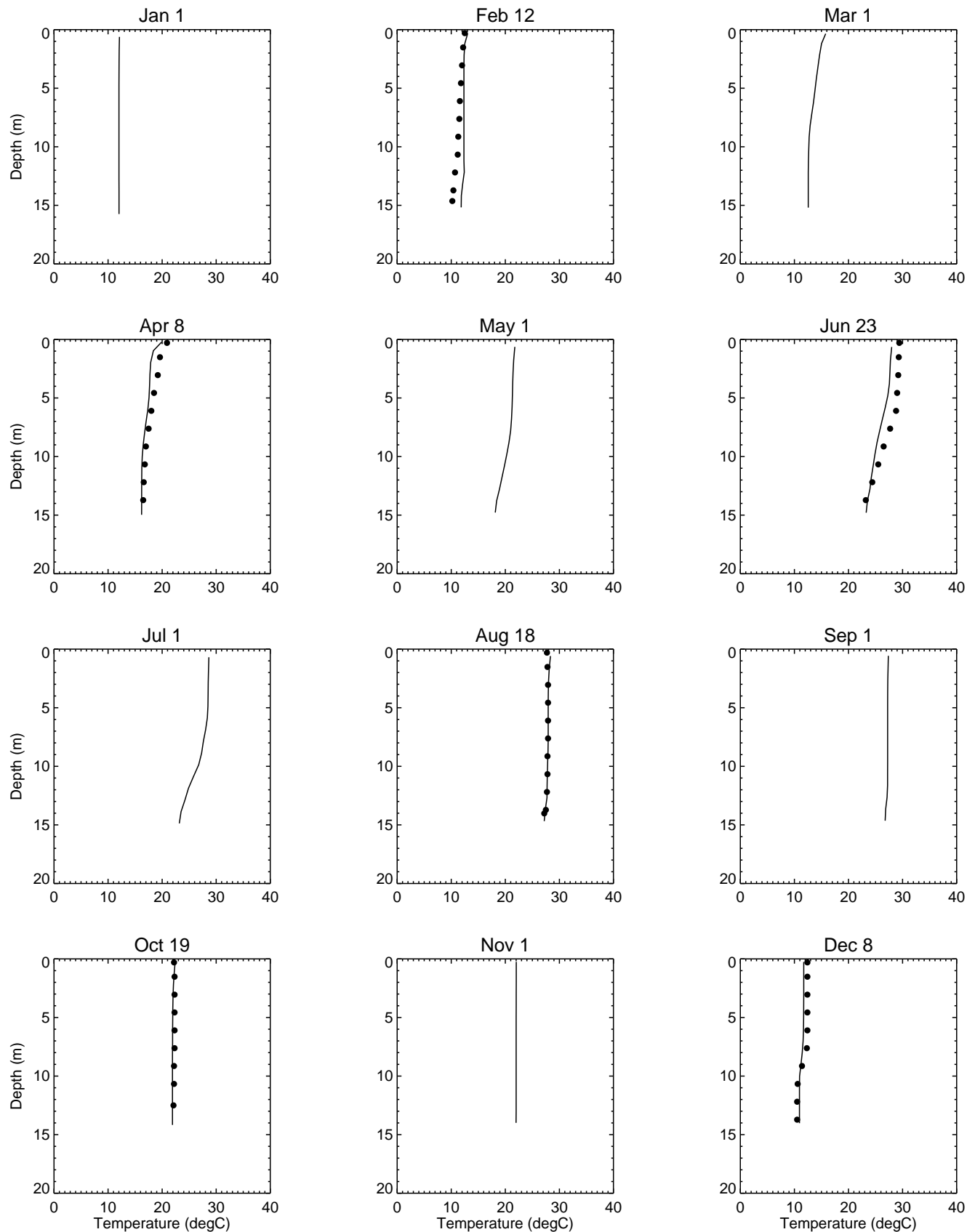*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 2006

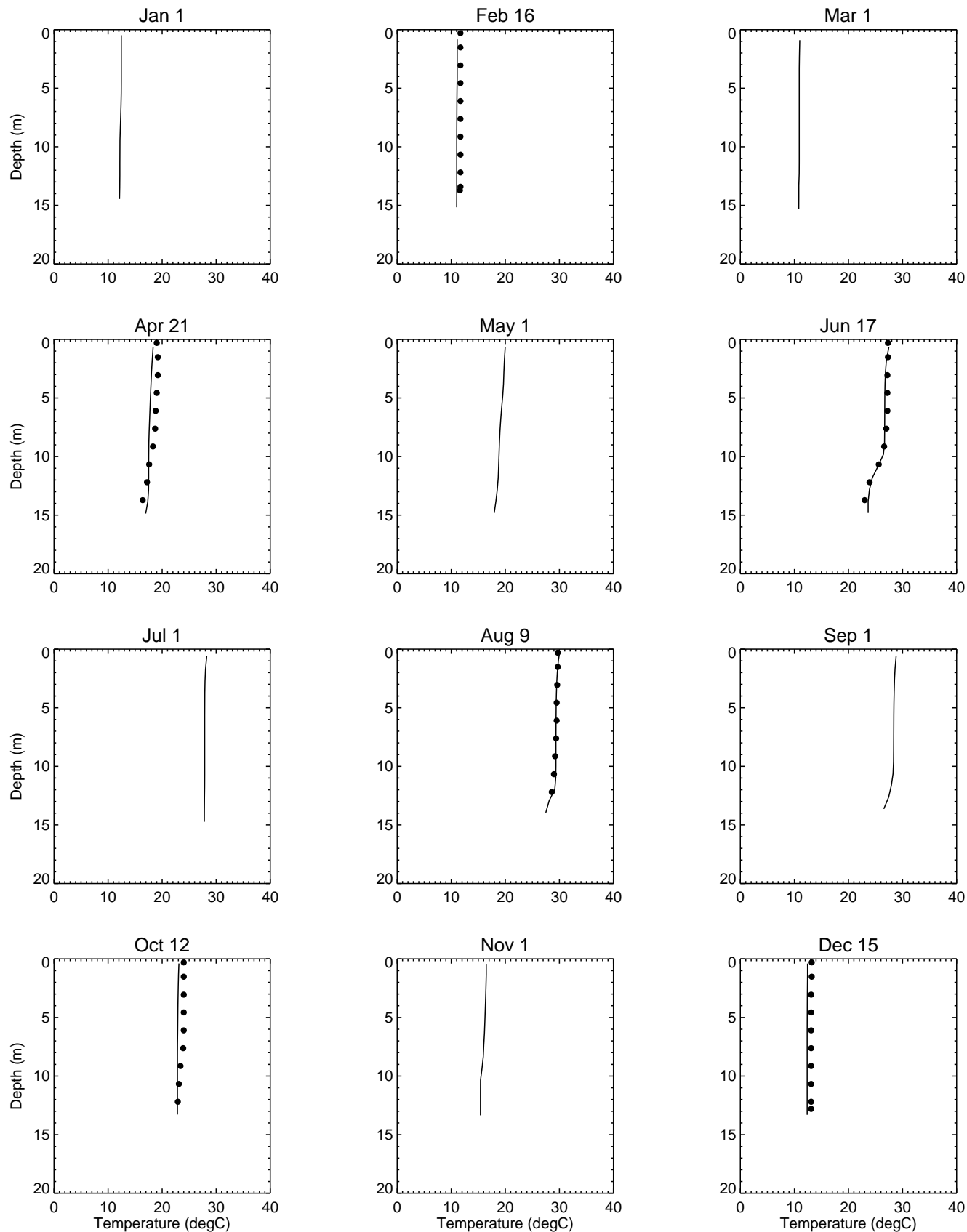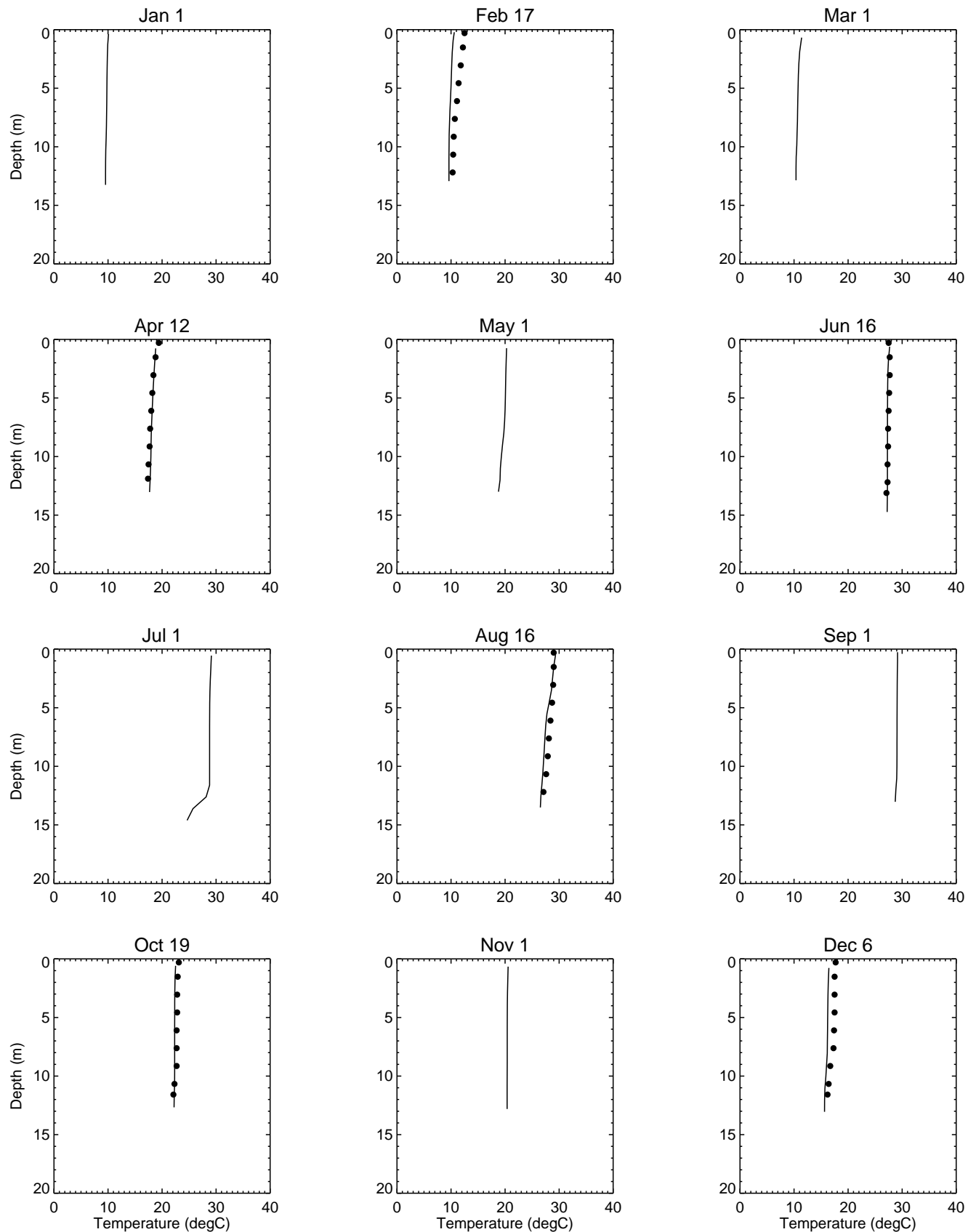*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1   Feb 1   Mar 1

Apr 2   May 1   Jun 4

Jul 1   Aug 1   Sep 1

Oct 1   Nov 1   Dec 3

Depth (m)

Temperature (degC)

——— Model (w1210-48)

● Data

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 2007

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR
QEA
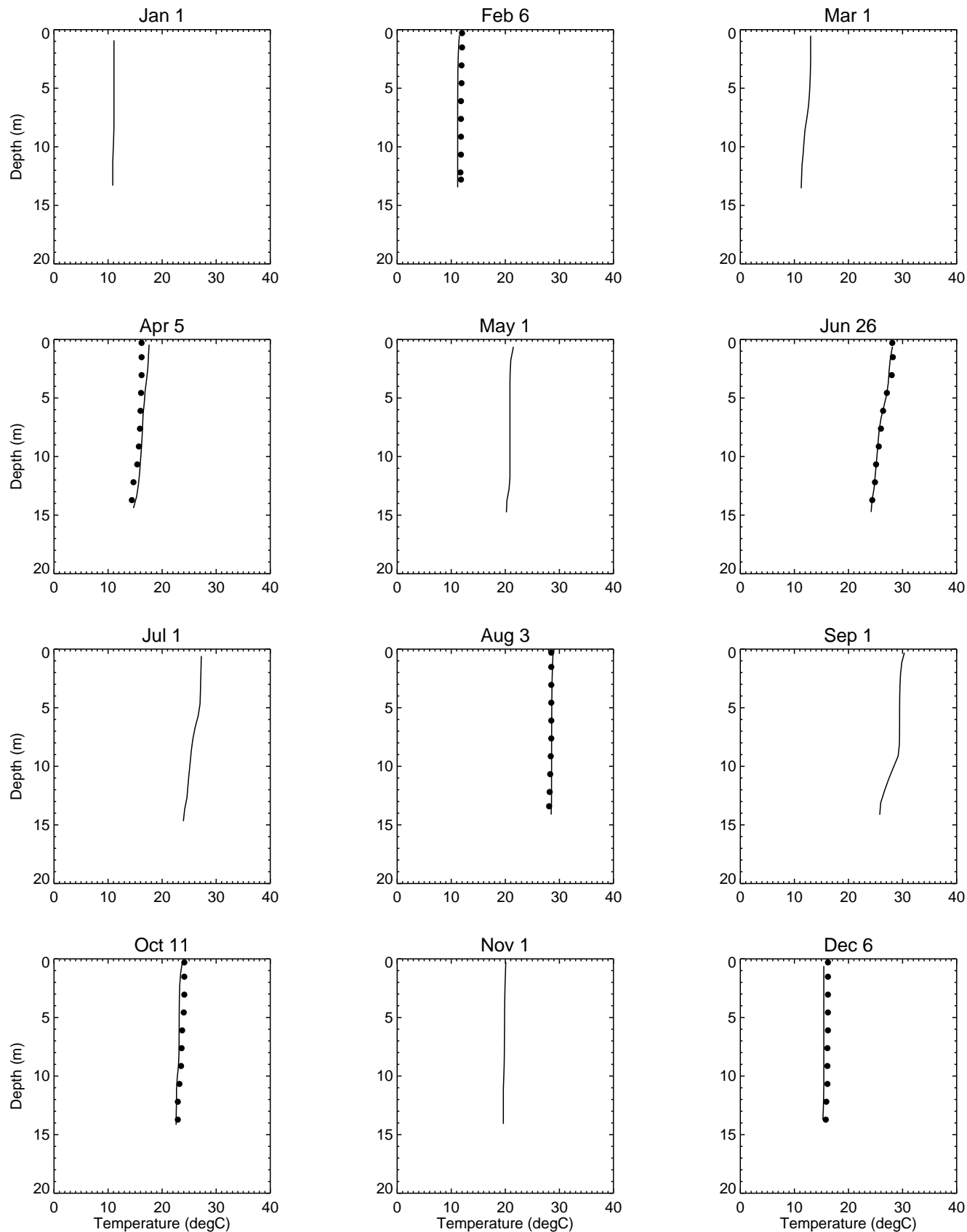PARSONS

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:01 2013

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 2008

Profiles shown for dates with available data else model results for first day of month shown.

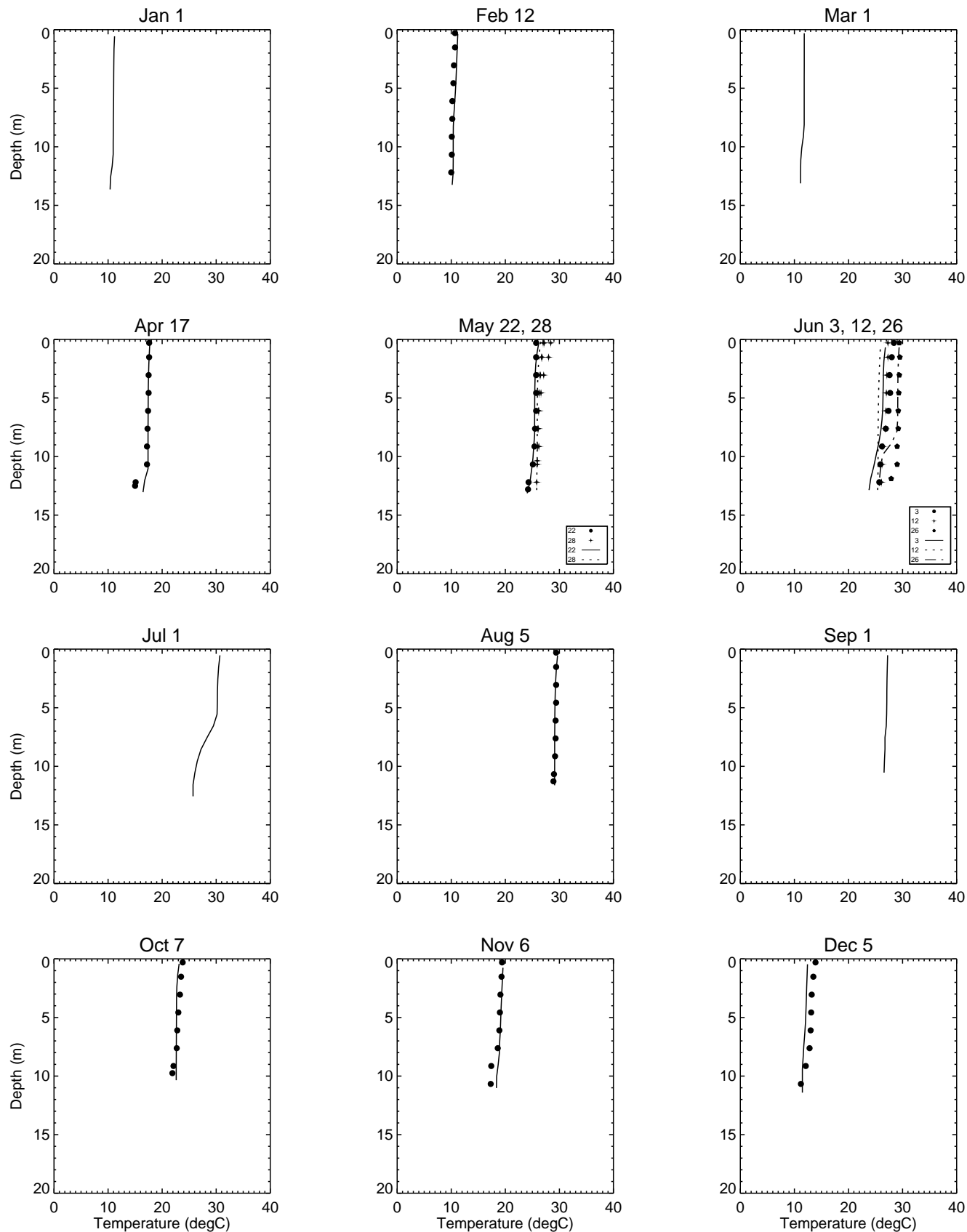CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 2009

Profiles shown for dates with available data else model results for first day of month shown.

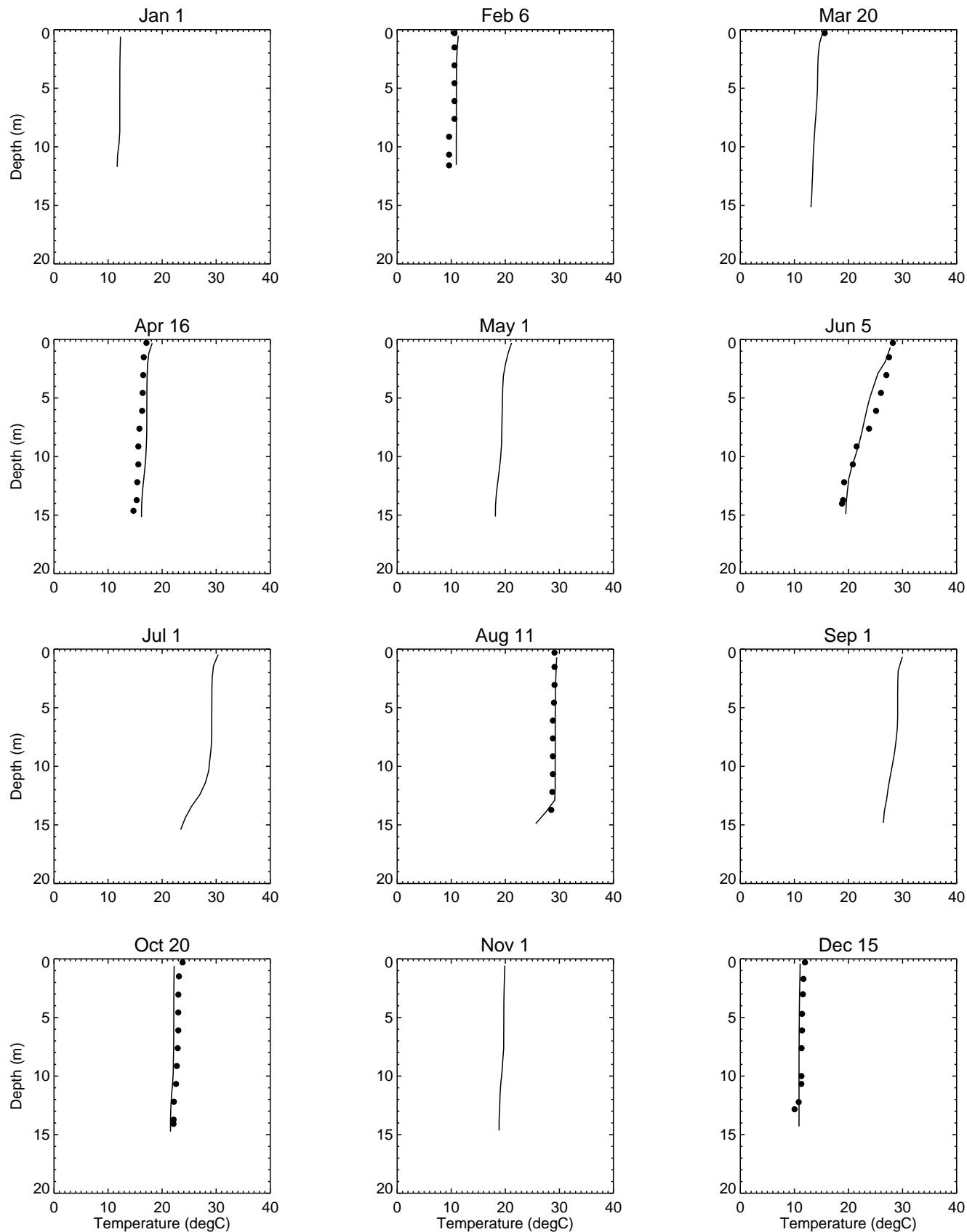CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 2010

Profiles shown for dates with available data else model results for first day of month shown.

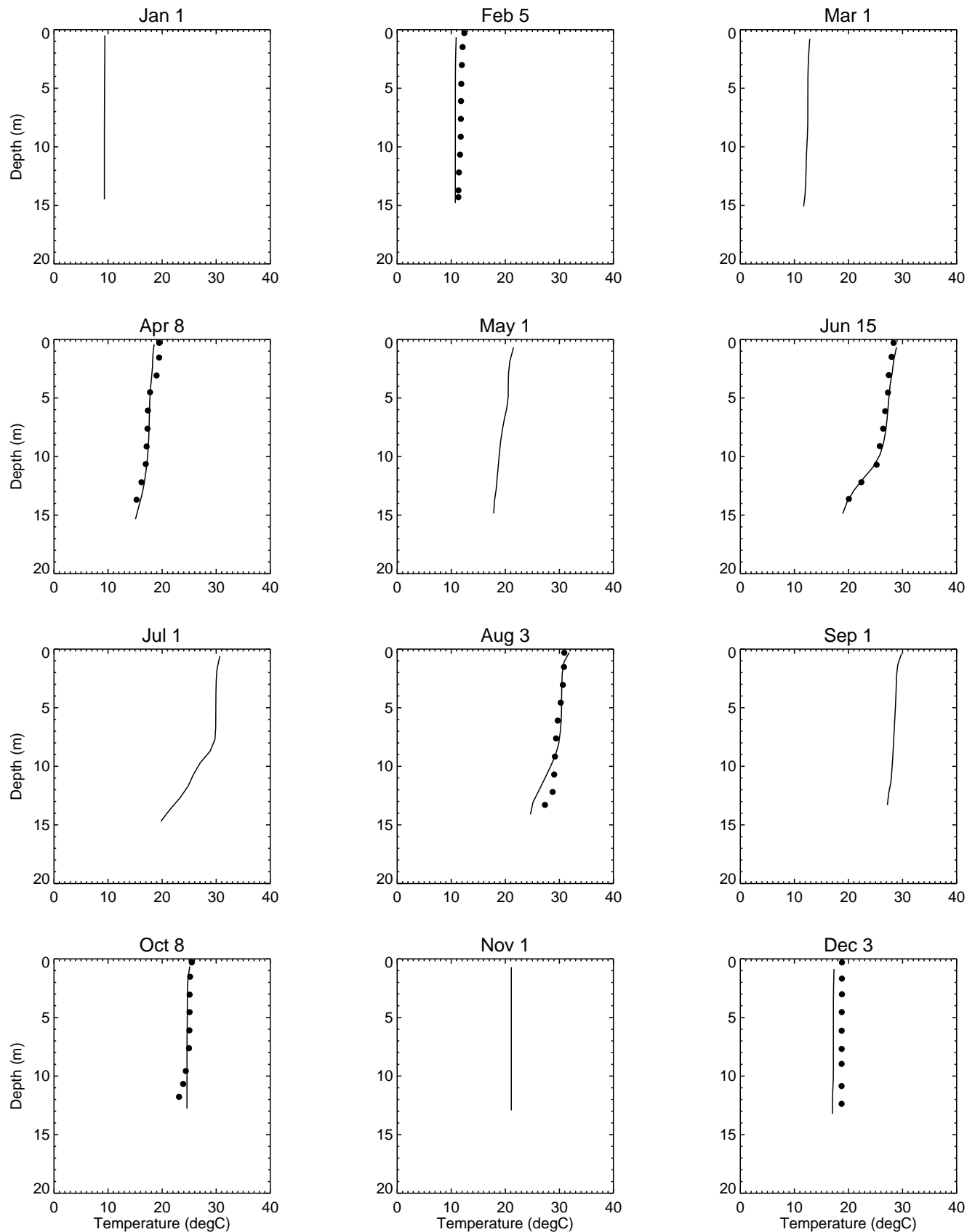CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-2

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Temperature - 2011

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 1984

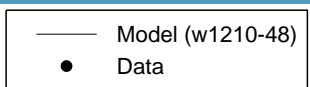*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
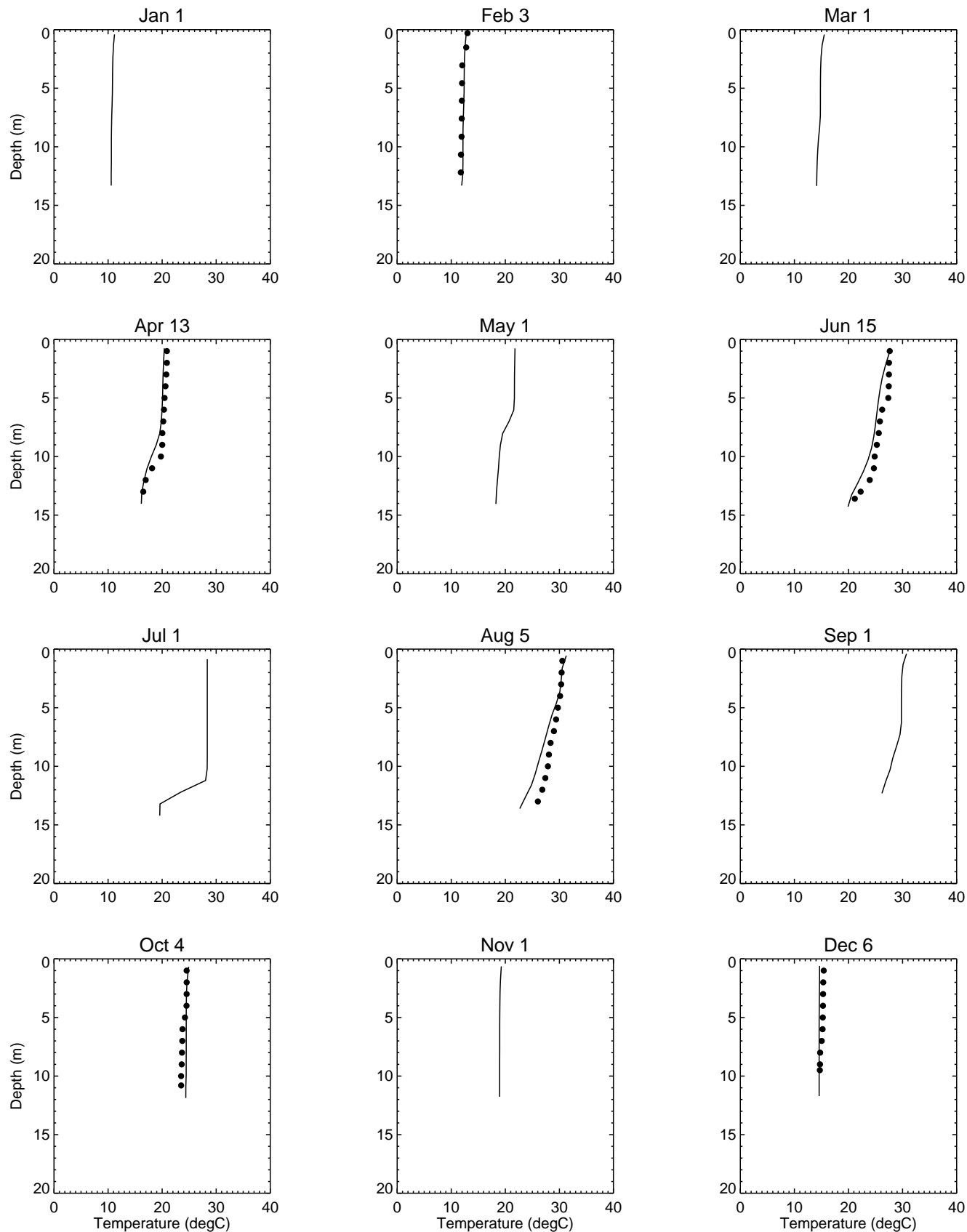Lower Colorado River Authority

Jan 23 · Feb 20 · Mar 20 · Apr 24 · May 23 · Jun 19 · Jul 1 · Aug 13, 28 · Sep 25 · Oct 23 · Nov 21 · Dec 17

Depth (m) vs Temperature (degC)

Model (w1210-48)
● Data

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 1985

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
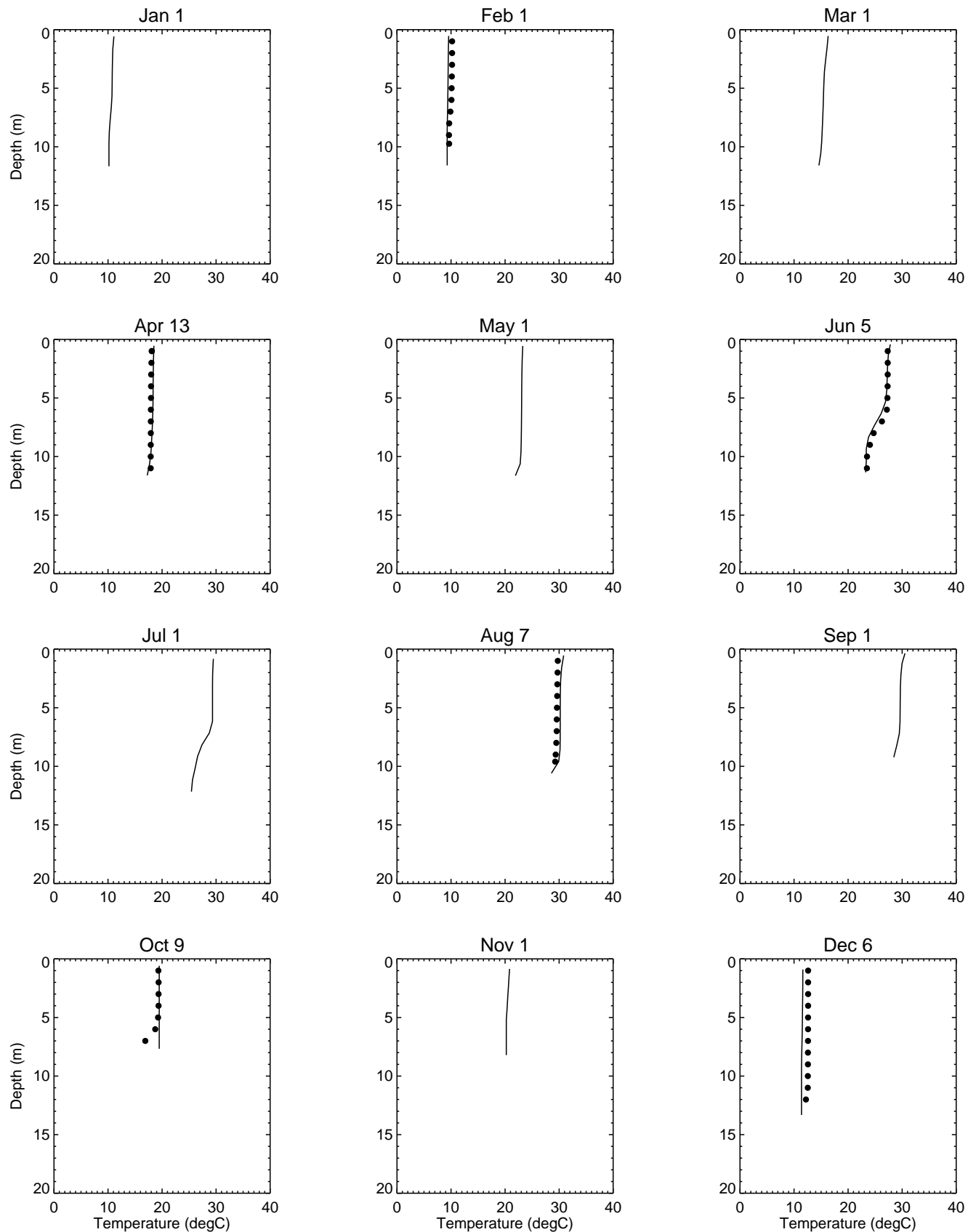Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:04 2013

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 1986

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
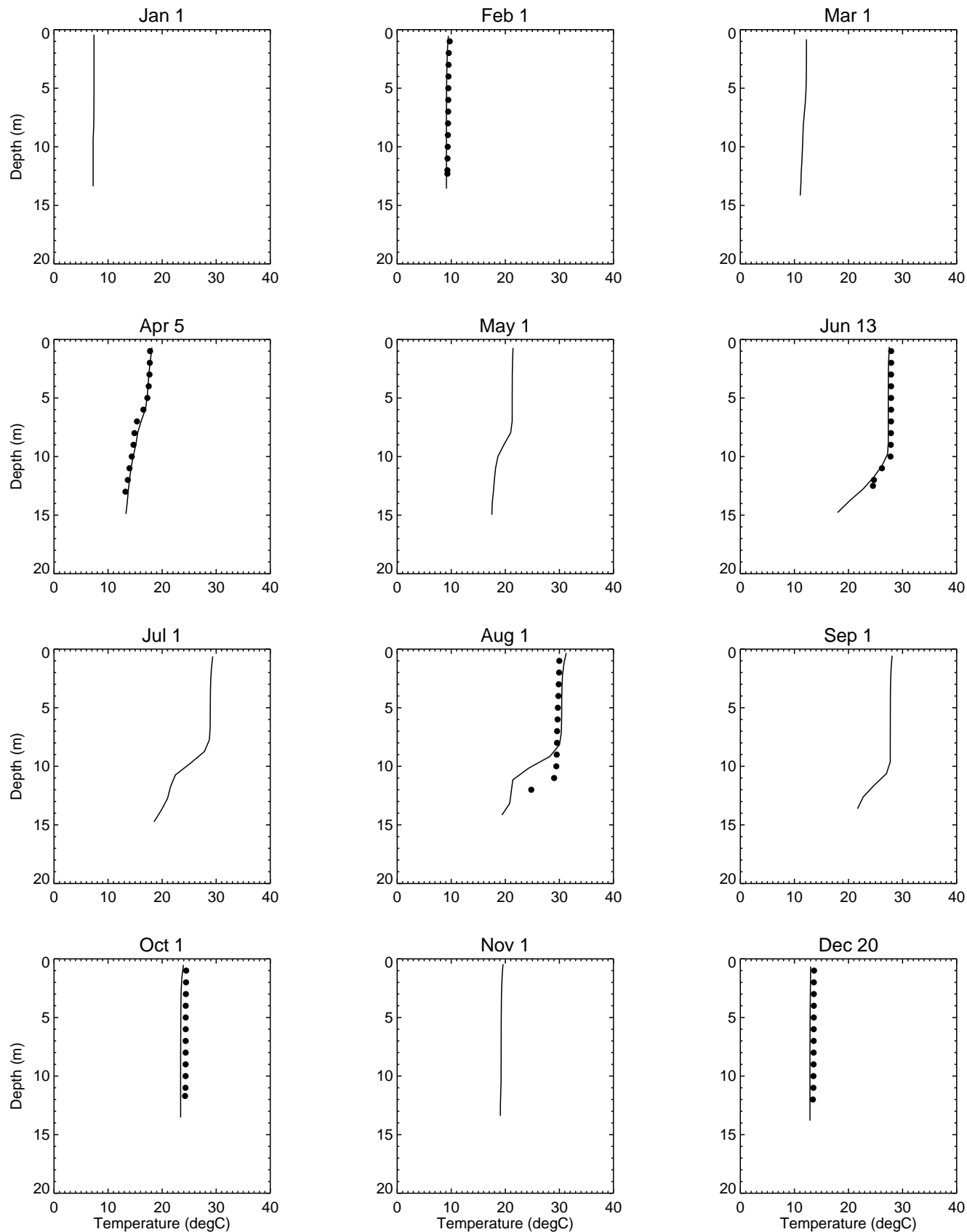
Lower Colorado River Authority

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 1987

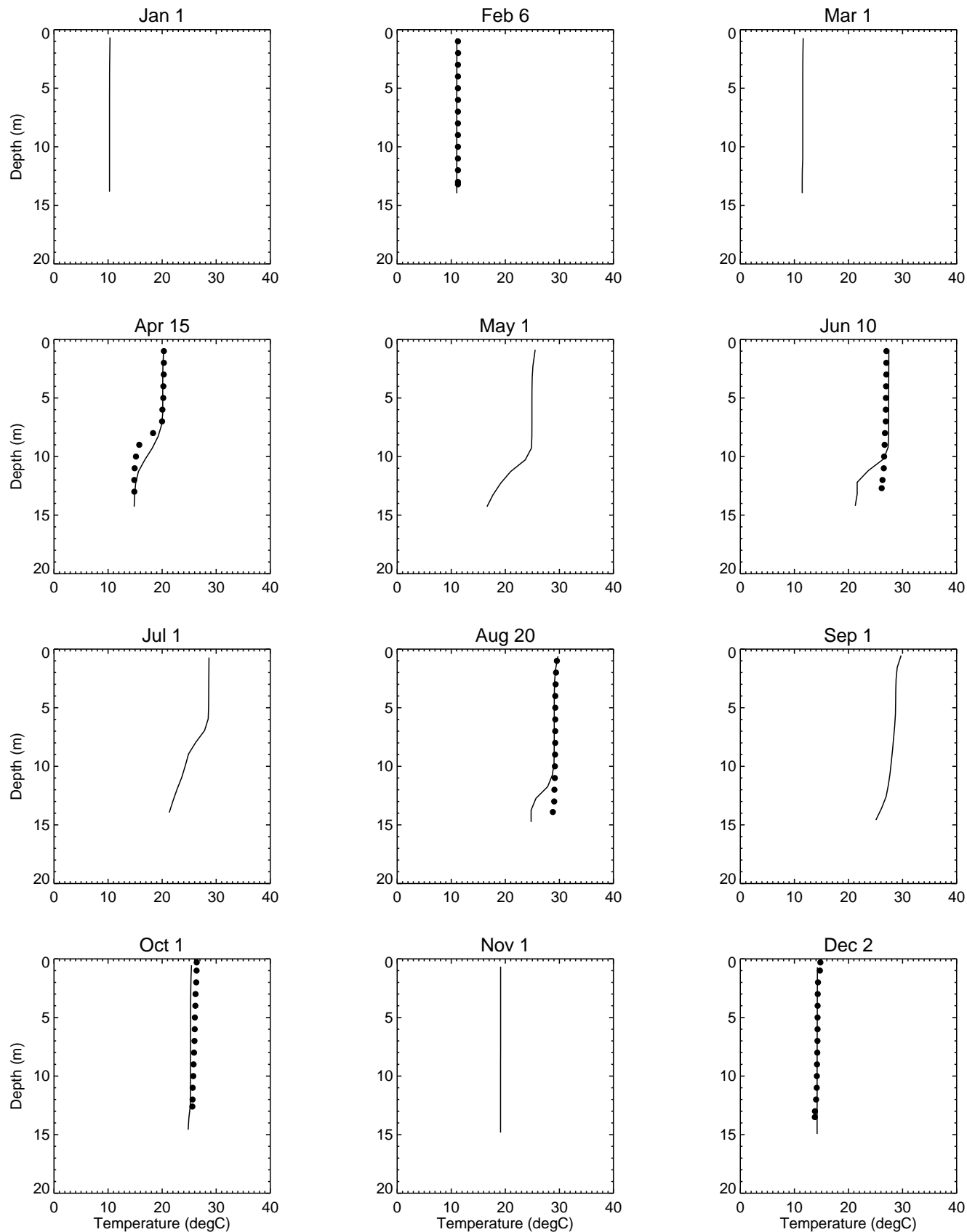*Profiles shown for dates with available data else model results for first day of month shown.*

Legend:
— Model (w1210-48)
● Data

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR
QEA
PARSONS

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 1988

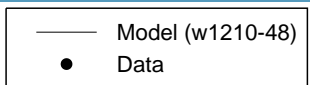*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
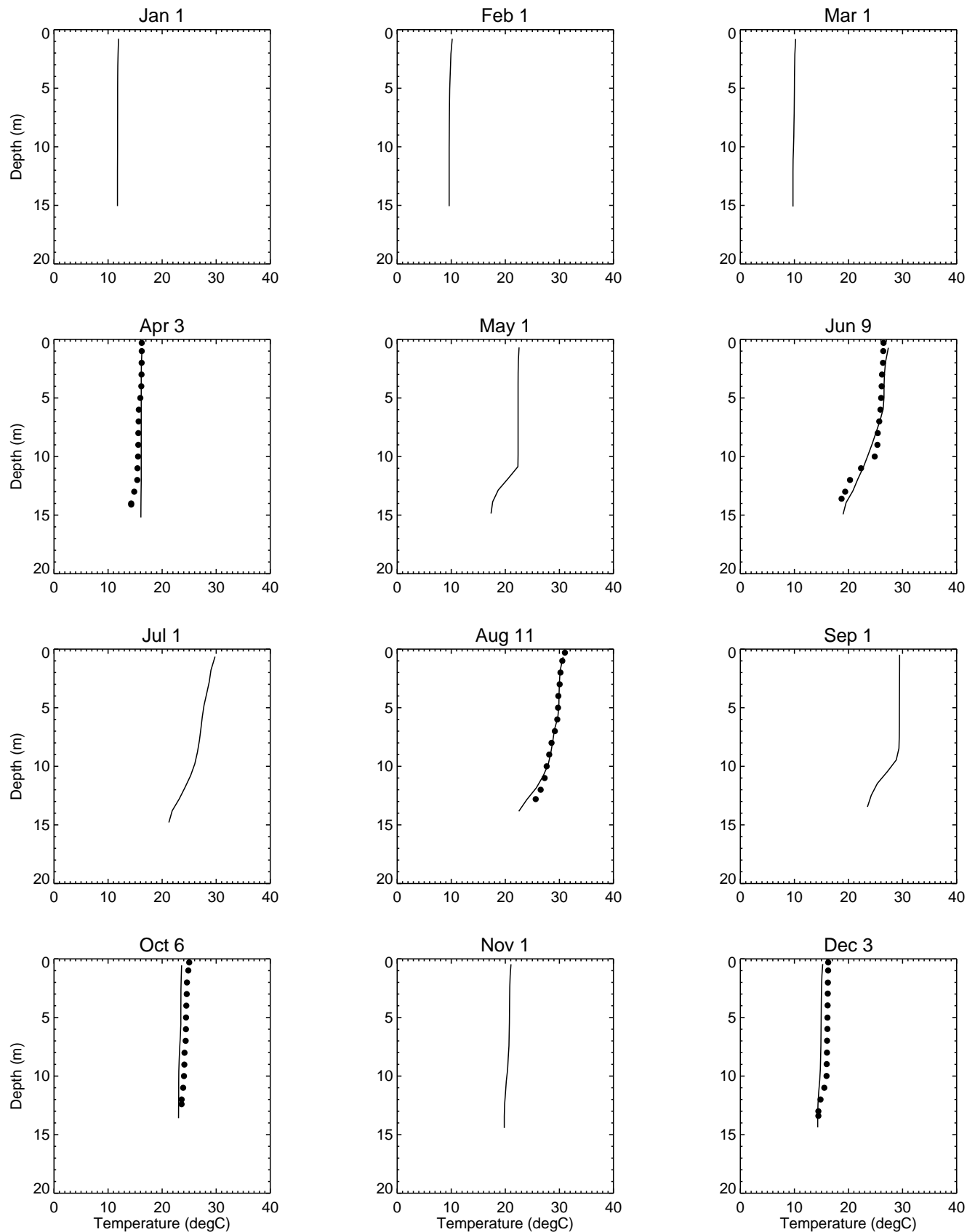
Lower Colorado River Authority

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 1989

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
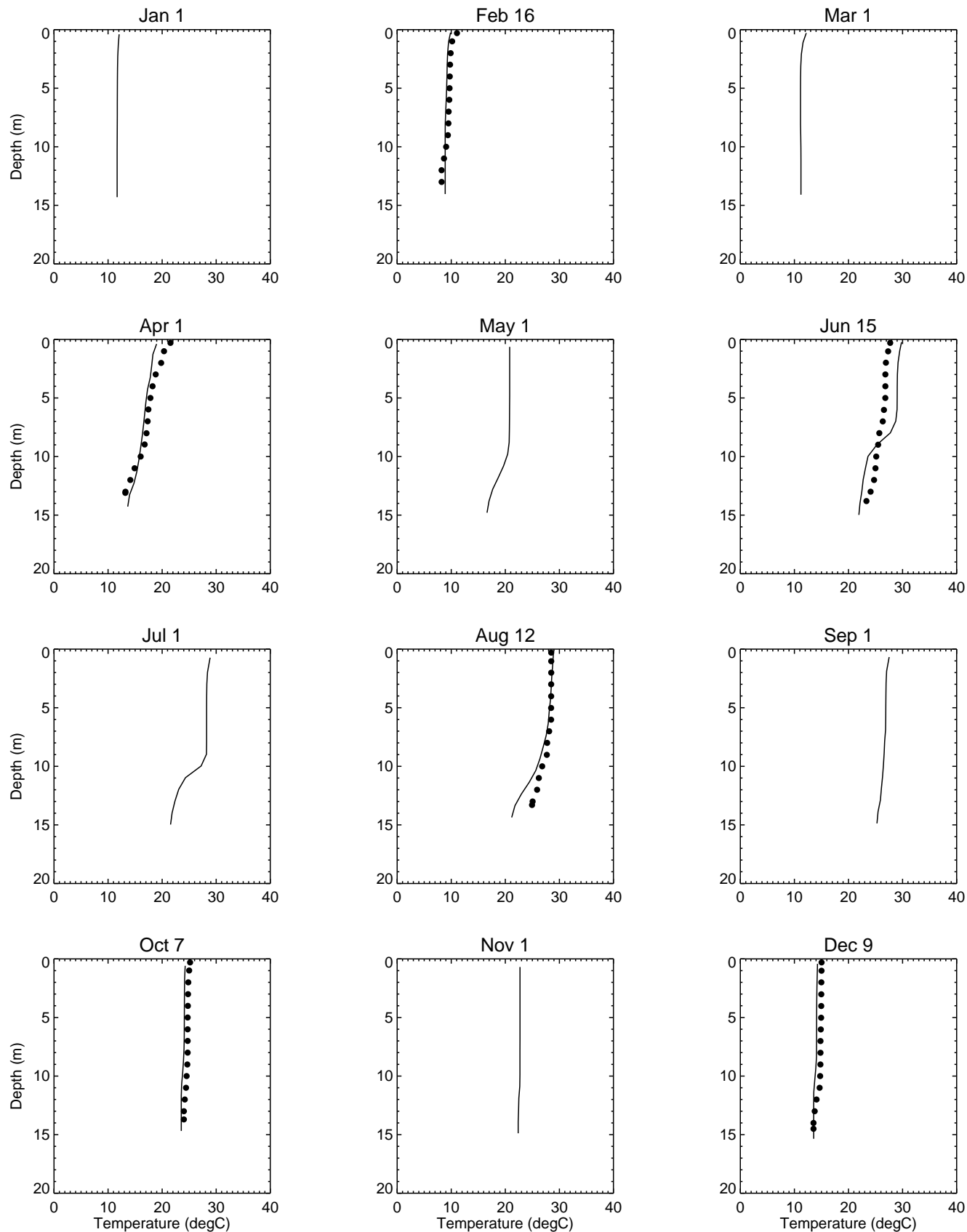
Lower Colorado River Authority

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 1990

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
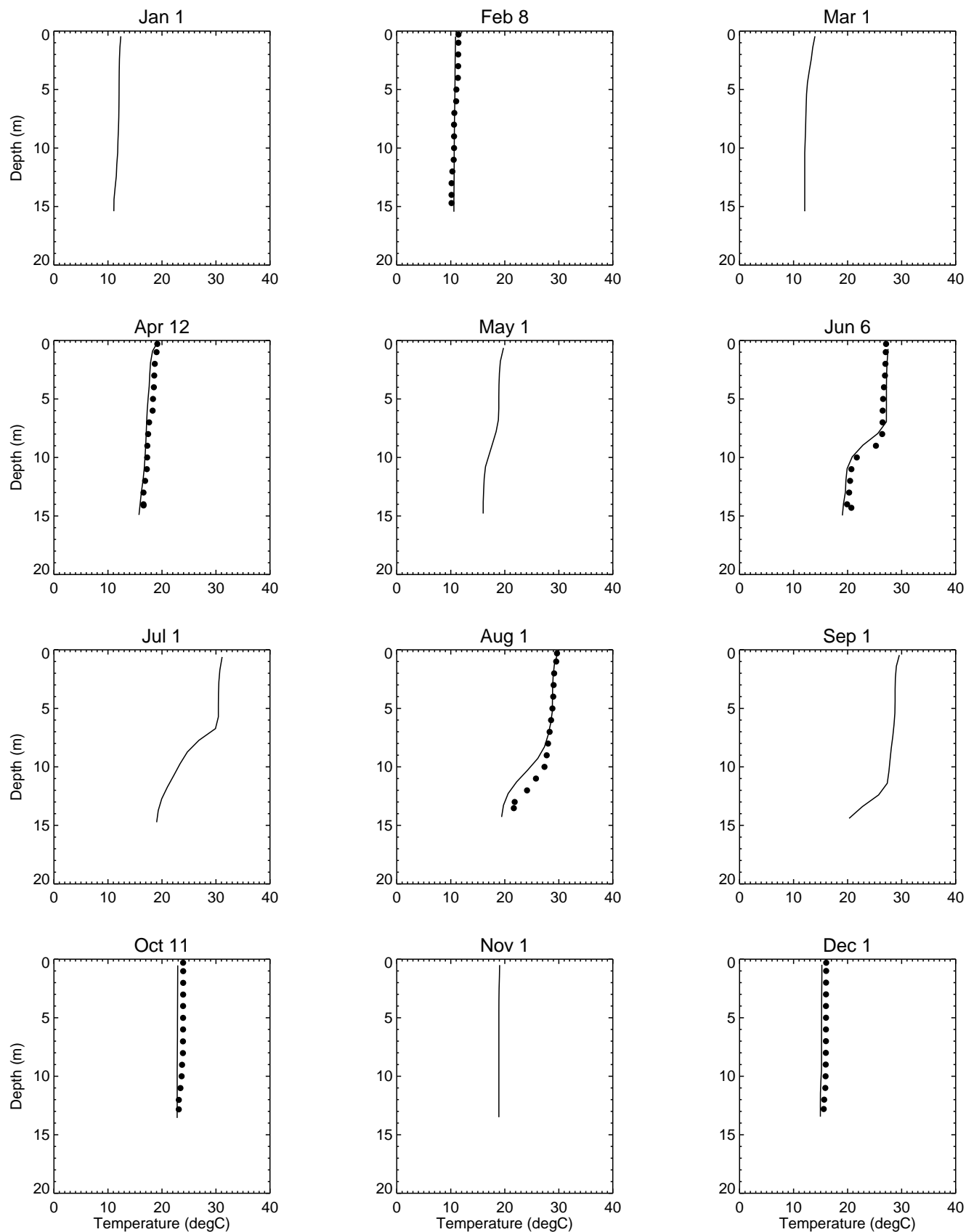
Lower Colorado River Authority

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 1991

Profiles shown for dates with available data else model results for first day of month shown.

Model (w1210-48)
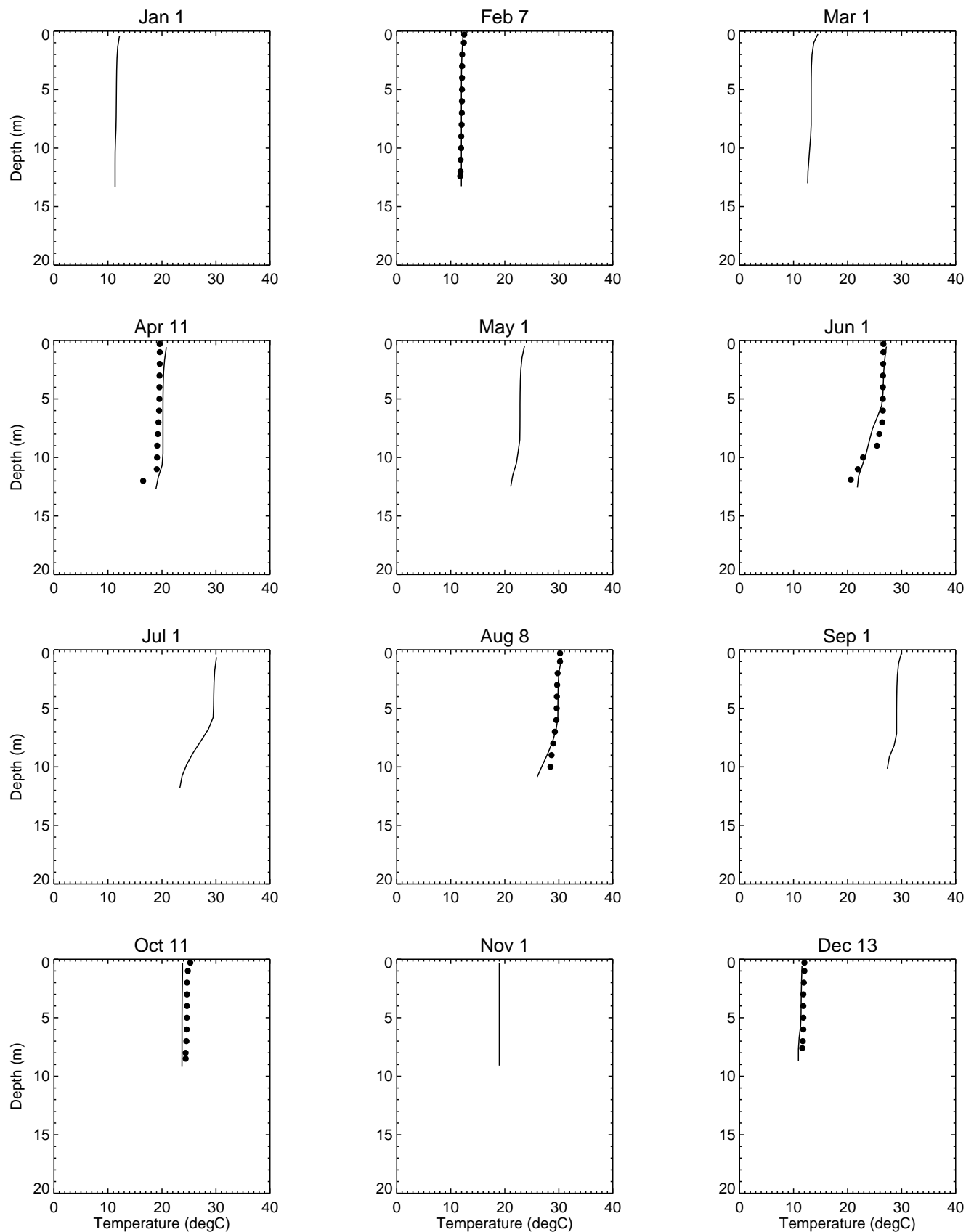● Data

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:04 2013

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
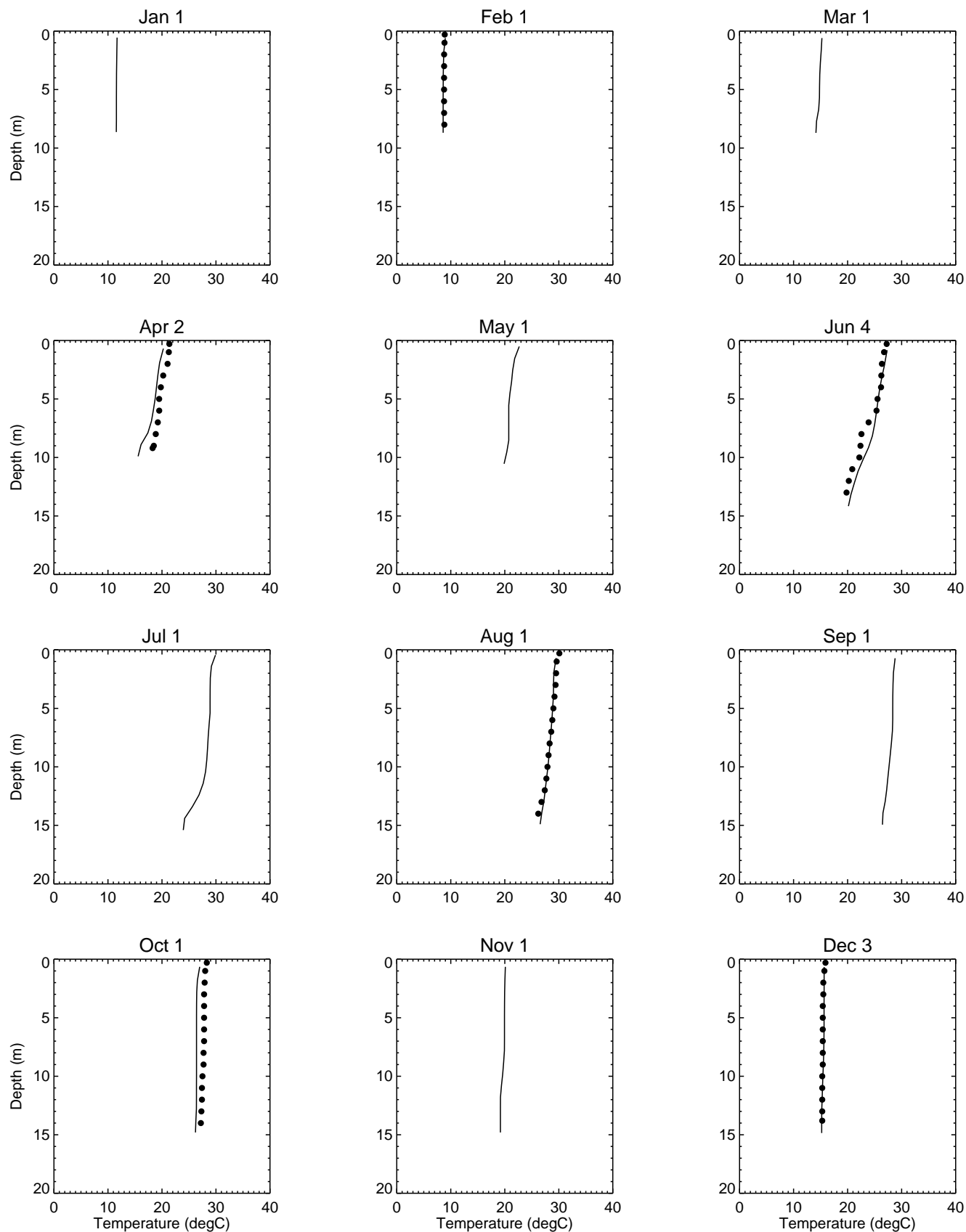
Lower Colorado River Authority

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 1994

Profiles shown for dates with available data else model results for first day of month shown.

Legend:
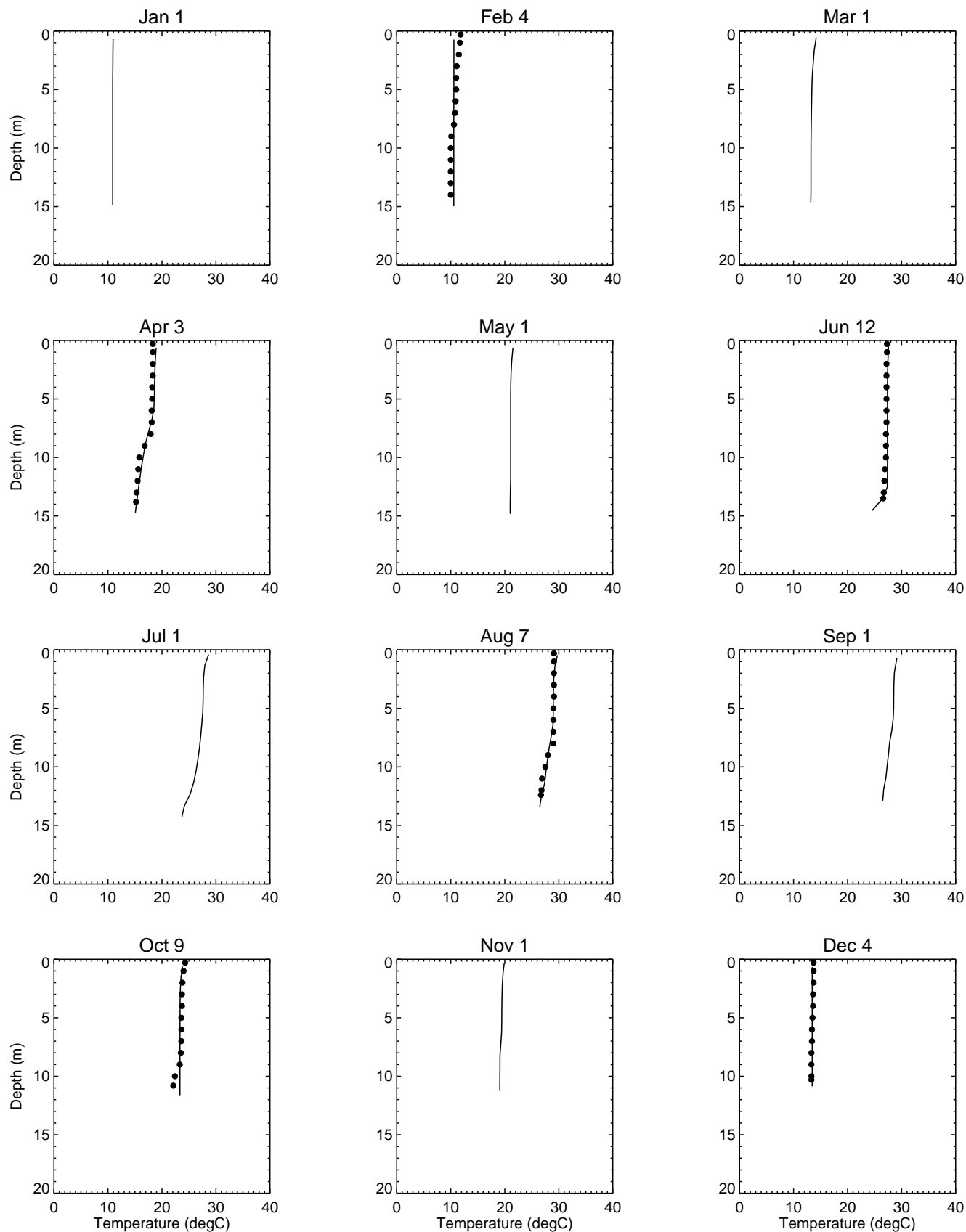— Model (w1210-48)
● Data

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 1995

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
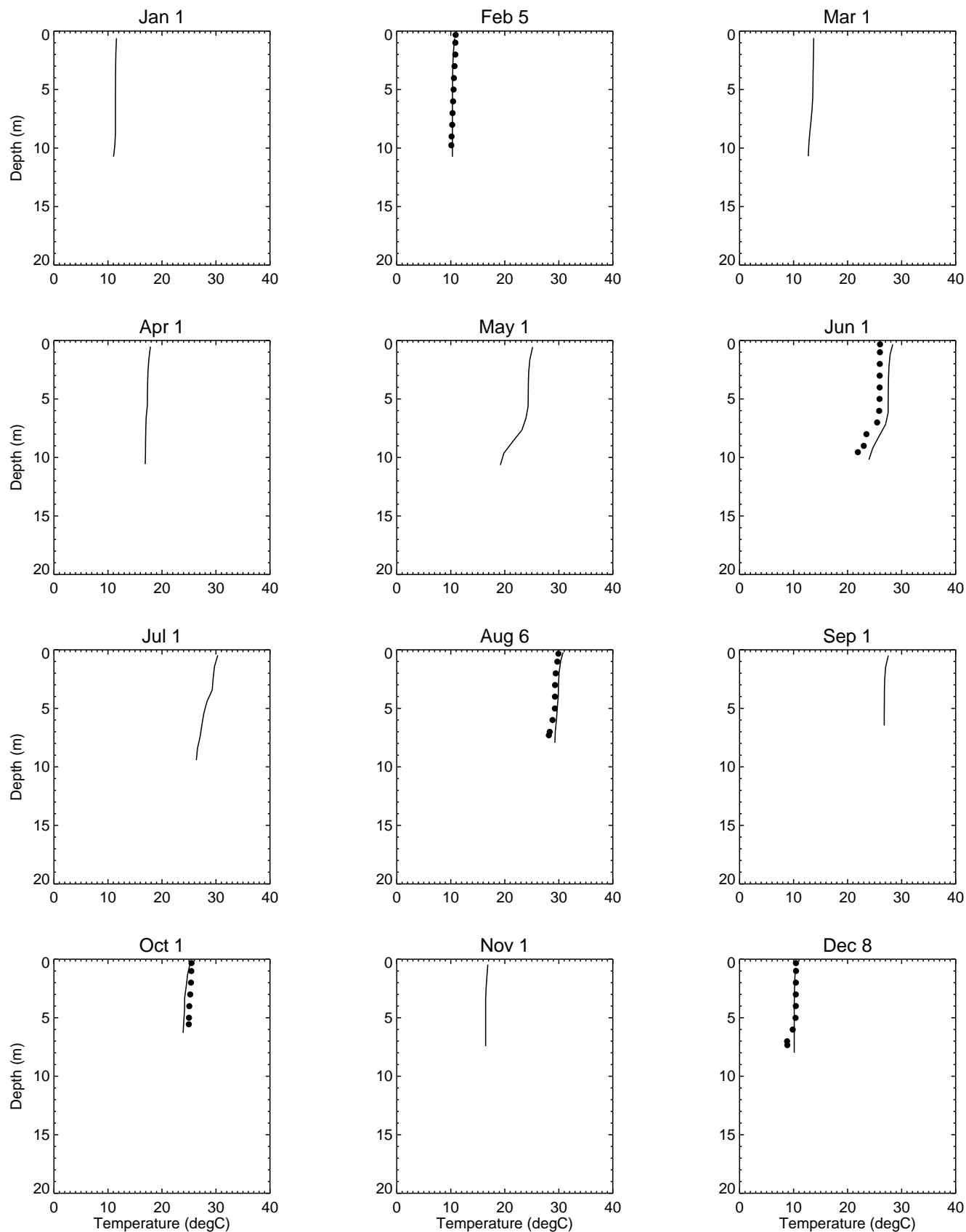
Lower Colorado River Authority

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 1996

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 1997

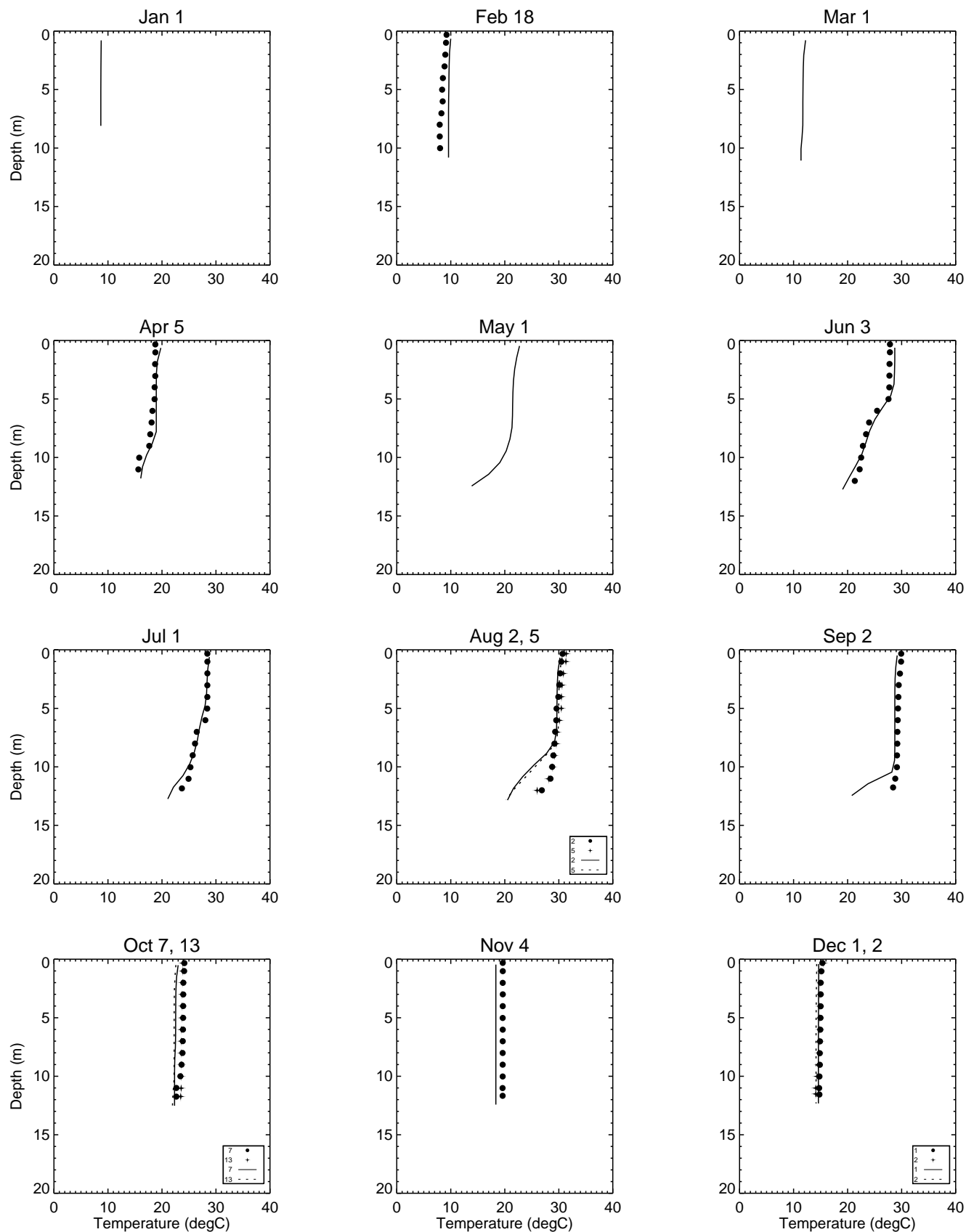*Profiles shown for dates with available data else model results for first day of month shown.*

Model (w1210-48)
● Data

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 1998

Profiles shown for dates with available data else model results for first day of month shown.

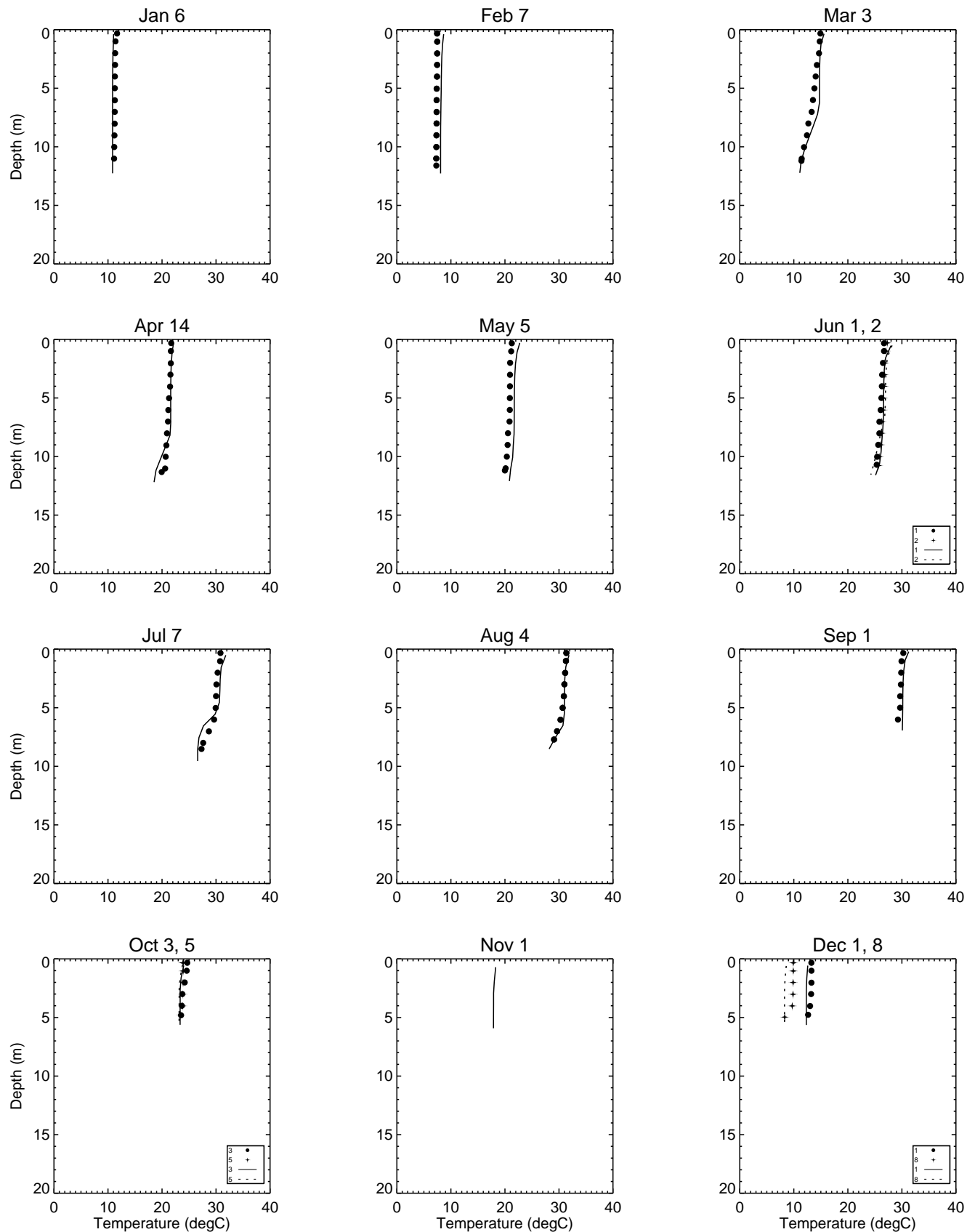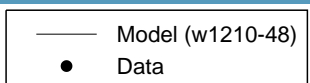CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 1999

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 2000

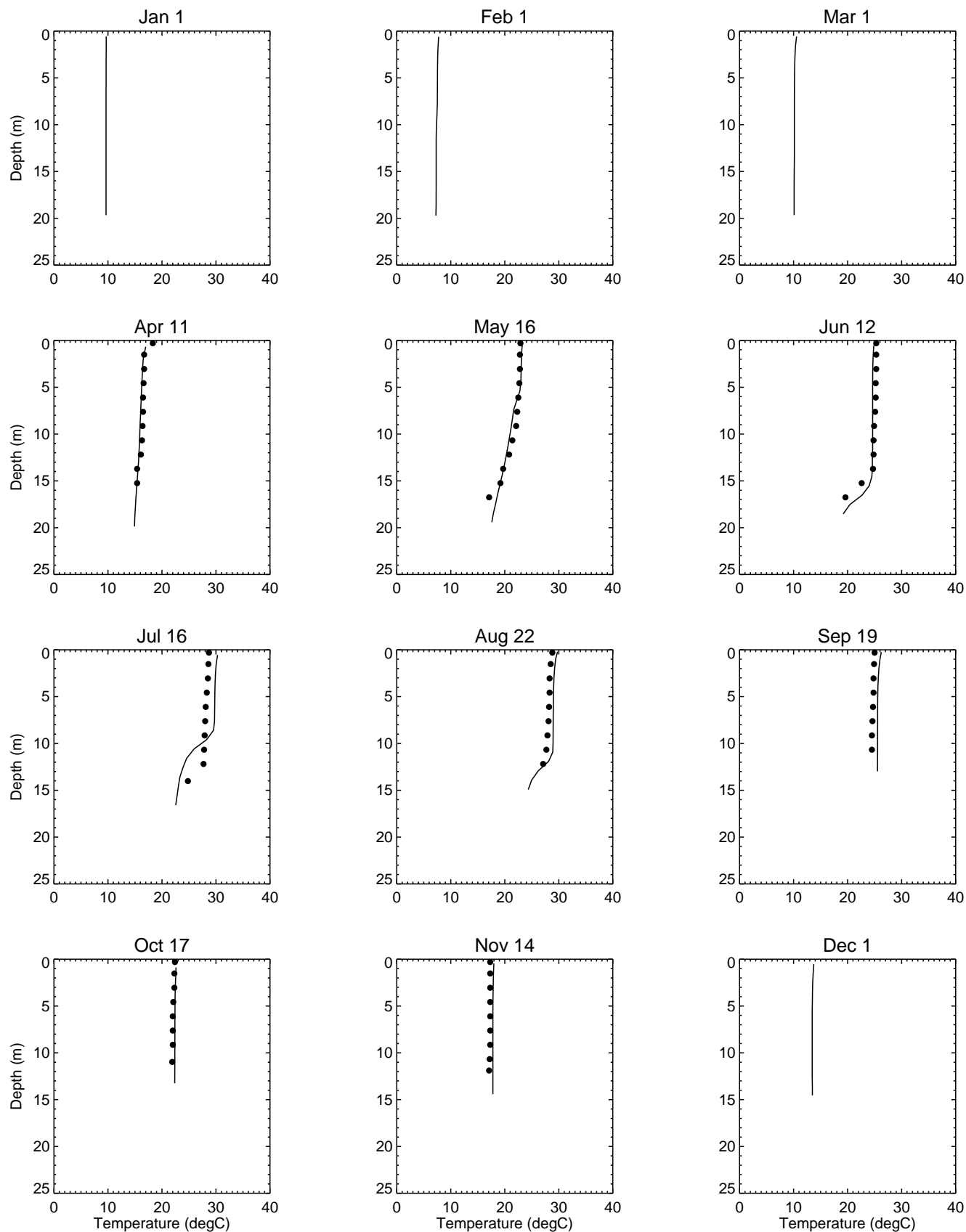*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 2001

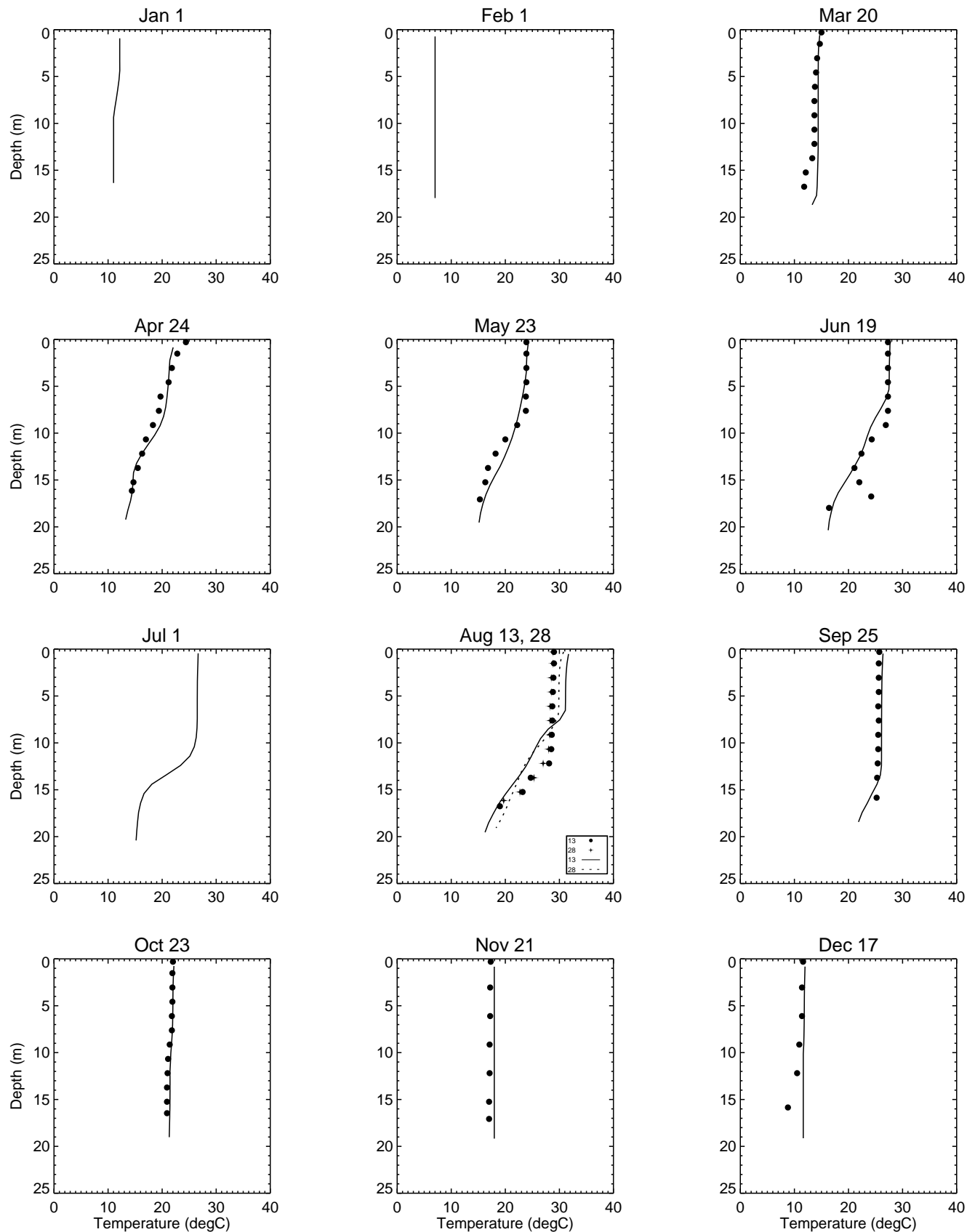*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:04 2013

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 2002

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
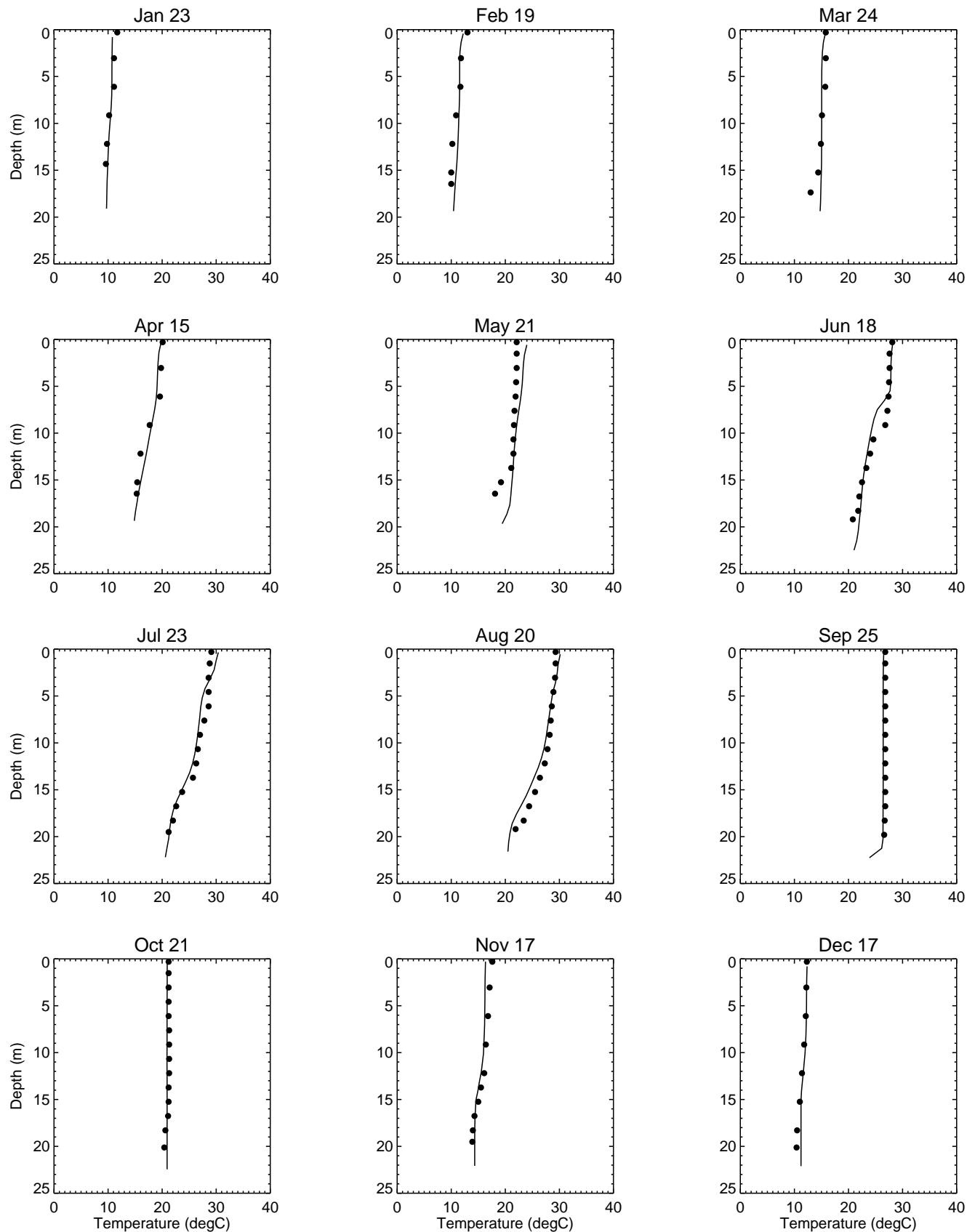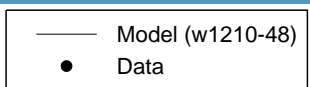
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:04 2013

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 2003

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
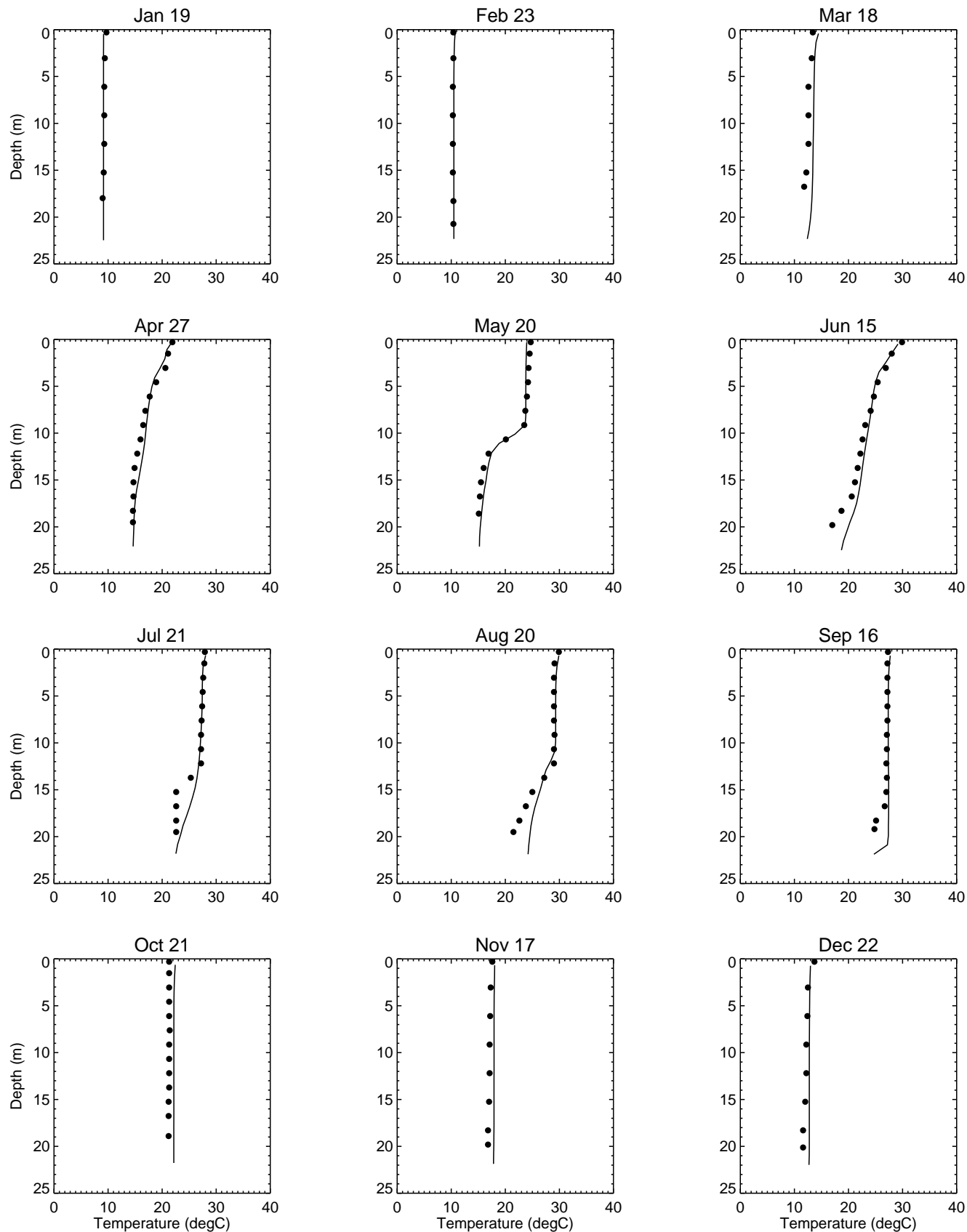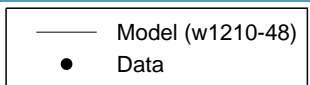
Lower Colorado River Authority

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 2004

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
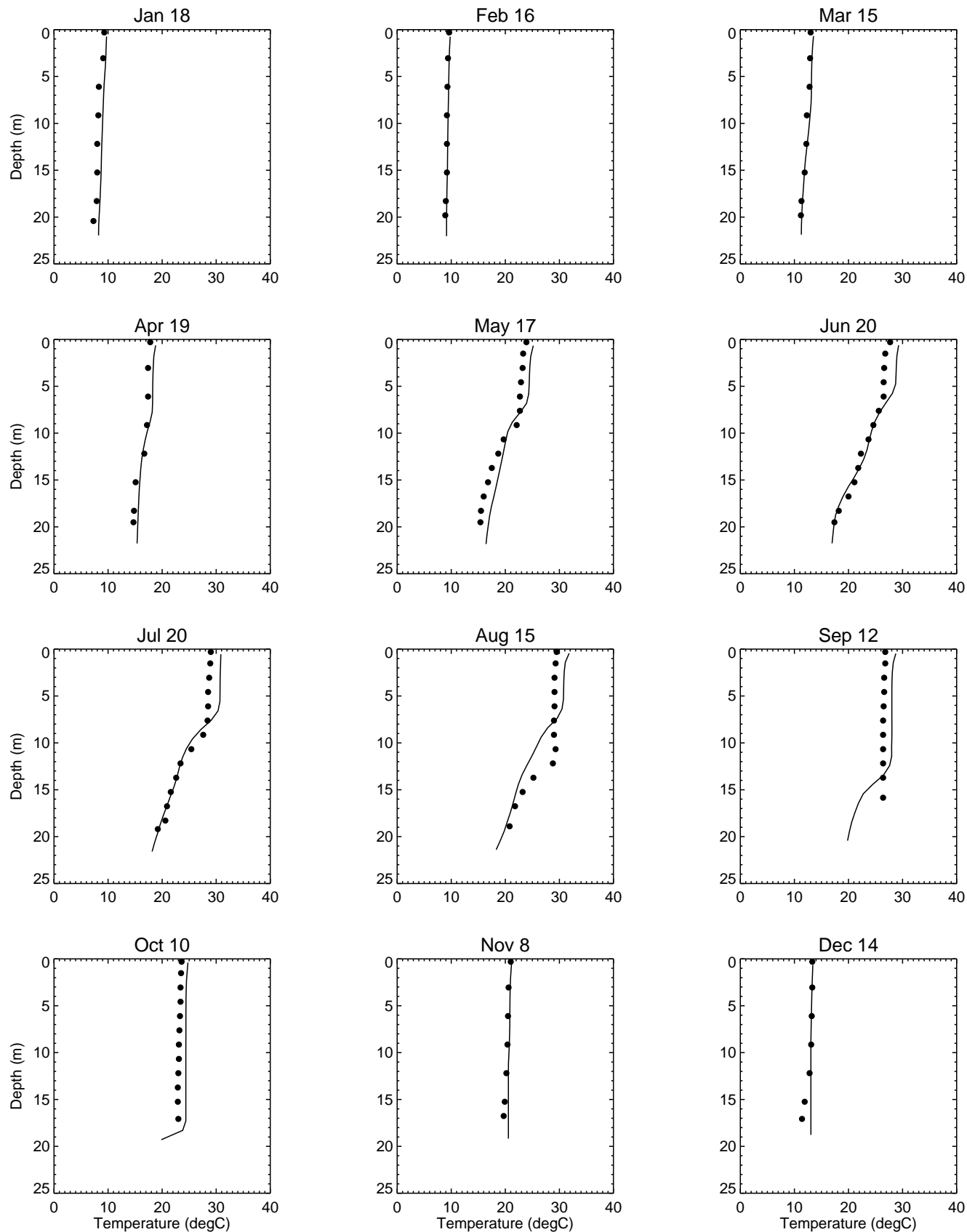
Lower Colorado River Authority

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 2005

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 2006

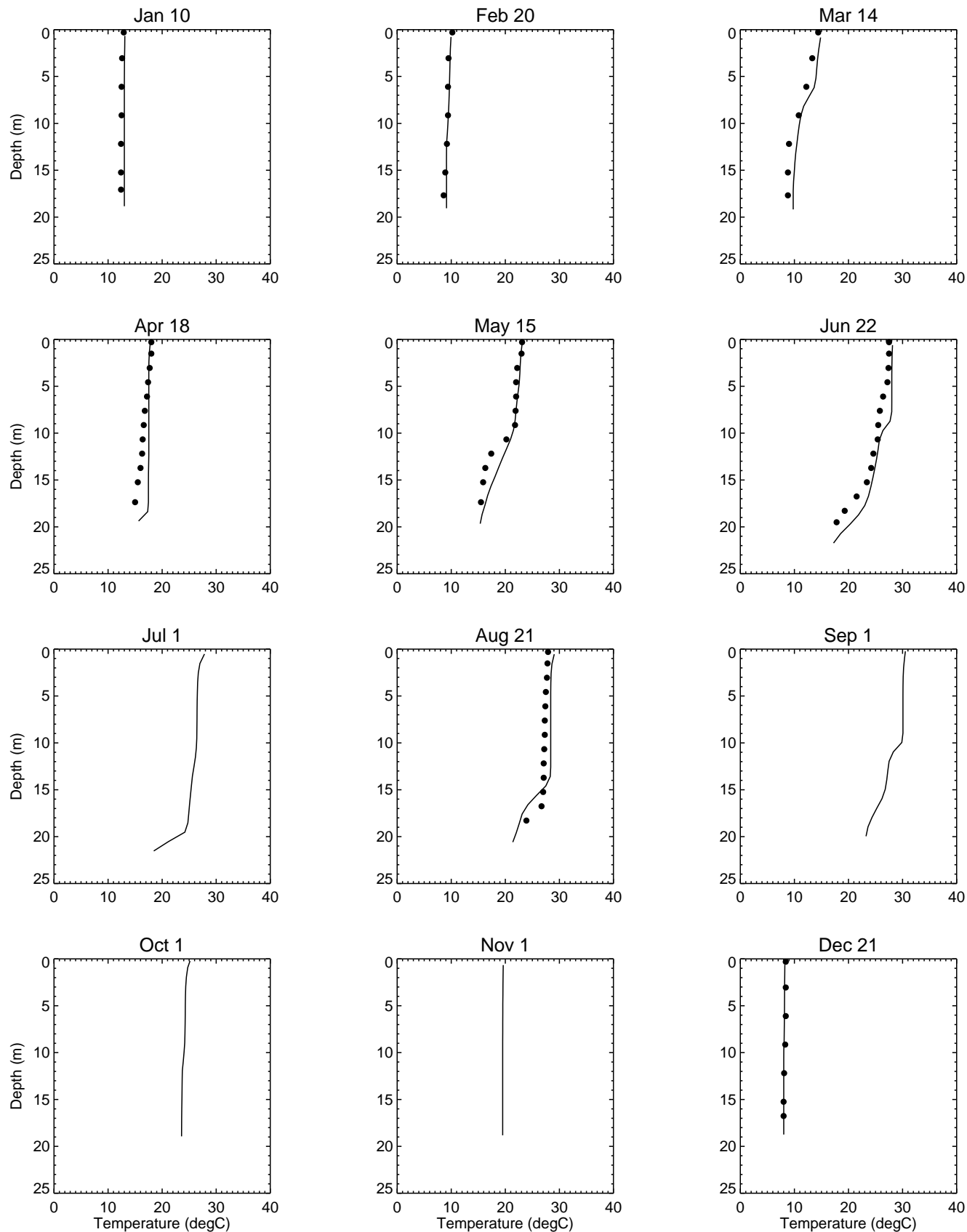*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 2007

Profiles shown for dates with available data else model results for first day of month shown.

Model (w1210-48)
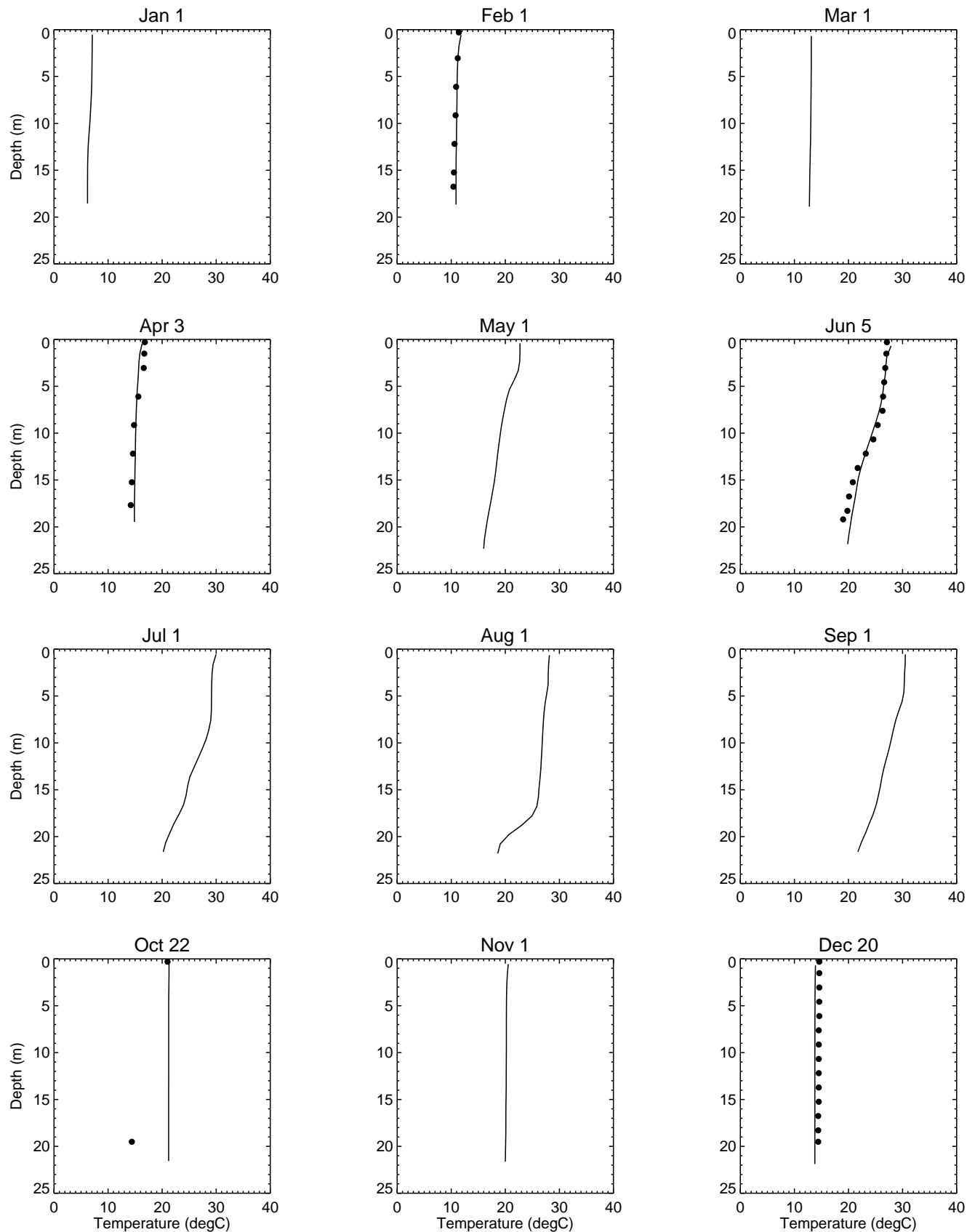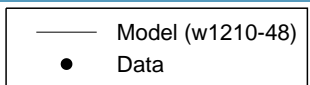● Data

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:04 2013

Lower Colorado River Authority

Jan 1

Feb 1

Mar 1

Apr 1

May 1

Jun 1

Jul 1

Aug 1

Sep 1

Oct 1

Nov 1

Dec 1

—— Model (w1210-48)

● Data

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 2008

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
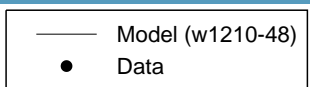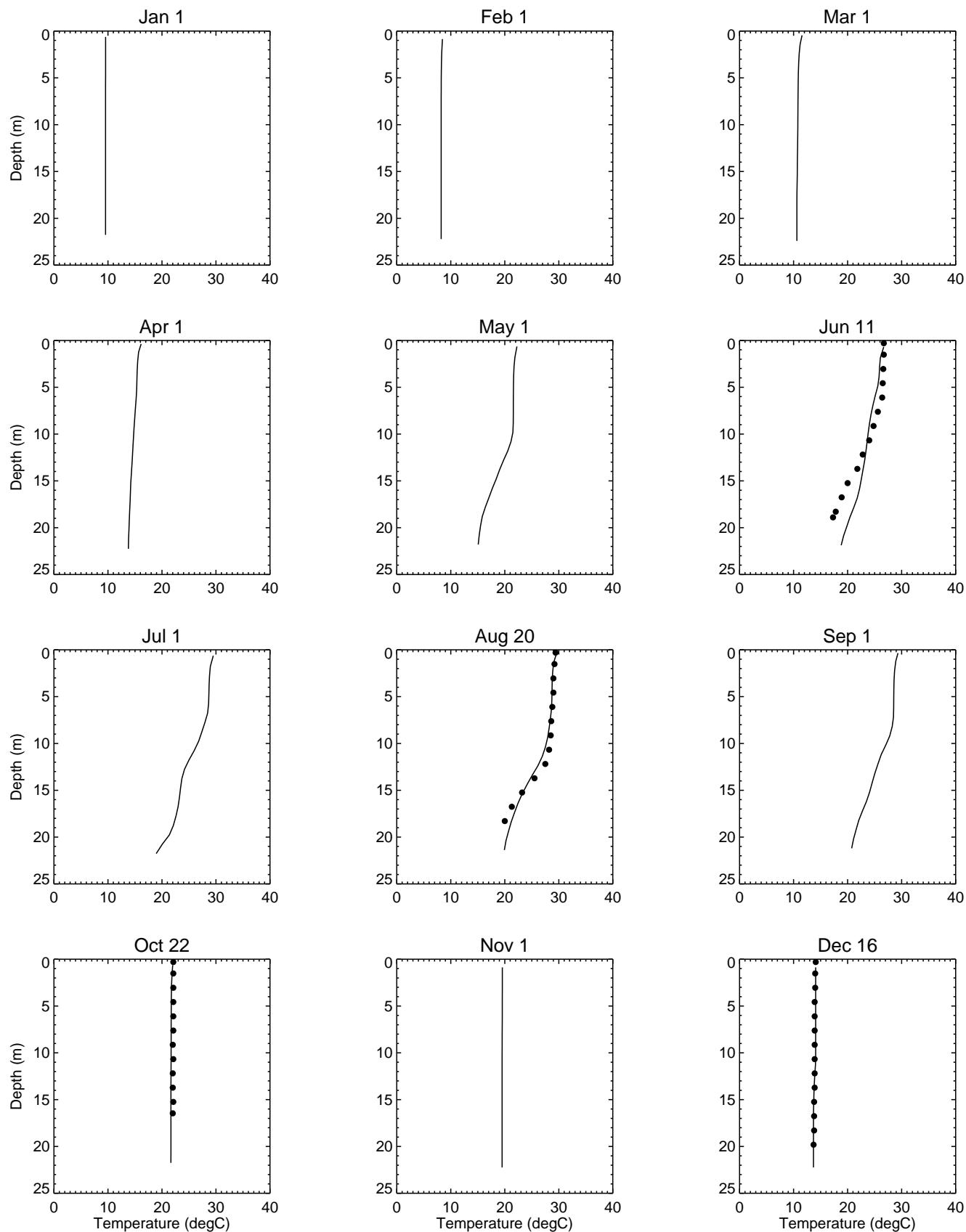
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:04 2013

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 2009

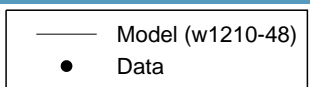*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
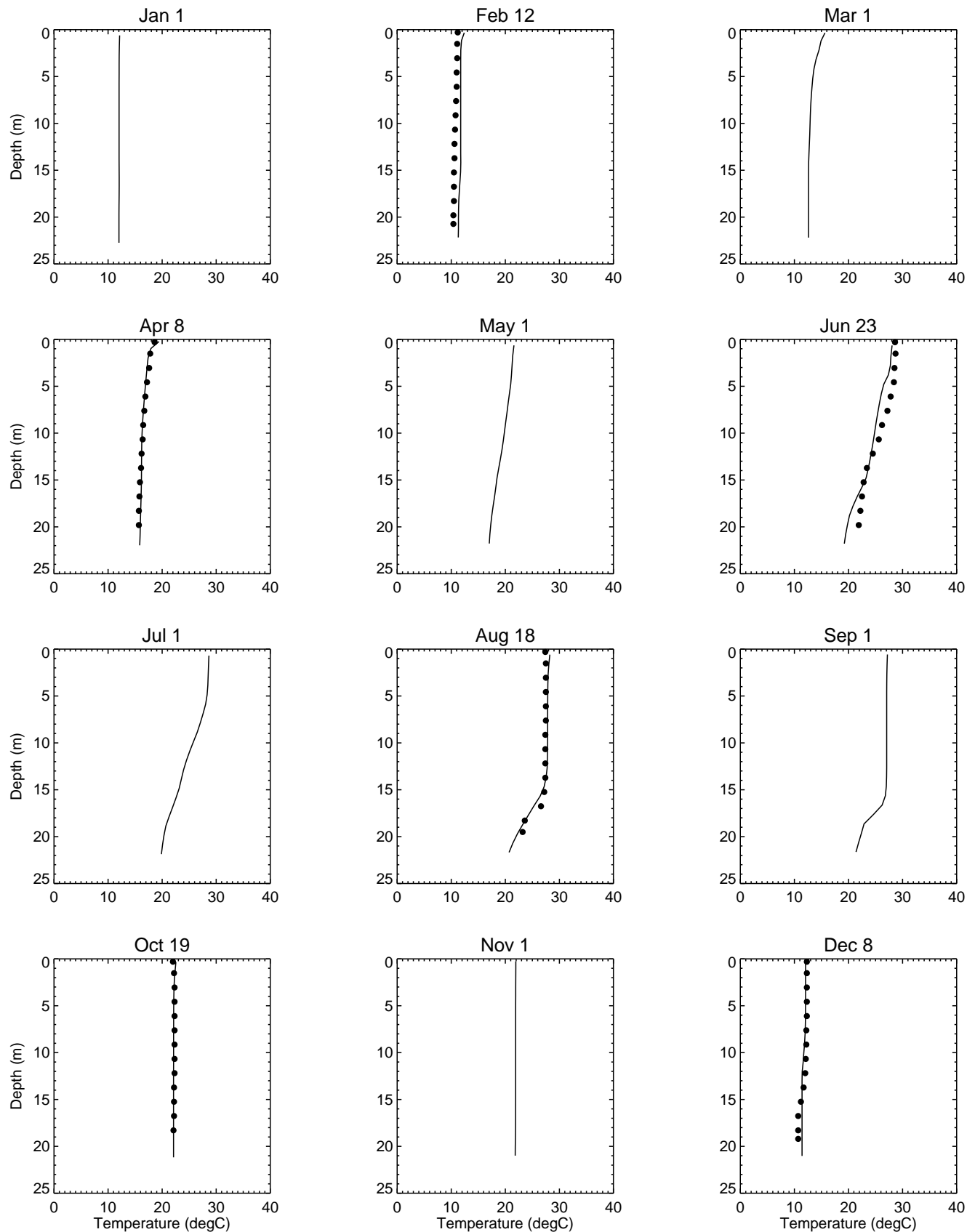
Lower Colorado River Authority

Figure G-3

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Temperature - 2010

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
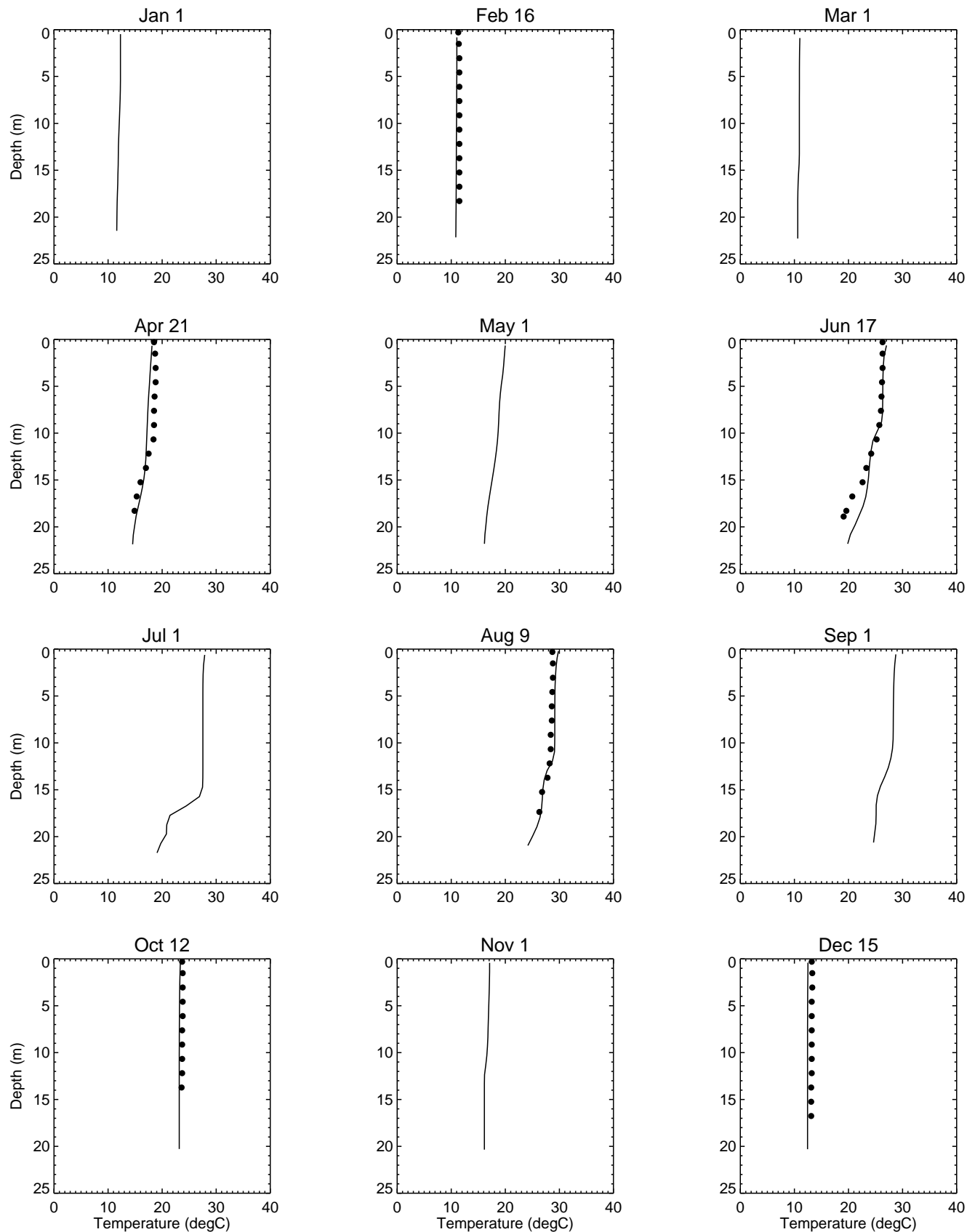
Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 1984

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 1985

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
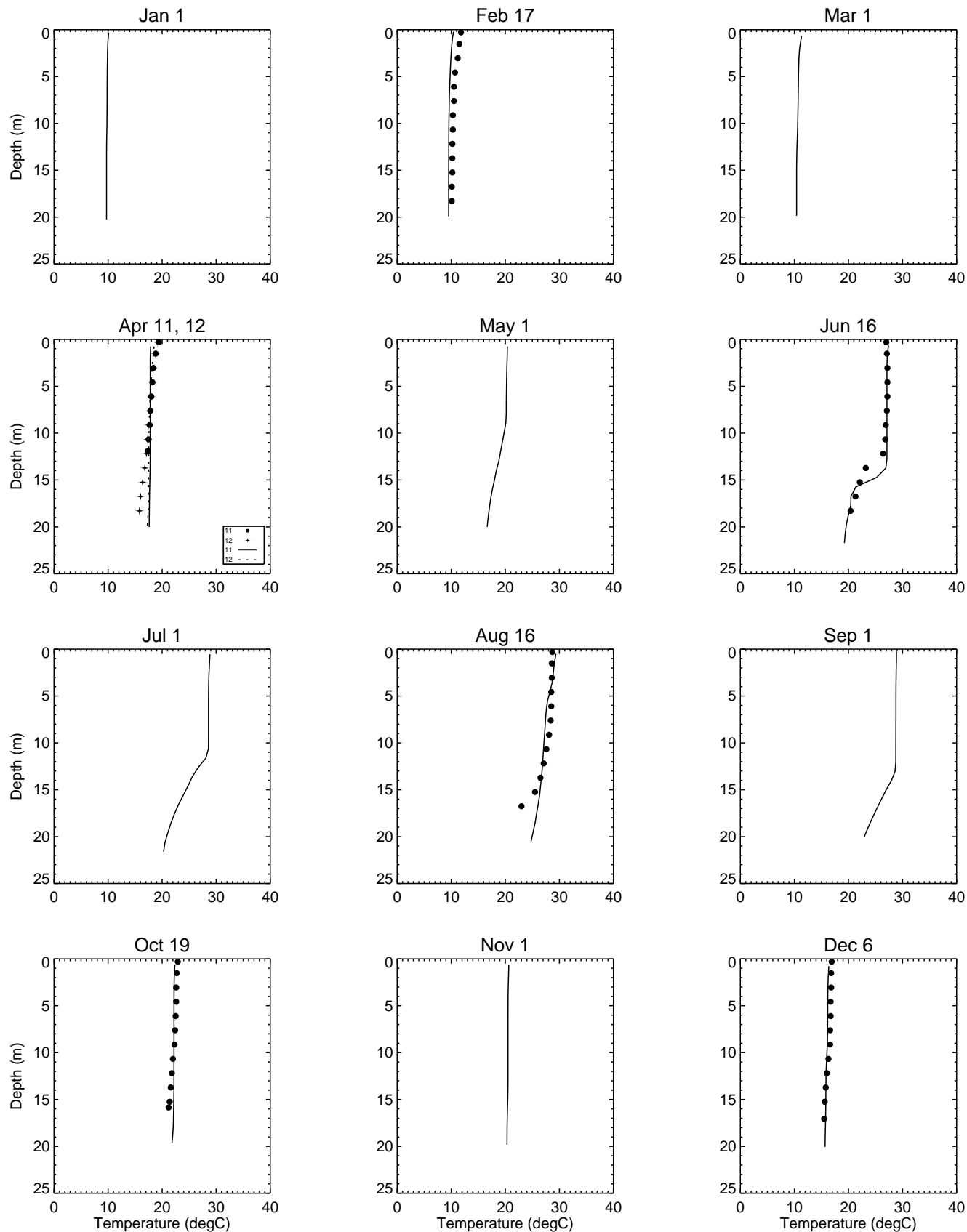Lower Colorado River Authority

Model (w1210-48)
• Data

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 1986

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
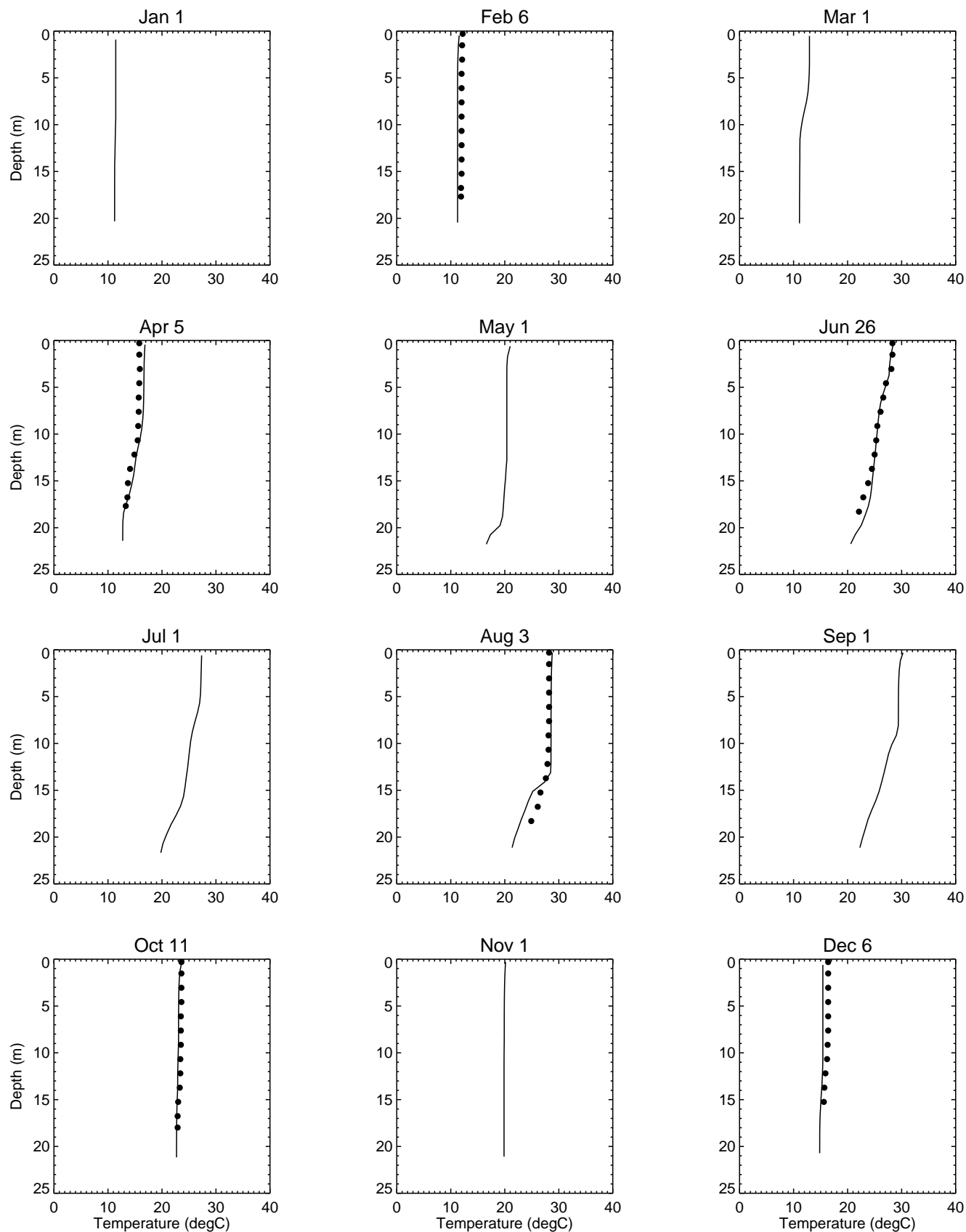
Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 1987

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
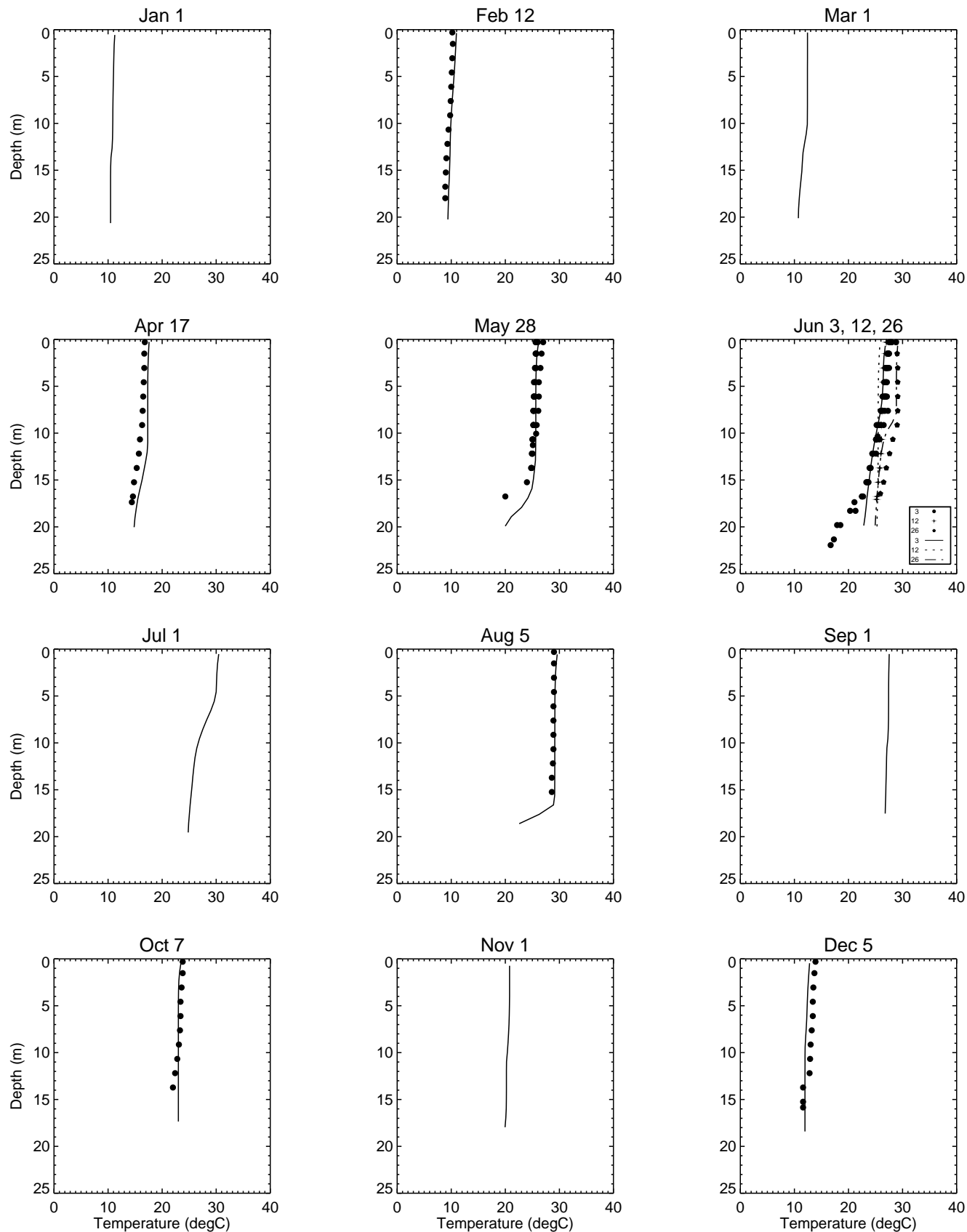Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 1989

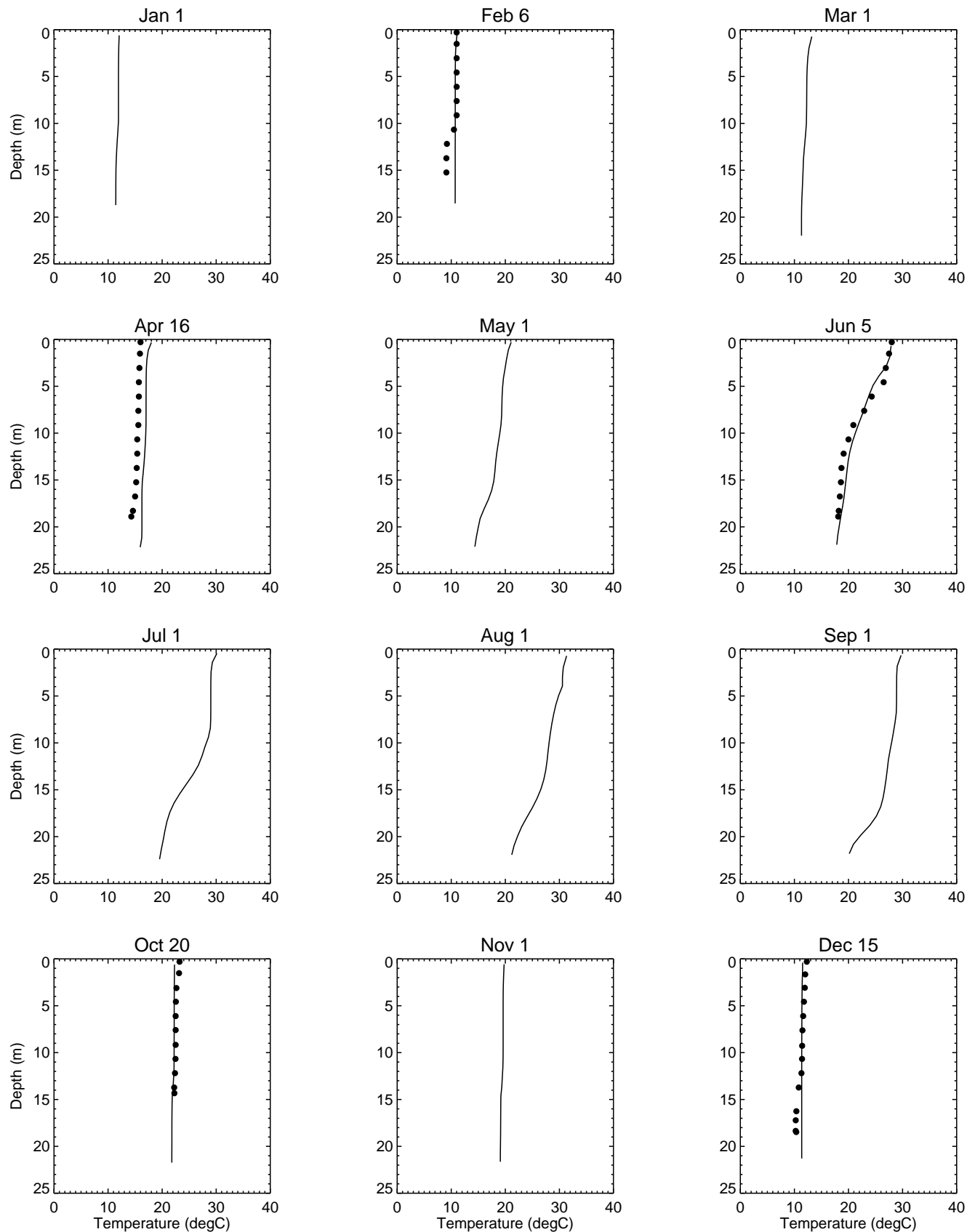*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:11:59 2013

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 1990

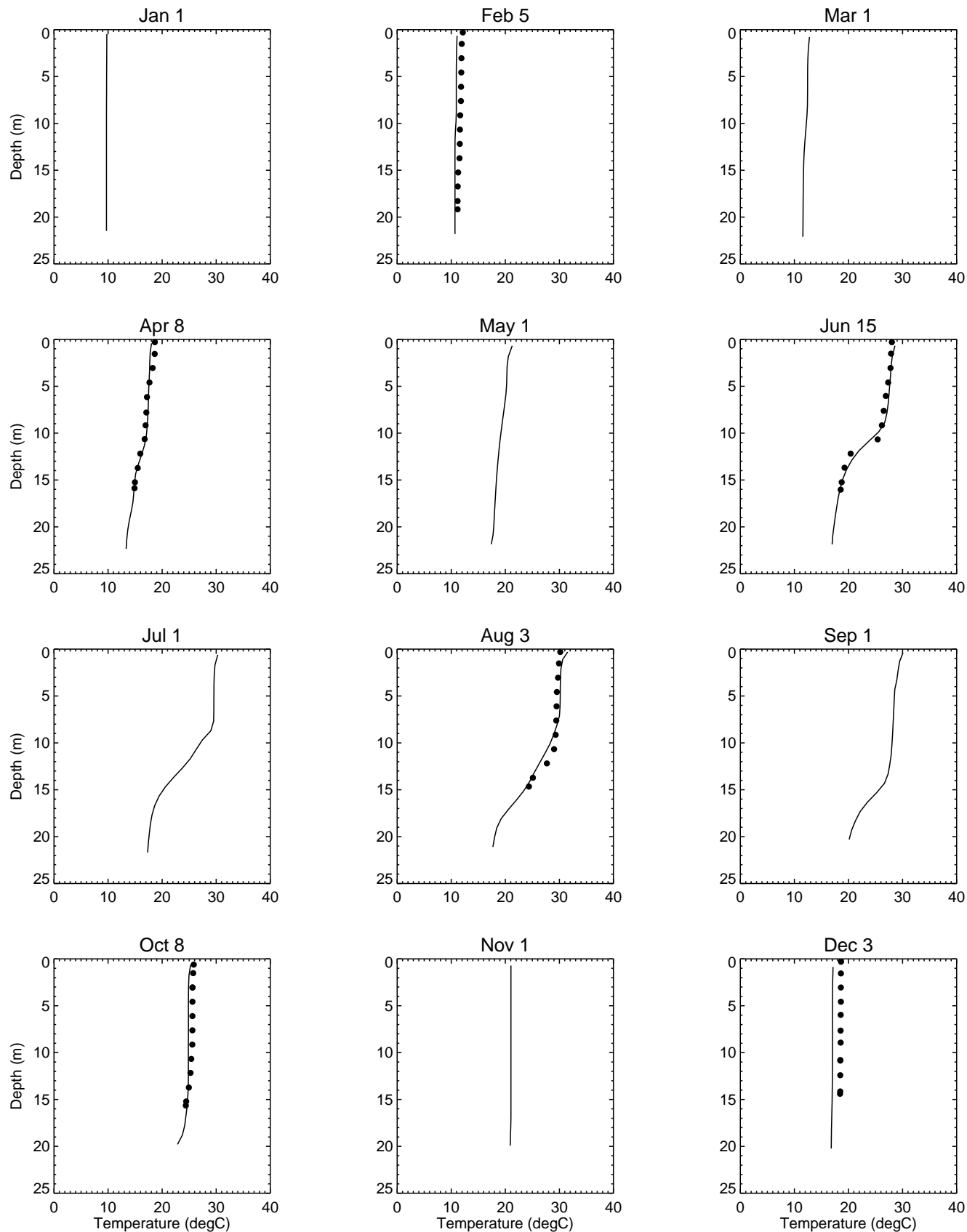*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 1991

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
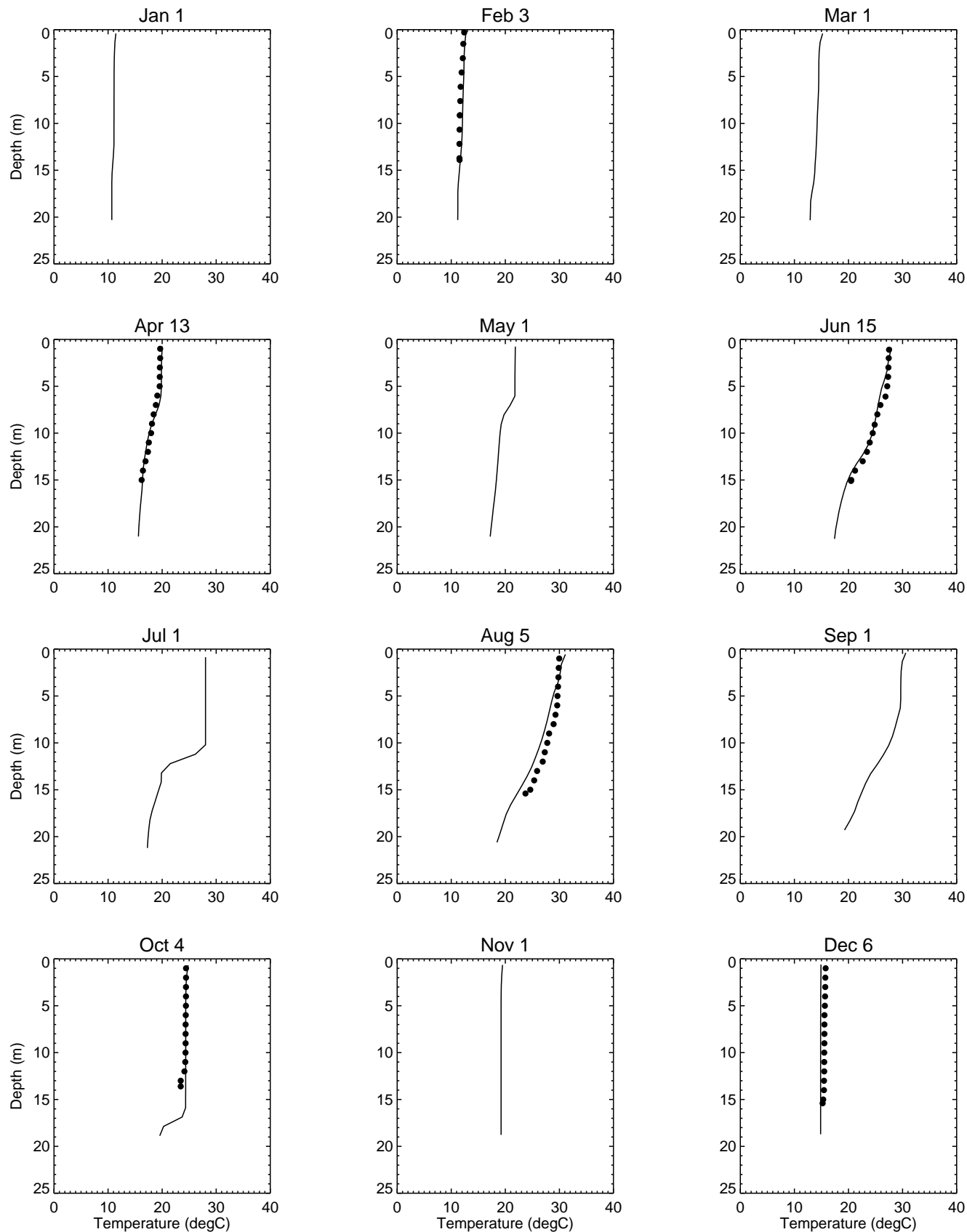Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 1992

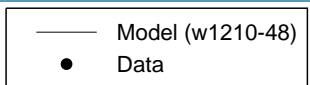*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Model (w1210-48)

● Data

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 1993

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
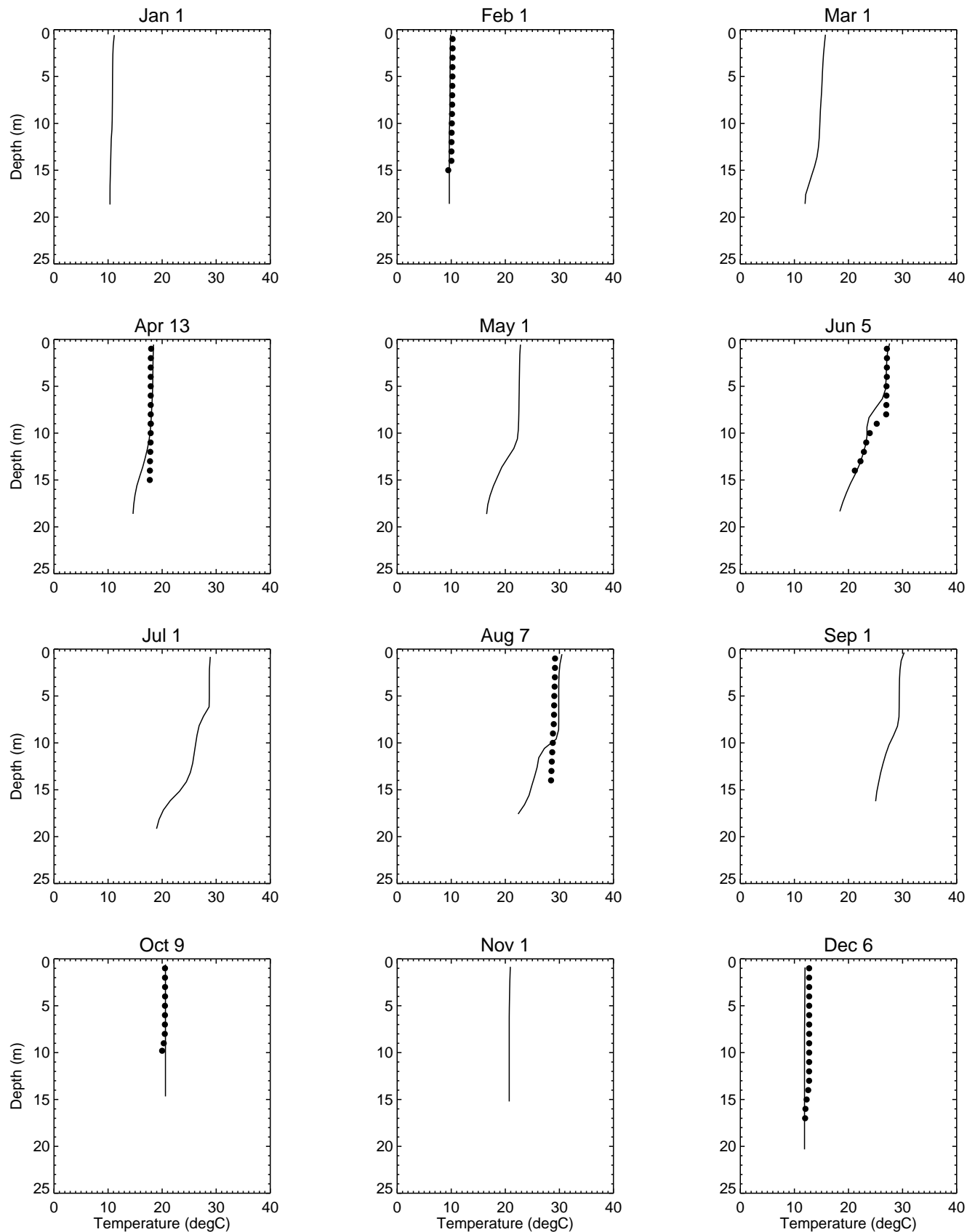
Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 1994

Profiles shown for dates with available data else model results for first day of month shown.

Model (w1210-48)
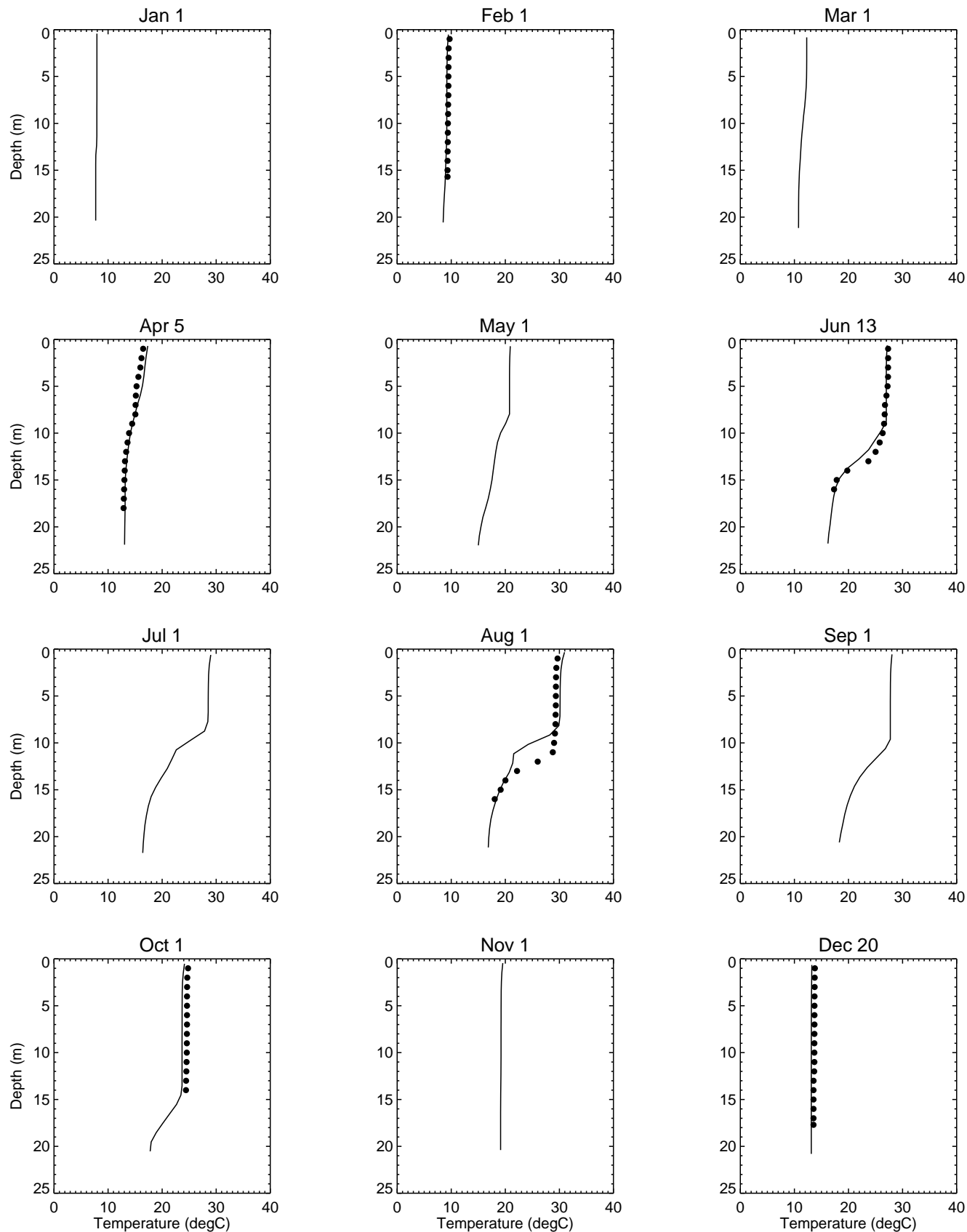● Data

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 1995

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
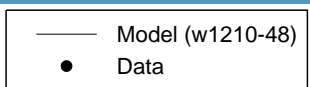Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 1996

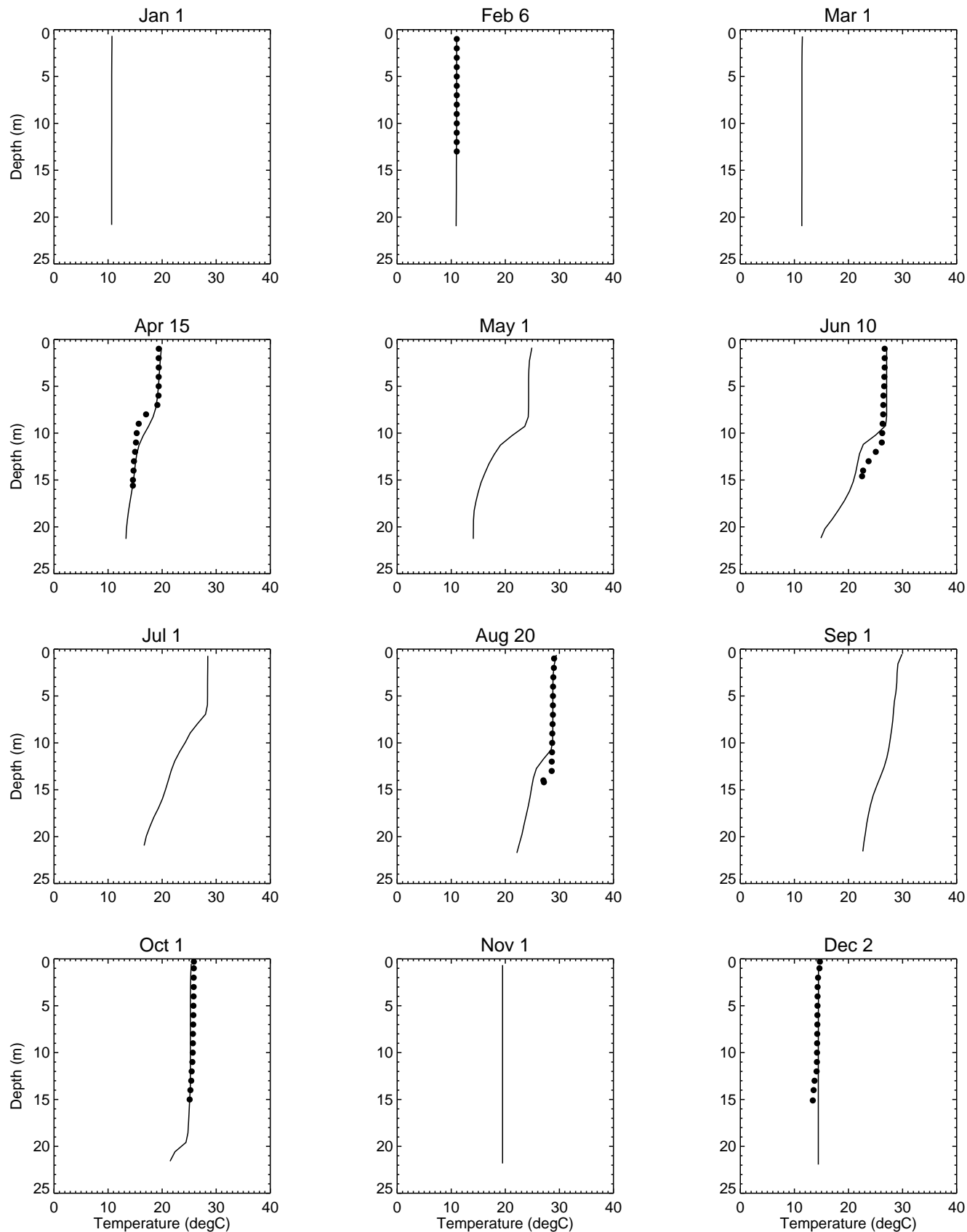*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 1997

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
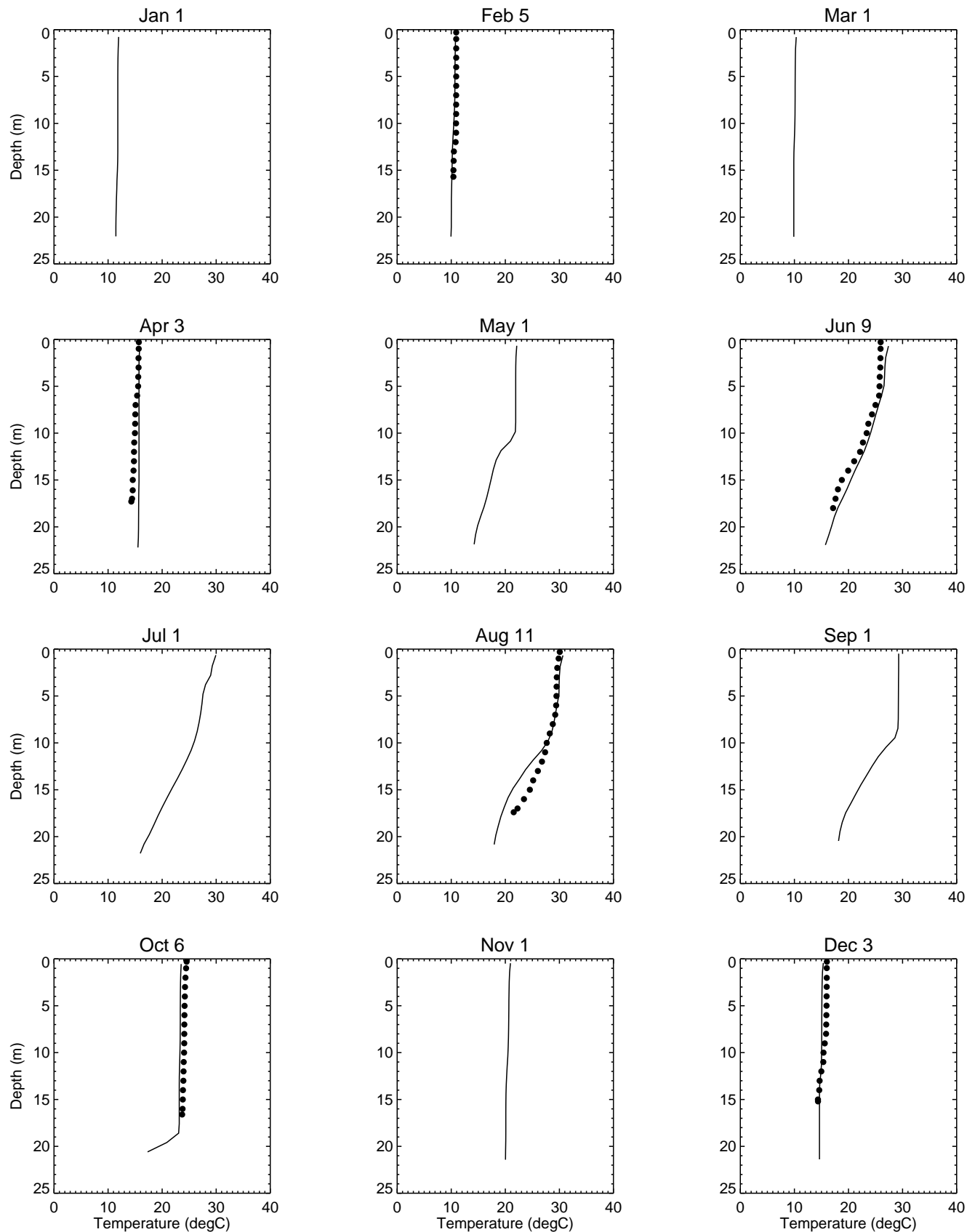
Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 1999

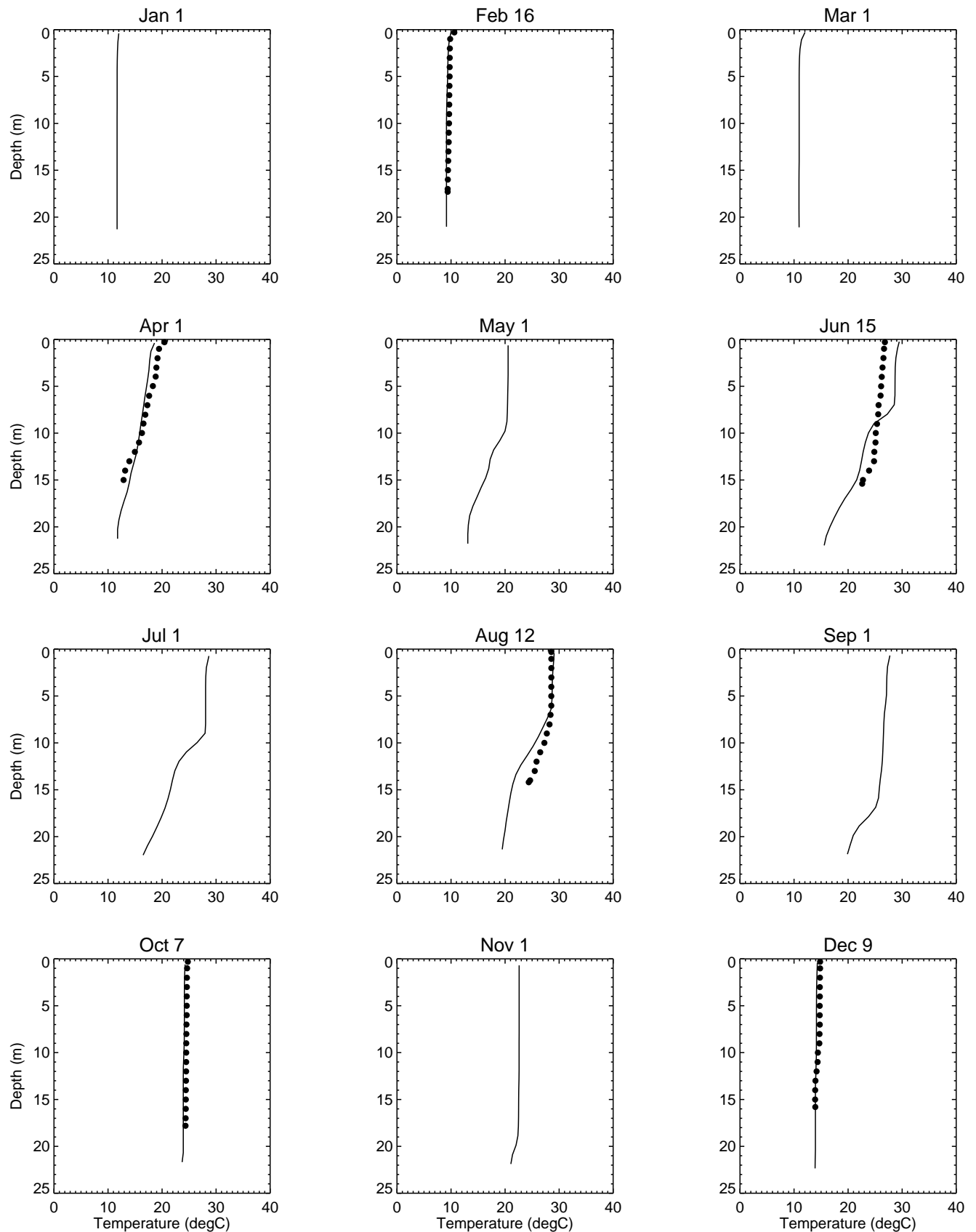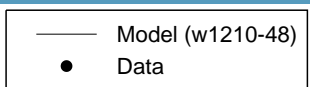*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 2000

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 2001

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
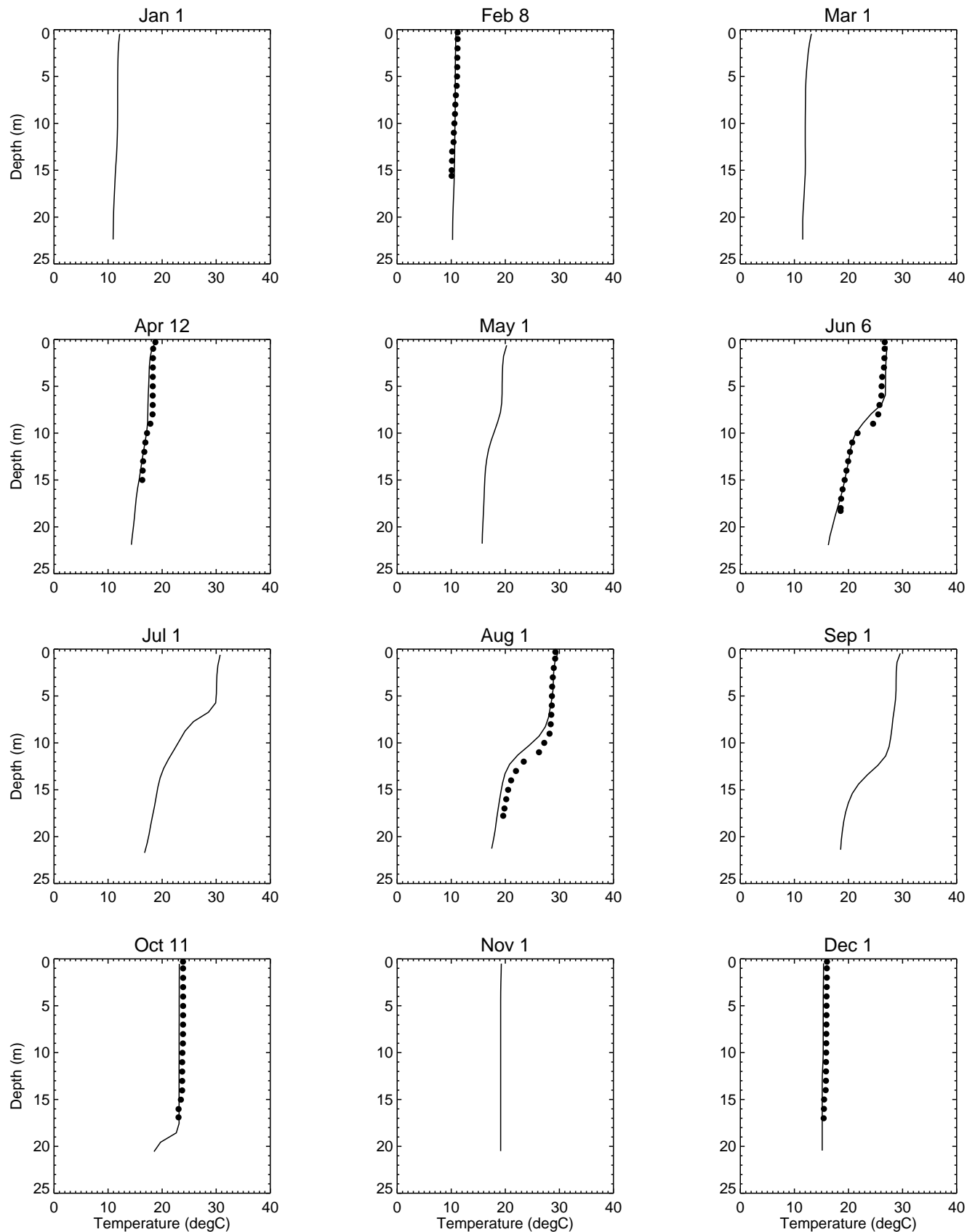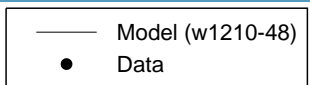
Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 2003

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
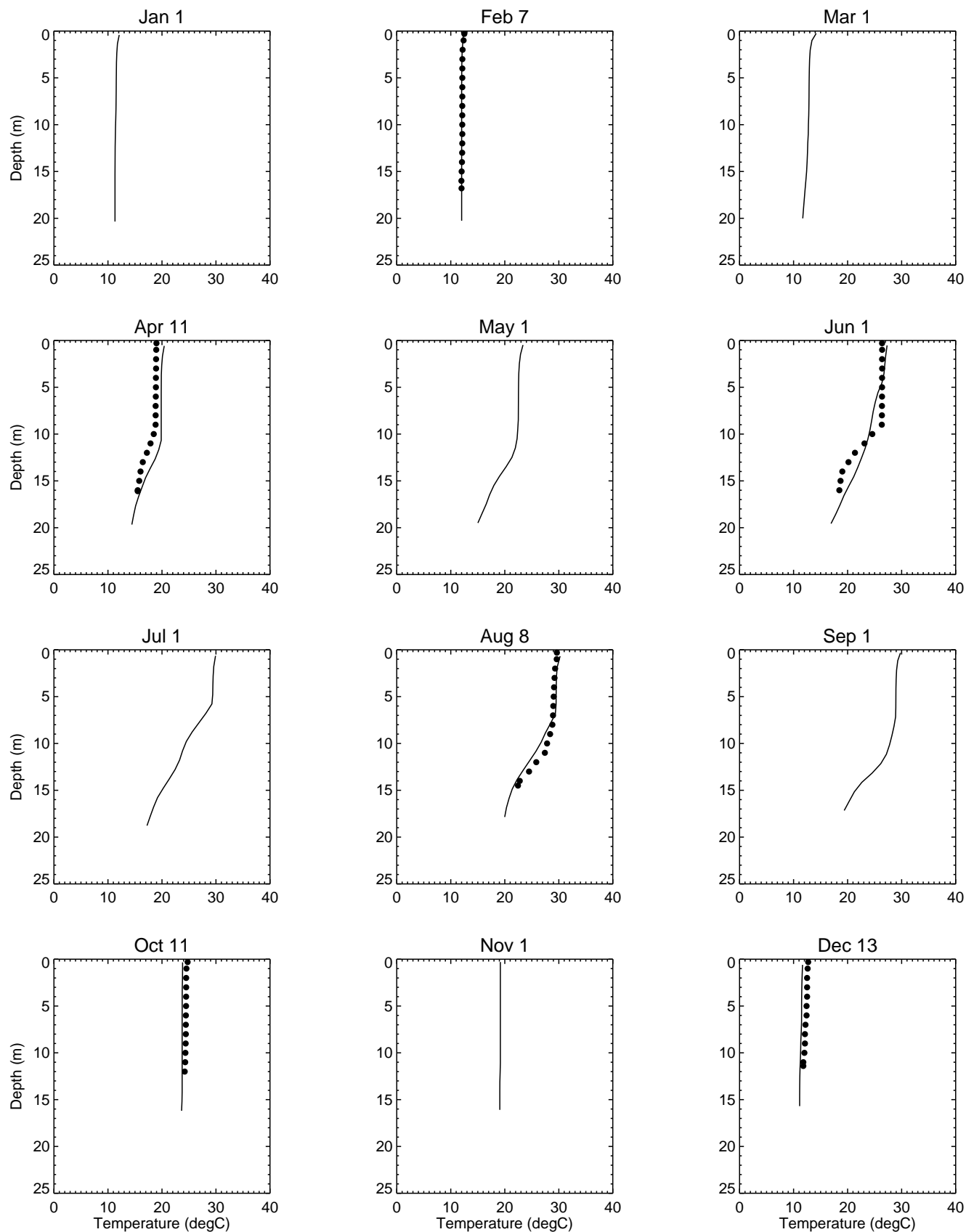
Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 2004

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 2005

Profiles shown for dates with available data else model results for first day of month shown.

Model (w1210-48)
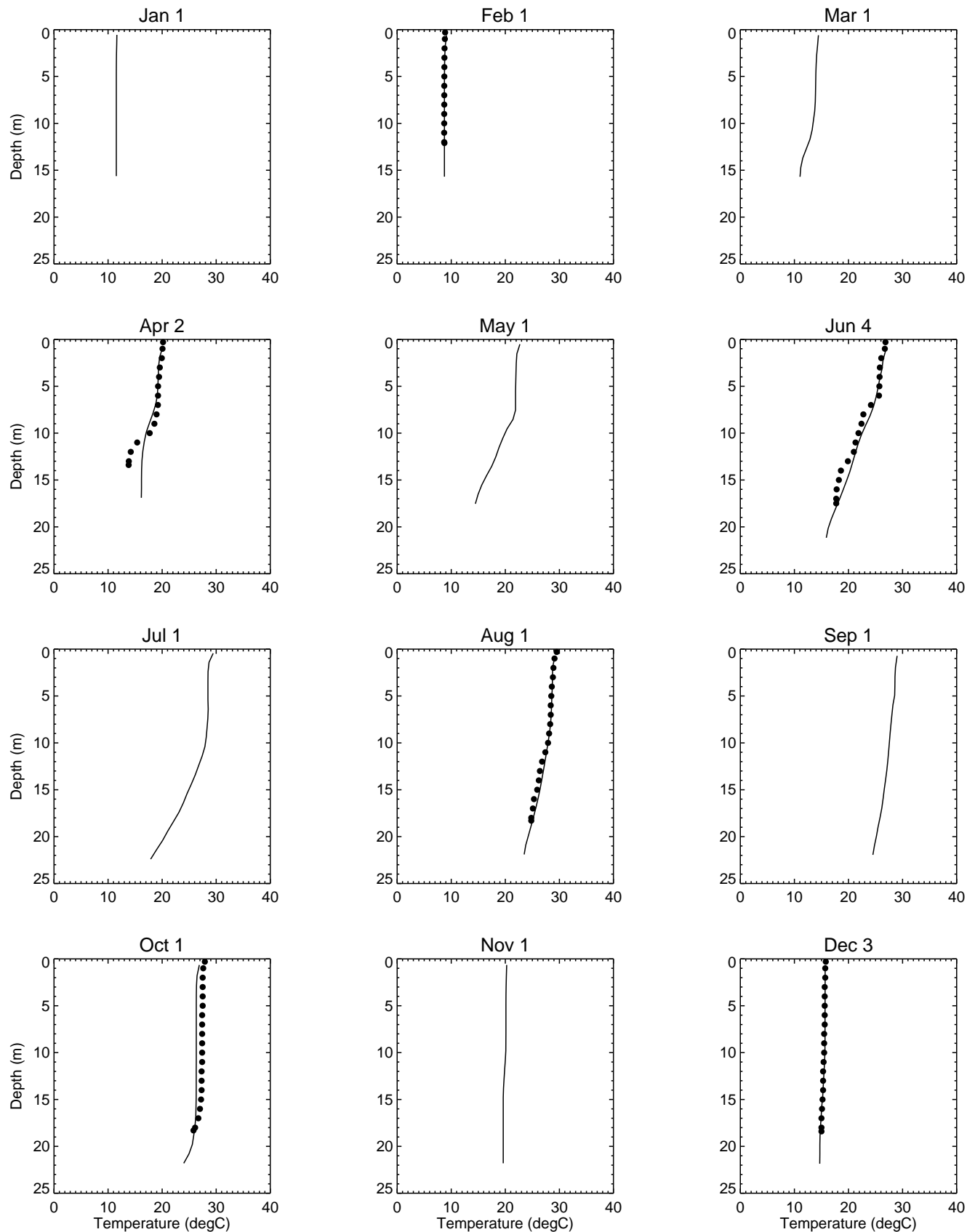● Data

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:00 2013

Model (w1210-48)
● Data

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 2006

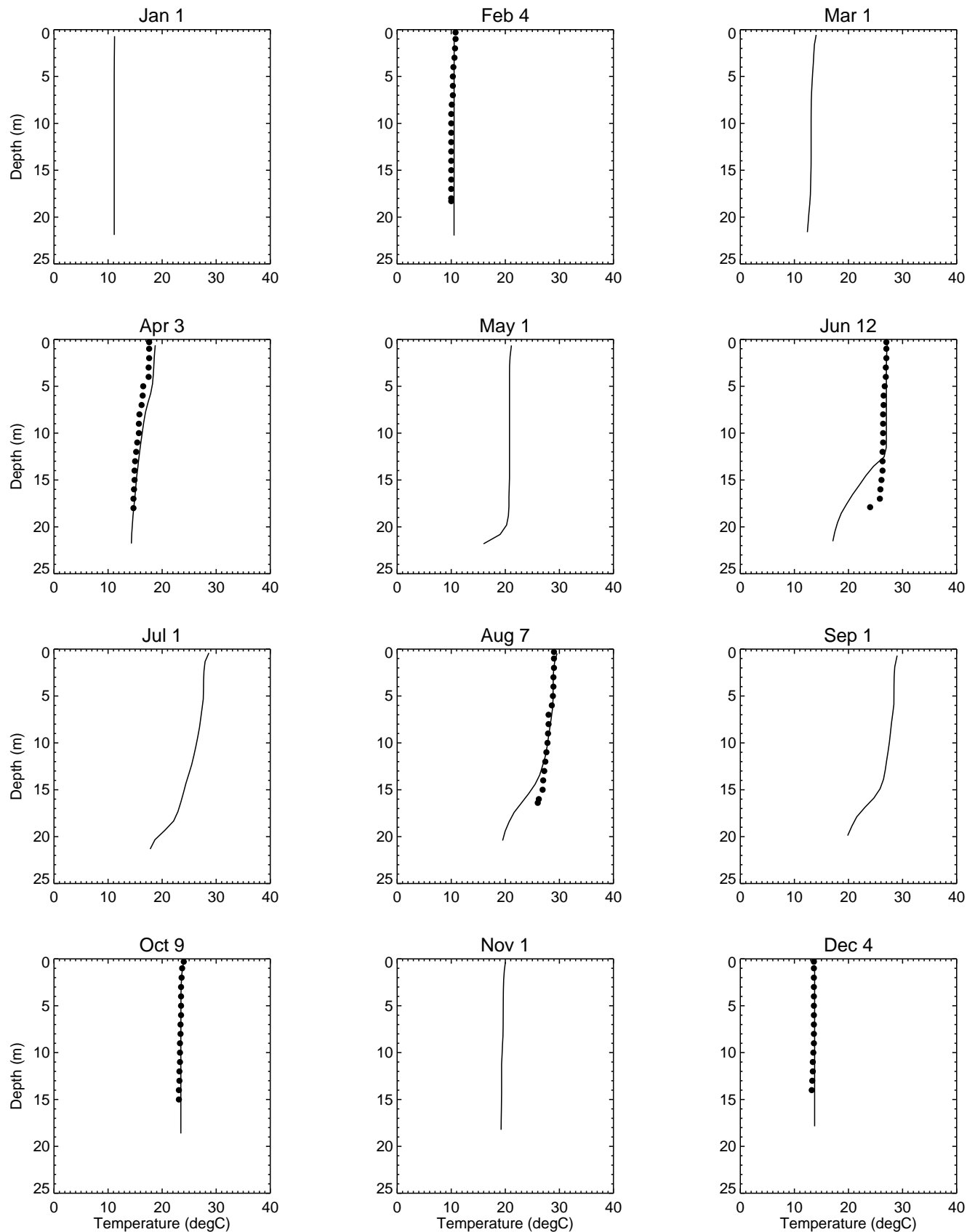*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
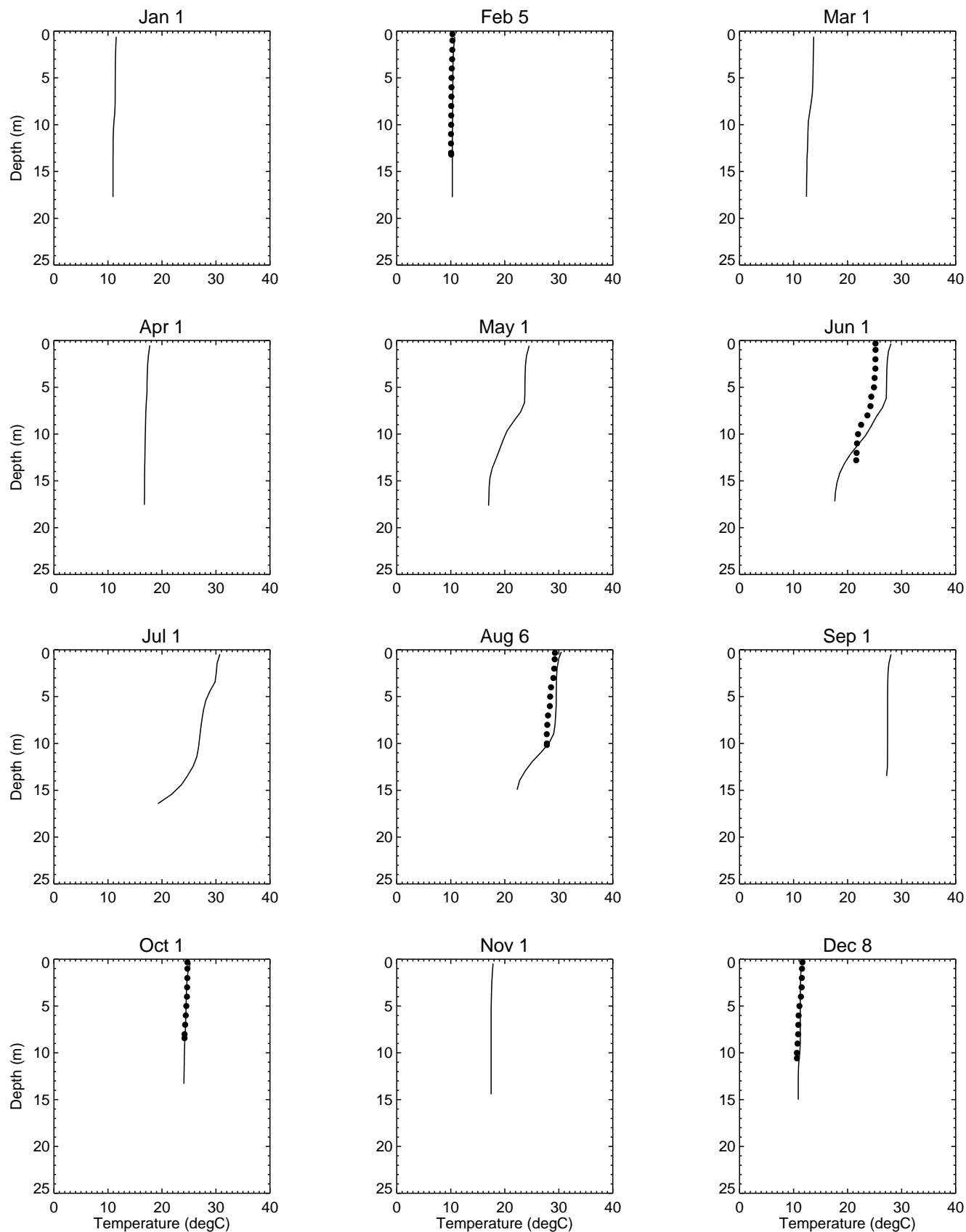
Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 2007

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 2008

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
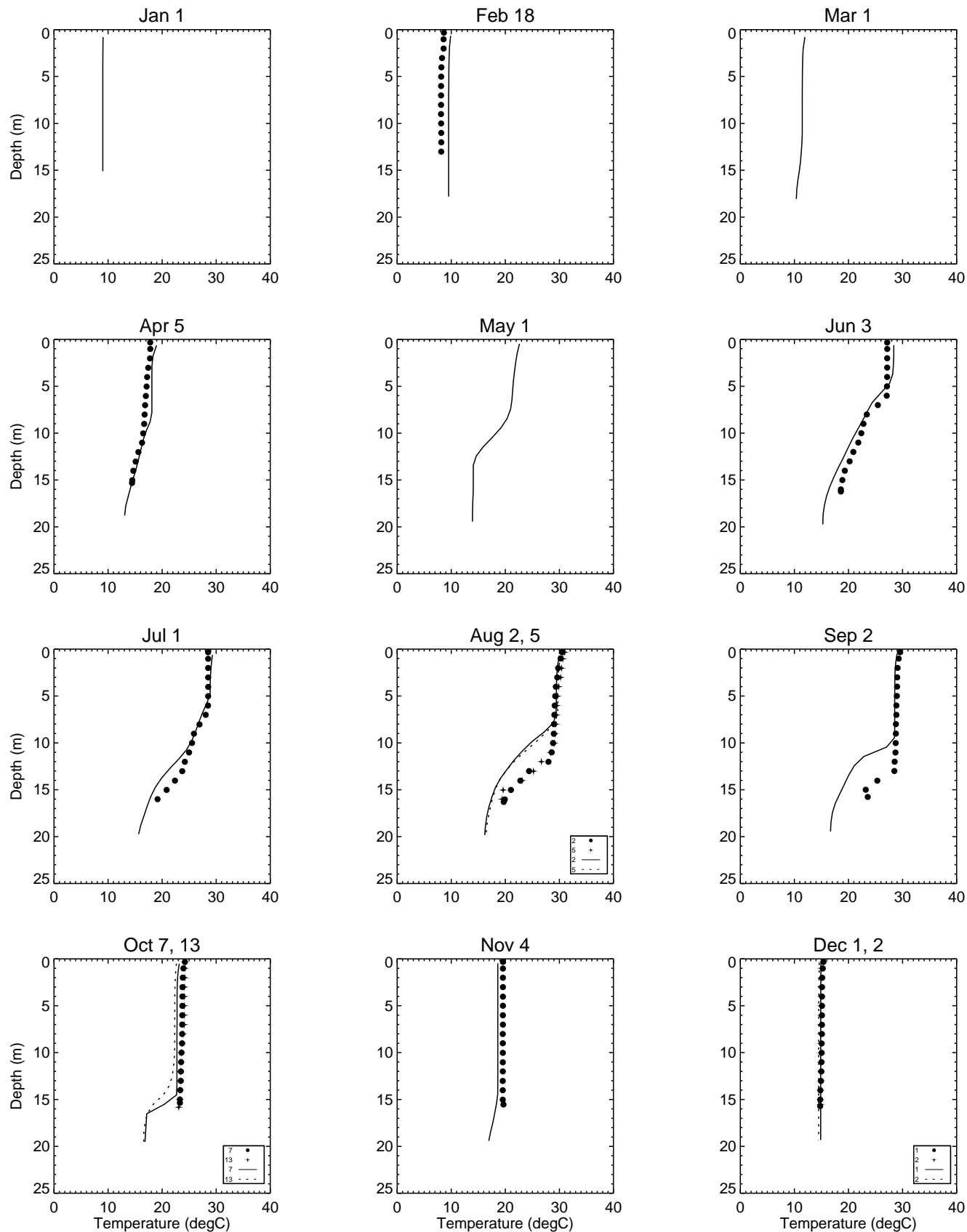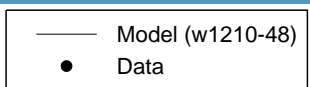
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:00 2013

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 2009

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
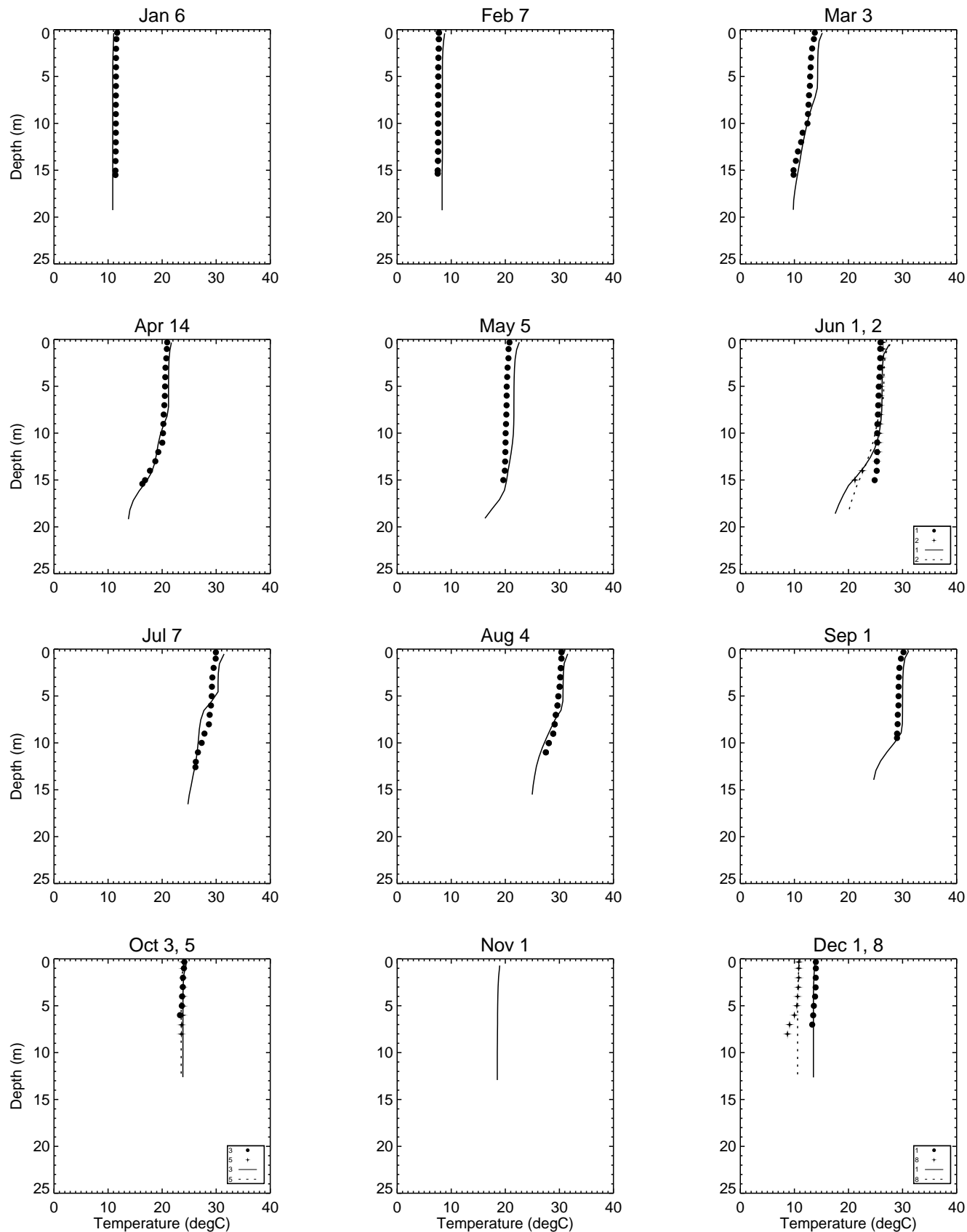
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:00 2013

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan near Beaver Creek Cove (Segment 6) - Temperature - 2010

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
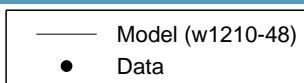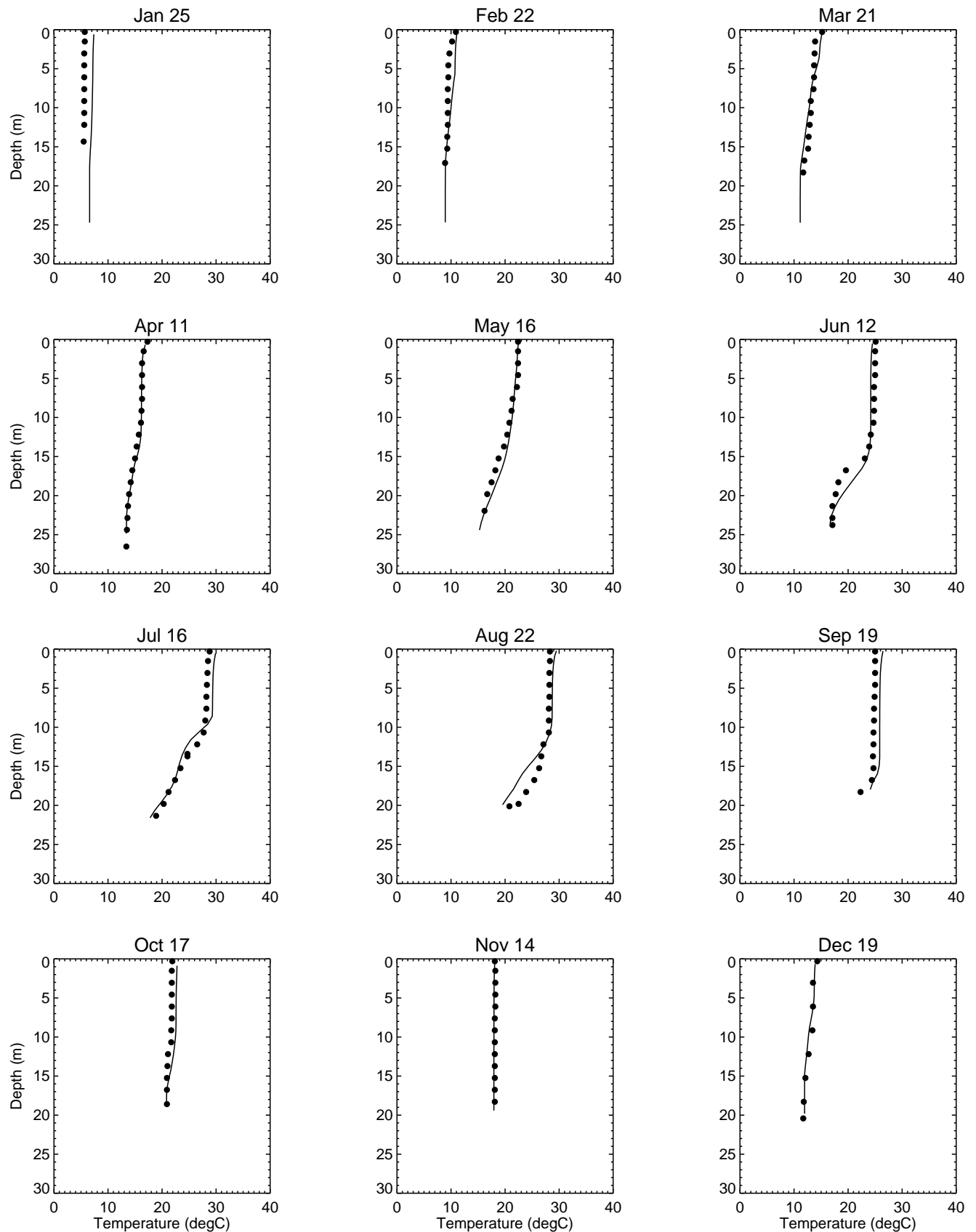
Lower Colorado River Authority

Figure G-4

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Temperature - 2011

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 1984

Profiles shown for dates with available data else model results for first day of month shown.
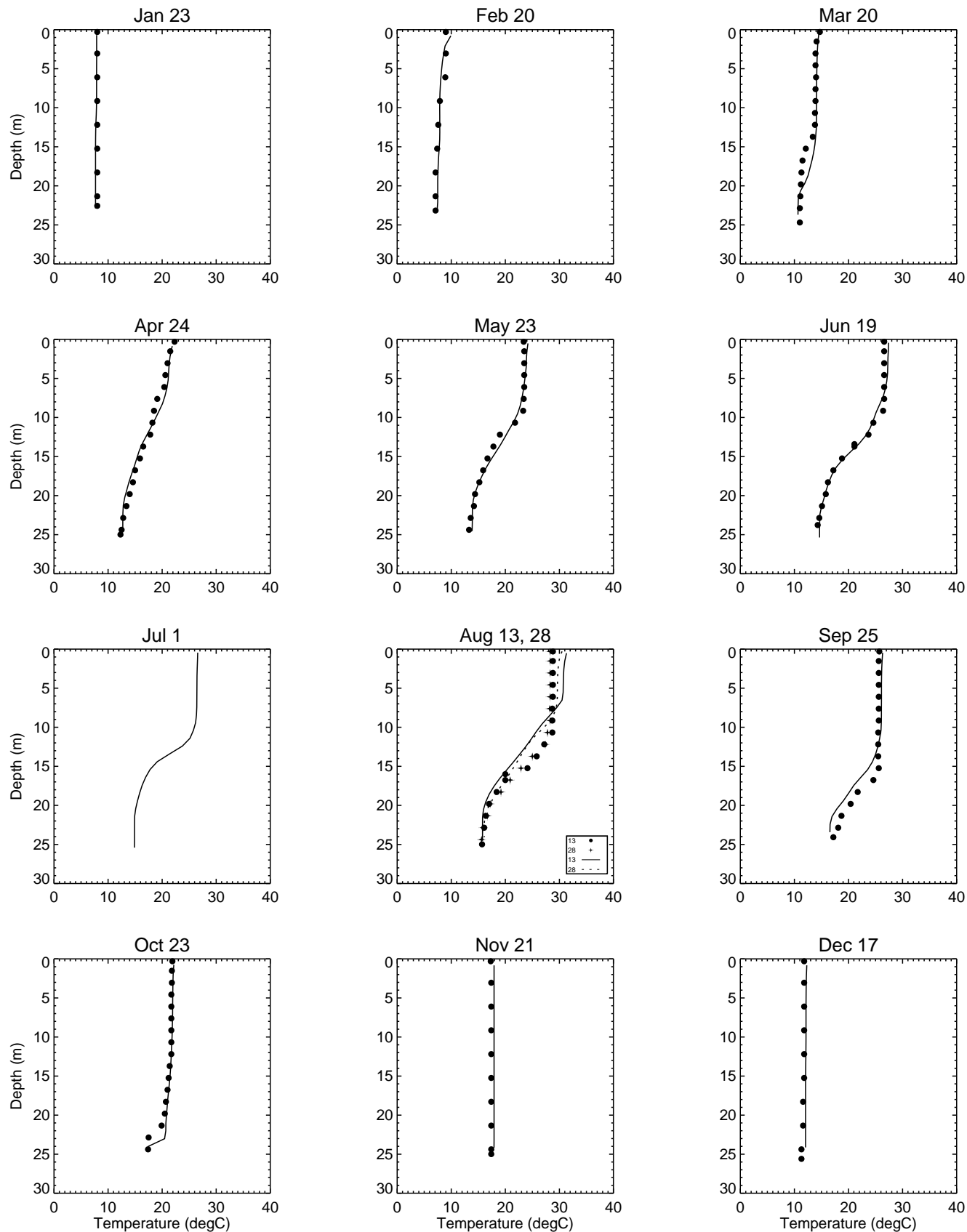
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 1985

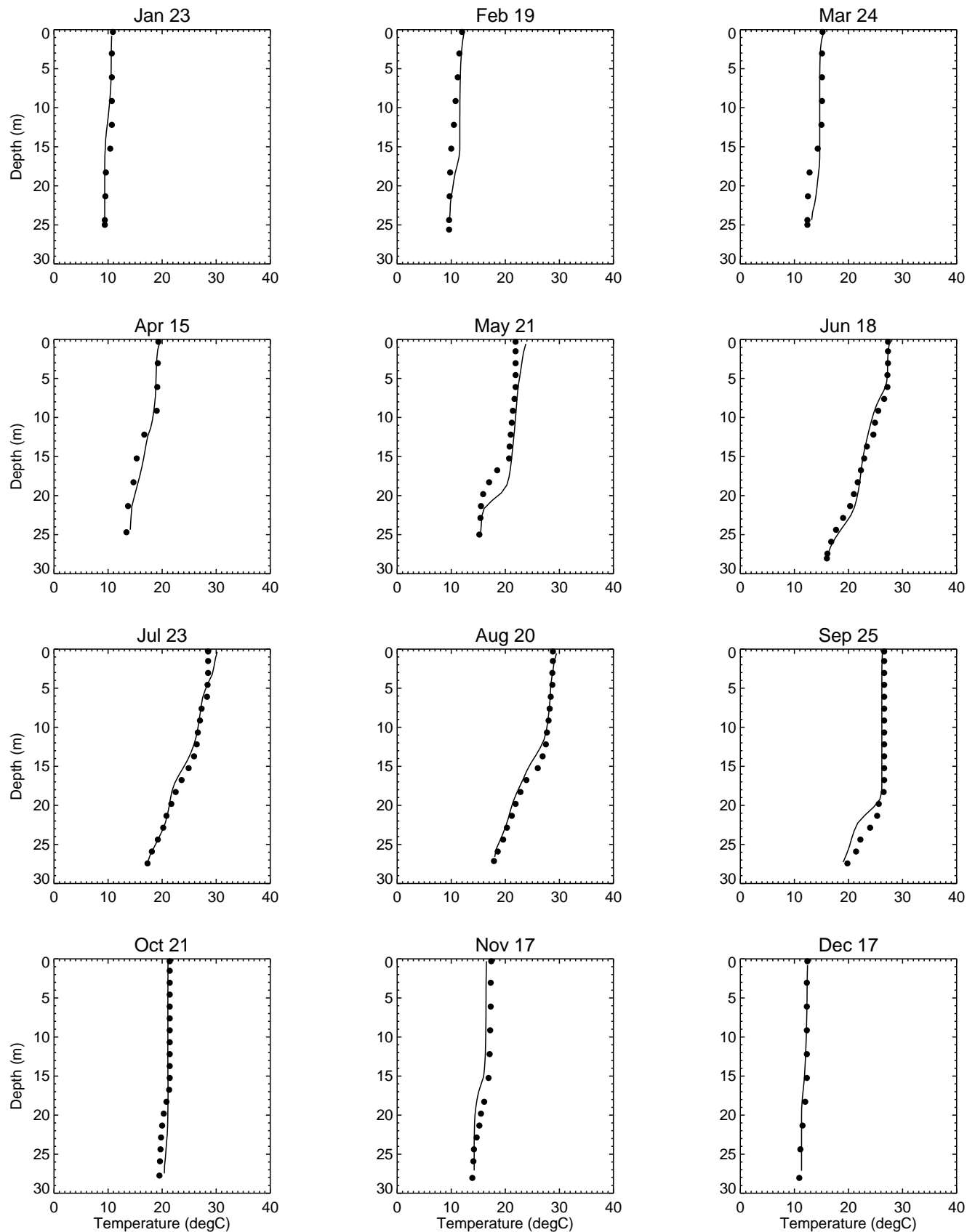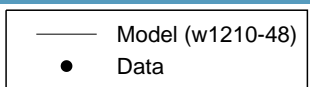*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:07 2013

Jan 23 · Feb 19 · Mar 24 · Apr 15 · May 21 · Jun 18 · Jul 23 · Aug 20 · Sep 25 · Oct 21 · Nov 17 · Dec 17

Temperature (degC)

—— Model (w1210-48)
● Data

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 1986

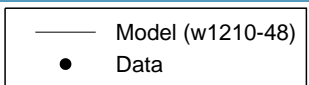*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
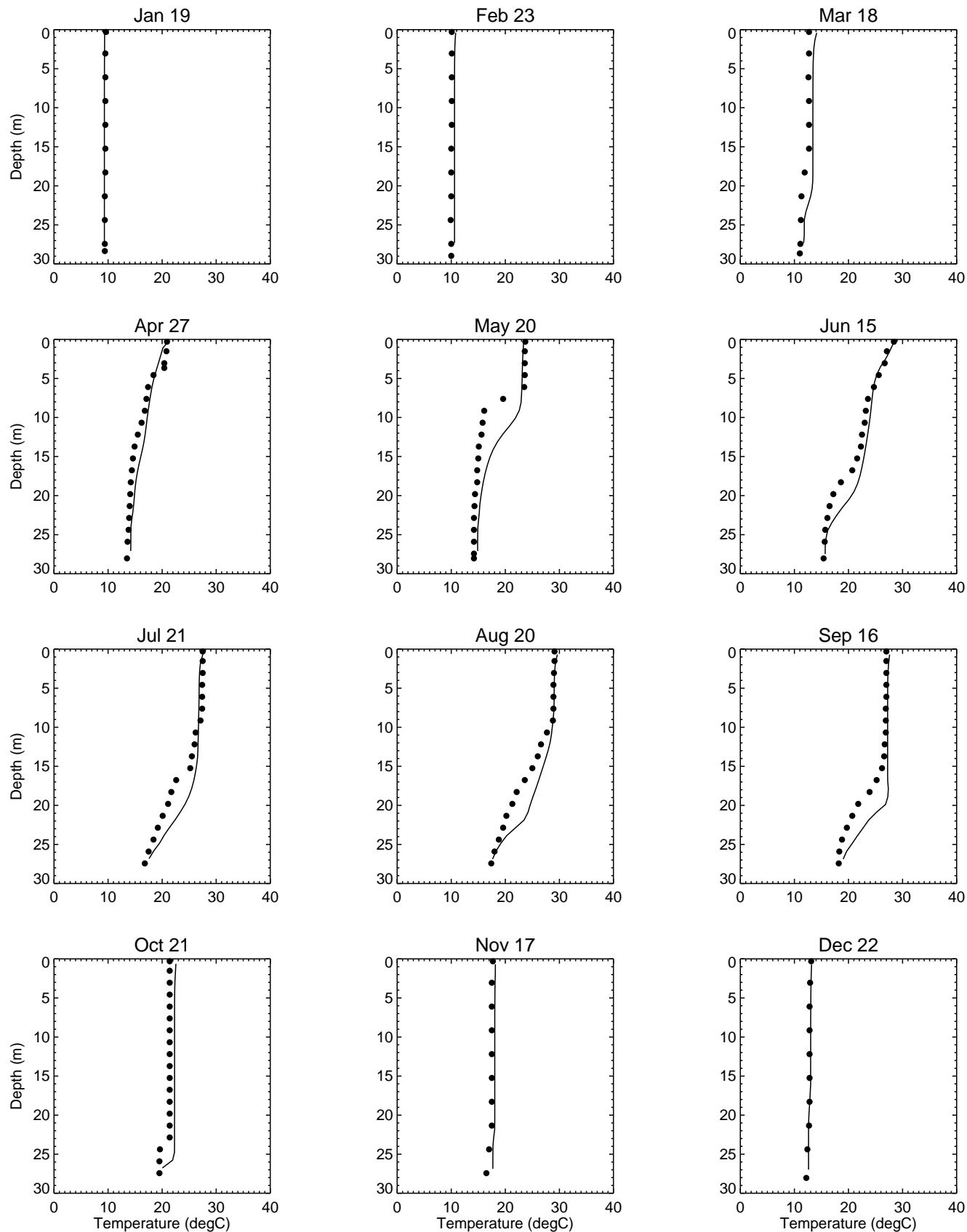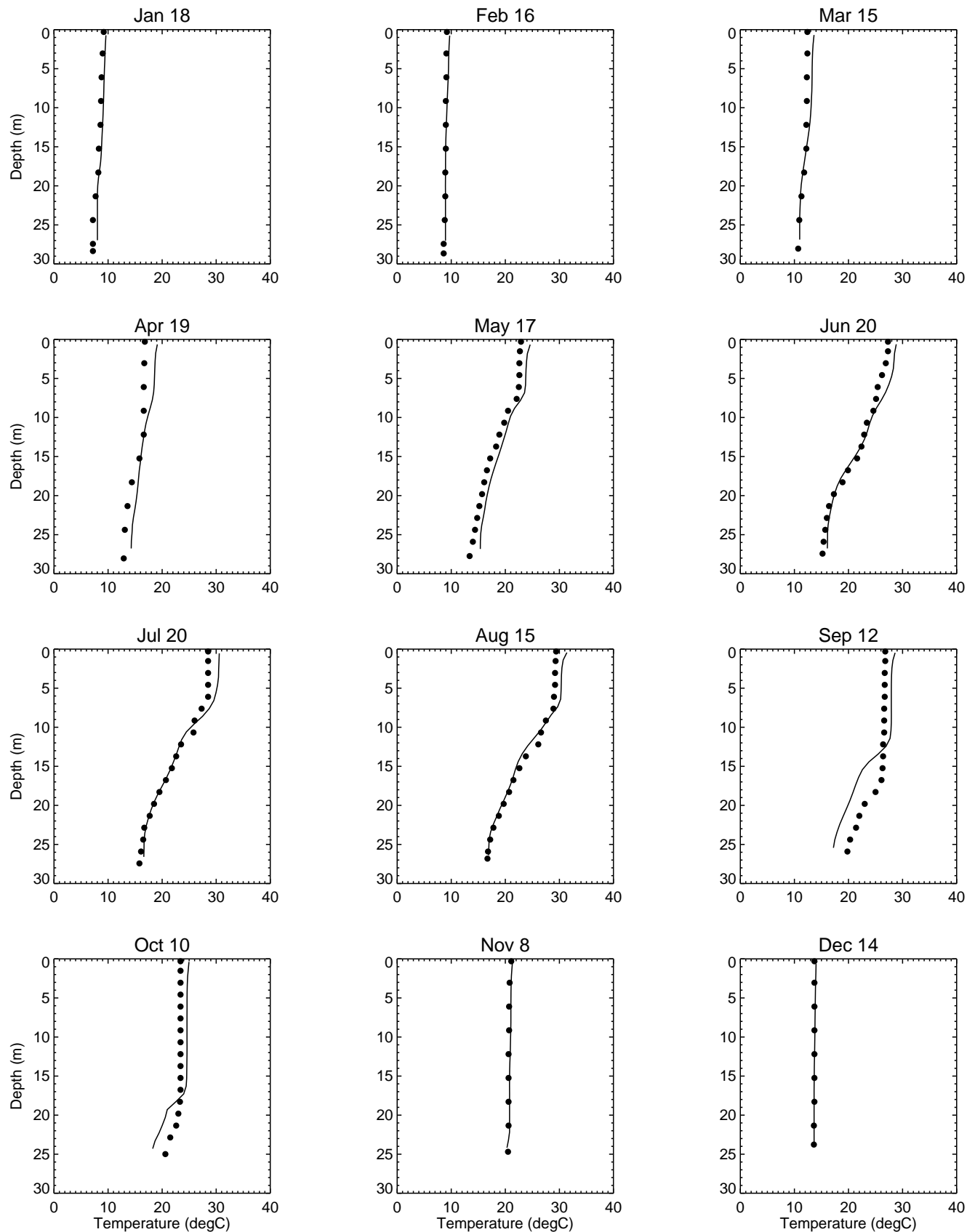
Lower Colorado River Authority

ANCHOR QEA PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:07 2013

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 1988

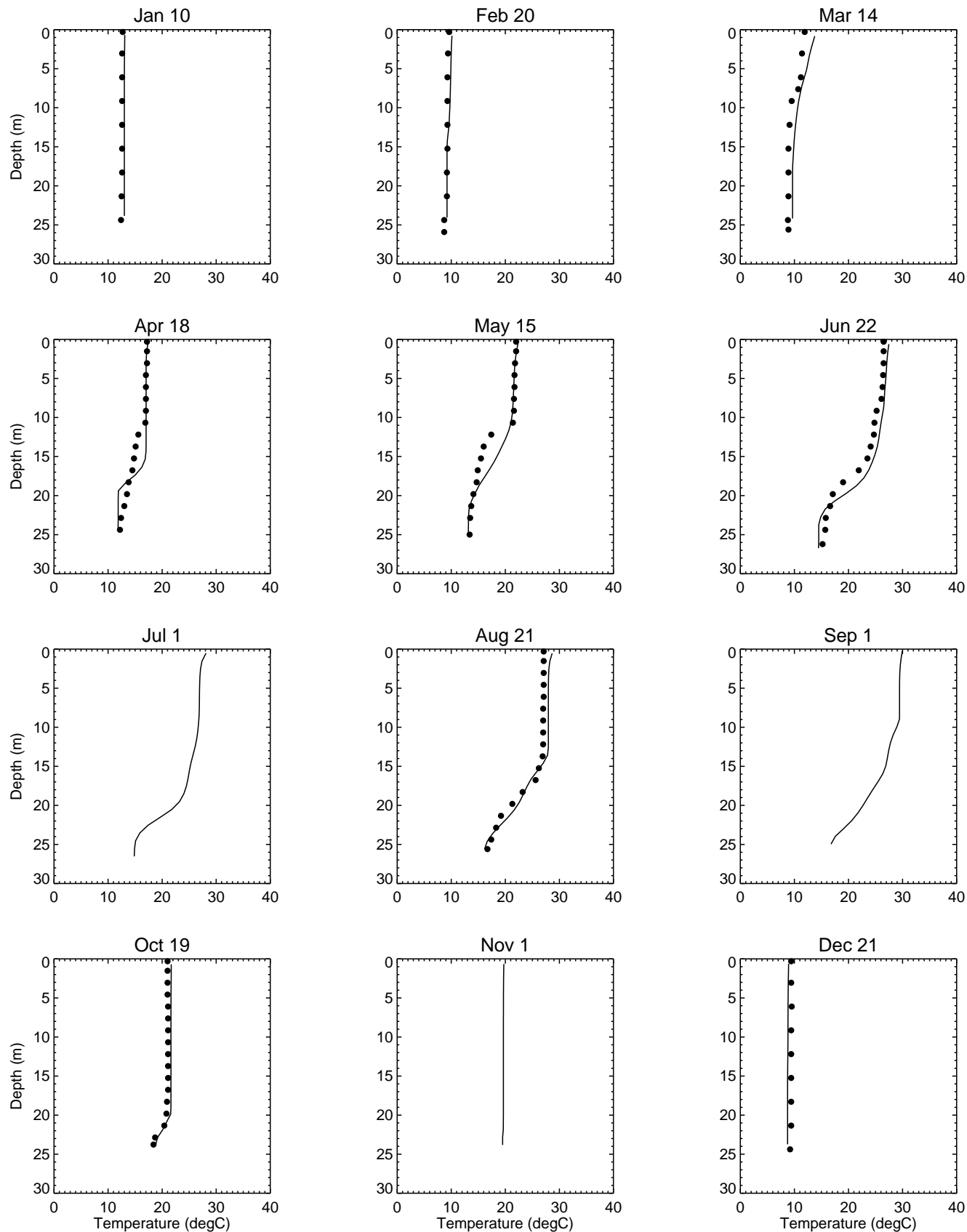*Profiles shown for dates with available data else model results for first day of month shown.*

Model (w1210-48)
● Data

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 1989

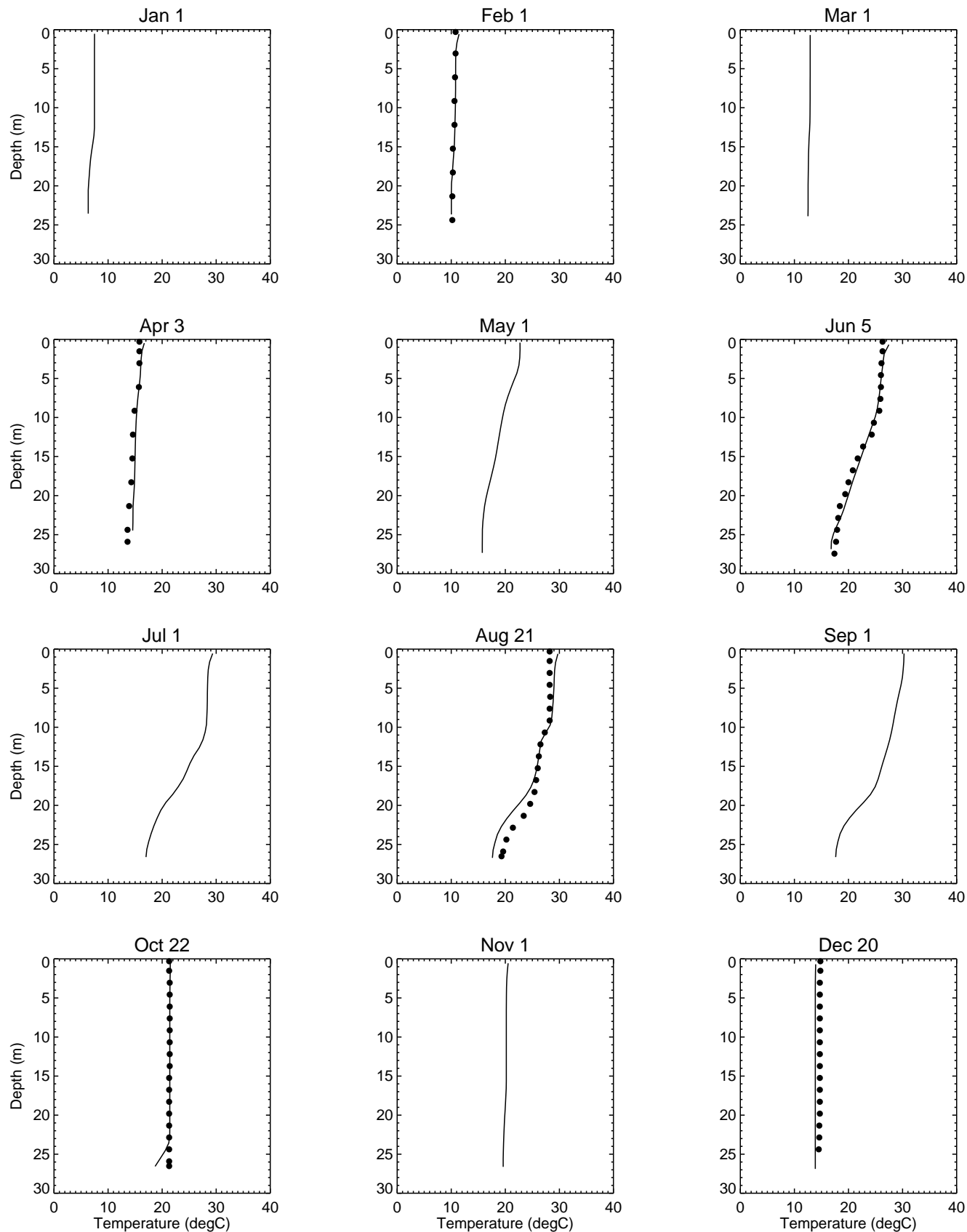*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 1990

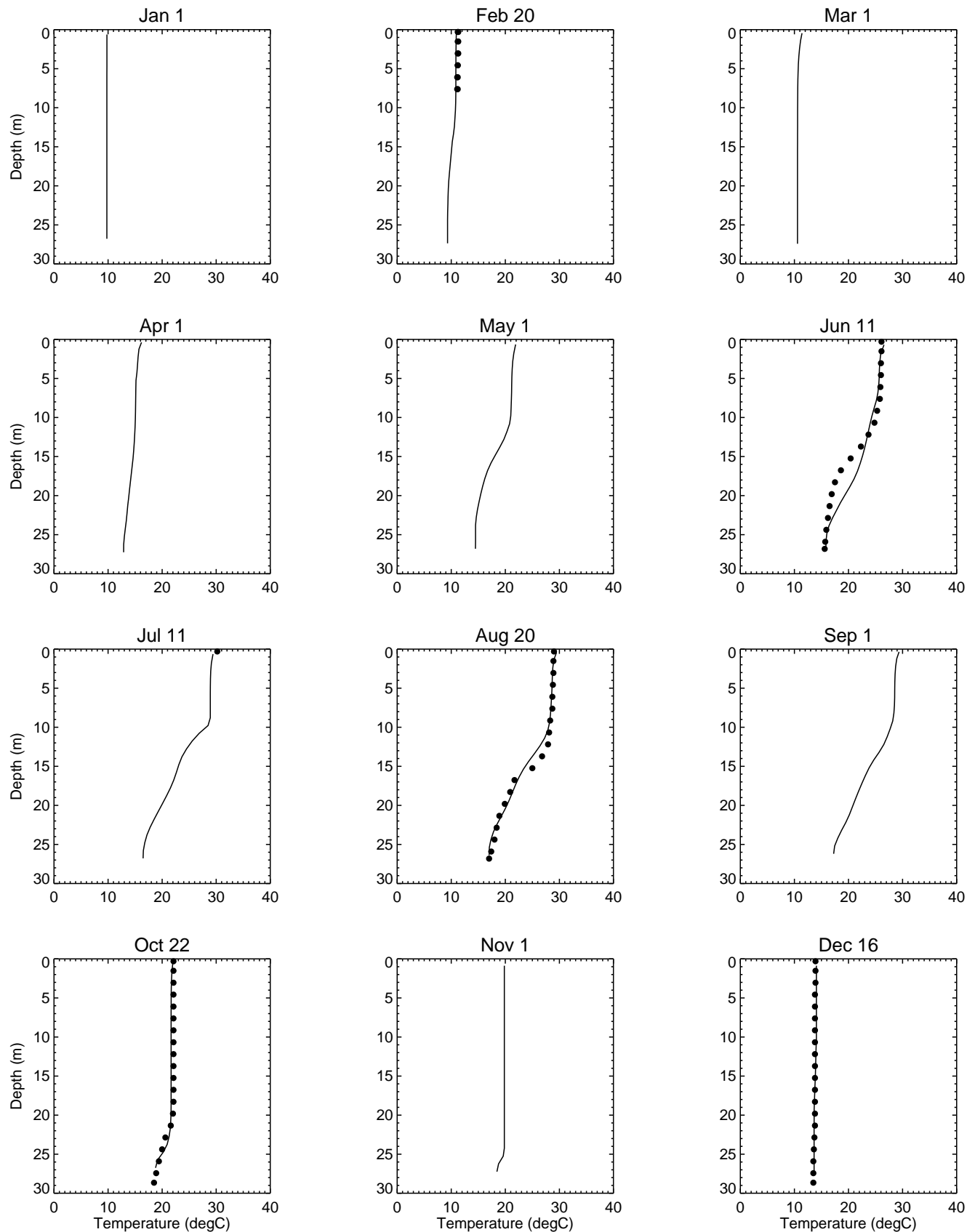*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 1991

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
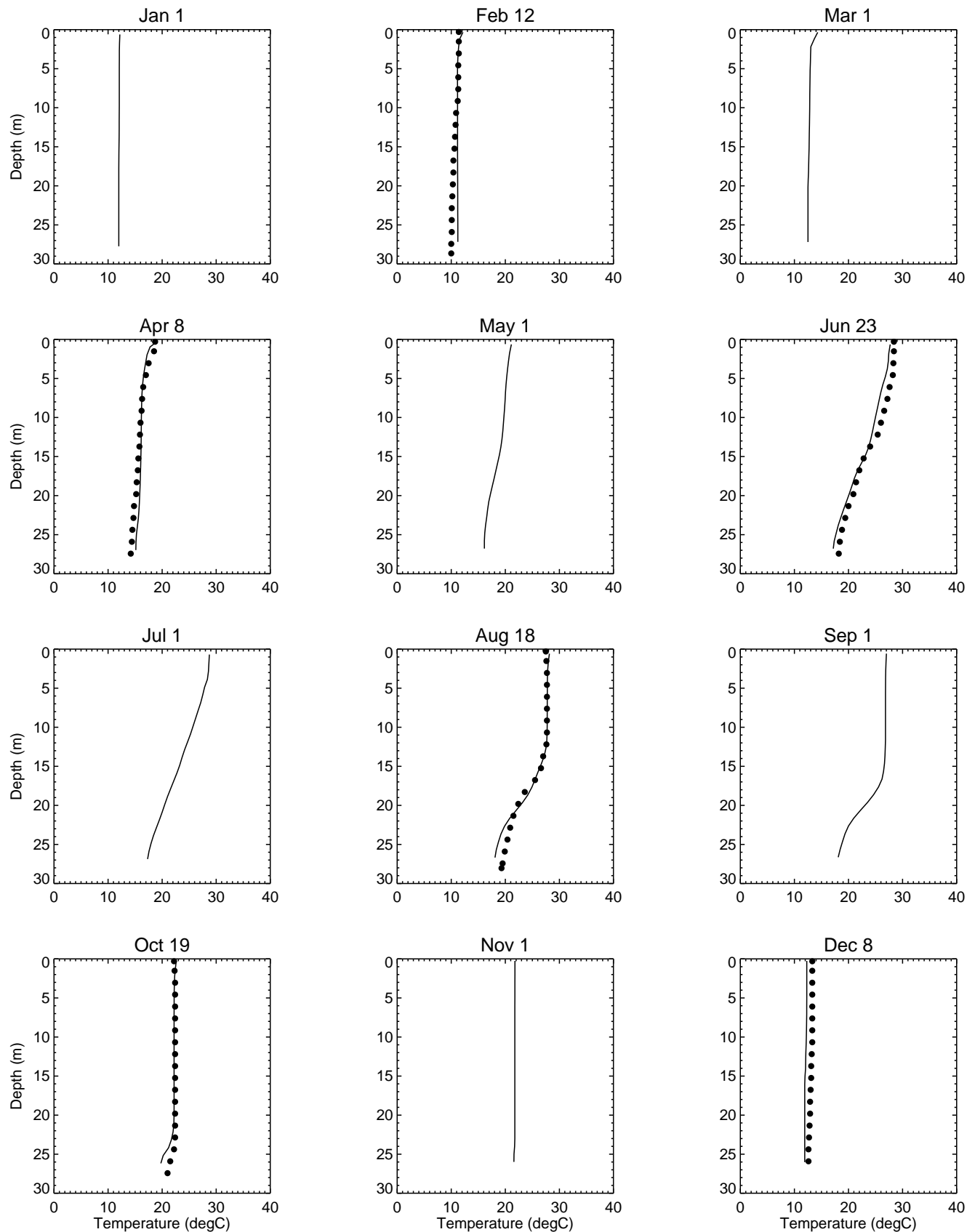
Lower Colorado River Authority

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 1993

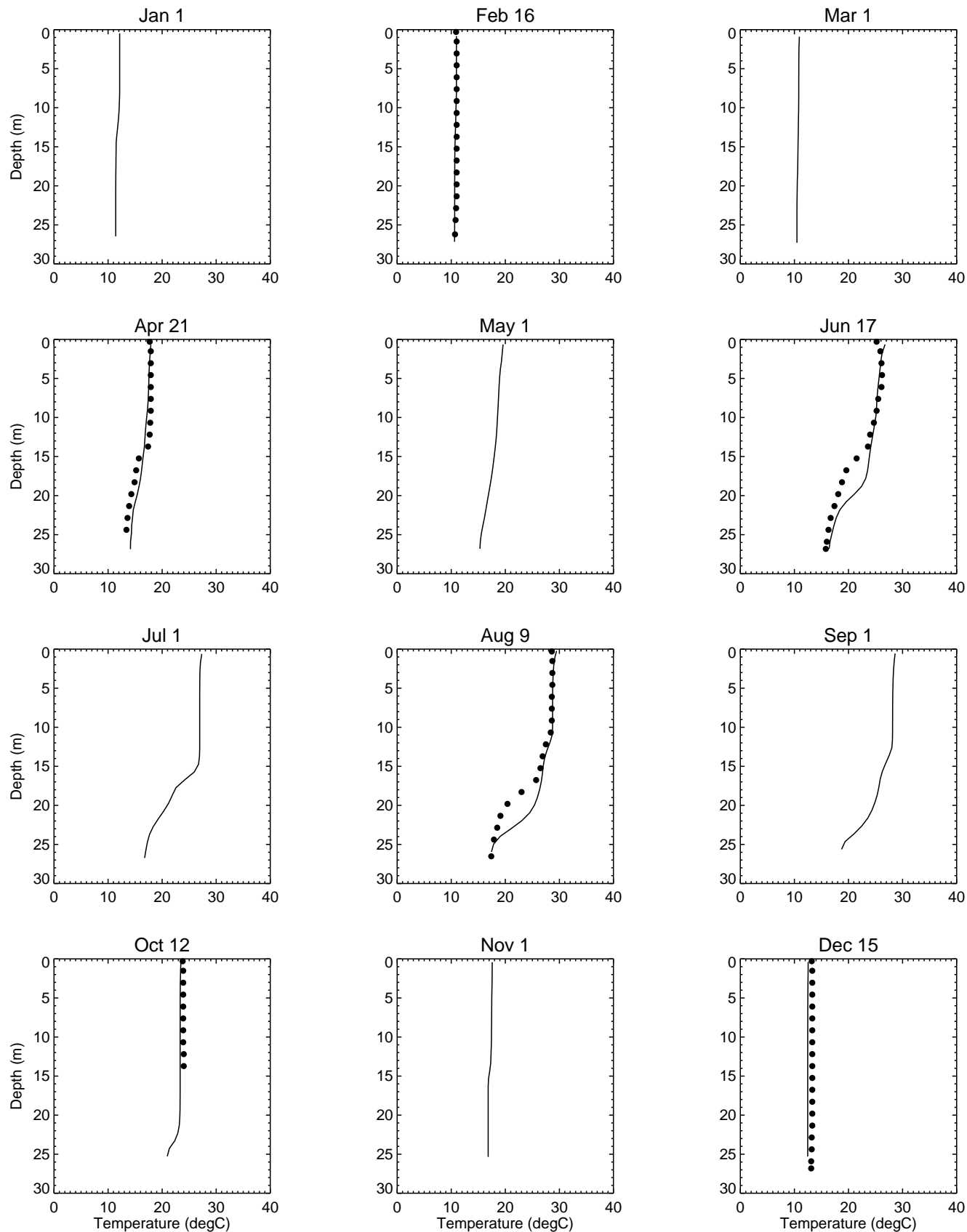*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 1994

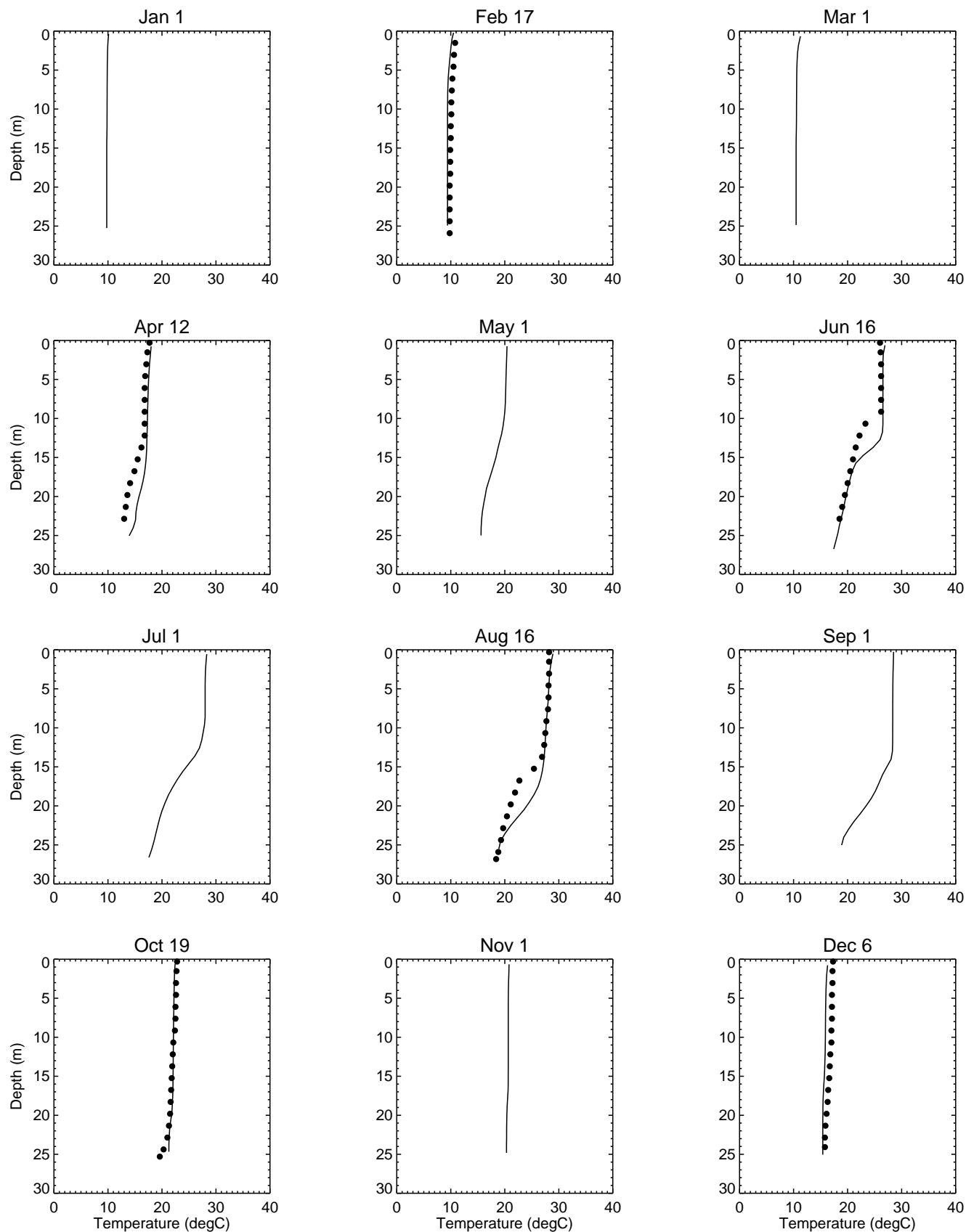*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 1995

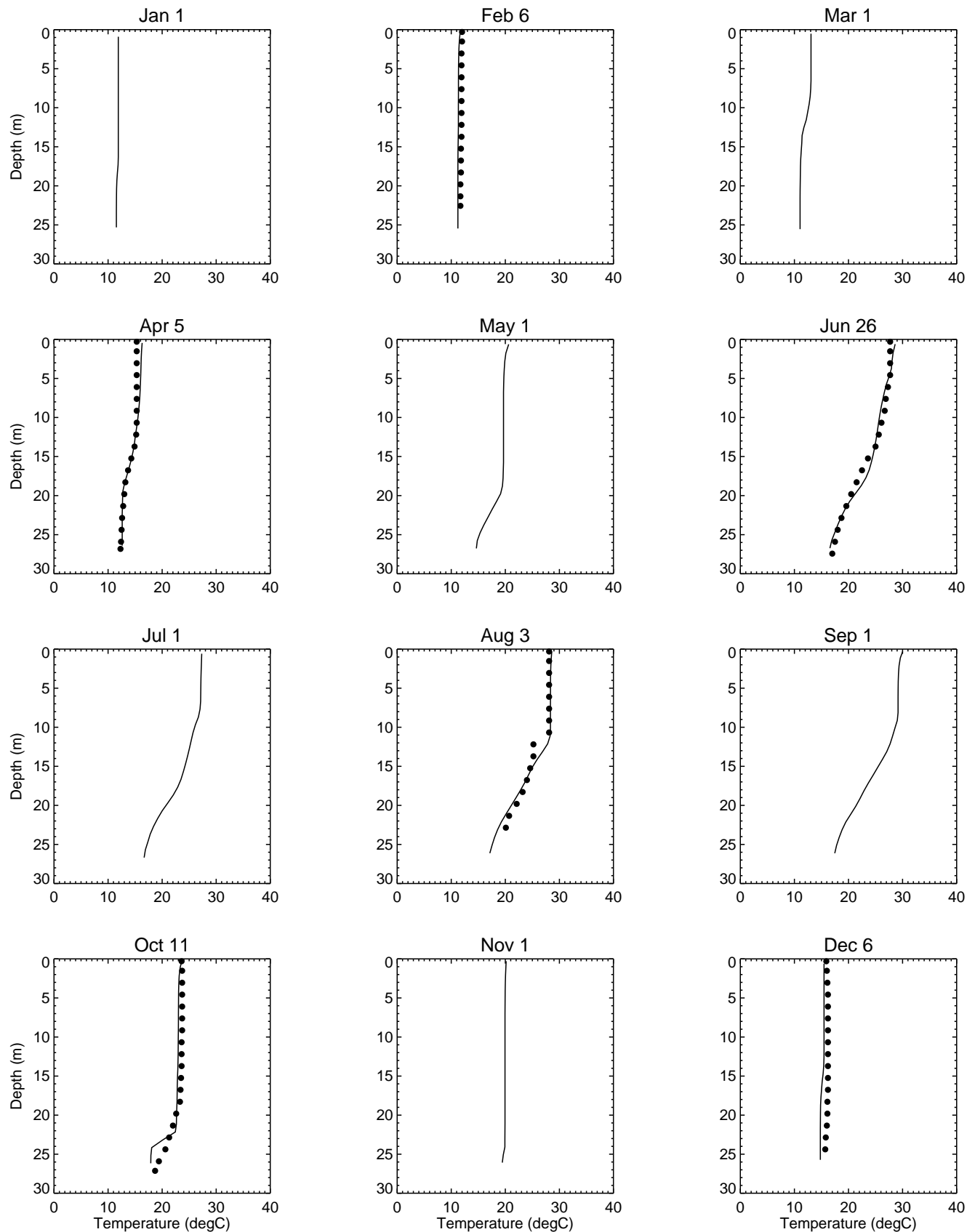*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:07 2013

Jan 1   Feb 12   Mar 1

Apr 17   May 28   Jun 3, 12, 26

Jul 1   Aug 5   Sep 1

Oct 7   Nov 1   Dec 5

—— Model (w1210-48)
● Data

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 1996

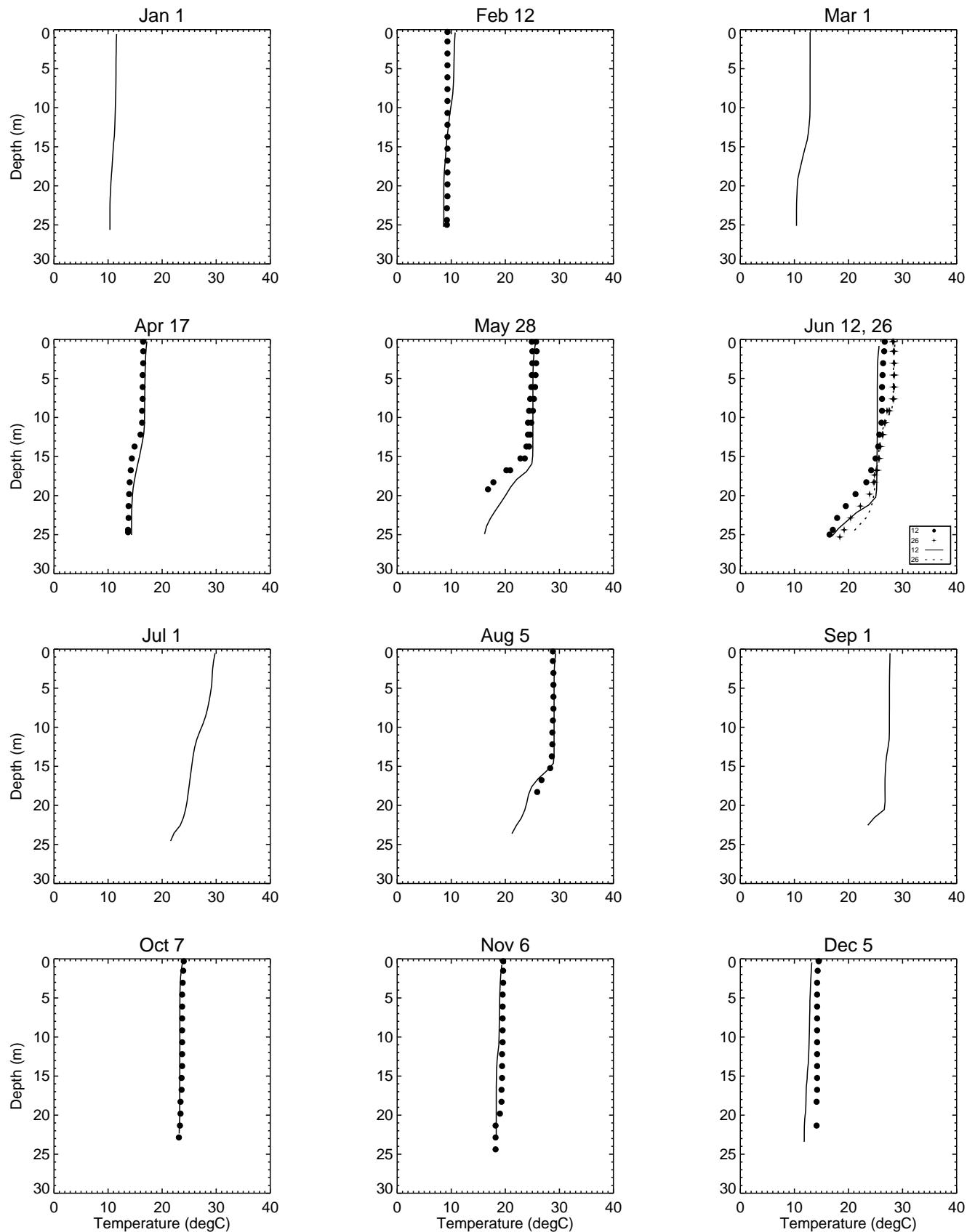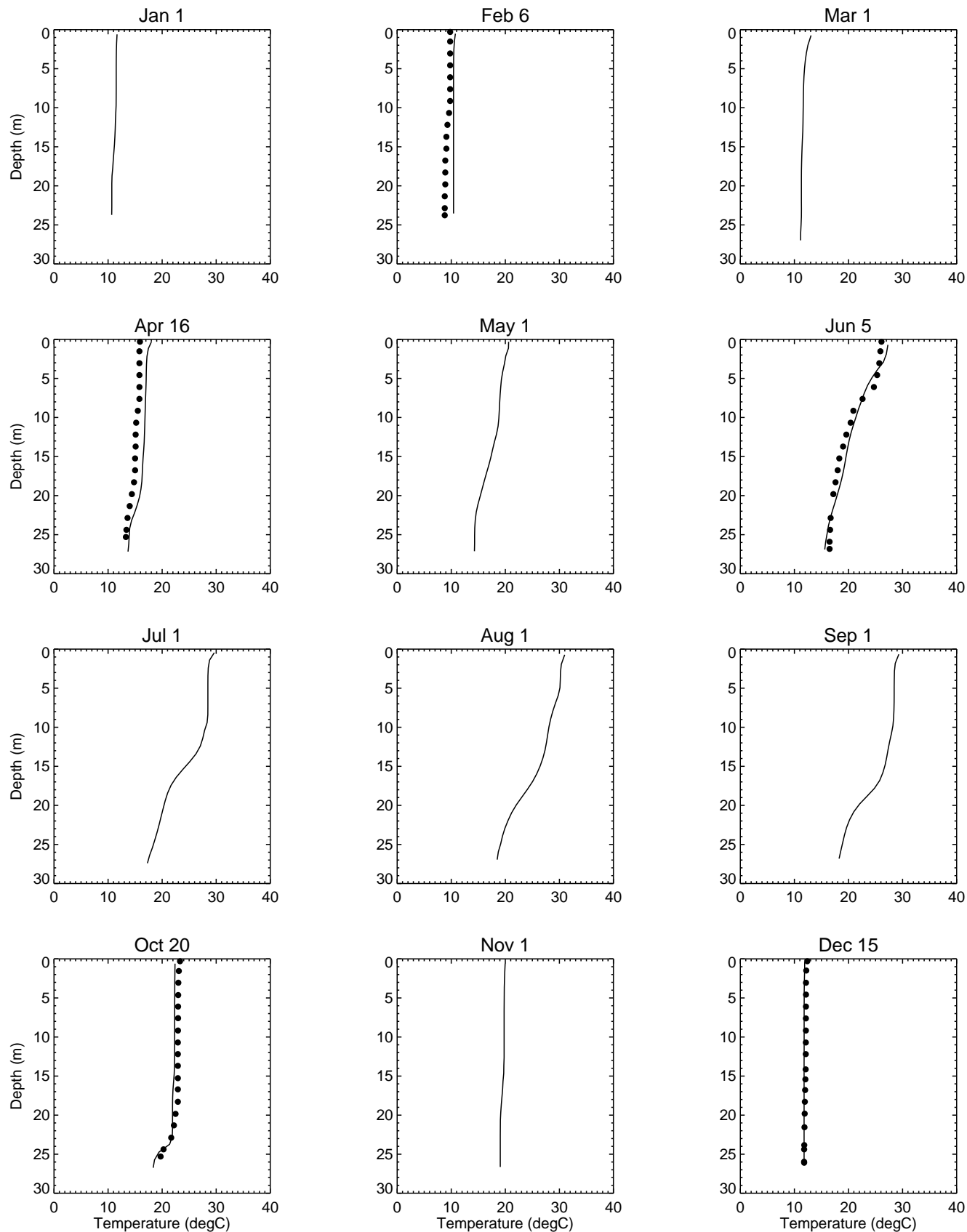*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:07 2013

ANCHOR QEA
PARSONS

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 1997

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
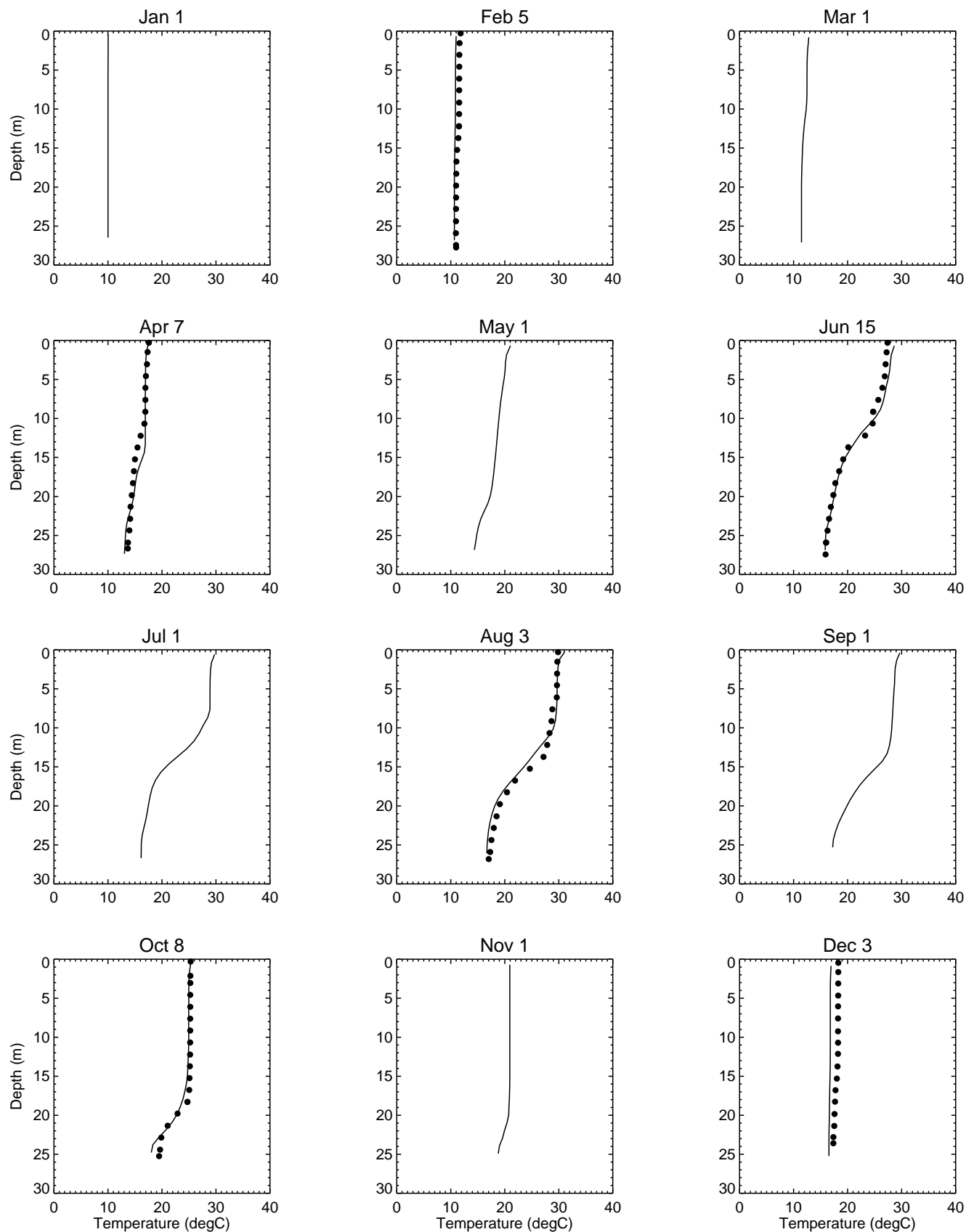
Lower Colorado River Authority

Jan 1 · Feb 5 · Mar 1 · Apr 8 · May 1 · Jun 15 · Jul 1 · Aug 3 · Sep 1 · Oct 8 · Nov 1 · Dec 3

—— Model (w1210-48)
● Data

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 1998

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
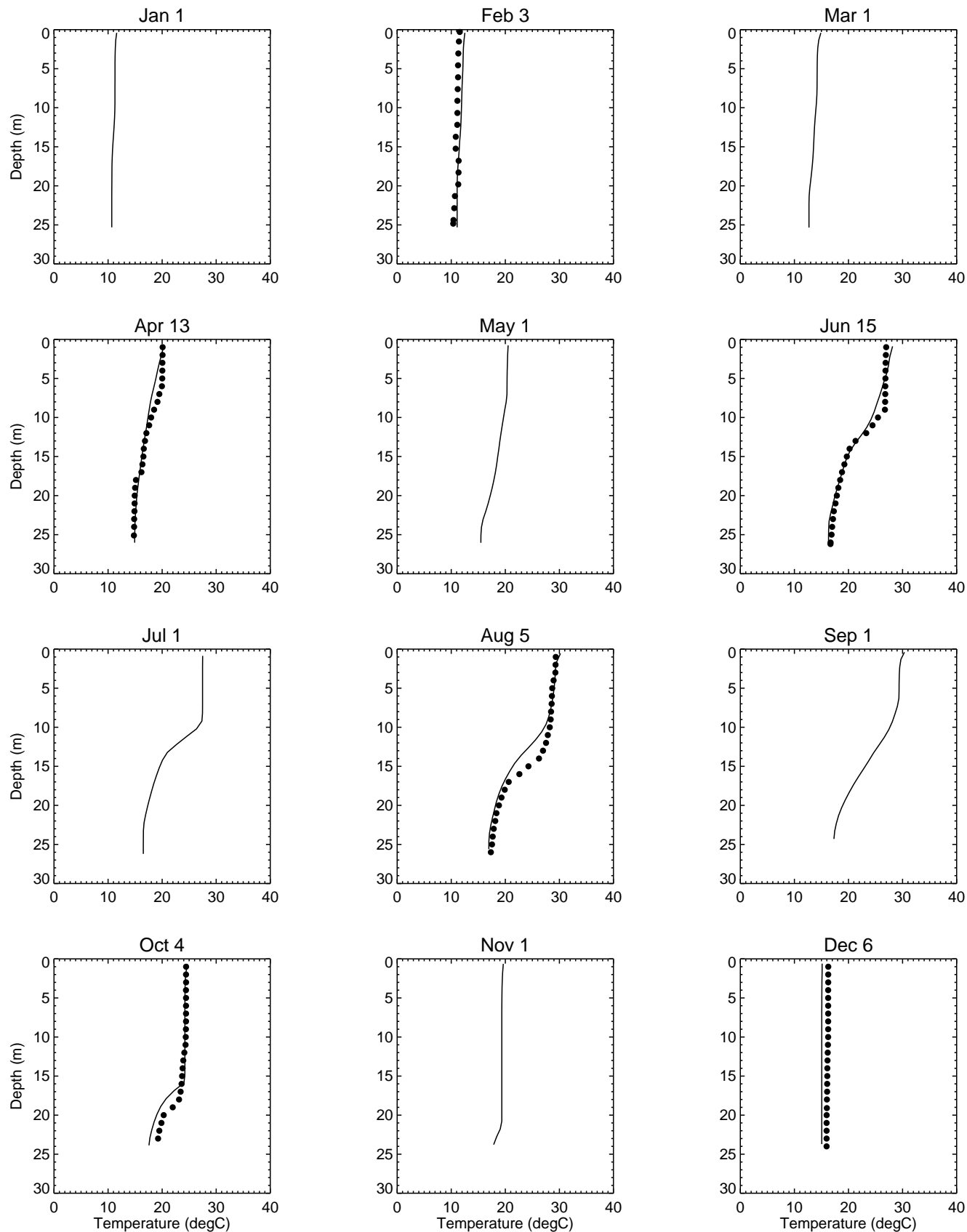
Lower Colorado River Authority

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 1999

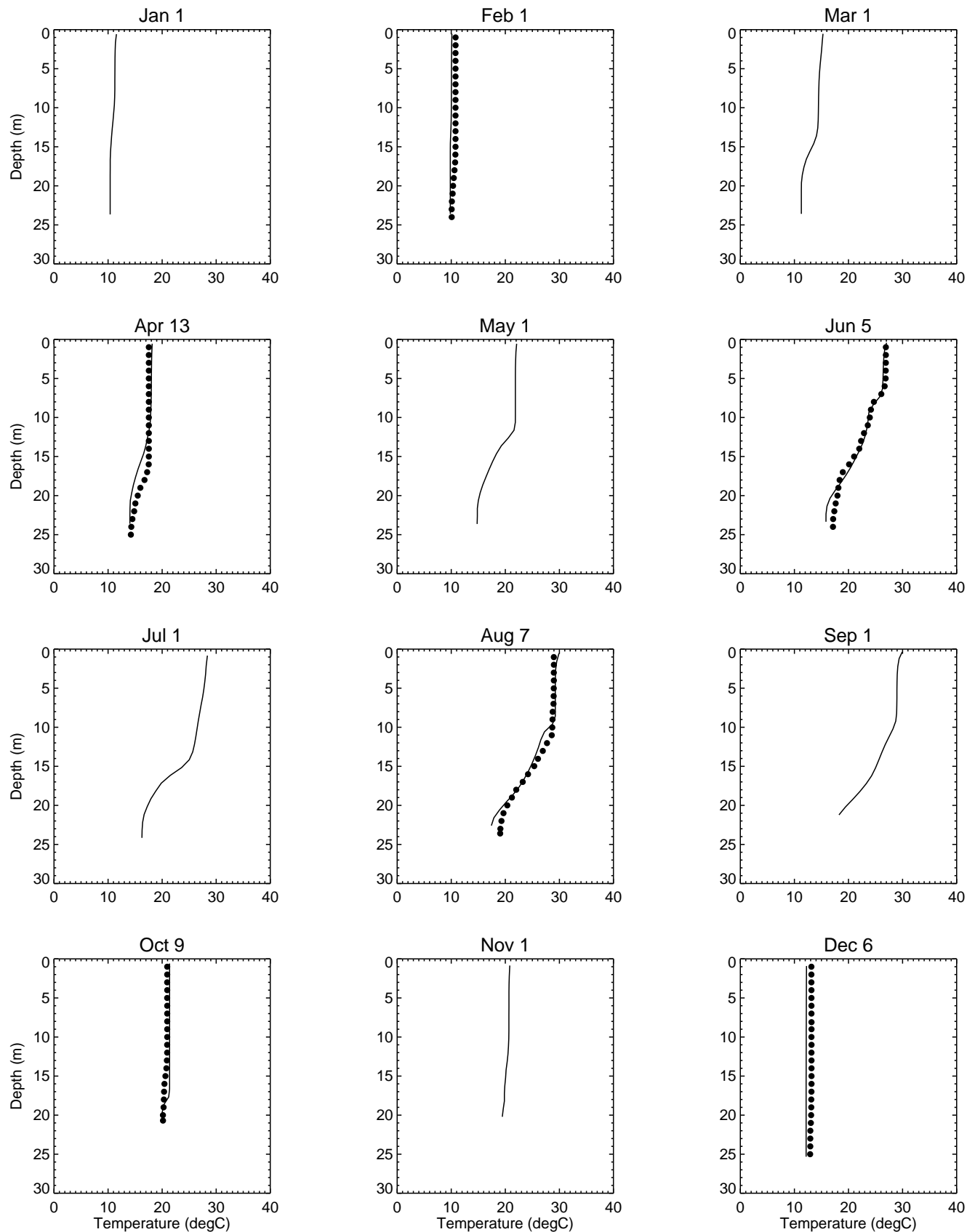*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 2000

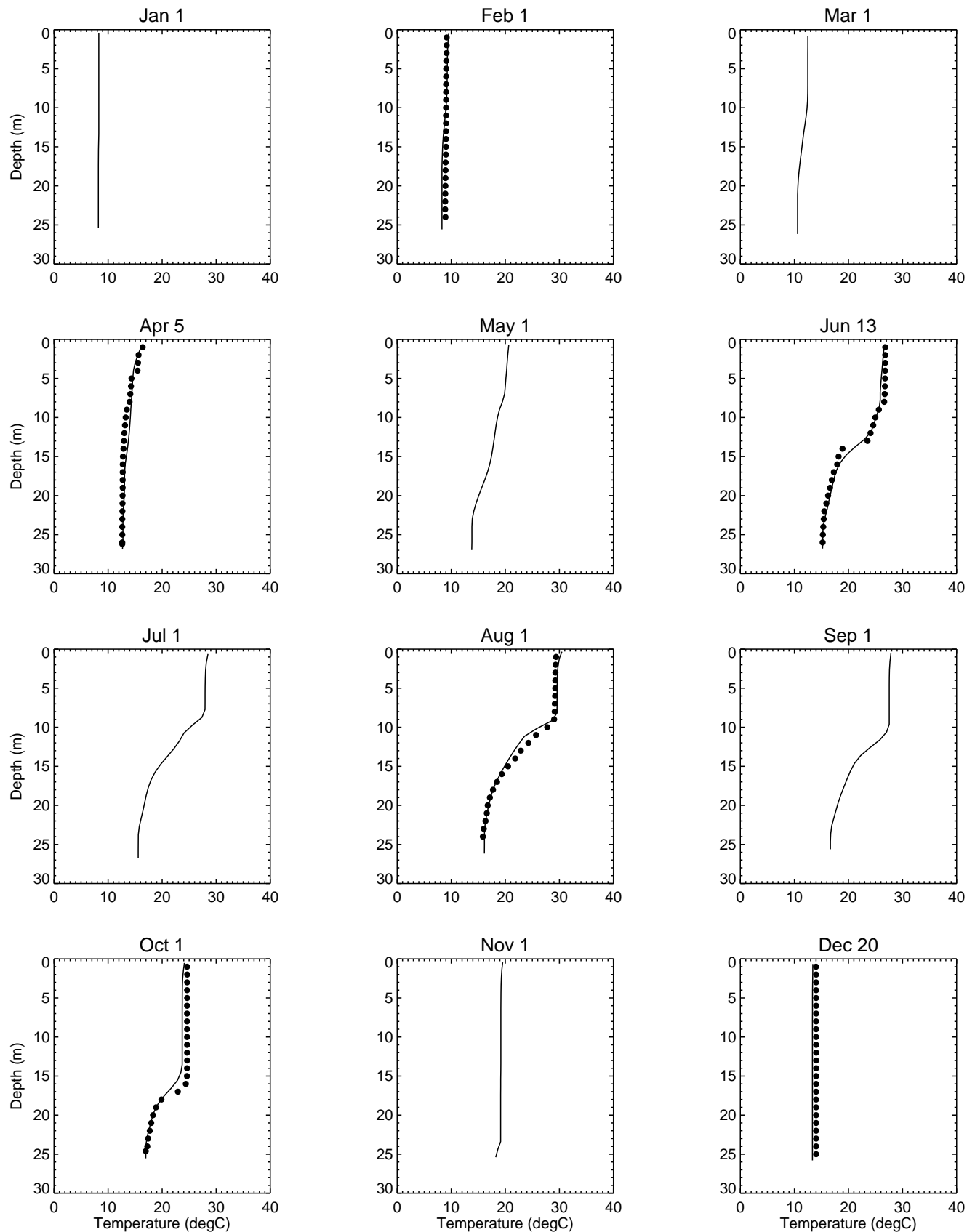*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 2001

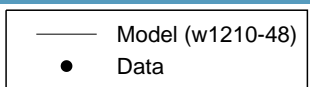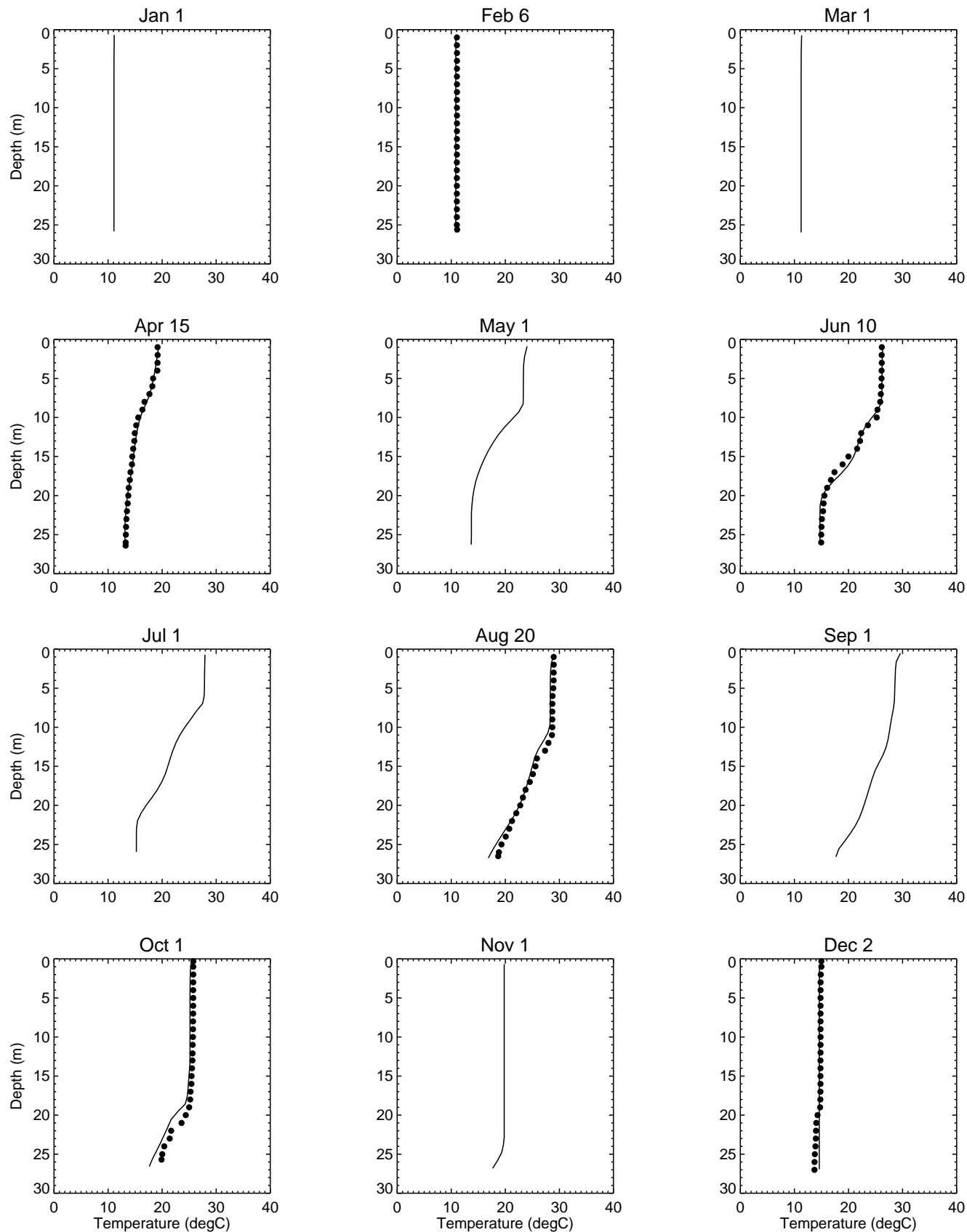*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 2002

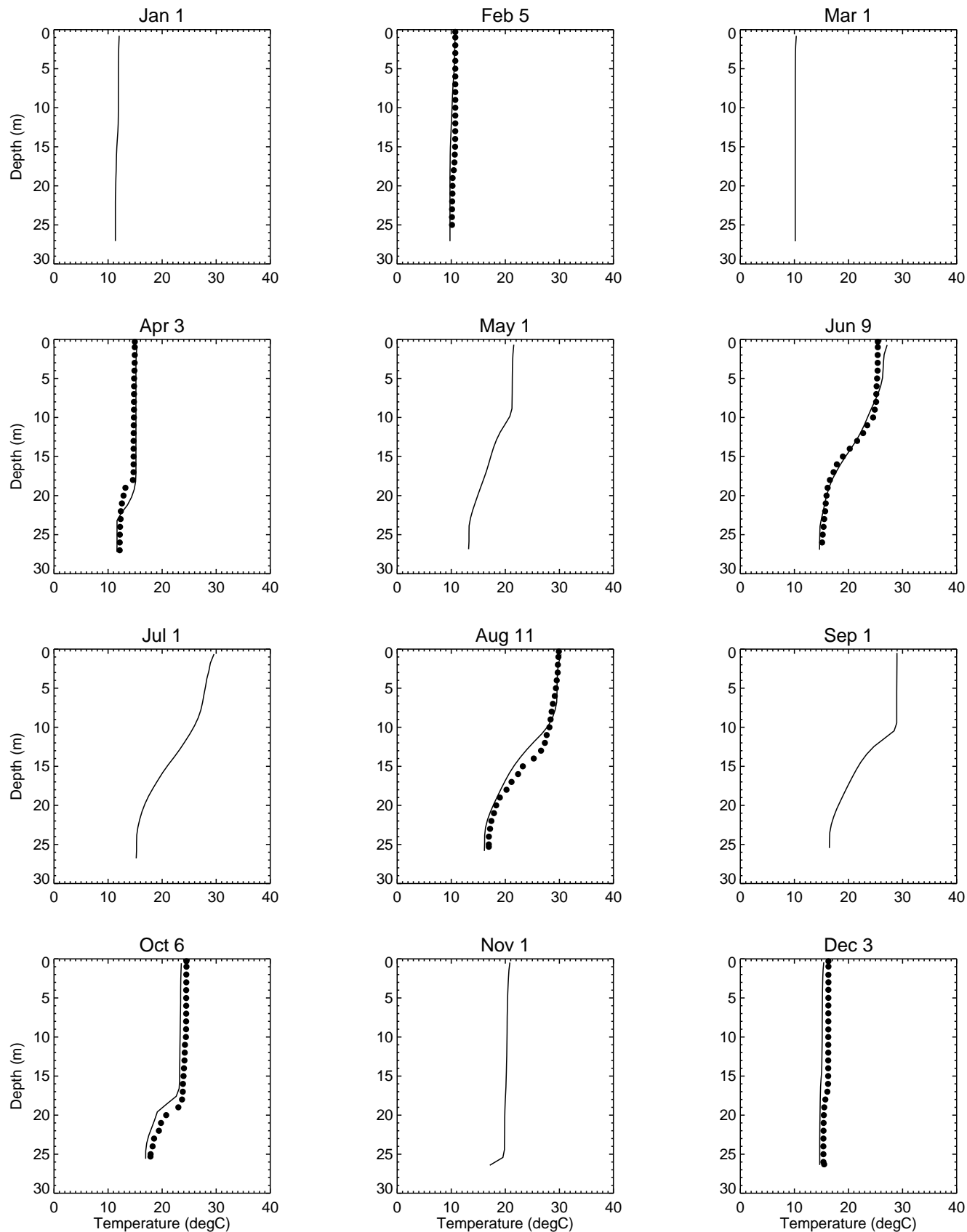*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:07 2013

Jan 1 — Feb 5 — Mar 1 — Apr 3 — May 1 — Jun 9 — Jul 1 — Aug 11 — Sep 1 — Oct 6 — Nov 1 — Dec 3

Depth (m) vs Temperature (degC)

——— Model (w1210-48)
● Data

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 2003

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
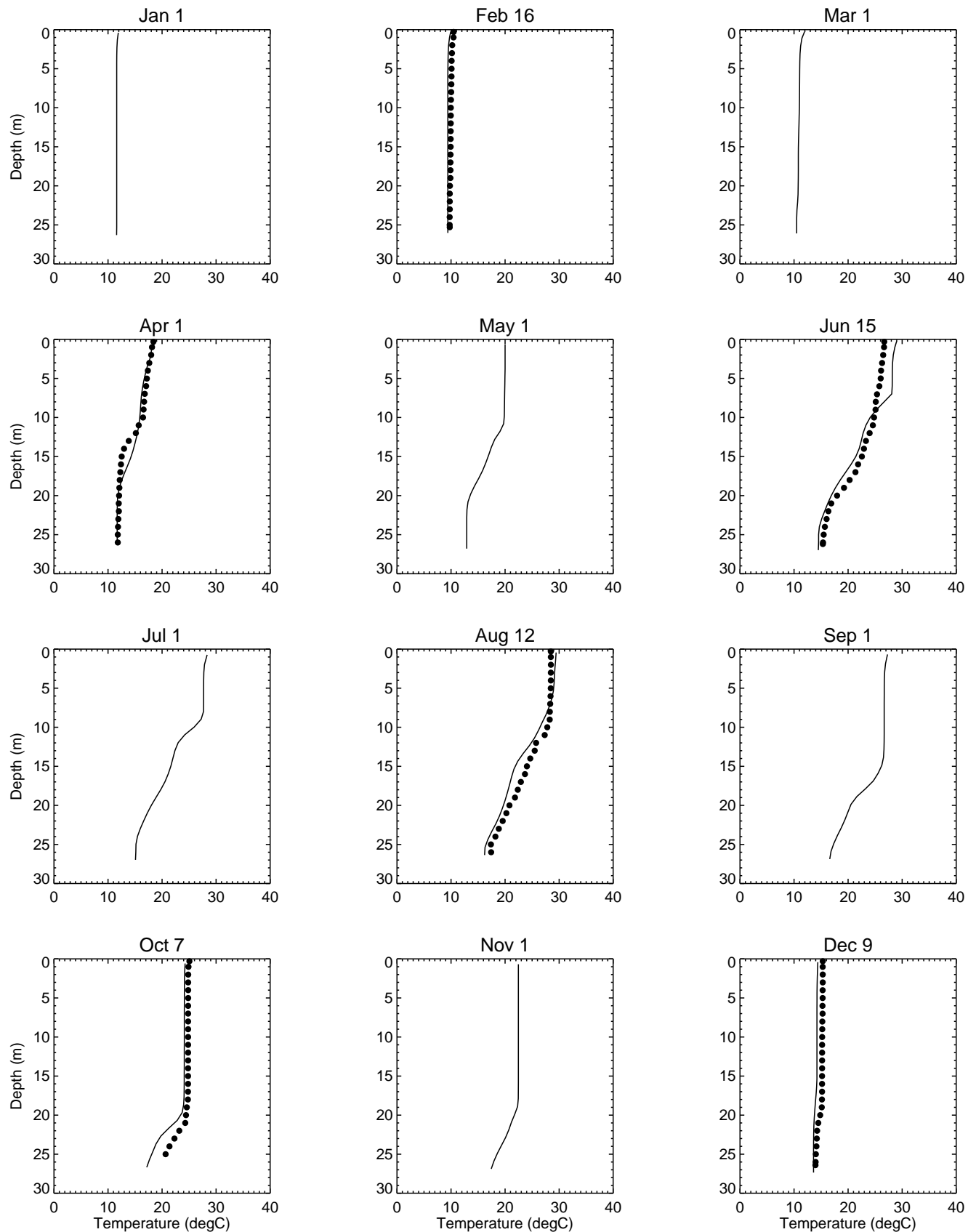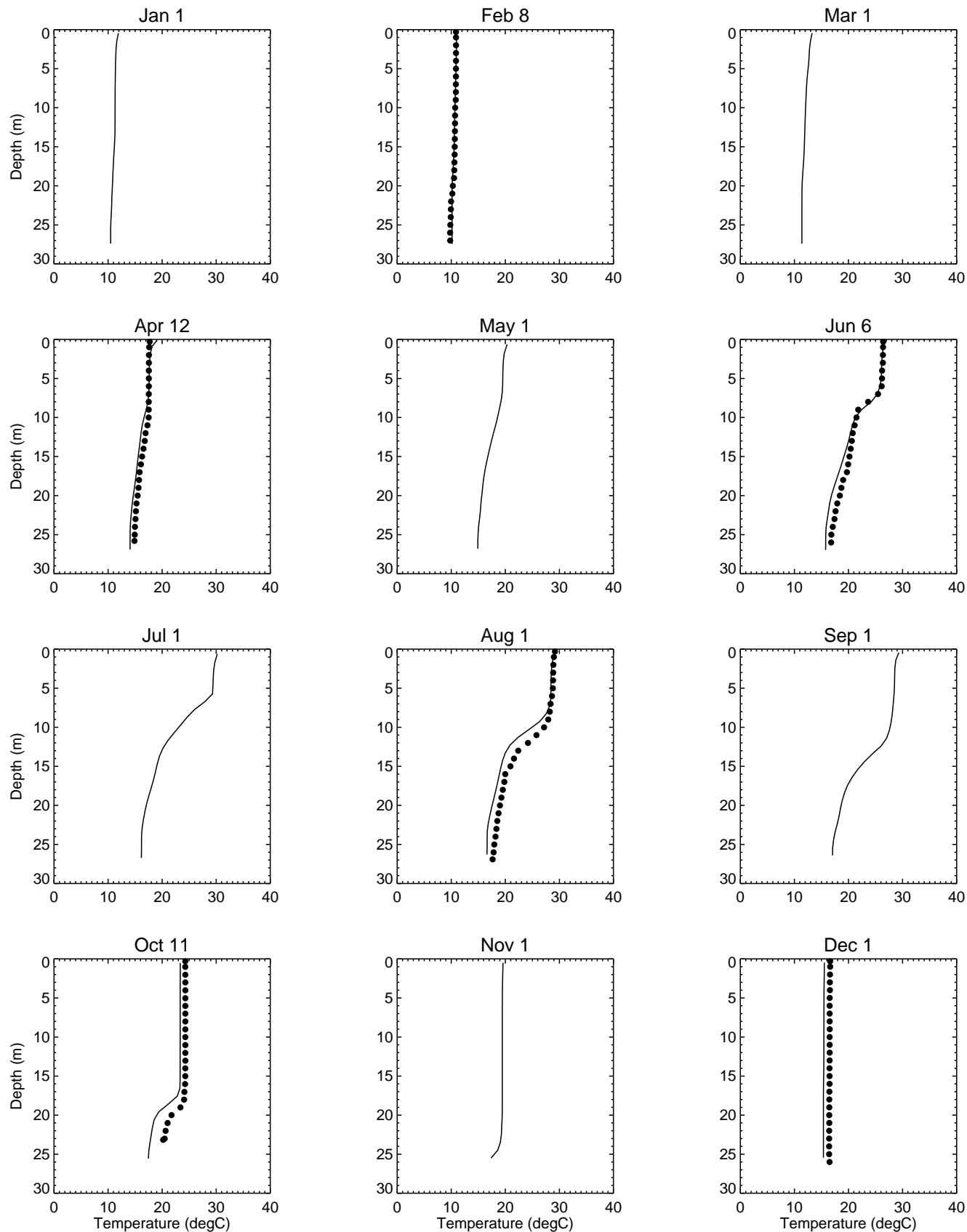Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:07 2013

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 2004

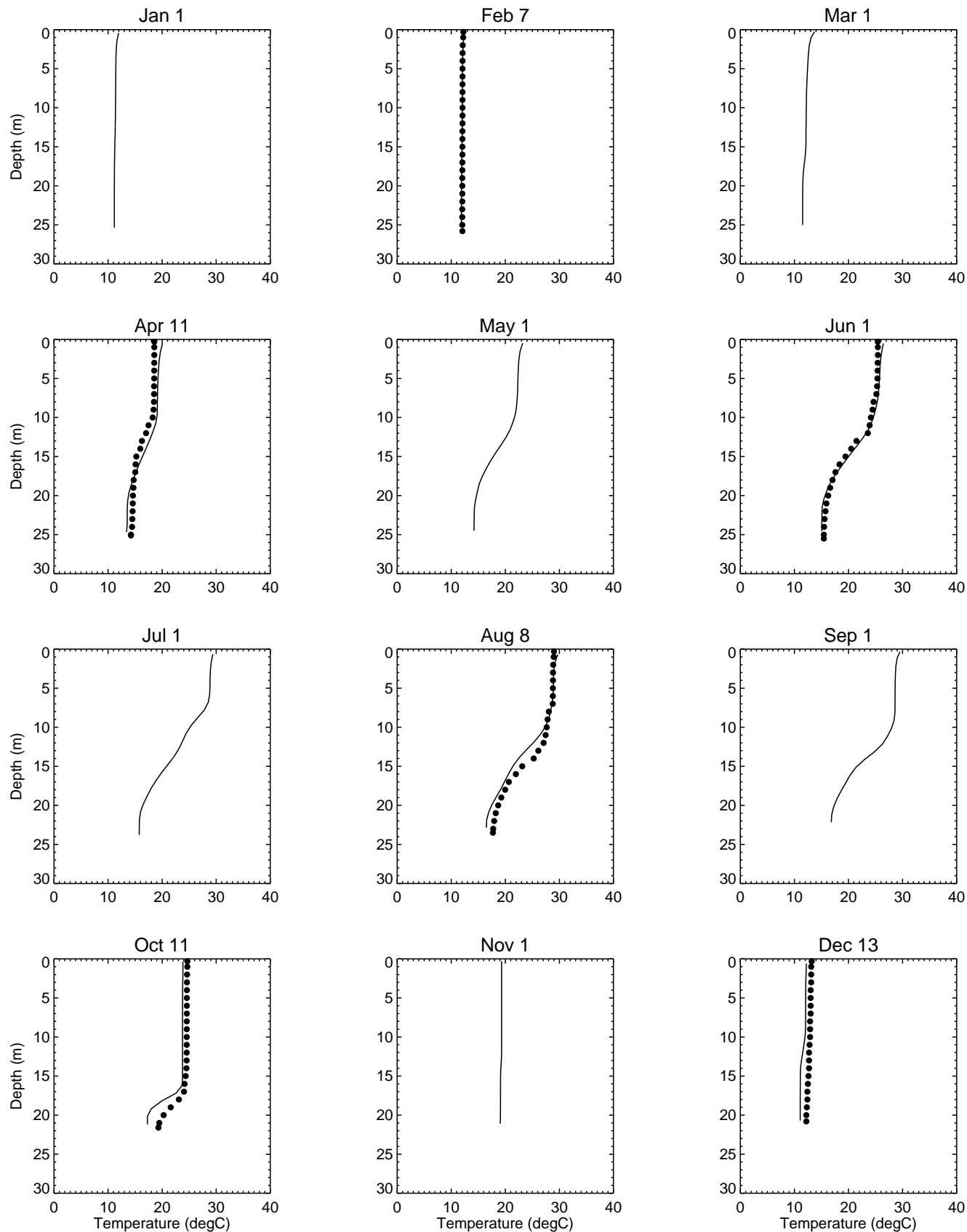*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:07 2013

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 2005

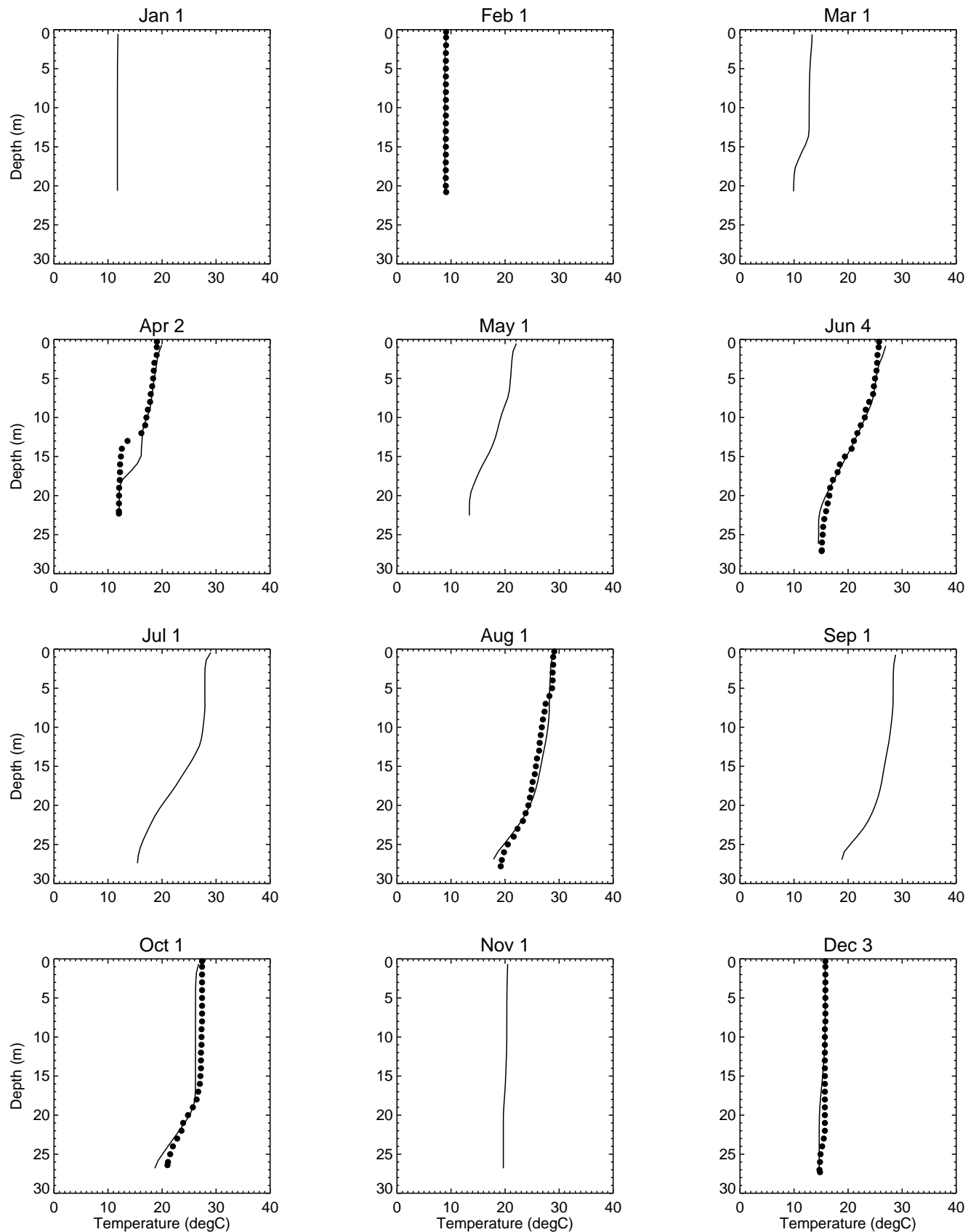*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:07 2013

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 2006

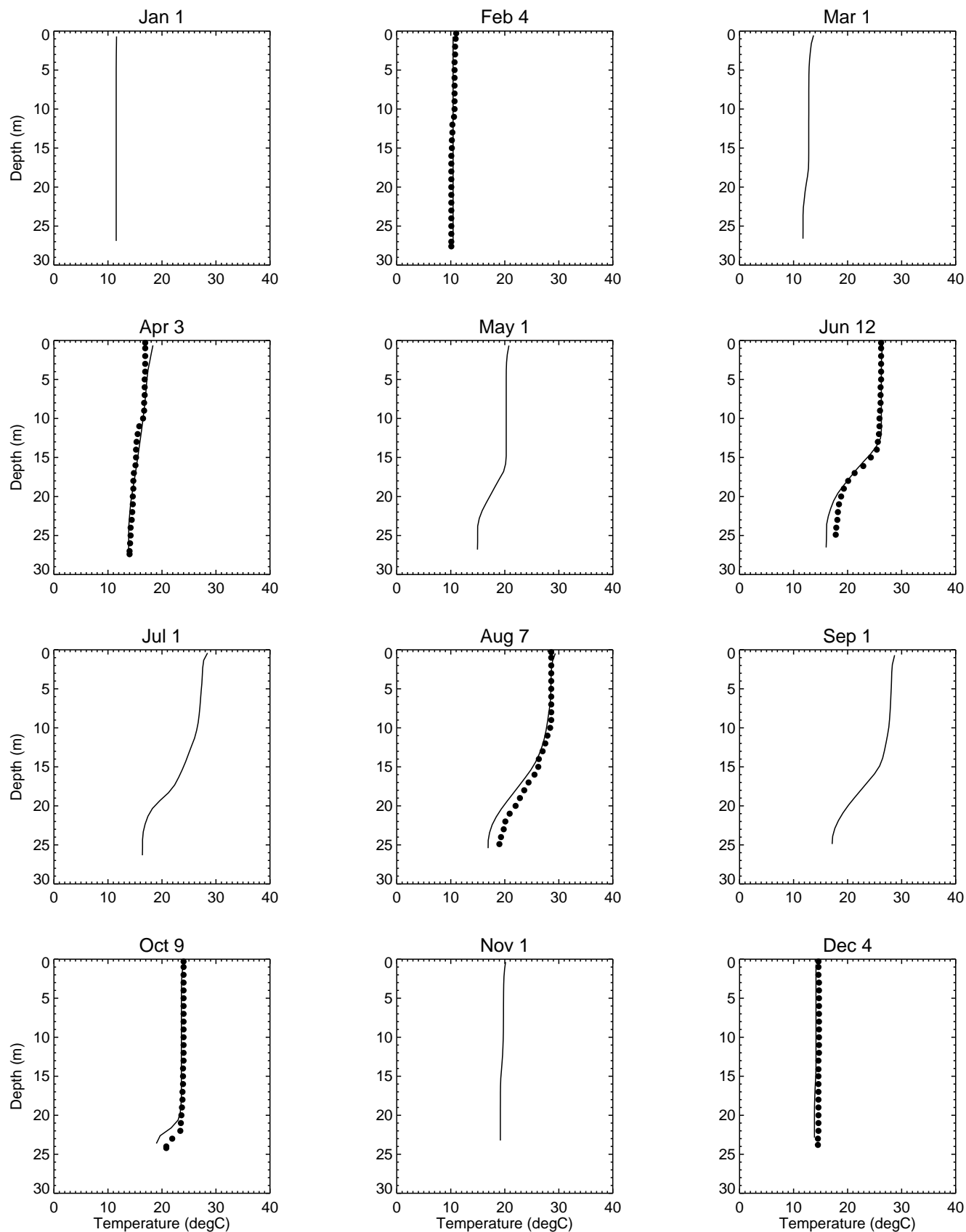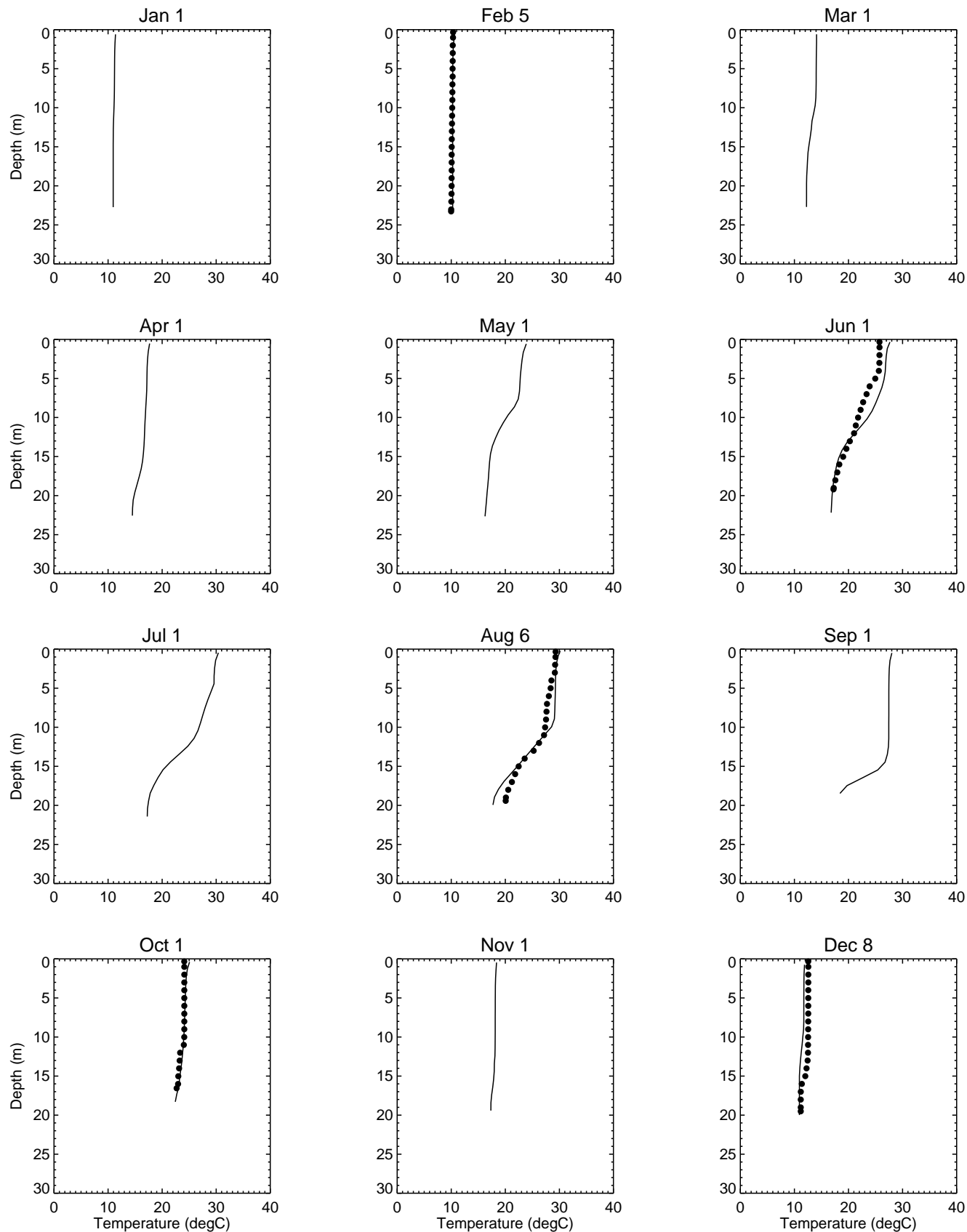*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:07 2013

Jan 1 Feb 1 Mar 1

Apr 2 May 1 Jun 4

Jul 1 Aug 1 Sep 1

Oct 1 Nov 1 Dec 3

——— Model (w1210-48)
● Data

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 2007

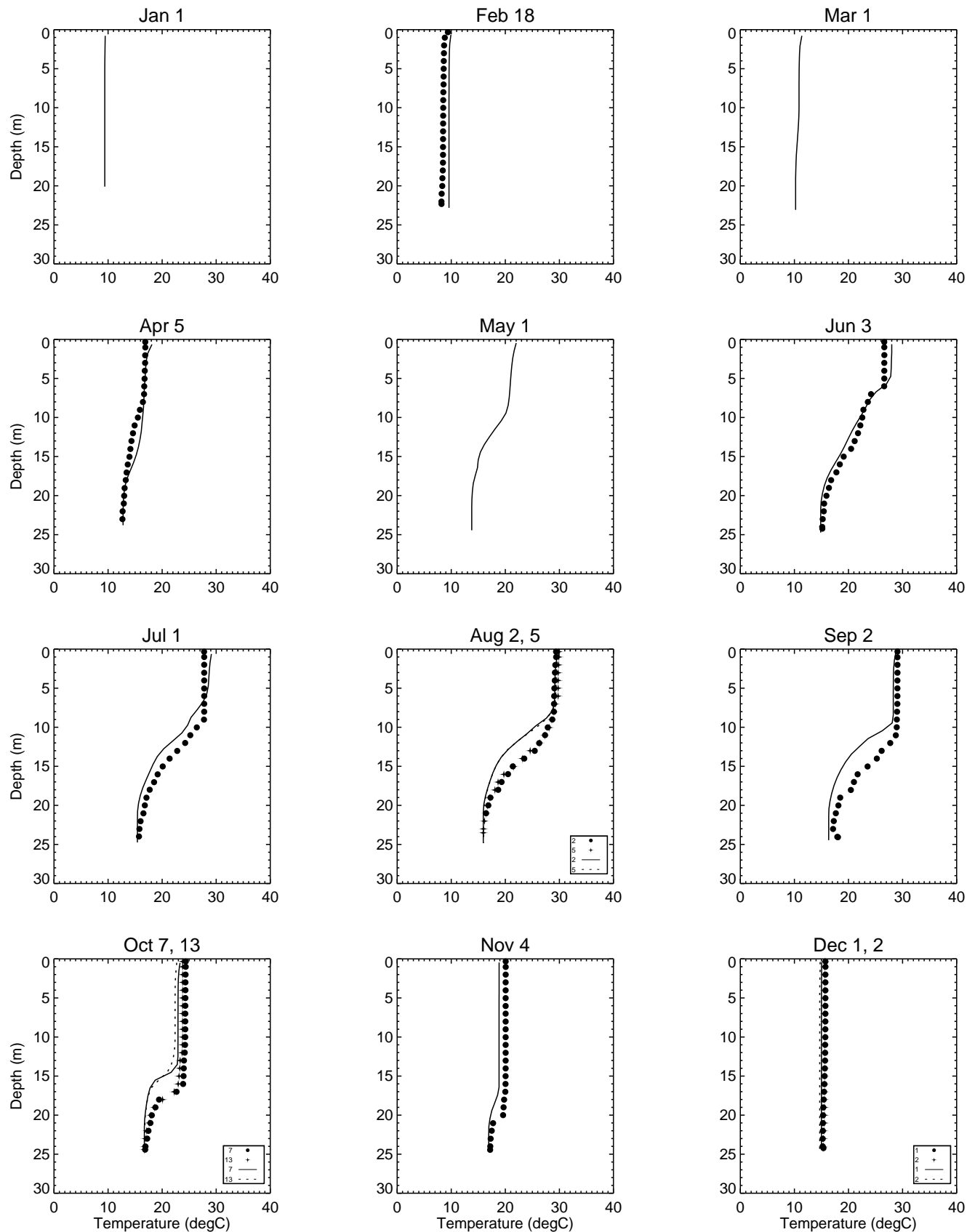*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:08 2013

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 2008

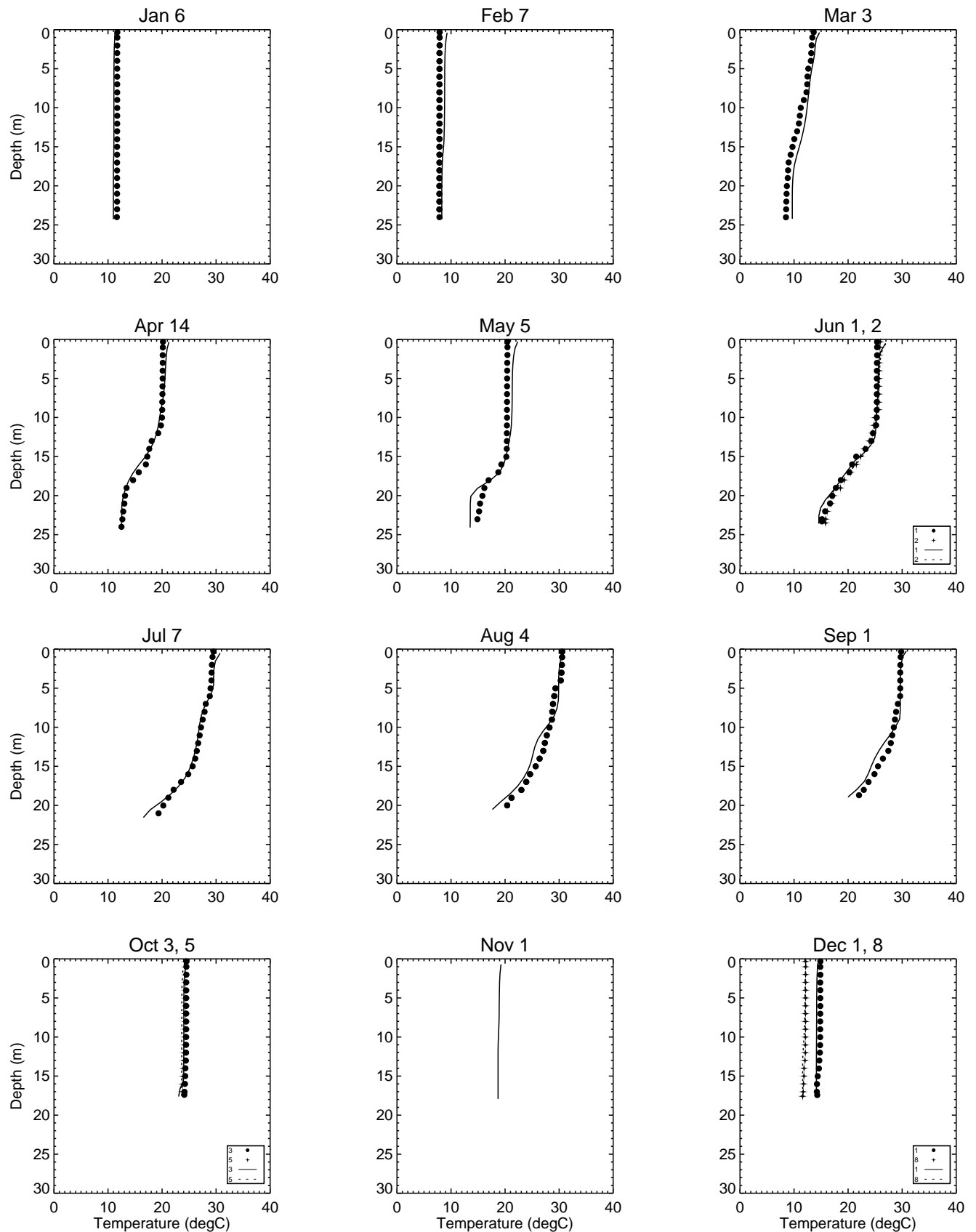*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1   Feb 5   Mar 1

Apr 1   May 1   Jun 1

Jul 1   Aug 6   Sep 1

Oct 1   Nov 1   Dec 8

Model (w1210-48)

● Data

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 2009

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
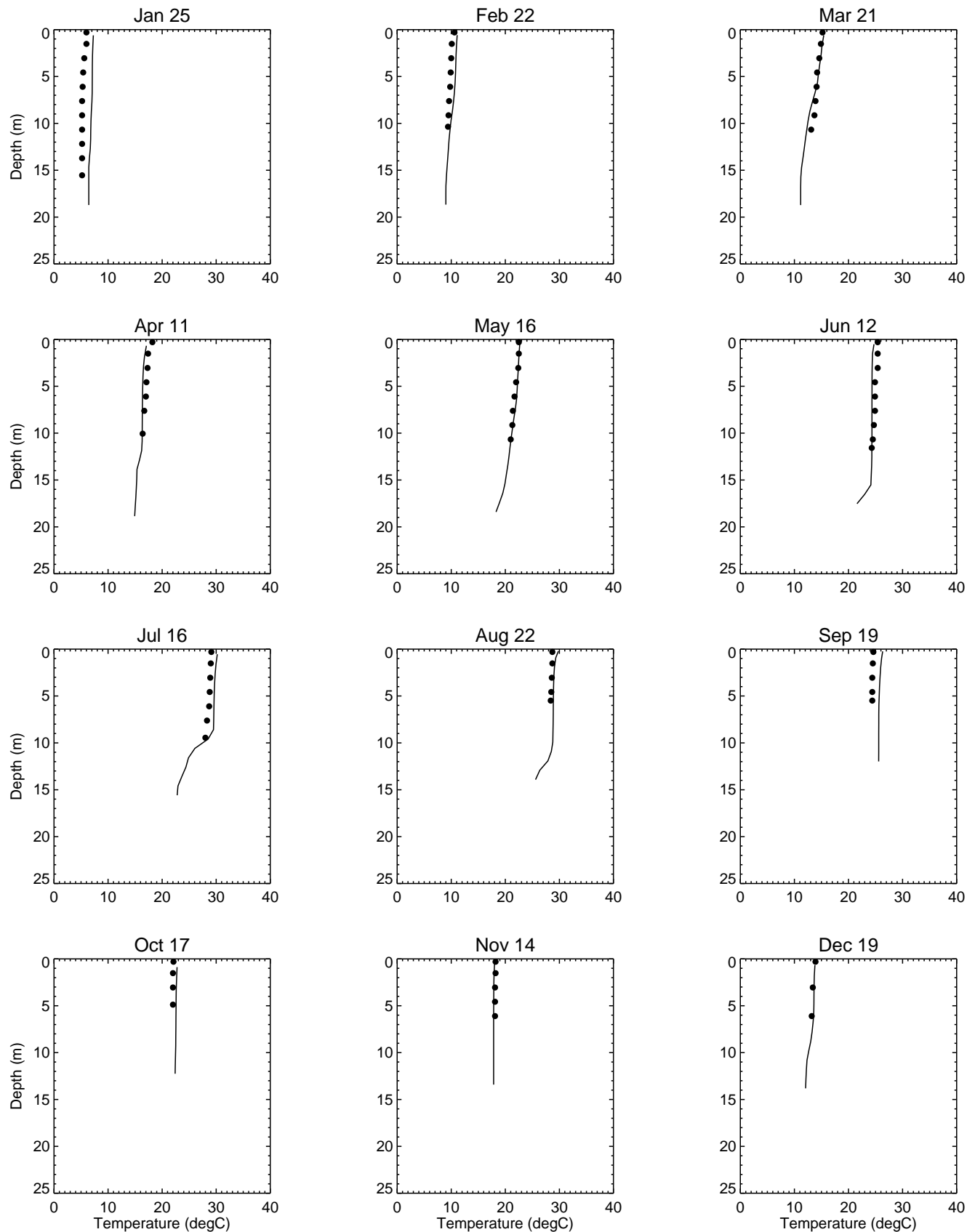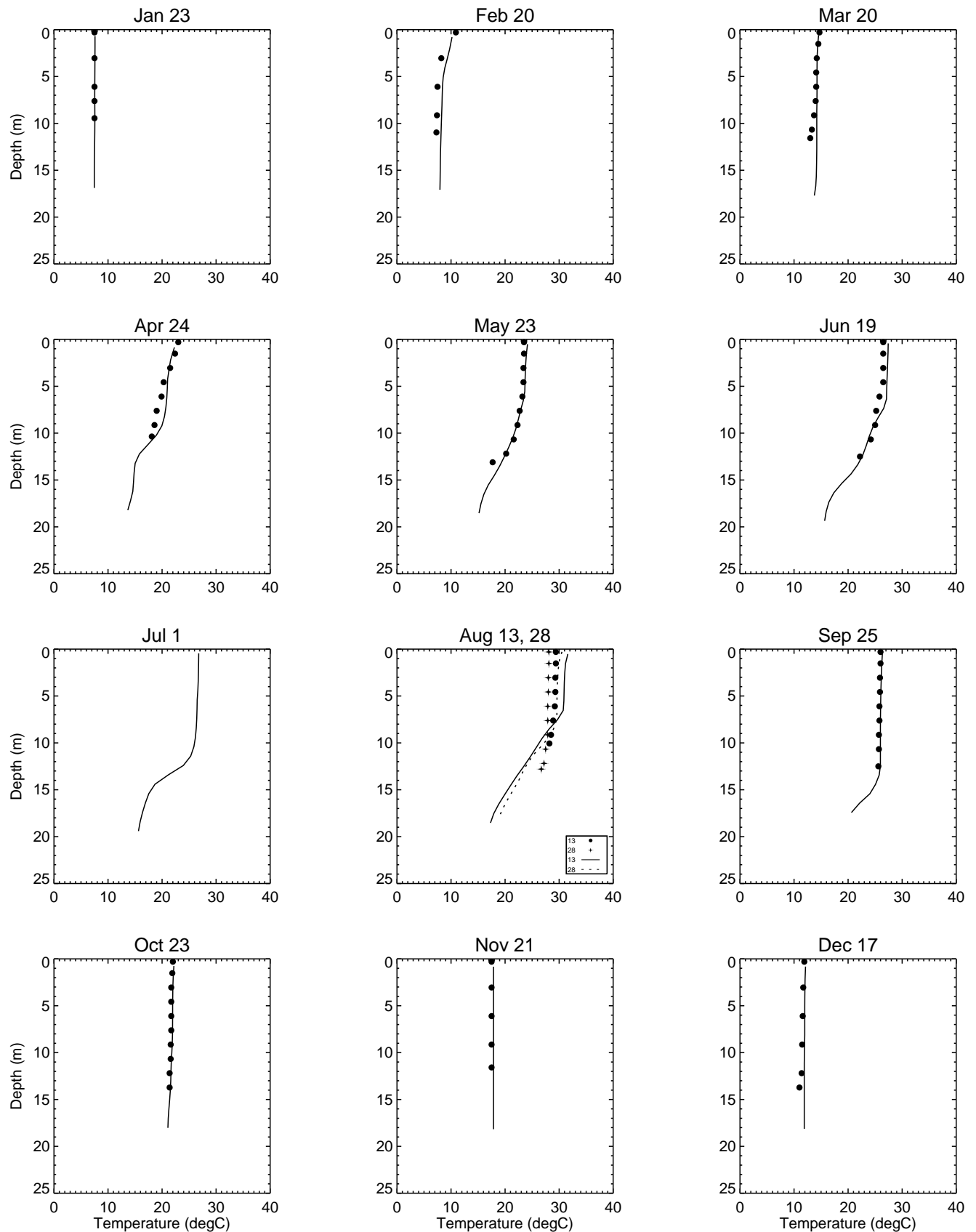
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:08 2013

Jan 1 · Feb 18 · Mar 1 · Apr 5 · May 1 · Jun 3 · Jul 1 · Aug 2, 5 · Sep 2 · Oct 7, 13 · Nov 4 · Dec 1, 2

Model (w1210-48)
● Data

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 2010
Profiles shown for dates with available data else model results for first day of month shown.
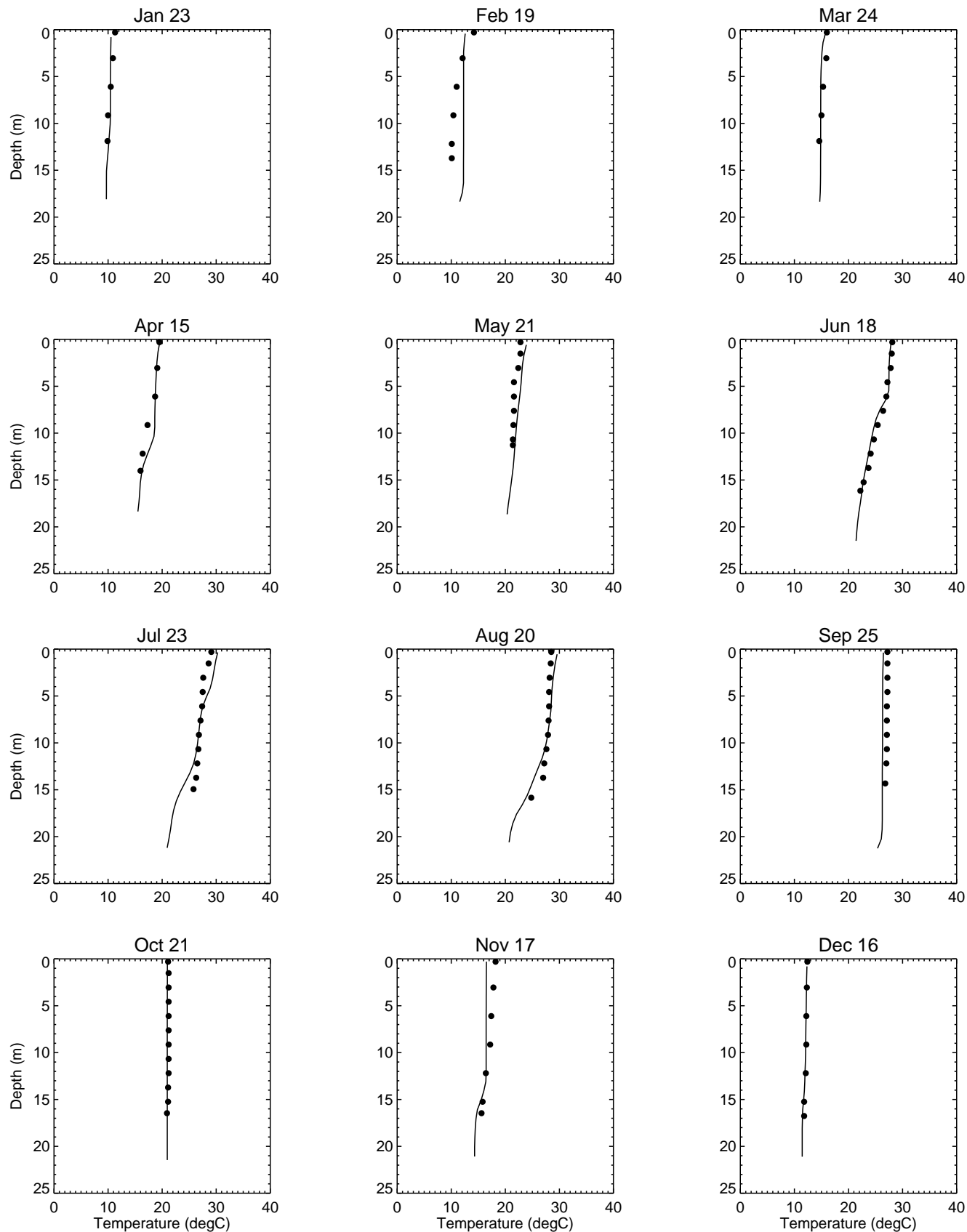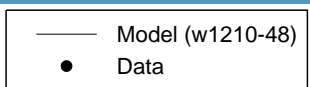
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:08 2013

Figure G-5

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Temperature - 2011

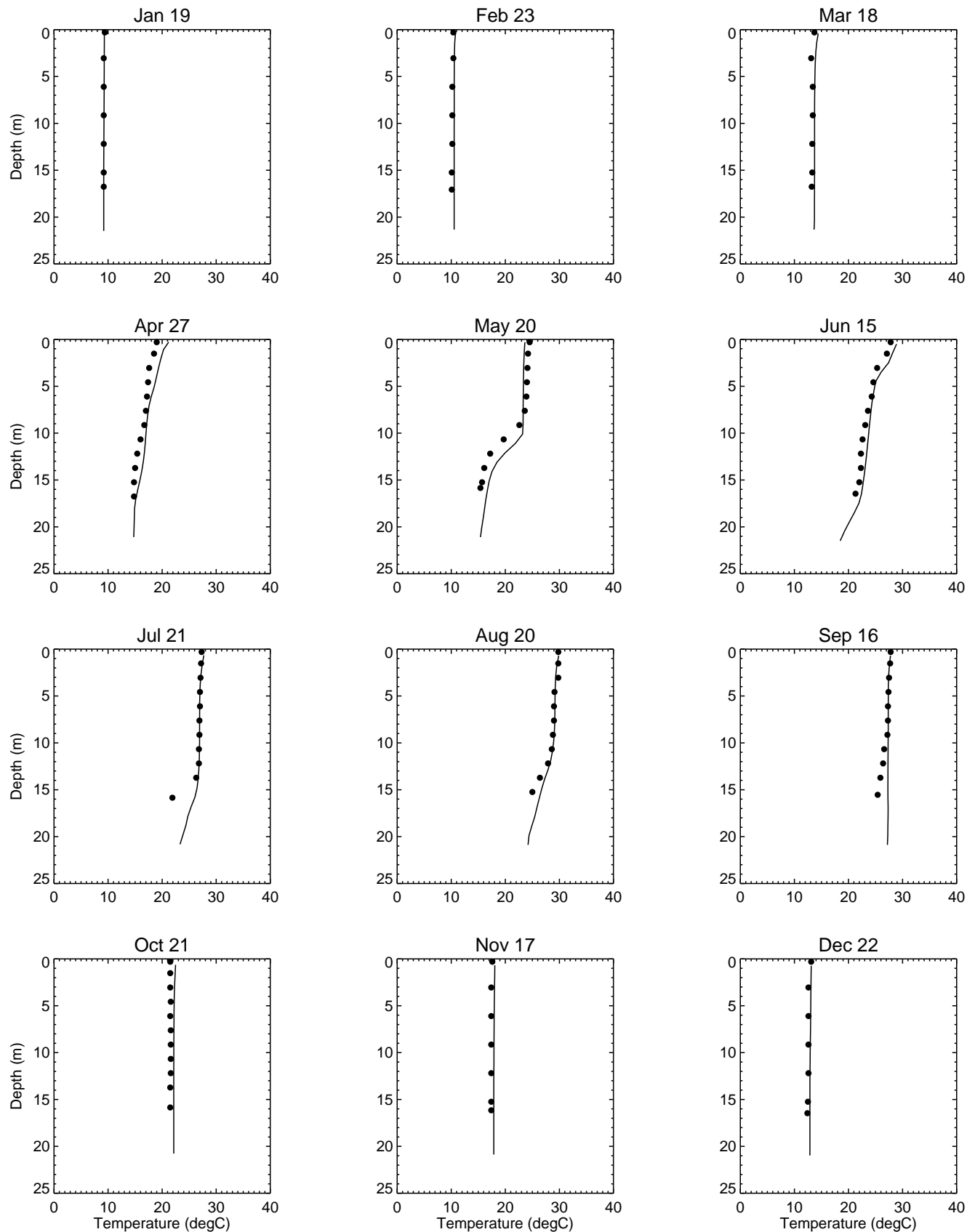*Profiles shown for dates with available data else model results for first day of month shown.*

Model (w1210-48)
● Data

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 1984

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
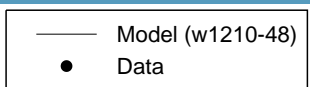
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:11 2013

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 1985

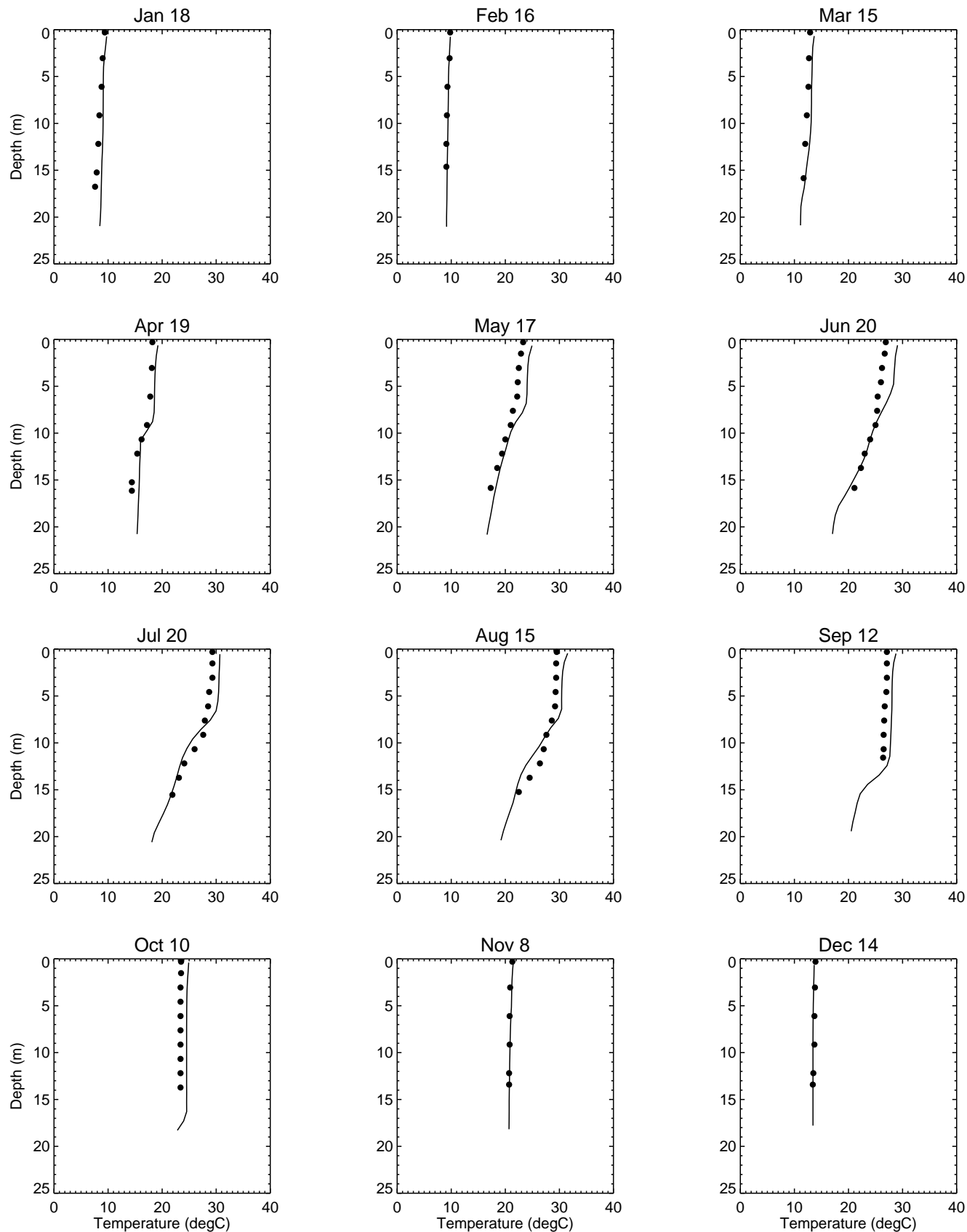*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:11 2013

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 1986

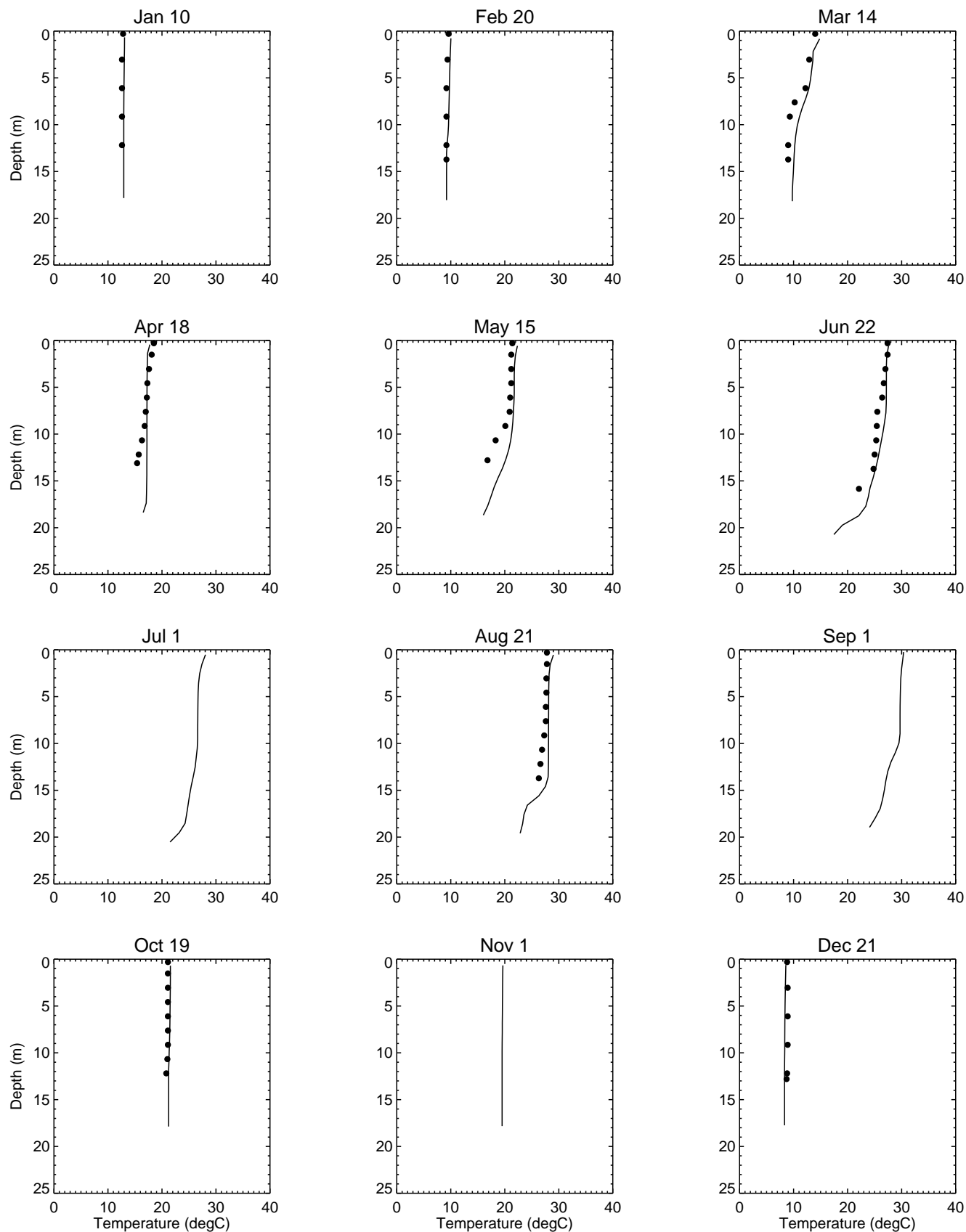*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
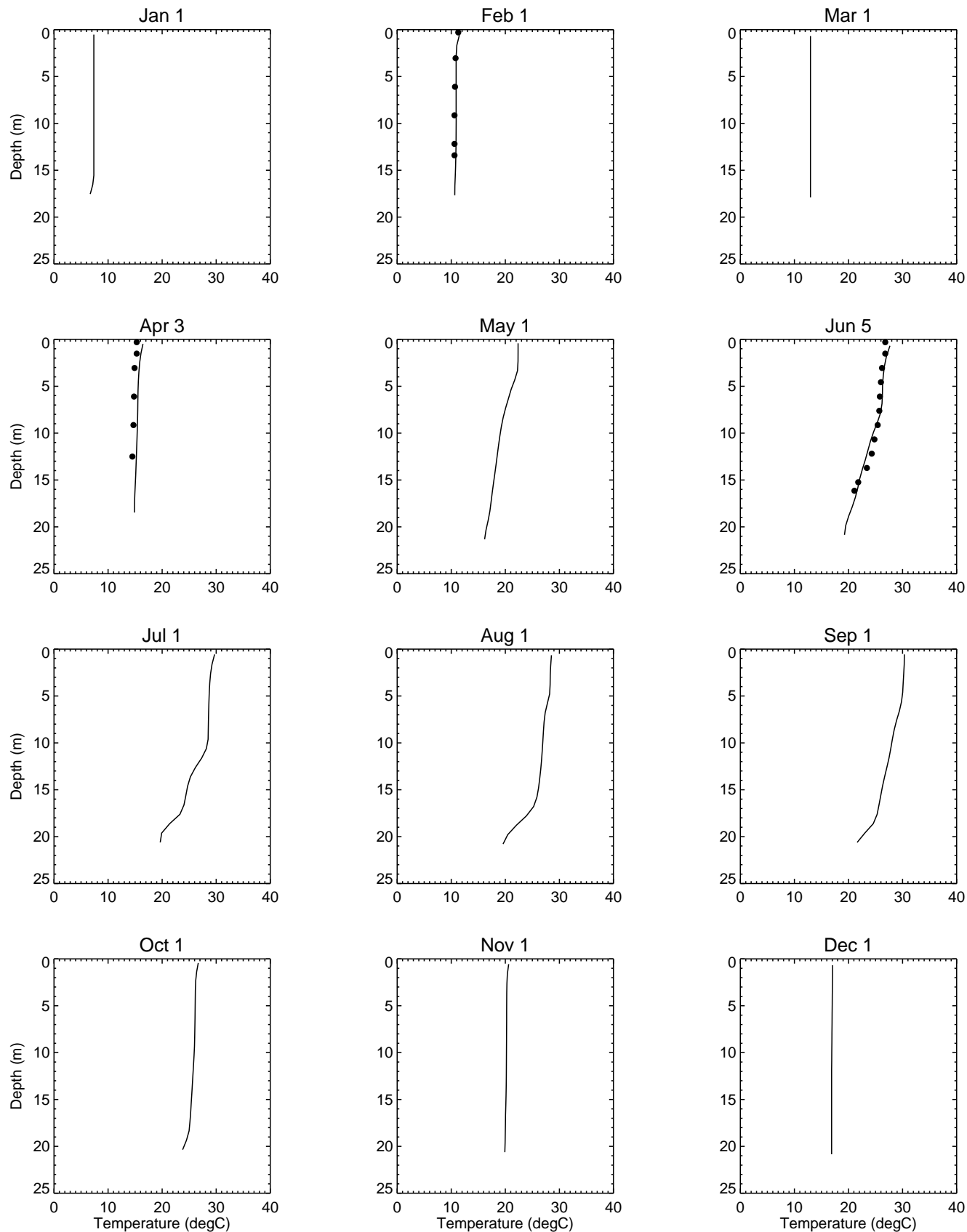
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:11 2013

Figure G-6
Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 1987

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
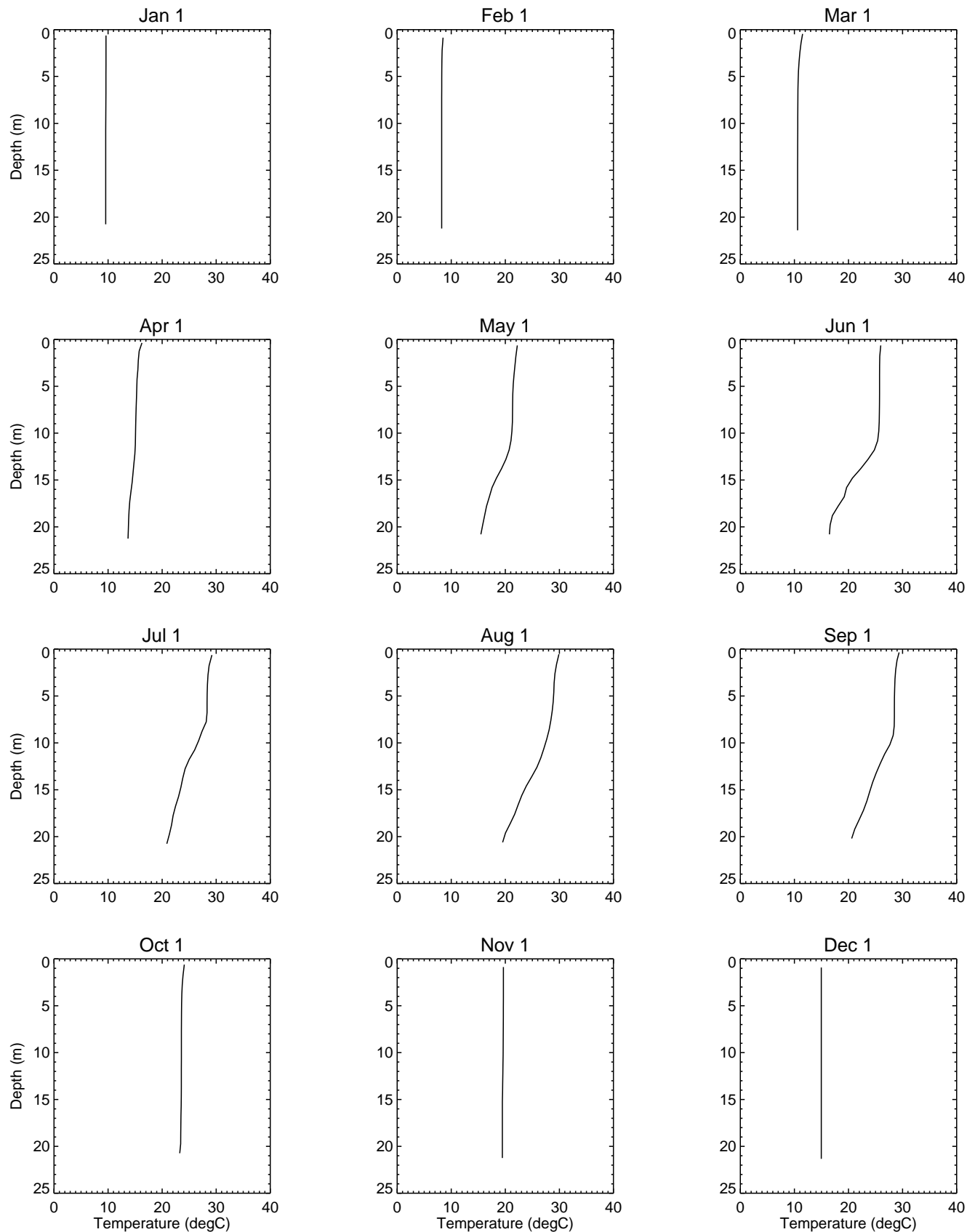Lower Colorado River Authority

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 1988

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
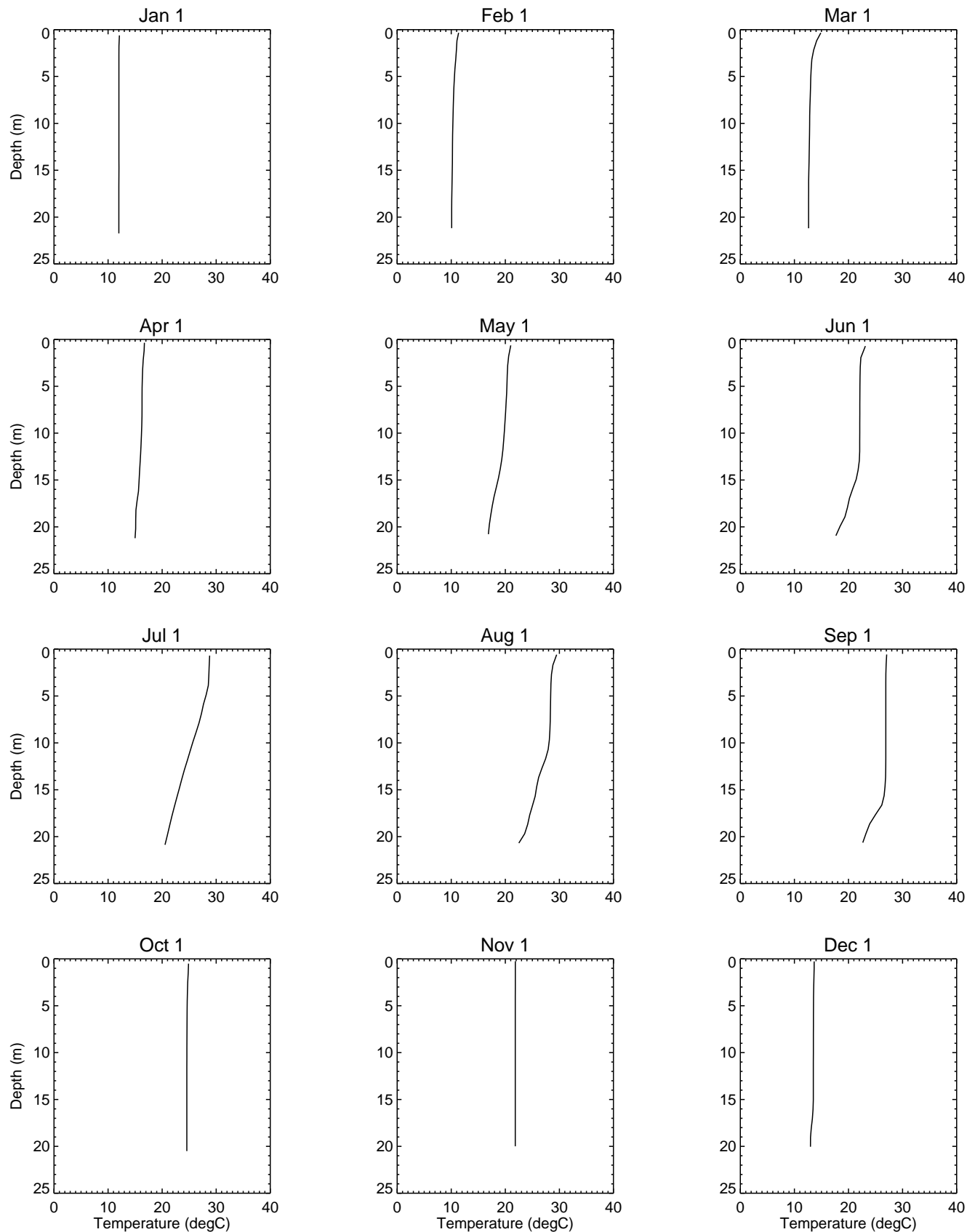
Lower Colorado River Authority

Jan 10

Feb 20

Mar 14

Apr 18

May 15

Jun 22

Jul 1

Aug 21

Sep 1

Oct 19

Nov 1

Dec 21

Temperature (degC)

Model (w1210-48)

● Data

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 1989

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
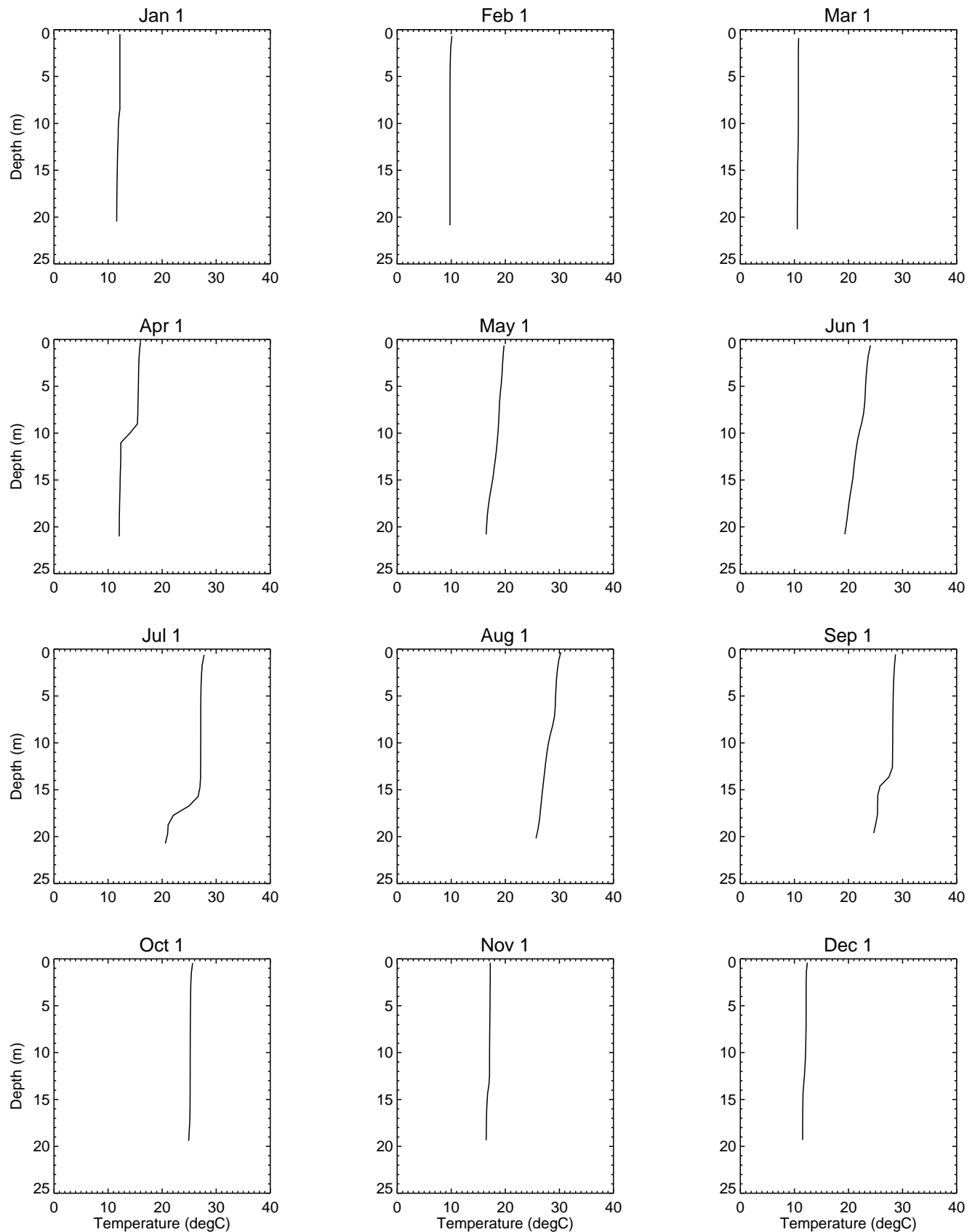
Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 1990

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
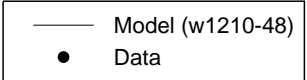Lower Colorado River Authority

Jan 1 · Feb 20 · Mar 1 · Apr 1 · May 1 · Jun 11 · Jul 11 · Aug 20 · Sep 1 · Oct 22 · Nov 1 · Dec 16

Depth (m)

Temperature (degC)

—— Model (w1210-48)
● Data

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 1991

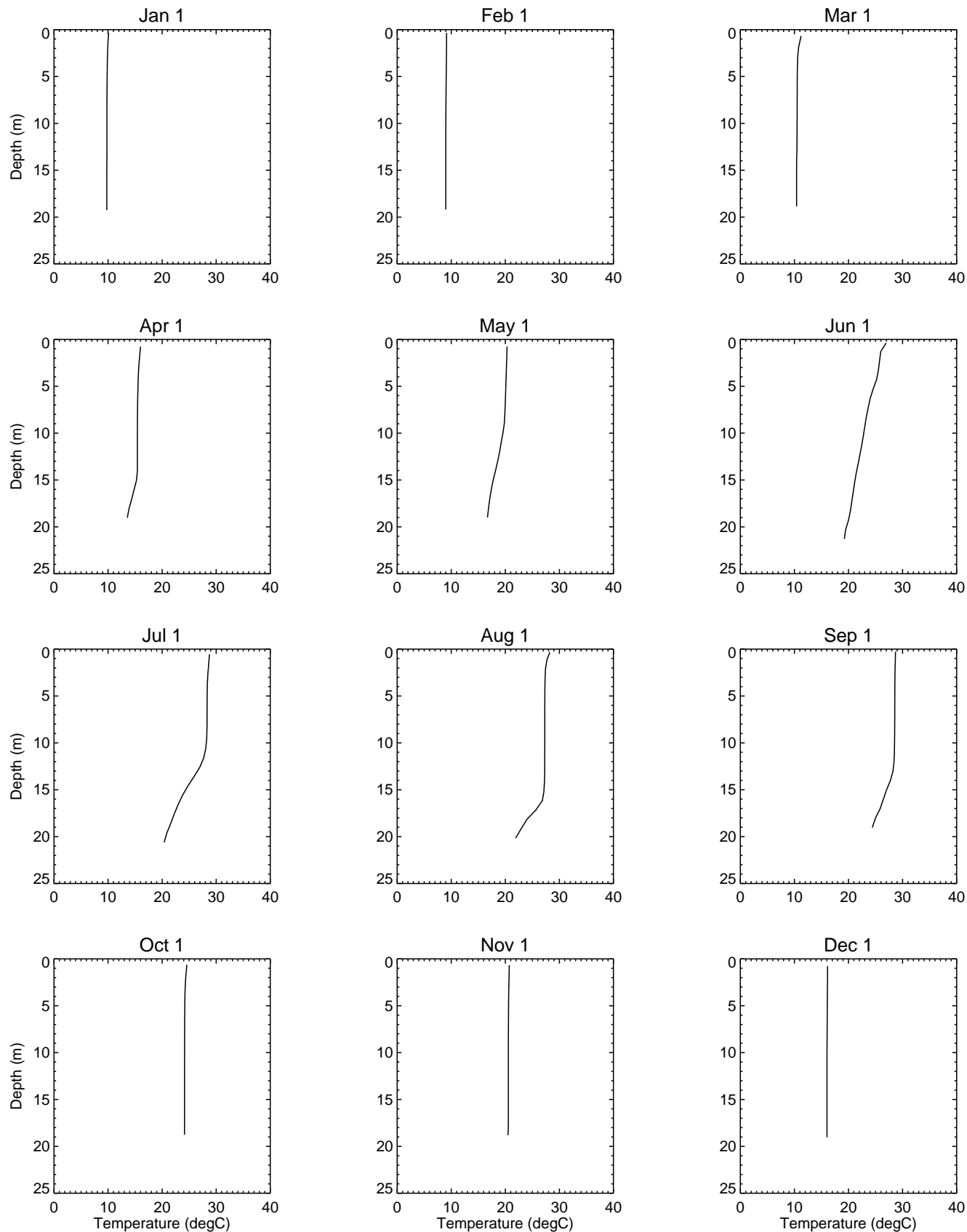*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:11 2013

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 1992

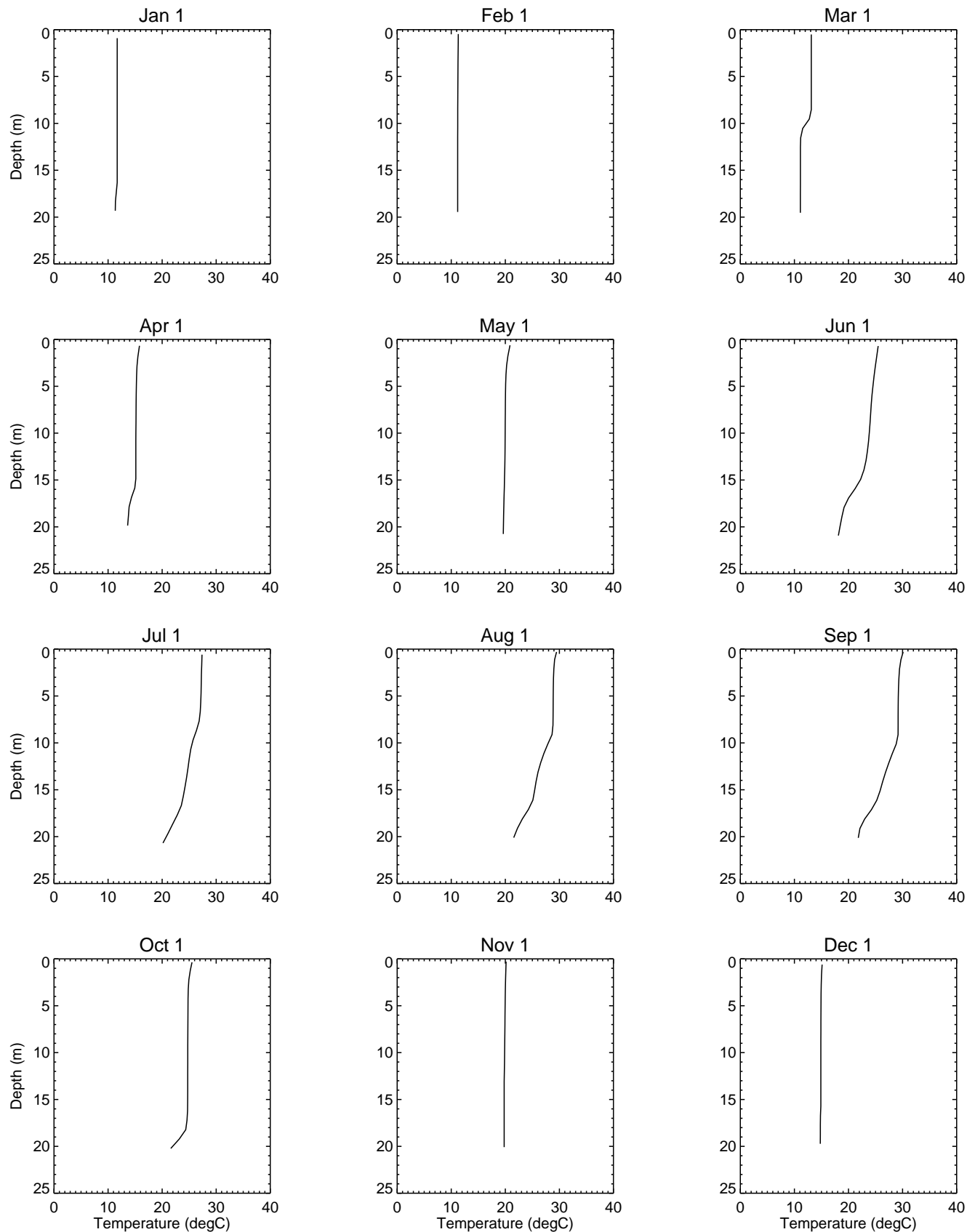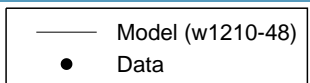*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 1993

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
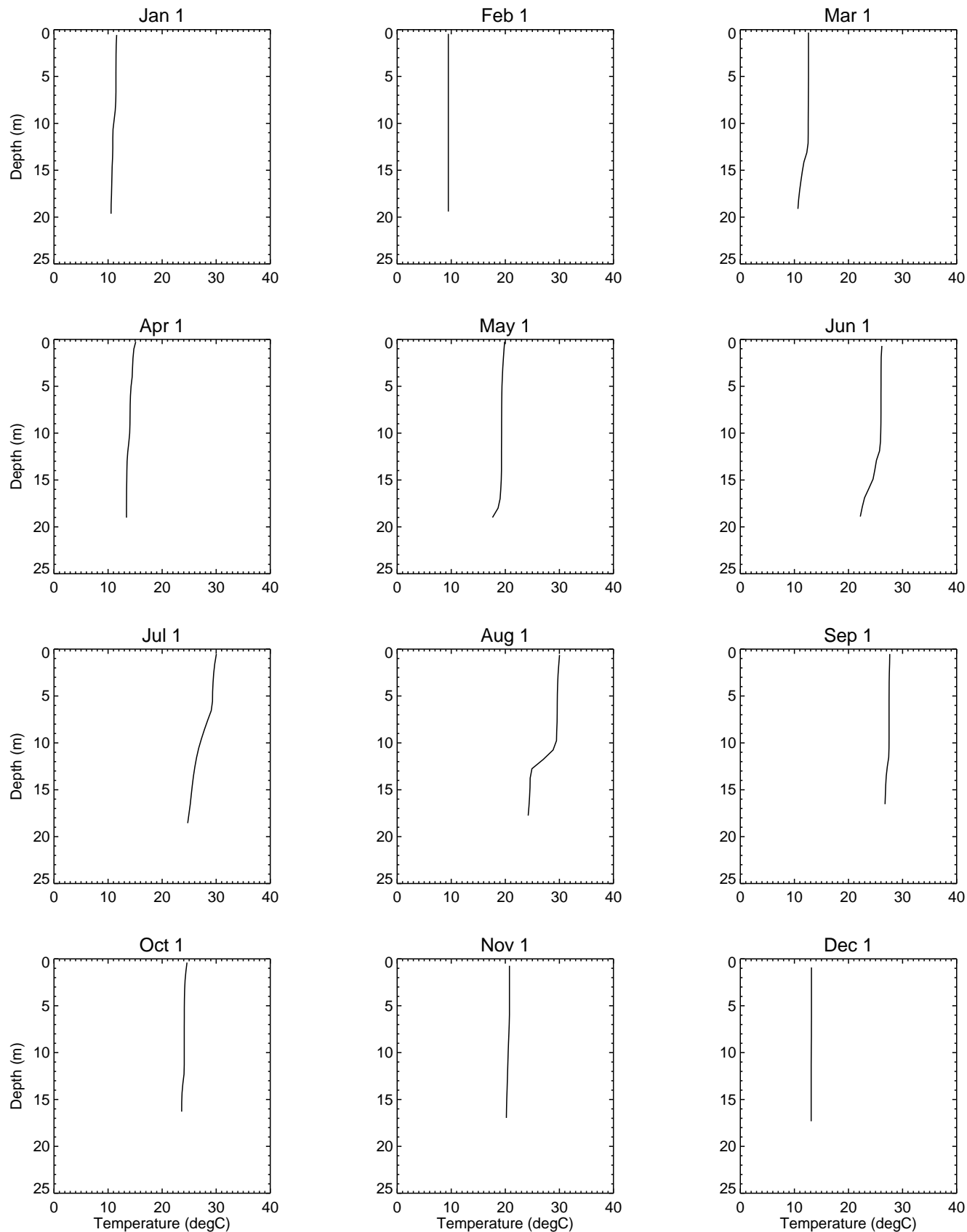
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:11 2013

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 1994

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
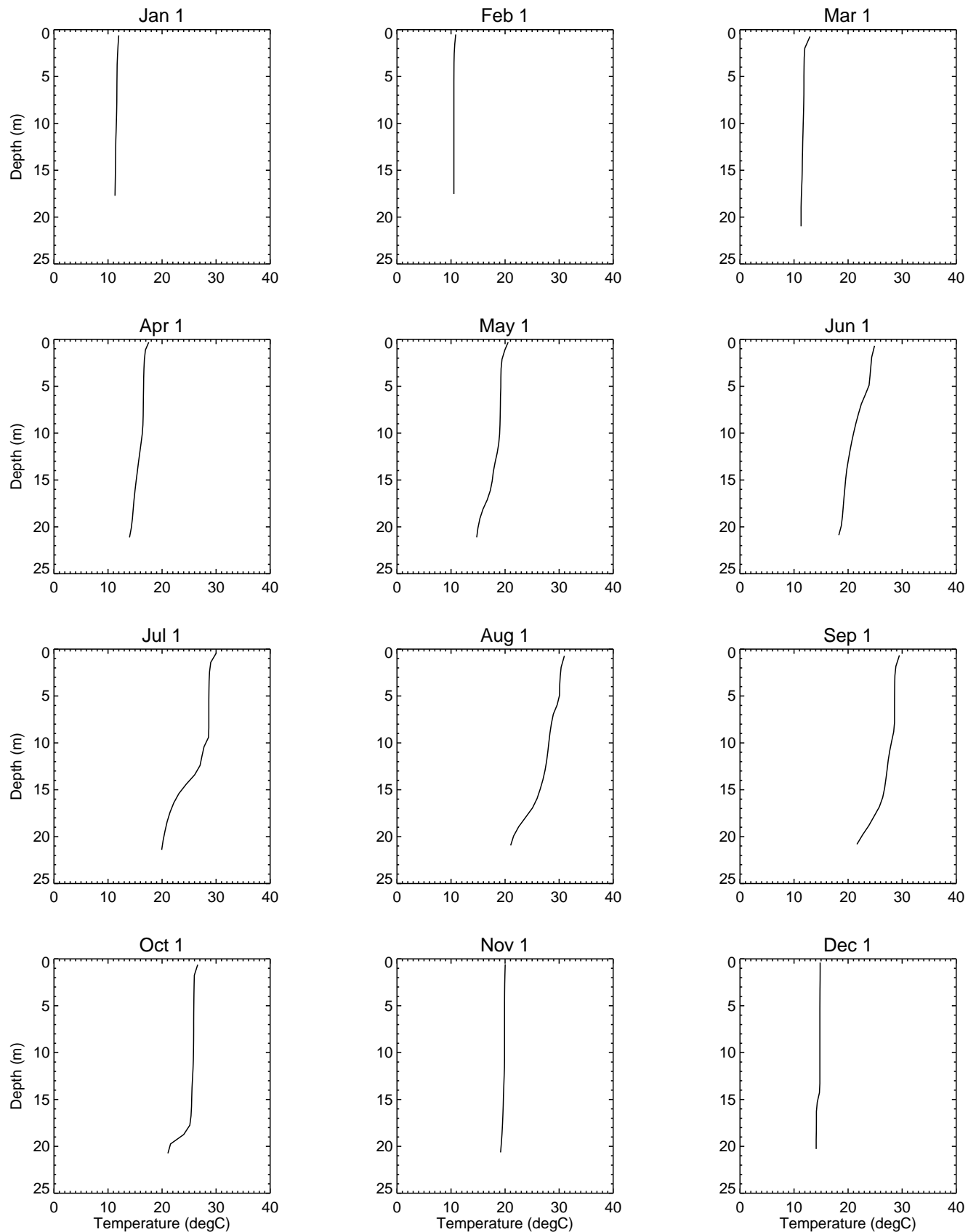
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:11 2013

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 1996

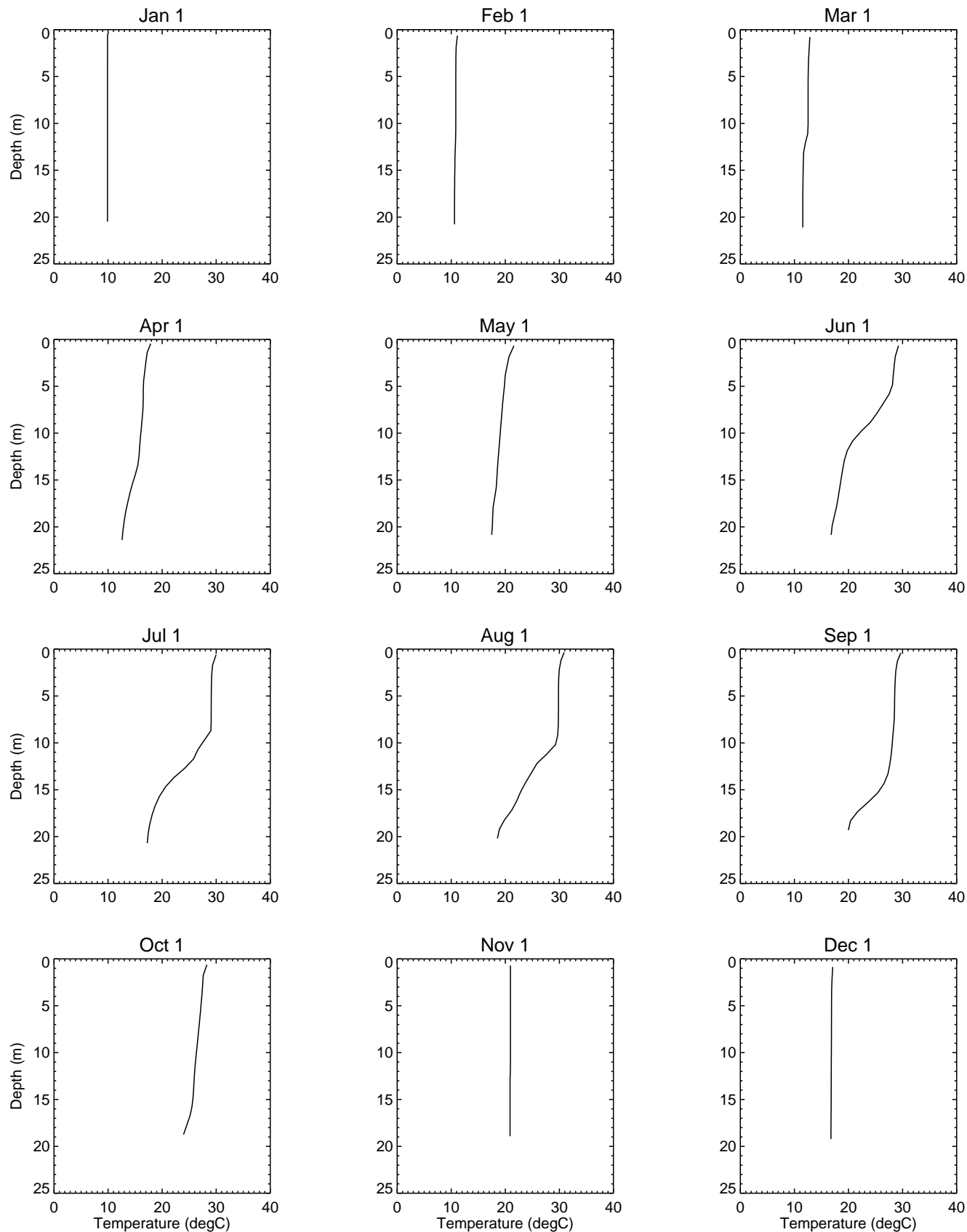*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 6 · Mar 1 · Apr 16 · May 1 · Jun 5 · Jul 1 · Aug 1 · Sep 1 · Oct 20 · Nov 1 · Dec 15

——— Model (w1210-48)
● Data

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 1997

Profiles shown for dates with available data else model results for first day of month shown.
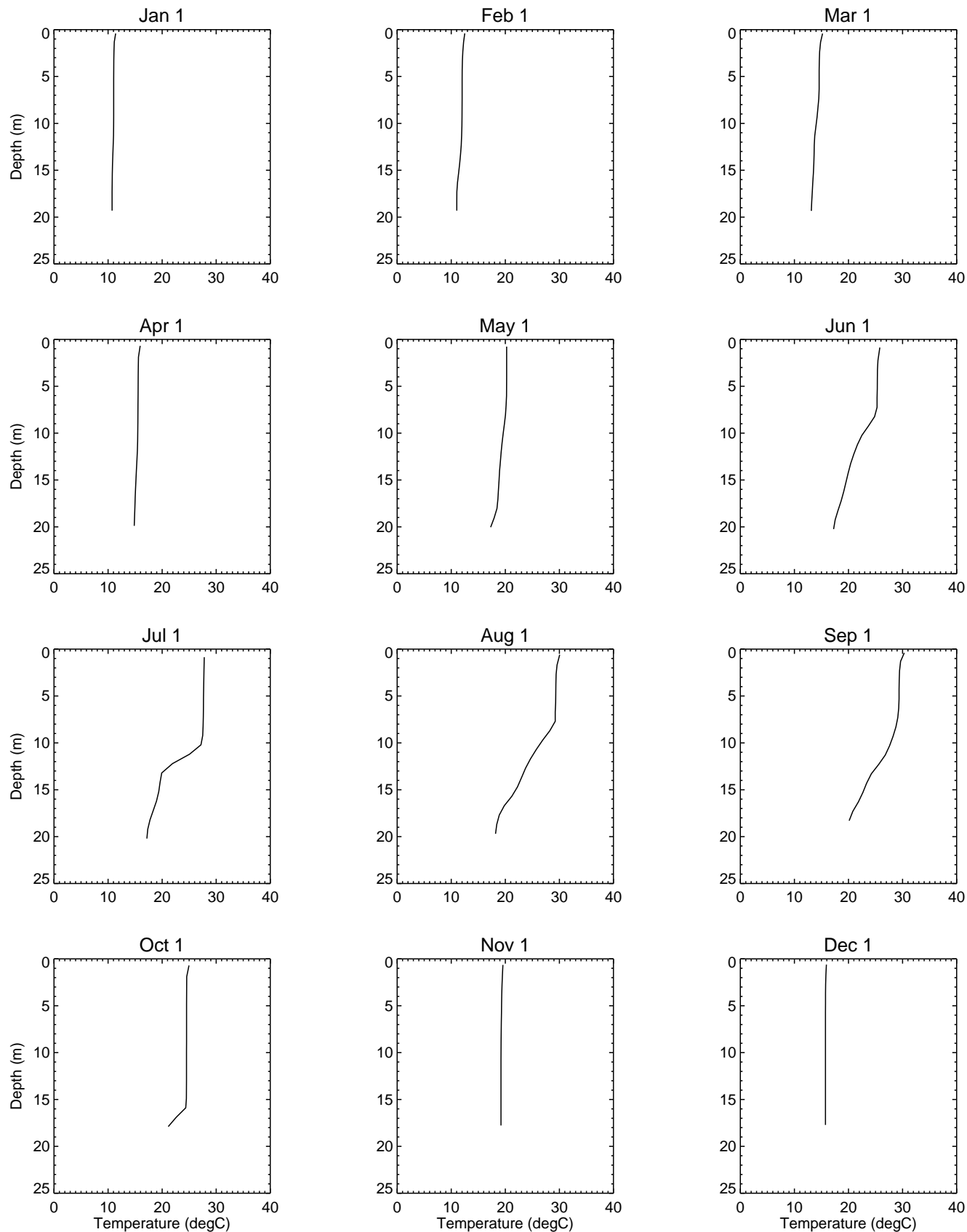
CREMs Phase 4: Lake Buchanan
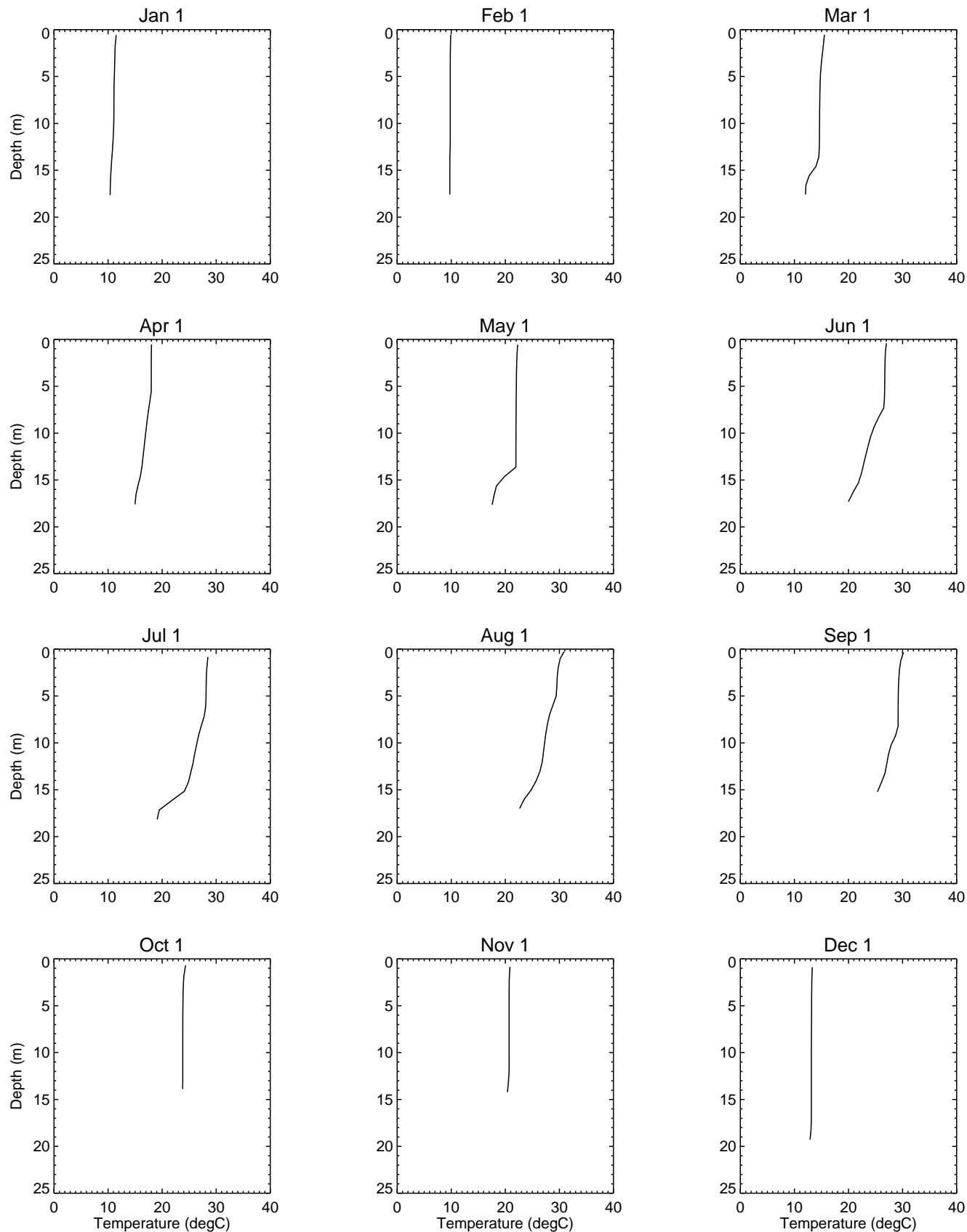
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:12 2013

Jan 1   Feb 5   Mar 1

Apr 7   May 1   Jun 15

Jul 1   Aug 3   Sep 1

Oct 8   Nov 1   Dec 3

Model (w1210-48)
● Data

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 1998

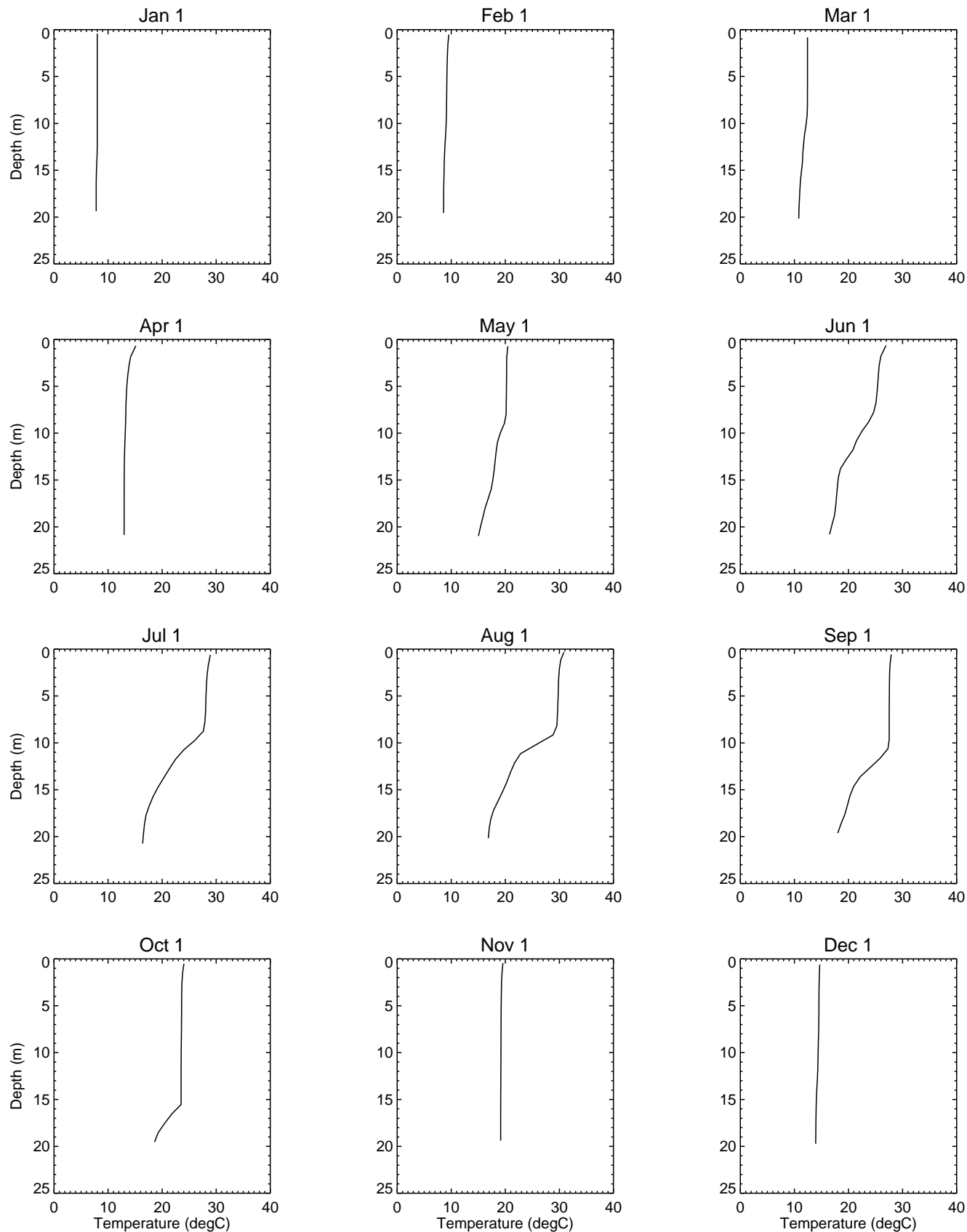*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:12 2013

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 1999

Profiles shown for dates with available data else model results for first day of month shown.

