Upper East Coast Floridan Aquifer System Groundwater Monitoring Network Data Report 1999 – 2007

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Justin Zumbro, P.G. and Simon Sunderland, P.G.

Hydrogeology Unit, Resource Evaluation Section, Water Supply Bureau

South Florida Water Management District | 3301 Gun Club Road | West Palm Beach, FL 33406

EXECUTIVE SUMMARY

The South Florida Water Management District (SFWMD or District) created the Upper East Coast Floridan aquifer system (UECFAS) groundwater monitoring network based on the recommendations of a diverse committee of stakeholders involved in the public planning process for the 1998 *Upper East Coast Water Supply Plan* (SFWMD 1998). The purpose of the UECFAS groundwater monitoring network was to collect information to develop the relationships between water levels, water quality, and water use in the UEC Planning Area, encompassing all of Martin and St. Lucie counties and the northeastern portion of Okeechobee County. Data collection for the project began in January 1999 and ended in 2007.

The UECFAS groundwater monitoring network was developed by combining spatially distributed, representative wells from the SFWMD potentiometric well network and the United States Department of Agriculture Natural Resource Conservation Service (NRCS) FAS well network under several cooperative agreements between the two agencies. A total of 73 wells (14 District wells and 59 NRCS wells) were used for monitoring various combinations of FAS groundwater levels, groundwater quality, and monthly pumping volumes from select agricultural wells, as well as precipitation data, collected between 1999 and 2007 at citrus groves located throughout the UEC Planning Area. This data report presents a summary of the project history and the collected data.

The groundwater level data collected during this project show that FAS water levels in the monitored wells were stable between 1999 and 2007, except for FAS monitor wells located in citrus groves close to wells where extensive agricultural pumping from the FAS was occurring. Chloride concentrations in all the FAS groundwater quality samples collected from UECFAS groundwater monitoring network wells ranged from 230 milligrams per liter (mg/L) to 2,300 mg/L, and the total dissolved solids (TDS) concentrations ranged from 410 mg/L to 6,540 mg/L, indicative of brackish groundwater.

Total FAS groundwater use was monitored by the NRCS at agricultural wells in each of the citrus groves. Monthly water use was generally greatest during the dry seasons with significantly less pumping generally occurring during the wet seasons. About 60% of the total groundwater pumping recorded during this study occurred at wells in groves 6 and 29. Total pumpage ranged from less than 1 acre-foot per year to 8,906 acre-feet per year.

Since the monitoring project ended, the region has undergone extensive development with a related decrease in agricultural land use and FAS water use. Currently, agricultural users in the UEC Planning Area rely primarily on surface water to meet their demands, and the FAS is used primarily for freeze protection or emergency backup supply due to its brackish water quality. Because agricultural water demands are expected to decrease over the planning horizon, existing surface water sources — with FAS sources as a backup supply — can continue to meet 2045 agricultural demands (SFWMD 2021).

Brackish groundwater from the FAS is used within the UEC Planning Area by seven public supply utilities, six golf courses, several agricultural users, and one power generation facility (SFWMD 2021). Public supply utilities within the UEC Planning Area rely on fresh groundwater from the surficial aquifer system (SAS) and brackish groundwater from the FAS (SFWMD 2021). Two public supply utilities have proposed to withdraw from the FAS beginning in 2023 and 2028 (SFWMD 2021).

Precipitation data collected across the UEC Planning Area illustrate the seasonal variation in rainfall across the study area, with most of the rain falling during the rainy season, between April and October each year. Average yearly rainfall was approximately 42 inches per year at all of the rain gauges installed at the monitored citrus groves.

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ACRONYMS AND ABBREVIATIONS

APPZ	Avon Park permeable zone
bls	below land surface
District	South Florida Water Management District
FAS	Floridan aquifer system
ft	foot
ICU	intermediate confining unit
LFA	Lower Floridan aquifer
MCU	middle confining unit
mg/L	milligrams per liter
NGVD29	National Geodetic Vertical Datum of 1929
NRCS	Natural Resource Conservation Service
QA/QC	quality assurance quality control
RFGW	Regional Floridan Groundwater Network
SAS	surficial aquifer system
SFWMD	South Florida Water Management District
TDS	total dissolved solids
UFA	Upper Floridan aquifer
UFA-upper	upper permeable zone (of the UFA)
UEC	Upper East Coast
UECFAS	Upper East Coast Floridan aquifer system
USGS	United States Geological Survey

1 INTRODUCTION

The South Florida Water Management District (SFWMD or District) Upper East Coast (UEC) Planning Area (**Figure 1**) covers approximately 1,230 square miles and includes all of Martin and St. Lucie counties and the northeastern portion of Okeechobee County. In response to the recommendations of a diverse committee of stakeholders involved in the public planning process for the 1998 *Upper East Coast Water Supply Plan* (SFWMD 1998), the District established the Upper East Coast Floridan aquifer system (UECFAS) groundwater monitoring network. The purpose of the UECFAS groundwater monitoring network was to collect information to develop the relationships between water levels, water quality, and water use in the UEC Planning Area. Data collection for the project began in January 1999 and ended in 2007.

The primary aim of this report is to present the data collected from the UECFAS groundwater monitoring network in a tabular and graphical format for future reference because most of the data are not publicly available. This report also describes the history of the project, including the establishment of several cooperative UECFAS groundwater monitoring network agreements between the SFWMD and the United States Department of Agriculture Natural Resource Conservation Service (NRCS). Hydrogeologic data presented in this report include FAS water level, water quality, and water use data as well as precipitation data collected from rain gauges at the citrus groves where the NRCS wells were located. A total of 73 wells (14 District wells and 59 NRCS wells) were used for monitoring various combinations of water levels, water quality, and water use in the UECFAS groundwater monitoring network.

Prior to the 1980s, the FAS was a relatively unused water source for UEC public water supply users. Groundwater from the FAS was primarily used by UEC citrus farmers as a supplemental source of irrigation water. At the time, most of the public supply for the region came from the overlying surficial aquifer system (SAS), which generally has relatively higher quality (less saline) water and is more economical to tap with wells. However, by the late 1980s, use of the SAS was reaching its sustainable limits. Soon after, most coastal utilities in the UEC either began using or planned to use FAS groundwater to help meet their needs. Public supply utilities generally blend FAS groundwater with fresh water or treat the FAS groundwater using reverse osmosis prior to distribution.

Preliminary evaluations presented in the 1998 *Upper East Coast Water Supply Plan* (SFWMD 1998) indicated that the FAS could help meet current and projected urban and agricultural water use demands. However, the District had limited information on water use and long-term ramifications to water levels and water quality in the FAS due to sustained groundwater withdrawals. Because of this, the UECFAS groundwater monitoring network was created to provide insight into the relationships between water levels, water quality, and water use across the UEC Planning Area.

Since the time of this monitoring project, increasing development and changing land use has eliminated much of the agricultural land and associated FAS water use in the UEC Planning Area. According to the 2021 *Upper East Coast Water Supply Plan Update* (SFWMD 2021), water users in the UEC Planning Area rely on surface water, groundwater (fresh and brackish), and reclaimed water to meet urban and agricultural demands.

In 2019, approximately 83% of agricultural demands in the UEC Planning Area were met with surface water, and this percentage is expected to remain the same through 2045 (SFWMD 2021). However, irrigated agricultural acreage and associated demands are projected to decrease approximately 26% from 2019 to 2045 (SFWMD 2021).

Groundwater from the SAS for agriculture is utilized to a much lesser extent. The FAS is used primarily for freeze protection or emergency backup supply due to the brackish water quality that typically requires blending with fresh water prior to its use for irrigation. Brackish groundwater from the FAS is used within the UEC Planning Area by seven public supply utilities, six golf courses, several agricultural users, and one power generation facility (SFWMD 2021). Public supply utilities within the UEC Planning Area rely on fresh groundwater from the SAS and brackish groundwater from the FAS (SFWMD 2021). Two public supply utilities have proposed to withdraw from the FAS beginning in 2023 and 2028. These utilities use reverse osmosis treatment and have a combined treatment capacity of 59.04 million gallons per day. In 2019, FAS water met 69% of public supply demand (SFWMD 2021).

Current and future FAS demands in the UEC Planning Area were simulated using the SFWMD's East Coast Floridan Model to assess the potential impacts of withdrawals on water levels, water quality, and the viability of the source through the planning horizon (SFWMD 2021). The model results indicate no large-scale changes in water levels or water quality in the FAS are expected for most of the model domain through 2045. However, there are some isolated areas with potential issues that may require further evaluation such as the northeastern portion of the planning area (SFWMD 2021).

Current review and analyses of FAS data indicate there have been no substantial regional changes; however, some local changes in water quality have been observed, which may be the result of localized pumping stresses or hydrologic conditions (SFWMD 2021). FAS users may need to spread out withdrawal facilities or reduce individual well pumping rates to mitigate water quality changes. These areas should continue to be monitored through a coordinated effort with utilities and other FAS stakeholders (SFWMD 2021).

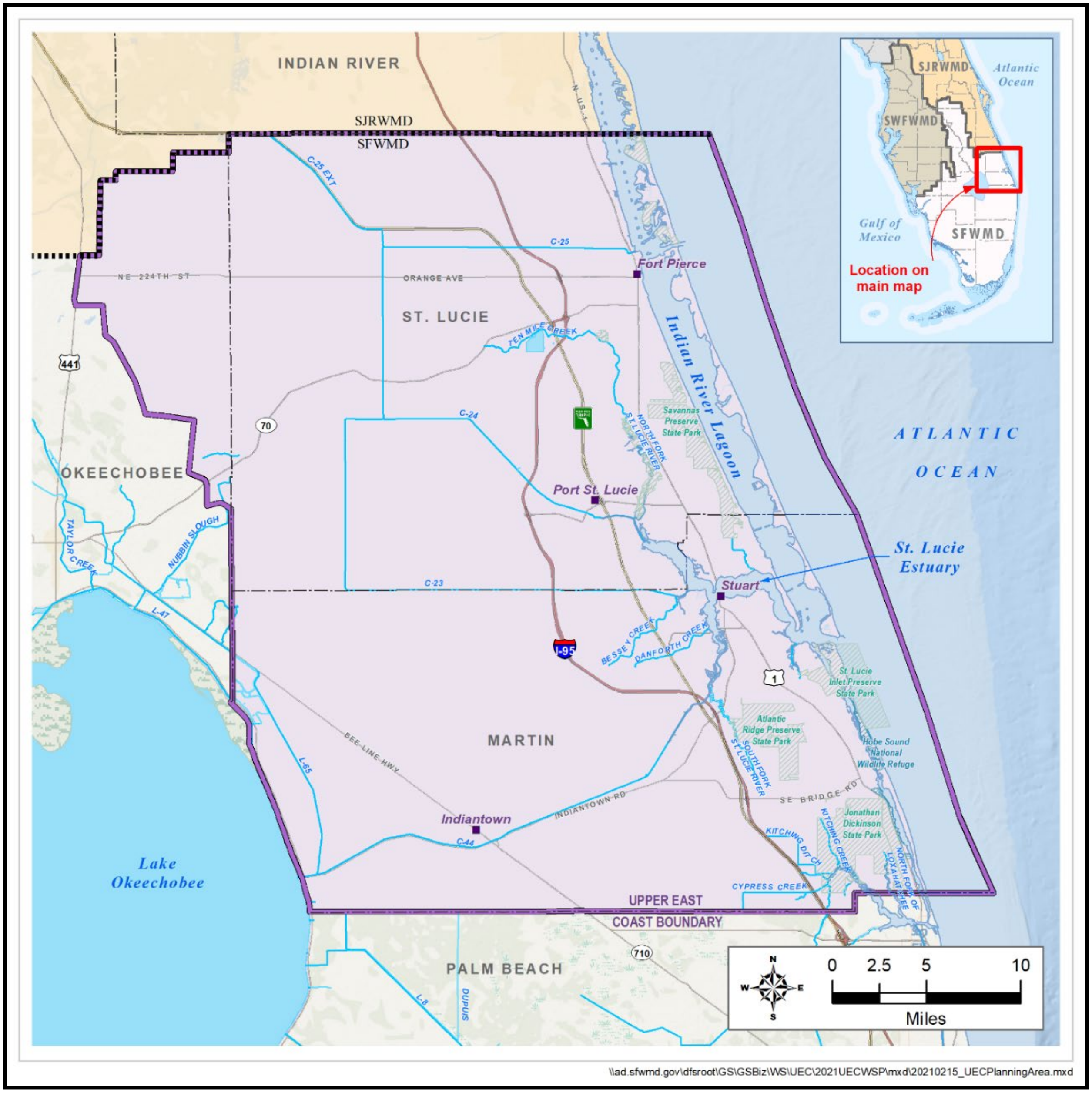

Figure 1. UEC Planning Area.

1.1 History and Development of the UECFAS Groundwater Monitoring Network

In the late 1980s, the SFWMD established a FAS potentiometric well network, including wells in Glades, Highlands, Okeechobee, Martin, Palm Beach, and St. Lucie counties. Water level measurements were collected twice a year from the wells in this network: once during the dry season and once during the wet season. The potentiometric network combined water level data from other water management districts and the United States Geological Survey (USGS) and used those data to develop and publish semiannual potentiometric surface maps of the FAS (Kinnaman and Dixon 2011).

In 1995, the NRCS established a FAS groundwater monitoring network under a cooperative agreement with the SFWMD to evaluate citrus crop irrigation water use from FAS wells in St. Lucie County (see **Section 1.2**). This network was part of the Indian River Lagoon Surface Water Improvement and Management Plan that documented the frequency, quantity, and timing of water use from the FAS.

The UECFAS groundwater monitoring network was created under a series of cooperative agreements (see **Section 1.2**) between the SFWMD and the NRCS with the intention of establishing a comprehensive set of FAS groundwater monitoring sites across the UEC Planning Area. Spatially distributed, representative wells from the SFWMD's potentiometric monitoring well network were combined with the NRCS monitoring well network. **Figure 2** shows the locations of all the SFWMD and NRCS monitoring wells from which water level and/or water quality and water use data were collected. **Appendix A** provides a table of all the wells shown in **Figure 2** and includes the well coordinates, total depth, and cased depth for each well. The NRCS network wells are preceded by "NRCS" in the well ID, and the first number of the well name indicates in which citrus grove the well is located. For instance, NRCS wells named 2-2 and 2-3 are wells 2 and 3 located in citrus grove 2 (illustrated in **Figure 2**).

Based on the cooperative agreements, the District managed the wells selected from the potentiometric well network, and the NRCS managed the wells selected from its citrus grove network. Groundwater level monitoring was not fully implemented until mid-2002 due to logistical issues involving the installation of pressure transducers in the flowing artesian wells. From 2006 through 2007, land use in the region began to shift from agricultural to residential. This led to a decline in the number of wells in the network and made it difficult to find replacement well sites. By the end of 2007, the District's funding priorities changed and the intensive monitoring in the UEC Planning Area was replaced by the more extensive regional FAS groundwater network (RFGW). This data report presents all available data collected between 1999 and 2007 as part of the UECFAS groundwater monitoring network.

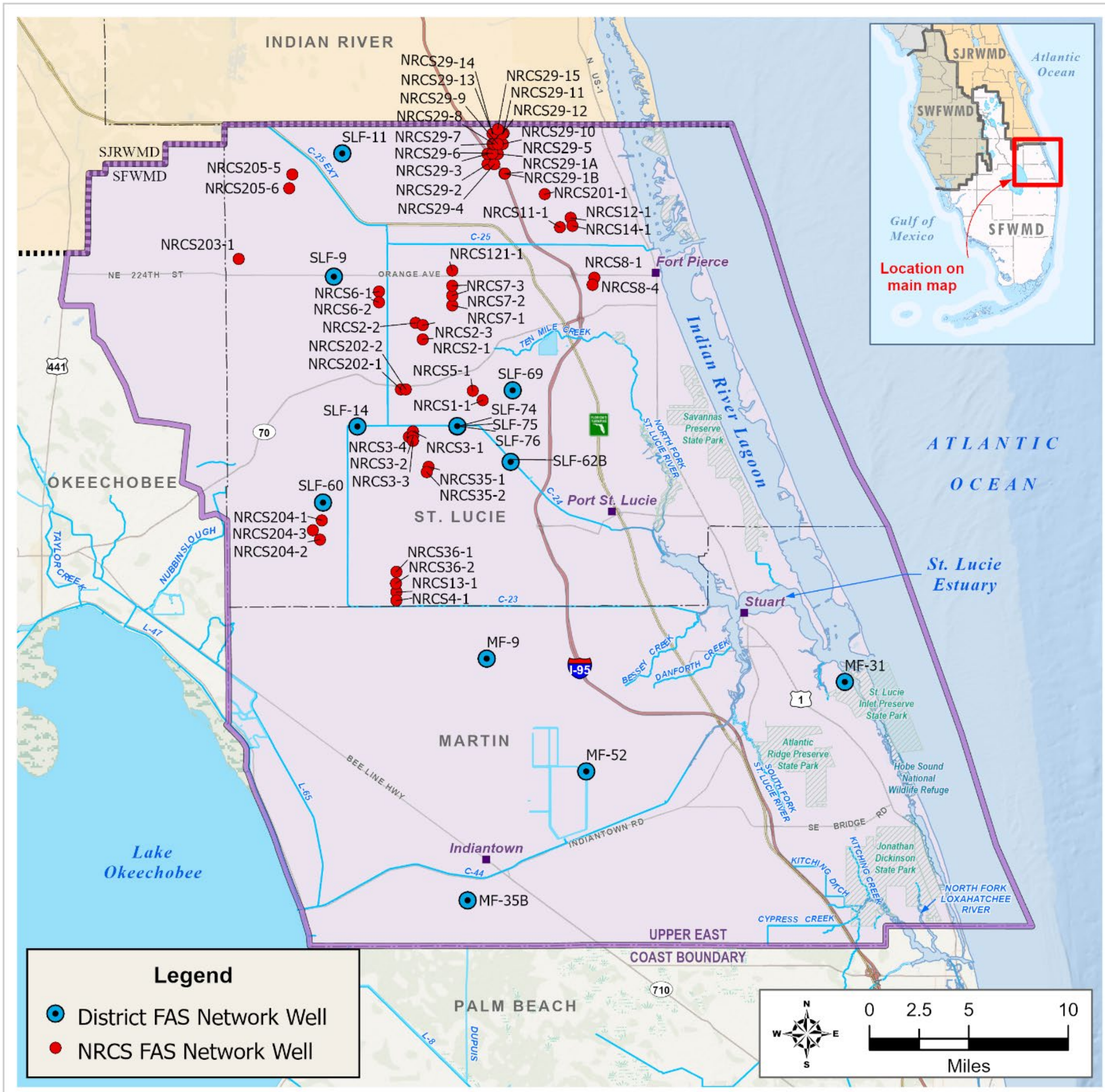

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Figure 2. UECFAS groundwater monitoring network.

1.2 Cooperative Agreements

The SFWMD entered into a series of cooperative agreements to combine its potentiometric well network with the NRCS citrus grove well network to establish the UECFAS groundwater monitoring network. Between 1995 and 2007, four cooperative agreements were used to join the two networks, identify additional monitor wells, collect groundwater elevation and groundwater quality data, and perform general maintenance on the wells and monitoring equipment.

The first cooperative agreement, Contract C-6775, was executed in August 1995 and expired in August 2001. The District used this contract to help the NRCS establish its network as part of the Indian River Lagoon Surface Water Improvement and Management Plan. The original purpose of the NRCS network was to document the frequency, quantity, and timing of water use from the FAS and determine how water from the aquifer affected surface water discharges to the Indian River Lagoon. The scope of work required the NRCS to install flowmeters on FAS wells in St. Lucie County and collect monthly flow and specific conductance data. Under this contract, 42 wells from 16 citrus groves were metered. The NRCS submitted quarterly data reports to the District.

The second cooperative agreement, Contract C-11746, was executed in December 1999 and was a 1-year agreement that overlapped with and expanded the scope of Contract C-6775. C-11746 was the initial contract used to manage the NRCS network after it was included into the UECFAS groundwater monitoring network and was designed to identify additional FAS monitor wells, expand the water level and water quality monitoring program, and complete well surveying and geophysical logging. This contract expired in March 2001 after a no-cost extension was granted to complete the scope of work. C-11746 allowed the NRCS to locate additional wells to improve network coverage and increased the number of wells monitored to 52 in 21 groves. The NRCS located 15 additional wells in five groves and installed flowmeters on seven of these wells. This contract also expanded the water quality monitoring to include analyses for chloride and total dissolved solids (TDS). The NRCS collected water samples for these parameters quarterly in conjunction with the sampling for the District portion of the UECFAS groundwater monitoring network. The scope of work for Contract C-11746 required the NRCS to perform a location and elevation survey of the 42 wells metered under Contract C-6775.

The third cooperative agreement, Contract C-12349, was executed in November 2000 and continued the work started under Contract C-11746. This agreement ran for 4 years, expiring in November 2004. Under this agreement, the NRCS installed flowmeters on the remaining eight wells identified under Contract C-11746, surveyed the 15 wells identified under C-11746, and continued collecting data. This contract also covered the deployment of 11 dataloggers to collect continuous water level measurements in selected wells. The NRCS downloaded the water level data monthly and maintained the units.

The fourth and final cooperative agreement, Contract OT050195, was executed in October 2004 and continued the data collection and maintenance covered under C-12349. Under this agreement, the NRCS collected water level, water quality, and water use data monthly and performed flowmeter maintenance and well head repairs when necessary. This agreement was scheduled to end in October 2009. However, the District terminated the agreement in April 2008 due to changing priorities and budget constraints.

2 REGIONAL GEOMORPHOLOGY, CLIMATE, GEOLOGY, AND HYDROGEOLOGY

2.1 Regional Geomorphology

The main physiographic region in the UEC Planning Area is known as the Eastern Valley, part of the Atlantic Coastal Lowlands (Cooke 1939). The average land surface elevation in the planning area is about 35 feet above the National Geodetic Vertical Datum of 1929 (NGVD29) with a maximum elevation of approximately 60 feet above NGVD29 in the western portion of the UEC Planning Area within the Osceola Plain. The planning area is bounded by the Atlantic Ocean to the east, Indian River County to the north, Palm Beach County to the south, and Lake Okeechobee and Okeechobee County to the west (**Figure 1**).

2.2 Climate

The climate of the UEC Planning Area is subtropical with long, hot, humid, wet summers and mild, dry winters. The daily temperature averages 73.9 degrees Fahrenheit (°F) with an average temperature range of 64.9 °F to 81.9 °F. Seasonal variation in rainfall is pronounced, with approximately 70% of the annual rainfall occurring during the wet season from May through October. Long-term average annual rainfall in the region is approximately 50 inches.

2.3 Regional Geology

This report uses geologic formation names used by the SFWMD and the USGS. **Figure 3** is a generalized hydrostratigraphic column for the UEC Planning Area (modified from Reese 2004). Note that while the middle semiconfining unit, the Lower Floridan aquifer (LFA), and the Sub-Floridan confining unit are shown in **Figure 3**, these units were not penetrated by the wells used in the UECFAS groundwater monitoring network. Wells that were part of this network penetrated geologic formations as old as the late to middle Eocene Epoch Avon Park Formation. As such, the following subsections provide a general description of the geologic formations including and younger than the middle to upper portions of the Avon Park Formation.

2.3.1 Holocene and Plio-Pleistocene Formations

Geologic units of the Holocene, Pleistocene, and Pliocene epochs in the UEC Planning Area include, from youngest to oldest, the Holocene Pamlico Sand, the Pleistocene Anastasia Formation and Fort Thompson Formation, and the Pliocene Tamiami Formation. Total thickness of these four geologic units is up to 250 feet in the UEC Planning Area, and these units are often discontinuous and difficult to correlate through the planning area (Reese 2004). The Pamlico Sand is composed of quartz sand with shell beds (Reese and Memberg 2000). The Anastasia Formation is composed of quartz sand, shells, and coquina (Reese and Memberg 2000). The Fort Thompson Formation is composed of alternating beds of marine molluscan limestone and freshwater marl (Reese and Memberg 2000). The Tamiami Formation consists of silt; sandy clay; sandy, shelly limestone; calcareous sandstone; and quartz sand (Reese 2004).

2.3.2 Hawthorn Group

The Miocene Epoch to late Oligocene Epoch Hawthorn Group overlies the Suwannee Limestone and includes the Arcadia Formation and the overlying Peace River Formation. The Hawthorn Group consists of an interbedded sequence of widely varying lithologies and components, including limestone, mudstone, dolomite, dolosilt, shell, quartz sand, clay, abundant phosphate grains, and mixtures of these materials (Reese 2004). The Peace River Formation is mostly siliciclastic rock, whereas the Arcadia Formation is mostly carbonate rock. The Hawthorn Group is distinguished from the underlying units by elevated gamma ray log responses; variable siliciclastic and phosphatic content; and green, olive-gray, or light gray coloration.

2.3.3 Basal Hawthorn/Suwannee Limestone Unit

Reese and Memberg (2000) identified a basal unit underlying a marker unit in the Hawthorn Group. Referred to as the basal Hawthorn/Suwannee Limestone unit, this marker unit can be subdivided into two units with gradational contacts based on gamma ray log responses (Reese 2004). Reese reported that the lower interval is generally composed of limestone, whereas the upper interval contains more clay, silt, and phosphate grains. The lower limestone unit may be equivalent to the Suwannee Limestone, and is thickest near the coast. The marker unit above the basal Hawthorn/Suwannee Limestone unit has a characteristic gamma ray response and thickness throughout Lee, Hendry, Collier, and Palm Beach counties, and is composed of micritic limestone, marl, and clay, with minor to trace amounts of phosphate grains (Reese 2004).

The early Oligocene Epoch Suwannee Limestone consists predominantly of pale orange to tan, fossiliferous, carbonate packstone to grainstone with minor amounts of quartz sand and rare to absent phosphate grains (Reese 2004). Lukasiewicz (1992), following precedent established by previous SFWMD publications (Brown and Reece 1979, Brown 1980, Reece et al. 1980), mapped the position of the Suwannee Limestone and the underlying Ocala Limestone throughout the UEC Planning Area. The Suwannee Limestone was identified in well SLF-73 from 490 to 560 feet below land surface (bls). In central St. Lucie County, the thickness of the Suwannee Limestone is approximately 50 to 60 feet. Reese (2004) identified an example interval of the Suwannee Limestone in the log for well PB-1197 from 1,050 to 1,110 feet bls.

2.3.4 Ocala Limestone

The late Eocene Epoch Ocala Limestone consists of micritic or chalky limestone, calcarenitic limestone, and coquinoid limestone (Reese 2004). It is characterized by abundant large benthic foraminifera such as *Operculinoides* sp., *Camerina* sp., and *Lepidocyclina* sp. (Peacock 1983).

2.3.5 Avon Park Formation

The middle Eocene Epoch Avon Park Formation consists of micritic to fossiliferous limestone, dolomitic limestone, and dolostone or dolomite (Reese 2004). Moderately to well sorted, fine- to medium-grained calcarenite is present in places. Foraminifera characteristic of the Avon Park Formation are cone-shaped *Dictyoconus* sp. (Duncan et al. 1994).

The top of the Avon Park Formation is marked in some places by light brown, finely crystalline to fossiliferous dolomitic limestone or dolomite thinly interbedded with limestone (Reese 2004). A thick interval mostly containing dolomite but commonly interbedded with limestone often is present in the middle to lower part of the Avon Park Formation. The thickness of the formation ranges from less than 900 to more than 1,600 feet (Miller 1986).

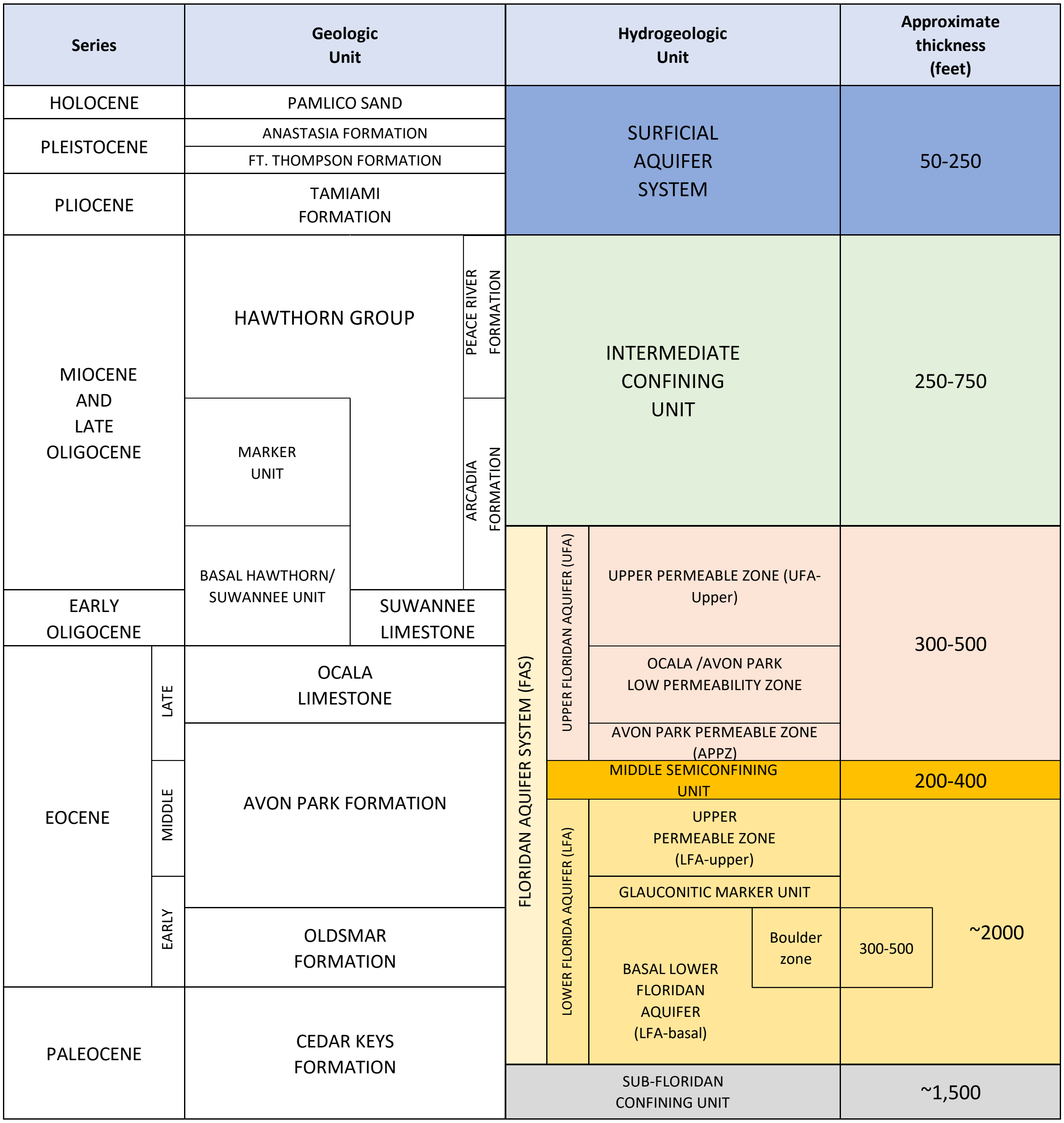

Figure 3. Generalized geologic and hydrogeologic units in the UEC Planning Area, Martin and St. Lucie counties, Florida. Modified from USGS WRIR 03-4242, Figure 3 (Reese 2004).

2.4 Hydrogeologic Framework

Figure 3 shows the hydrogeologic units found in the UEC Planning Area and their relation to the geologic units. Only the hydrogeologic units and confining units penetrated by the wells discussed in this report are described below.

The principal water-bearing units in the UEC Planning Area are the SAS and the FAS. These two aquifer systems are separated by the intermediate confining unit (ICU). The deepest wells in the UECFAS groundwater monitoring network were no deeper than the Avon Park permeable zone (APPZ), so aquifers deeper than the APPZ are not discussed here. Brief descriptions of these hydrogeologic units are provided in the sections below.

2.4.1 Surficial Aquifer System

The SAS is unconfined and recharged by rainfall, canals, lakes, reservoirs, irrigation water, and, possibly, upward leakage from the FAS. The thickness of the SAS varies from less than 50 feet to more than 250 feet in the UEC Planning Area (Brown and Reece 1979). The SAS consists of quartz sand, silt, clay, shell beds, coquina, calcareous sandstone, and sandy, shelly limestone (Reese 2004). The base of the SAS is commonly defined as the depth where sediments grade from sand into clayey sand or clay; however, basal sediments can also consist of limestone (Reese 2004) (**Figure 3**). The SAS provides most of the potable water supply in the UEC Planning Area.

2.4.2 Intermediate Confining Unit

The ICU confines the Upper Floridan aquifer (UFA) and separates it from the overlying SAS. The top of the ICU is often equivalent to the top of the Hawthorn Group but can extend into the overlying Tamiami Formation. The lithology of the ICU is variable and includes fine-grained sediments such as clay, marl, micritic limestone, and silt. The upper contact of the ICU ranges from less than 80 feet bls in northwestern St. Lucie County to more than 200 feet bls in southeastern Martin and northeastern Palm Beach counties (Lukasiewicz 1992). Throughout much of St. Lucie County, the ICU is approximately 400 to 500 feet thick. The ICU is not known to have permeable water-bearing zones in the UEC Planning Area.

2.4.3 Floridan Aquifer System

The FAS is defined as a vertically continuous sequence of permeable carbonate rocks that are hydraulically connected in varying degrees and whose permeability generally is several orders of magnitude greater than that of the rocks bounding the system above and below (Reese 2004). The FAS in southern Florida consists predominantly of limestone with dolomitic limestone and dolomite becoming more common in the deeper portions of the aquifer system. The FAS is generally divided into the UFA and the LFA, separated by the middle confining unit (MCU) (**Figure 3**). Wells included in this study terminate in the UFA.

Upper Floridan Aquifer

In general, the UFA is delineated based on permeability characteristics, lithologic descriptions, and interpretation of geophysical logs (Reese 2004). Therefore, neither the top nor the base of the UFA necessarily conforms to geologic formation or time-stratigraphic boundaries. The UFA is generally composed of multiple thin flow zones of high-permeability rock interlayered with thicker zones of low-permeability material. The top of the UFA approximately coincides with the top of the basal Hawthorn/Suwannee Limestone unit (**Figure 3**), except in coastal areas where it lies within this unit at the base of a section rich in clay and phosphate (Reese 2004). Groundwater occurs under flowing artesian conditions, except to the west where the UFA underlies the Osceola Plain (Reese 2004).

In the UEC Planning Area (**Figure 3**), the UFA is divided (from youngest to oldest) into the upper permeable zone (UFA-upper), the Ocala/Avon Park low-permeability zone, and the APPZ. The thickness of the UFA is approximately 500 feet (Lukasiewicz 1992).

Upper Permeable Zone (UFA-Upper)

Flow zones in the FAS are often identified in boreholes using a combination of flowmeter data, water temperature, packer test data, and caliper logs. Some UFA flow zones are areally extensive and seem to coincide with formation boundaries (Reese 2004). Three to four producing zones were mapped in the UFA by Brown and Reece (1979), and two mappable, extensive flow zones were identified at the base of the Suwannee Limestone and Ocala Limestone, respectively (Brown and Reece 1979, Lukasiewicz 1992). Reese (2004) reported that the shallowest flow zone in the UFA is 90 feet above the base of the basal Hawthorn/Suwannee Limestone unit in northeastern Palm Beach County. Transmissivity varies from 7,000 ft^2/day to more than 70,000 ft^2/day in the UFA, with the greatest transmissivity zones located in northwestern St. Lucie County and the lowest transmissivities near the Atlantic coastline (Reese 2004).

Ocala/Avon Park Low-Permeability Zone

The Ocala/Avon Park low-permeability zone separates the UFA-upper from the underlying APPZ. In portions of the UEC Planning Area, the Ocala/Avon Park low-permeability zone was encountered from 860 to 1,080 feet bls (Shaw and Geddes 2020). The Ocala/Avon Park low-permeability zone is distinguished from the UFA-upper by a lack of large-scale secondary permeability.

Avon Park Permeable Zone

The APPZ usually lies between the UFA and LFA within the MCU (Reese and Richardson 2008). The MCU is equivalent to the Ocala/Avon Park low-permeability zone and the middle semiconfining unit, with the APPZ located between these two semiconfining units (as shown in **Figure 3**). The APPZ is generally greater than 200 feet thick in the UEC Planning Area (Reese and Richardson 2008).

The APPZ is characterized by thick beds of dolostone with interbedded limestone and dolomitic limestone (Reese and Richardson 2008). The high overall permeability of the APPZ is primarily associated with extensive fracturing, but cavernous or karstic, intergranular, and intercrystalline permeability can also be present (Reese and Richardson 2008). Dolostone in the APPZ varies from poorly to moderately consolidated and sucrosic to dense, hard, and massive (Reese and Richardson 2008). Other characteristics of the APPZ include some increases in gamma ray counts due to dolostone, and varying resistivity and porosity curves due to fracturing. Caliper logs are often close to gauge (i.e., drilled diameter), with numerous abrupt and large hole enlargements due to fractures and dissolution (Reese and Richardson 2008). In some areas, the APPZ is hydraulically connected to the UFA (Reese 2004).

3 NETWORK DESIGN AND DATA COLLECTION

3.1 Network Design and Composition

The UECFAS groundwater monitoring network was designed to provide the best possible spatial coverage using available FAS wells across Martin and St. Lucie counties. Access agreements were obtained by the District for privately owned wells, and the NRCS received permission to monitor the citrus grove irrigation wells in its network. The locations of all the UECFAS groundwater monitoring network wells are shown in **Figure 2**. **Table 1** lists the wells in the UECFAS groundwater monitoring network and the parameters monitored at each well. A total of 73 wells (14 District wells and 59 NRCS wells) were used for monitoring various combinations of water levels, water quality, and water use in the UECFAS groundwater monitoring network. Additional location and well construction information for these wells is included in **Appendix A**.

Table 1. UECFAS groundwater monitoring network wells and parameters monitored.

Well ID	Monitoring Entity	Water Level	Water Quality	Water Use
MF-9	District	X	X	
MF-31	District	X	X	
MF-35B	District	X	X	
MF-52	District	X	X	
SLF-9	District		X	
SLF-11	District		X	
SLF-14	District	X	X	
SLF-21	District	X	X	
SLF-60	District		X	
SLF-62	District	X	X	
SLF-69	District	X	X	
SLF-74	District	X	X	
SLF-75	District	X	X	
SLF-76	District	X	X	
1-1	NRCS		X	X
2-1	NRCS			X
2-2	NRCS	X	X	X
2-3	NRCS	X		X
3-1	NRCS			X
3-2	NRCS		X	X
3-3	NRCS	X	X	X
3-4	NRCS			X
4-1	NRCS		X	X
5-1	NRCS	X	X	X
6-1	NRCS		X	X
6-2	NRCS			X
7-1	NRCS		X	X
7-2	NRCS		X	X
7-3	NRCS			X
8-1	NRCS	X		X
8-2	NRCS			X
8-3	NRCS			X
8-4	NRCS		X	X
11-1	NRCS	X	X	X
12-1	NRCS	X	X	X
13-1	NRCS		X	X

Well ID	Monitoring Entity	Water Level	Water Quality	Water Use
14-1	NRCS		X	X
29-1A	NRCS			X
29-1B	NRCS			X
29-2	NRCS			X
29-3	NRCS			X
29-4	NRCS			X
29-5	NRCS			X
29-6	NRCS			X
29-7	NRCS			X
29-8	NRCS		X	X
29-9	NRCS			X
29-10	NRCS			X
29-11	NRCS		X	X
29-12	NRCS			X
29-13	NRCS	X		X
29-14	NRCS			X
29-15	NRCS			X
35-1	NRCS		X	X
35-2	NRCS	X		X
36-1	NRCS		X	X
36-2	NRCS			X
121-1	NRCS	X	X	X
201-1	NRCS	X	X	X
202-1	NRCS		X	X
202-2	NRCS		X	X
203-1	NRCS	X	X	X
204-1	NRCS	X	X	X
204-2	NRCS		X	X
204-3	NRCS		X	X
204-4	NRCS			X
205-1	NRCS			X
205-2	NRCS			X
205-3	NRCS			X
205-4	NRCS			X
205-5	NRCS	X		X
205-6	NRCS		X	X
205-7	NRCS			X
	Total	25	41	59

NRCS = Natural Resource Conservation Service.

3.2 Site Identification and Data Collection

This section discusses site identification and the data collected from the UECFAS groundwater monitoring network.

3.2.1 Identification of New Sites

The following information was provided by the NRCS to the District when monitoring wells were added to the network:

- Photographs of the new wells

- Well location maps
- Descriptions of the wellheads
- Work needed to install a flowmeter on each well
- Proposed schedule for a physical survey of the wells

In January 2001, geophysical logging (natural gamma and caliper) was completed in 11 of the NRCS wells by MV Geophysical Surveys, Inc. to determine the casing depths and total depths of the wells. This information, along with well construction information obtained from the District's ePermitting database was used to identify which hydrostratigraphic zones of the FAS were monitored by each well. The upper 90 to 320 feet of open hole in nine of the 11 wells in **Table 2** intercept a zone of elevated natural gamma responses as shown in the natural gamma logs, underlain by a zone of much lower and consistent natural gamma responses. The caliper logs do not show a clear correlation between gamma response and borehole diameter. In some cases, the low gamma response zones have enlarged borehole diameters, and in other wells, the low gamma response zones have diameters closer to the bit size. However, the gamma logs are most useful in identifying the transition from the overlying Hawthorn Group materials and the underlying carbonate-dominated rock of the FAS. In summary, the natural gamma logs indicate that these NRCS-monitored agricultural wells intercept what is likely the UFA and include both a deeper carbonate-dominated section of relatively low natural gamma responses (around 10 to 20 American Petroleum Institute [API] standard units), and an overlying portion of what is likely the basal Hawthorn/Suwannee Limestone unit, with elevated natural gamma ray peaks of 100 to 150 API standard units. Wells NRCS 3-3 and NRCS 35-2 show elevated natural gamma responses throughout their open hole monitoring intervals, indicating that these two wells may solely monitor the basal Hawthorn/Suwannee Limestone unit, which is part of the UFA in the UEC Planning Area (Reese 2004). The results of the geophysical logging are summarized in **Table 2**.

Table 2. Well construction data obtained from 2001 geophysical logging.

Well ID	Total Depth (ft bls)	Open Interval (ft bls)	Well Casing Diameter (inches)	Hydrostratigraphic Zone Monitored
NRCS 1-1	825	296	8	UFA
NRCS 2-1	823	260	6	UFA
NRCS 3-3	499	330	8	UFA
NRCS 5-1	808	300	8	UFA
NRCS 7-1	878	278	8	UFA
NRCS 8-4	893	340	6	UFA
NRCS 11-1	893	120	6	UFA
NRCS 12-1	917	345	6	UFA
NRCS 29-8	893	278	6	UFA
NRCS 35-2	527	352	6	UFA
NRCS 121-1	804	316	6	UFA

bls = below land surface; ft = foot; NRCS = Natural Resource Conservation Service; UFA = Upper Floridan aquifer.

3.2.2 Groundwater Level Data Collection

The District manually collected depth-to-groundwater measurements twice a year in the UEC Planning Area prior to the establishment of the cooperative agreements between the District and the NRCS. However, this data collection schedule did not provide enough information to ascertain long-term and seasonal groundwater level trends. In contrast to semiannual manual measurements, electronically collected water level data allows for continuous collection of water level data at 15-minute intervals, year-round, providing a more detailed and complete record of water level changes over time in the FAS. A Campbell Scientific CR10X datalogger and Rittmeyer (Model MPxSGRN) pressure transducer connected to a telemetry system were installed in all the District's UECFAS wells. The District performed routine maintenance at these sites to ensure accurate readings. The NRCS installed In-Situ, Inc. MiniTroll pressure transducers in each of their UECFAS wells and manually downloaded the pressure transducer data monthly.

Groundwater level data were collected from pressure transducers at 11 District wells and 14 NRCS wells (**Table 1**). Hydrographs for each well show water level trends over the course of this study. Hydrographs for each District-monitored well are included in **Appendix B**, and hydrographs for the NRCS-monitored wells are included in **Appendix C**.

3.2.3 Groundwater Quality Sample Collection

Groundwater quality samples were collected from network wells on a quarterly basis and analyzed for chloride and TDS. Specific conductance was measured in the field using a hand-held water quality meter. The District retained a contractor (GFA International) to collect water quality samples from the District wells. The NRCS collected water quality samples from the wells in its network. To ensure the collection of representative groundwater samples, a minimum of three well volumes were purged from each well prior to sample collection. The District's quality assurance/quality control (QA/QC) protocols were followed when collecting these groundwater samples. Water quality data from the UECFAS groundwater monitoring network are stored in DBHYDRO, the District's environmental database that contains historical and up-to-date hydrologic, meteorologic, hydrogeologic, and water quality data.

3.2.4 Groundwater Use Data Collection

The NRCS installed flowmeters on 58 wells (**Table 3**) over the course of the project and recorded total monthly groundwater use (pumpage) from each well. The NRCS prepared quarterly reports that described the water use data and the monthly groundwater quality data.

Table 3. NRCS wells monitored for monthly pumpage.

Well ID	
1-1	29-2
2-1	29-3
2-2	29-4
2-3	29-5
3-1	29-6
3-2	29-7
3-3	29-8
3-4	29-9
4-1	29-10
5-1	29-11
6-1	29-12
6-2	29-13
11-1	29-14
12-1	29-15
13-1	35-1
14-1	35-2
29-1A	36-1
29-1B	36-2

3.2.5 Precipitation Data Collection

In conjunction with the water level, water quality, and water use data, the NRCS also collected monthly precipitation data at 23 rain gauges at various citrus groves throughout St. Lucie County.

3.3 Network Maintenance

By September 2002, the UECFAS groundwater monitoring network was fully established across the UEC Planning Area. Both the District and the NRCS performed routine maintenance and calibration of datalogging equipment and maintenance of wellheads. All the District wellheads were repaired and retrofitted to accommodate pressure transducers and dataloggers. The NRCS wells that had dataloggers installed were also retrofitted to accommodate the In-Situ, Inc. Mini Trolls. Well SLF-17 was abandoned during the project.

4 DATA SUMMARY

4.1 Water Level Data

Groundwater elevation hydrographs for the water level data collected from the UECFAS groundwater monitoring network from 2002 to 2007 are presented in **Appendix B** (District network wells) and **Appendix C** (NRCS network wells).

The hydrographs for the District-monitored wells (**Appendix B**) generally show seasonal water level fluctuations of up to 7 feet and, at one well (SLF-69), temporary water level drawdowns due to pumping. The hydrographs for the NRCS-monitored wells (**Appendix C**) show similar seasonal water level elevation variations as the District wells, with the effects of agricultural pumping evident in many of the wells.

The hydrographs for many of the NRCS wells (Wells 2-3, 3-3, 5-1, 11-1, 12-1, 29-13, 35-2, 203-1, 205-5, and 204-1) show clear evidence of pumping in the citrus groves (**Appendix C**). Wells 3-3, 5-1, 11-1, 12-1, 29-13, 201-1 203-1, 205-5, and 204-1 show an overall decreasing trend in groundwater elevations over the course of this study, while the groundwater elevations in the other wells appear to have remained stable during the monitoring period. The hydrographs that show increasing groundwater elevations over time are generally located relatively far away from other agricultural pumping areas (such as grove 29) and, therefore, are not significantly affected by pumping.

Many of the hydrographs for the NRCS citrus grove wells have straight, sharp drops in groundwater elevations that recover quickly. These drops in groundwater elevations represent pressure drops in these wells when the wells were used for irrigation. These wells are artesian. Therefore, when the landowner opened the well head valve for irrigation, the pressure dropped in the well, and this pressure drop was recorded by the transducer installed on the wellhead.

NRCS wells that were not being pumped for irrigation during the study do not show these pressure/water level drops. NRCS wells 2-2, 8-1, and 121-1 showed an overall increase in groundwater elevations during the monitoring period, and the water levels at NRCS 2-3 remained stable. Some of the time-series plots show sharp spikes/increases in water levels that were related to times when hurricanes or large tropical storms passed over the area. These spikes occurred due to the decrease in barometric pressure caused by the storms, allowing the water levels to rise in the wells.

4.2 Water Quality Data

Brackish water has a chloride concentration between 250 milligrams per liter (mg/L) and 19,000 mg/L (seawater). In the UEC Planning Area, water from the FAS typically has chloride concentrations greater than 1,000 mg/L and is considered brackish (SFWMD 2021), corresponding to the range of chloride concentrations shown in **Table 4**. Desalination or blending with fresh water is required before this water is suitable for most uses, including irrigation and human consumption. Water quality in the FAS decreases substantially from central to southern Florida, with increasing hardness, chloride, and salinity. Salinity also increases with depth, making the deeper producing zones of the FAS less desirable for use than shallower parts of the system (SFWMD 2021).

Groundwater samples collected by the District and the NRCS were analyzed for chloride and TDS between March 2001 and October 2007 as shown in **Table 4**. Chloride concentrations in all the samples ranged from 230 mg/L to 2,300 mg/L, indicative of brackish water. The TDS concentrations ranged from 410 mg/L to 6,540 mg/L.

All 16 of the wells with average chloride concentrations greater than 1,000 mg/L (**Table 4**) are located more than 10 miles inland, and west of I-95, except for MF-31, which is located near the Atlantic coast, southeast of Stuart. These 16 wells include nine of the District-monitored (non-agricultural) wells, with the remainder being NRCS wells located in citrus groves. As noted above, elevated chloride concentrations greater than 1,000 mg/L are characteristic of the UFA throughout the UEC Planning Area. The lack of a clear spatial distribution of elevated chloride concentration in this study's data also supports this characteristic of the UFA in this region. Wells with relatively lower chloride concentrations (**Table 4**) may be open to portions of the basal Hawthorn/Suwannee Limestone unit as well as the deeper, carbonate portions of the UFA, as discussed in **Section 3.2.1**, causing mixing of "deep" groundwater containing relatively elevated chloride concentrations with groundwater from relatively fresher, shallower aquifer zones that contain relatively lower chloride concentrations.

Table 4. Chloride and total dissolved solids concentrations in groundwater samples, UECFAS groundwater monitoring network.

Well ID	Monitoring Entity	Total # of Chloride Samples	Total # of TDS Samples	Sample Date Range	Chloride (mg/L)			Total Dissolved Solids (mg/L)		
					Min	Max	Average	Min	Max	Average
MF-9	District	23	23	2001-2007	980	1,400	1,223	2,400	3,400	2,779
MF-31	District	23	23	2001-2007	790	1,300	1,024	1,700	3,000	2,359
MF-35B	District	23	23	2001-2007	1,000	2,100	1,593	2,000	4,100	3,391
MF-52	District	9	10	2001-2004	740	1,100	1,049	2,000	2,600	2,370
SLF-9	District	22	22	2001-2007	716	1,700	1,306	1,400	3,700	2,884
SLF-11	District	22	23	2001-2007	580	920	814	1,600	2,800	2,046
SLF-14	District	22	23	2001-2007	800	1,300	1,050	1,600	3,100	2,260
SLF-21	District	22	23	2001-2007	230	350	289	582	1,100	869
SLF-60	District	9	11	2001-2004	690	1,800	1,171	2,518	3,600	2,518
SLF-62	District	22	24	2001-2007	880	1,800	1,332	2,220	3,600	3,017
SLF-69	District	22	9	2001-2004	510	820	690	1,500	2,000	1,644
SLF-74	District	8	11	2001-2004	1,300	2,300	1,975	4,000	5,900	4,873
SLF-75	District	8	10	2001-2004	770	1,100	964	1,900	3,100	2,310
SLF-76	District	8	10	2001-2004	640	1,500	1,243	2,100	4,100	3,070
NRCS 1-1	NRCS	22	20	1996-2006	430	1,670	1,087	2,200	4,610	2,799
NRCS 2-2	NRCS	22	21	1996-2006	670	1,160	880	1,800	3,890	2,230
NRCS 3-2	NRCS	22	20	1996-2006	400	1,010	540	1,100	2,590	1,528
NRCS 3-3	NRCS	2	2	1996-2001	640	895	640	1,400	1,869	1,635
NRCS 4-1	NRCS	23	23	1996-2006	440	1,190	702	1,200	3,070	1,766
NRCS 5-1	NRCS	21	22	1996-2006	370	1,160	844	1,300	3,870	2,086
NRCS 6-1	NRCS	21	21	1996-2006	420	1,400	1,025	1,000	3,650	2,371
NRCS 7-1	NRCS	2	2	1996-2001	850	2,070	850	1,700	3,640	2,670
NRCS 7-2	NRCS	11	11	1996-2003	520	831	589	1,300	1,631	1,439
NRCS 8-4	NRCS	7	7	2001-2002	500	570	539	1,200	1,400	1,271
NRCS 11-1	NRCS	21	21	2001-2006	390	600	502	1,000	1,630	1,259
NRCS 12-1	NRCS	22	21	1996-2006	330	615	443	900	1,410	1,080
NRCS 13-1	NRCS	23	22	1996-2006	890	1,350	1,035	950	4,180	2,260
NRCS 14-1	NRCS	21	21	1996-2006	410	510	458	900	1,820	1,215
NRCS 29-8	NRCS	17	18	2001-2005	340	870	722	410	1,900	1,606
NRCS 29-11	NRCS	1	1	2001	850	850	850	1,700	1,700	1,700

Well ID	Monitoring Entity	Total # of Chloride Samples	Total # of TDS Samples	Sample Date Range	Chloride (mg/L)			Total Dissolved Solids (mg/L)		
					Min	Max	Average	Min	Max	Average
NRCS 35-1	NRCS	22	22	2001-2006	1,300	2,300	1,555	1,600	6,540	3,652
NRCS 36-1	NRCS	19	19	2001-2005	650	1,000	830	1,600	2,200	1,874
NRCS 121-1	NRCS	7	7	2001-2002	820	1,200	1,017	2,000	2,500	2,200
NRCS 201-1	NRCS	19	18	2001-2005	560	770	690	1,400	2,160	1,620
NRCS 202-1	NRCS	18	17	2002-2006	540	760	658	1,100	2,820	1,478
NRCS 202-2	NRCS	3	3	2001	630	690	670	1,500	1,700	1,600
NRCS 203-1	NRCS	19	19	2001-2006	360	1,100	672	1,100	3,100	1,748
NRCS 204-1	NRCS	2	2	2003, 2005	330	660	495	990	1,600	1,295
NRCS 204-2	NRCS	1	1	2001	530	530	530	1,400	1,400	1,400
NRCS 204-3	NRCS	17	16	2001-2006	290	510	378	500	1,660	1,018
NRCS 205-6	NRCS	19	19	2001-2006	430	1,800	1,337	1,200	4,300	3,338

mg/L = milligrams per liter; NRCS = Natural Resource Conservation Service; TDS = total dissolved solids.

4.2.1 *Water Quality Time-Series Plots*

Time-series plots of chloride and TDS concentrations in groundwater samples collected from the UECFAS groundwater monitoring network were created for every well that had more than two groundwater samples collected and analyzed during the project. These water quality time-series plots are presented in **Appendix D** (District-monitored wells) and **Appendix E** (NRCS-monitored wells) and show fluctuations likely influenced by pumping and seasonal variations in groundwater elevation.

4.3 Water Use Data

The NRCS recorded groundwater use (pumpage) at 59 agricultural wells and recorded the total monthly groundwater volume pumped from each well between March 1996 and December 2007. Some wells only have partial records during that time frame, while others were monitored the entire time.

Table 5 shows the total volume of water pumped from 36 of the 59 NRCS citrus grove wells between 1997 and 2006 with the total volumes of water pumped ranked from high to low. Total pumpage ranged from 8,906 acre-feet at NRCS 6-2, to less than 1 acre-foot at NRCS 3-4. The 13 NRCS wells not listed in **Table 5** were wells where little pumping occurred, generally over a short time frame. The wells located in grove 6 and grove 29 accounted for about 60% of the groundwater pumped between March 1996 and December 2007. A tabulation of yearly water pumpage totals by well and time-series plots of monthly groundwater pumpage volumes by well are presented in **Appendix F**.

Table 5. Total groundwater volumes pumped by selected NRCS wells (1997–2006).

Rank	Total volume pumped (acre-feet)	Total volume pumped (gallons)	NRCS Well ID
1	8,906	2,902,112,700	6-2
2	5,495	1,790,400,000	6-1
3	5,485	1,787,232,700	29-14
4	4,333	1,412,010,100	35-1
5	3,365	1,096,609,200	5-1
6	2,991	974,650,800	29-11

Rank	Total volume pumped (acre-feet)	Total volume pumped (gallons)	NRCS Well ID
7	2,267	738,660,700	29-5
8	1,948	634,848,900	4-1
9	1,905	620,718,400	1-1
10	1,732	564,299,600	29-2
11	1,223	398,410,800	11-1
12	1,193	388,839,200	3-1
13	1,089	354,695,900	3-2
14	1,024	333,607,500	29-9
15	965	314,362,900	29-15
16	760	247,676,000	29-3
17	690	224,815,000	3-3
18	682	222,196,300	29-1A
19	667	217,396,500	12-1
20	632	205,989,900	36-1
21	516	168,256,000	29-1B
22	462	150,462,100	29-12
23	453	147,470,600	2-3
24	334	108,923,100	29-4
25	305	99,309,800	14-1
26	301	98,119,800	29-6
27	258	83,965,100	2-2
28	169	55,014,700	13-1
29	133	43,448,100	29-13
30	123	40,106,400	2-1
31	51	16,594,700	29-10
32	51	16,559,200	29-7
33	22	7,041,200	35-2
34	20	6,456,000	29-8
35	5	1,724,800	36-2
36	0.1	27,400	3-4

NRCS = Natural Resource Conservation Service.

4.4 Precipitation Data

The NRCS collected monthly rainfall data at 23 rain gauges distributed across St. Lucie County. Plots showing the monthly rainfall totals at each citrus grove rain gauge are presented in **Appendix G**. The gauges at groves 206 and 207 collected limited data during the end of 2006 and 2007. The data show how most of the precipitation occurs during the wet season, between April and October of each year. The average yearly rainfall recorded at all the sites was 42.3 inches.

5 CONCLUSIONS

The water level data collected during this project show that FAS water levels in the monitored wells were generally stable between 1999 and 2007, except for select FAS monitor wells located close to wells where extensive agricultural pumping from the FAS caused groundwater levels to fluctuate. Seasonal groundwater fluctuations are evident in the hydrographs, with seasonal water level fluctuations of up to 7 feet occurring between the wet and dry seasons each year.

Natural gamma ray logs collected at 11 NRCS citrus grove monitor wells indicate that their open intervals are monitoring the UFA. The open-hole intervals in many cases appear to include both carbonate rock and overlying sediments of the basal Hawthorn/Suwannee Limestone unit, consistent with characteristic gamma ray log patterns from UEC groundwater monitoring network wells presented by Reese (2004).

Chloride concentrations in all the FAS groundwater quality samples collected from the UECFAS groundwater monitoring network wells ranged from 230 mg/L to 2,300 mg/L. The TDS concentrations ranged from 410 mg/L to 6,540 mg/L, indicative of brackish groundwater. Groundwater from the FAS typically has chloride concentrations greater than 1,000 mg/L and is considered brackish (SFWMD 2021). This agrees with the range of chloride concentrations shown in **Table 4**. Desalination or blending with fresh water is required before this water is suitable for most uses, including irrigation and human consumption. This is supported by wells with relatively elevated chloride and TDS concentrations being located throughout the UEC Planning Area, with some wells located inland and others located near the coast. No clearly discernable water quality trends are present in the groundwater quality time-series data.

Total groundwater use at each of the citrus groves varied from year to year, but monthly water use was generally greatest during the dry seasons with significantly less pumping generally occurring during the wet seasons. About 60% of the total groundwater pumping recorded during this study occurred at wells in groves 6 and 29. Total pumpage recorded during this project ranged from less than 1 acre-foot to 8,906 acre-feet.

Since 2007, increasing development and changing land use has eliminated much of the agricultural land and associated FAS water use in the UEC Planning Area. In 2019, approximately 83% of agricultural demands in the UEC Planning Area were met with surface water, and this percentage is expected to remain the same through 2045 (SFWMD 2021). However, irrigated agricultural acreage and associated demands are projected to decrease approximately 26% from 2019 to 2045 (SFWMD 2021).

Precipitation data collected across the UEC Planning Area illustrates the seasonal variation in rainfall across the study area, with most of the precipitation occurring between April and October each year. During the rainy season of each year, less pumping occurred in the NRCS citrus grove wells. The average yearly rainfall recorded at all the sites was 42.3 inches.

Current review and analyses of FAS data indicate there have been no substantial regional changes; however, some local changes in water quality have been observed, which may be the result of localized pumping stresses or hydrologic conditions (SFWMD 2021). FAS users may need to spread out withdrawal facilities or reduce individual well pumping rates to mitigate water quality changes. These areas should continue to be monitored through a coordinated effort with utilities and other FAS stakeholders (SFWMD 2021).

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APPENDICES

APPENDIX A:
UECFAS GROUNDWATER MONITORING NETWORK WELL LOCATIONS AND CONSTRUCTION INFORMATION

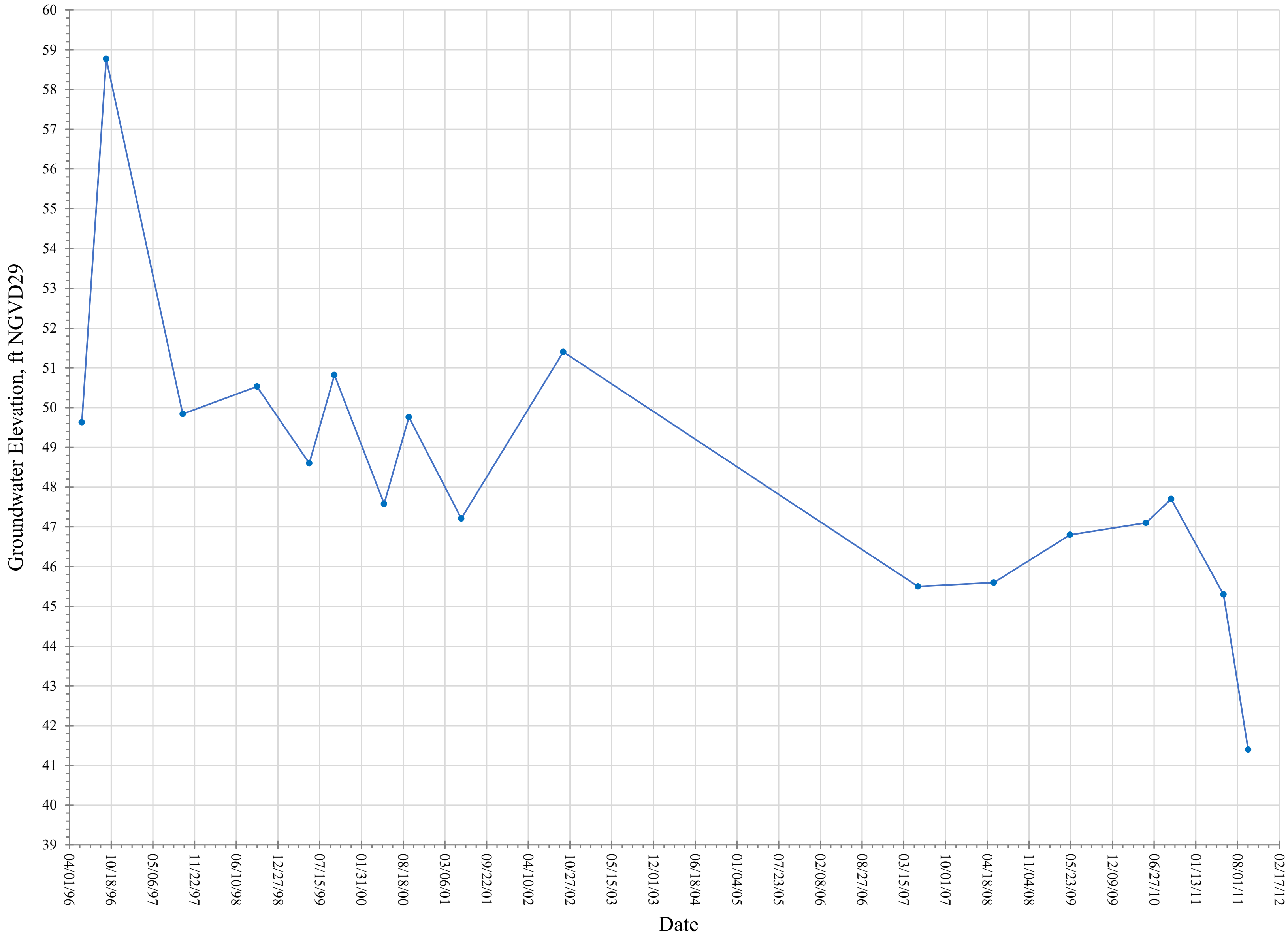
Well ID	Description	Latitude, degrees, mins, sec	Longitude, degrees, mins, sec	County	Cased Depth, ft bls	Total Depth, ft bls
MF-9	Allapattah Properties, Inc.	27 10 04	-80 27 59	Martin	360	810
MF-31	Mile Grant Country Club	27 08 58	-80 10 26	Martin	844	1,092
MF-35B	Replacement well for MF-35	26 59 28	-80 28 58	Martin	390	1,340
MF-52	Tropical Fruits	27 05 06	-80 23 08	Martin	400	1,320
SLF-9	Adams Ranch	27 26 50	-80 35 25	St. Lucie	256	1,058
SLF-11	Green Ranch Fellsmere 4 SE	27 32 14	-80 34 59	St. Lucie	224	948
SLF-14	STL-220 Sunsweet Groves-Macarthur Farms	27 20 16	-80 34 17	St. Lucie	318	1,288
SLF-21	Floridan aquifer well in a citrus grove	27 25 42	-80 24 07	St. Lucie	156	707
SLF-60	Evans Property Bluefield Grove	27 16 56	-80 35 59	St. Lucie	10	900
SLF-62B	A. Duda and Son-Horse Pasture Well	27 18 41	-80 26 46	St. Lucie	355	733
SLF-69	Scotto	27 21 49	-80 26 39	St. Lucie	420	866
SLF-74	C24 Floridan Aquifer Well	27 20 16	-80 29 23	St. Lucie	1068	1,450
SLF-75	C24 Floridan Aquifer Well	27 20 16	-80 29 23	St. Lucie	480	700
SLF-76	C24 Floridan Aquifer Well	27 20 16	-80 29 23	St. Lucie	790	860
NRCS1-1	Floridan aquifer well in central St. Lucie County	27 21 23	-80 28 08	St. Lucie	296	825
NRCS2-1	Floridan aquifer well in a citrus grove	27 24 05	-80 31 04	St. Lucie	260	823
NRCS2-2	Floridan aquifer well in central St. Lucie County	27 24 47	-80 31 24	St. Lucie	150	1,250
NRCS2-3	Floridan aquifer well in a citrus grove	27 24 41	-80 31 03	St. Lucie	150	1,250
NRCS11-1	Floridan aquifer well in northeast St. Lucie County	27 28 58	-80 24 18	St. Lucie	120	893
NRCS12-1	Floridan aquifer well in northeast St. Lucie County	27 29 22	-80 23 45	St. Lucie	345	917
NRCS121-1	Floridan aquifer well in north central St. Lucie County	27 27 05	-80 29 36	St. Lucie	316	804
NRCS13-1	Floridan aquifer well in central St. Lucie County	27 13 00	-80 32 24	St. Lucie	300	1,300
NRCS14-1	Floridan aquifer well in northeast St. Lucie County	27 29 01	-80 23 41	St. Lucie	280	940
NRCS201-1	Floridan aquifer well in northeast St. Lucie County	27 30 24	-80 25 02	St. Lucie	350	900
NRCS202-1	Floridan aquifer well in west central St. Lucie County	27 21 53	-80 32 08	St. Lucie	No Data	600
NRCS202-2	Floridan aquifer well in west central St. Lucie County	27 21 53	-80 31 54	St. Lucie	380	1,000
NRCS203-1	Floridan aquifer well in northwest St. Lucie County	27 27 37	-80 40 06	St. Lucie	350	900
NRCS204-1	Floridan aquifer well in southwest St. Lucie County	27 16 10	-80 36 03	St. Lucie	380	1,140
NRCS204-2	Floridan aquifer well in a citrus grove	27 15 19	-80 36 08	St. Lucie	380	1,120
NRCS204-3	Floridan aquifer well in southwest St. Lucie County	27 15 43	-80 36 29	St. Lucie	350	1,100
NRCS205-5	Floridan aquifer well in a citrus grove	27 31 19	-80 37 27	St. Lucie	240	1,020
NRCS205-6	Floridan aquifer well in central St. Lucie County	27 30 42	-80 37 36	St. Lucie	224	1,140
NRCS29-1A	Floridan aquifer well in a citrus grove	27 31 19	-80 27 37	St. Lucie	No Data	1,120
NRCS29-1B	Floridan aquifer well in a citrus grove	28 31 19	-80 27 38	St. Lucie	No Data	1,120
NRCS29-2	Floridan aquifer well in a citrus grove	27 31 44	-80 27 50	St. Lucie	No Data	700
NRCS29-3	Floridan aquifer well in a citrus grove	27 32 11	-80 27 50	St. Lucie	No Data	1,166
NRCS29-4	Floridan aquifer well in a citrus grove	27 31 44	-80 27 30	St. Lucie	No Data	700
NRCS29-5	Floridan aquifer well in a citrus grove	27 32 11	-80 27 21	St. Lucie	No Data	700
NRCS29-6	Floridan aquifer well in a citrus grove	27 32 13	-80 27 35	St. Lucie	No Data	700
NRCS29-7	Floridan aquifer well in a citrus grove	27 32 37	-80 27 36	St. Lucie	No Data	1,100
NRCS29-8	Floridan aquifer well in north central St. Lucie County	27 32 37	-80 27 31	St. Lucie	278	893
NRCS29-9	Floridan aquifer well in a citrus grove	27 32 37	-80 27 20	St. Lucie	No Data	1,084
NRCS29-10	Floridan aquifer well in a citrus grove	27 32 37	-80 27 05	St. Lucie	No Data	1,100
NRCS29-11	Floridan aquifer well in a citrus grove	27 33 05	-80 27 03	St. Lucie	No Data	1,100
NRCS29-12	Floridan aquifer well in a citrus grove	27 33 03	-80 27 07	St. Lucie	No Data	700
NRCS29-13	Floridan aquifer well in a citrus grove	27 33 04	-80 27 34	St. Lucie	150	700
NRCS29-14	Floridan aquifer well in a citrus grove	27 33 04	-80 27 36	St. Lucie	No Data	924
NRCS29-15	Floridan aquifer well in a citrus grove	27 33 15	80 27 20	St. Lucie	No Data	No data
NRCS3-1	Floridan aquifer well in a citrus grove	27 20 02	-80 31 33	St. Lucie	200	1,000
NRCS3-2	Floridan aquifer well in central St. Lucie County	27 19 49	-80 31 33	St. Lucie	200	1,000
NRCS3-3	Floridan aquifer well in a citrus grove	27 19 37	-80 31 33	St. Lucie	330	499
NRCS3-4	Floridan aquifer well in a citrus grove	27 19 48	-80 31 45	St. Lucie	No Data	No data
NRCS35-1	Floridan aquifer well in central St. Lucie County	27 18 29	-80 30 48	St. Lucie	300	808
NRCS35-2	Floridan aquifer well in a citrus grove	27 18 15	-80 30 54	St. Lucie	352	527
NRCS36-1	Floridan aquifer well in south central St. Lucie County	27 13 53	-80 32 24	St. Lucie	400	1,500
NRCS36-2	Floridan aquifer well in a citrus grove	27 13 23	-80 32 26	St. Lucie	400	1,500
NRCS4-1	Floridan aquifer well in south central St. Lucie County	27 12 38	-80 32 24	St. Lucie	300	1,300
NRCS5-1	Floridan aquifer well in central St. Lucie County	27 21 49	-80 28 37	St. Lucie	300	808
NRCS6-1	Floridan aquifer well in west central St. Lucie County	27 26 10	-80 33 12	St. Lucie	400	1,000
NRCS6-2	Floridan aquifer well in a citrus grove	27 25 42	-80 33 13	St. Lucie	400	1,000
NRCS7-1	Floridan aquifer well in a citrus grove	27 25 33	-80 29 36	St. Lucie	278	878
NRCS7-2	Floridan aquifer well in central St. Lucie County	27 25 59	-80 29 36	St. Lucie	200	1,000
NRCS7-3	Floridan aquifer well in a citrus grove	27 26 25	-80 29 36	St. Lucie	200	1,000
NRCS8-1	Floridan aquifer well in a citrus grove	27 26 44	-80 22 38	St. Lucie	No Data	1,000
NRCS8-2	Floridan aquifer well in a citrus grove	27 26 33	-80 22 41	St. Lucie	No Data	1,000
NRCS8-3	Floridan aquifer well in a citrus grove	27 26 33	-80 22 42	St. Lucie	No Data	1,000
NRCS8-4	Floridan aquifer well in east central St. Lucie County	27 26 26	-80 22 42	St. Lucie	340	893

APPENDIX B:
HYDROGRAPHS FOR DISTRICT-MONITORED UECFAS GROUNDWATER MONITORING NETWORK WELLS

LIST OF FIGURES

Figure B-1. MF-9 Groundwater Elevations B-3
Figure B-2. MF-31 Groundwater Elevations B-4
Figure B-3. MF-35B Groundwater Elevations B-5
Figure B-4. MF-52 Groundwater Elevations B-6
Figure B-5. SLF-14 Groundwater Elevations B-7
Figure B-6. SLF-21 Groundwater Elevations B-8
Figure B-7. SLF-62B Groundwater Elevations B-9
Figure B-8. SLF-69 Groundwater Elevations B-10
Figure B-9. SLF-74 Groundwater Elevations B-11
Figure B-10. SLF-75 Groundwater Elevations B-12

Figure B-1. MF-9



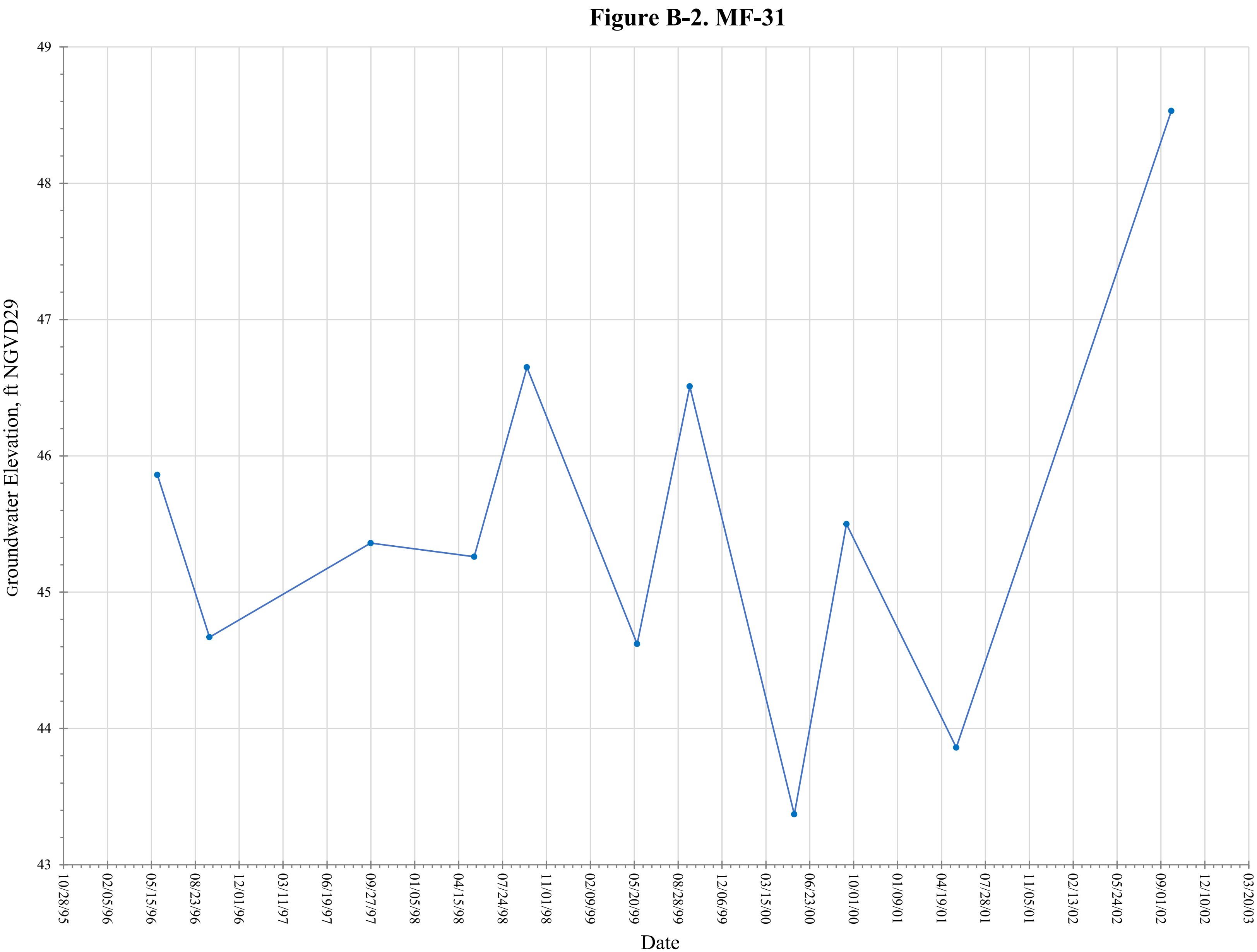


Figure B-2. MF-31
Groundwater Elevation, ft NGVD29
49
48
47
46
45
44
43
10/28/95
02/05/96
05/15/96
08/23/96
12/01/96
03/11/97
06/19/97
09/27/97
01/05/98
04/15/98
07/24/98
11/01/98
02/09/99
05/20/99
08/28/99
12/06/99
03/15/00
06/23/00
10/01/00
01/09/01
04/19/01
07/28/01
11/05/01
02/13/02
05/24/02
09/01/02
12/10/02
03/20/03
Date

Figure B-3. MF-35B

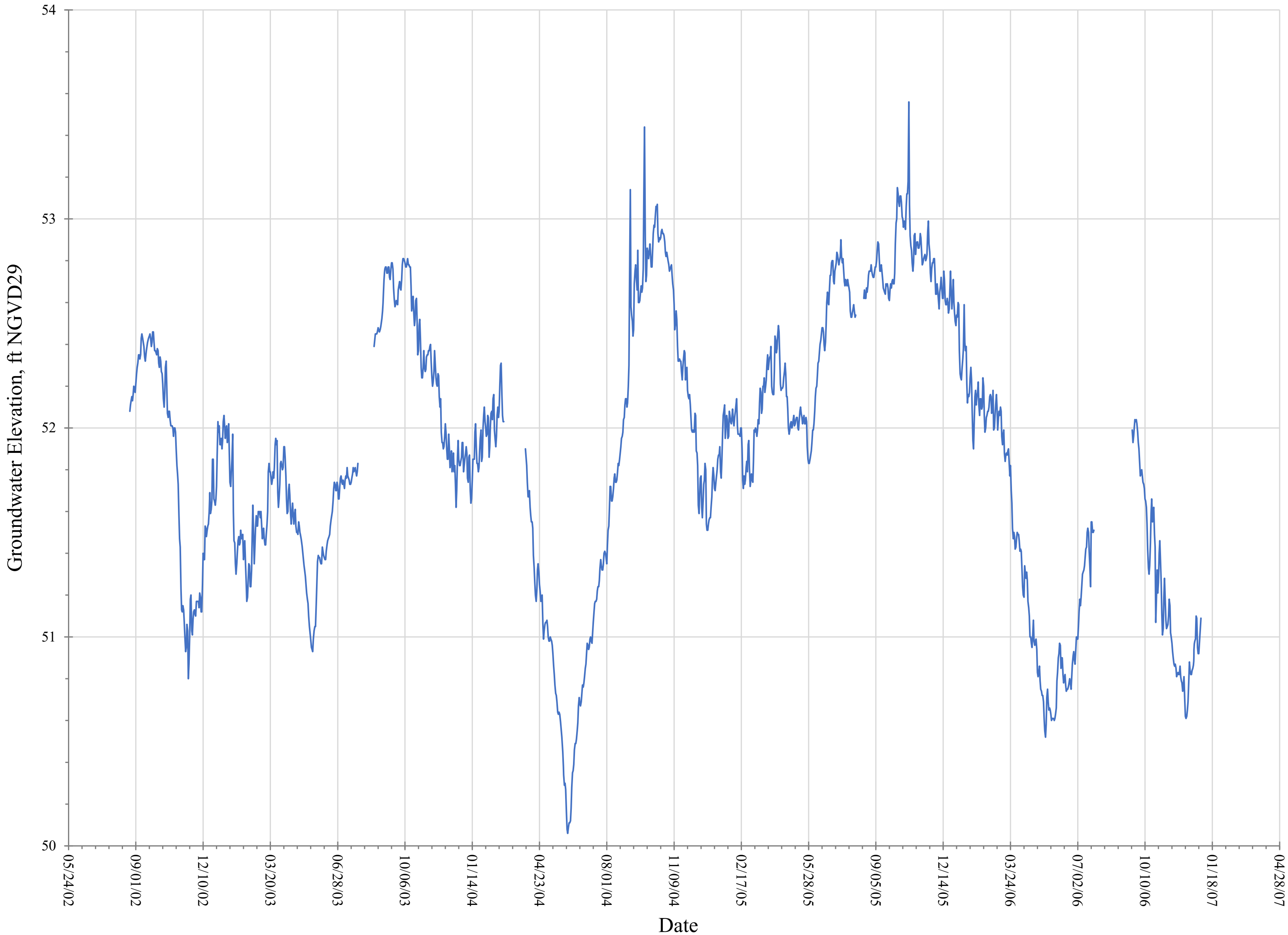


Figure B-4. MF-52

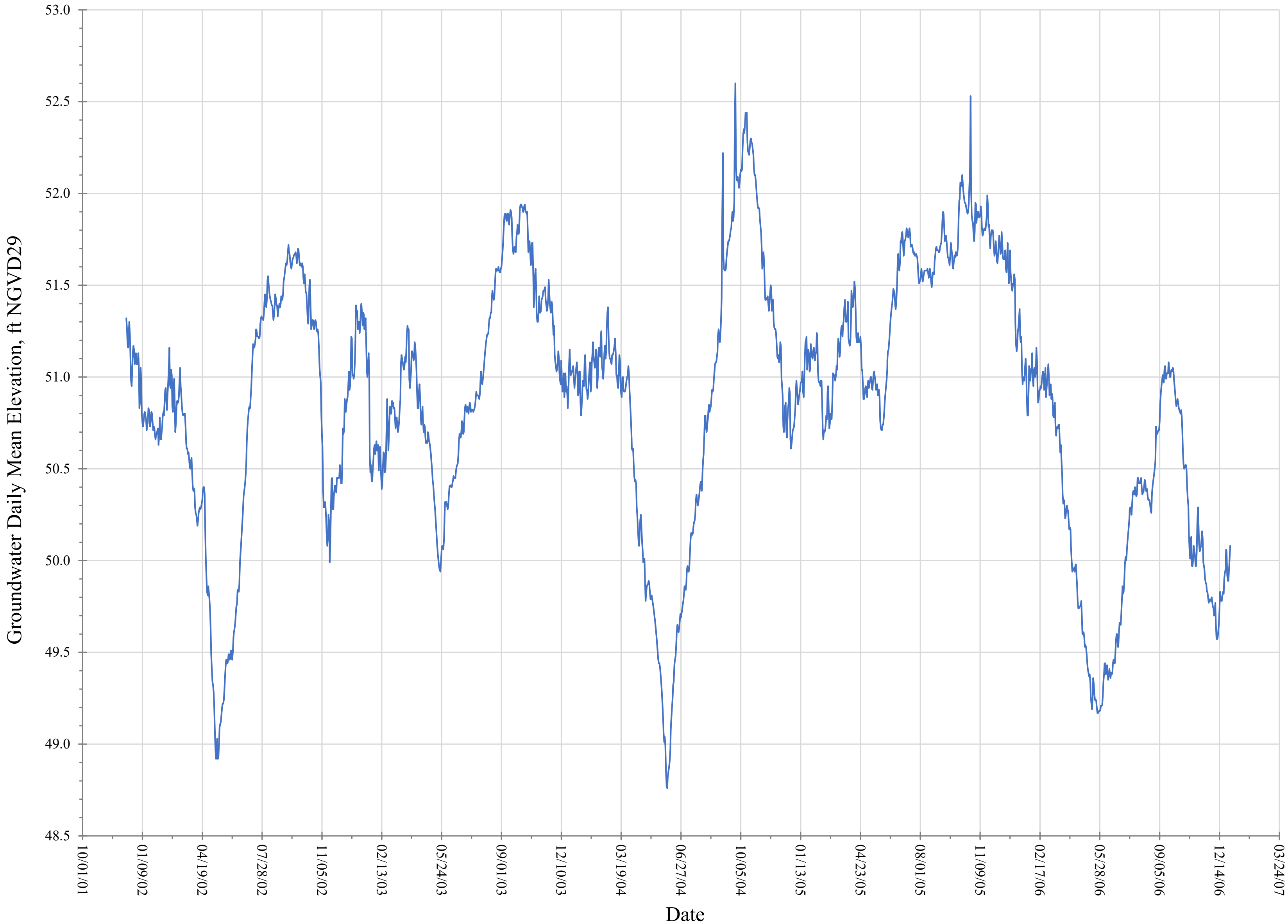


Figure B-5. SLF-14

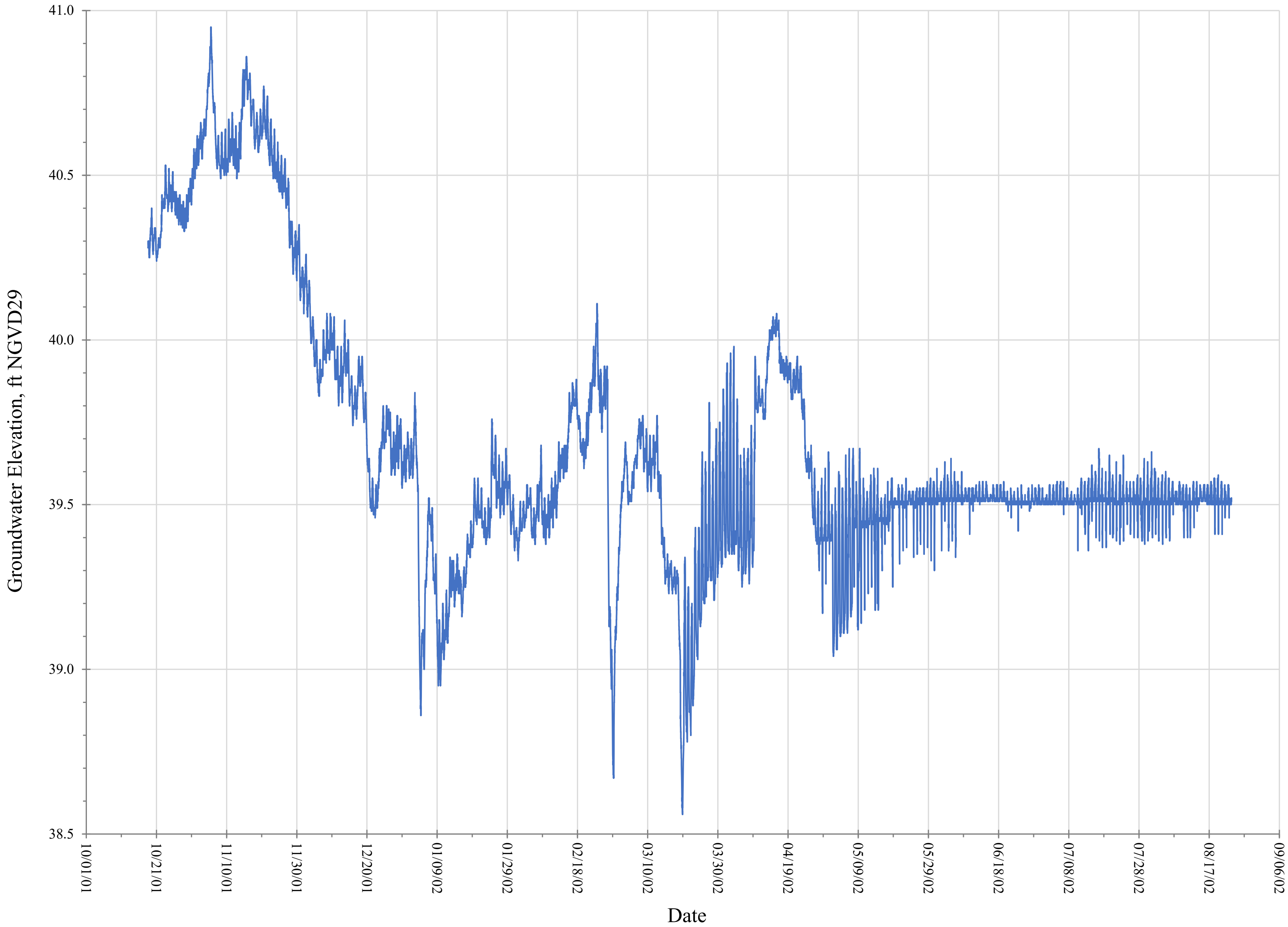


Figure B-6. SLF-21

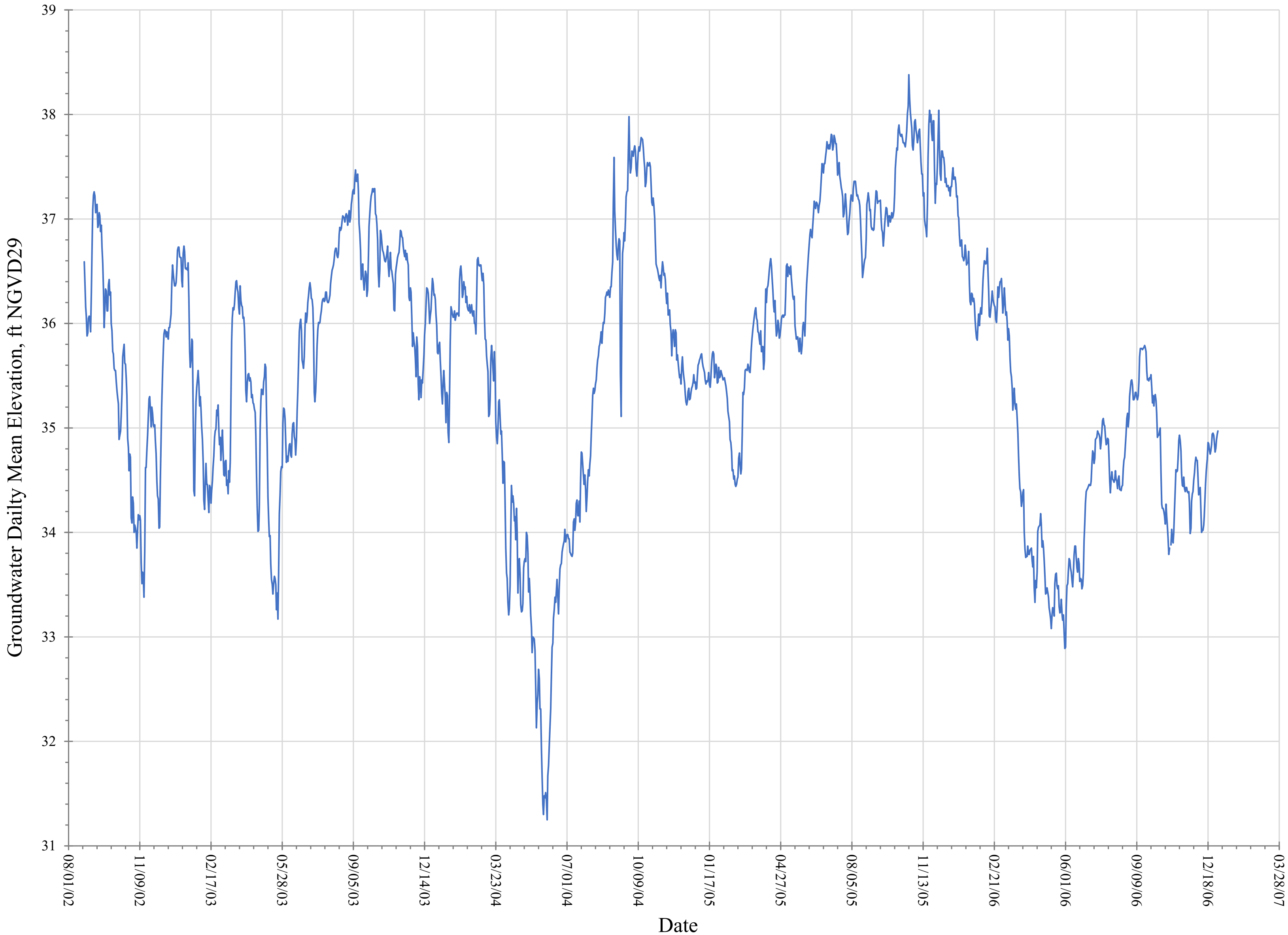


Figure B-7. SLF-62B

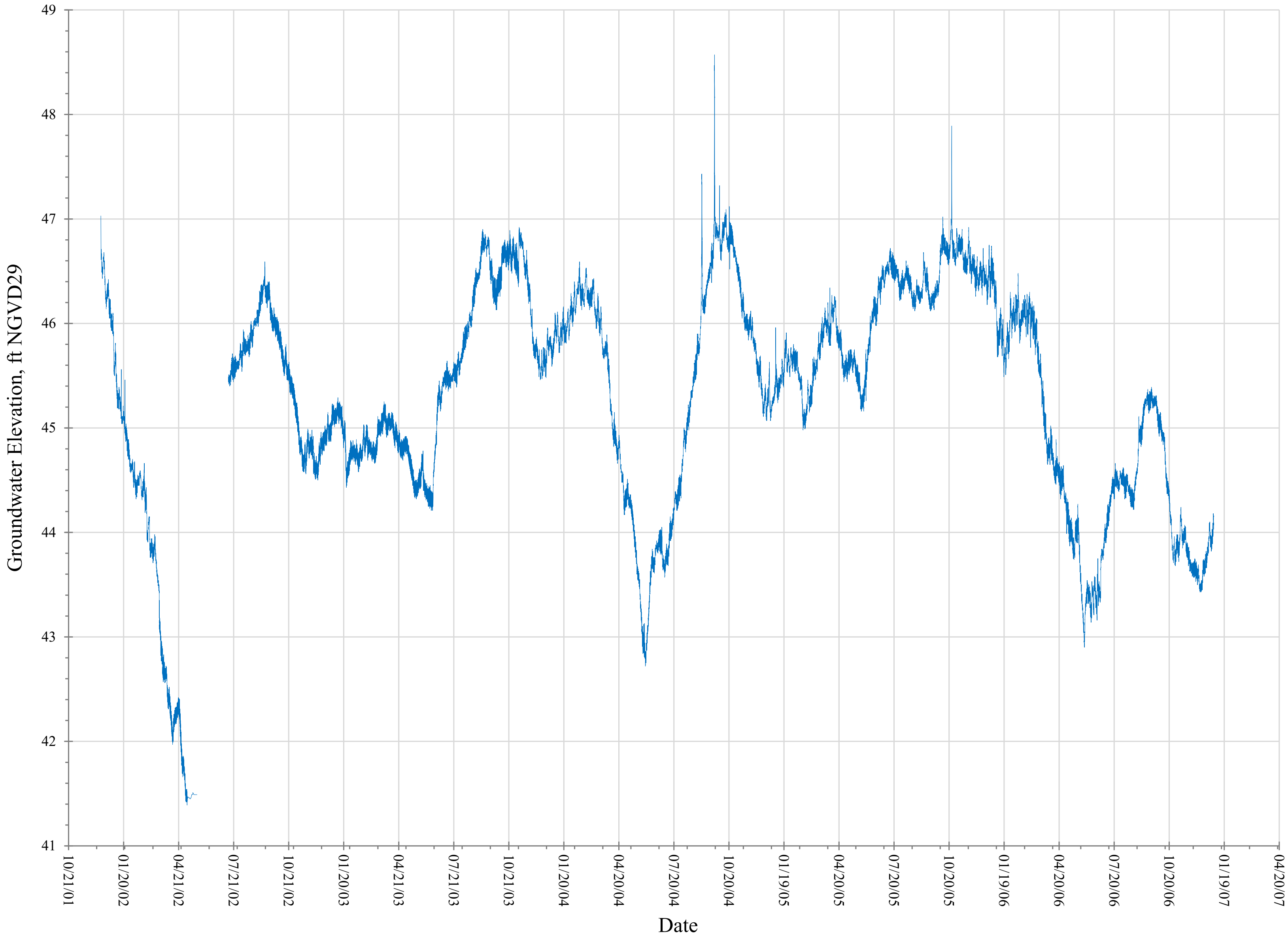


Figure B-8. SLF-69

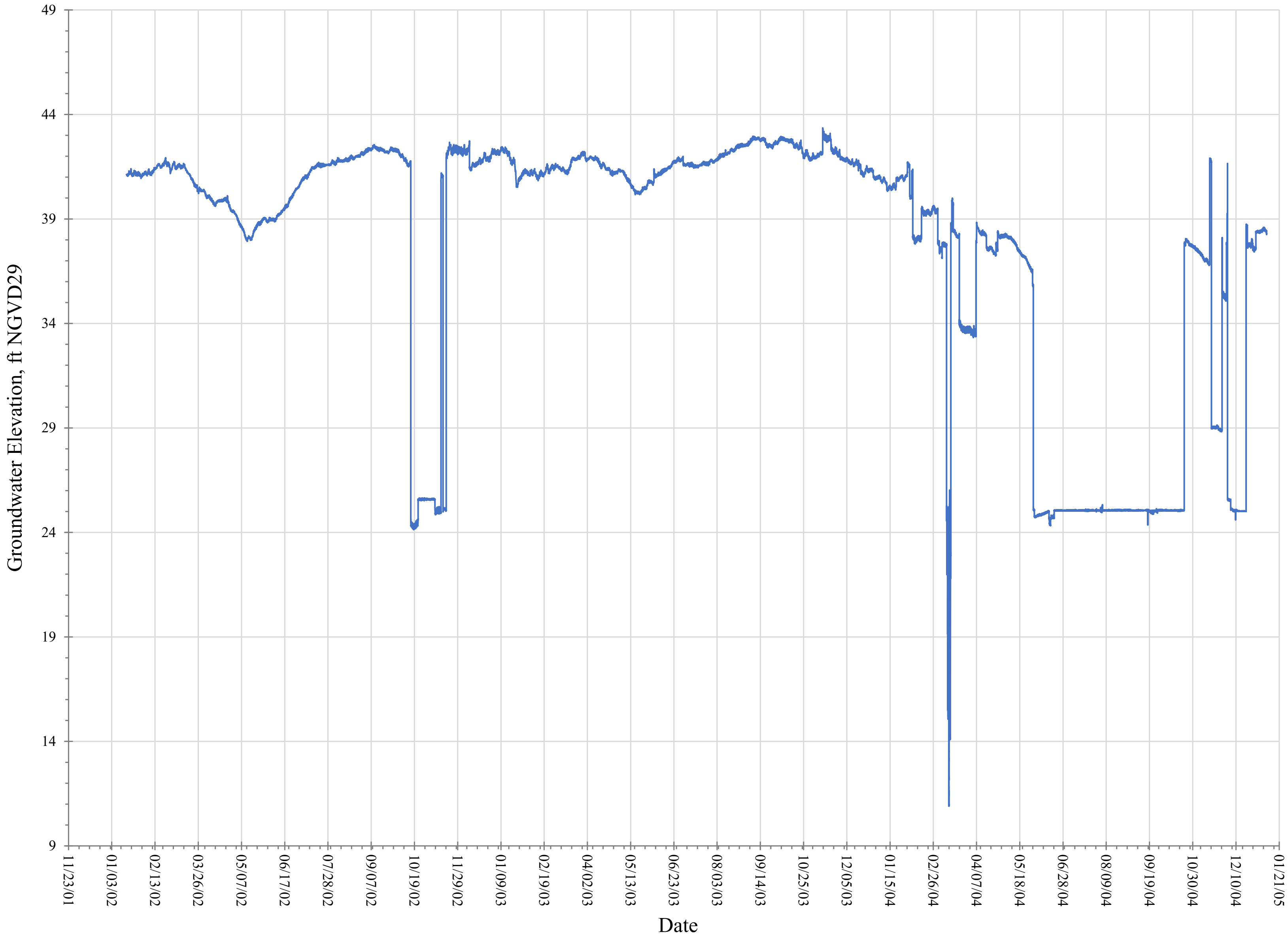


Figure B-9. SF-74

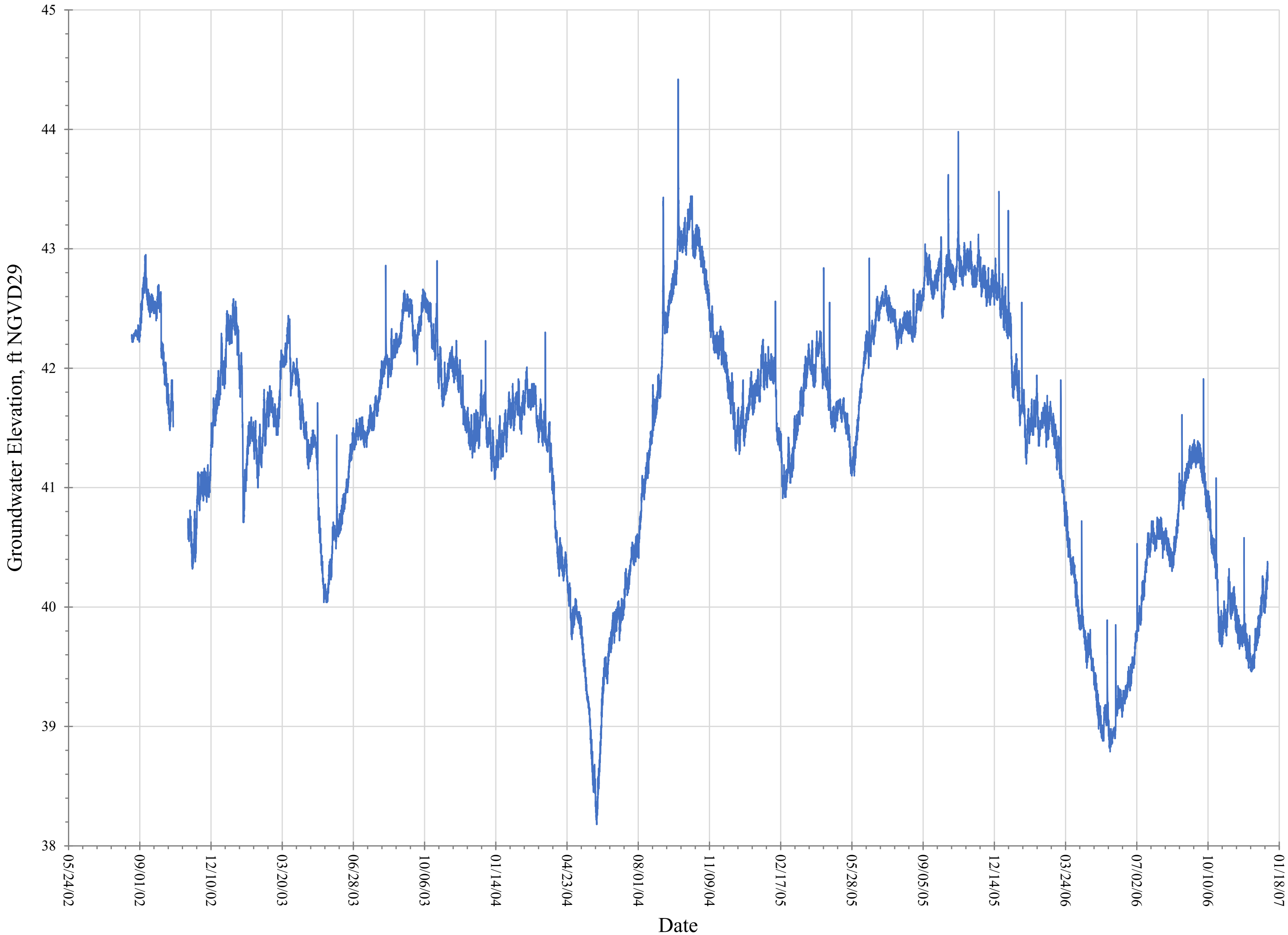
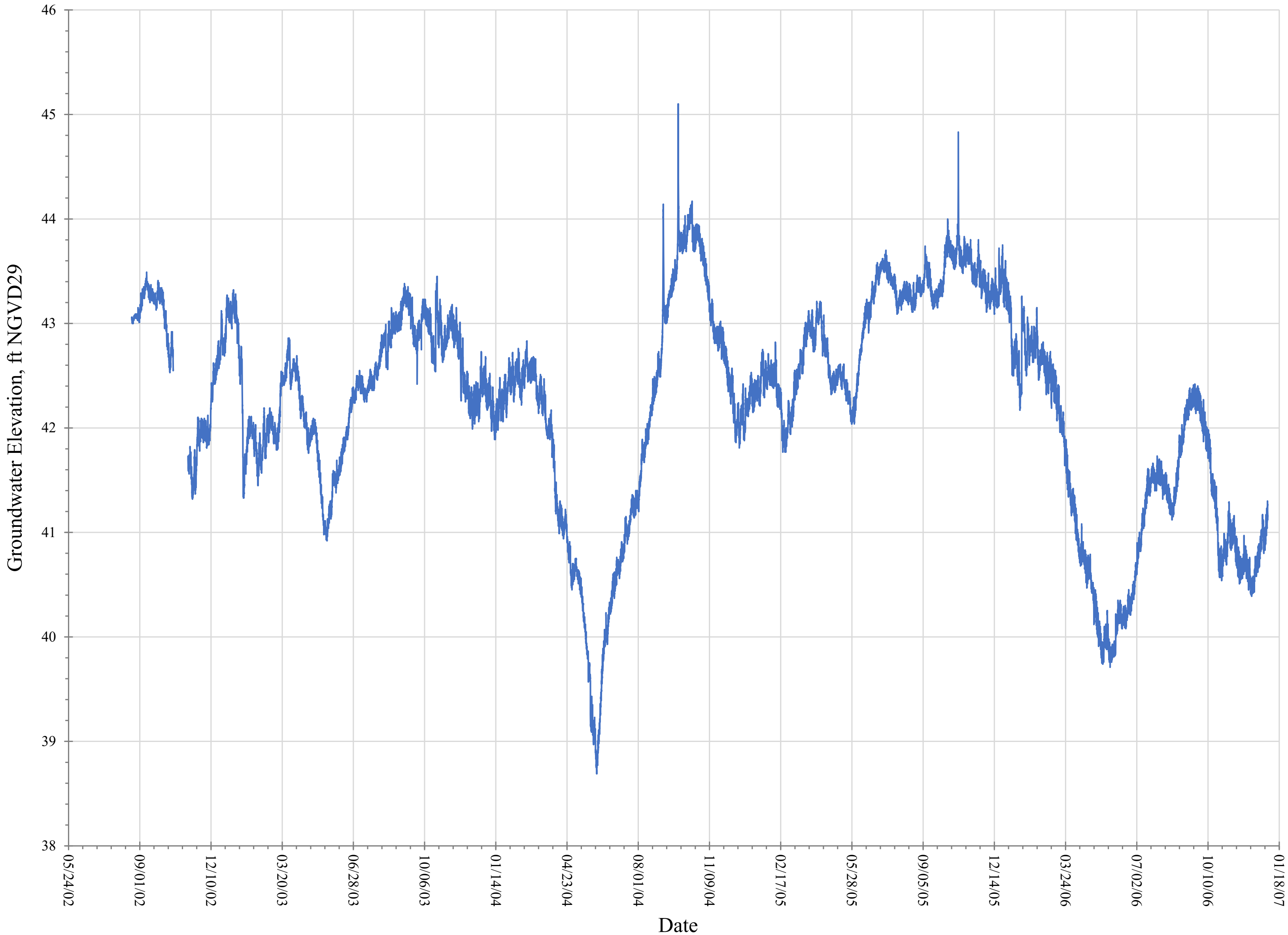


Figure B-10. SLF-75

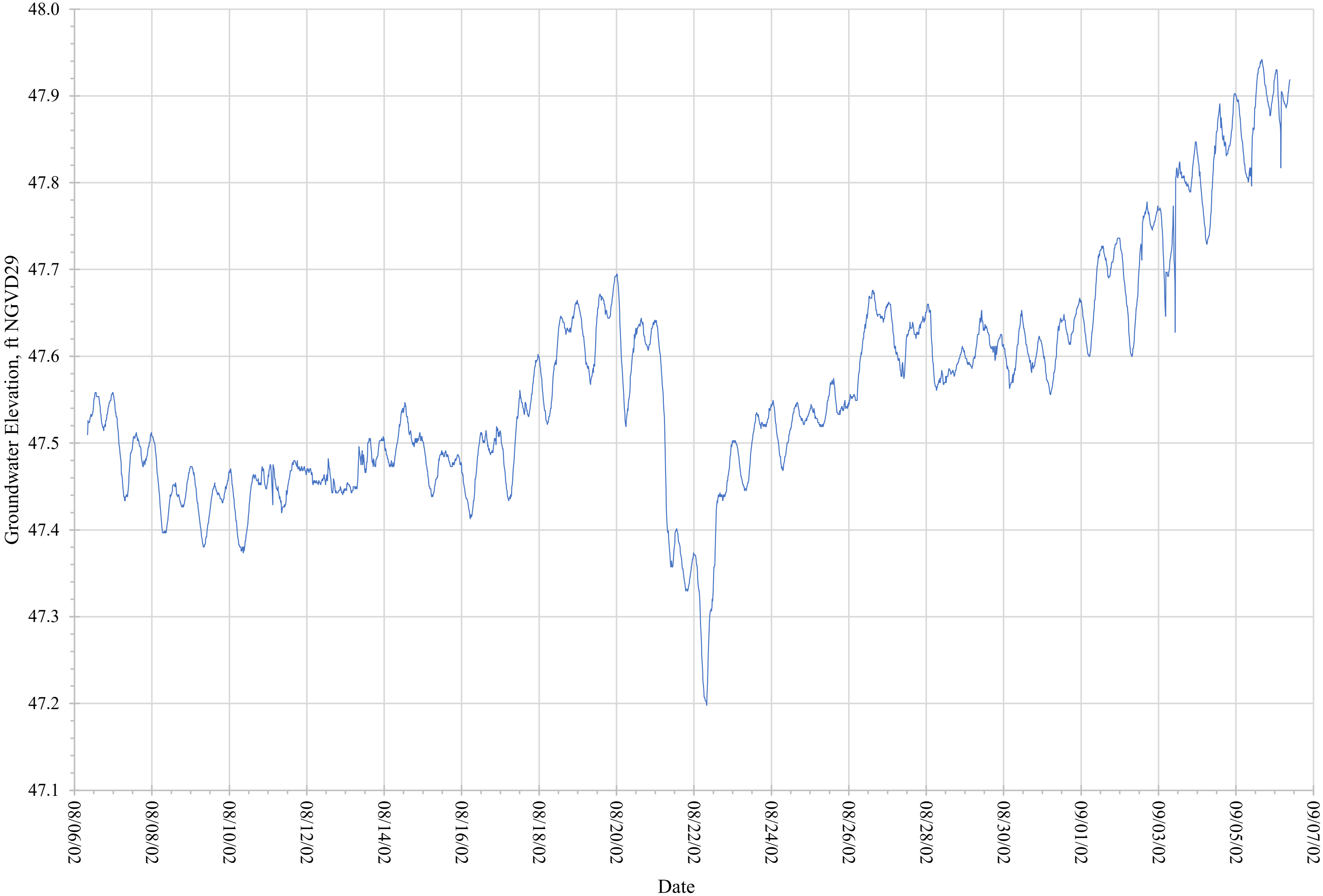


APPENDIX C:
HYDROGRAPHS FOR NRCS-MONITORED UECFAS GROUNDWATER MONITORING NETWORK WELLS

LIST OF FIGURES

Figure C-1. NRCS 2-2 Groundwater Elevations C-3
Figure C-2. NRCS 2-3 Groundwater Elevations C-4
Figure C-3. RCS 3-3 Groundwater Elevations C-5
Figure C-4. NRCS 5-1 Groundwater Elevations C-6
Figure C-5. NRCS 8-1 Groundwater Elevations C-7
Figure C-6. NRCS 11-1 Groundwater Elevations C-8
Figure C-7. NRCS 12-1 Groundwater Elevations C-9
Figure C-8. NRCS 29-13 Groundwater Elevations C-10
Figure C-9. NRCS 35-2 Groundwater Elevations C-11
Figure C-10. NRCS 121-1 Groundwater Elevations C-12
Figure C-11. NRCS 201-1 Groundwater Elevations C-13
Figure C-12. NRCS 203-1 Groundwater Elevations C-14
Figure C-13. NRCS 204-1 Groundwater Elevations C-15
Figure C-14. NRCS 205-5 Groundwater Elevations C-16

Figure C-1. NRCS 2-2



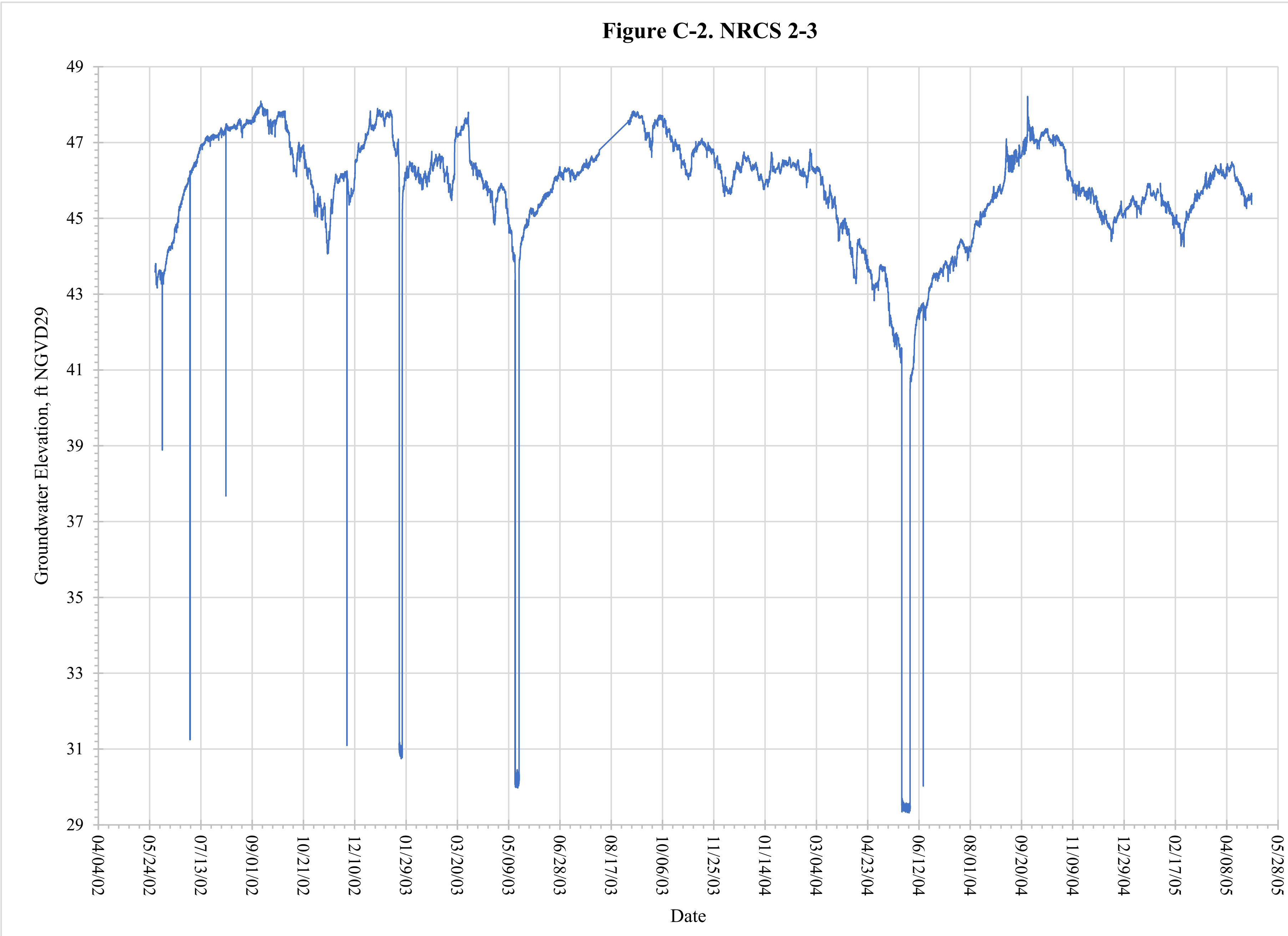


Figure C-2. NRCS 2-3
Groundwater Elevation, ft NGVD29
49
47
45
43
41
39
37
35
33
31
29
04/04/02
05/24/02
07/13/02
09/01/02
10/21/02
12/10/02
01/29/03
03/20/03
05/09/03
06/28/03
08/17/03
10/06/03
11/25/03
01/14/04
03/04/04
04/23/04
06/12/04
08/01/04
09/20/04
11/09/04
12/29/04
02/17/05
04/08/05
05/28/05
Date