Legend:
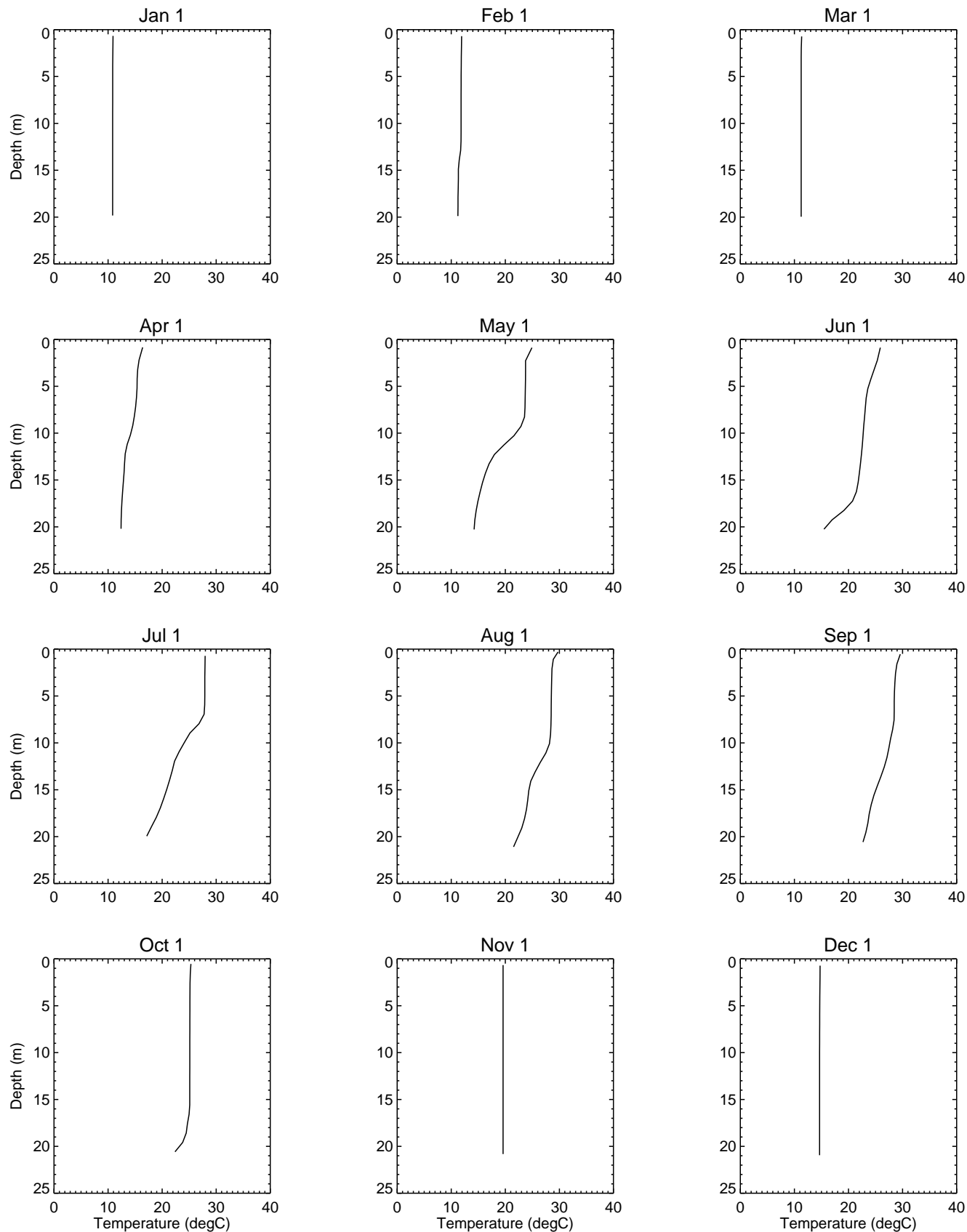— Model (w1210-48)
● Data

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 2000

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
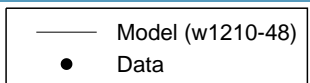
Lower Colorado River Authority

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 2001

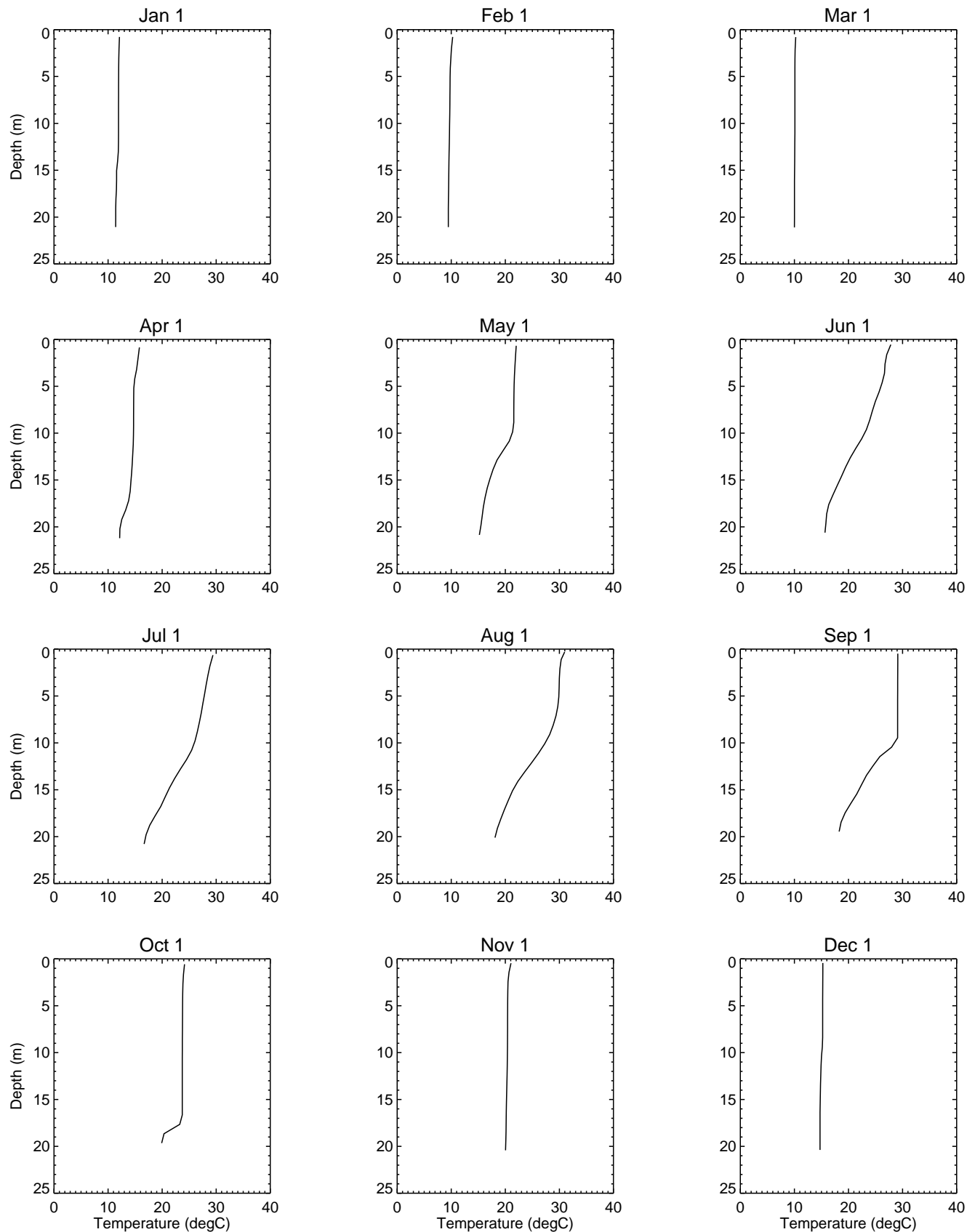*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 2003

Profiles shown for dates with available data else model results for first day of month shown.
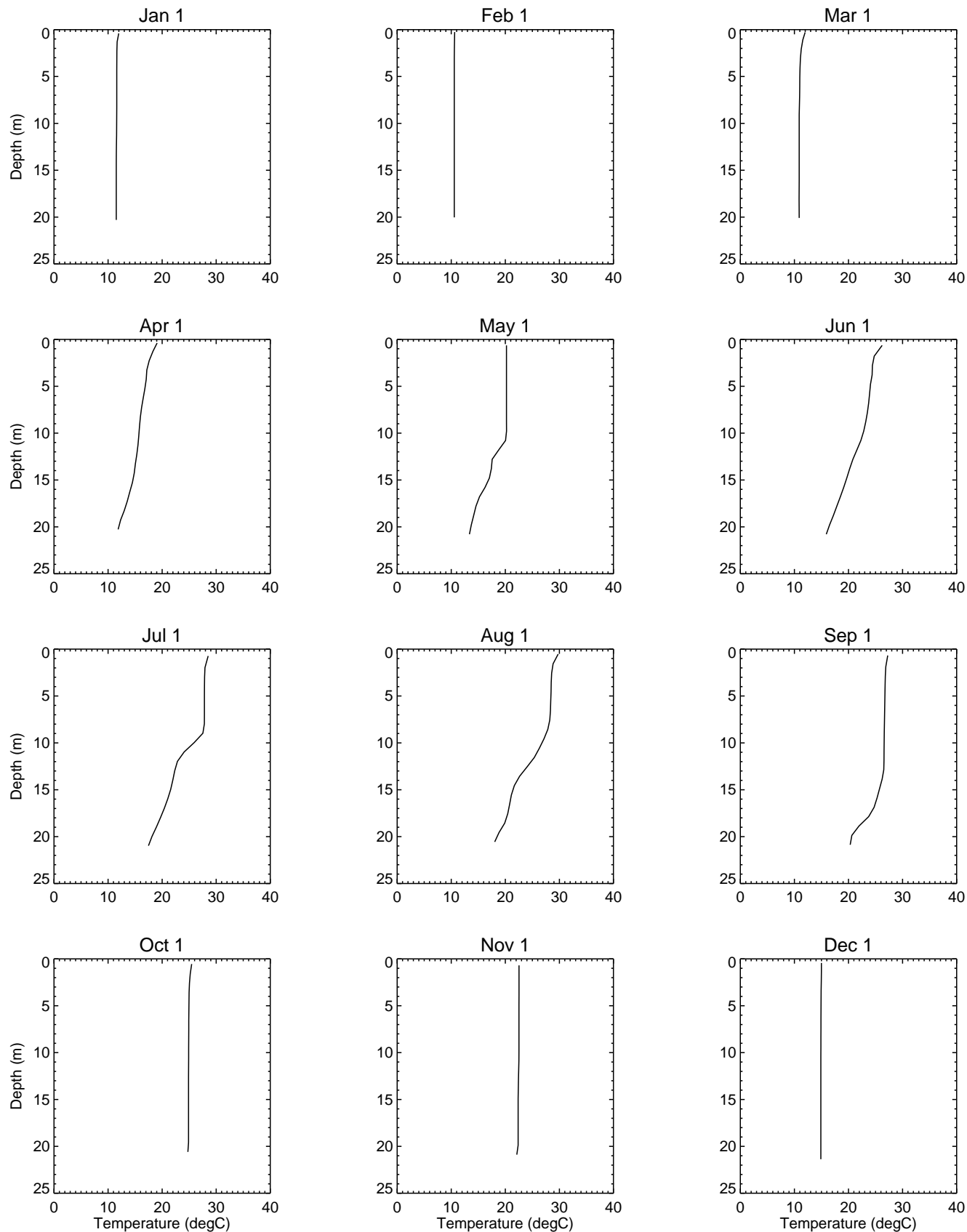
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 2004

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
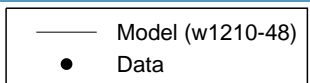
Lower Colorado River Authority

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 2005

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
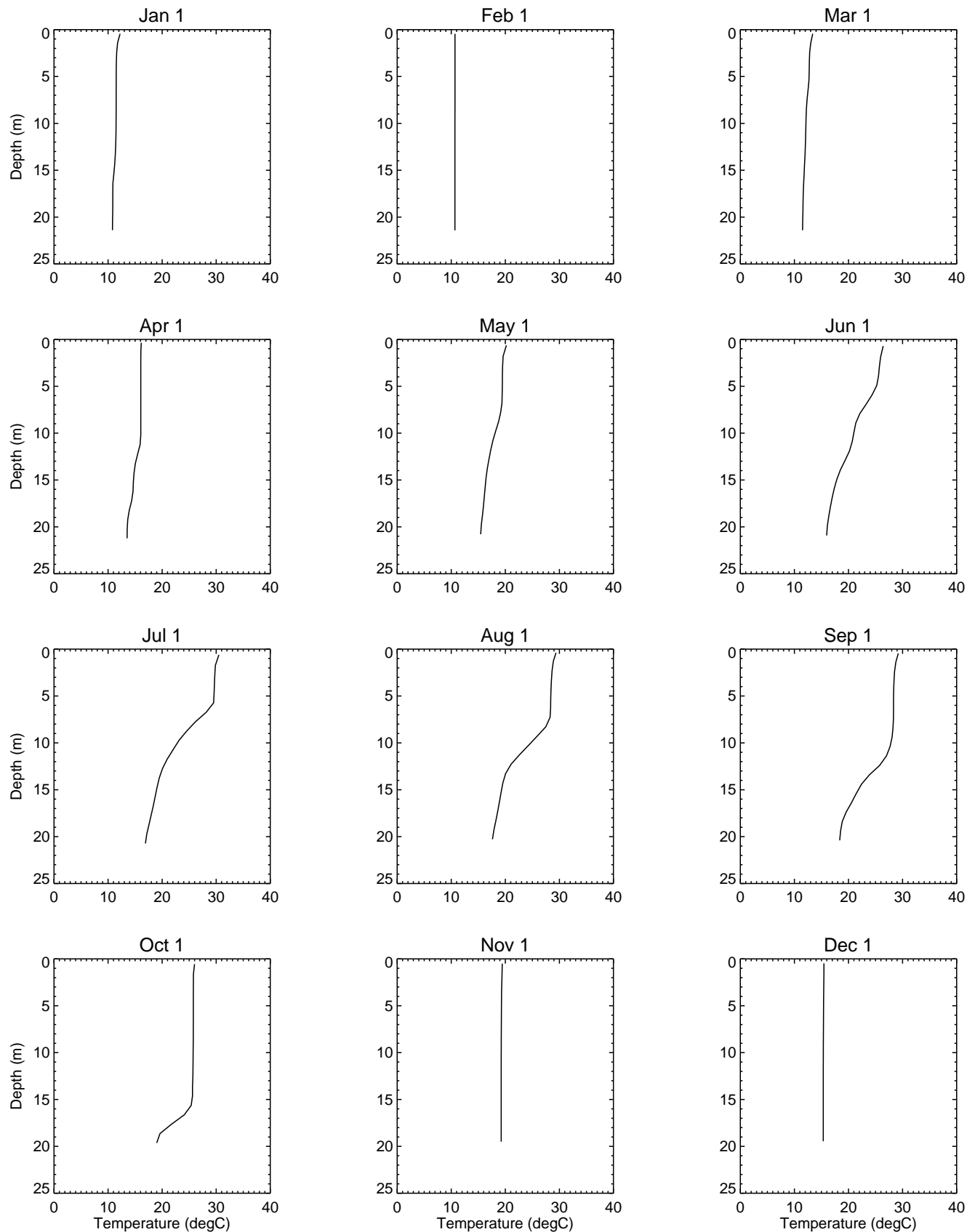
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:12 2013

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 2006

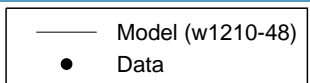*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
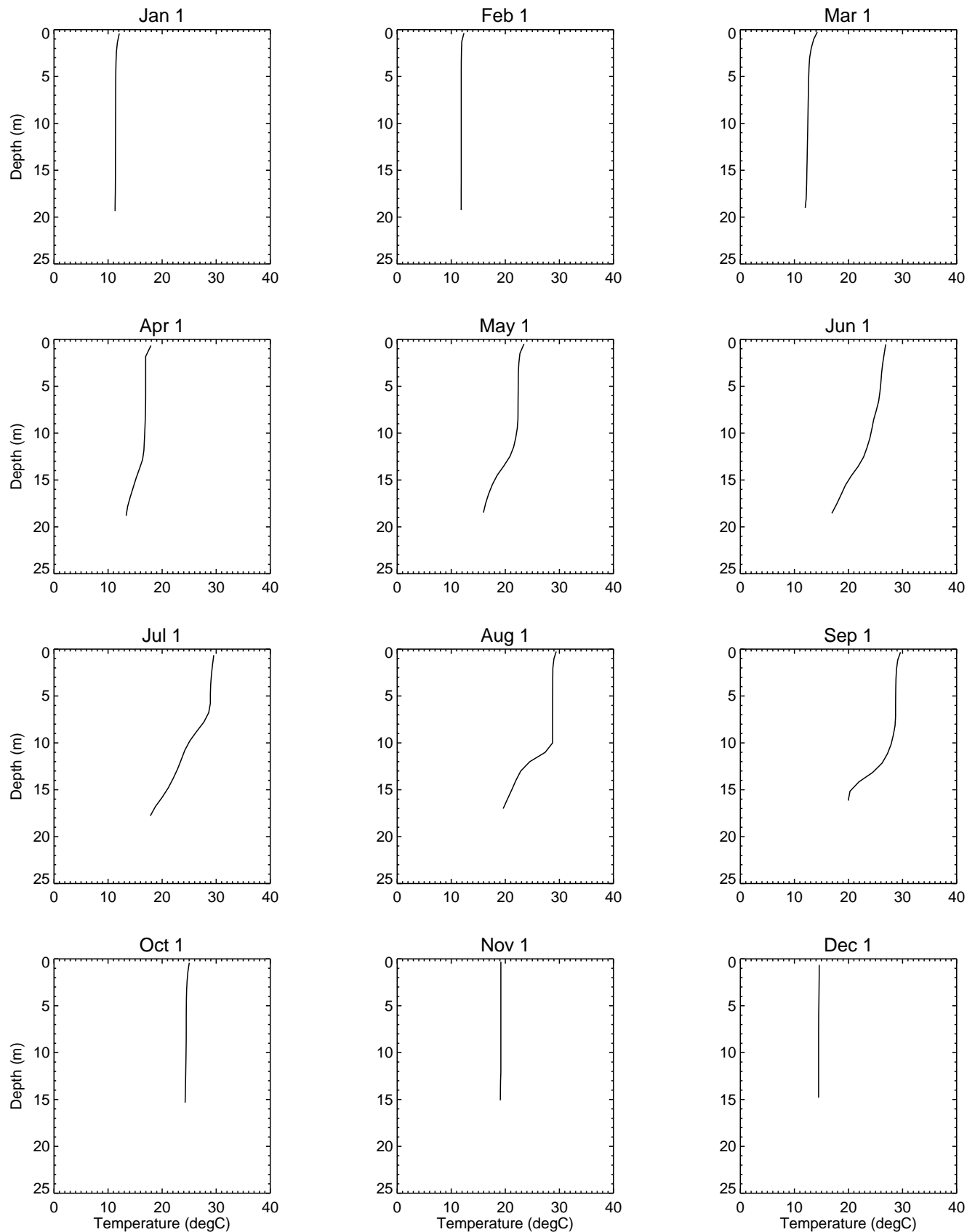
Lower Colorado River Authority

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 2007

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
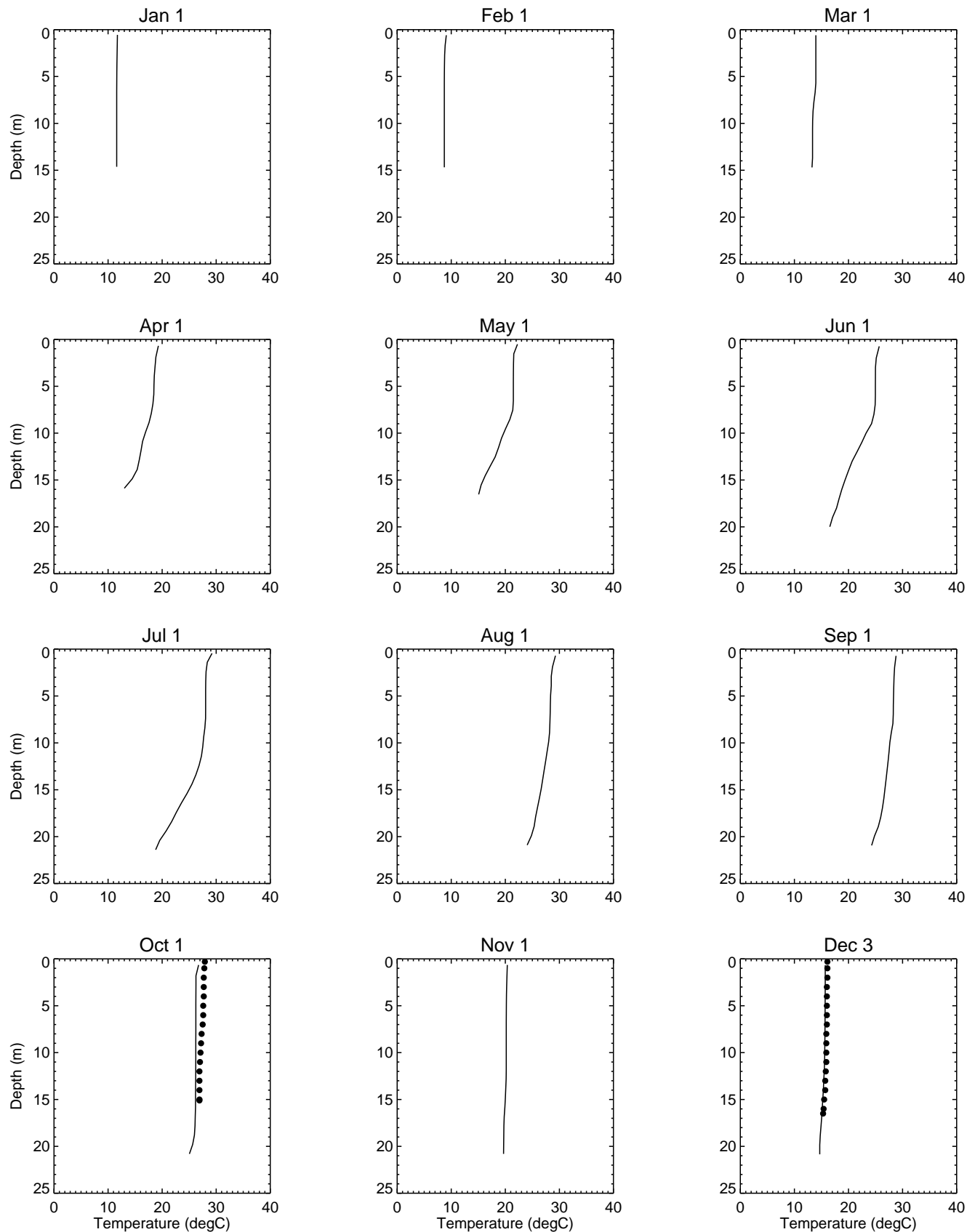
Lower Colorado River Authority

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 2008

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
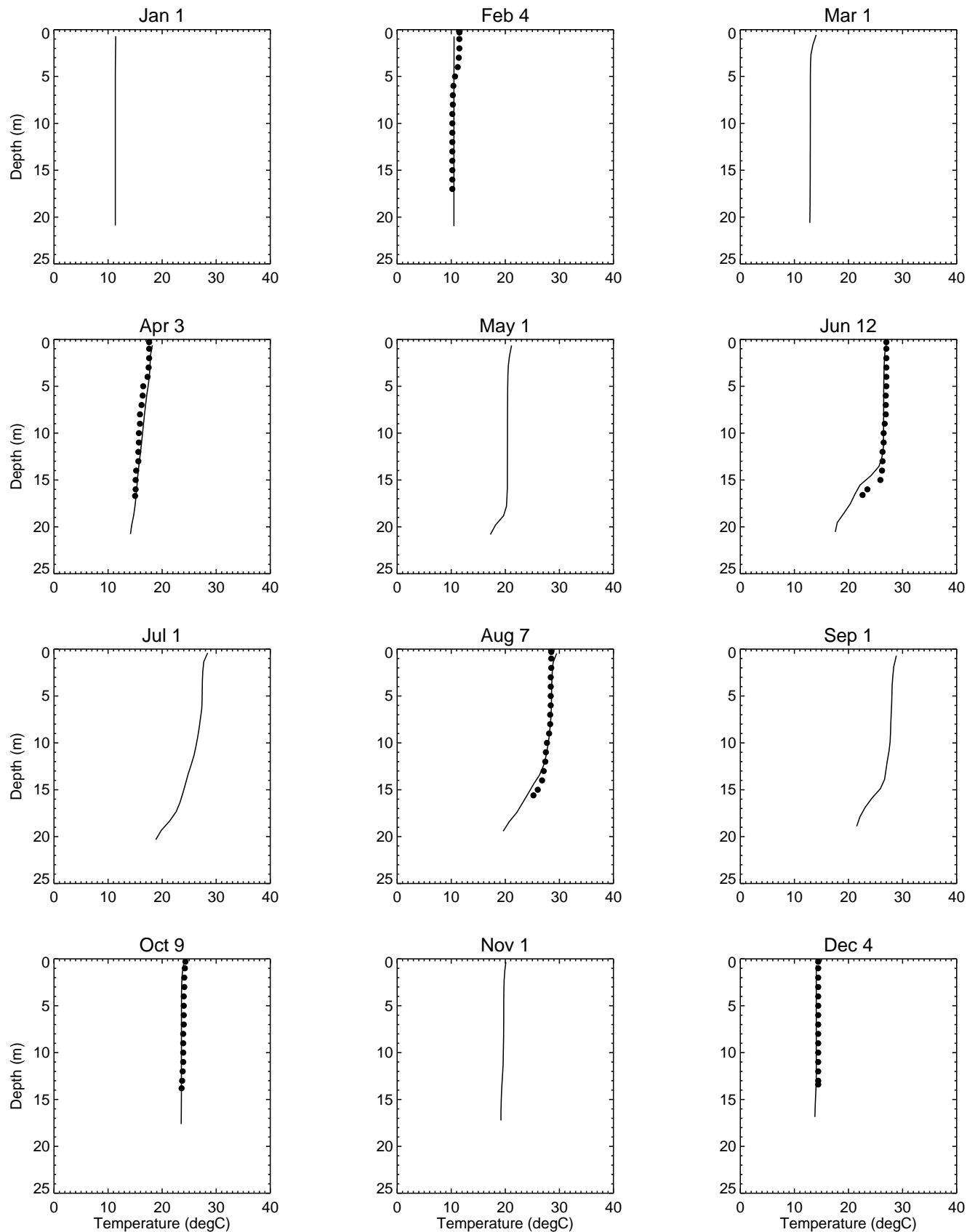
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:12 2013

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 2009

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
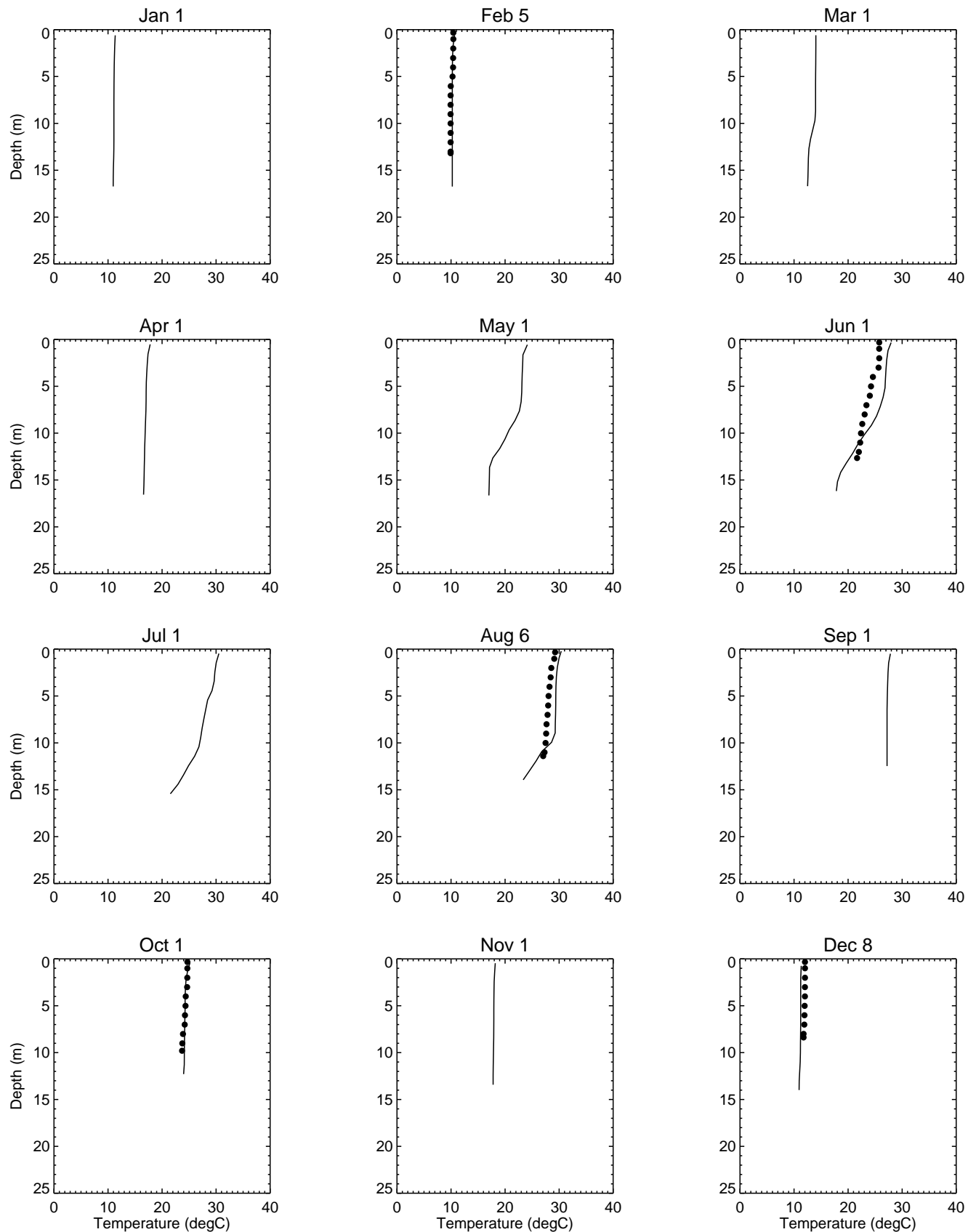
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:12 2013

Jan 1 | Feb 18 | Mar 1
Apr 5 | May 1 | Jun 3
Jul 1 | Aug 2, 5 | Sep 2
Oct 7, 13 | Nov 4 | Dec 1, 2

—— Model (w1210-48)
● Data

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 2010

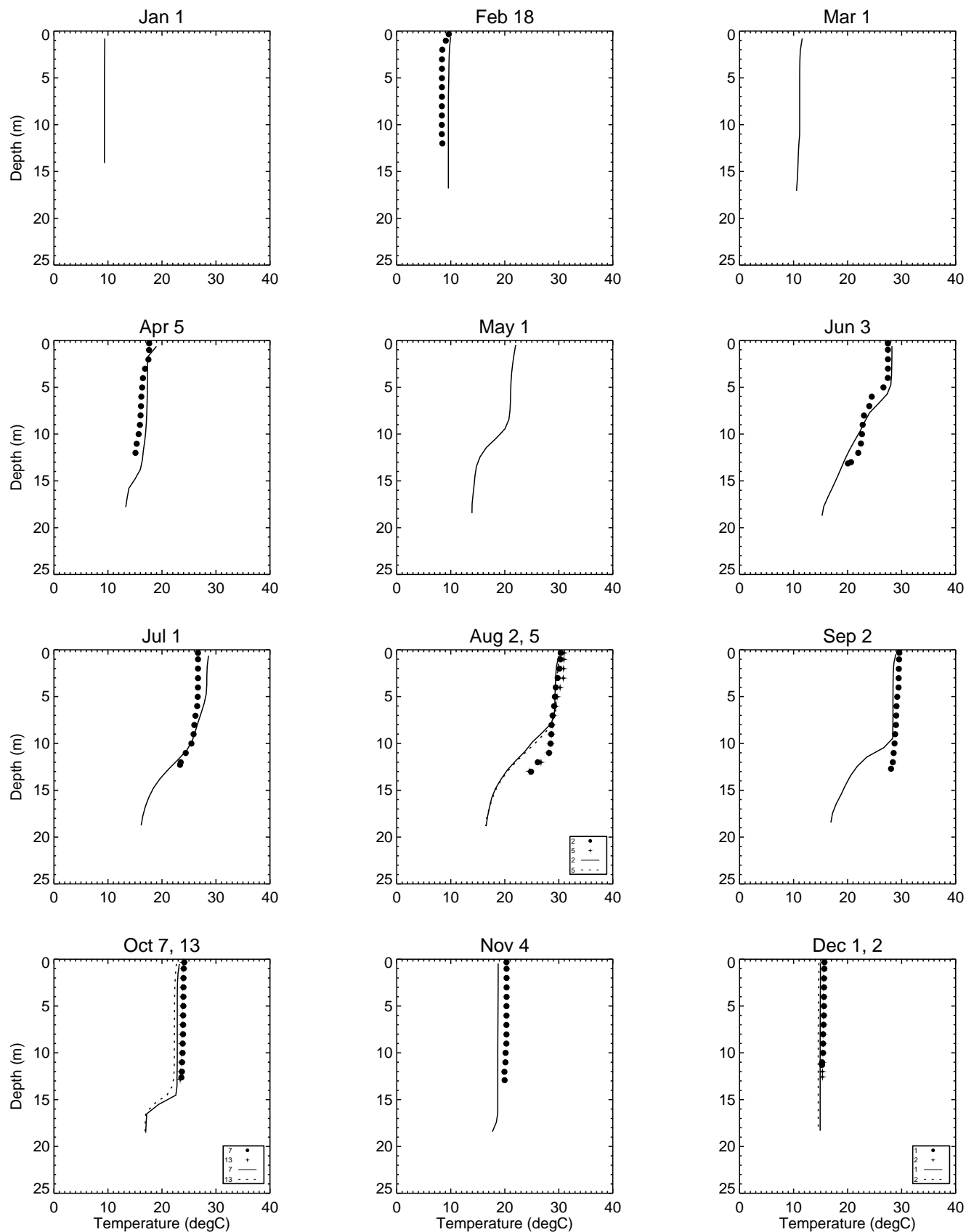*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:12 2013

Figure G-6

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Temperature - 2011

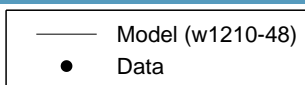*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:12 2013

Jan 25 · Feb 22 · Mar 21 · Apr 11 · May 16 · Jun 12 · Jul 16 · Aug 22 · Sep 19 · Oct 17 · Nov 14 · Dec 19
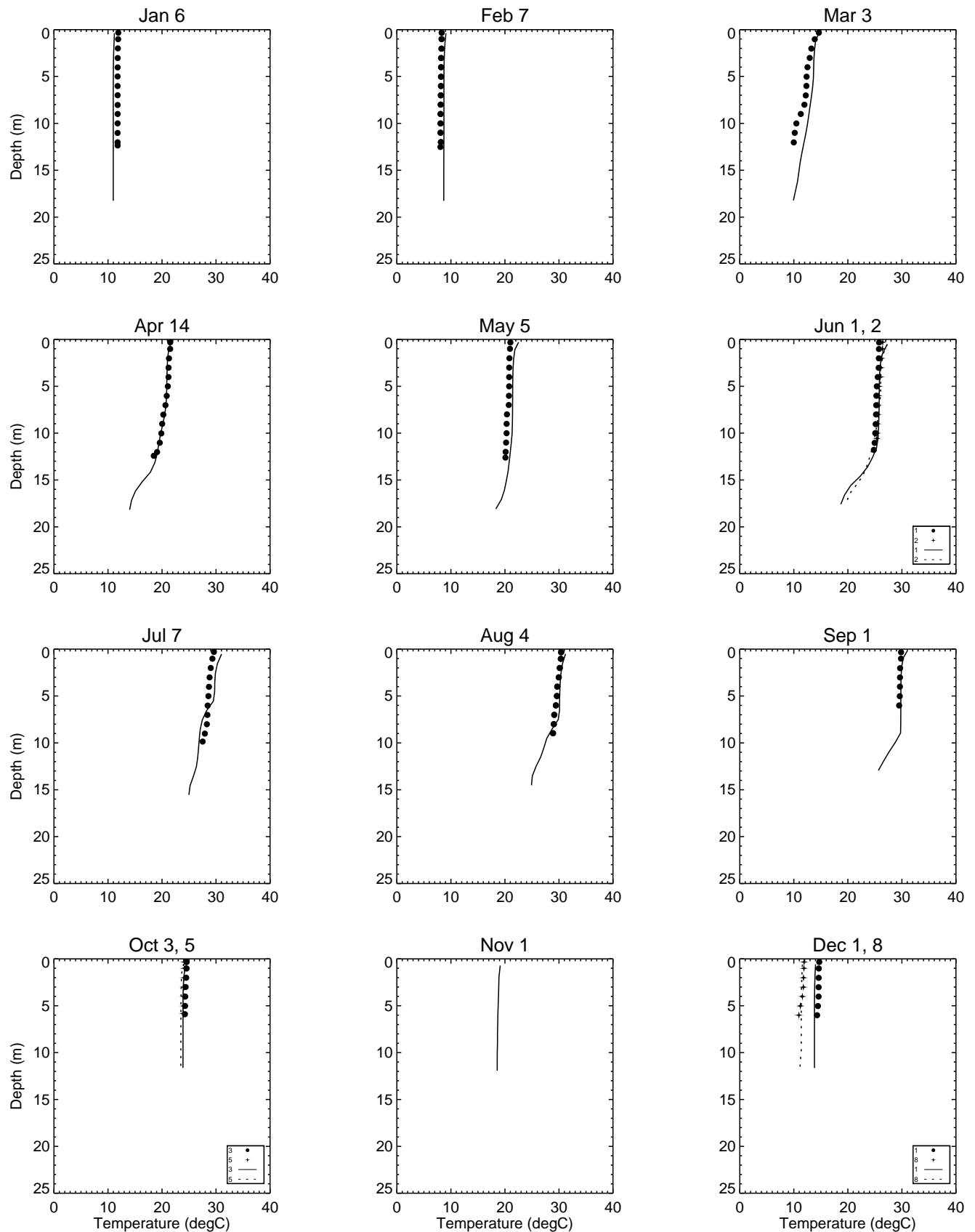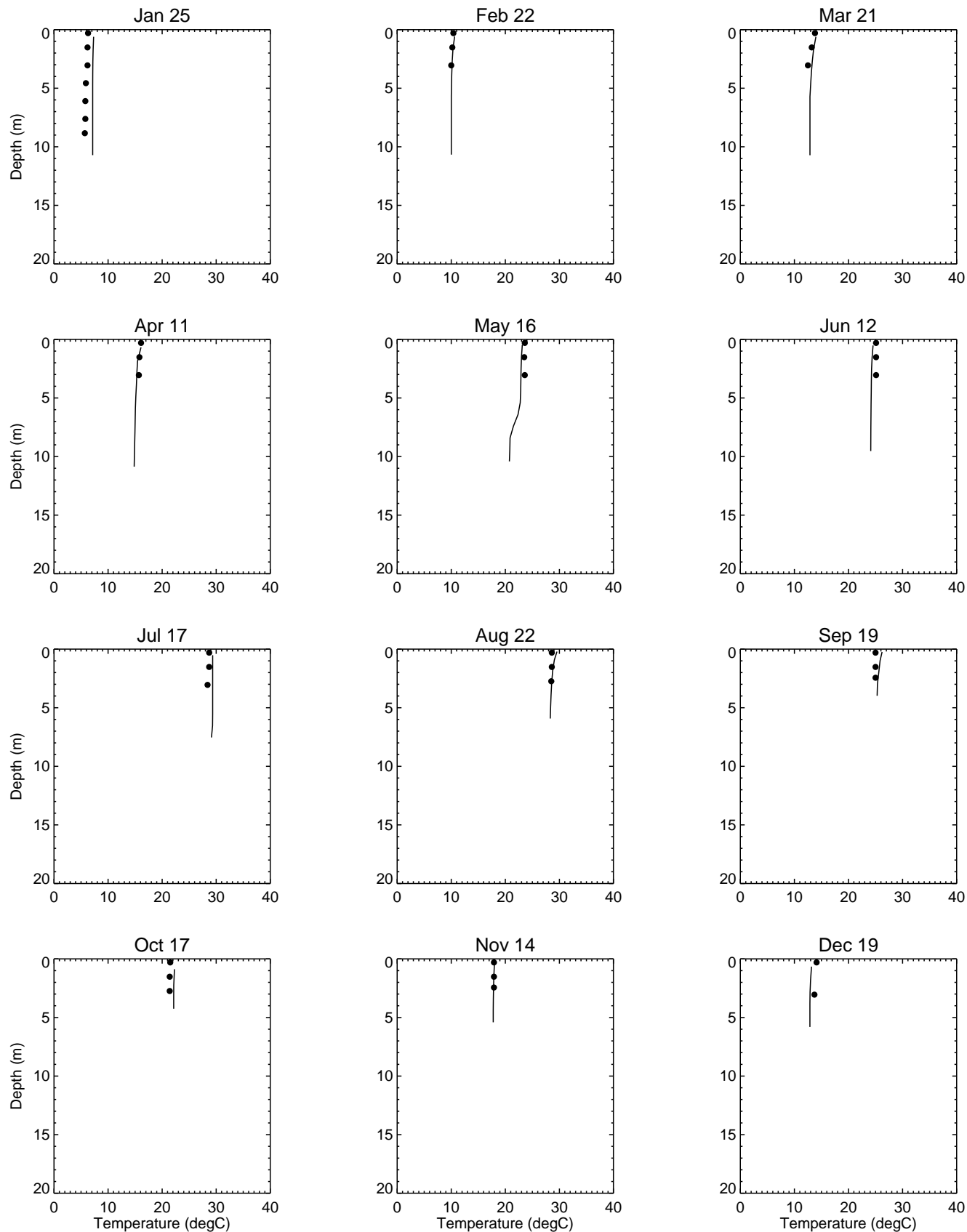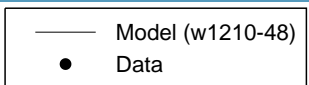
Model (w1210-48)
● Data

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 1984

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:15 2013

ANCHOR QEA
PARSONS

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 1985

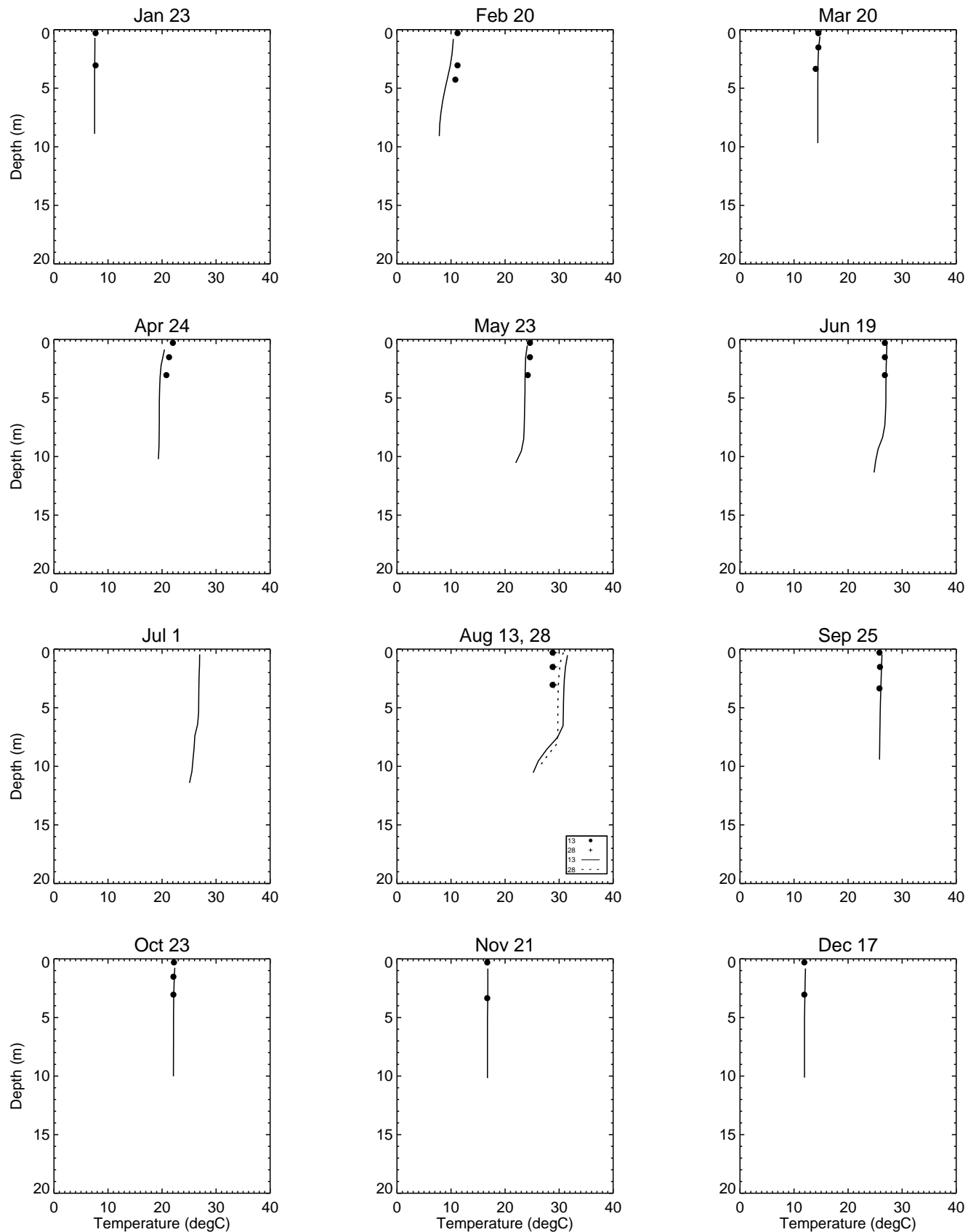*Profiles shown for dates with available data else model results for first day of month shown.*

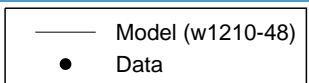CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:15 2013

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 1986

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
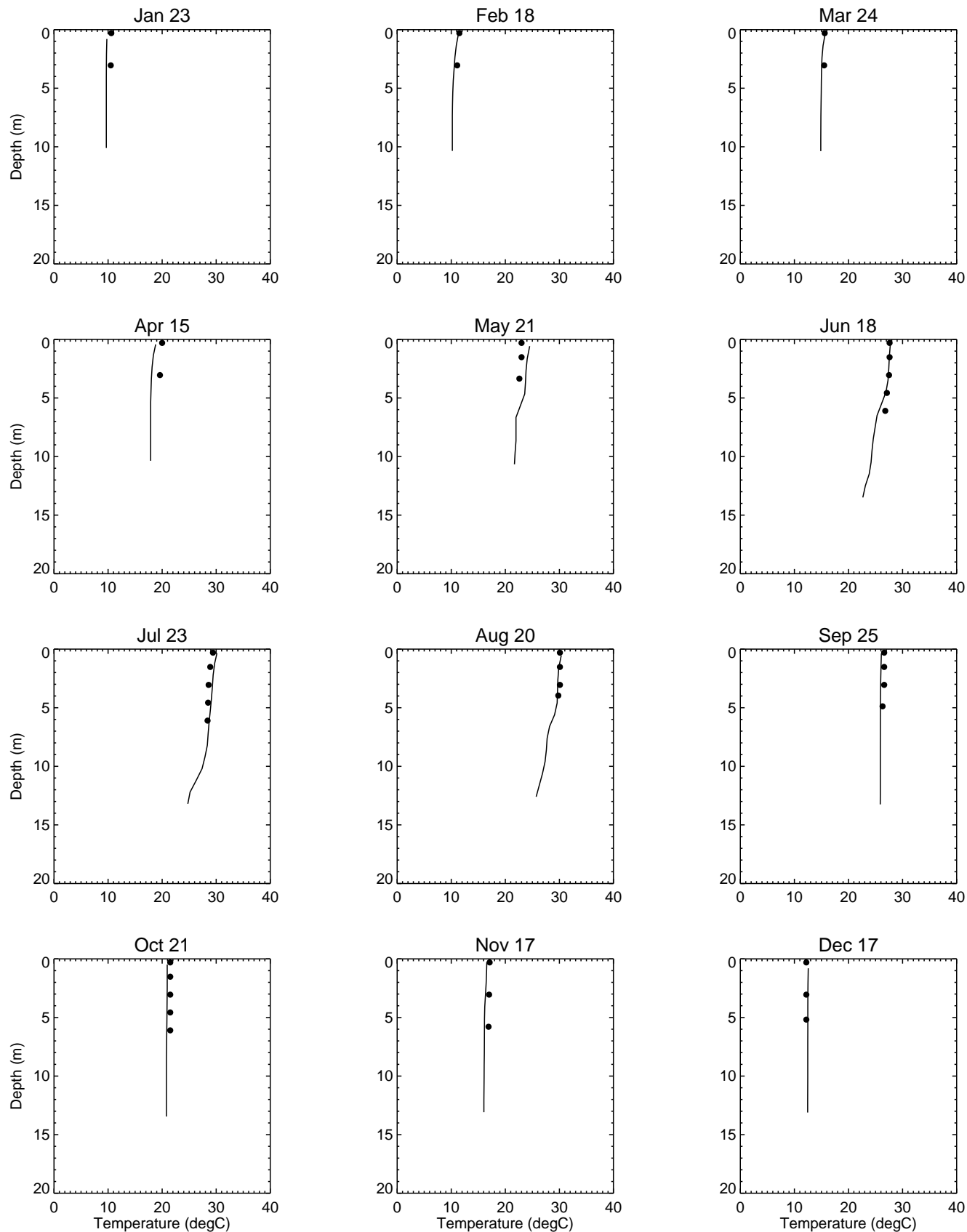
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:15 2013

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 1988

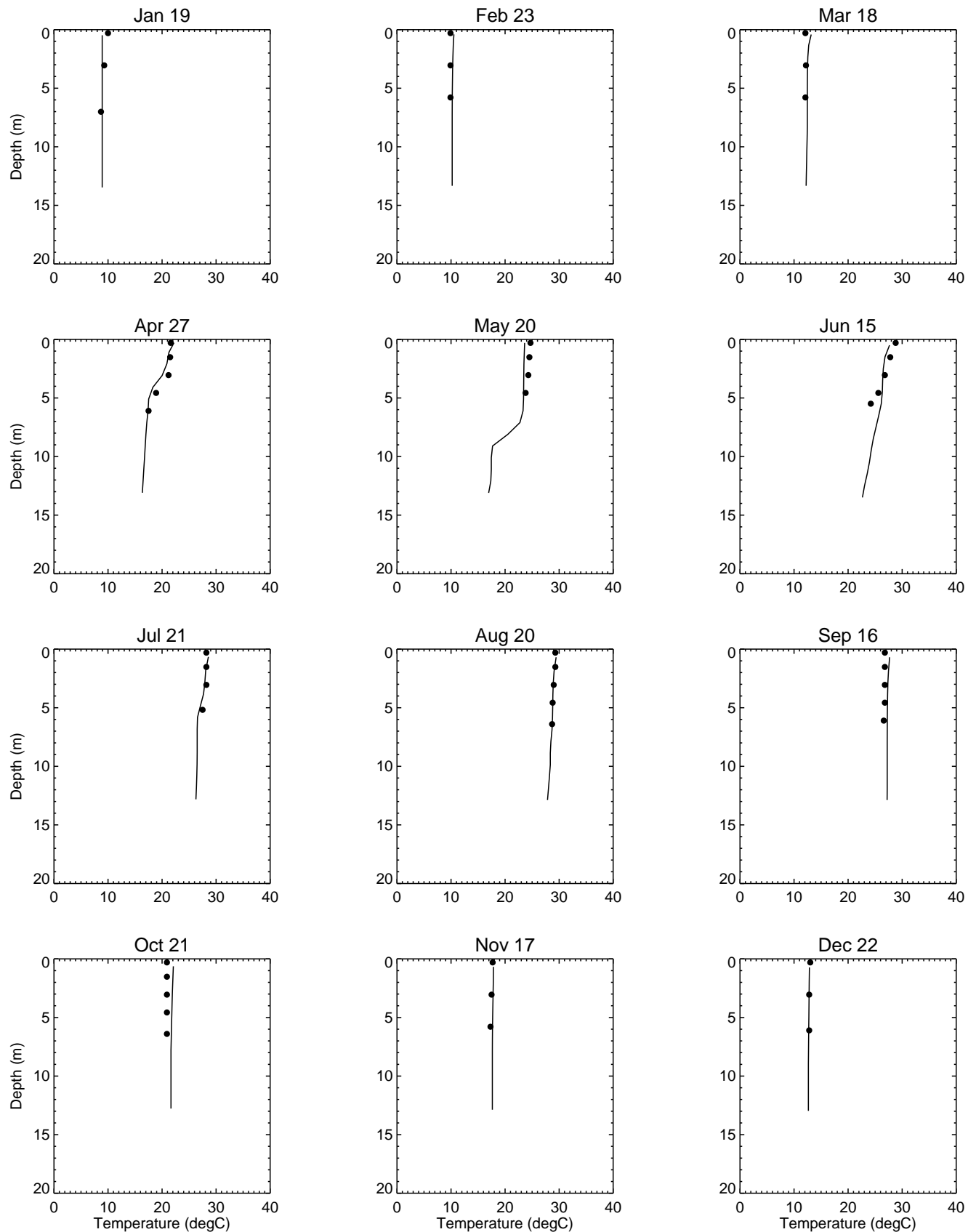*Profiles shown for dates with available data else model results for first day of month shown.*

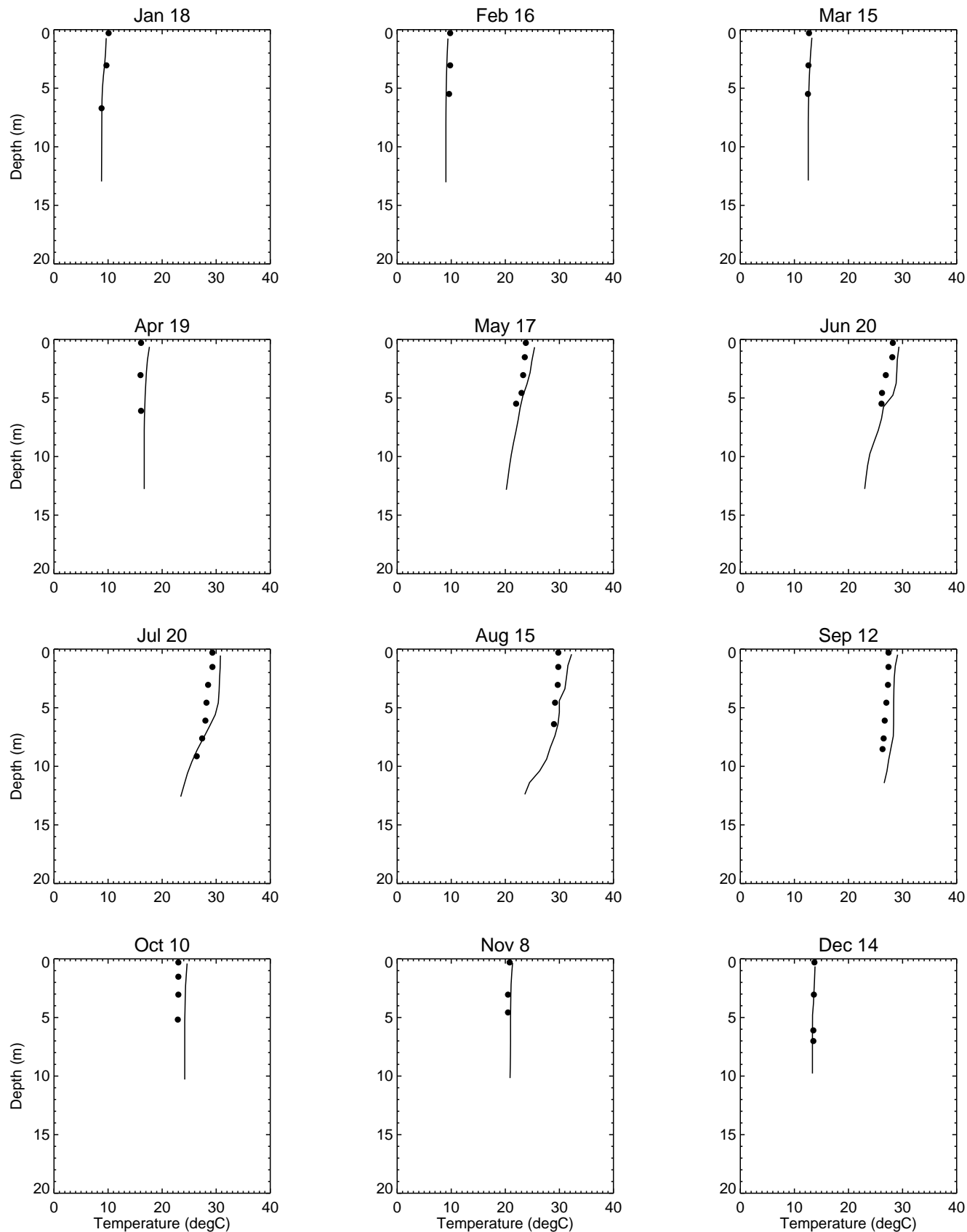CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:16 2013

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 1990

Profiles shown for dates with available data else model results for first day of month shown.

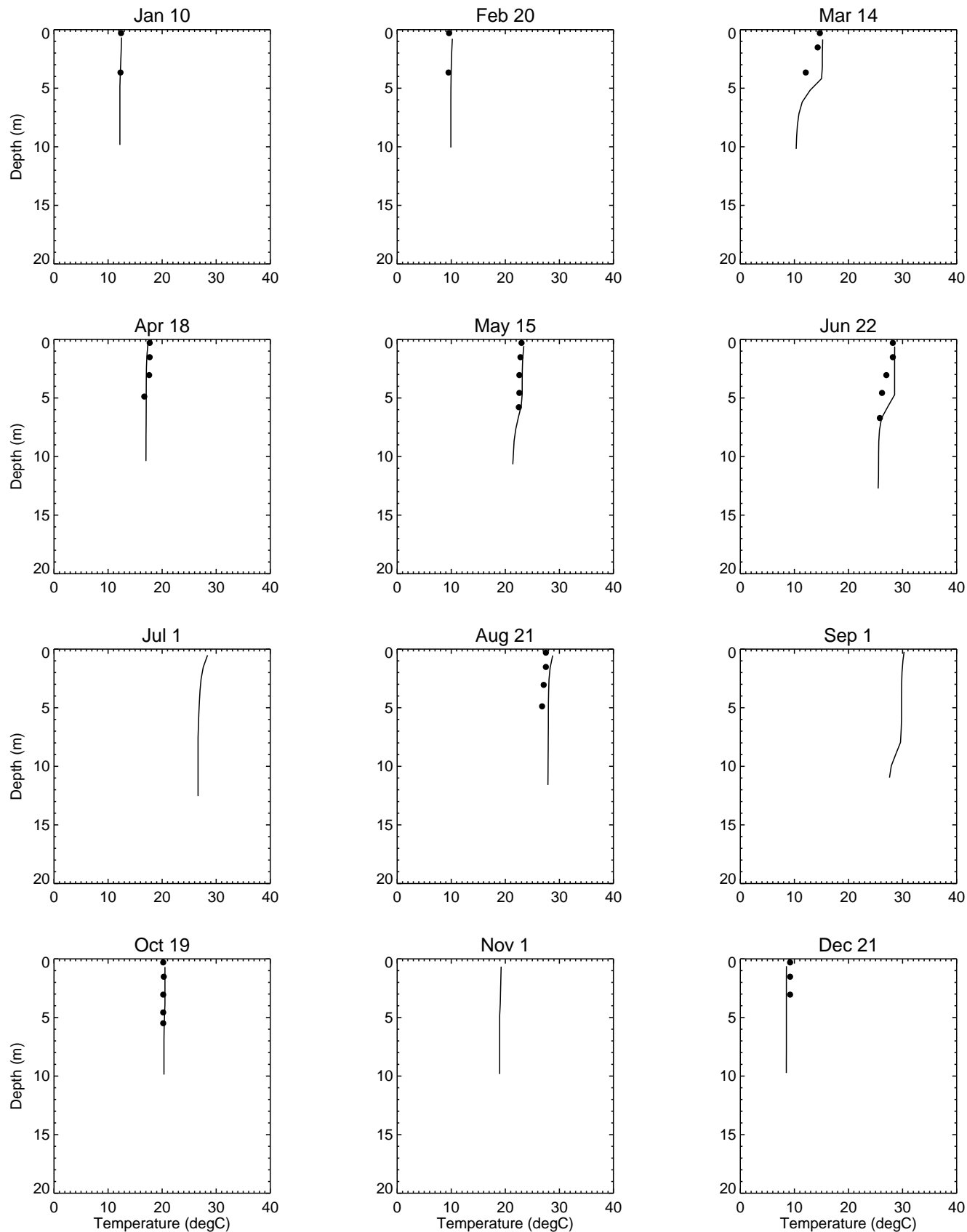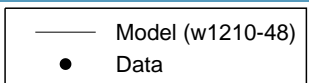CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figures arranged in a 4×3 grid showing vertical temperature profiles (Depth (m) on y-axis from 0 to 25, Temperature (degC) on x-axis from 0 to 40) for each month:

Jan 1, Feb 1, Mar 1
Apr 1, May 1, Jun 1
Jul 1, Aug 1, Sep 1
Oct 1, Nov 1, Dec 1

Legend:
——— Model (w1210-48)
● Data

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 1991

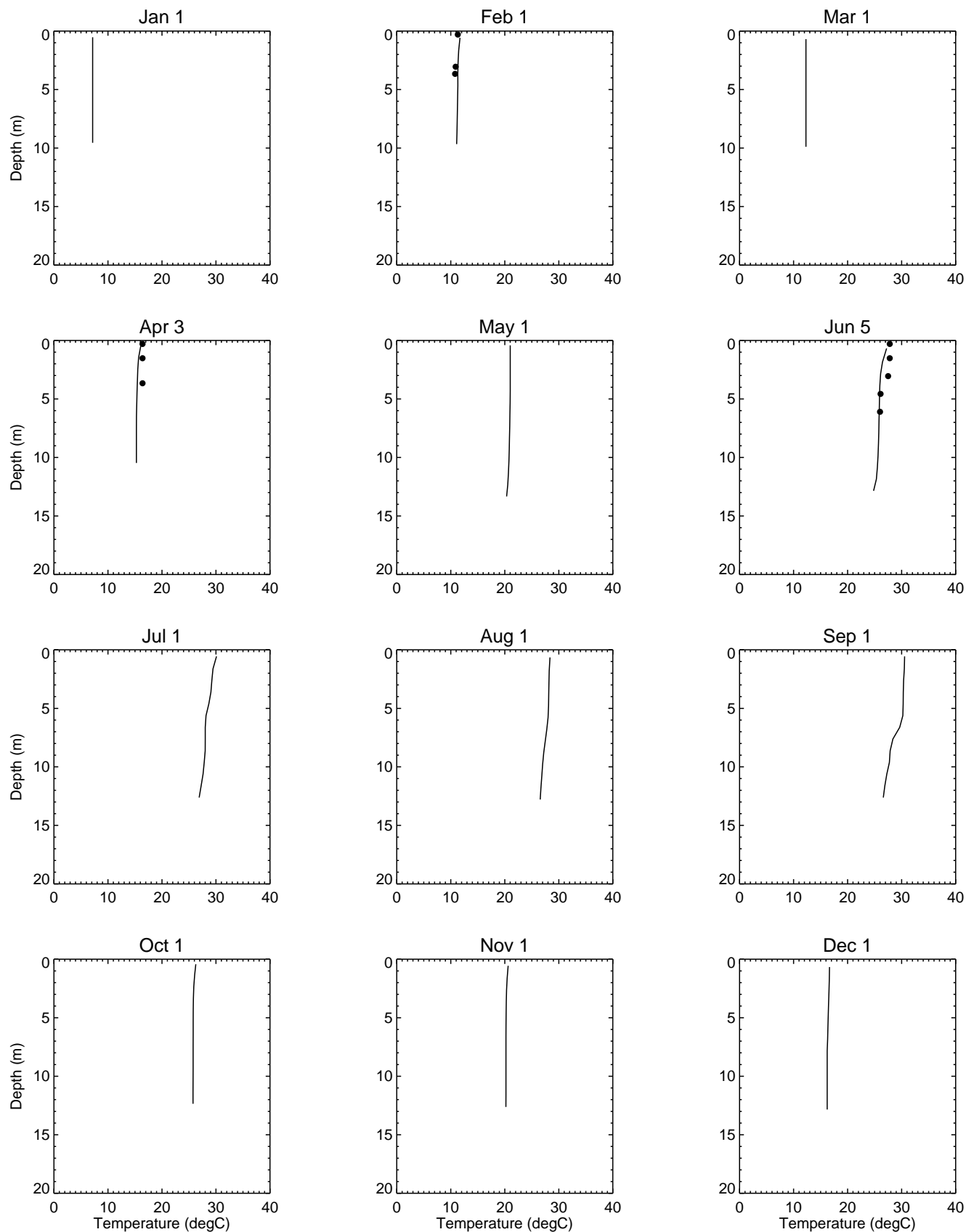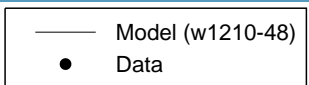*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:16 2013

ANCHOR
QEA
PARSONS

Jan 1 Feb 1 Mar 1
Apr 1 May 1 Jun 1
Jul 1 Aug 1 Sep 1
Oct 1 Nov 1 Dec 1

Depth (m) — Temperature (degC)

——— Model (w1210-48)
● Data

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 1992
Profiles shown for dates with available data else model results for first day of month shown.

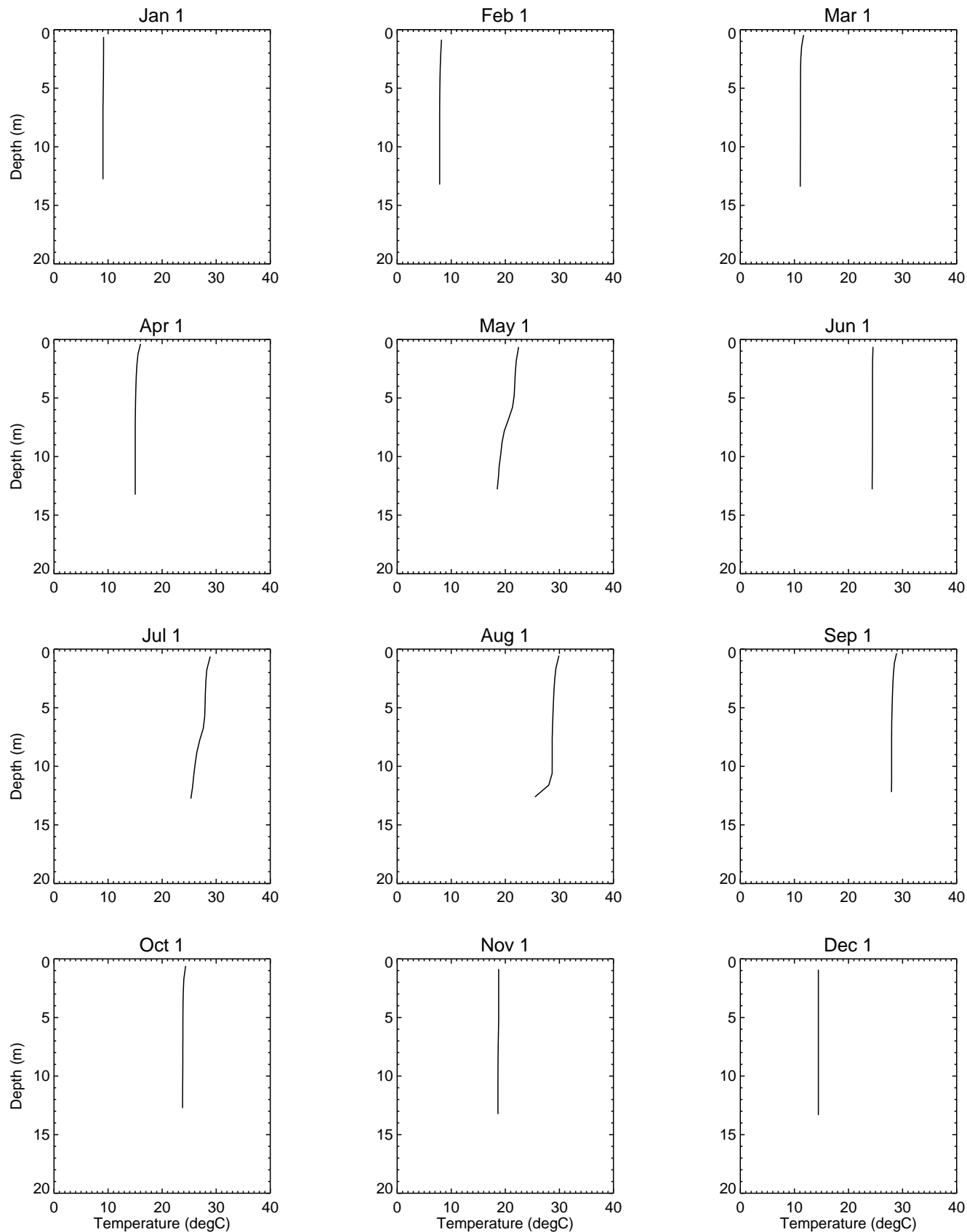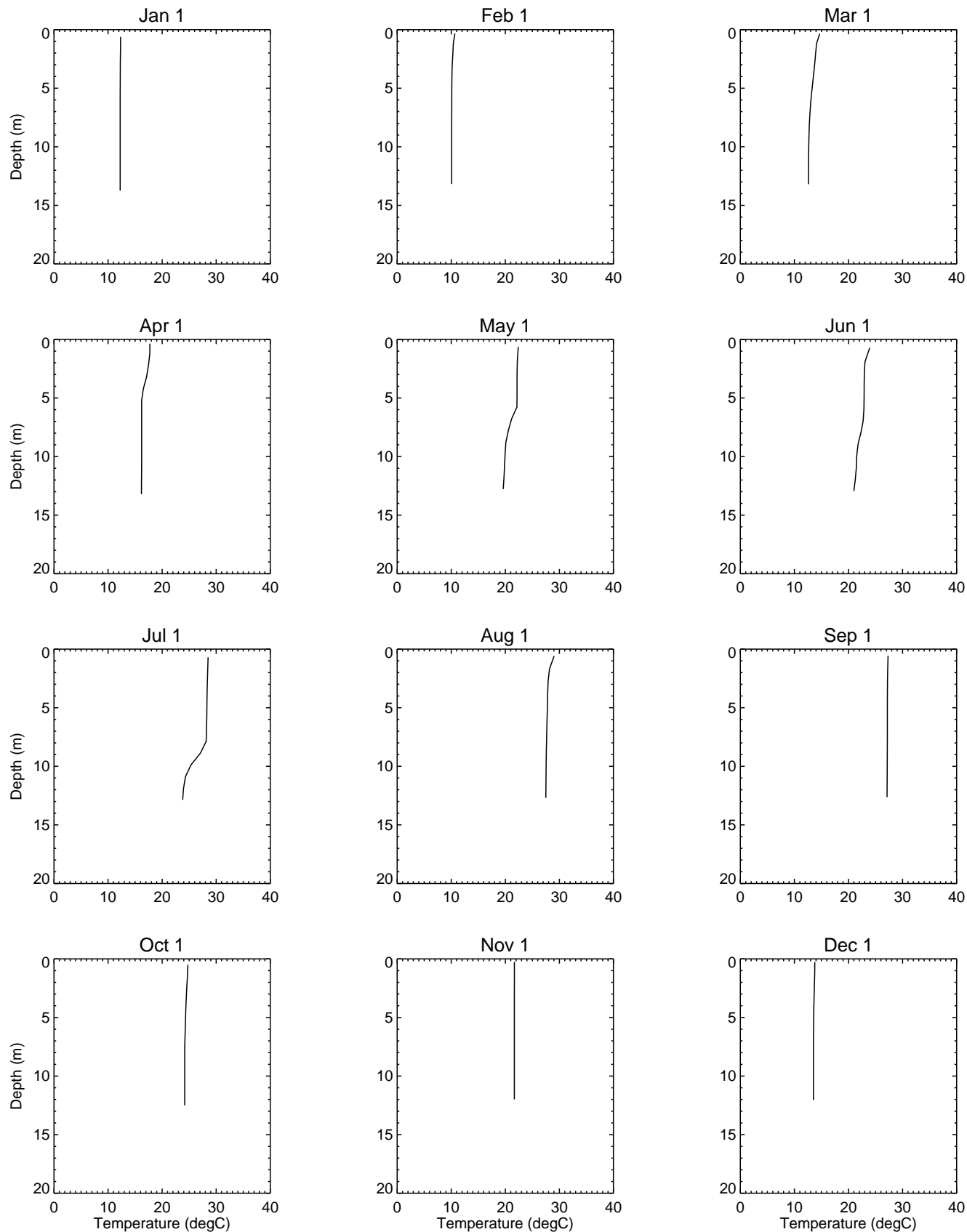CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA PARSONS

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 1993

Profiles shown for dates with available data else model results for first day of month shown.

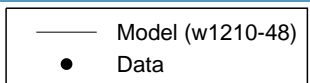CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 1994

Profiles shown for dates with available data else model results for first day of month shown.

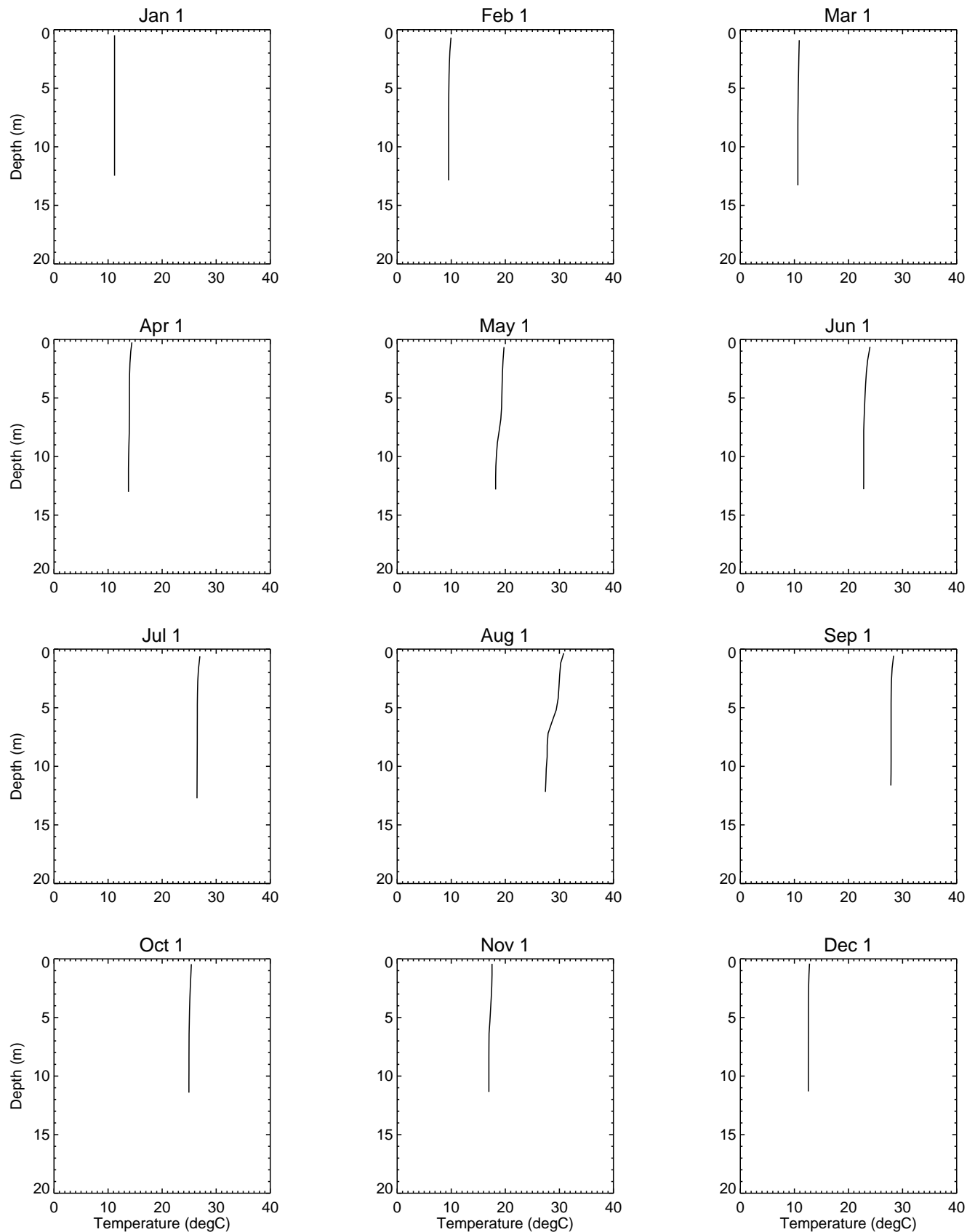CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 1995

Profiles shown for dates with available data else model results for first day of month shown.

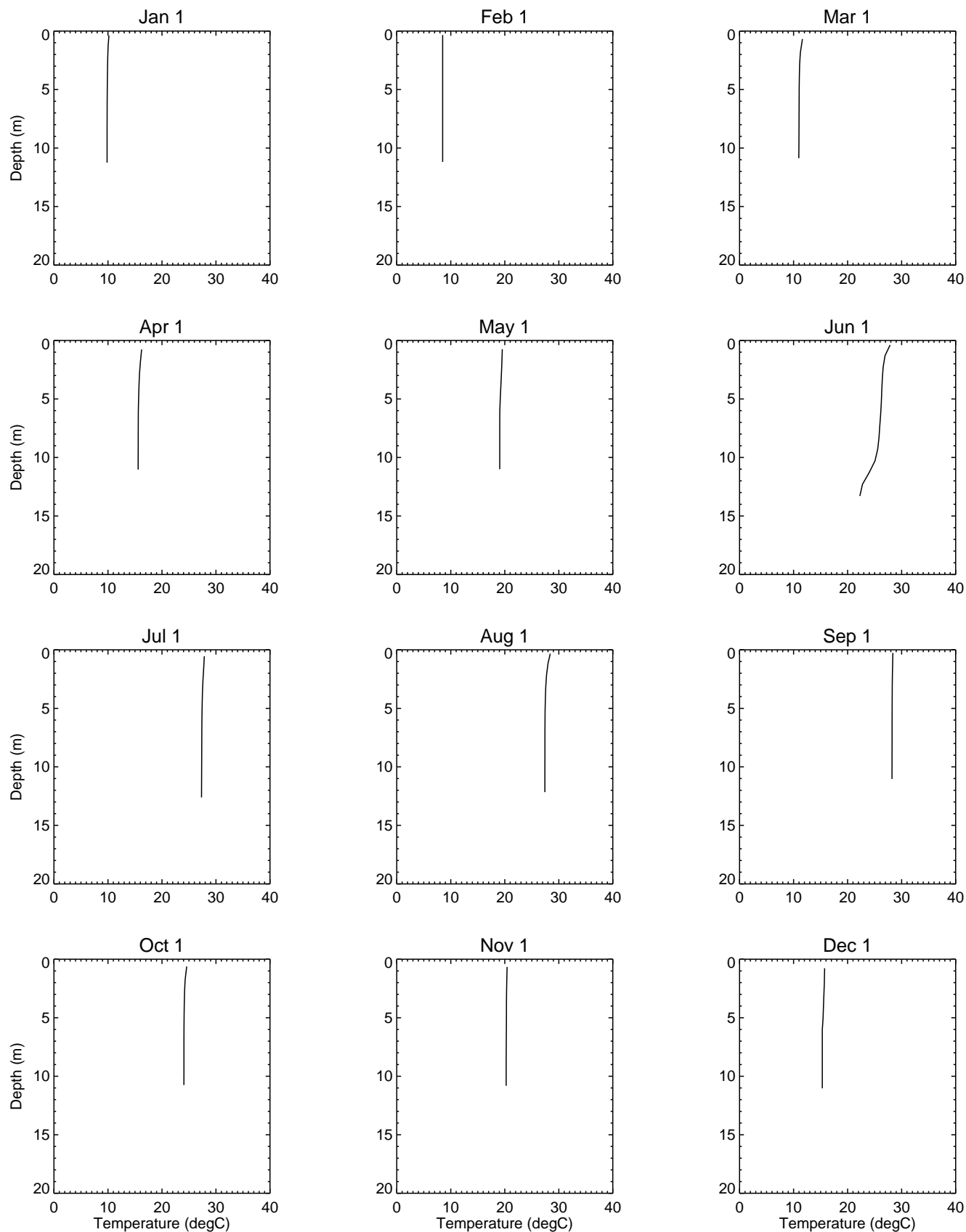CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 1996

Profiles shown for dates with available data else model results for first day of month shown.

Model (w1210-48)
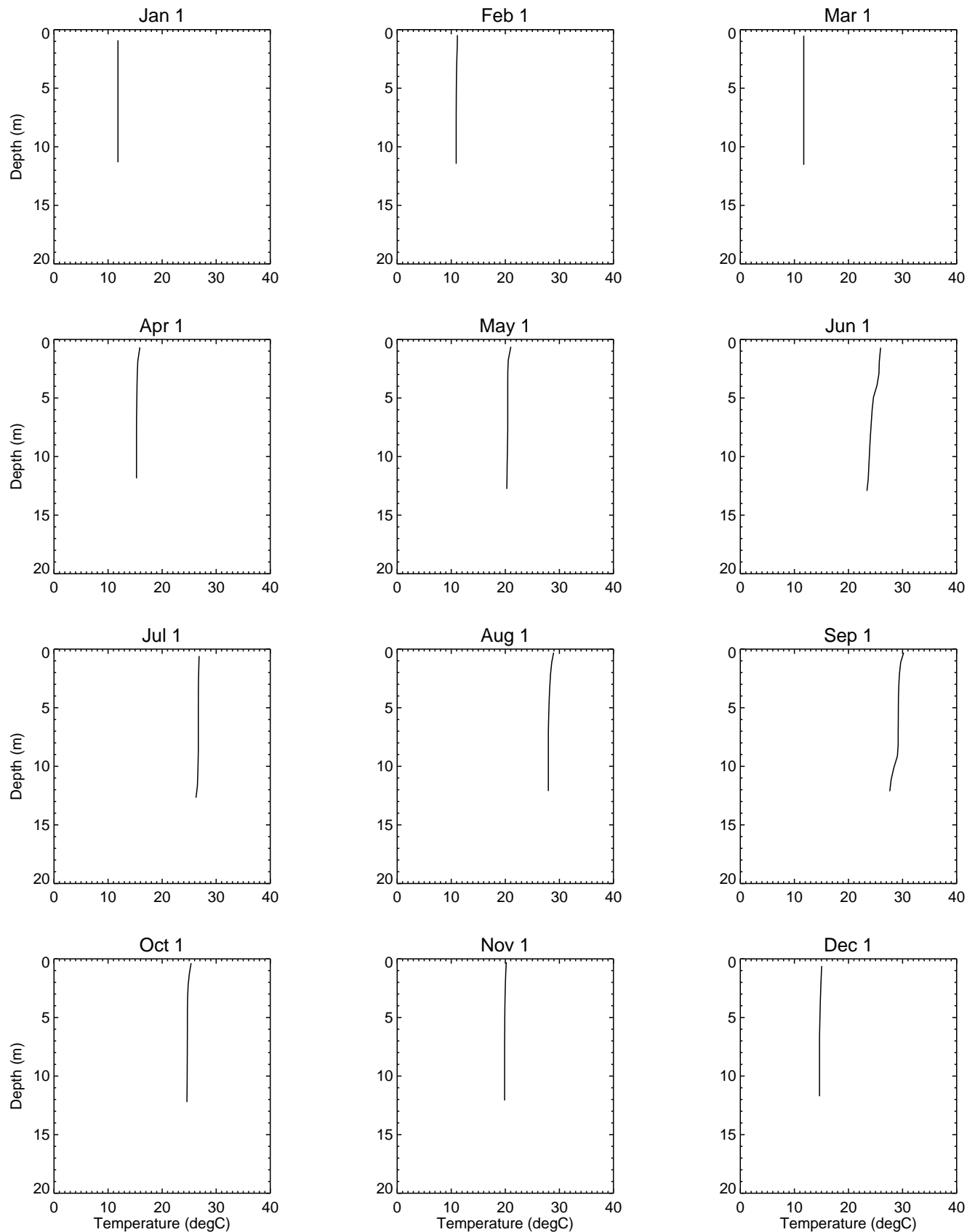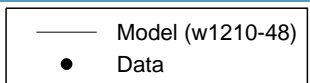● Data

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:16 2013

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 1998

Profiles shown for dates with available data else model results for first day of month shown.

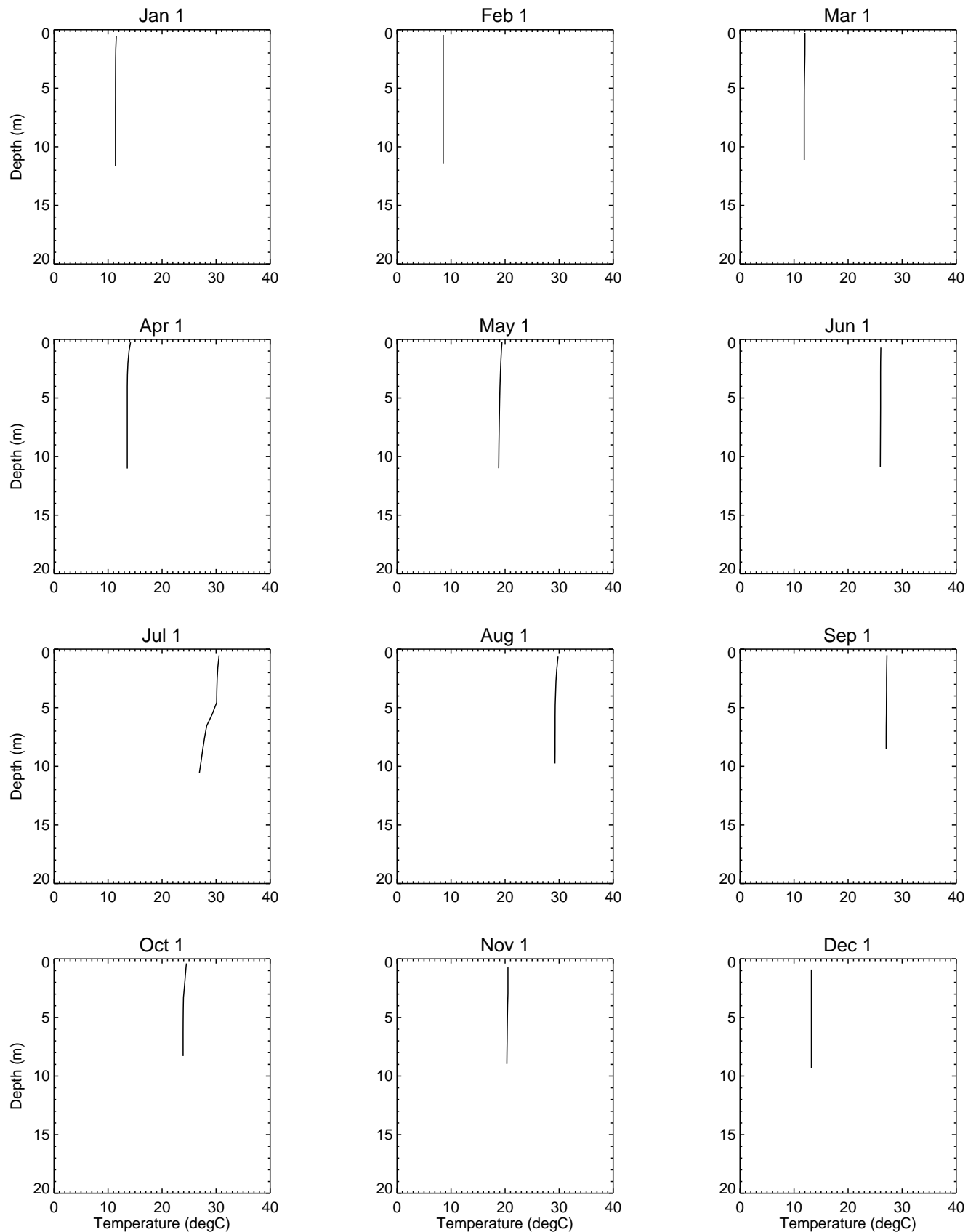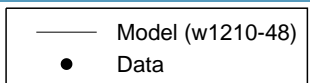CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:16 2013

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 1999

Profiles shown for dates with available data else model results for first day of month shown.

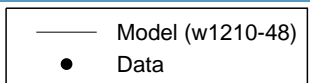CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 2000

Profiles shown for dates with available data else model results for first day of month shown.

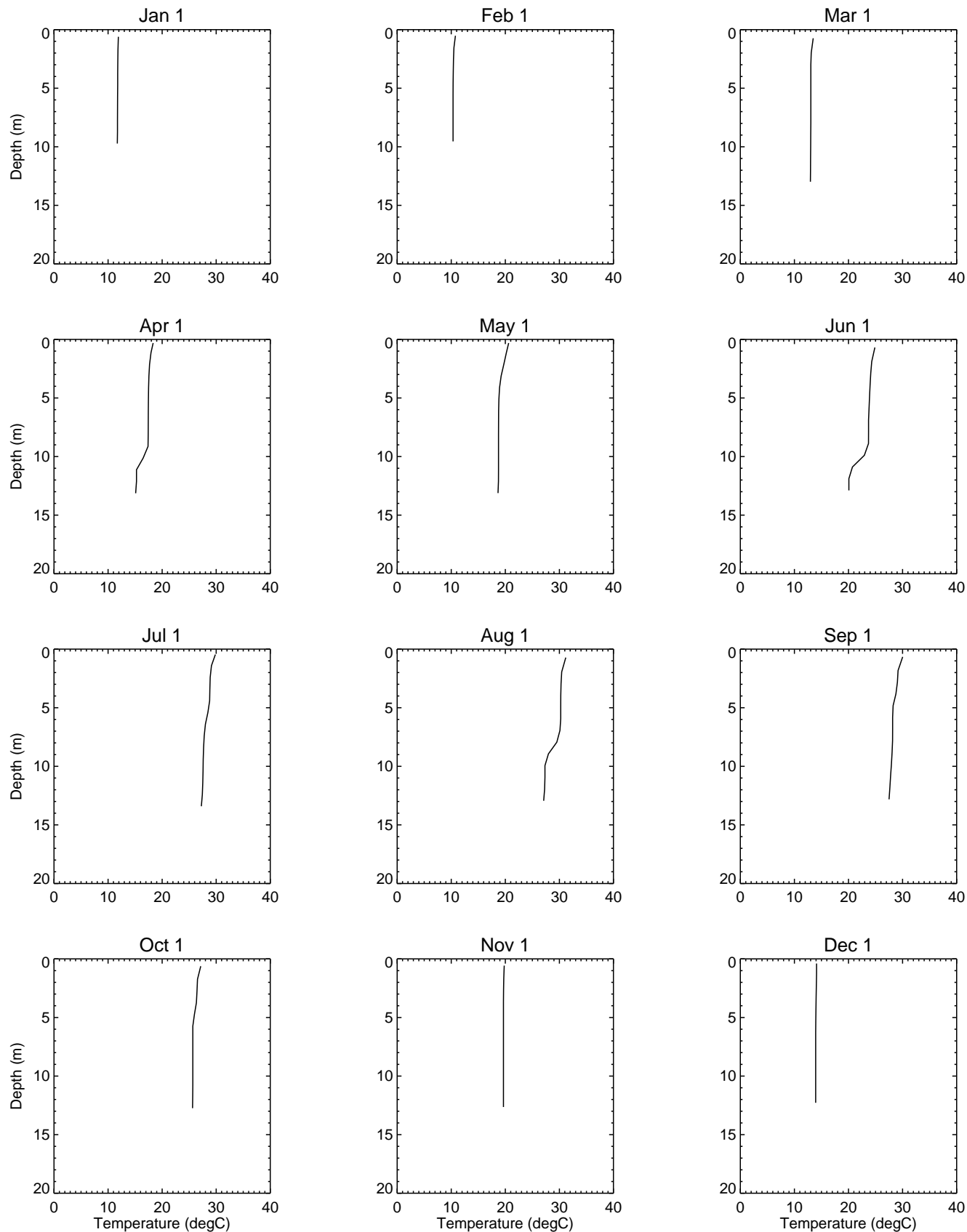CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 2001

Profiles shown for dates with available data else model results for first day of month shown.

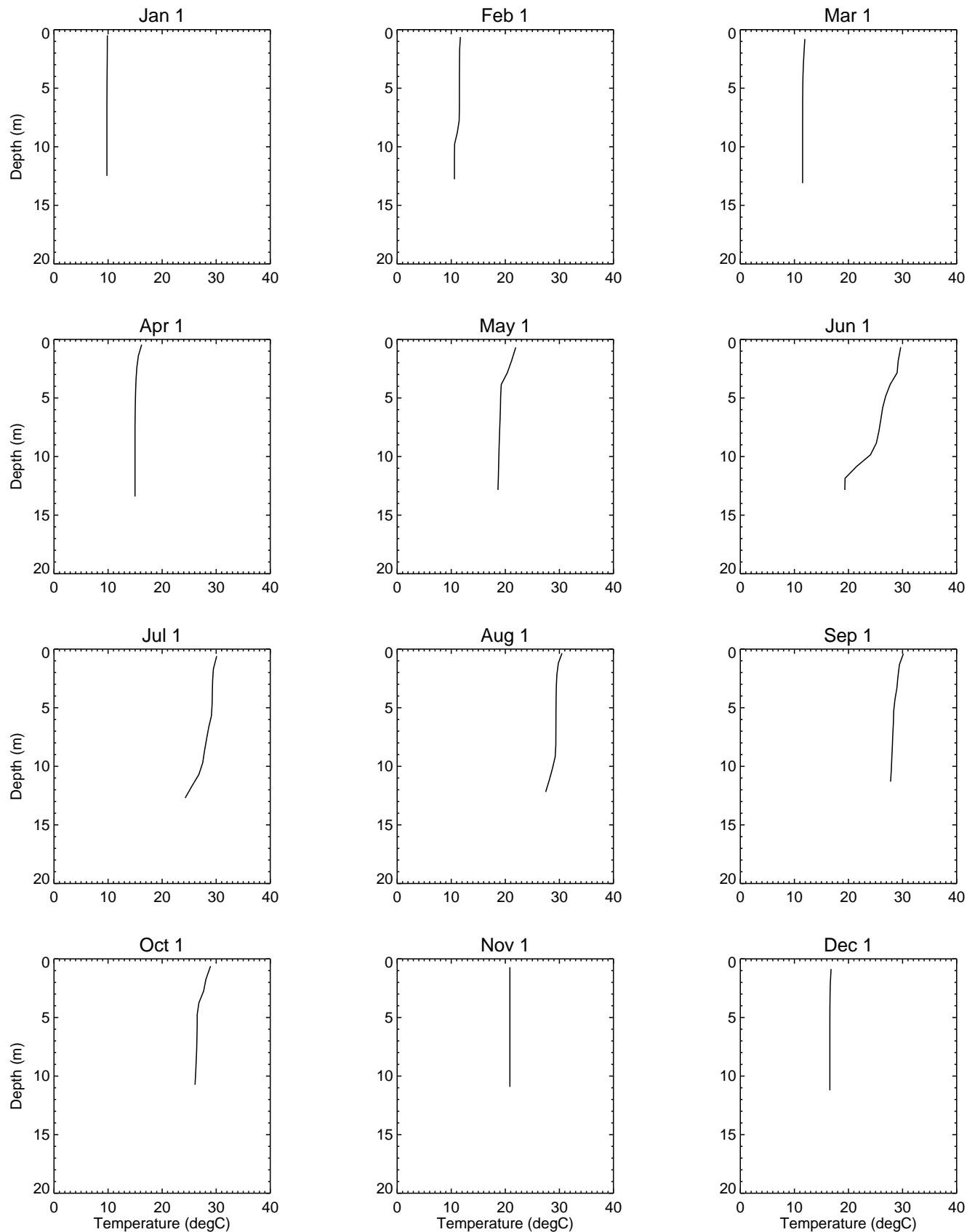CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 2002

Profiles shown for dates with available data else model results for first day of month shown.

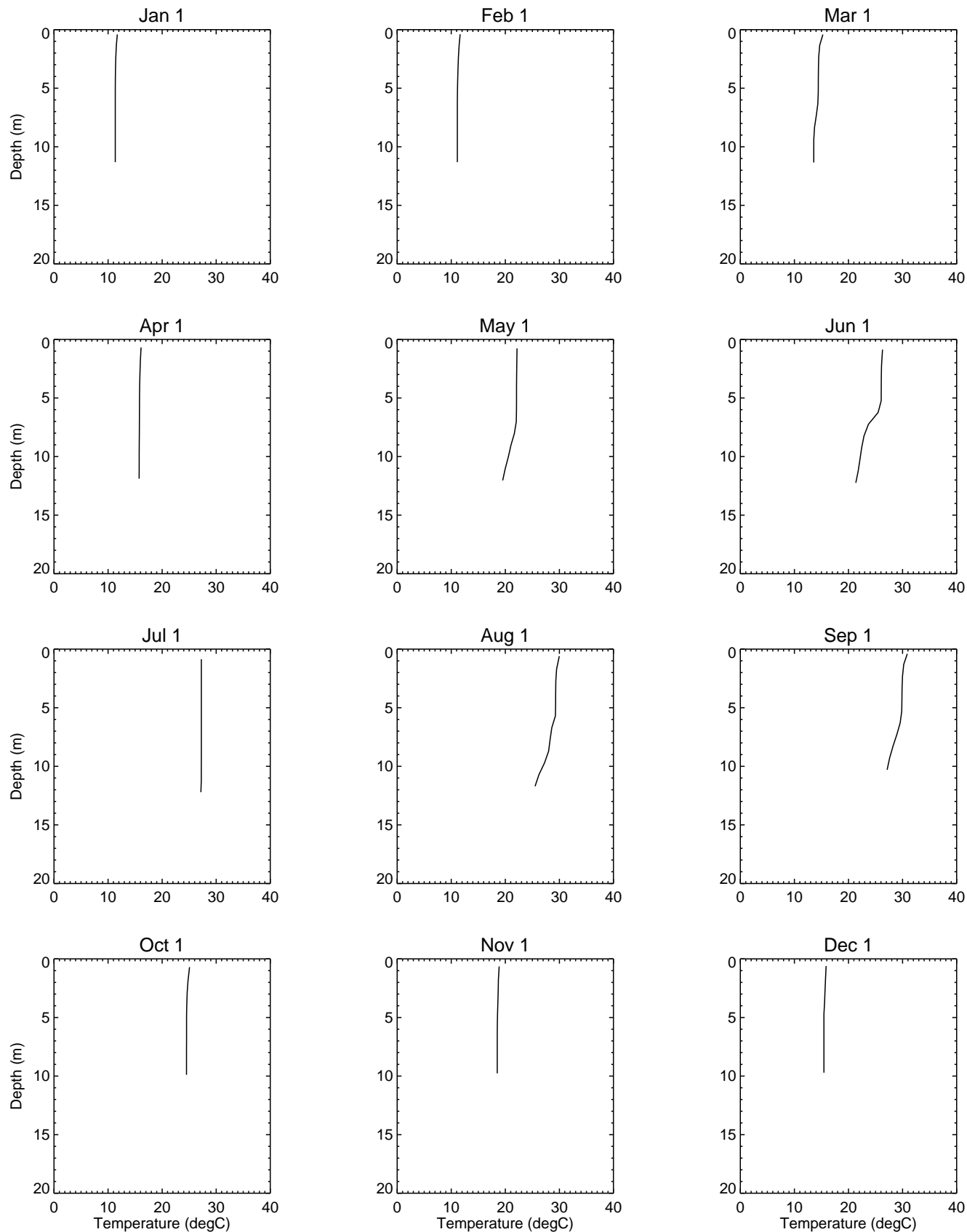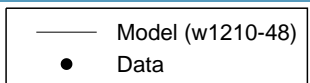CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 2004

Profiles shown for dates with available data else model results for first day of month shown.

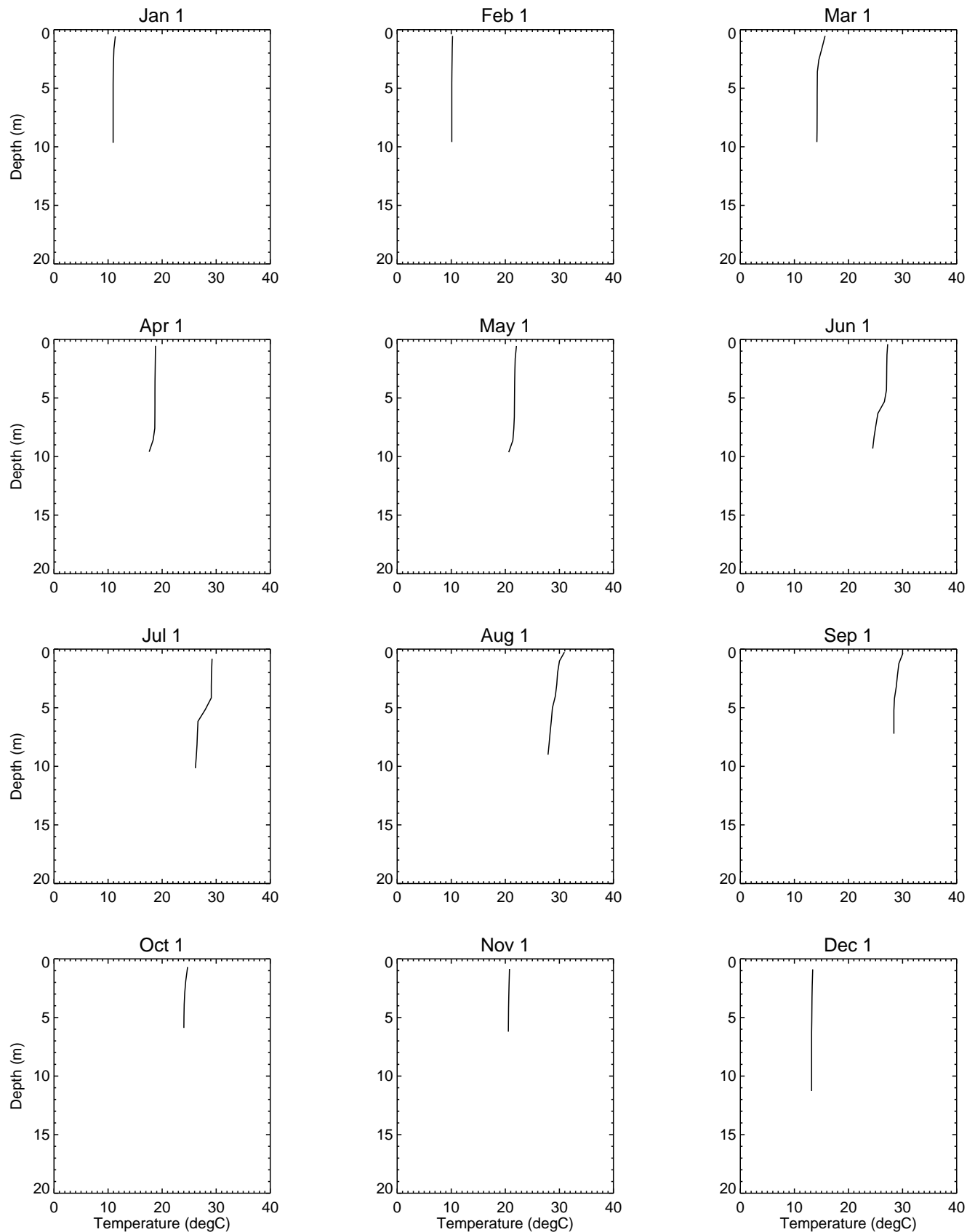CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 2005

Profiles shown for dates with available data else model results for first day of month shown.

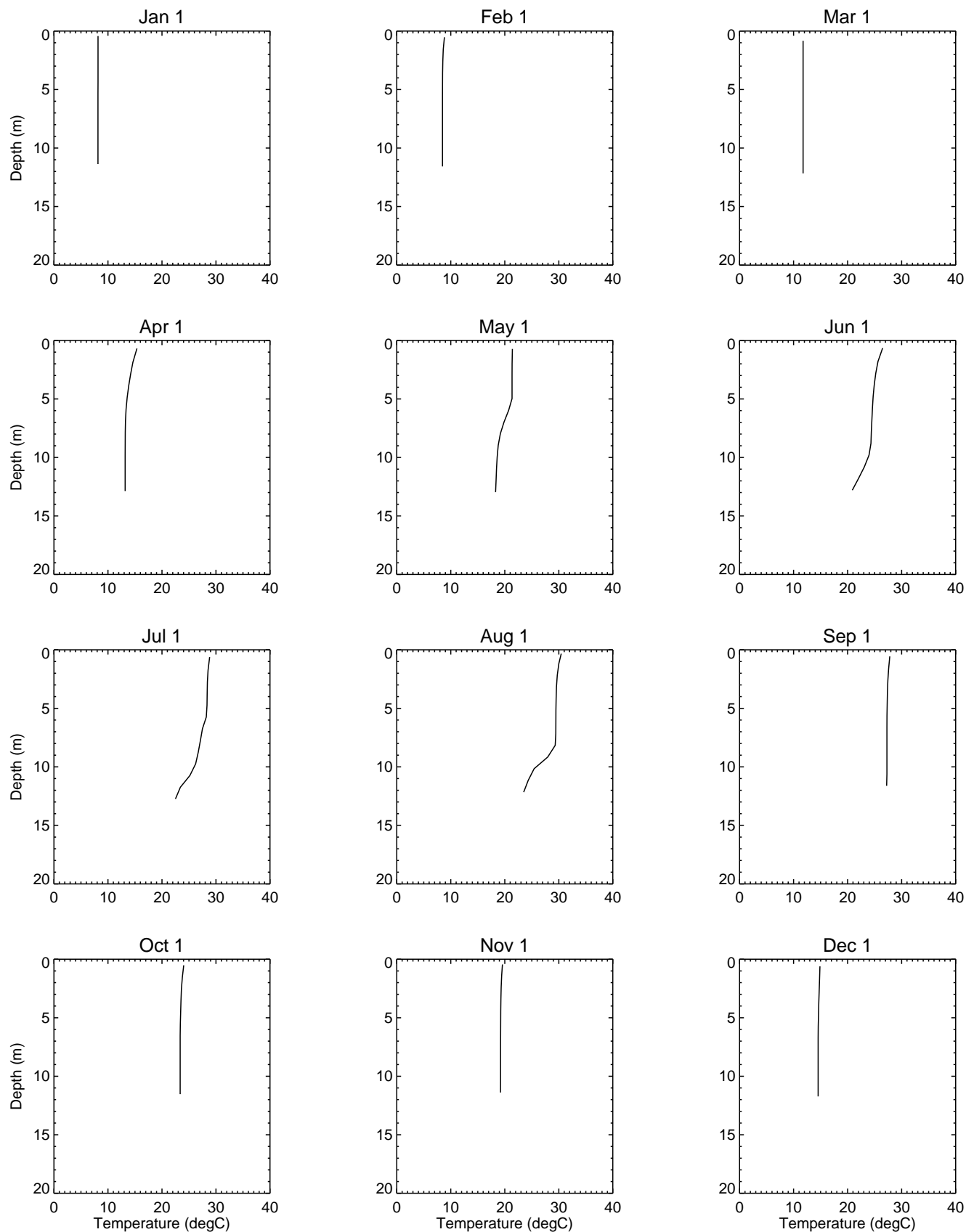CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m)

Temperature (degC)

—— Model (w1210-48)
● Data

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 2006
Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA
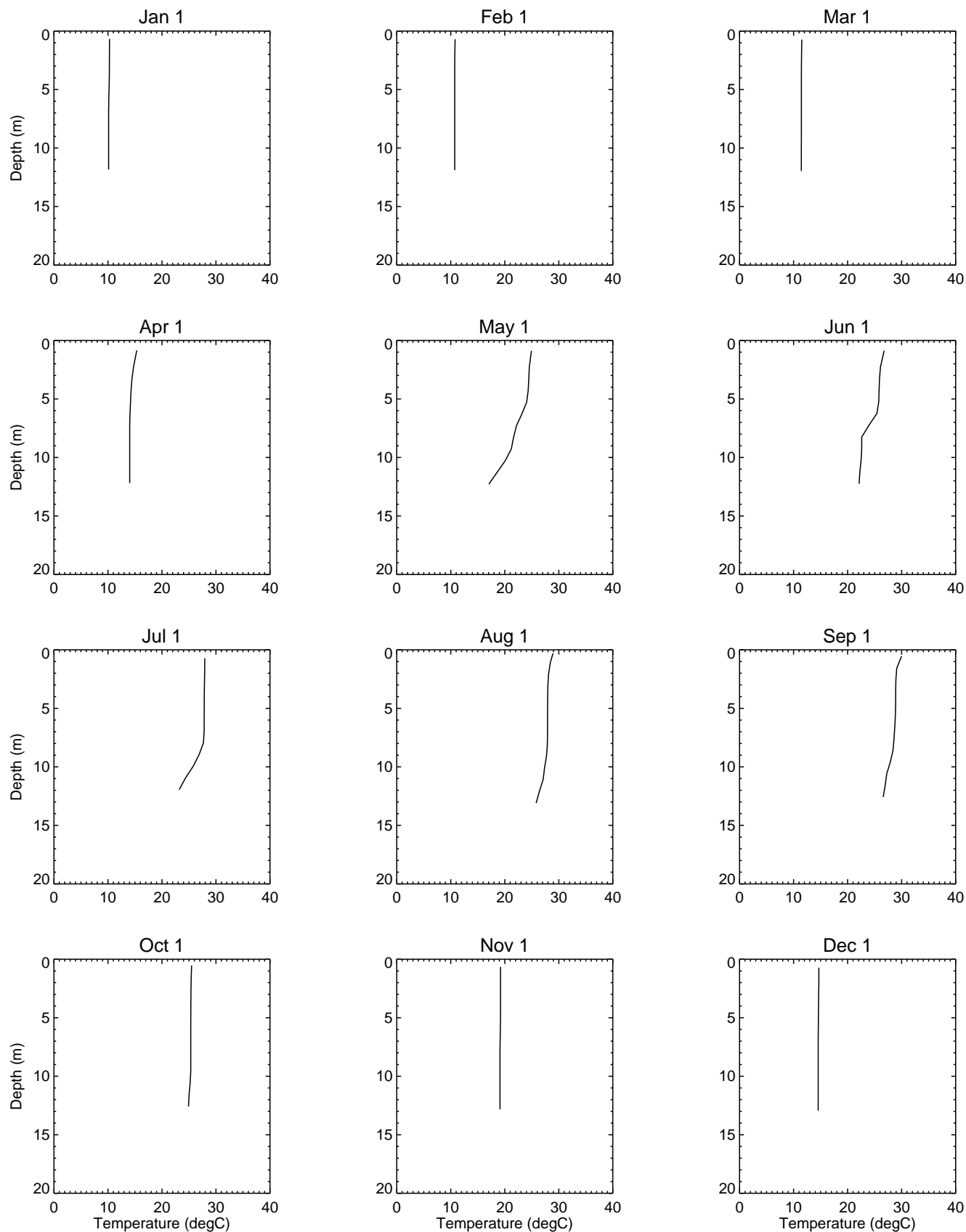PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:16 2013

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 2007

Profiles shown for dates with available data else model results for first day of month shown.

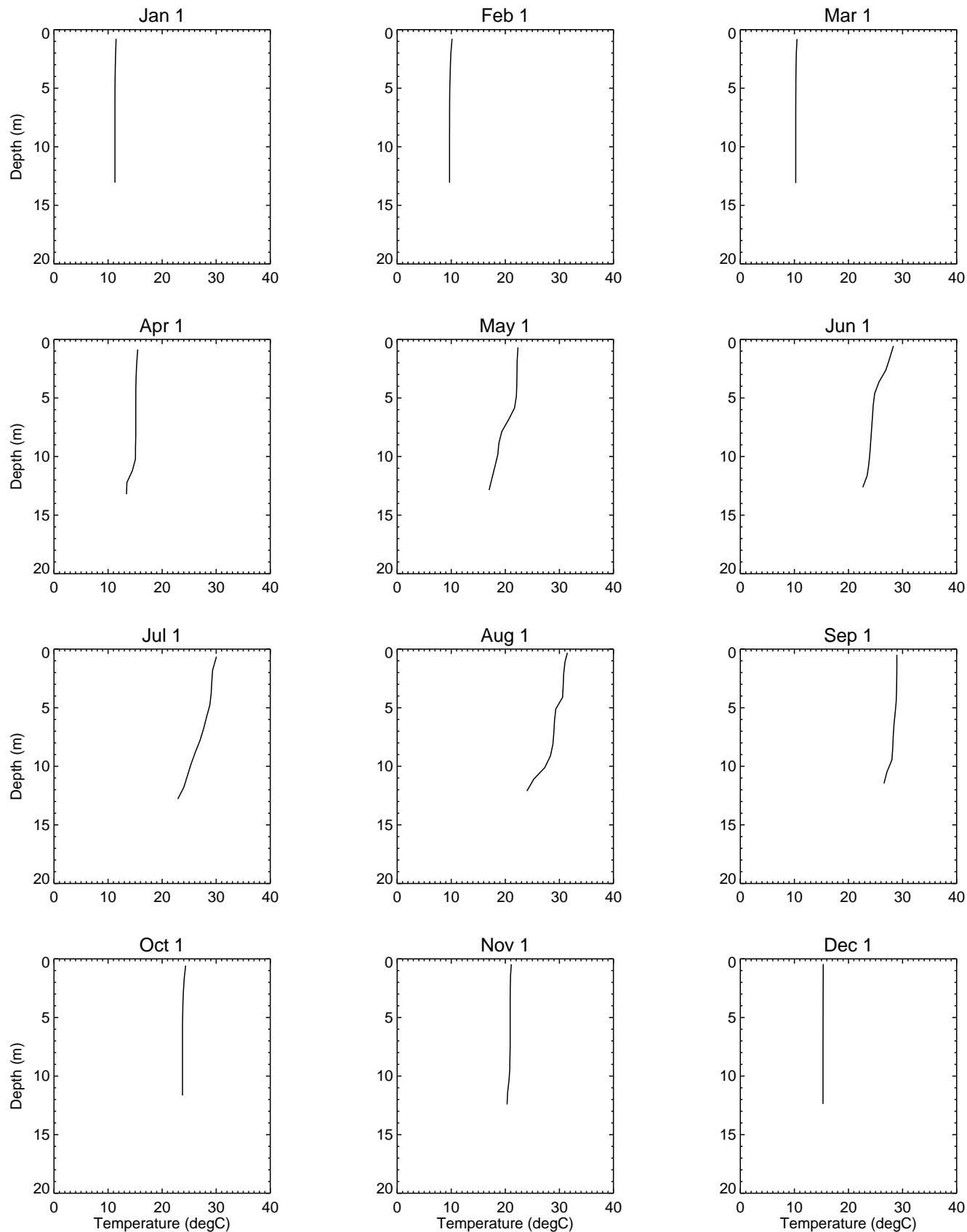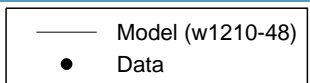CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 | Feb 4 | Mar 1
Apr 3 | May 1 | Jun 12
Jul 1 | Aug 7 | Sep 1
Oct 9 | Nov 1 | Dec 4

Temperature (degC)

——— Model (w1210-48)
● Data

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 2008

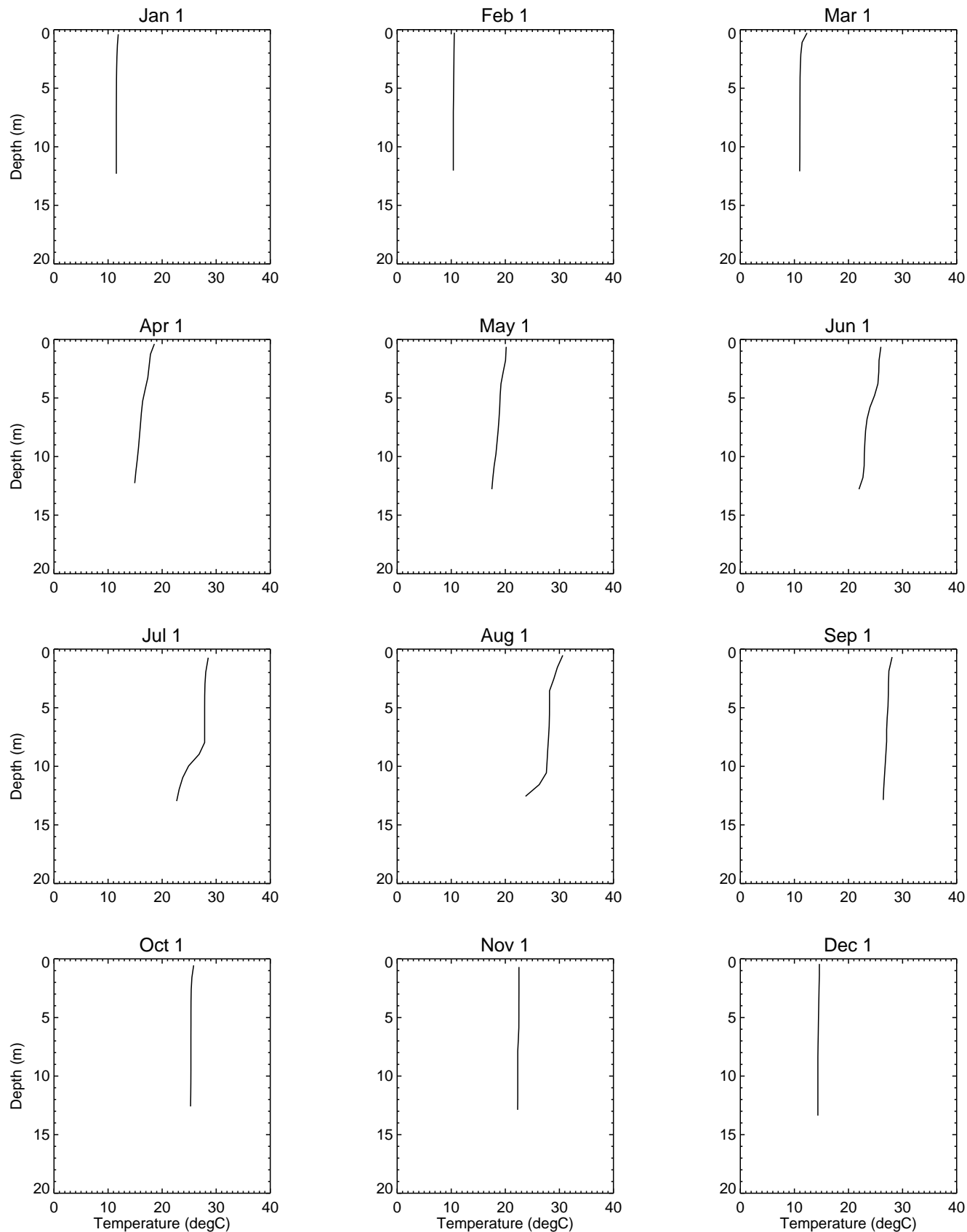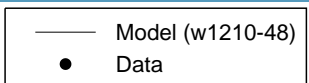*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 2009

Profiles shown for dates with available data else model results for first day of month shown.

Model (w1210-48)
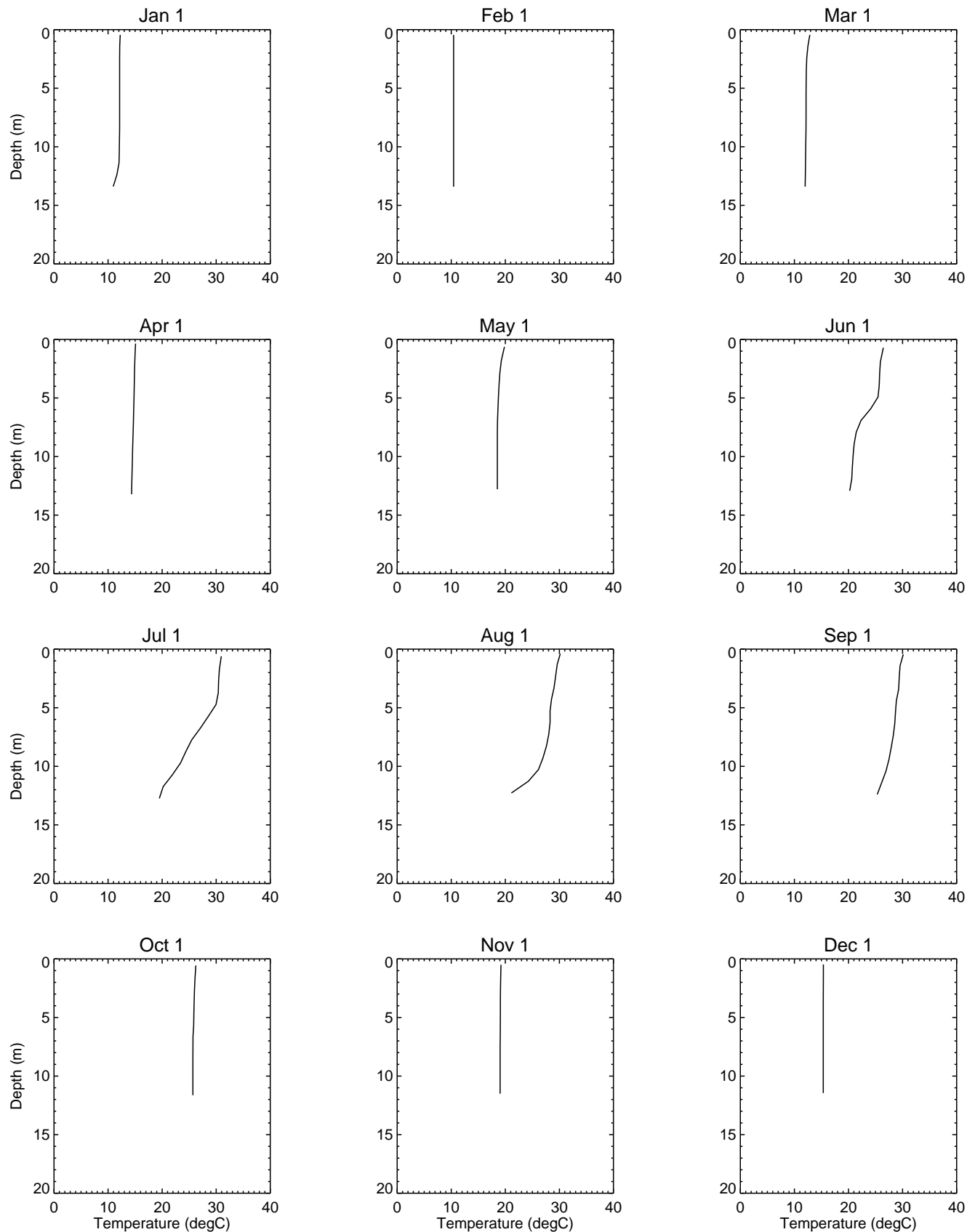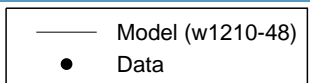Data

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:16 2013

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 2010

Profiles shown for dates with available data else model results for first day of month shown.

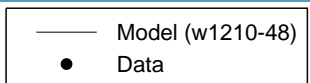CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-7

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Temperature - 2011

Profiles shown for dates with available data else model results for first day of month shown.

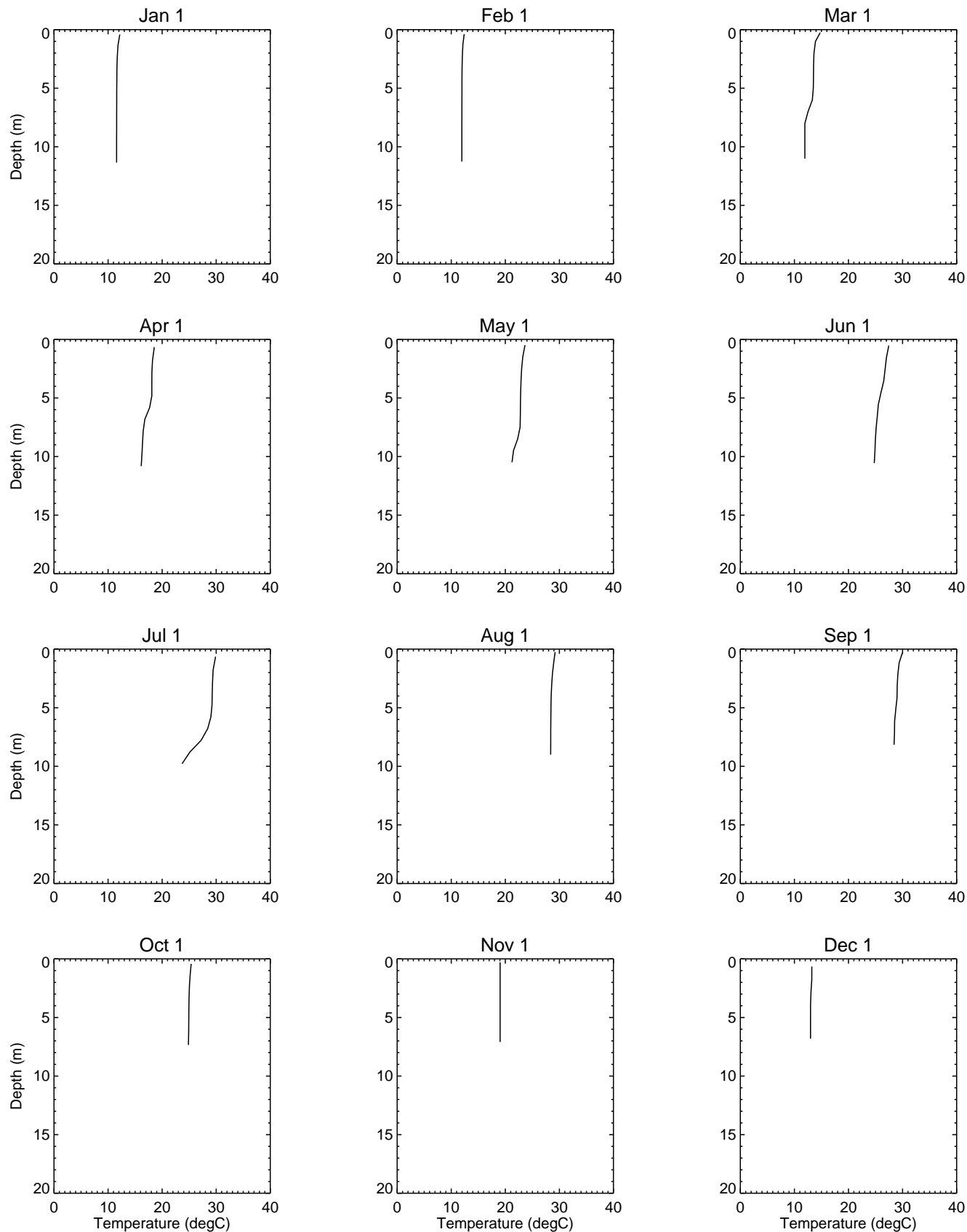CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
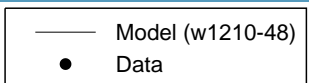Fri Jan 25 18:13:16 2013
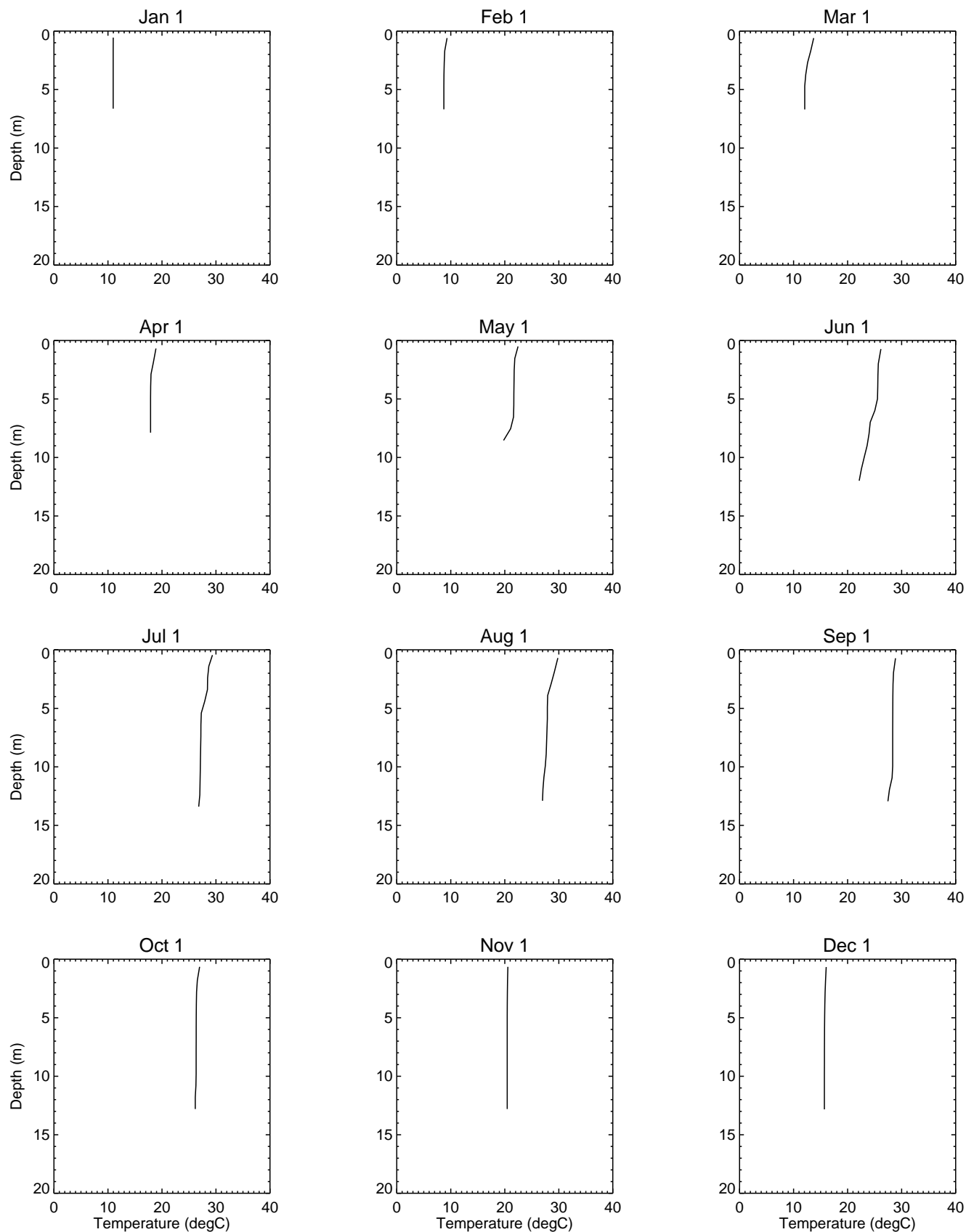
Model (w1210-48)
Data

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 1984

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
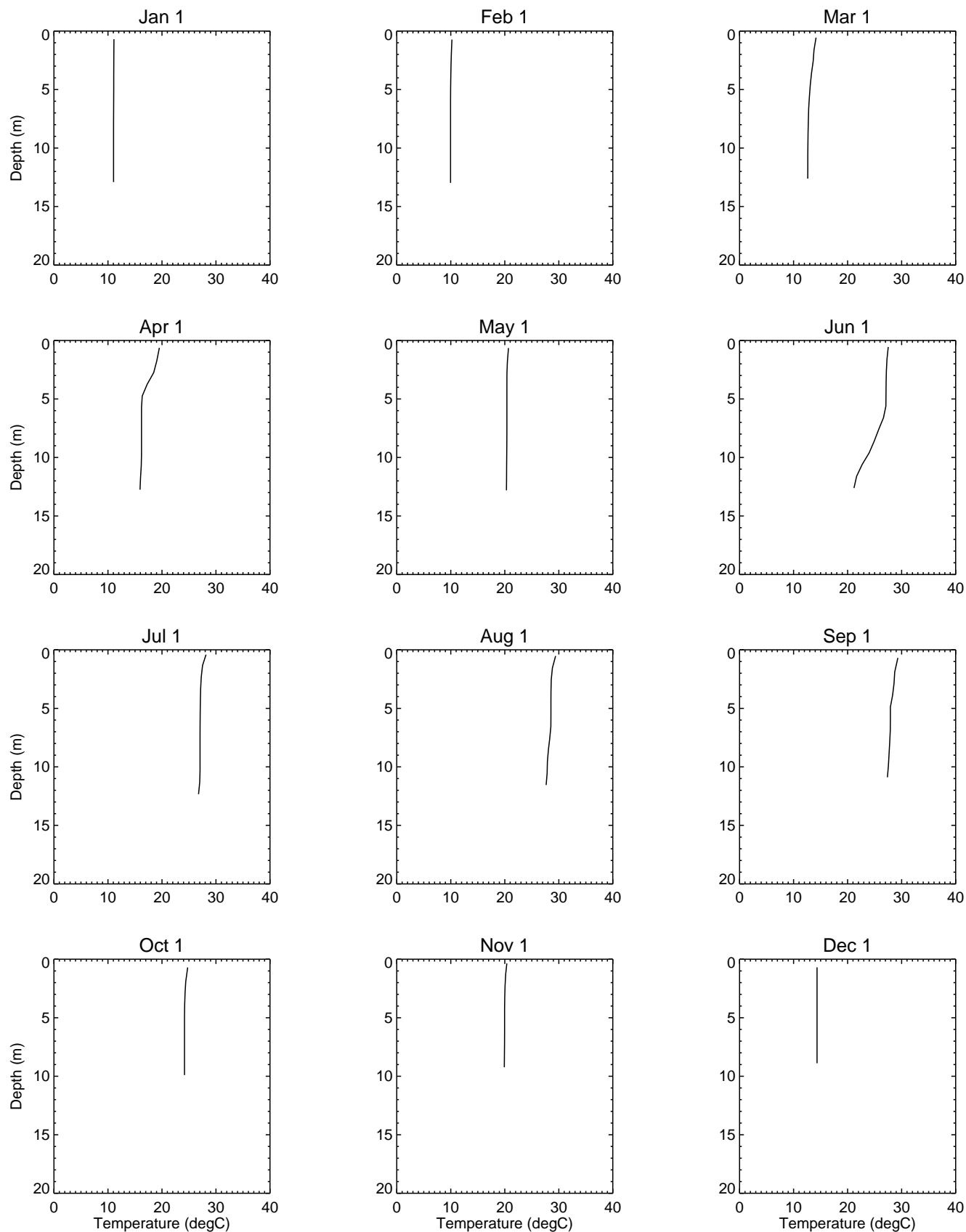Fri Jan 25 18:13:18 2013

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 1985

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 1986

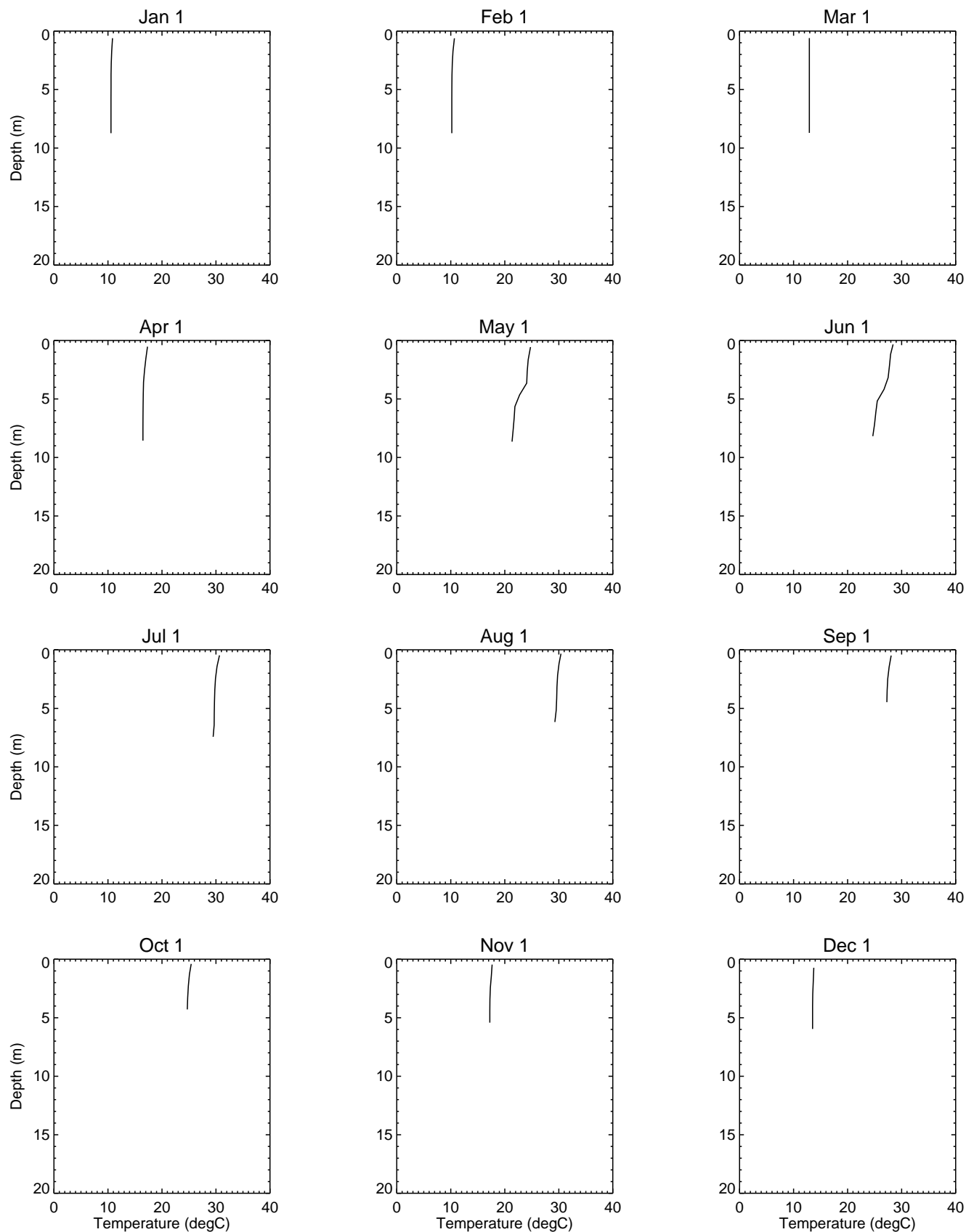*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 19   Feb 23   Mar 18

Apr 27   May 20   Jun 15

Jul 21   Aug 20   Sep 16

Oct 21   Nov 17   Dec 22
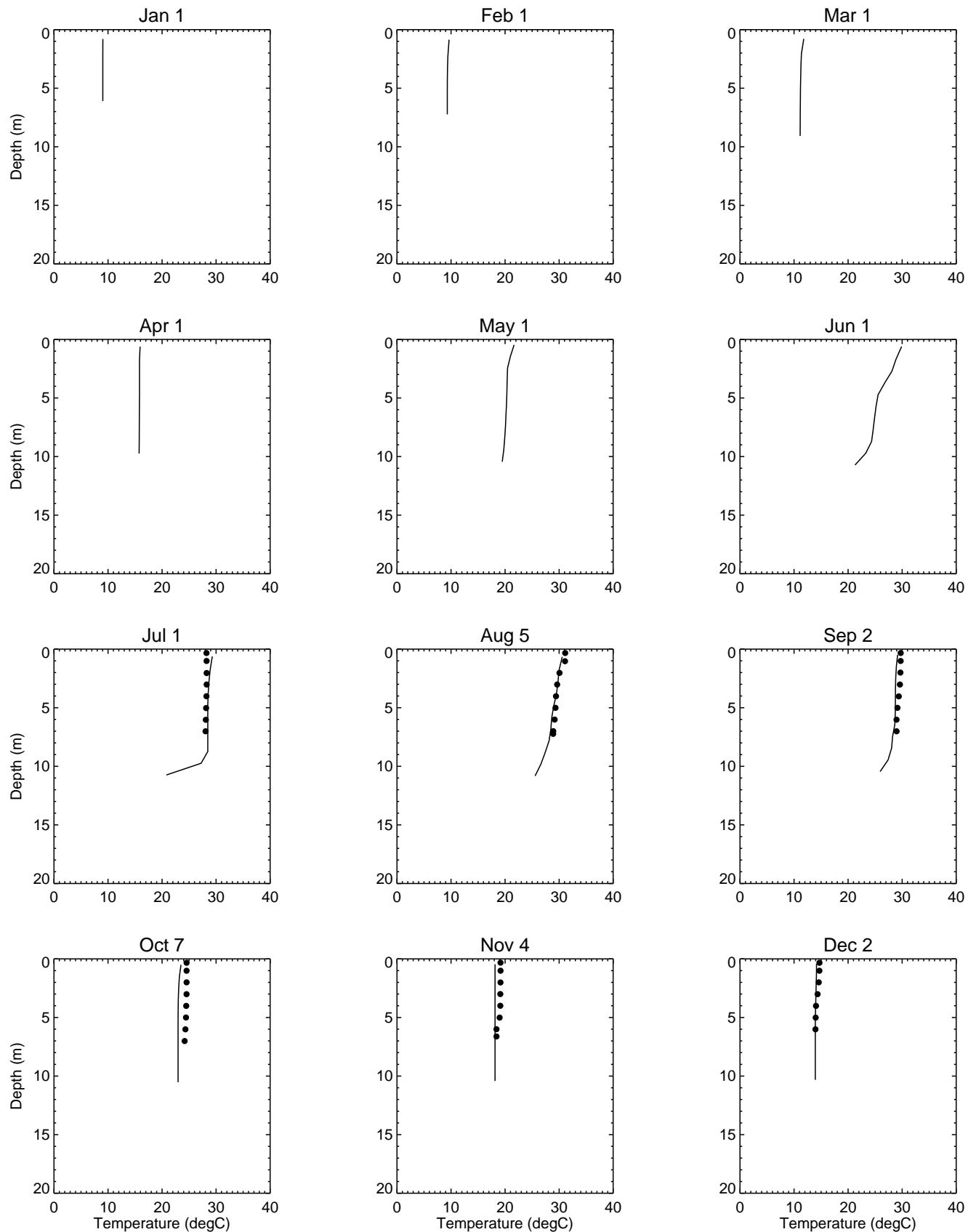
—— Model (w1210-48)

● Data

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 1987

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
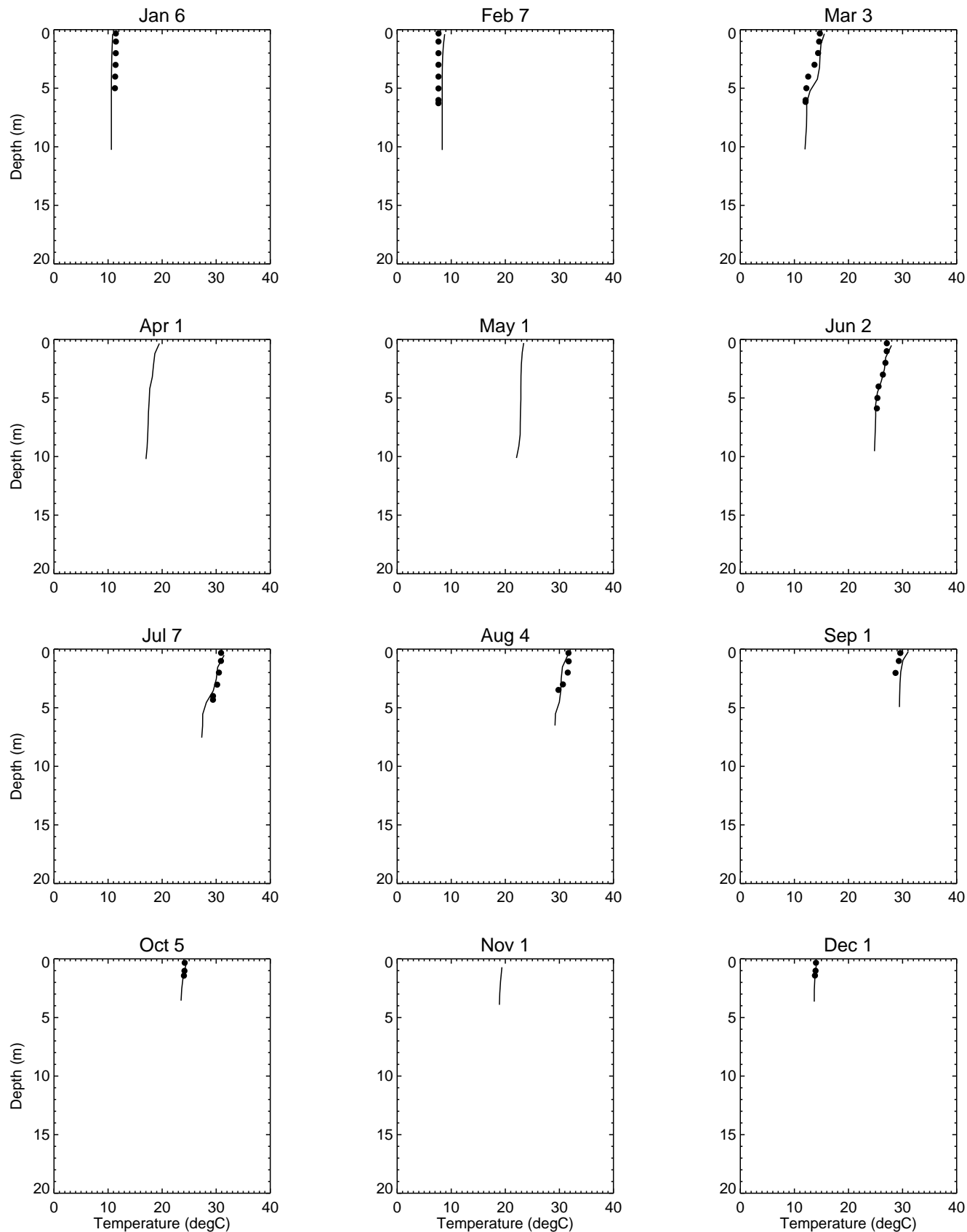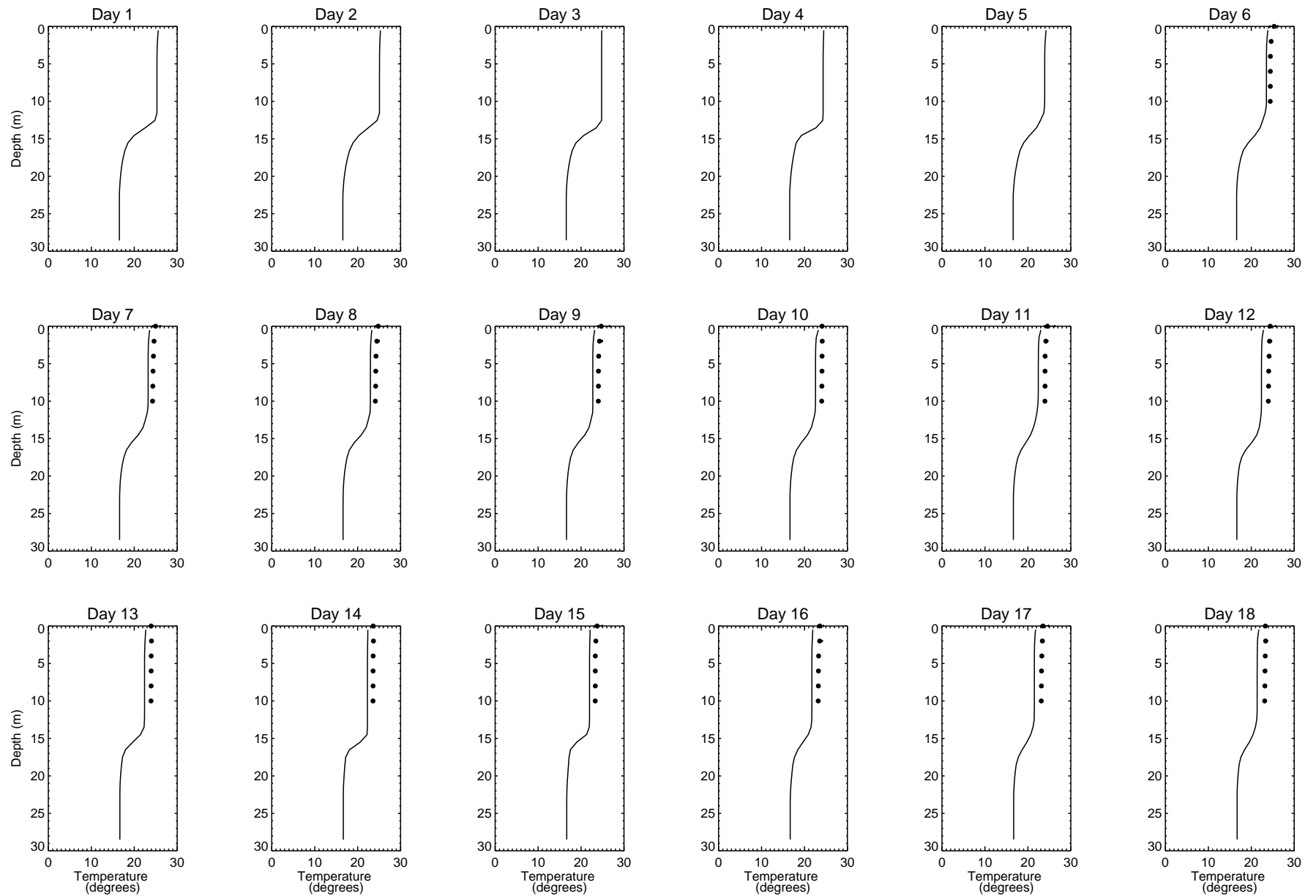Fri Jan 25 18:13:18 2013

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 1988

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 10 · Feb 20 · Mar 14 · Apr 18 · May 15 · Jun 22 · Jul 1 · Aug 21 · Sep 1 · Oct 19 · Nov 1 · Dec 21

——— Model (w1210-48)
● Data

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 1989

Profiles shown for dates with available data else model results for first day of month shown.
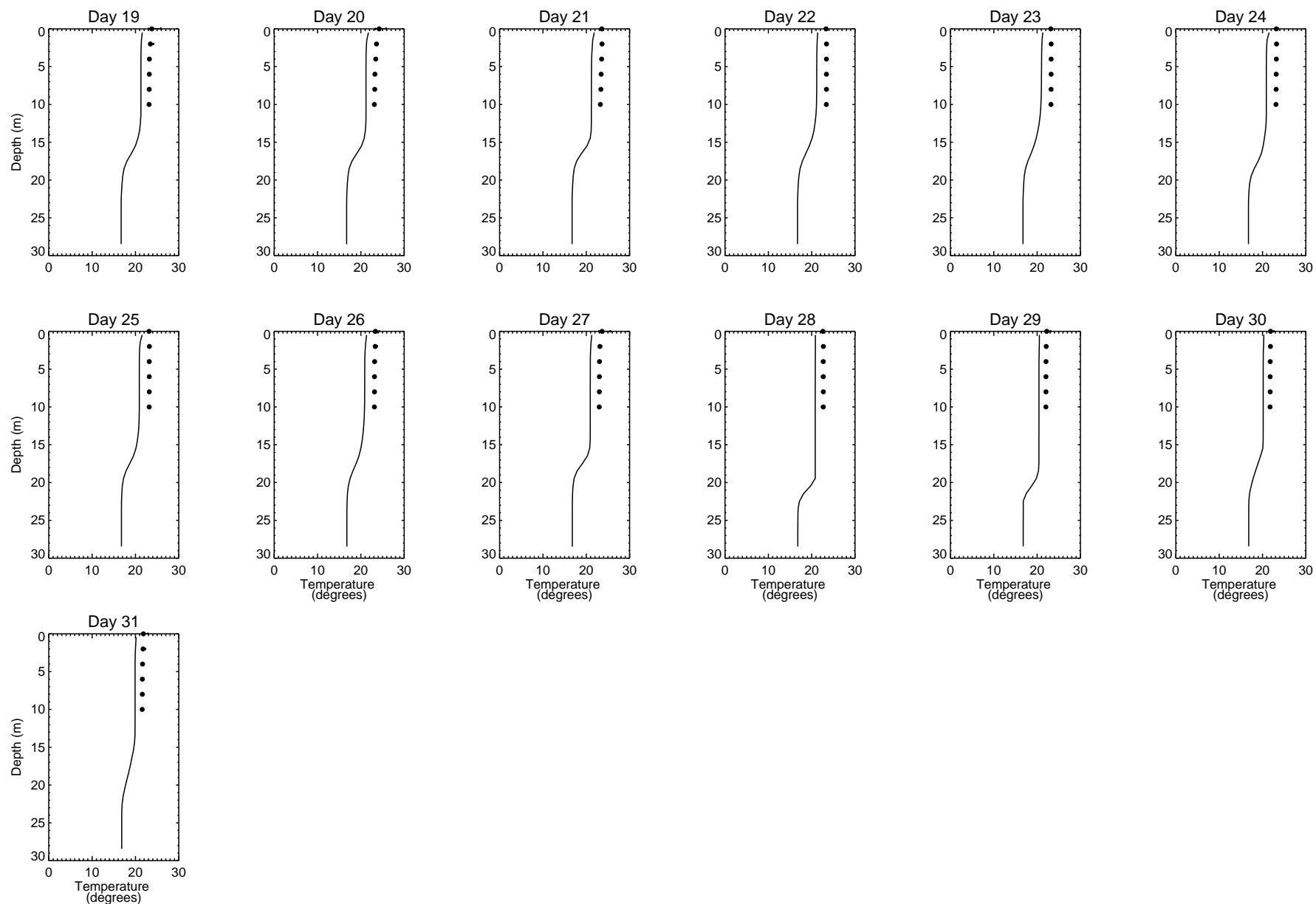
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:18 2013

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 1990

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 1991

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 1993

Profiles shown for dates with available data else model results for first day of month shown.

Model (w1210-48)
● Data

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 1994

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 1995

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:19 2013

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 1996

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:19 2013

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 1997

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 1998

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1   Feb 1   Mar 1

Apr 1   May 1   Jun 1

Jul 1   Aug 1   Sep 1

Oct 1   Nov 1   Dec 1

——— Model (w1210-48)

● Data

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 1999

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 2000

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 2001

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 2002

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:19 2013

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 2003

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1   Feb 1   Mar 1
Apr 1   May 1   Jun 1
Jul 1   Aug 1   Sep 1
Oct 1   Nov 1   Dec 1

Depth (m) — Temperature (degC)

———— Model (w1210-48)
●   Data

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 2004

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:19 2013

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 2005

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:19 2013

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 2006

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 2007

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Jan 1

Feb 1

Mar 1

Apr 1

May 1

Jun 1

Jul 1

Aug 1

Sep 1

Oct 1

Nov 1

Dec 1

Model (w1210-48)

● Data

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 2008

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:19 2013

Figure G-8

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 2009

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-8
Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Temperature - 2011

Profiles shown for dates with available data else model results for first day of month shown.

Legend:
— Model (w1210-48)
● Data

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-9

Model Versus Thermistor Data - October 2010

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

CREMs Phase 4: Lake Buchanan
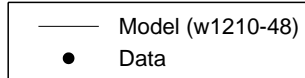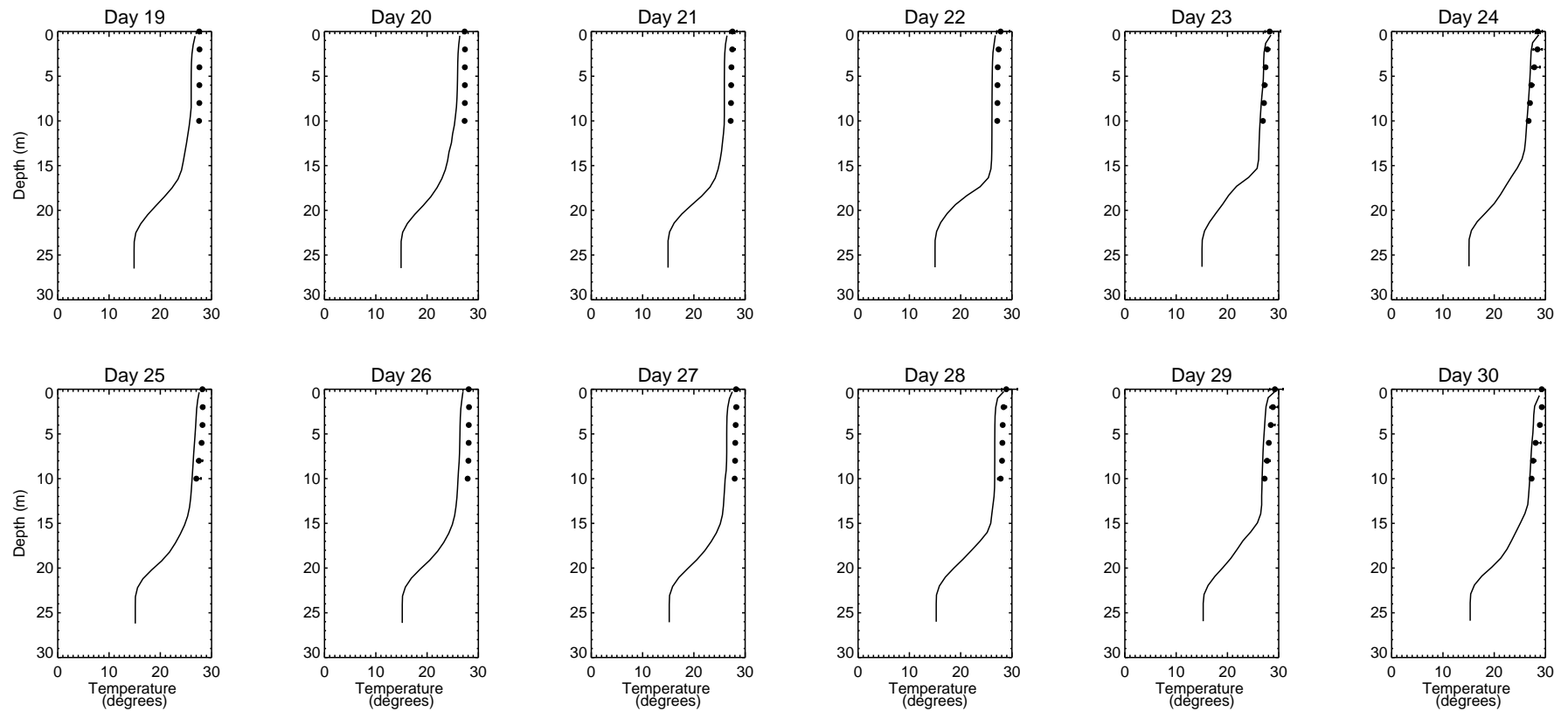Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-9

Model Versus Thermistor Data - October 2010

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

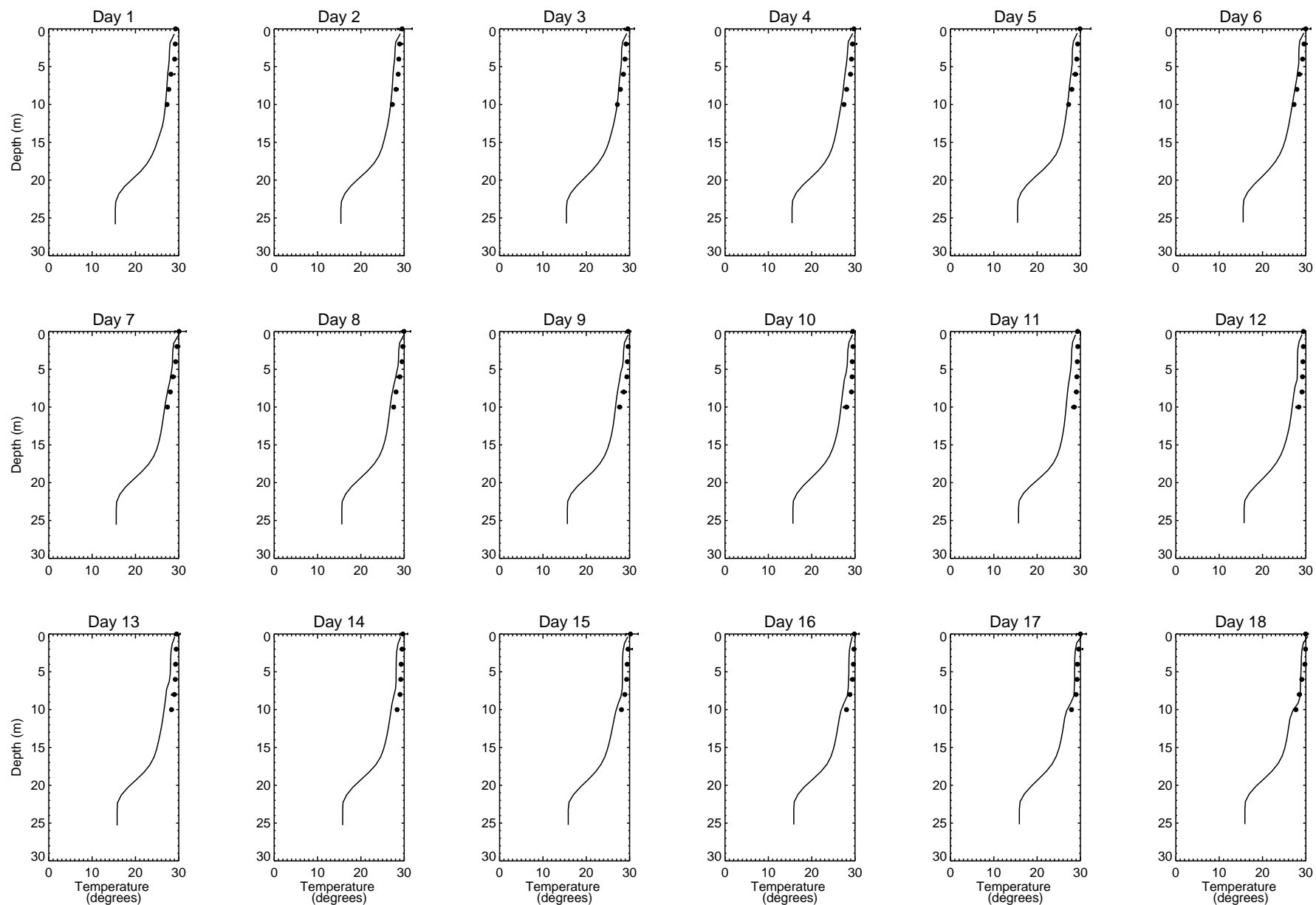CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-9

Model Versus Thermistor Data - November 2010

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

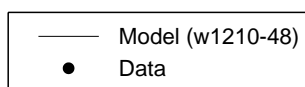CREMs Phase 4: Lake Buchanan
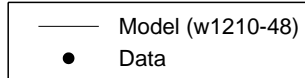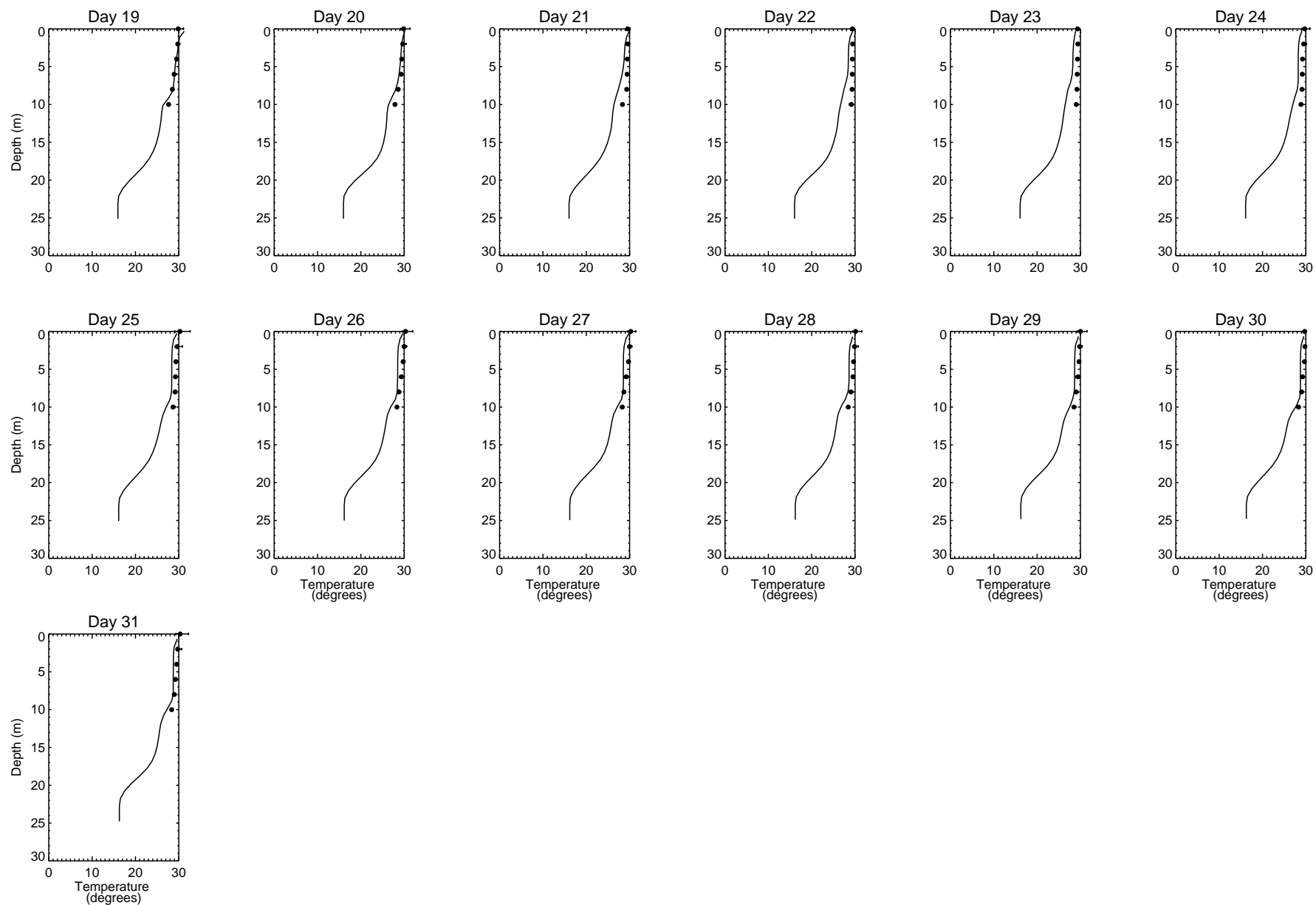Lower Colorado River Authority

Model (w1210-48)
● Data

Day 19 | Day 20 | Day 21 | Day 22 | Day 23 | Day 24
Day 25 | Day 26 | Day 27 | Day 28 | Day 29 | Day 30

Model Versus Thermistor Data - November 2010

Figure G-9

Model (w1210-48)
● Data

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-9

Model Versus Thermistor Data - December 2010

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

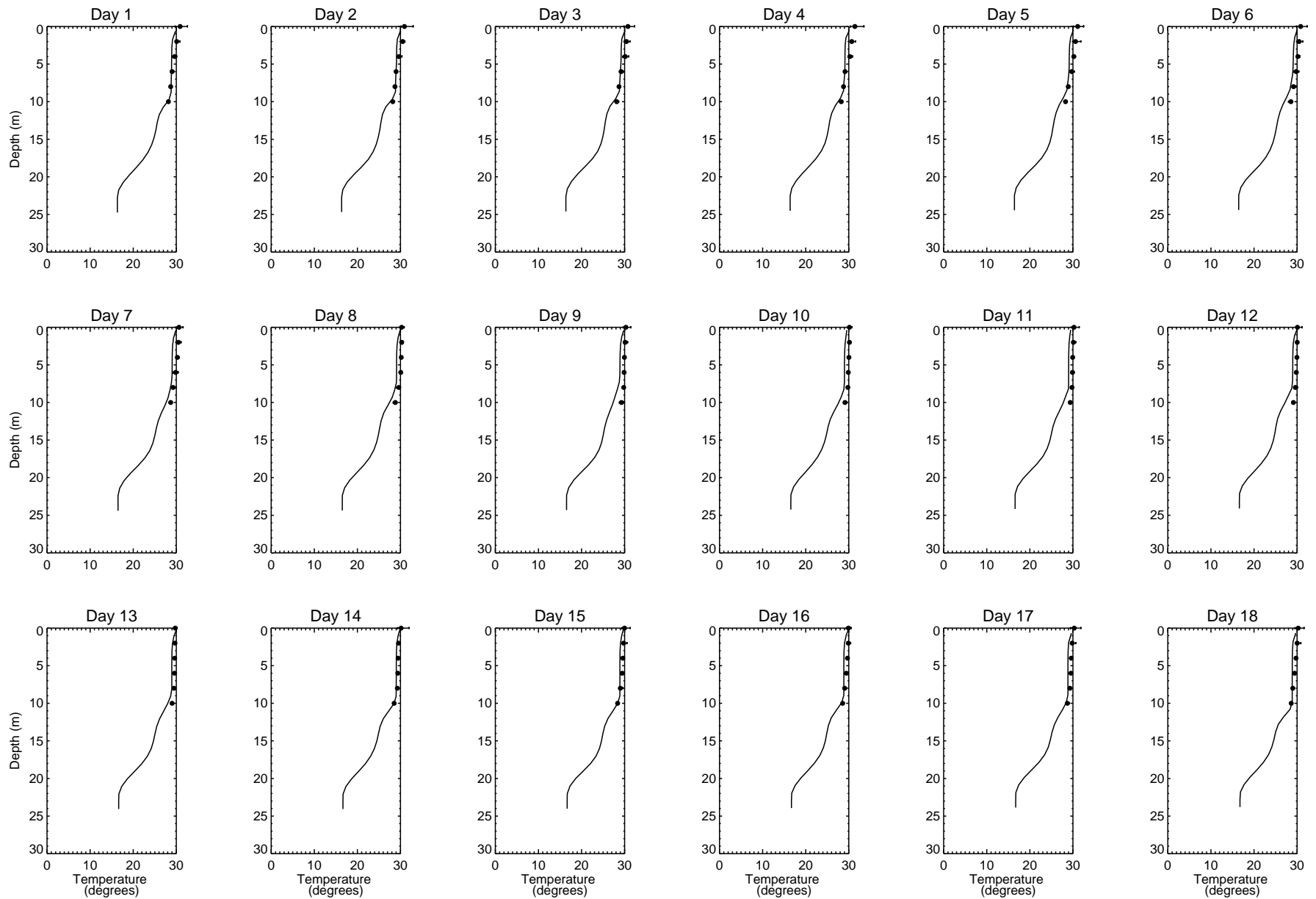CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-9

Model Versus Thermistor Data - December 2010

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

CREMs Phase 4: Lake Buchanan
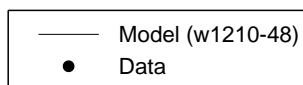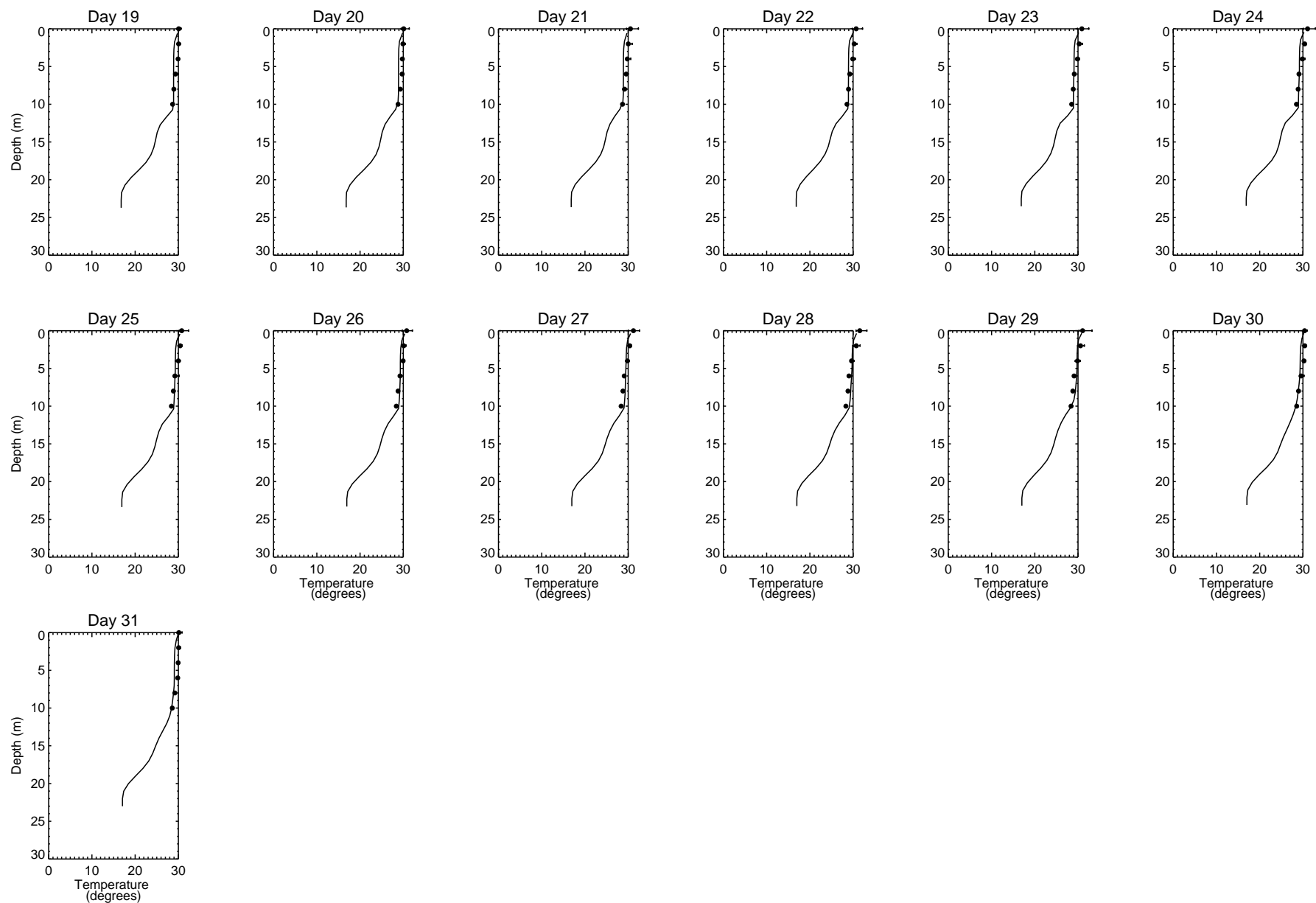Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-9

Model Versus Thermistor Data - Jan 2011

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-9

Model Versus Thermistor Data - Jan 2011

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

CREMs Phase 4: Lake Buchanan
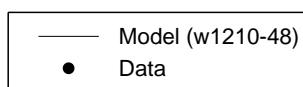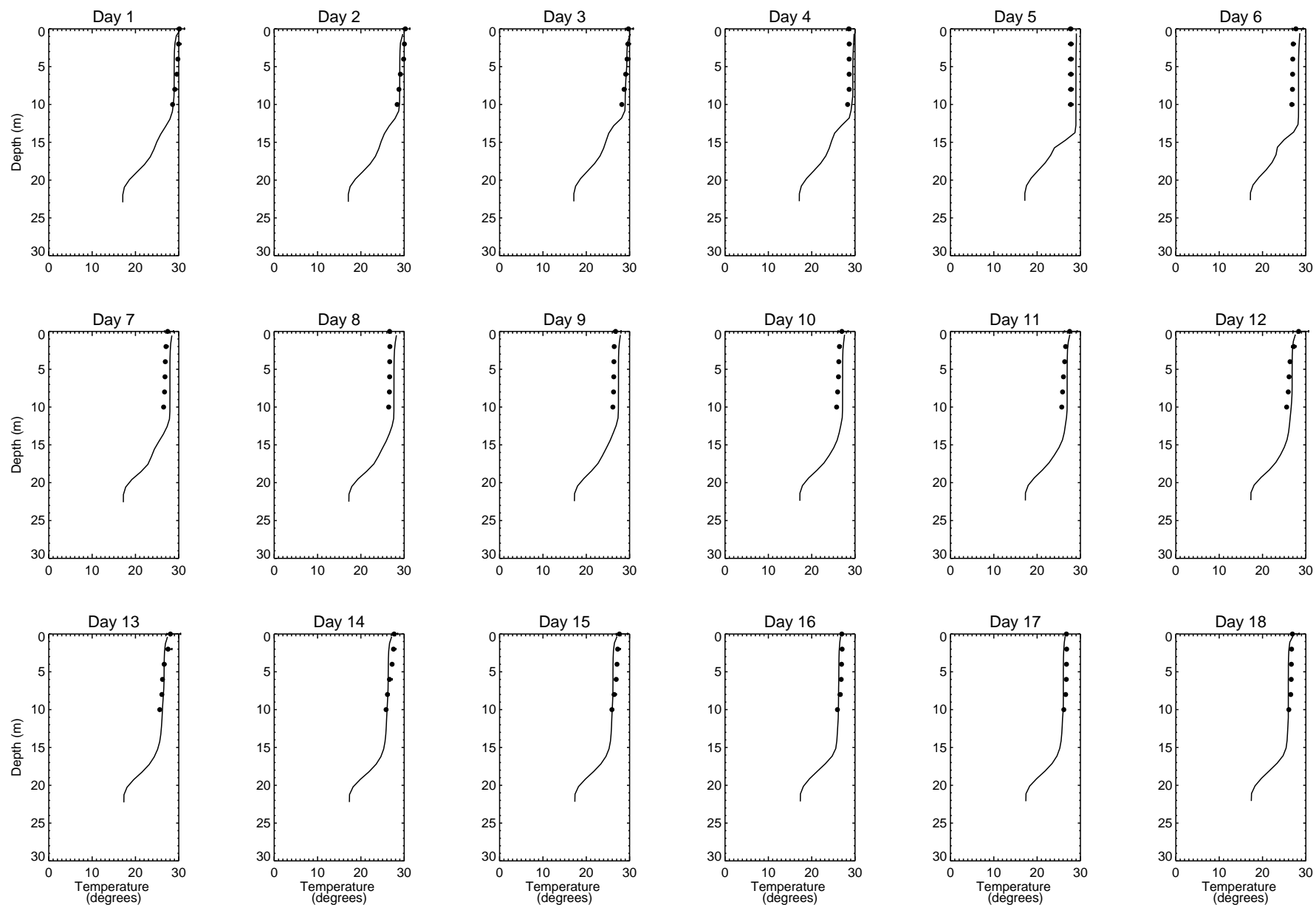Lower Colorado River Authority

Figure G-9

Model Versus Thermistor Data - February 2011

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

CREMs Phase 4: Lake Buchanan
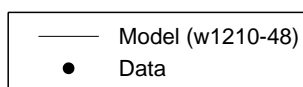Lower Colorado River Authority

Model (w1210-48)
● Data

EC - D:\D_drive\Projects\LCRA\CREMS\Analysis\Phase4_Buchanan\wq\profiles\Buch_thermistor_profiles.pro
Thu Jan 31 17:50:40 2013

Day 19   Day 20   Day 21   Day 22   Day 23   Day 24

Day 25   Day 26   Day 27   Day 28

Figure G-9

Model Versus Thermistor Data - February 2011

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

CREMs Phase 4: Lake Buchanan
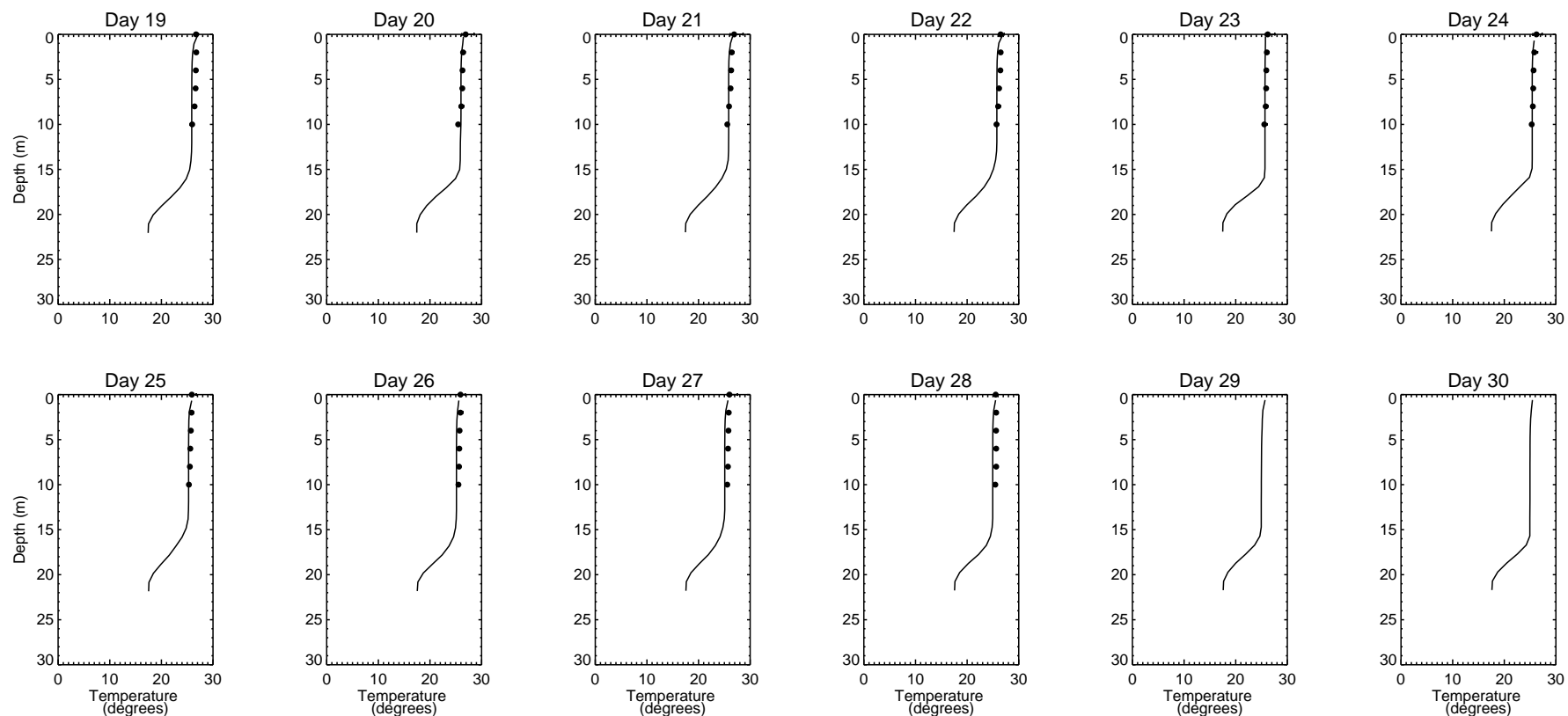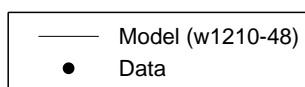Lower Colorado River Authority

——— Model (w1210-48)

●   Data

Figure G-9

Model Versus Thermistor Data - March 2011

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

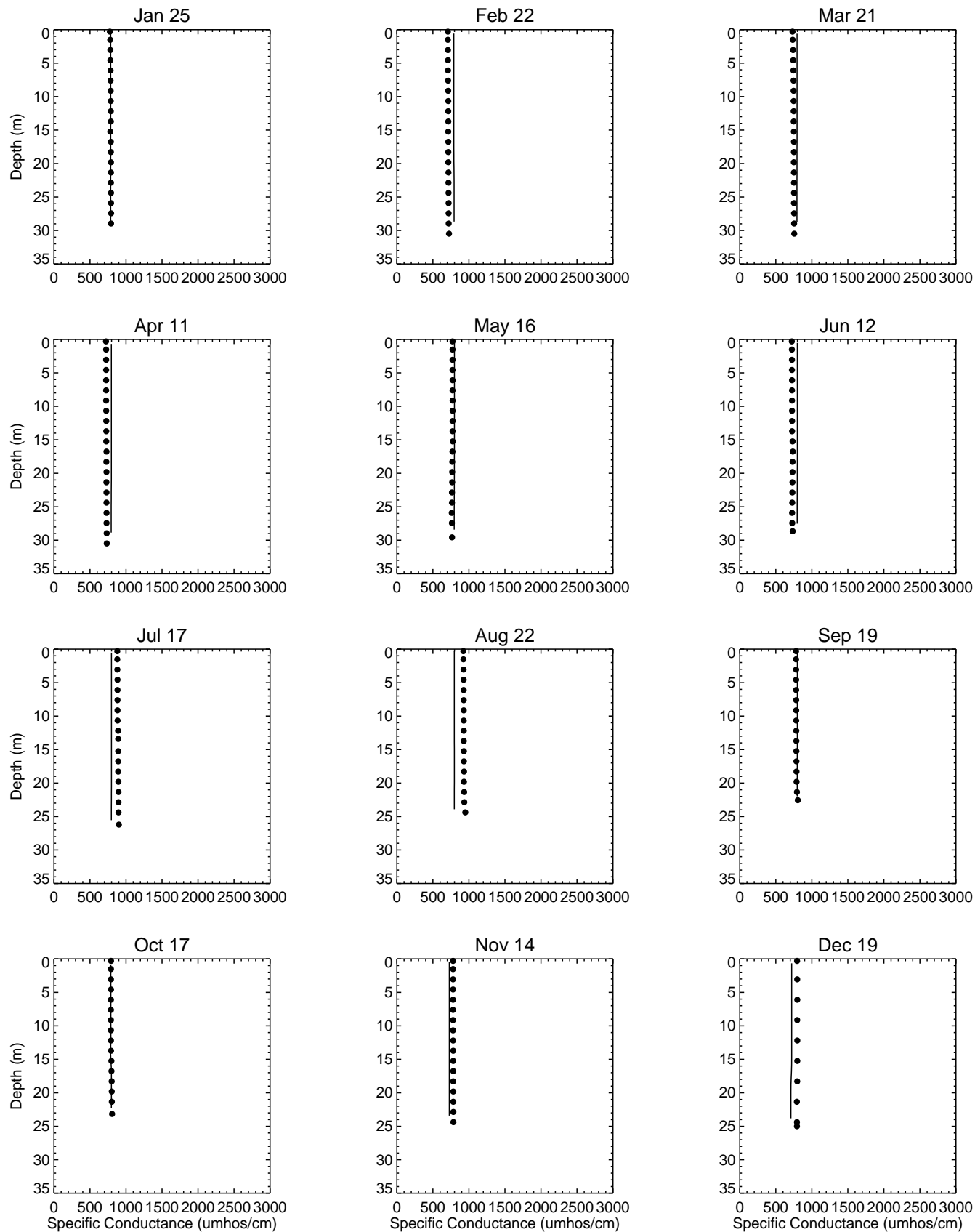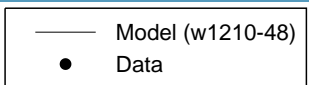CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Model (w1210-48)
● Data

EC - D:\D_drive\Projects\LCRA\CREMS\Analysis\Phase4_Buchanan\wq\profiles\Buch_thermistor_profiles.pro
Thu Jan 31 17:50:41 2013

Figure G-9

Model Versus Thermistor Data - March 2011

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.
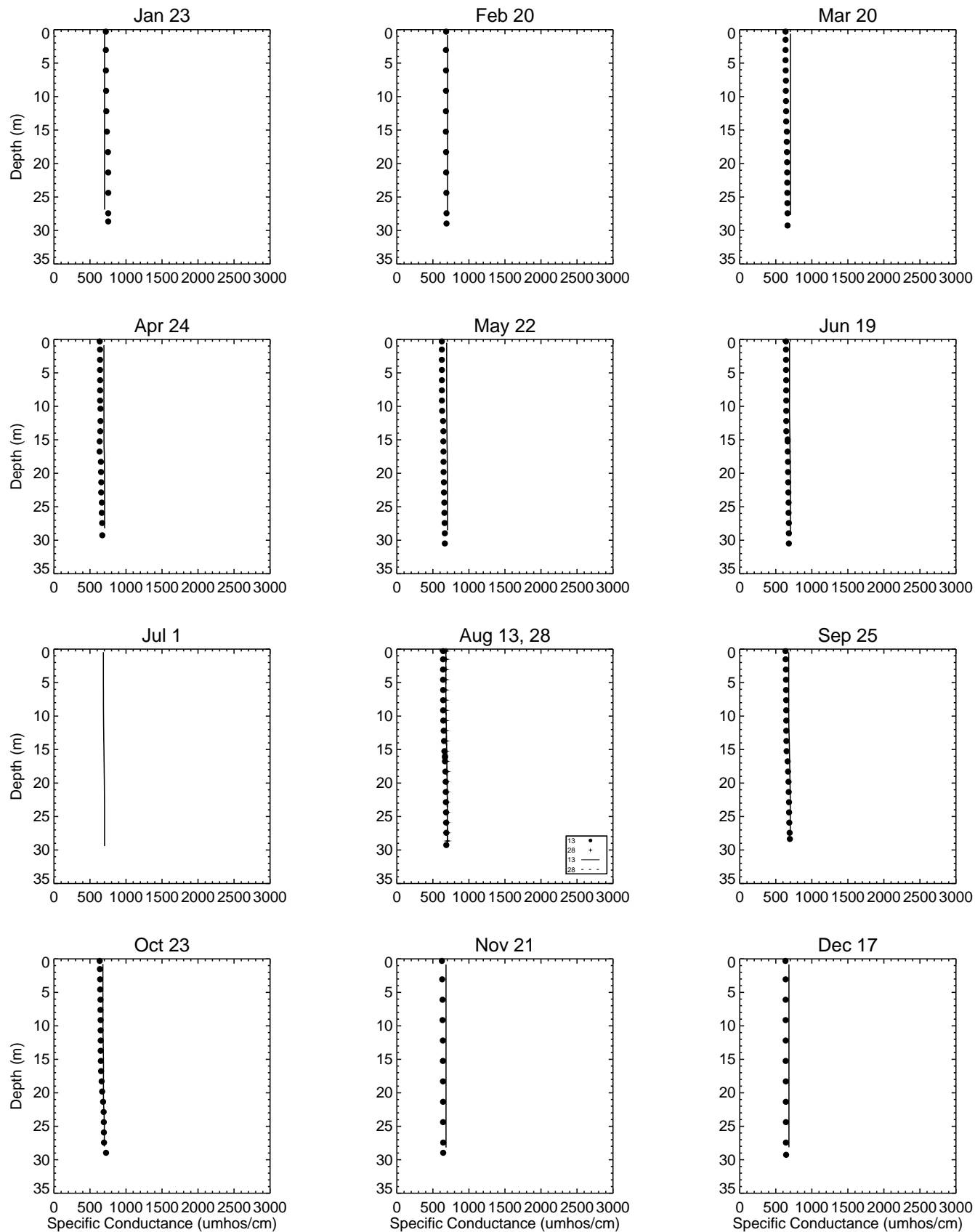
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Model (w1210-48)
● Data

EC - D:\D_drive\Projects\LCRA\CREMS\Analysis\Phase4_Buchanan\wq\profiles\Buch_thermistor_profiles.pro
Thu Jan 31 17:50:42 2013

Figure G-9

Model Versus Thermistor Data - April 2011

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Model (w1210-48)
● Data

Day 19 Day 20 Day 21 Day 22 Day 23 Day 24

Day 25 Day 26 Day 27 Day 28 Day 29 Day 30

——— Model (w1210-48)

● Data

Figure G-9

Model Versus Thermistor Data - April 2011

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-9

Model Versus Thermistor Data - May 2011

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Legend:
— Model (w1210-48)
● Data

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Analysis\Phase4_Buchanan\wq\profiles\Buch_thermistor_profiles.pro
Thu Jan 31 17:50:43 2013

Figure G-9

Model Versus Thermistor Data - May 2011

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-9

Model Versus Thermistor Data - June 2011

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Legend:
— Model (w1210-48)
● Data

Day 19　Day 20　Day 21　Day 22　Day 23　Day 24

Day 25　Day 26　Day 27　Day 28　Day 29　Day 30

Model (w1210-48)

● Data

ANCHOR QEA PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Analysis\Phase4_Buchanan\wq\profiles\Buch_thermistor_profiles.pro
Thu Jan 31 17:50:45 2013

Day 1 · Day 2 · Day 3 · Day 4 · Day 5 · Day 6
Day 7 · Day 8 · Day 9 · Day 10 · Day 11 · Day 12
Day 13 · Day 14 · Day 15 · Day 16 · Day 17 · Day 18

Temperature (degrees)
Depth (m)

Model (w1210-48)
● Data

Figure G-9

Model Versus Thermistor Data - July 2011

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Analysis\Phase4_Buchanan\wq\profiles\Buch_thermistor_profiles.pro
Thu Jan 31 17:50:46 2013

Figure G-9

Model Versus Thermistor Data - July 2011

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Legend:
— Model (w1210-48)
● Data

Figure G-9

Model Versus Thermistor Data - August 2011

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-9

Model Versus Thermistor Data - August 2011

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Model (w1210-48)
● Data

EC - D:\D_drive\Projects\LCRA\CREMS\Analysis\Phase4_Buchanan\wq\profiles\Buch_thermistor_profiles.pro
Thu Jan 31 17:50:47 2013

Figure G-9

Model Versus Thermistor Data - September 2011

Data available for top 10m at Station 12347 (Lake Buchanan at Rocky Point)
Daily averages shown with error bars indicating hourly ranges.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Model (w1210-48)
● Data

EC - D:\D_drive\Projects\LCRA\CREMS\Analysis\Phase4_Buchanan\wq\profiles\Buch_thermistor_profiles.pro
Thu Jan 31 17:50:48 2013

Day 19 | Day 20 | Day 21 | Day 22 | Day 23 | Day 24
Day 25 | Day 26 | Day 27 | Day 28 | Day 29 | Day 30

Temperature (degrees)

Depth (m)

— Model (w1210-48)
● Data

EC - D:\D_drive\Projects\LCRA\CREMS\Analysis\Phase4_Buchanan\wq\profiles\Buch_thermistor_profiles.pro
Thu Jan 31 17:50:48 2013

ANCHOR QEA
PARSONS

Jan 25, Feb 22, Mar 21, Apr 11, May 16, Jun 12, Jul 17, Aug 22, Sep 19, Oct 17, Nov 14, Dec 19

Depth (m)

Specific Conductance (umhos/cm)

——— Model (w1210-48)
● Data

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 1984

Profiles shown for dates with available data else model results for first day of month shown.
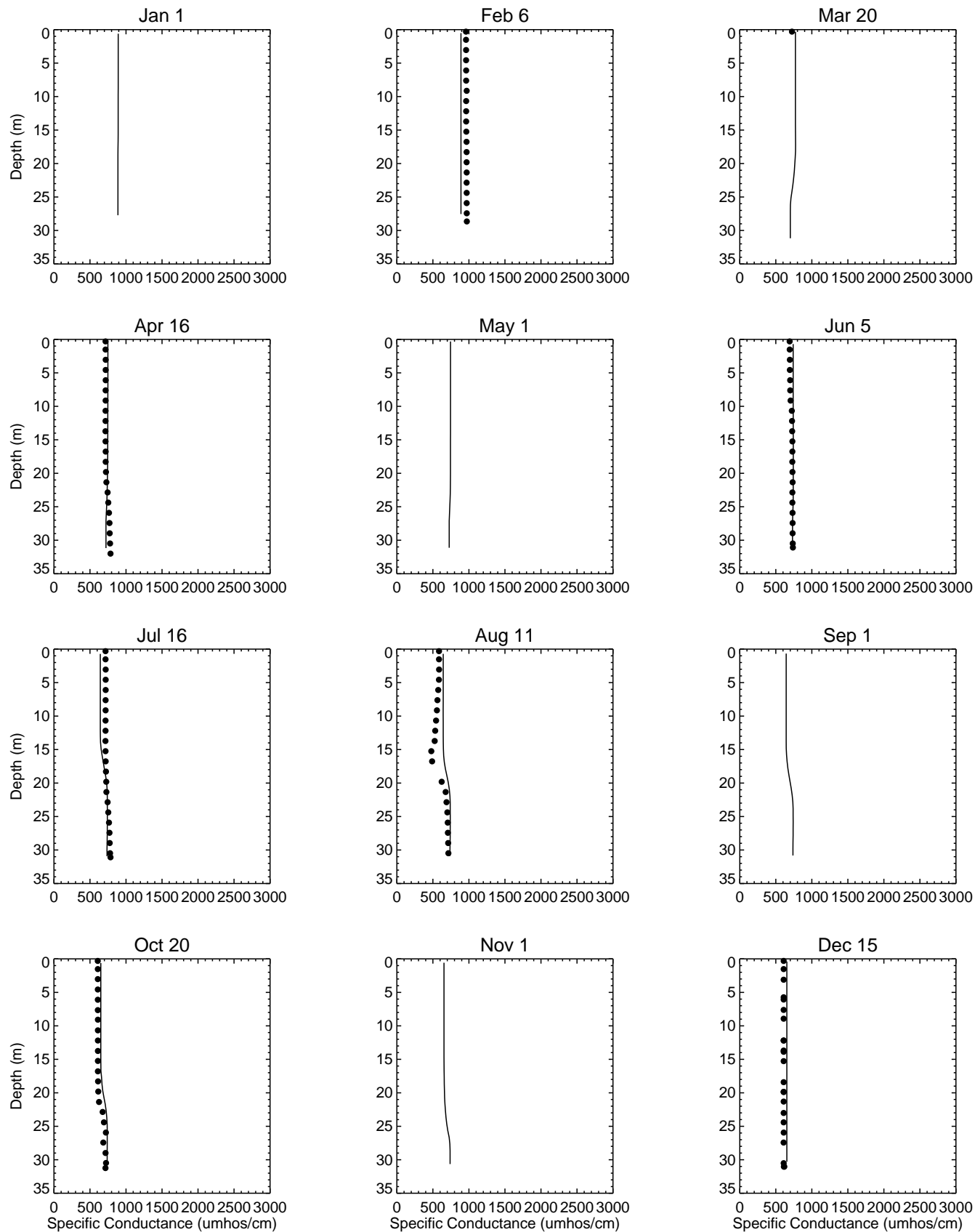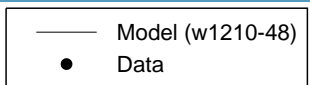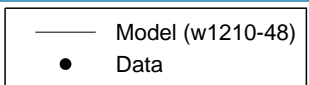
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 1985

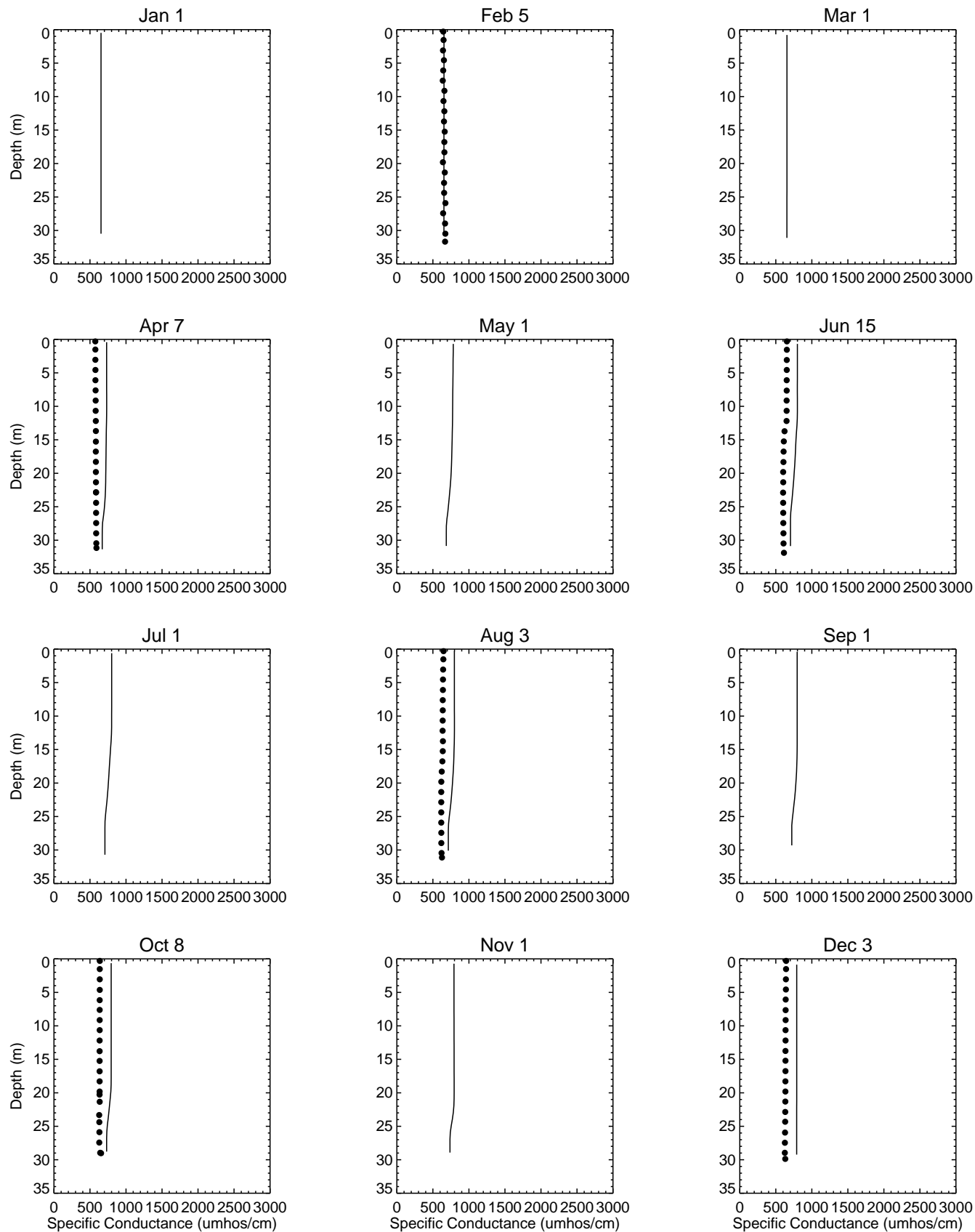*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 23 · Feb 19 · Mar 24 · Apr 15 · May 21 · Jun 18 · Jul 23 · Aug 20 · Sep 25 · Oct 21 · Nov 17 · Dec 17

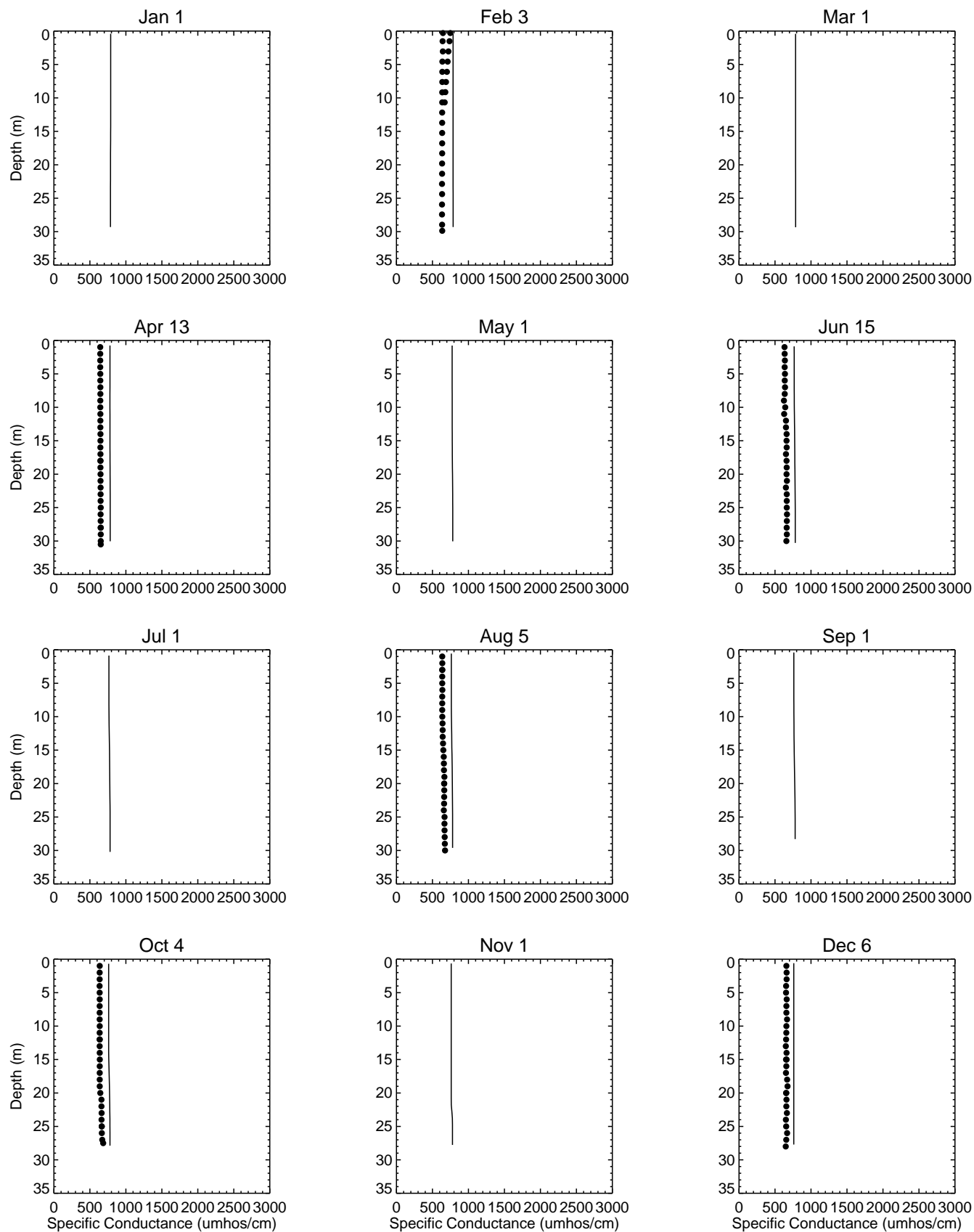Specific Conductance (umhos/cm)

——— Model (w1210-48)
● Data

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 1986

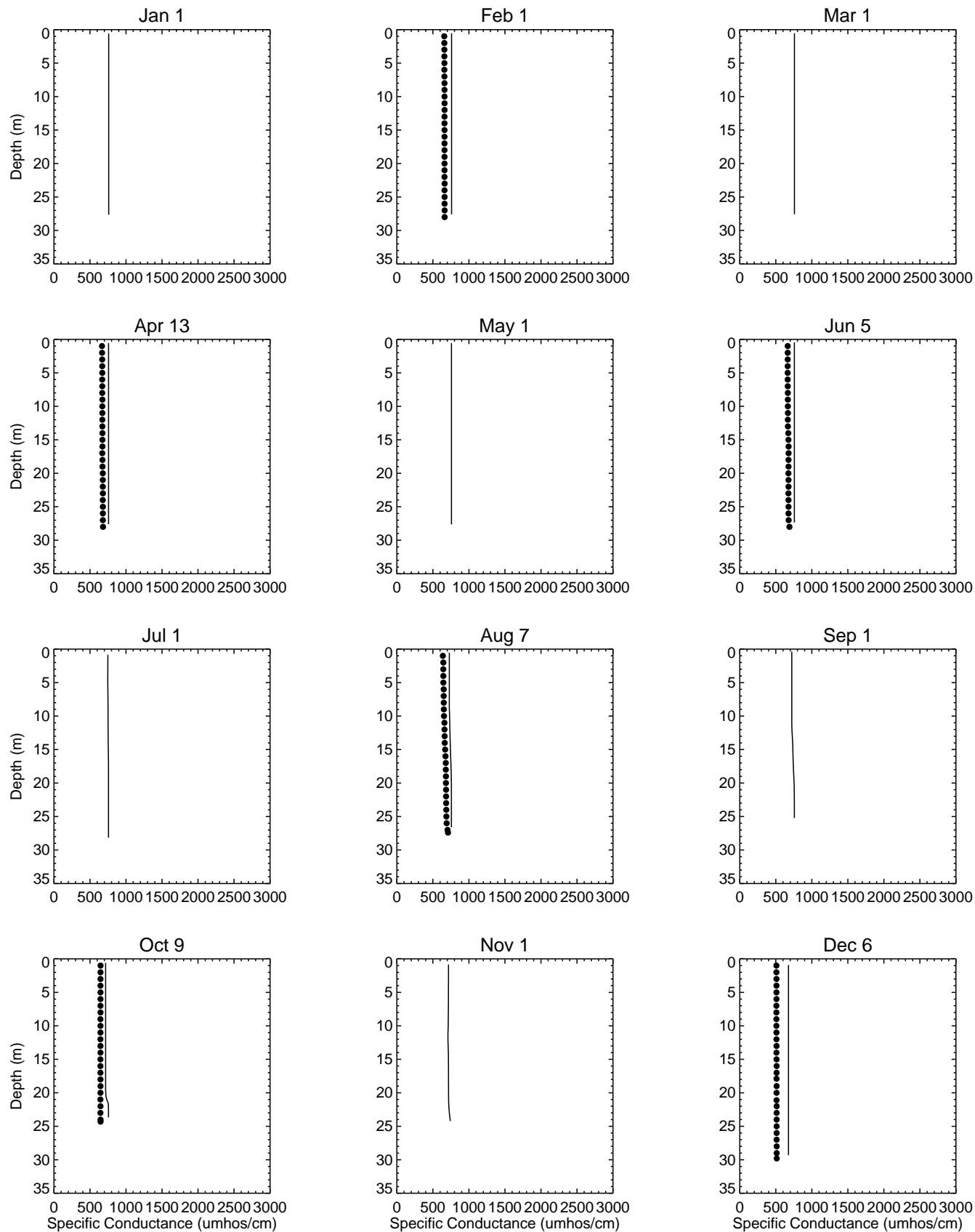*Profiles shown for dates with available data else model results for first day of month shown.*

ANCHOR
QEA
PARSONS

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
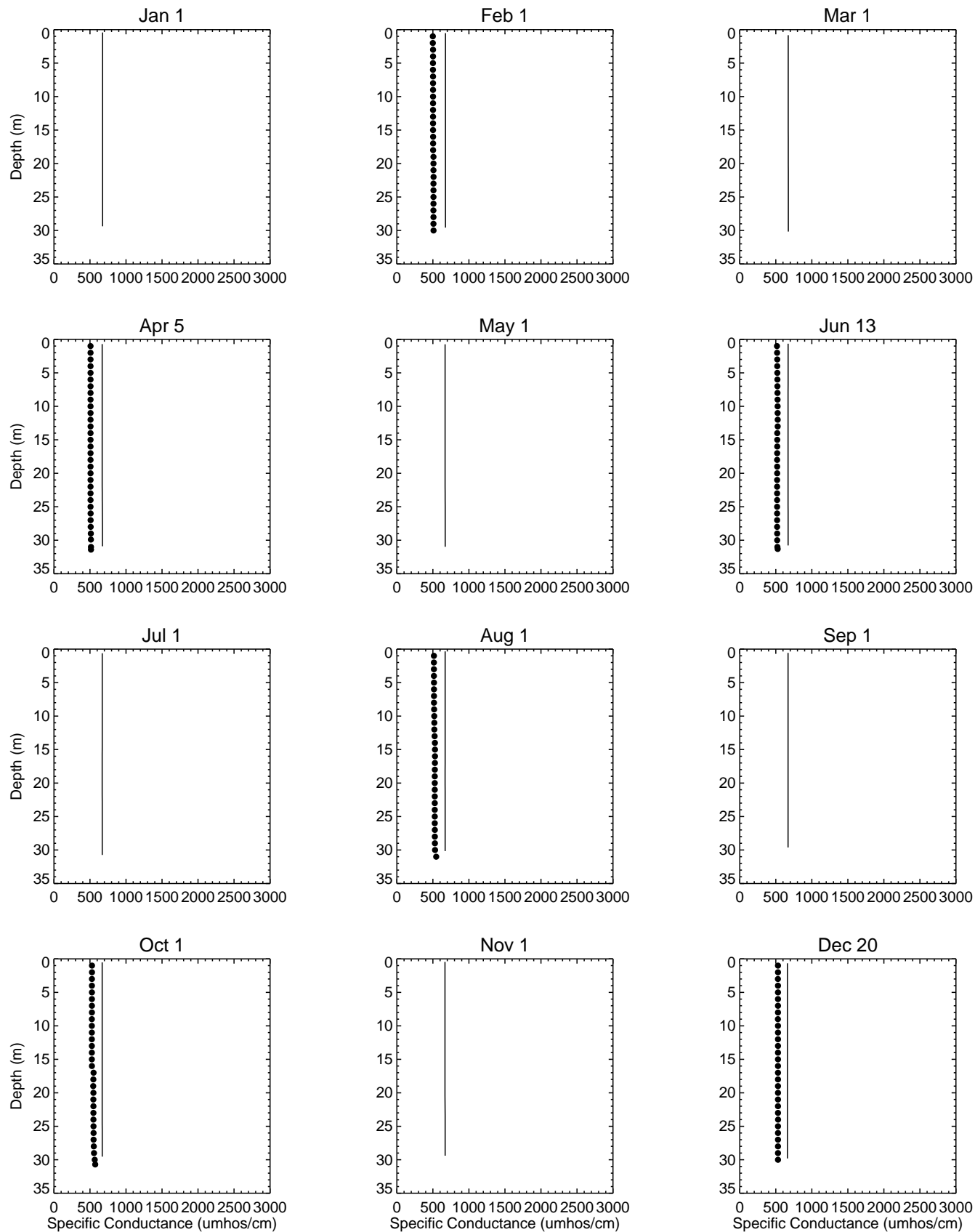Fri Jan 25 18:13:22 2013

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 1987

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 1988

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
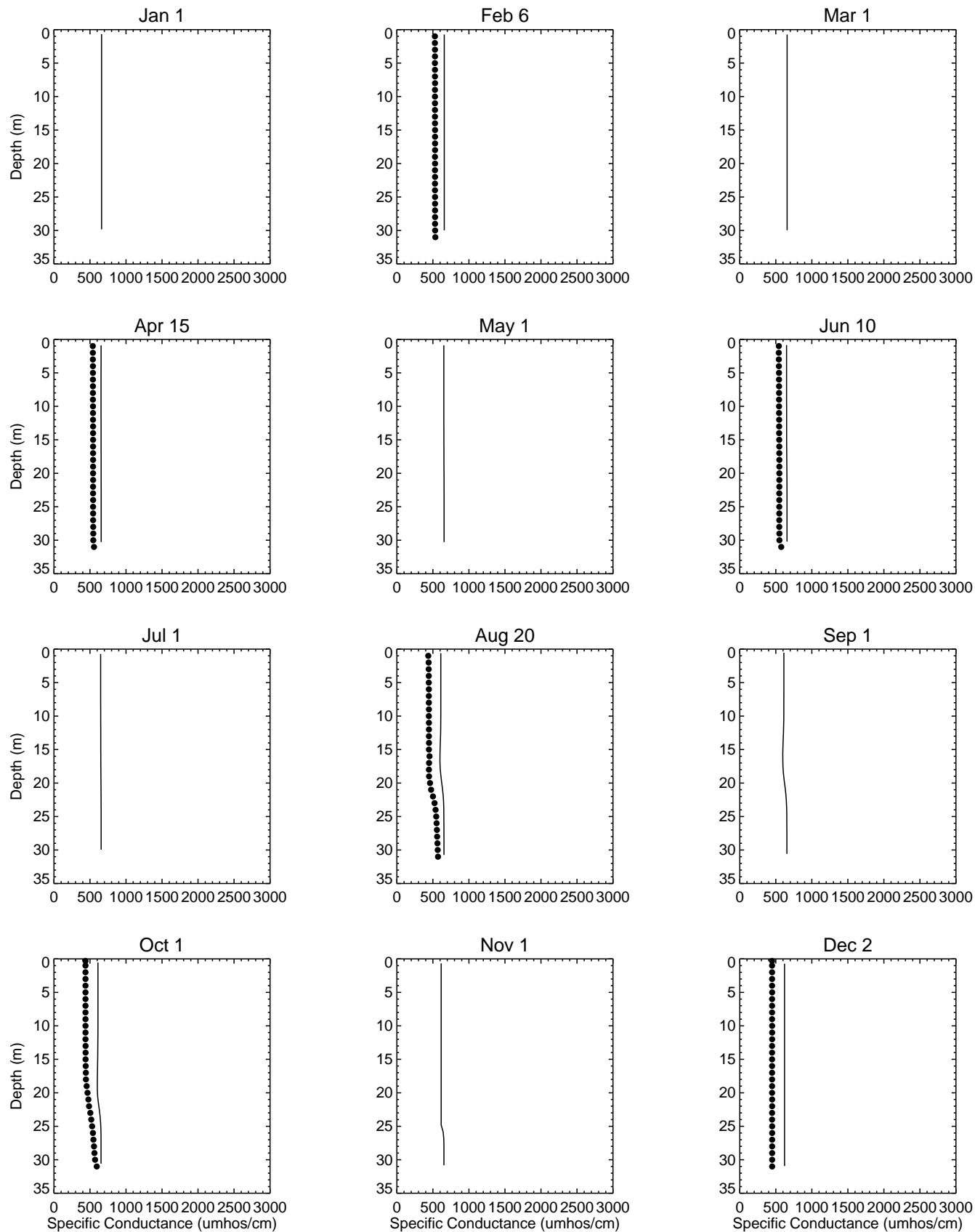
Lower Colorado River Authority

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 1989

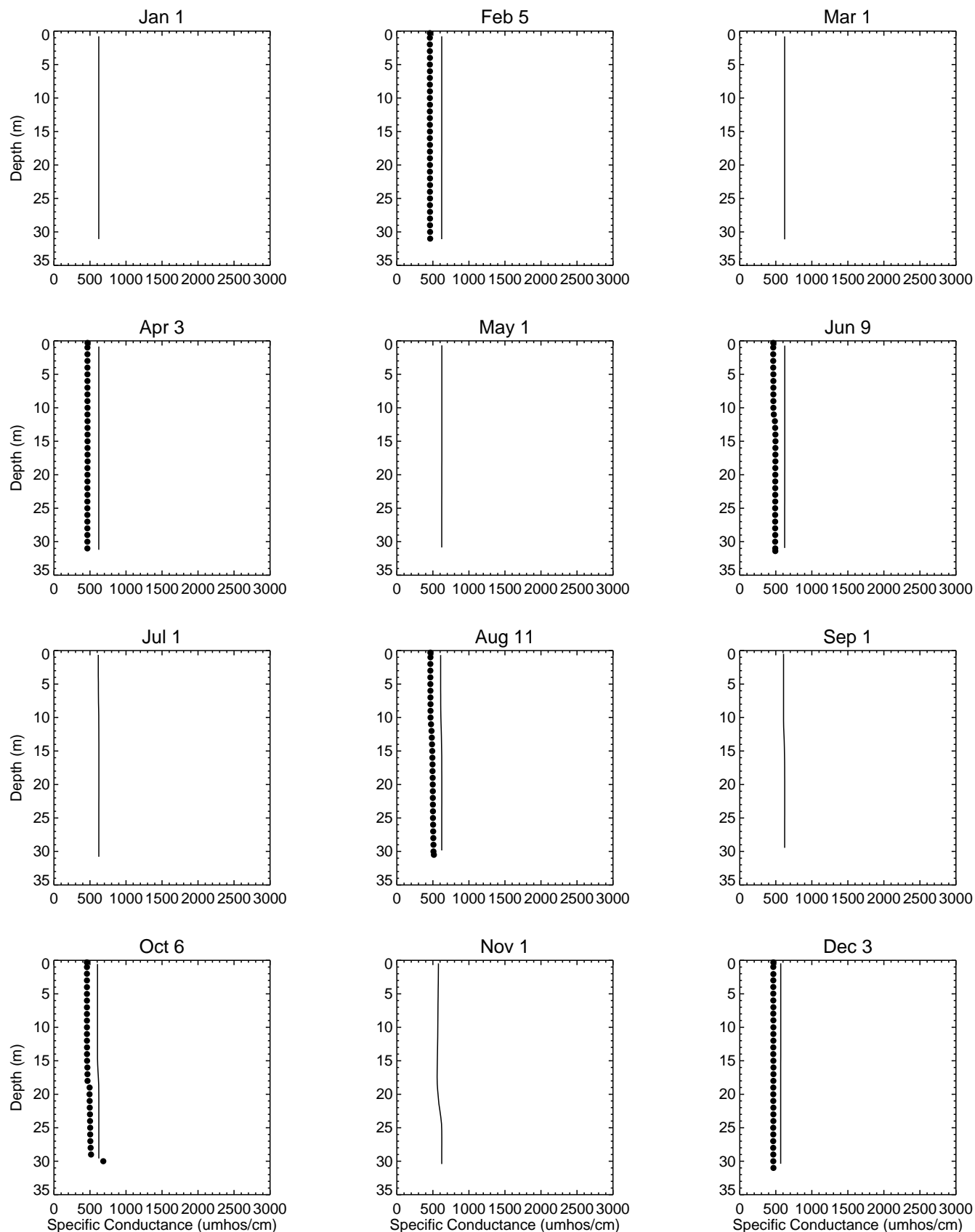*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:22 2013

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 1990

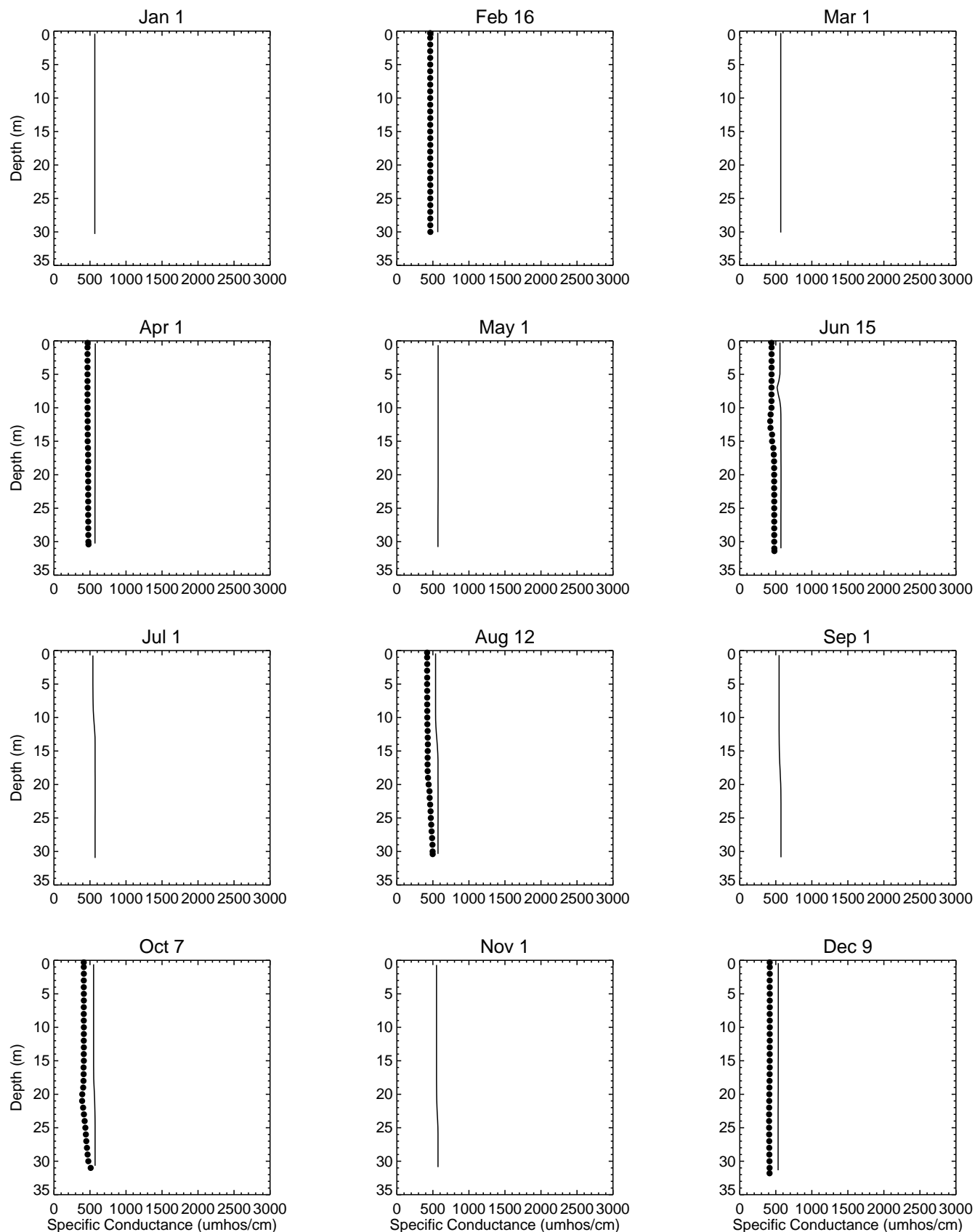*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 1991

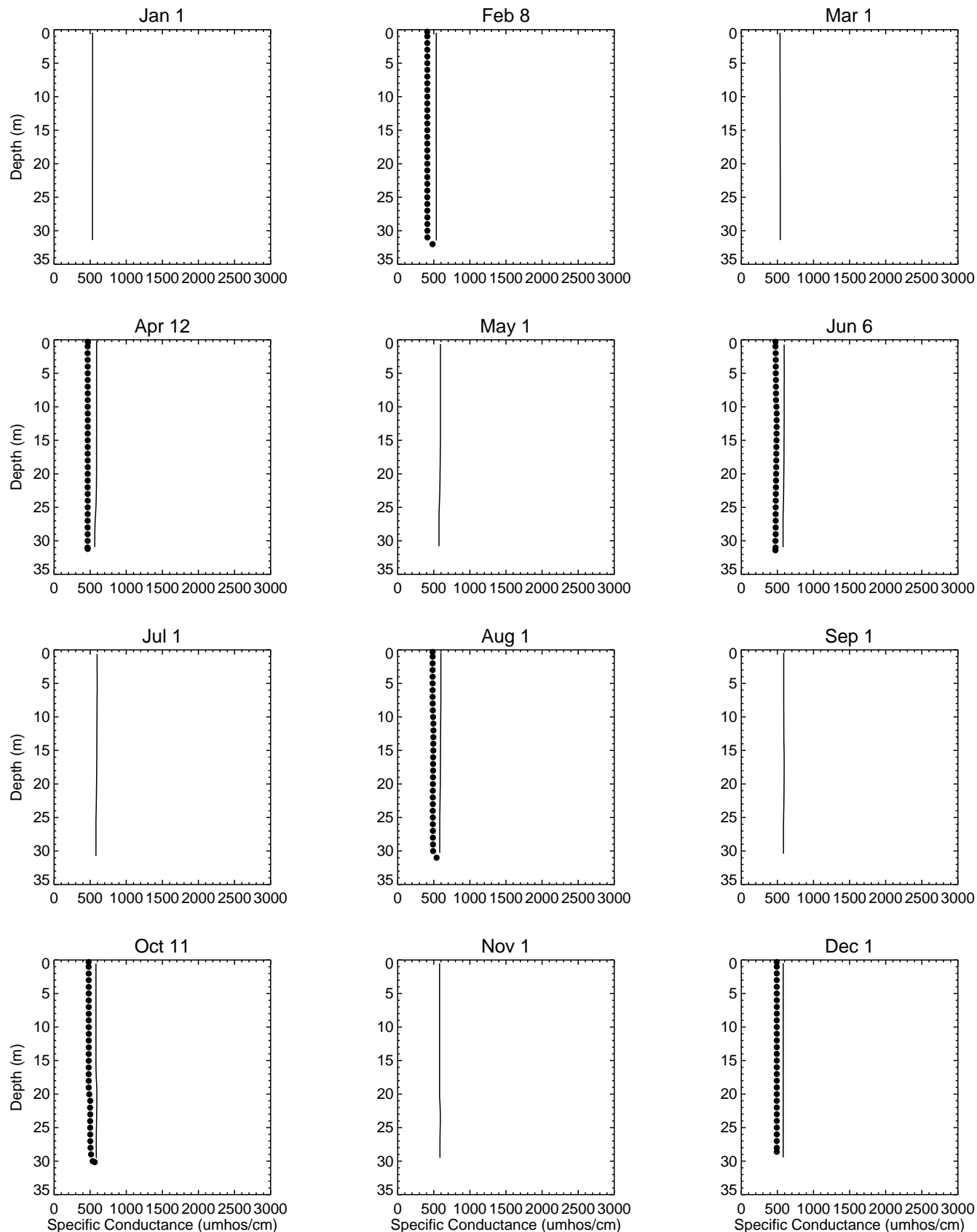*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 1992

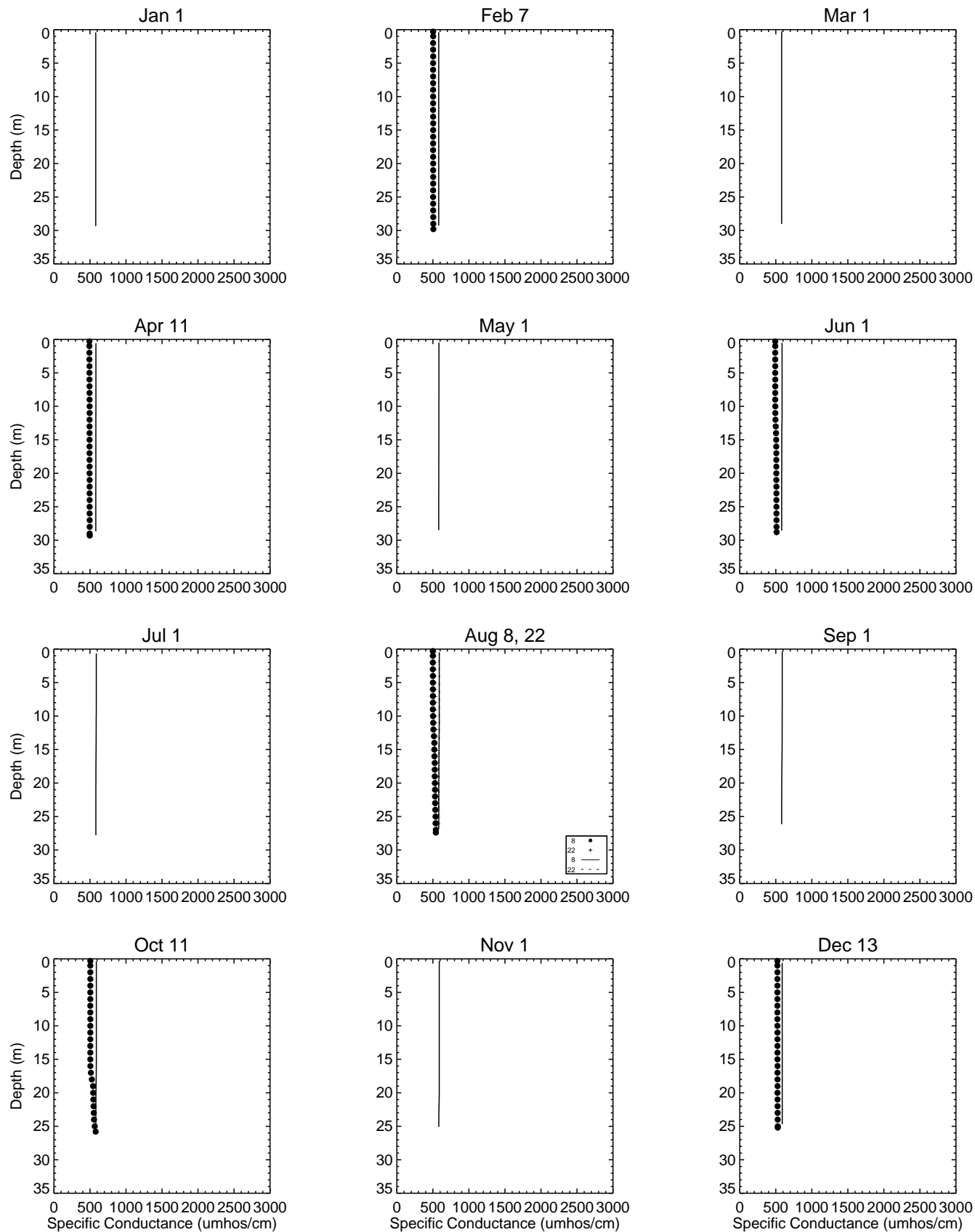*Profiles shown for dates with available data else model results for first day of month shown.*

Model (w1210-48)
● Data

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 1993

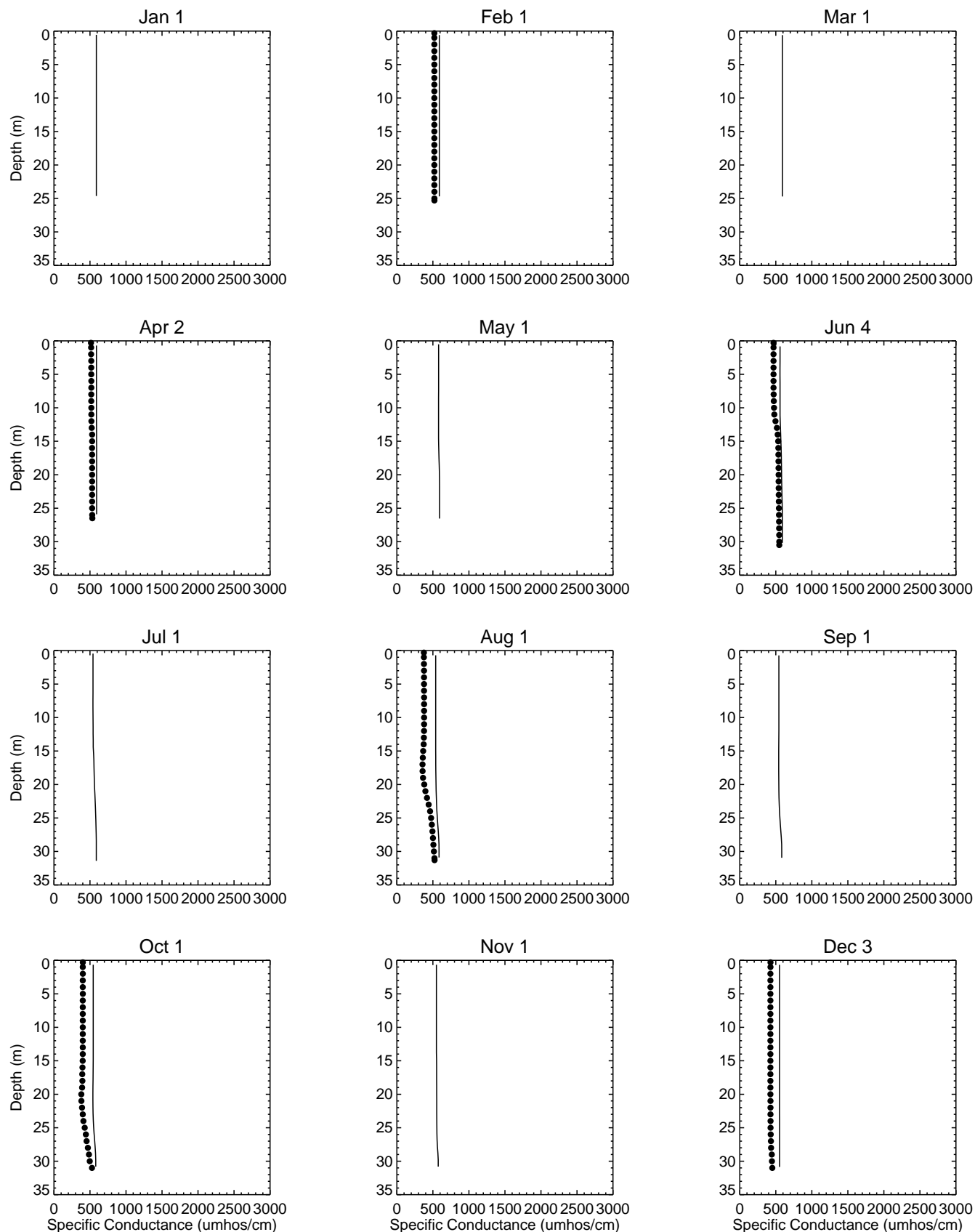*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
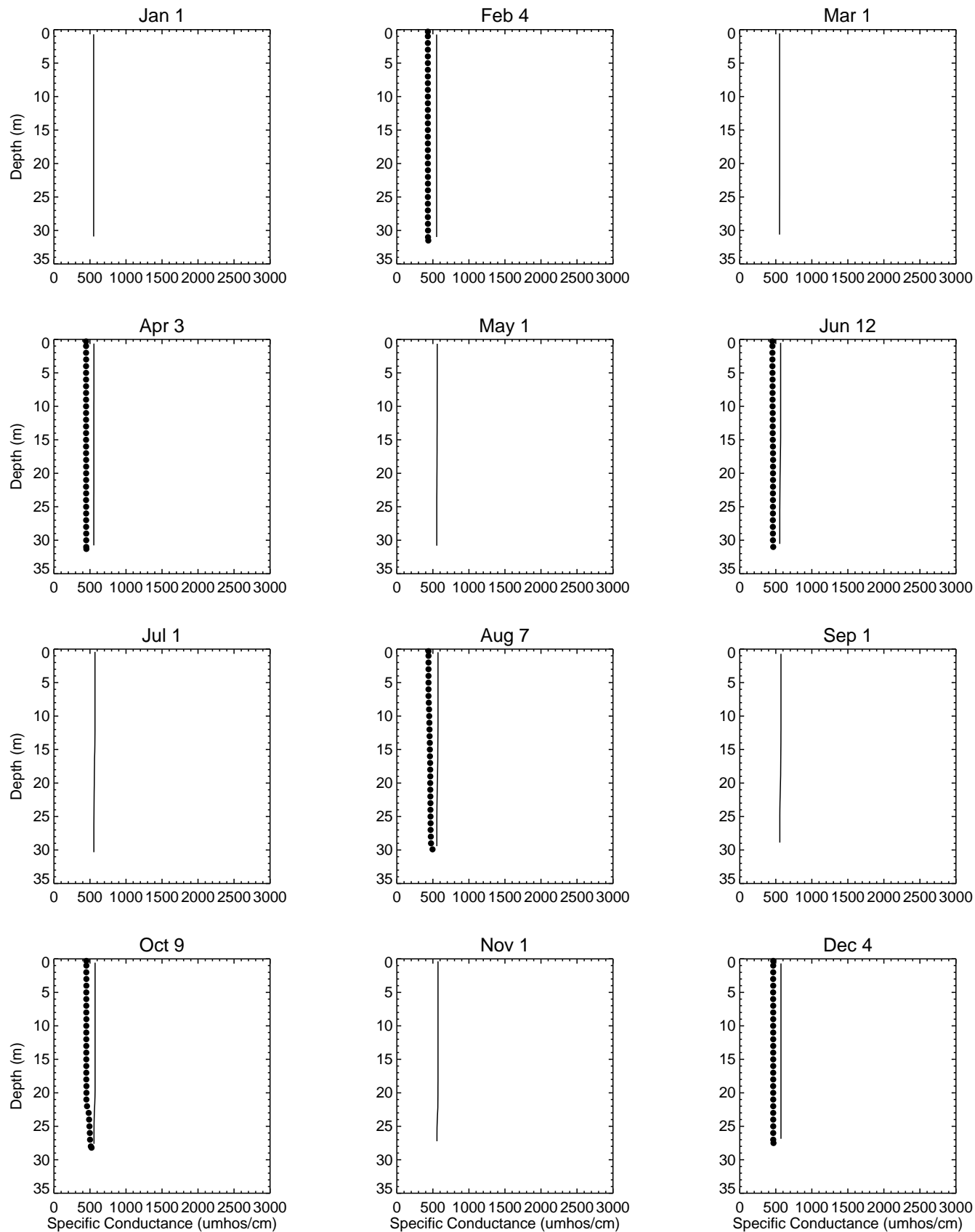Fri Jan 25 18:13:22 2013

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 1994

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:22 2013

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 1995

Profiles shown for dates with available data else model results for first day of month shown.

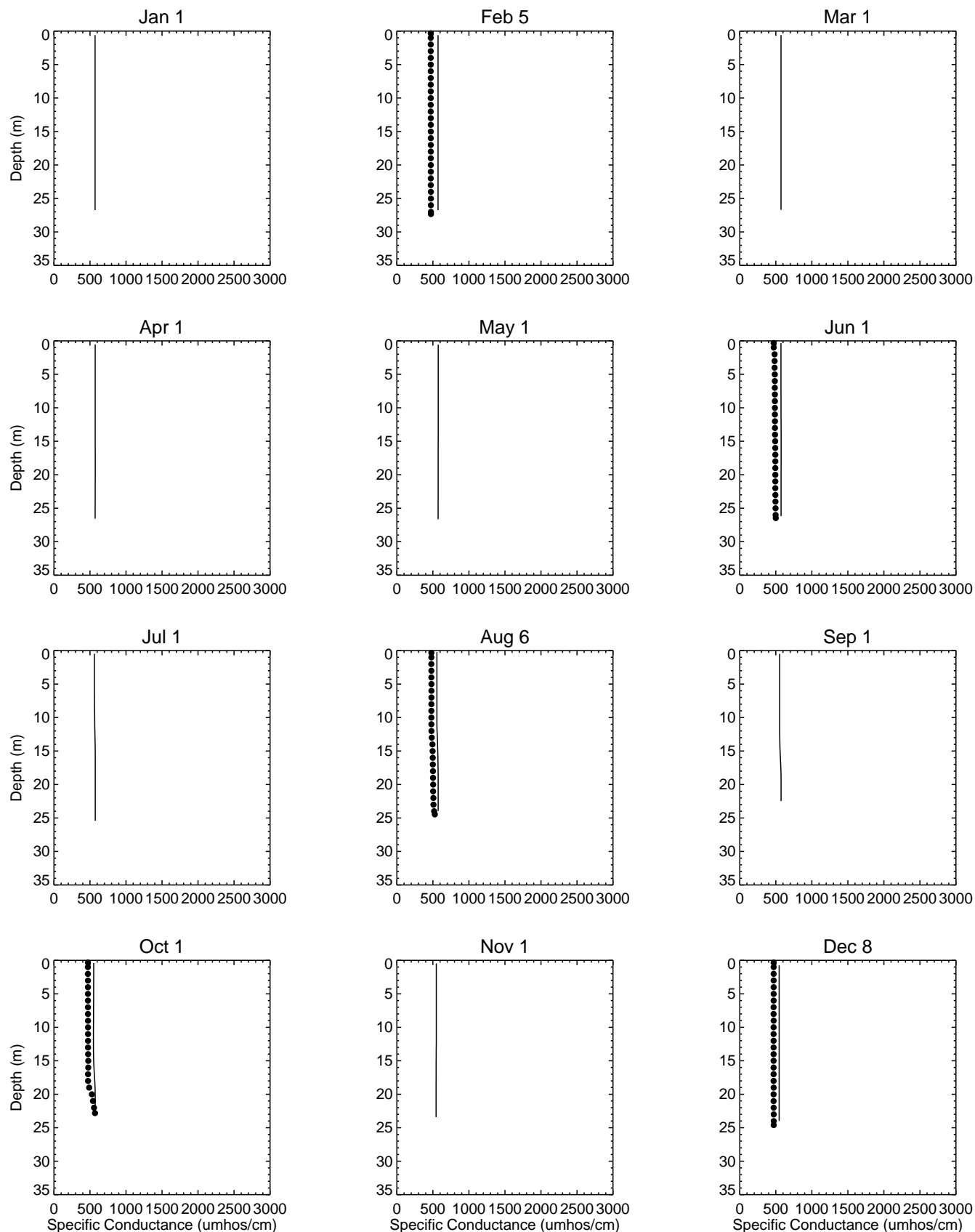CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:22 2013

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
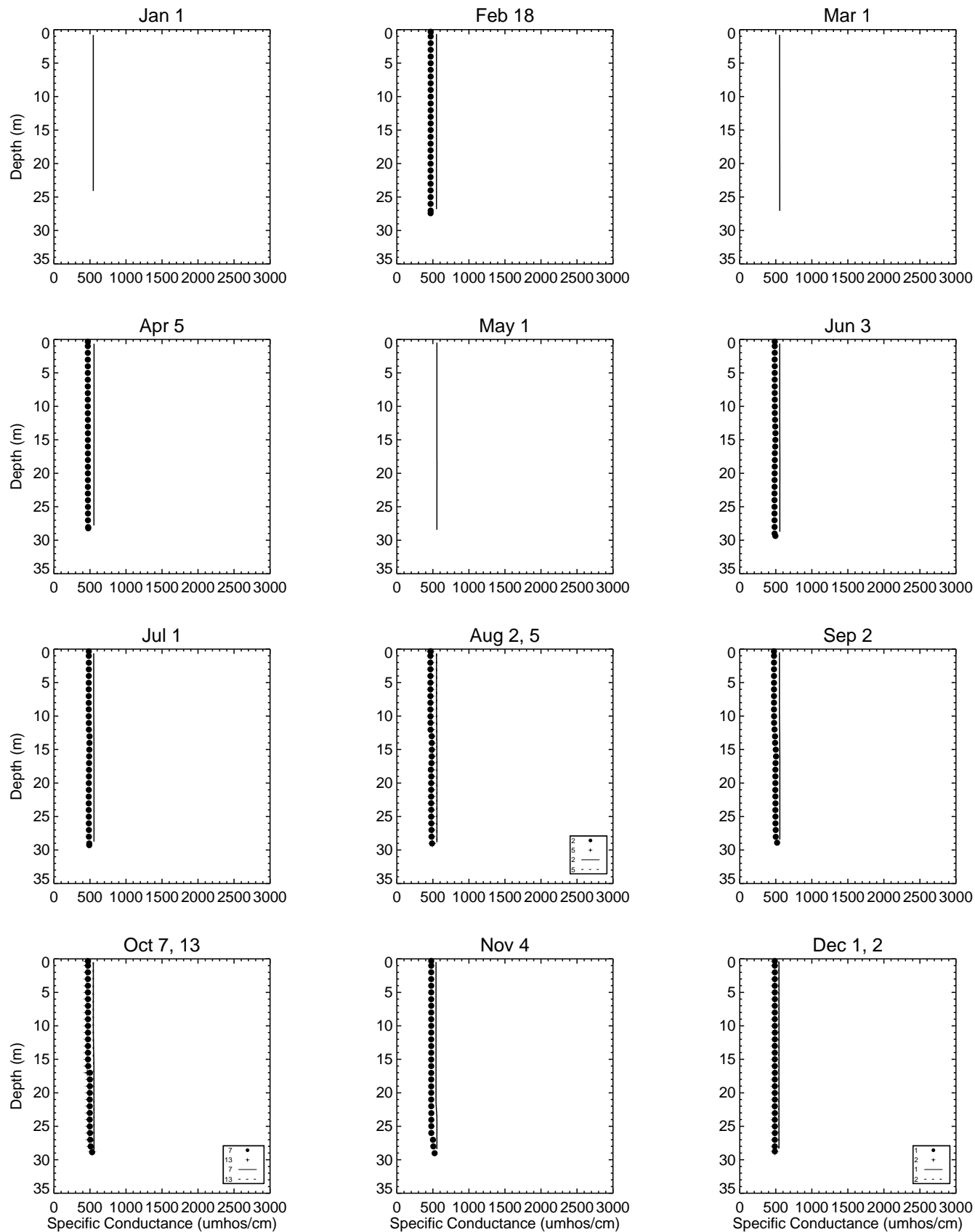near Buchanan Dam (Segment 13) - Specific Conductance - 1996

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 1997

Profiles shown for dates with available data else model results for first day of month shown.

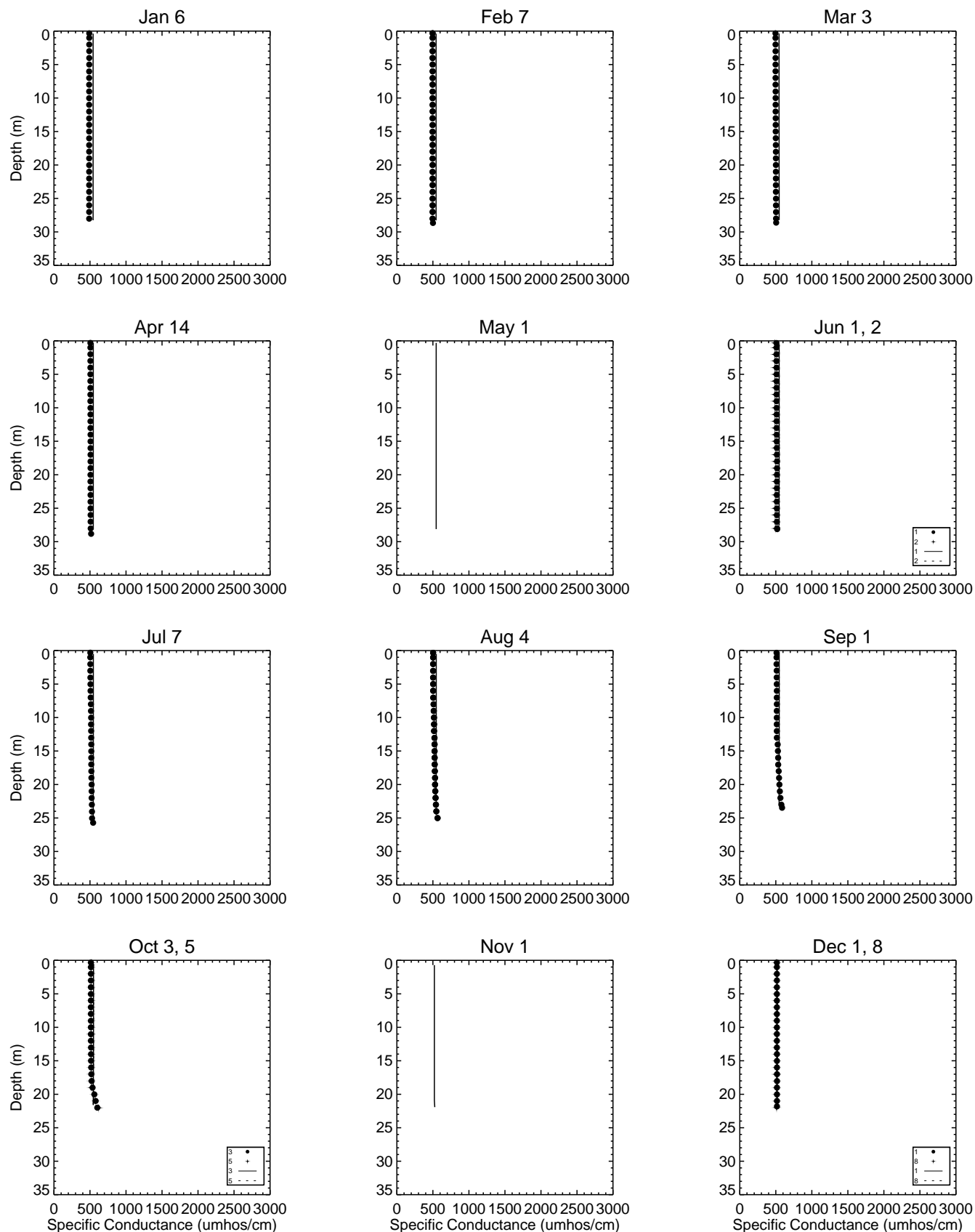CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-10
Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 1998
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 1999

Profiles shown for dates with available data else model results for first day of month shown.
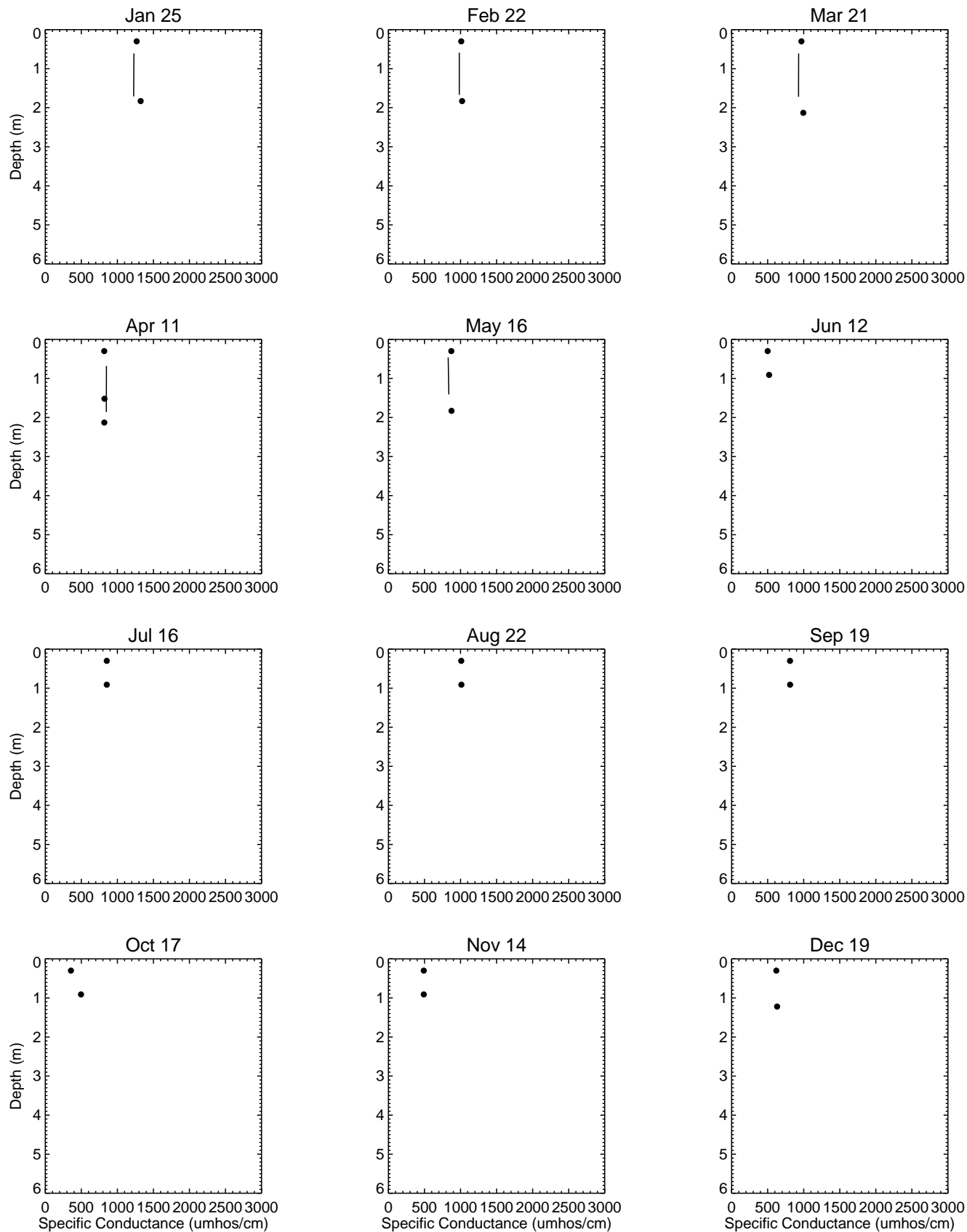
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:23 2013

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 2000

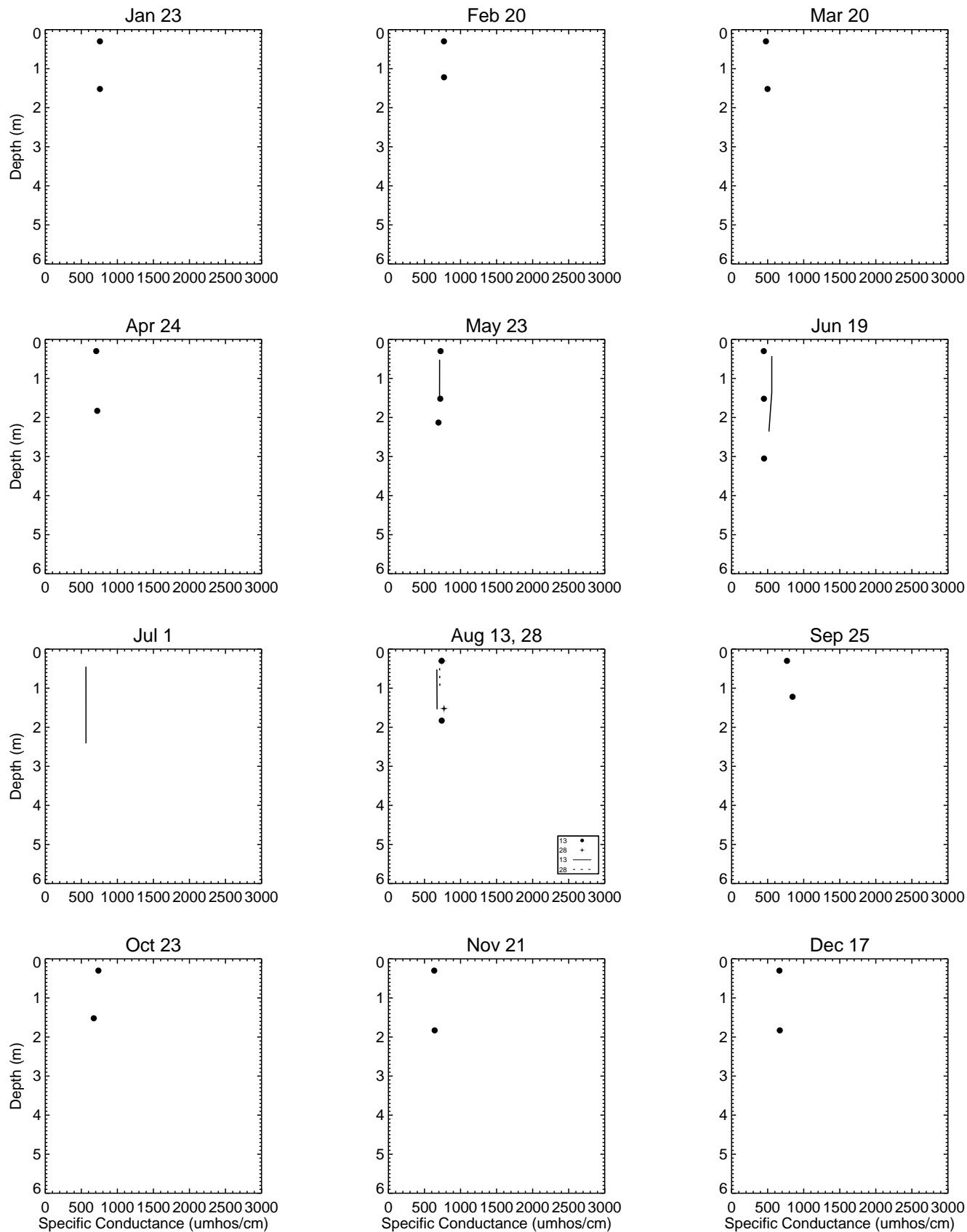*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 2001

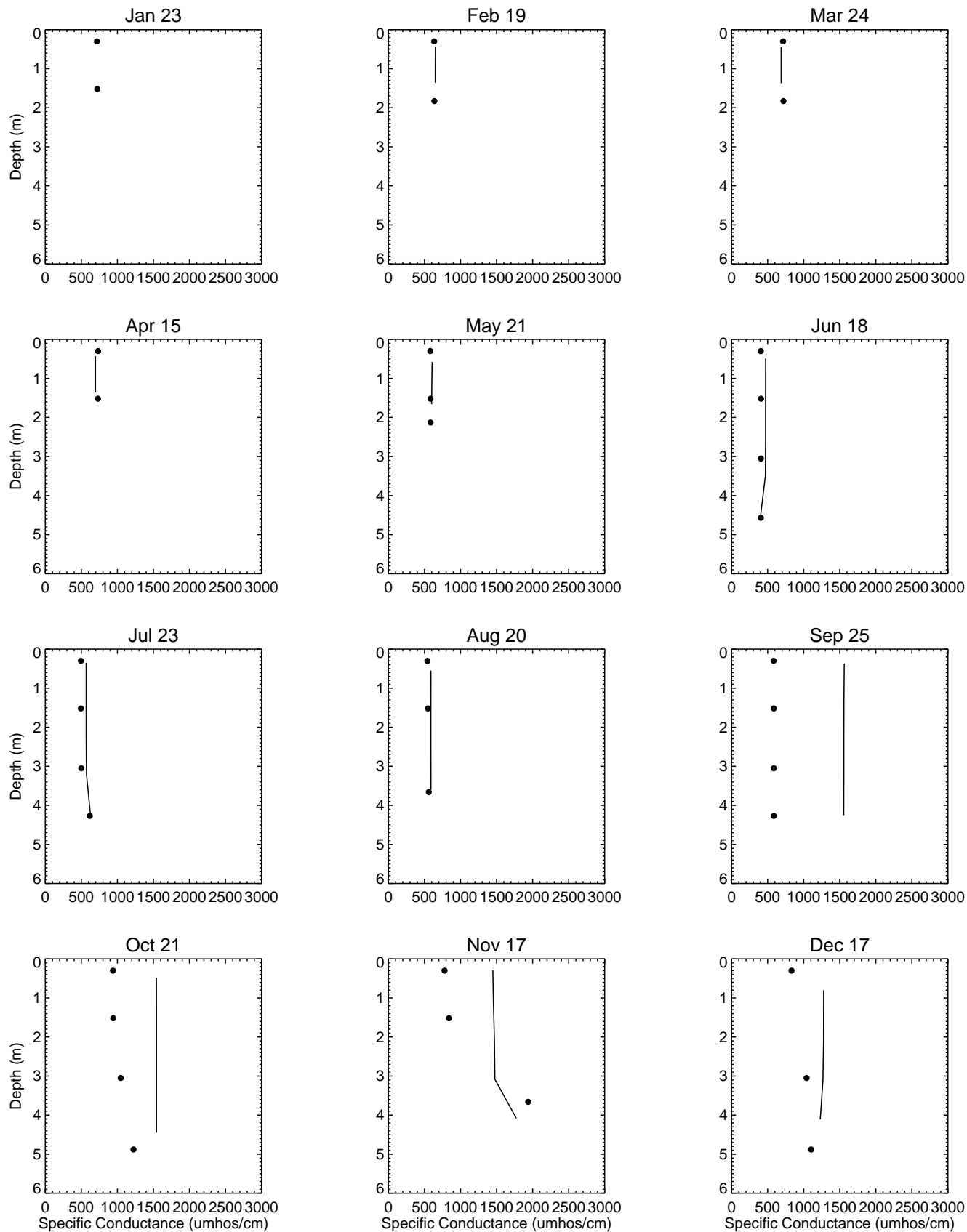*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 2002

Profiles shown for dates with available data else model results for first day of month shown.

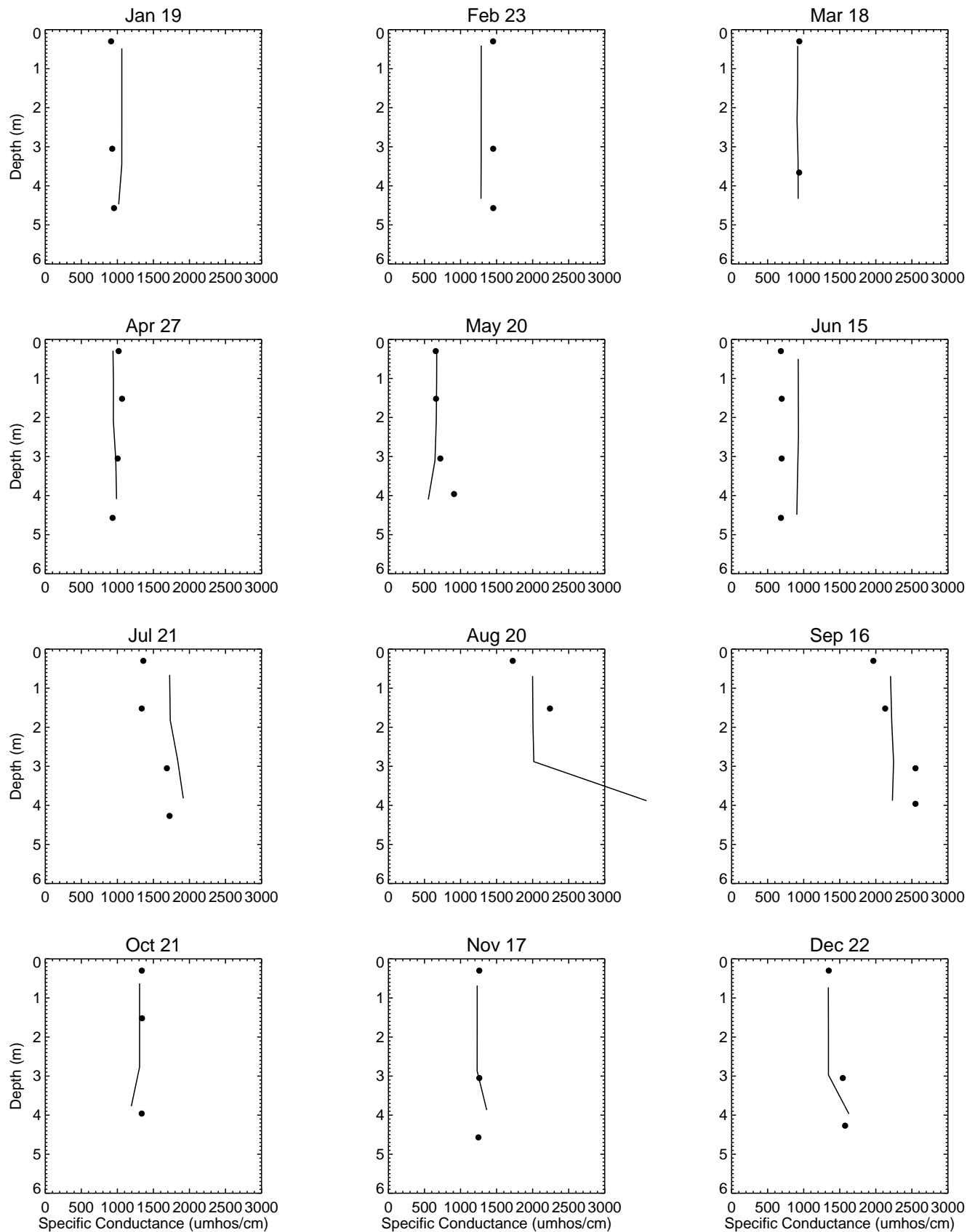CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 2003

Profiles shown for dates with available data else model results for first day of month shown.

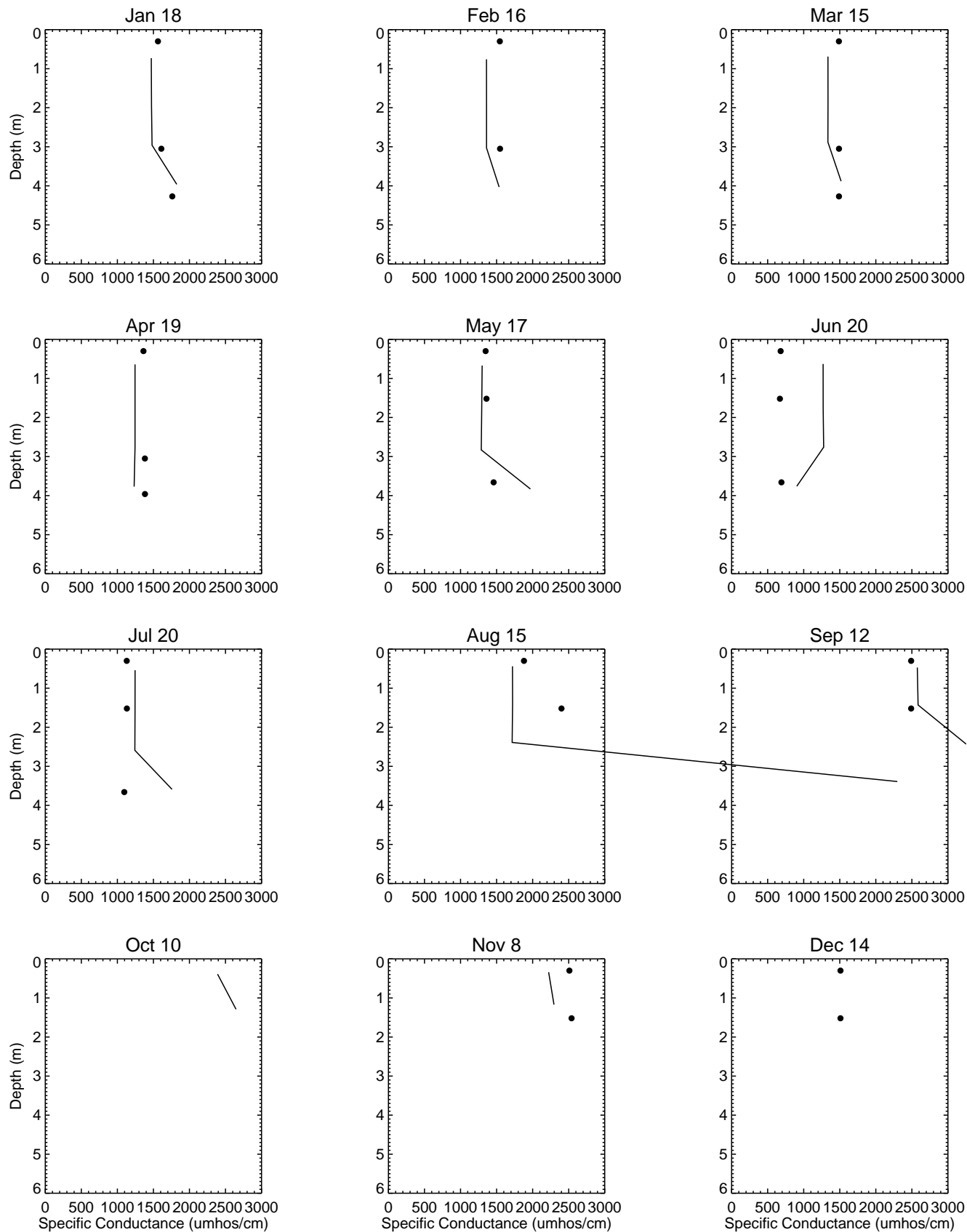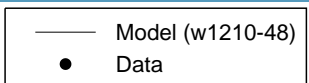CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 Feb 16 Mar 1 Apr 1 May 1 Jun 15 Jul 1 Aug 12 Sep 1 Oct 7 Nov 1 Dec 9

Depth (m)

Specific Conductance (umhos/cm)

Model (w1210-48)
Data

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 2004

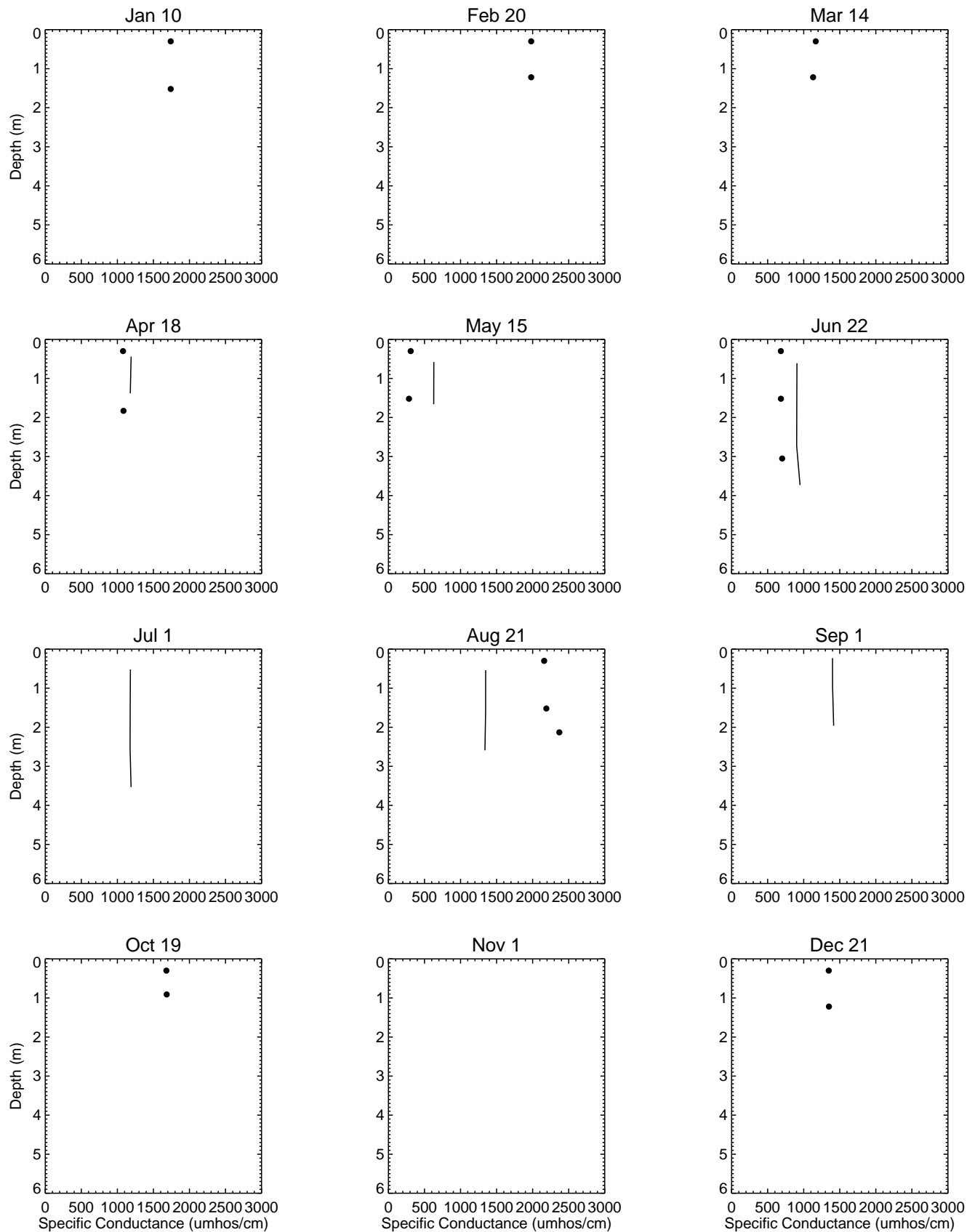*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:23 2013

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 2005

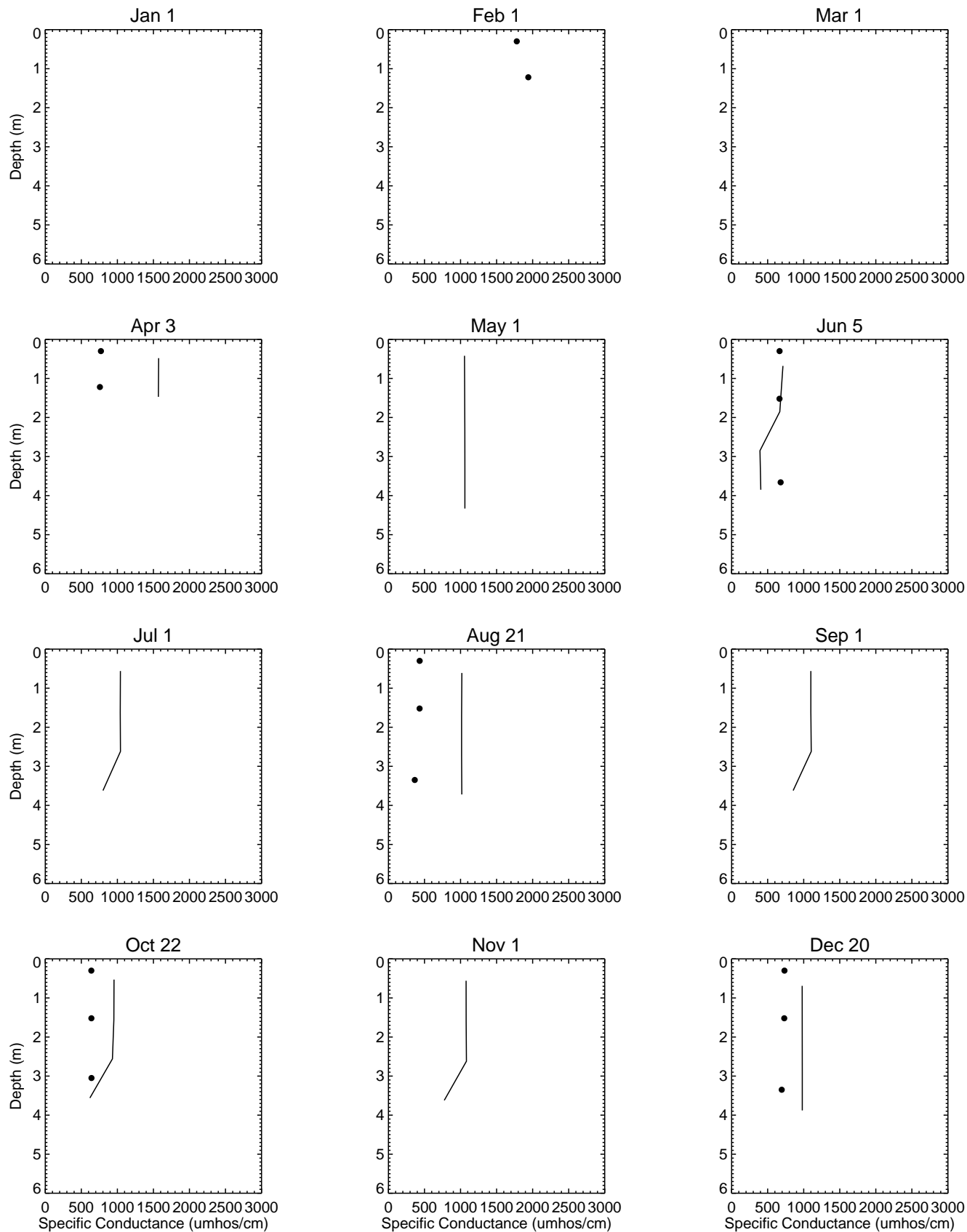*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:23 2013

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 2006

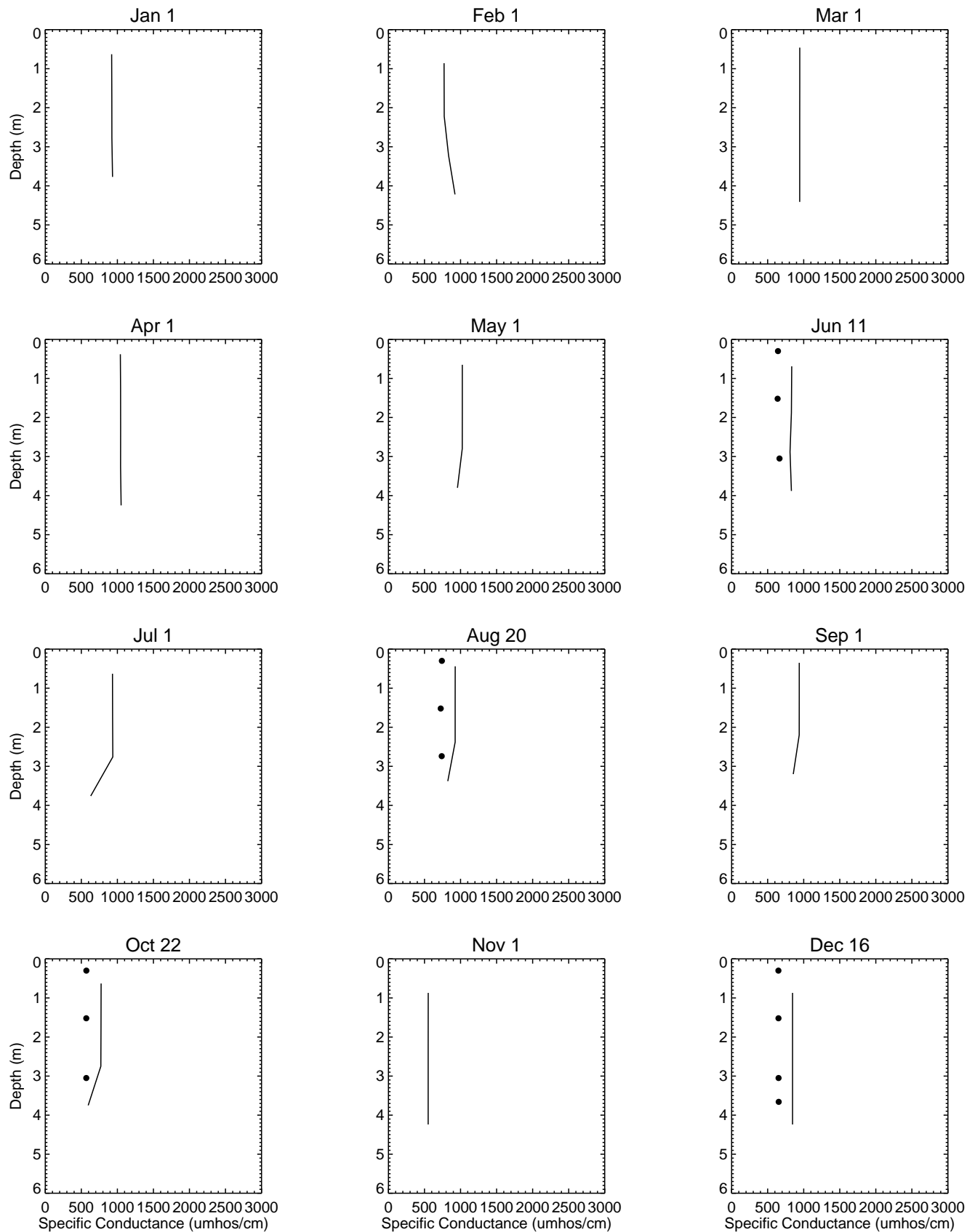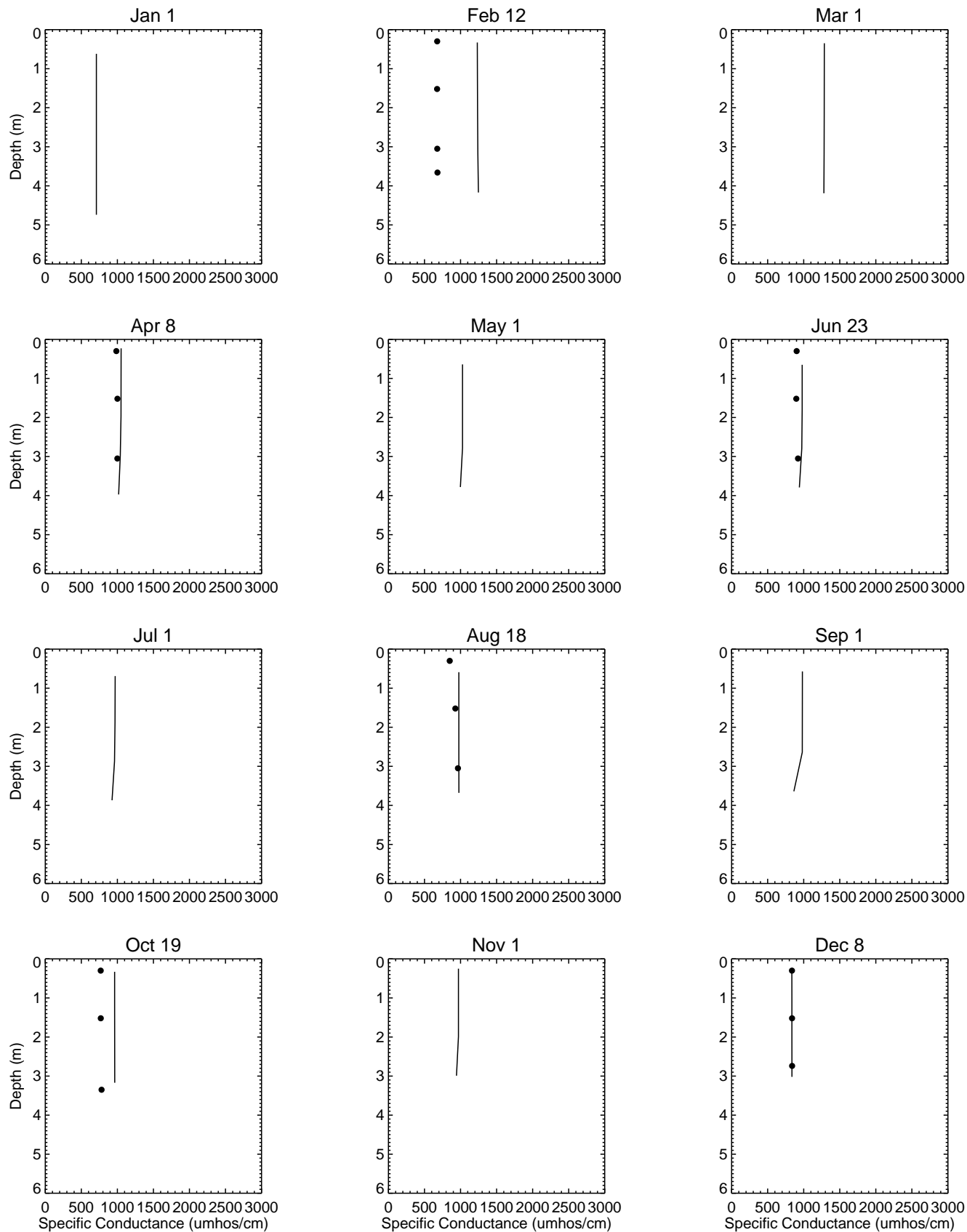*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:23 2013

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 2007

Profiles shown for dates with available data else model results for first day of month shown.

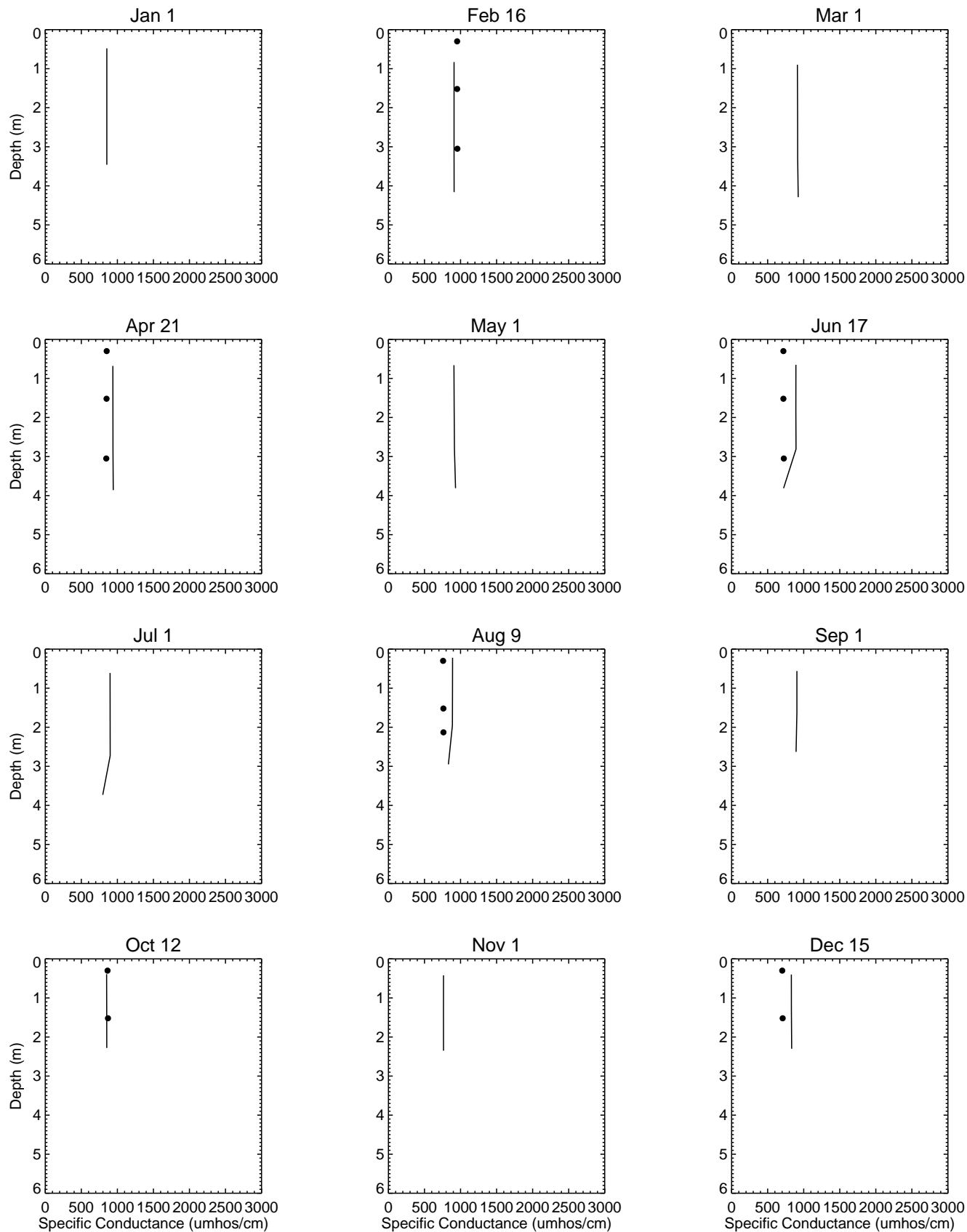CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 2008

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 2009

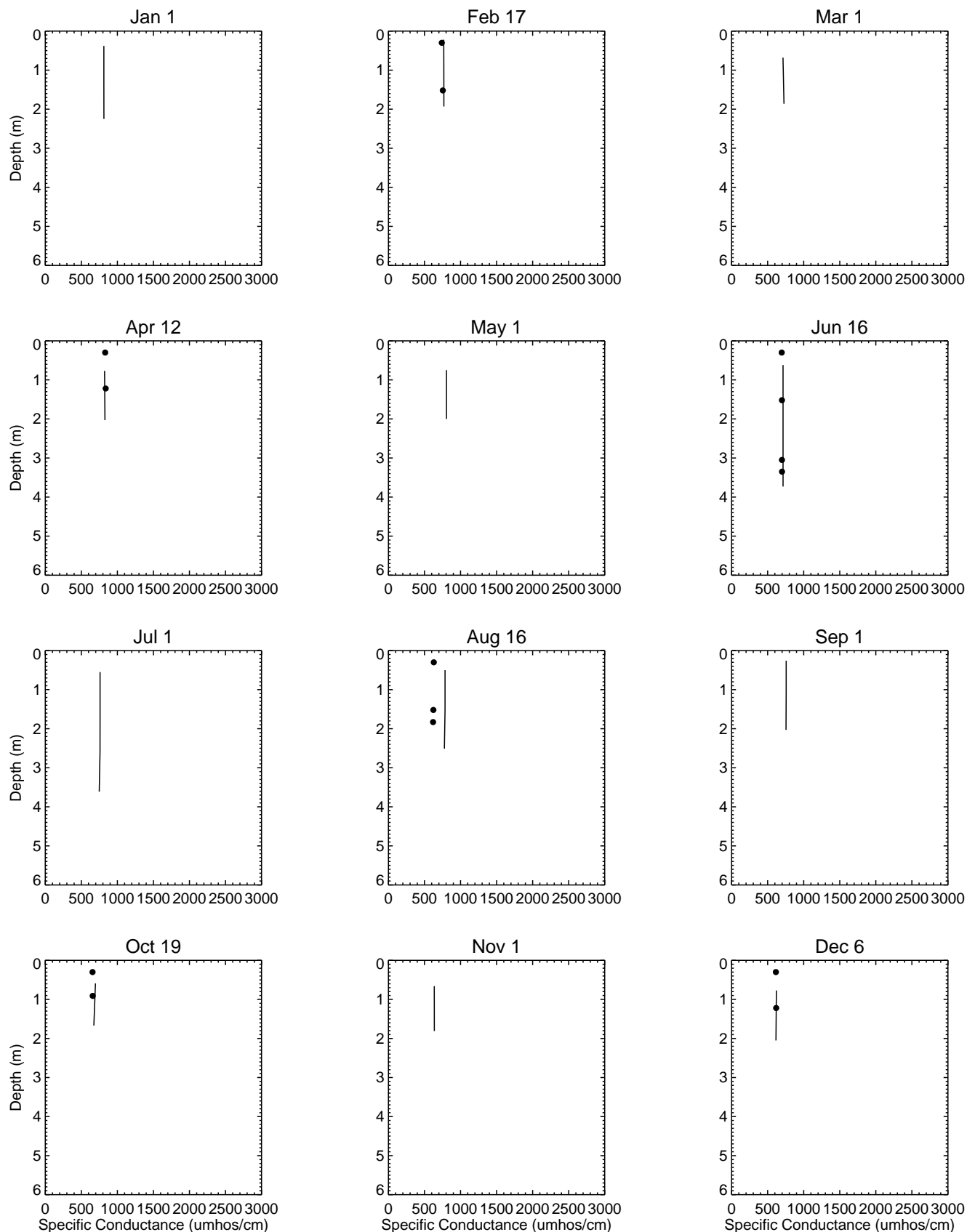*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 2010

Profiles shown for dates with available data else model results for first day of month shown.

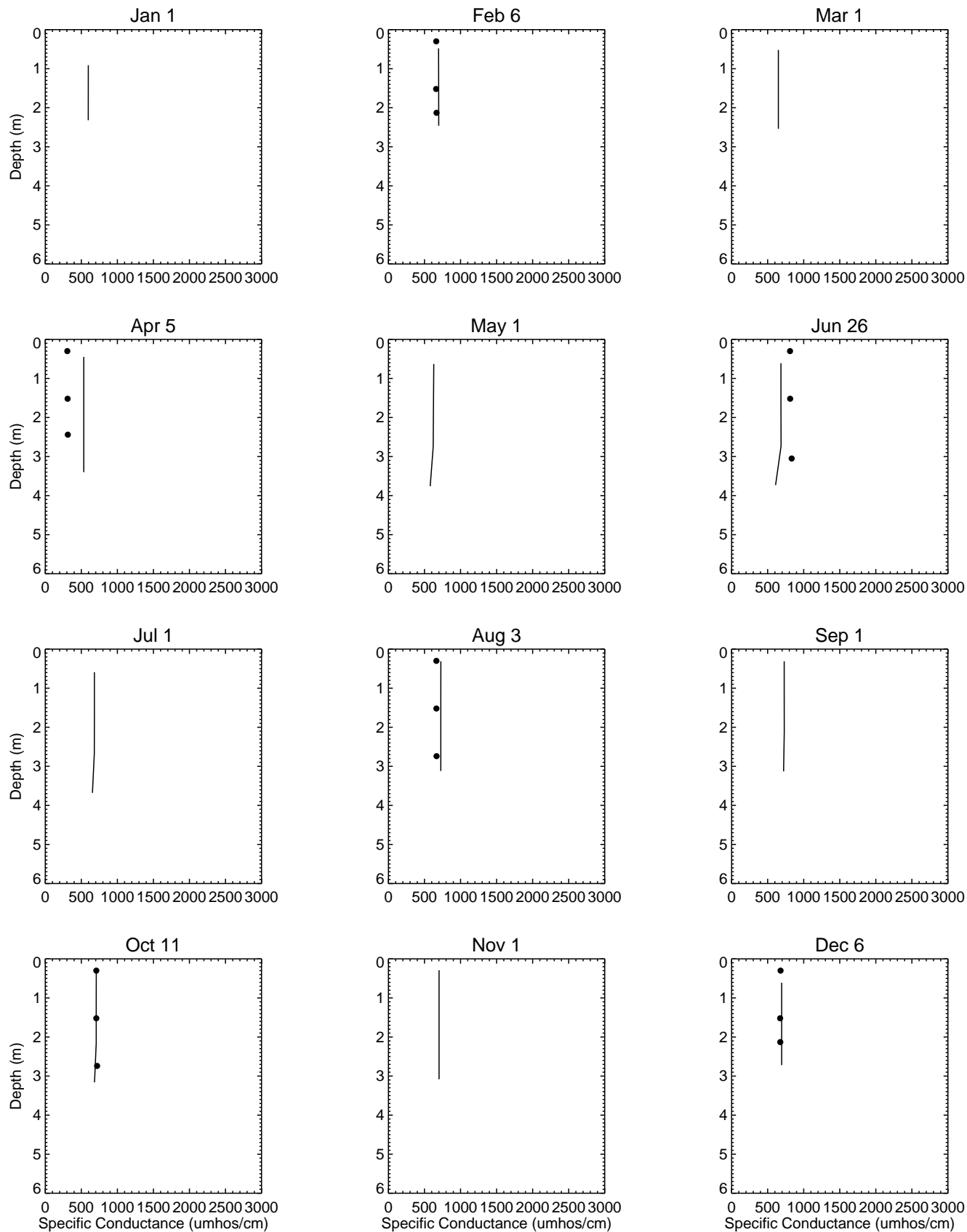CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-10

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Specific Conductance - 2011

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Jan 25 · Feb 22 · Mar 21 · Apr 11 · May 16 · Jun 12 · Jul 16 · Aug 22 · Sep 19 · Oct 17 · Nov 14 · Dec 19

Depth (m) — Specific Conductance (umhos/cm)

——— Model (w1210-48)
● Data

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 1984

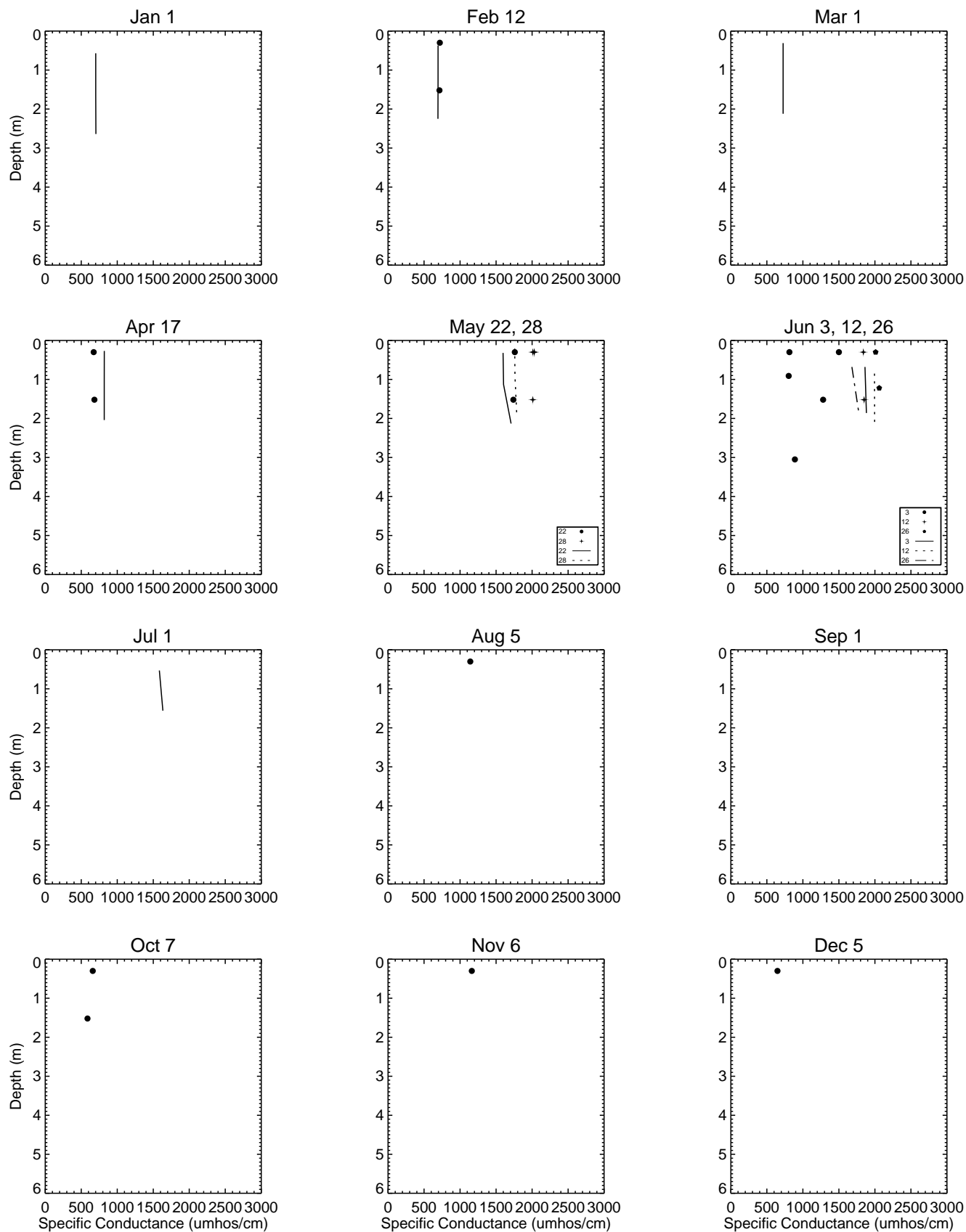*Profiles shown for dates with available data else model results for first day of month shown.*
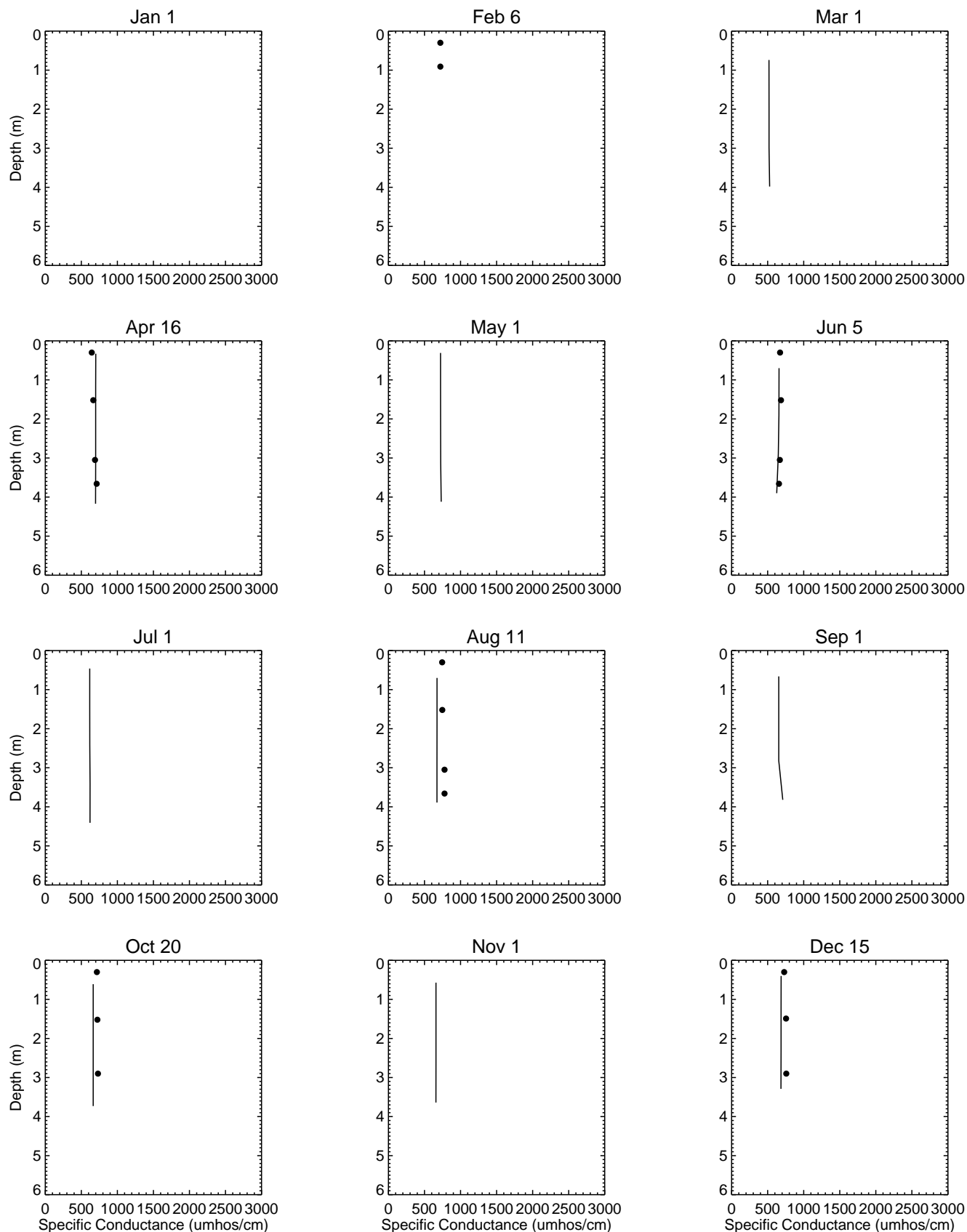
ANCHOR QEA PARSONS

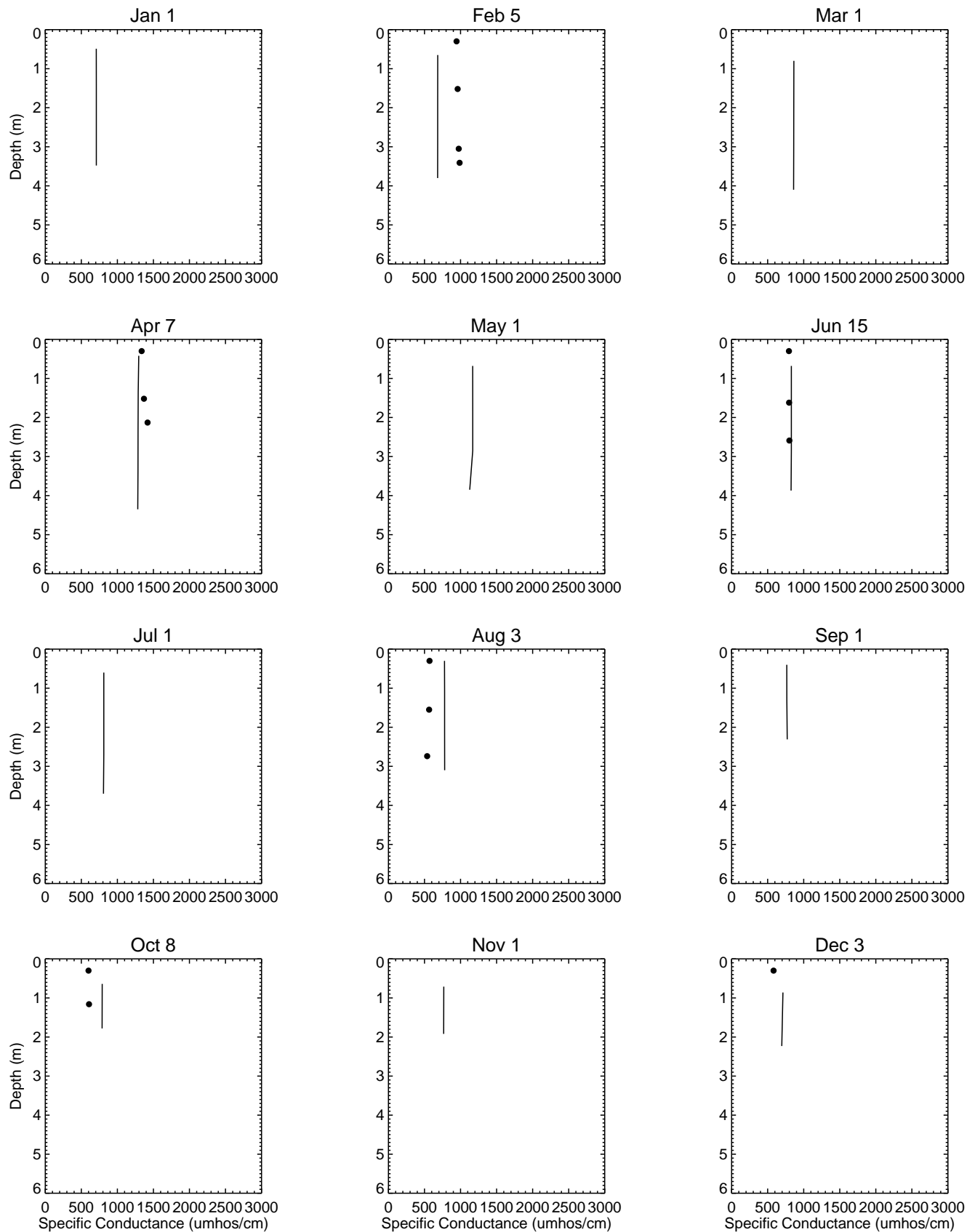CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 1985

Profiles shown for dates with available data else model results for first day of month shown.

Model (w1210-48)
Data

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 1986

Profiles shown for dates with available data else model results for first day of month shown.
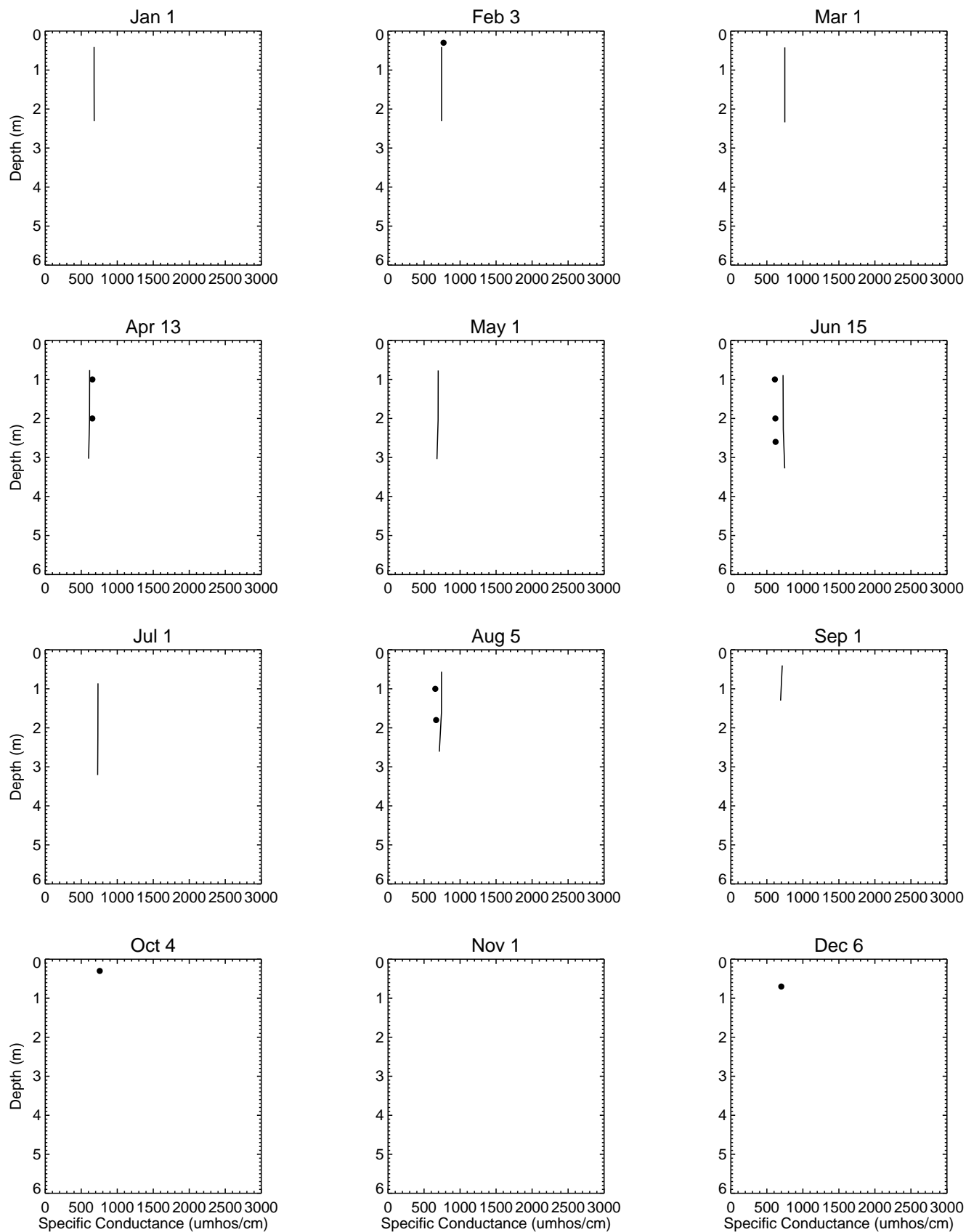
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 1987

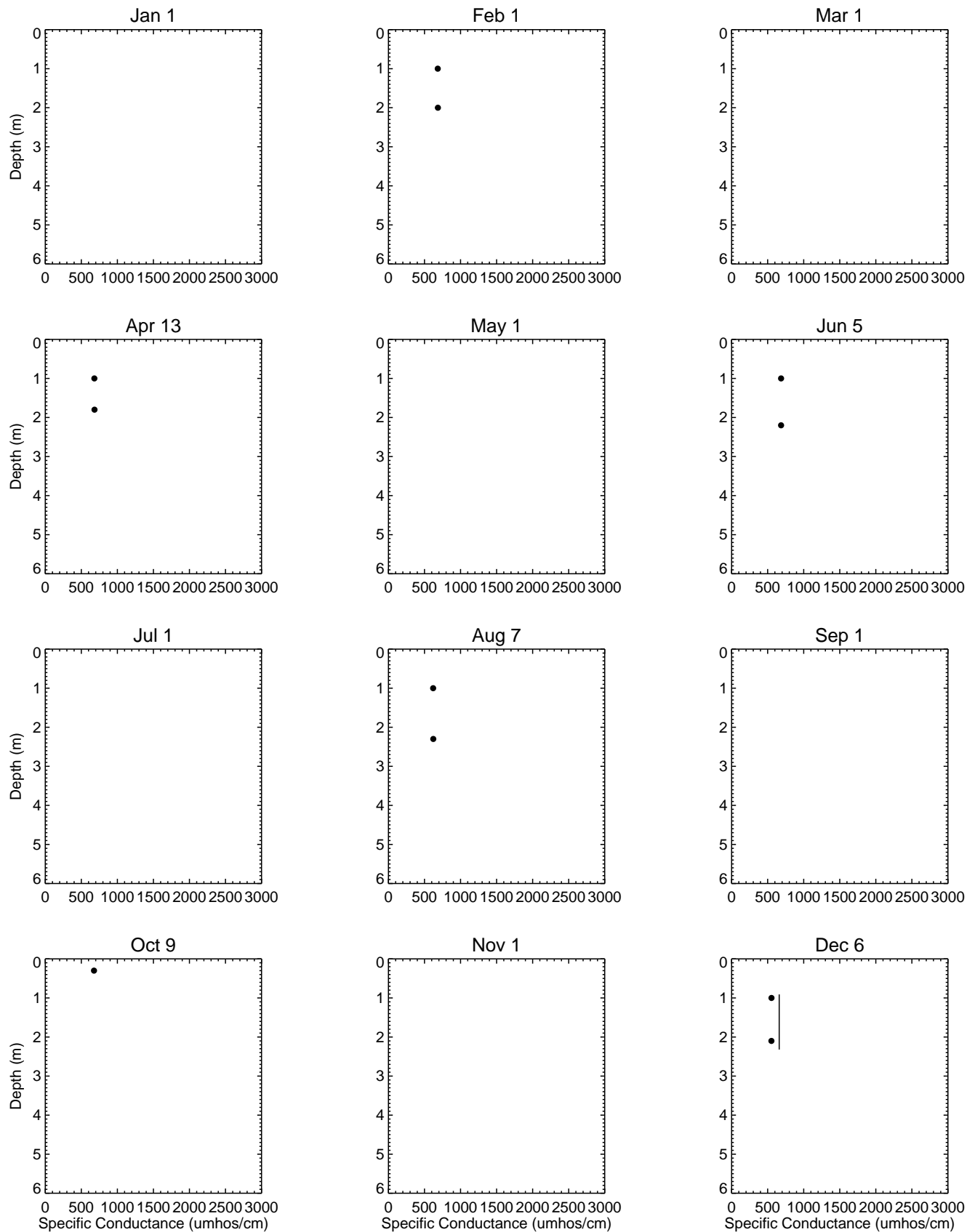*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 1989

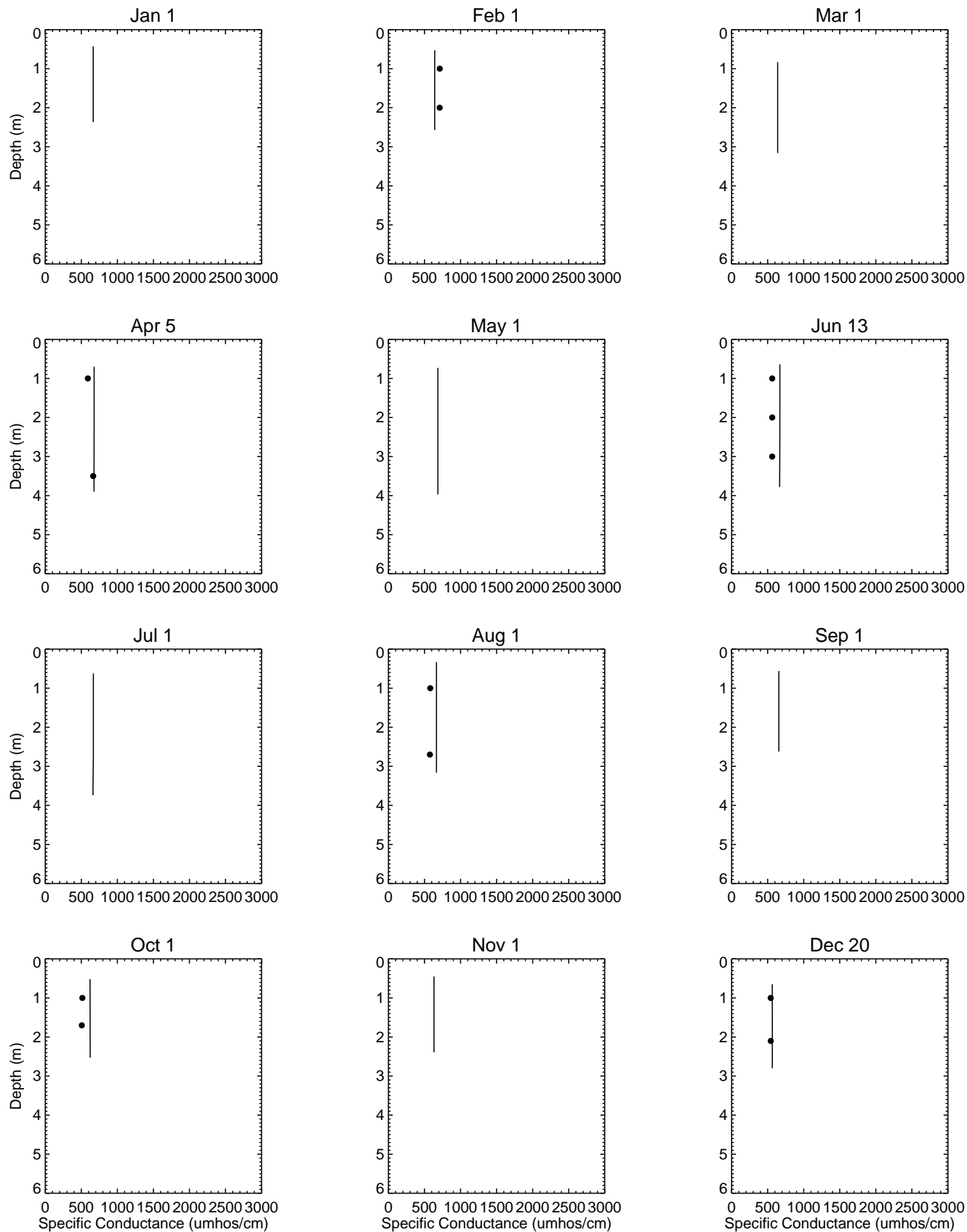*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 1990

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

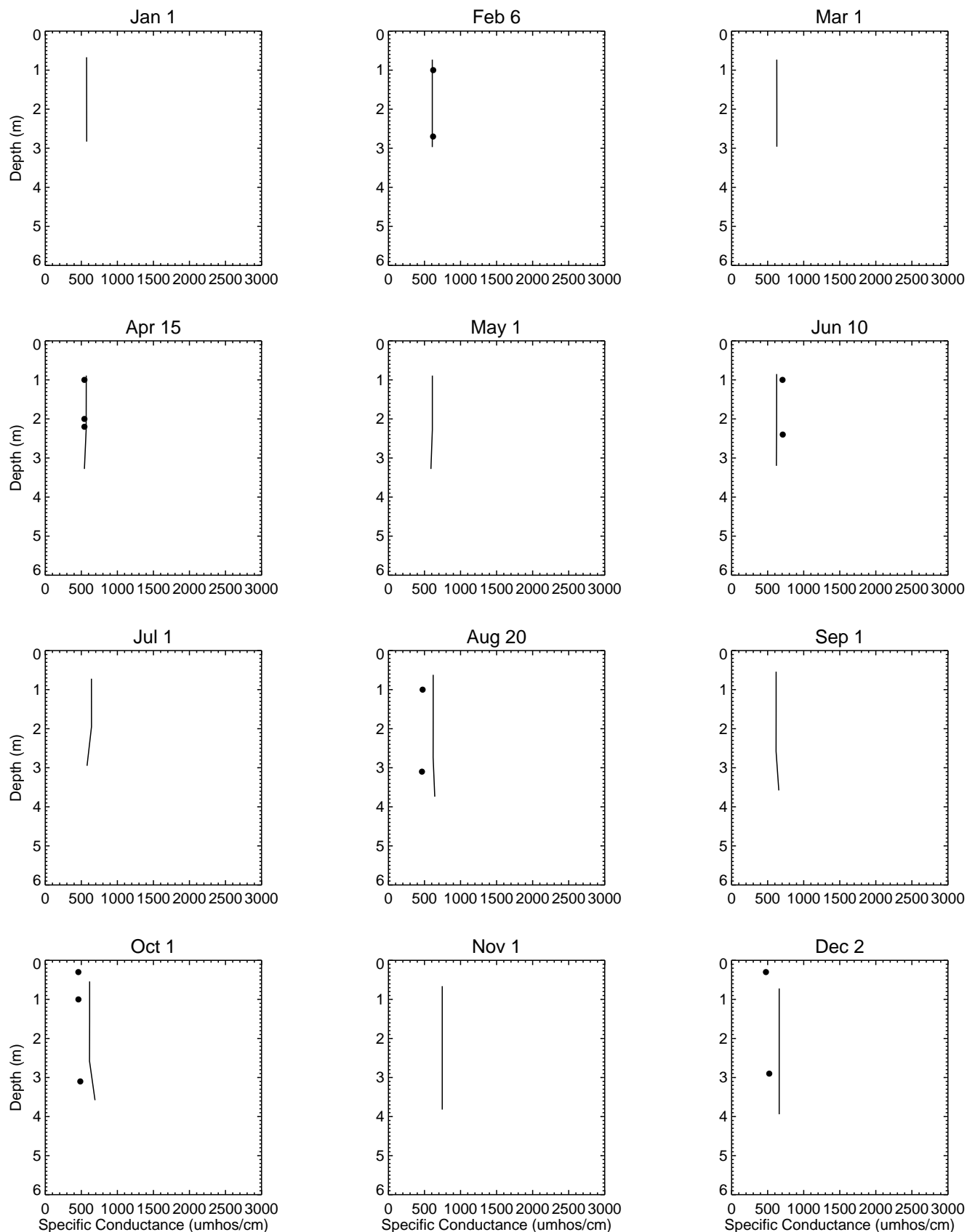Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 1991

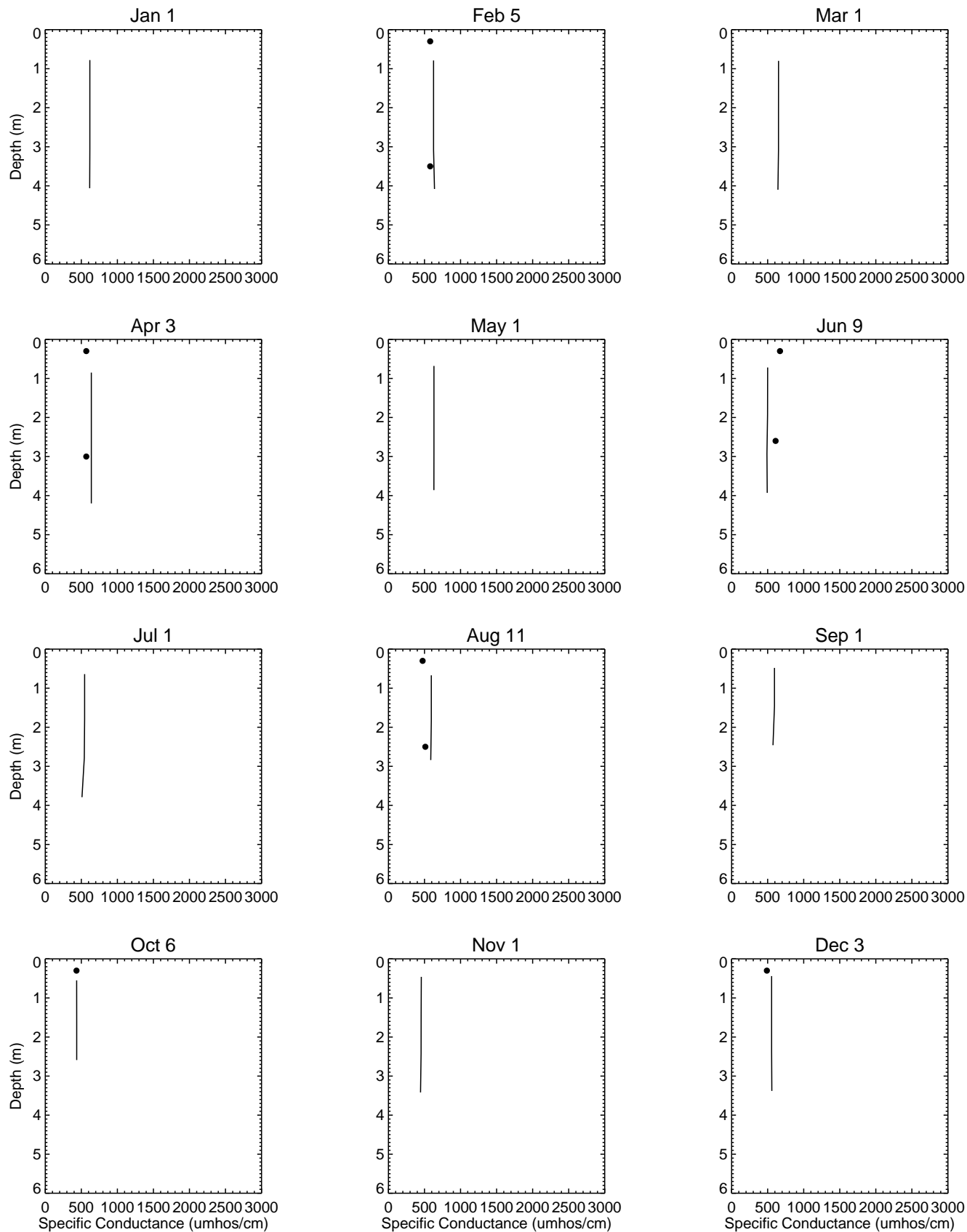*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 1993

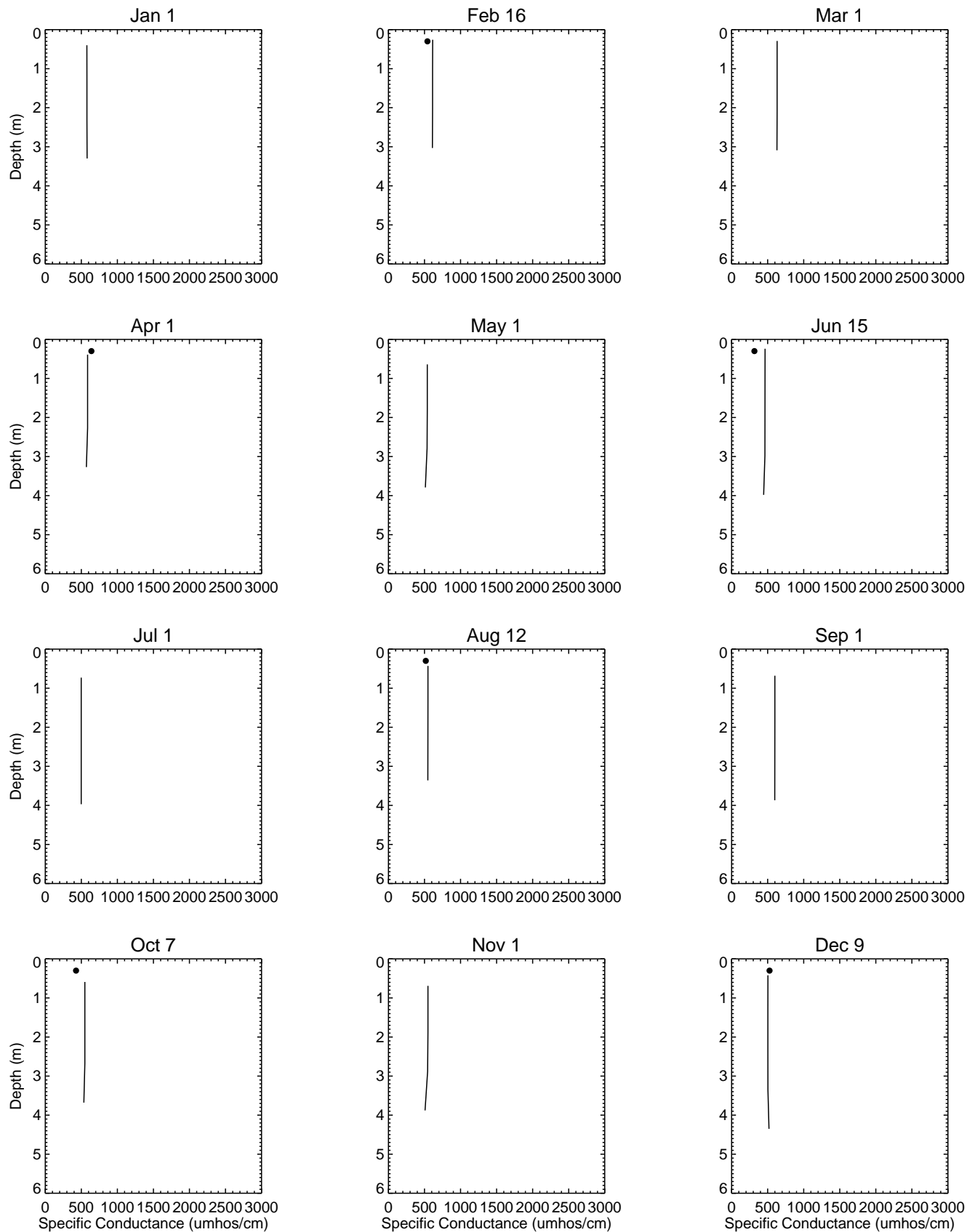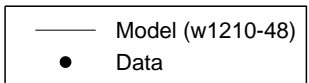*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
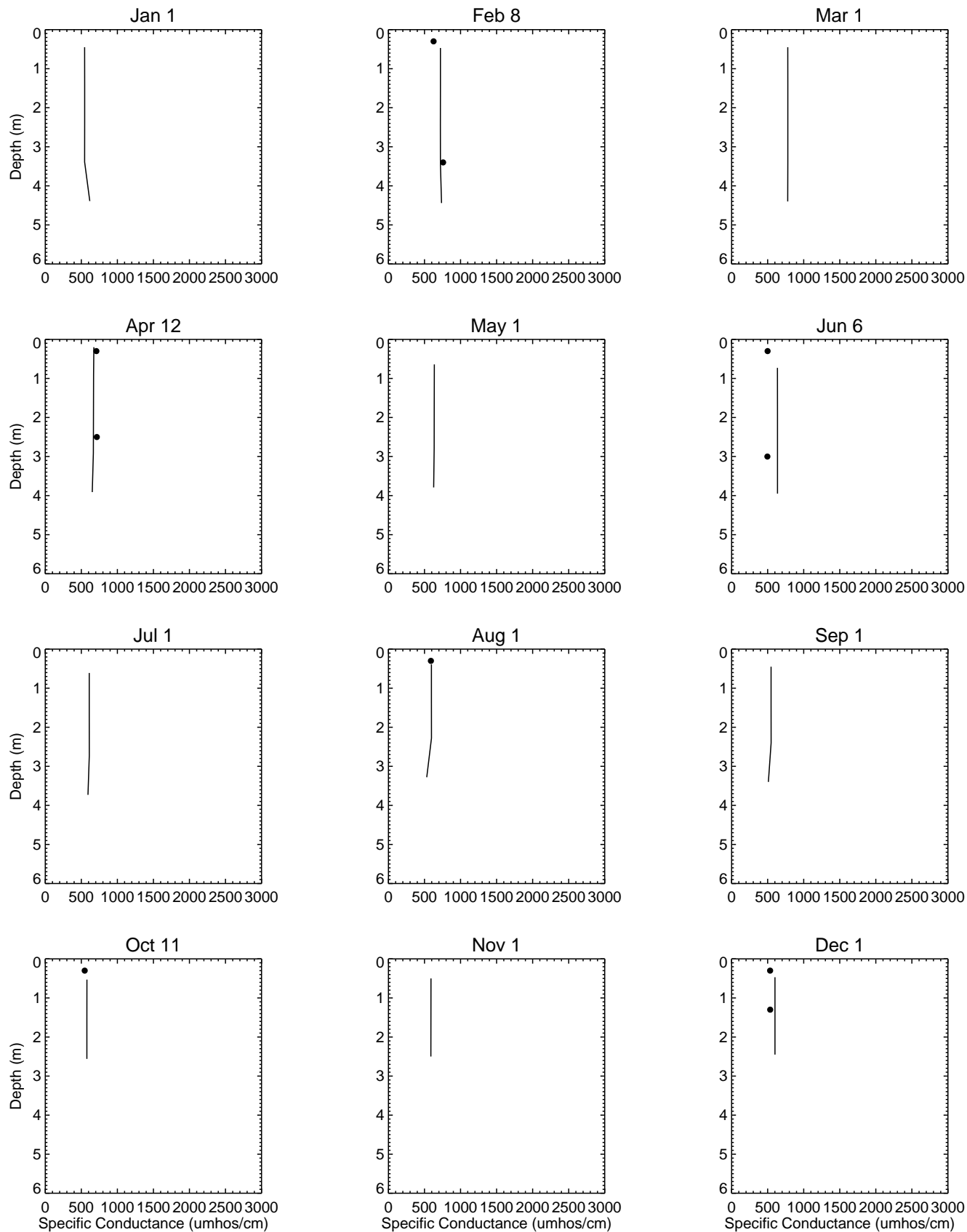
Lower Colorado River Authority

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 1994

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
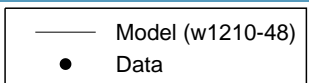Fri Jan 25 18:13:26 2013

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 1995

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
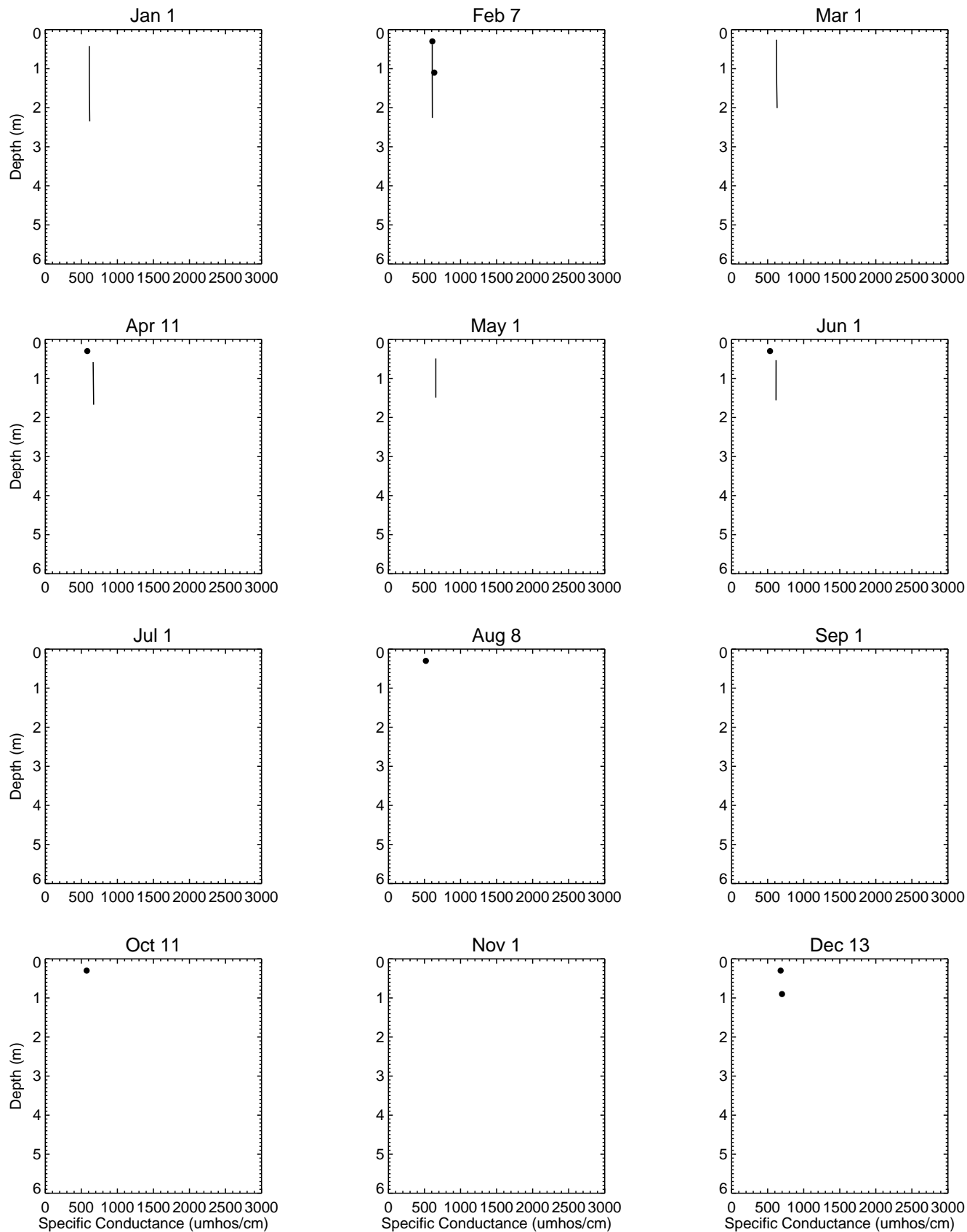Lower Colorado River Authority

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 1996

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
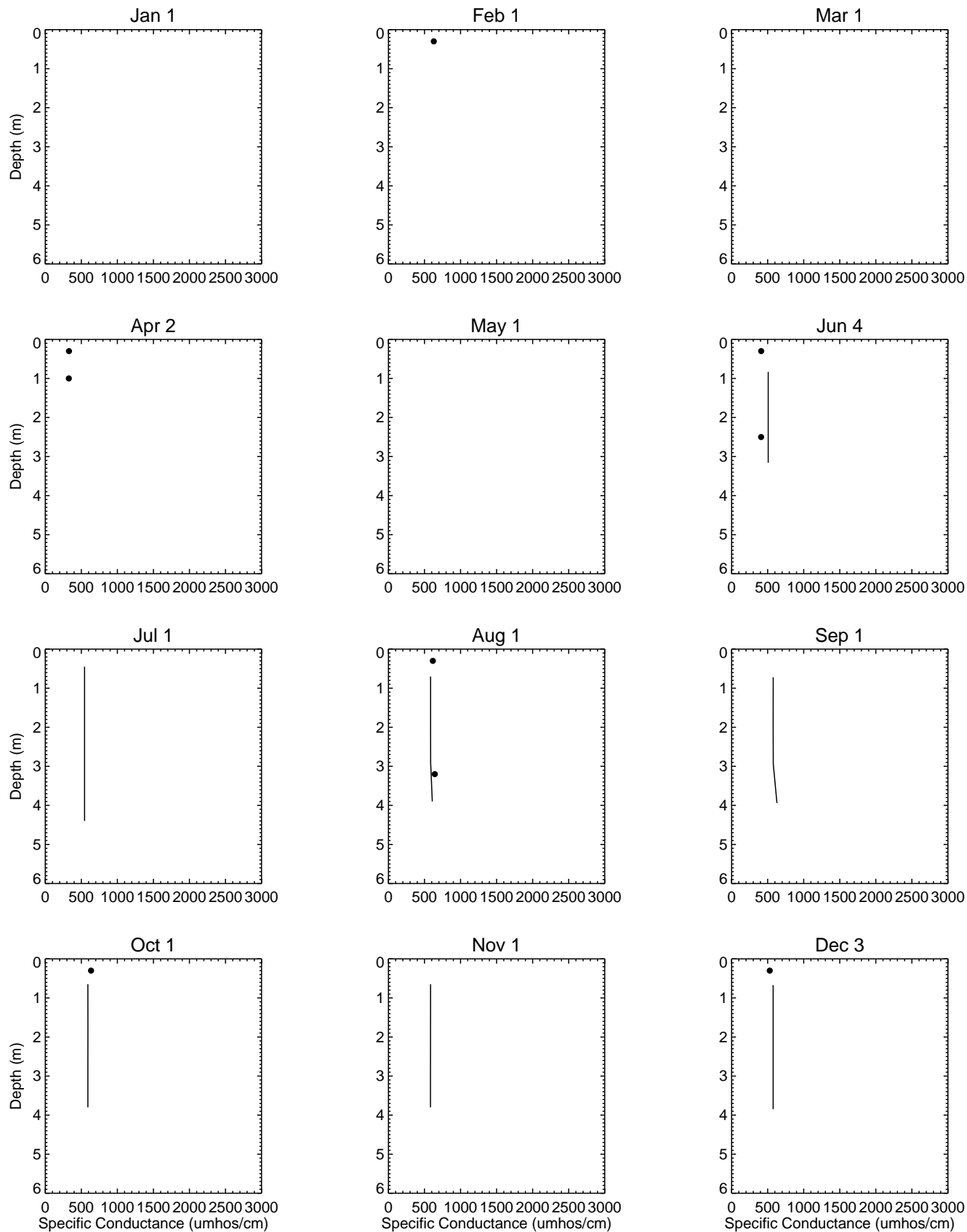Fri Jan 25 18:13:26 2013

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 1997

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
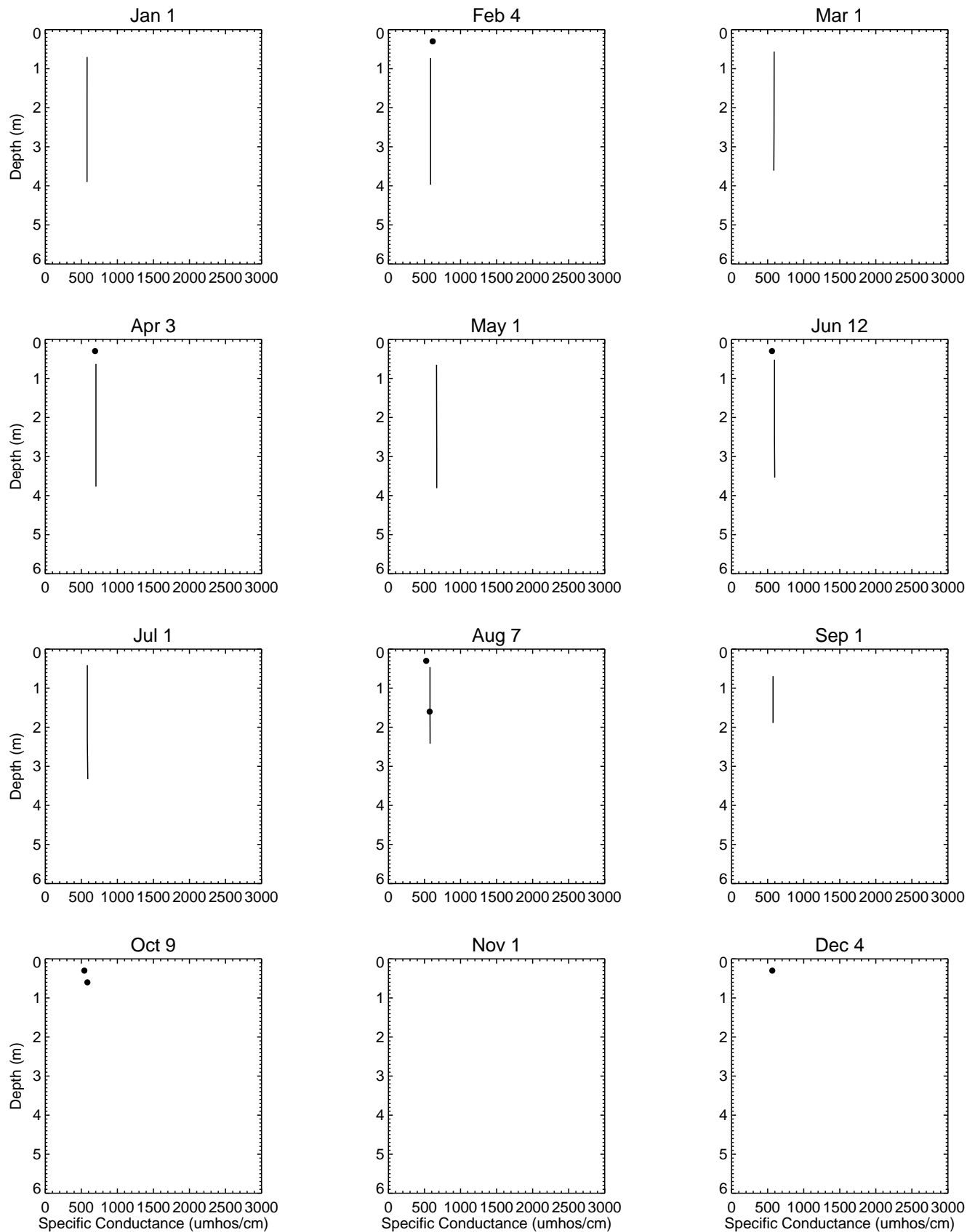
Lower Colorado River Authority

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 1998

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 1999

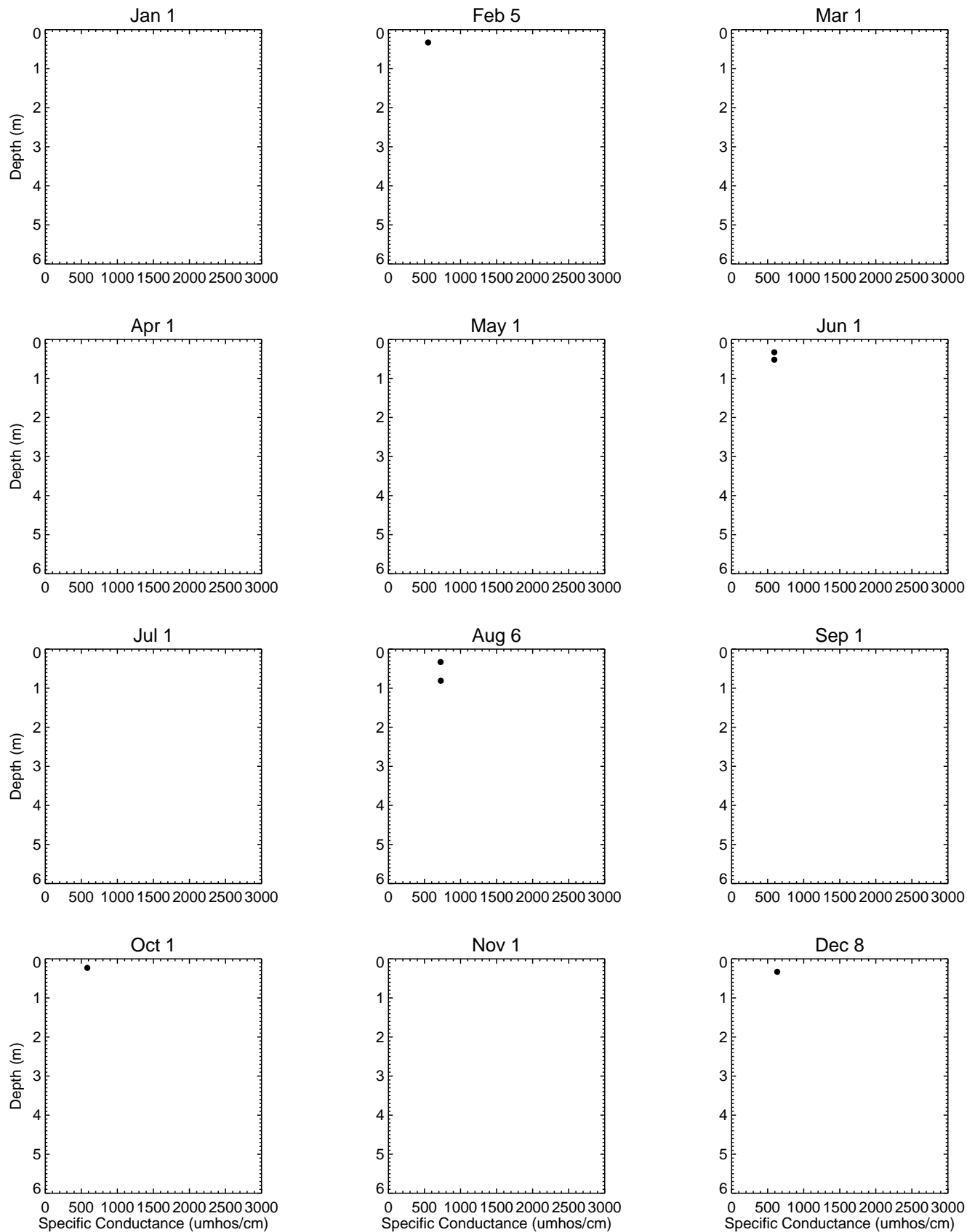*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 — Feb 1 — Mar 1 — Apr 13 — May 1 — Jun 5 — Jul 1 — Aug 7 — Sep 1 — Oct 9 — Nov 1 — Dec 6

Depth (m) / Specific Conductance (umhos/cm)
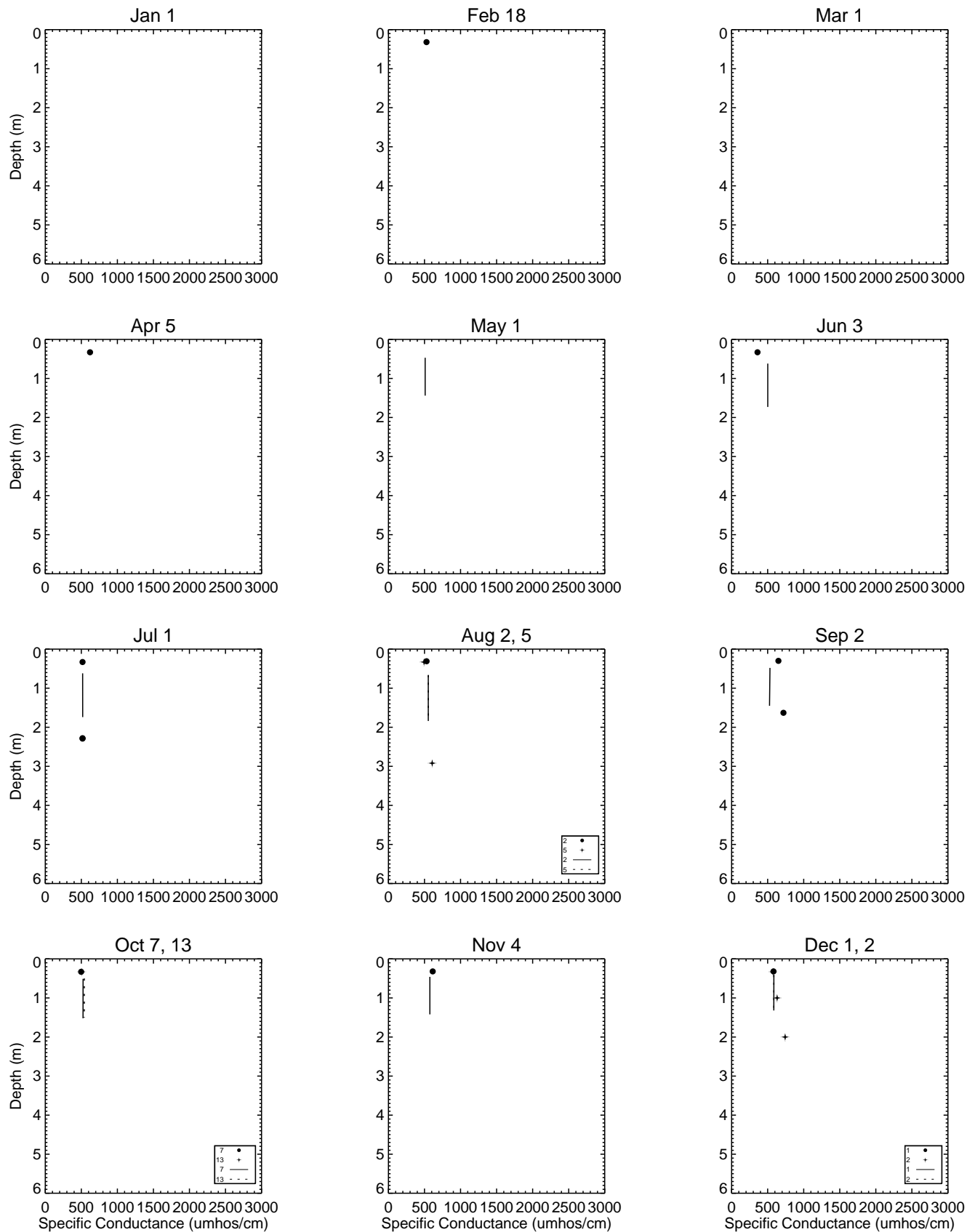
Model (w1210-48)
● Data

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 2000

Profiles shown for dates with available data else model results for first day of month shown.
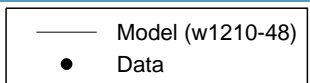
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:26 2013

Jan 1 Feb 1 Mar 1 Apr 5 May 1 Jun 13 Jul 1 Aug 1 Sep 1 Oct 1 Nov 1 Dec 20

Depth (m)
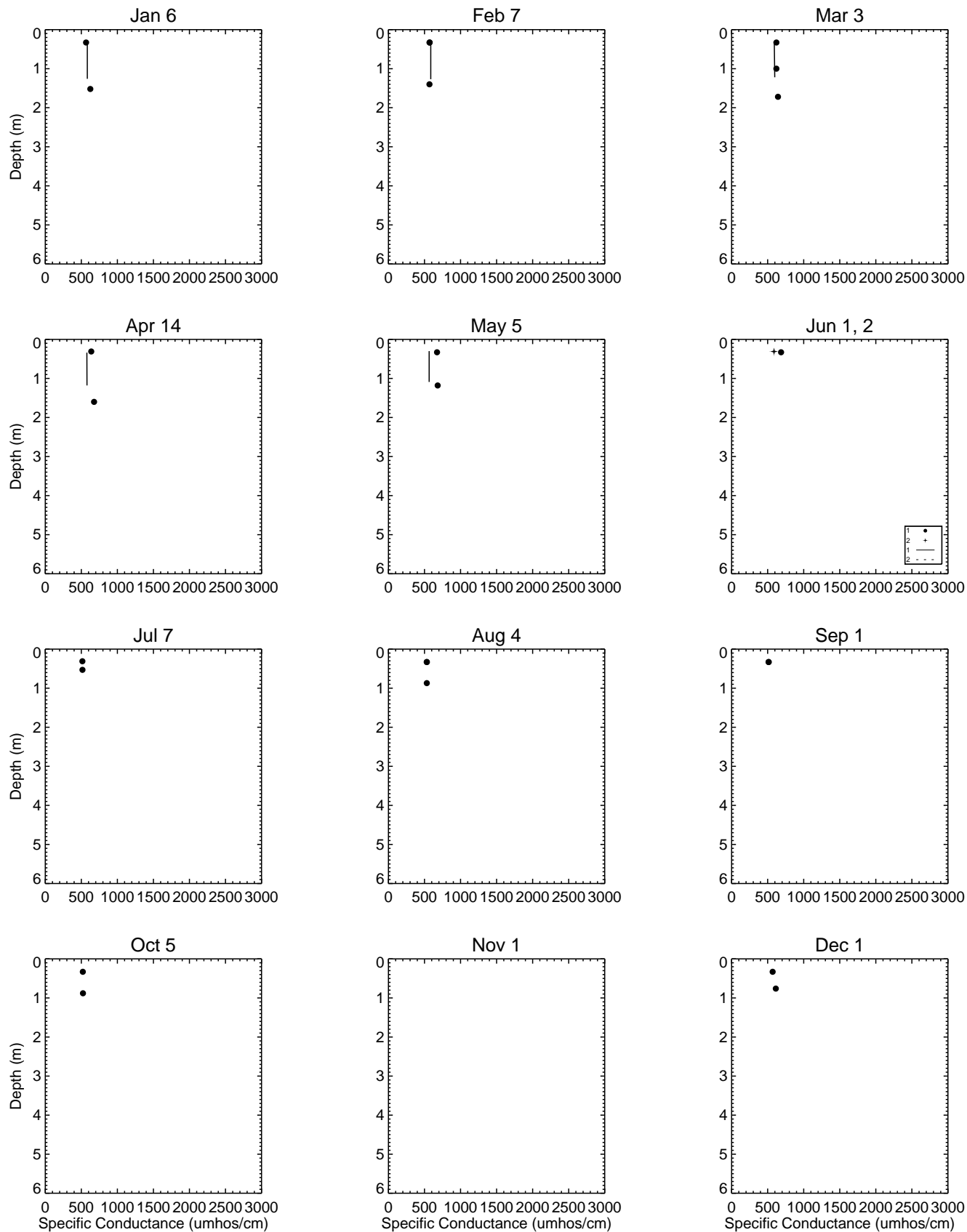
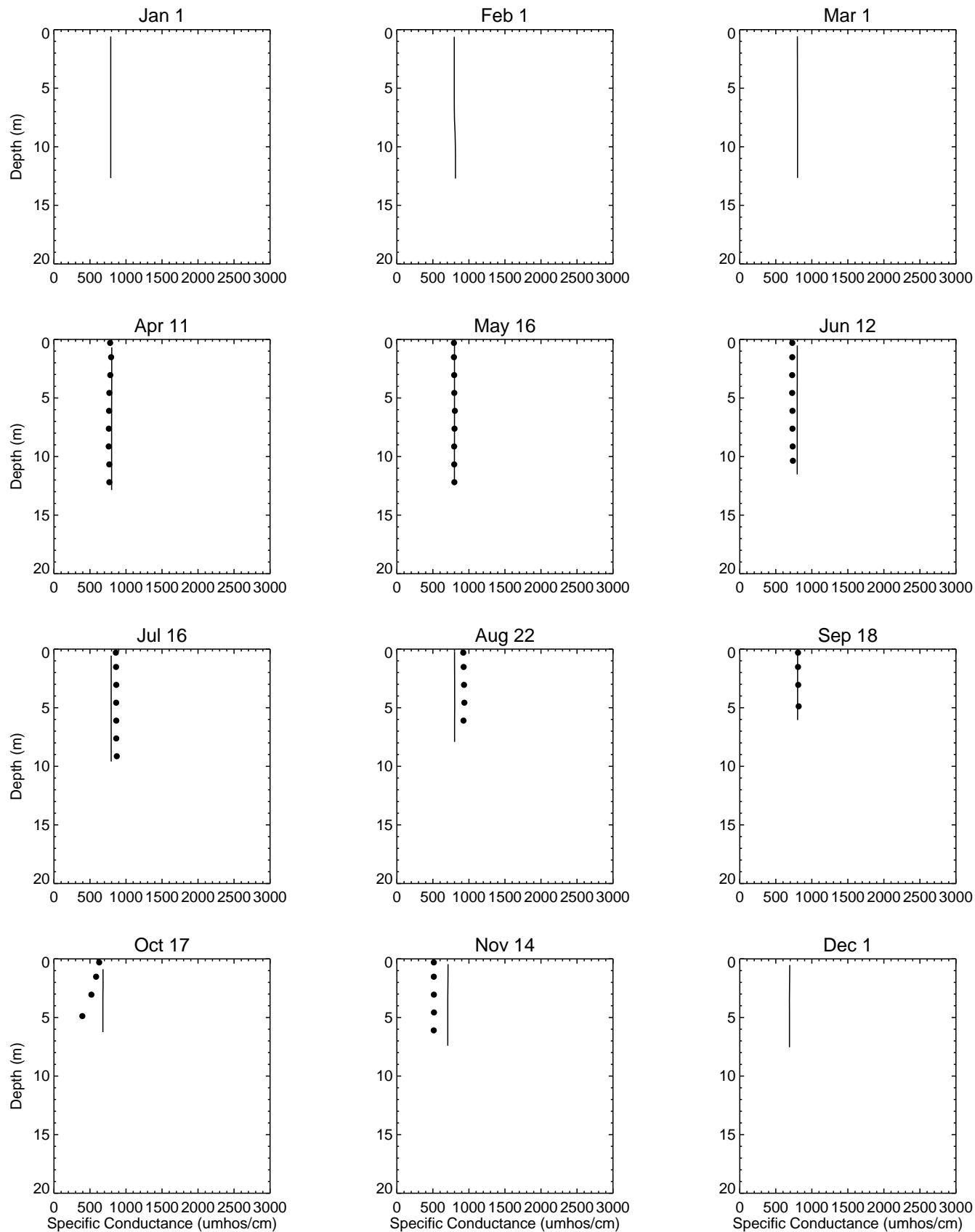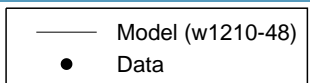Specific Conductance (umhos/cm)

—— Model (w1210-48)
● Data

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 2001

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA PARSONS

Jan 1   Feb 6   Mar 1

Apr 15   May 1   Jun 10

Jul 1   Aug 20   Sep 1

Oct 1   Nov 1   Dec 2

Depth (m)

Specific Conductance (umhos/cm)

—— Model (w1210-48)
● Data

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 2002

Profiles shown for dates with available data else model results for first day of month shown.
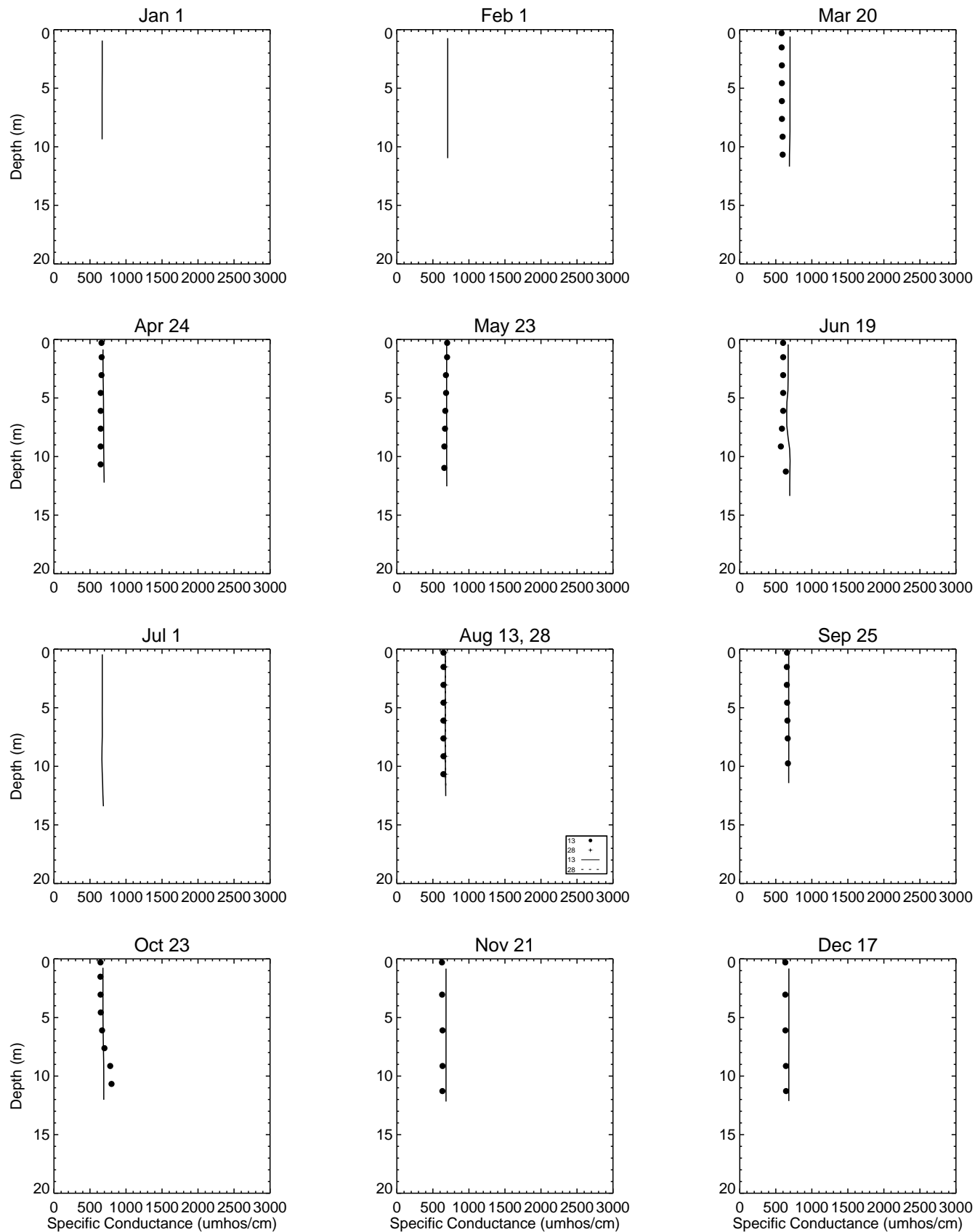
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:26 2013

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 2003

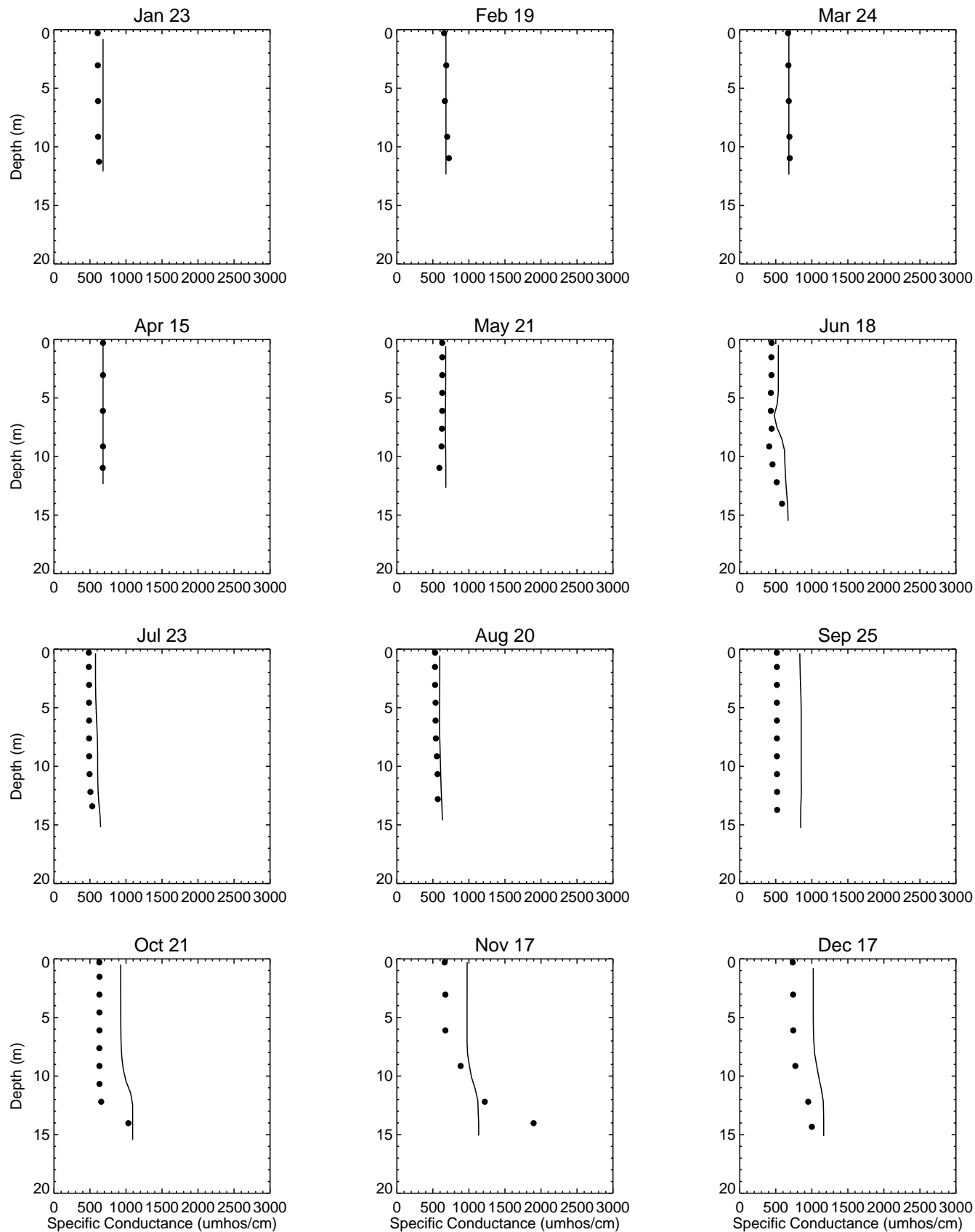*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 2004

Profiles shown for dates with available data else model results for first day of month shown.

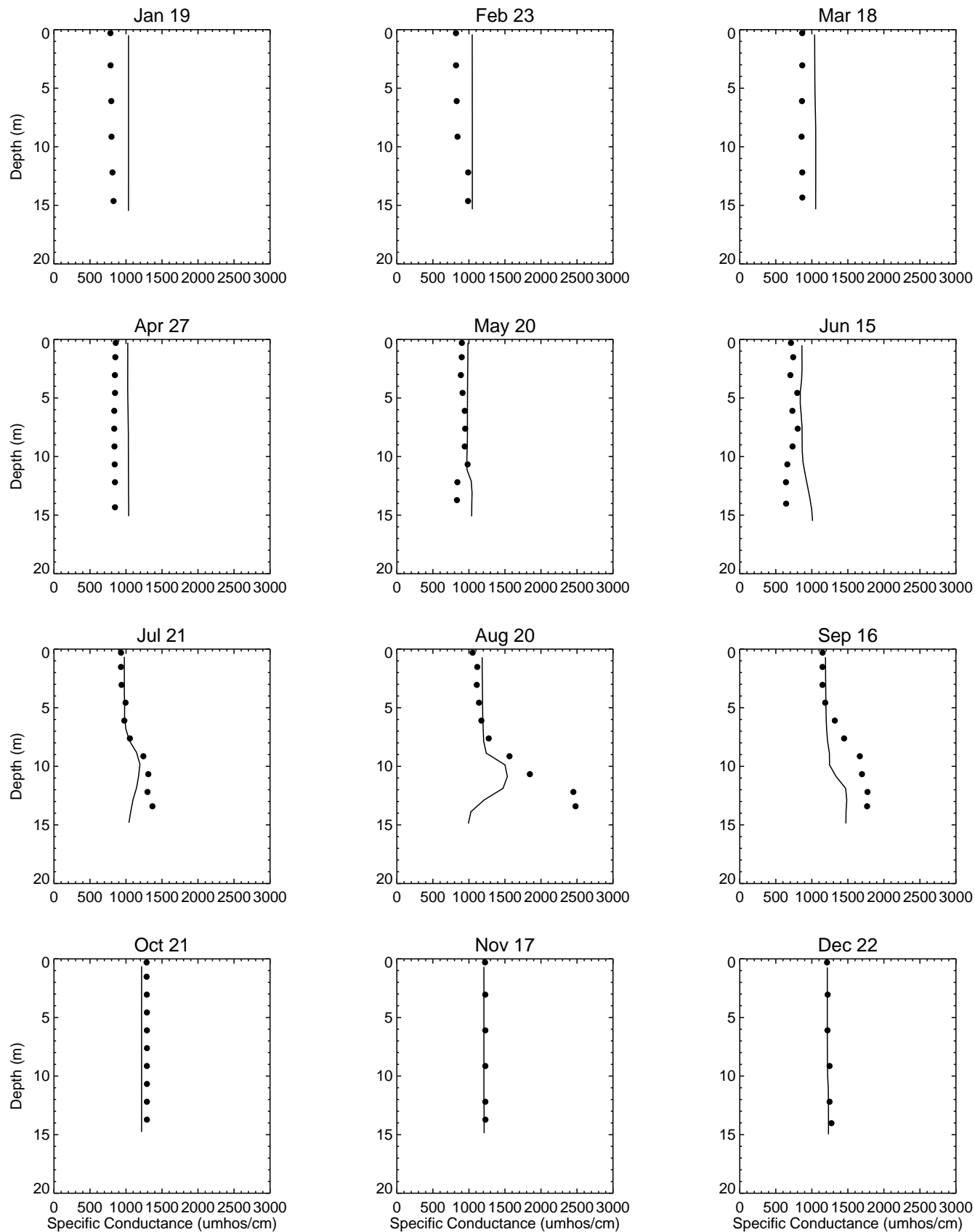CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 2005

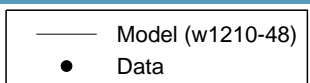*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 2006

Profiles shown for dates with available data else model results for first day of month shown.

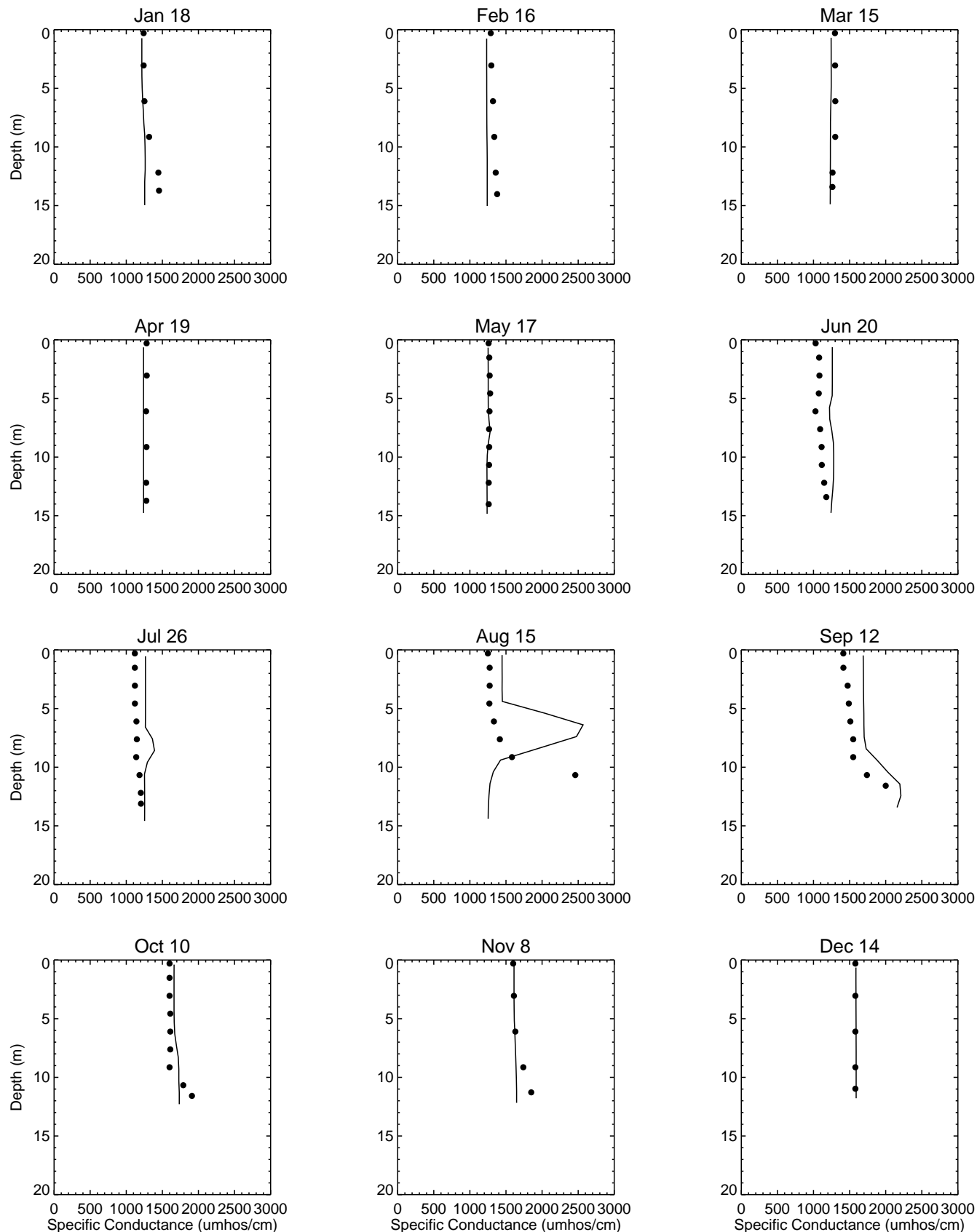CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 2007

Profiles shown for dates with available data else model results for first day of month shown.

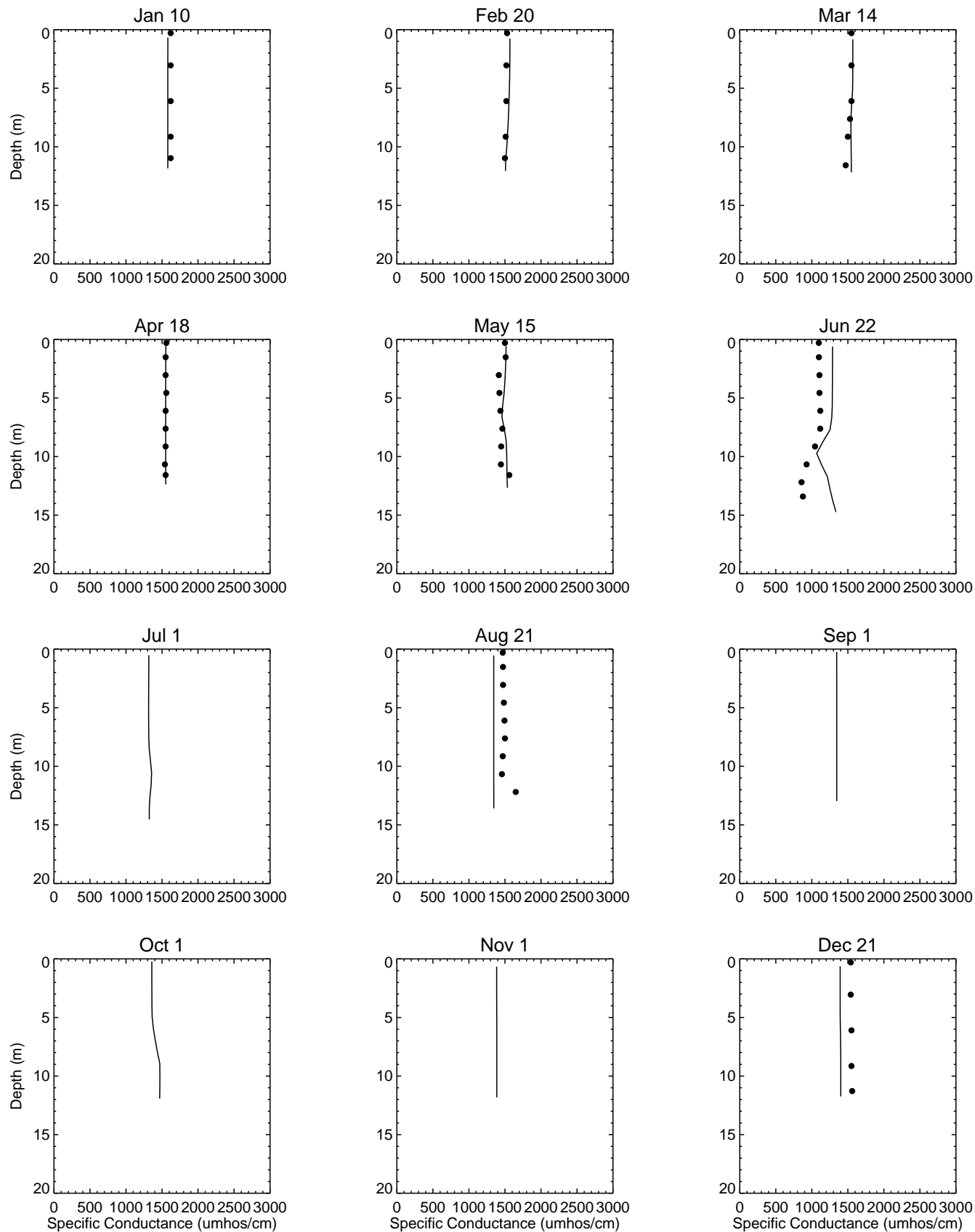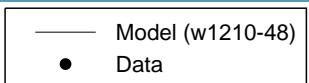CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 2008

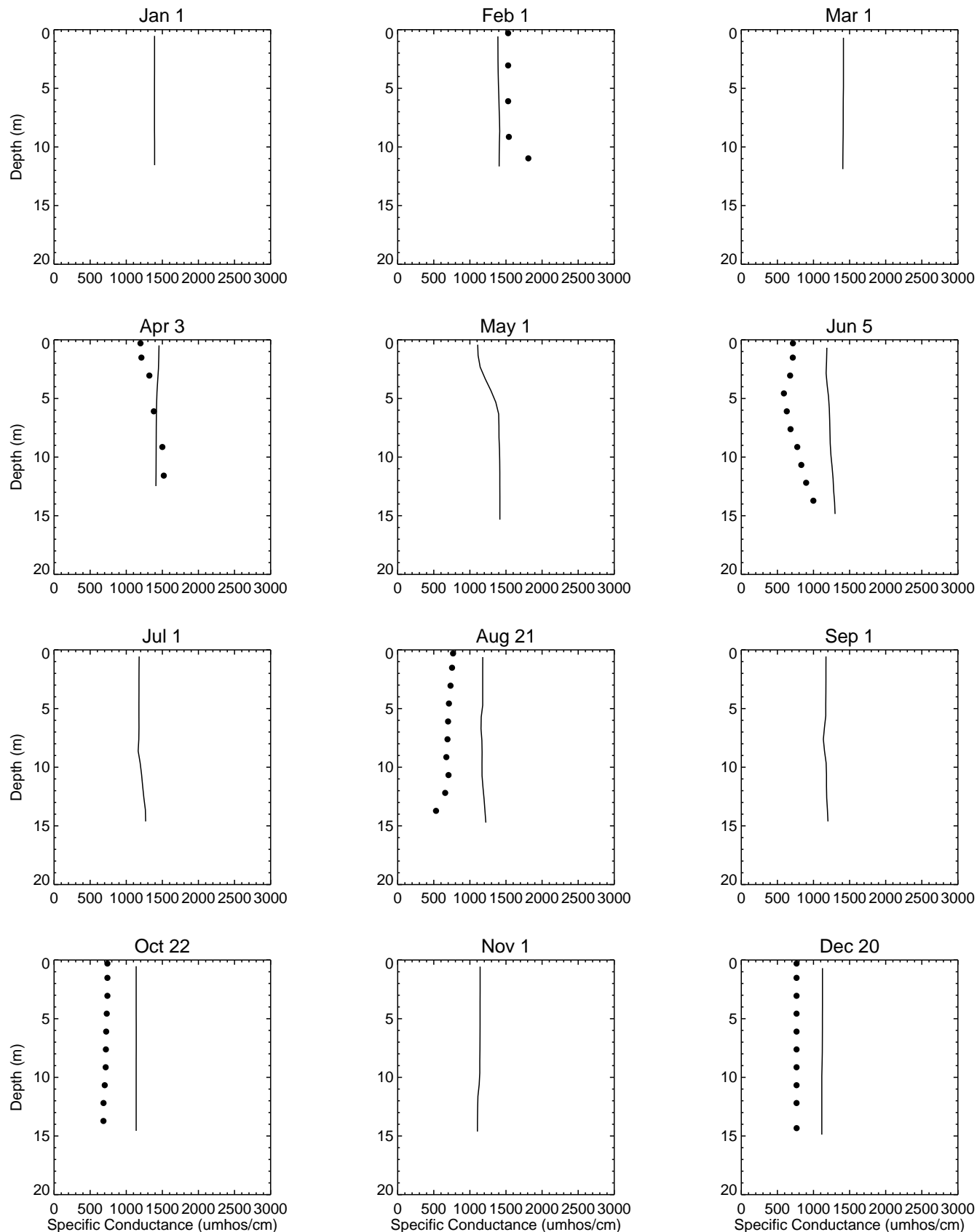*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 2009

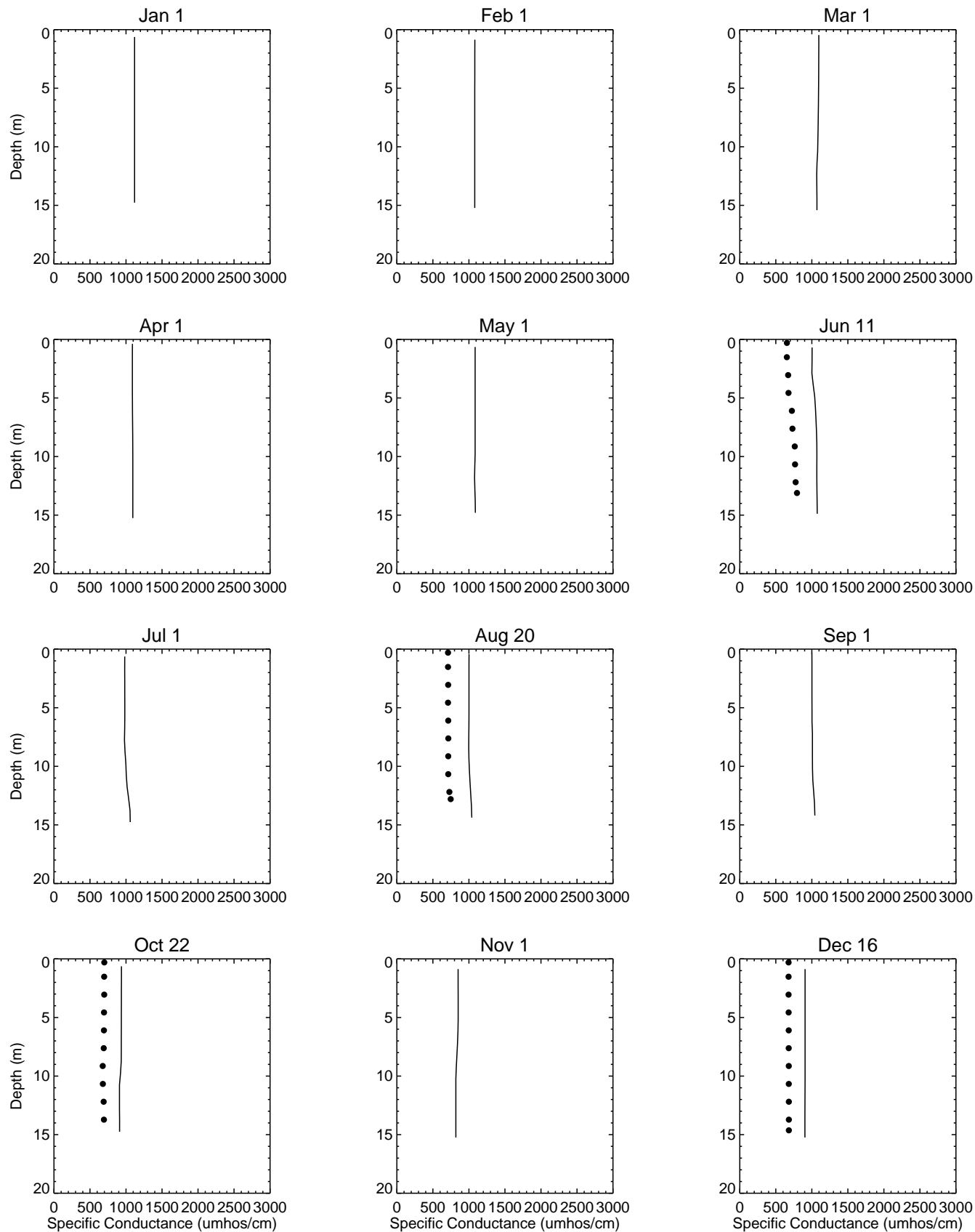*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:26 2013

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 2010

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-11

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Specific Conductance - 2011

Profiles shown for dates with available data else model results for first day of month shown.