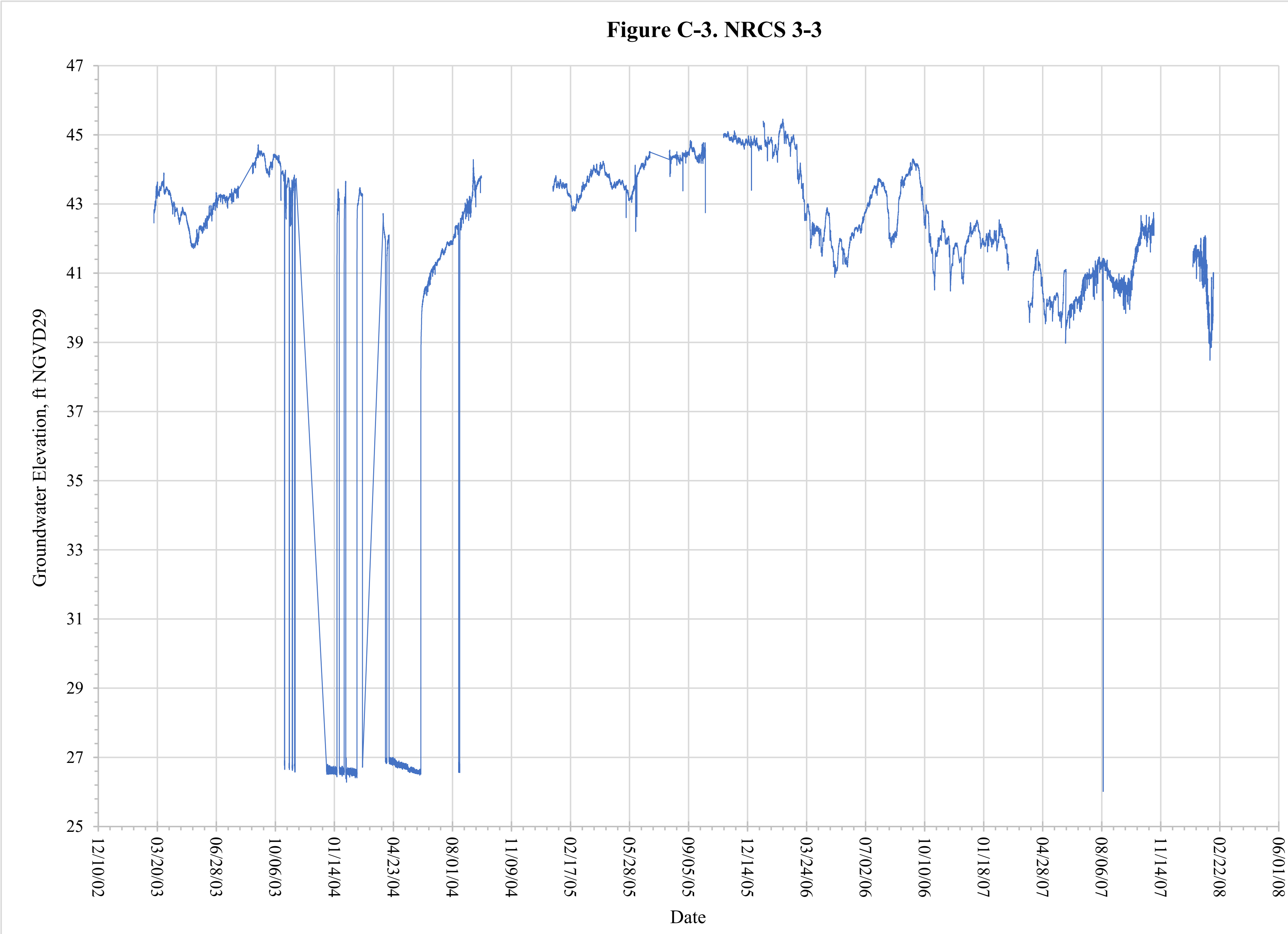


Figure C-3. NRCS 3-3
Groundwater Elevation, ft NGVD29
47
45
43
41
39
37
35
33
31
29
27
25
12/10/02
03/20/03
06/28/03
10/06/03
01/14/04
04/23/04
08/01/04
11/09/04
02/17/05
05/28/05
09/05/05
12/14/05
03/24/06
07/02/06
10/10/06
01/18/07
04/28/07
08/06/07
11/14/07
02/22/08
06/01/08
Date

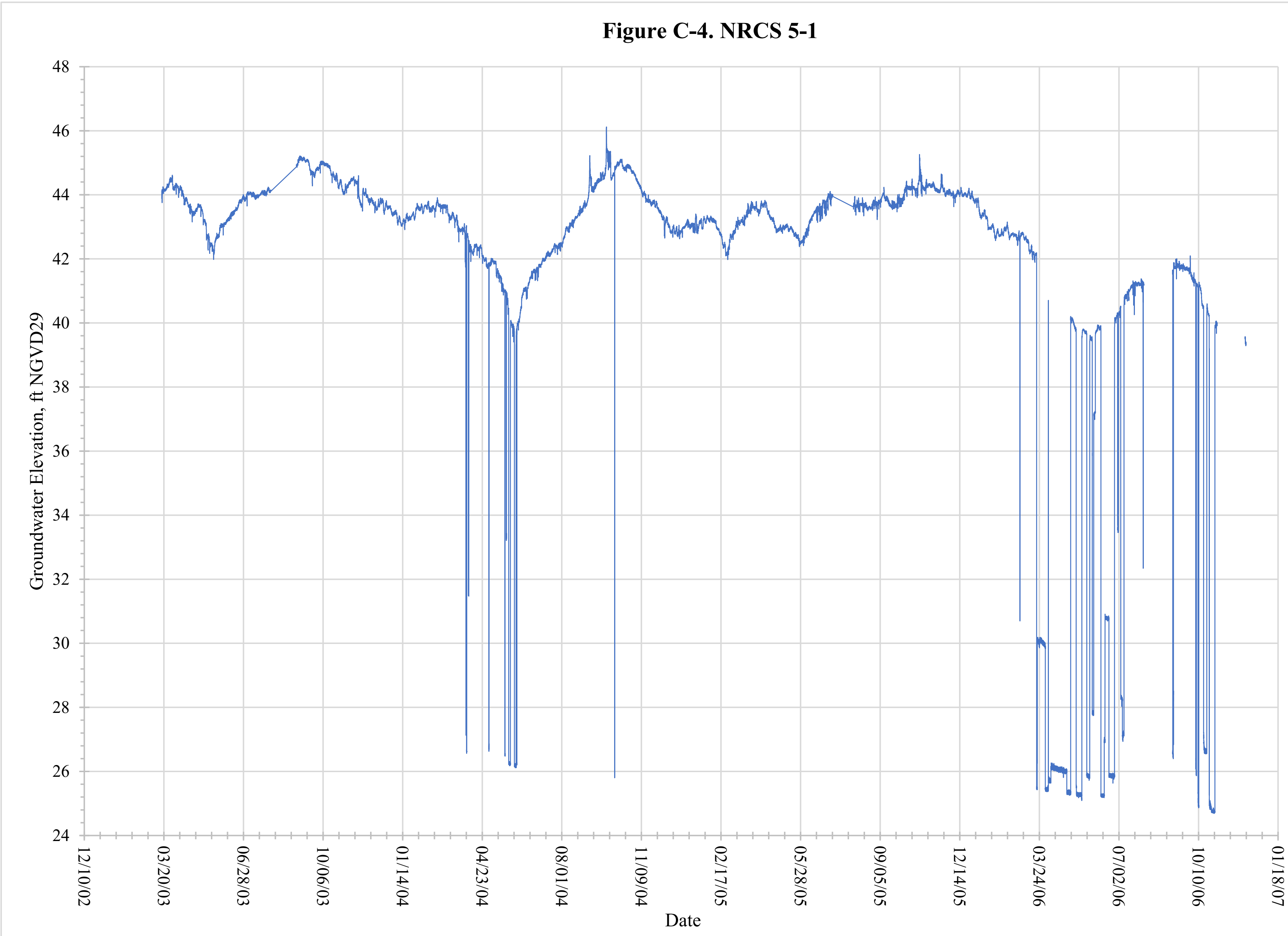


Figure C-4. NRCS 5-1
Groundwater Elevation, ft NGVD29
48
46
44
42
40
38
36
34
32
30
28
26
24
12/10/02
03/20/03
06/28/03
10/06/03
01/14/04
04/23/04
08/01/04
11/09/04
02/17/05
05/28/05
09/05/05
12/14/05
03/24/06
07/02/06
10/10/06
01/18/07
Date

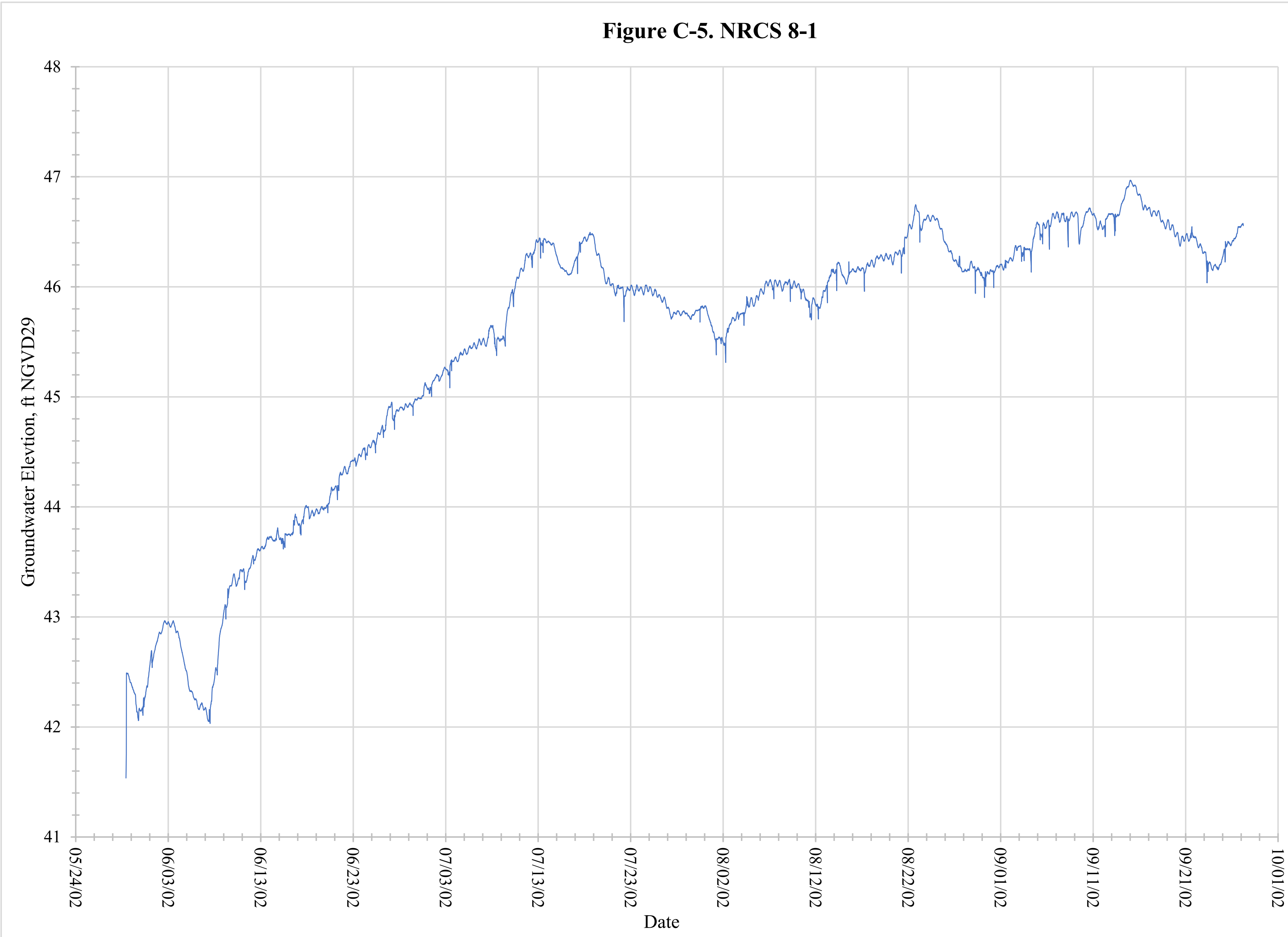


Figure C-5. NRCS 8-1
Groundwater Elevtion, ft NGVD29
Date
48
47
46
45
44
43
42
41
05/24/02
06/03/02
06/13/02
06/23/02
07/03/02
07/13/02
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09/21/02
10/01/02

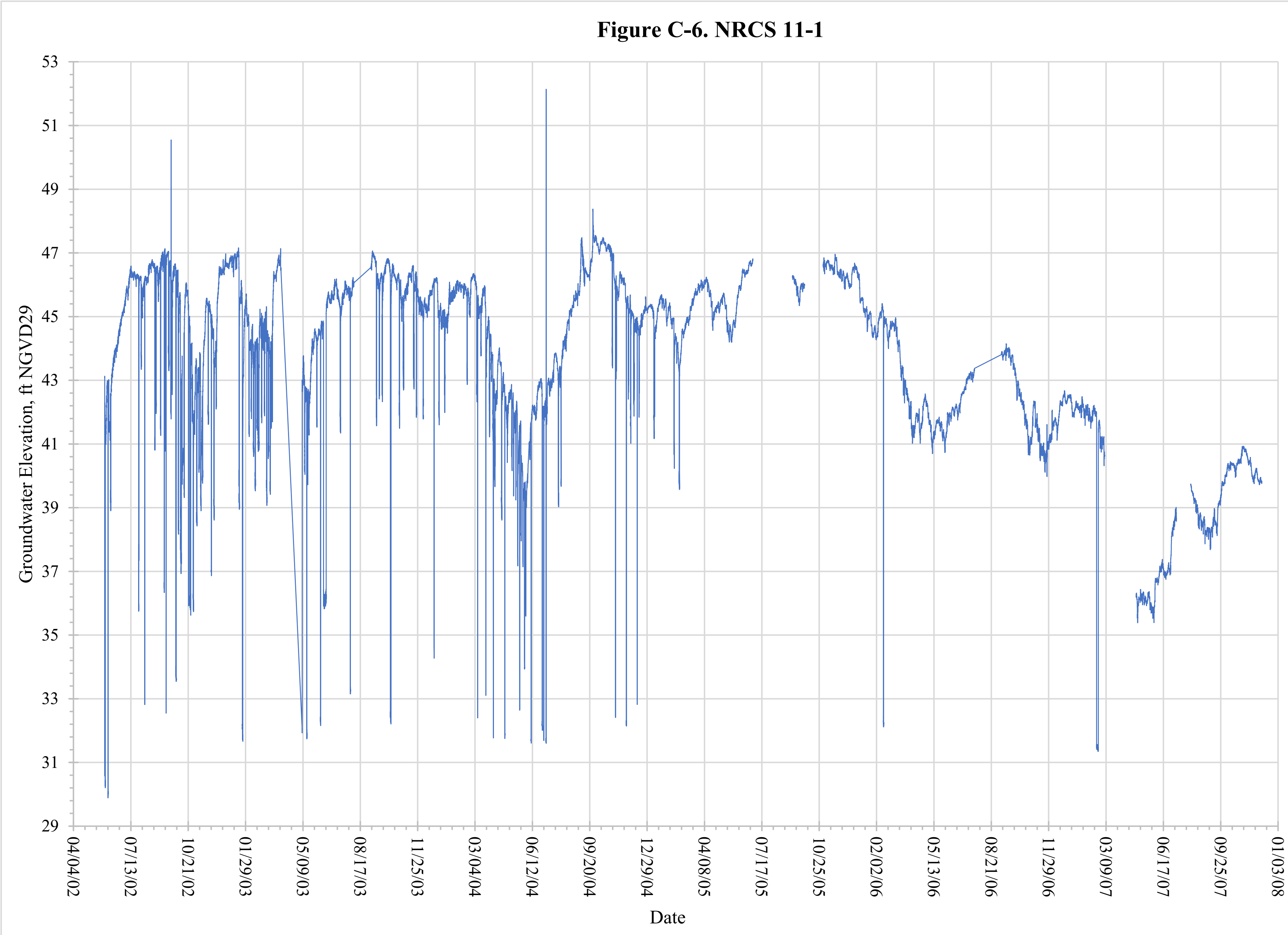

Figure C-6. NRCS 11-1
Groundwater Elevation, ft NGVD29
53
51
49
47
45
43
41
39
37
35
33
31
29
04/04/02
07/13/02
10/21/02
01/29/03
05/09/03
08/17/03
11/25/03
03/04/04
06/12/04
09/20/04
12/29/04
04/08/05
07/17/05
10/25/05
02/02/06
05/13/06
08/21/06
11/29/06
03/09/07
06/17/07
09/25/07
01/03/08
Date

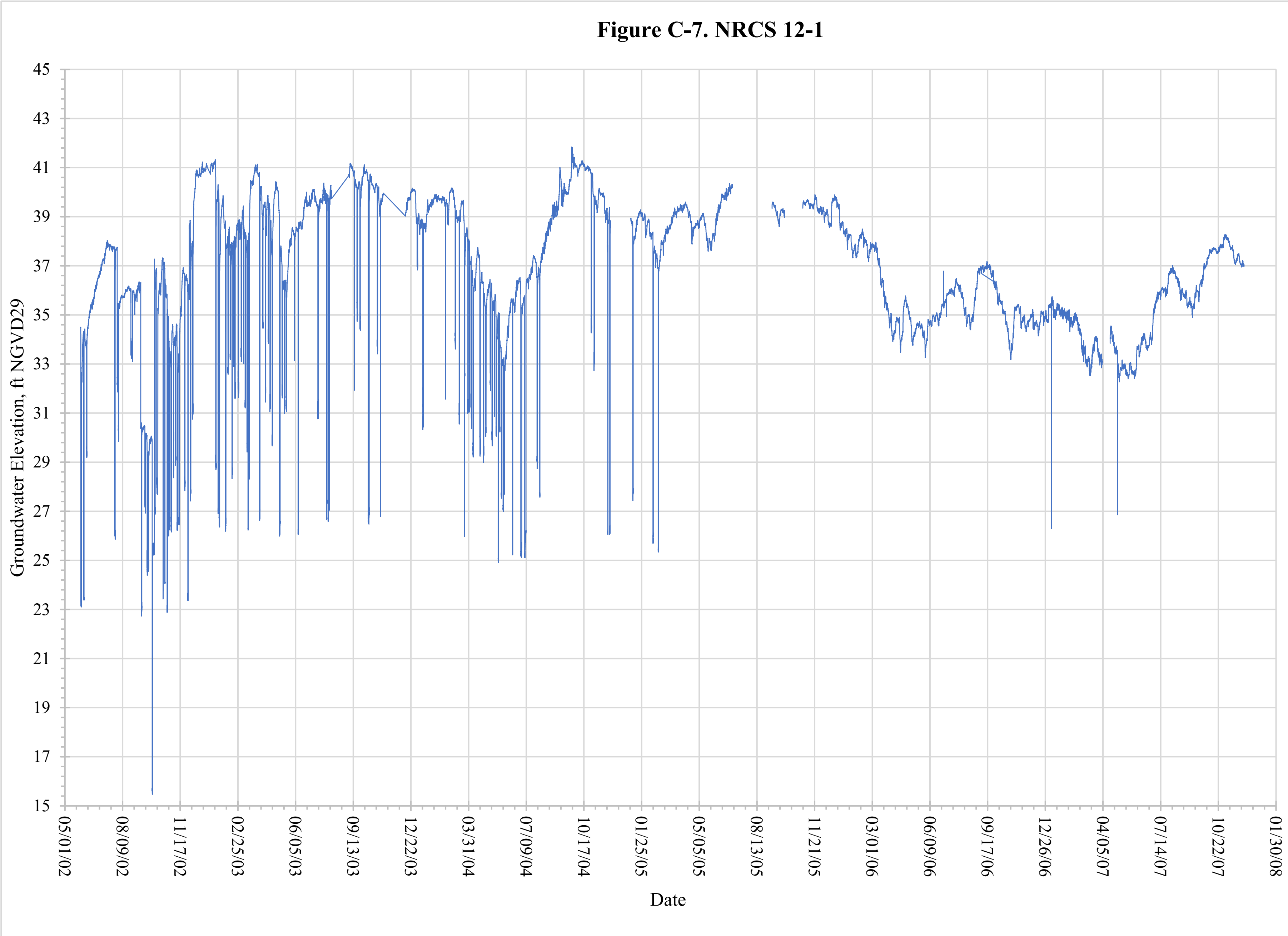

Figure C-7. NRCS 12-1
Groundwater Elevation, ft NGVD29
45
43
41
39
37
35
33
31
29
27
25
23
21
19
17
15
05/01/02
08/09/02
11/17/02
02/25/03
06/05/03
09/13/03
12/22/03
03/31/04
07/09/04
10/17/04
01/25/05
05/05/05
08/13/05
11/21/05
03/01/06
06/09/06
09/17/06
12/26/06
04/05/07
07/14/07
10/22/07
01/30/08
Date

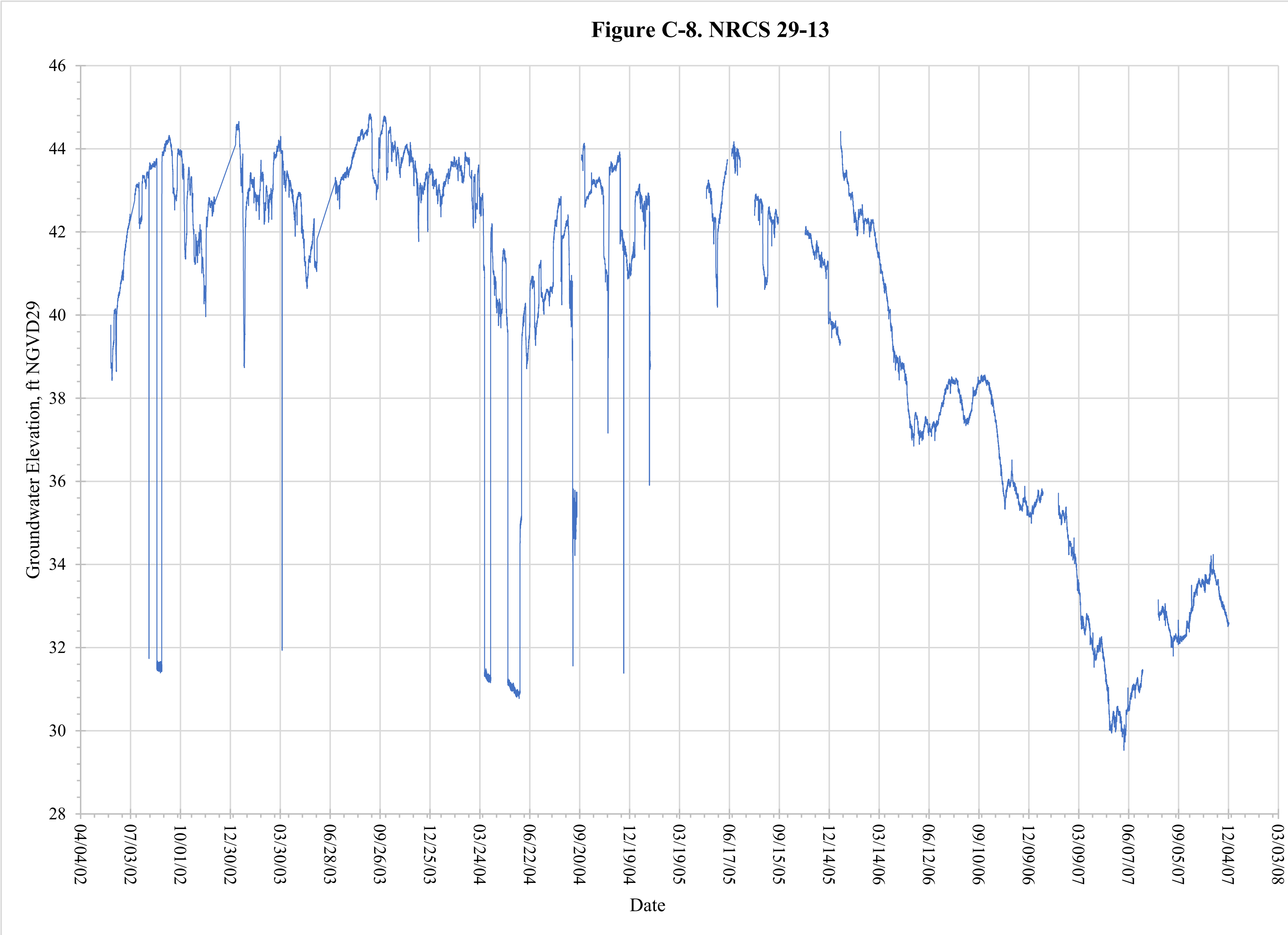

Figure C-8. NRCS 29-13
Groundwater Elevation, ft NGVD29
46
44
42
40
38
36
34
32
30
28
04/04/02
07/03/02
10/01/02
12/30/02
03/30/03
06/28/03
09/26/03
12/25/03
03/24/04
06/22/04
09/20/04
12/19/04
03/19/05
06/17/05
09/15/05
12/14/05
03/14/06
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12/04/07
03/03/08
Date

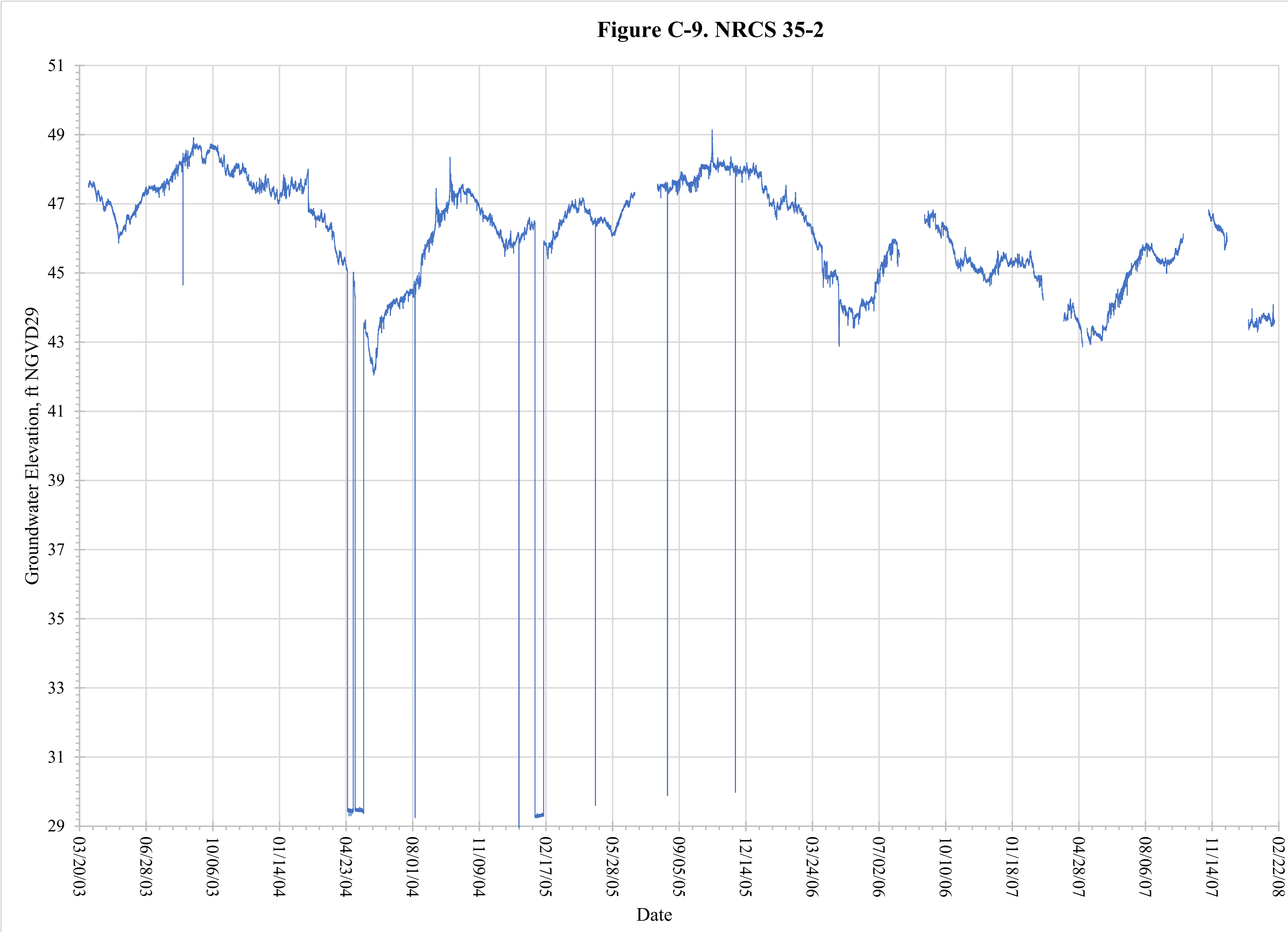


Figure C-9. NRCS 35-2
Groundwater Elevation, ft NGVD29
51
49
47
45
43
41
39
37
35
33
31
29
03/20/03
06/28/03
10/06/03
01/14/04
04/23/04
08/01/04
11/09/04
02/17/05
05/28/05
09/05/05
12/14/05
03/24/06
07/02/06
10/10/06
01/18/07
04/28/07
08/06/07
11/14/07
02/22/08
Date

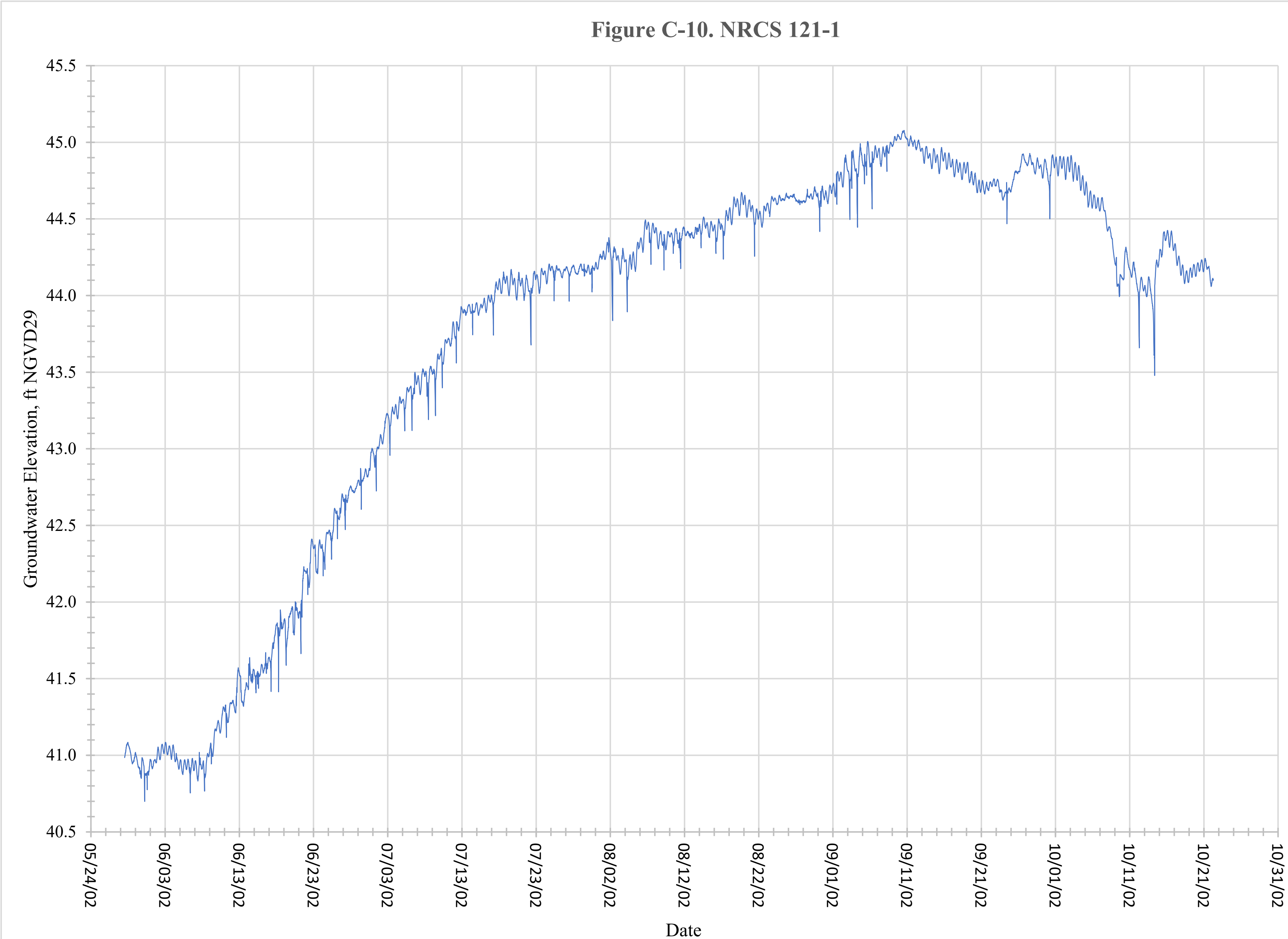


Figure C-10. NRCS 121-1
Groundwater Elevation, ft NGVD29
45.5
45.0
44.5
44.0
43.5
43.0
42.5
42.0
41.5
41.0
40.5
05/24/02
06/03/02
06/13/02
06/23/02
07/03/02
07/13/02
07/23/02
08/02/02
08/12/02
08/22/02
09/01/02
09/11/02
09/21/02
10/01/02
10/11/02
10/21/02
10/31/02
Date

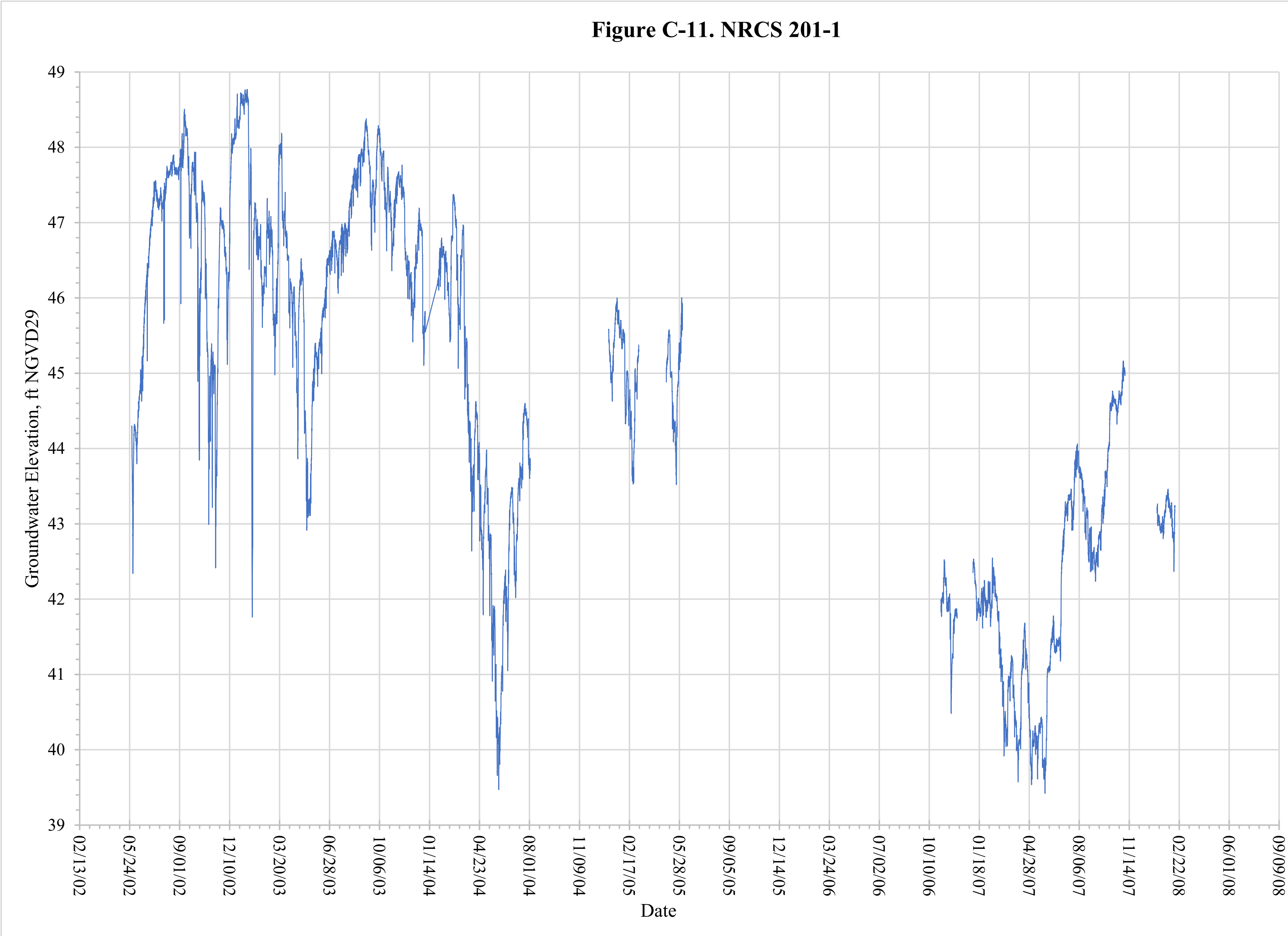
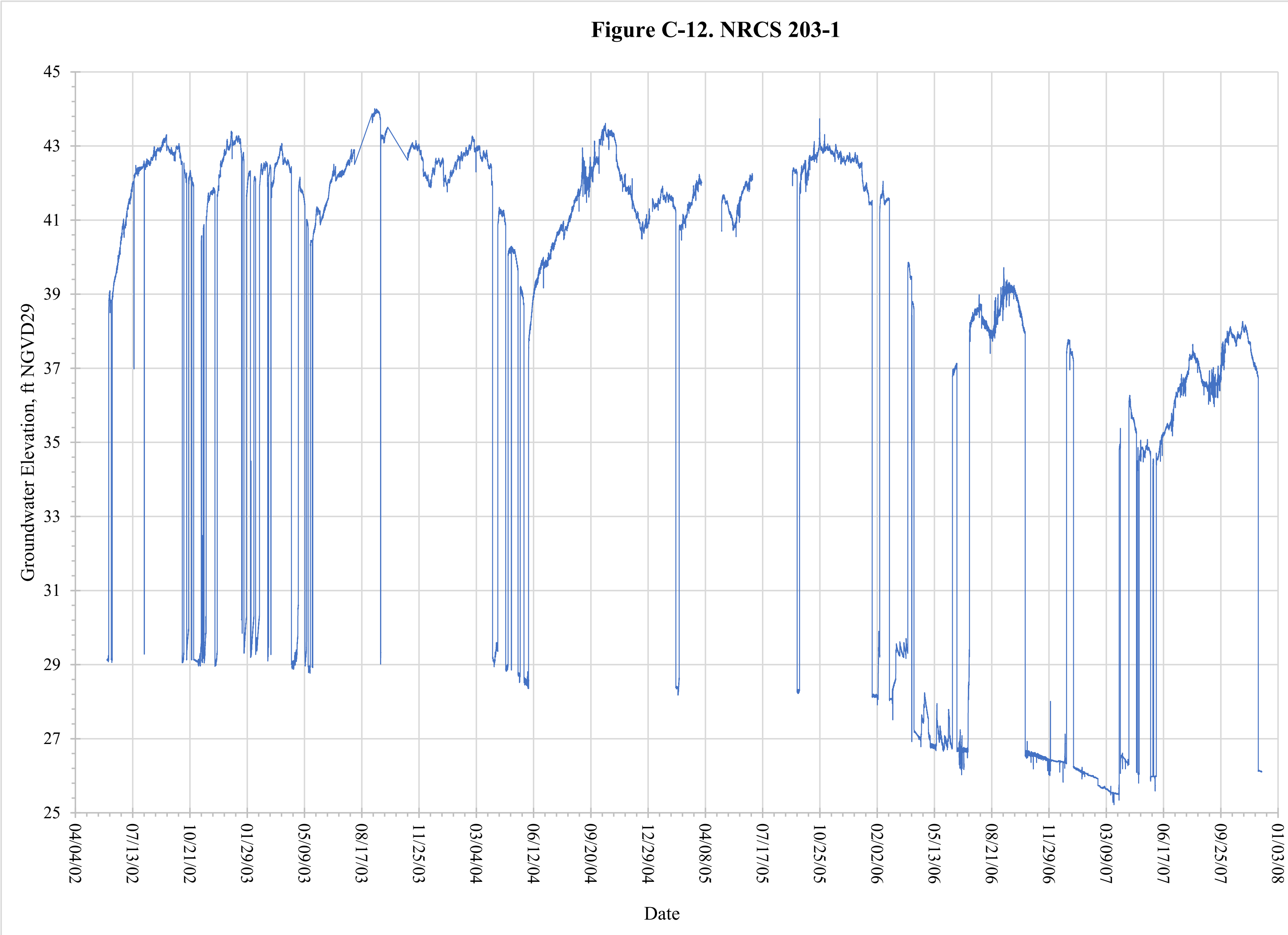


Figure C-11. NRCS 201-1
Groundwater Elevation, ft NGVD29
Date
49
48
47
46
45
44
43
42
41
40
39
02/13/02
05/24/02
09/01/02
12/10/02
03/20/03
06/28/03
10/06/03
01/14/04
04/23/04
08/01/04
11/09/04
02/17/05
05/28/05
09/05/05
12/14/05
03/24/06
07/02/06
10/10/06
01/18/07
04/28/07
08/06/07
11/14/07
02/22/08
06/01/08
09/09/08

Figure C-12. NRCS 203-1



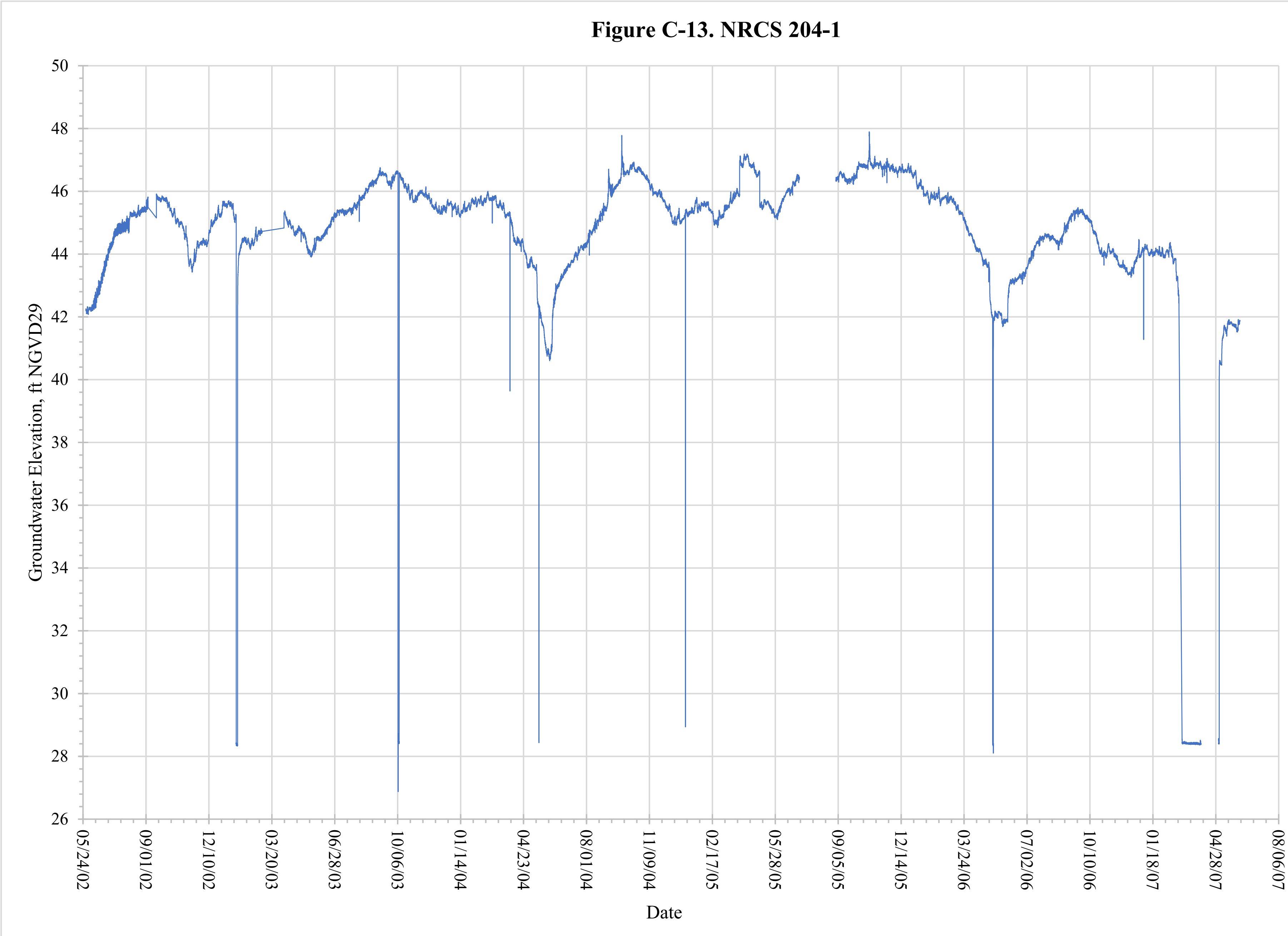


Figure C-13. NRCS 204-1
50
48
46
44
42
40
38
36
34
32
30
28
26
Groundwater Elevation, ft NGVD29
05/24/02
09/01/02
12/10/02
03/20/03
06/28/03
10/06/03
01/14/04
04/23/04
08/01/04
11/09/04
02/17/05
05/28/05
09/05/05
12/14/05
03/24/06
07/02/06
10/10/06
01/18/07
04/28/07
08/06/07
Date

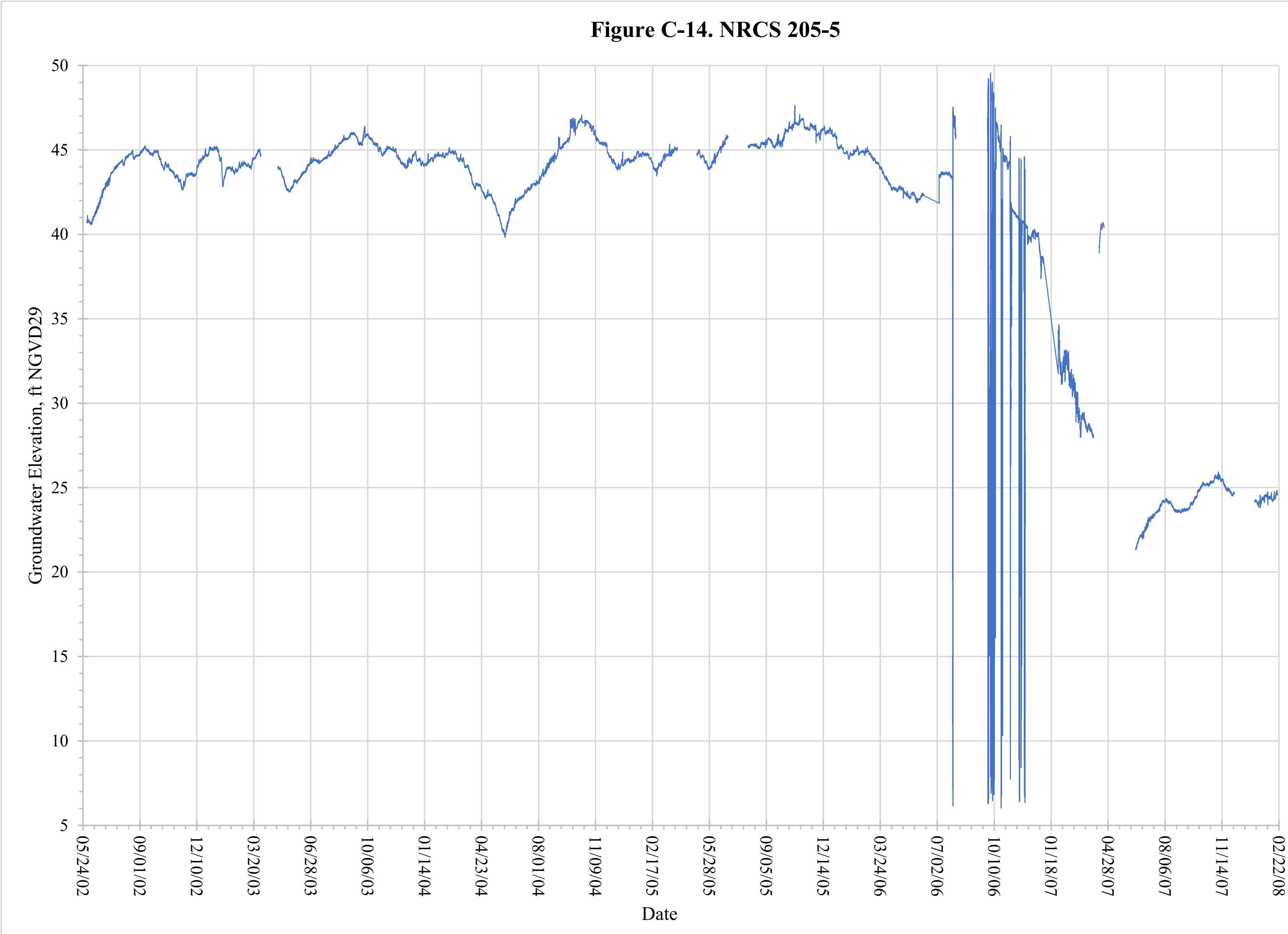


Figure C-14. NRCS 205-5
Groundwater Elevation, ft NGVD29
50
45
40
35
30
25
20
15
10
5
05/24/02
09/01/02
12/10/02
03/20/03
06/28/03
10/06/03
01/14/04
04/23/04
08/01/04
11/09/04
02/17/05
05/28/05
09/05/05
12/14/05
03/24/06
07/02/06
10/10/06
01/18/07
04/28/07
08/06/07
11/14/07
02/22/08
Date

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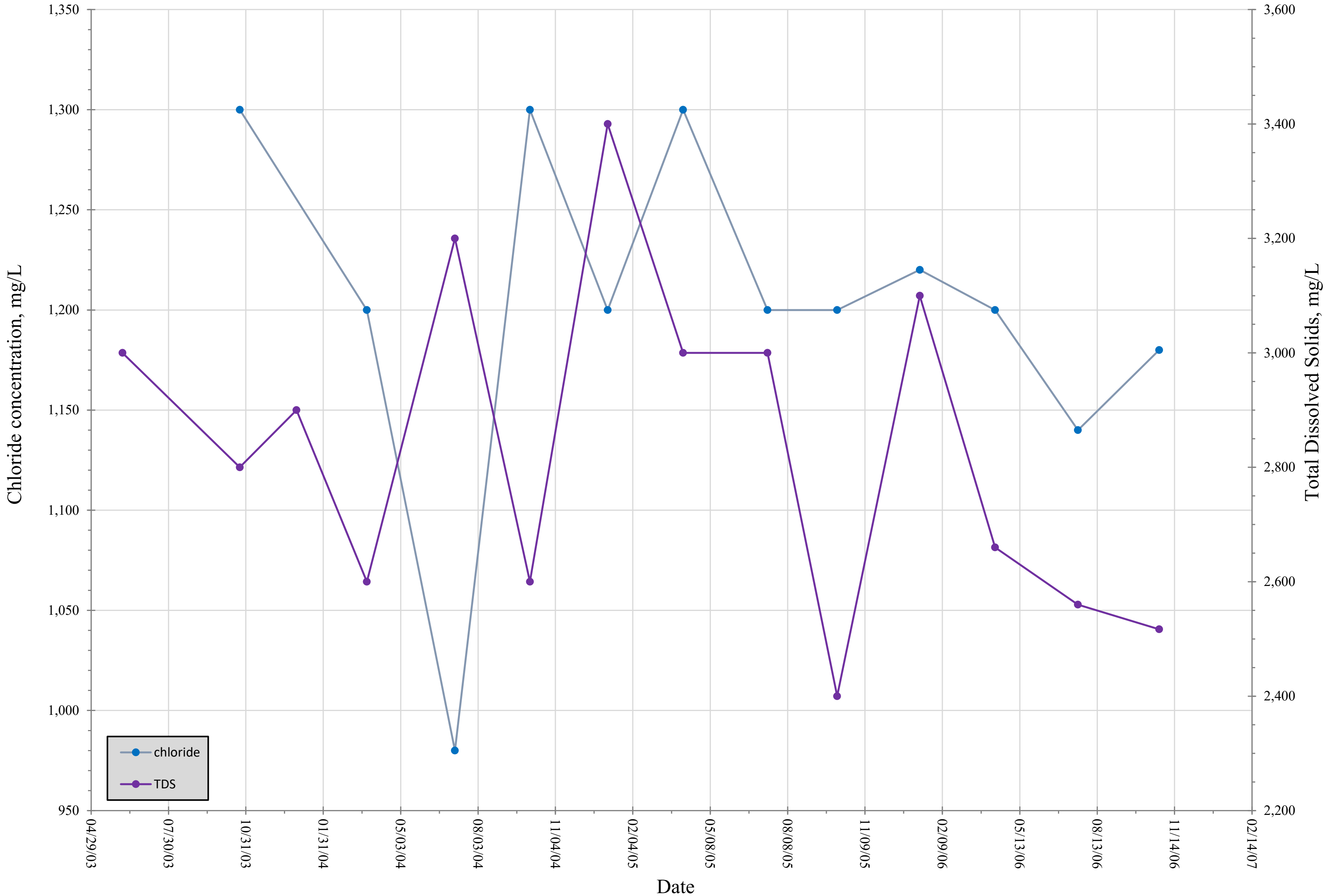
Figure D-1. MF-9



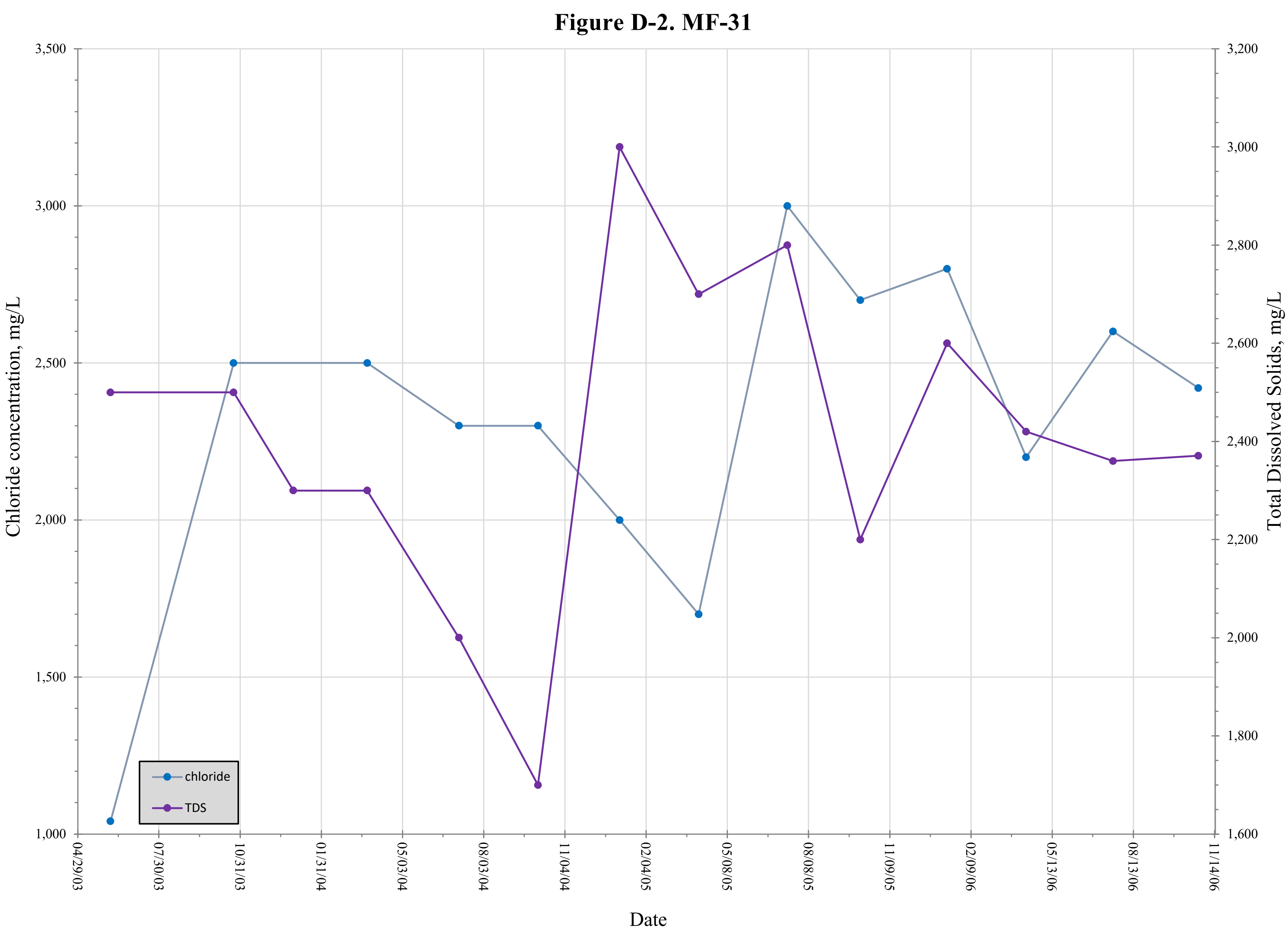


Figure D-2. MF-31
Chloride concentration, mg/L
Total Dissolved Solids, mg/L
Date
3,500
3,000
2,500
2,000
1,500
1,000
3,200
3,000
2,800
2,600
2,400
2,200
2,000
1,800
1,600
04/29/03
07/30/03
10/31/03
01/31/04
05/03/04
08/03/04
11/04/04
02/04/05
05/08/05
08/08/05
11/09/05
02/09/06
05/13/06
08/13/06
11/14/06
chloride
TDS