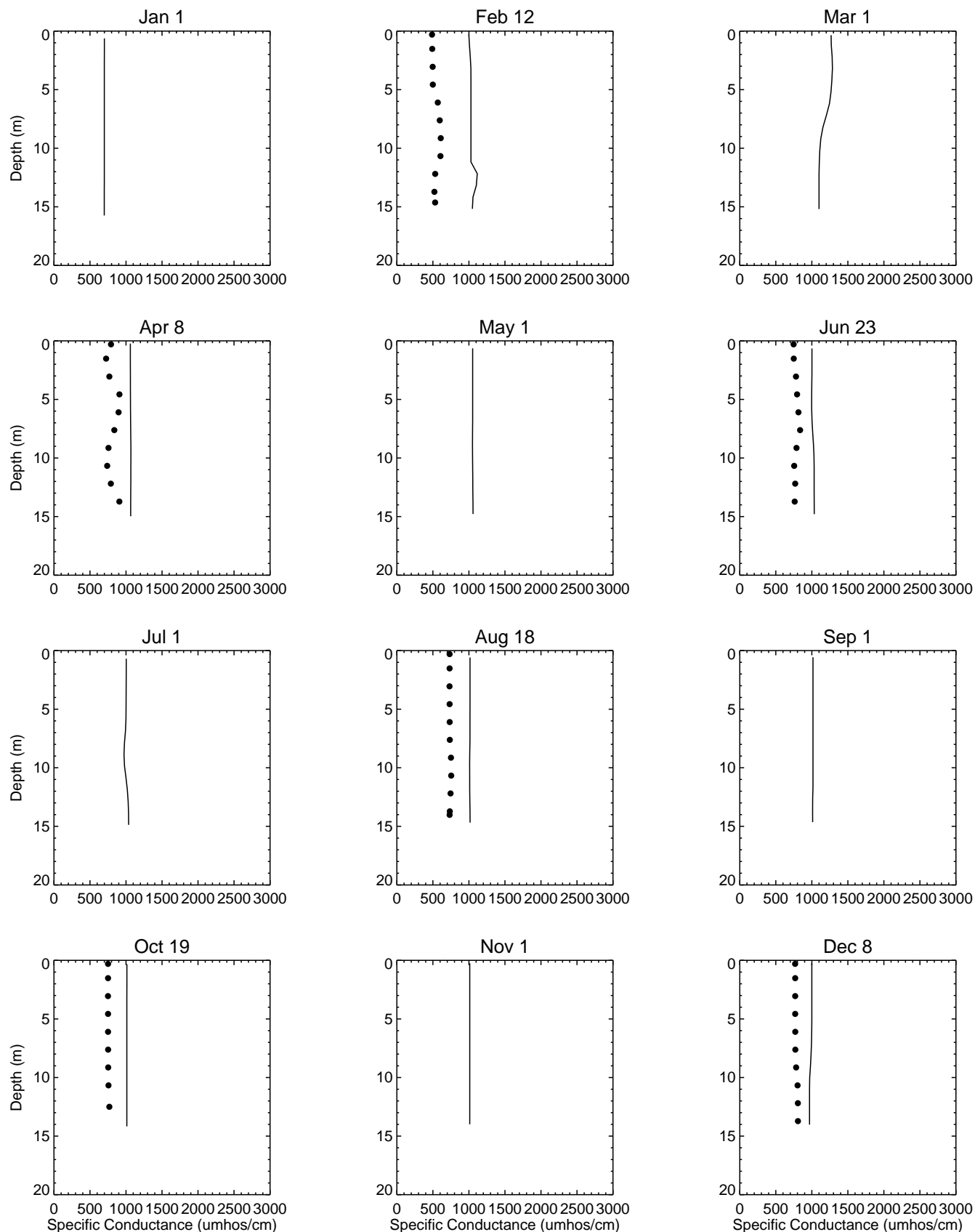CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 1984

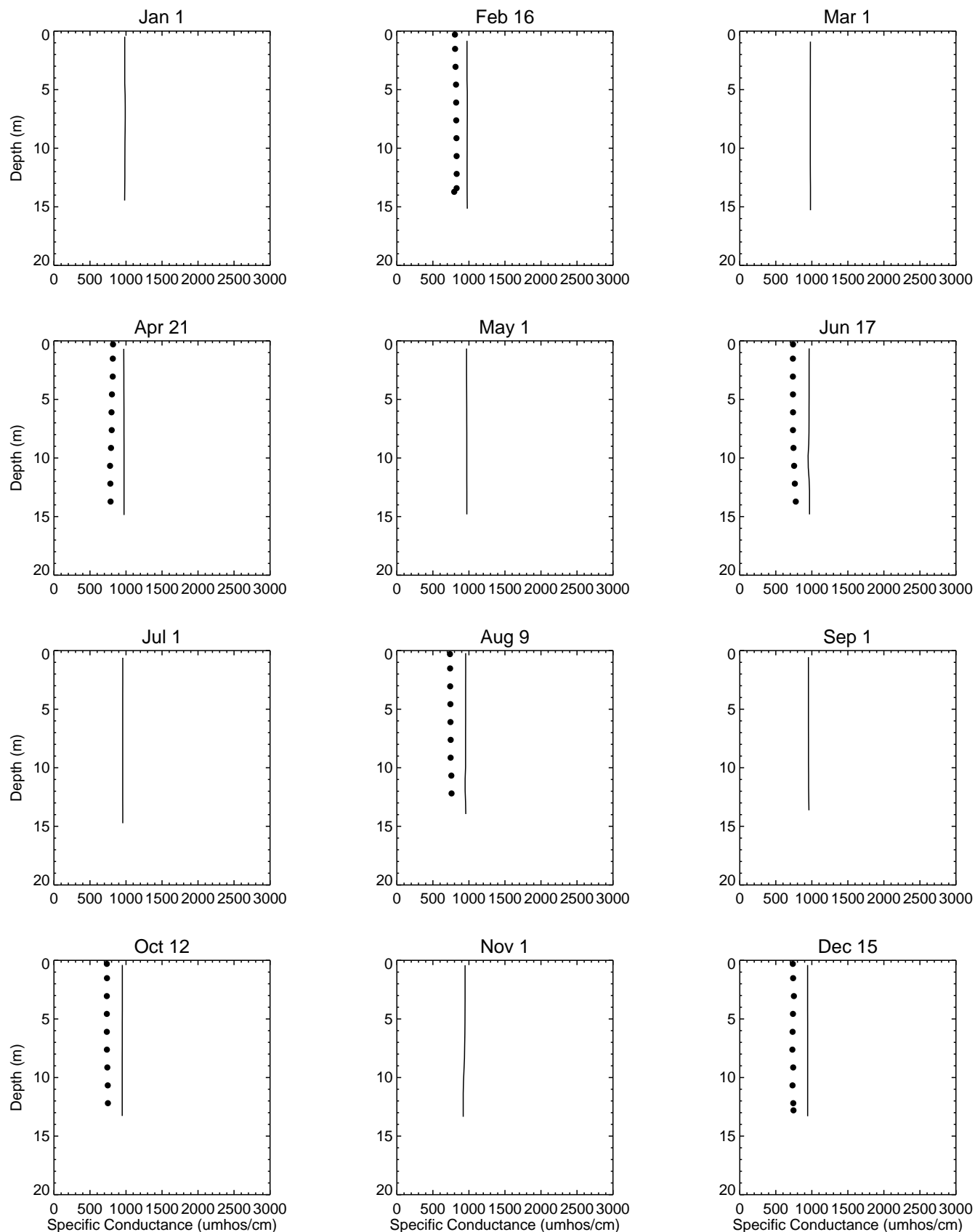*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 1985

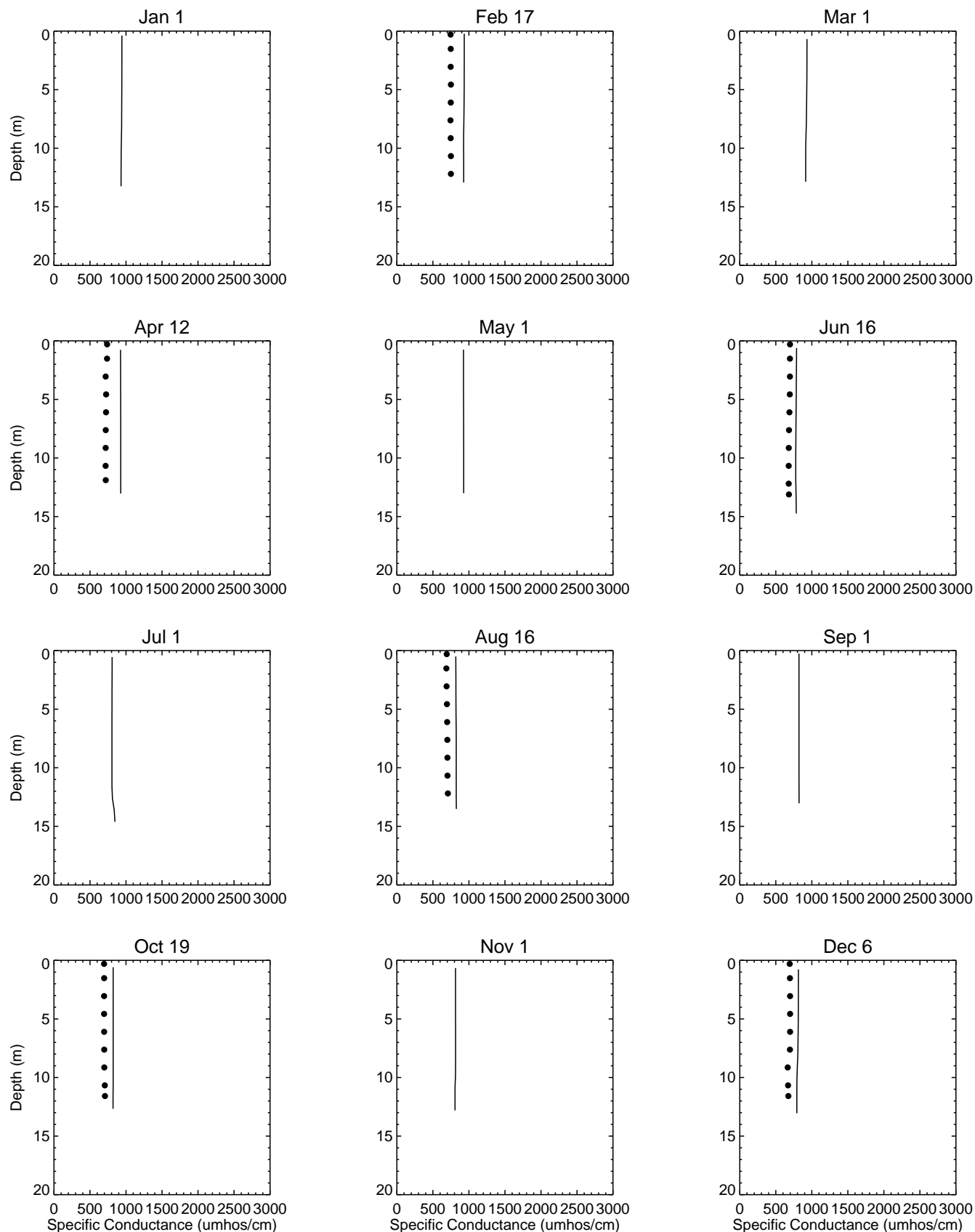*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
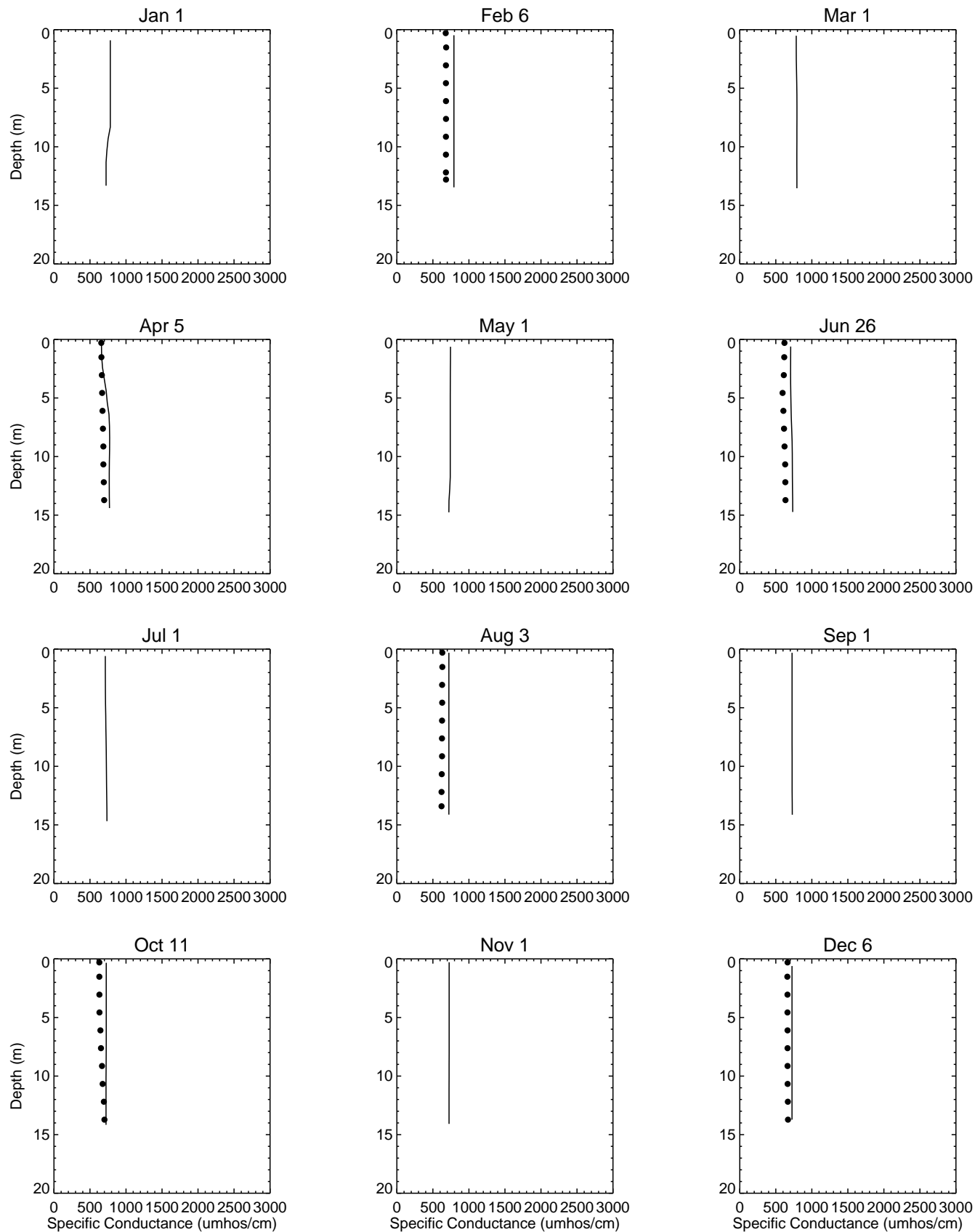Lower Colorado River Authority

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 1986

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 1987

Profiles shown for dates with available data else model results for first day of month shown.
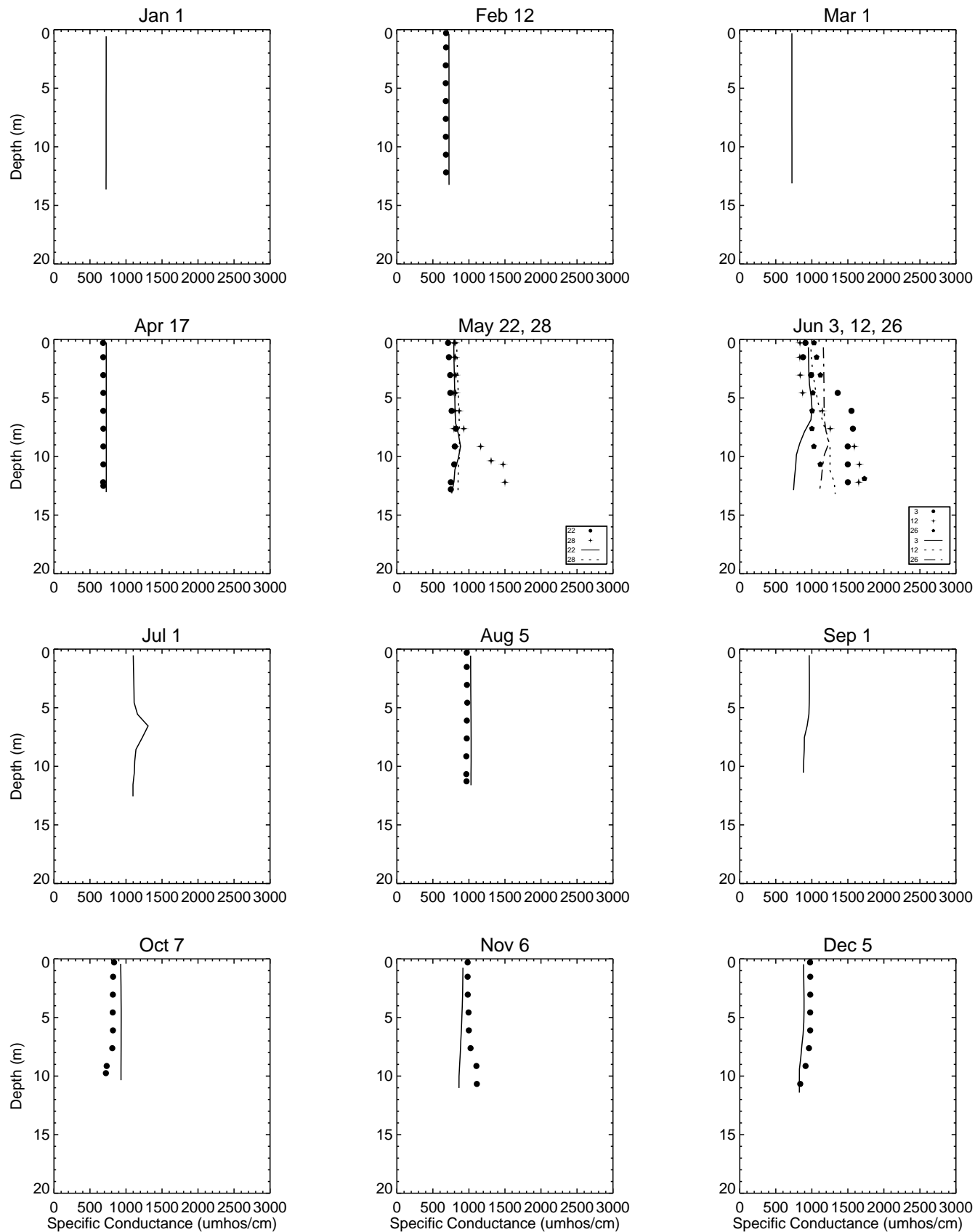
Model (w1210-48)
● Data

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 1988

Profiles shown for dates with available data else model results for first day of month shown.
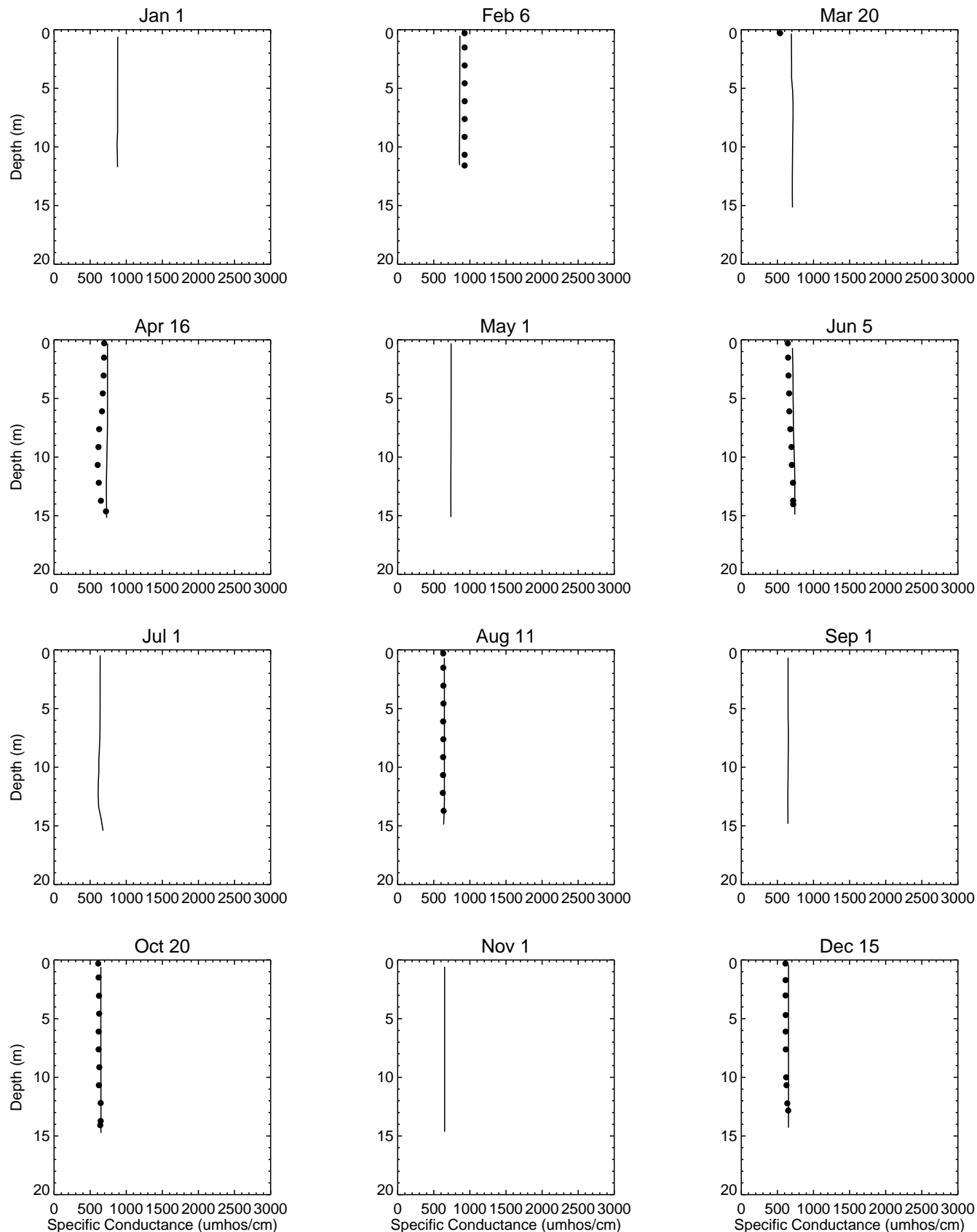
Model (w1210-48)
Data

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority
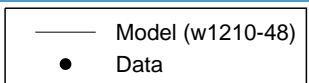
Model (w1210-48)
● Data

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 1989

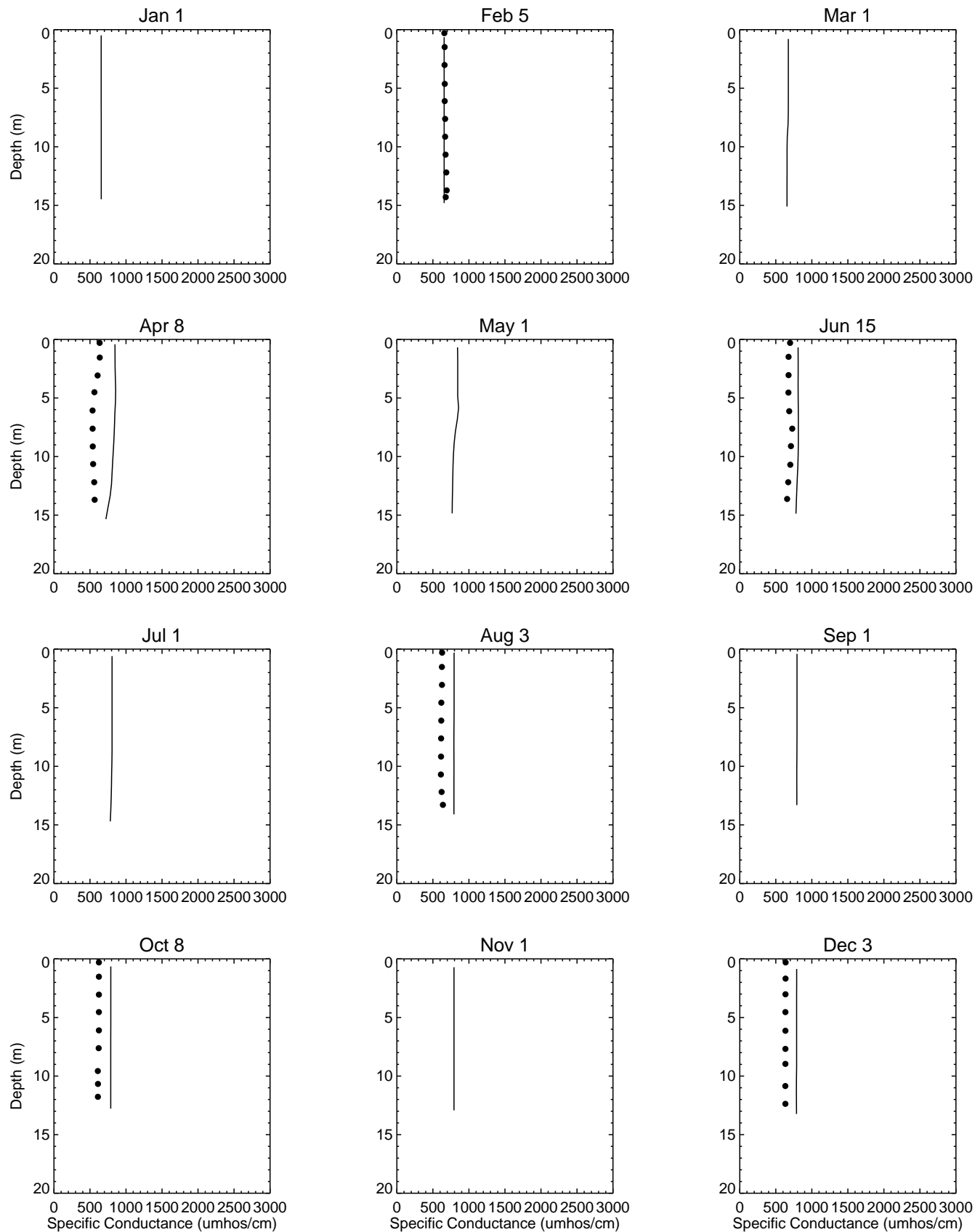*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 1990

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 — Feb 1 — Mar 1 — Apr 1 — May 1 — Jun 11 — Jul 1 — Aug 20 — Sep 1 — Oct 22 — Nov 1 — Dec 16

Specific Conductance (umhos/cm)
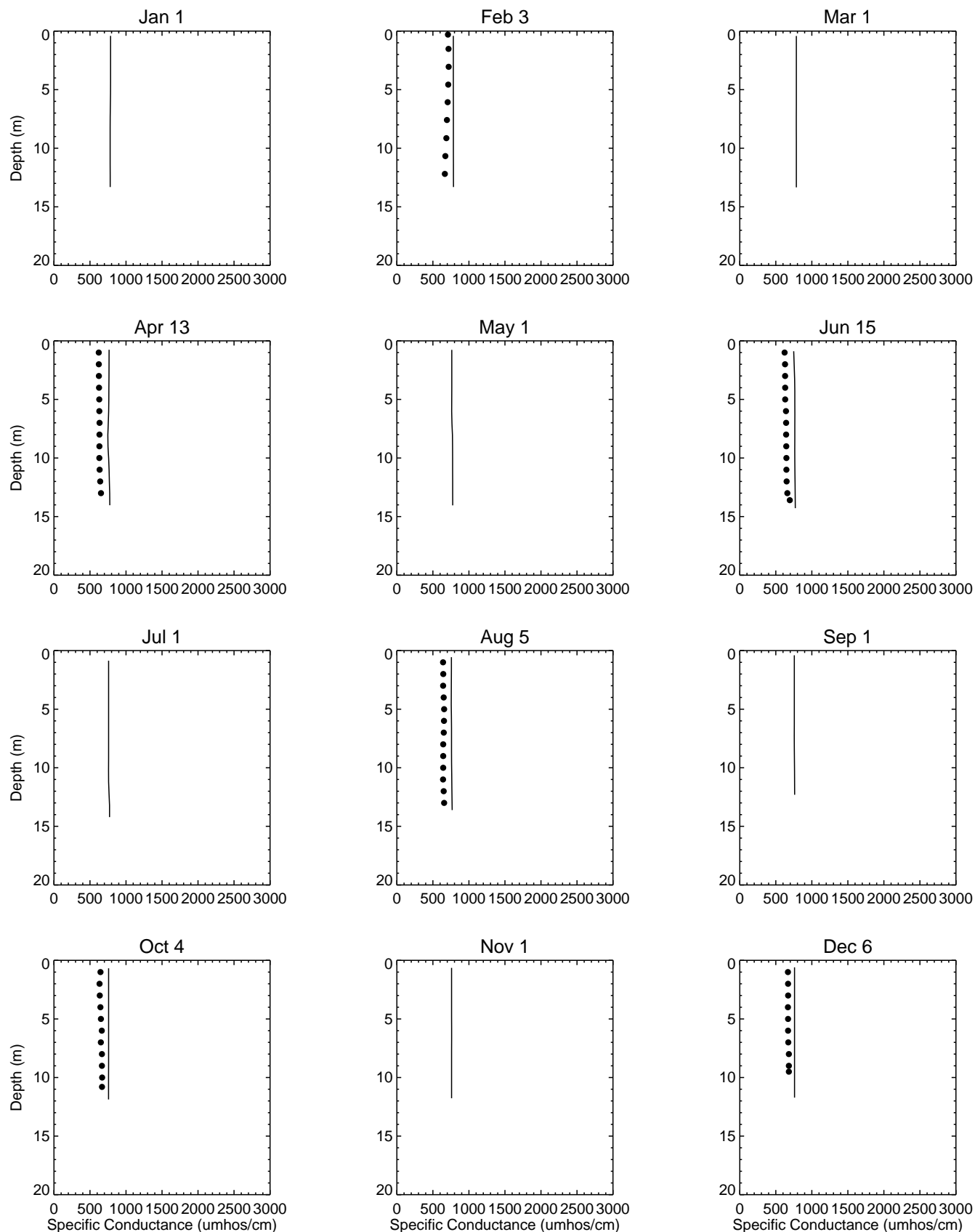
Model (w1210-48)
● Data

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 1991
Profiles shown for dates with available data else model results for first day of month shown.
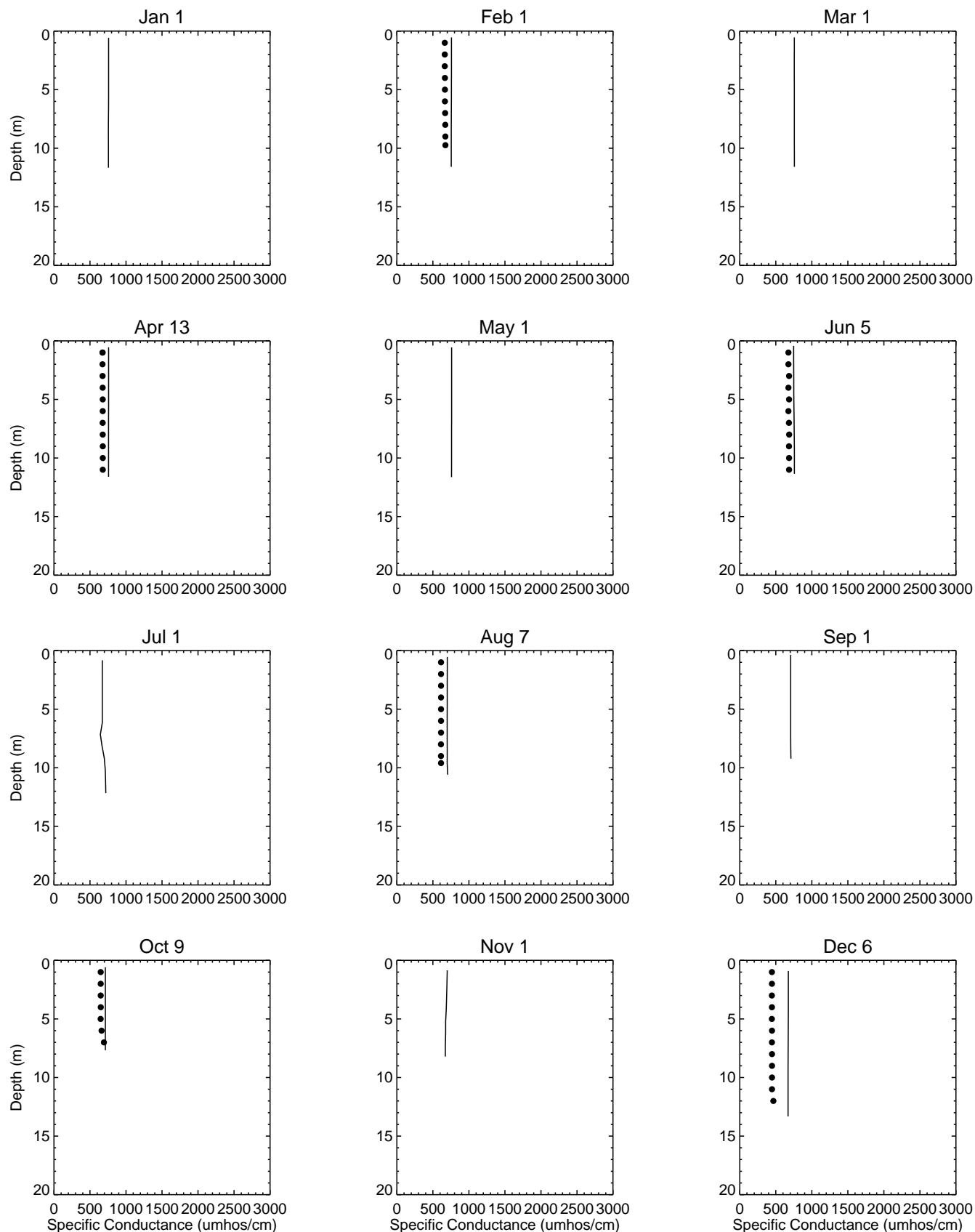
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 1992

Profiles shown for dates with available data else model results for first day of month shown.
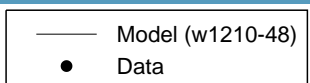
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 1993

Profiles shown for dates with available data else model results for first day of month shown.
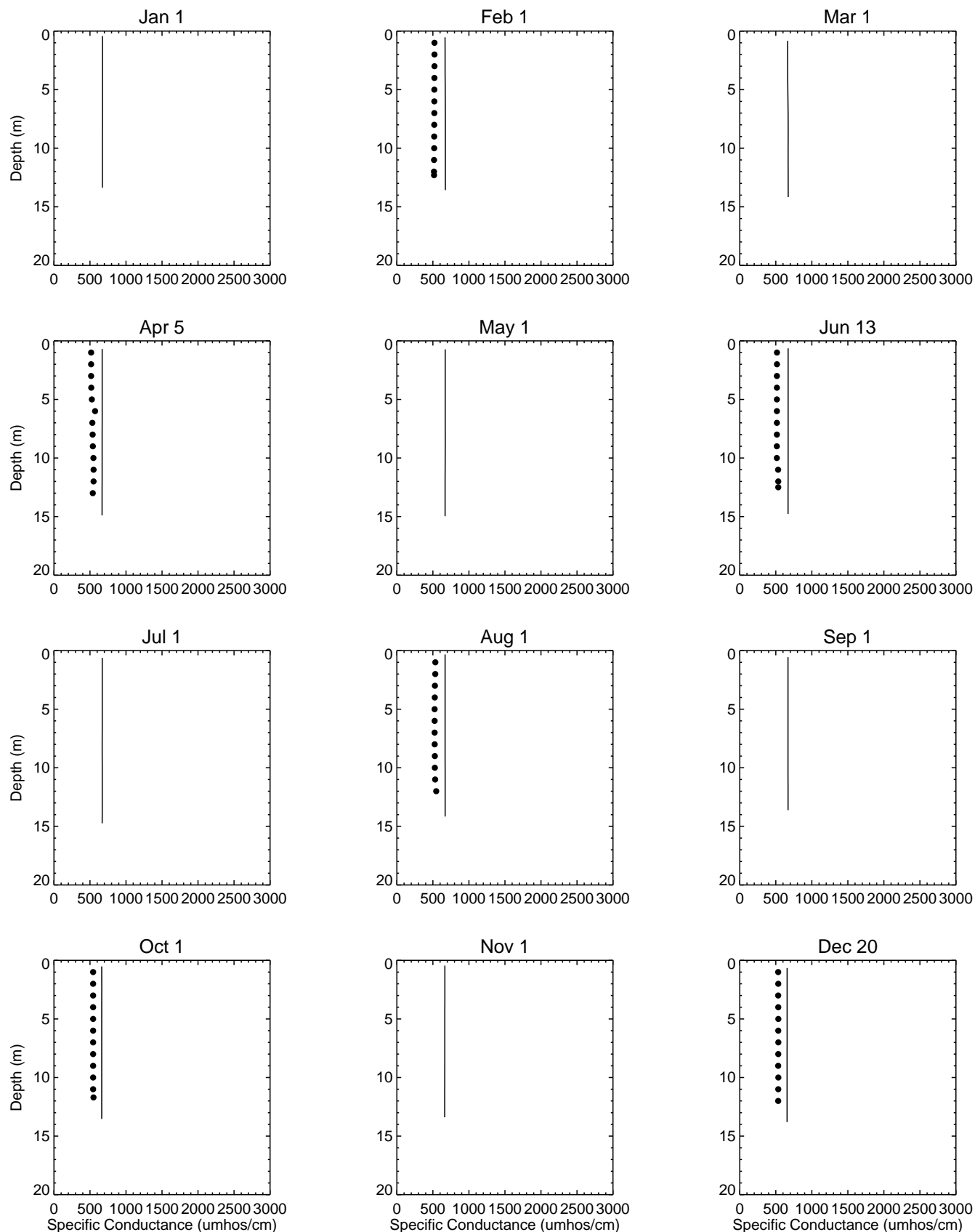
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 1995

Profiles shown for dates with available data else model results for first day of month shown.
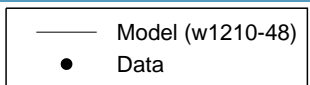
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:03 2013
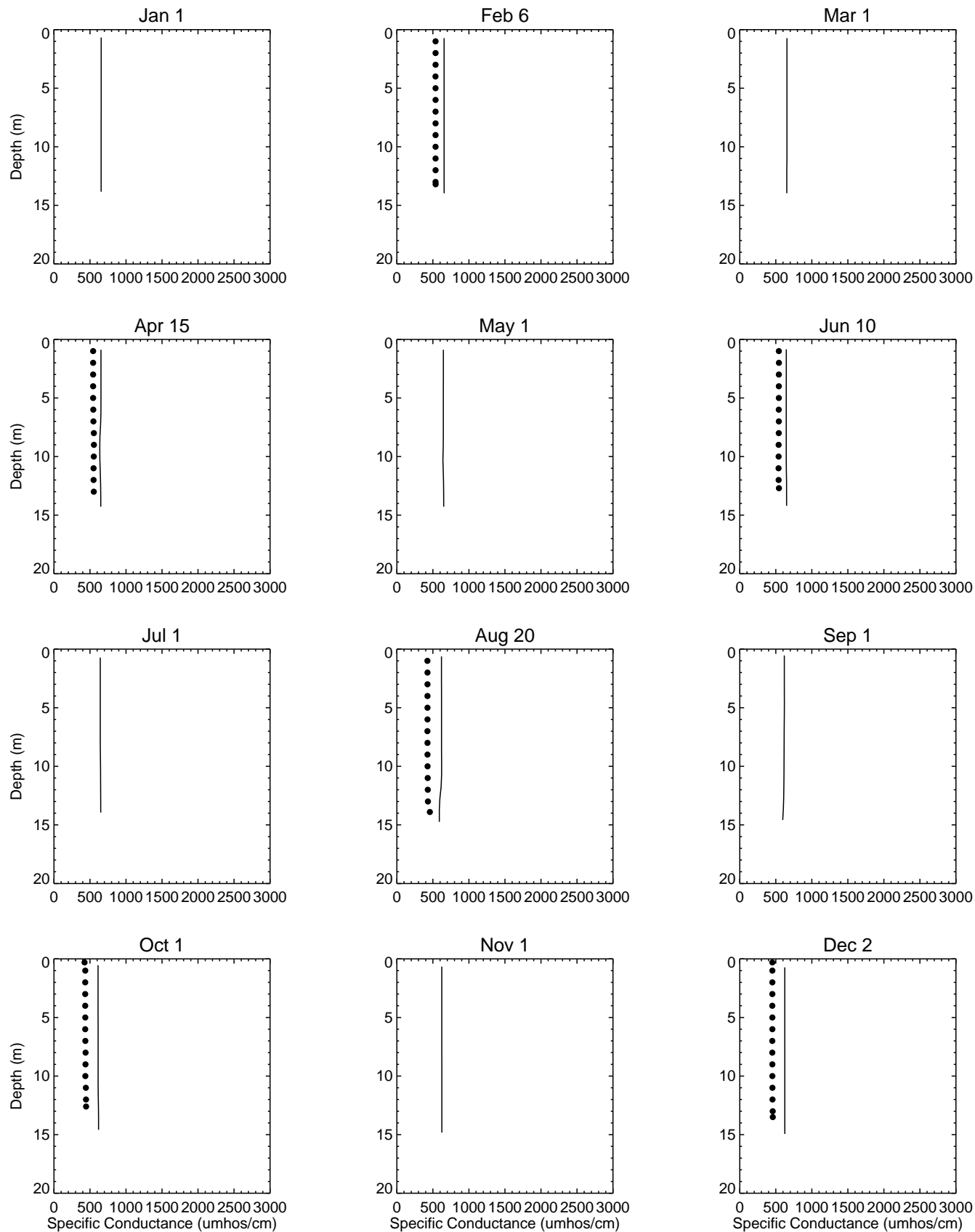
Model (w1210-48)
● Data

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 1996

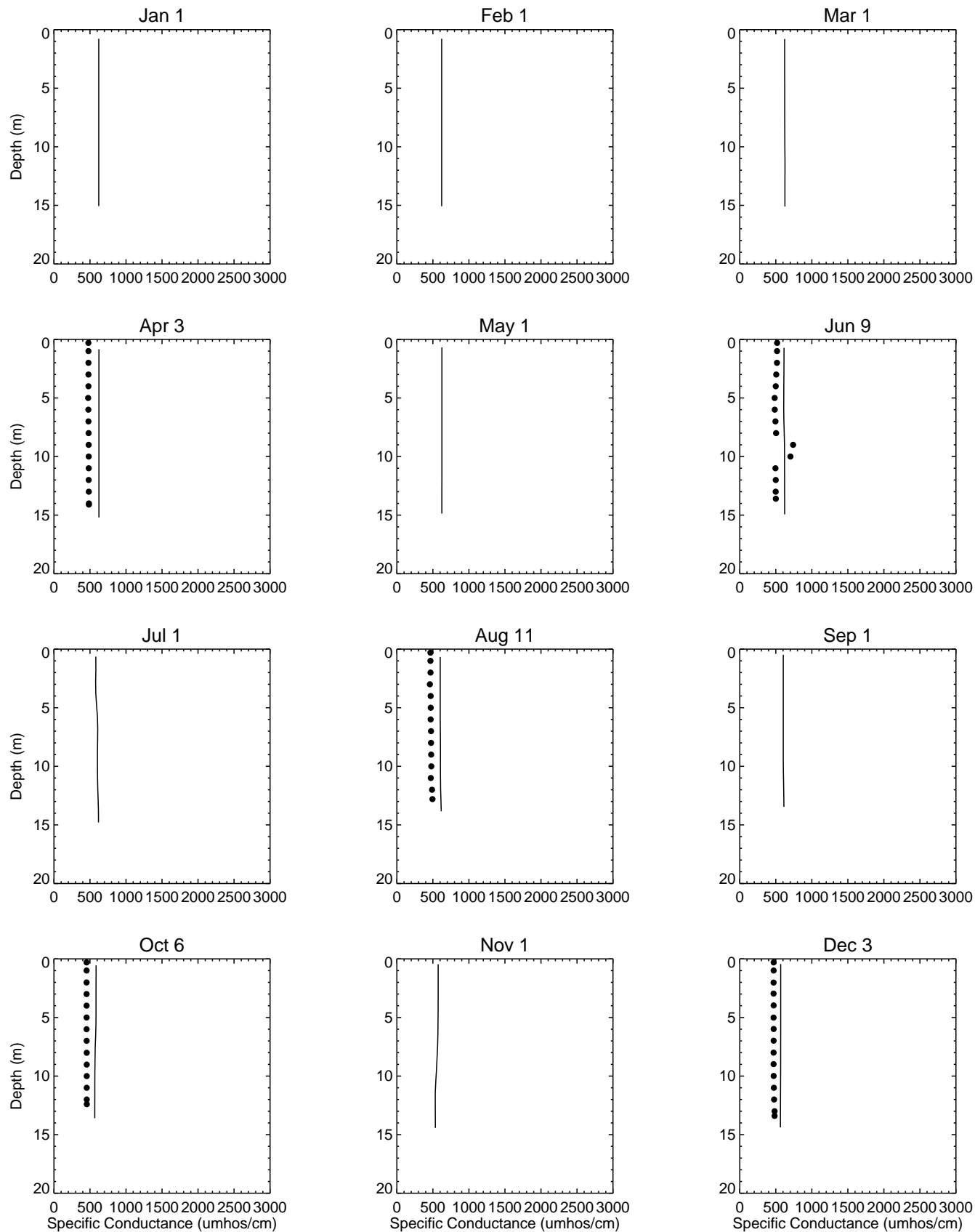*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:03 2013

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 1997

Profiles shown for dates with available data else model results for first day of month shown.
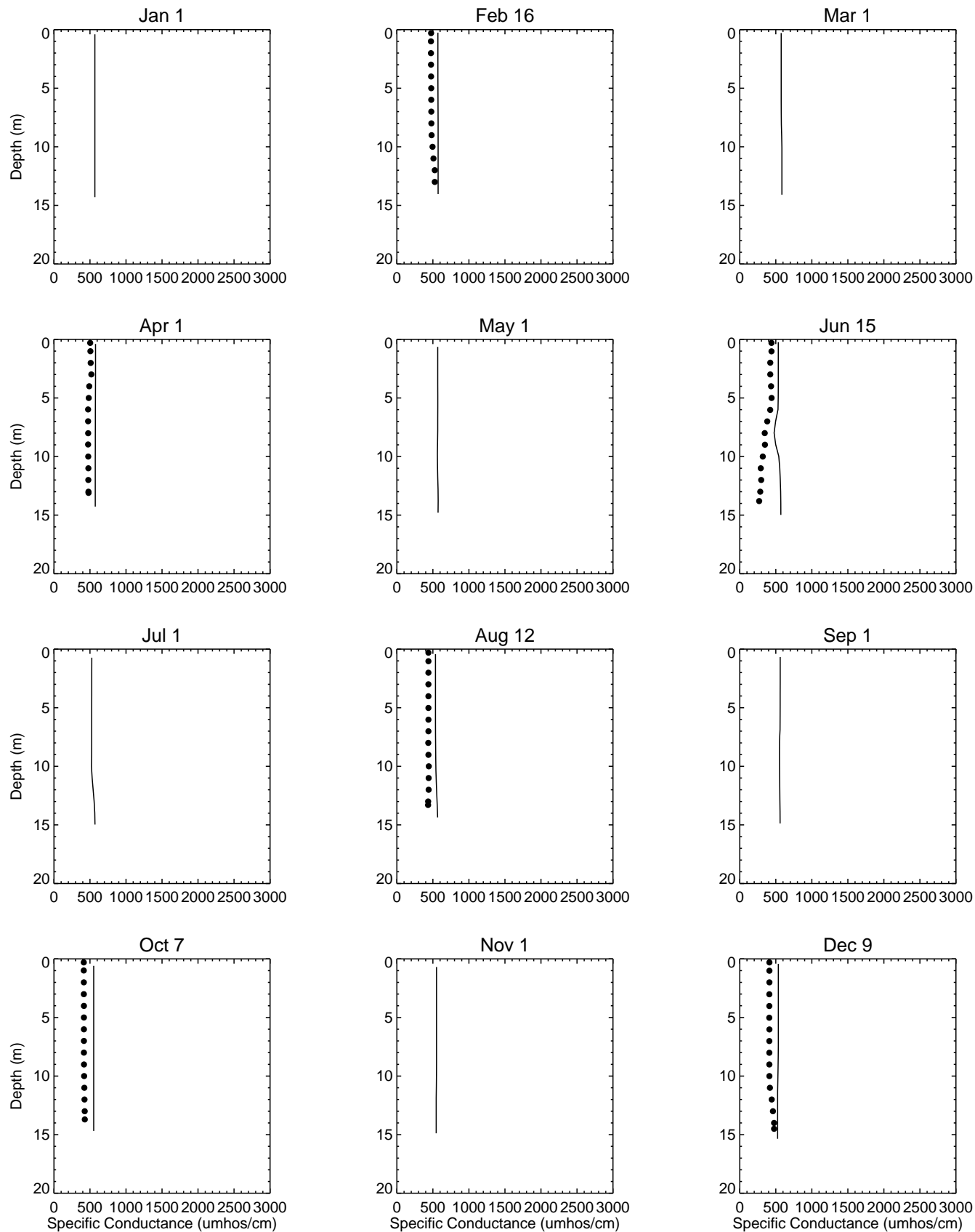
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:03 2013

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 1998

Profiles shown for dates with available data else model results for first day of month shown.
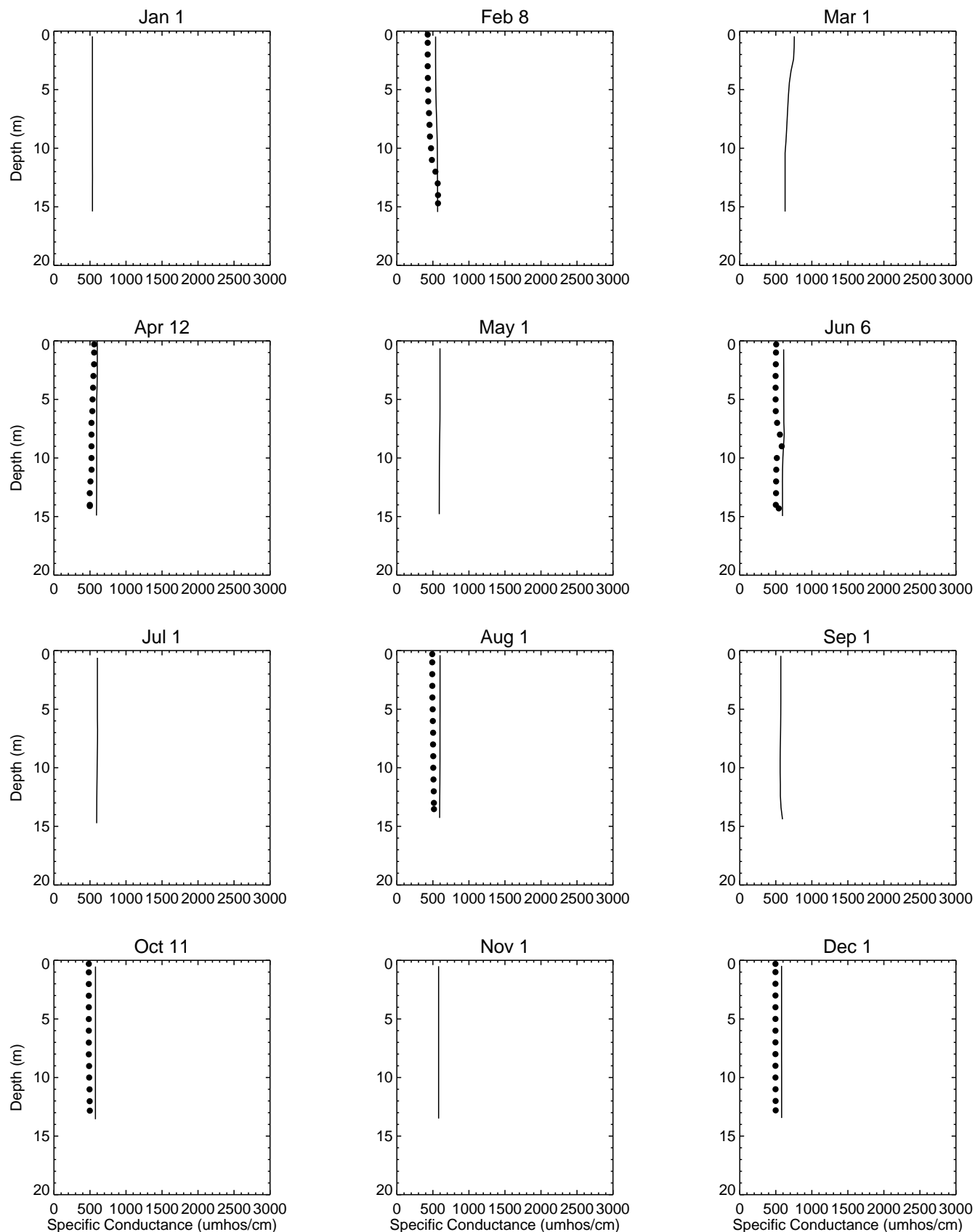
CREMs Phase 4: Lake Buchanan
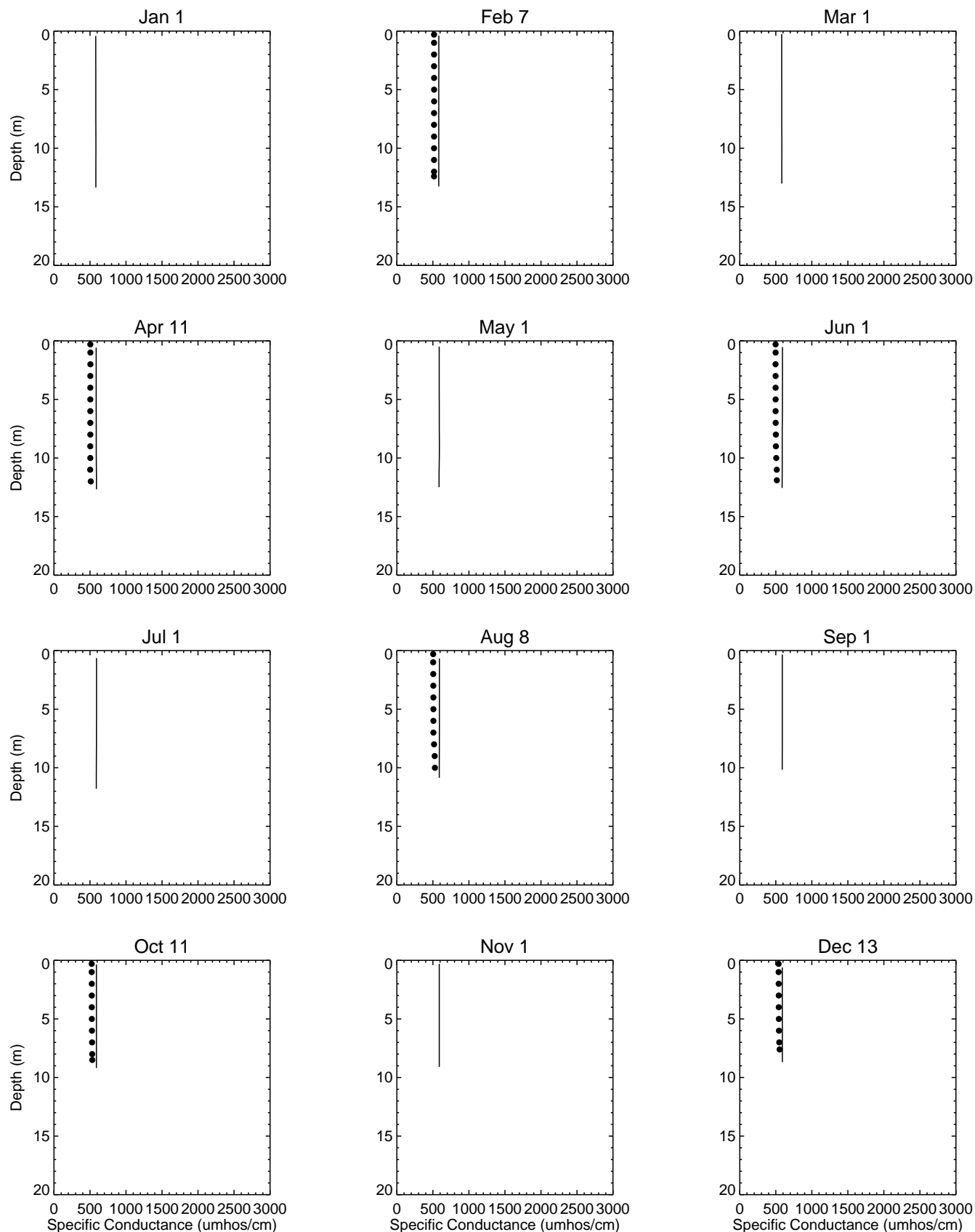
Lower Colorado River Authority

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 1999

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
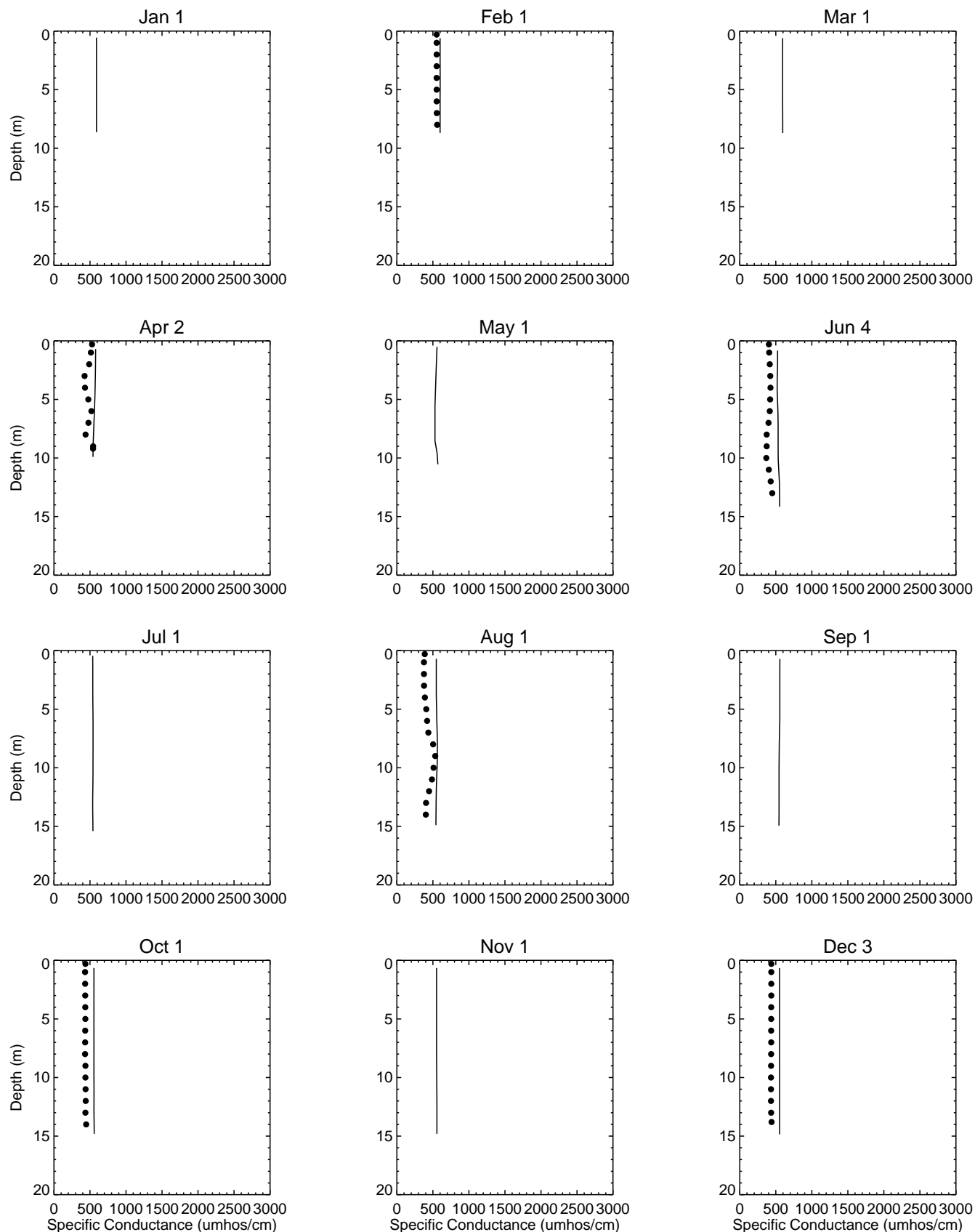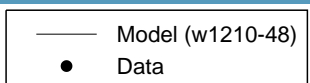
Lower Colorado River Authority

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 2000

Profiles shown for dates with available data else model results for first day of month shown.

Model (w1210-48)
Data

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Vertical Profiles of Model Versus Data for Lake Buchanan near Beaver Creek Cove (Segment 6) - Specific Conductance - 2001

Figure G-12

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
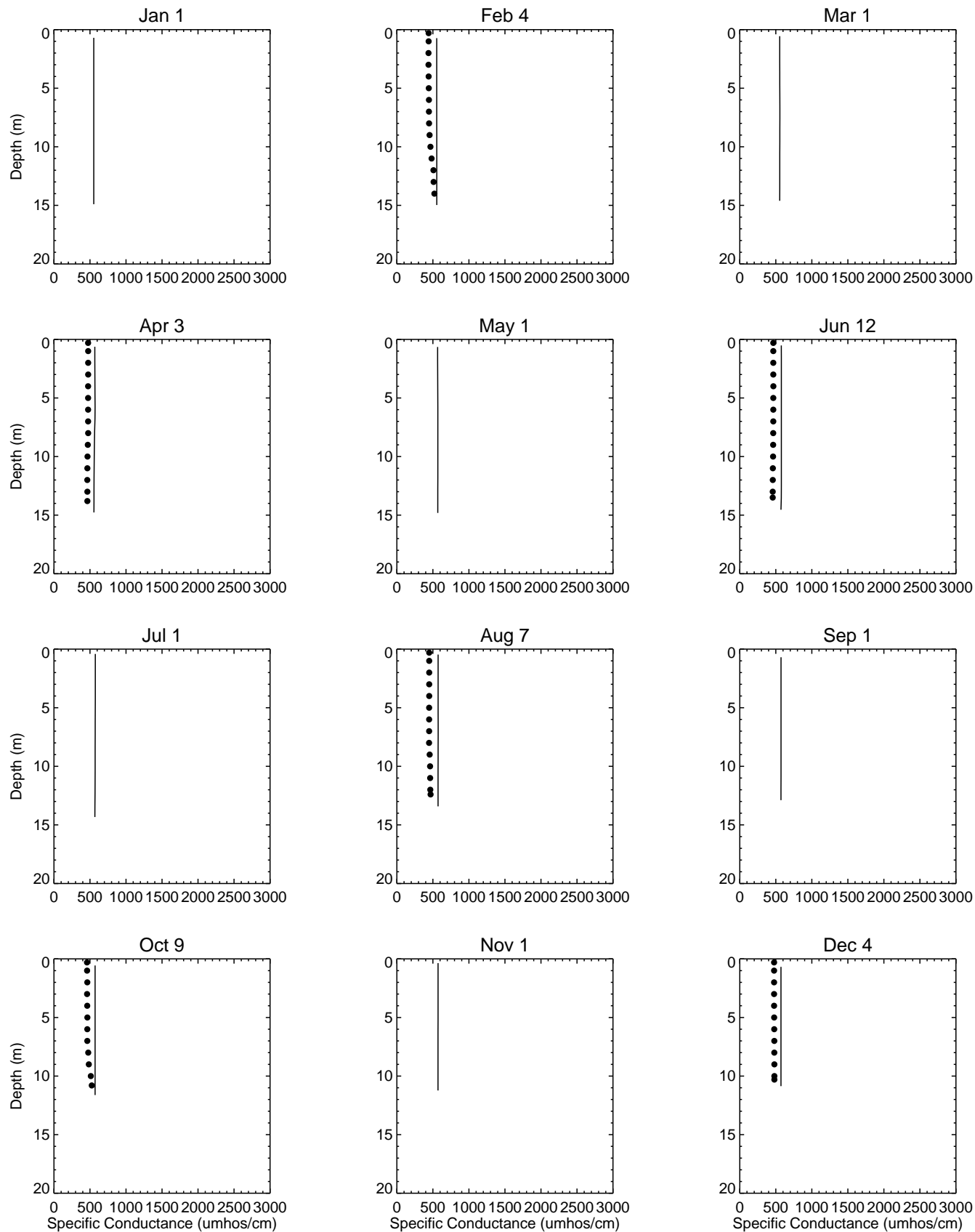
Lower Colorado River Authority

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 2003

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 2004

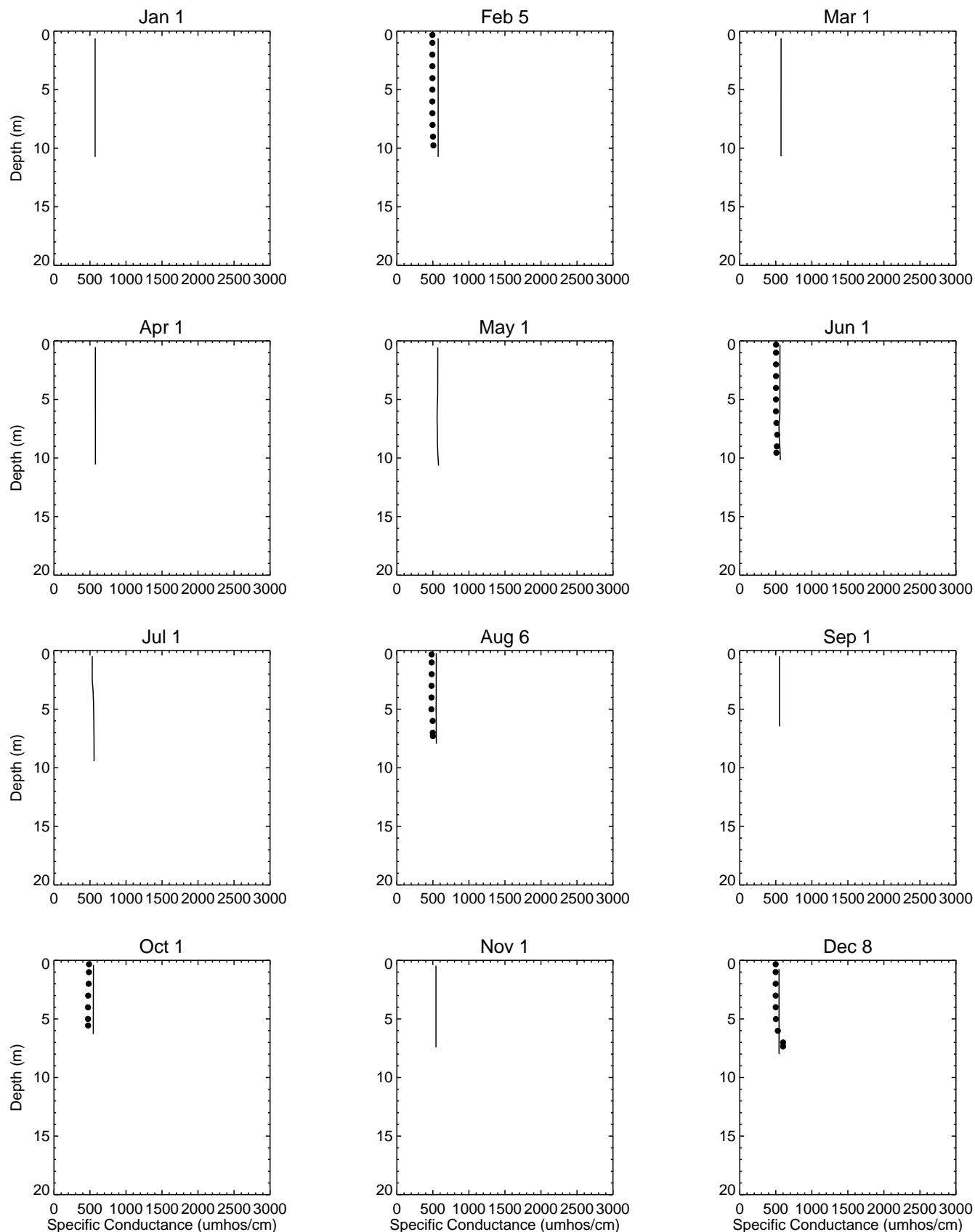*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 2005

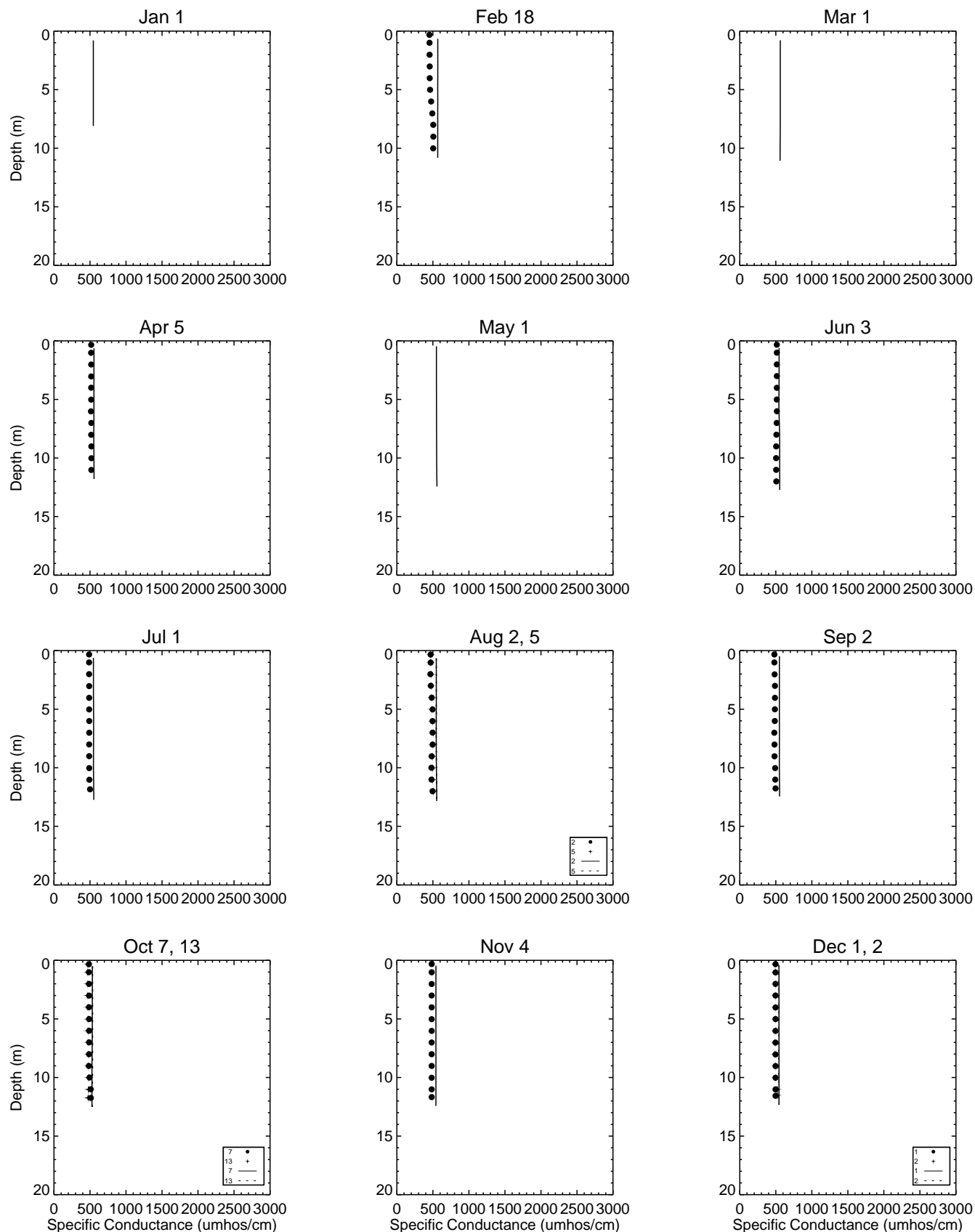*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
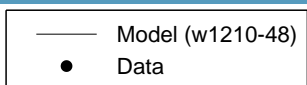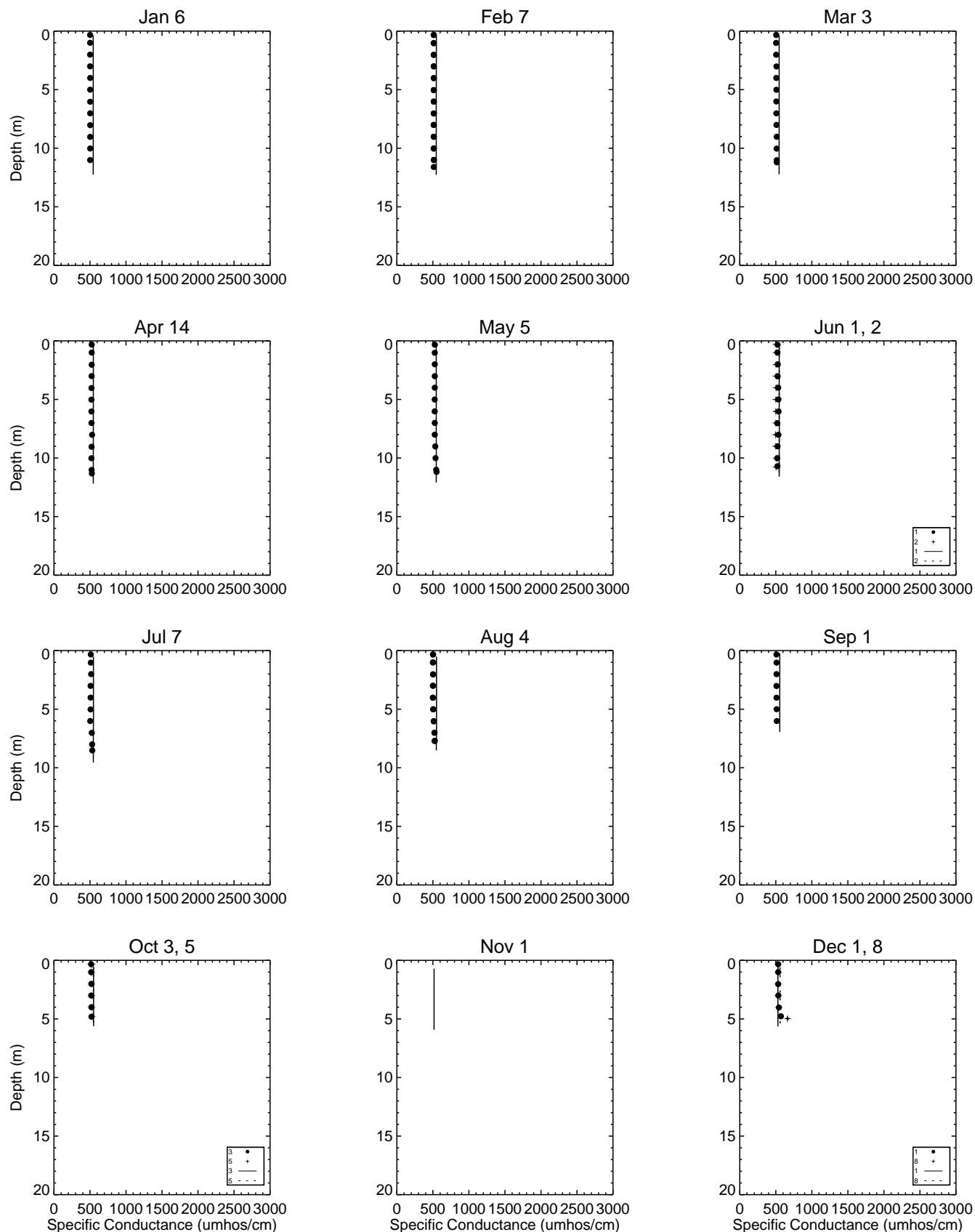Lower Colorado River Authority

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 2006

Profiles shown for dates with available data else model results for first day of month shown.

Model (w1210-48)
● Data

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:03 2013

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 2007

Profiles shown for dates with available data else model results for first day of month shown.
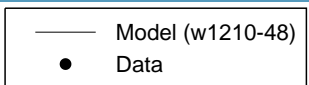
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 2008

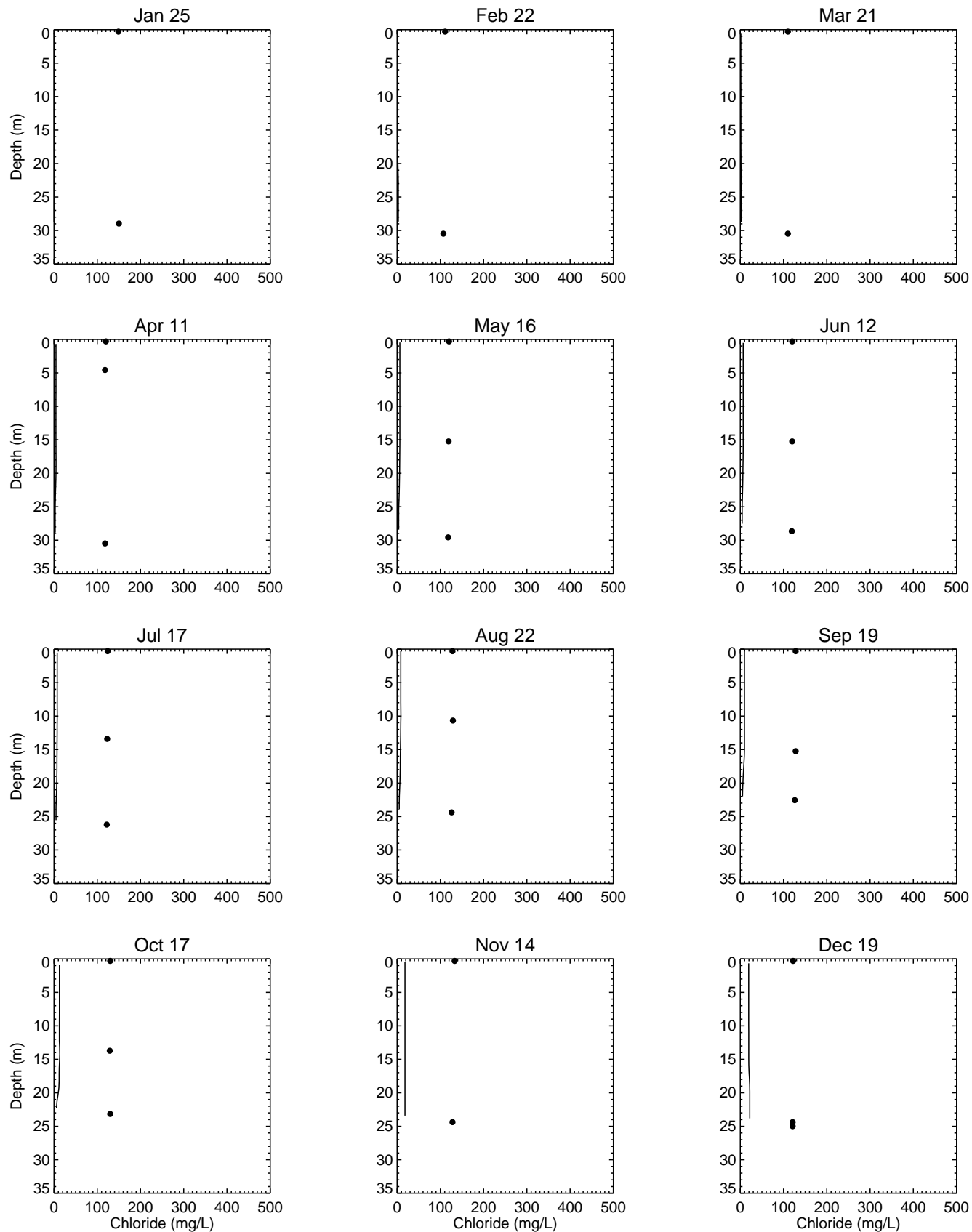*Profiles shown for dates with available data else model results for first day of month shown.*
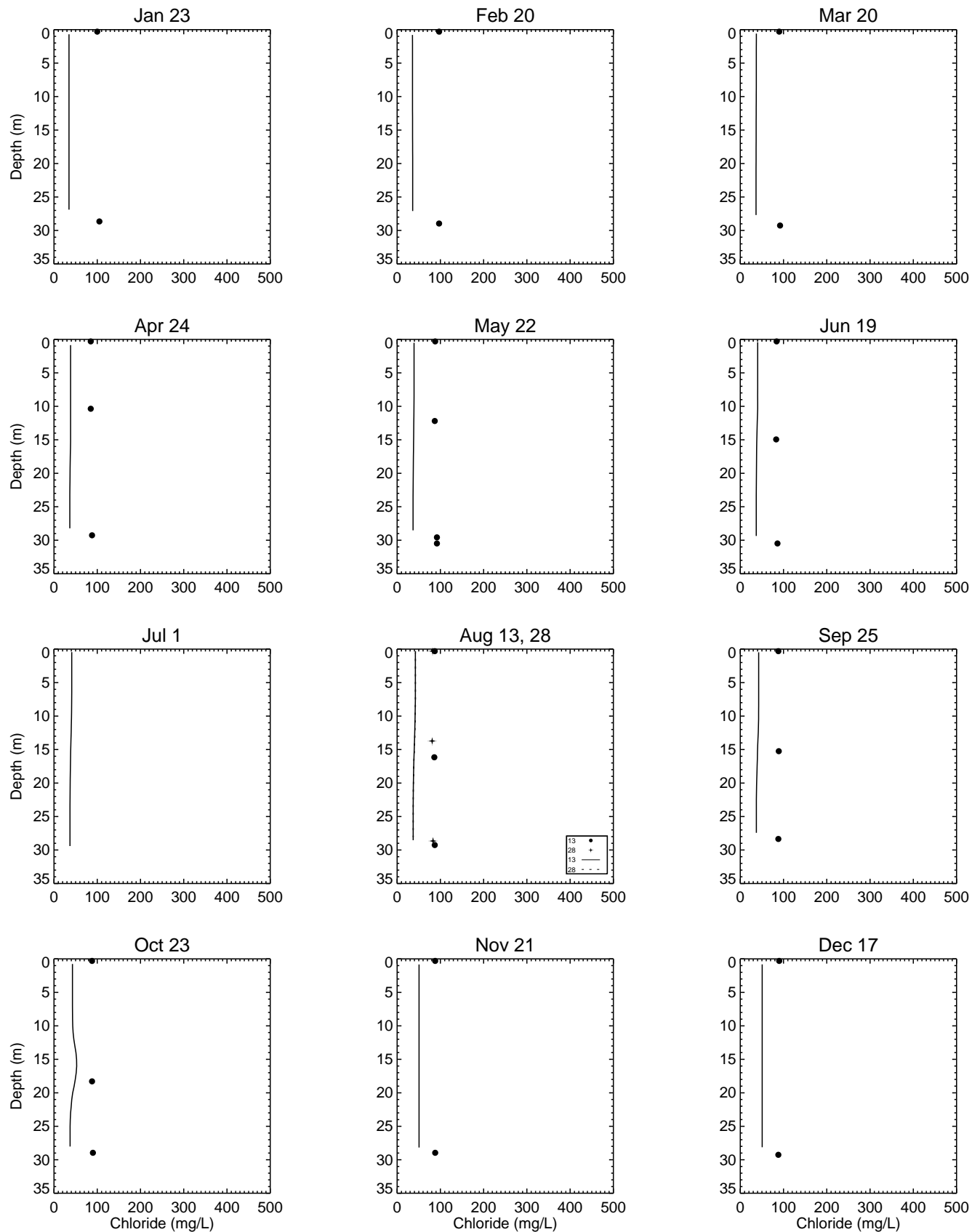
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Jan 1 · Feb 5 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 6 · Sep 1 · Oct 1 · Nov 1 · Dec 8

Depth (m) vs Specific Conductance (umhos/cm)

——— Model (w1210-48)
● Data

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 2009
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 2010

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-12

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Specific Conductance - 2011

Profiles shown for dates with available data else model results for first day of month shown.
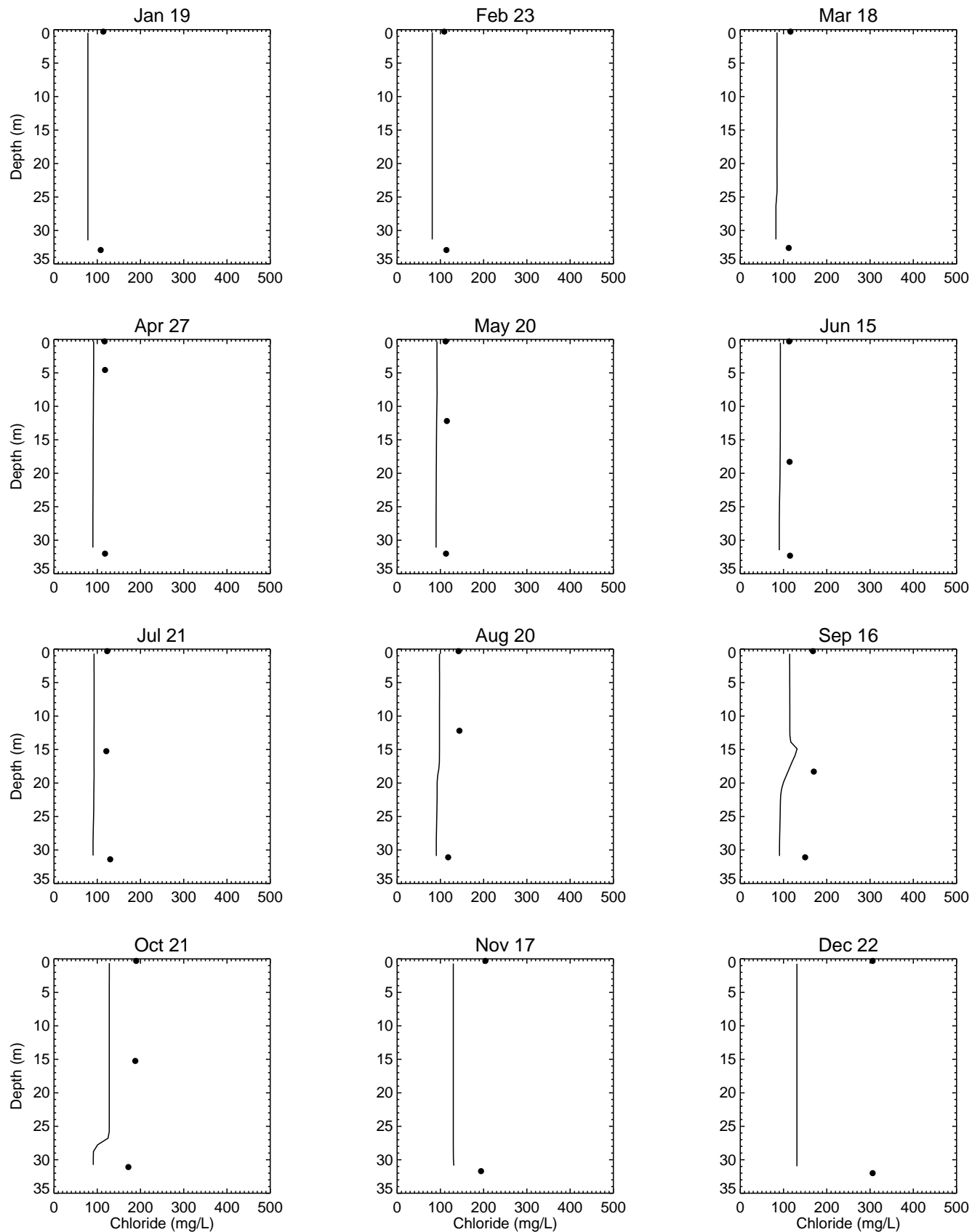
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 1984

Profiles shown for dates with available data else model results for first day of month shown.
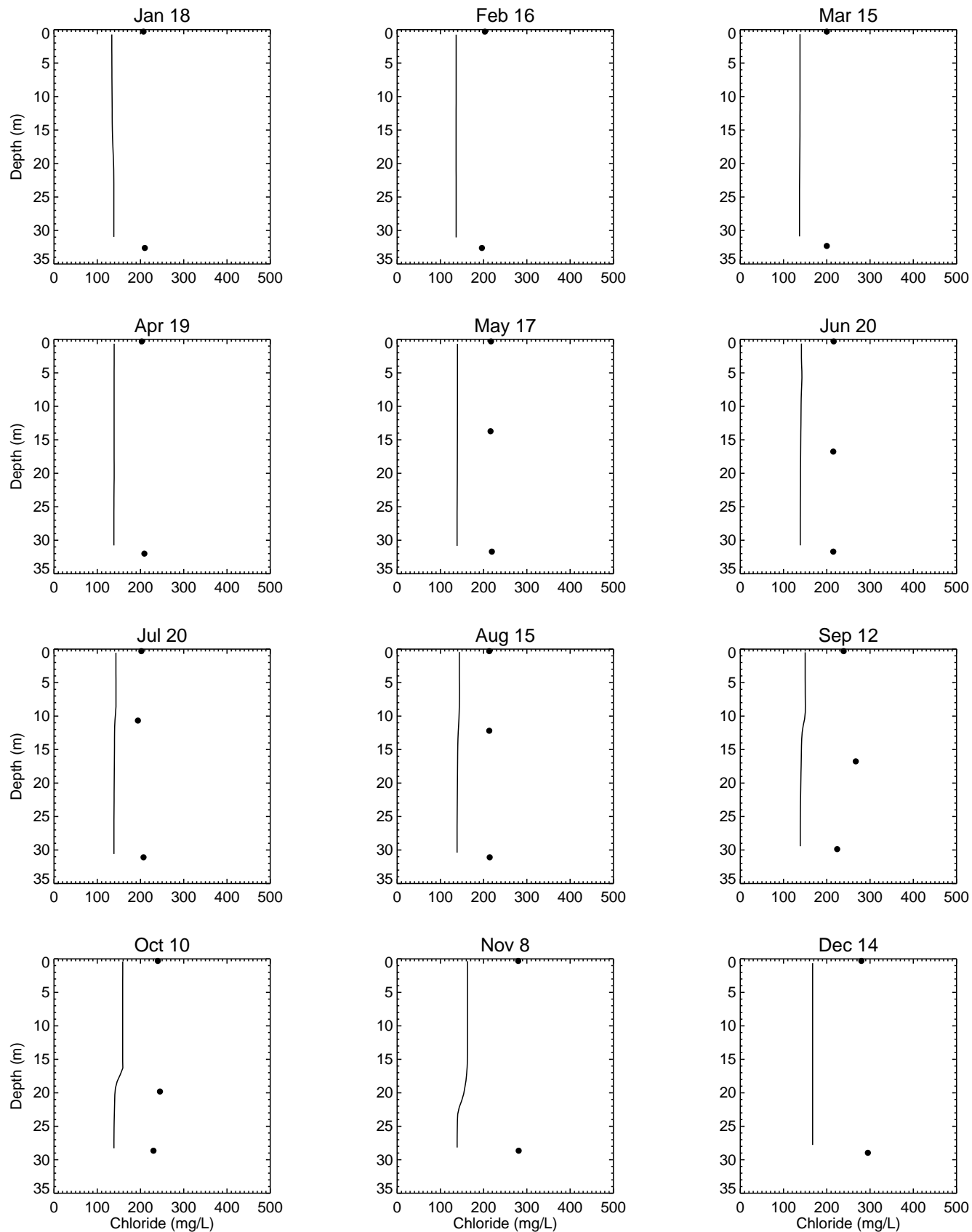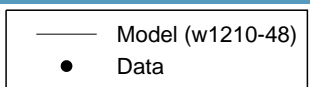
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 1985

Profiles shown for dates with available data else model results for first day of month shown.
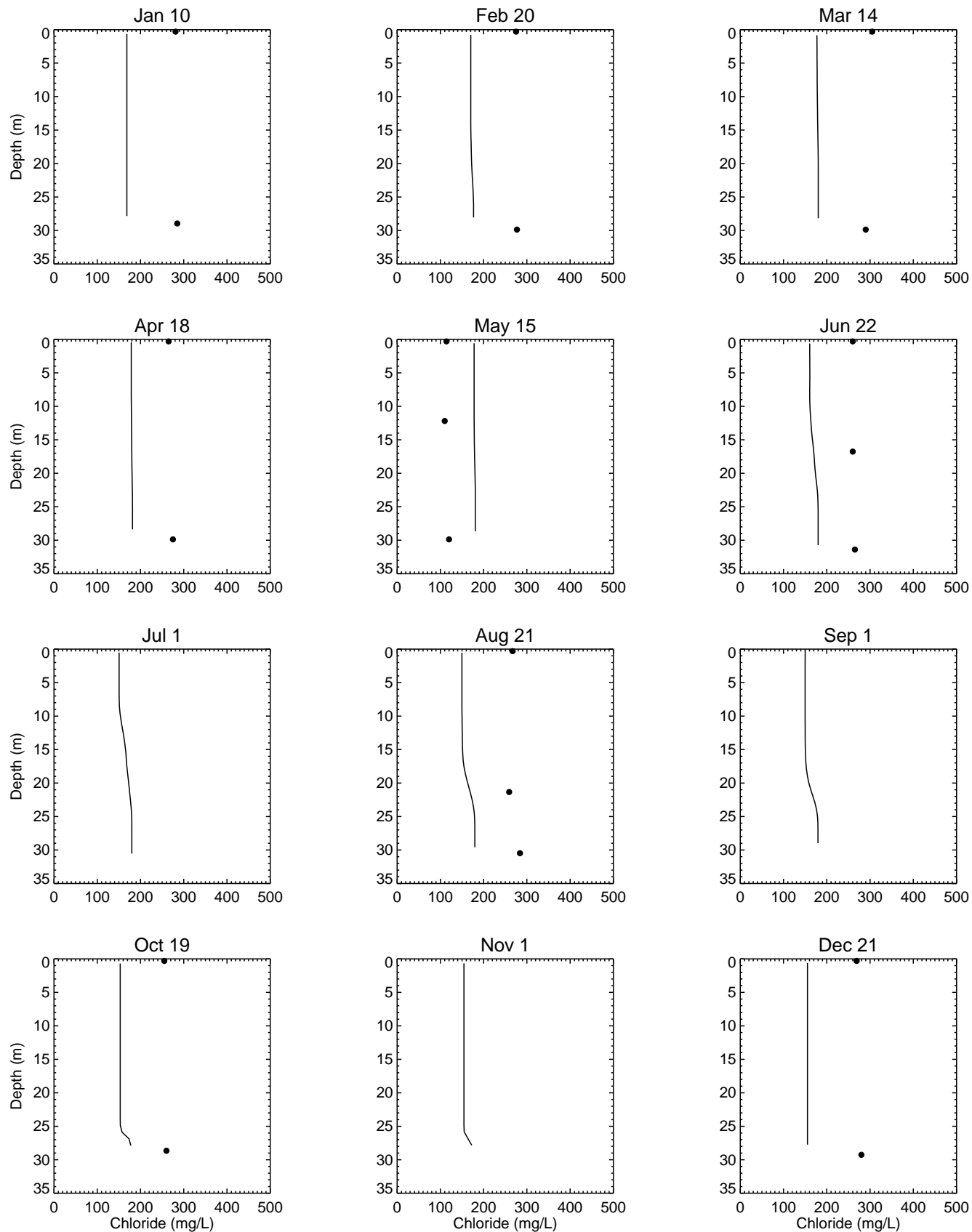
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:54 2013

Jan 23 Feb 19 Mar 24 Apr 15 May 21 Jun 18 Jul 23 Aug 20 Sep 25 Oct 21 Nov 17 Dec 17

Chloride (mg/L)

Model (w1210-48)
Data

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 1986

Profiles shown for dates with available data else model results for first day of month shown.
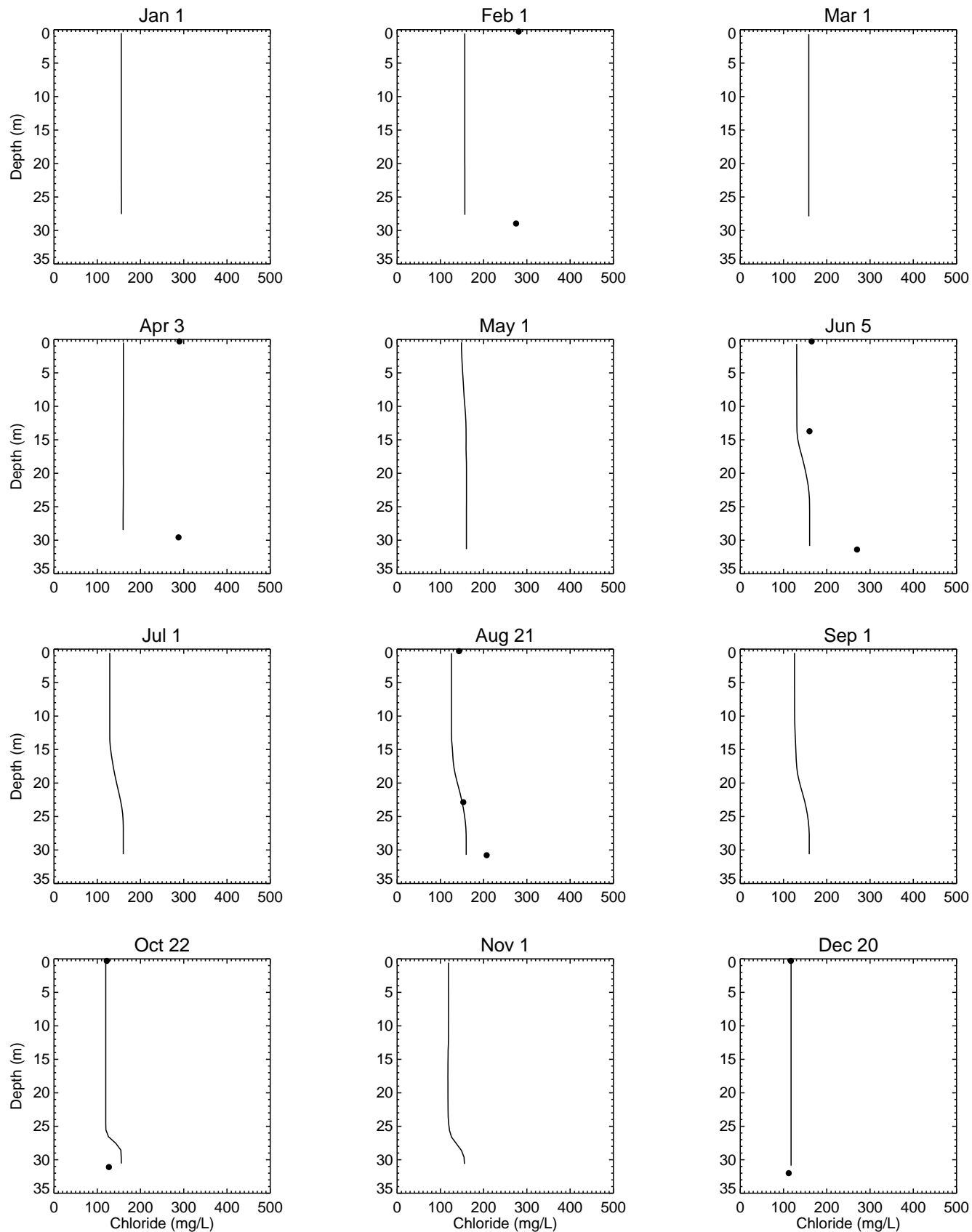
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 1987

Profiles shown for dates with available data else model results for first day of month shown.
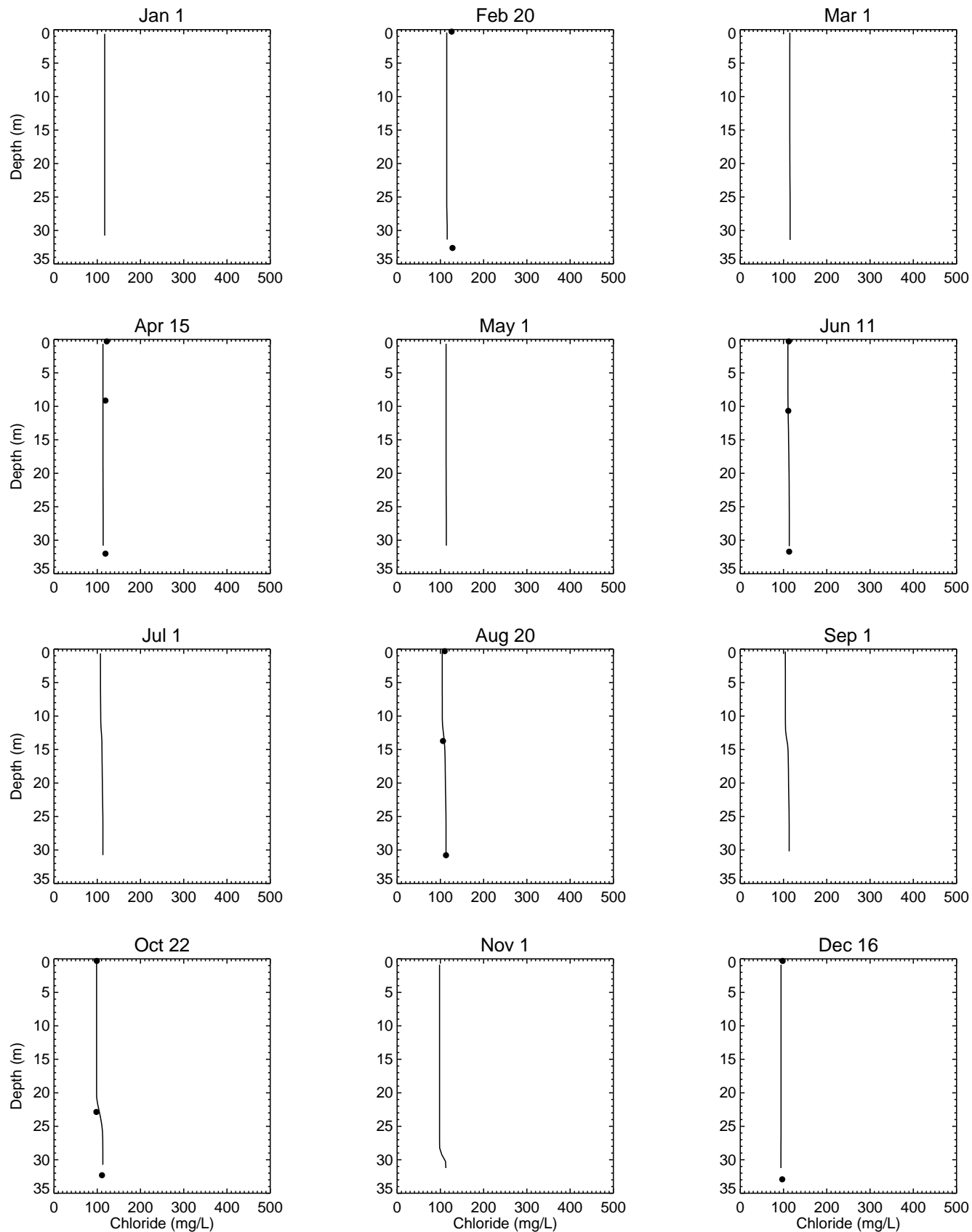
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 18 · Feb 16 · Mar 15 · Apr 19 · May 17 · Jun 20 · Jul 20 · Aug 15 · Sep 12 · Oct 10 · Nov 8 · Dec 14
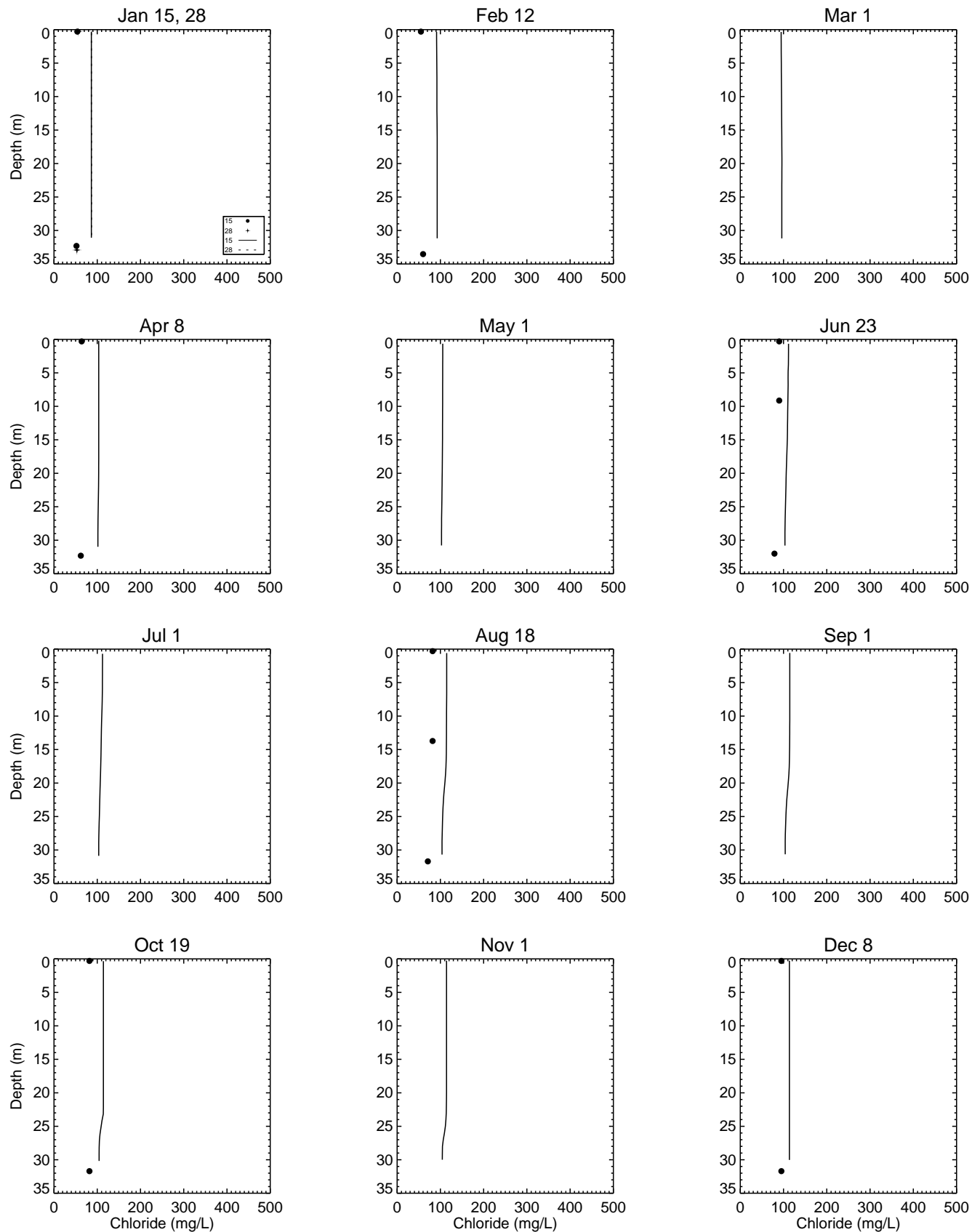
Chloride (mg/L)

——— Model (w1210-48)

● Data

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 1988

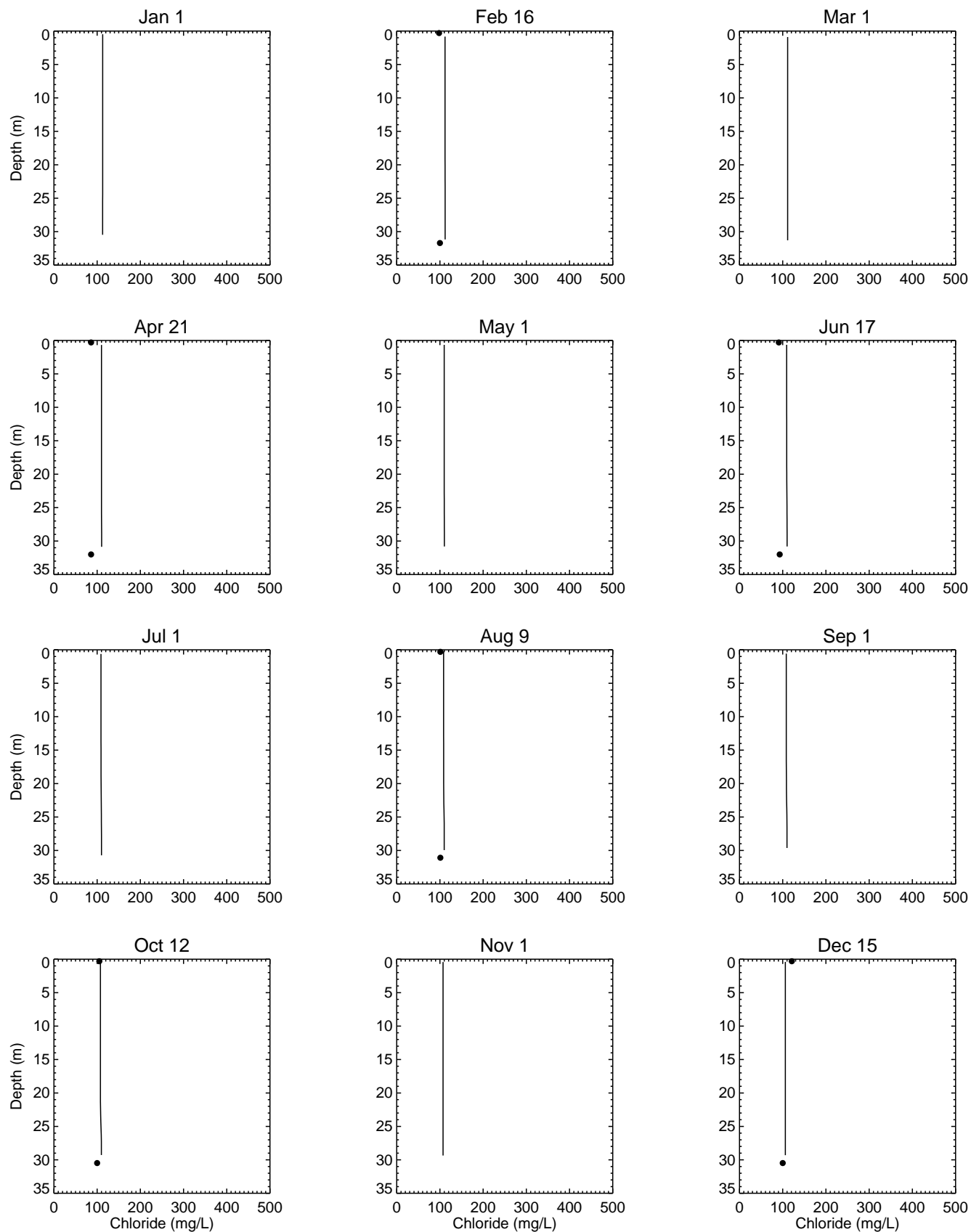*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 1989

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 1990

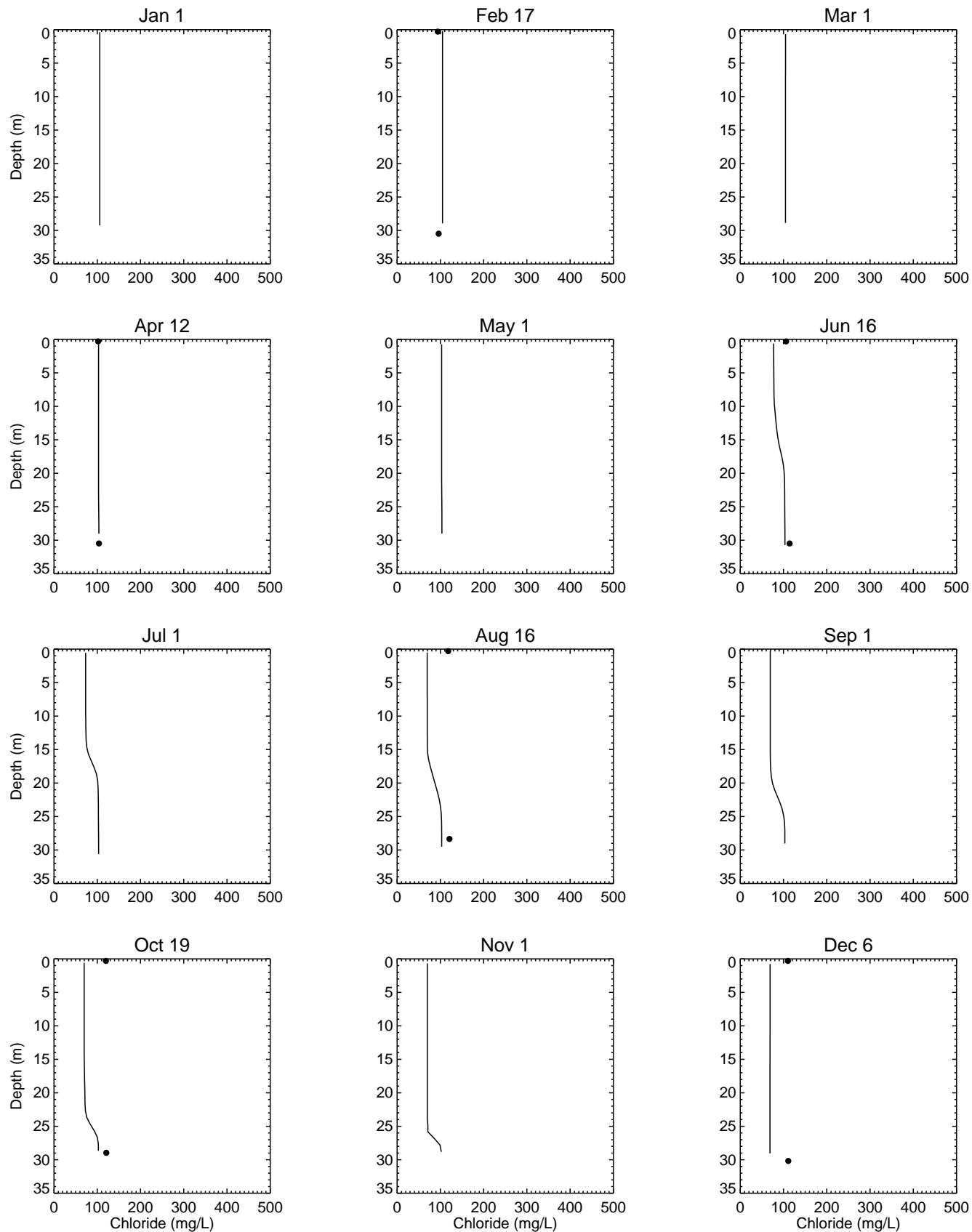*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 1991

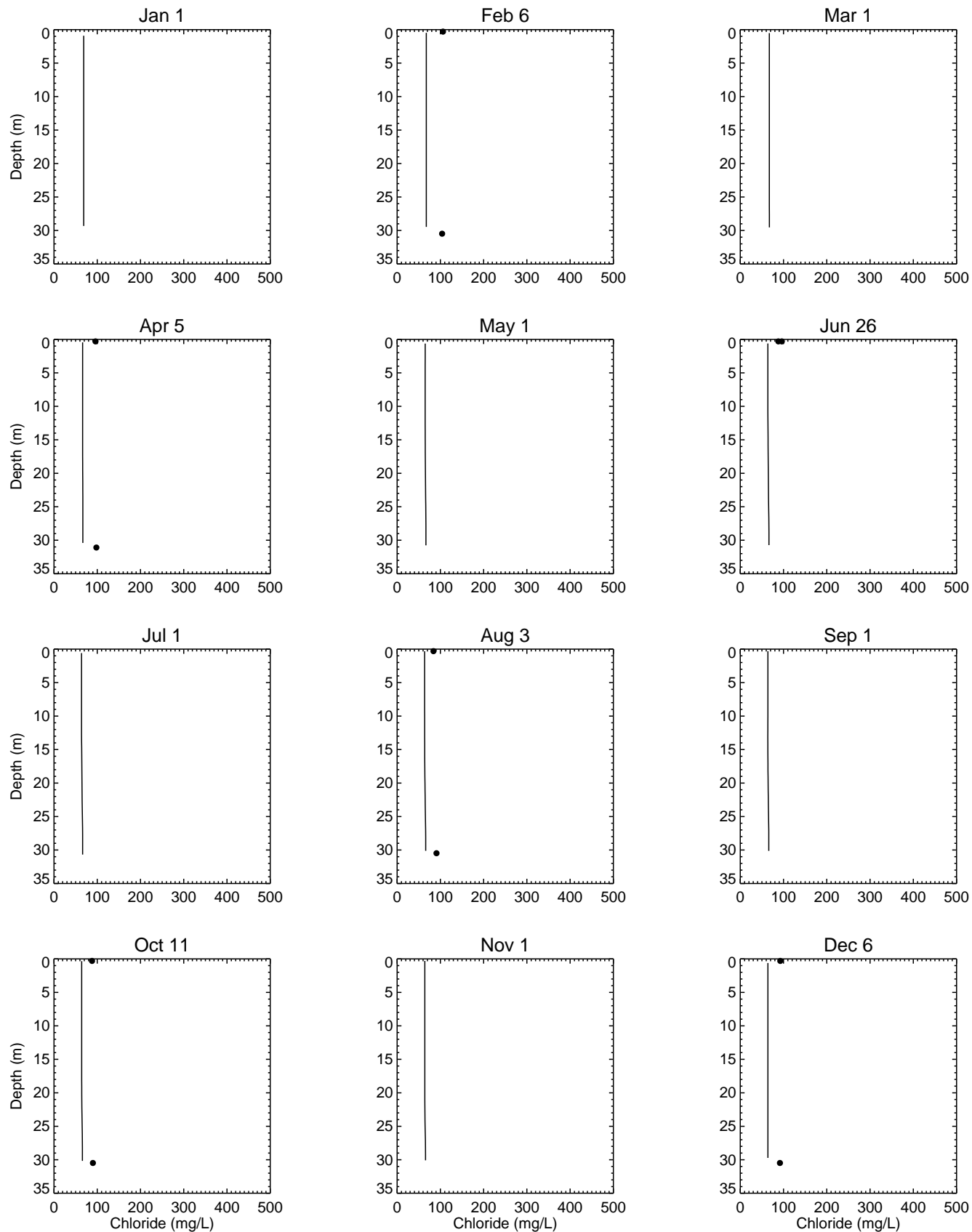*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
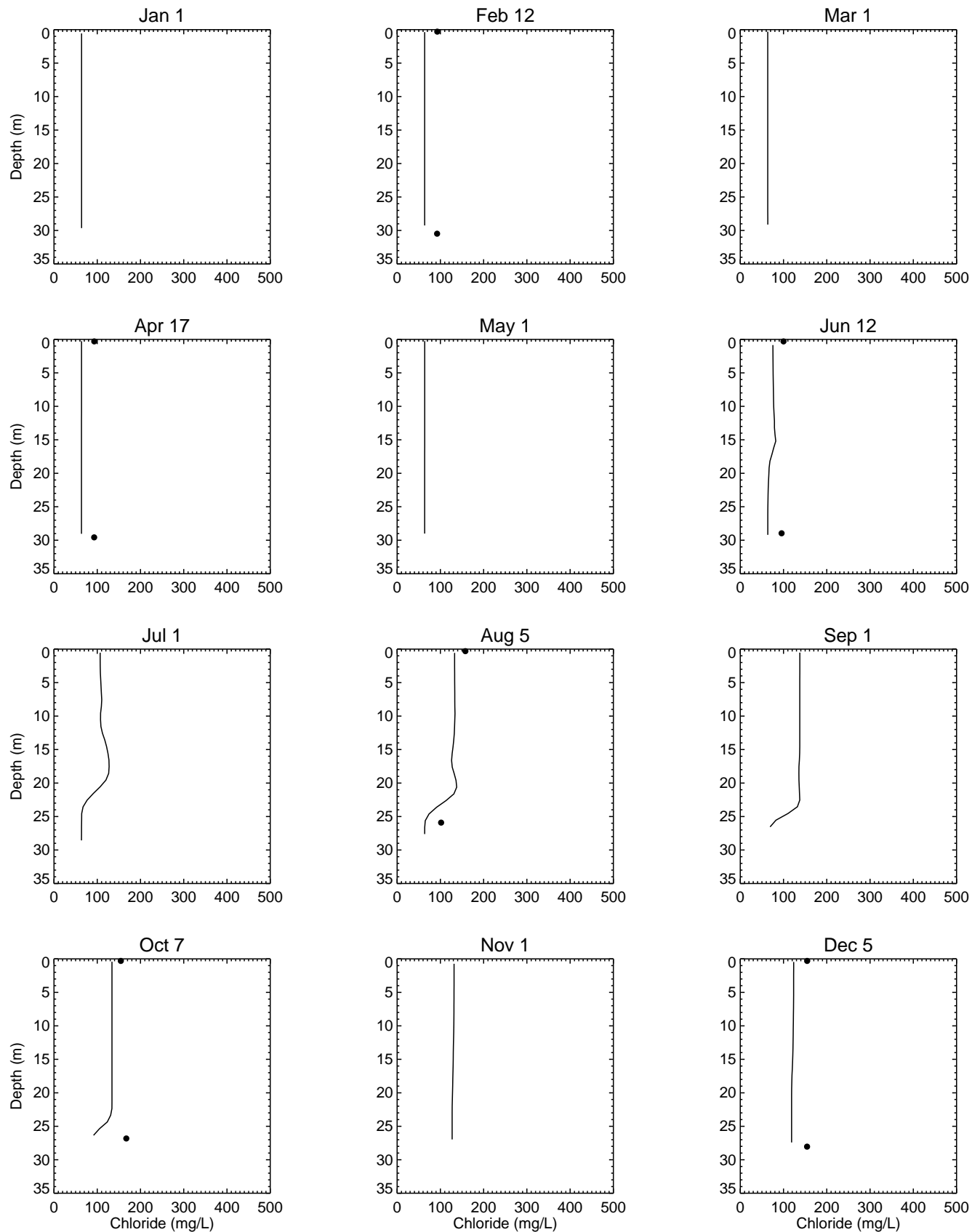Lower Colorado River Authority

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 1993

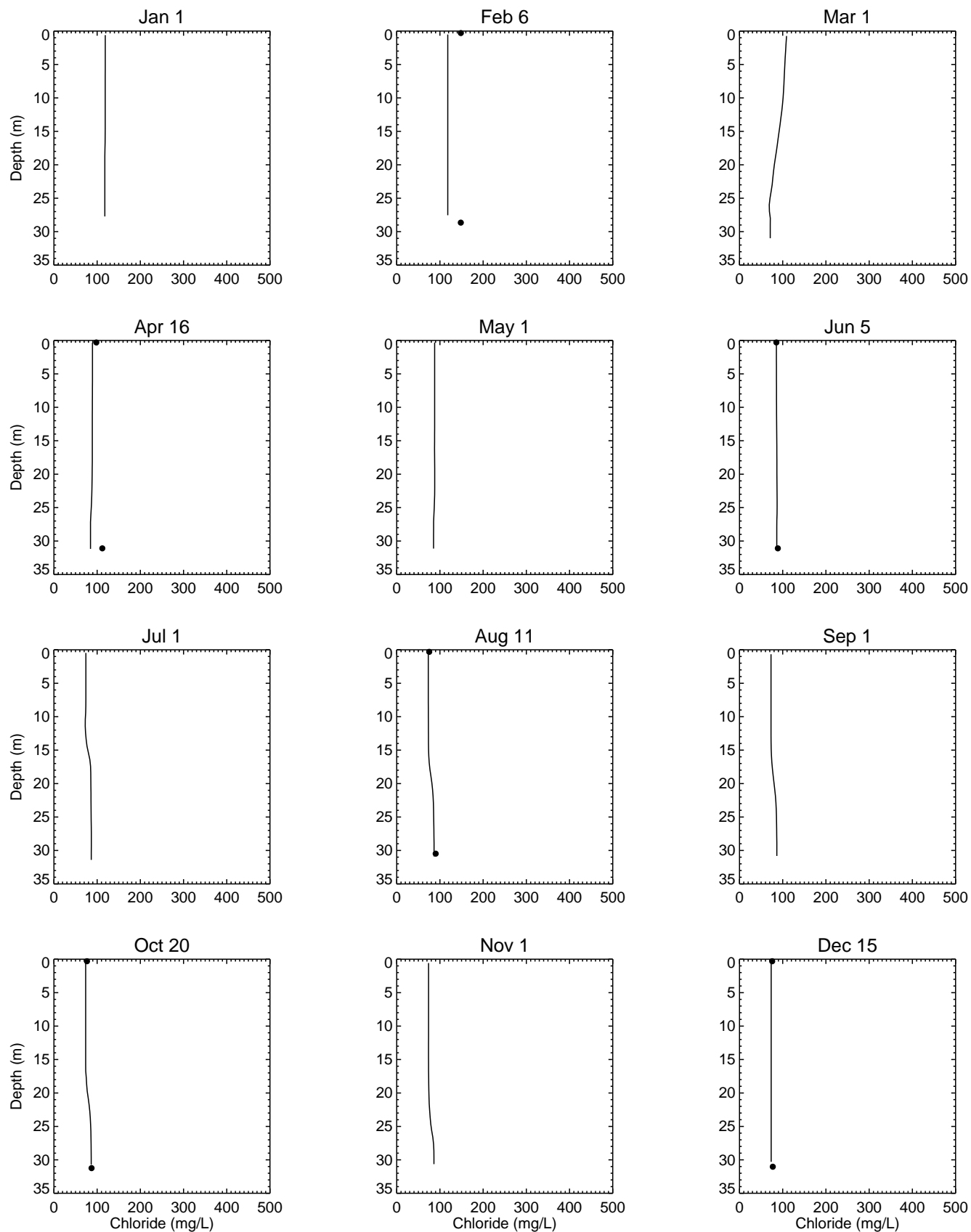*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
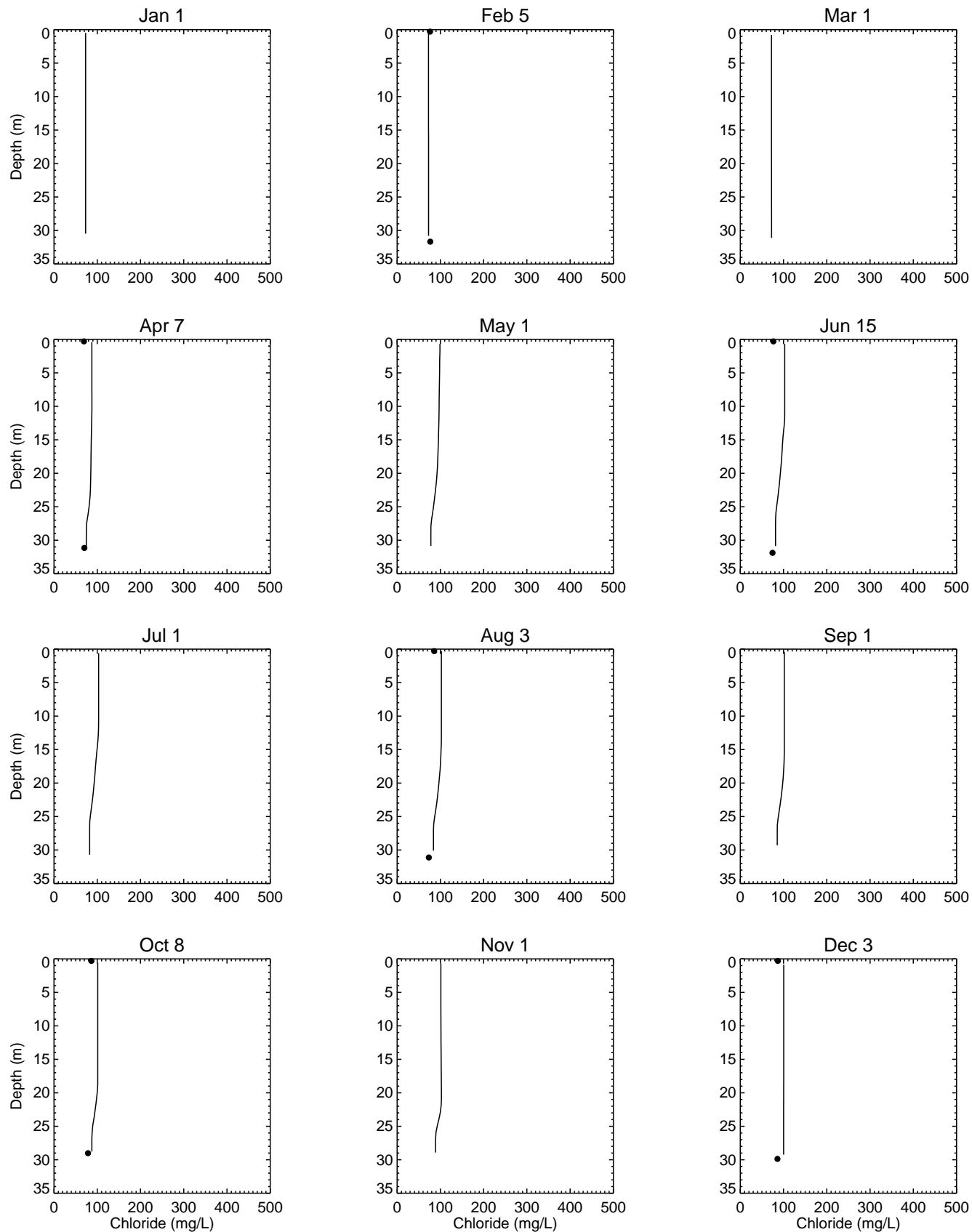Fri Jan 25 18:13:55 2013

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan near Buchanan Dam (Segment 13) - Chloride - 1994

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 Feb 6 Mar 1
Apr 5 May 1 Jun 26
Jul 1 Aug 3 Sep 1
Oct 11 Nov 1 Dec 6

Chloride (mg/L)

Depth (m)

—— Model (w1210-48)
● Data

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:55 2013

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 1996

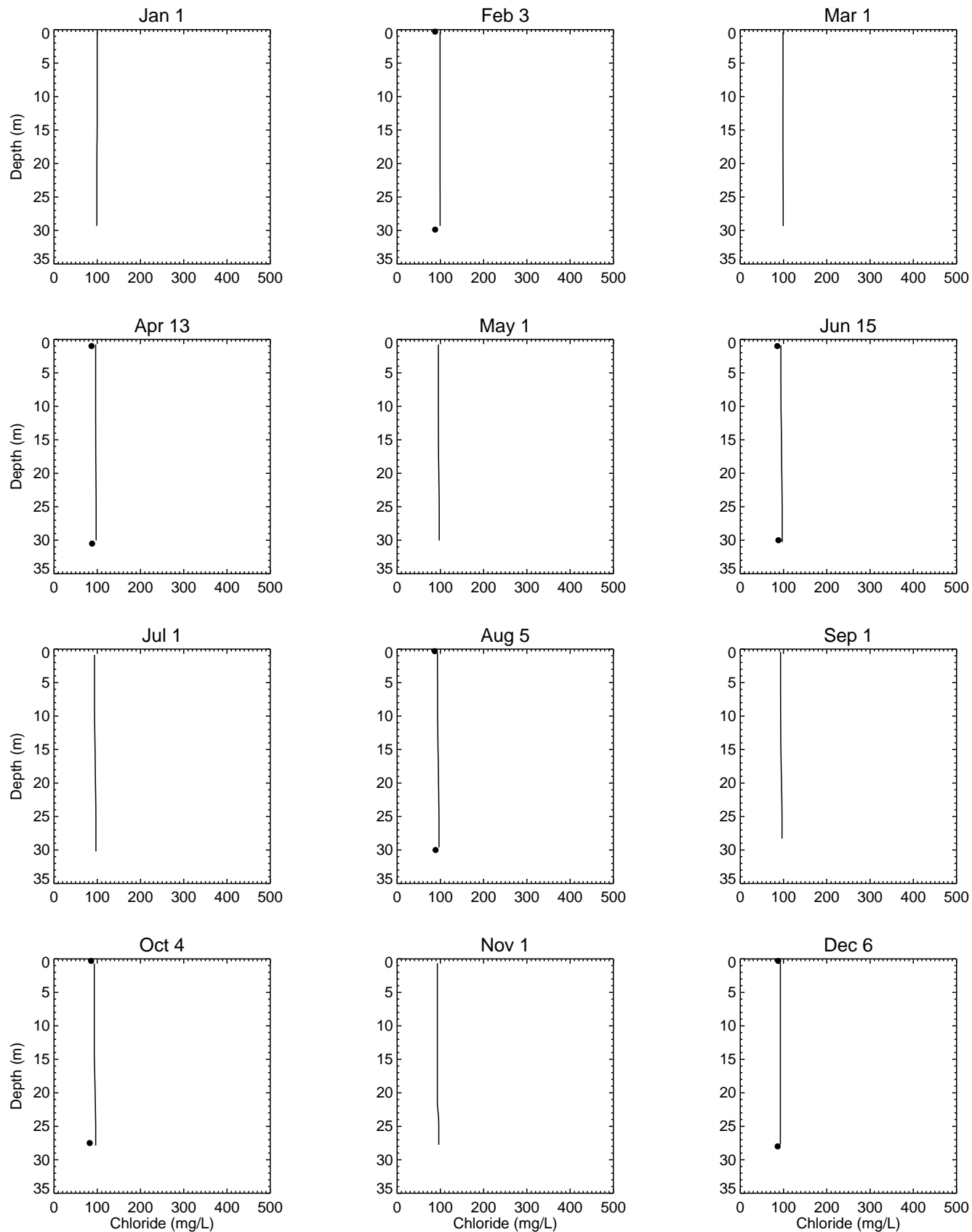*Profiles shown for dates with available data else model results for first day of month shown.*
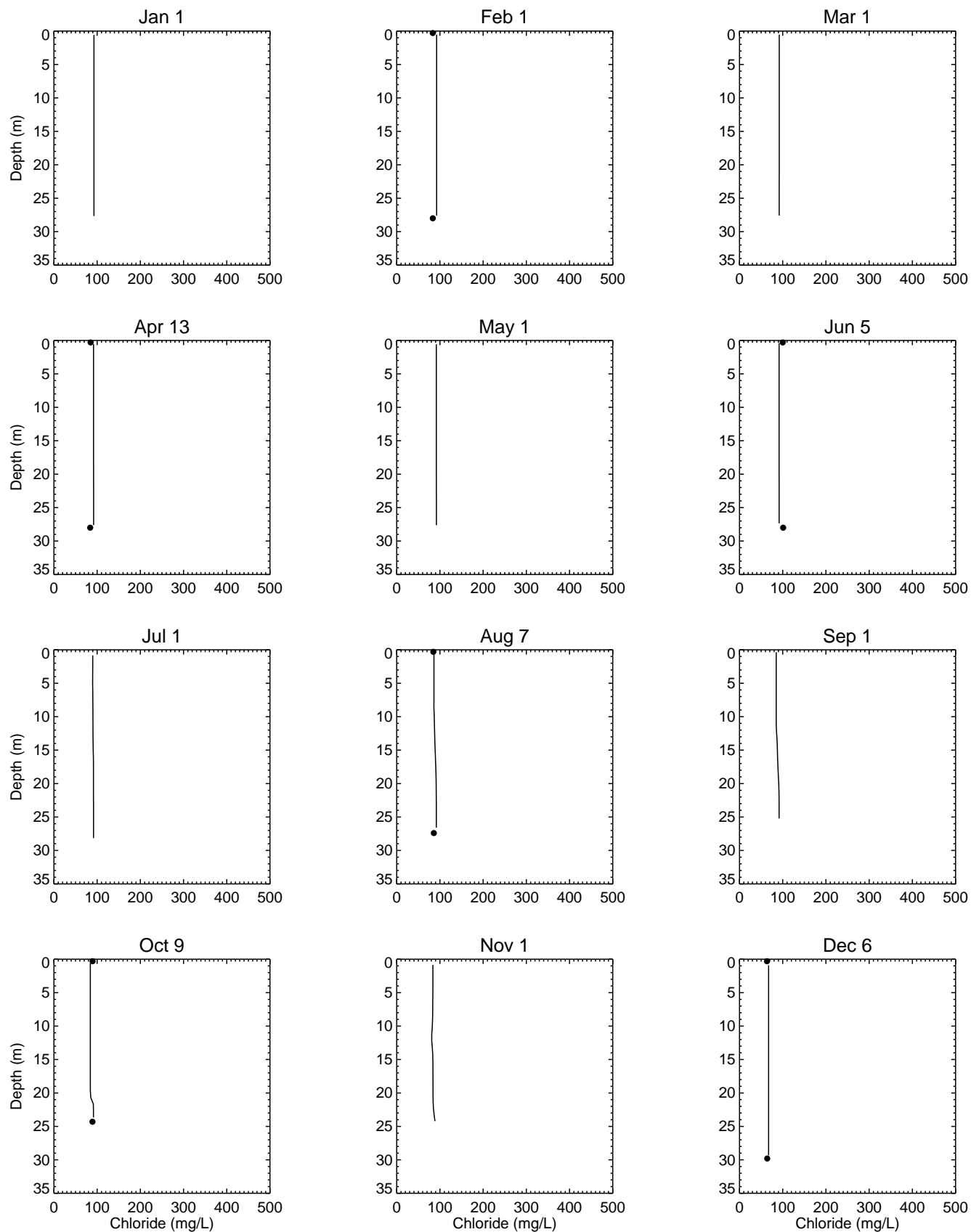
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 6 · Mar 1 · Apr 16 · May 1 · Jun 5 · Jul 1 · Aug 11 · Sep 1 · Oct 20 · Nov 1 · Dec 15

Model (w1210-48)
Data

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 1997

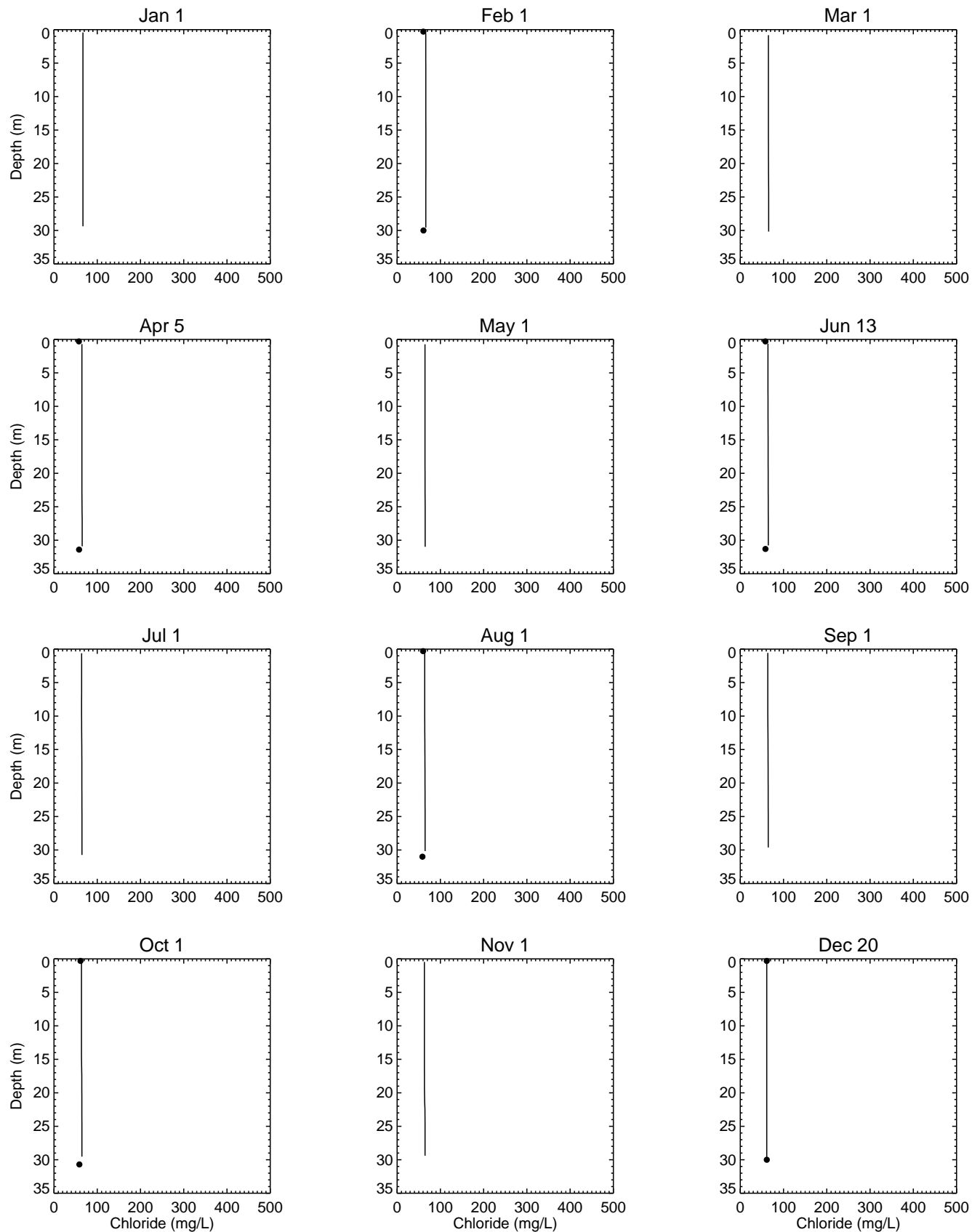*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 1998

Profiles shown for dates with available data else model results for first day of month shown.
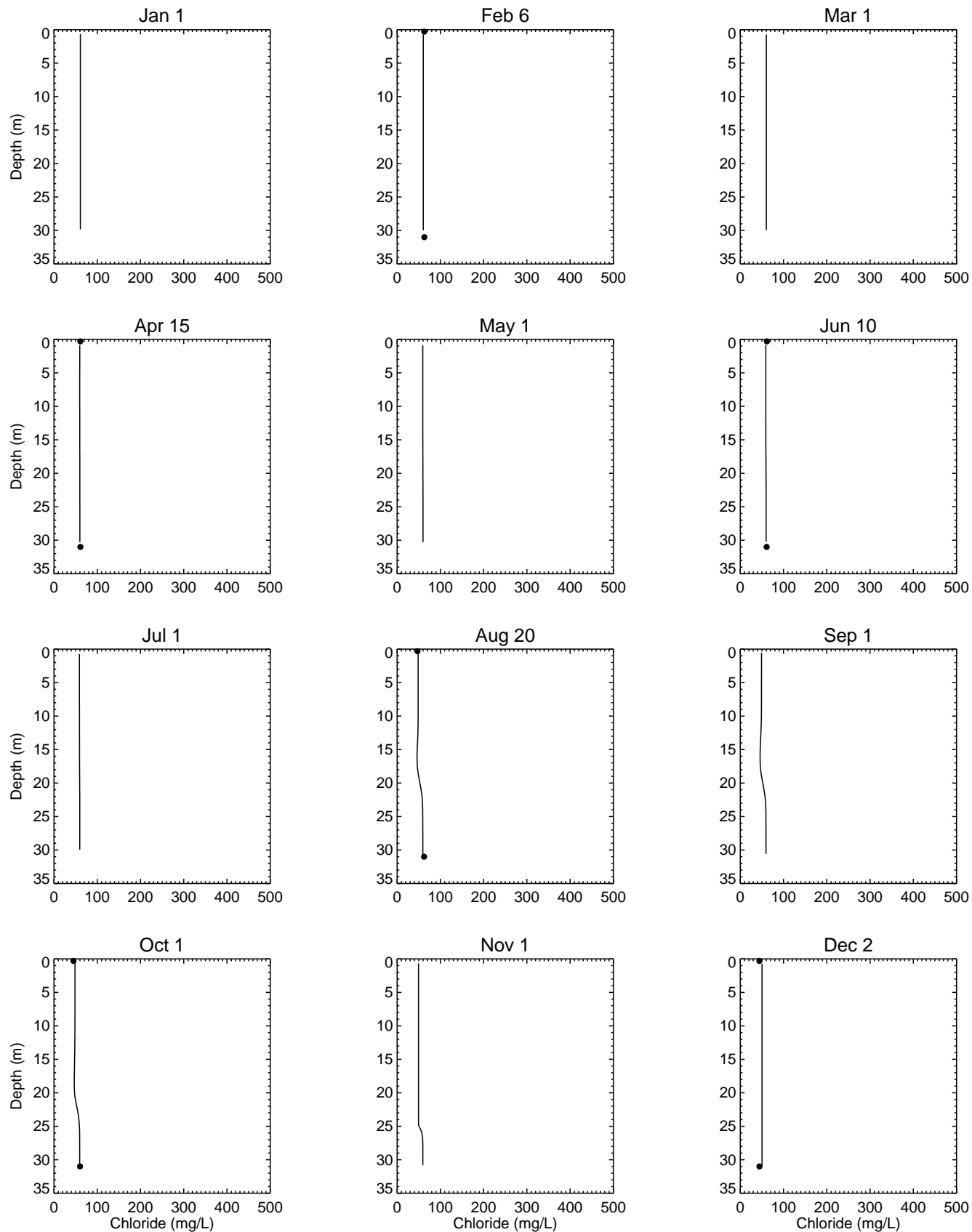
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 1999

Profiles shown for dates with available data else model results for first day of month shown.
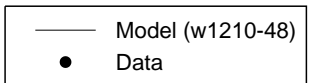
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
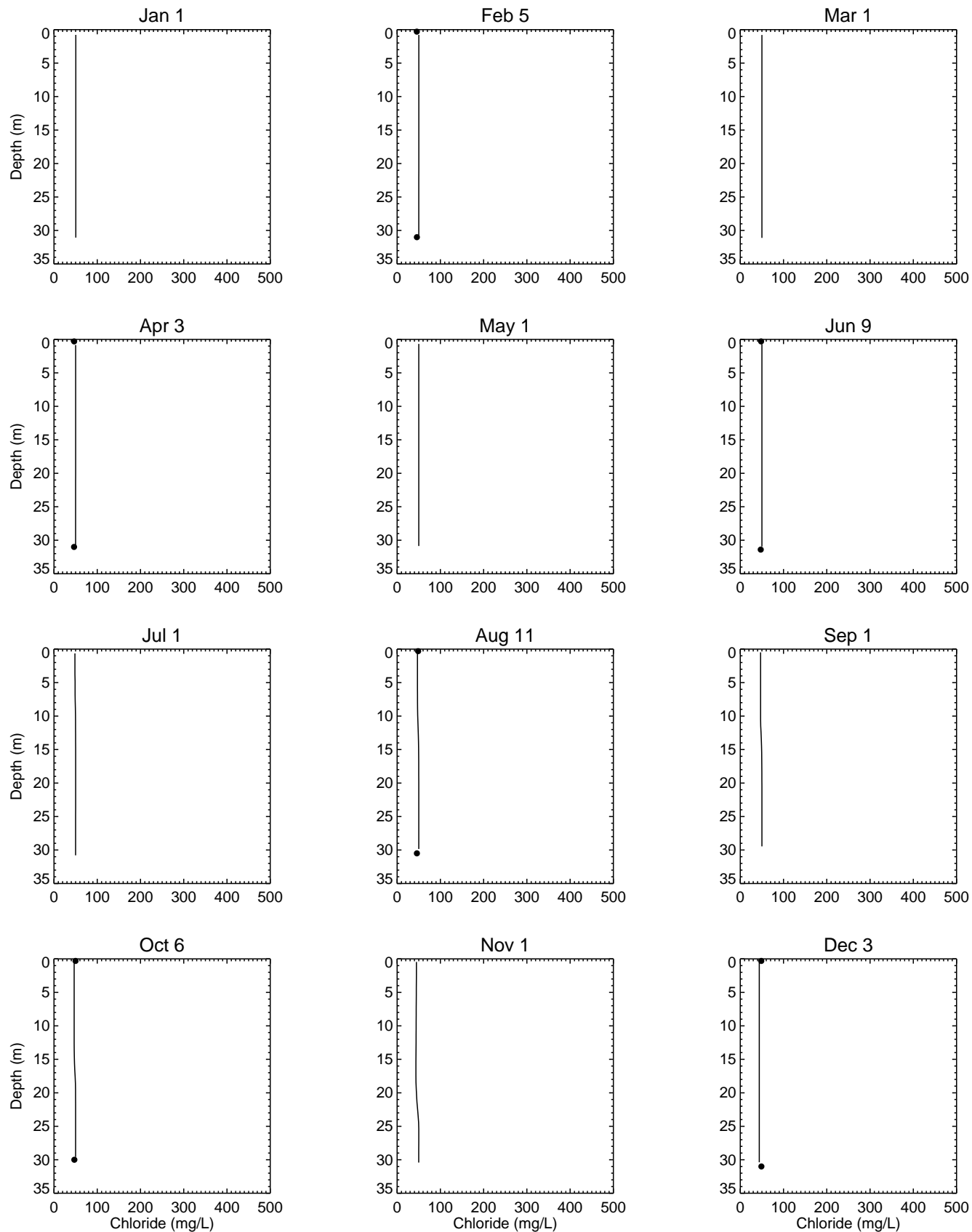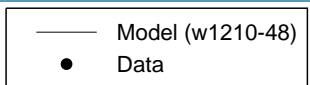Fri Jan 25 18:13:55 2013

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 2000

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:55 2013

Jan 1 — Feb 1 — Mar 1 — Apr 5 — May 1 — Jun 13 — Jul 1 — Aug 1 — Sep 1 — Oct 1 — Nov 1 — Dec 20

Depth (m)

Chloride (mg/L)
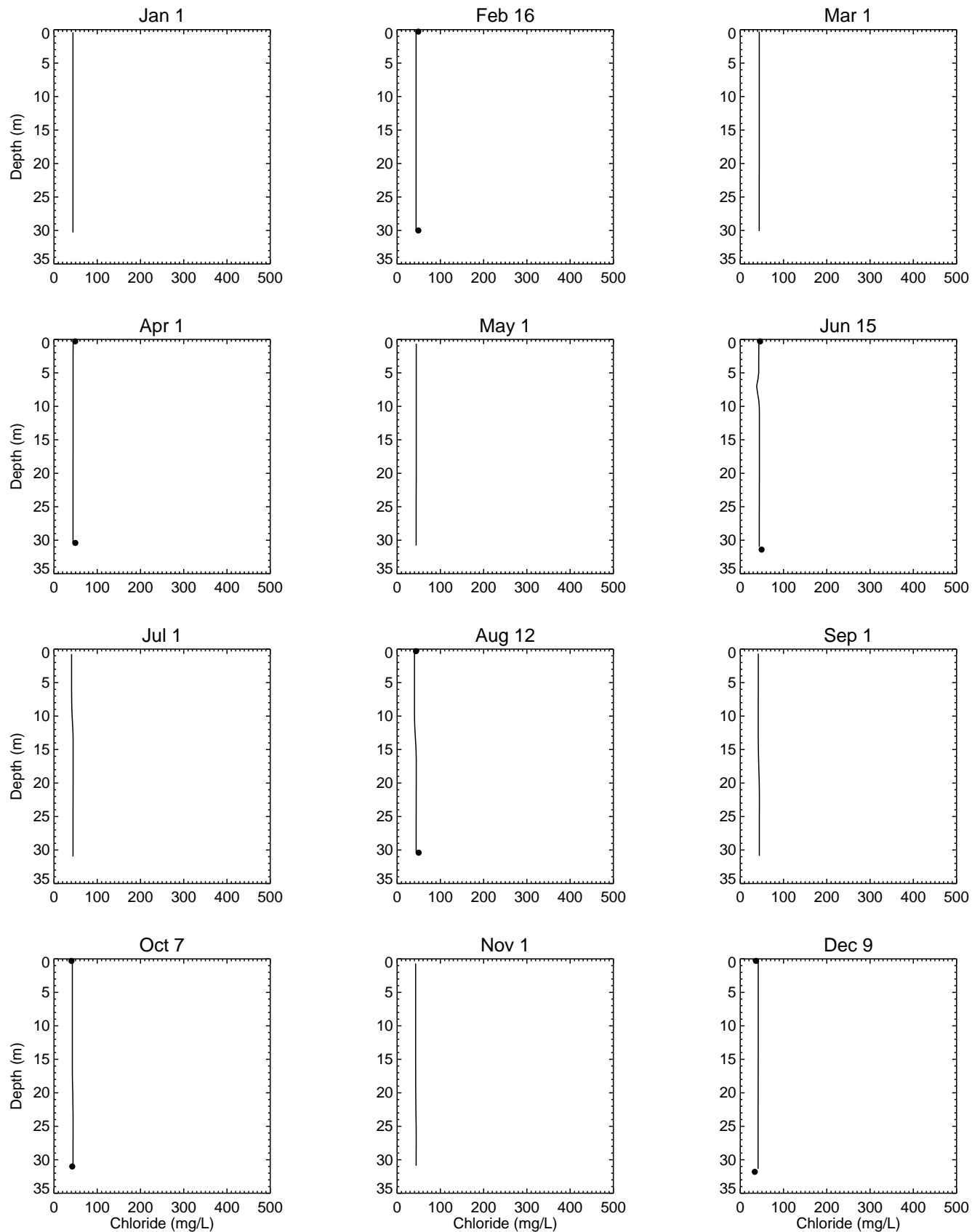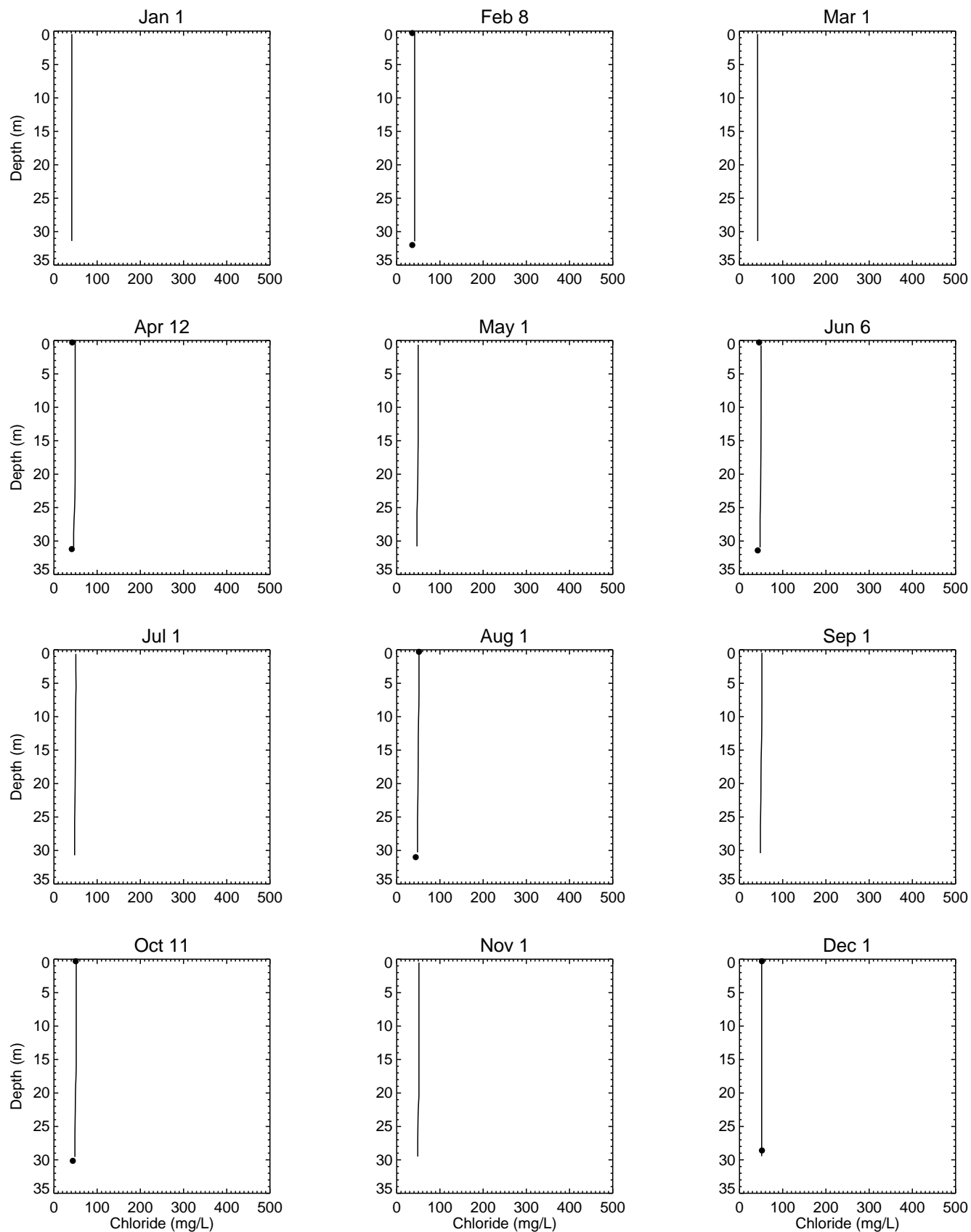
Model (w1210-48)
● Data

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 2001

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:55 2013

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
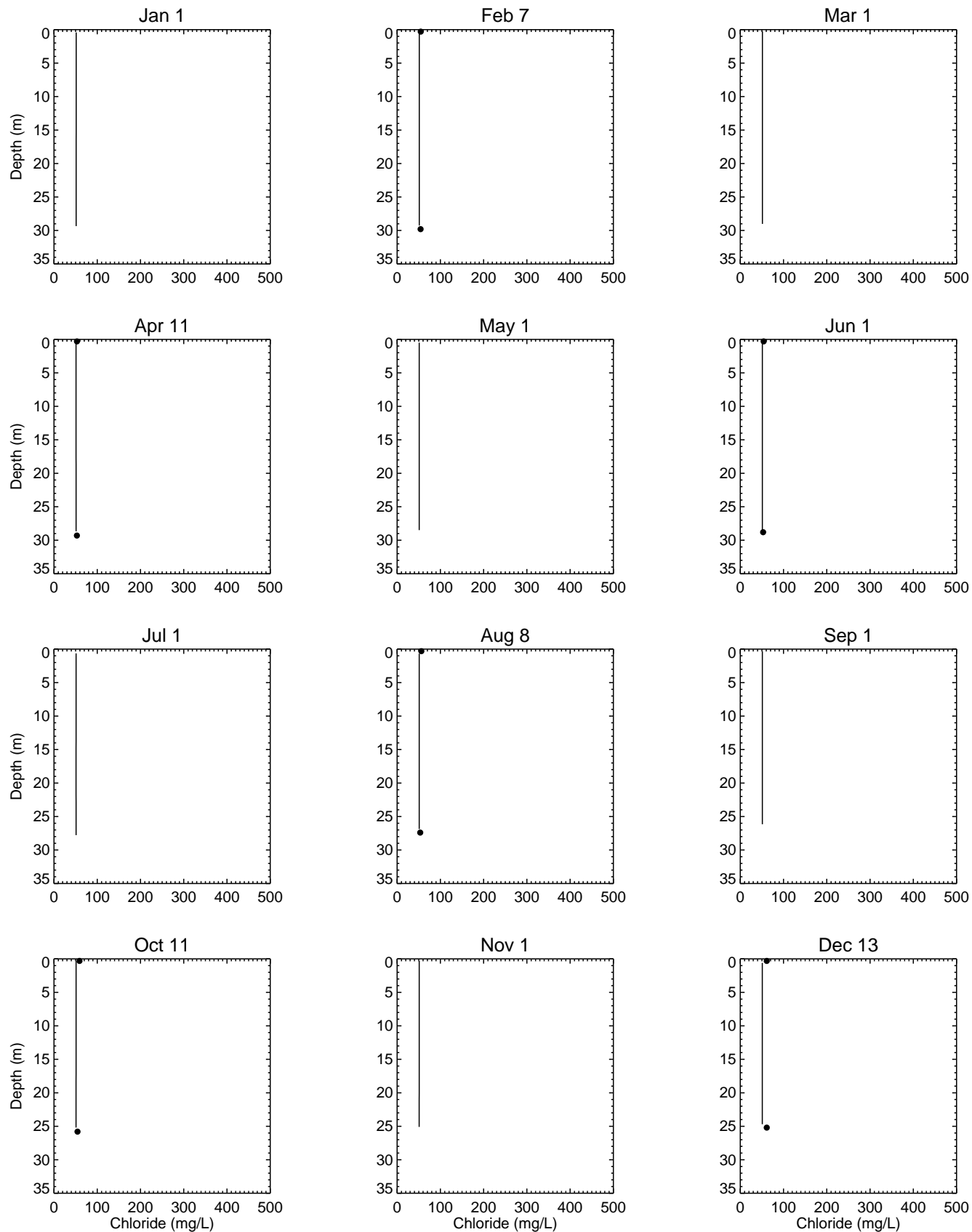near Buchanan Dam (Segment 13) - Chloride - 2002

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:55 2013

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 2003

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
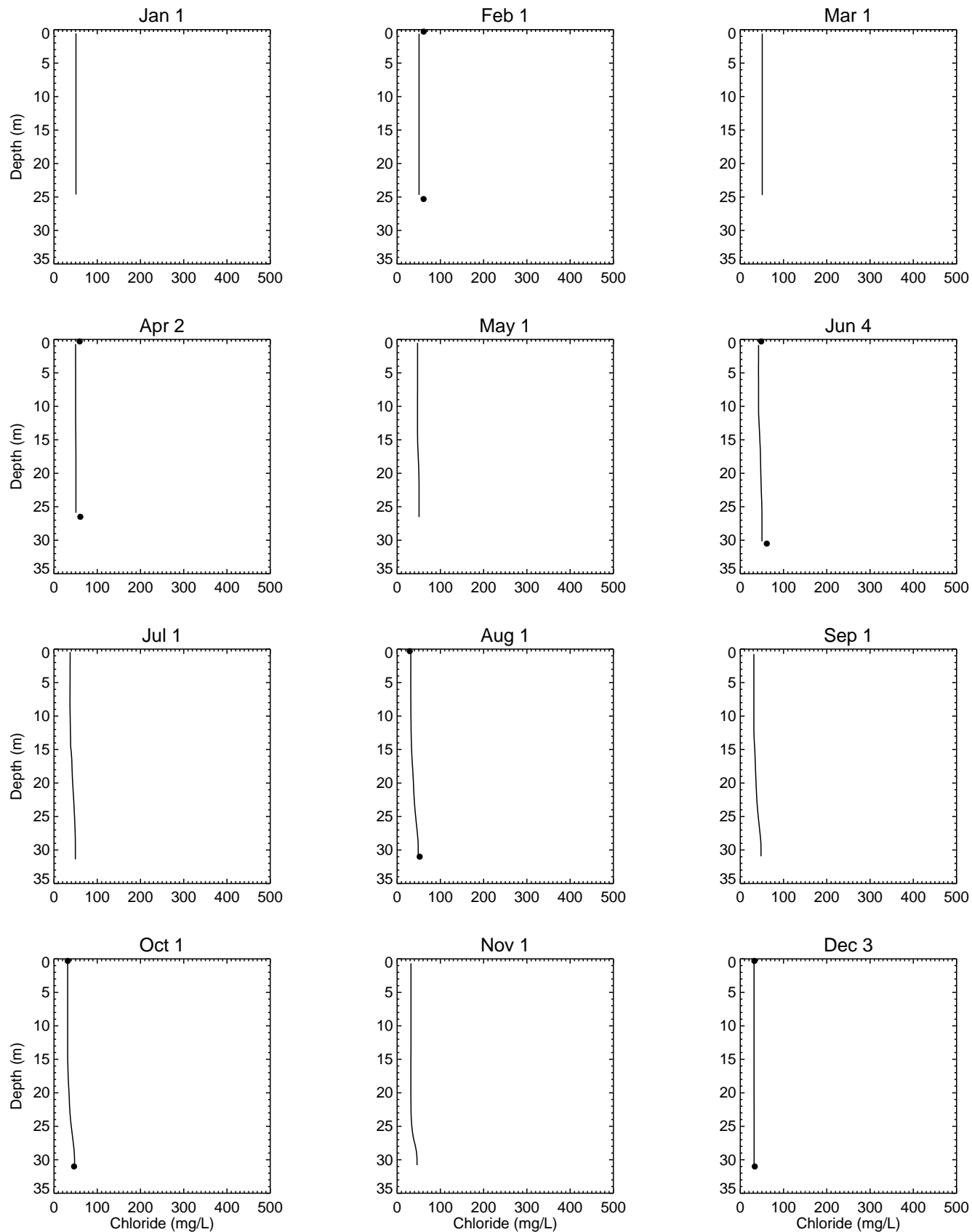
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:55 2013

Jan 1

Feb 16

Mar 1

Apr 1

May 1

Jun 15

Jul 1

Aug 12

Sep 1

Oct 7

Nov 1

Dec 9

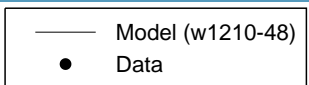Chloride (mg/L)

Depth (m)
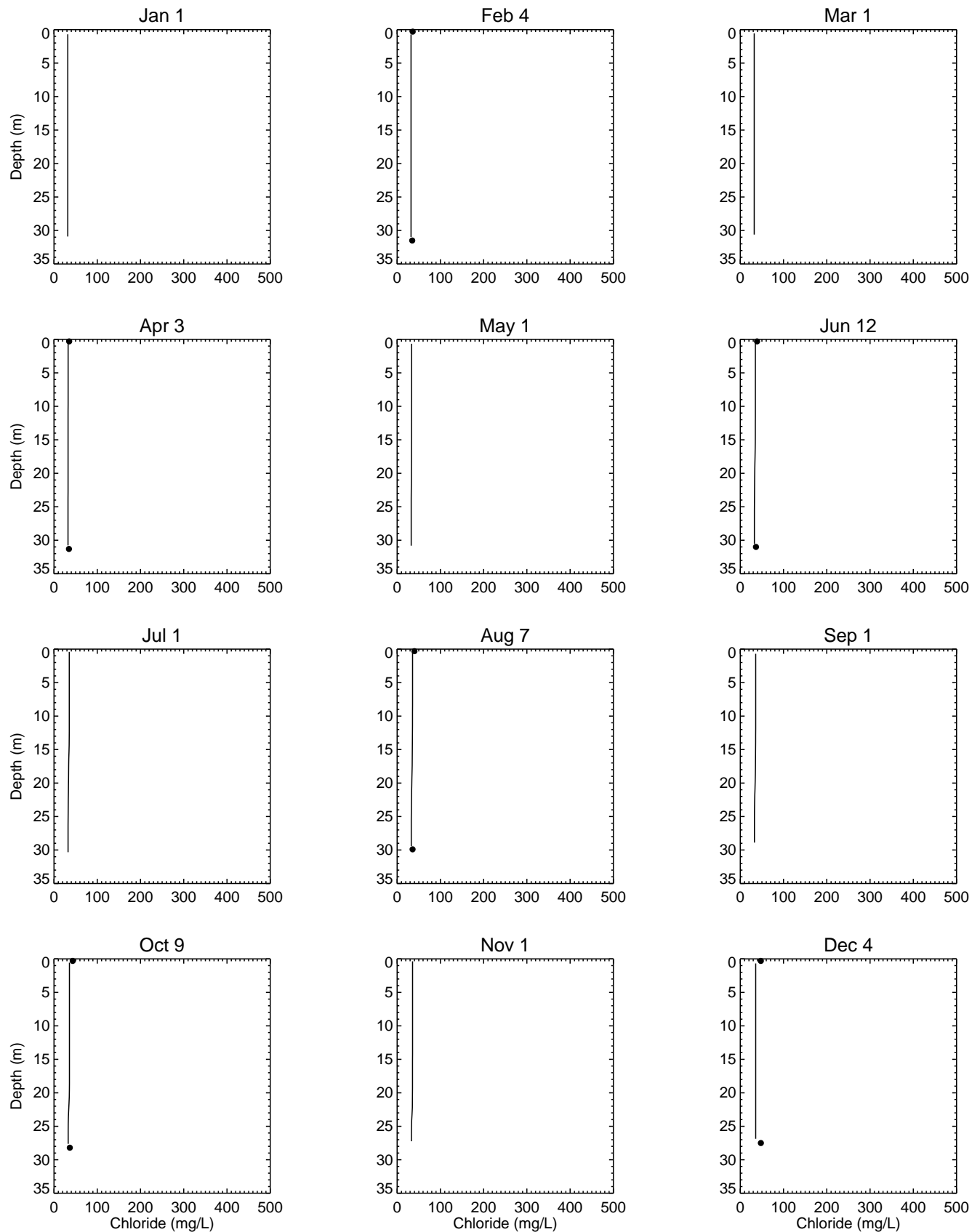
——— Model (w1210-48)
● Data

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 2004

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR
QEA
PARSONS

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 2005

Profiles shown for dates with available data else model results for first day of month shown.
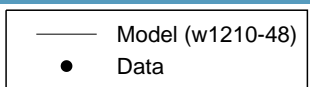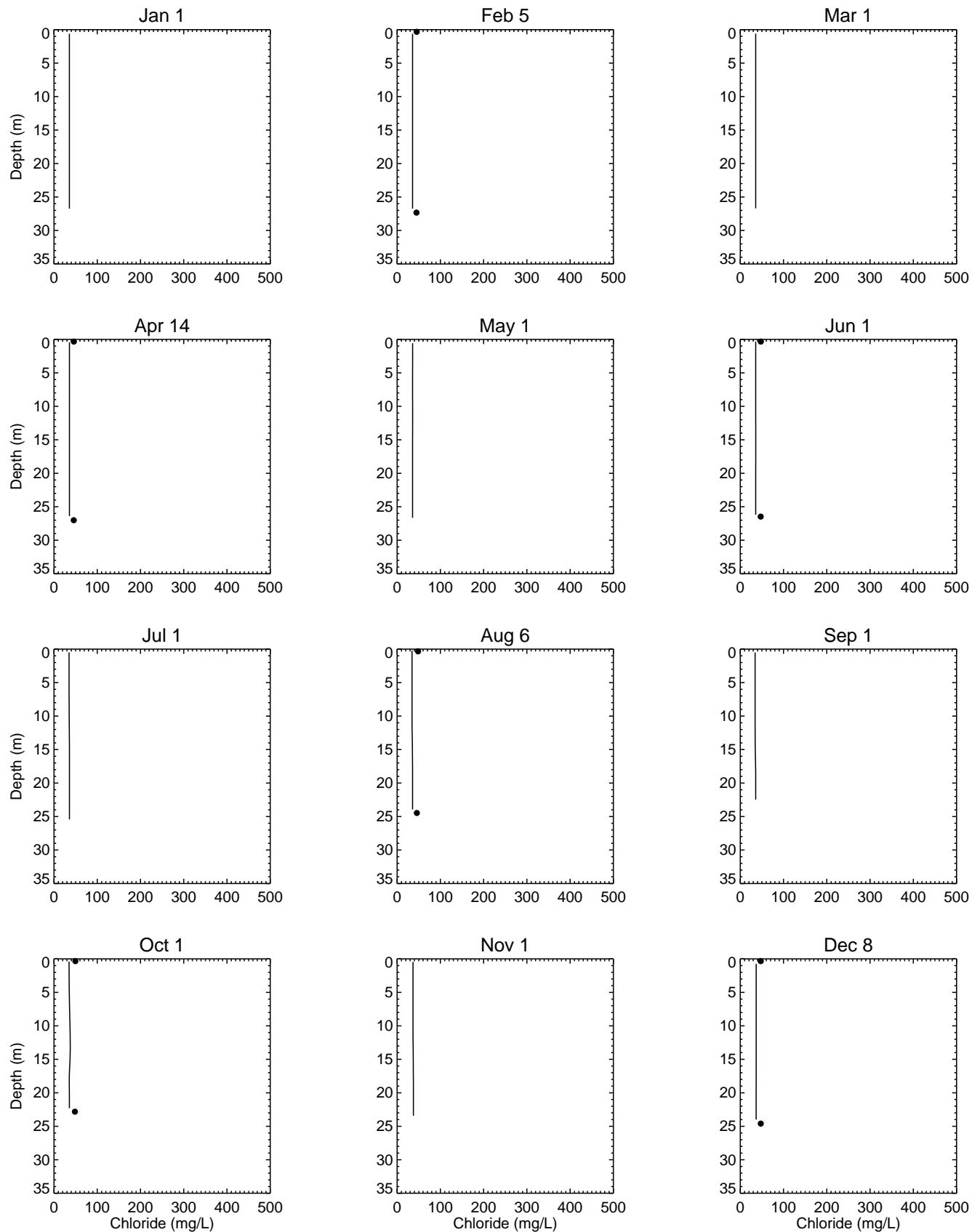
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 2006

Profiles shown for dates with available data else model results for first day of month shown.

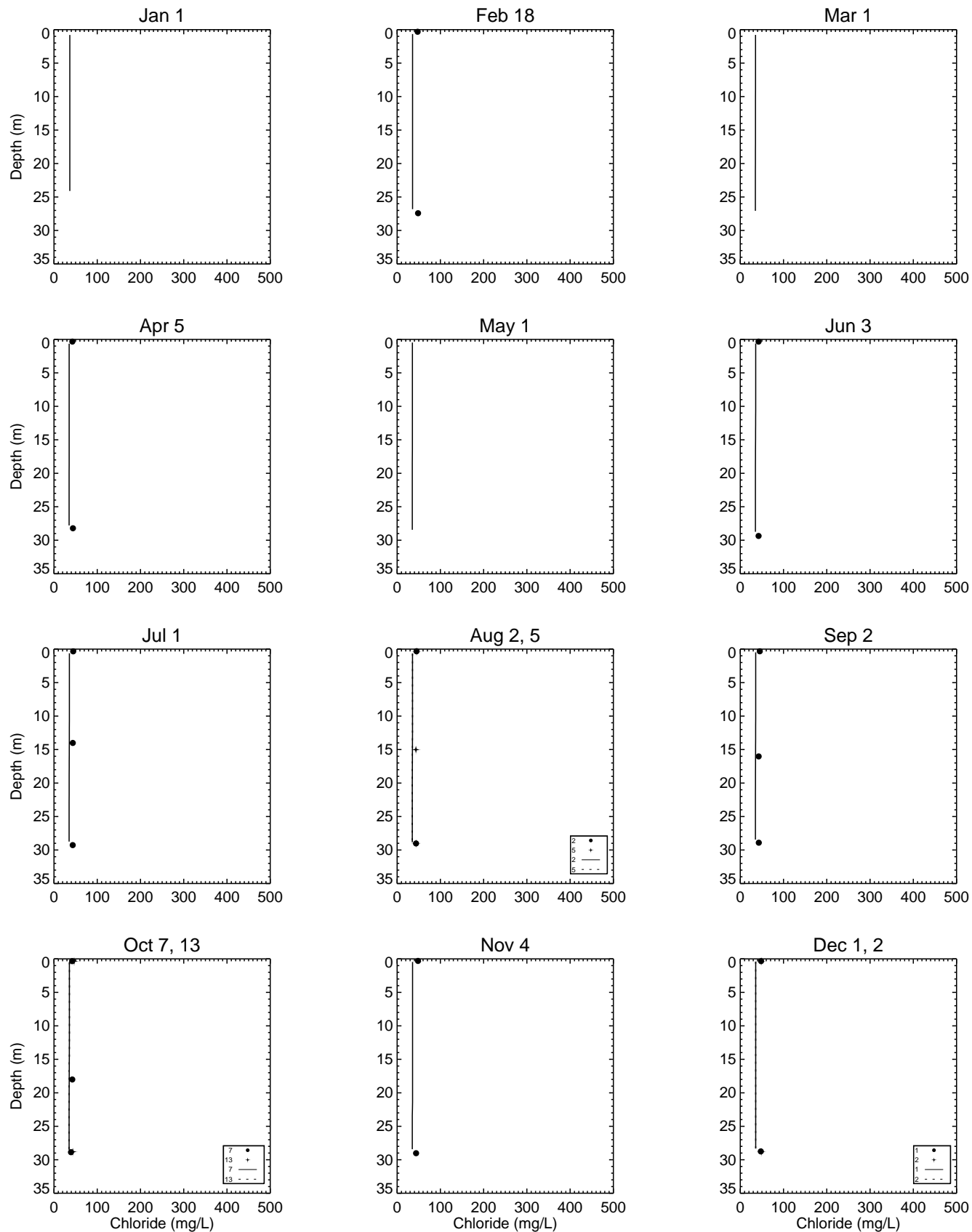CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 2007

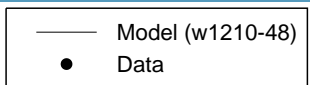*Profiles shown for dates with available data else model results for first day of month shown.*

Legend:
— Model (w1210-48)
● Data

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 2008

Profiles shown for dates with available data else model results for first day of month shown.
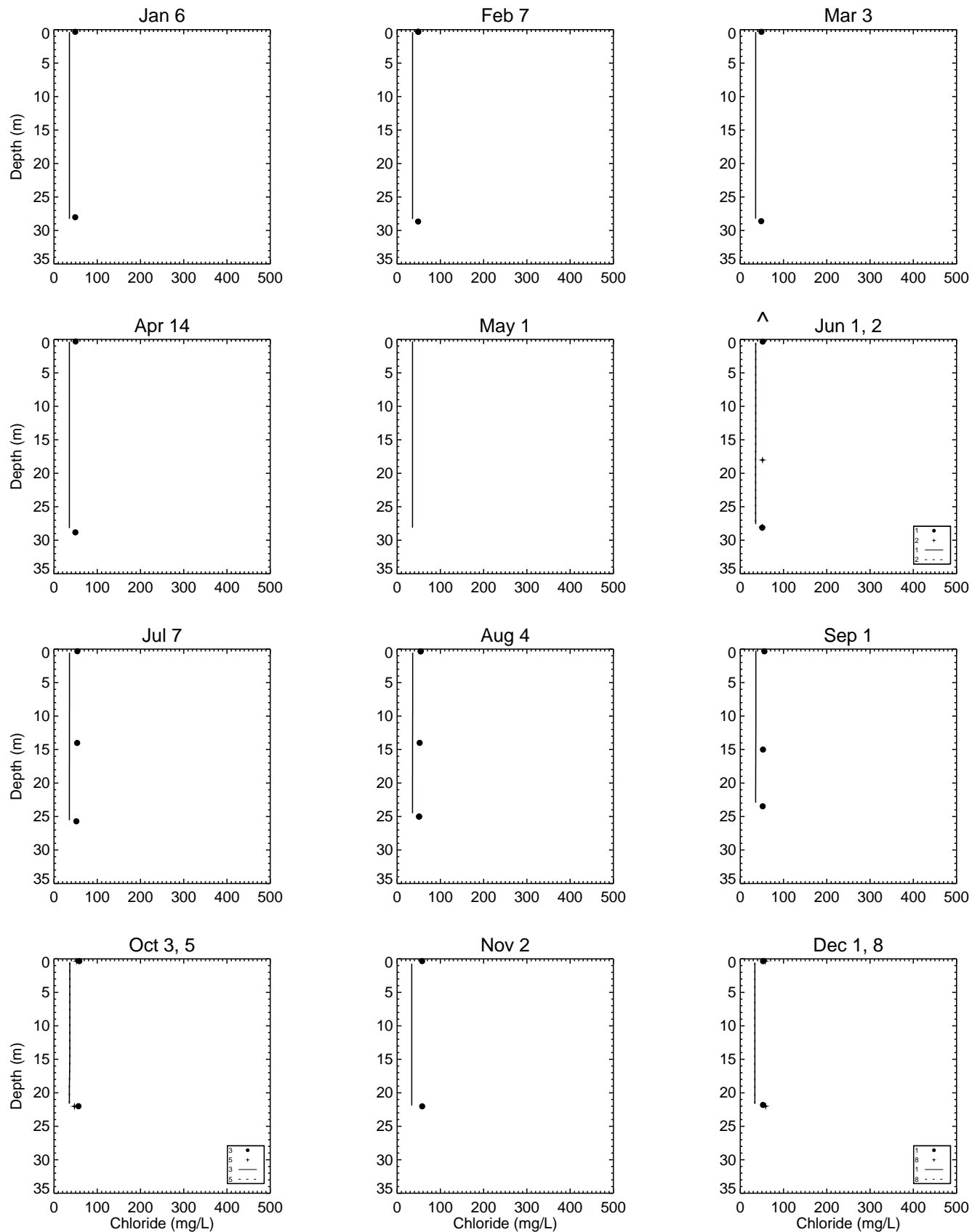
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 2009

Profiles shown for dates with available data else model results for first day of month shown.
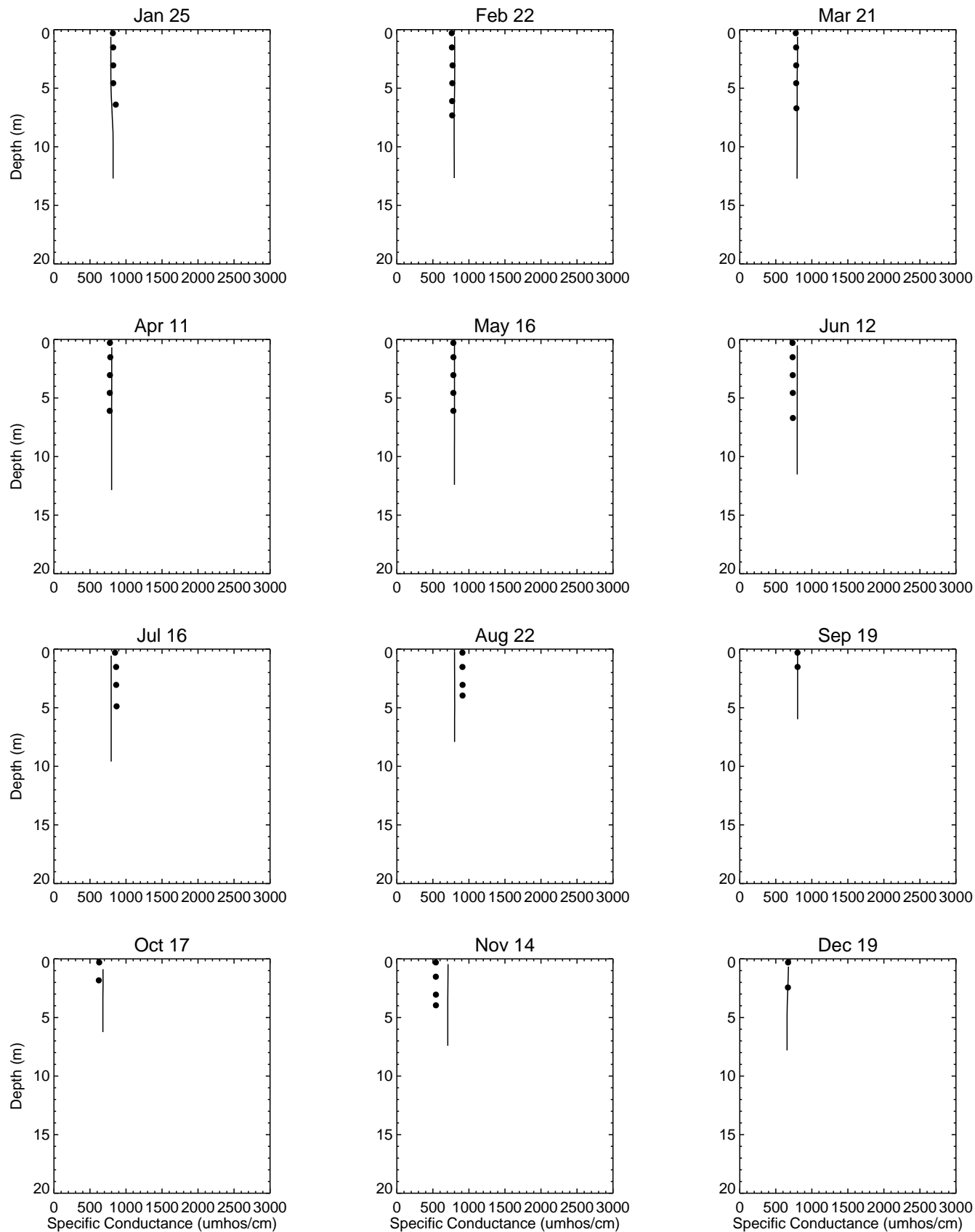
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Chloride - 2010

Profiles shown for dates with available data else model results for first day of month shown.
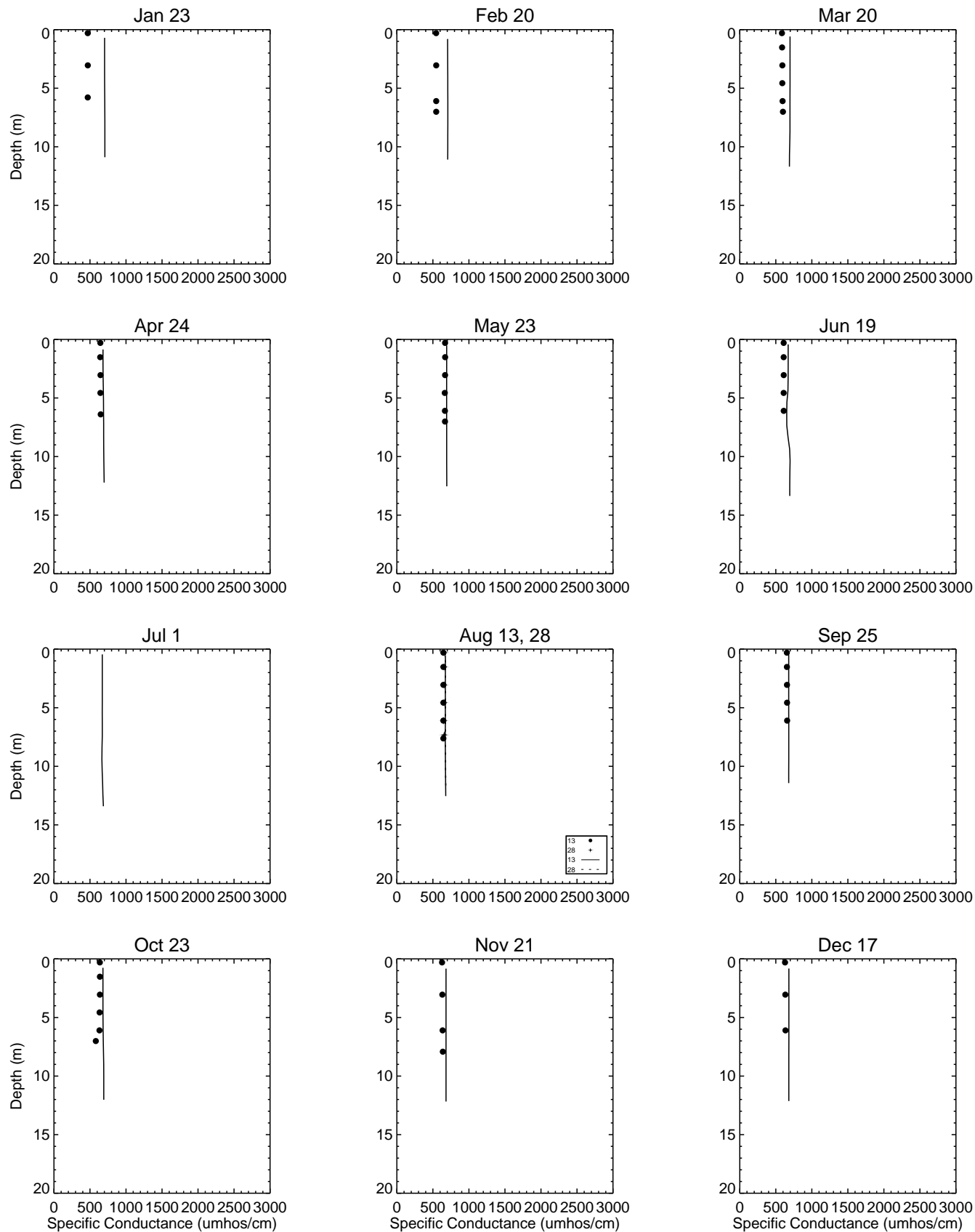
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:55 2013

Figure G-18

Vertical Profiles of Model Versus Data for Lake Buchanan
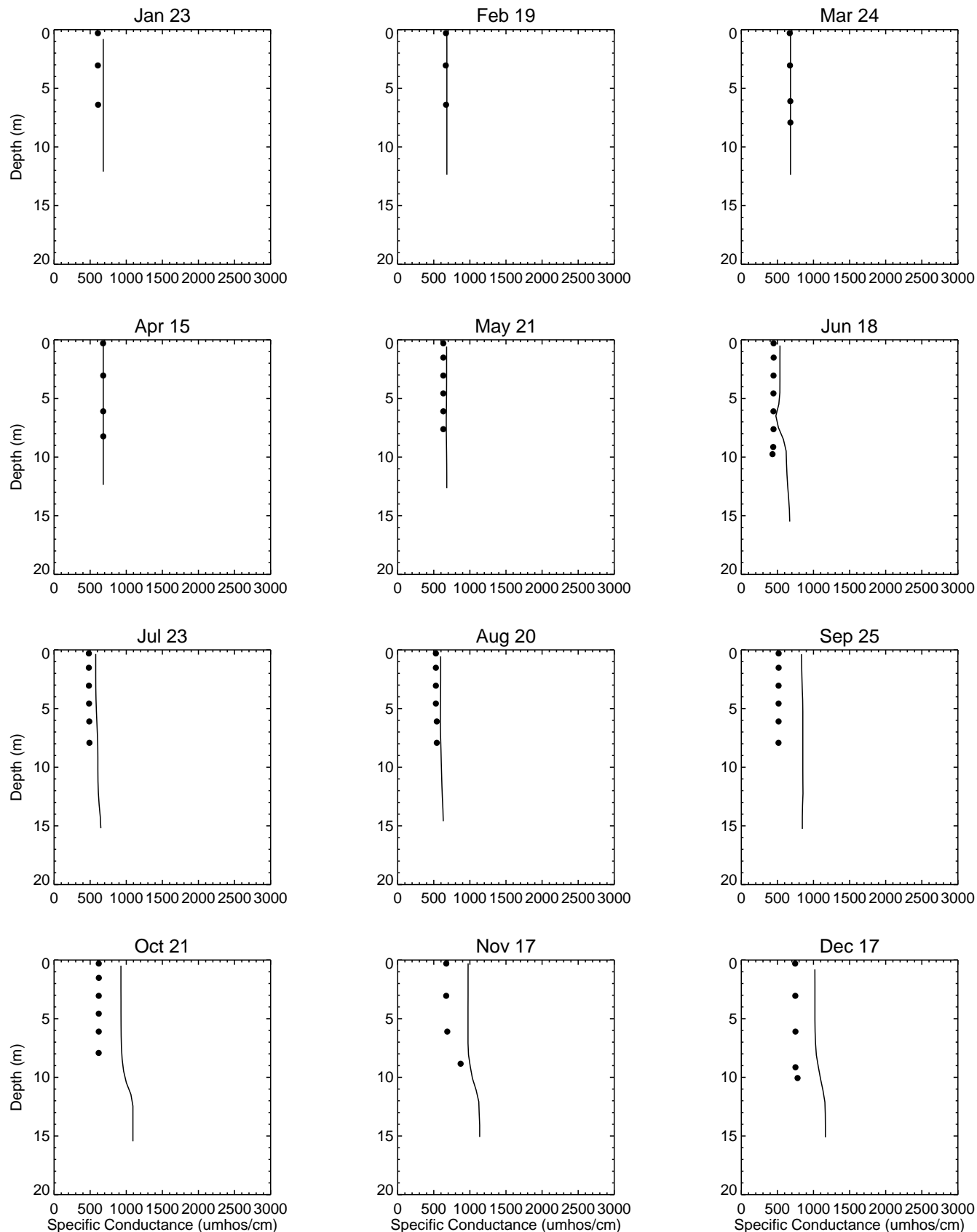near Buchanan Dam (Segment 13) - Chloride - 2011

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 1984

Profiles shown for dates with available data else model results for first day of month shown.

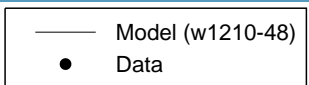CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 1985

Profiles shown for dates with available data else model results for first day of month shown.

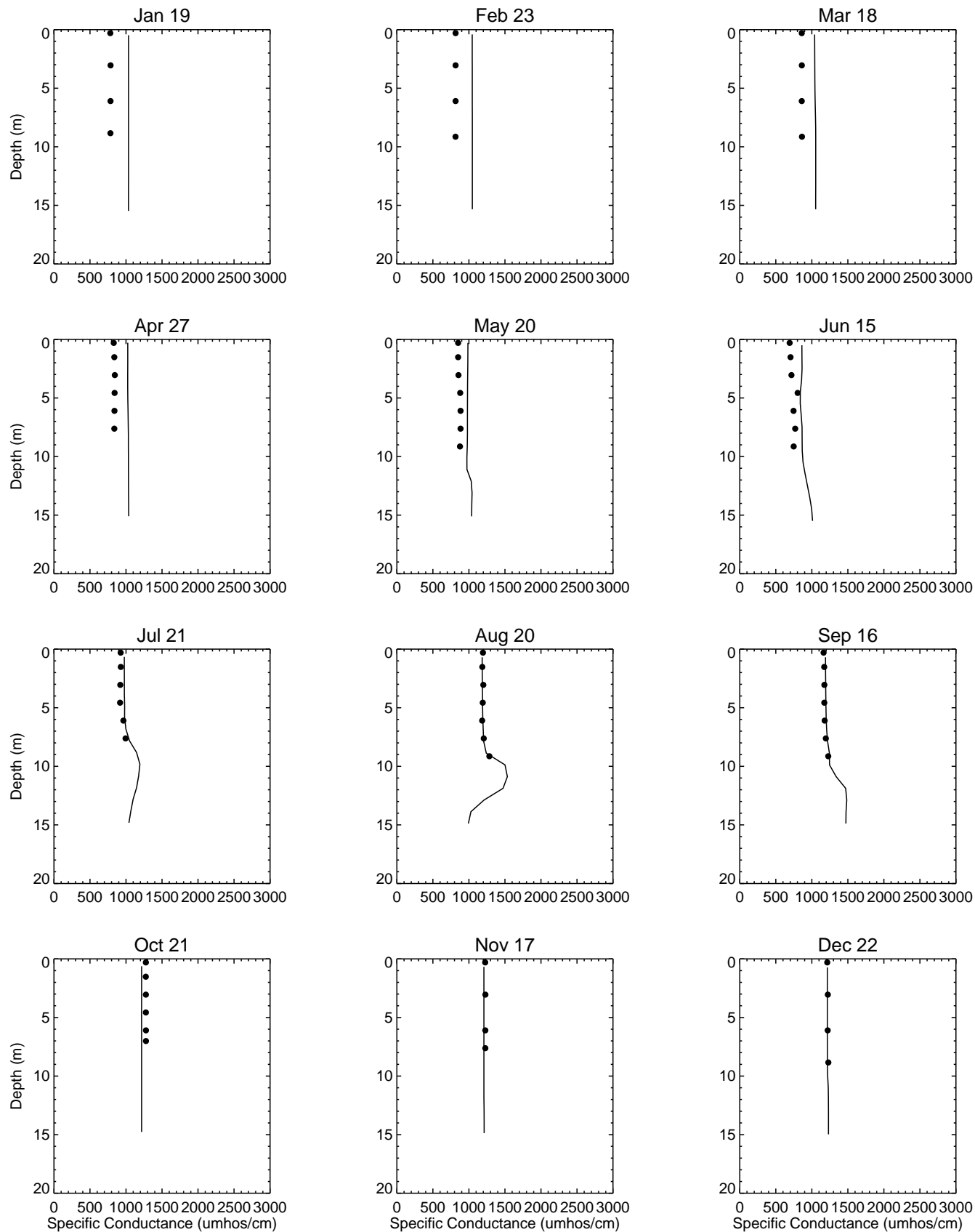CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 1986

Profiles shown for dates with available data else model results for first day of month shown.
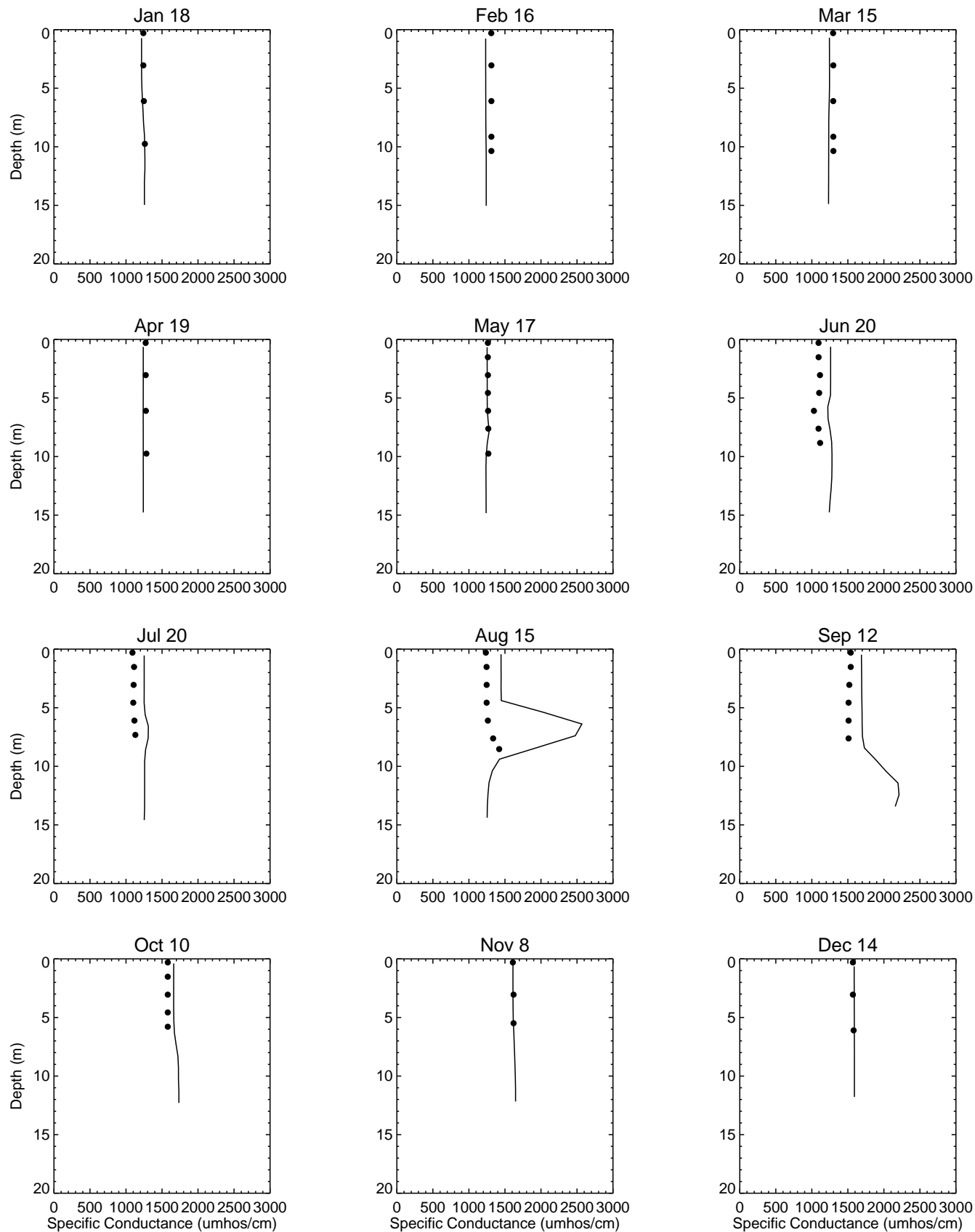
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 1987

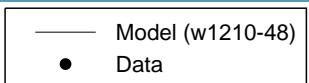*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 18 · Feb 16 · Mar 15 · Apr 19 · May 17 · Jun 20 · Jul 20 · Aug 15 · Sep 12 · Oct 10 · Nov 8 · Dec 14

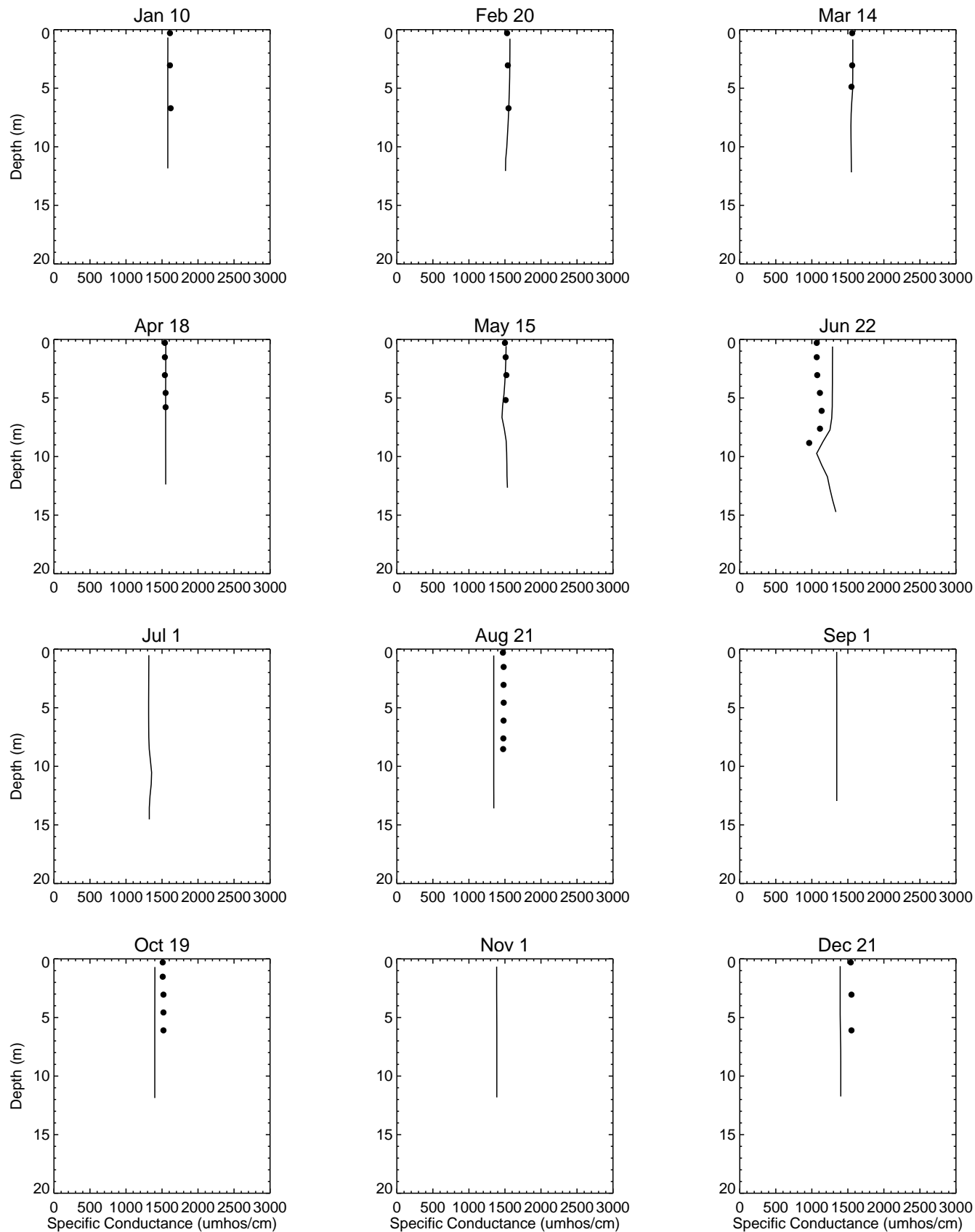Specific Conductance (umhos/cm)

——— Model (w1210-48)
● Data

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 1988

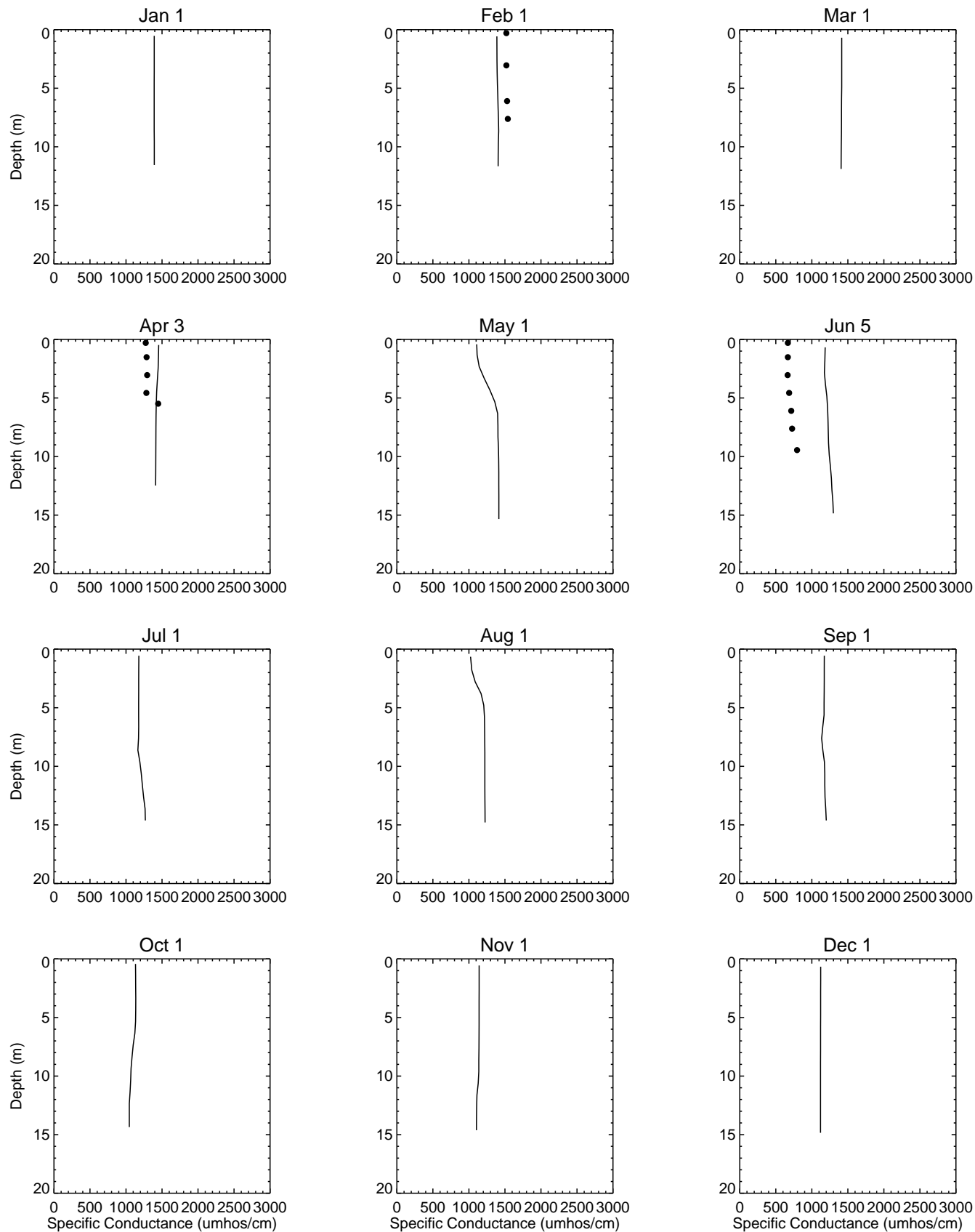*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:28 2013

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 1989

Profiles shown for dates with available data else model results for first day of month shown.
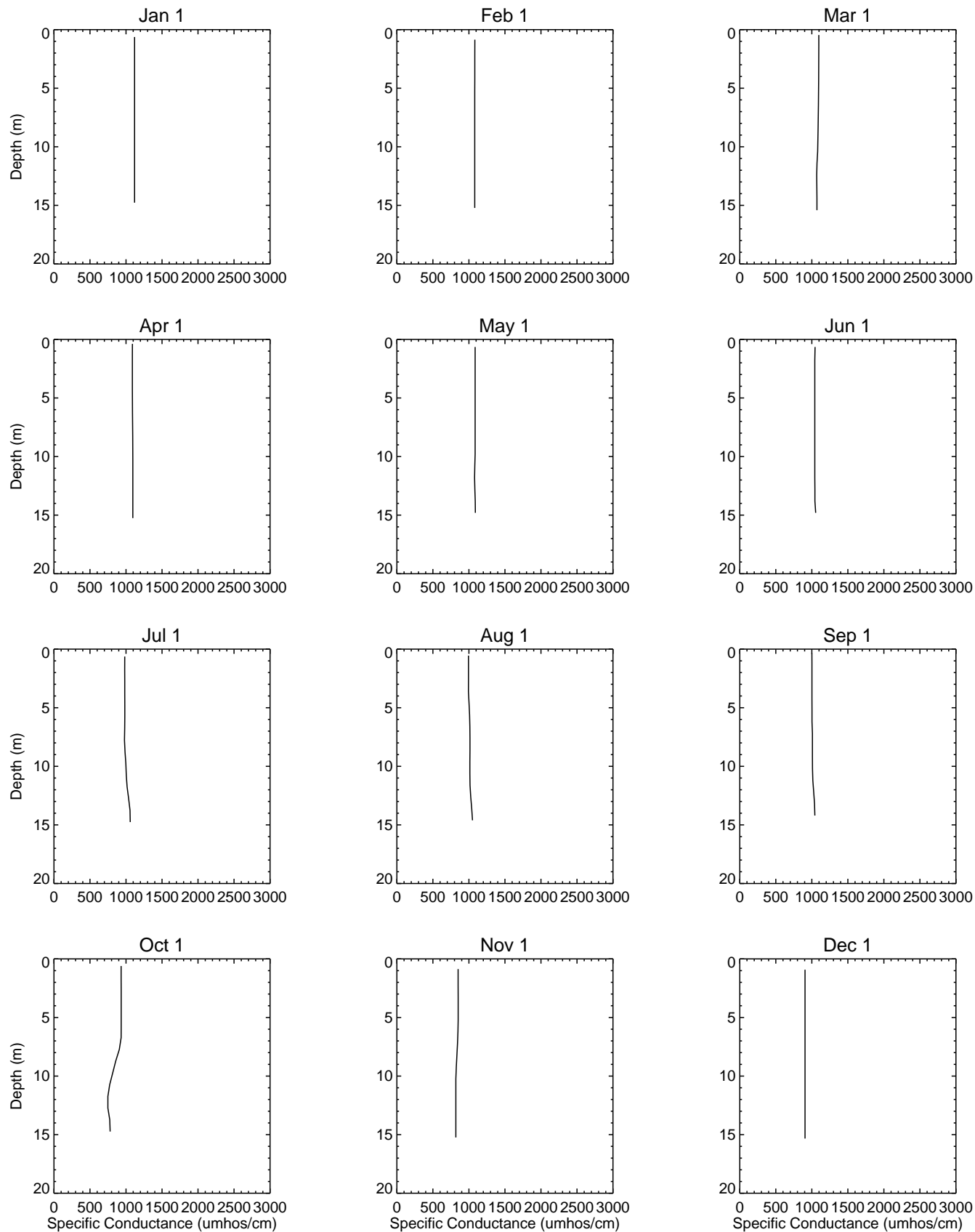
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:28 2013

Model (w1210-48)
● Data

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 1990

Profiles shown for dates with available data else model results for first day of month shown.
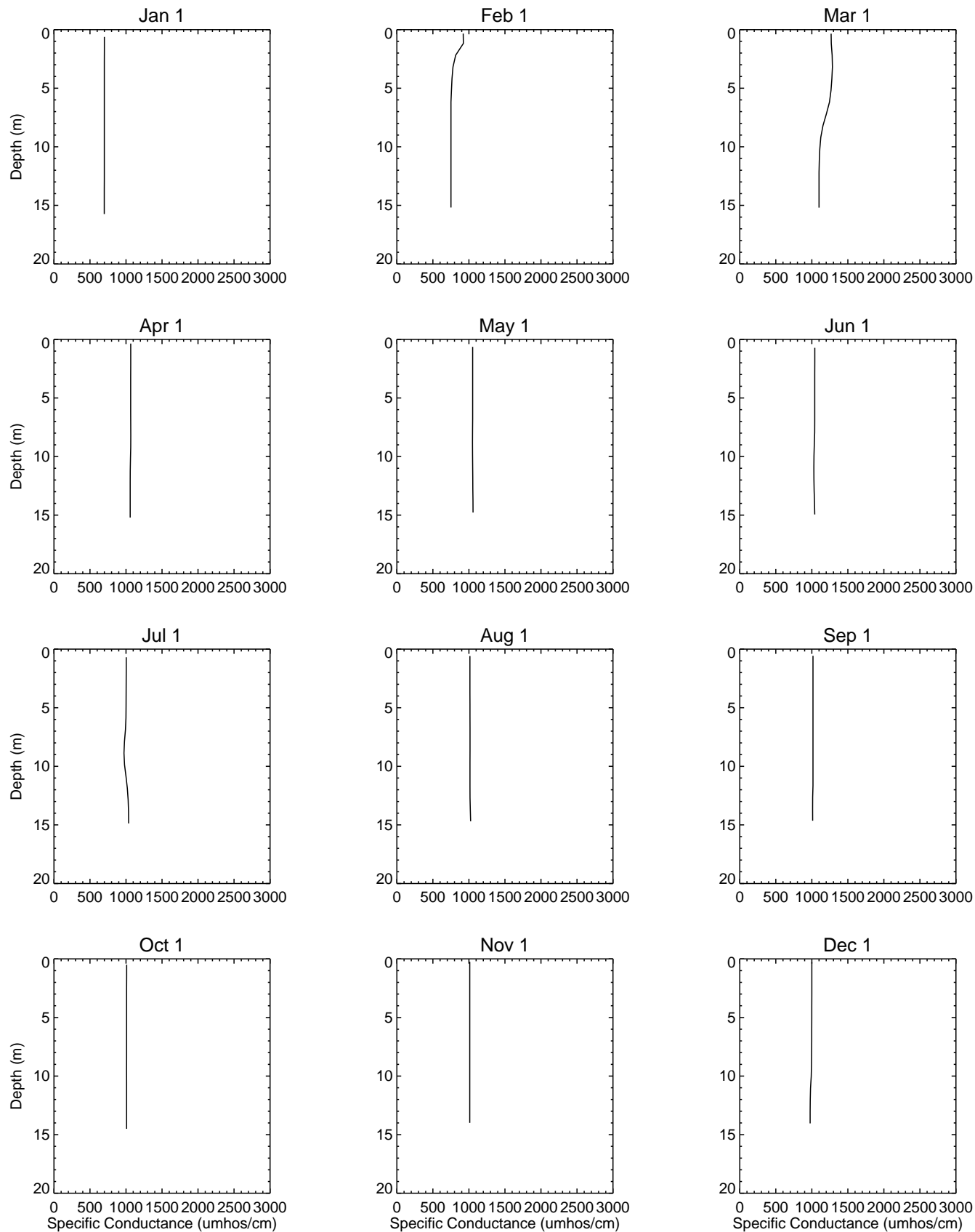
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 1991

Profiles shown for dates with available data else model results for first day of month shown.
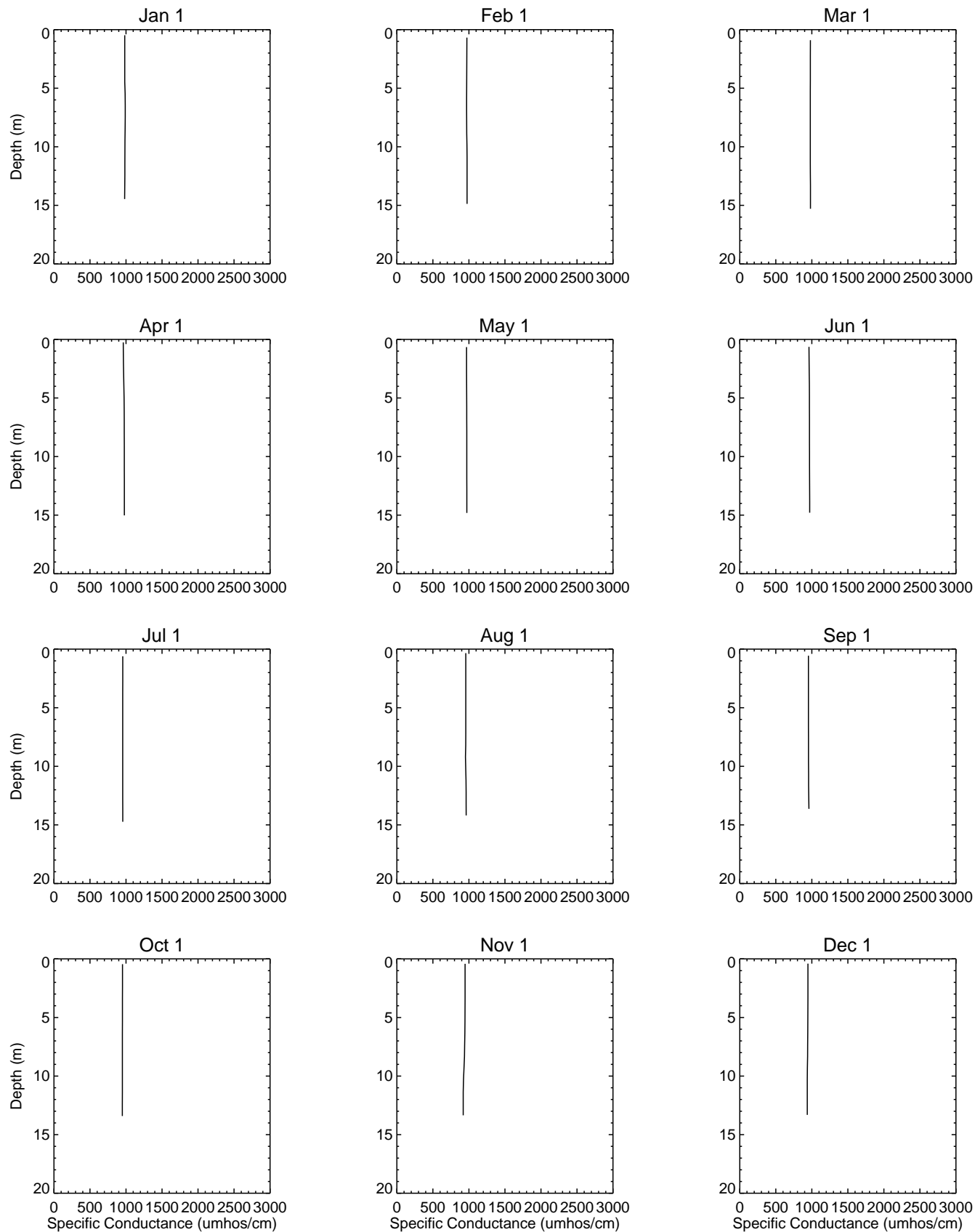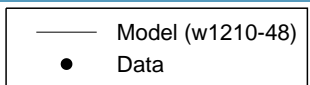
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1   Feb 1   Mar 1

Apr 1   May 1   Jun 1

Jul 1   Aug 1   Sep 1

Oct 1   Nov 1   Dec 1

Specific Conductance (umhos/cm)

Model (w1210-48)
Data

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 1992

Profiles shown for dates with available data else model results for first day of month shown.
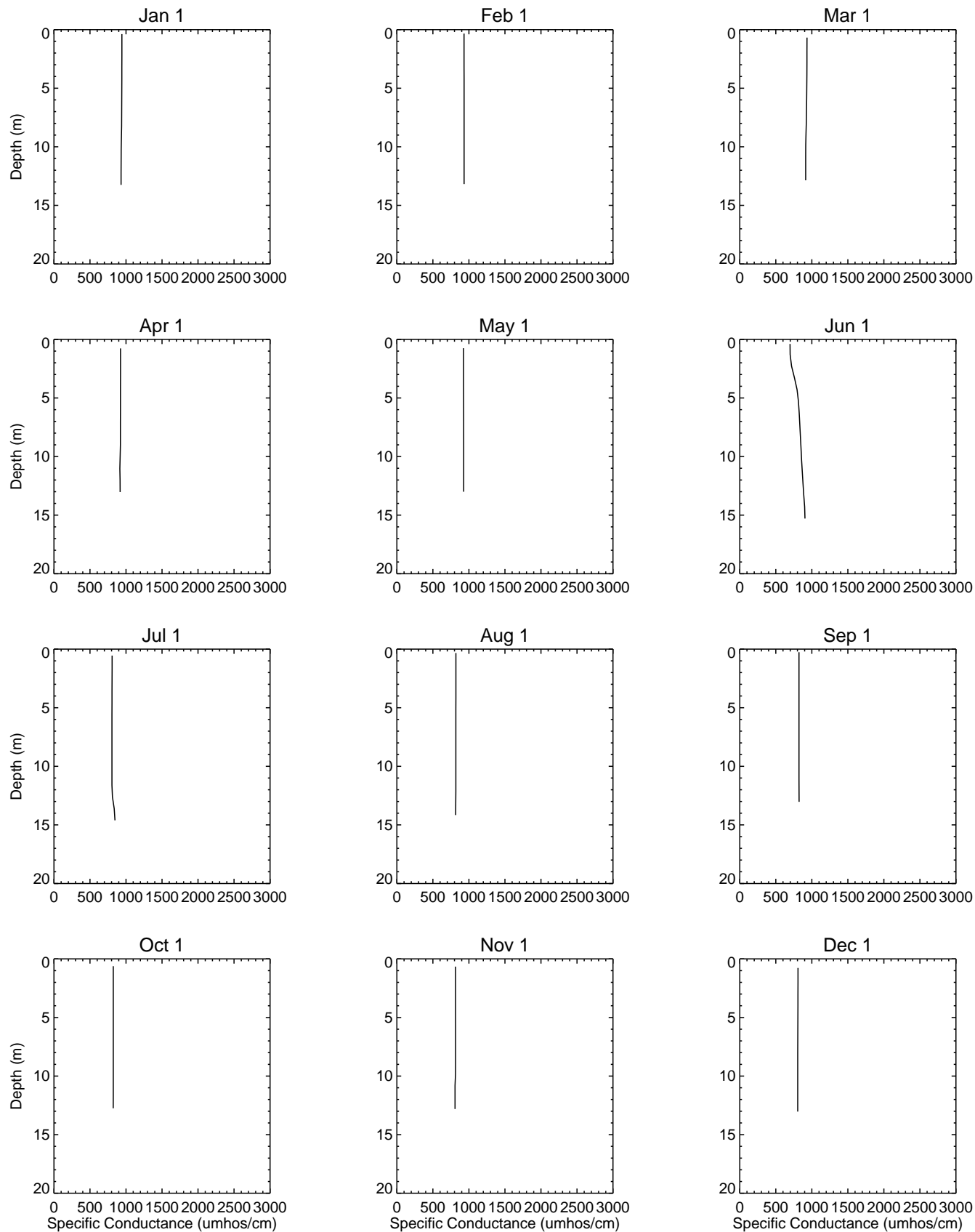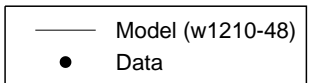
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:28 2013

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 1993

Profiles shown for dates with available data else model results for first day of month shown.
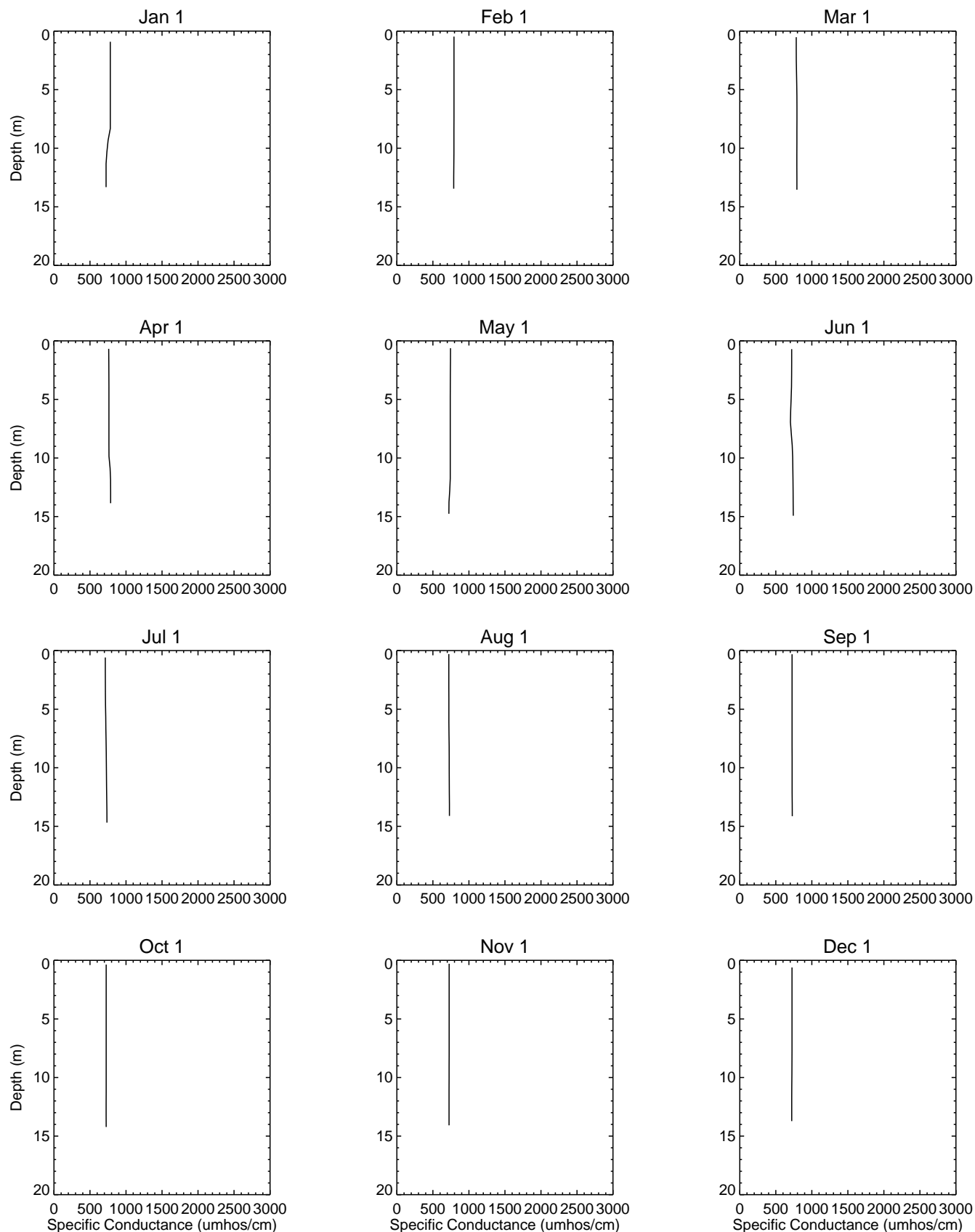
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 1994

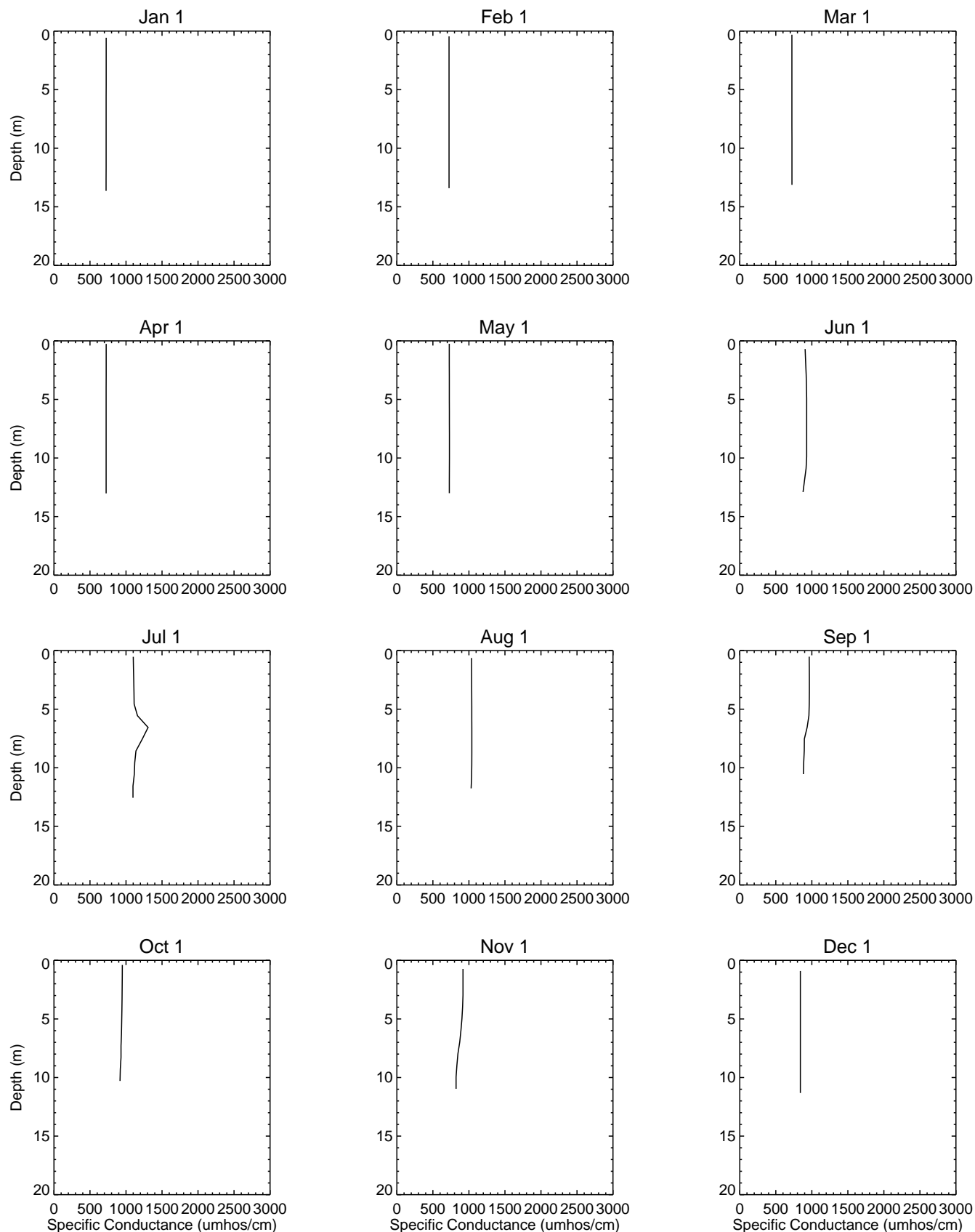*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Specific Conductance (umhos/cm)

——— Model (w1210-48)
● Data

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 1995

Profiles shown for dates with available data else model results for first day of month shown.
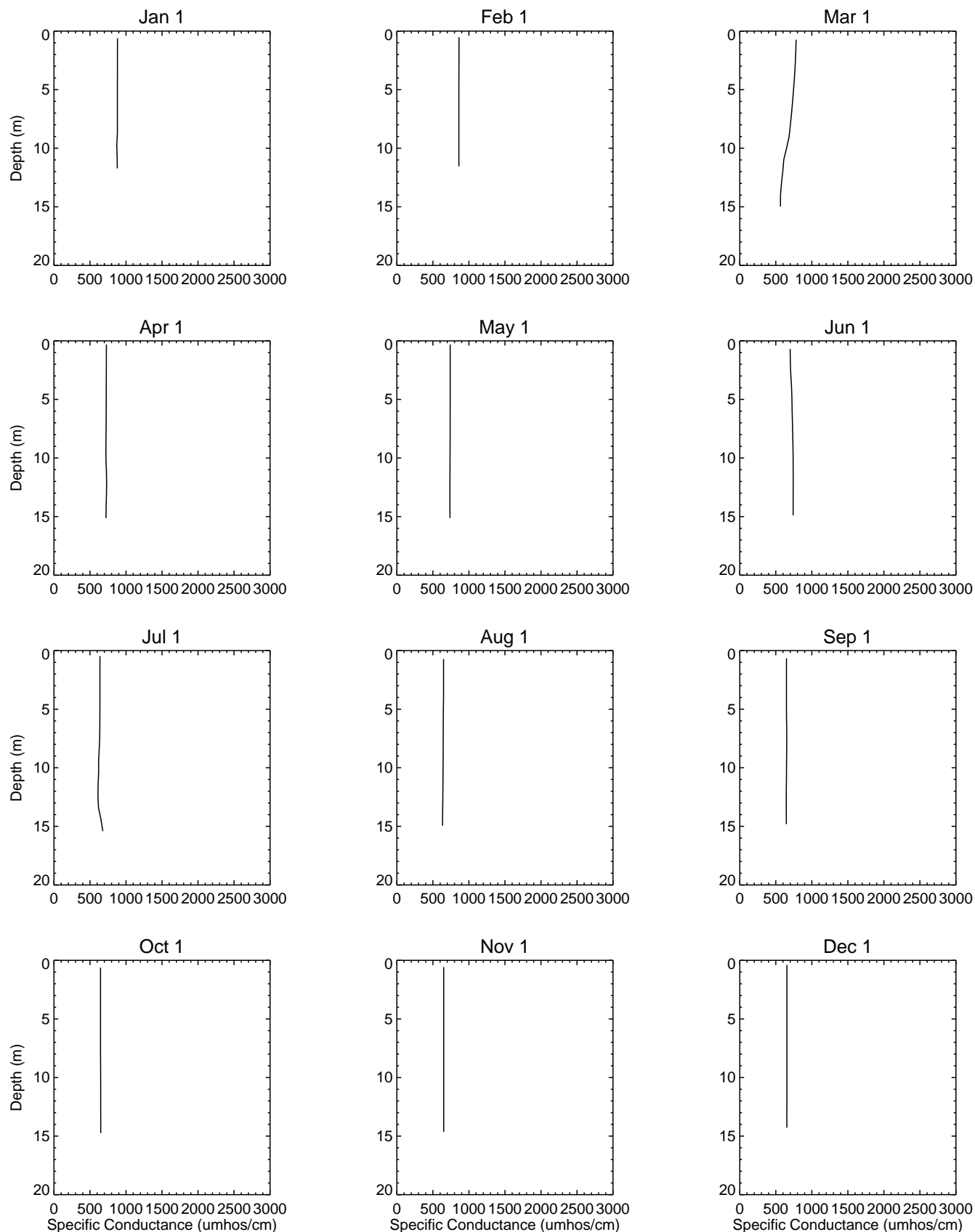
ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:28 2013

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 1996

Profiles shown for dates with available data else model results for first day of month shown.
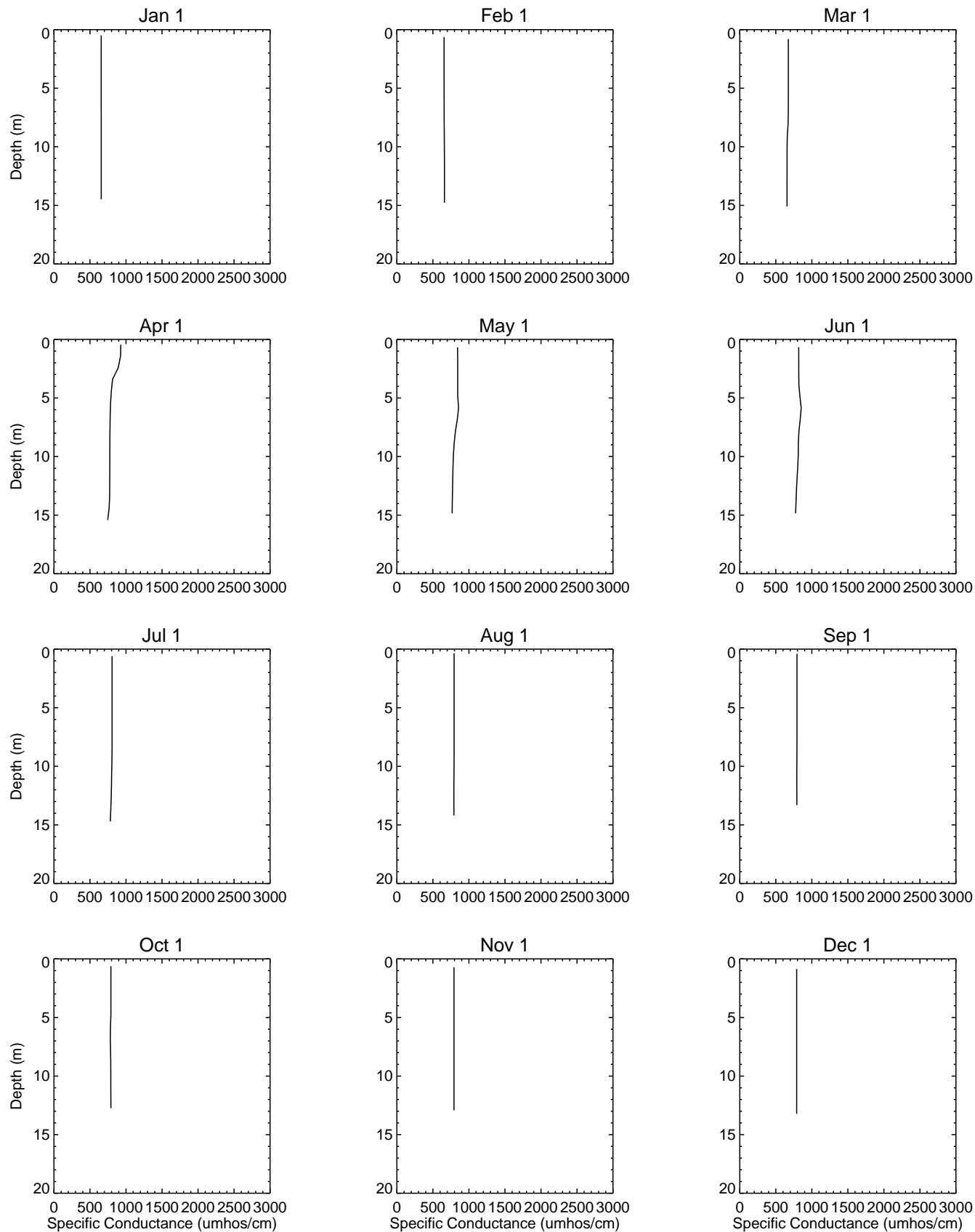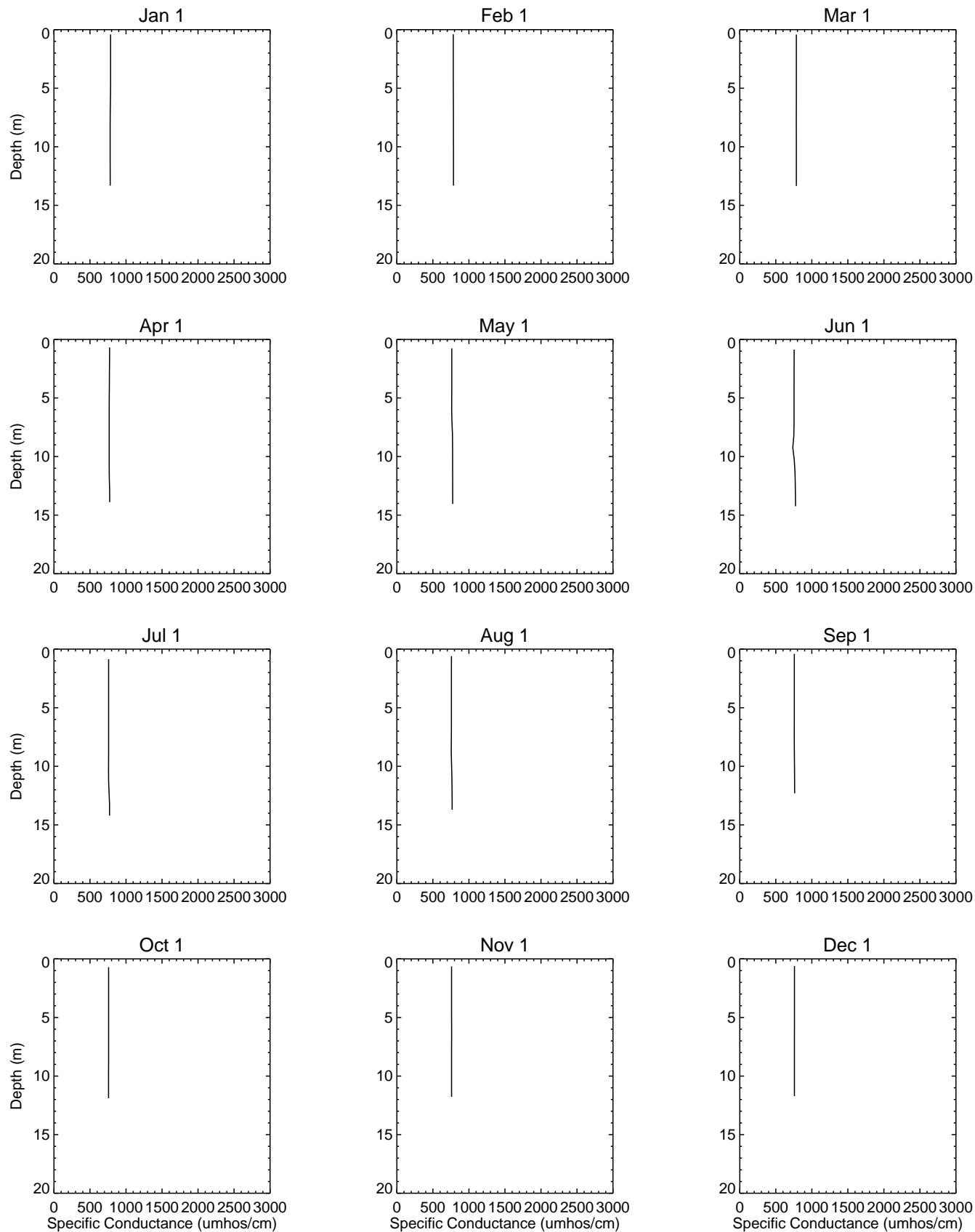
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:28 2013

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 1997

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
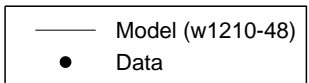Lower Colorado River Authority

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 1998

Profiles shown for dates with available data else model results for first day of month shown.
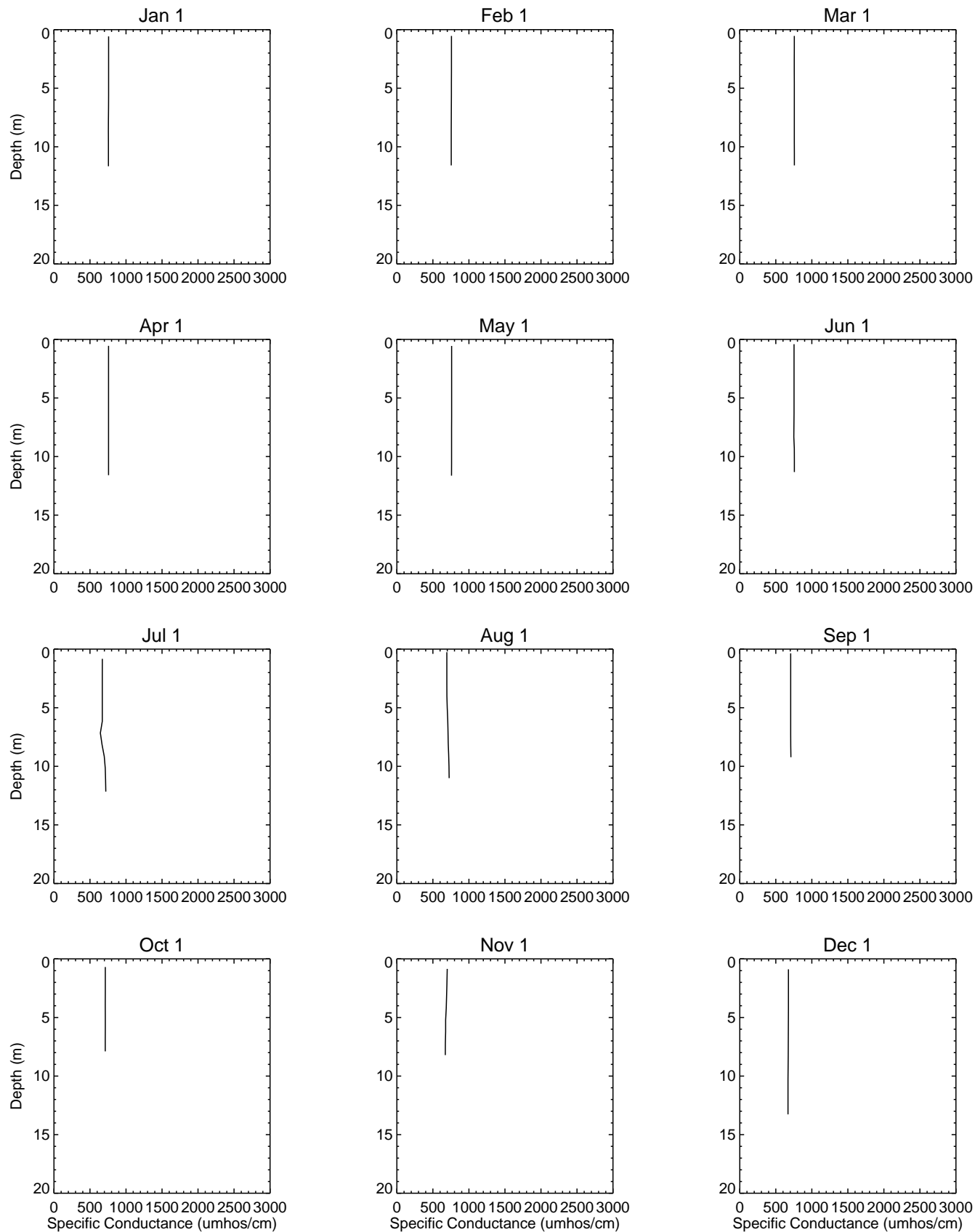
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 1999

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1, Feb 1, Mar 1, Apr 1, May 1, Jun 1, Jul 1, Aug 1, Sep 1, Oct 1, Nov 1, Dec 1

Depth (m)

Specific Conductance (umhos/cm)
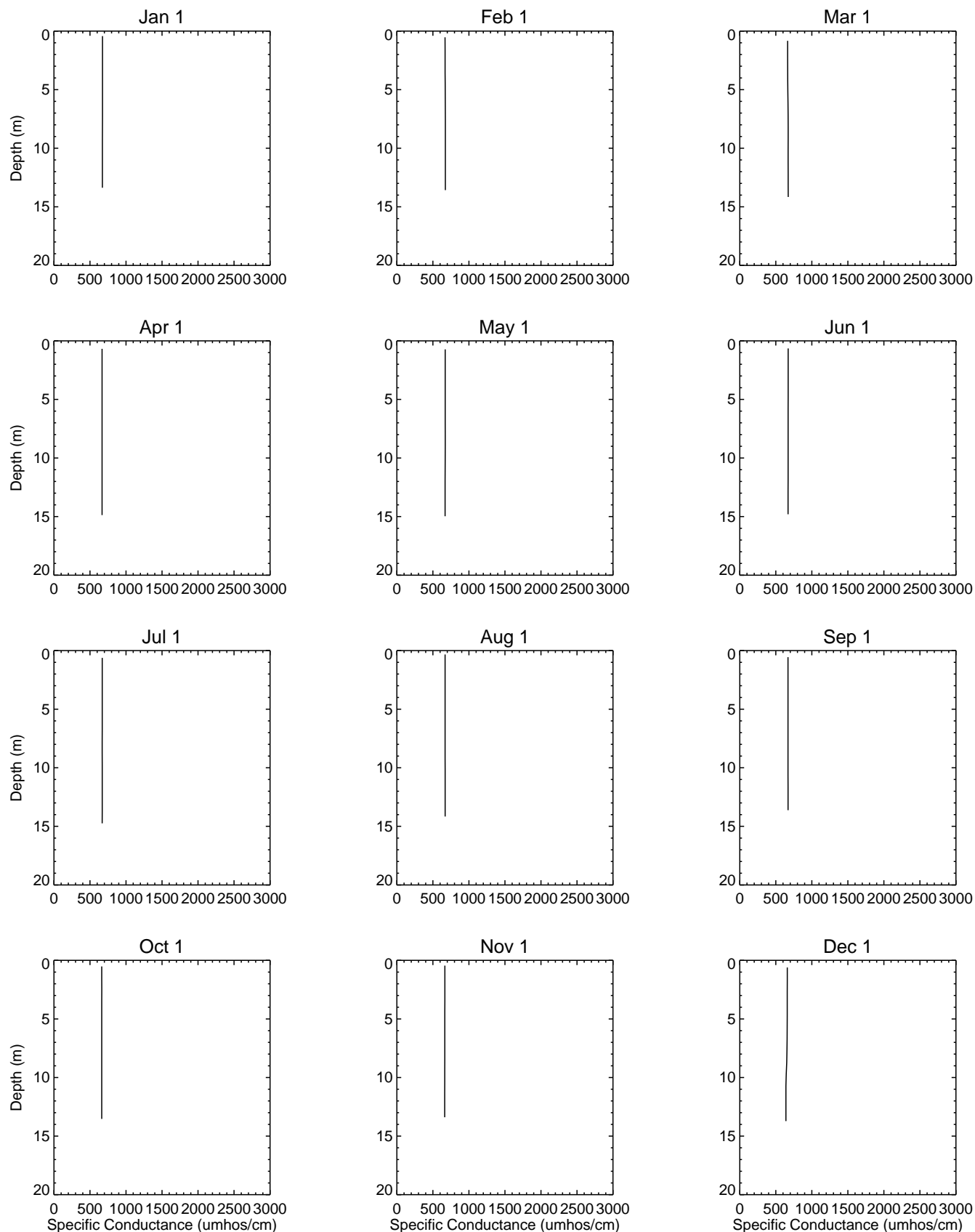
Model (w1210-48)
● Data

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 2000

Profiles shown for dates with available data else model results for first day of month shown.
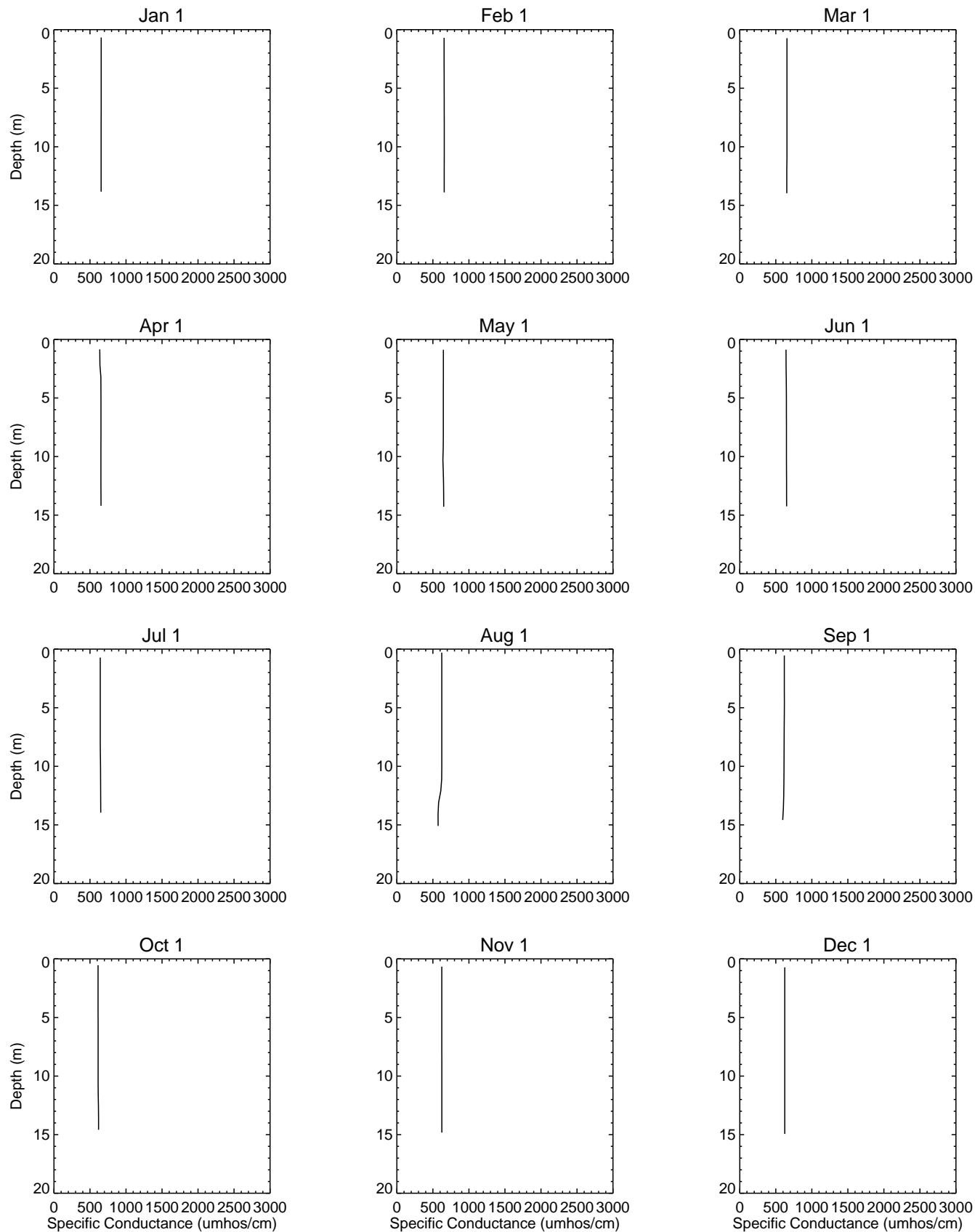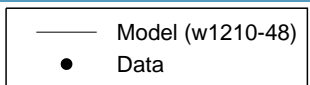
ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 2001

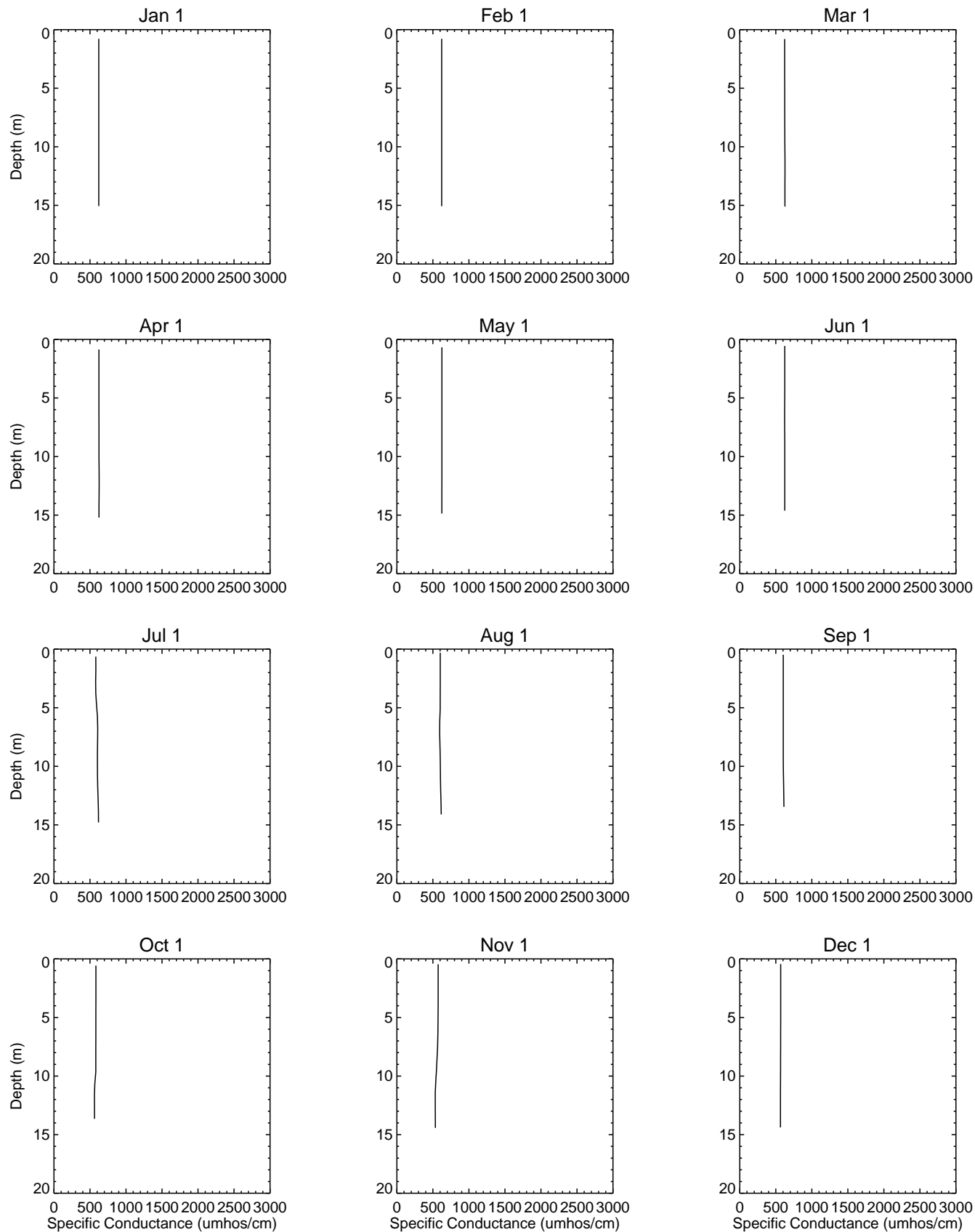*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 | Feb 1 | Mar 1
Apr 1 | May 1 | Jun 1
Jul 1 | Aug 1 | Sep 1
Oct 1 | Nov 1 | Dec 1

Depth (m)

Specific Conductance (umhos/cm)

—— Model (w1210-48)
● Data

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 2002

Profiles shown for dates with available data else model results for first day of month shown.
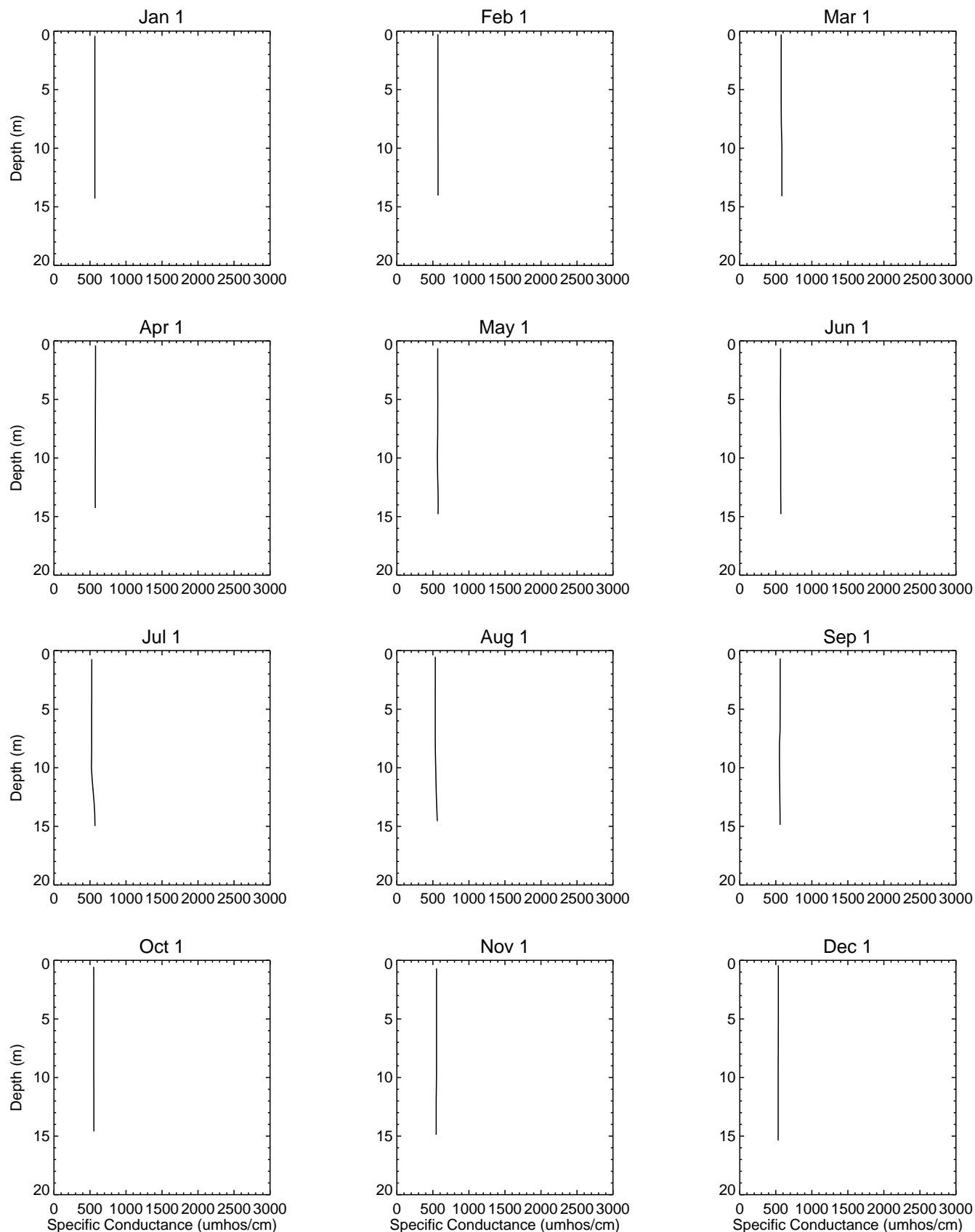
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 2003

Profiles shown for dates with available data else model results for first day of month shown.
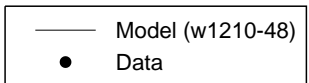
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 2004

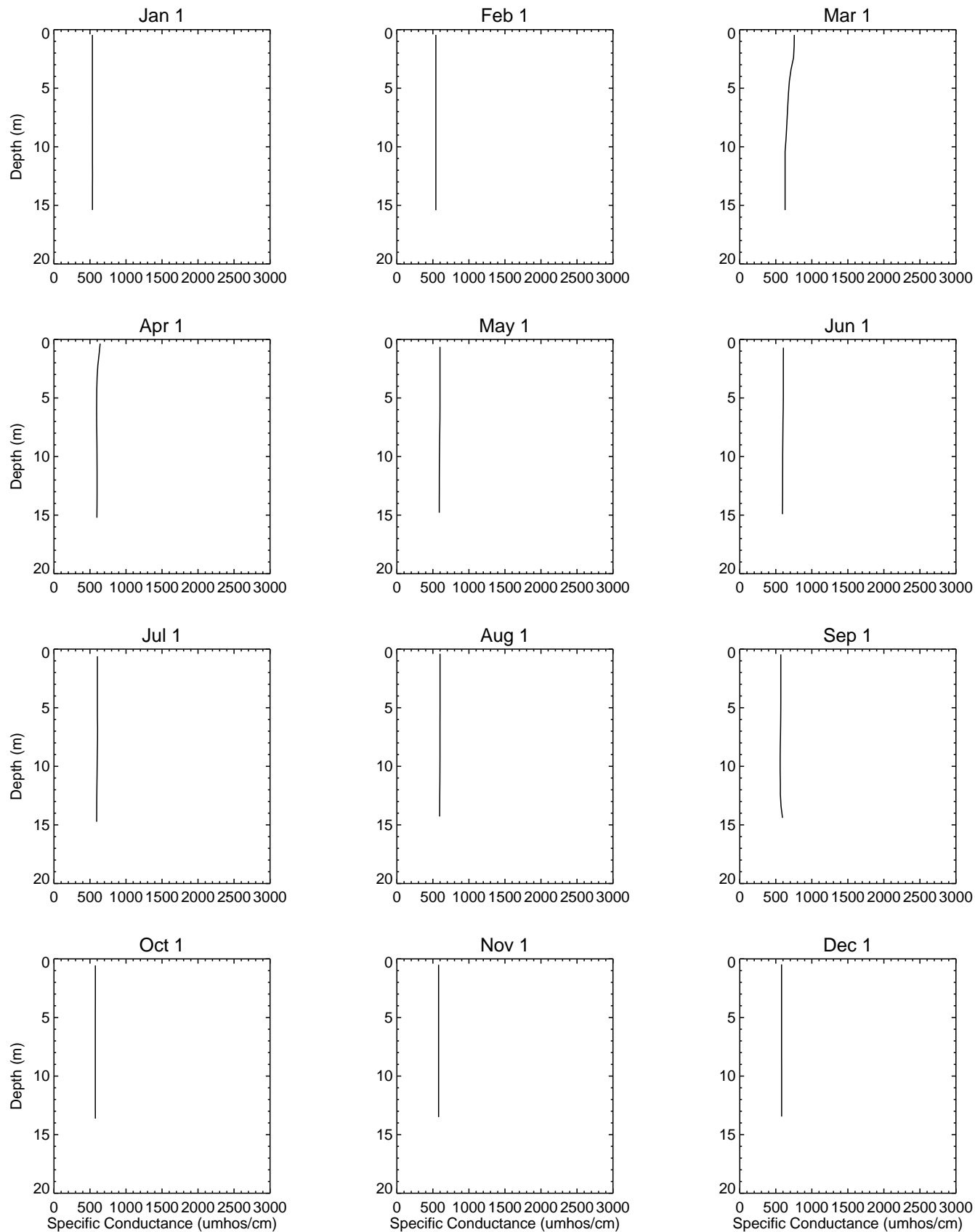*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1   Feb 1   Mar 1

Apr 1   May 1   Jun 1

Jul 1   Aug 1   Sep 1

Oct 1   Nov 1   Dec 1

Specific Conductance (umhos/cm)

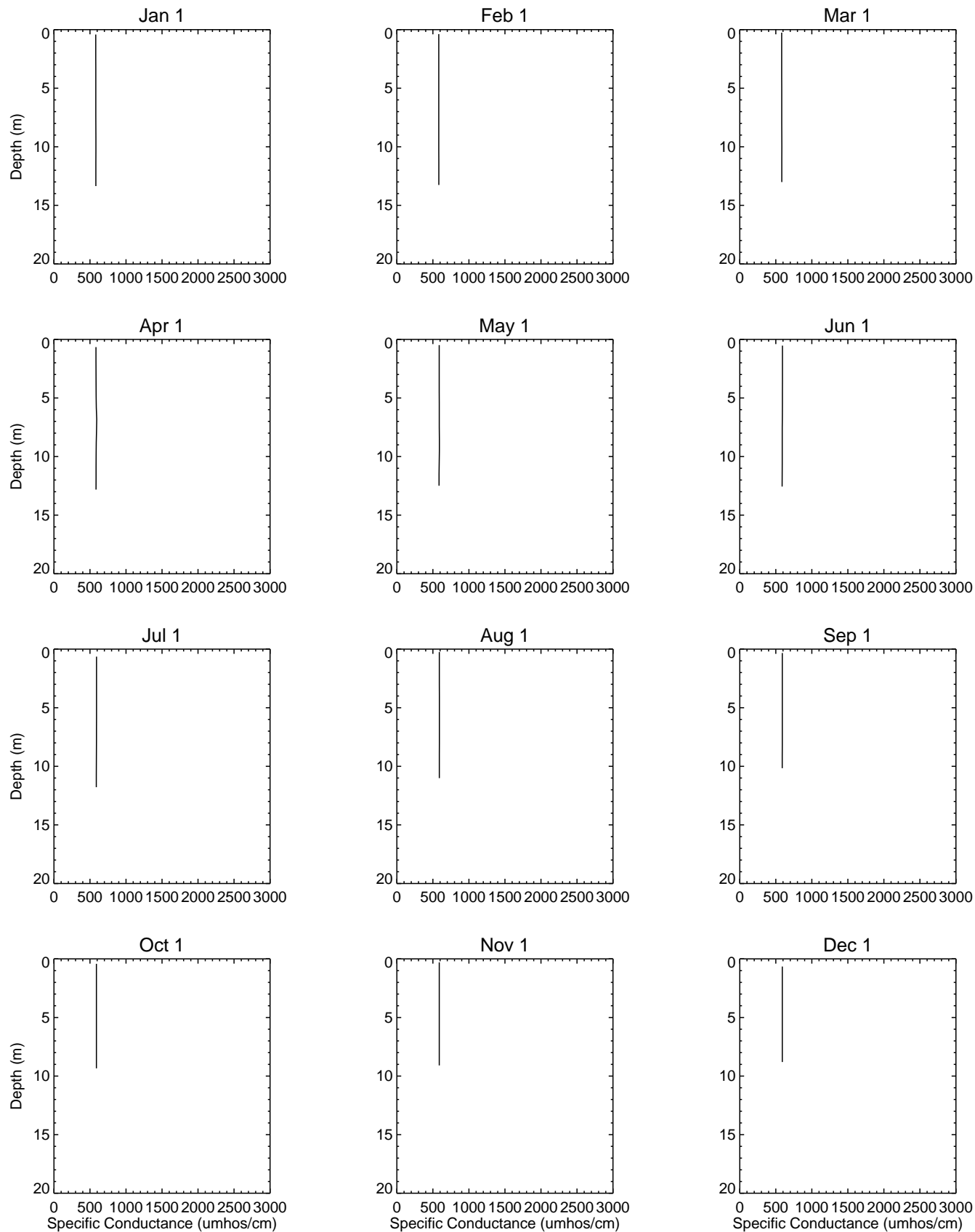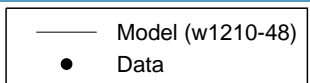——— Model (w1210-48)
● Data

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 2005

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:29 2013

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Specific Conductance (umhos/cm)
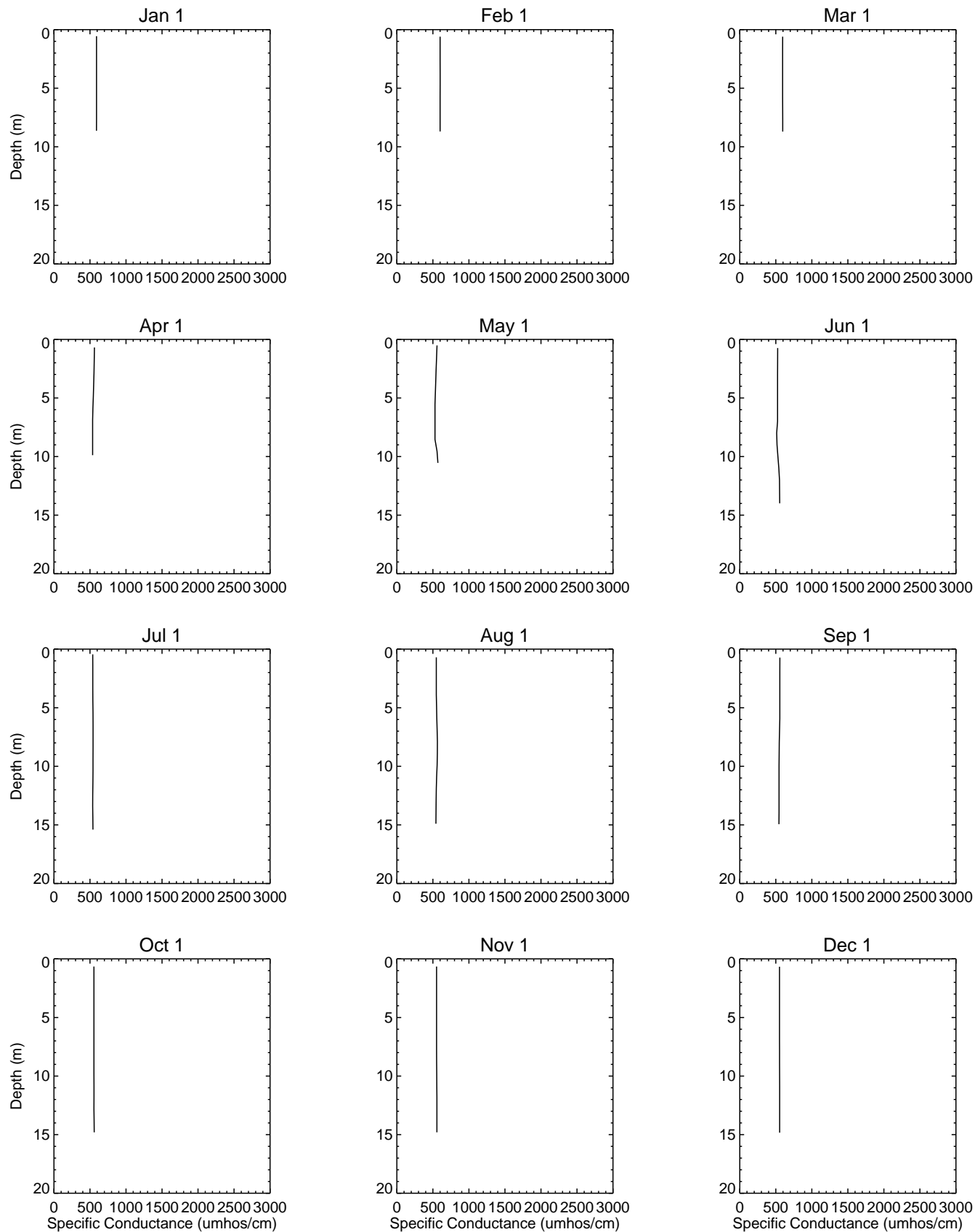
—— Model (w1210-48)
● Data

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 2006

Profiles shown for dates with available data else model results for first day of month shown.
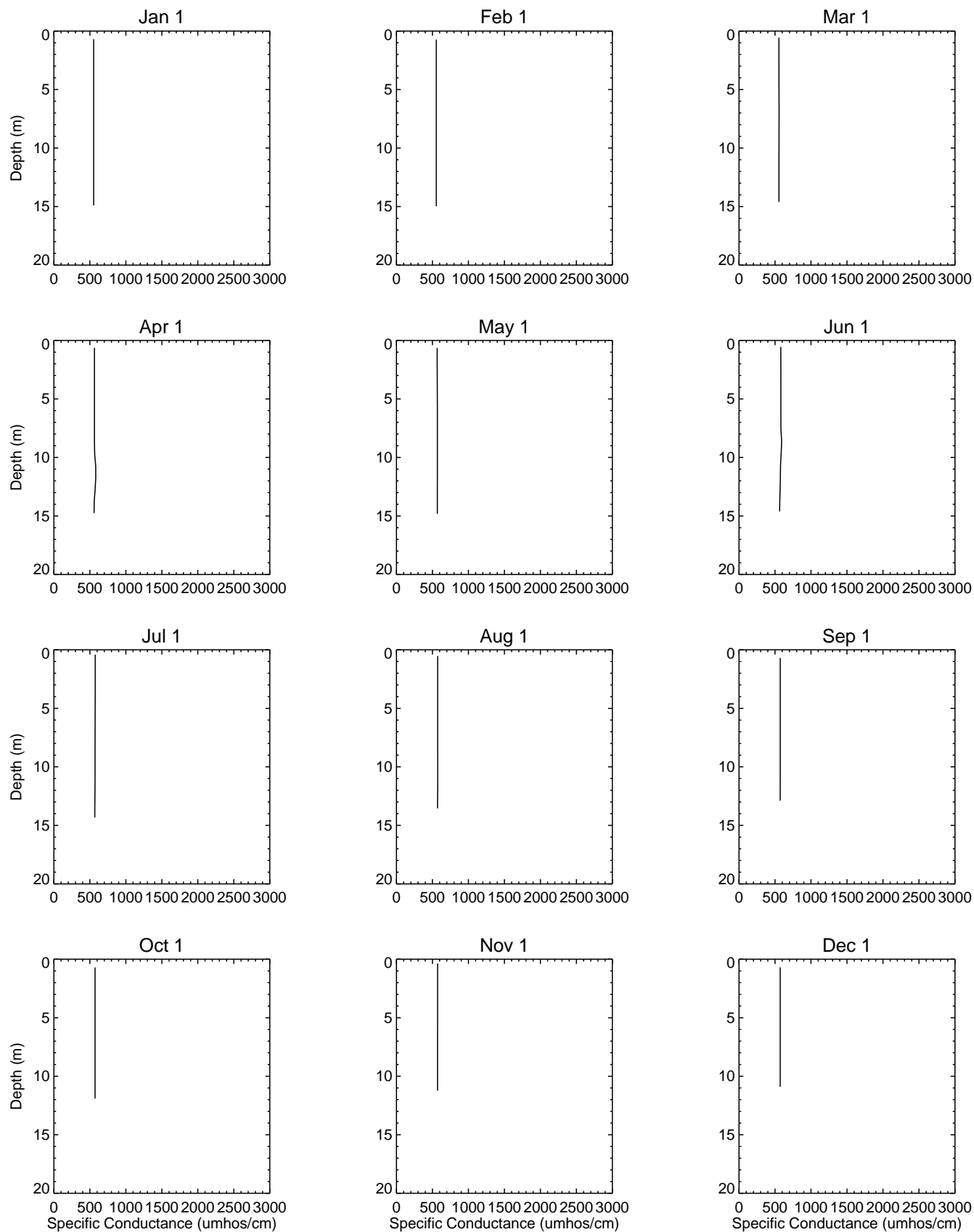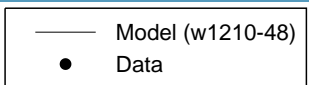
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:29 2013

ANCHOR QEA
PARSONS

Jan 1   Feb 1   Mar 1

Apr 1   May 1   Jun 1

Jul 1   Aug 1   Sep 1

Oct 1   Nov 1   Dec 1

Depth (m)

Specific Conductance (umhos/cm)
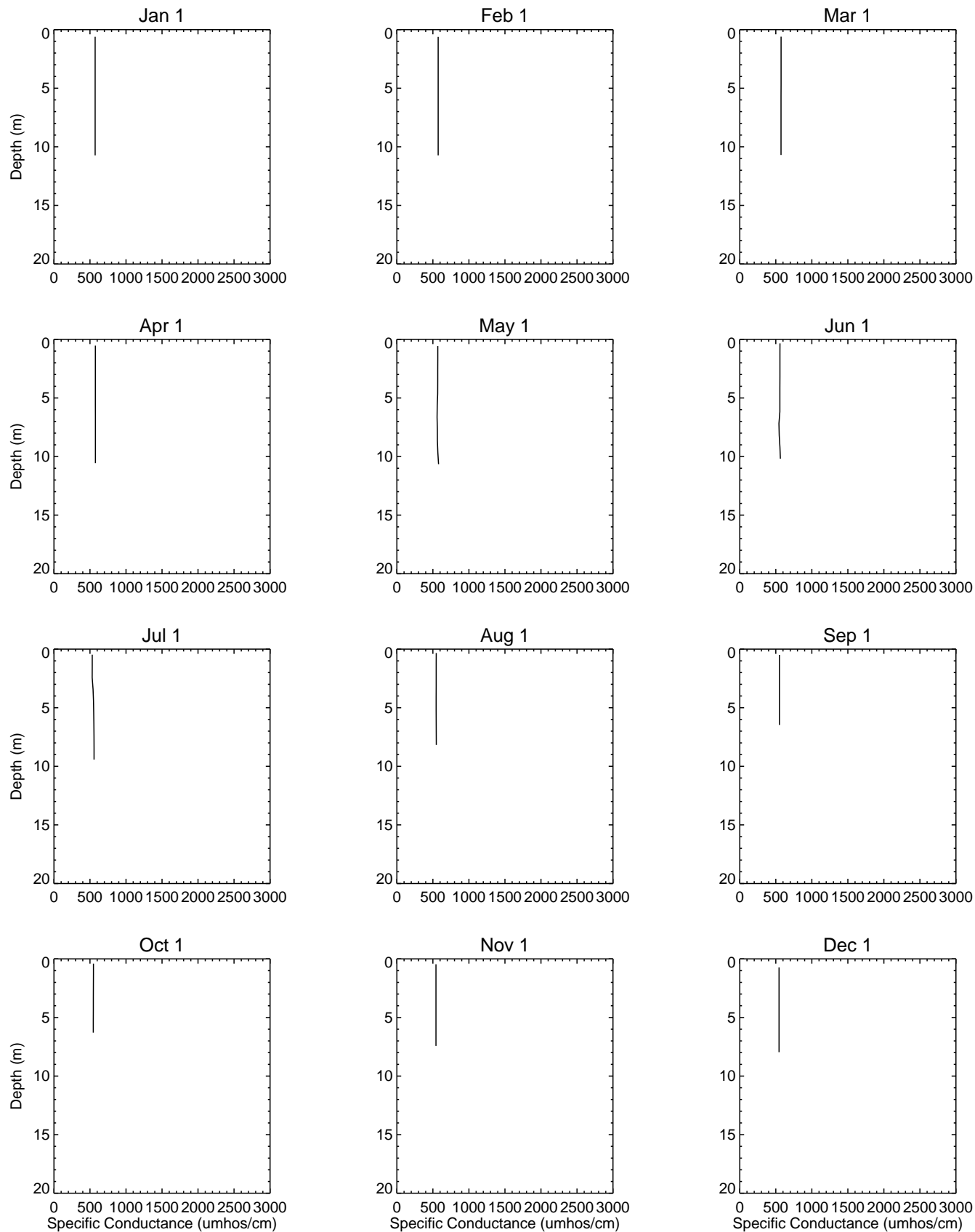
Model (w1210-48)
●   Data

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 2007

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
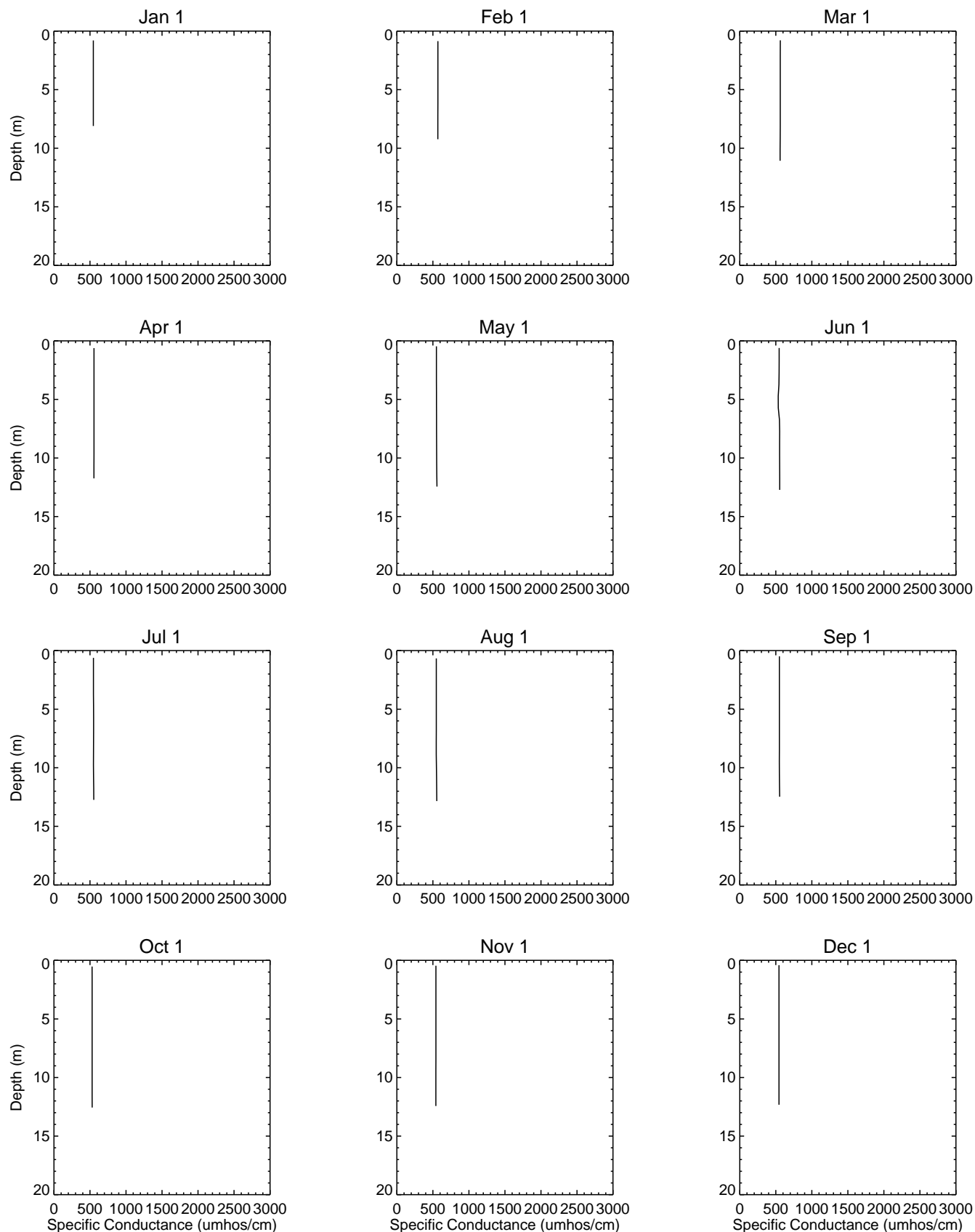
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:29 2013

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 2008

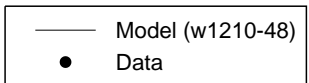*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 2009

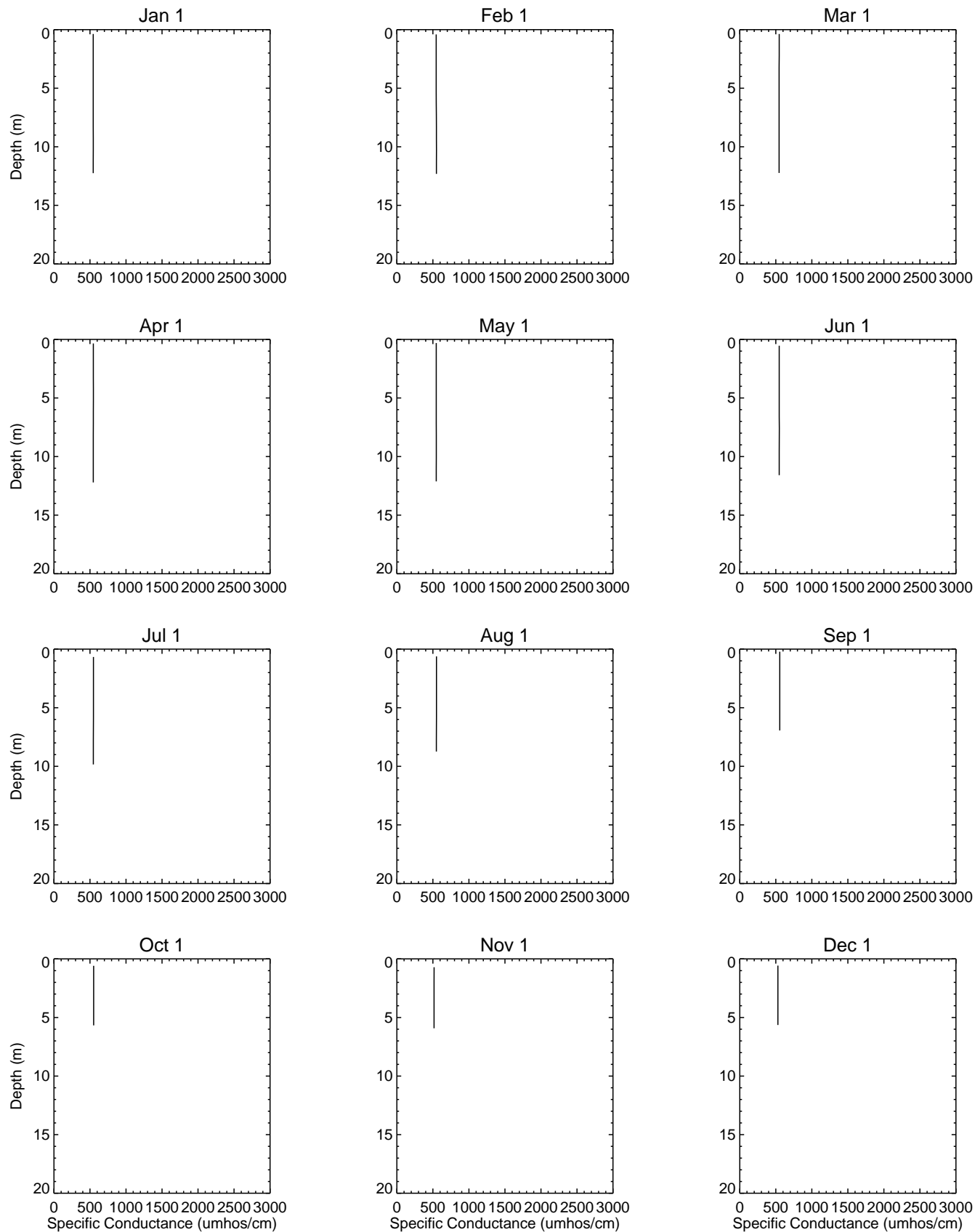*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m)

Specific Conductance (umhos/cm)

——— Model (w1210-48)
● Data

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 2010

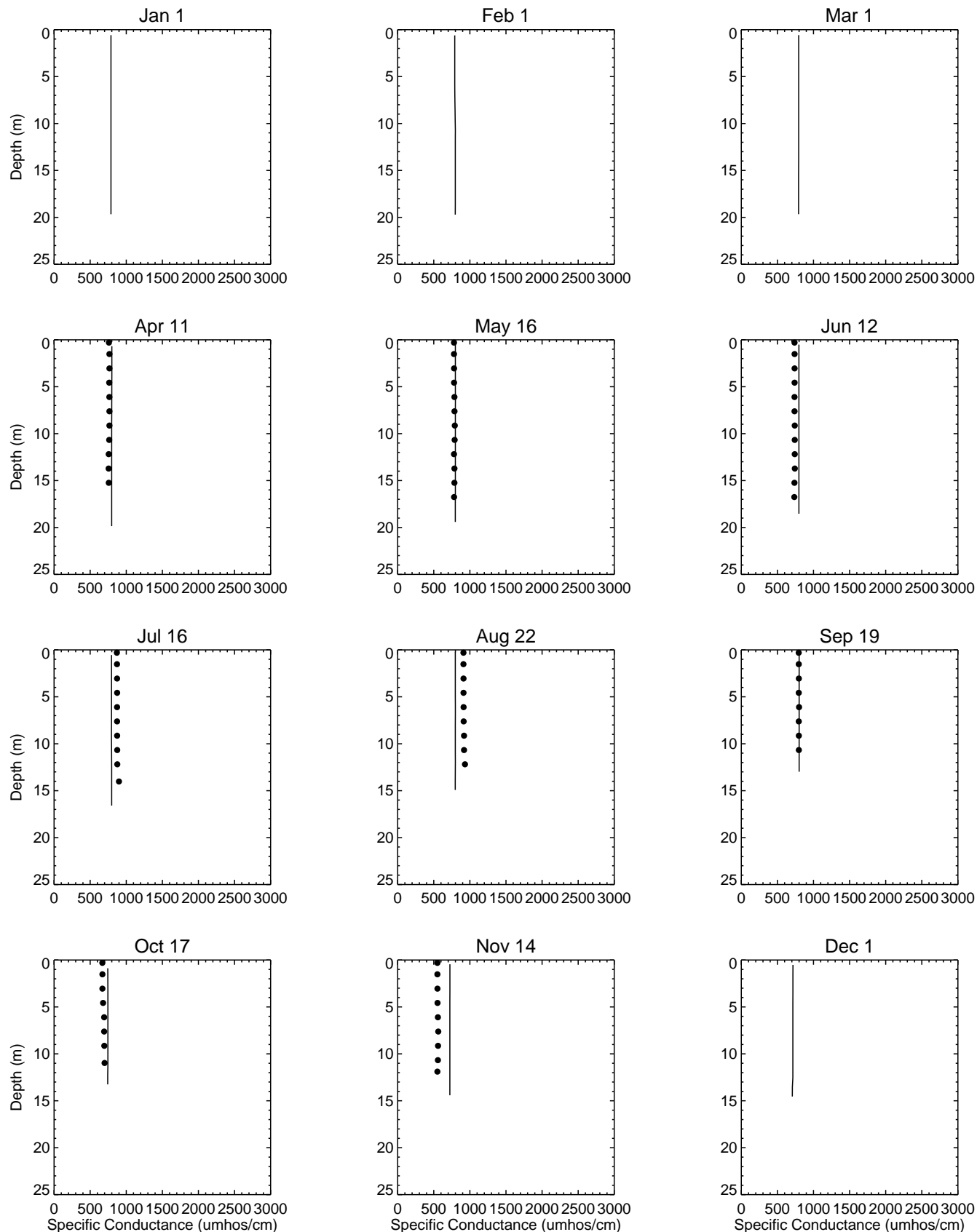*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-13

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Specific Conductance - 2011

Profiles shown for dates with available data else model results for first day of month shown.

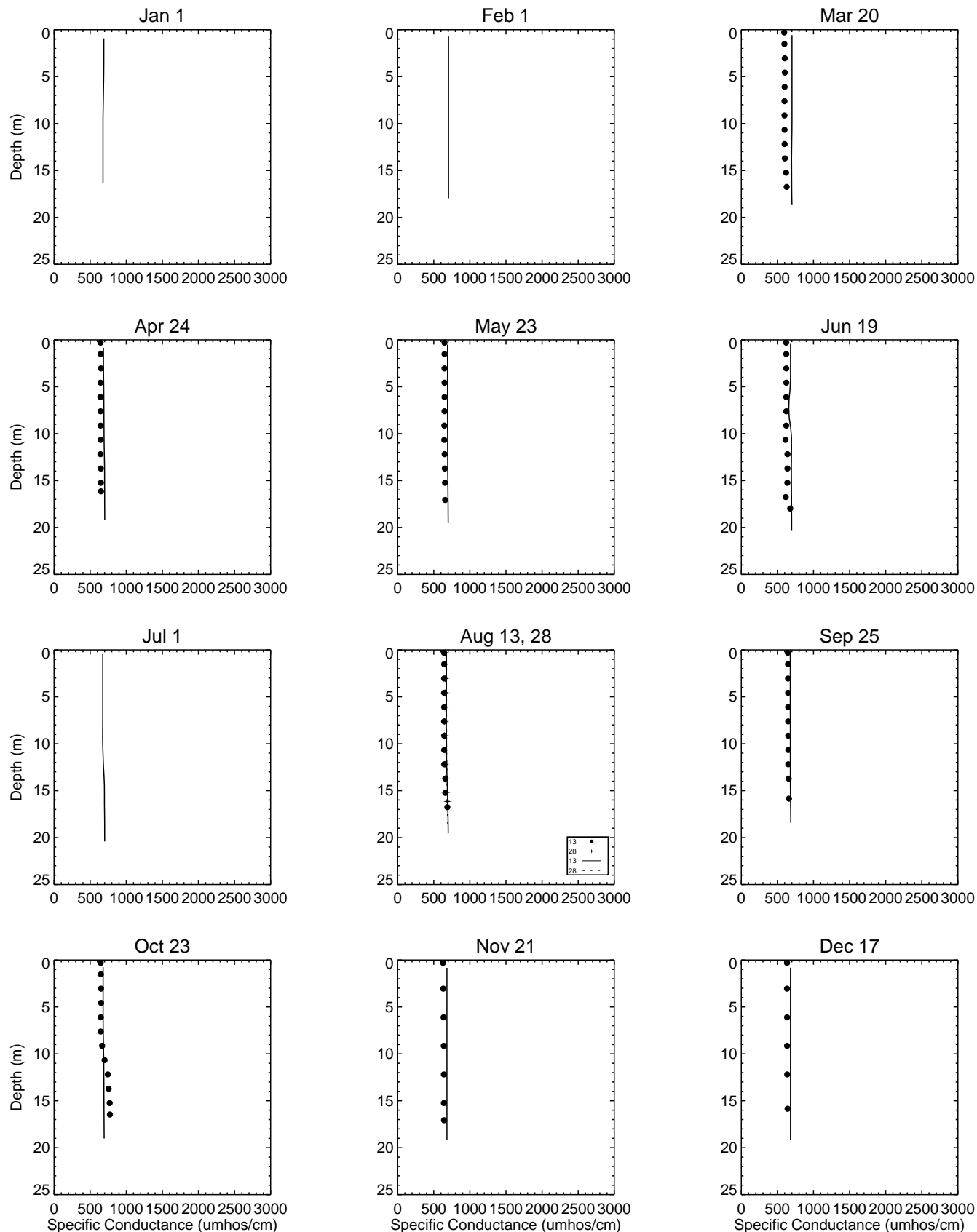CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Jan 1

Feb 1

Mar 1

Apr 11

May 16

Jun 12

Jul 16

Aug 22

Sep 19

Oct 17

Nov 14

Dec 1

Specific Conductance (umhos/cm)

Model (w1210-48)

Data

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 1984

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
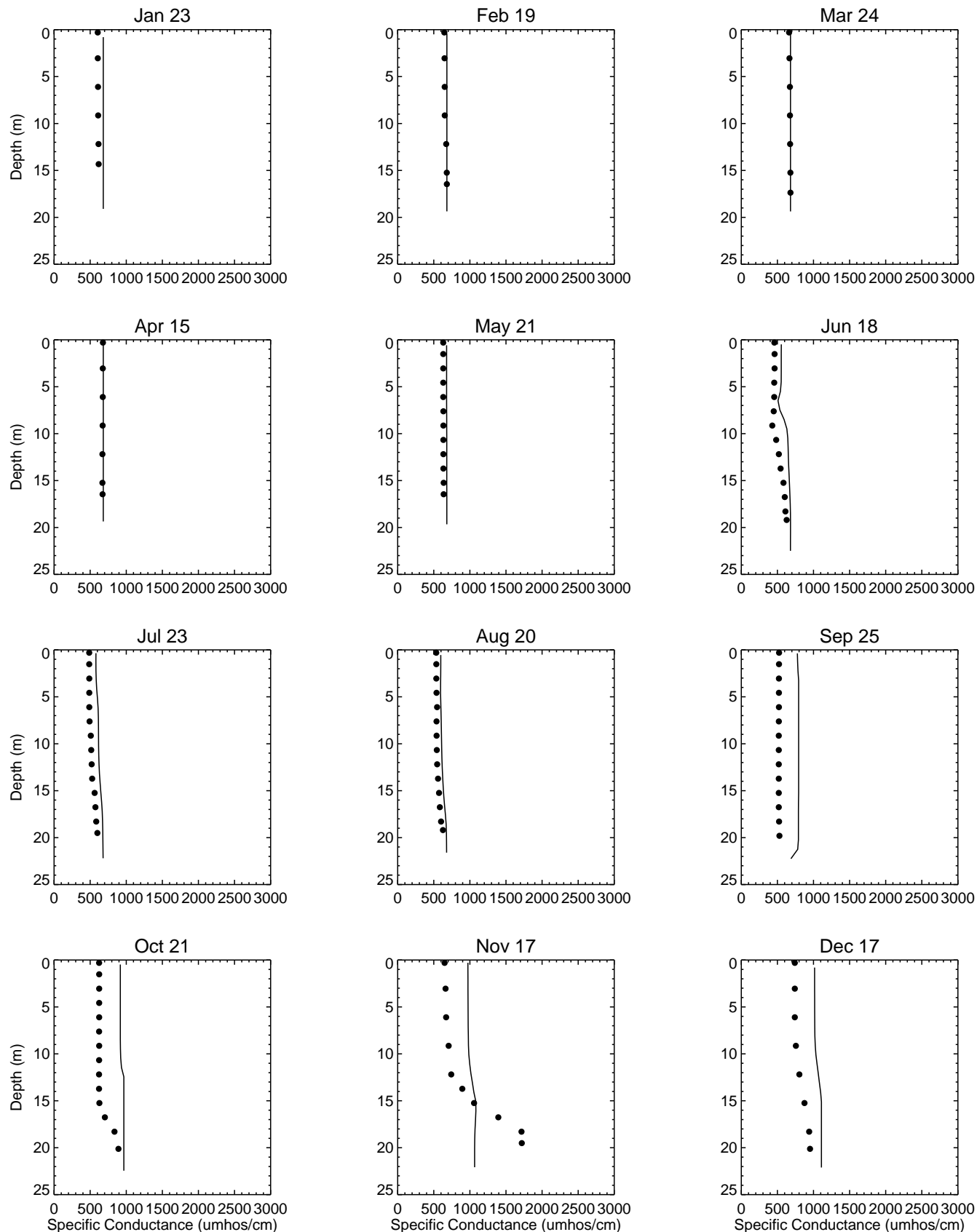
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
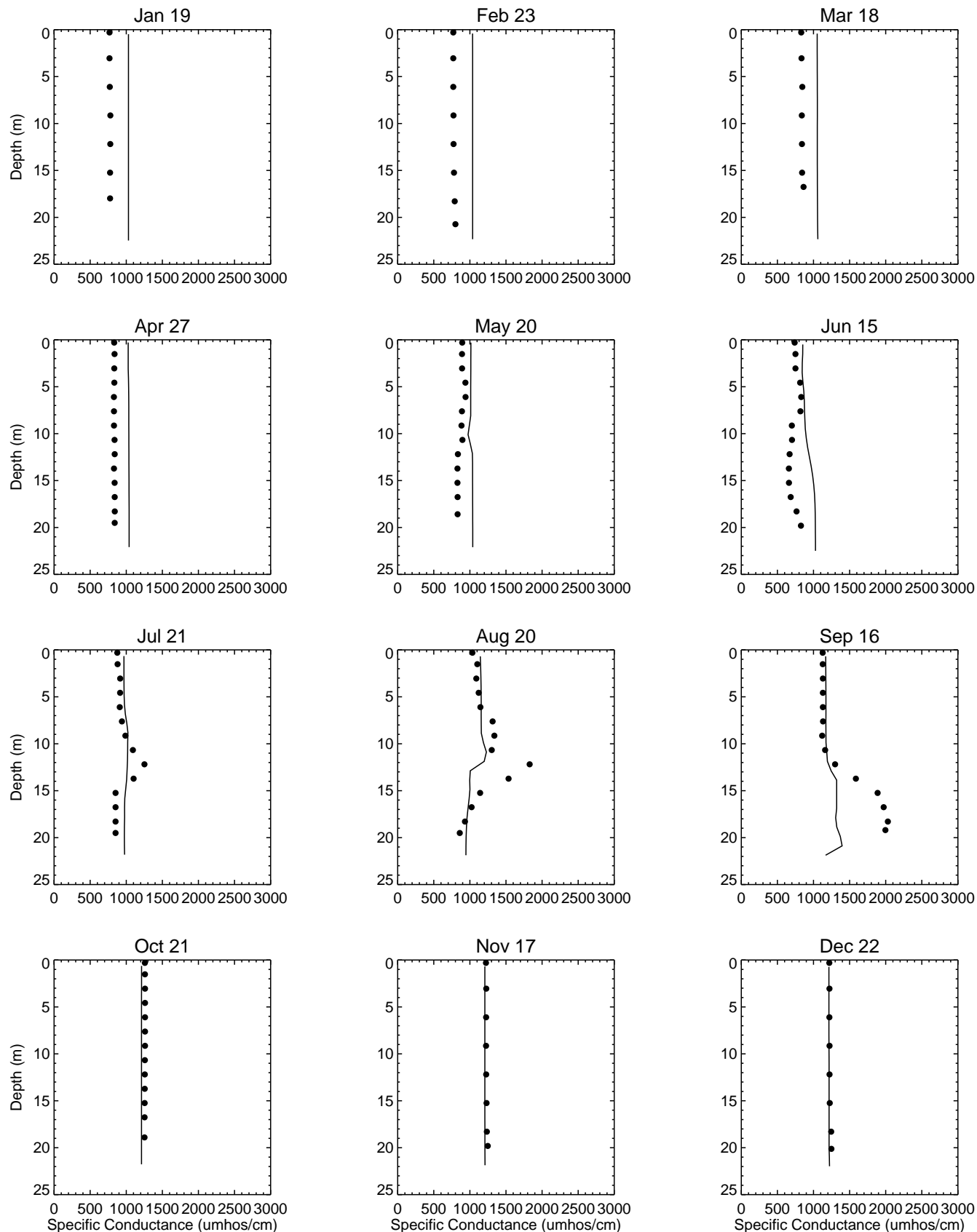Fri Jan 25 18:13:40 2013

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 1985

Profiles shown for dates with available data else model results for first day of month shown.
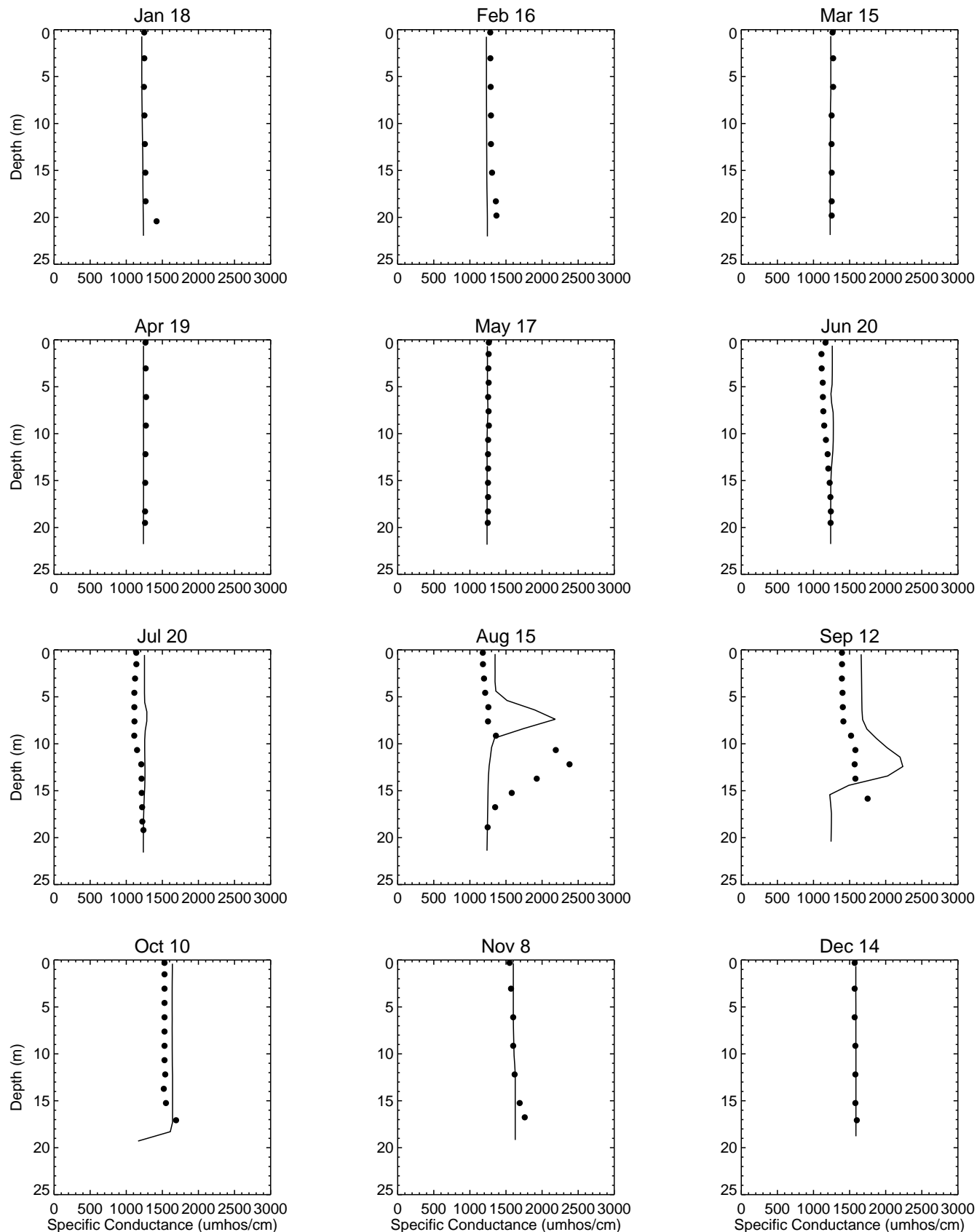
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 1986

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 1987
Profiles shown for dates with available data else model results for first day of month shown.
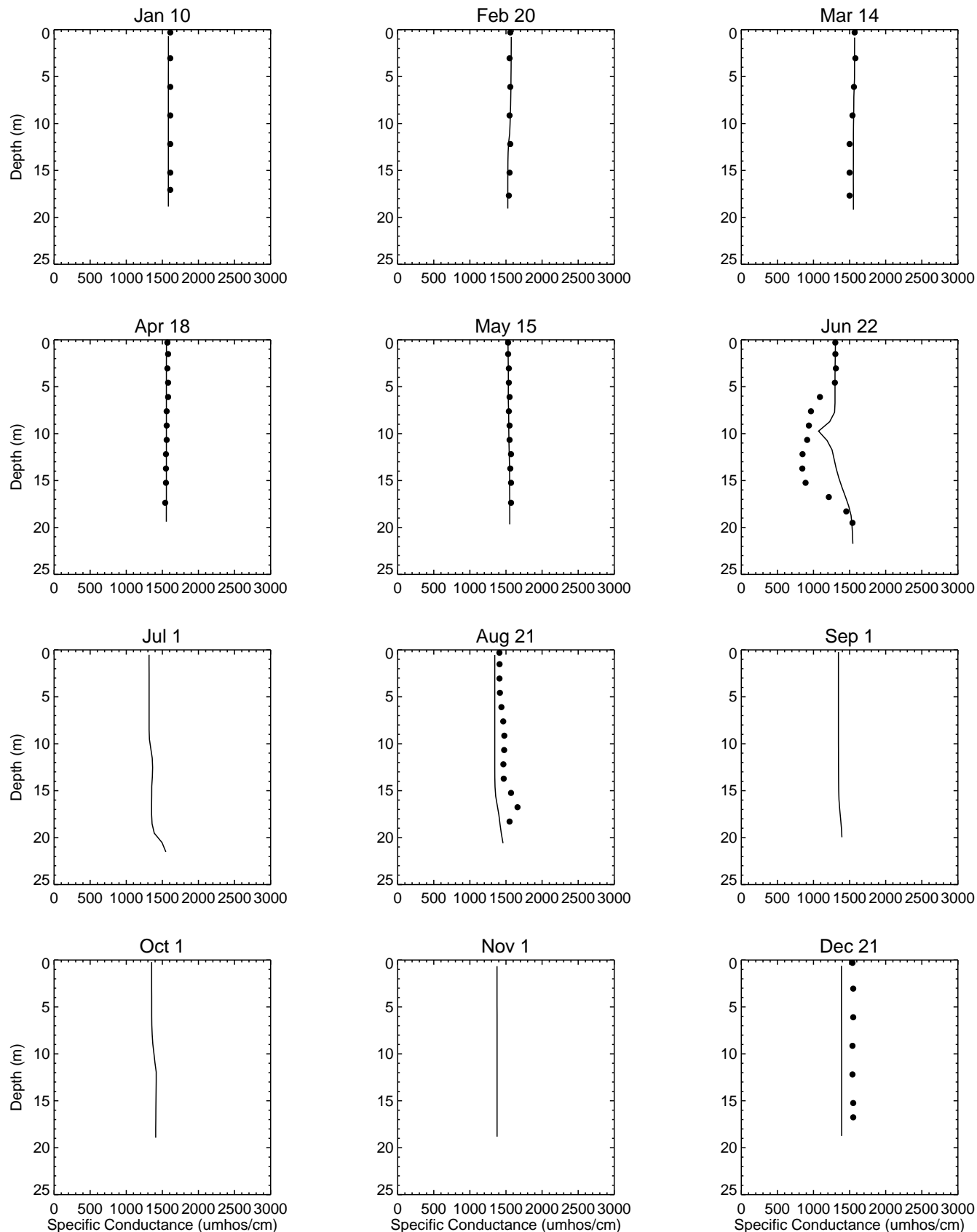
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Jan 18 · Feb 16 · Mar 15 · Apr 19 · May 17 · Jun 20 · Jul 20 · Aug 15 · Sep 12 · Oct 10 · Nov 8 · Dec 14

Specific Conductance (umhos/cm)

—— Model (w1210-48)

● Data

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 1988

Profiles shown for dates with available data else model results for first day of month shown.
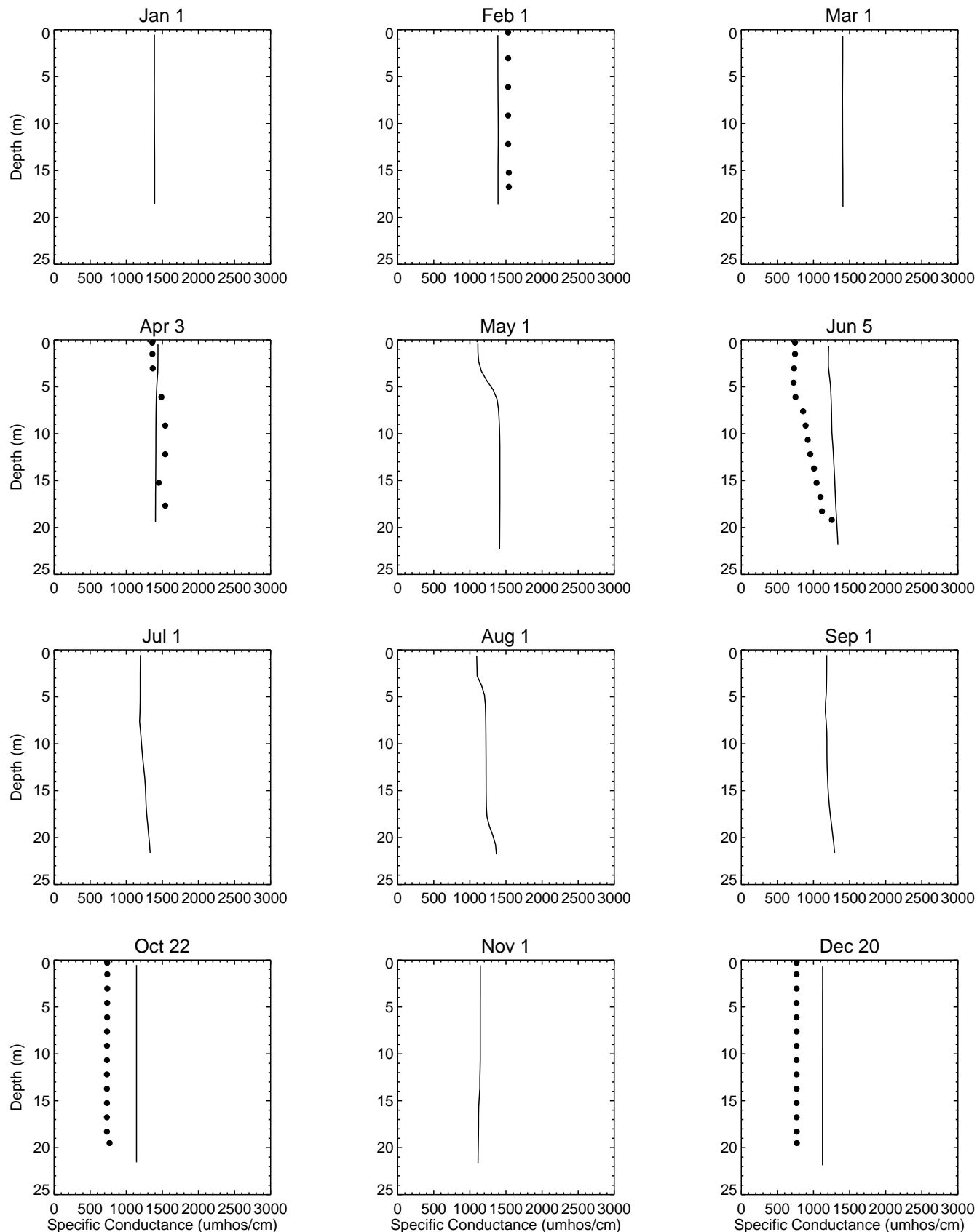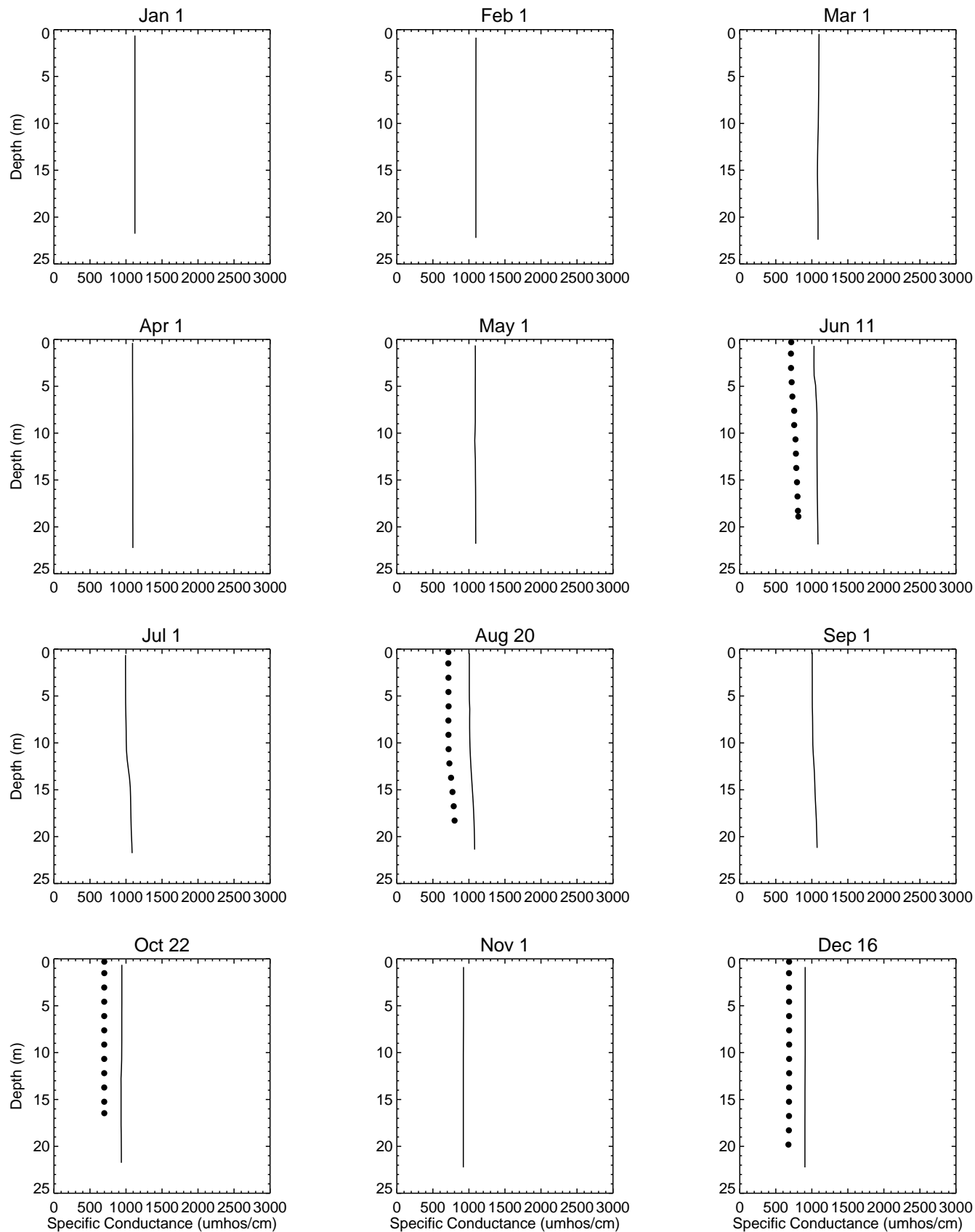
ANCHOR
QEA
PARSONS

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:40 2013

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 1989

Profiles shown for dates with available data else model results for first day of month shown.
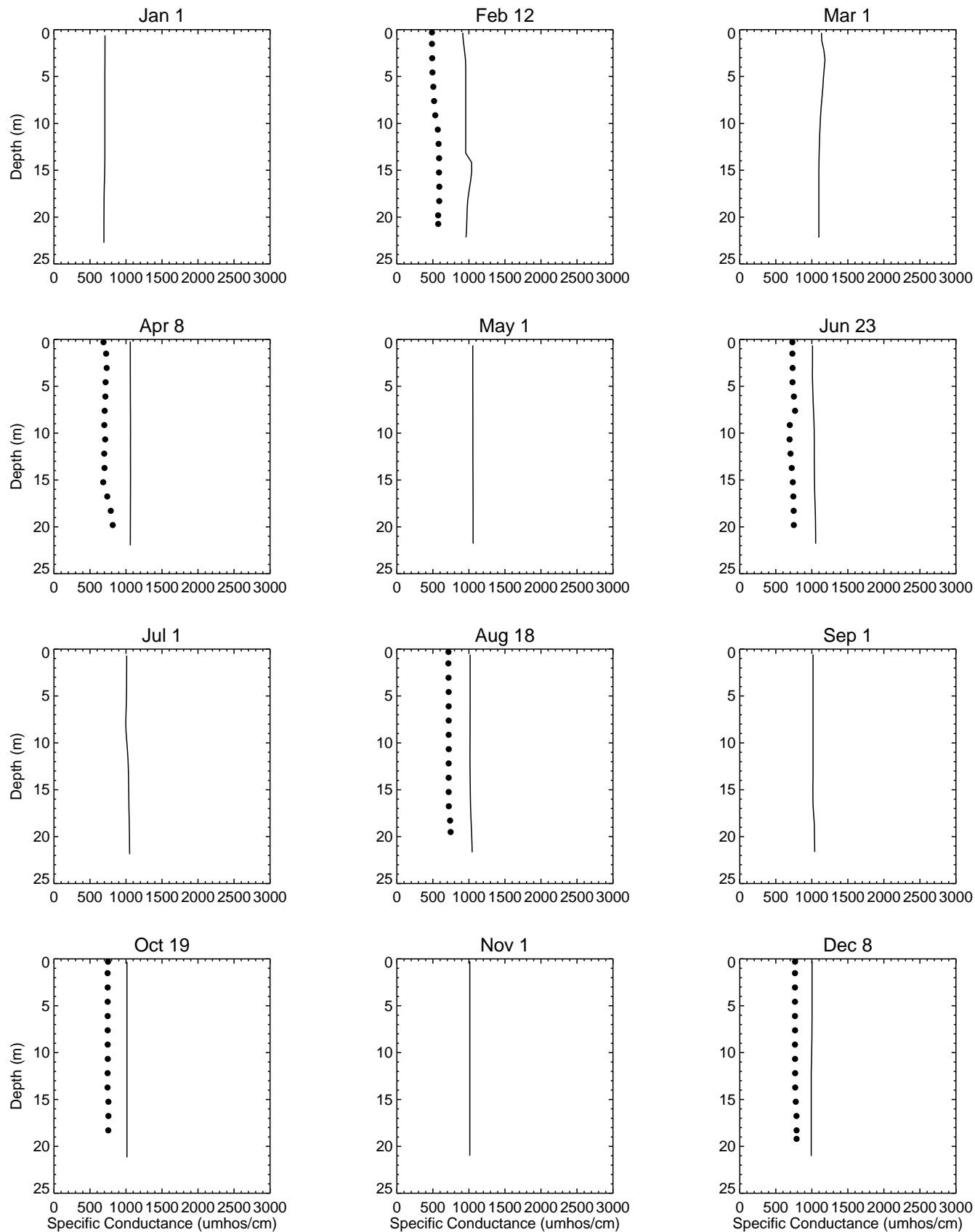
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 1990

Profiles shown for dates with available data else model results for first day of month shown.
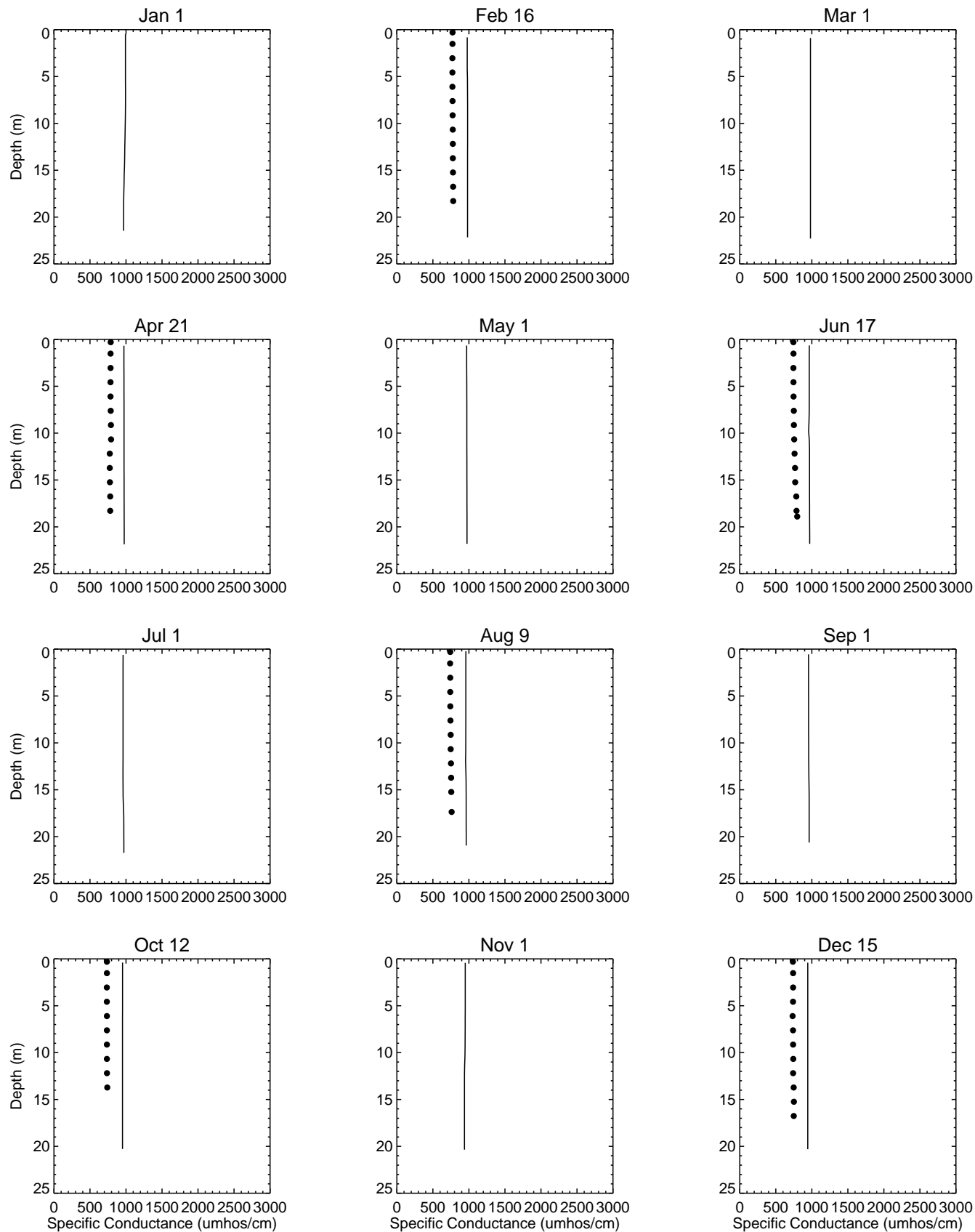
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 1991

Profiles shown for dates with available data else model results for first day of month shown.
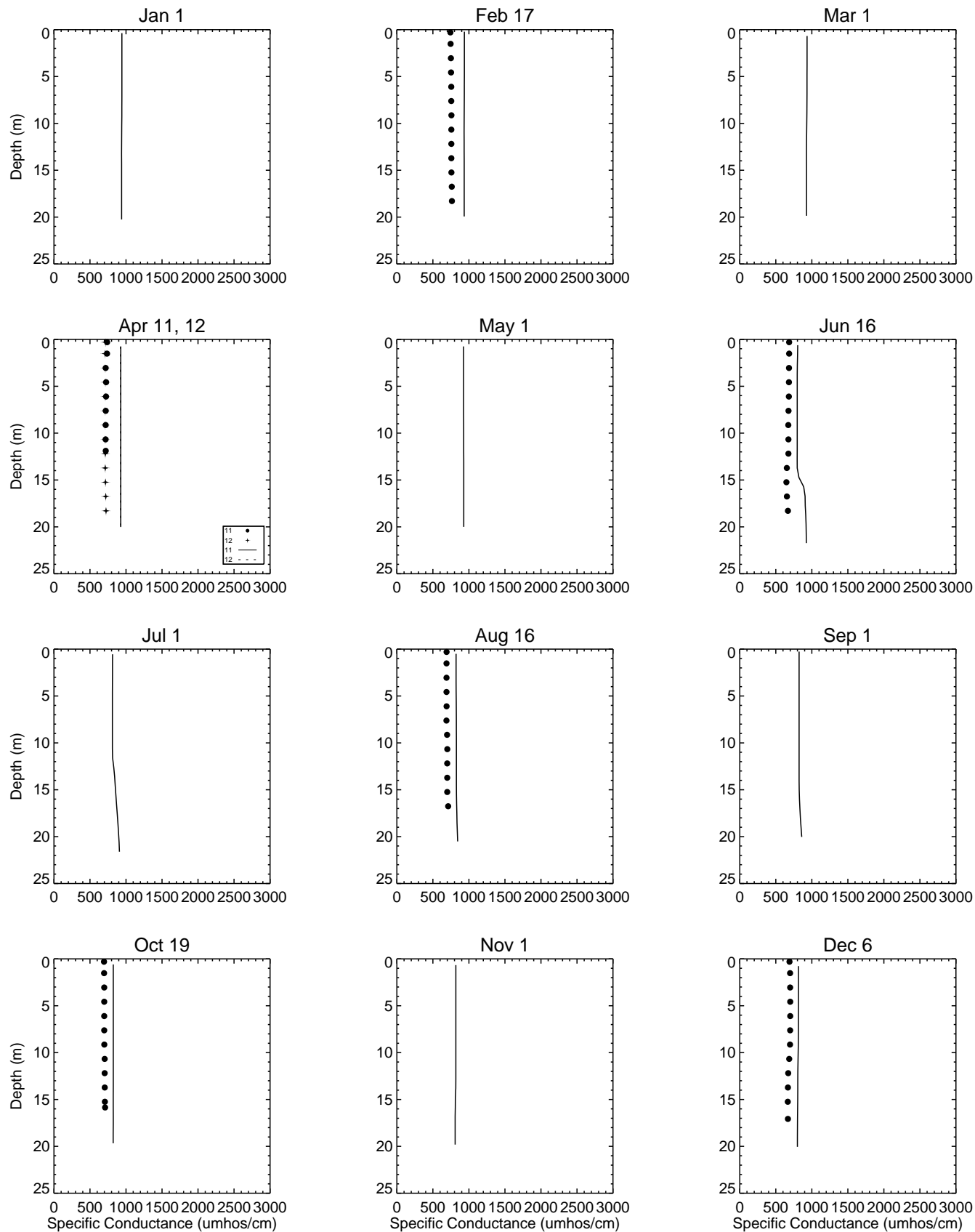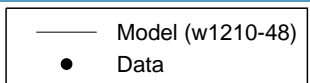
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 1992

Profiles shown for dates with available data else model results for first day of month shown.

Legend:
— Model (w1210-48)
● Data

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:40 2013

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 1993
Profiles shown for dates with available data else model results for first day of month shown.
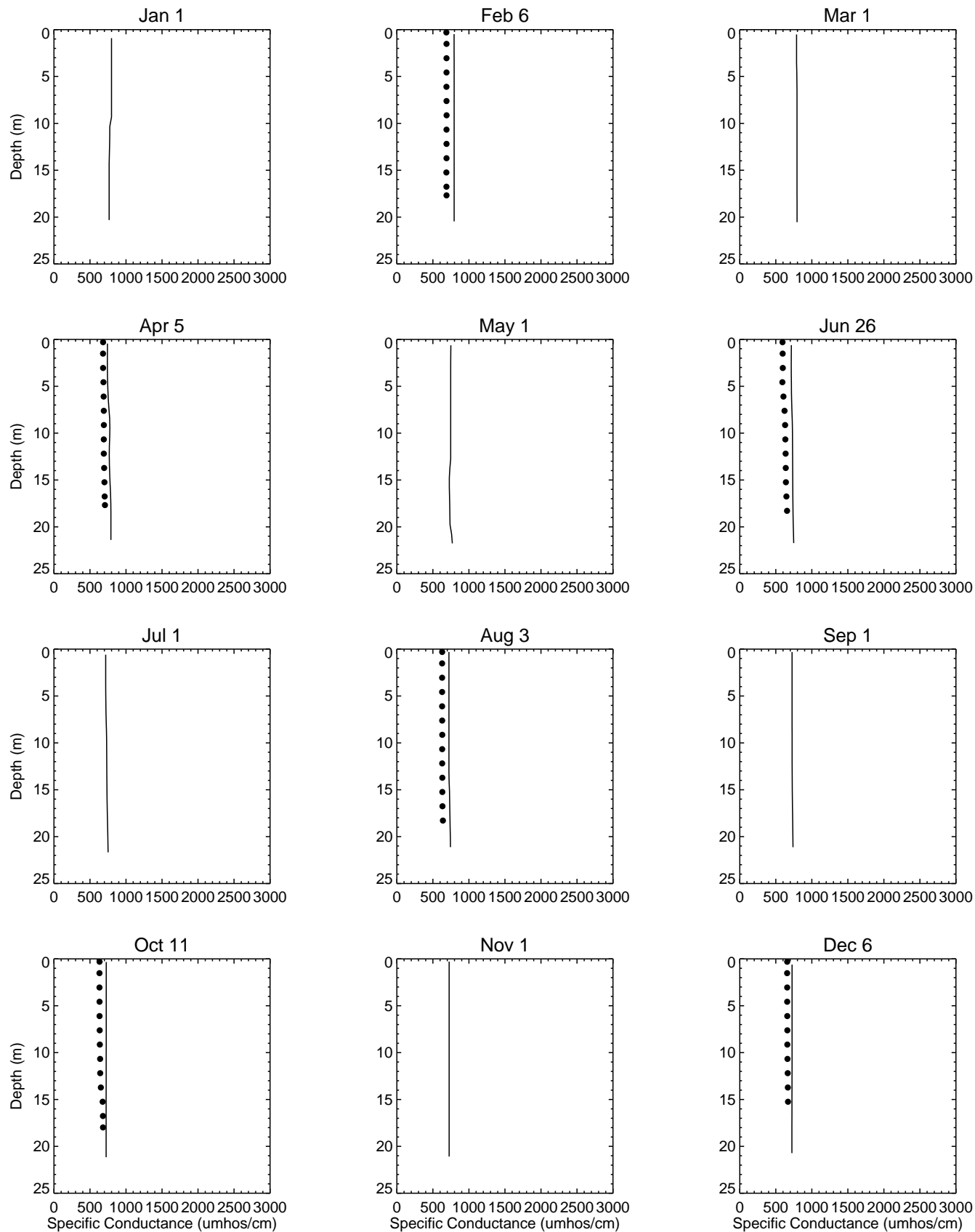
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
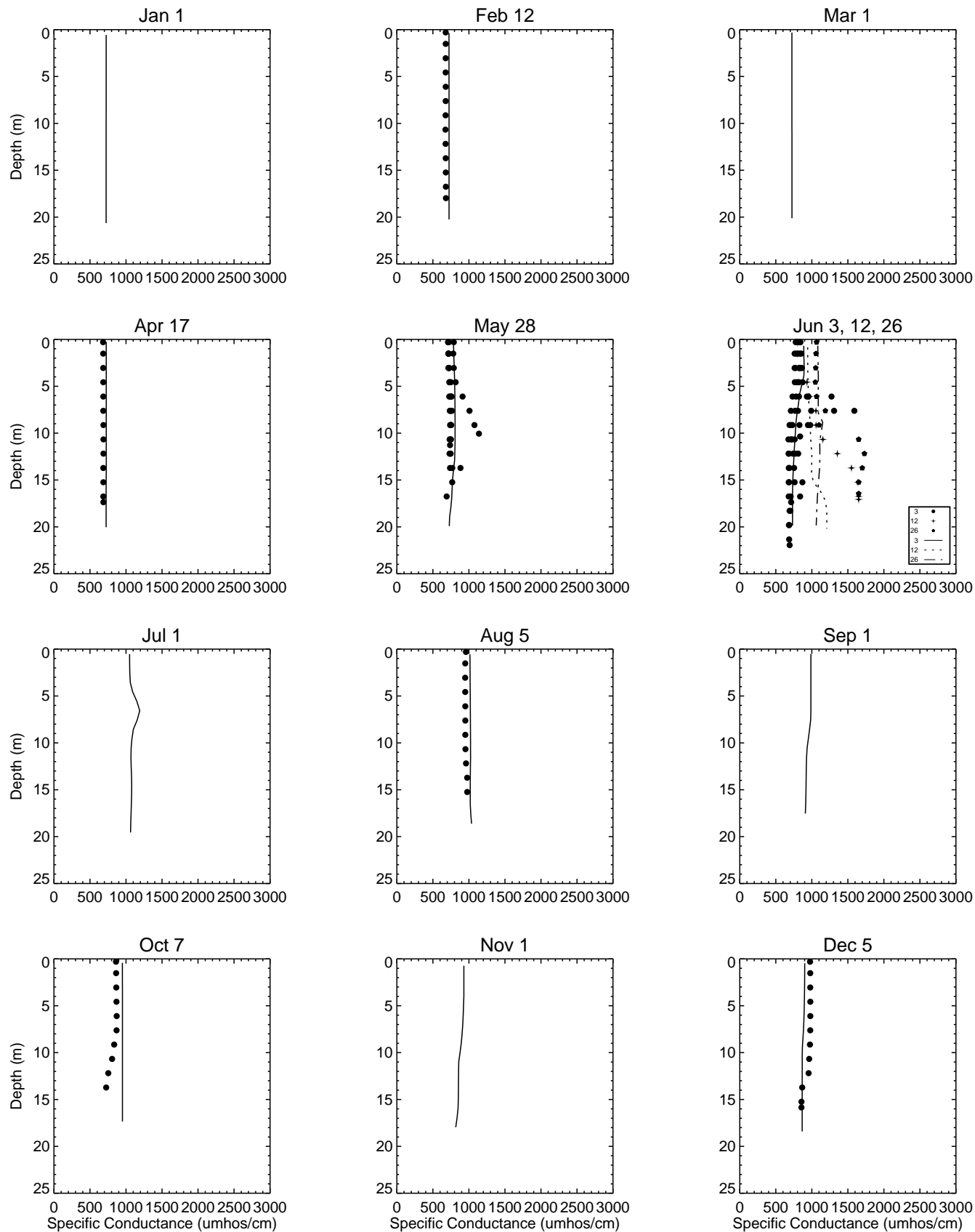Fri Jan 25 18:13:40 2013

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 1994

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 Feb 6 Mar 1

Apr 5 May 1 Jun 26

Jul 1 Aug 3 Sep 1

Oct 11 Nov 1 Dec 6

Specific Conductance (umhos/cm)
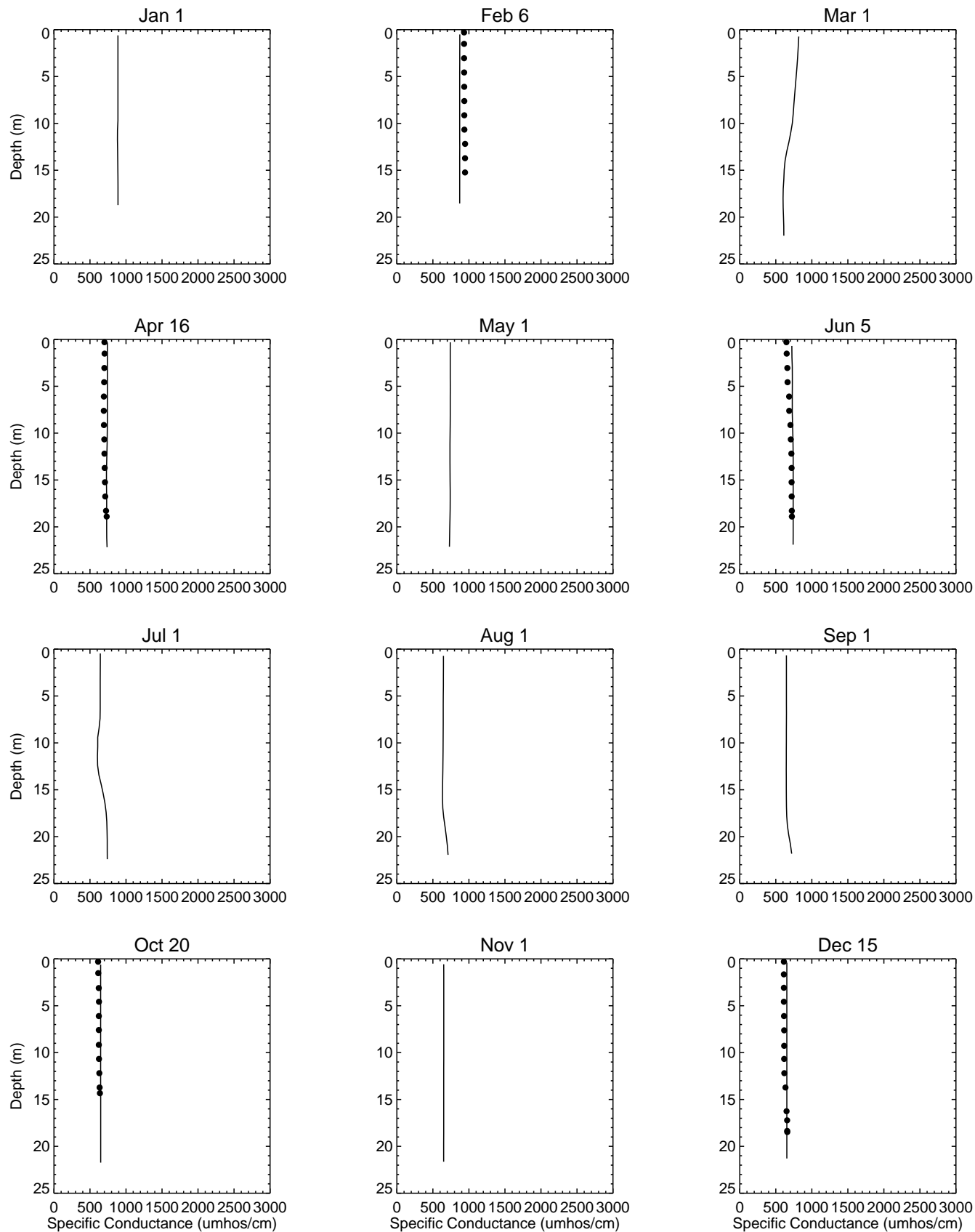
——— Model (w1210-48)

● Data

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 1995

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
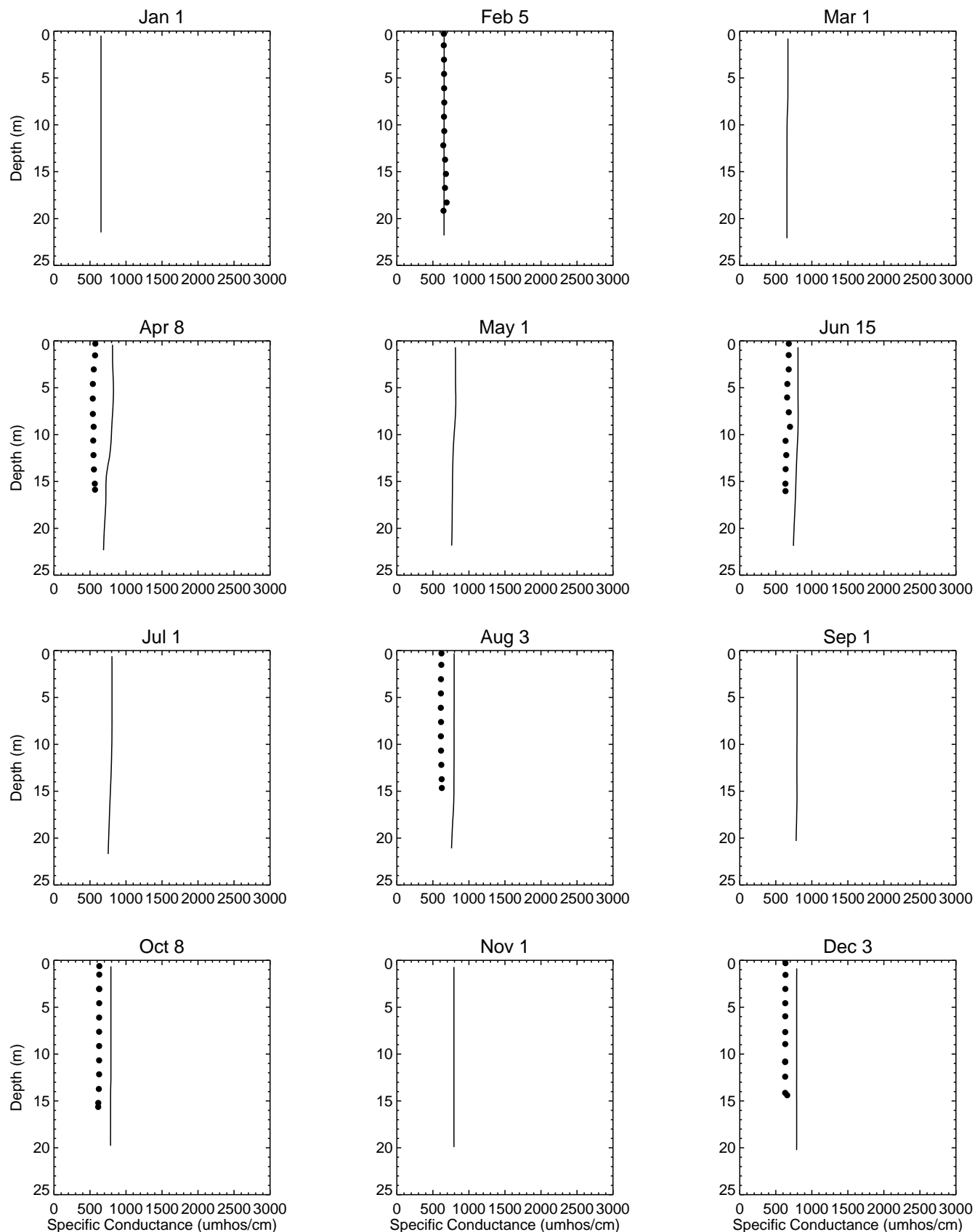
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:40 2013

Jan 1   Feb 12   Mar 1

Apr 17   May 28   Jun 3, 12, 26

Jul 1   Aug 5   Sep 1

Oct 7   Nov 1   Dec 5

Specific Conductance (umhos/cm)
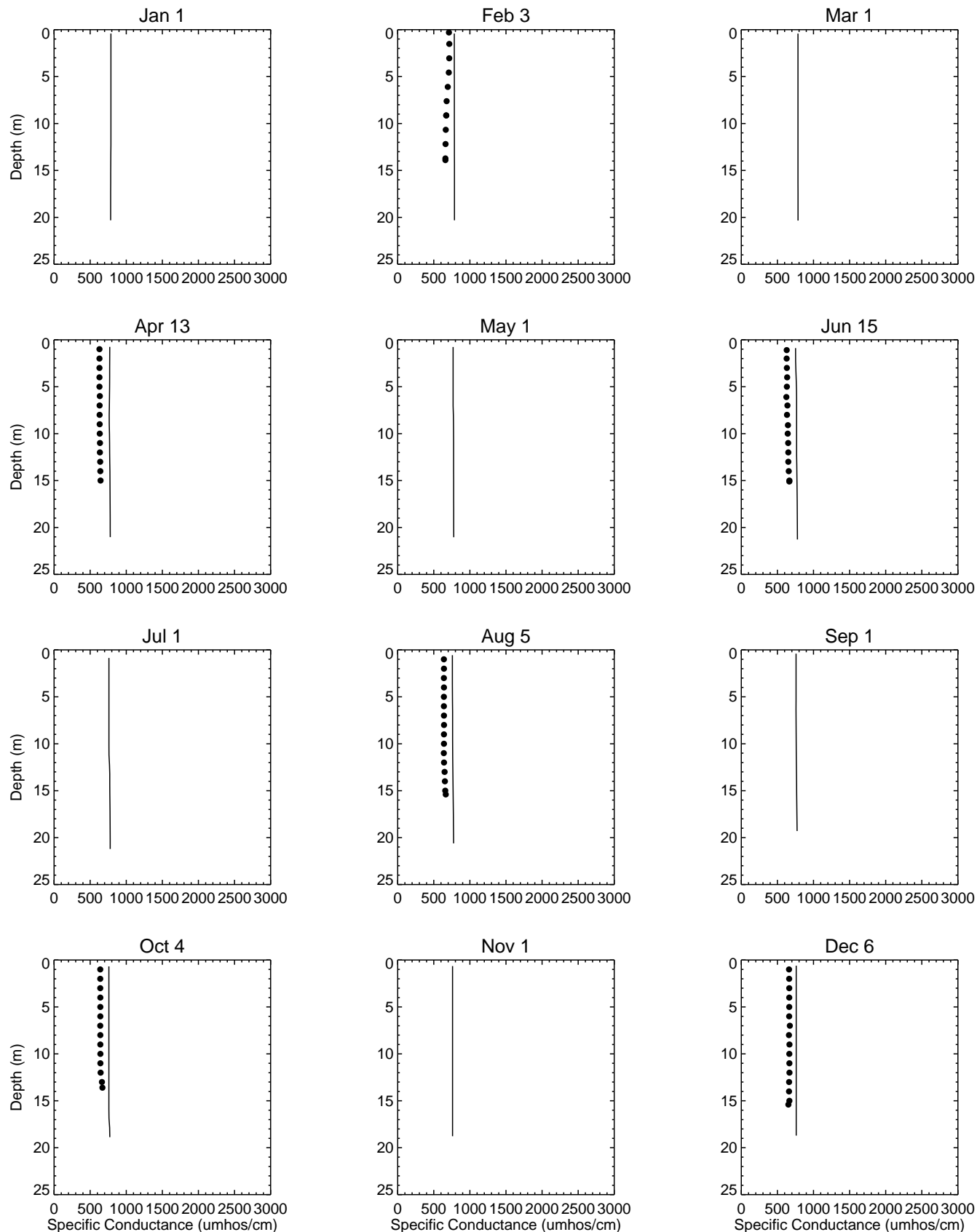
——— Model (w1210-48)
● Data

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 1996
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:40 2013

Jan 1 | Feb 6 | Mar 1
Apr 16 | May 1 | Jun 5
Jul 1 | Aug 1 | Sep 1
Oct 20 | Nov 1 | Dec 15

Specific Conductance (umhos/cm)
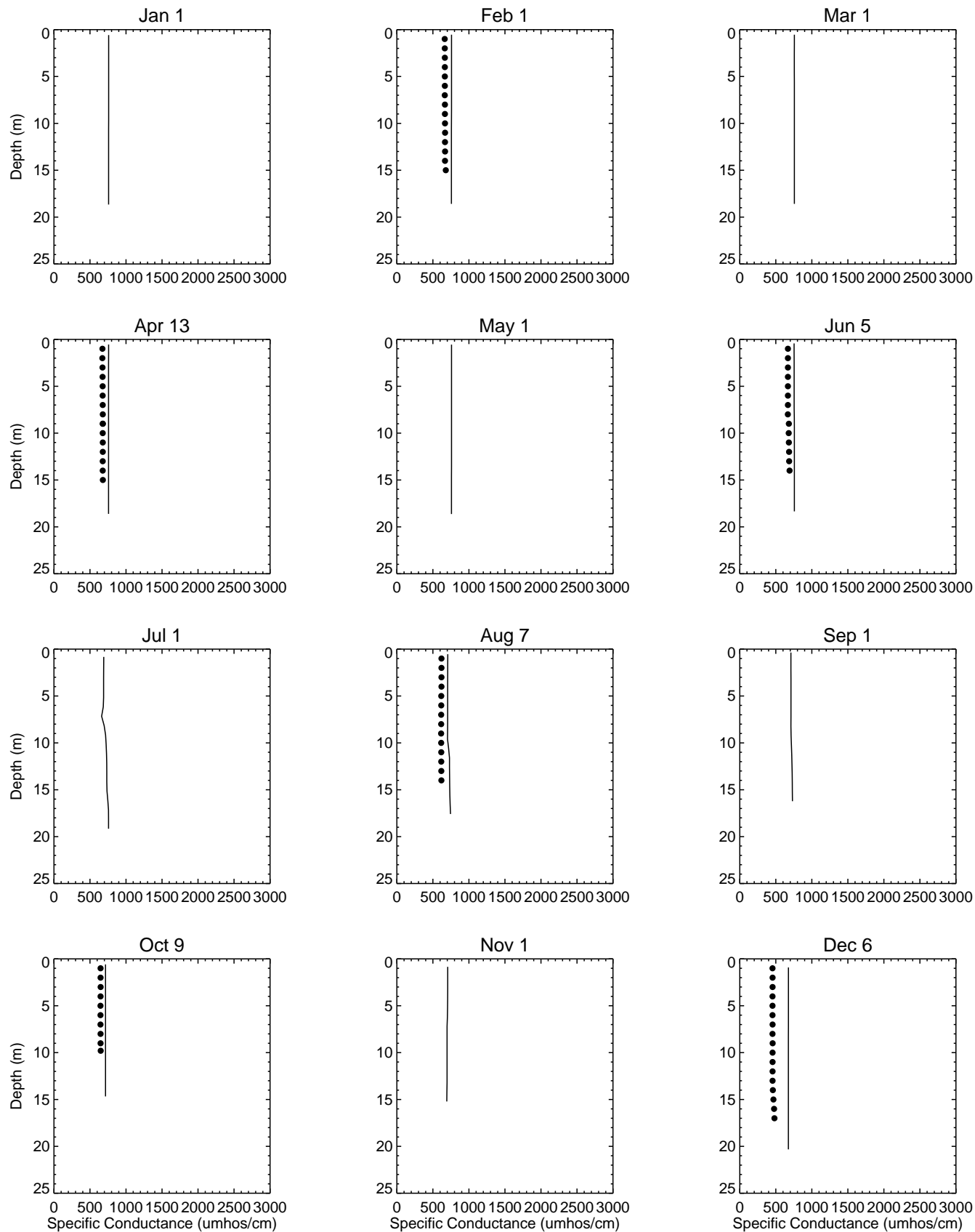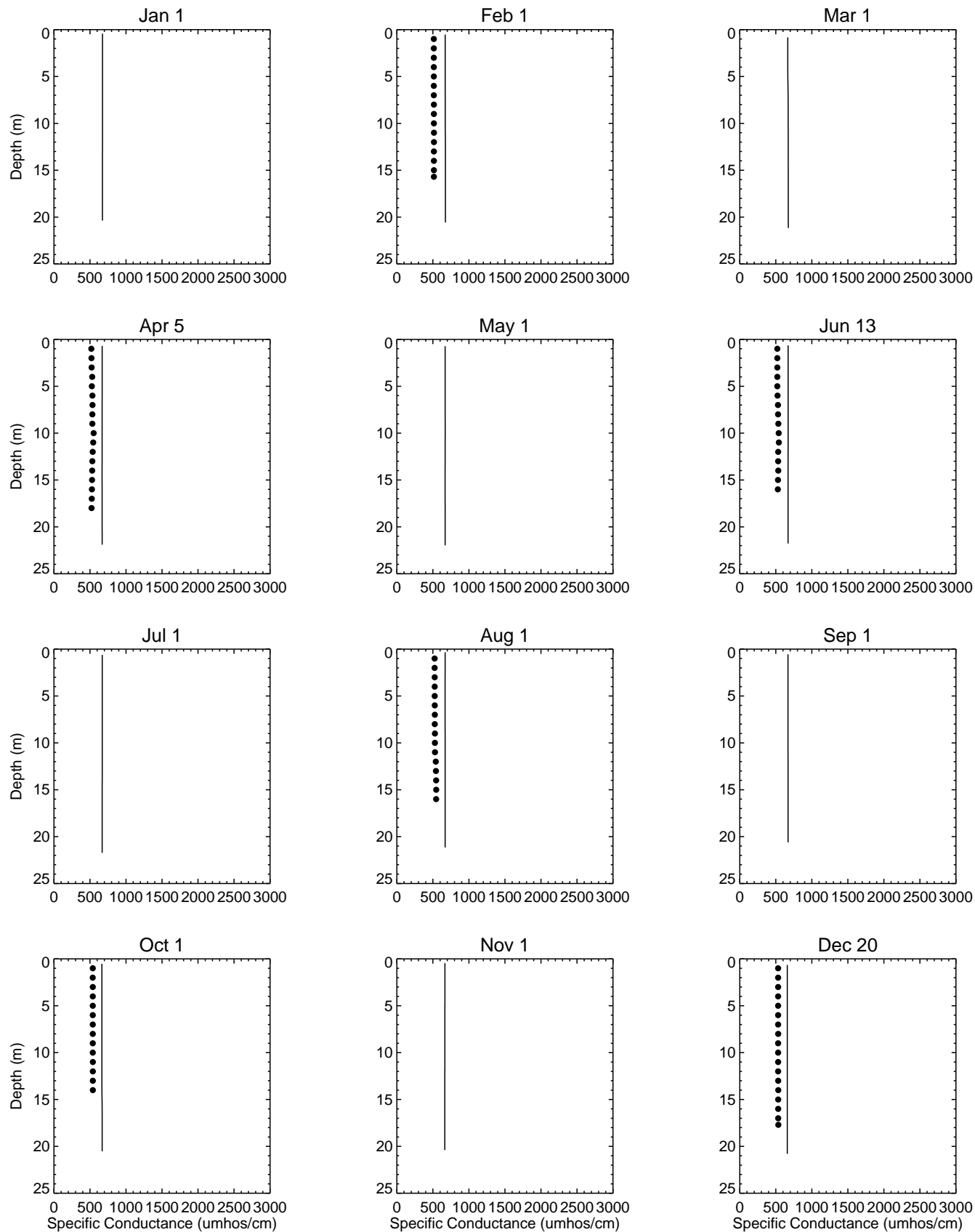
——— Model (w1210-48)
● Data

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 1997
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 1998

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
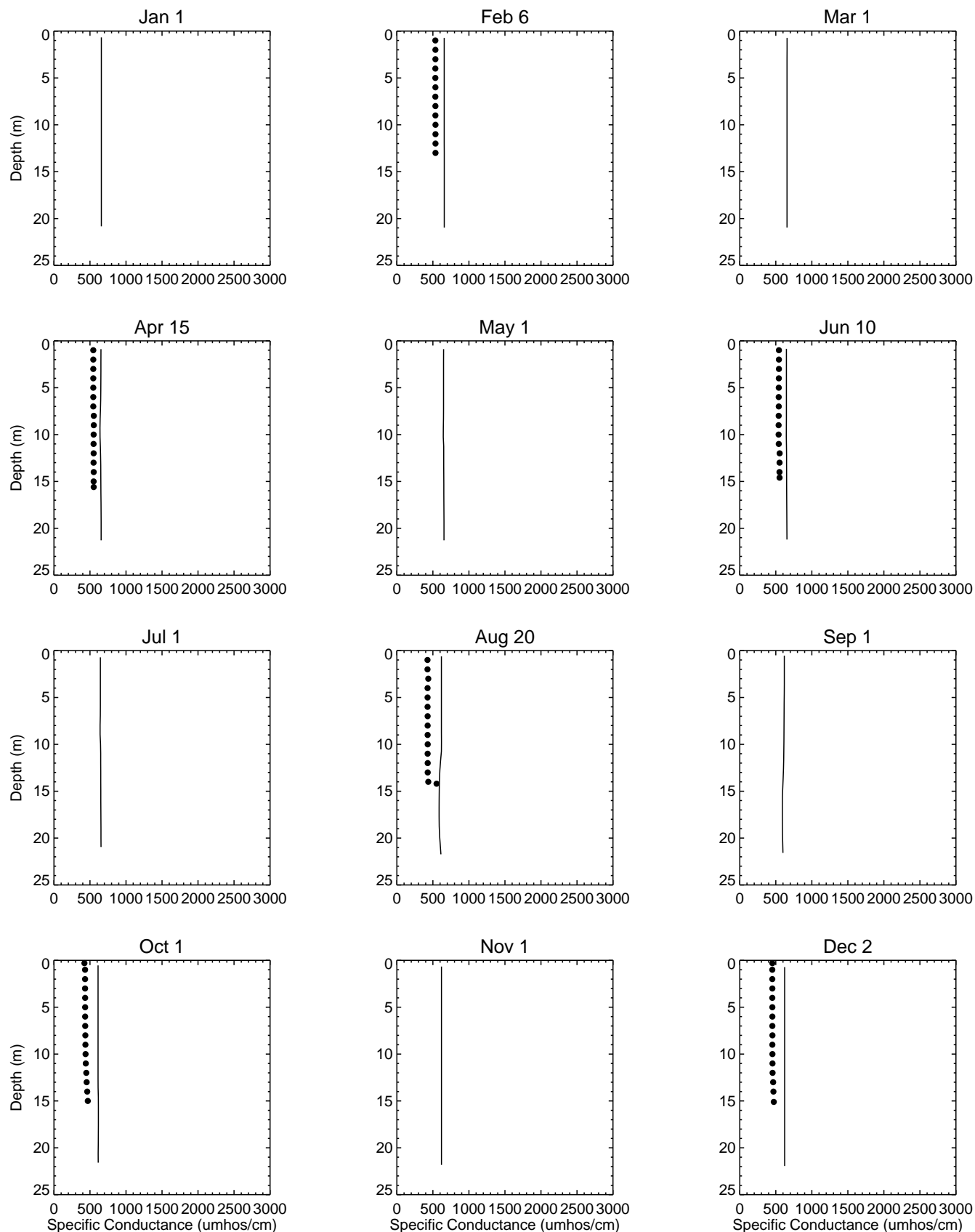
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:40 2013

Jan 1   Feb 3   Mar 1

Apr 13   May 1   Jun 15

Jul 1   Aug 5   Sep 1

Oct 4   Nov 1   Dec 6

Specific Conductance (umhos/cm)

——— Model (w1210-48)

● Data

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 1999

Profiles shown for dates with available data else model results for first day of month shown.
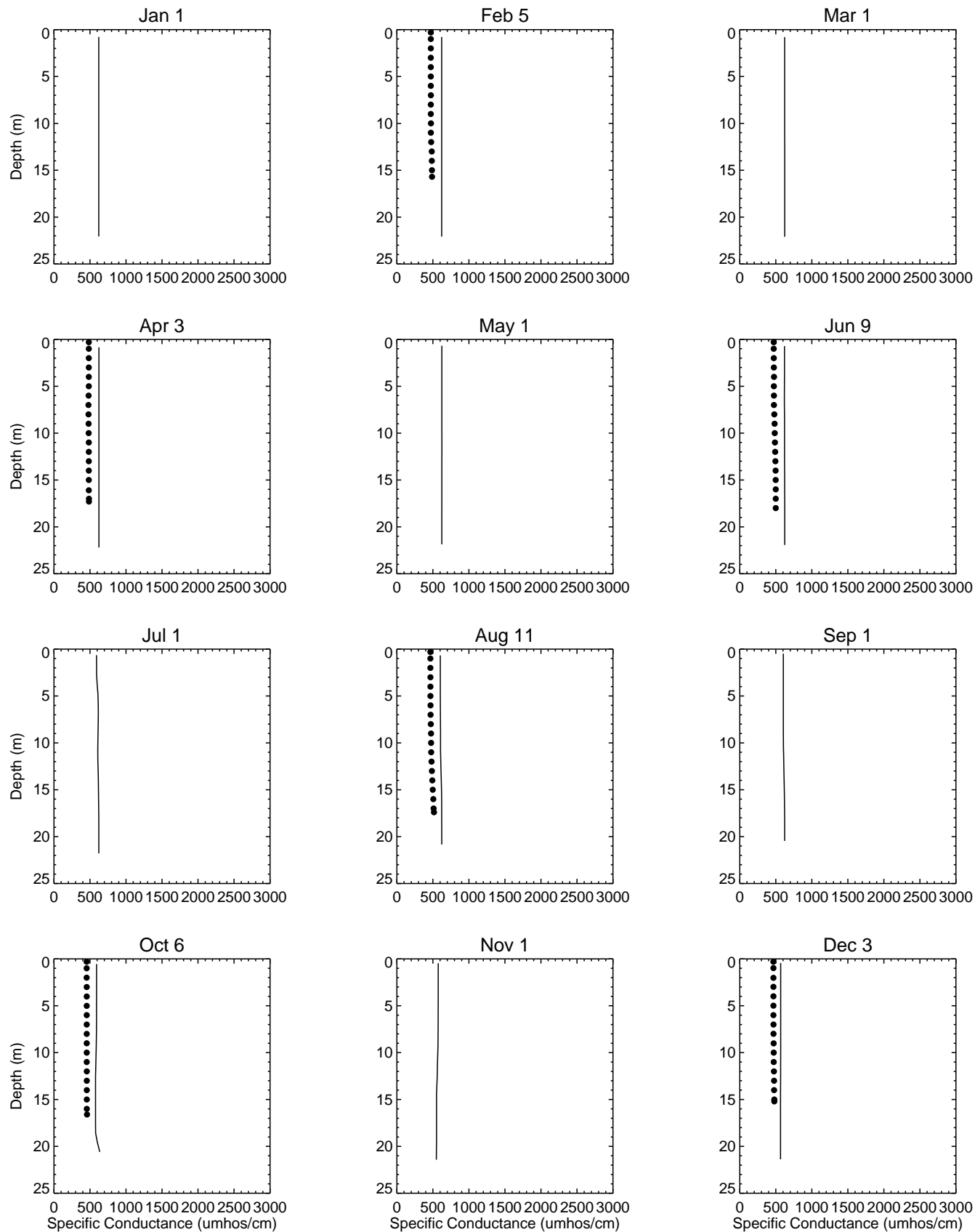
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:40 2013

Jan 1 Feb 1 Mar 1

Apr 13 May 1 Jun 5

Jul 1 Aug 7 Sep 1

Oct 9 Nov 1 Dec 6

Depth (m)

Specific Conductance (umhos/cm)
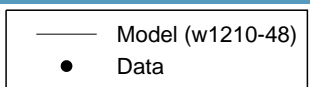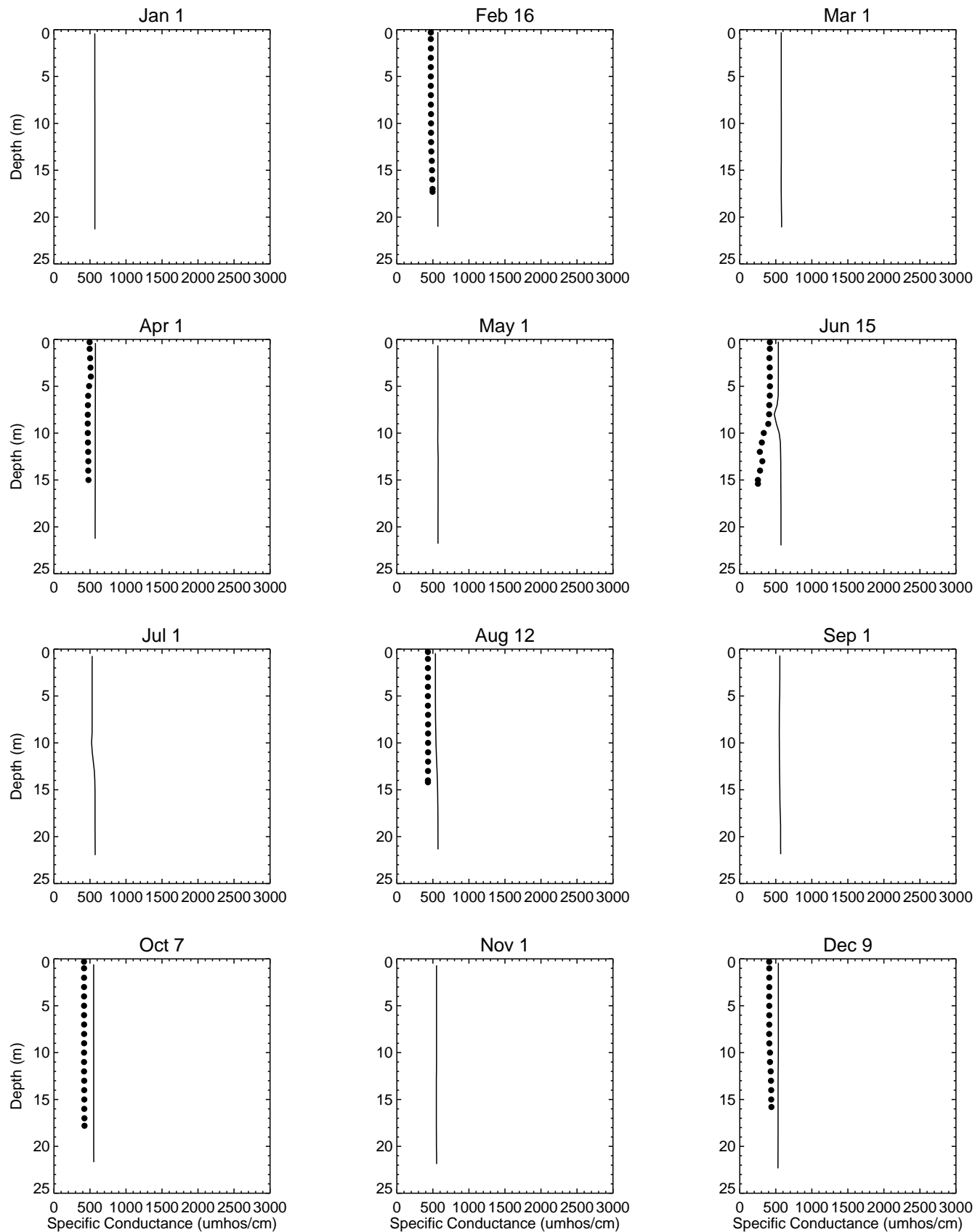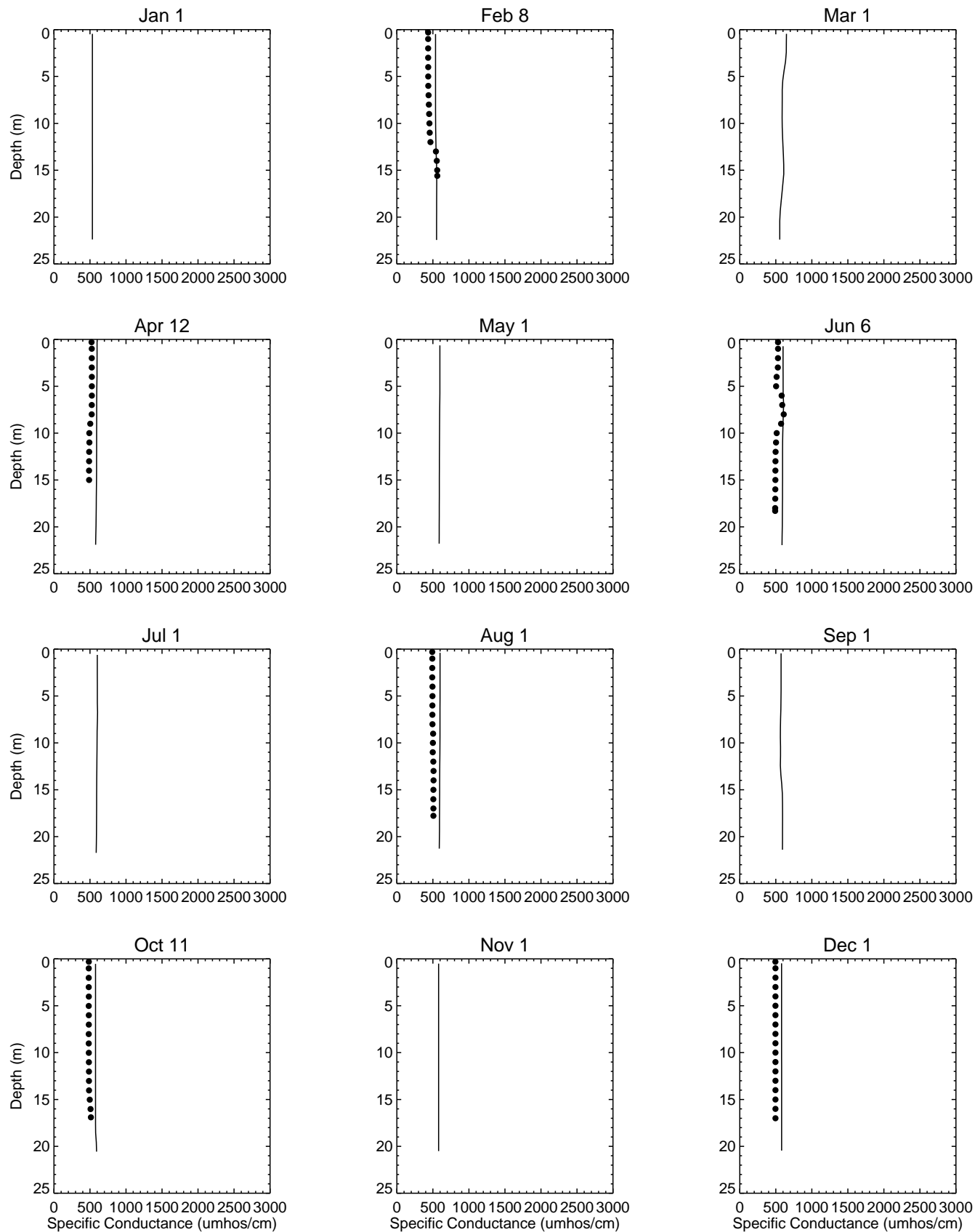
——— Model (w1210-48)
● Data

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 2000
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:40 2013

Jan 1　Feb 1　Mar 1

Apr 5　May 1　Jun 13

Jul 1　Aug 1　Sep 1
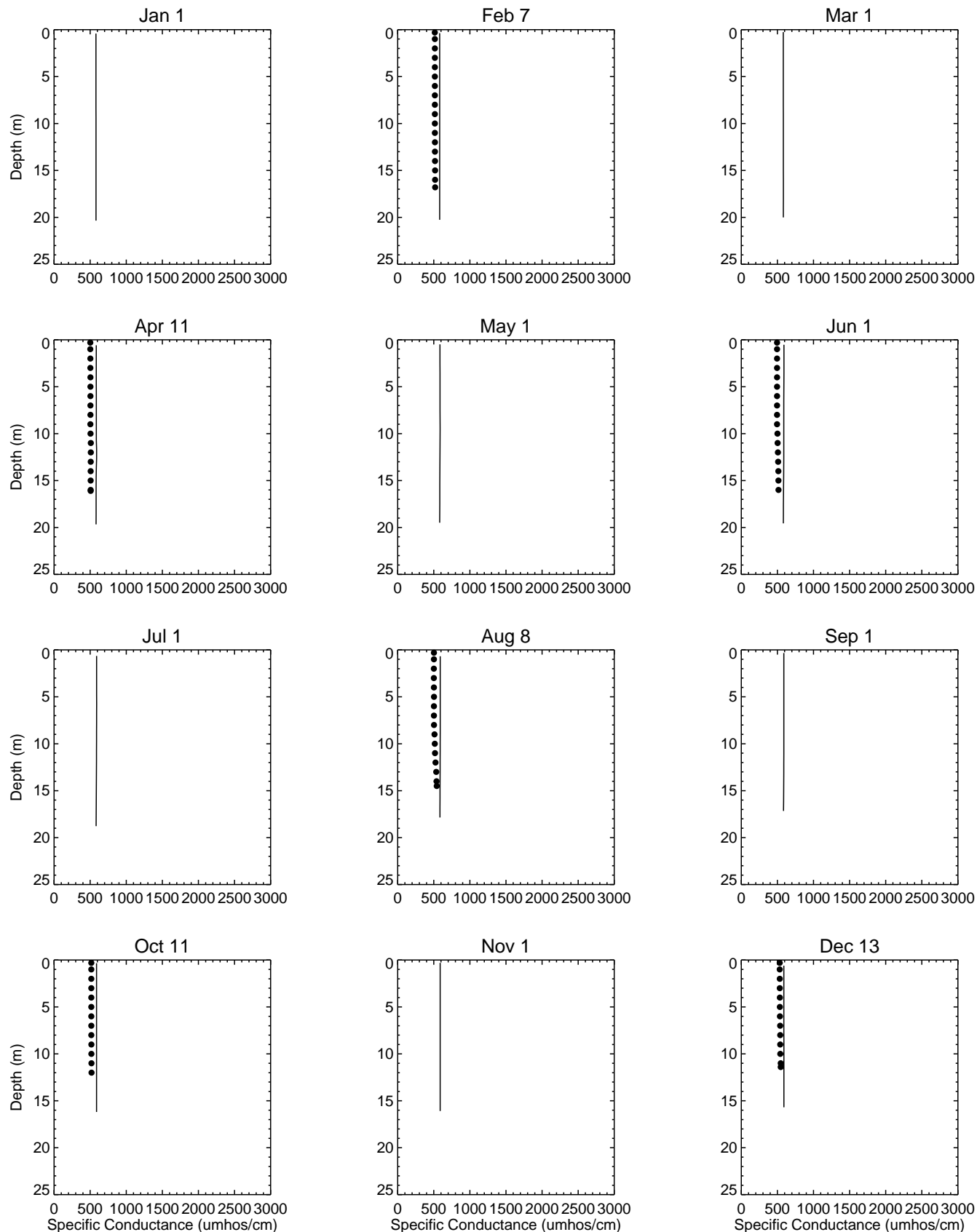
Oct 1　Nov 1　Dec 20

Model (w1210-48)
● Data

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 2001
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:40 2013

Jan 1 · Feb 6 · Mar 1 · Apr 15 · May 1 · Jun 10 · Jul 1 · Aug 20 · Sep 1 · Oct 1 · Nov 1 · Dec 2

Depth (m)

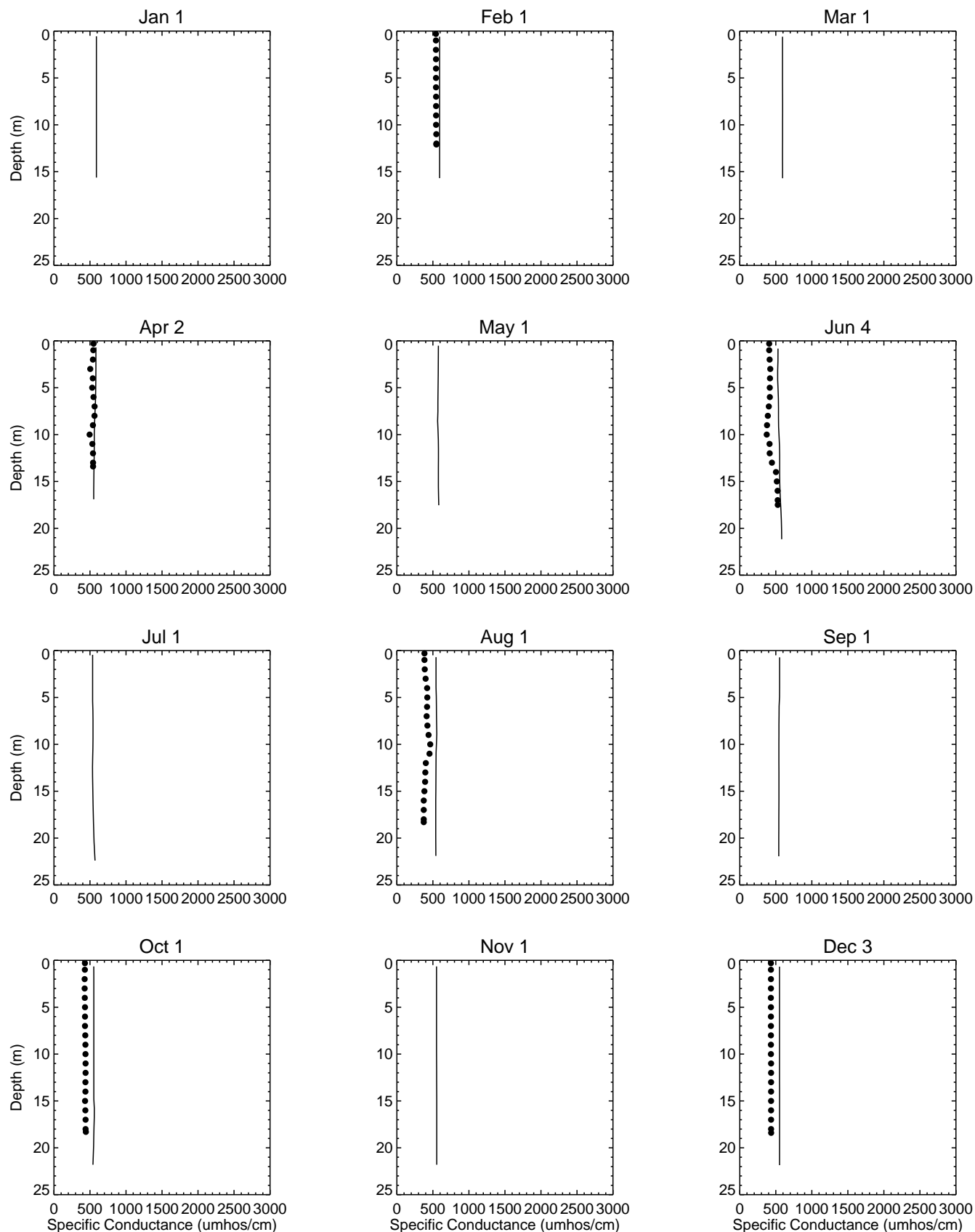Specific Conductance (umhos/cm)

Model (w1210-48)
Data

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 2002

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR
QEA
PARSONS

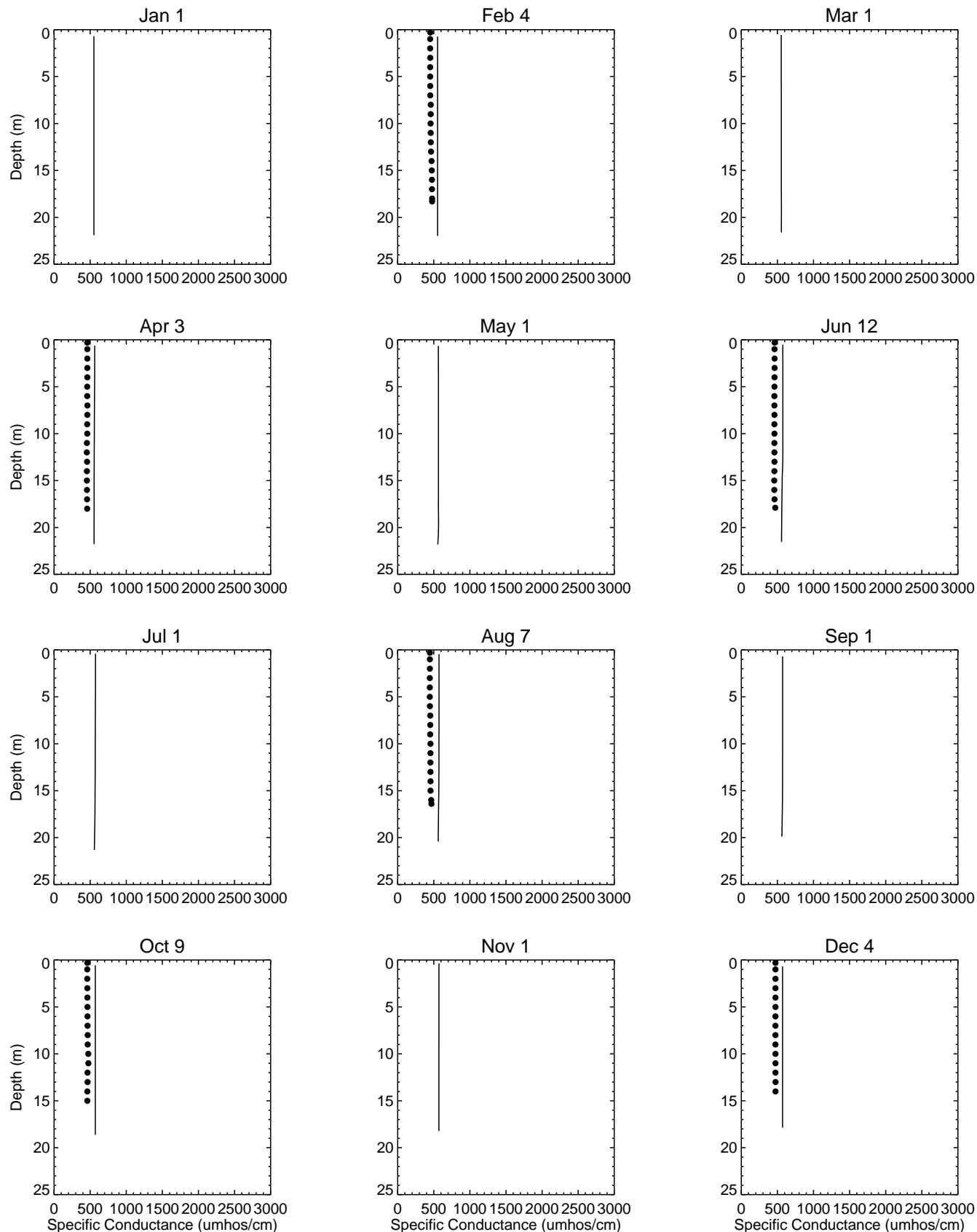CREMs Phase 4: Lake Buchanan
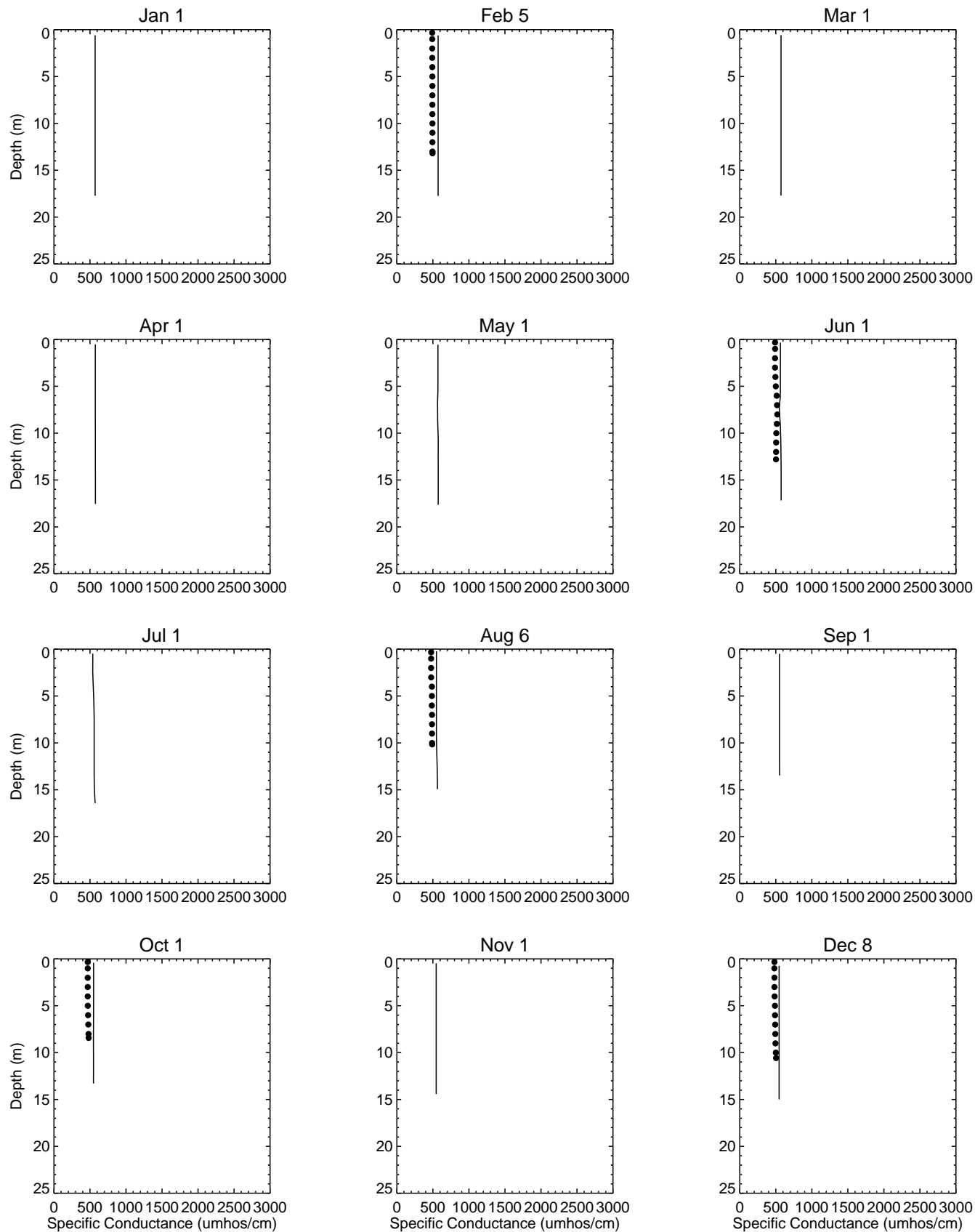Lower Colorado River Authority

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 2003

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 Feb 16 Mar 1 Apr 1 May 1 Jun 15 Jul 1 Aug 12 Sep 1 Oct 7 Nov 1 Dec 9

Depth (m)

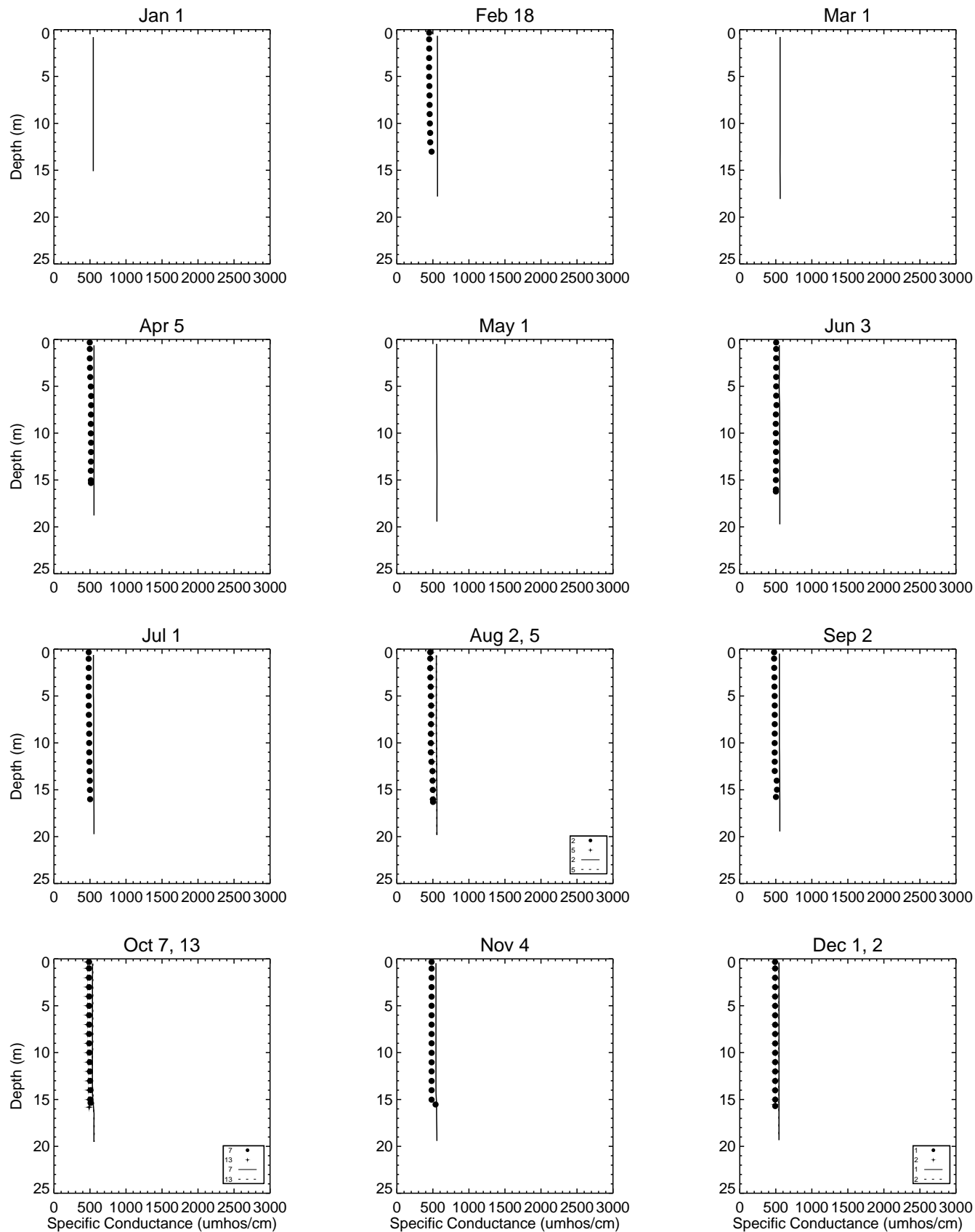Specific Conductance (umhos/cm)

Model (w1210-48)
Data

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 2004

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR
QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
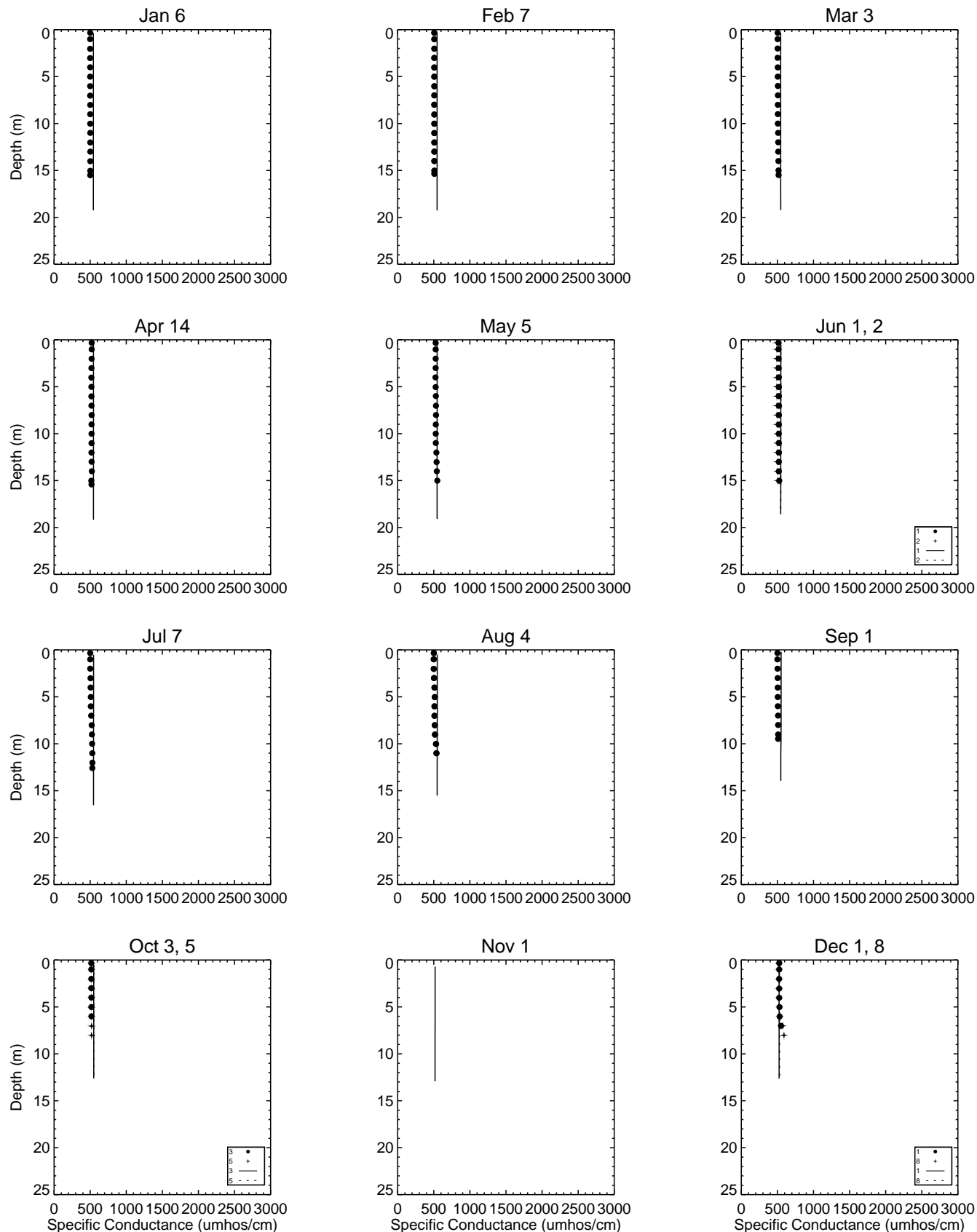Fri Jan 25 18:13:40 2013

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 2005

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
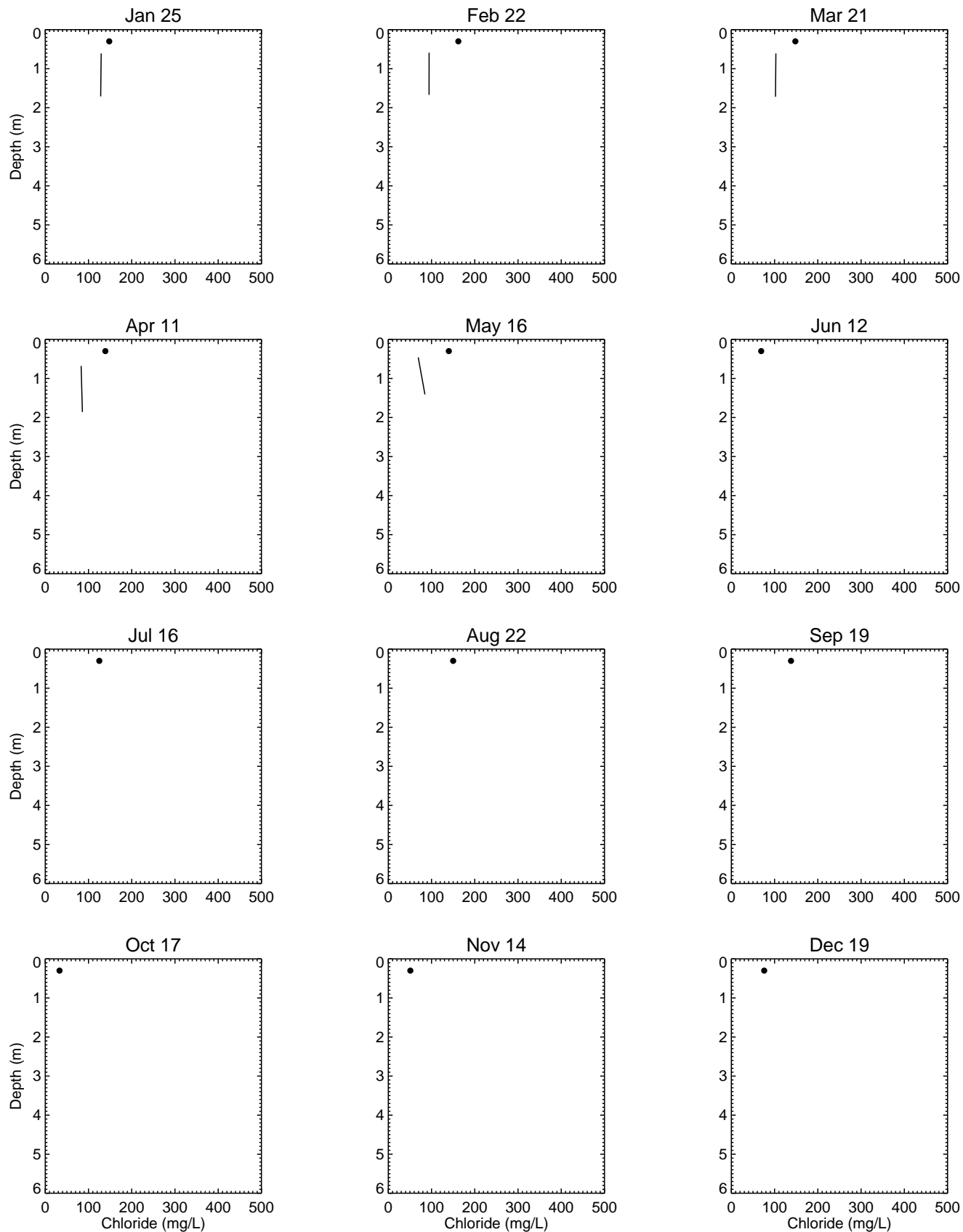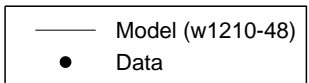
Lower Colorado River Authority

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 2006

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:41 2013

Jan 1 — Feb 1 — Mar 1 — Apr 2 — May 1 — Jun 4 — Jul 1 — Aug 1 — Sep 1 — Oct 1 — Nov 1 — Dec 3

Depth (m) vs Specific Conductance (umhos/cm)

—— Model (w1210-48)
● Data

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 2007
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
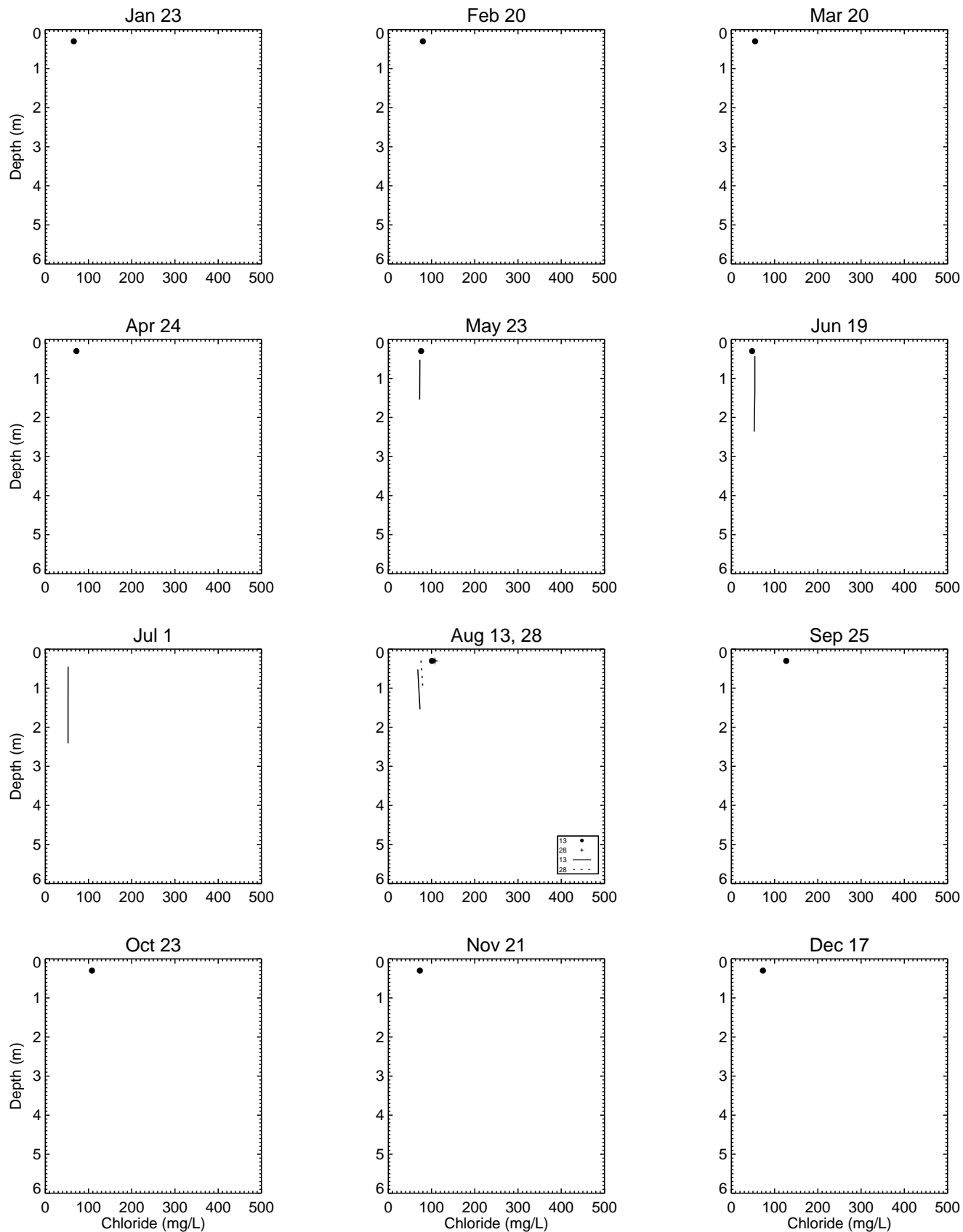Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:41 2013

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 2008
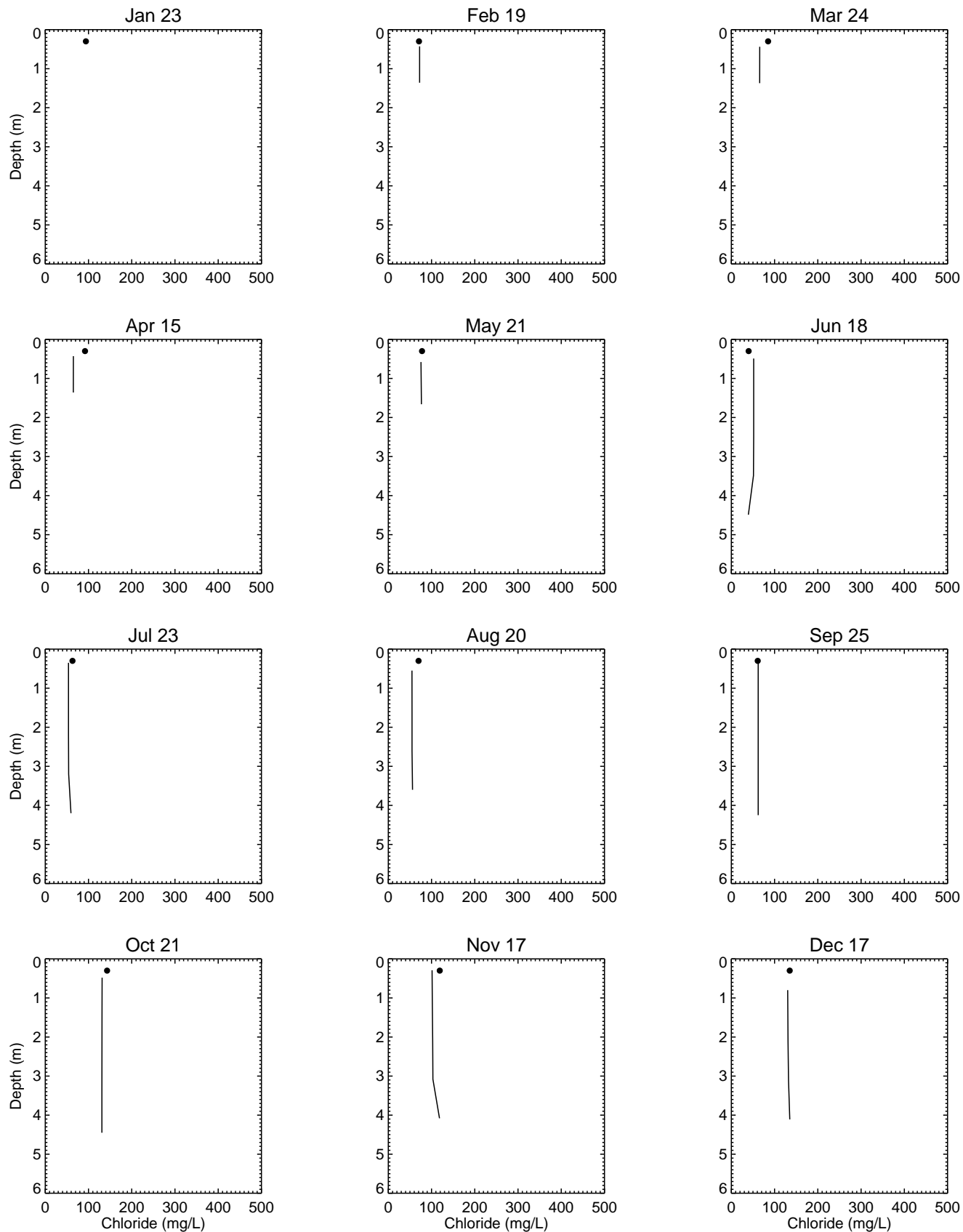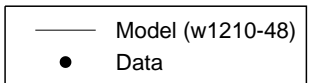
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 5 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 6 · Sep 1 · Oct 1 · Nov 1 · Dec 8

Specific Conductance (umhos/cm)

—— Model (w1210-48)
● Data

Model (w1210-48)

● Data

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 2010

Profiles shown for dates with available data else model results for first day of month shown.

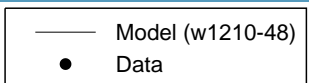CREMs Phase 4: Lake Buchanan
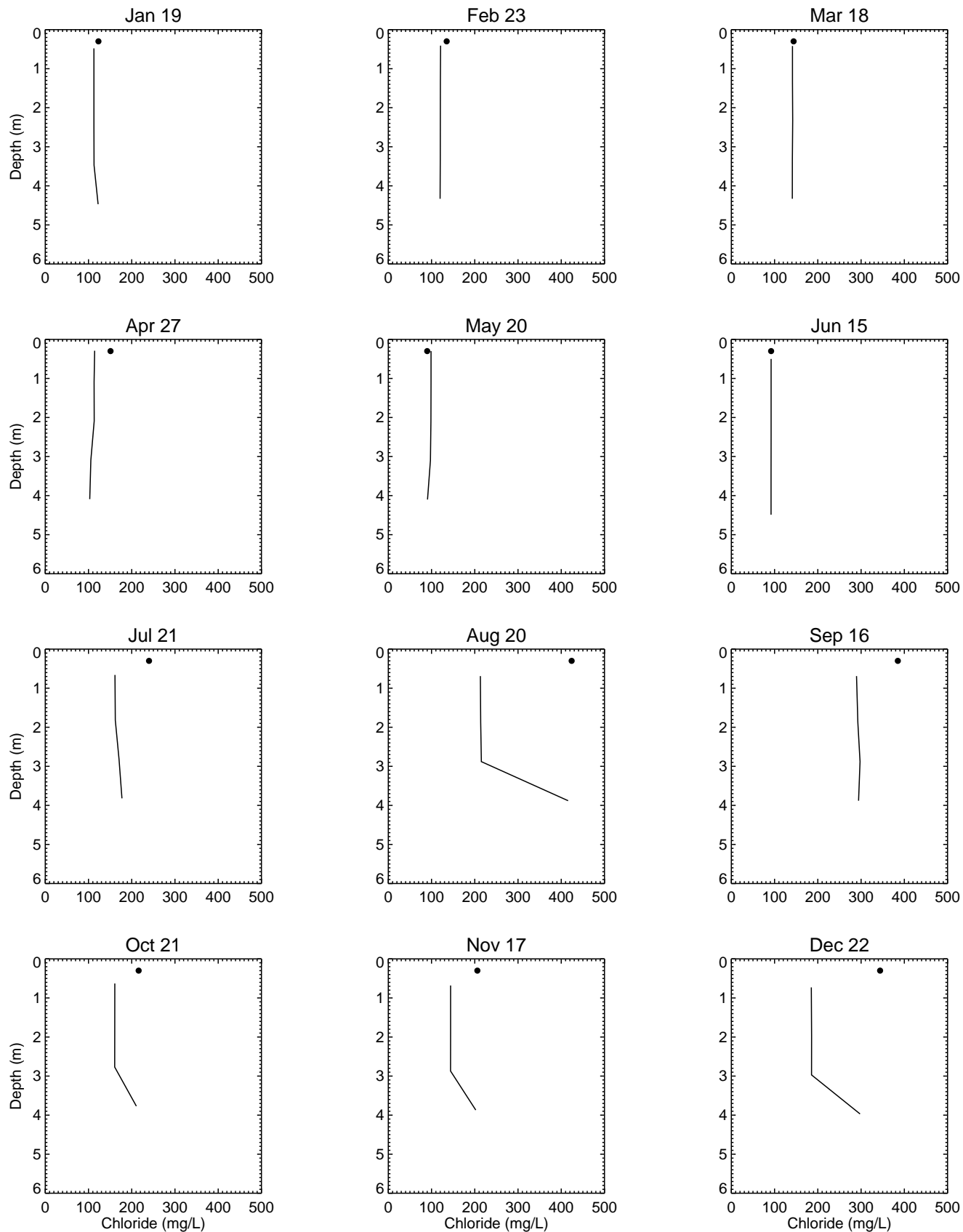
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:41 2013

Model (w1210-48)
● Data

Figure G-14

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Specific Conductance - 2011

Profiles shown for dates with available data else model results for first day of month shown.