Figure D-3. MF-35B

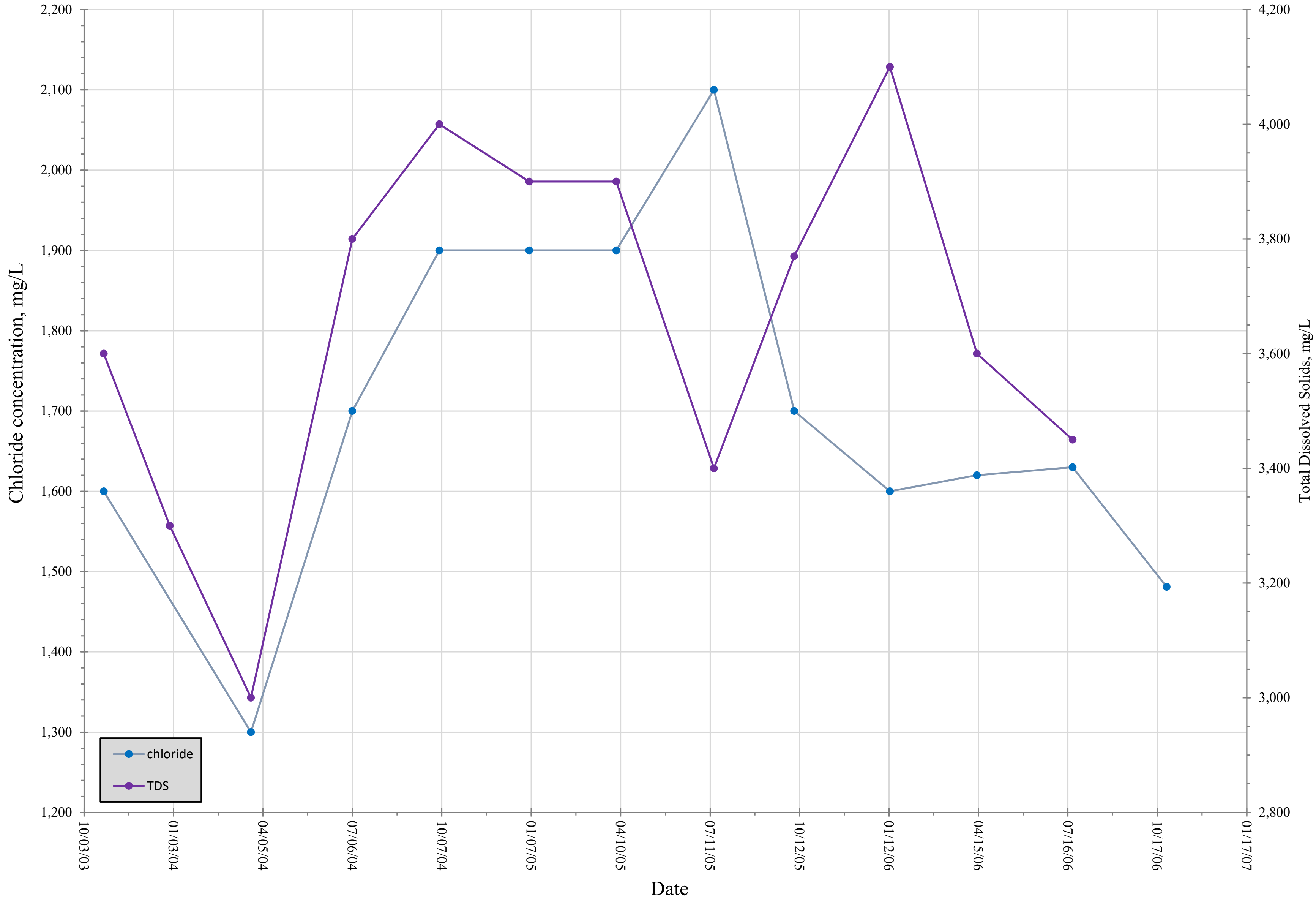


Figure D-4. MF-52

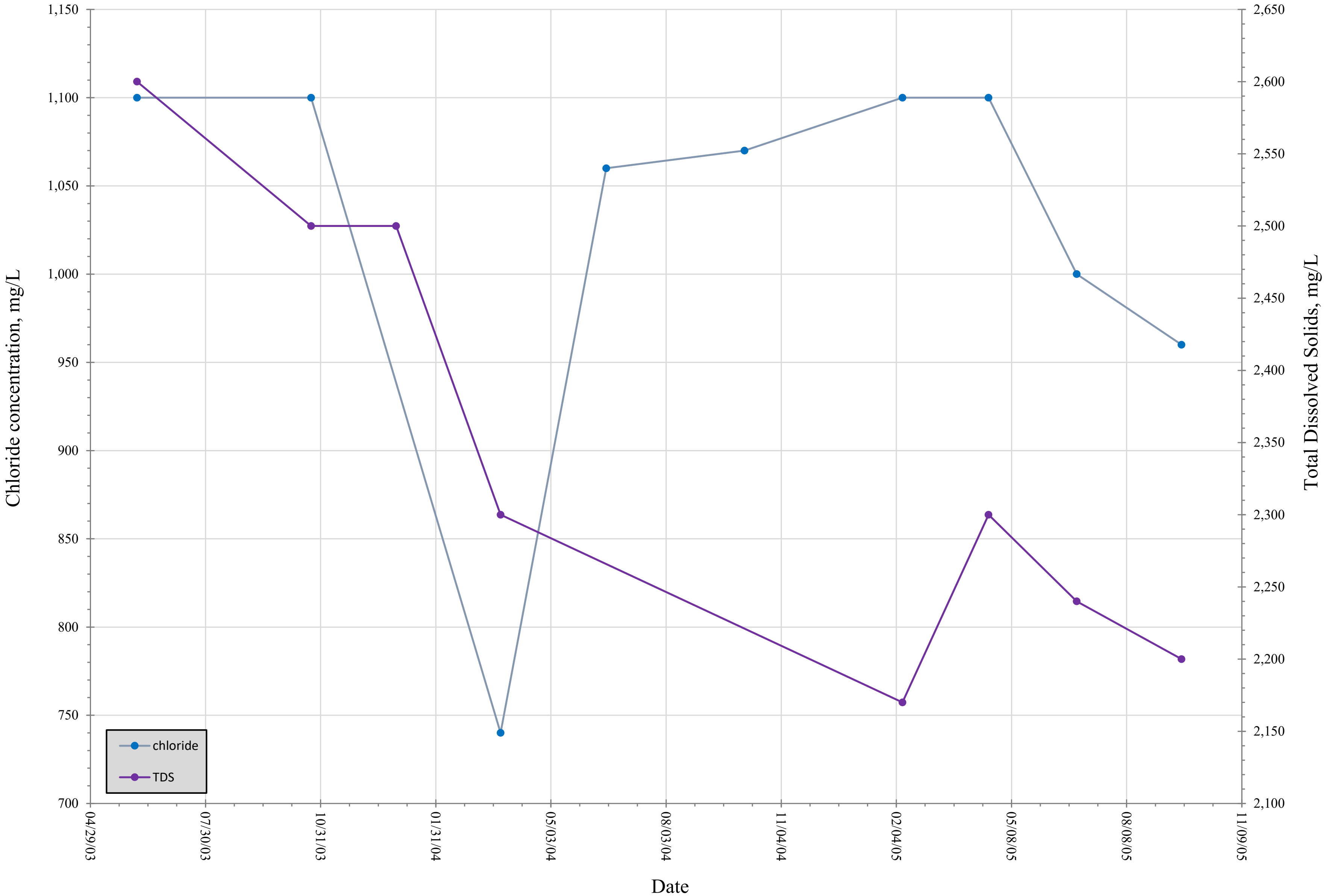


Figure D-5. SLF-9

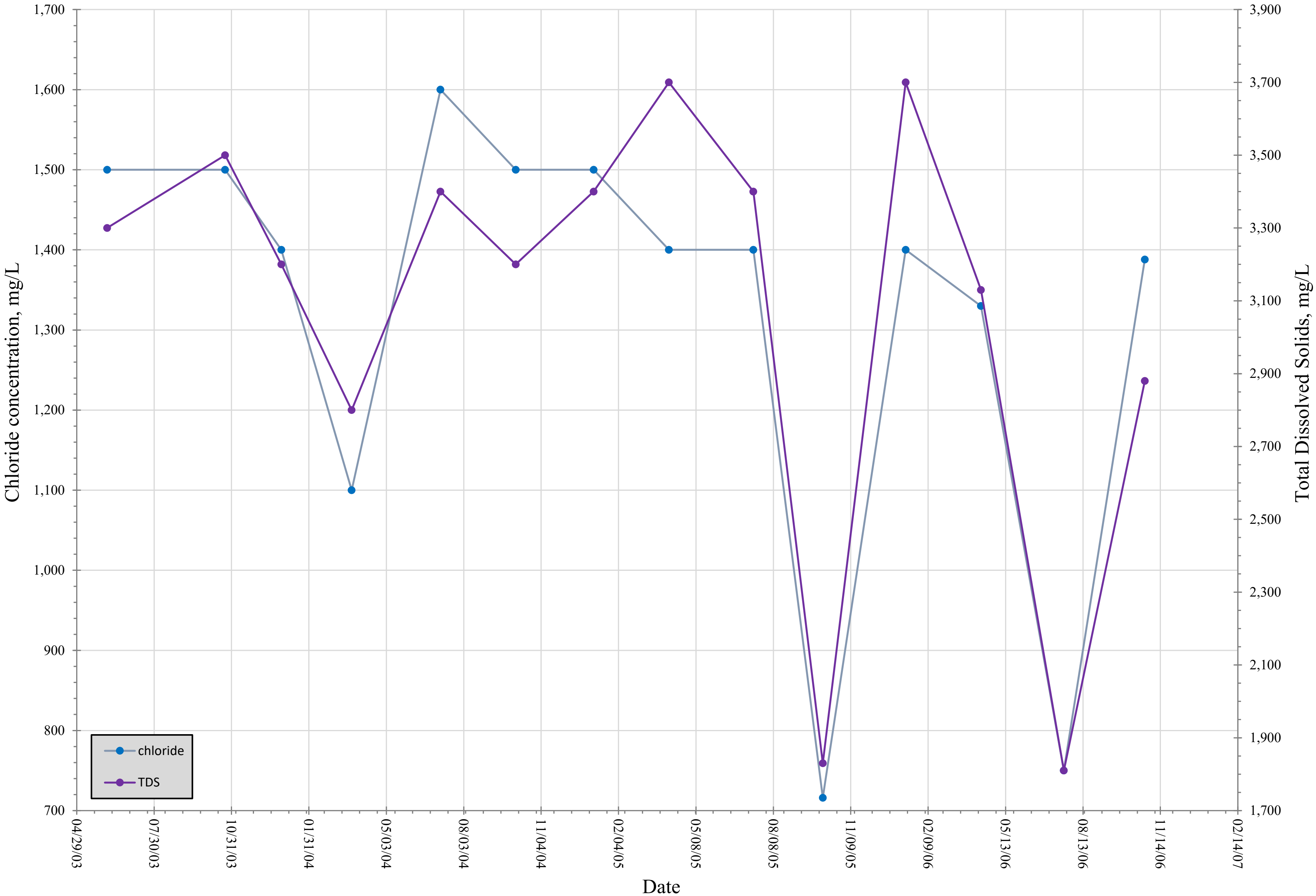


Figure D-6. SLF-11

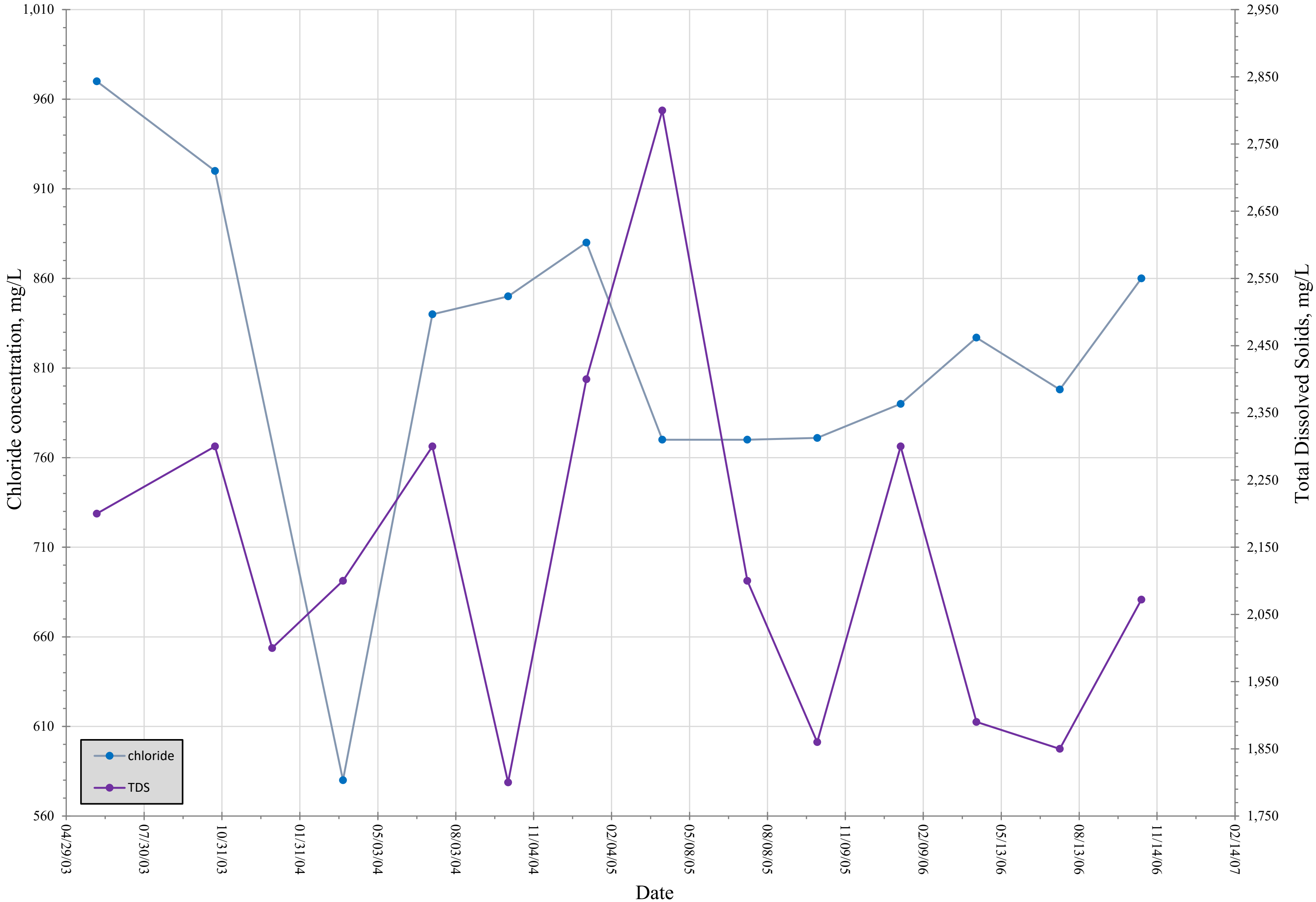


Figure D-7. SLF-14

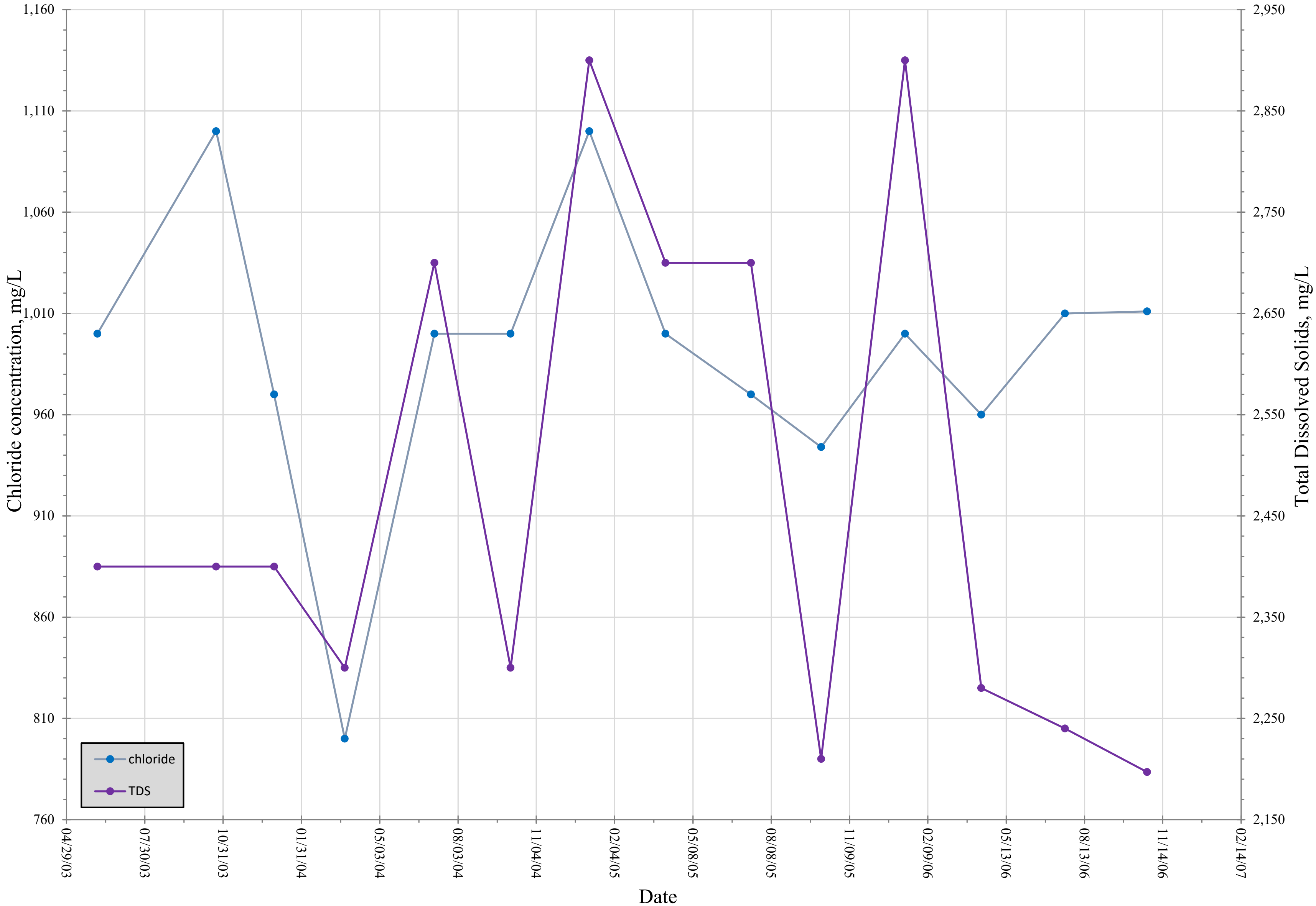


Figure D-8. SLF-21

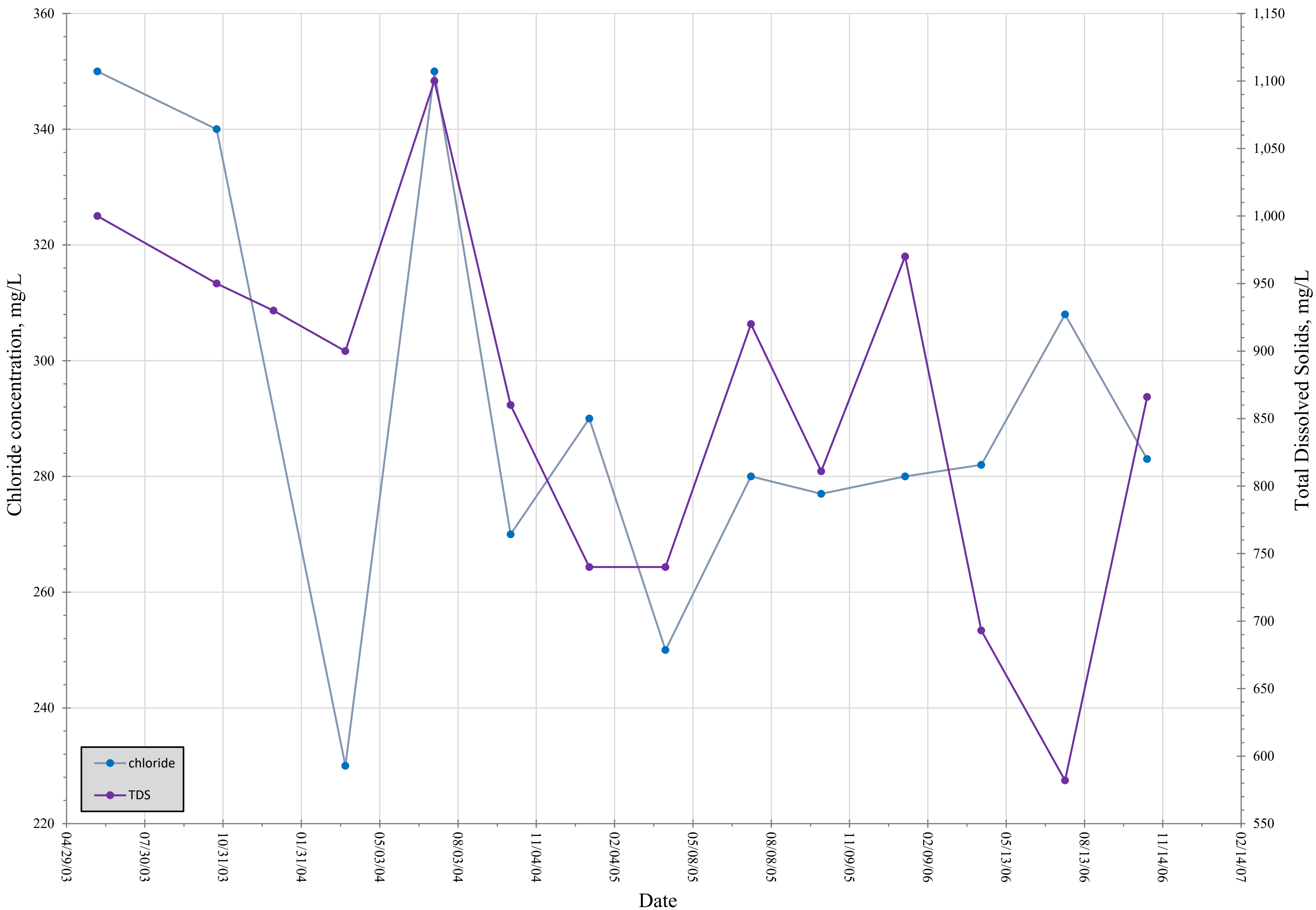


Figure D-9. SLF-60

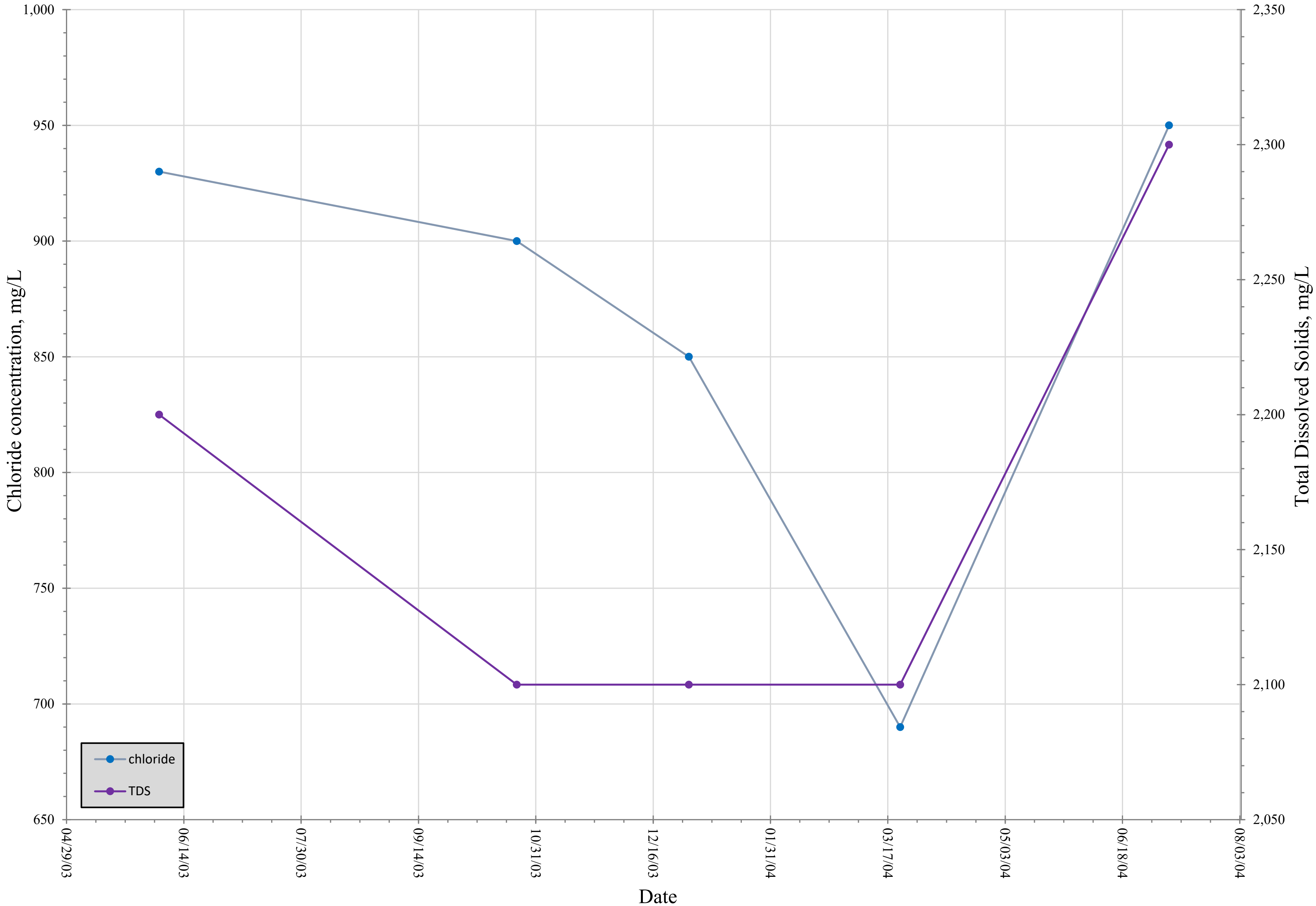


Figure D-10. SLF-62

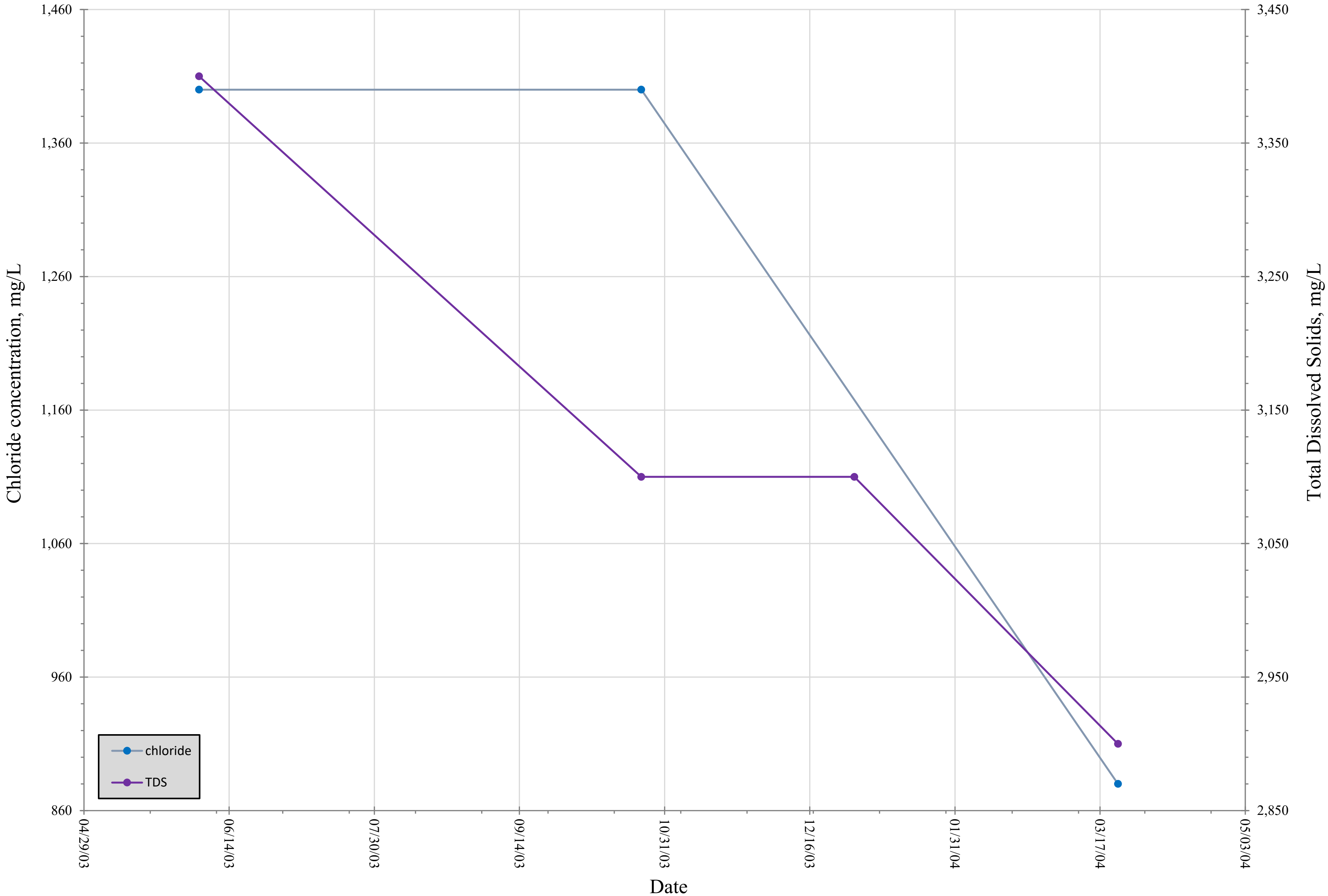


Figure D-11. SLF-62B

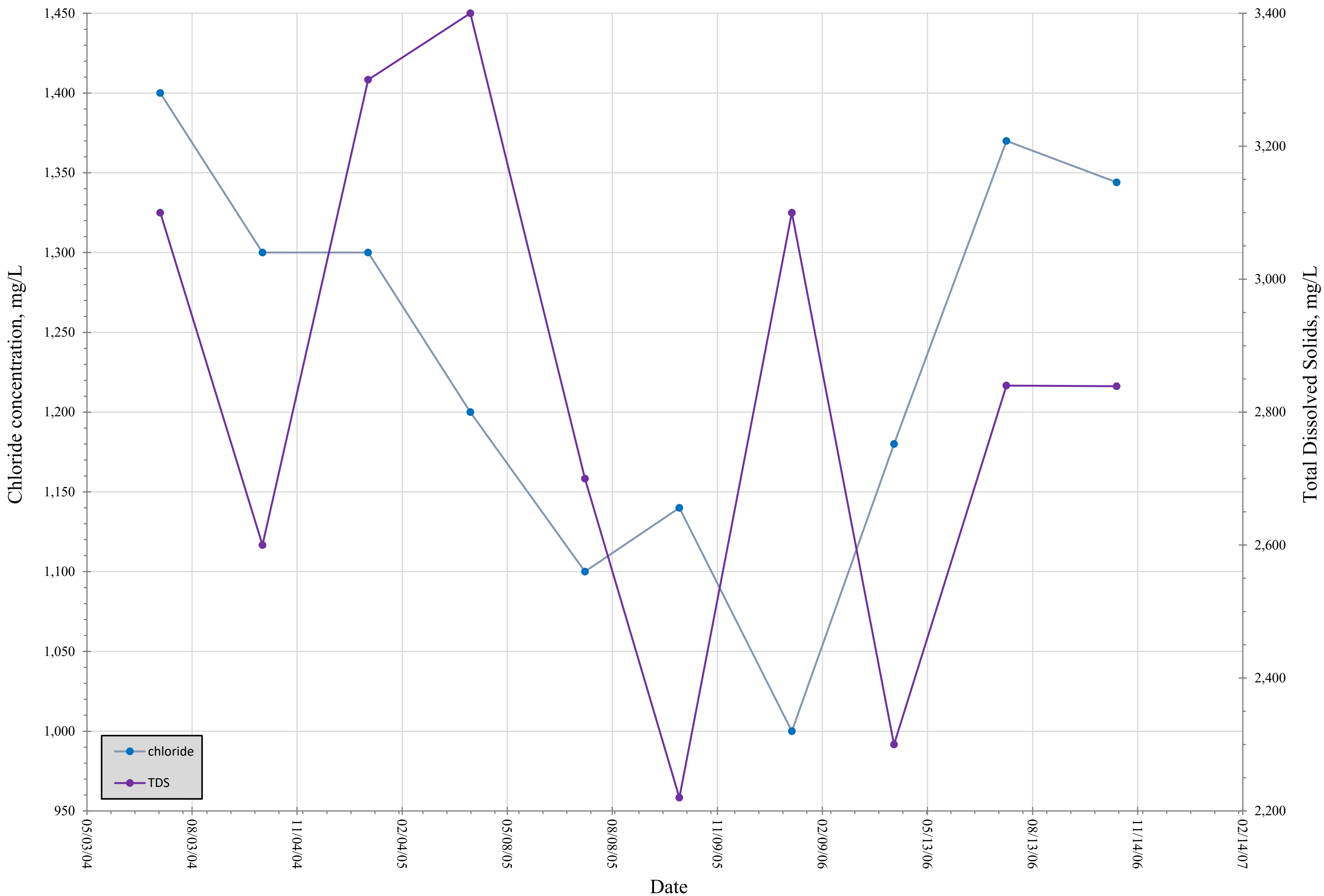


Figure D-12. SLF-69

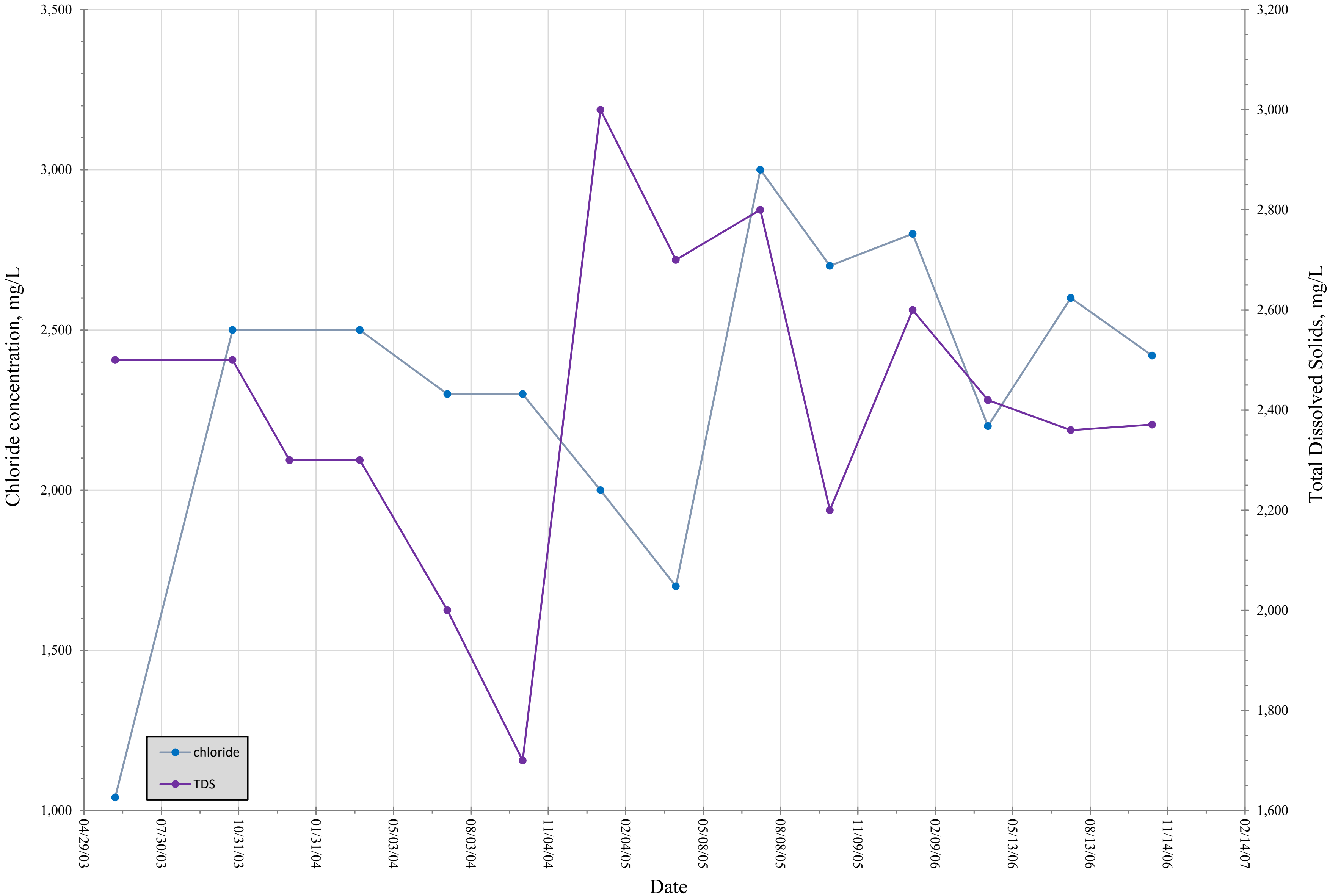


Figure D-13. SLF-74

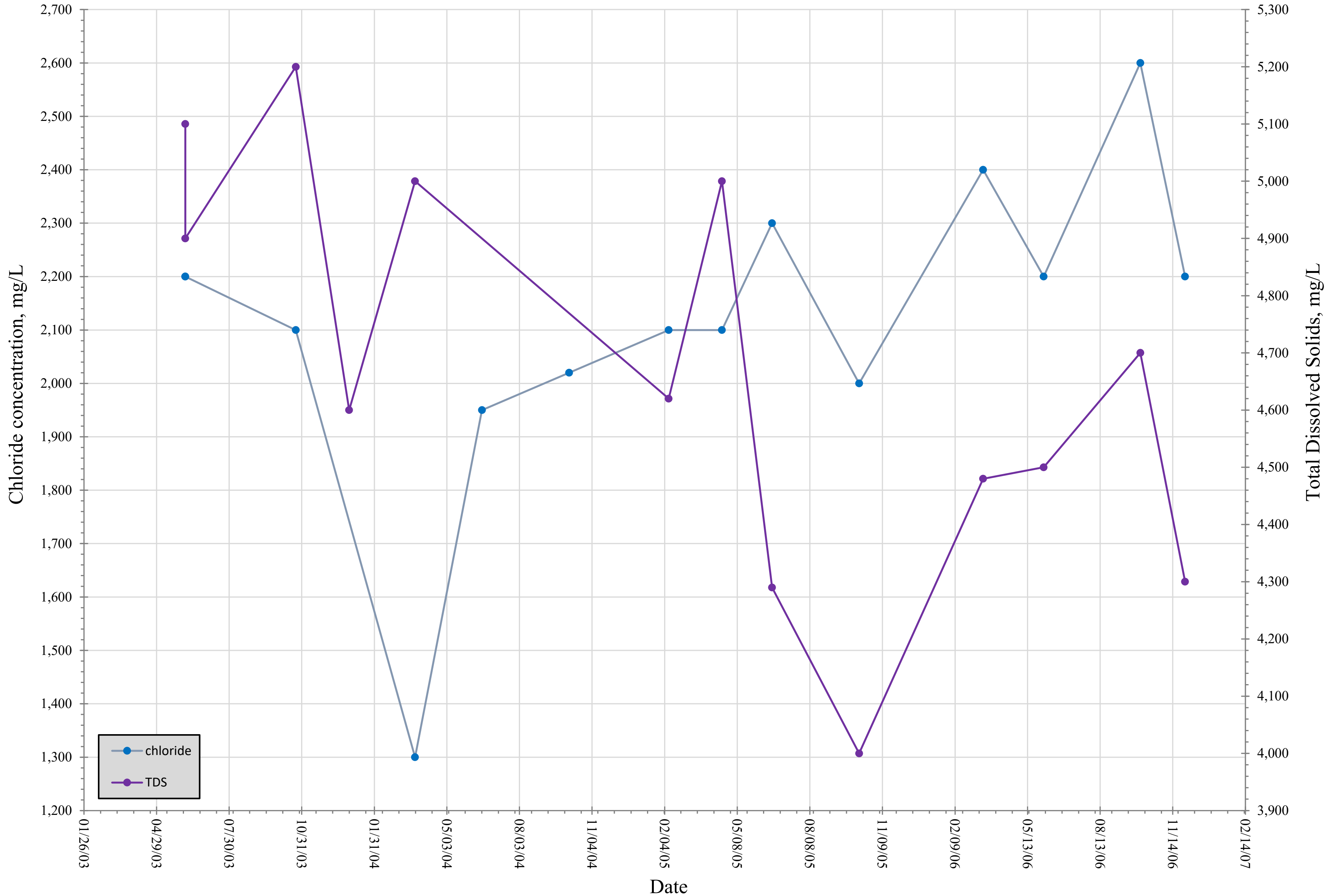


Figure D-14. SLF-75

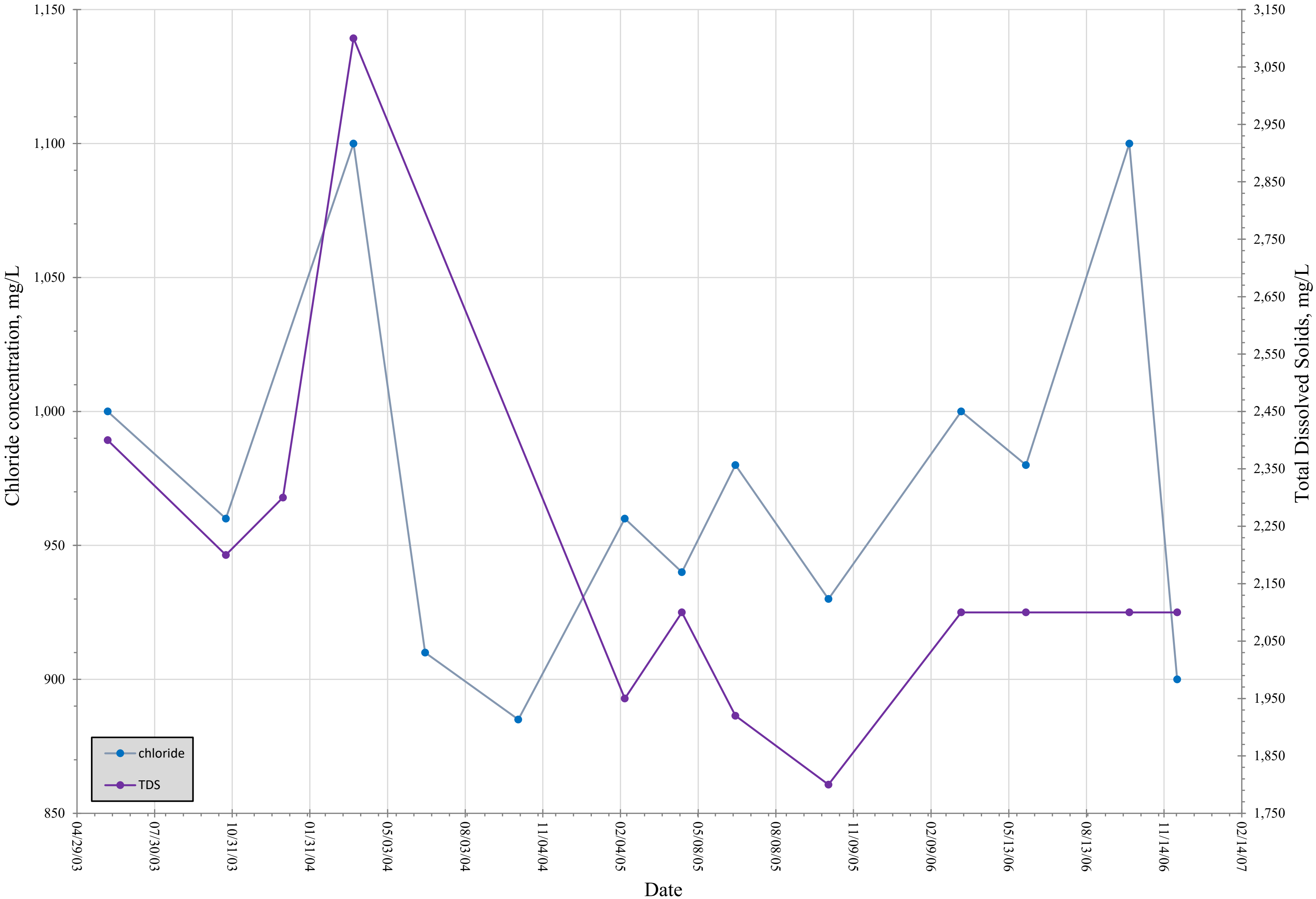
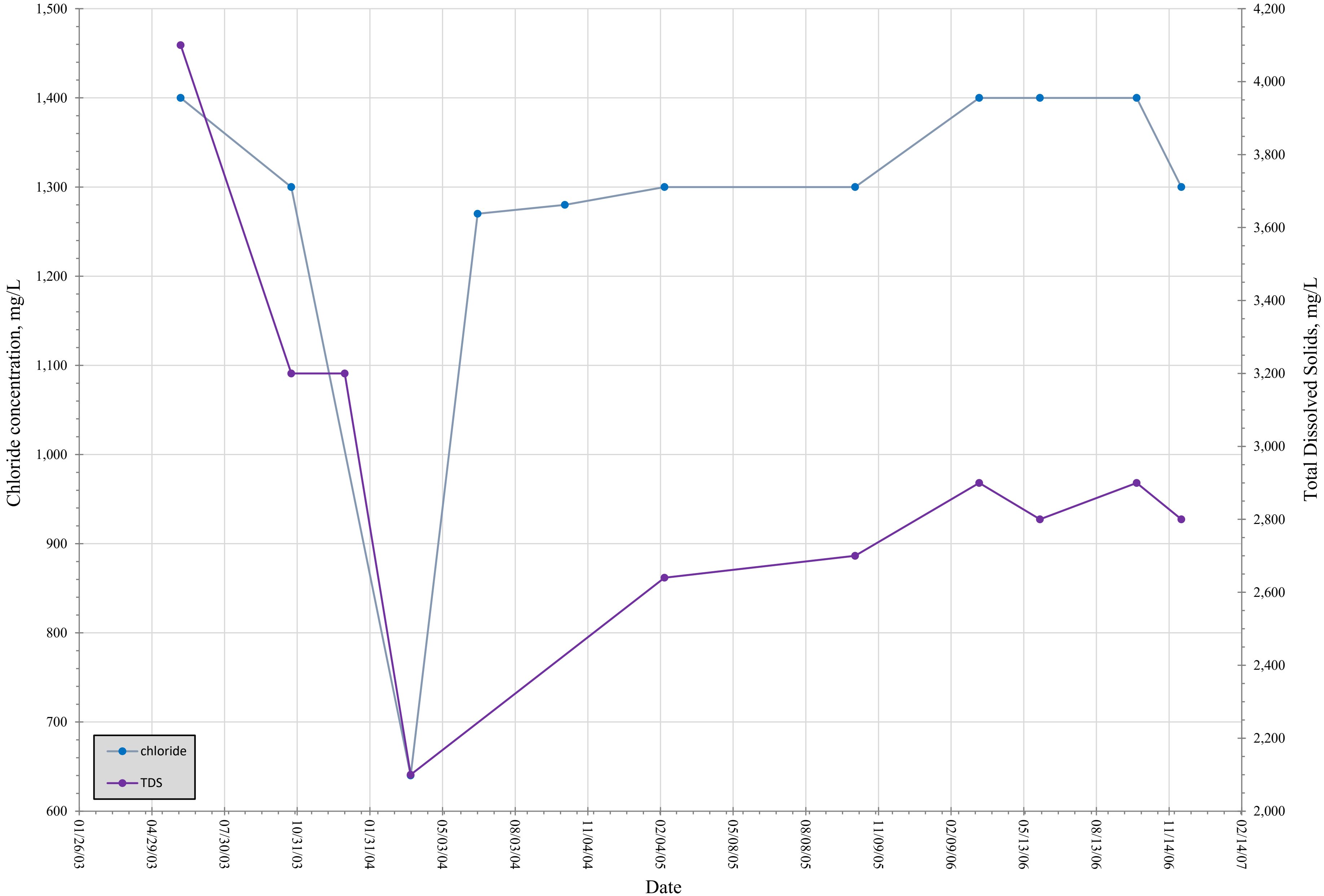


Figure D-15. SLF-76



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GROUNDWATER QUALITY TIME-SERIES PLOTS FOR NRCS-MONITORED UECFAS GROUNDWATER MONITORING NETWORK WELLS

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Figure E-16. NRCS 121-1 Groundwater Quality E-18
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Figure E-18. NRCS 202-1 Groundwater Quality E-20
Figure E-19. NRCS 203-1 Groundwater Quality E-21
Figure E-20. NRCS 204-3 Groundwater Quality E-22
Figure E-21. NRCS 205-6 Groundwater Quality E-23

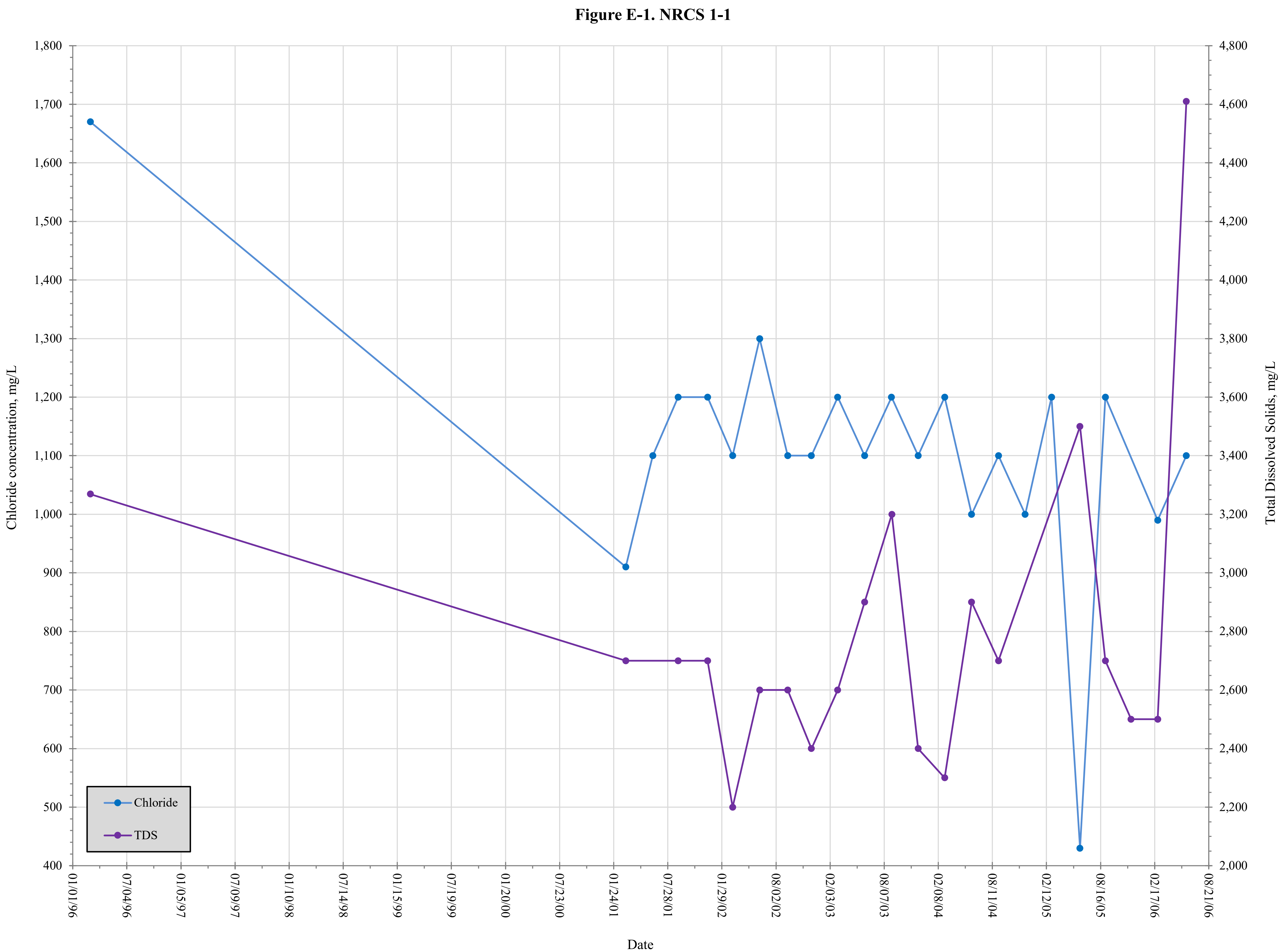

Figure E-1. NRCS 1-1
Chloride concentration, mg/L
Total Dissolved Solids, mg/L
Date
Chloride
TDS
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
4,800
4,600
4,400
4,200
4,000
3,800
3,600
3,400
3,200
3,000
2,800
2,600
2,400
2,200
2,000
01/01/96
07/04/96
01/05/97
07/09/97
01/10/98
07/14/98
01/15/99
07/19/99
01/20/00
07/23/00
01/24/01
07/28/01
01/29/02
08/02/02
02/03/03
08/07/03
02/08/04
08/11/04
02/12/05
08/16/05
02/17/06
08/21/06