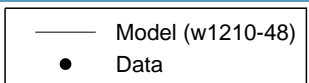CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 1984

Profiles shown for dates with available data else model results for first day of month shown.
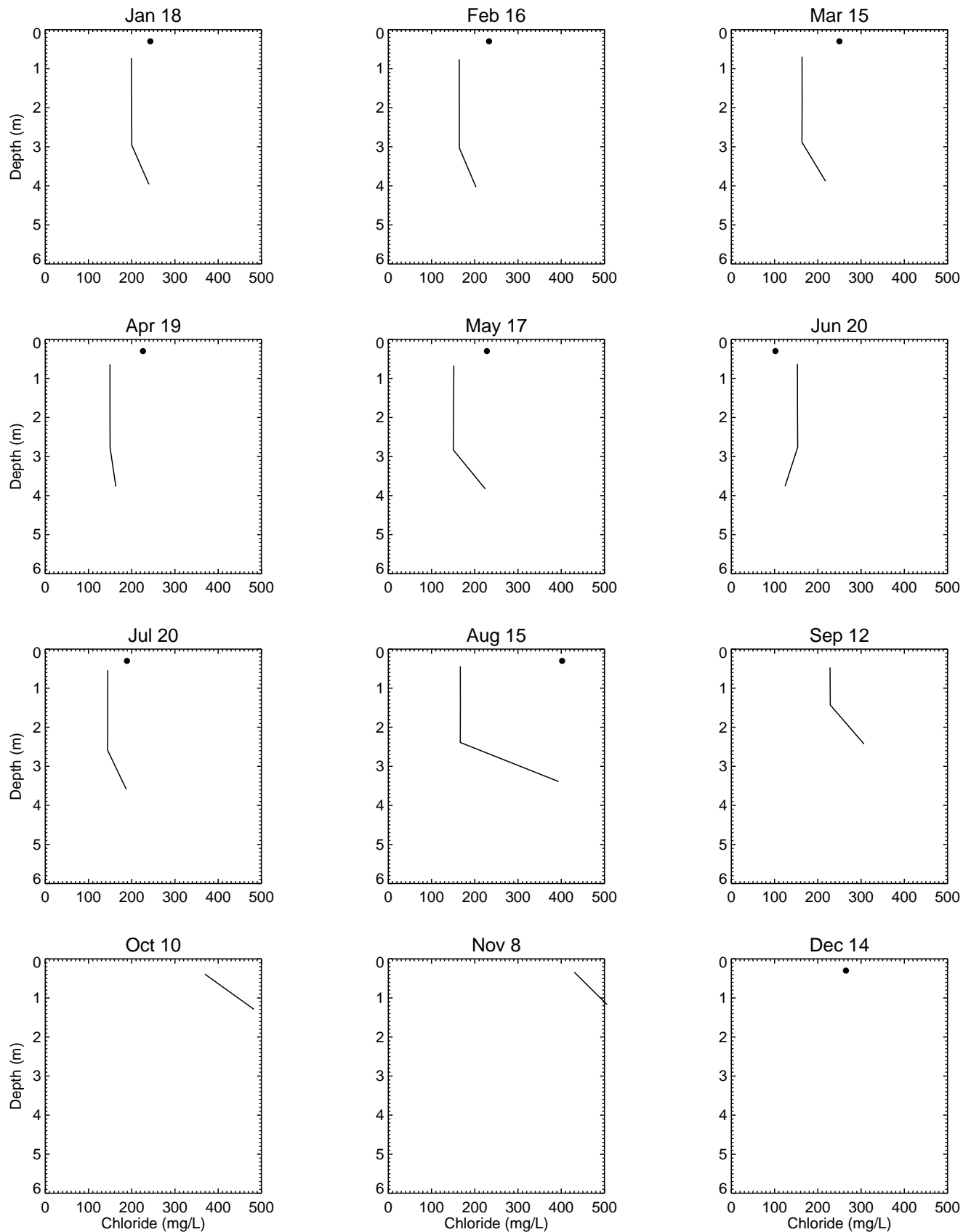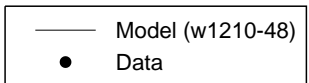
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 23   Feb 20   Mar 20

Apr 24   May 23   Jun 19

Jul 1   Aug 13, 28   Sep 25

Oct 23   Nov 21   Dec 17

Chloride (mg/L)
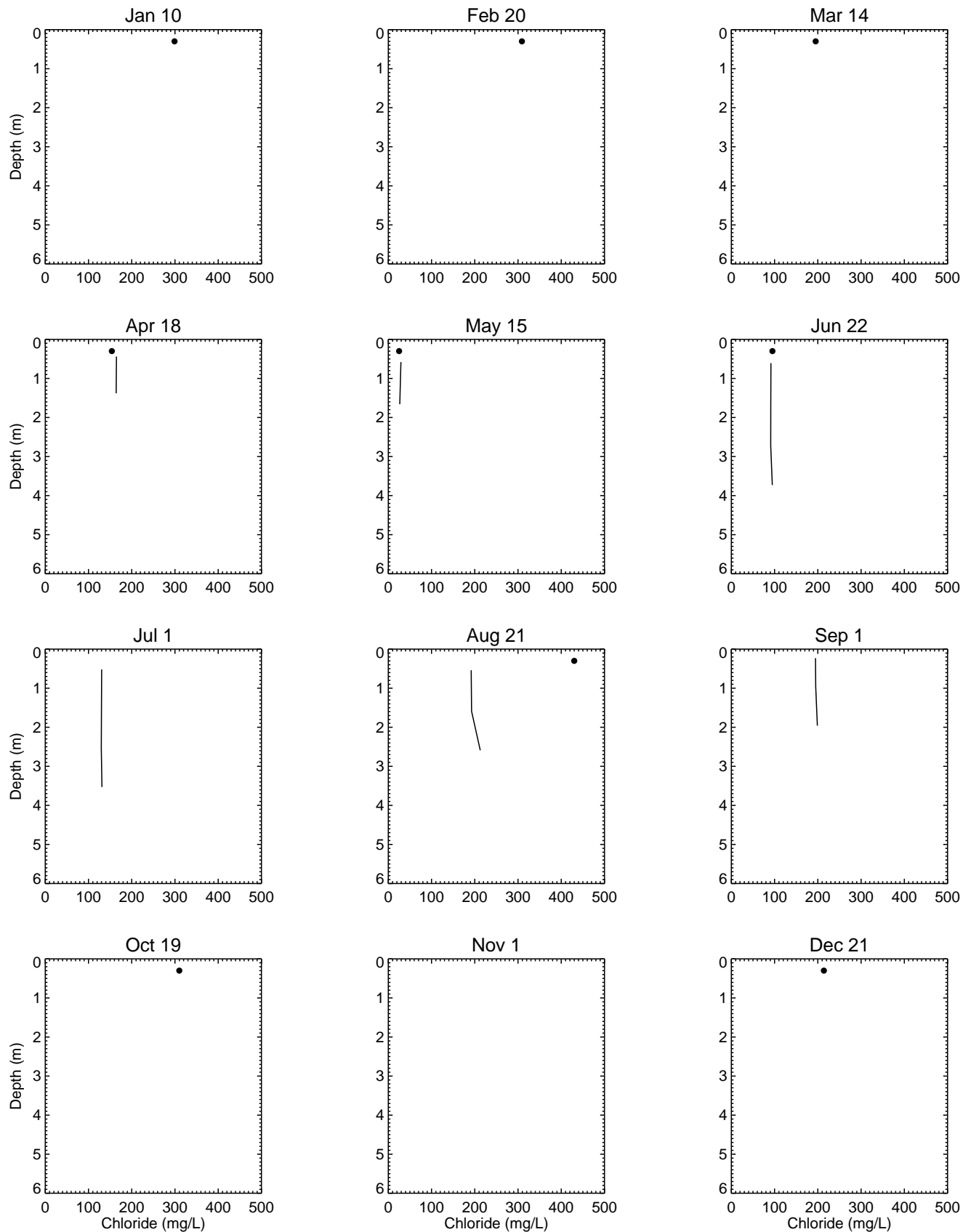
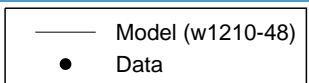——— Model (w1210-48)
●   Data

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 1985

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:57 2013

Jan 23 · Feb 19 · Mar 24 · Apr 15 · May 21 · Jun 18 · Jul 23 · Aug 20 · Sep 25 · Oct 21 · Nov 17 · Dec 17

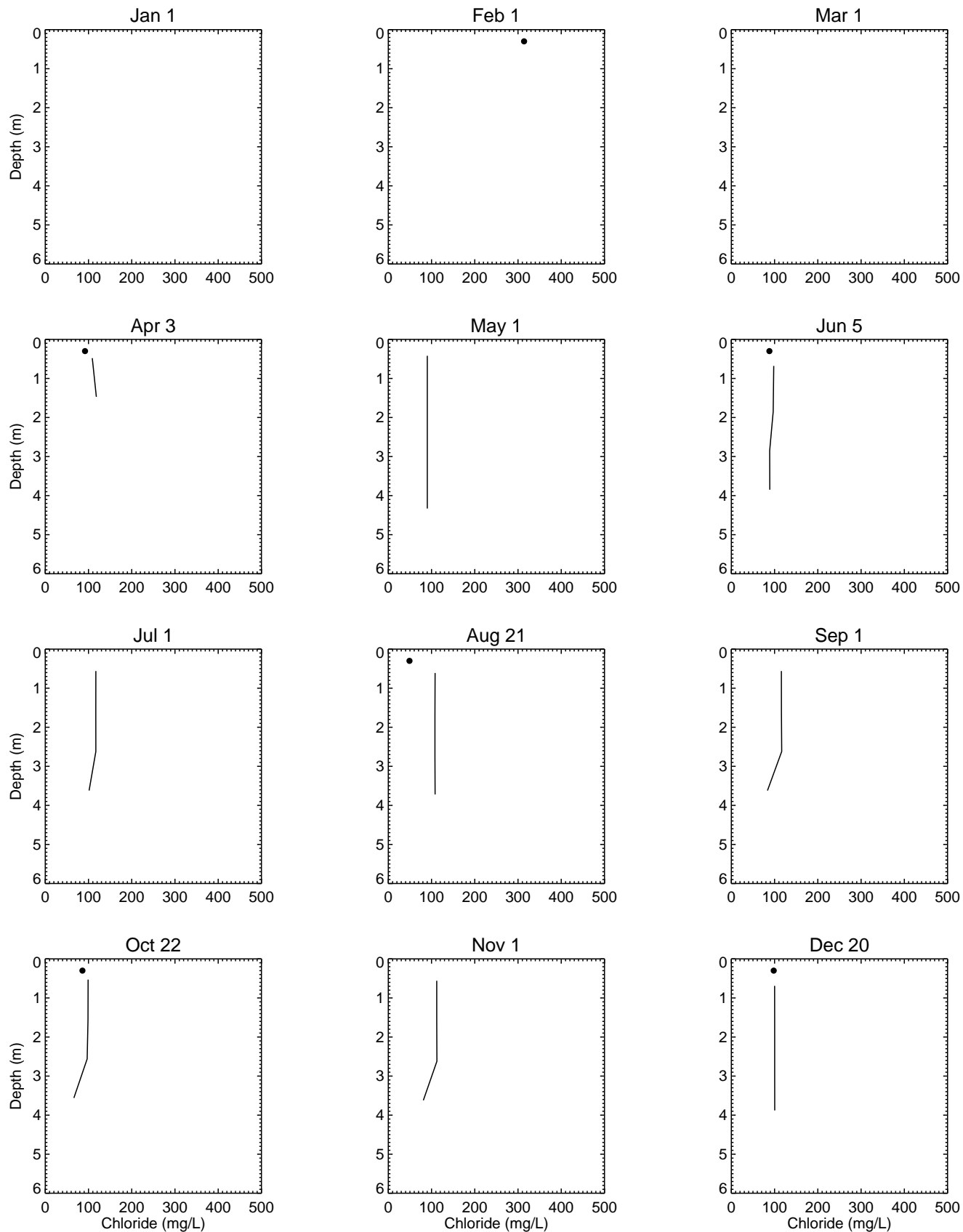Depth (m) · Chloride (mg/L)

Model (w1210-48)
● Data

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 1986

Profiles shown for dates with available data else model results for first day of month shown.
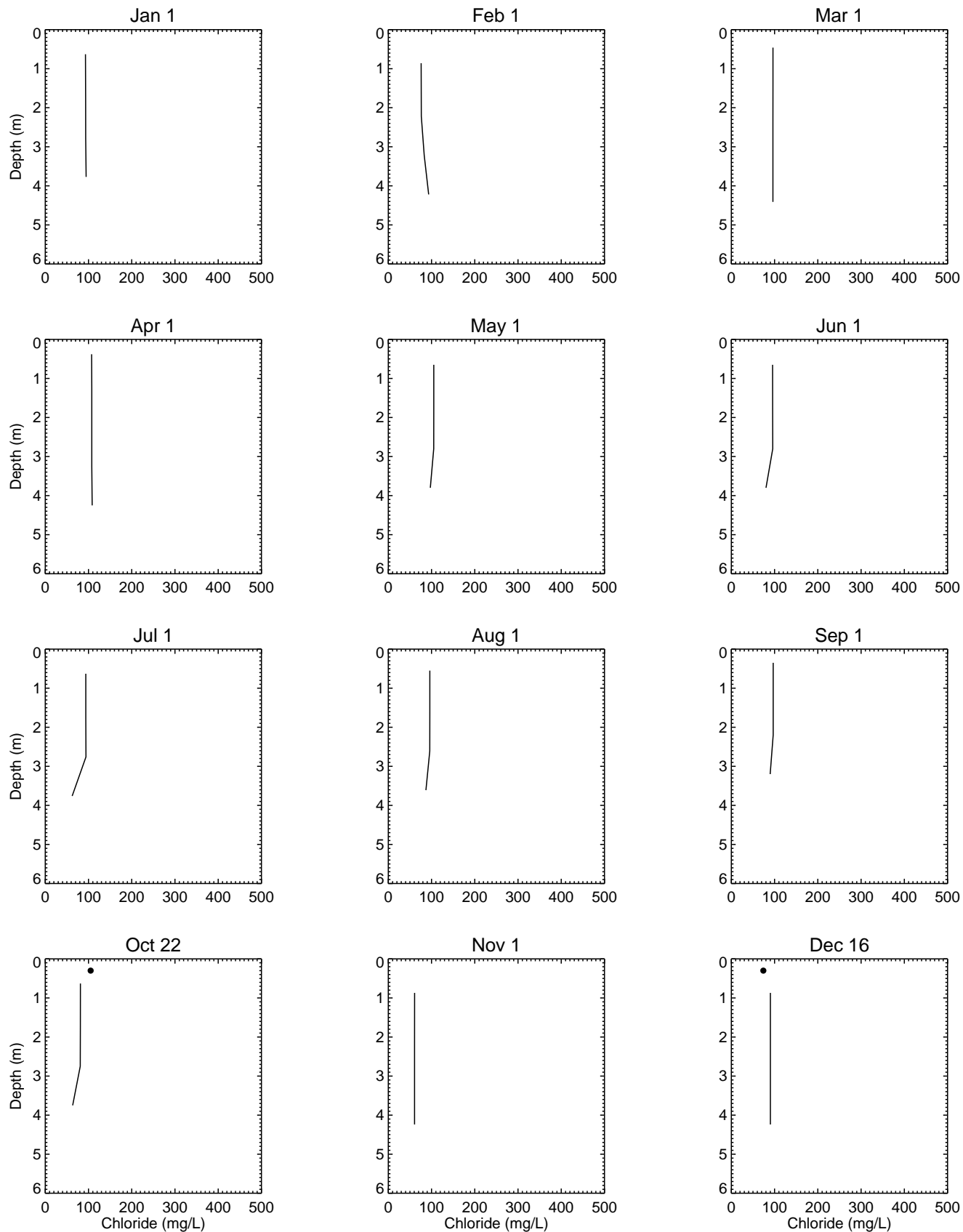
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:57 2013

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 1987

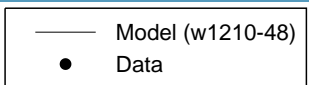*Profiles shown for dates with available data else model results for first day of month shown.*
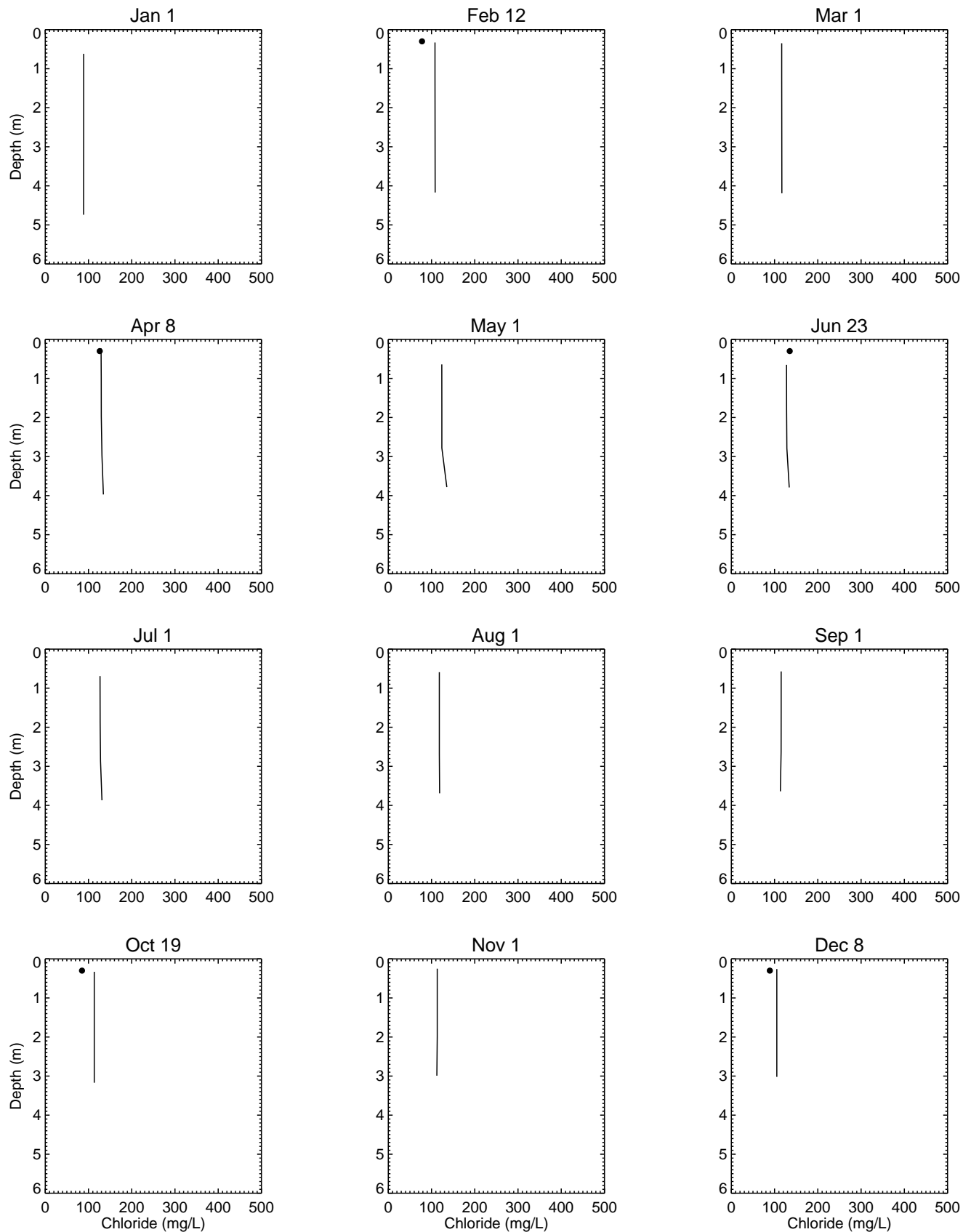
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 1988

Profiles shown for dates with available data else model results for first day of month shown.

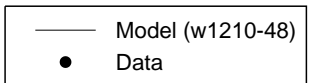CREMs Phase 4: Lake Buchanan
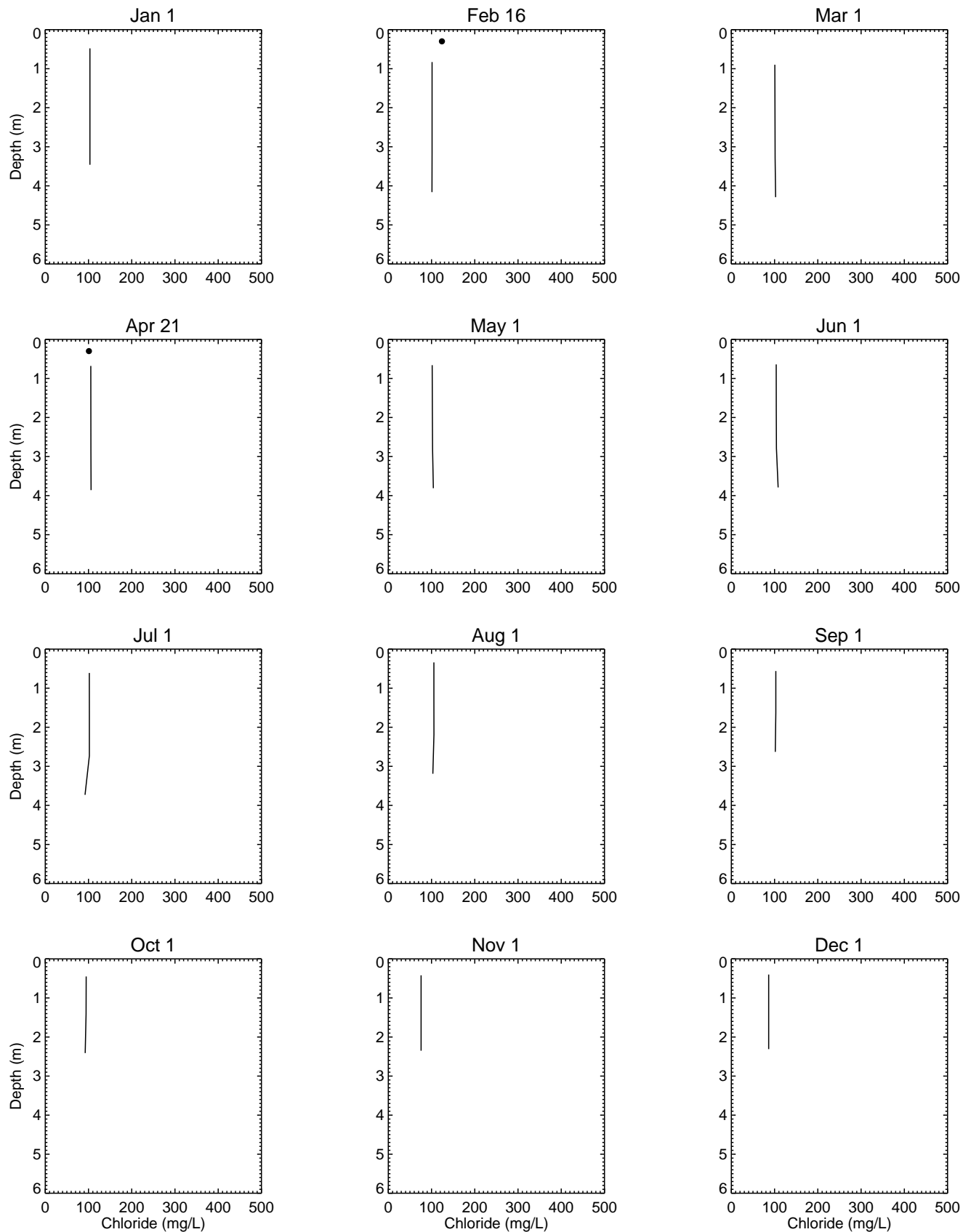
Lower Colorado River Authority

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 1989

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority
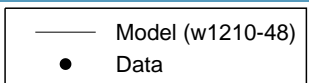
Model (w1210-48)

Data

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 1990

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
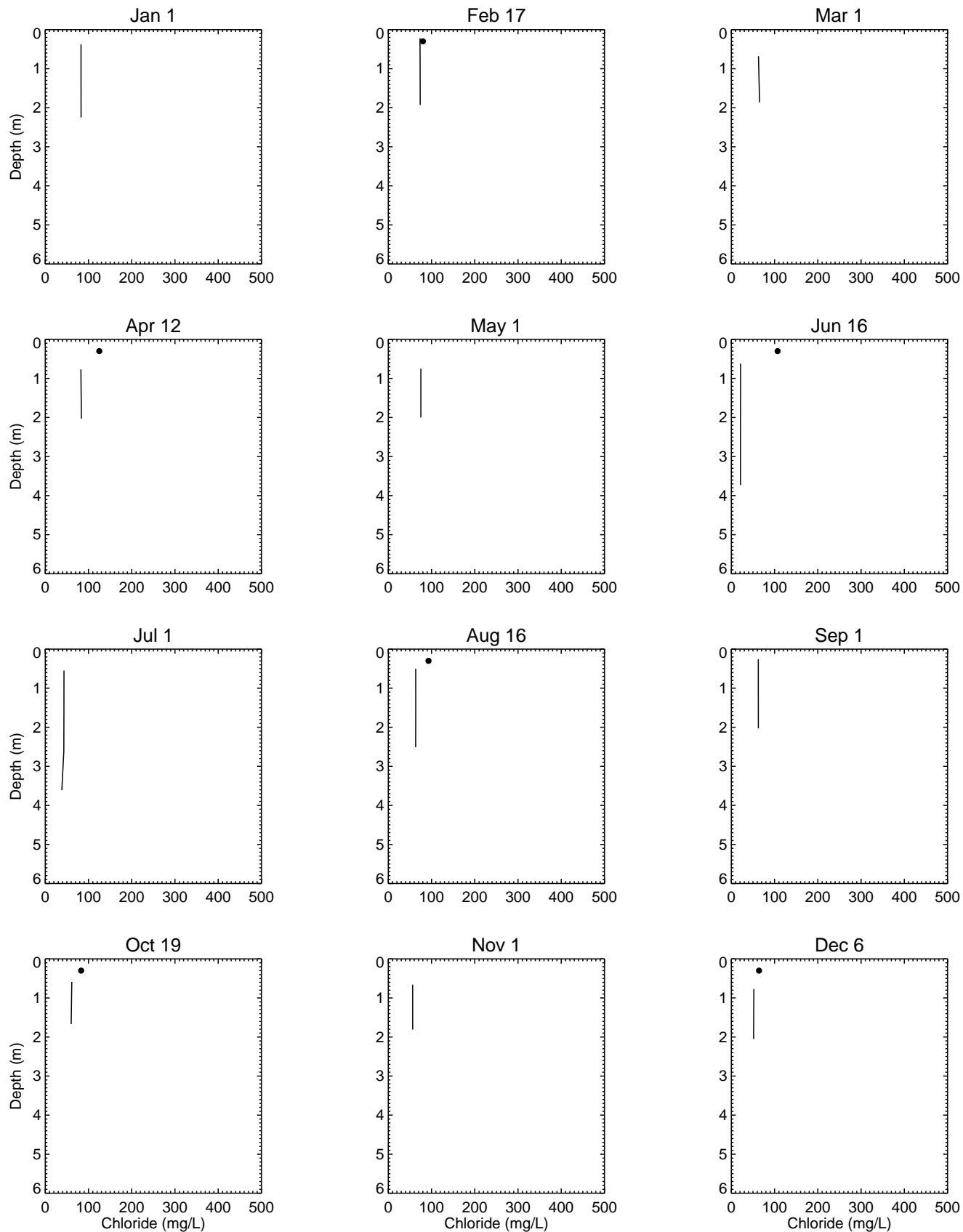
Lower Colorado River Authority

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 1991

Profiles shown for dates with available data else model results for first day of month shown.

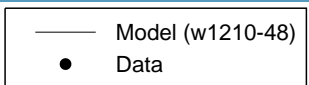CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 1992

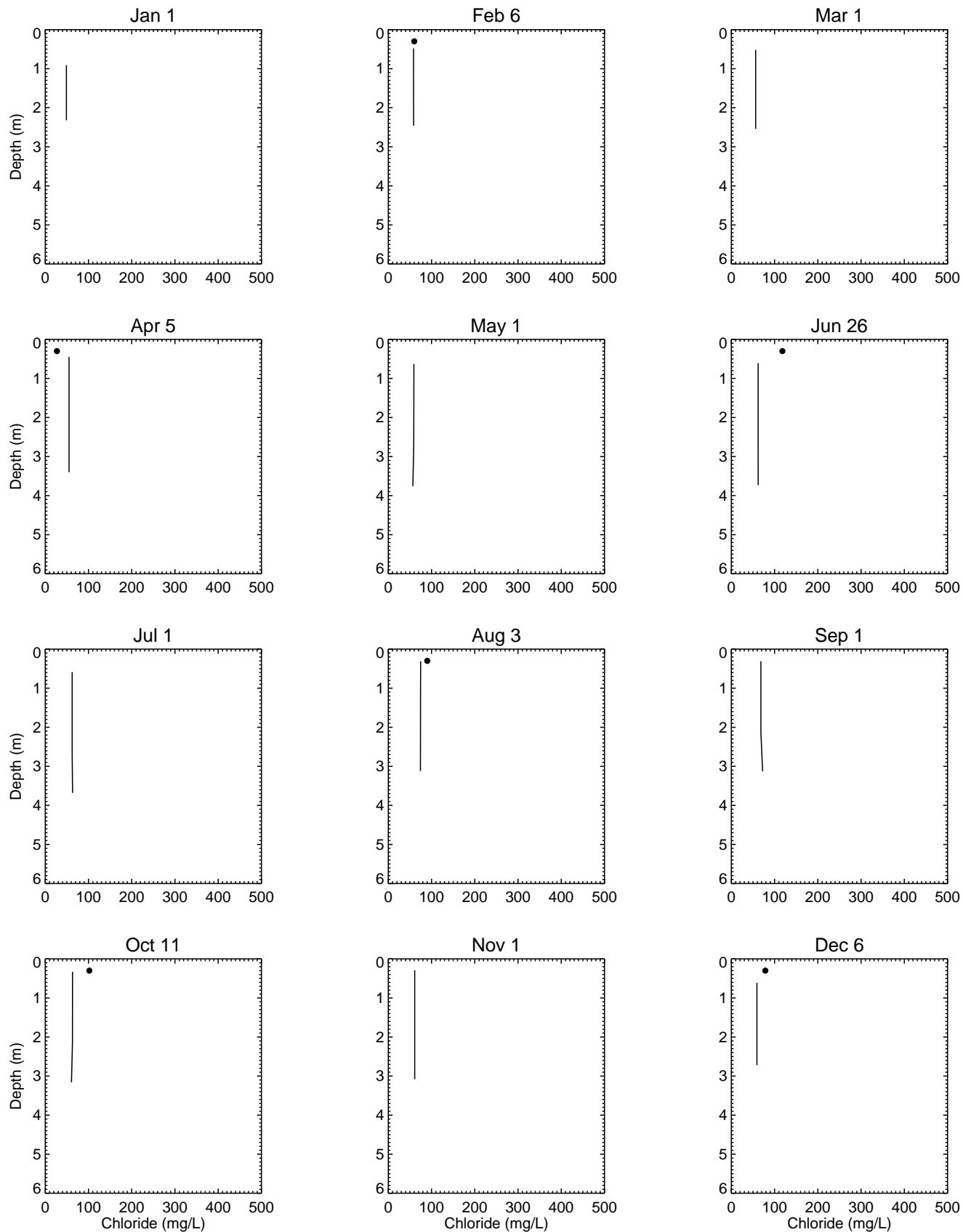*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
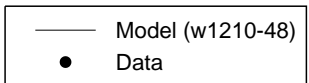
Lower Colorado River Authority

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 1993

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 — Feb 17 — Mar 1 — Apr 12 — May 1 — Jun 16 — Jul 1 — Aug 16 — Sep 1 — Oct 19 — Nov 1 — Dec 6

Depth (m)

Chloride (mg/L)

Model (w1210-48)
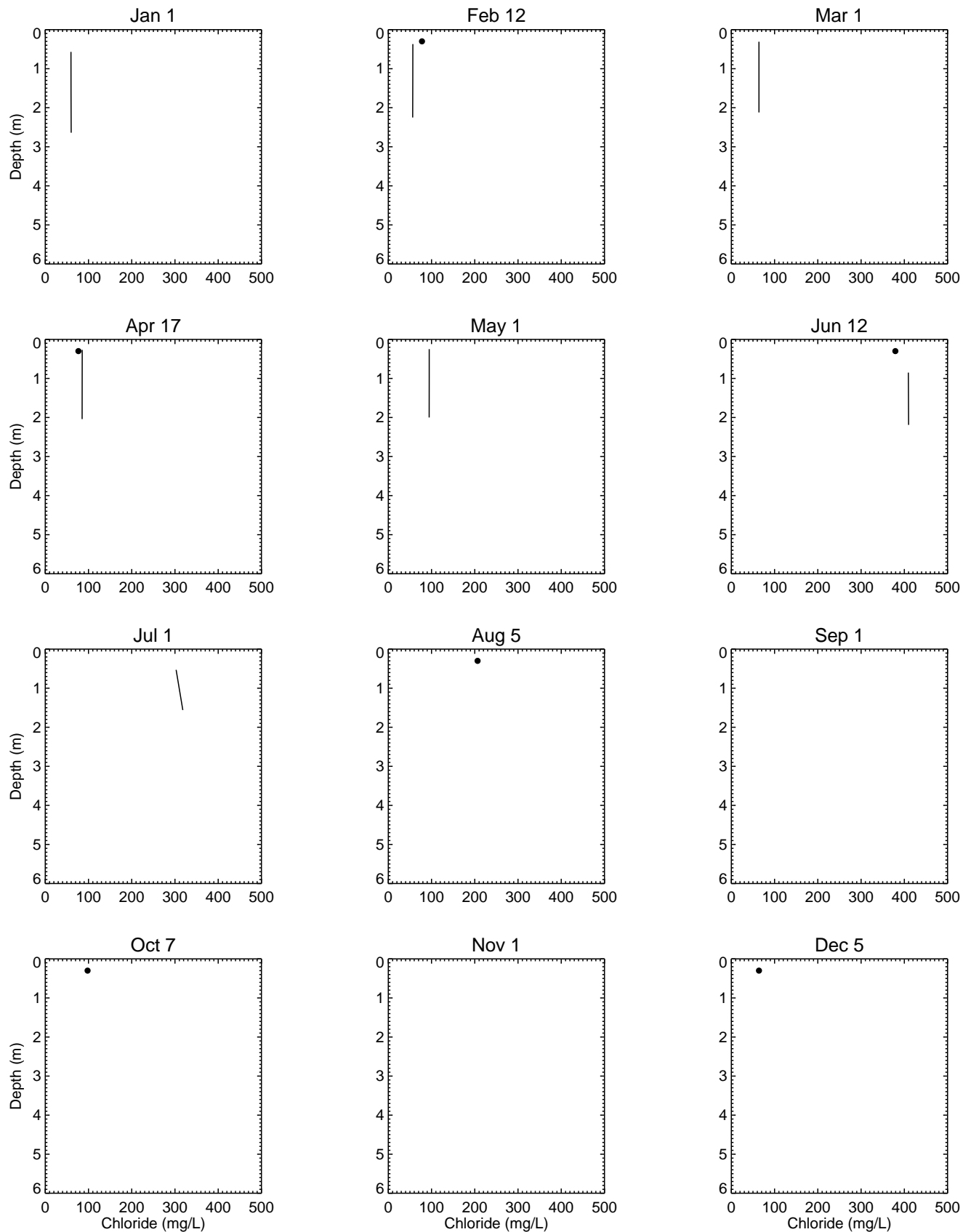● Data

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 1994

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 1995

Profiles shown for dates with available data else model results for first day of month shown.

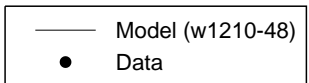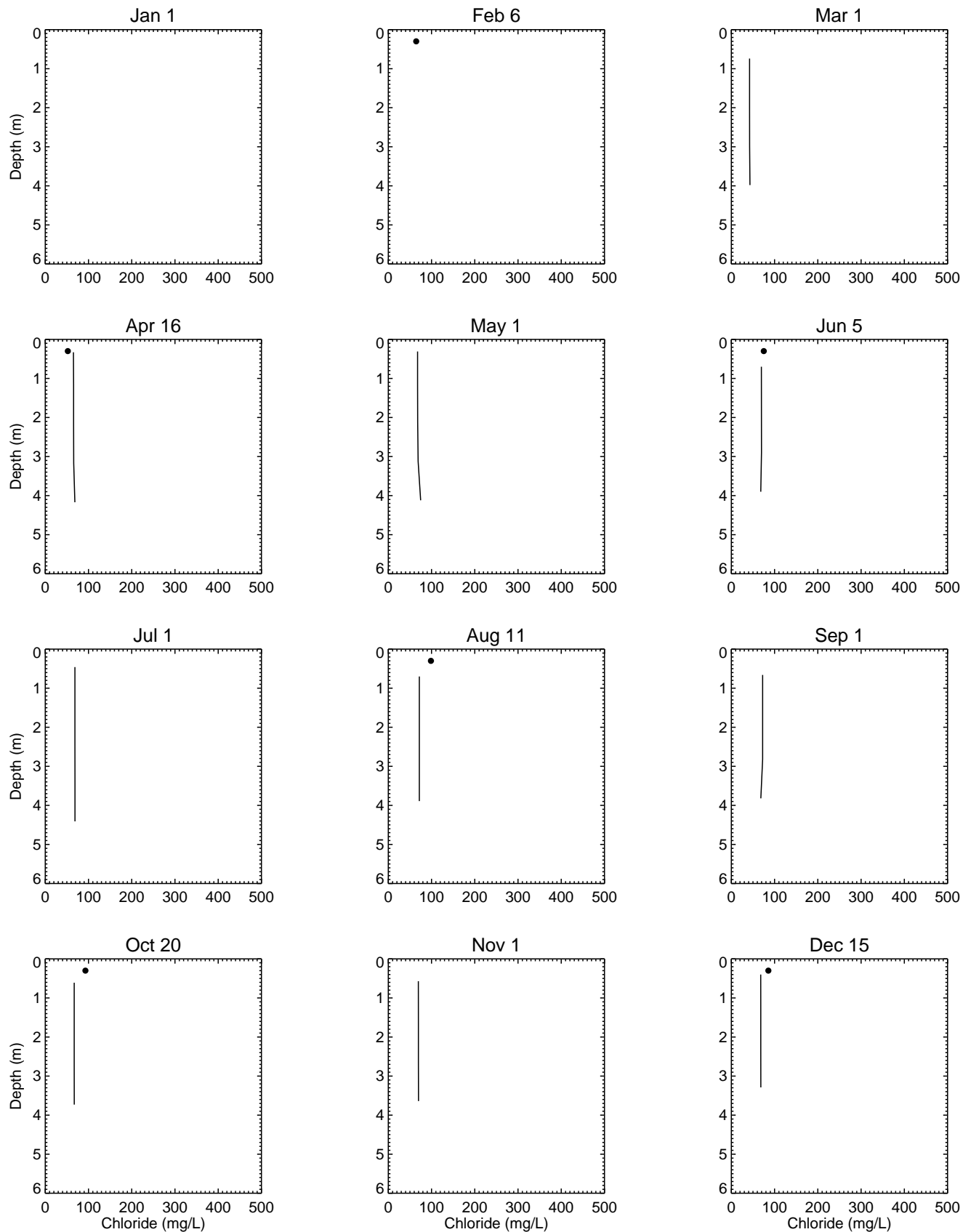CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 1996

Profiles shown for dates with available data else model results for first day of month shown.
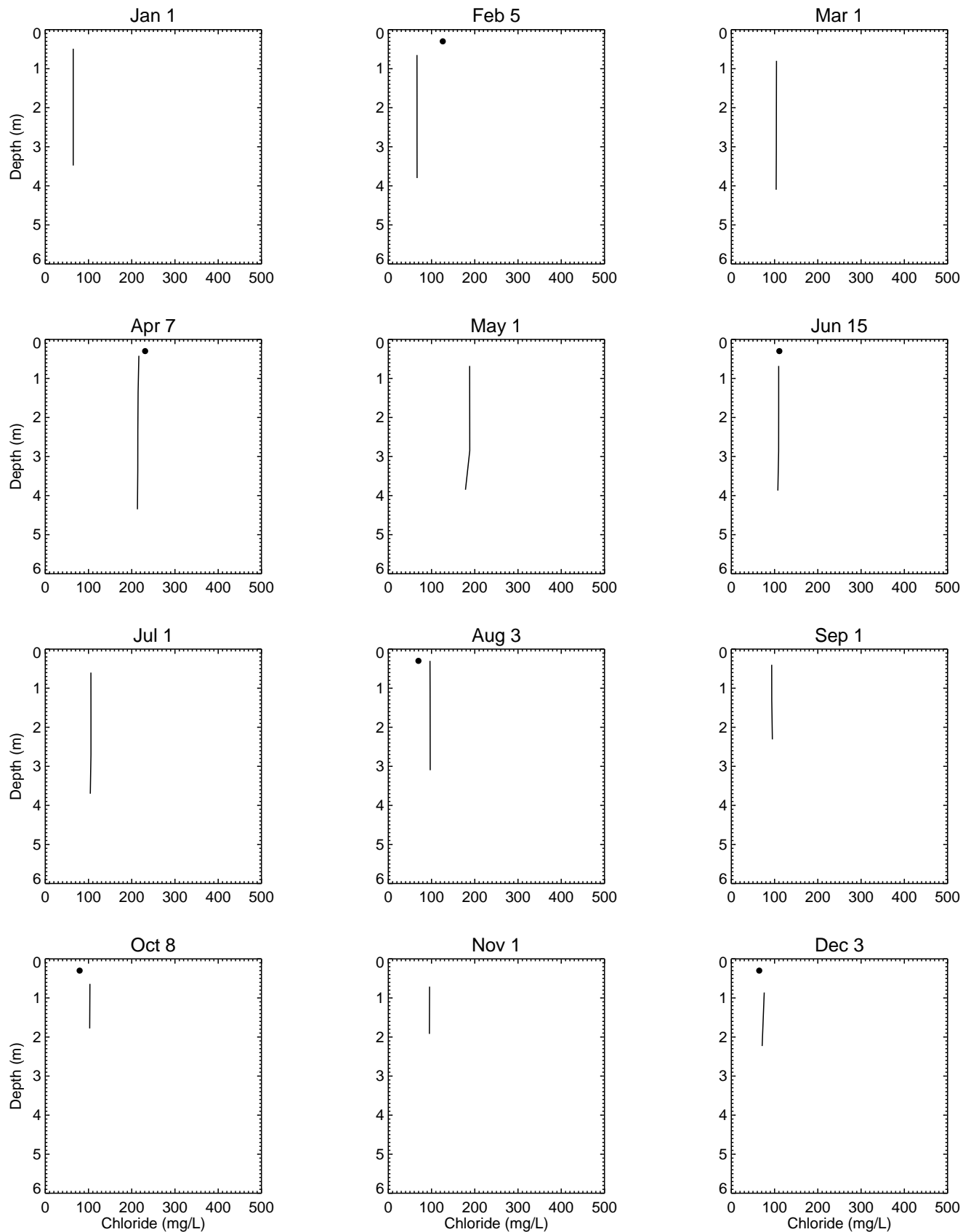
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 1997

Profiles shown for dates with available data else model results for first day of month shown.
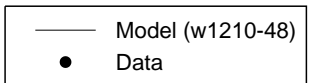
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:57 2013

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 1998

Profiles shown for dates with available data else model results for first day of month shown.
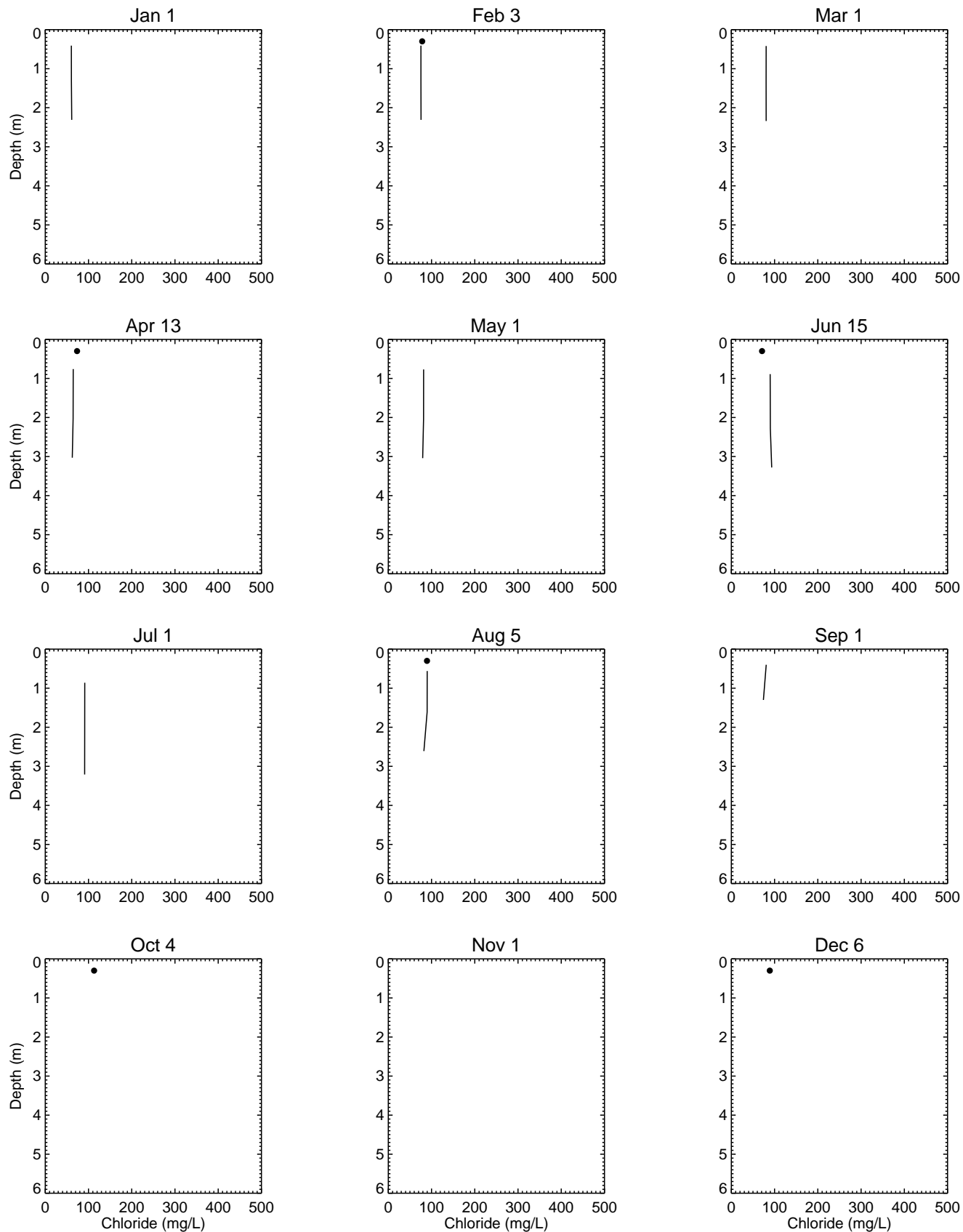
CREMs Phase 4: Lake Buchanan

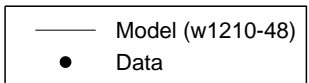Lower Colorado River Authority

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 1999

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
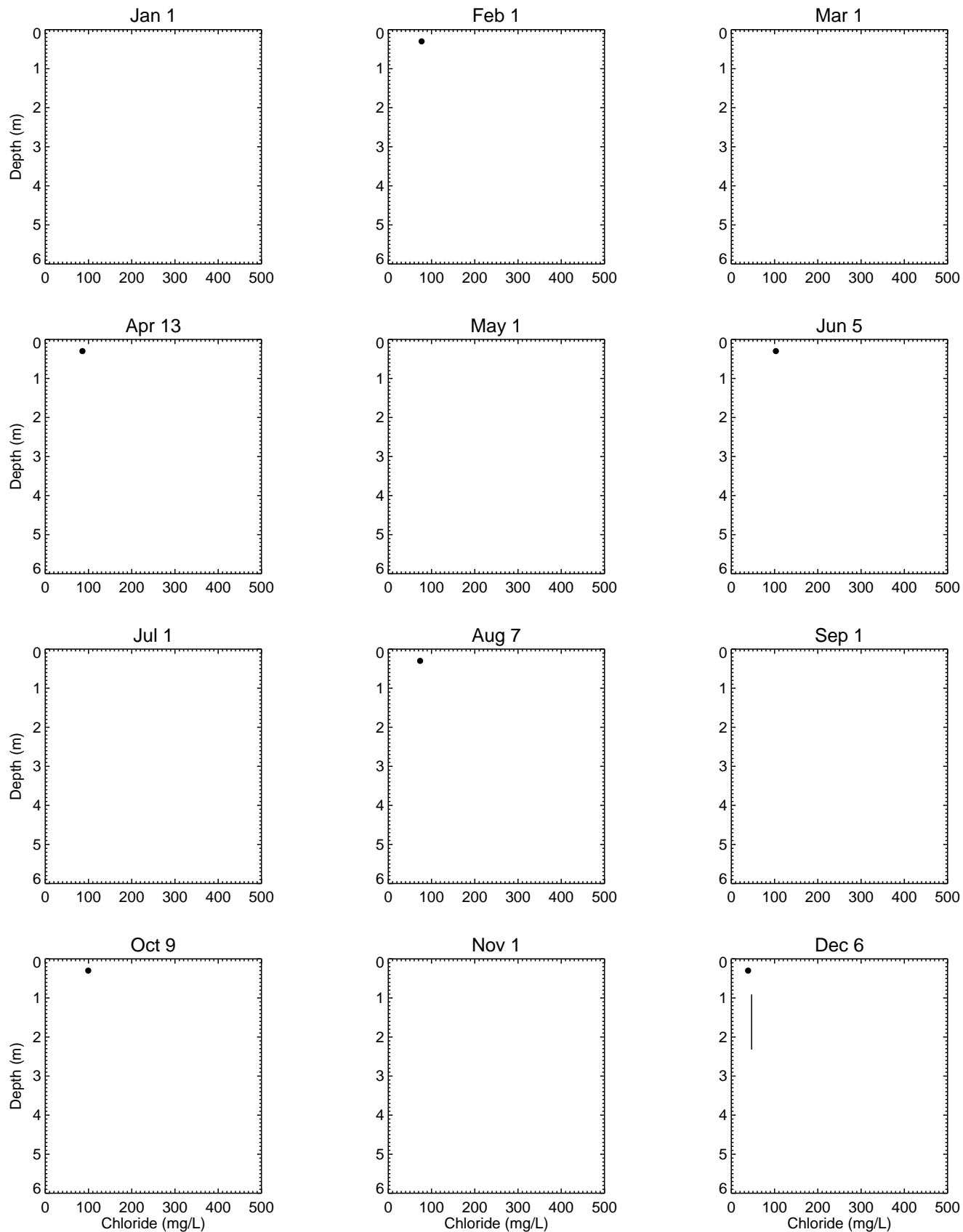Lower Colorado River Authority

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 2000

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
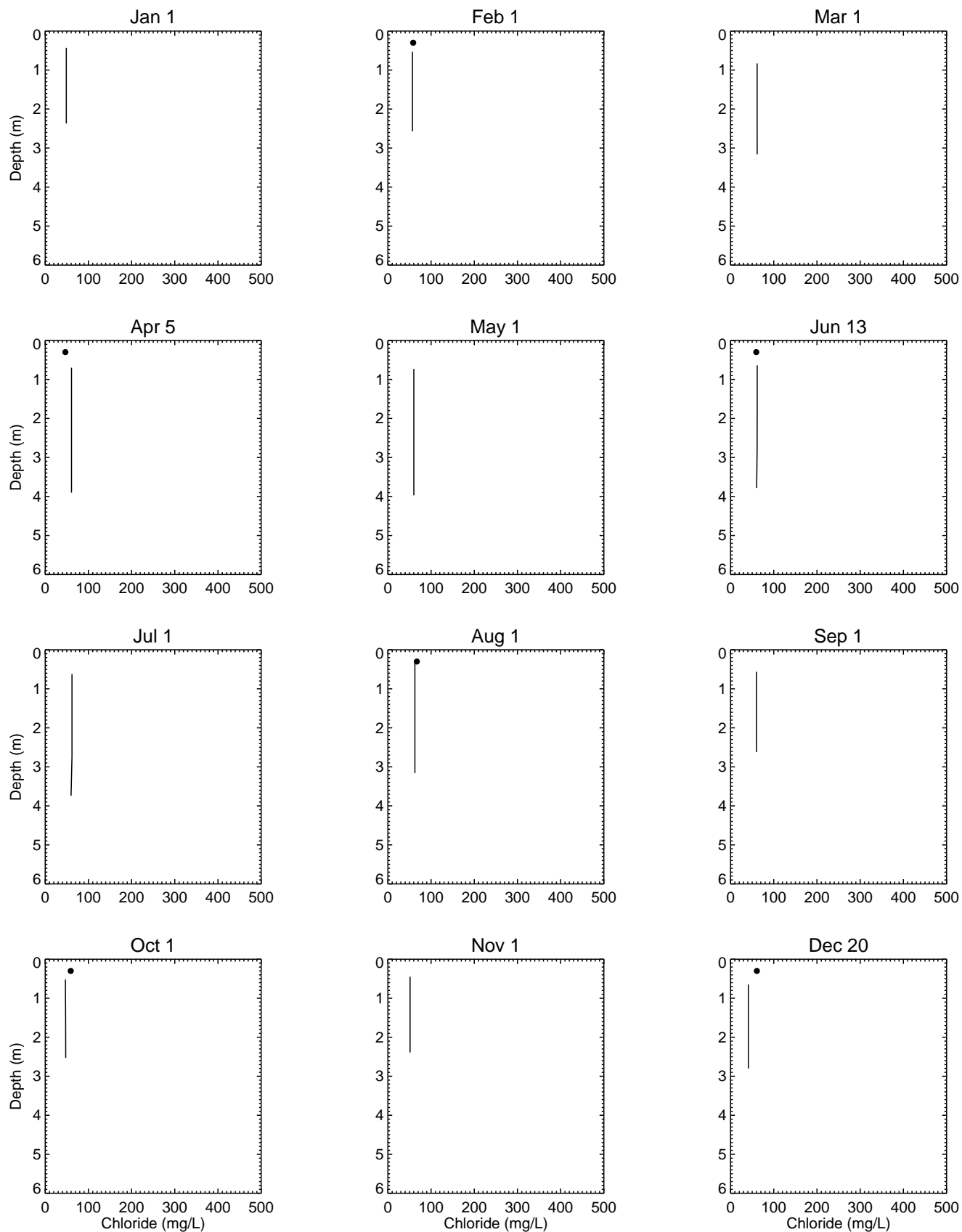Fri Jan 25 18:13:57 2013

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 2001

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
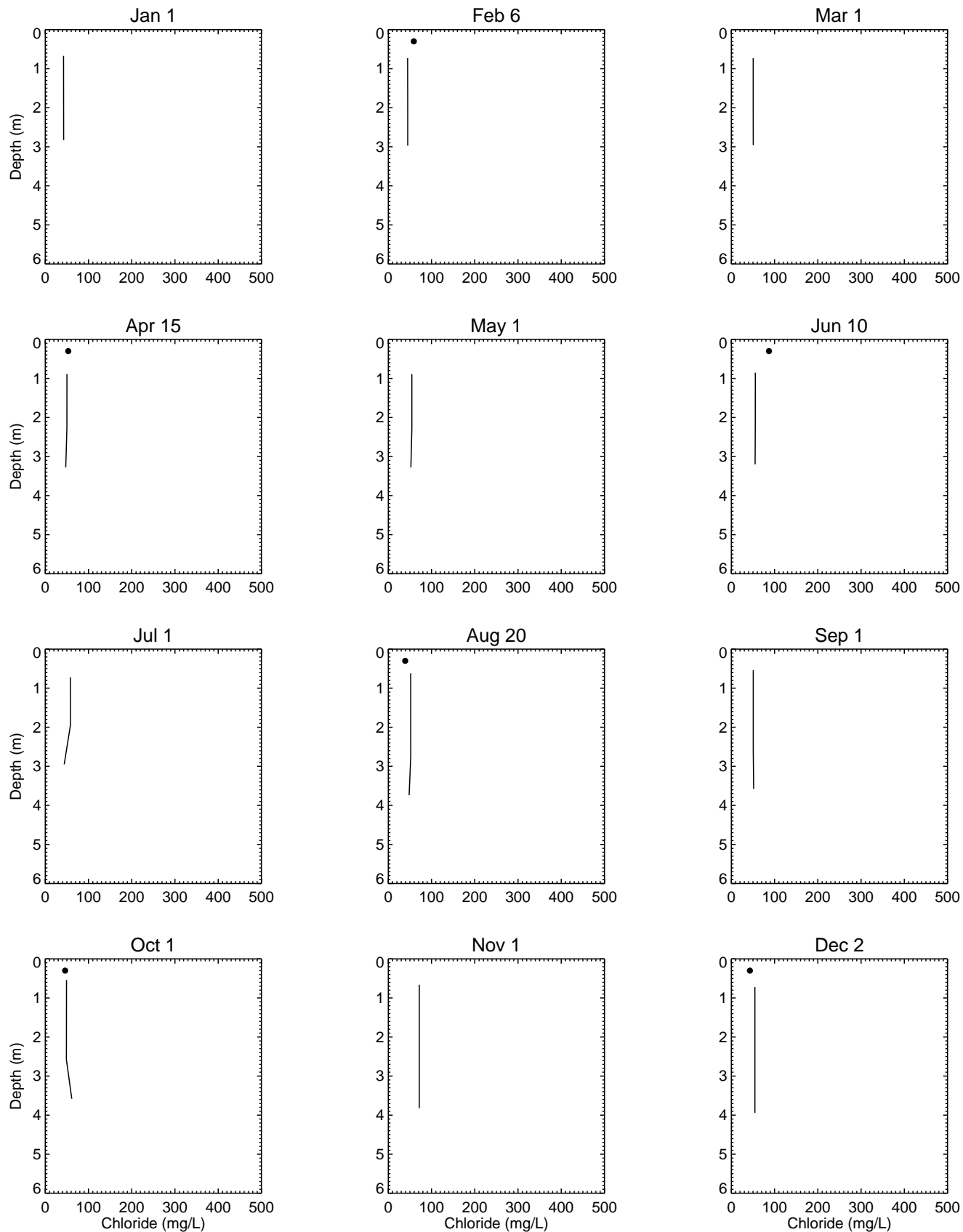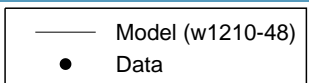Fri Jan 25 18:13:57 2013

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 2002

Profiles shown for dates with available data else model results for first day of month shown.

Model (w1210-48)
● Data

CREMs Phase 4: Lake Buchanan
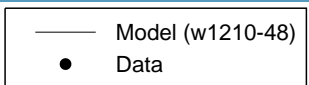Lower Colorado River Authority

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 2003

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

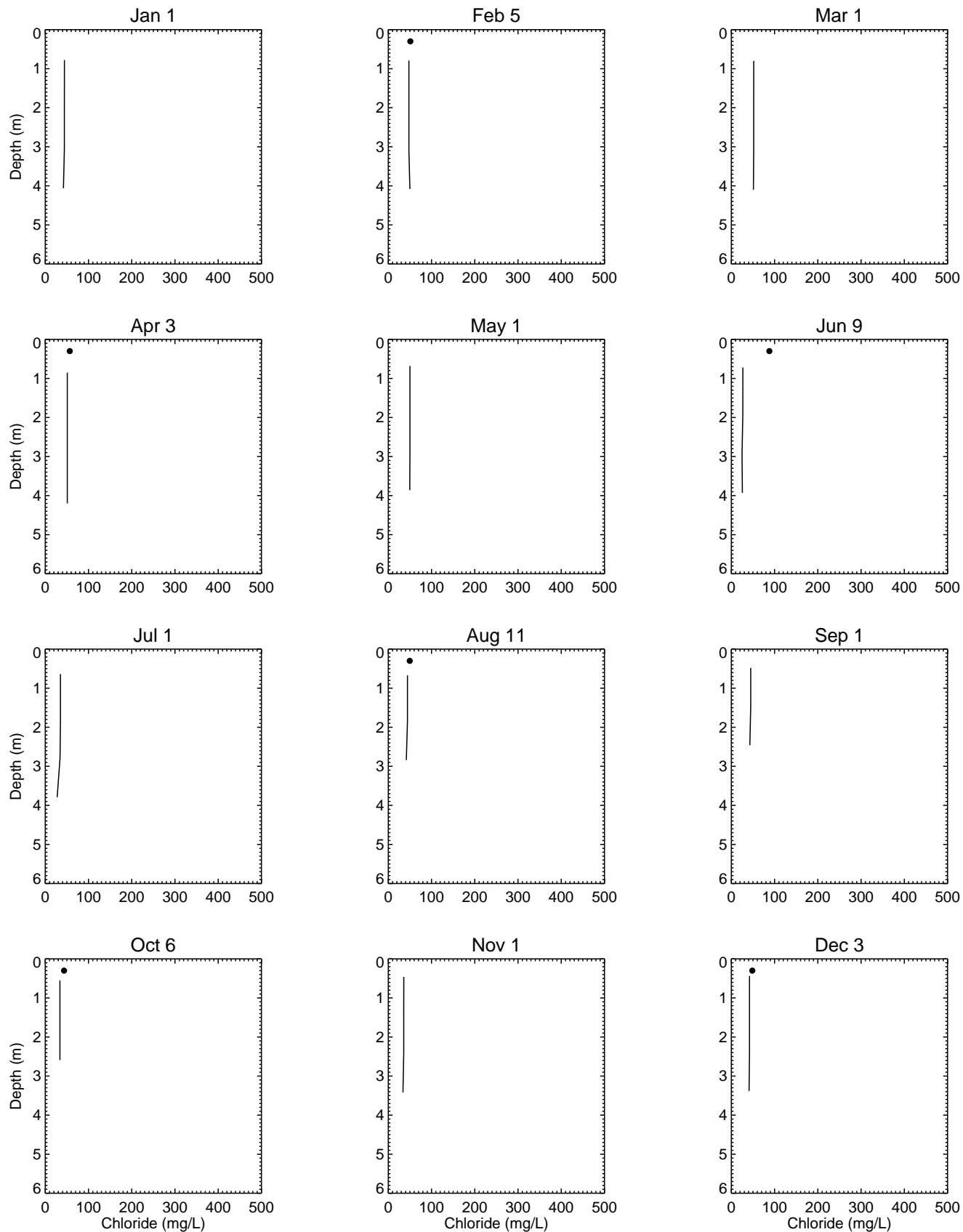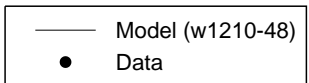Lower Colorado River Authority

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 2004

Profiles shown for dates with available data else model results for first day of month shown.

Legend:
— Model (w1210-48)
● Data

CREMs Phase 4: Lake Buchanan
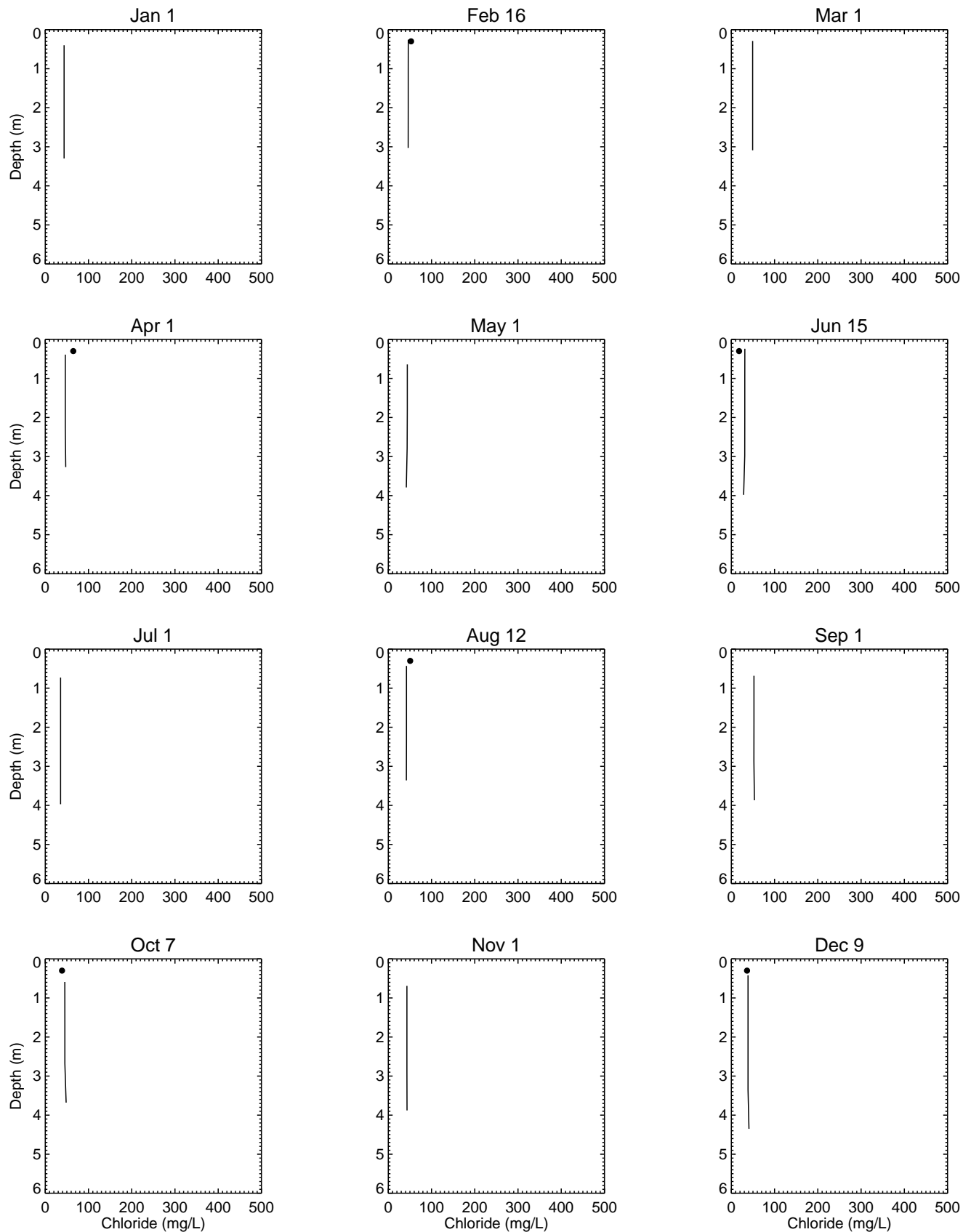
Lower Colorado River Authority

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 2005

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 7 · Mar 1 · Apr 11 · May 1 · Jun 1 · Jul 1 · Aug 8 · Sep 1 · Oct 11 · Nov 1 · Dec 13

Depth (m) vs Chloride (mg/L)

—— Model (w1210-48)
● Data

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 2006

Profiles shown for dates with available data else model results for first day of month shown.

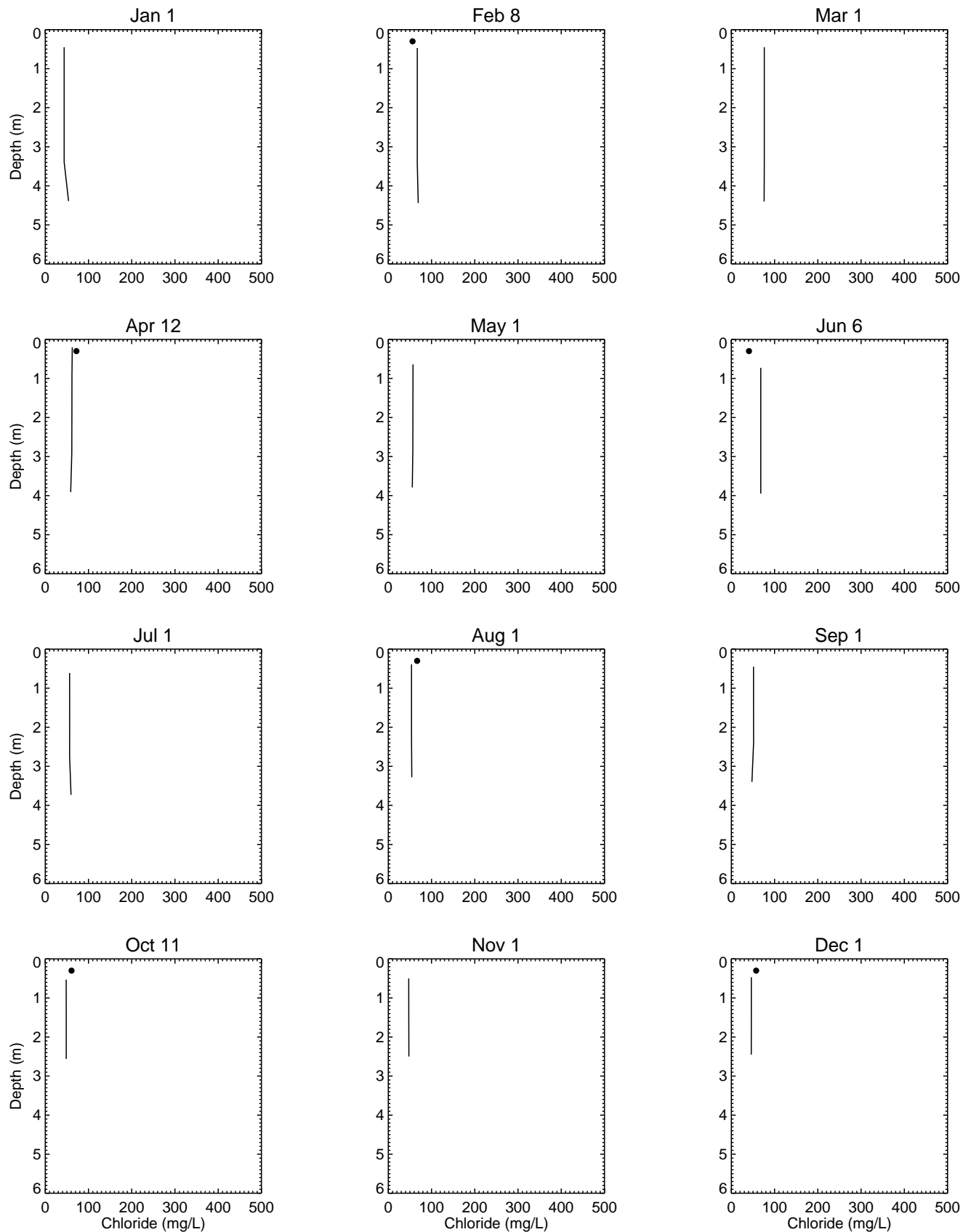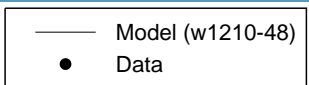CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:57 2013

ANCHOR QEA
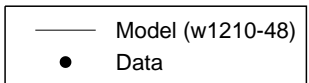PARSONS

Model (w1210-48)
● Data

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 2007

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Model (w1210-48)
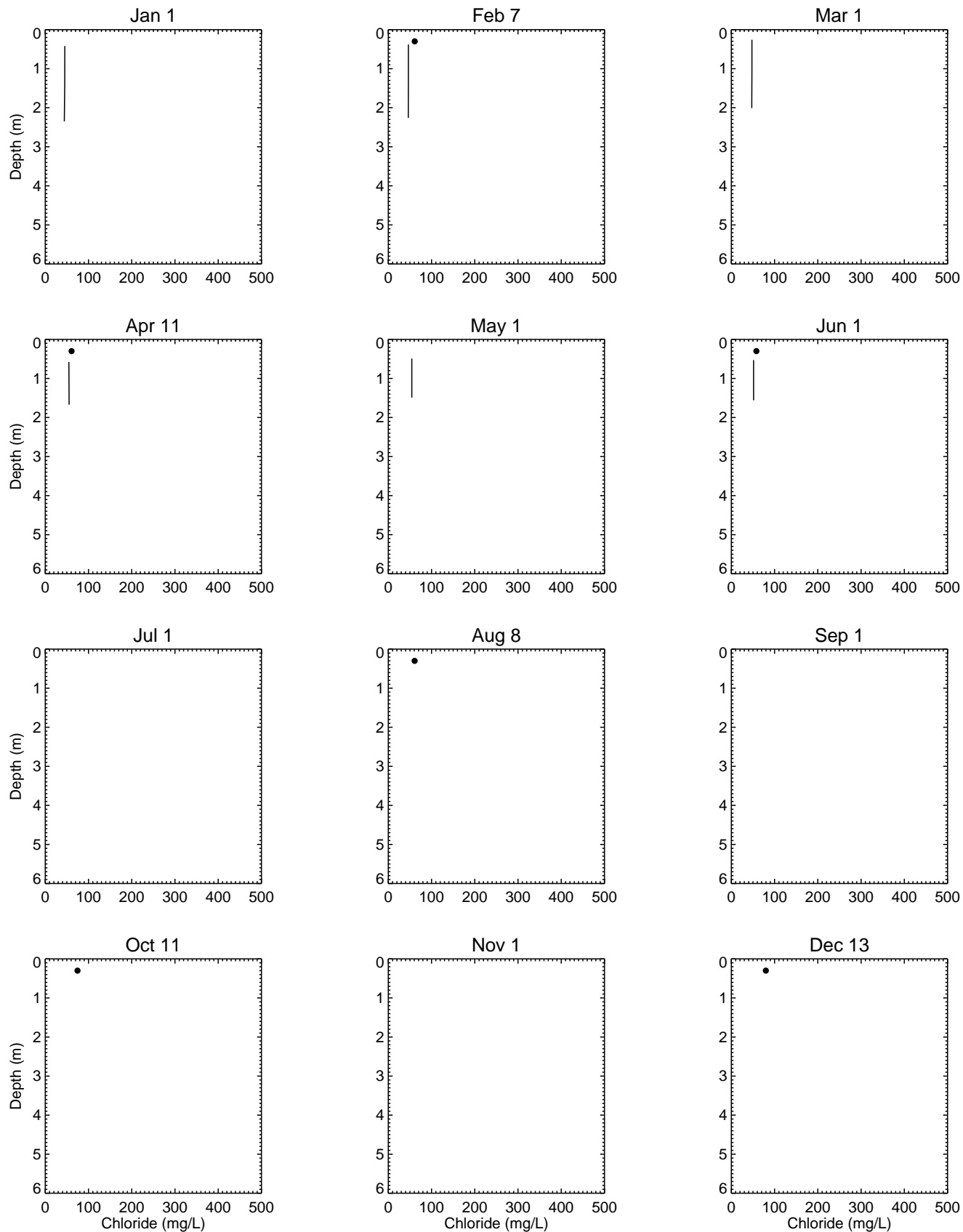● Data

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 2008

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
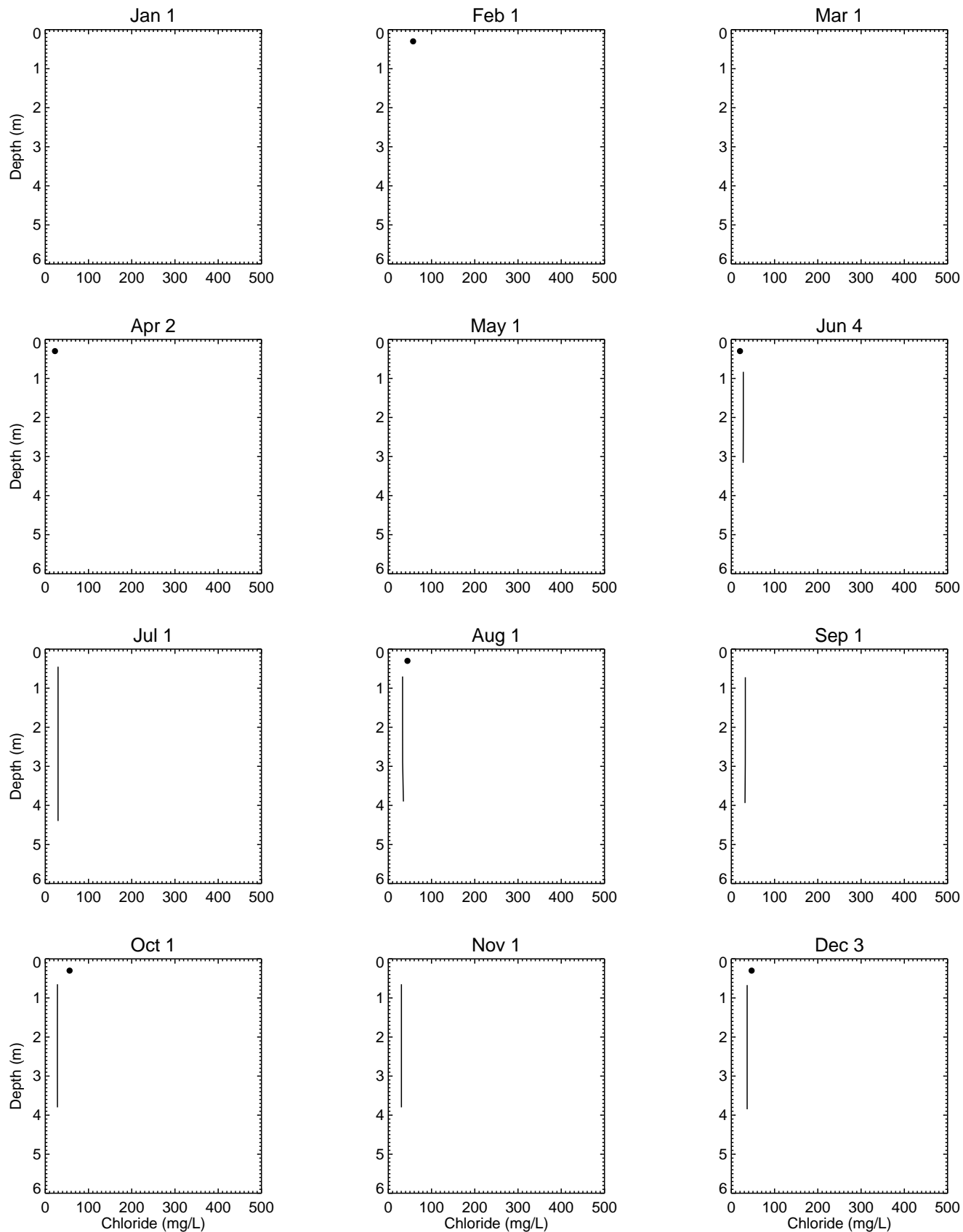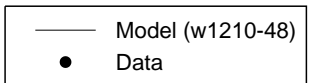Lower Colorado River Authority

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 2009

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Jan 1

Feb 18

Mar 1

Depth (m)

0
1
2
3
4
5
6

0 100 200 300 400 500

0 100 200 300 400 500

0 100 200 300 400 500

Apr 5

May 1

Jun 3

Depth (m)

Jul 1

Aug 2, 5

Sep 2

Depth (m)

Oct 7, 13

Nov 4

Dec 1, 2

Depth (m)

Chloride (mg/L)

Chloride (mg/L)

Chloride (mg/L)

——— Model (w1210-48)
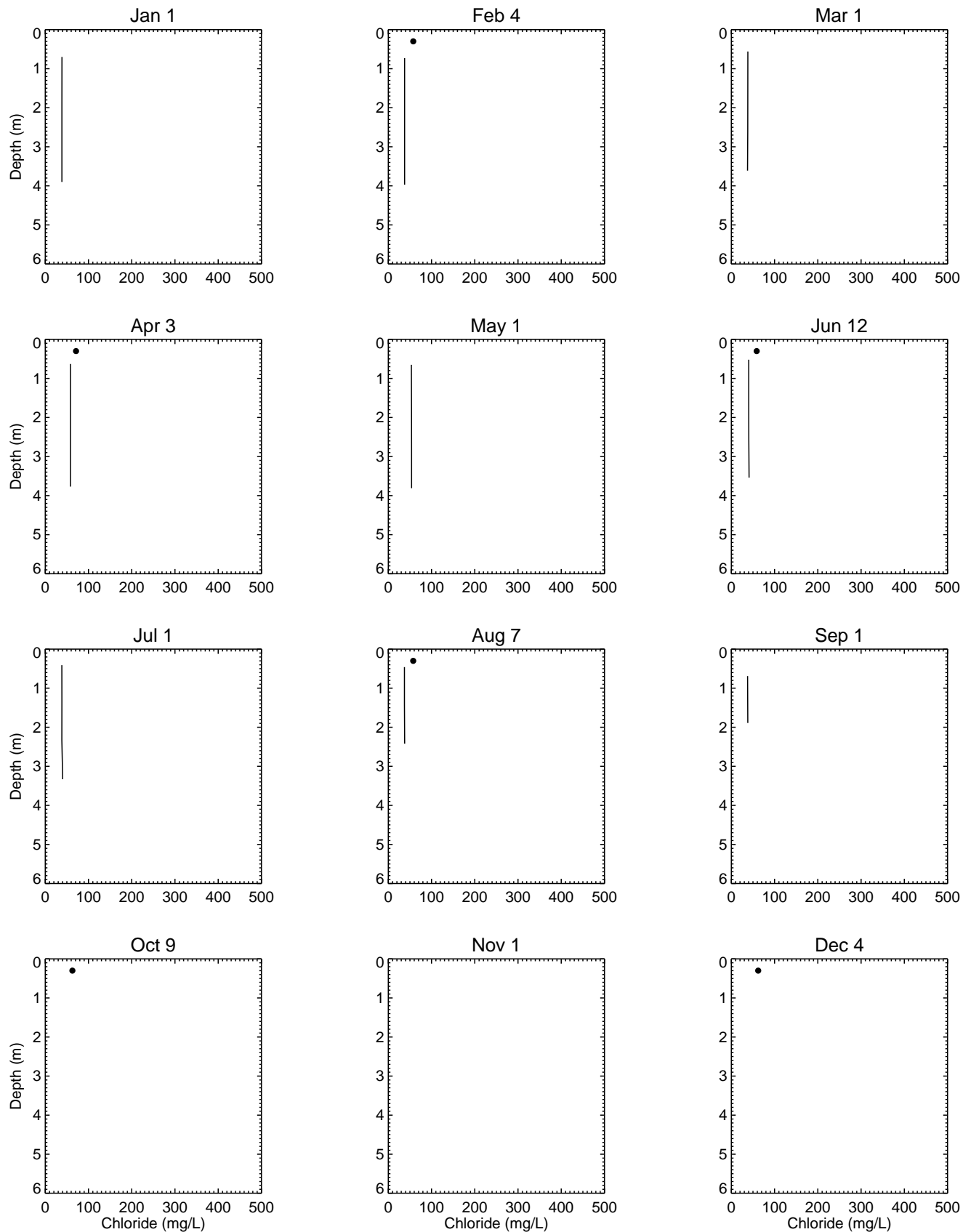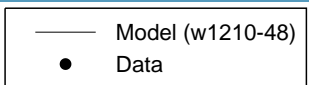
● Data

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 2010

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan
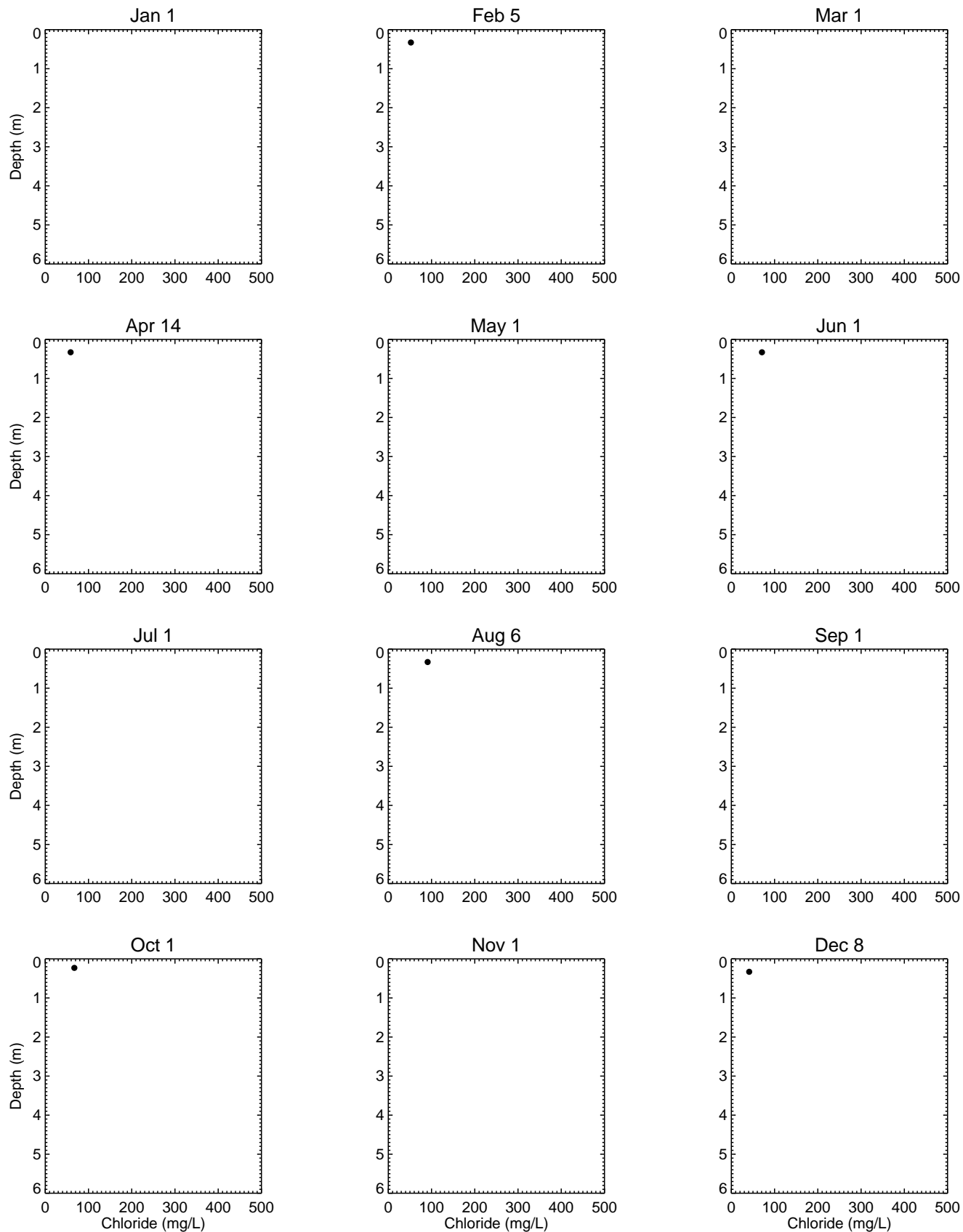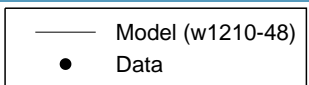
Lower Colorado River Authority

Figure G-19

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Chloride - 2011

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 25   Feb 22   Mar 21
Apr 11   May 16   Jun 12
Jul 16   Aug 22   Sep 19
Oct 17   Nov 14   Dec 19

Specific Conductance (umhos/cm)

——— Model (w1210-48)
● Data

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 1984

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
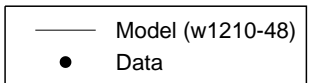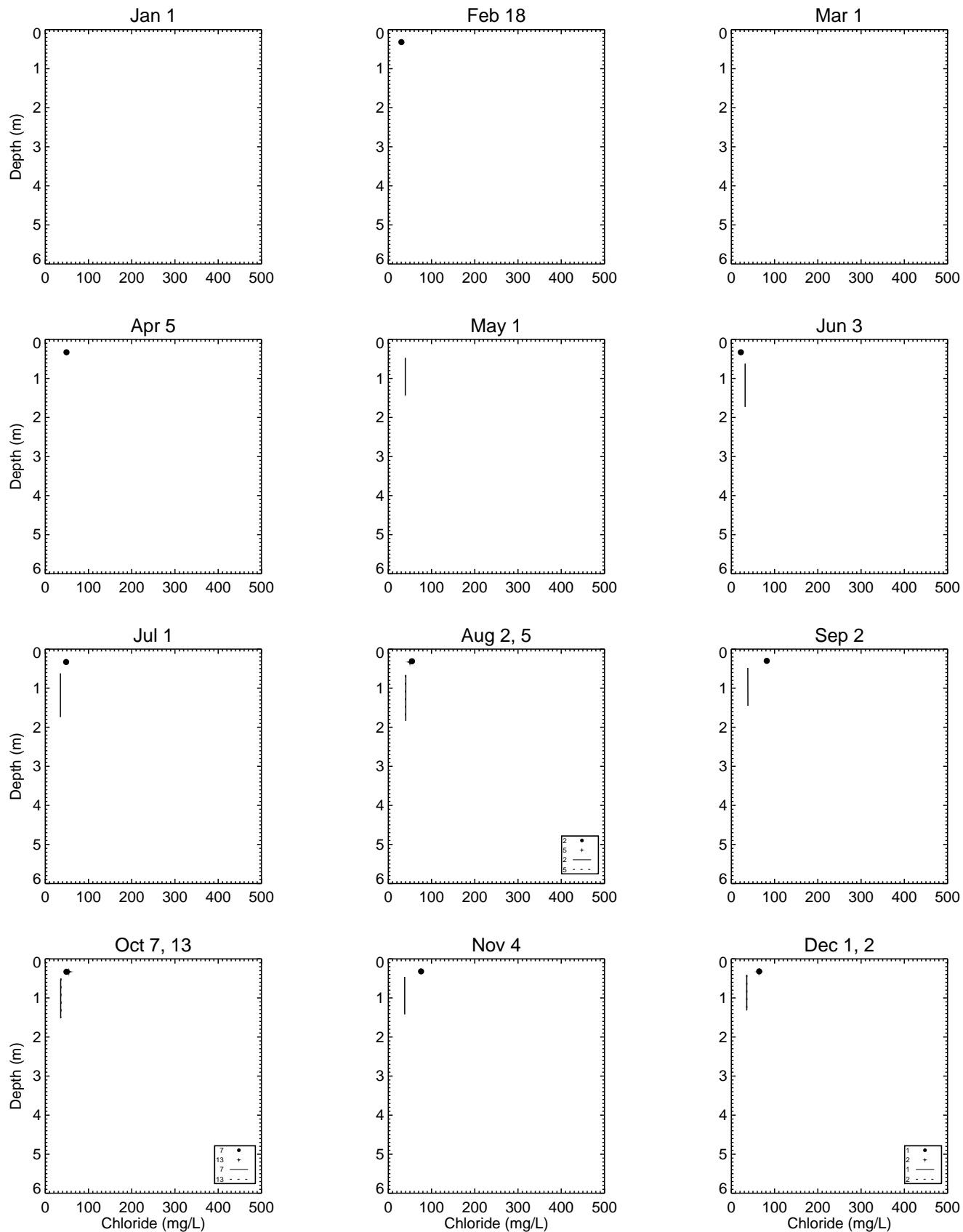at Rocky Point (Segment 9) - Specific Conductance - 1985

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:44 2013

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 1986

Profiles shown for dates with available data else model results for first day of month shown.

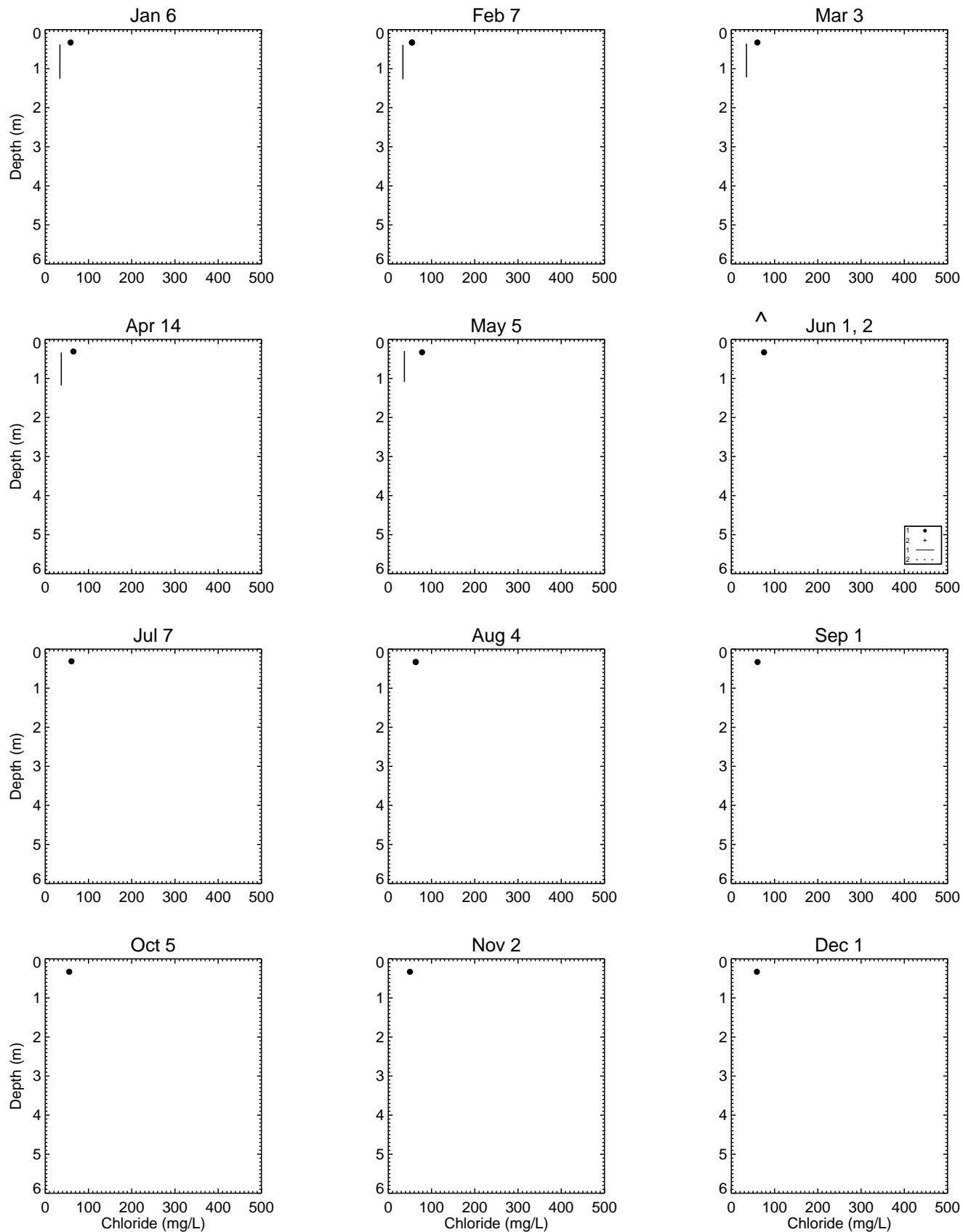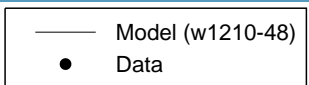CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 19 · Feb 23 · Mar 18 · Apr 27 · May 20 · Jun 15 · Jul 21 · Aug 20 · Sep 16 · Oct 21 · Nov 17 · Dec 22

Specific Conductance (umhos/cm)

Model (w1210-48)

Data

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 1987

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
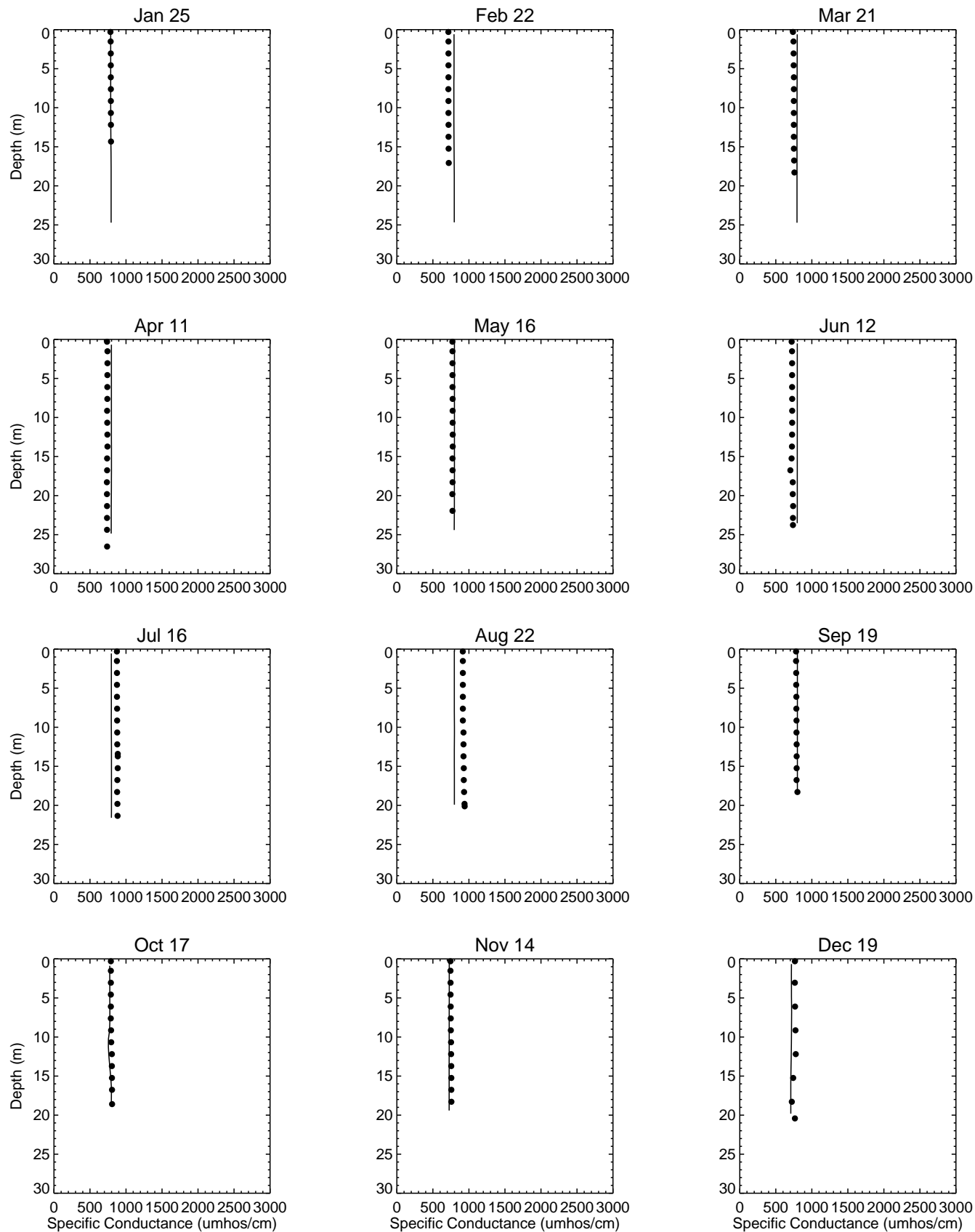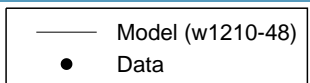PARSONS

Jan 18 Feb 16 Mar 15

Apr 19 May 17 Jun 20

Jul 20 Aug 15 Sep 12

Oct 10 Nov 8 Dec 14

Specific Conductance (umhos/cm)

Depth (m)

Model (w1210-48)
● Data

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 1988

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 1989

Profiles shown for dates with available data else model results for first day of month shown.

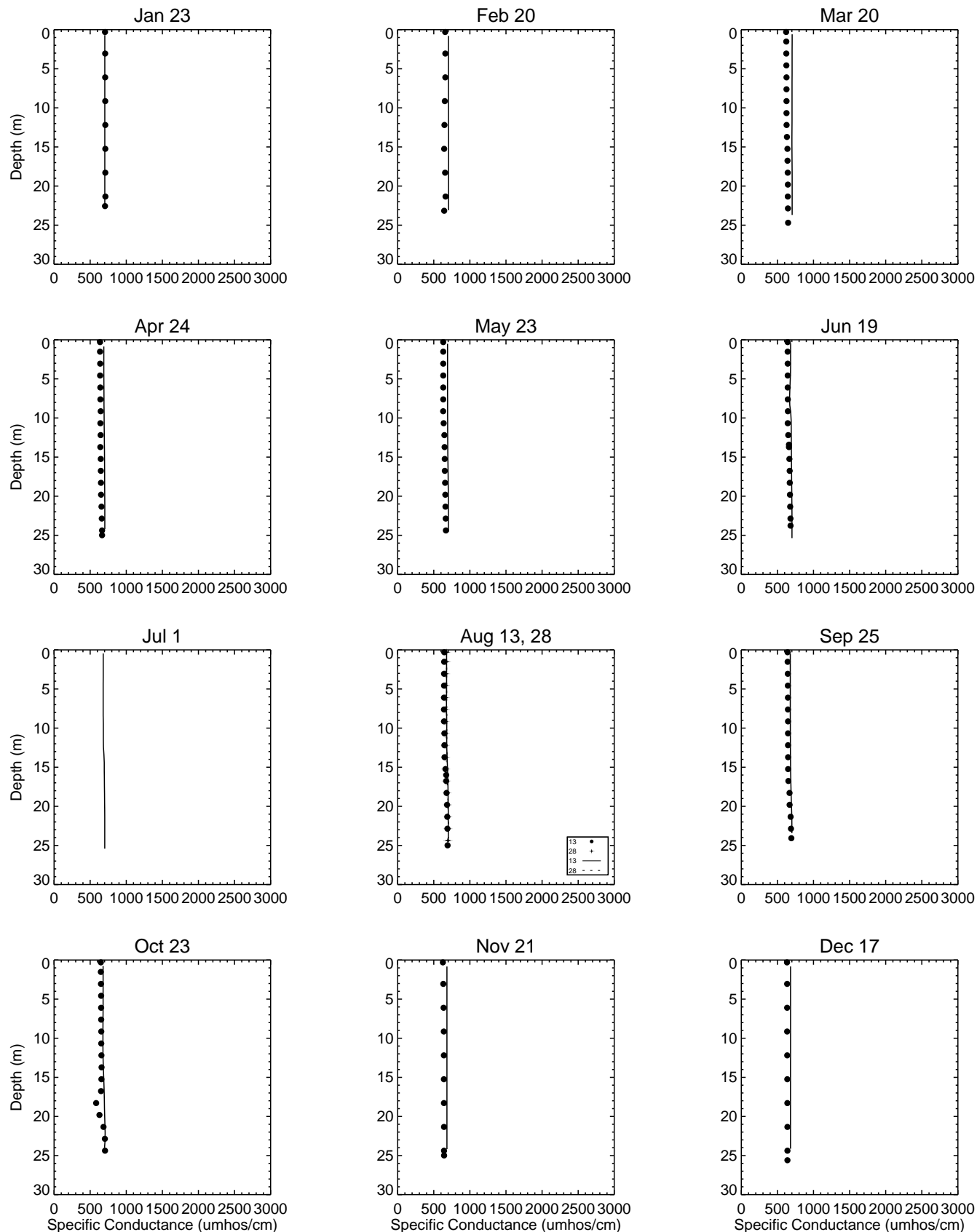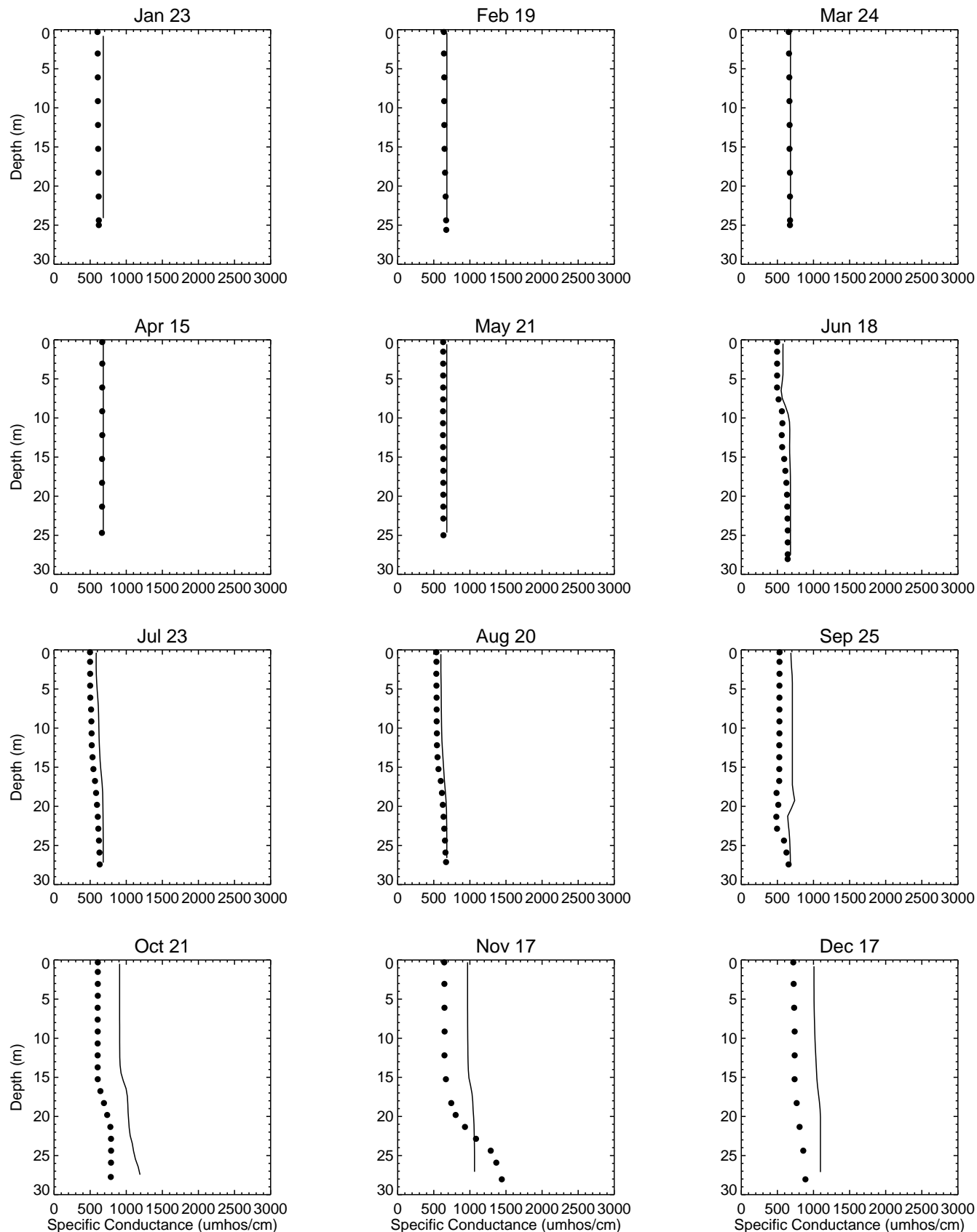CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:44 2013

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 1990

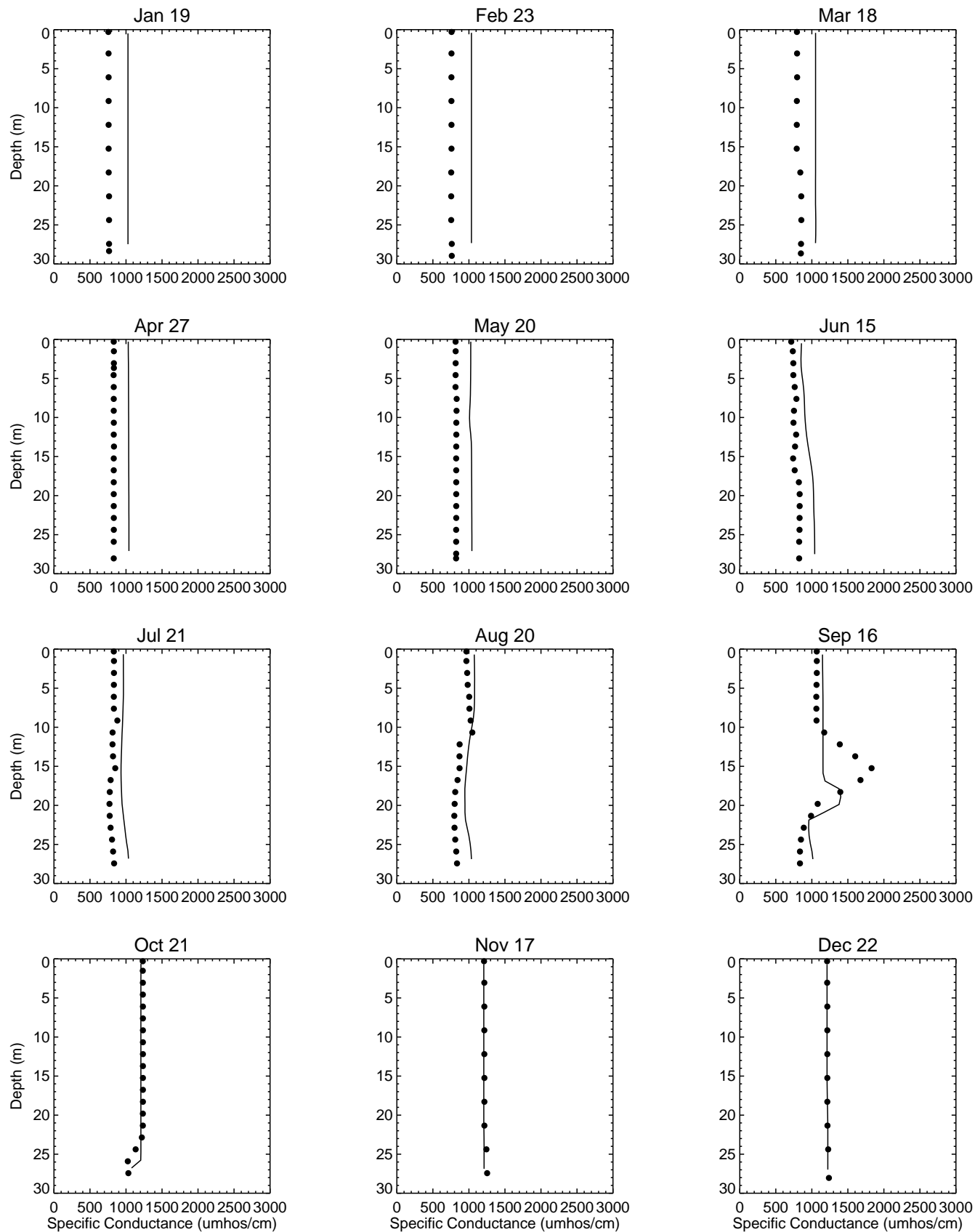*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 1991

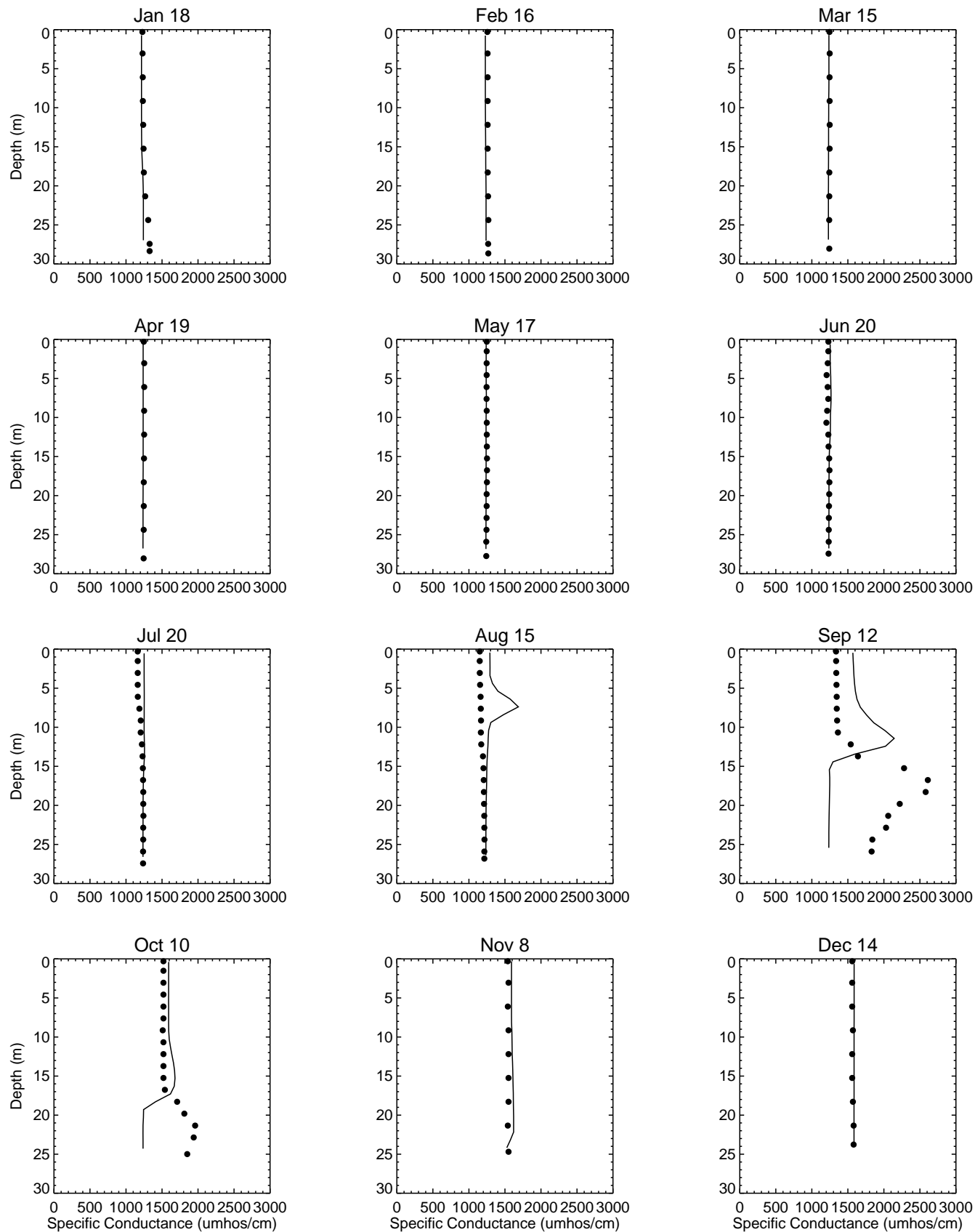*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 1992

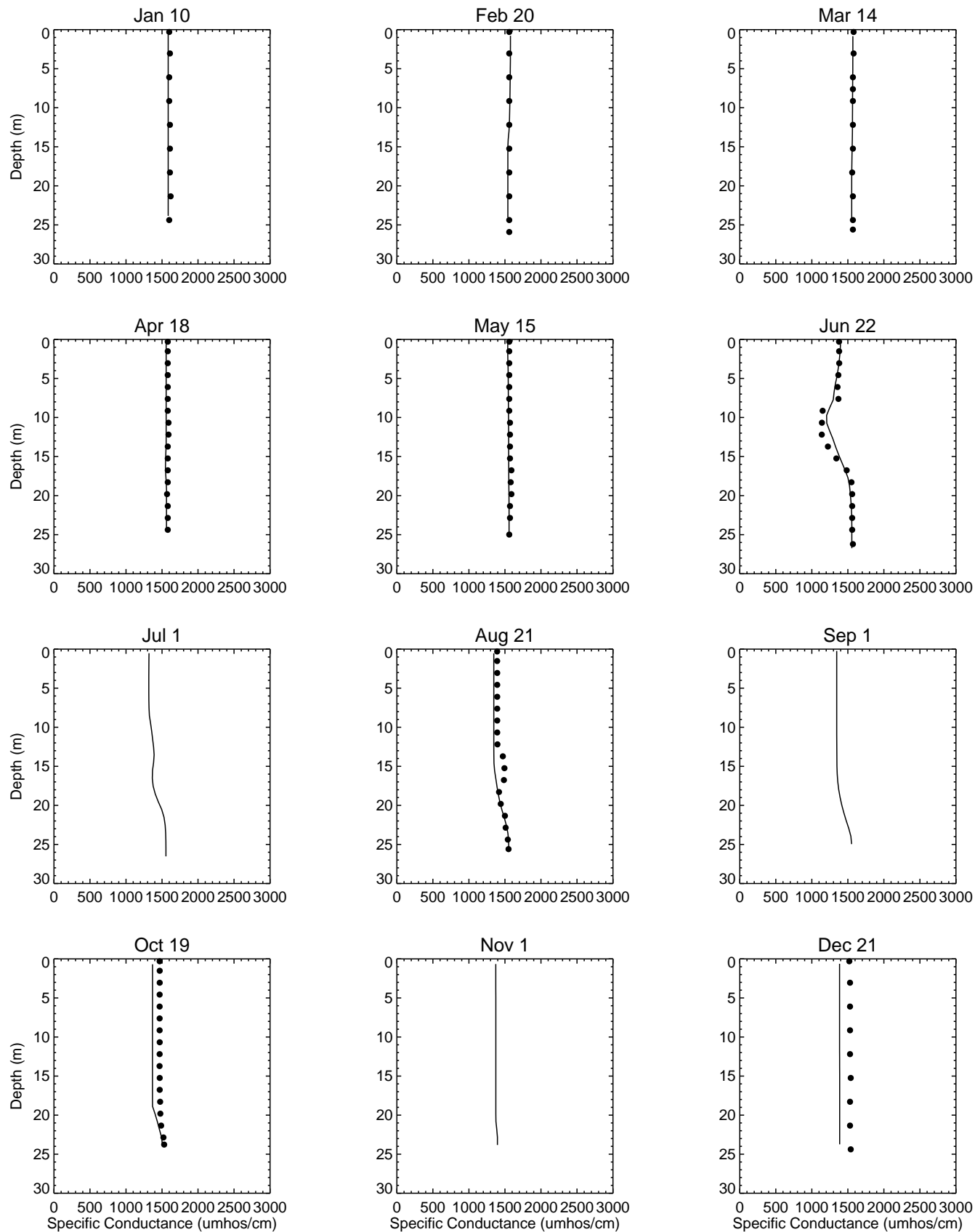*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 1993

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 1994

Profiles shown for dates with available data else model results for first day of month shown.
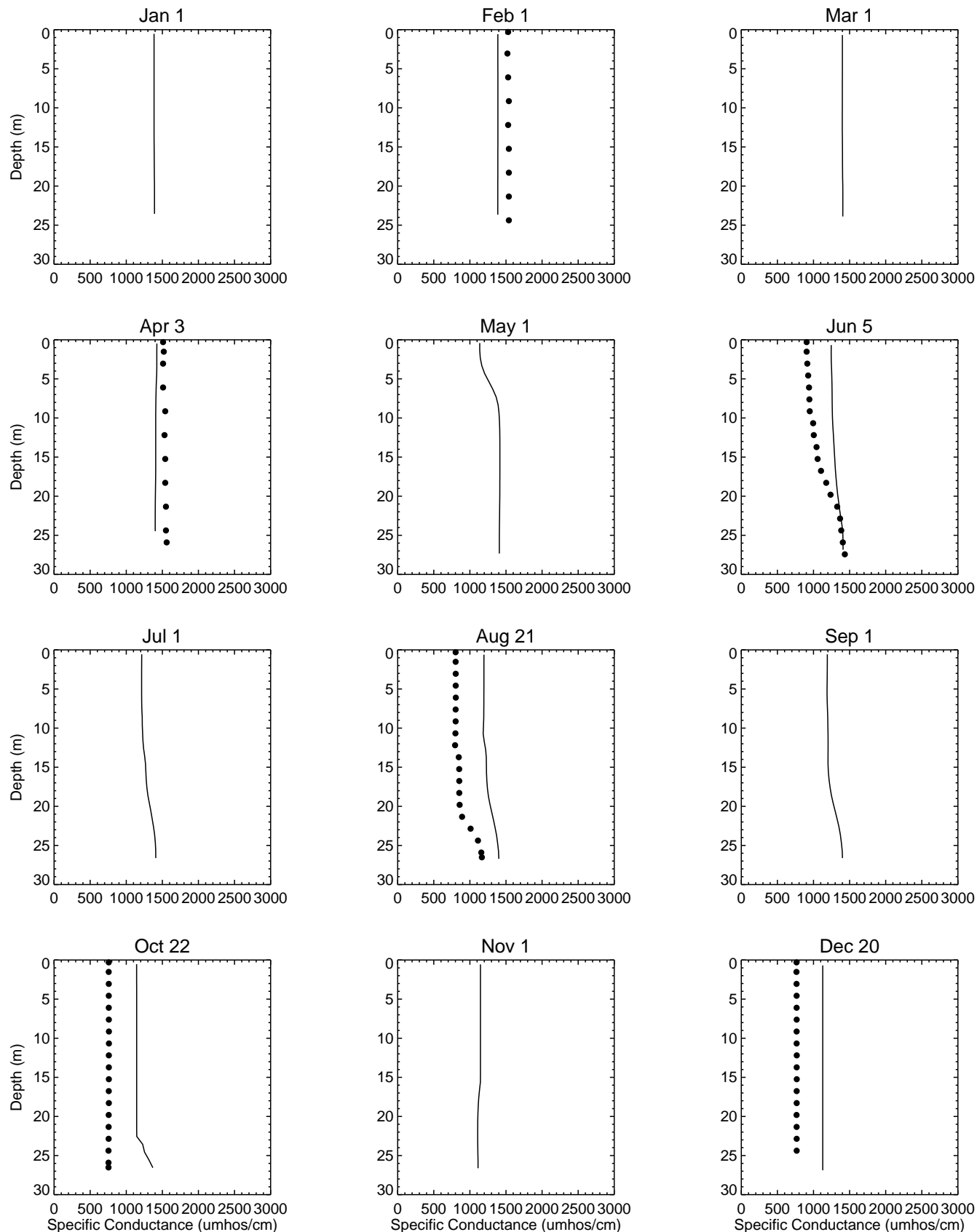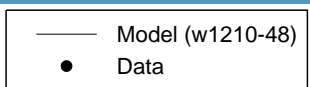
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 1995

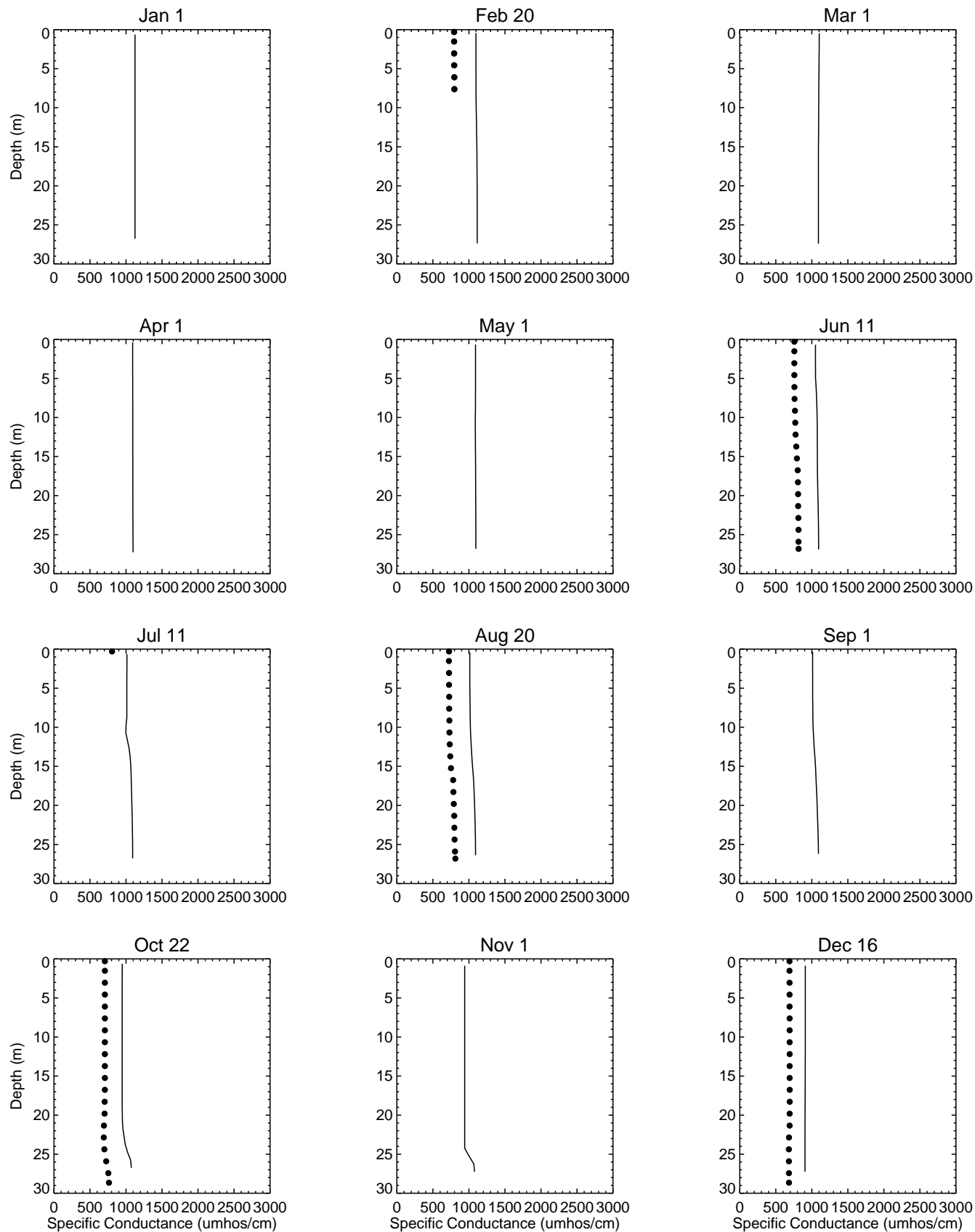*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1   Feb 12   Mar 1

Apr 17   May 28   Jun 12, 26

Jul 1   Aug 5   Sep 1

Oct 7   Nov 6   Dec 5

Depth (m)

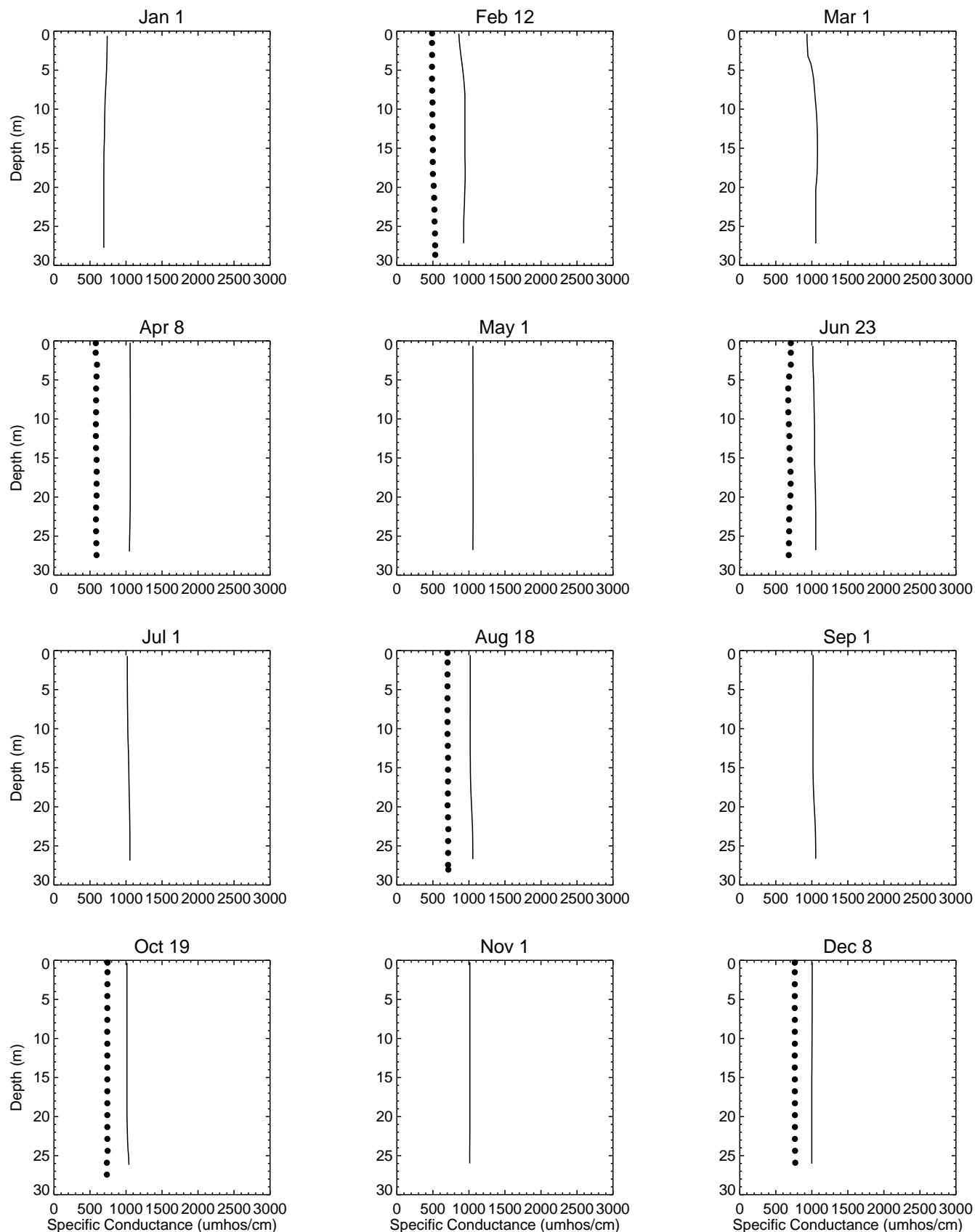Specific Conductance (umhos/cm)

———— Model (w1210-48)

●   Data

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 1996

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 1997

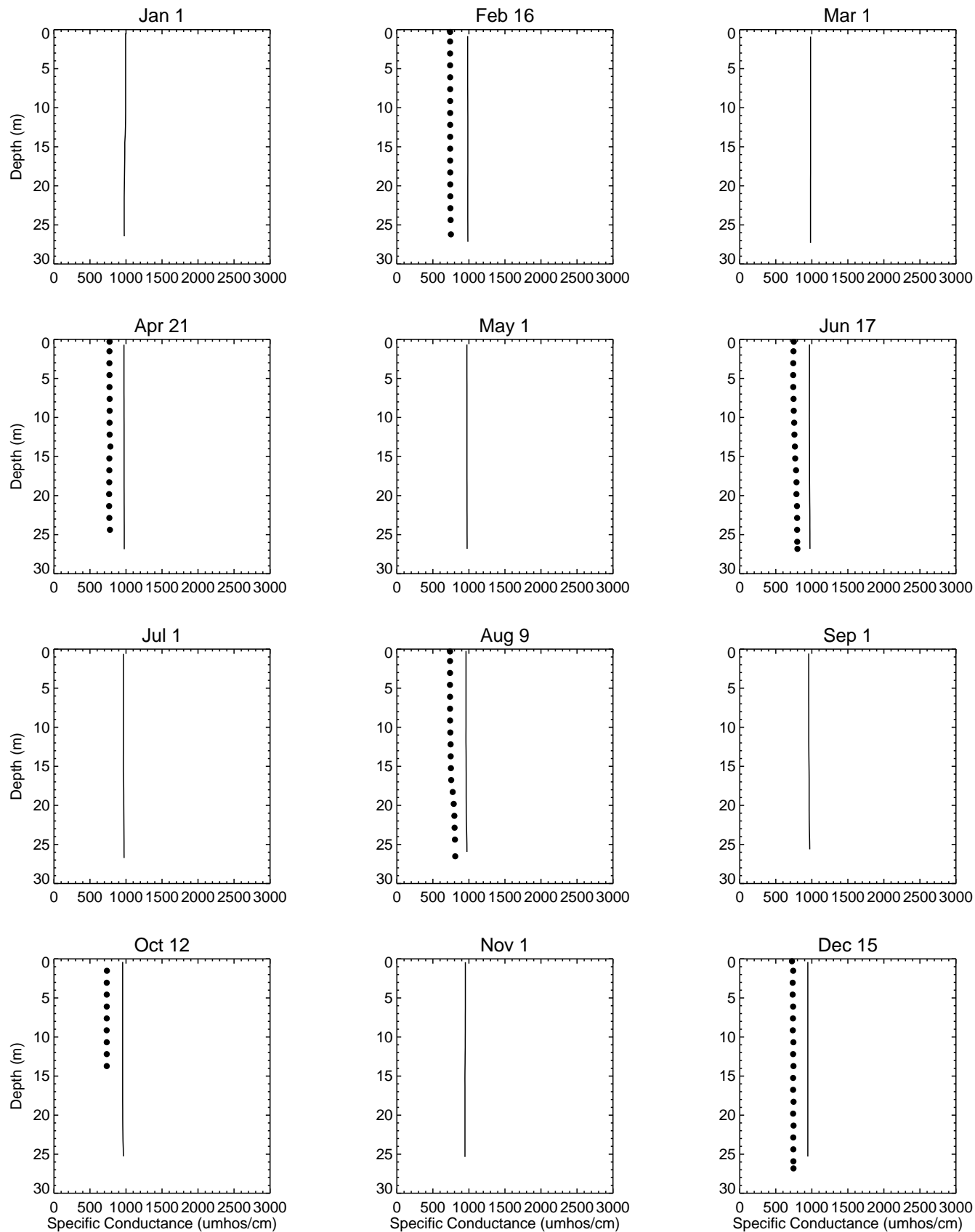*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 1998

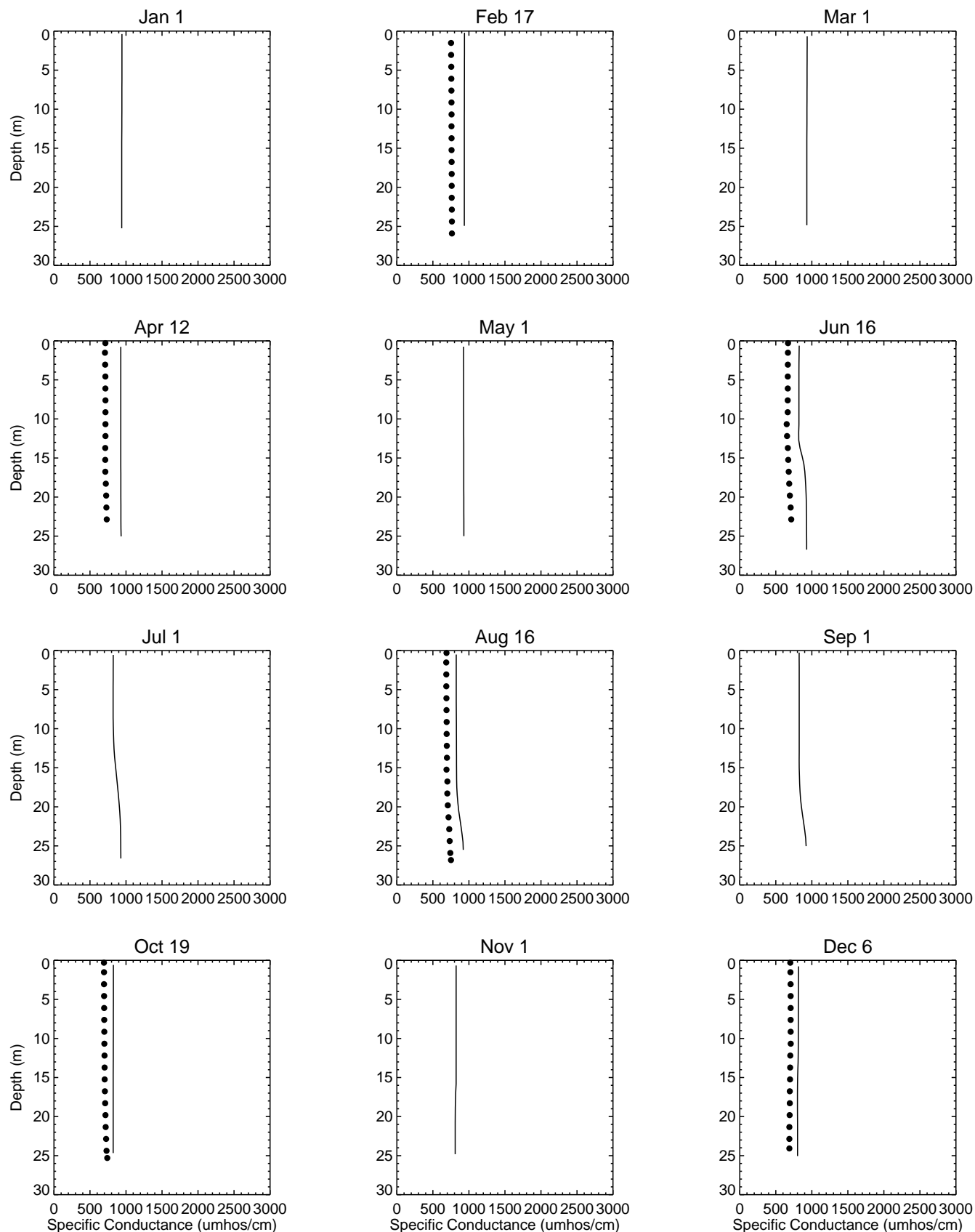*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 1999

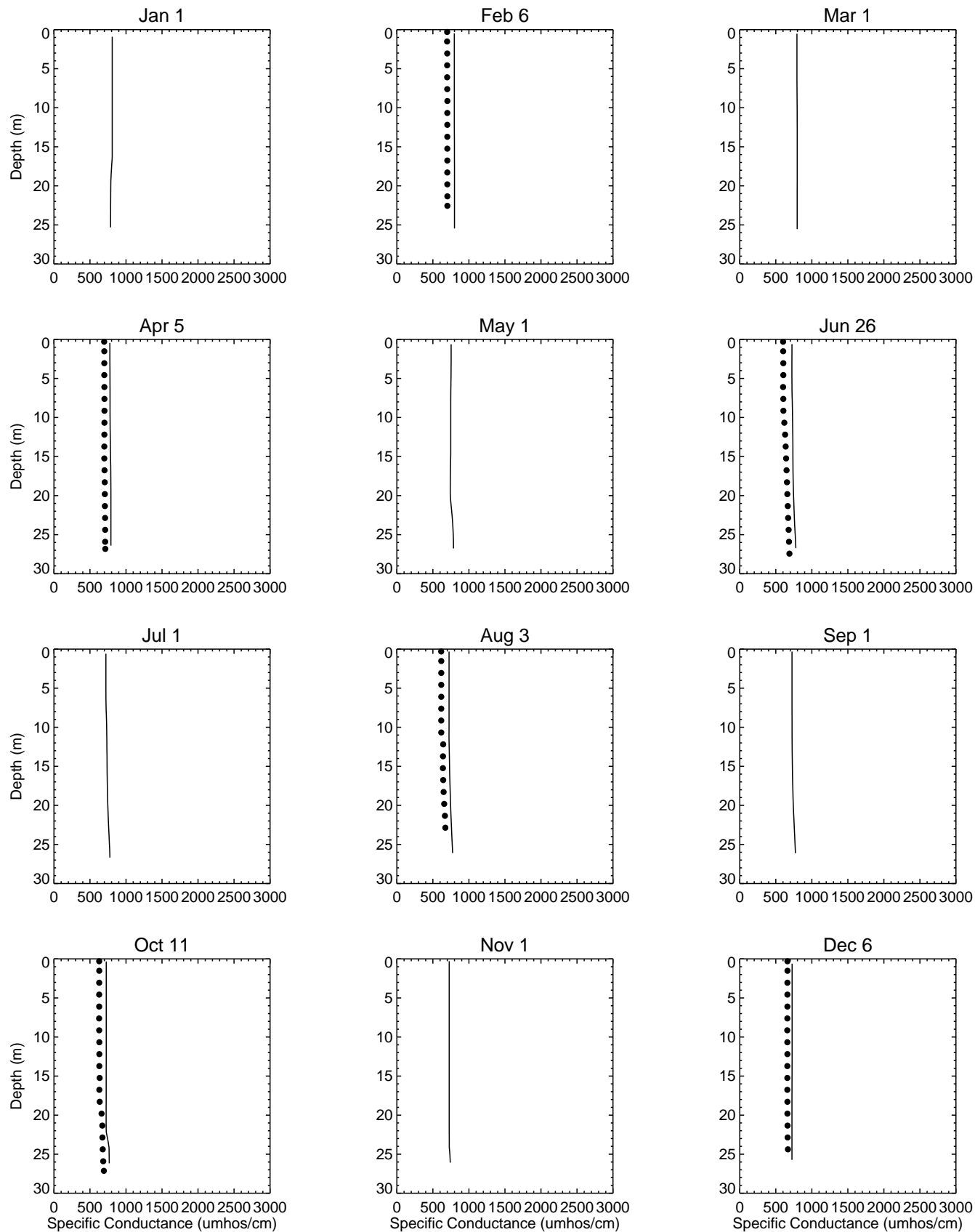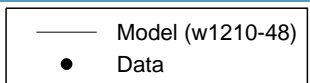*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:44 2013

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:45 2013

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 2001

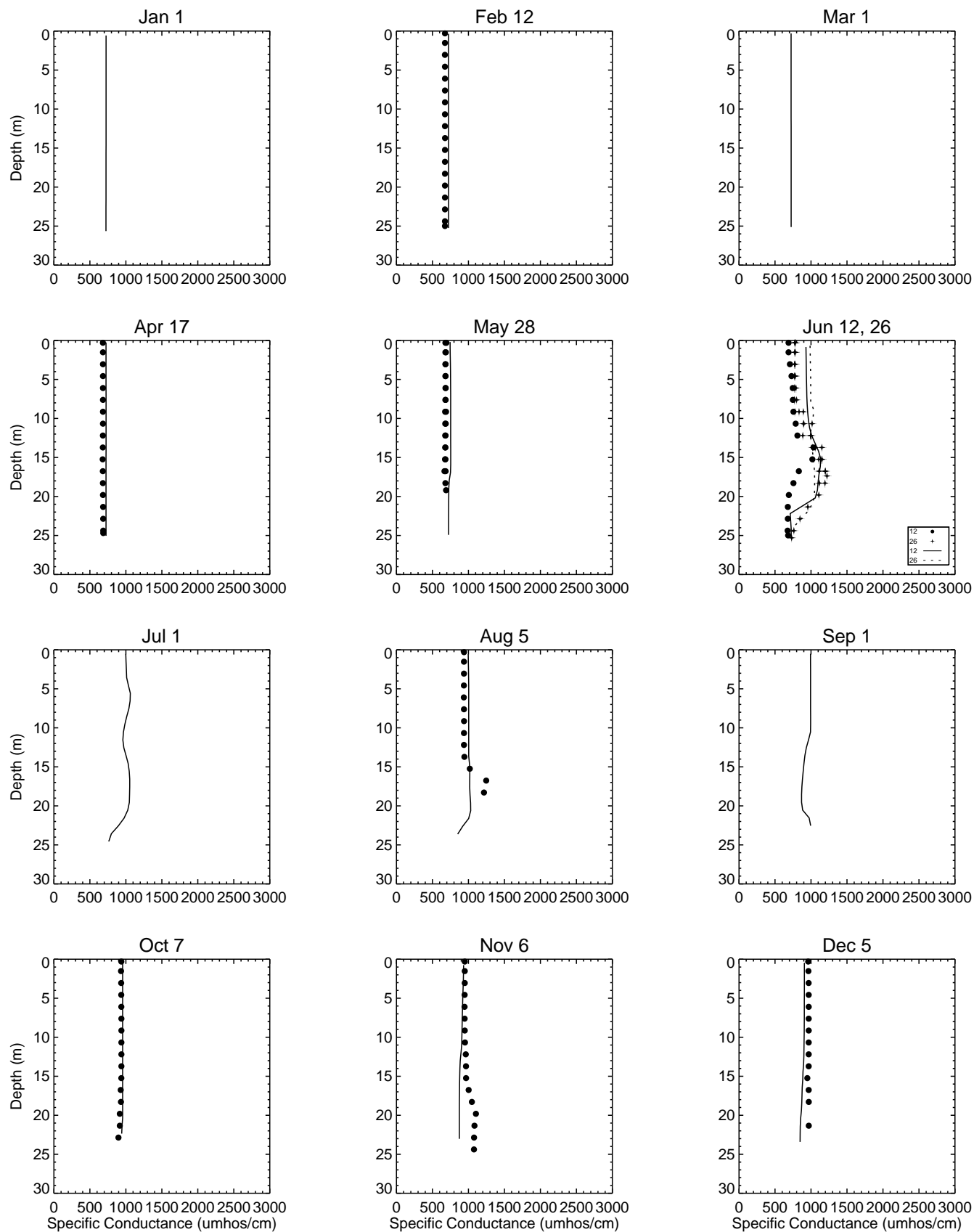*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 2002

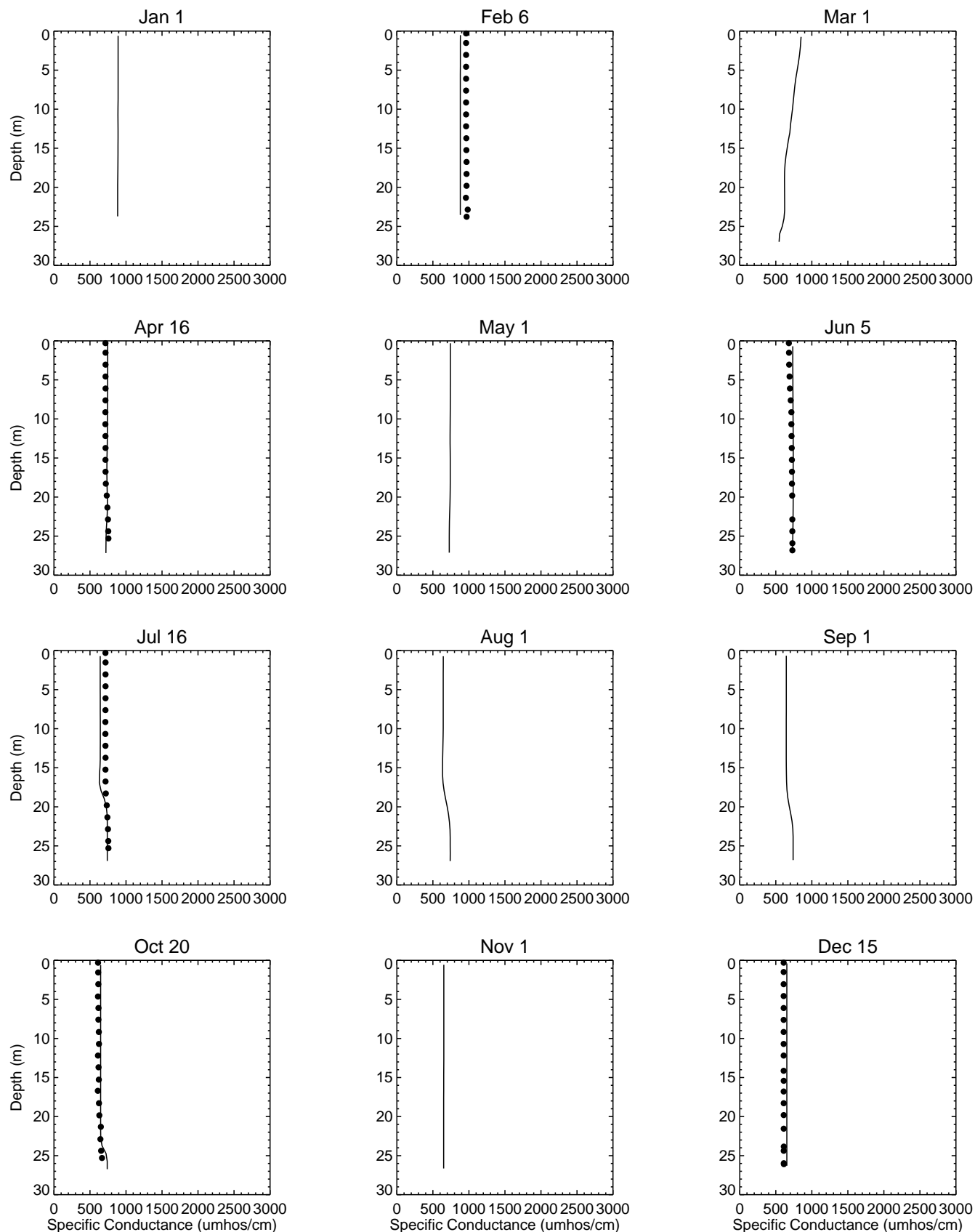*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 2003

Profiles shown for dates with available data else model results for first day of month shown.

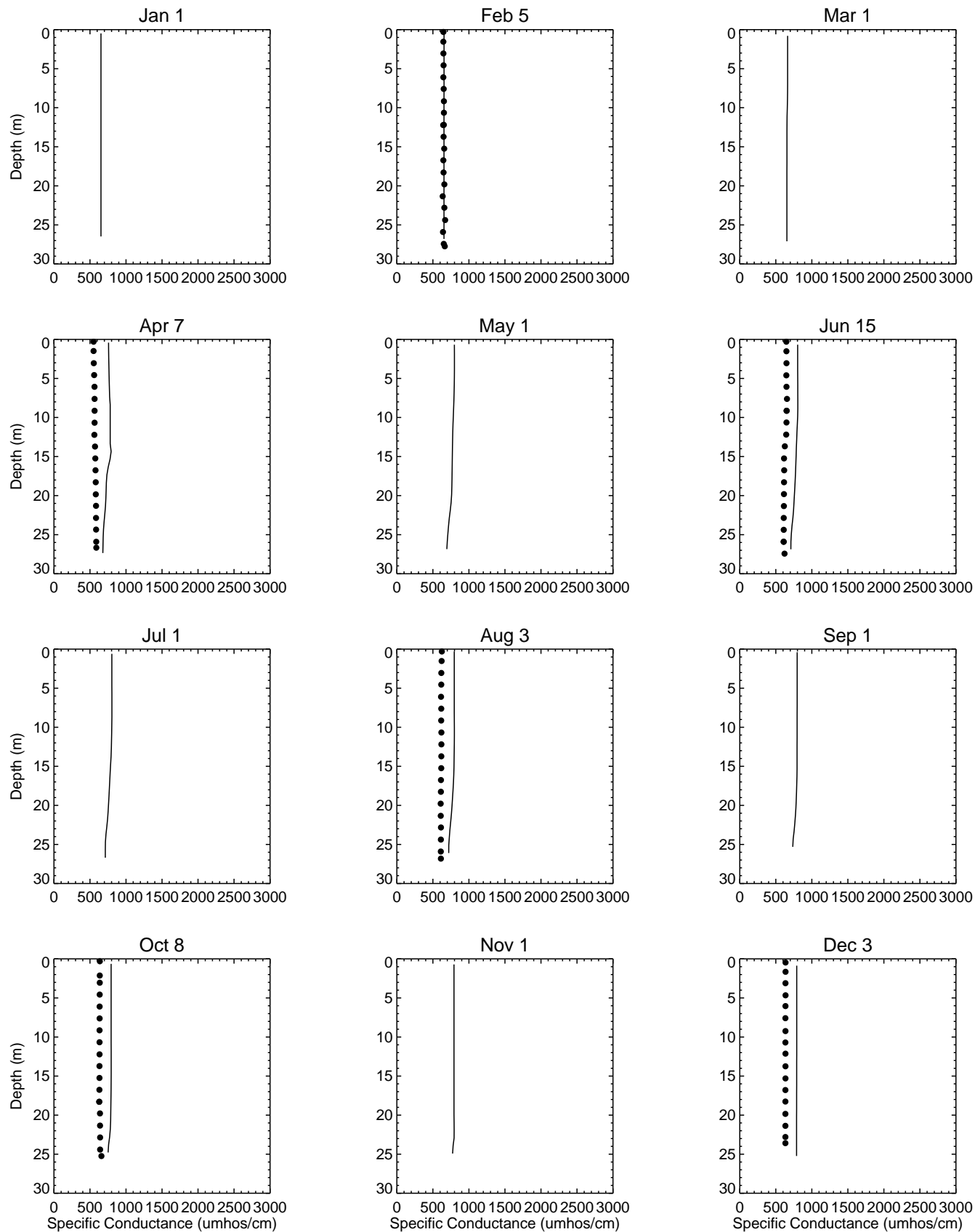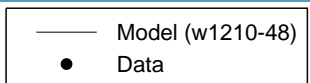CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 2004

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1   Feb 8   Mar 1

Apr 12   May 1   Jun 6

Jul 1   Aug 1   Sep 1

Oct 11   Nov 1   Dec 1

Specific Conductance (umhos/cm)
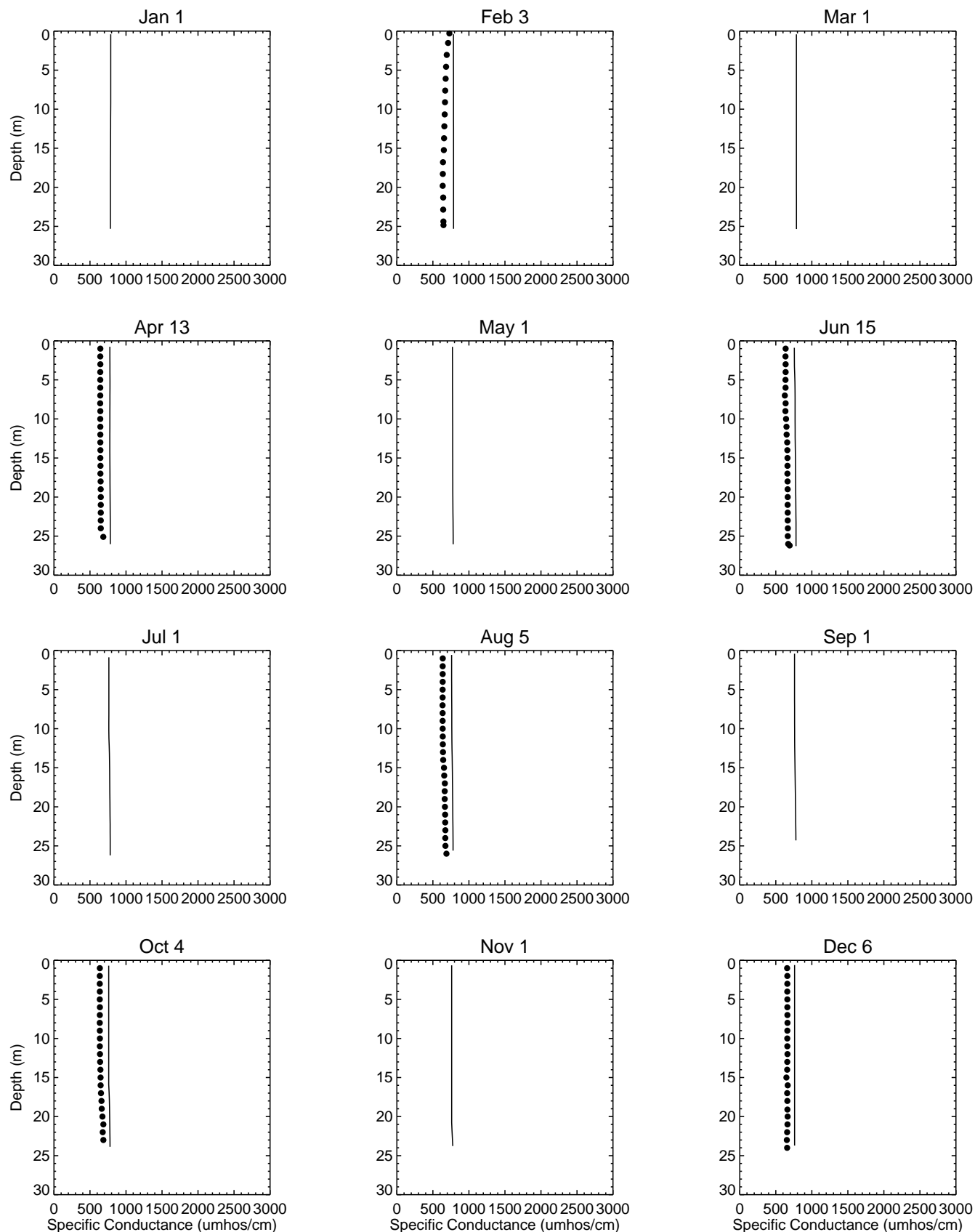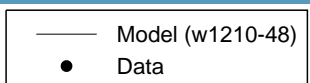
—— Model (w1210-48)
● Data

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 2005

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR
QEA
PARSONS

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 2006

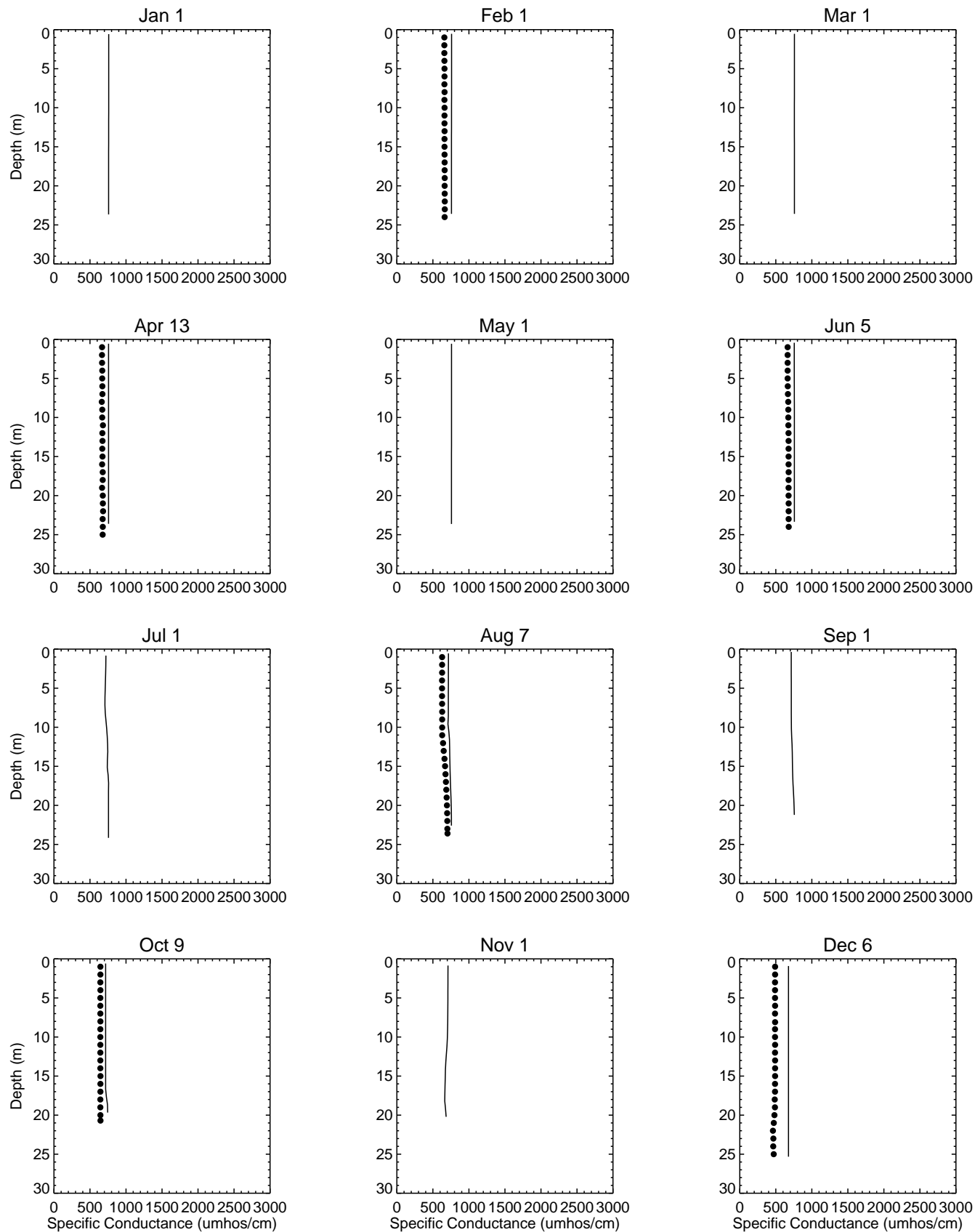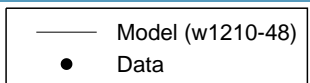*Profiles shown for dates with available data else model results for first day of month shown.*

Model (w1210-48)
Data

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
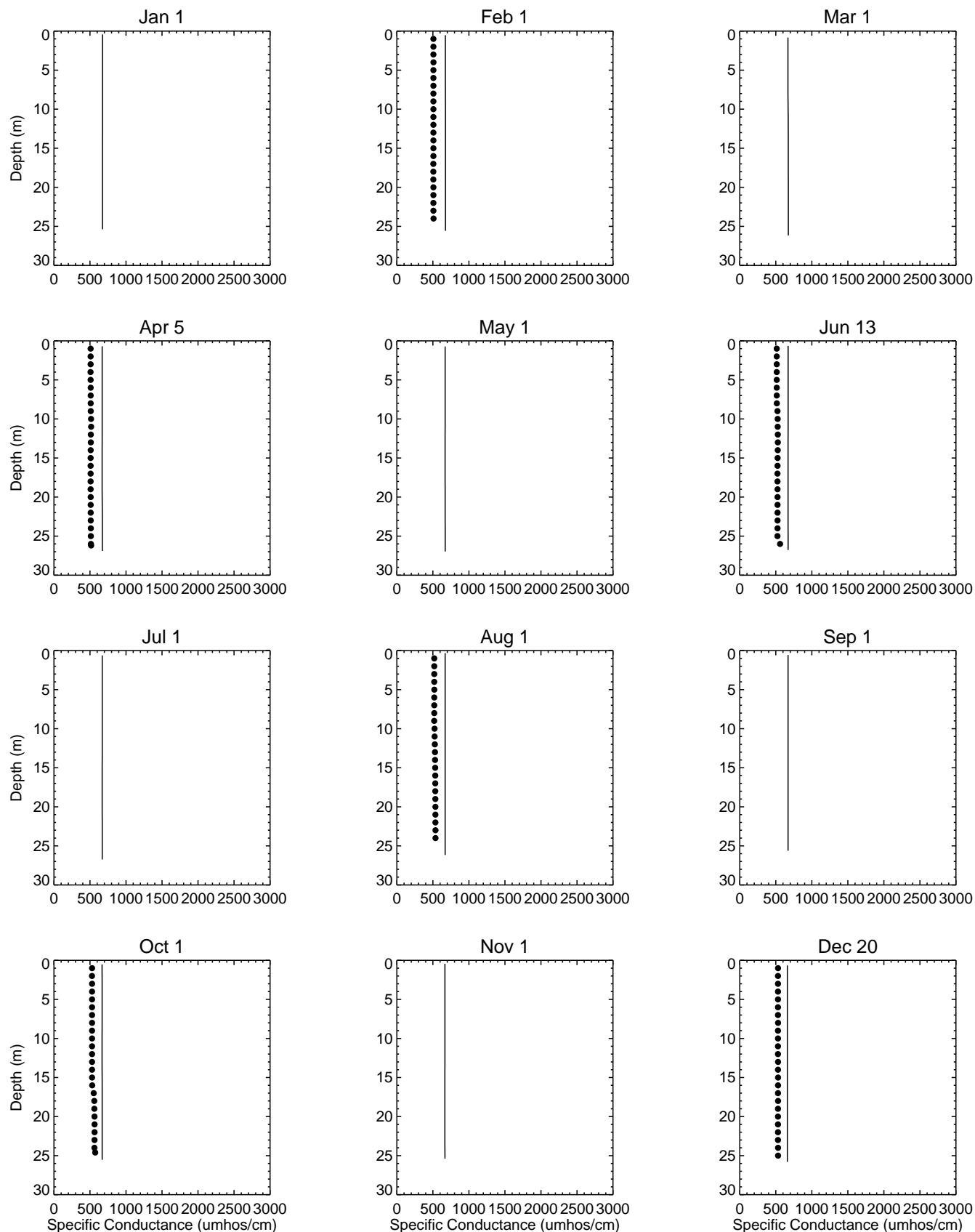Fri Jan 25 18:13:45 2013

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 2007

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 2008

Profiles shown for dates with available data else model results for first day of month shown.

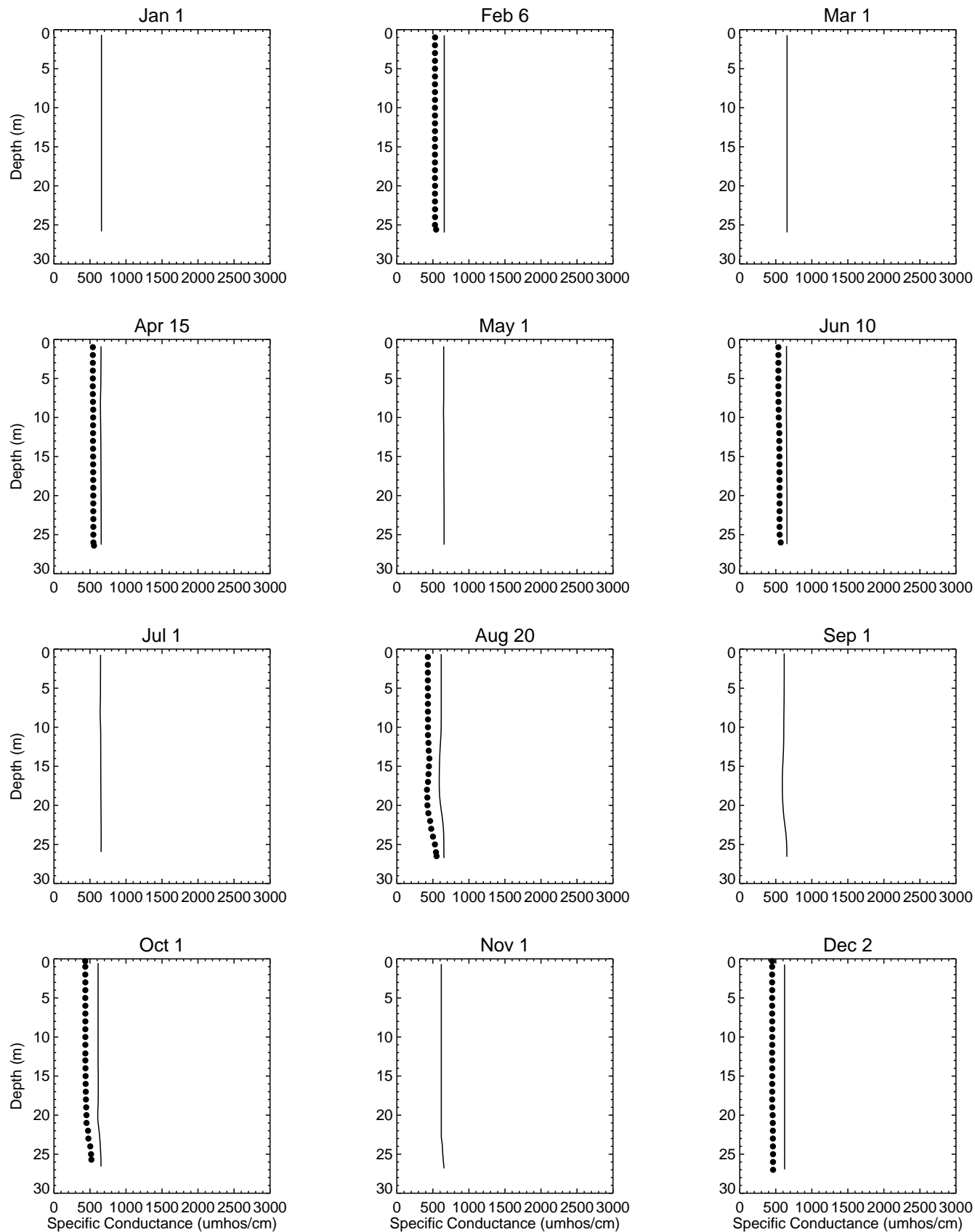CREMs Phase 4: Lake Buchanan
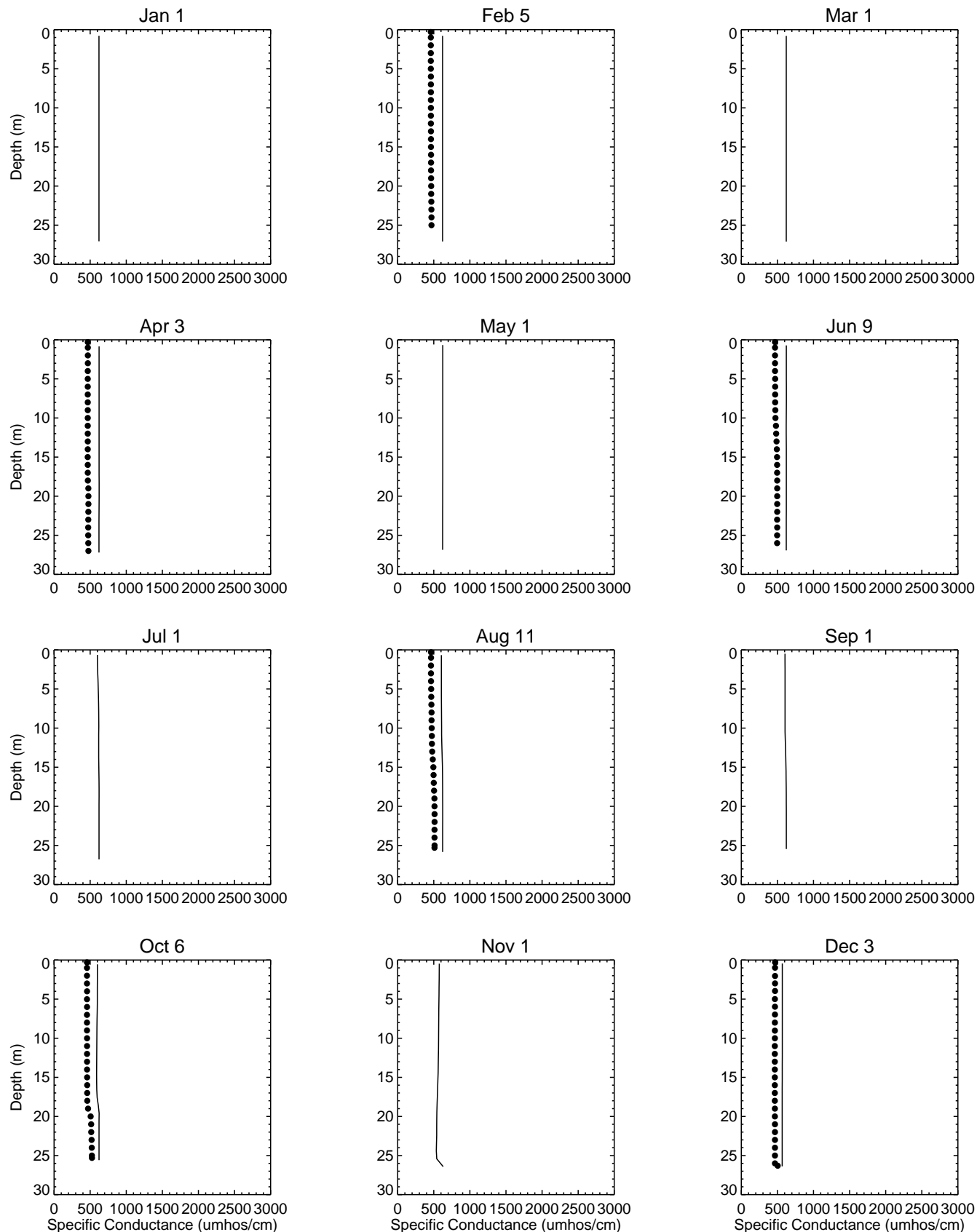
Lower Colorado River Authority

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 2009

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:45 2013

Jan 1   Feb 18   Mar 1
Apr 5   May 1   Jun 3
Jul 1   Aug 2, 5   Sep 2
Oct 7, 13   Nov 4   Dec 1, 2

Specific Conductance (umhos/cm)
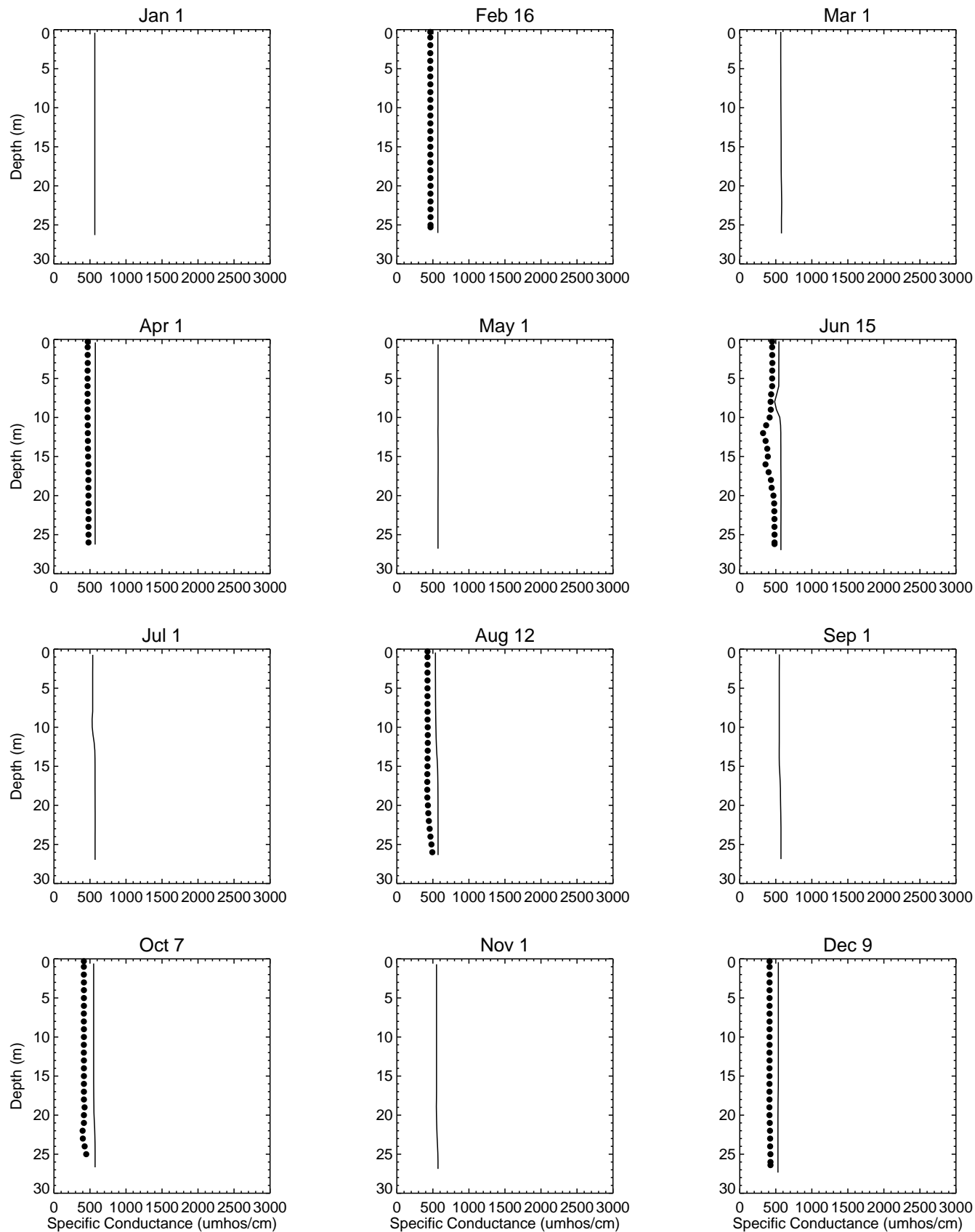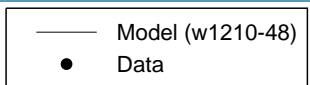
——— Model (w1210-48)
●   Data

Figure G-15

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 2010

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:45 2013

Figure G-15
Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Specific Conductance - 2011
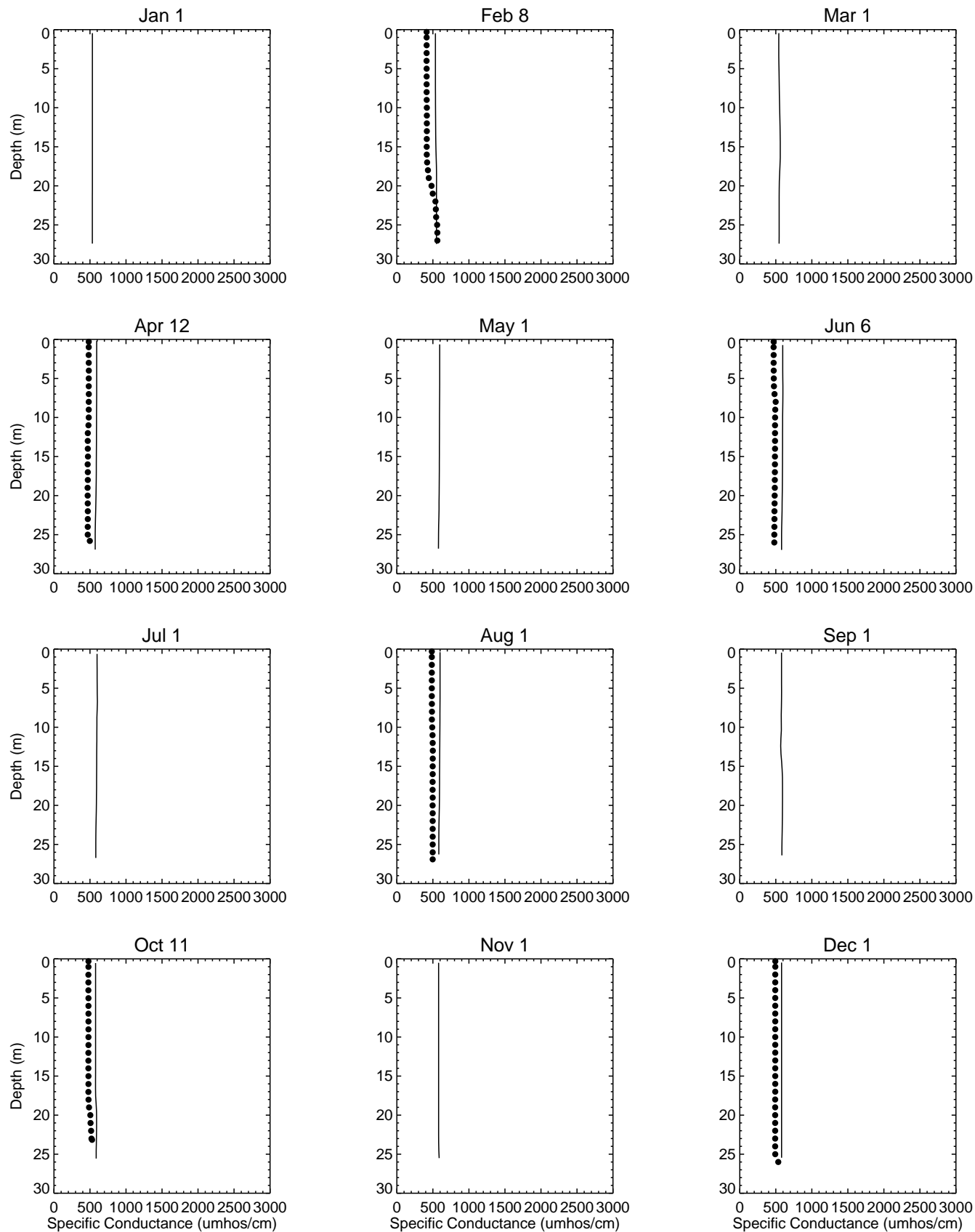*Profiles shown for dates with available data else model results for first day of month shown.*
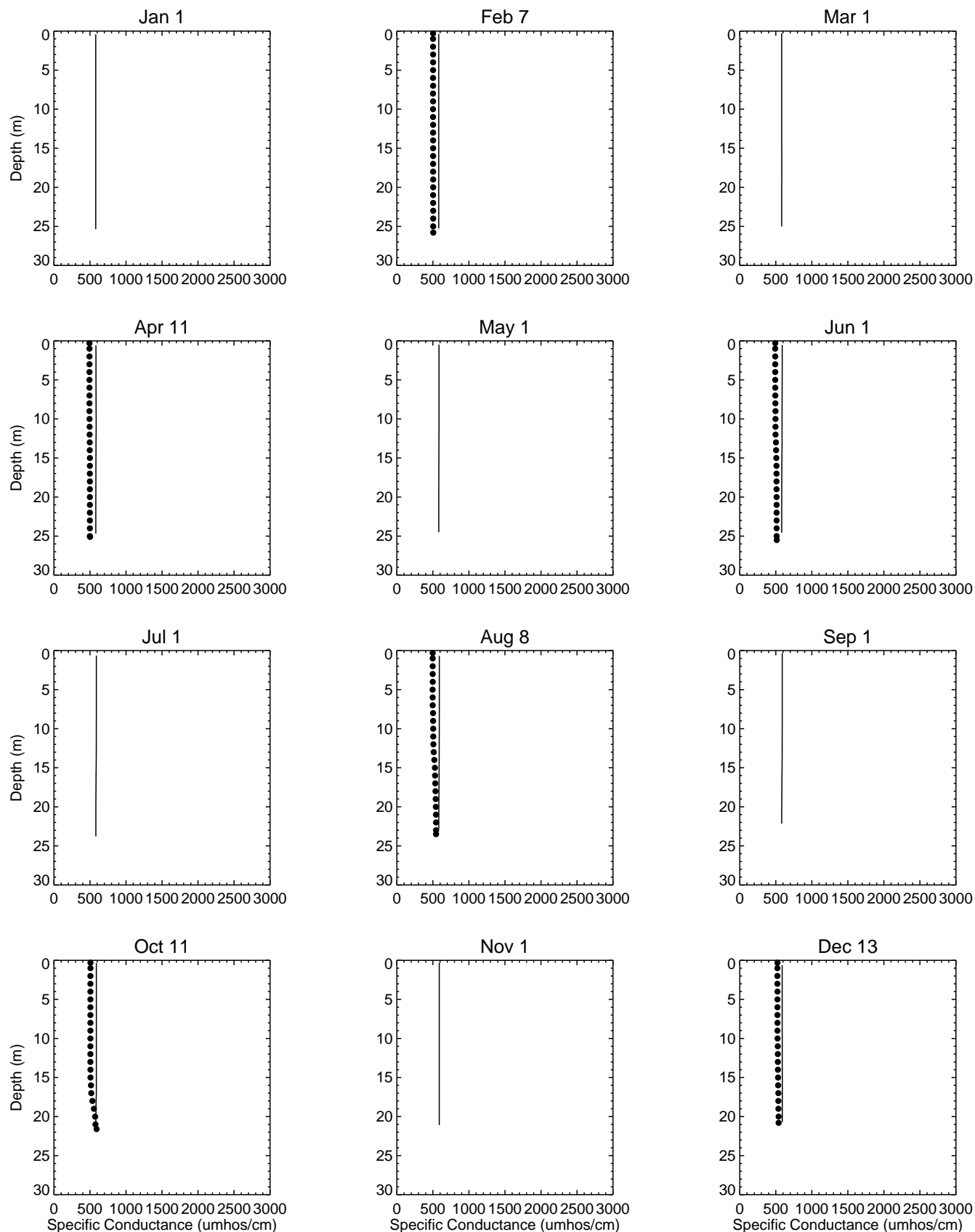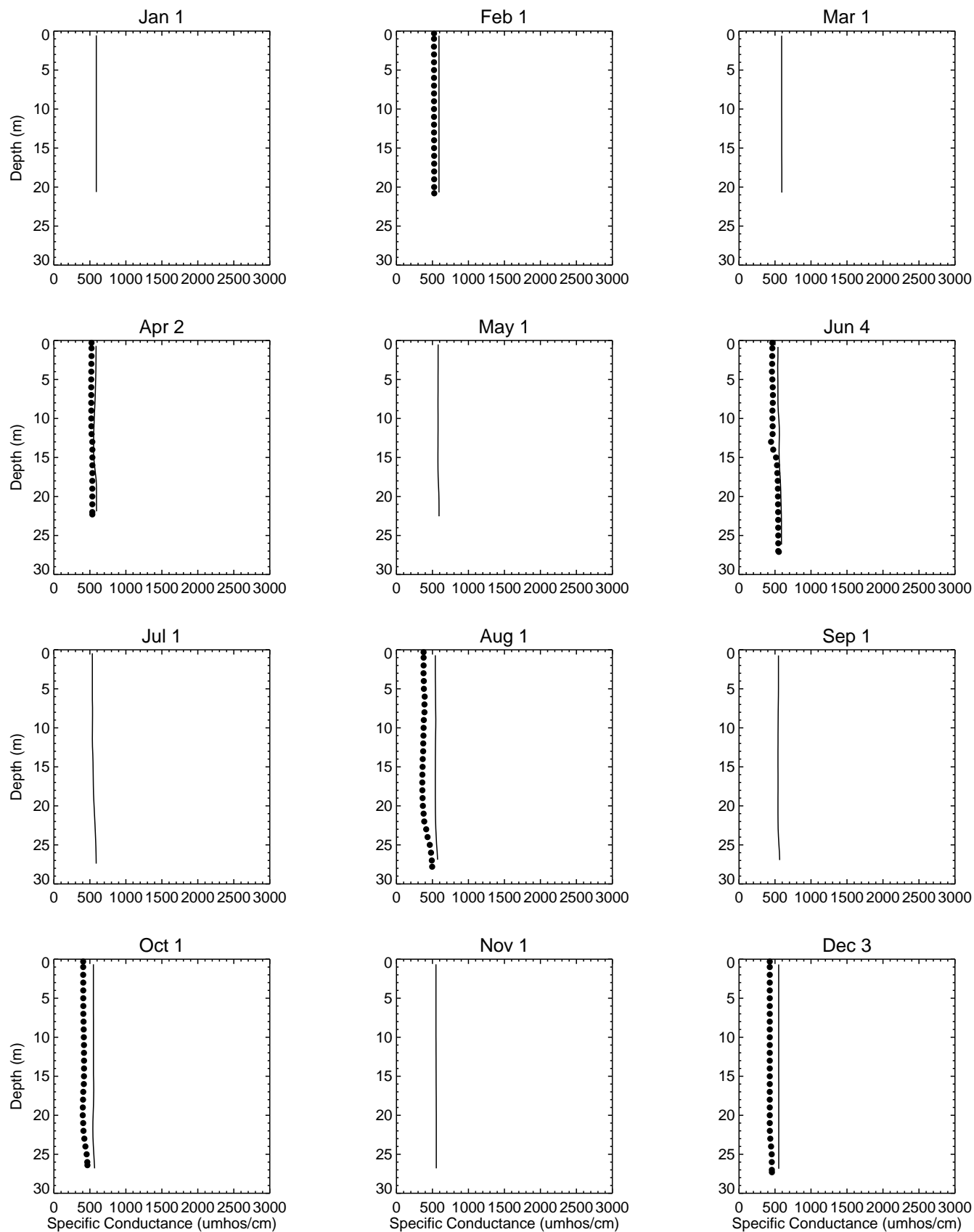
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Jan 25 — Feb 22 — Mar 21 — Apr 11 — May 16 — Jun 12 — Jul 16 — Aug 22 — Sep 19 — Oct 17 — Nov 14 — Dec 19

Specific Conductance (umhos/cm)

Model (w1210-48)
Data

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 1984

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR
QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 1985

Profiles shown for dates with available data else model results for first day of month shown.

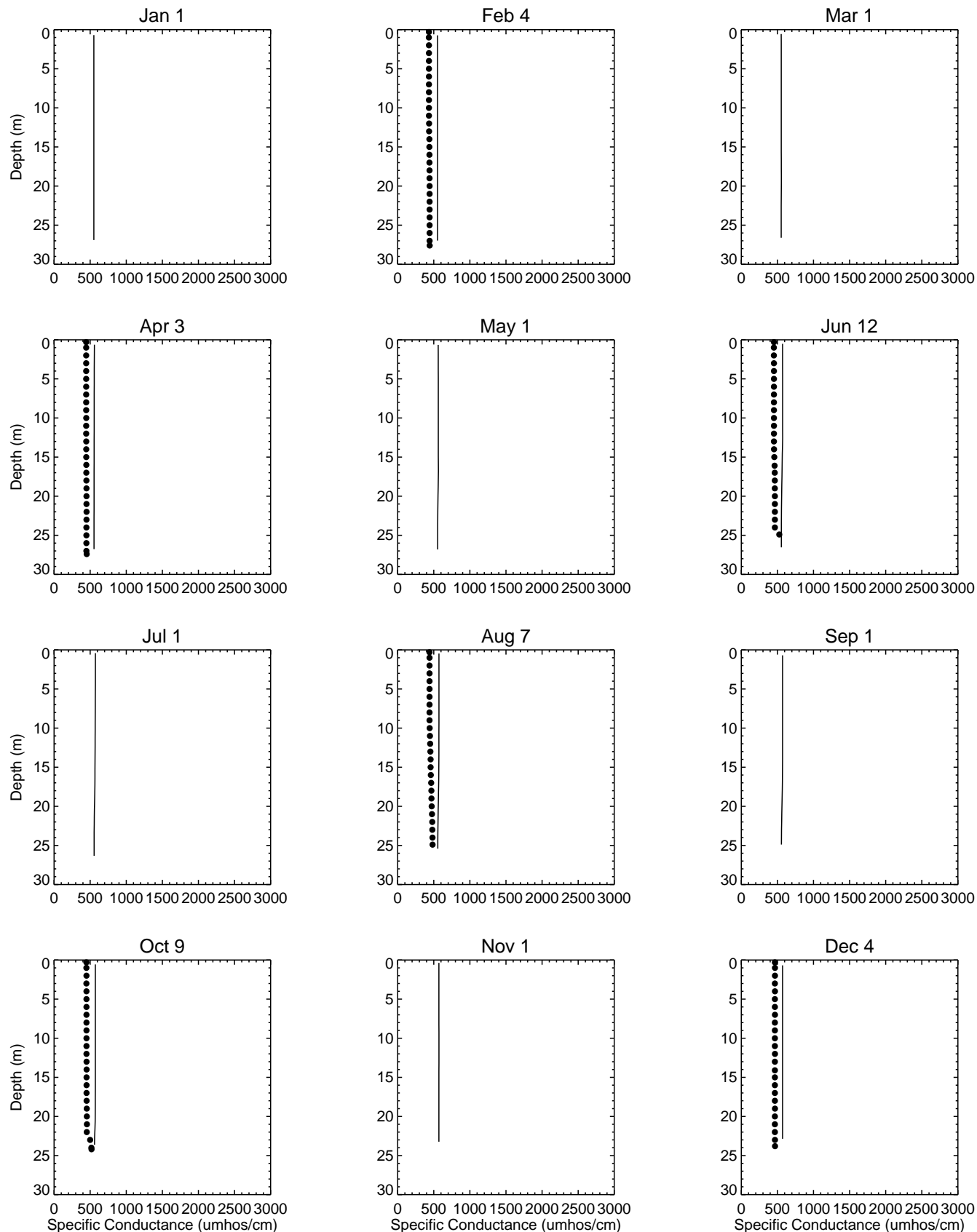CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:48 2013

Jan 23 Feb 19 Mar 24 Apr 15 May 21 Jun 18 Jul 23 Aug 20 Sep 25 Oct 21 Nov 17 Dec 16

Depth (m)

Specific Conductance (umhos/cm)

——— Model (w1210-48)
● Data

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 1986
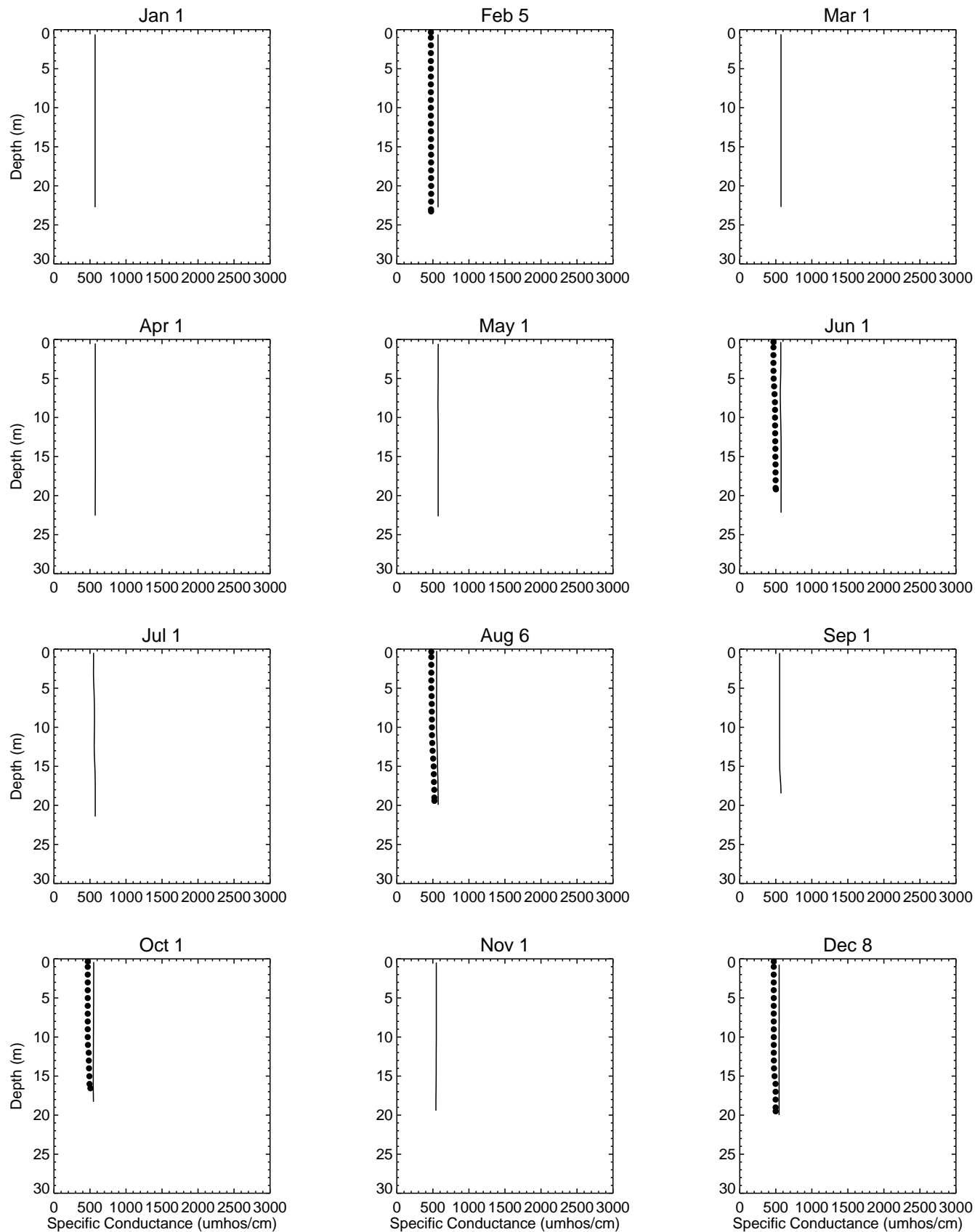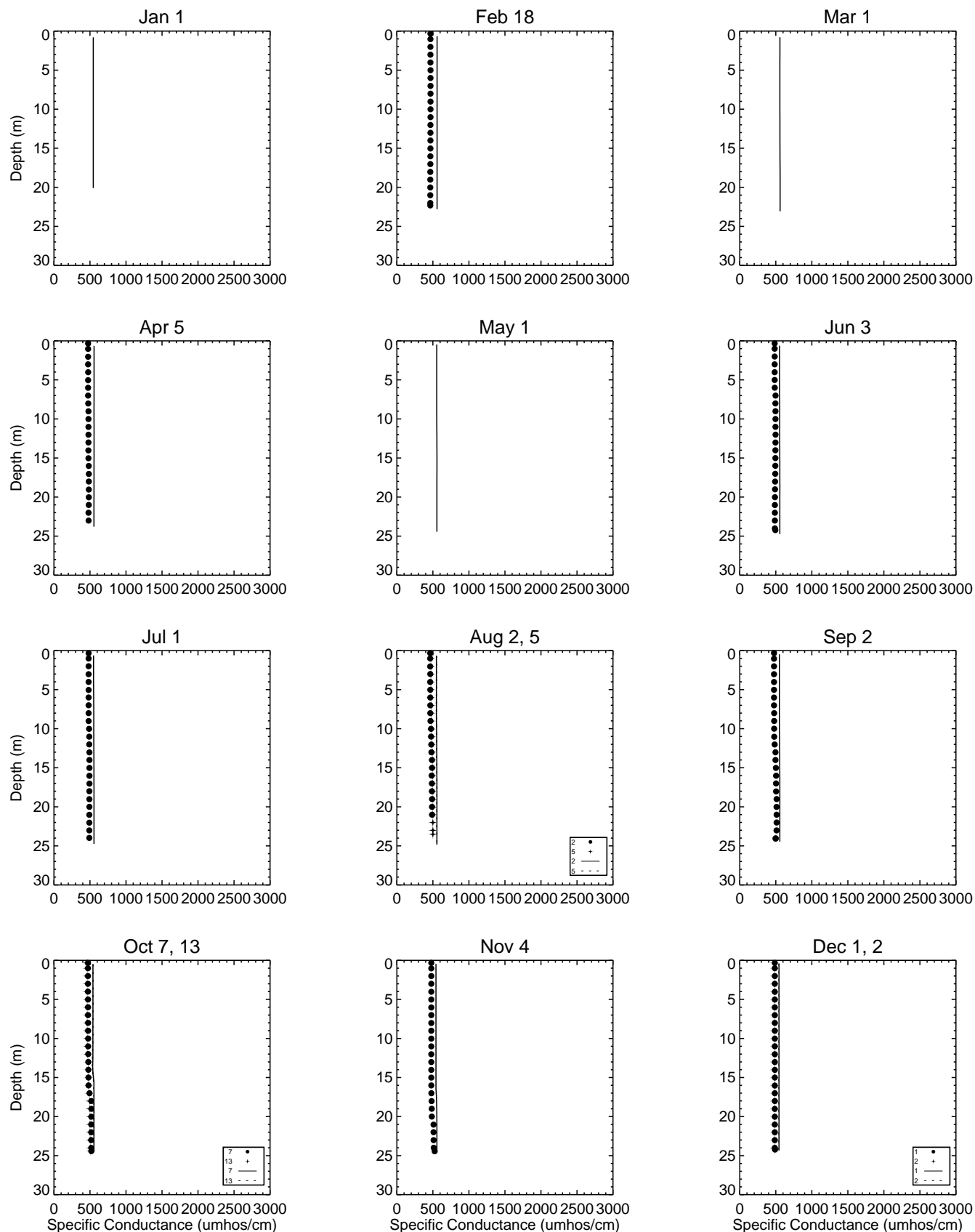*Profiles shown for dates with available data else model results for first day of month shown.*

ANCHOR
QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:48 2013

Jan 19 · Feb 23 · Mar 18 · Apr 27 · May 20 · Jun 15 · Jul 21 · Aug 20 · Sep 16 · Oct 21 · Nov 17 · Dec 22

—— Model (w1210-48)
● Data

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 1987

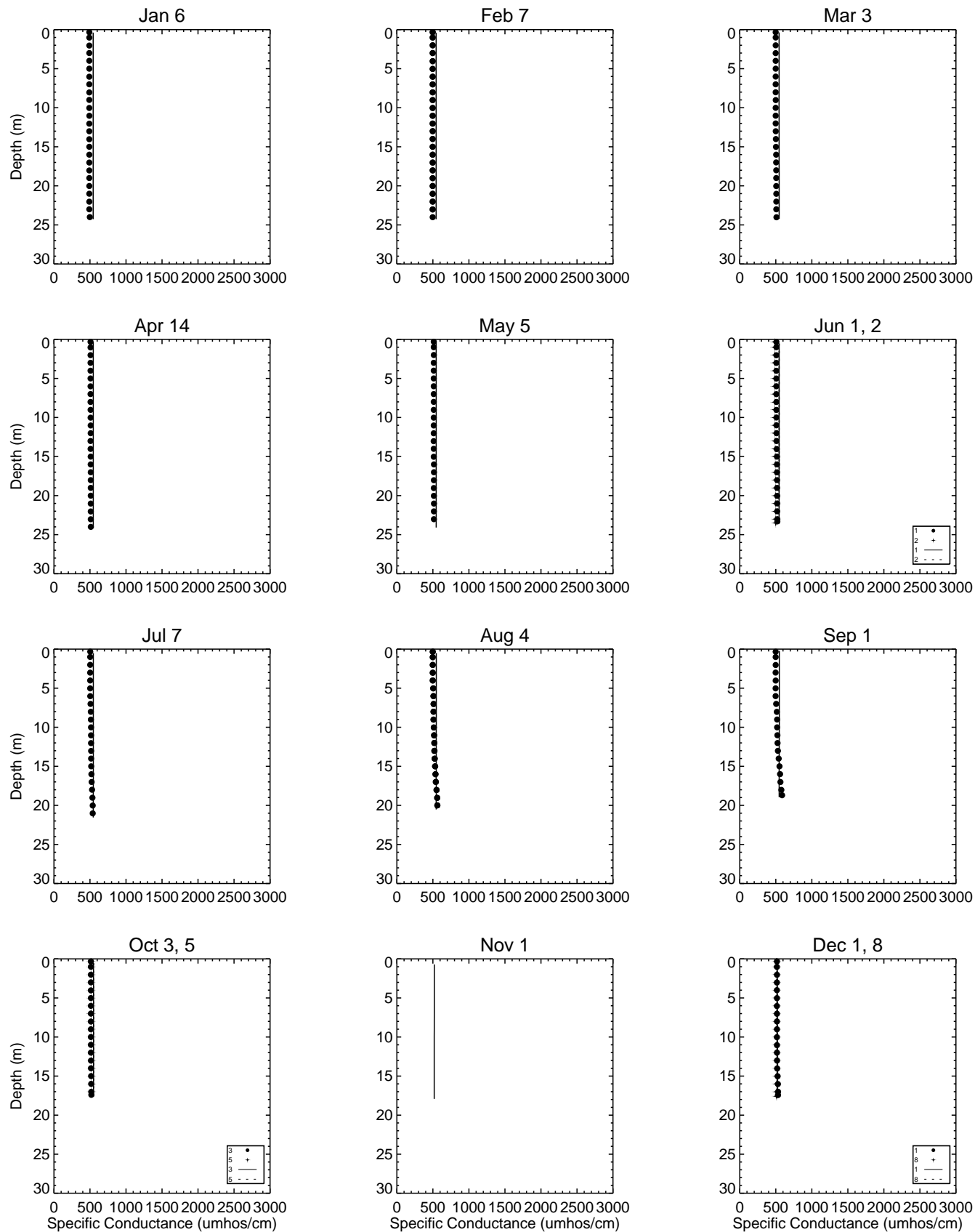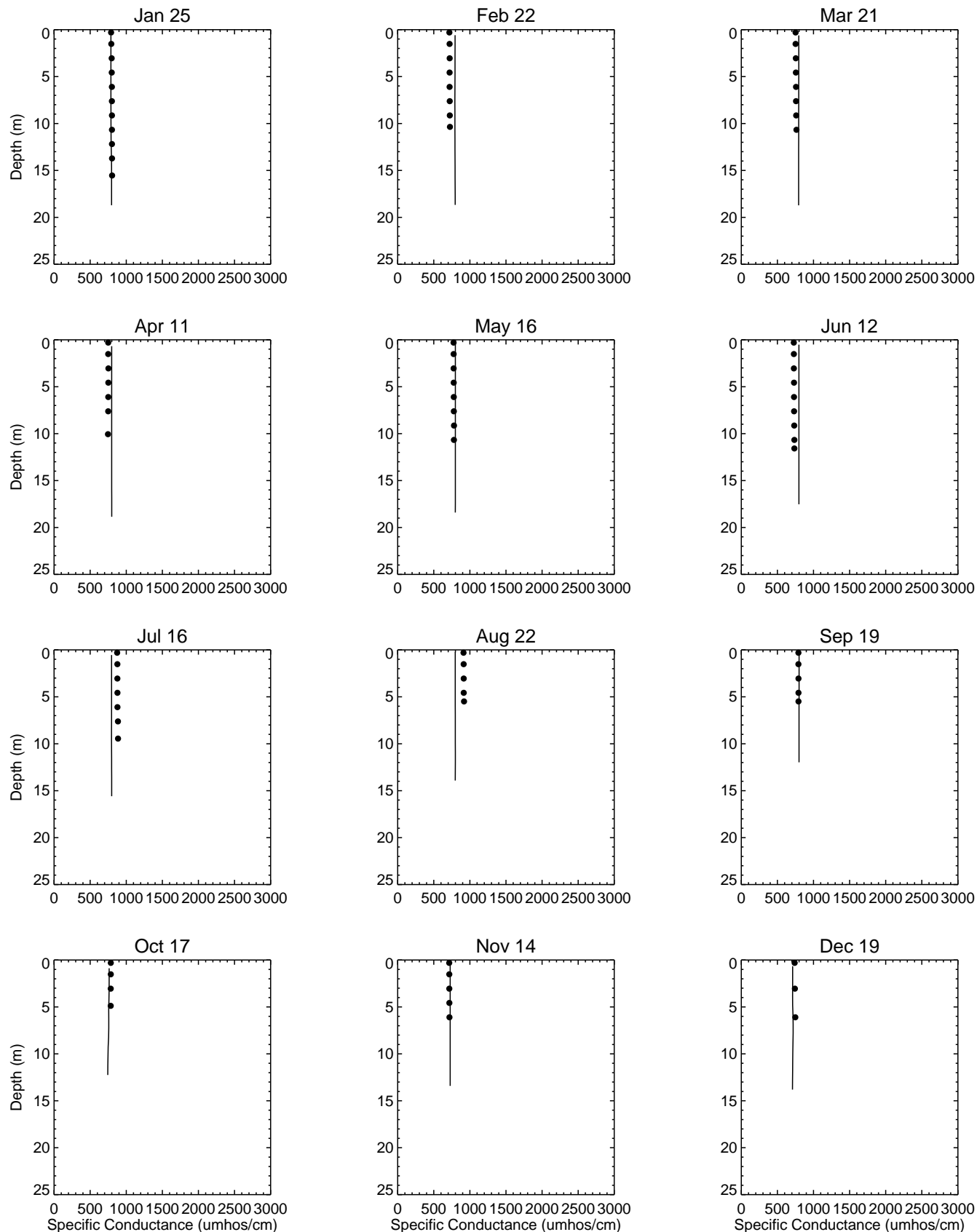*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:48 2013

Jan 18 Feb 16 Mar 15
Apr 19 May 17 Jun 20
Jul 20 Aug 15 Sep 12
Oct 10 Nov 8 Dec 14

Specific Conductance (umhos/cm)
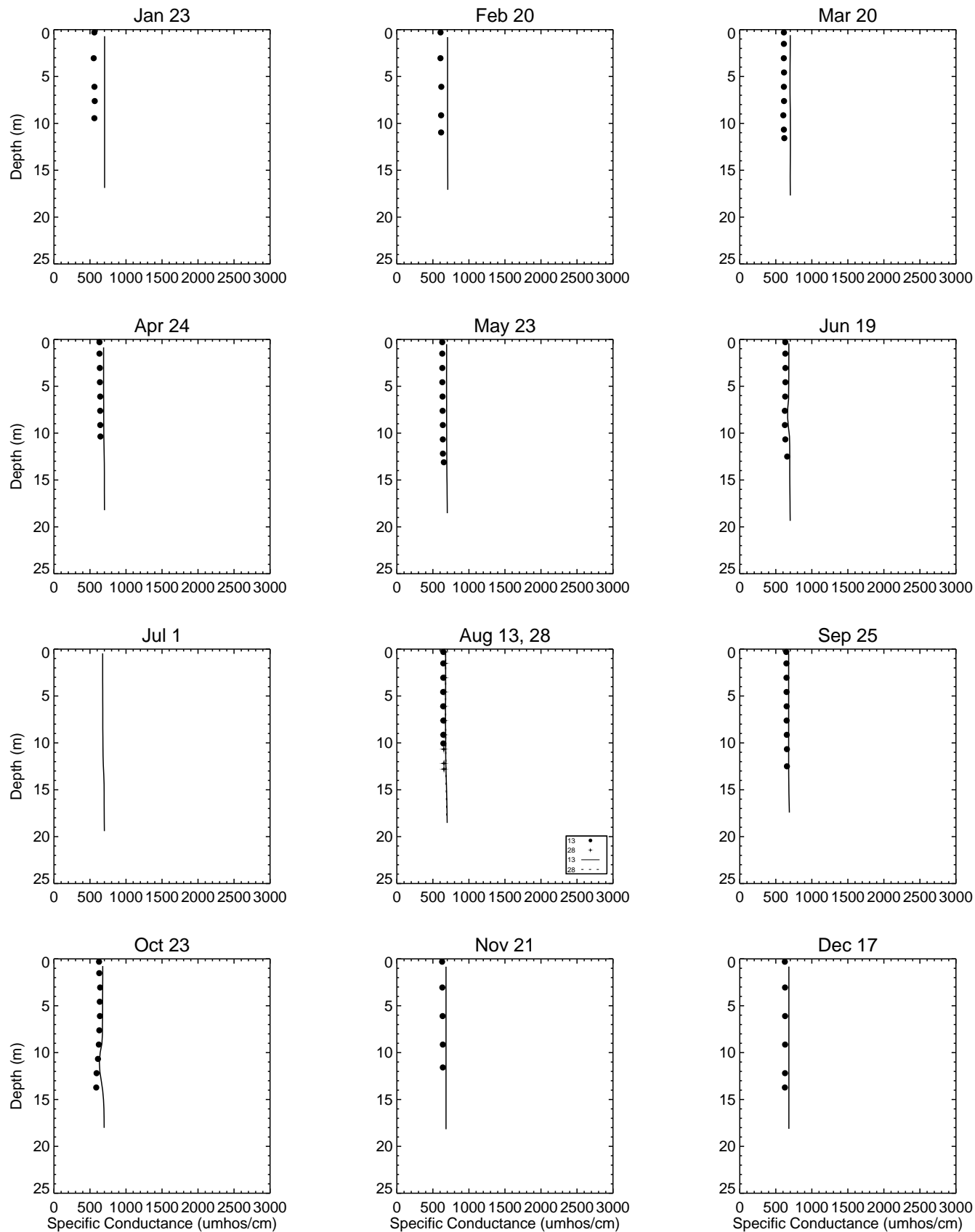
———— Model (w1210-48)
● Data

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 1988
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:48 2013

Jan 10 · Feb 20 · Mar 14 · Apr 18 · May 15 · Jun 22 · Jul 1 · Aug 21 · Sep 1 · Oct 19 · Nov 1 · Dec 21

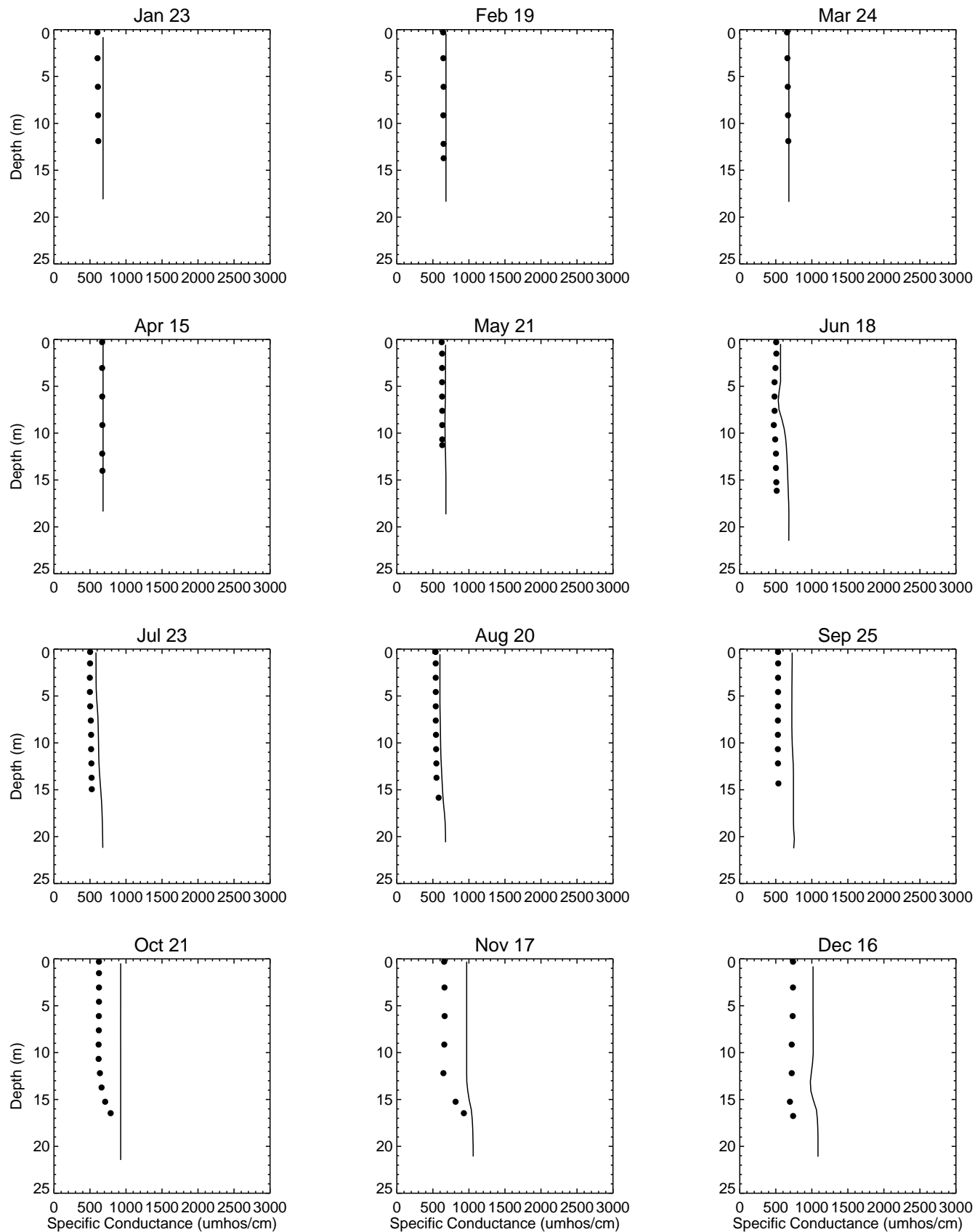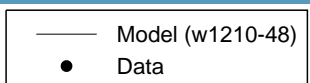Specific Conductance (umhos/cm)

——— Model (w1210-48)
● Data

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 1989

Profiles shown for dates with available data else model results for first day of month shown.
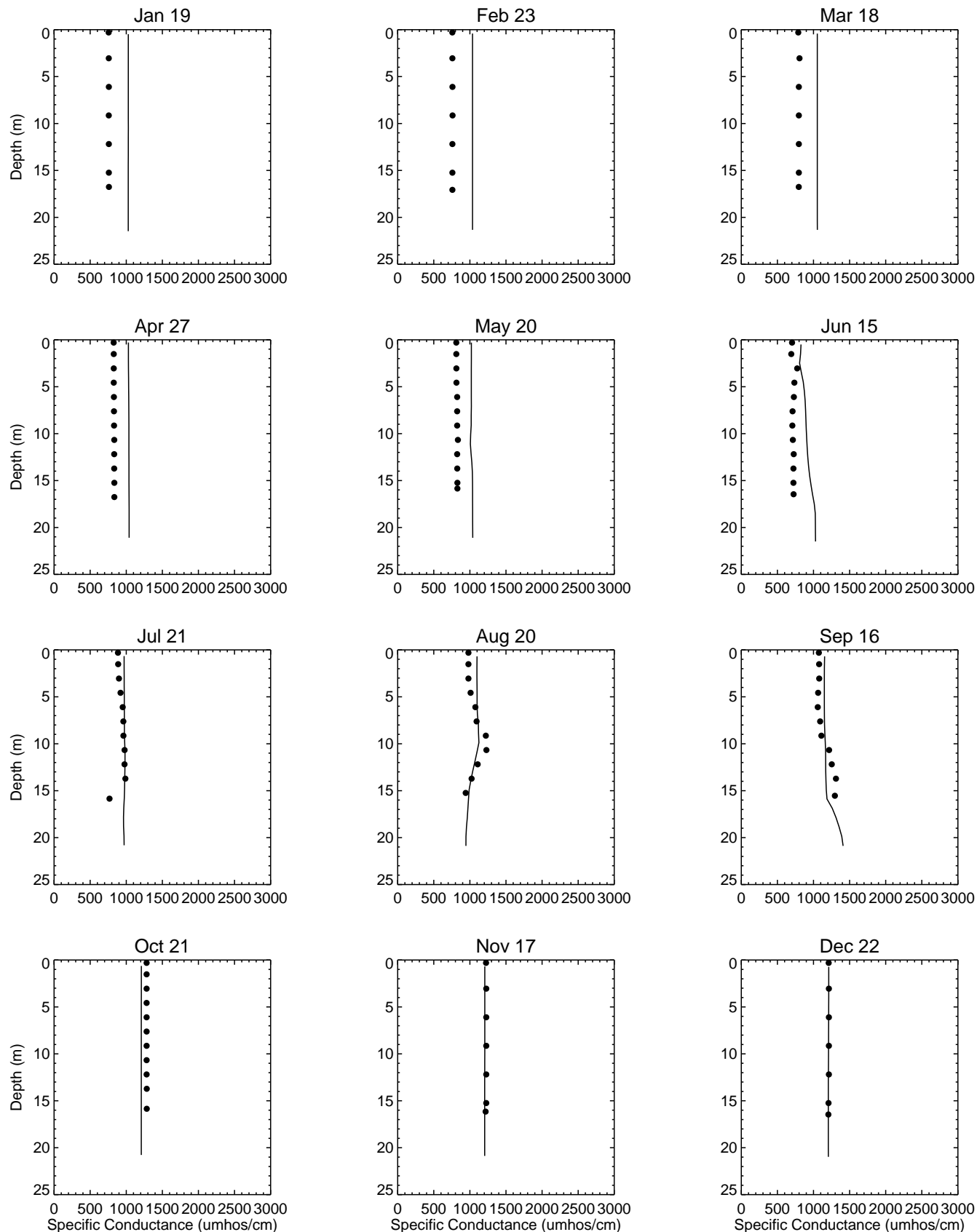
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:48 2013

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 1990

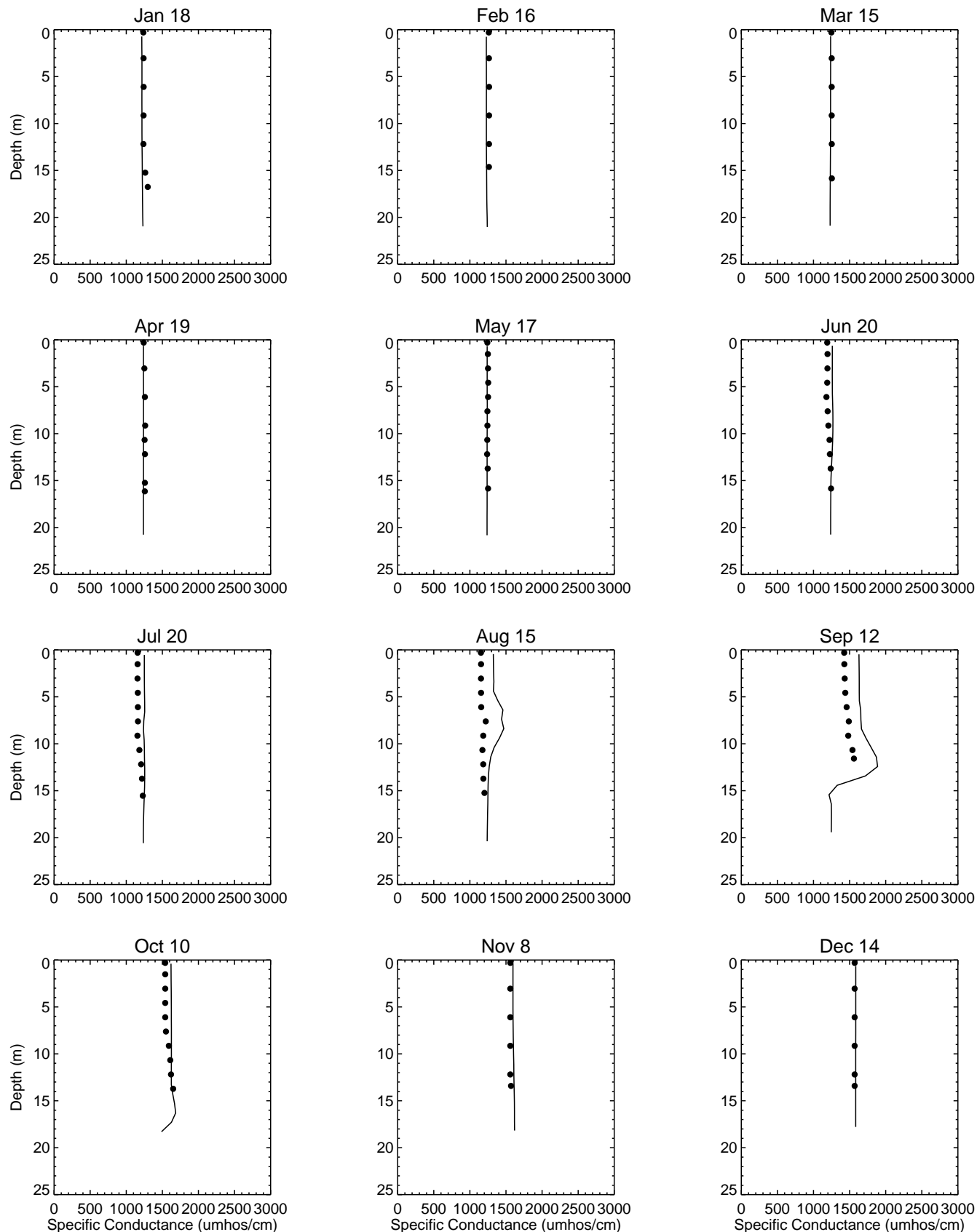*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:48 2013

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m)

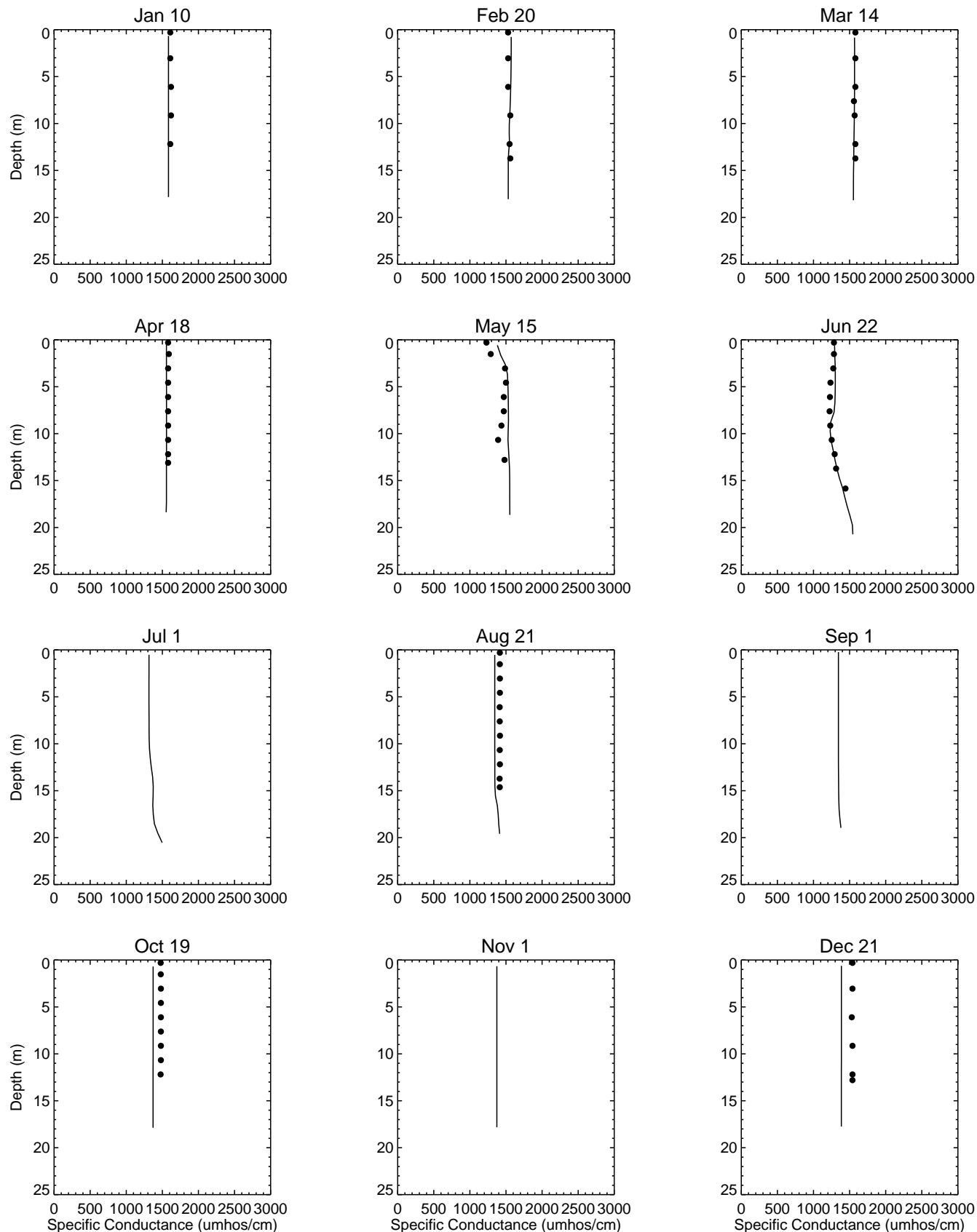Specific Conductance (umhos/cm)

Model (w1210-48)
● Data

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 1991

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Jan 1   Feb 1   Mar 1
Apr 1   May 1   Jun 1
Jul 1   Aug 1   Sep 1
Oct 1   Nov 1   Dec 1

Specific Conductance (umhos/cm)
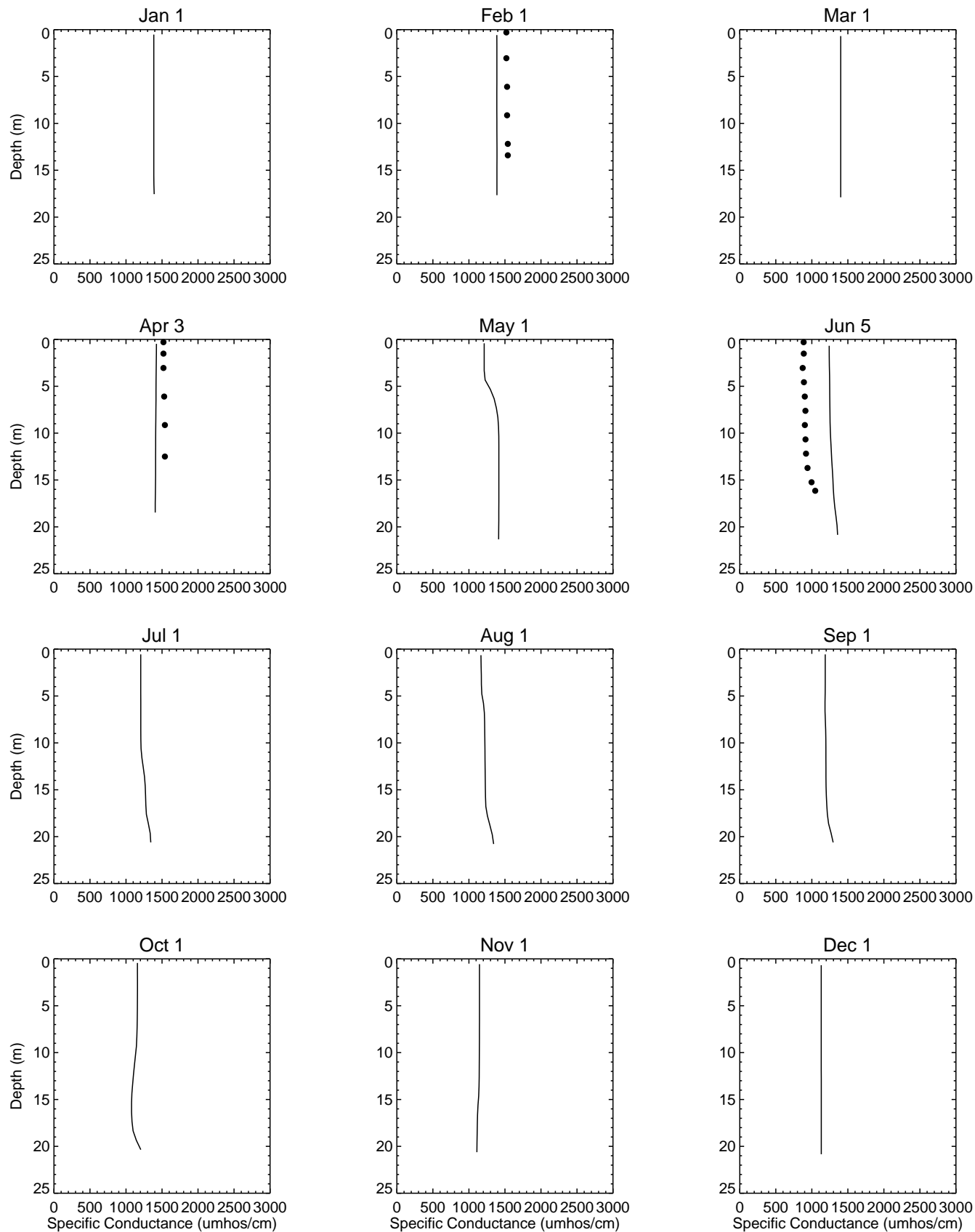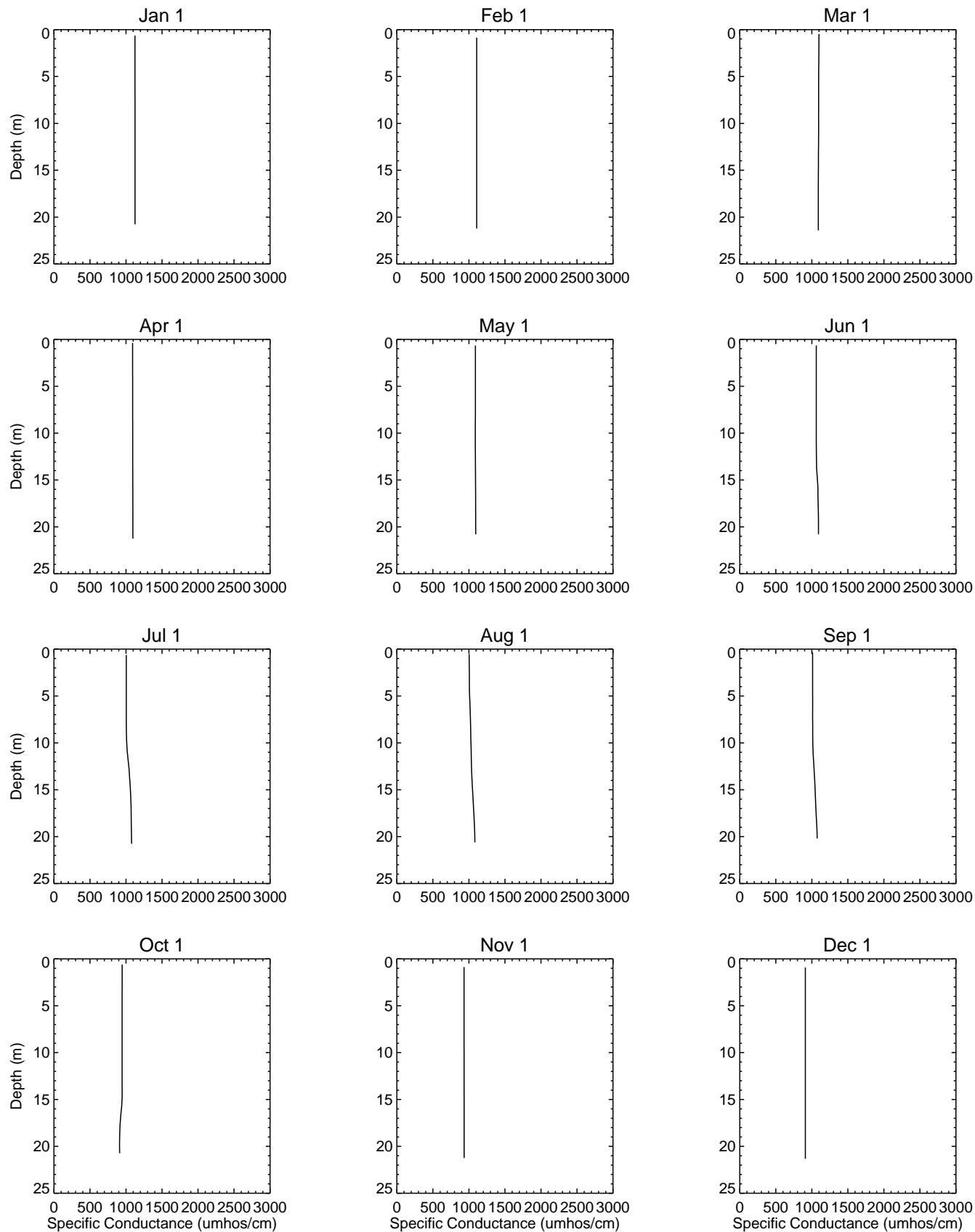
——— Model (w1210-48)
● Data

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 1992
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:48 2013

Jan 1 | Feb 1 | Mar 1 | Apr 1 | May 1 | Jun 1 | Jul 1 | Aug 1 | Sep 1 | Oct 1 | Nov 1 | Dec 1

Specific Conductance (umhos/cm)

Model (w1210-48)
● Data

ANCHOR
QEA
PARSONS

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 1994

Profiles shown for dates with available data else model results for first day of month shown.
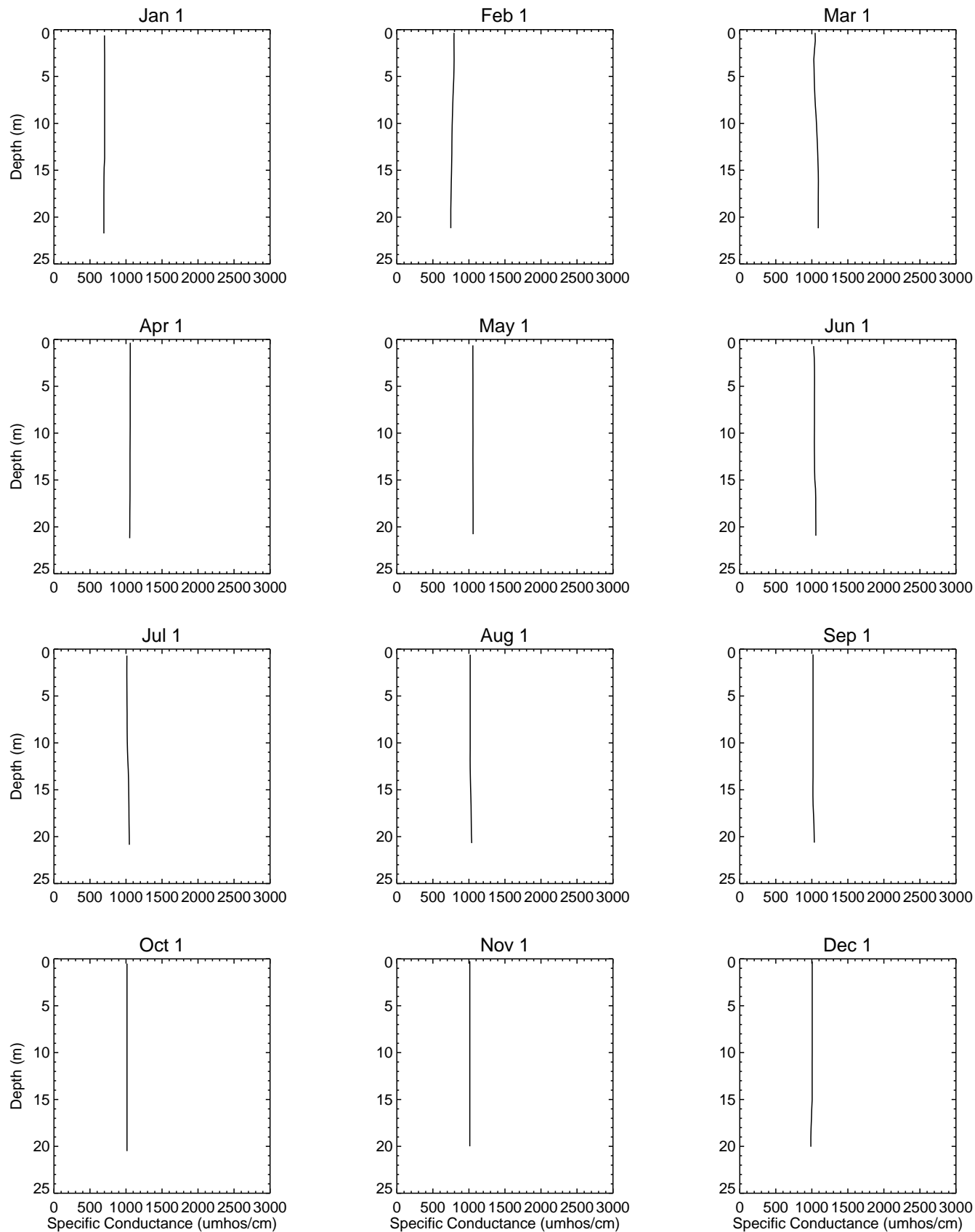
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:48 2013
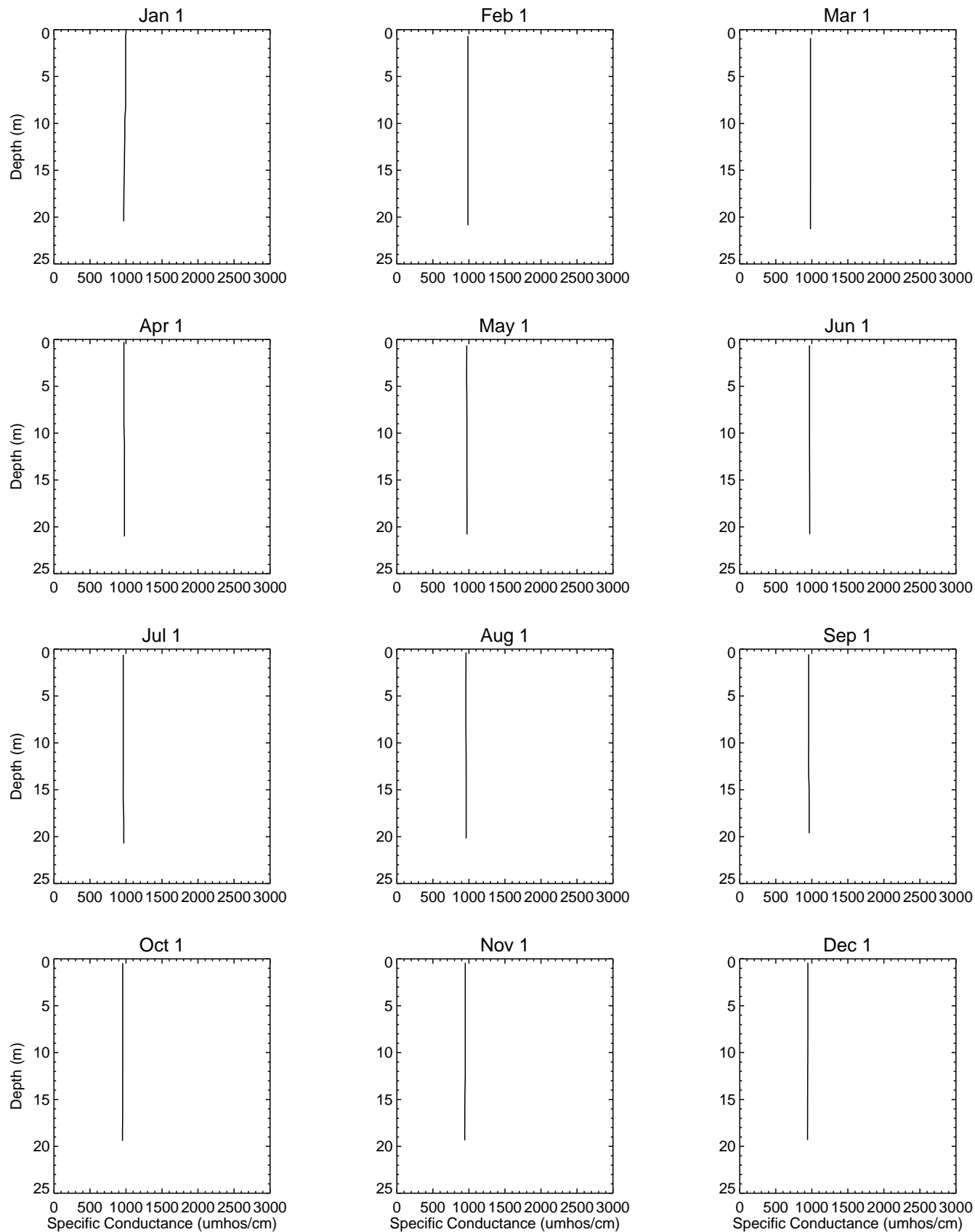
Model (w1210-48)
● Data

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 1995

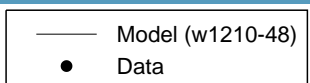*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 1997

Profiles shown for dates with available data else model results for first day of month shown.
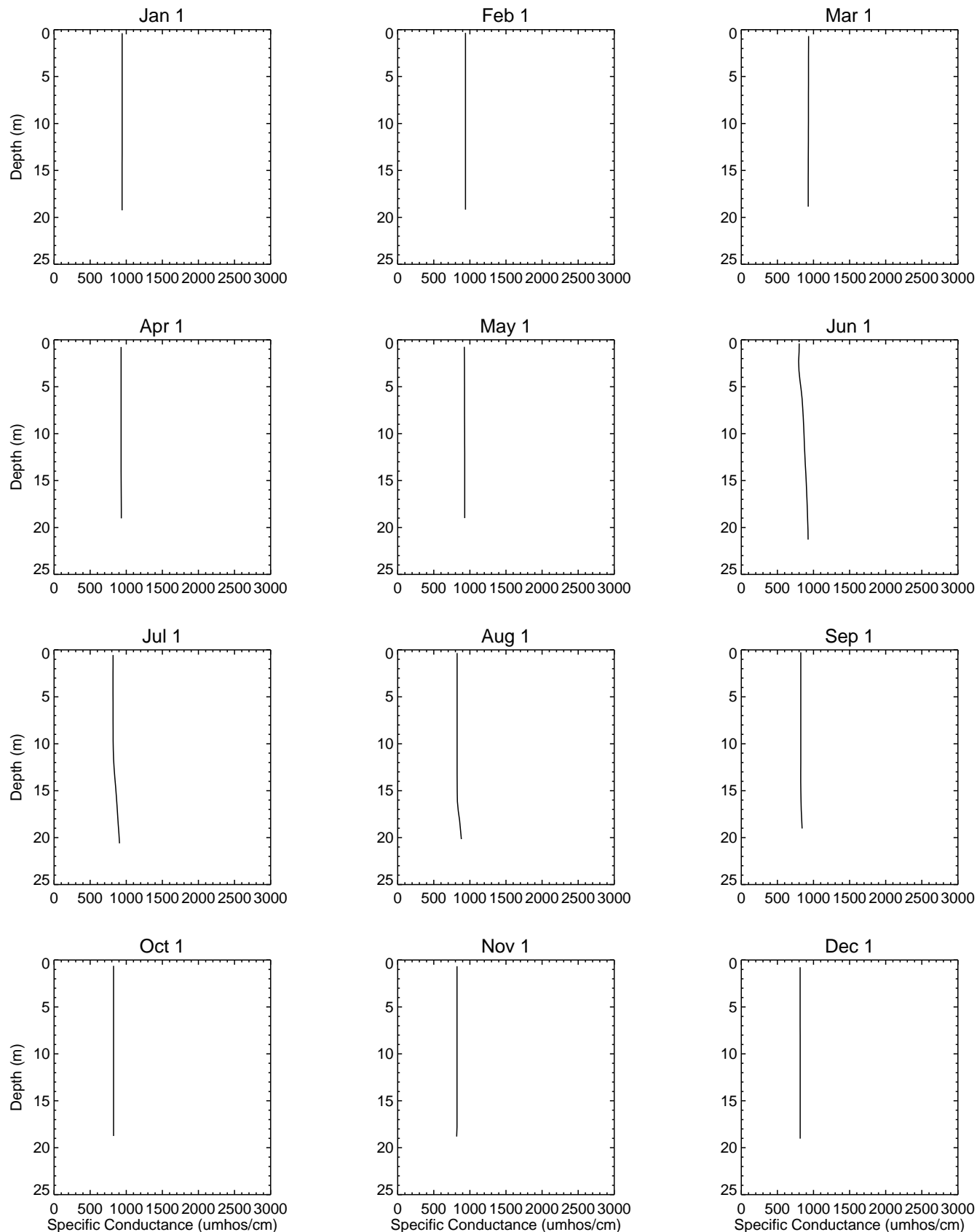
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:48 2013

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m)

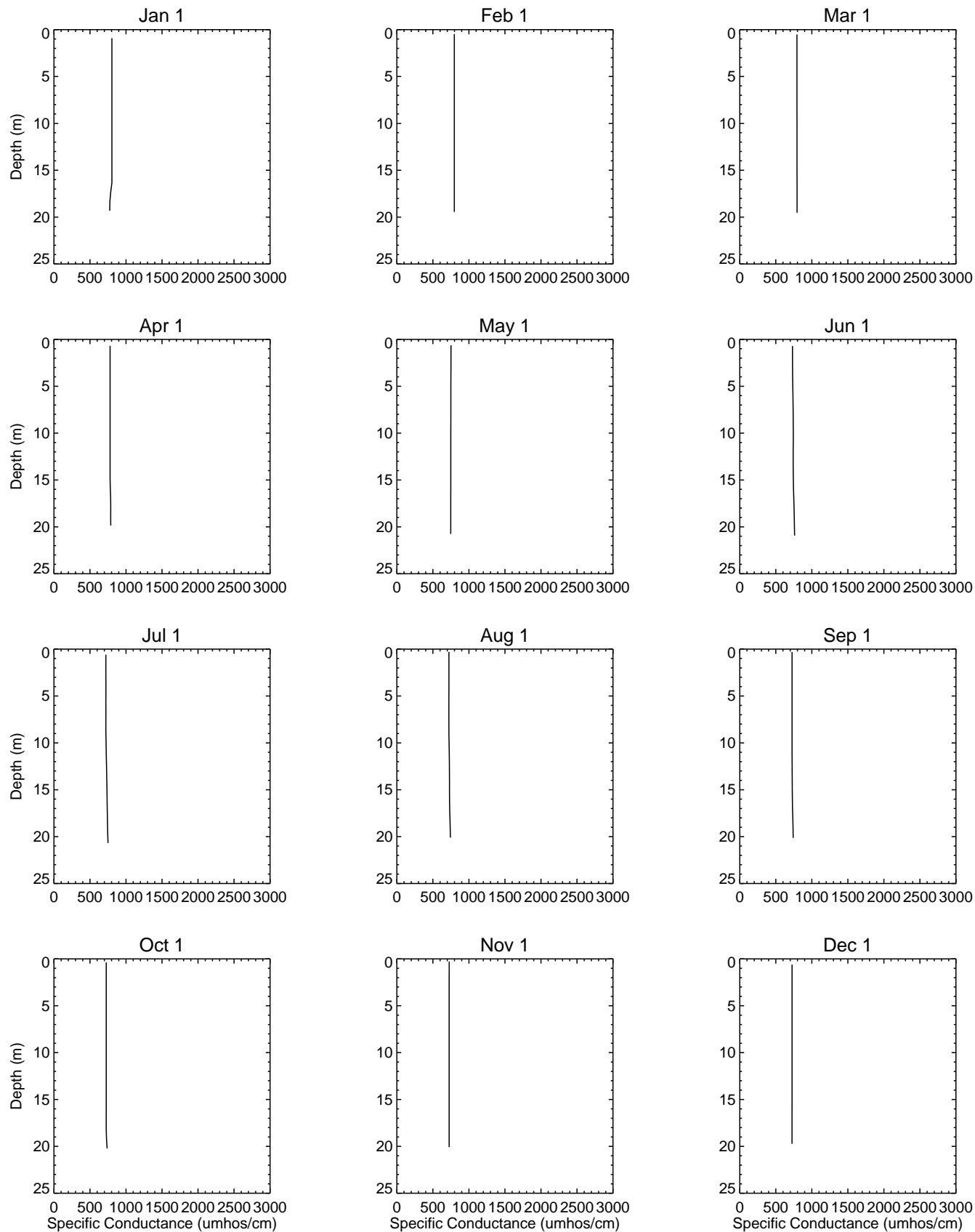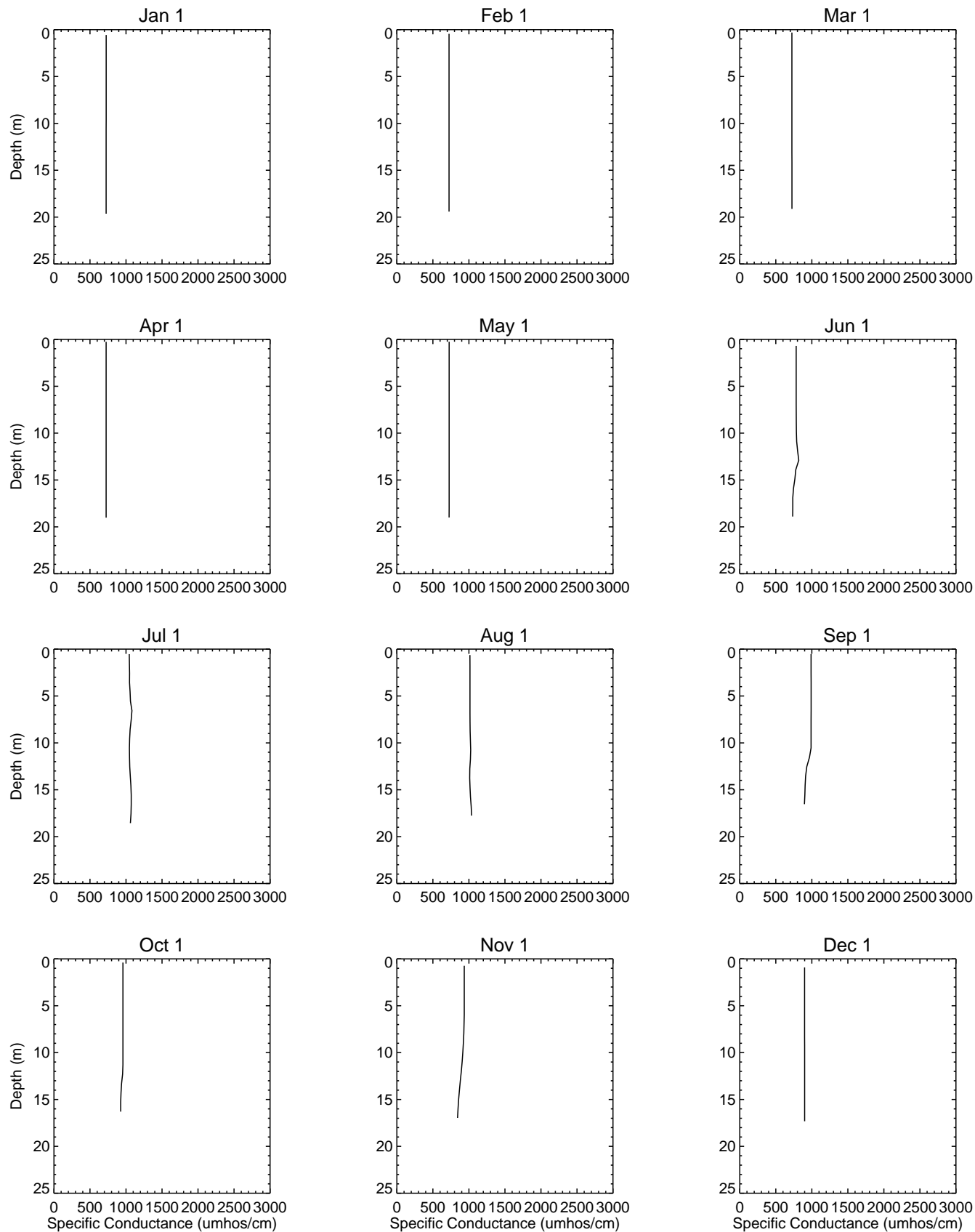Specific Conductance (umhos/cm)

——— Model (w1210-48)

● Data

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 1998

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
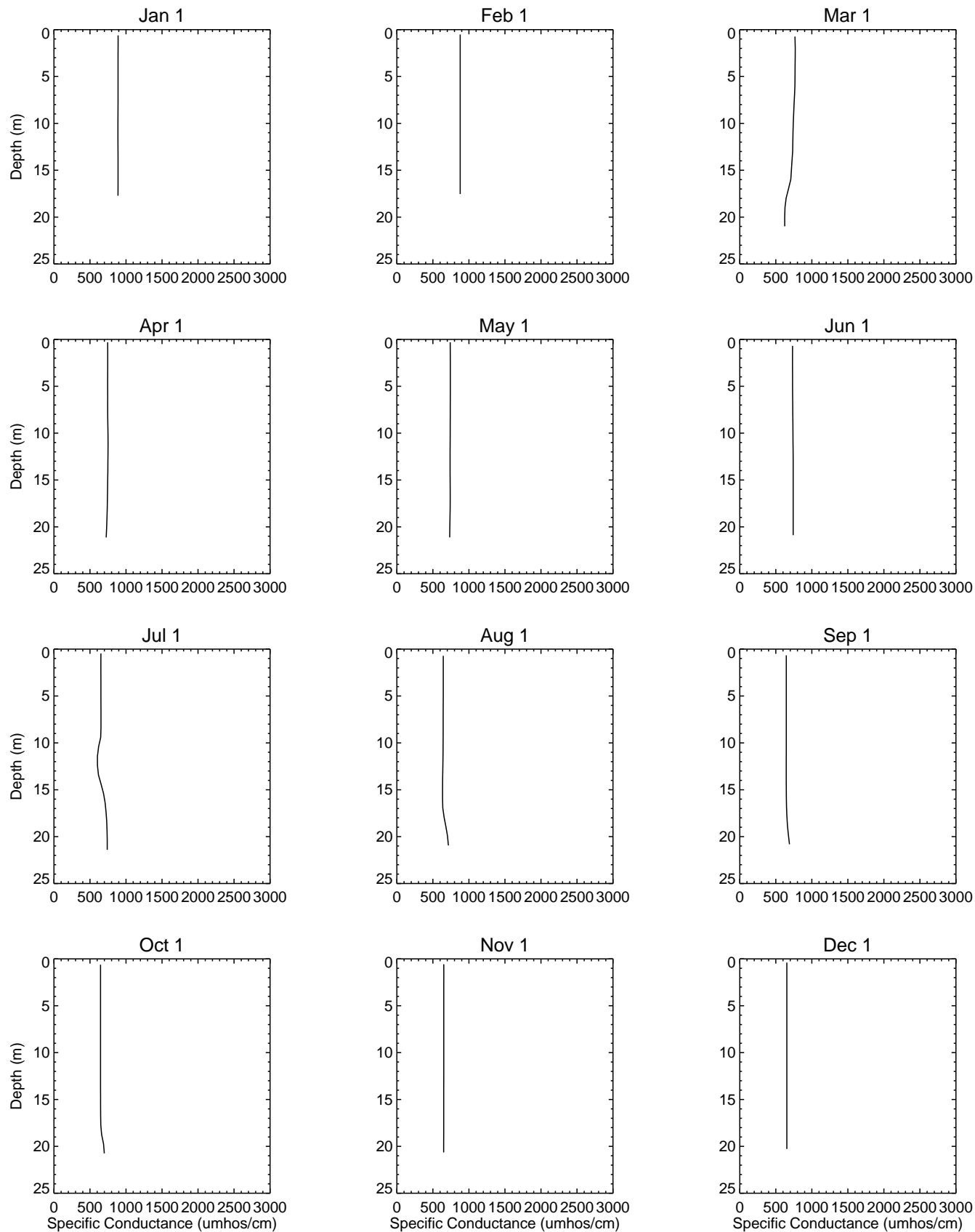Fri Jan 25 18:13:48 2013

Model (w1210-48)
● Data

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 1999

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
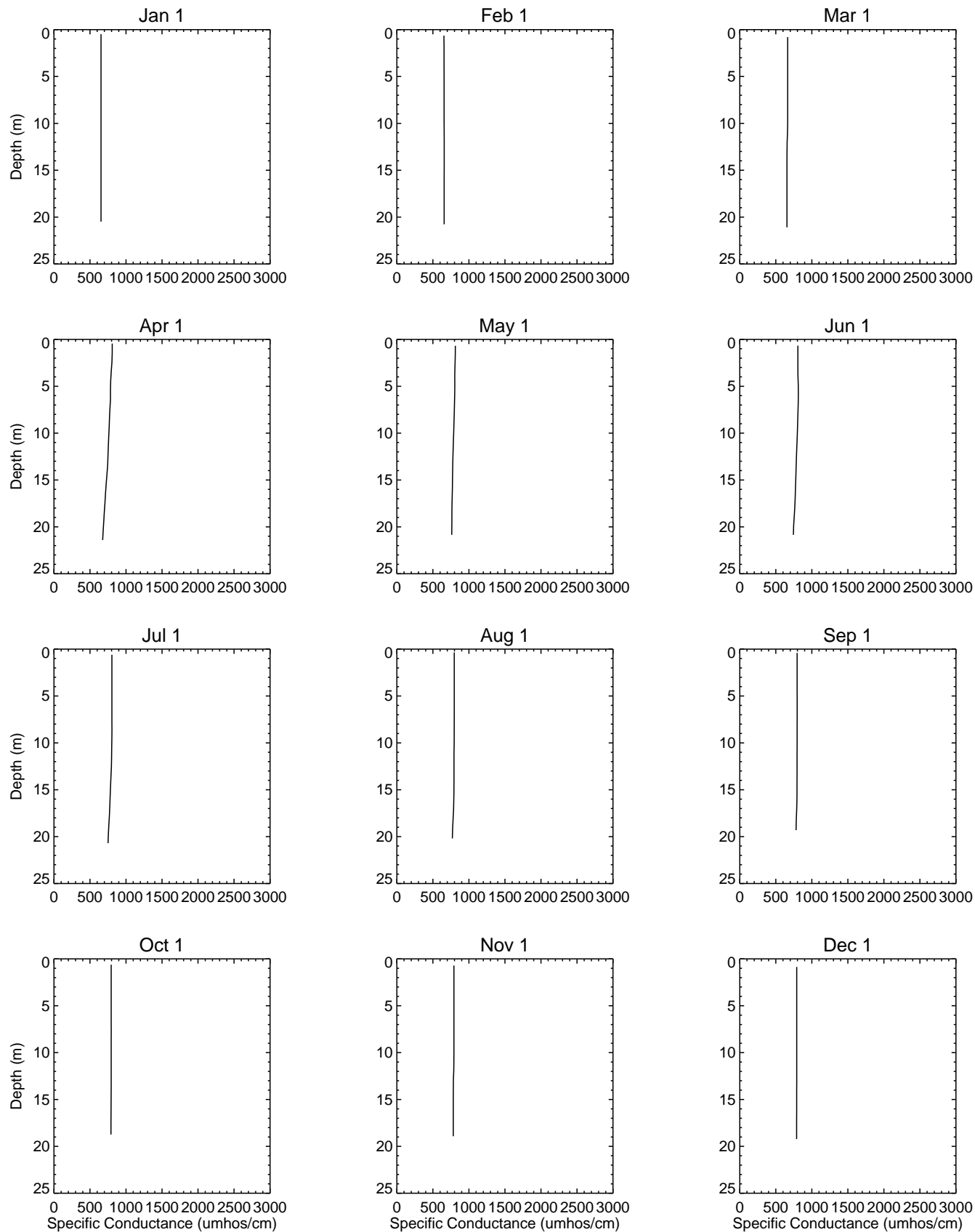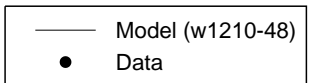Fri Jan 25 18:13:48 2013

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 2000

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:49 2013

Jan 1   Feb 1   Mar 1

Apr 1   May 1   Jun 1

Jul 1   Aug 1   Sep 1

Oct 1   Nov 1   Dec 1

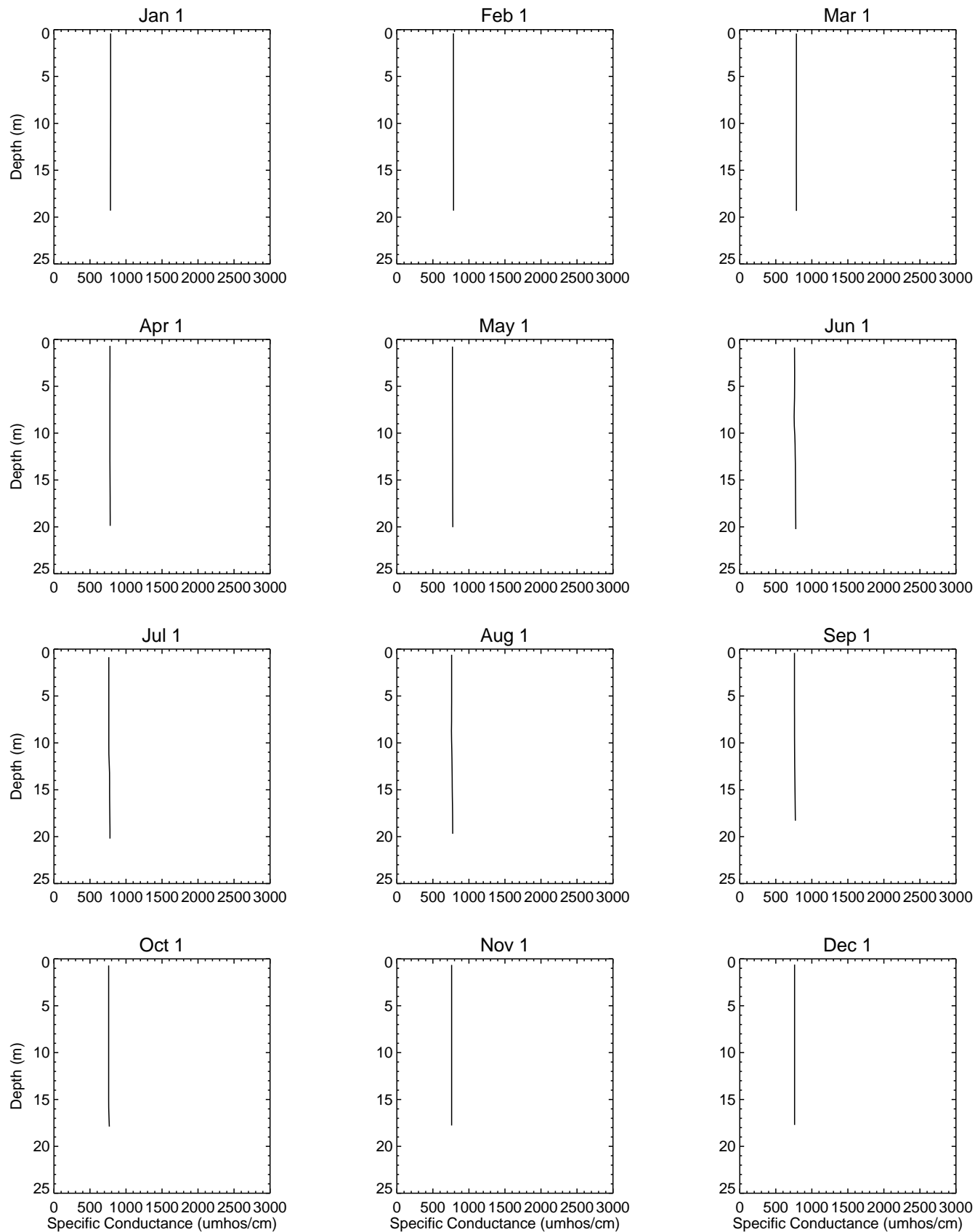Specific Conductance (umhos/cm)

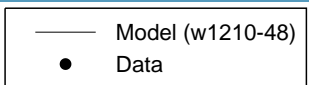——— Model (w1210-48)
●   Data

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 2001

Profiles shown for dates with available data else model results for first day of month shown.

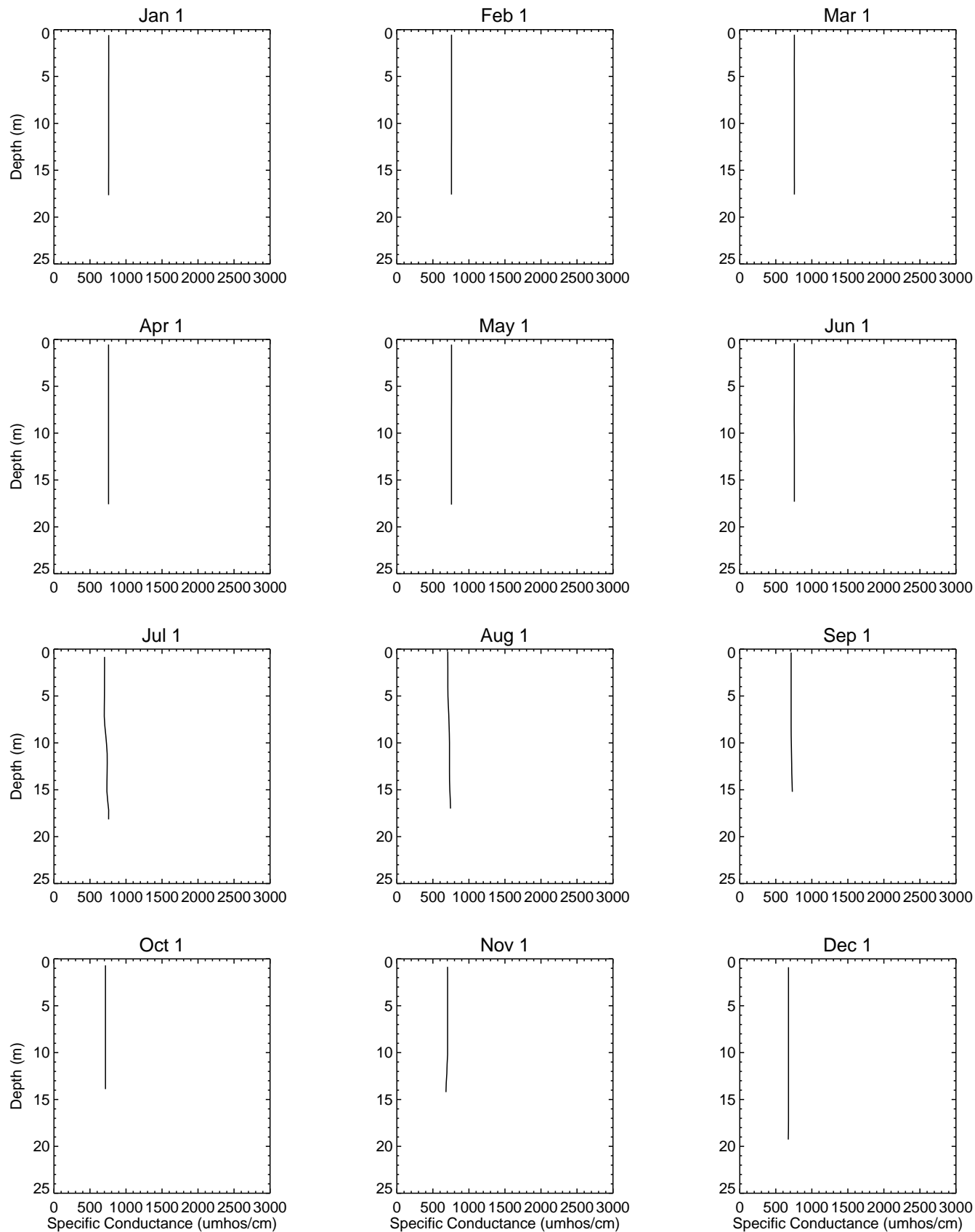CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 2002

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

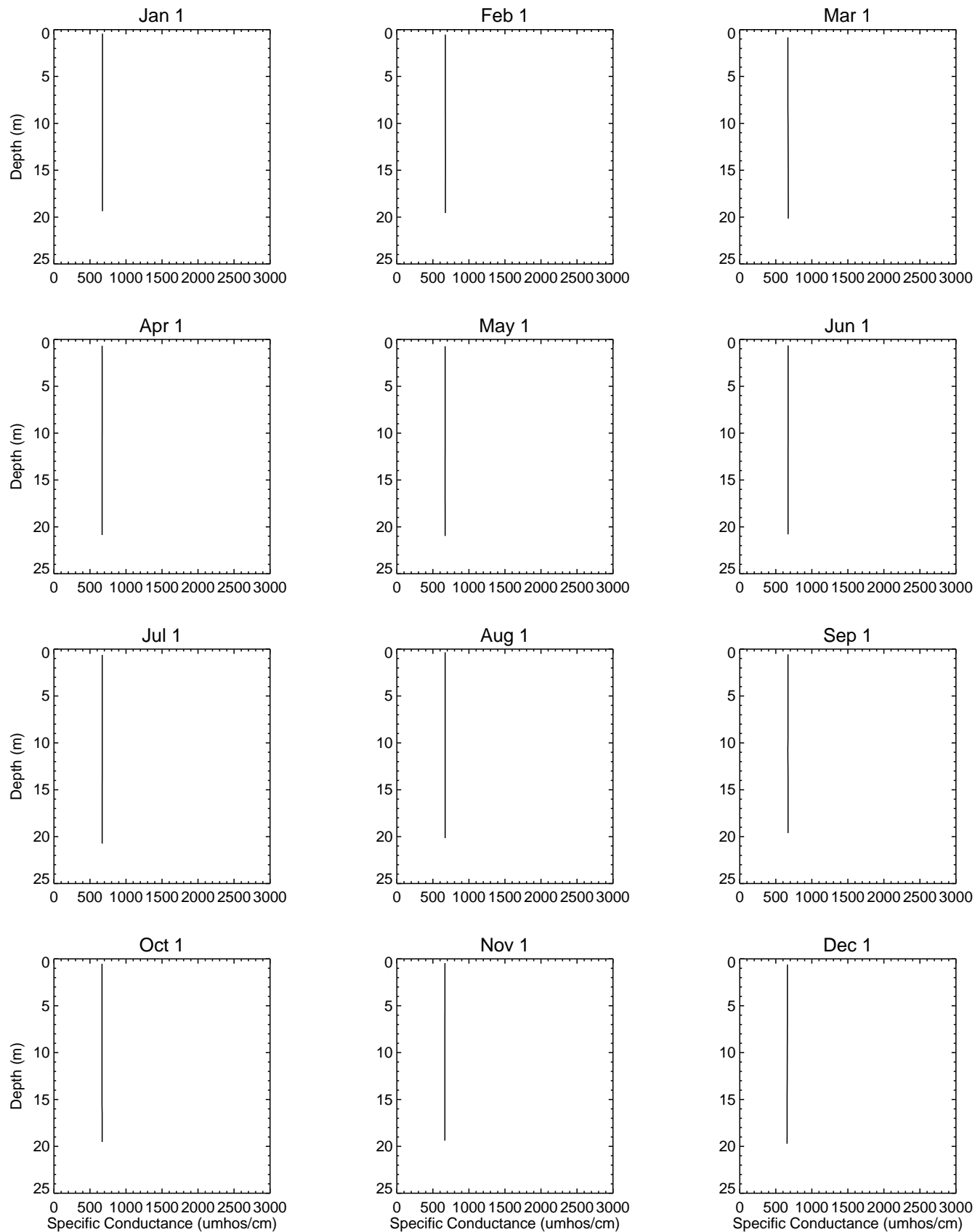Figure G-16
Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 2004
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority
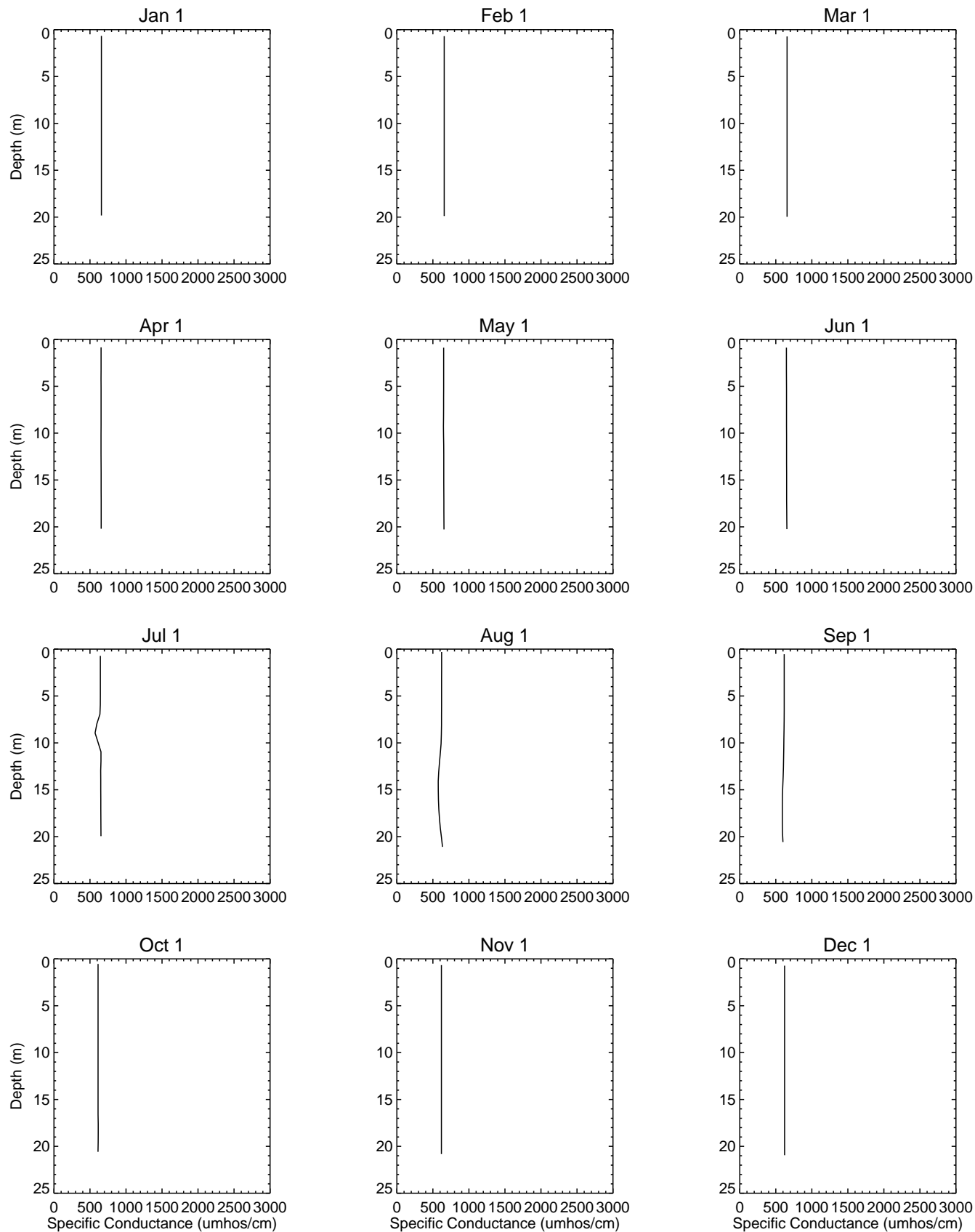
Model (w1210-48)
● Data

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 2005
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m)

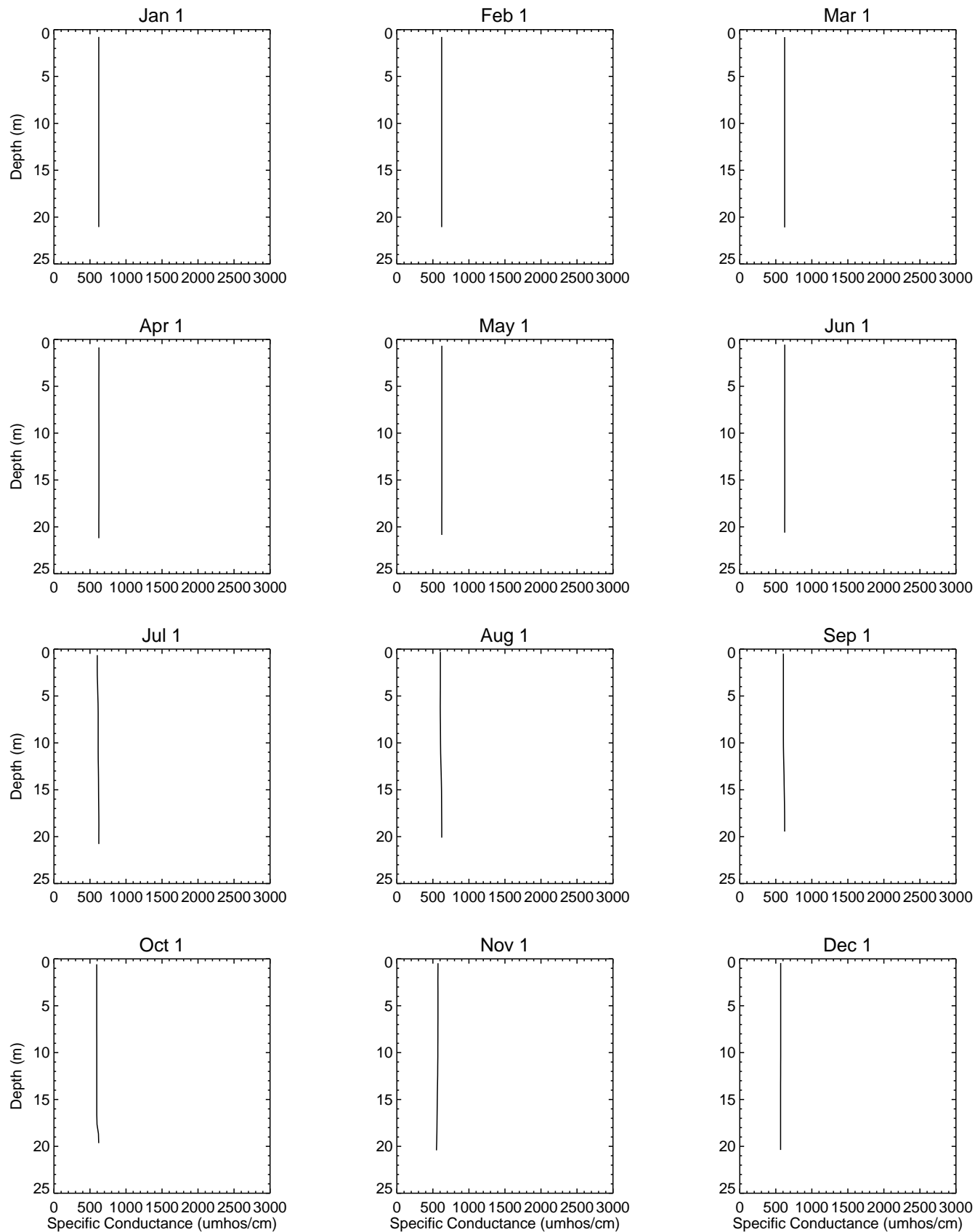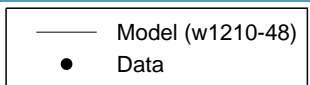Specific Conductance (umhos/cm)

Model (w1210-48)
• Data

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 2006

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
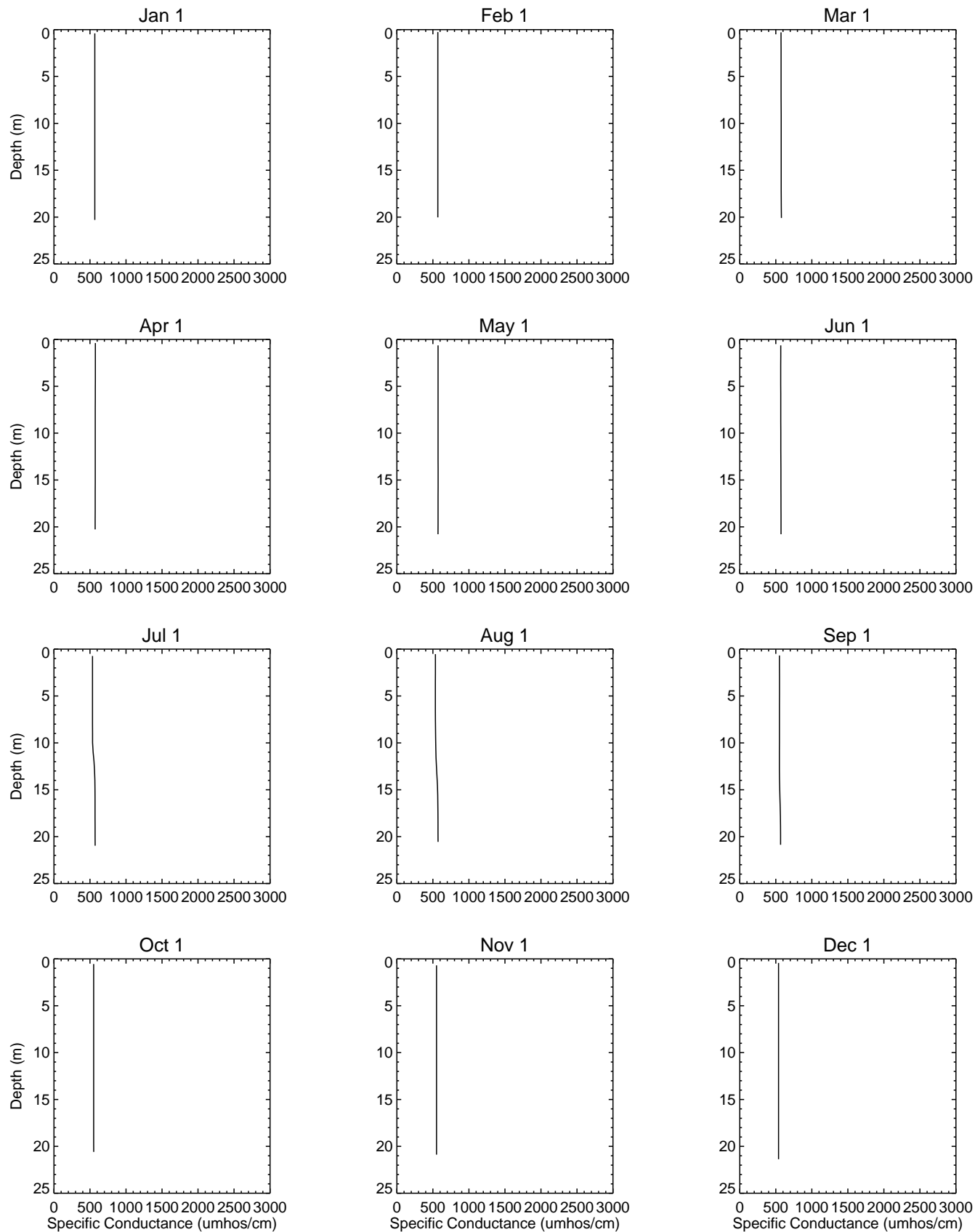Fri Jan 25 18:13:49 2013

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 2007

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 4 · Mar 1 · Apr 3 · May 1 · Jun 12 · Jul 1 · Aug 7 · Sep 1 · Oct 9 · Nov 1 · Dec 4

Specific Conductance (umhos/cm)
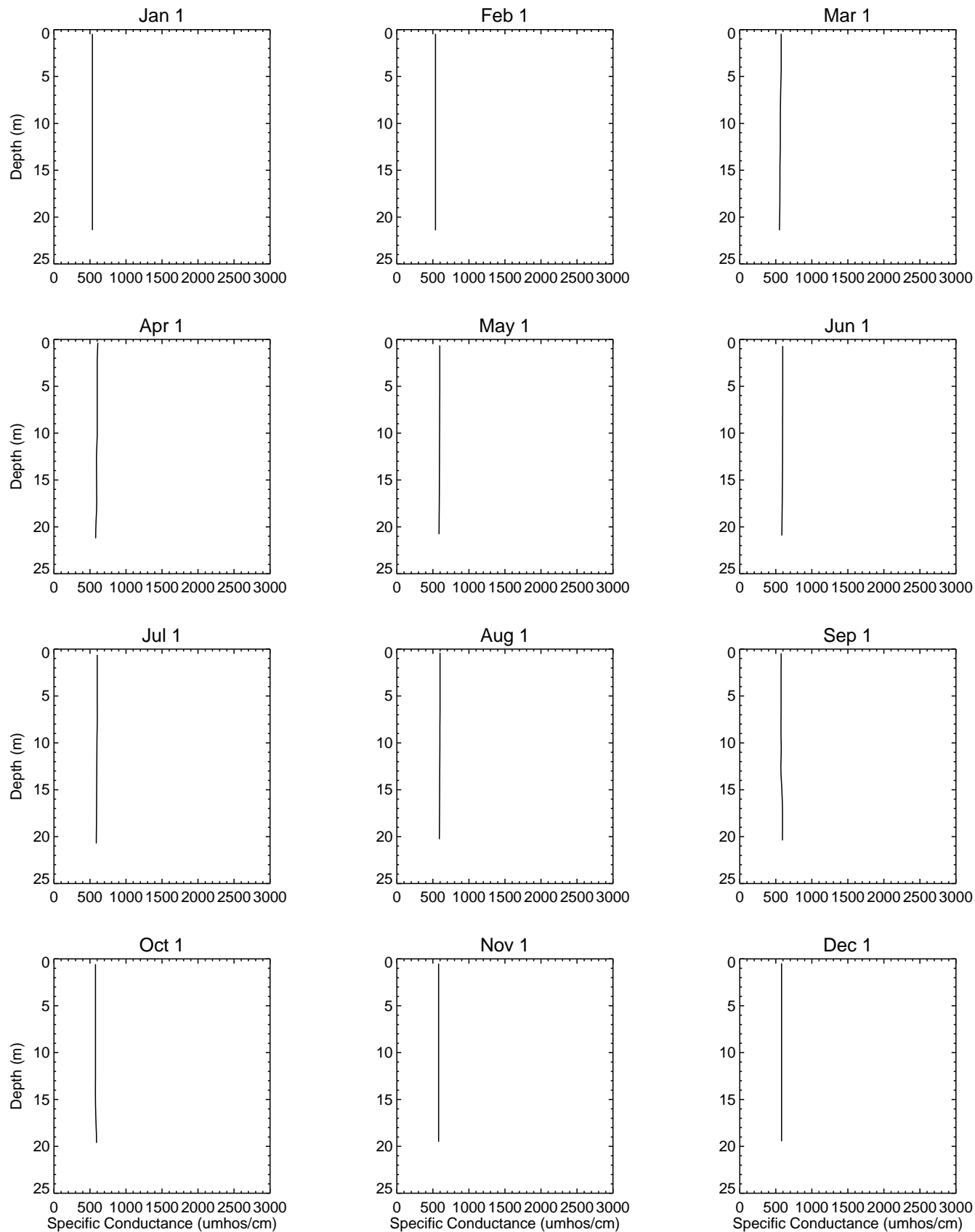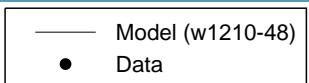
—— Model (w1210-48)
● Data

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 2008
Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR
QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:49 2013

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 2010

Profiles shown for dates with available data else model results for first day of month shown.
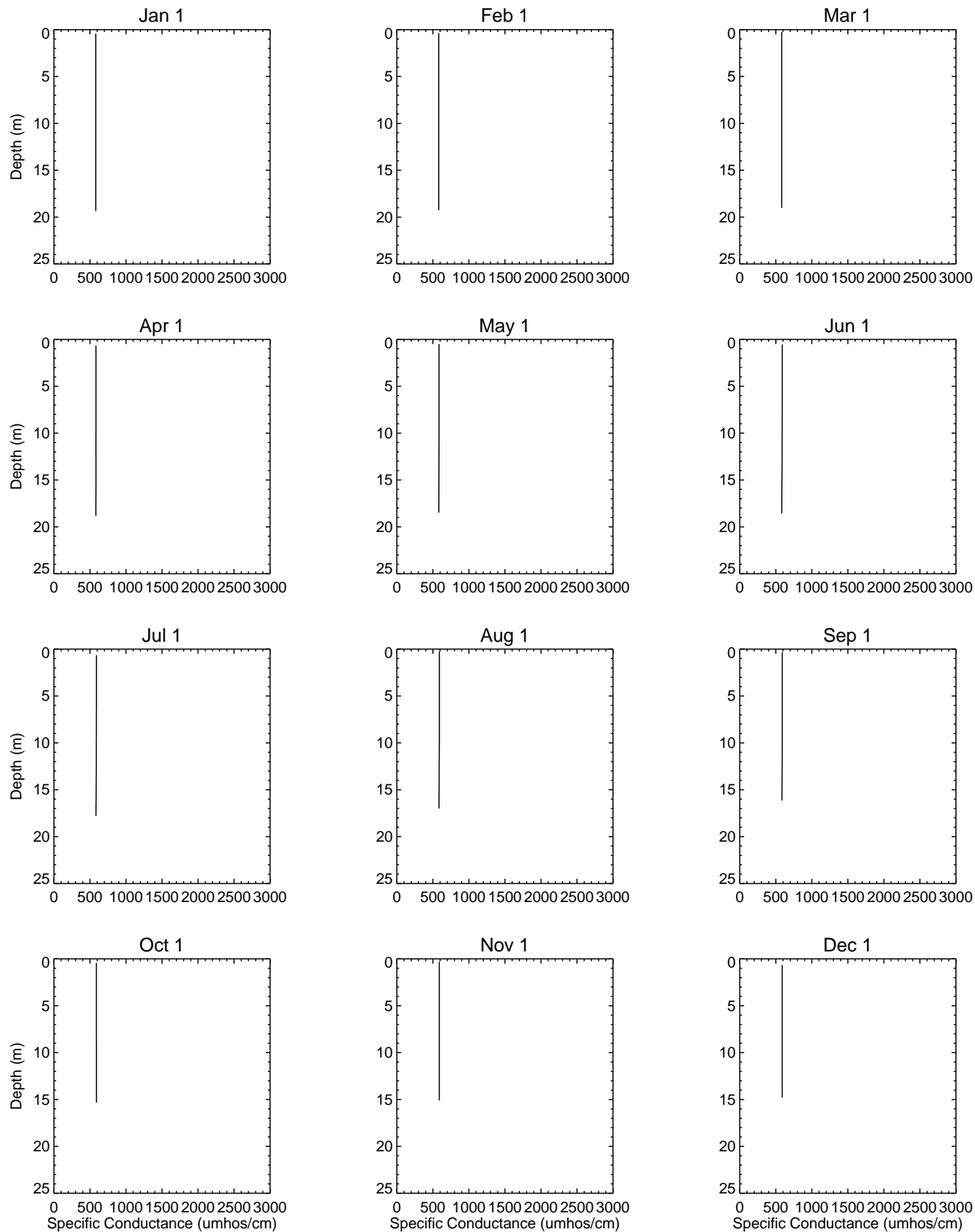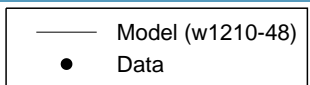
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-16

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Specific Conductance - 2011

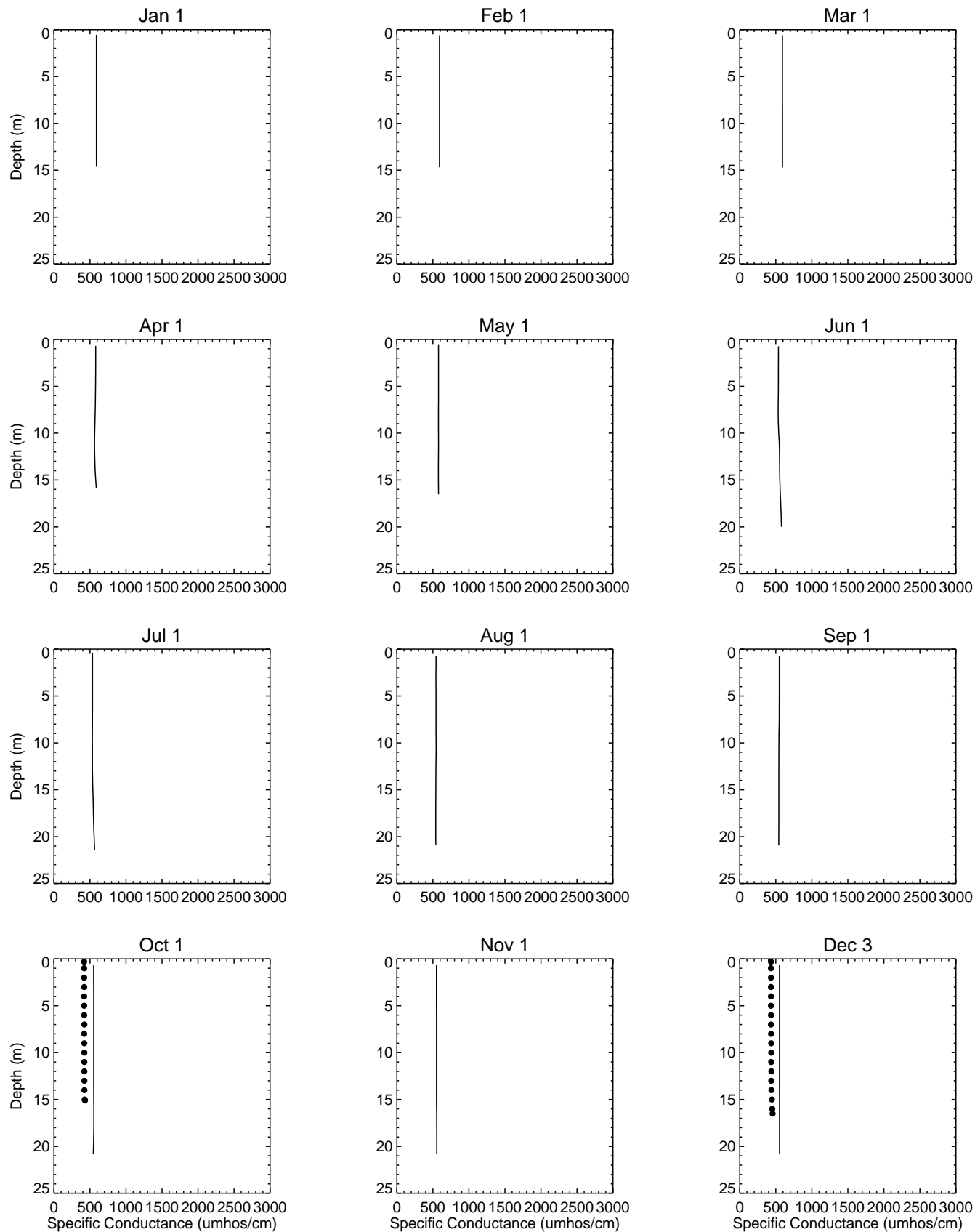*Profiles shown for dates with available data else model results for first day of month shown.*
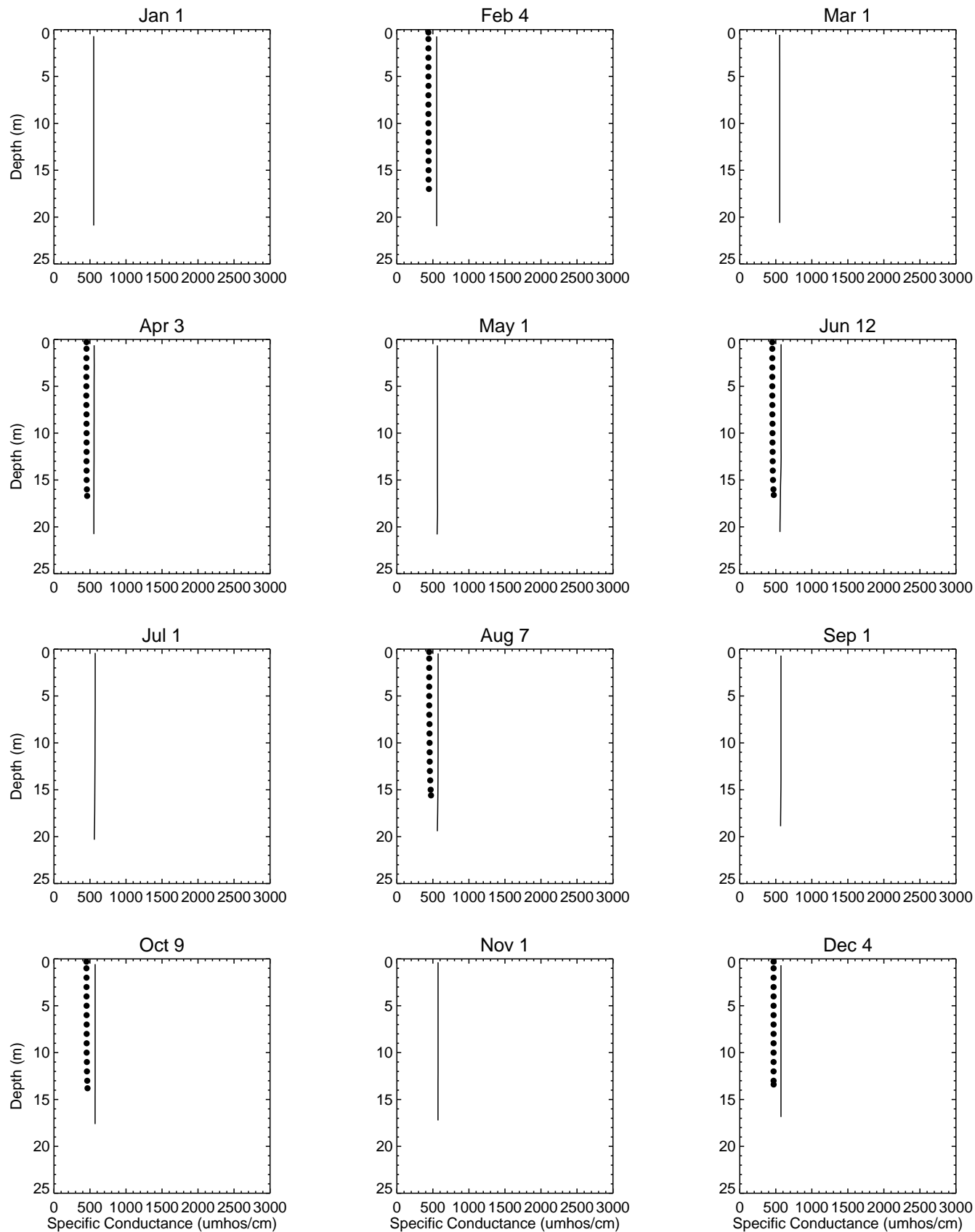
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Model (w1210-48)

● Data

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 1984

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 1985

Profiles shown for dates with available data else model results for first day of month shown.

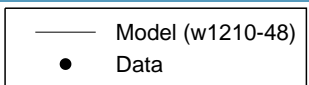CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 1986

Profiles shown for dates with available data else model results for first day of month shown.

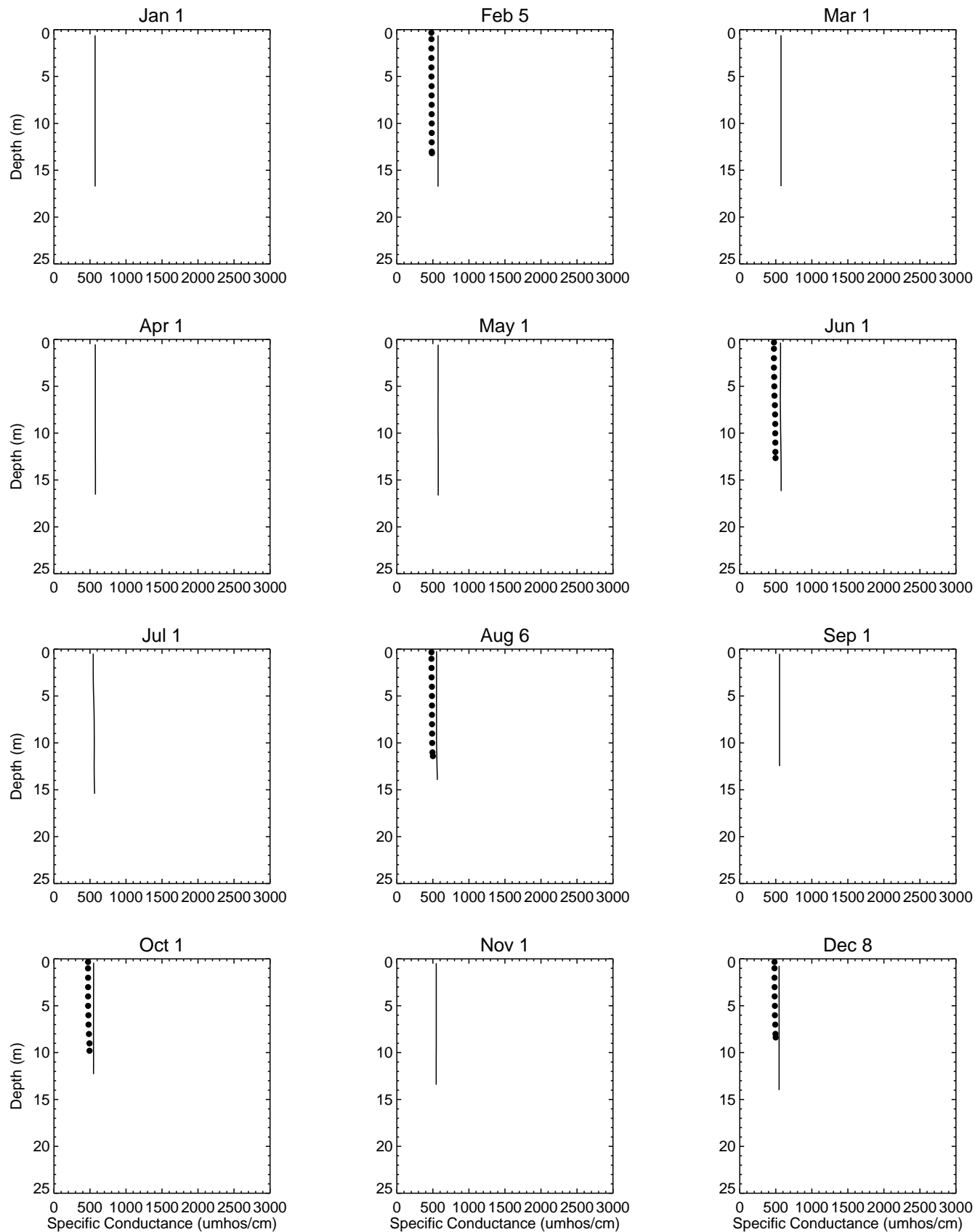CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:51 2013

Jan 19 · Feb 23 · Mar 18 · Apr 27 · May 20 · Jun 15 · Jul 21 · Aug 20 · Sep 16 · Oct 21 · Nov 17 · Dec 22

Specific Conductance (umhos/cm)

——— Model (w1210-48)
● Data

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 1987

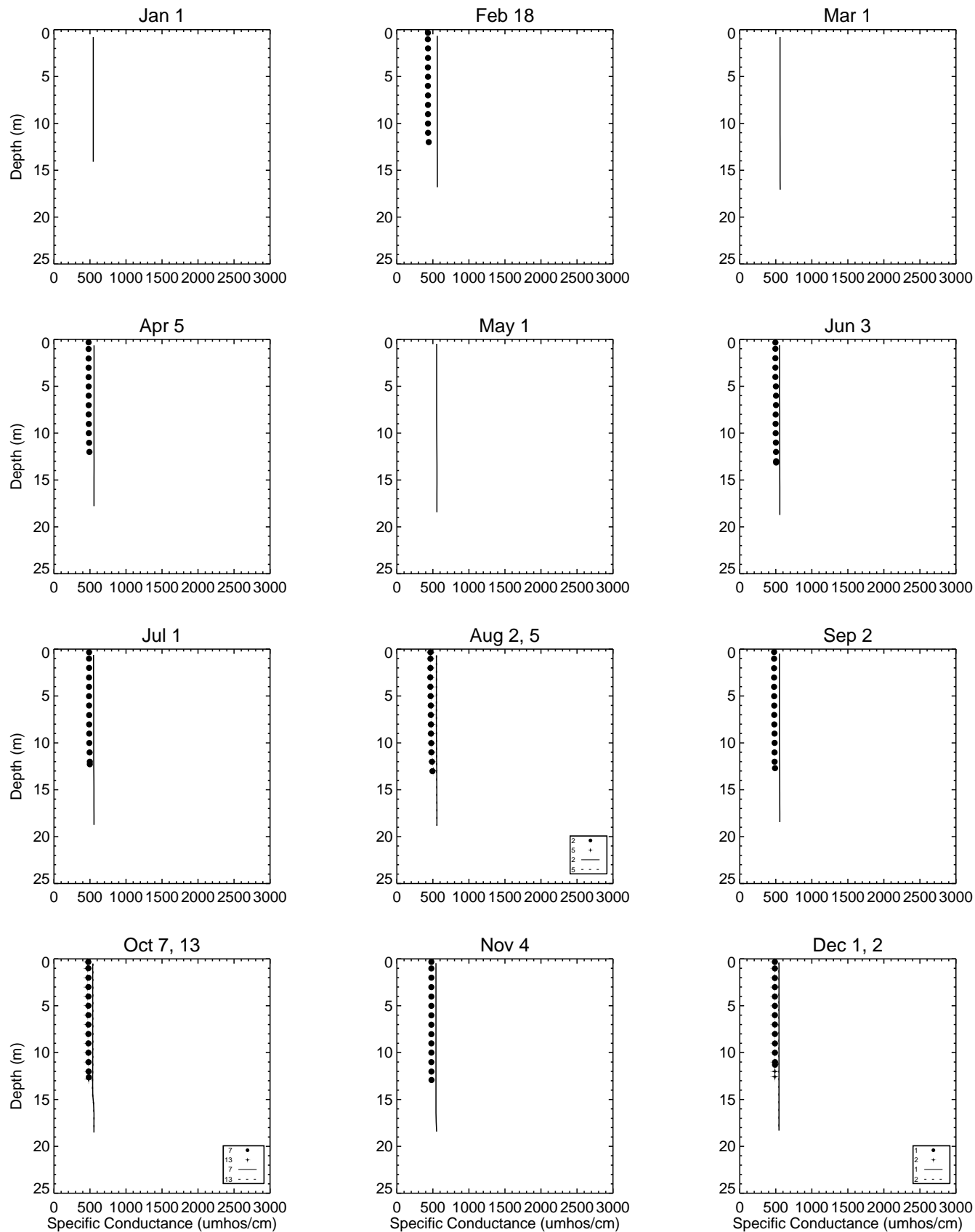*Profiles shown for dates with available data else model results for first day of month shown.*

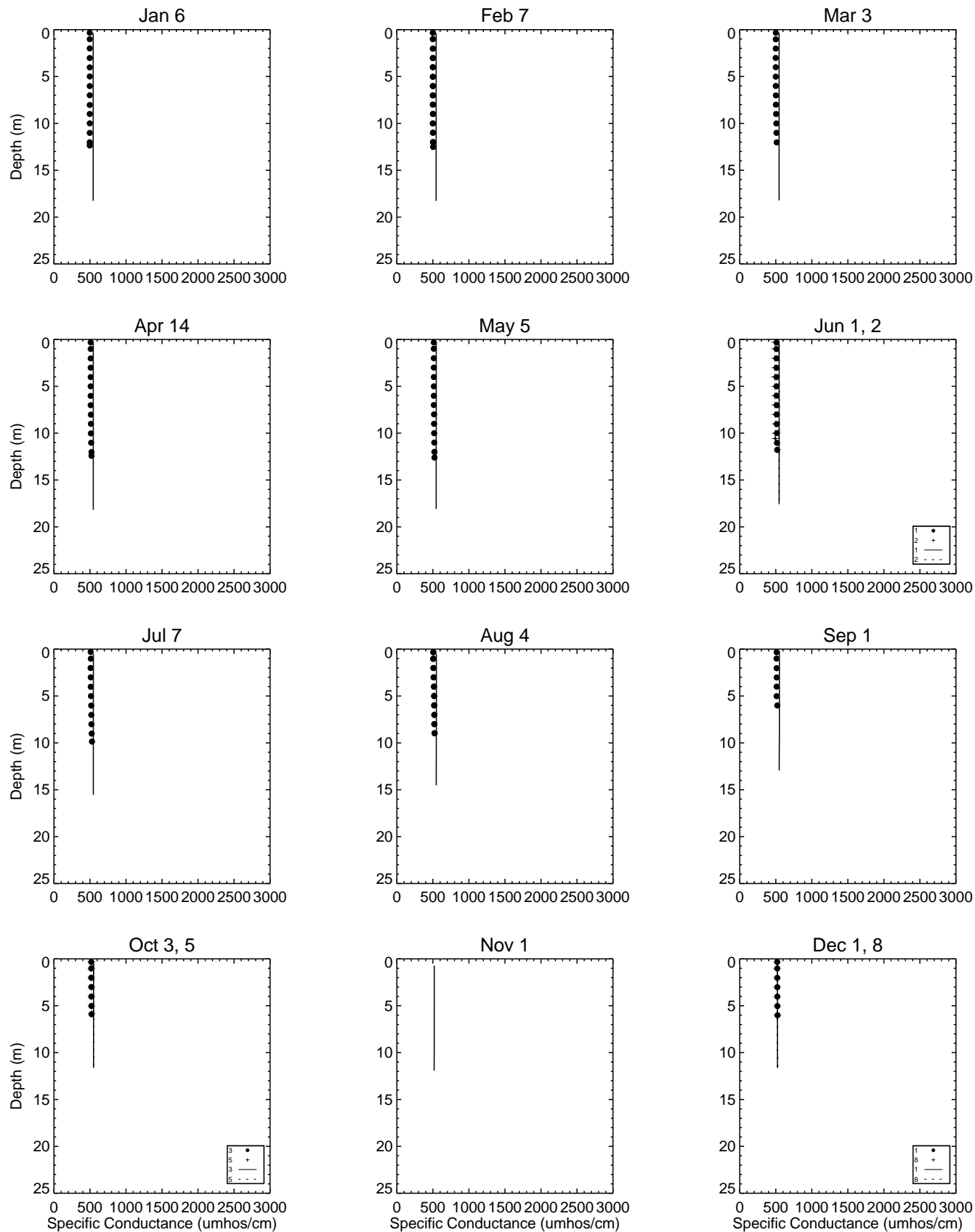CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 1988

Profiles shown for dates with available data else model results for first day of month shown.

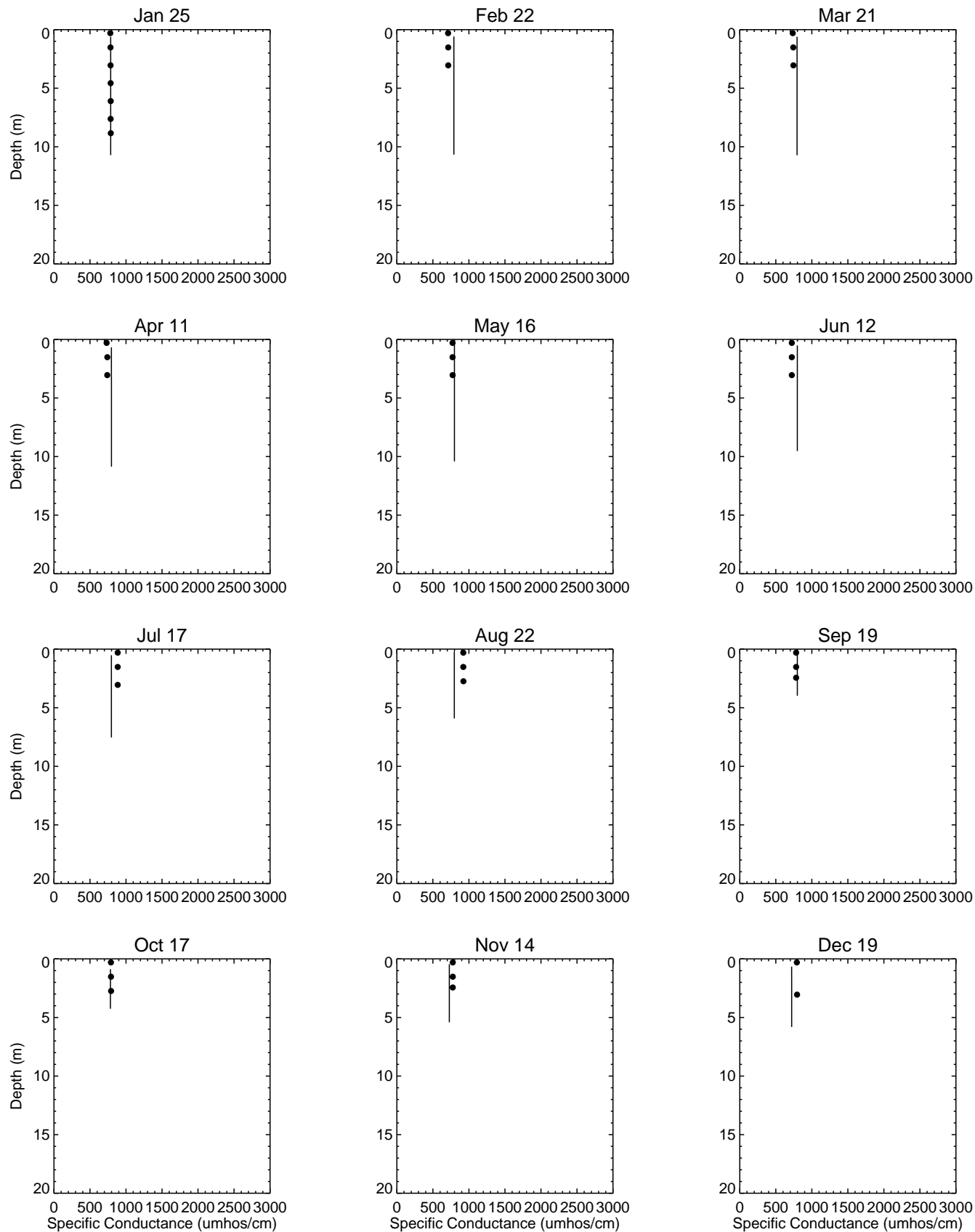CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:51 2013

Jan 10 · Feb 20 · Mar 14 · Apr 18 · May 15 · Jun 22 · Jul 1 · Aug 21 · Sep 1 · Oct 19 · Nov 1 · Dec 21
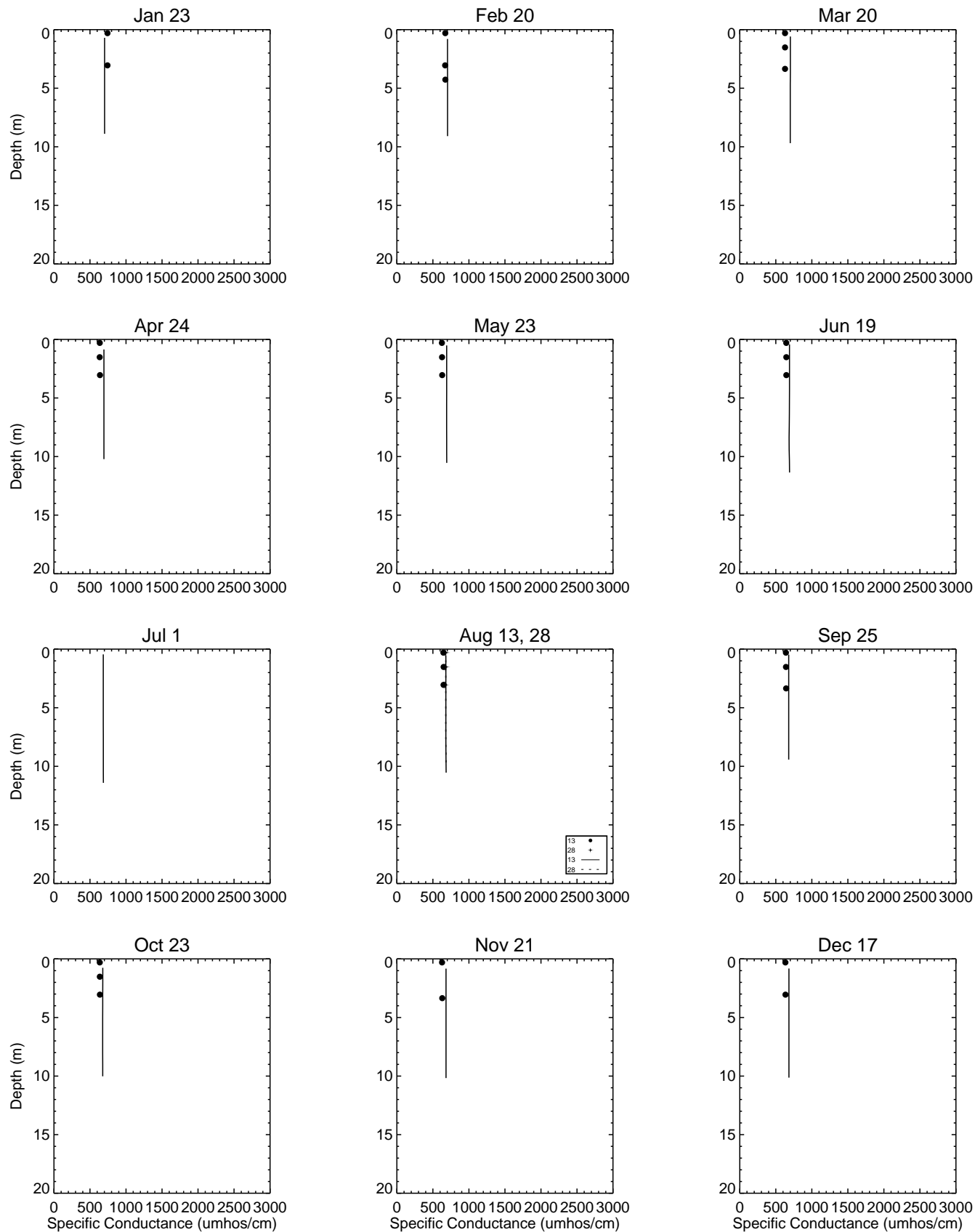
Model (w1210-48)
● Data

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 1989

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
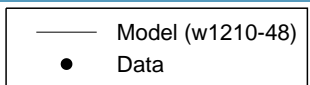Fri Jan 25 18:13:51 2013
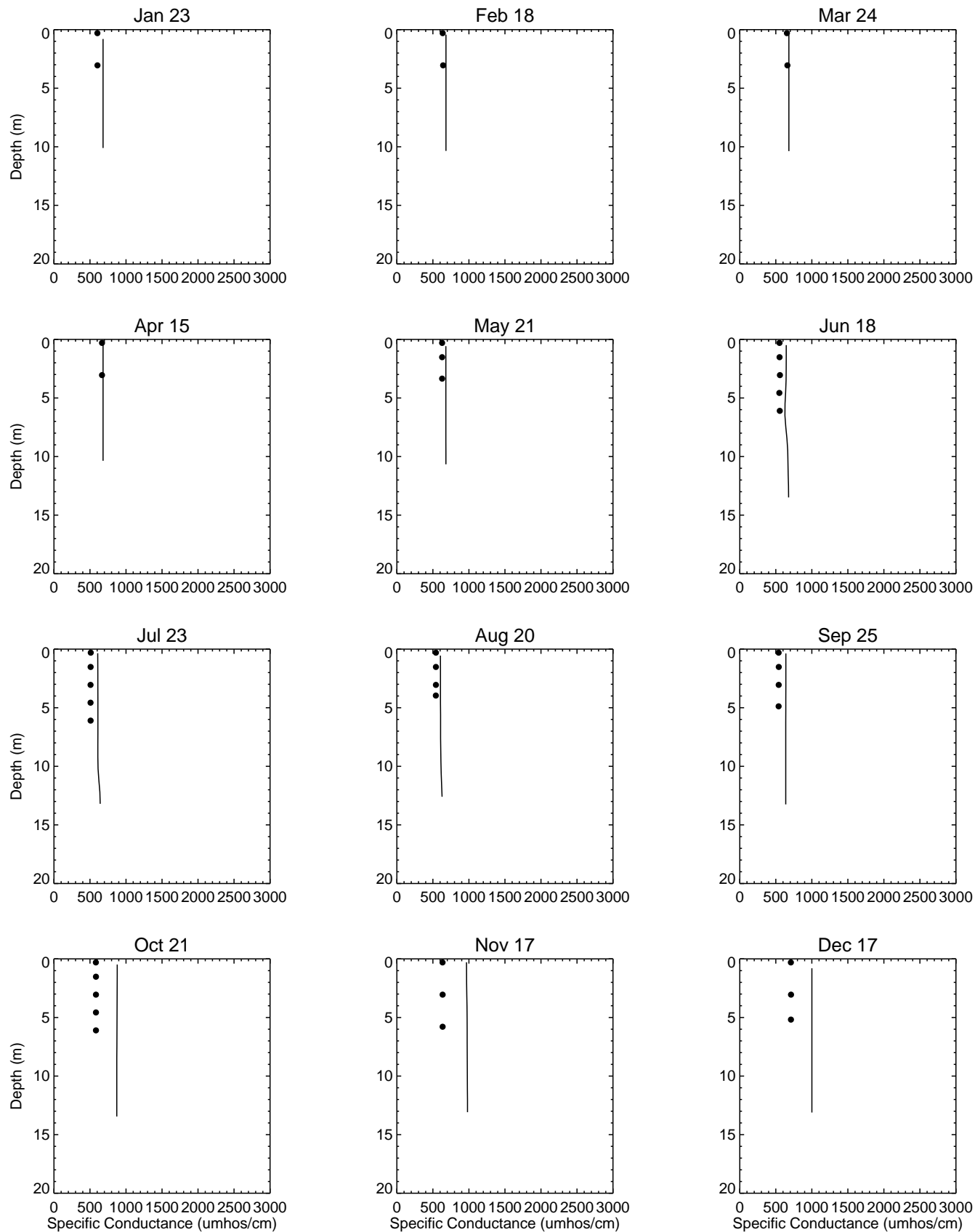
Model (w1210-48)
● Data

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 1990

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
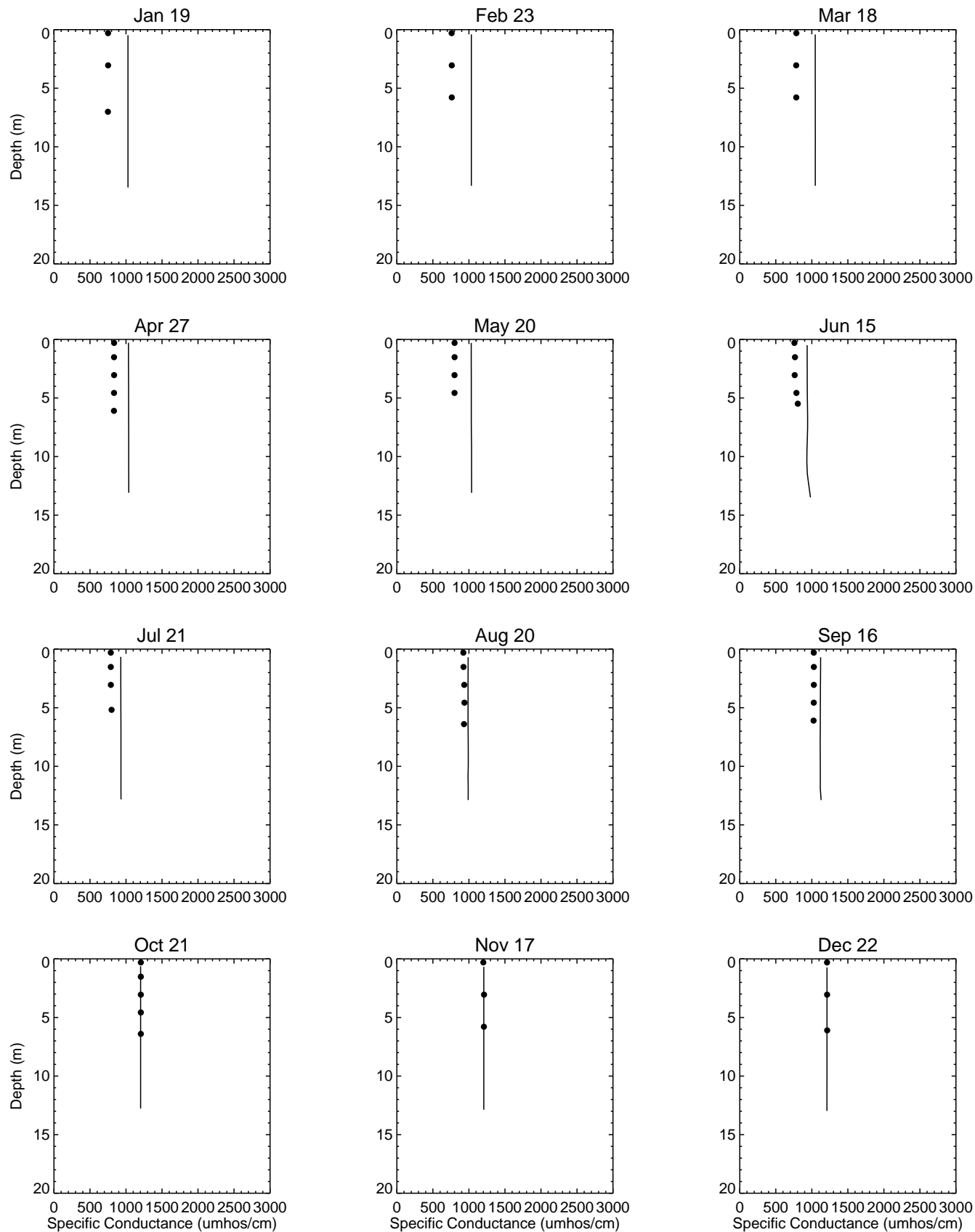Fri Jan 25 18:13:51 2013

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 1991

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 | Feb 1 | Mar 1
Apr 1 | May 1 | Jun 1
Jul 1 | Aug 1 | Sep 1
Oct 1 | Nov 1 | Dec 1

Depth (m)

Specific Conductance (umhos/cm)

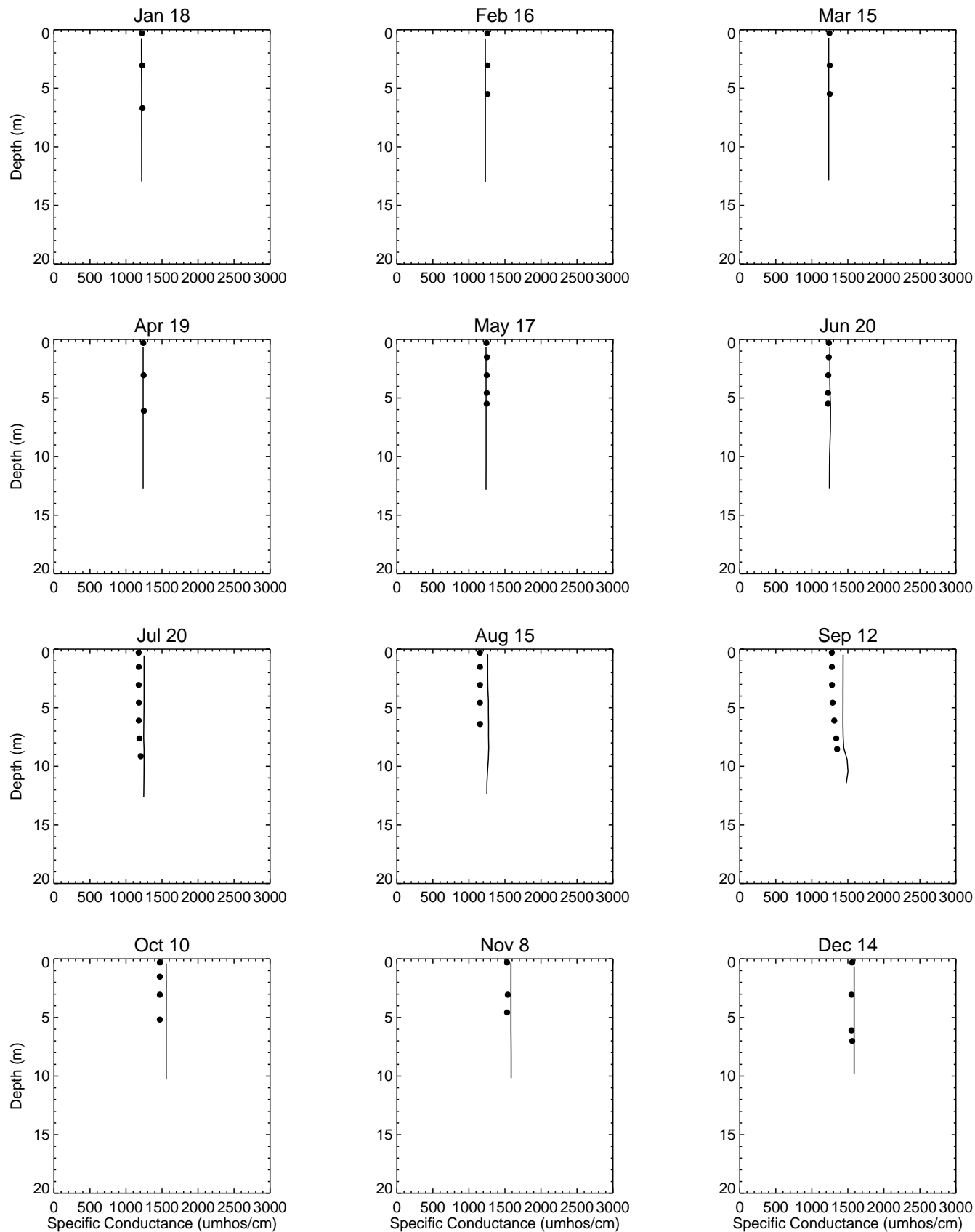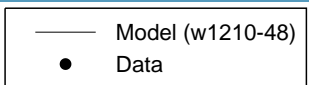——— Model (w1210-48)
● Data

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 1993

Profiles shown for dates with available data else model results for first day of month shown.

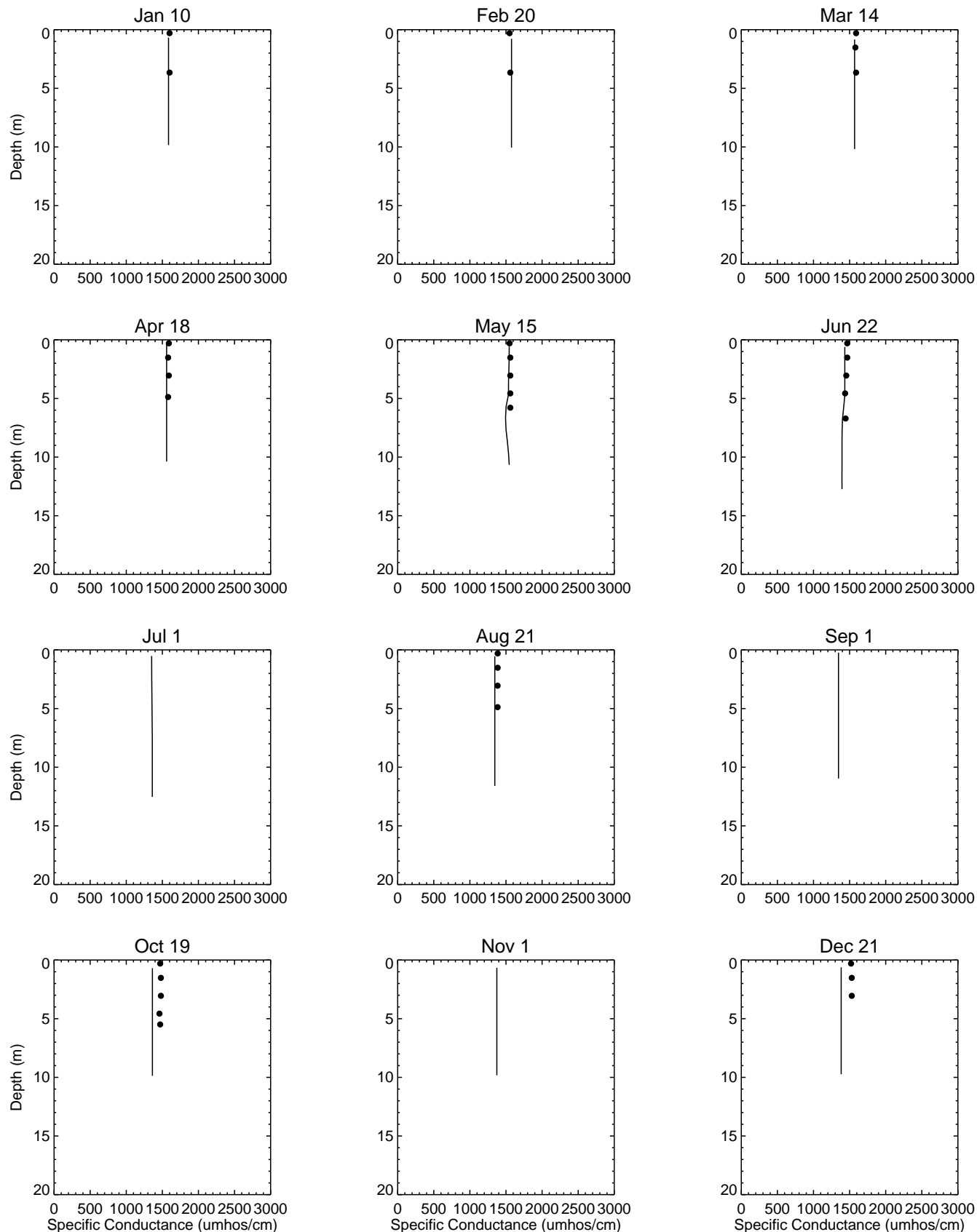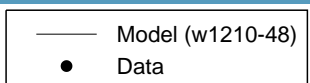CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:51 2013

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
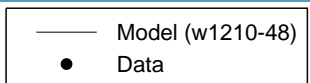at Golden Beach (Segment 26) - Specific Conductance - 1994

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1   Feb 1   Mar 1

Apr 1   May 1   Jun 1

Jul 1   Aug 1   Sep 1

Oct 1   Nov 1   Dec 1

Specific Conductance (umhos/cm)

Model (w1210-48)
● Data

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
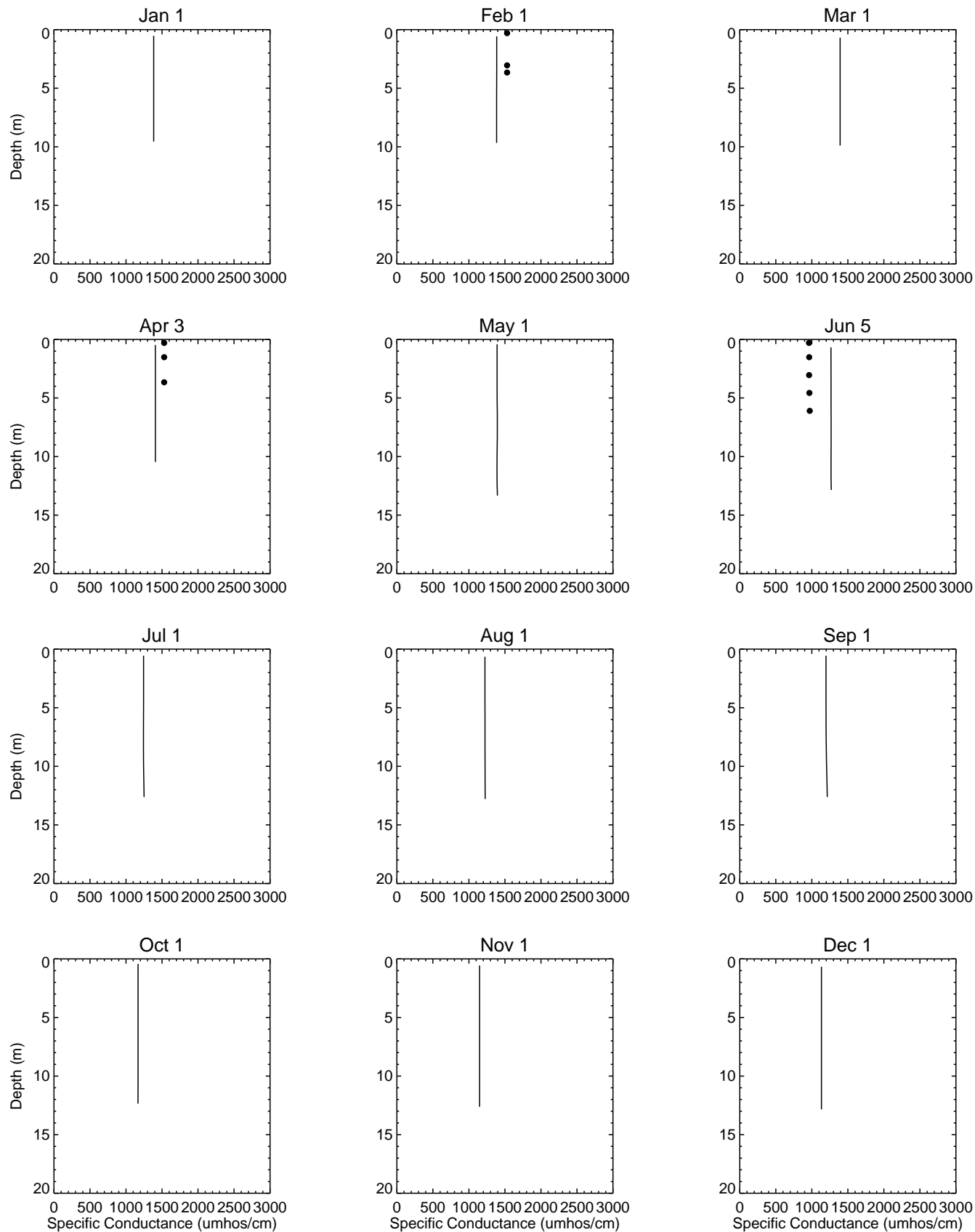at Golden Beach (Segment 26) - Specific Conductance - 1995

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
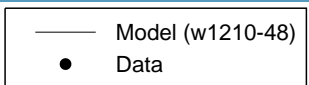Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:51 2013

Jan 1

Feb 1

Mar 1

Apr 1

May 1

Jun 1

Jul 1

Aug 1

Sep 1

Oct 1

Nov 1

Dec 1

Model (w1210-48)

● Data

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 1996

Profiles shown for dates with available data else model results for first day of month shown.

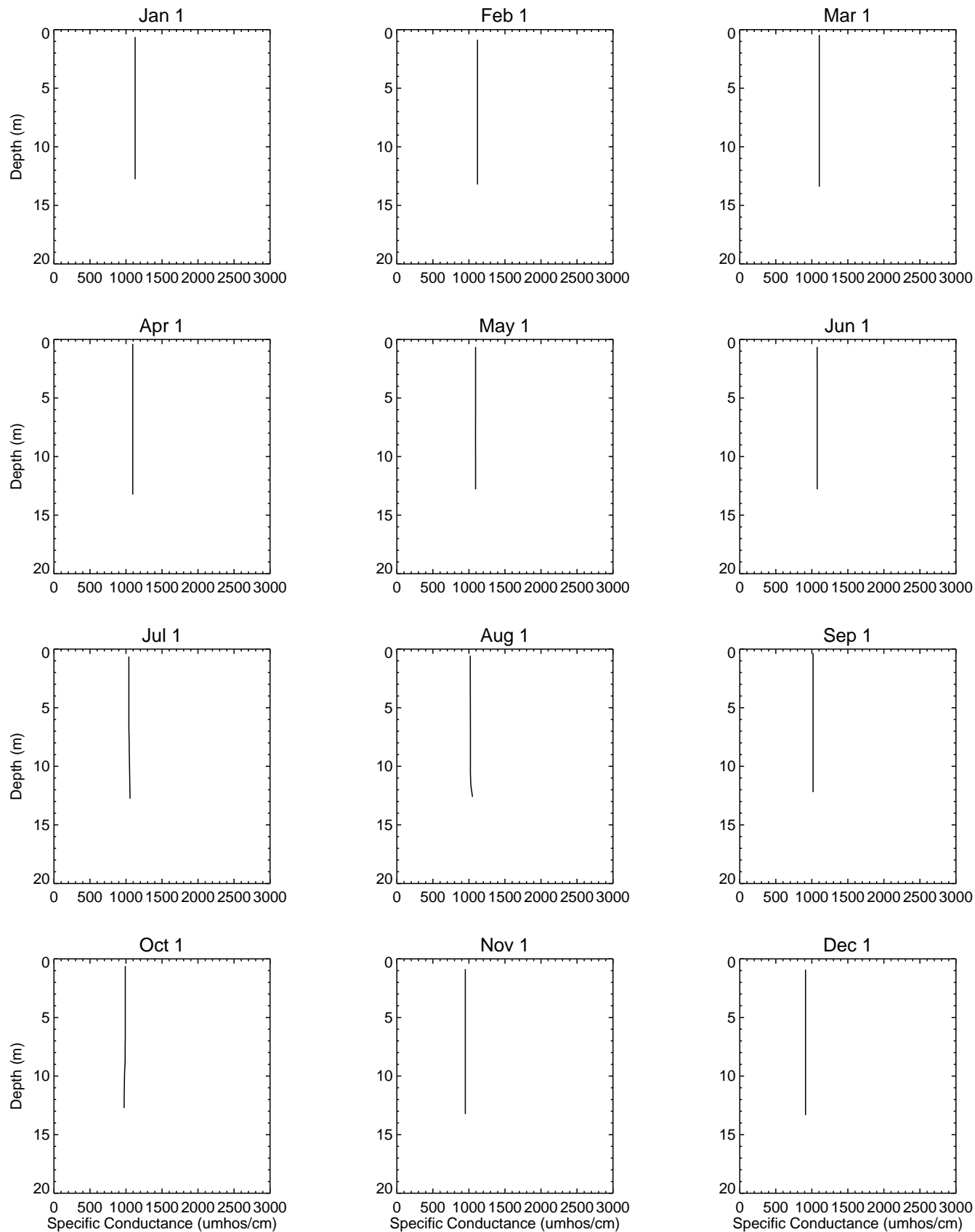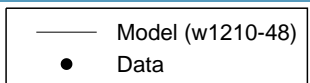CREMs Phase 4: Lake Buchanan
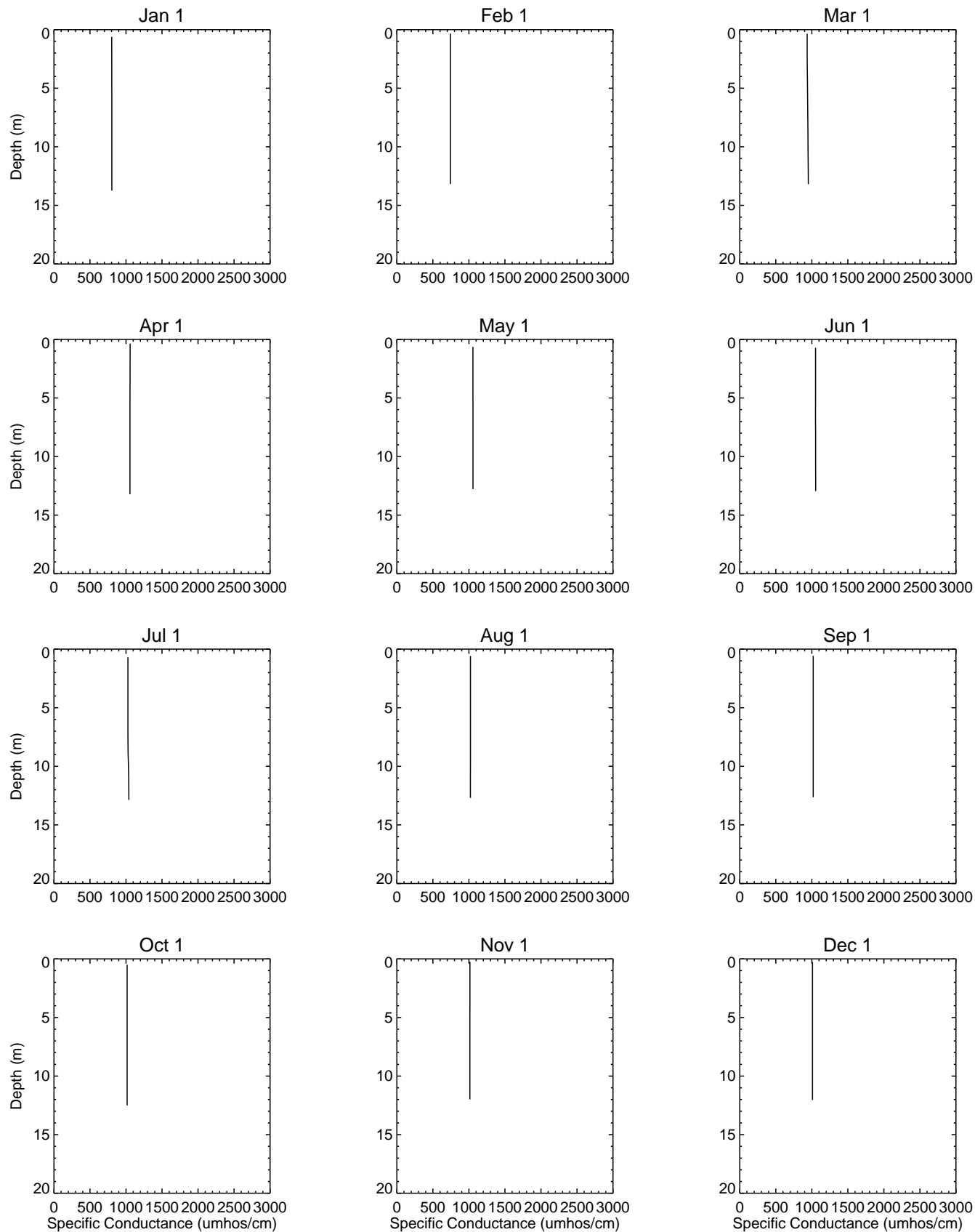
Lower Colorado River Authority

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 1997

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:51 2013

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m)

Specific Conductance (umhos/cm)

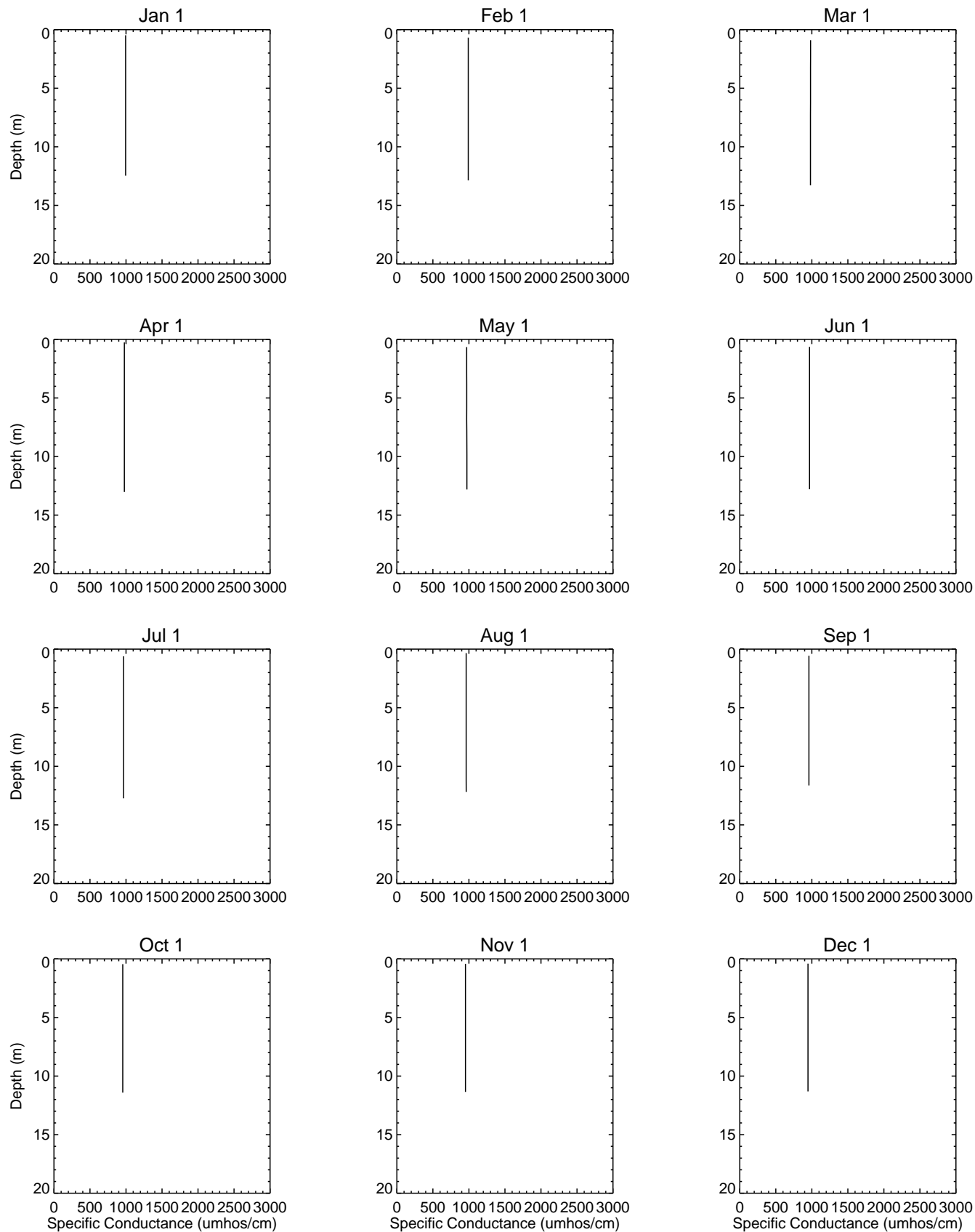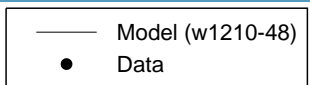———— Model (w1210-48)

● Data

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 1998

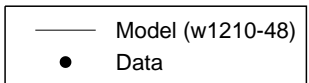*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:51 2013

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 1999

Profiles shown for dates with available data else model results for first day of month shown.
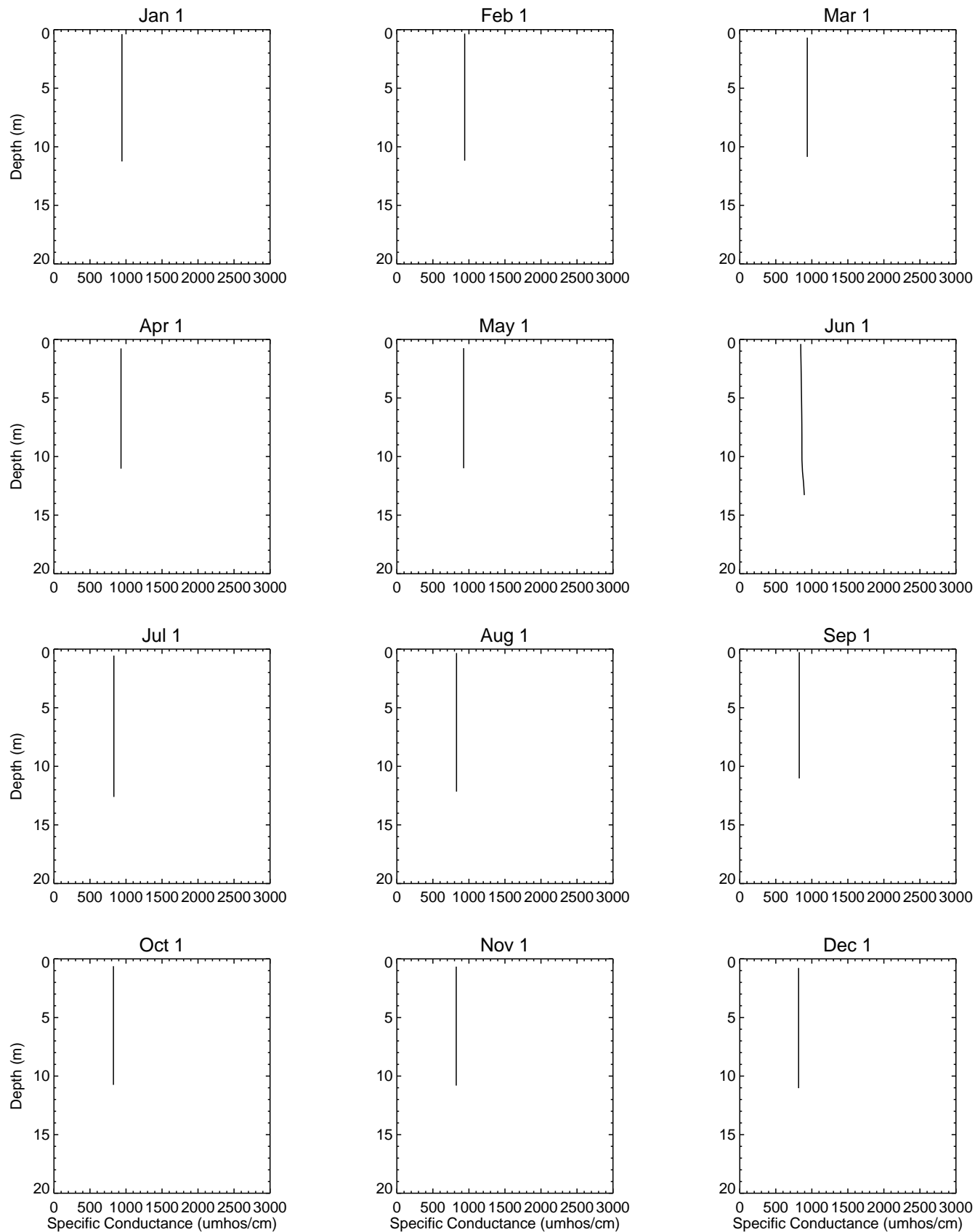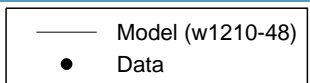
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Vertical Profiles of Model Versus Data for Lake Buchanan at Golden Beach (Segment 26) - Specific Conductance - 2000

Figure G-17

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 2001

Profiles shown for dates with available data else model results for first day of month shown.
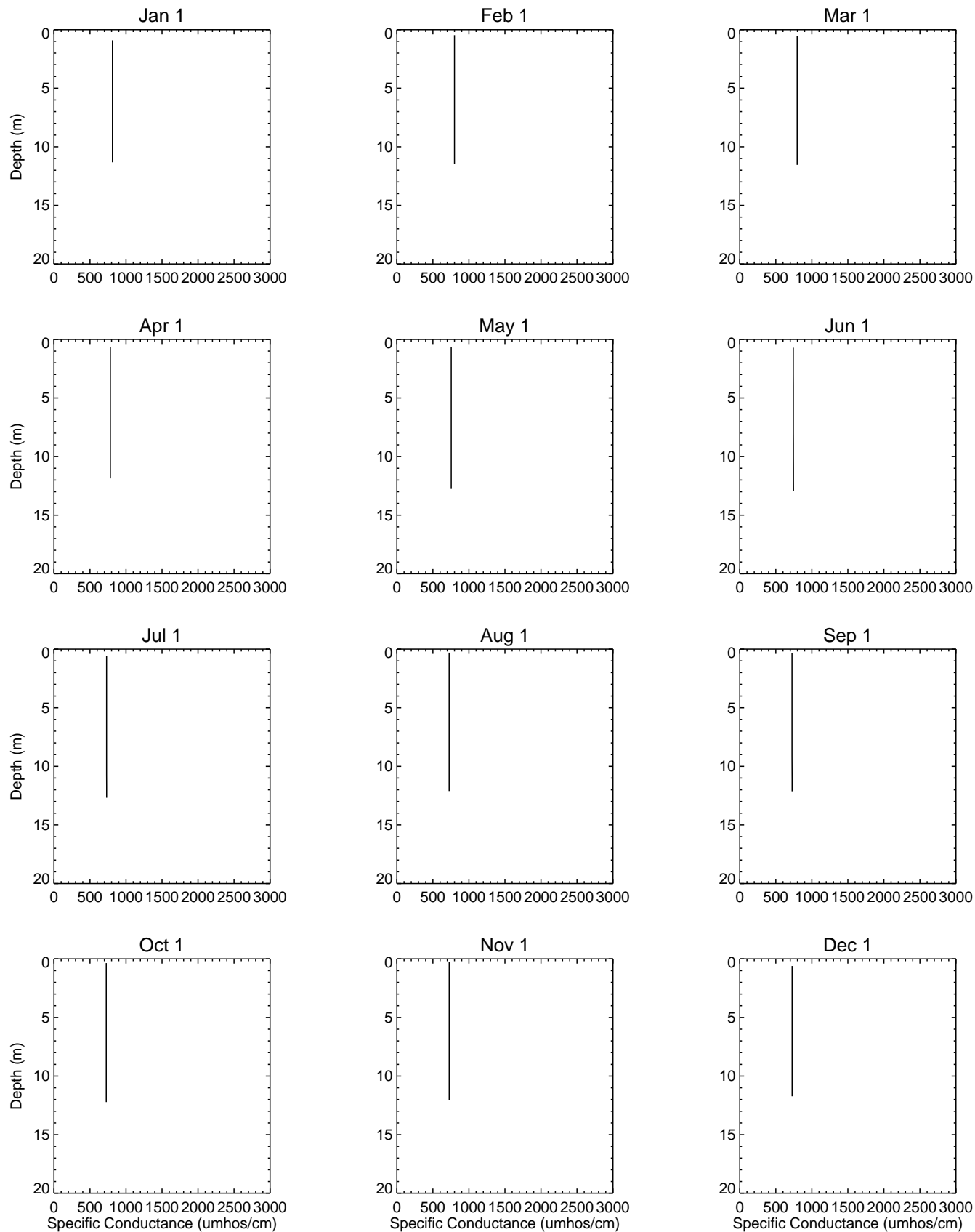
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 2002

Profiles shown for dates with available data else model results for first day of month shown.
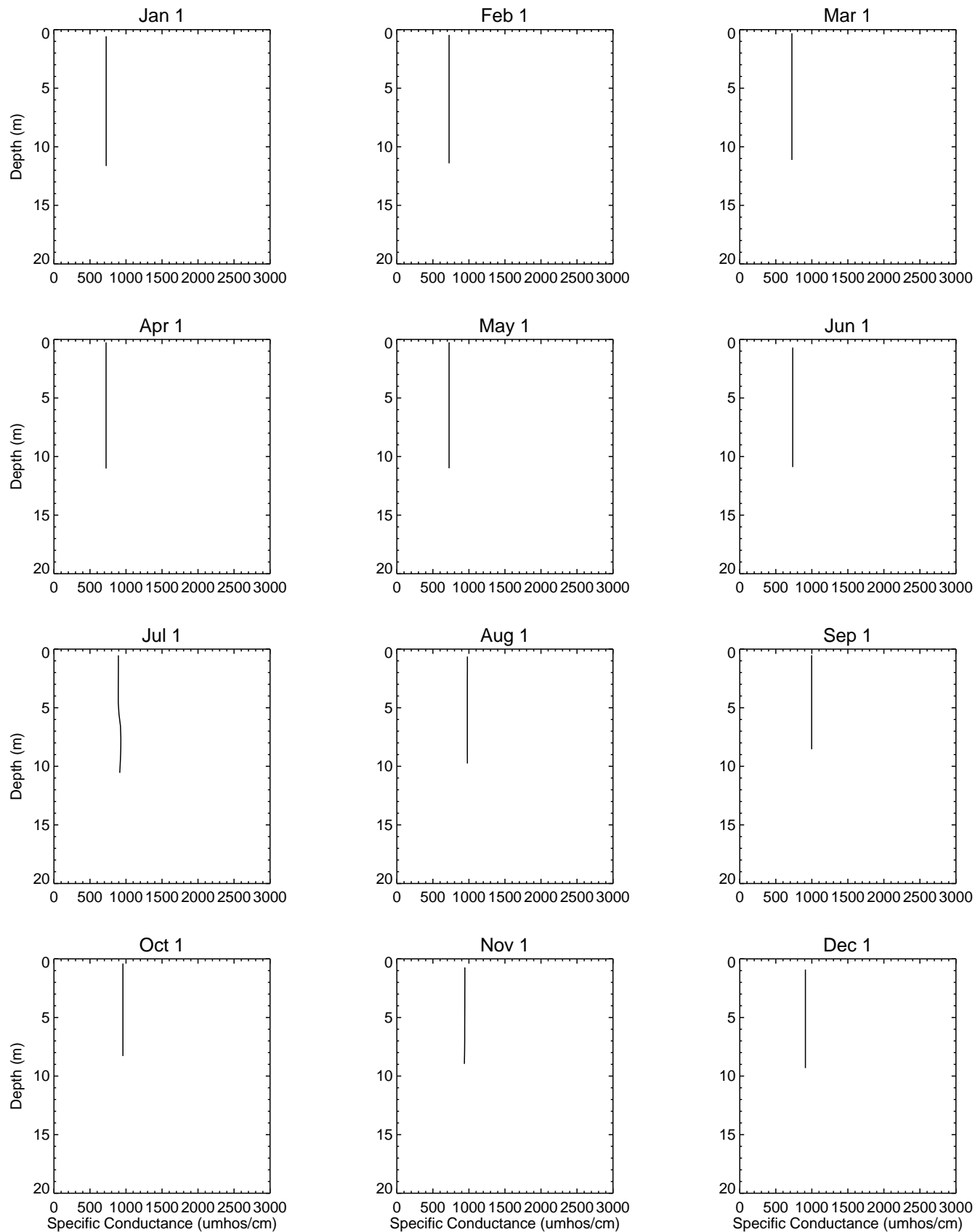
CREMs Phase 4: Lake Buchanan

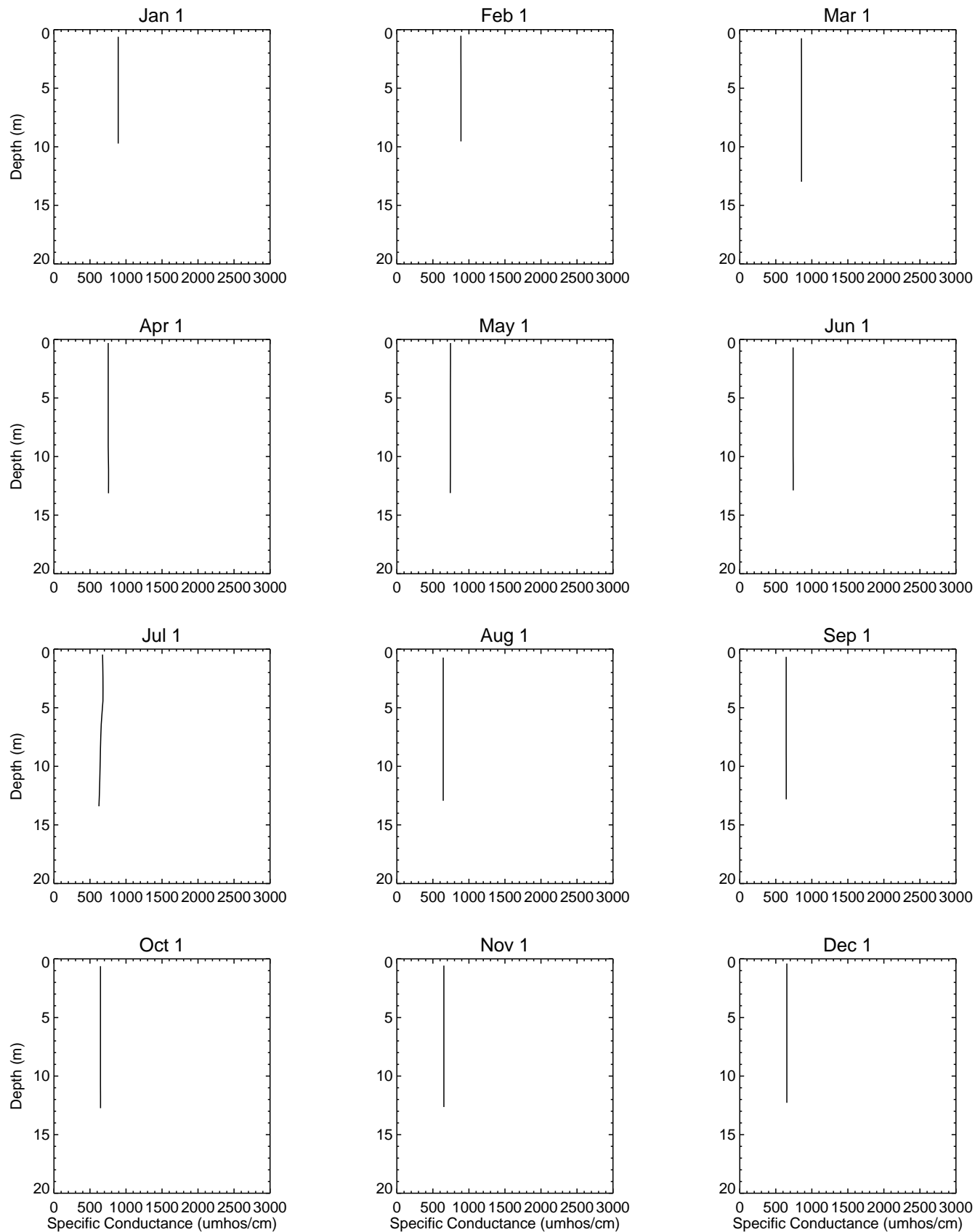Lower Colorado River Authority

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 2003

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1

Feb 1

Mar 1

Apr 1

May 1

Jun 1

Jul 1

Aug 1

Sep 1

Oct 1

Nov 1

Dec 1

Specific Conductance (umhos/cm)
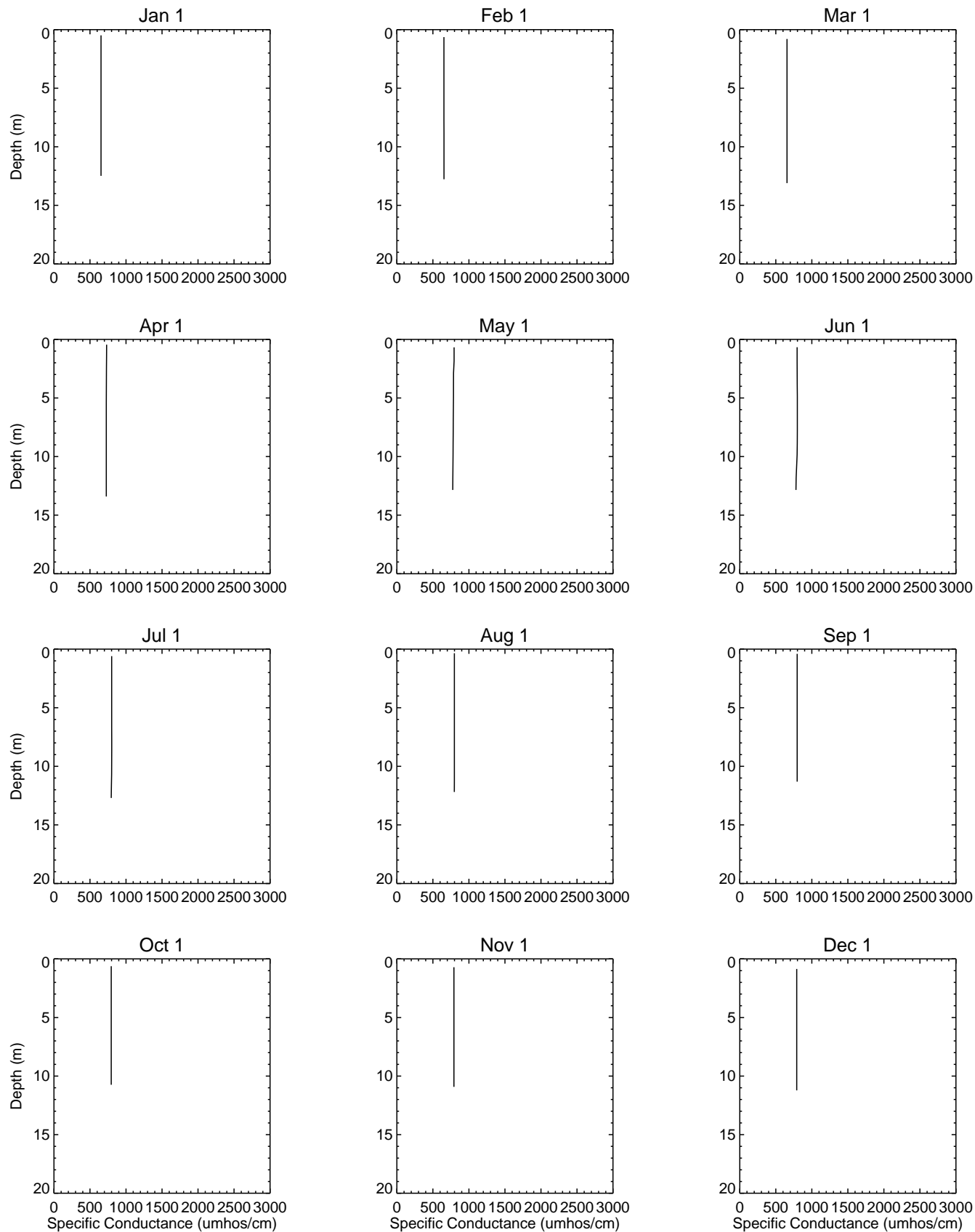
——— Model (w1210-48)

● Data

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
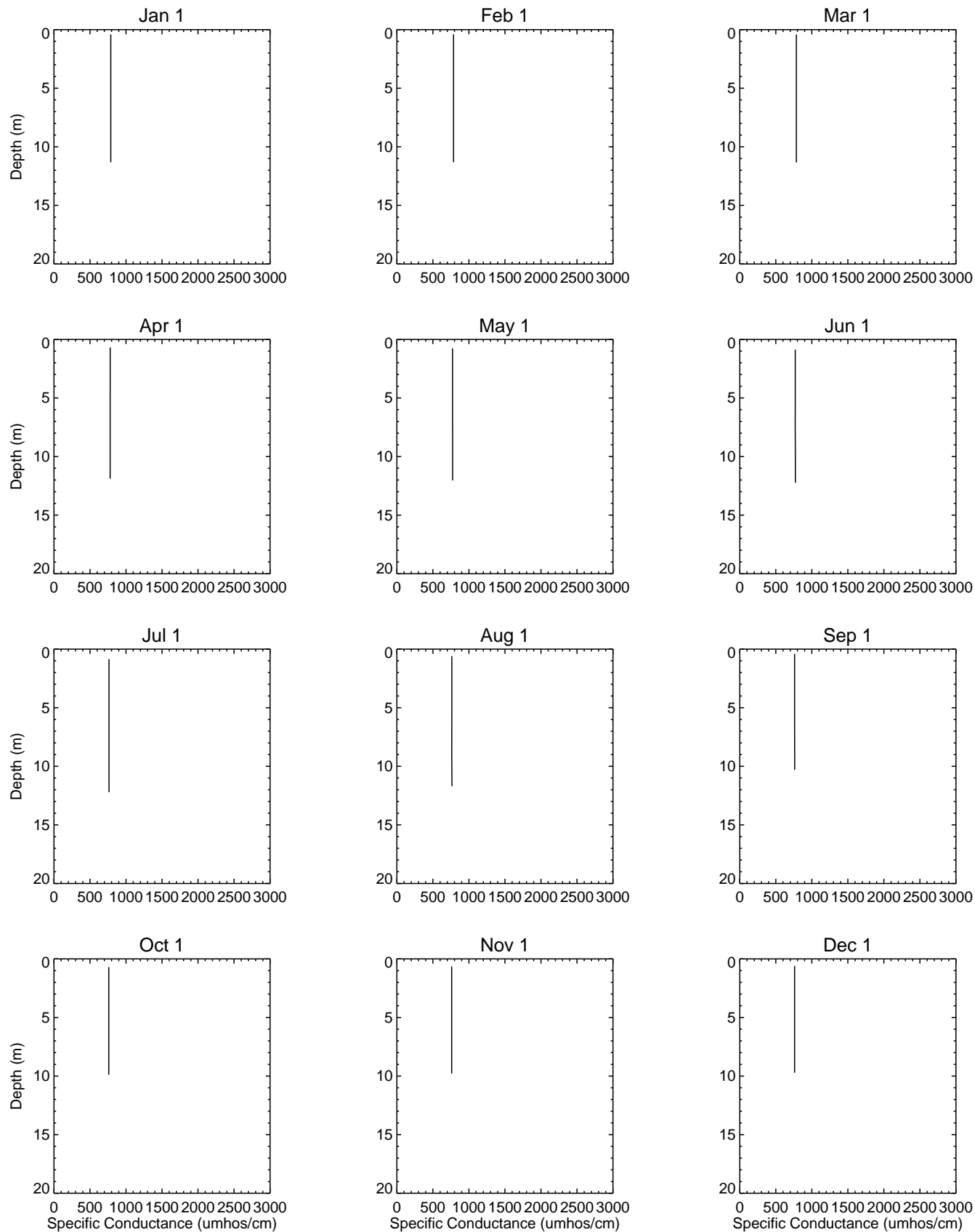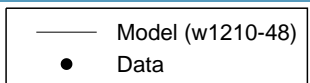at Golden Beach (Segment 26) - Specific Conductance - 2004

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:51 2013

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 2005

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
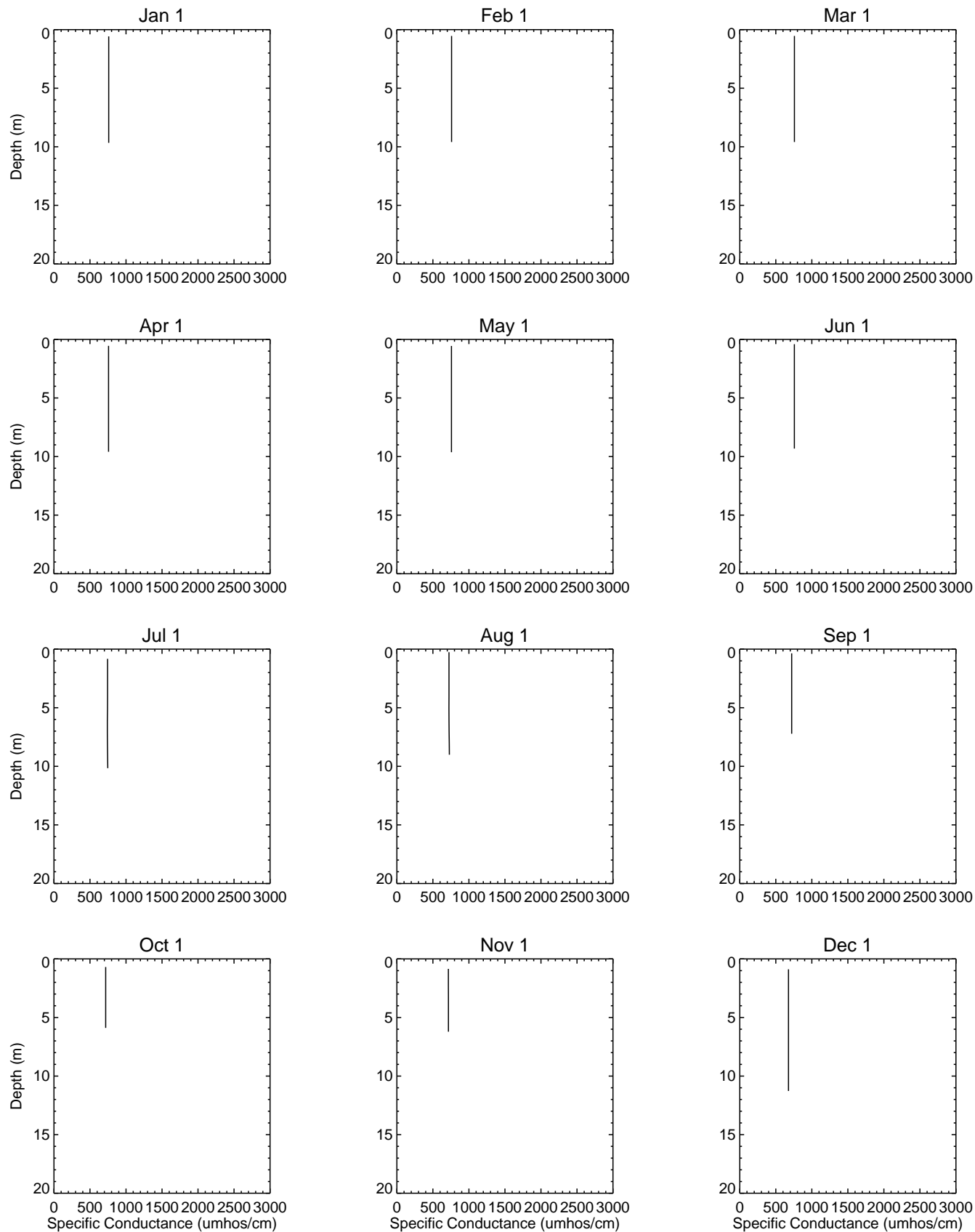Fri Jan 25 18:13:51 2013

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 2006

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

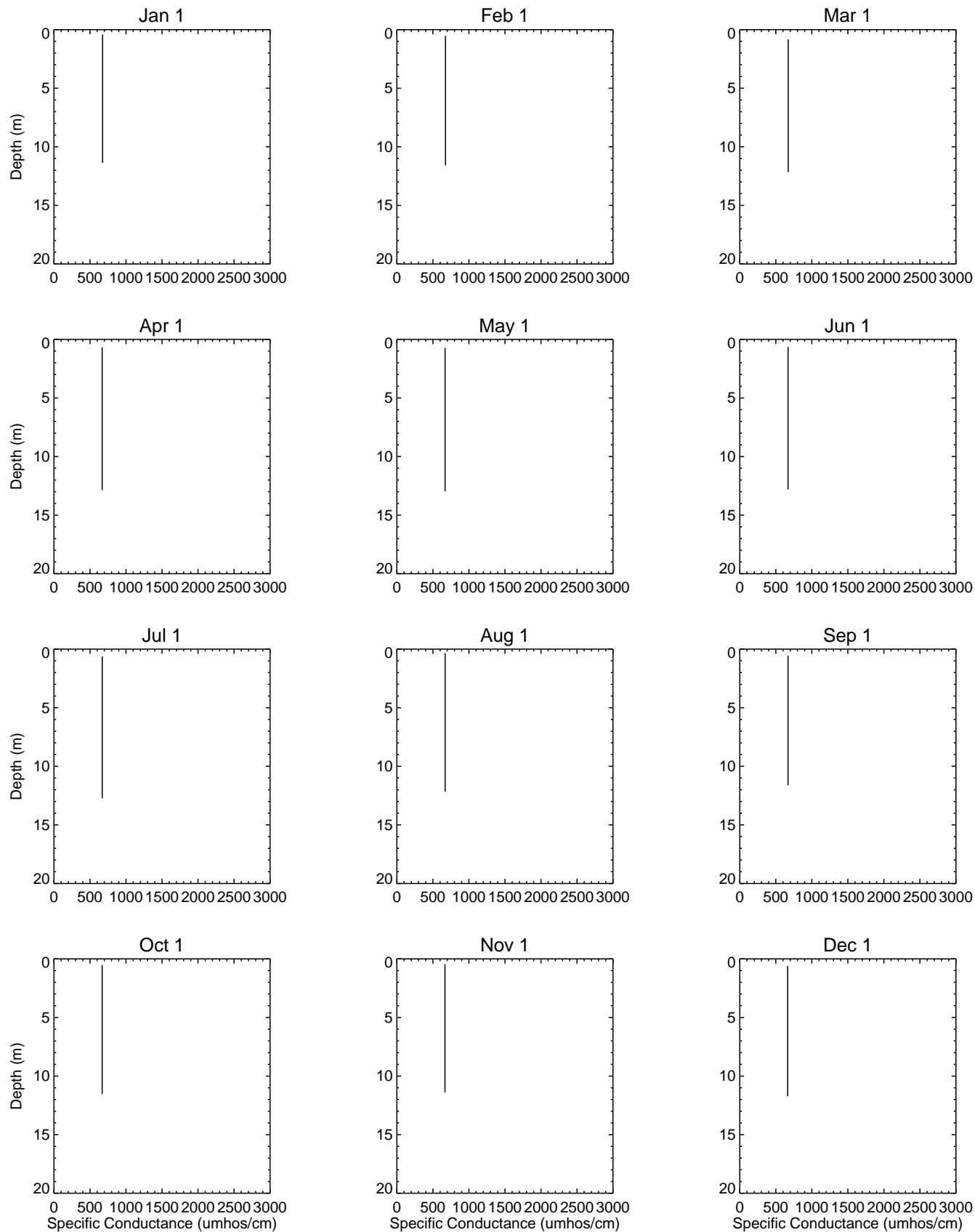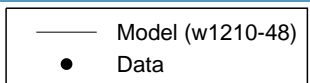Lower Colorado River Authority

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 2007

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
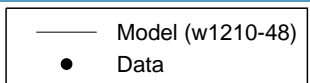Fri Jan 25 18:13:51 2013

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 2008

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Model (w1210-48)

● Data

Jan 1   Feb 1   Mar 1
Apr 1   May 1   Jun 1
Jul 1   Aug 5   Sep 2
Oct 7   Nov 4   Dec 2

Specific Conductance (umhos/cm)
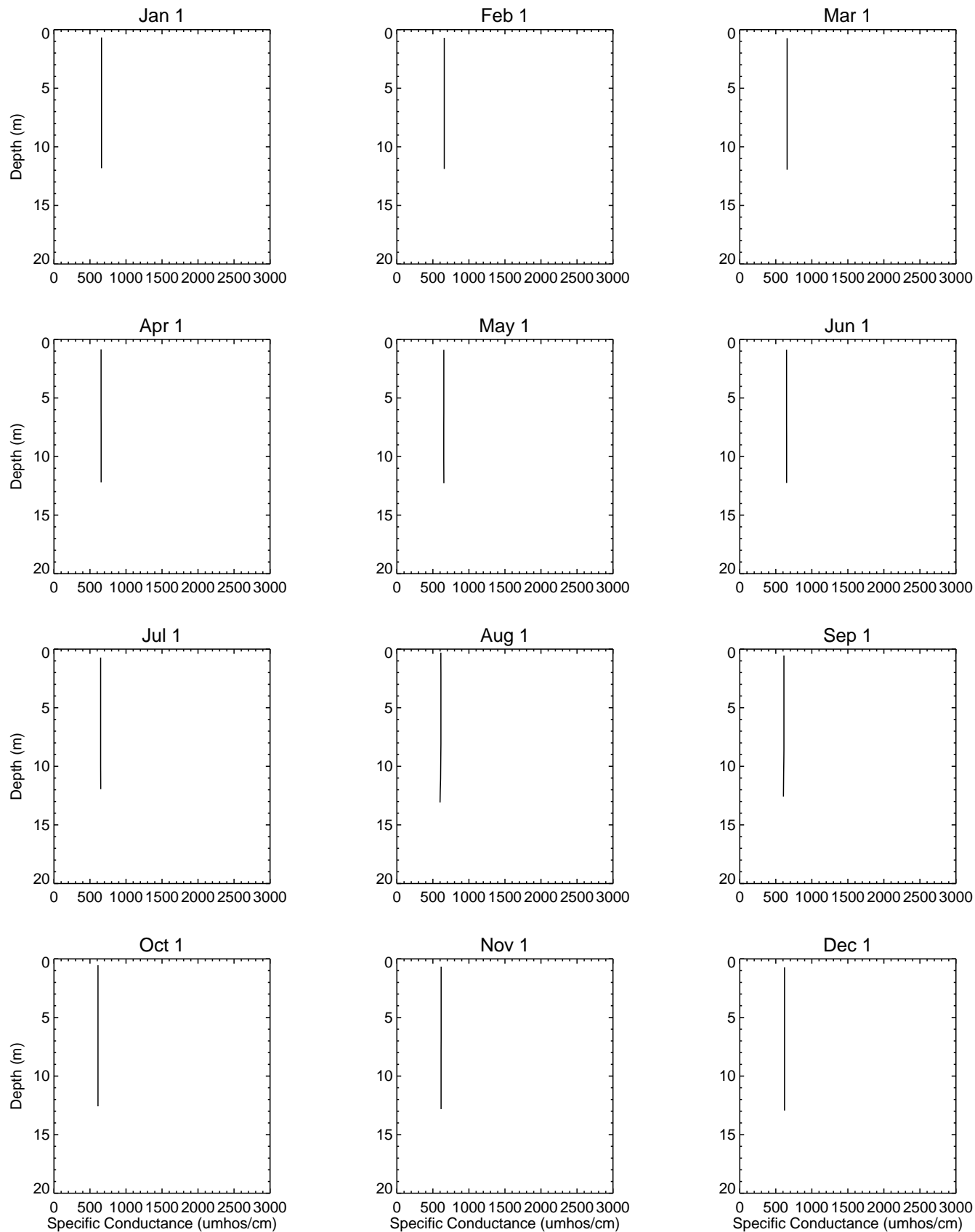
——— Model (w1210-48)
● Data

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 2010

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
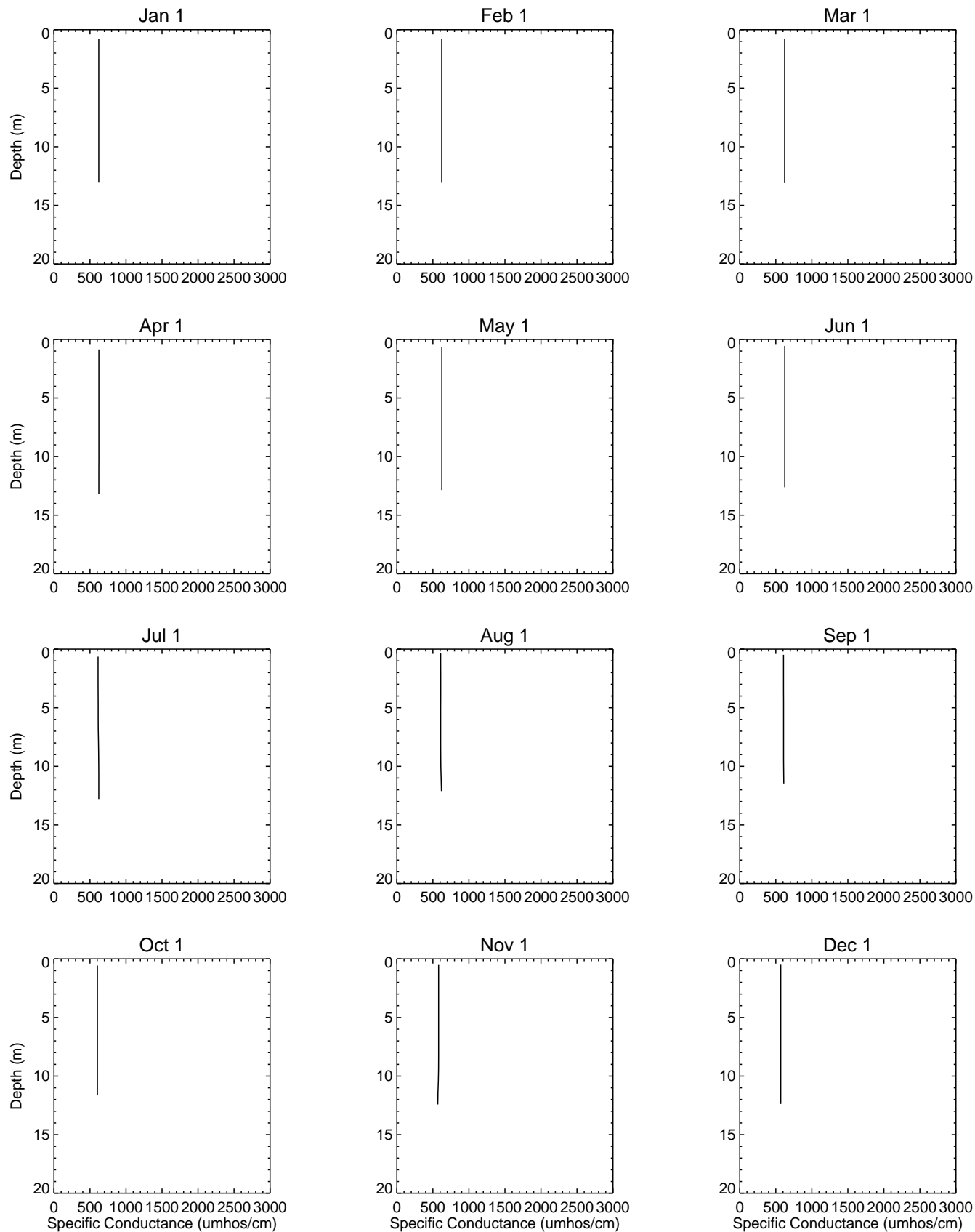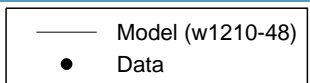Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
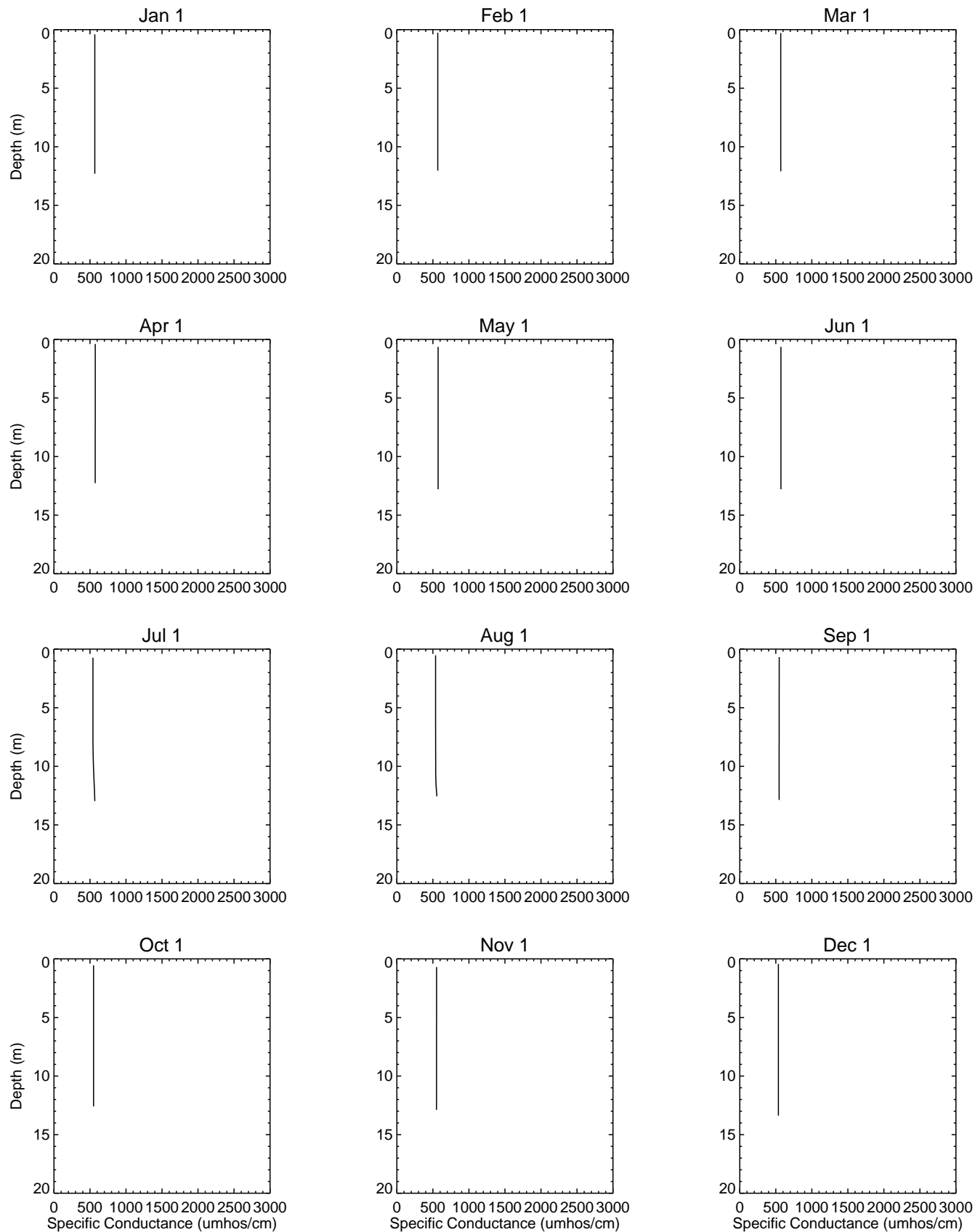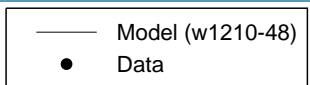Fri Jan 25 18:13:51 2013

Figure G-17

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Specific Conductance - 2011

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:13:51 2013

Jan 25 | Feb 22 | Mar 21
Apr 11 | May 16 | Jun 12
Jul 16 | Aug 22 | Sep 19
Oct 17 | Nov 14 | Dec 19

——— Model (w1210-48)
● Data

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 1984

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
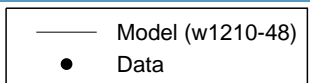Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:00 2013

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 1985

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
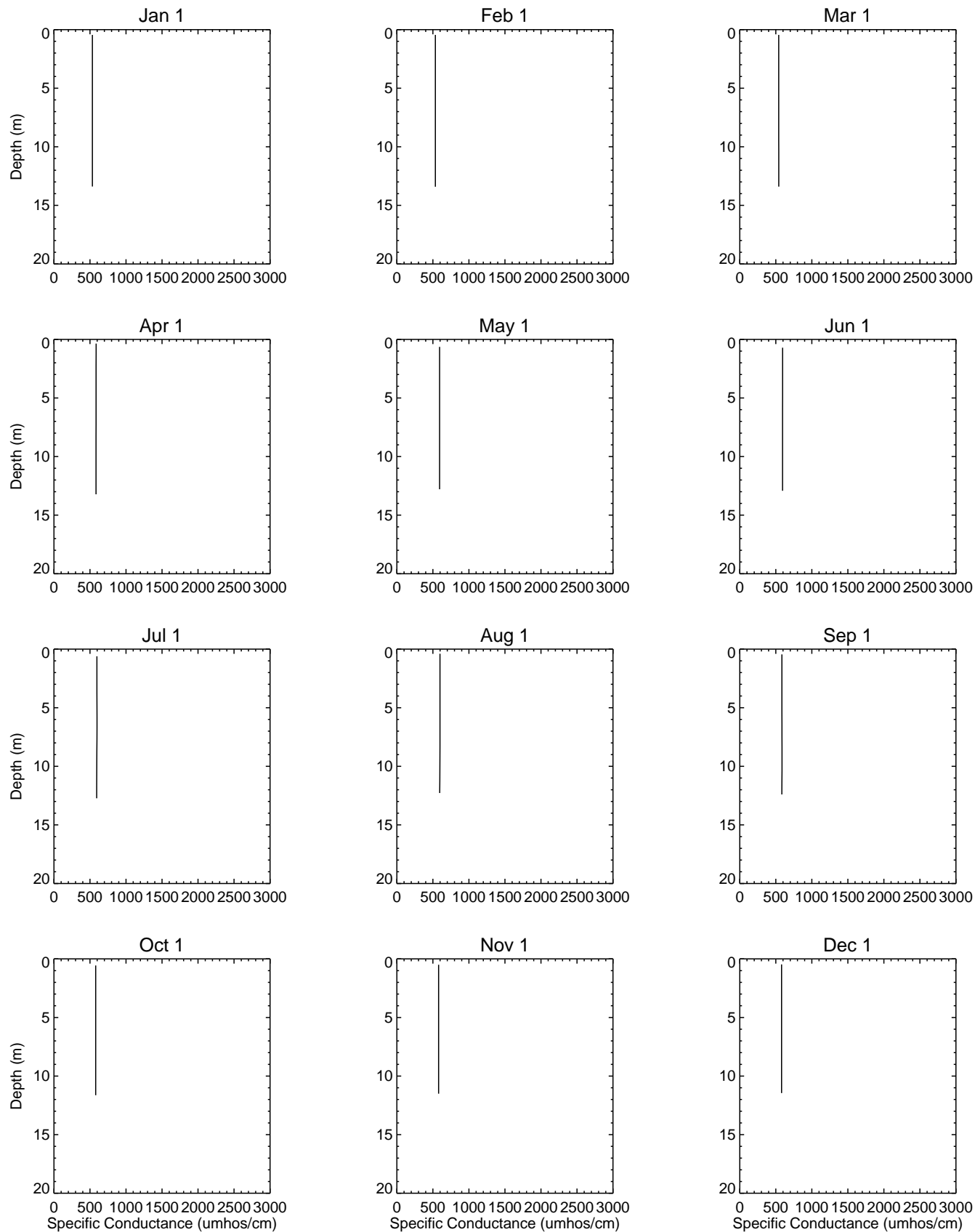
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:00 2013

Jan 23 / Feb 19 / Mar 24 / Apr 15 / May 21 / Jun 18 / Jul 23 / Aug 20 / Sep 25 / Oct 21 / Nov 17 / Dec 17

Model (w1210-48)
● Data

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
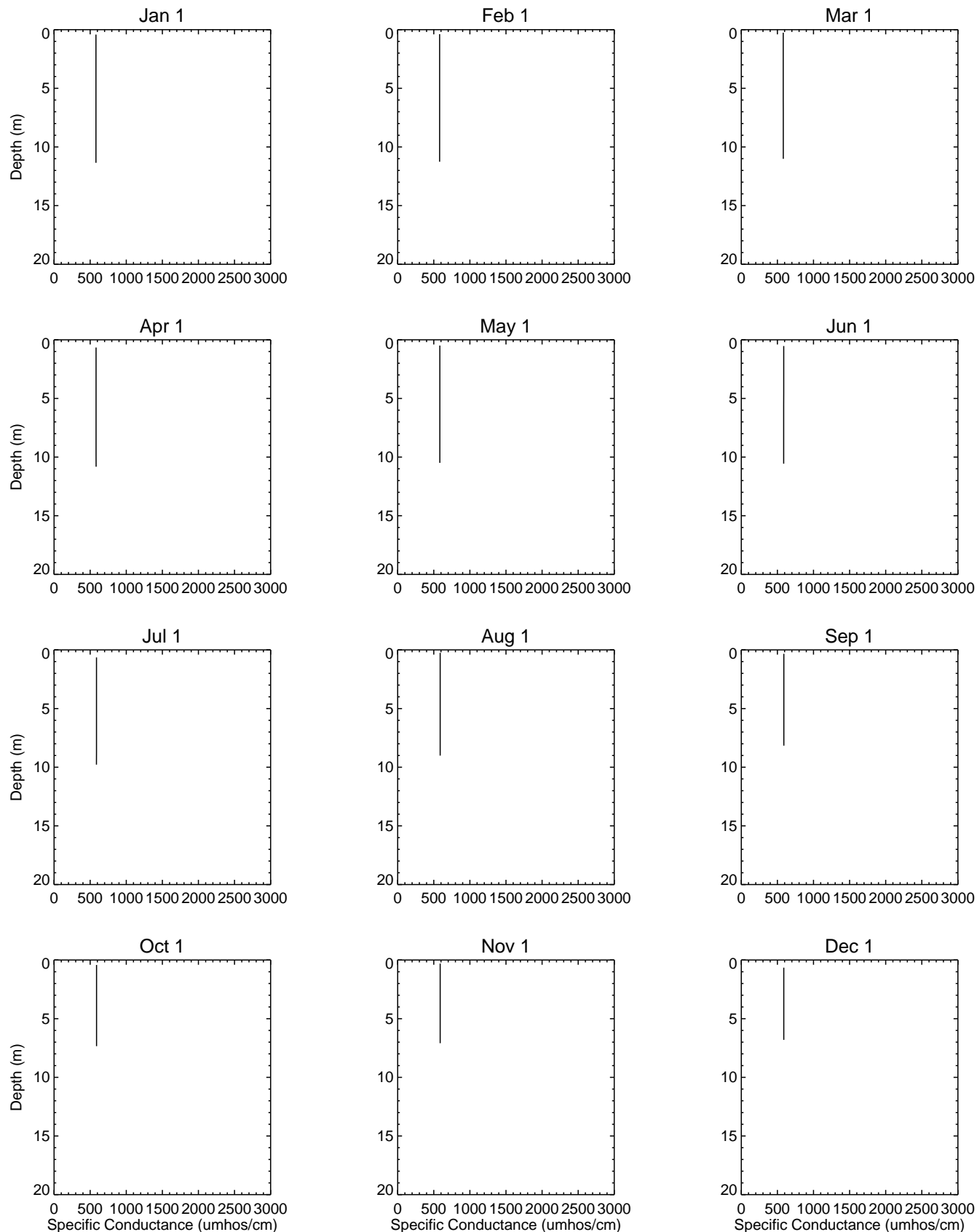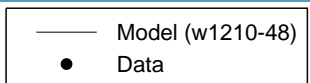at Buchanan Village (Segment 6) - Chloride - 1986

Profiles shown for dates with available data else model results for first day of month shown.

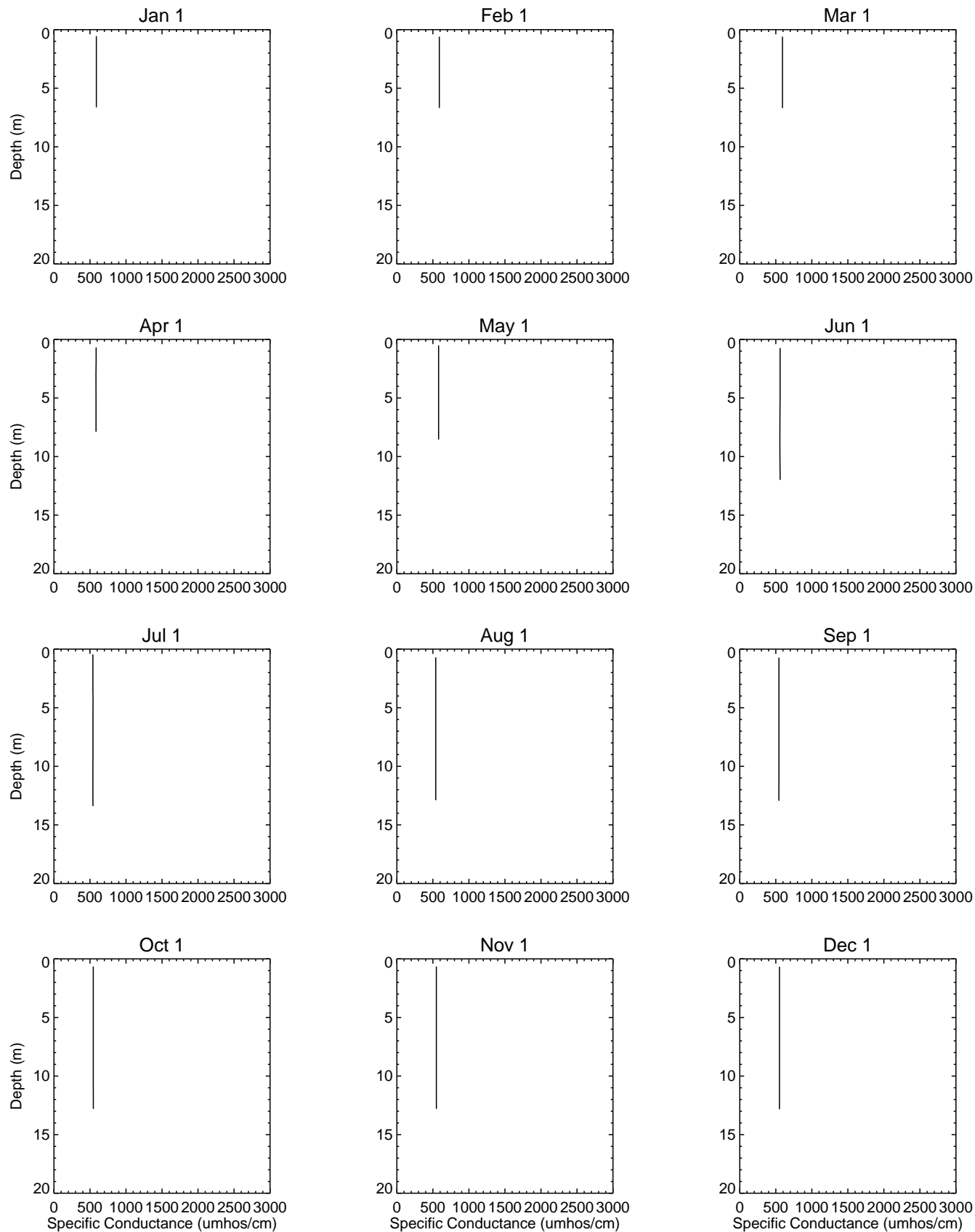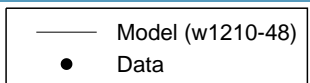CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Jan 19   Feb 23   Mar 18

Apr 27   May 20   Jun 15

Jul 21   Aug 20   Sep 16

Oct 21   Nov 17   Dec 22

——— Model (w1210-48)

●   Data

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 1987

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 18 · Feb 16 · Mar 15 · Apr 19 · May 17 · Jun 20 · Jul 20 · Aug 15 · Sep 12 · Oct 10 · Nov 8 · Dec 14

——— Model (w1210-48)
● Data

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 1988

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
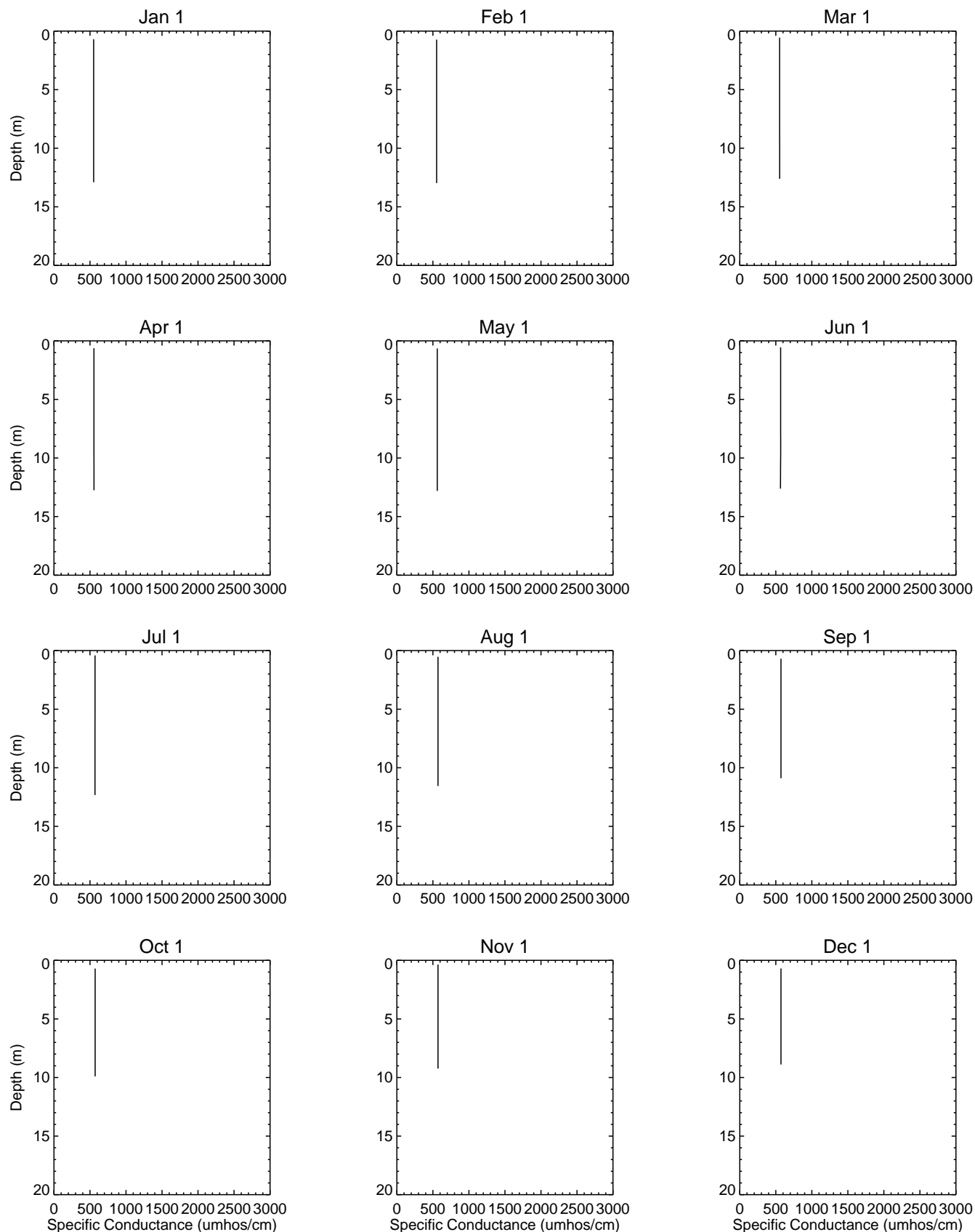
Lower Colorado River Authority

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 1990

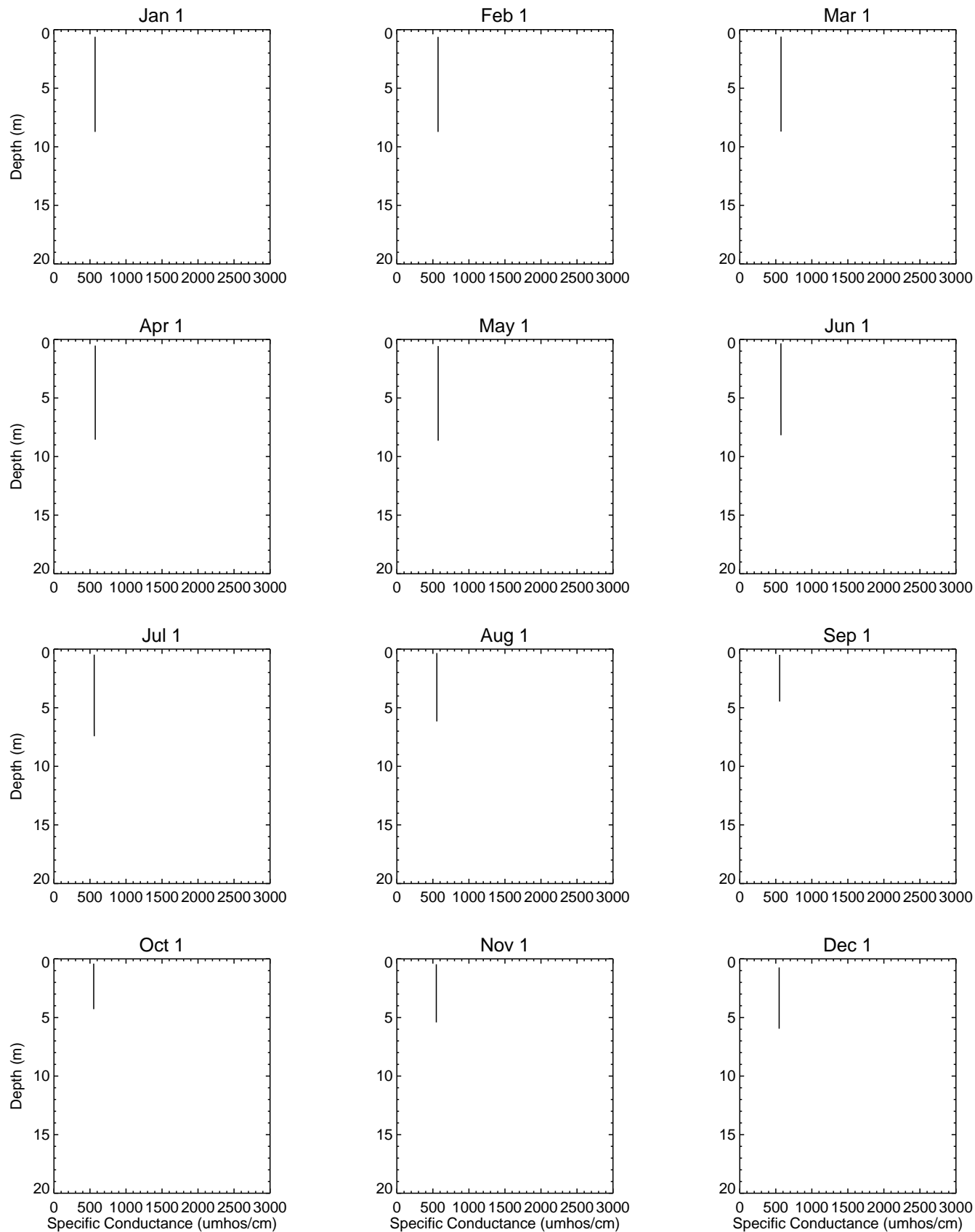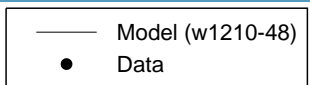*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m)

Chloride (mg/L)

——— Model (w1210-48)
● Data

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 1991

Profiles shown for dates with available data else model results for first day of month shown.

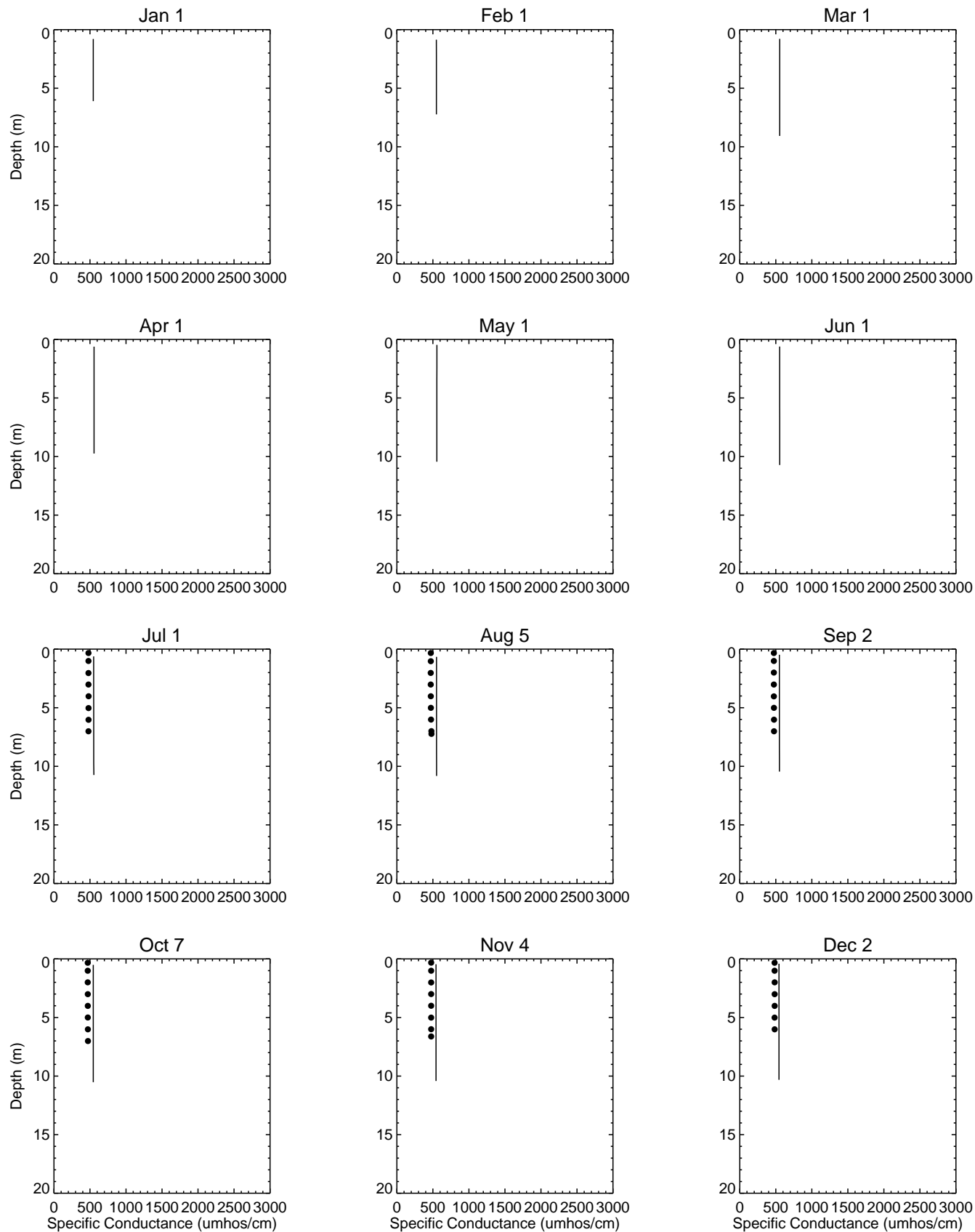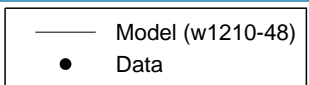CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:00 2013

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m) / Chloride (mg/L)

——— Model (w1210-48)
● Data

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 1992

Profiles shown for dates with available data else model results for first day of month shown.

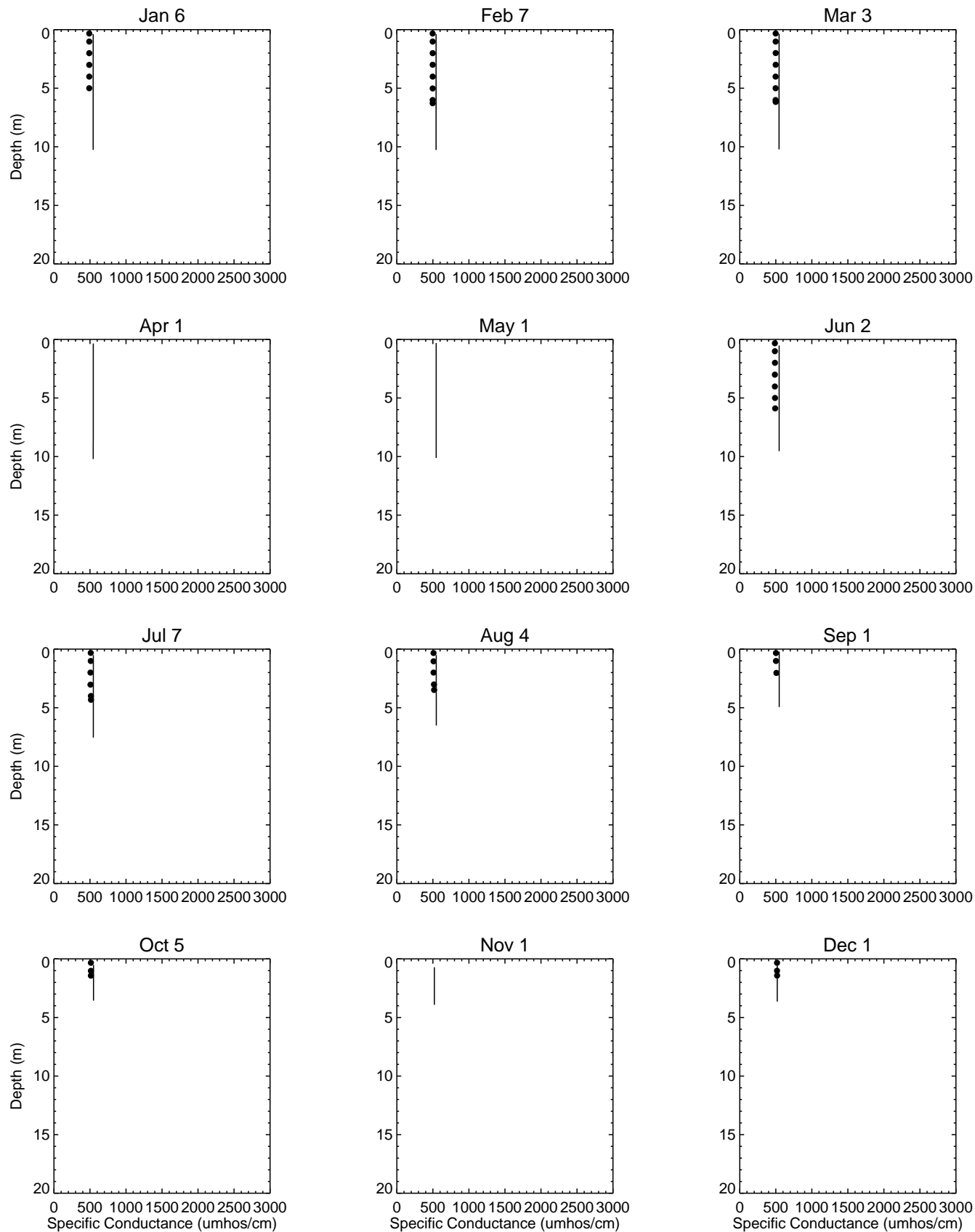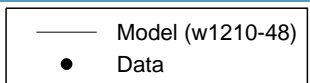CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

Jan 1

Feb 1

Mar 1

Apr 1

May 1

Jun 1

Jul 1

Aug 1

Sep 1

Oct 1

Nov 1

Dec 1

Chloride (mg/L)

Depth (m)

——— Model (w1210-48)

● Data

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 1993

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR
QEA
PARSONS

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m) vs Chloride (mg/L)

——— Model (w1210-48)
● Data

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 1994

Profiles shown for dates with available data else model results for first day of month shown.

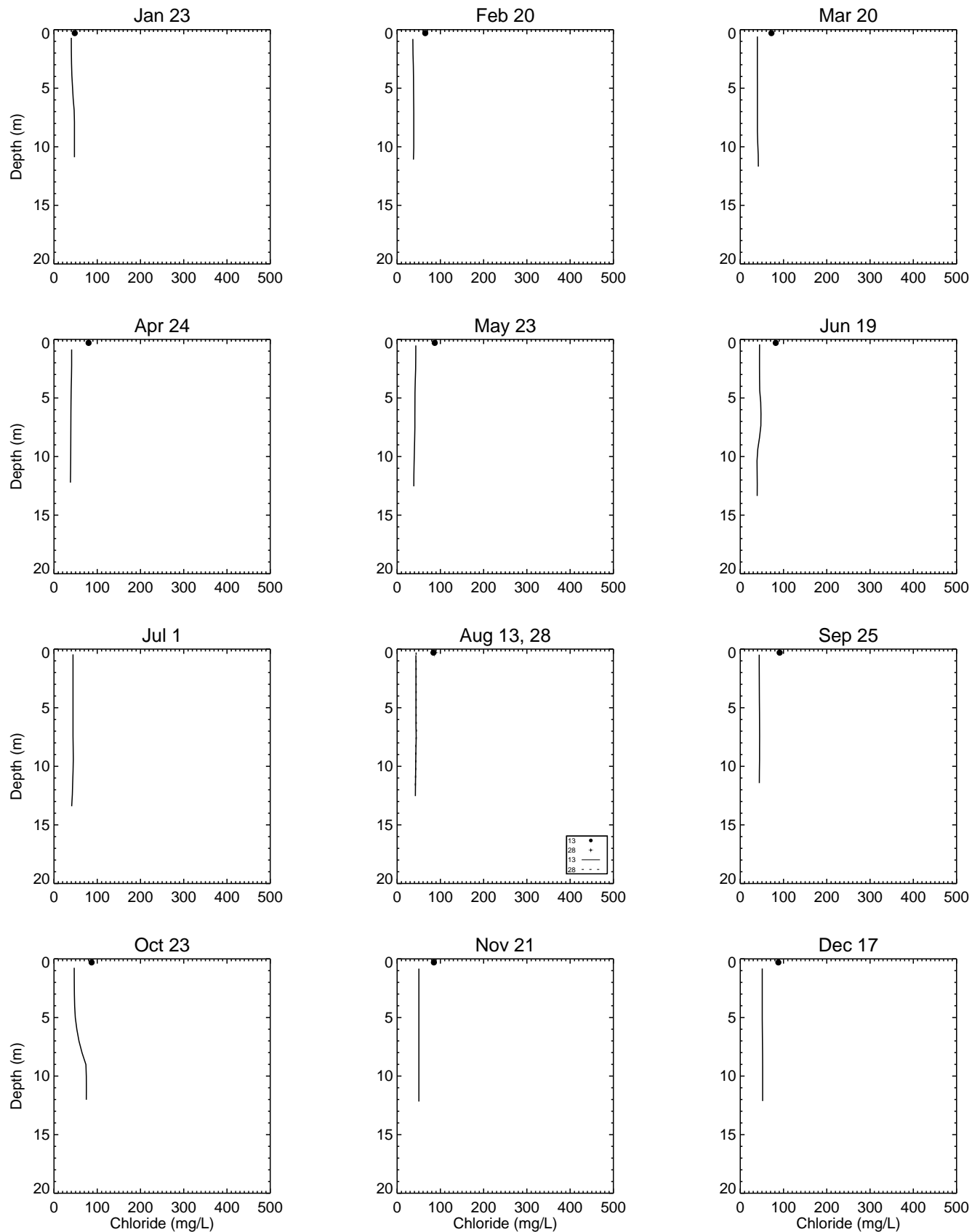CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:00 2013

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
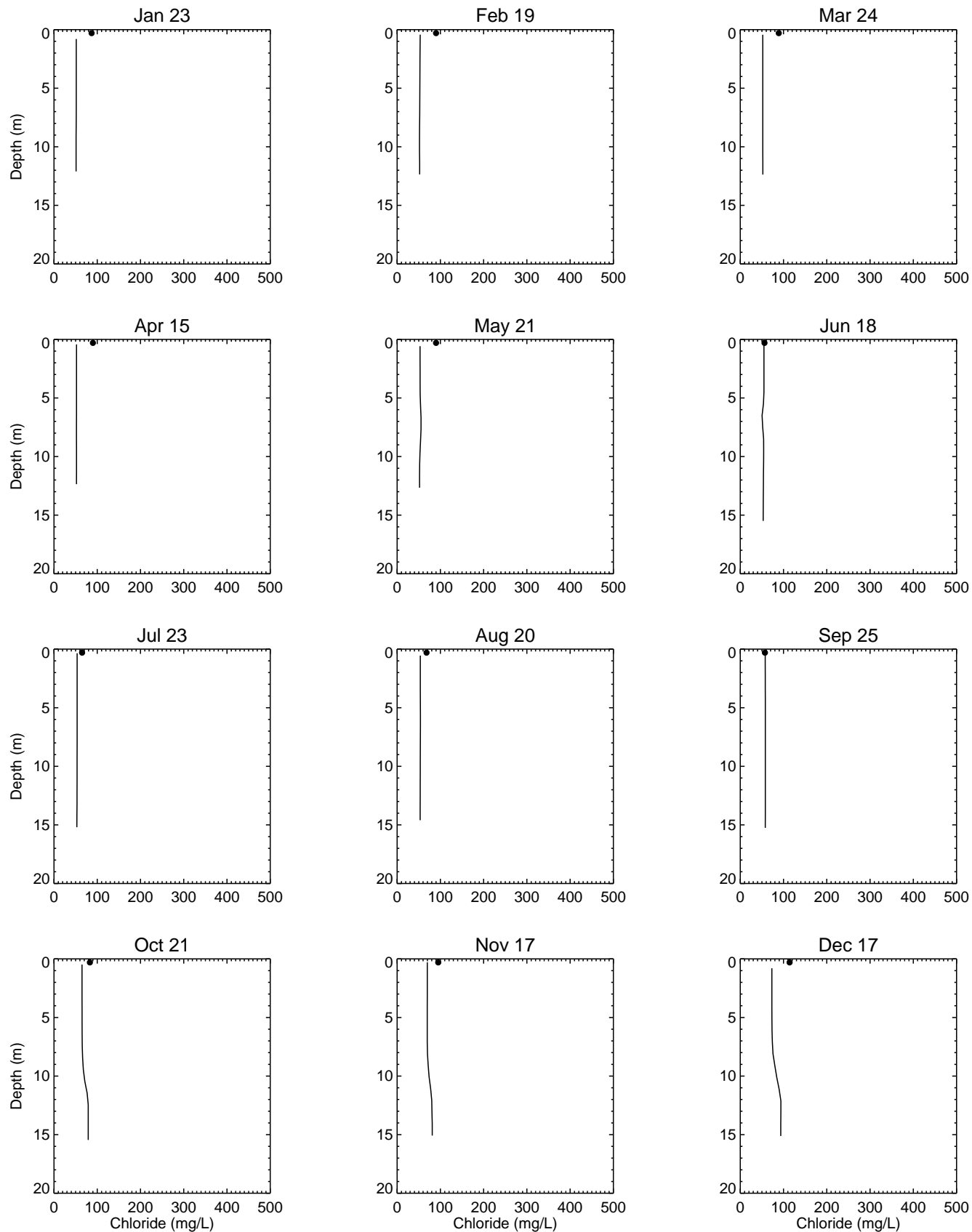at Buchanan Village (Segment 6) - Chloride - 1995

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 1996

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
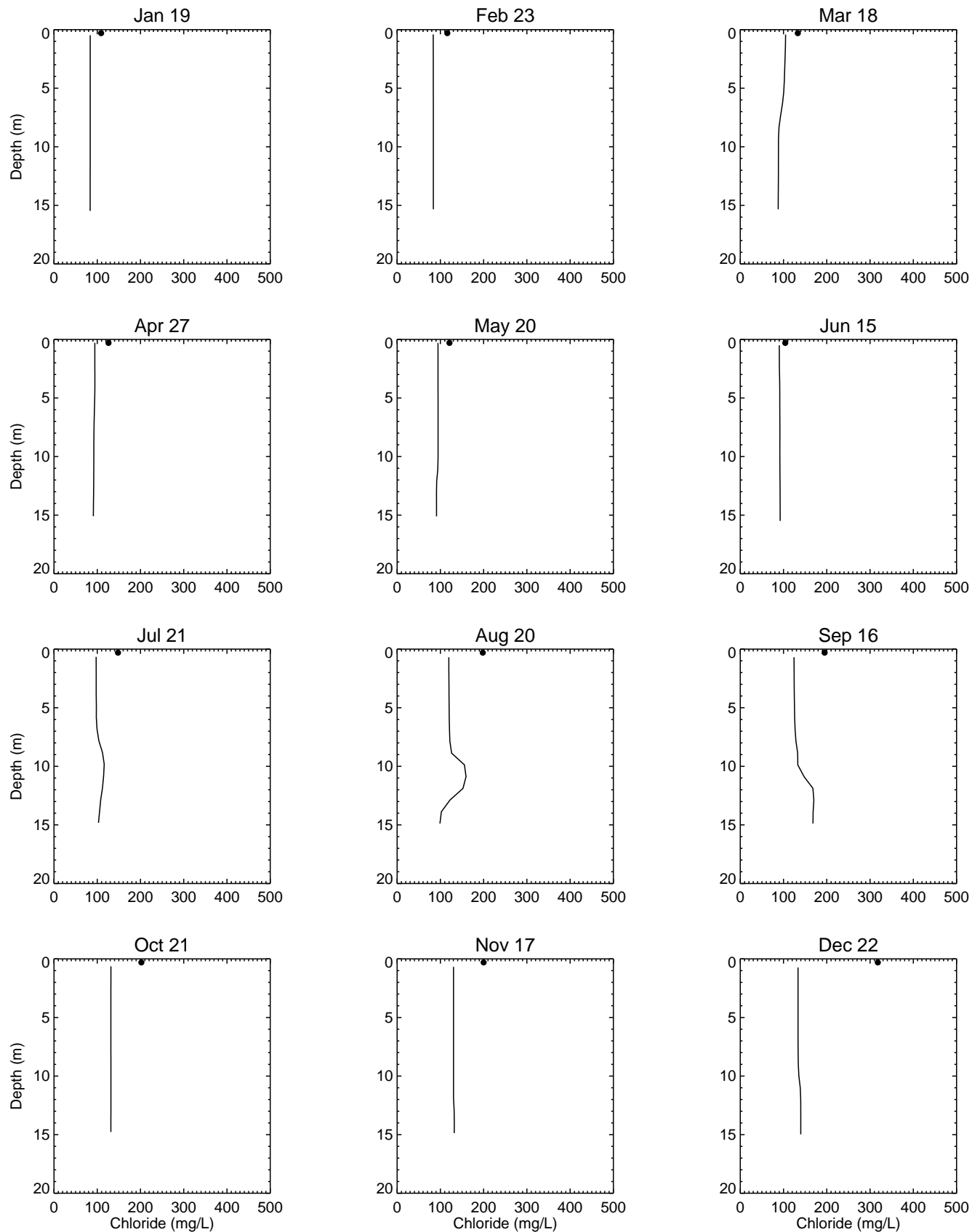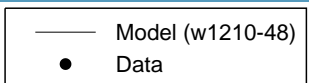
Lower Colorado River Authority

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 1997

Profiles shown for dates with available data else model results for first day of month shown.
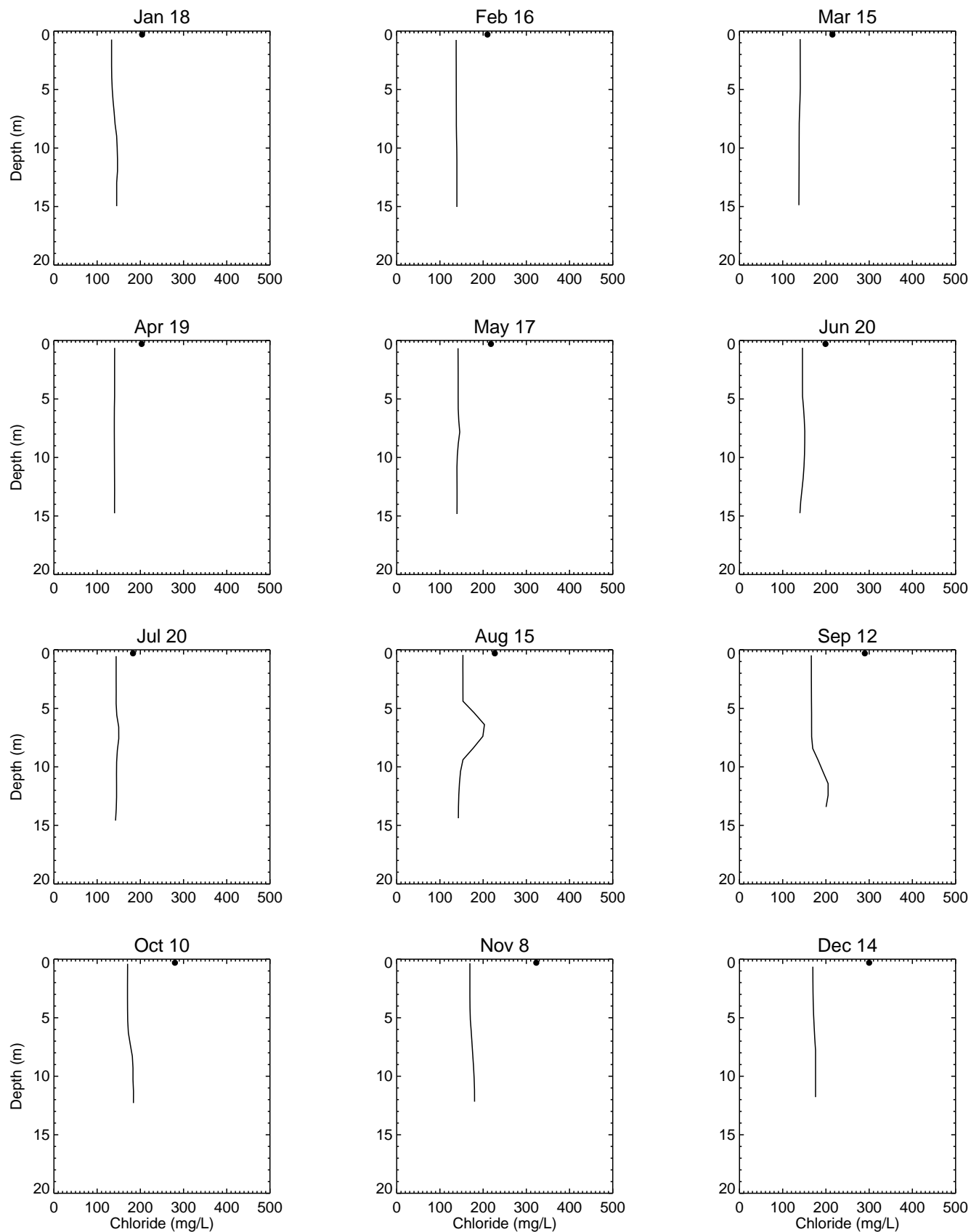
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 1998

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

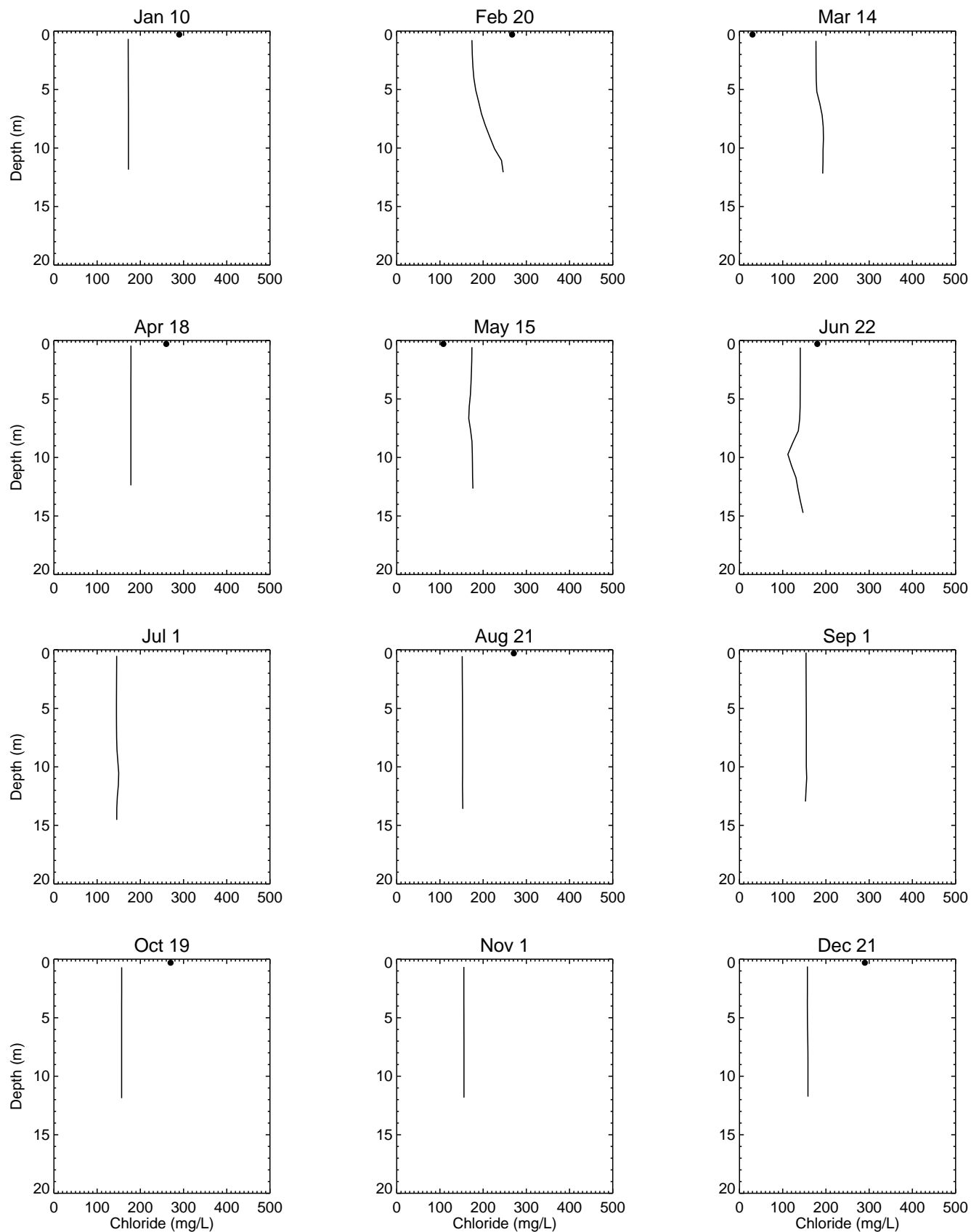Lower Colorado River Authority

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 1999

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m) / Chloride (mg/L)

——— Model (w1210-48)
● Data

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 2000

Profiles shown for dates with available data else model results for first day of month shown.

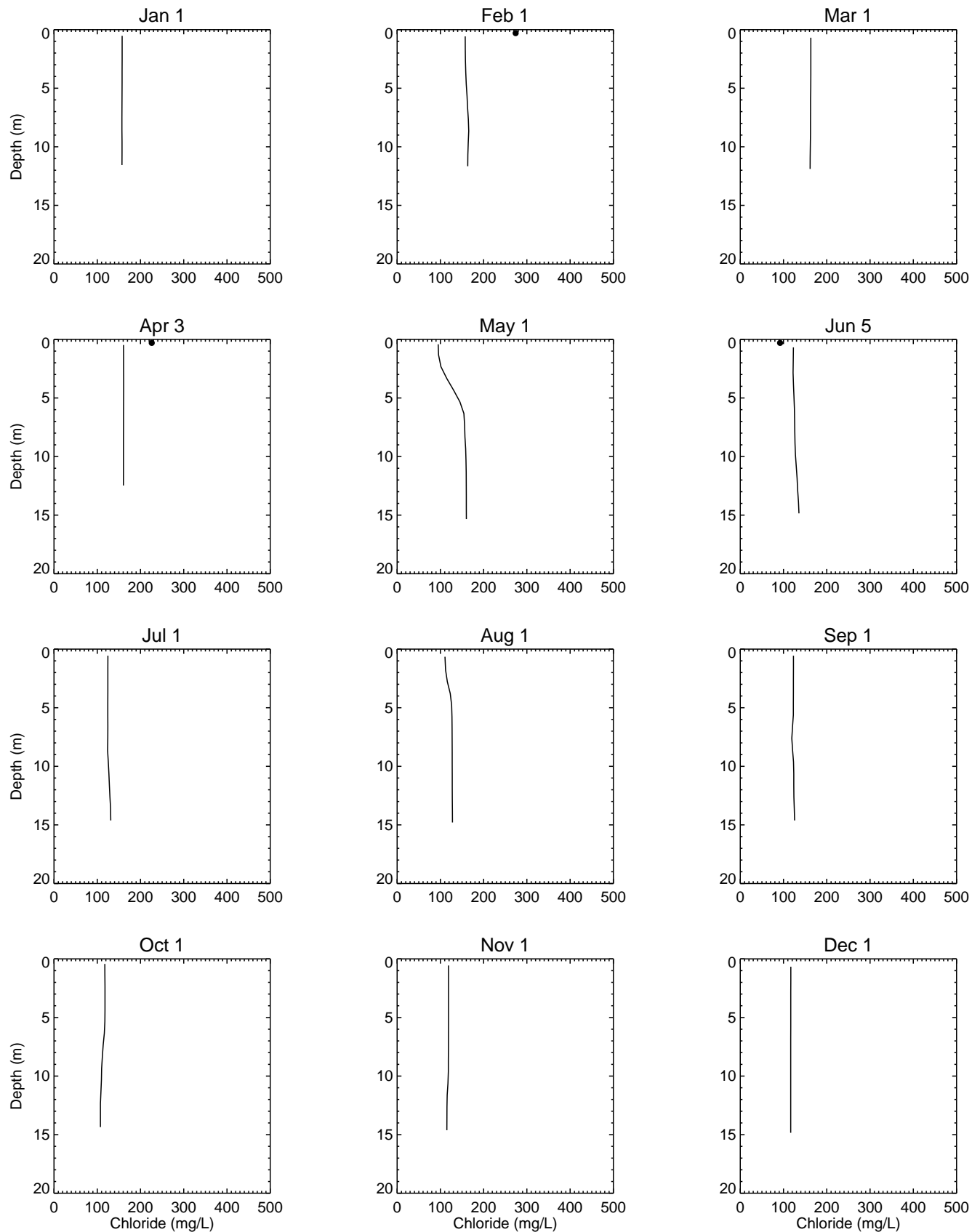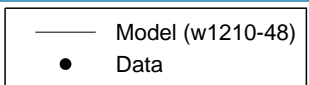CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Chloride (mg/L)
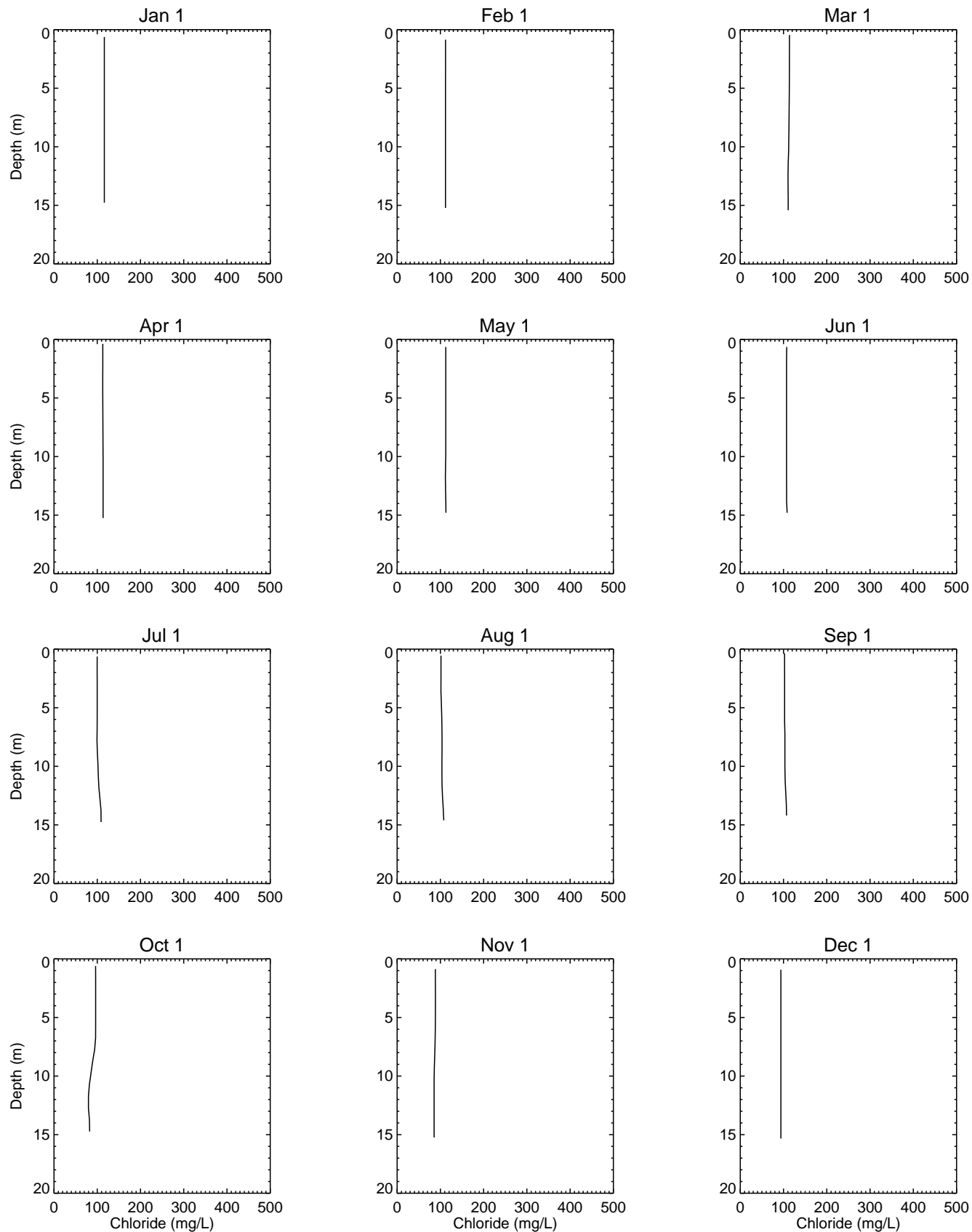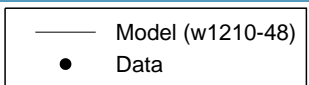
—— Model (w1210-48)
● Data

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 2001

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:00 2013

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 2002

Profiles shown for dates with available data else model results for first day of month shown.
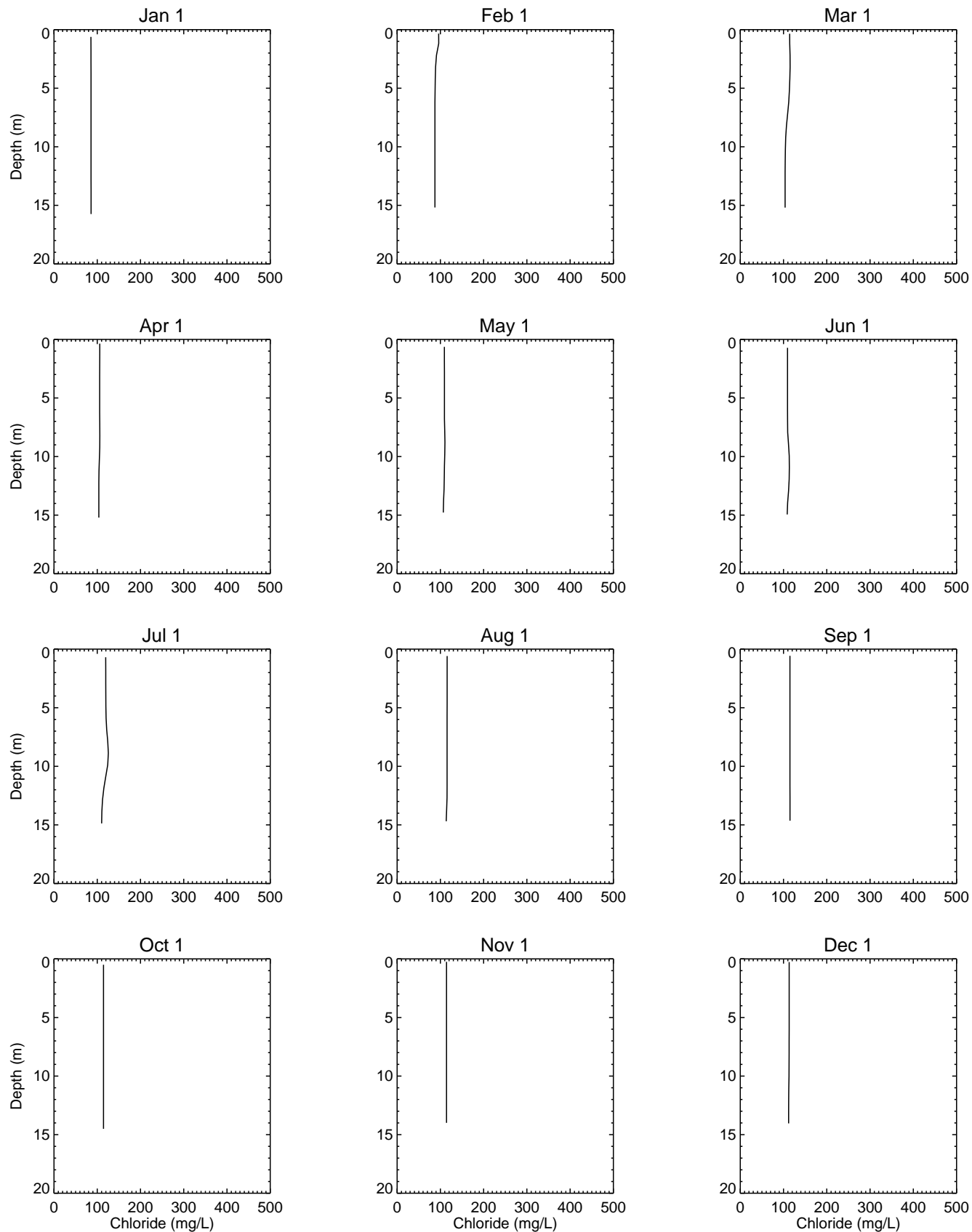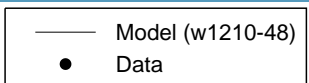
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 2003

Profiles shown for dates with available data else model results for first day of month shown.

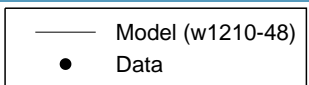CREMs Phase 4: Lake Buchanan
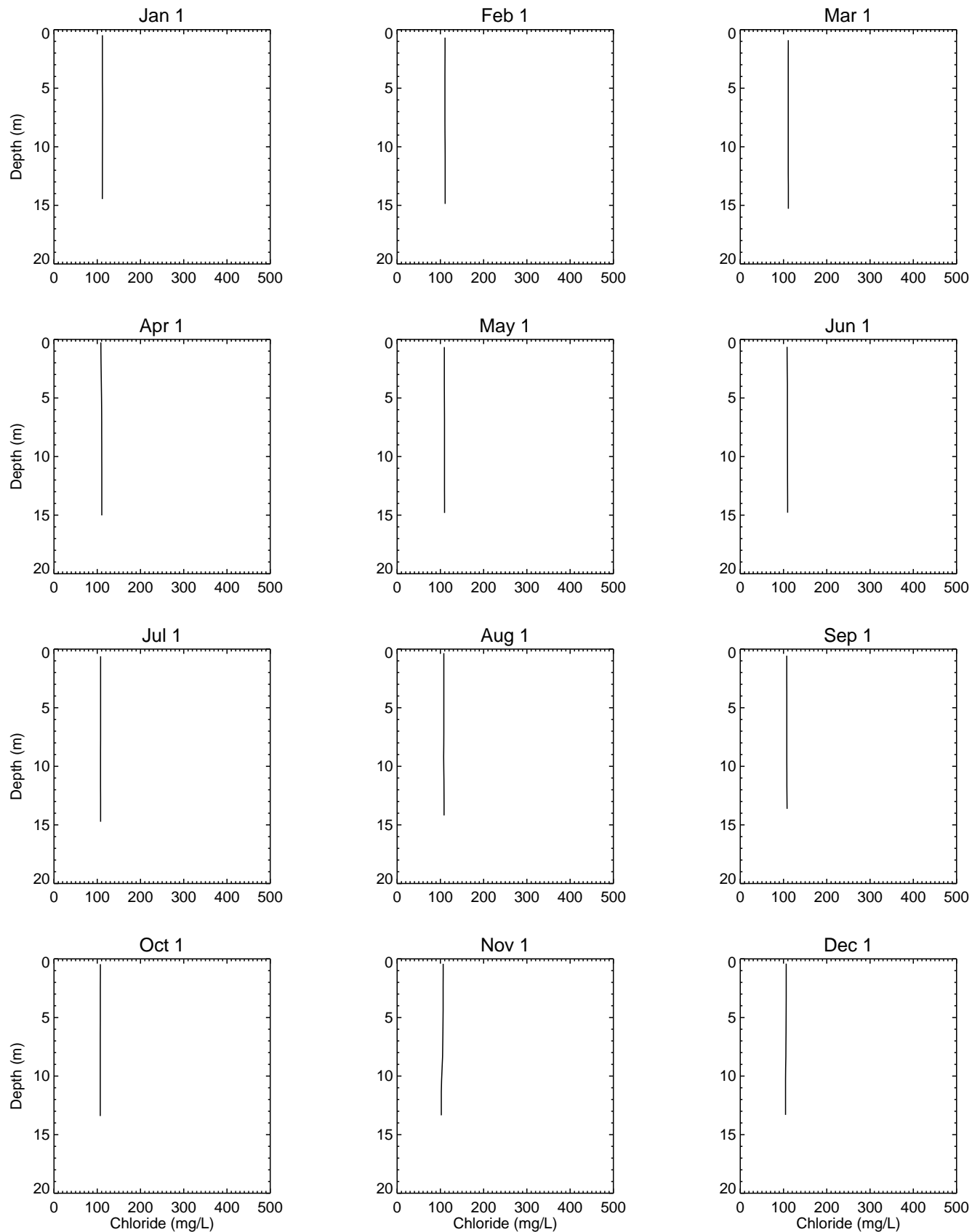
Lower Colorado River Authority

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 2004

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 2005

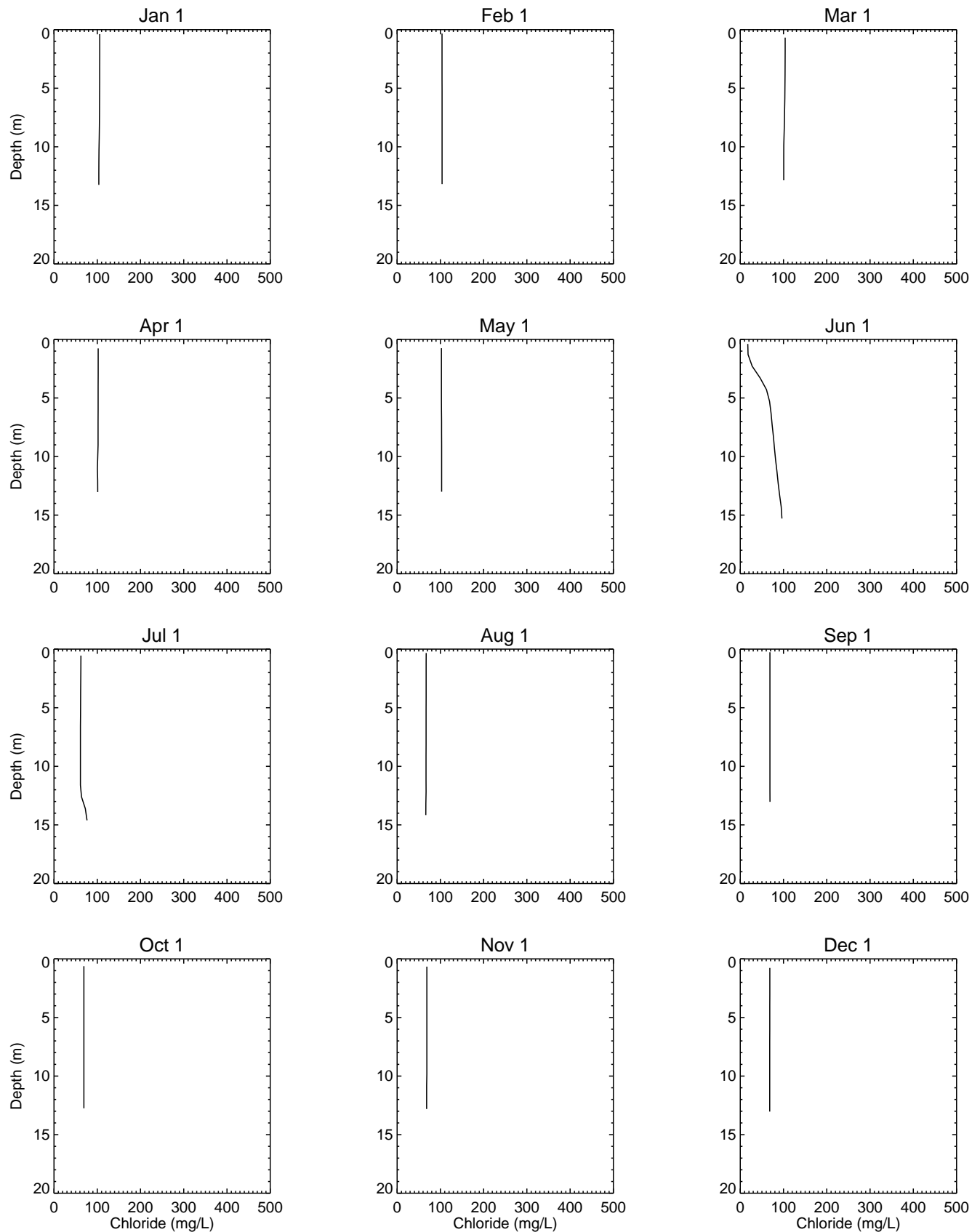*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 2006

Profiles shown for dates with available data else model results for first day of month shown.

Model (w1210-48)
● Data

CREMs Phase 4: Lake Buchanan
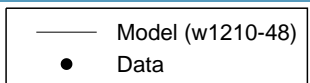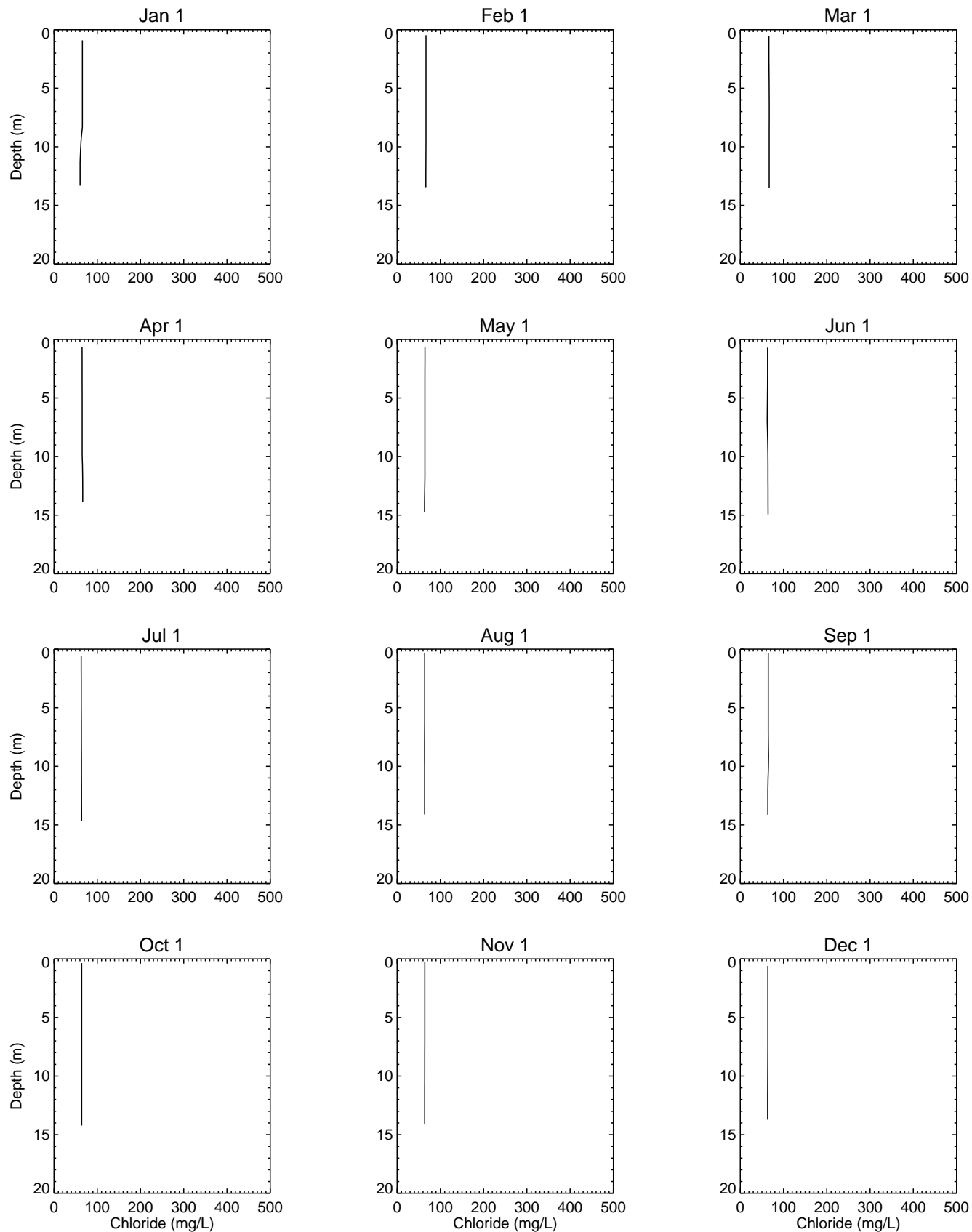Lower Colorado River Authority

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 2007

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 2008

Profiles shown for dates with available data else model results for first day of month shown.

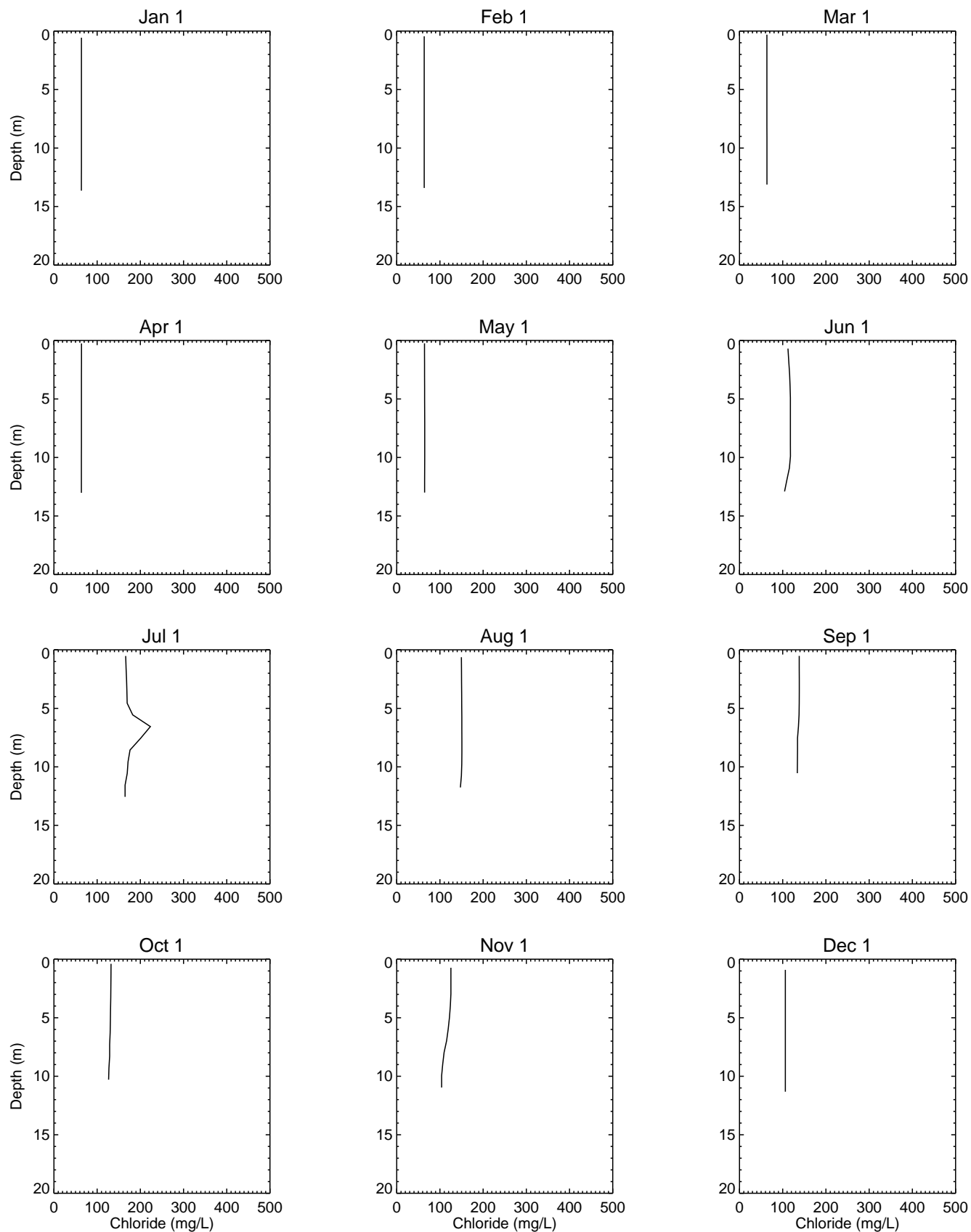CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1　　Feb 1　　Mar 1

Apr 1　　May 1　　Jun 1

Jul 1　　Aug 1　　Sep 1

Oct 1　　Nov 1　　Dec 1
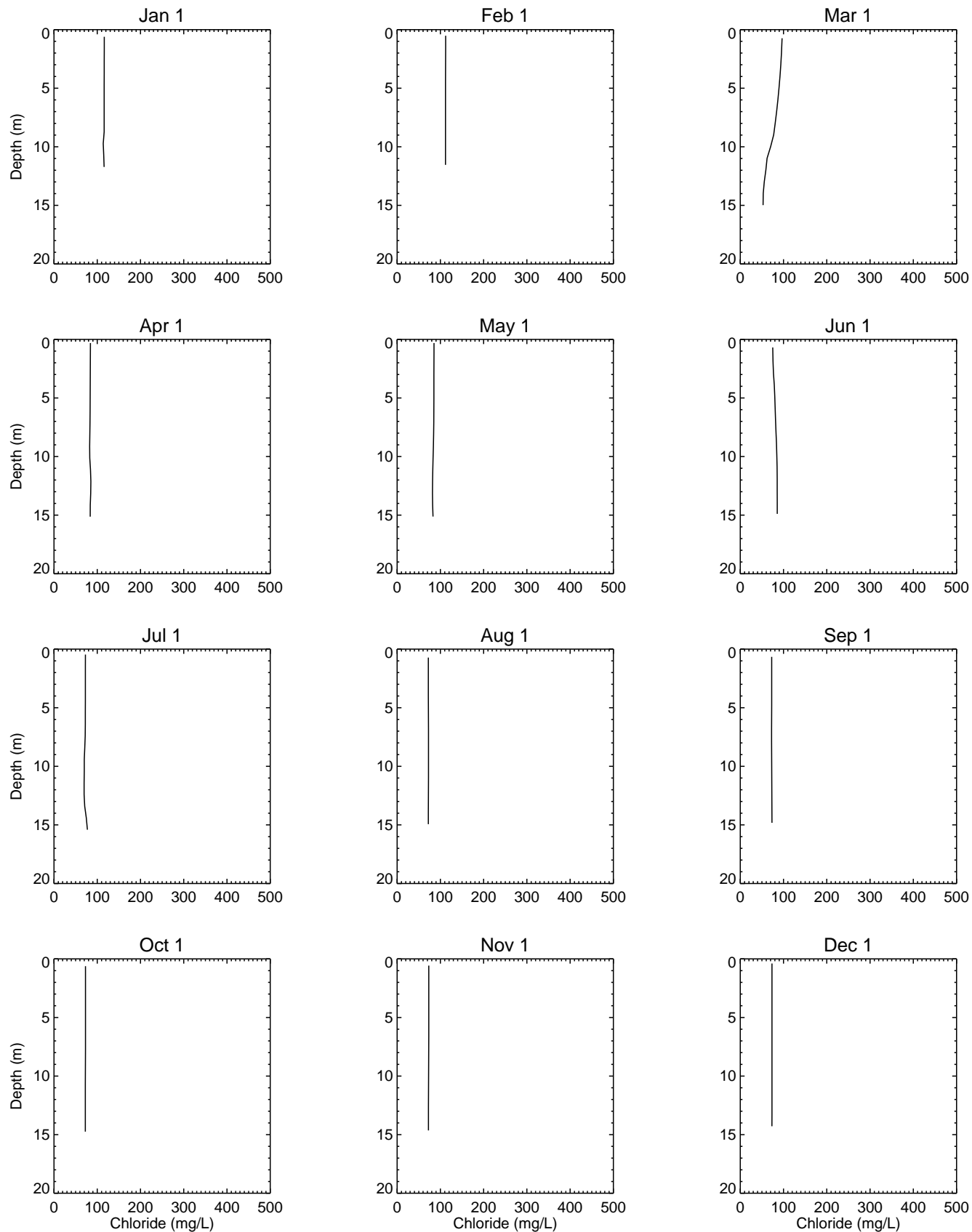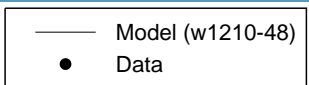
Chloride (mg/L)

Depth (m)

Model (w1210-48)
●　Data

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 2009

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 | Feb 1 | Mar 1
Apr 1 | May 1 | Jun 1
Jul 1 | Aug 1 | Sep 1
Oct 1 | Nov 1 | Dec 1

Chloride (mg/L)

Depth (m)
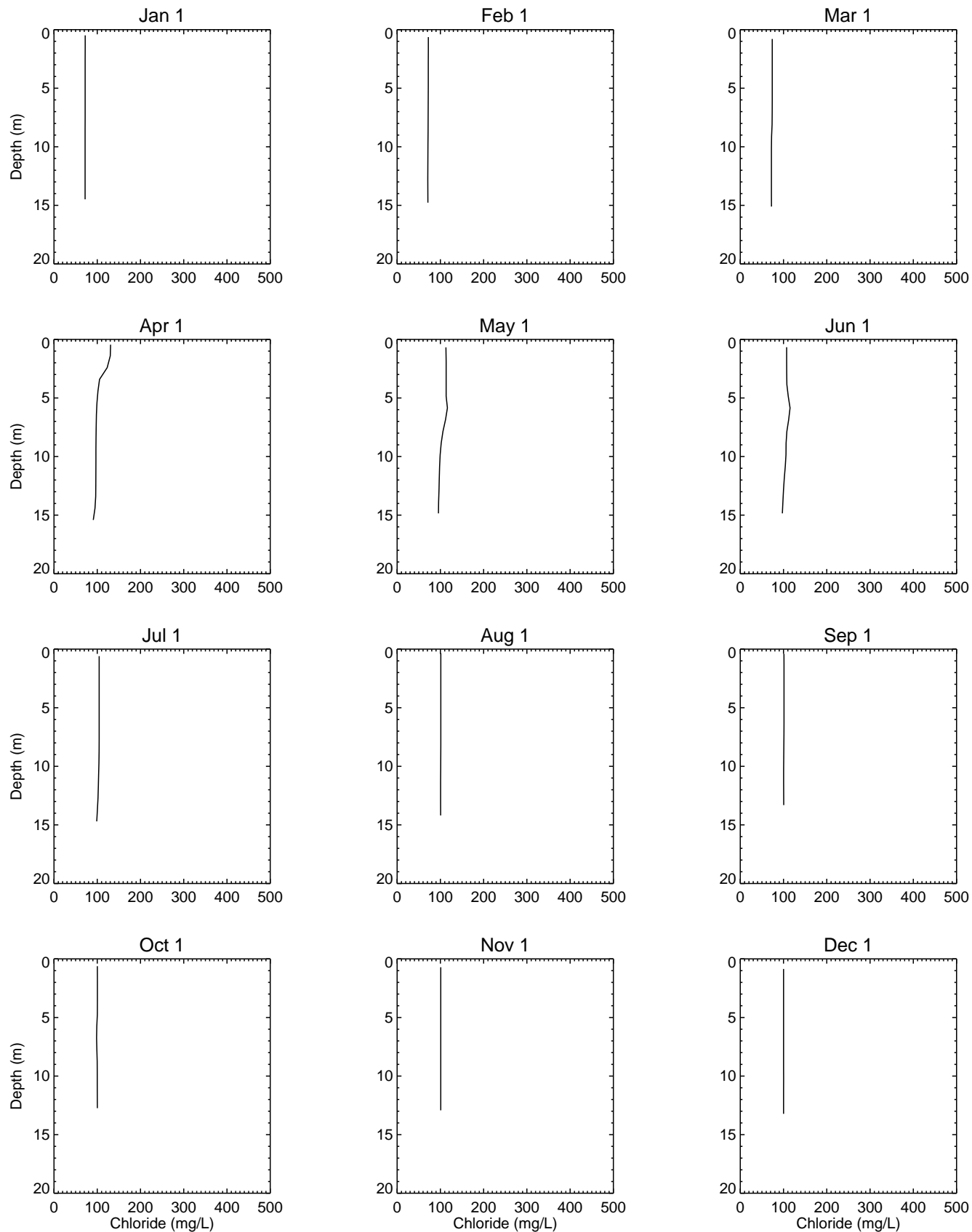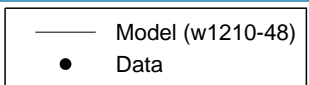
——— Model (w1210-48)
● Data

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 2010

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:00 2013

ANCHOR QEA
PARSONS

Figure G-20

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Chloride - 2011

Profiles shown for dates with available data else model results for first day of month shown.

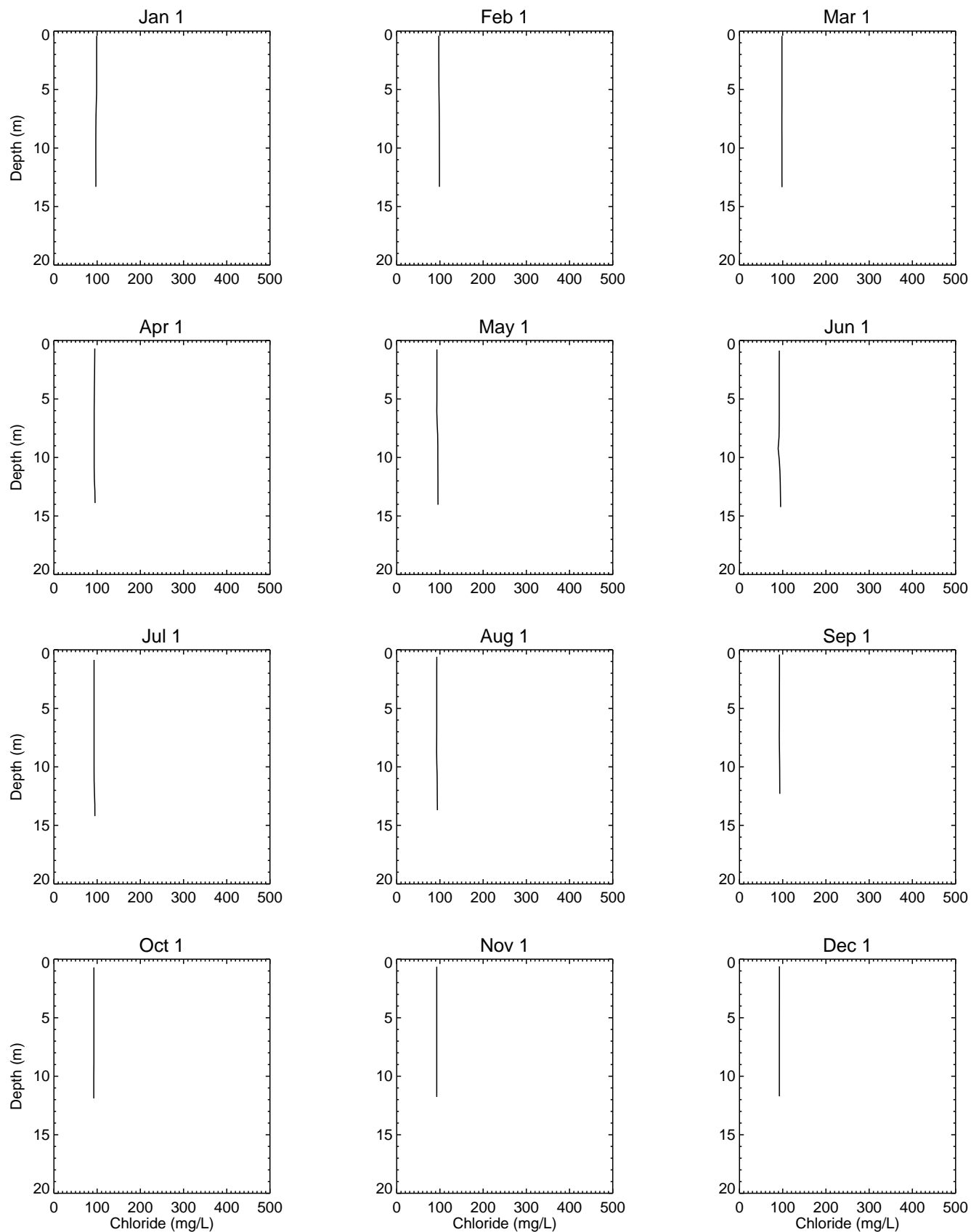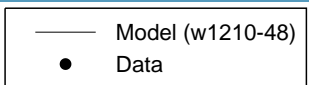CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 1984

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 1985

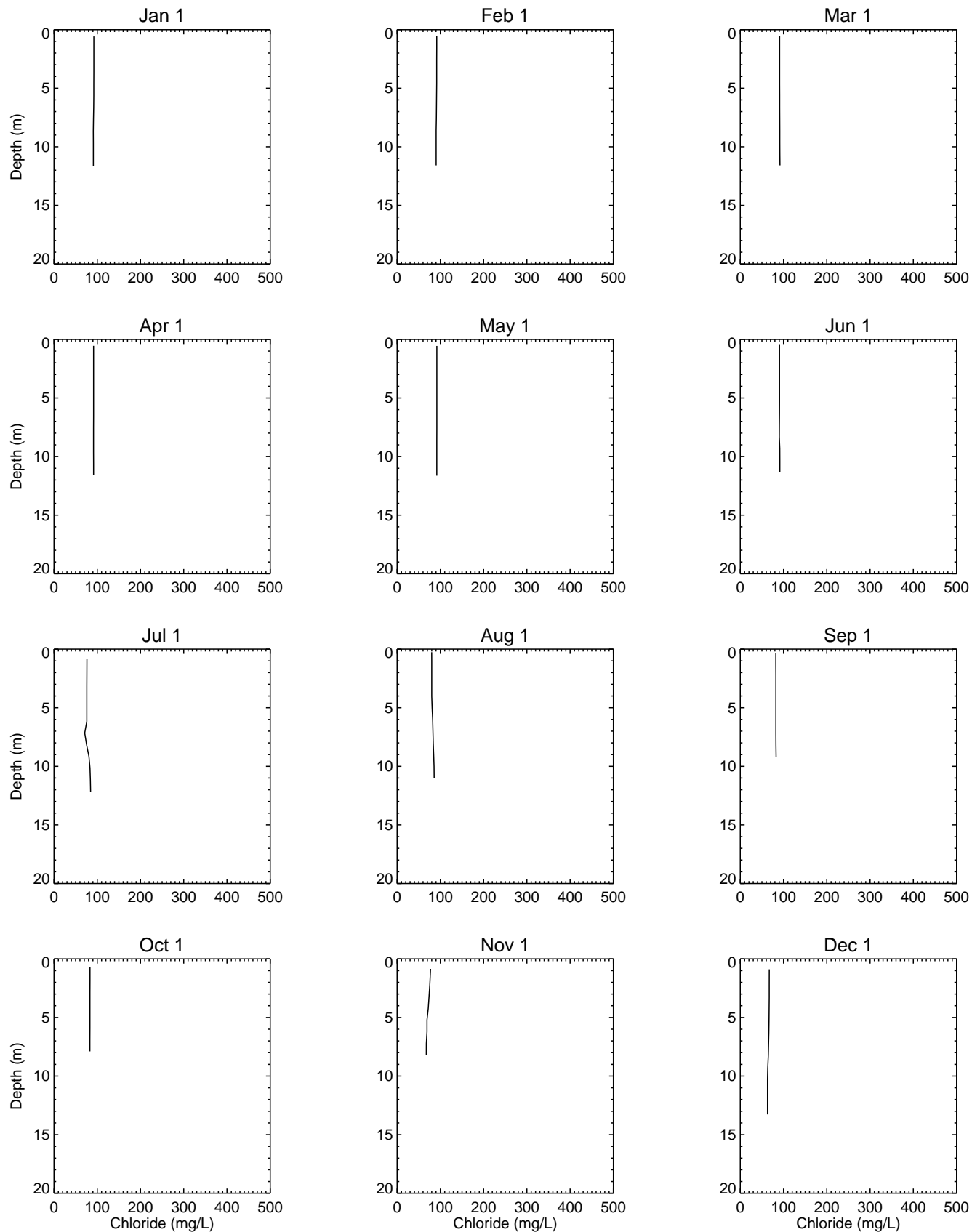*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 1987

Profiles shown for dates with available data else model results for first day of month shown.

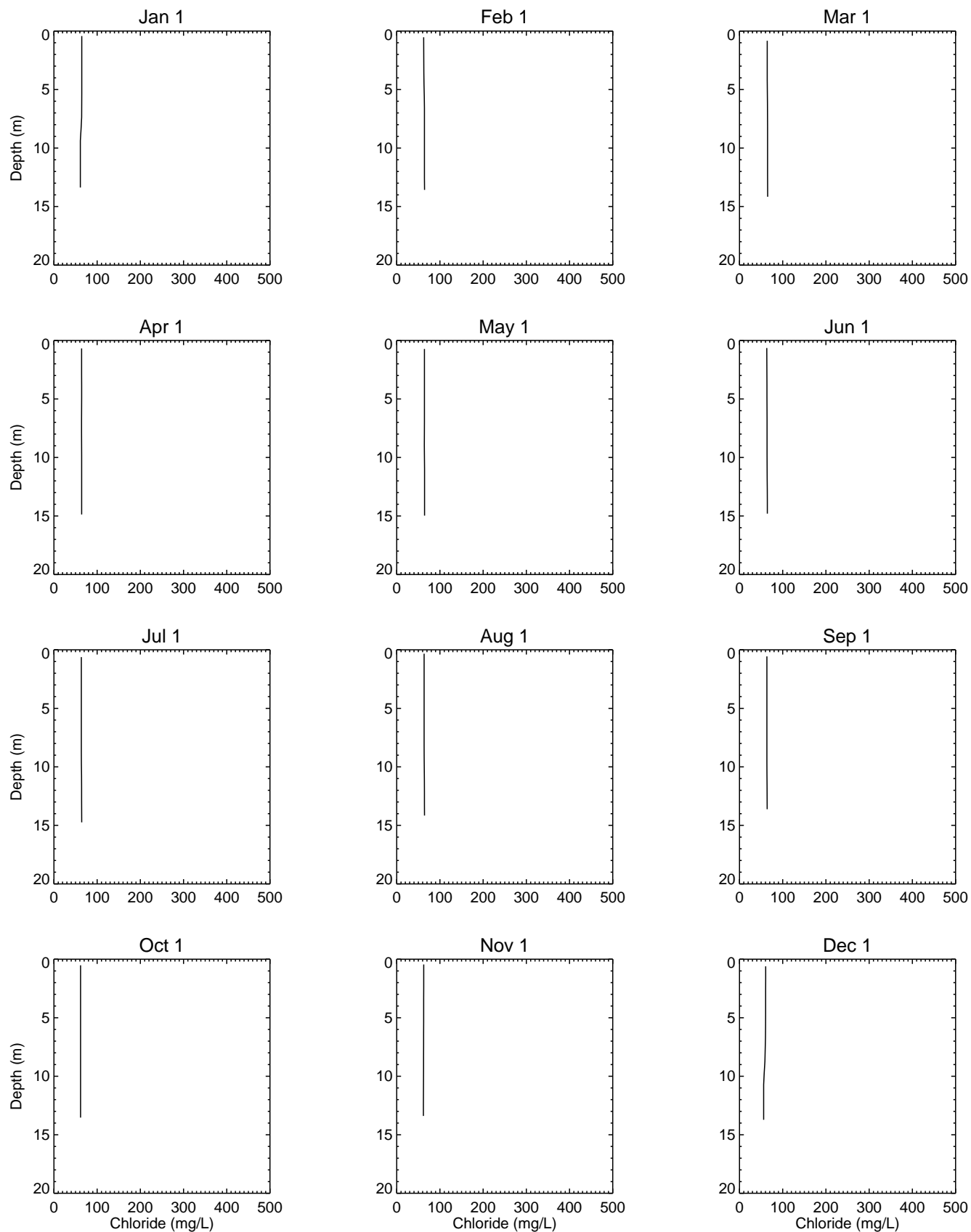CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 1988

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
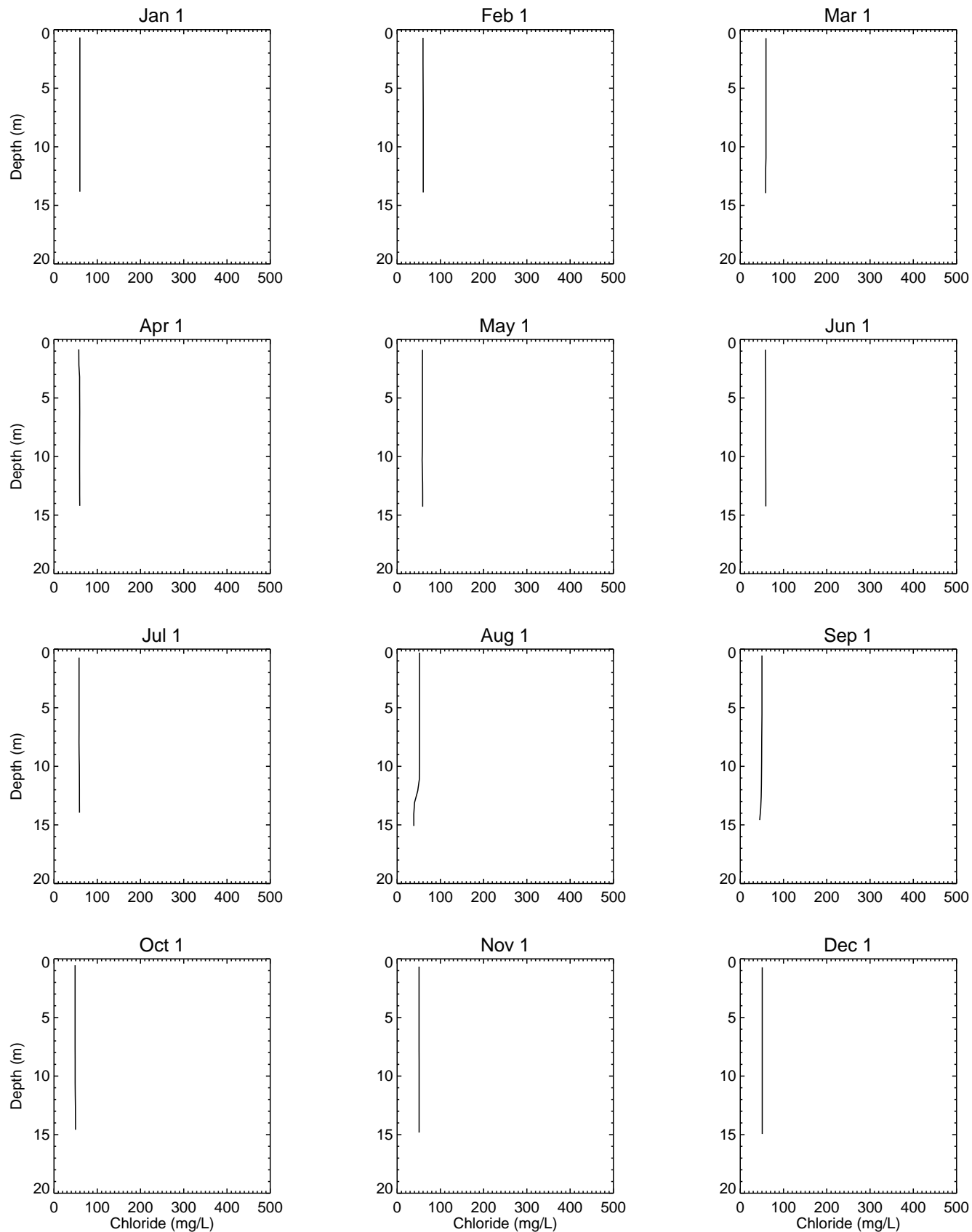near Beaver Creek Cove (Segment 6) - Chloride - 1989

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 1990

Profiles shown for dates with available data else model results for first day of month shown.

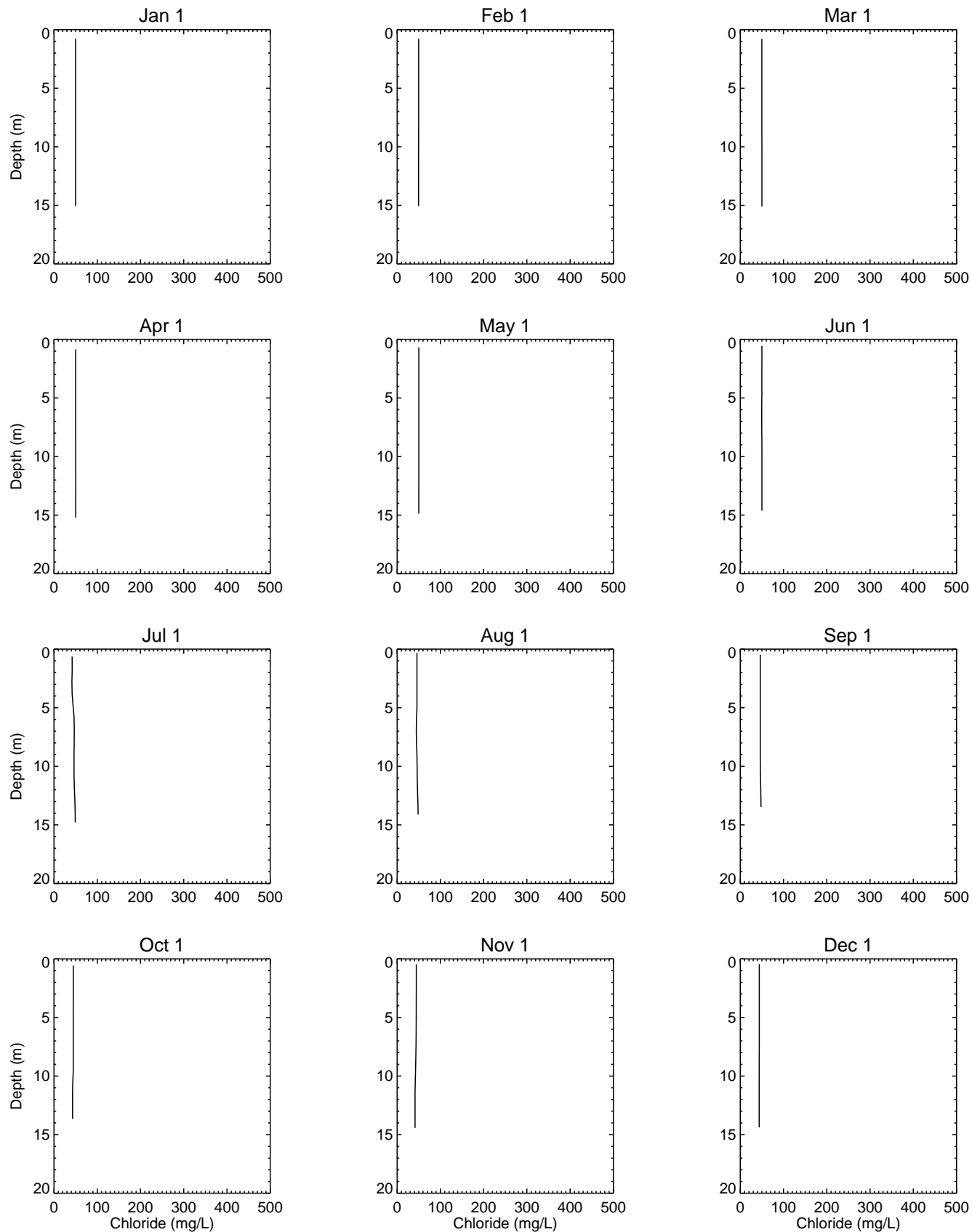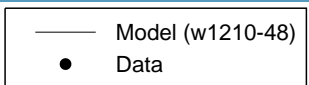CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 1991

Profiles shown for dates with available data else model results for first day of month shown.

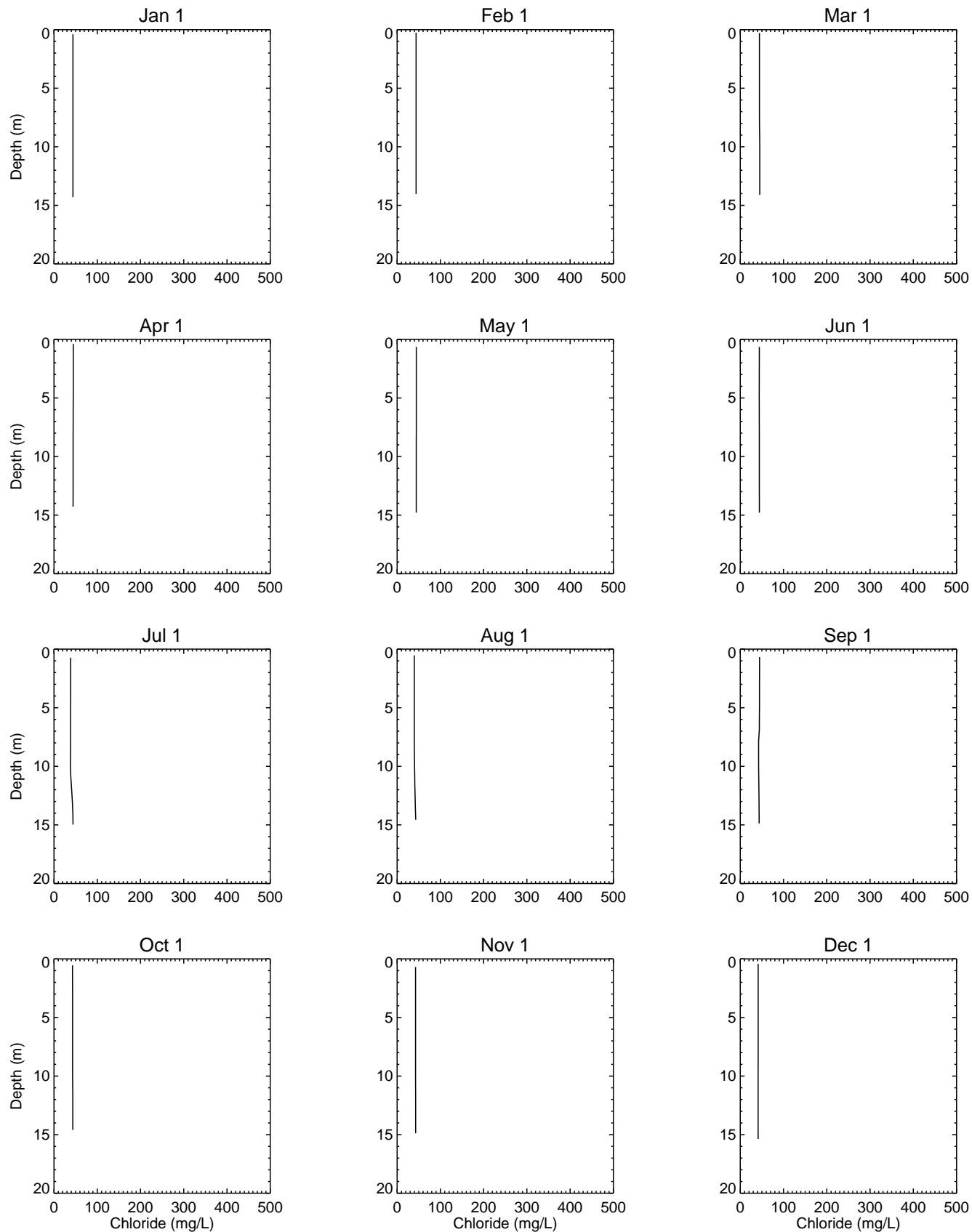CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 1993

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
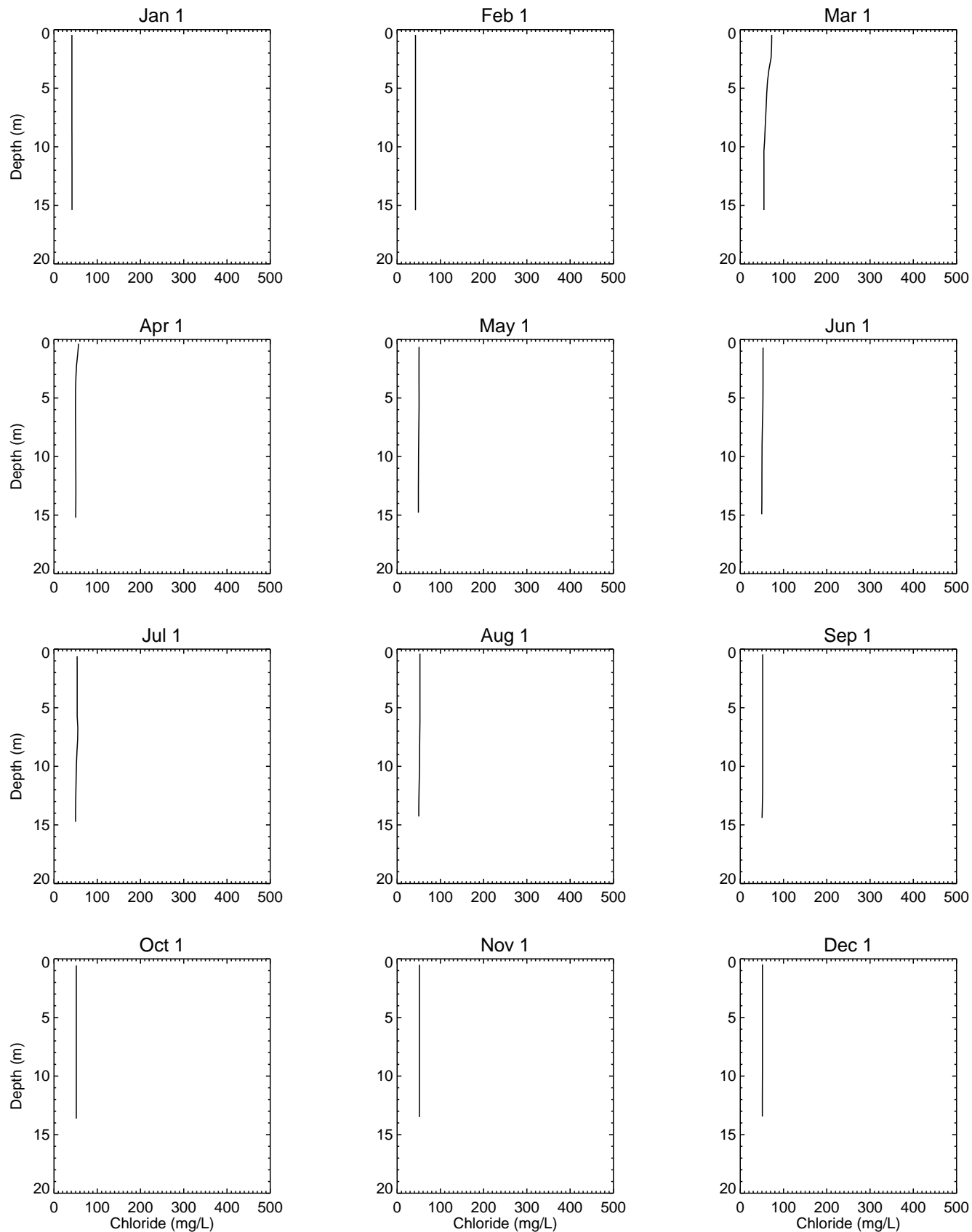
Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 1994

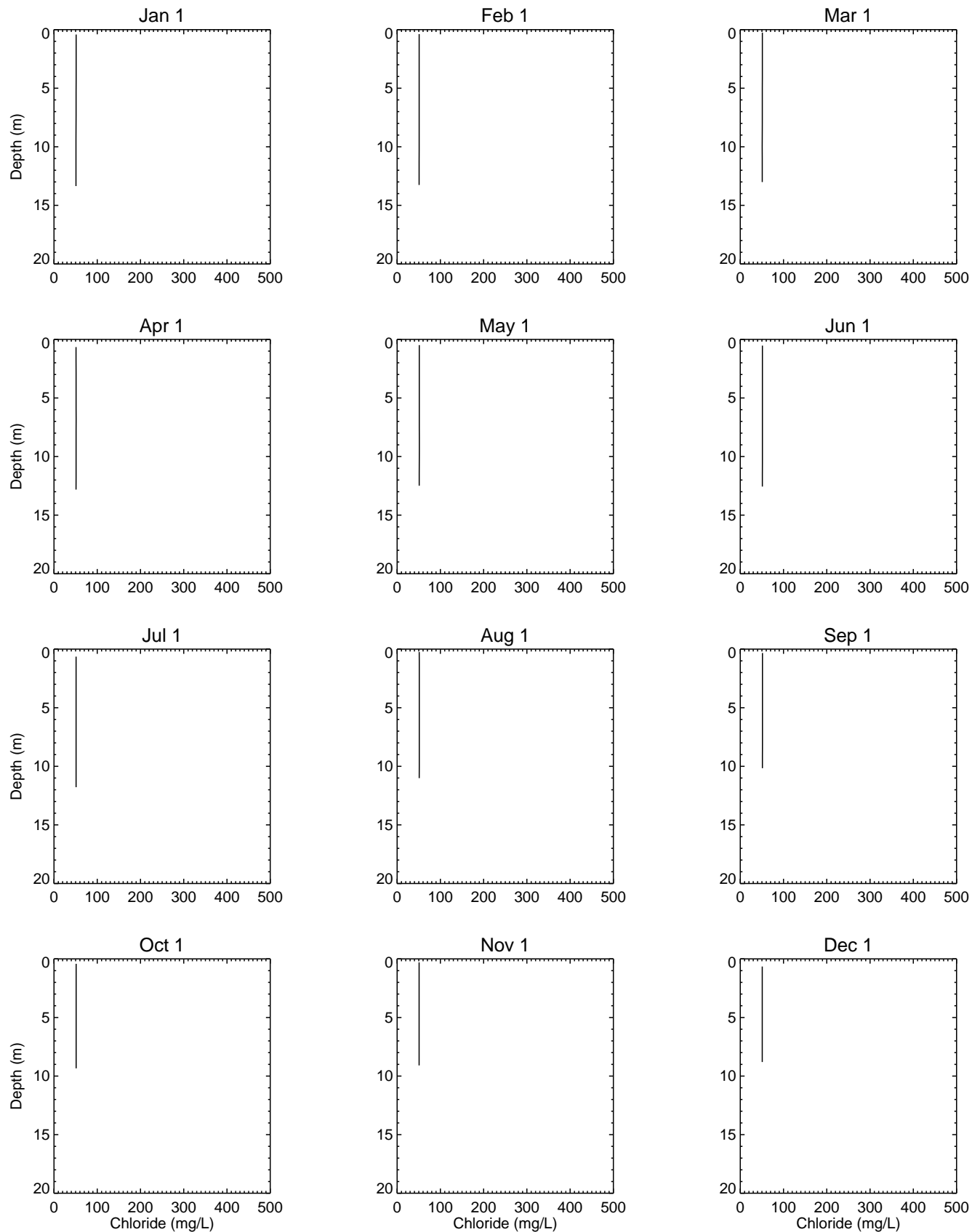*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 1995

Profiles shown for dates with available data else model results for first day of month shown.

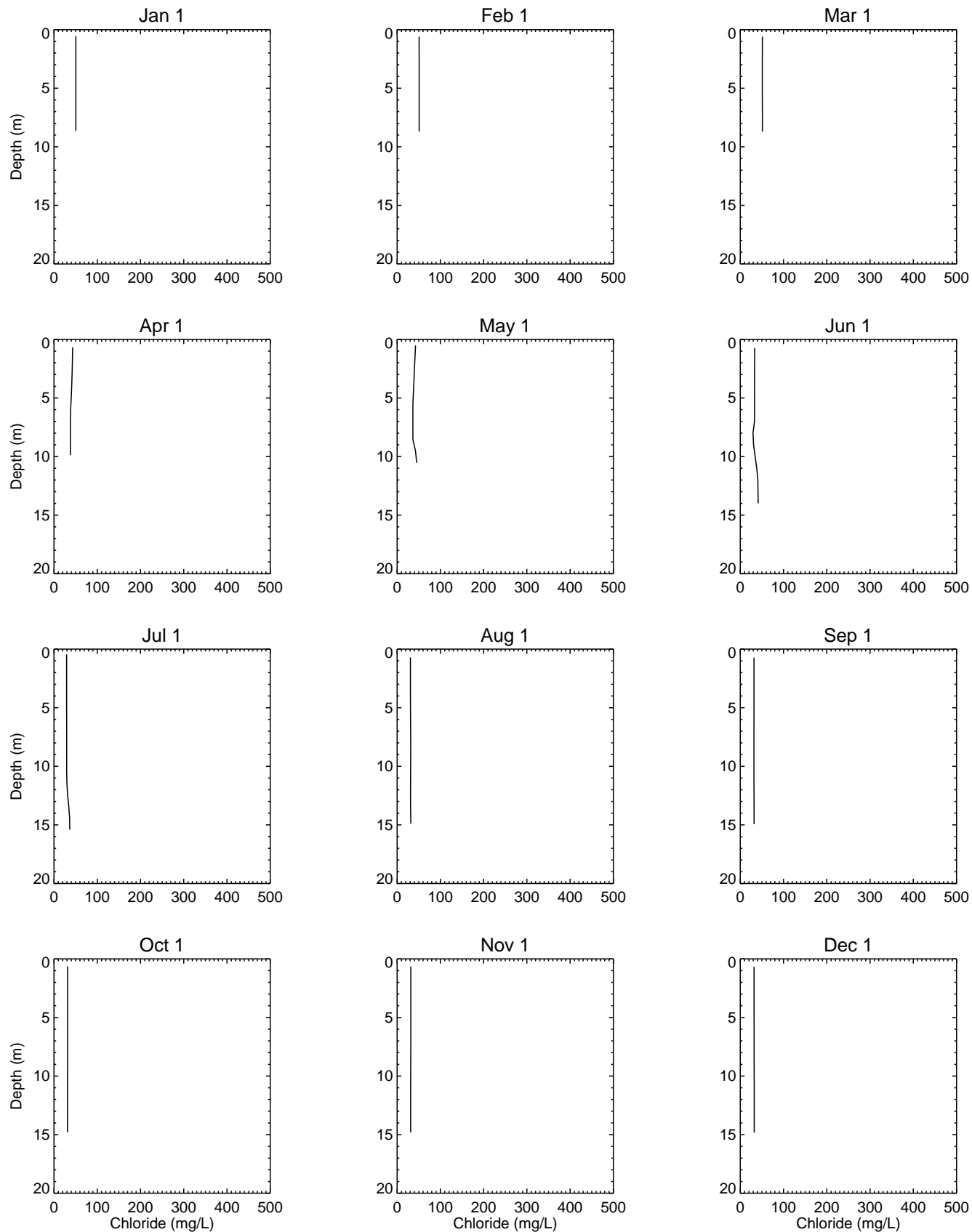CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 1996

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

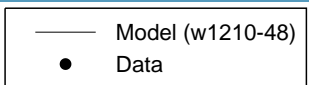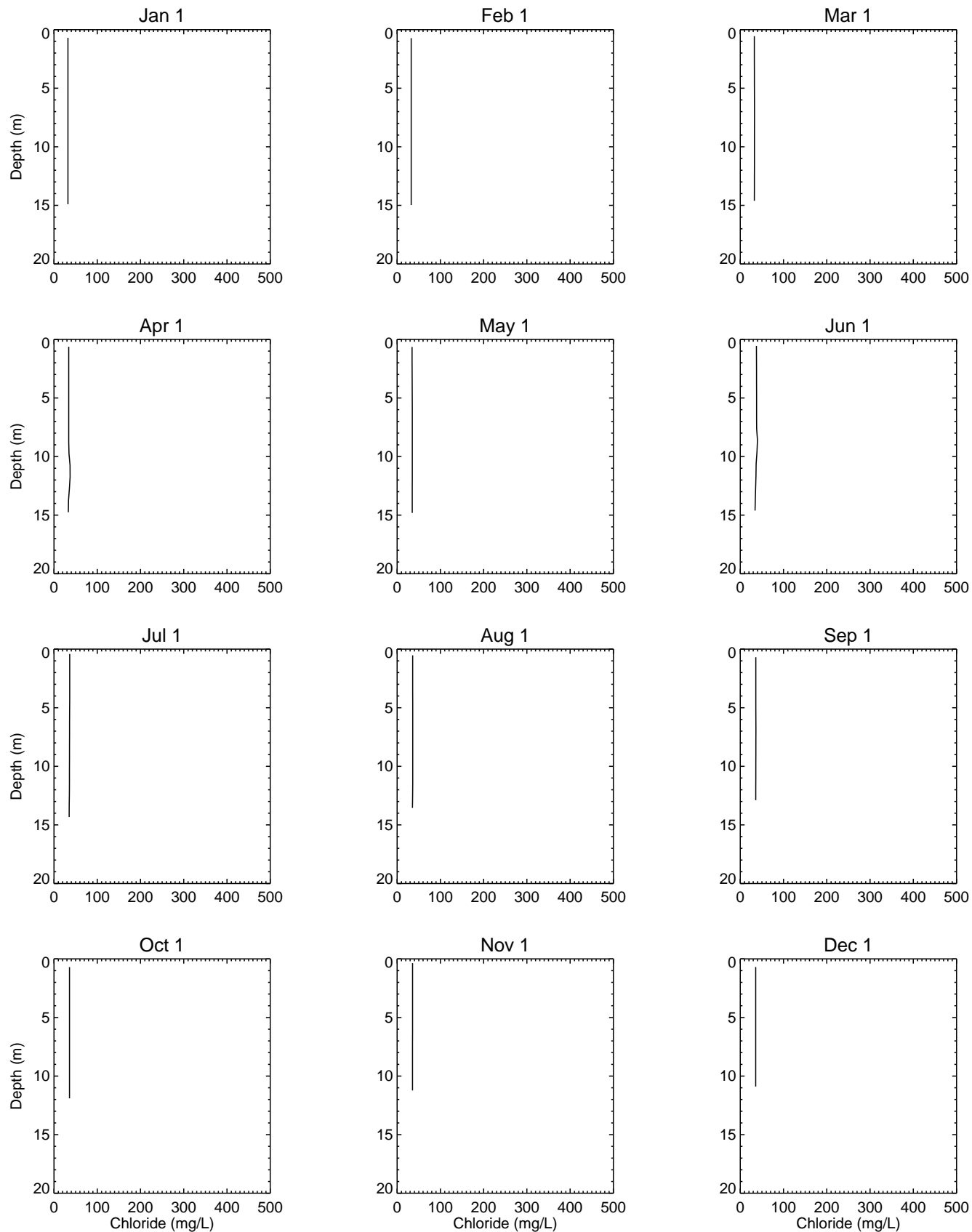Lower Colorado River Authority

Jan 1   Feb 6   Mar 1

Apr 16   May 1   Jun 5

Jul 1   Aug 11   Sep 1

Oct 20   Nov 1   Dec 15

Chloride (mg/L)

Depth (m)

——— Model (w1210-48)
● Data

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 1997

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
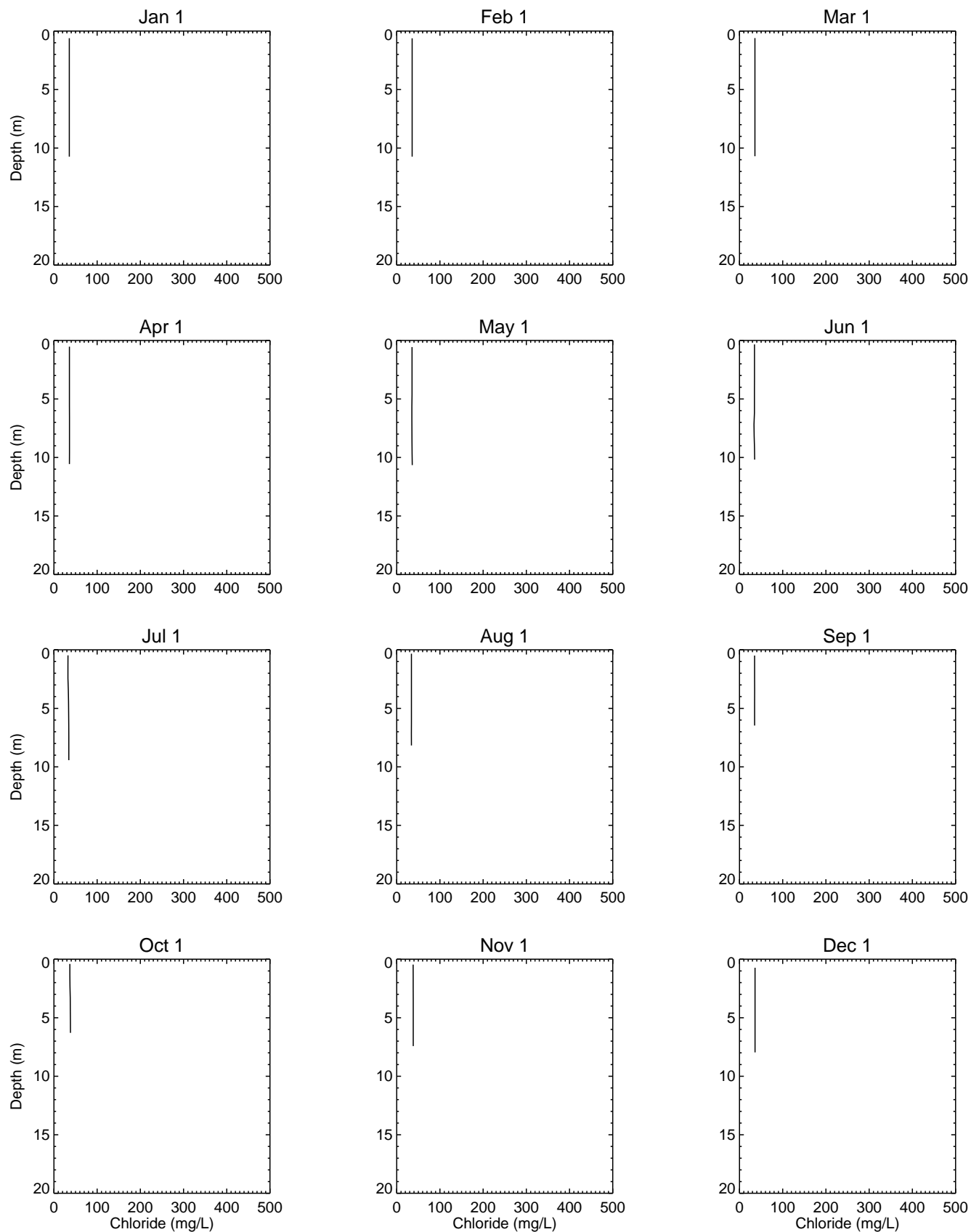
Lower Colorado River Authority

Jan 1   Feb 5   Mar 1

Apr 8   May 1   Jun 15

Jul 1   Aug 3   Sep 1

Oct 8   Nov 1   Dec 3

——— Model (w1210-48)
● Data

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
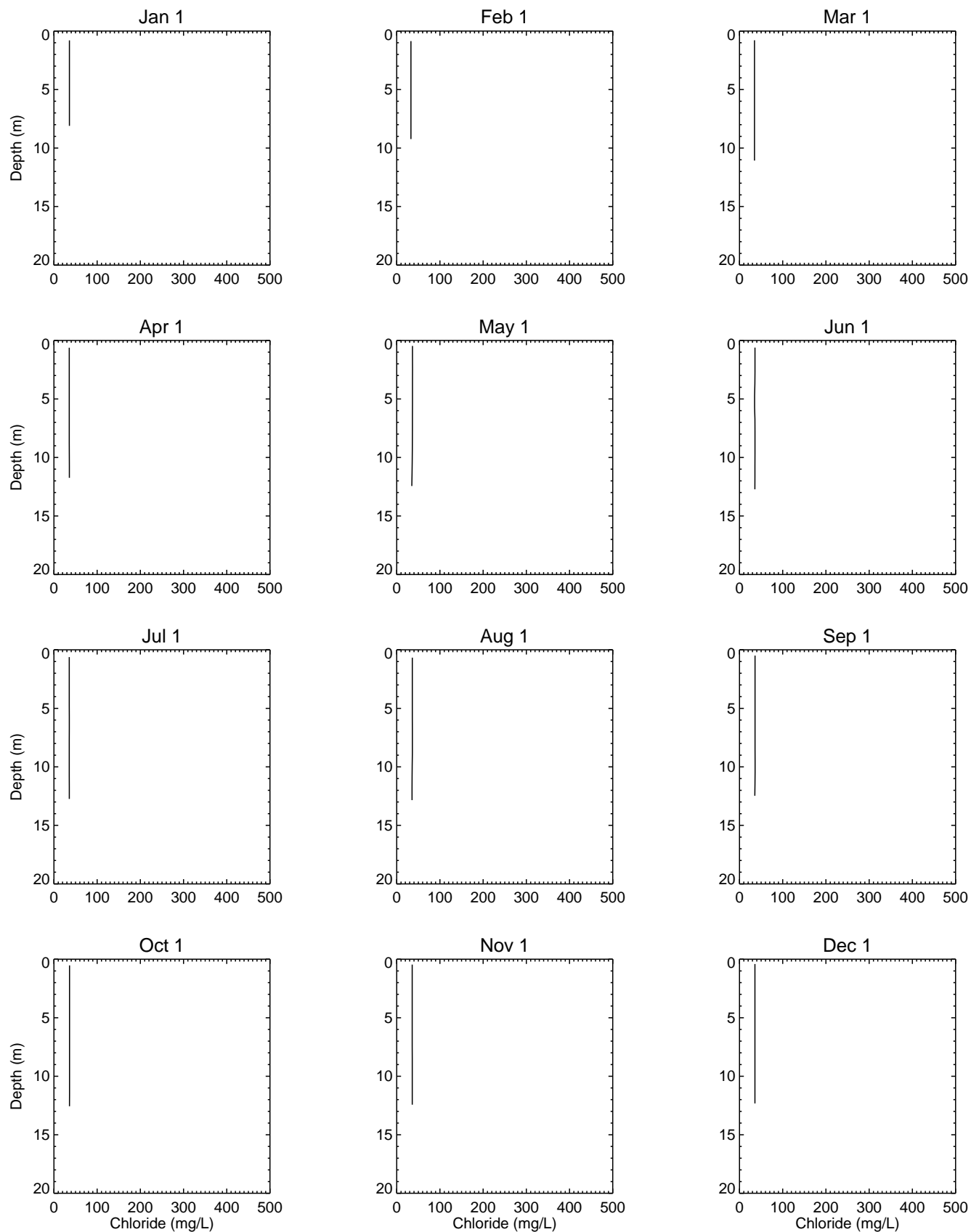near Beaver Creek Cove (Segment 6) - Chloride - 1998

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

Jan 1 | Feb 3 | Mar 1
Apr 13 | May 1 | Jun 15
Jul 1 | Aug 5 | Sep 1
Oct 4 | Nov 1 | Dec 6

——— Model (w1210-48)
● Data

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 1999

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
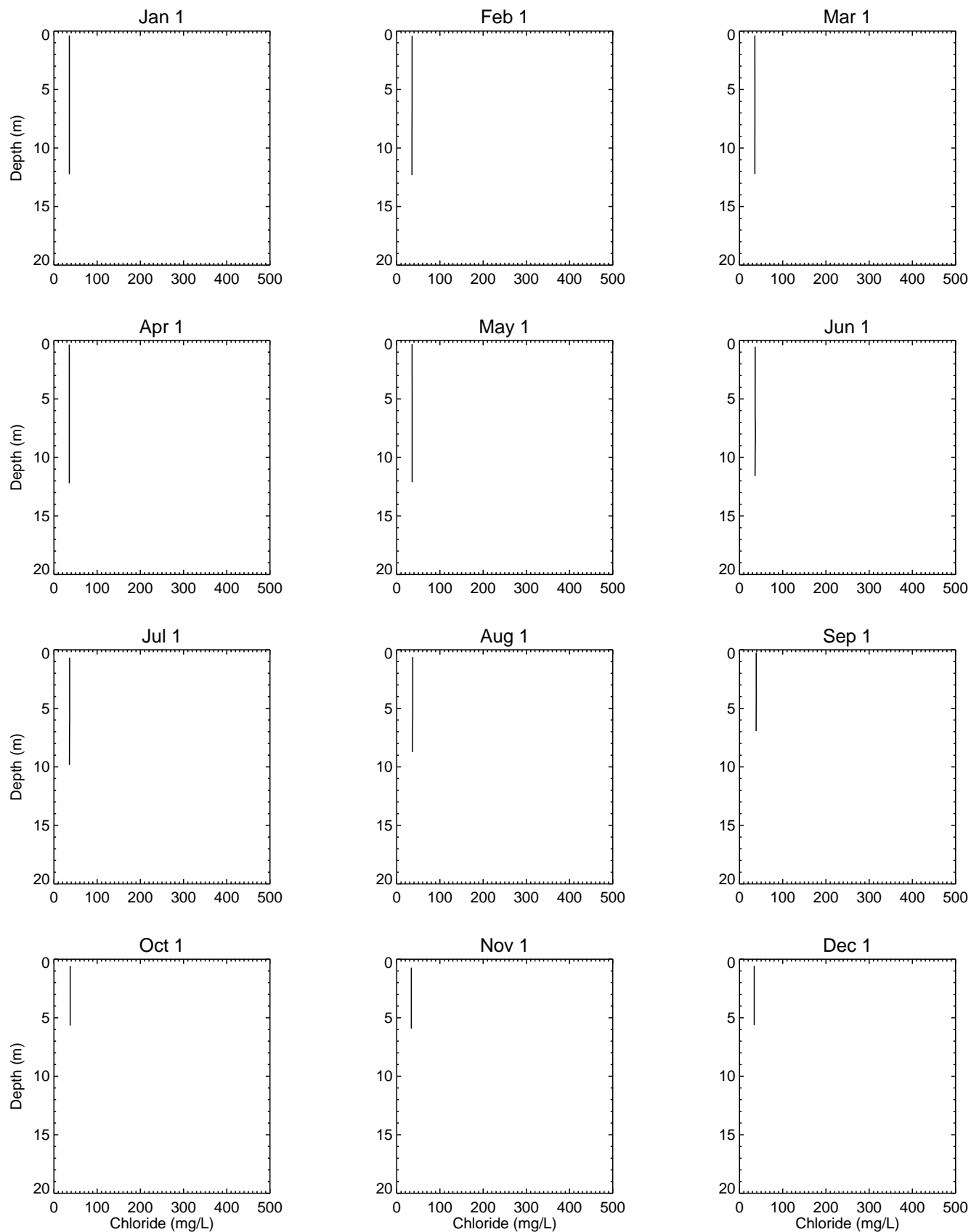Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 2000

Profiles shown for dates with available data else model results for first day of month shown.

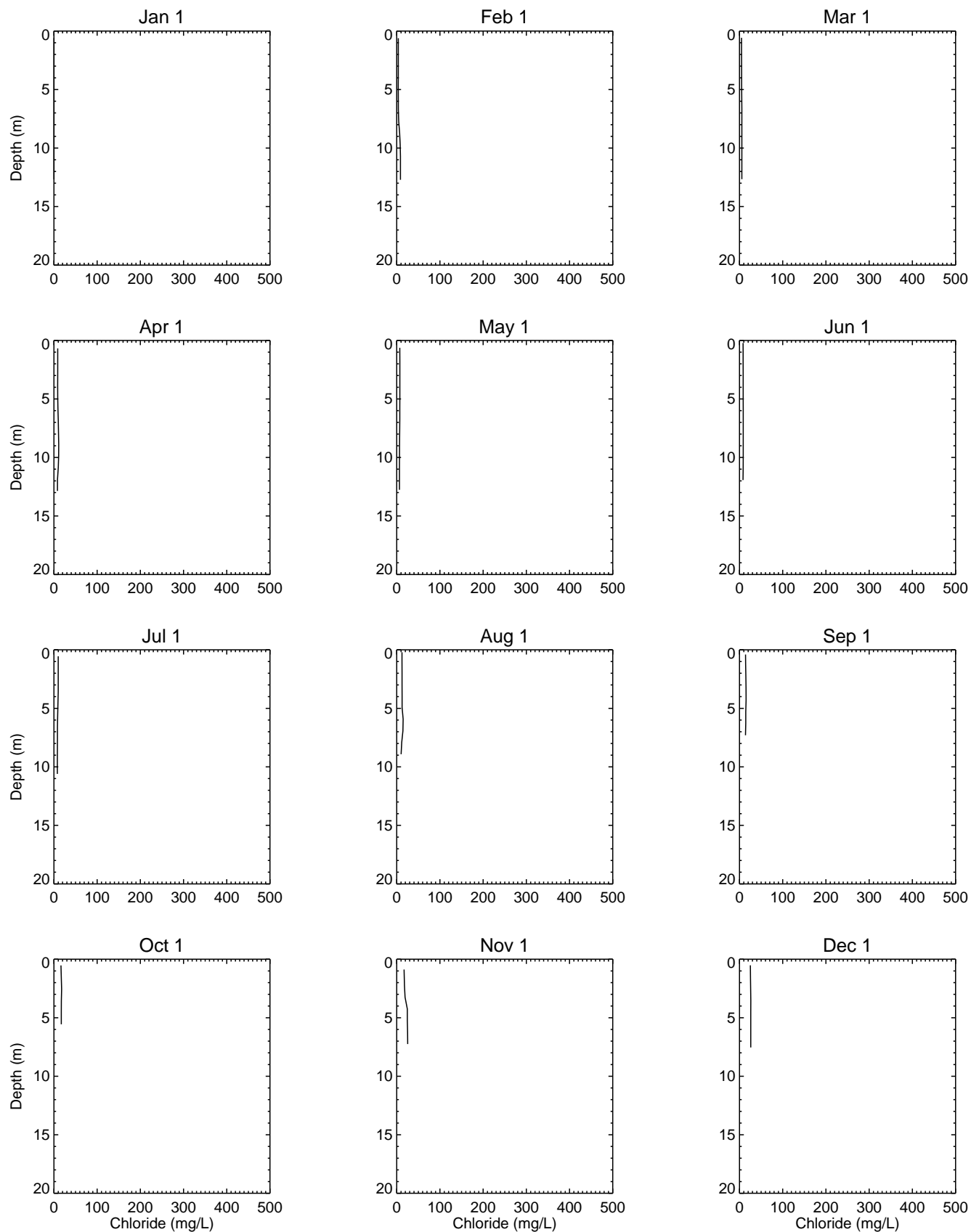CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 5 · May 1 · Jun 13 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 20

Chloride (mg/L)

Depth (m)

—— Model (w1210-48)
● Data

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 2001

Profiles shown for dates with available data else model results for first day of month shown.
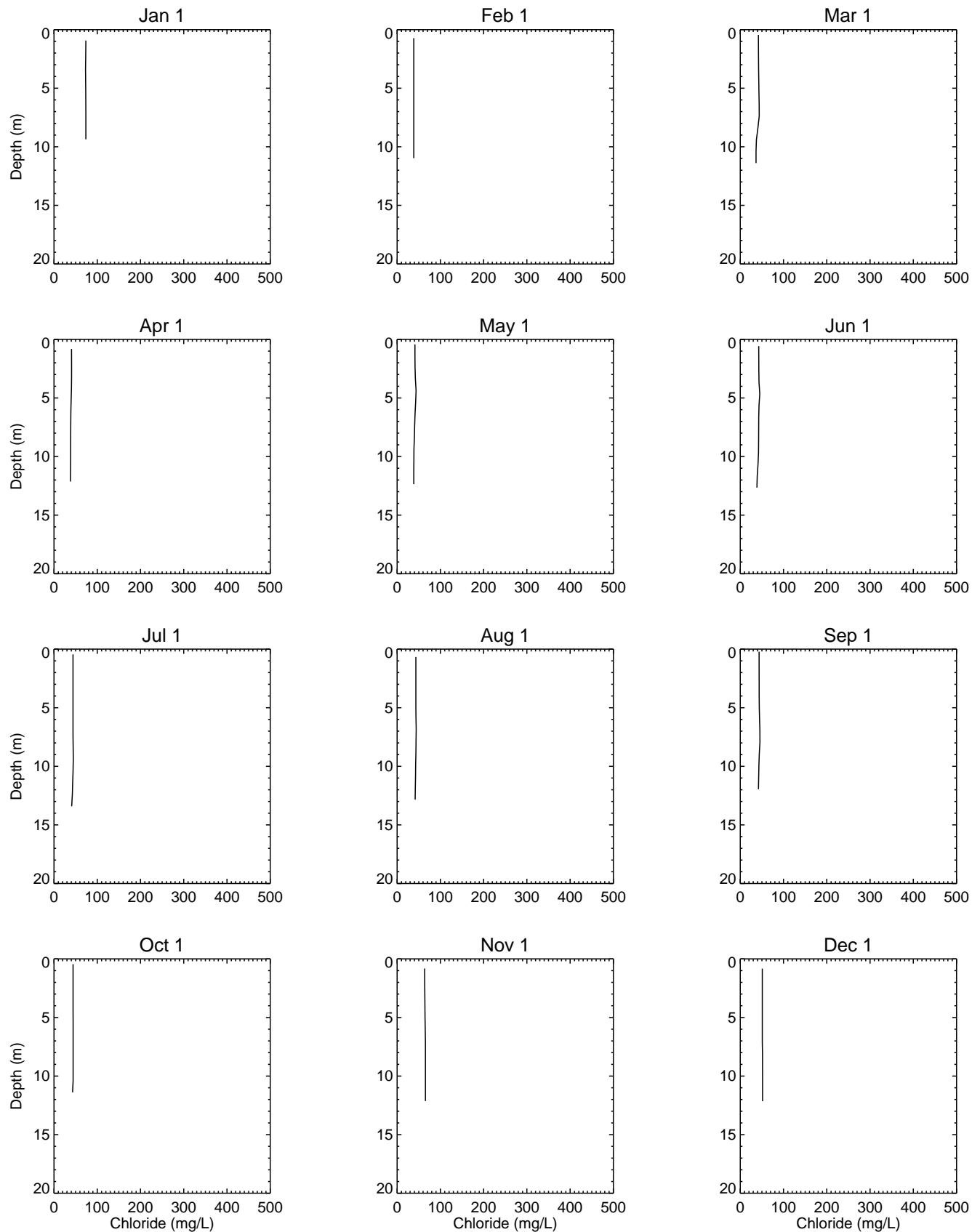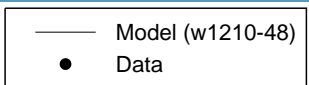
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:06 2013

Jan 1 · Feb 6 · Mar 1 · Apr 15 · May 1 · Jun 10 · Jul 1 · Aug 20 · Sep 1 · Oct 1 · Nov 1 · Dec 2

——— Model (w1210-48)
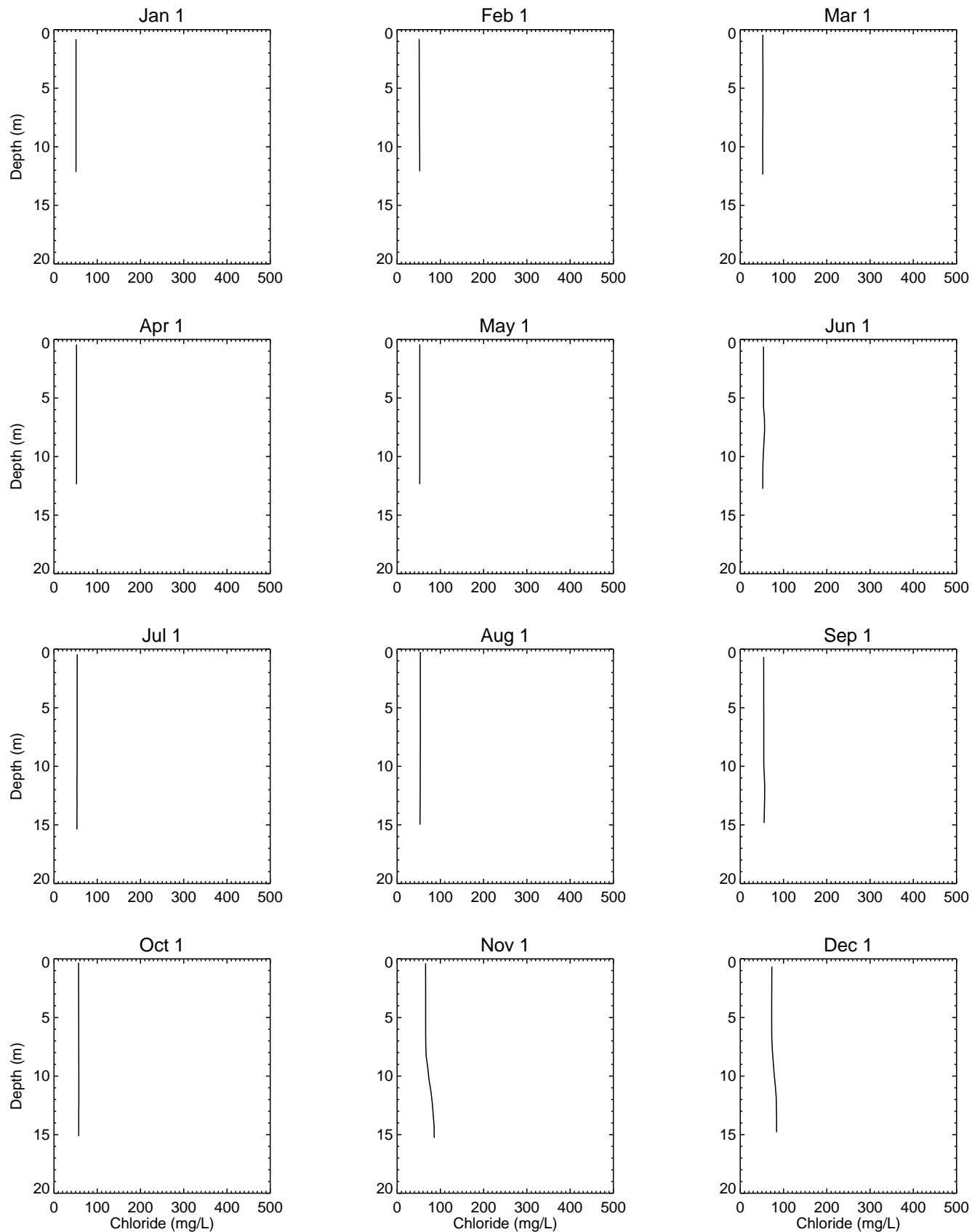● Data

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 2002

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:06 2013

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 2003

Profiles shown for dates with available data else model results for first day of month shown.

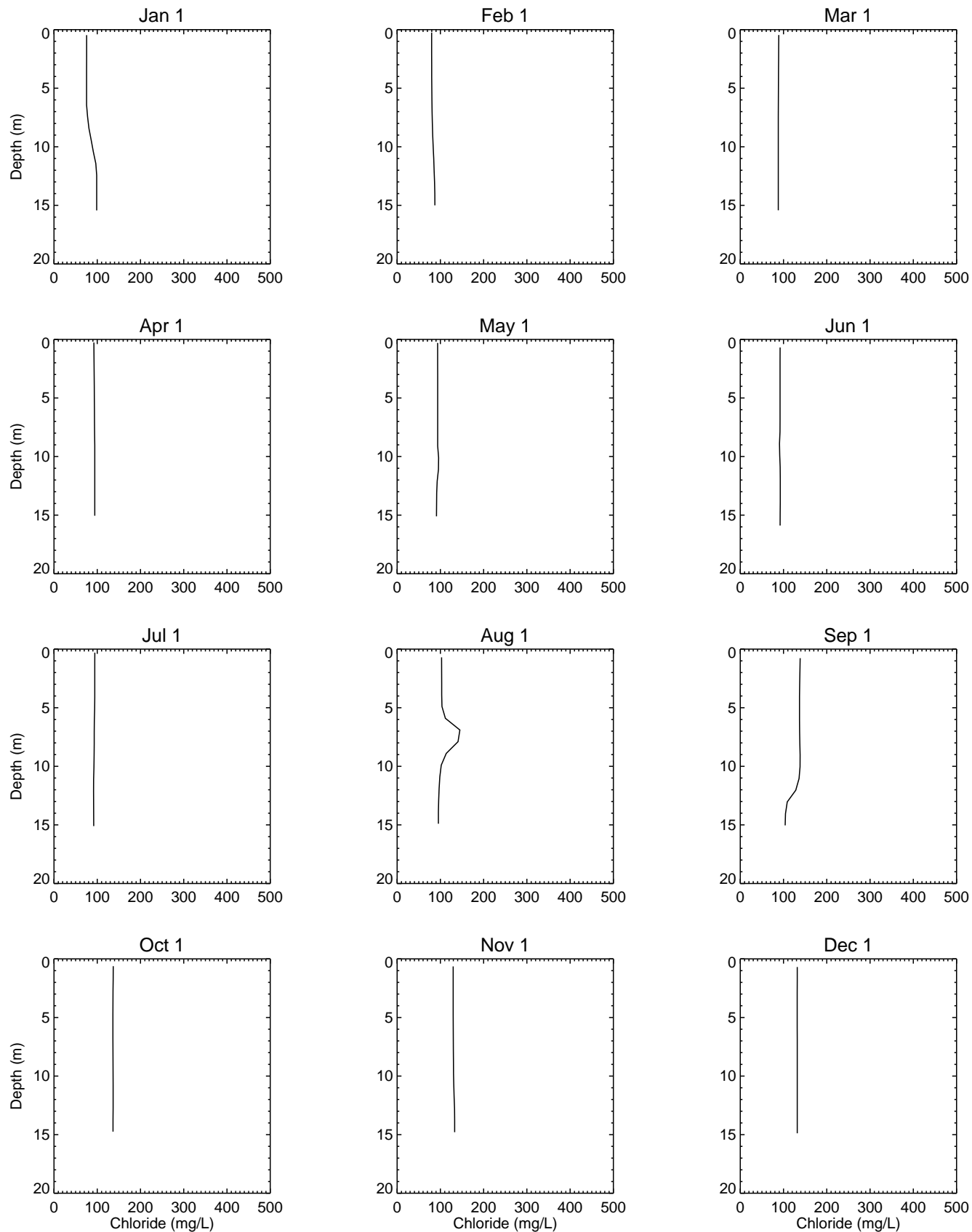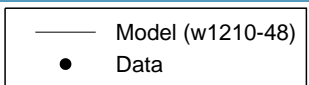CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 2004

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 2005

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
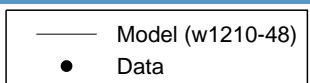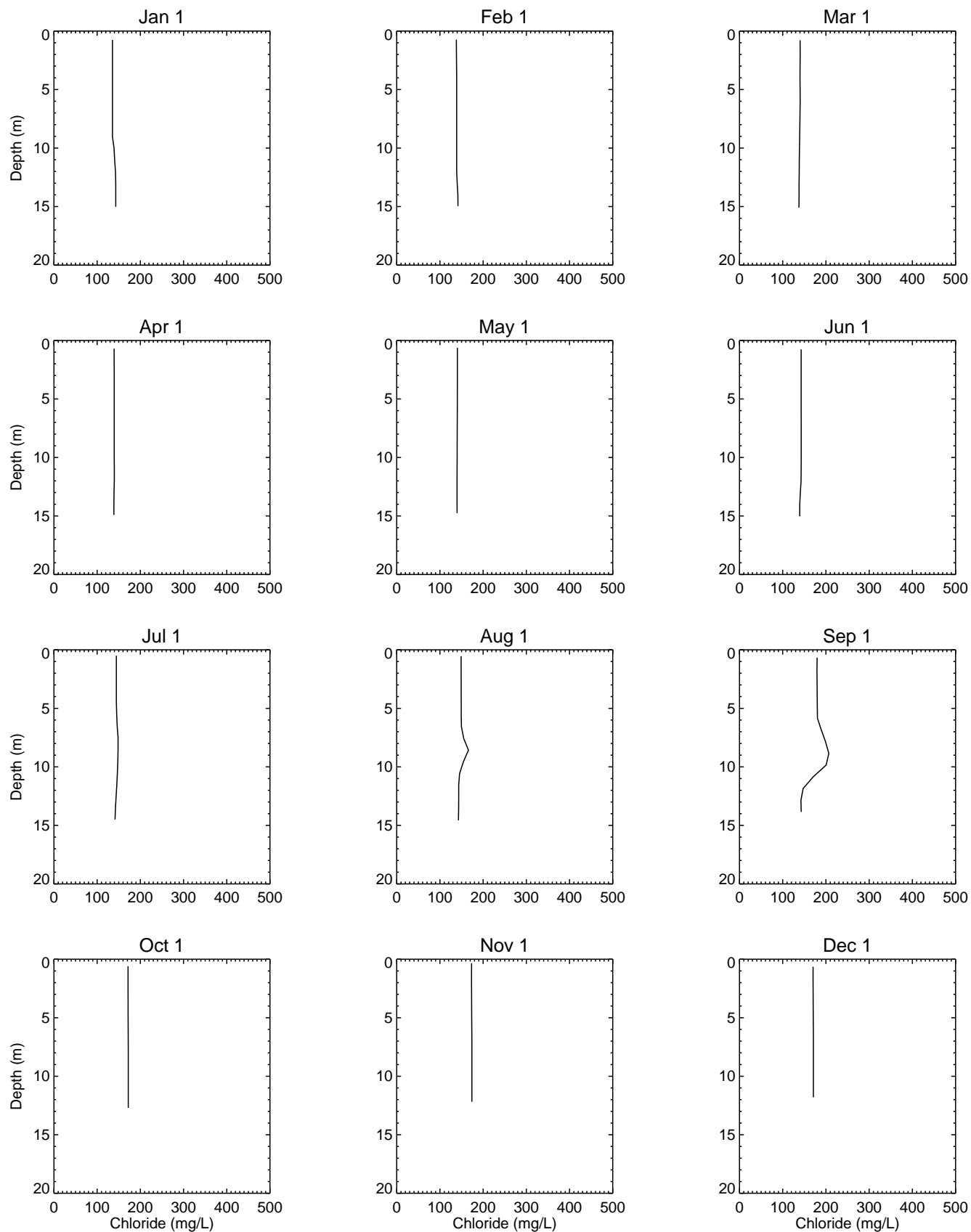
Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 2006

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

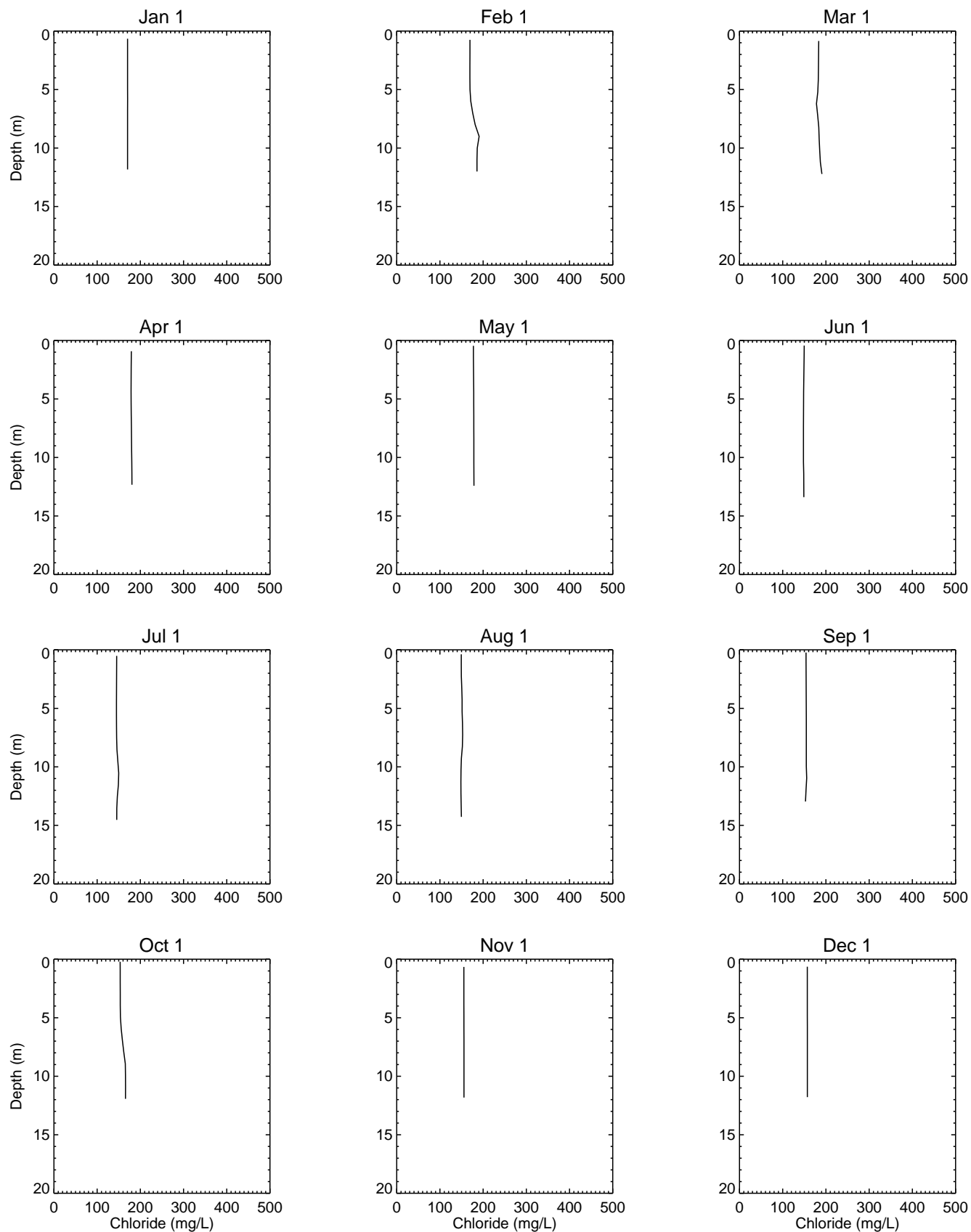Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 2007

Profiles shown for dates with available data else model results for first day of month shown.

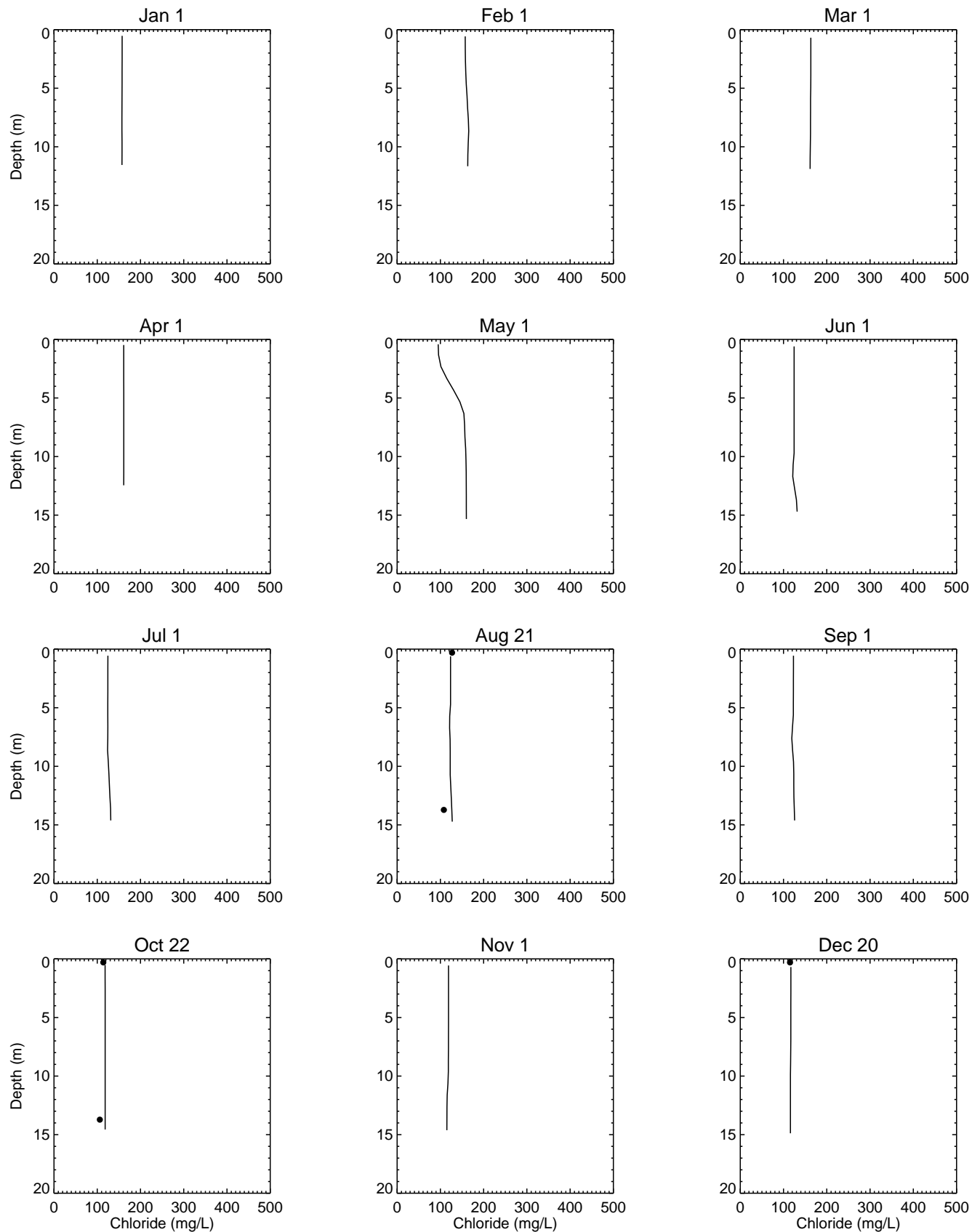CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:06 2013

Jan 1   Feb 4   Mar 1

Apr 3   May 1   Jun 12

Jul 1   Aug 7   Sep 1
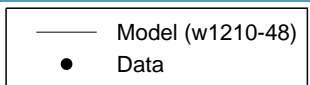
Oct 9   Nov 1   Dec 4

—— Model (w1210-48)
● Data

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 2008

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 2009

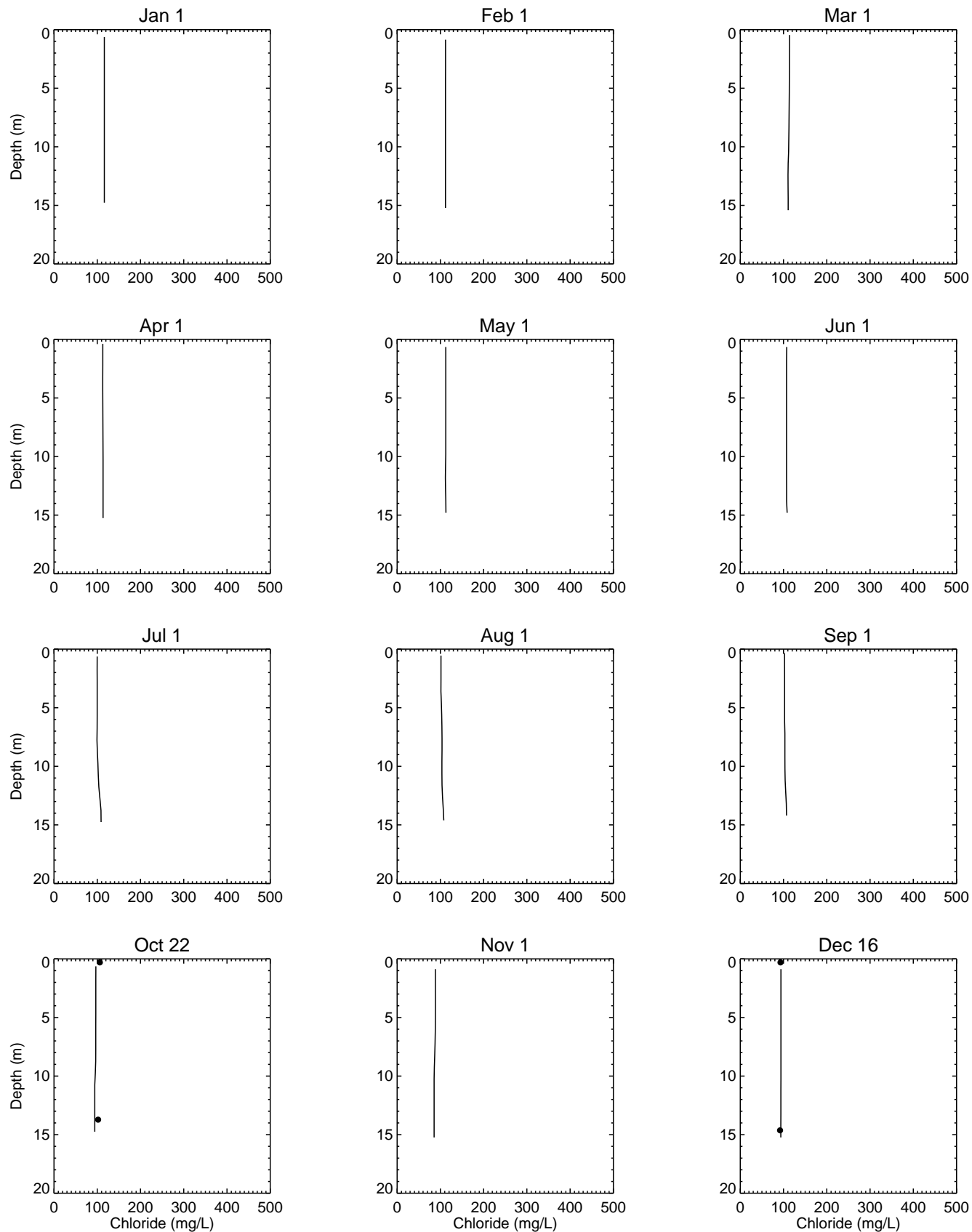*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 2010

Profiles shown for dates with available data else model results for first day of month shown.
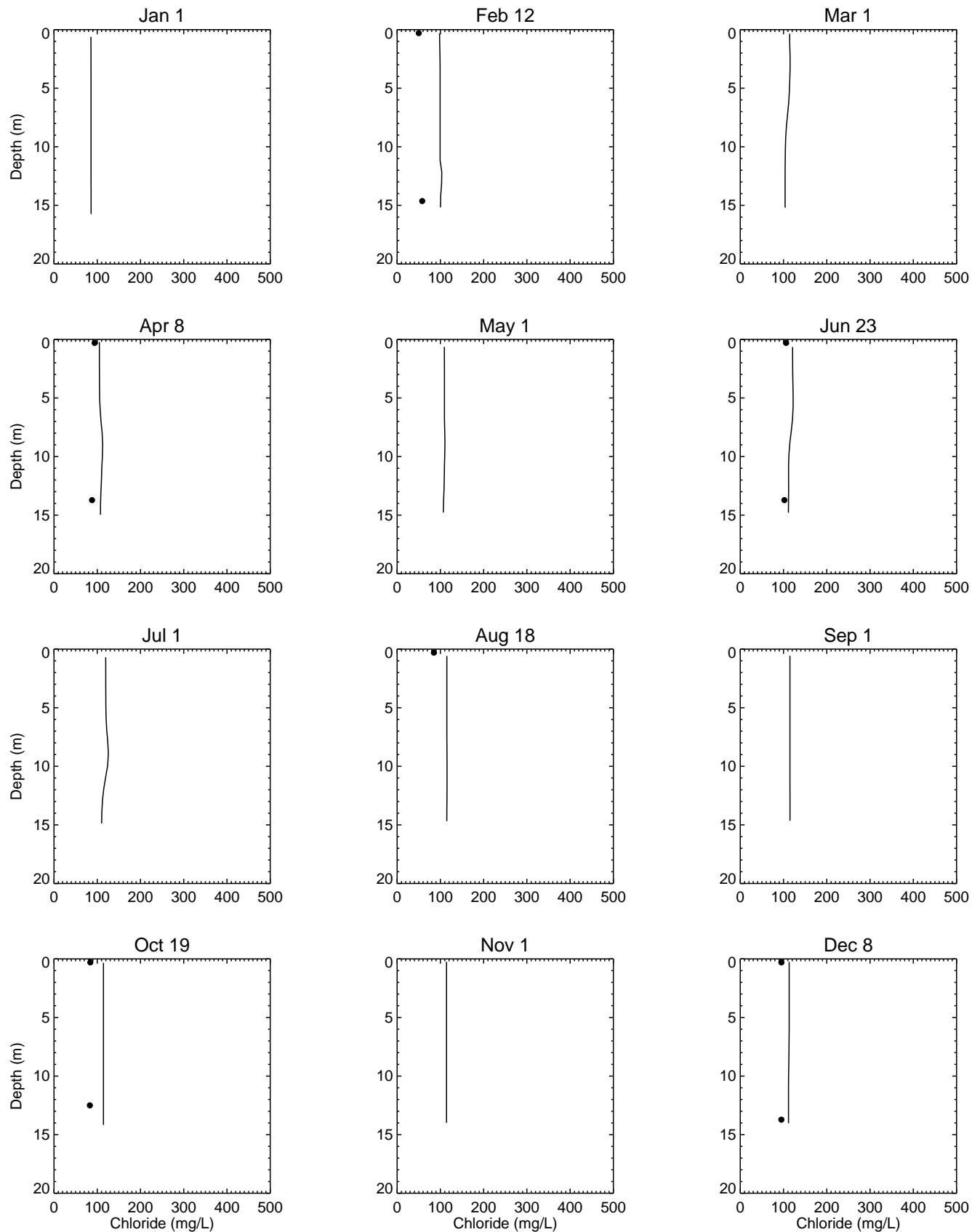
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:06 2013

Figure G-21

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Chloride - 2011

Profiles shown for dates with available data else model results for first day of month shown.
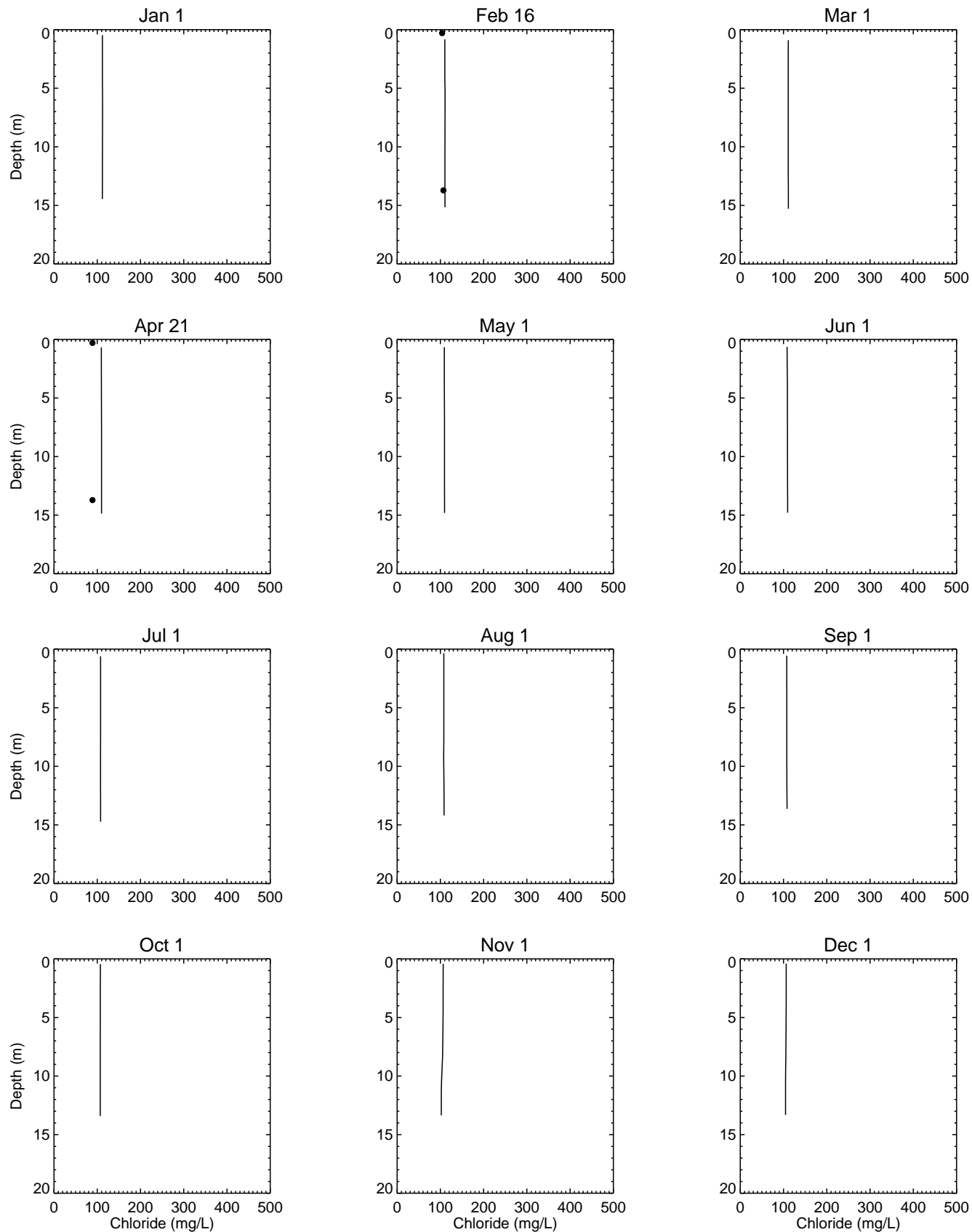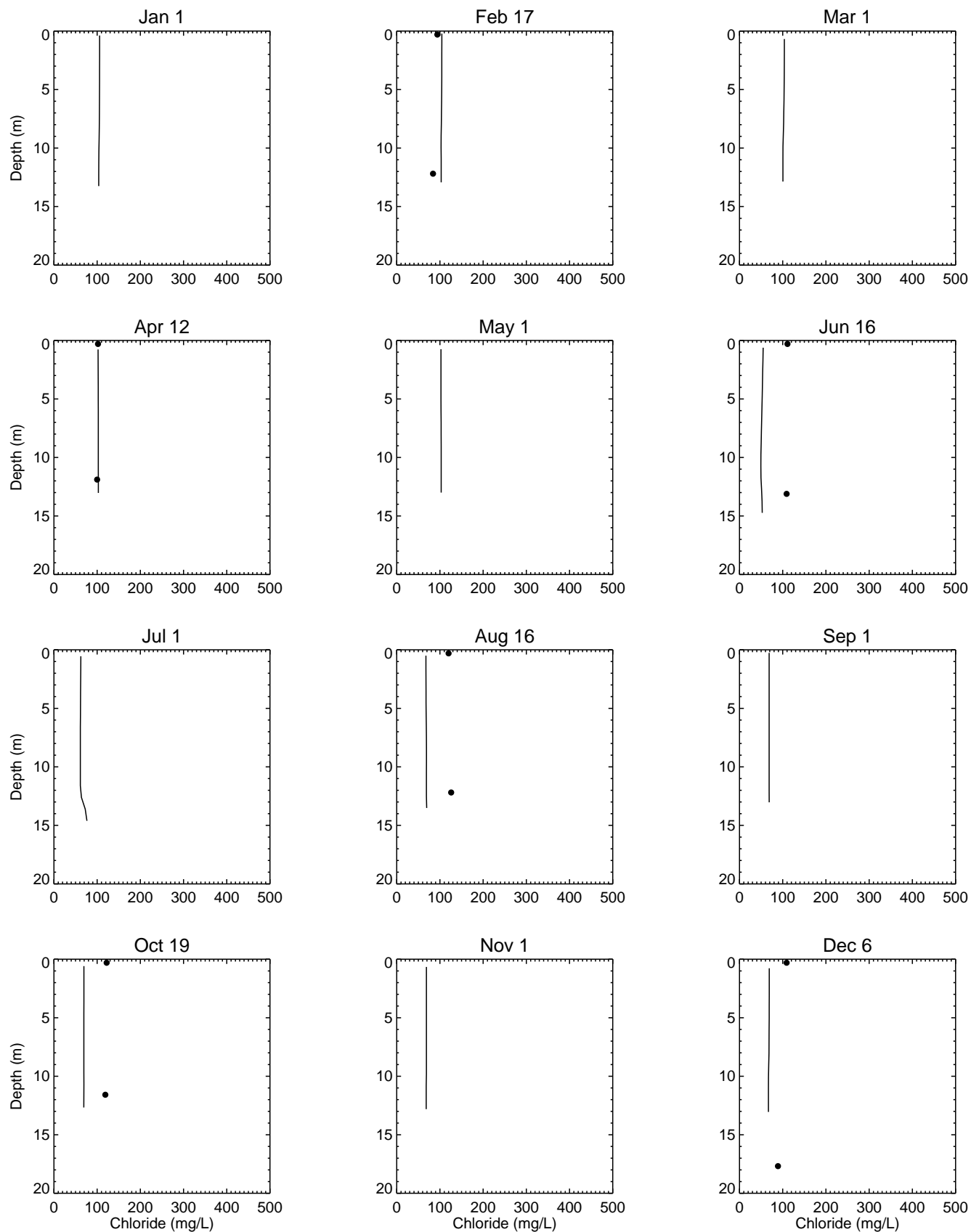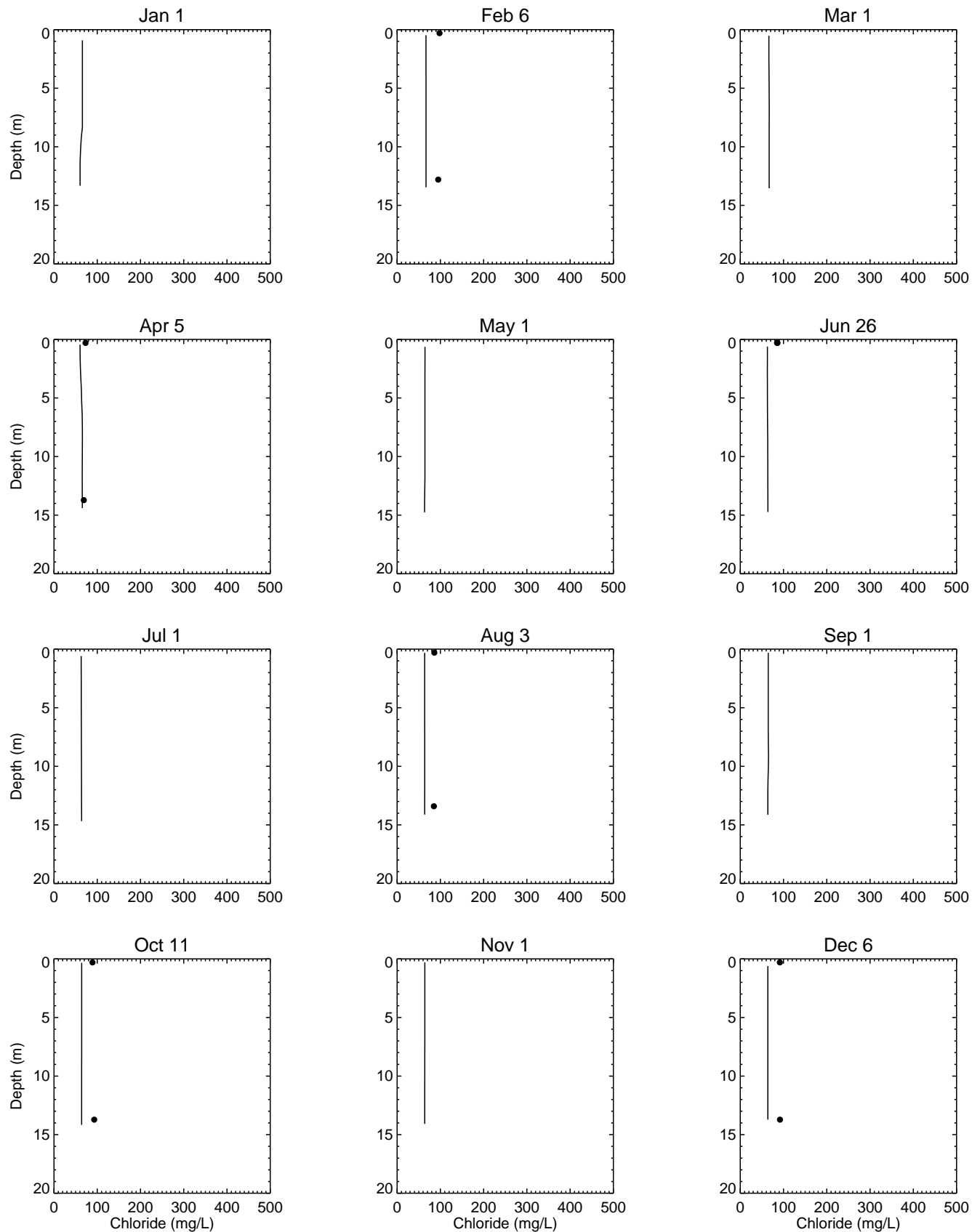
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 / Feb 1 / Mar 1 / Apr 1 / May 1 / Jun 1 / Jul 1 / Aug 1 / Sep 1 / Oct 1 / Nov 1 / Dec 1

Vertical profile plots of Depth (m) versus Chloride (mg/L) for each month.

——— Model (w1210-48)
● Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 1984

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 1985

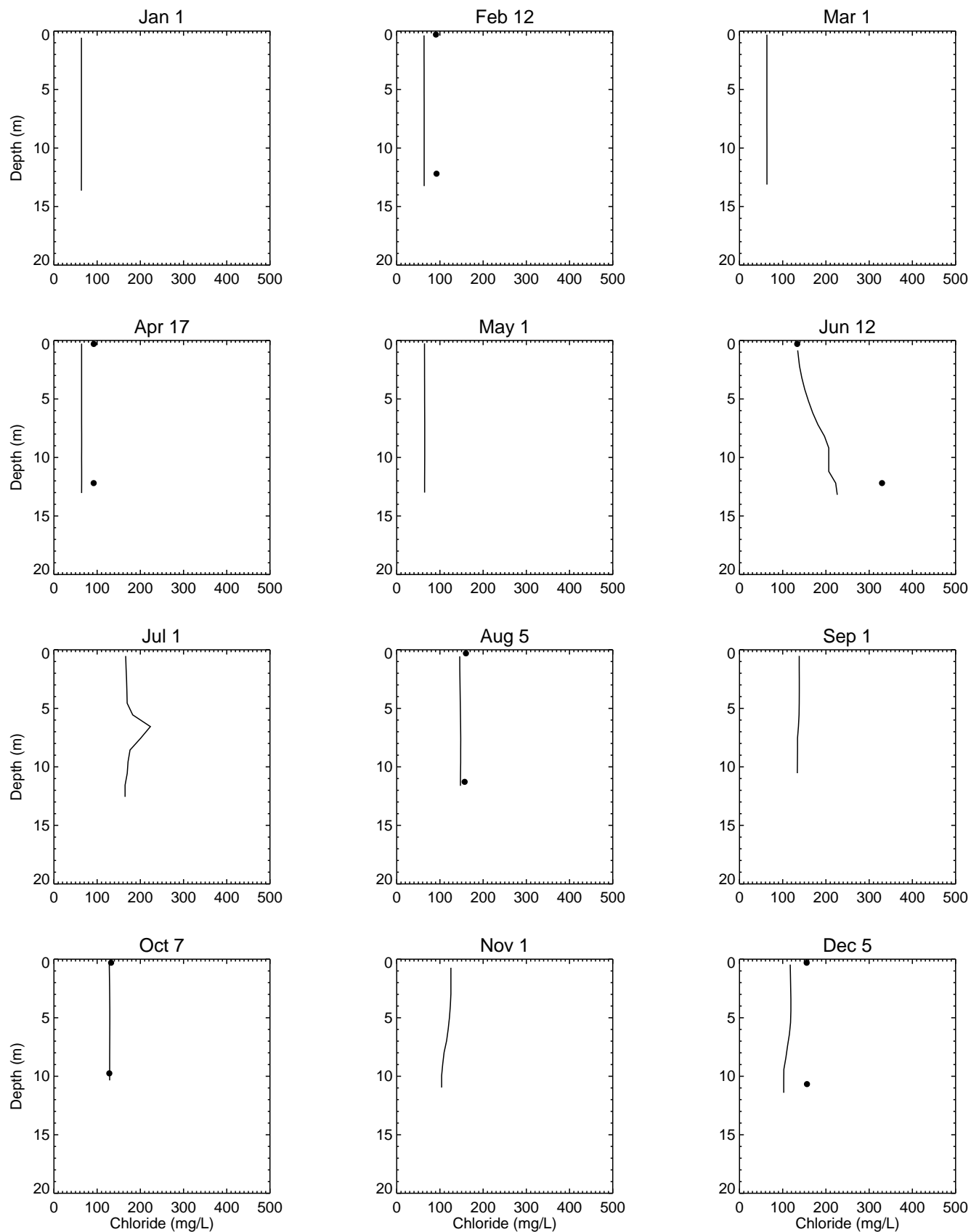*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:11 2013

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m)

Chloride (mg/L)

—— Model (w1210-48)
● Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 1986

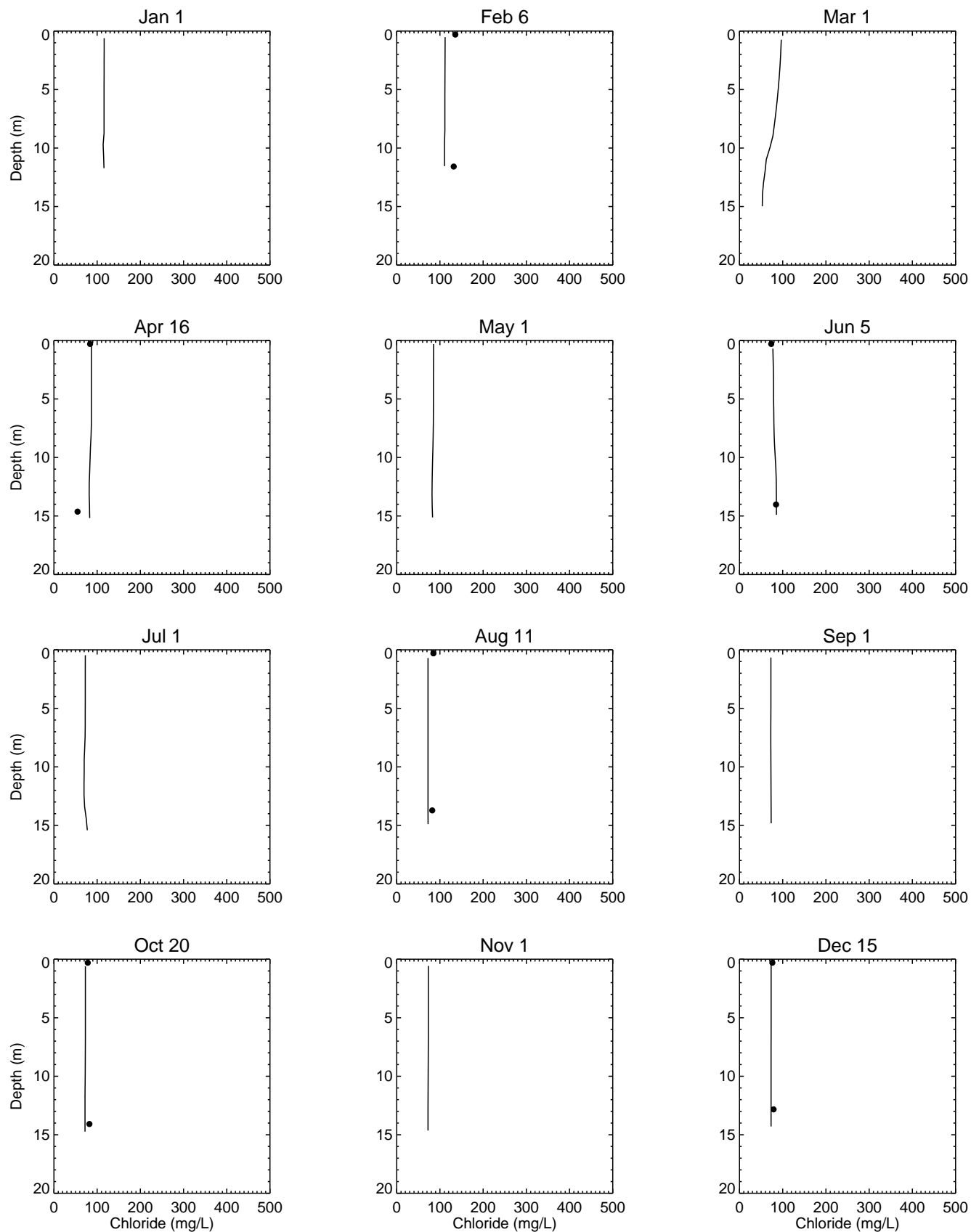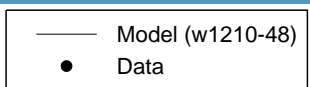*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

Jan 1 | Feb 1 | Mar 1
Apr 1 | May 1 | Jun 1
Jul 1 | Aug 1 | Sep 1
Oct 1 | Nov 1 | Dec 1

Depth (m) axes 0–25, Chloride (mg/L) axes 0–500

——— Model (w1210-48)
● Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 1987

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA
PARSONS

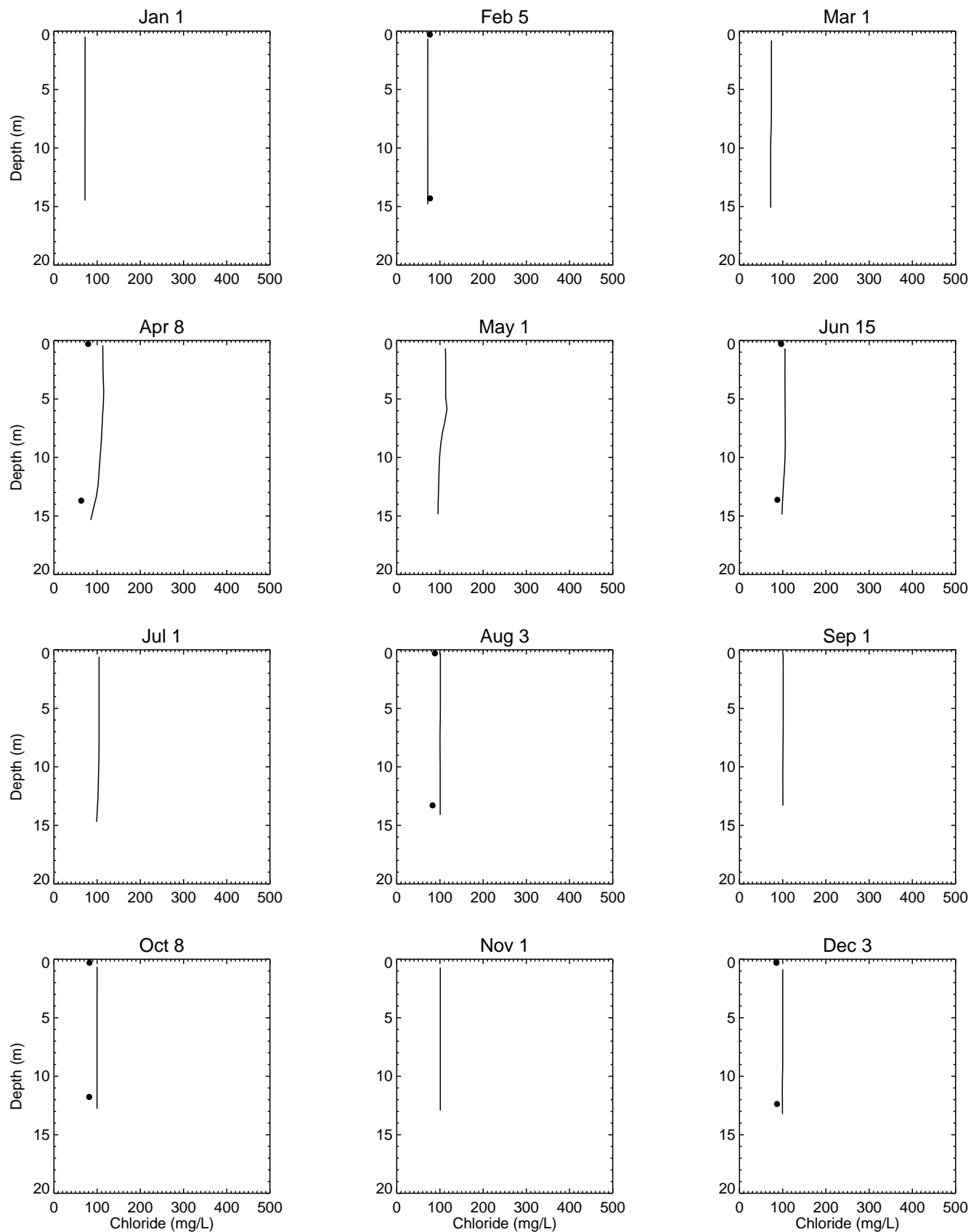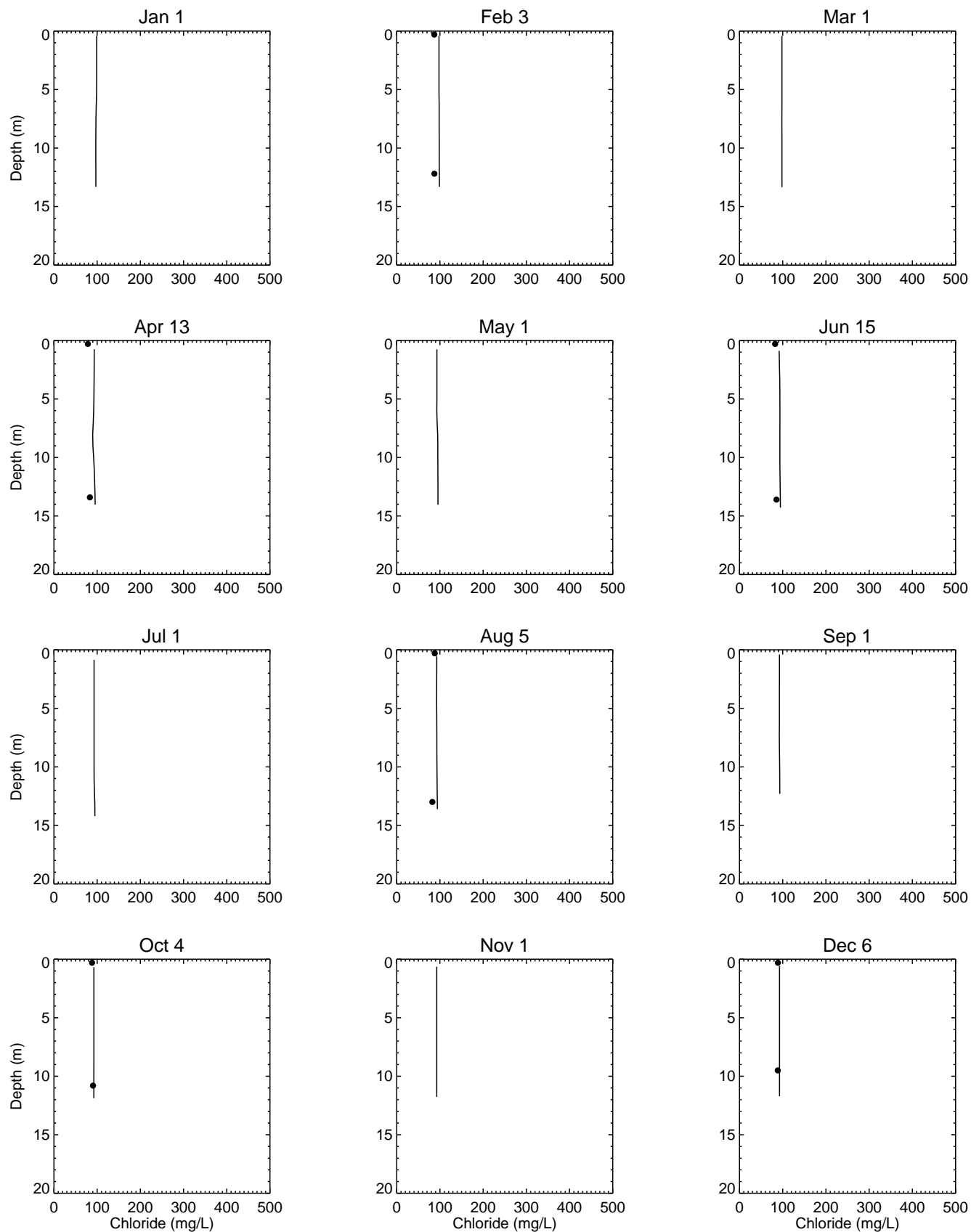CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:12 2013

Jan 1   Feb 1   Mar 1

Apr 1   May 1   Jun 1

Jul 1   Aug 1   Sep 1

Oct 1   Nov 1   Dec 1

Depth (m)

Chloride (mg/L)

——— Model (w1210-48)

●   Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 1988

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
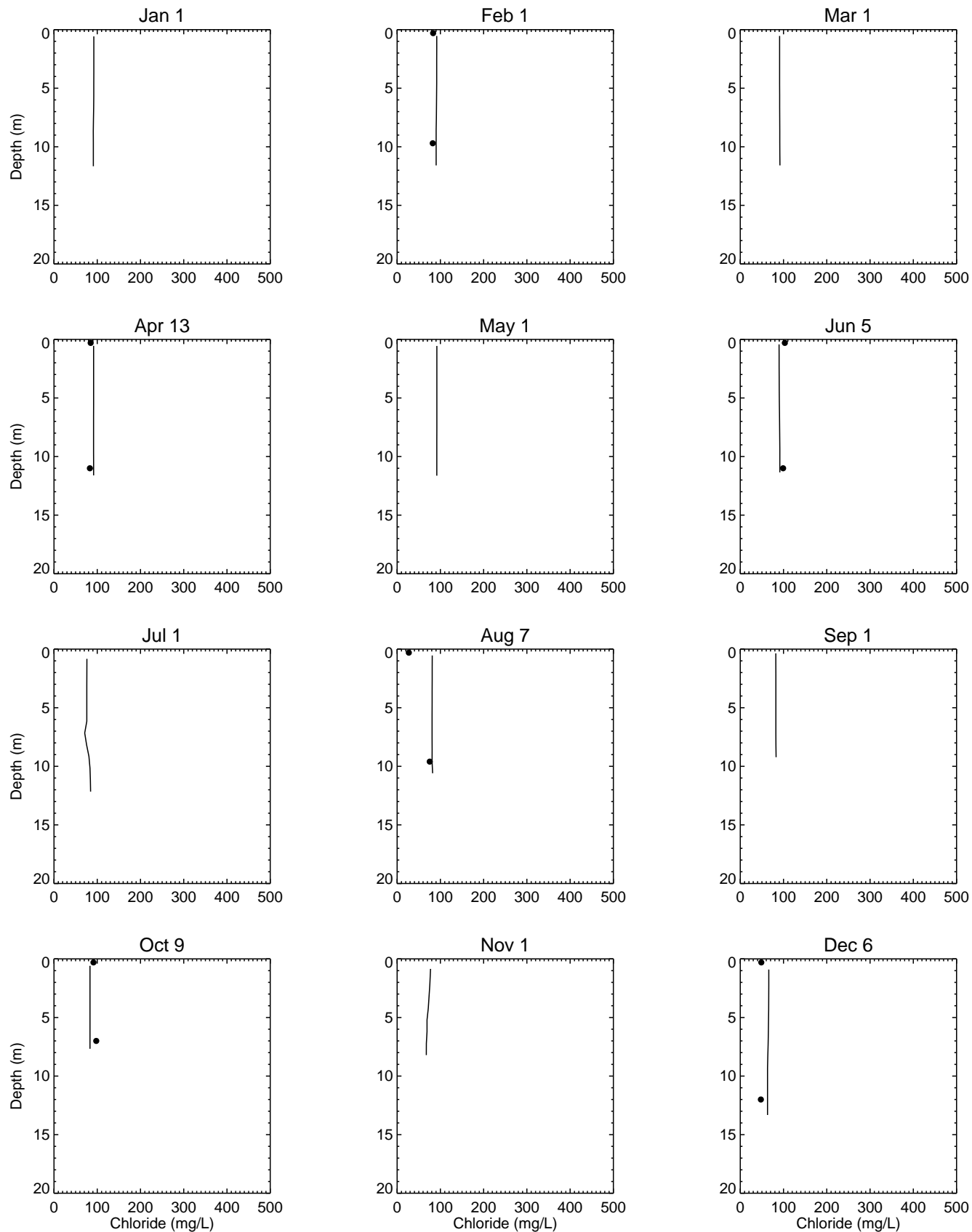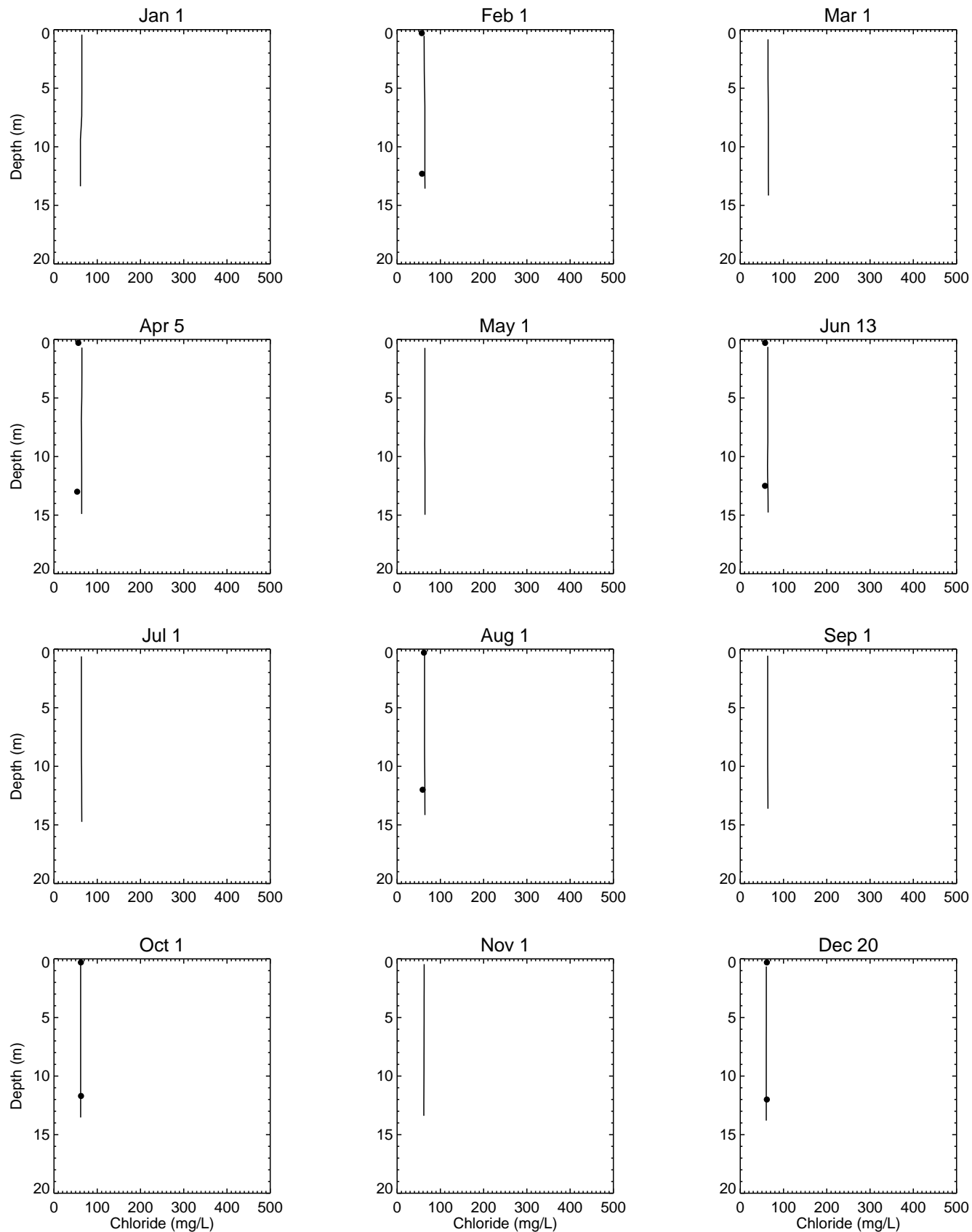
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:12 2013

Jan 1   Feb 1   Mar 1
Apr 1   May 1   Jun 1
Jul 1   Aug 1   Sep 1
Oct 1   Nov 1   Dec 1

Depth (m)
Chloride (mg/L)

——— Model (w1210-48)
● Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 1989

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
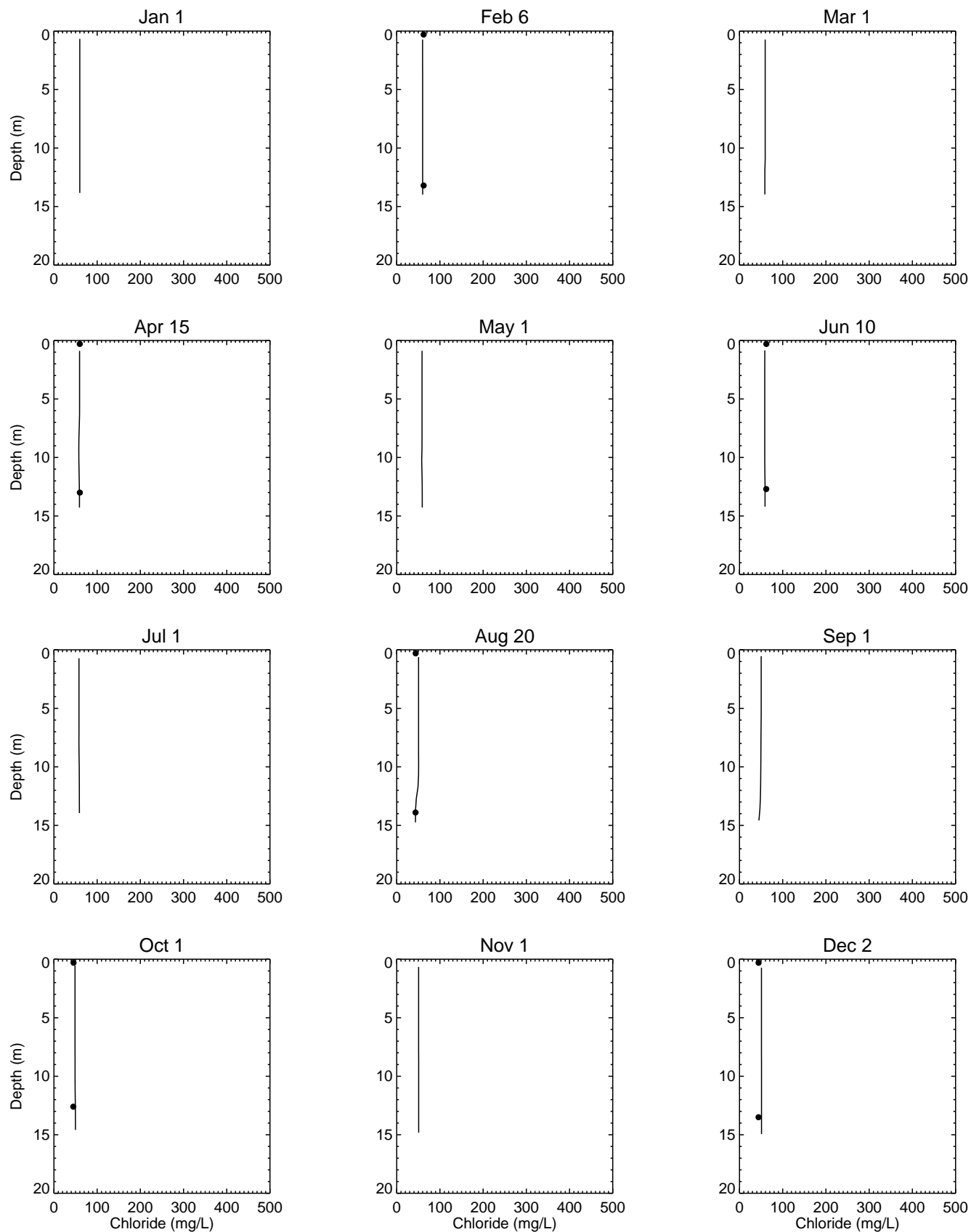
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:12 2013

ANCHOR
QEA
PARSONS

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 1990

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
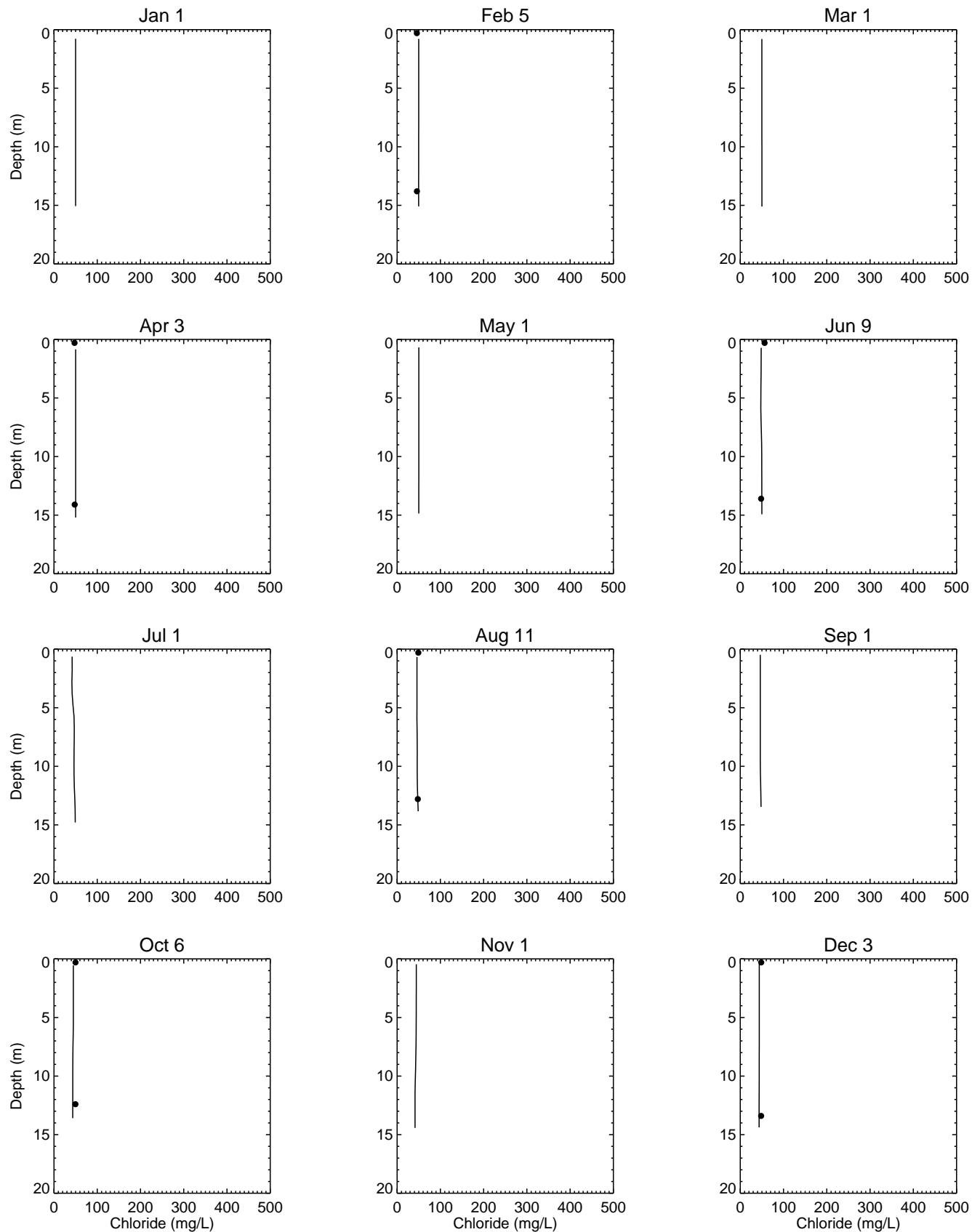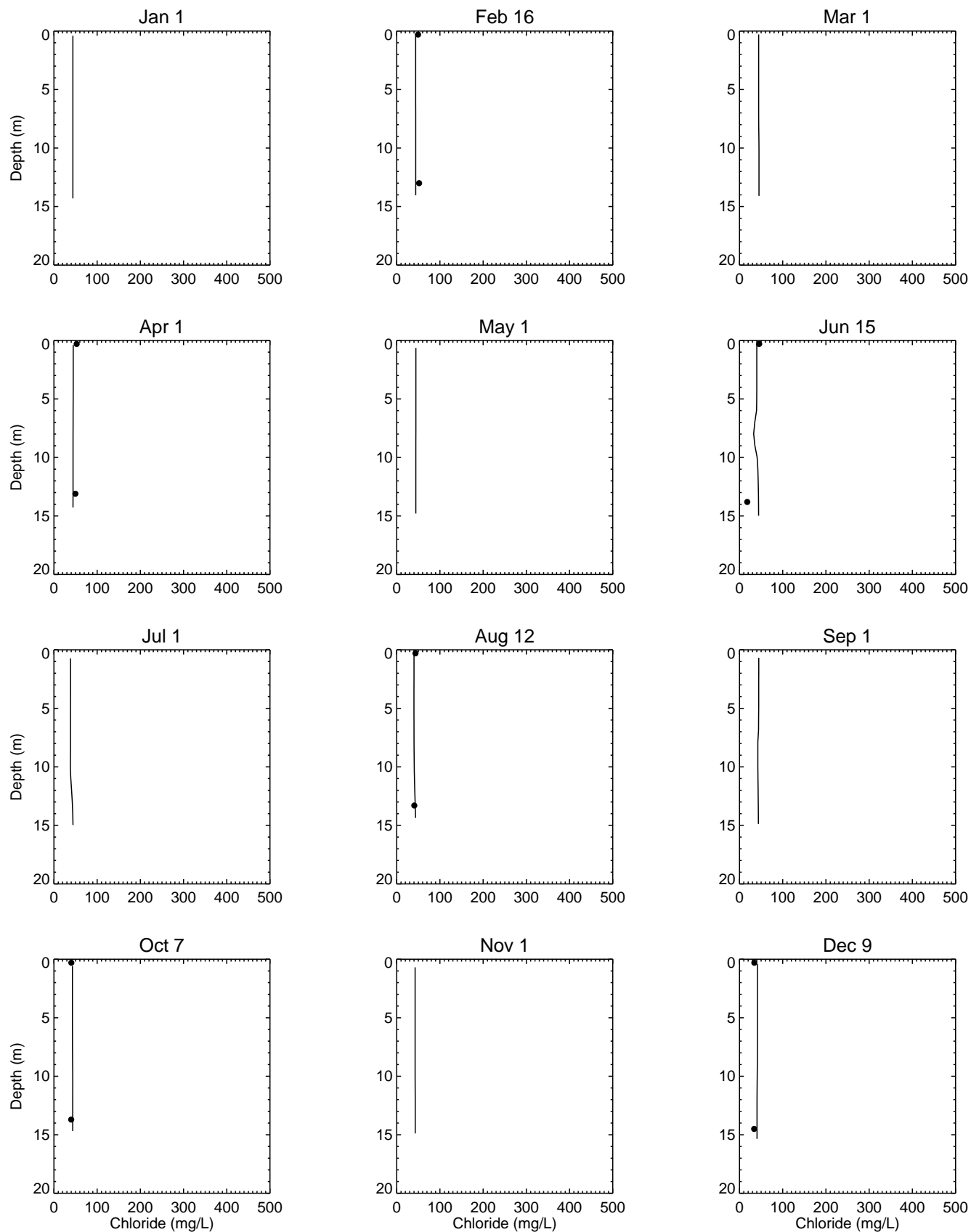
Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m)

Chloride (mg/L)

——— Model (w1210-48)
● Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 1991

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
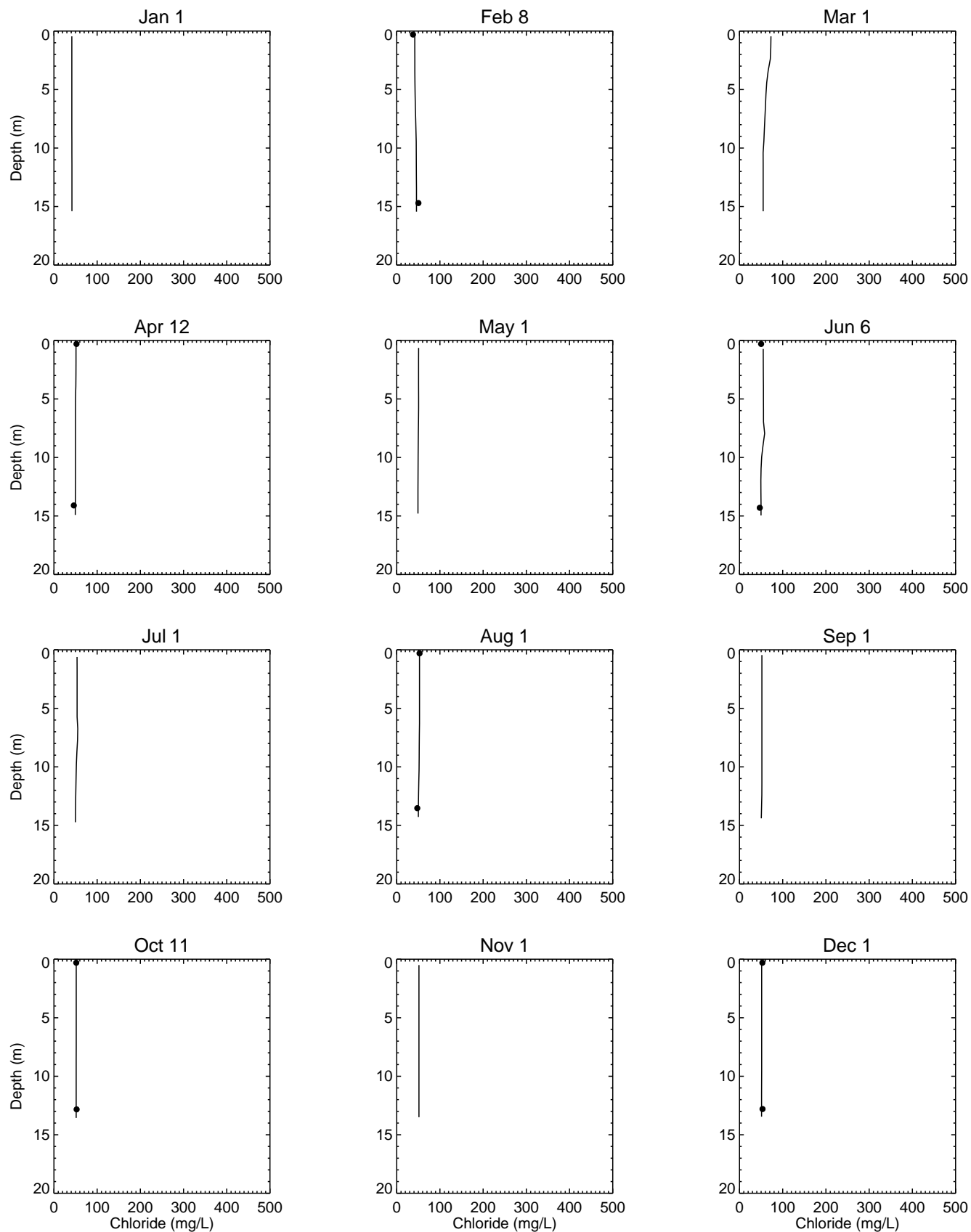Lower Colorado River Authority

ANCHOR QEA
PARSONS

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m) — Chloride (mg/L)

——— Model (w1210-48)
● Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
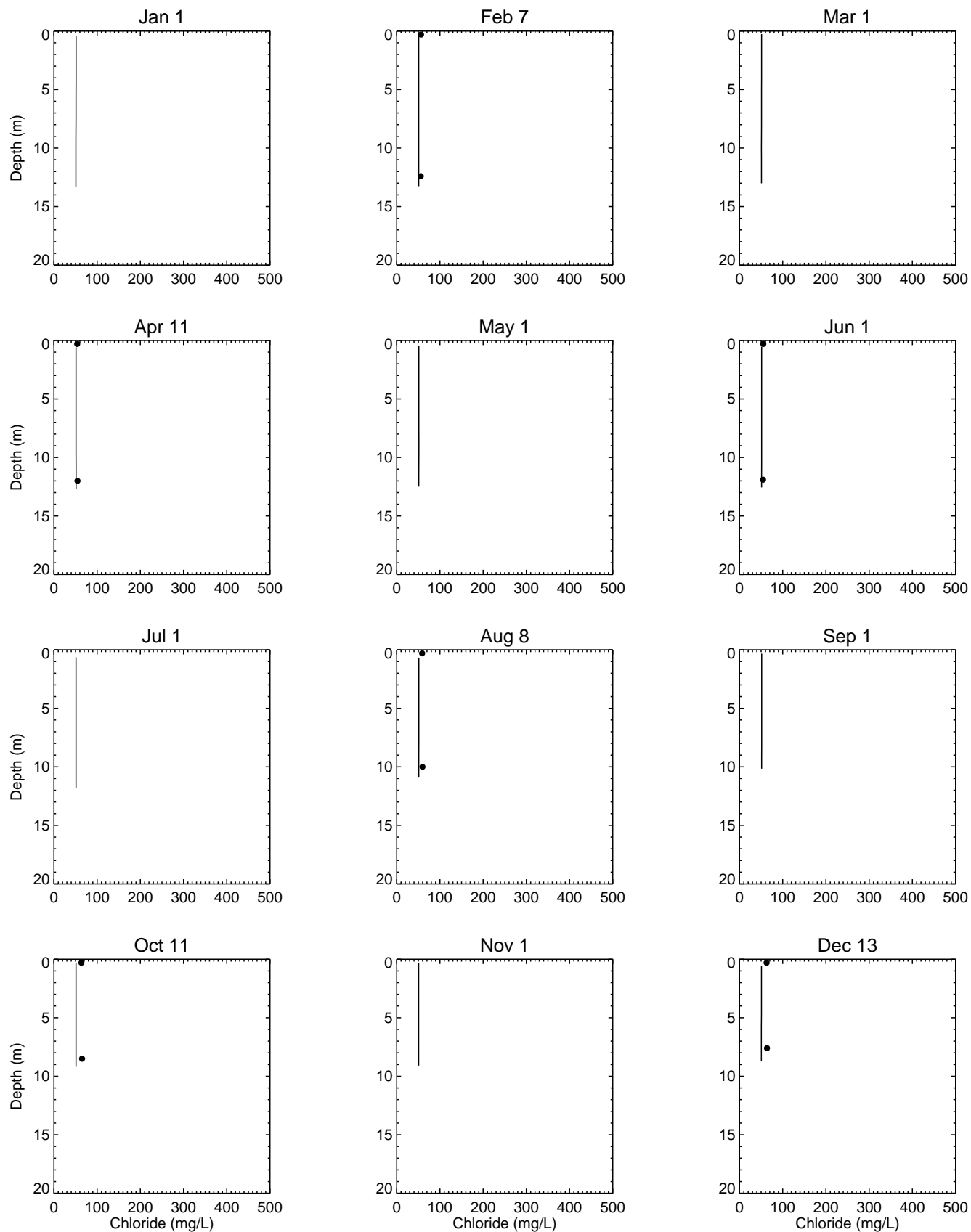Lower Colorado River Authority

ANCHOR QEA
PARSONS

Jan 1

Feb 1

Mar 1

Apr 1

May 1

Jun 1

Jul 1

Aug 1

Sep 1

Oct 1

Nov 1

Dec 1

Depth (m)

Chloride (mg/L)

— Model (w1210-48)

● Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 1993

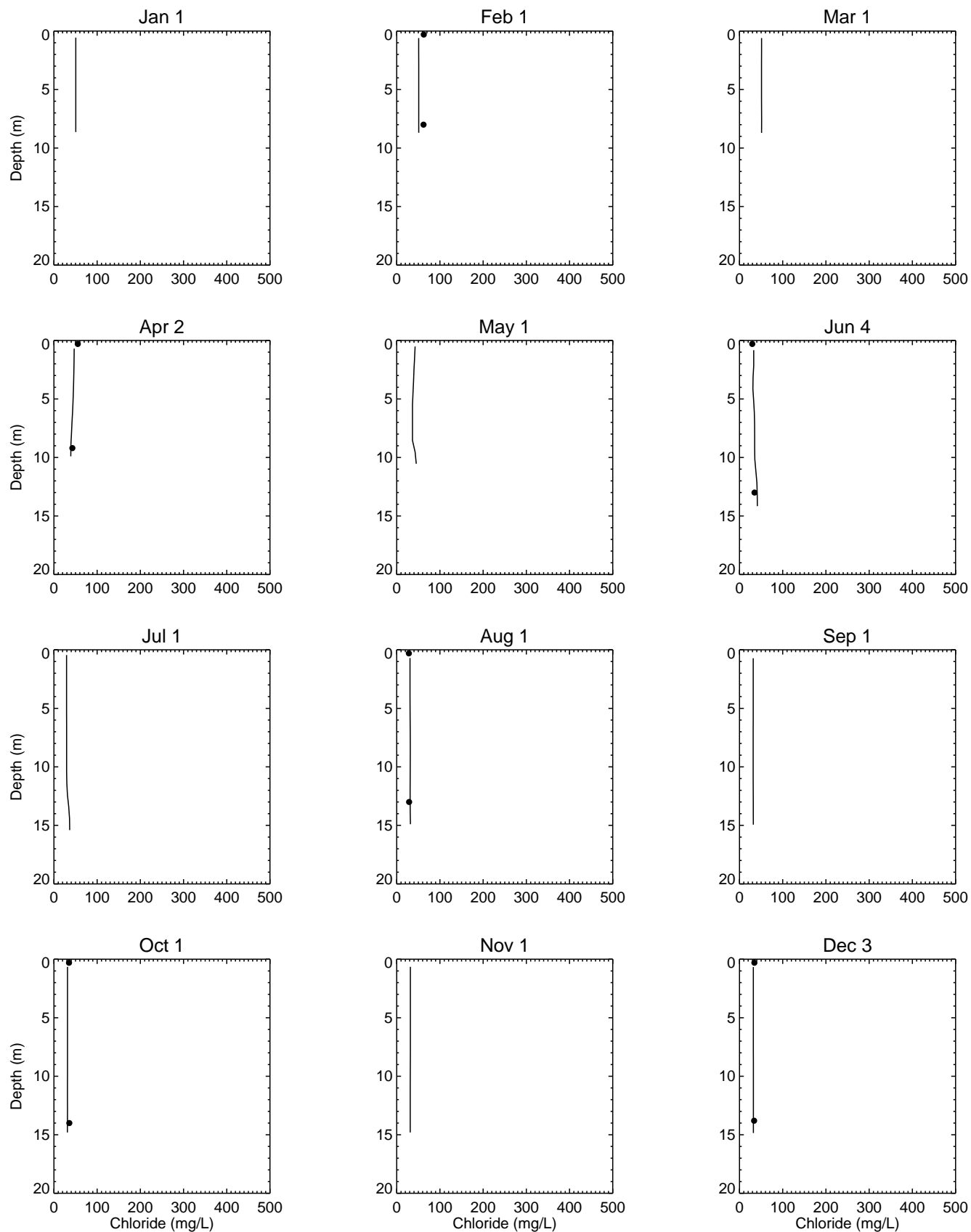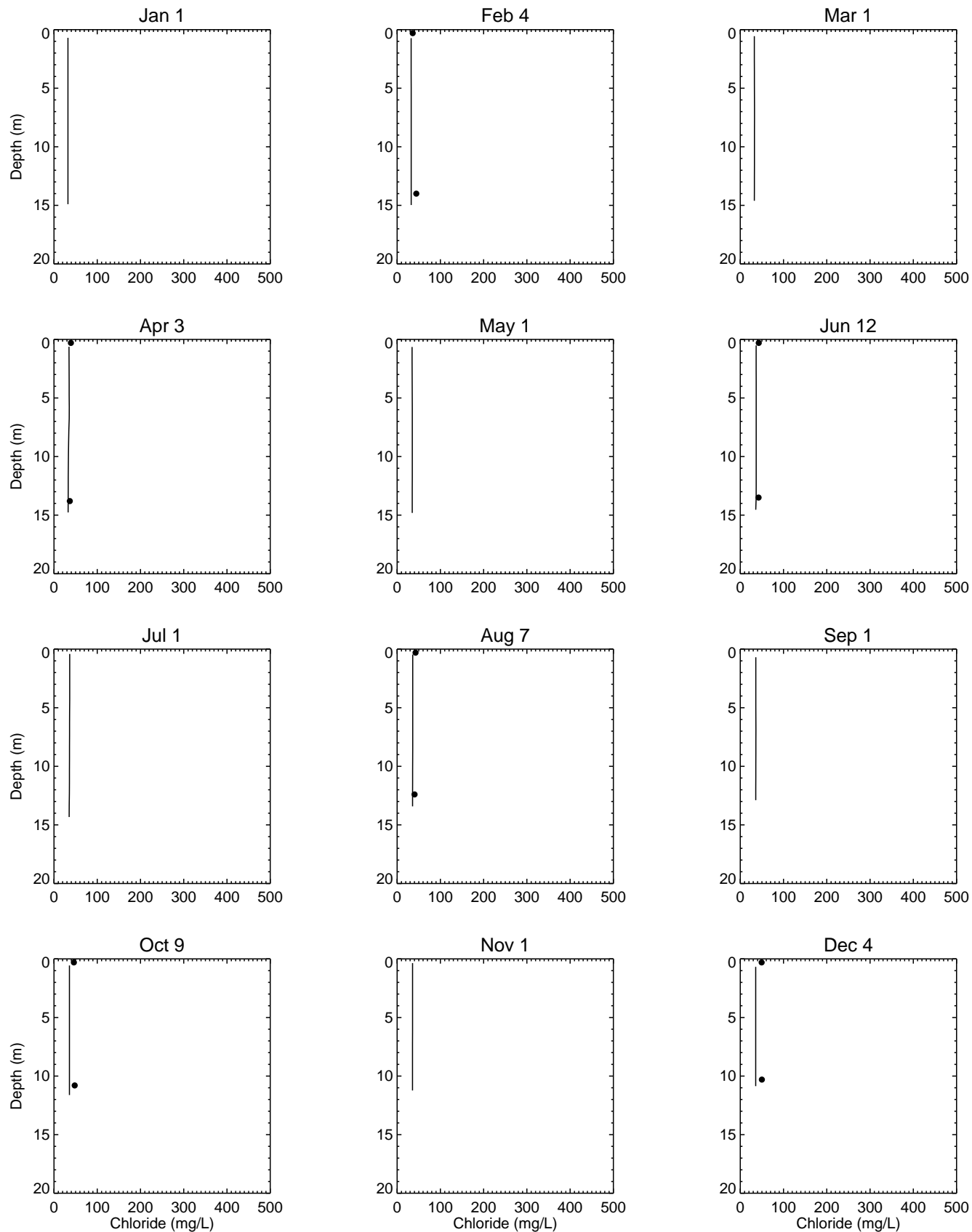*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:12 2013

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Chloride (mg/L)

Depth (m)

——— Model (w1210-48)
● Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 1995

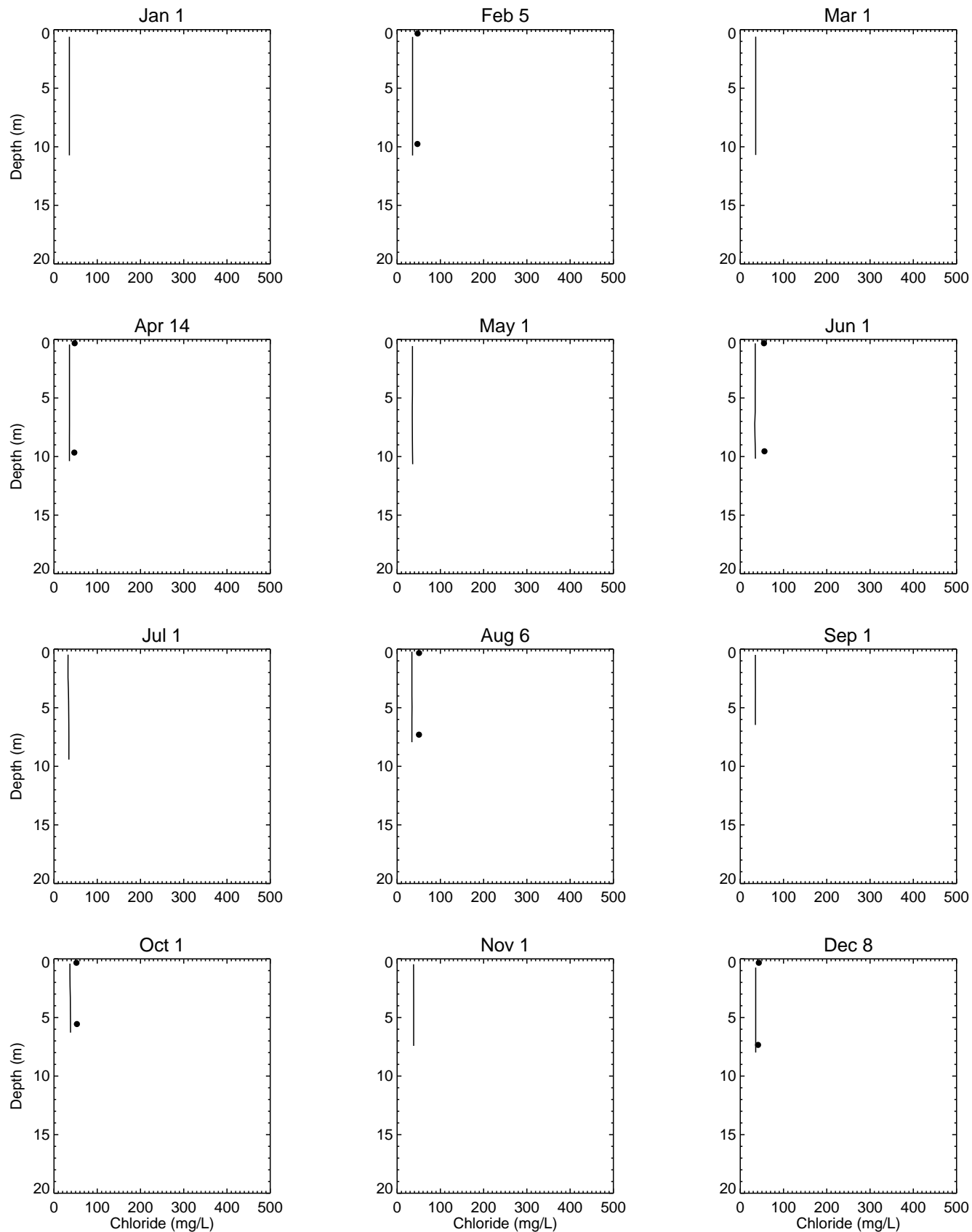*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:12 2013

ANCHOR QEA
PARSONS

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 1996

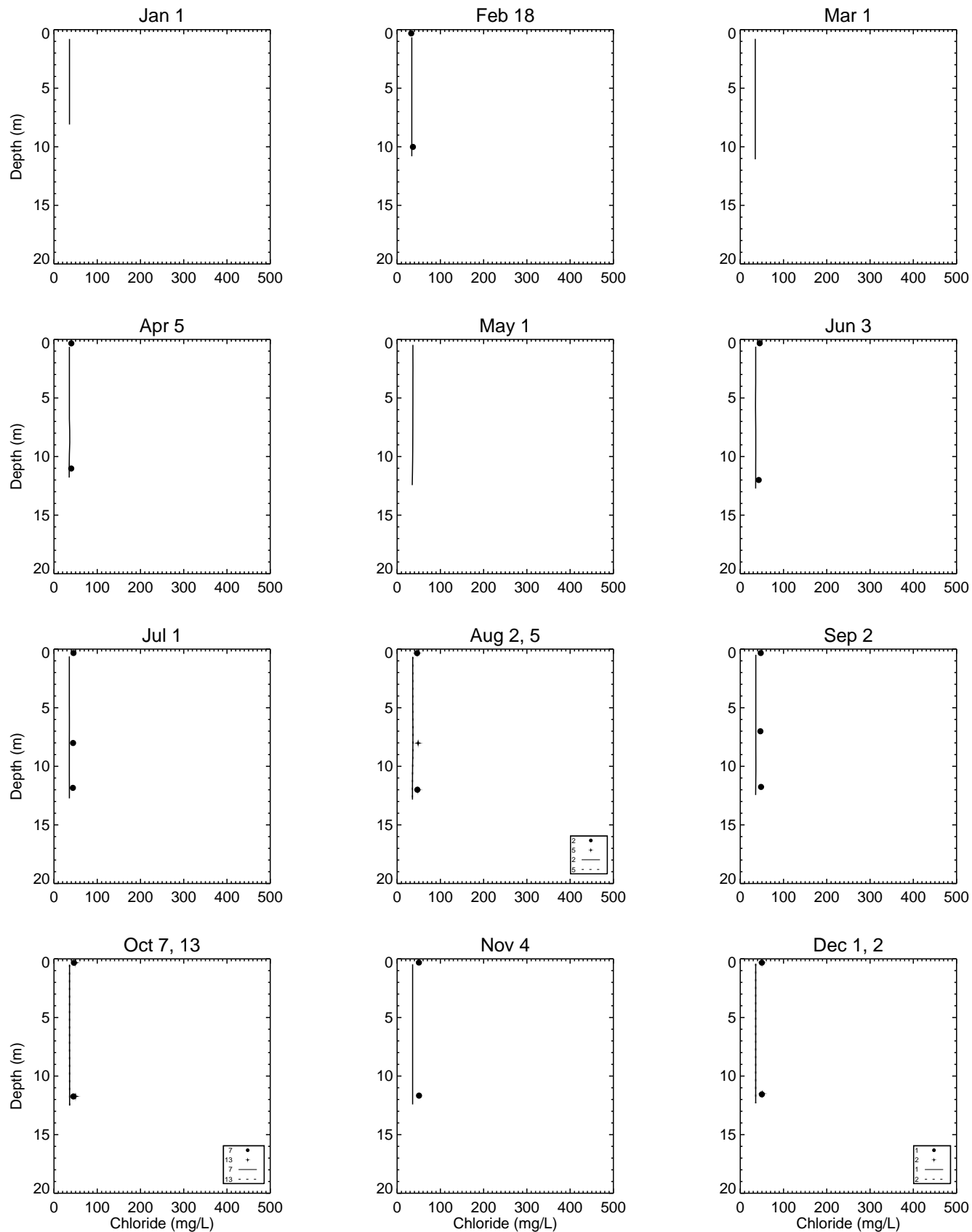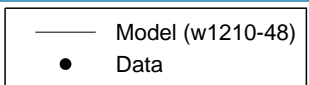*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Vertical axes: Depth (m). Horizontal axes: Chloride (mg/L)

Model (w1210-48)
● Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 1997

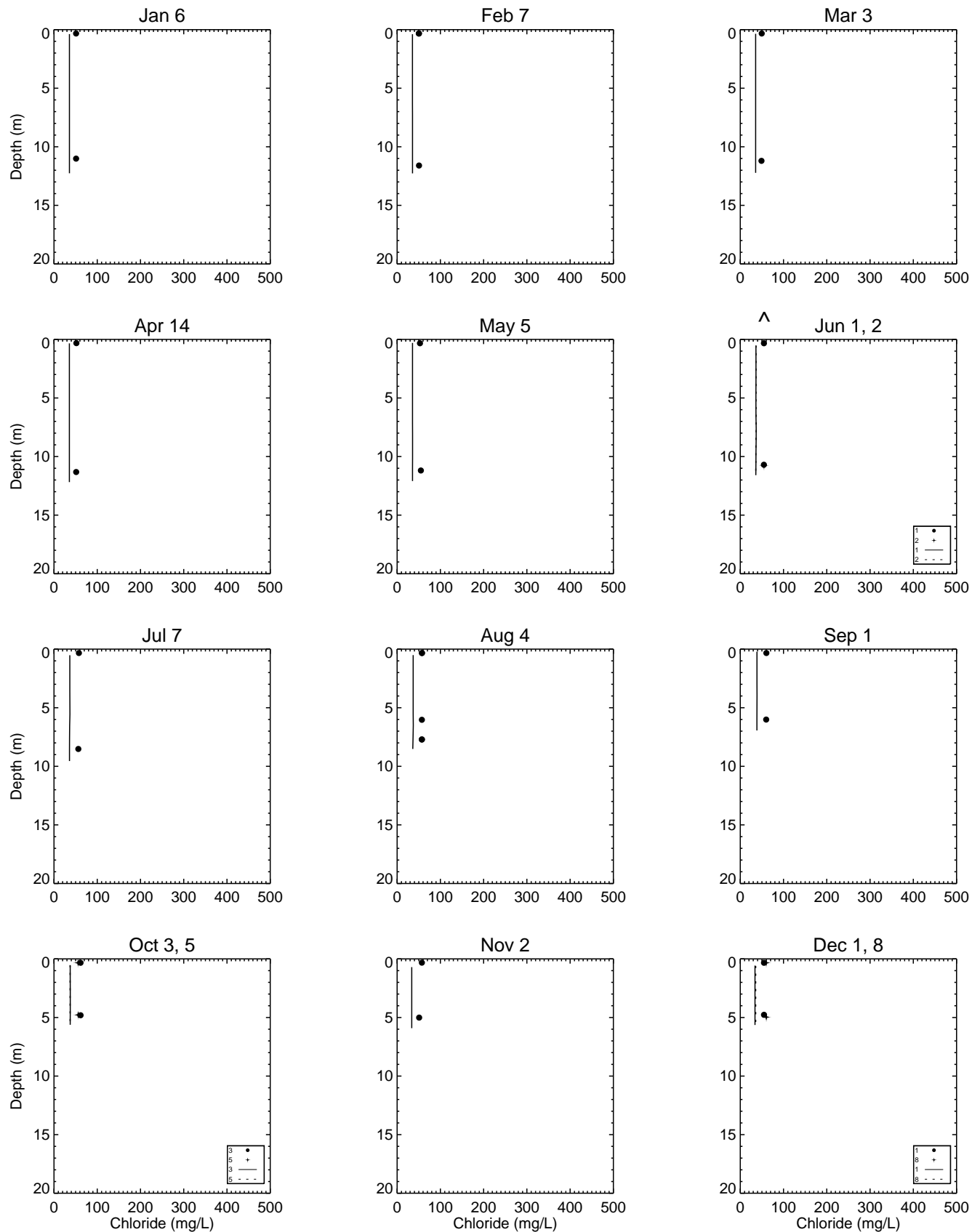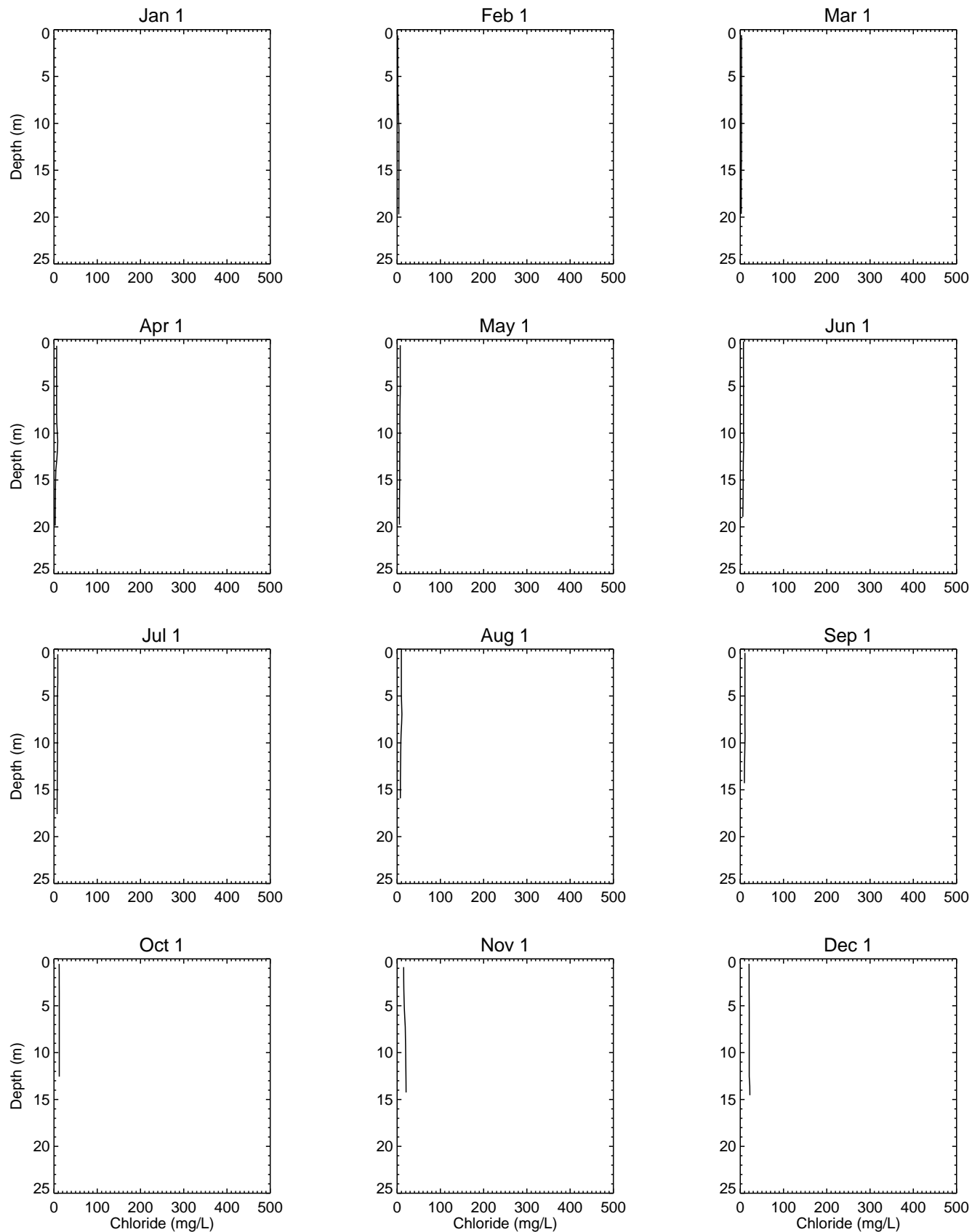*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
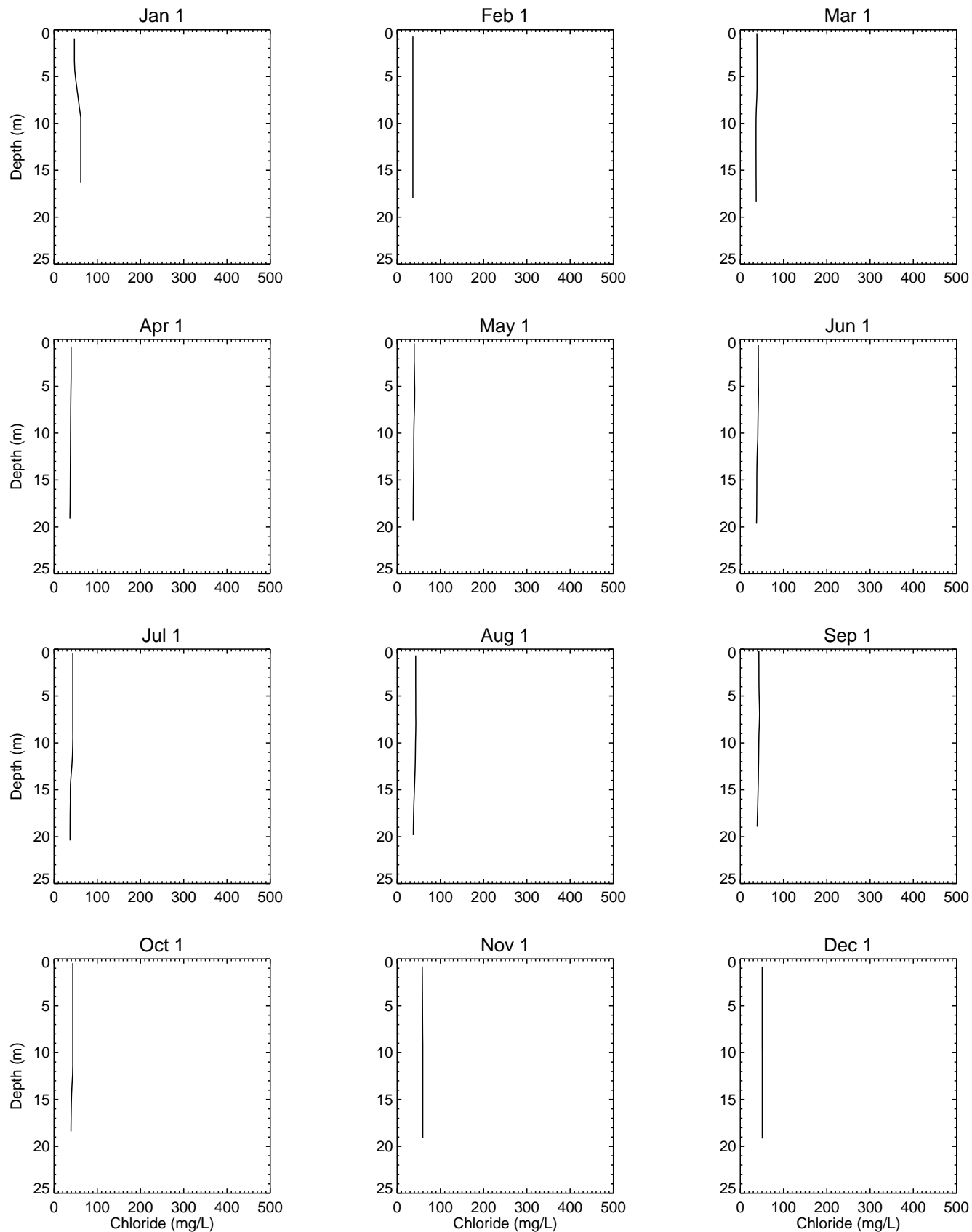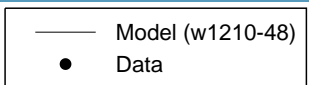Fri Jan 25 18:14:12 2013

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 1998

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1

Depth (m)

0 5 10 15 20 25

0 100 200 300 400 500

Feb 1

0 5 10 15 20 25

0 100 200 300 400 500

Mar 1

0 5 10 15 20 25

0 100 200 300 400 500

Apr 1

Depth (m)

0 5 10 15 20 25

0 100 200 300 400 500

May 1

0 5 10 15 20 25

0 100 200 300 400 500

Jun 1

0 5 10 15 20 25

0 100 200 300 400 500

Jul 1

Depth (m)

0 5 10 15 20 25

0 100 200 300 400 500

Aug 1

0 5 10 15 20 25

0 100 200 300 400 500

Sep 1

0 5 10 15 20 25

0 100 200 300 400 500

Oct 1

Depth (m)

0 5 10 15 20 25

0 100 200 300 400 500

Chloride (mg/L)

Nov 1

0 5 10 15 20 25

0 100 200 300 400 500

Chloride (mg/L)

Dec 1

0 5 10 15 20 25

0 100 200 300 400 500

Chloride (mg/L)

——— Model (w1210-48)
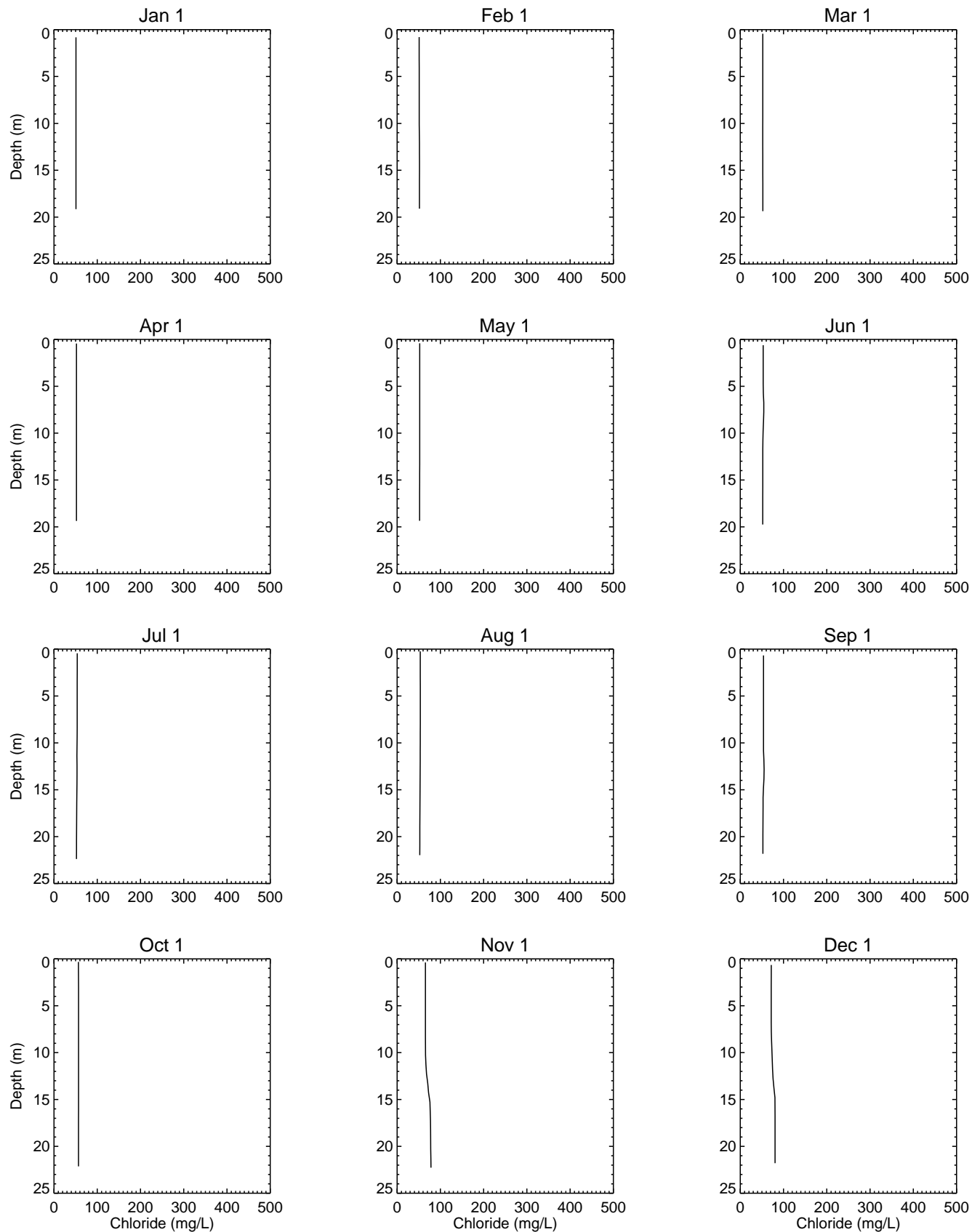
● Data

ANCHOR QEA
PARSONS

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 1999

Profiles shown for dates with available data else model results for first day of month shown.
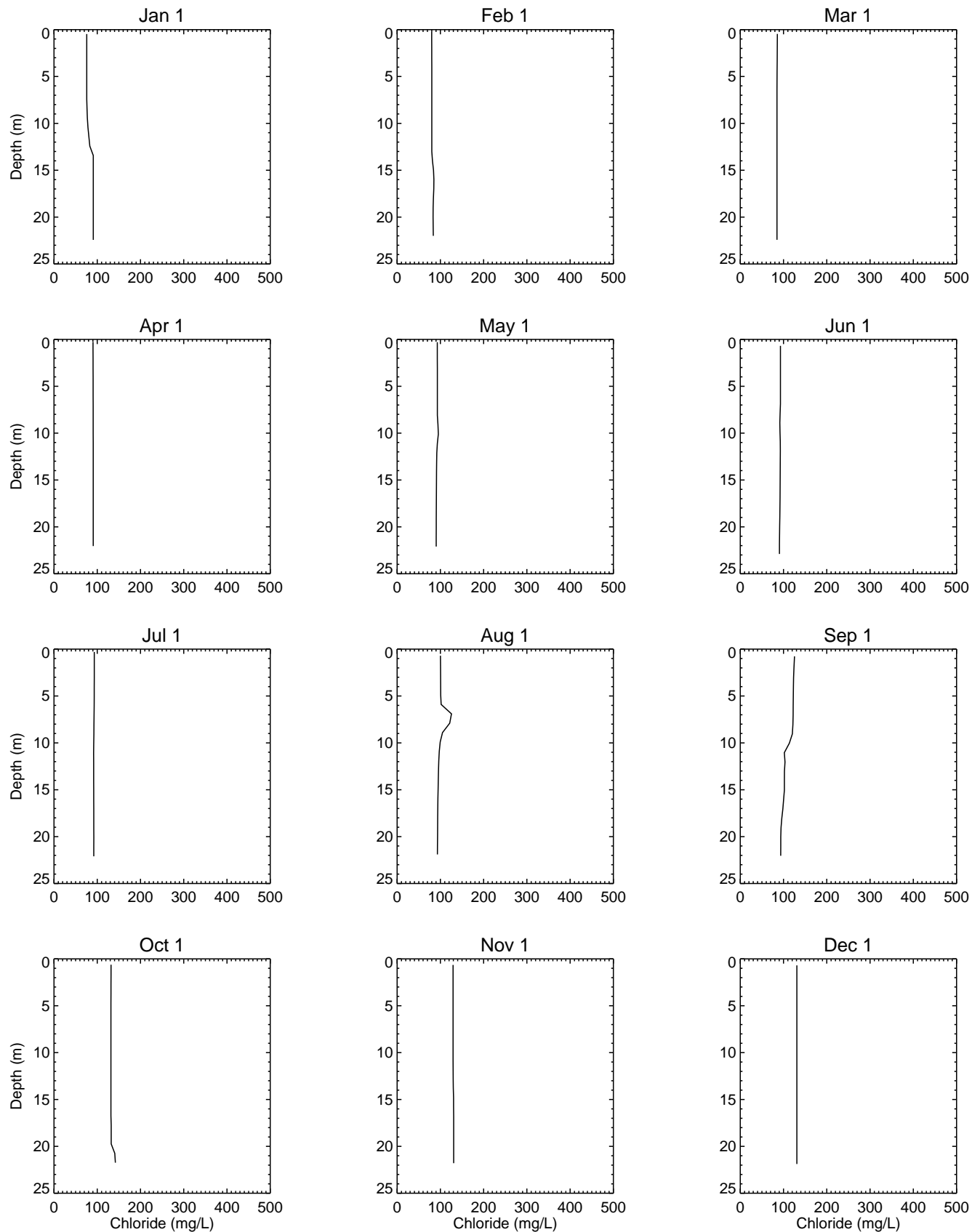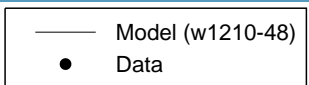
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1   Feb 1   Mar 1

Apr 1   May 1   Jun 1

Jul 1   Aug 1   Sep 1

Oct 1   Nov 1   Dec 1

Chloride (mg/L)

—— Model (w1210-48)
● Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 2000

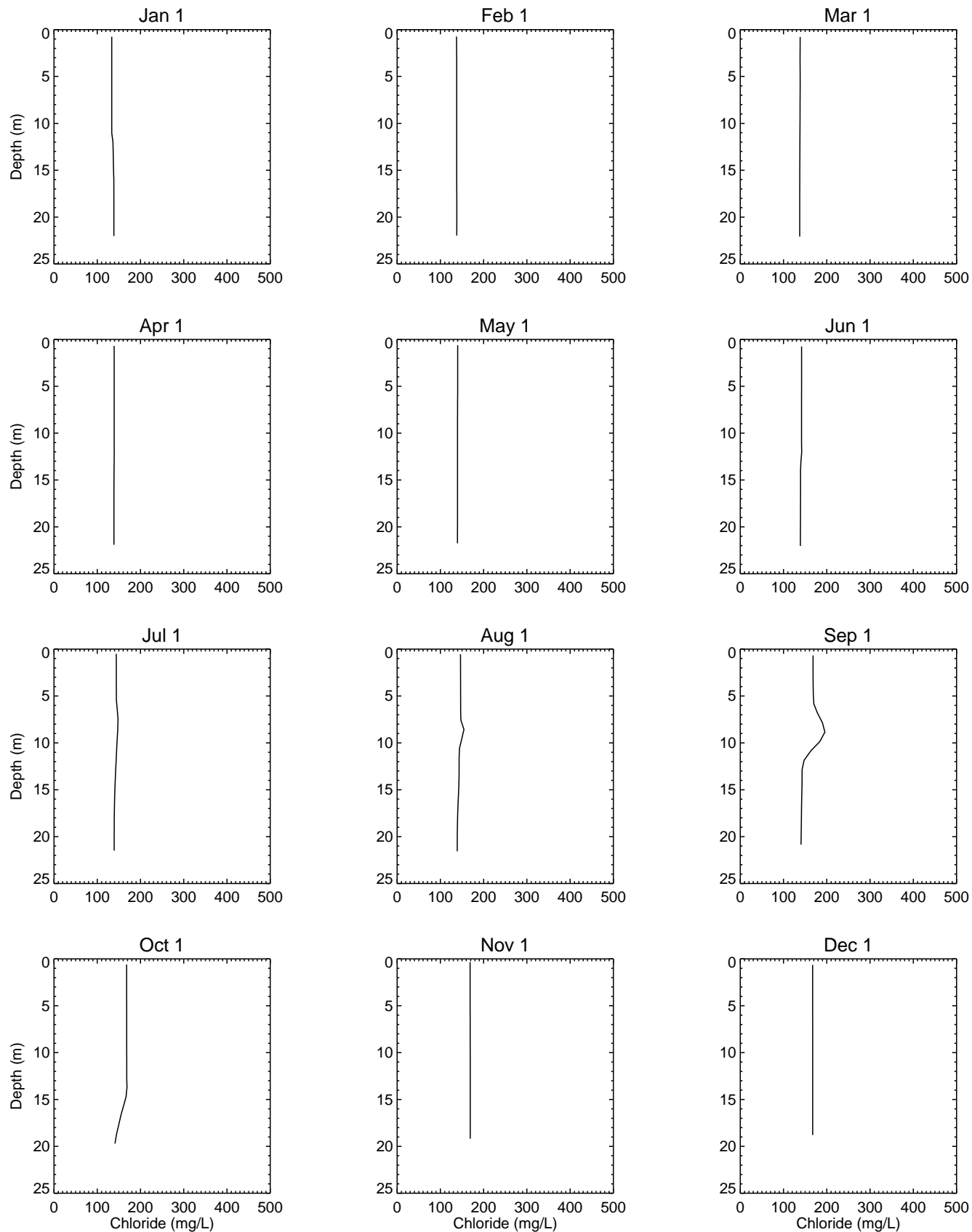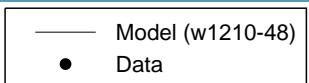*Profiles shown for dates with available data else model results for first day of month shown.*

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:12 2013

Jan 1 Feb 1 Mar 1
Apr 1 May 1 Jun 1
Jul 1 Aug 1 Sep 1
Oct 1 Nov 1 Dec 1

Depth (m)

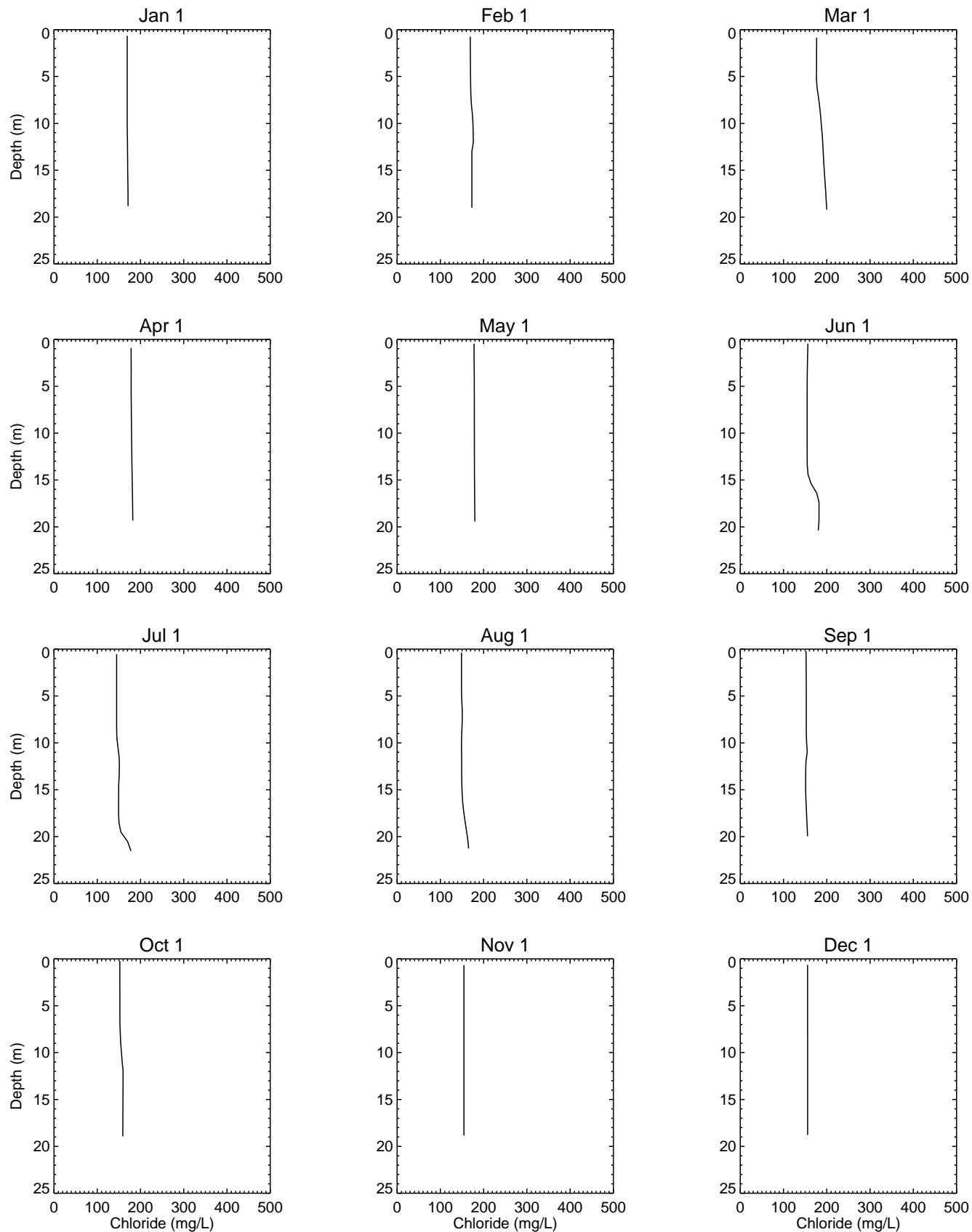Chloride (mg/L)

—— Model (w1210-48)
●   Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 2001

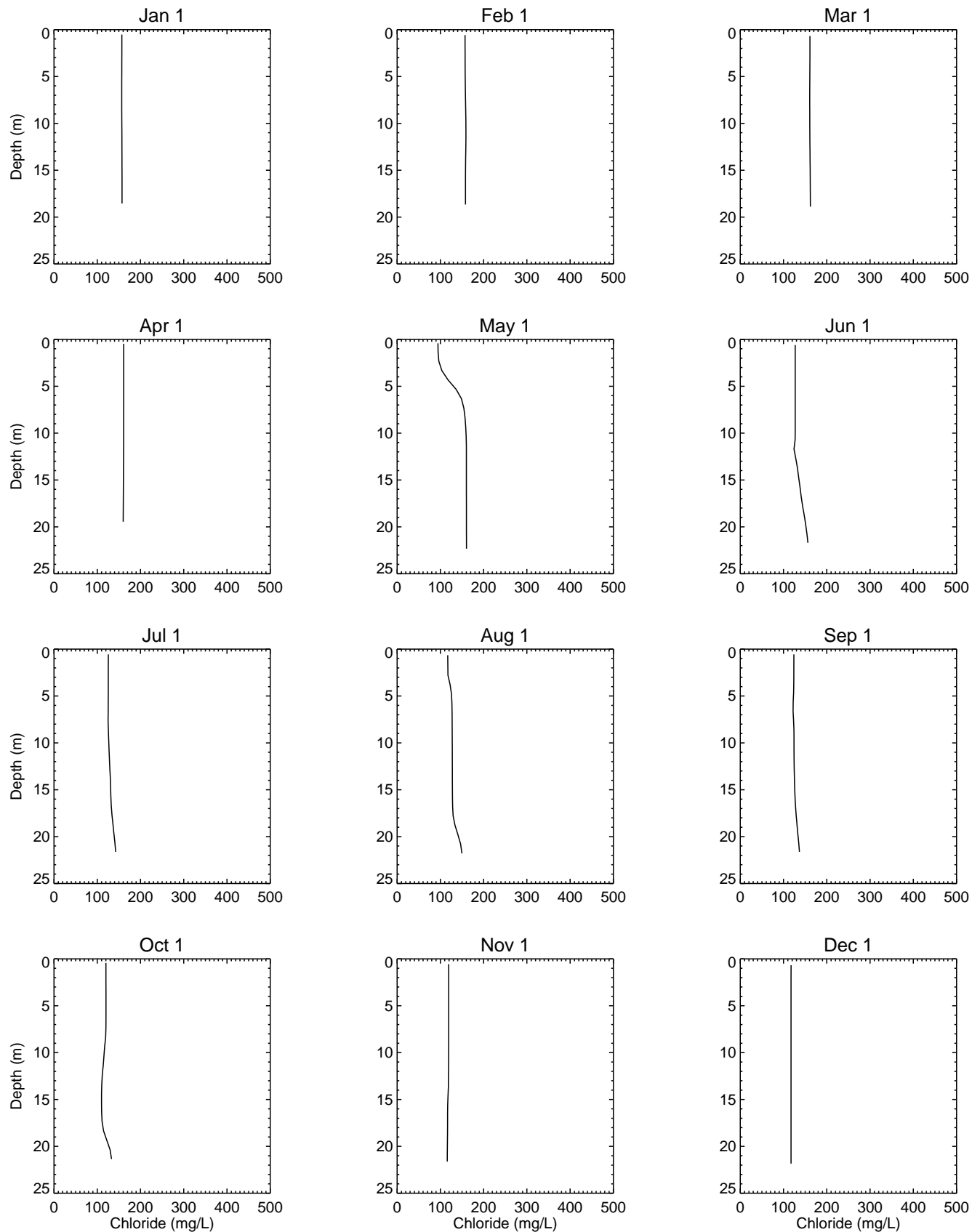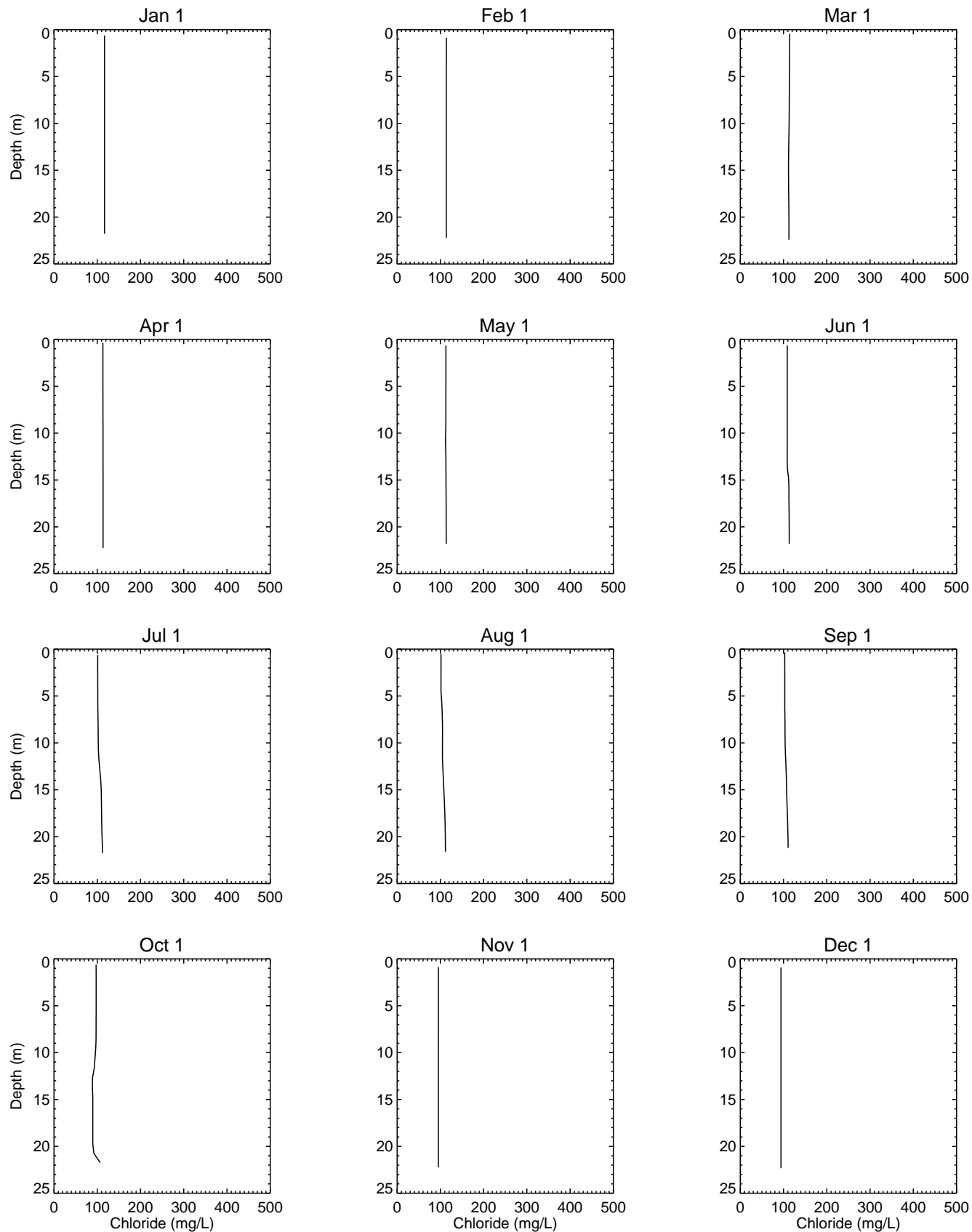*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:12 2013

Figure depicts twelve vertical profile plots (Jan 1 through Dec 1) of Chloride (mg/L) versus Depth (m).

Jan 1

Feb 1

Mar 1

Apr 1

May 1

Jun 1

Jul 1

Aug 1

Sep 1

Oct 1

Nov 1

Dec 1

Depth (m)

Chloride (mg/L)

——— Model (w1210-48)

● Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 2002

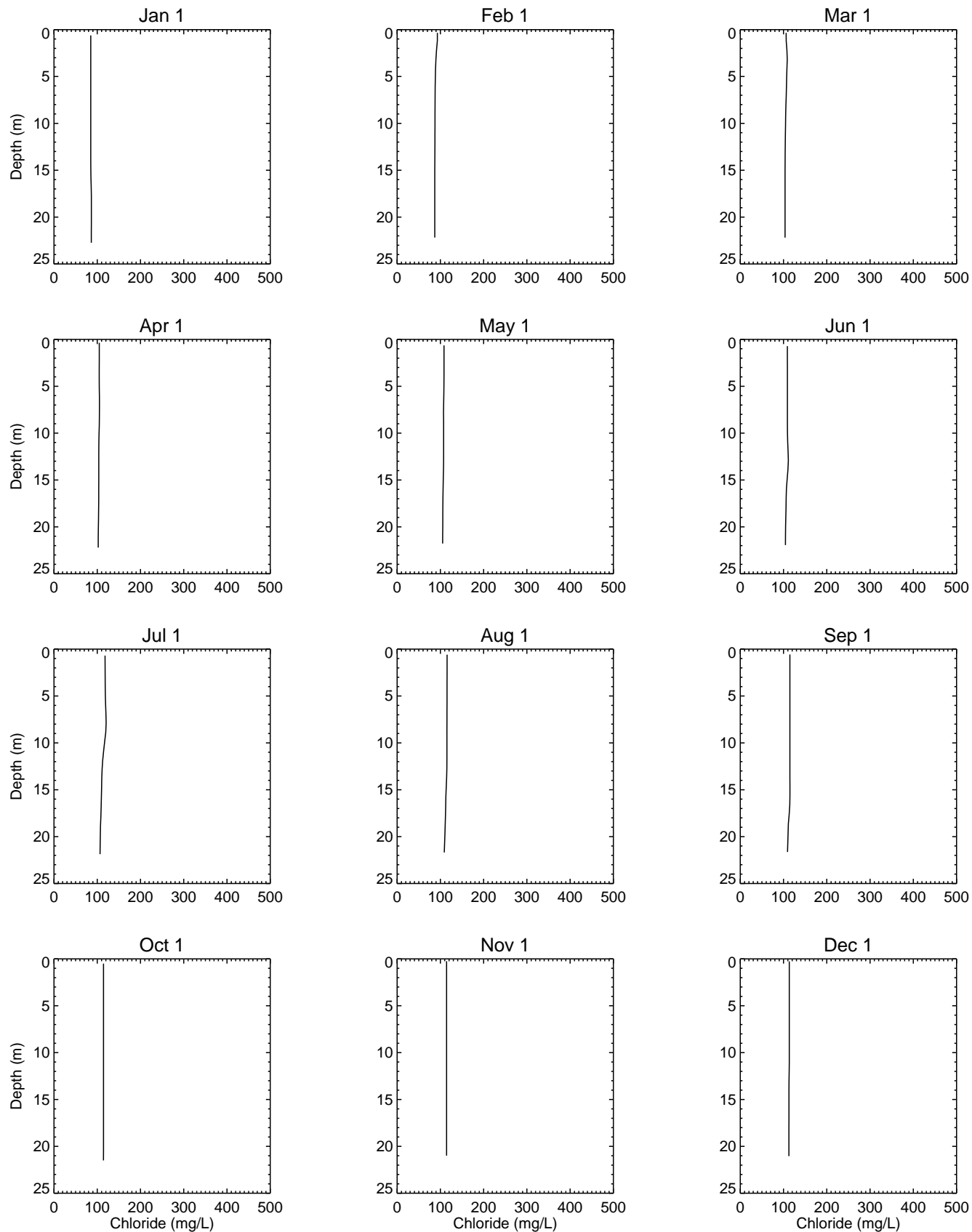*Profiles shown for dates with available data else model results for first day of month shown.*

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan
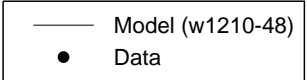
Lower Colorado River Authority

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 2003

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
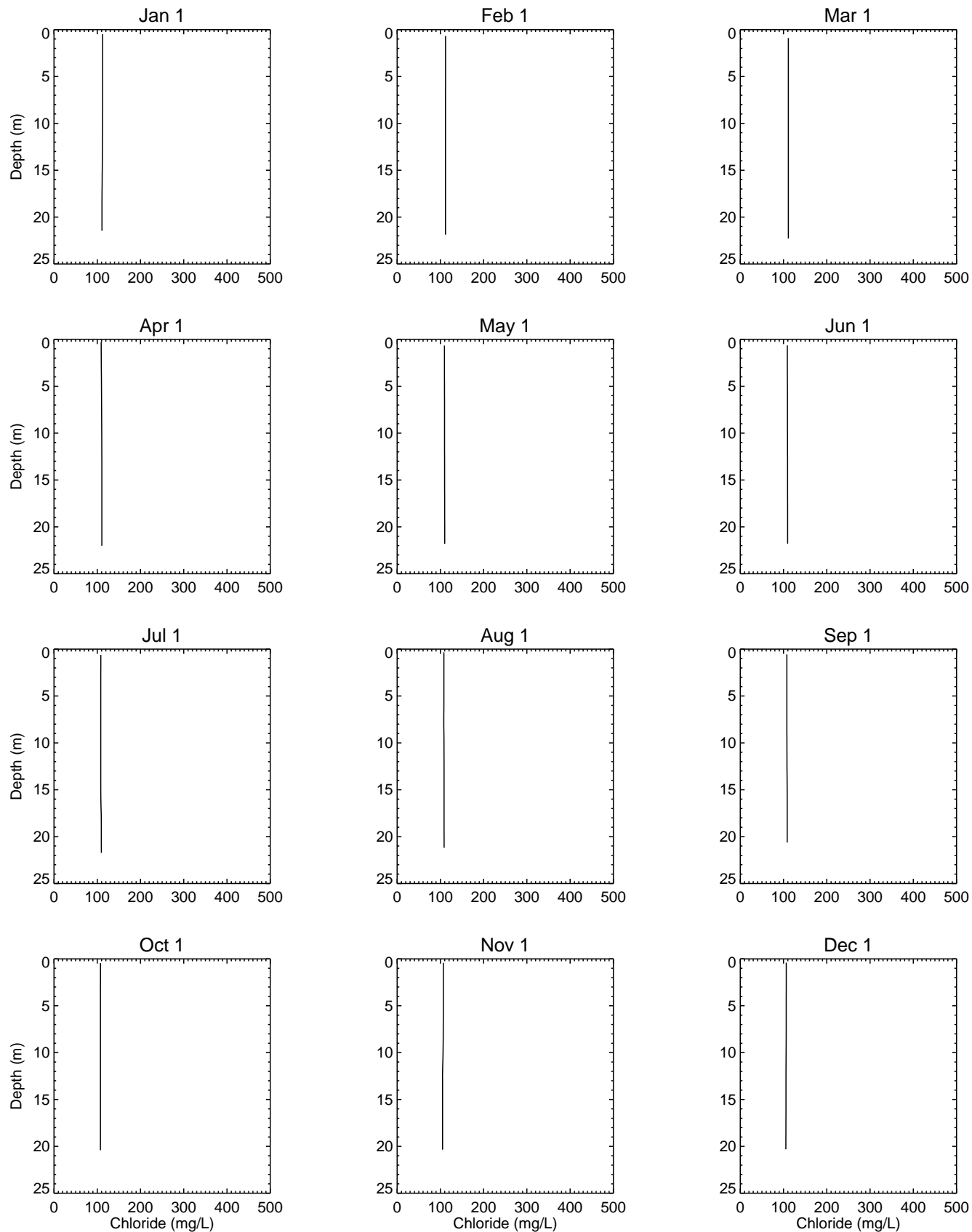Fri Jan 25 18:14:12 2013

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
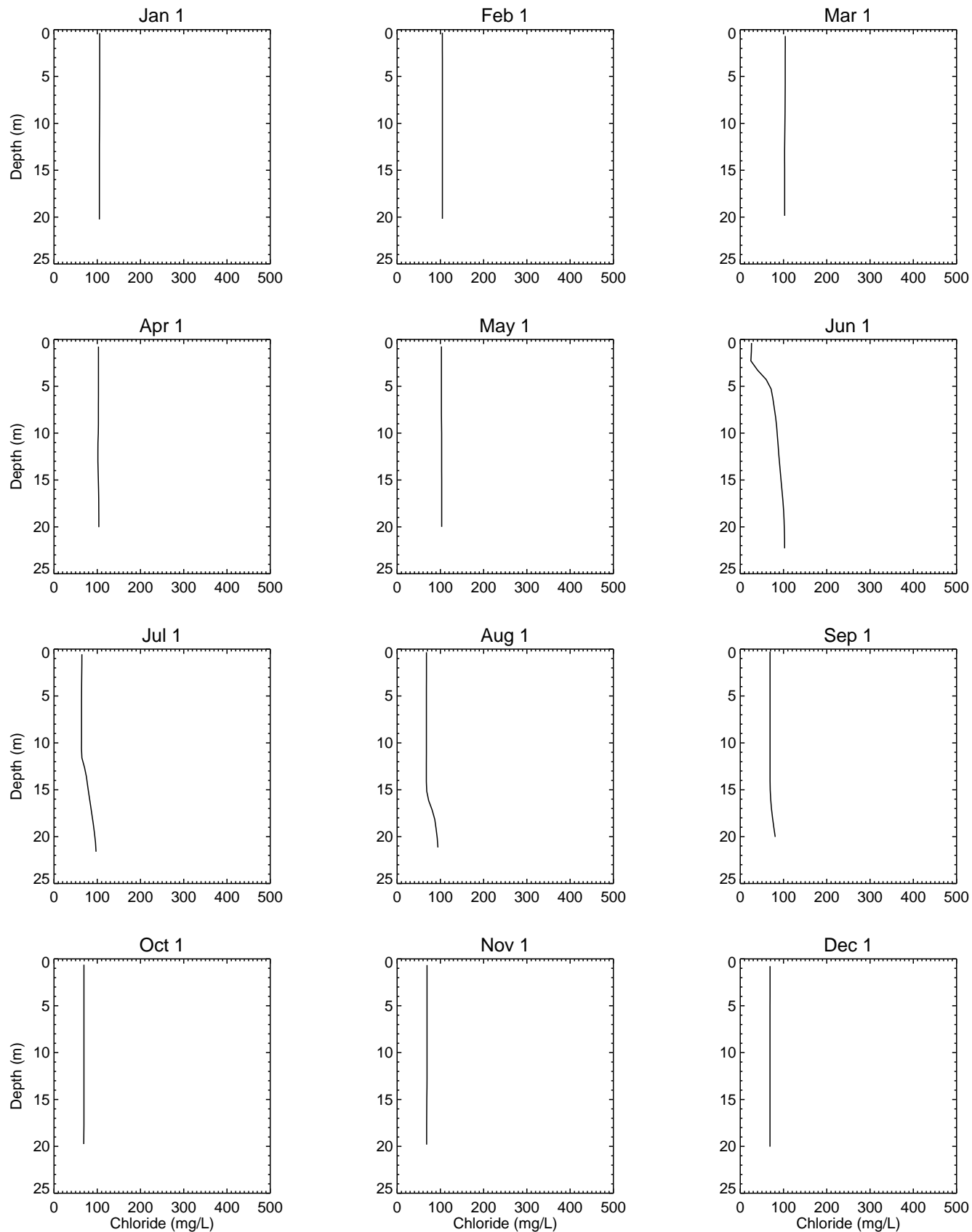~3/4 mi South of Garret Island (Segment 7) - Chloride - 2004

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:12 2013

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 2005

Profiles shown for dates with available data else model results for first day of month shown.

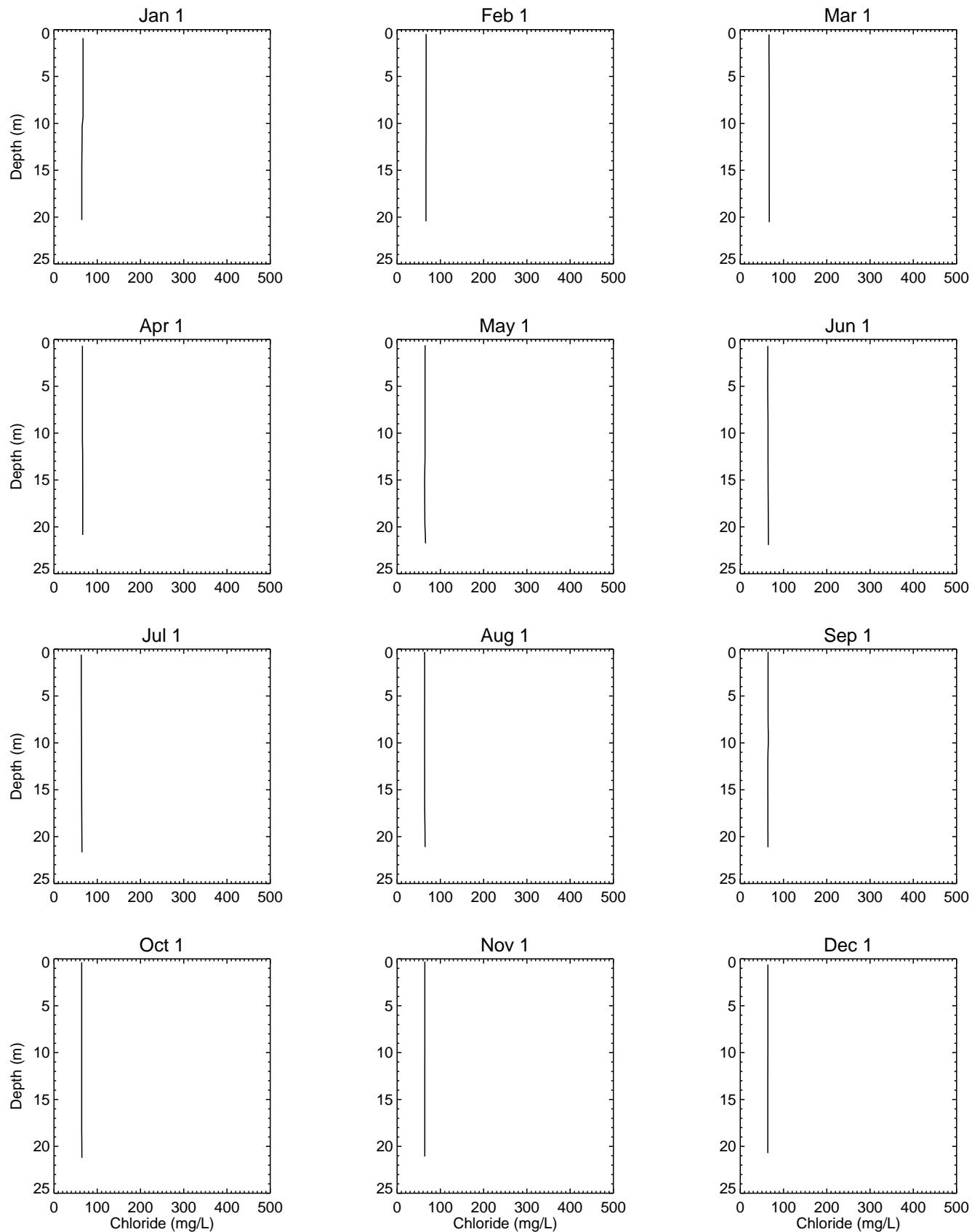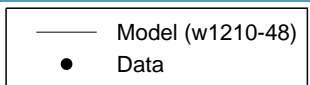CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 2006

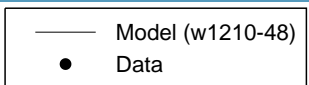*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Jan 1　Feb 1　Mar 1

Apr 1　May 1　Jun 1

Jul 1　Aug 1　Sep 1

Oct 1　Nov 1　Dec 1

Chloride (mg/L)

—— Model (w1210-48)
● Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 2007

Profiles shown for dates with available data else model results for first day of month shown.
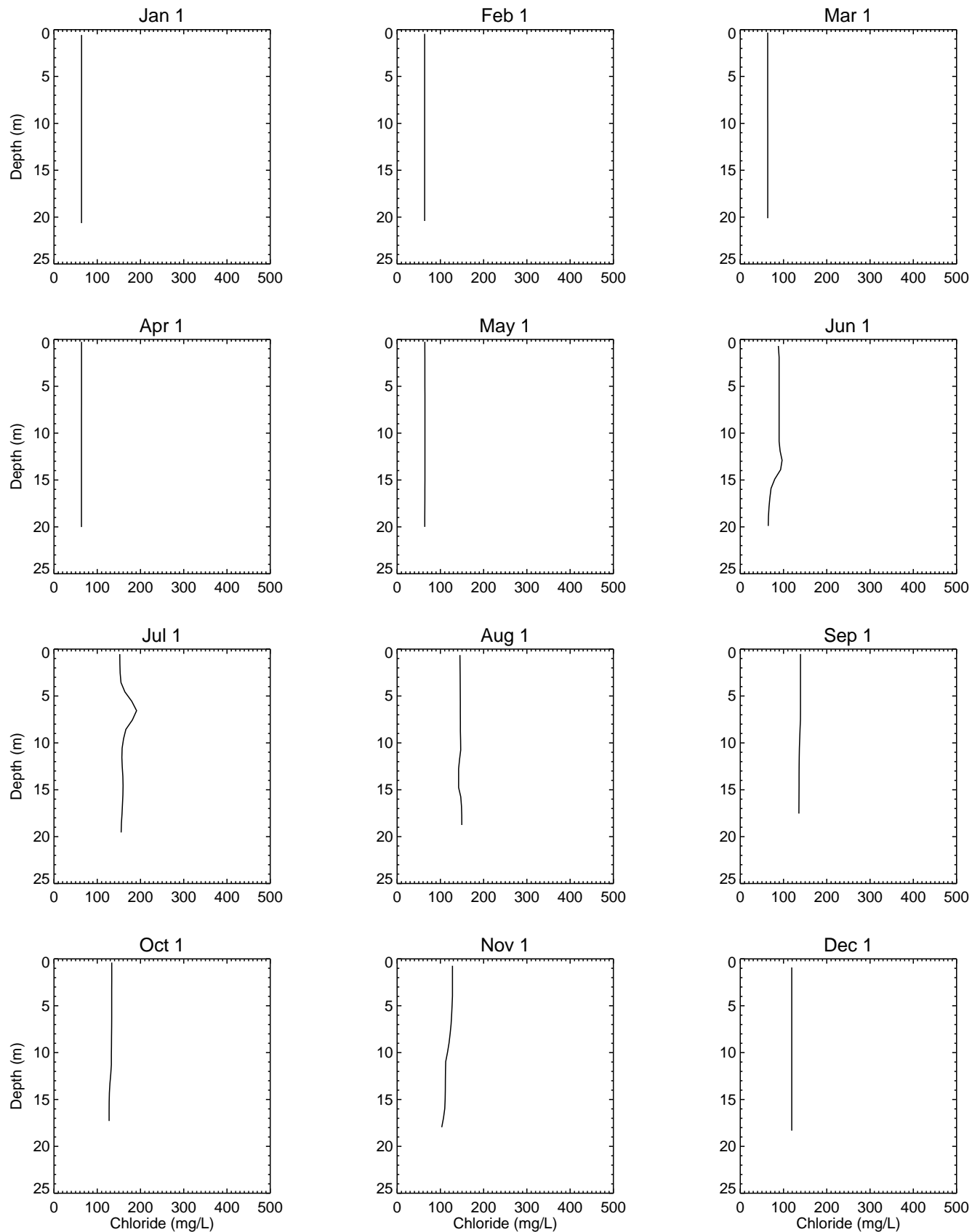
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR
QEA
PARSONS

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 2008

Profiles shown for dates with available data else model results for first day of month shown.
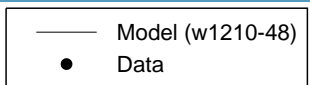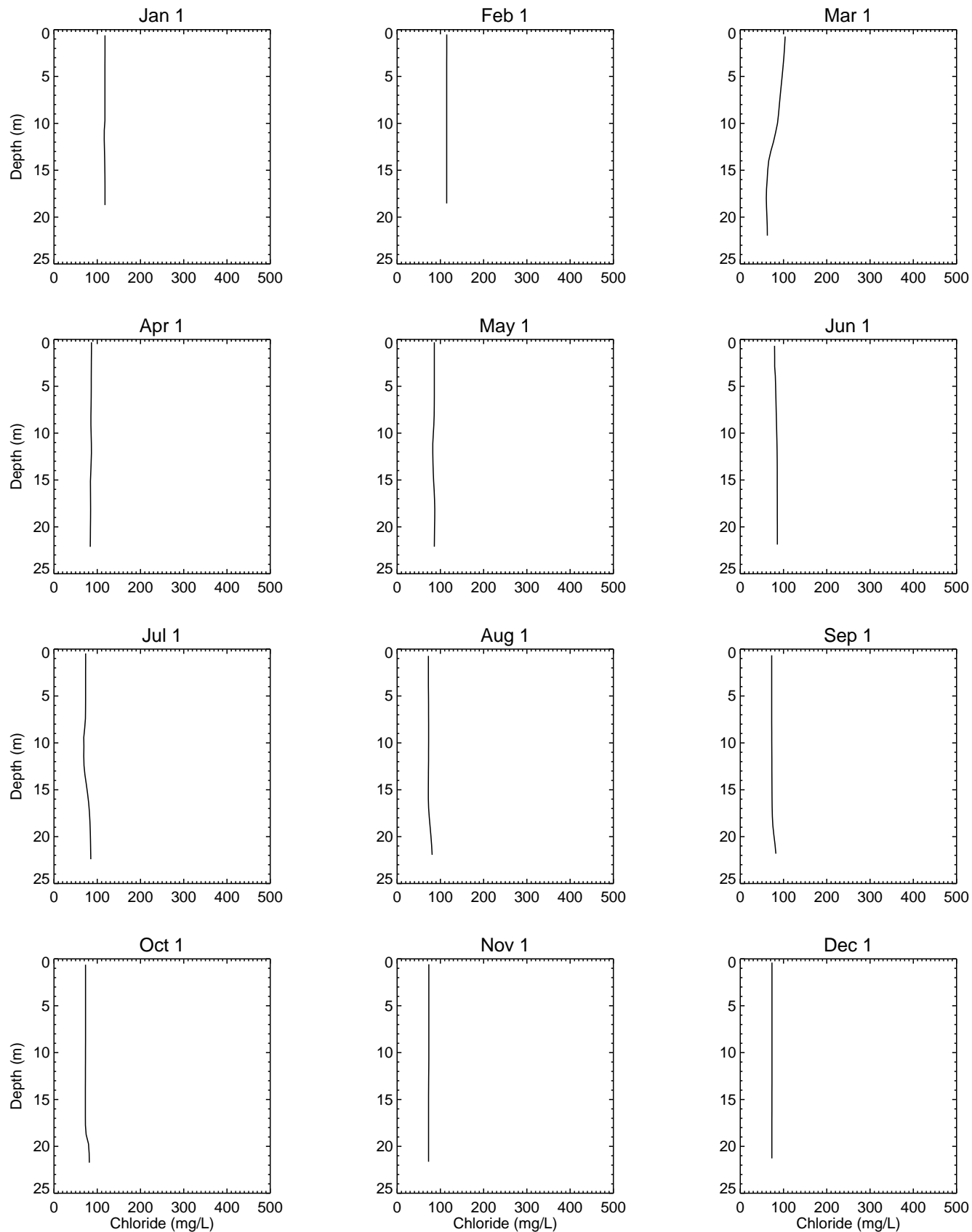
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1   Feb 1   Mar 1

Apr 1   May 1   Jun 1

Jul 1   Aug 1   Sep 1

Oct 1   Nov 1   Dec 1

— Model (w1210-48)
● Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 2009

Profiles shown for dates with available data else model results for first day of month shown.
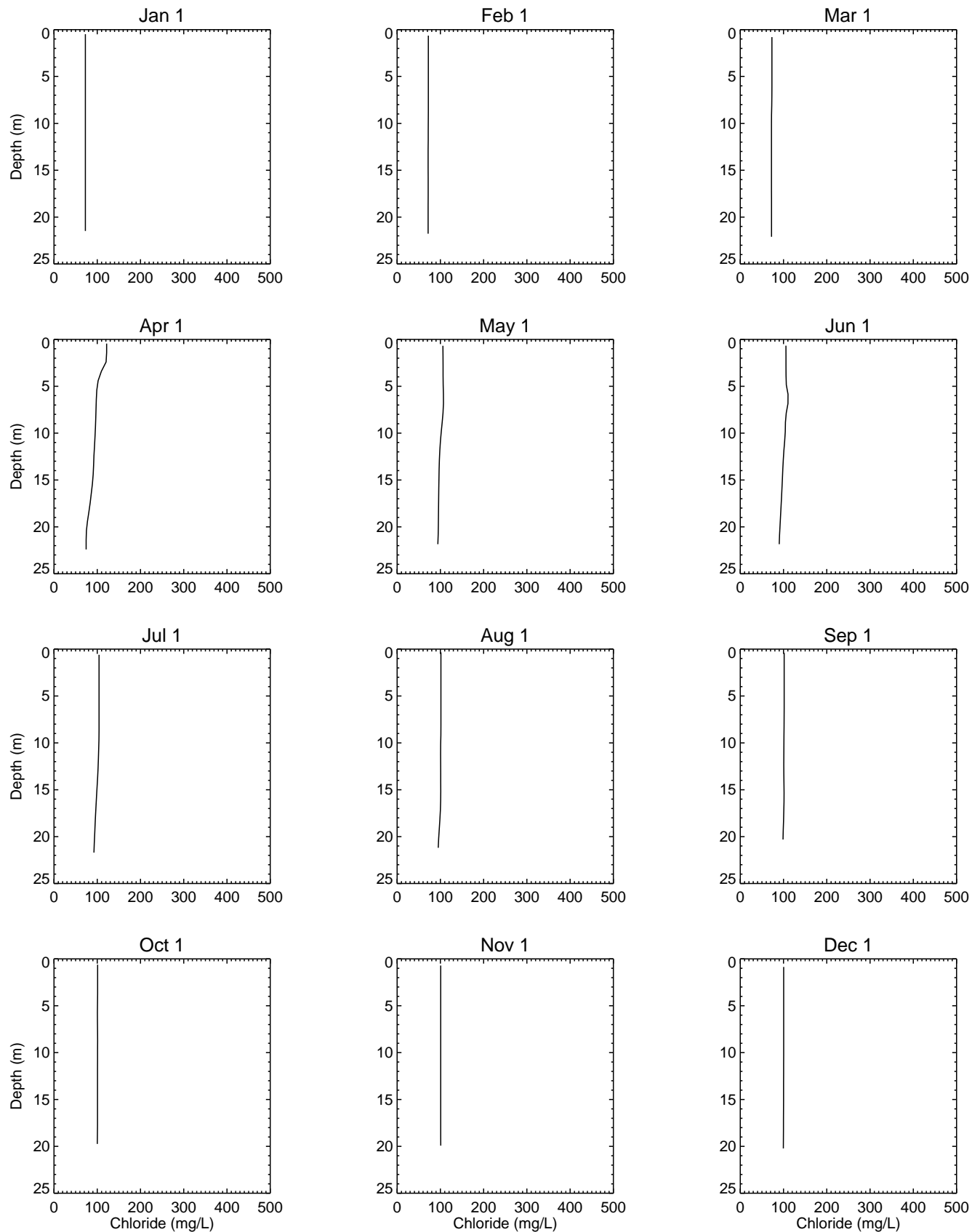
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:12 2013

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 5 · Sep 2 · Oct 7 · Nov 4 · Dec 2

Depth (m) — Chloride (mg/L)

Model (w1210-48)
● Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 2010

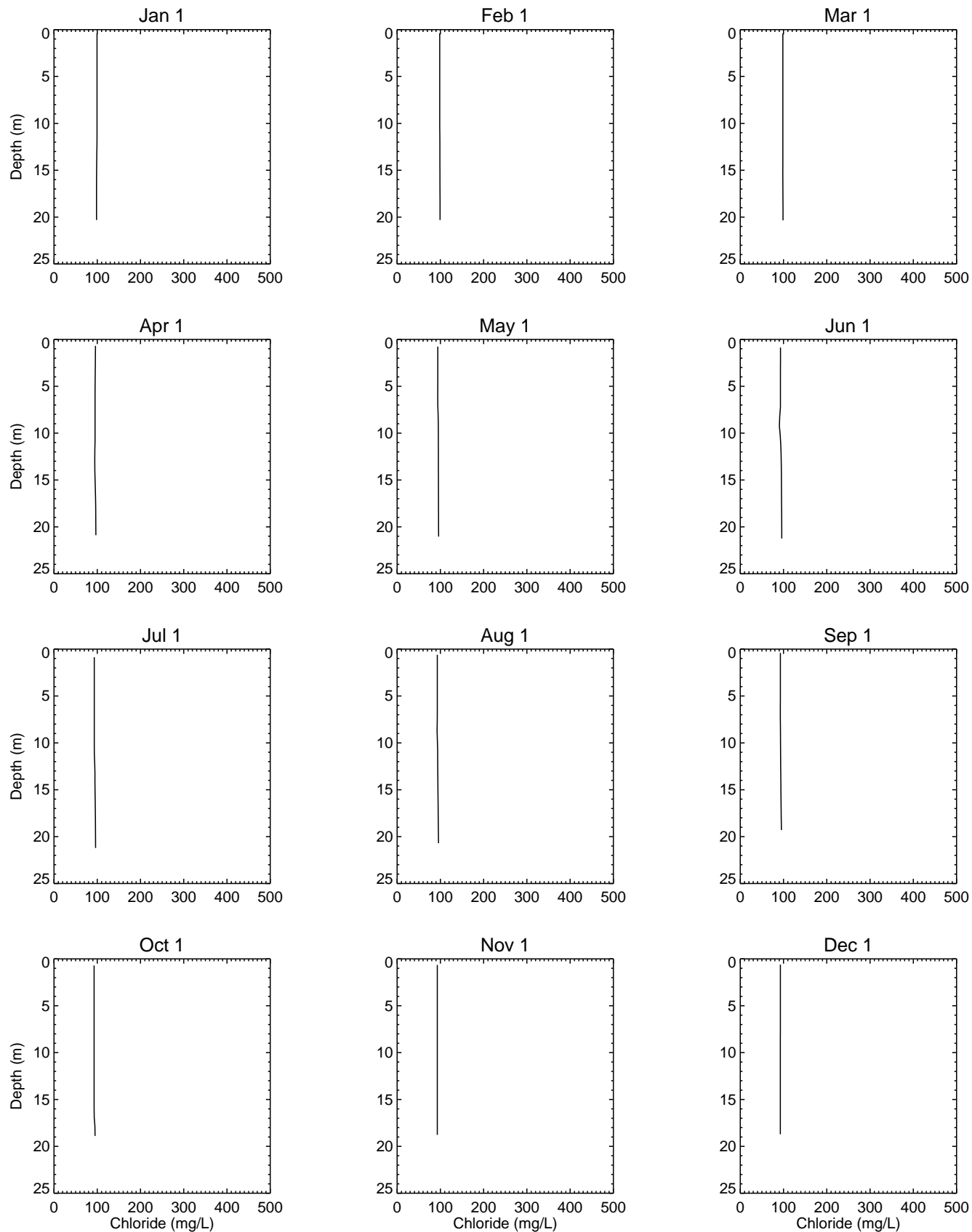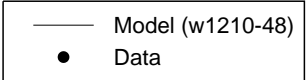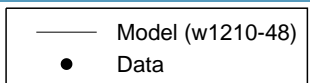*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:12 2013

Jan 6 | Feb 7 | Mar 3
Apr 1 | May 5 | ^ Jun 2
Jul 7 | Aug 4 | Sep 1
Oct 5 | Nov 2 | Dec 1

Model (w1210-48)
● Data

Figure G-22

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Chloride - 2011

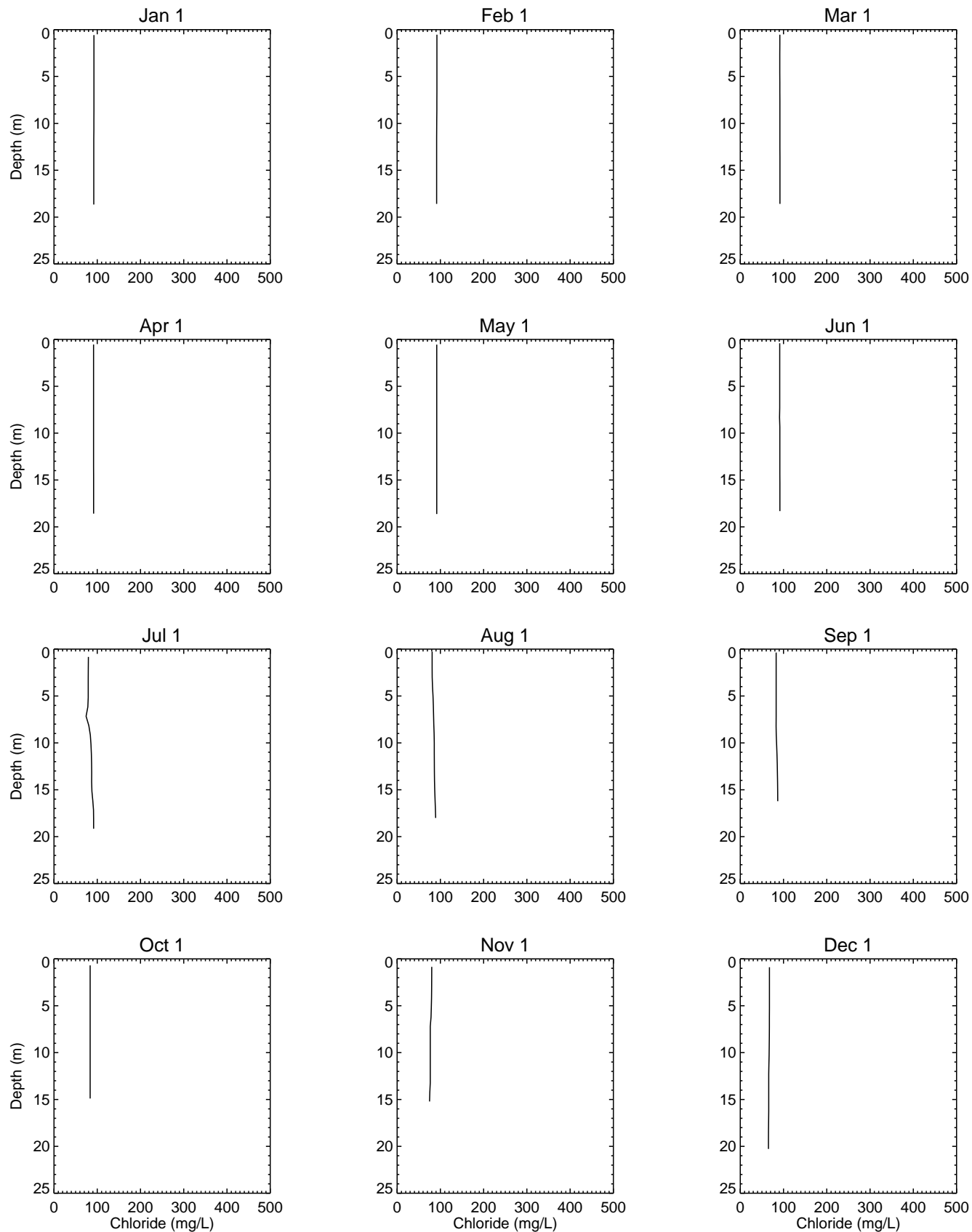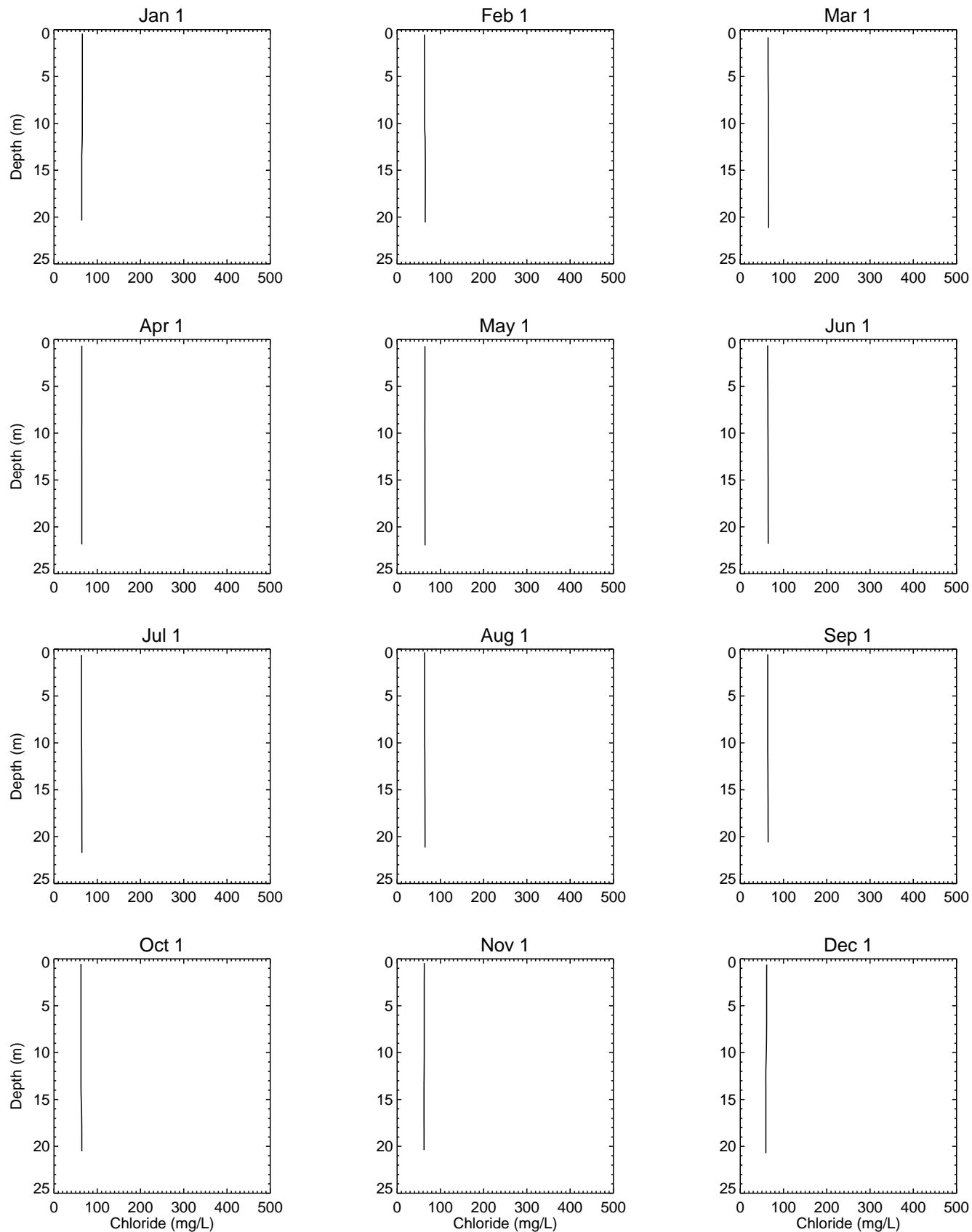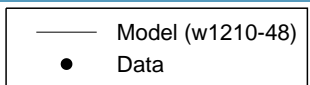*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 1984

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 23 · Feb 20 · Mar 20 · Apr 24 · May 23 · Jun 19 · Jul 1 · Aug 13, 28 · Sep 25 · Oct 23 · Nov 21 · Dec 17

Depth (m) — Chloride (mg/L)

Model (w1210-48)
● Data

Figure G-23
Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 1985

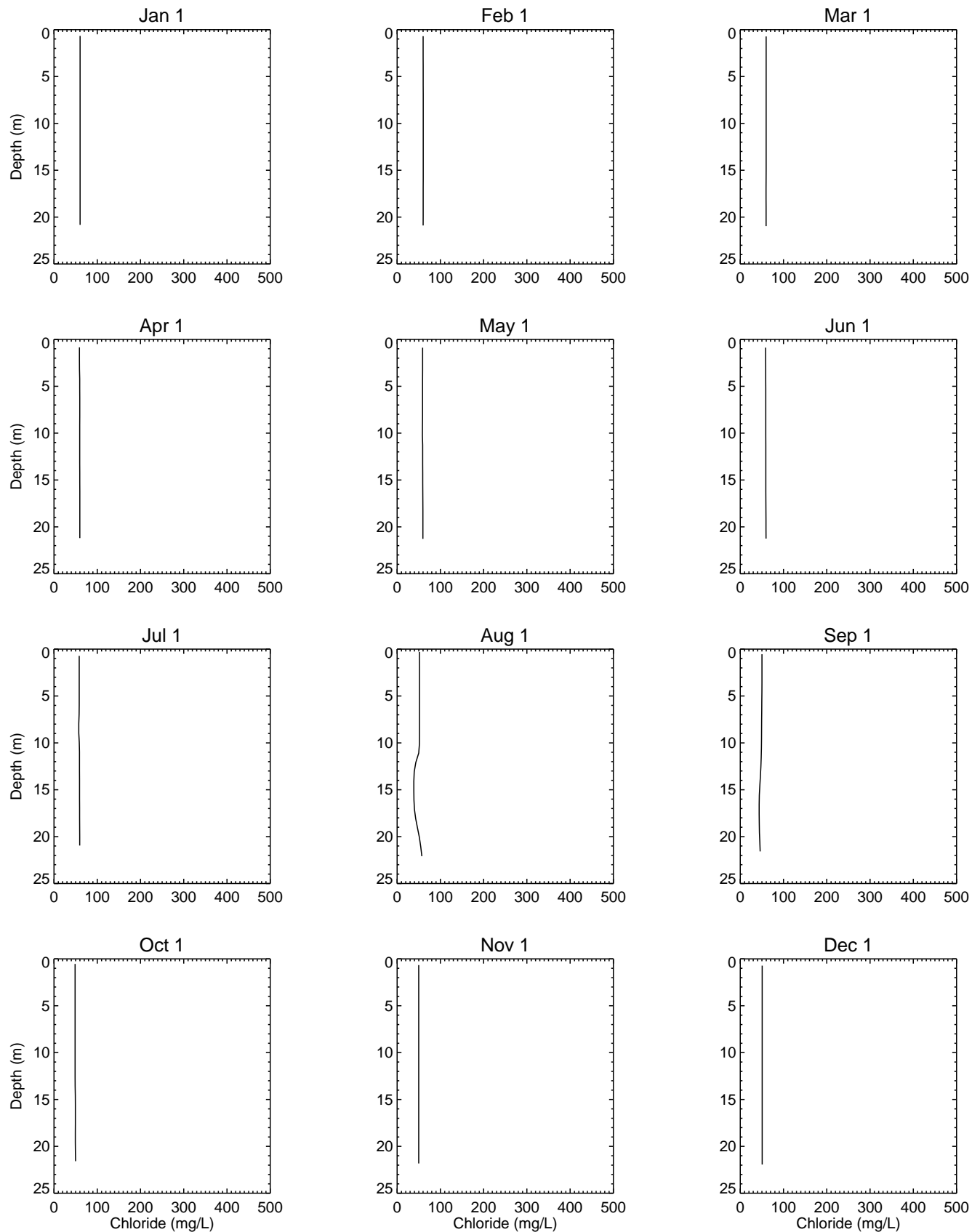*Profiles shown for dates with available data else model results for first day of month shown.*

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:15 2013

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 1986

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
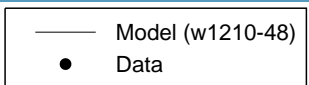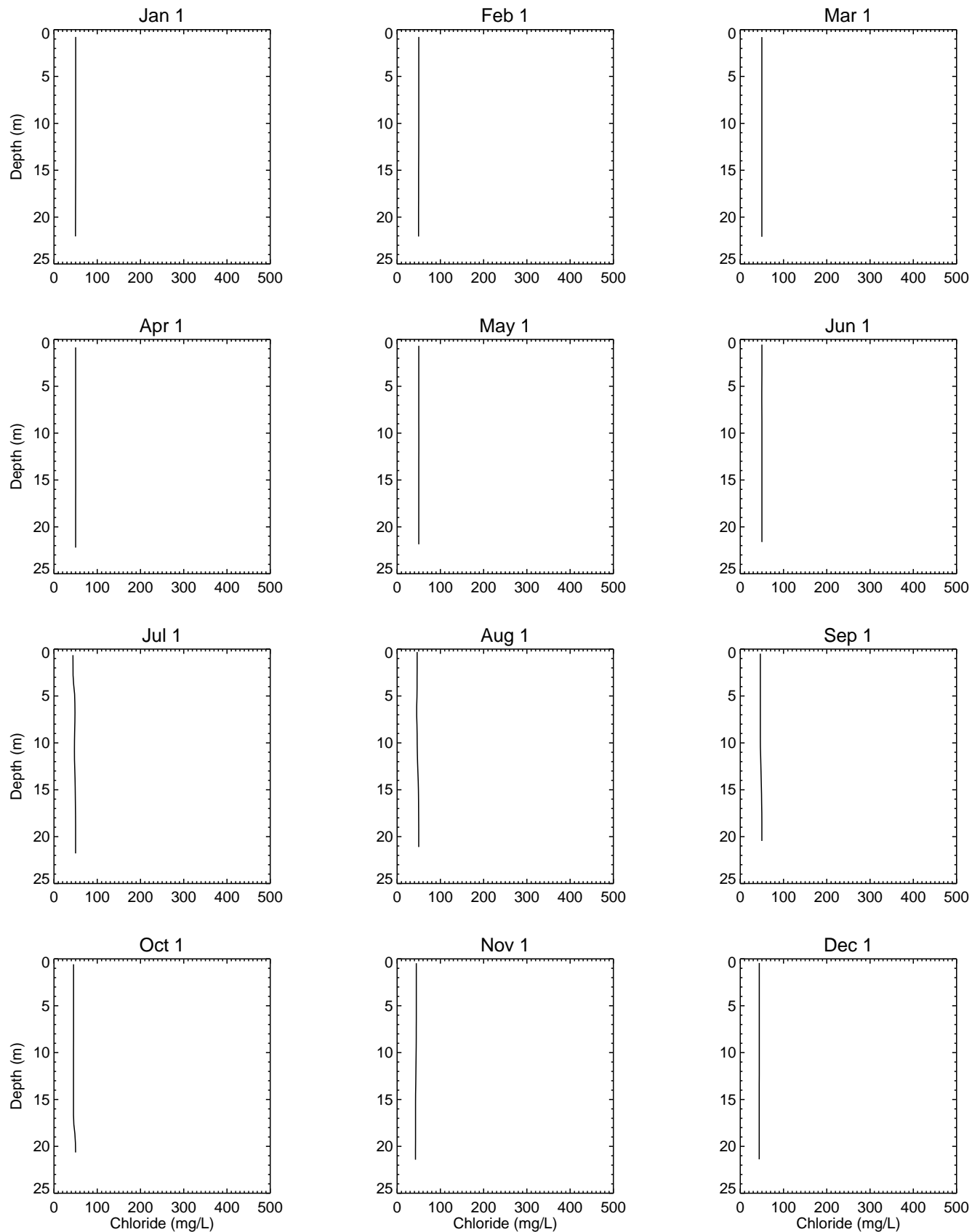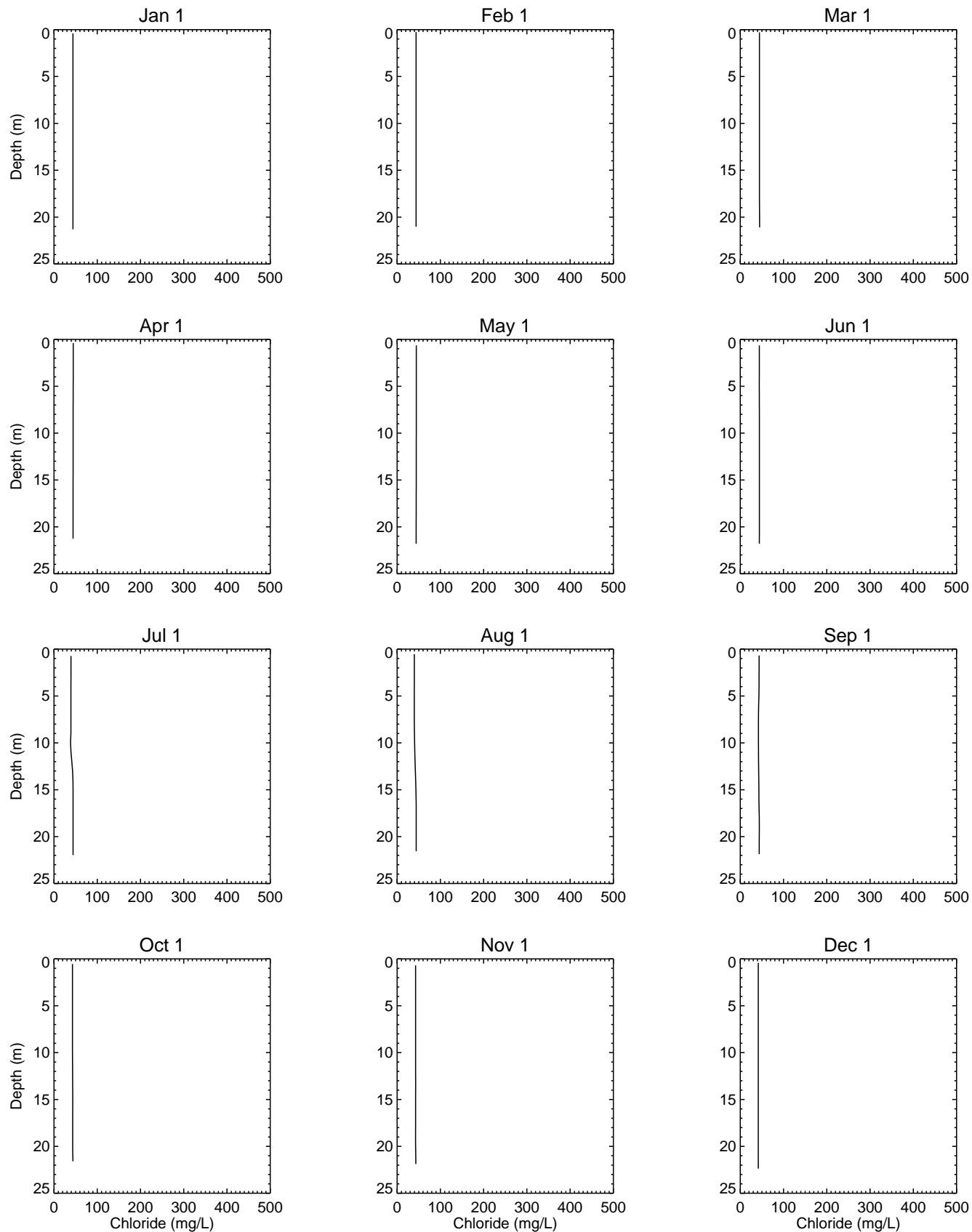
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:15 2013

Jan 18 · Feb 16 · Mar 15 · Apr 19 · May 17 · Jun 20 · Jul 20 · Aug 15 · Sep 12 · Oct 10 · Nov 8 · Dec 14

—— Model (w1210-48)

● Data

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 1988

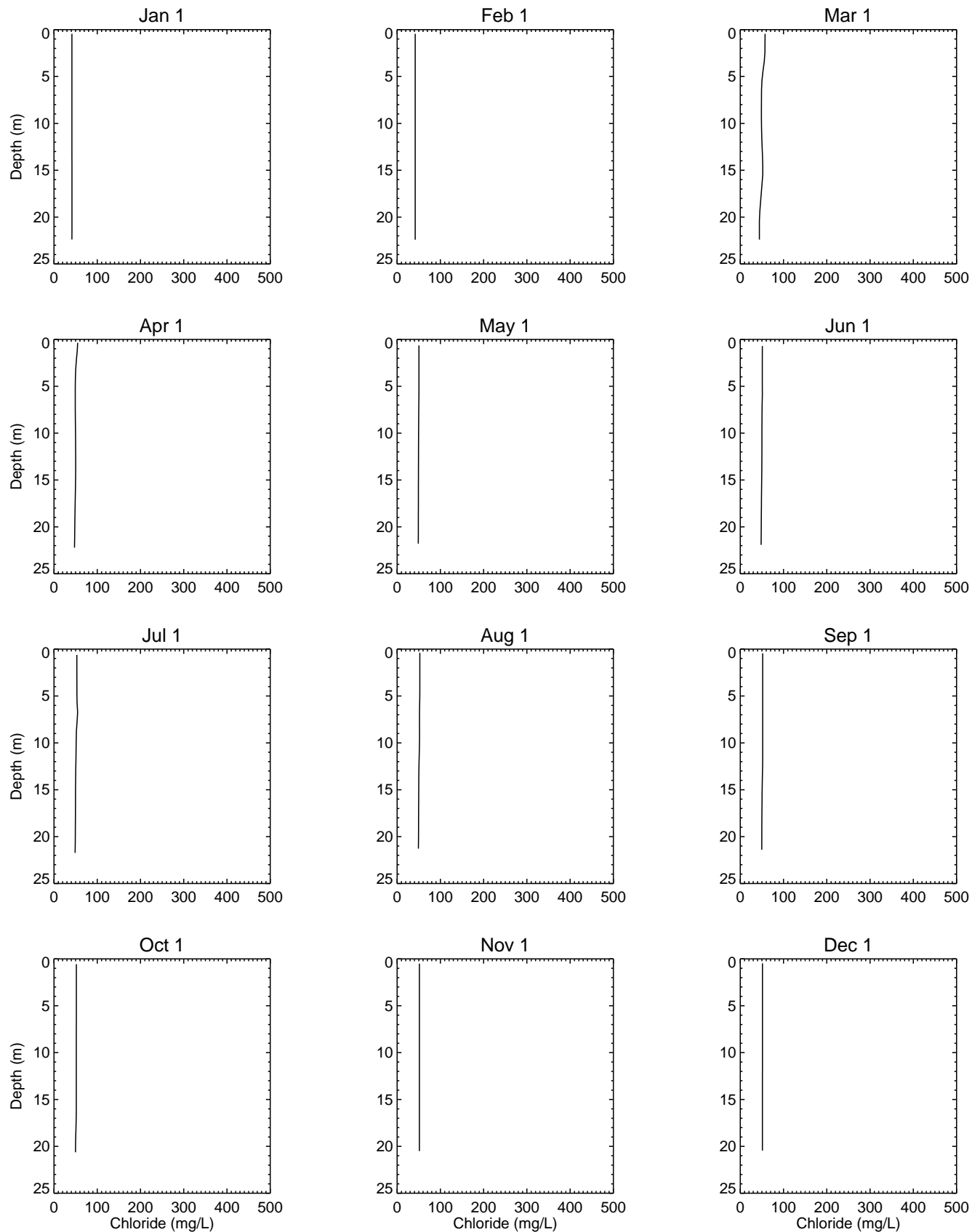*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 1989

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
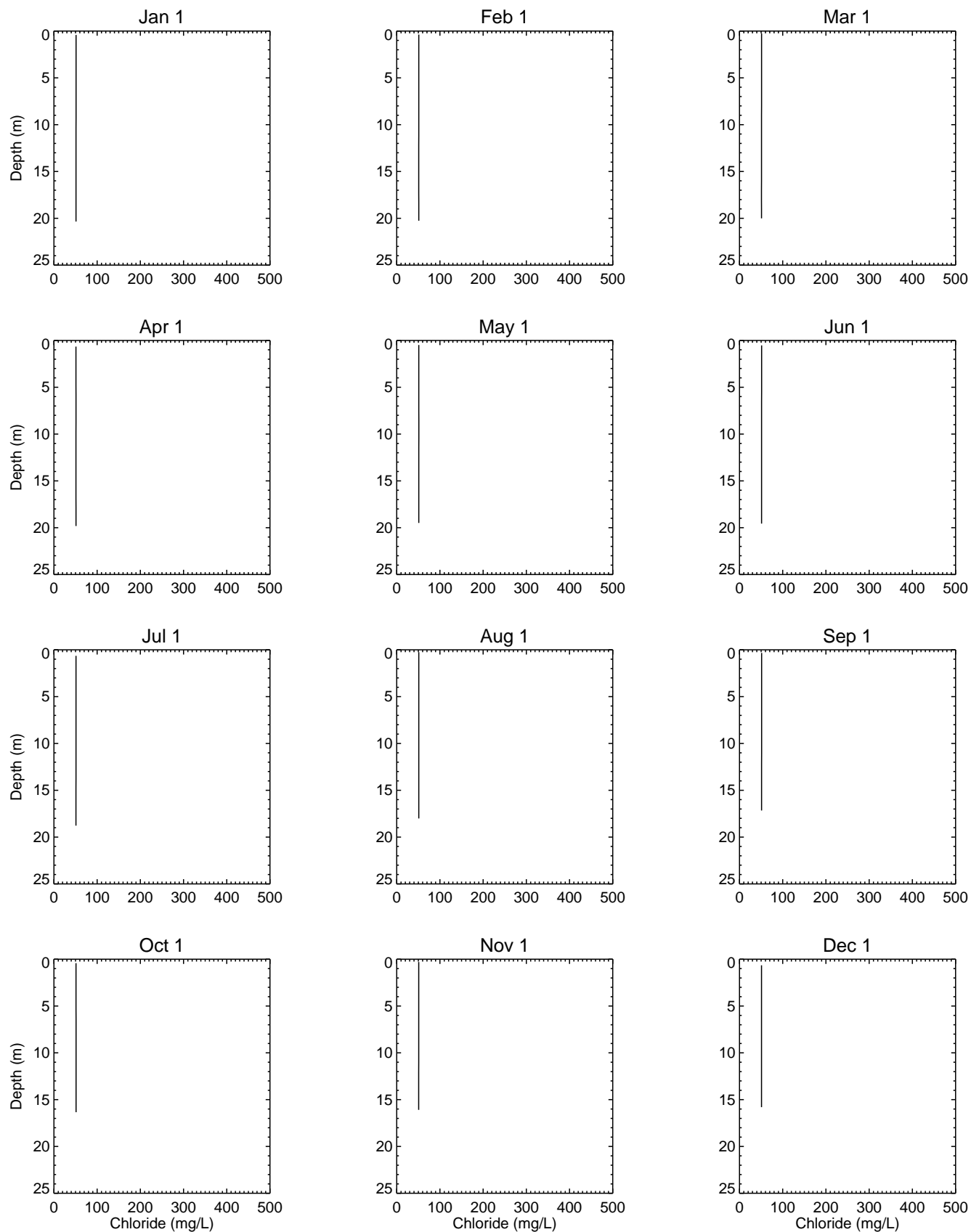Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 1990

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 1991

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
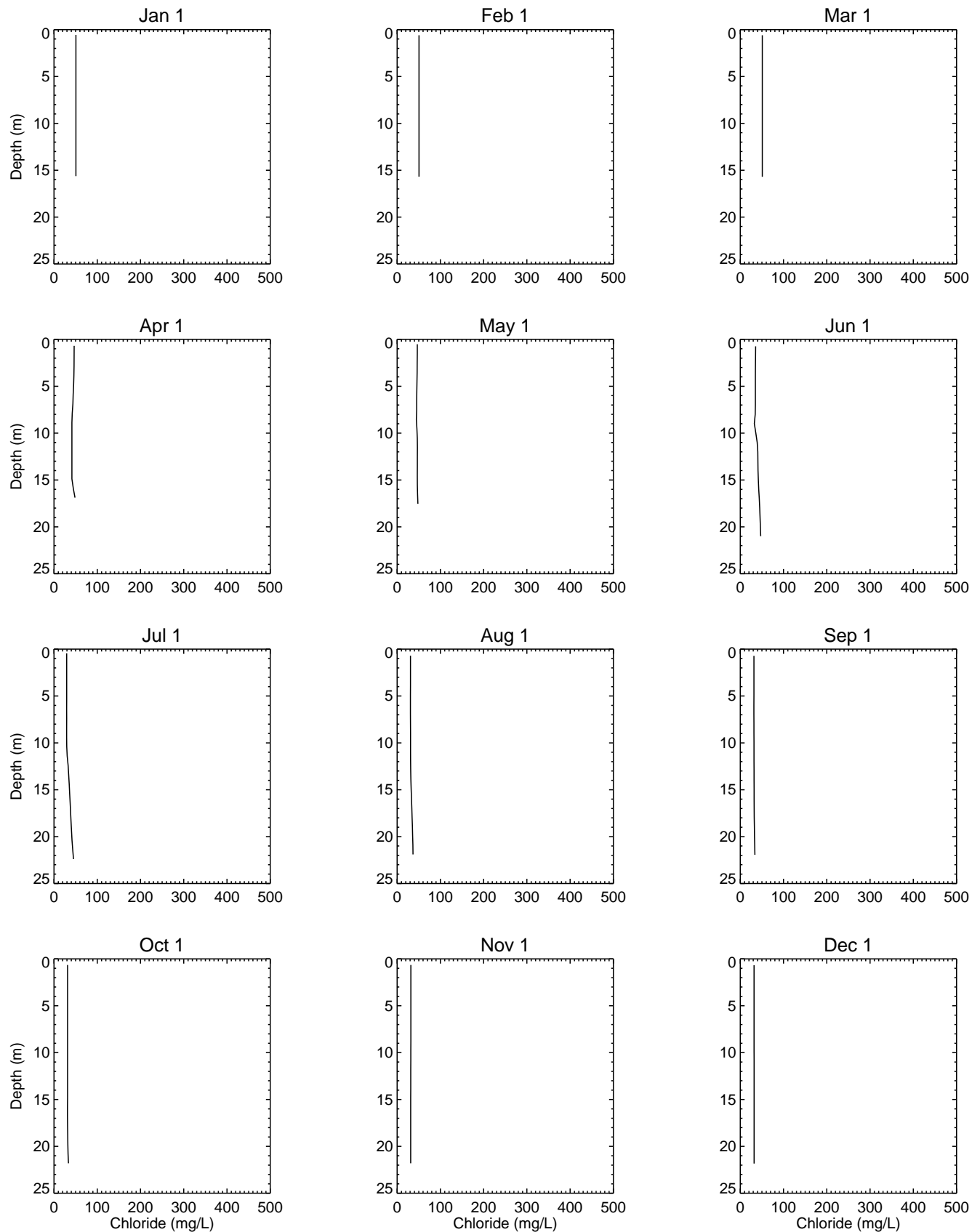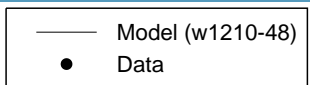
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:16 2013

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
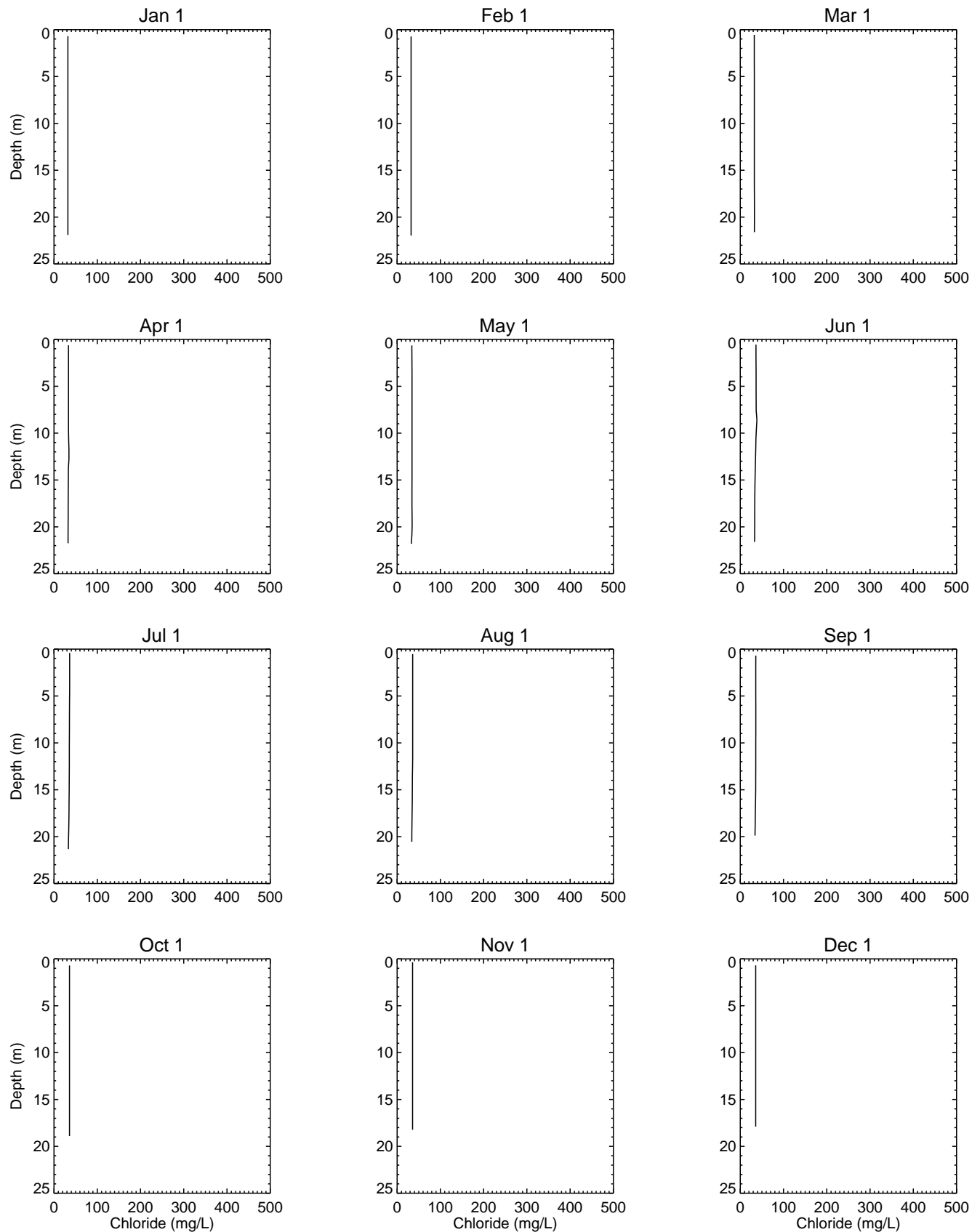
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:16 2013

Jan 1 · Feb 16 · Mar 1 · Apr 21 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m) · Chloride (mg/L)

—— Model (w1210-48)
● Data

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 1993

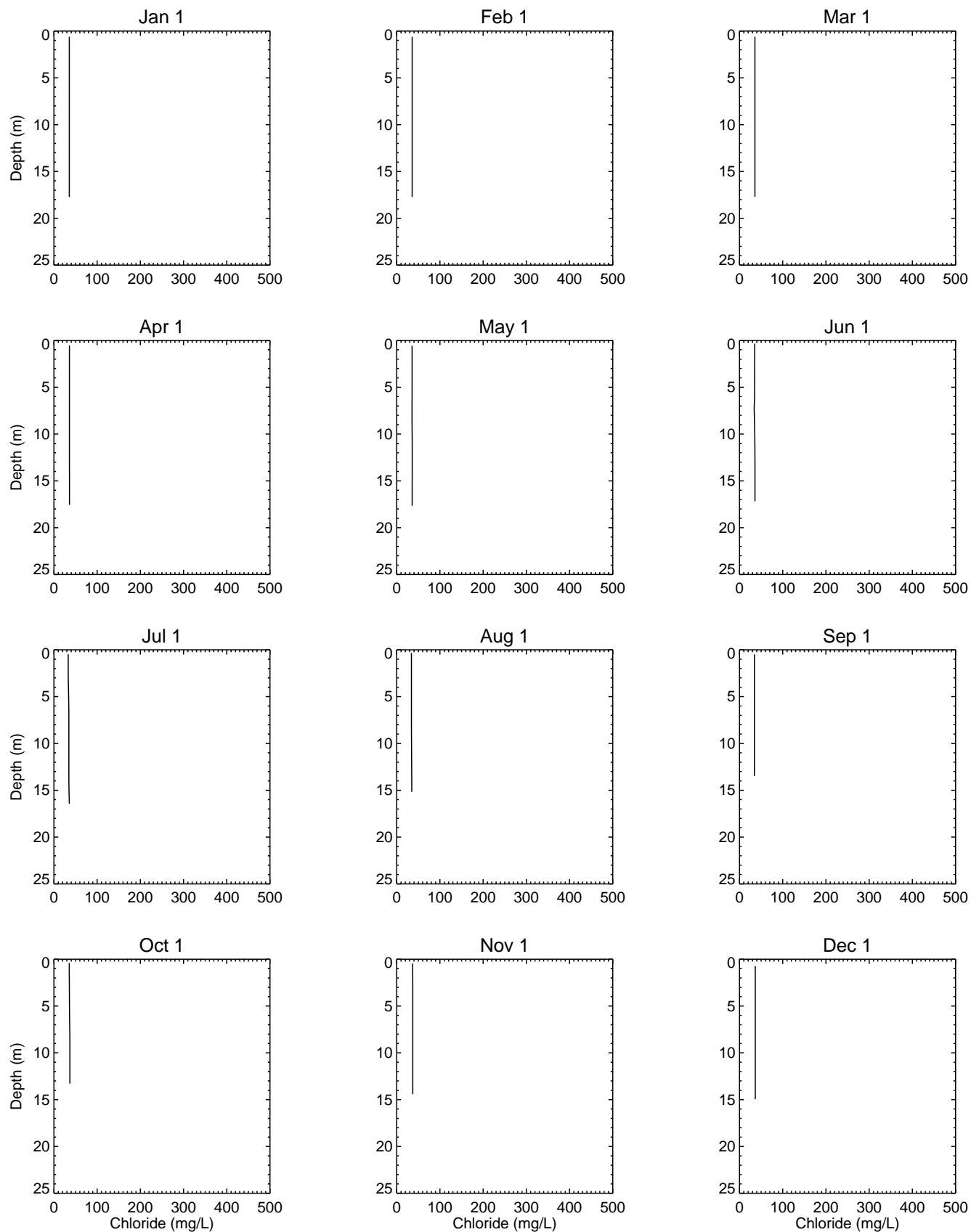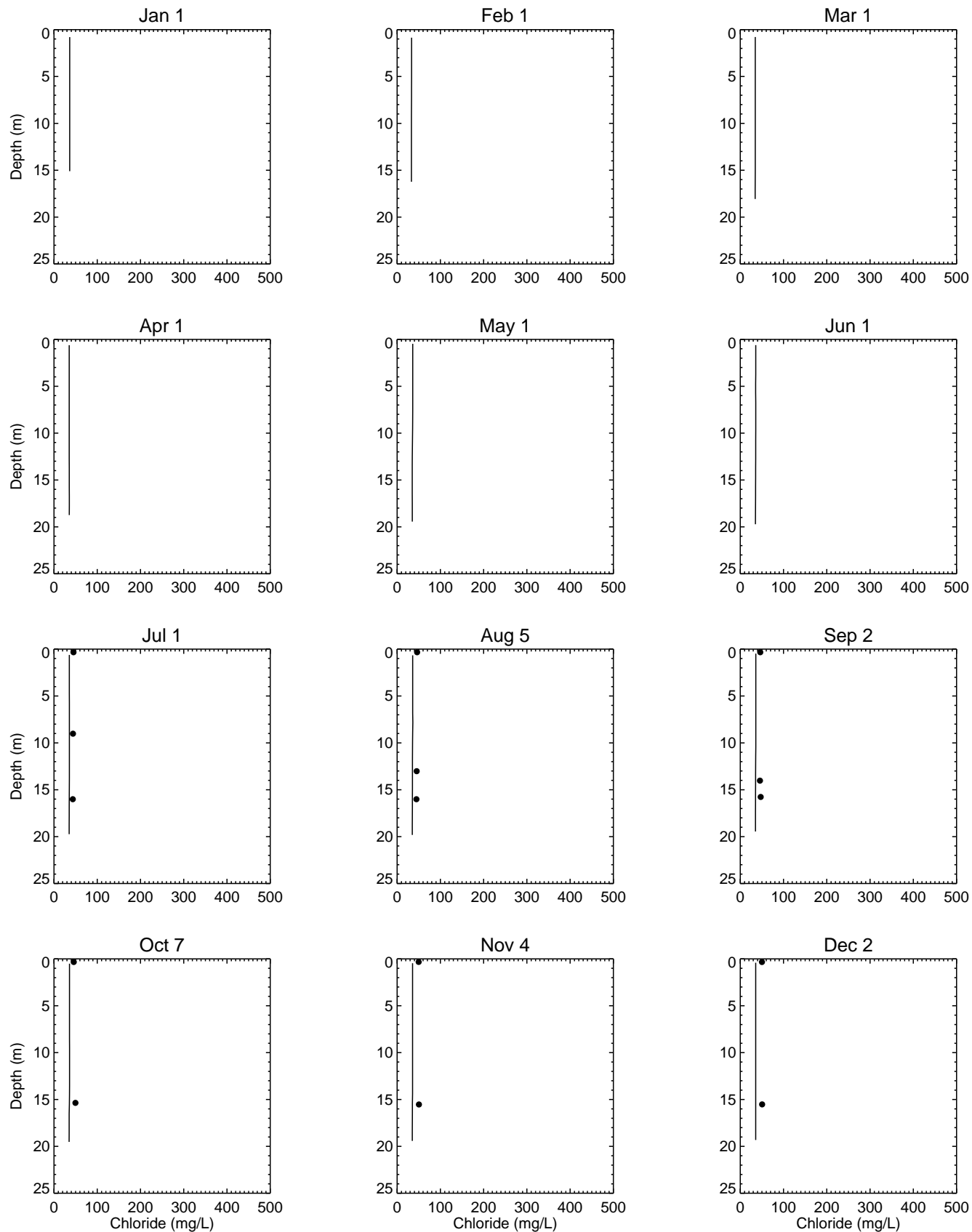*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

Jan 1   Feb 17   Mar 1

Apr 12   May 1   Jun 16

Jul 1   Aug 16   Sep 1

Oct 19   Nov 1   Dec 6

Chloride (mg/L)

—— Model (w1210-48)
● Data

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 1994

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
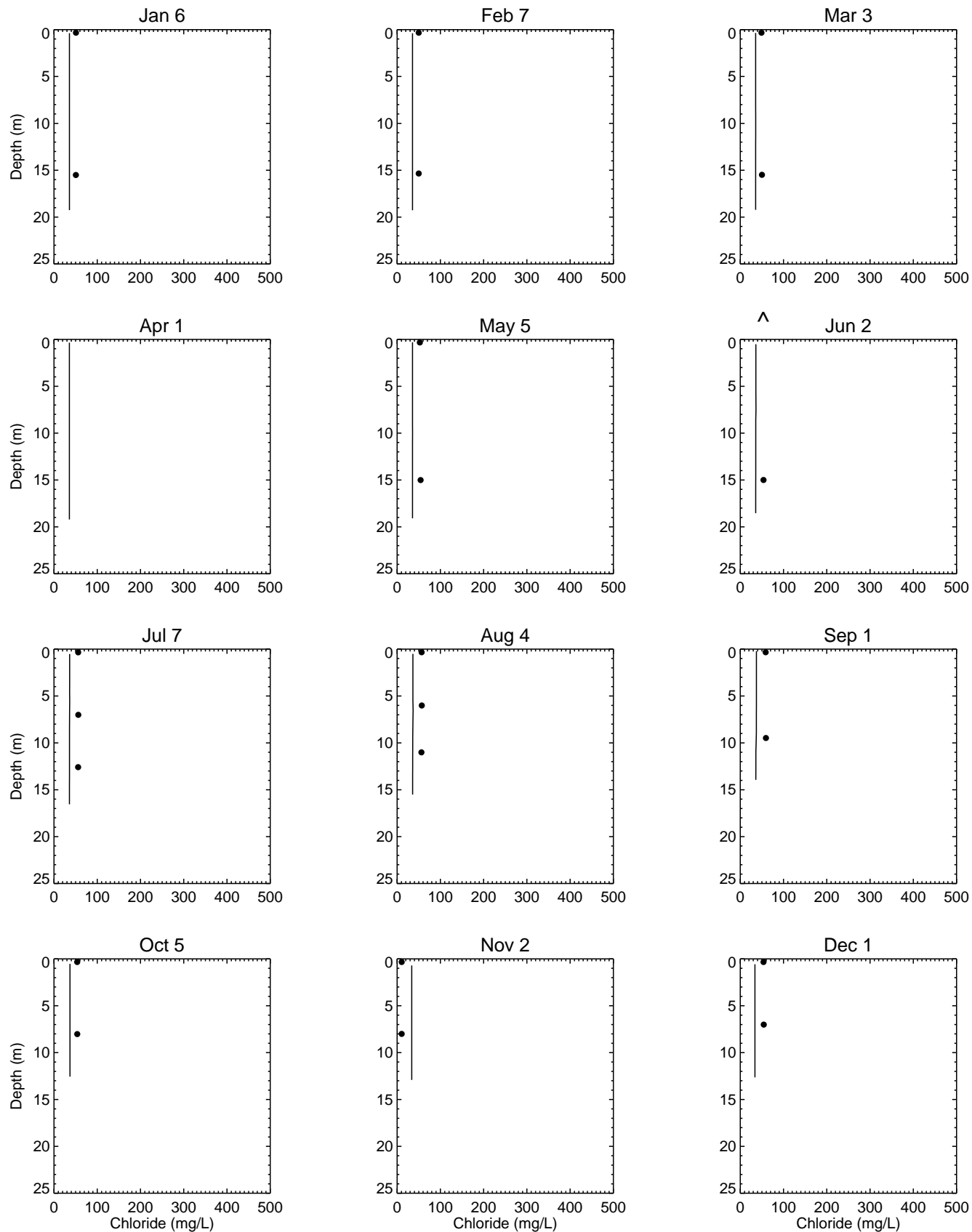
Lower Colorado River Authority

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 1995

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
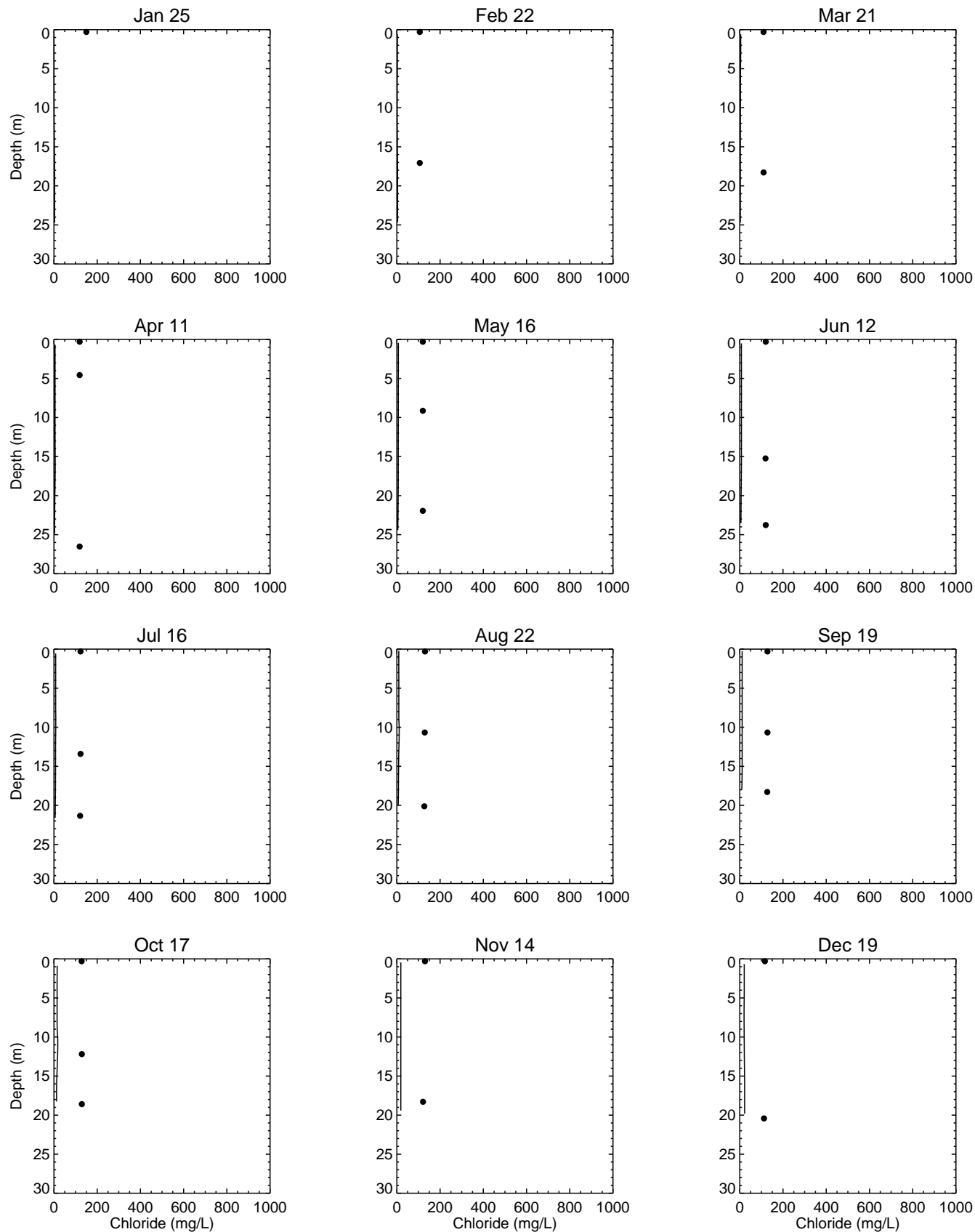
Lower Colorado River Authority

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 1996

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 — Feb 1 — Mar 1

Apr 16 — May 1 — Jun 5

Jul 1 — Aug 11 — Sep 1

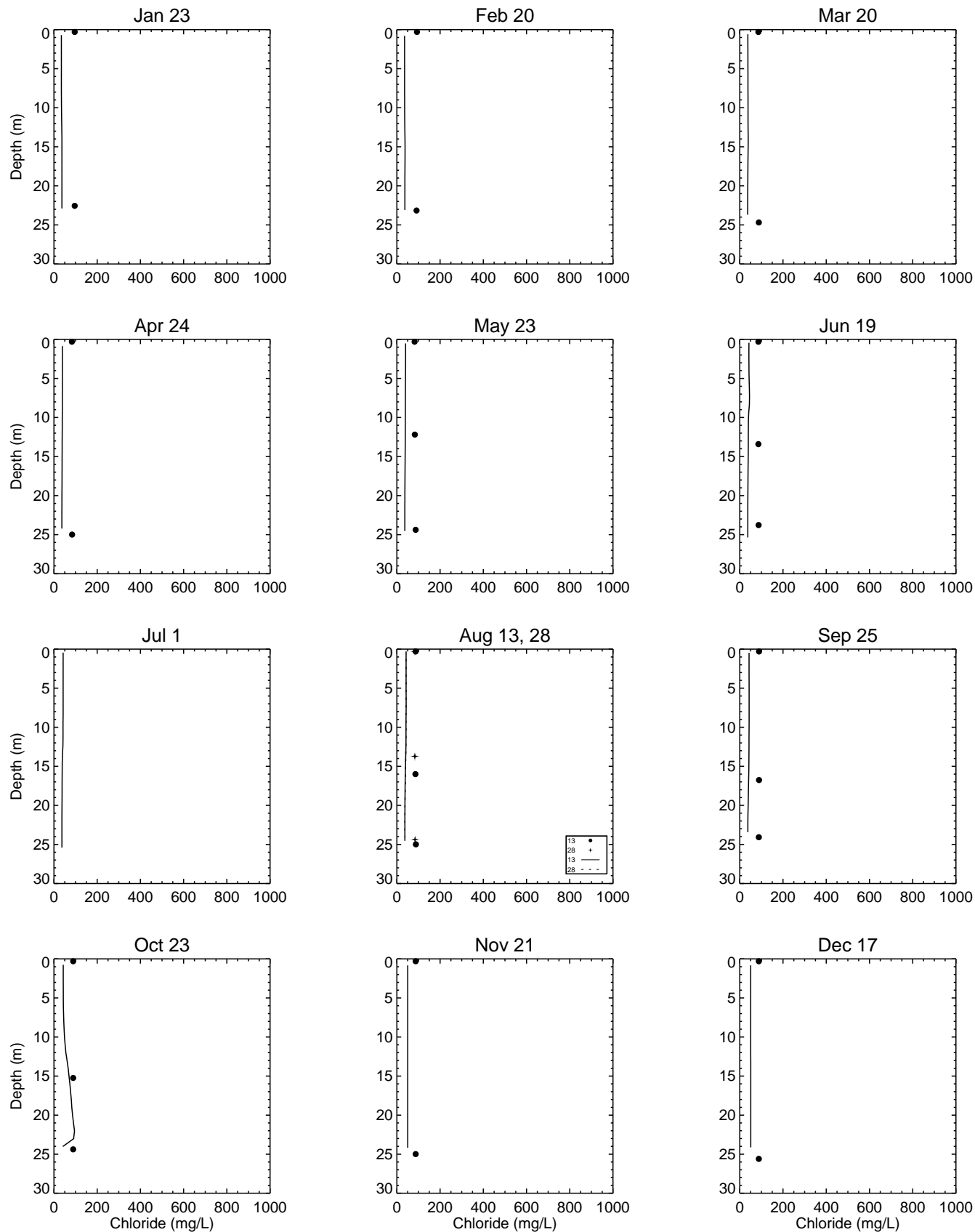Oct 20 — Nov 1 — Dec 15

——— Model (w1210-48)
● Data

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 1997

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 1998

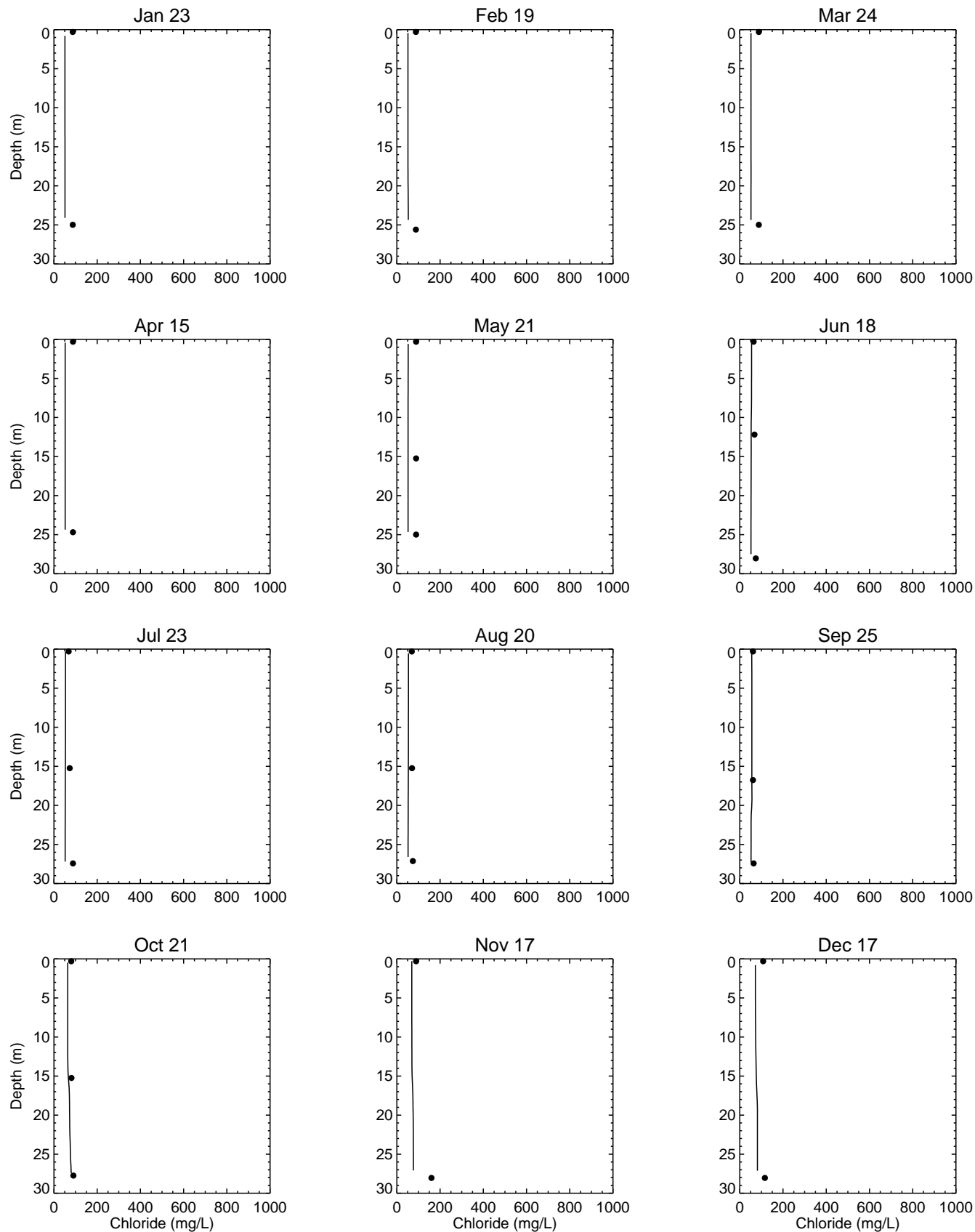*Profiles shown for dates with available data else model results for first day of month shown.*
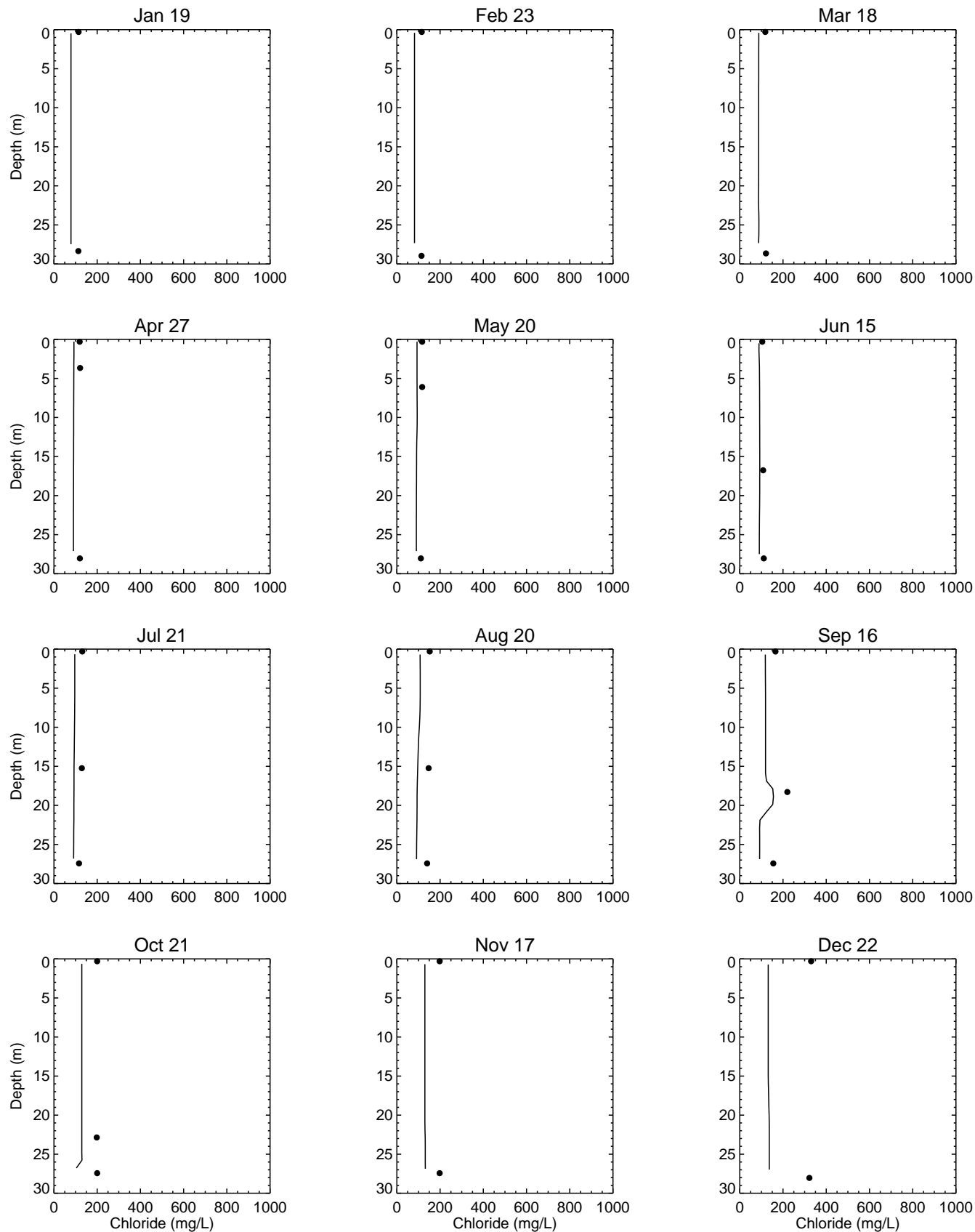
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:16 2013

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 1999

Profiles shown for dates with available data else model results for first day of month shown.
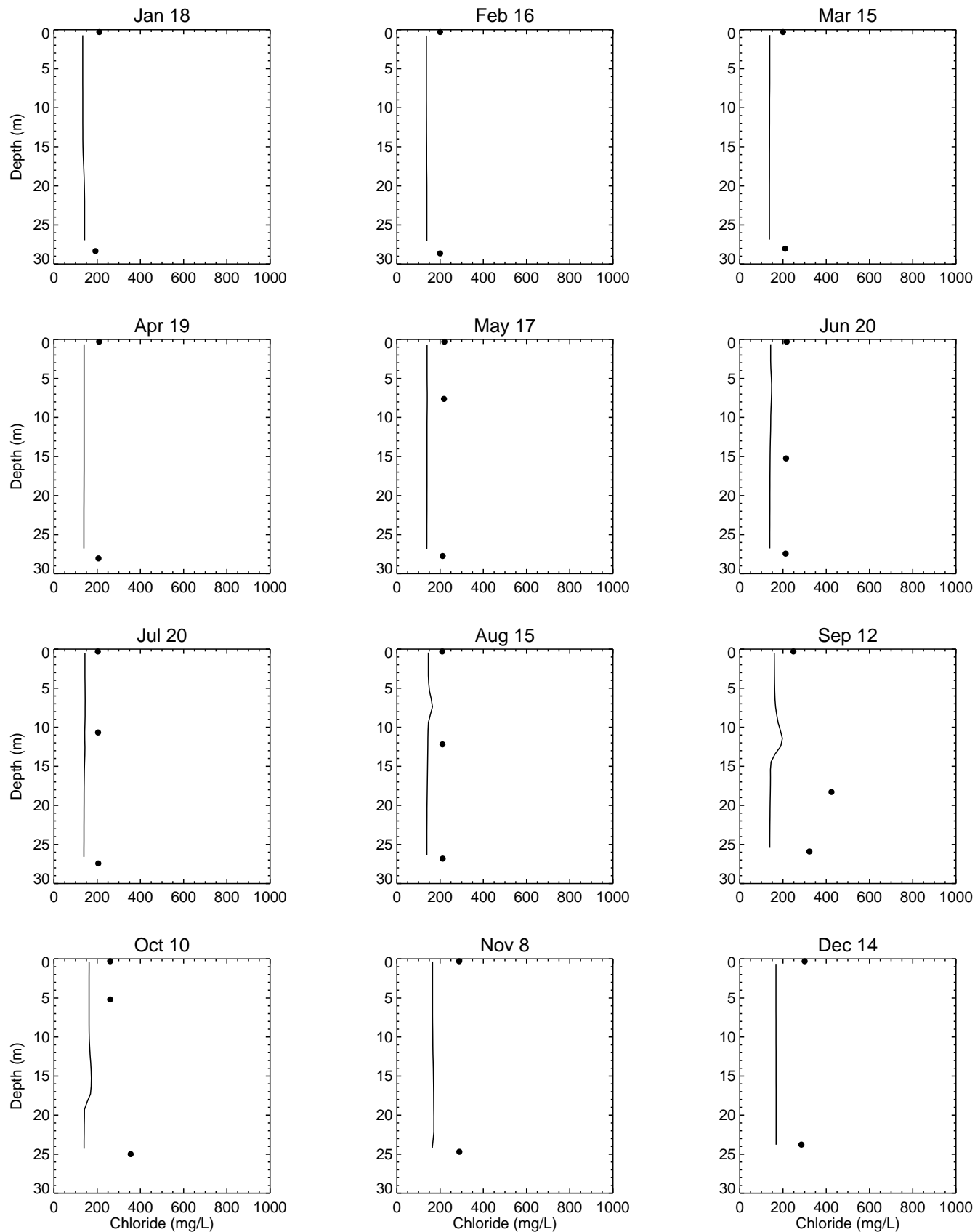
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 | Feb 1 | Mar 1
Apr 13 | May 1 | Jun 5
Jul 1 | Aug 7 | Sep 1
Oct 9 | Nov 1 | Dec 6

Chloride (mg/L)

Depth (m)

—— Model (w1210-48)
● Data

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 2000

Profiles shown for dates with available data else model results for first day of month shown.
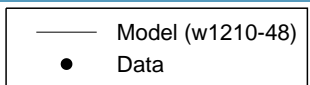
ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 2001

Profiles shown for dates with available data else model results for first day of month shown.
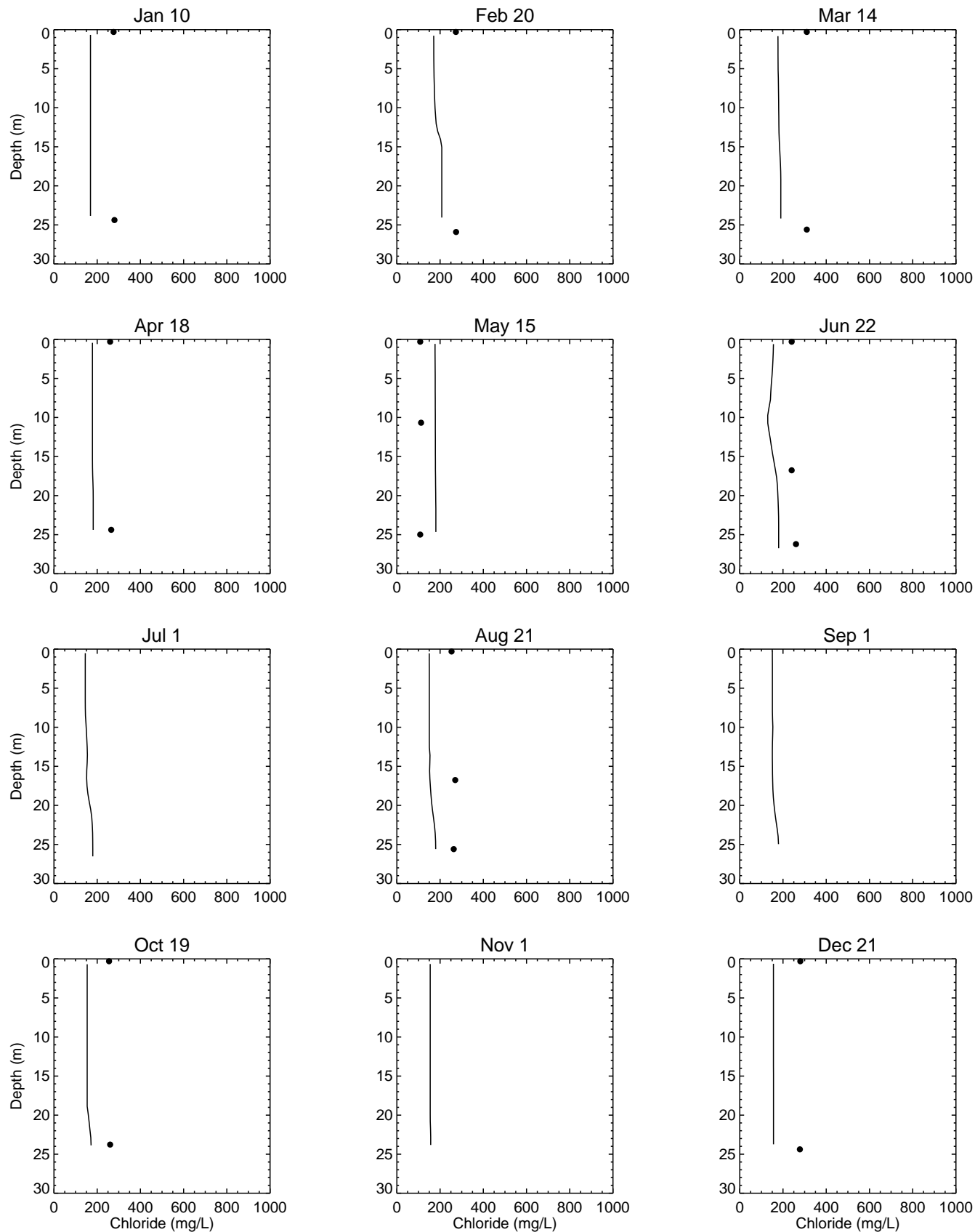
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
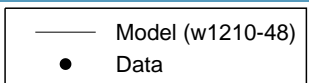at Rocky Point (Segment 9) - Chloride - 2002

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
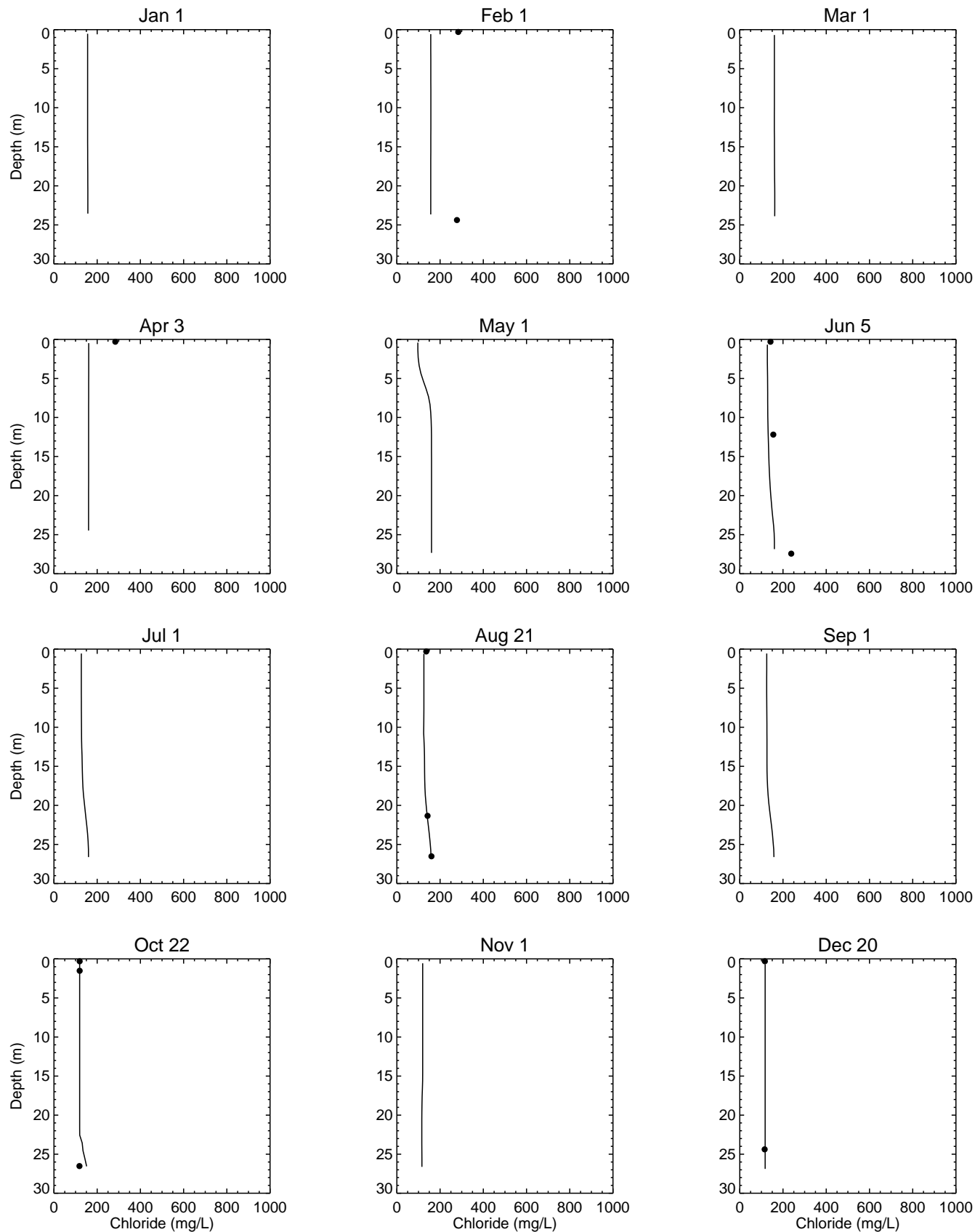at Rocky Point (Segment 9) - Chloride - 2003

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 2004

Profiles shown for dates with available data else model results for first day of month shown.