Figure E-2. NRCS 2-2

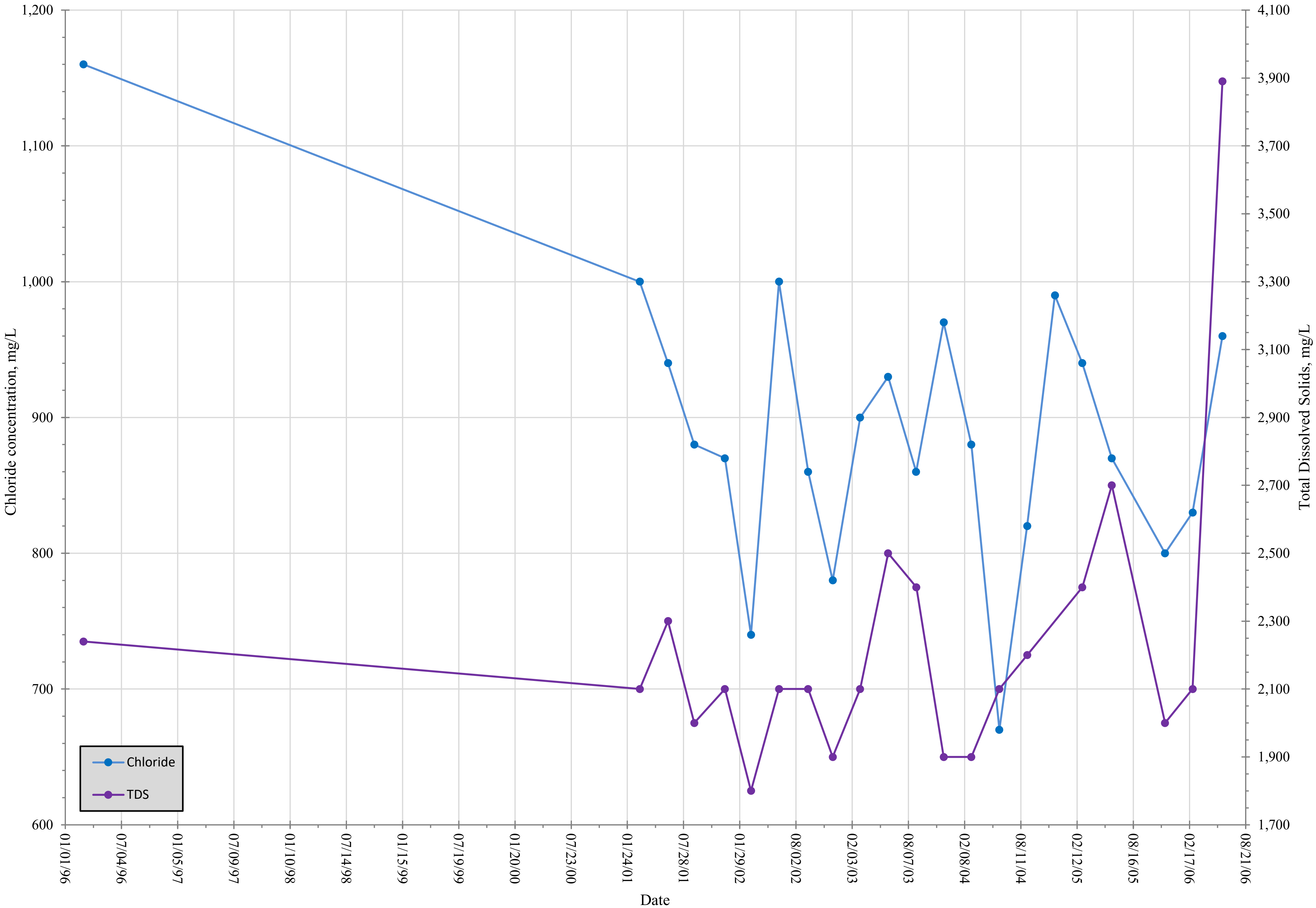

Figure E-3. NRCS 3-2

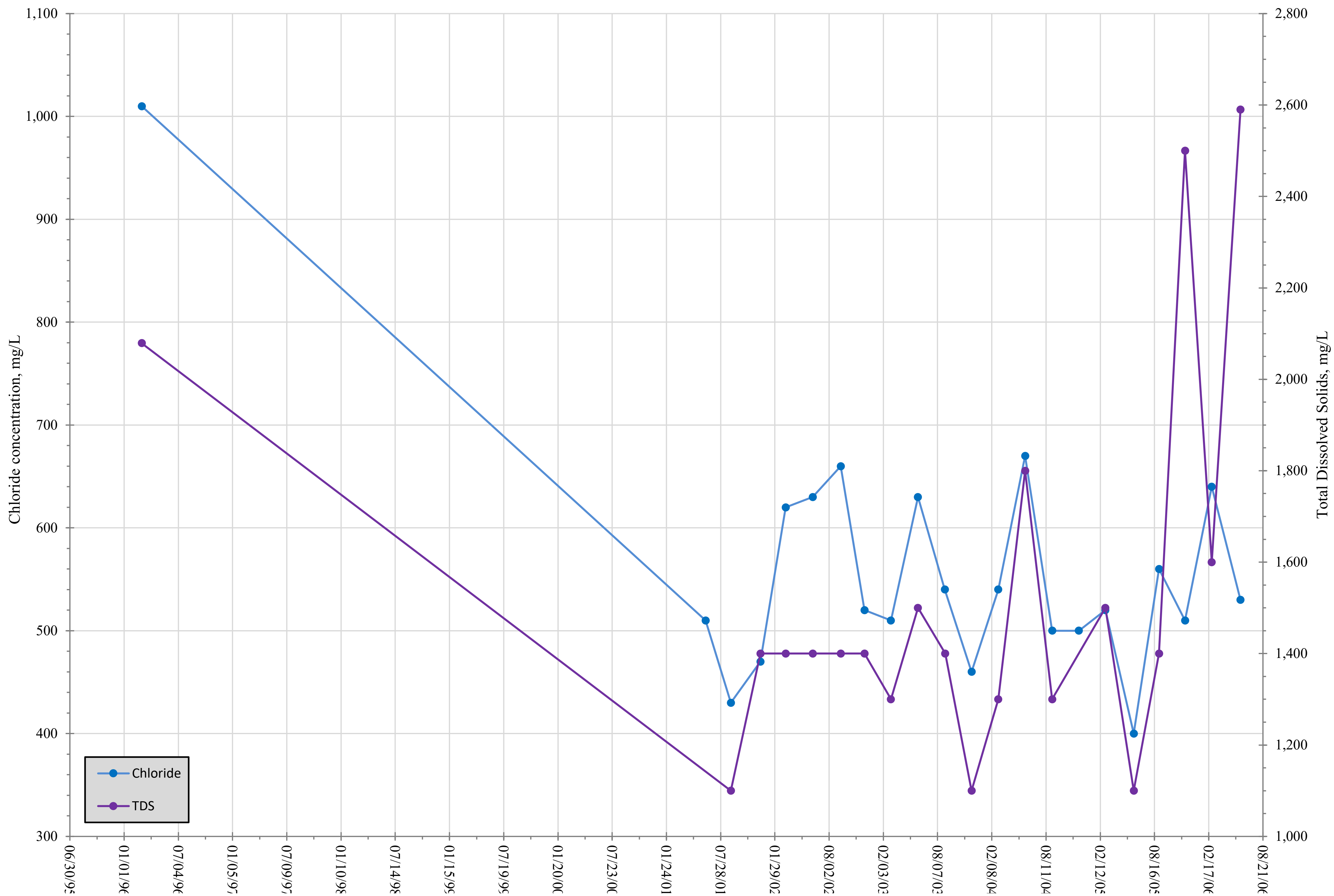

Figure E-4. NRCS 4-1

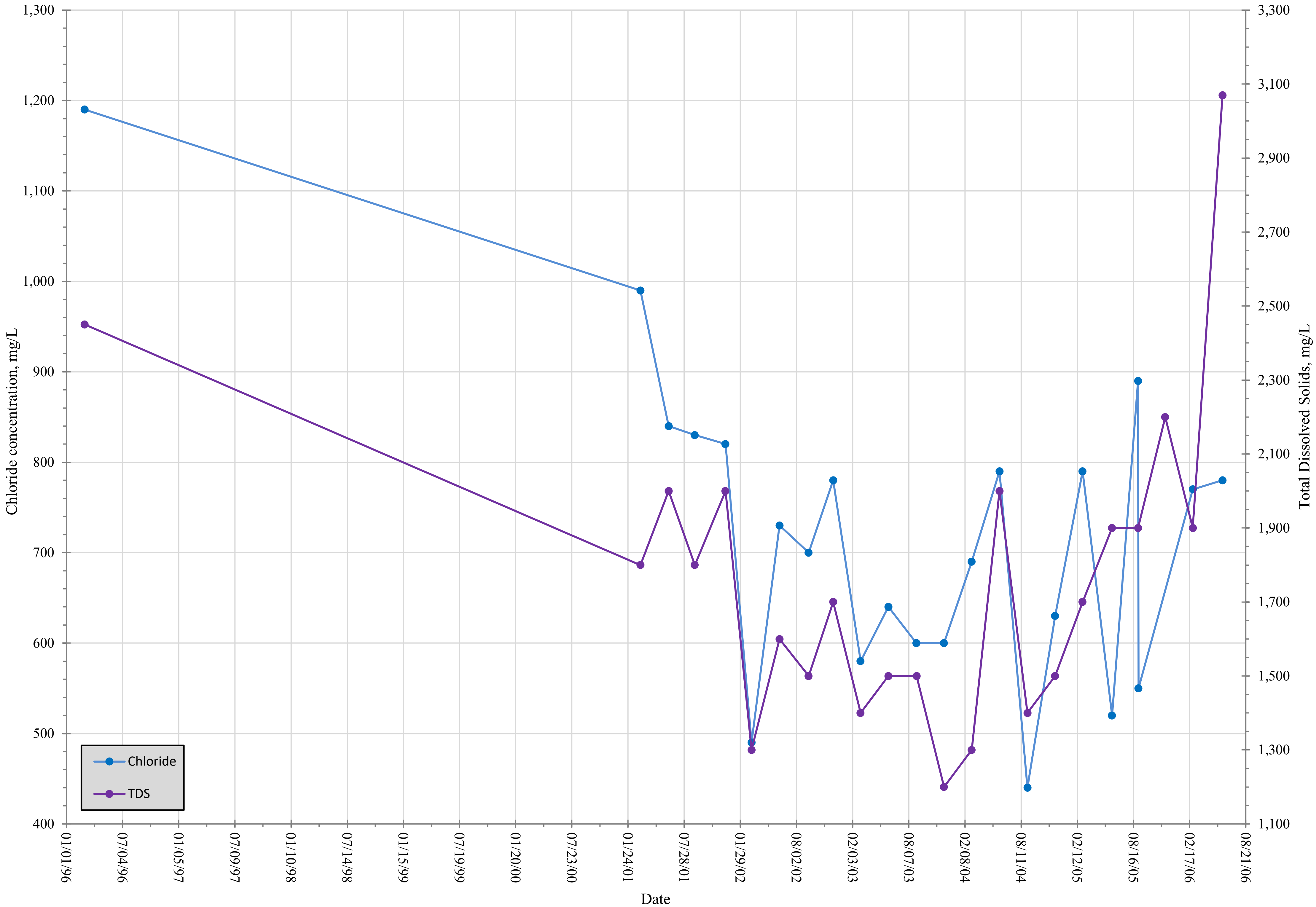

Figure E-5. NRCS 5-1

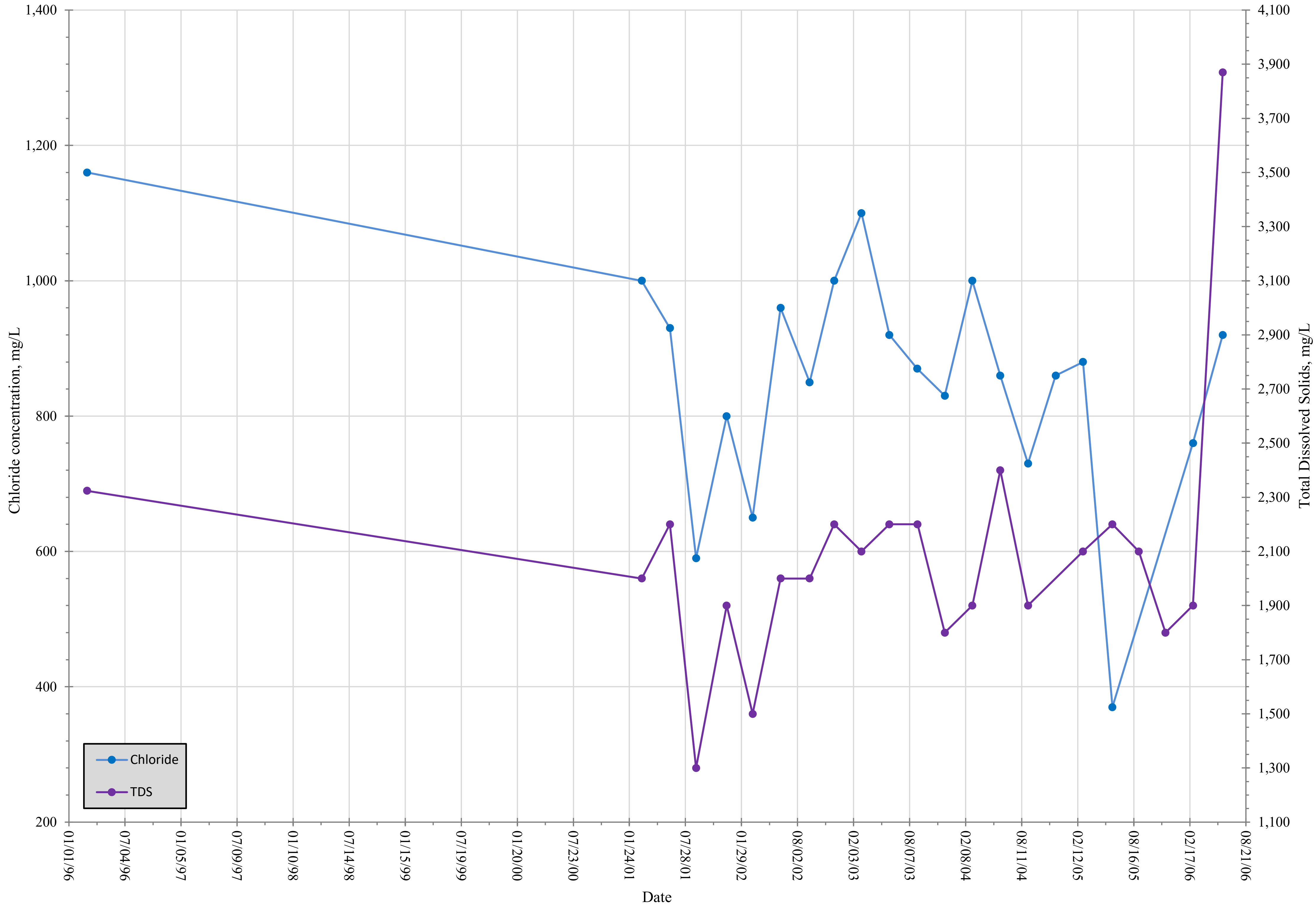

Figure E-6. NRCS 6-1

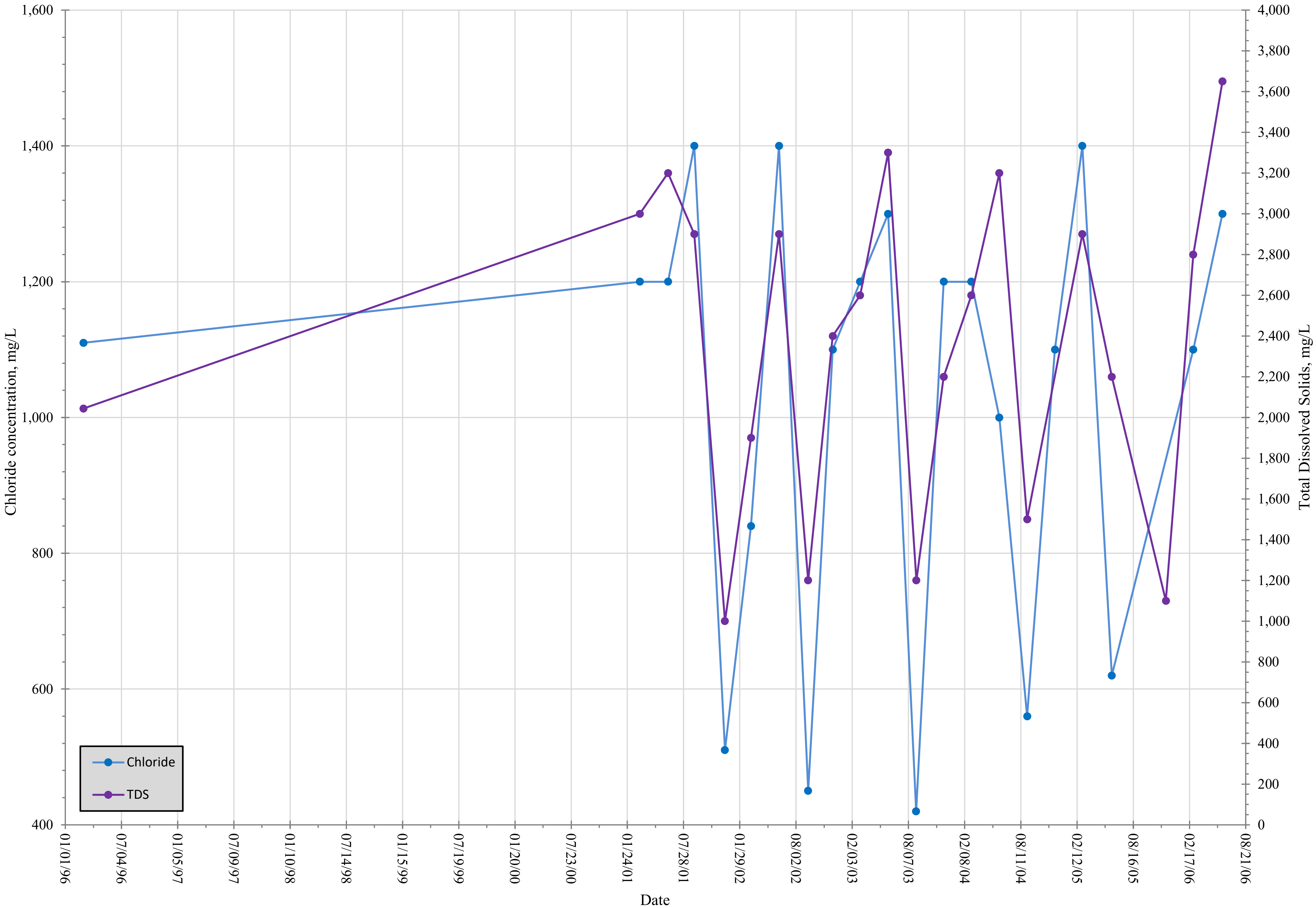

Figure E-7. NRCS 7-2

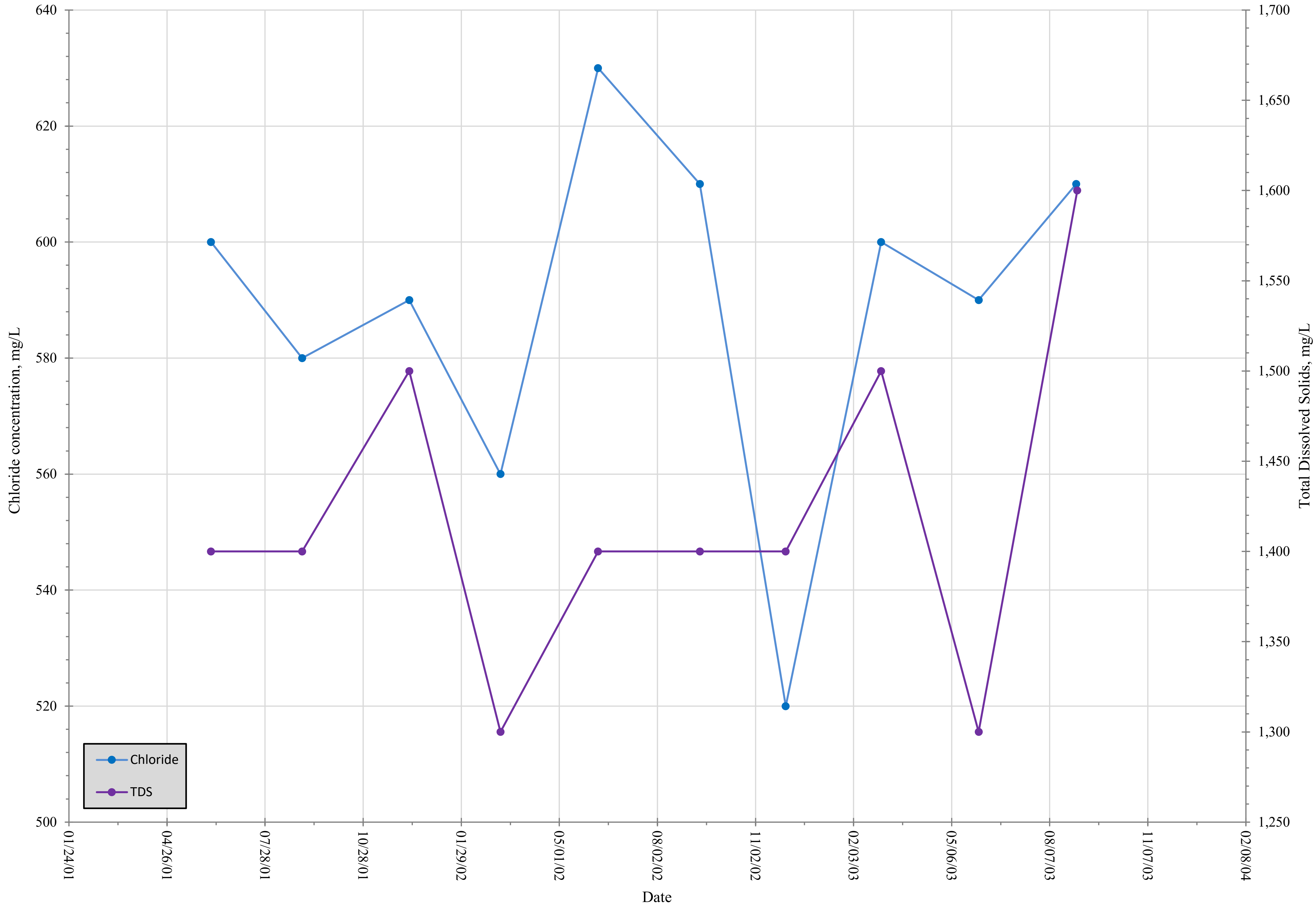

Figure E-8. NRCS 8-4

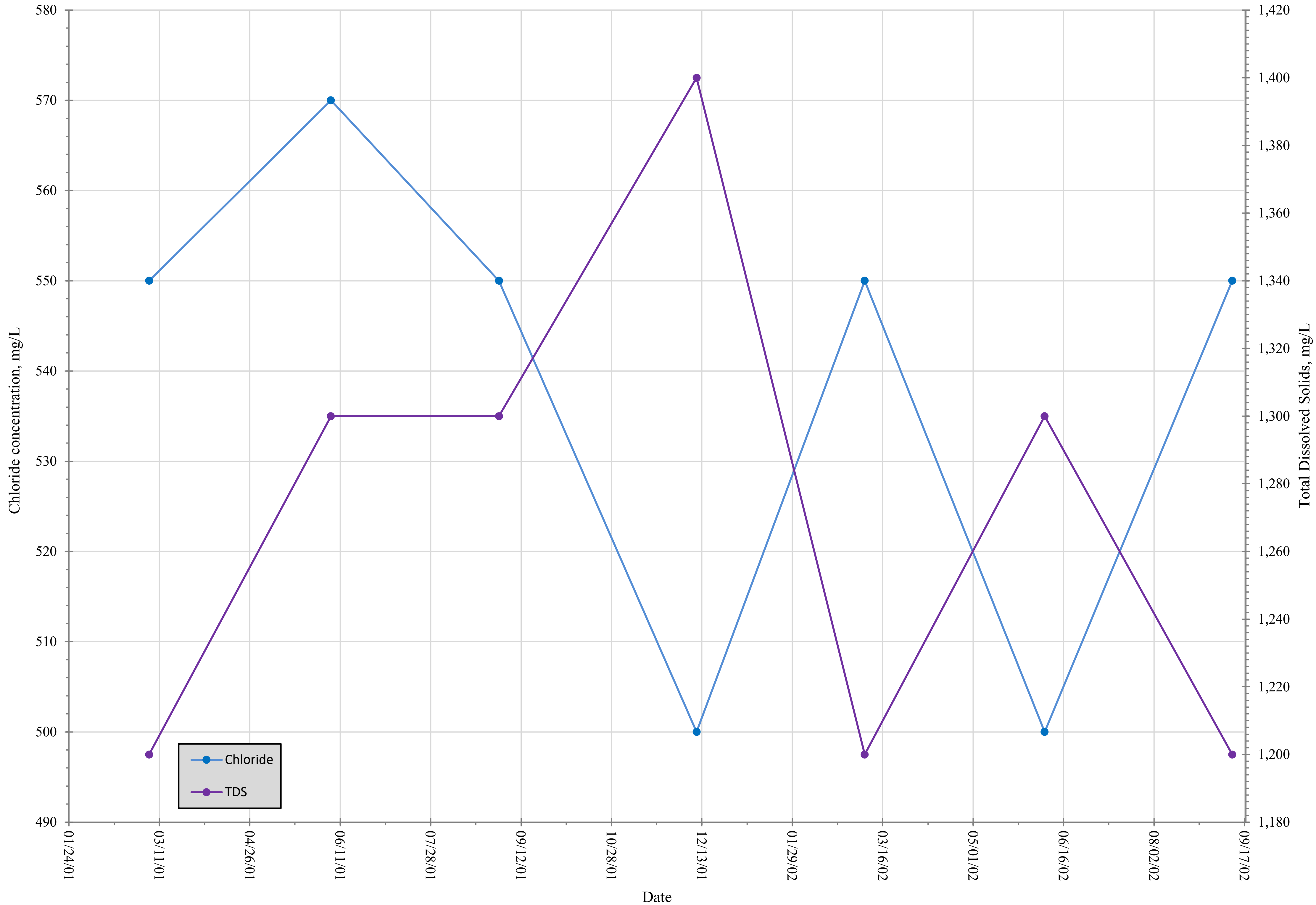

Figure E-9. NRCS 11-1

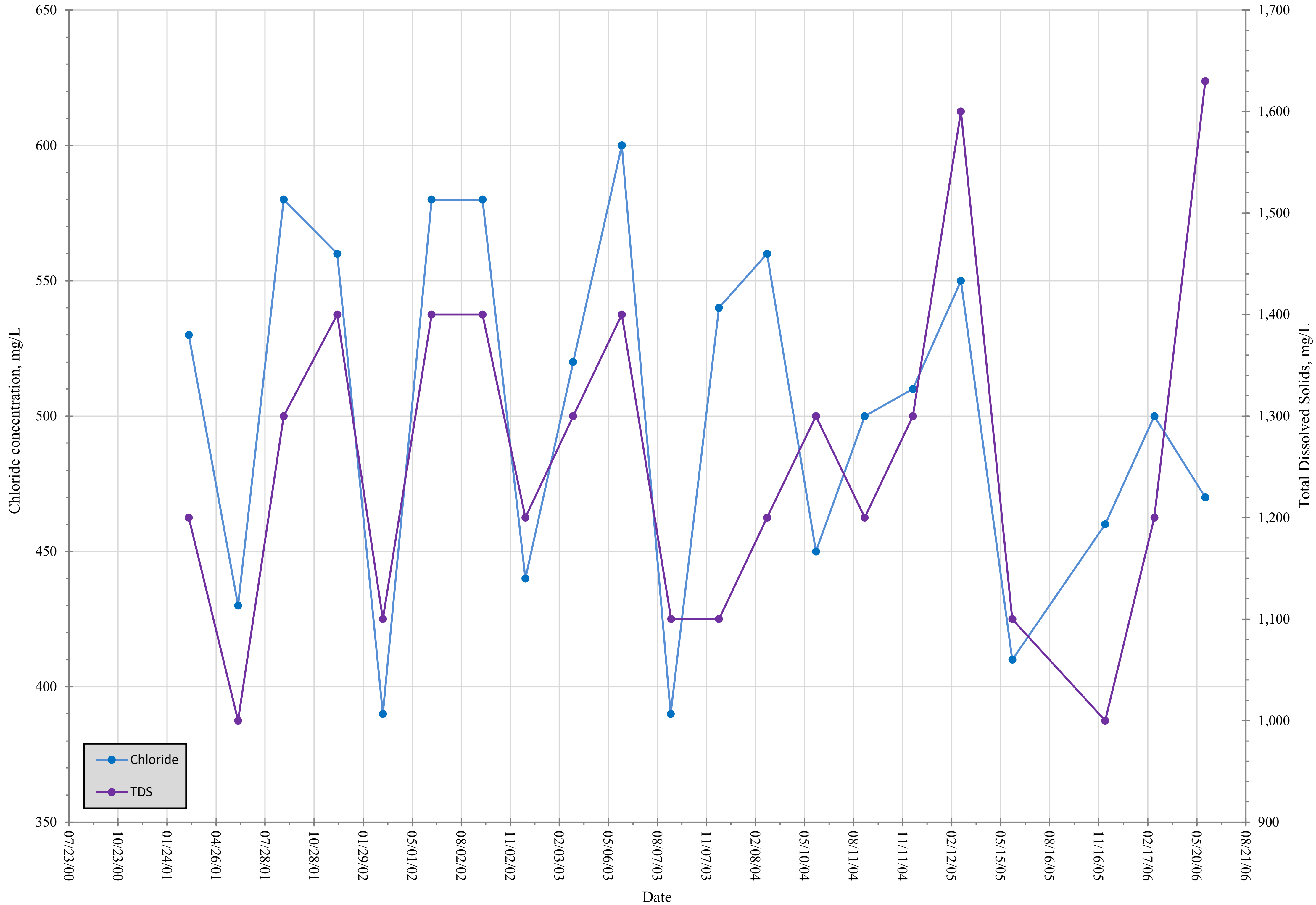

Figure E-10. NRCS 12-1

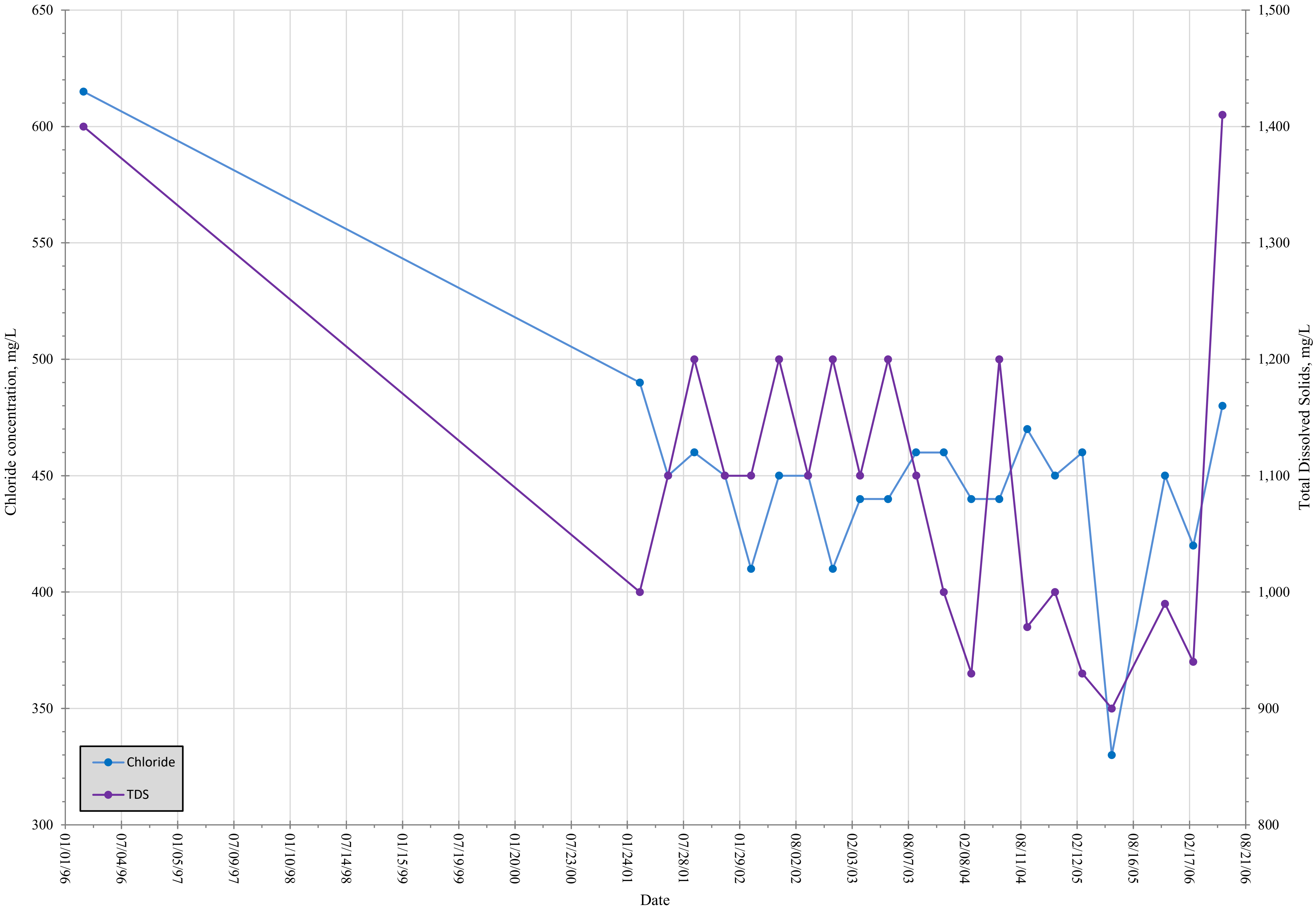

Figure E-11. NRCS 13-1

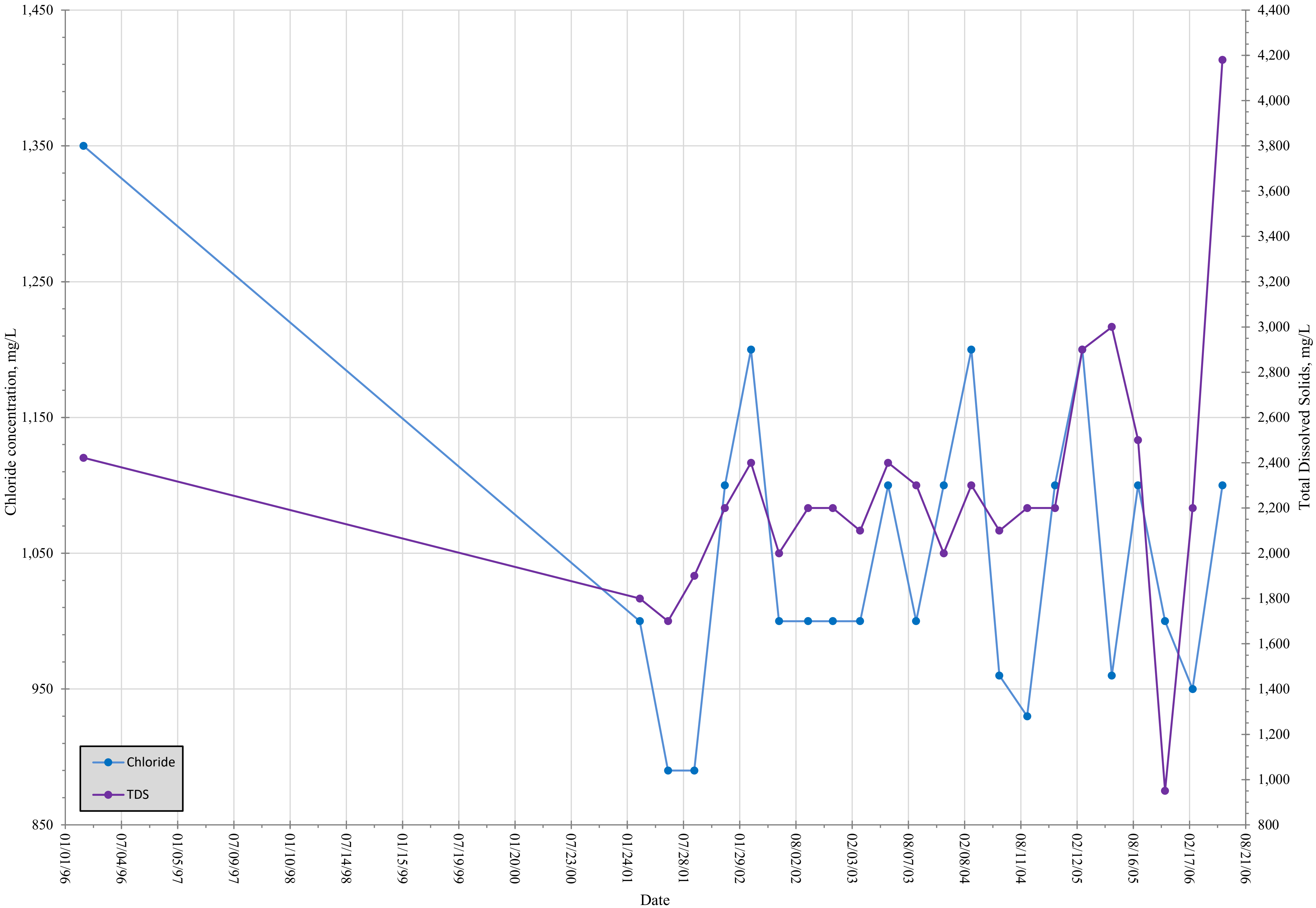

Figure E-12. NRCS 14-1

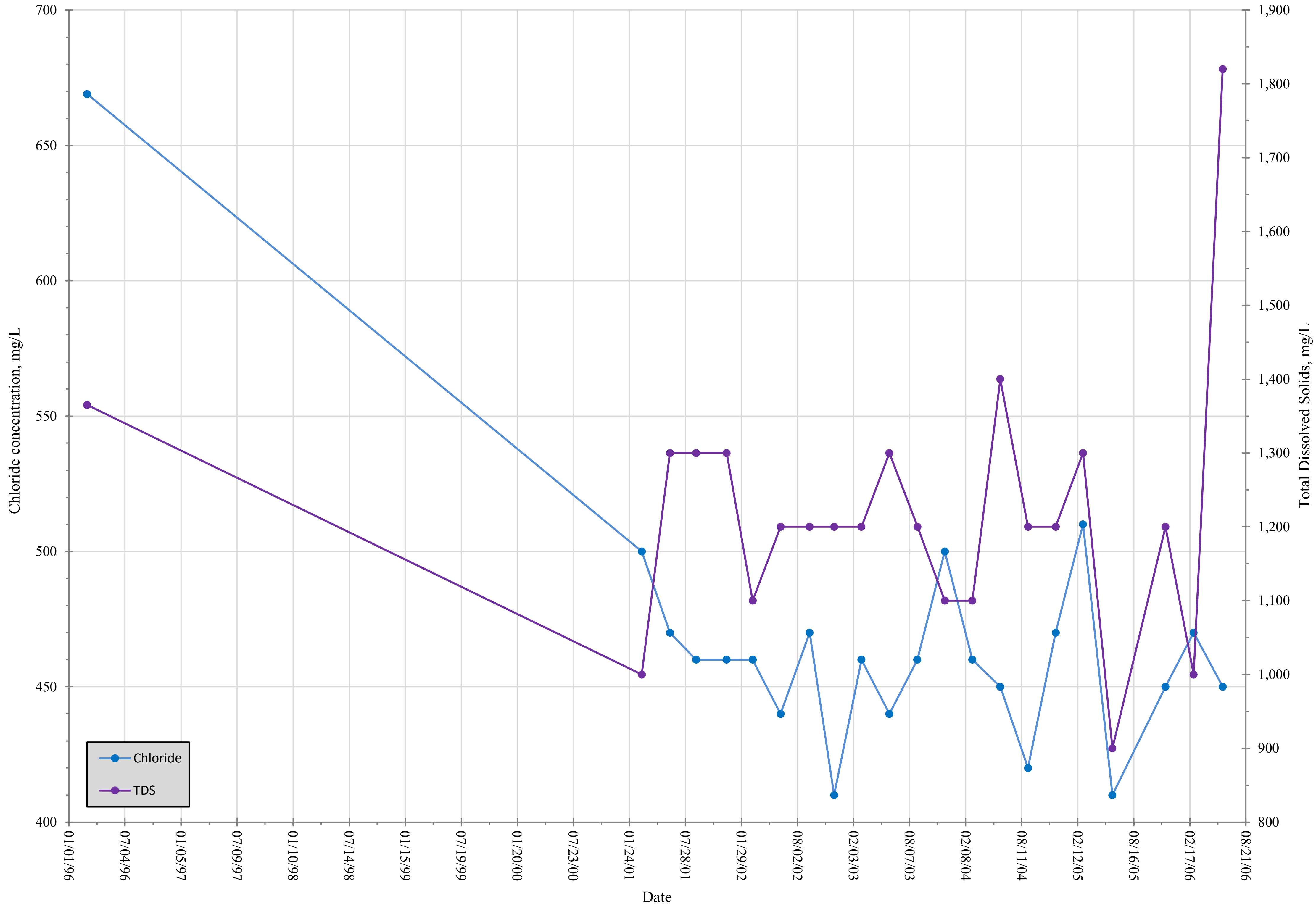

Figure E-13. NRCS 29-8

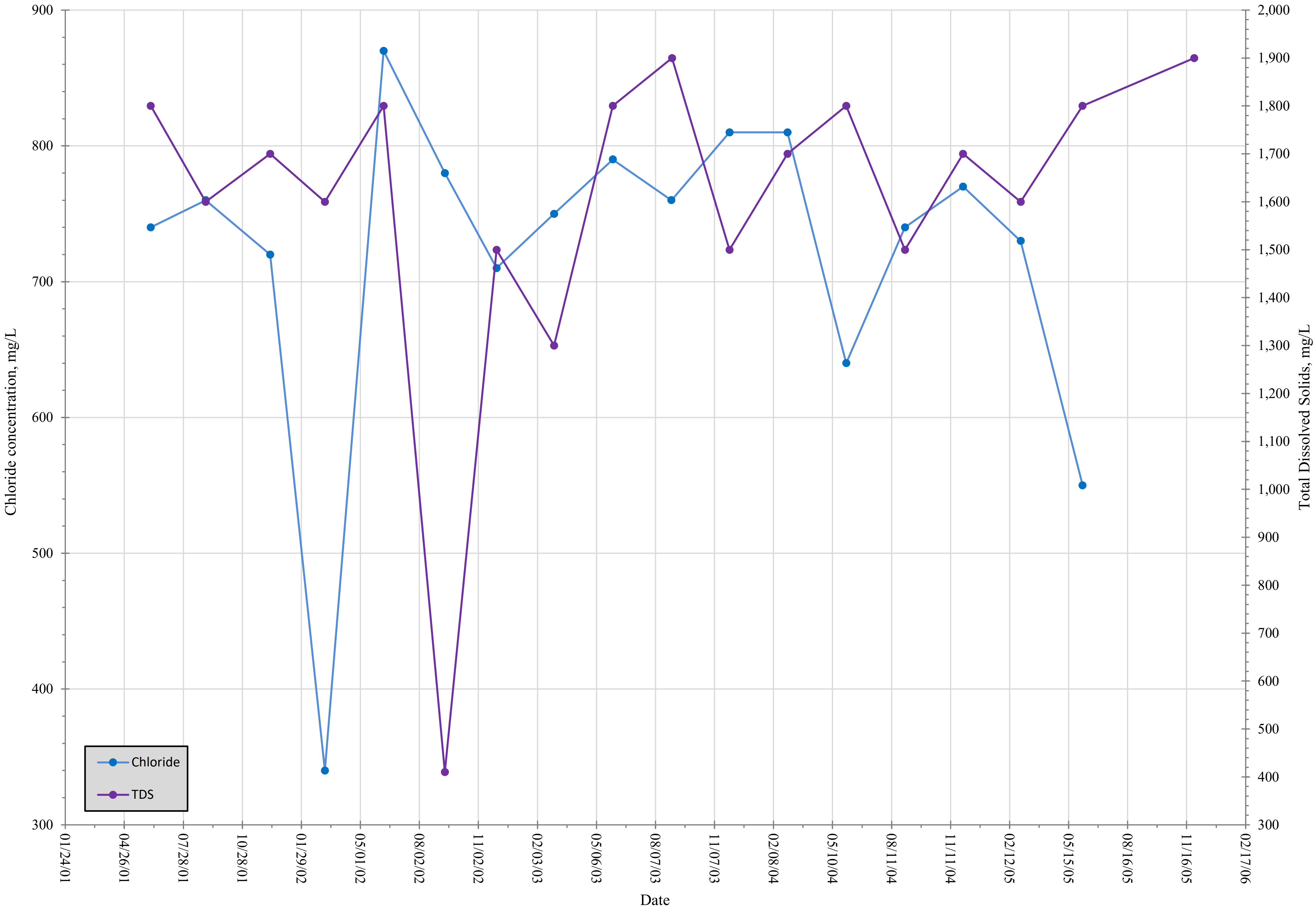

Figure E-14. NRCS 35-1

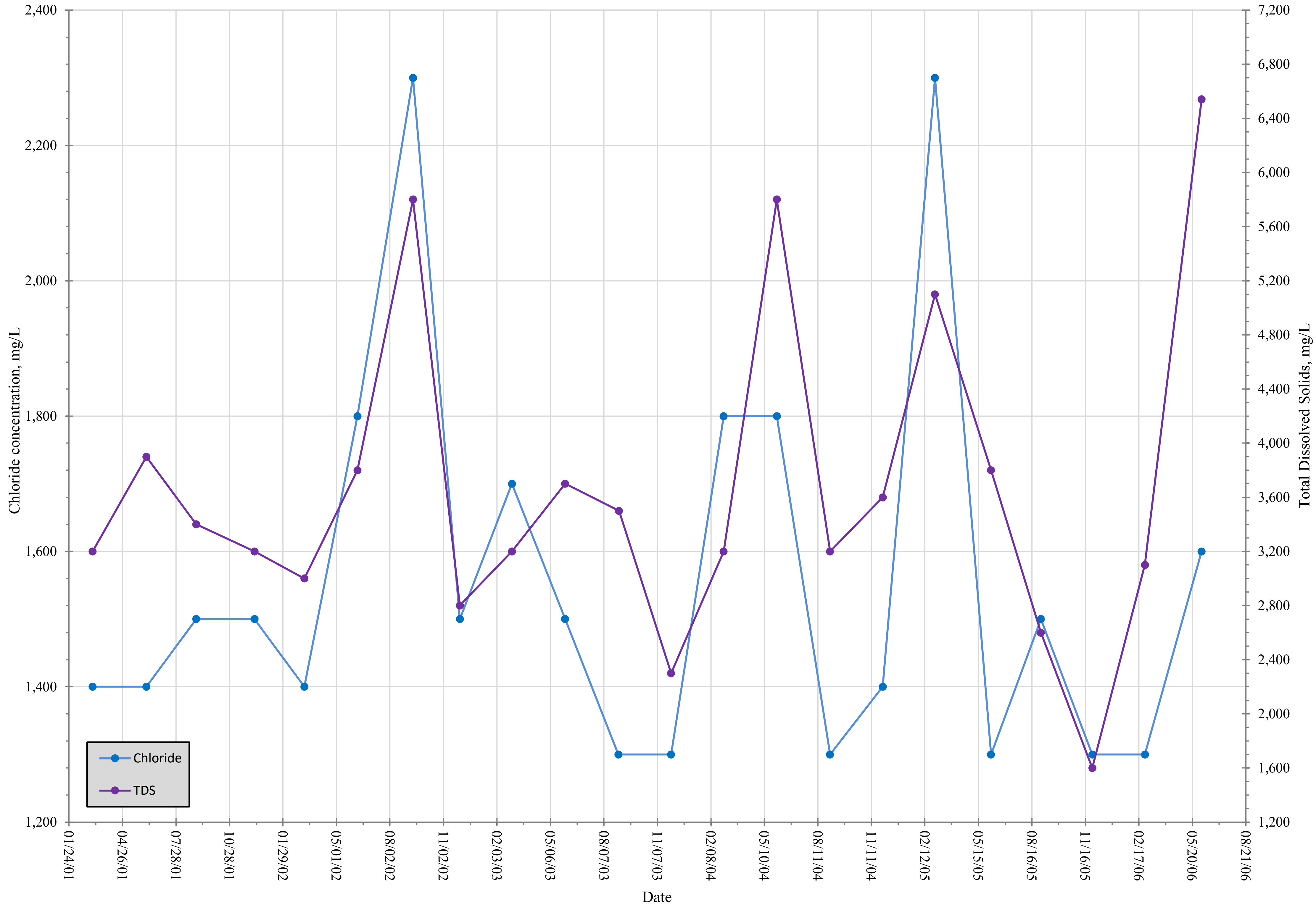

Figure E-15. NRCS 36-1

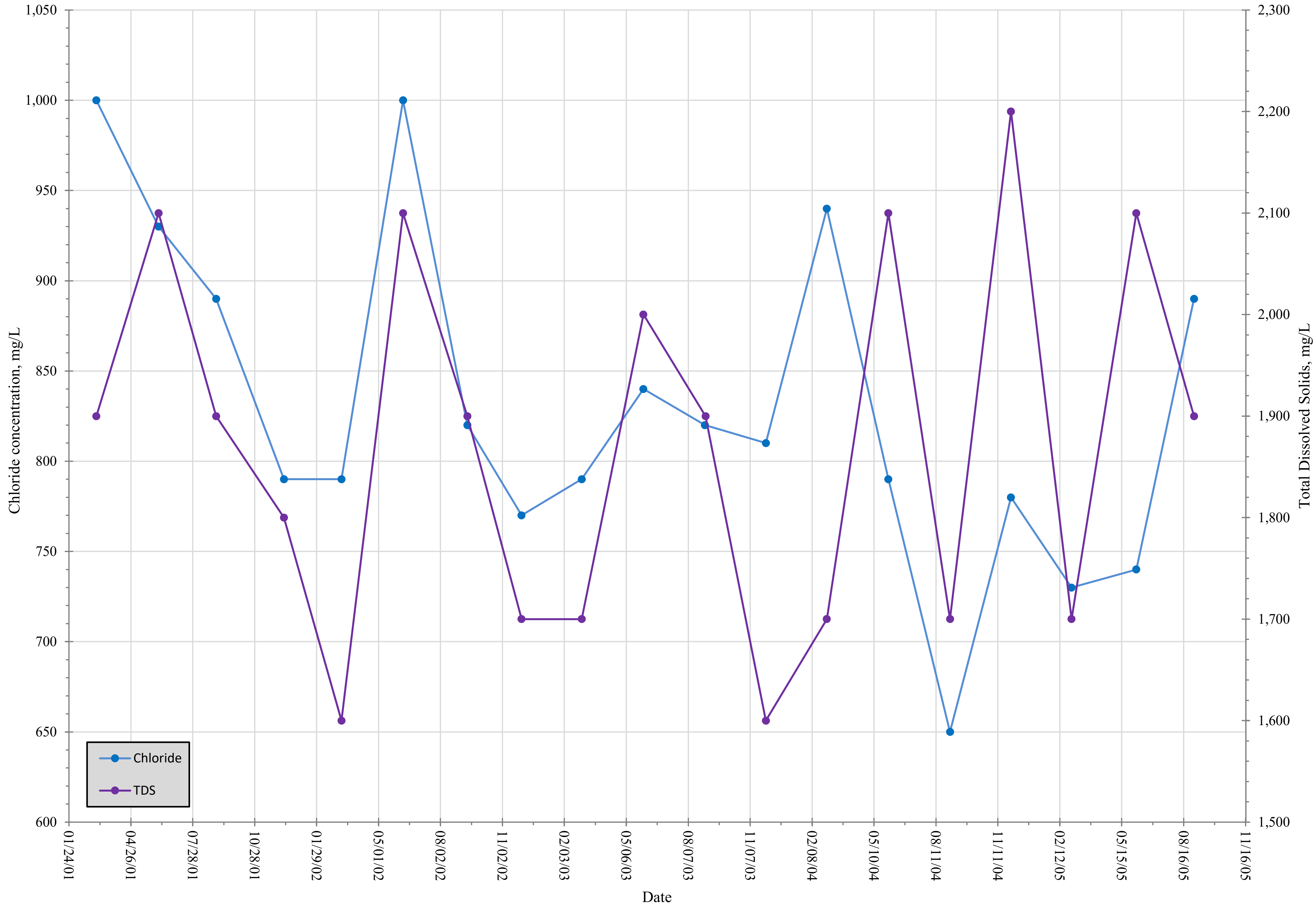

Figure E-16. NRCS 121-1

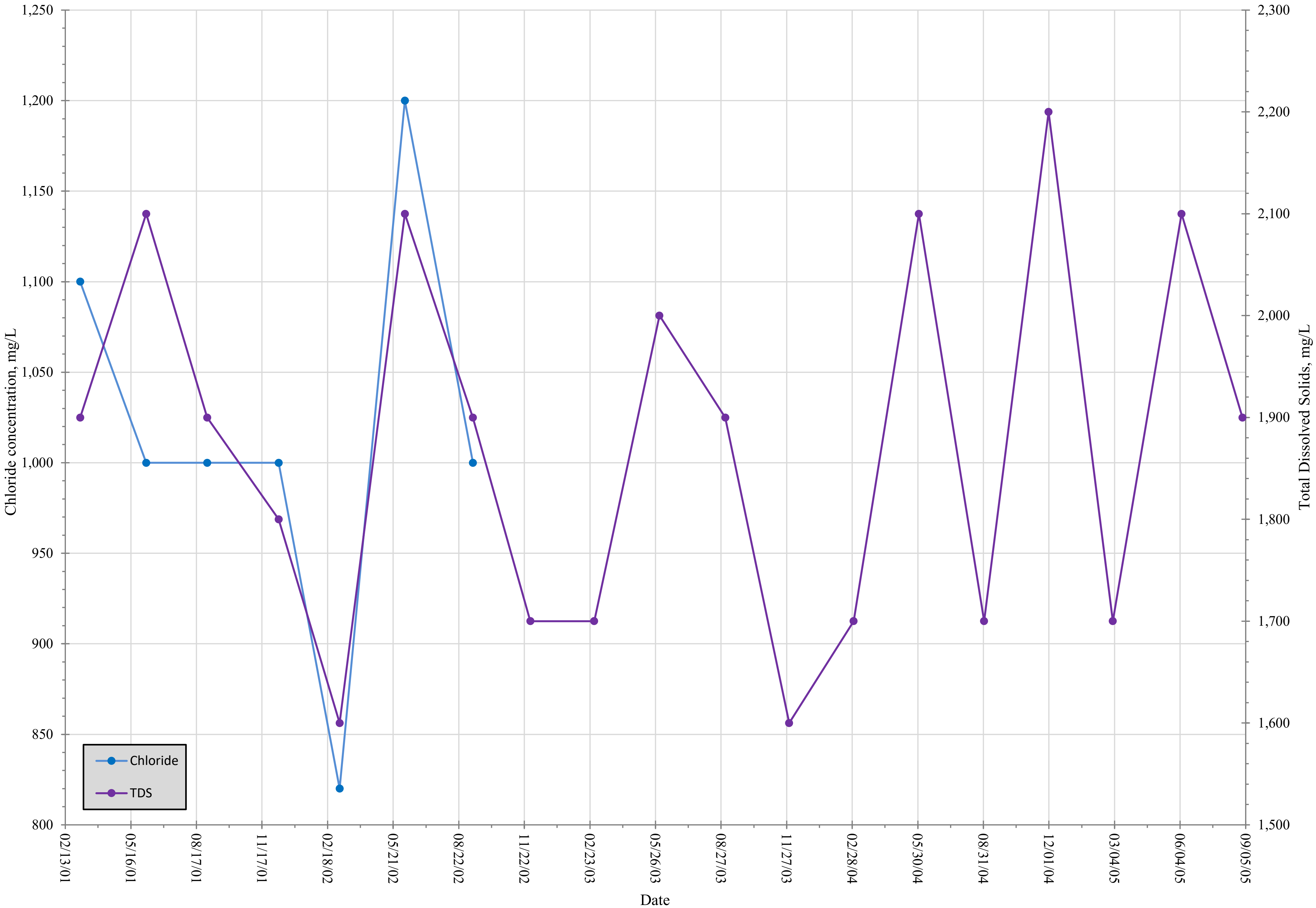

Figure E-17. NRCS 201-1

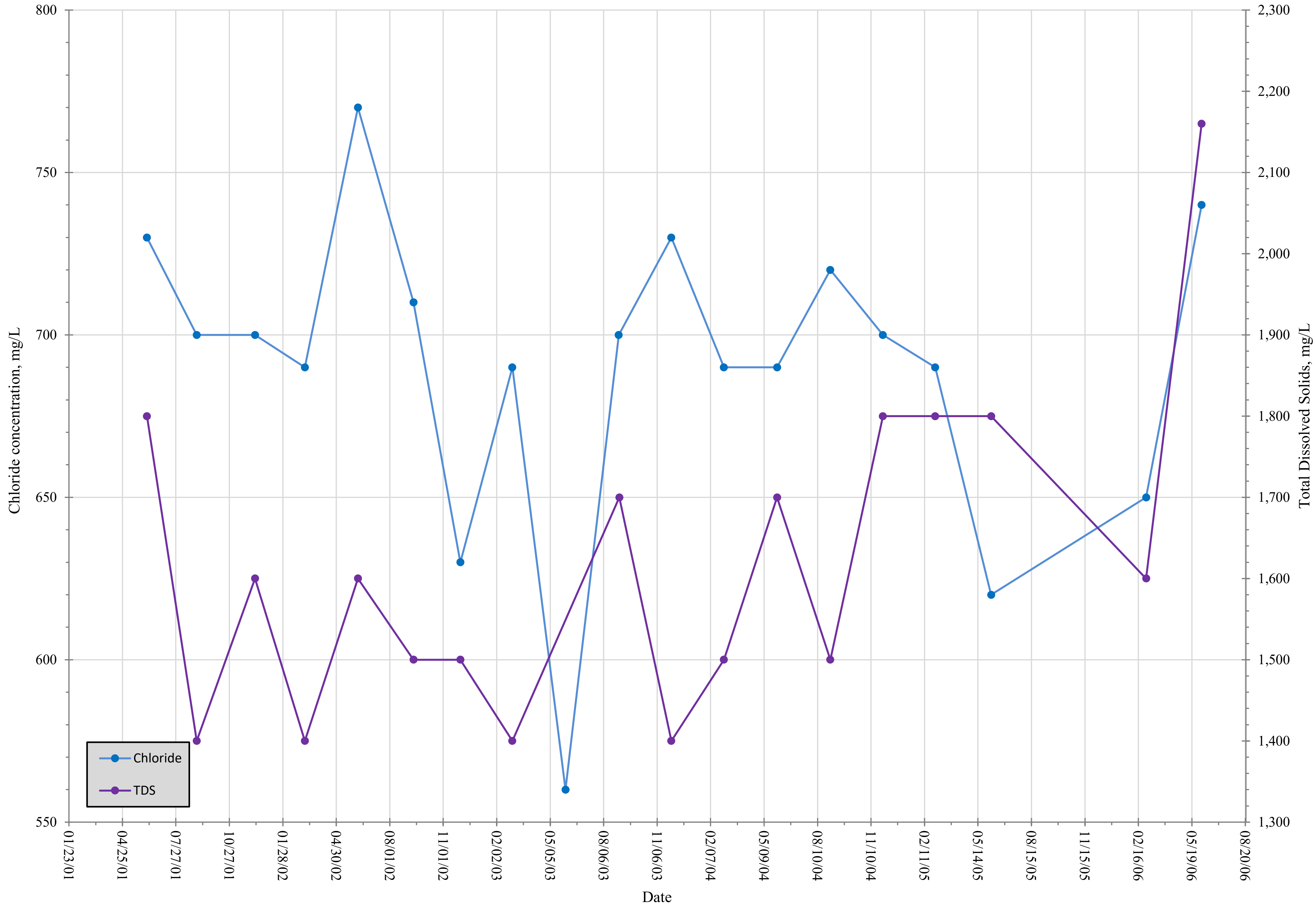

Figure E-18. NRCS 202-1

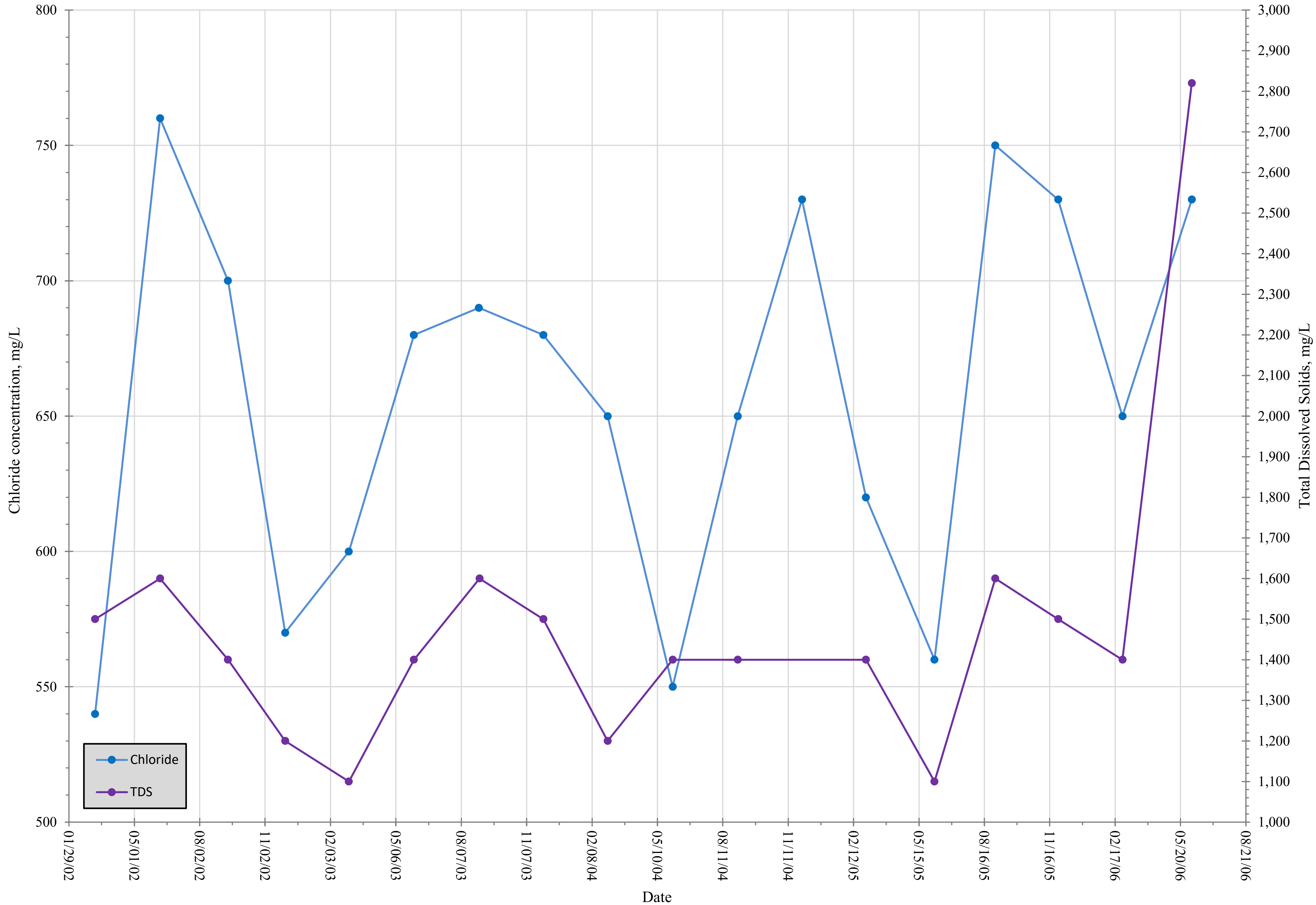

Figure E-19. NRCS 203-1

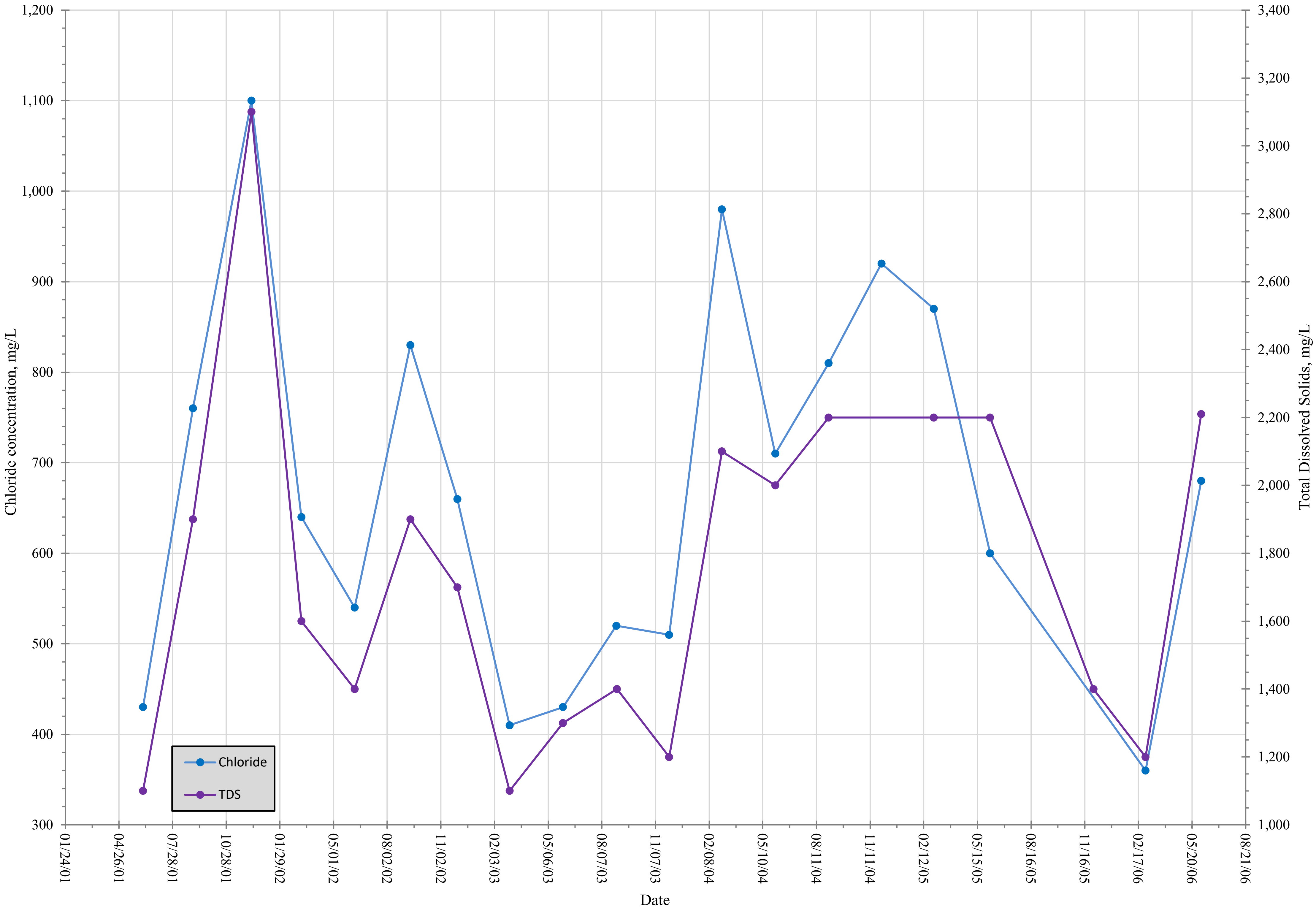

Figure E-20. NRCS 204-3

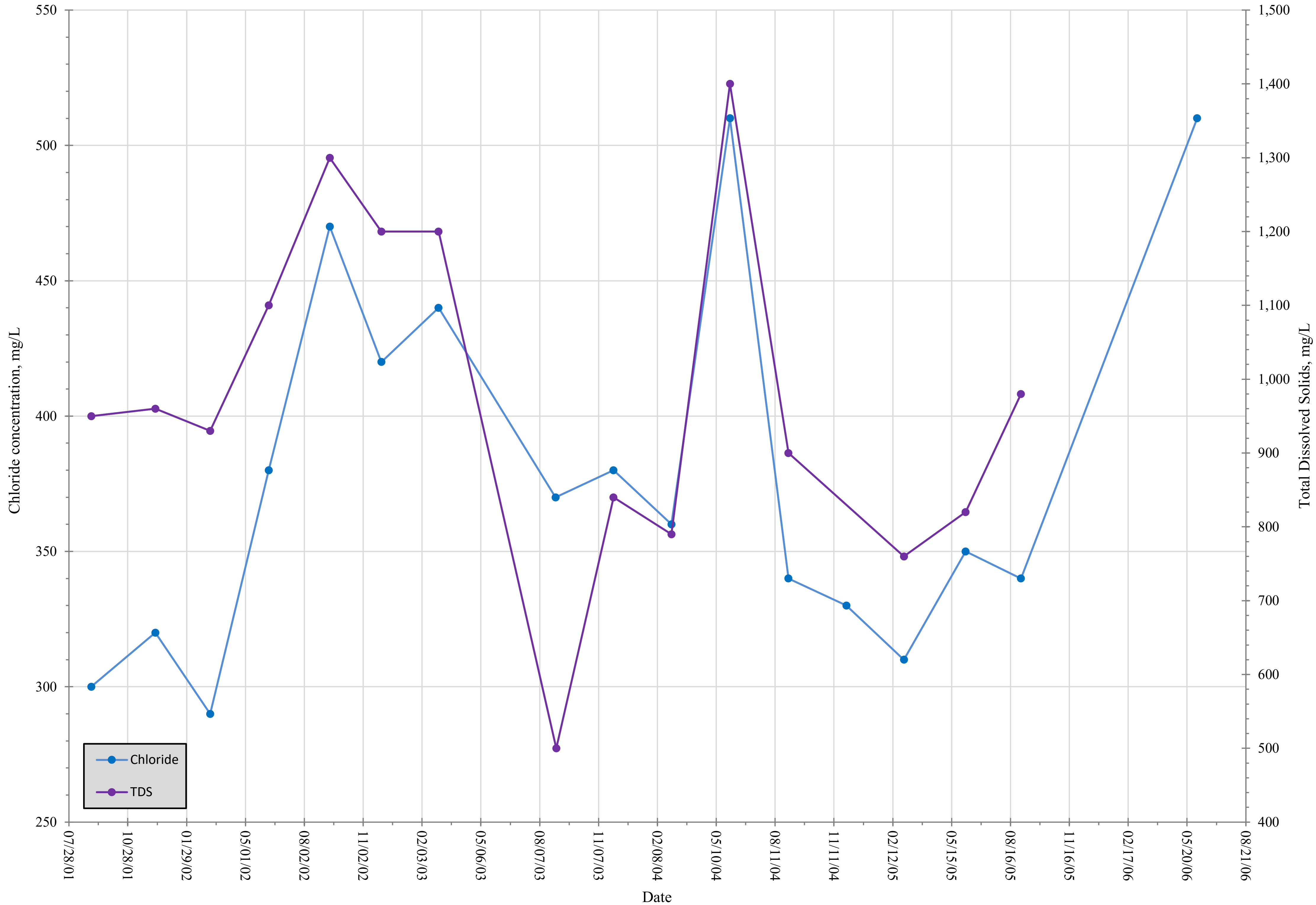

Figure E-21. NRCS 205-6

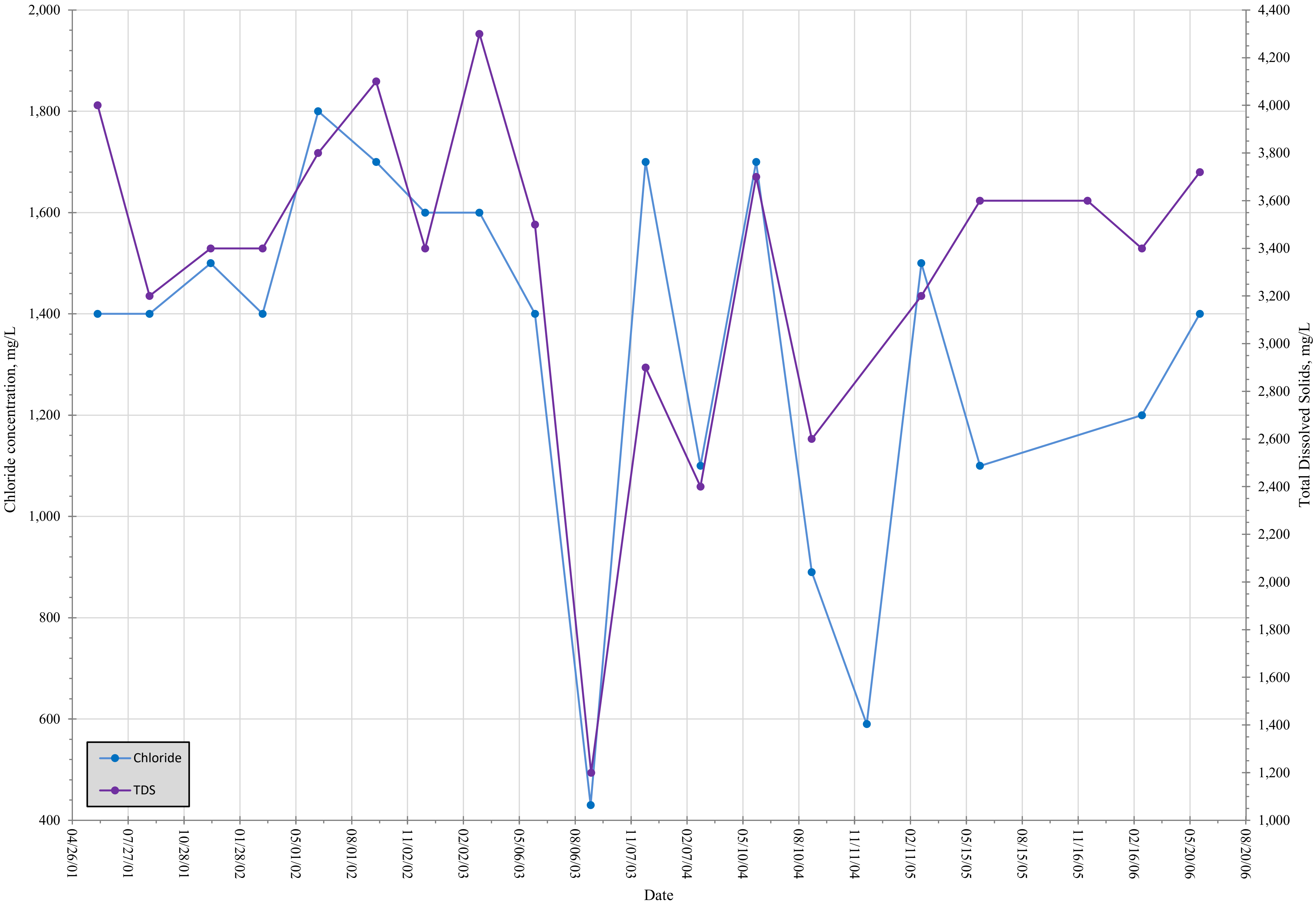

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Table F-1. Water Use Totals by Year at NRCS Wells

Well ID (2006)	2006 Total, gal	2006 Total, acre-ft	Well ID (2005)	2005 Total, gal	2005 Total, acre-ft	Well ID (2004)	2004 Total, gal	2004 Total, acre-ft
5-1	740,212,200	2,272	29-2	123,054,000	378	35-1	192,774,000	592
6-1	374,725,000	1,150	6-1	122,033,000	375	6-1	169,074,000	519
6-2	221,452,600	680	29-1A	116,863,700	359	29-5	133,896,500	411
1-1	197,250,400	605	29-14	78,773,500	242	29-14	129,618,500	398
3-2	105,334,400	323	4-1	76,445,500	235	29-11	110,864,600	340
35-1	99,089,300	304	29-11	71,482,500	219	29-2	108,434,800	333
4-1	70,196,700	215	6-2	65,855,300	202	6-2	106,611,900	327
3-1	56,061,900	172	29-5	54,171,800	166	3-1	98,487,500	302
3-3	50,941,300	156	35-1	44,526,100	137	29-1A	81,061,200	249
12-1	10,007,100	31	29-3	26,815,700	82	3-2	80,588,500	247
14-1	9,098,200	28	29-9	17,046,000	52	1-1	73,115,300	224
11-1	6,325,800	19	1-1	13,964,800	43	3-3	64,099,800	197
13-1	1,448,100	4	29-6	5,424,200	17	29-9	62,735,100	193
2-3	26,600	0.08	35-2	4,270,500	13	29-3	46,956,800	144
2-2	11,200	0.03	12-1	1,475,100	5	4-1	43,290,700	133
35-2	4,200	0.01	2-3	1,434,000	4	36-1	41,319,900	127
3-4	3,900	0.01	14-1	784,000	2	29-12	22,513,400	69
2-1	2,000	0.01	11-1	639,000	2	13-1	18,380,200	56
29-1A	0	0	3-2	131,400	0.40	29-6	11,185,600	34
29-1B	0	0	13-1	102,800	0.32	14-1	10,569,600	32
29-2	0	0	29-12	77,700	0.24	2-2	10,340,000	32
29-3	0	0	3-3	29,800	0.09	12-1	7,755,300	24
29-4	0	0	36-1	16,900	0.05	2-3	5,846,900	18
29-5	0	0	29-15	16,700	0.05	29-13	5,800,300	18
29-6	0	0	2-2	15,700	0.05	11-1	5,229,100	16
29-7	0	0	29-10	10,000	0.03	5-1	3,705,500	11
29-8	0	0	5-1	9,000	0.03	29-15	21,600	0.07
29-9	0	0	3-1	6,500	0.02	35-2	20,200	0.06
29-10	0	0	29-4	4,200	0.01	29-10	13,800	0.04
29-11	0	0	29-8	4,100	0.01	3-4	9,900	0.03
29-12	0	0	29-13	2,600	0.01	29-7	9,300	0.03
29-13	0	0	3-4	2,400	0.01	29-4	9,000	0.03
29-14	0	0	2-1	2,300	0.01	29-8	8,100	0.02
29-15	0	0	36-2	1,800	0.01	36-2	6,800	0.02
36-1	0	0	29-7	1,700	0.01	2-1	3,700	0.01
36-2	0	0	29-1B	-	0.00	29-1B	-	0.00

Well ID (2003)	2003 Total, gal	2003 Total, acre-ft	Well ID (2002)	2002 Total, gal	2002 Total, acre-ft	Well ID (2001)	2001 Total, gal	2001 Total, acre-ft
29-15	209,205,600	642	6-1	172,693,000	530	29-14	420,444,000	1,290
29-5	109,972,100	337	29-5	108,196,800	332	6-1	227,054,000	697
6-1	92,202,000	283	11-1	98,499,500	302	6-2	171,962,000	528
1-1	66,180,700	203	6-2	85,584,300	263	29-5	114,522,600	351
6-2	54,179,600	166	35-1	79,083,000	243	29-11	79,594,200	244
4-1	42,688,100	131	29-14	72,776,300	223	4-1	78,647,400	241
29-3	25,817,400	79	29-11	67,402,000	207	5-1	60,253,300	185
29-2	23,982,200	74	4-1	55,441,500	170	29-3	52,637,700	162
14-1	22,684,200	70	29-3	55,256,400	170	29-2	51,524,800	158
29-11	20,774,600	64	29-12	40,214,000	123	3-1	50,235,200	154
29-14	20,155,000	62	29-2	38,544,700	118	29-12	39,222,400	120
29-6	19,572,800	60	1-1	23,166,500	71	29-6	35,463,300	109
3-2	16,792,600	52	5-1	16,255,500	50	3-2	30,668,200	94
3-1	12,477,100	38	36-1	15,255,500	47	3-3	20,610,900	63
5-1	12,325,200	38	29-6	13,066,600	40	29-15	16,741,000	51
12-1	10,801,100	33	12-1	12,162,400	37	2-2	16,335,200	50
29-1A	10,108,000	31	2-3	8,439,100	26	36-1	13,824,500	42
2-2	9,415,300	29	14-1	6,616,100	20	12-1	12,066,000	37
3-3	9,014,100	28	13-1	6,571,800	20	14-1	9,449,400	29
13-1	8,467,200	26	3-1	6,039,700	19	29-13	9,325,200	29
29-12	8,322,600	26	29-9	5,809,300	18	1-1	7,137,800	22
36-1	8,253,300	25	29-4	3,008,200	9	2-3	6,630,900	20
11-1	7,825,600	24	29-13	2,204,500	7	11-1	5,682,400	17
2-3	5,188,700	16	36-2	1,342,600	4	29-4	5,669,700	17
29-10	4,226,000	13	29-10	921,400	3	29-1A	5,472,400	17
29-9	3,930,300	12	29-7	755,500	2	2-1	4,700,600	14
29-4	3,334,300	10	29-15	706,400	2	29-7	3,681,000	11
2-1	3,276,200	10	29-8	399,700	1	13-1	3,576,300	11
29-7	3,023,300	9	3-3	23,800	0.07	35-1	582,300	2
29-8	1,557,300	4.78	3-2	18,800	0.06	36-2	345,600	1
35-1	252,600	0.78	2-2	17,800	0.05	29-10	140,400	0.43
3-4	11,200	0.03	35-2	7,800	0.02	29-9	115,700	0.36
29-13	2,700	0.01	2-1	5,000	0.02	29-8	74,700	0.23
35-2	2,400	0.01	3-4	0	0	35-2	13,800	0.04
36-2	1,100	0.003	29-1A	0	0	3-4	0	0
29-1B	-	0	29-1B	0	0	29-1B	0	0

Well ID (2000)	2000 Total, gal	2000 Total, acre-ft	Well ID (1999)	1999 Total, gal	1999 Total, acre-ft	Well ID (1998)	1998 Total, gal	1998 Total, acre-ft
6-2	2,143,506,000	6,578	29-14	236,145,600	725	35-1	985,389,000	3,024
6-1	235,534,000	723	1-1	158,145,400	485	29-14	258,968,000	795
29-14	234,035,200	718	5-1	138,909,300	426	11-1	209,550,000	643
29-9	217,361,100	667	6-1	137,516,000	422	29-11	122,169,500	375
29-11	215,067,100	660	2-3	103,763,900	318	6-1	111,922,000	343
29-5	167,216,400	513	29-2	101,943,000	313	4-1	48,915,600	150
12-1	124,531,100	382	29-11	92,503,600	284	29-2	37,288,300	114
29-4	96,889,900	297	4-1	85,072,800	261	29-1B	26,897,600	83
5-1	93,157,300	286	36-1	51,580,000	158	1-1	25,463,300	78
3-1	89,012,300	273	6-2	44,491,000	137	3-2	24,785,000	76
4-1	82,044,500	252	3-1	38,441,900	118	3-1	24,652,900	76
29-2	72,253,400	222	3-2	34,737,000	107	36-1	19,336,700	59
36-1	50,166,300	154	2-2	30,603,600	94	5-1	15,471,300	47
3-2	48,778,000	150	3-3	16,052,600	49	12-1	11,998,000	37
11-1	48,532,900	149	29-9	15,908,300	49	3-3	11,802,400	36
3-3	45,594,500	140	12-1	14,812,900	45	2-1	11,008,800	34
1-1	44,948,100	138	29-1B	10,917,400	34	14-1	10,335,600	32
29-3	40,175,300	123	14-1	10,442,000	32	6-2	8,445,000	26
29-12	40,096,500	123	11-1	9,328,700	29	29-9	7,546,800	23
29-13	25,052,300	77	2-1	9,195,200	28	29-1A	2,250,800	7
29-1B	19,833,800	61	13-1	4,758,300	15	13-1	2,019,800	6
2-2	17,201,000	53	35-2	2,034,300	6	29-6	1,331,100	4
2-3	16,125,700	49	29-1A	1,728,000	5	29-13	1,008,400	3
14-1	14,370,900	44	29-15	716,400	2	29-15	815,900	3
2-1	11,908,700	37	29-10	365,100	1	29-10	368,200	1
29-10	10,530,300	32	29-7	289,700	1	29-7	291,000	1
29-6	10,005,400	31	35-1	231,000	1	29-8	144,000	0.44
13-1	9,557,400	29	29-6	224,600	1	2-2	9,900	0.03
35-1	9,081,800	28	29-8	143,400	0.44	29-12	6,900	0.02
29-7	8,497,700	26	29-13	50,200	0.15	35-2	6,700	0.02
29-8	4,117,900	13	36-2	3,400	0.01	2-3	6,000	0.02
29-1A	3,400,000	10	29-3	2,700	0.01	29-3	3,200	0.01
35-2	23,500	0.07	29-12	2,300	0.01	29-4	2,600	0.01
29-15	10,200	0.03	29-4	1,700	0.01	36-2	2,400	0.01
36-2	4,200	0.01	3-4	0	0	3-4	0	0
3-4	0	0	29-5	0	0	29-5	0	0

Well ID (1997)	1997 Total, gal	1997 Total, acre-ft
29-14	336,316,600	1,032
29-11	194,792,700	598
6-1	147,647,000	453
29-1B	110,607,200	339
29-15	86,129,100	264
4-1	52,106,100	160
29-5	50,684,500	156
5-1	16,310,600	50
3-1	13,424,200	41
3-2	12,862,000	39
12-1	11,787,500	36
1-1	11,346,100	35
29-2	7,274,400	22
11-1	6,797,800	21
3-3	6,645,800	20
36-1	6,236,800	19
14-1	4,959,800	15
29-9	3,154,900	10
29-6	1,846,200	6
29-1A	1,312,200	4
35-1	1,001,000	3
35-2	657,800	2
13-1	132,800	0.41
6-2	25,000	0.08
29-10	19,500	0.06
36-2	16,900	0.05
2-2	15,400	0.05
29-3	10,800	0.03
29-7	10,000	0.03
2-3	8,800	0.03
29-8	6,800	0.02
29-12	6,300	0.02
2-1	3,900	0.01
29-4	3,500	0.01
29-13	1,900	0.01
3-4	0	0