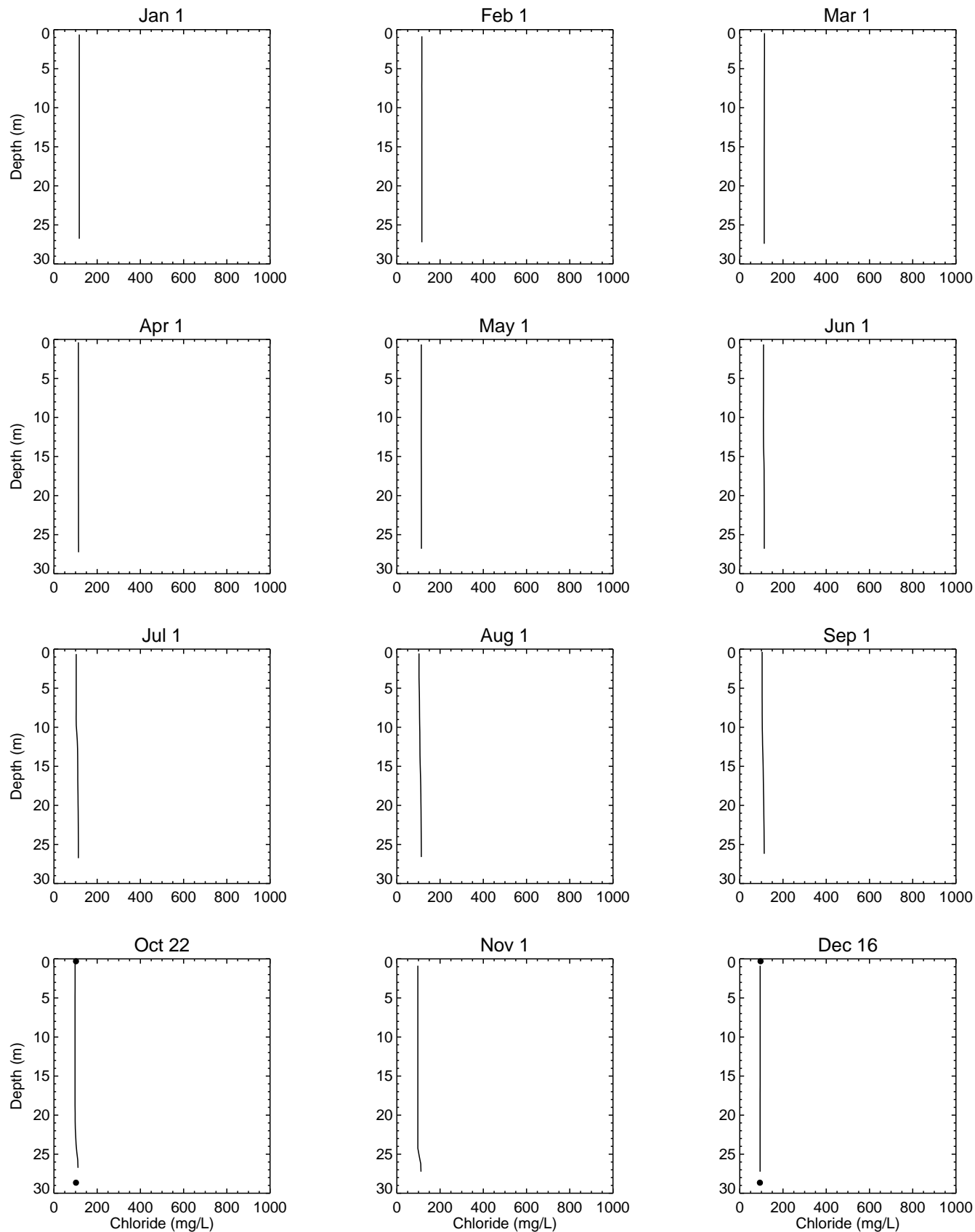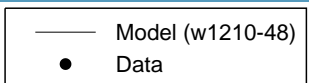CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:16 2013

Jan 1   Feb 8   Mar 1

Apr 12   May 1   Jun 6

Jul 1   Aug 1   Sep 1

Oct 11   Nov 1   Dec 1

—— Model (w1210-48)
● Data

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 2005

Profiles shown for dates with available data else model results for first day of month shown.
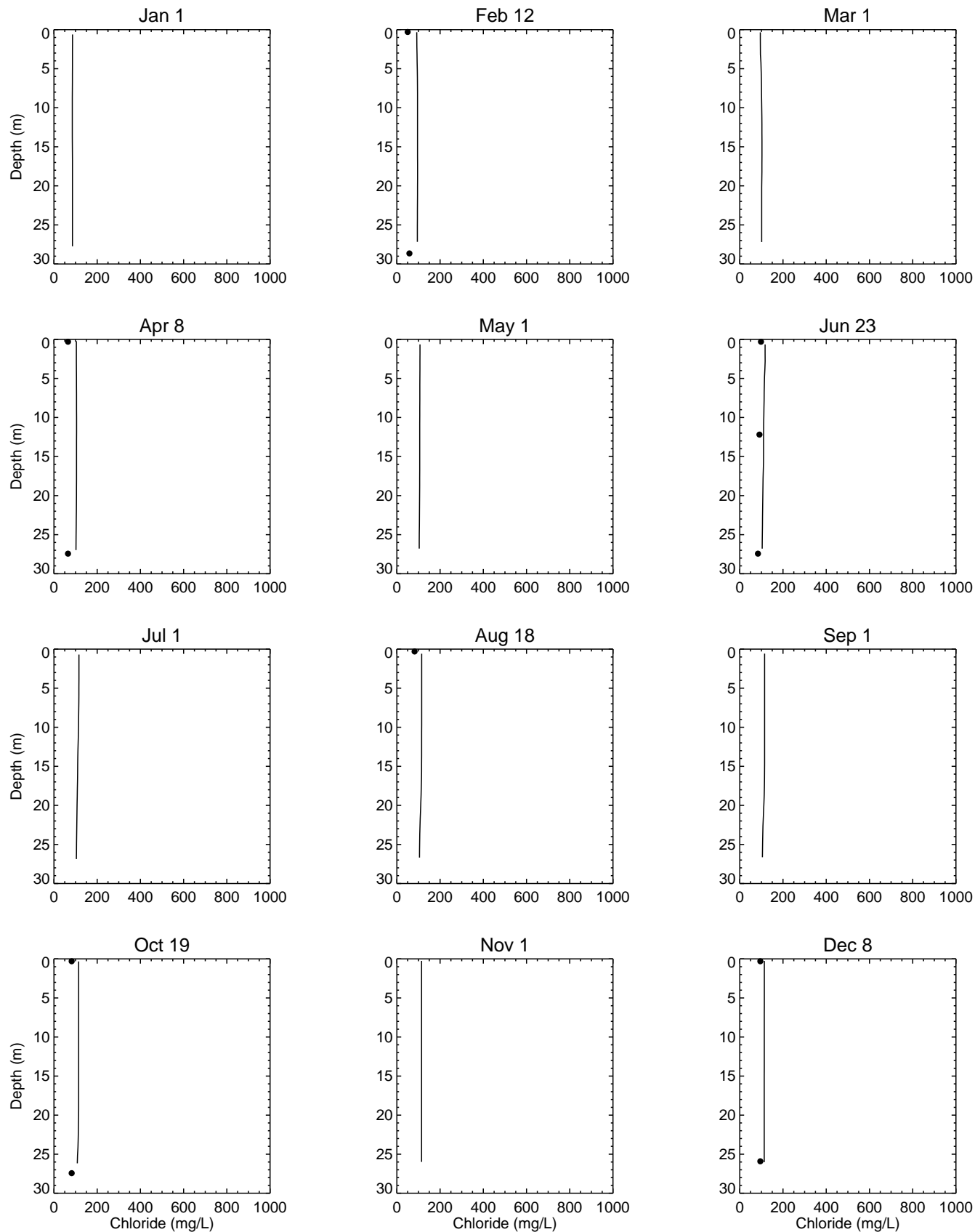
CREMs Phase 4: Lake Buchanan
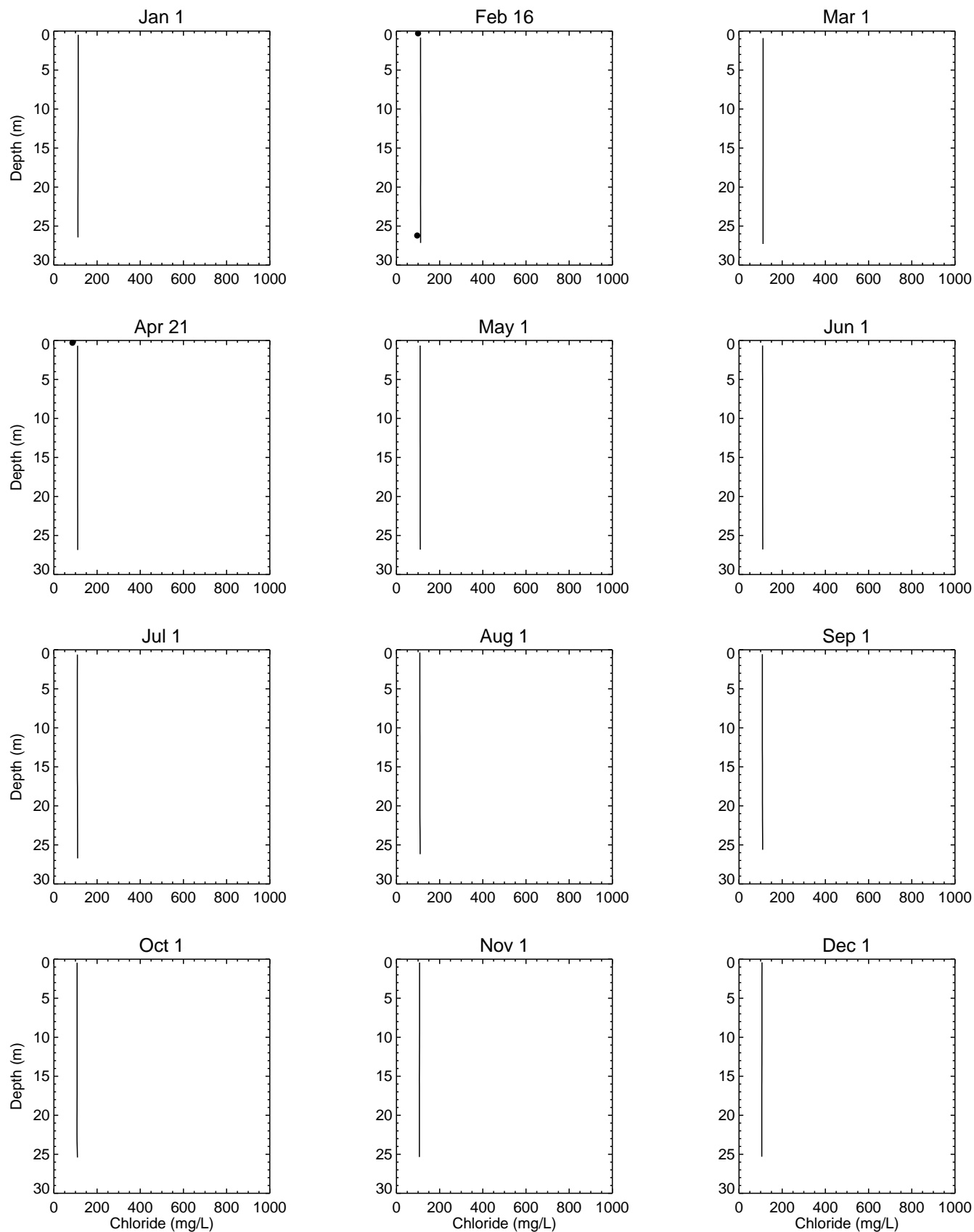
Lower Colorado River Authority

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 2006

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:16 2013

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 2007

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
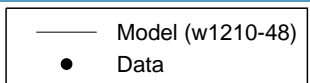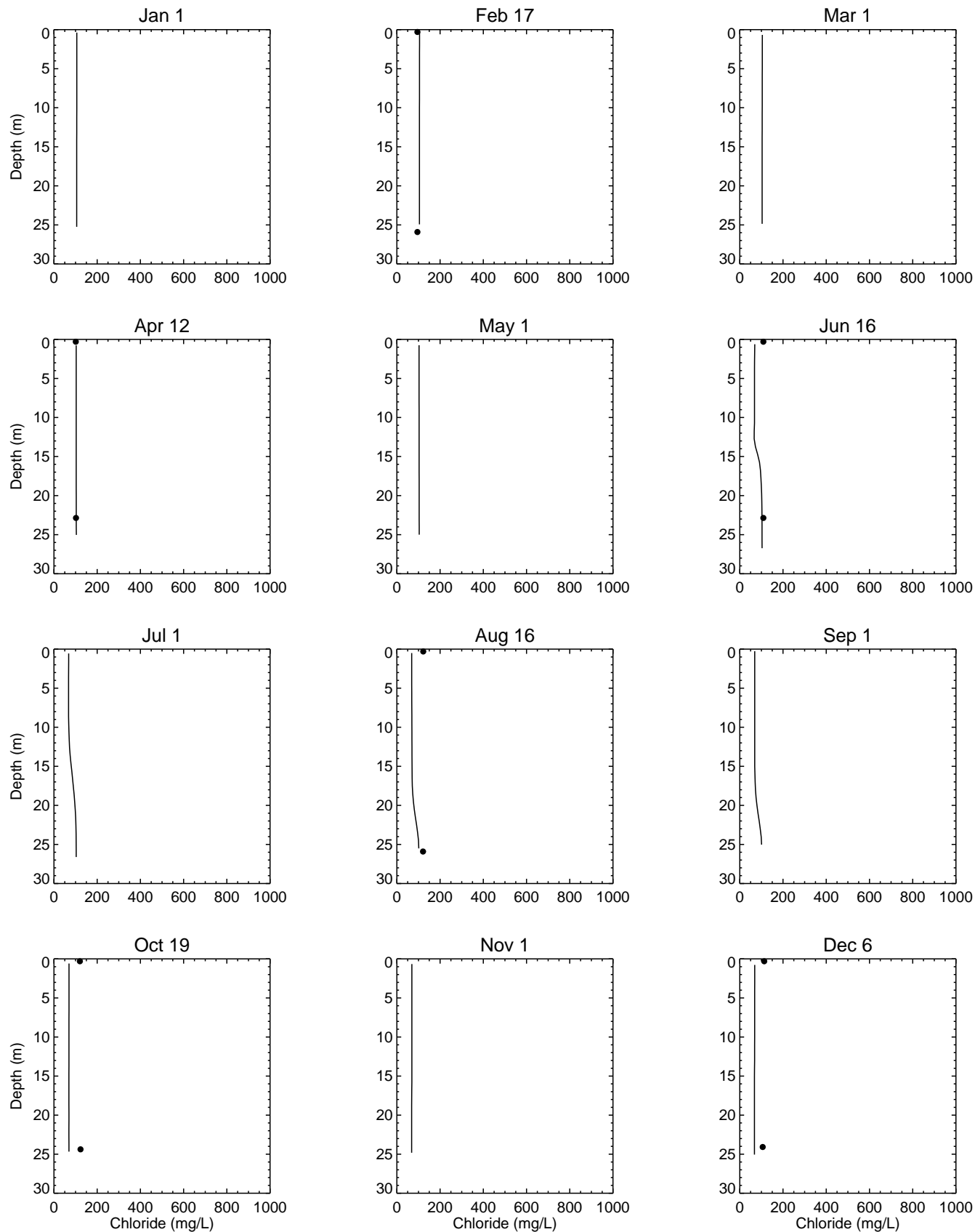
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:16 2013

Jan 1

Feb 4

Mar 1

Apr 3

May 1

Jun 12

Jul 1

Aug 7

Sep 1

Oct 9

Nov 1

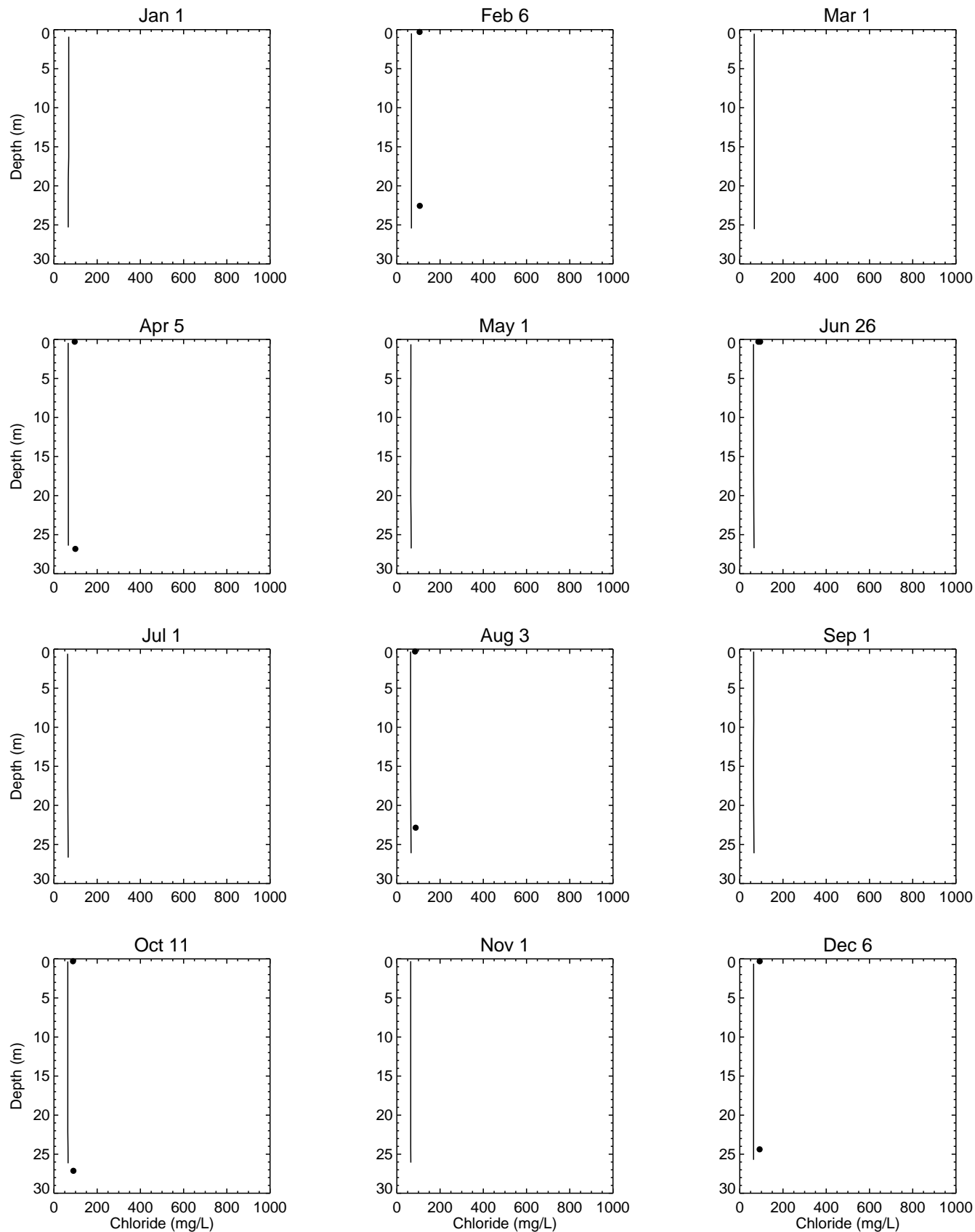## Dec 4

Model (w1210-48)
● Data

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 2008

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
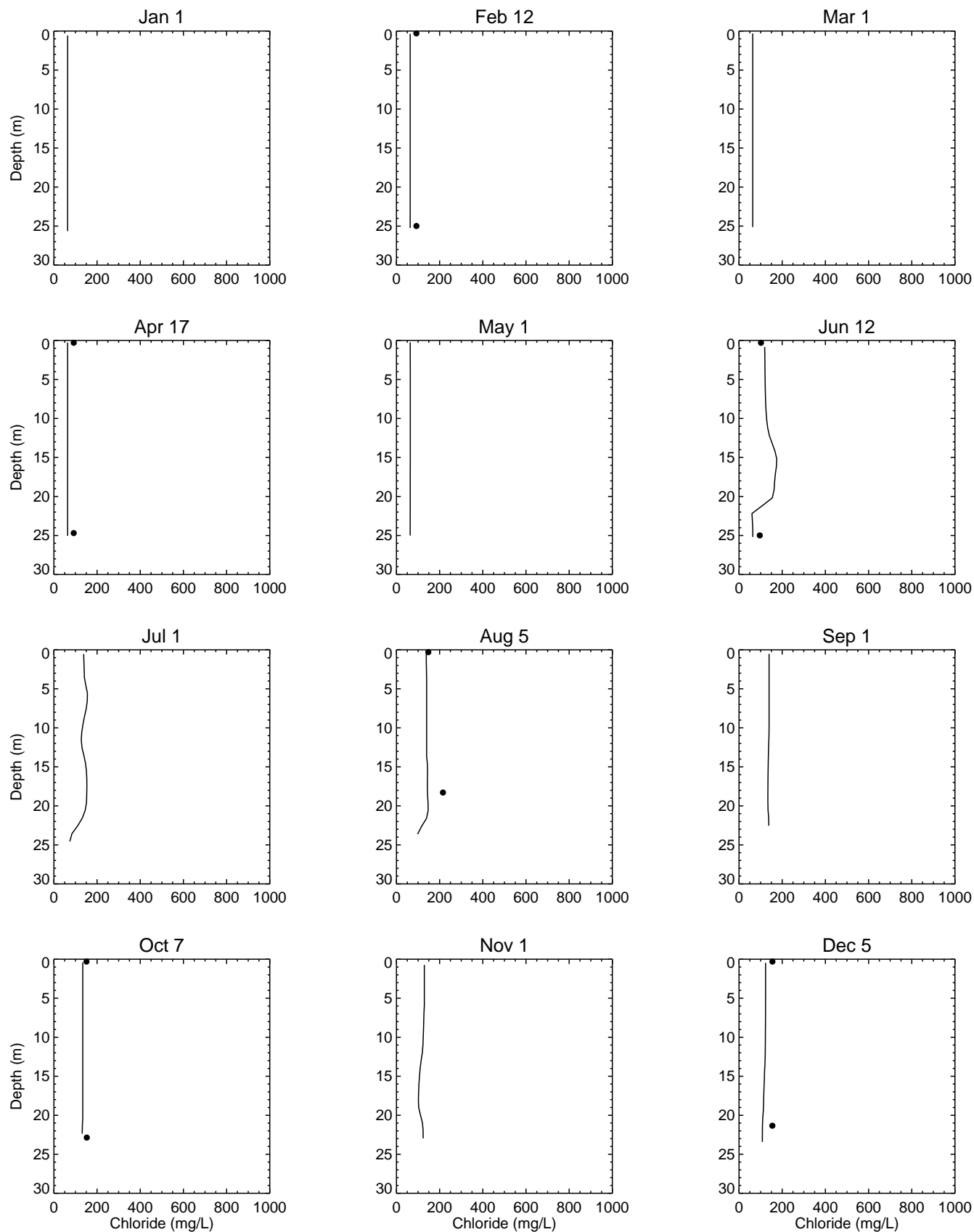
Lower Colorado River Authority

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 2009

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 2010

Profiles shown for dates with available data else model results for first day of month shown.

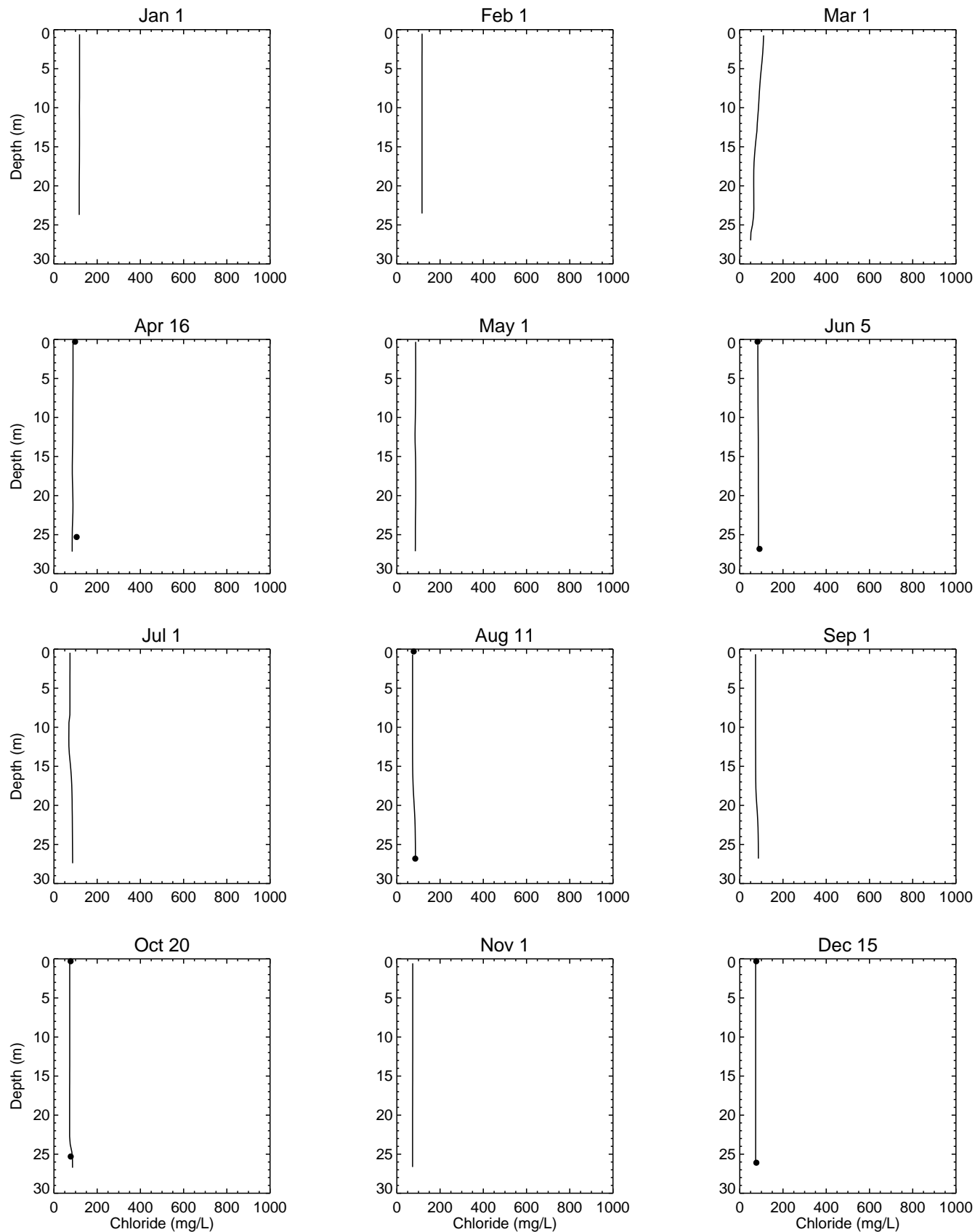CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:16 2013

Jan 6
Feb 7
Mar 3
Apr 14
May 5
^ Jun 1, 2
Jul 7
Aug 4
Sep 1
Oct 3, 5
Nov 2
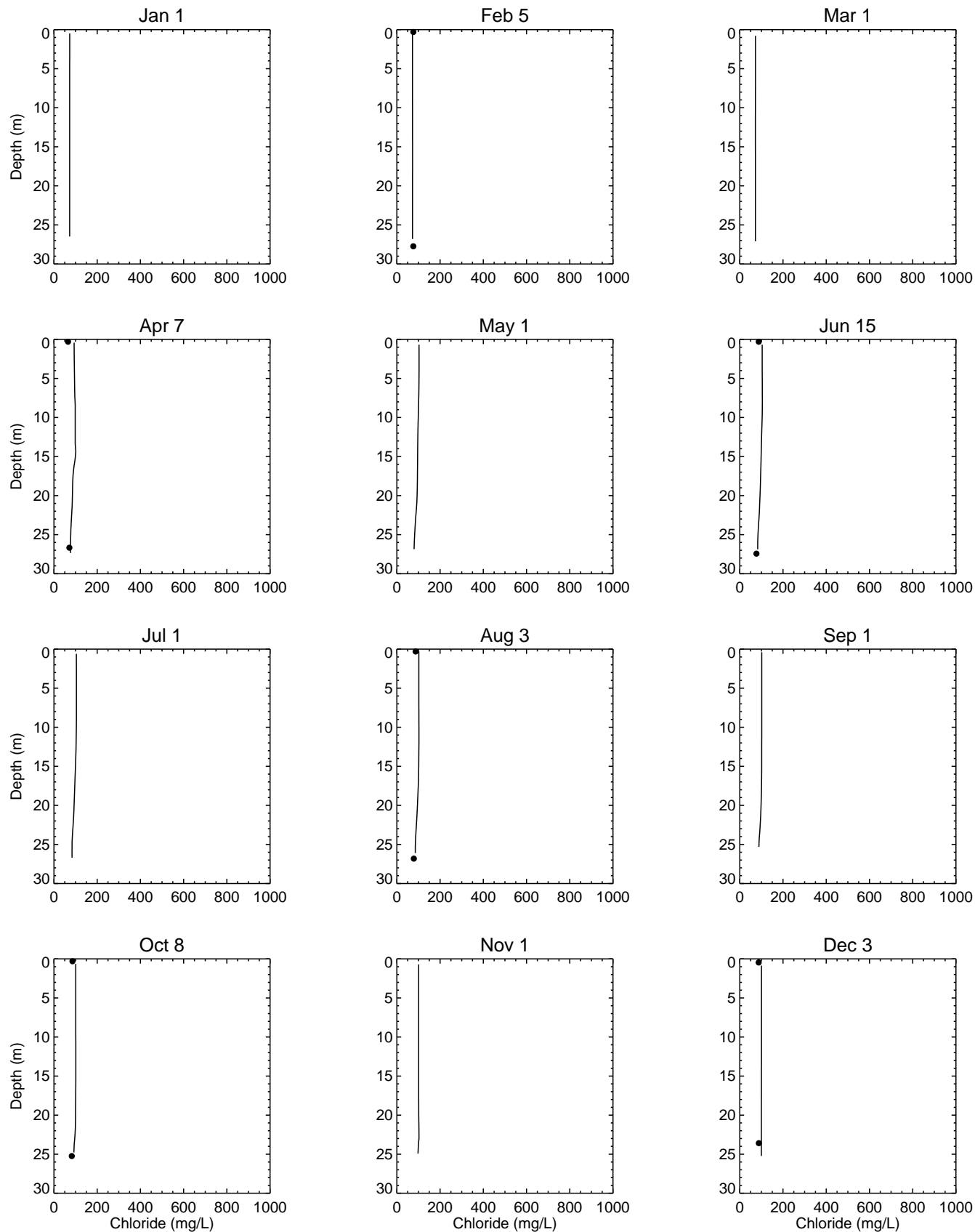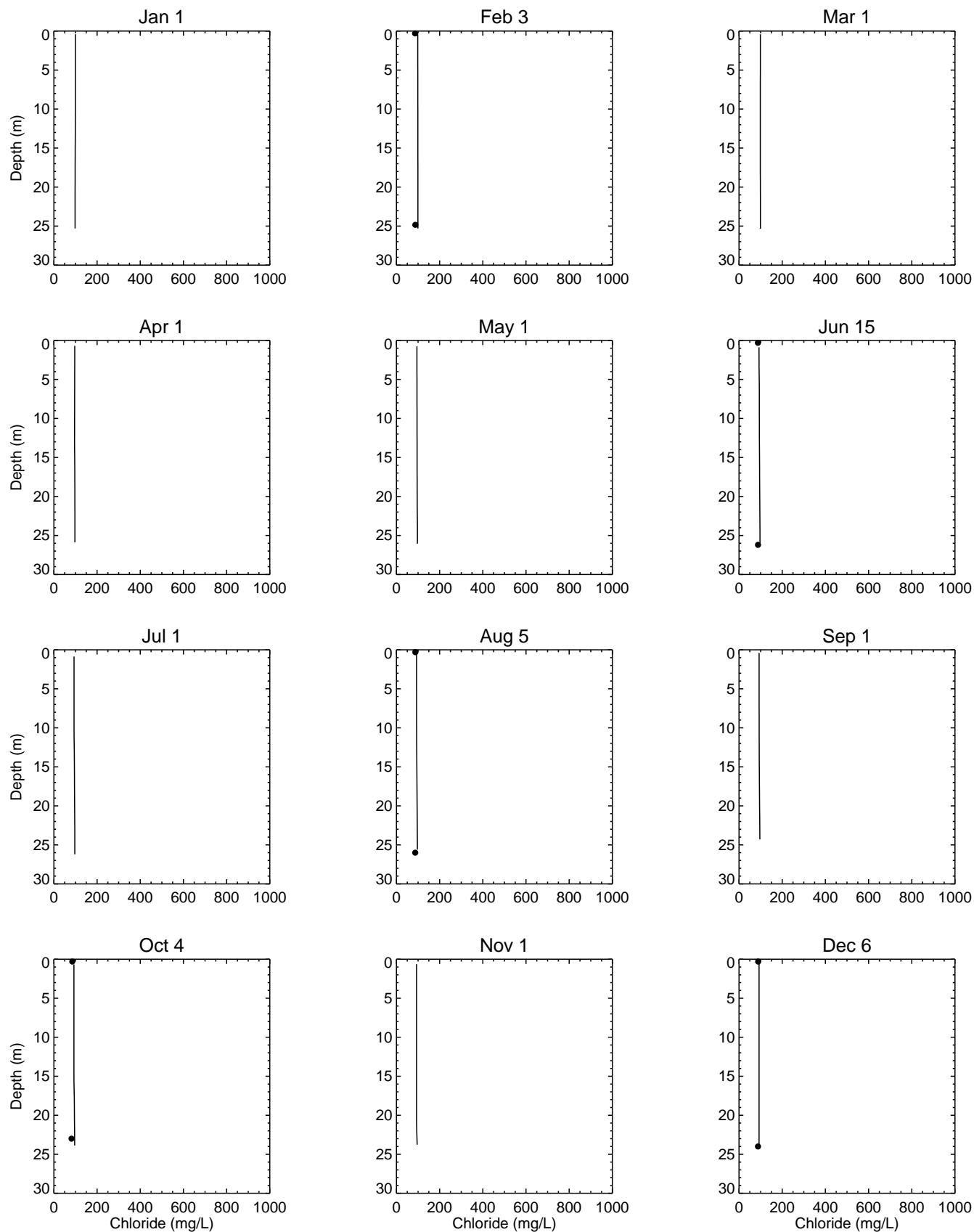## Dec 1, 8
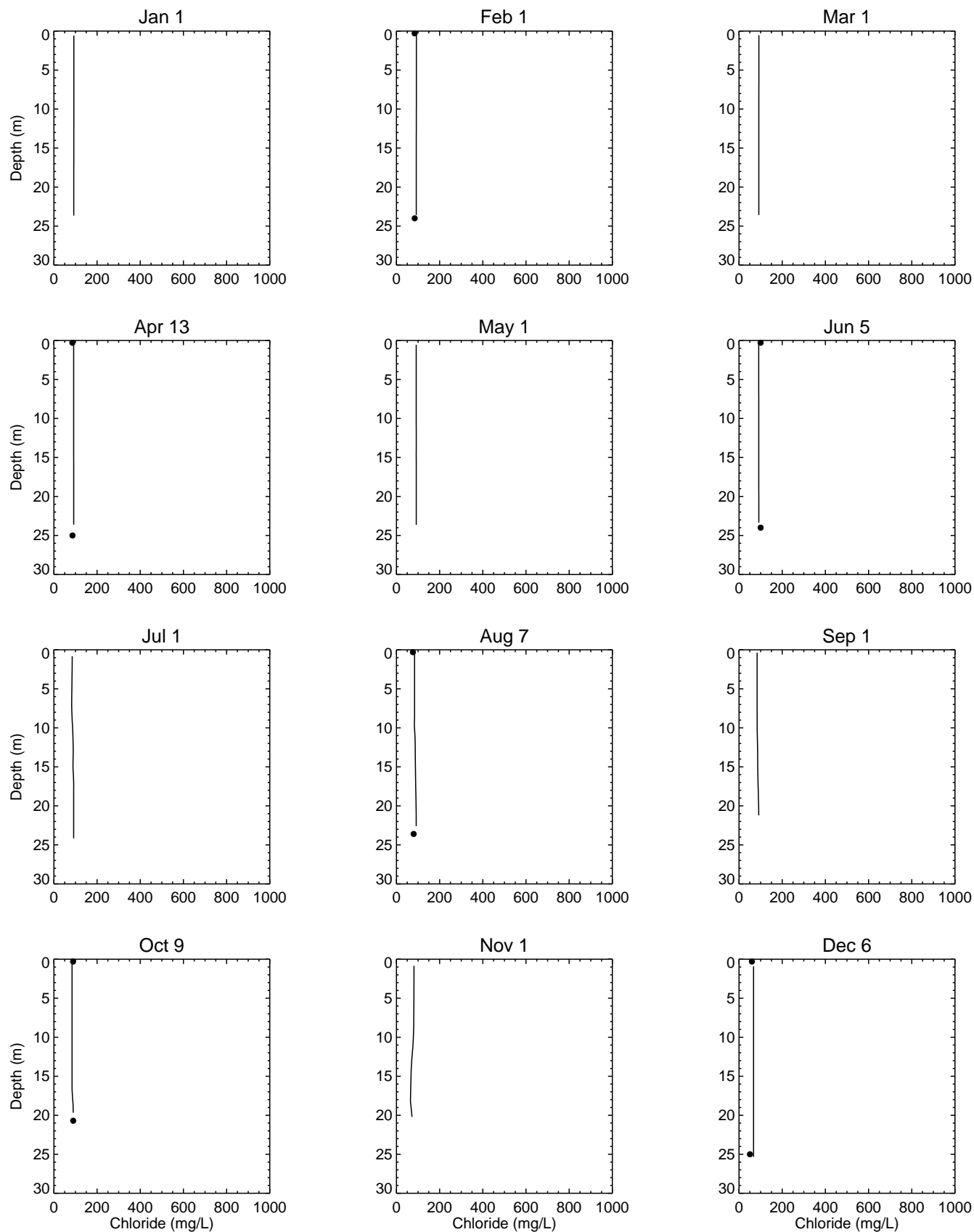
Model (w1210-48)

● Data

Figure G-23

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Chloride - 2011

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 25 Feb 22 Mar 21
Apr 11 May 16 Jun 12
Jul 16 Aug 22 Sep 19
Oct 17 Nov 14 Dec 19

Model (w1210-48)
• Data

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 1984
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 1985

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
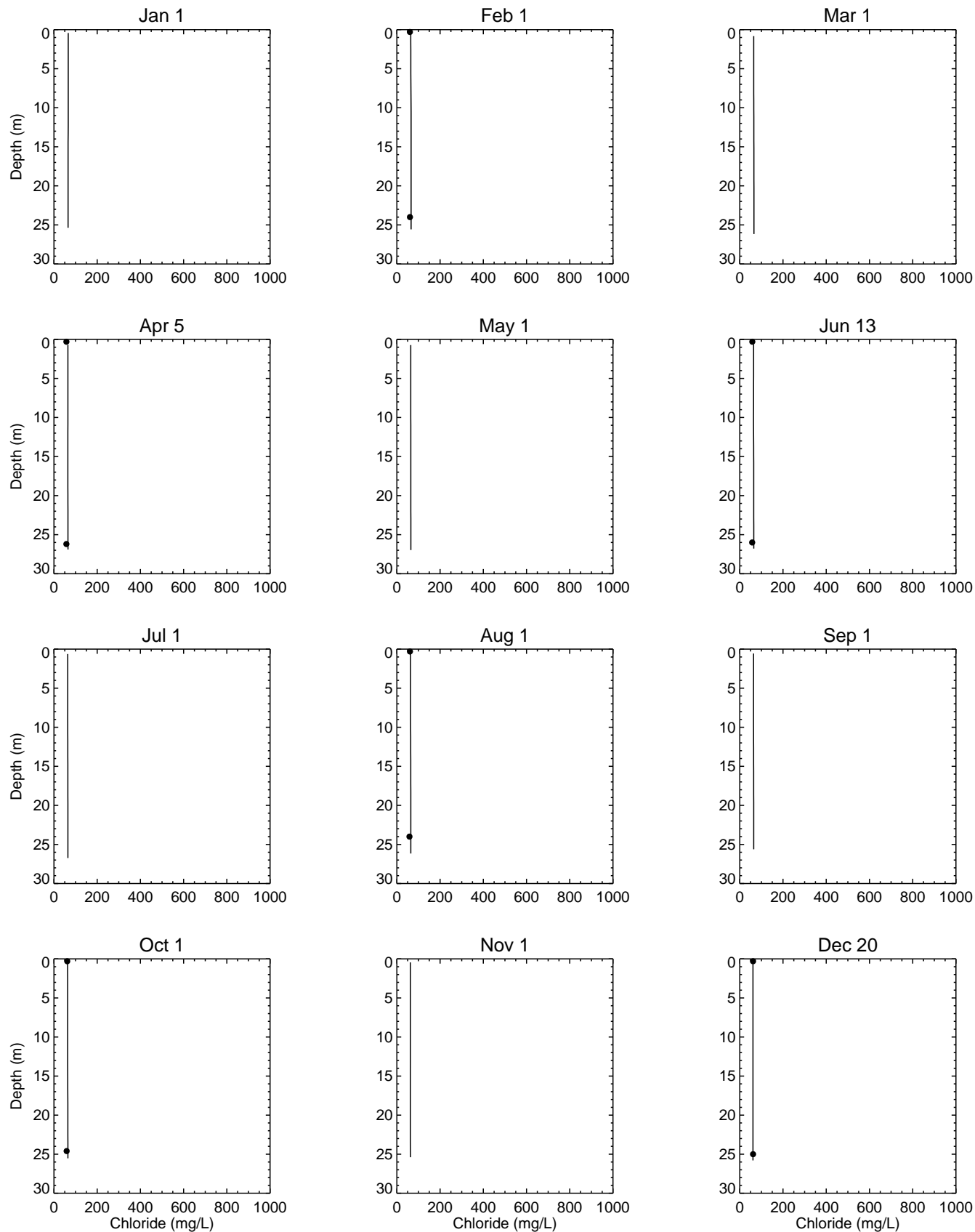
Lower Colorado River Authority

Jan 23 · Feb 19 · Mar 24 · Apr 15 · May 21 · Jun 18 · Jul 23 · Aug 20 · Sep 25 · Oct 21 · Nov 17 · Dec 16

Chloride (mg/L)

—— Model (w1210-48)

● Data

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 1986

Profiles shown for dates with available data else model results for first day of month shown.
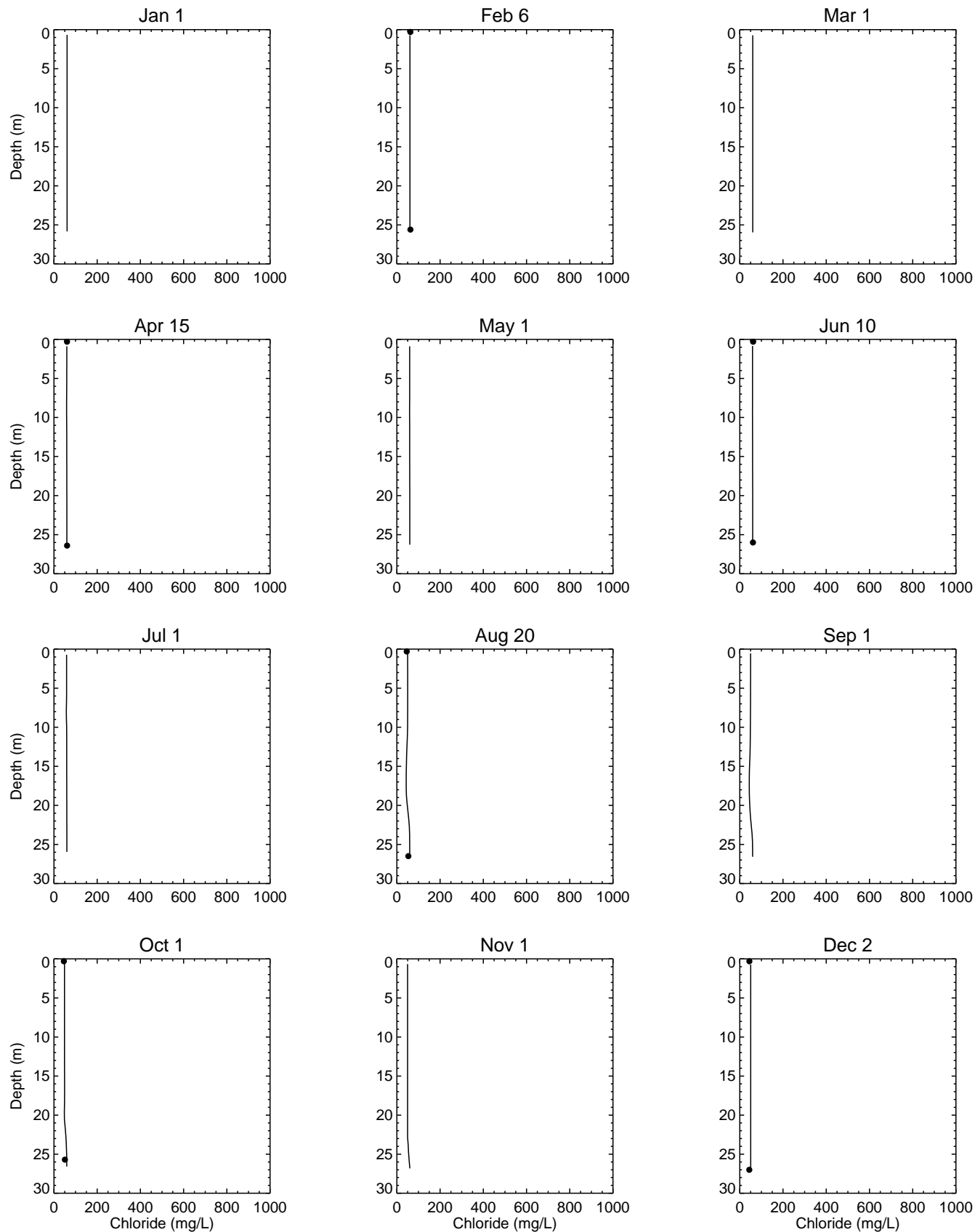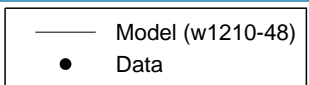
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:19 2013

Jan 19   Feb 23   Mar 18
Apr 27   May 20   Jun 15
Jul 21   Aug 20   Sep 16
Oct 21   Nov 17   Dec 22

——— Model (w1210-48)
● Data

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 1987

Profiles shown for dates with available data else model results for first day of month shown.
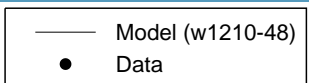
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR
QEA
PARSONS

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 1988

Profiles shown for dates with available data else model results for first day of month shown.
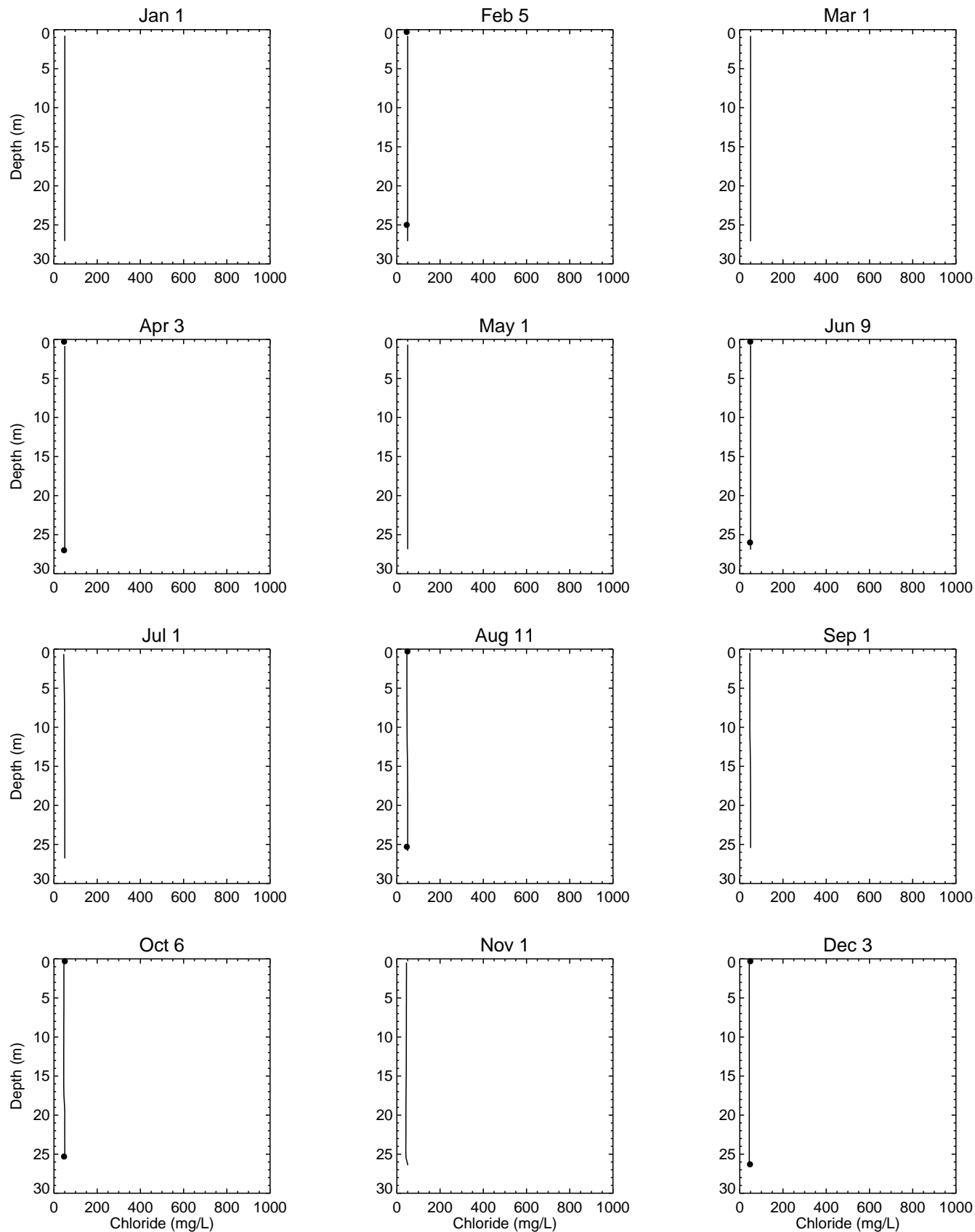
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

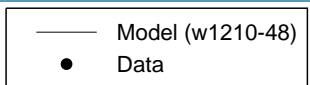EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:19 2013

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 1989

Profiles shown for dates with available data else model results for first day of month shown.

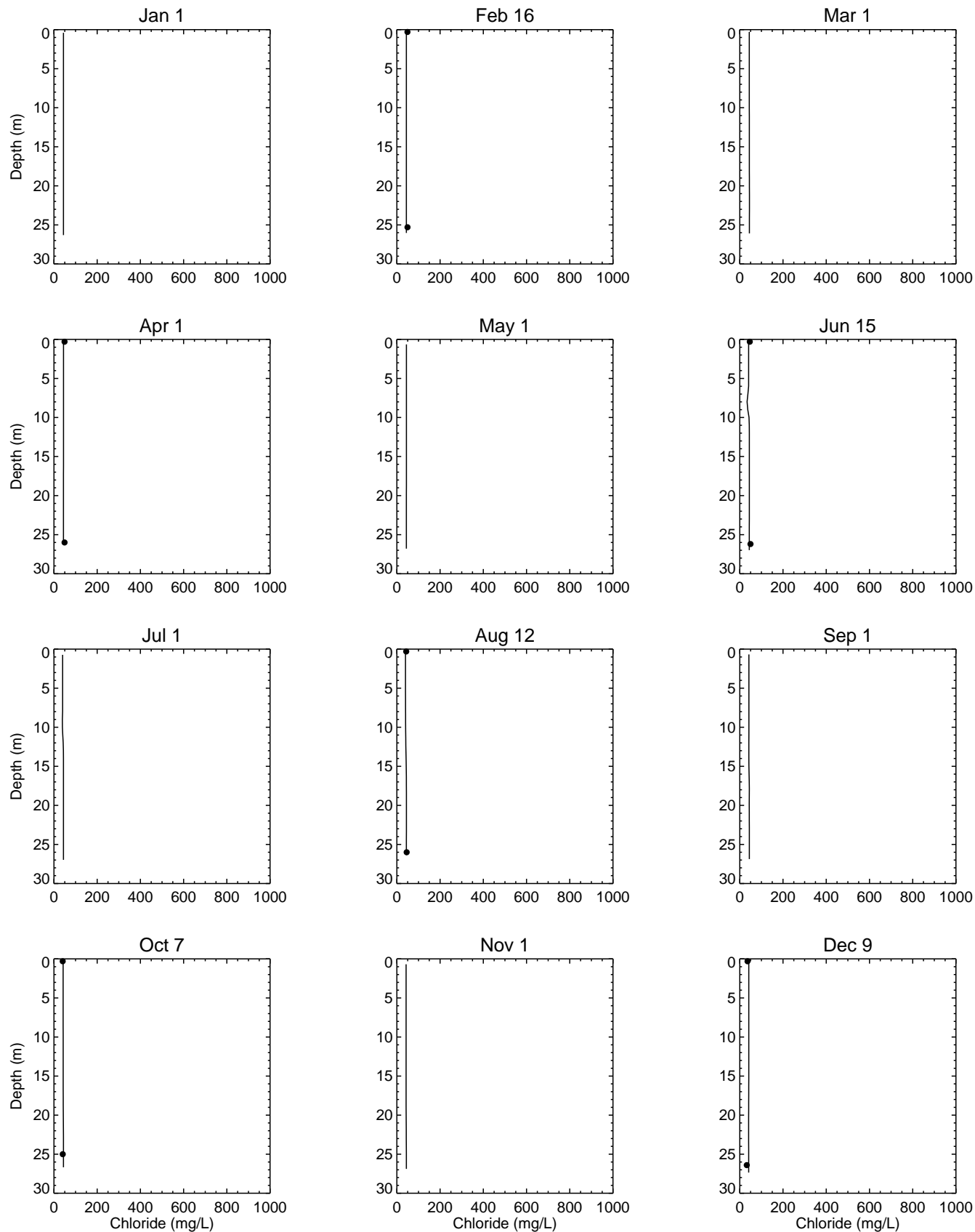CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 1990

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
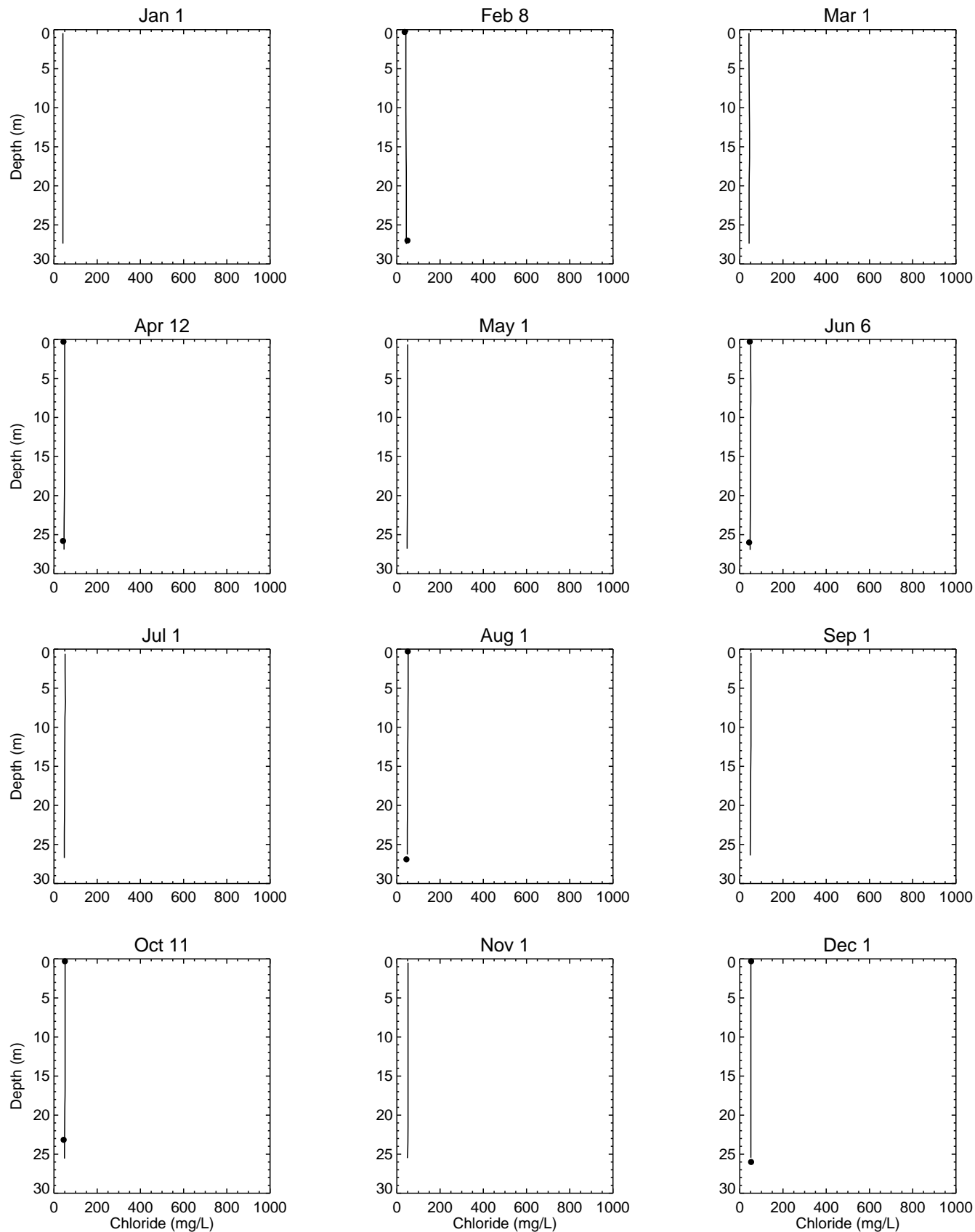
Lower Colorado River Authority

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 1991
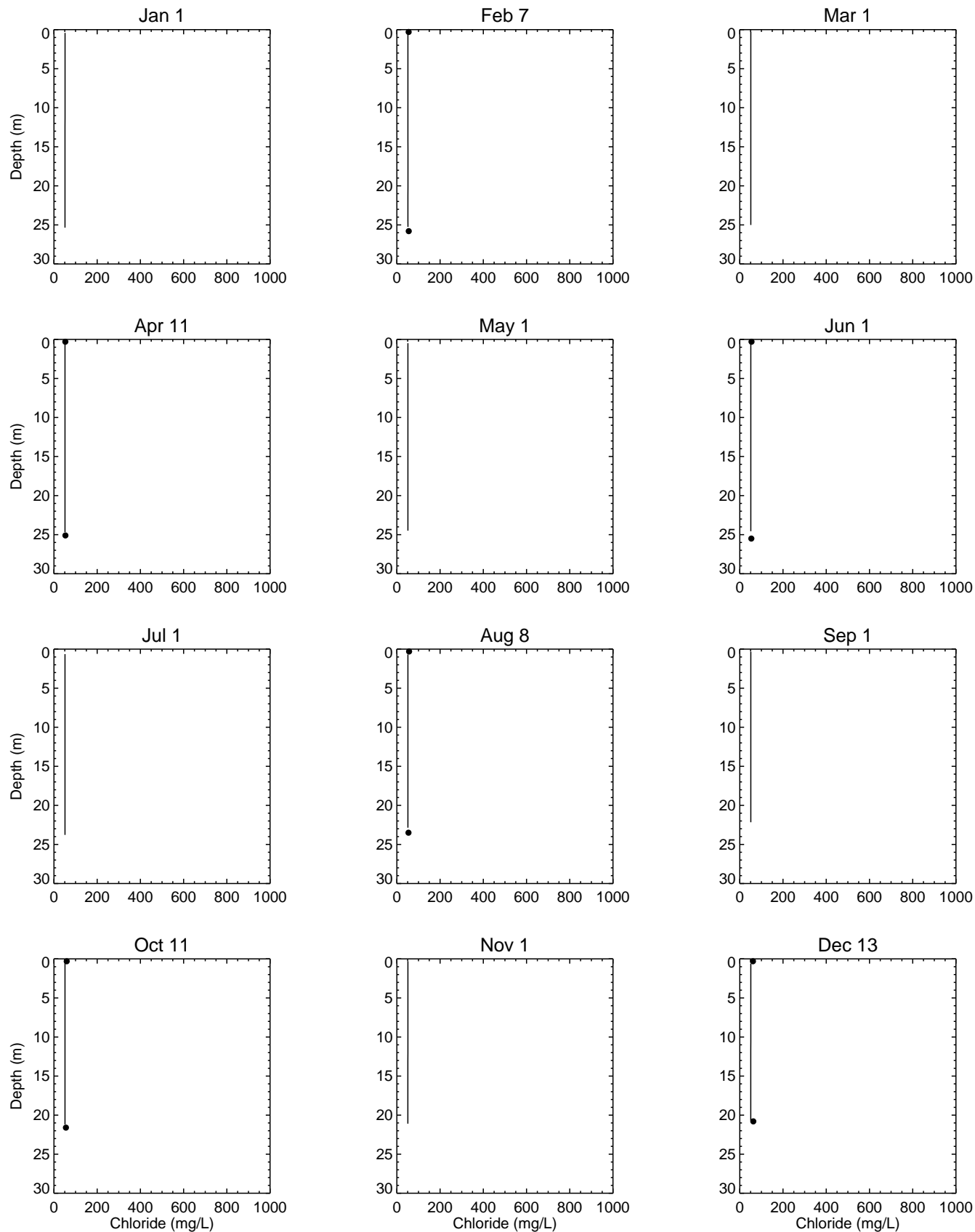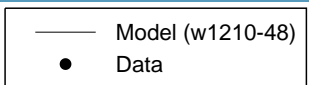
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 — Feb 1 — Mar 1 — Apr 1 — May 1 — Jun 1 — Jul 1 — Aug 1 — Sep 1 — Oct 1 — Nov 1 — Dec 1

Vertical profiles of Chloride (mg/L) versus Depth (m) for each month.

——— Model (w1210-48)
● Data

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:19 2013

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 1993

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
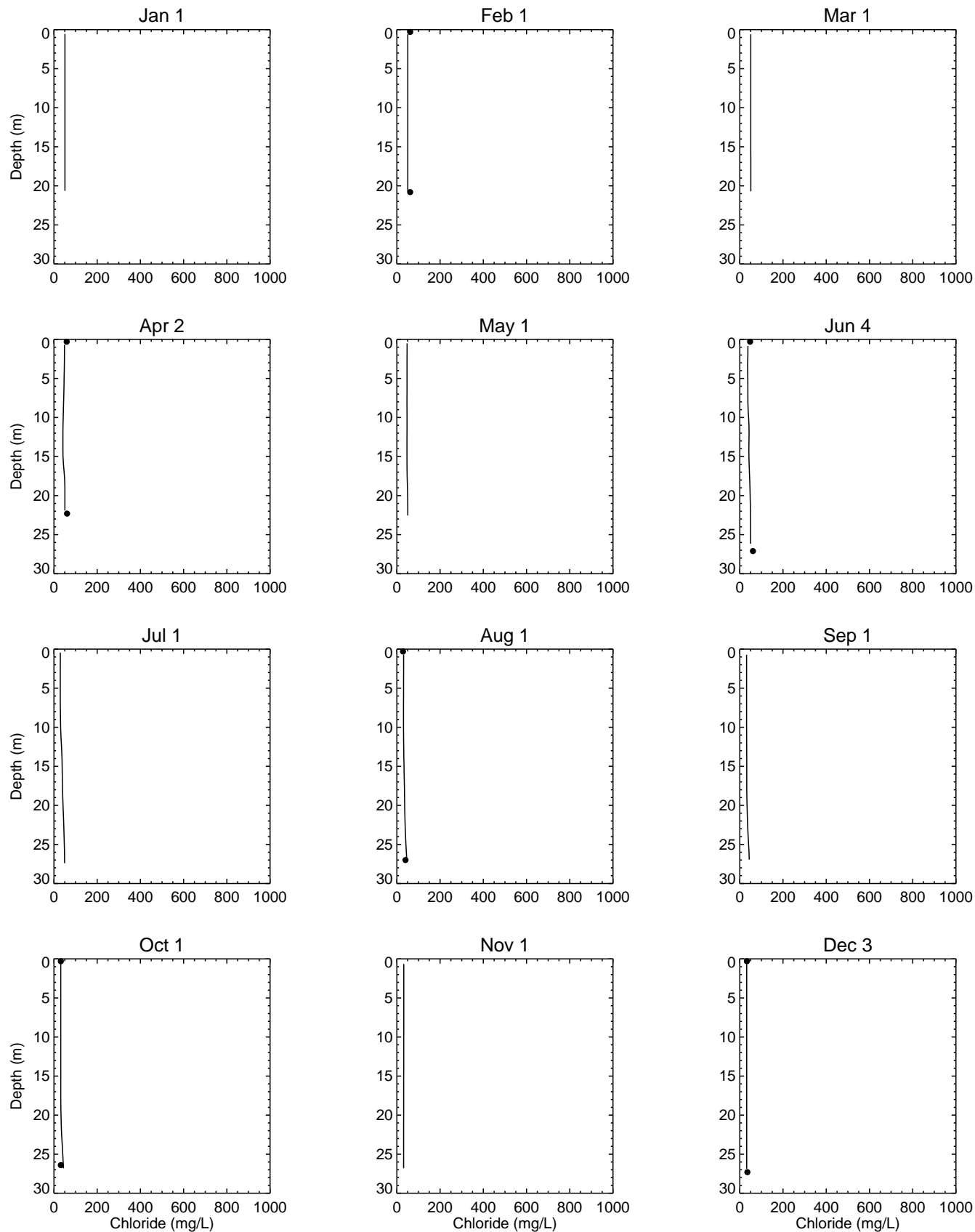
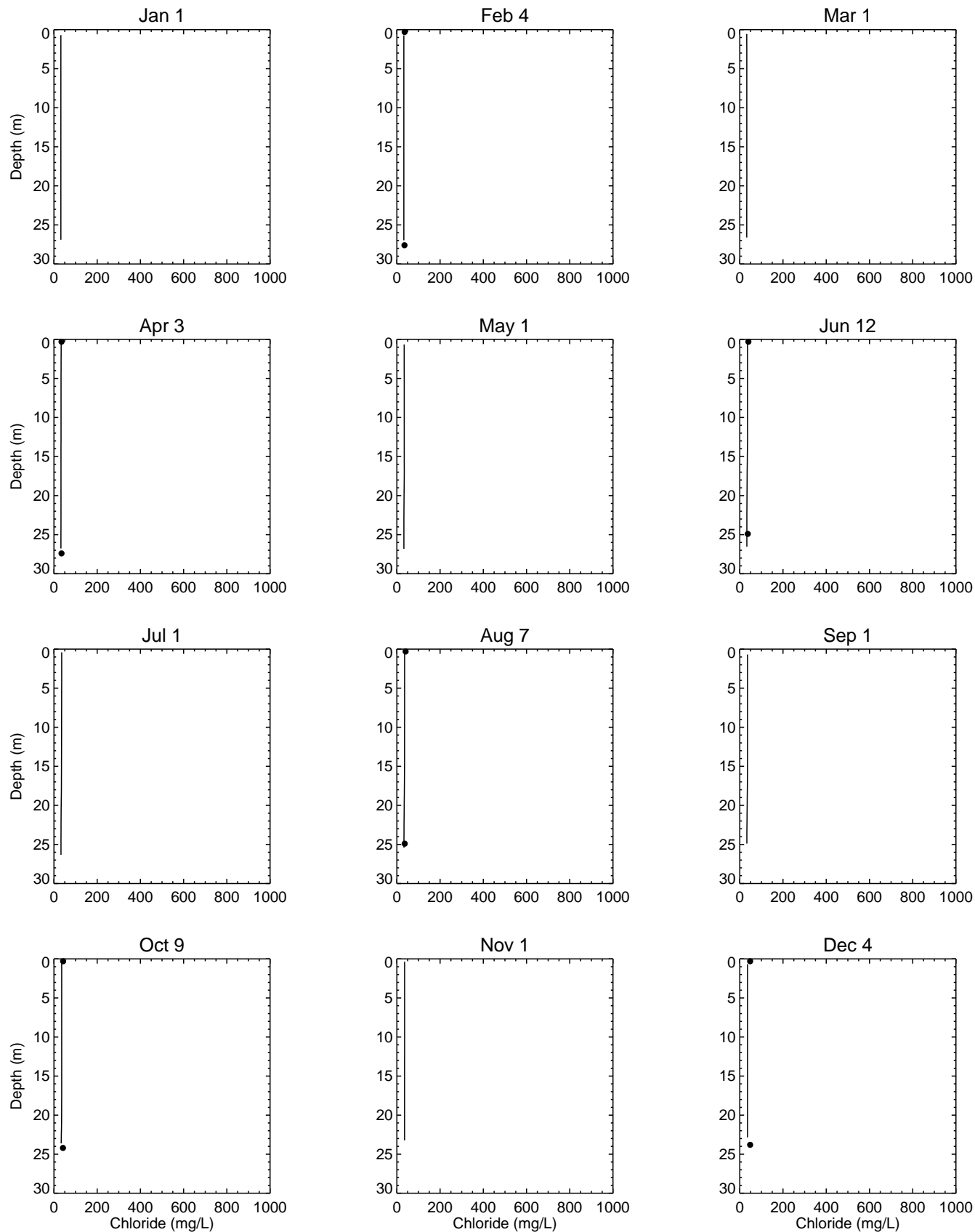Lower Colorado River Authority

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 1994

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
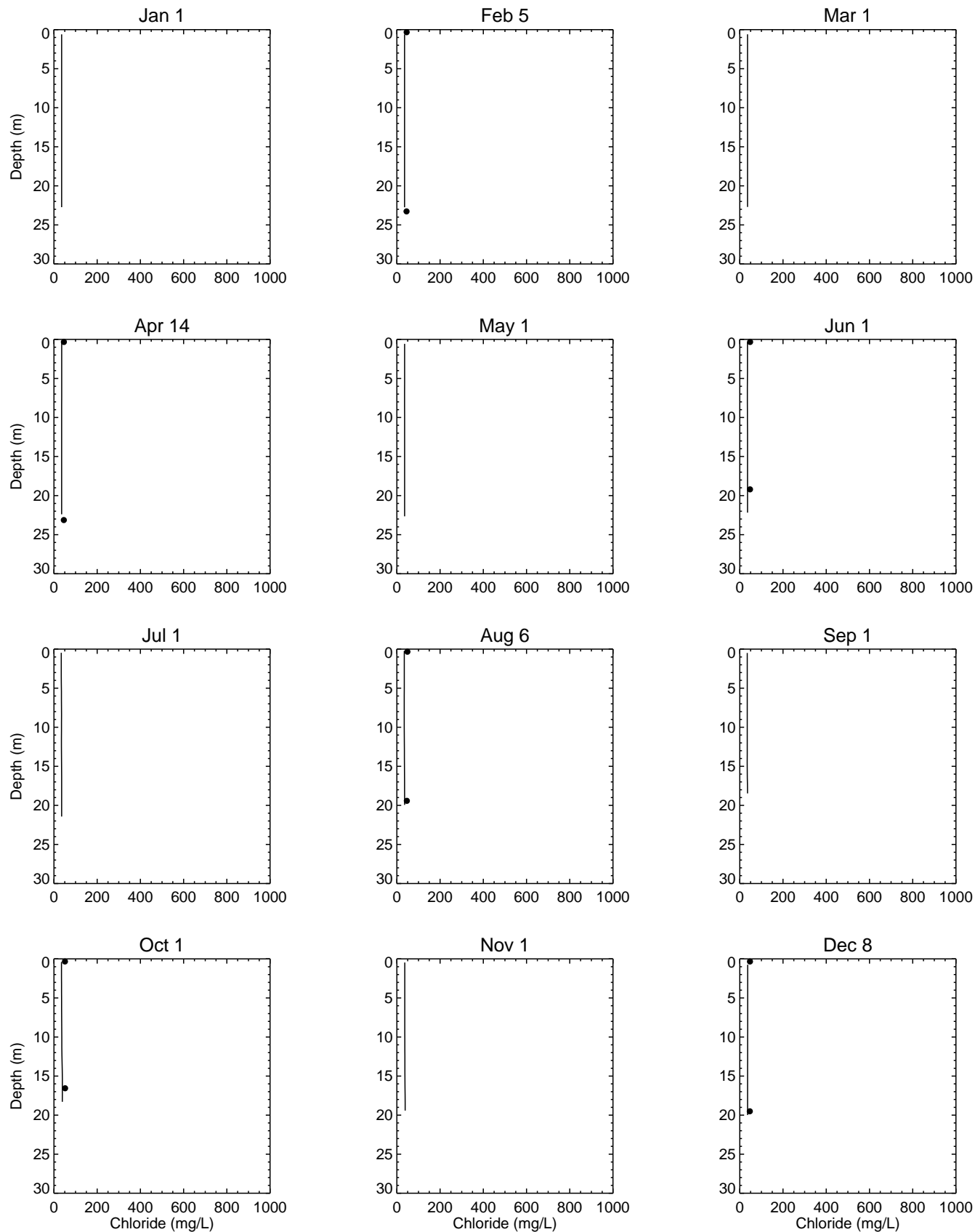
Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-24
Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 1995
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
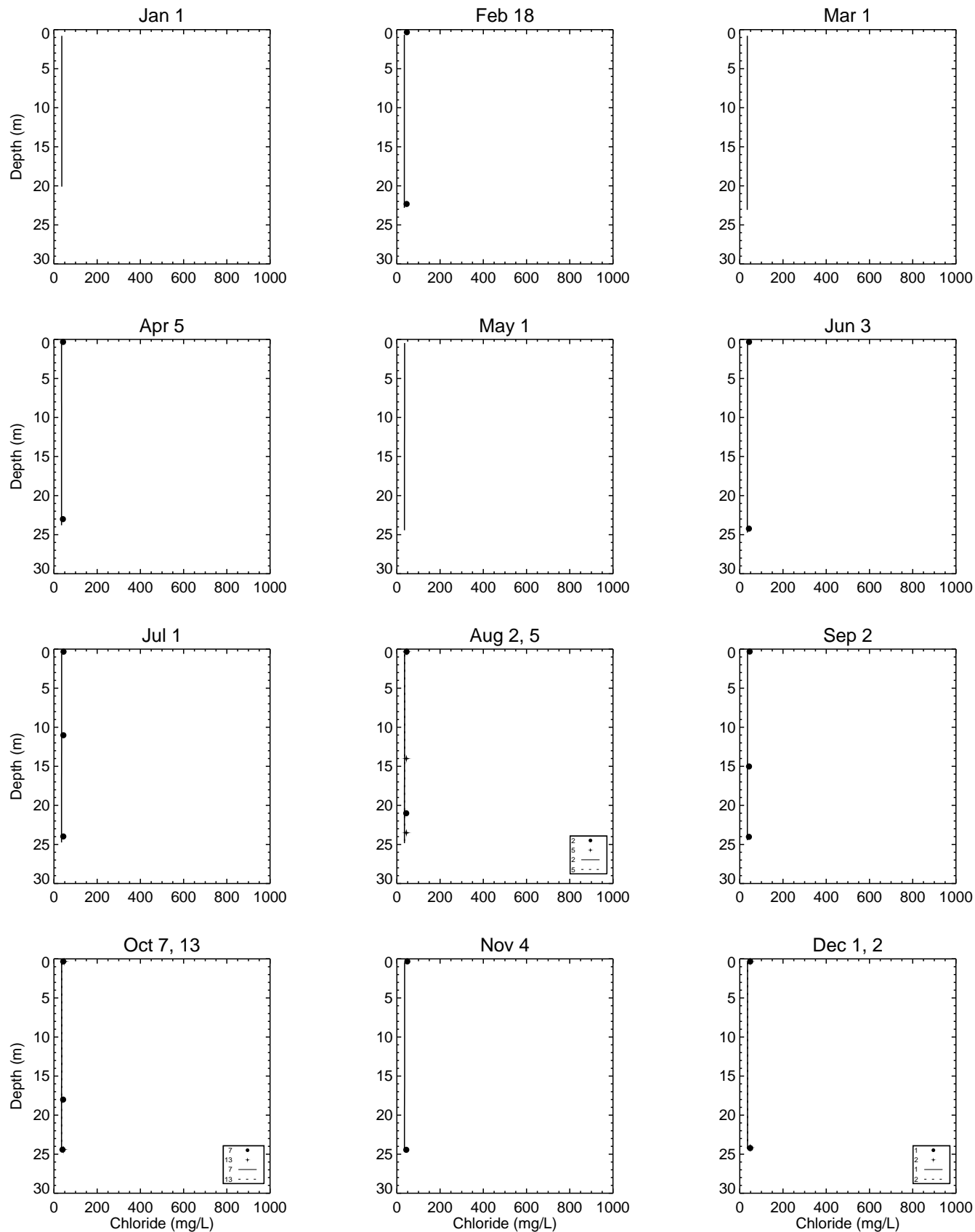Lower Colorado River Authority

Jan 1 / Feb 1 / Mar 1 / Apr 1 / May 1 / Jun 1 / Jul 1 / Aug 1 / Sep 1 / Oct 1 / Nov 1 / Dec 1

Depth (m)

Chloride (mg/L)

——— Model (w1210-48)
● Data

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 1996

Profiles shown for dates with available data else model results for first day of month shown.

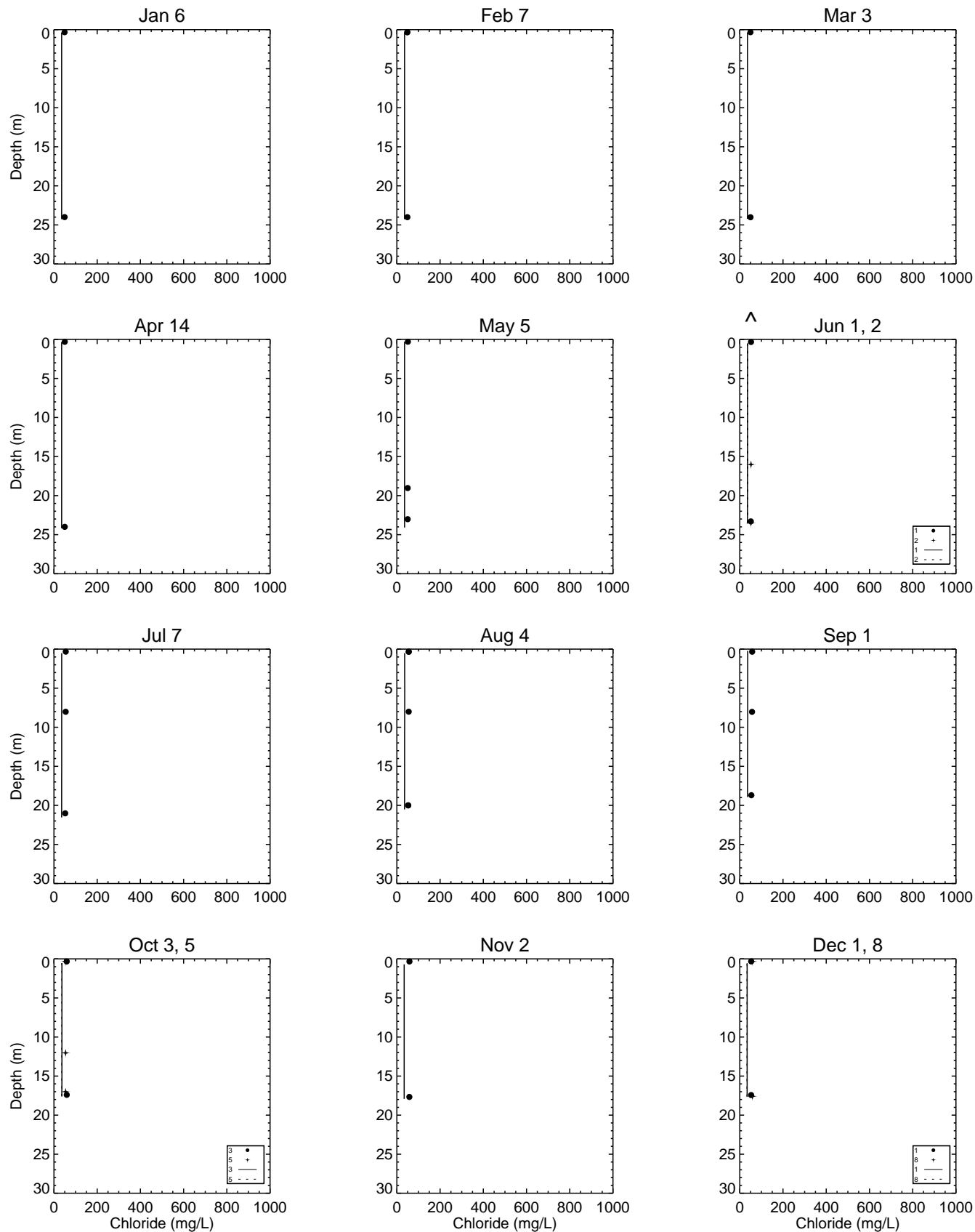CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:19 2013

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m)

Chloride (mg/L)

———— Model (w1210-48)

● Data

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 1998

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

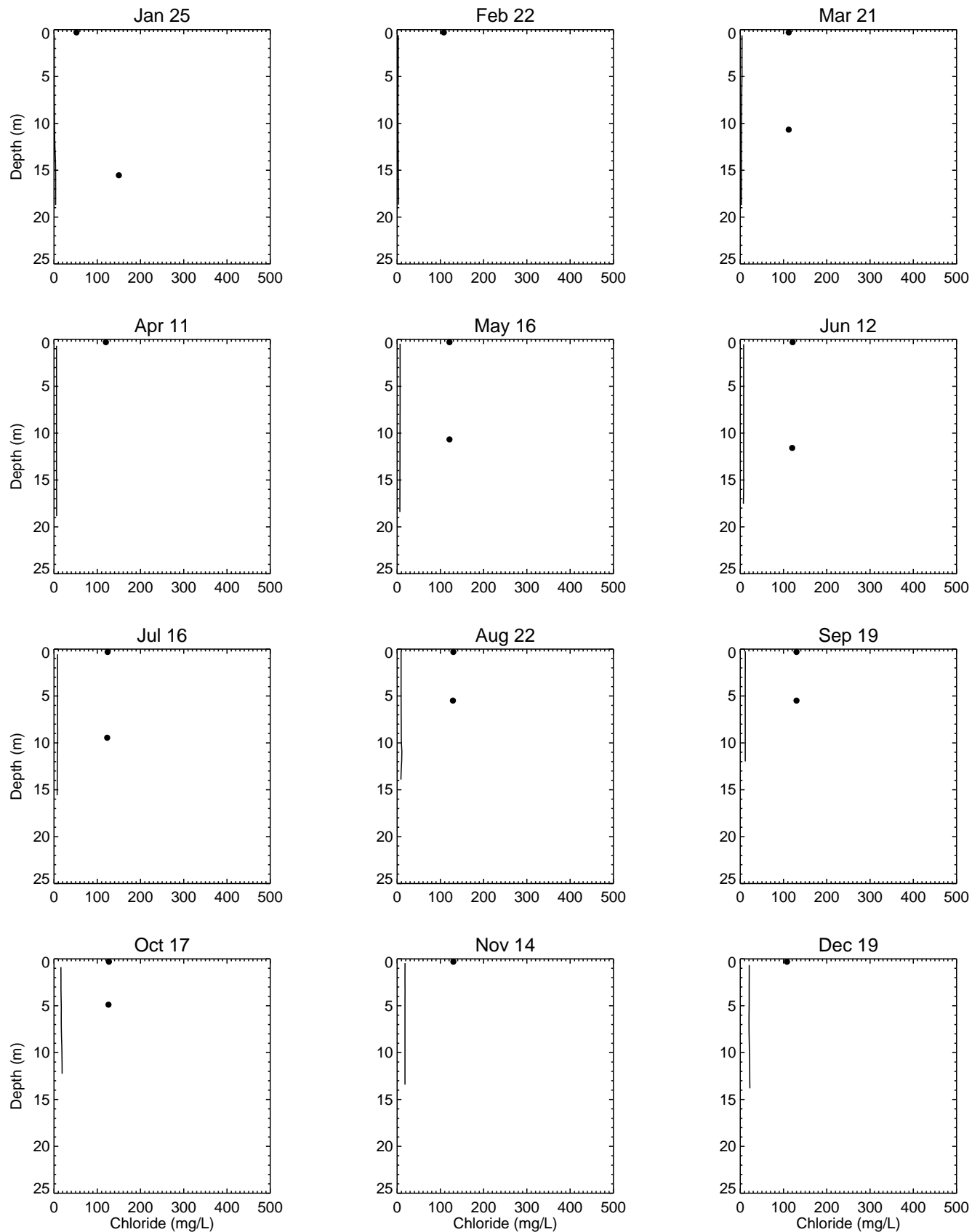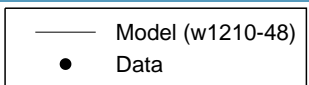Lower Colorado River Authority

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 1999

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
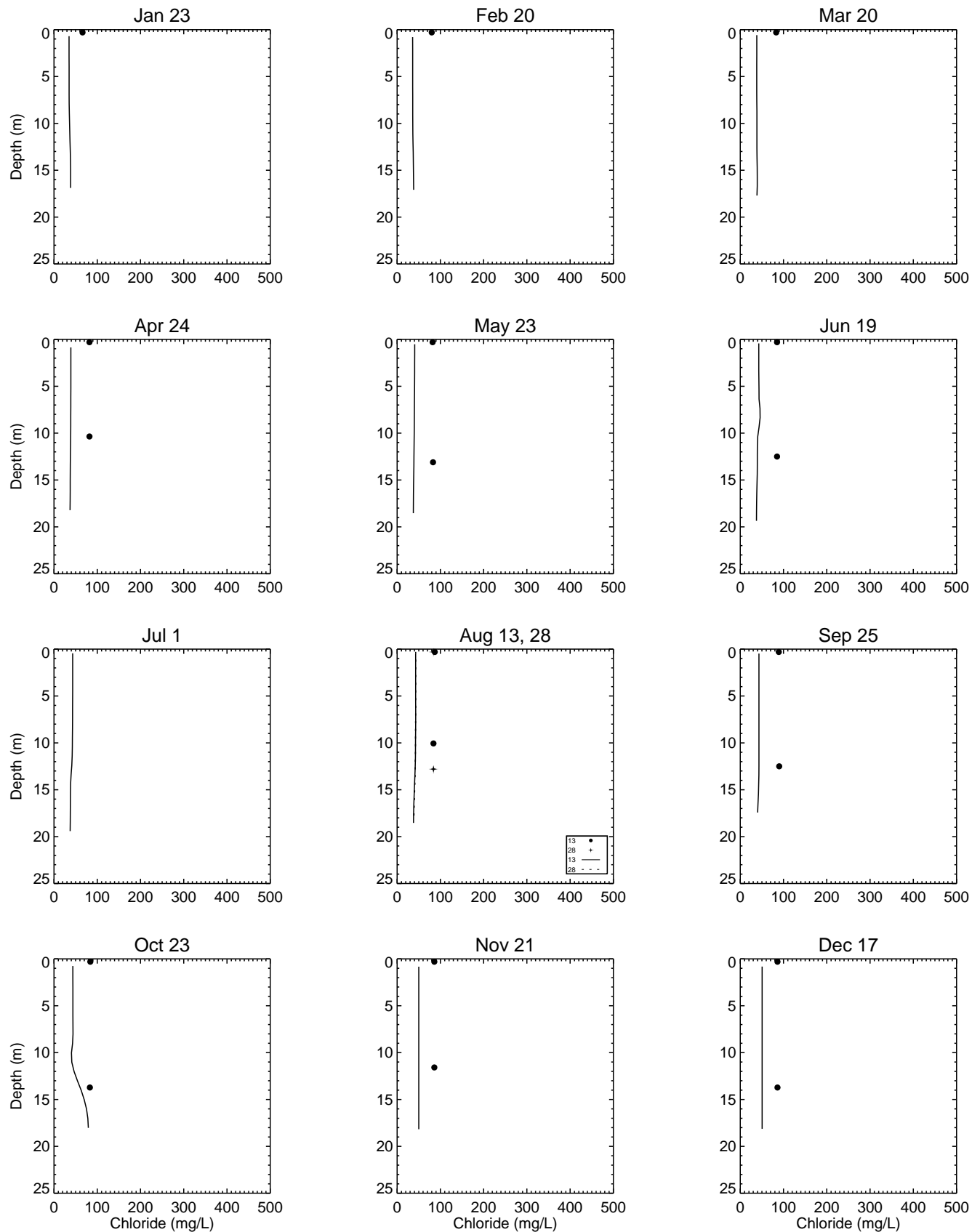
Lower Colorado River Authority

Jan 1 | Feb 1 | Mar 1
Apr 1 | May 1 | Jun 1
Jul 1 | Aug 1 | Sep 1
Oct 1 | Nov 1 | Dec 1

Depth (m) / Chloride (mg/L)
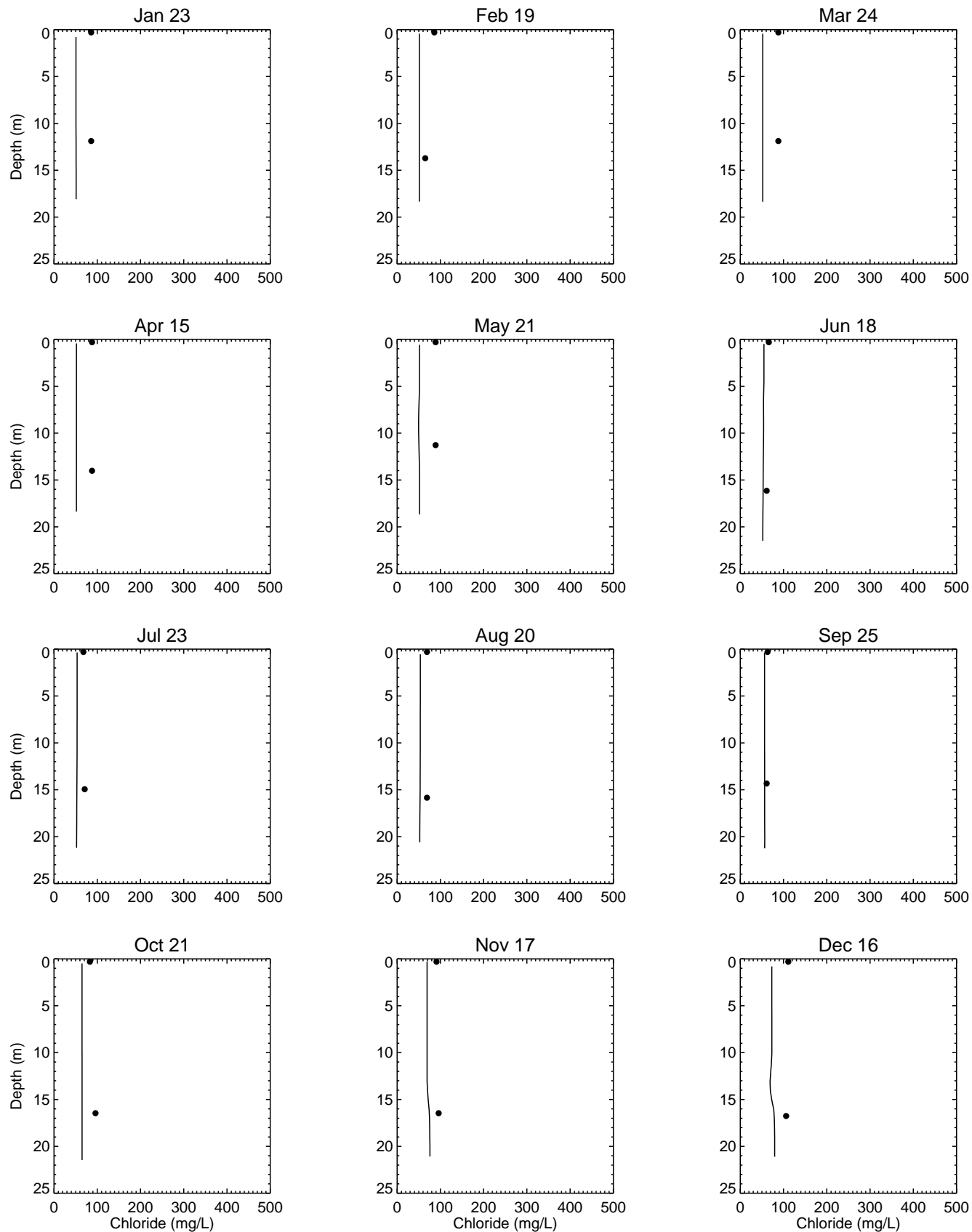
———— Model (w1210-48)
● Data

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 2000
Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 2001

Profiles shown for dates with available data else model results for first day of month shown.
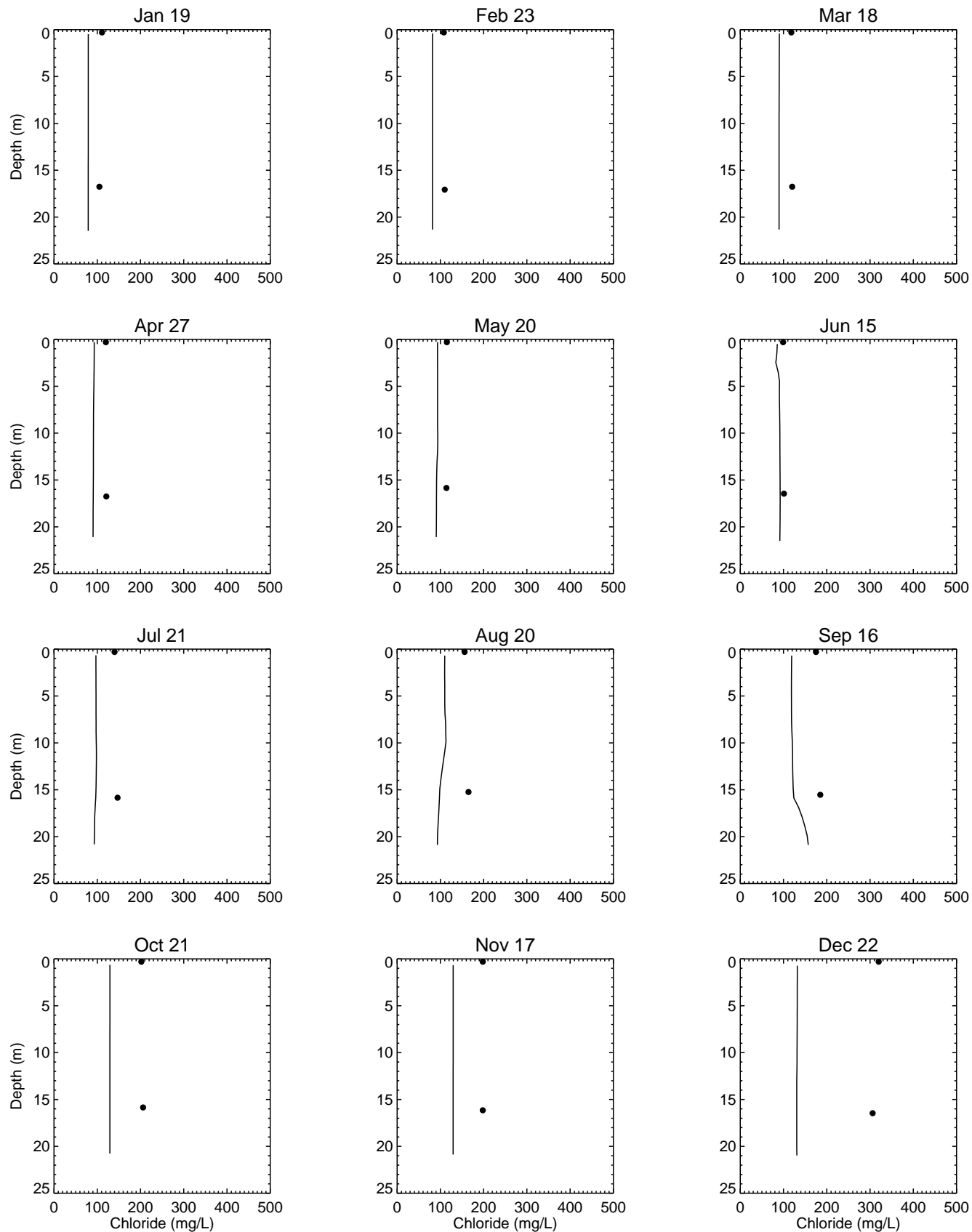
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
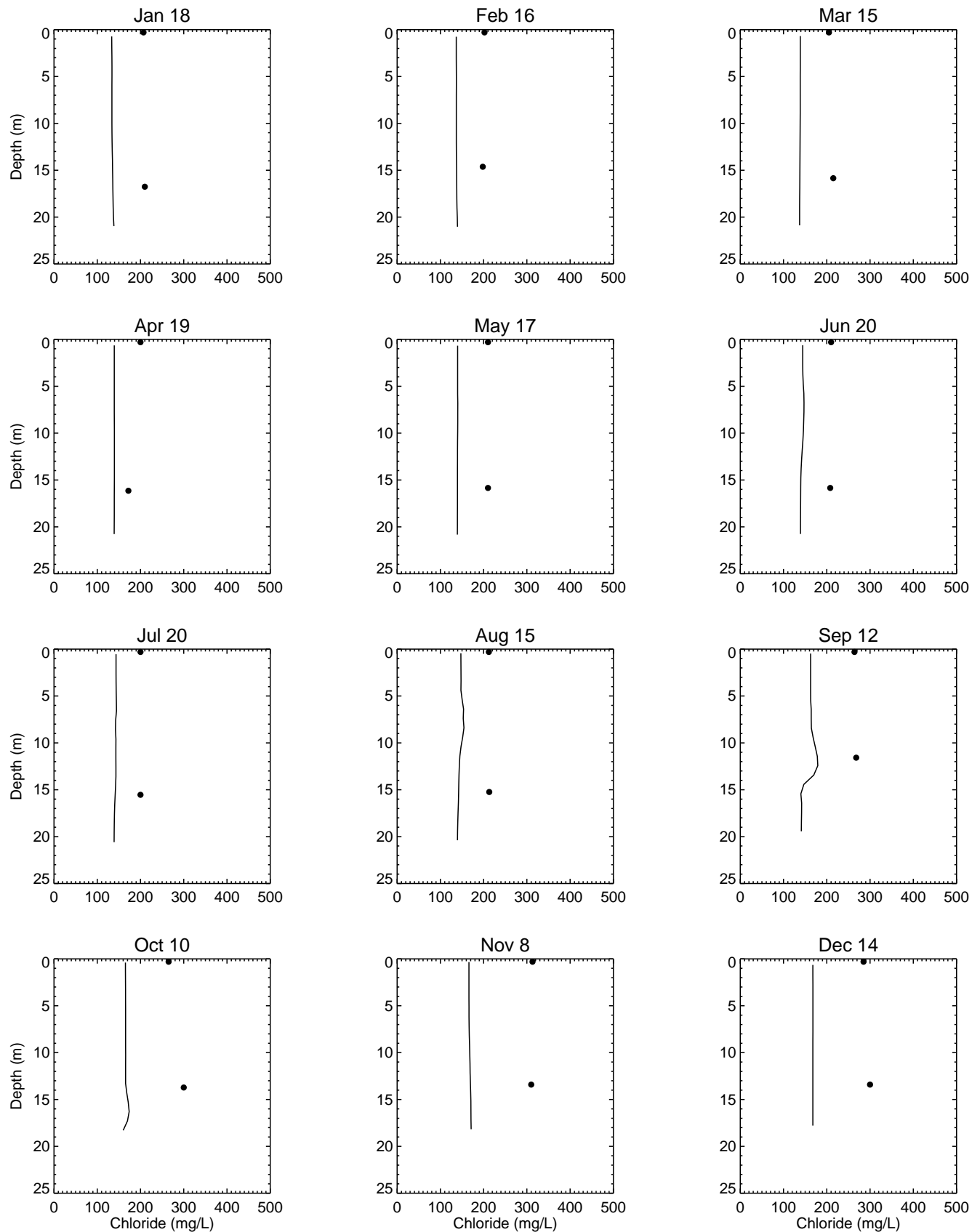Fri Jan 25 18:14:19 2013

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 2002

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

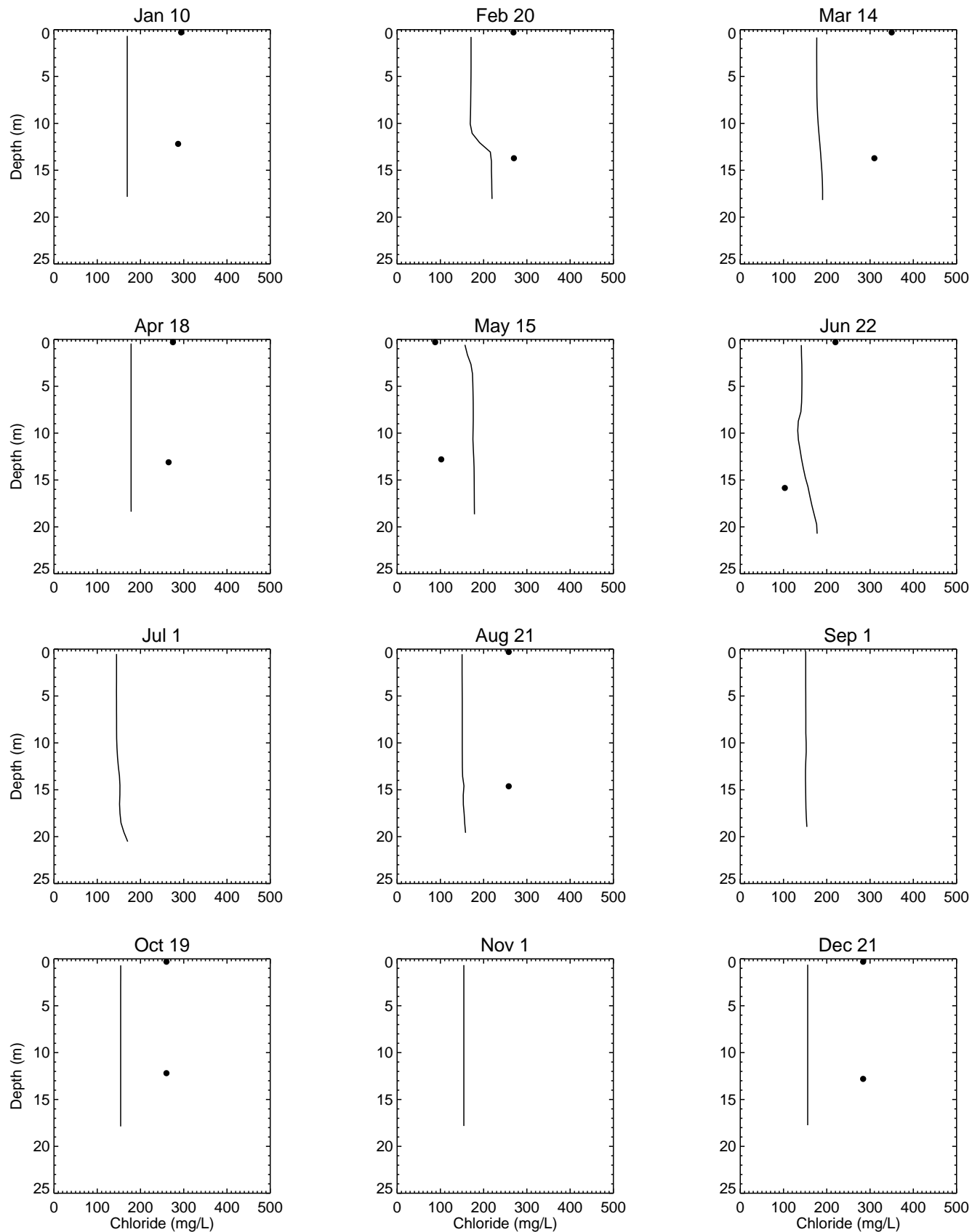Depth (m) — Chloride (mg/L)
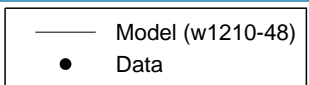
——— Model (w1210-48)
● Data

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 2003

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

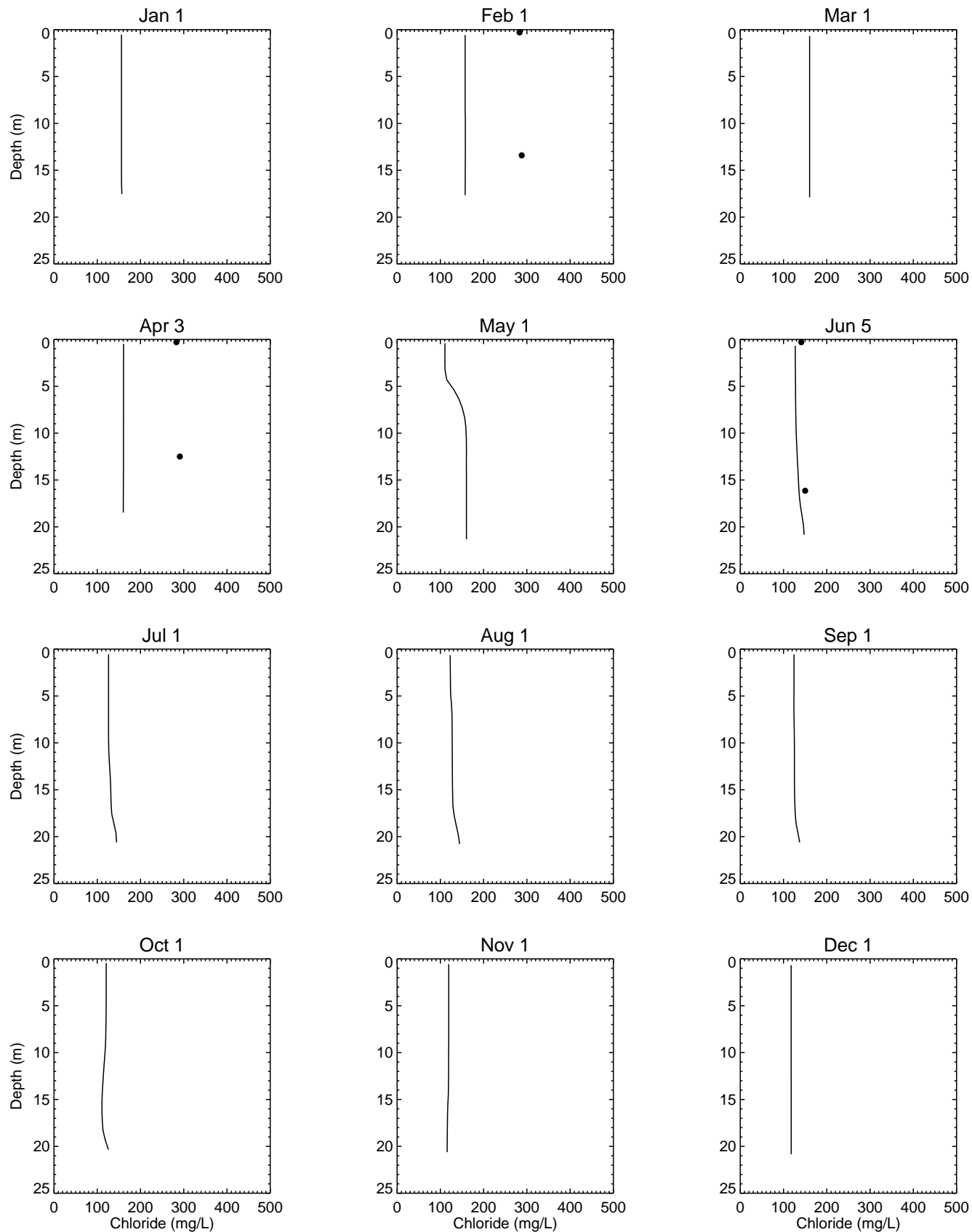Chloride (mg/L)

Model (w1210-48)

● Data

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 2004

Profiles shown for dates with available data else model results for first day of month shown.
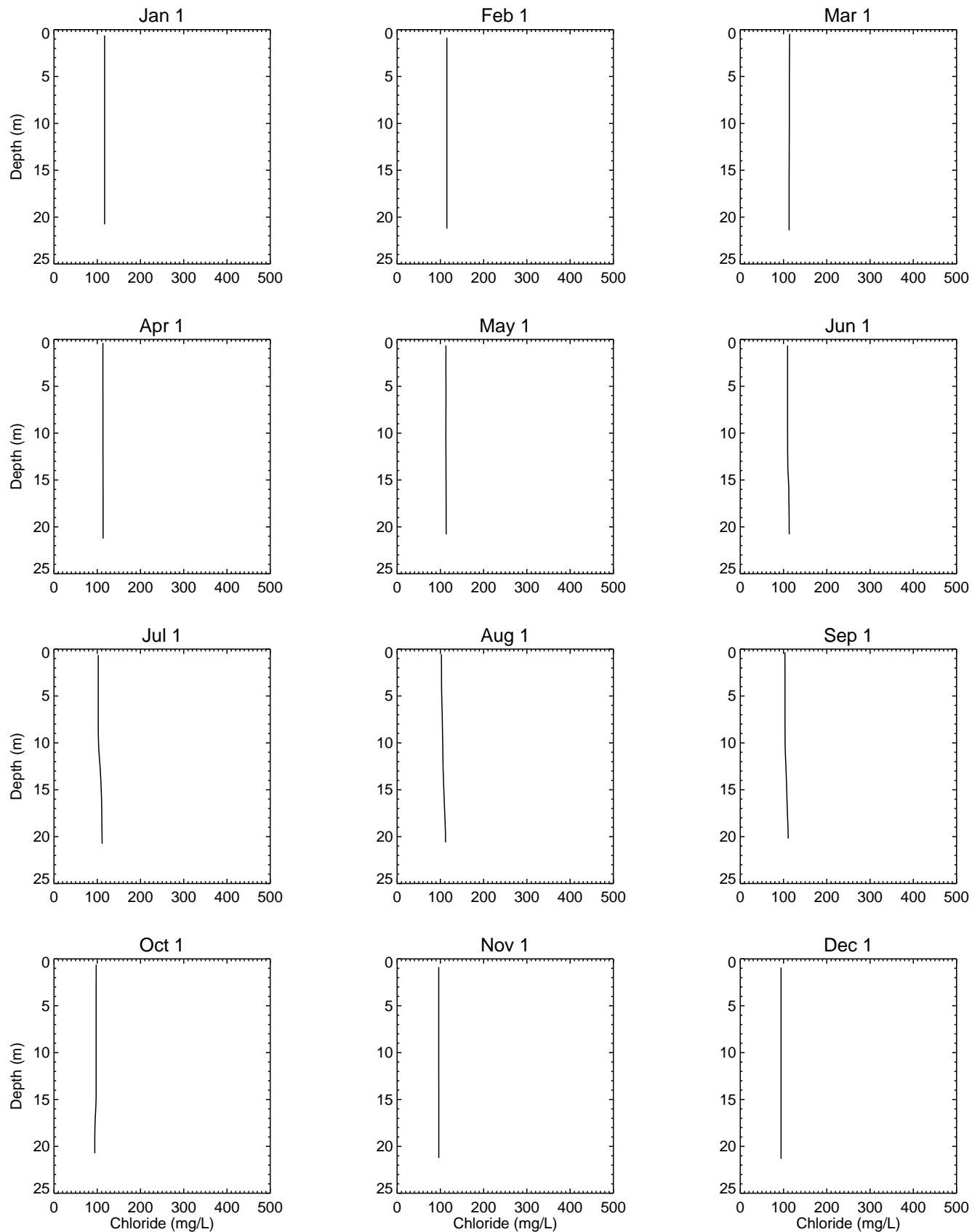
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:19 2013

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 2005

Profiles shown for dates with available data else model results for first day of month shown.
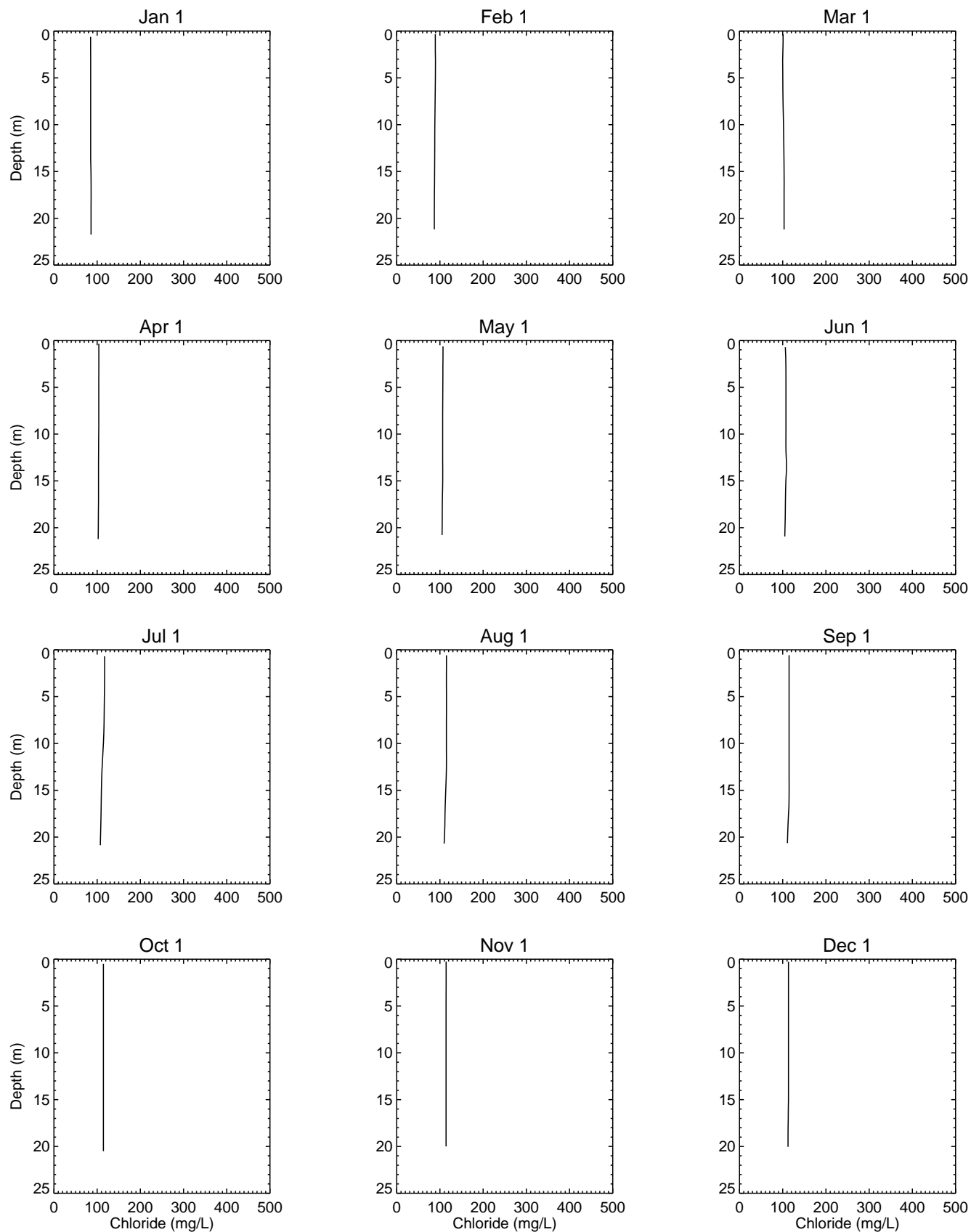
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 Feb 1 Mar 1
Apr 1 May 1 Jun 1
Jul 1 Aug 1 Sep 1
Oct 1 Nov 1 Dec 1

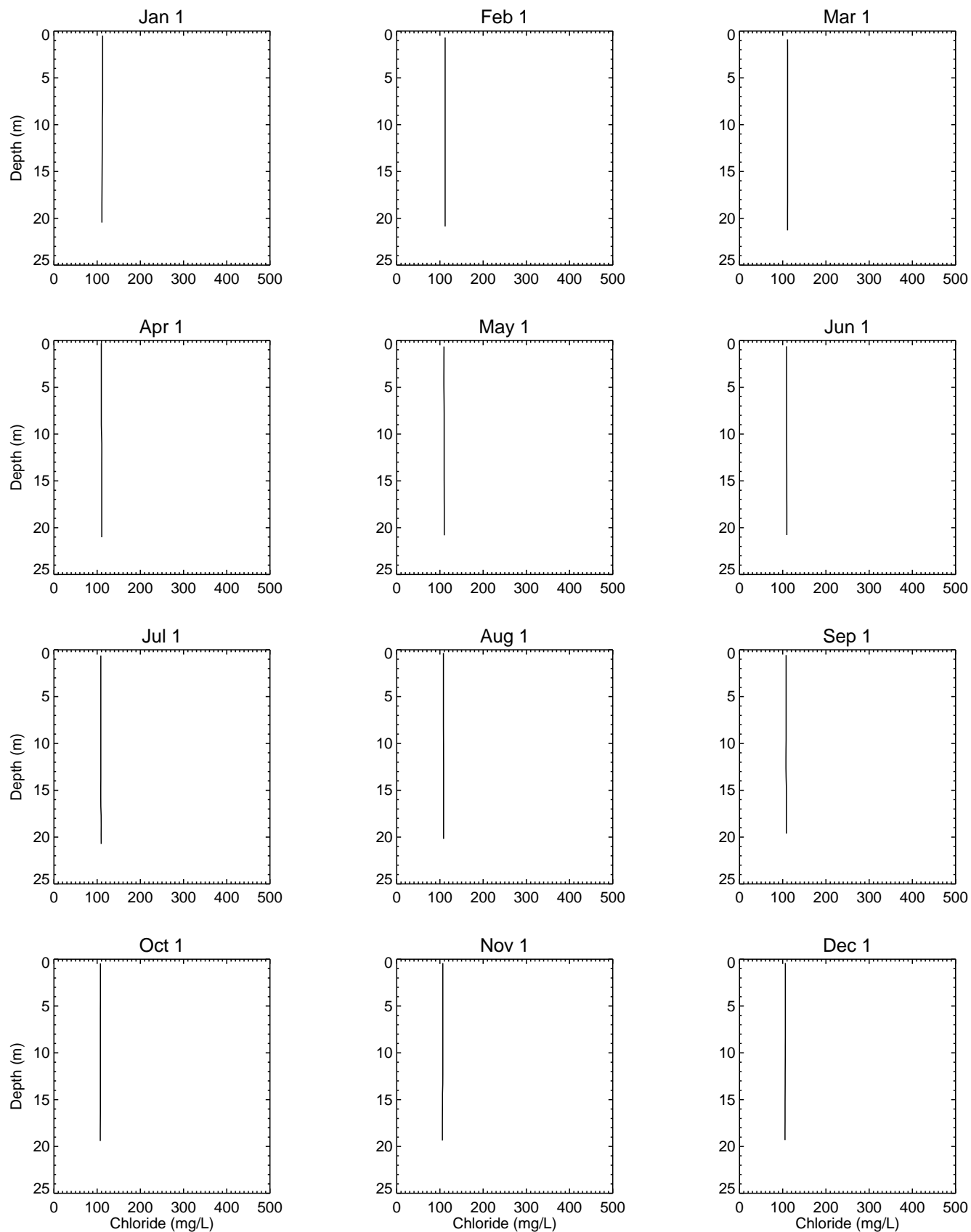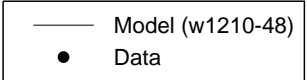Chloride (mg/L)

Depth (m)

——— Model (w1210-48)
●   Data

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 2006

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:19 2013

Lower Colorado River Authority

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 2007

Profiles shown for dates with available data else model results for first day of month shown.
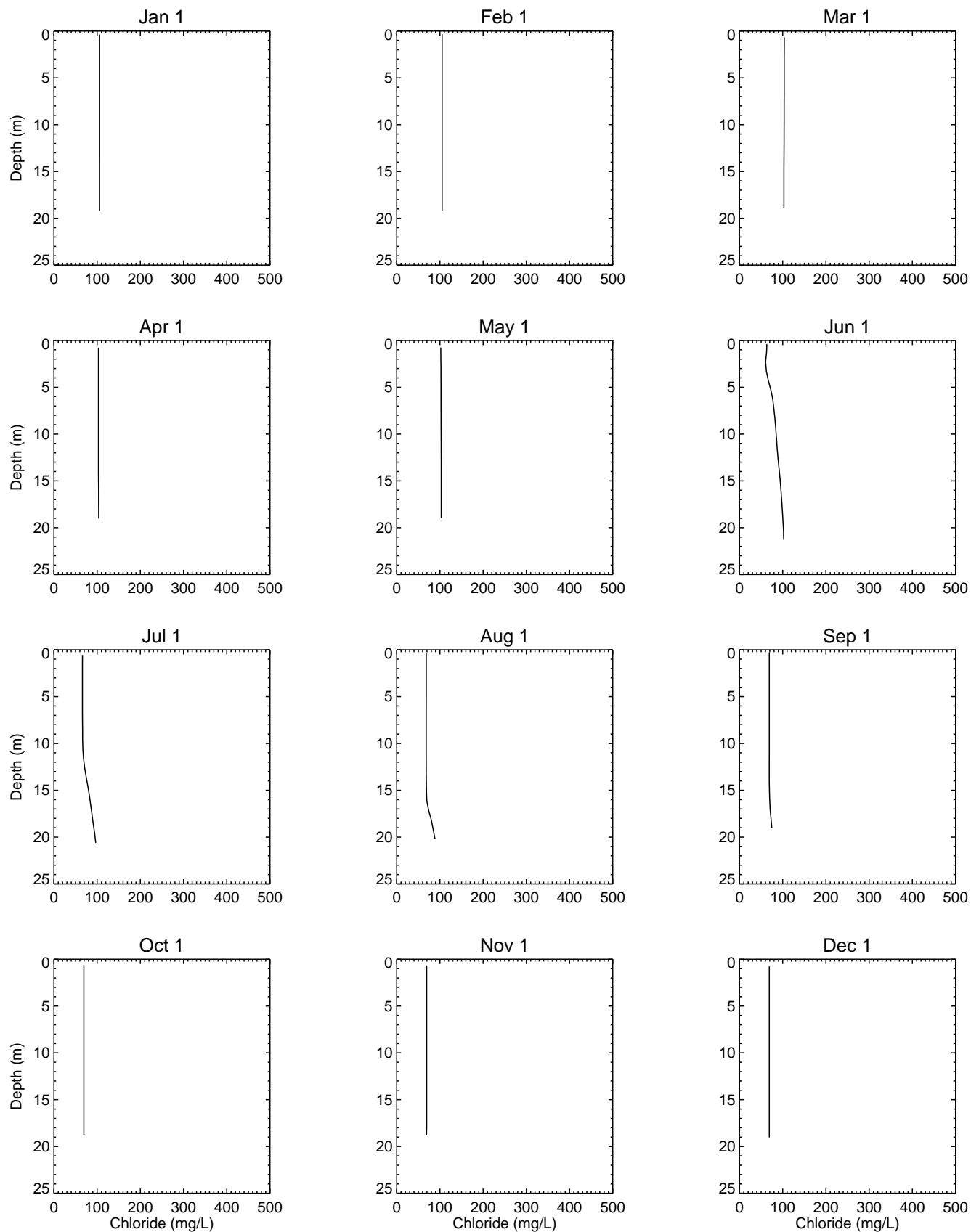
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 4 · Mar 1 · Apr 3 · May 1 · Jun 12 · Jul 1 · Aug 7 · Sep 1 · Oct 9 · Nov 1 · Dec 4
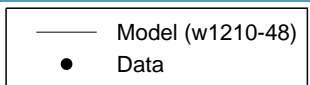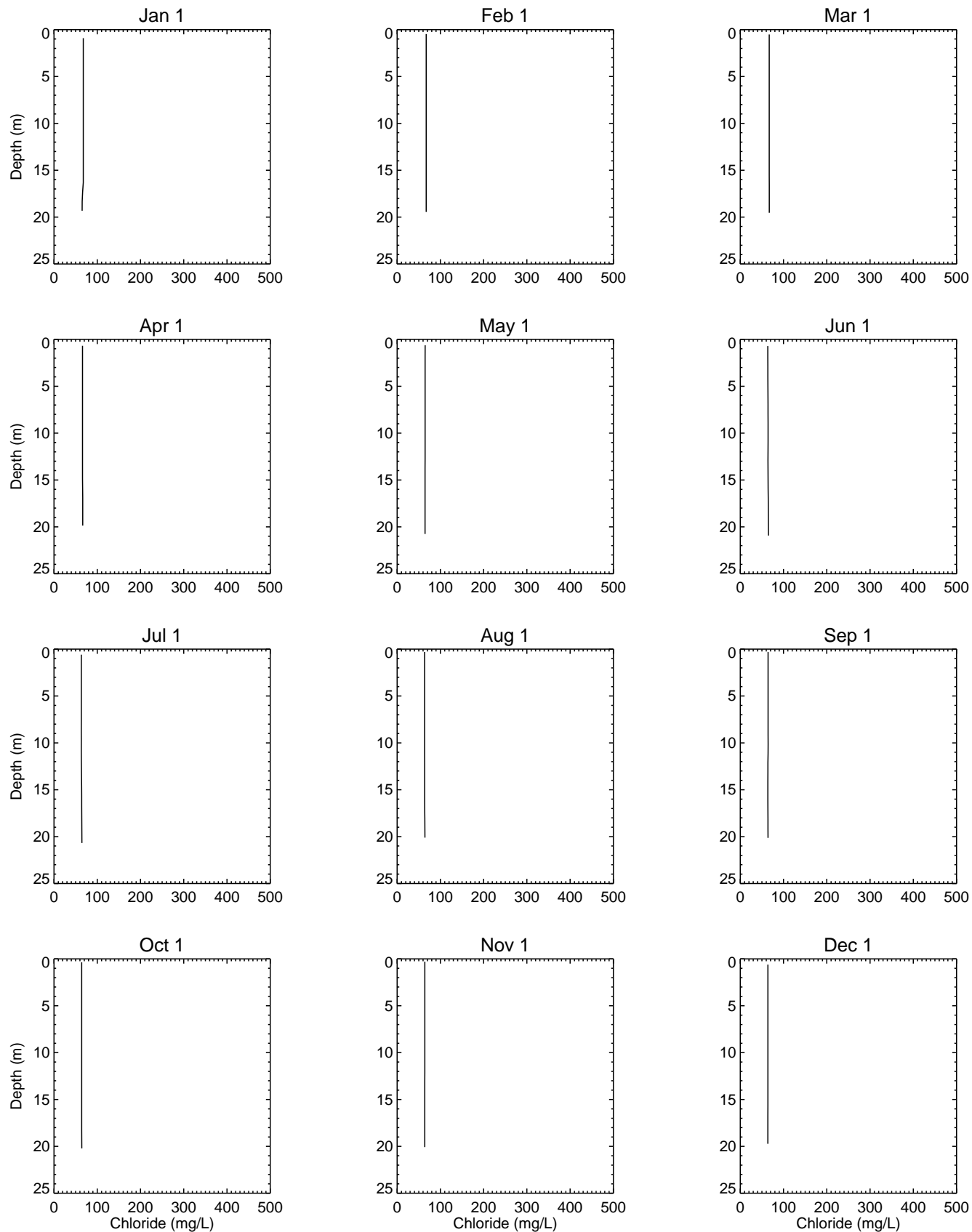
Chloride (mg/L)

Model (w1210-48)
● Data

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 2008

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:19 2013

Jan 1 — Feb 5 — Mar 1 — Apr 14 — May 1 — Jun 1 — Jul 1 — Aug 6 — Sep 1 — Oct 1 — Nov 1 — Dec 8
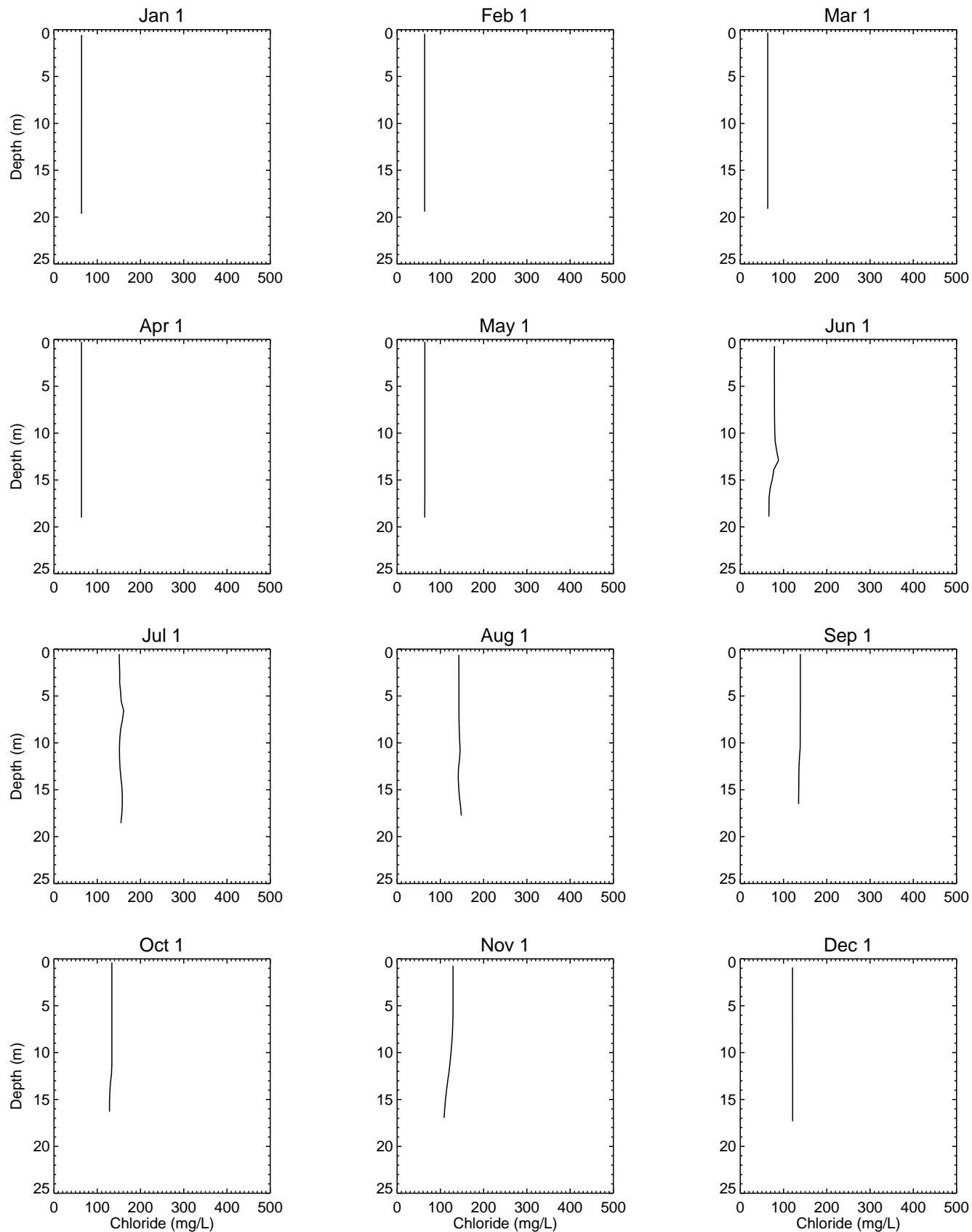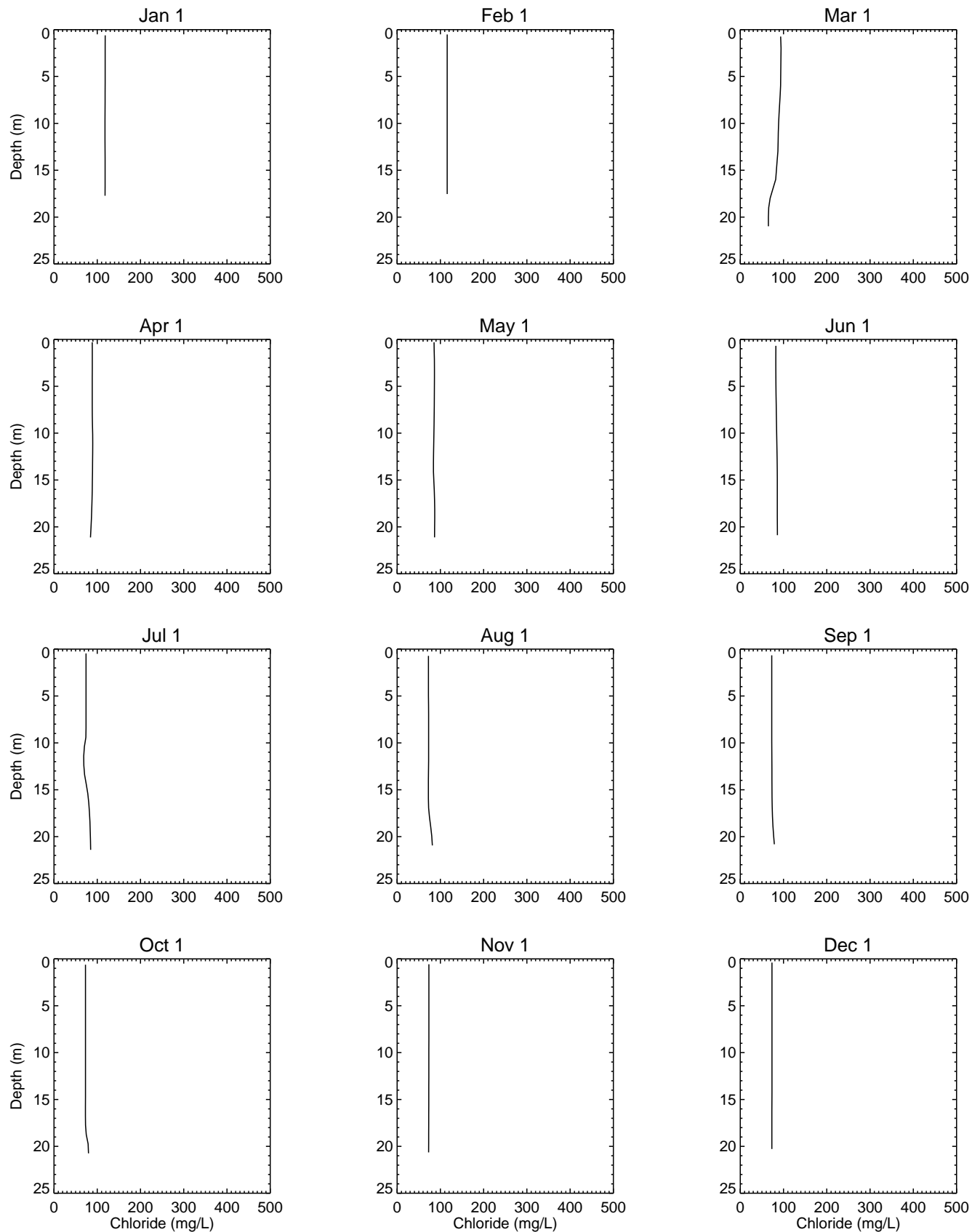
——— Model (w1210-48)
● Data

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 2009

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 2010

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:19 2013

Figure G-24

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Chloride - 2011

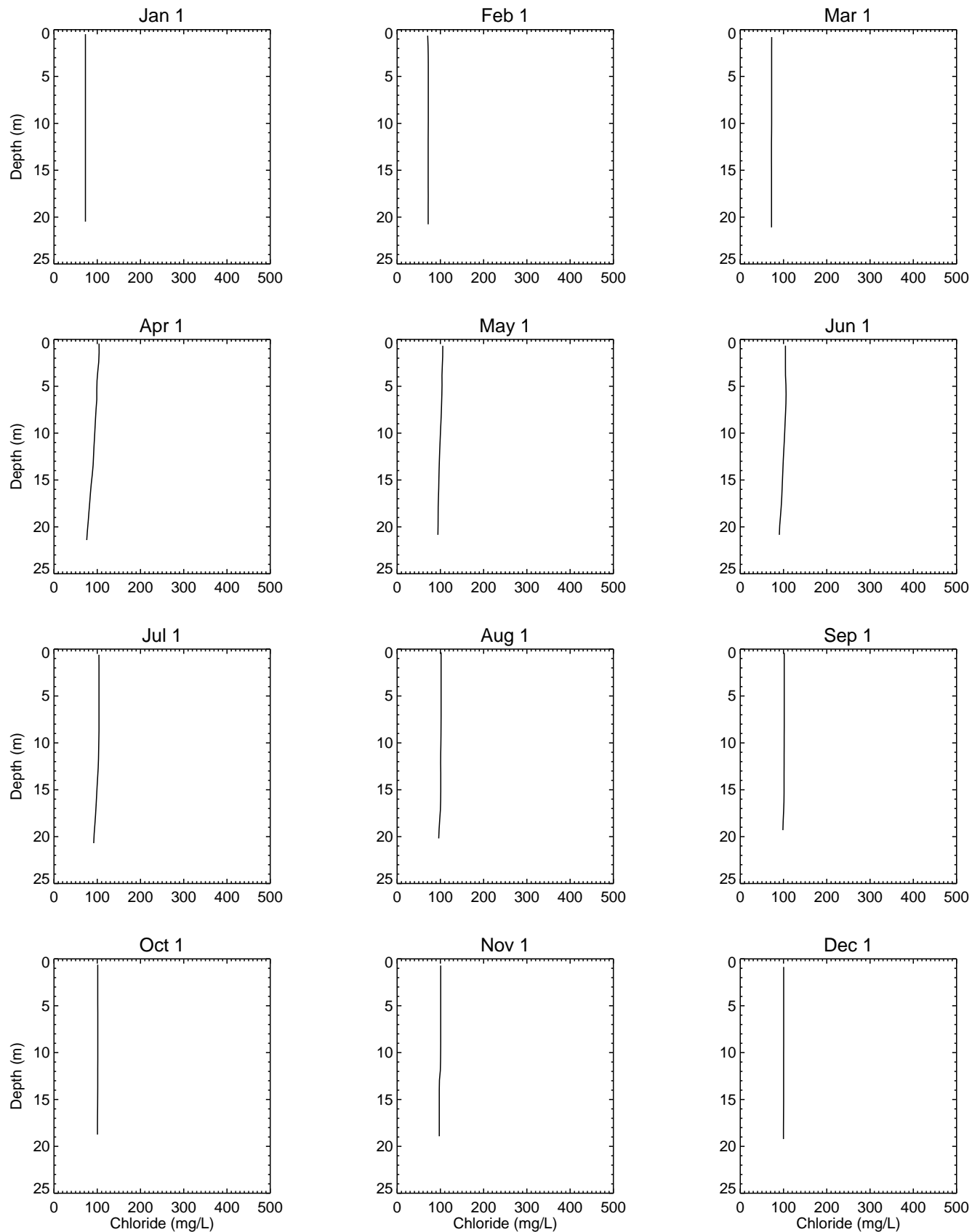*Profiles shown for dates with available data else model results for first day of month shown.*
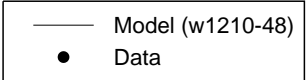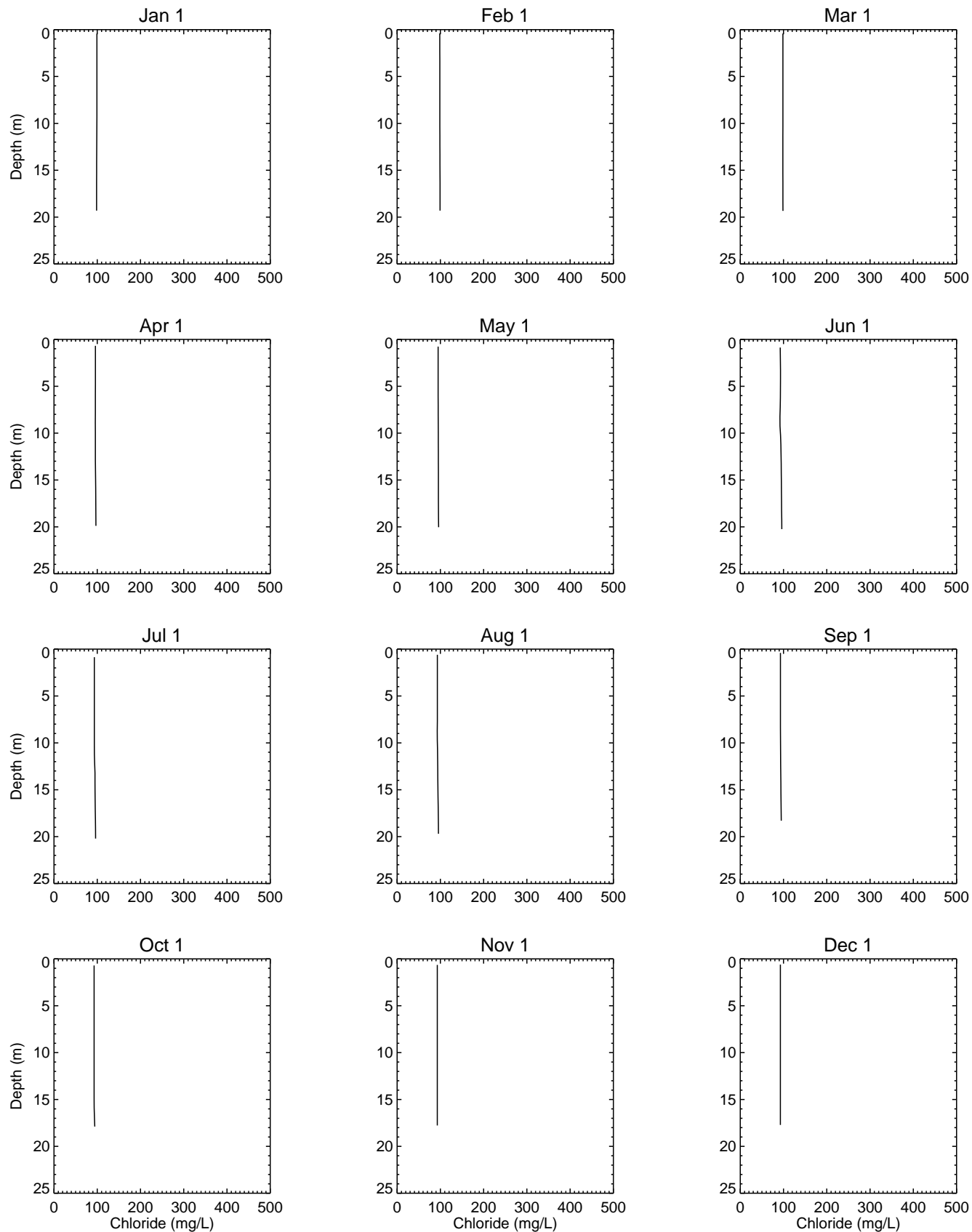
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 25 · Feb 22 · Mar 21 · Apr 11 · May 16 · Jun 12 · Jul 17 · Aug 22 · Sep 19 · Oct 17 · Nov 14 · Dec 19

Depth (m)

Chloride (mg/L)

——— Model (w1210-48)
● Data

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 1984

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

Jan 23 | Feb 20 | Mar 20
Apr 24 | May 23 | Jun 19
Jul 1 | Aug 13, 28 | Sep 25
Oct 23 | Nov 21 | Dec 17

Model (w1210-48)
● Data

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 1985

Profiles shown for dates with available data else model results for first day of month shown.

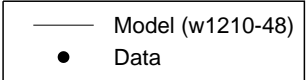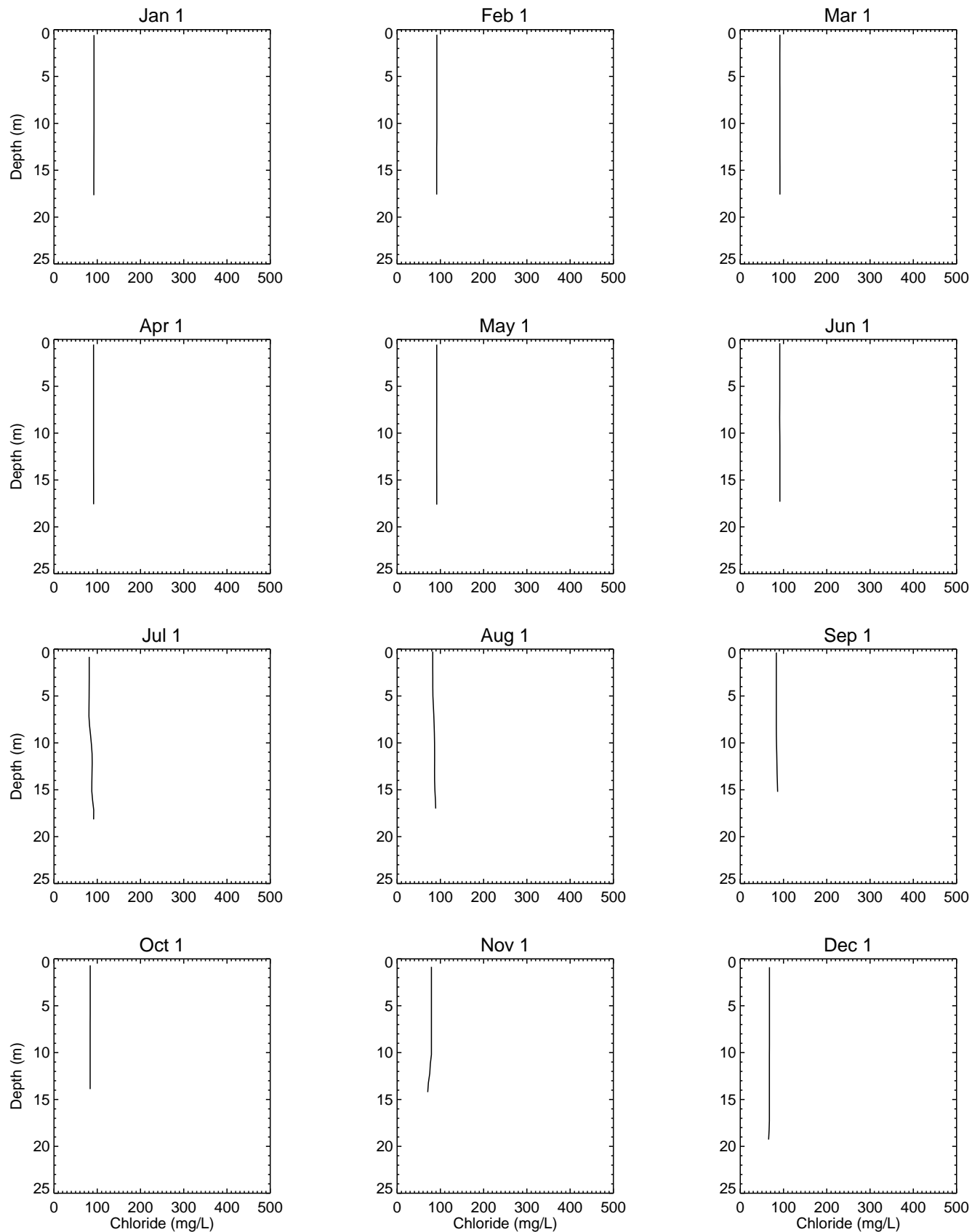CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:21 2013

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 1986

Profiles shown for dates with available data else model results for first day of month shown.

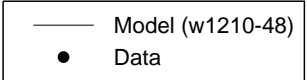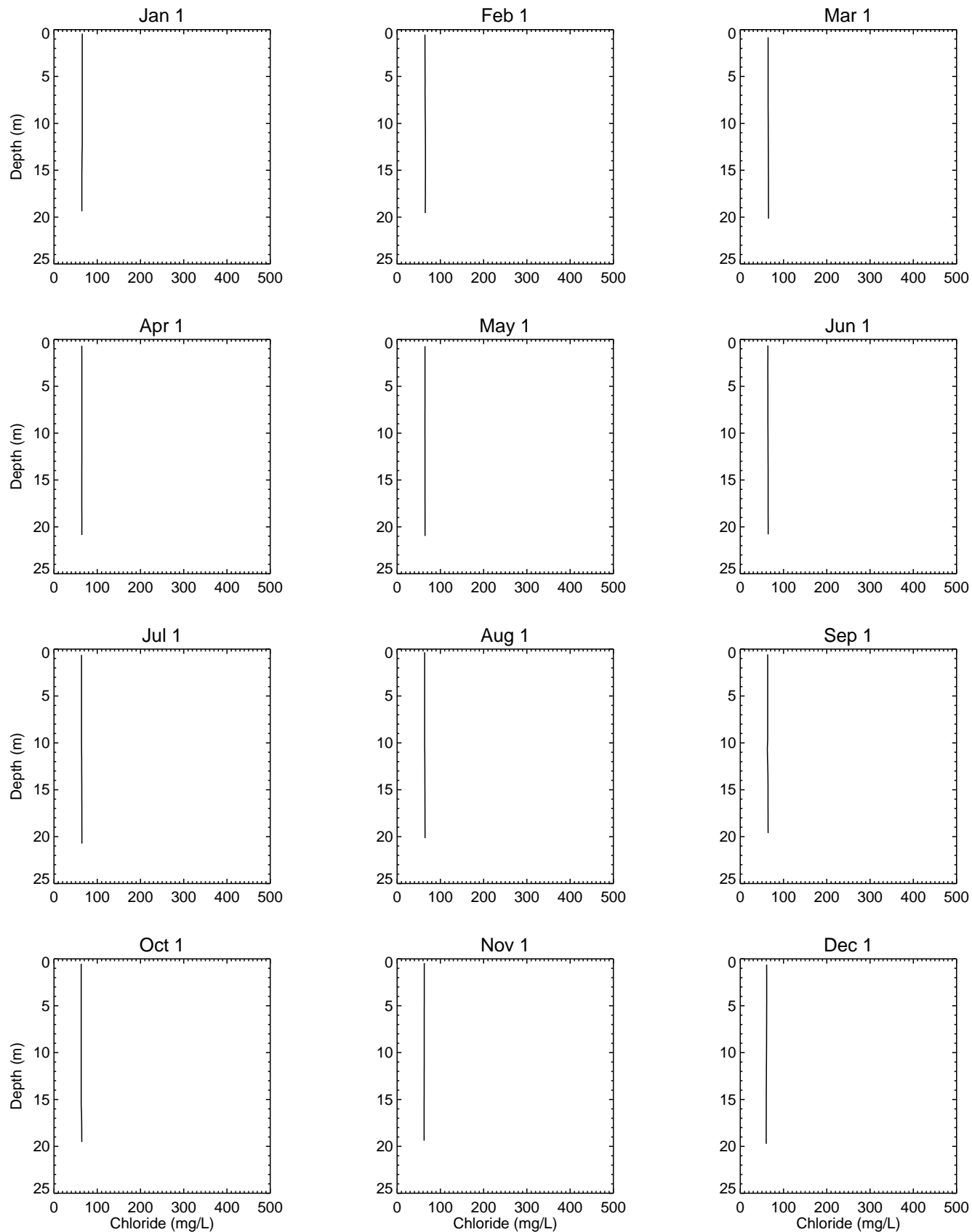CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan at Golden Beach (Segment 26) - Chloride - 1987

Profiles shown for dates with available data else model results for first day of month shown.

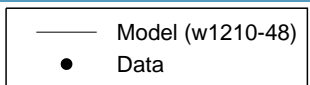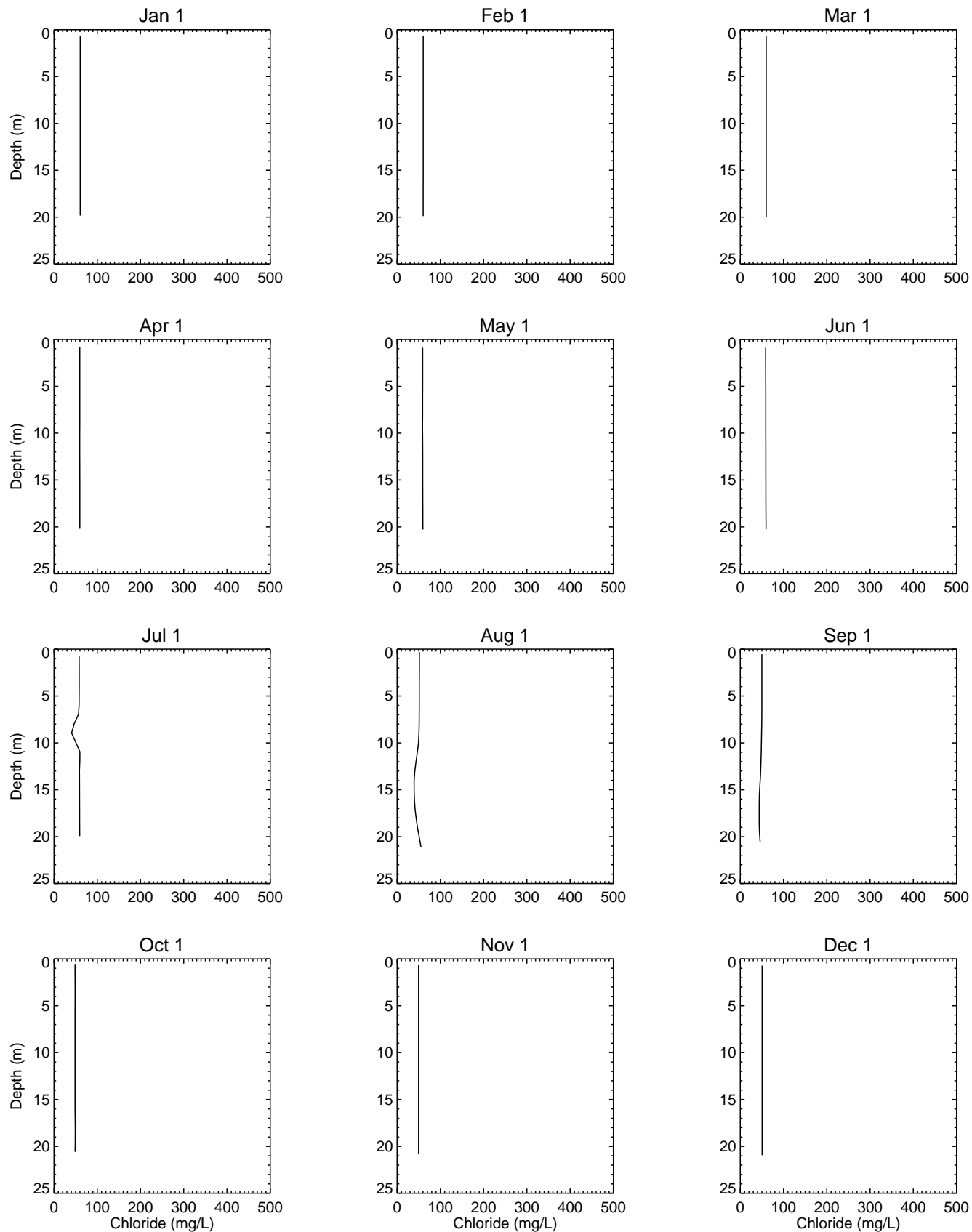CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:21 2013

Jan 18 | Feb 16 | Mar 15

Apr 19 | May 17 | Jun 20

Jul 20 | Aug 15 | Sep 12

Oct 10 | Nov 8 | Dec 14

Depth (m)

Chloride (mg/L)

—— Model (w1210-48)
● Data

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 1988

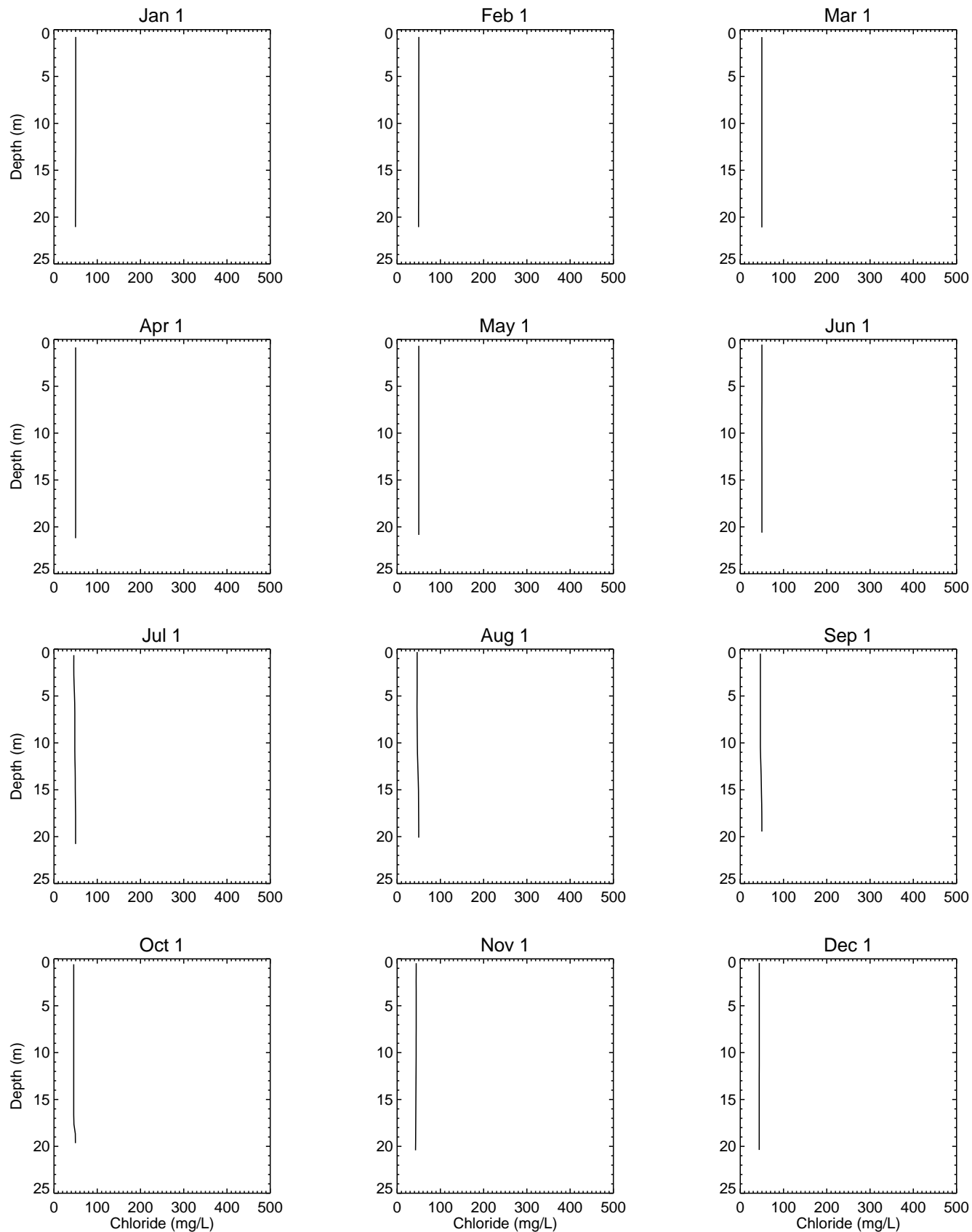*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

Jan 10 · Feb 20 · Mar 14 · Apr 18 · May 15 · Jun 22 · Jul 1 · Aug 21 · Sep 1 · Oct 19 · Nov 1 · Dec 21

Model (w1210-48)
• Data

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 1989

Profiles shown for dates with available data else model results for first day of month shown.

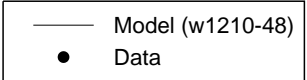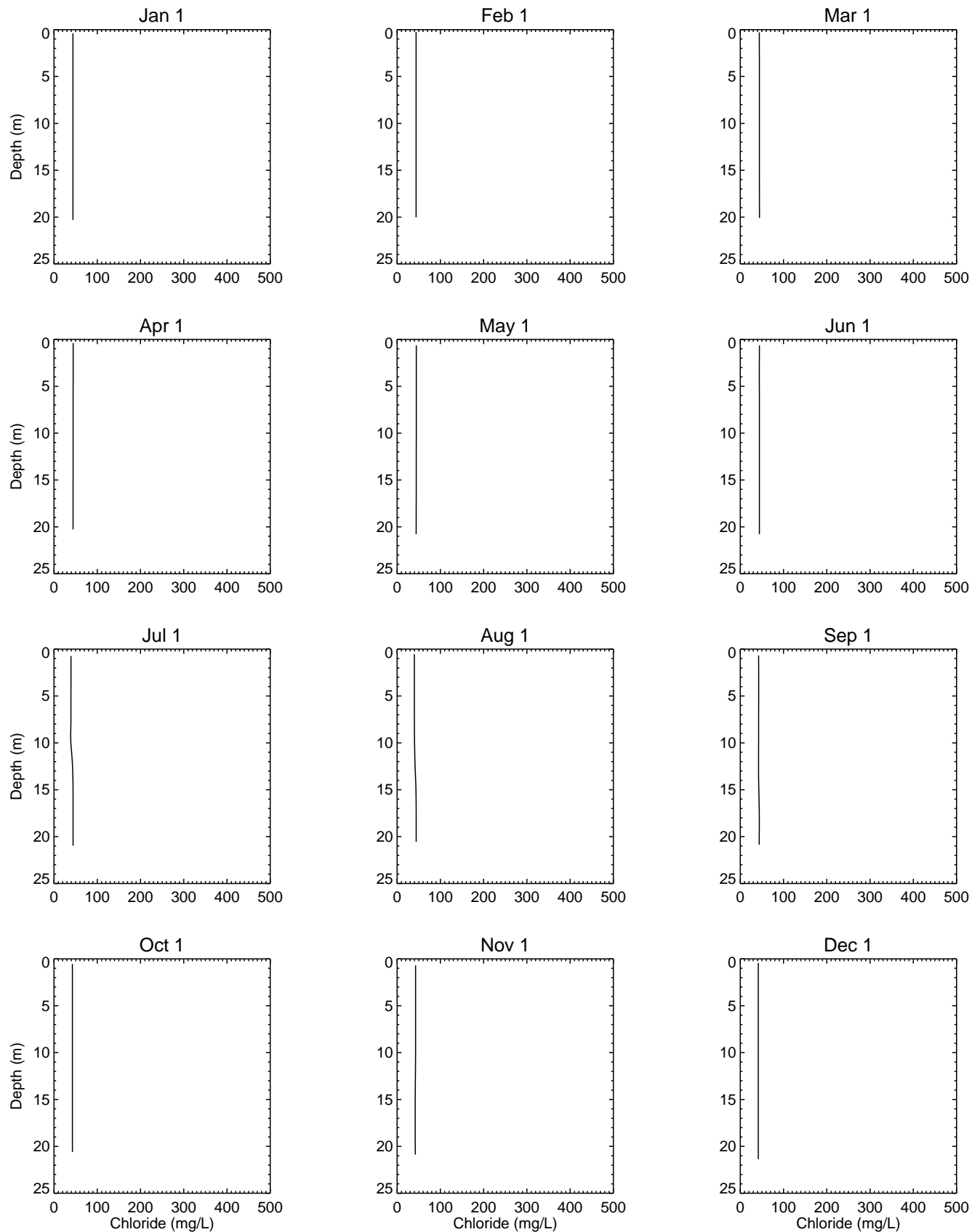CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:21 2013

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 1990

Profiles shown for dates with available data else model results for first day of month shown.

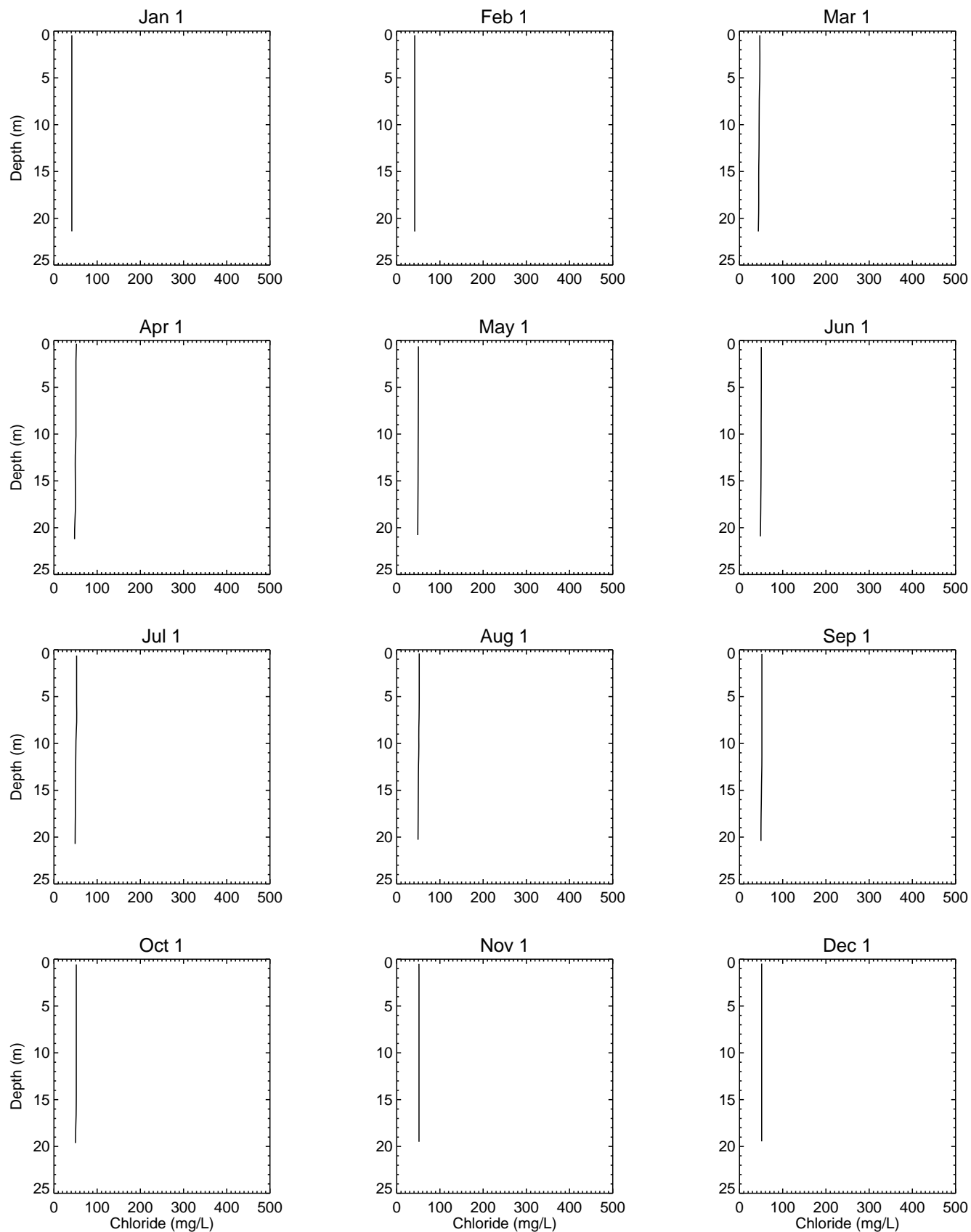CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1

Feb 1

Mar 1

Apr 1

May 1

Jun 1

Jul 1

Aug 1

Sep 1

Oct 1

Nov 1

Dec 1

——— Model (w1210-48)

● Data

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 1991

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR
QEA
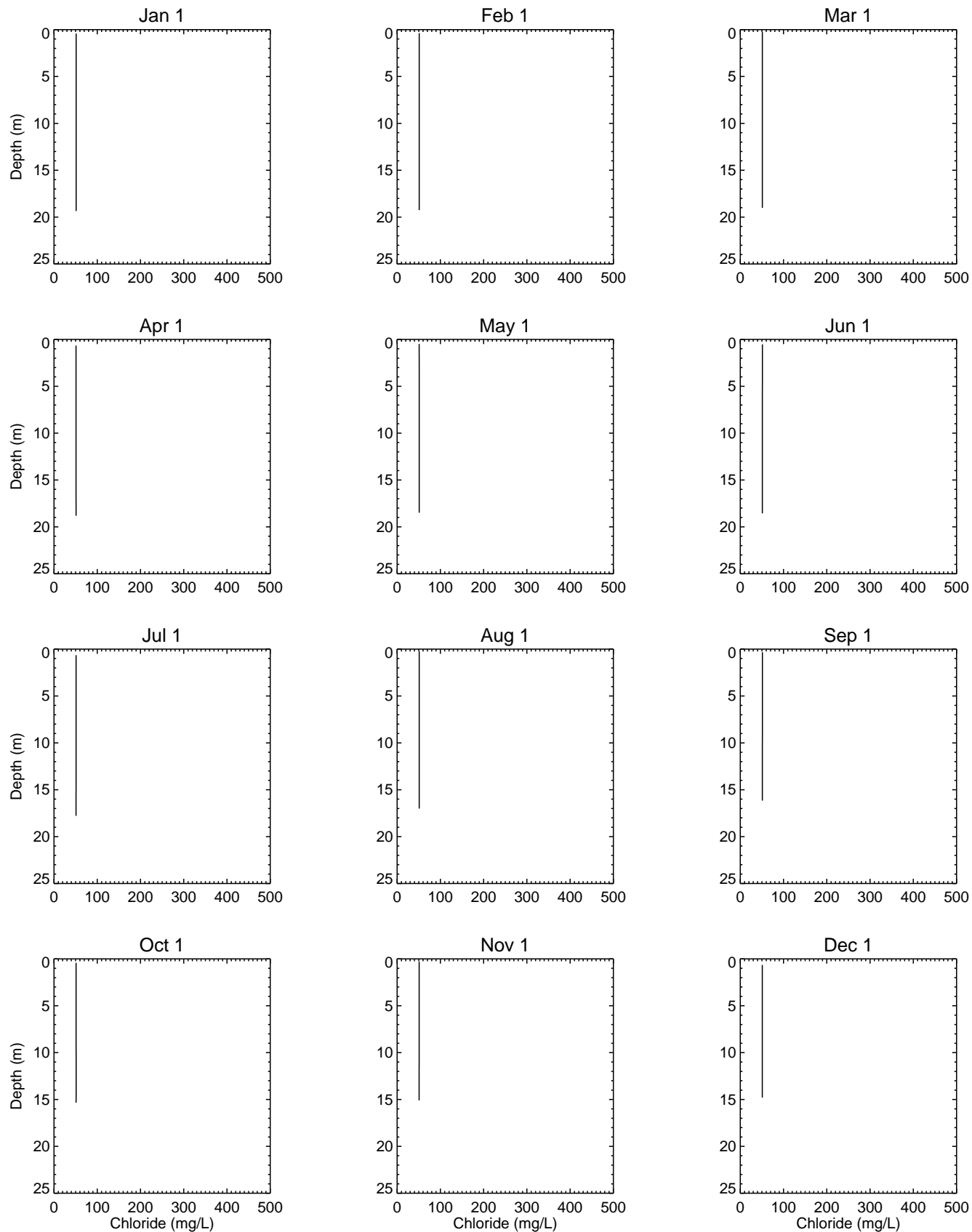**PARSONS**

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m) — Chloride (mg/L)

——— Model (w1210-48)
● Data

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 1992

Profiles shown for dates with available data else model results for first day of month shown.

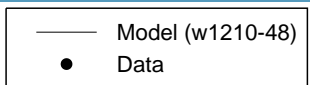CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 1993

Profiles shown for dates with available data else model results for first day of month shown.

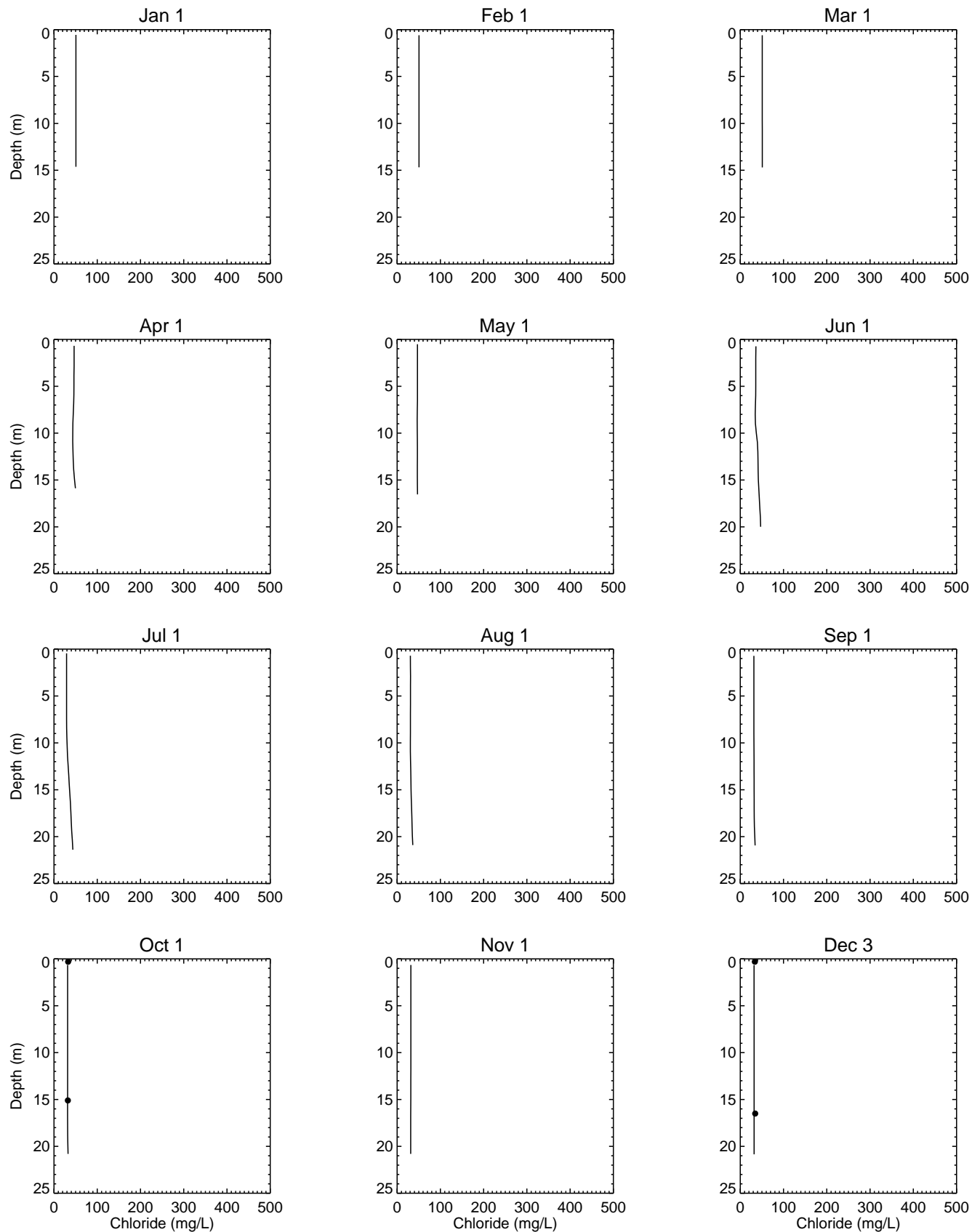CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 Feb 1 Mar 1
Apr 1 May 1 Jun 1
Jul 1 Aug 1 Sep 1
Oct 1 Nov 1 Dec 1

Depth (m)
Chloride (mg/L)

——— Model (w1210-48)
● Data

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 1994

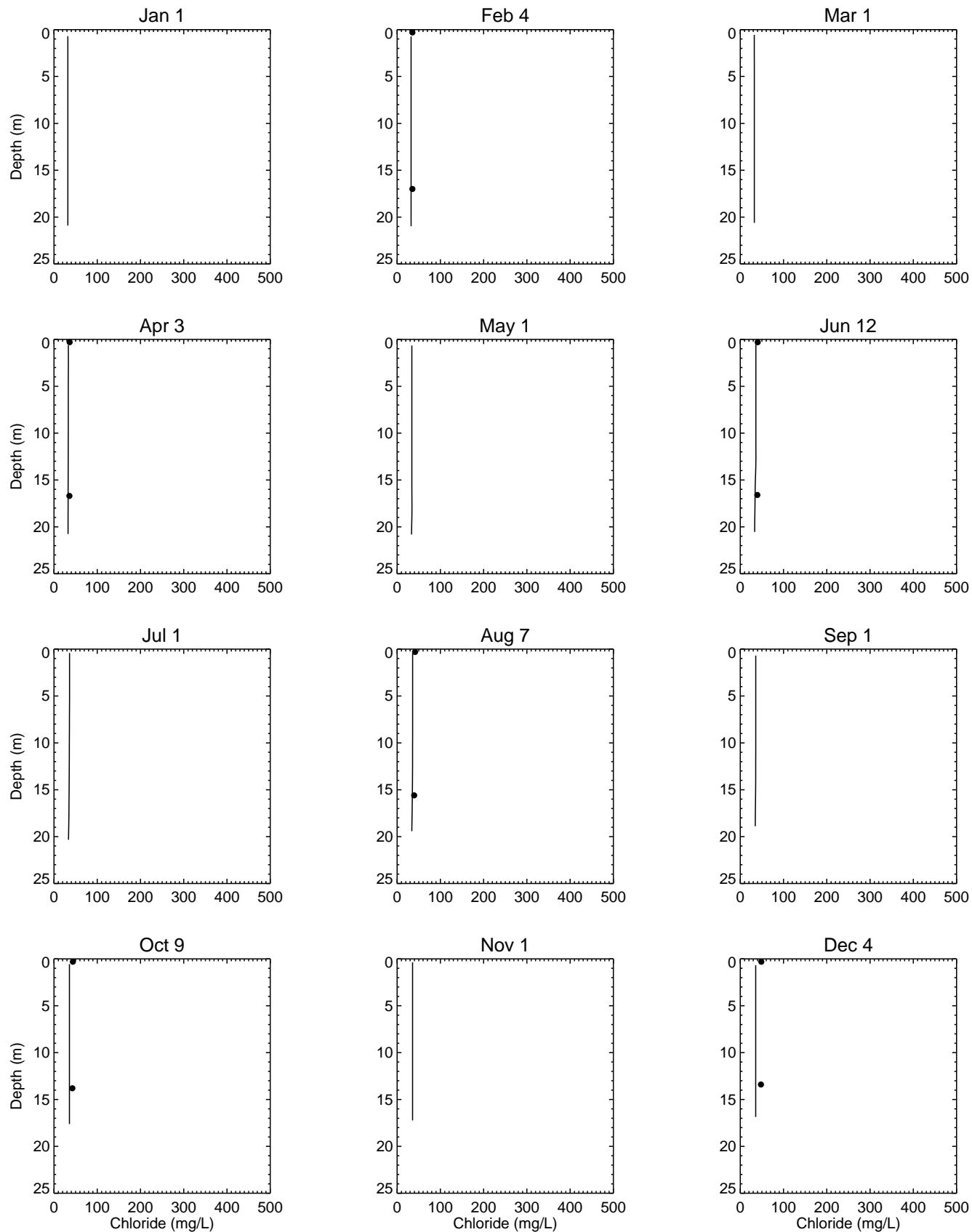*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
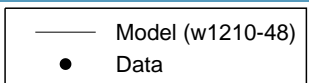
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:21 2013

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 1995

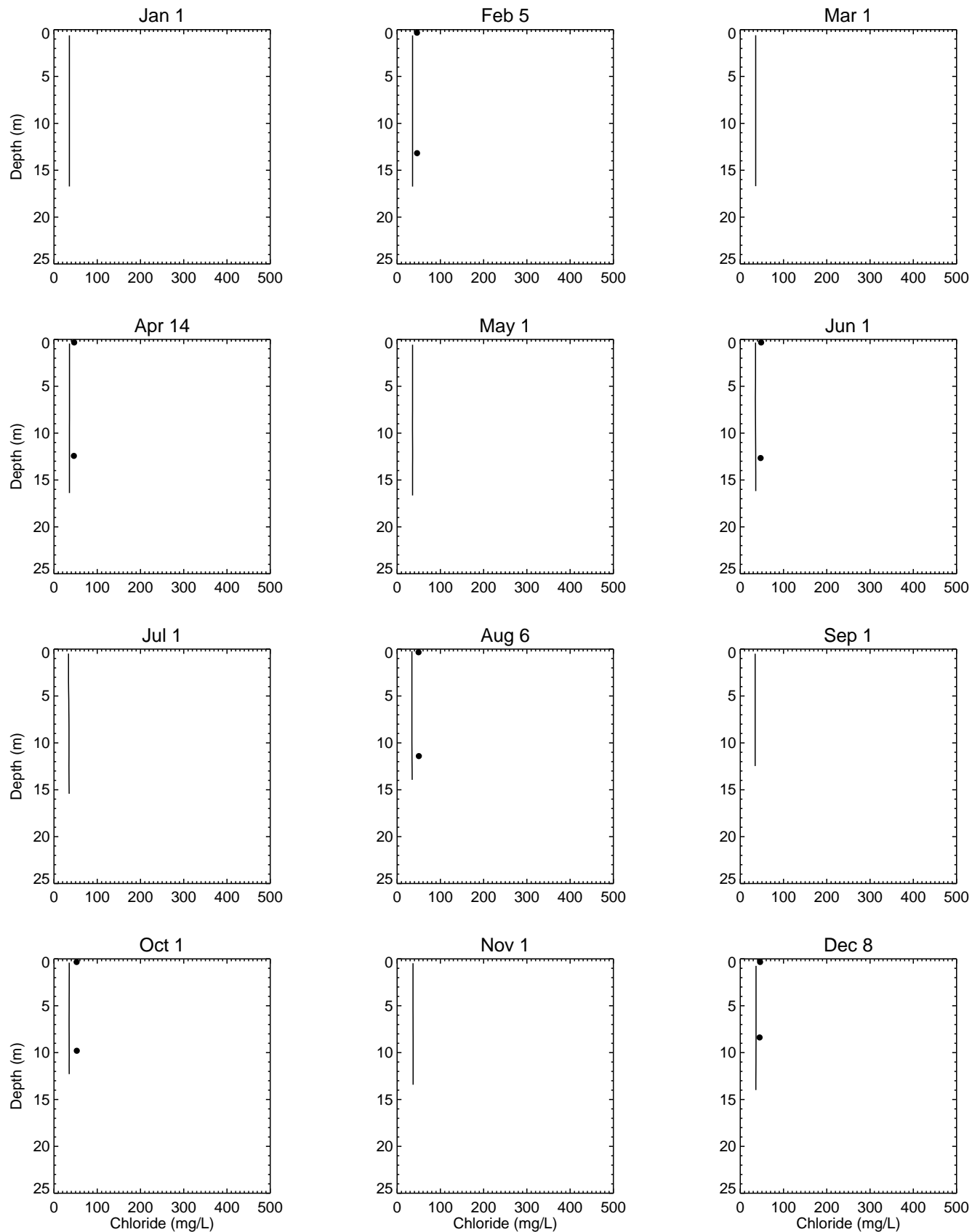*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 1996

Profiles shown for dates with available data else model results for first day of month shown.

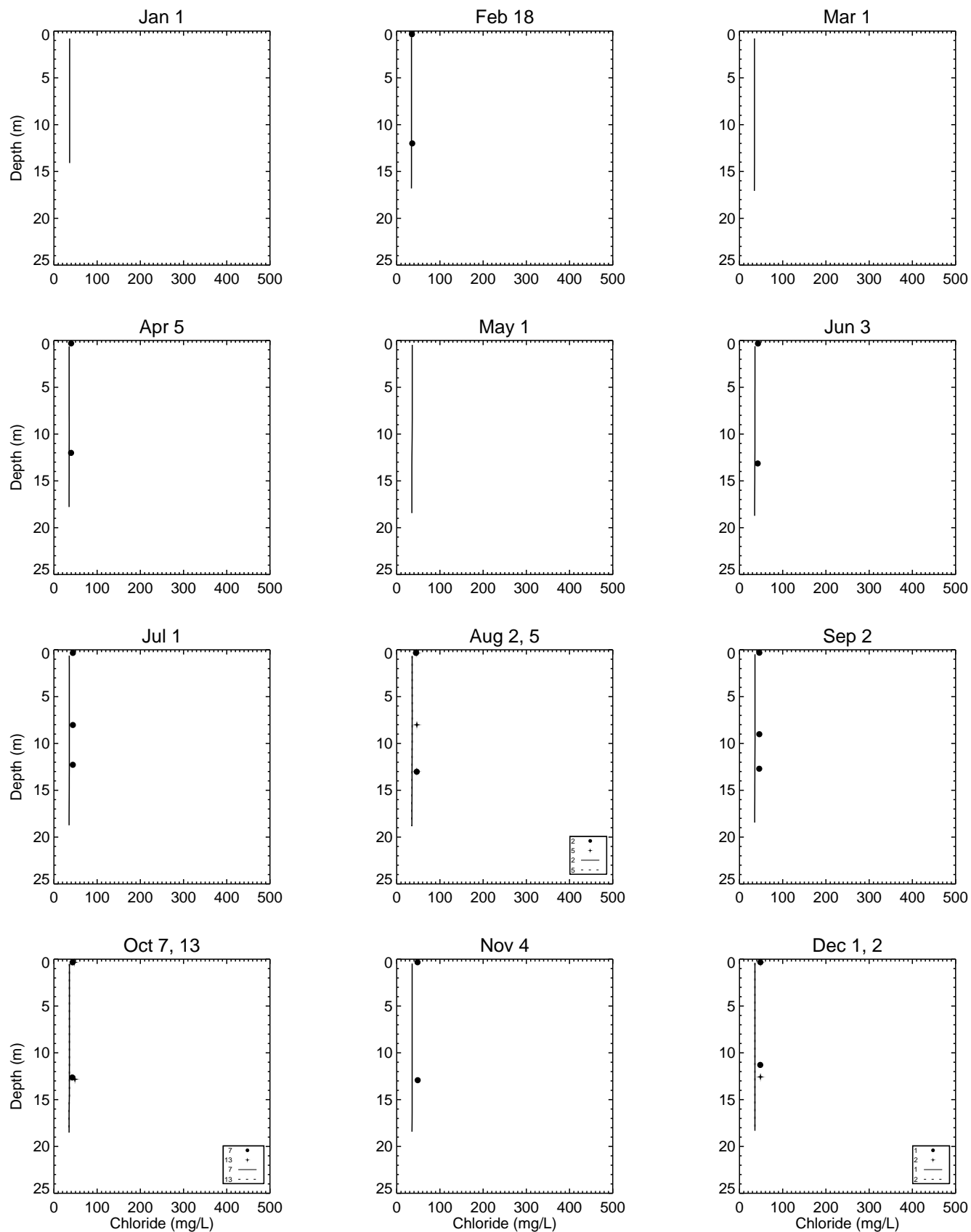CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 1997

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

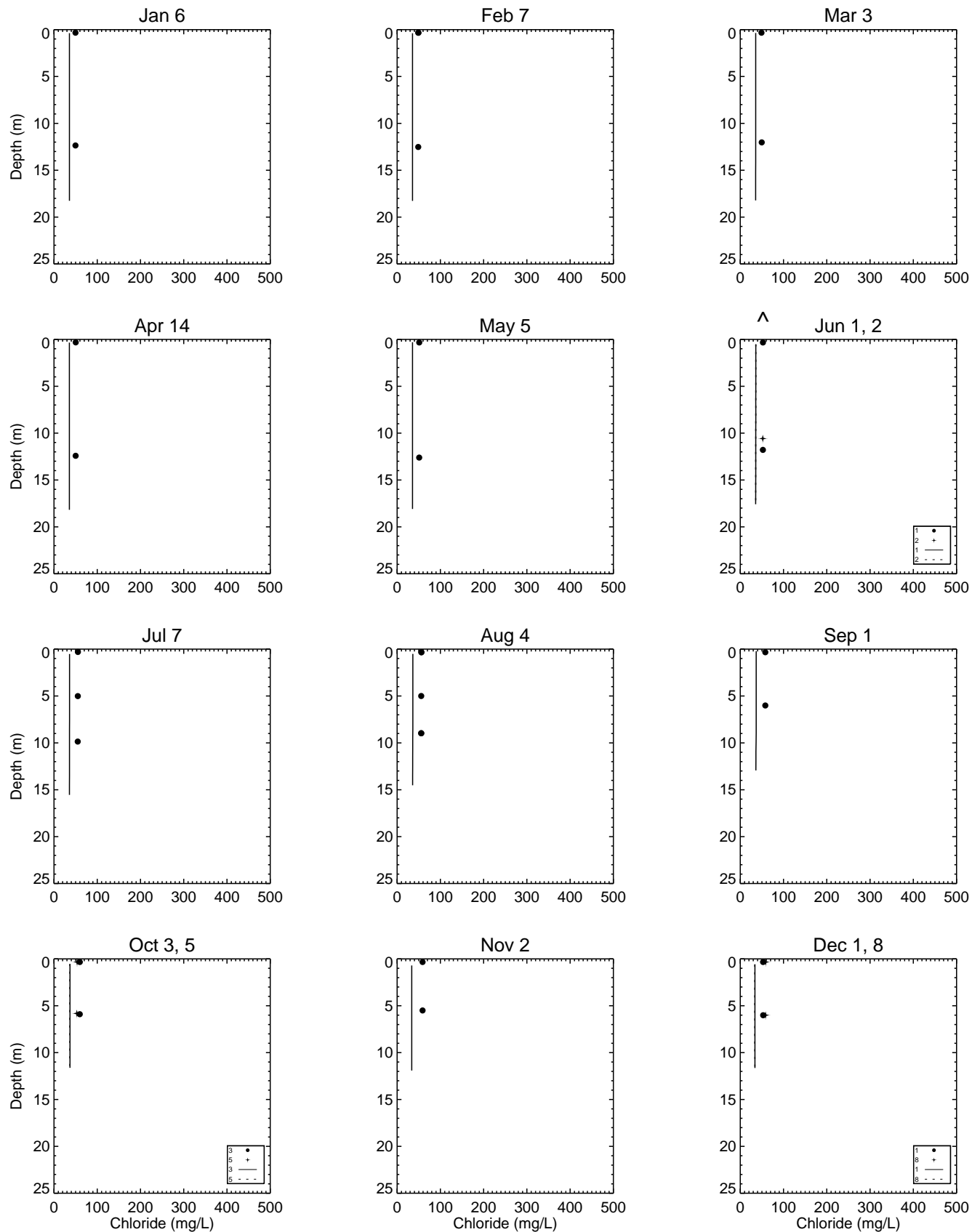Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:21 2013

Jan 1   Feb 1   Mar 1

Apr 1   May 1   Jun 1

Jul 1   Aug 1   Sep 1

Oct 1   Nov 1   Dec 1

—— Model (w1210-48)

● Data

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 1998

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
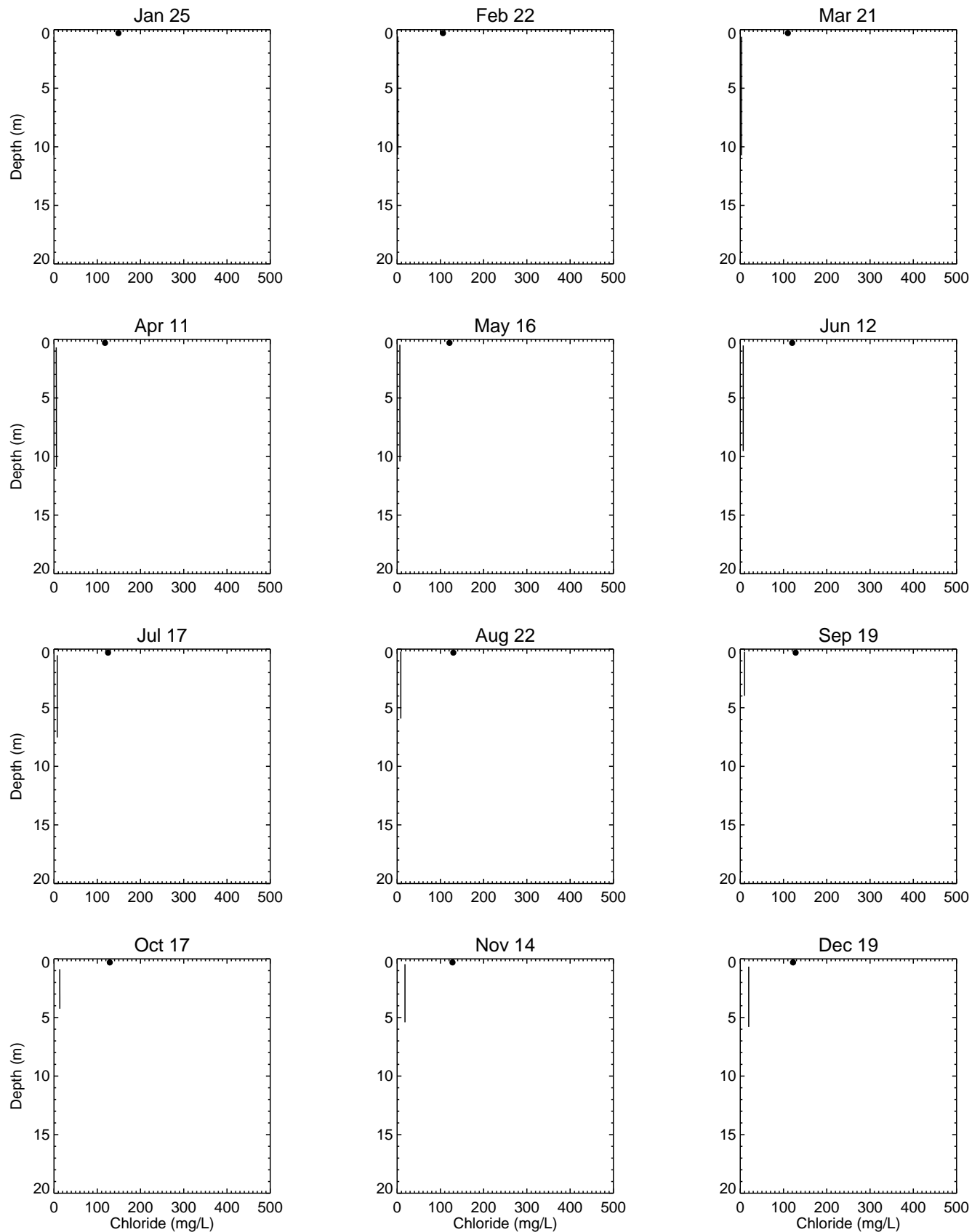
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
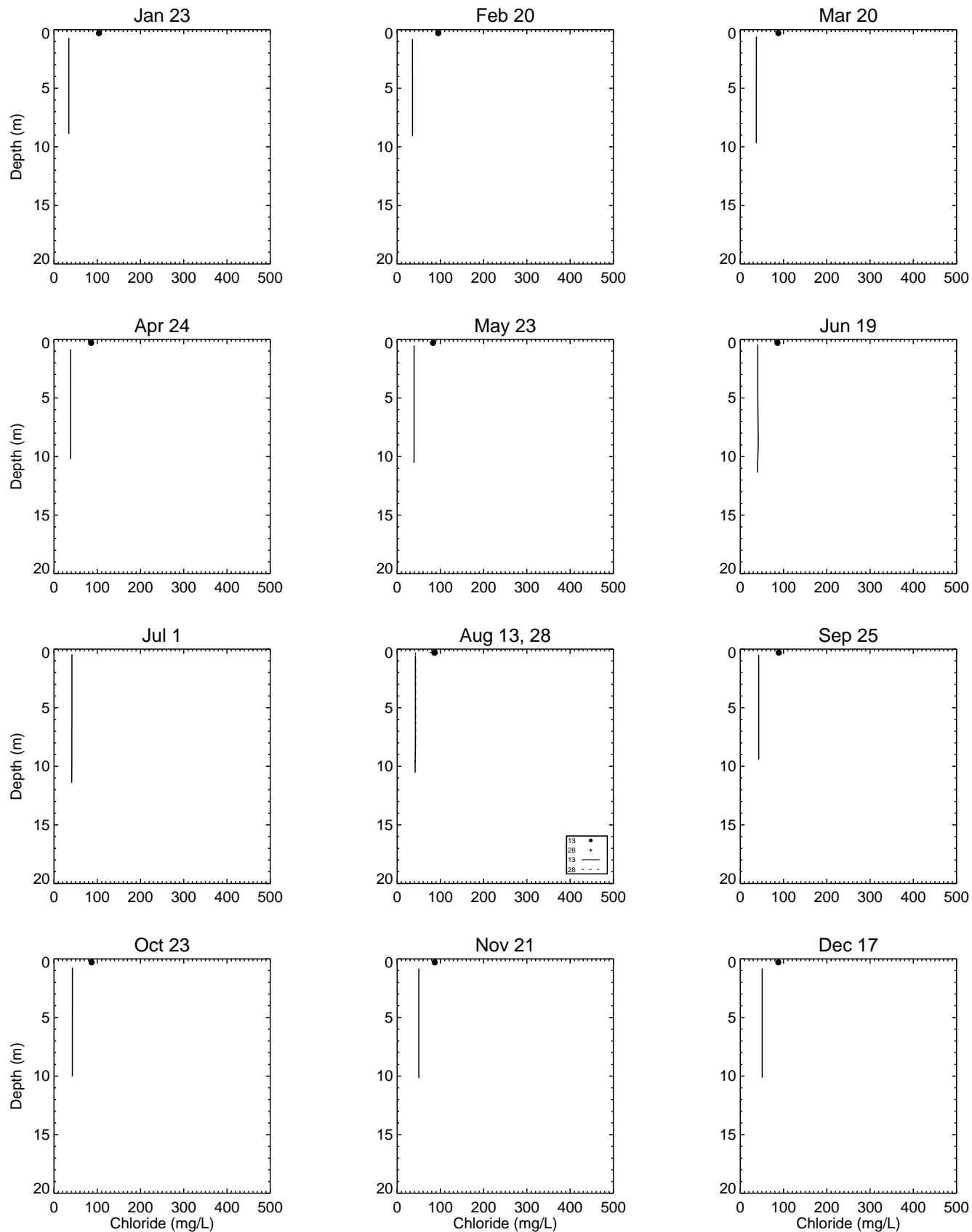Fri Jan 25 18:14:21 2013

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 1999

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 2000

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
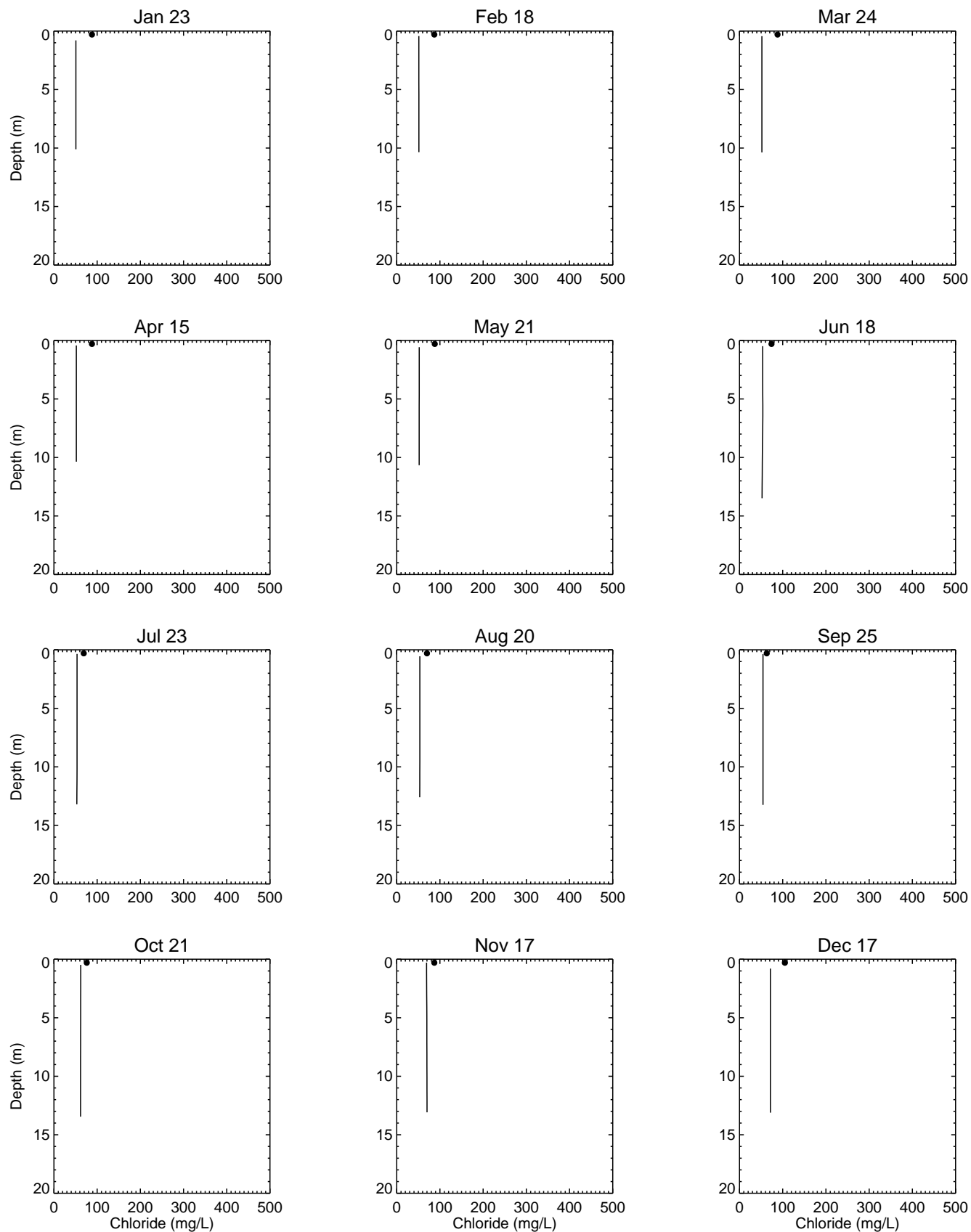Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Chloride (mg/L)
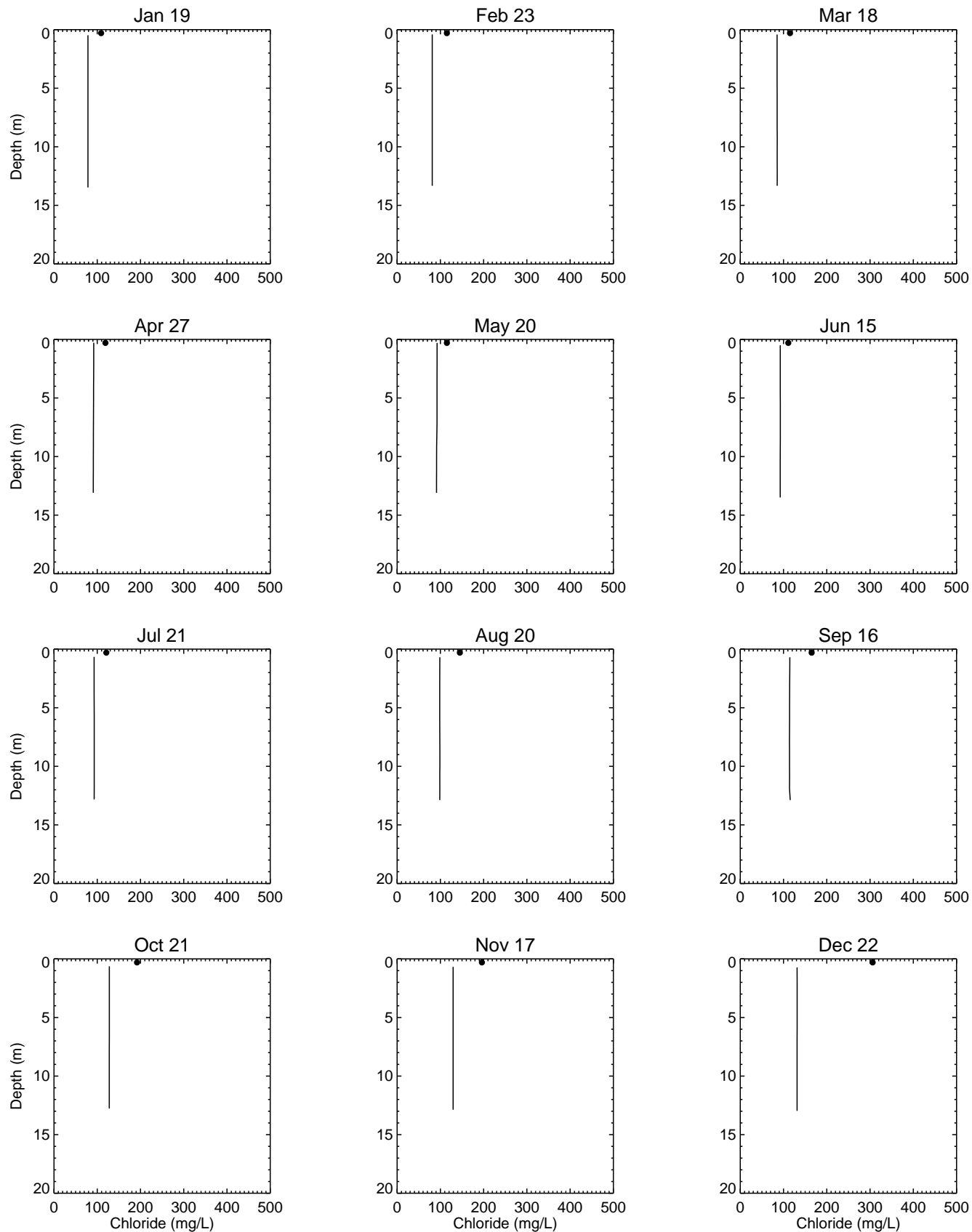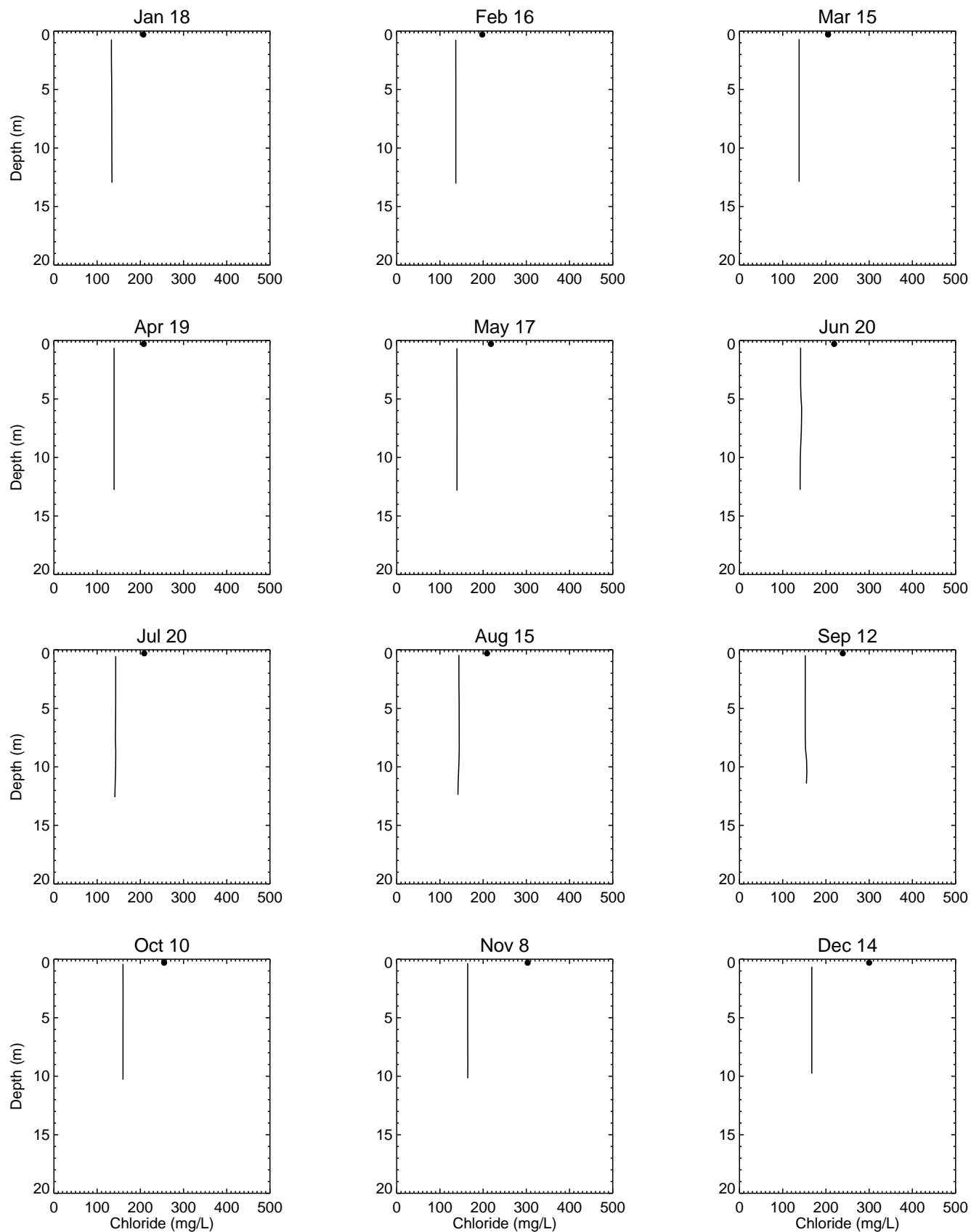
——— Model (w1210-48)
●   Data

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 2001

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:21 2013

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan at Golden Beach (Segment 26) - Chloride - 2002

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 | Feb 1 | Mar 1
Apr 1 | May 1 | Jun 1
Jul 1 | Aug 1 | Sep 1
Oct 1 | Nov 1 | Dec 1

Depth (m) vs Chloride (mg/L)
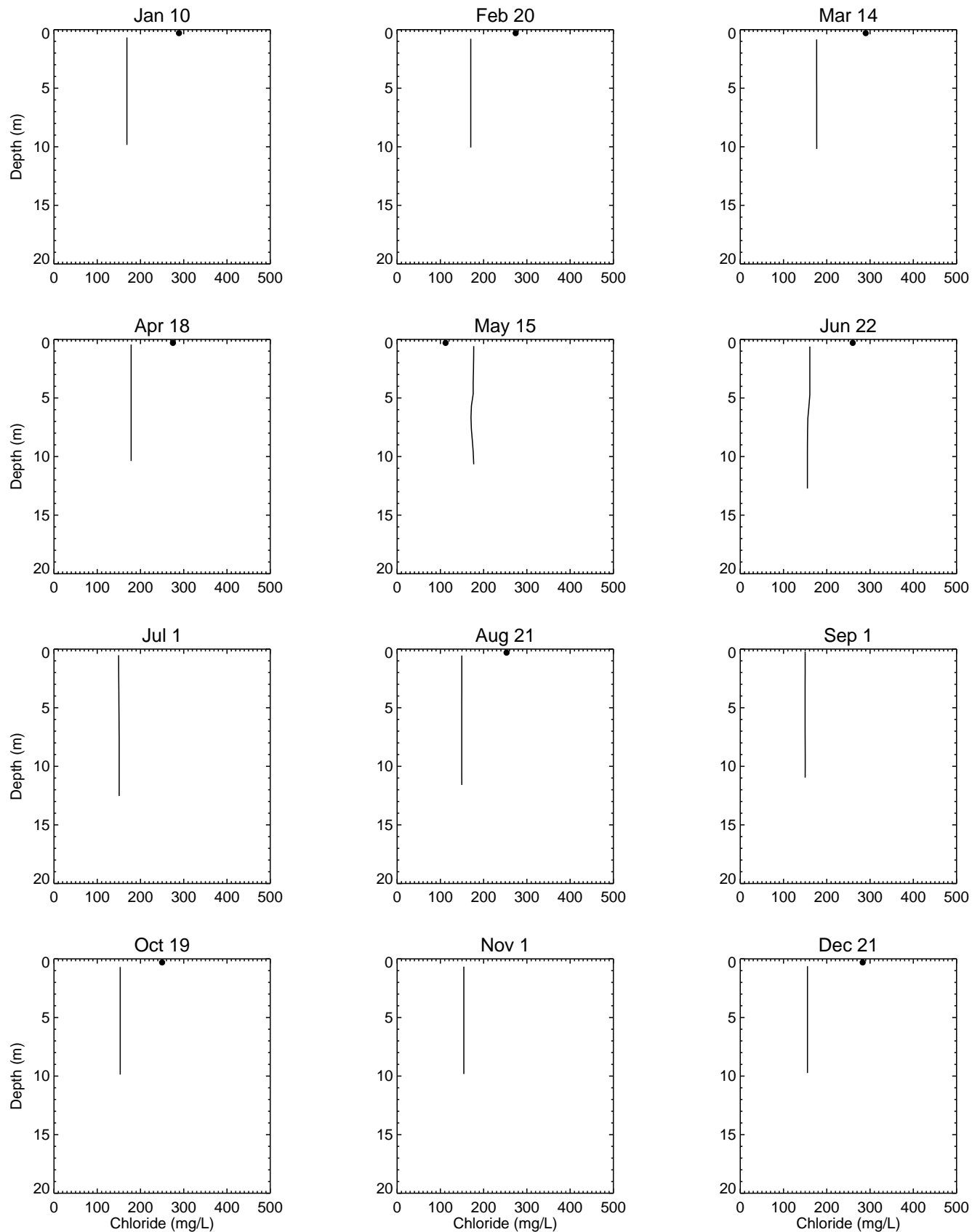
——— Model (w1210-48)
● Data

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
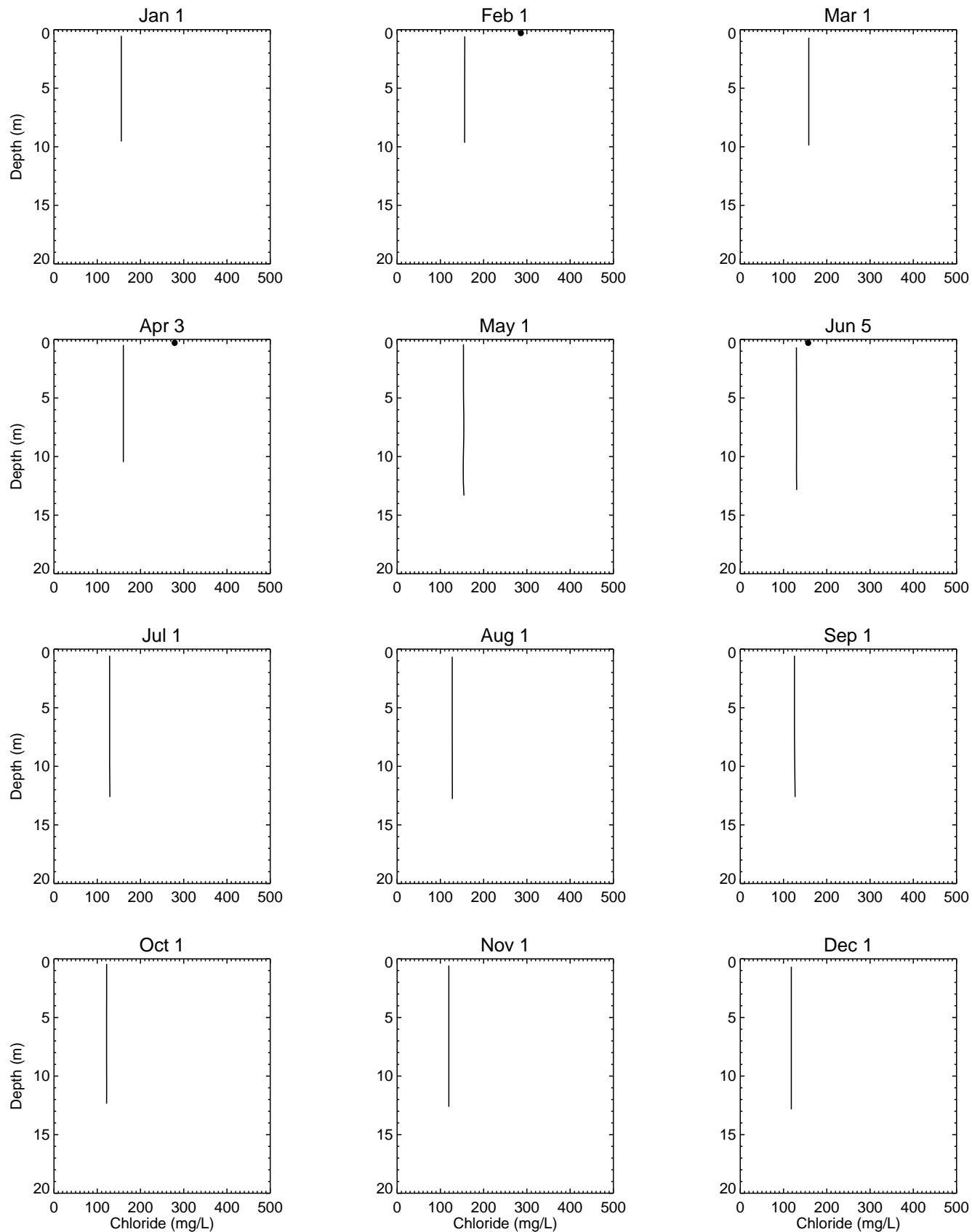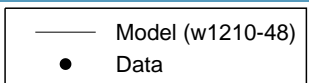at Golden Beach (Segment 26) - Chloride - 2003

Profiles shown for dates with available data else model results for first day of month shown.

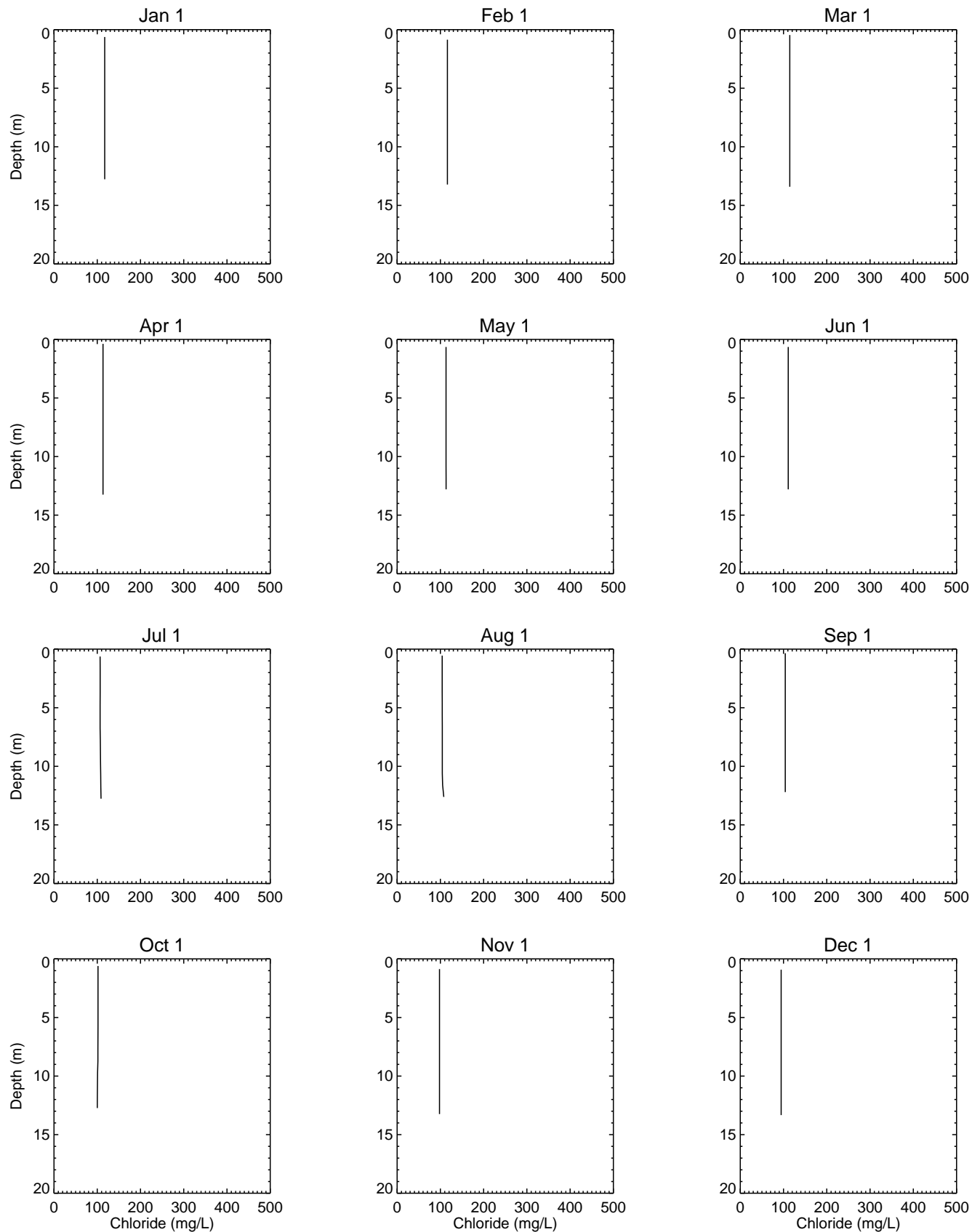CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:22 2013

Jan 1 | Feb 1 | Mar 1
Apr 1 | May 1 | Jun 1
Jul 1 | Aug 1 | Sep 1
Oct 1 | Nov 1 | Dec 1

Depth (m) vs Chloride (mg/L)

———— Model (w1210-48)
● Data

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 2004

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR
QEA
PARSONS

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:22 2013

Jan 1 | Feb 1 | Mar 1
Apr 1 | May 1 | Jun 1
Jul 1 | Aug 1 | Sep 1
Oct 1 | Nov 1 | Dec 1

Depth (m)

Chloride (mg/L)

——— Model (w1210-48)
● Data

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 2005

Profiles shown for dates with available data else model results for first day of month shown.
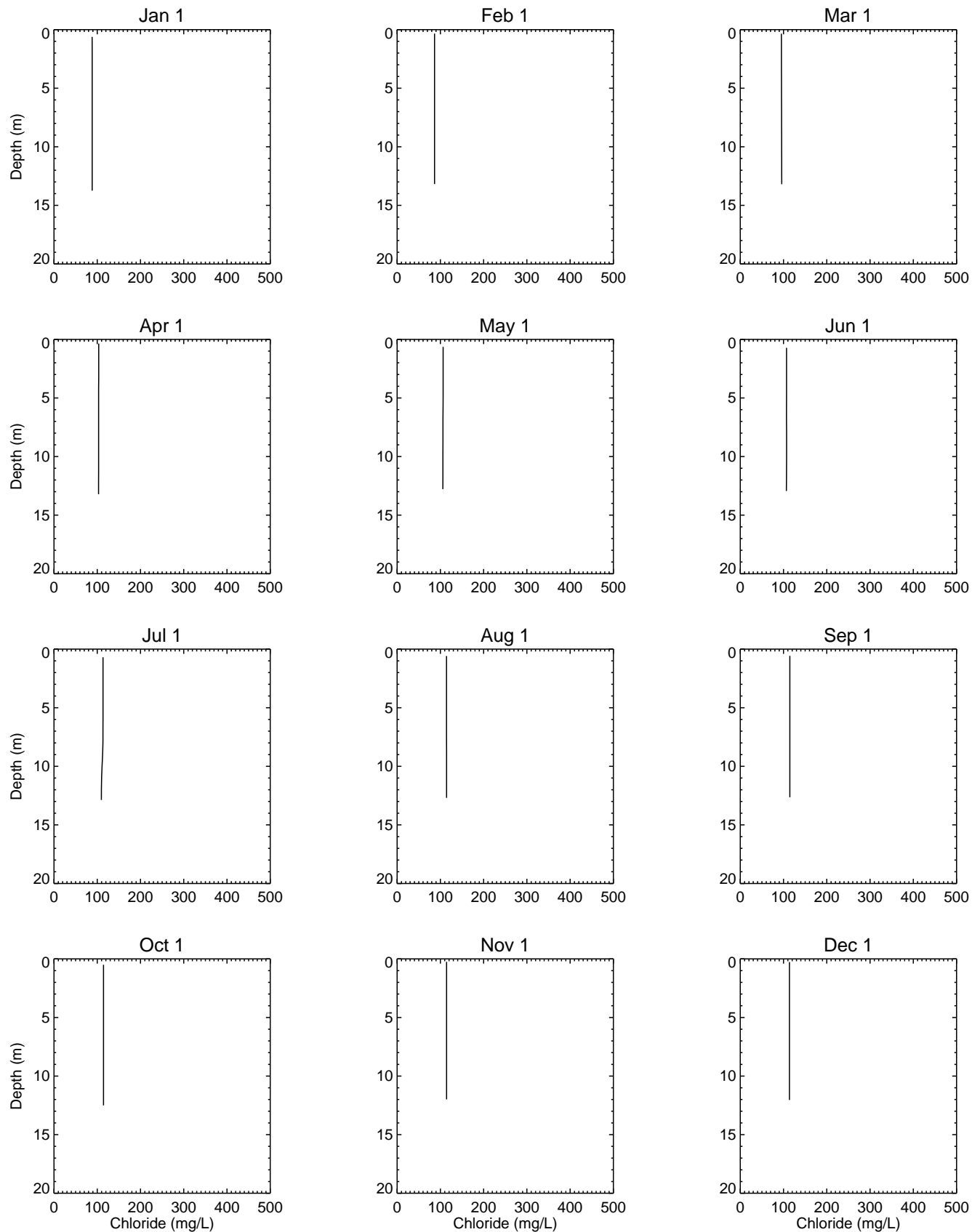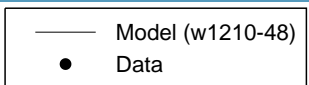
ANCHOR
QEA
PARSONS

CREMs Phase 4: Lake Buchanan

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:22 2013

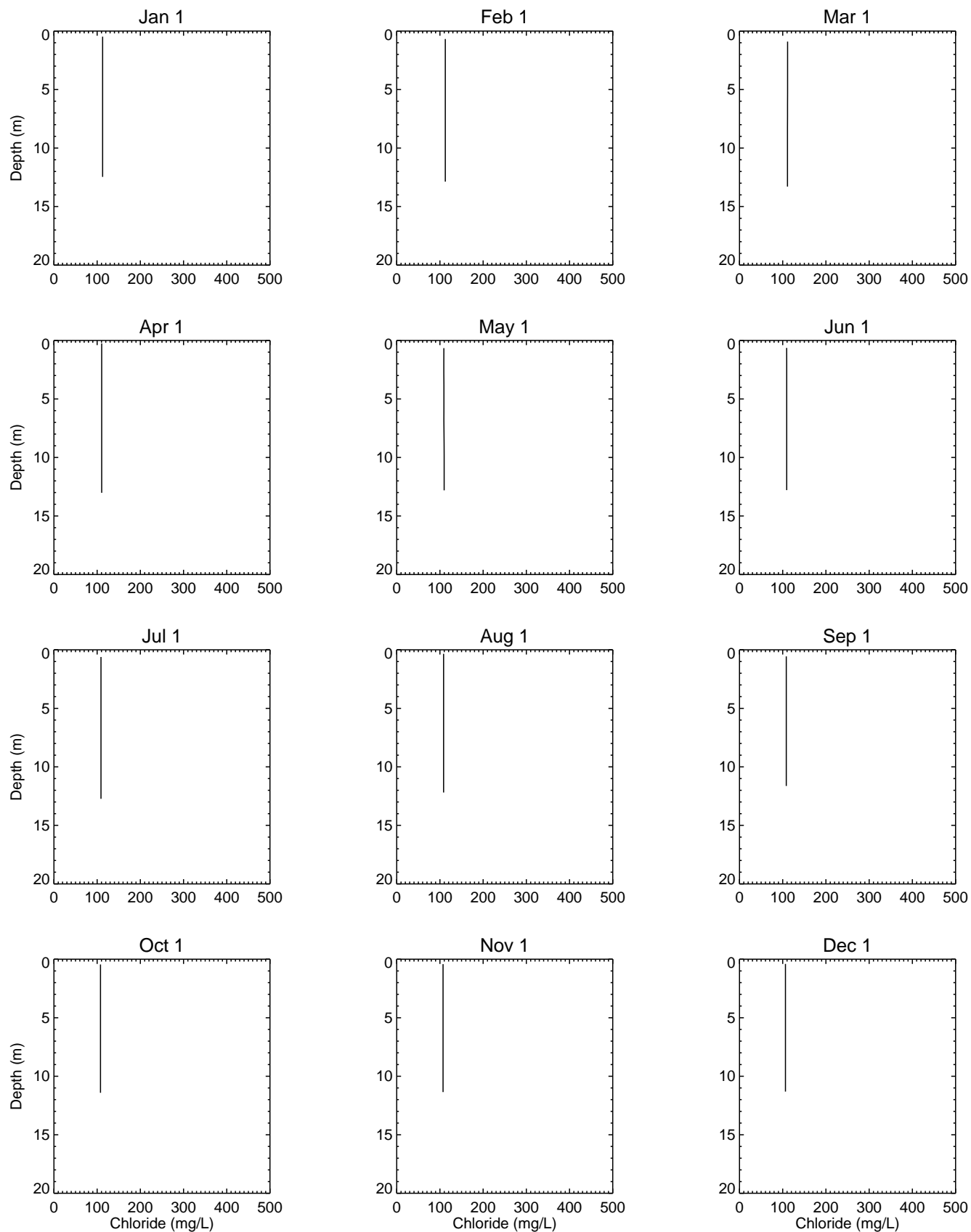Lower Colorado River Authority

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 2006

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1   Feb 1   Mar 1
Apr 1   May 1   Jun 1
Jul 1   Aug 1   Sep 1
Oct 1   Nov 1   Dec 1

Depth (m)

Chloride (mg/L)

—— Model (w1210-48)
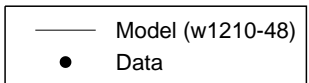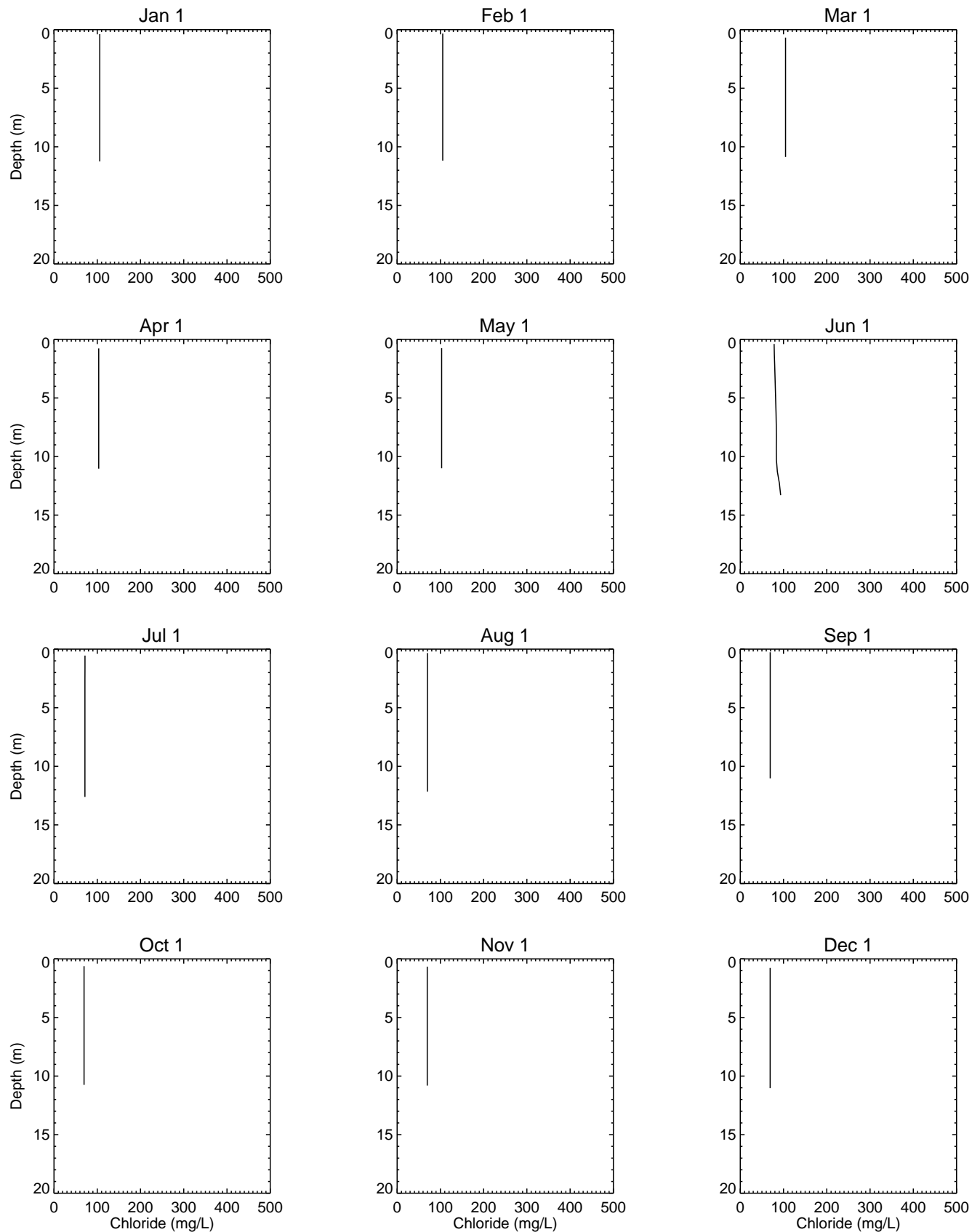●   Data

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 2007

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:22 2013

Lower Colorado River Authority

Jan 1 — Feb 1 — Mar 1

Apr 1 — May 1 — Jun 1

Jul 1 — Aug 1 — Sep 1

Oct 1 — Nov 1 — Dec 1

Chloride (mg/L)

Depth (m)

—— Model (w1210-48)

● Data

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 2008

Profiles shown for dates with available data else model results for first day of month shown.

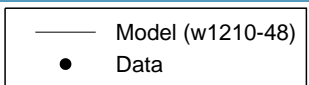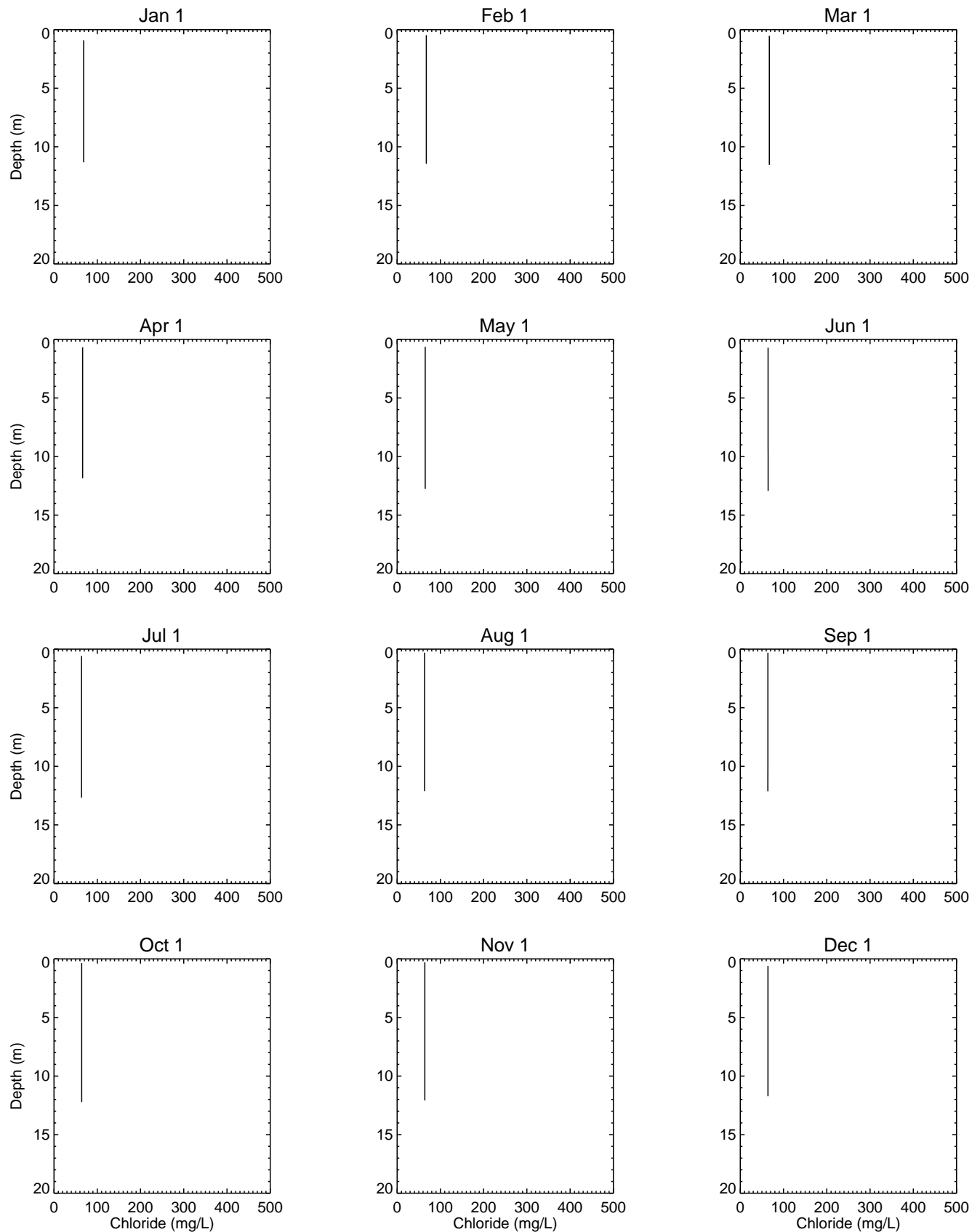CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:22 2013

ANCHOR QEA
PARSONS

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 2009

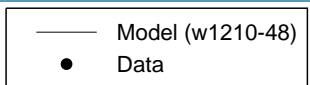*Profiles shown for dates with available data else model results for first day of month shown.*
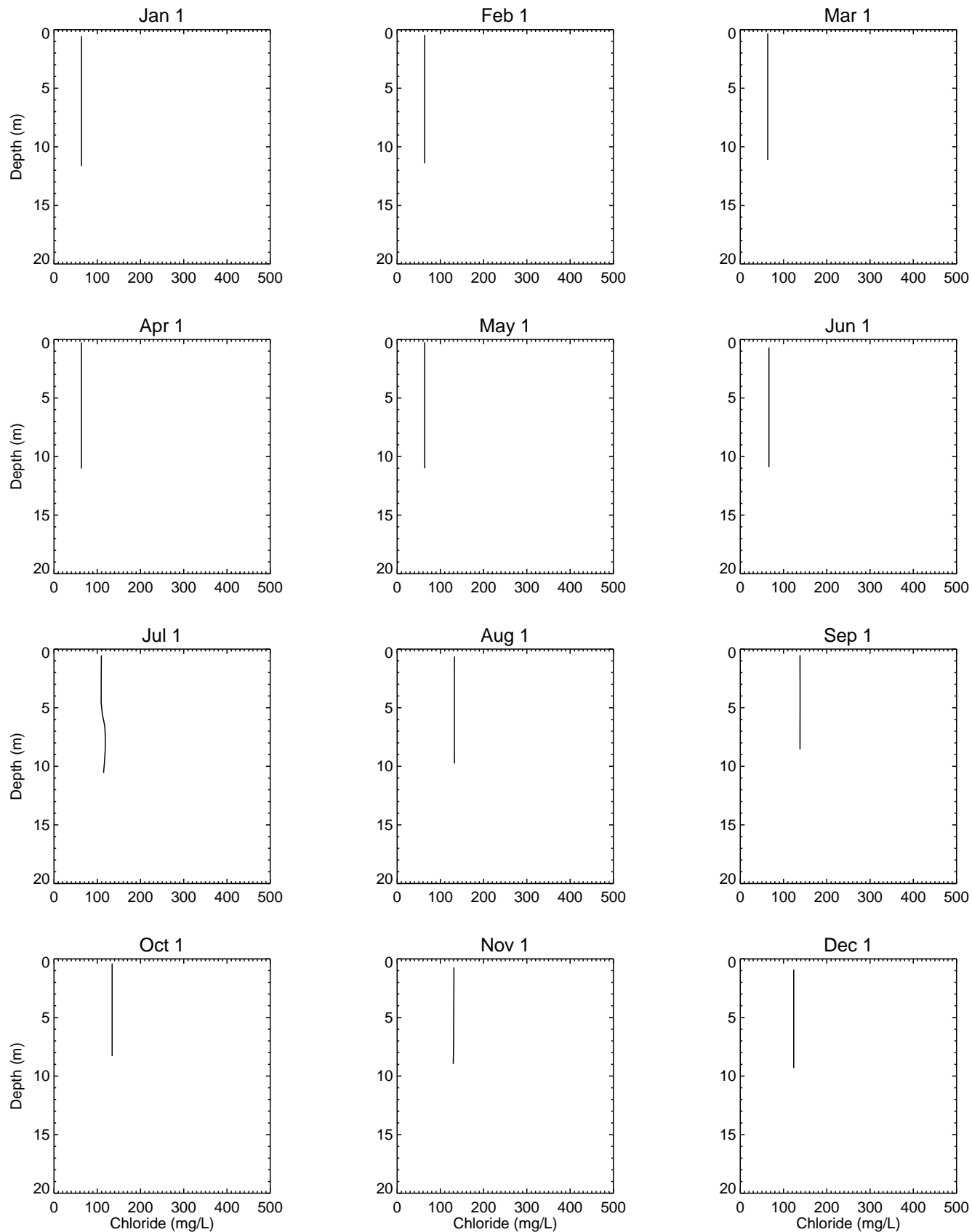
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:14:22 2013

Jan 1   Feb 1   Mar 1

Apr 1   May 1   Jun 1

Jul 1   Aug 5   Sep 2

Oct 7   Nov 4   Dec 2

Depth (m)

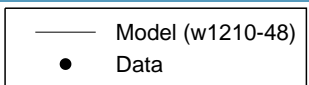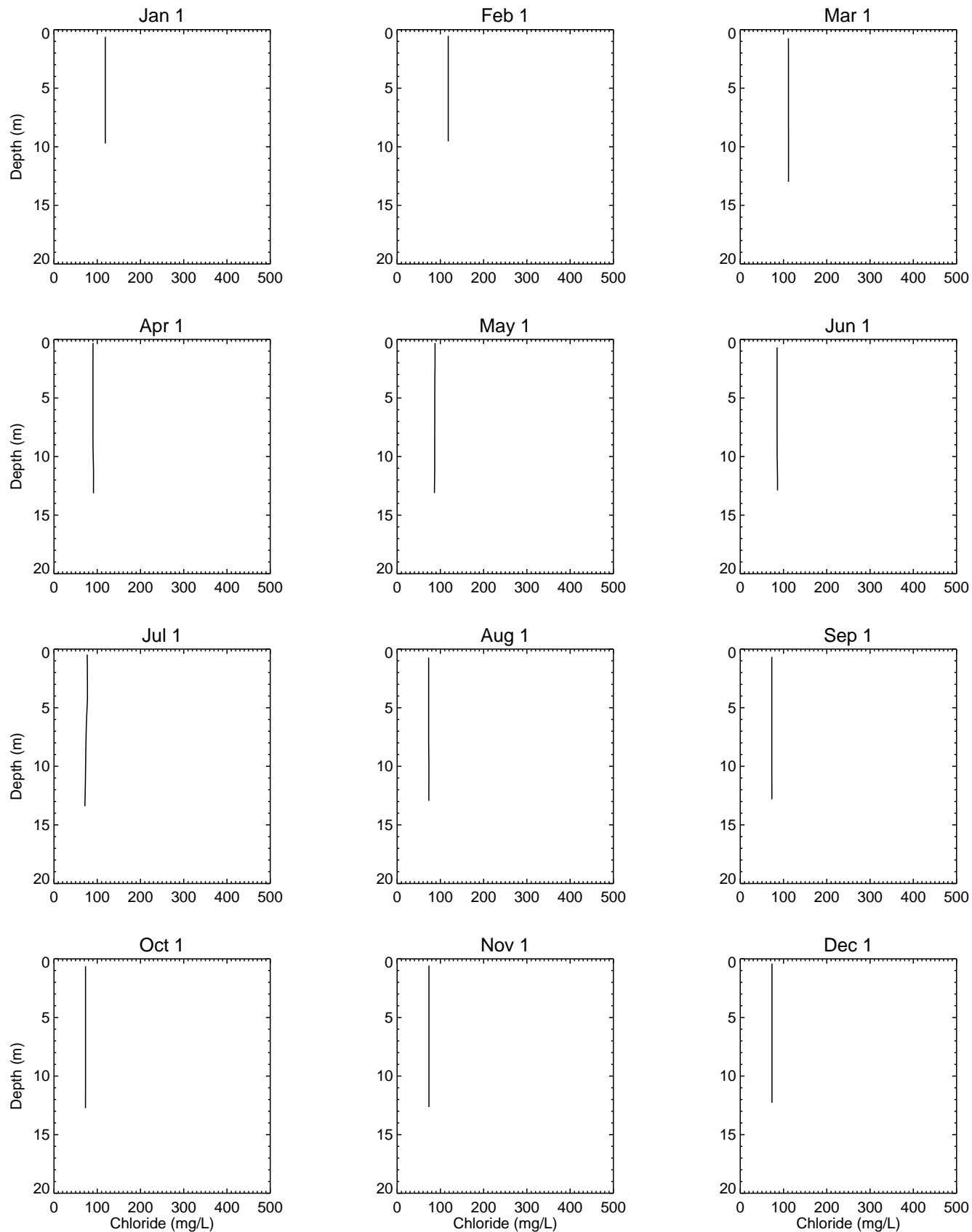Chloride (mg/L)

—— Model (w1210-48)
●   Data

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 2010

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
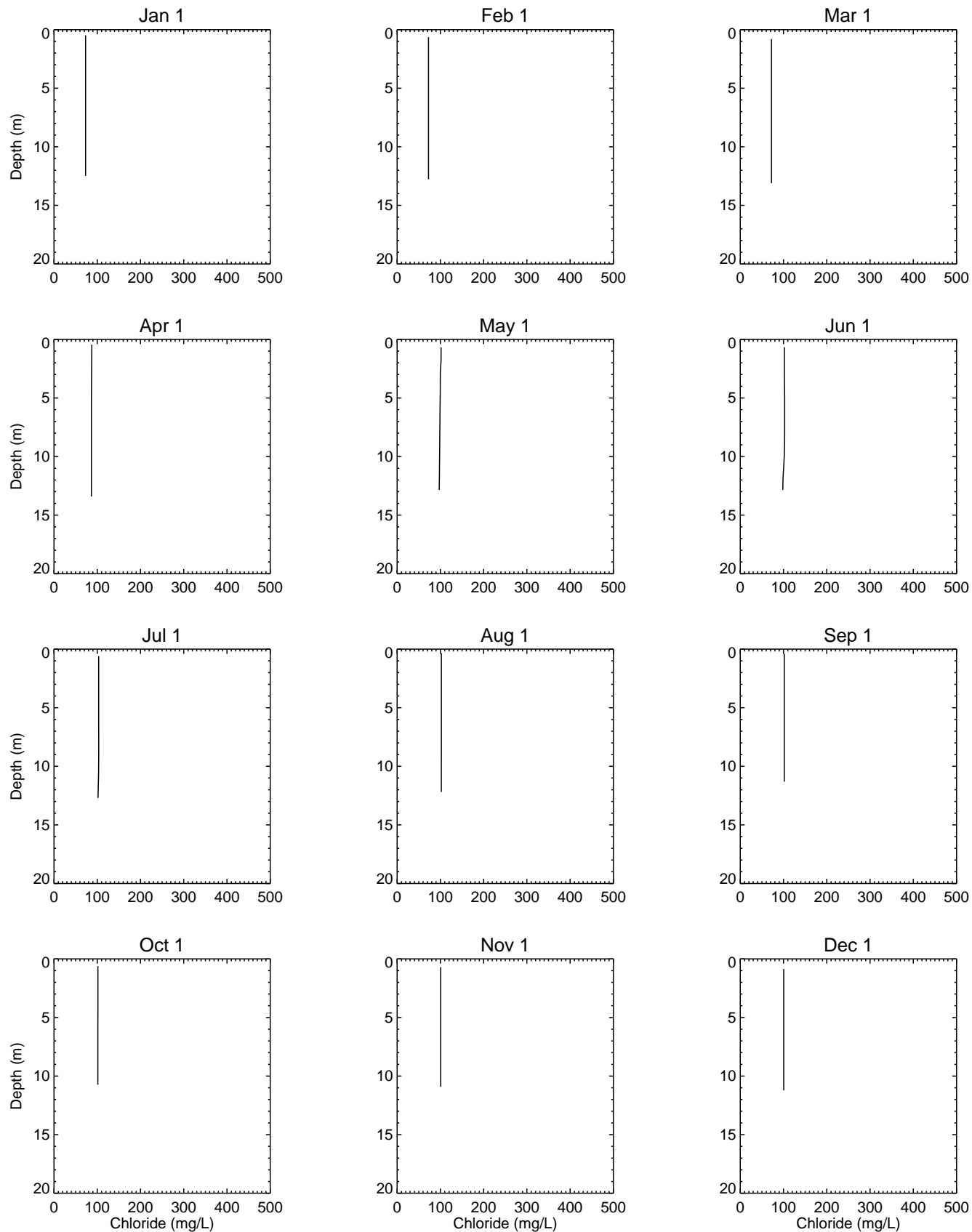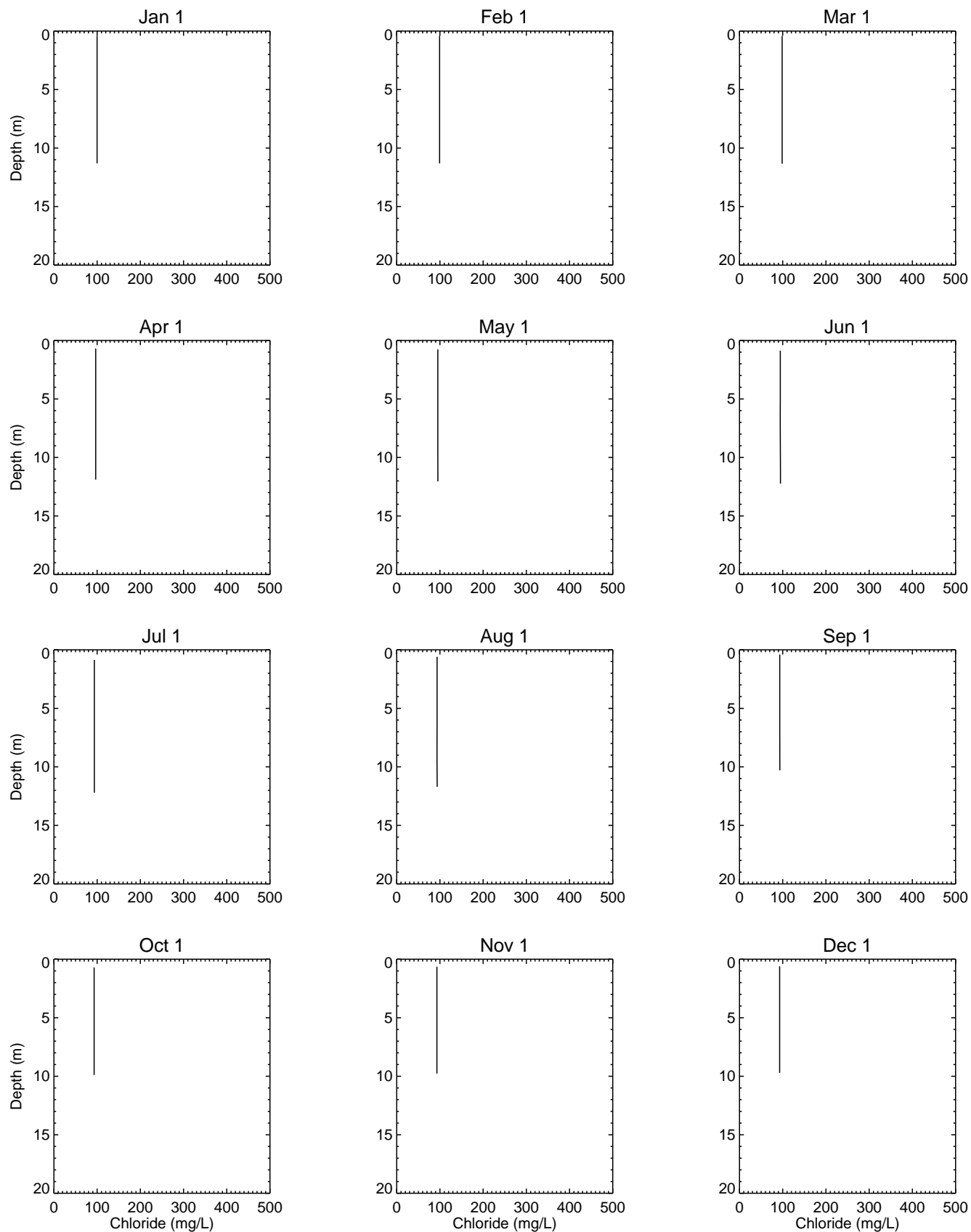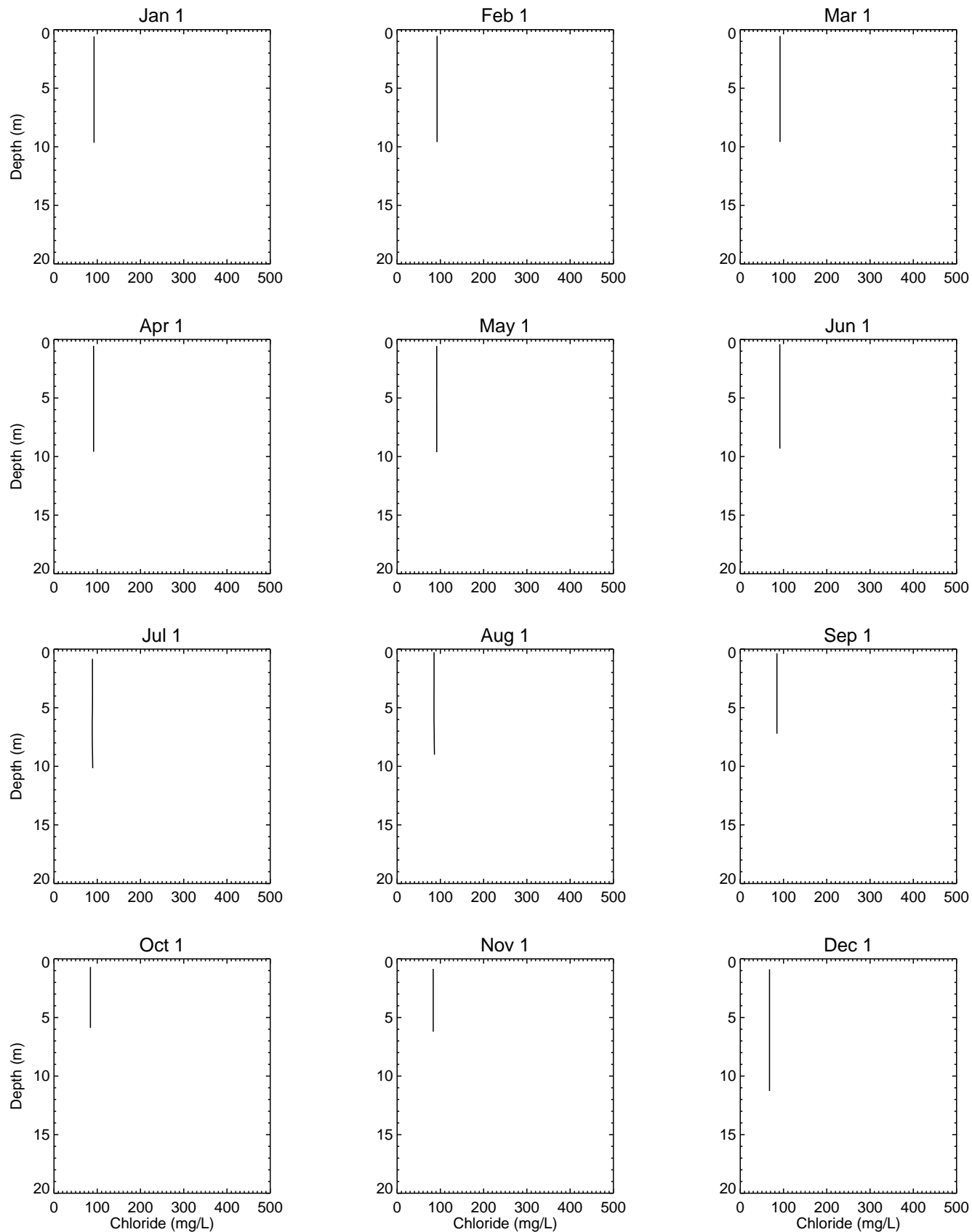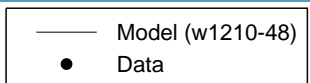Fri Jan 25 18:14:22 2013

Figure G-25

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Chloride - 2011

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 1984

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:35 2013

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 1985

Profiles shown for dates with available data else model results for first day of month shown.

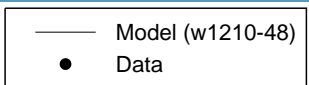CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:35 2013

Jan 23 · Feb 19 · Mar 24 · Apr 15 · May 21 · Jun 18 · Jul 23 · Aug 20 · Sep 25 · Oct 21 · Nov 17 · Dec 17

Depth (m) vs Dissolved Oxygen (mg/L)

Model (w1210-48)
● Data

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 1986

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

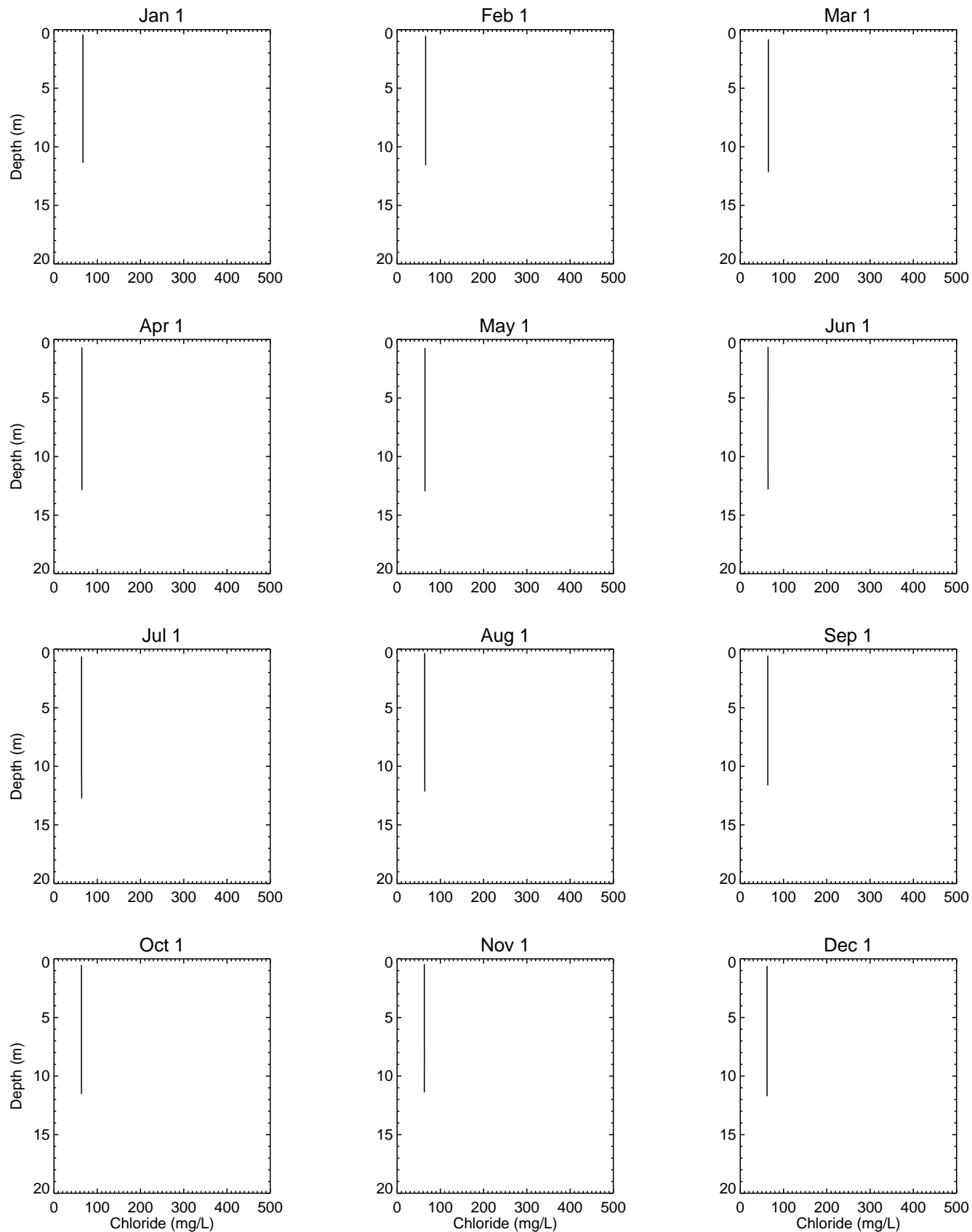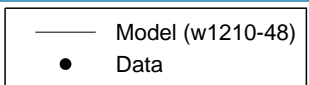EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:35 2013

Jan 19 · Feb 23 · Mar 18 · Apr 27 · May 20 · Jun 15 · Jul 21 · Aug 20 · Sep 16 · Oct 21 · Nov 17 · Dec 22

Dissolved Oxygen (mg/L)

—— Model (w1210-48)
● Data

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 1987

Profiles shown for dates with available data else model results for first day of month shown.

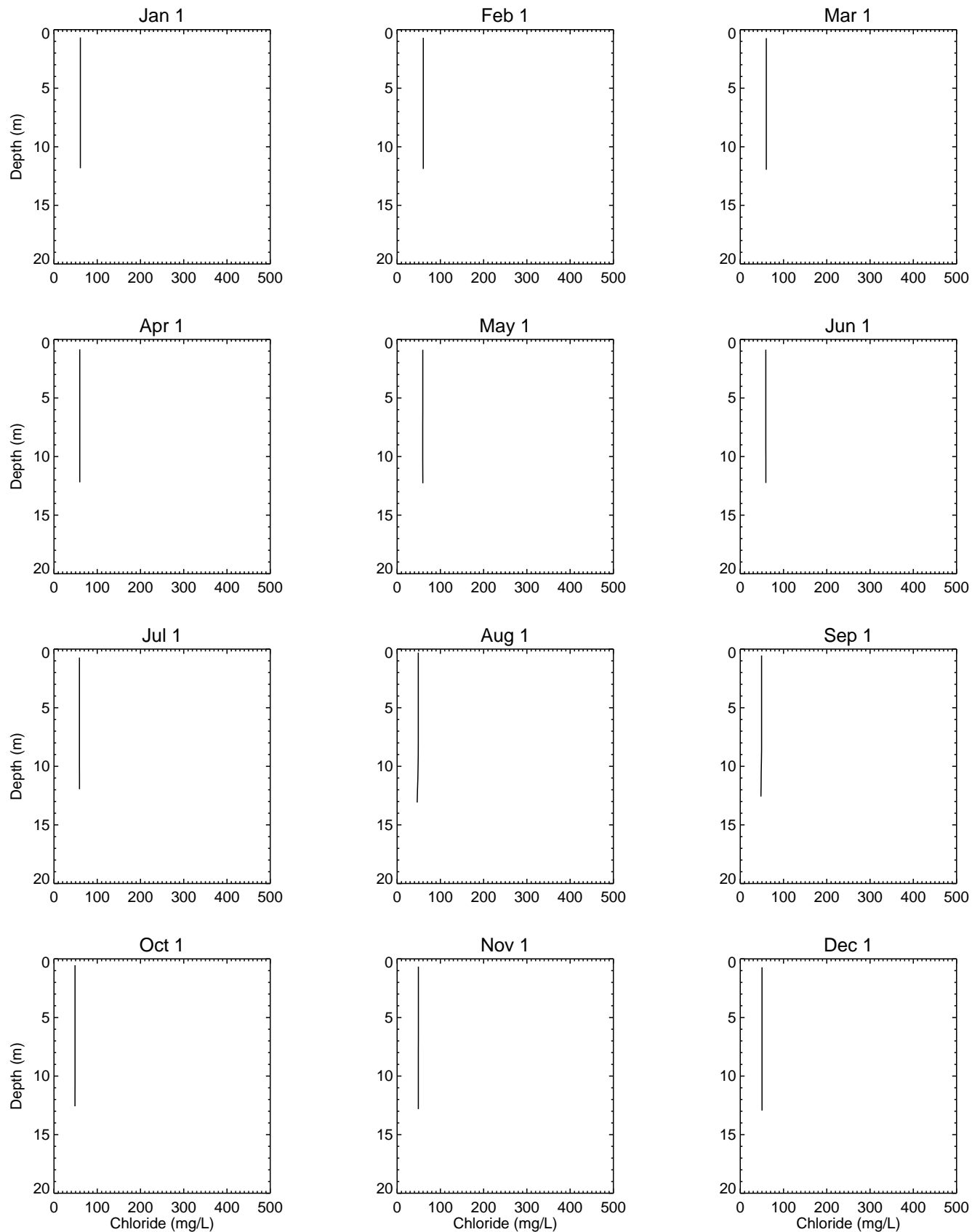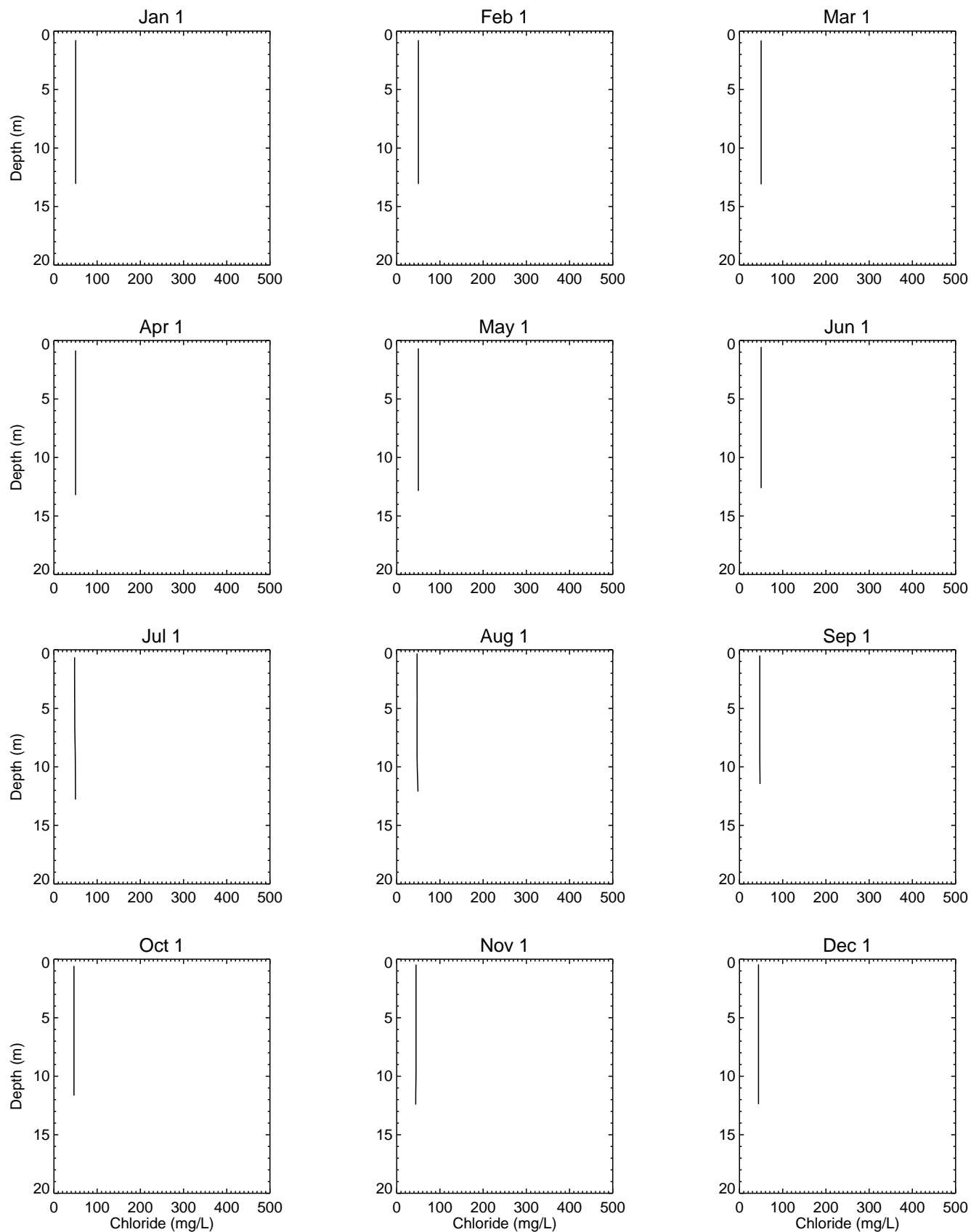CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:35 2013

Jan 18 Feb 16 Mar 15
Apr 19 May 17 Jun 20
Jul 20 Aug 15 Sep 12
Oct 10 Nov 8 Dec 14

Dissolved Oxygen (mg/L)

—— Model (w1210-48)
● Data

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 1988

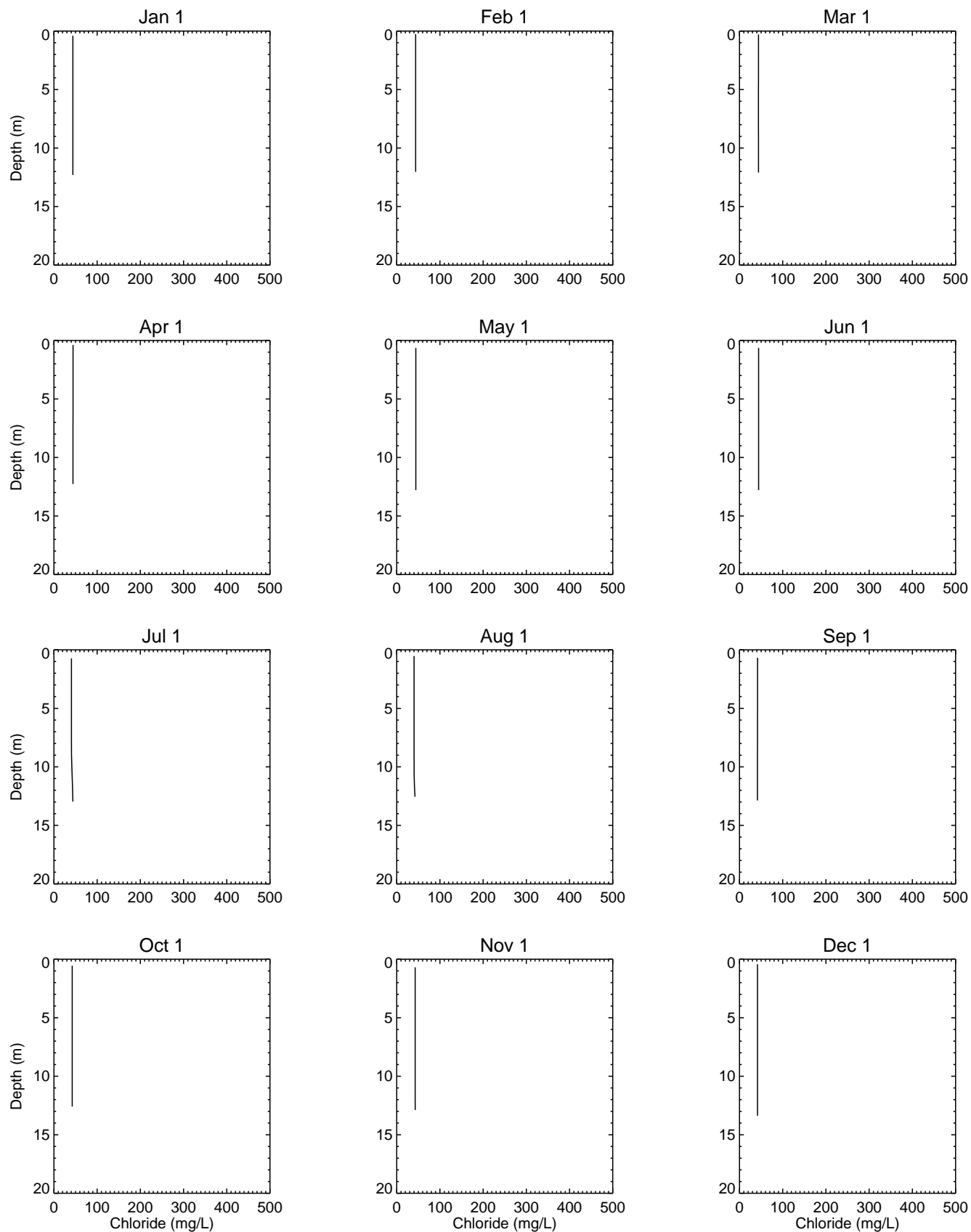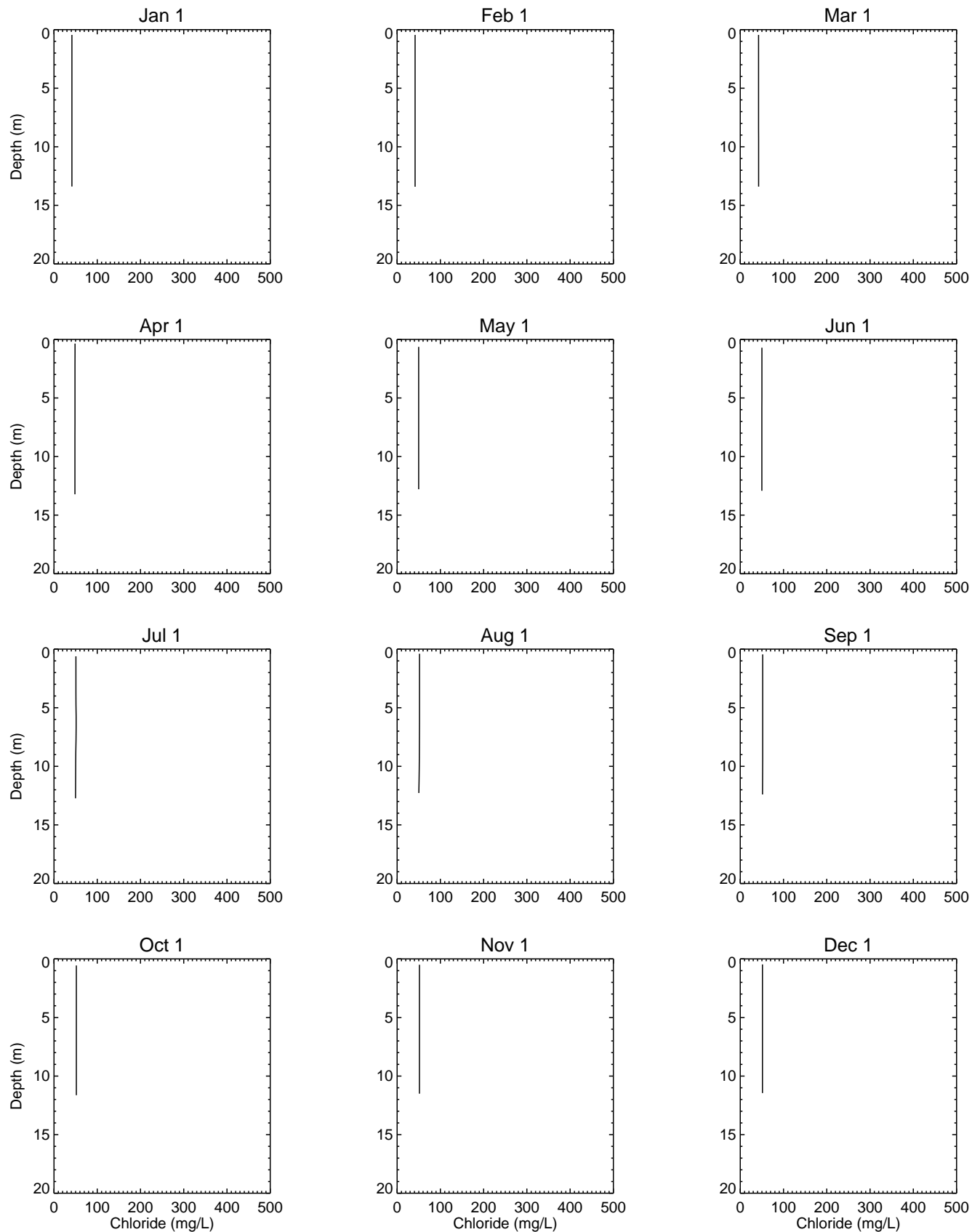*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:35 2013

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
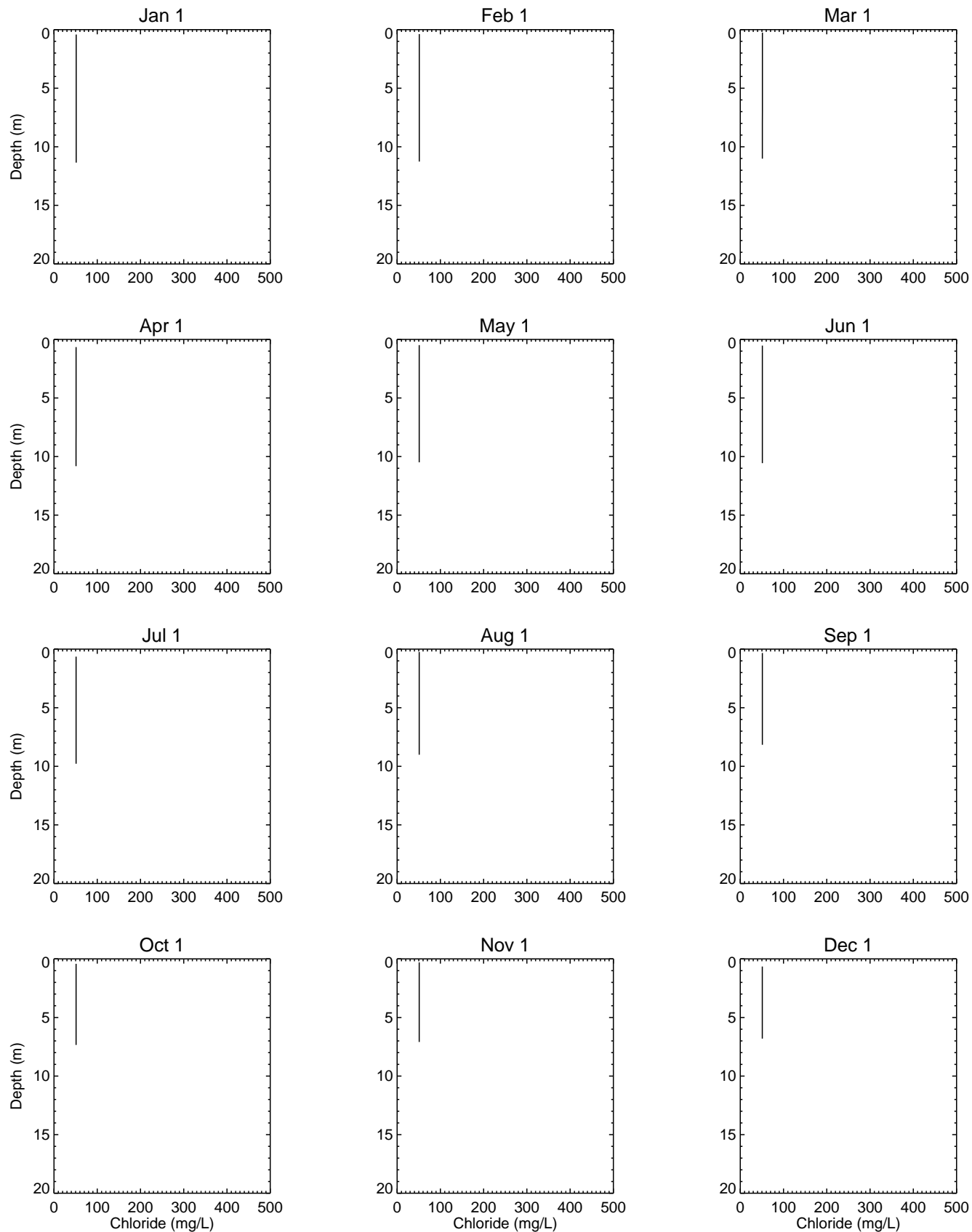near Buchanan Dam (Segment 13) - Dissolved Oxygen - 1989

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 3 · May 1 · Jun 5 · Jul 1 · Aug 21 · Sep 1 · Oct 22 · Nov 1 · Dec 20

Depth (m)

Dissolved Oxygen (mg/L)

—— Model (w1210-48)
● Data

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 1990

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA PARSONS
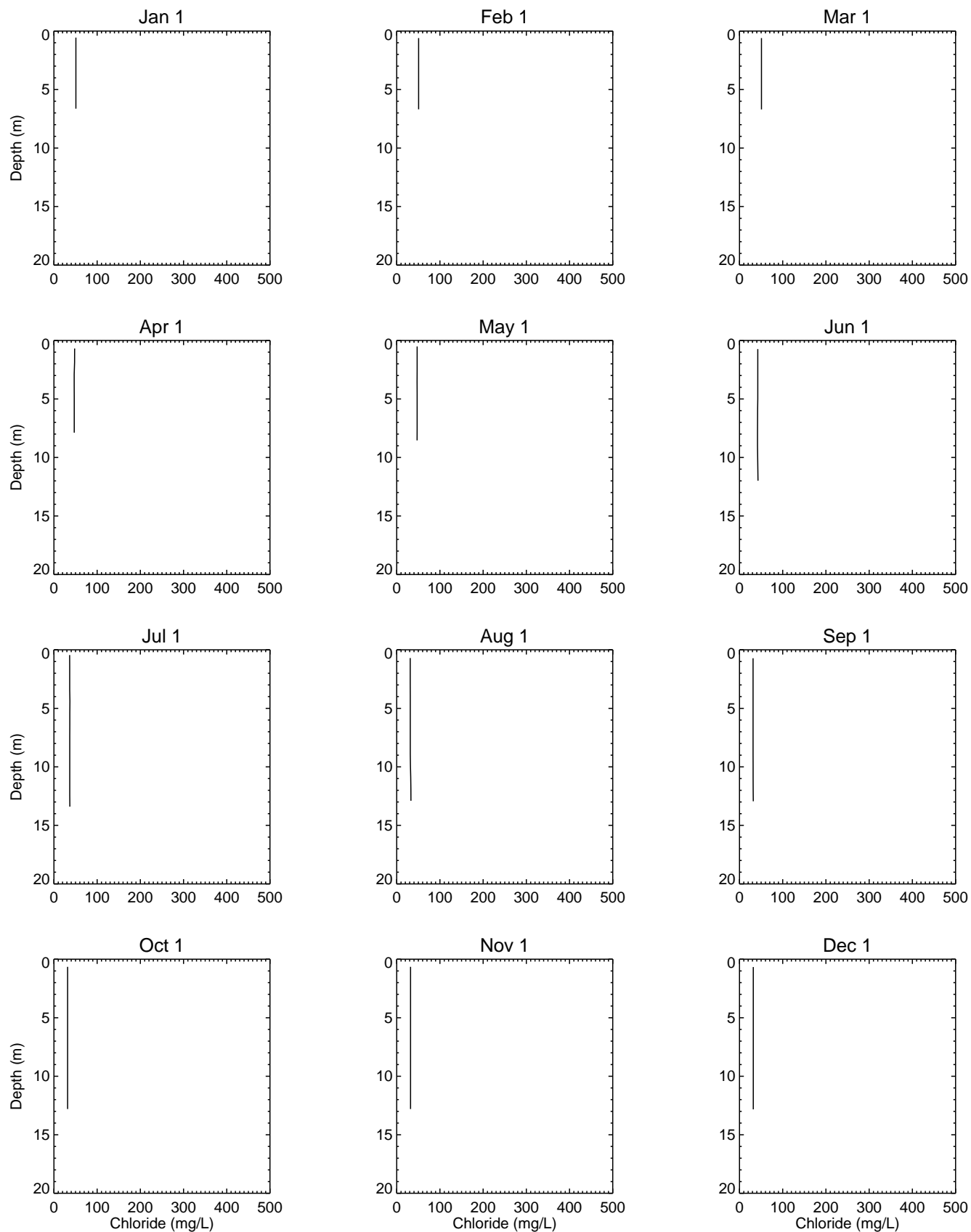
EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:35 2013

Model (w1210-48)
● Data

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 1991

Profiles shown for dates with available data else model results for first day of month shown.

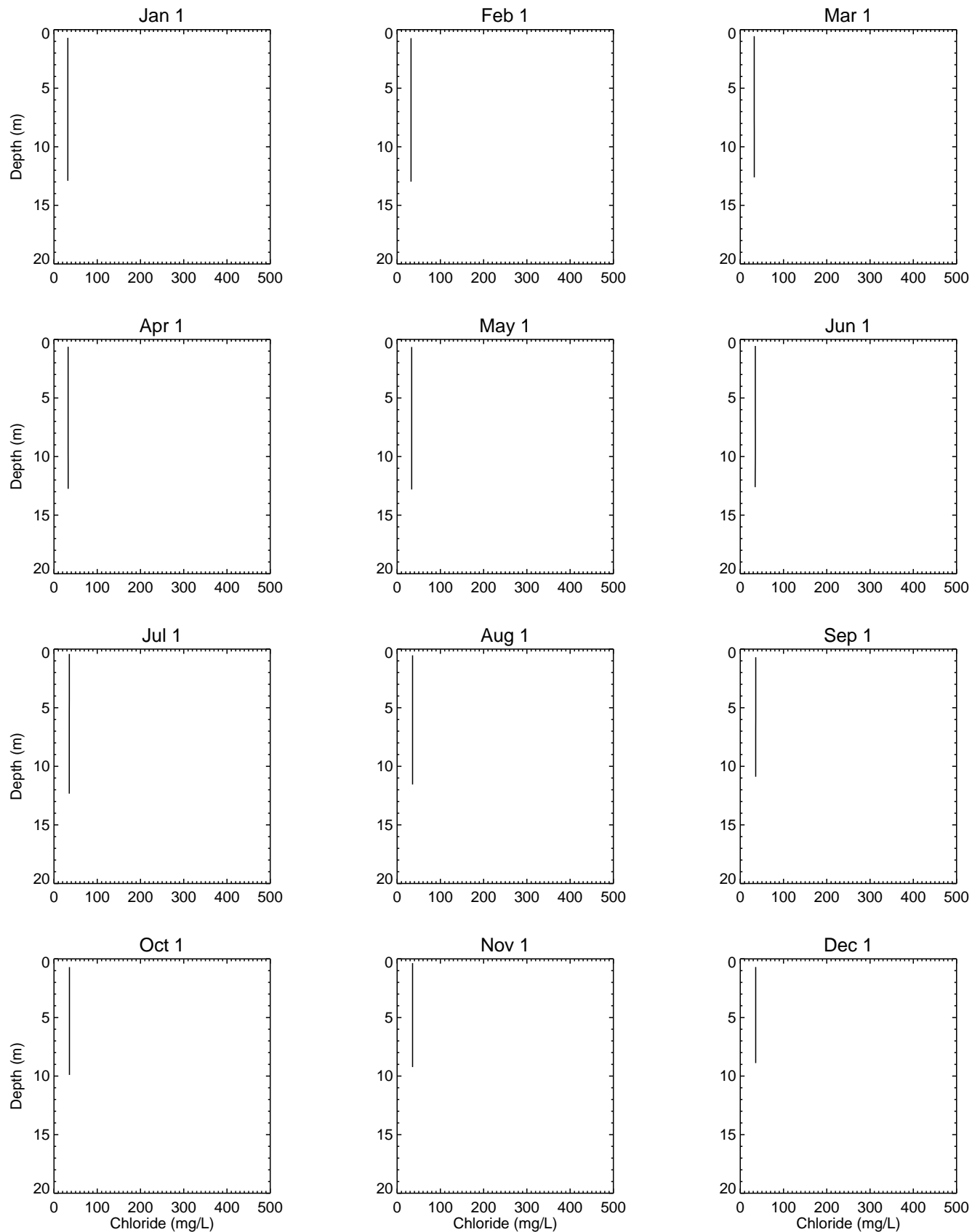CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

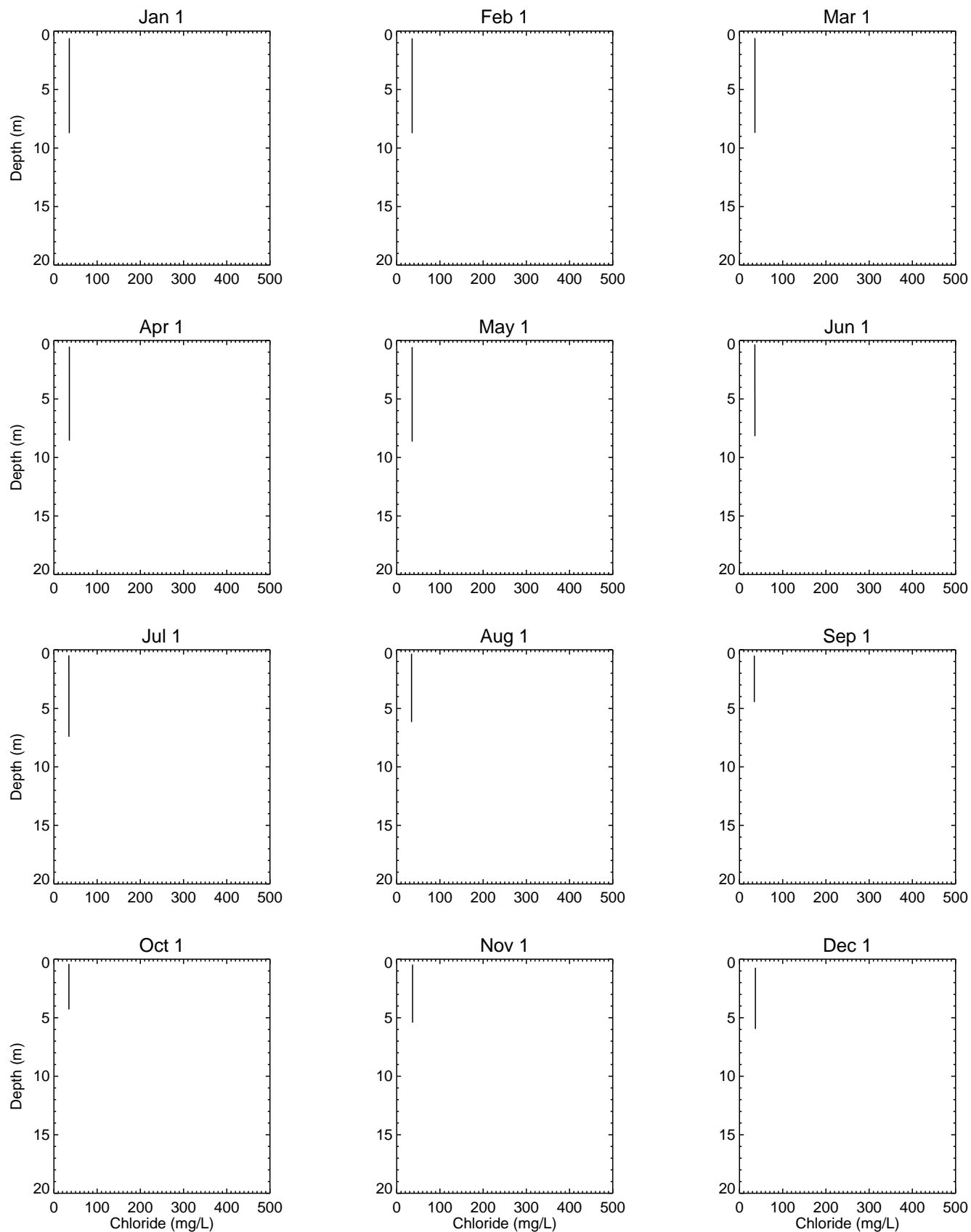Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:35 2013

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 1993

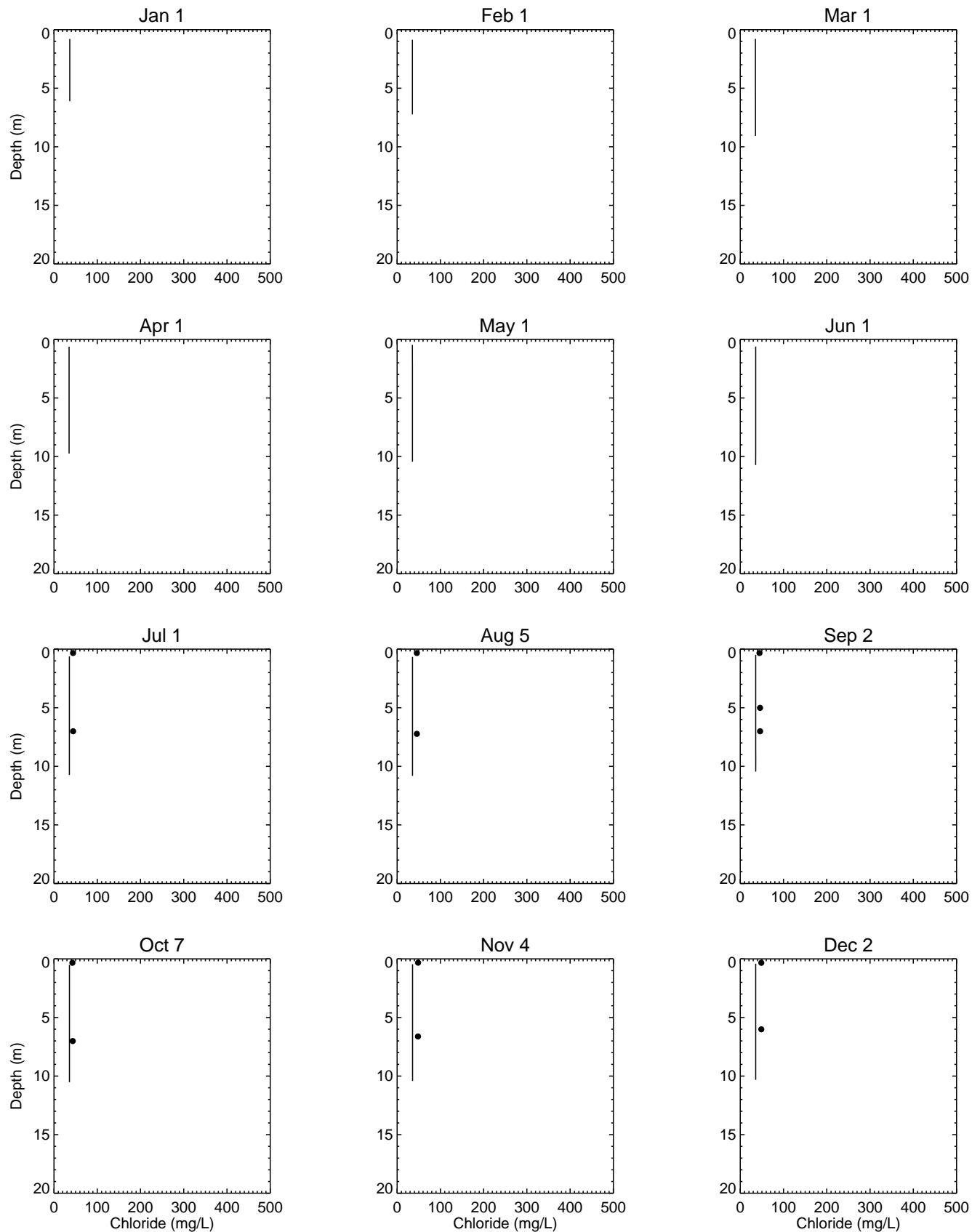*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan near Buchanan Dam (Segment 13) - Dissolved Oxygen - 1994

Profiles shown for dates with available data else model results for first day of month shown.
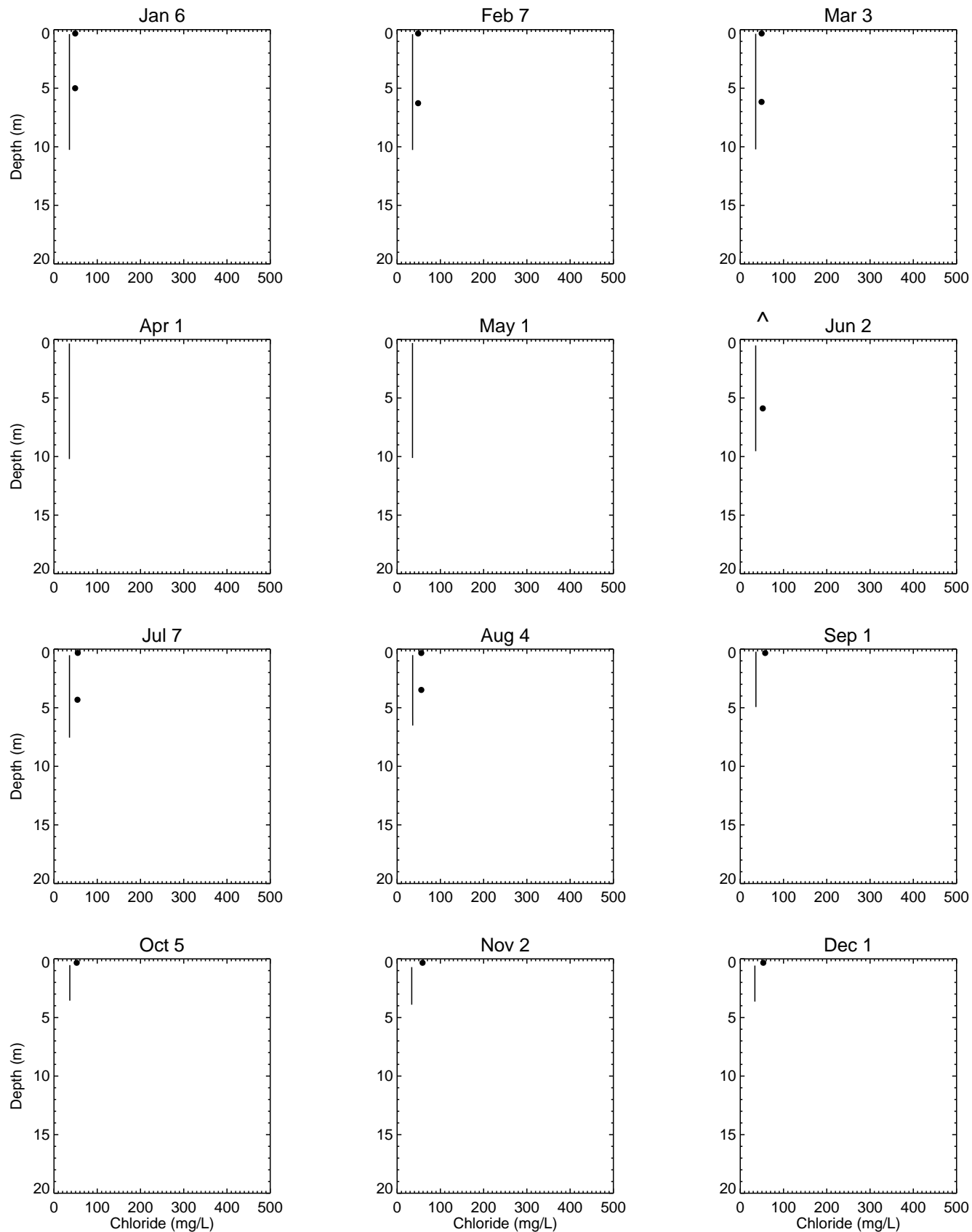
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 1995

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

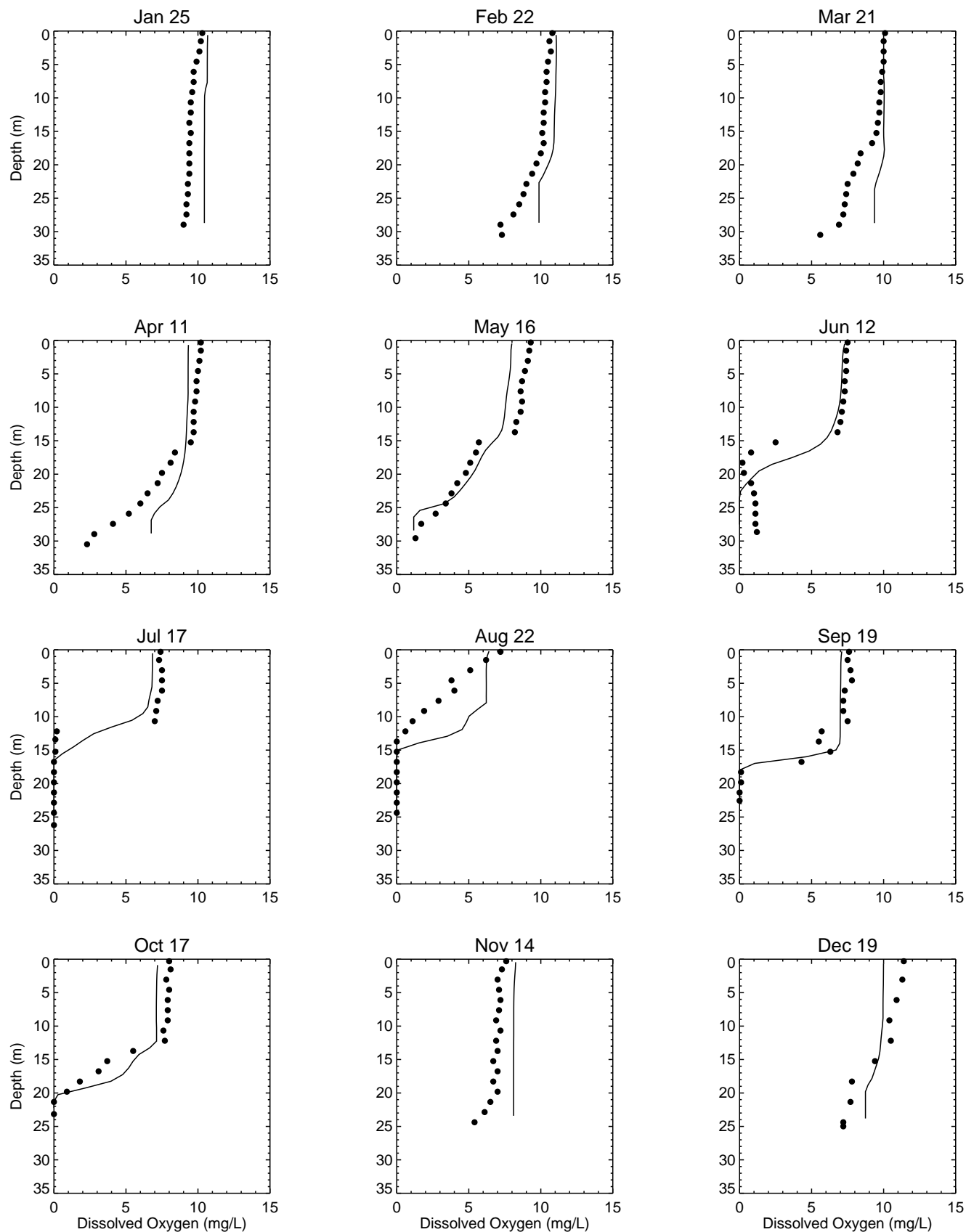Lower Colorado River Authority

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 1996

Profiles shown for dates with available data else model results for first day of month shown.

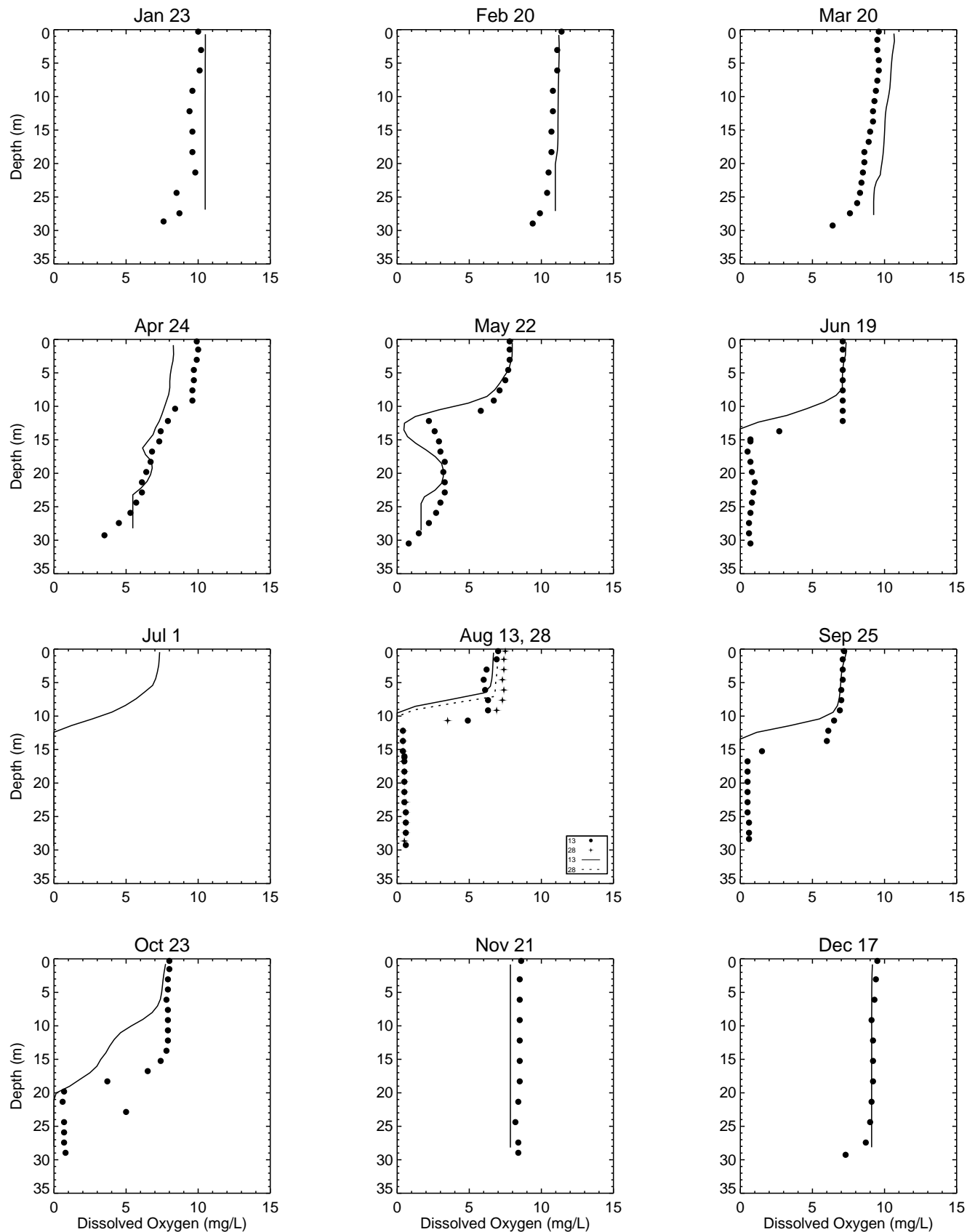CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:35 2013

Model (w1210-48)
● Data

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 1997

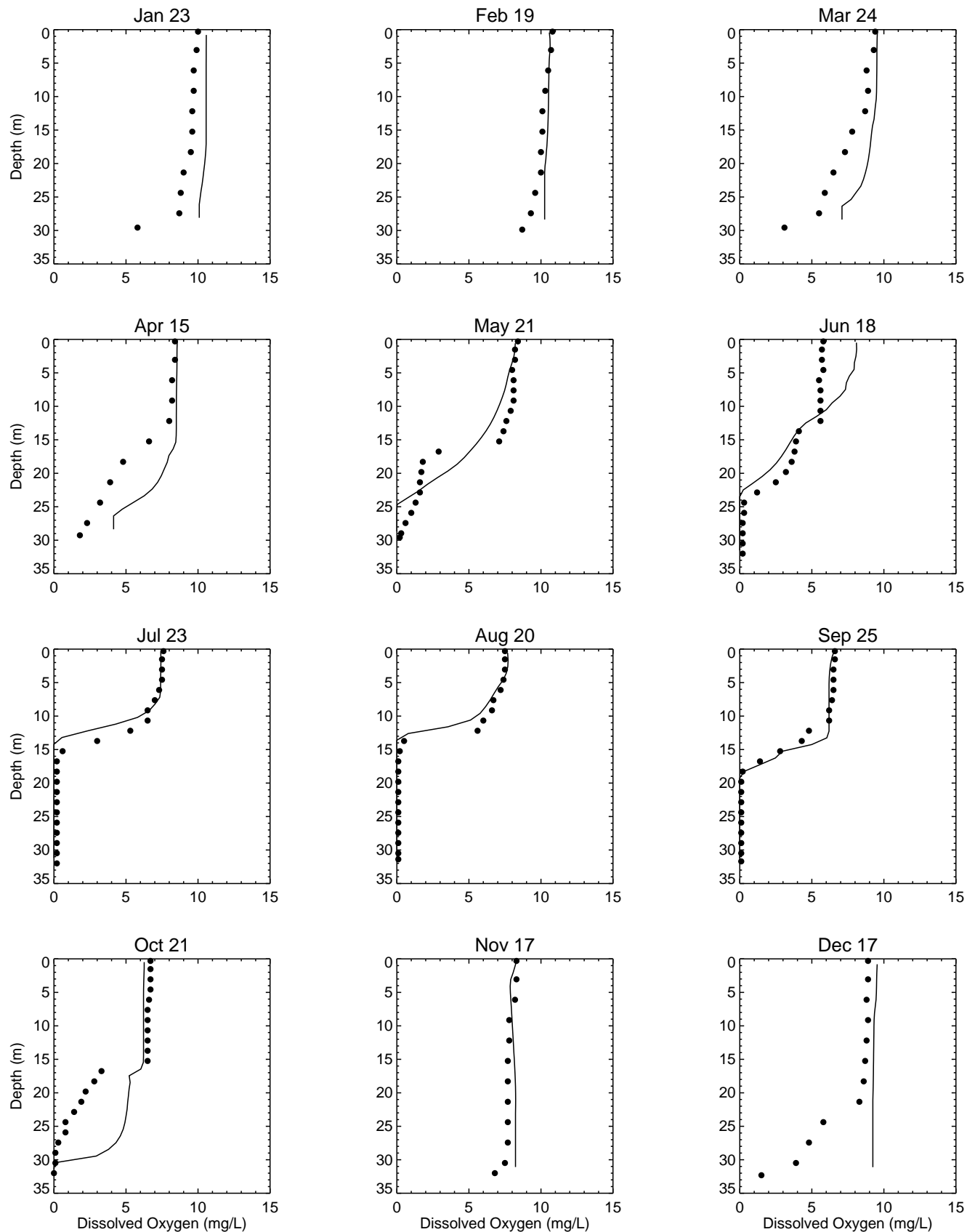*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1   Feb 5   Mar 1

Apr 7   May 1   Jun 15

Jul 1   Aug 3   Sep 1

Oct 8   Nov 1   Dec 3

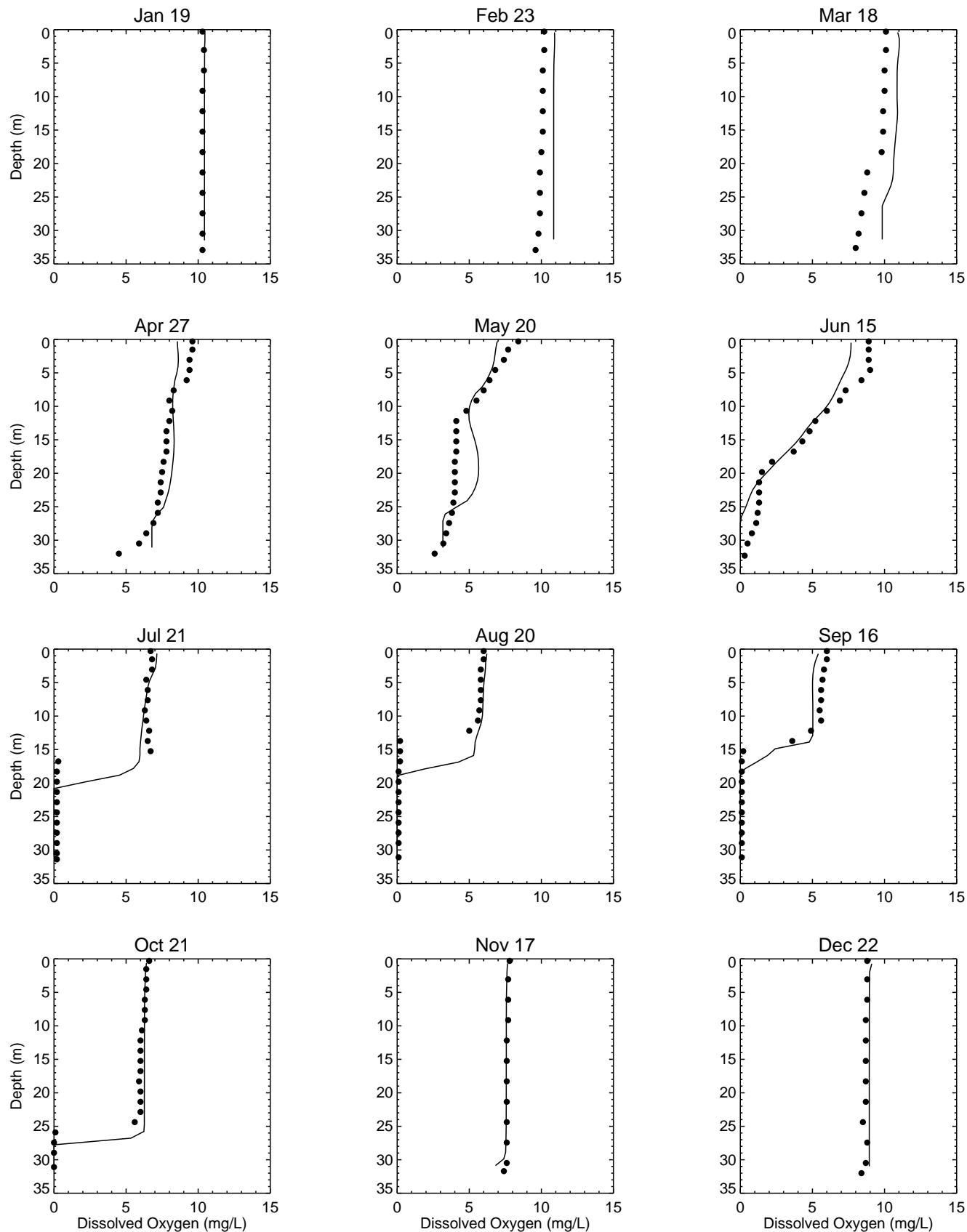Dissolved Oxygen (mg/L)

——— Model (w1210-48)
● Data

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 1998

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:35 2013

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 1999

Profiles shown for dates with available data else model results for first day of month shown.
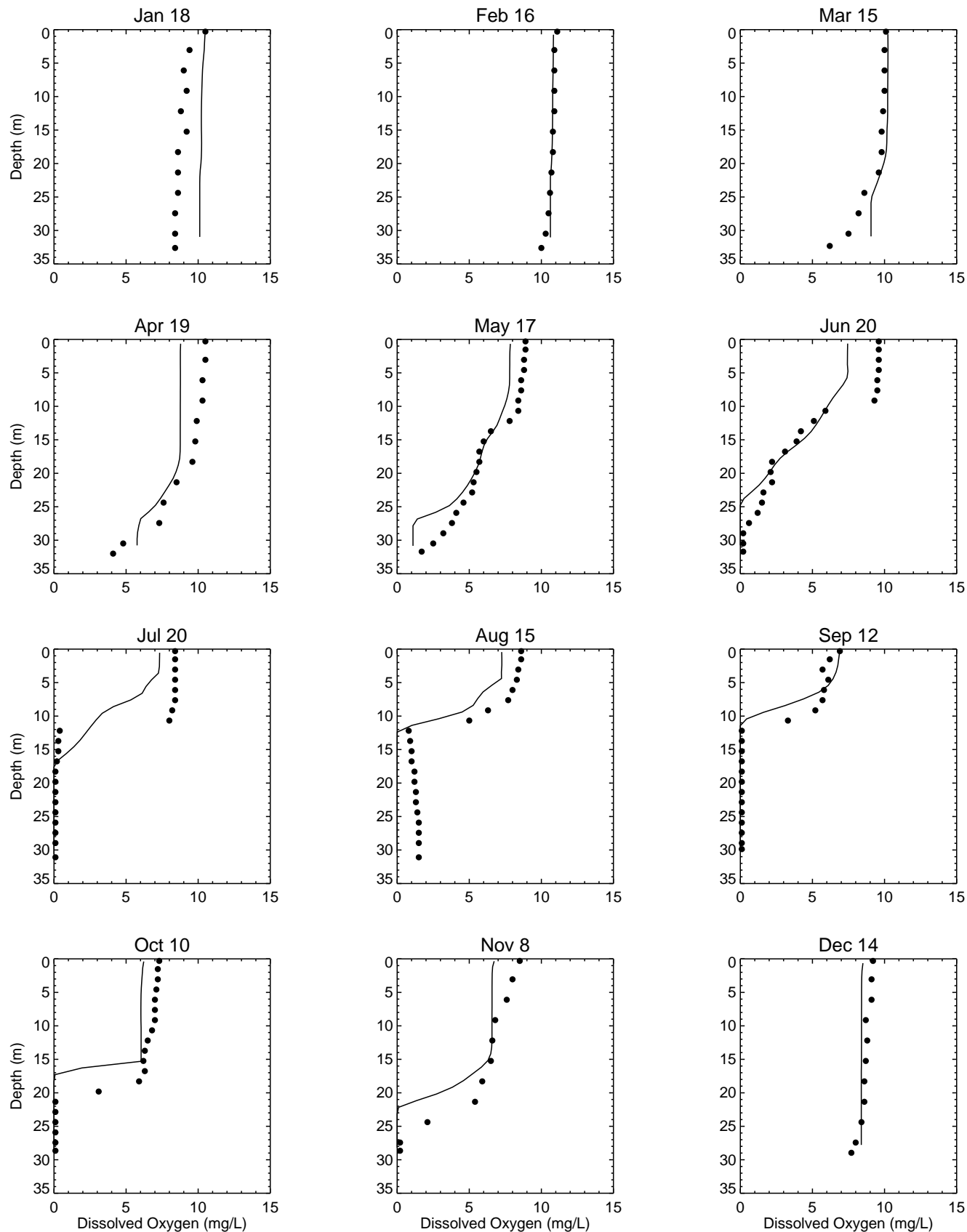
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 2000

Profiles shown for dates with available data else model results for first day of month shown.
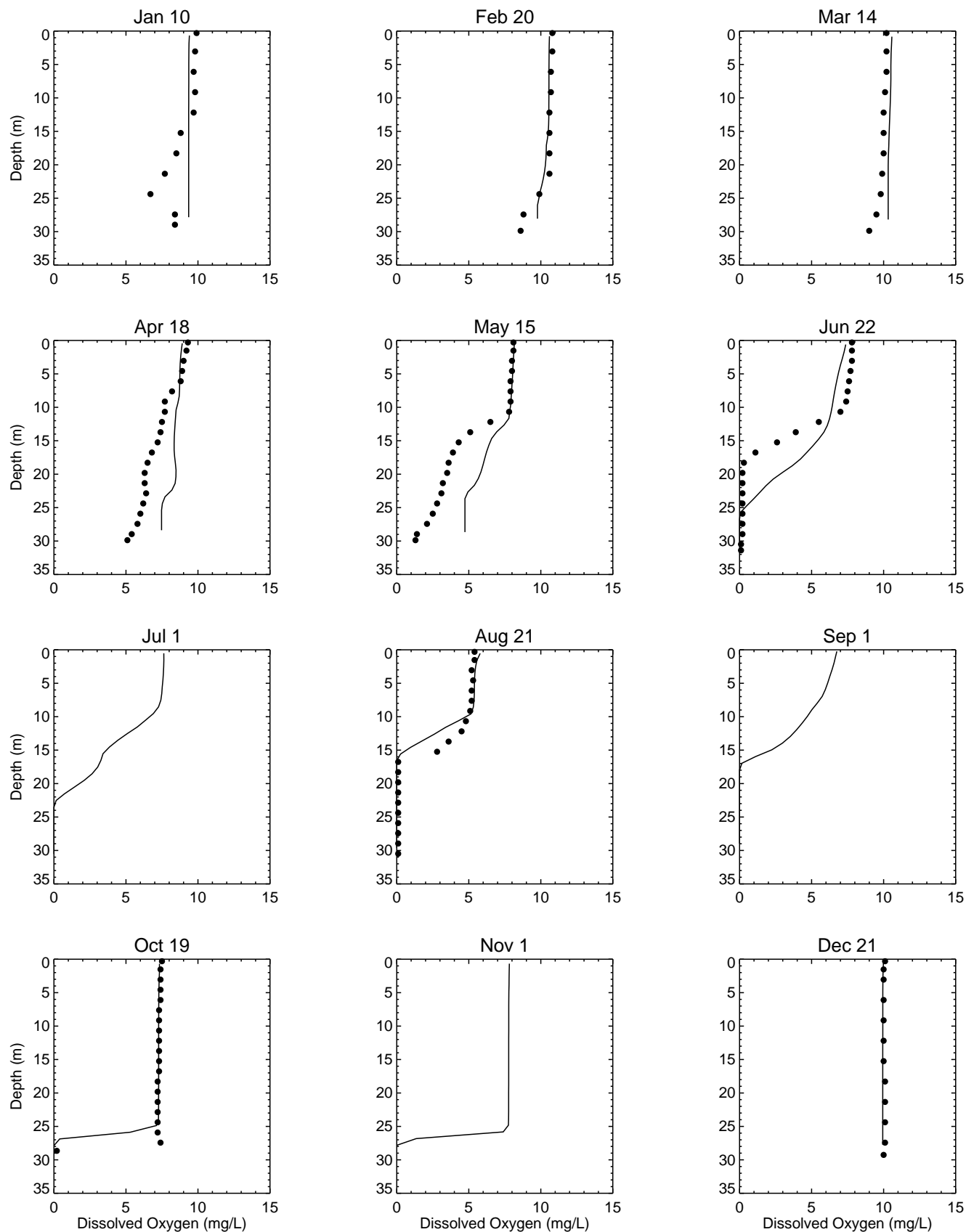
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1　Feb 6　Mar 1
Apr 15　May 1　Jun 10
Jul 1　Aug 20　Sep 1
Oct 1　Nov 1　Dec 2

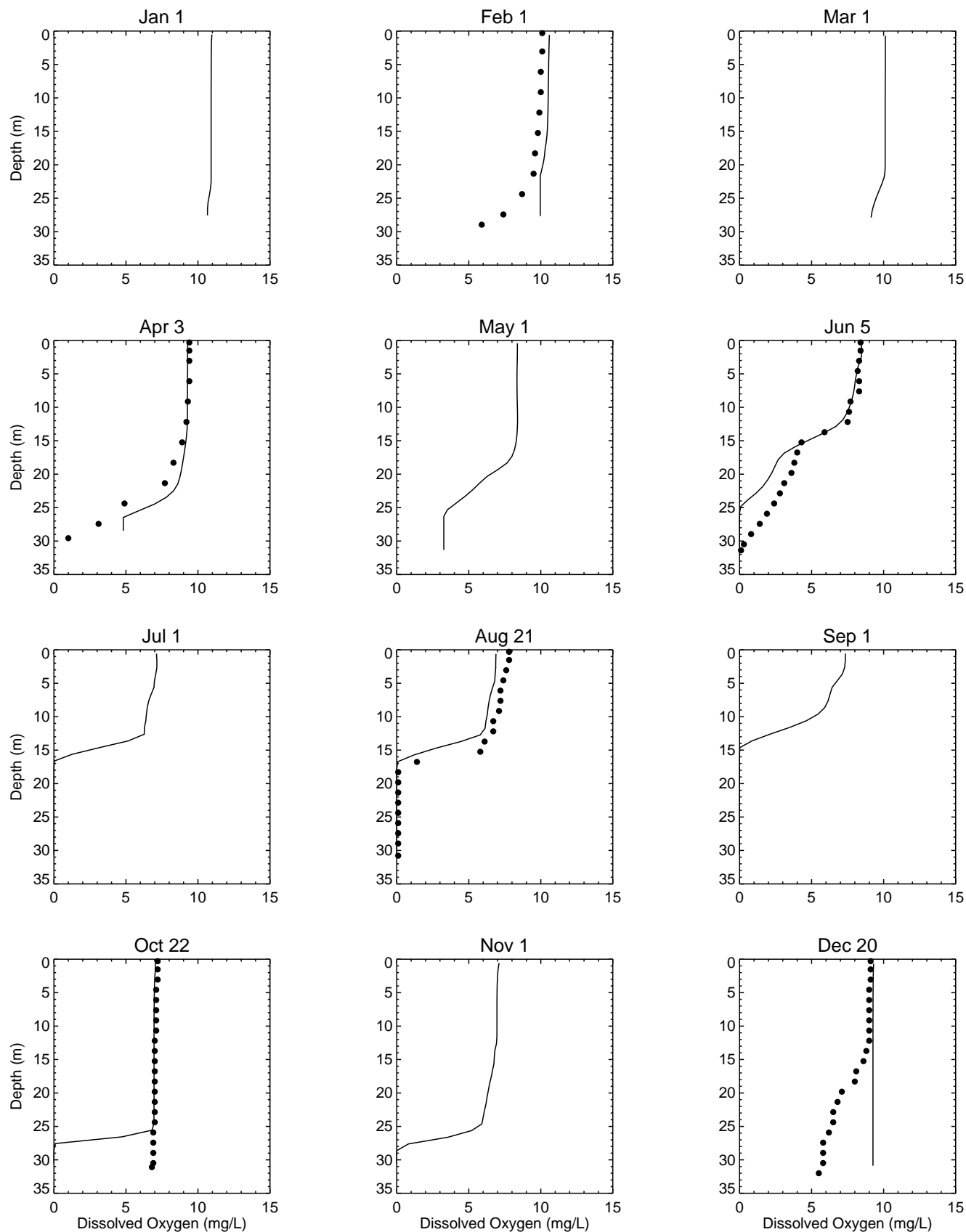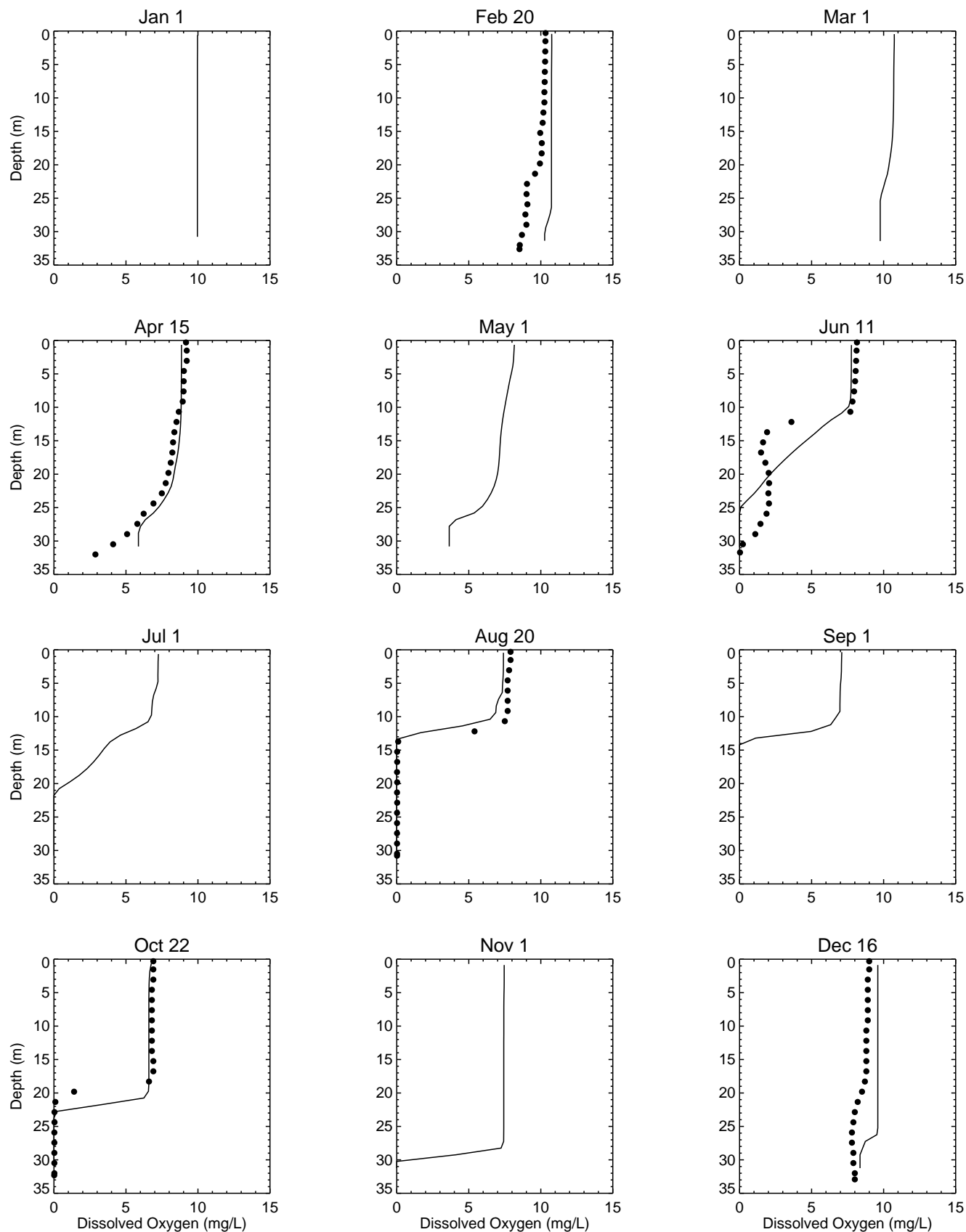Dissolved Oxygen (mg/L)

——— Model (w1210-48)
● Data

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 2002

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:35 2013

Jan 1 | Feb 5 | Mar 1
Apr 3 | May 1 | Jun 9
Jul 1 | Aug 11 | Sep 1
Oct 6 | Nov 1 | Dec 3

Depth (m) / Dissolved Oxygen (mg/L)

—— Model (w1210-48)
● Data

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 2003

Profiles shown for dates with available data else model results for first day of month shown.
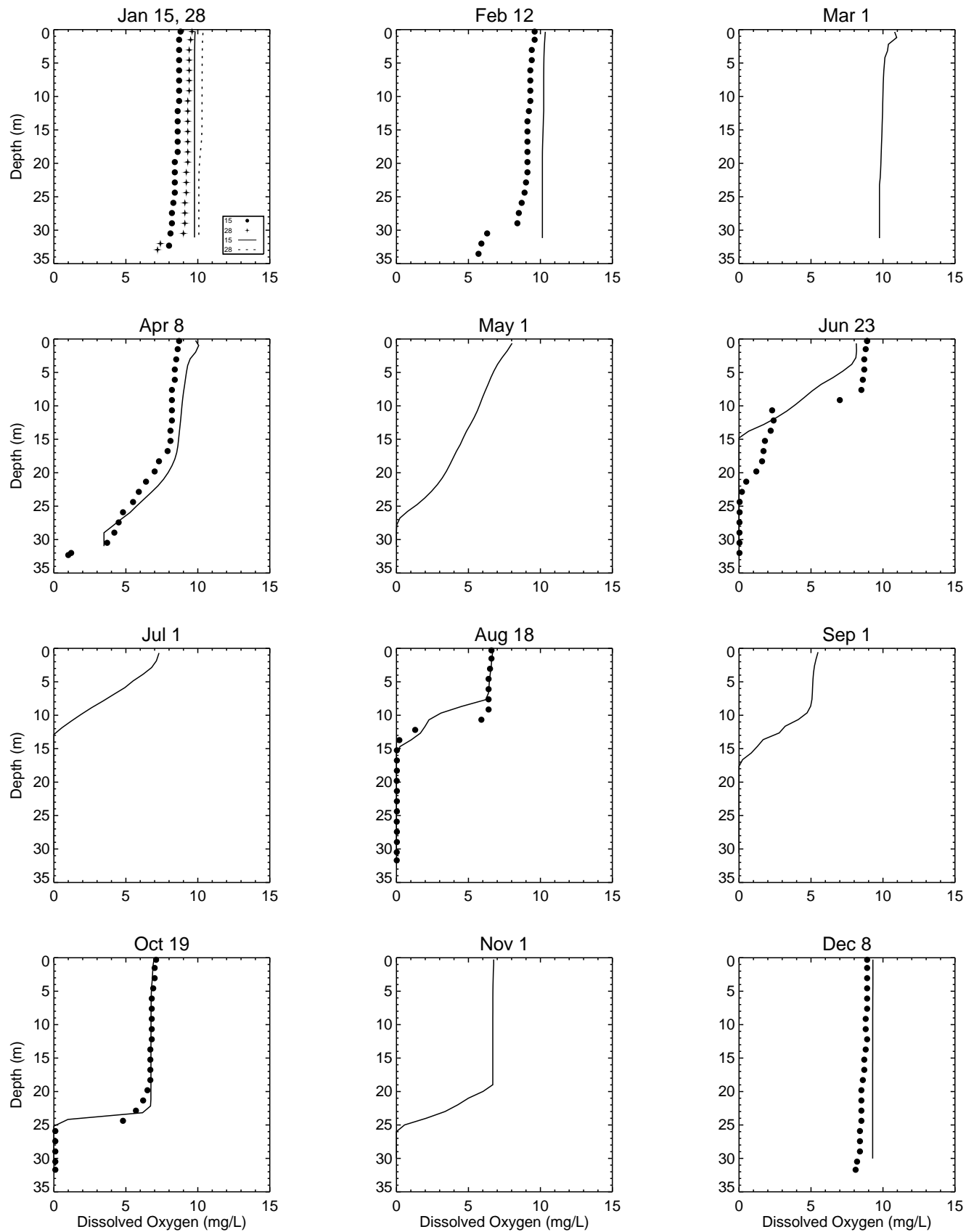
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:35 2013

ANCHOR QEA
PARSONS

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 2004

Profiles shown for dates with available data else model results for first day of month shown.
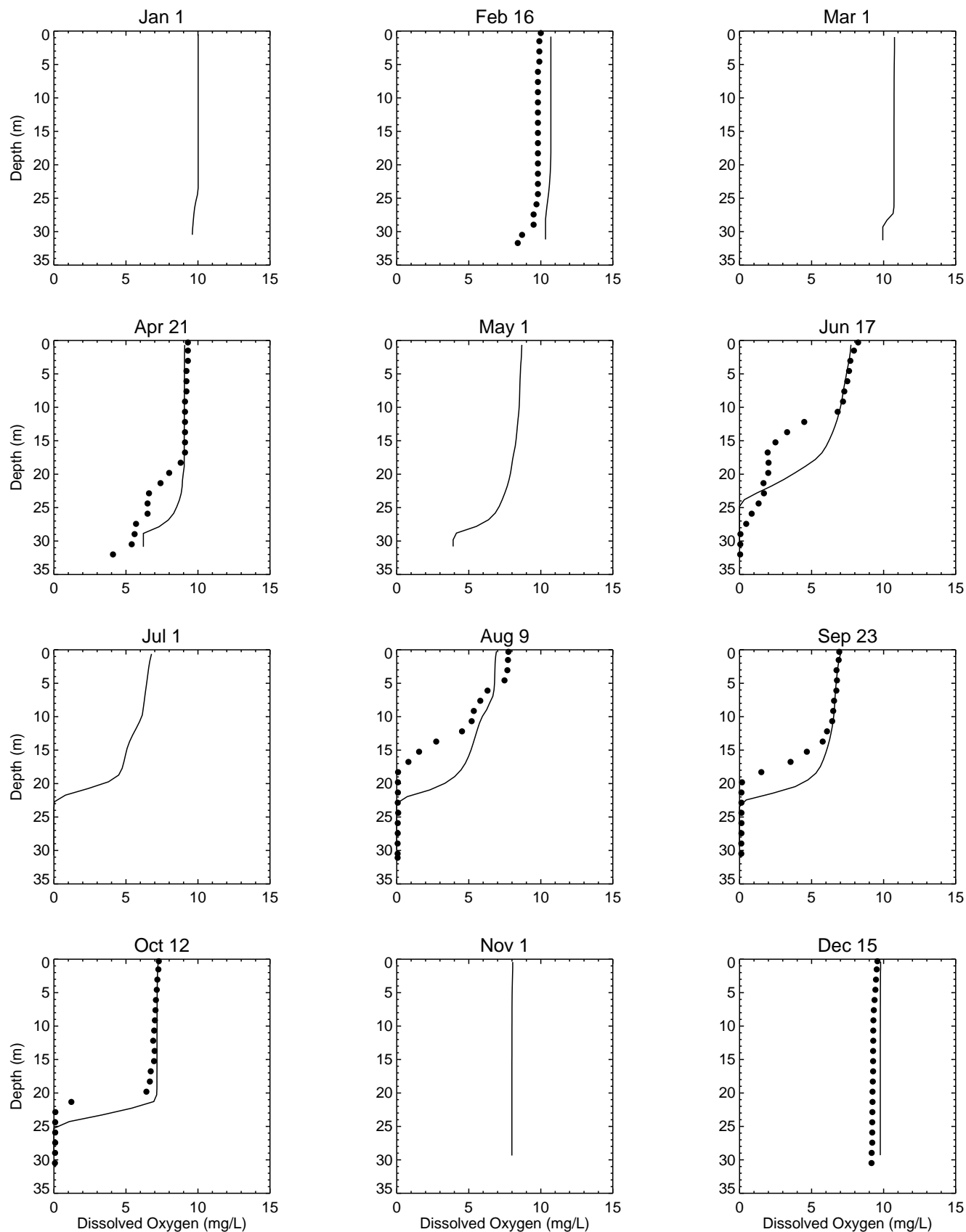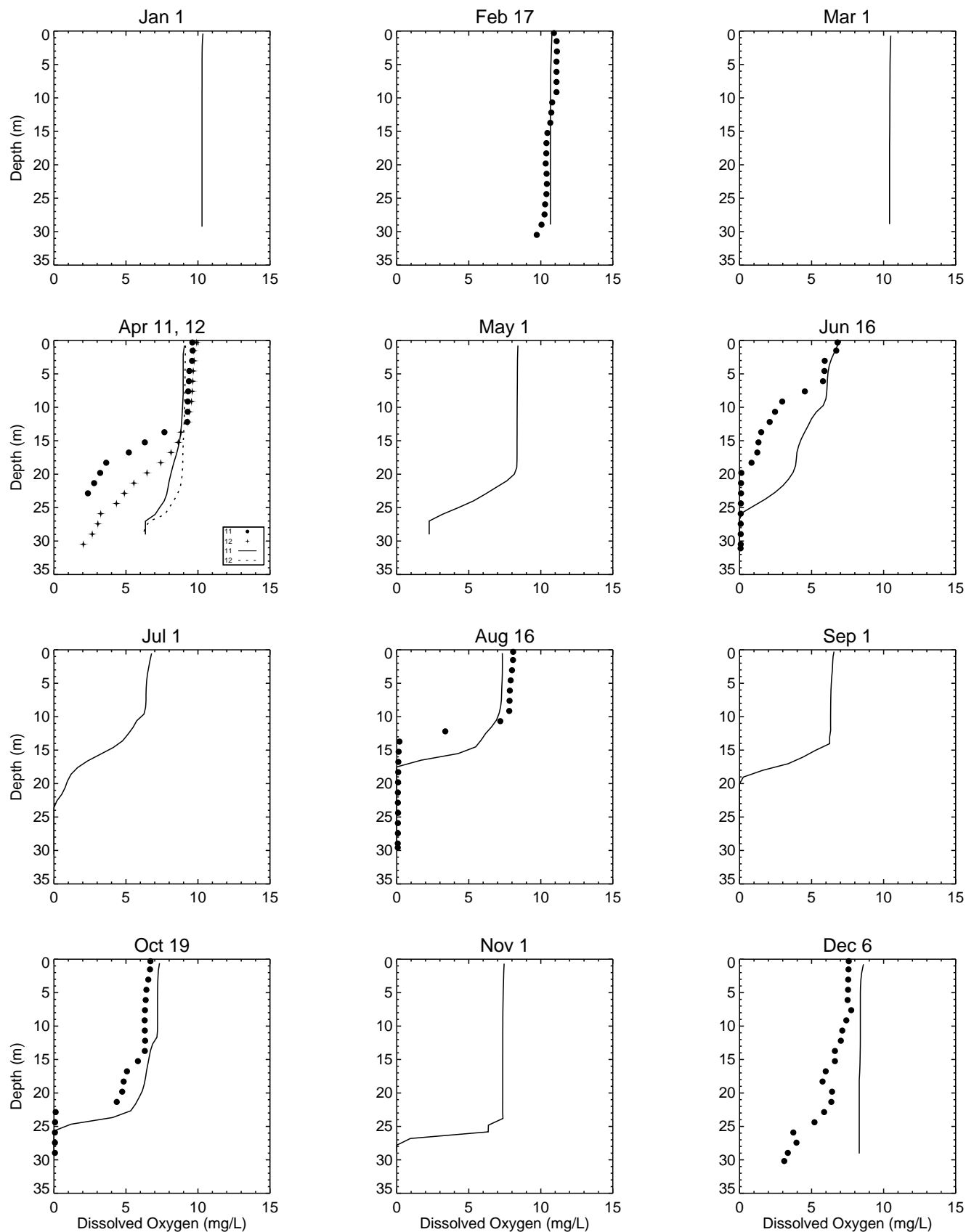
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:35 2013

Jan 1 · Feb 8 · Mar 1 · Apr 12 · May 1 · Jun 6 · Jul 1 · Aug 1 · Sep 1 · Oct 11 · Nov 1 · Dec 1

Vertical profiles with axes Dissolved Oxygen (mg/L) (0–15) and Depth (m) (0–35).

——— Model (w1210-48)
● Data

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 2005

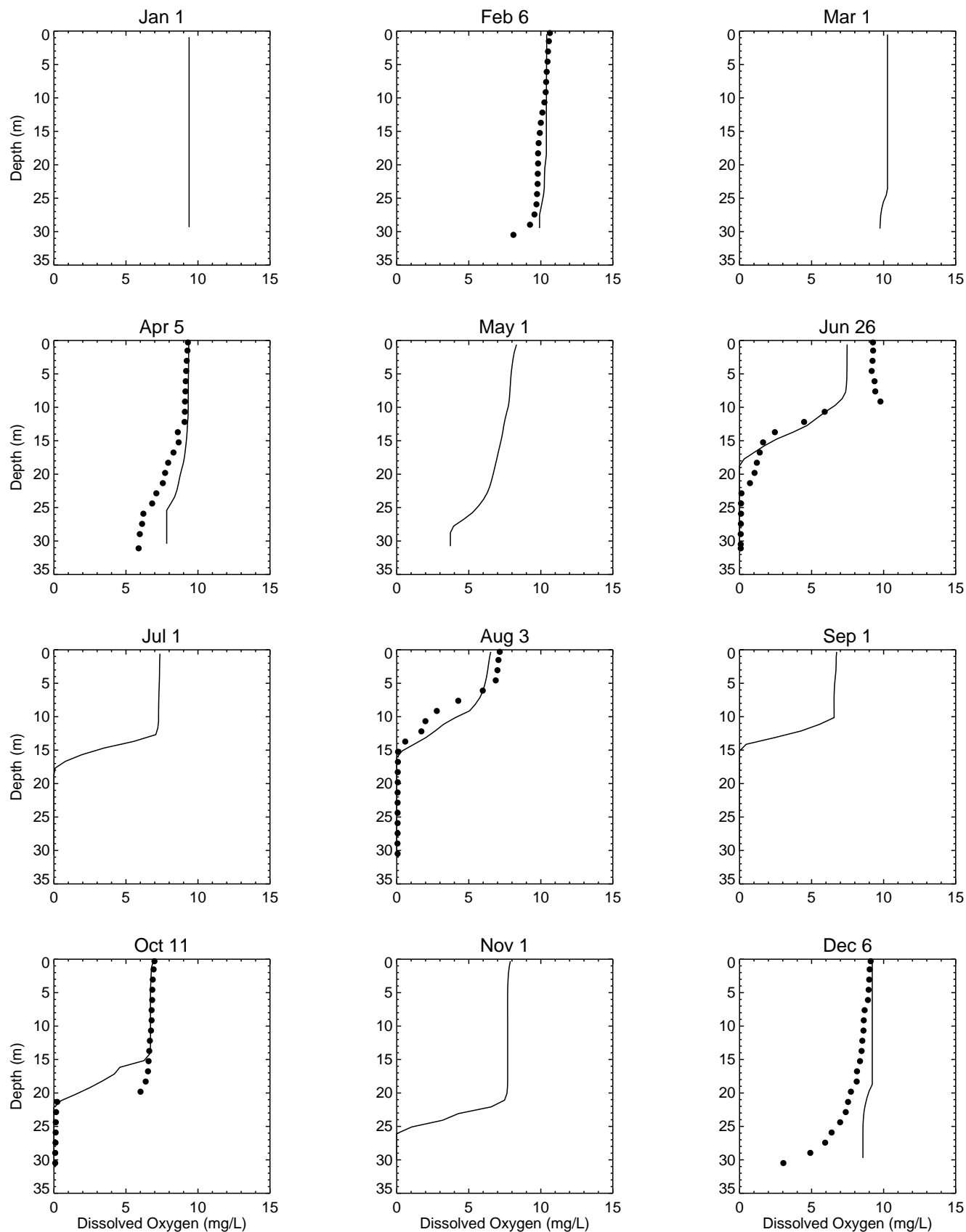*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
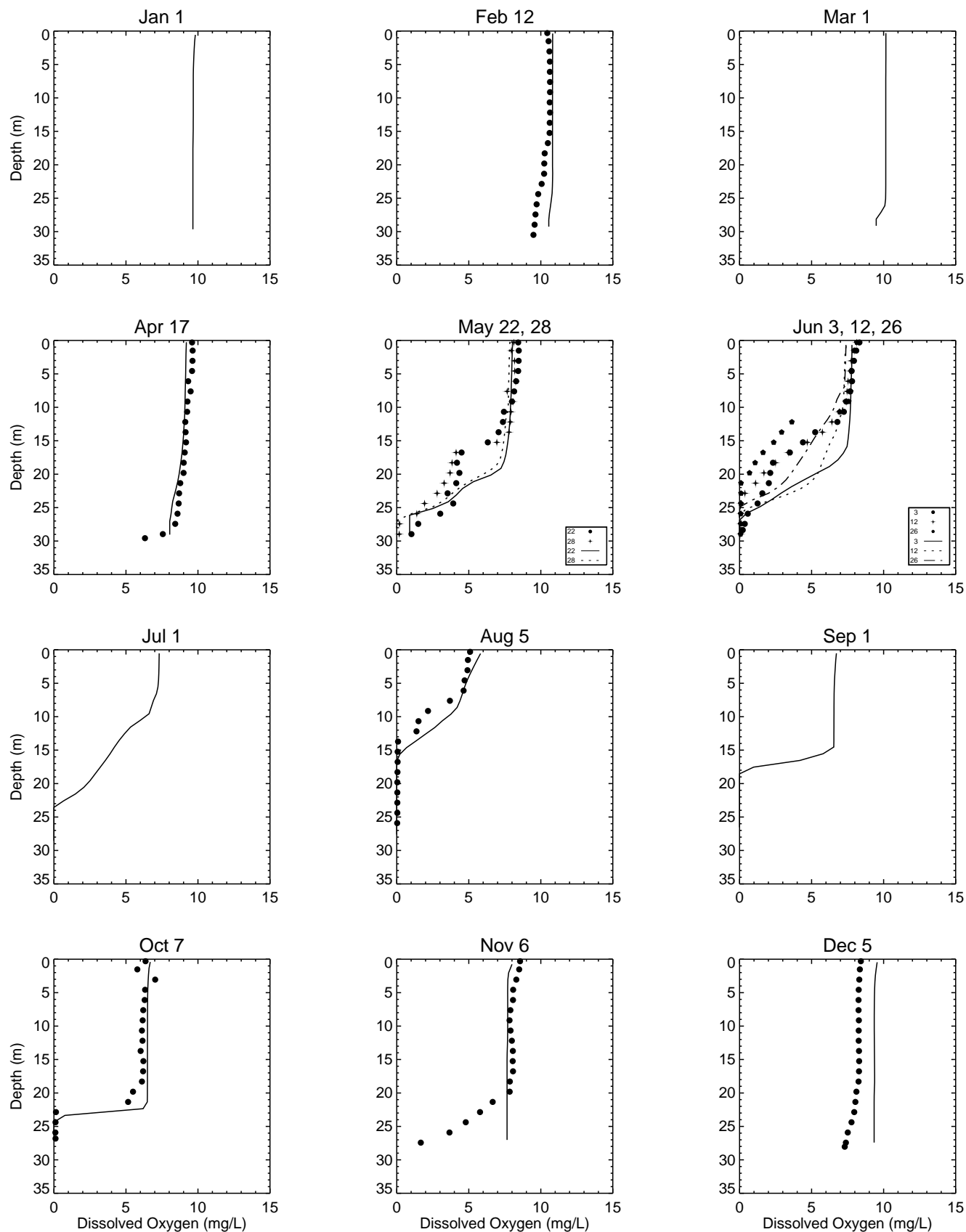Fri Jan 25 18:12:35 2013

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 2006

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 2007

Profiles shown for dates with available data else model results for first day of month shown.
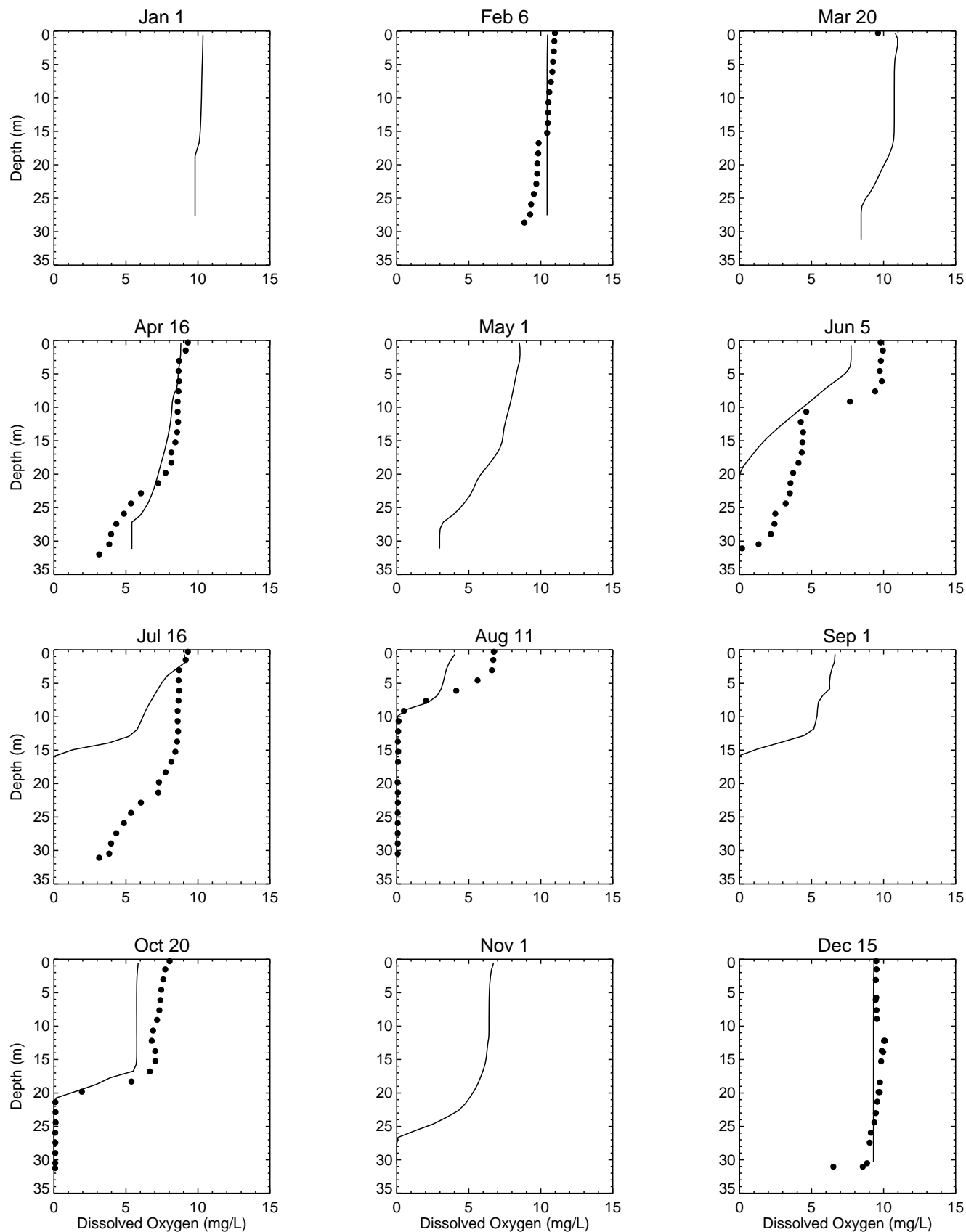
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1   Feb 4   Mar 1

Apr 3   May 1   Jun 12

Jul 1   Aug 7   Sep 1

Oct 9   Nov 1   Dec 4

Depth (m)

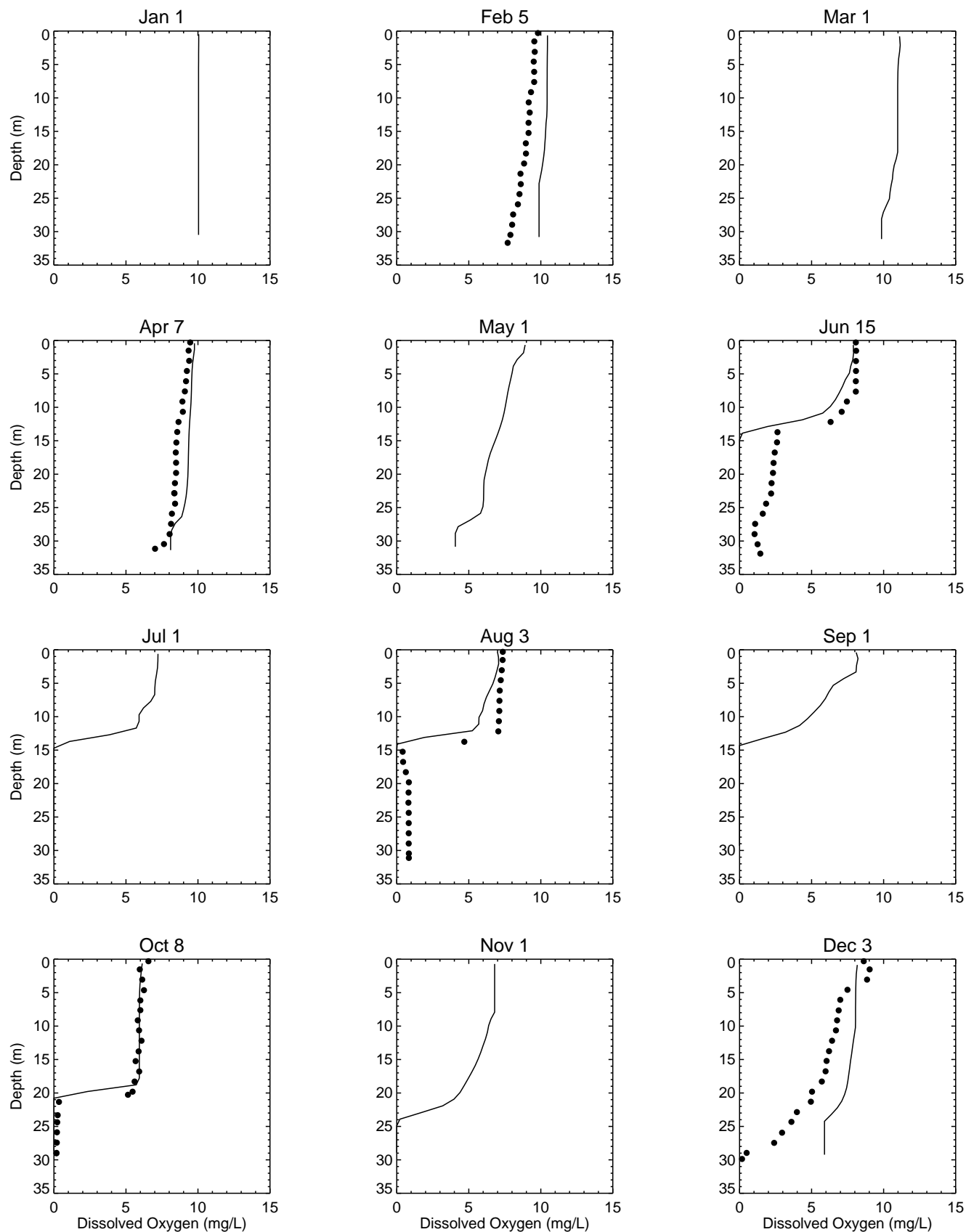Dissolved Oxygen (mg/L)
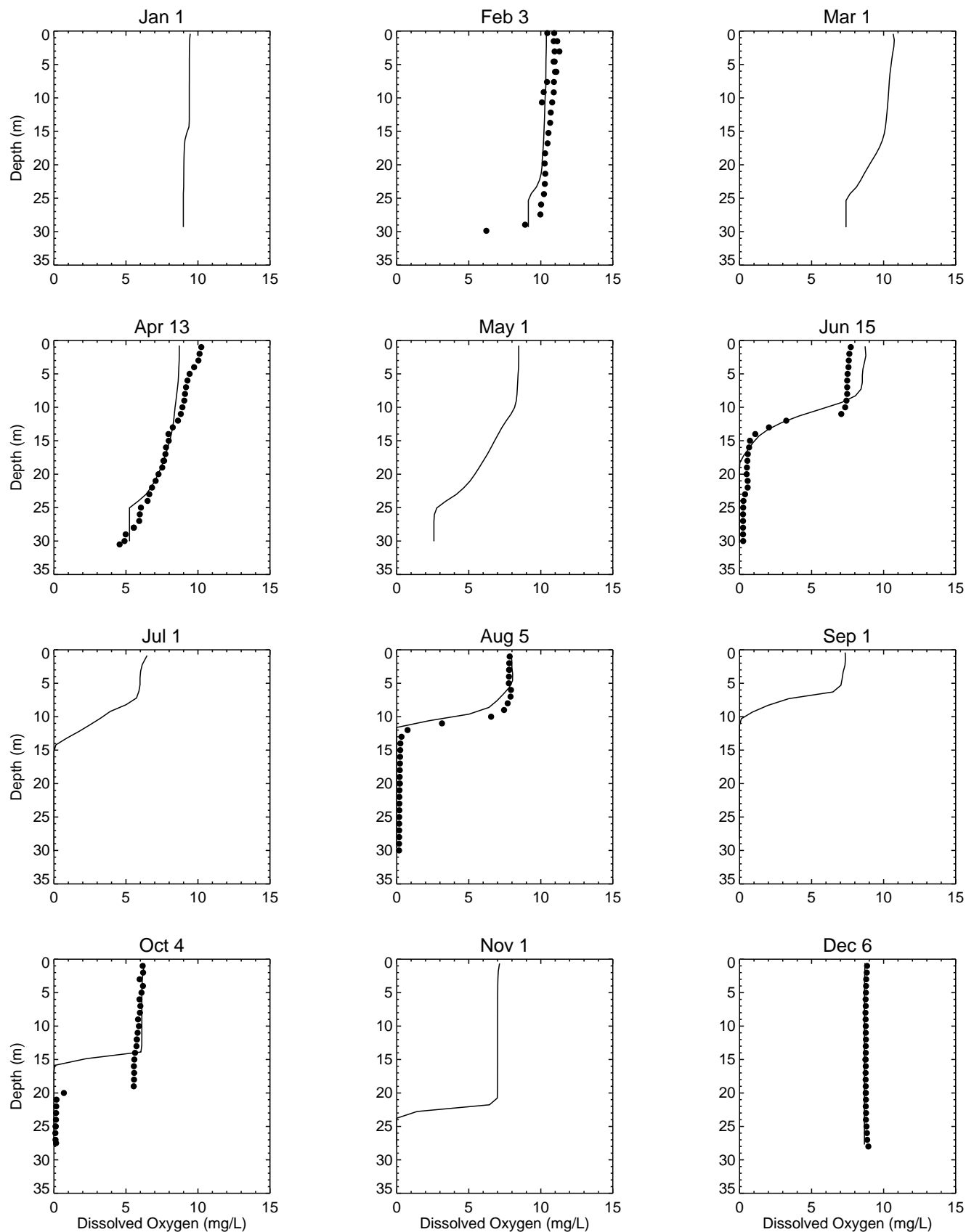
——— Model (w1210-48)
● Data

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 2008

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:36 2013

Jan 1   Feb 5   Mar 1
Apr 1   May 1   Jun 1
Jul 1   Aug 6   Sep 1
Oct 1   Nov 1   Dec 8

——— Model (w1210-48)
●   Data

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 2009

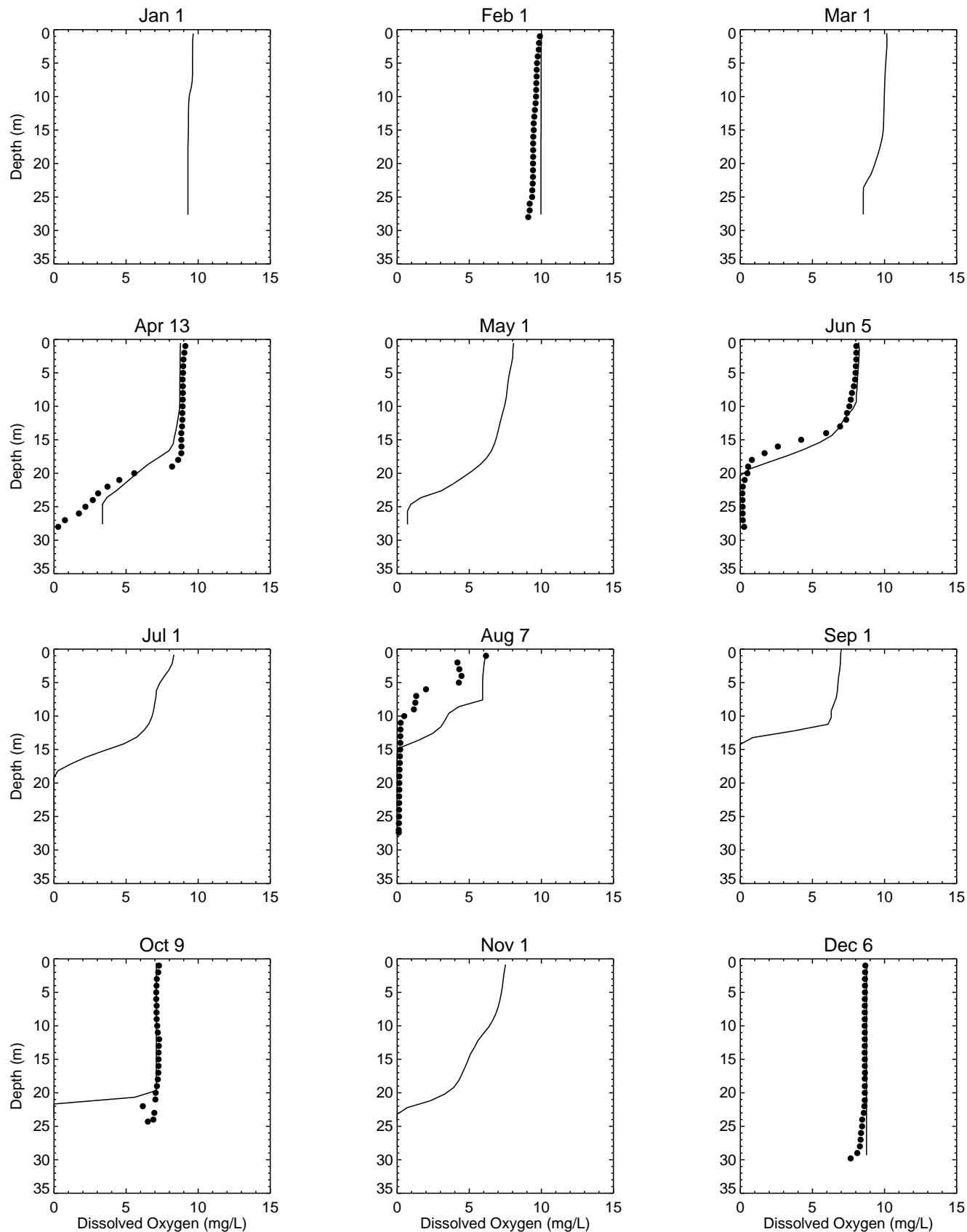*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
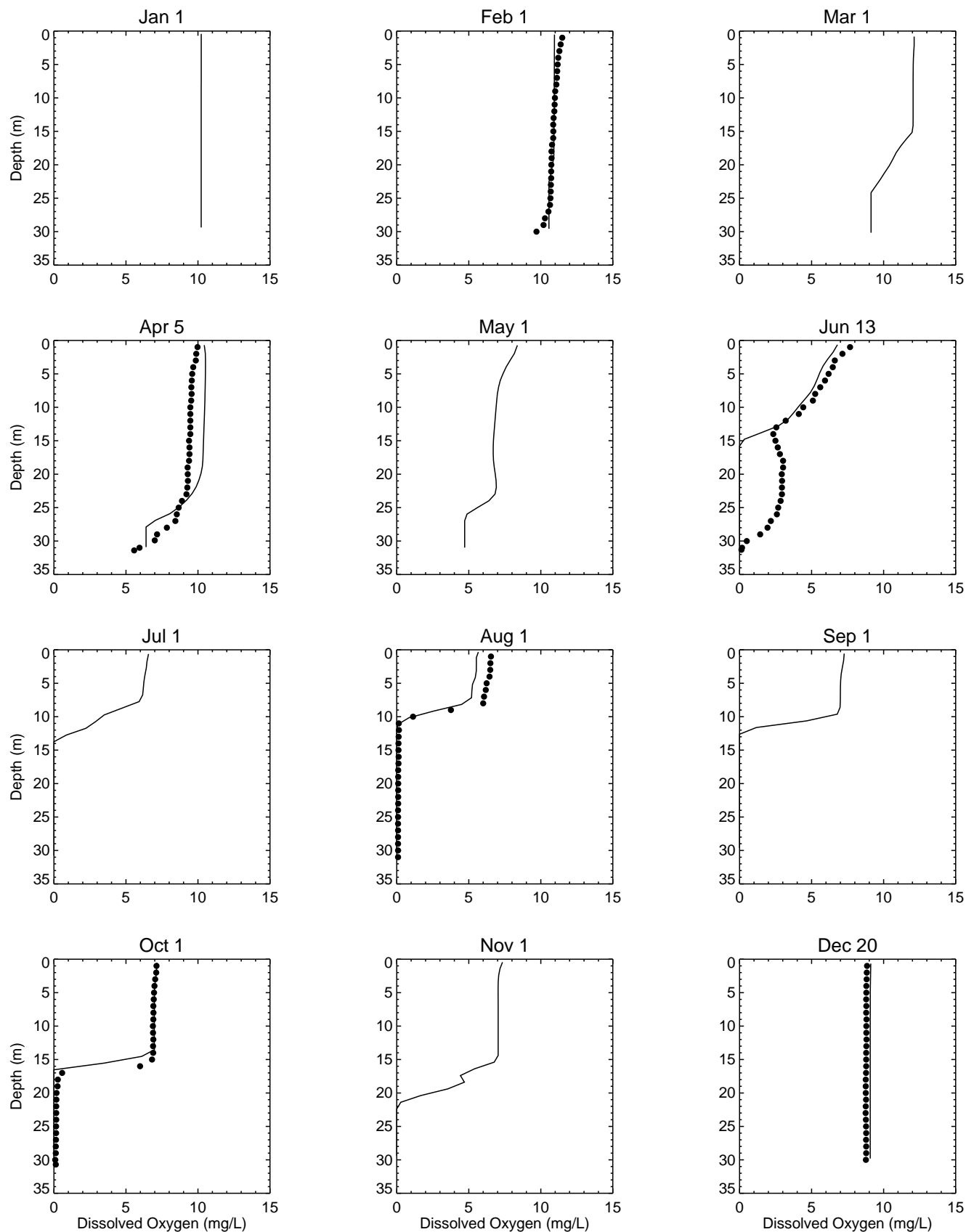Fri Jan 25 18:12:36 2013

Model (w1210-48)
● Data

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 2010

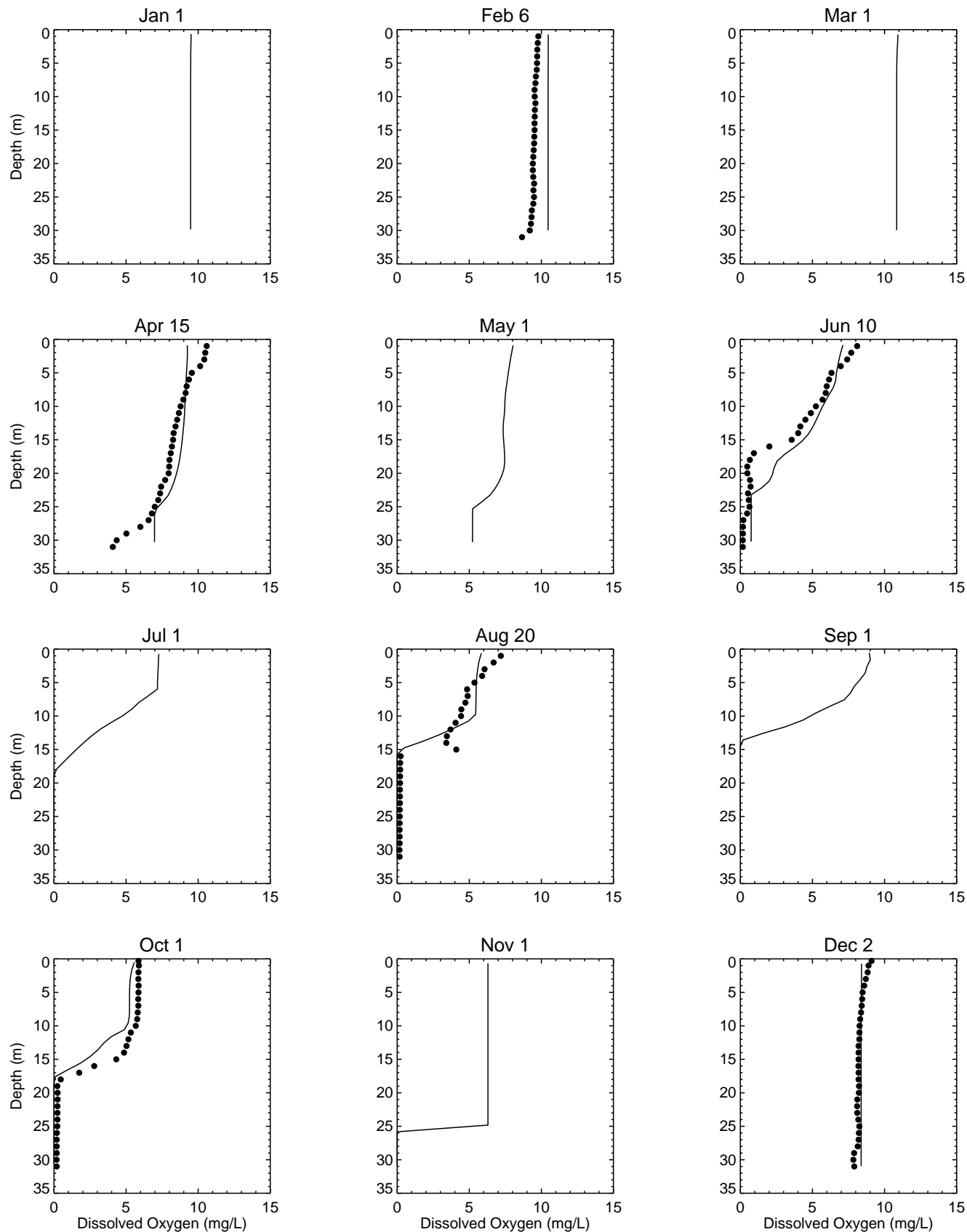*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 6 Feb 7 Mar 3

Apr 14 May 1 Jun 1, 2

Jul 7 Aug 4 Sep 1

Oct 3, 5 Nov 1 Dec 1, 8

Dissolved Oxygen (mg/L)

—— Model (w1210-48)
● Data

Figure G-26

Vertical Profiles of Model Versus Data for Lake Buchanan
near Buchanan Dam (Segment 13) - Dissolved Oxygen - 2011

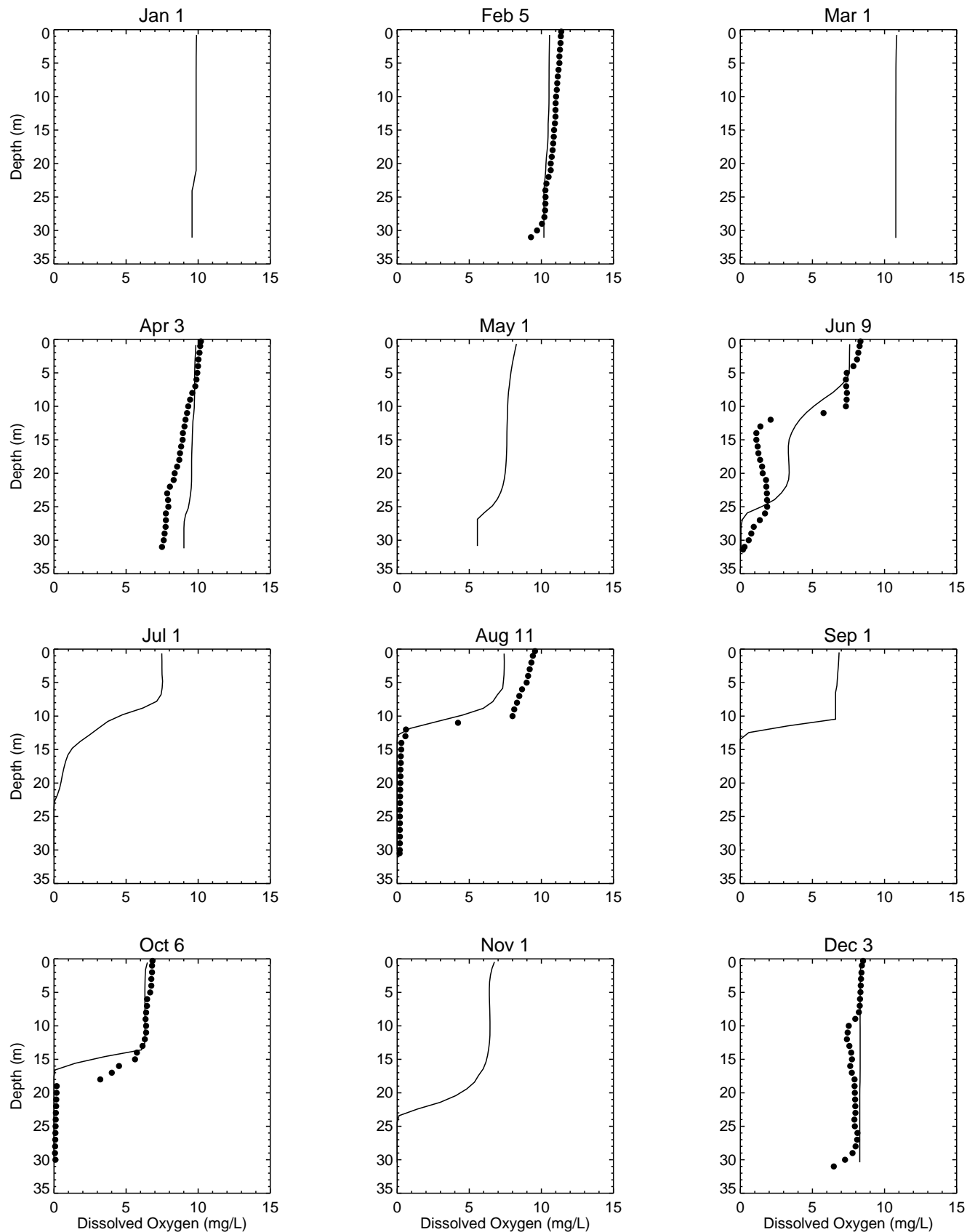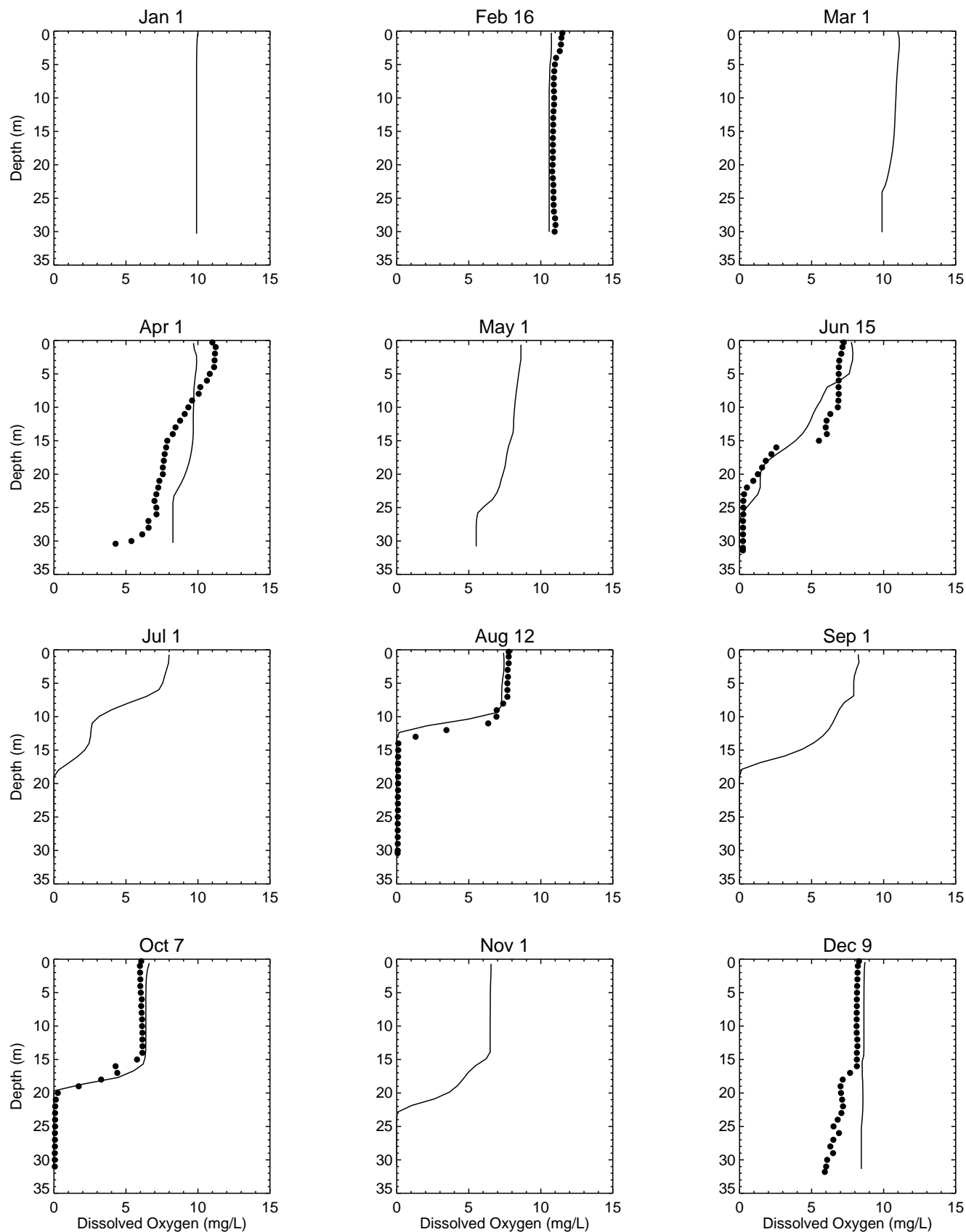*Profiles shown for dates with available data else model results for first day of month shown.*
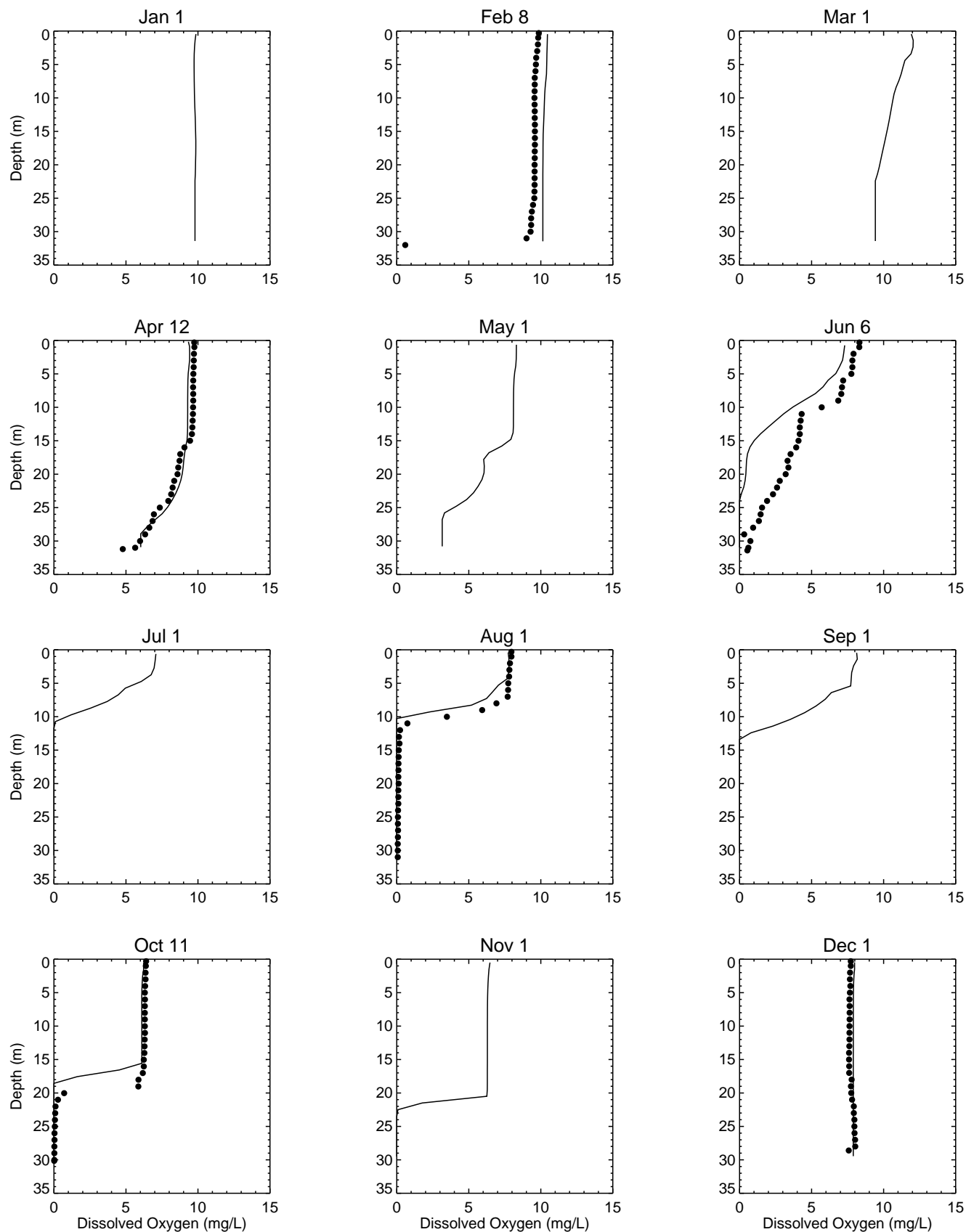
ANCHOR
QEA
PARSONS

CREMs Phase 4: Lake Buchanan

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:36 2013

Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 1984

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 1985

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 1986

Profiles shown for dates with available data else model results for first day of month shown.

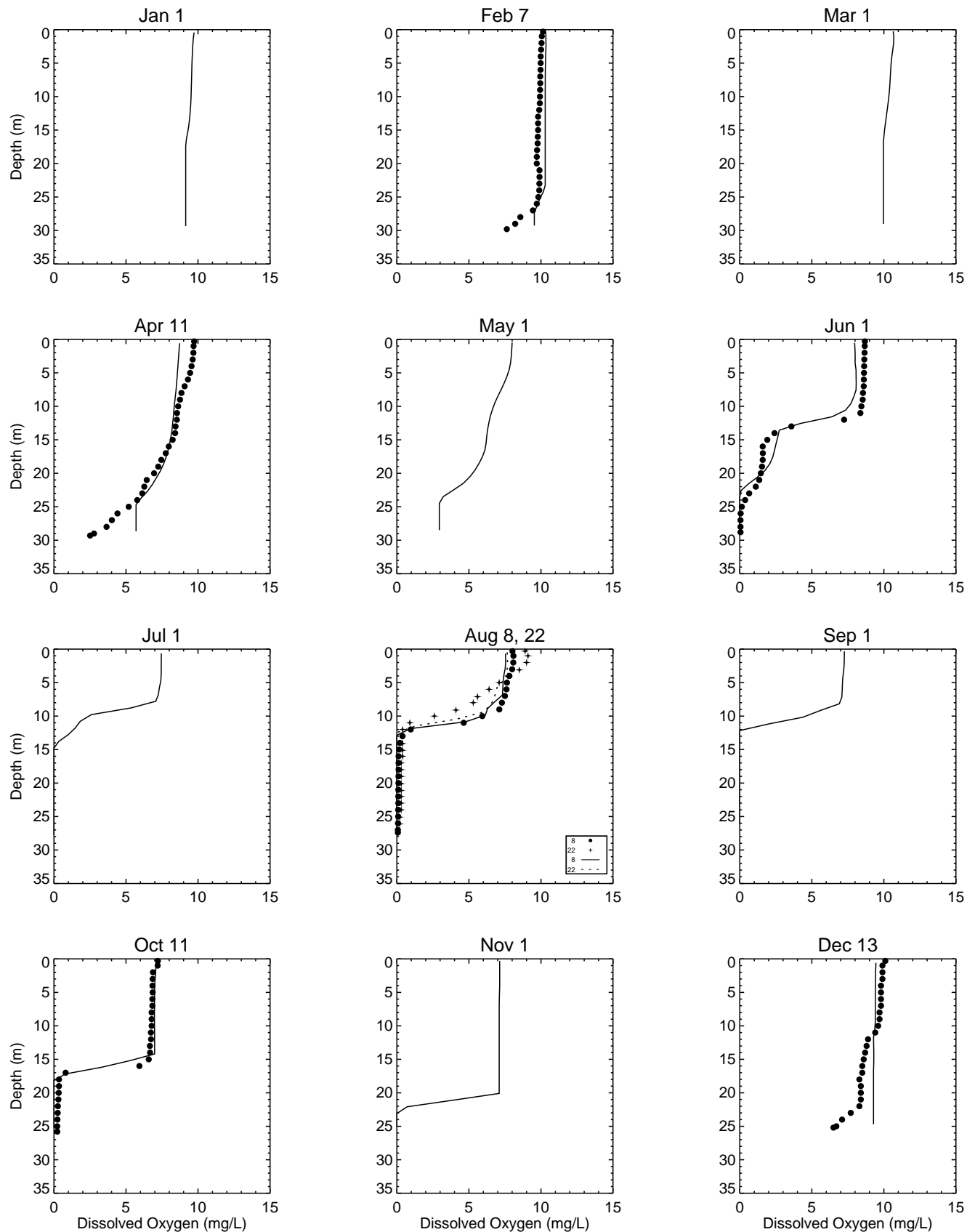CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 1987

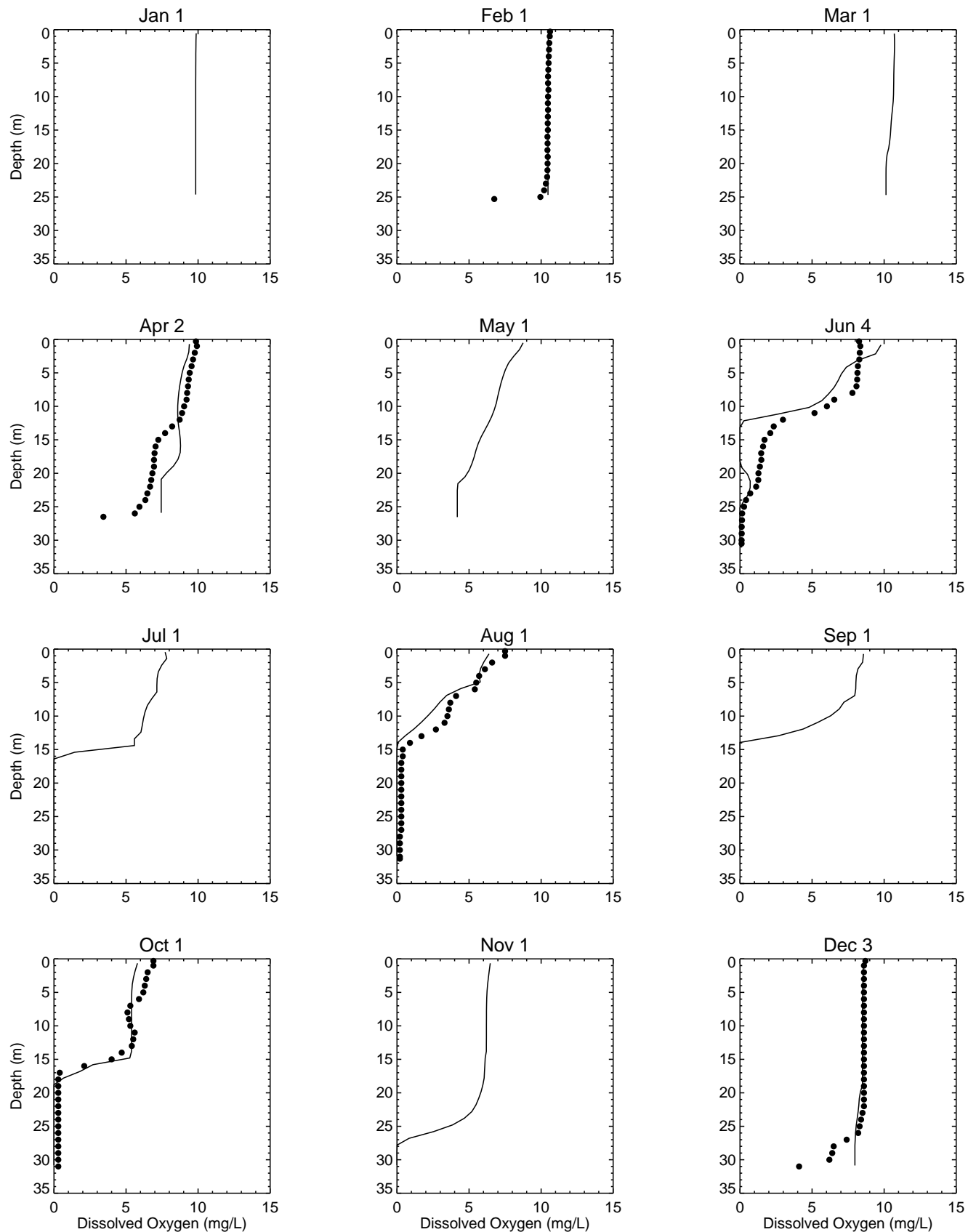*Profiles shown for dates with available data else model results for first day of month shown.*

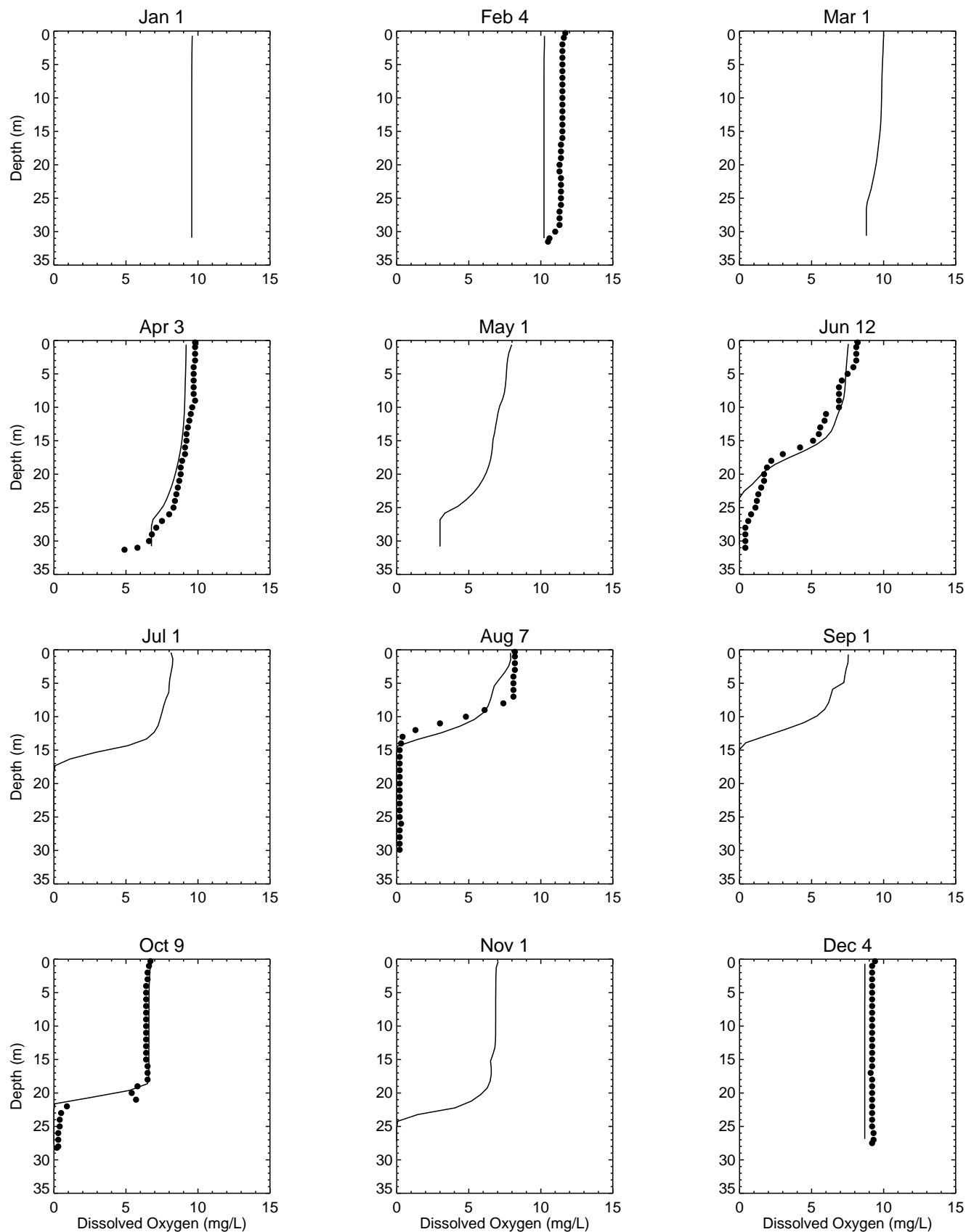CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:38 2013

Model (w1210-48)
● Data

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 1988

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 1989

Profiles shown for dates with available data else model results for first day of month shown.
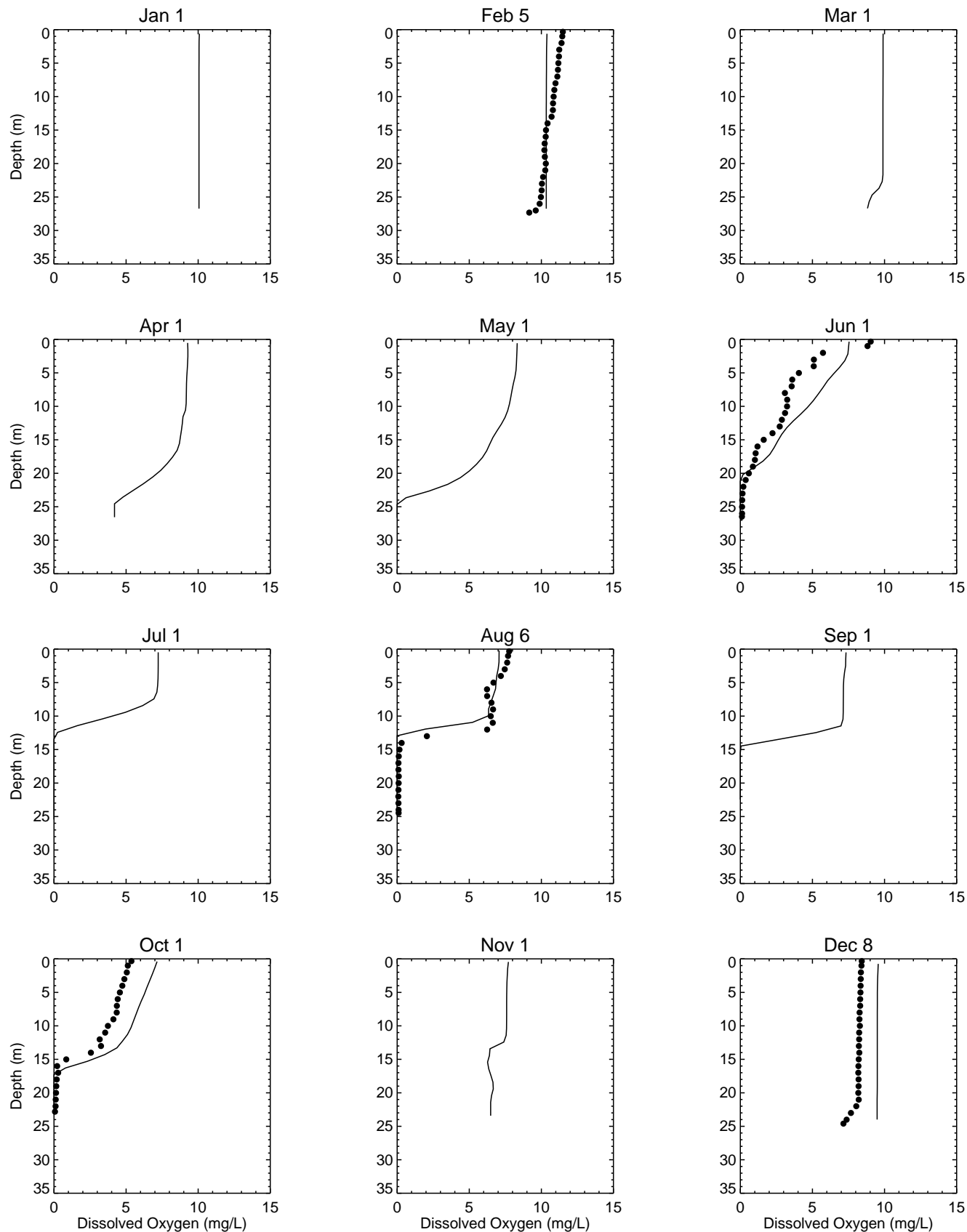
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 1990

Profiles shown for dates with available data else model results for first day of month shown.

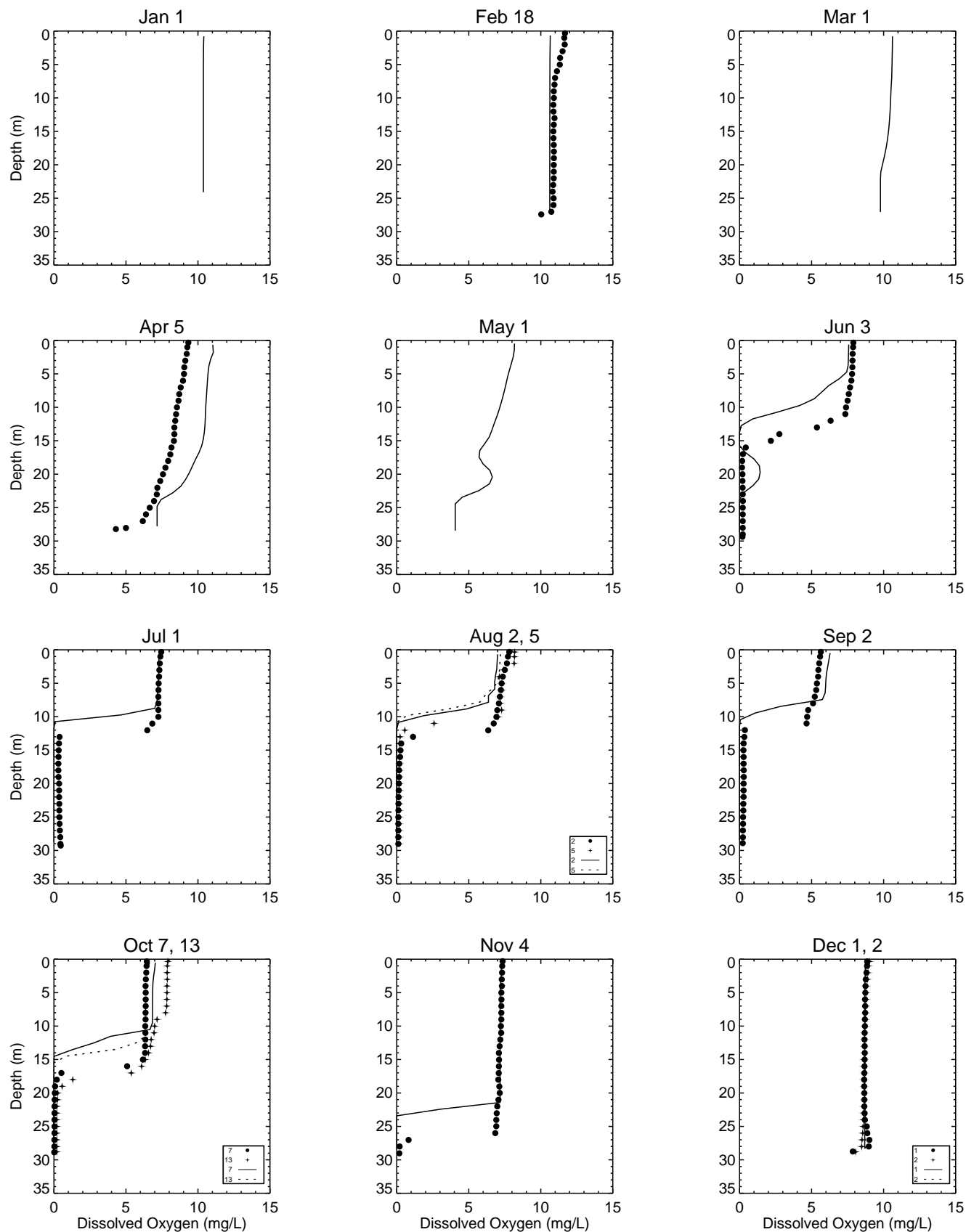CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:38 2013

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 1991

Profiles shown for dates with available data else model results for first day of month shown.

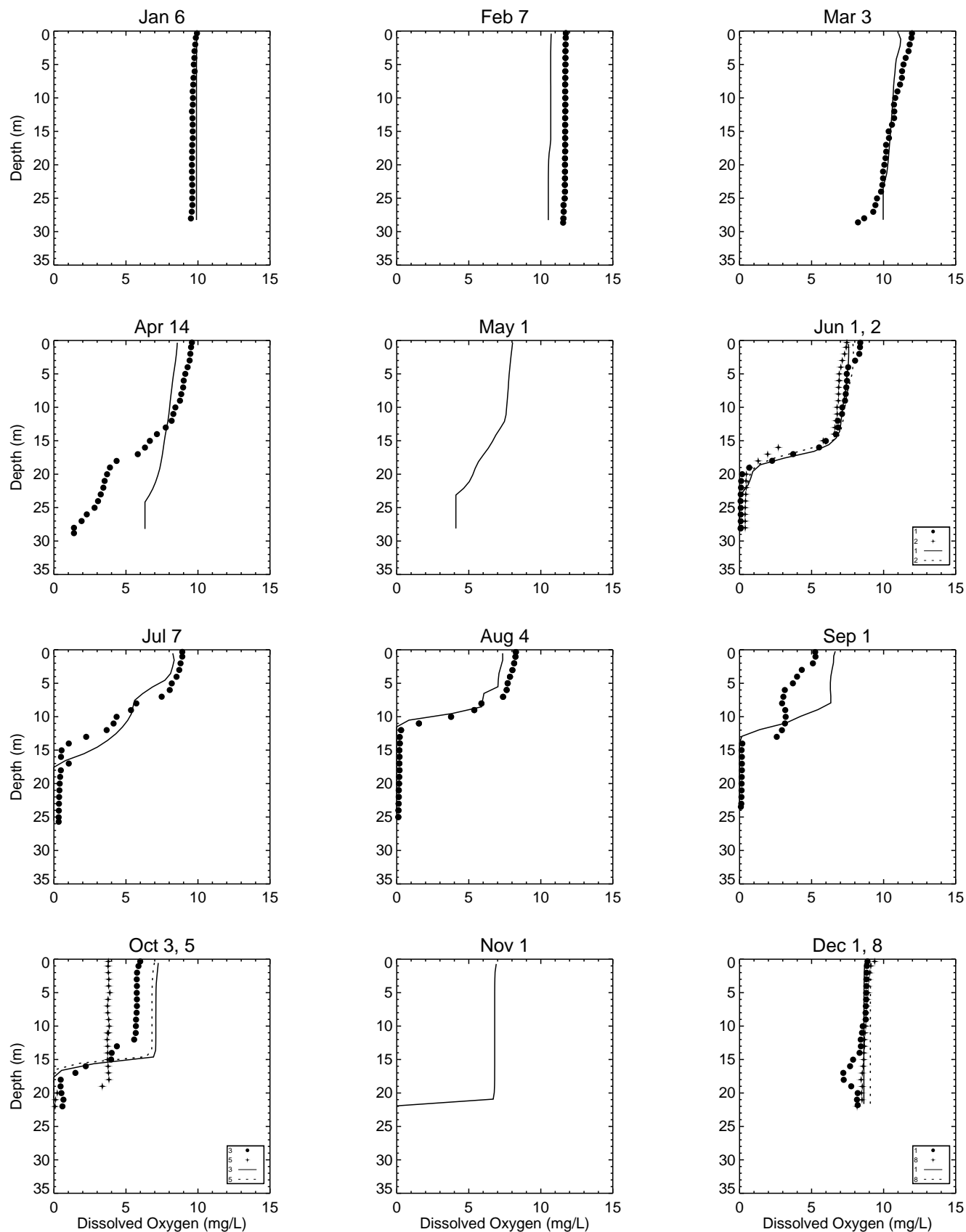CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 1992

Profiles shown for dates with available data else model results for first day of month shown.

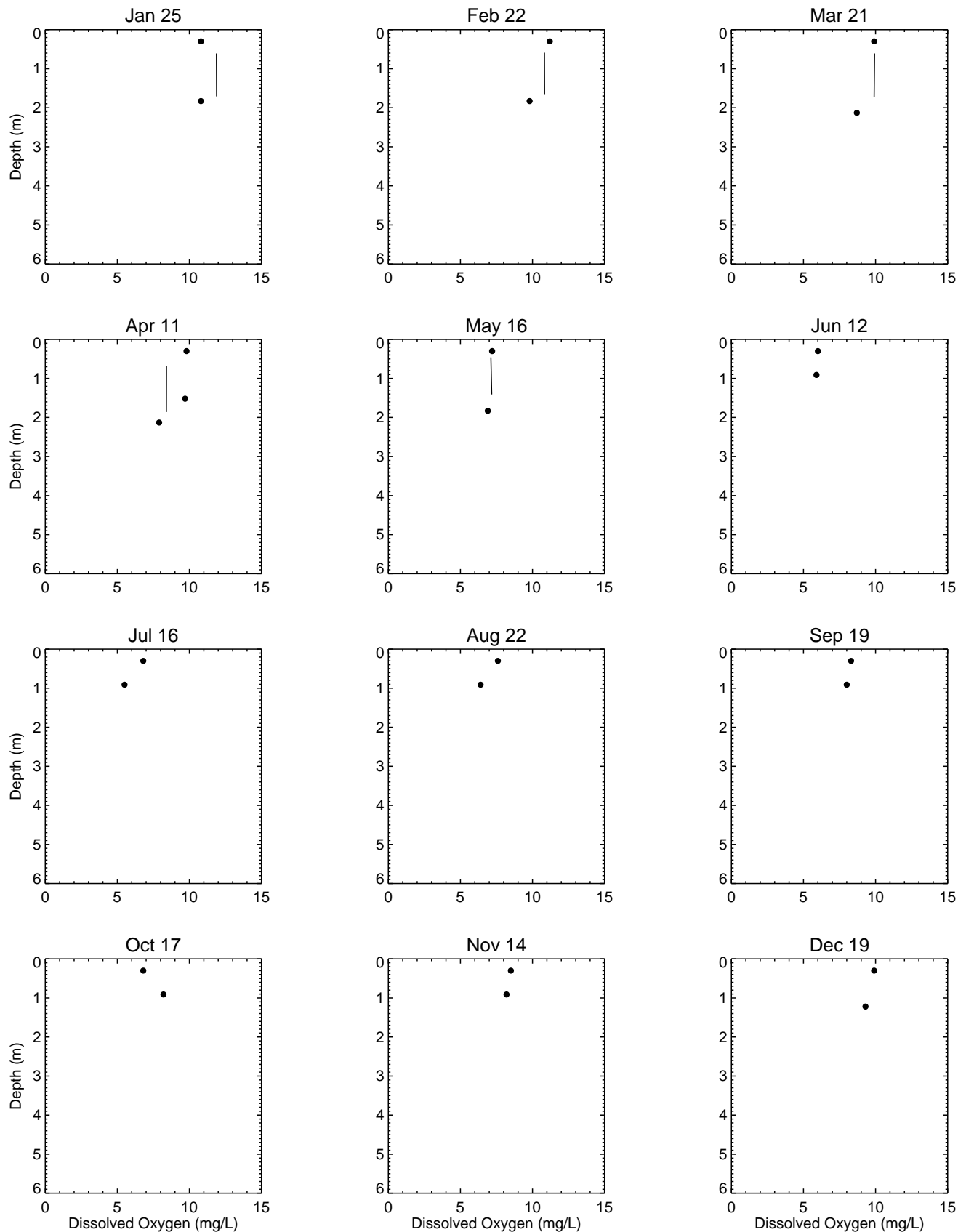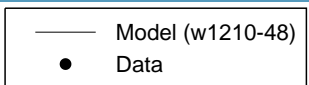CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:38 2013
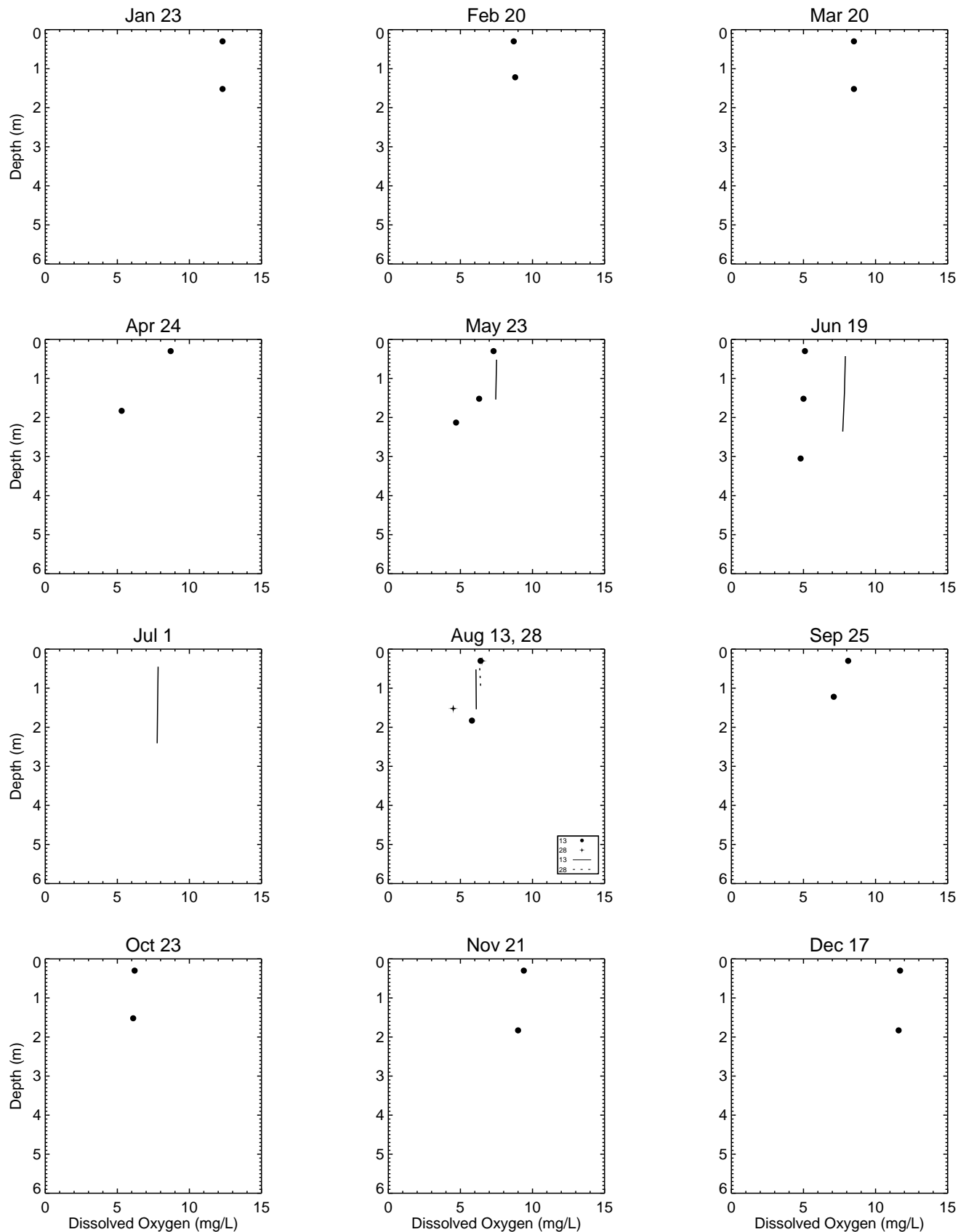
Model (w1210-48)
● Data

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 1993

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 1994

Profiles shown for dates with available data else model results for first day of month shown.

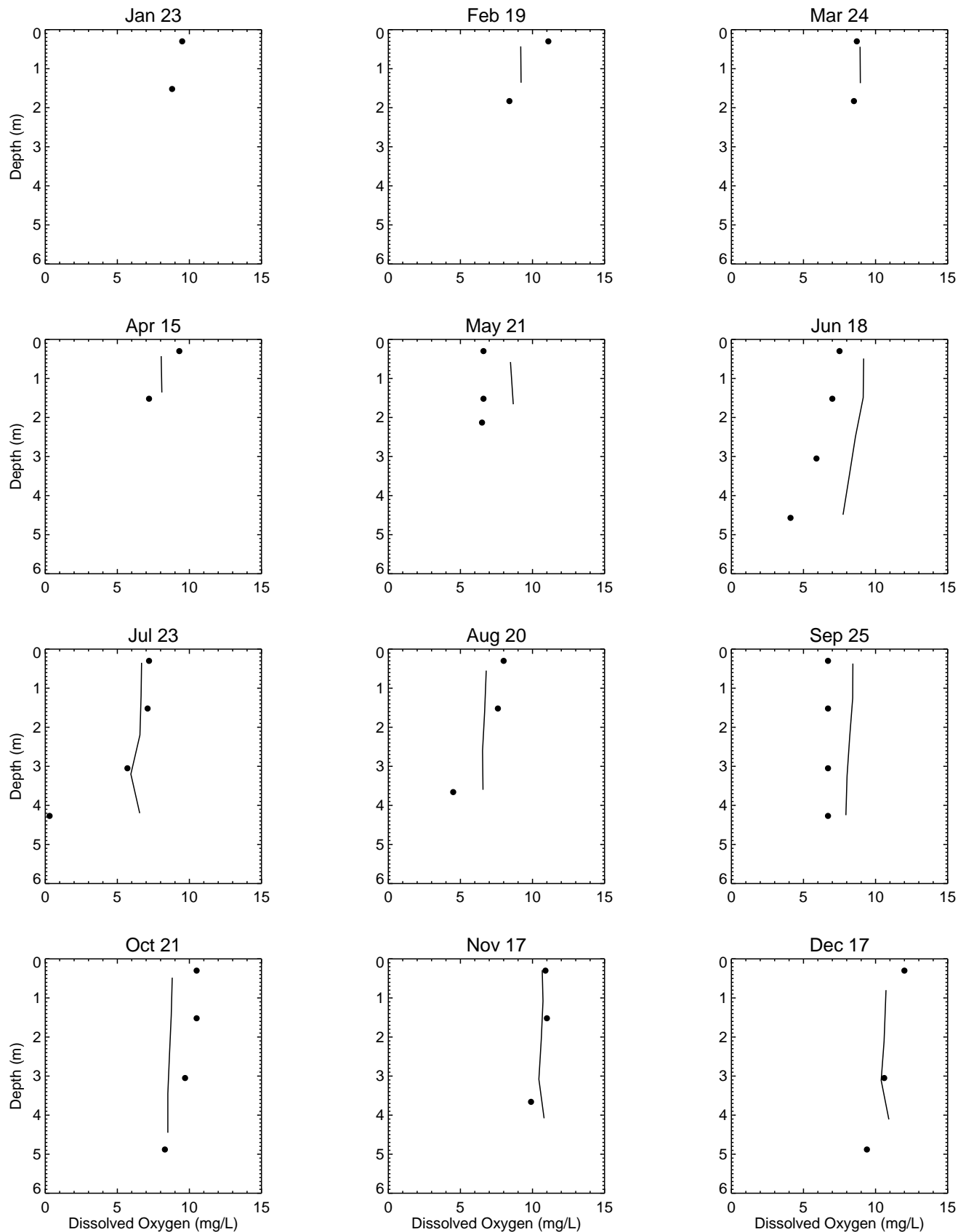CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:38 2013

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 1995

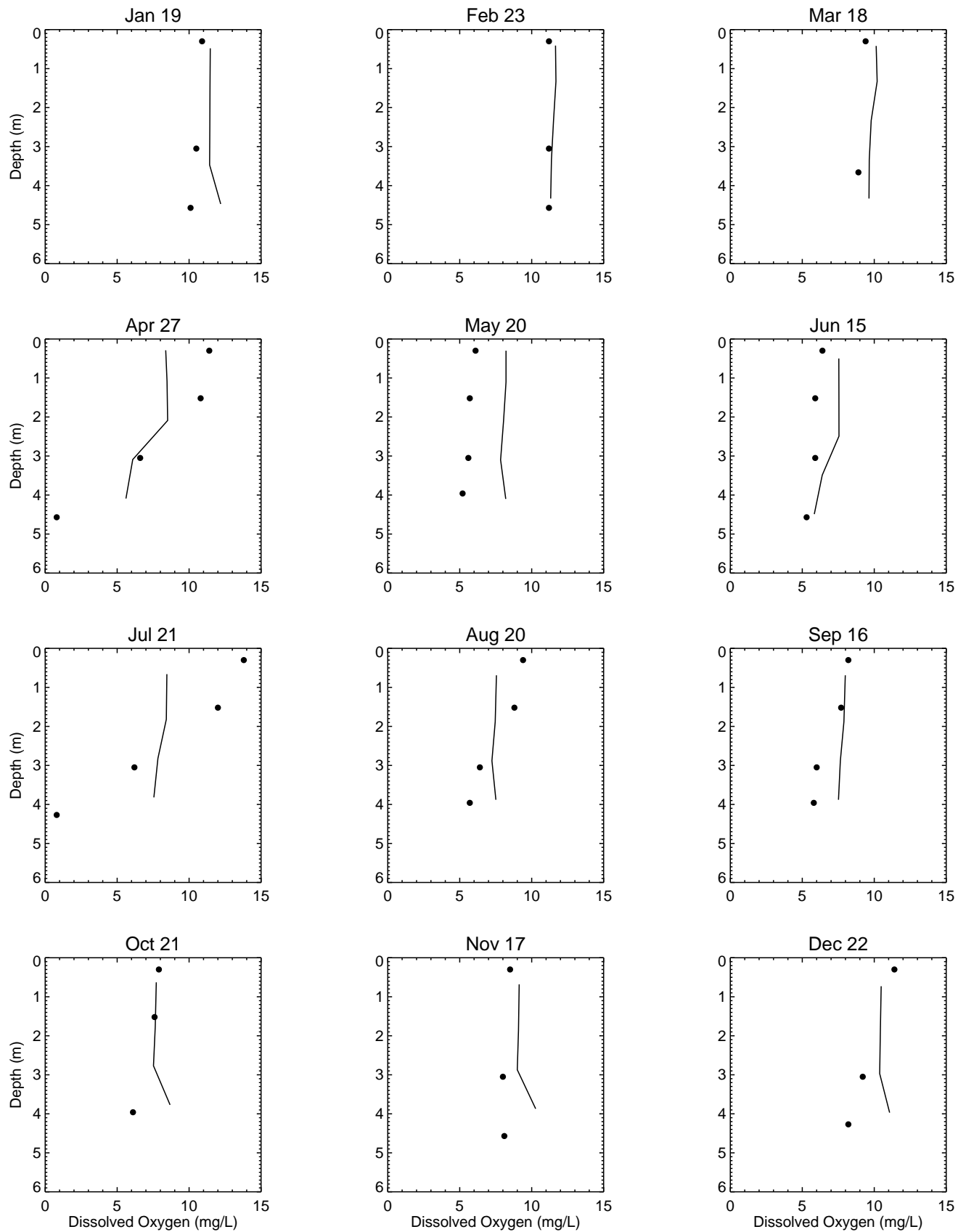*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 1996

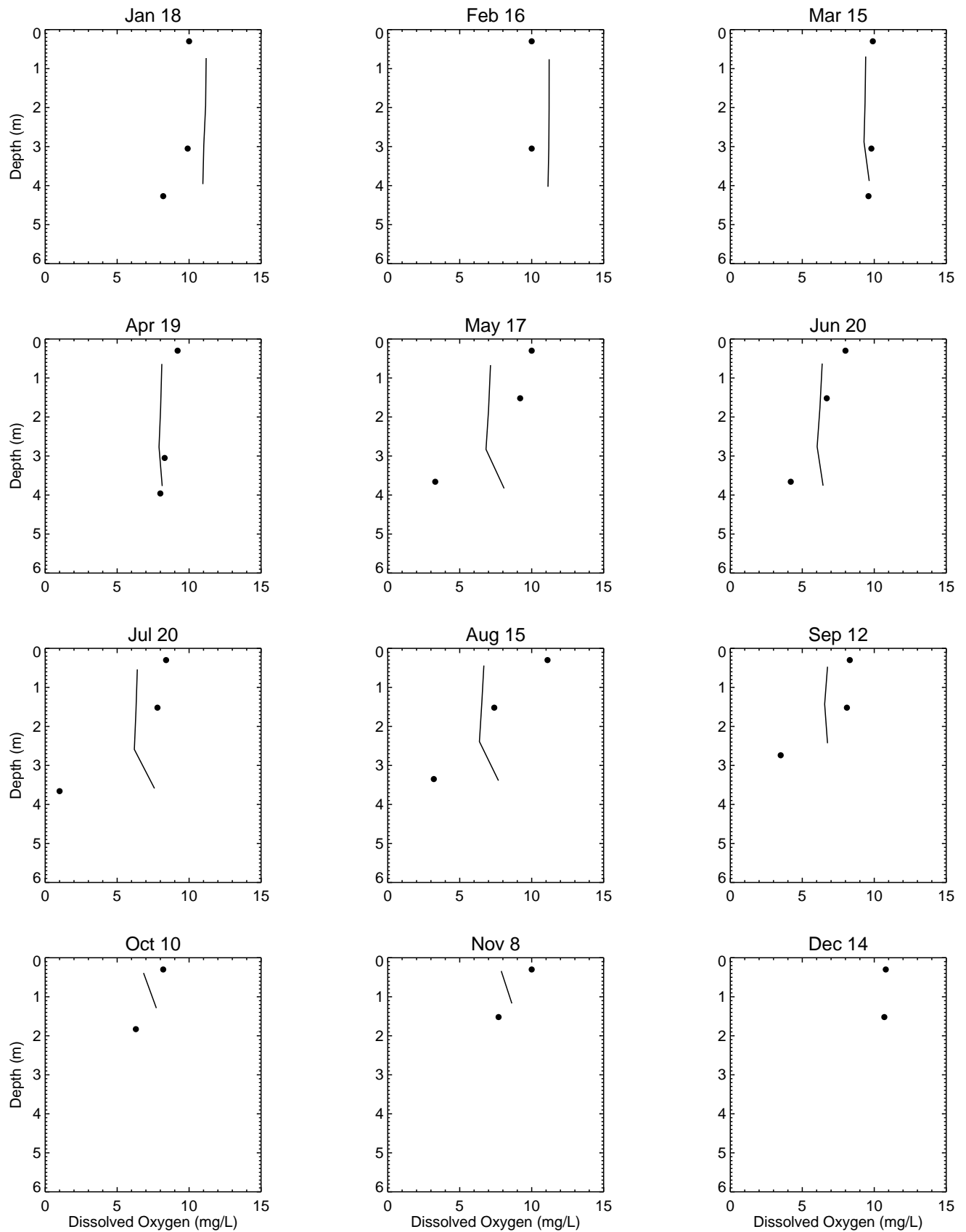*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 1997

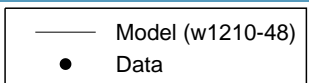*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:38 2013

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 1998

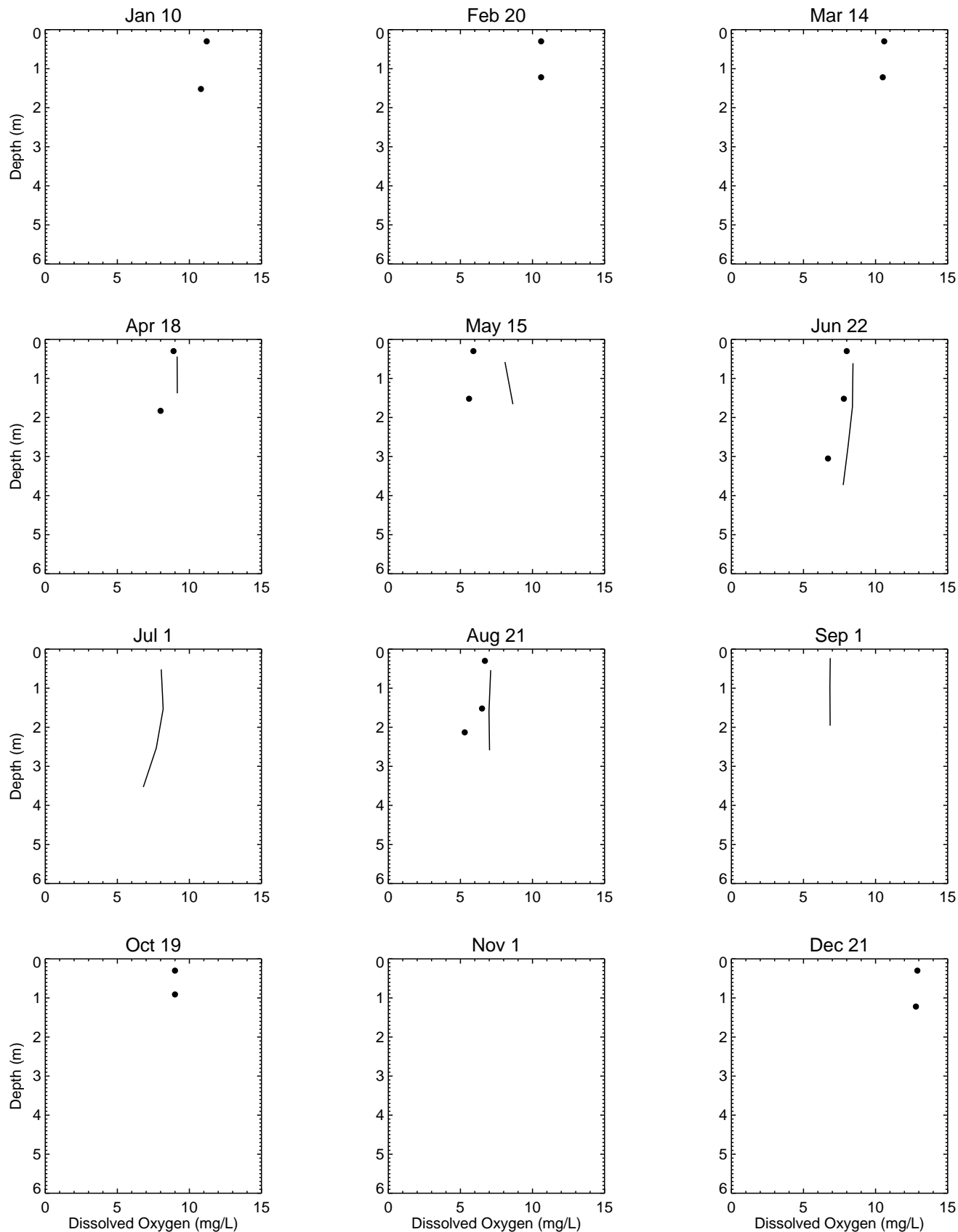*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

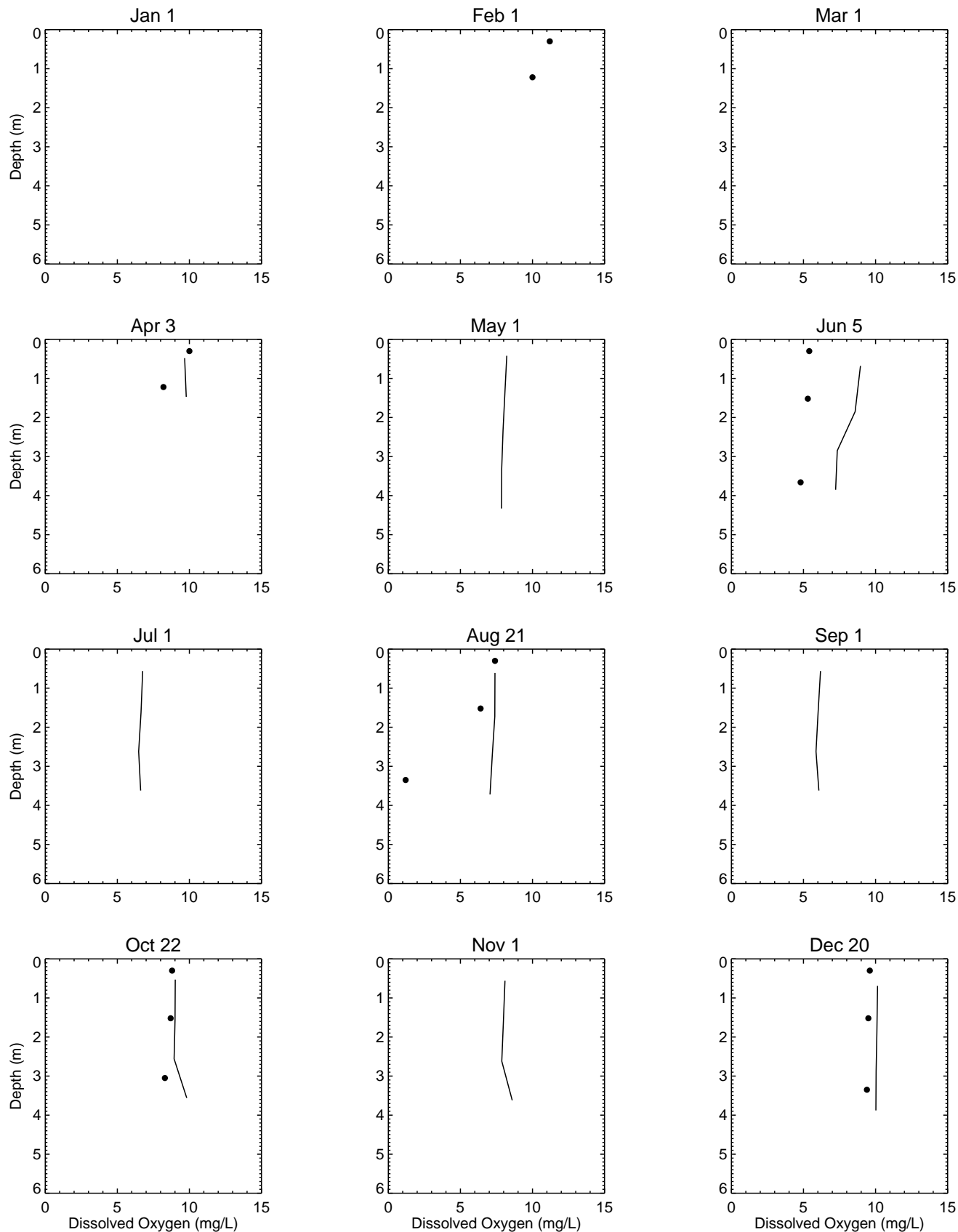Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 1999

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 2000

Profiles shown for dates with available data else model results for first day of month shown.
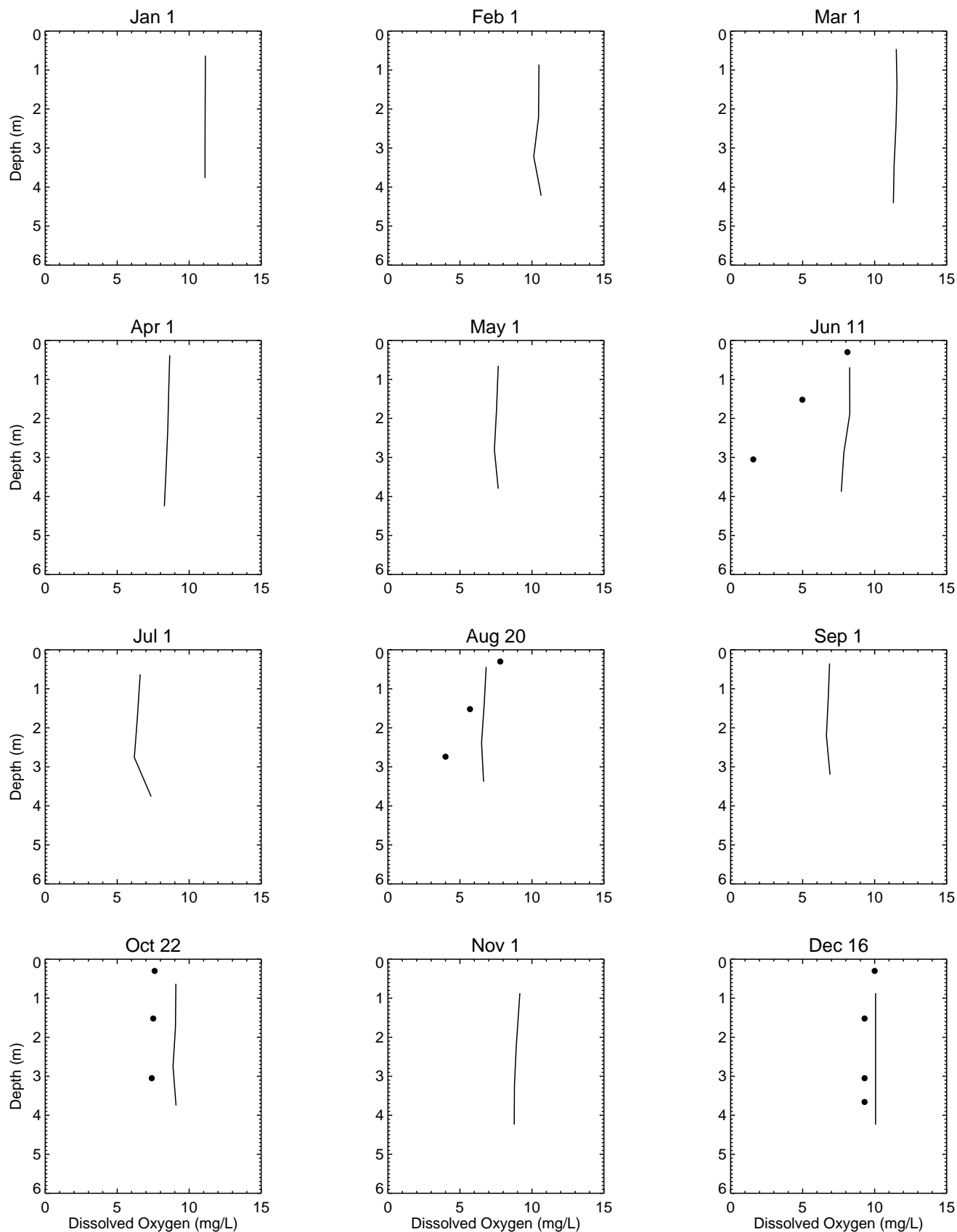
Model (w1210-48)

● Data

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
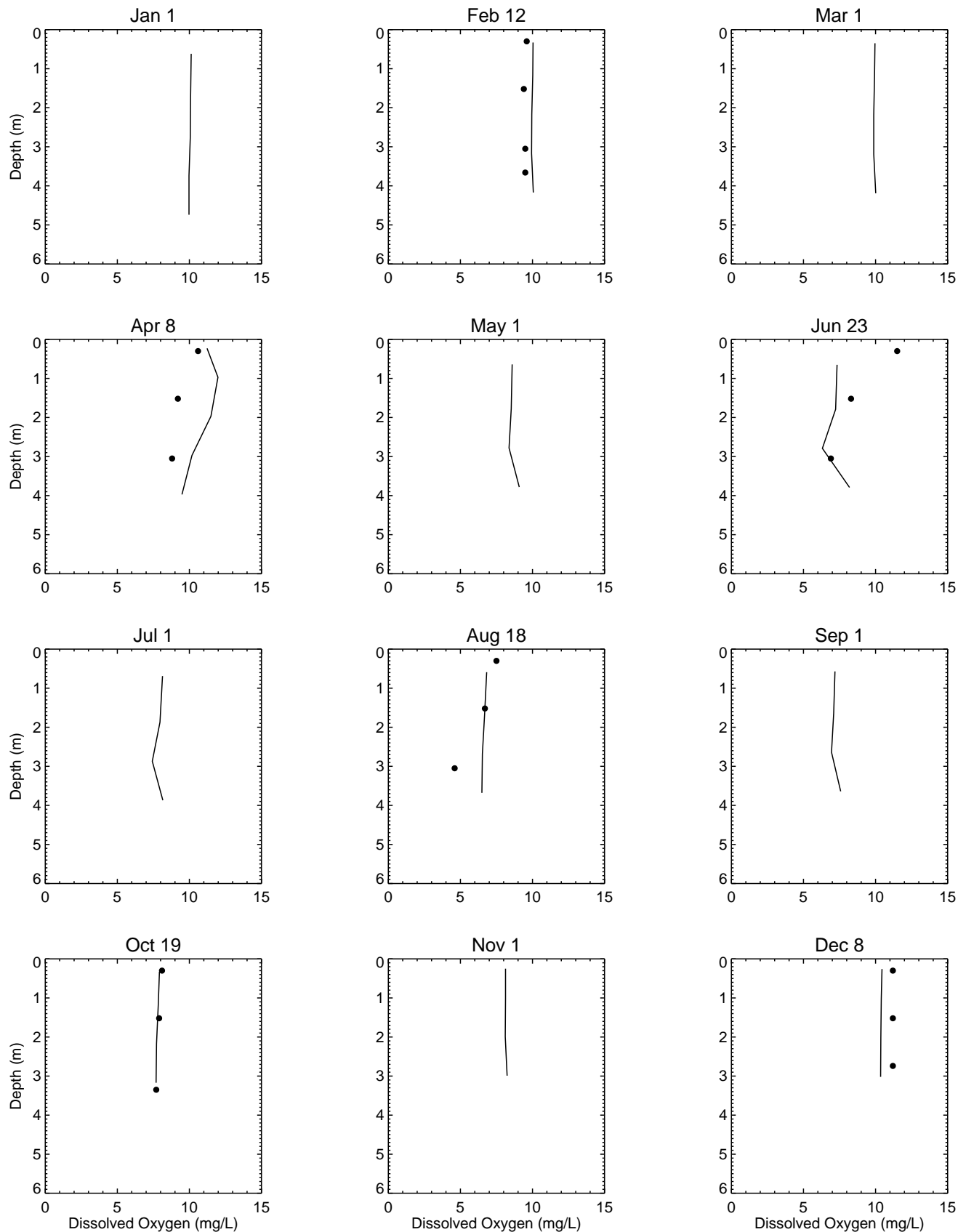Fri Jan 25 18:12:38 2013

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 2001

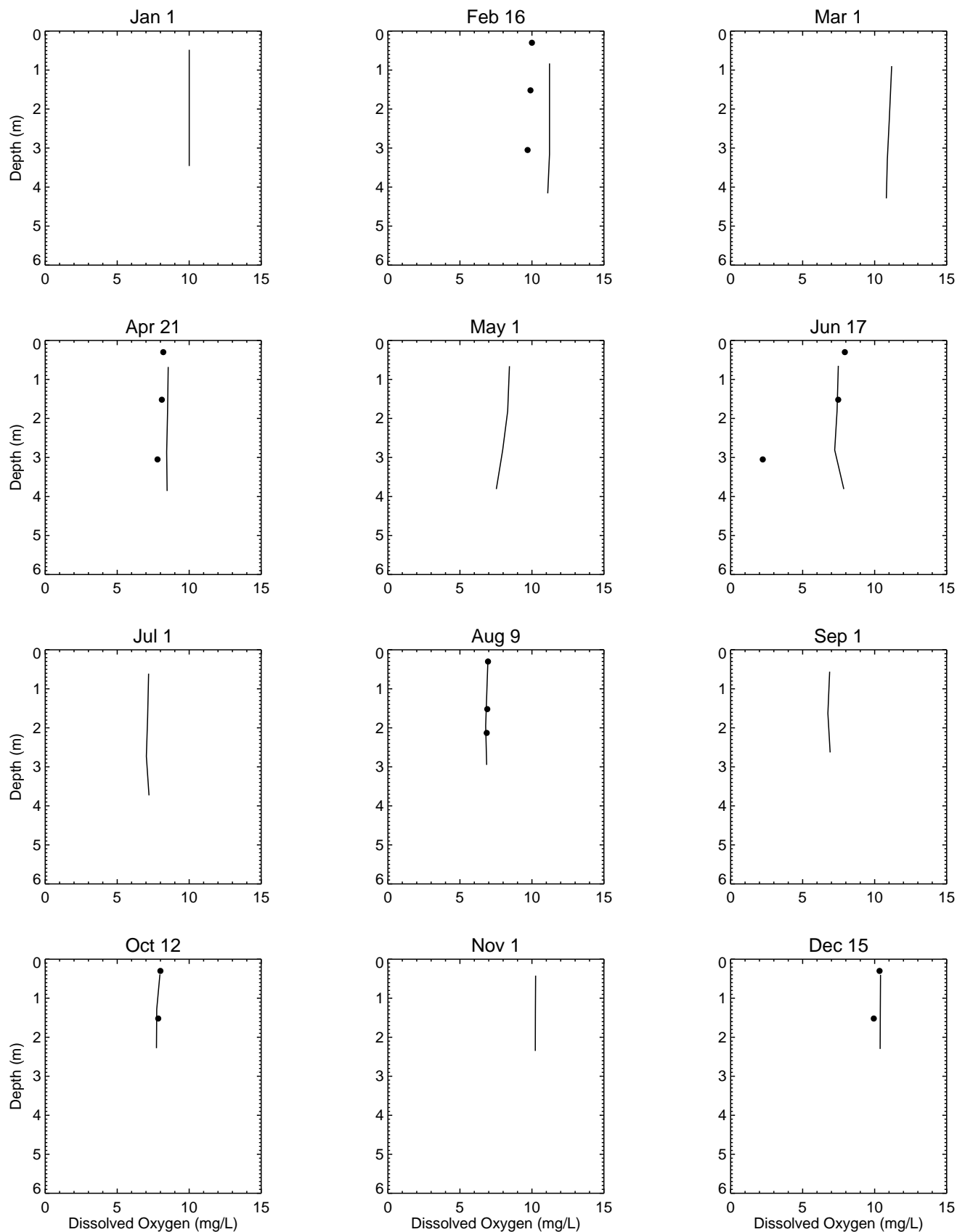*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 2002

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 2003

Profiles shown for dates with available data else model results for first day of month shown.
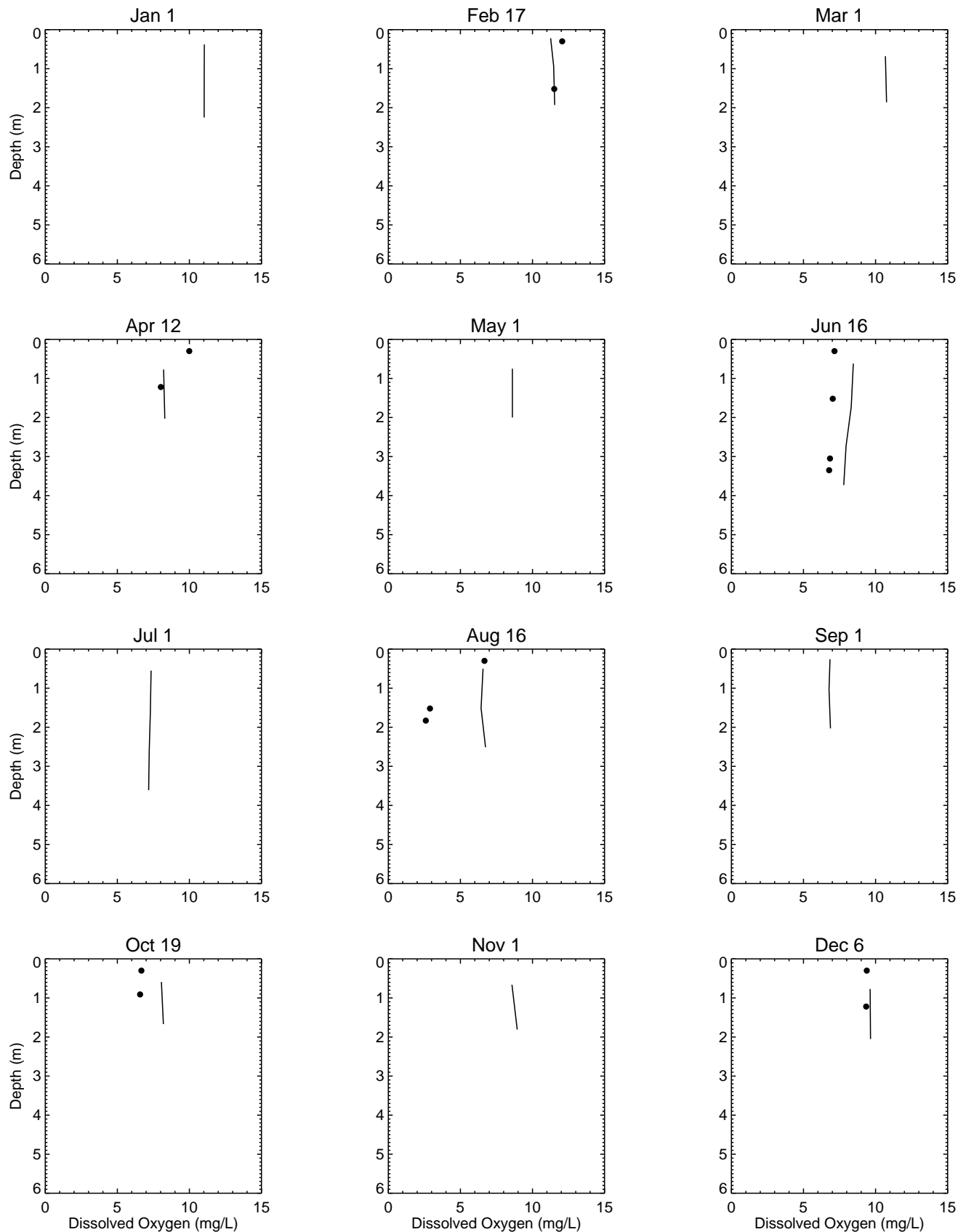
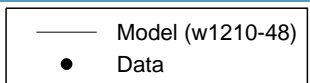CREMs Phase 4: Lake Buchanan
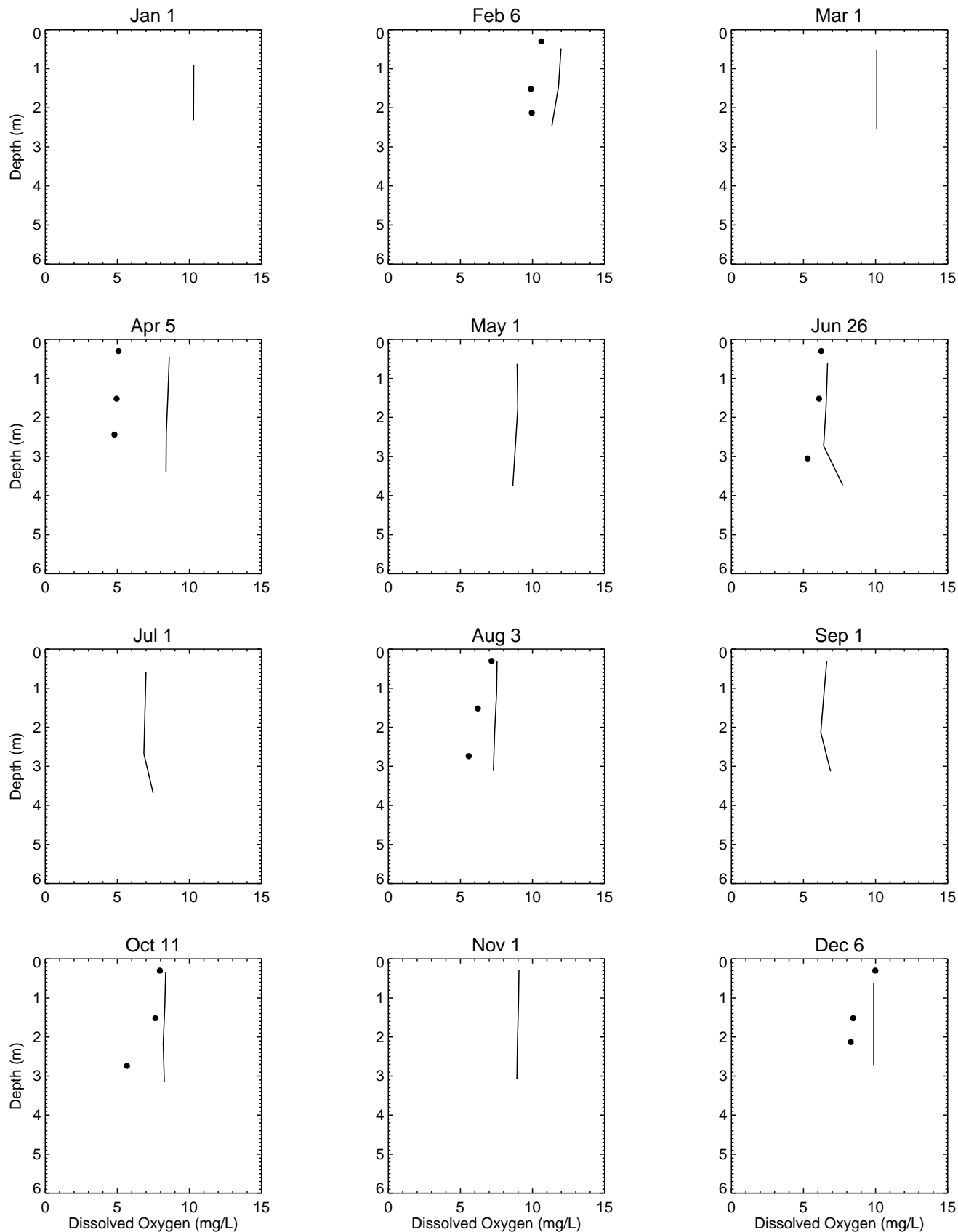
Lower Colorado River Authority

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 2004

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:38 2013
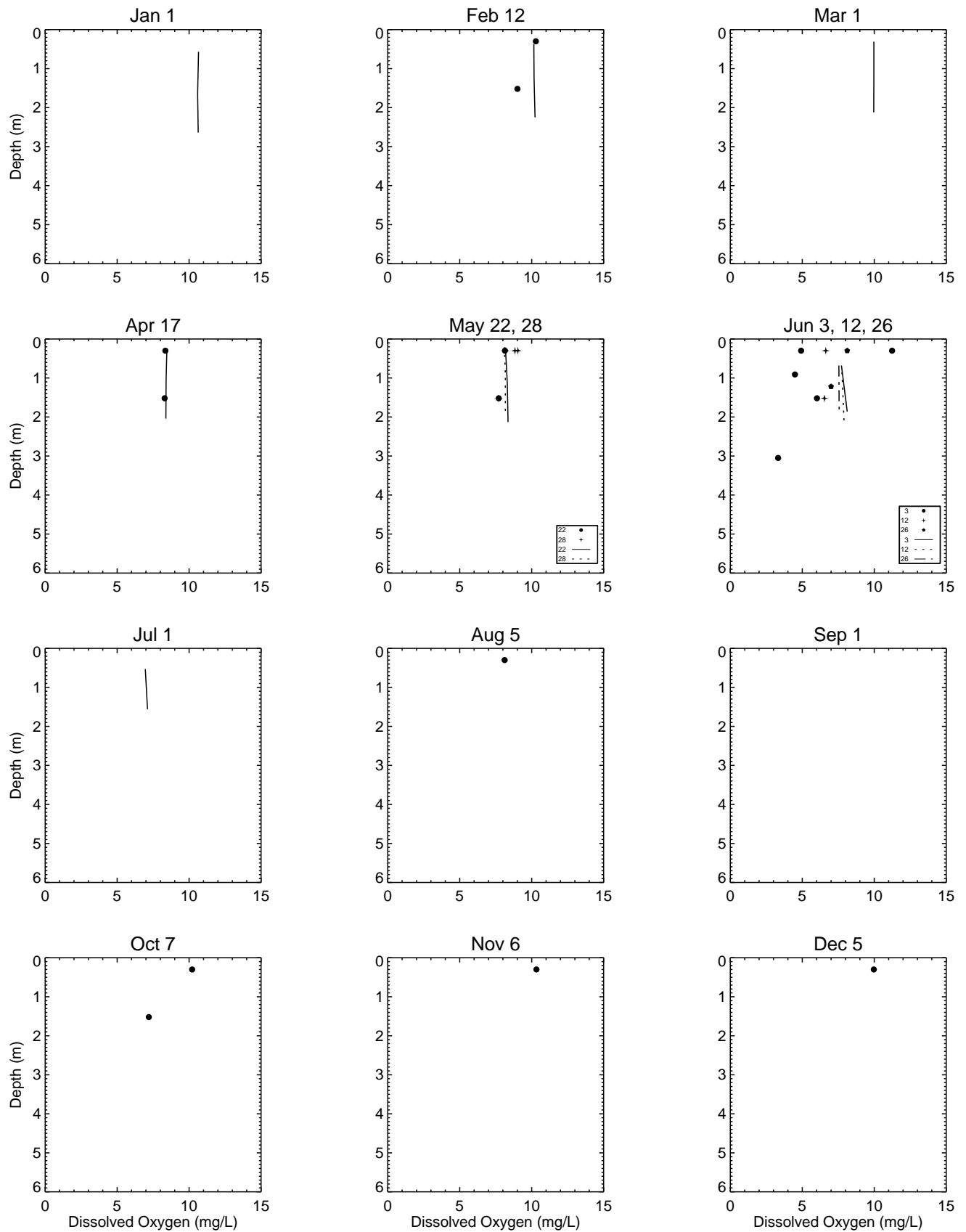
Model (w1210-48)
● Data

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 2005

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:38 2013

Jan 1 — Feb 7 — Mar 1 — Apr 11 — May 1 — Jun 1 — Jul 1 — Aug 8 — Sep 1 — Oct 11 — Nov 1 — Dec 13

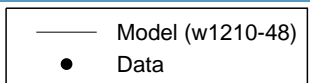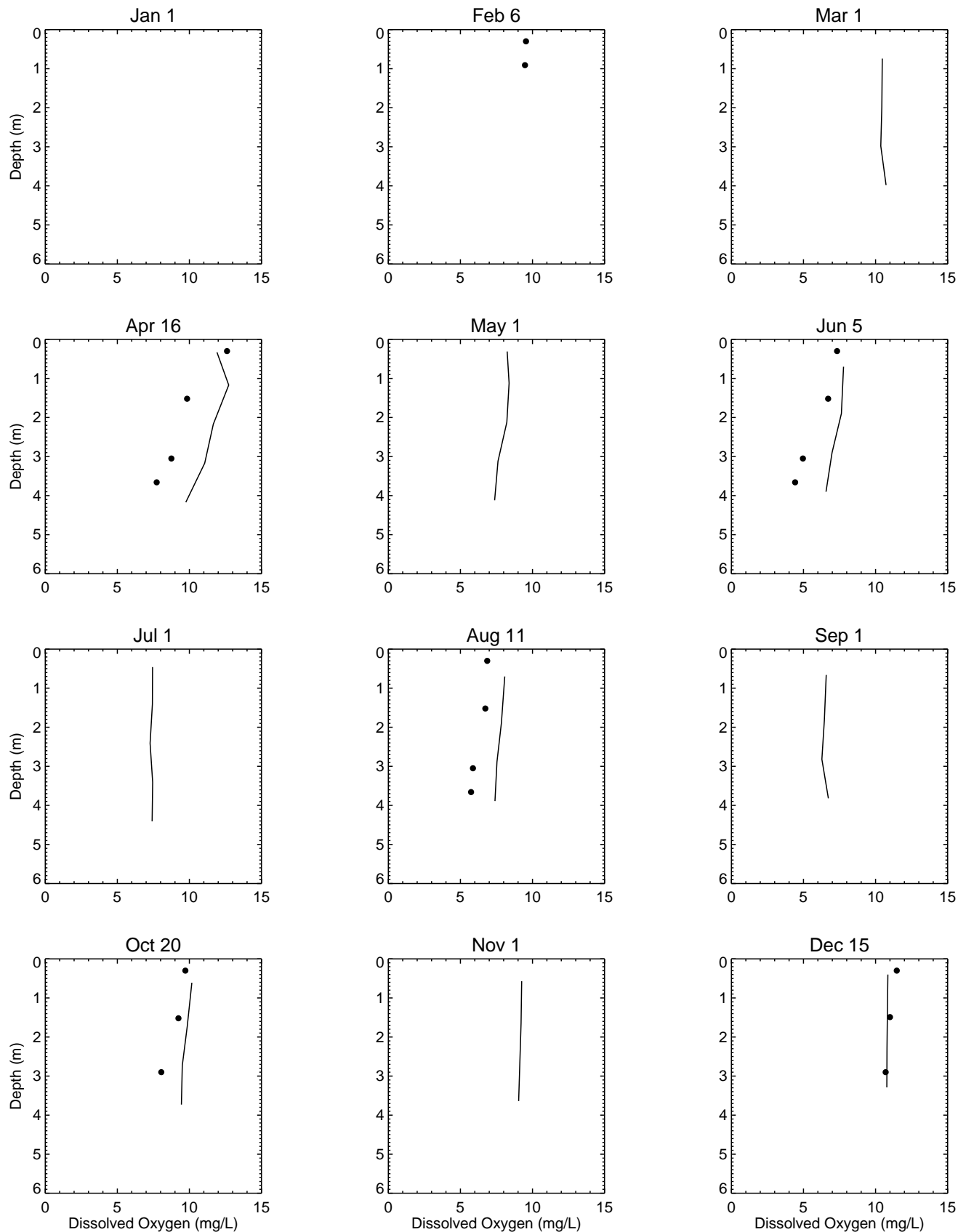Depth (m) / Dissolved Oxygen (mg/L)

—— Model (w1210-48)
● Data

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 2006

Profiles shown for dates with available data else model results for first day of month shown.
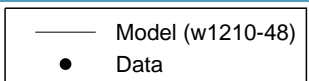
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:38 2013

Jan 1 — Feb 1 — Mar 1 — Apr 2 — May 1 — Jun 4 — Jul 1 — Aug 1 — Sep 1 — Oct 1 — Nov 1 — Dec 3

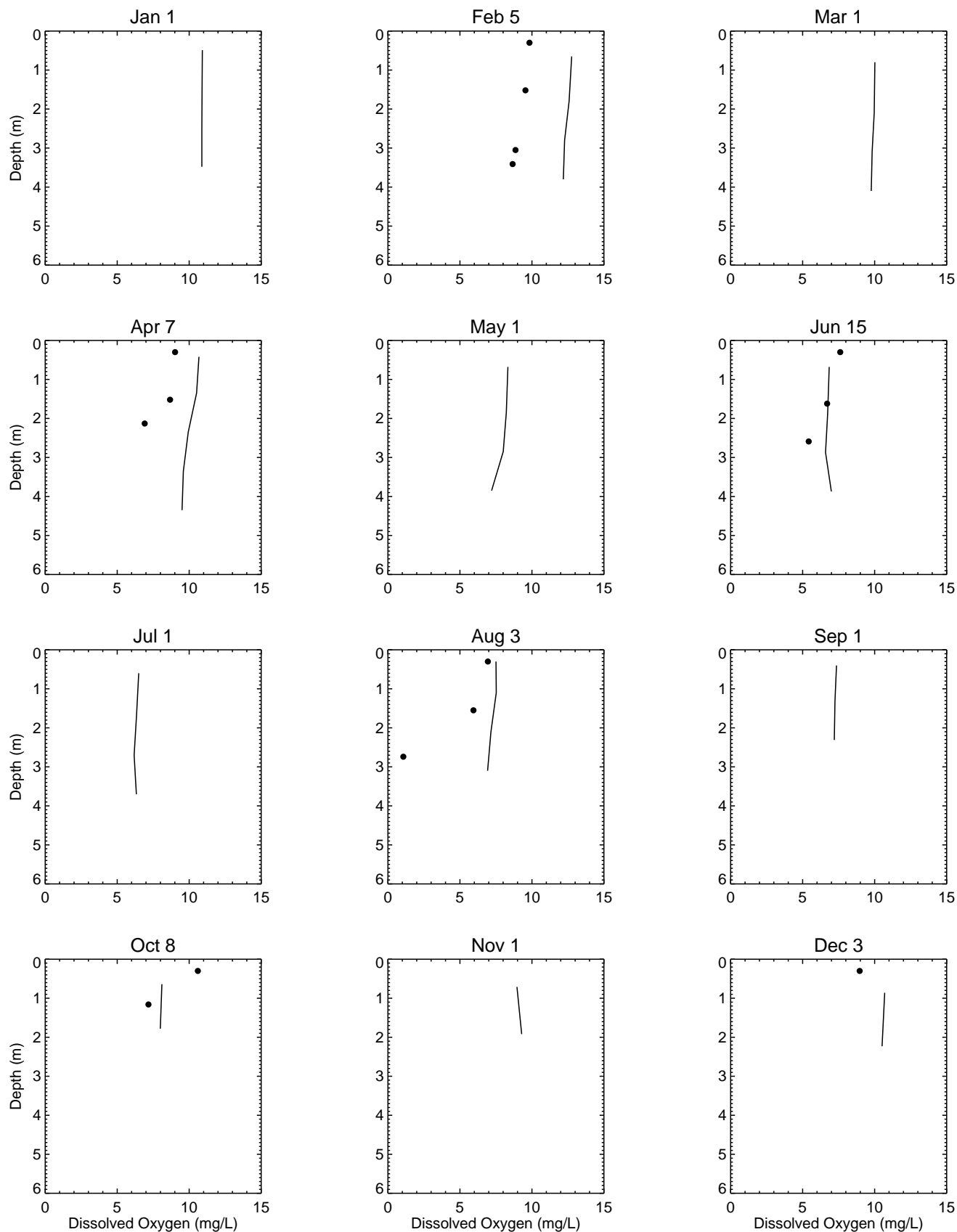Depth (m) / Dissolved Oxygen (mg/L)

Model (w1210-48)
Data

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 2007

Profiles shown for dates with available data else model results for first day of month shown.
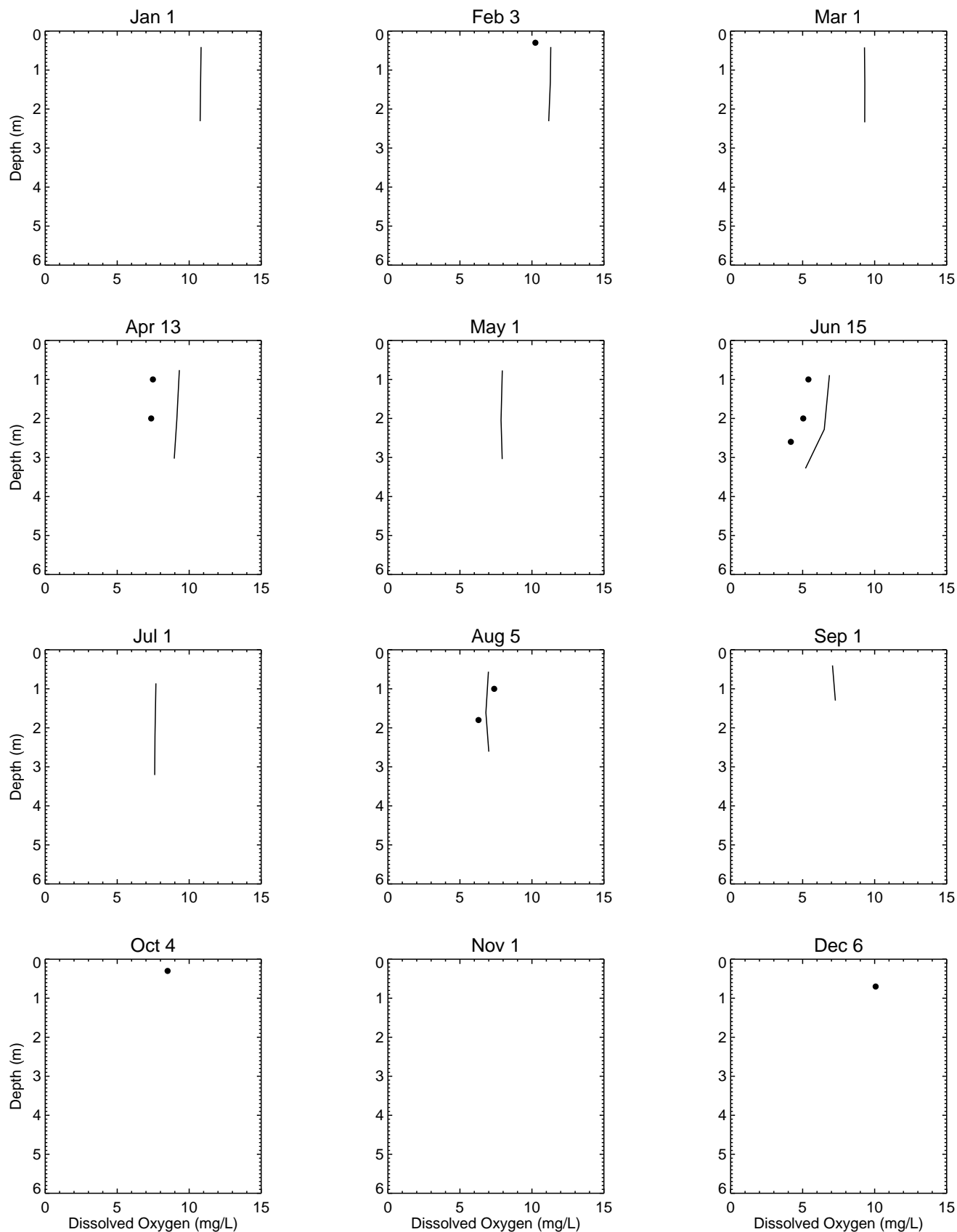
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

Jan 1 · Feb 4 · Mar 1 · Apr 3 · May 1 · Jun 12 · Jul 1 · Aug 7 · Sep 1 · Oct 9 · Nov 1 · Dec 4
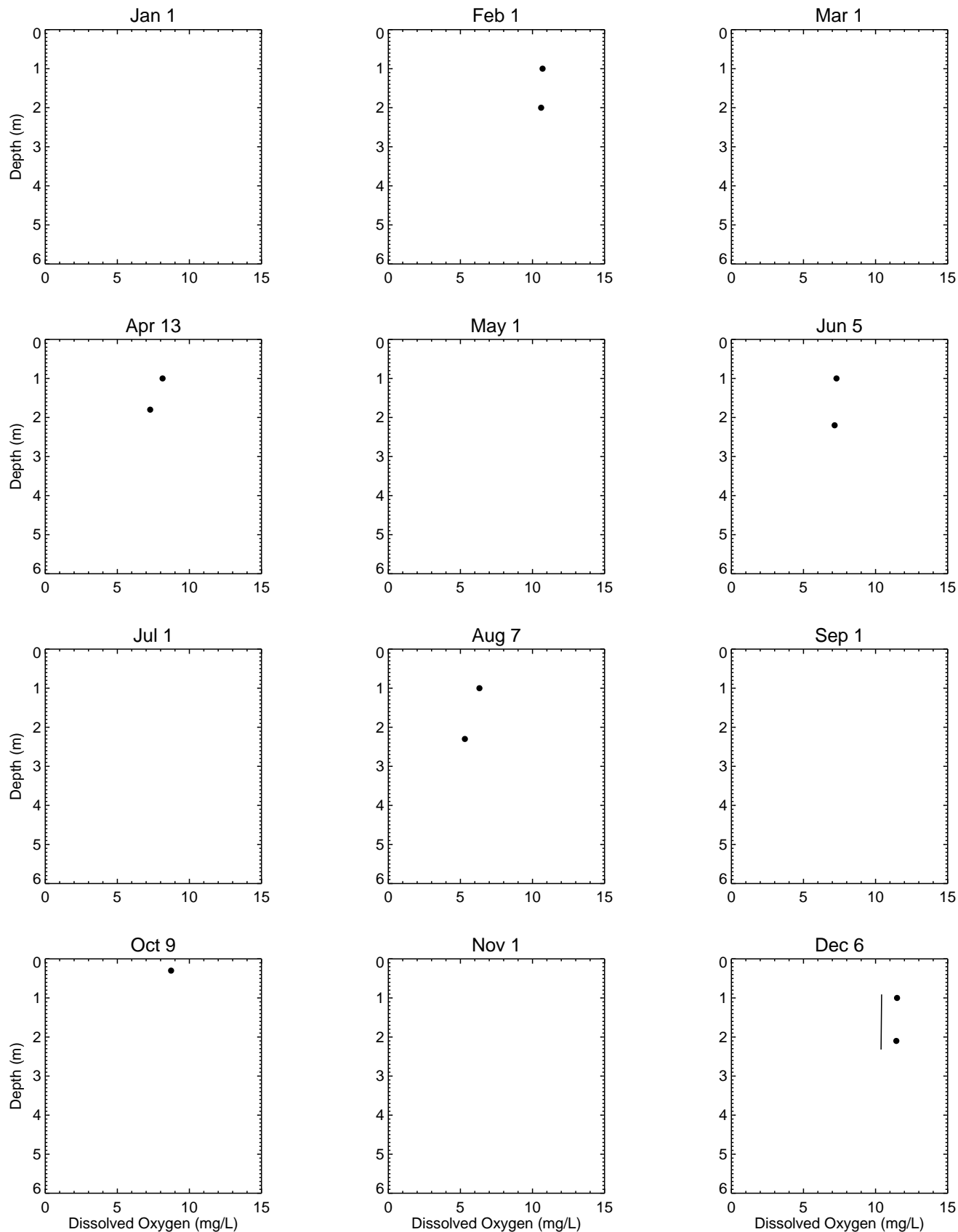
Depth (m)

Dissolved Oxygen (mg/L)

——— Model (w1210-48)
● Data

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 2008

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
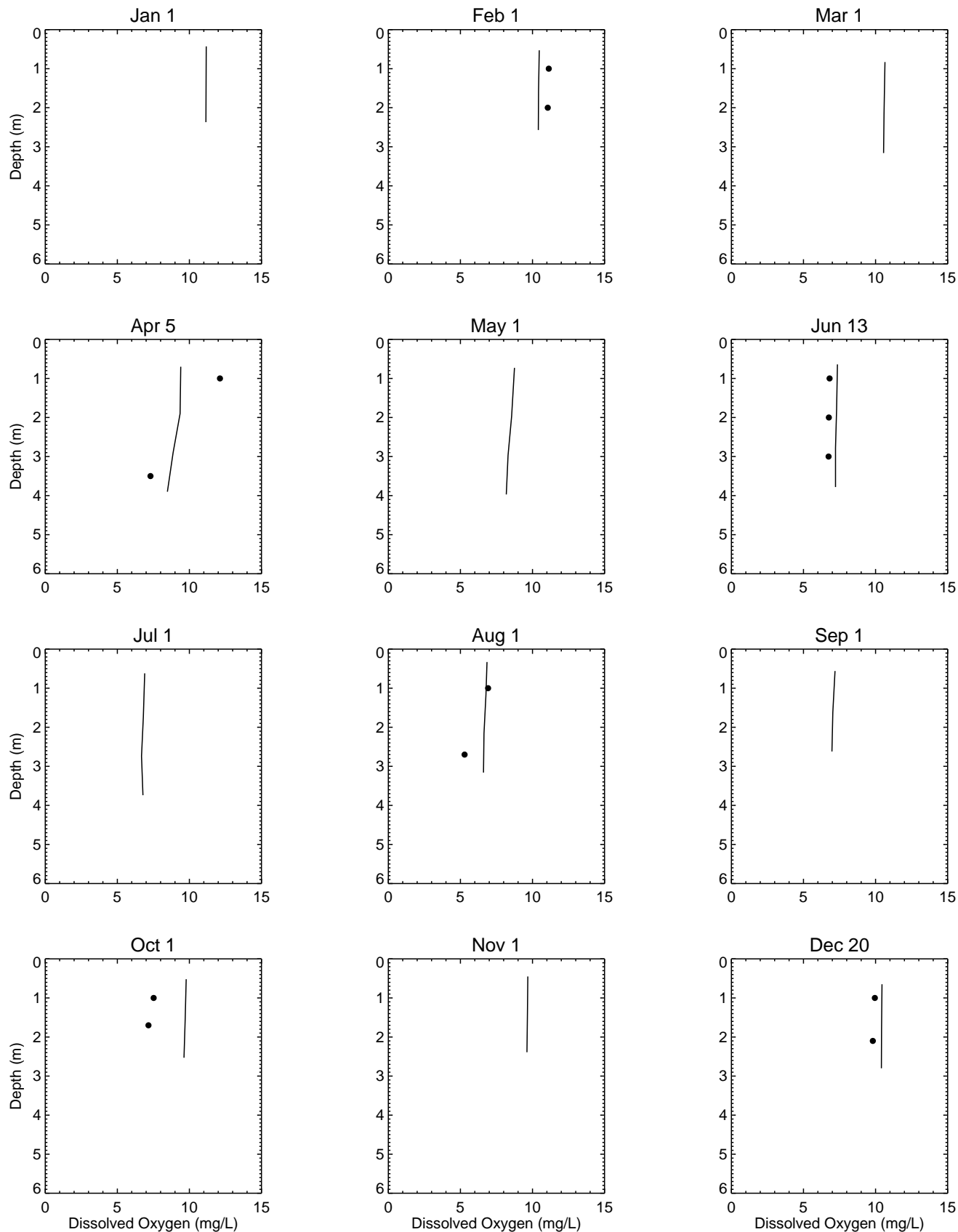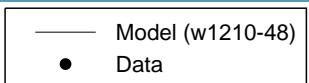Fri Jan 25 18:12:38 2013

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 2009

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
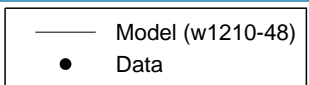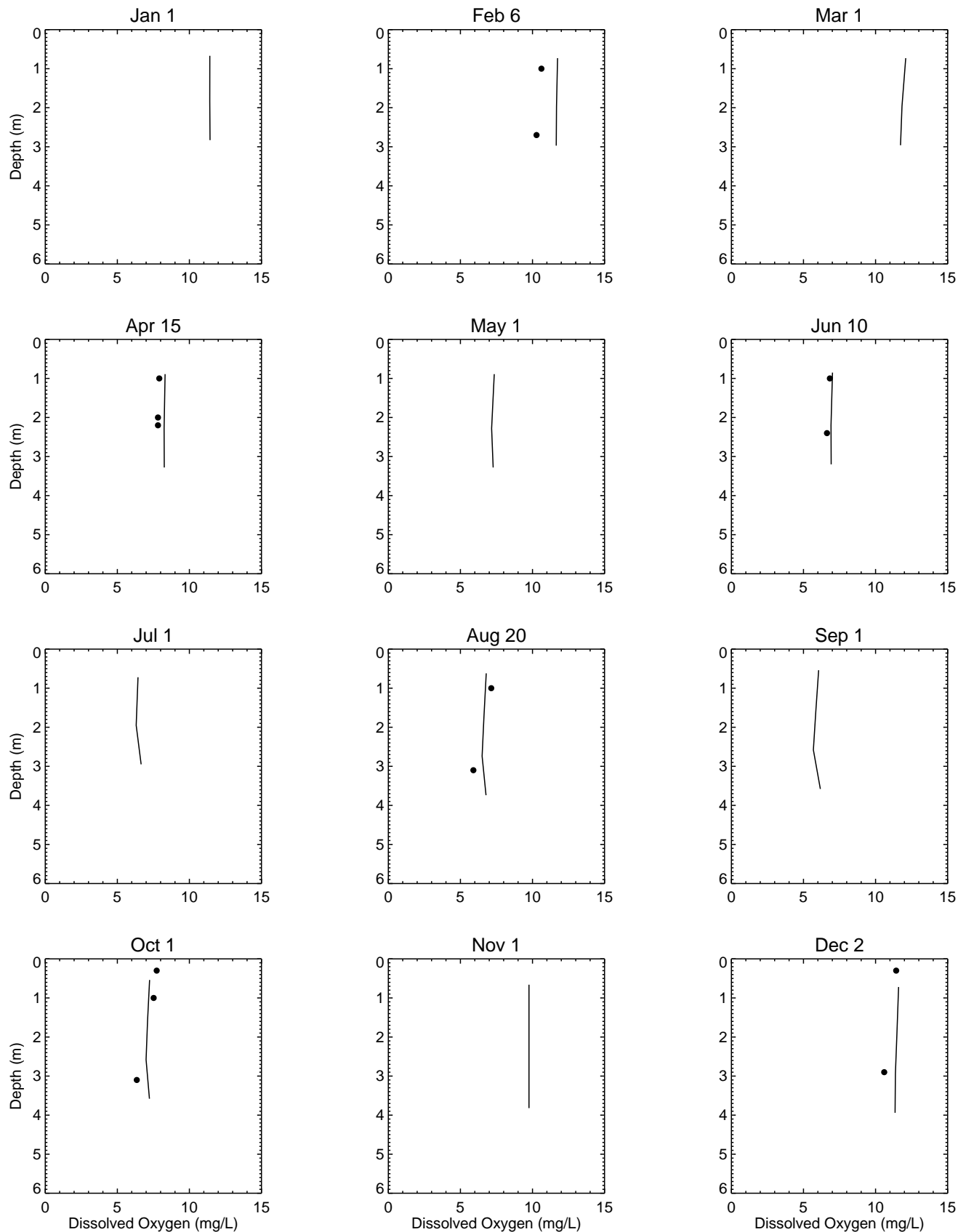Fri Jan 25 18:12:38 2013

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 2010

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
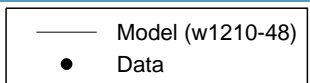
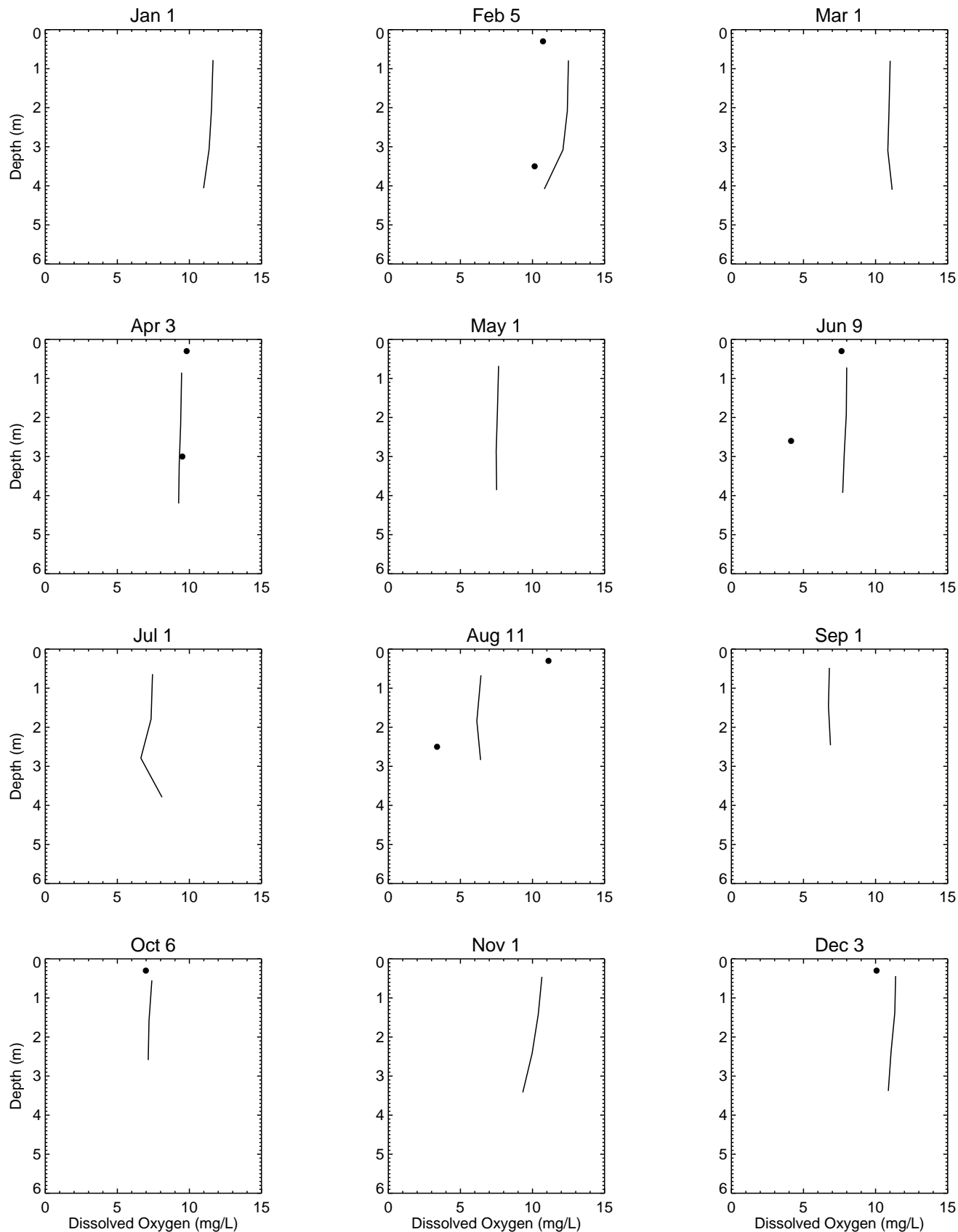Lower Colorado River Authority

Figure G-27

Vertical Profiles of Model Versus Data for Lake Buchanan
near Lake Headwater (Segment 2) - Dissolved Oxygen - 2011

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 25 · Feb 22 · Mar 21 · Apr 11 · May 16 · Jun 12 · Jul 16 · Aug 22 · Sep 19 · Oct 17 · Nov 14 · Dec 19

Depth (m)

Dissolved Oxygen (mg/L)

——— Model (w1210-48)
● Data

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 1984

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR
QEA
PARSONS

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:41 2013

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 1985

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
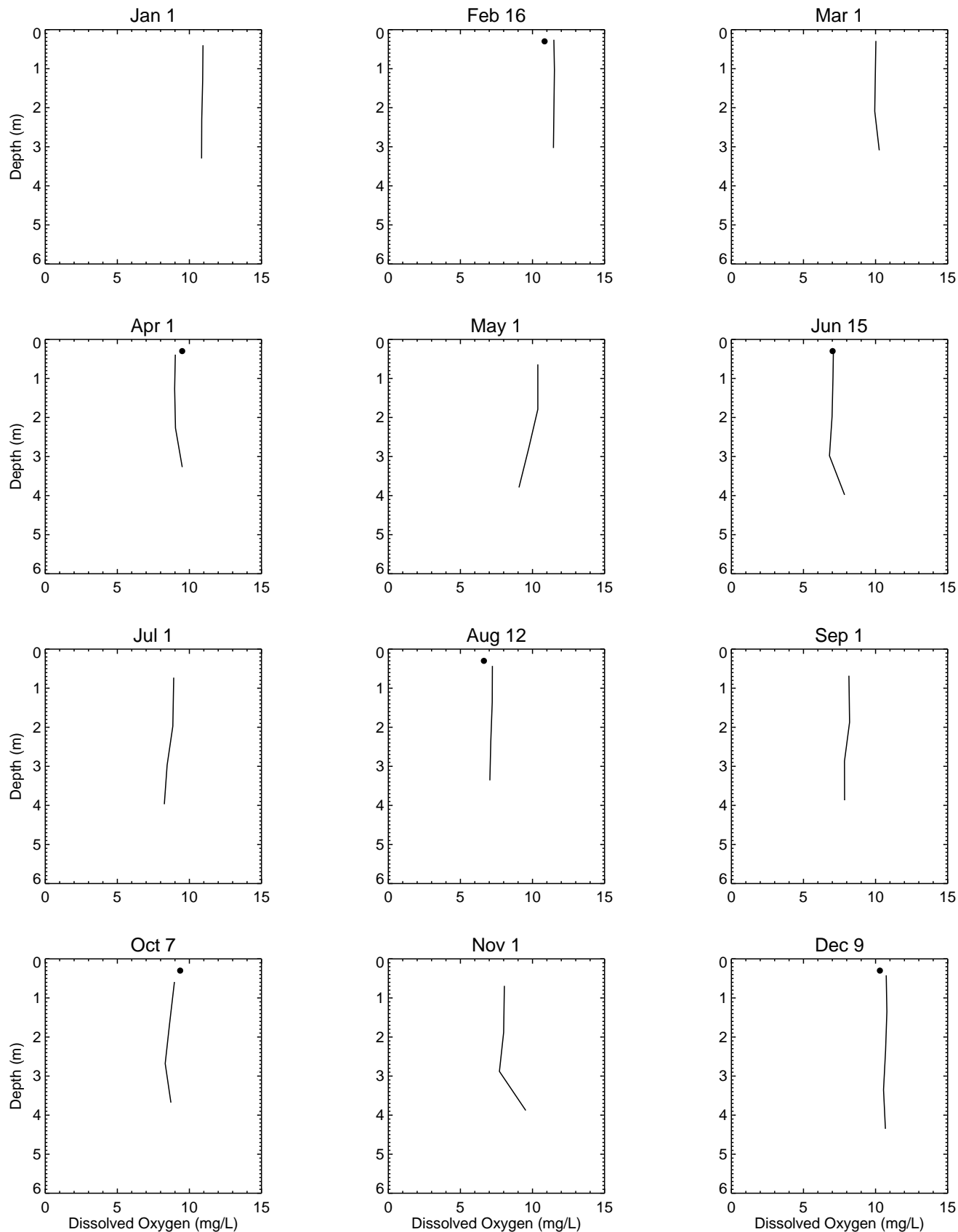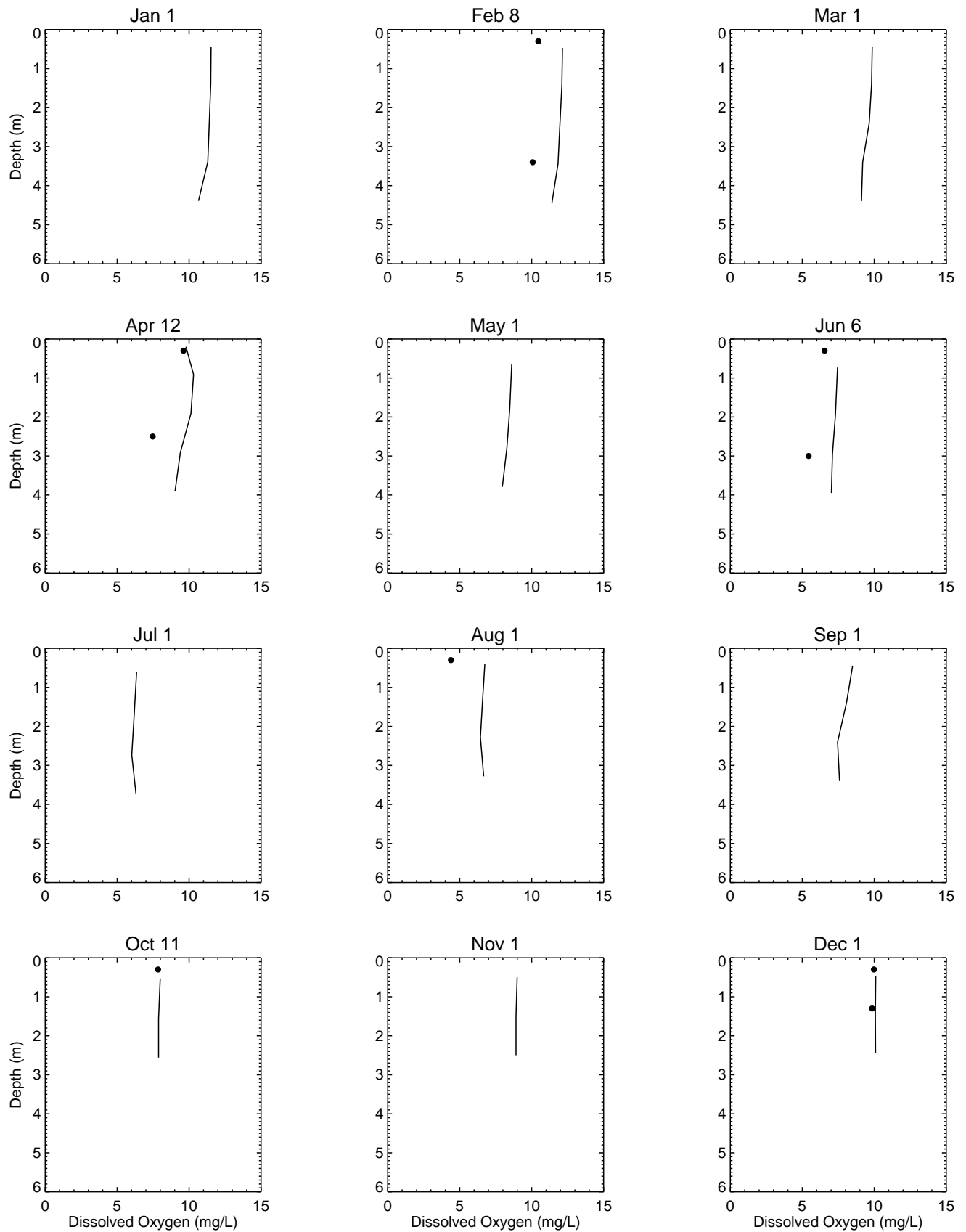
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:41 2013

Jan 23 · Feb 19 · Mar 24 · Apr 15 · May 21 · Jun 18 · Jul 23 · Aug 20 · Sep 25 · Oct 21 · Nov 17 · Dec 17

Dissolved Oxygen (mg/L)

—— Model (w1210-48)
● Data

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 1986

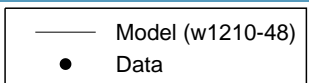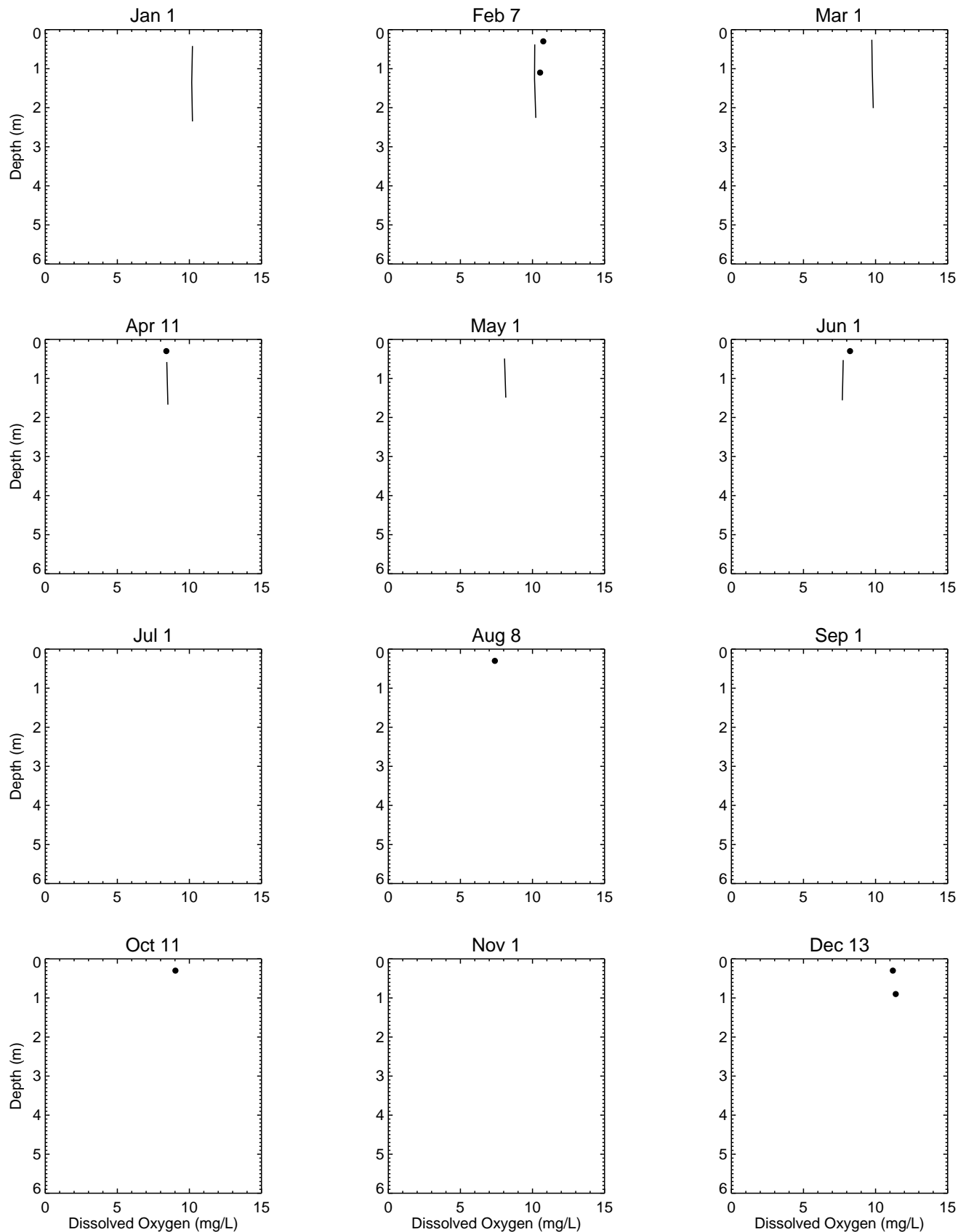*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:41 2013

Jan 19 · Feb 23 · Mar 18 · Apr 27 · May 20 · Jun 15 · Jul 21 · Aug 20 · Sep 16 · Oct 21 · Nov 17 · Dec 22

Dissolved Oxygen (mg/L)

—— Model (w1210-48)
● Data

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 1987

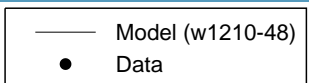*Profiles shown for dates with available data else model results for first day of month shown.*

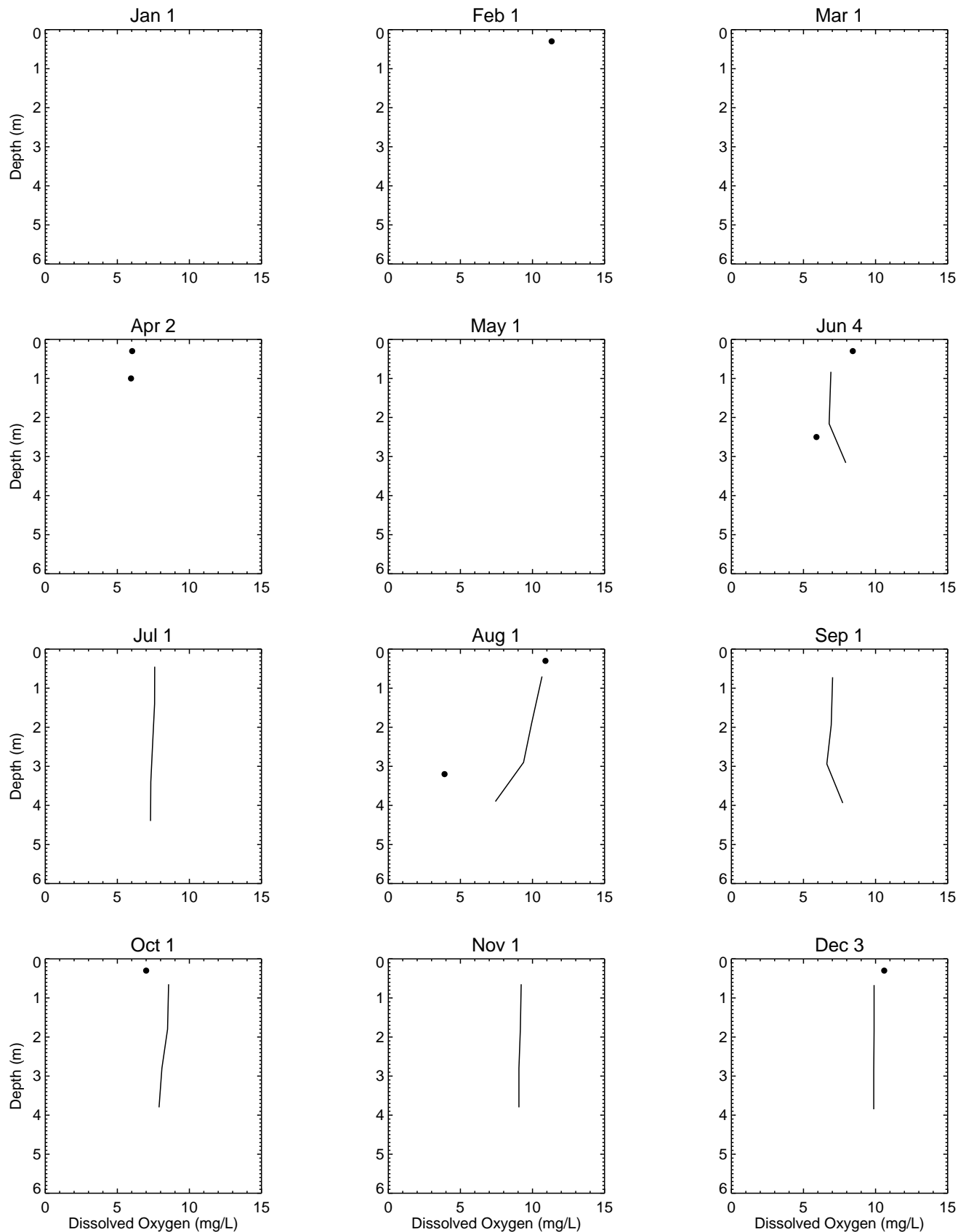CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR
QEA
PARSONS

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 1988

Profiles shown for dates with available data else model results for first day of month shown.

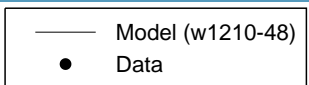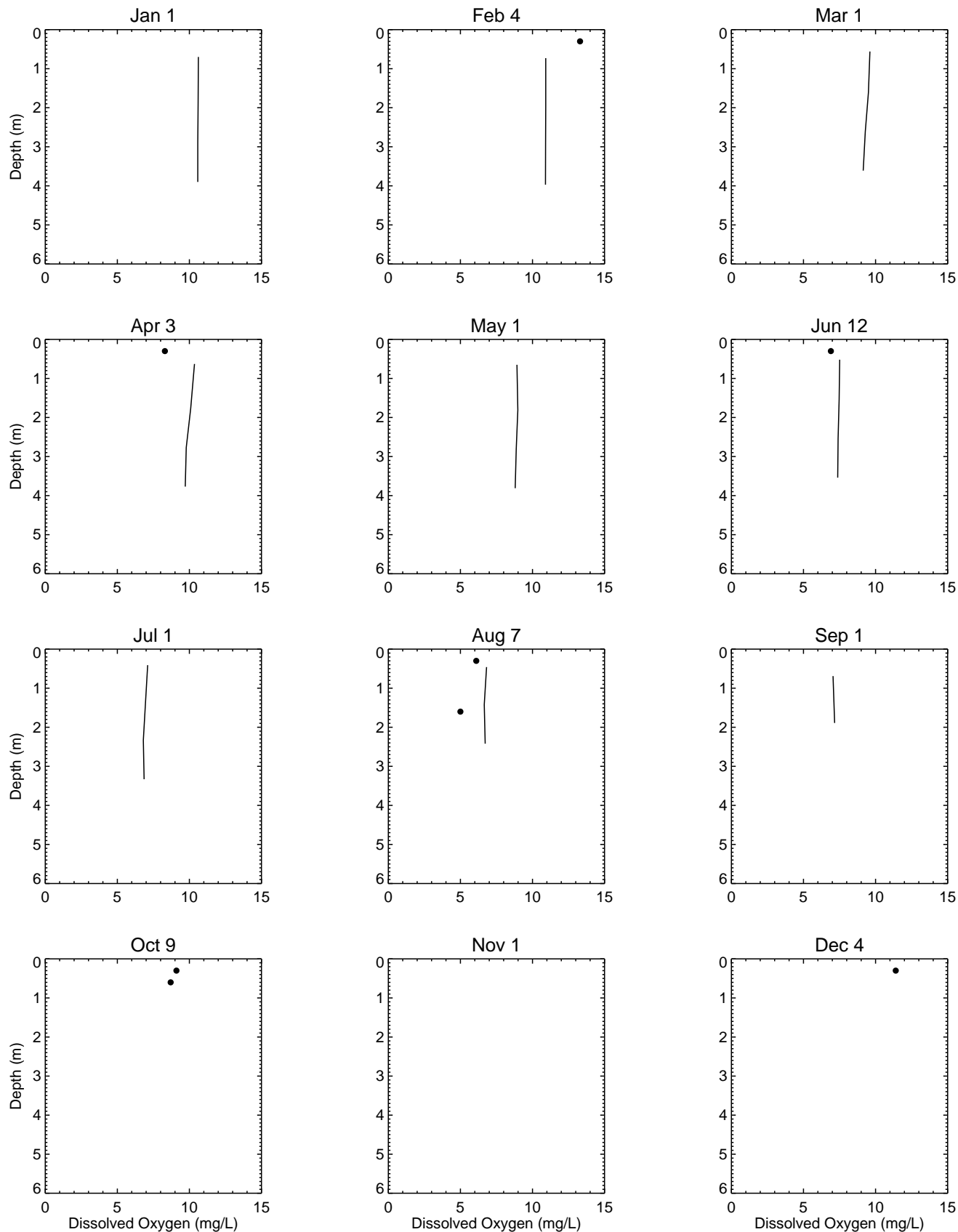CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:41 2013

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 1989

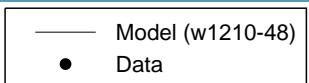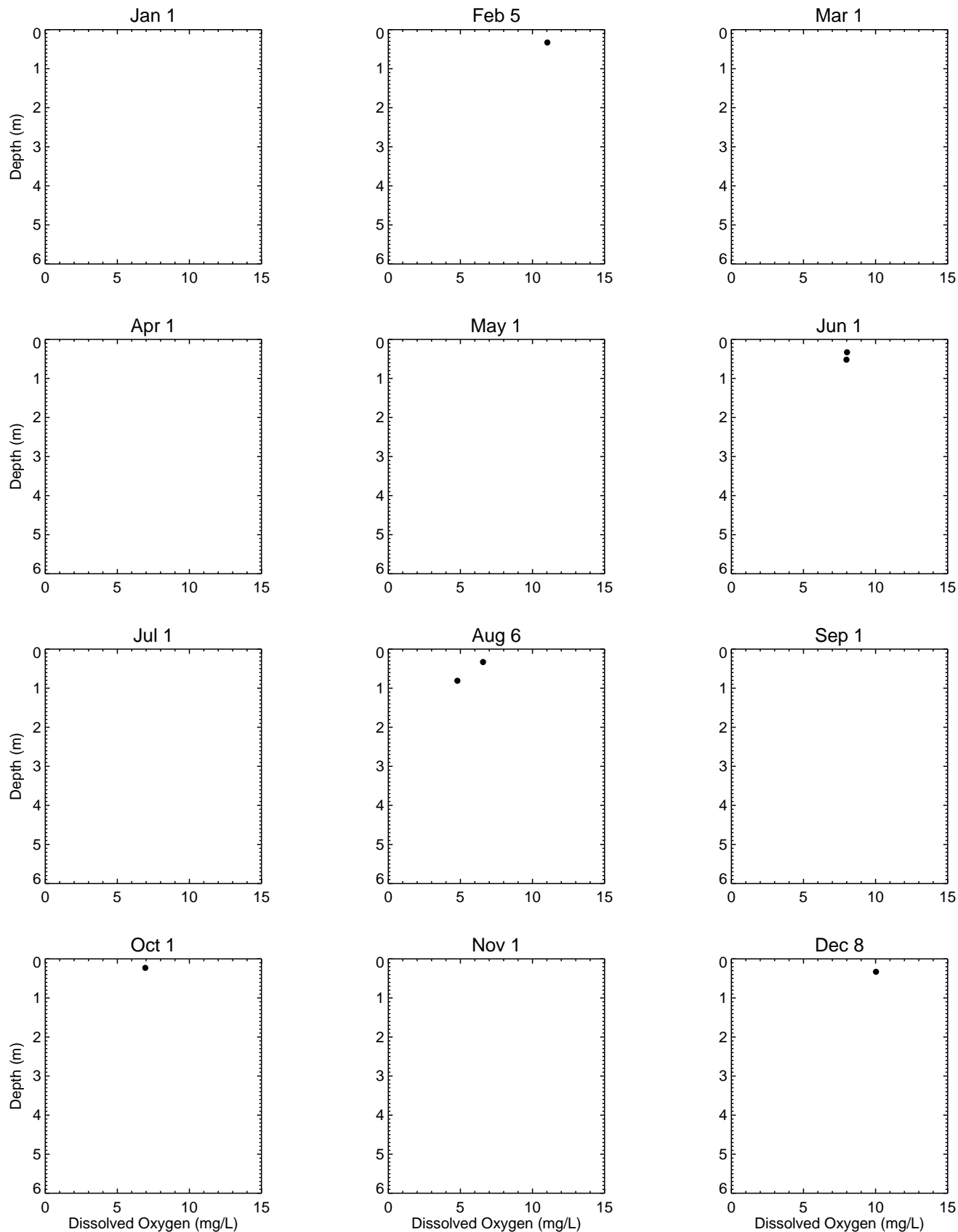*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:41 2013

Jan 1   Feb 1   Mar 1

Apr 3   May 1   Jun 5

Jul 1   Aug 1   Sep 1

Oct 1   Nov 1   Dec 1

Dissolved Oxygen (mg/L)

—— Model (w1210-48)
● Data

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 1990

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
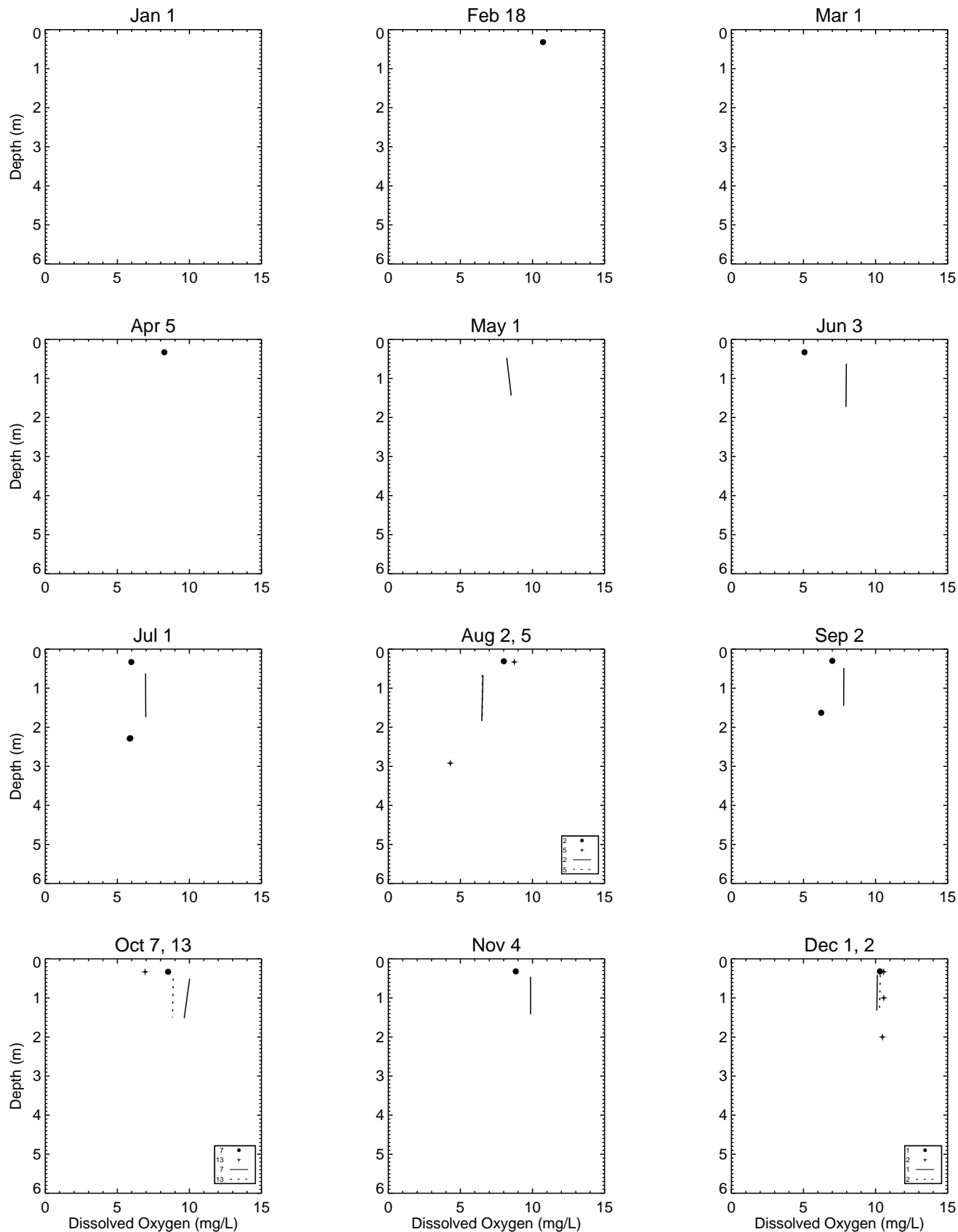
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:41 2013

Model (w1210-48)
● Data

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 1991

Profiles shown for dates with available data else model results for first day of month shown.

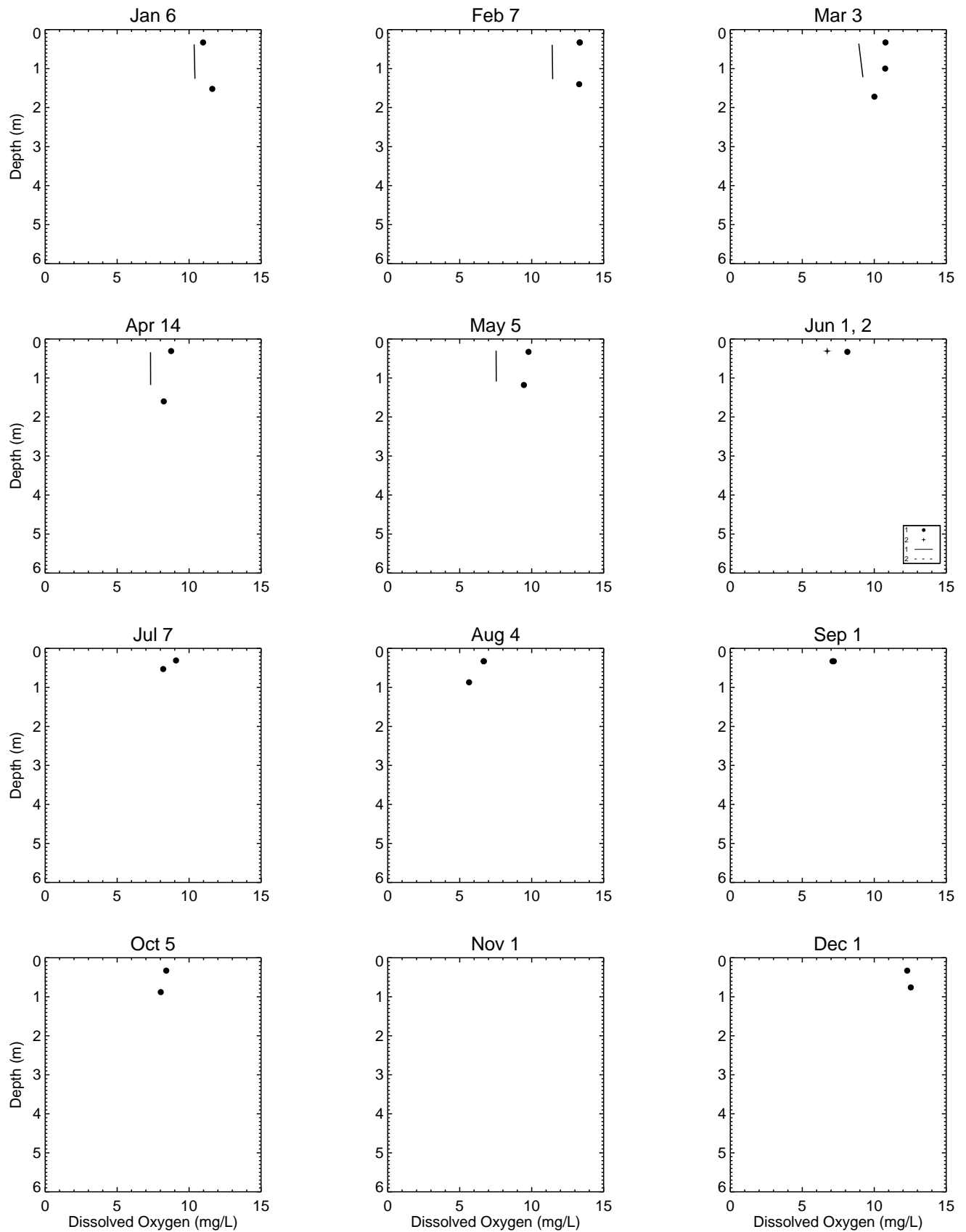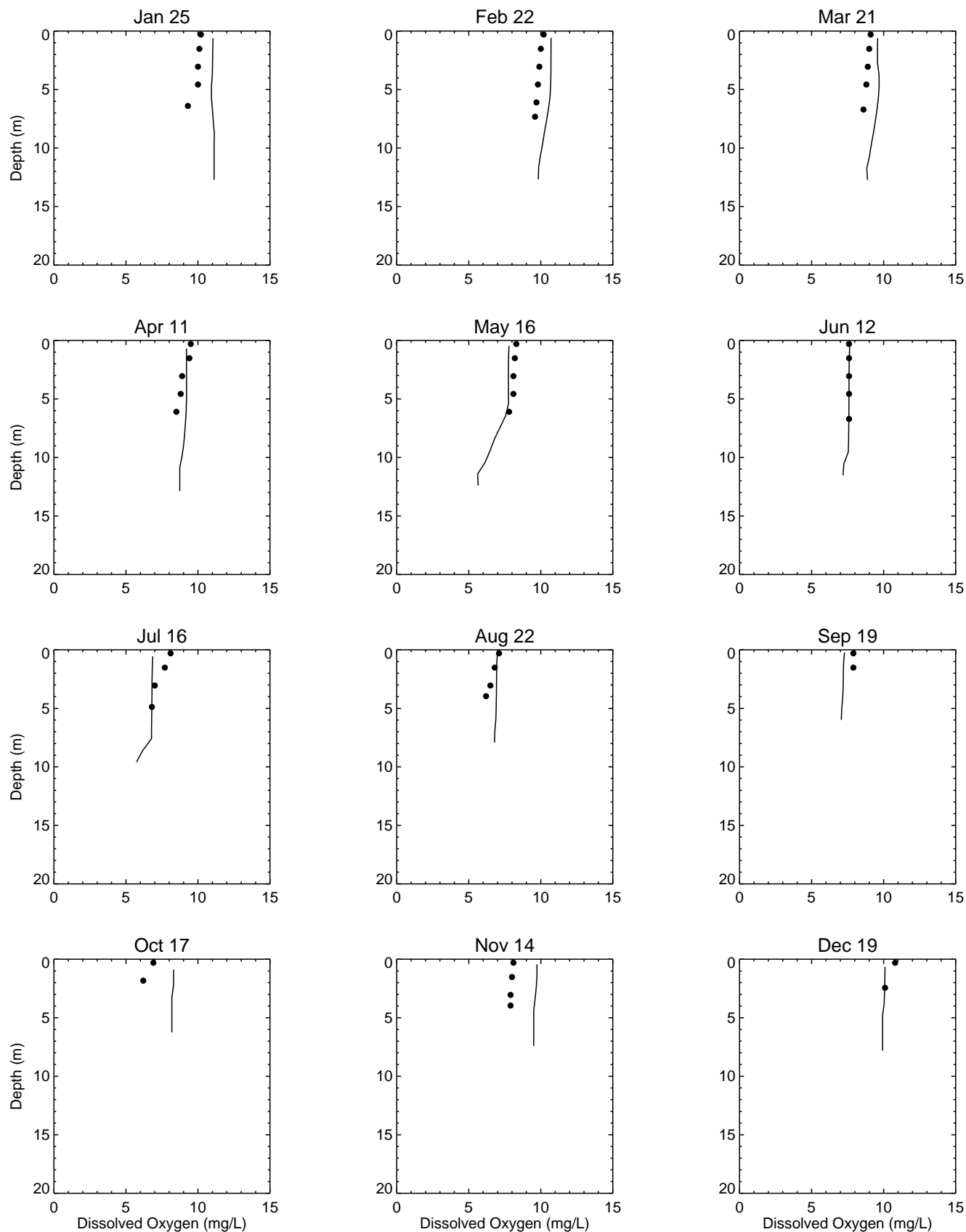CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:41 2013

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Dissolved Oxygen (mg/L)
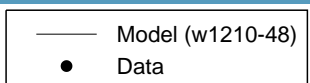
Depth (m)

———— Model (w1210-48)
● Data

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
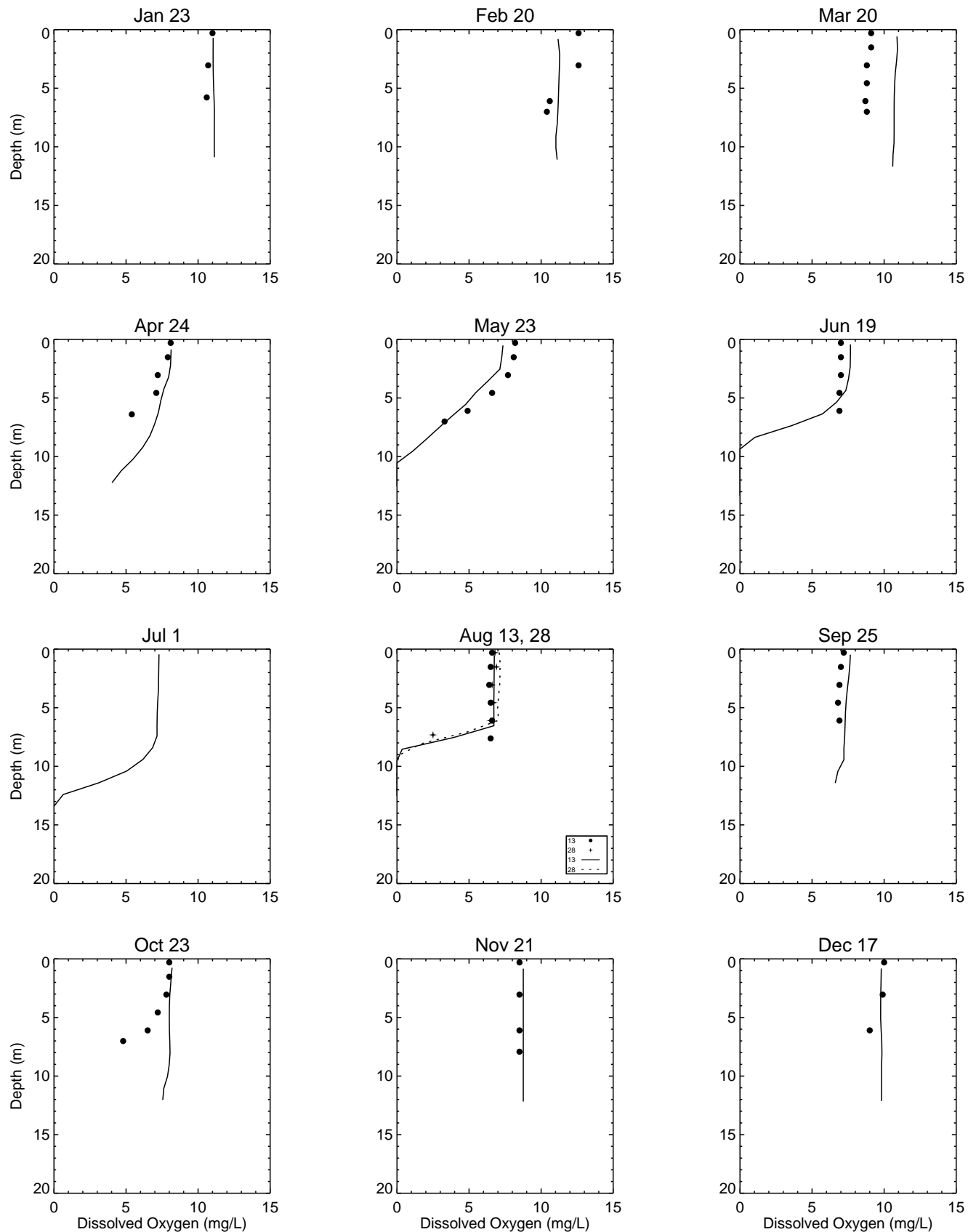
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 1993

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

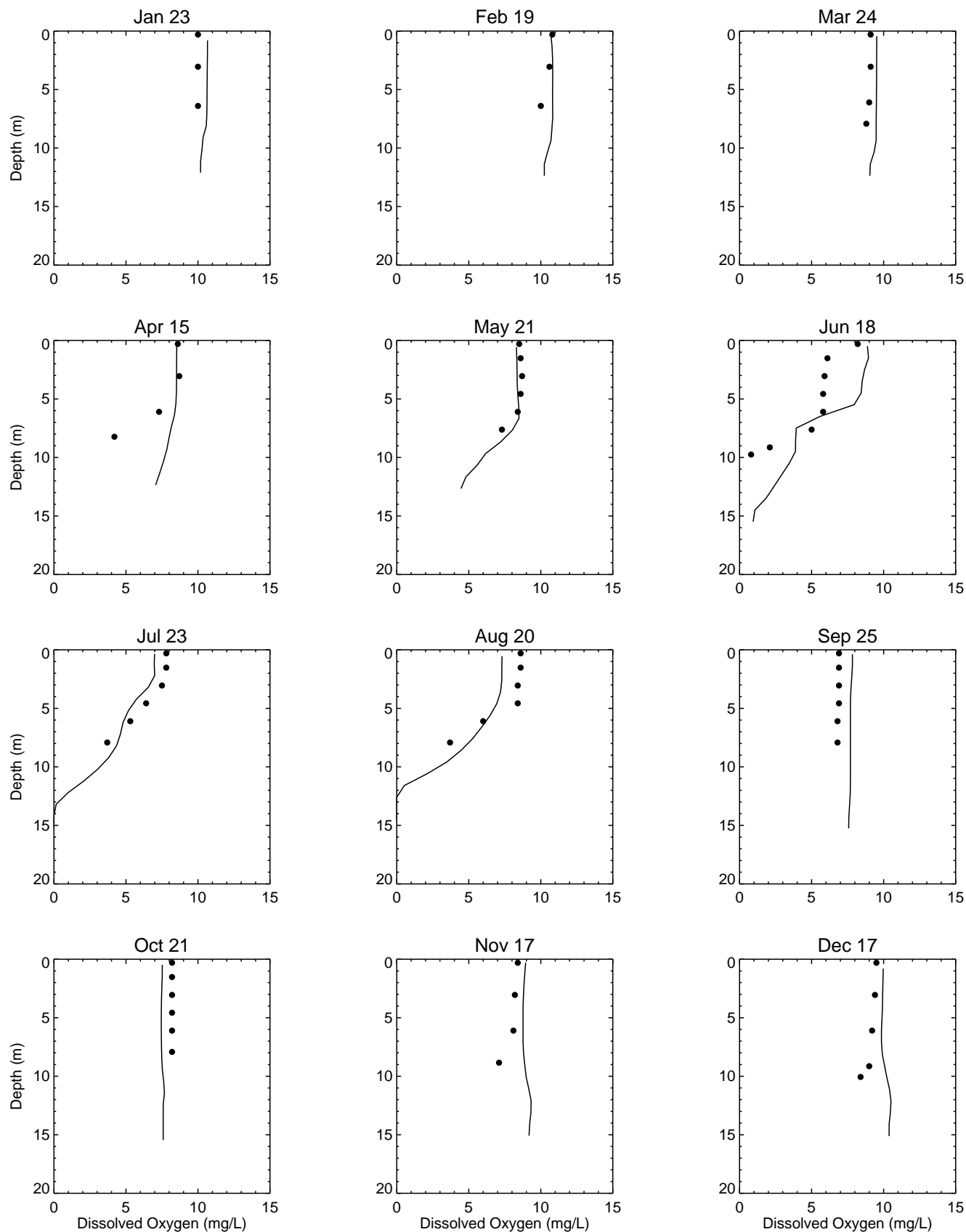Lower Colorado River Authority
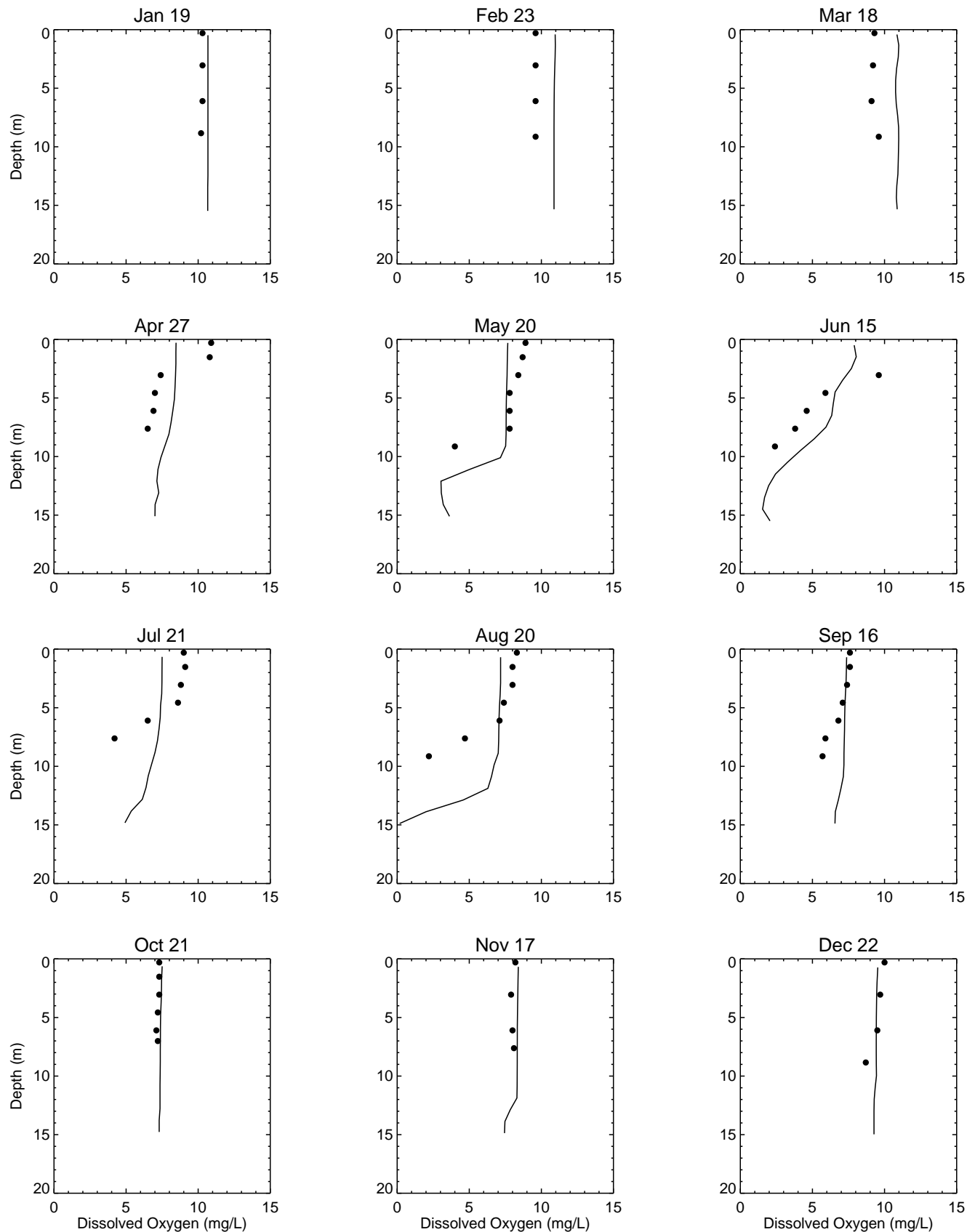
Model (w1210-48)
● Data

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 1994

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 / Feb 1 / Mar 1 / Apr 1 / May 1 / Jun 1 / Jul 1 / Aug 1 / Sep 1 / Oct 1 / Nov 1 / Dec 1

Dissolved Oxygen (mg/L)
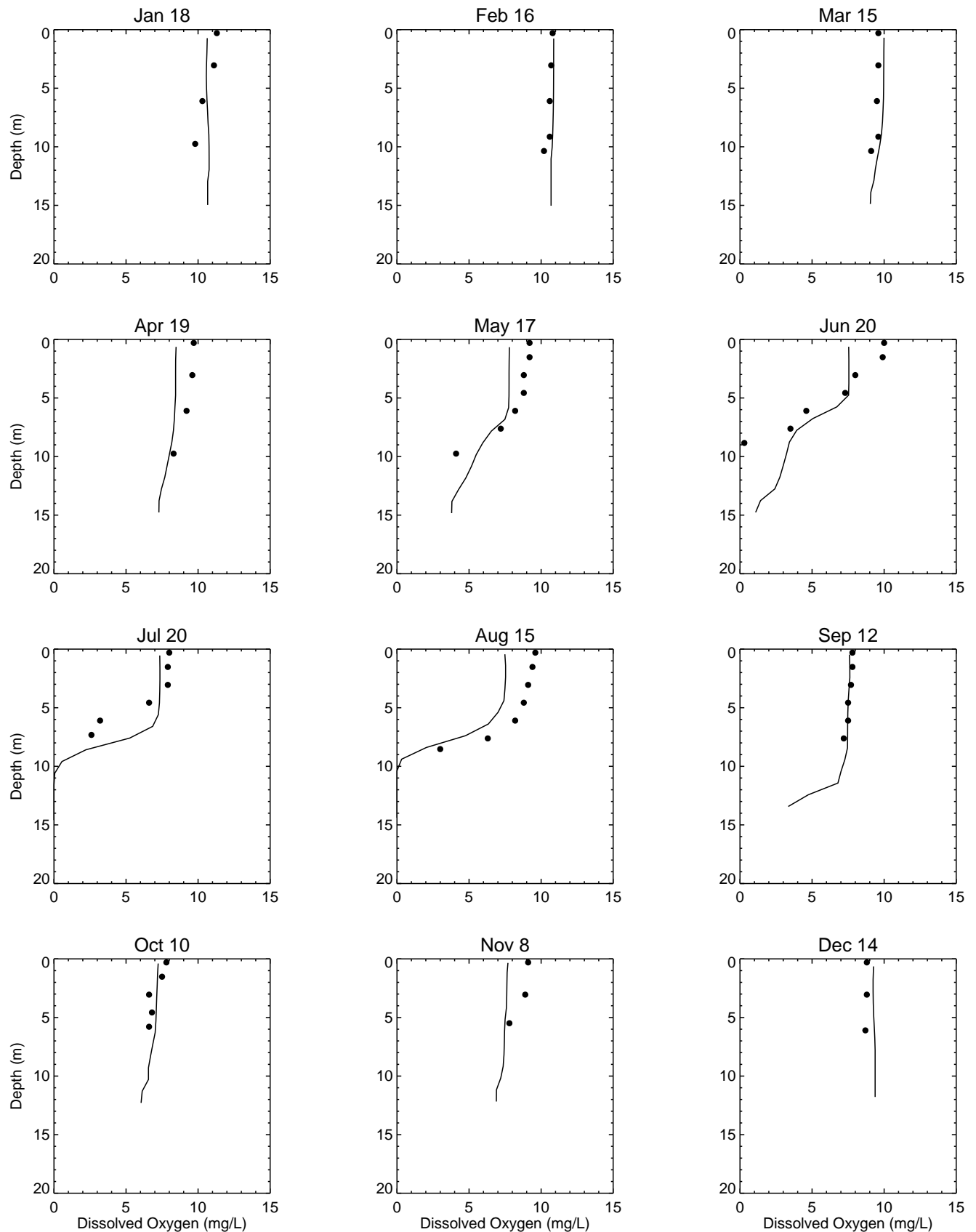
Depth (m)

Model (w1210-48)
● Data

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 1995

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
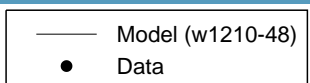Fri Jan 25 18:12:41 2013

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 1996

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority
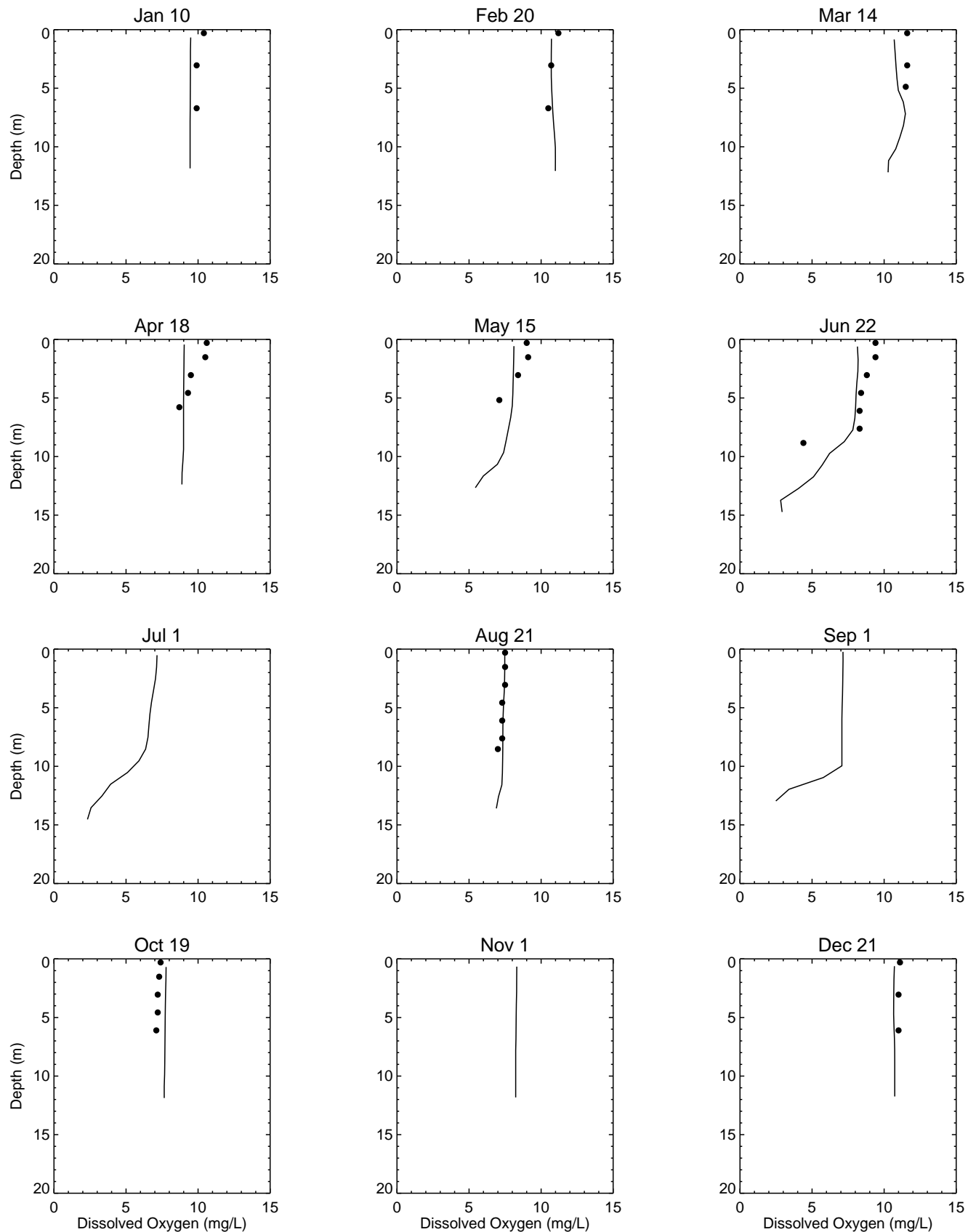
Legend:
— Model (w1210-48)
● Data

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 1997

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

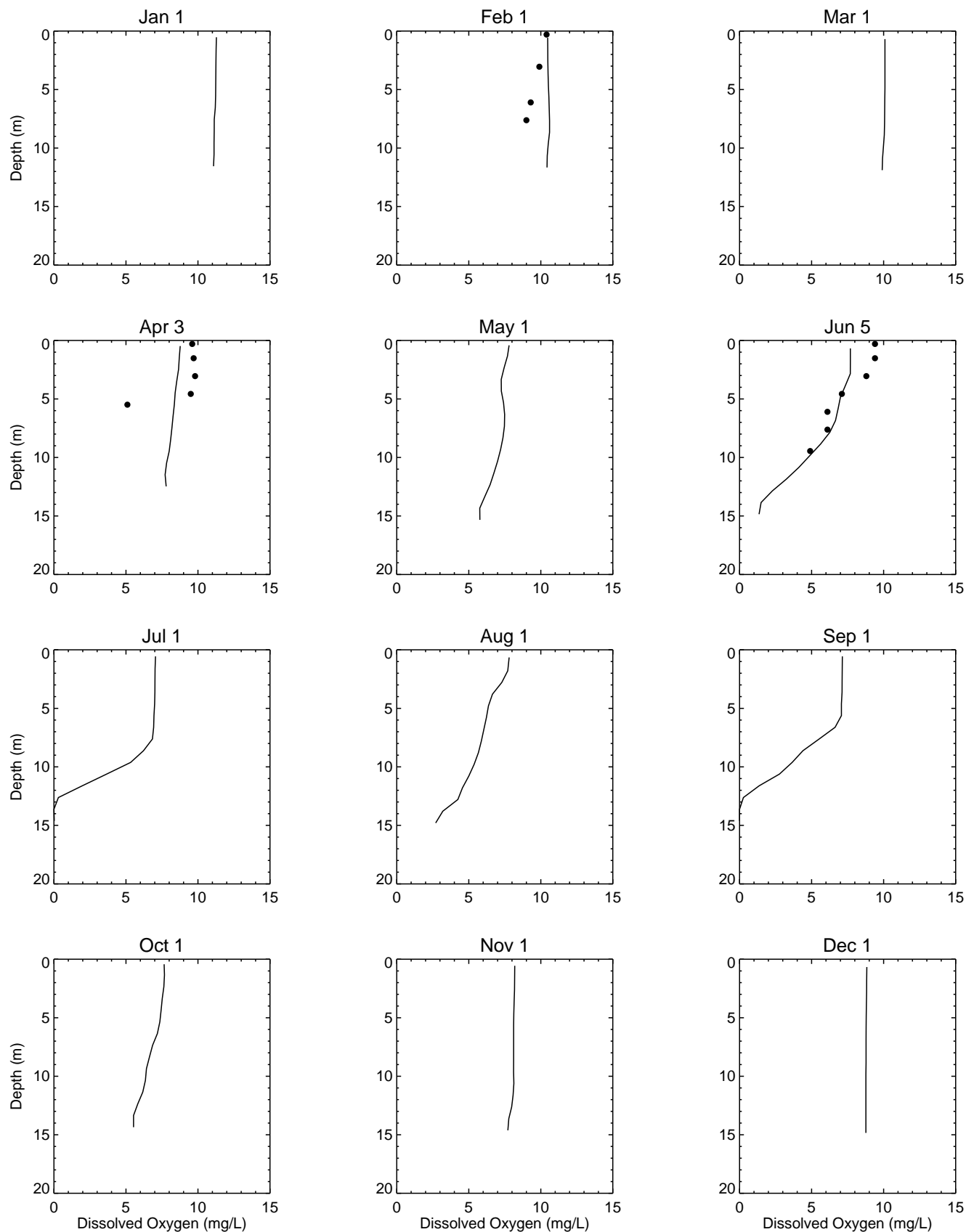Lower Colorado River Authority

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 1998

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 1999

Profiles shown for dates with available data else model results for first day of month shown.
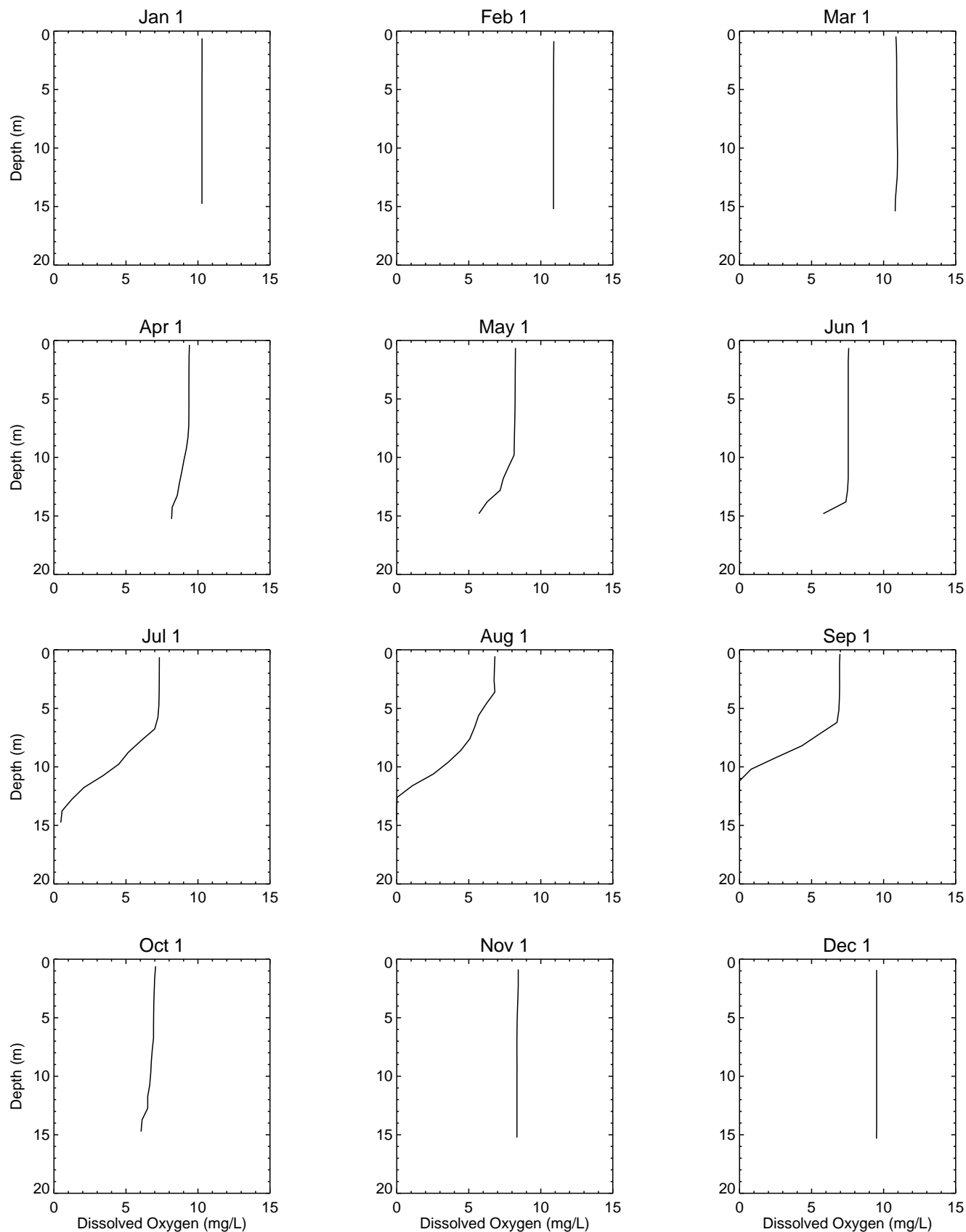
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 2000

Profiles shown for dates with available data else model results for first day of month shown.
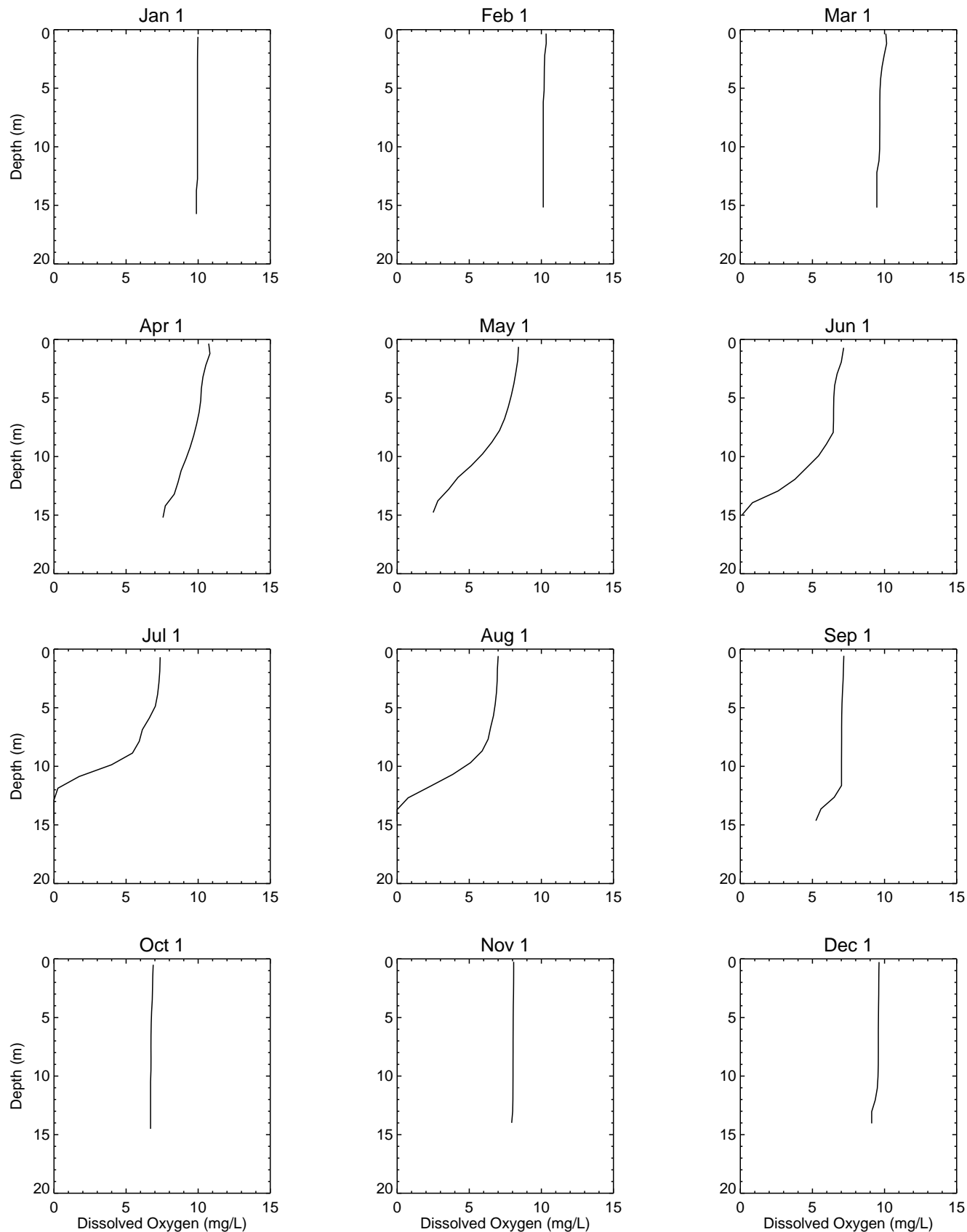
CREMs Phase 4: Lake Buchanan
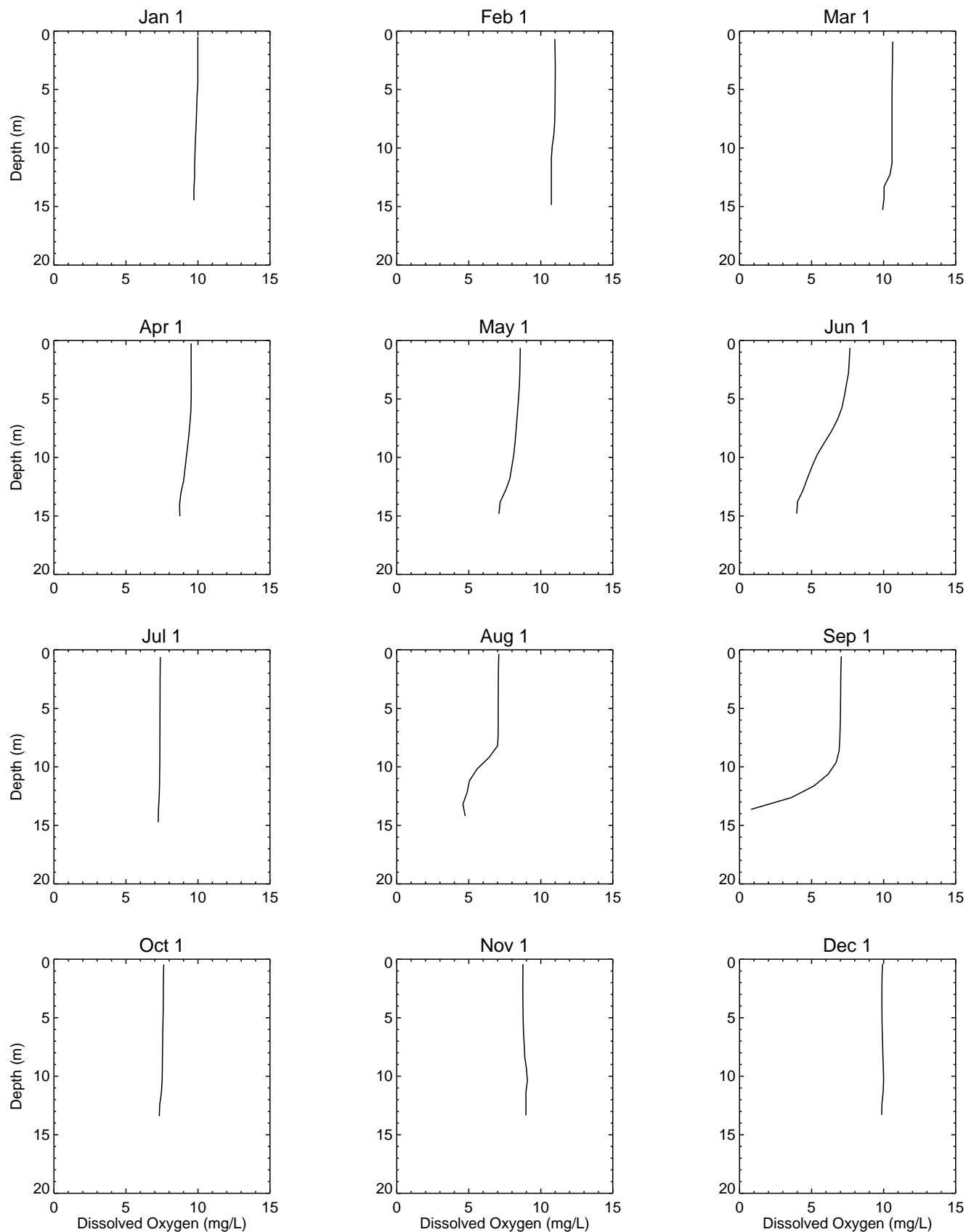
Lower Colorado River Authority

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 2001

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 2002

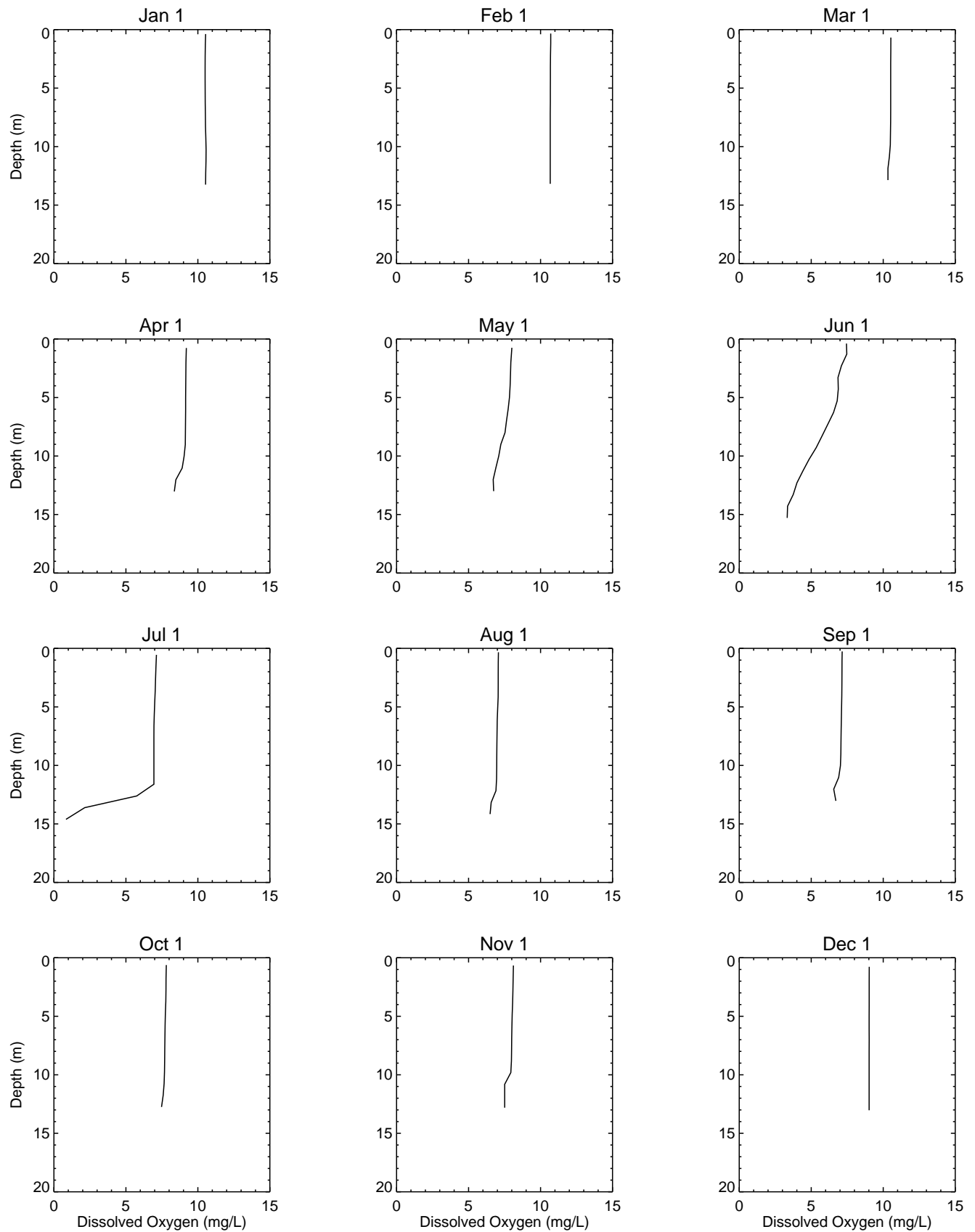*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1

Feb 1

Mar 1

Apr 1

May 1

Jun 1

Jul 1

Aug 1

Sep 1

Oct 1

Nov 1

Dec 1

Depth (m)

Dissolved Oxygen (mg/L)
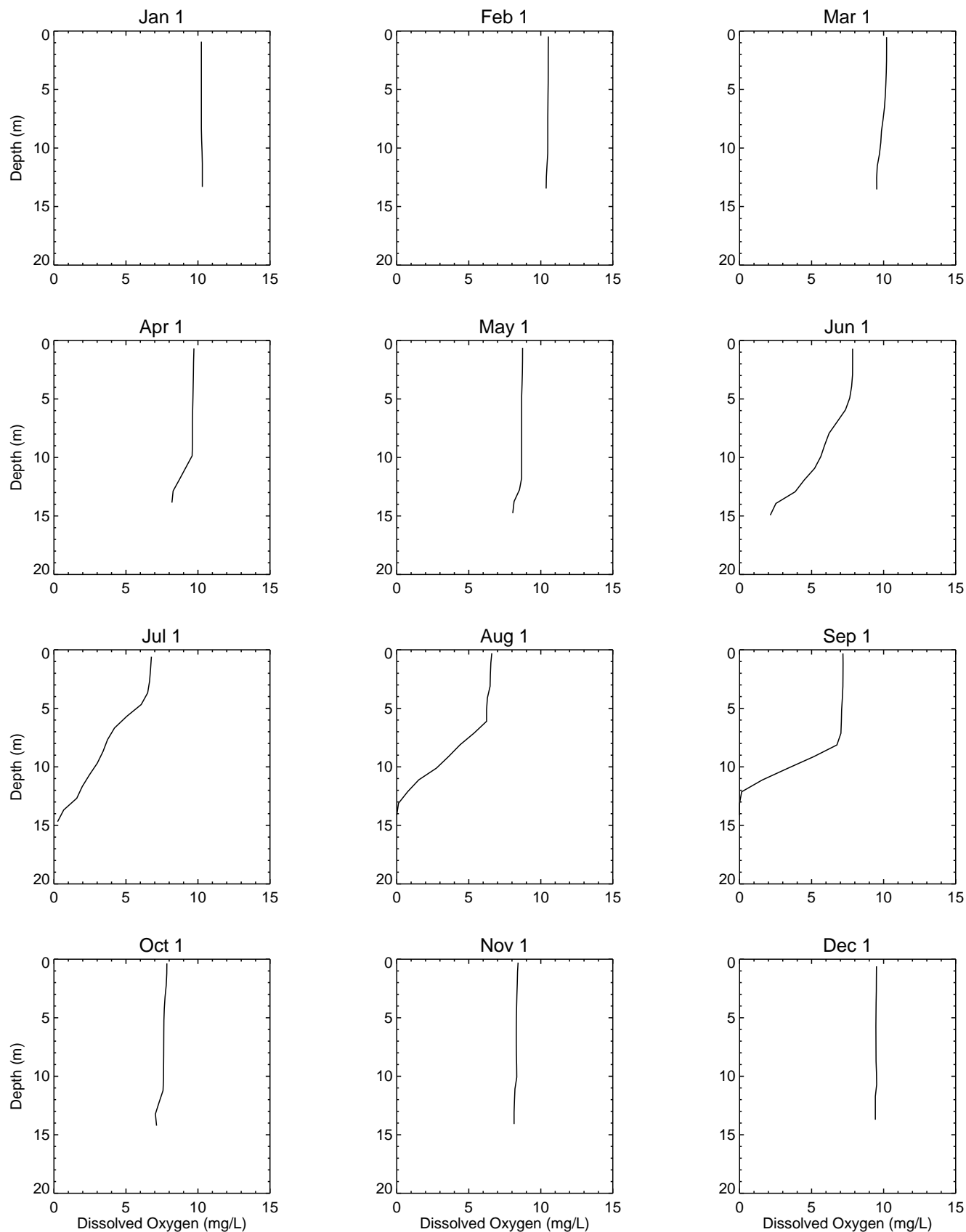
——— Model (w1210-48)

● Data

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 2004

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR
QEA
PARSONS

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Dissolved Oxygen (mg/L)

Depth (m)
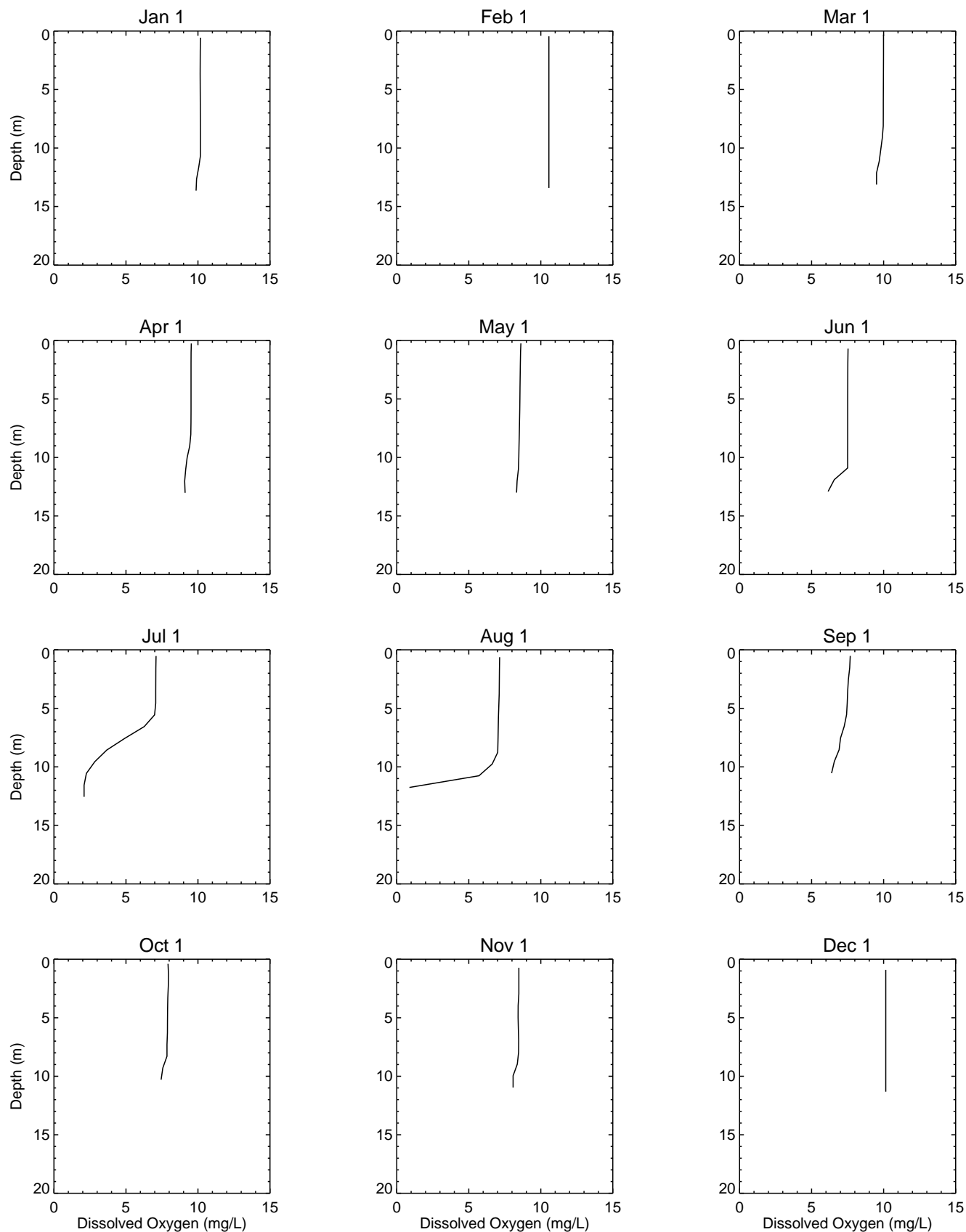
—— Model (w1210-48)
● Data

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 2005

Profiles shown for dates with available data else model results for first day of month shown.
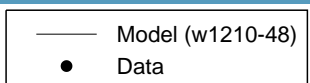
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
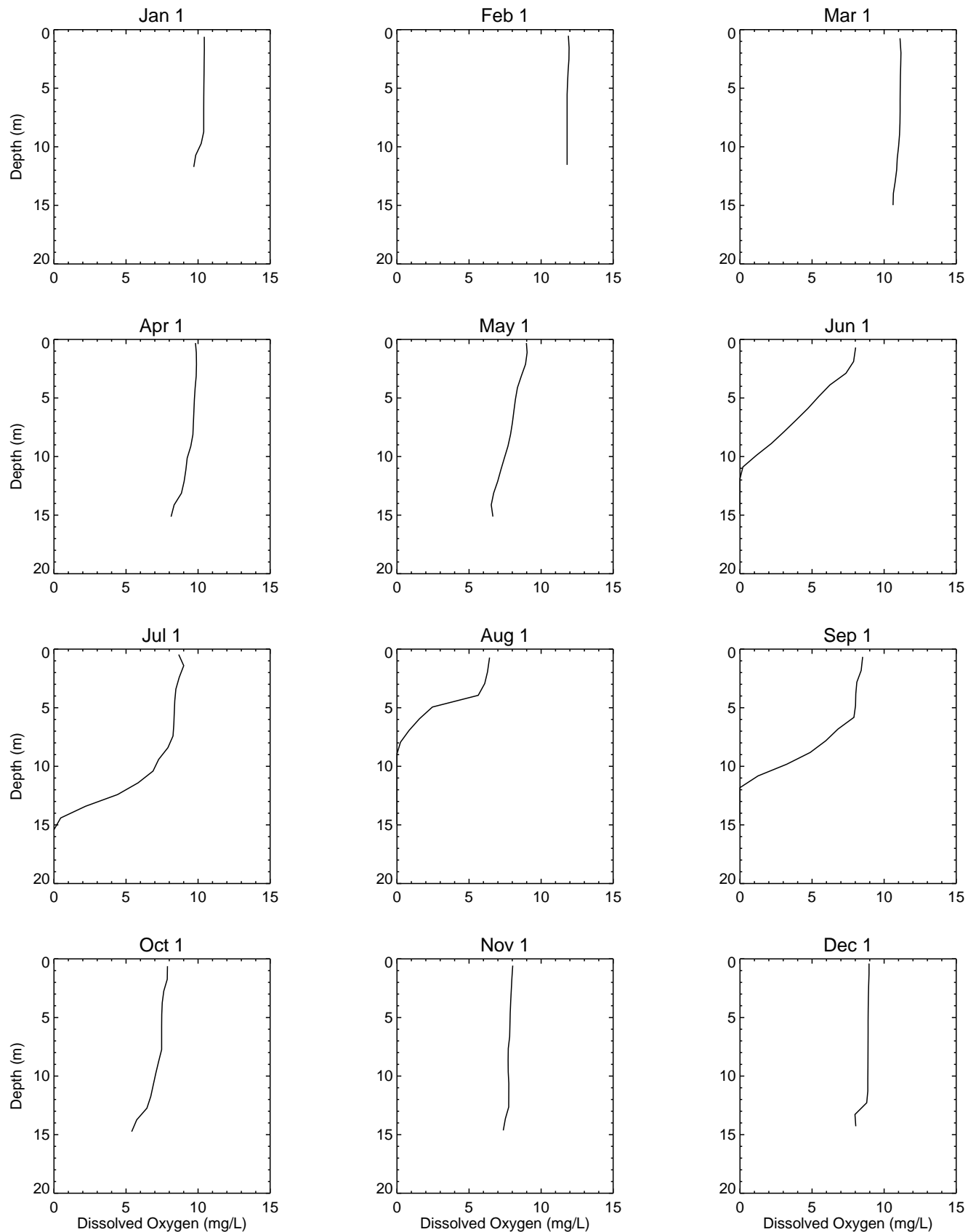Fri Jan 25 18:12:41 2013

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 2006

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m)

Dissolved Oxygen (mg/L)
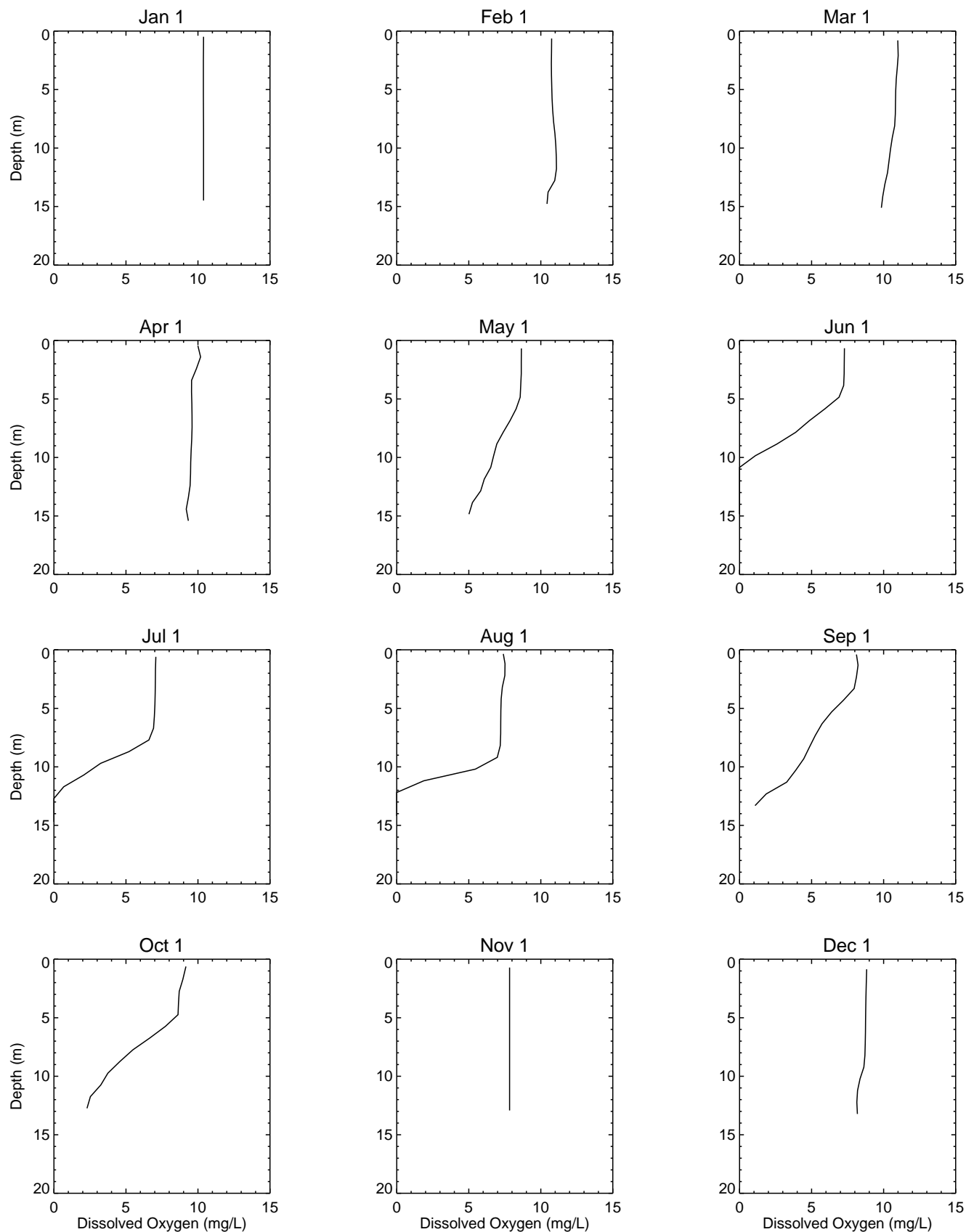
Model (w1210-48)
● Data

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 2007

Profiles shown for dates with available data else model results for first day of month shown.
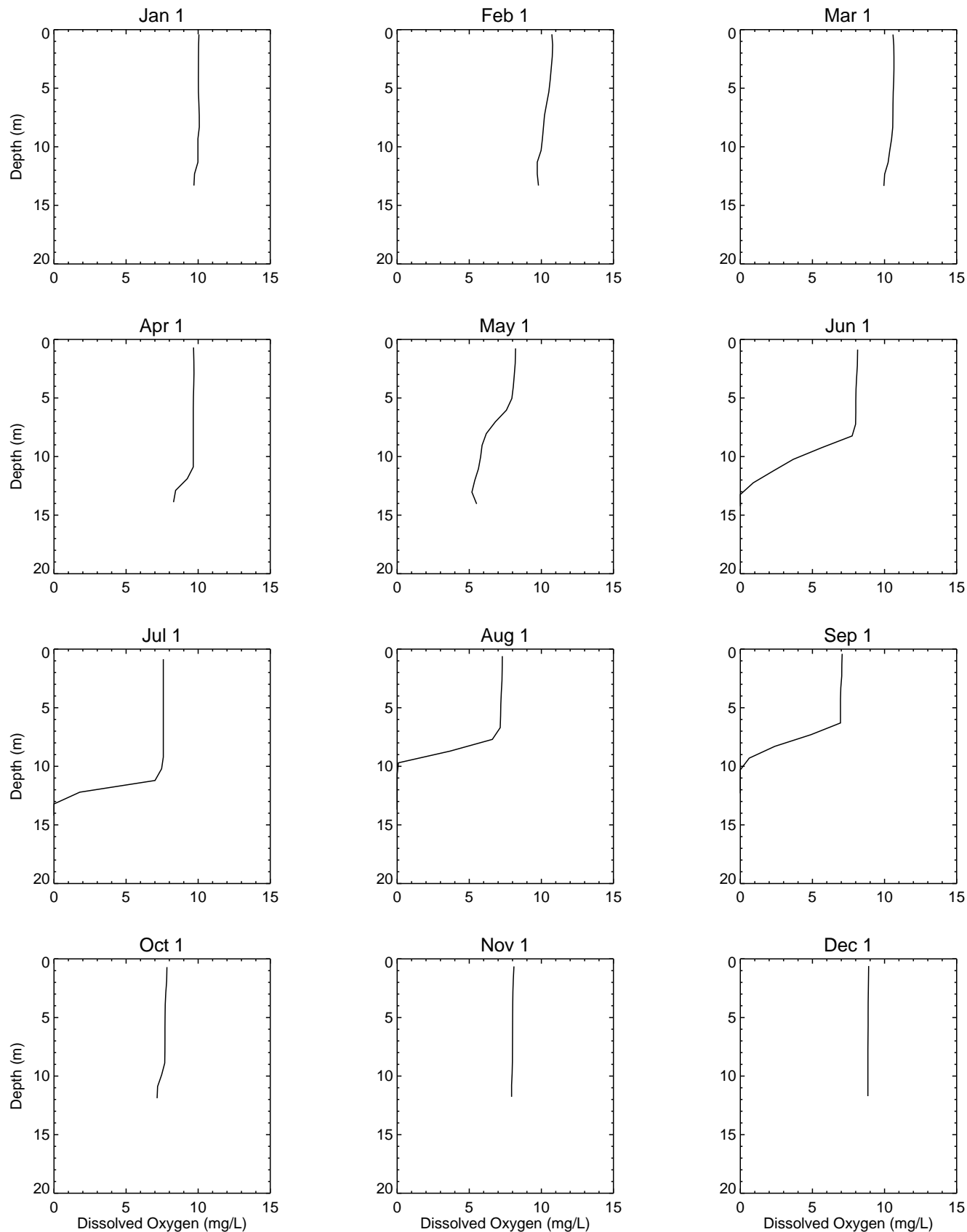
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:41 2013

Model (w1210-48)
● Data

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 2008

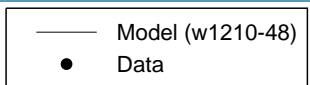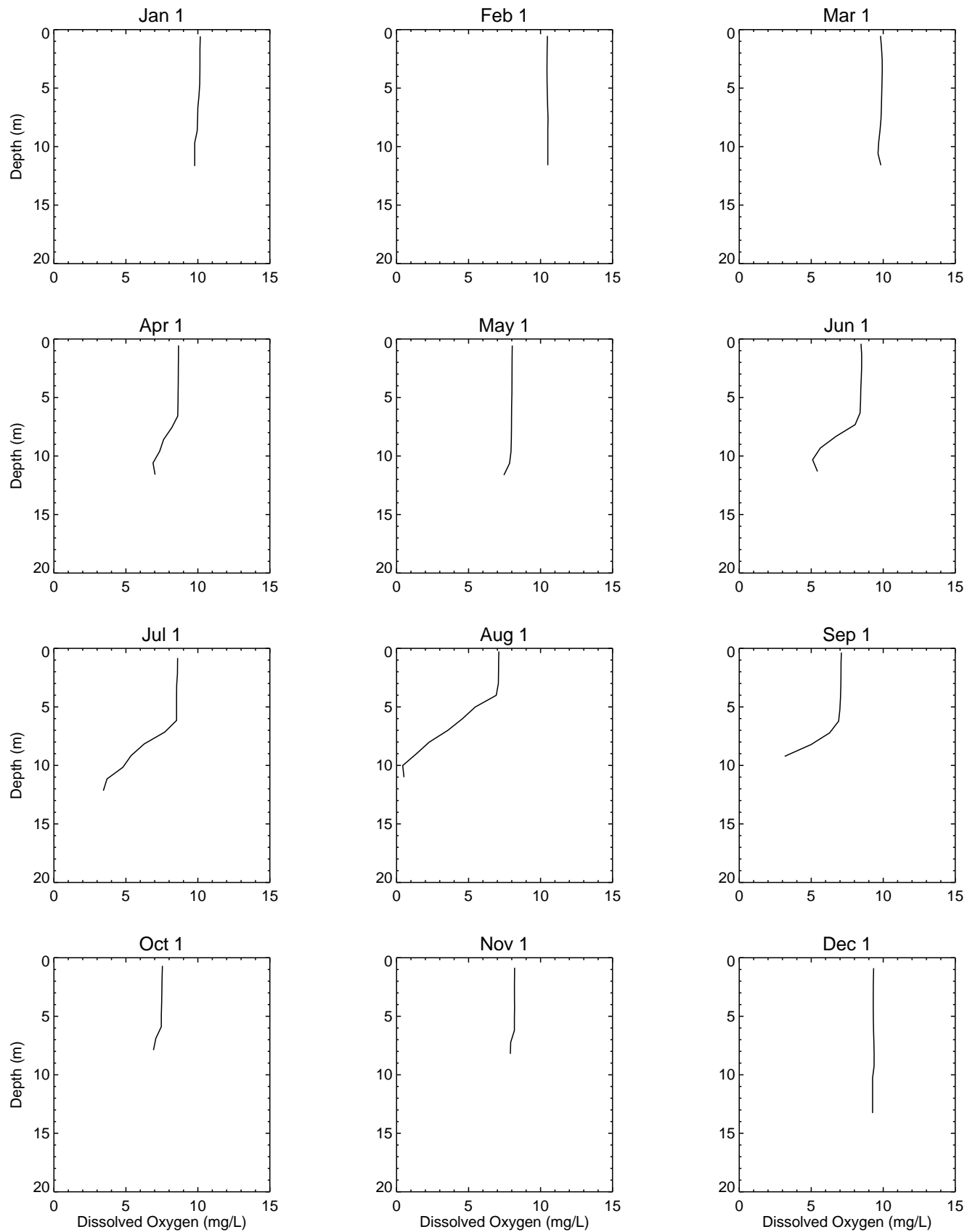*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
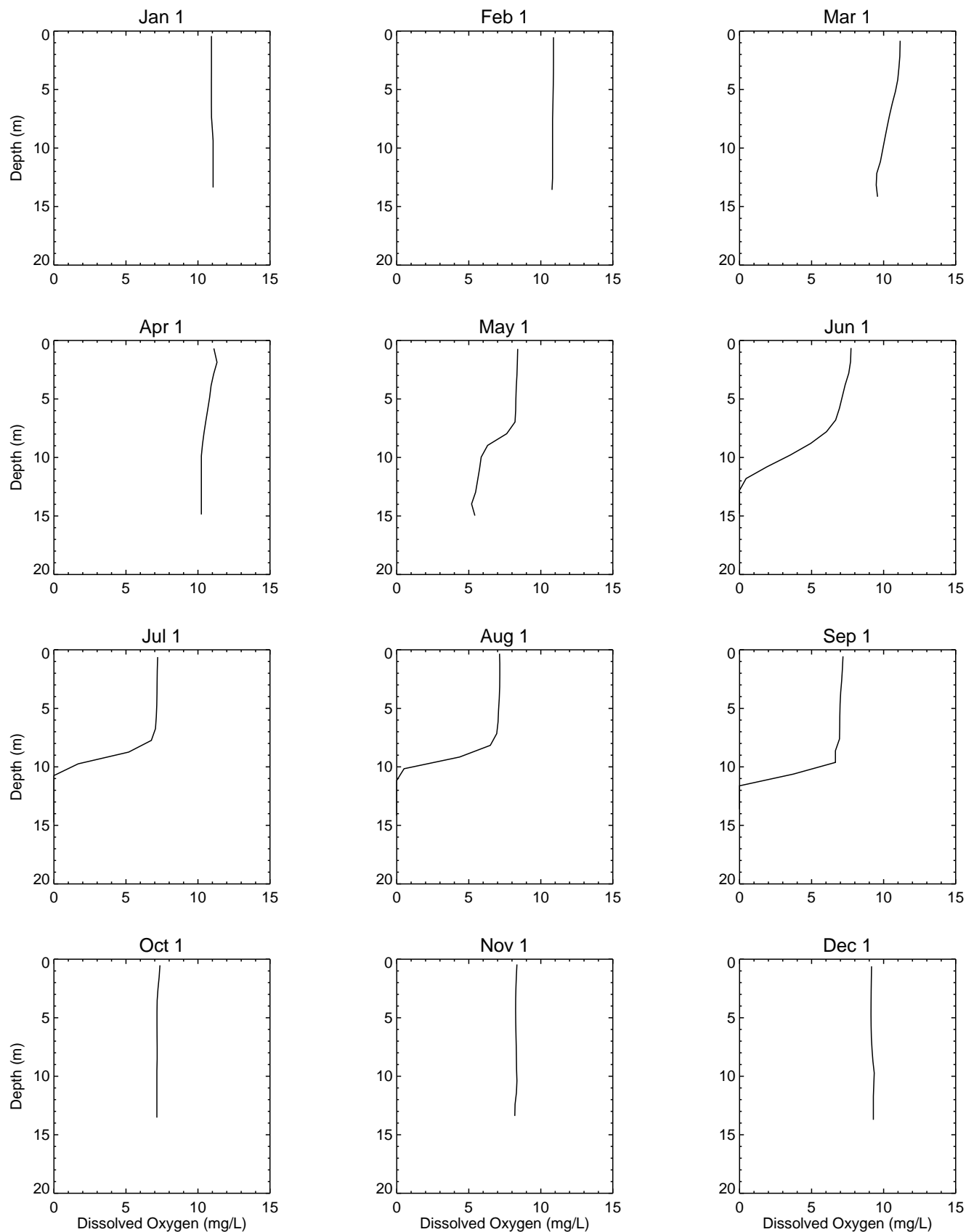Fri Jan 25 18:12:41 2013

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 2009

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 2010

Profiles shown for dates with available data else model results for first day of month shown.
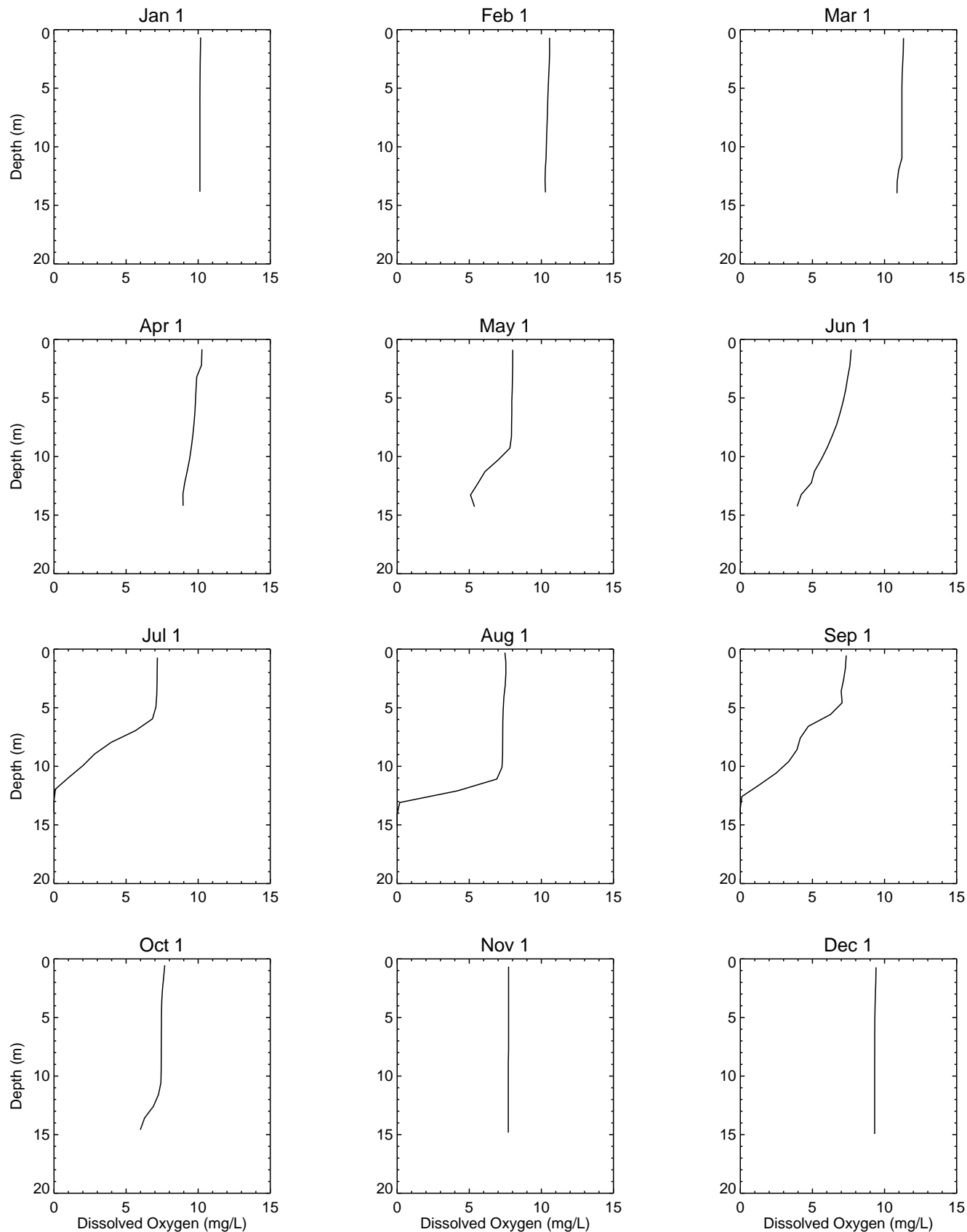
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1   Feb 1   Mar 1

Apr 1   May 1   Jun 1

Jul 1   Aug 1   Sep 1

Oct 1   Nov 1   Dec 1

Dissolved Oxygen (mg/L)

——— Model (w1210-48)

● Data

Figure G-28

Vertical Profiles of Model Versus Data for Lake Buchanan
at Buchanan Village (Segment 6) - Dissolved Oxygen - 2011

Profiles shown for dates with available data else model results for first day of month shown.
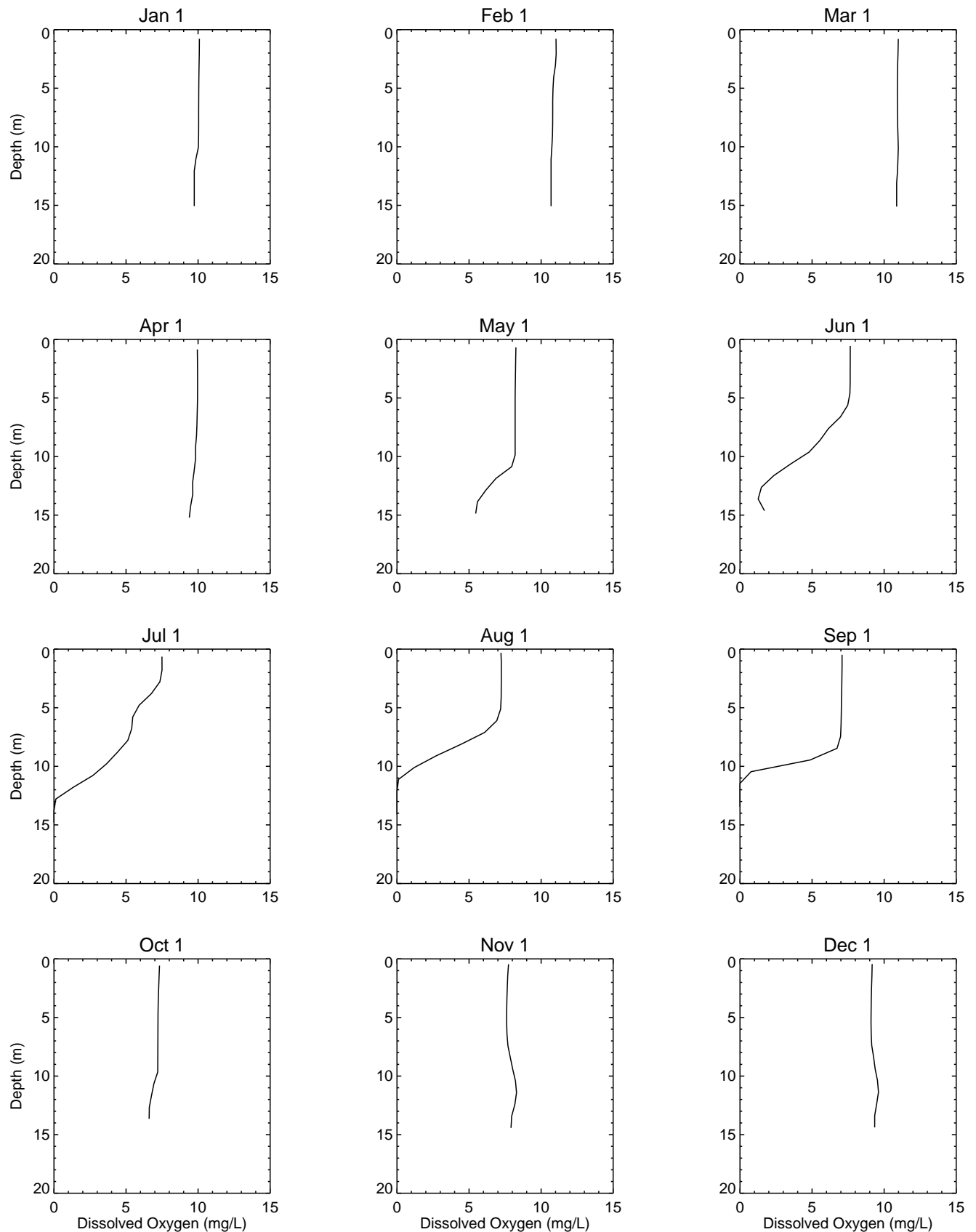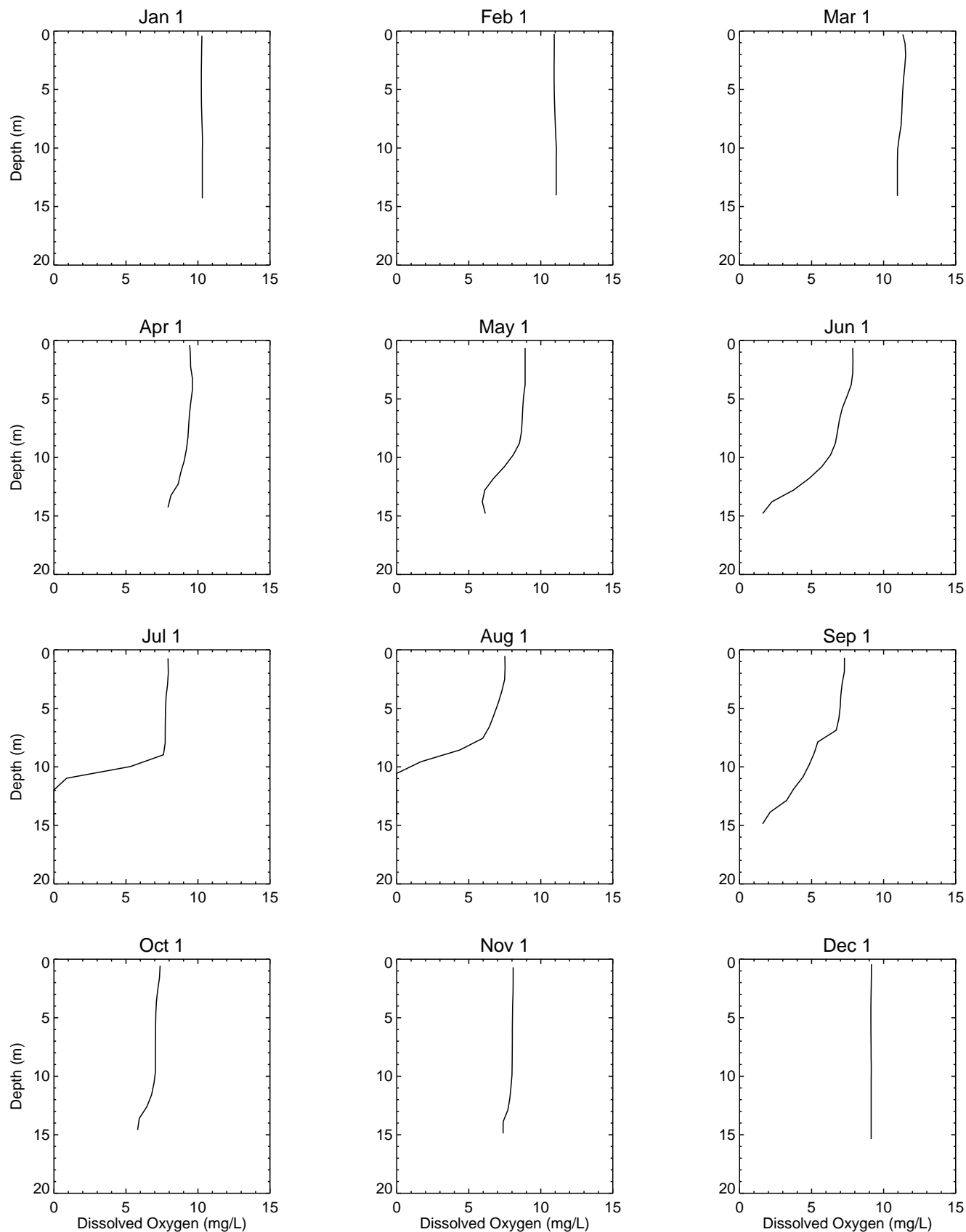
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:41 2013

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 1984

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 1985

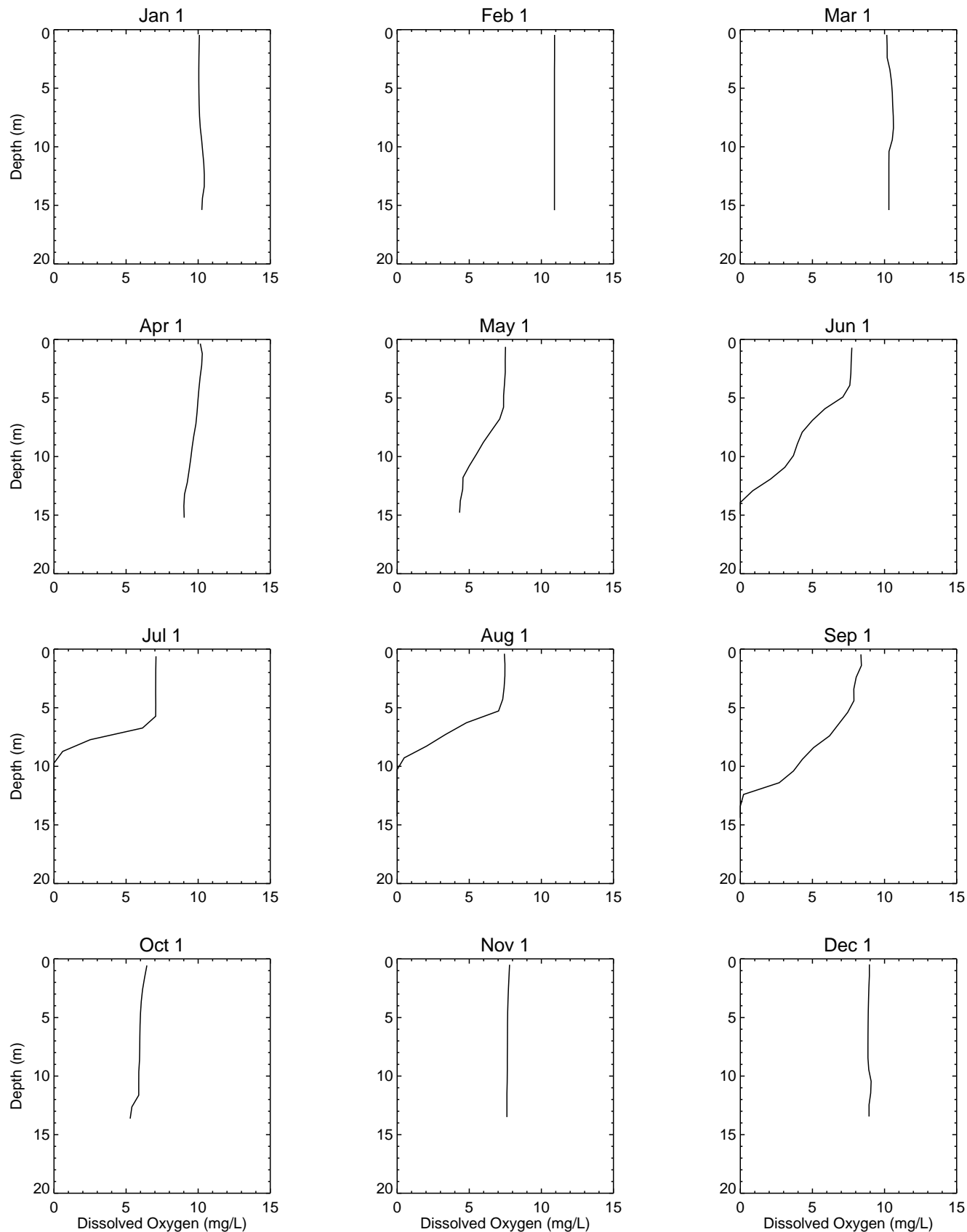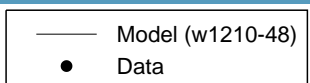*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:11:56 2013

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 1986

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
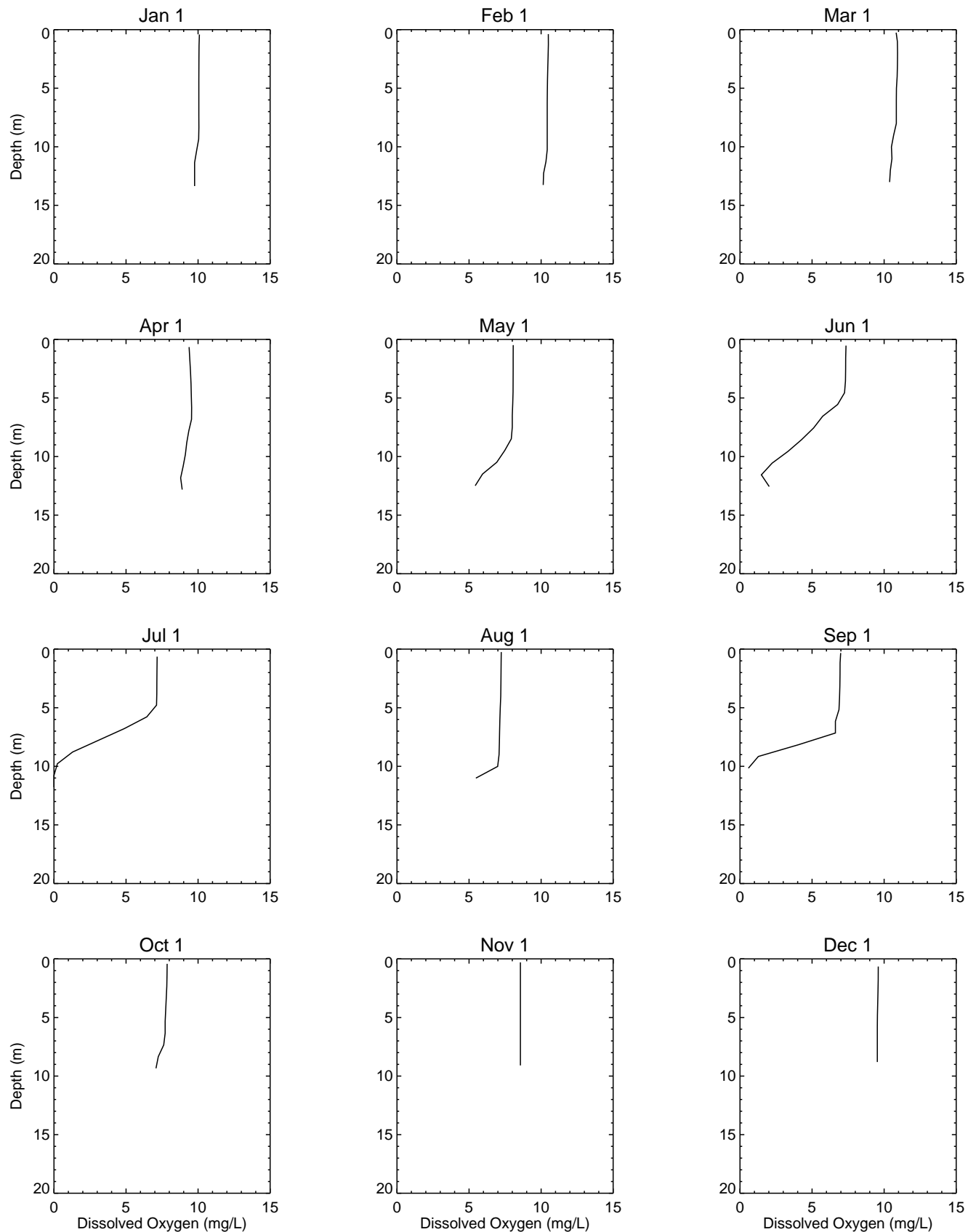
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:11:56 2013

Model (w1210-48)
● Data

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 1987

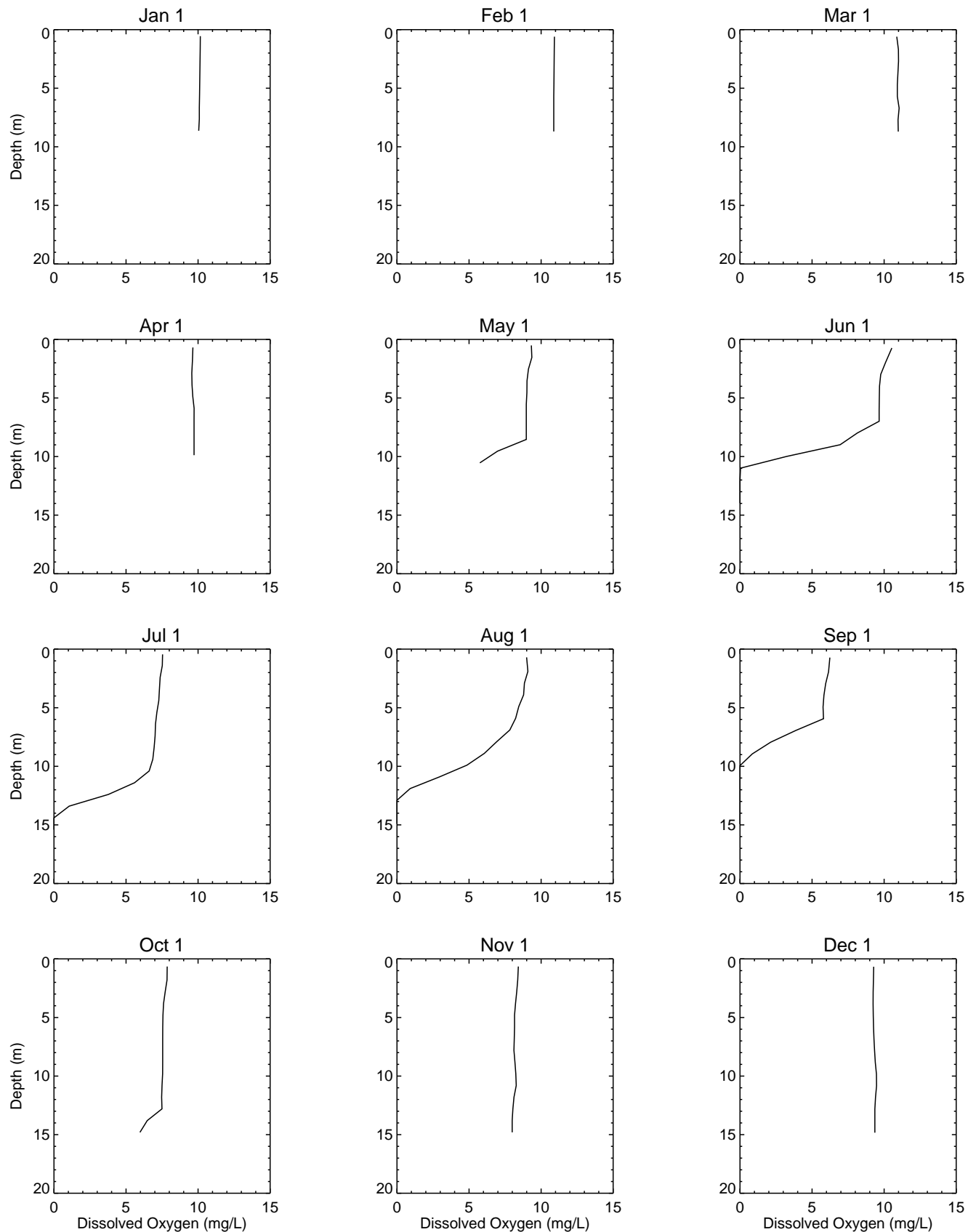*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:11:56 2013

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 1988

Profiles shown for dates with available data else model results for first day of month shown.
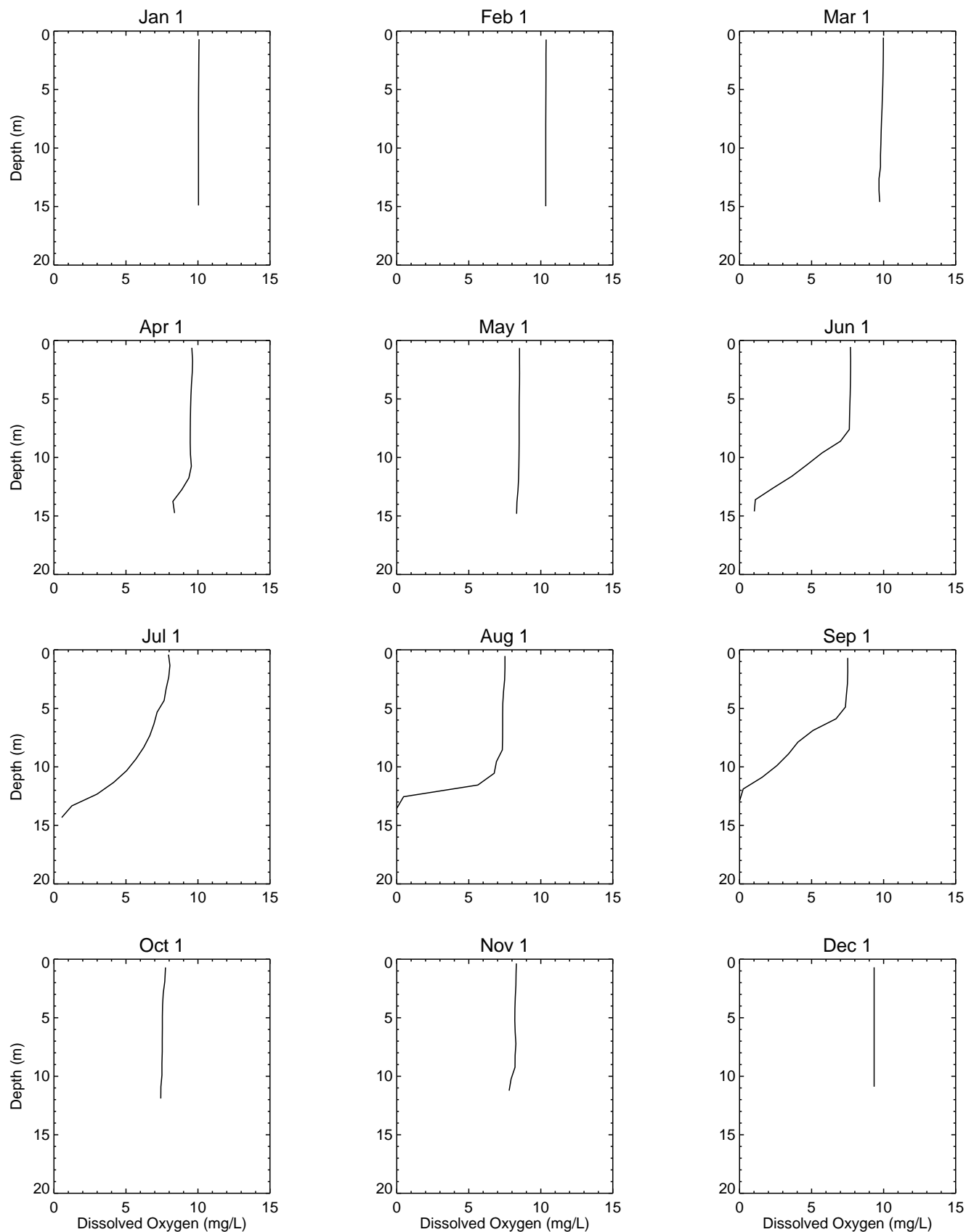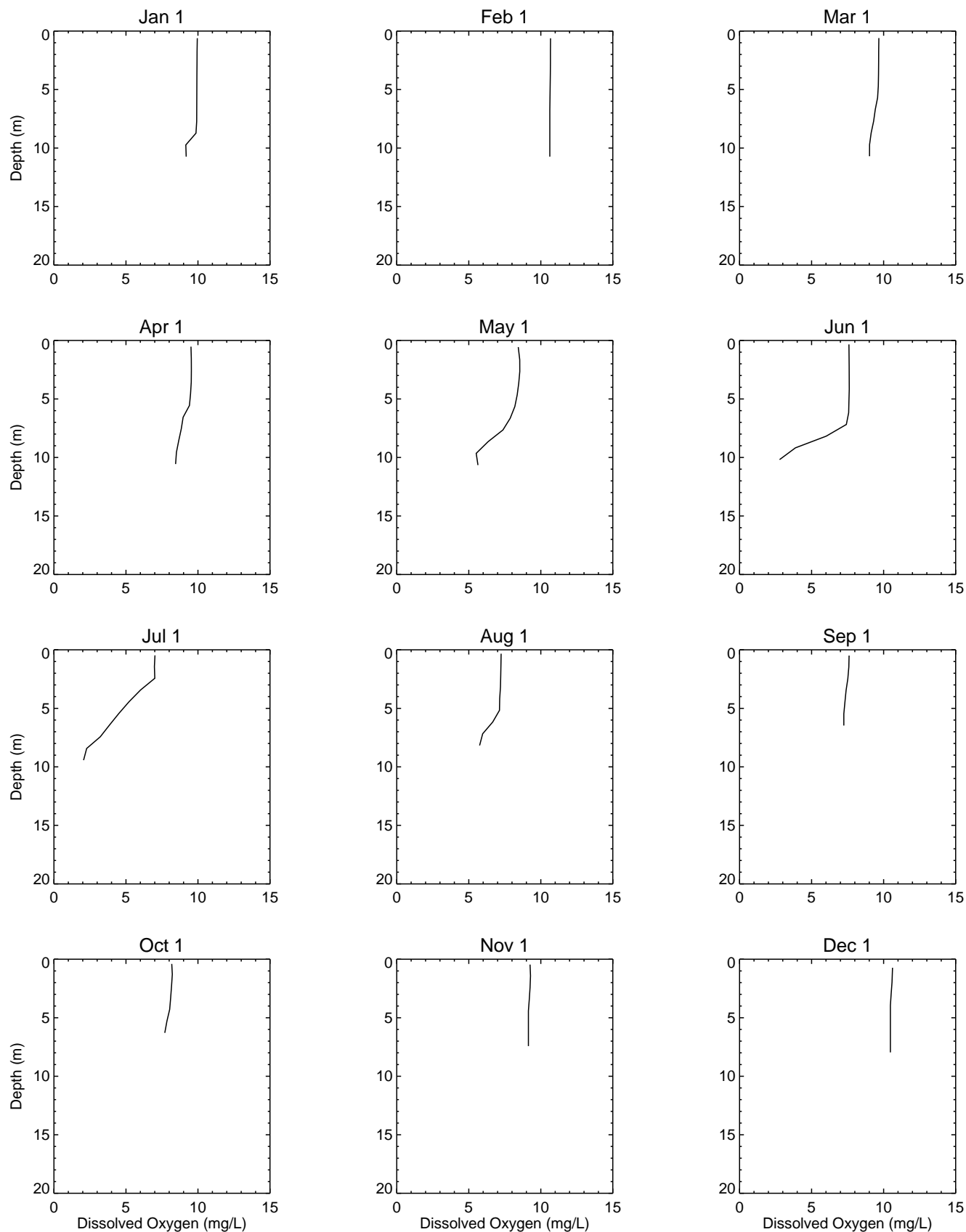
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:11:56 2013

Jan 1   Feb 1   Mar 1

Apr 3   May 1   Jun 5

Jul 1   Aug 21   Sep 1

Oct 22   Nov 1   Dec 20

Depth (m)

Dissolved Oxygen (mg/L)

—— Model (w1210-48)
● Data

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 1990

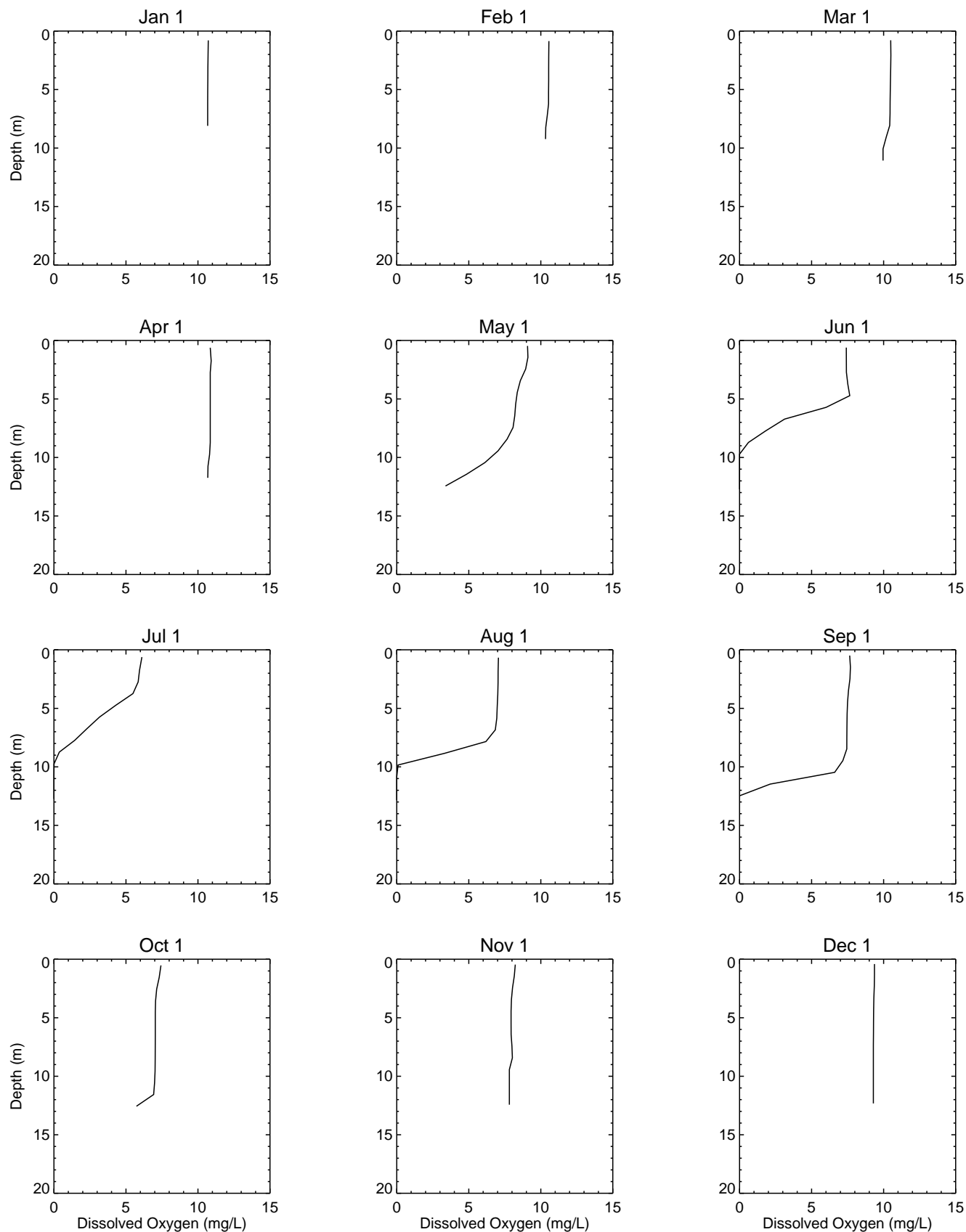*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR
QEA
PARSONS

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 1991

Profiles shown for dates with available data else model results for first day of month shown.

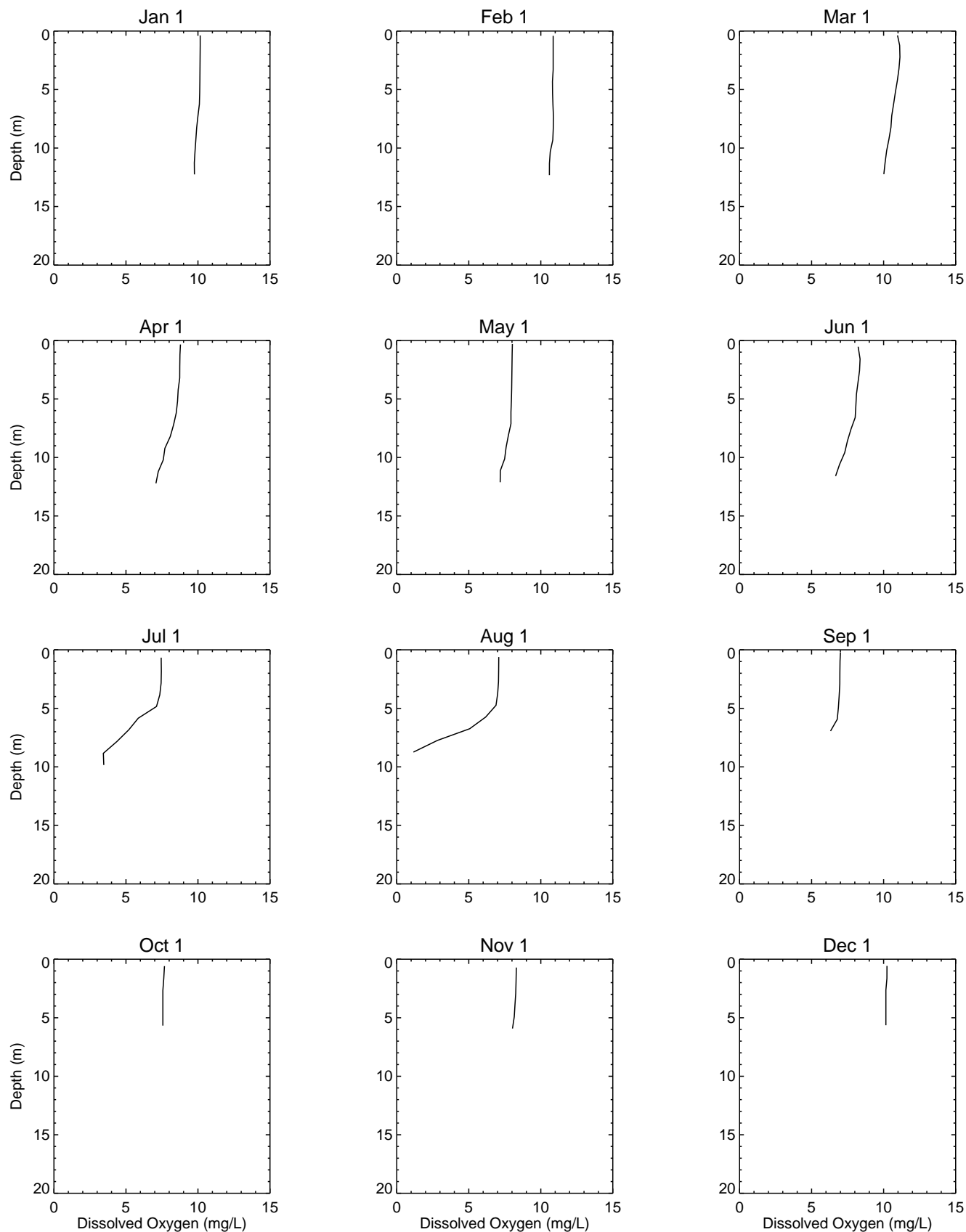CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:11:57 2013

Model (w1210-48)
● Data

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 1992

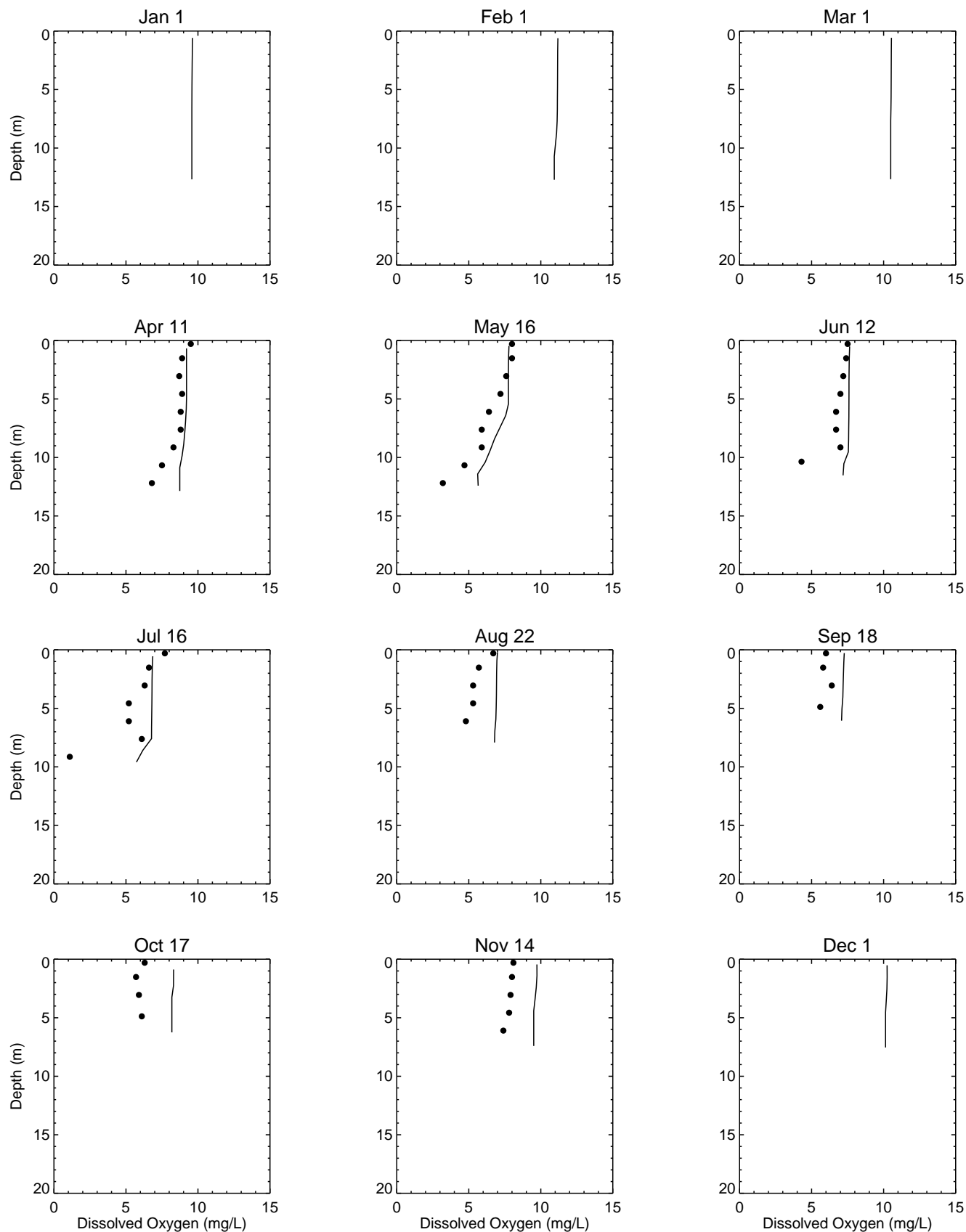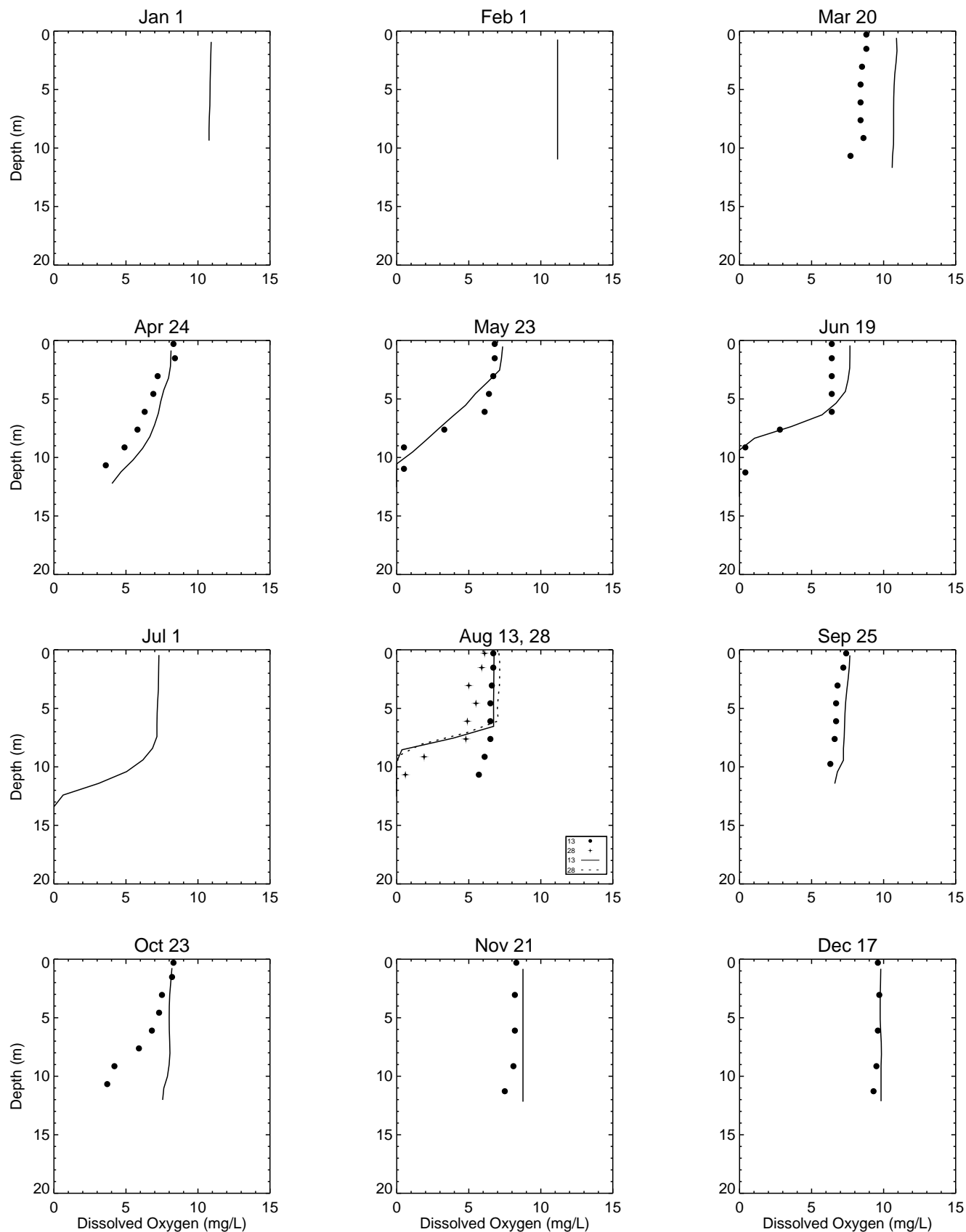*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 1993

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
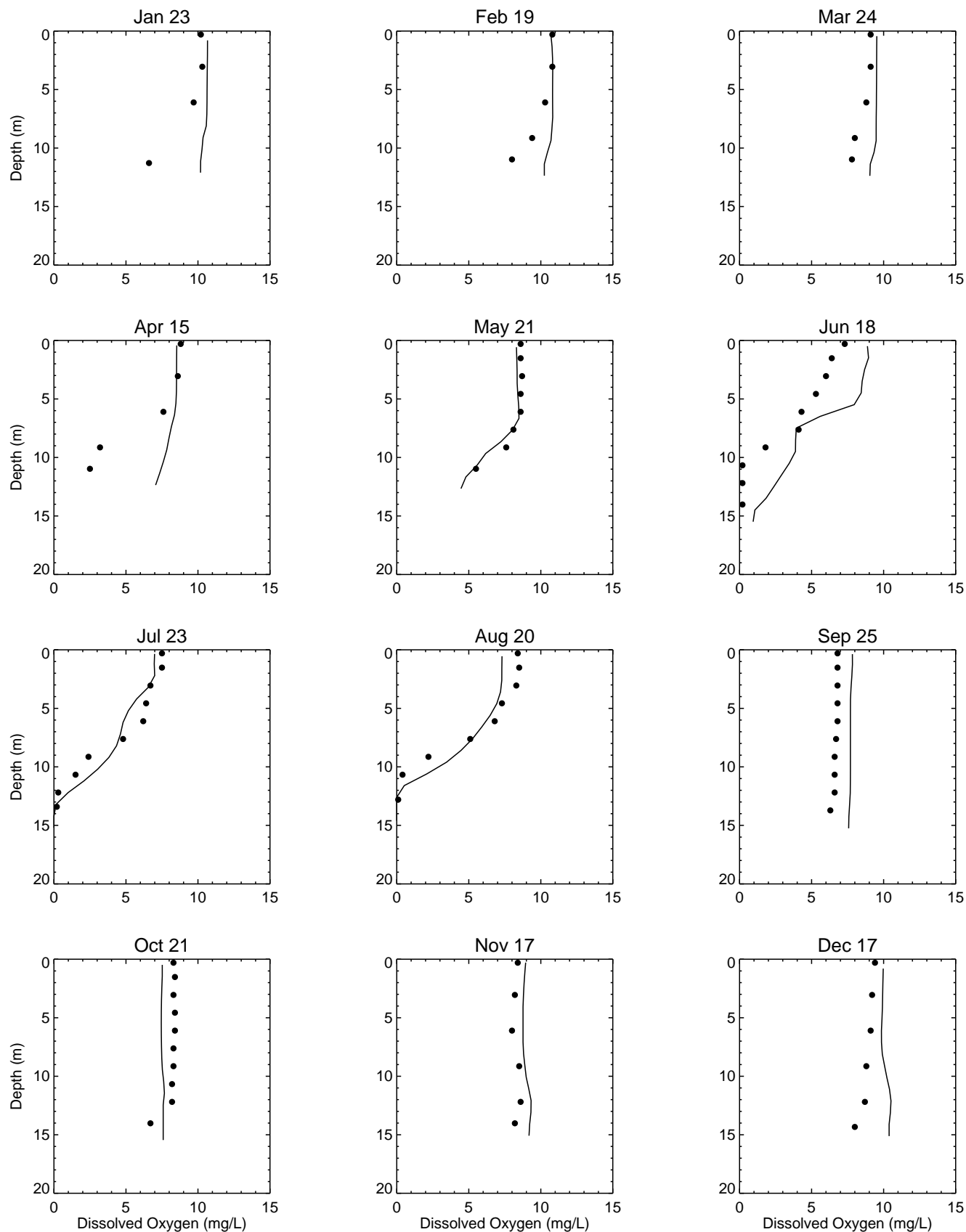Fri Jan 25 18:11:57 2013

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 1995

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
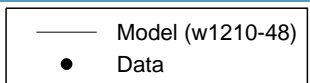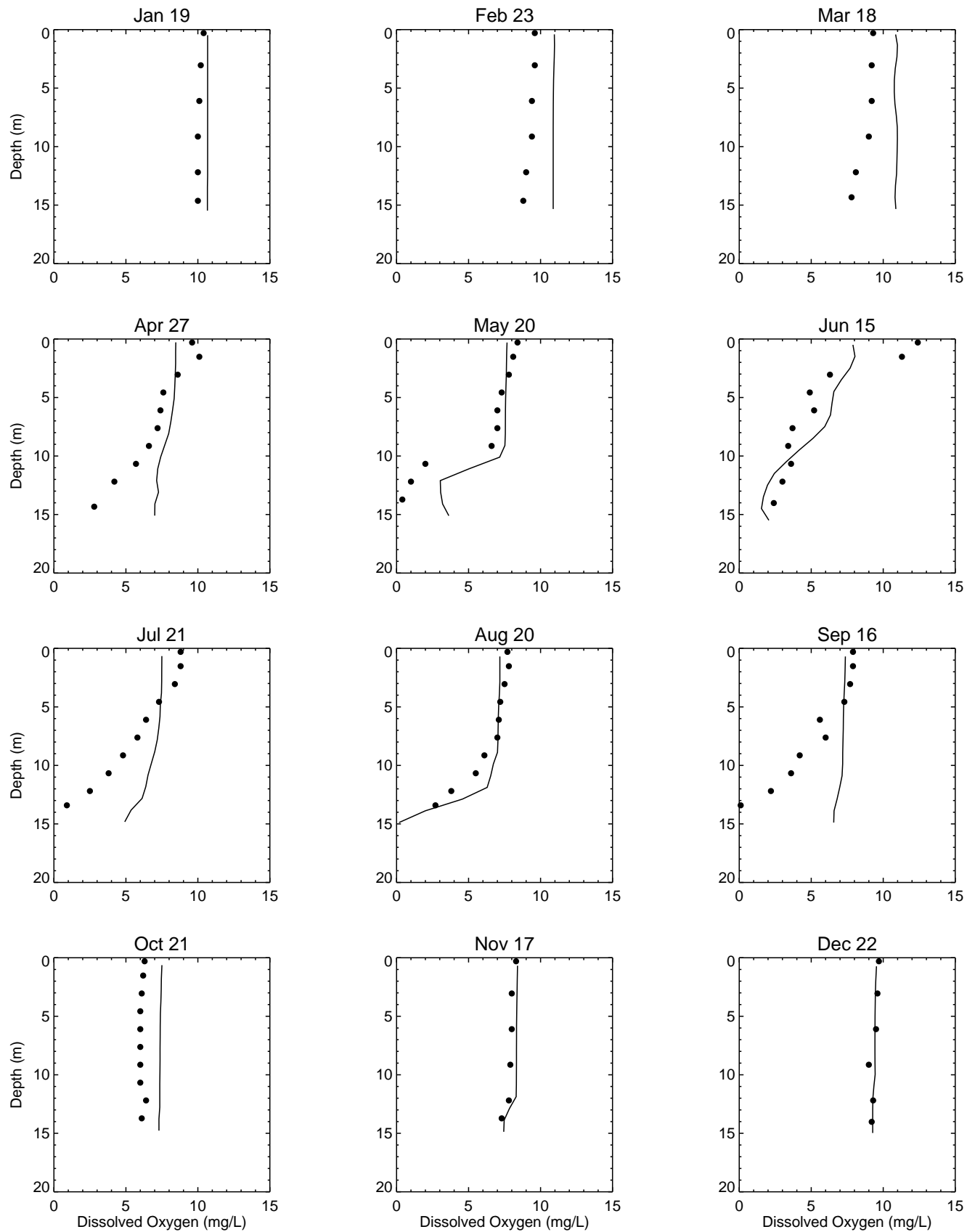
Lower Colorado River Authority

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 1996

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 1997

Profiles shown for dates with available data else model results for first day of month shown.

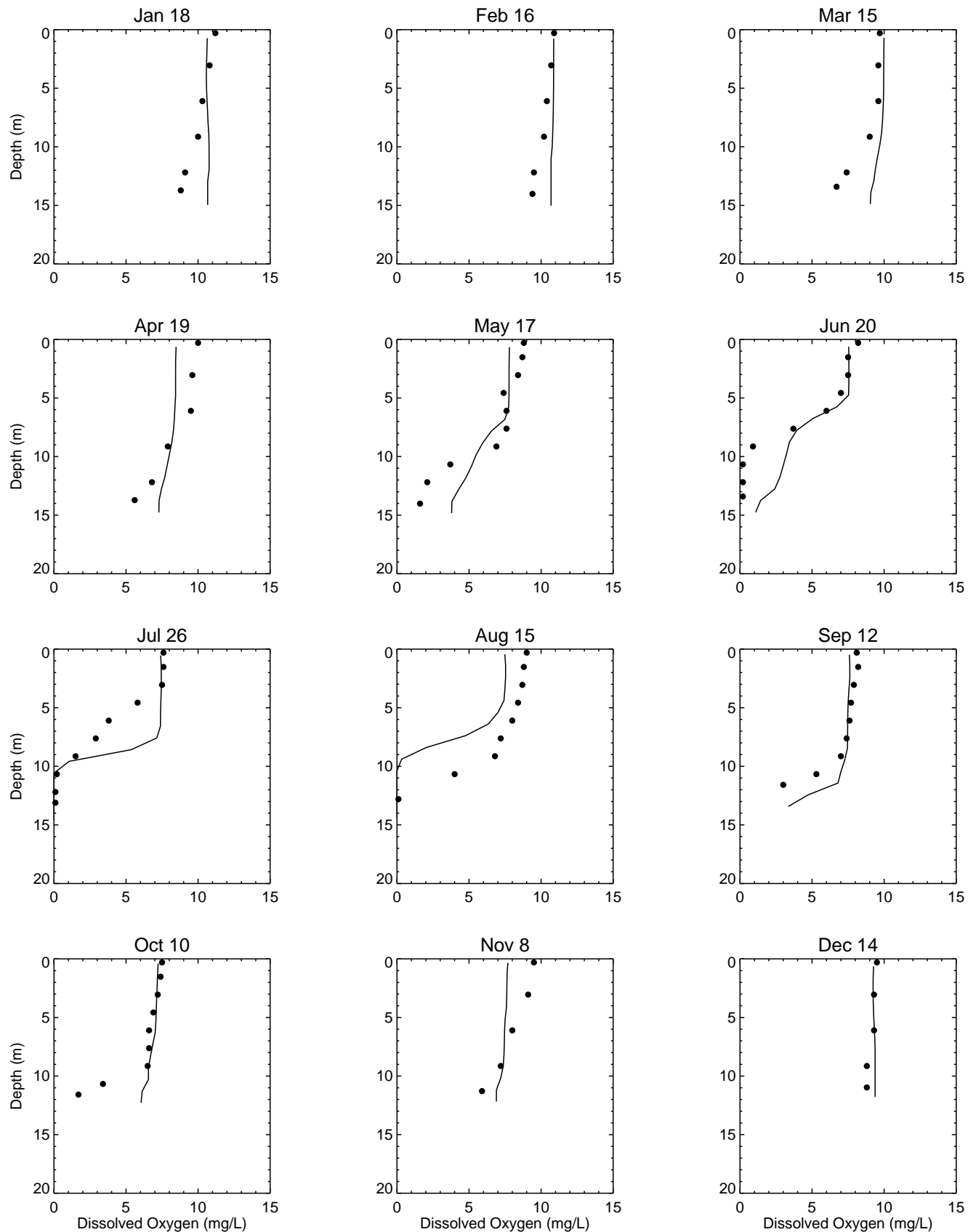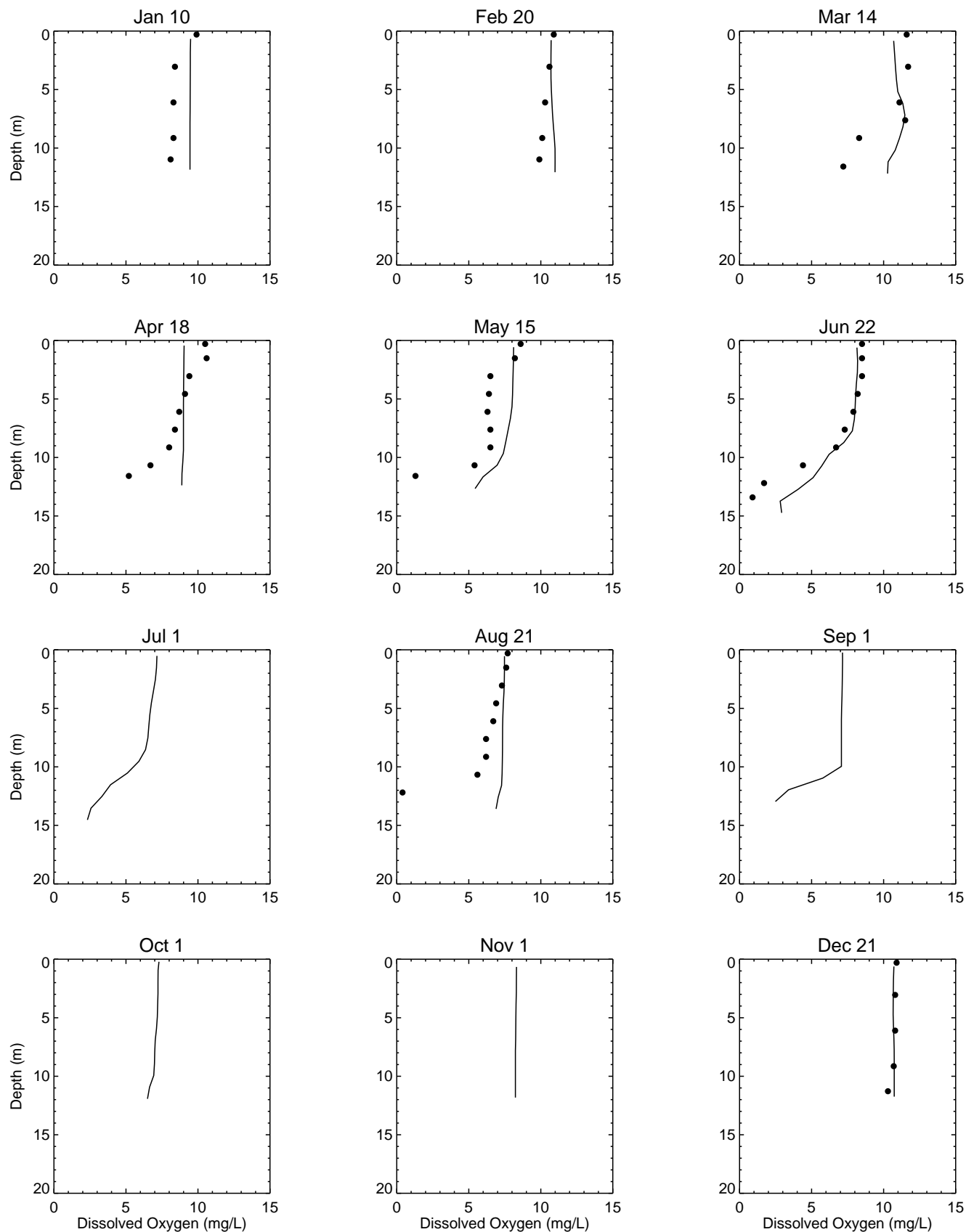CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Jan 1 · Feb 5 · Mar 1 · Apr 8 · May 1 · Jun 15 · Jul 1 · Aug 3 · Sep 1 · Oct 8 · Nov 1 · Dec 3

Vertical Profiles of Model Versus Data for Lake Buchanan near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 1998

——— Model (w1210-48)
● Data

Figure G-29

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:11:57 2013

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
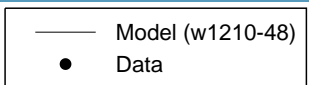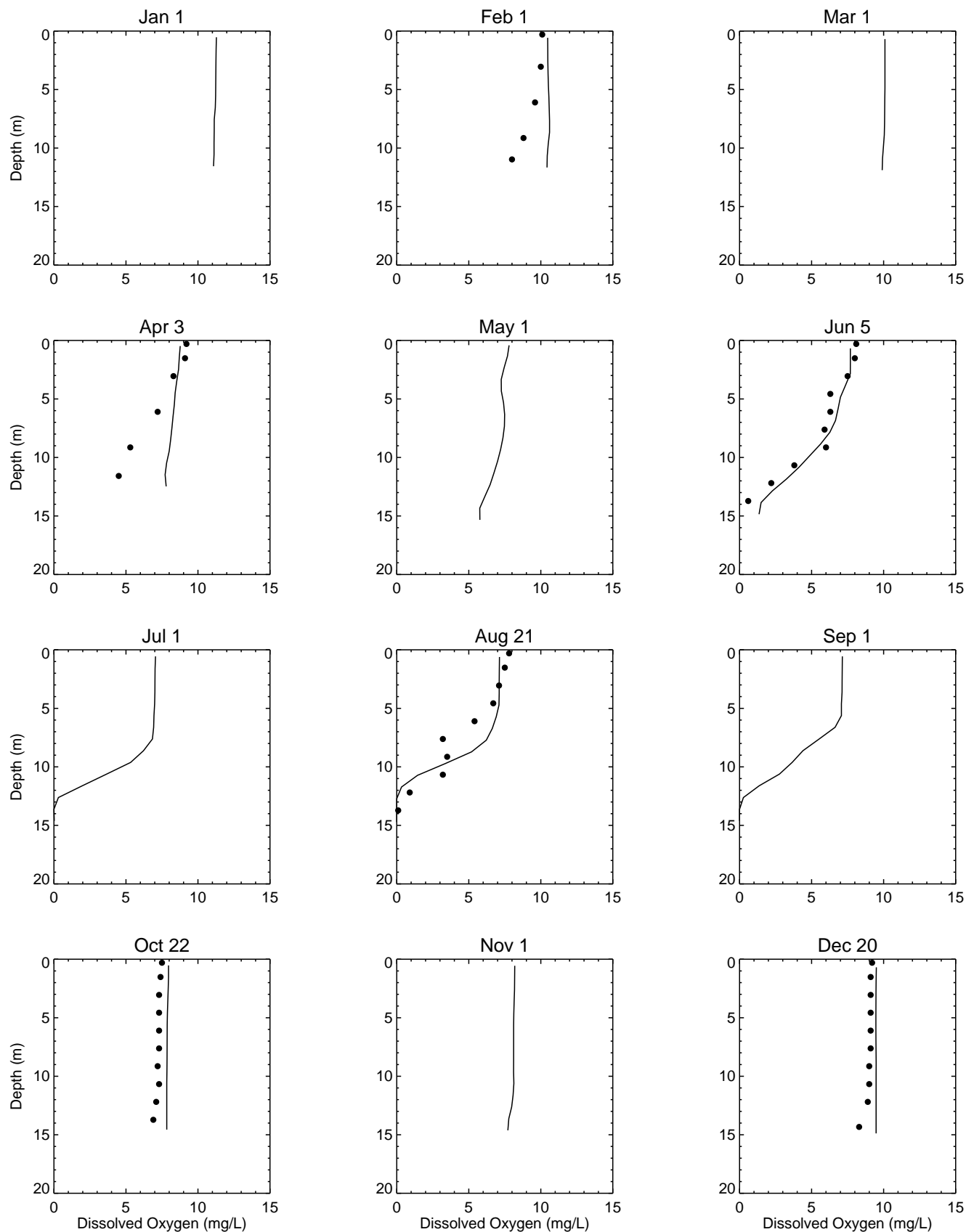near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 1999

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 2000

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
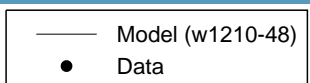
Lower Colorado River Authority

Model (w1210-48)

● Data

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 2001

Profiles shown for dates with available data else model results for first day of month shown.

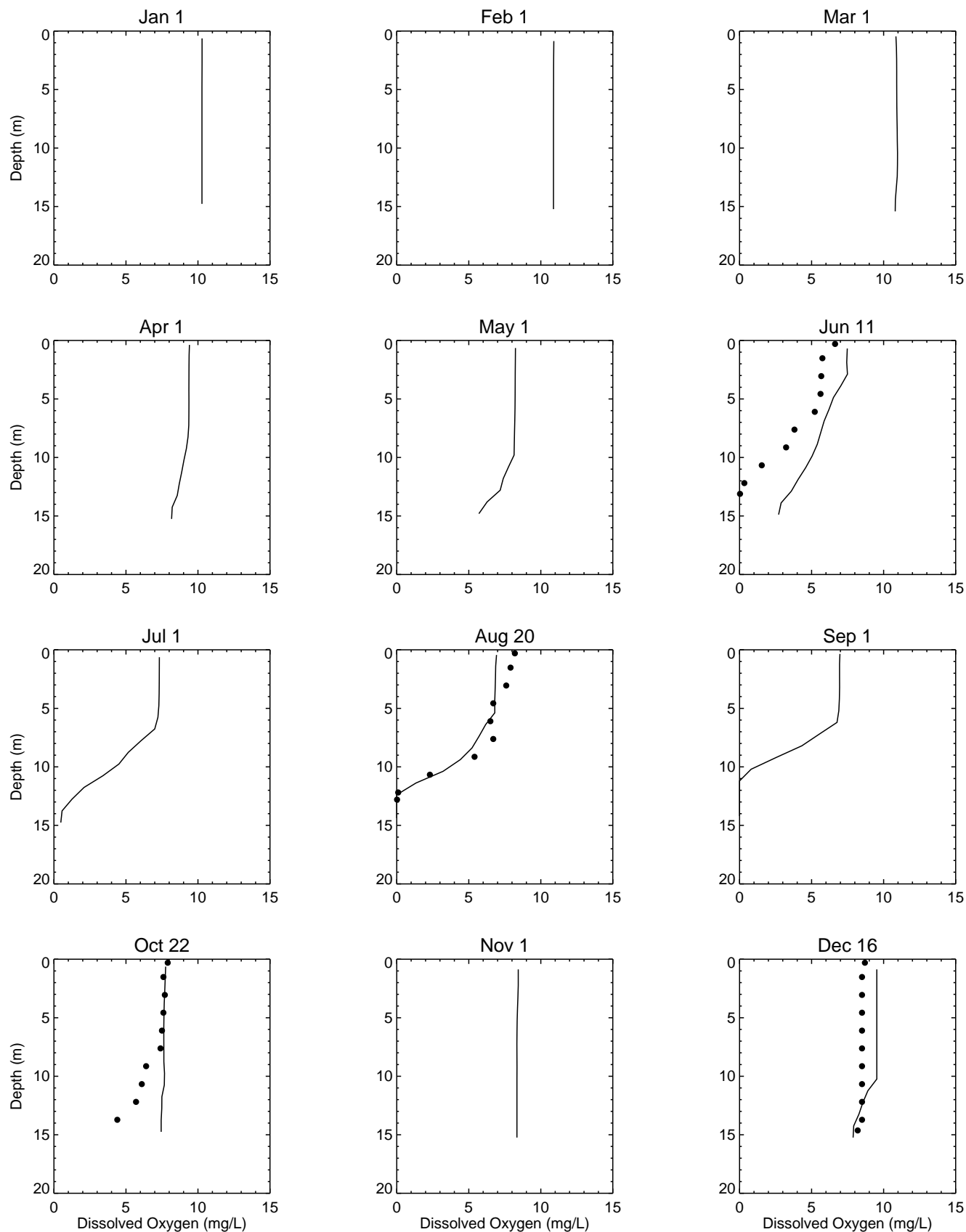CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 2002

Profiles shown for dates with available data else model results for first day of month shown.
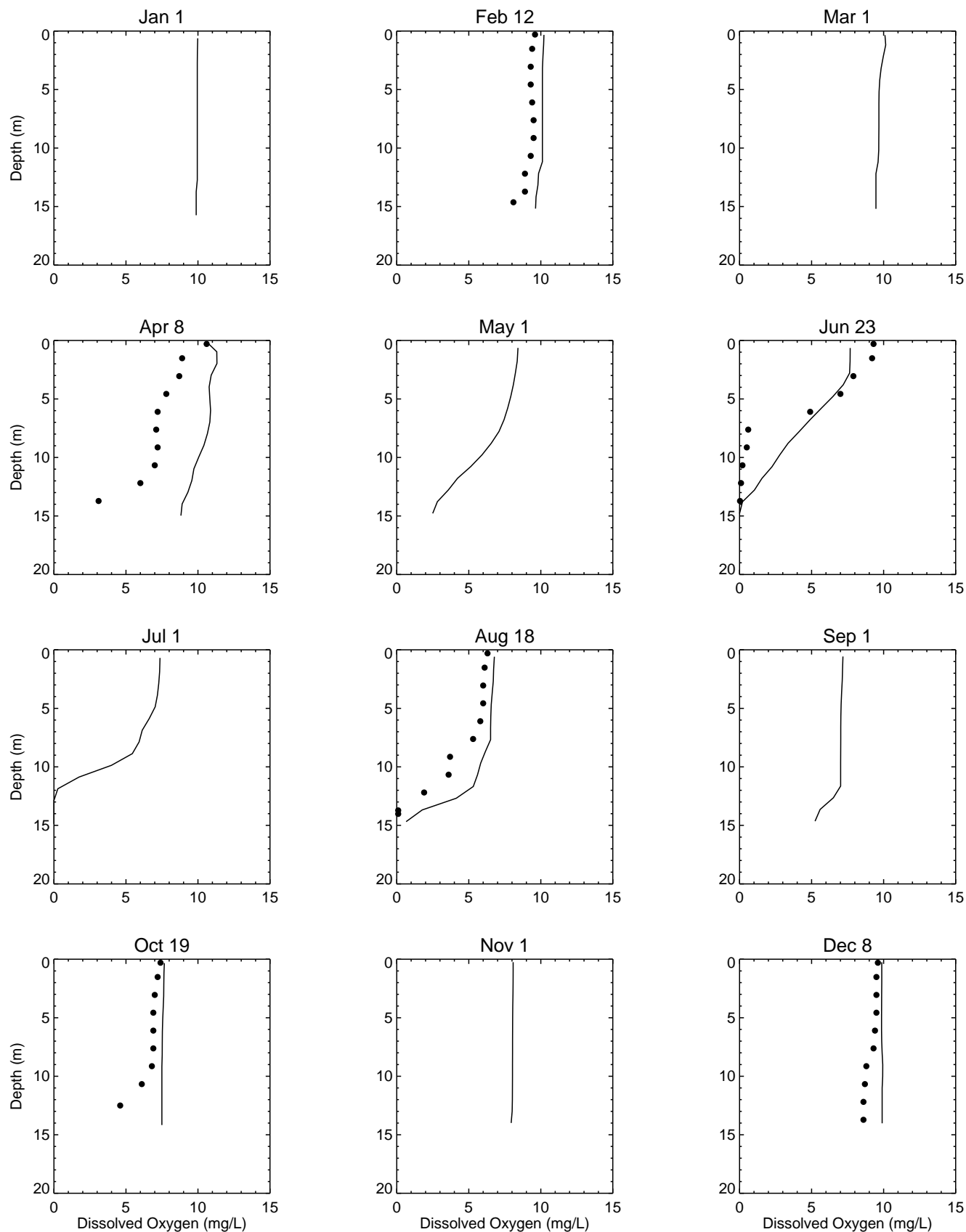
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:11:57 2013

Jan 1 — Feb 1 — Mar 1 — Apr 3 — May 1 — Jun 9 — Jul 1 — Aug 11 — Sep 1 — Oct 6 — Nov 1 — Dec 3

Vertical profiles of Dissolved Oxygen (mg/L) versus Depth (m).
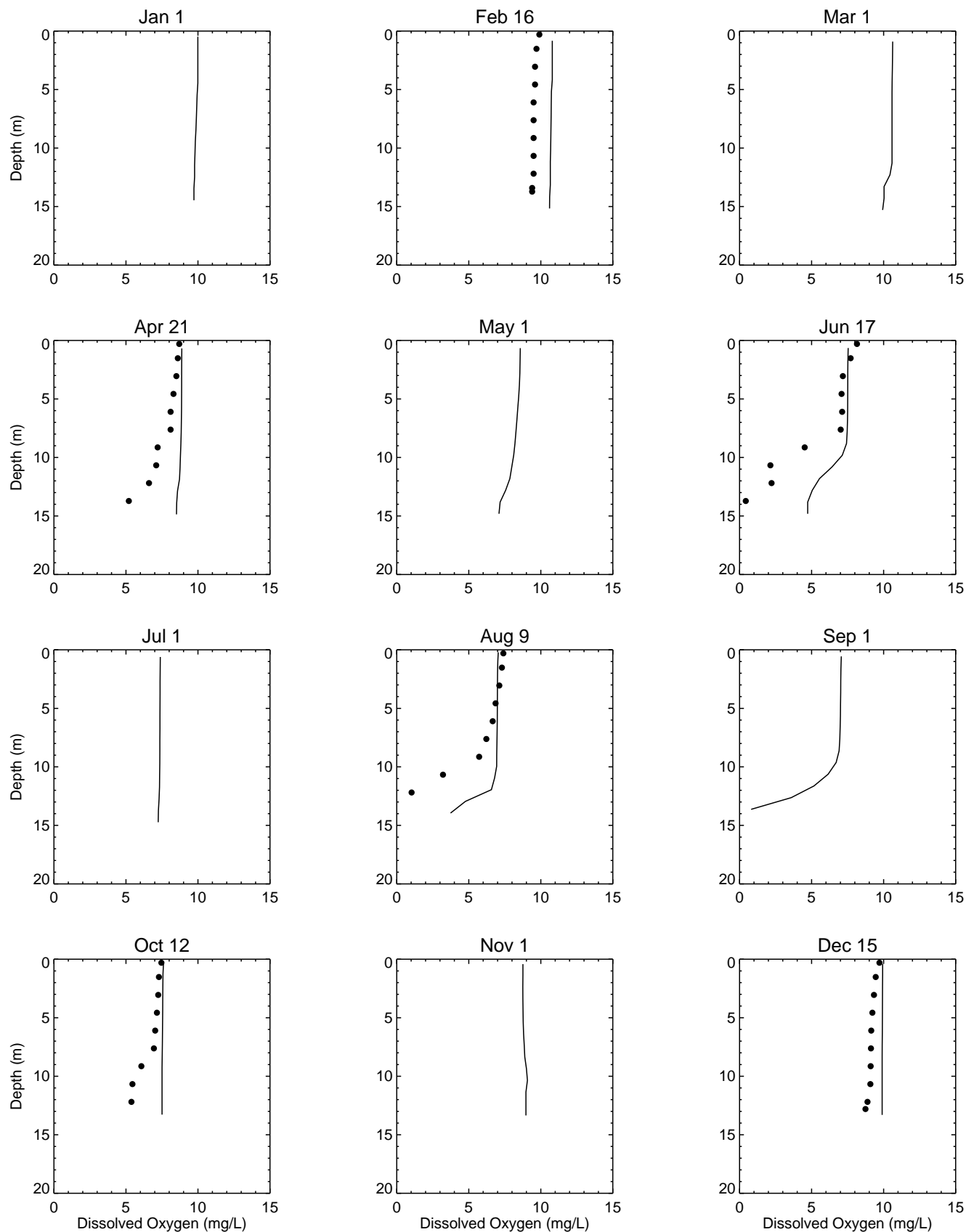
Model (w1210-48)
● Data

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 2003

Profiles shown for dates with available data else model results for first day of month shown.
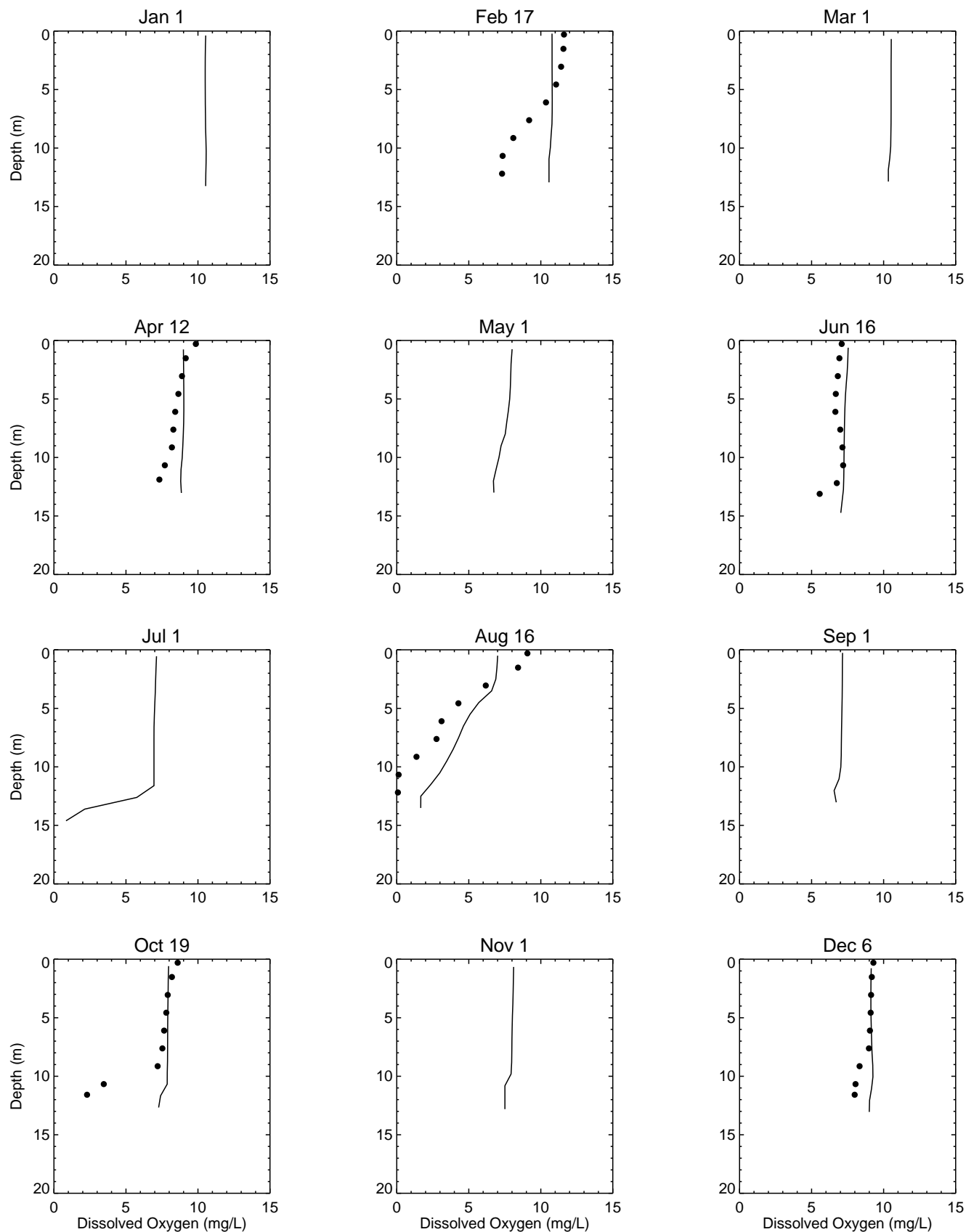
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Jan 1　　Feb 16　　Mar 1

Apr 1　　May 1　　Jun 15

Jul 1　　Aug 12　　Sep 1

Oct 7　　Nov 1　　Dec 9

Dissolved Oxygen (mg/L)
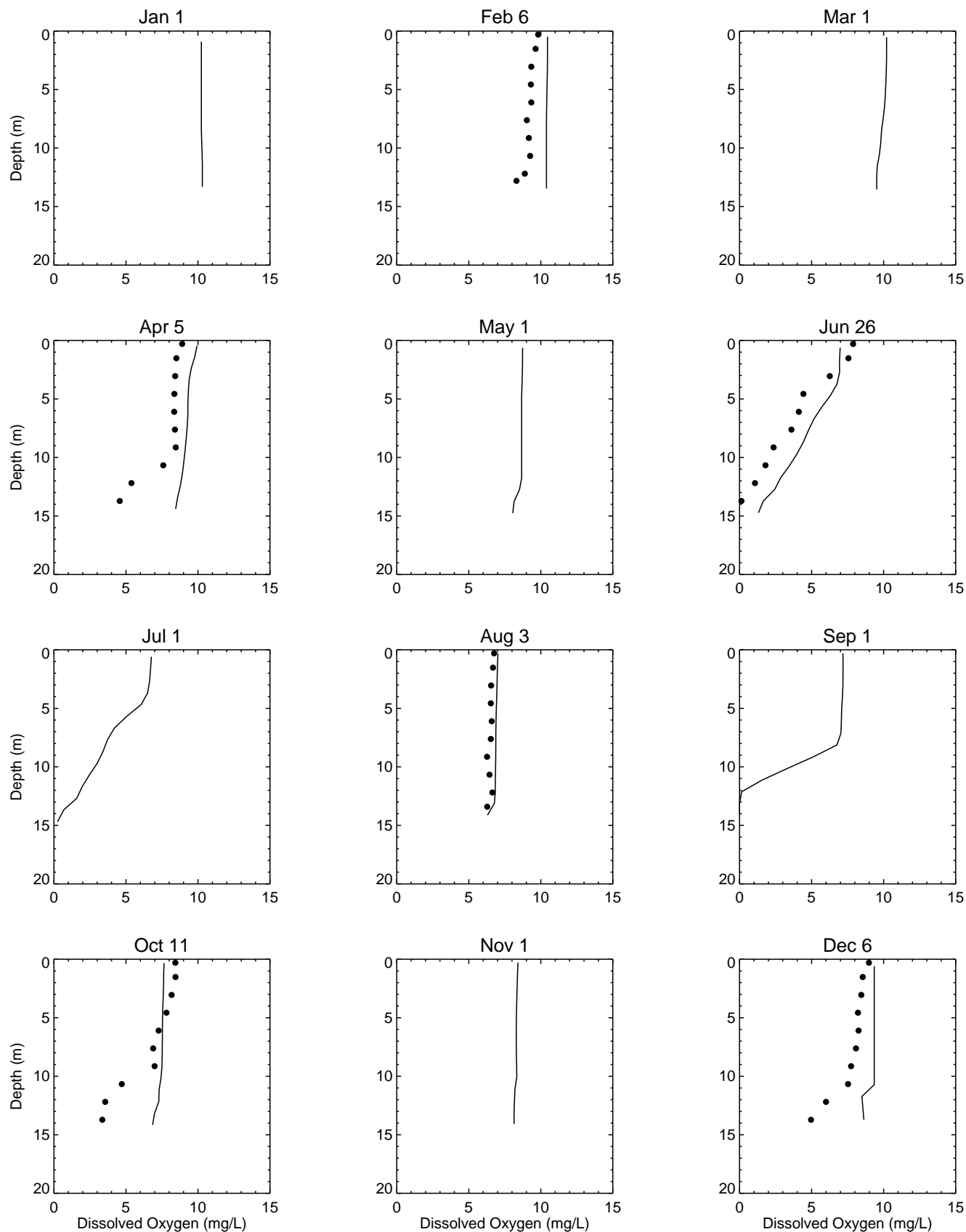
Depth (m)

——— Model (w1210-48)
● Data

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 2004

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:11:57 2013

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 2006

Profiles shown for dates with available data else model results for first day of month shown.
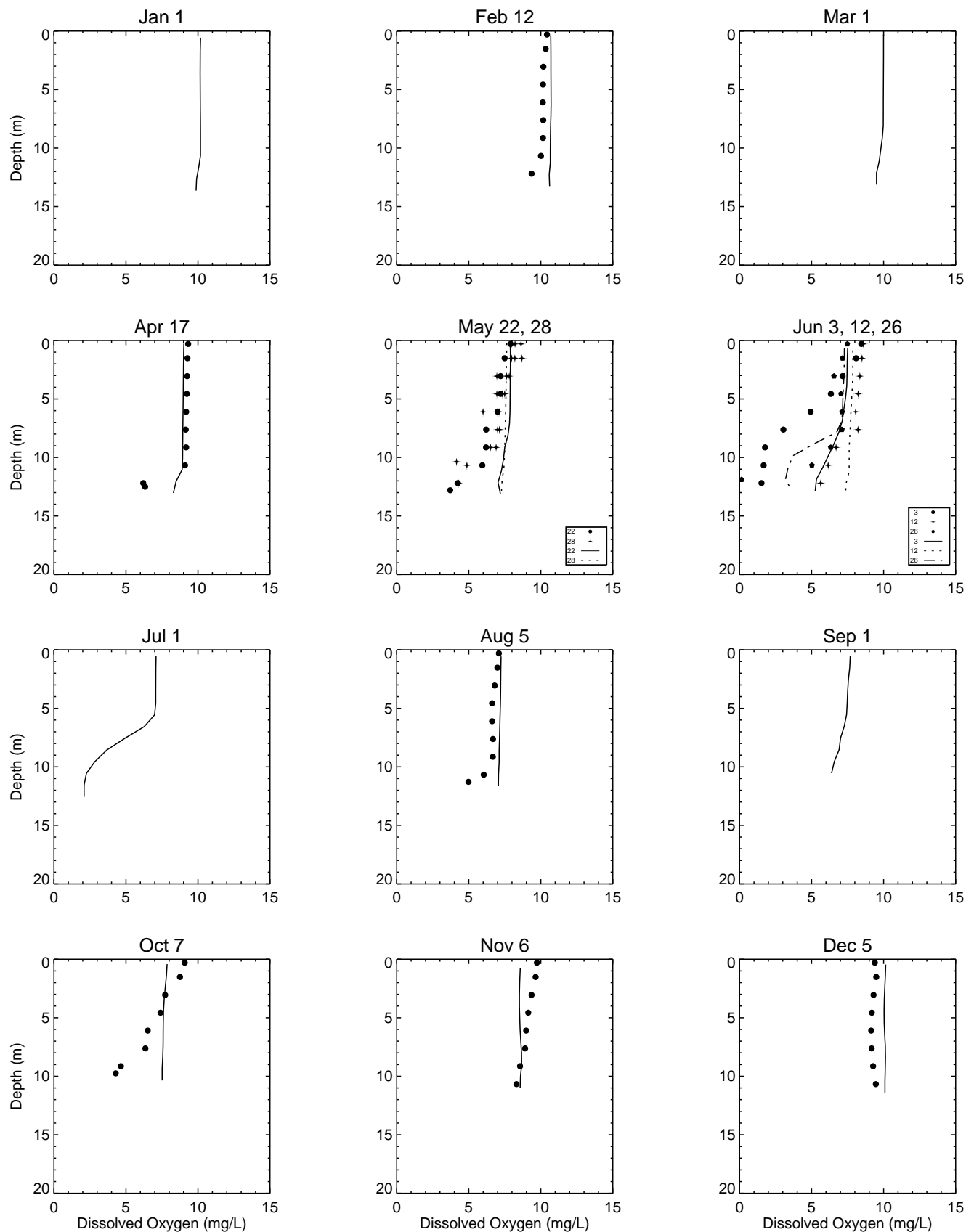
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 2007

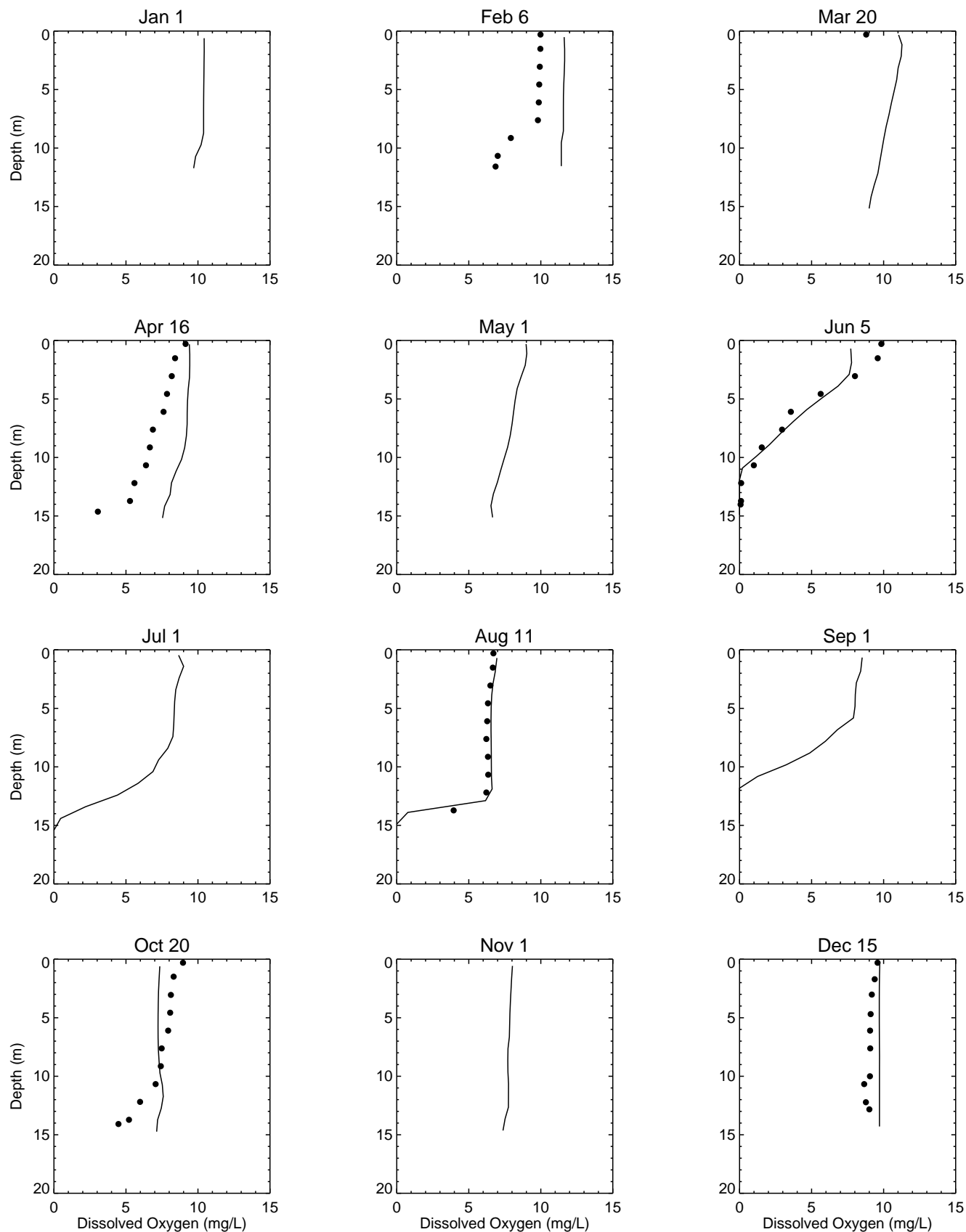*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 — Feb 4 — Mar 1 — Apr 3 — May 1 — Jun 12 — Jul 1 — Aug 7 — Sep 1 — Oct 9 — Nov 1 — Dec 4

Dissolved Oxygen (mg/L)

—— Model (w1210-48)
● Data

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 2008

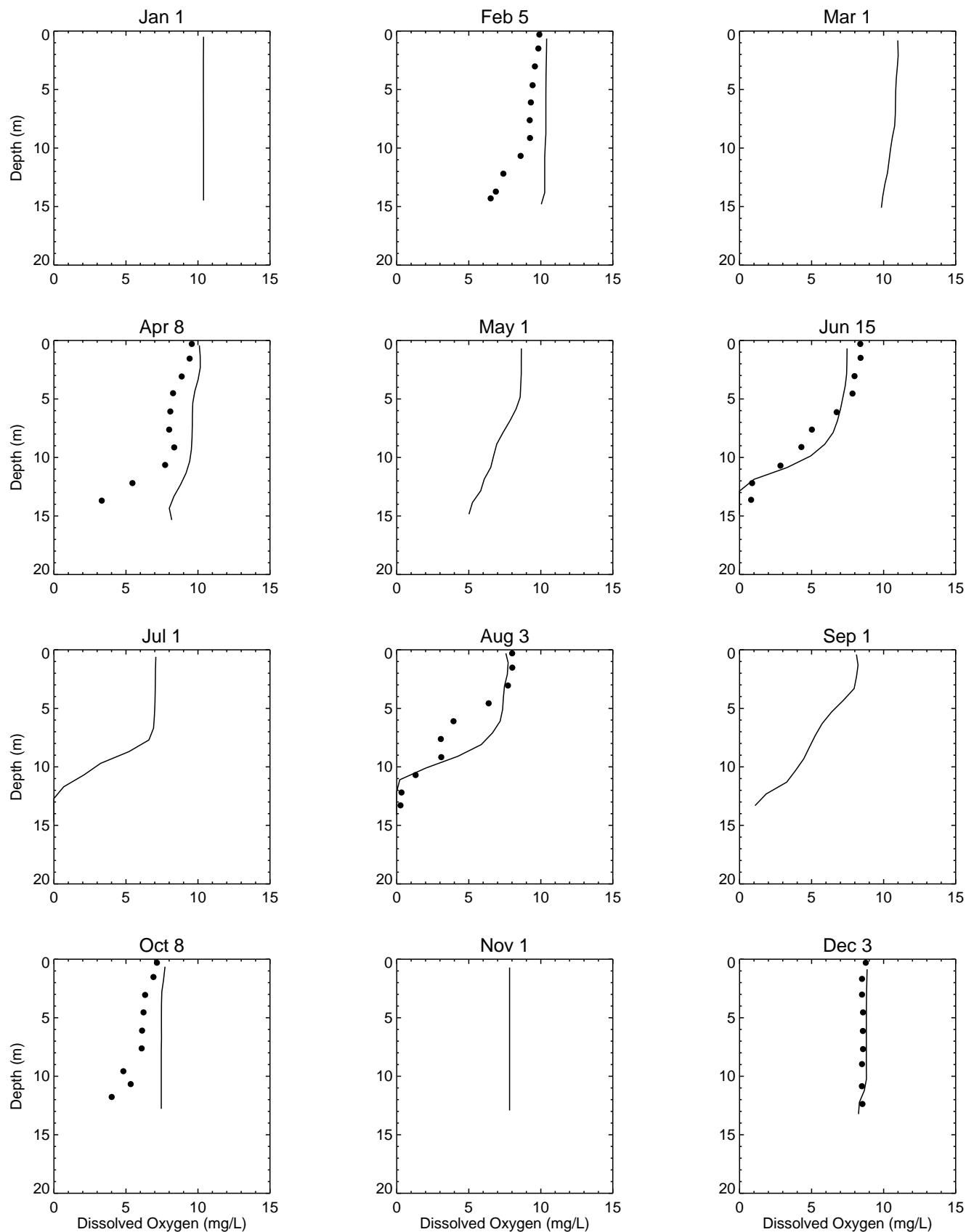*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
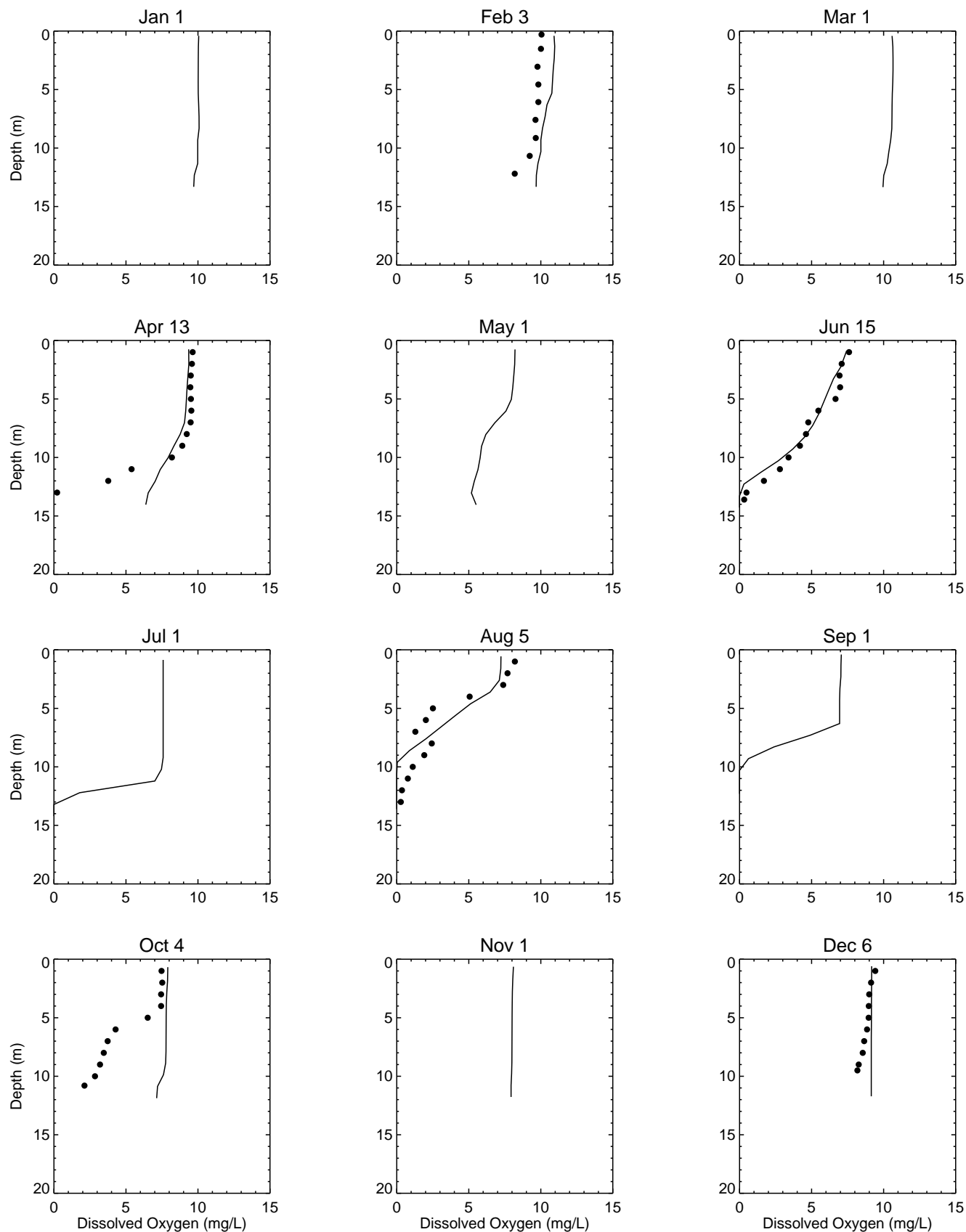Lower Colorado River Authority

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 2009

Profiles shown for dates with available data else model results for first day of month shown.

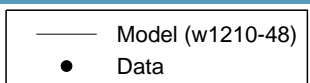CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:11:57 2013

Jan 1 · Feb 18 · Mar 1 · Apr 5 · May 1 · Jun 3 · Jul 1 · Aug 2, 5 · Sep 2 · Oct 7, 13 · Nov 4 · Dec 1, 2

Depth (m)

Dissolved Oxygen (mg/L)

——— Model (w1210-48)
● Data

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 2010

Profiles shown for dates with available data else model results for first day of month shown.

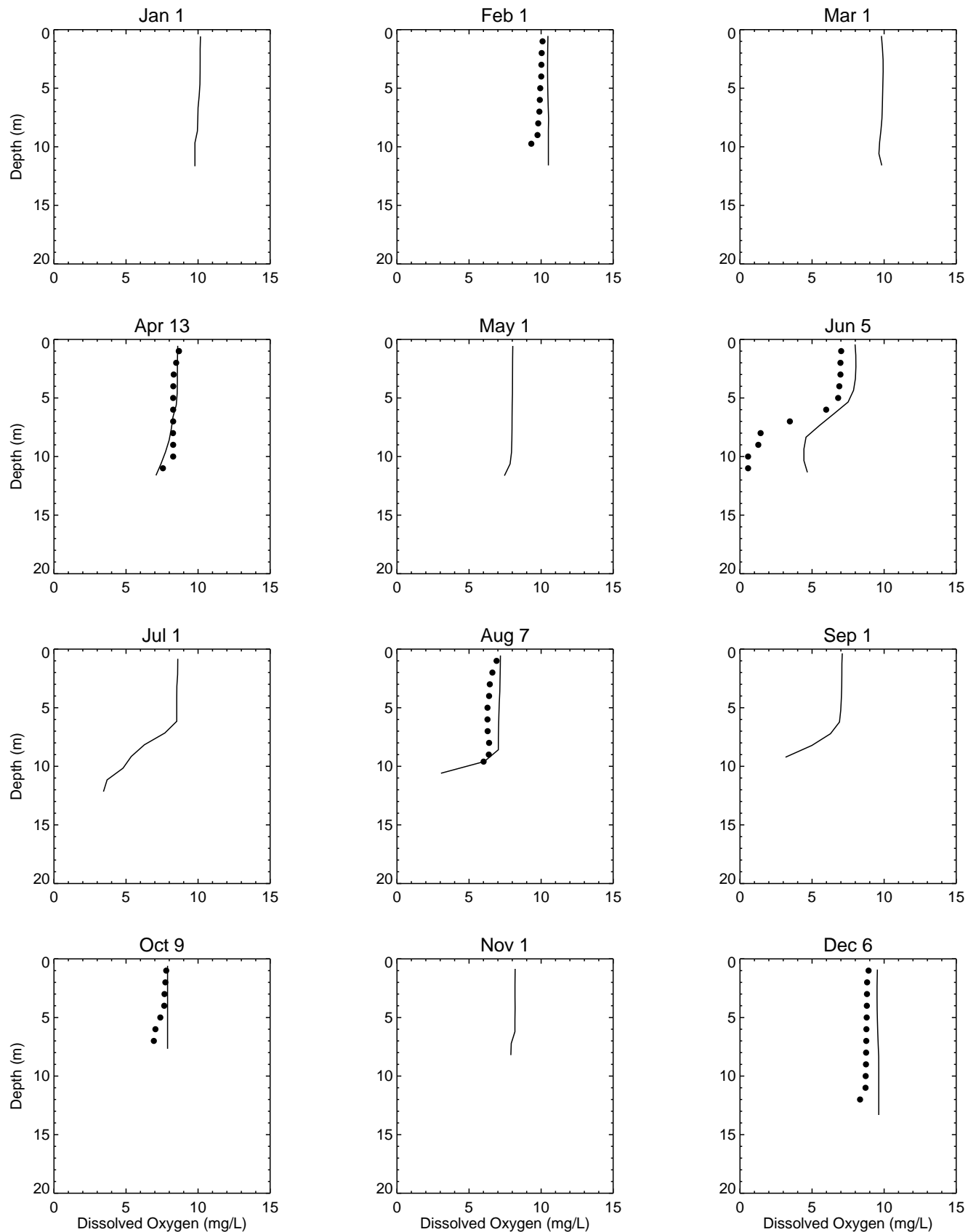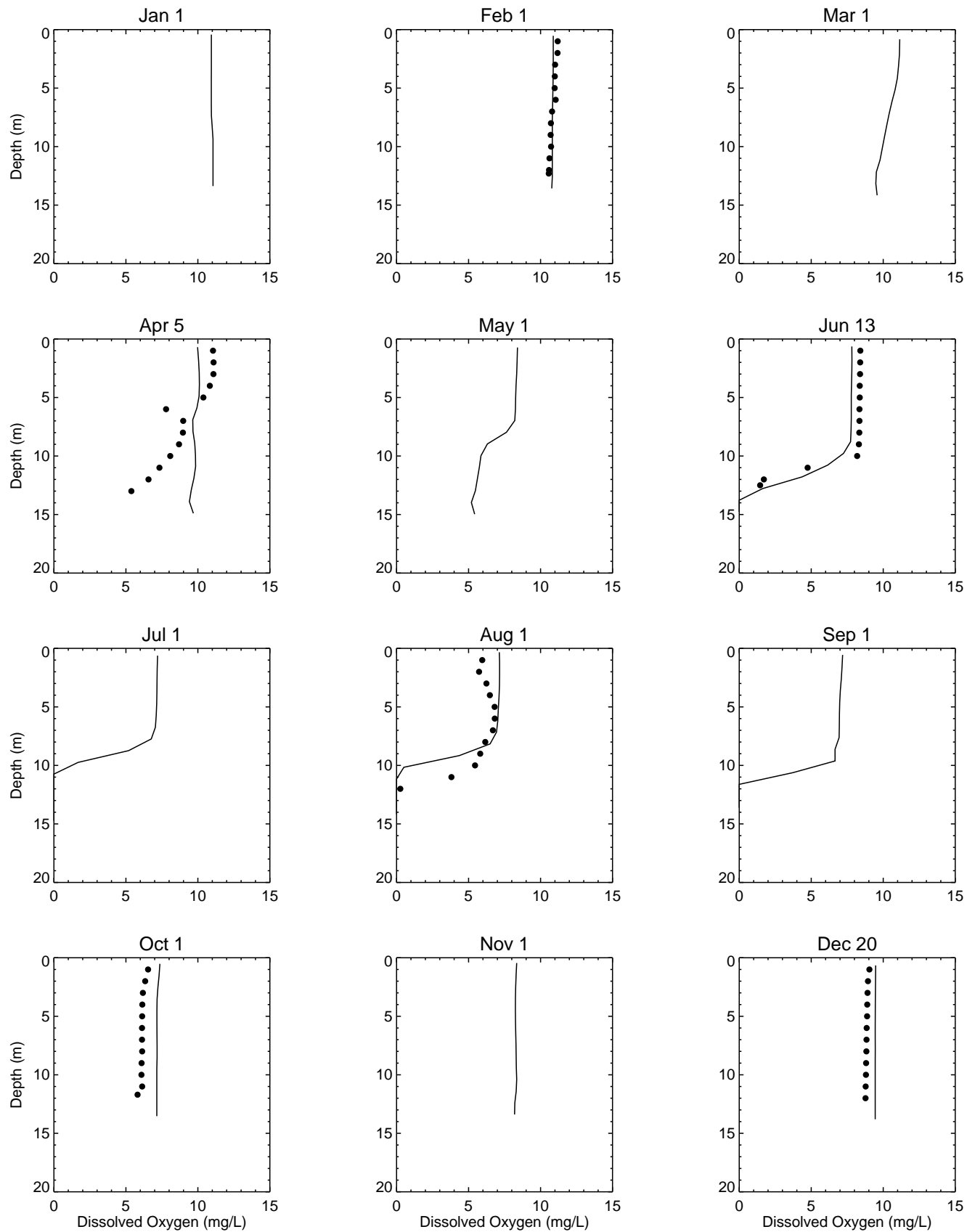CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:11:57 2013

Jan 6 · Feb 7 · Mar 3 · Apr 14 · May 5 · Jun 1, 2 · Jul 7 · Aug 4 · Sep 1 · Oct 3, 5 · Nov 1 · Dec 1, 8
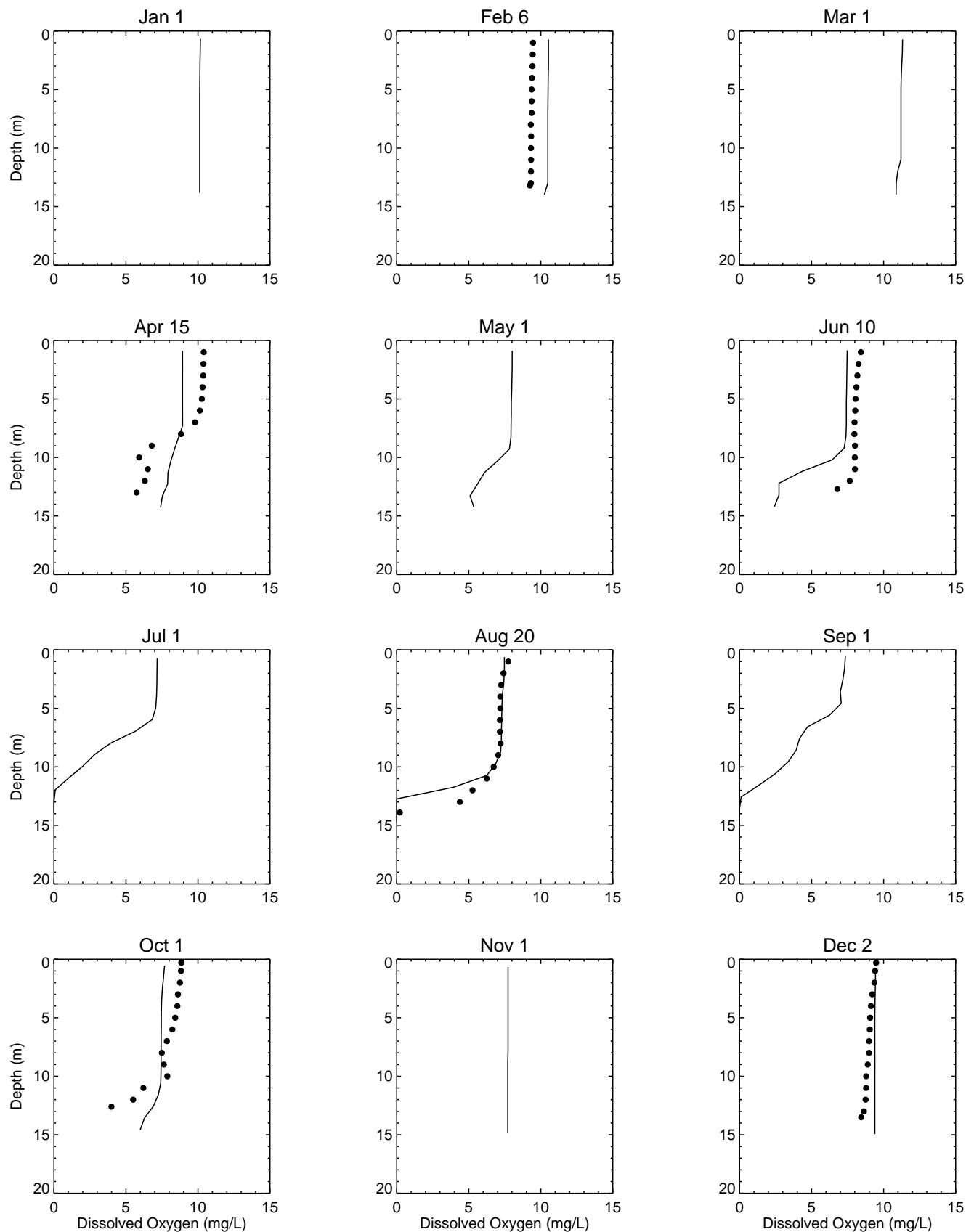
Model (w1210-48)

Data

Figure G-29

Vertical Profiles of Model Versus Data for Lake Buchanan
near Beaver Creek Cove (Segment 6) - Dissolved Oxygen - 2011

Profiles shown for dates with available data else model results for first day of month shown.
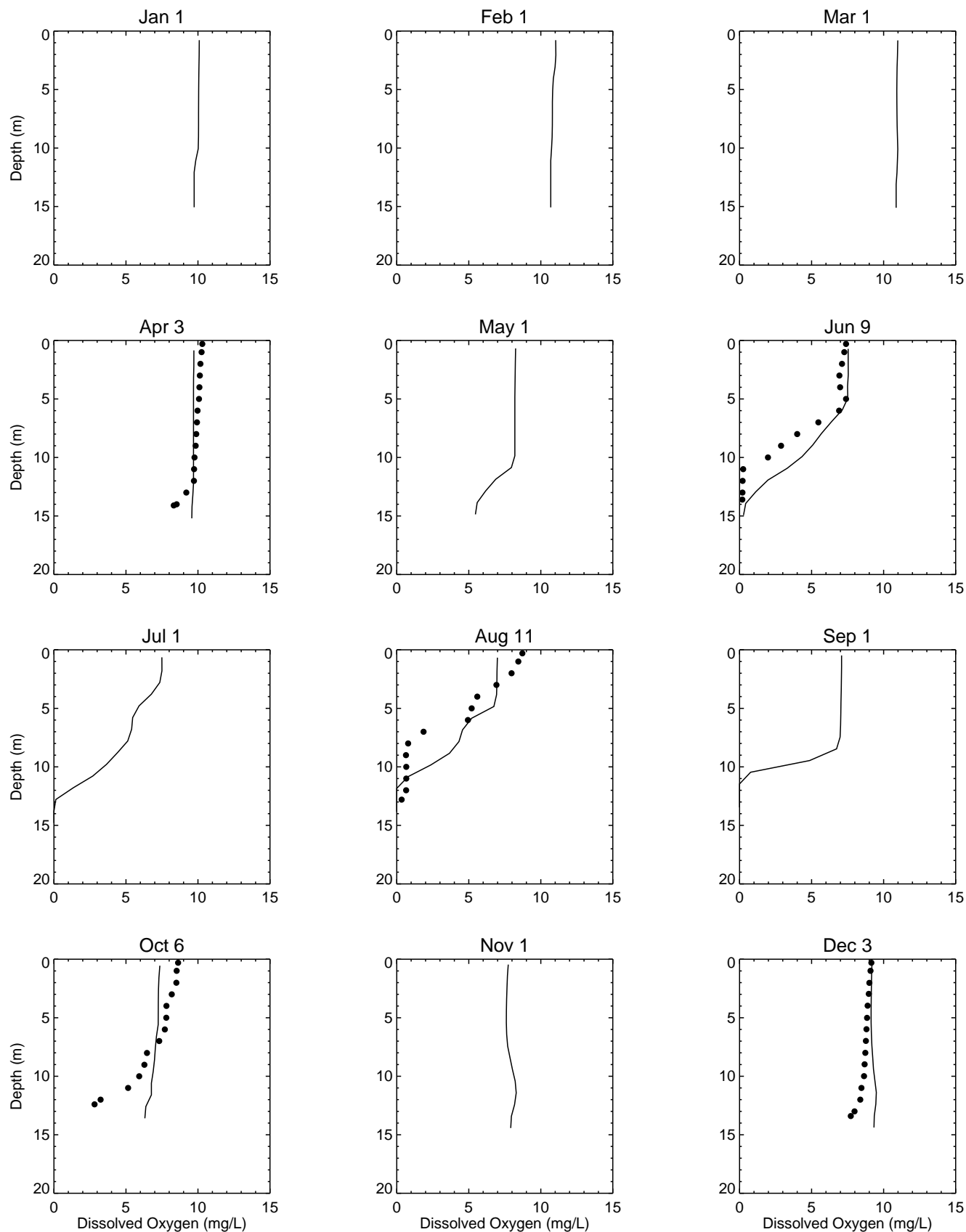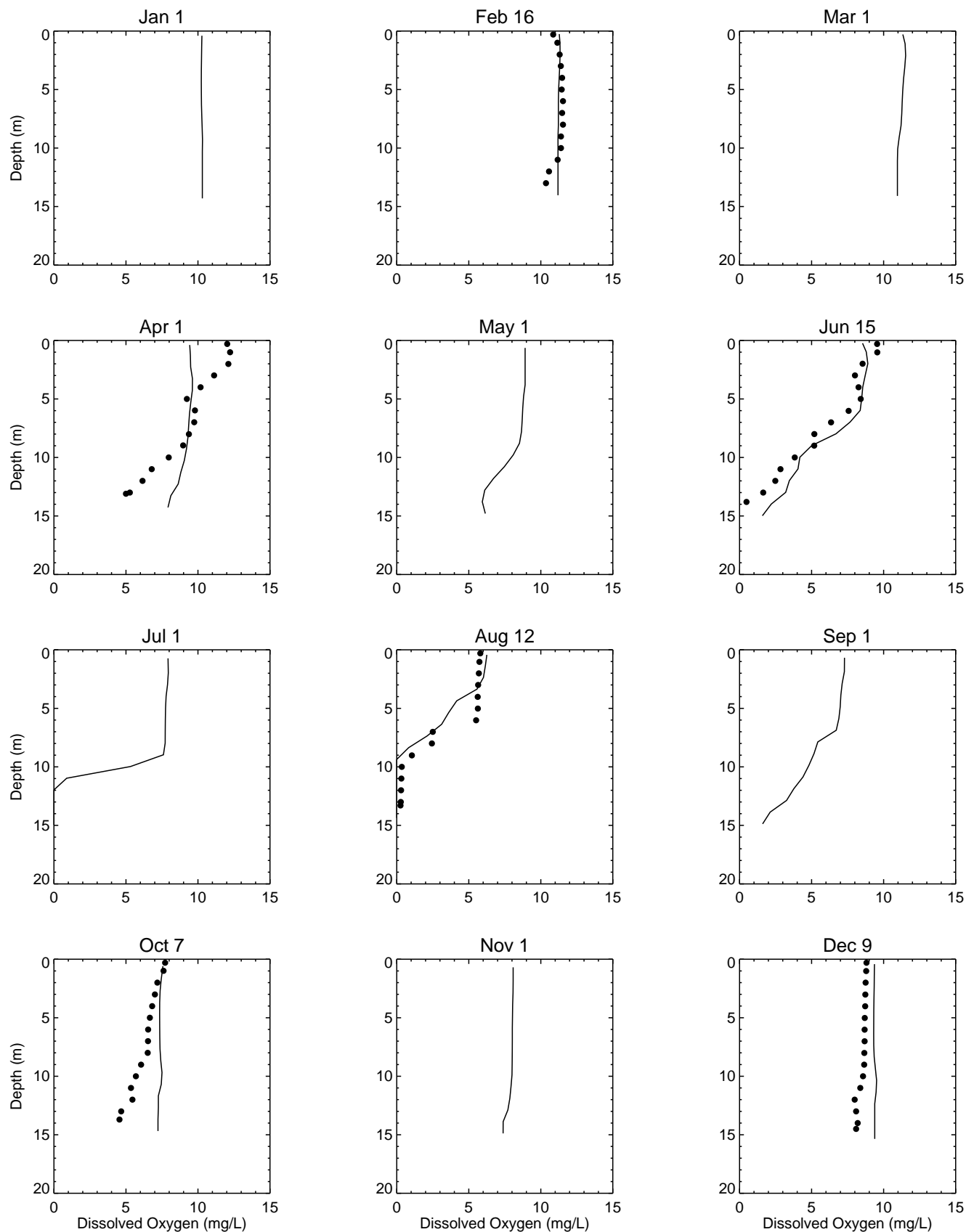
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:11:57 2013

Jan 1 · Feb 1 · Mar 1 · Apr 11 · May 16 · Jun 12 · Jul 16 · Aug 22 · Sep 19 · Oct 17 · Nov 14 · Dec 1

Depth (m) · Dissolved Oxygen (mg/L)

——— Model (w1210-48)
● Data

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 1984
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

Figure G-30
Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 1985
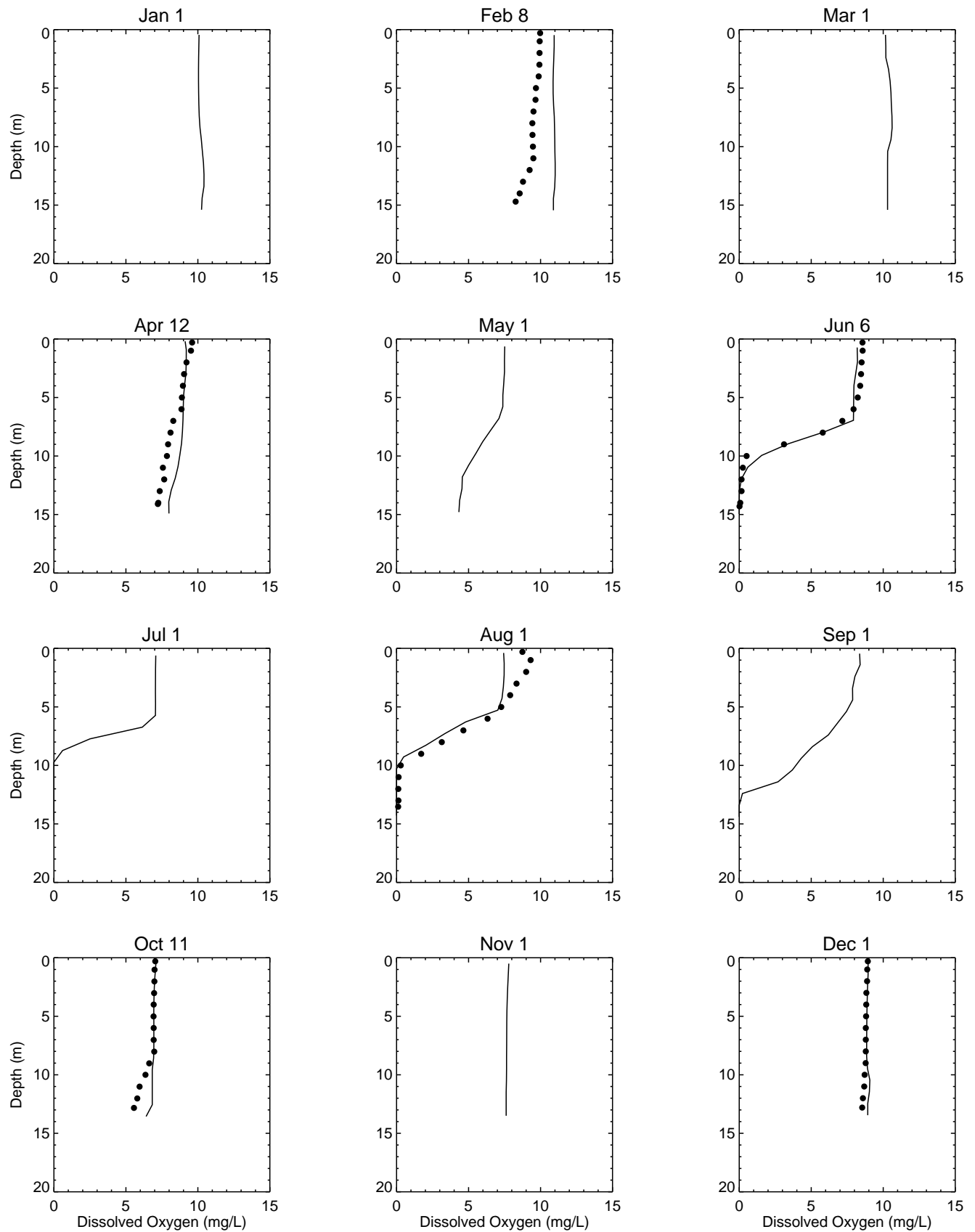*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 1986

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
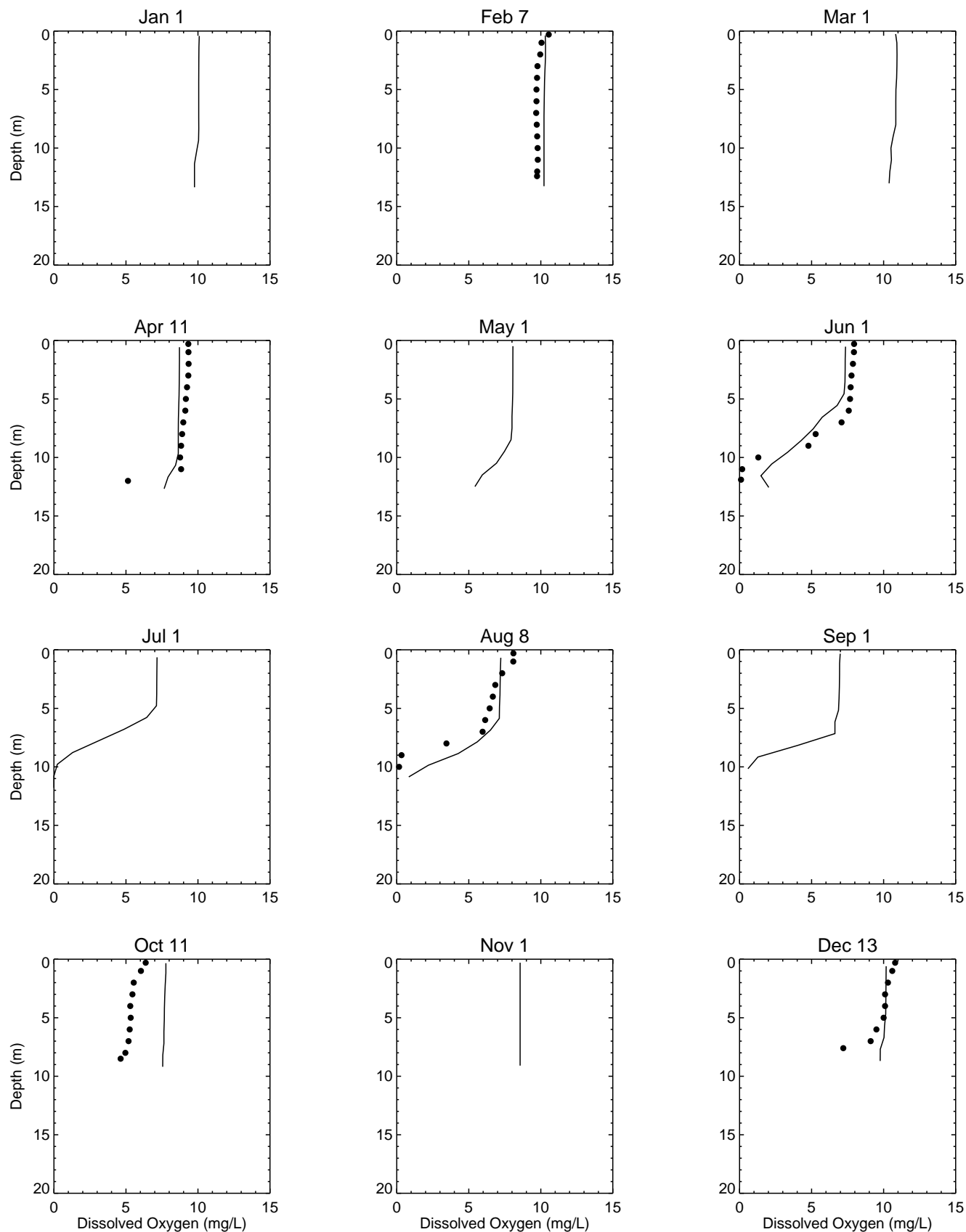
Lower Colorado River Authority

Jan 19 · Feb 23 · Mar 18 · Apr 27 · May 20 · Jun 15 · Jul 21 · Aug 20 · Sep 16 · Oct 21 · Nov 17 · Dec 22

Depth (m) — Dissolved Oxygen (mg/L)

—— Model (w1210-48)
● Data

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 1987

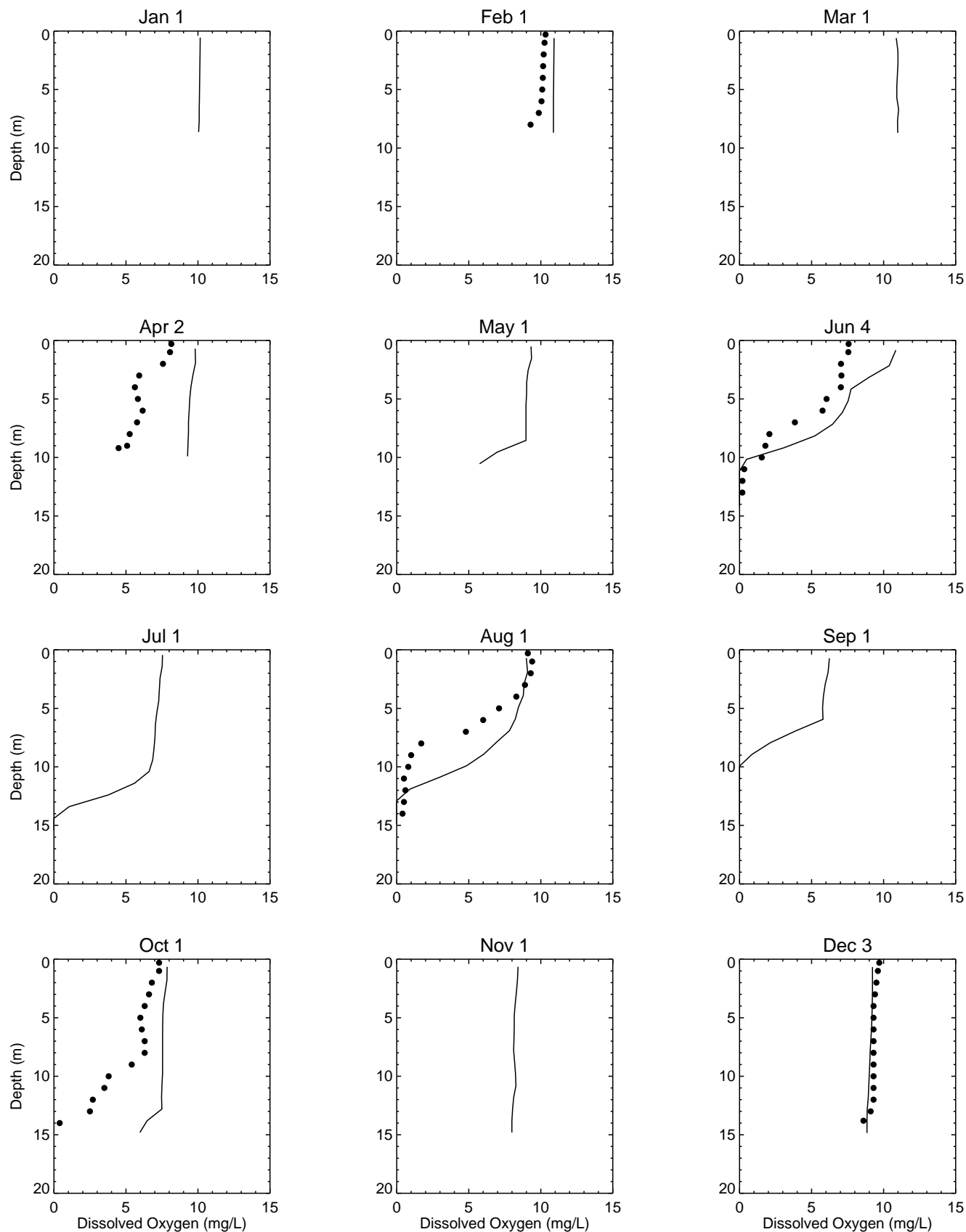*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA PARSONS

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 1988

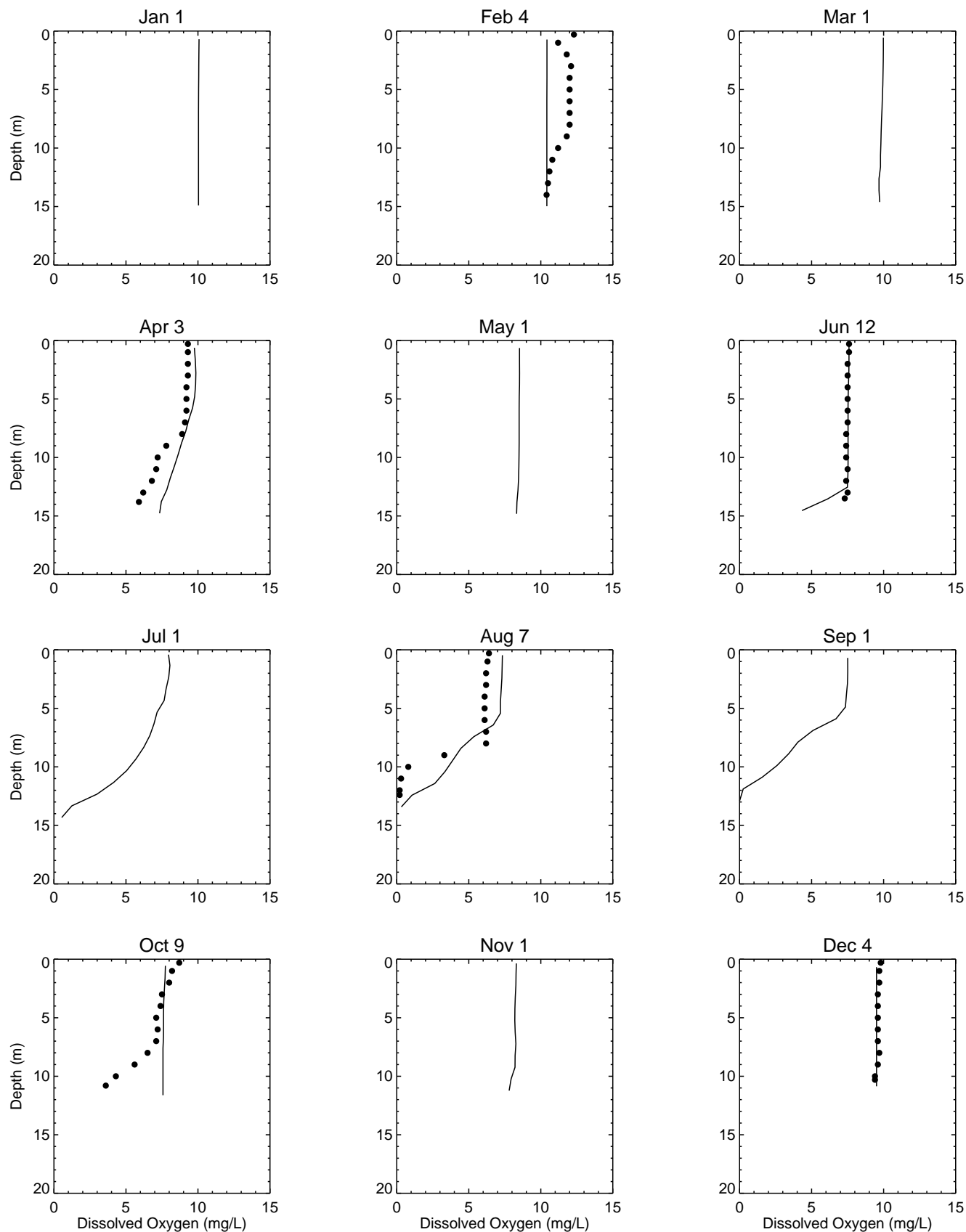*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 1989

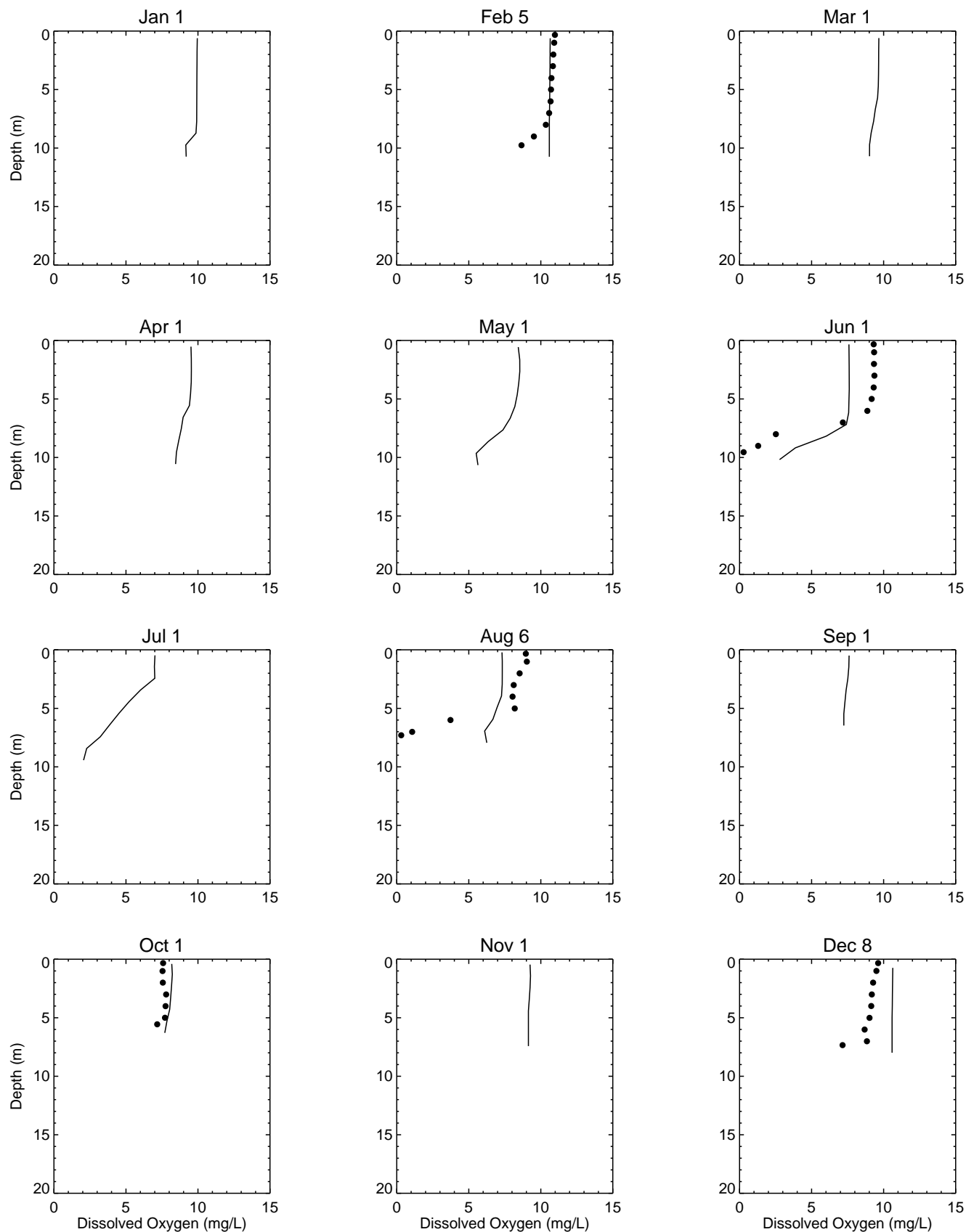*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:44 2013

Jan 1   Feb 1   Mar 1

Apr 3   May 1   Jun 5

Jul 1   Aug 1   Sep 1

Oct 22   Nov 1   Dec 20

Dissolved Oxygen (mg/L)

—— Model (w1210-48)
● Data

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 1990
Profiles shown for dates with available data else model results for first day of month shown.

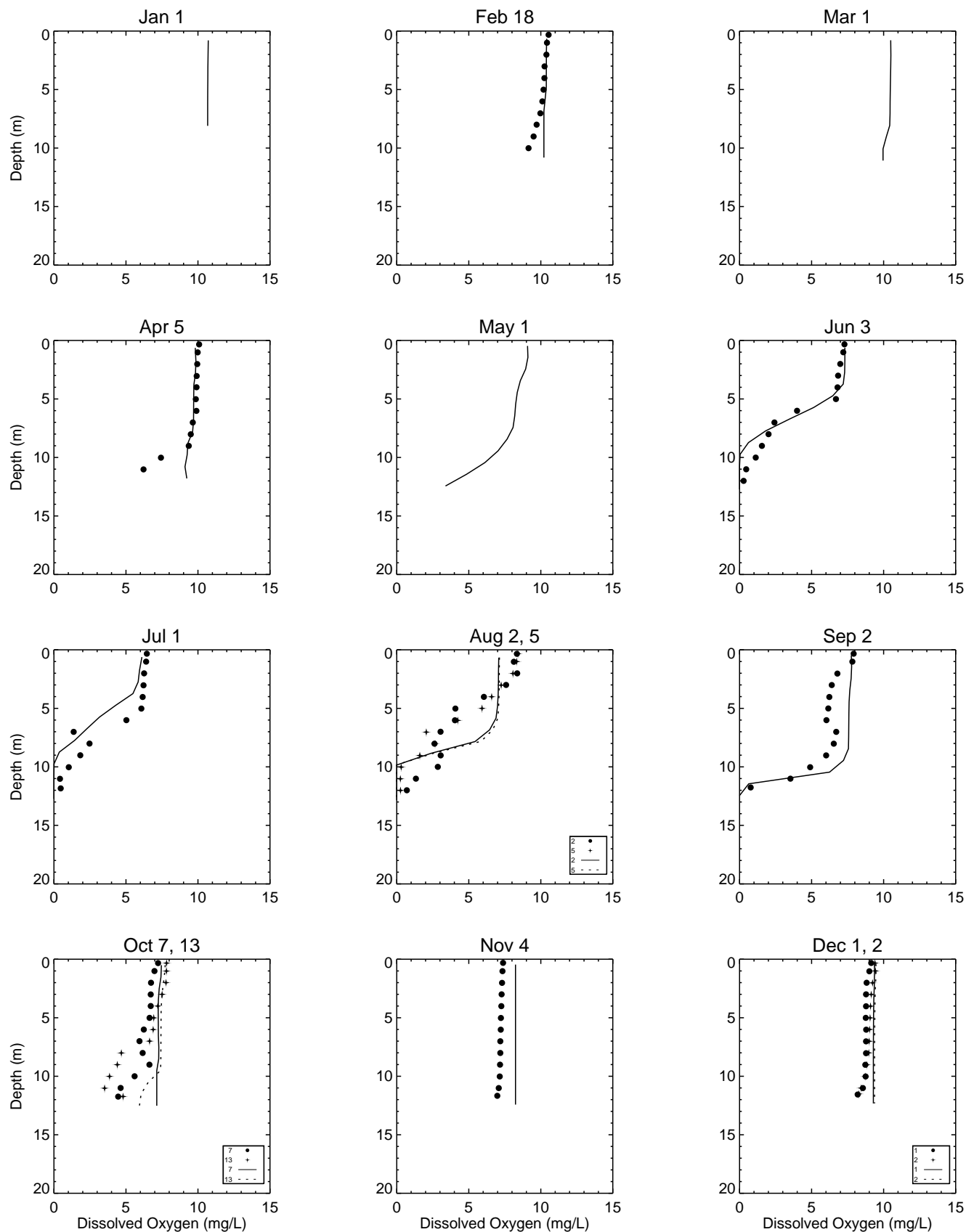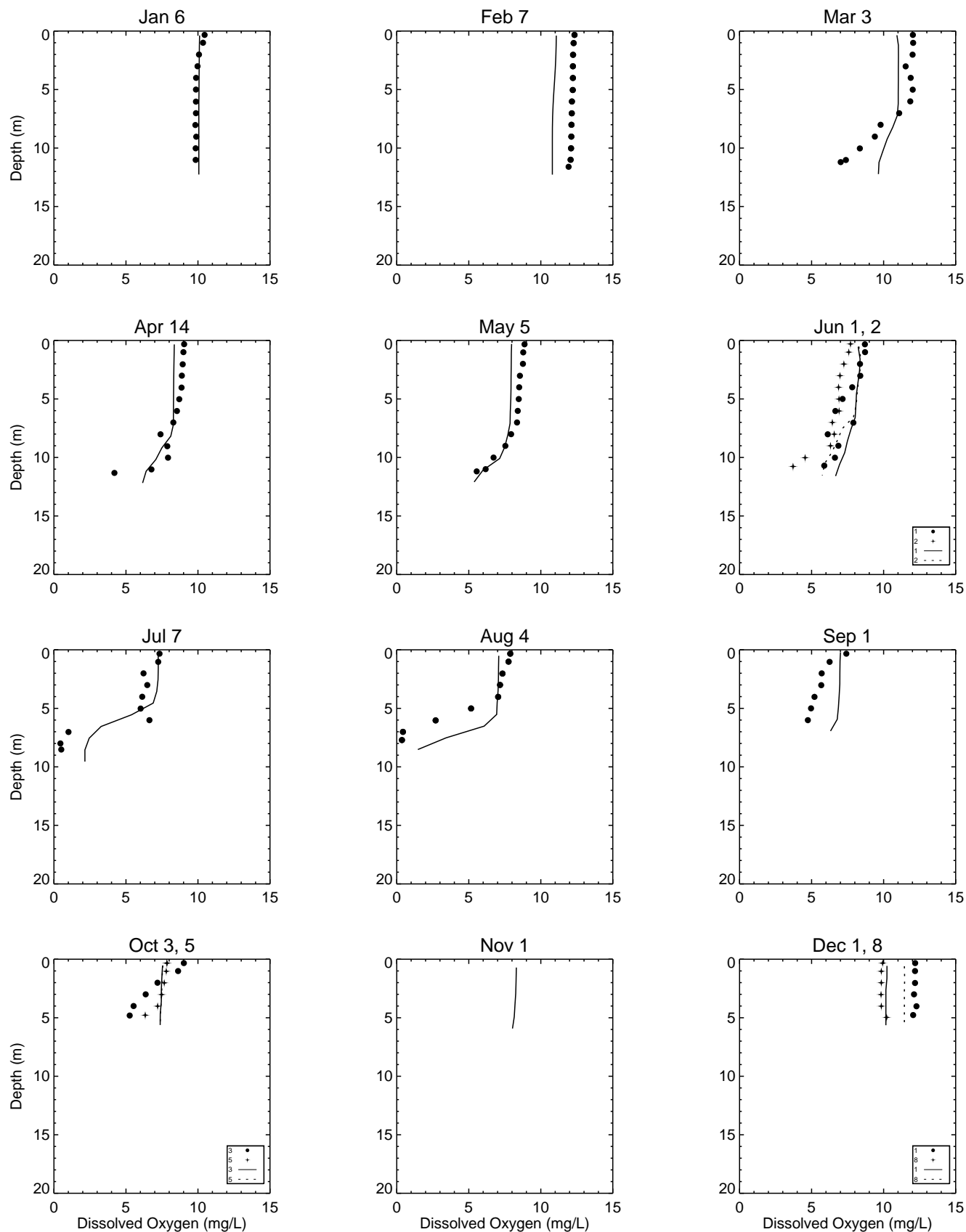CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:44 2013

ANCHOR
QEA
PARSONS

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 1991

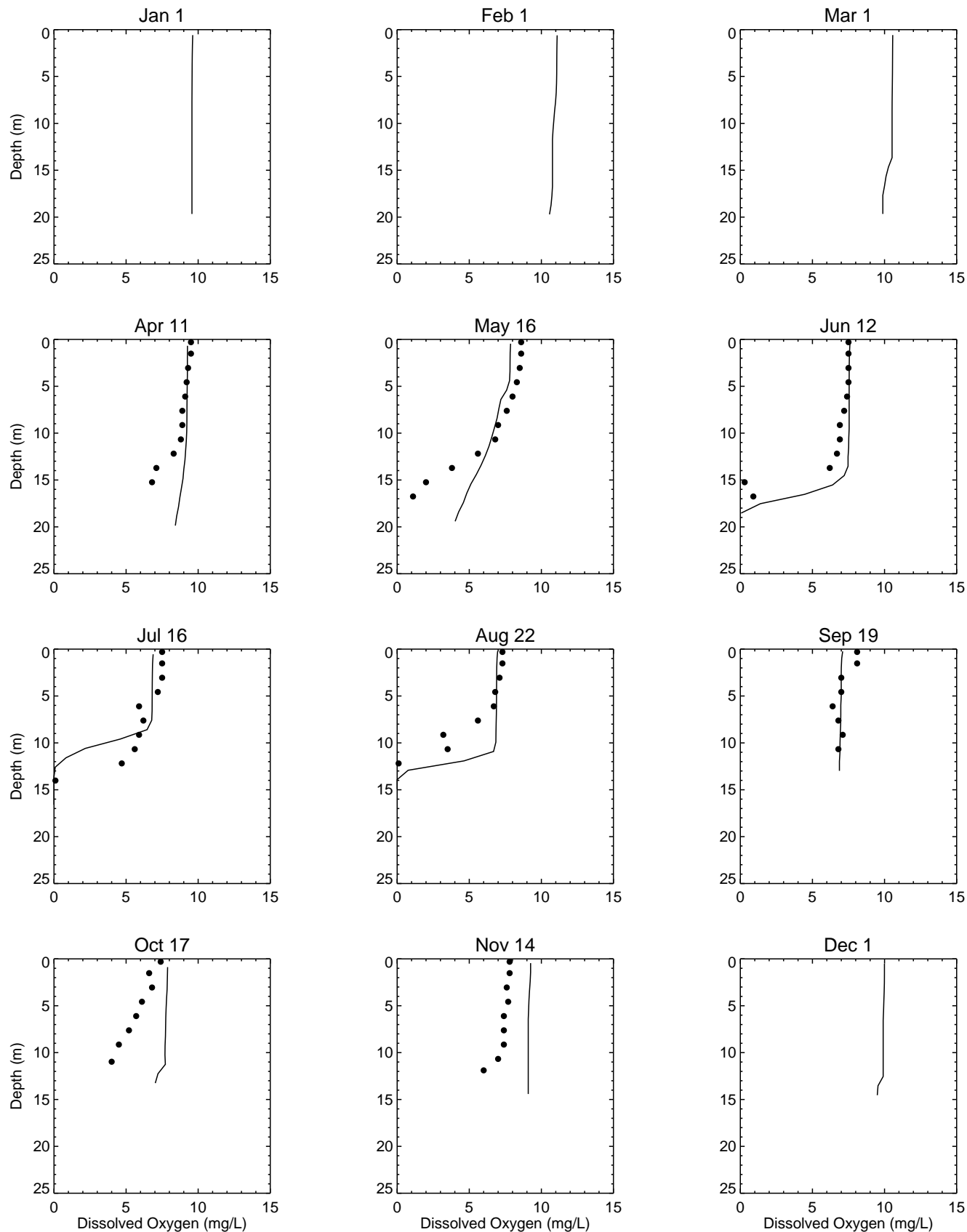*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority
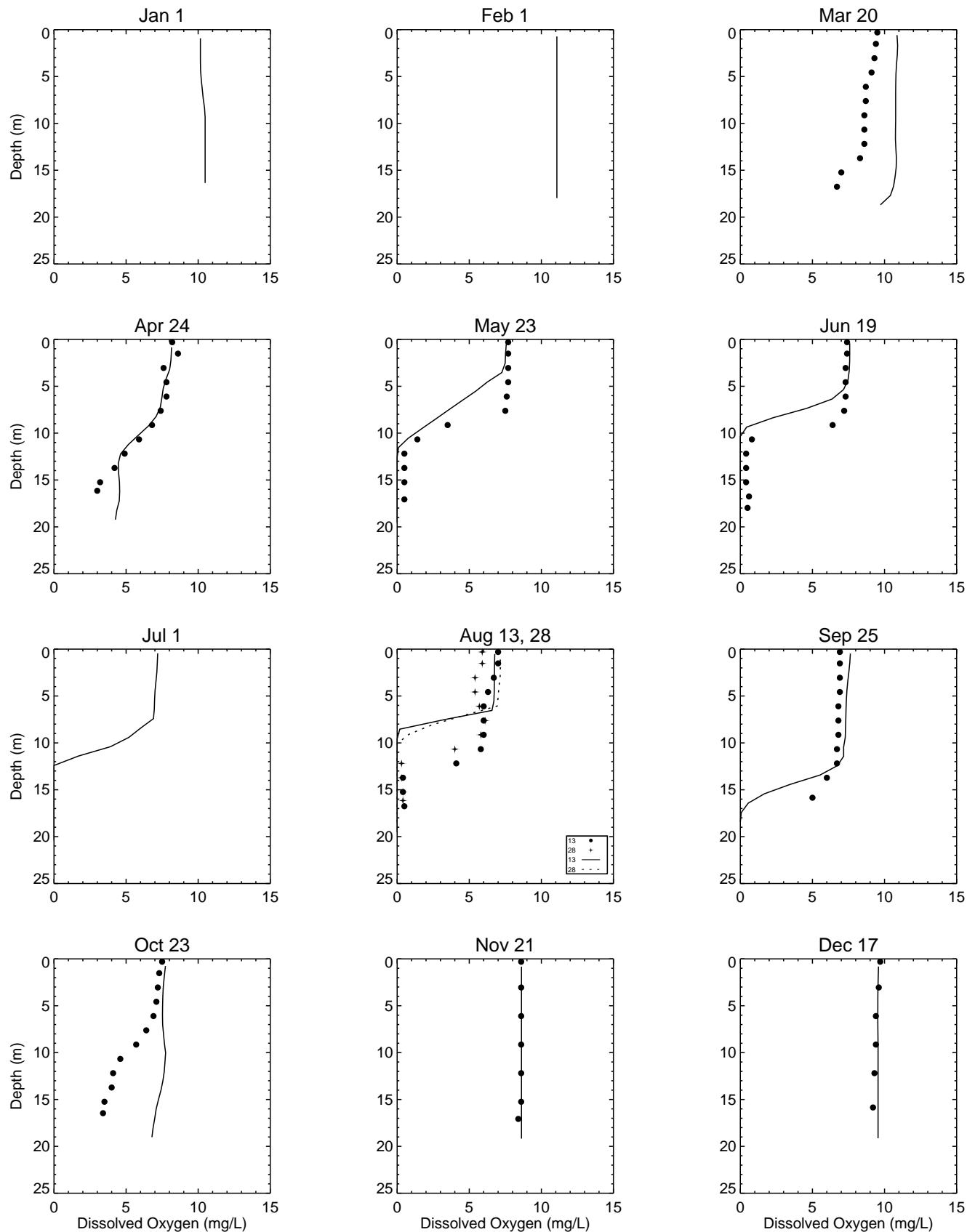
Model (w1210-48)
● Data

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:44 2013

Jan 1 / Feb 16 / Mar 1 / Apr 21 / May 1 / Jun 17 / Jul 1 / Aug 9 / Sep 1 / Oct 12 / Nov 1 / Dec 15

Depth (m)

Dissolved Oxygen (mg/L)

——— Model (w1210-48)
●   Data

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 1993

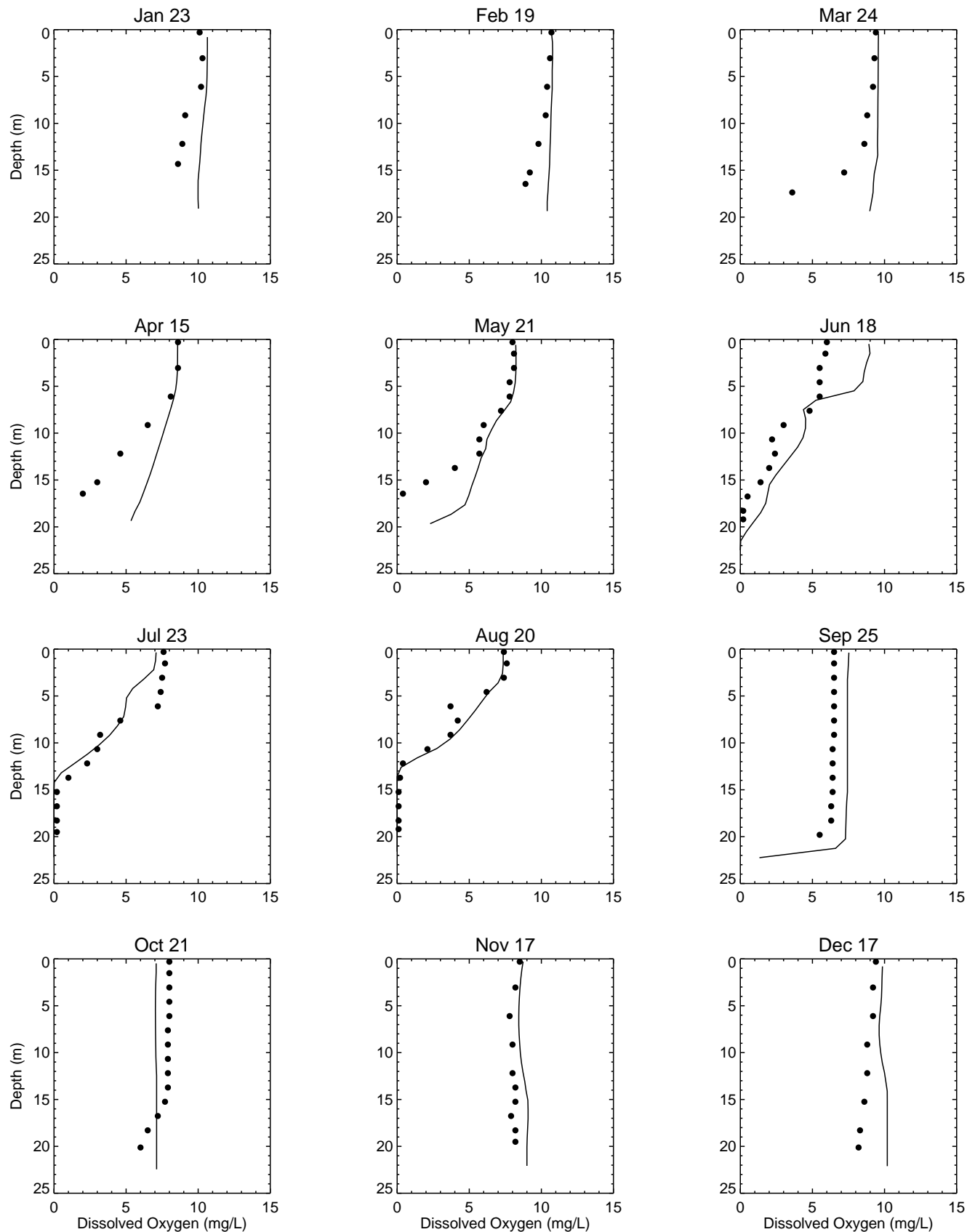*Profiles shown for dates with available data else model results for first day of month shown.*

ANCHOR
QEA
PARSONS

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
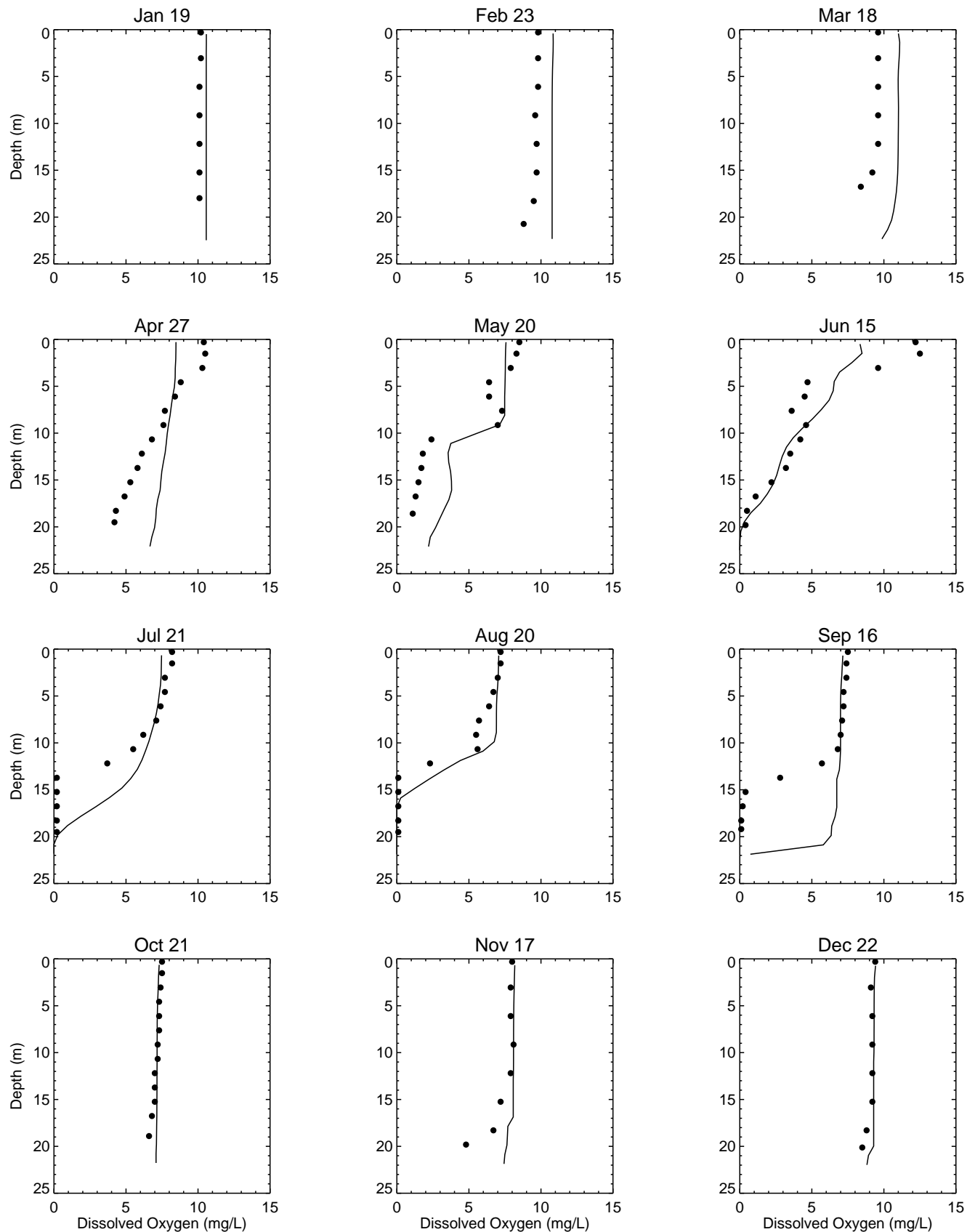Fri Jan 25 18:12:44 2013

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 1994

Profiles shown for dates with available data else model results for first day of month shown.
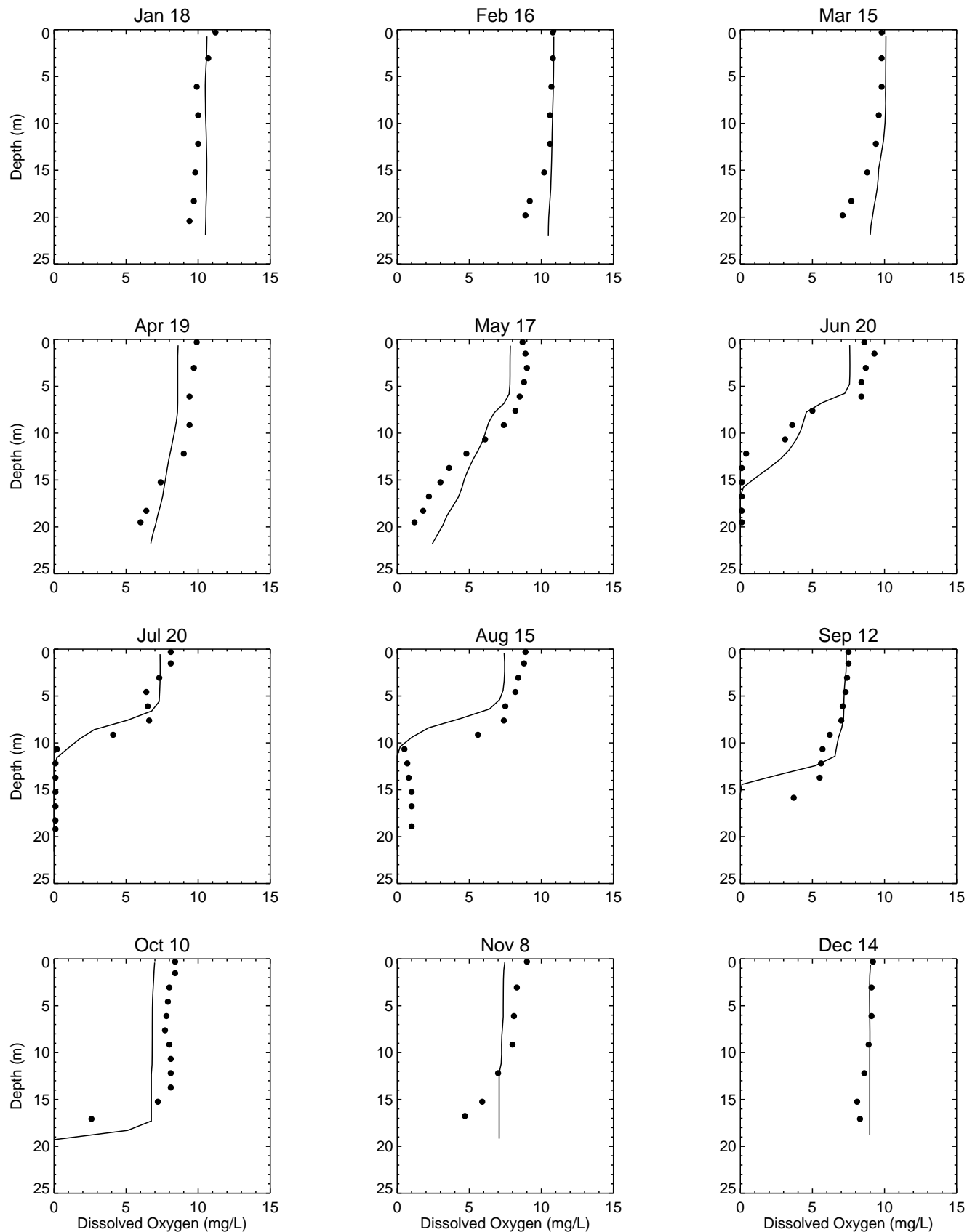
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

— Model (w1210-48)
● Data

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:44 2013

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 1995

Profiles shown for dates with available data else model results for first day of month shown.
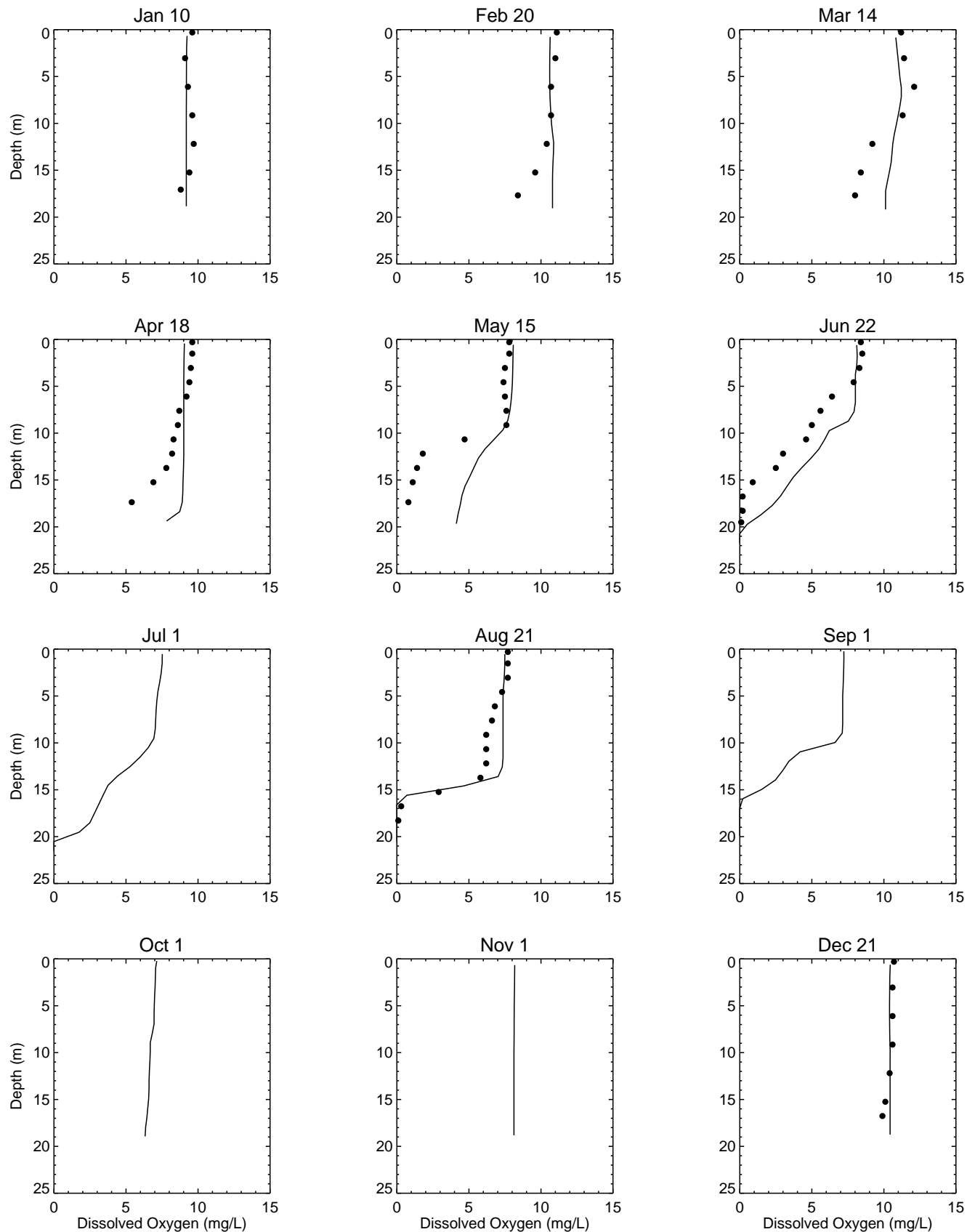
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:44 2013

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 1997

Profiles shown for dates with available data else model results for first day of month shown.
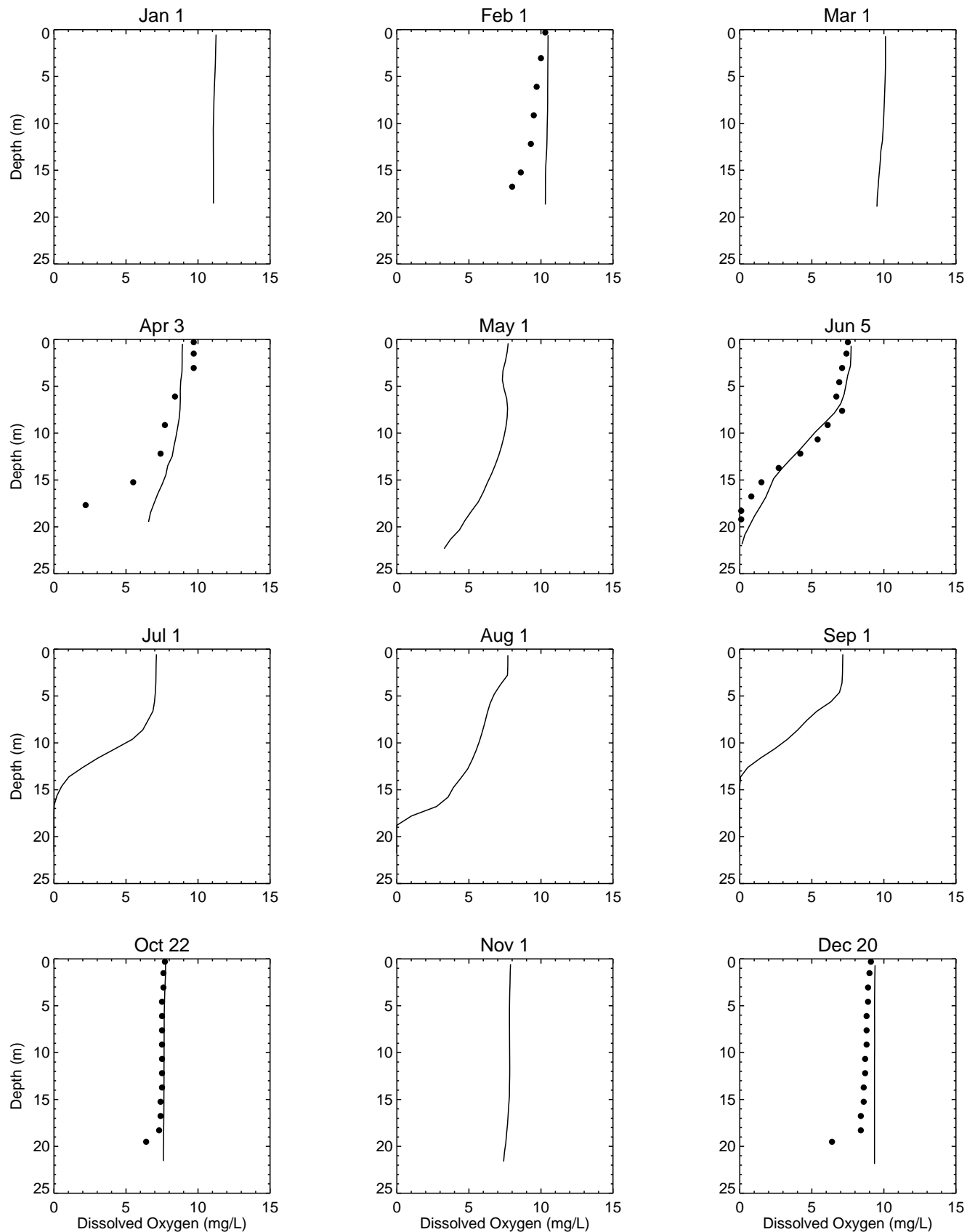
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:44 2013

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 1998

Profiles shown for dates with available data else model results for first day of month shown.
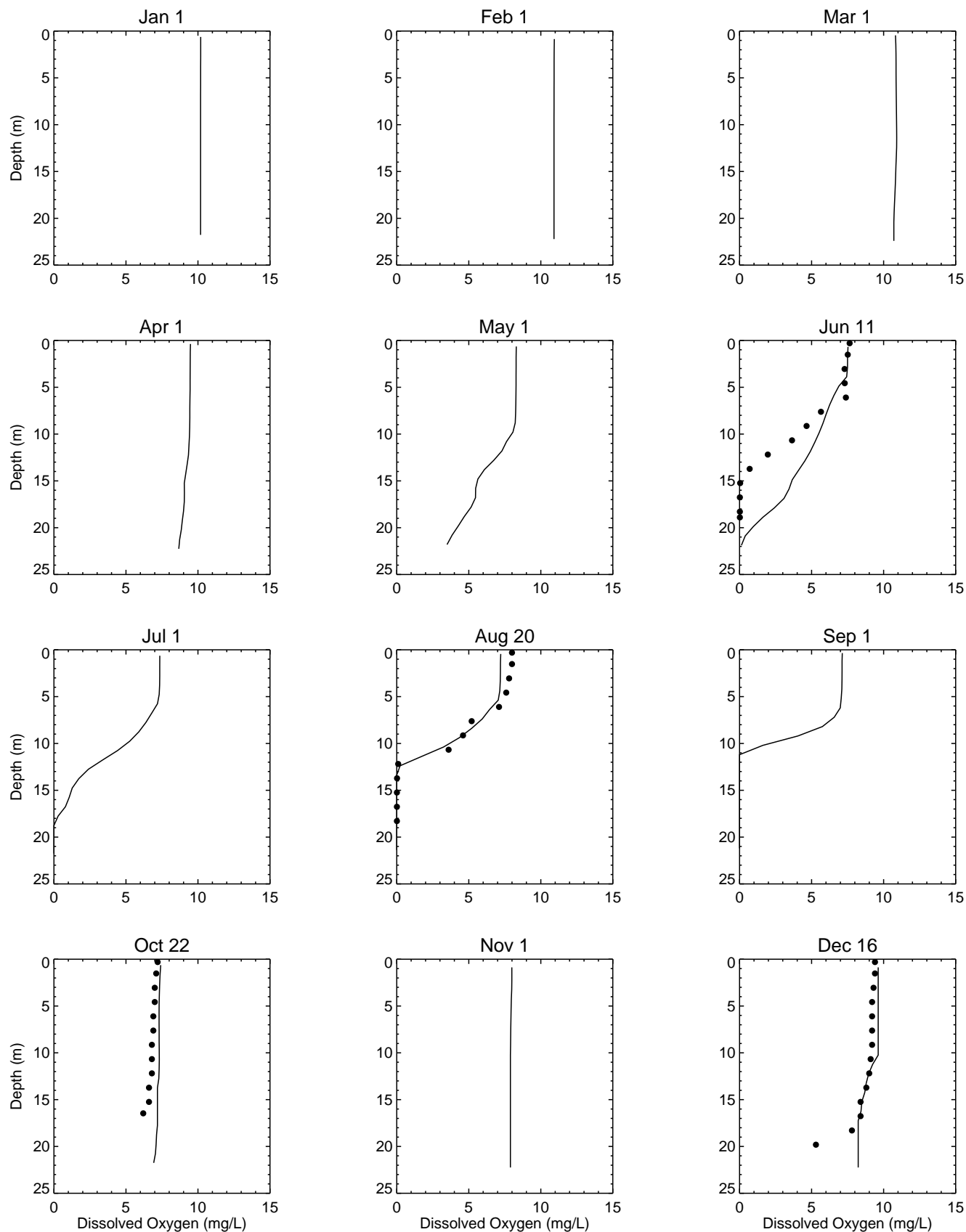
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
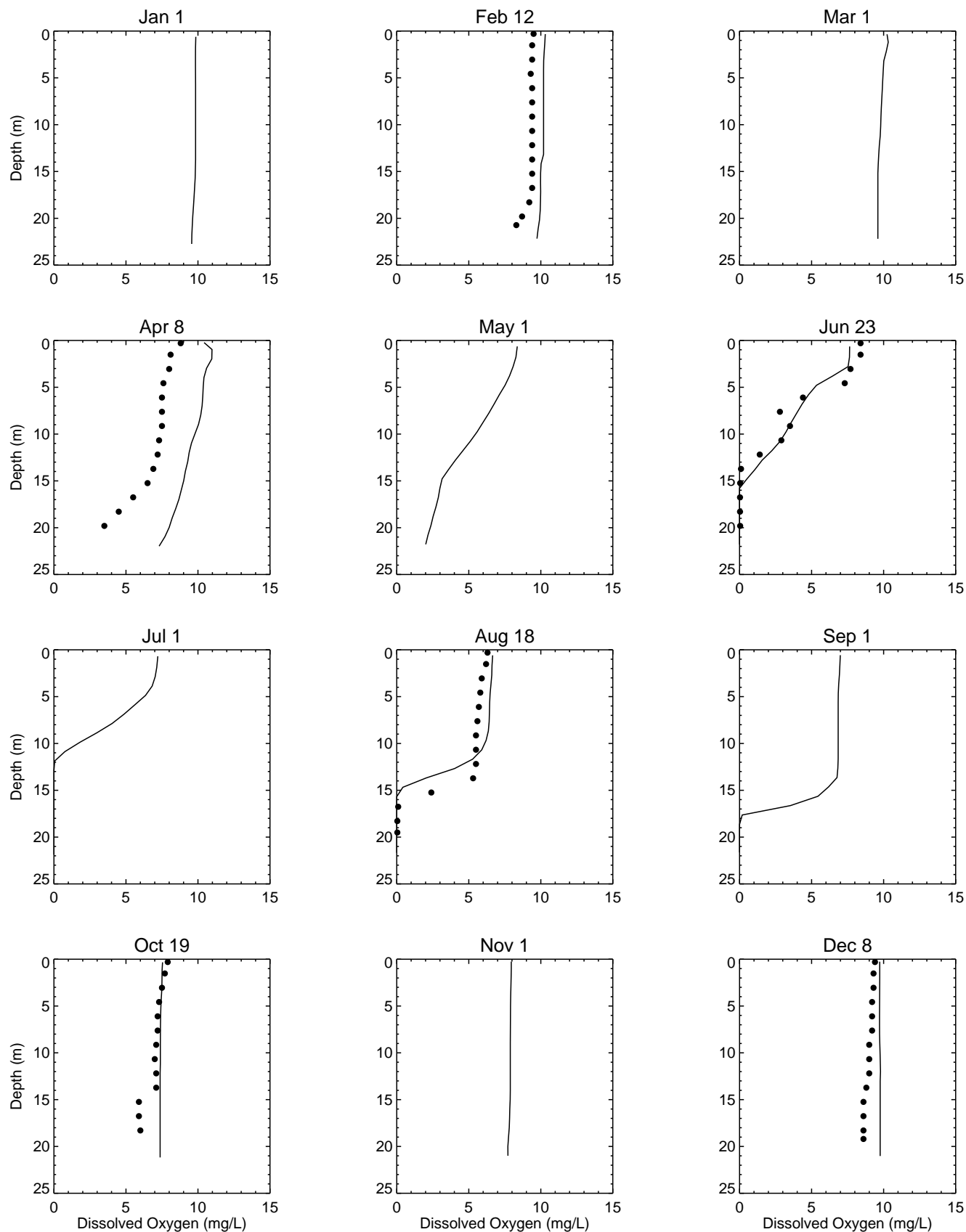Fri Jan 25 18:12:44 2013

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 1999

Profiles shown for dates with available data else model results for first day of month shown.

Legend:
— Model (w1210-48)
● Data

ANCHOR QEA PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:44 2013

Jan 1 | Feb 1 | Mar 1
Apr 13 | May 1 | Jun 5
Jul 1 | Aug 7 | Sep 1
Oct 9 | Nov 1 | Dec 6

Dissolved Oxygen (mg/L)

——— Model (w1210-48)
● Data

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 2000
Profiles shown for dates with available data else model results for first day of month shown.