Figure F-1. NRCS 1-1

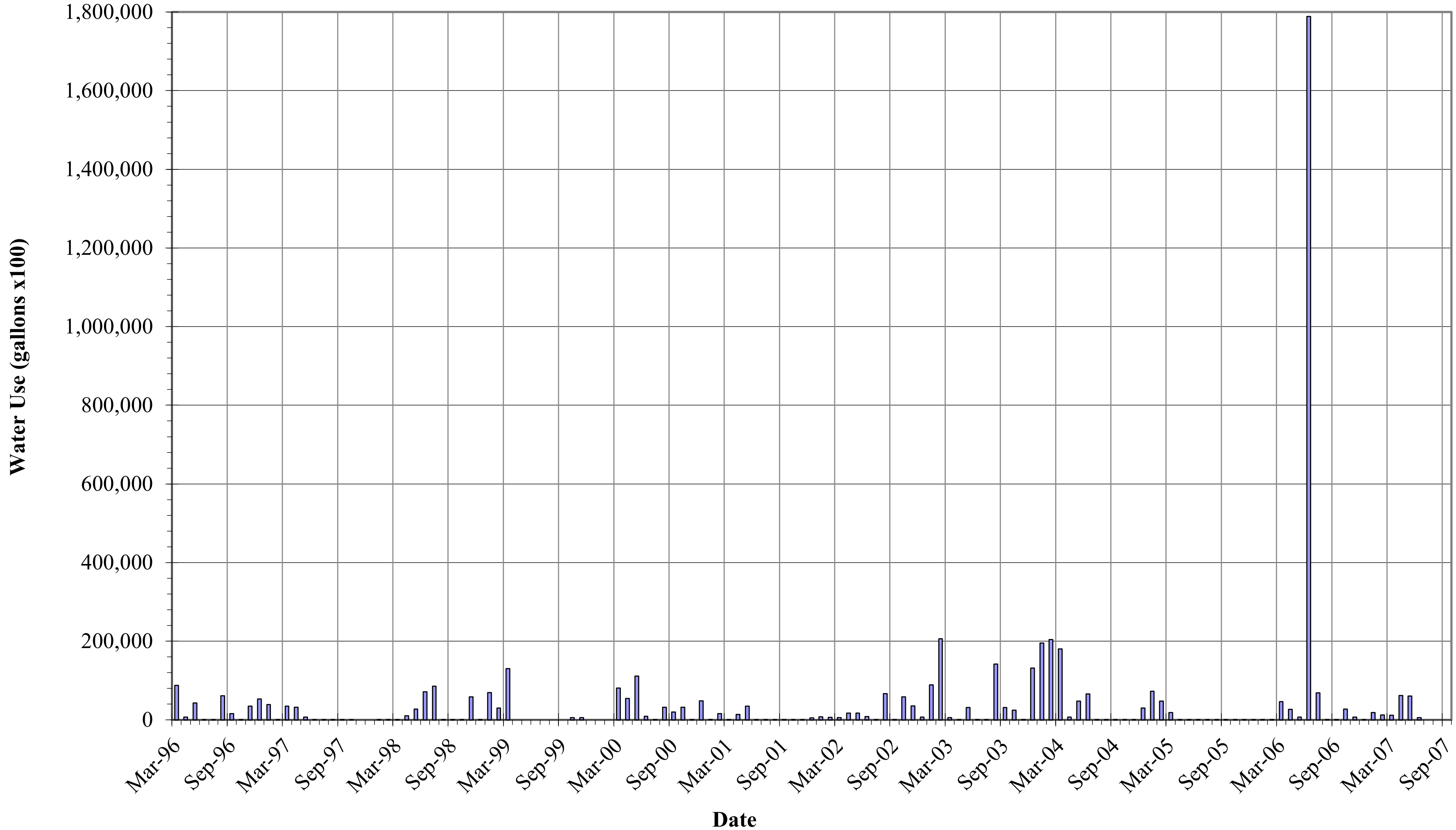


Figure F-2. NRCS 2-1

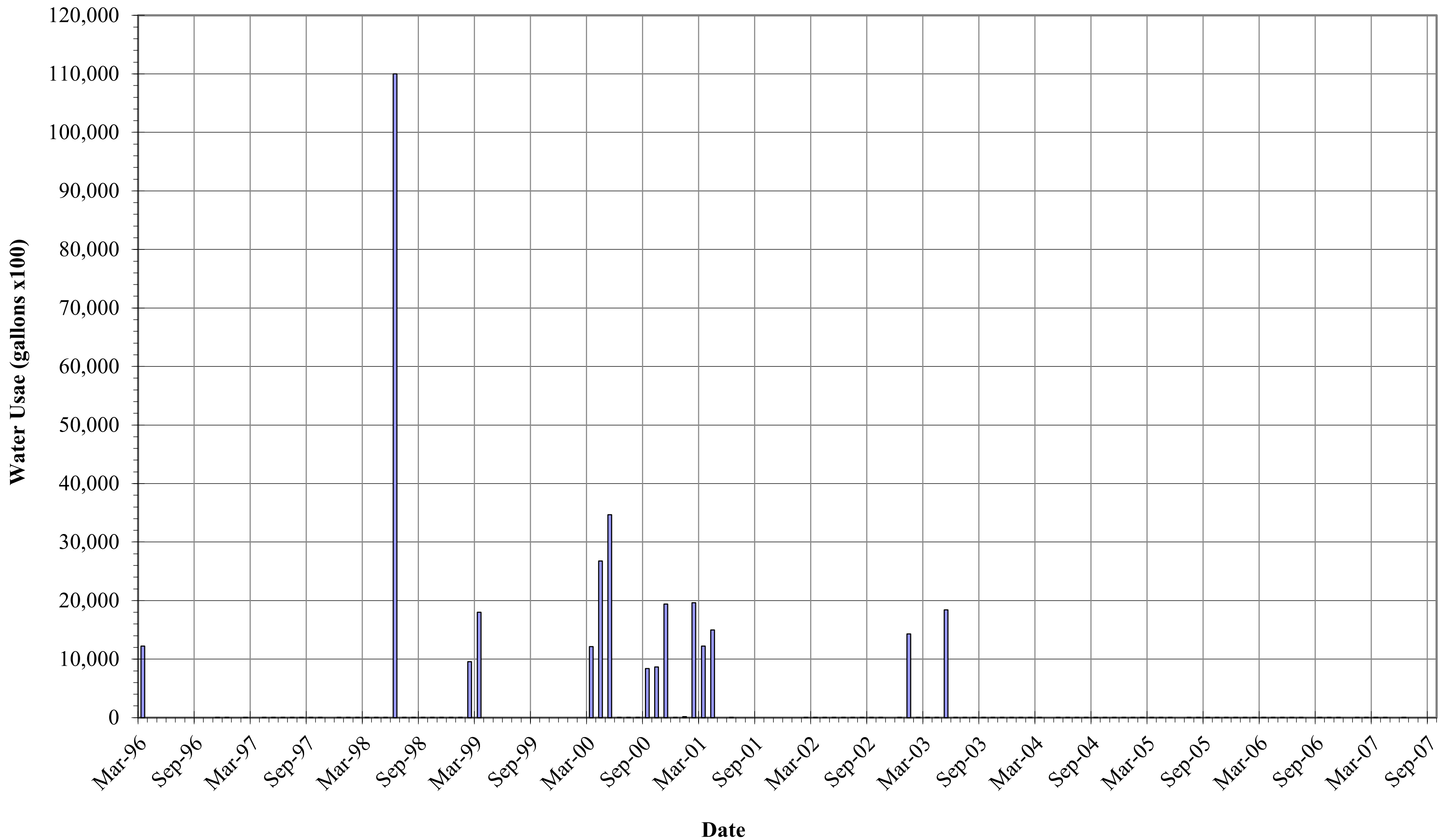


Figure F-3. NRCS 2-2

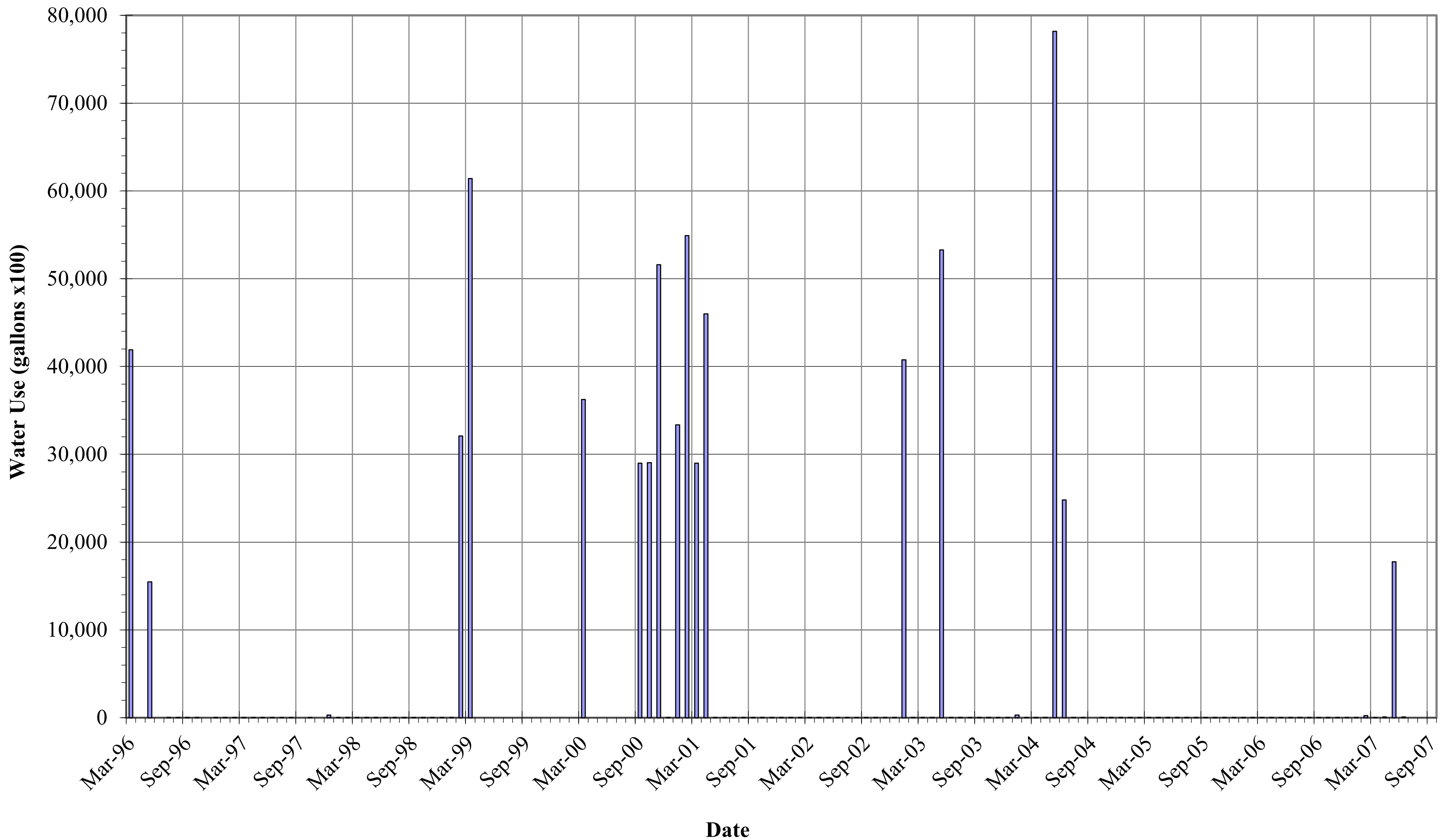


Figure F-4. NRCS 2-3

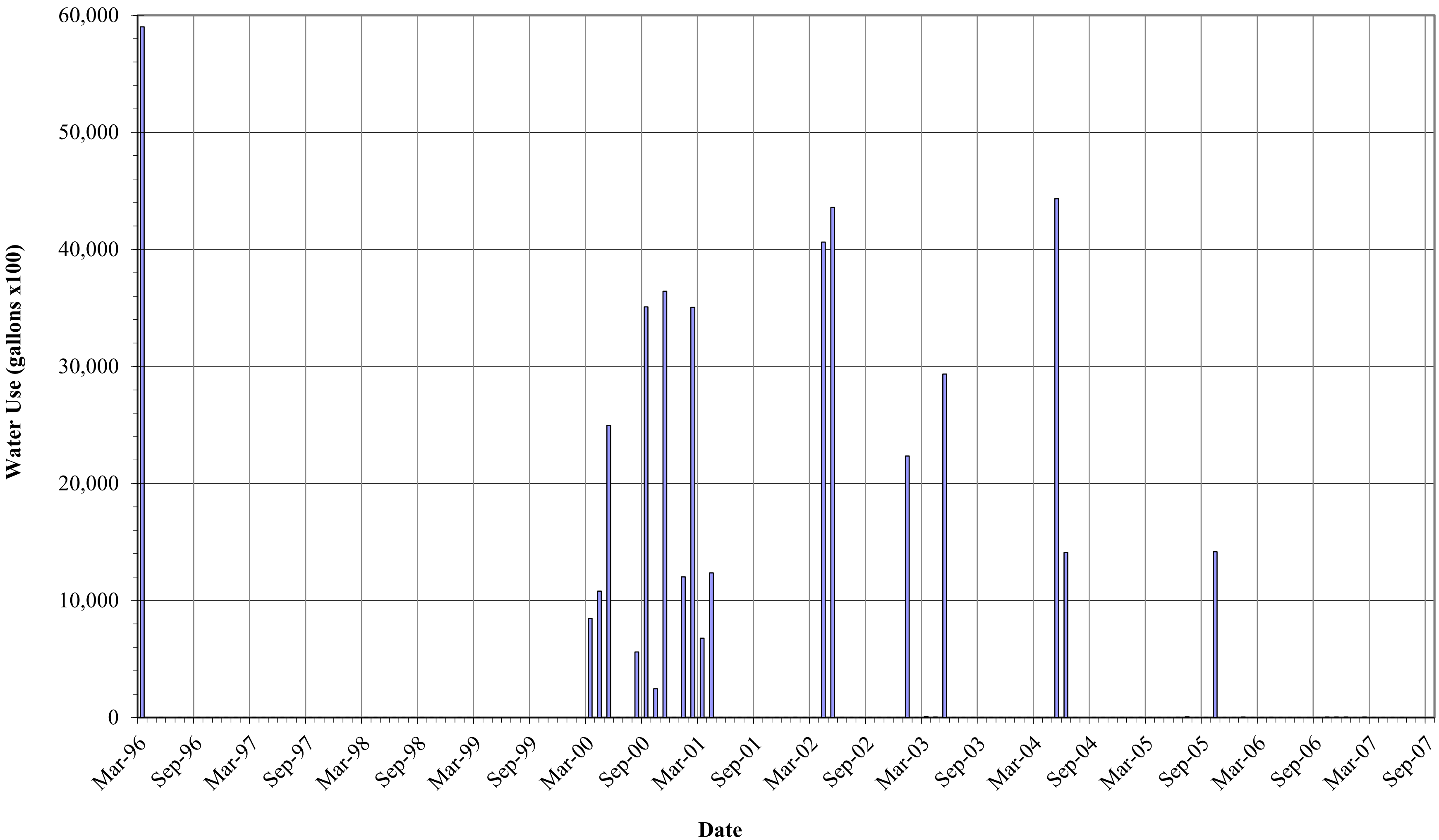


Figure F-5. NRCS 2-4

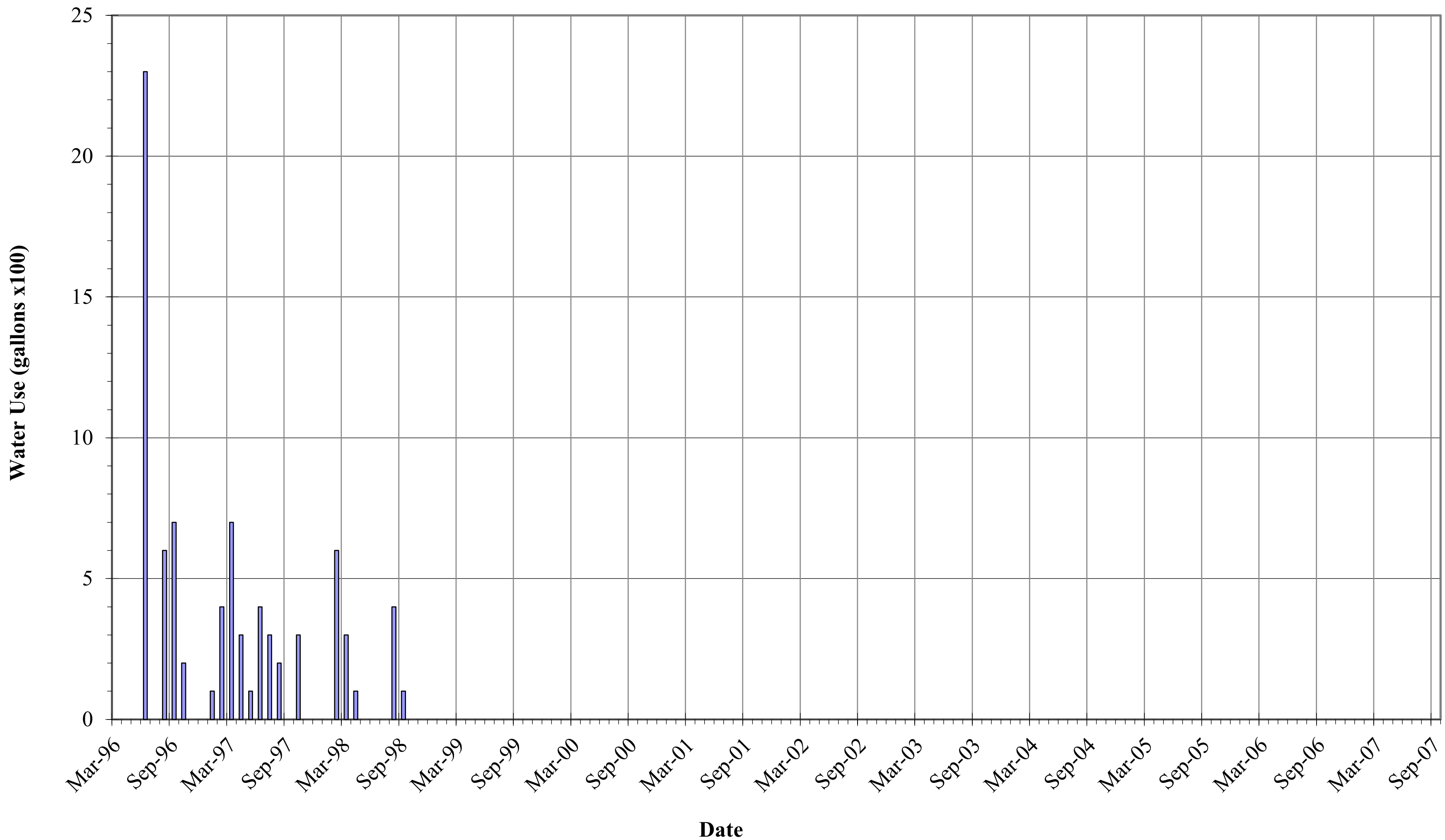


Figure F-6. NRCS 2-5

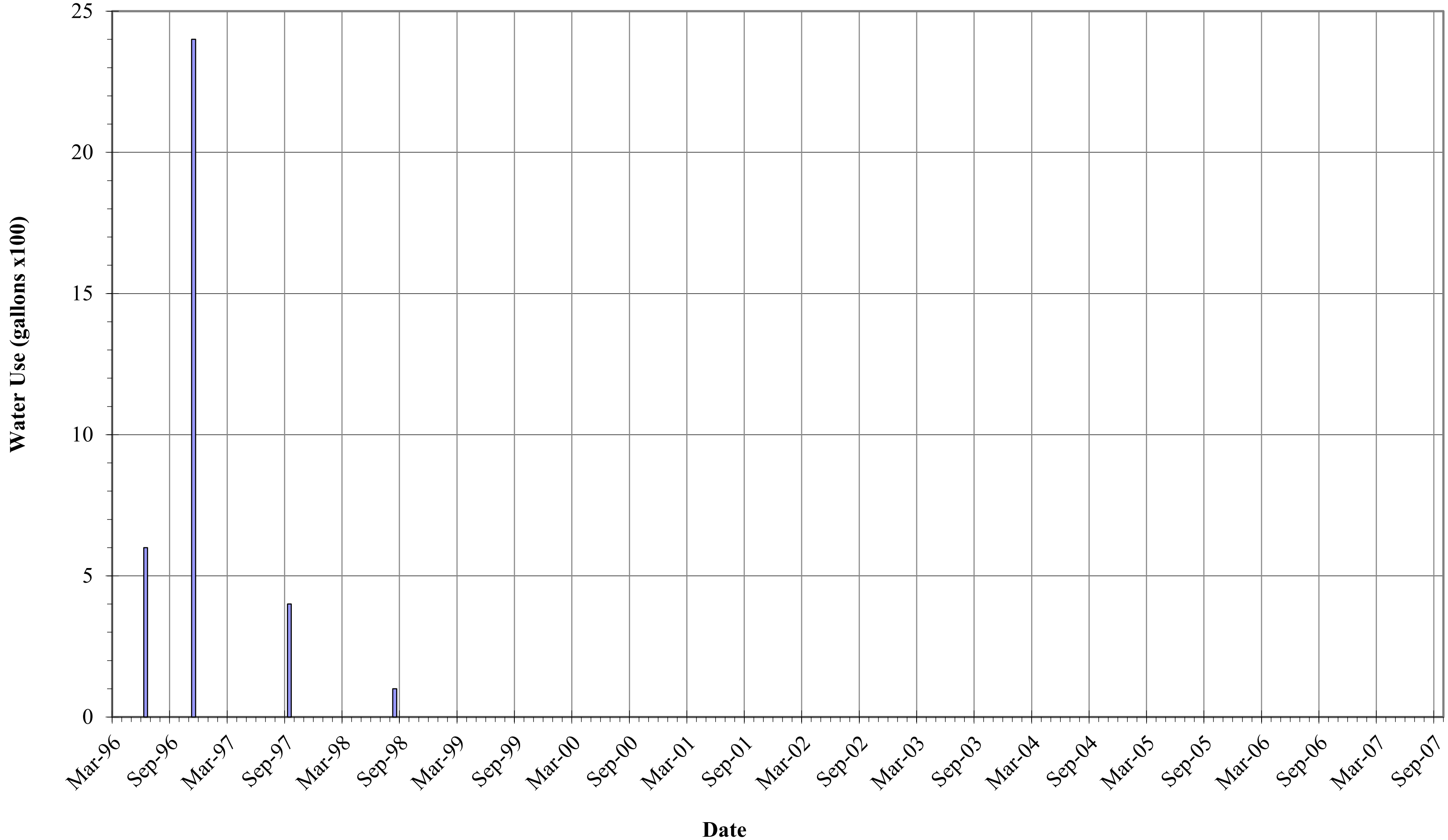


Figure F-7. NRCS 3-1

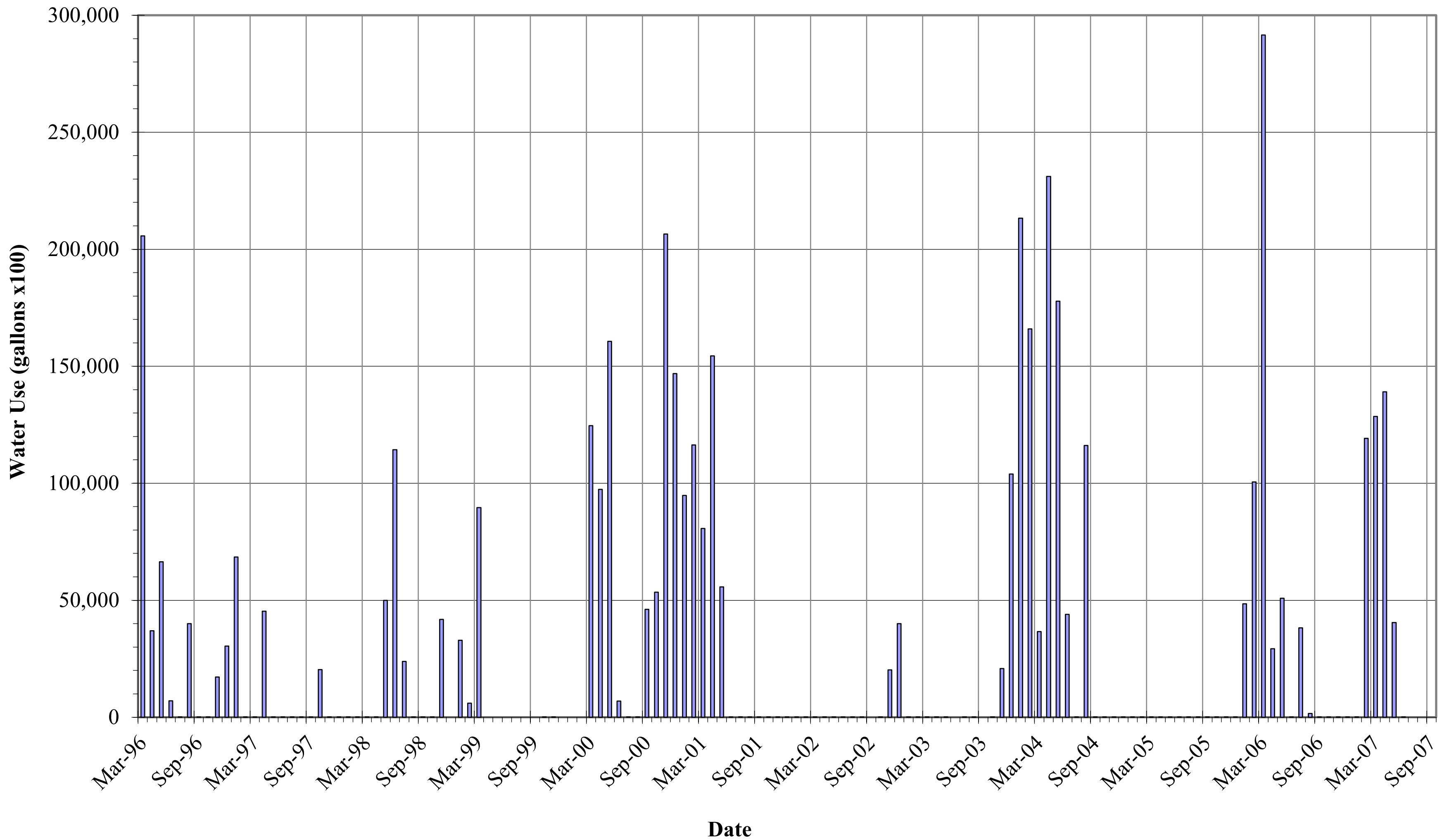


Figure F-8. NRCS 3-2

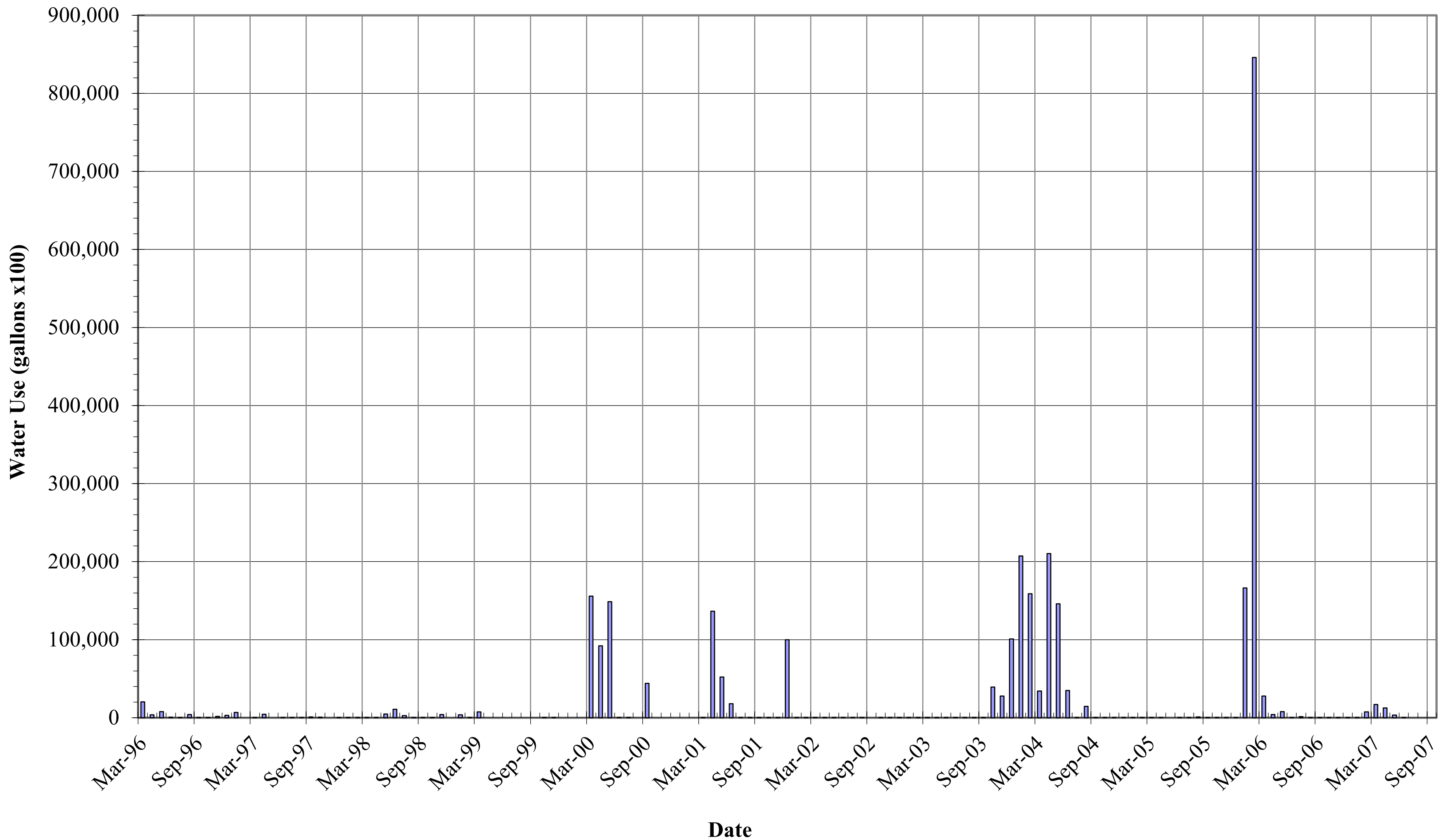


Figure F-9. NRCS 3-3

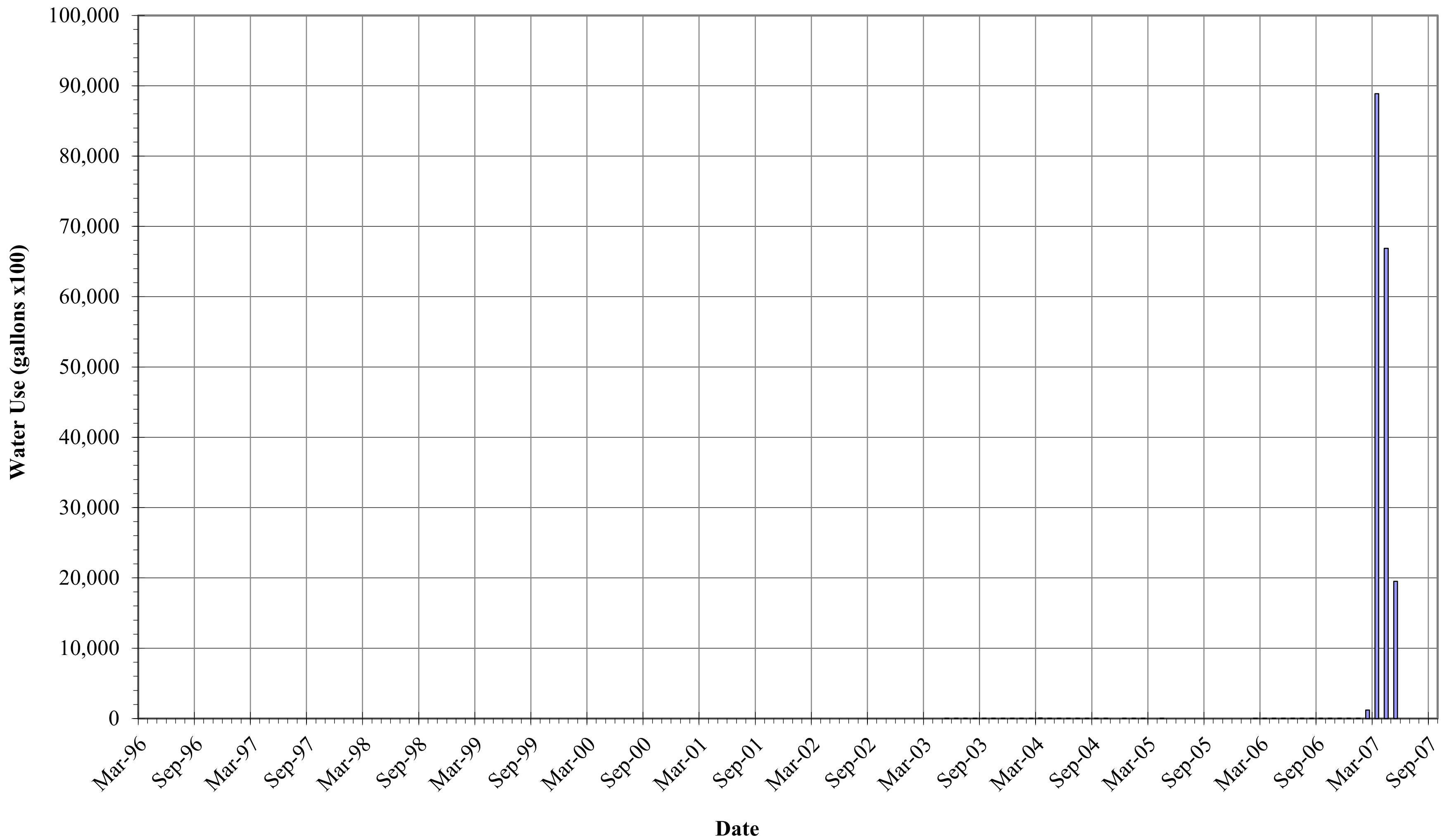


Figure F-10. NRCS 4-1

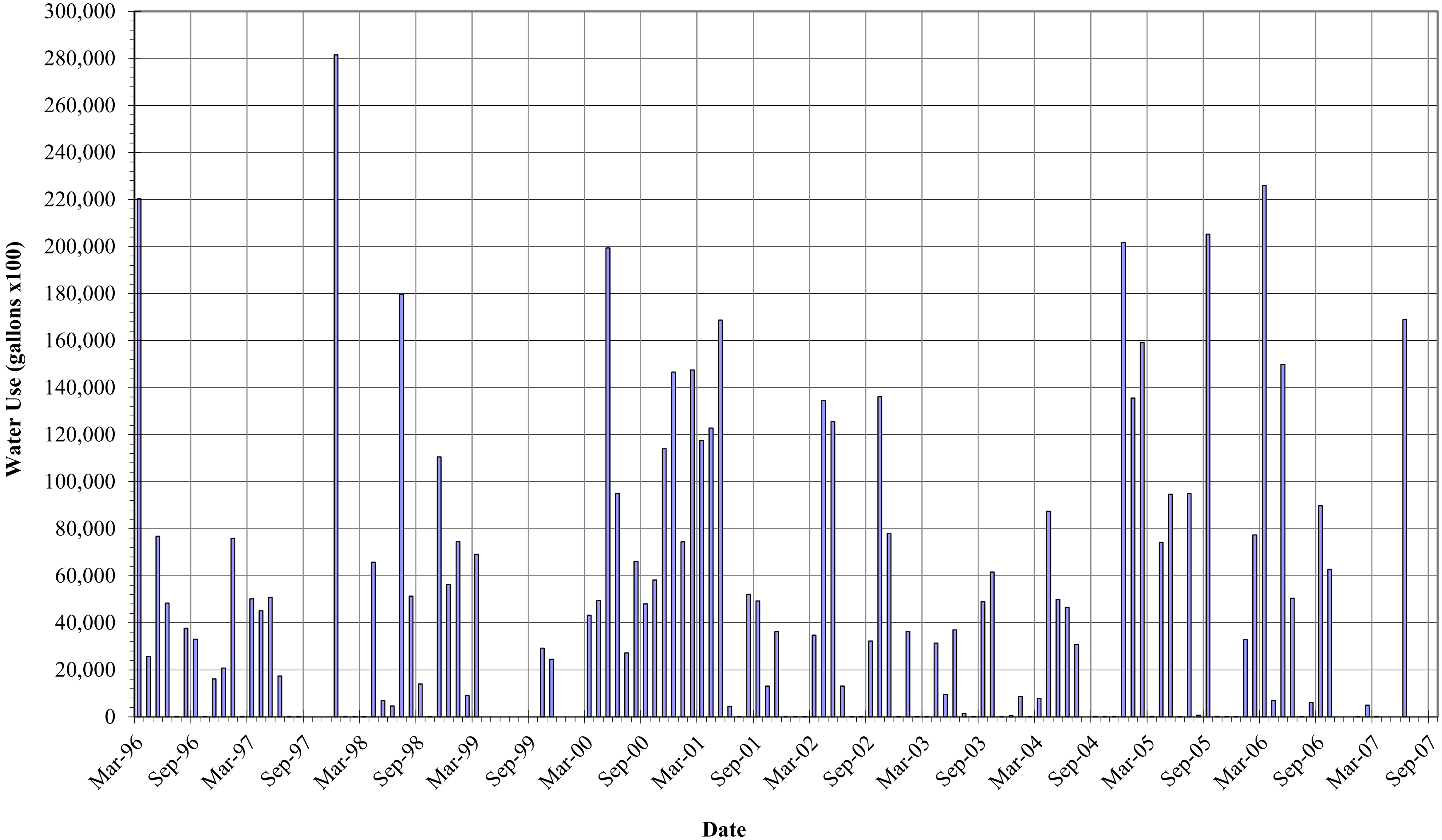


Figure F-11. NRCS 5-1

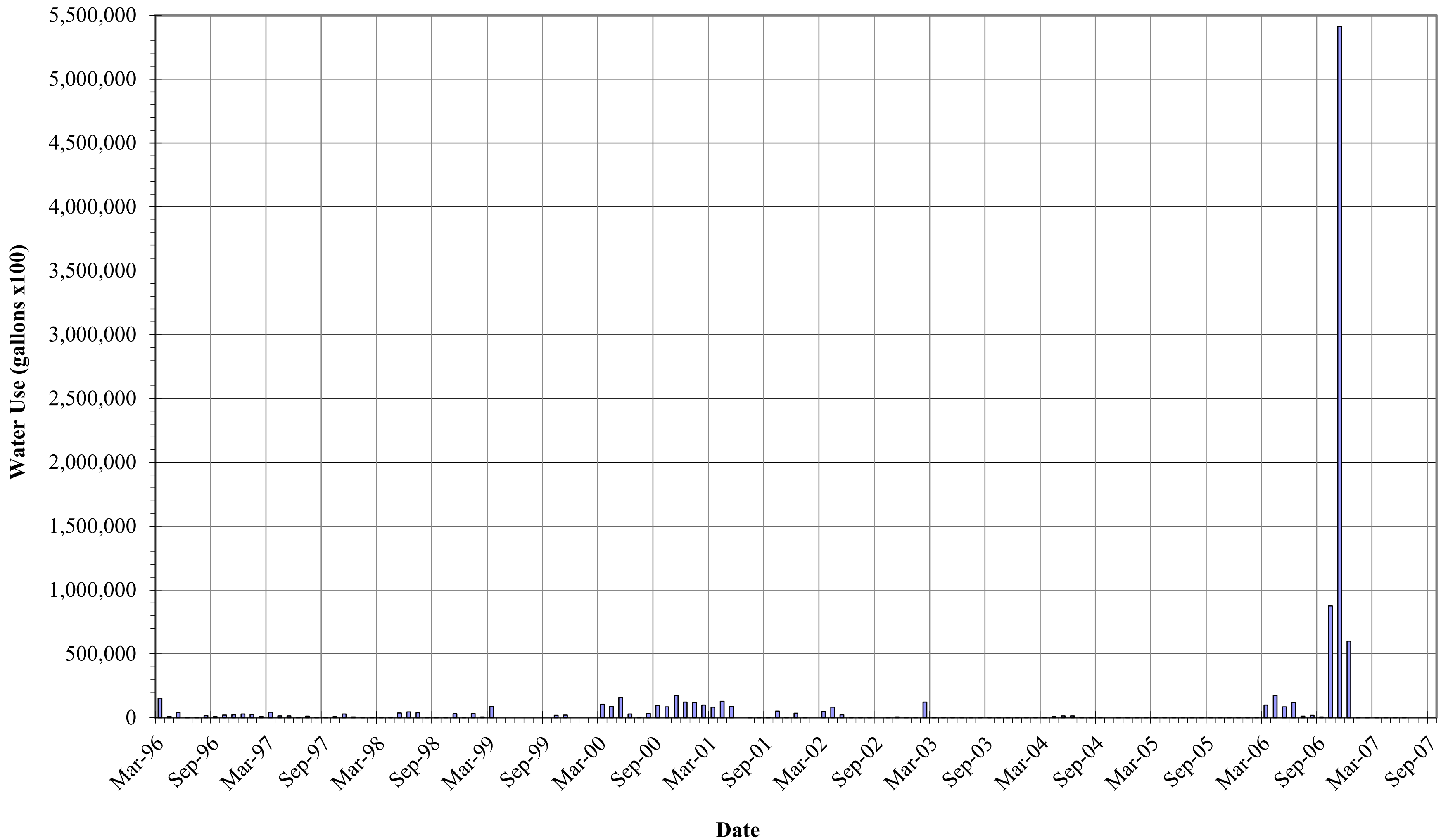


Figure F-12. NRCS 6-1

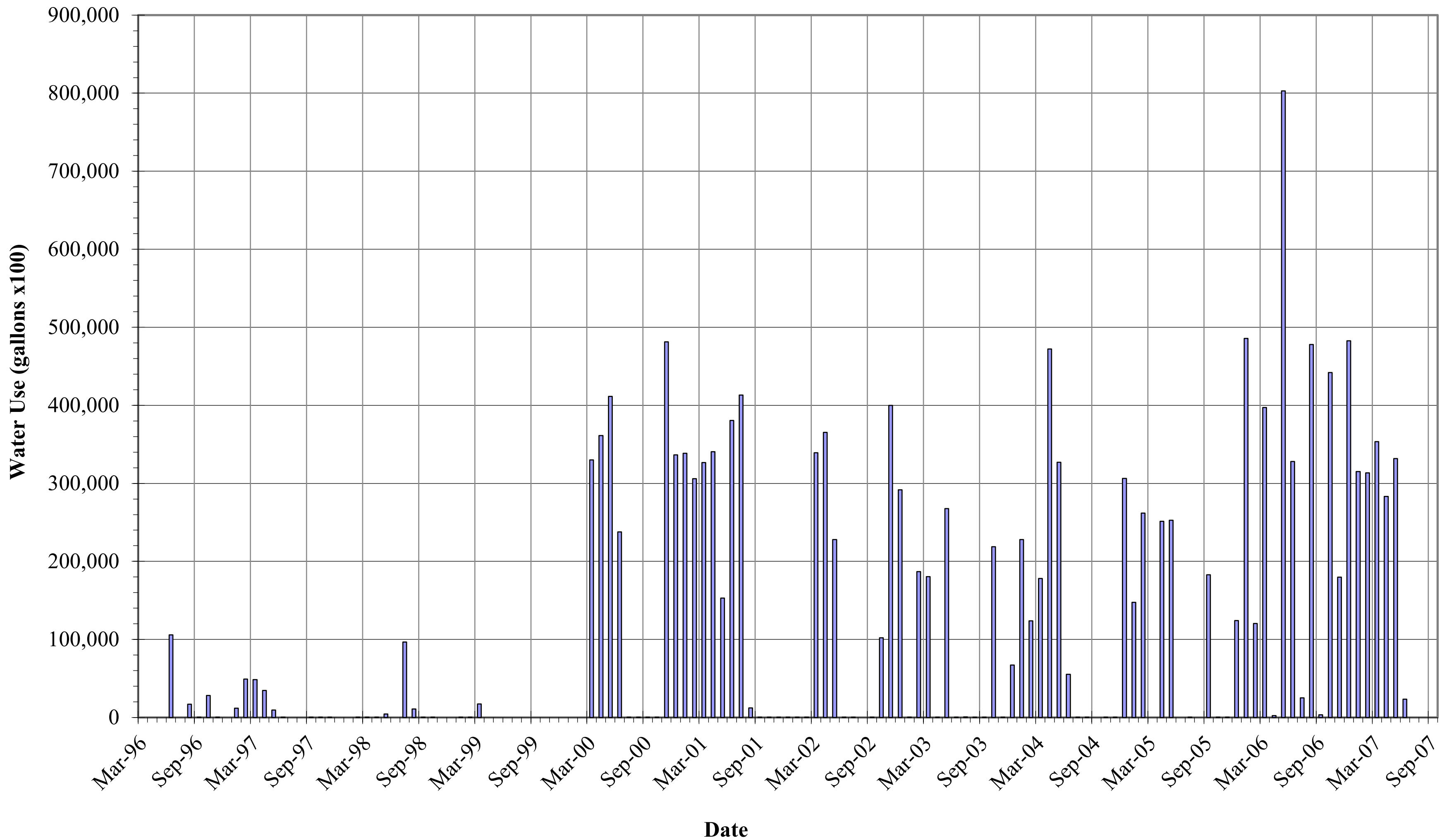


Figure F-13. NRCS 6-2

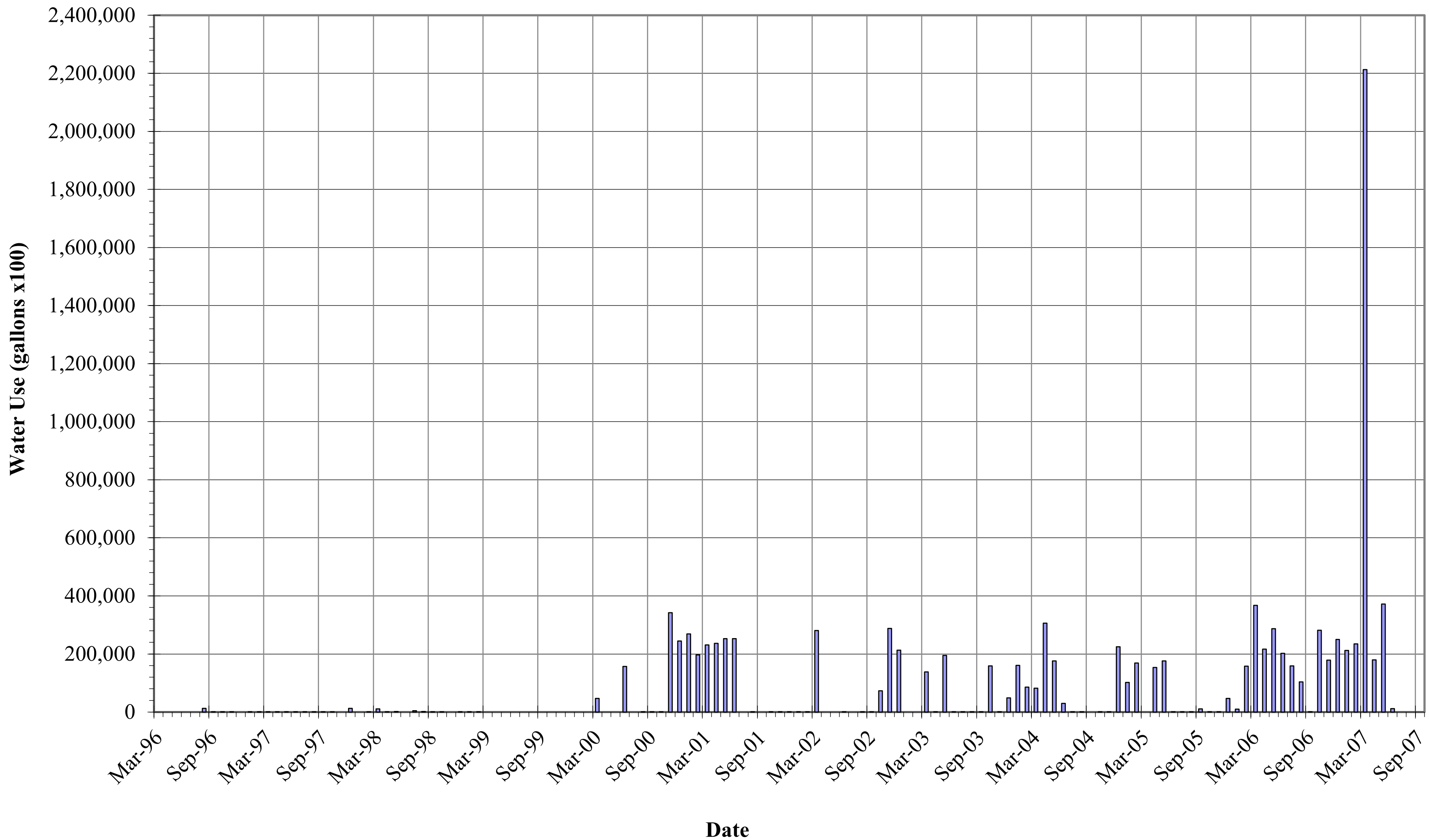


Figure F-14. NRCS 7-1

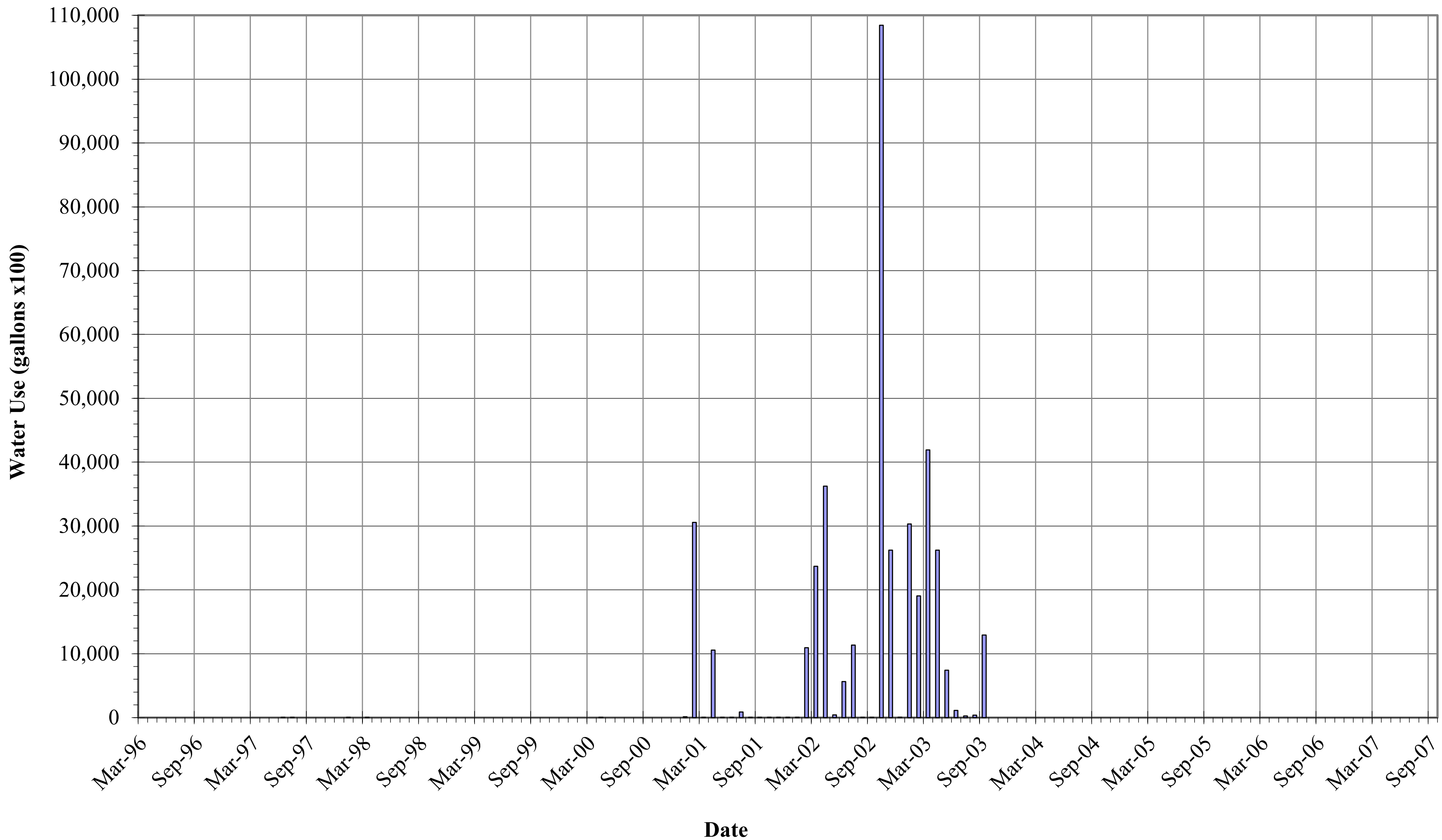


Figure F-15. NRCS 7-2

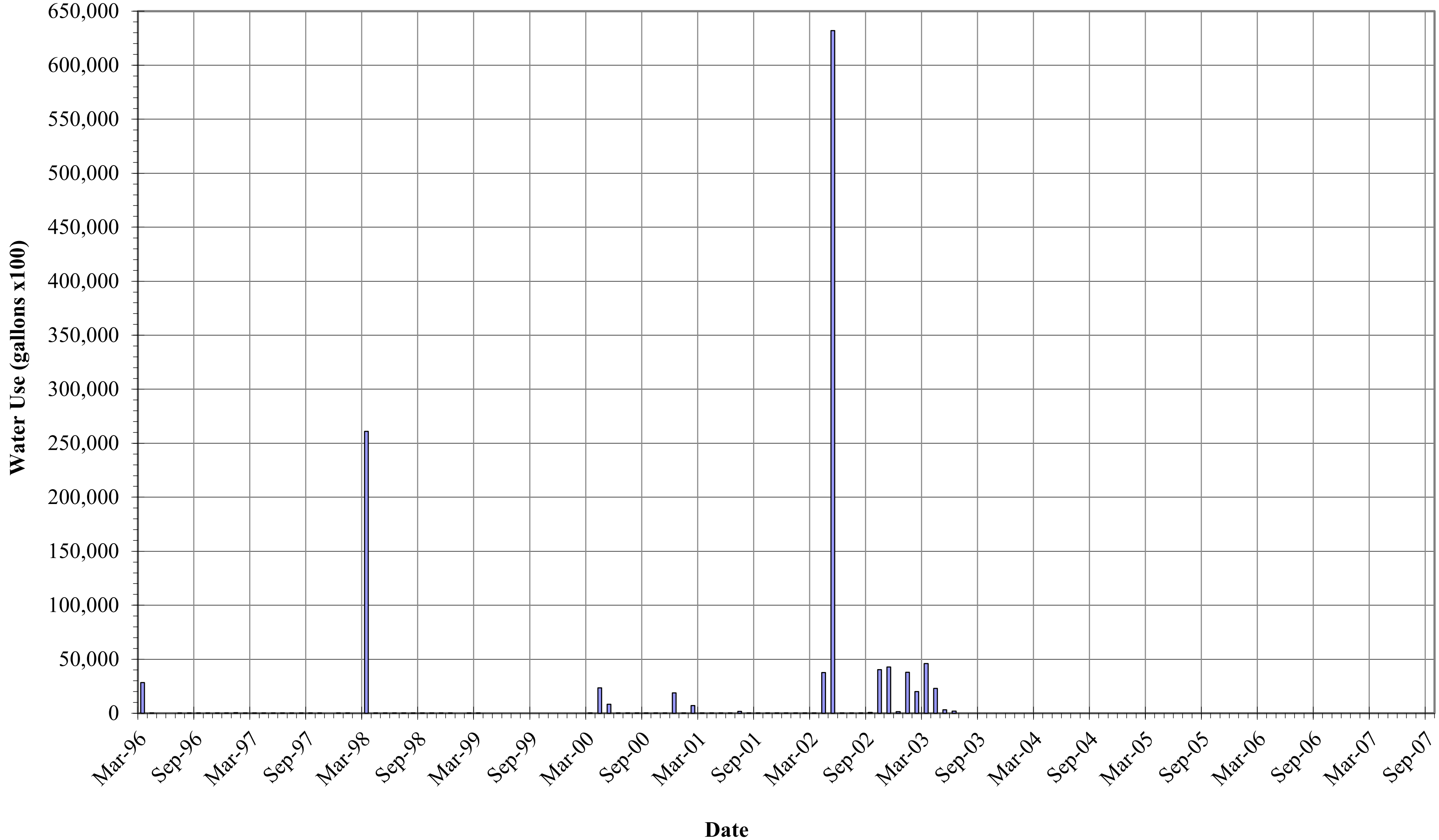


Figure F-16. NRCS 7-3

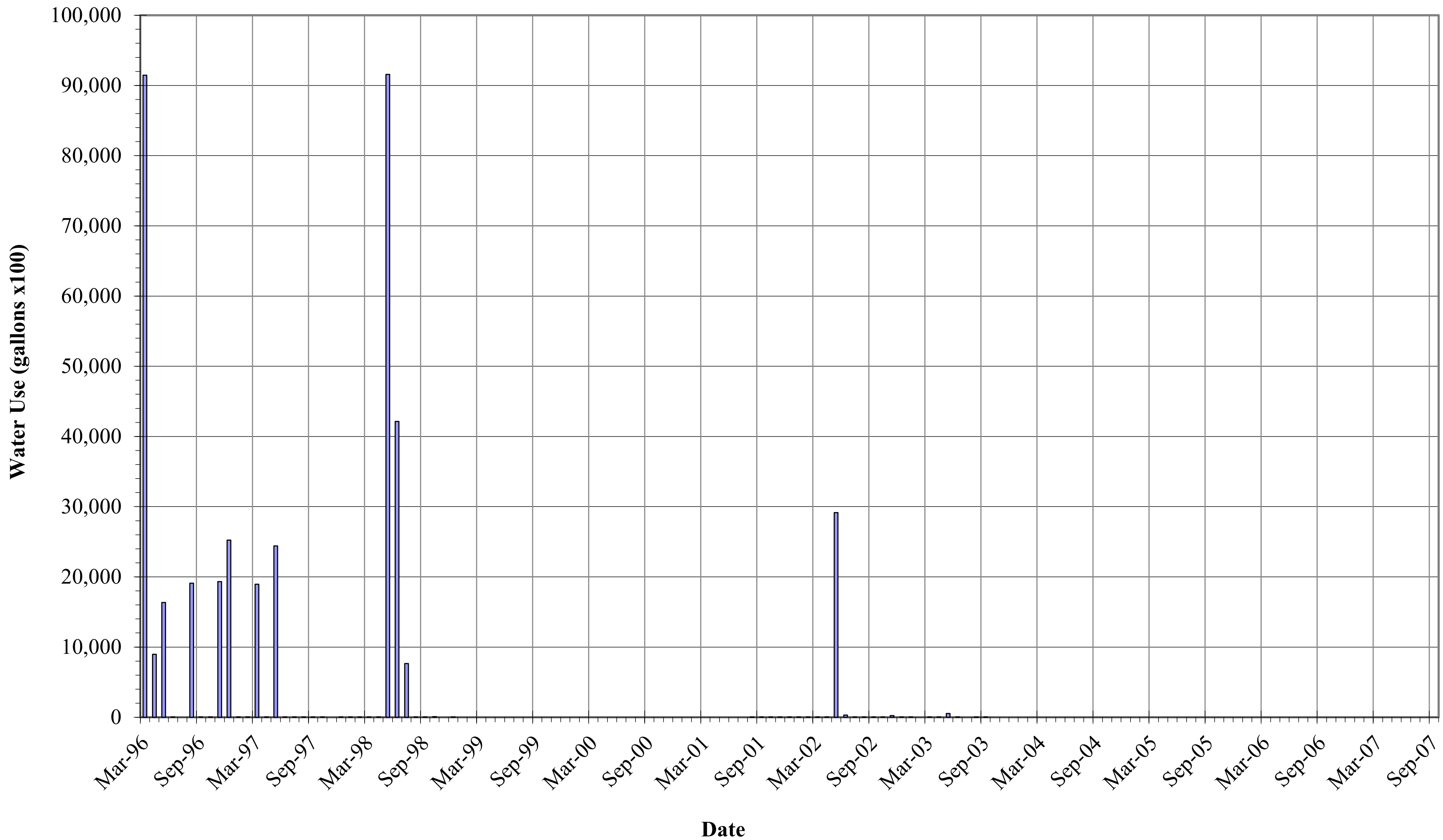


Figure F-17. NRCS 8-1

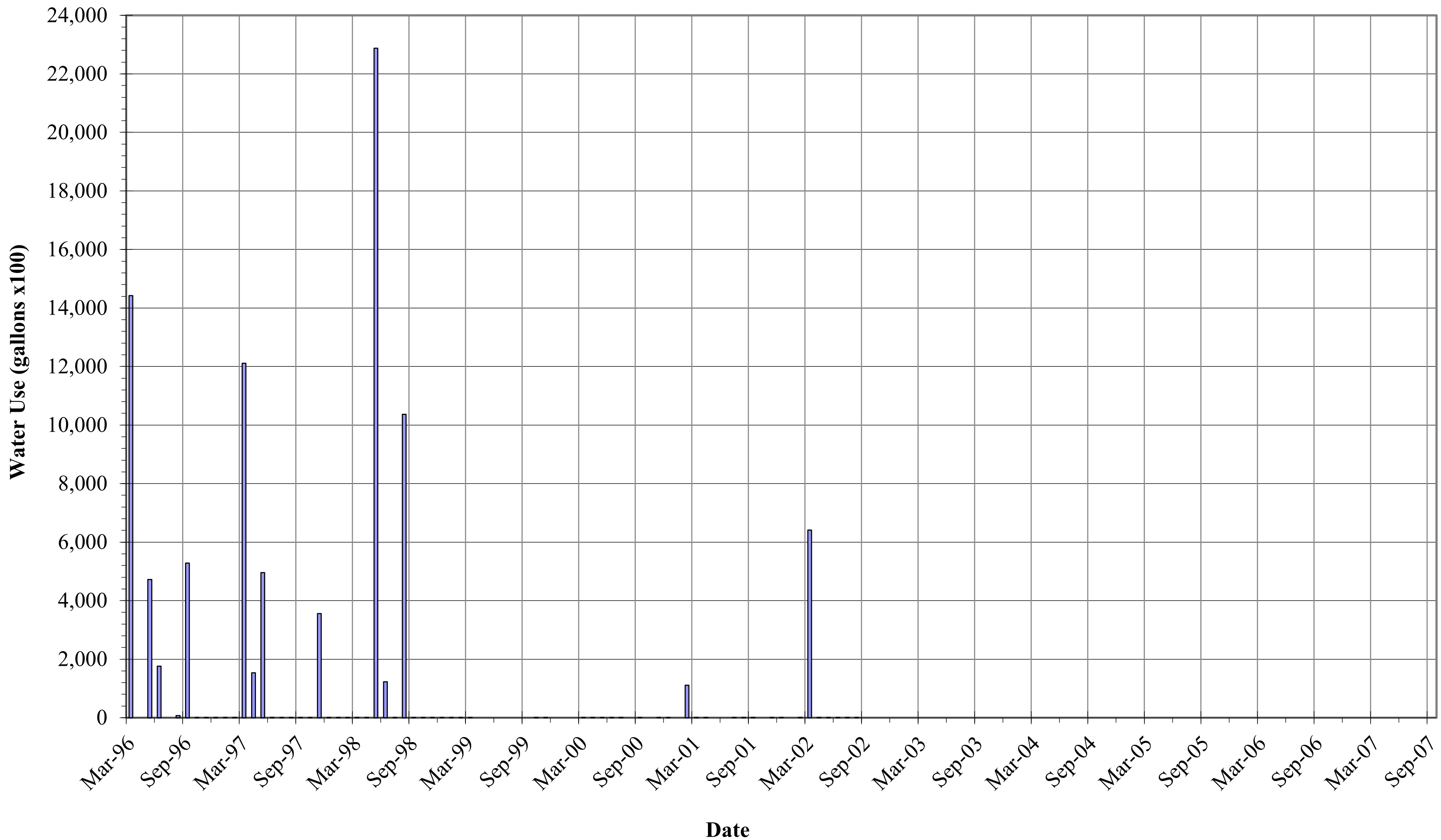


Figure F-18. NRCS 8-2

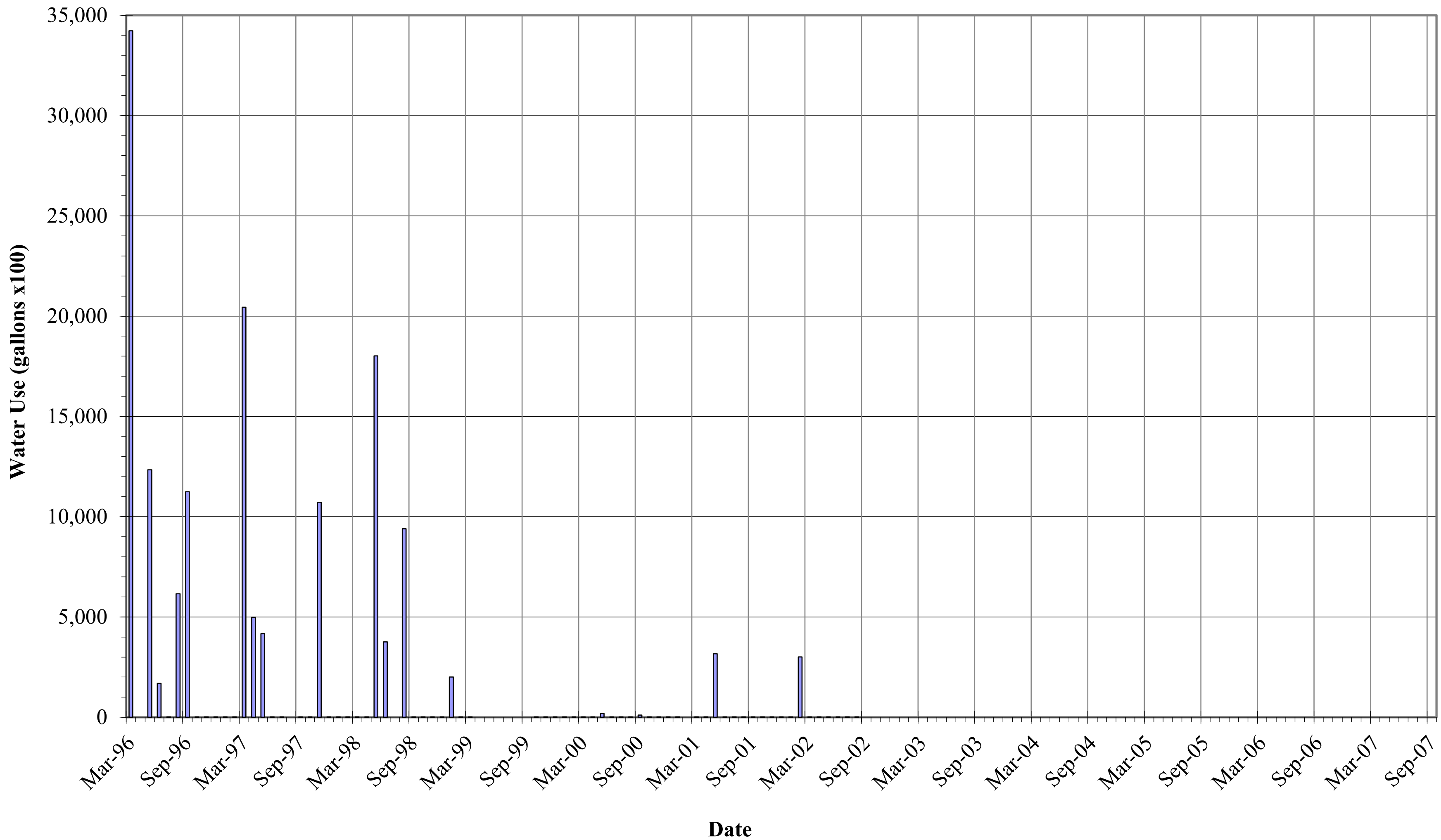


Figure F-19. NRCS 8-3

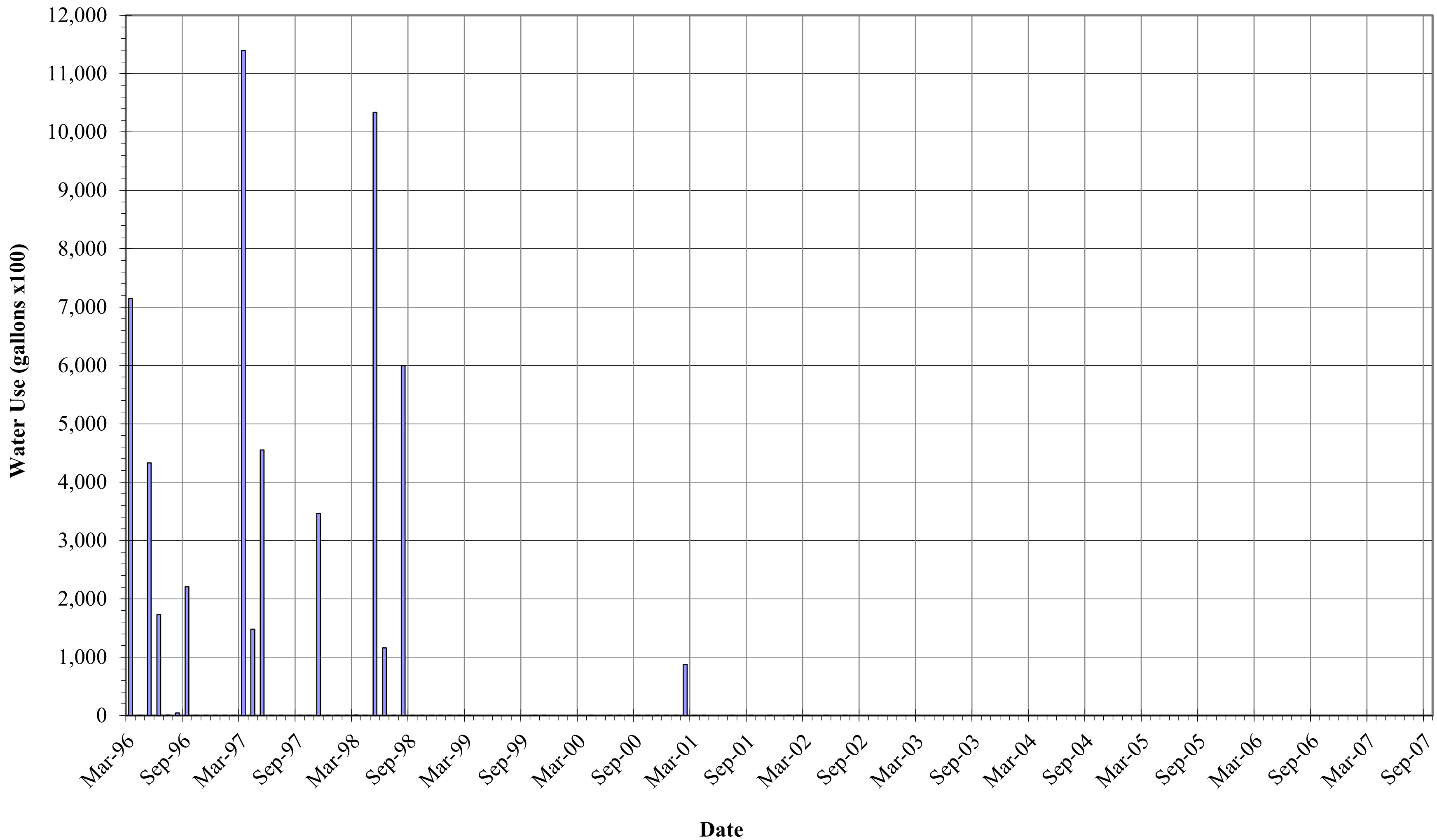


Figure F-20. NRCS 8-4

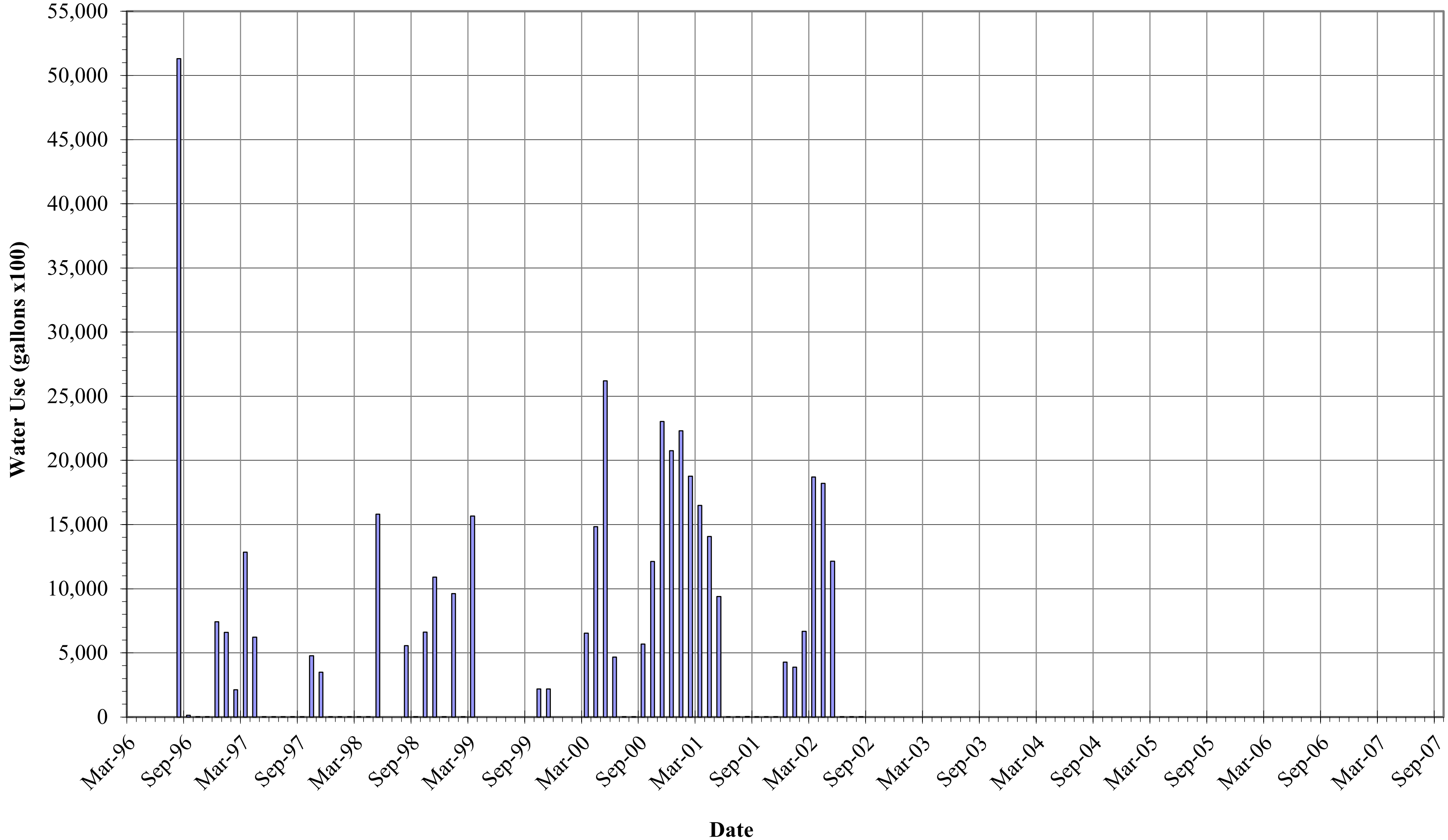


Figure F-21. NRCS 11-1

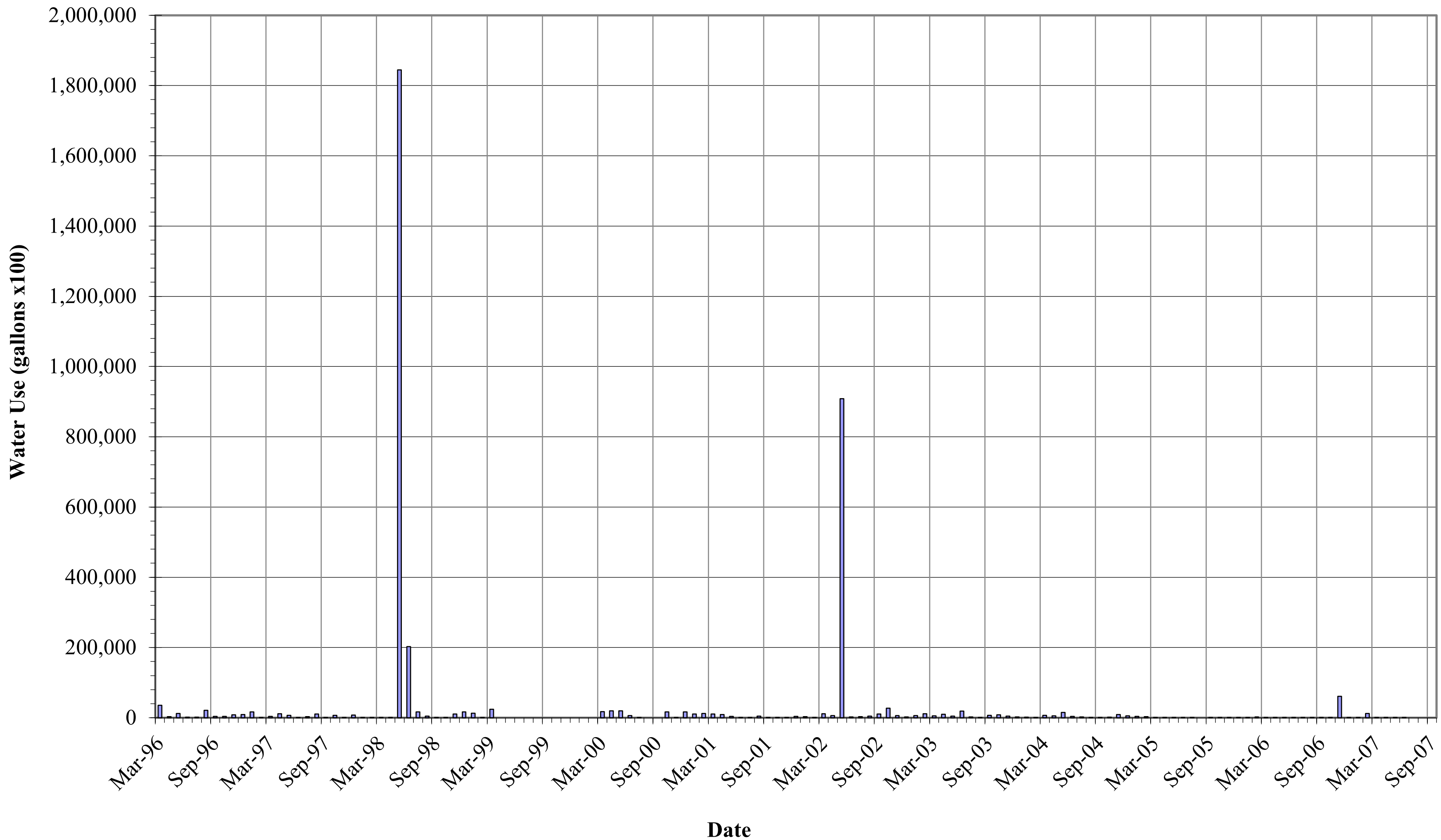


Figure F-22. NRCS 12-1