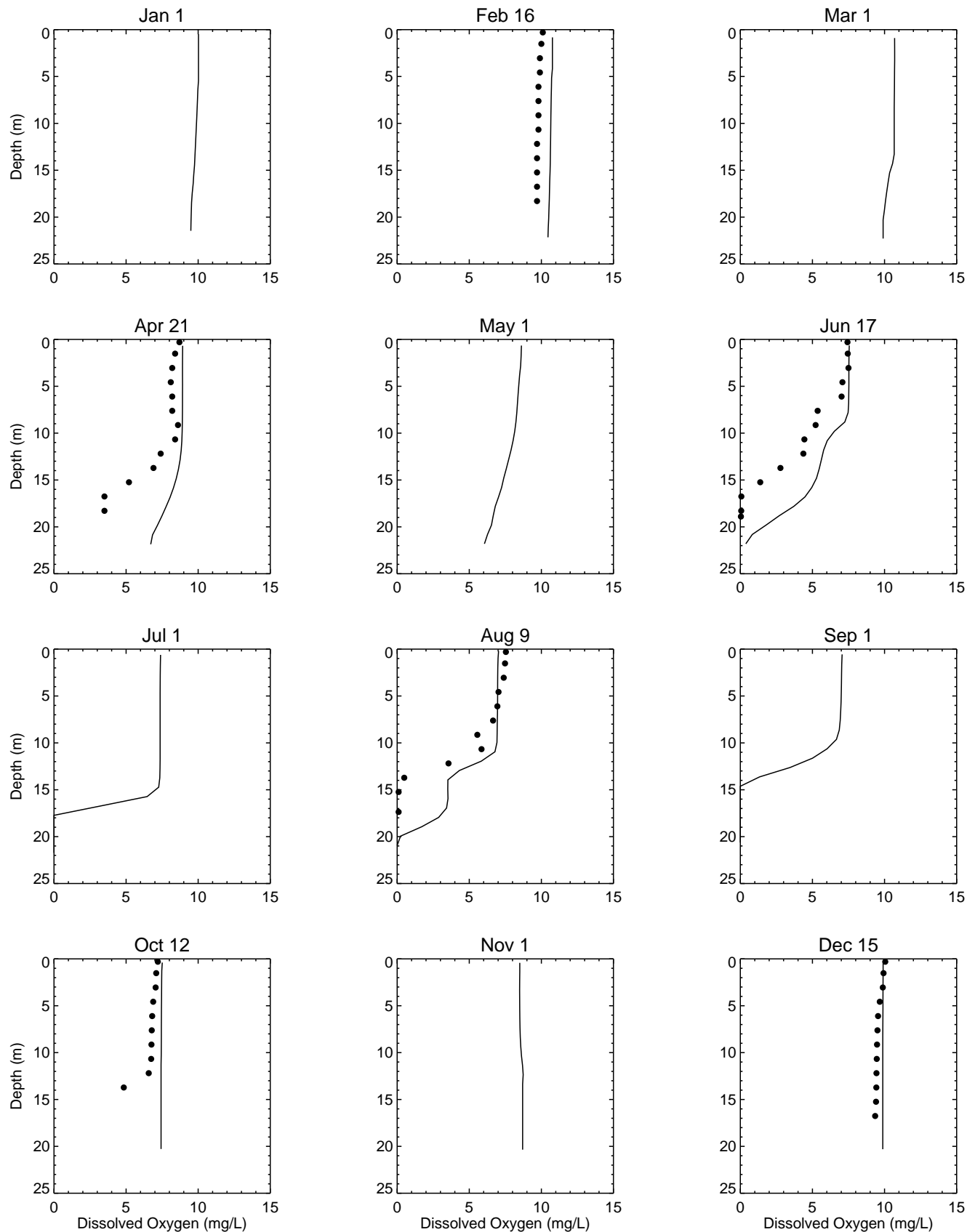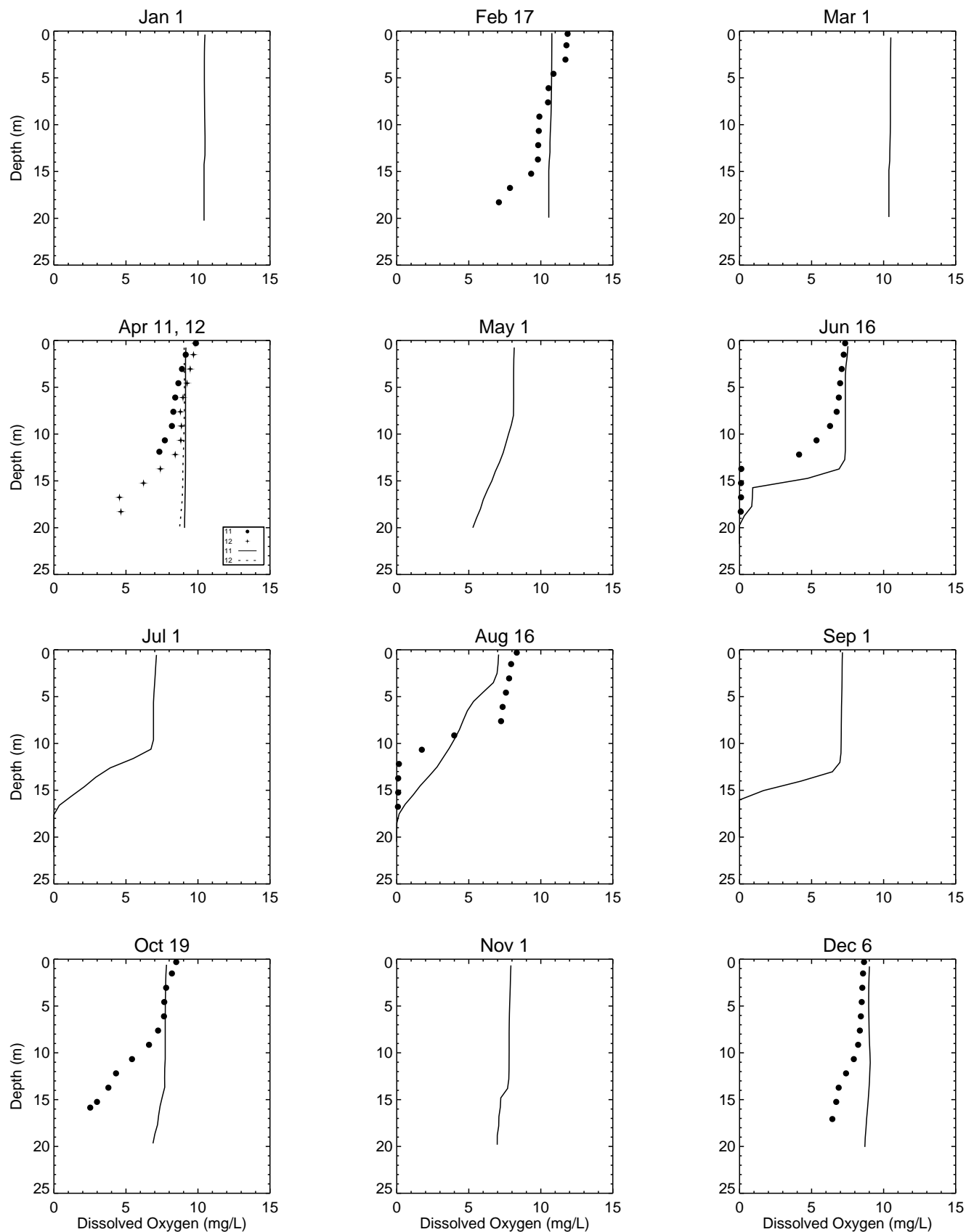CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:44 2013

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 2002

Profiles shown for dates with available data else model results for first day of month shown.
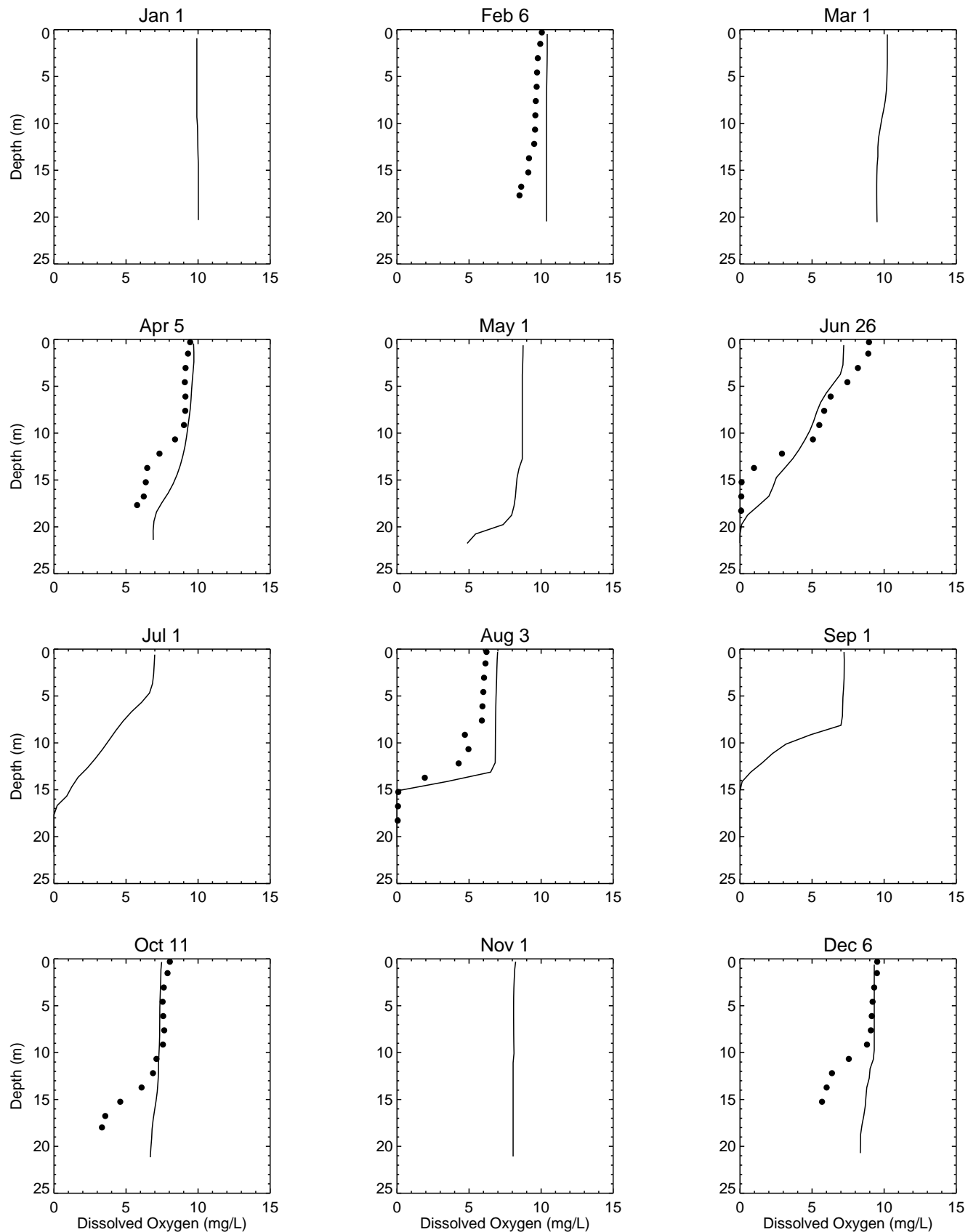
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 — Feb 5 — Mar 1 — Apr 3 — May 1 — Jun 9 — Jul 1 — Aug 11 — Sep 1 — Oct 6 — Nov 1 — Dec 3

Depth (m)

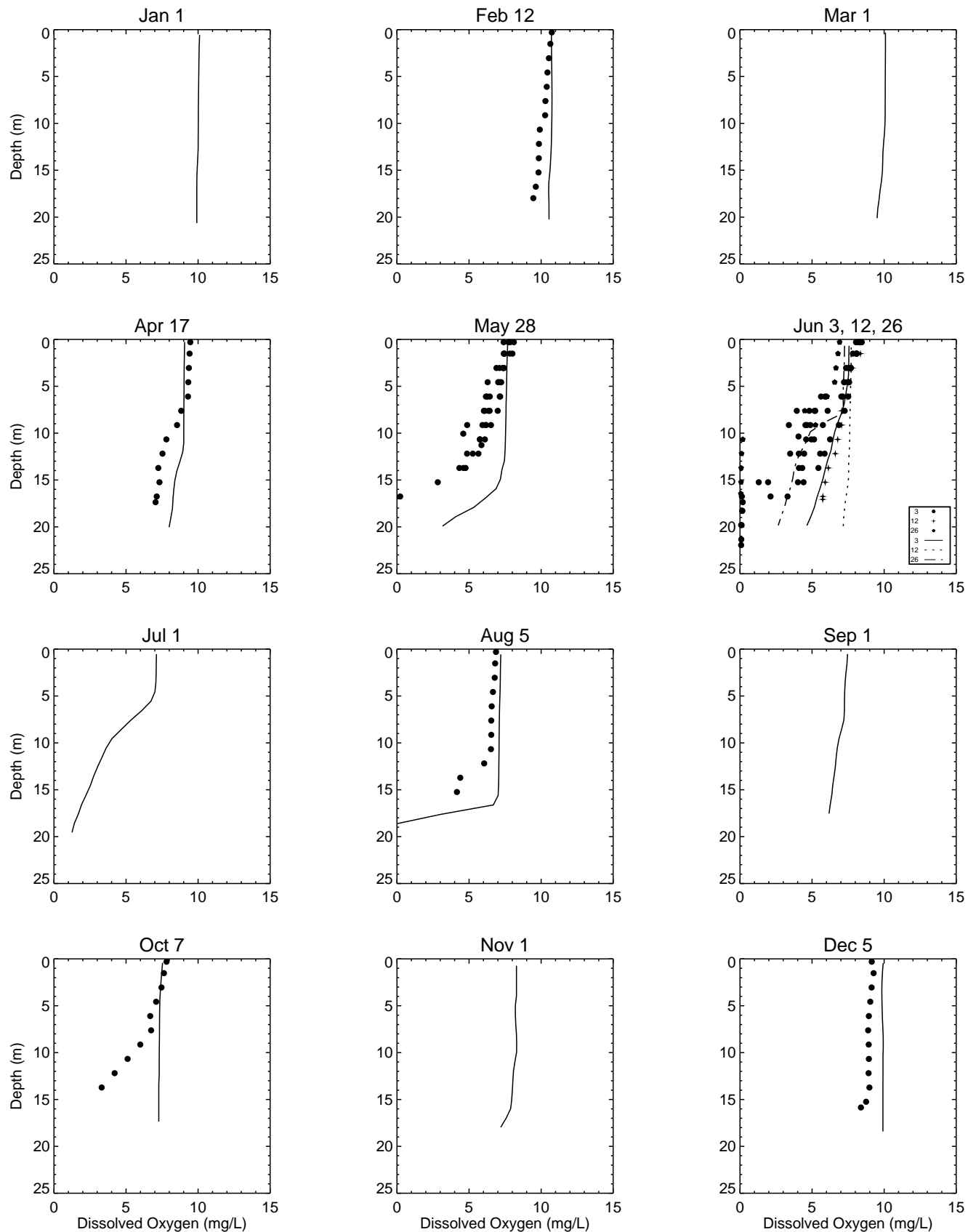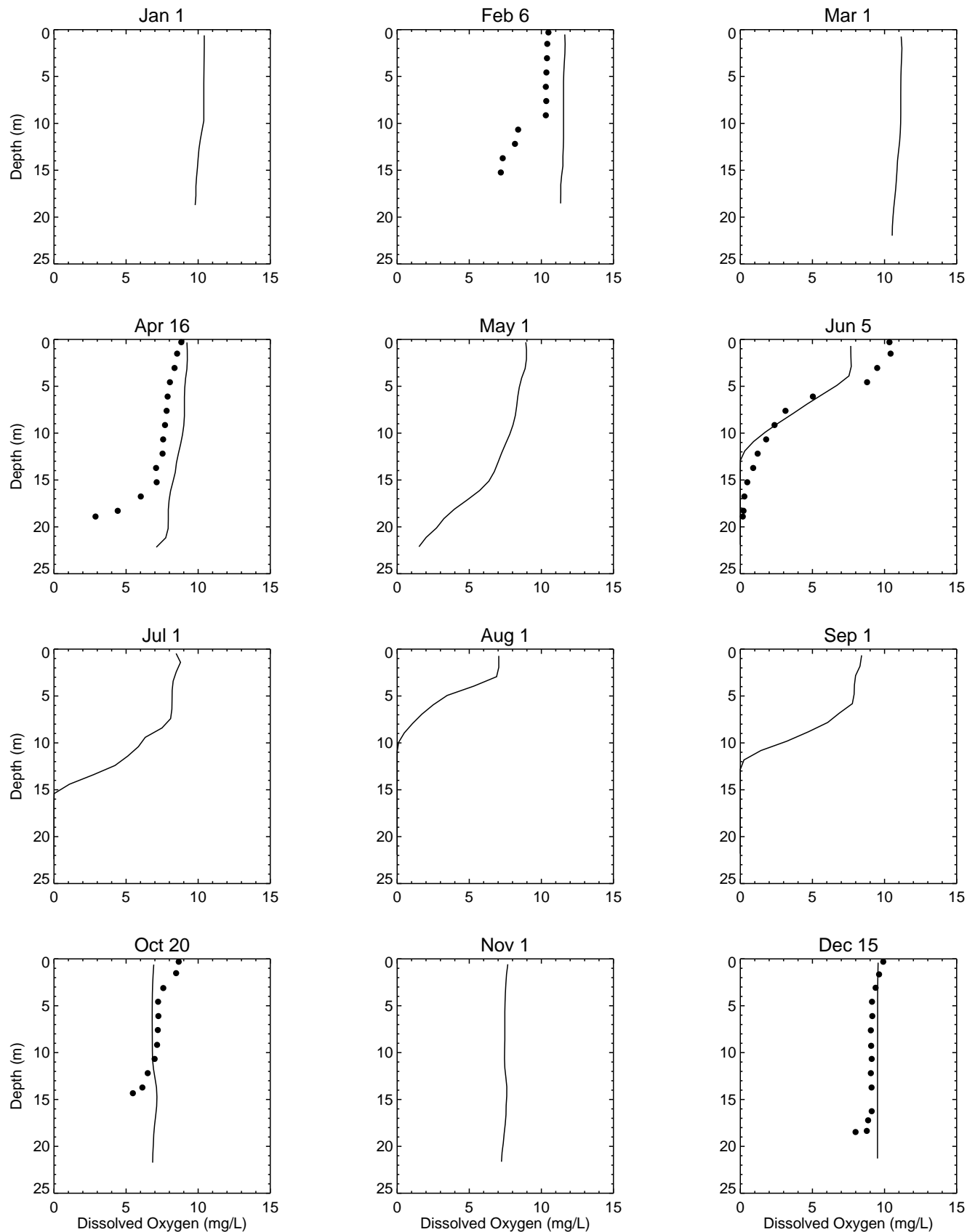Dissolved Oxygen (mg/L)

——— Model (w1210-48)
● Data

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 2003
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:44 2013

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 2004
Profiles shown for dates with available data else model results for first day of month shown.
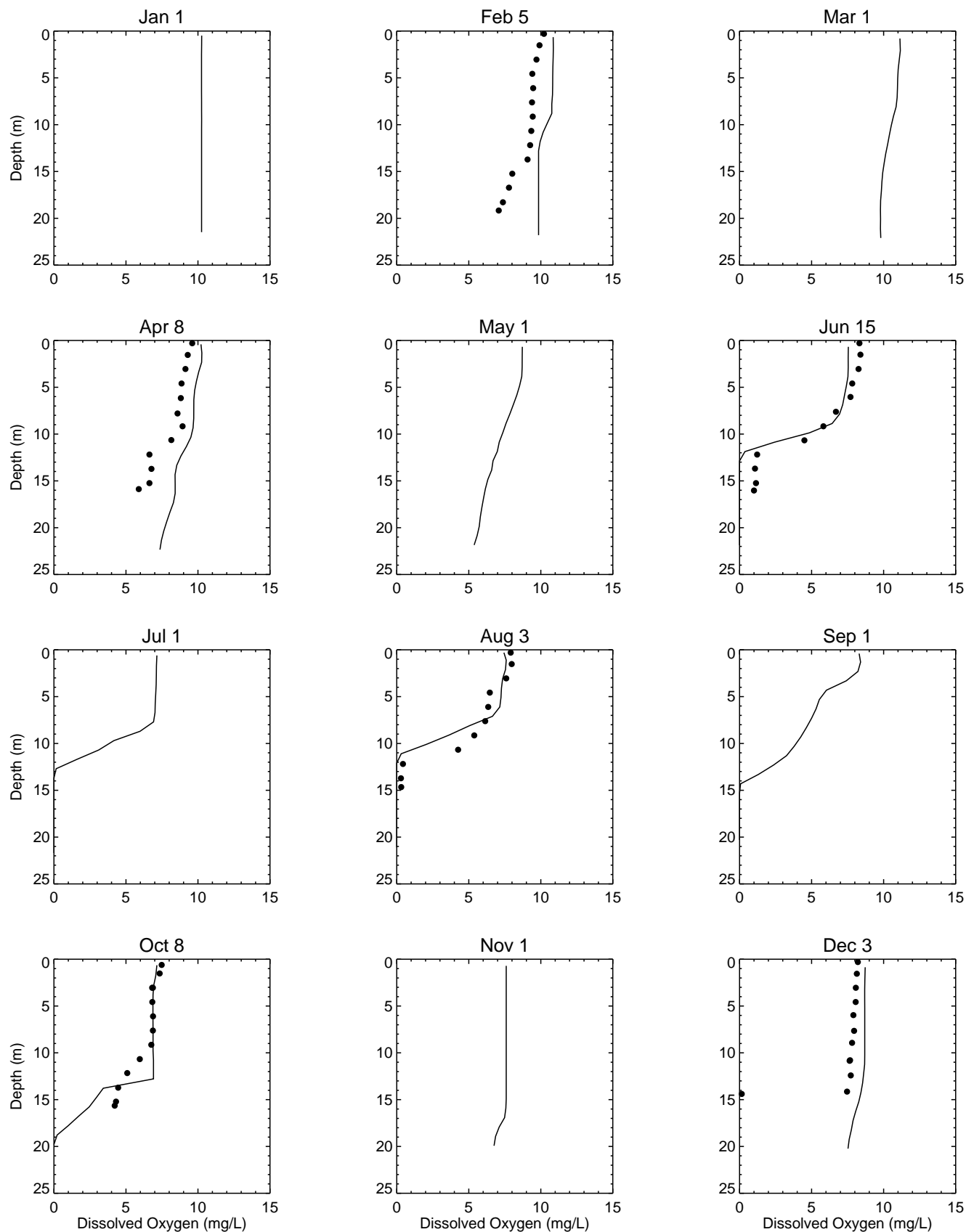
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Jan 1 Feb 8 Mar 1 Apr 12 May 1 Jun 6 Jul 1 Aug 1 Sep 1 Oct 11 Nov 1 Dec 1

Depth (m)

Dissolved Oxygen (mg/L)
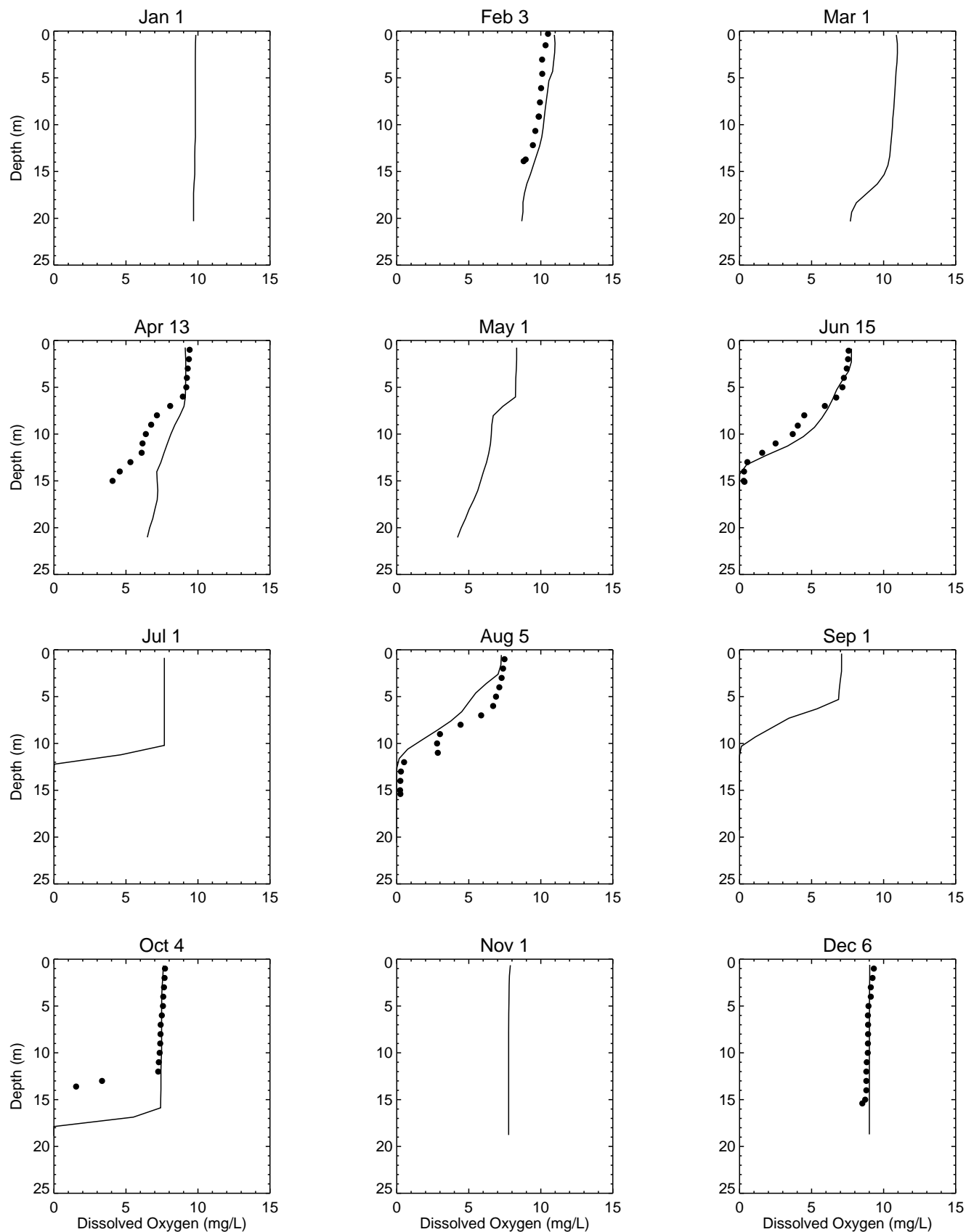
—— Model (w1210-48)
● Data

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 2005
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:44 2013

Jan 1 · Feb 7 · Mar 1 · Apr 11 · May 1 · Jun 1 · Jul 1 · Aug 8 · Sep 1 · Oct 11 · Nov 1 · Dec 13
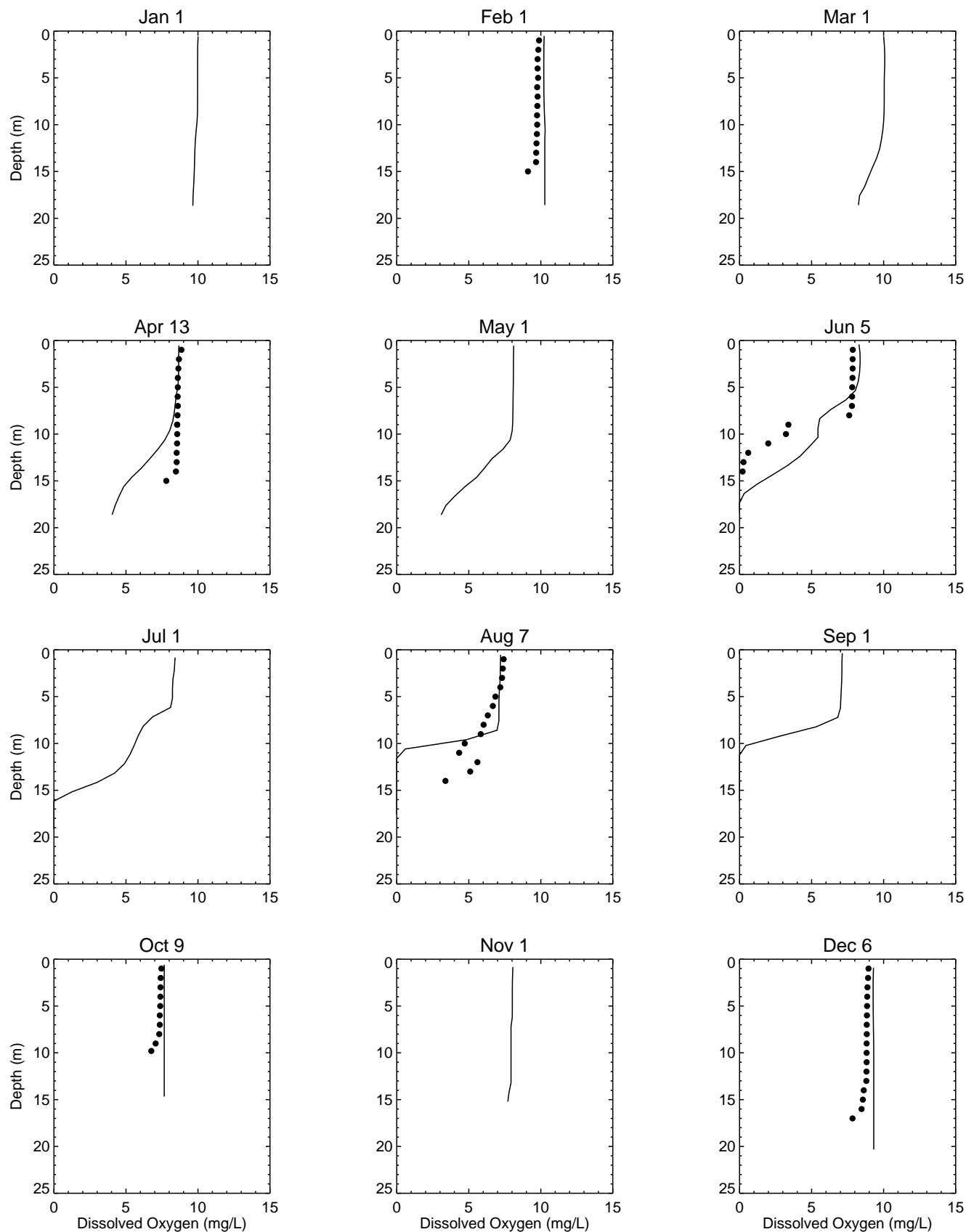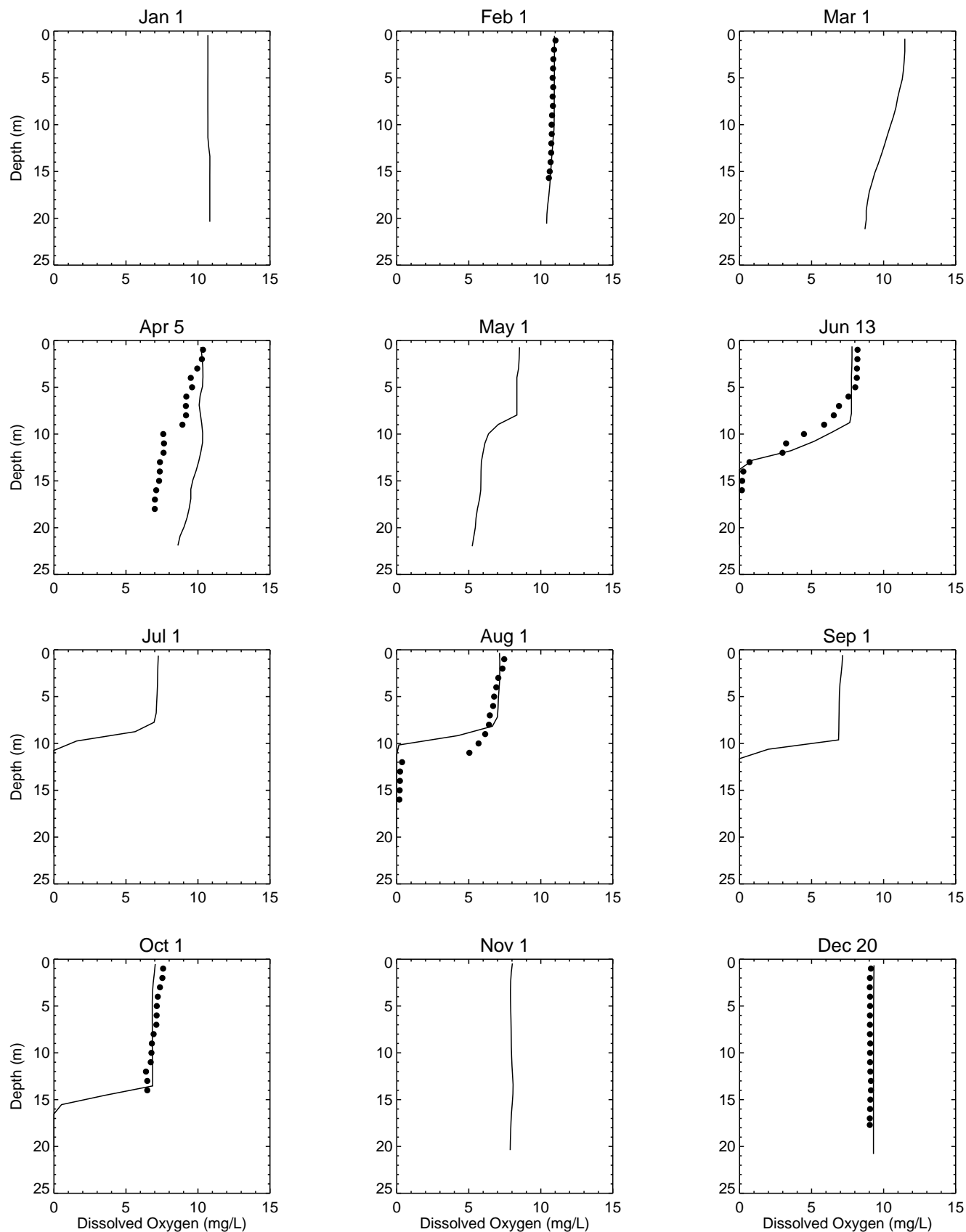
Model (w1210-48)
Data

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 2006

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:44 2013

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 2007
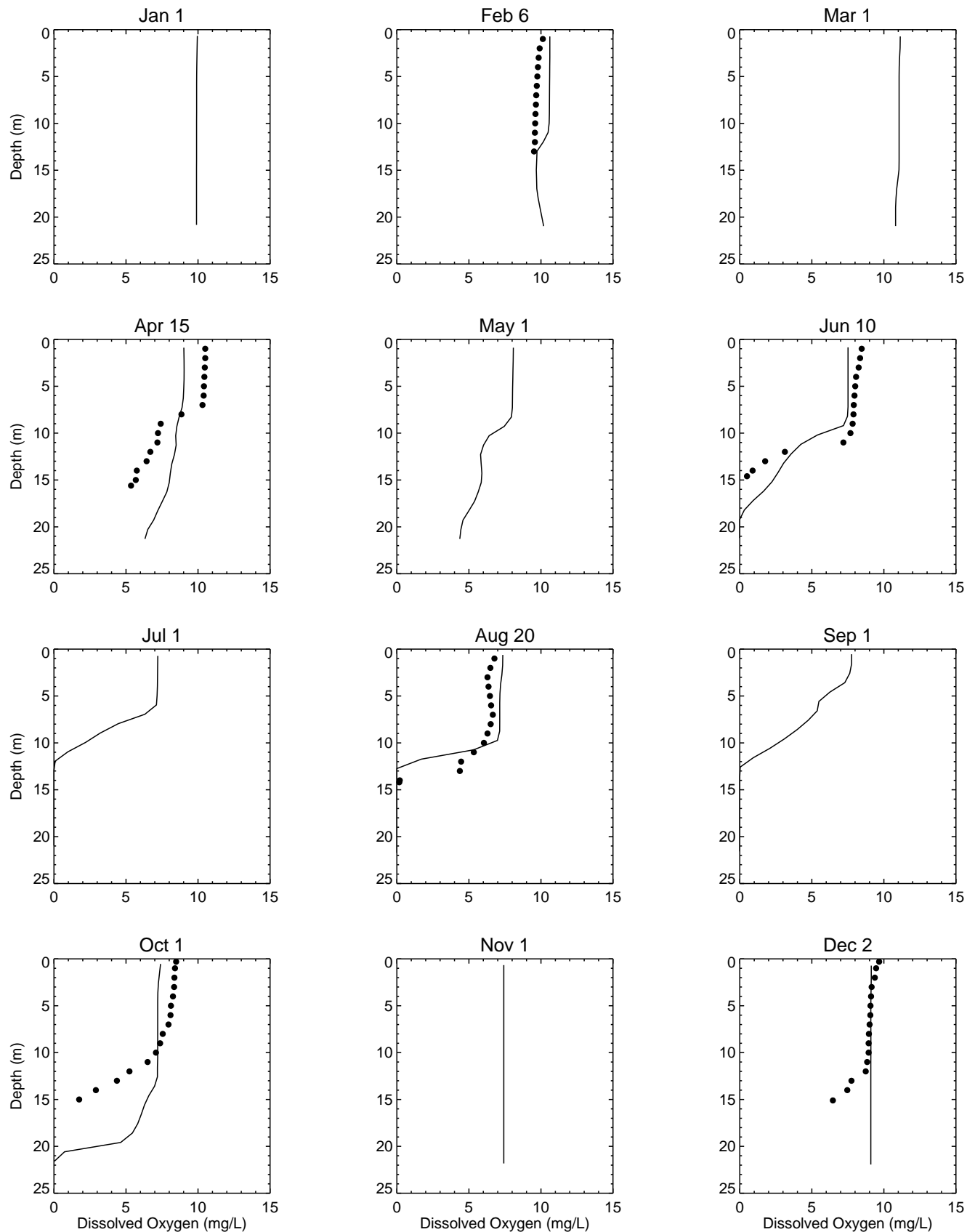
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:44 2013

Jan 1   Feb 4   Mar 1

Apr 3   May 1   Jun 12

Jul 1   Aug 7   Sep 1

Oct 9   Nov 1   Dec 4

Dissolved Oxygen (mg/L)

—— Model (w1210-48)
● Data

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 2008
Profiles shown for dates with available data else model results for first day of month shown.

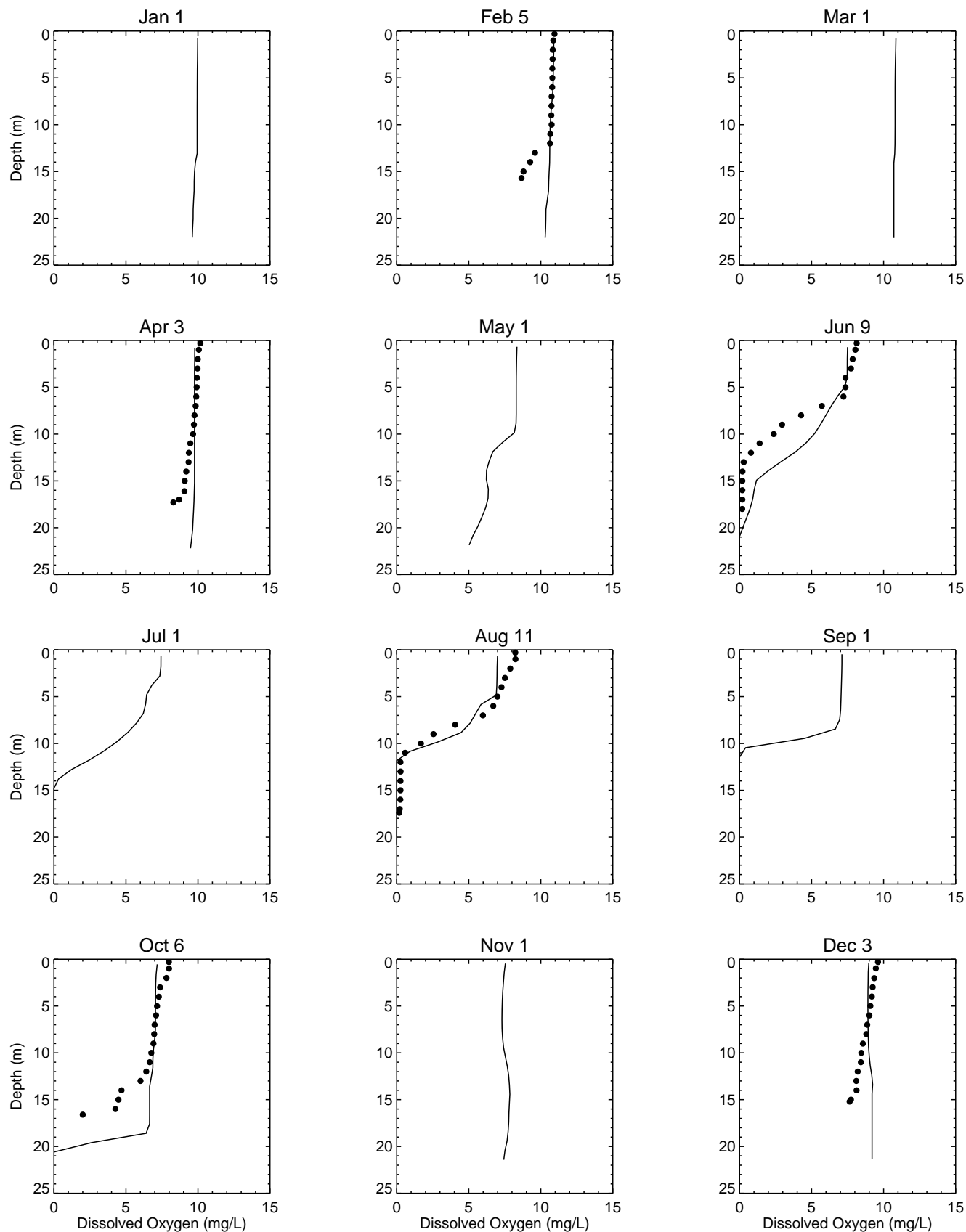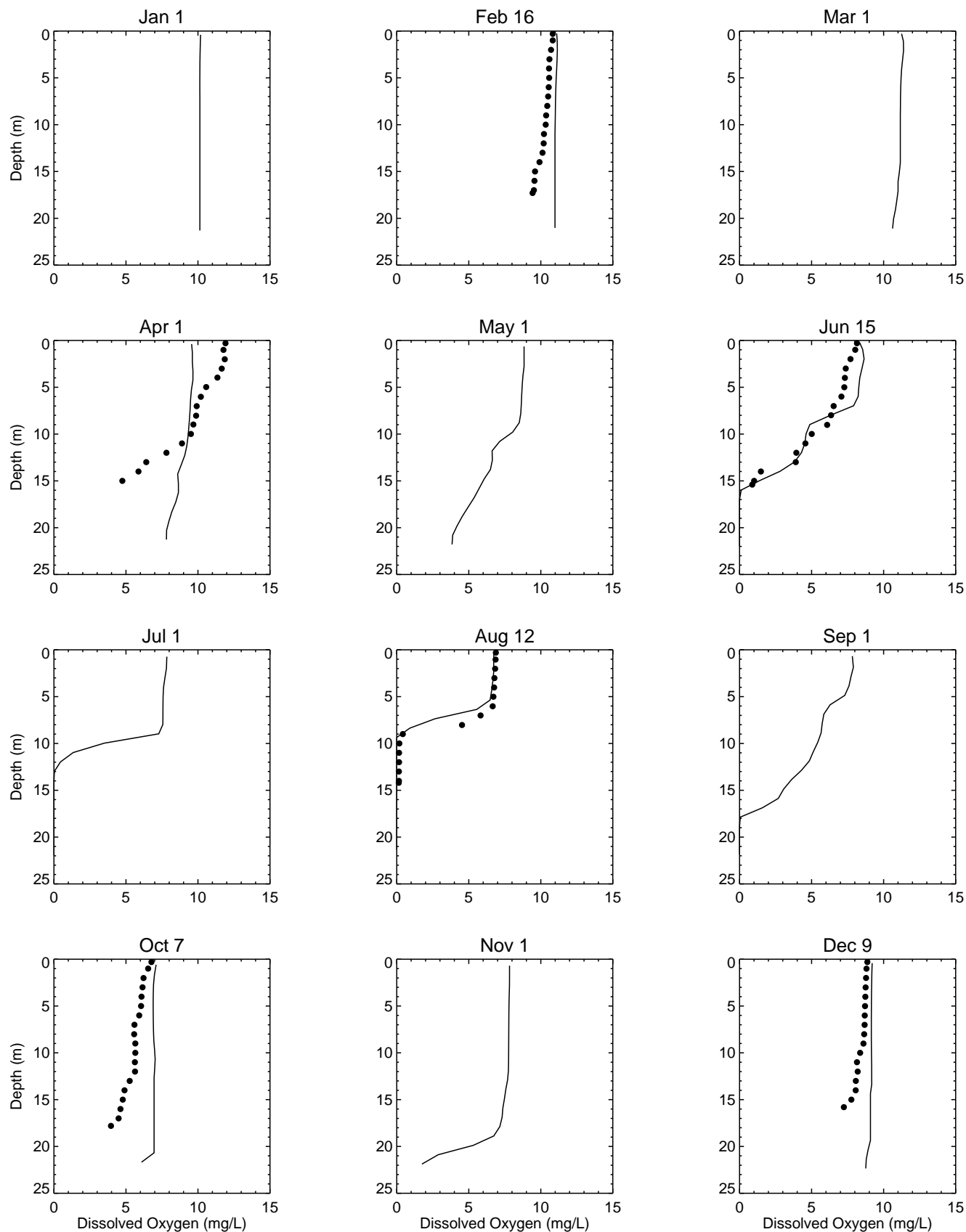CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:44 2013

Jan 1 · Feb 5 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 6 · Sep 1 · Oct 1 · Nov 1 · Dec 8

Dissolved Oxygen (mg/L)
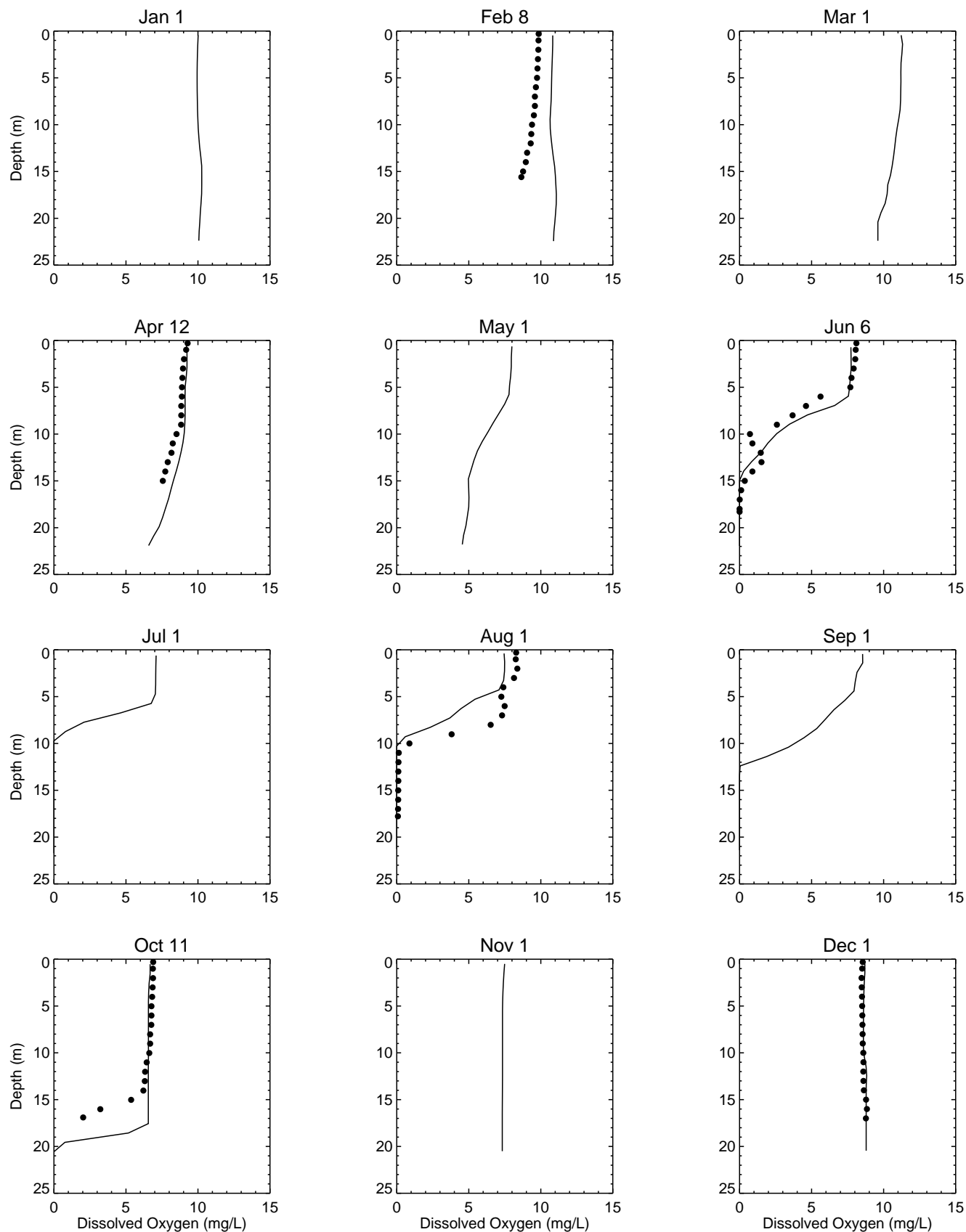
Depth (m)

—— Model (w1210-48)
● Data

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 2009
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:44 2013

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 2010
Profiles shown for dates with available data else model results for first day of month shown.
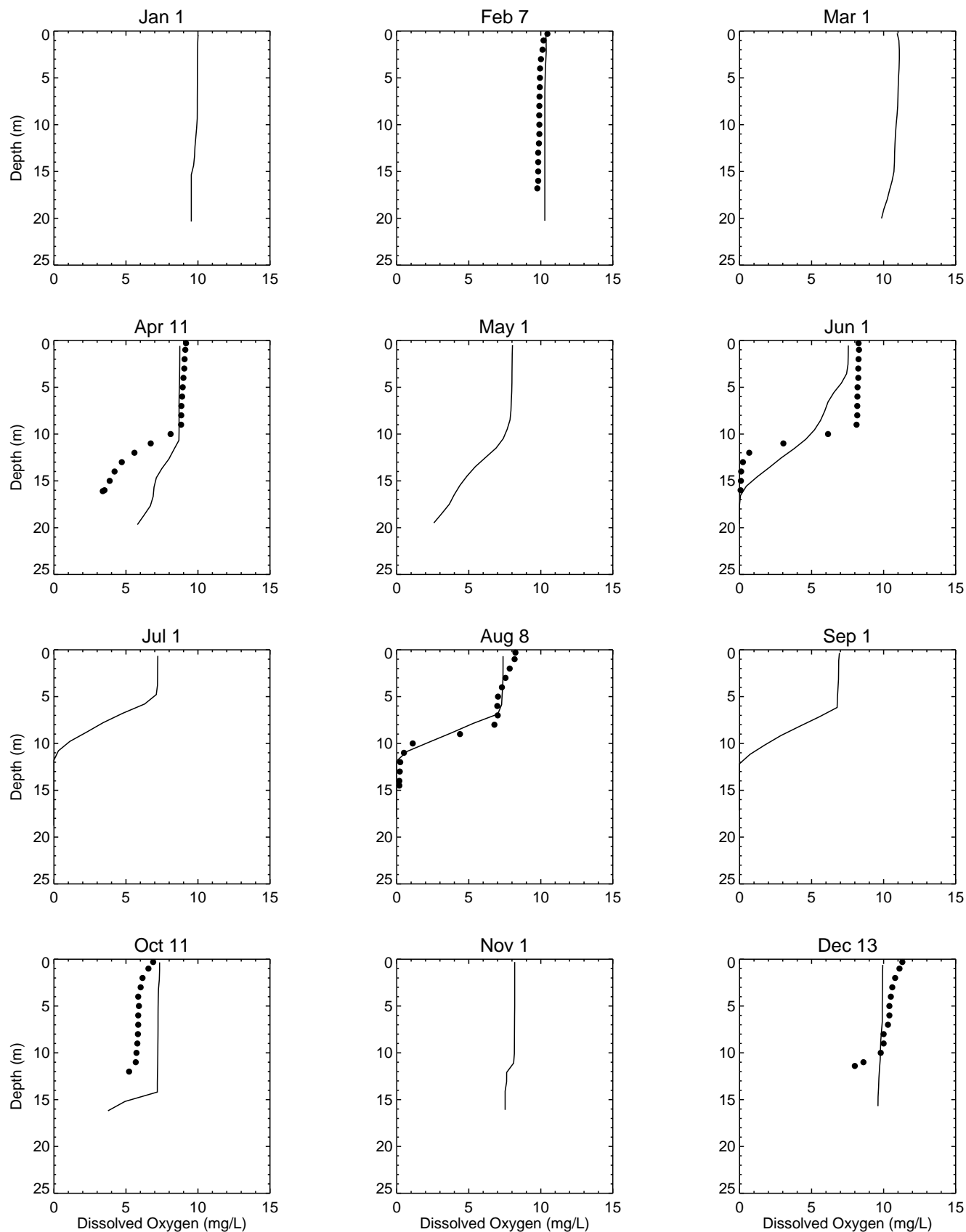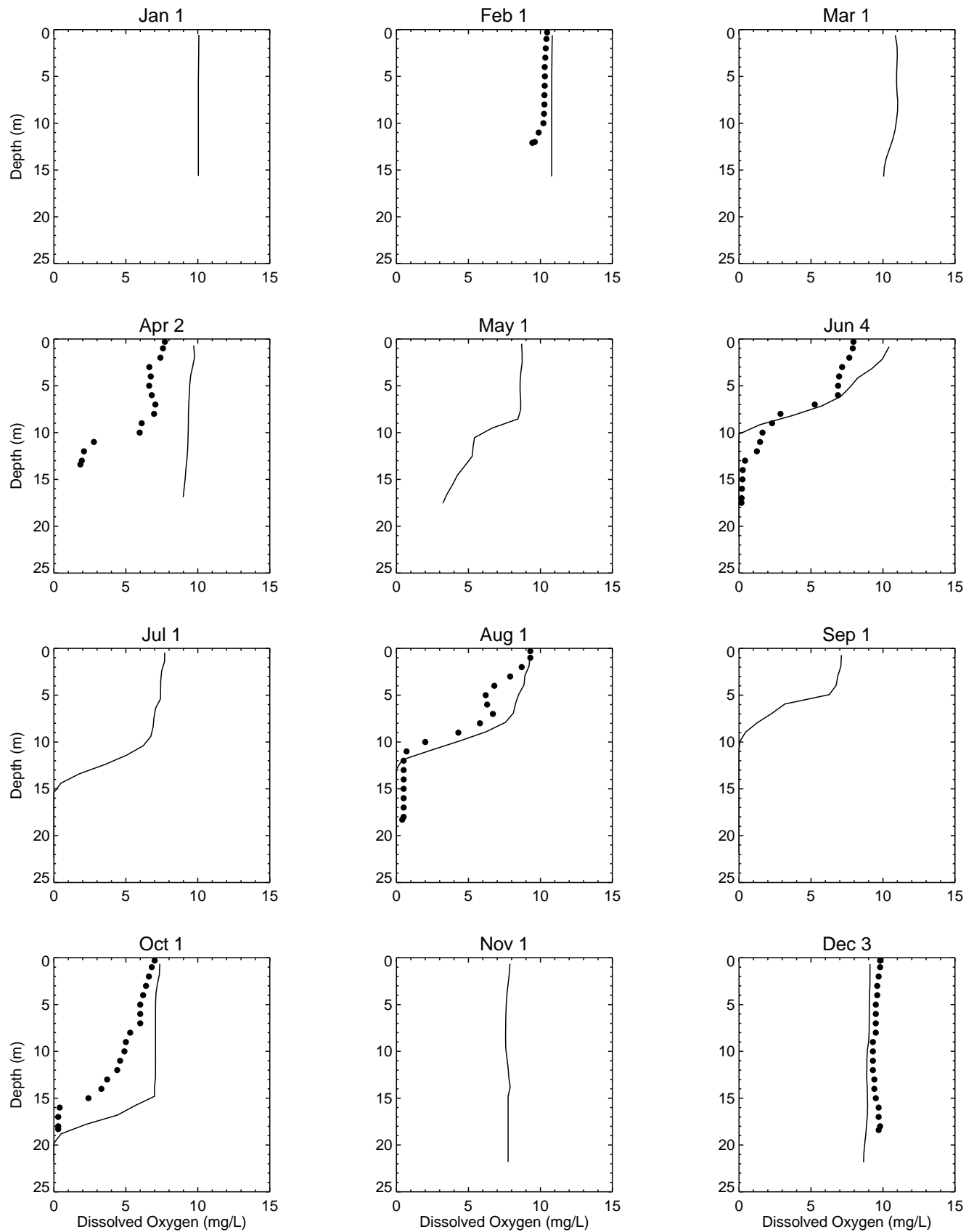
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:44 2013

Jan 6 | Feb 7 | Mar 3

Apr 14 | May 5 | Jun 1, 2

Jul 7 | Aug 4 | Sep 1

Oct 3, 5 | Nov 1 | Dec 1, 8

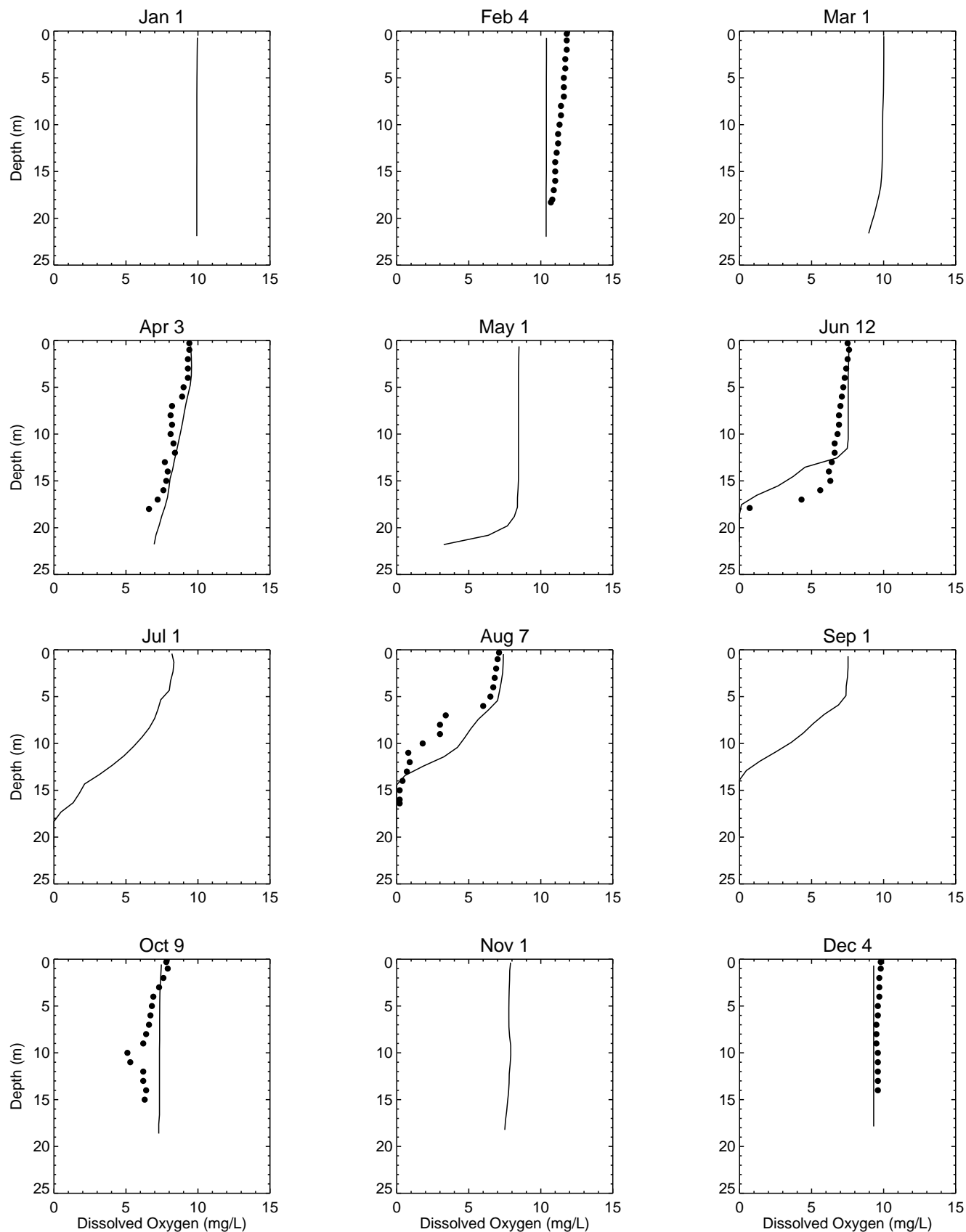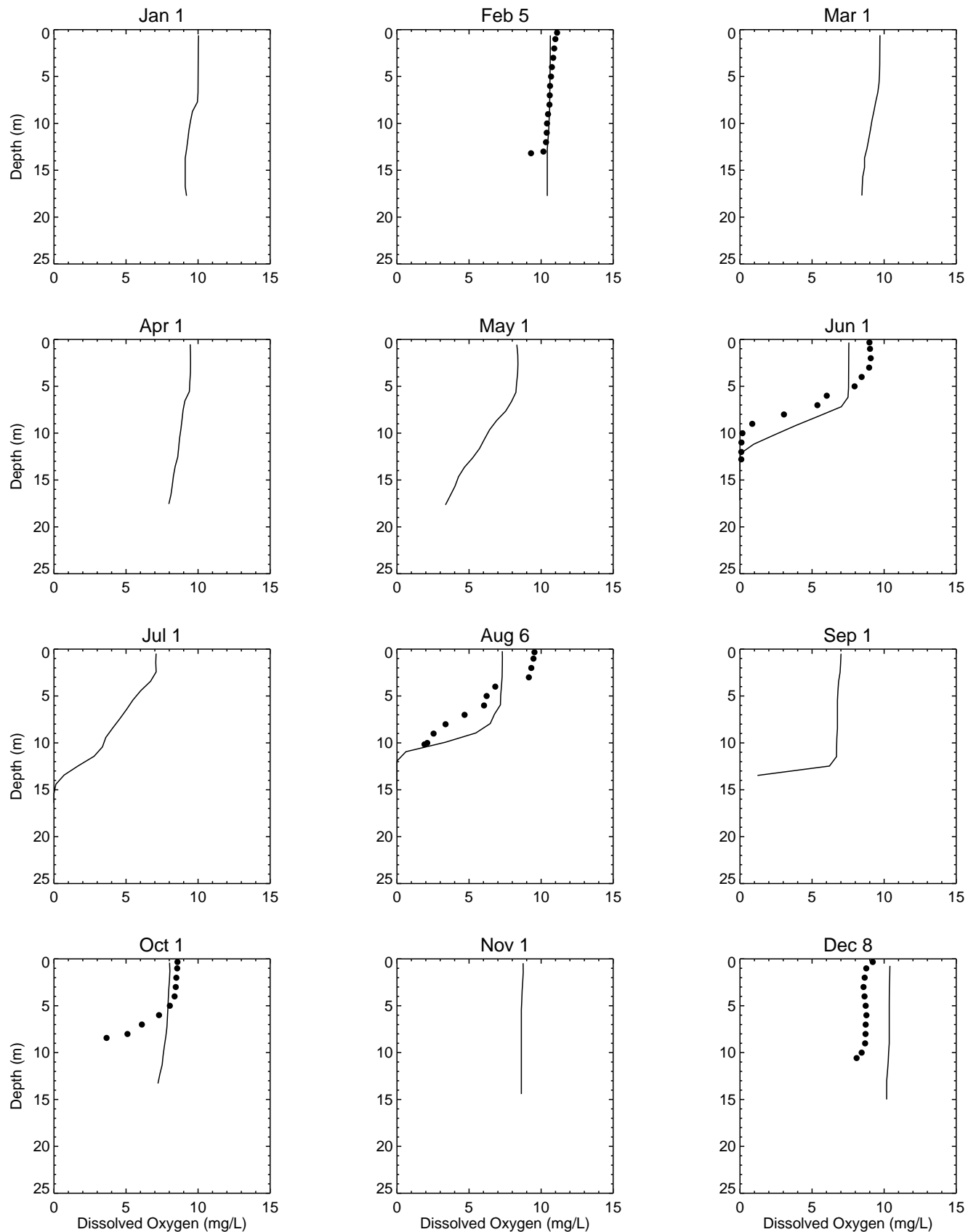Dissolved Oxygen (mg/L)

Model (w1210-48)
Data

Figure G-30

Vertical Profiles of Model Versus Data for Lake Buchanan
~3/4 mi South of Garret Island (Segment 7) - Dissolved Oxygen - 2011
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR
QEA
PARSONS

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 1985

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 23 · Feb 19 · Mar 24 · Apr 15 · May 21 · Jun 18 · Jul 23 · Aug 20 · Sep 25 · Oct 21 · Nov 17 · Dec 17

Dissolved Oxygen (mg/L)

Depth (m)

——— Model (w1210-48)
● Data

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 1986

Profiles shown for dates with available data else model results for first day of month shown.

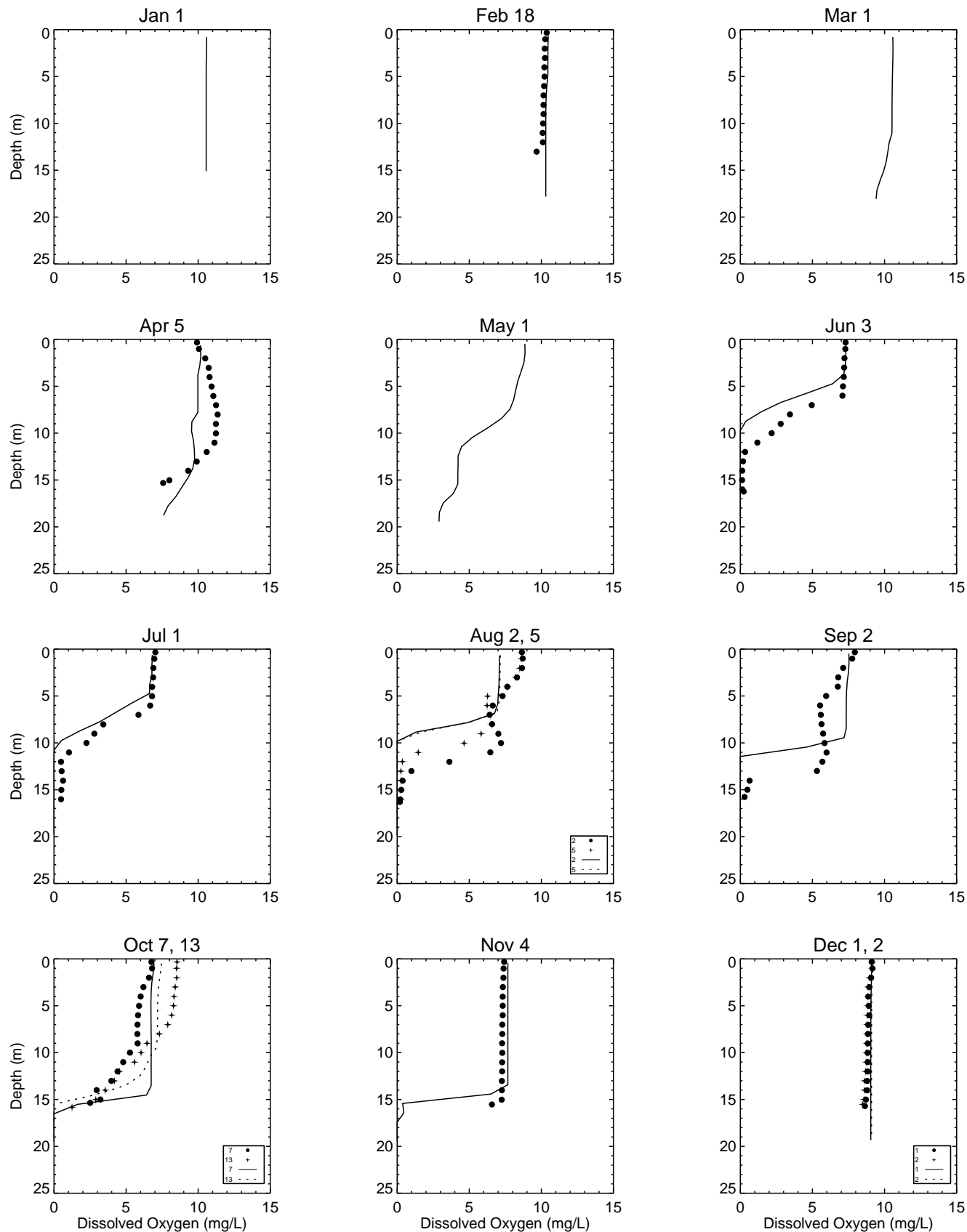CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:47 2013

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 1987

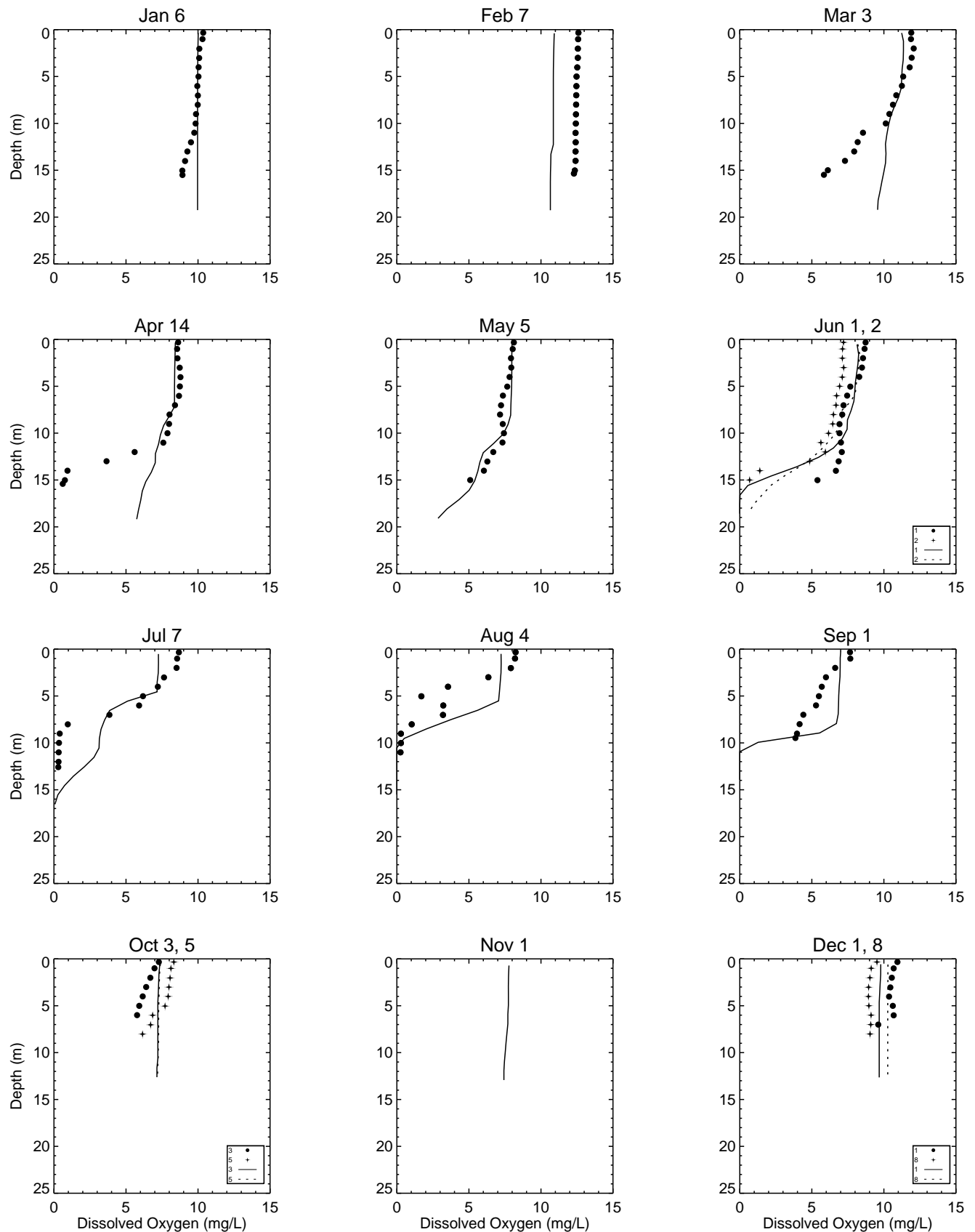*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 1988

Profiles shown for dates with available data else model results for first day of month shown.
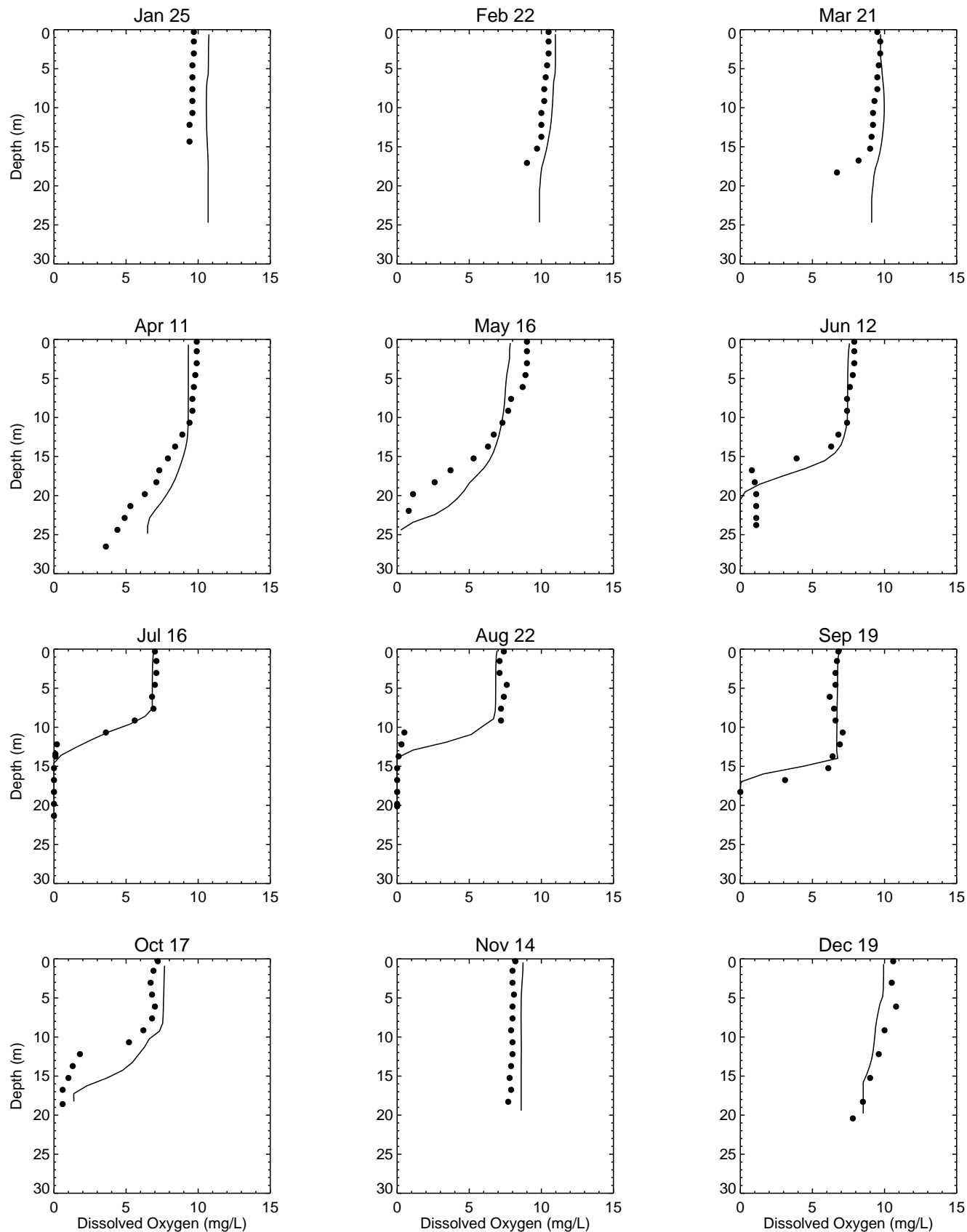
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 10 · Feb 20 · Mar 14 · Apr 18 · May 15 · Jun 22 · Jul 1 · Aug 21 · Sep 1 · Oct 19 · Nov 1 · Dec 21

Depth (m)
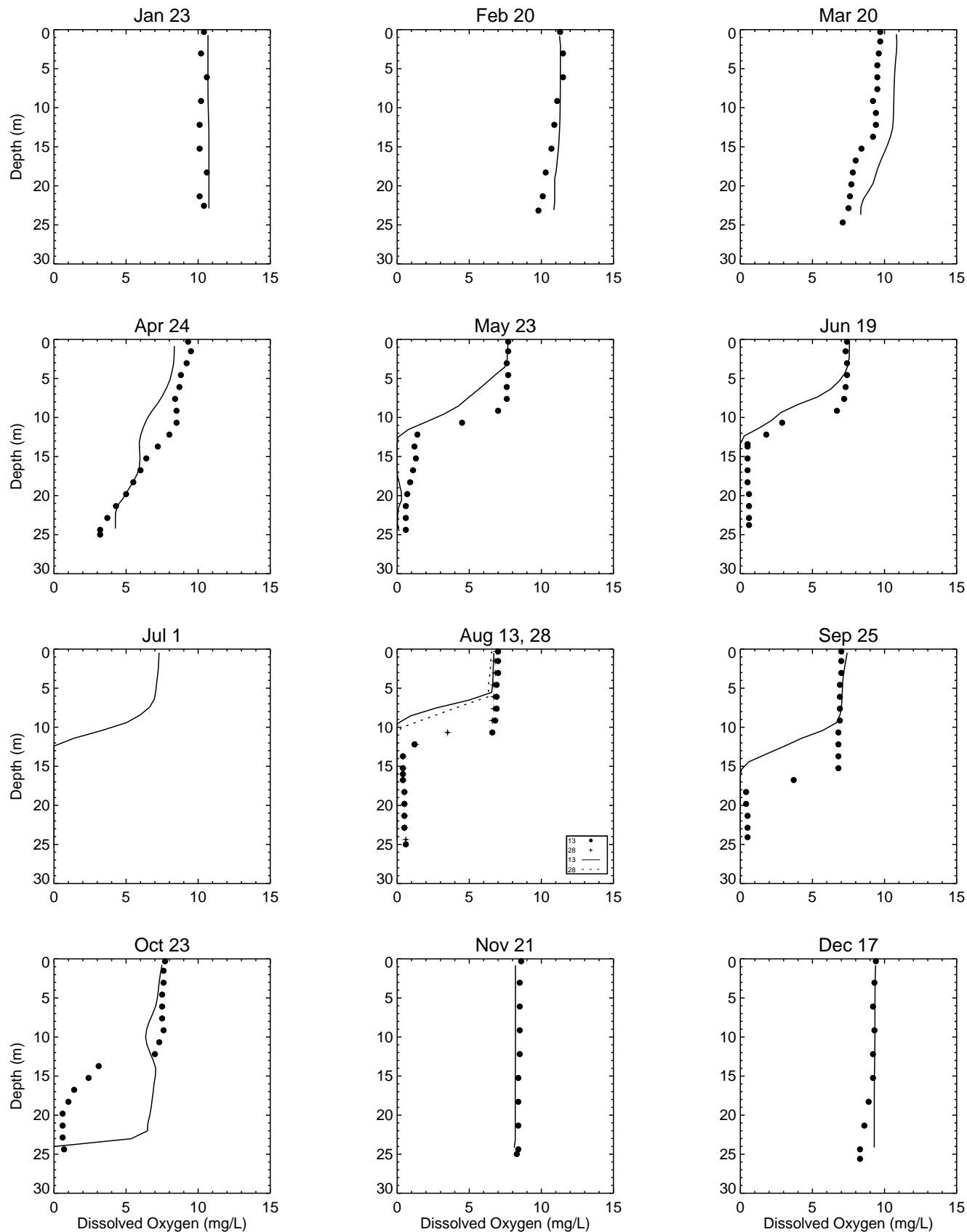
Dissolved Oxygen (mg/L)

—— Model (w1210-48)
● Data

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 1989

Profiles shown for dates with available data else model results for first day of month shown.
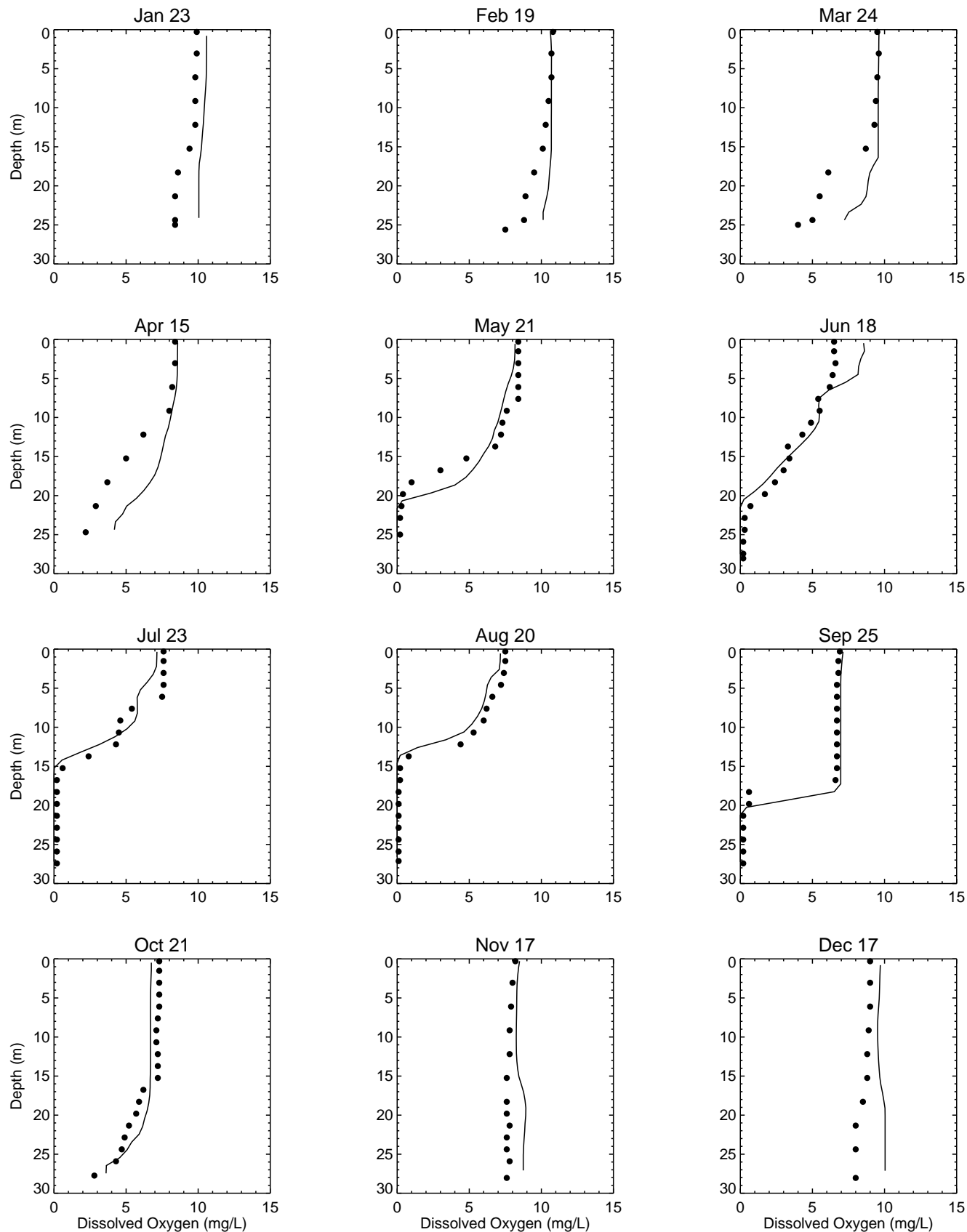
CREMs Phase 4: Lake Buchanan

ANCHOR QEA PARSONS

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
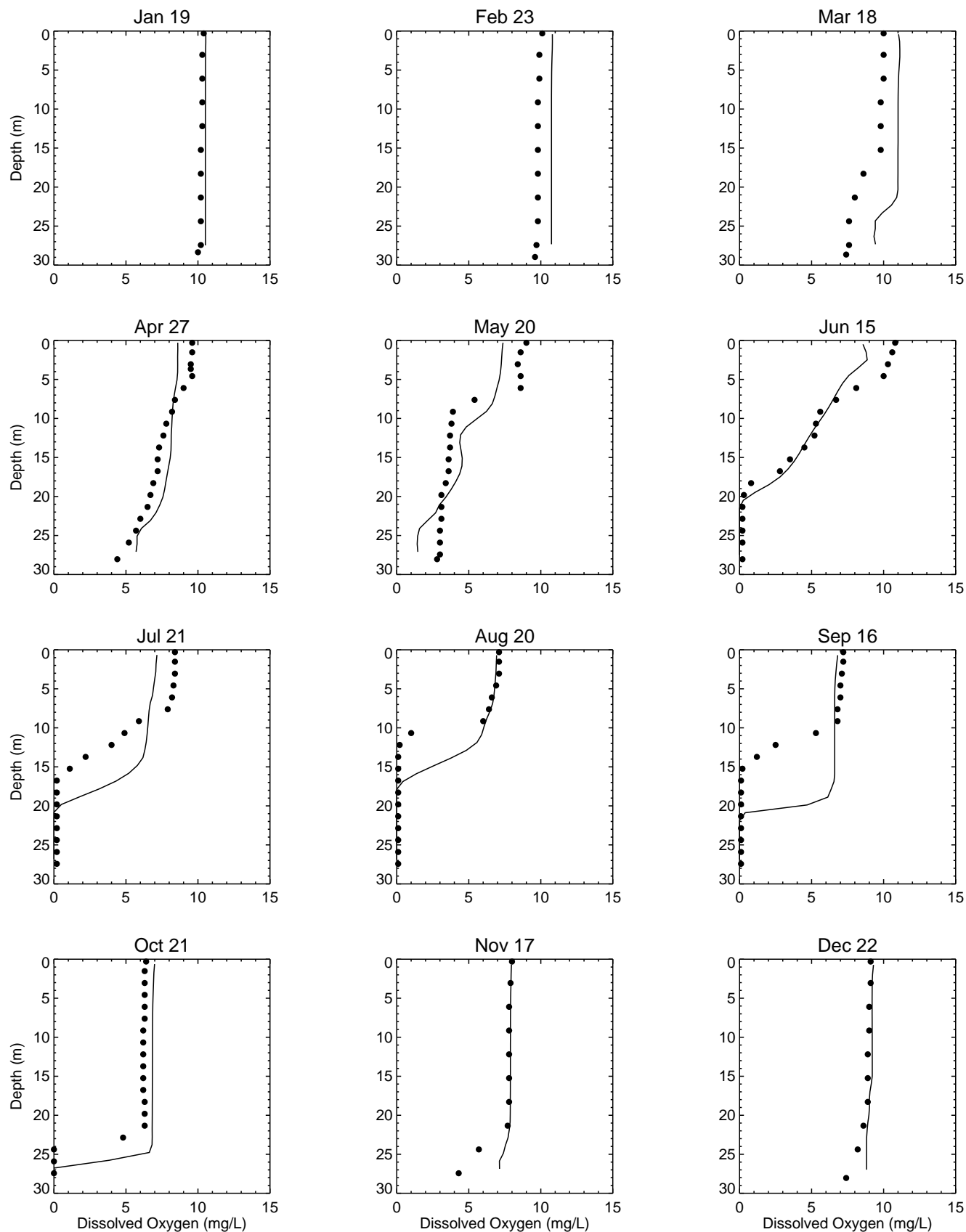Fri Jan 25 18:12:47 2013

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 1990

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 20 · Mar 1 · Apr 1 · May 1 · Jun 11 · Jul 11 · Aug 20 · Sep 1 · Oct 22 · Nov 1 · Dec 16
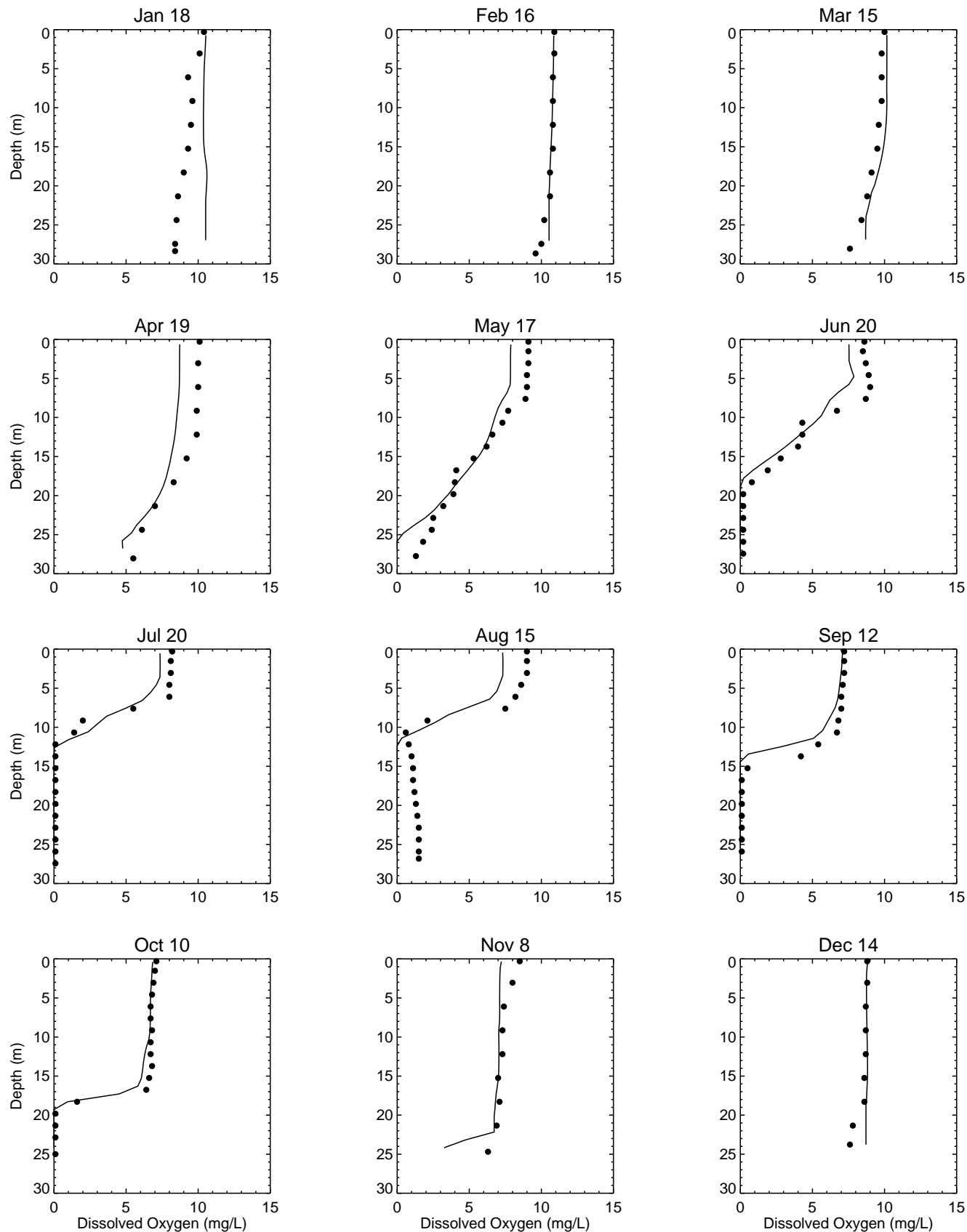
—— Model (w1210-48)
● Data

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 1991

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
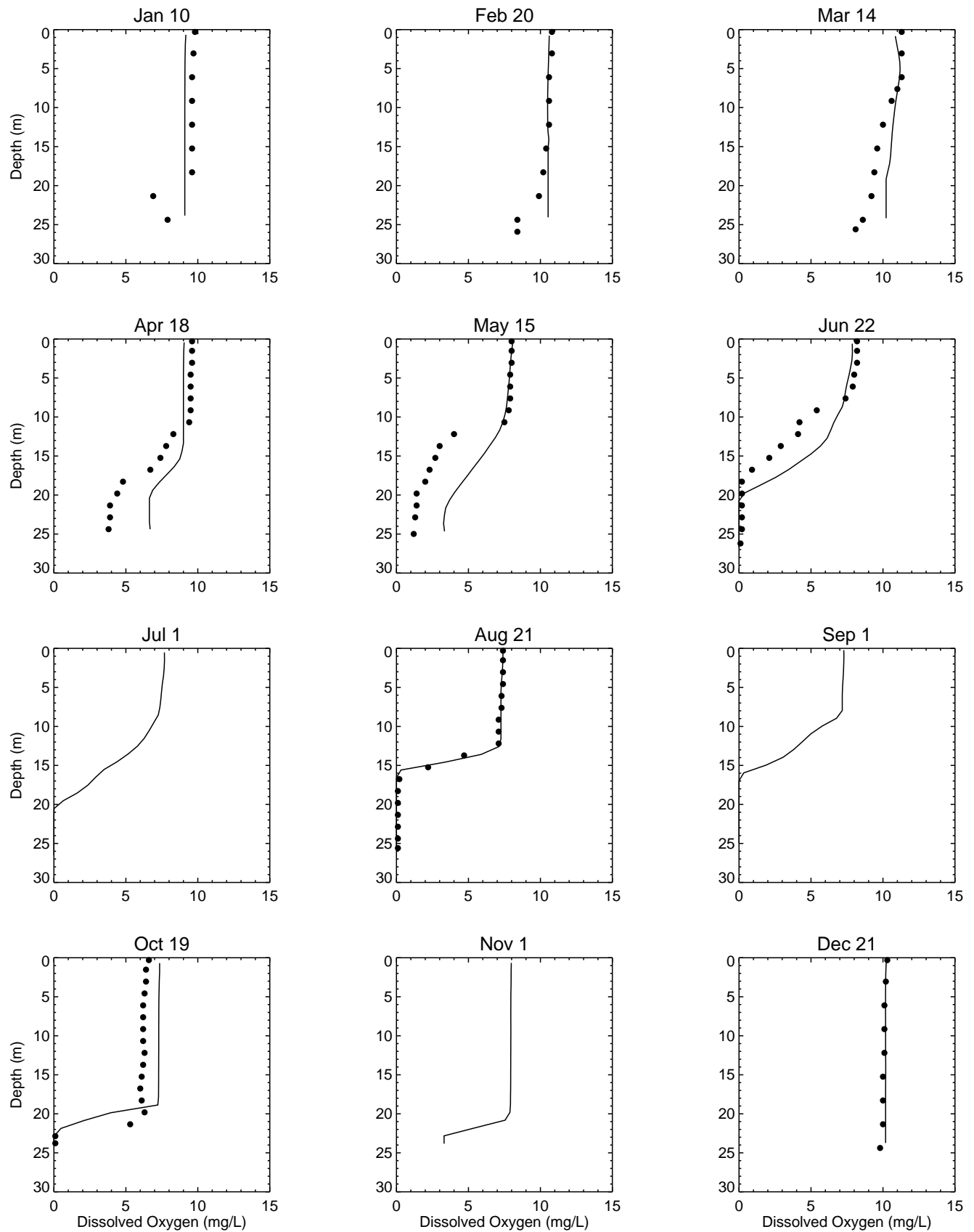Fri Jan 25 18:12:48 2013

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 1994

Profiles shown for dates with available data else model results for first day of month shown.

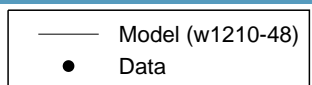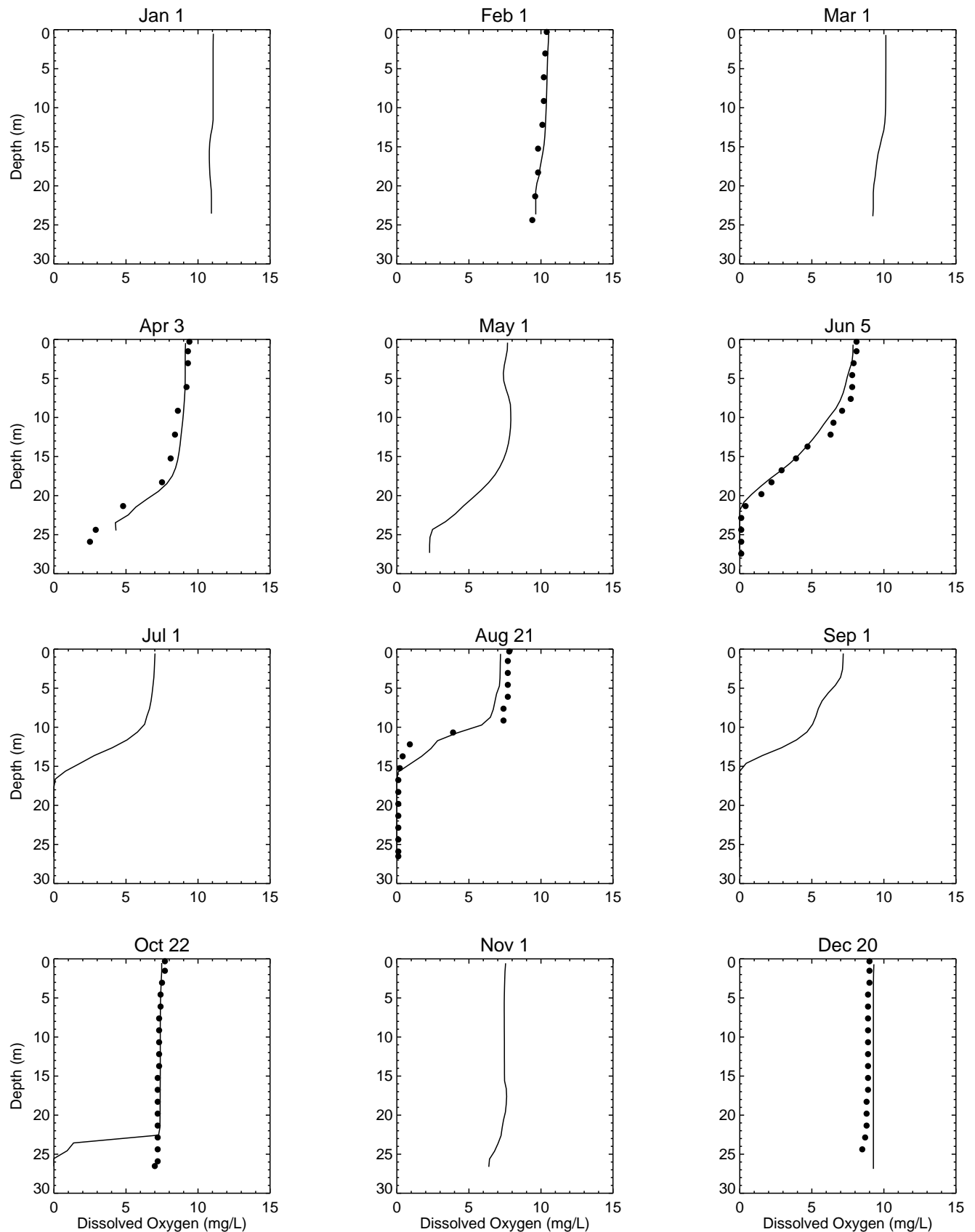CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1   Feb 6   Mar 1

Apr 5   May 1   Jun 26

Jul 1   Aug 3   Sep 1

Oct 11   Nov 1   Dec 6

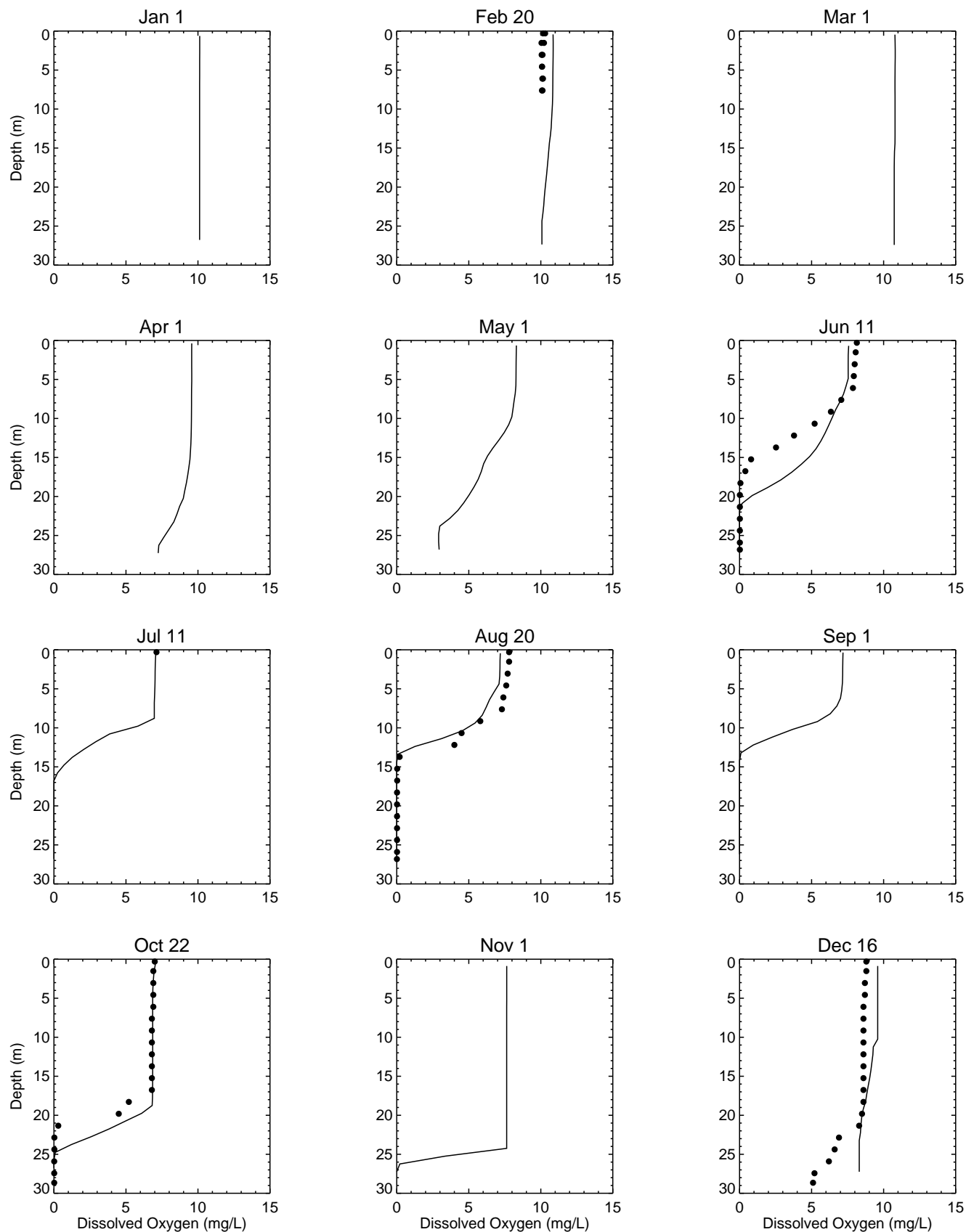—— Model (w1210-48)

● Data

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 1995

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:48 2013

Jan 1   Feb 12   Mar 1

Apr 17   May 28   Jun 12, 26

Jul 1   Aug 5   Sep 1

Oct 7   Nov 6   Dec 5

Depth (m)

Dissolved Oxygen (mg/L)
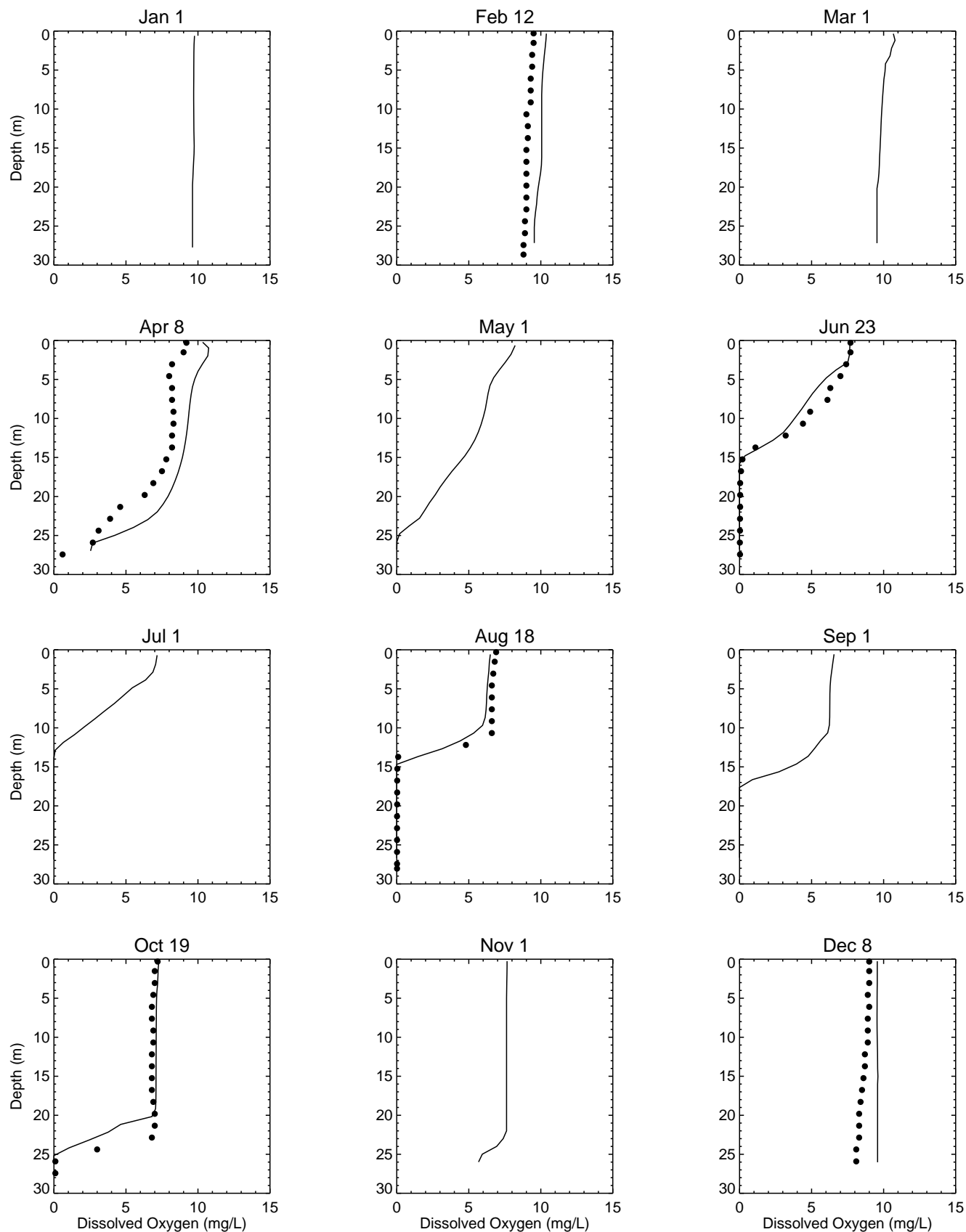
—— Model (w1210-48)
● Data

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 1996

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR
QEA
PARSONS

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 Feb 6 Mar 1 Apr 16 May 1 Jun 5 Jul 16 Aug 1 Sep 1 Oct 20 Nov 1 Dec 15

Dissolved Oxygen (mg/L)

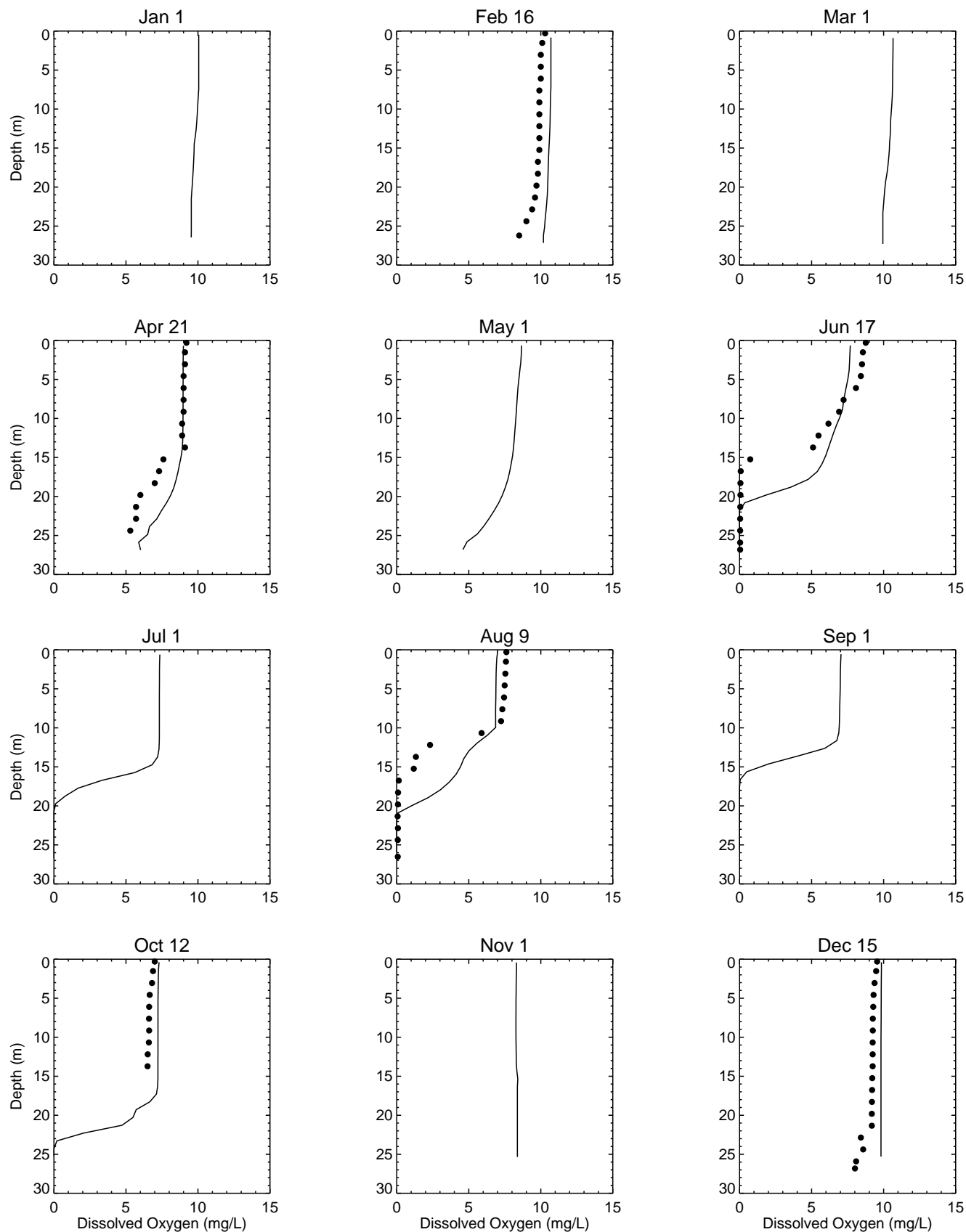—— Model (w1210-48)
● Data

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 1997

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
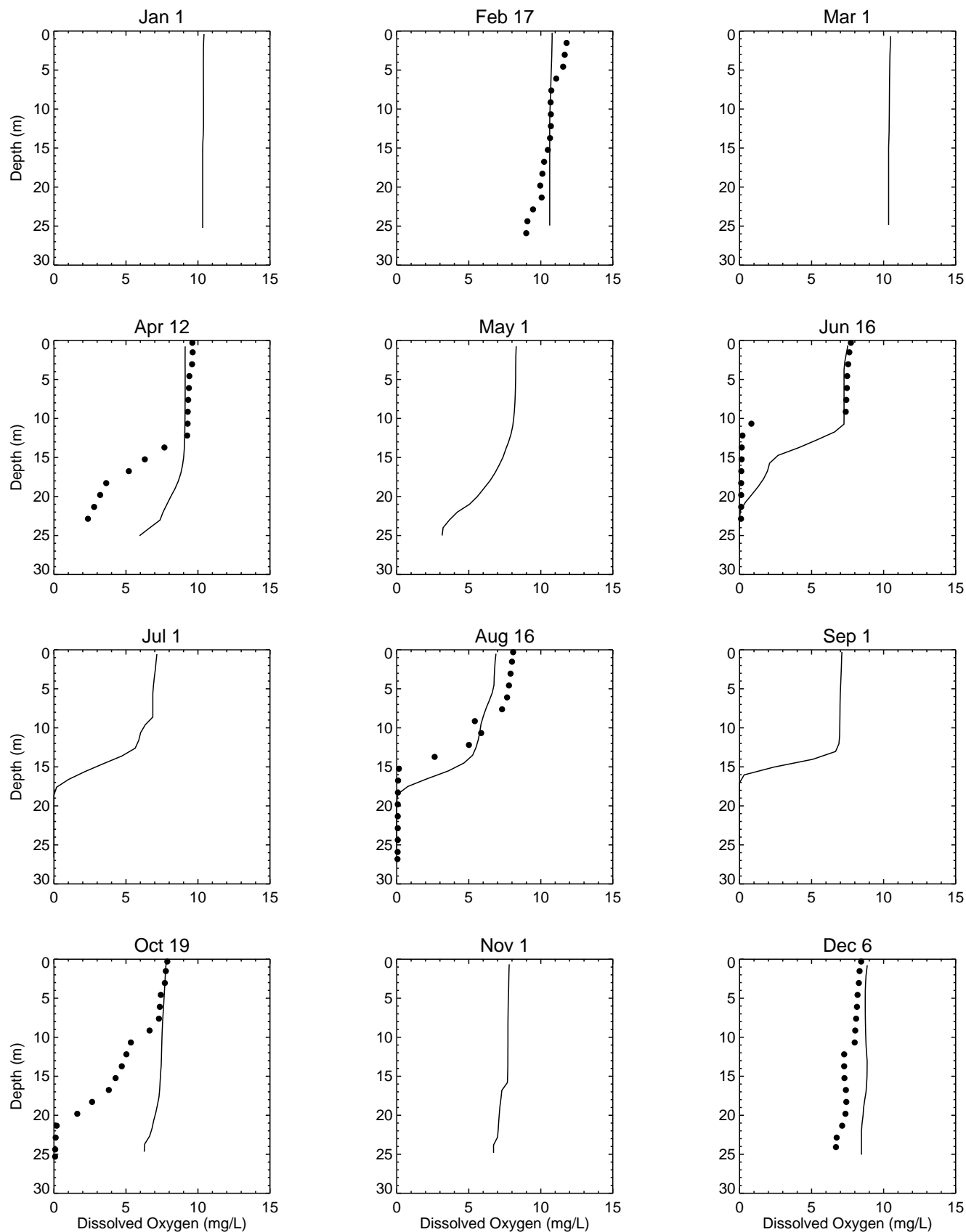
Lower Colorado River Authority

ANCHOR QEA PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:48 2013

Jan 1 · Feb 3 · Mar 1 · Apr 13 · May 1 · Jun 15 · Jul 1 · Aug 5 · Sep 1 · Oct 4 · Nov 1 · Dec 6

Dissolved Oxygen (mg/L)
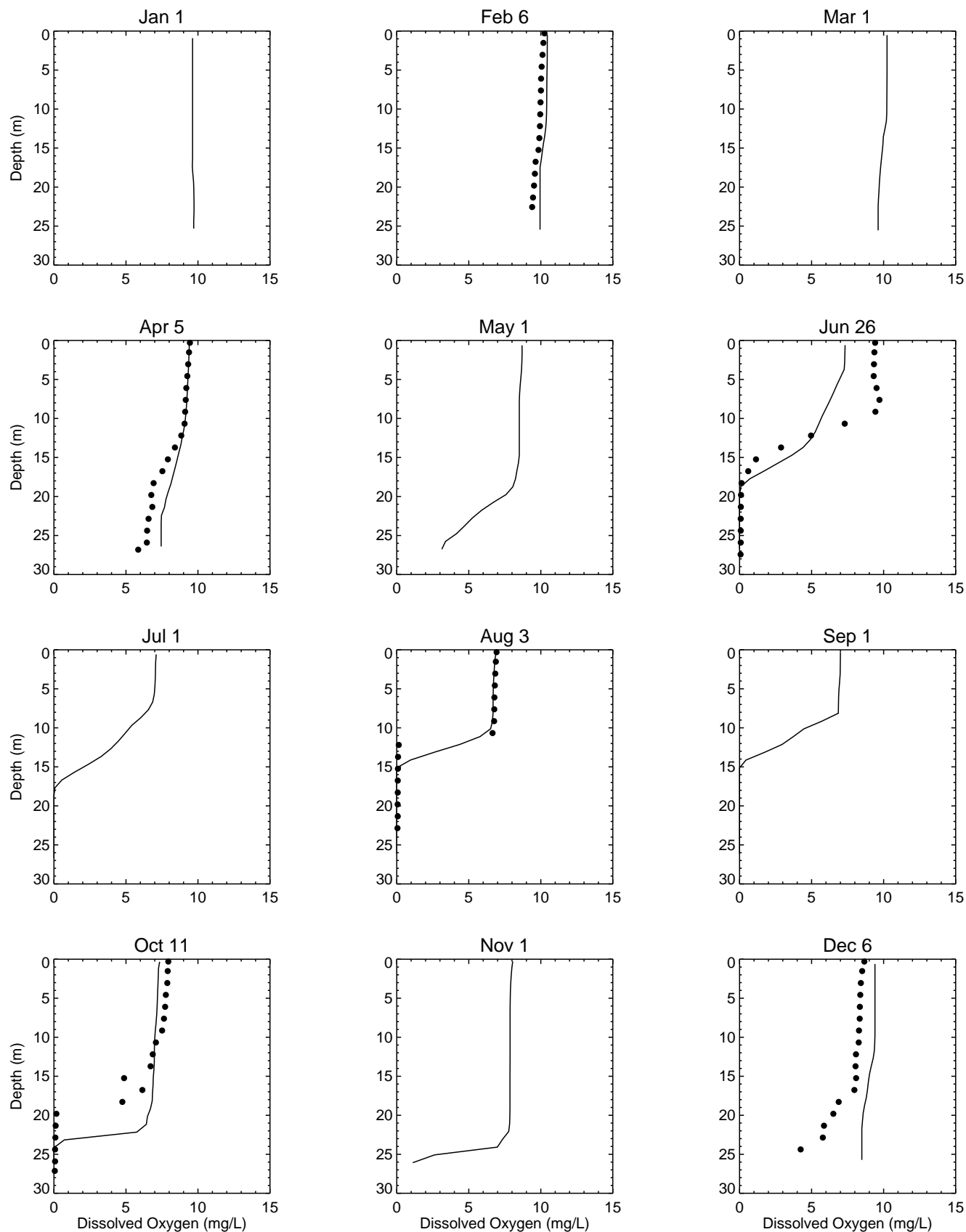
—— Model (w1210-48)
● Data

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 1999

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
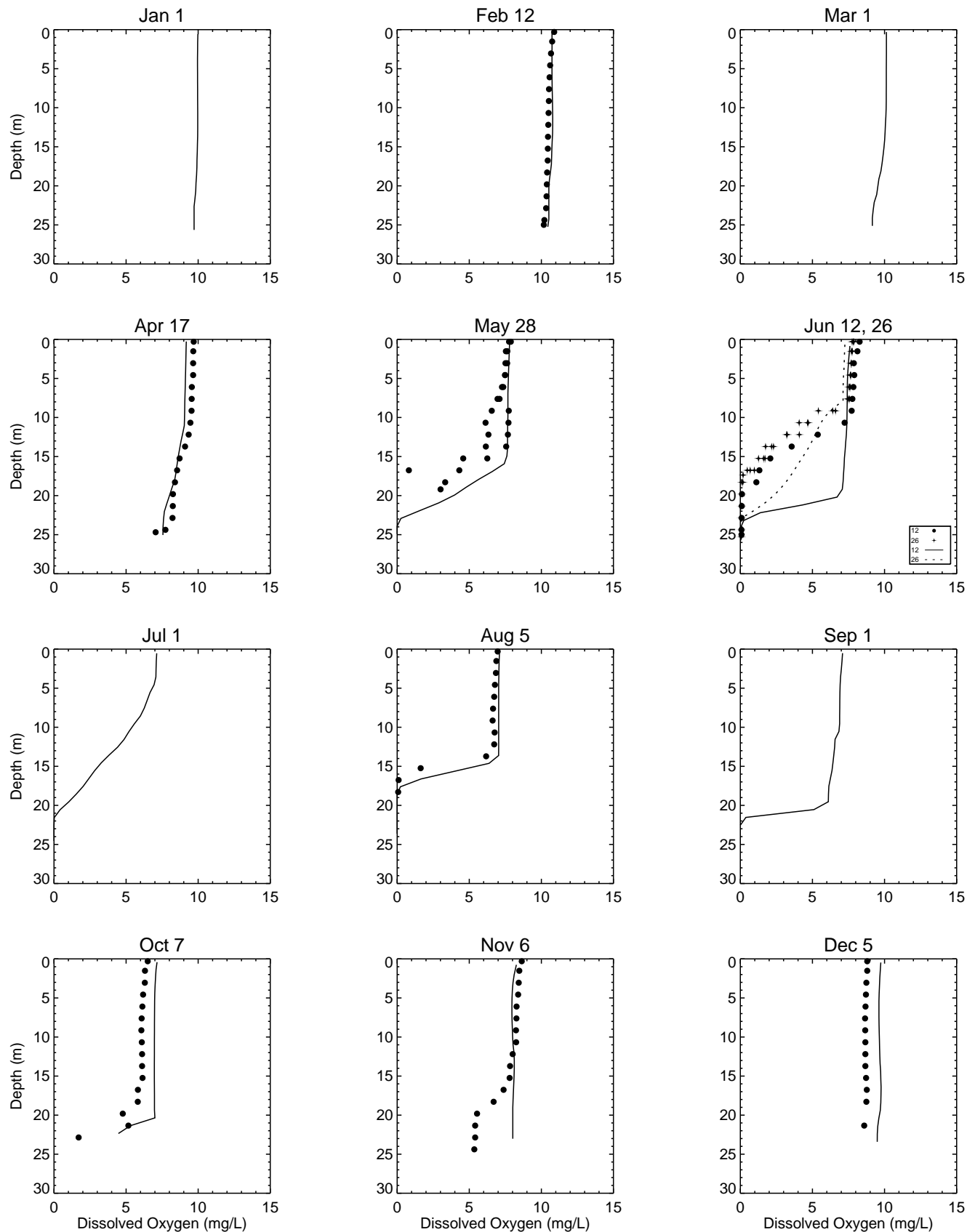Lower Colorado River Authority

ANCHOR QEA
PARSONS

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 2000

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:48 2013

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 2001

Profiles shown for dates with available data else model results for first day of month shown.
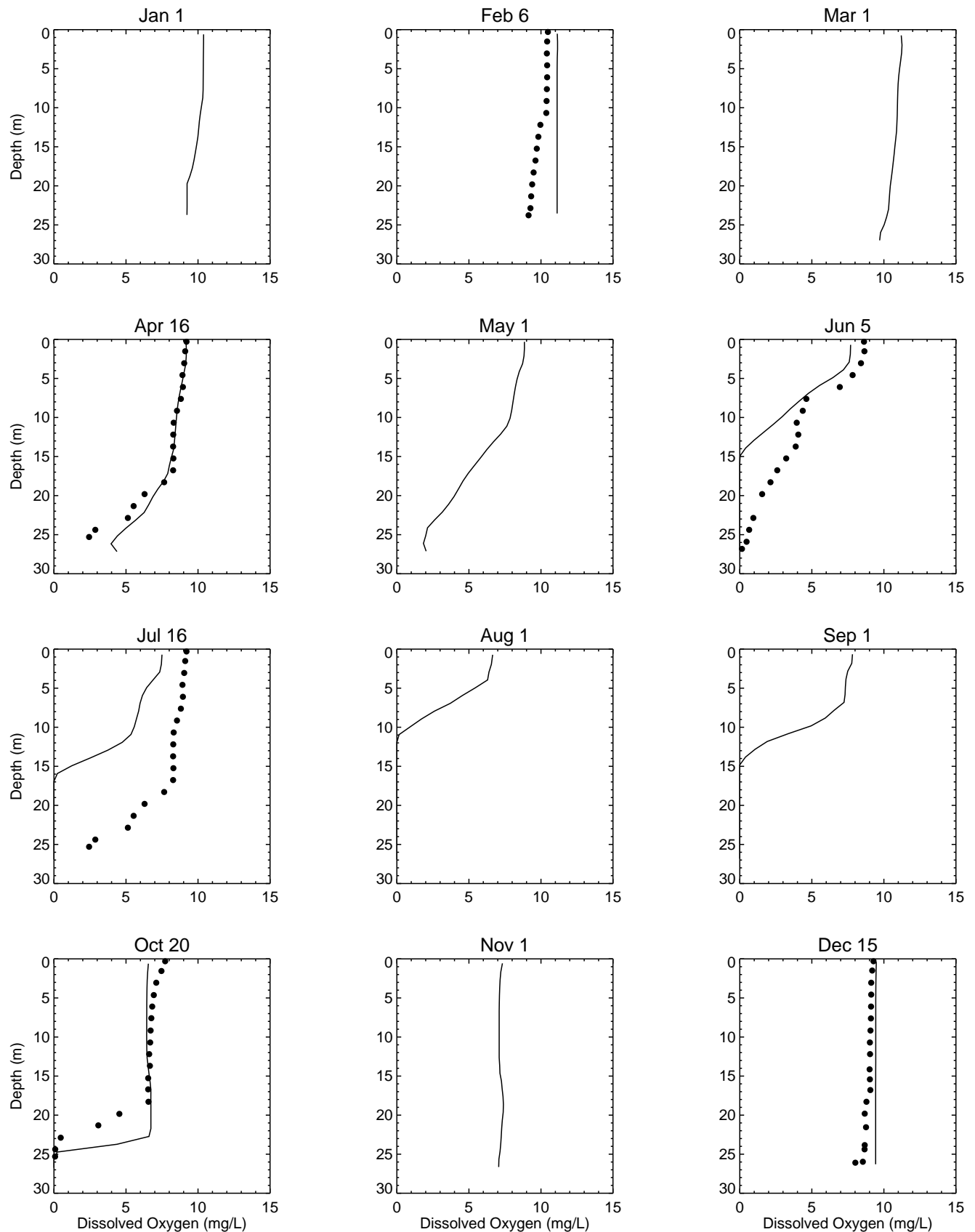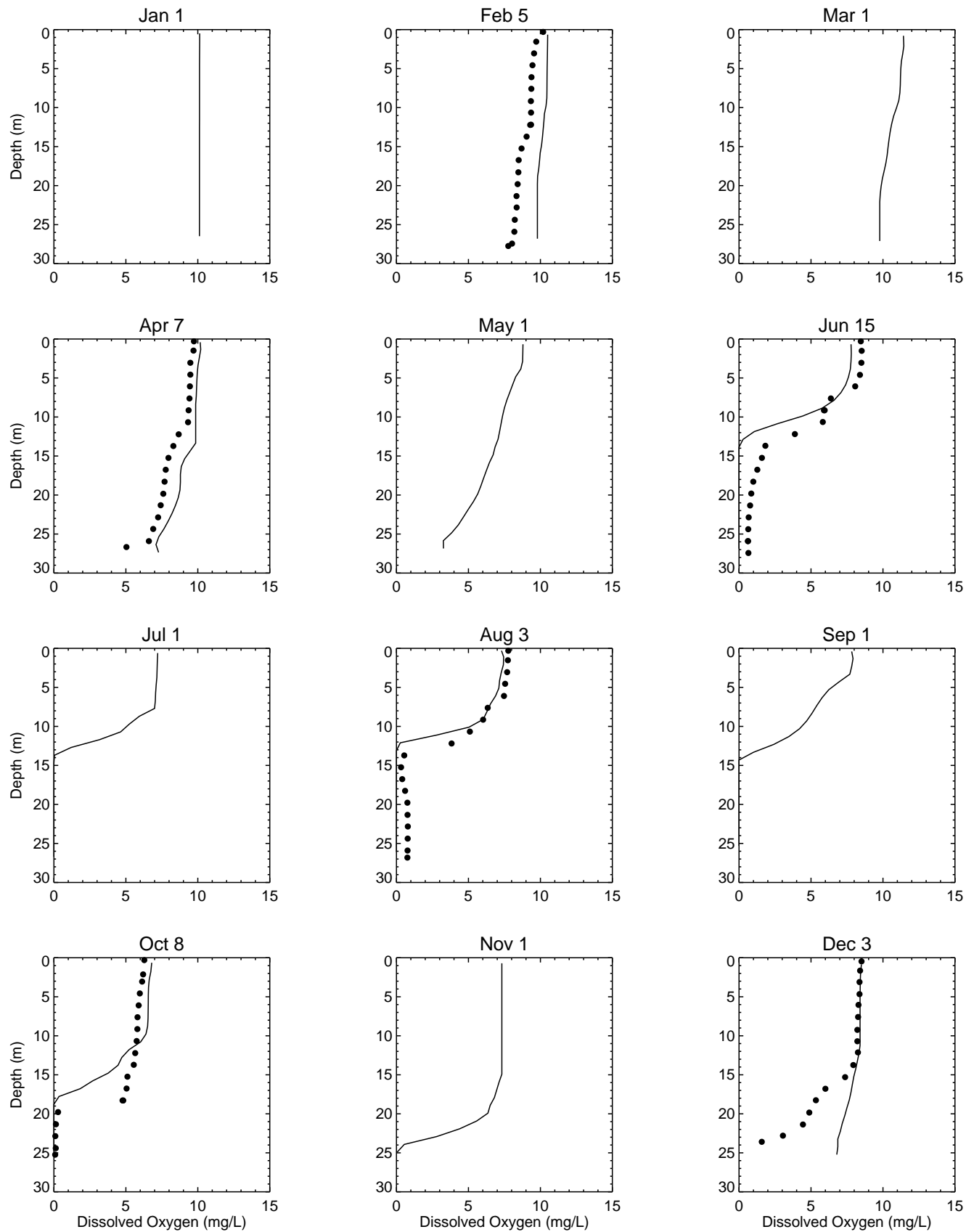
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 Feb 6 Mar 1 Apr 15 May 1 Jun 10 Jul 1 Aug 20 Sep 1 Oct 1 Nov 1 Dec 2

Depth (m)

Dissolved Oxygen (mg/L)
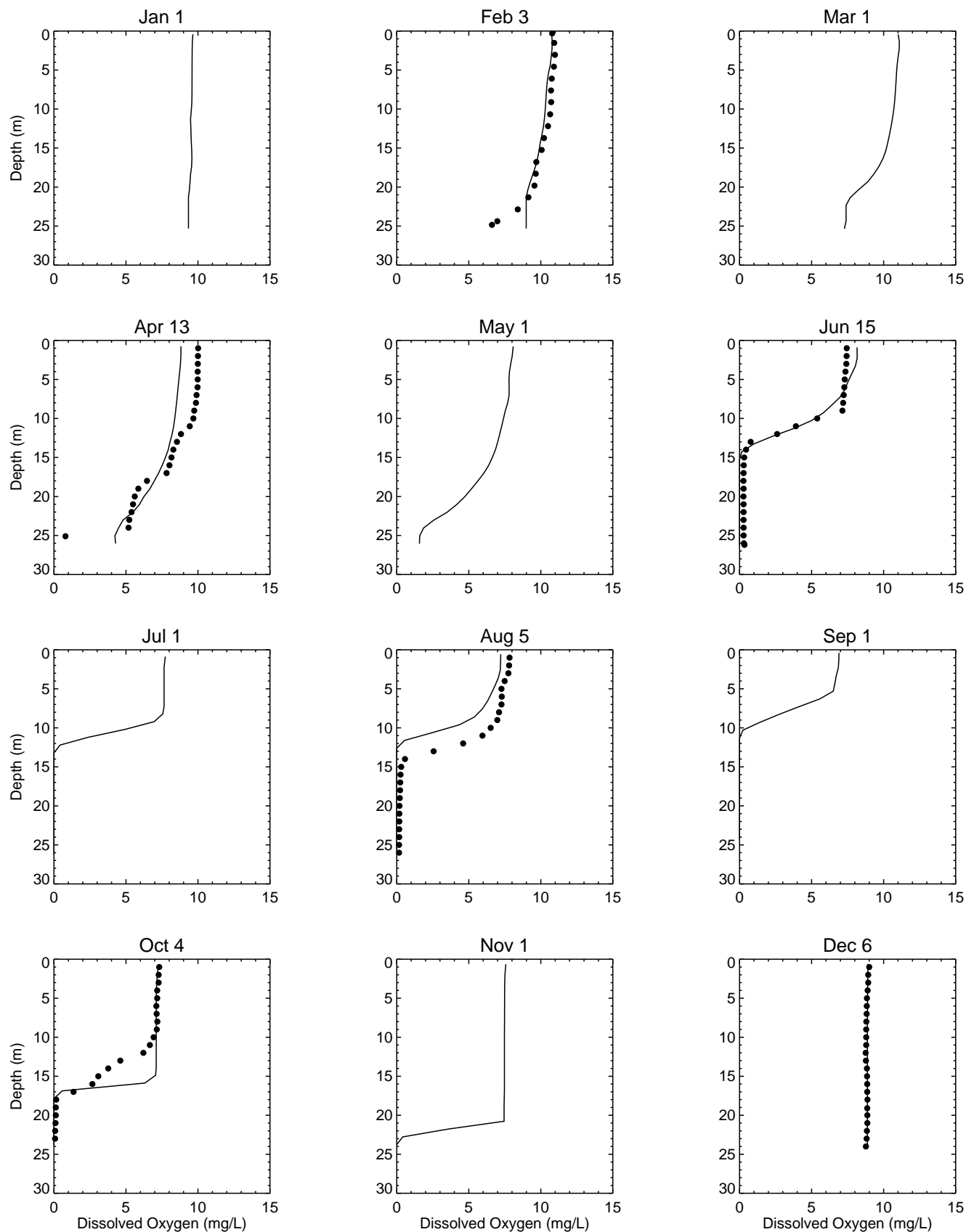
——— Model (w1210-48)
● Data

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 2002

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:48 2013
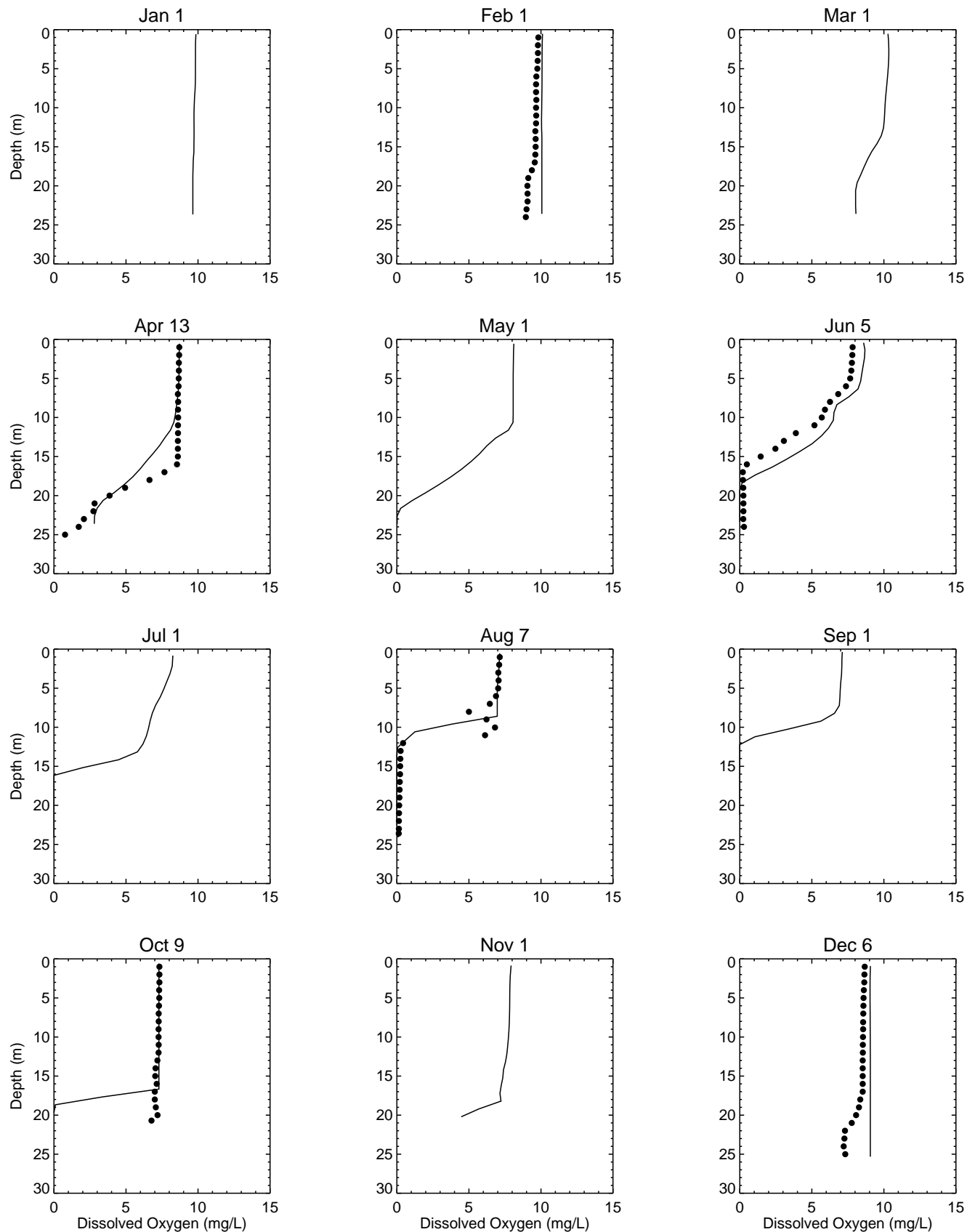
Model (w1210-48)
● Data

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 2003

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:48 2013

Jan 1 • Feb 16 • Mar 1 • Apr 1 • May 1 • Jun 15 • Jul 1 • Aug 12 • Sep 1 • Oct 7 • Nov 1 • Dec 9

Depth (m) vs Dissolved Oxygen (mg/L)
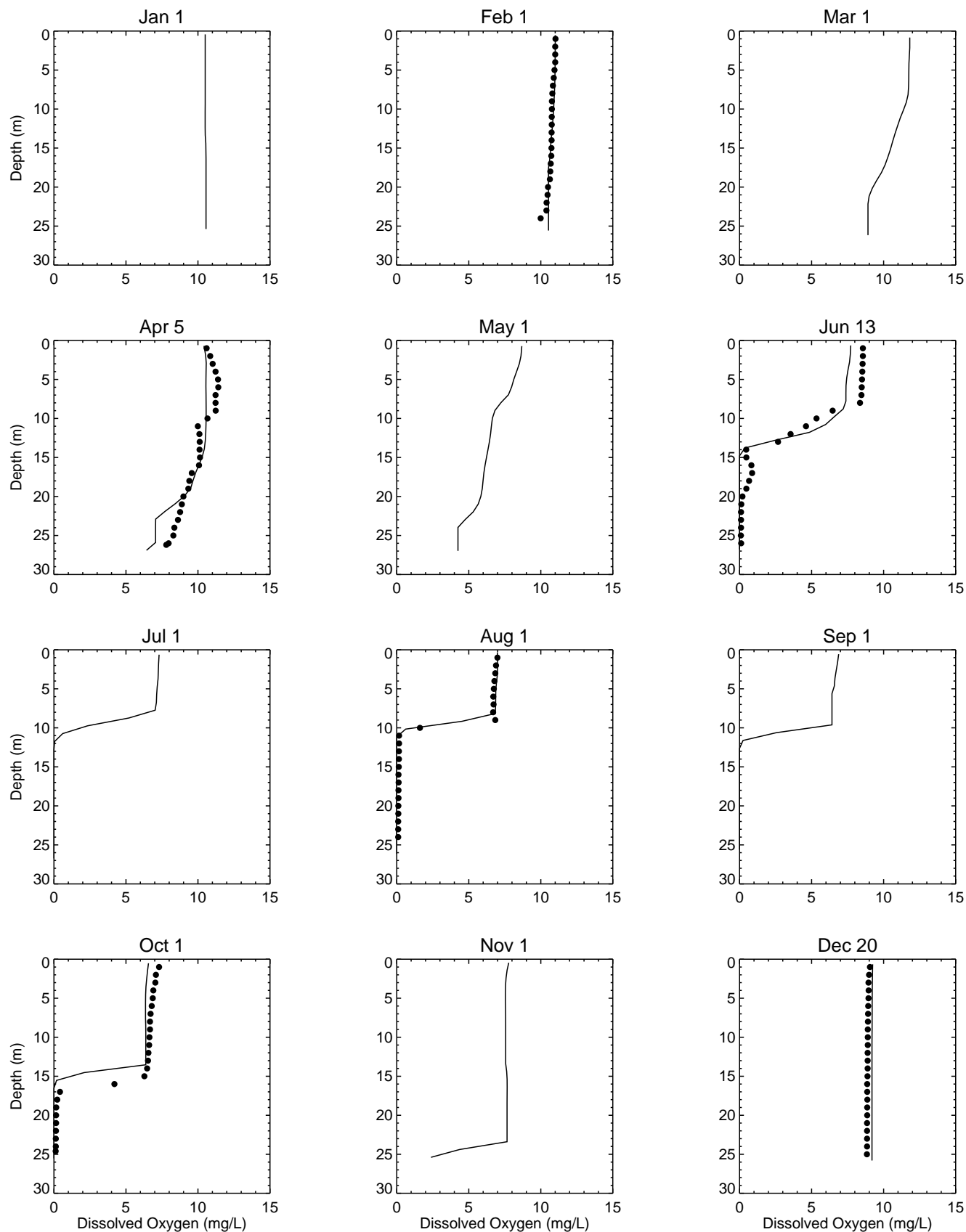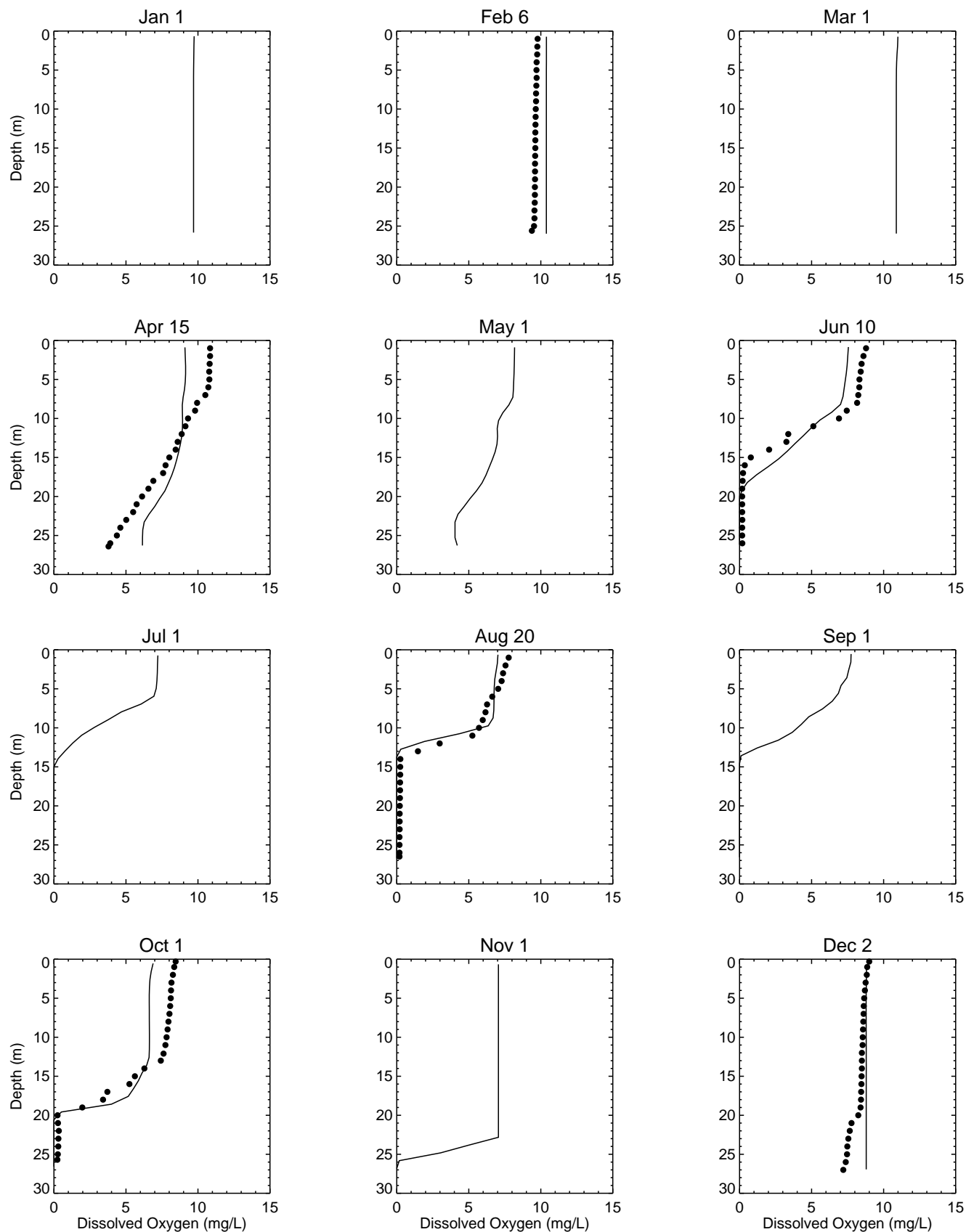
——— Model (w1210-48)
● Data

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 2004

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 2005

Profiles shown for dates with available data else model results for first day of month shown.
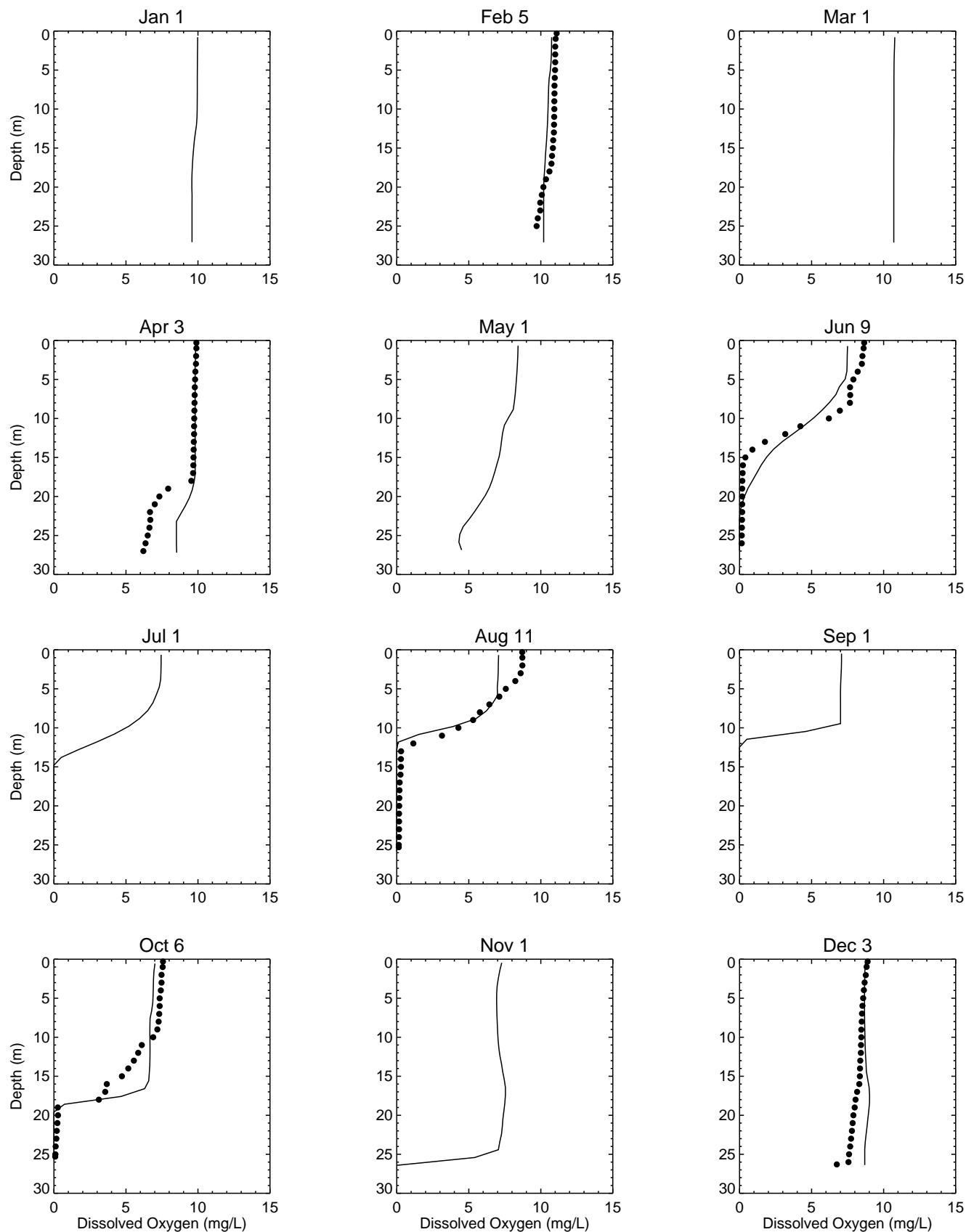
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 2006

Profiles shown for dates with available data else model results for first day of month shown.

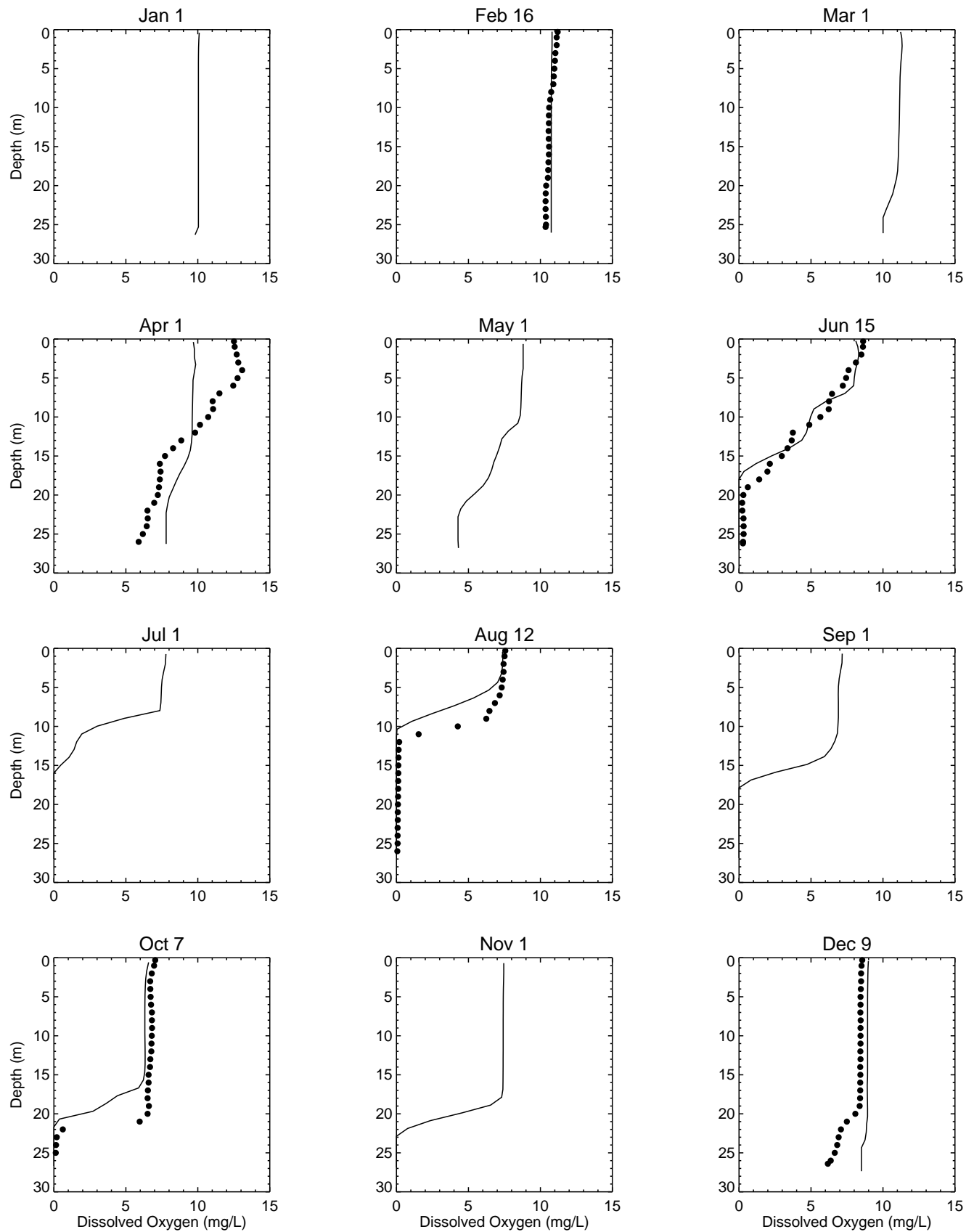CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 2007

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:48 2013

Jan 1 — Feb 4 — Mar 1 — Apr 3 — May 1 — Jun 12 — Jul 1 — Aug 7 — Sep 1 — Oct 9 — Nov 1 — Dec 4

Depth (m) vs. Dissolved Oxygen (mg/L)
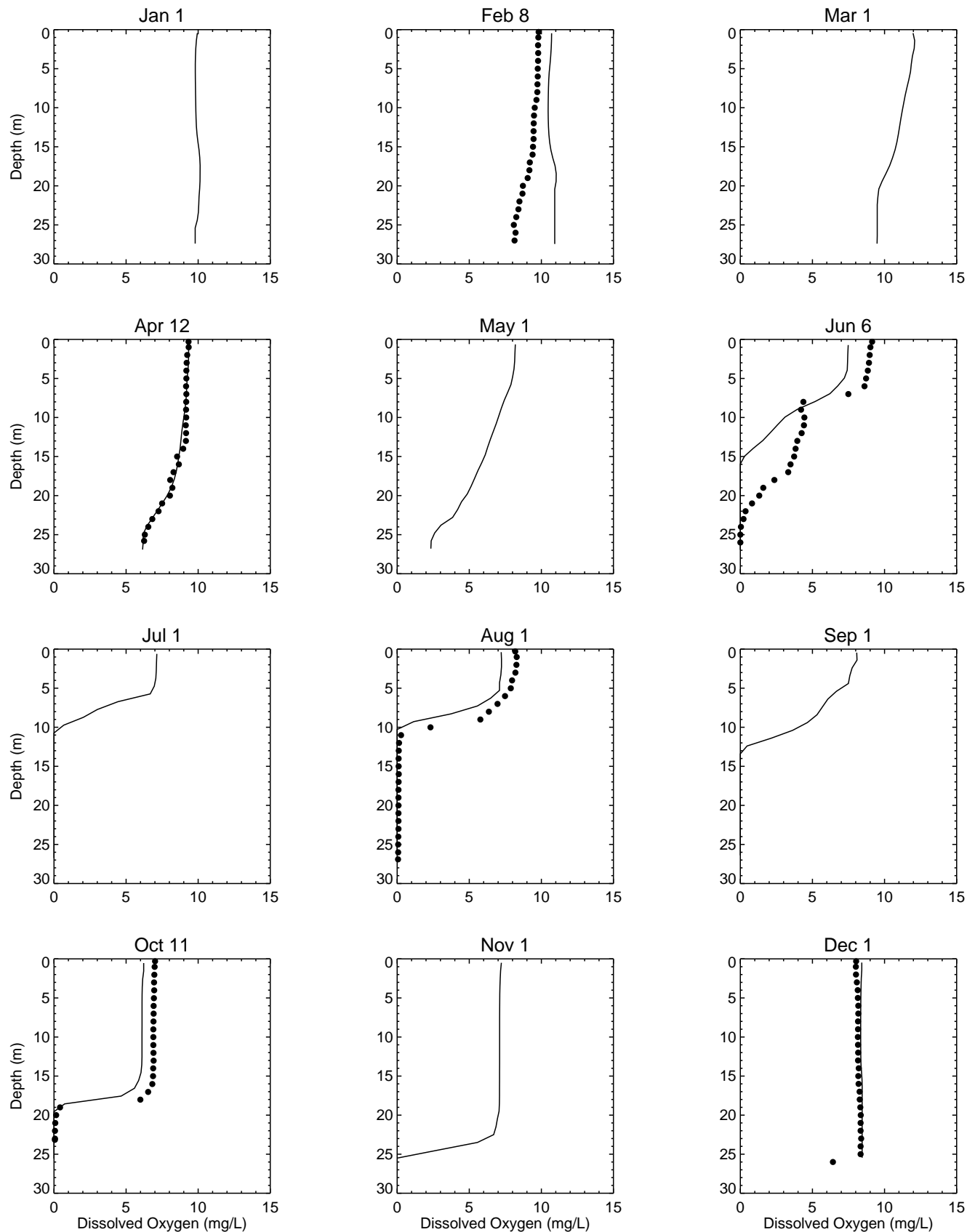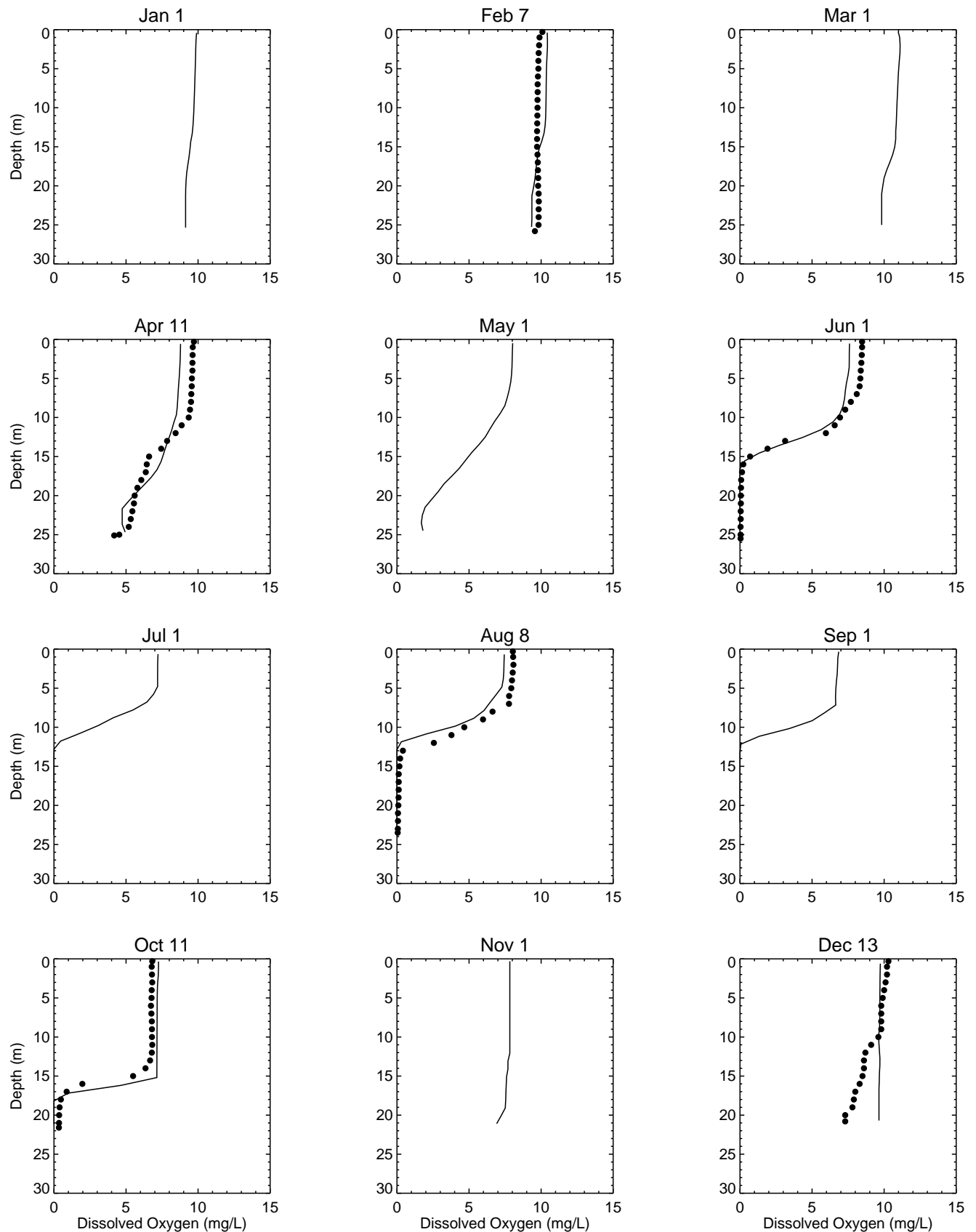
——— Model (w1210-48)
● Data

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 2008

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:48 2013
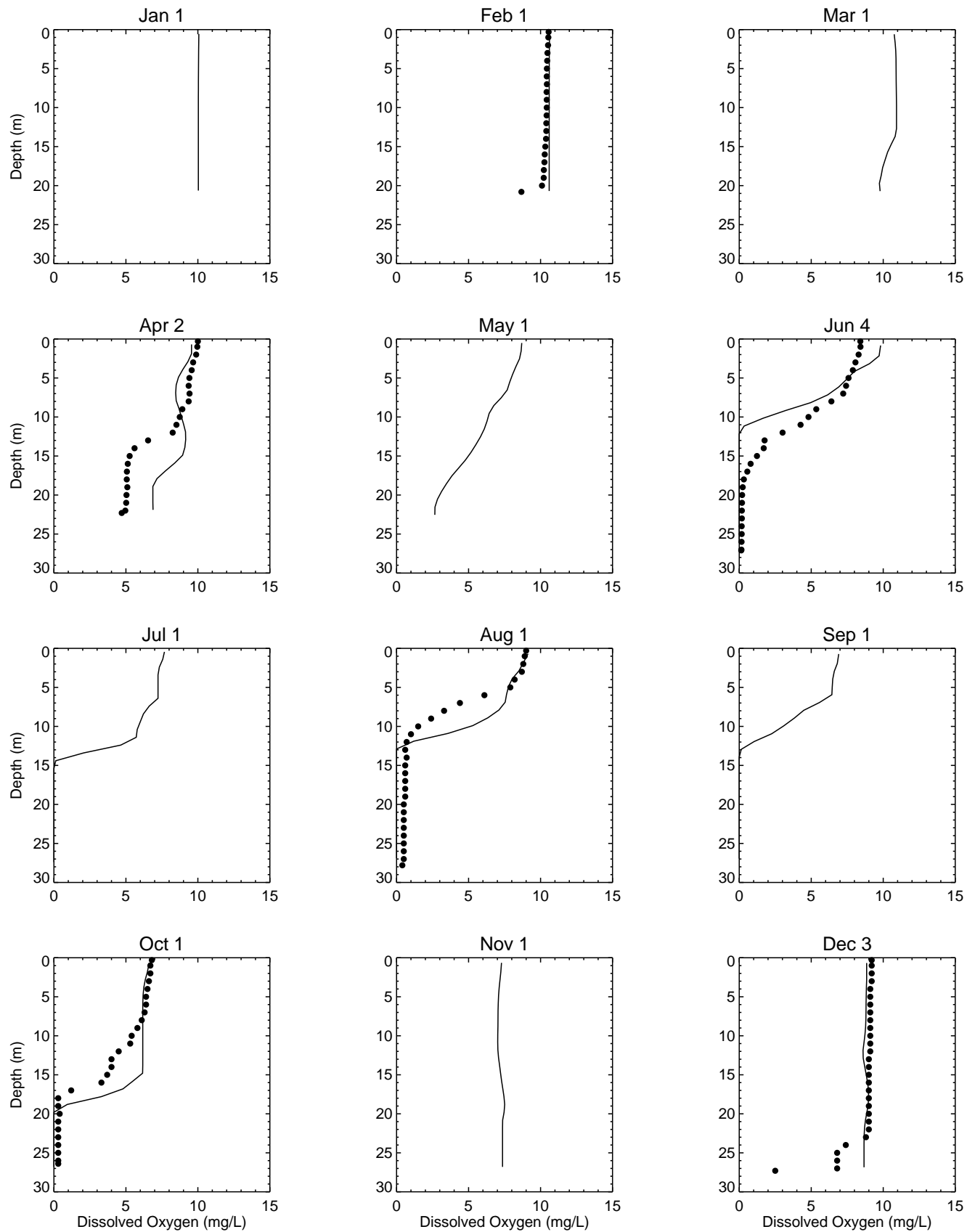
Model (w1210-48)
● Data

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 2009

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 | Feb 18 | Mar 1

Apr 5 | May 1 | Jun 3

Jul 1 | Aug 2, 5 | Sep 2

Oct 7, 13 | Nov 4 | Dec 1, 2
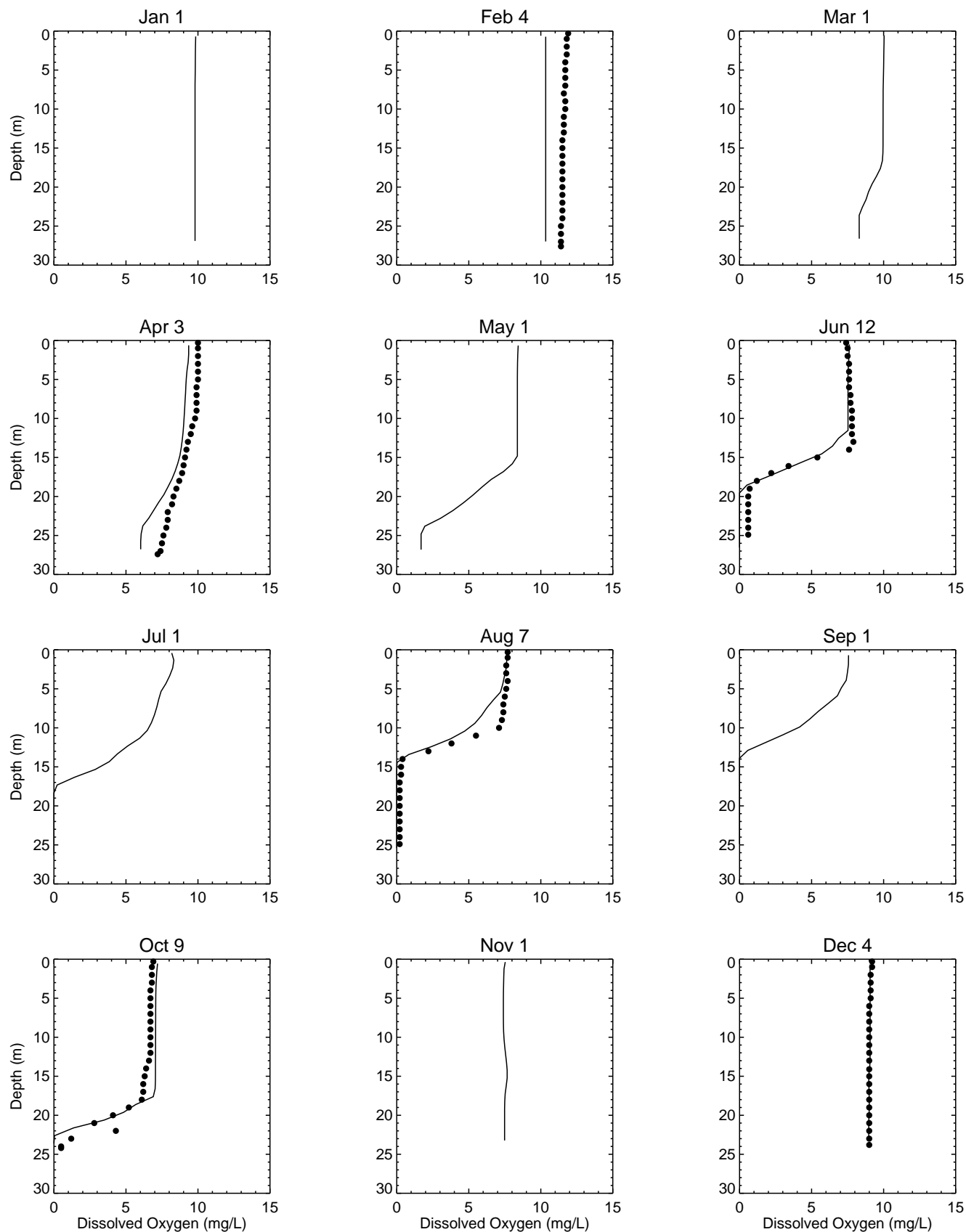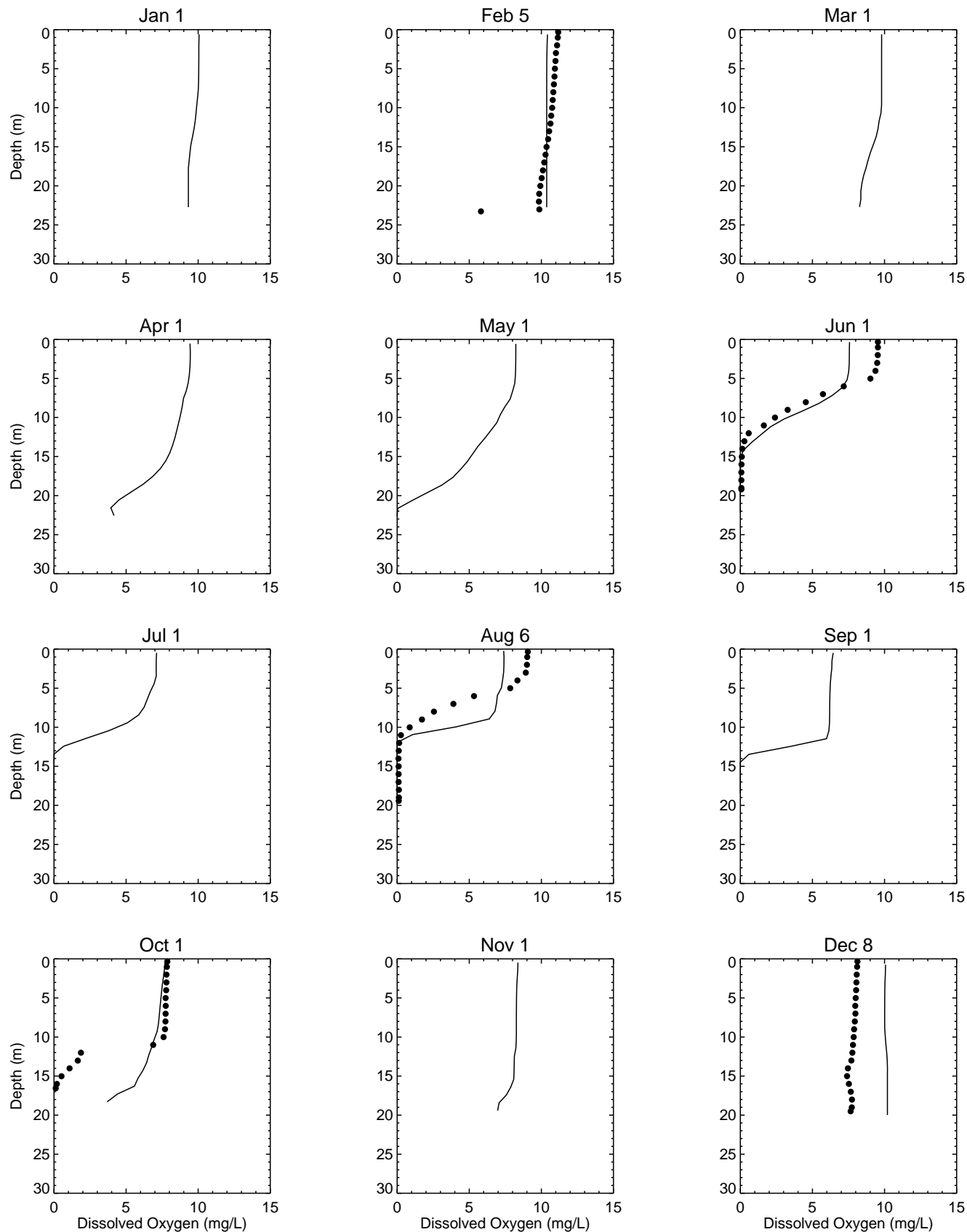
—— Model (w1210-48)
● Data

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 2010

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:48 2013

Jan 6 • Feb 7 • Mar 3 • Apr 14 • May 5 • Jun 1, 2 • Jul 7 • Aug 4 • Sep 1 • Oct 3, 5 • Nov 1 • Dec 1, 8

Depth (m)
Dissolved Oxygen (mg/L)

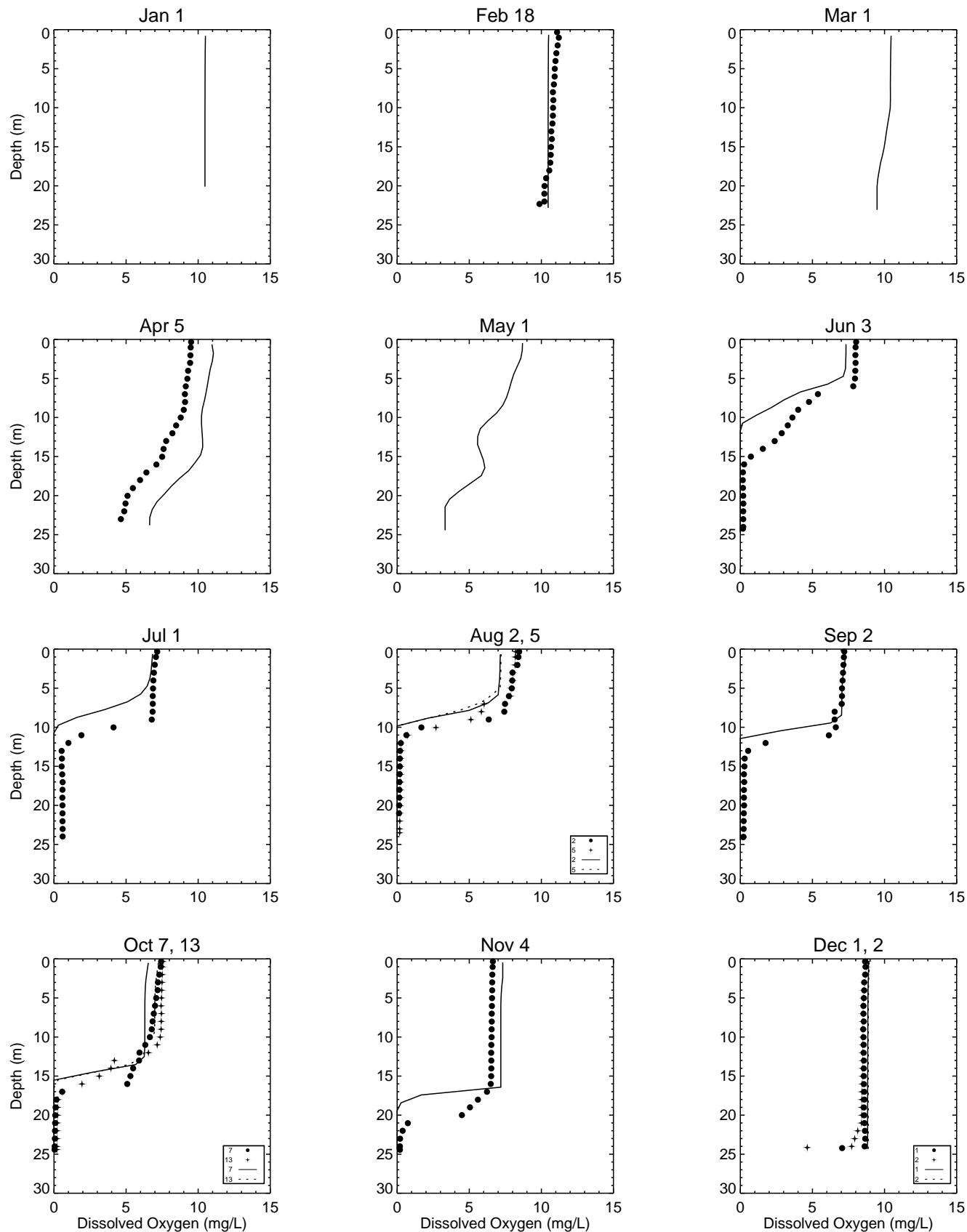——— Model (w1210-48)
● Data

Figure G-31

Vertical Profiles of Model Versus Data for Lake Buchanan
at Rocky Point (Segment 9) - Dissolved Oxygen - 2011

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
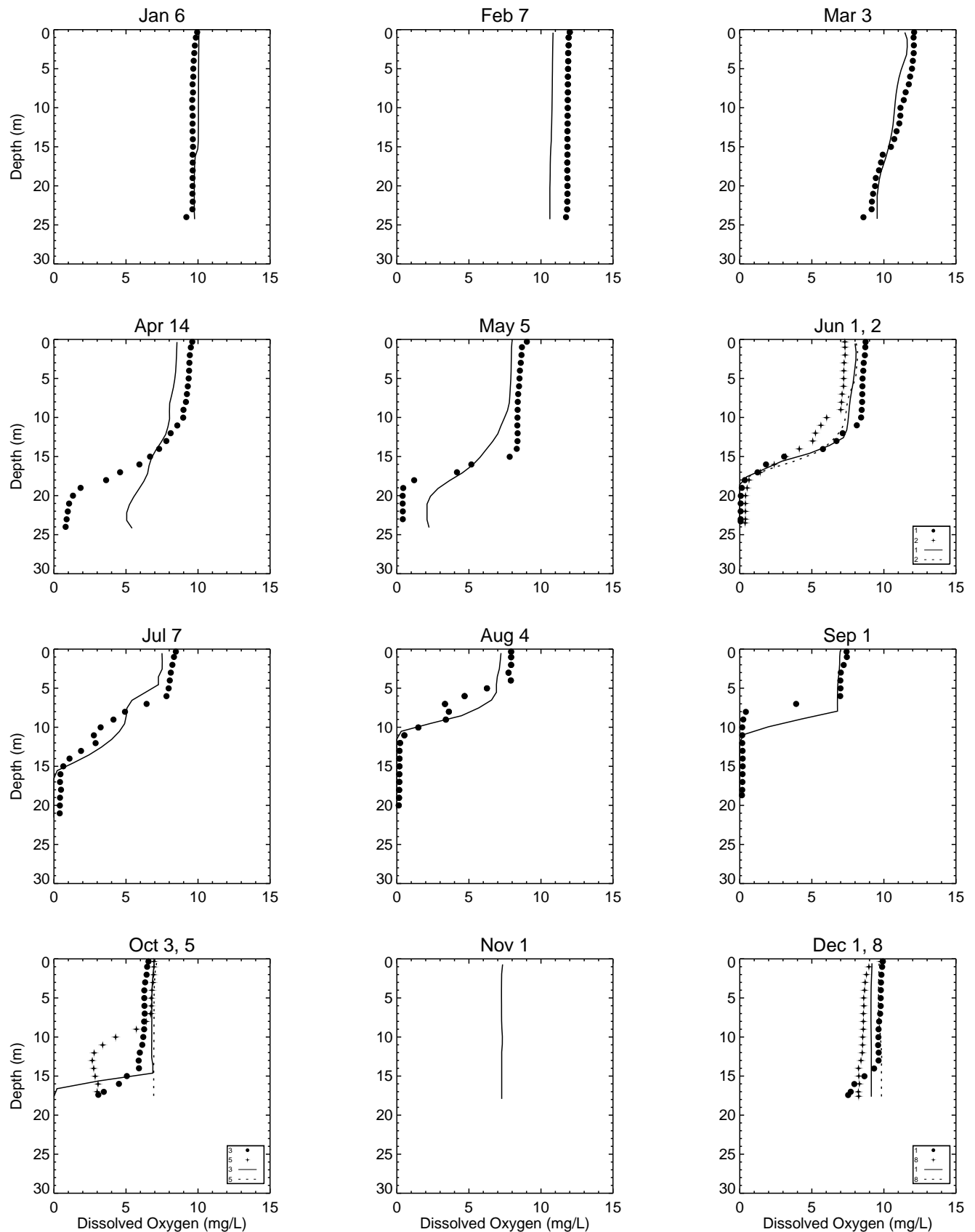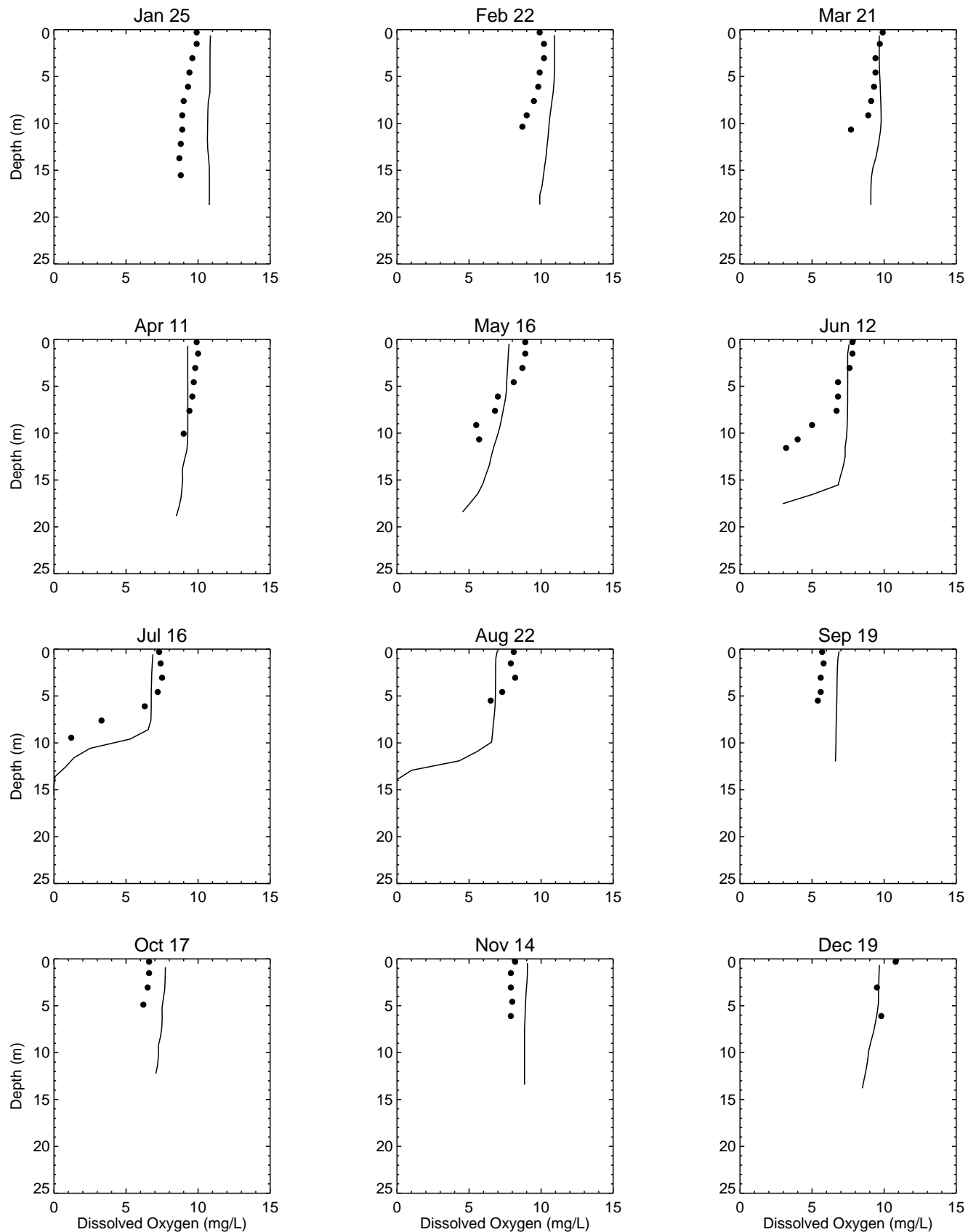
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:48 2013

Jan 25 · Feb 22 · Mar 21 · Apr 11 · May 16 · Jun 12 · Jul 16 · Aug 22 · Sep 19 · Oct 17 · Nov 14 · Dec 19

Depth (m)

Dissolved Oxygen (mg/L)

——— Model (w1210-48)
● Data

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 1984

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR
QEA
PARSONS

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
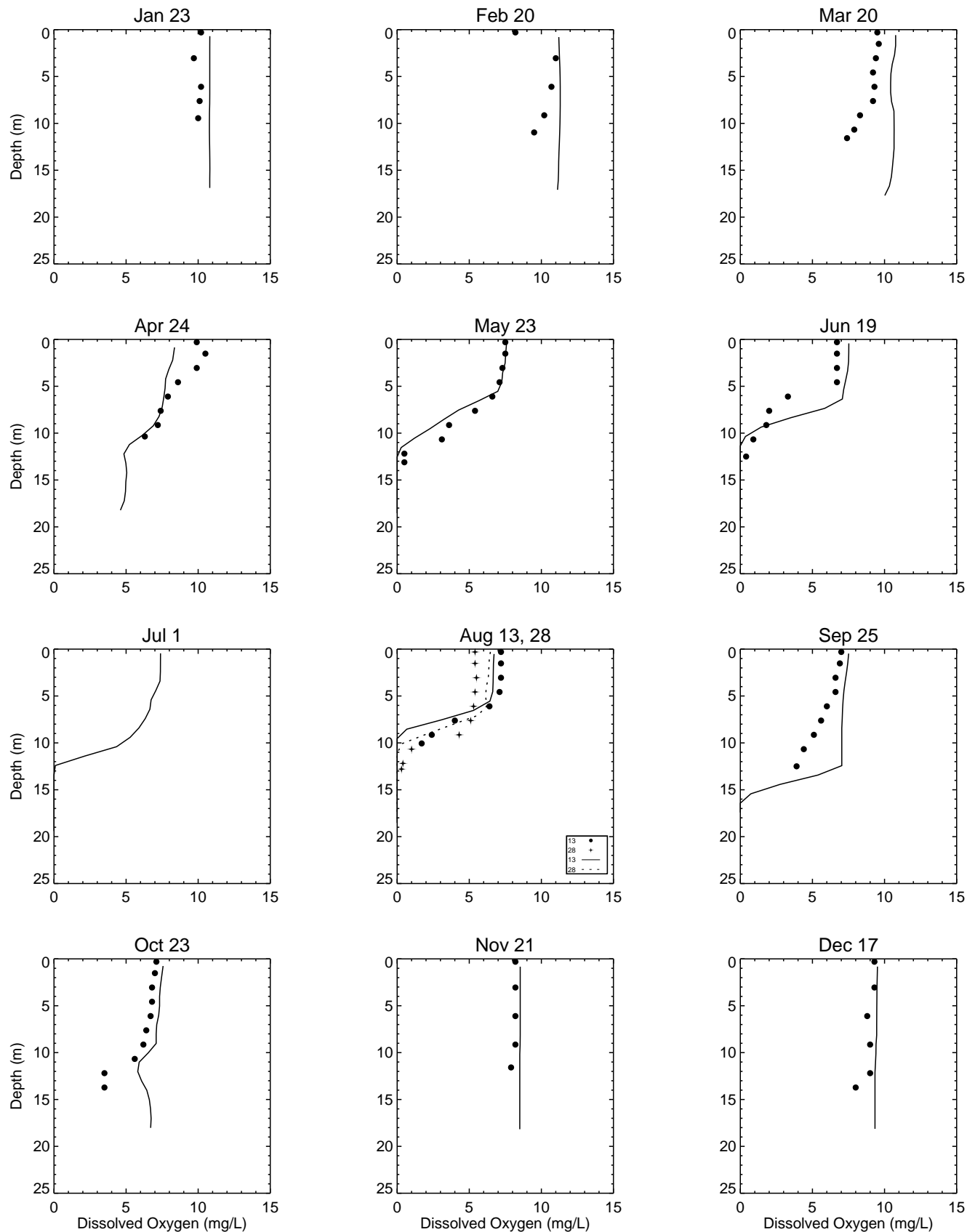Fri Jan 25 18:12:51 2013

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 1985

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 23 · Feb 19 · Mar 24 · Apr 15 · May 21 · Jun 18 · Jul 23 · Aug 20 · Sep 25 · Oct 21 · Nov 17 · Dec 16

Depth (m)

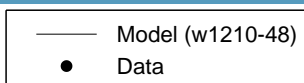Dissolved Oxygen (mg/L)
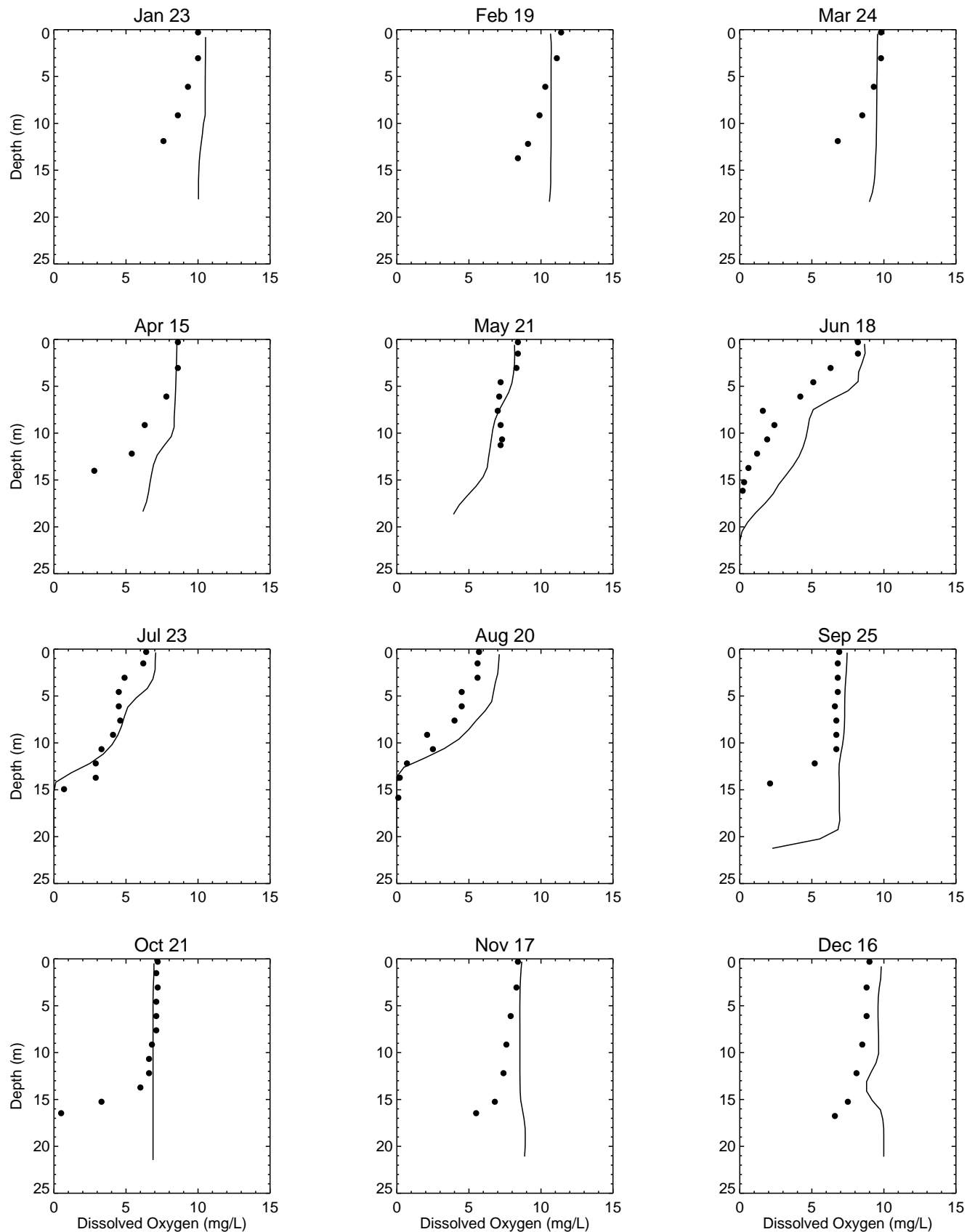
——— Model (w1210-48)
● Data

Figure G-32
Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 1986
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR
QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:51 2013

Jan 19 | Feb 23 | Mar 18
Apr 27 | May 20 | Jun 15
Jul 21 | Aug 20 | Sep 16
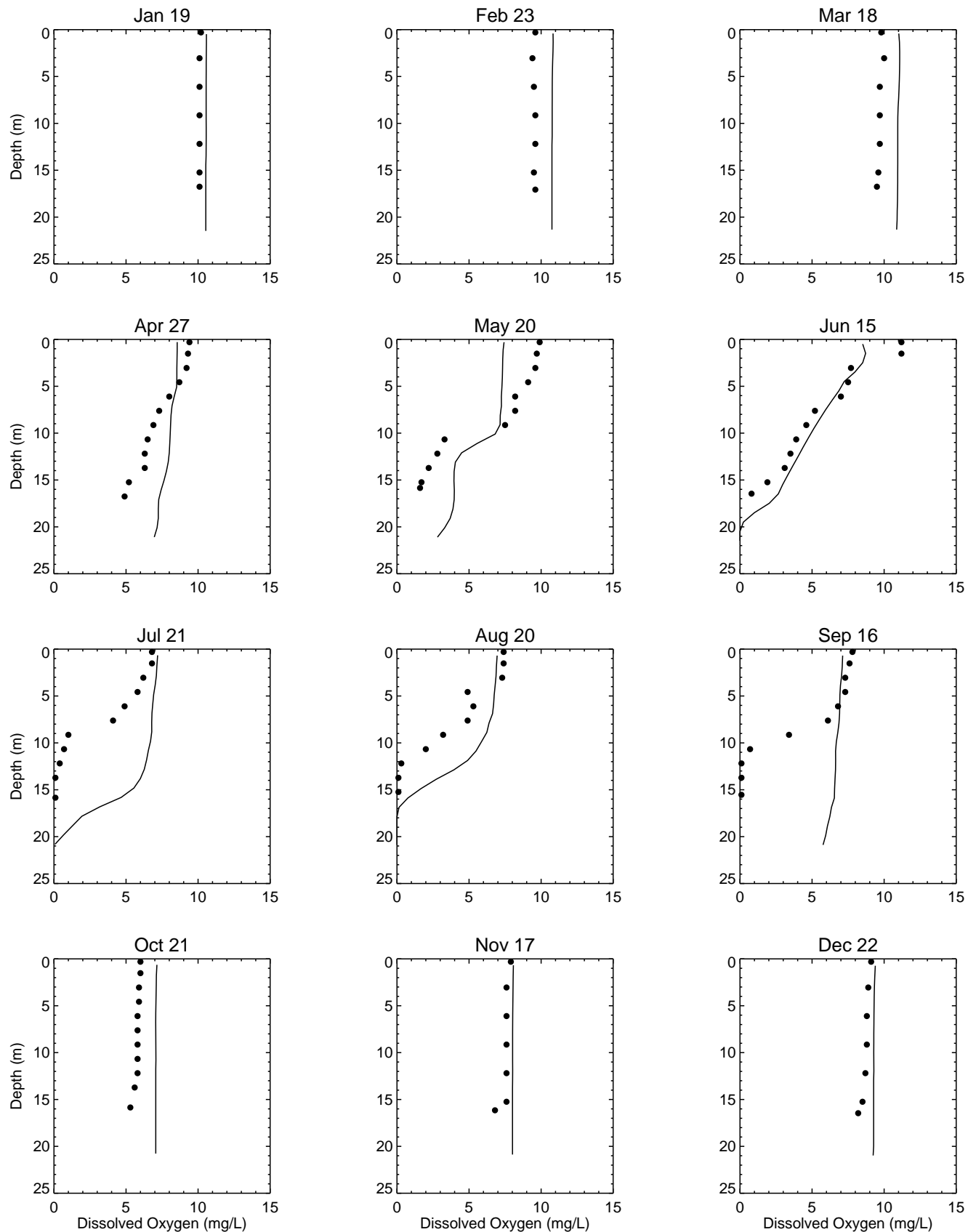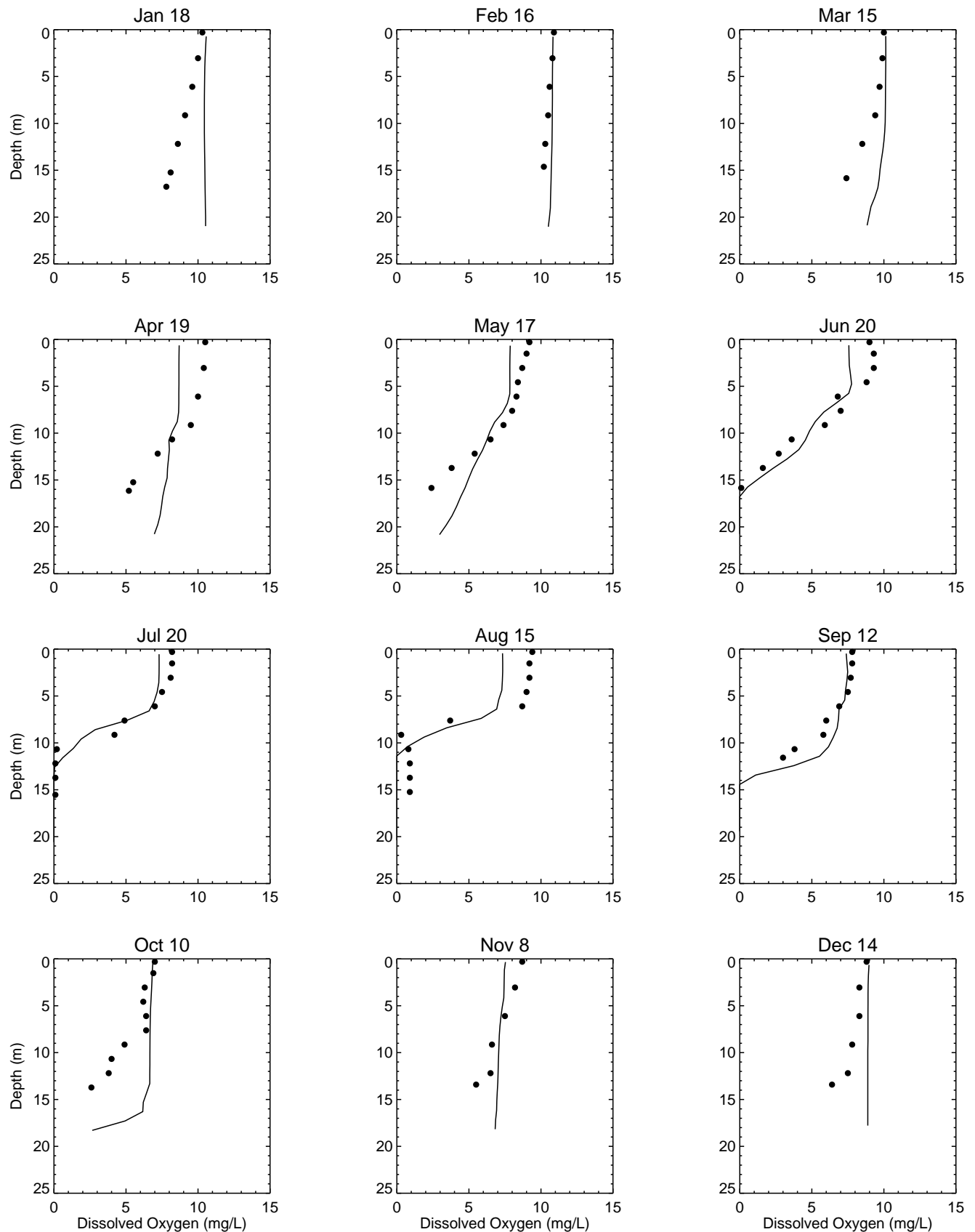Oct 21 | Nov 17 | Dec 22

——— Model (w1210-48)
● Data

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 1987

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
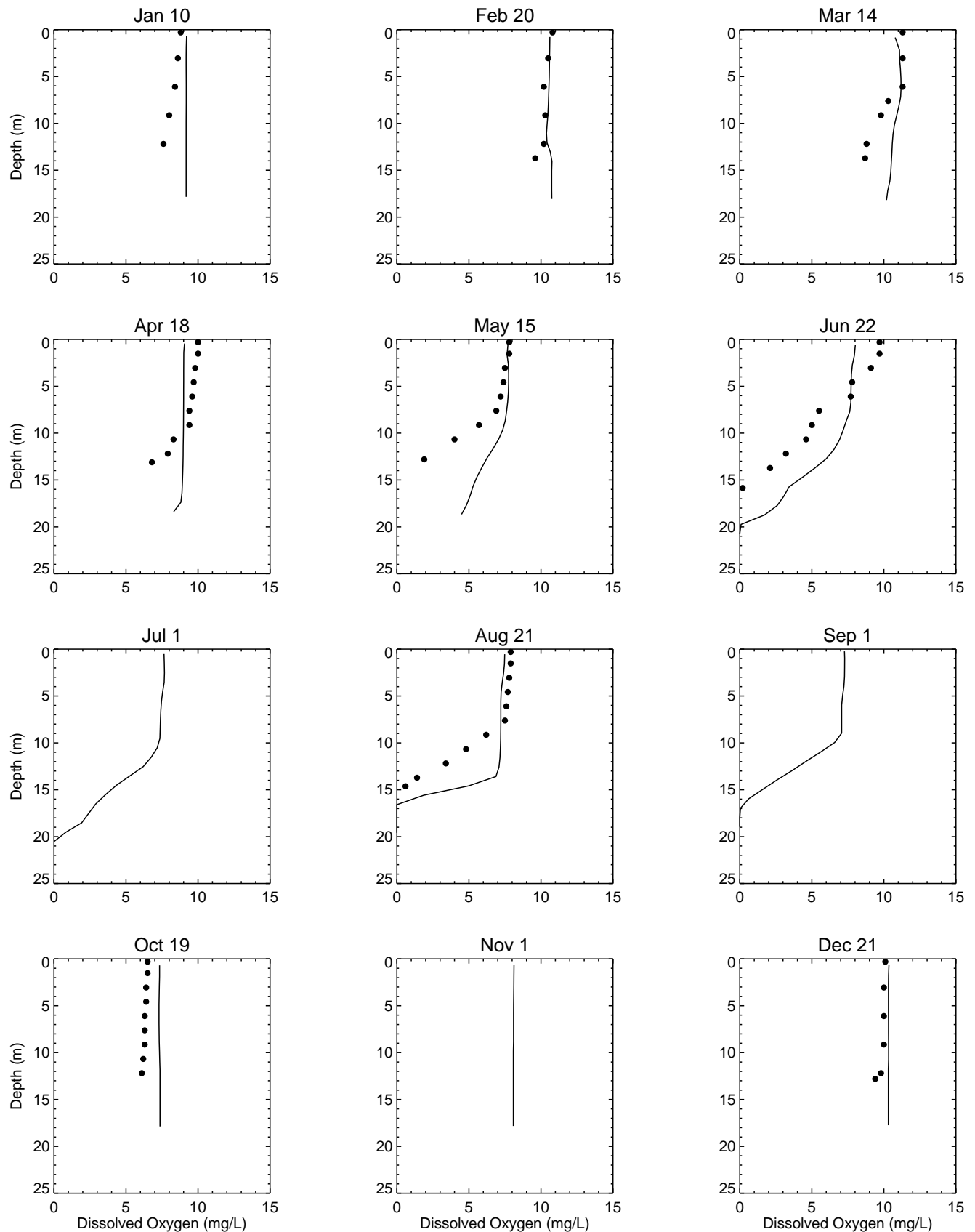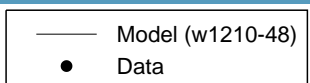
Lower Colorado River Authority

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 1988

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:51 2013

Jan 1 / Feb 1 / Mar 1 / Apr 3 / May 1 / Jun 5 / Jul 1 / Aug 1 / Sep 1 / Oct 1 / Nov 1 / Dec 1

Dissolved Oxygen (mg/L)
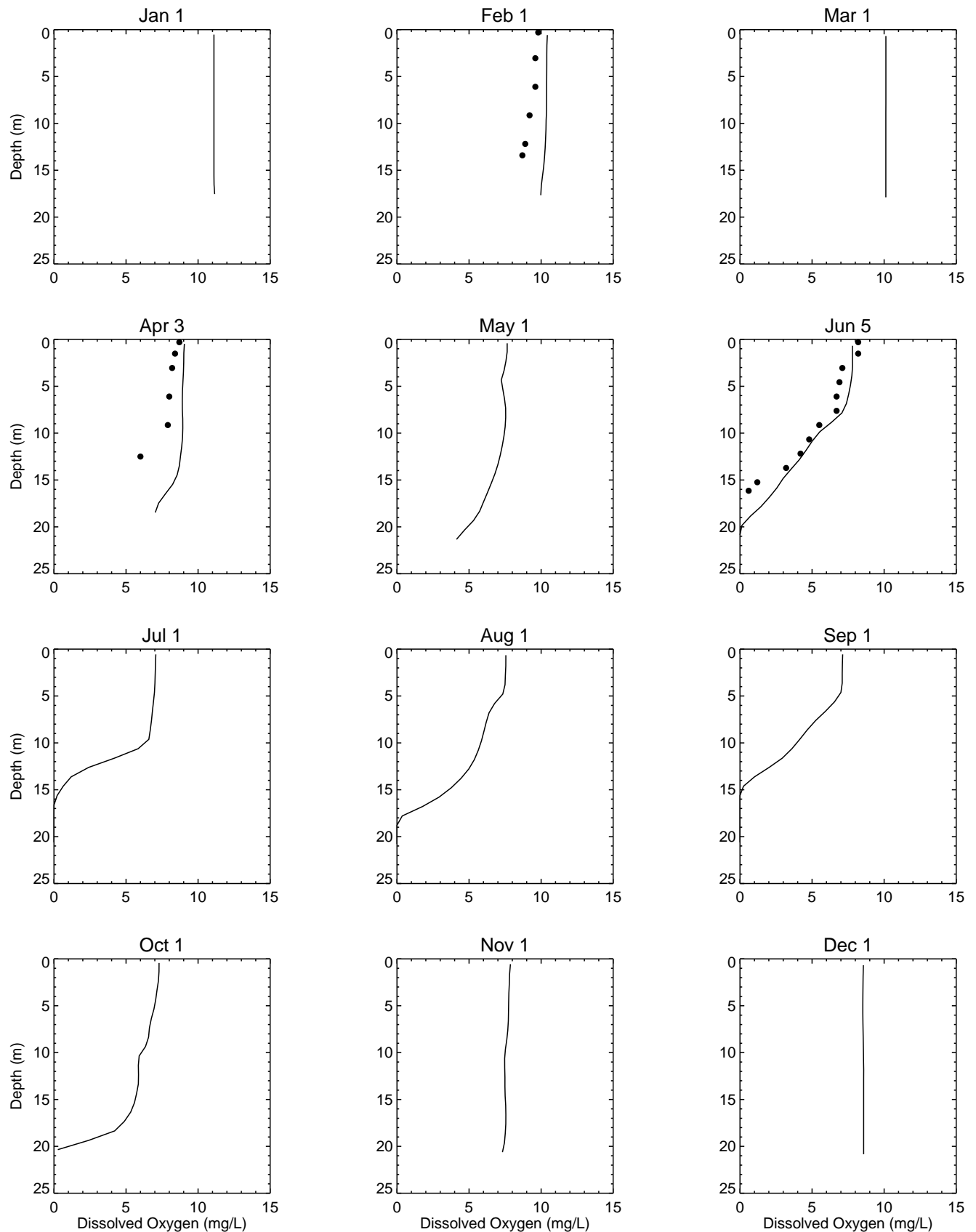
Depth (m)

——— Model (w1210-48)
● Data

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 1990
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

ANCHOR QEA PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:51 2013

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 1991

Profiles shown for dates with available data else model results for first day of month shown.
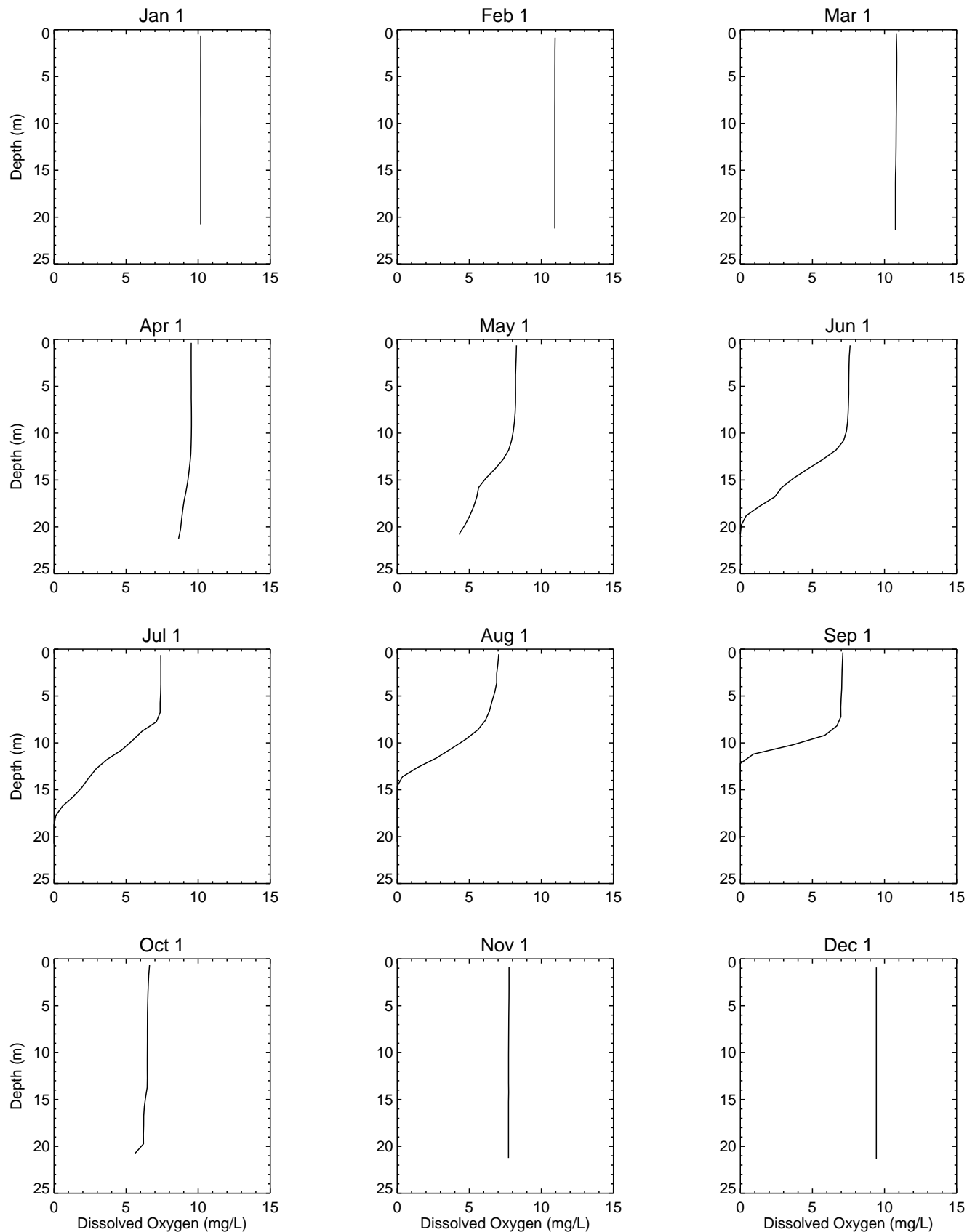
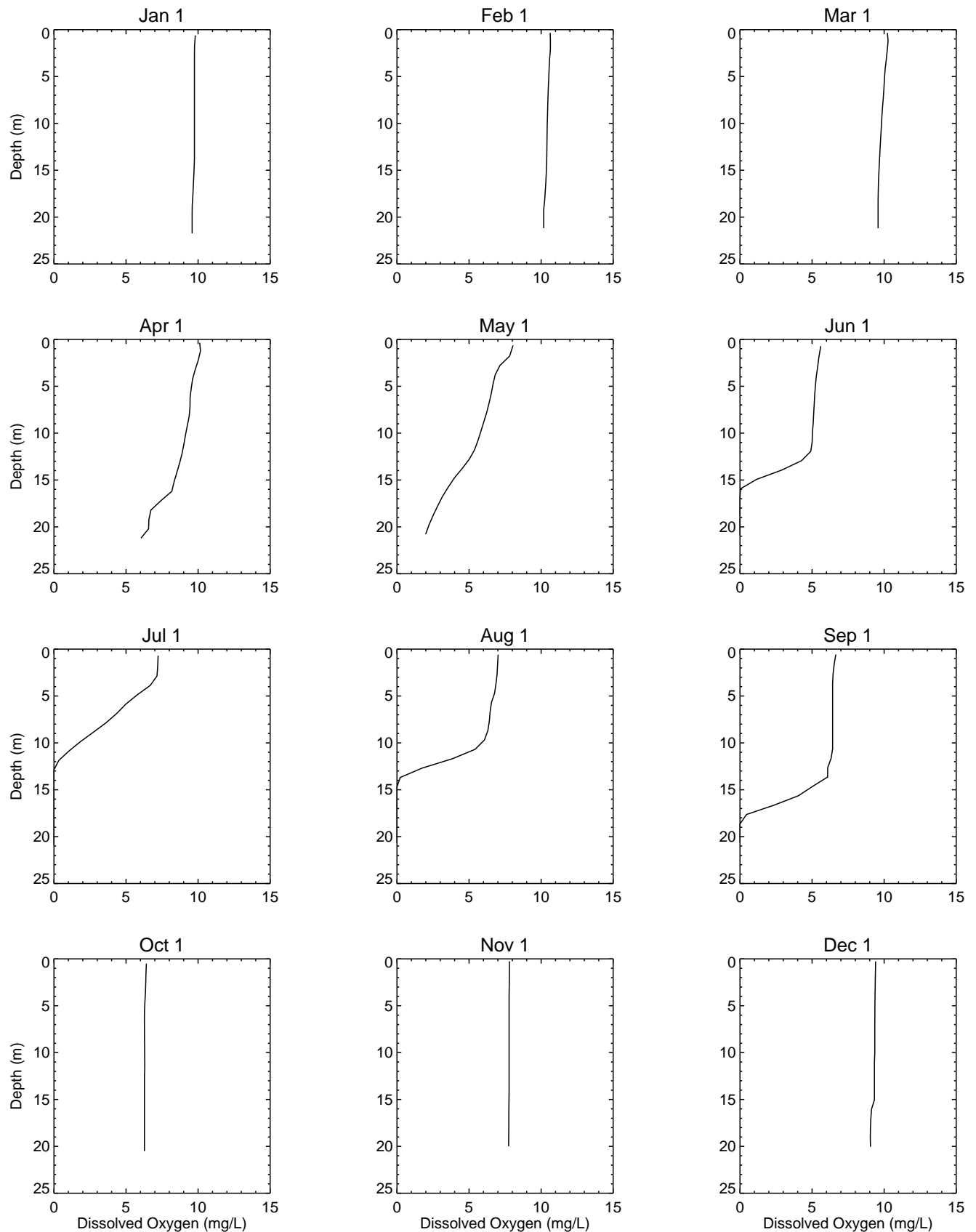CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
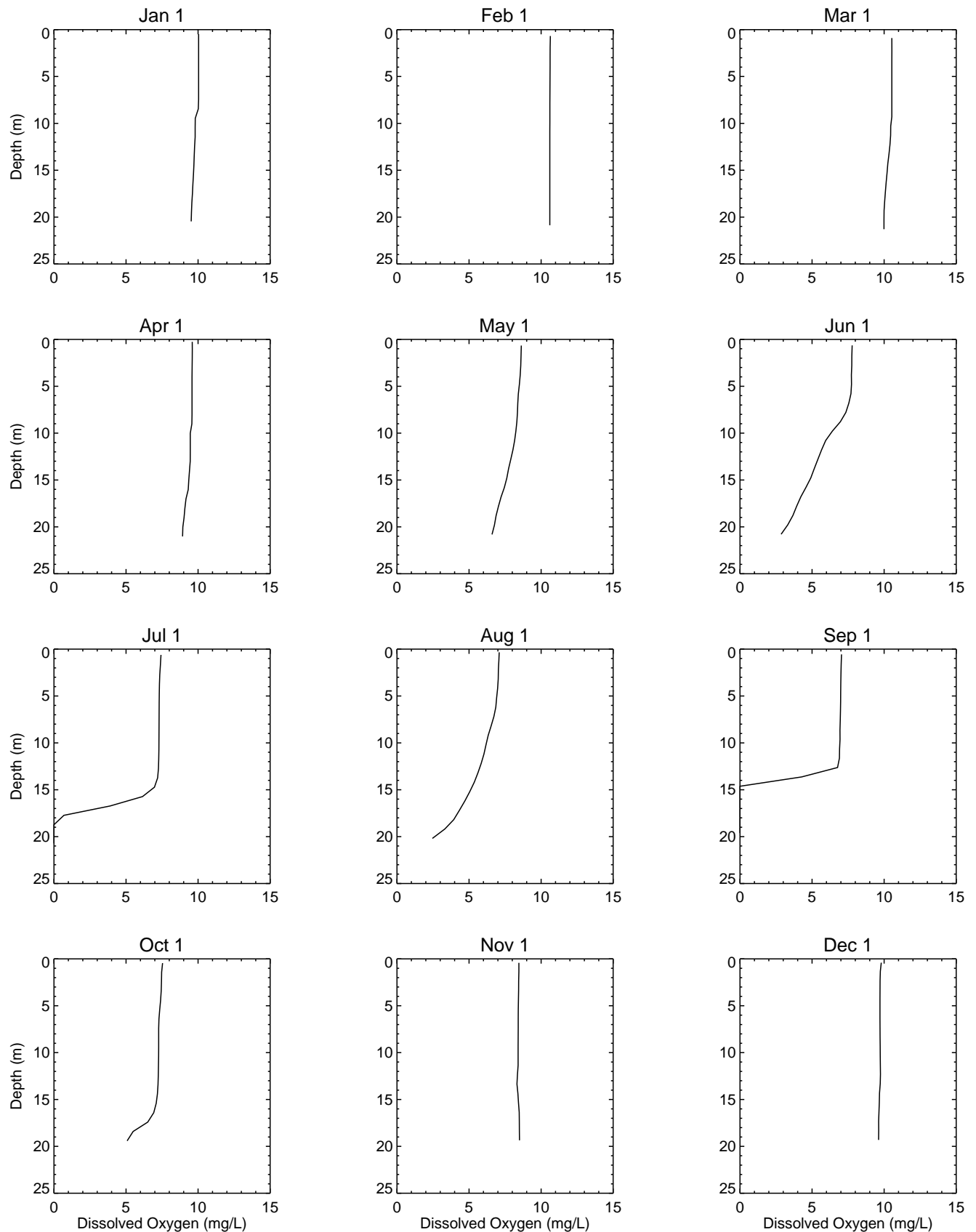
Lower Colorado River Authority

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 1993

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
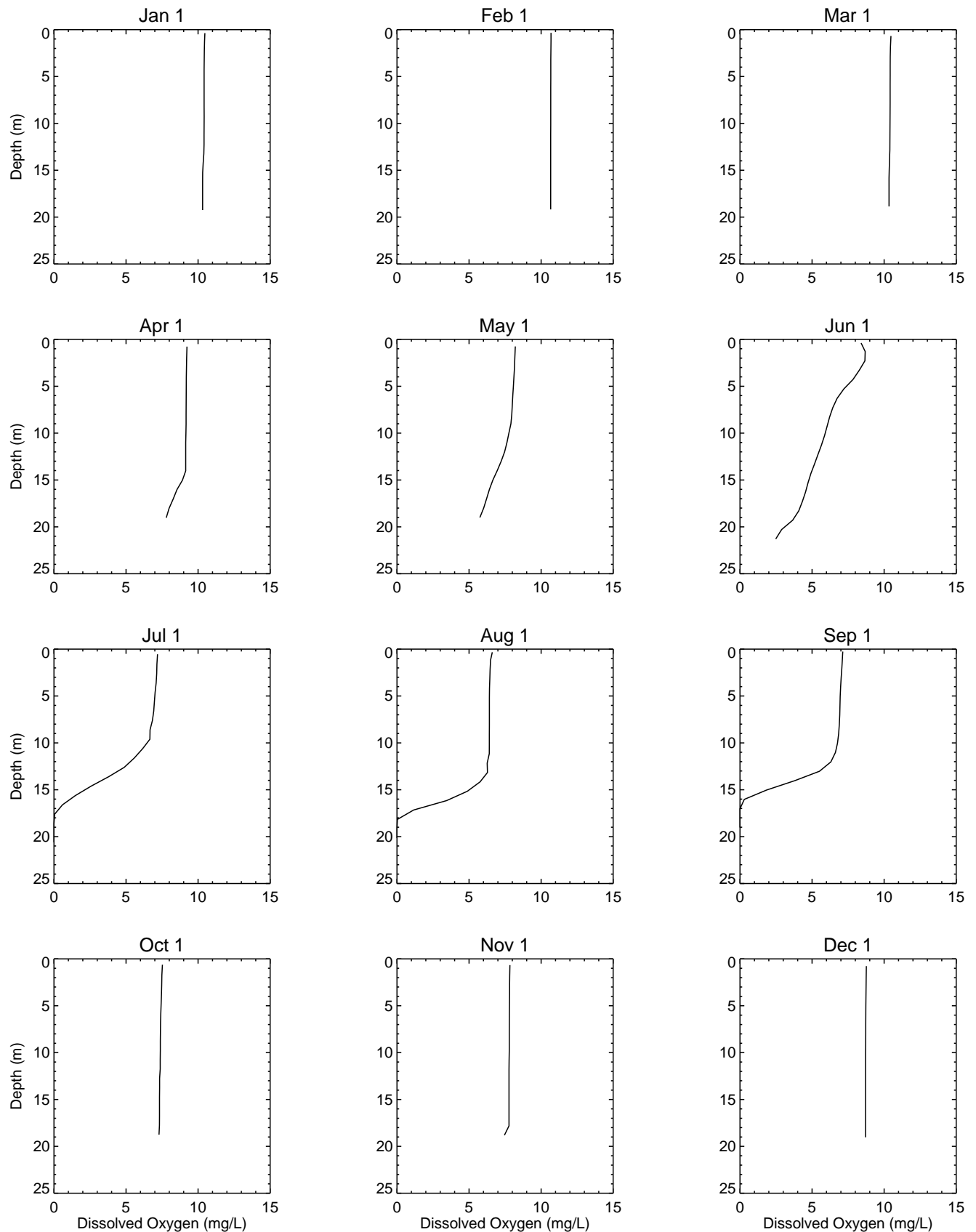Fri Jan 25 18:12:51 2013

Figure G-32
Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 1994
Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:51 2013

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m) vs Dissolved Oxygen (mg/L)
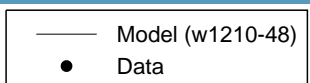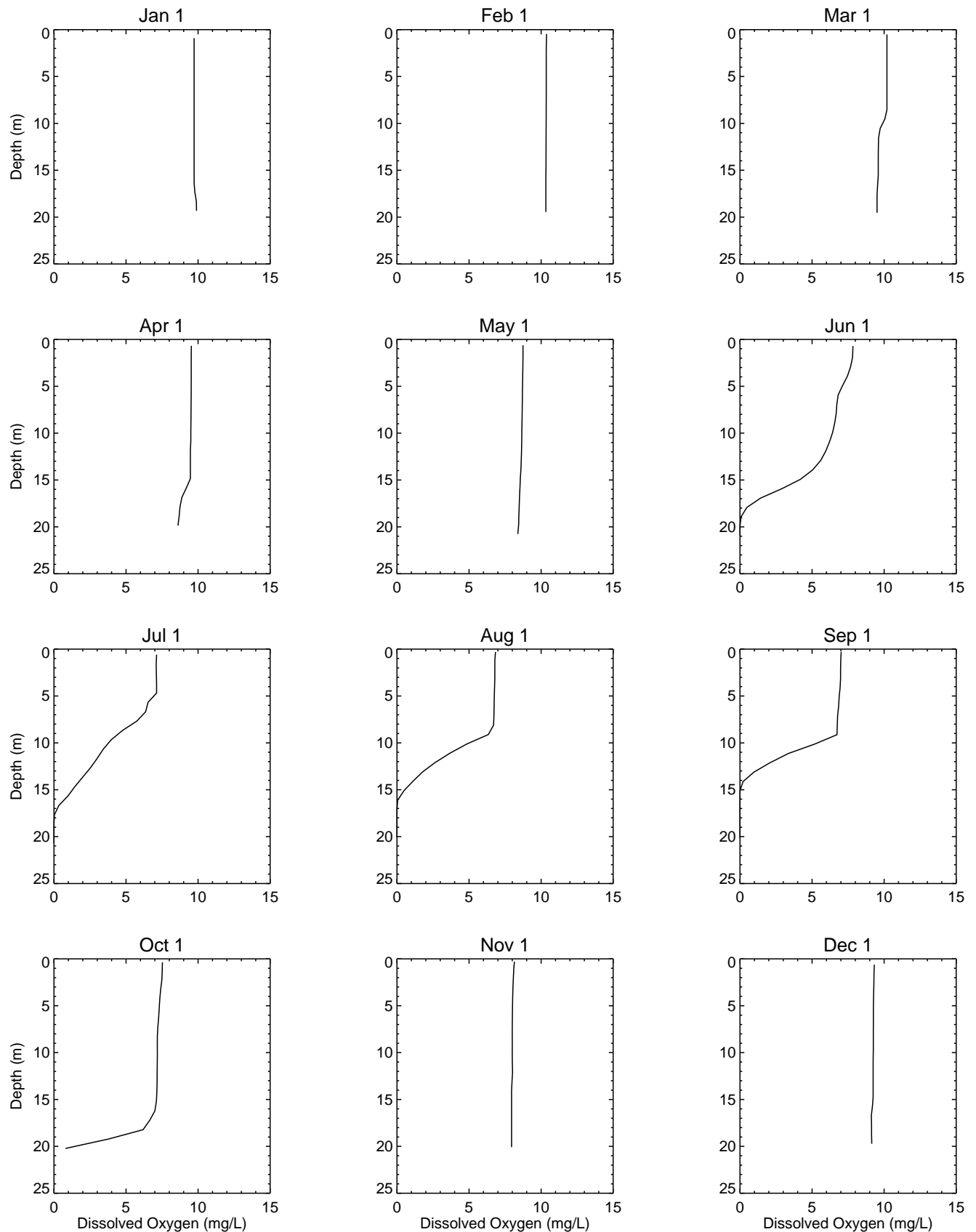
Model (w1210-48)
● Data

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 1995

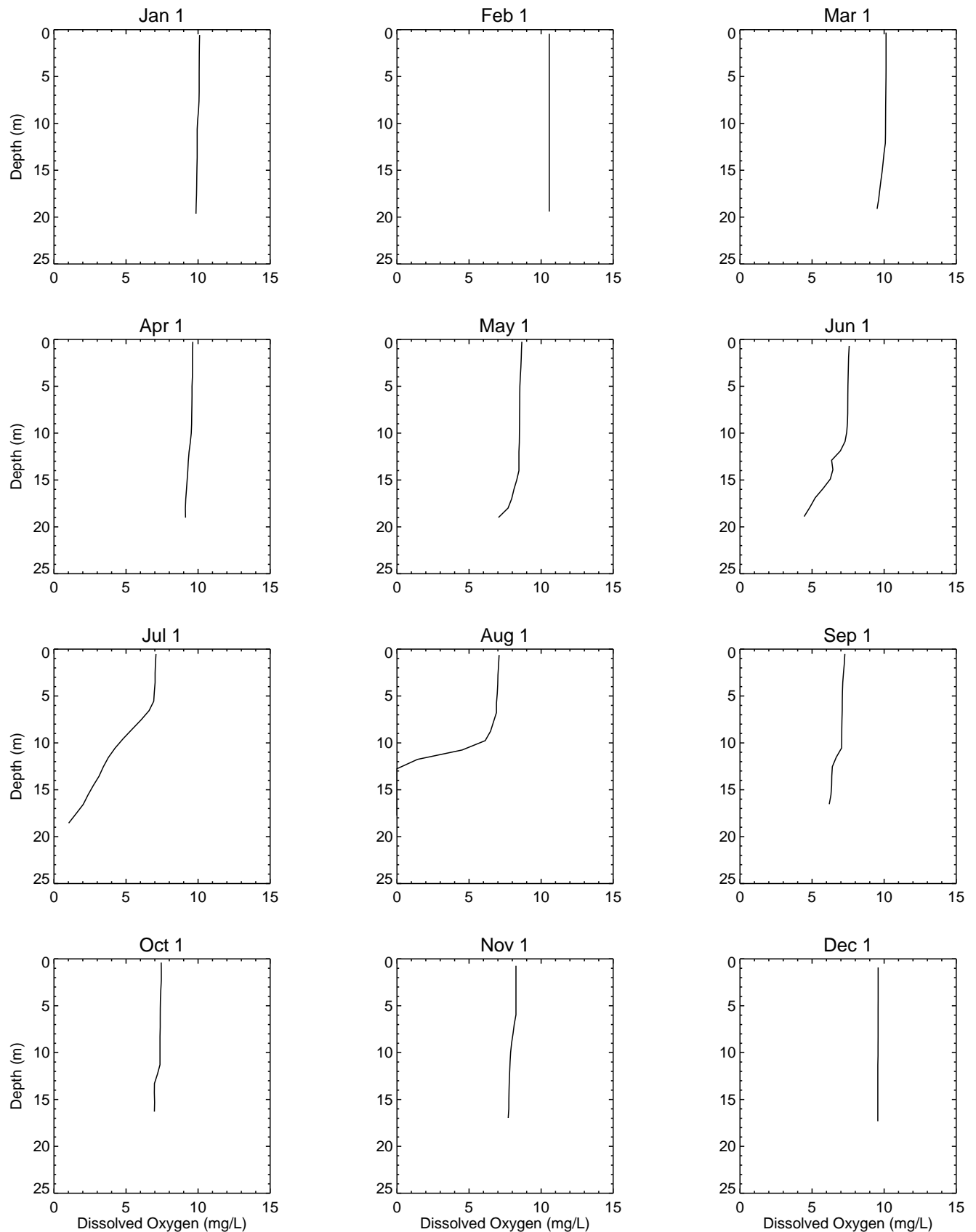*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:51 2013

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 1996

Profiles shown for dates with available data else model results for first day of month shown.
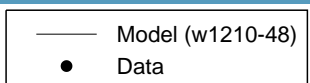
CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Jan 1   Feb 1   Mar 1

Apr 1   May 1   Jun 1

Jul 1   Aug 1   Sep 1

Oct 1   Nov 1   Dec 1
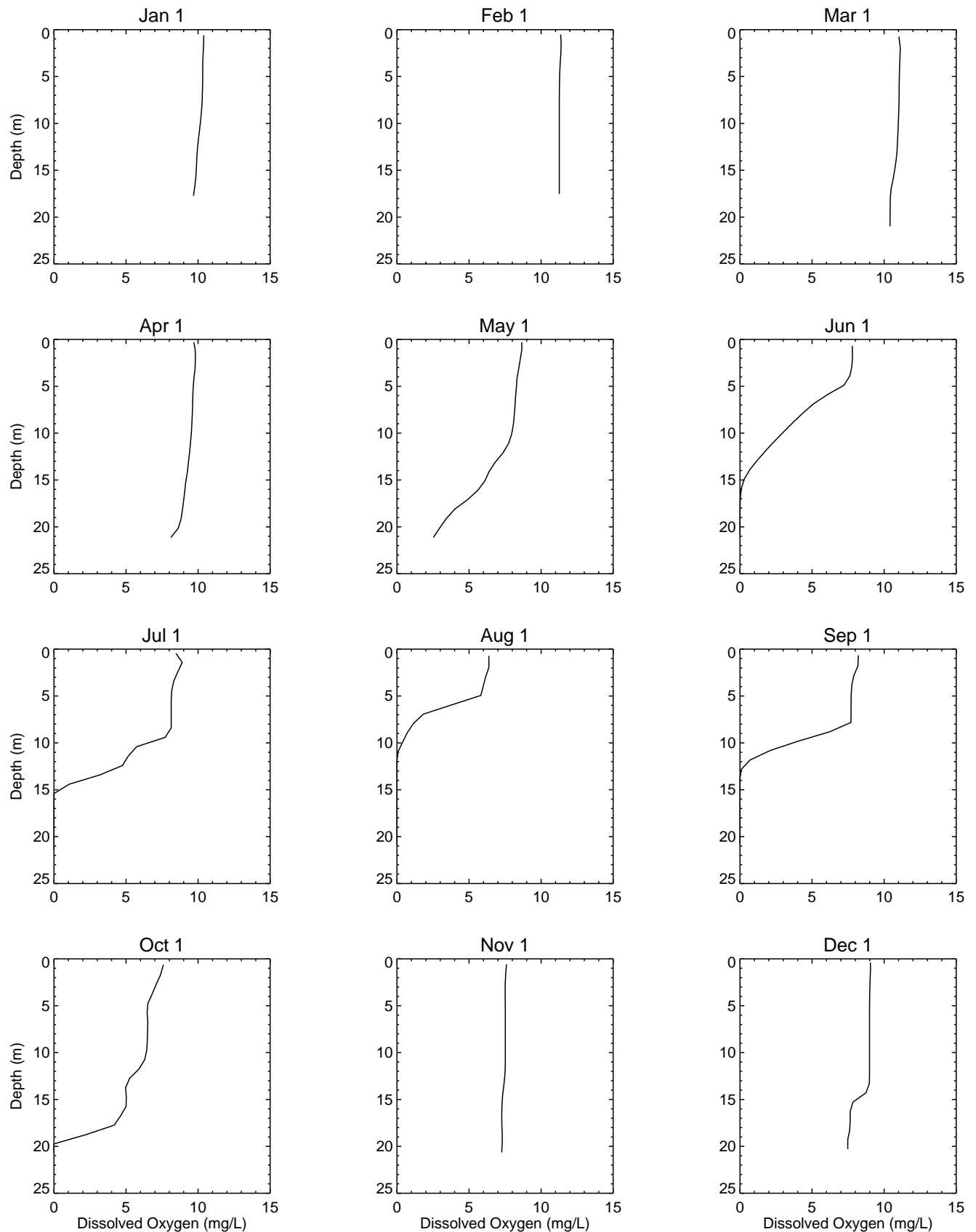
—— Model (w1210-48)
● Data

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 1997

Profiles shown for dates with available data else model results for first day of month shown.
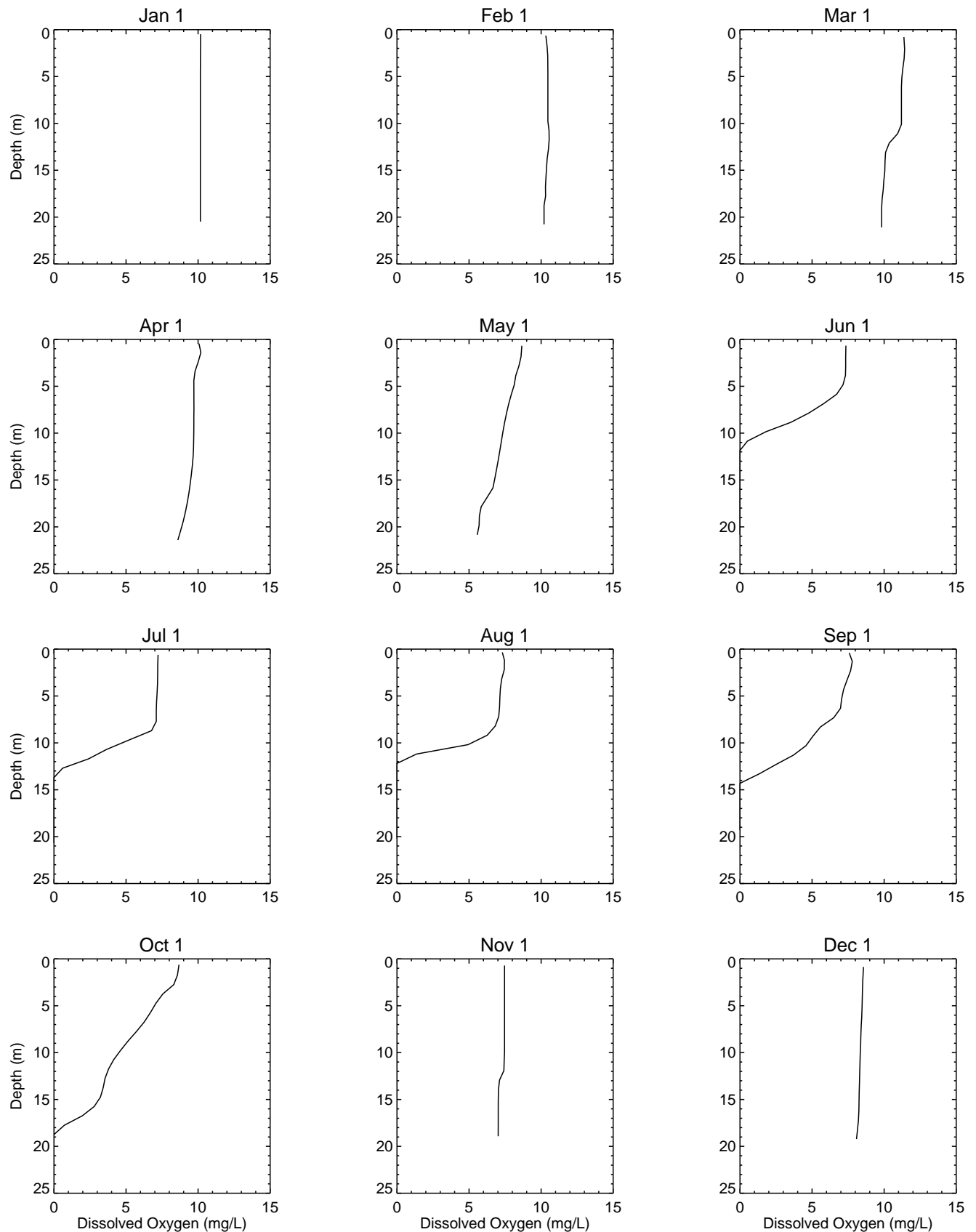
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 1998

Profiles shown for dates with available data else model results for first day of month shown.

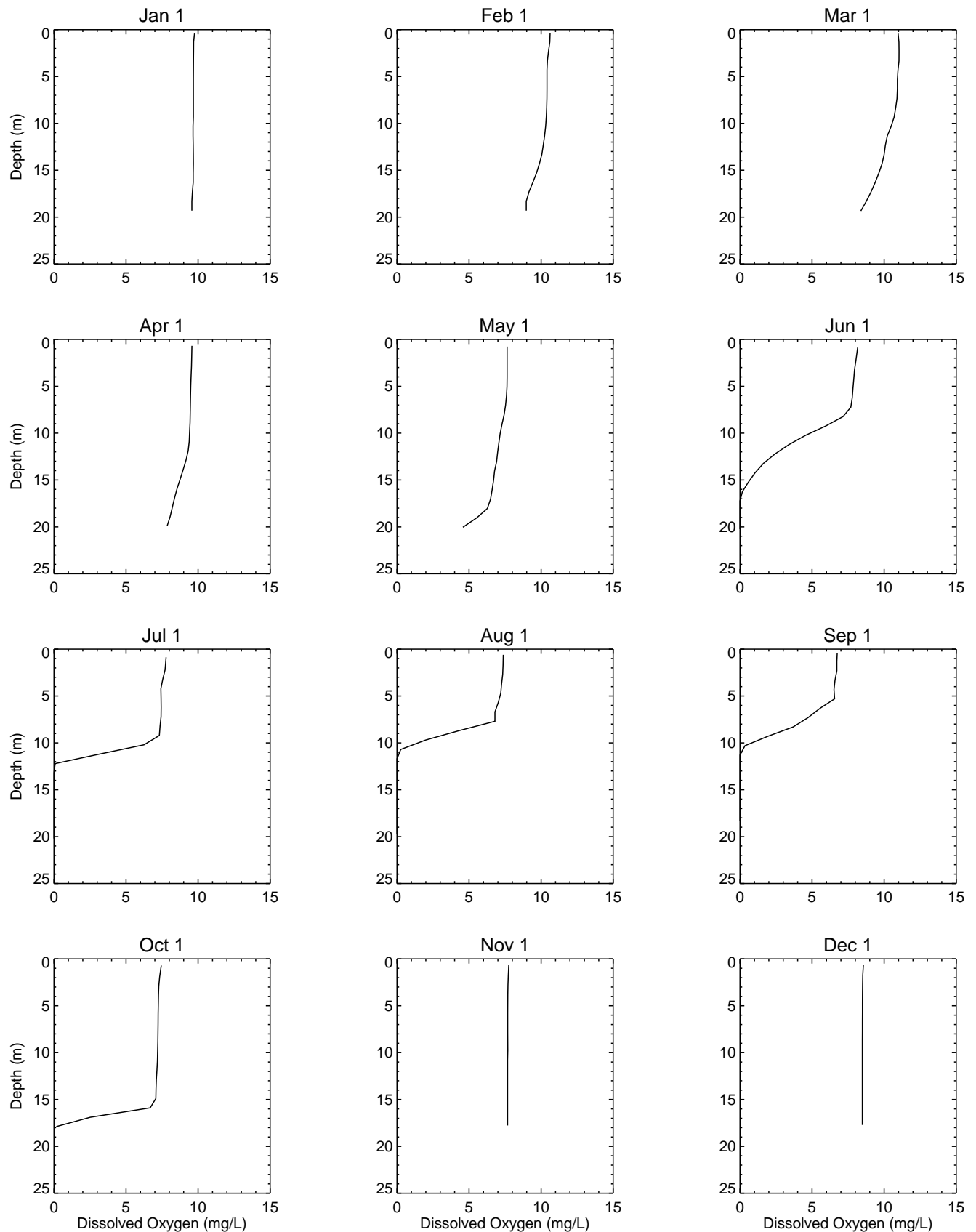CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 1999

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1, Feb 1, Mar 1, Apr 1, May 1, Jun 1, Jul 1, Aug 1, Sep 1, Oct 1, Nov 1, Dec 1

Depth (m)

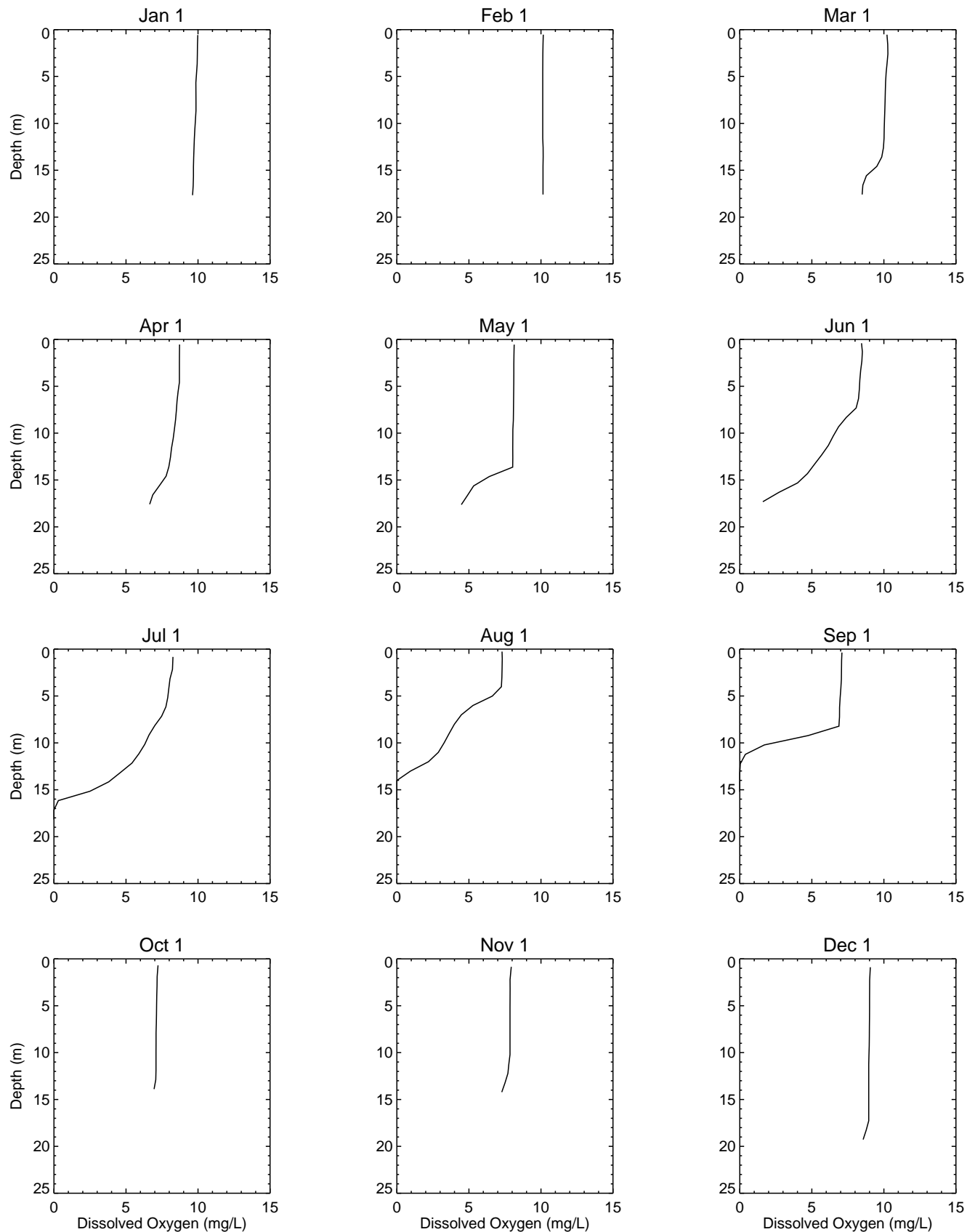Dissolved Oxygen (mg/L)
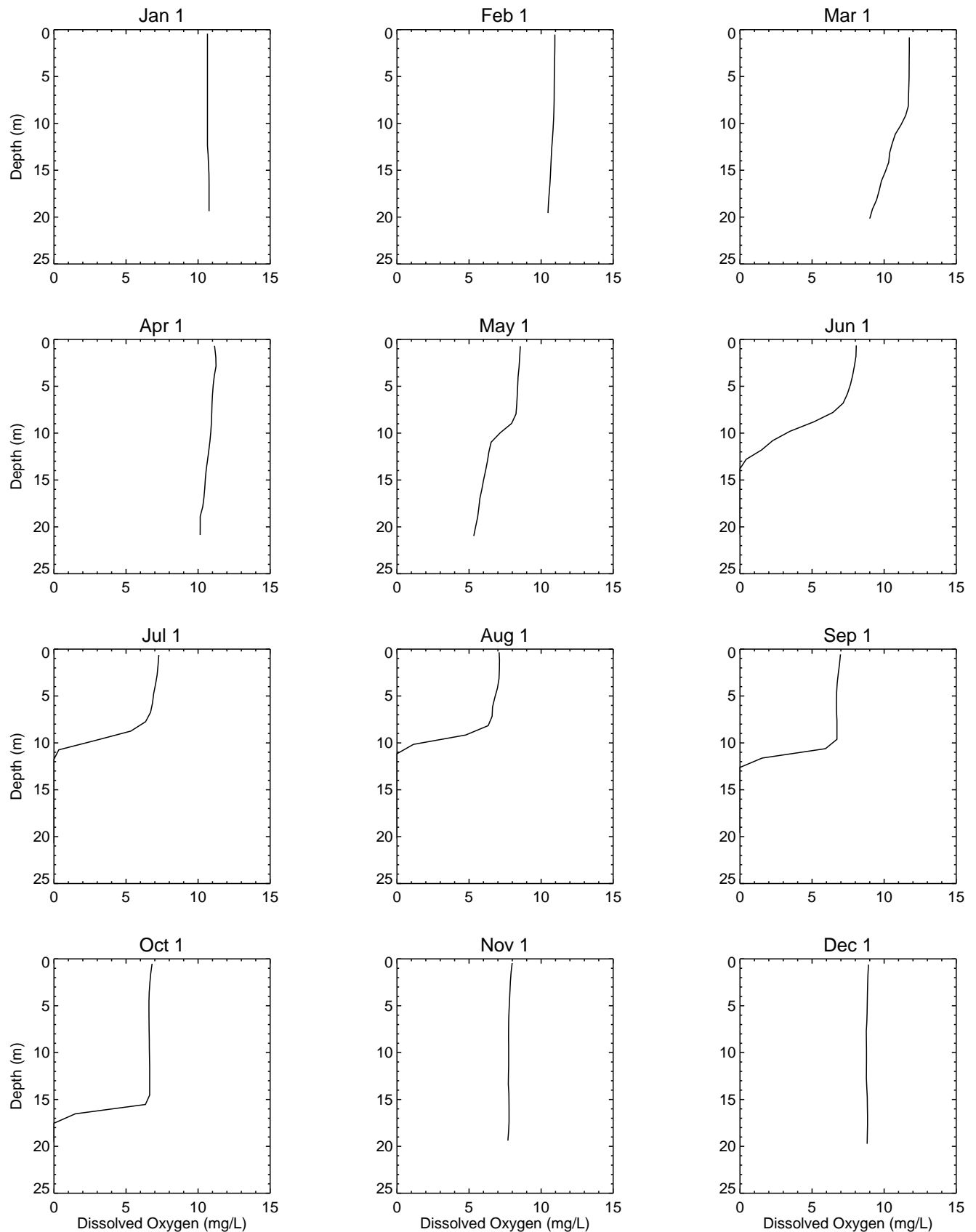
Model (w1210-48)
● Data

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 2000

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 Feb 1 Mar 1

Apr 1 May 1 Jun 1

Jul 1 Aug 1 Sep 1

Oct 1 Nov 1 Dec 1

Depth (m)

Dissolved Oxygen (mg/L)
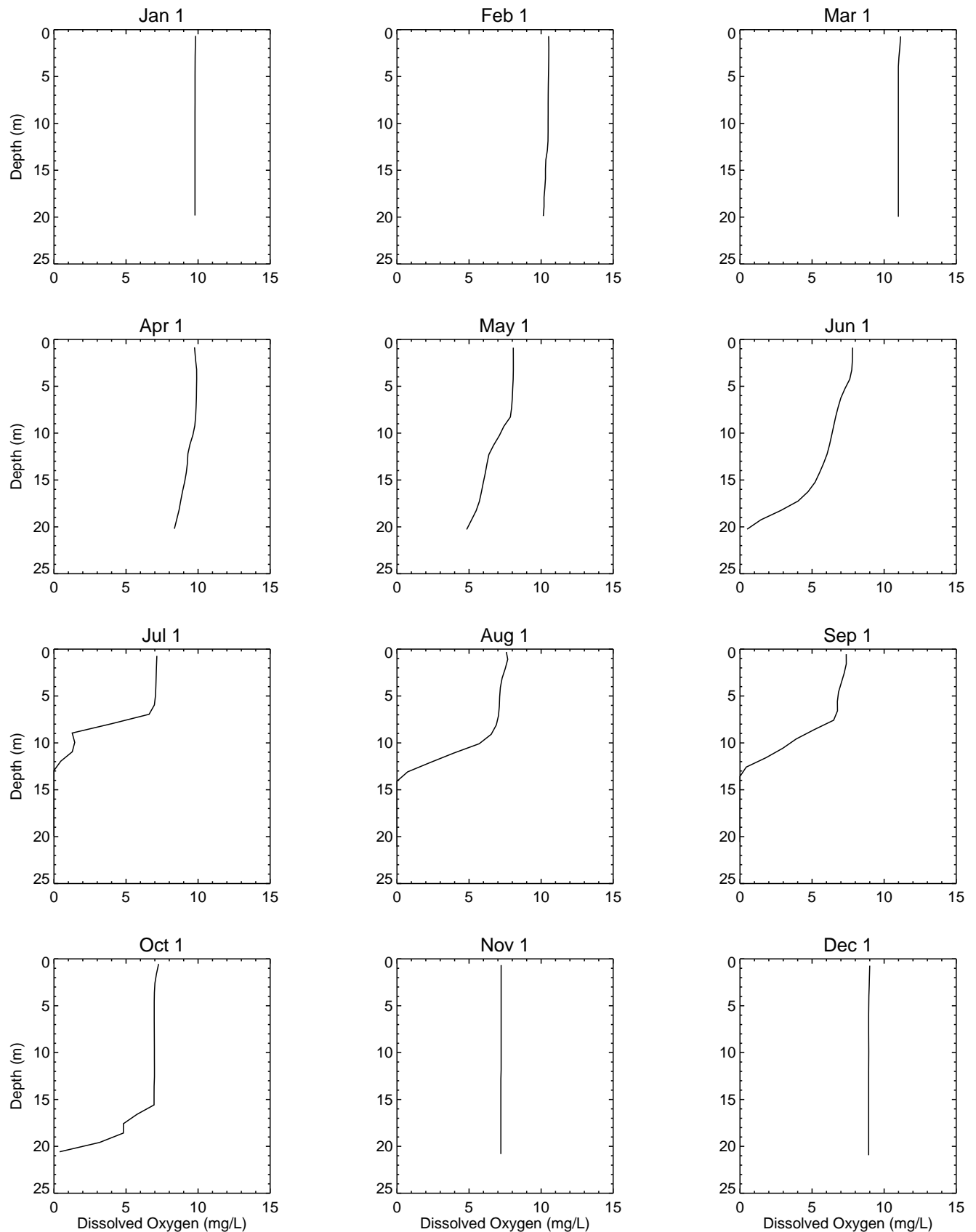
——— Model (w1210-48)
● Data

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 2001

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR
QEA
PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:52 2013

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m) vs Dissolved Oxygen (mg/L)
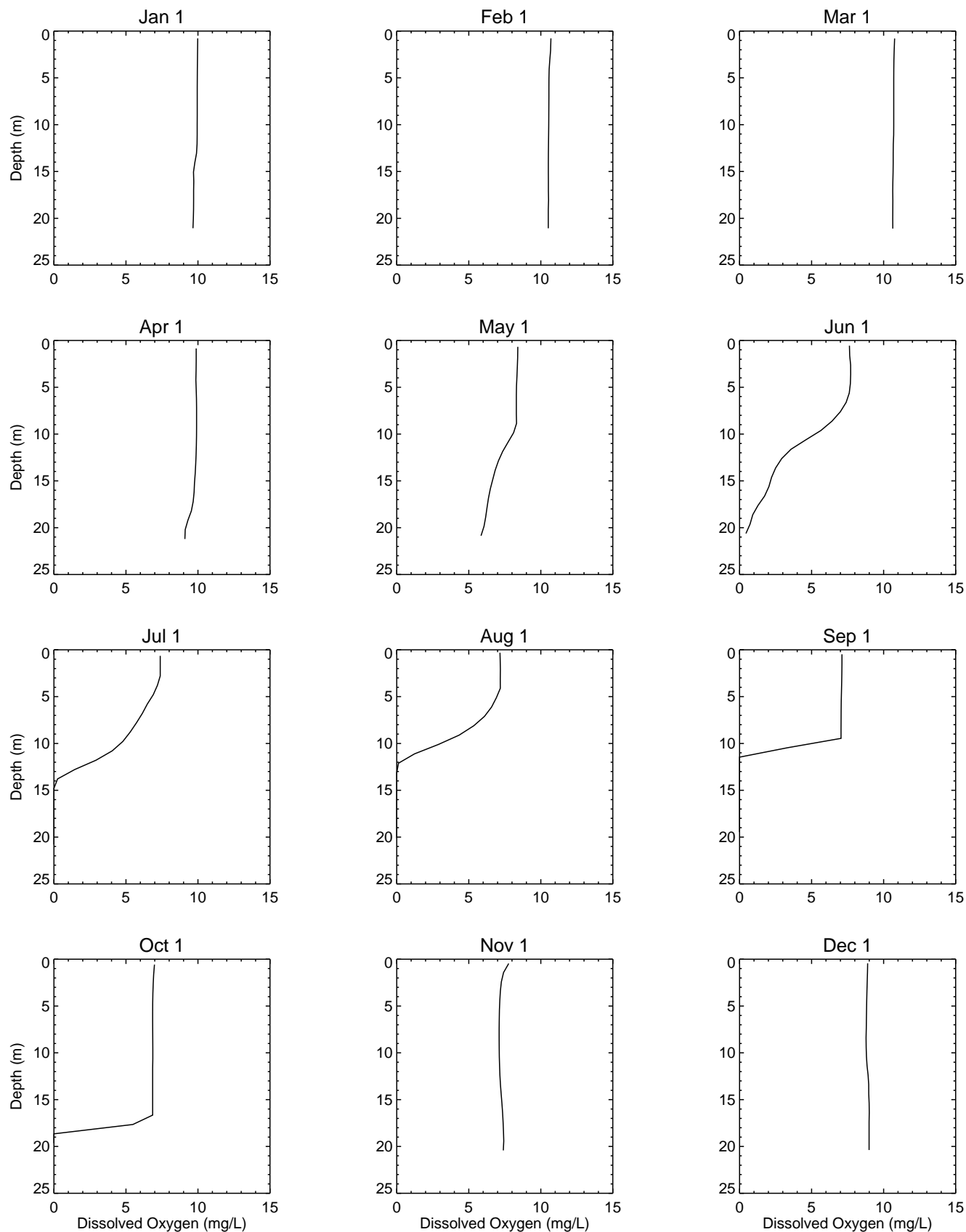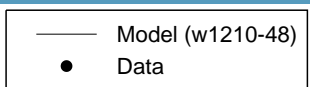
Model (w1210-48)
● Data

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 2002

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
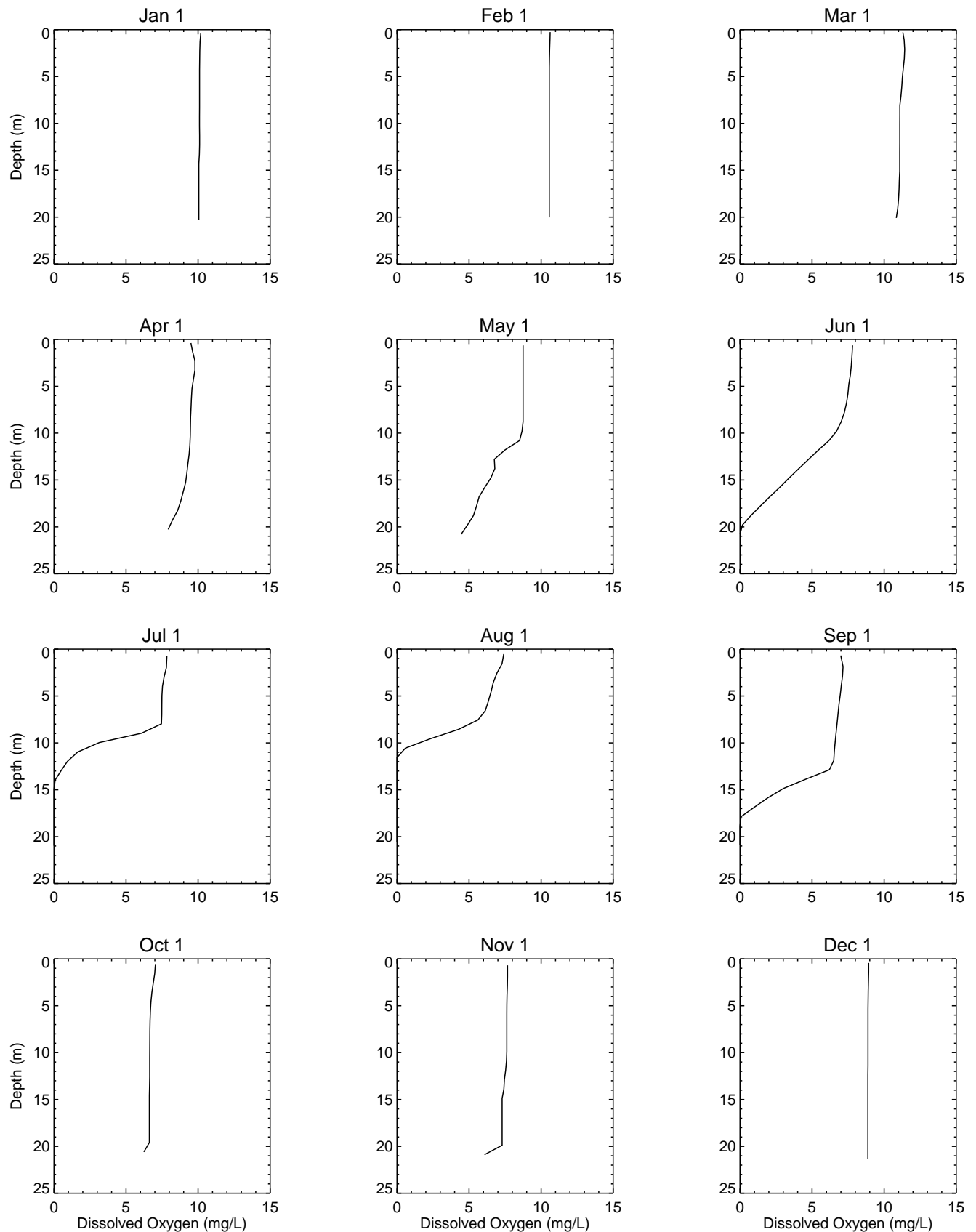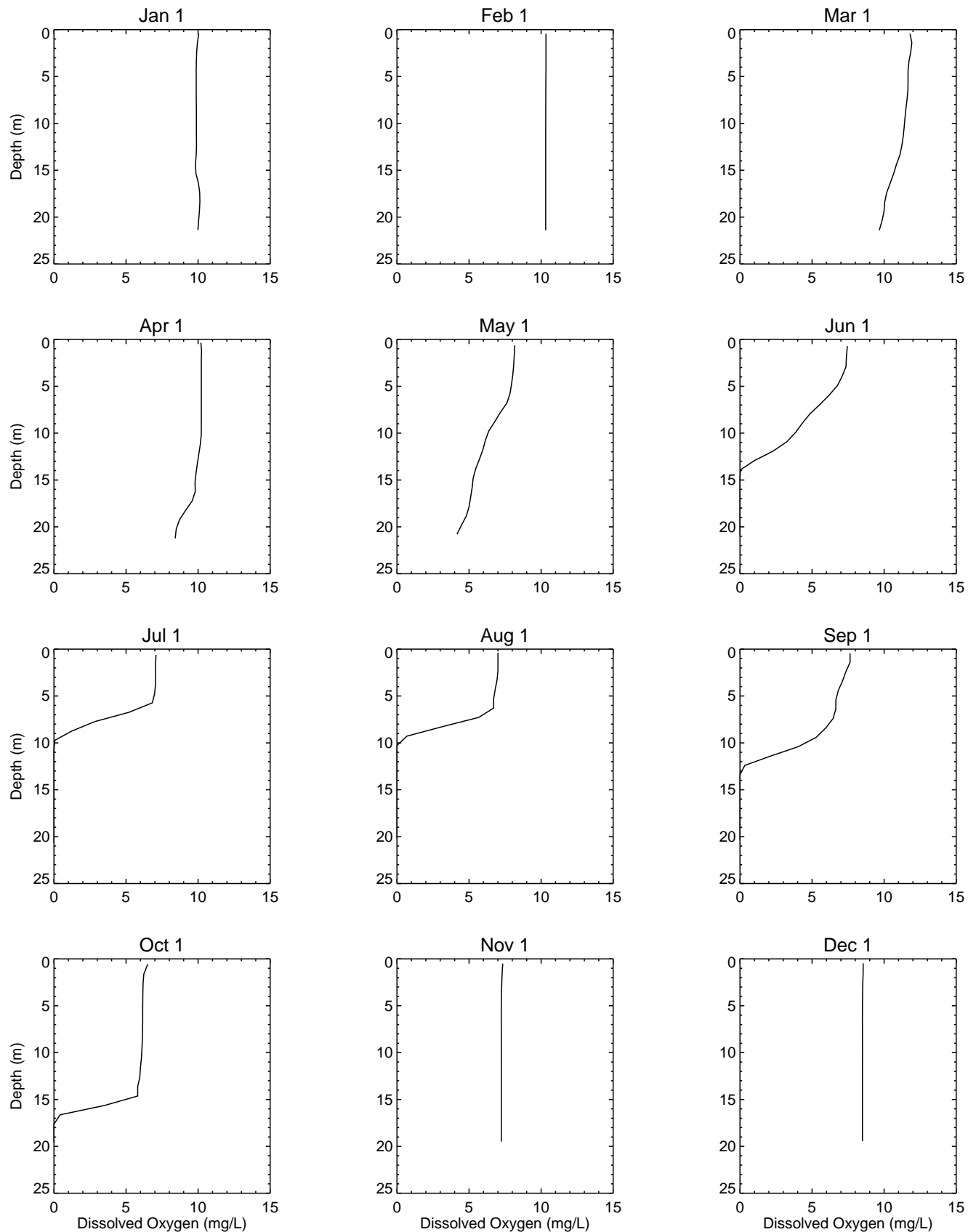Fri Jan 25 18:12:52 2013

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 2003

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

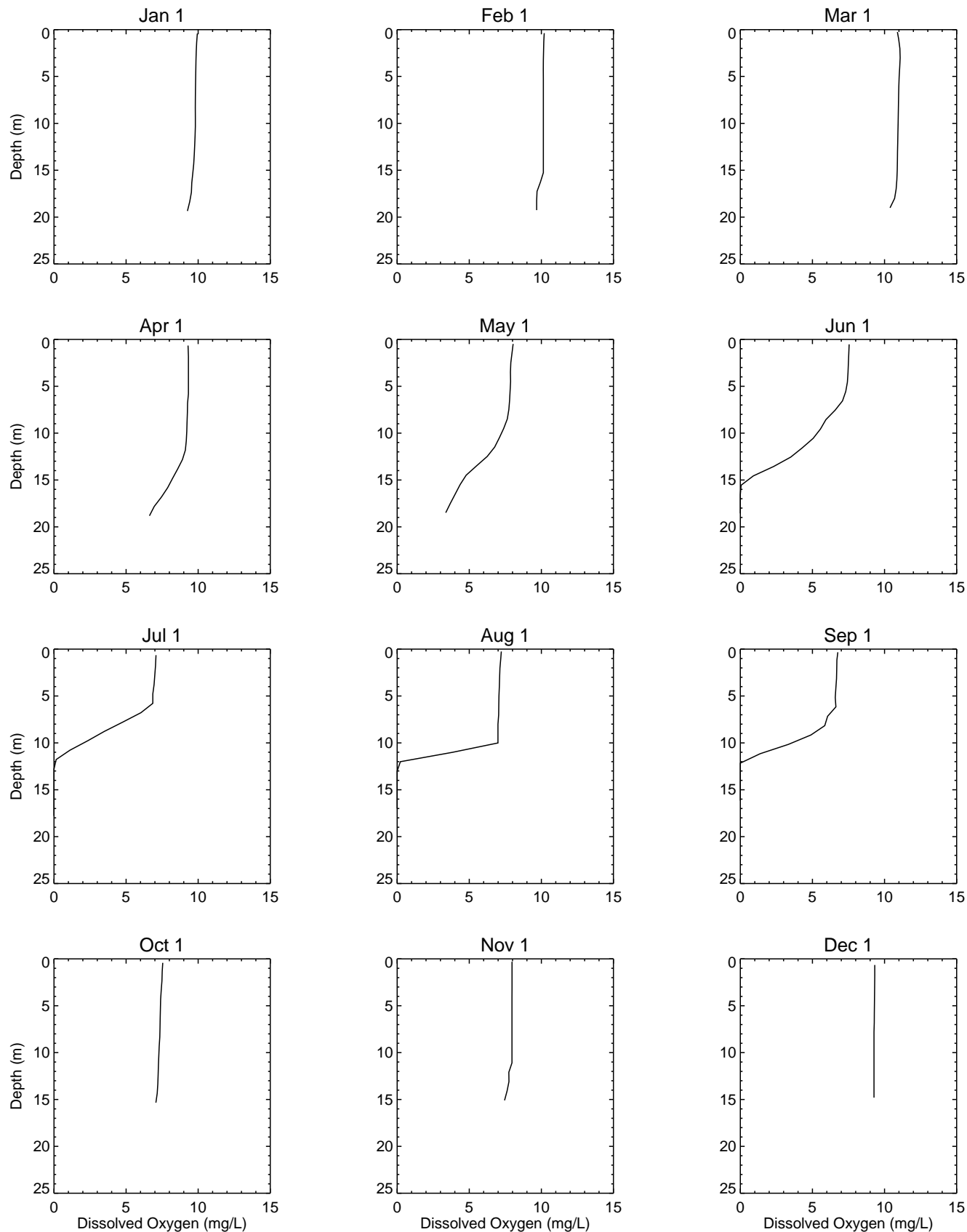Depth (m) vs Dissolved Oxygen (mg/L)

Model (w1210-48)
● Data

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 2004

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA
PARSONS

CREMs Phase 4: Lake Buchanan
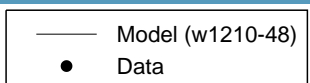
Lower Colorado River Authority

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 2005

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

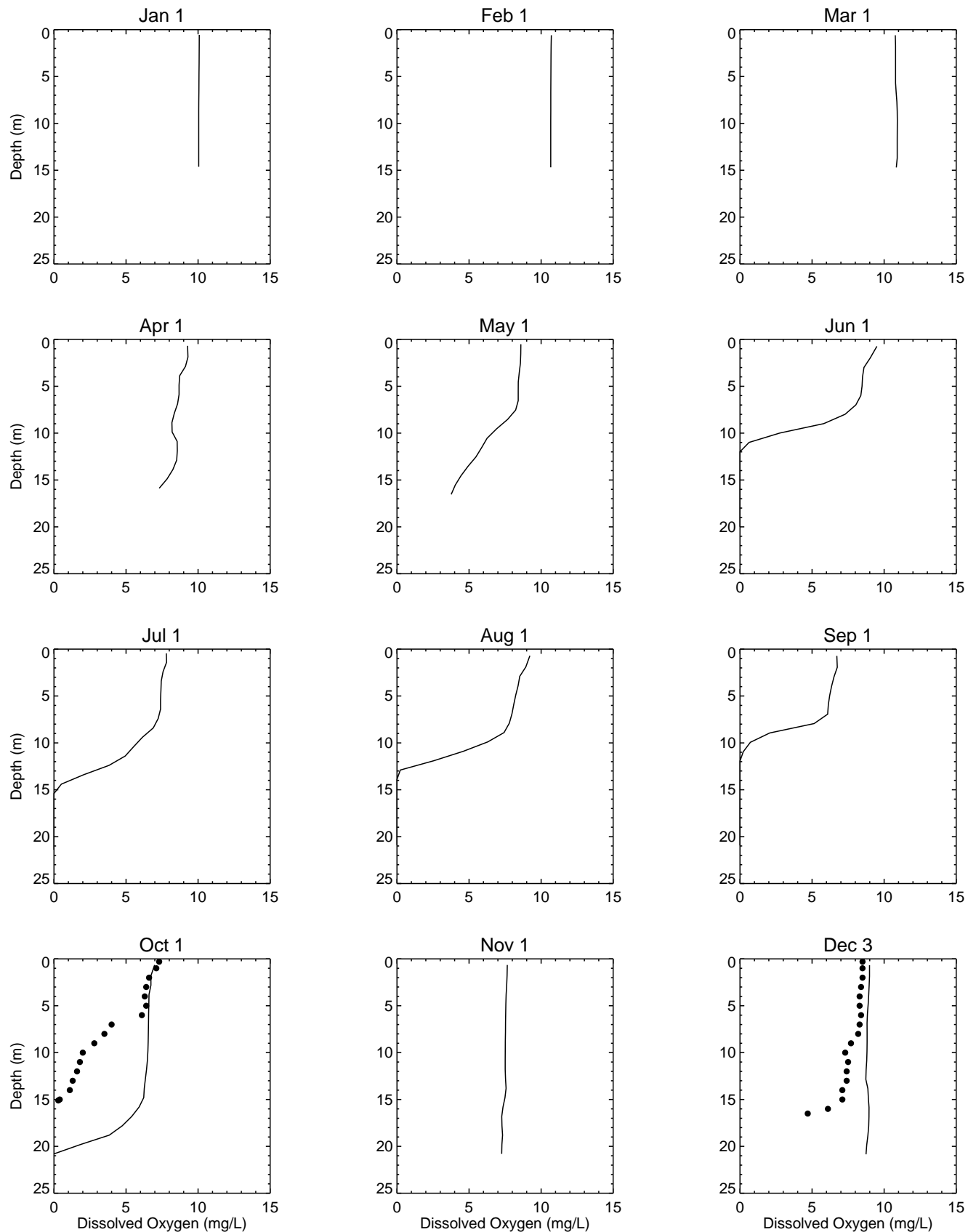Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 2007

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 2008

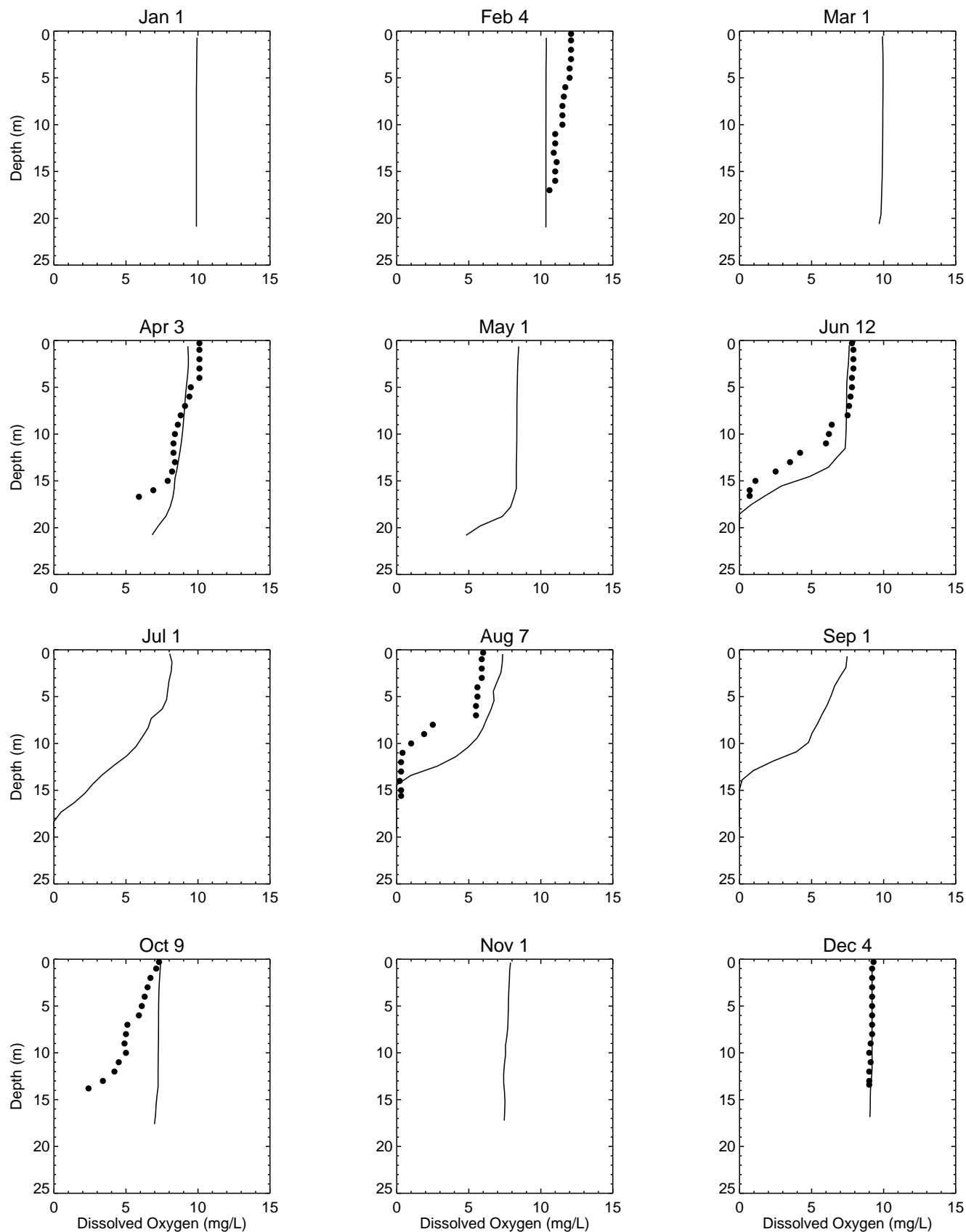*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
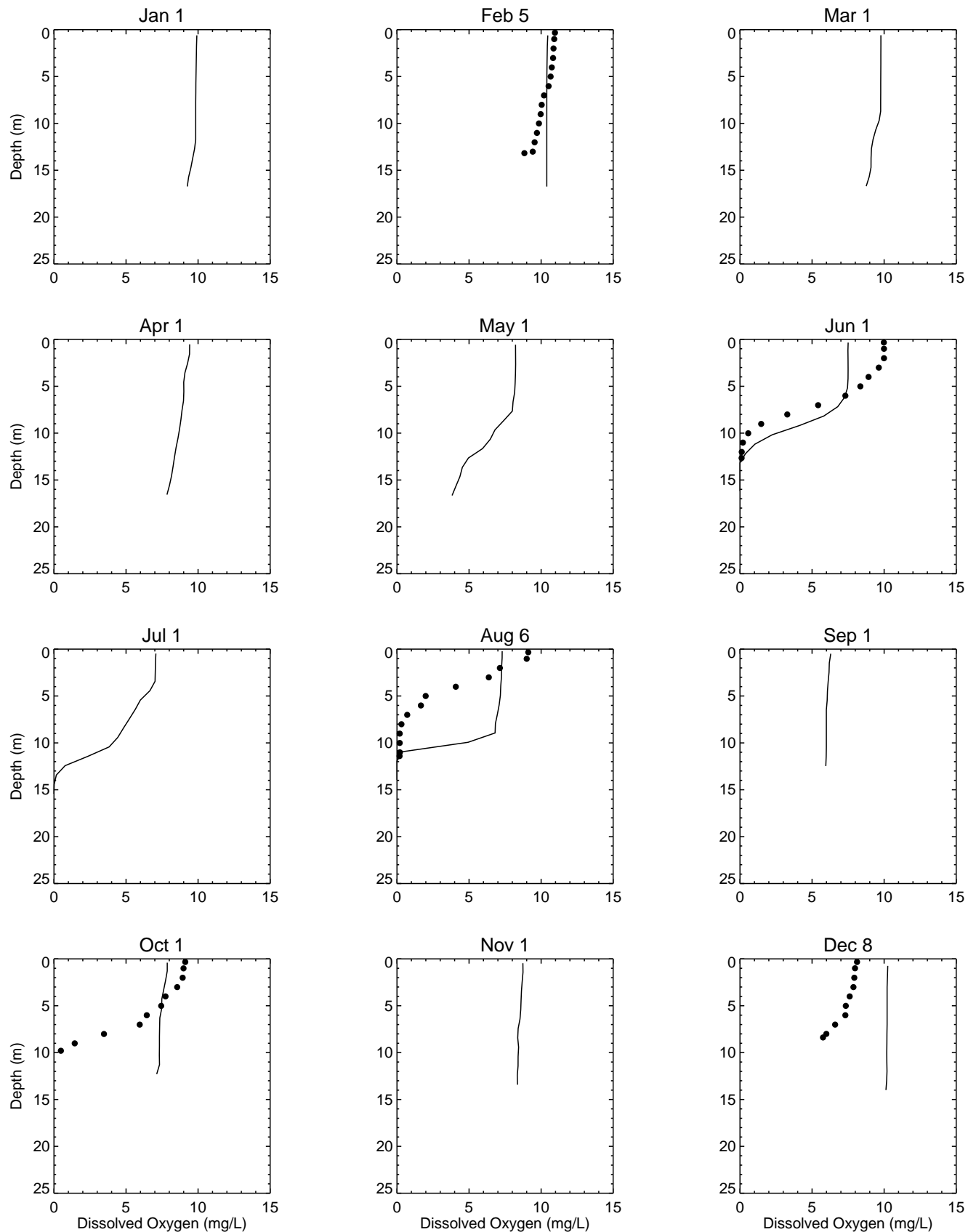Fri Jan 25 18:12:52 2013

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 2009

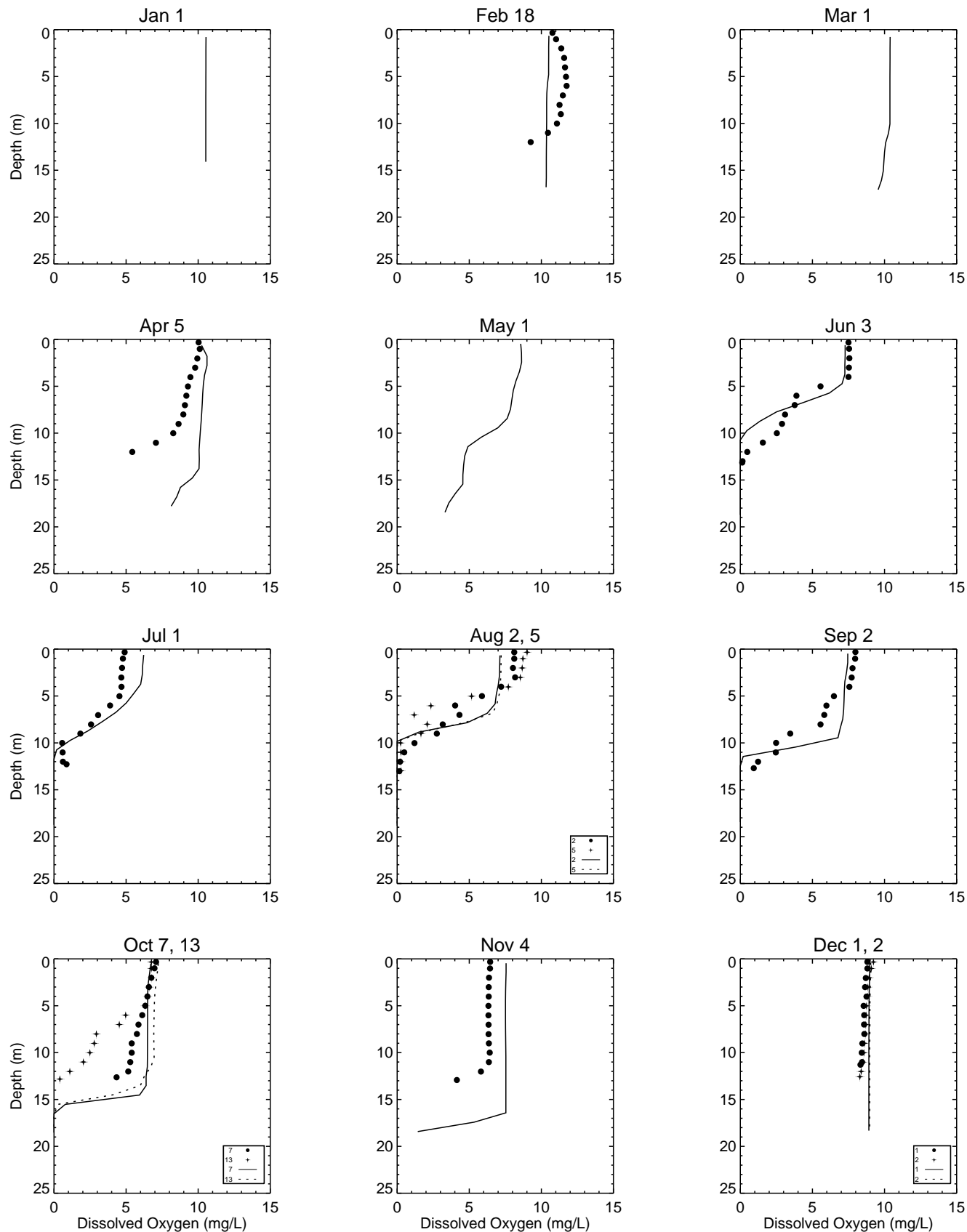*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:52 2013

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 2010

Profiles shown for dates with available data else model results for first day of month shown.
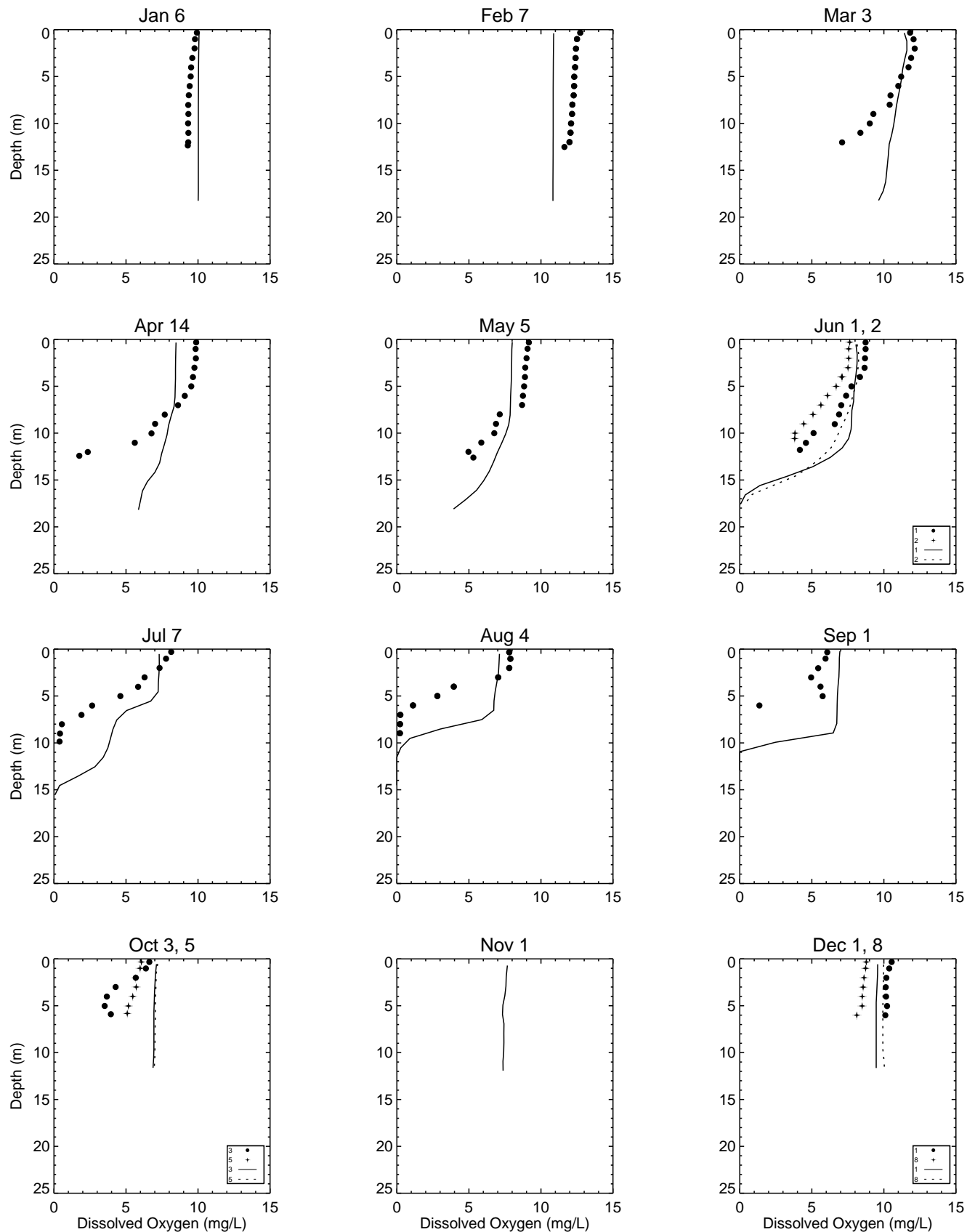
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:52 2013

Figure G-32

Vertical Profiles of Model Versus Data for Lake Buchanan
at confluence of Council and Morgan Creeks (Segment 18) - Dissolved Oxygen - 2011

Profiles shown for dates with available data else model results for first day of month shown.
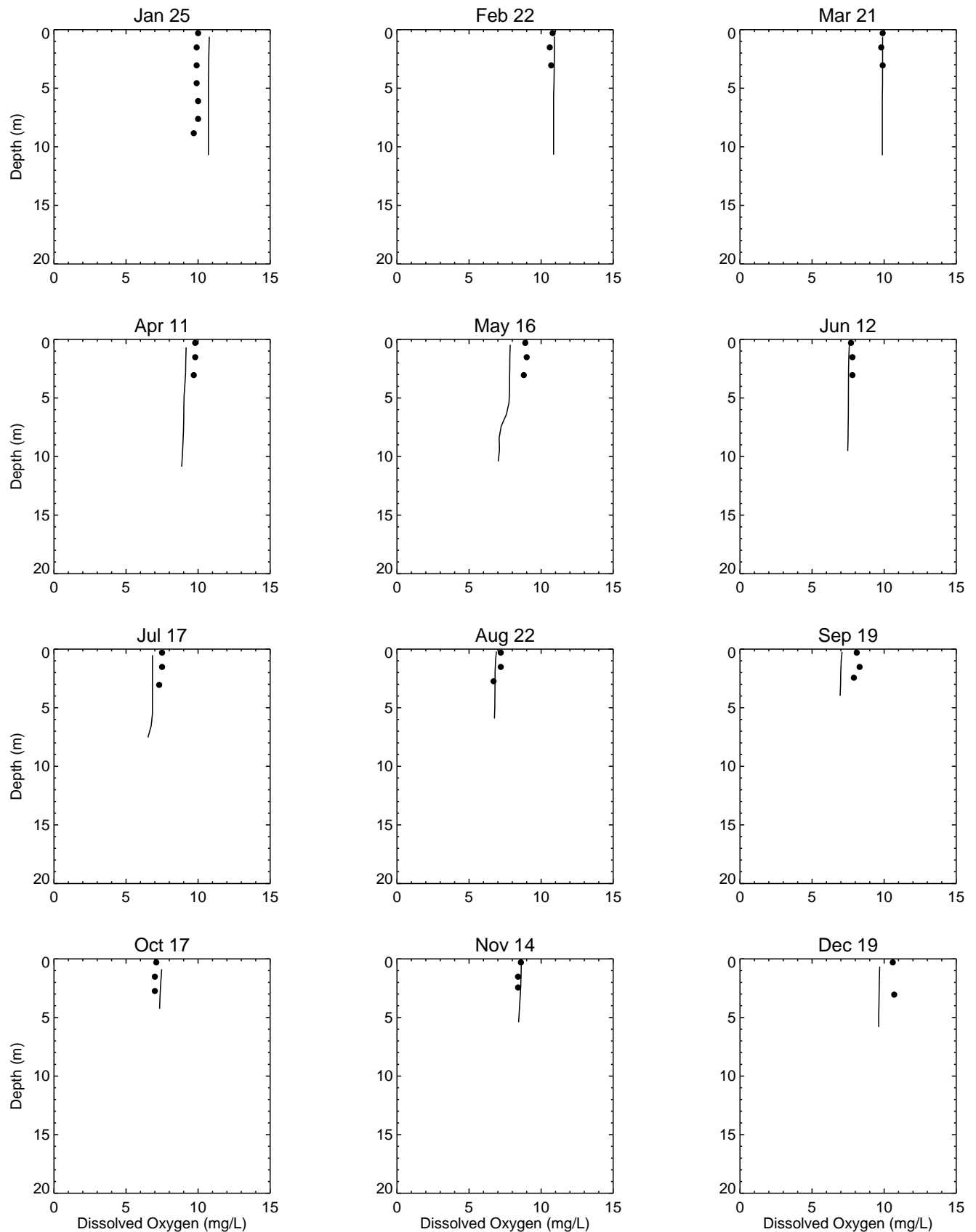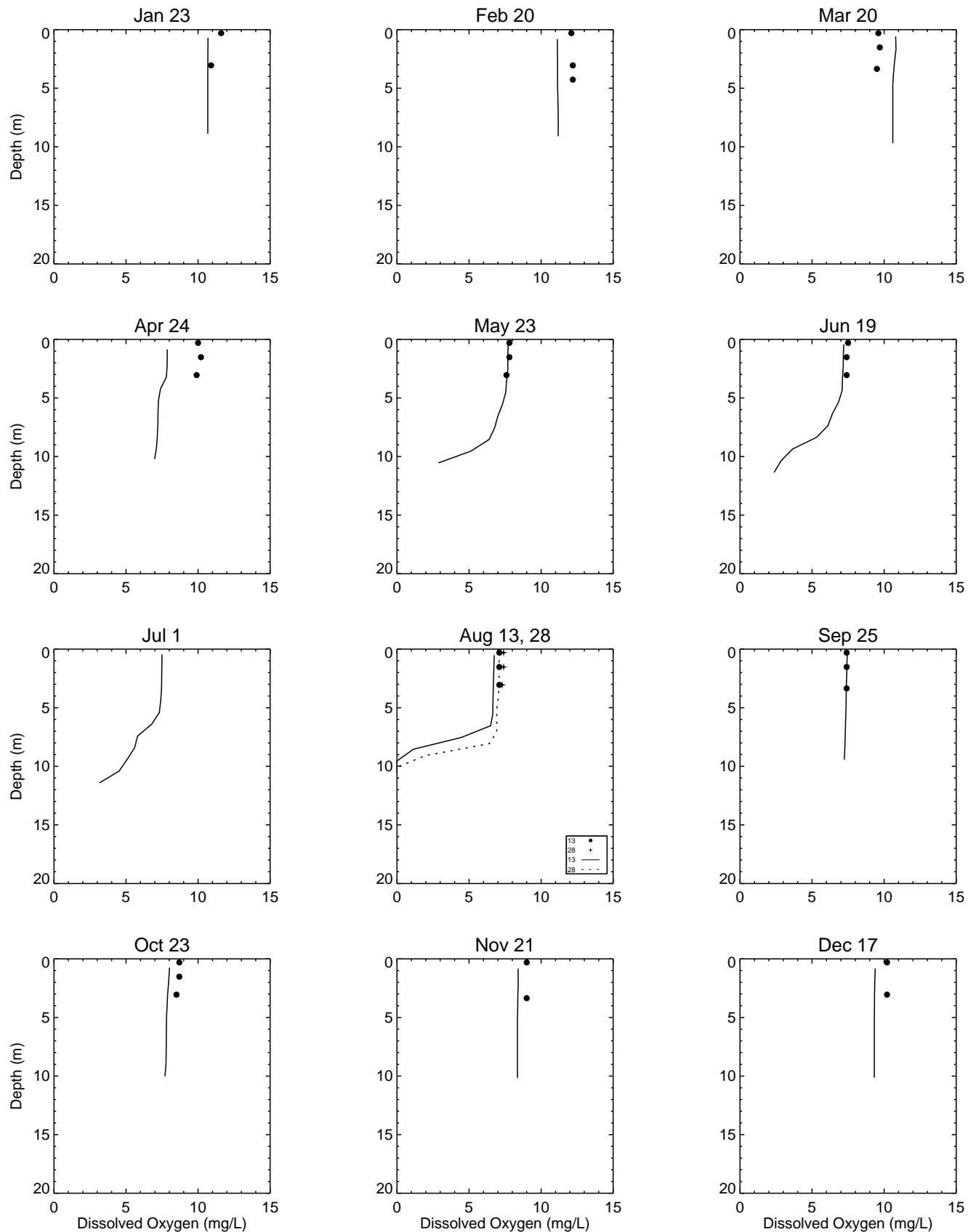
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:52 2013

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:54 2013

Jan 23 | Feb 20 | Mar 20
Apr 24 | May 23 | Jun 19
Jul 1 | Aug 13, 28 | Sep 25
Oct 23 | Nov 21 | Dec 17

Dissolved Oxygen (mg/L)

Model (w1210-48)
● Data

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 1985

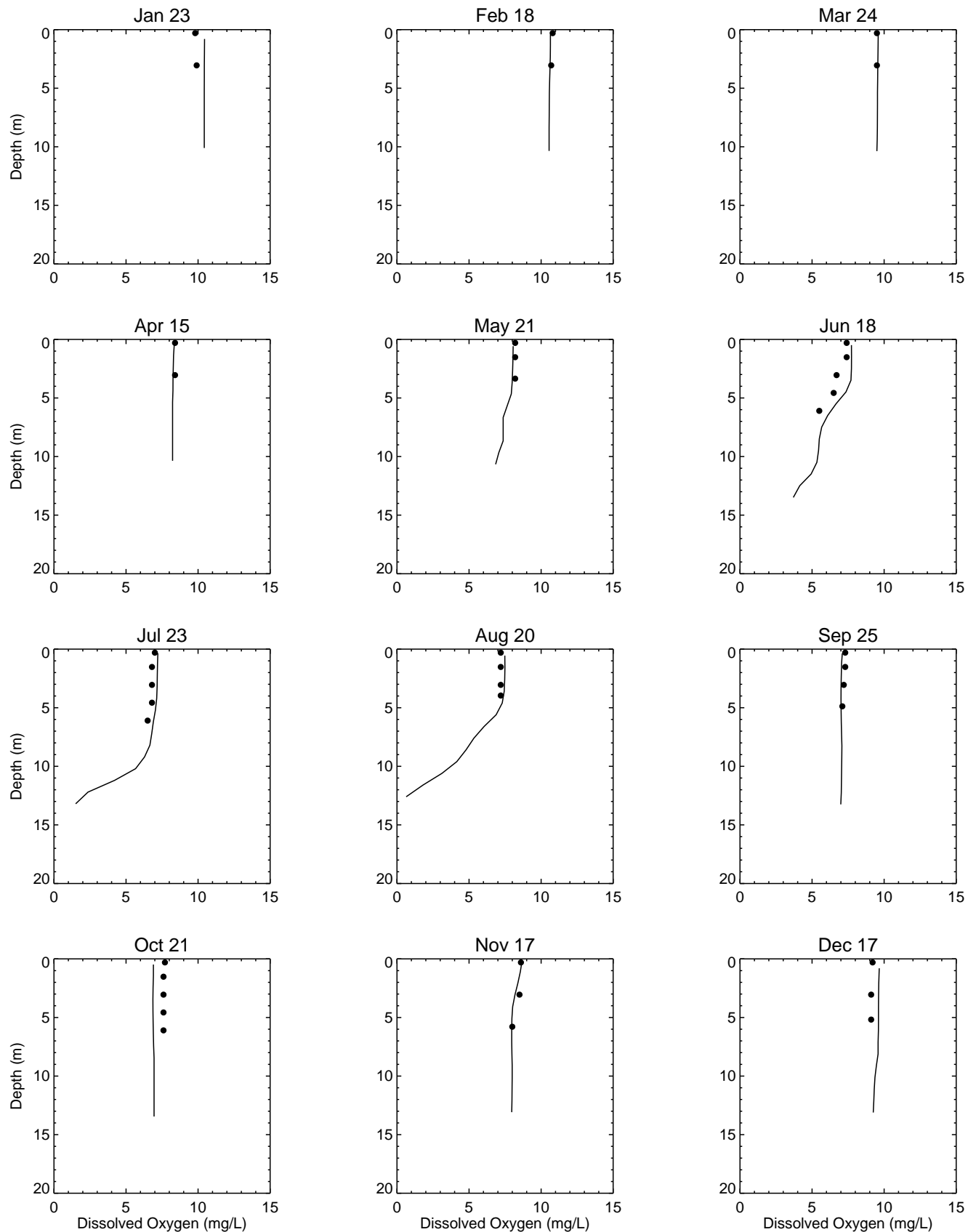*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:54 2013

ANCHOR
QEA
PARSONS

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan at Golden Beach (Segment 26) - Dissolved Oxygen - 1986

Profiles shown for dates with available data else model results for first day of month shown.
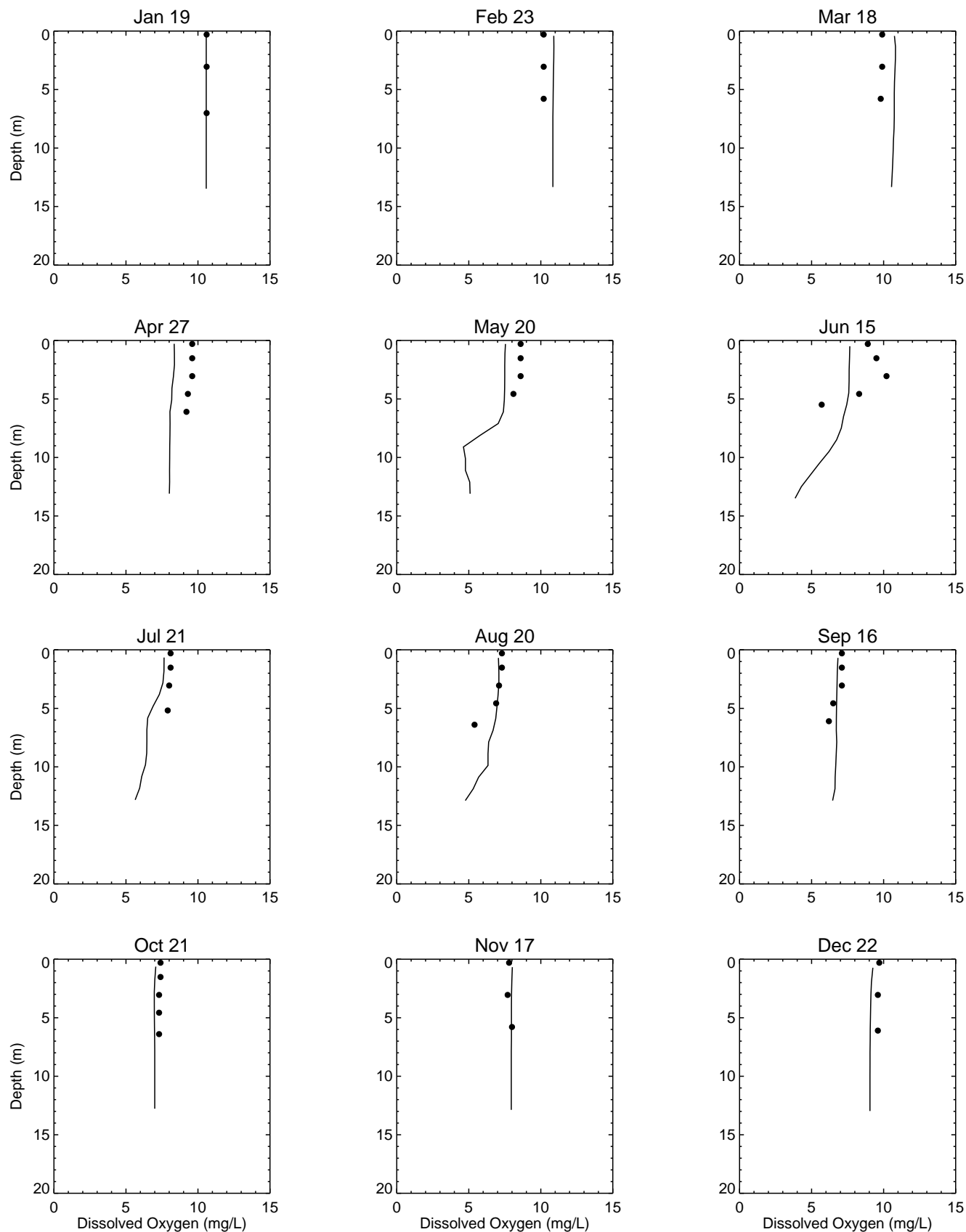
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:54 2013

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 1987

Profiles shown for dates with available data else model results for first day of month shown.
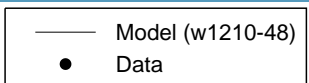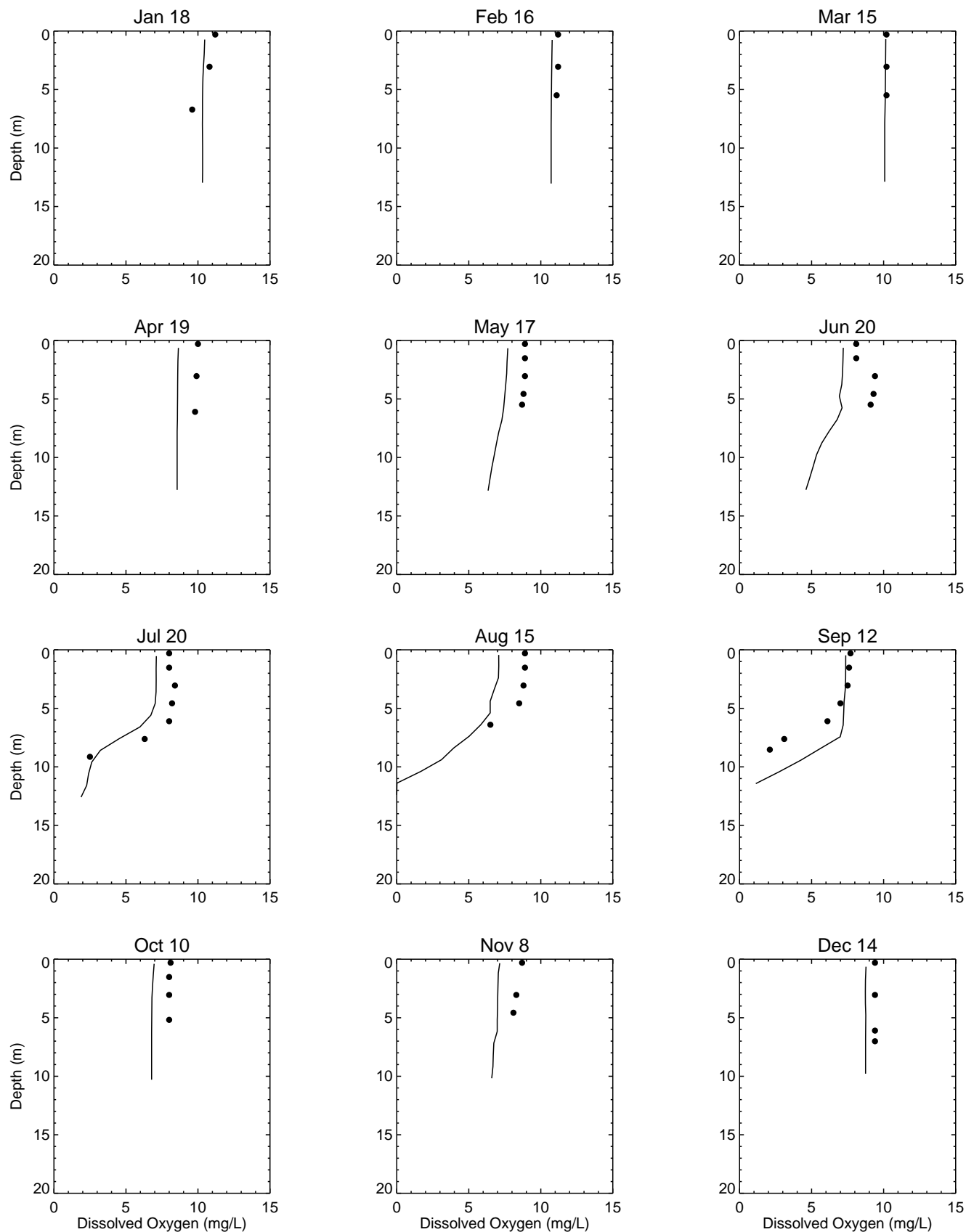
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 1988

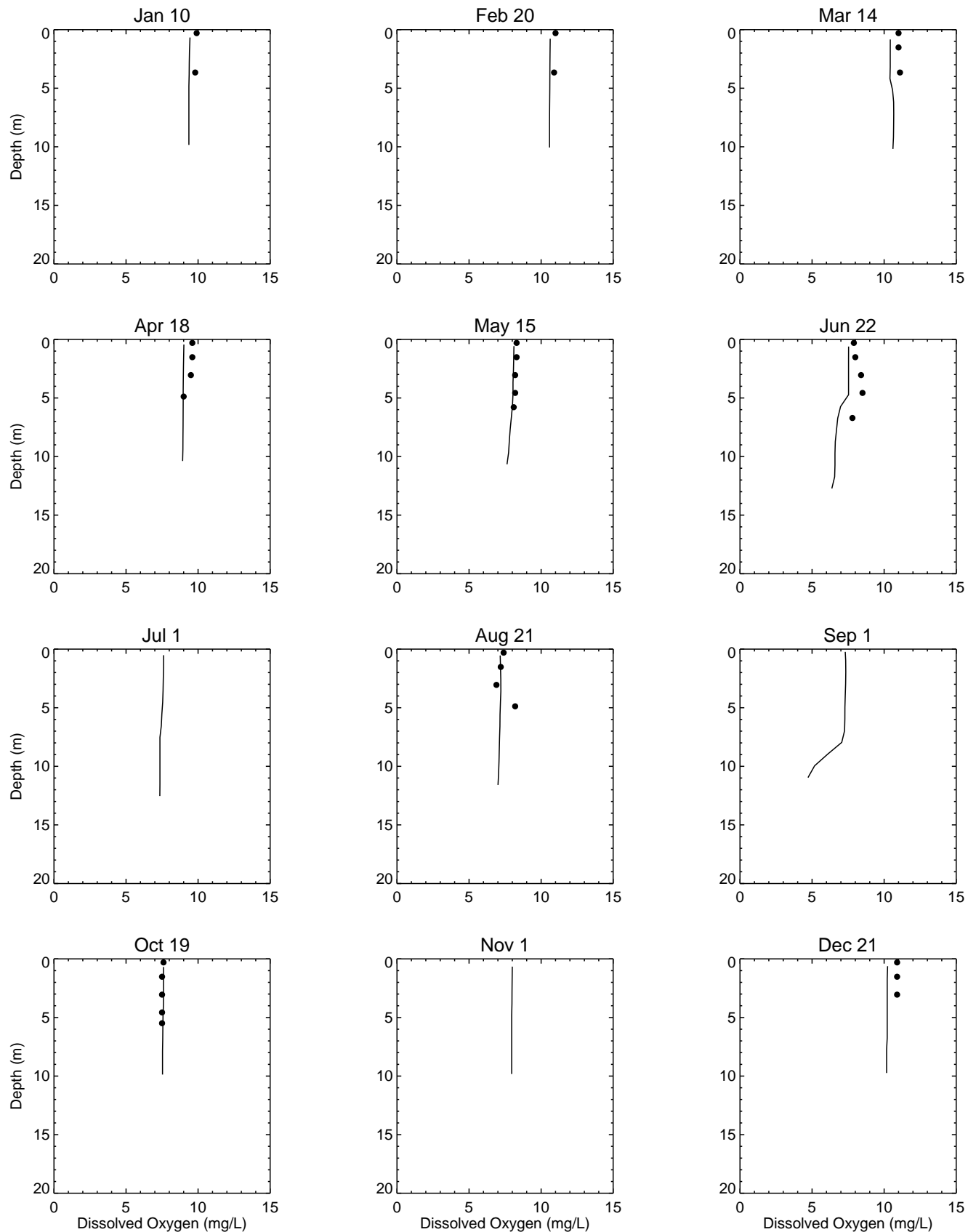*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 10 Feb 20 Mar 14

Apr 18 May 15 Jun 22

Jul 1 Aug 21 Sep 1

Oct 19 Nov 1 Dec 21

Dissolved Oxygen (mg/L)
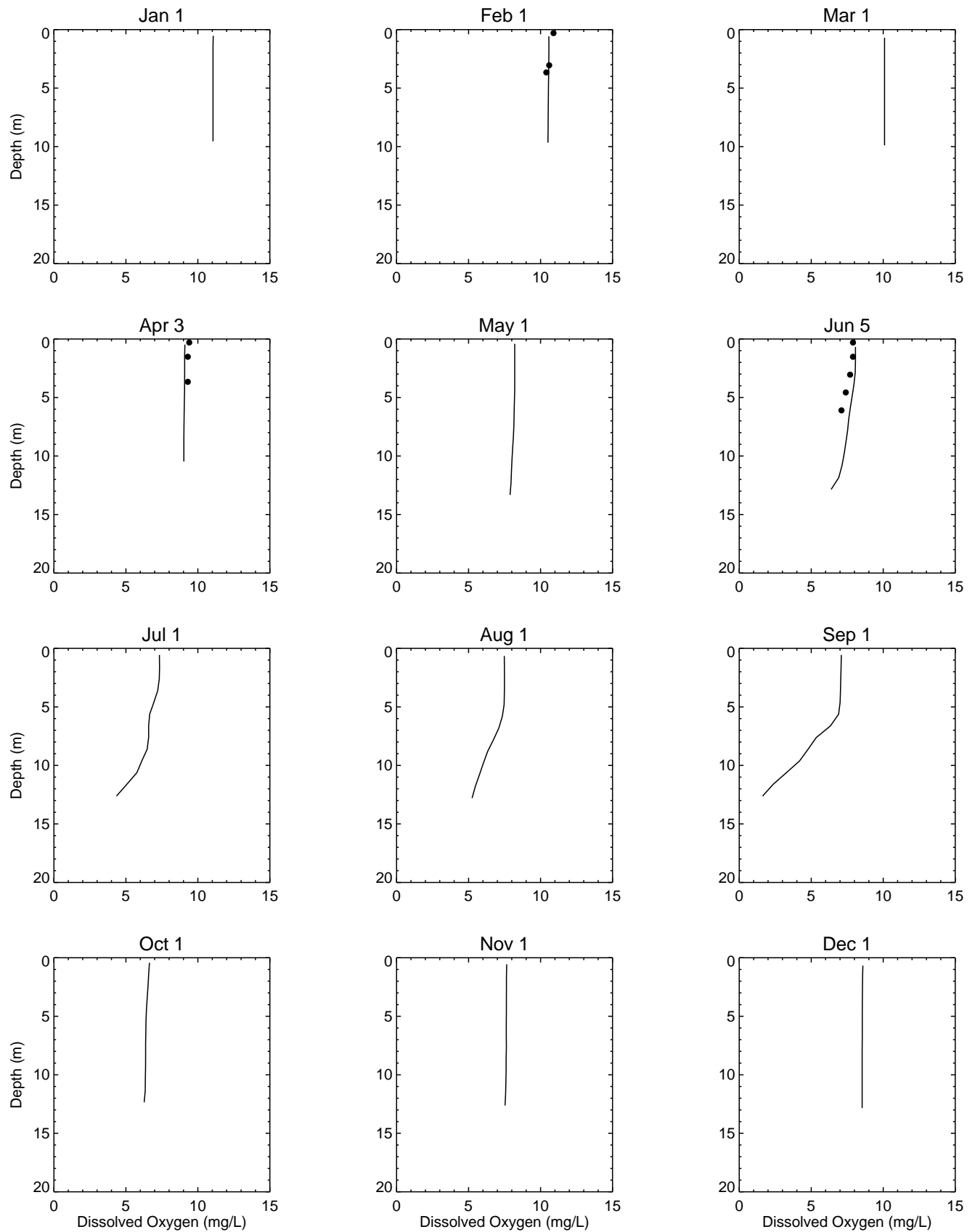
——— Model (w1210-48)
● Data

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 1989

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:54 2013

ANCHOR
QEA
PARSONS

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 1990

Profiles shown for dates with available data else model results for first day of month shown.
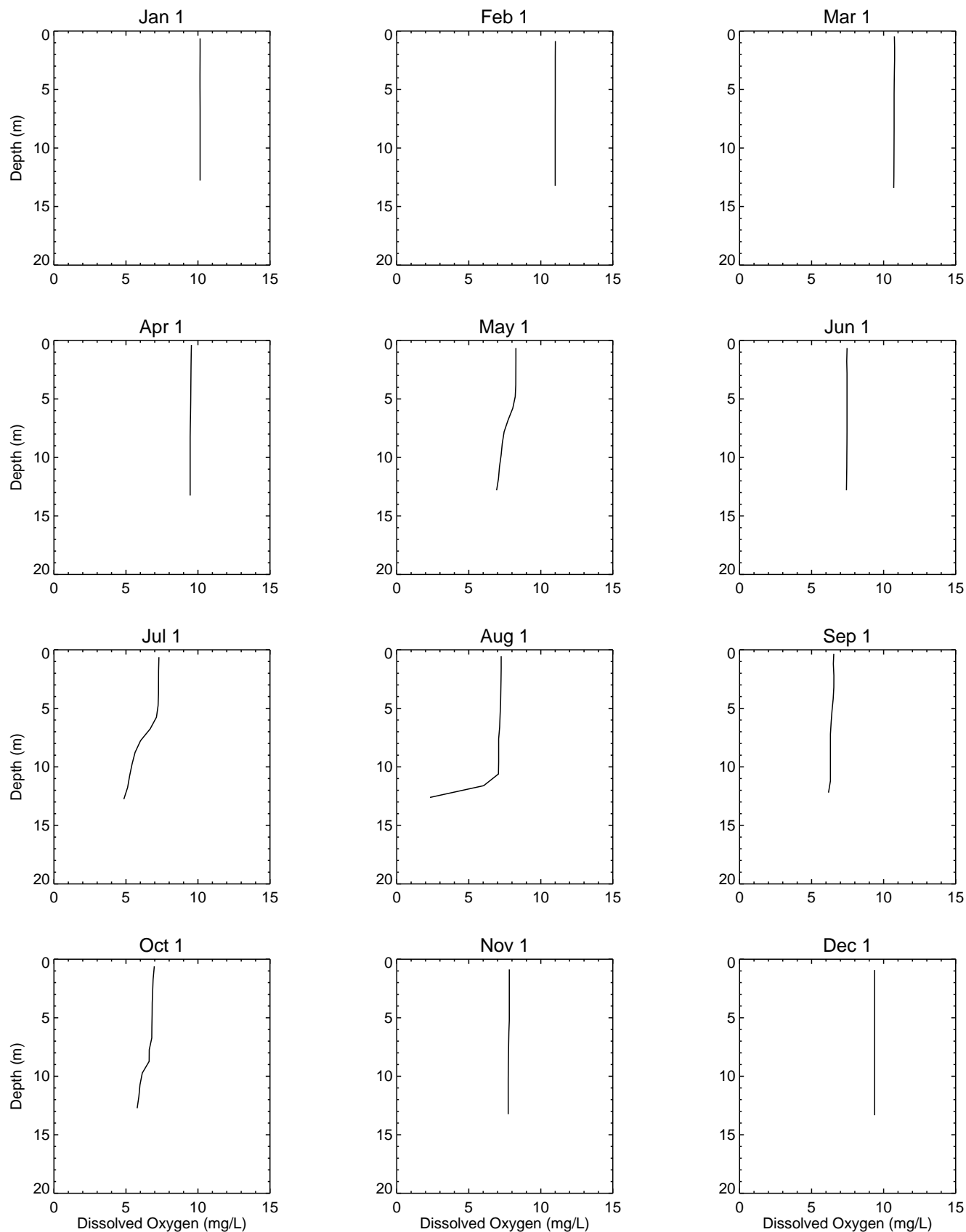
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:54 2013
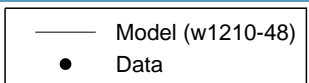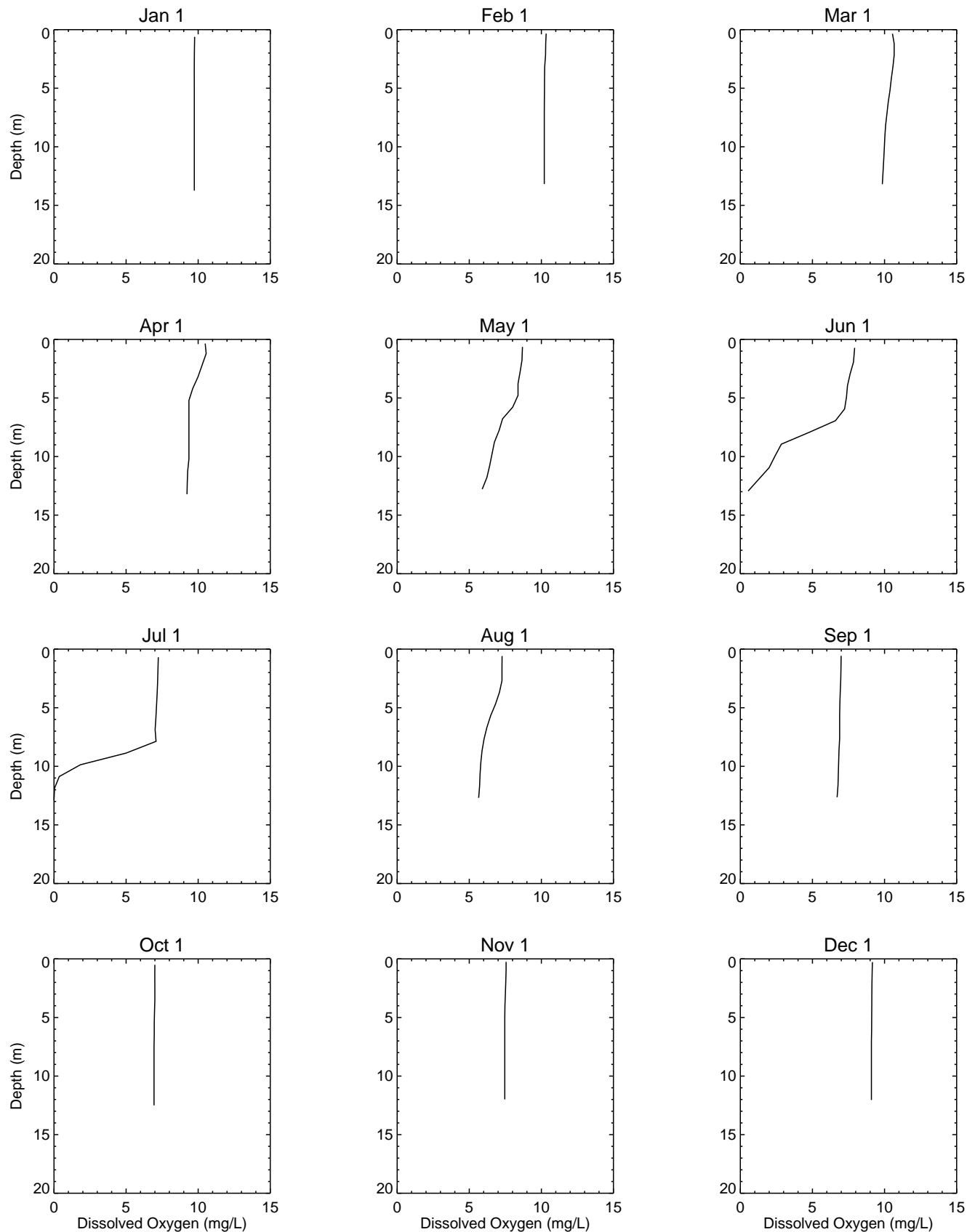
Model (w1210-48)
● Data

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 1991

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

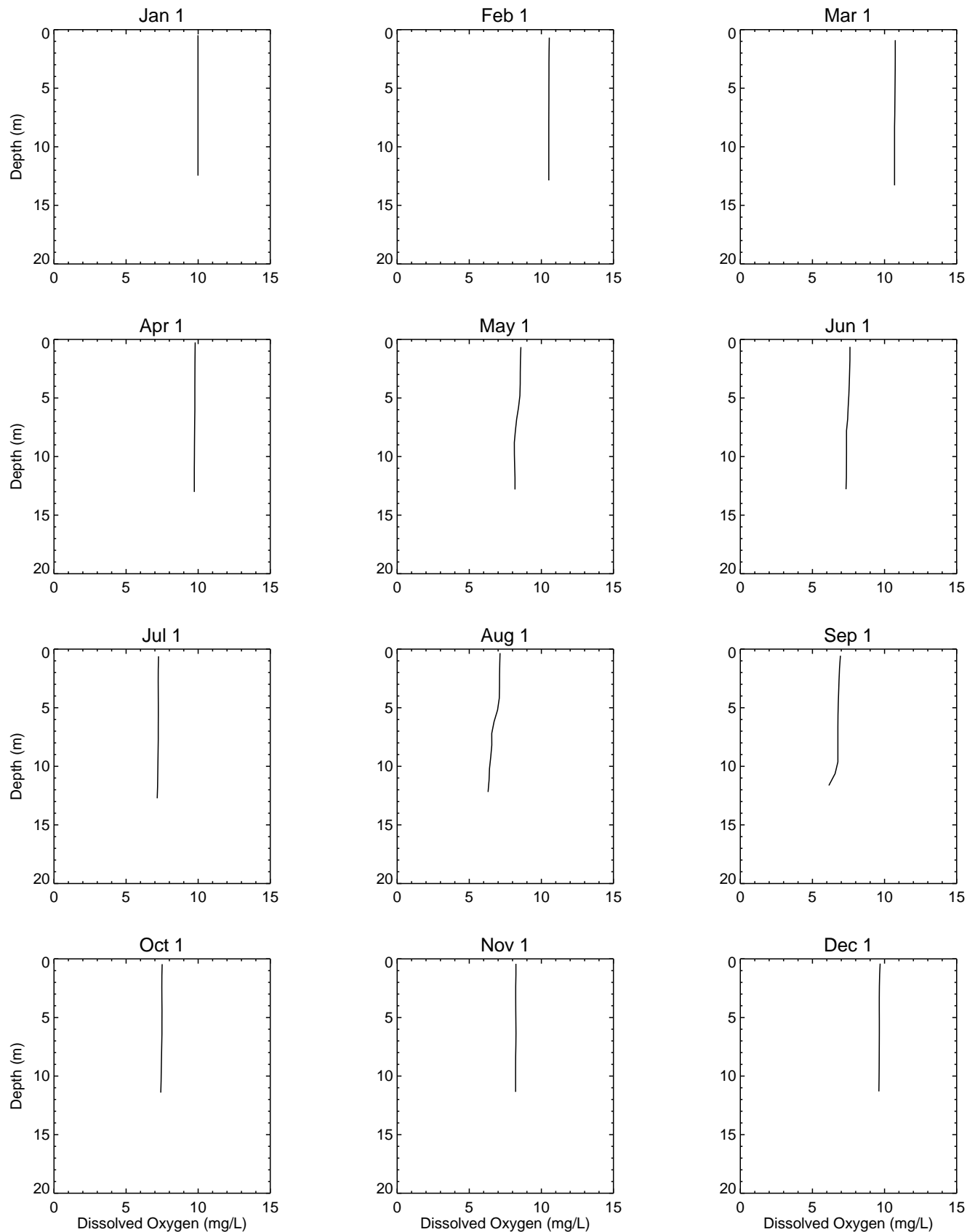Lower Colorado River Authority

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 1992

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1
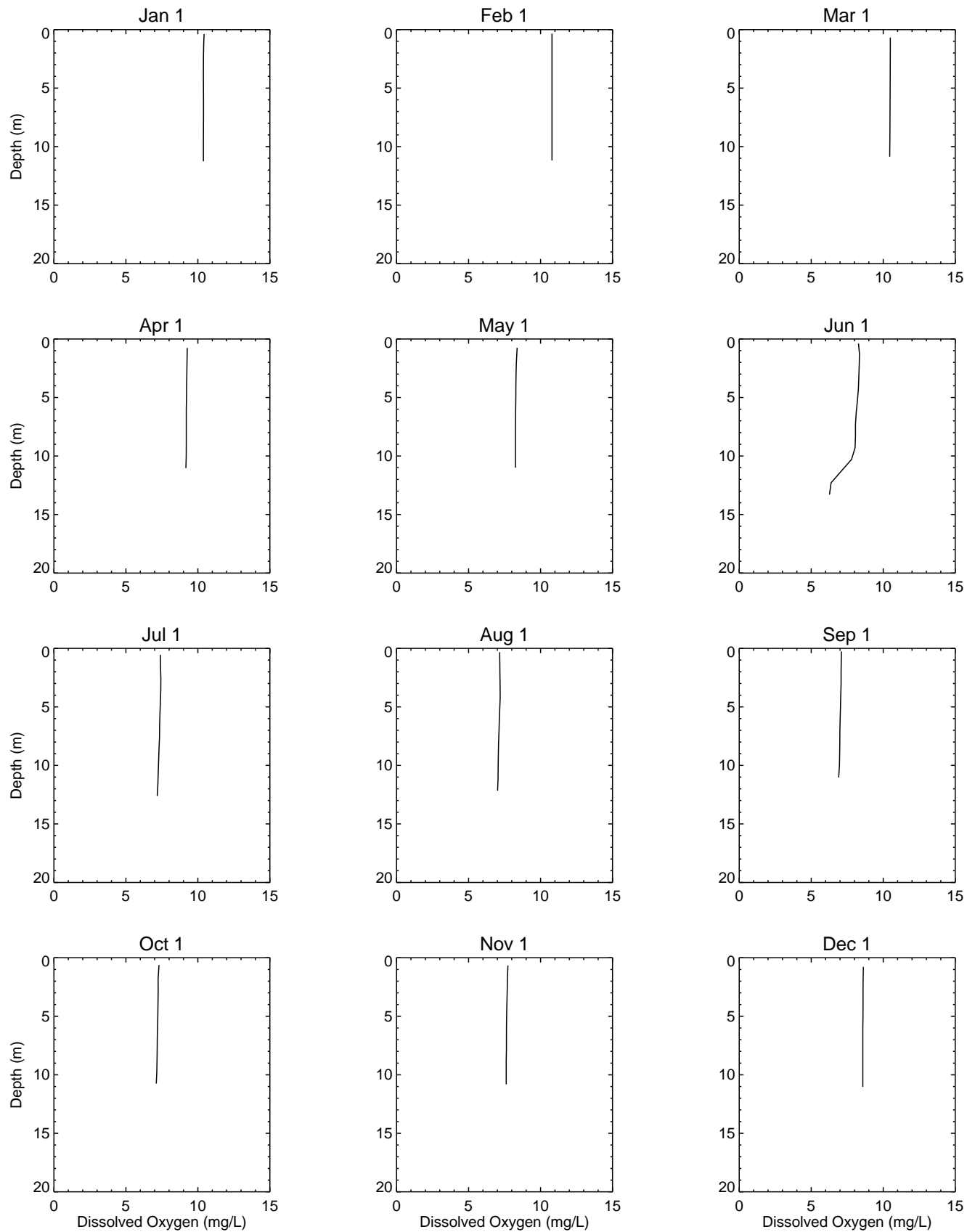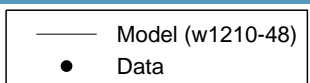
Model (w1210-48)
● Data

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 1993

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:54 2013

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Dissolved Oxygen (mg/L)

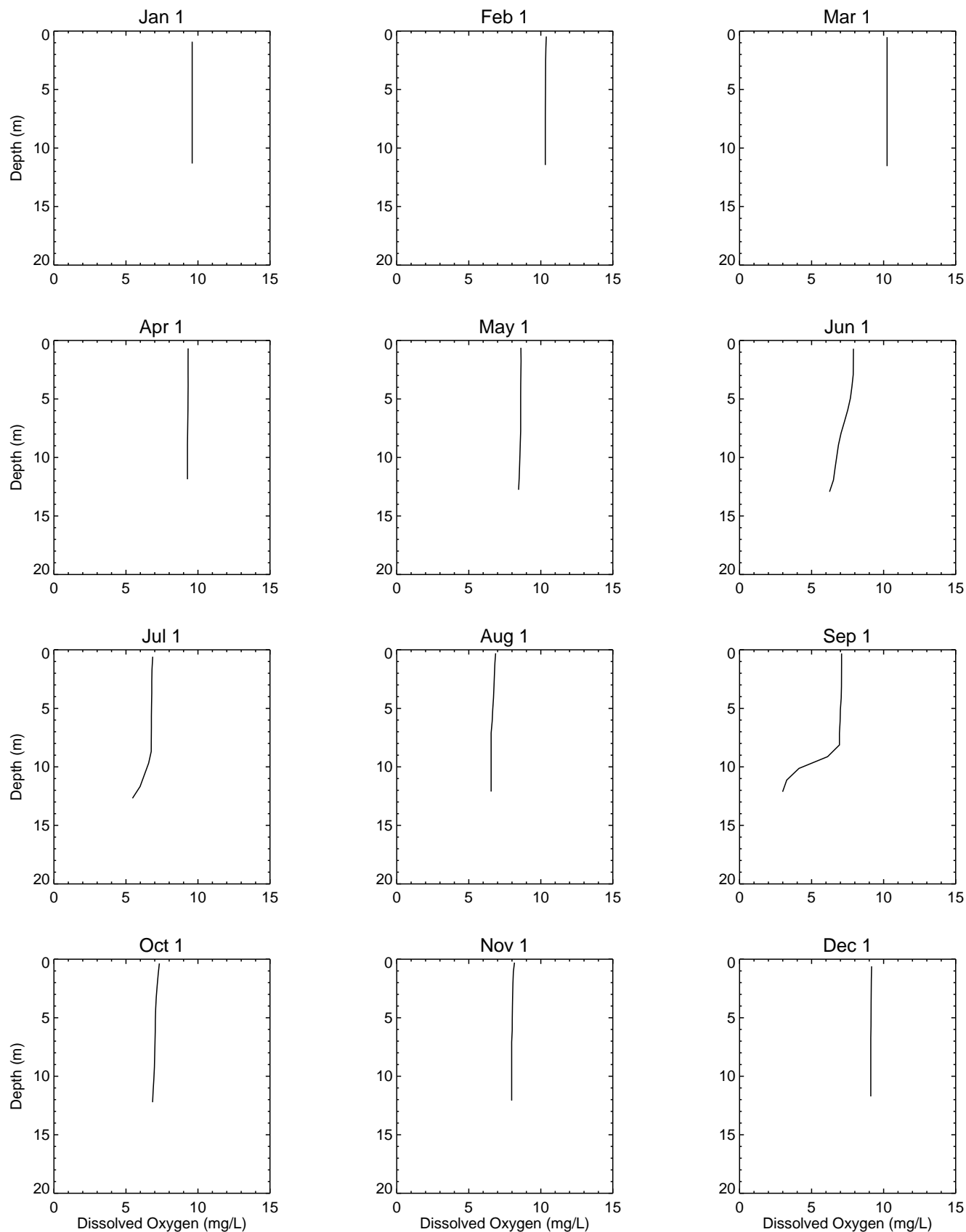Depth (m)

—— Model (w1210-48)
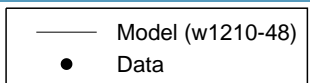● Data

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 1994

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
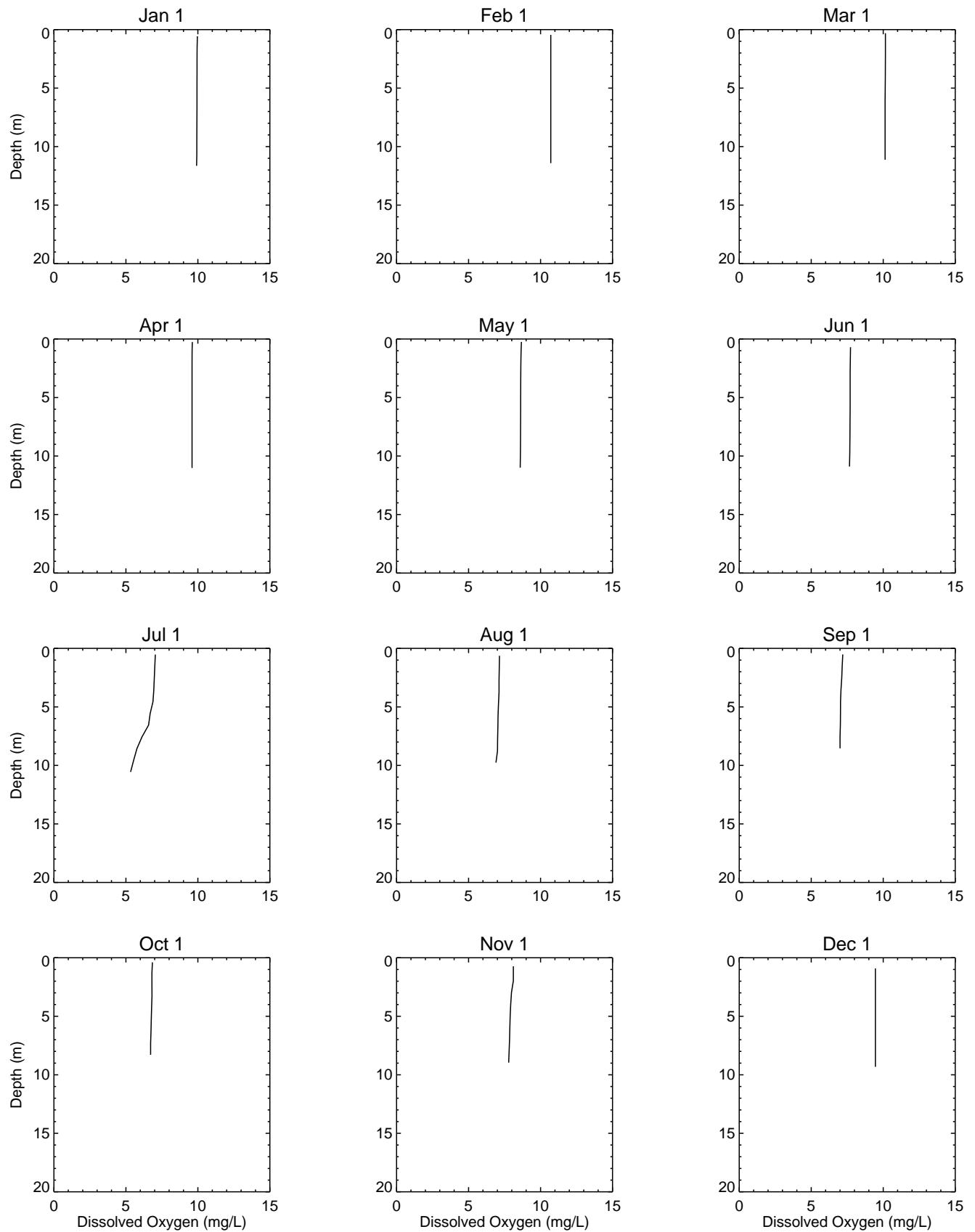Fri Jan 25 18:12:54 2013

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 1995

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Depth (m)

Dissolved Oxygen (mg/L)
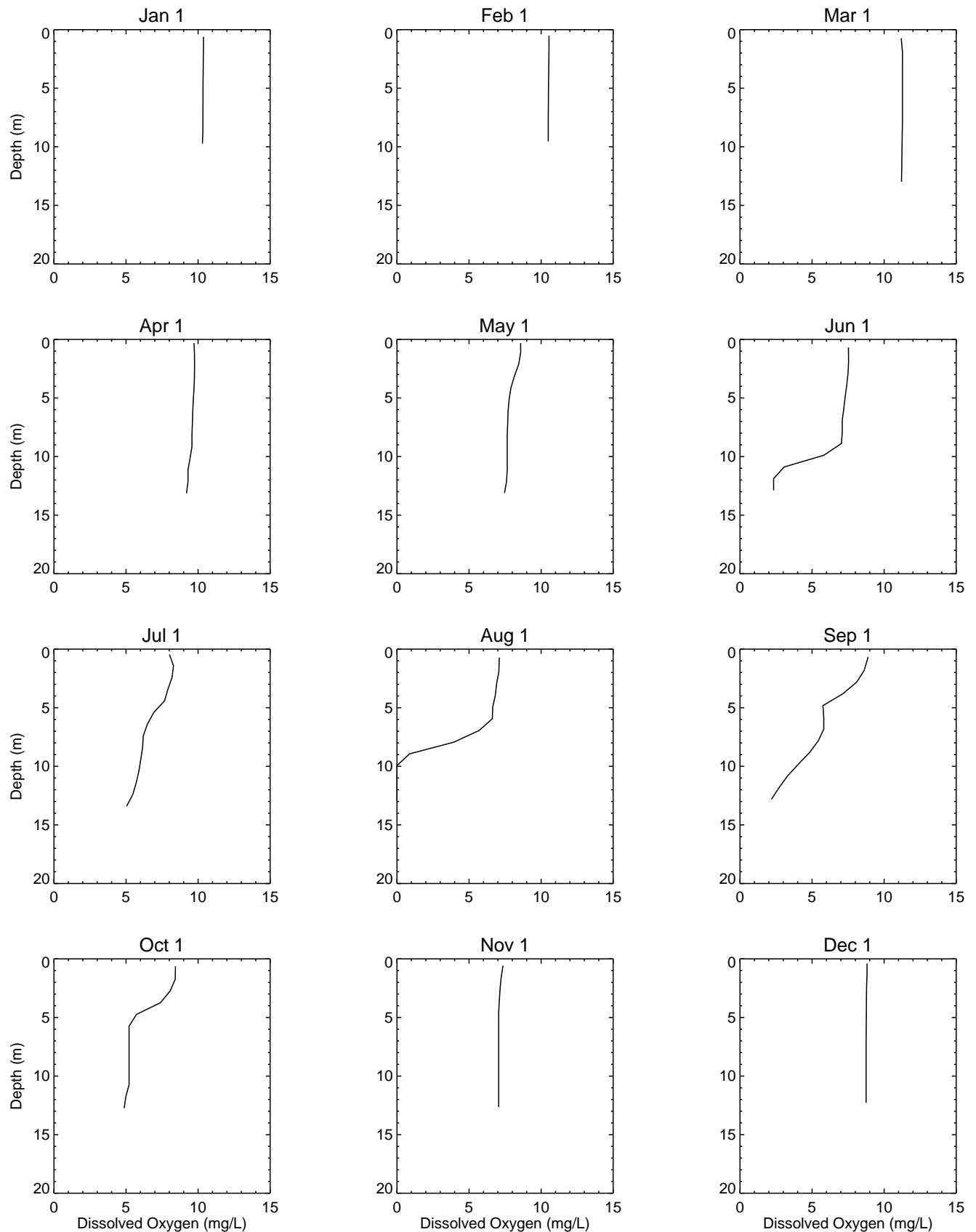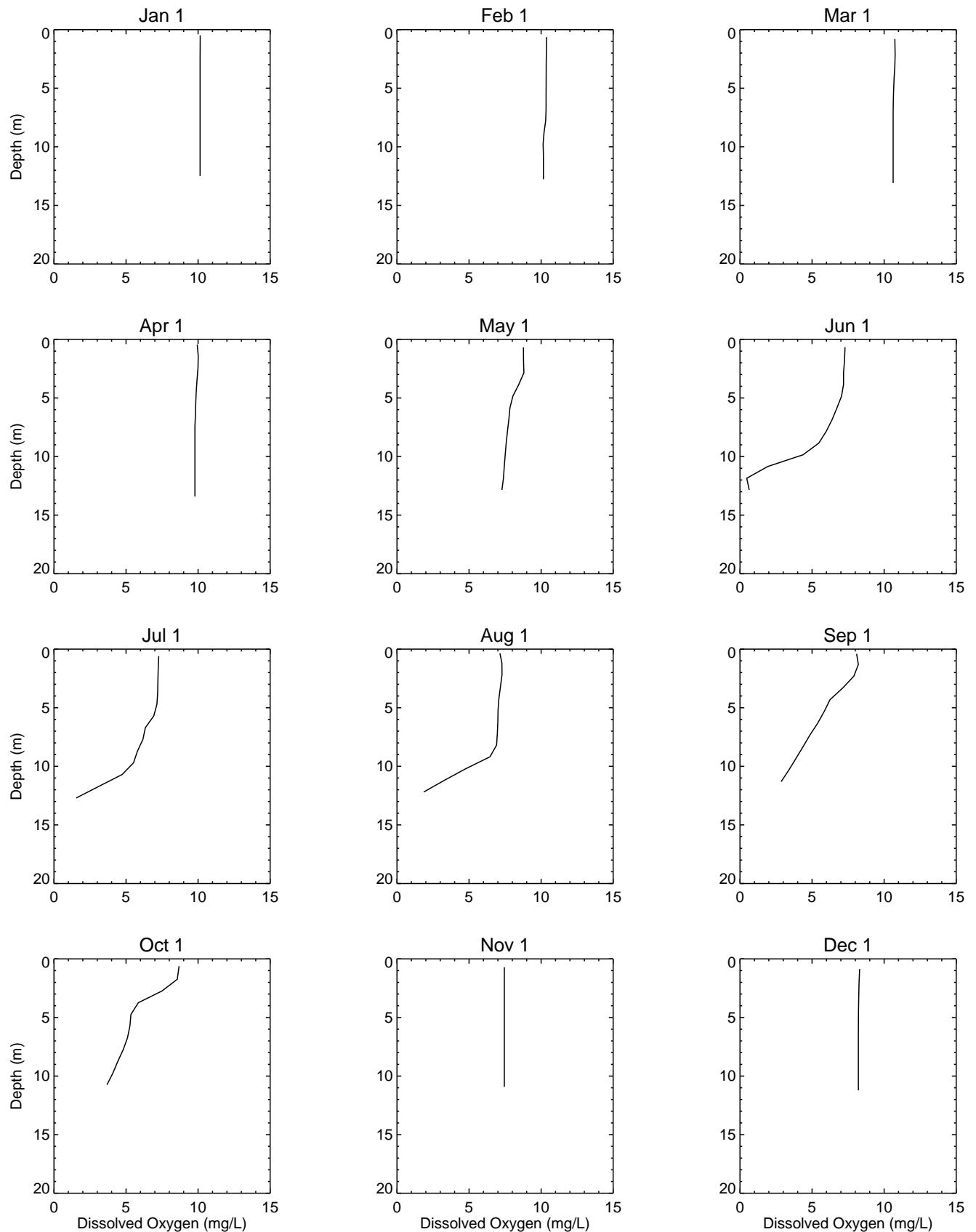
—— Model (w1210-48)
● Data

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 1996

Profiles shown for dates with available data else model results for first day of month shown.

ANCHOR QEA PARSONS

CREMs Phase 4: Lake Buchanan
Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 1 · Sep 1 · Oct 1 · Nov 1 · Dec 1

Dissolved Oxygen (mg/L)

Model (w1210-48)
● Data

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 1997

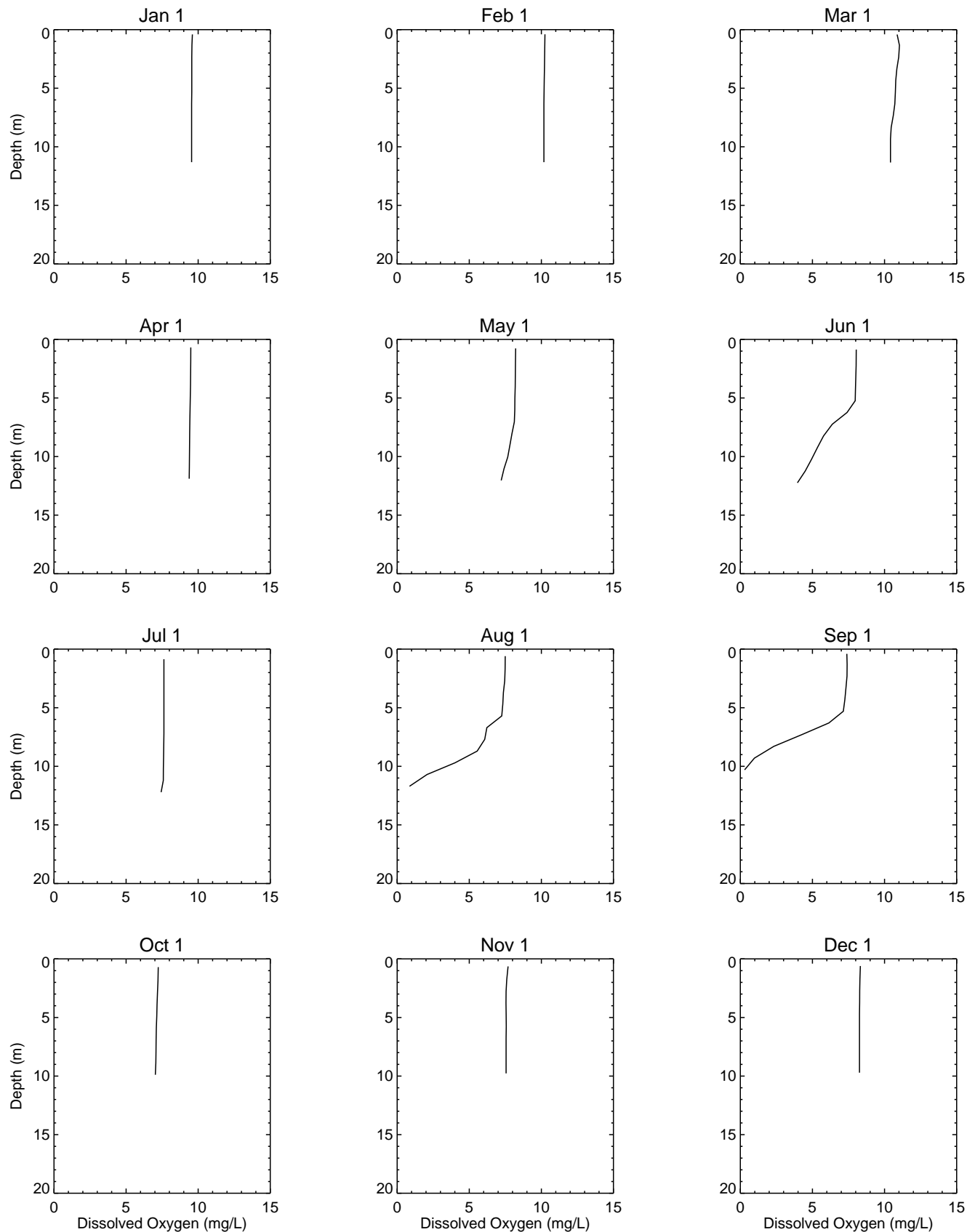*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR
QEA
PARSONS

Model (w1210-48)

● Data

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 1998

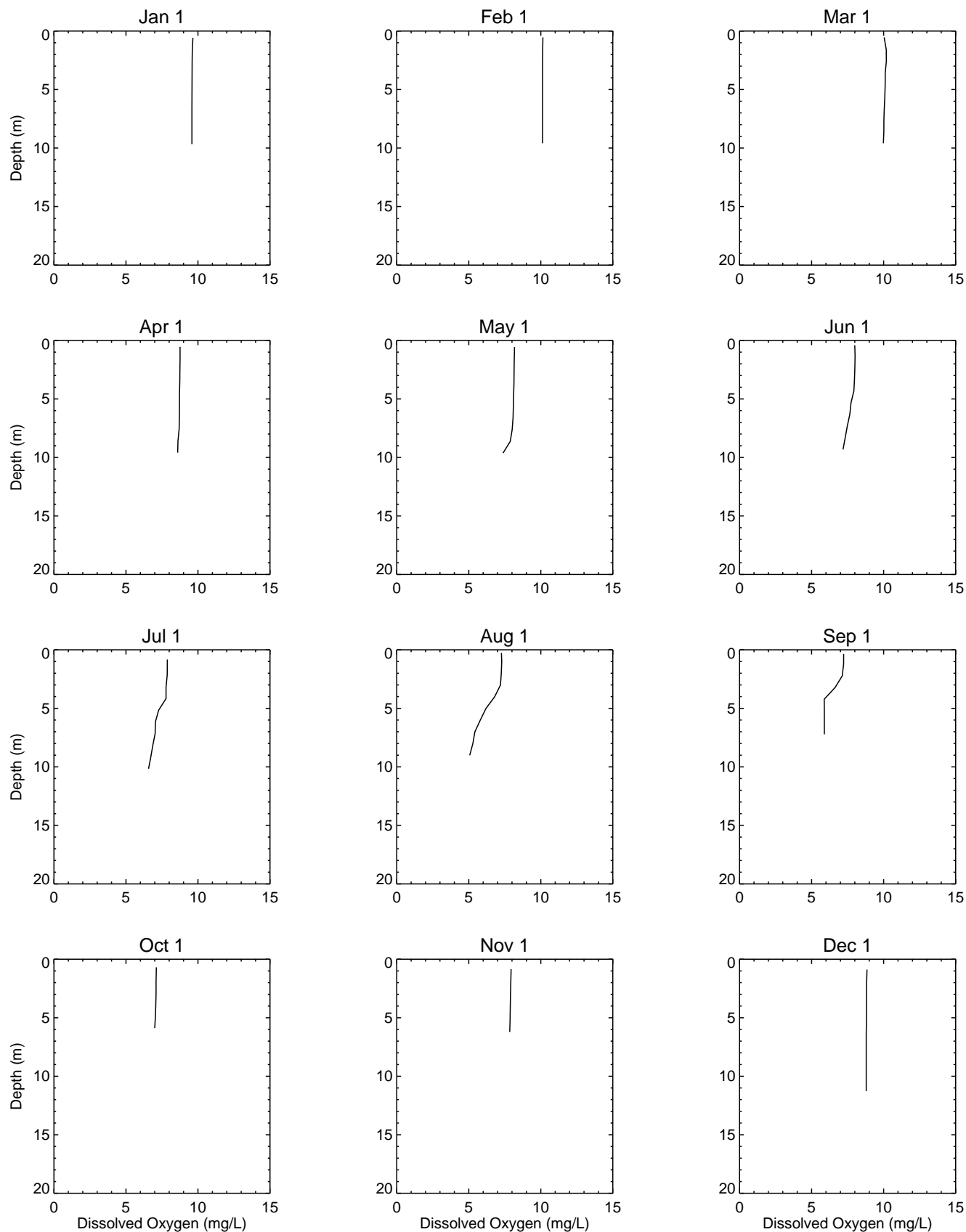*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1　Feb 1　Mar 1　Apr 1　May 1　Jun 1　Jul 1　Aug 1　Sep 1　Oct 1　Nov 1　Dec 1

Model (w1210-48)
● Data

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 1999

Profiles shown for dates with available data else model results for first day of month shown.
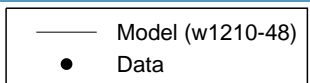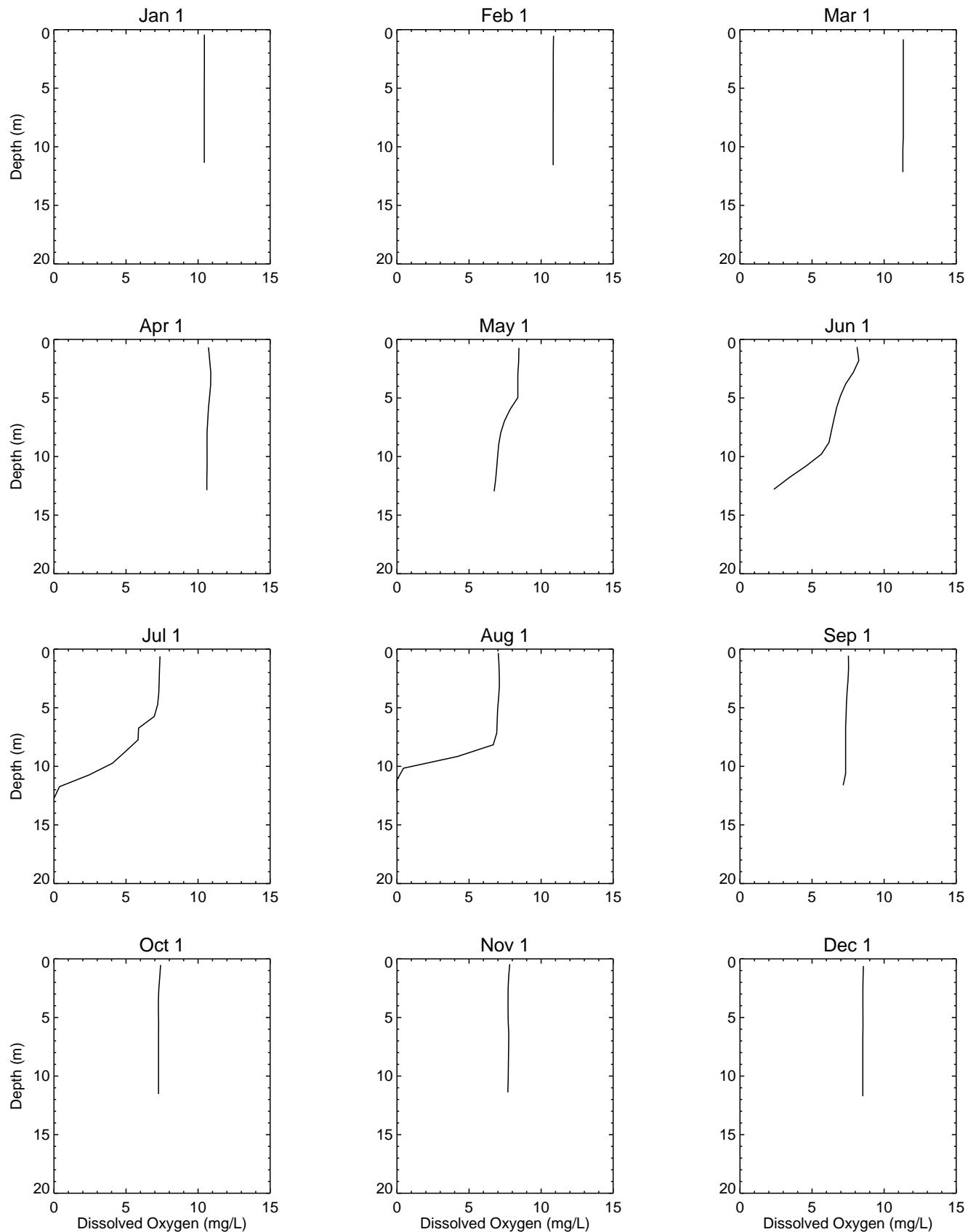
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 2000

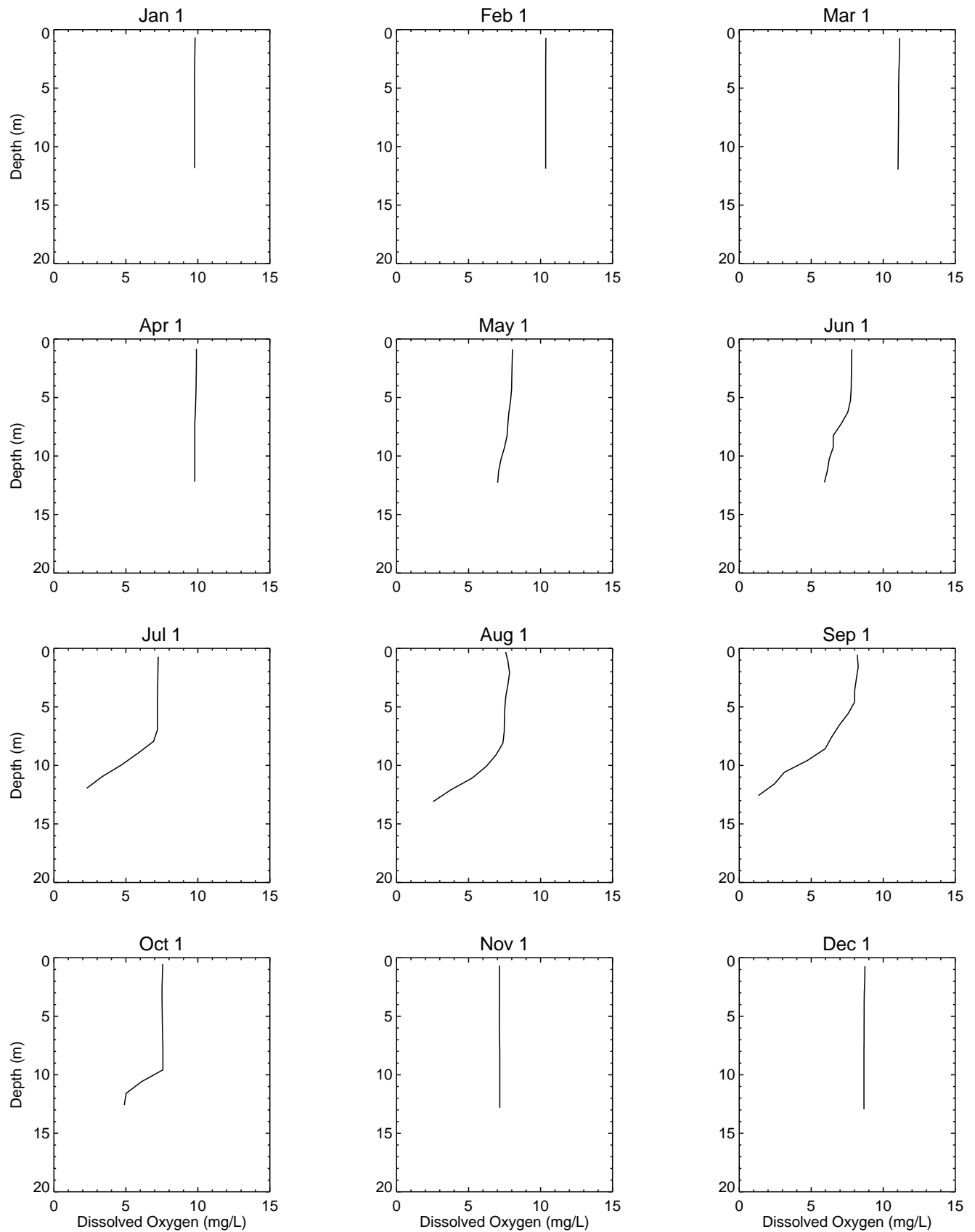*Profiles shown for dates with available data else model results for first day of month shown.*

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 2001

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

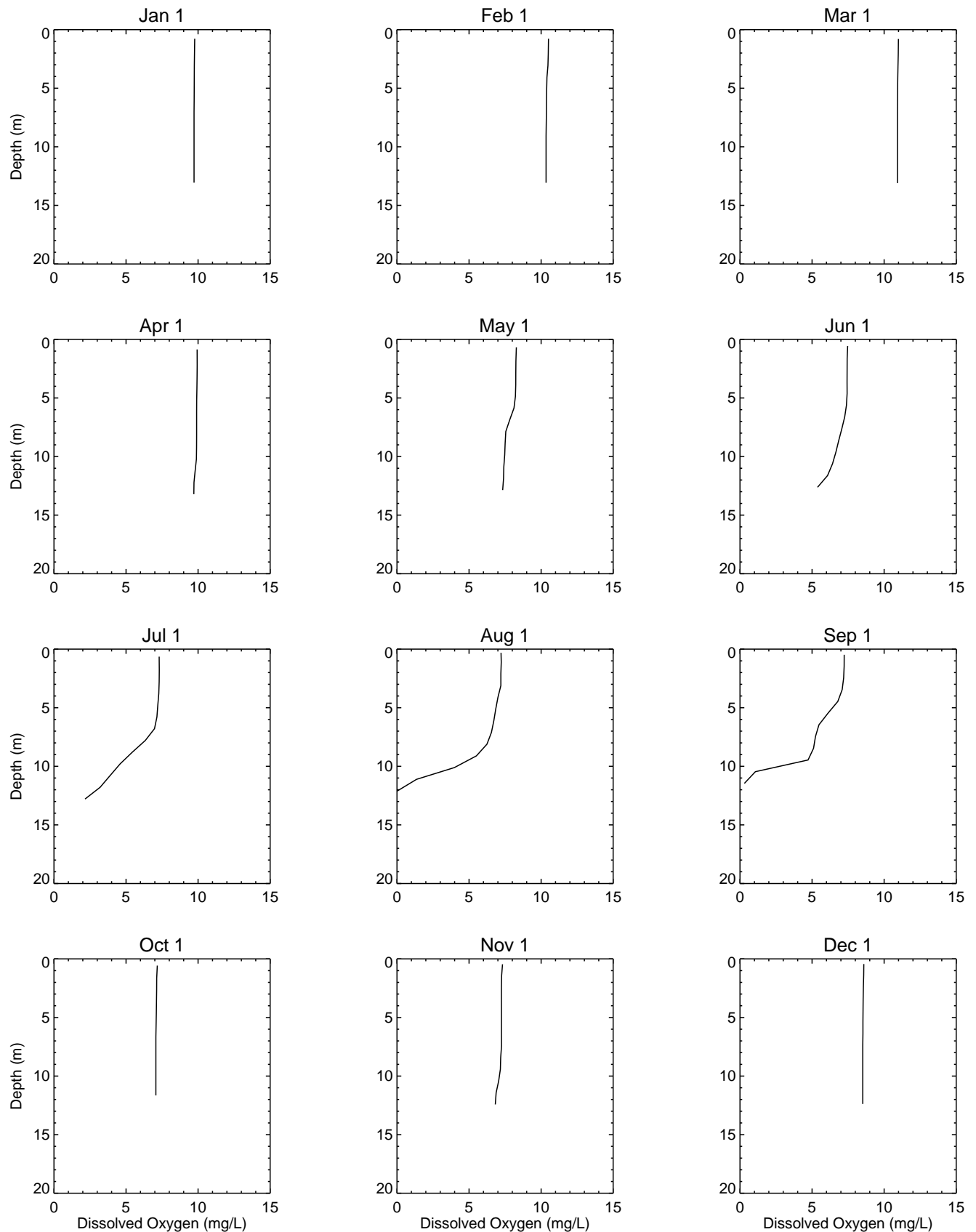Lower Colorado River Authority

Model (w1210-48)
● Data

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 2002

Profiles shown for dates with available data else model results for first day of month shown.

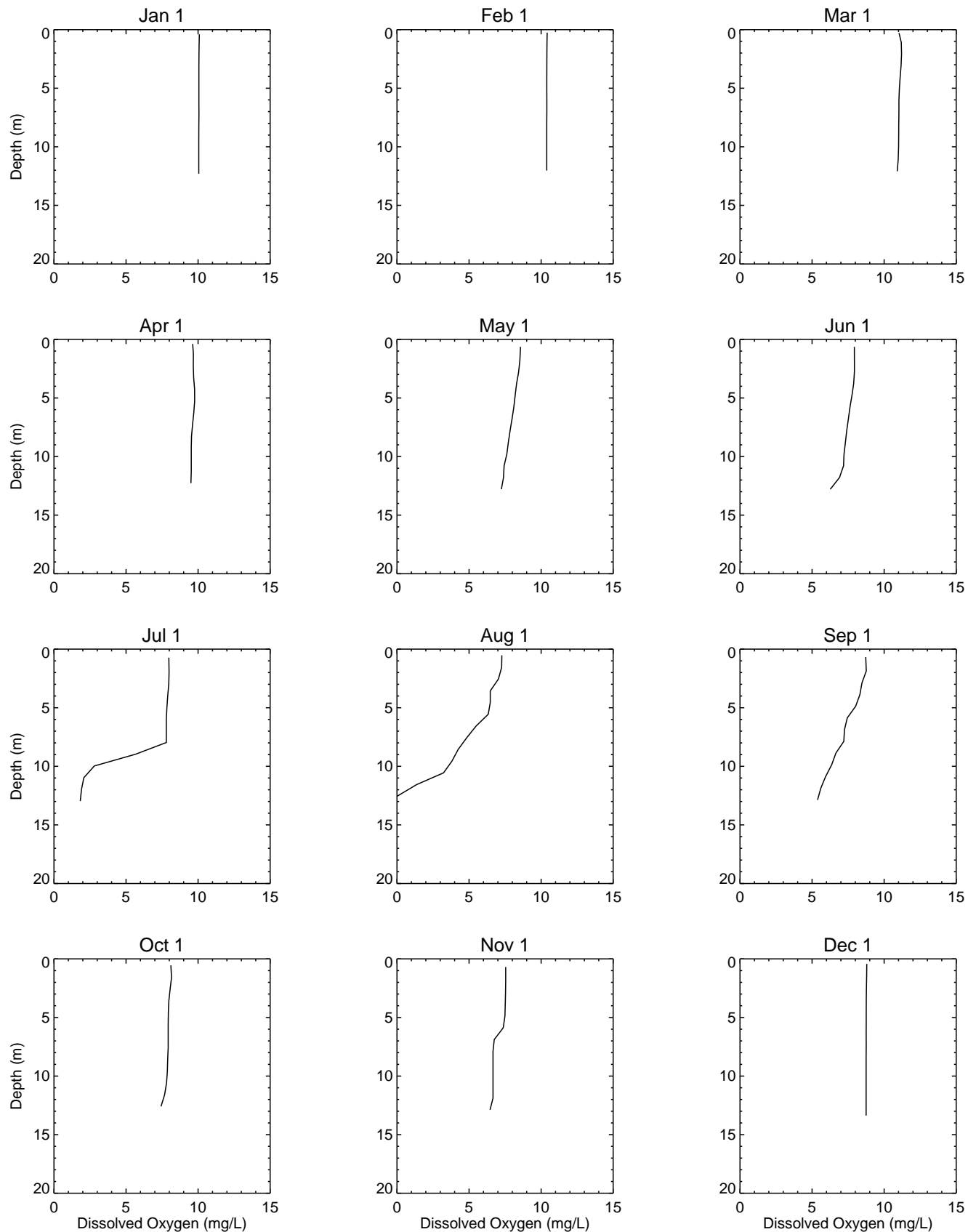CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 2003

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority
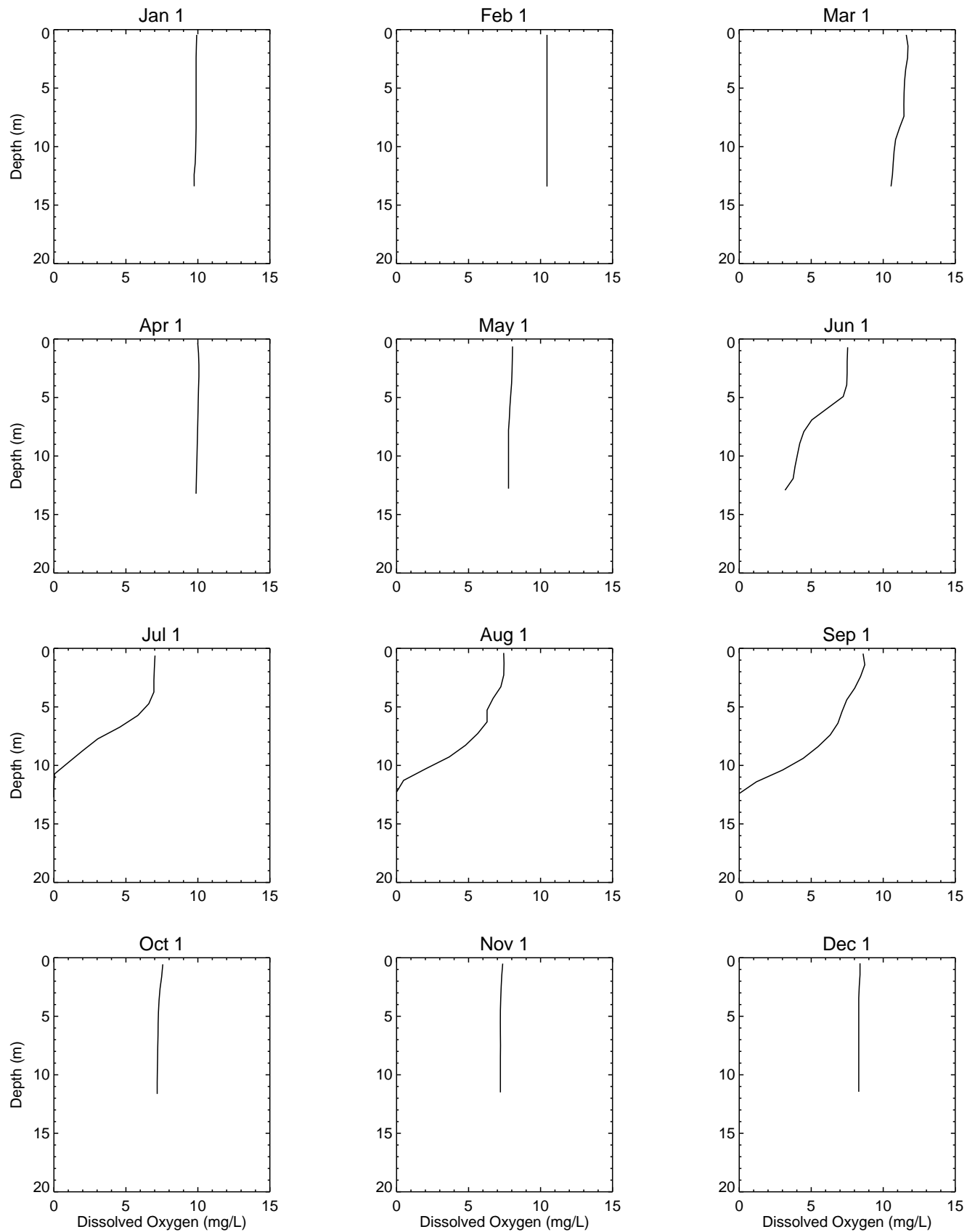
Model (w1210-48)
● Data

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 2004

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:54 2013

Jan 1   Feb 1   Mar 1

Apr 1   May 1   Jun 1

Jul 1   Aug 1   Sep 1

Oct 1   Nov 1   Dec 1

Dissolved Oxygen (mg/L)
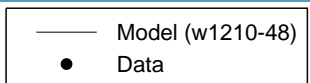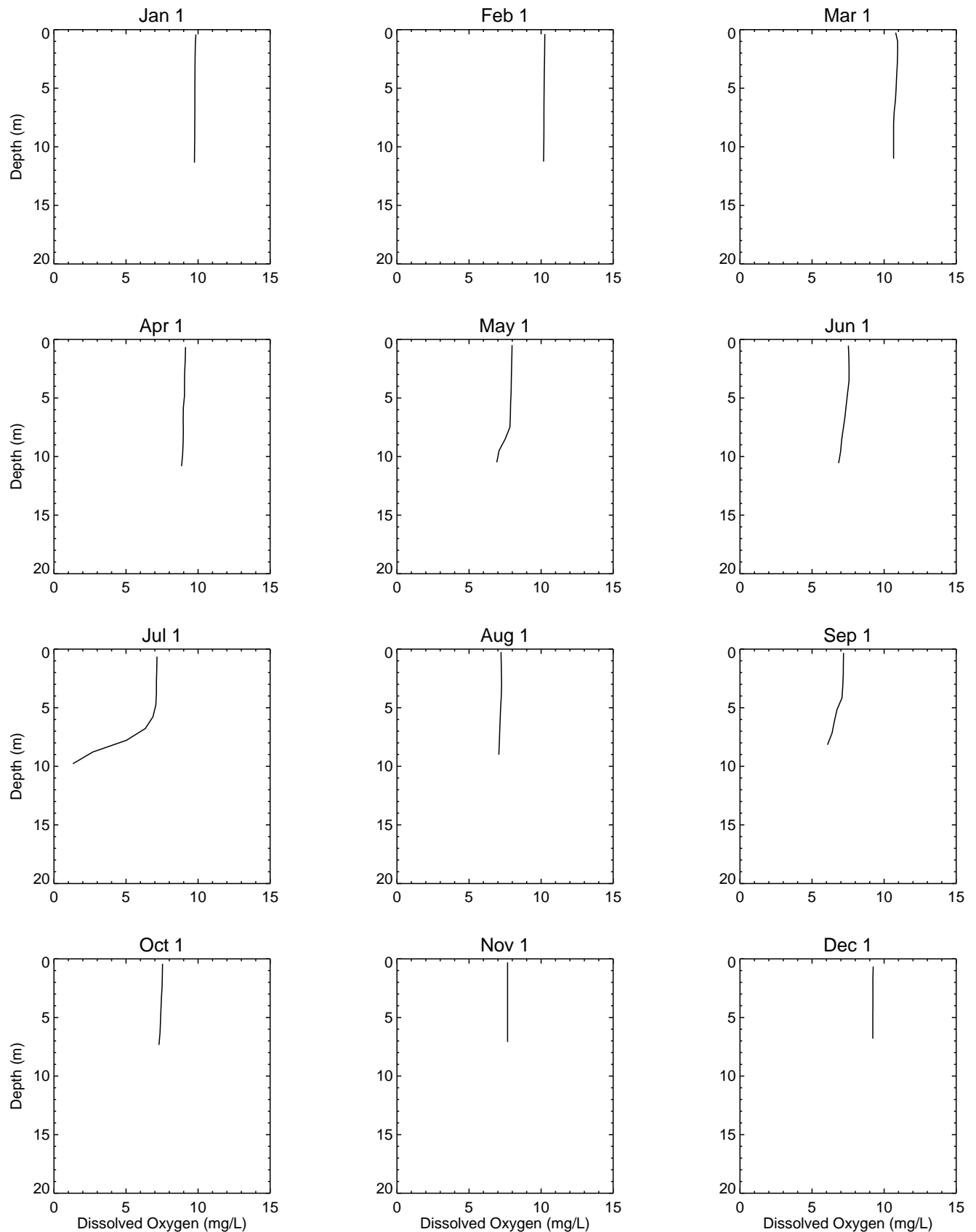
——— Model (w1210-48)

●   Data

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 2005

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

Jan 1 • Feb 1 • Mar 1 • Apr 1 • May 1 • Jun 1 • Jul 1 • Aug 1 • Sep 1 • Oct 1 • Nov 1 • Dec 1

Dissolved Oxygen (mg/L)

Depth (m)
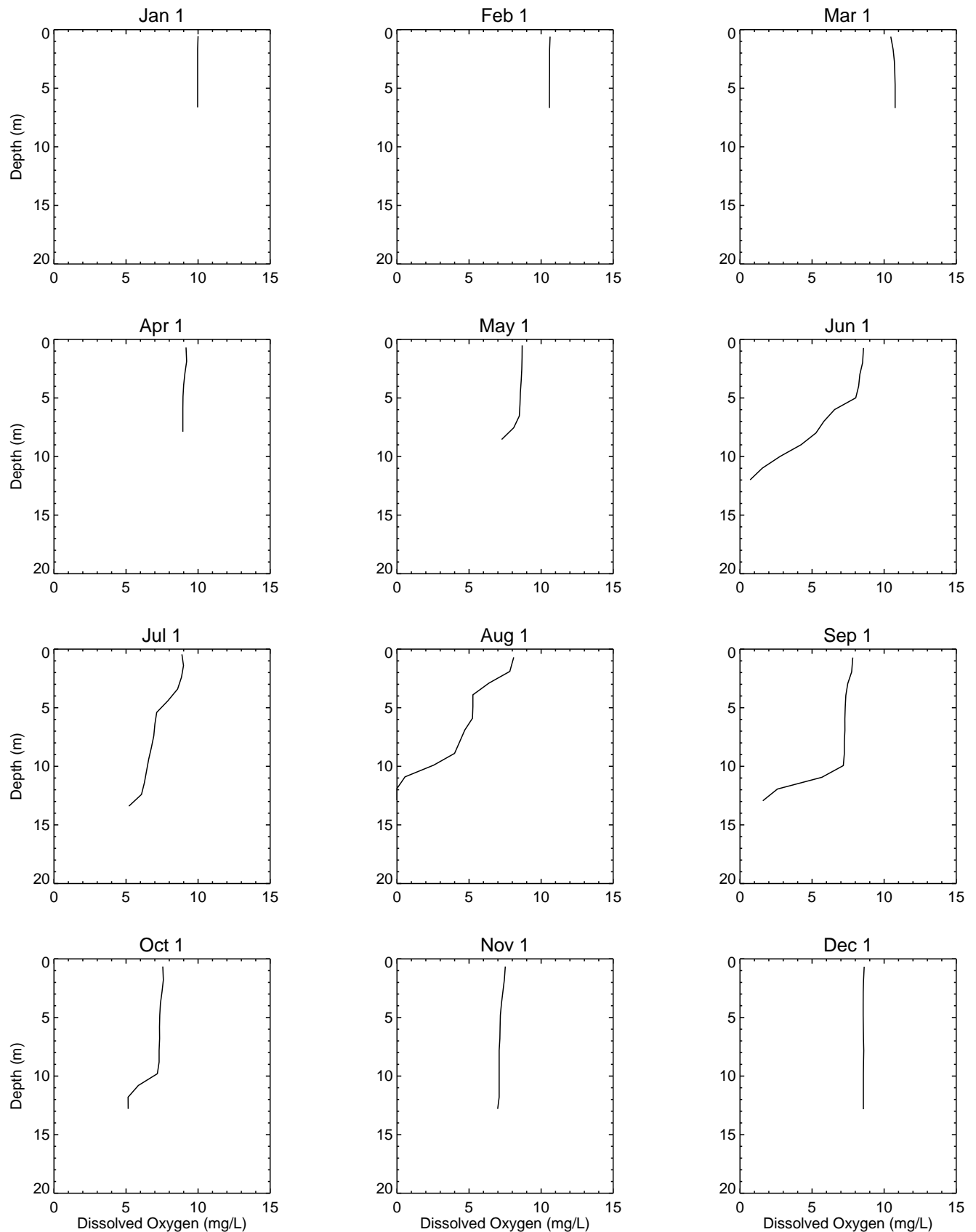
——— Model (w1210-48)

● Data

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 2006

Profiles shown for dates with available data else model results for first day of month shown.
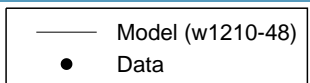
CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

ANCHOR QEA
PARSONS

Jan 1   Feb 1   Mar 1

Apr 1   May 1   Jun 1

Jul 1   Aug 1   Sep 1

Oct 1   Nov 1   Dec 1
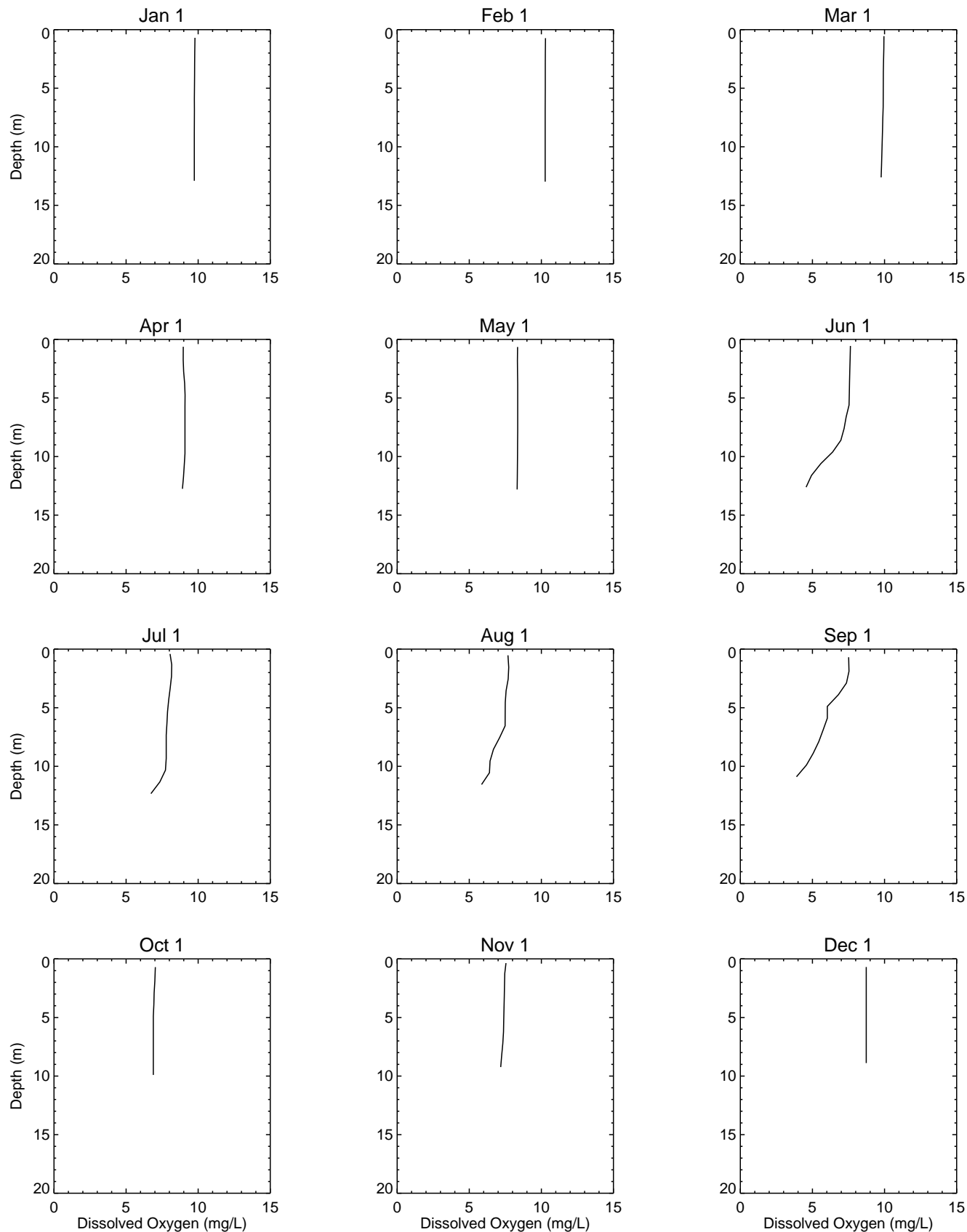
—— Model (w1210-48)
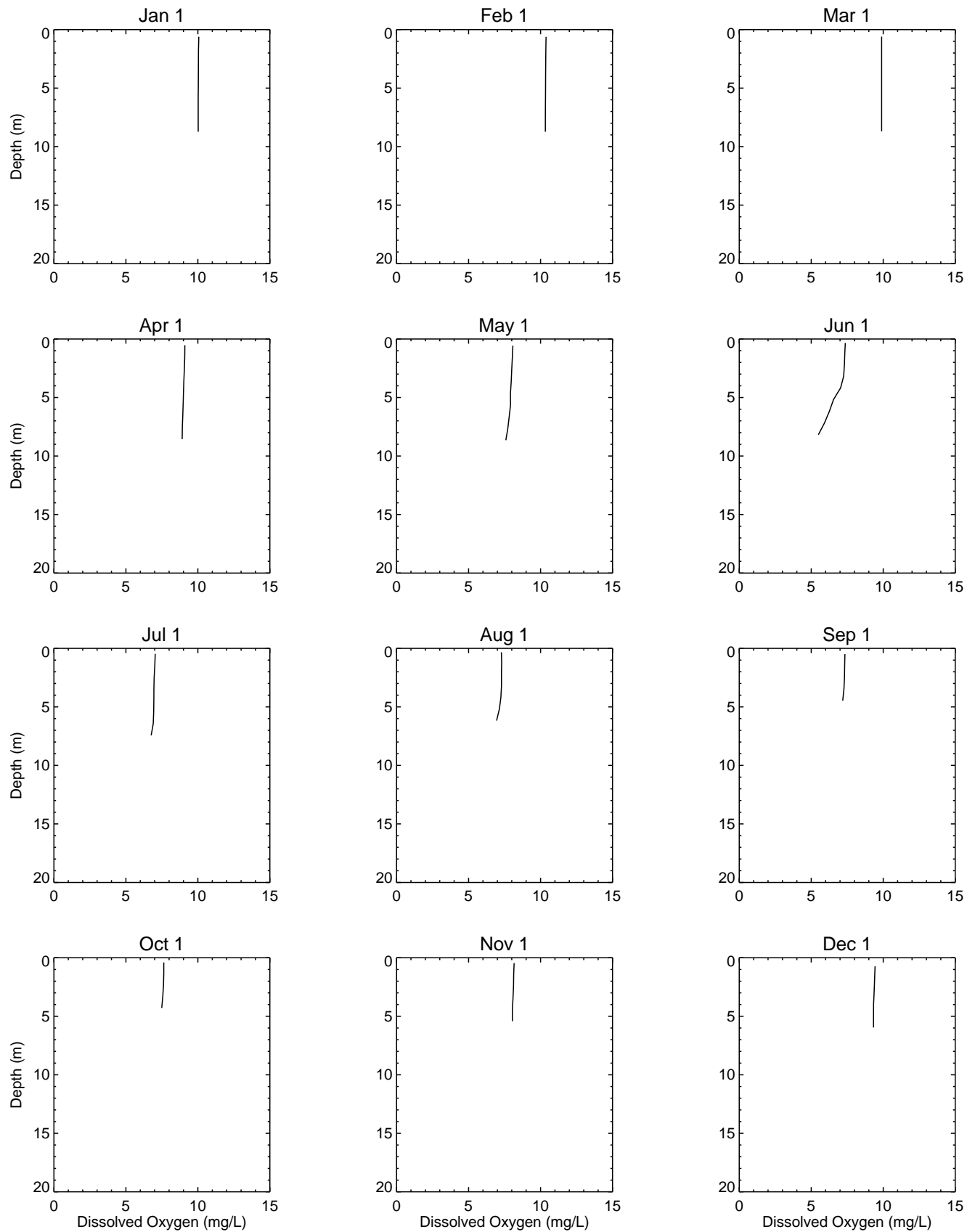● Data

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 2007

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
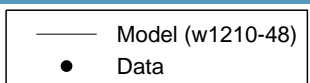Fri Jan 25 18:12:54 2013

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 2009

Profiles shown for dates with available data else model results for first day of month shown.

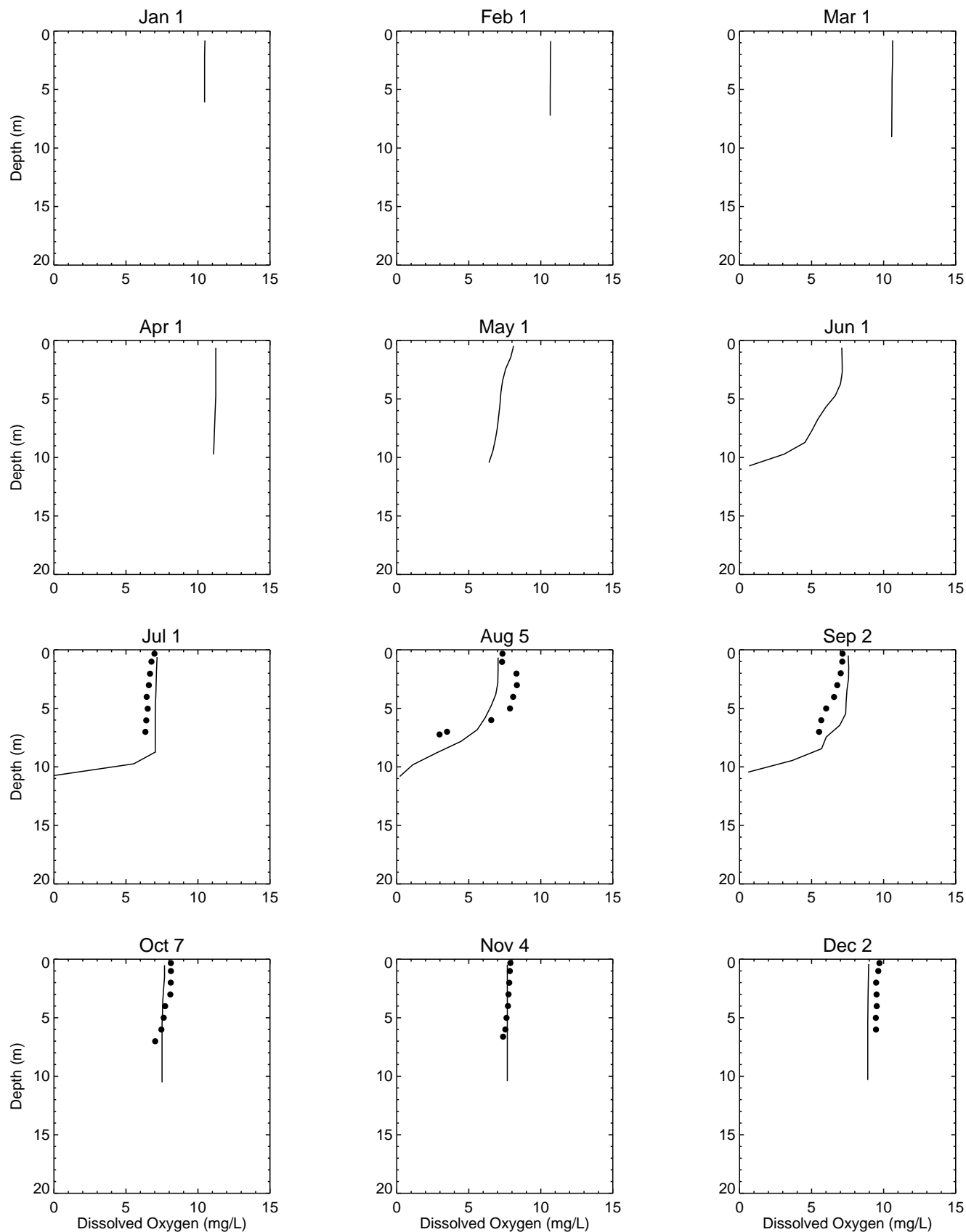CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

Jan 1 · Feb 1 · Mar 1 · Apr 1 · May 1 · Jun 1 · Jul 1 · Aug 5 · Sep 2 · Oct 7 · Nov 4 · Dec 2

Depth (m)

Dissolved Oxygen (mg/L)

—— Model (w1210-48)
● Data

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 2010

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority
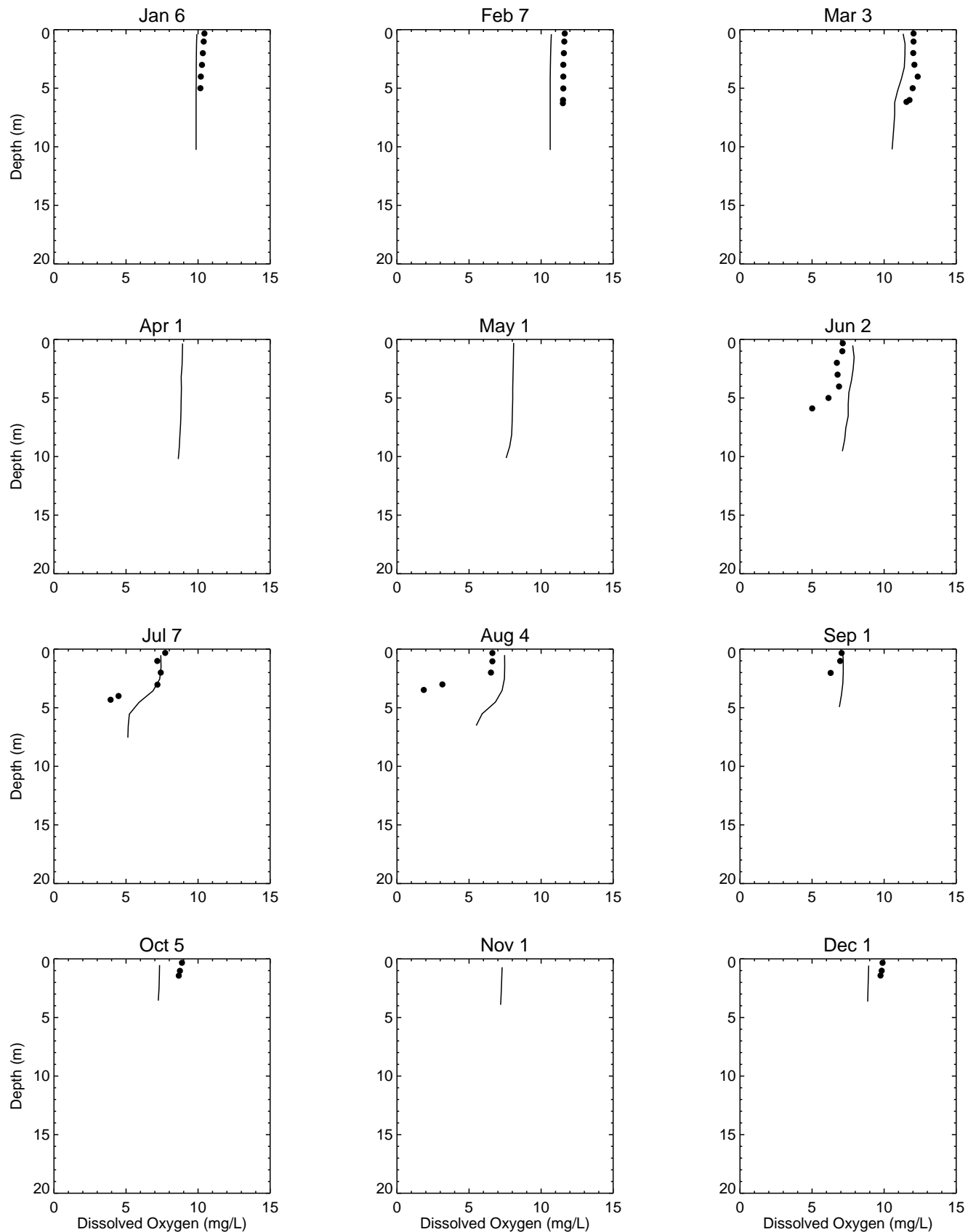
ANCHOR QEA
PARSONS

Figure G-33

Vertical Profiles of Model Versus Data for Lake Buchanan
at Golden Beach (Segment 26) - Dissolved Oxygen - 2011

Profiles shown for dates with available data else model results for first day of month shown.

CREMs Phase 4: Lake Buchanan

Lower Colorado River Authority

EC - D:\D_drive\Projects\LCRA\CREMS\Model\Phase4_Buchanan\CE-QUAL-W2\postprocess\Buch_vertprofiles.pro
Fri Jan 25 18:12:54 2013