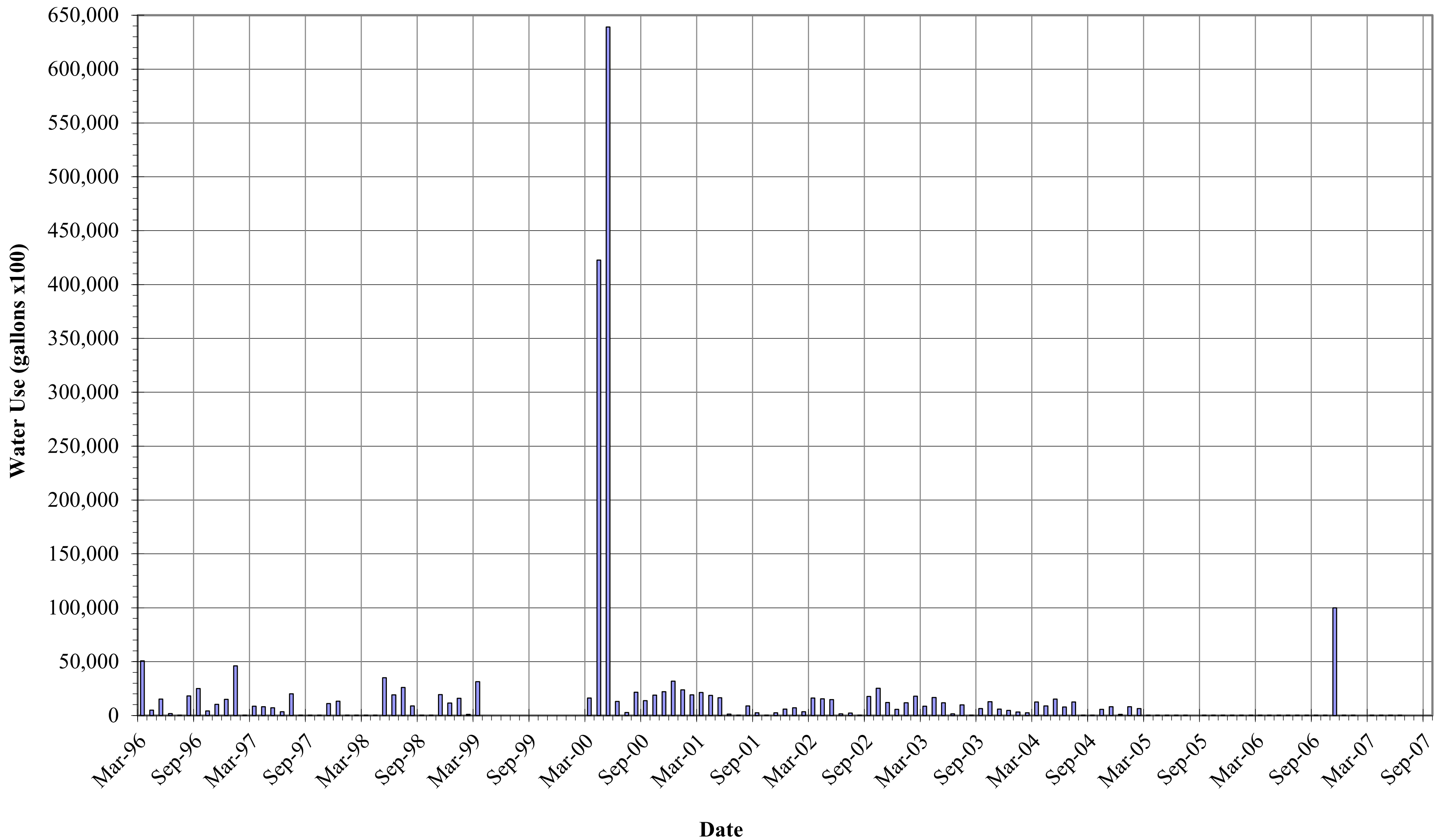


Figure F-23. NRCS 13-1

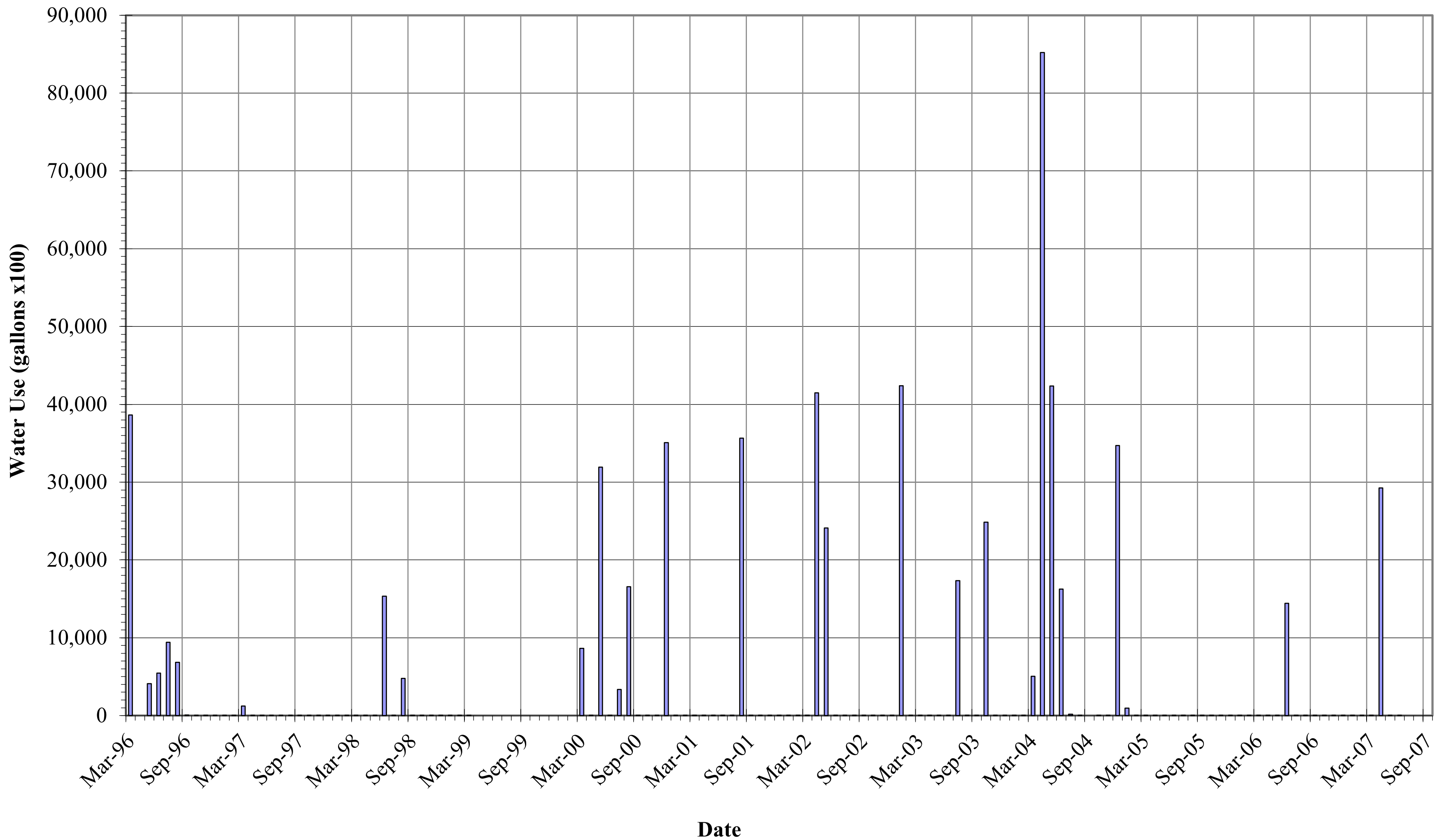


Figure F-24. NRCS 14-1

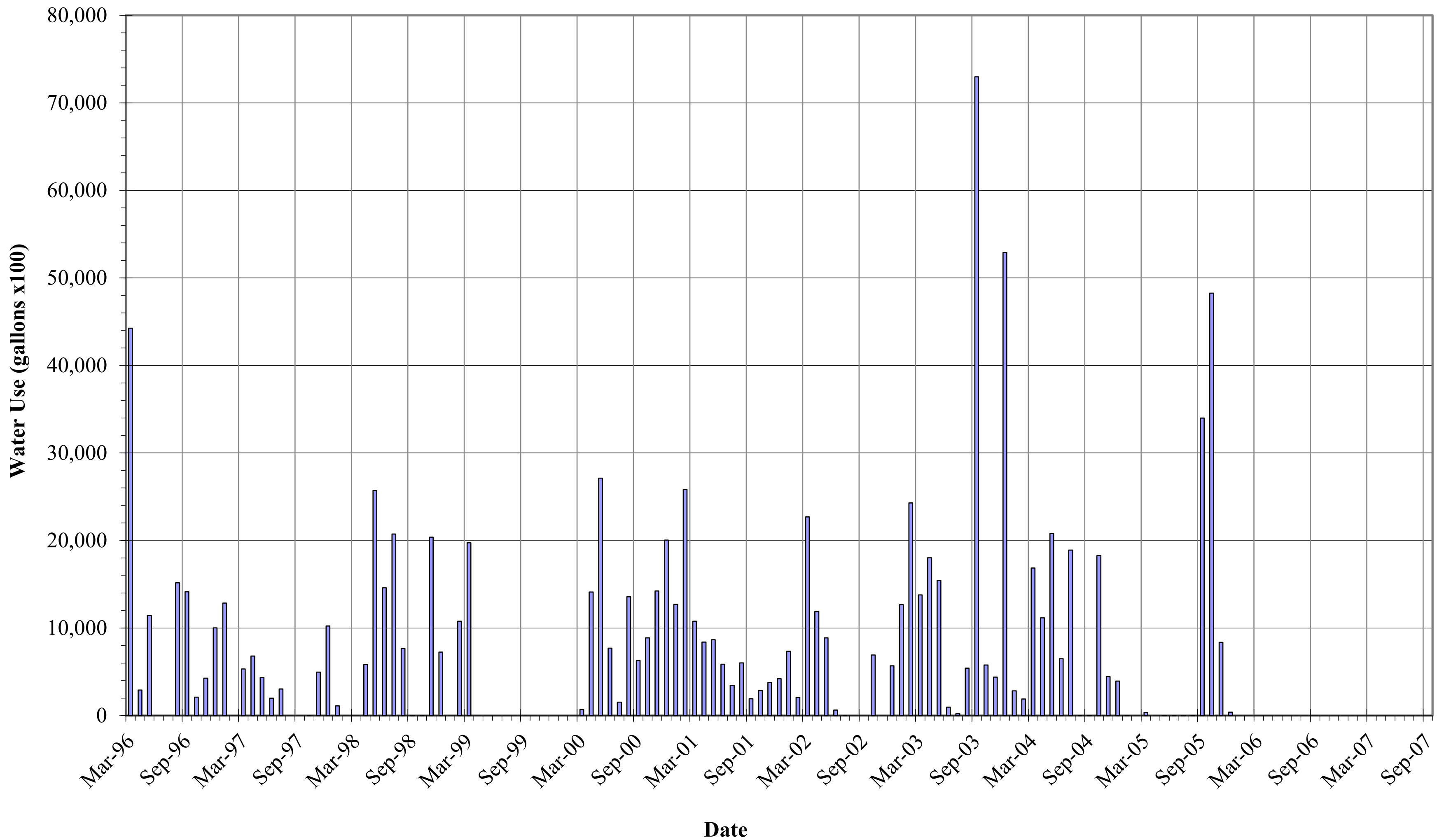


Figure F-25. NRCS 29-1A

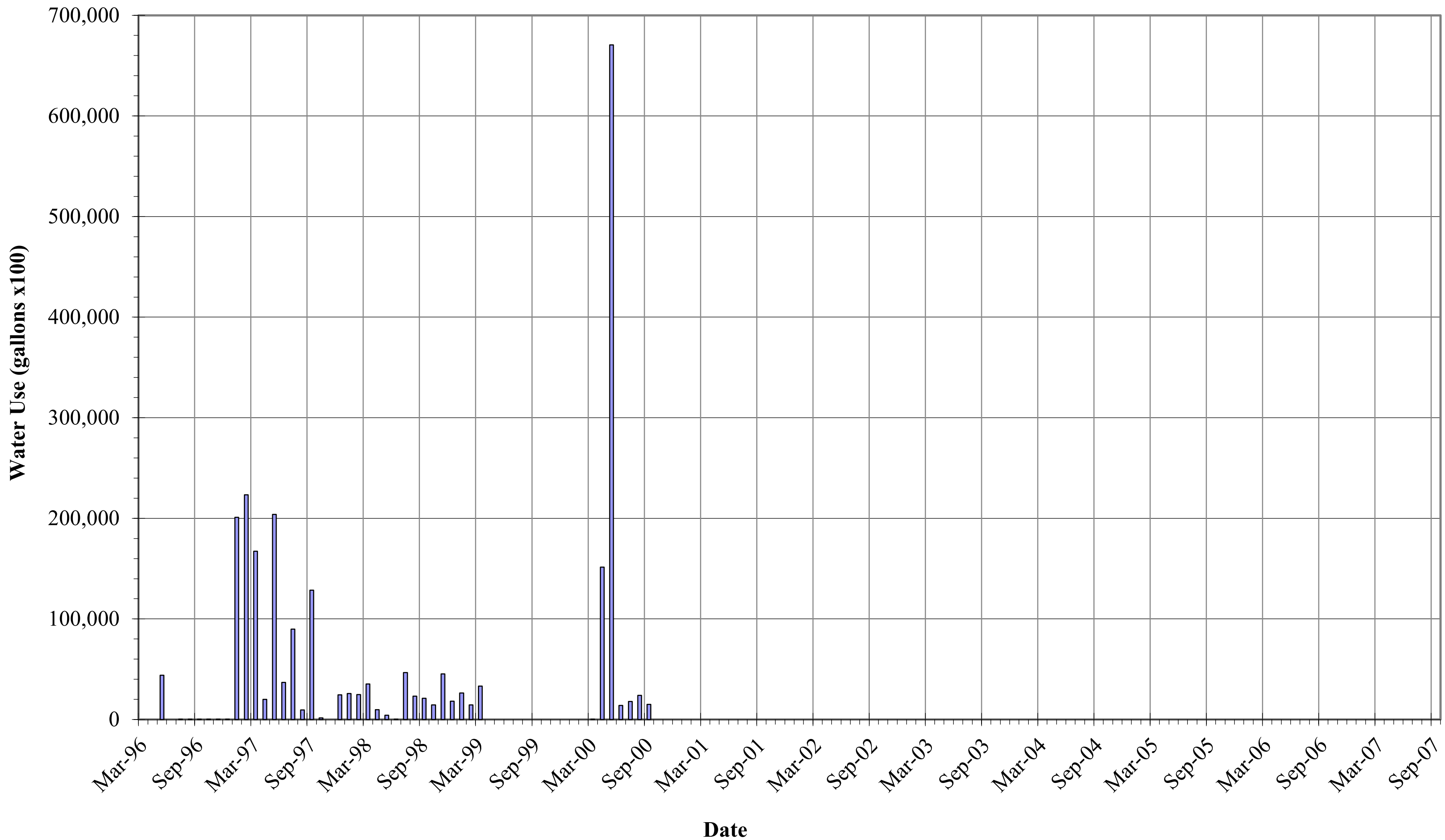


Figure F-26. NRCS 29-1B

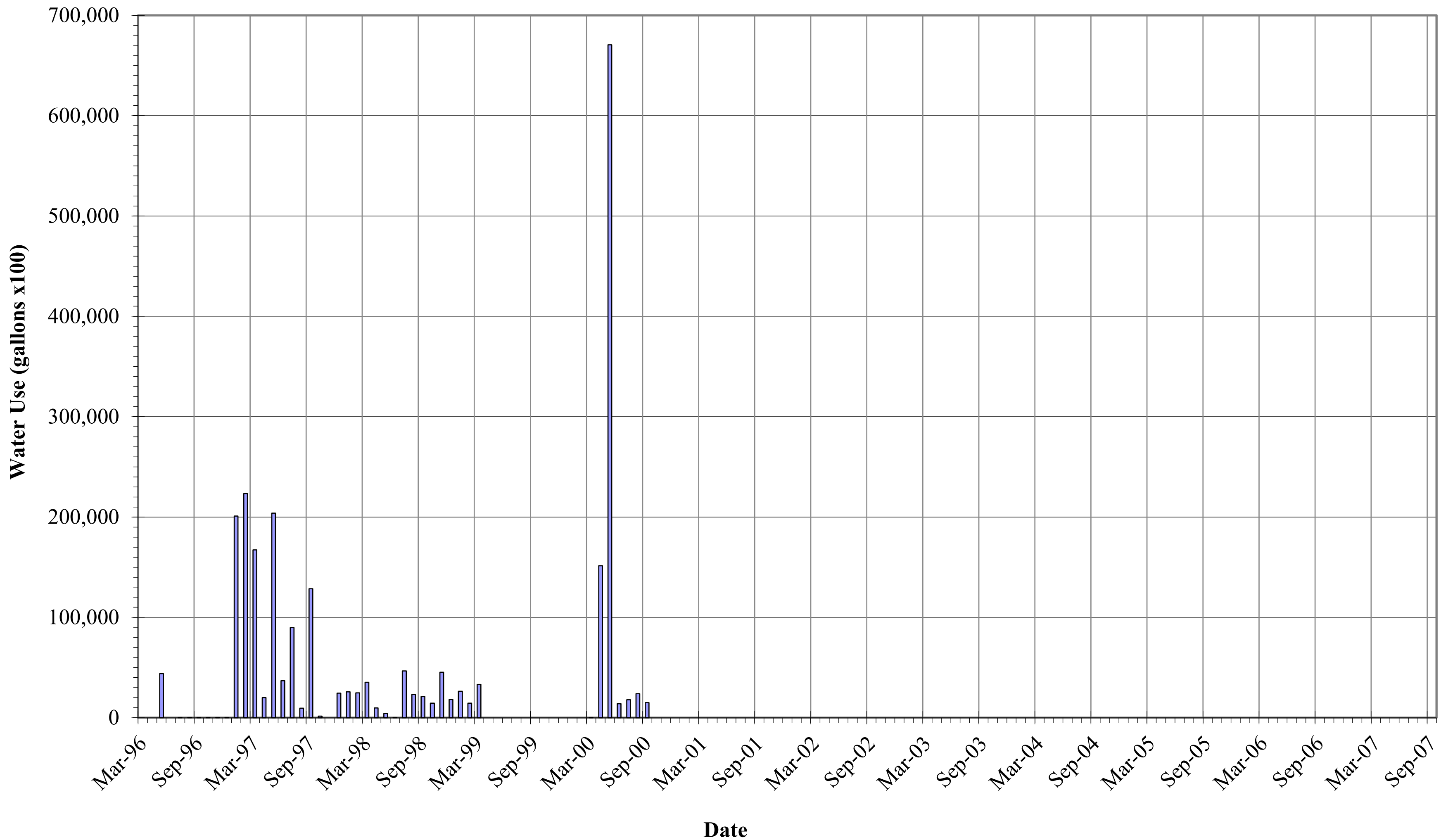


Figure F-27. NRCS 29-2

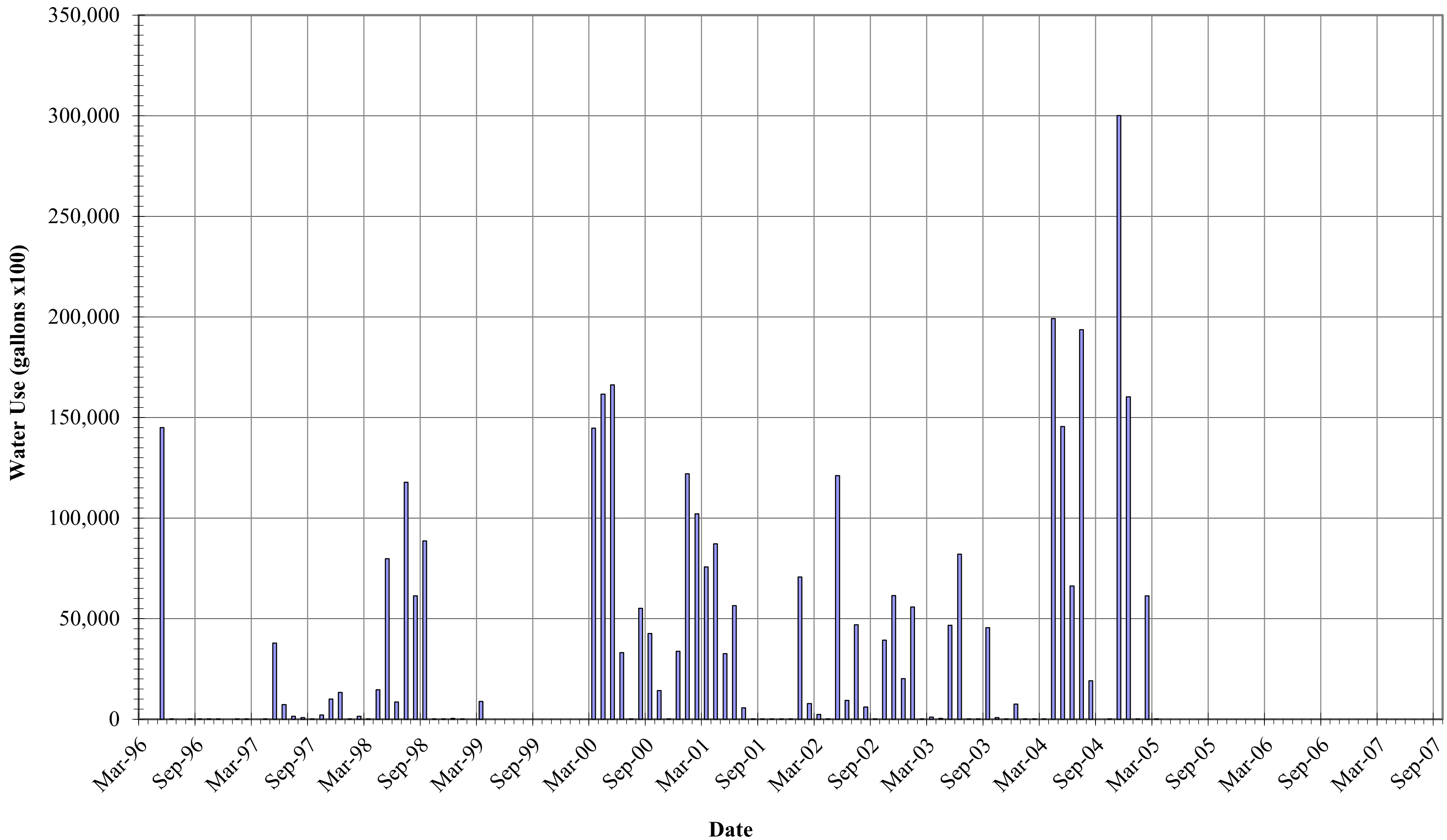


Figure F-28. NRCS 29-3

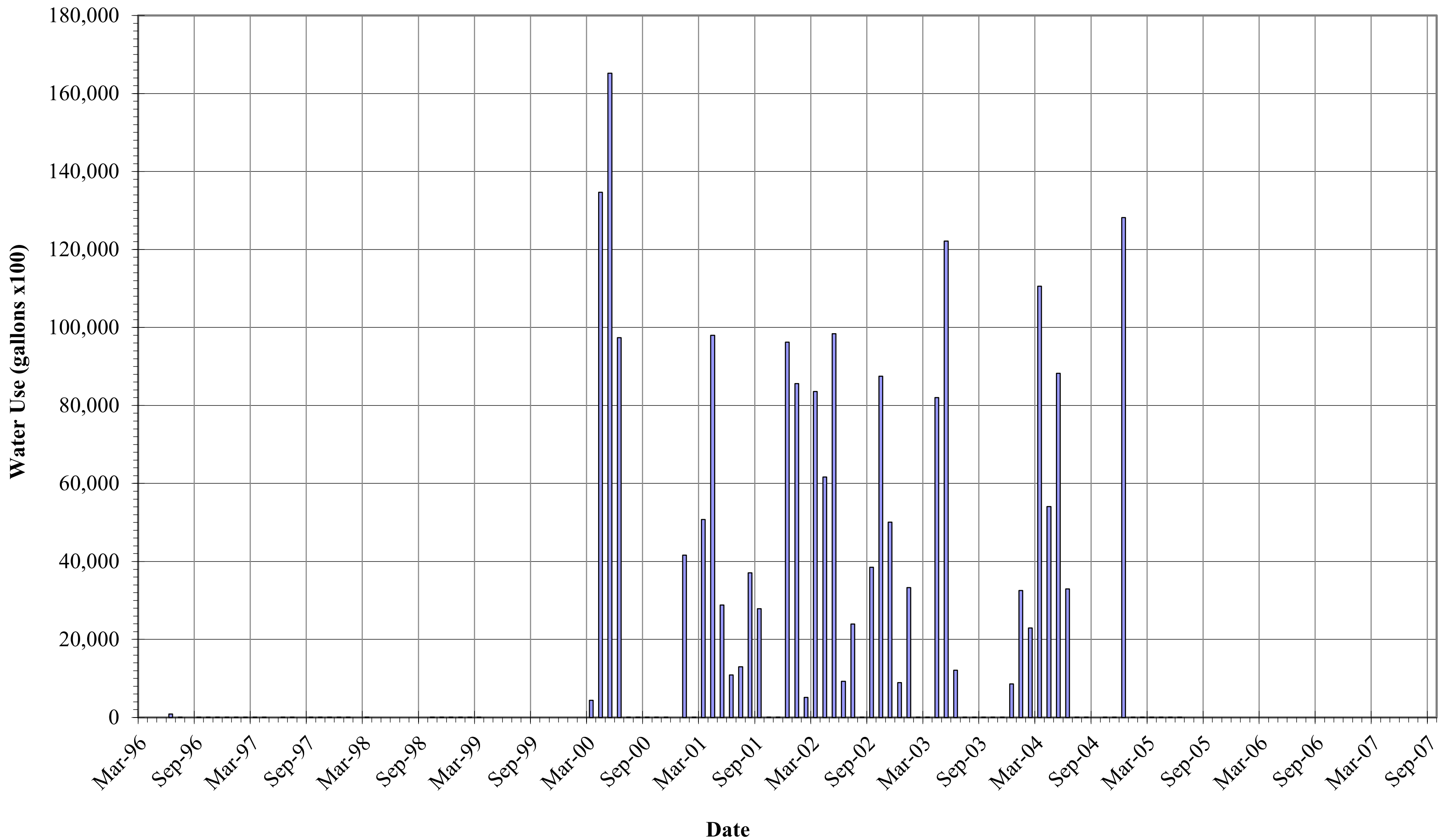


Figure F-29. NRCS 29-4

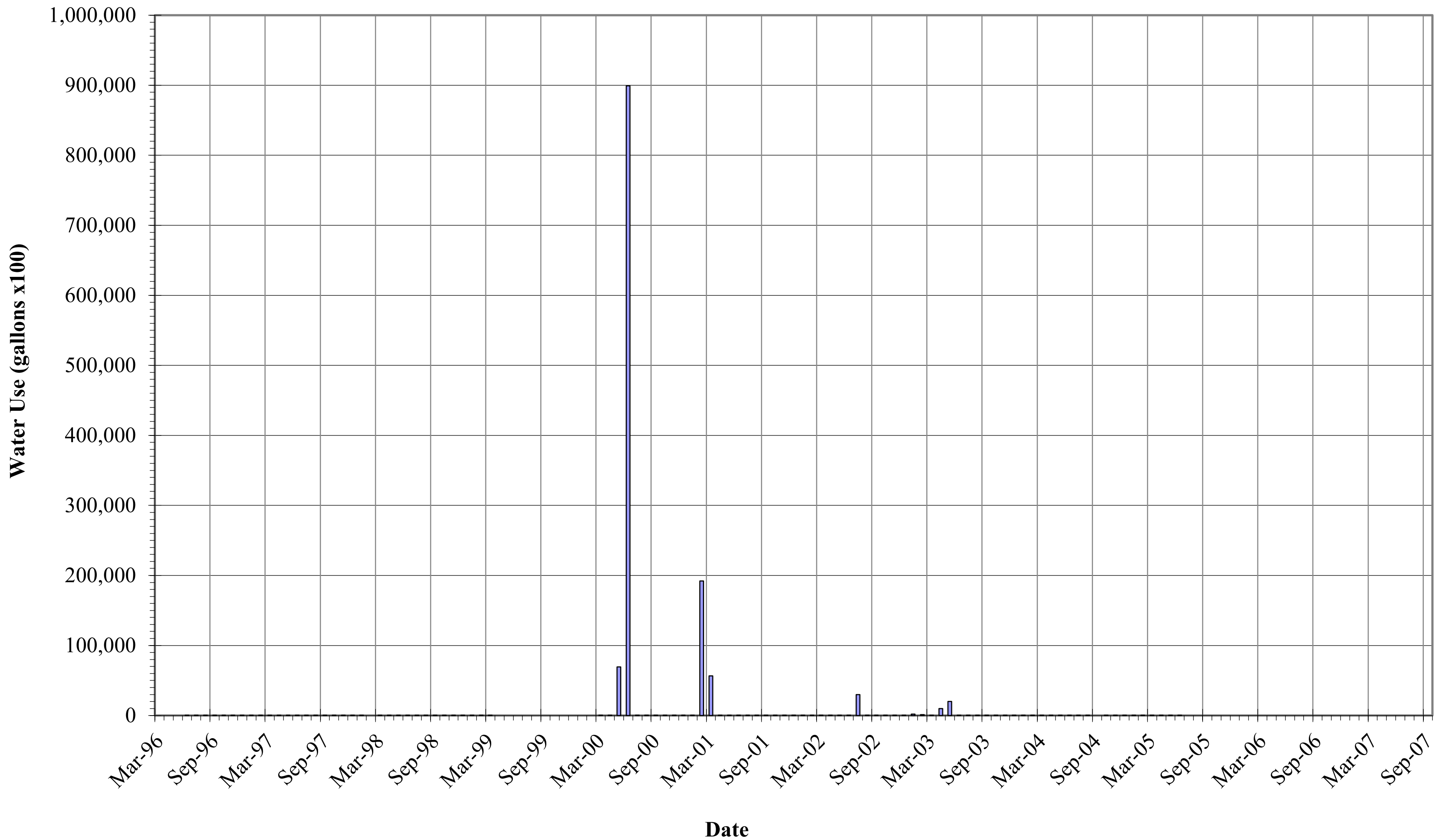


Figure F-30. NRCS 29-5

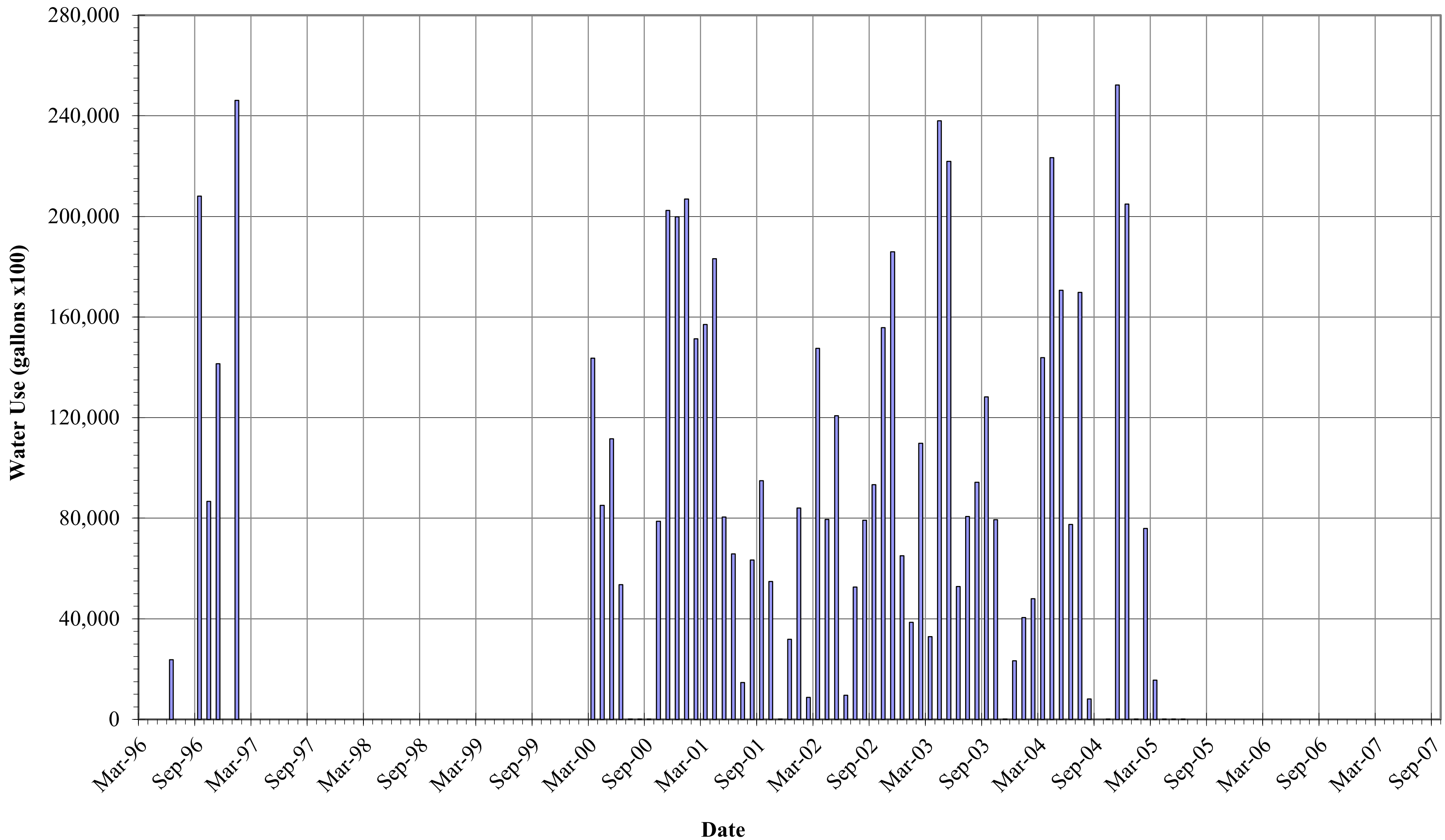


Figure F-31. NRCS 29-6

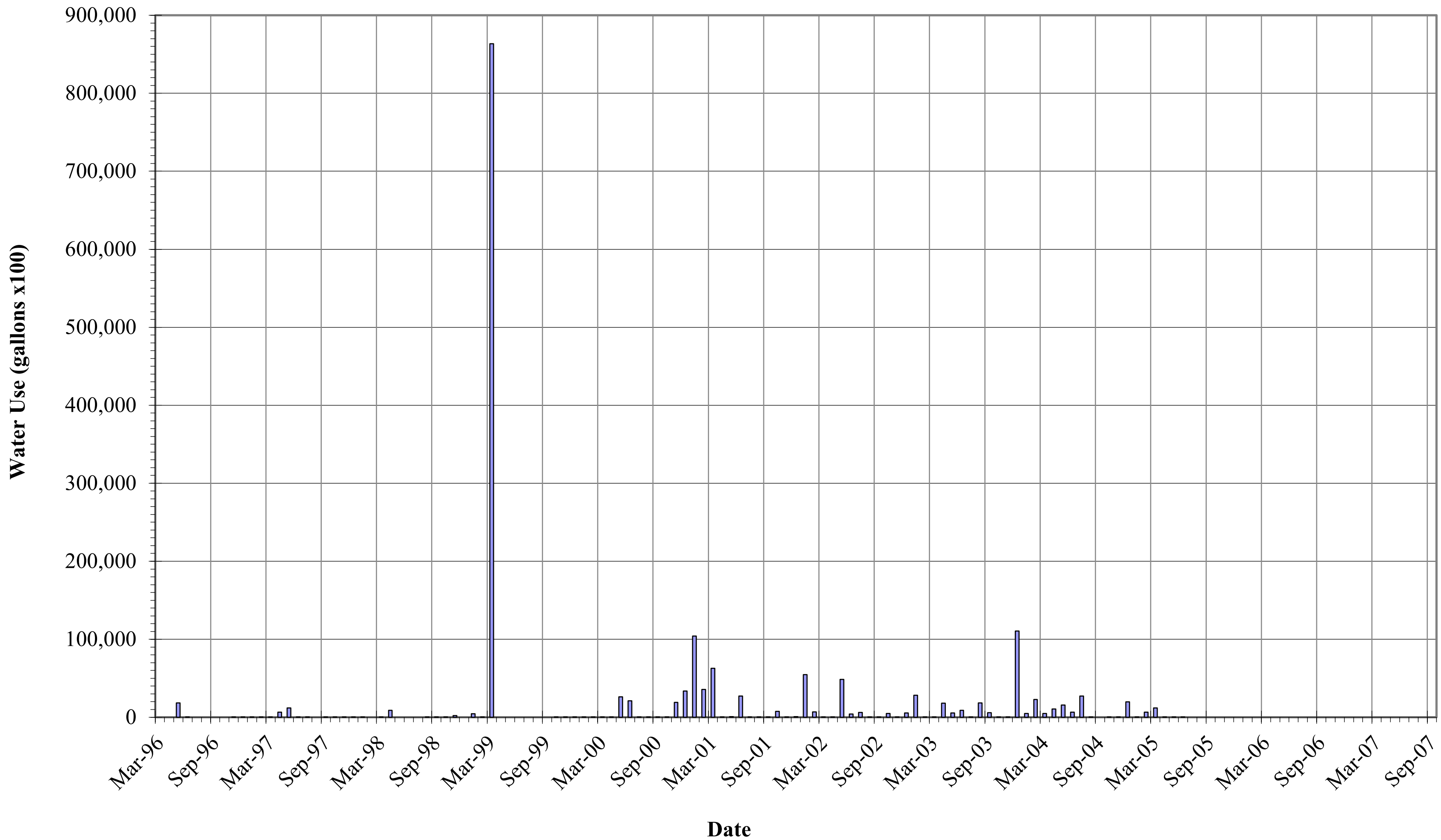


Figure F-32. NRCS 29-7

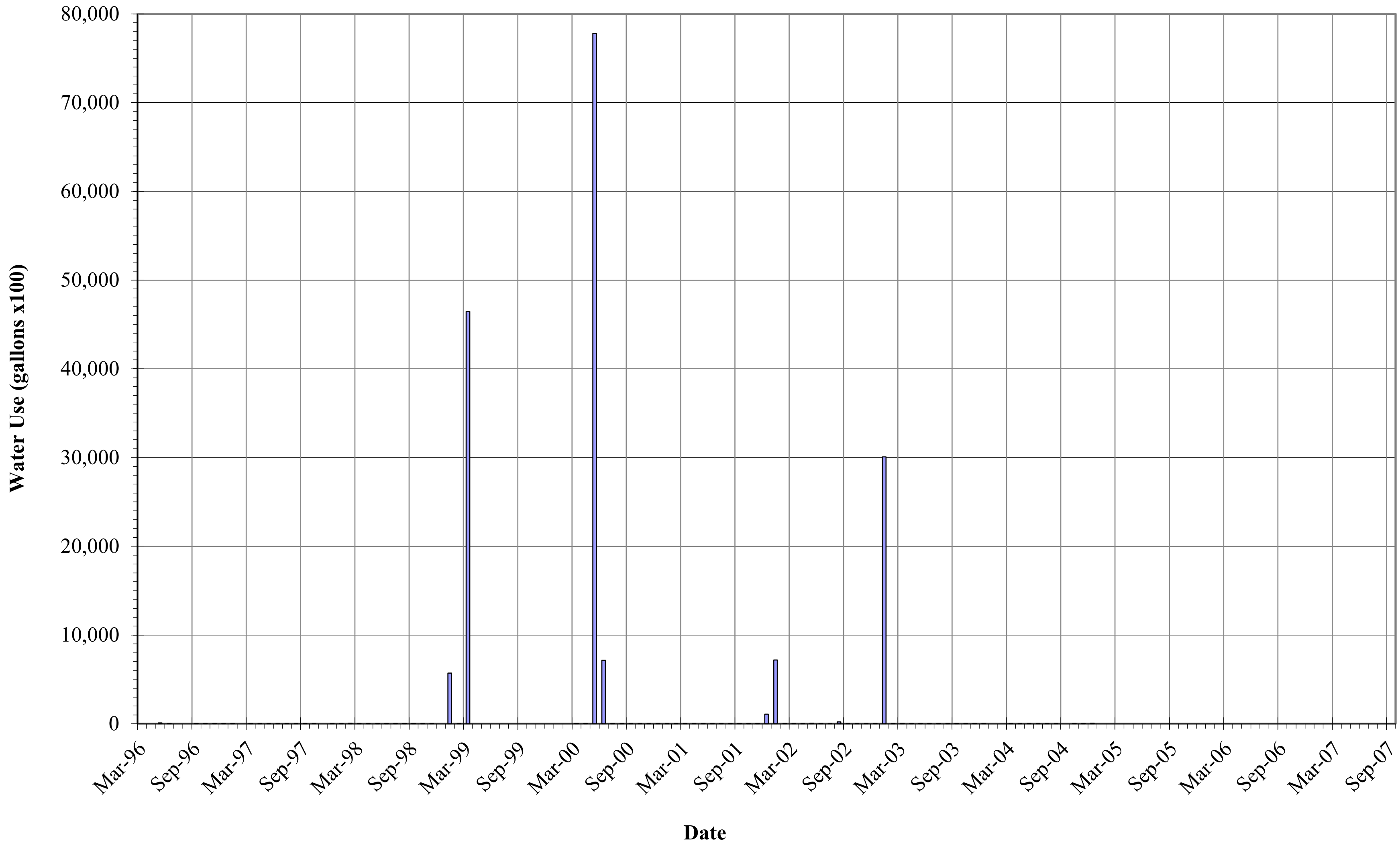


Figure F-33. NRCS 29-8

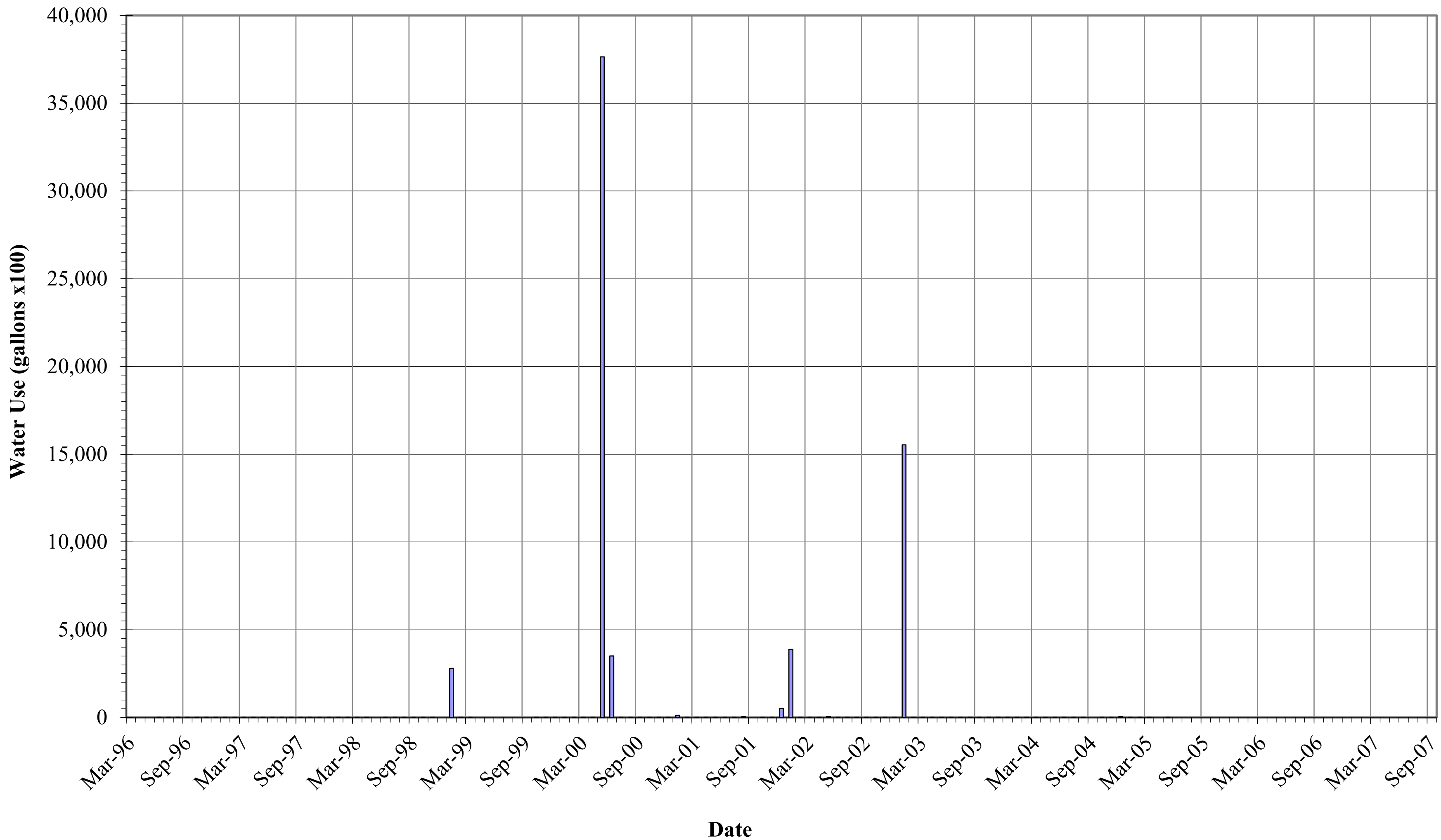


Figure F-34. NRCS 29-9

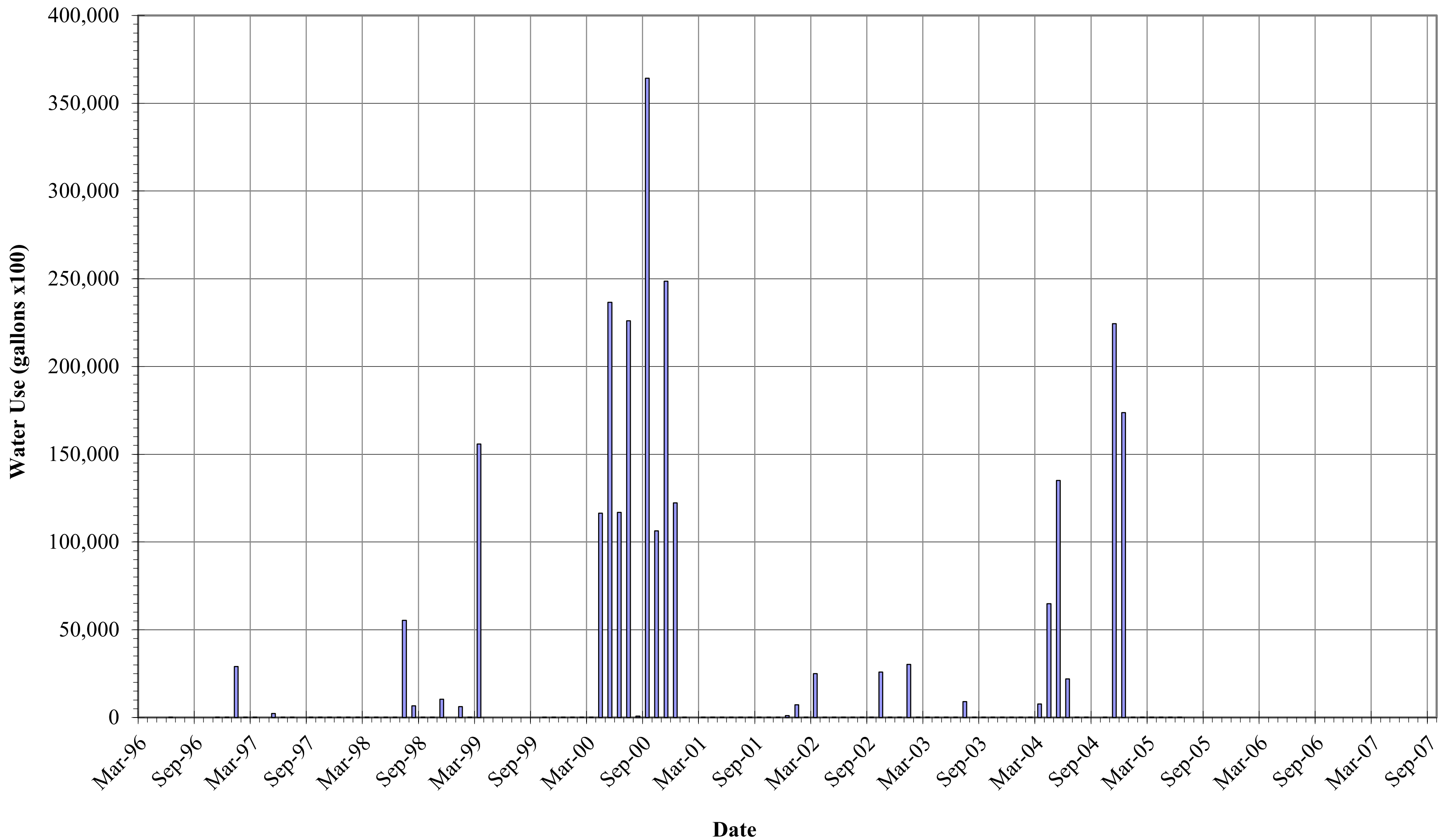


Figure F-35. NRCS 29-10

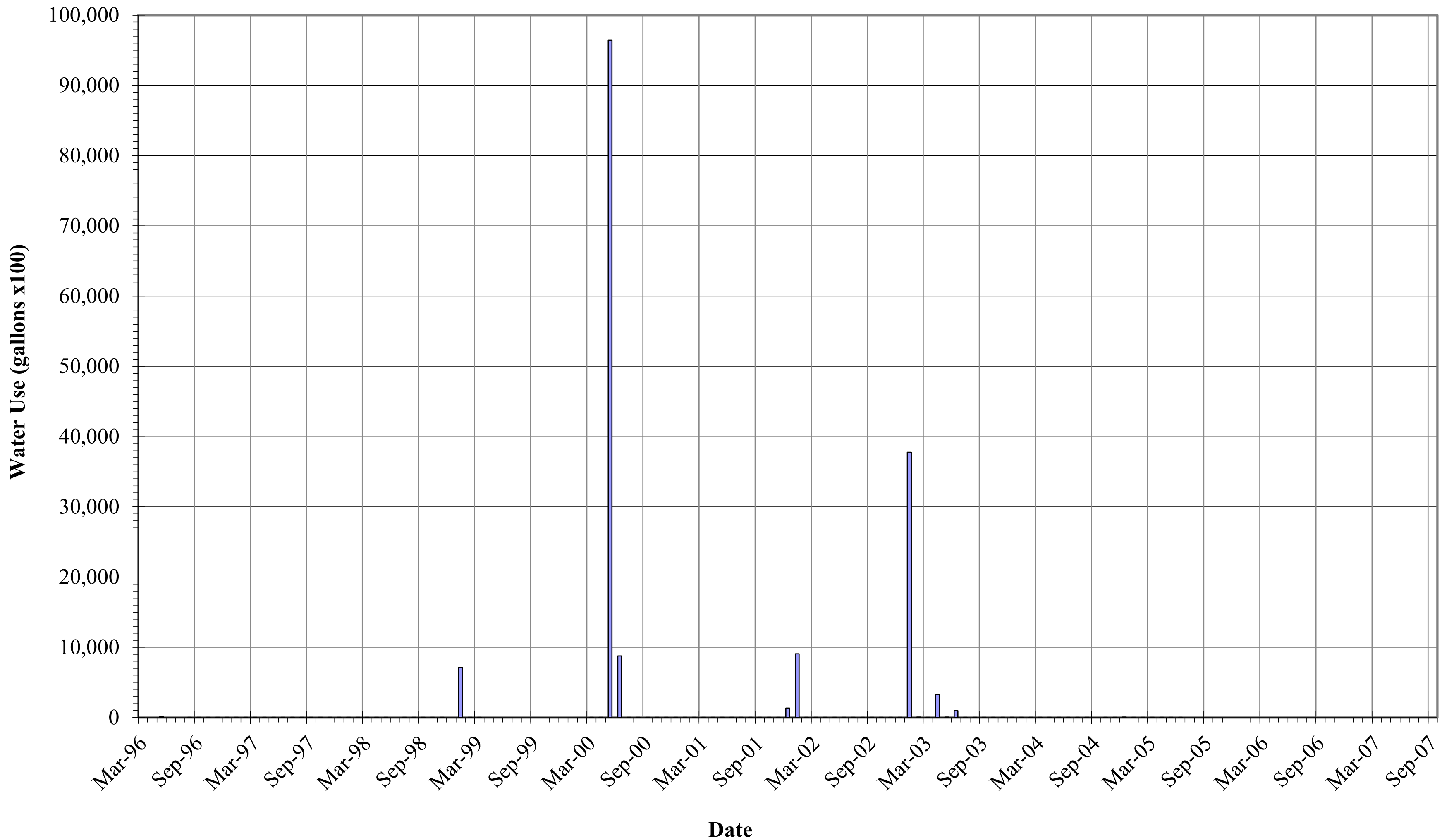


Figure F-36. NRCS 29-11

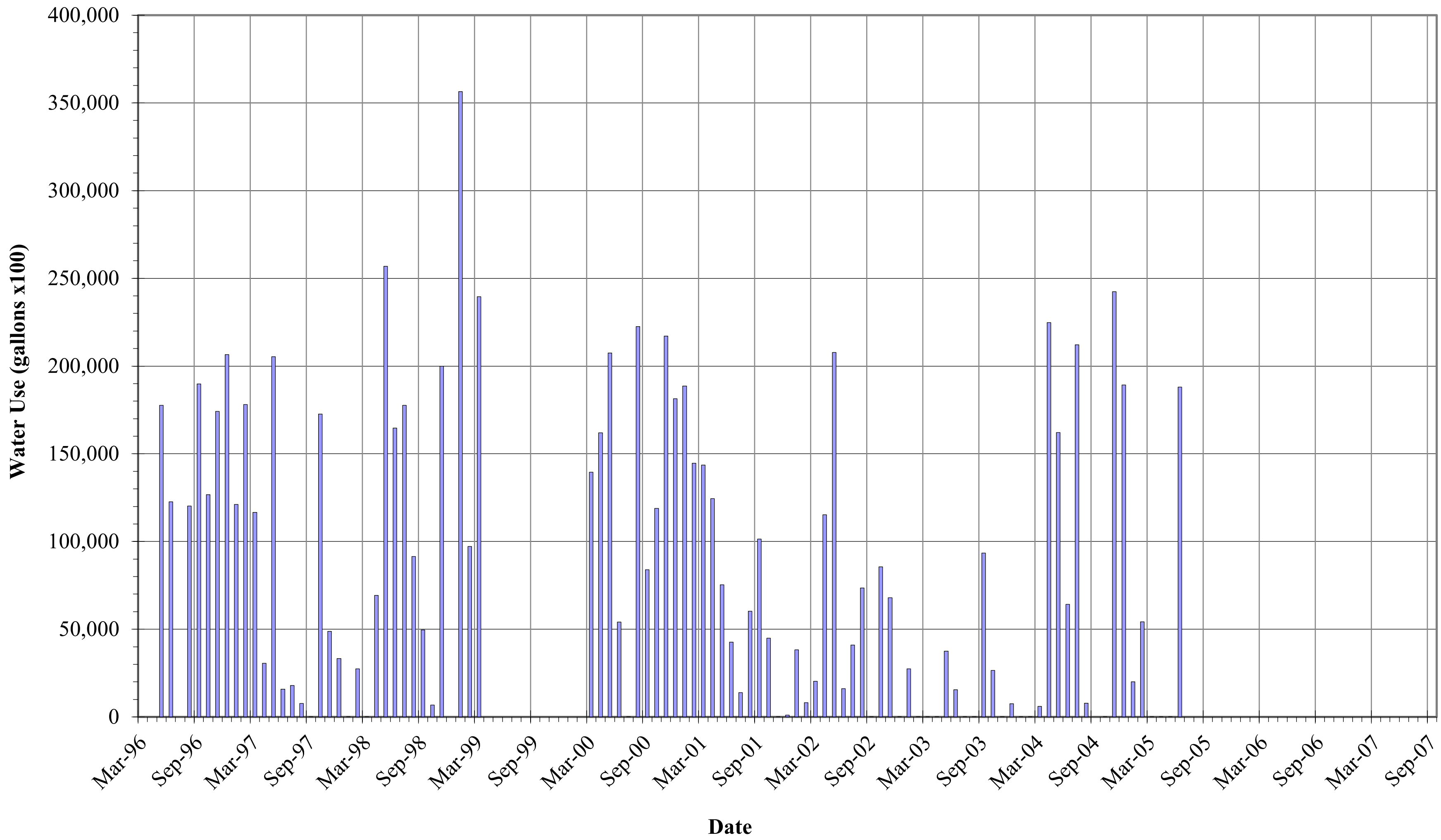


Figure F-37. NRCS 29-12

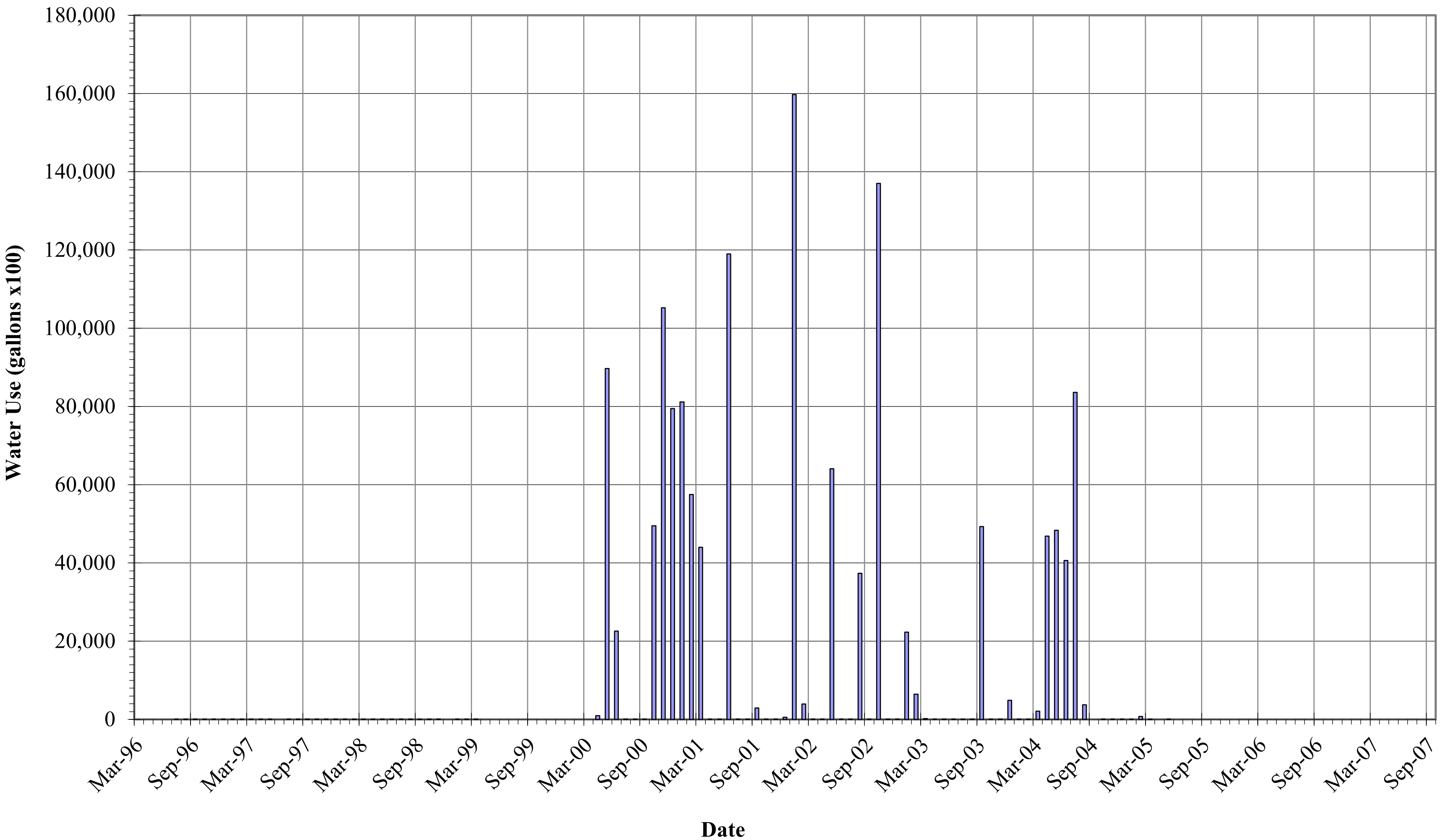


Figure F-38. NRCS 29-13

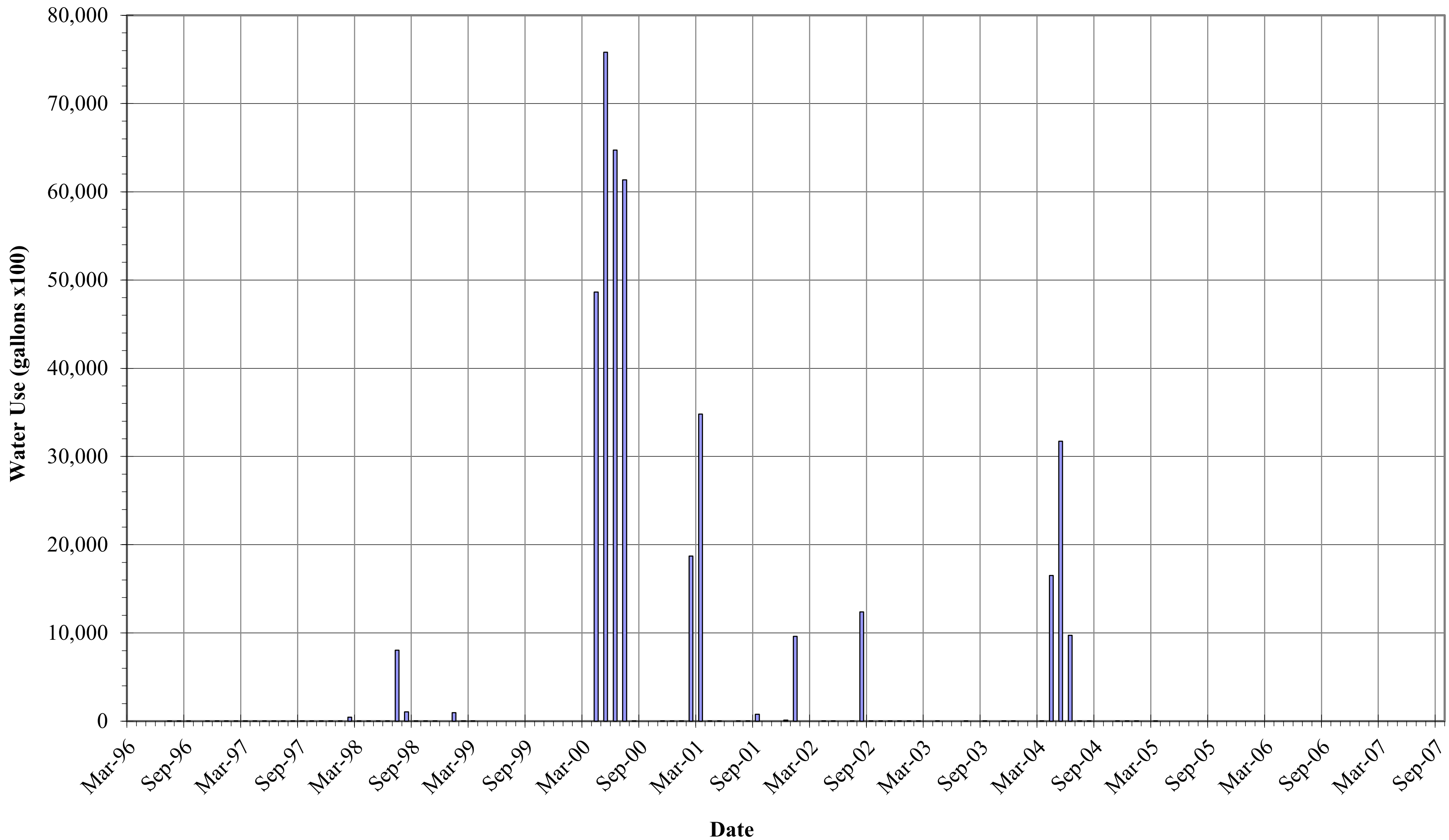


Figure F-39. NRCS 29-14

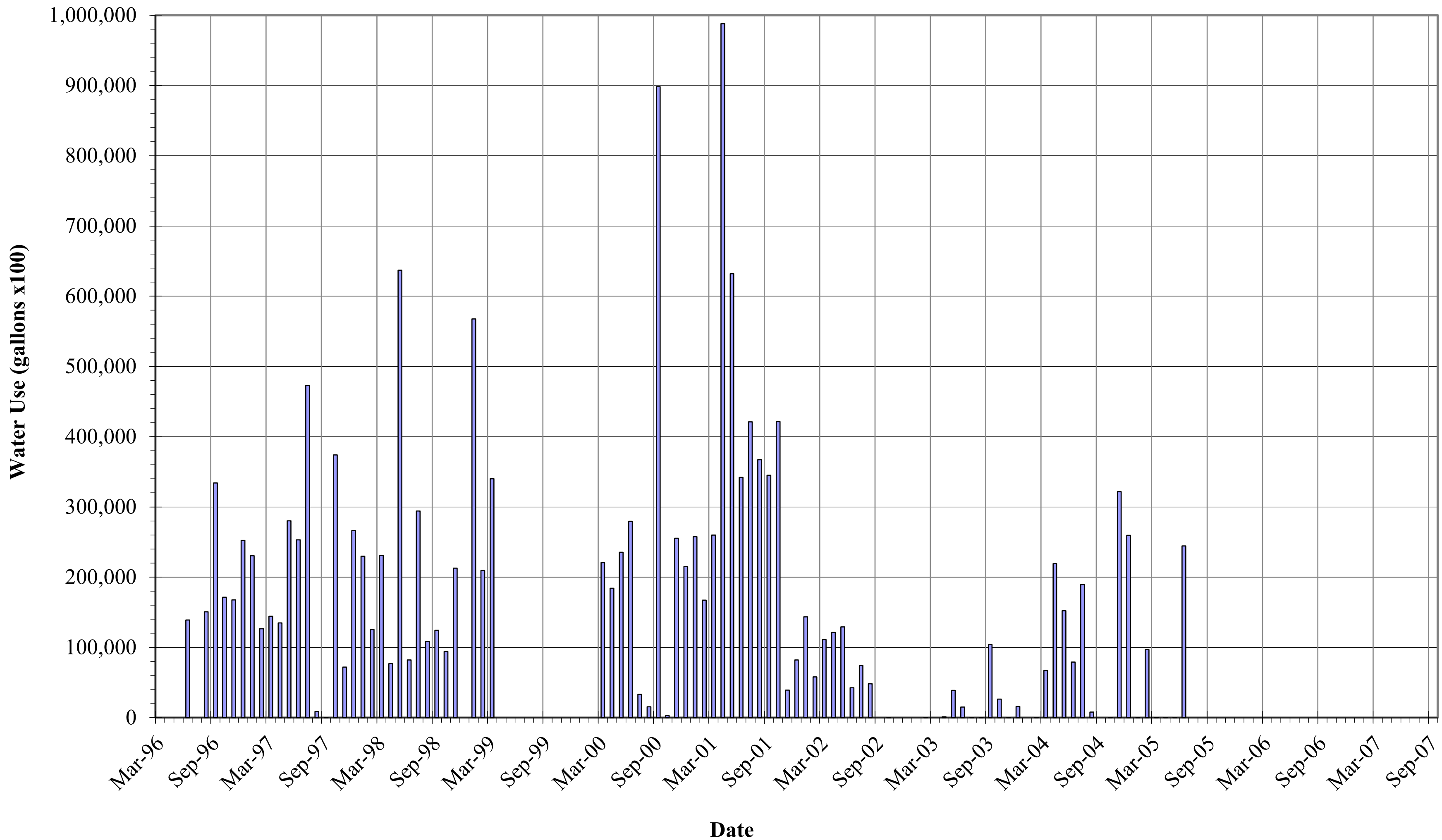


Figure F-40. NRCS 29-15

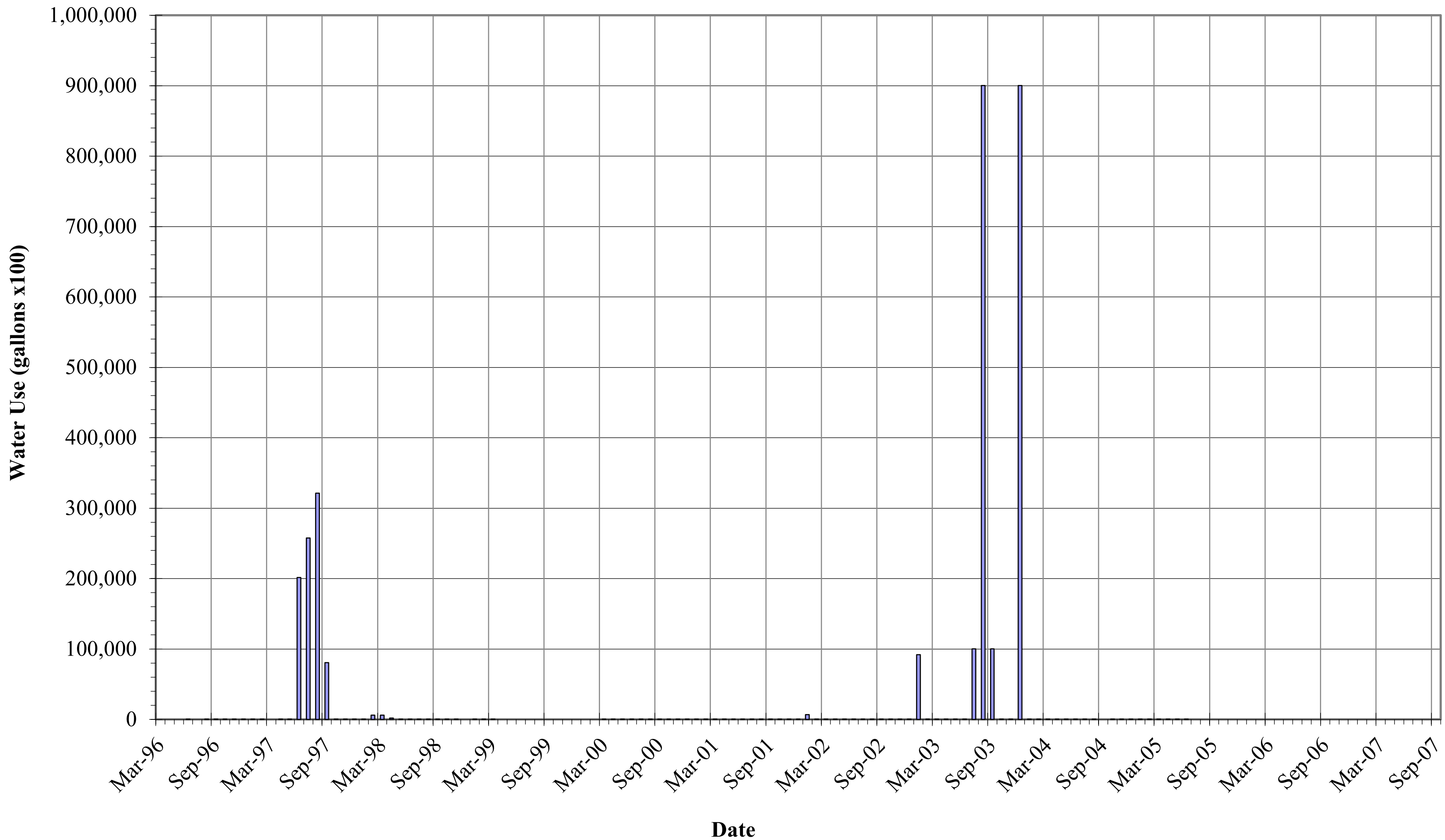


Figure F-41. NRCS 35-1

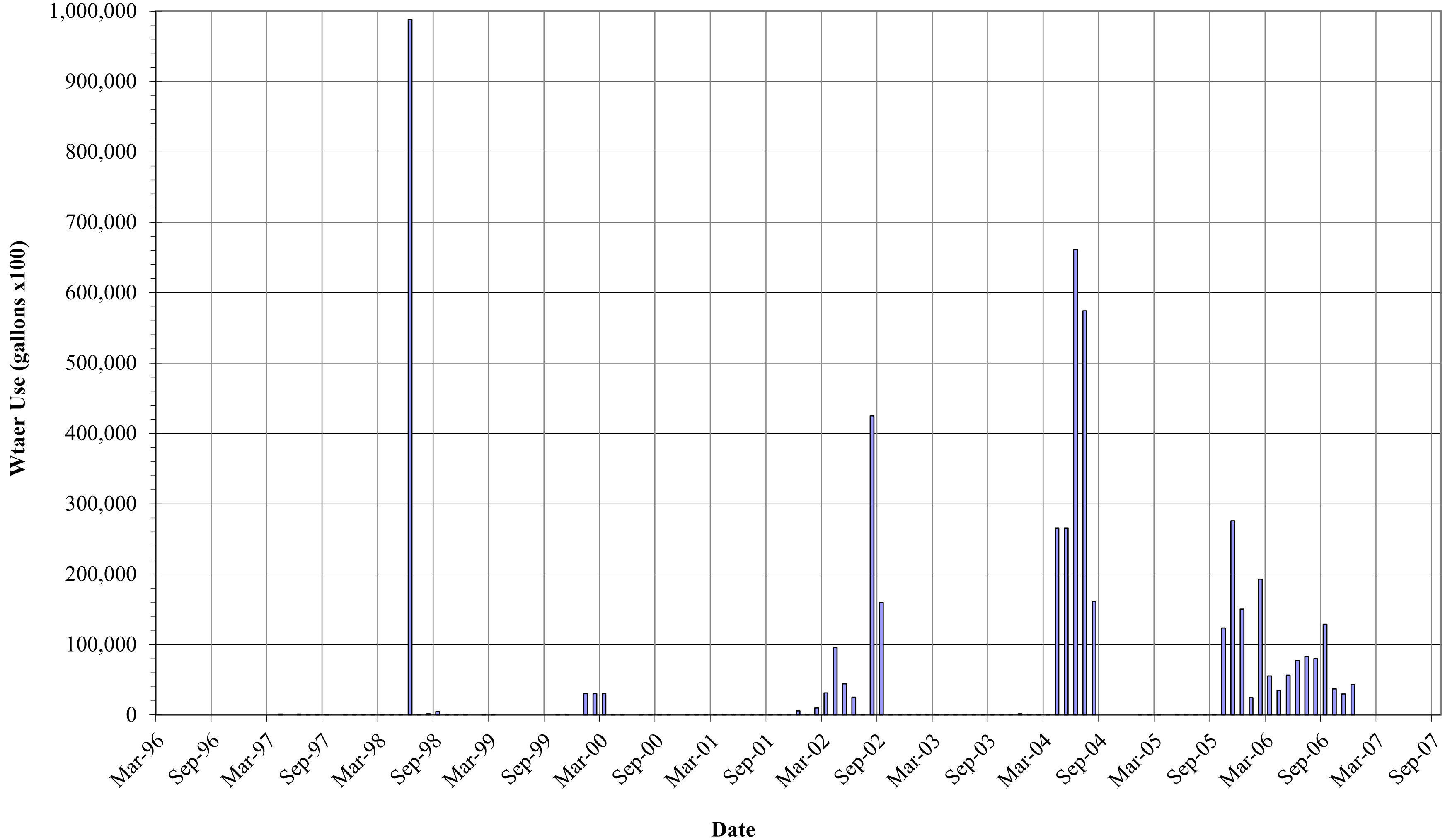


Figure F-42. NRCS 35-2

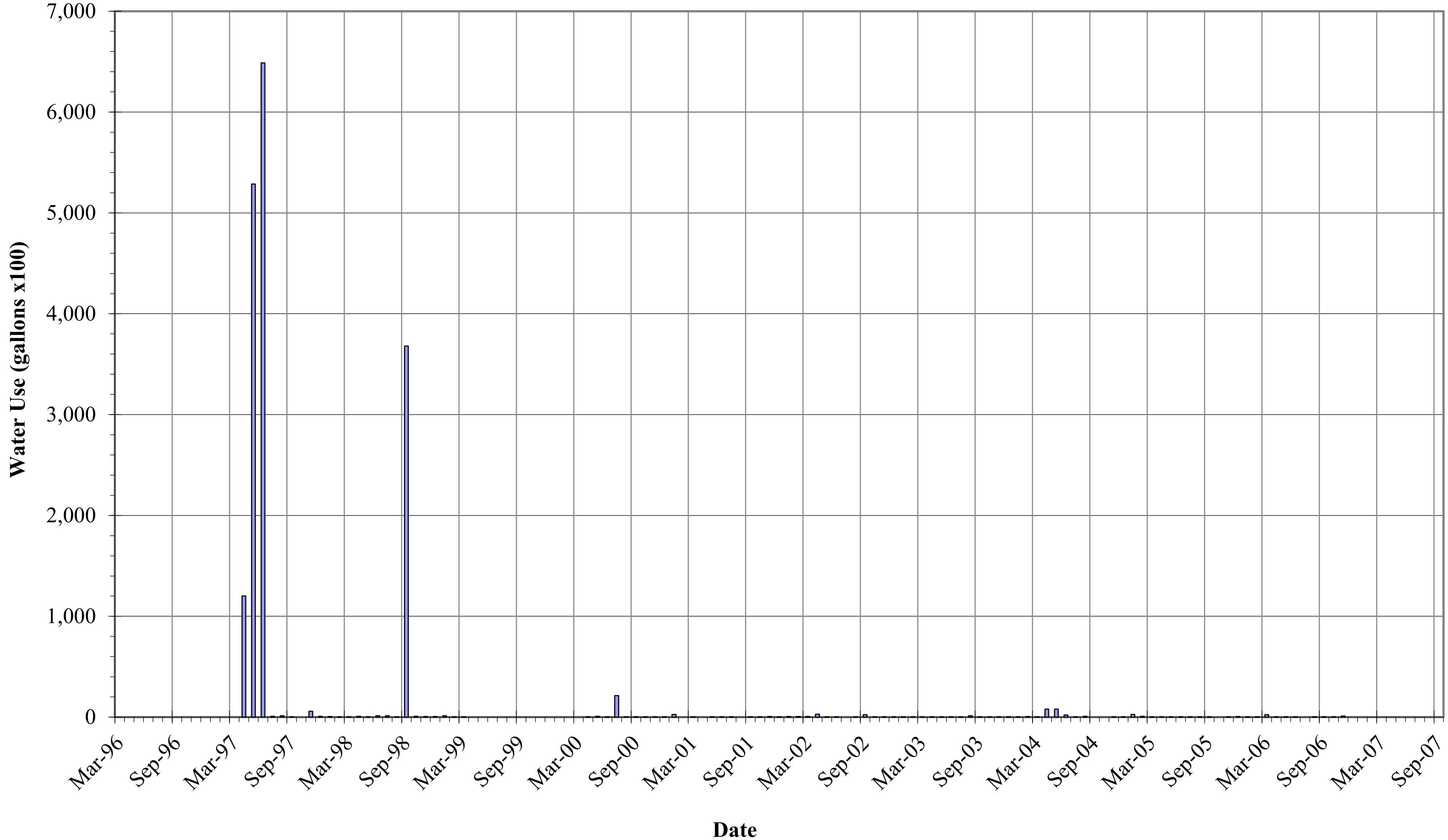


Figure F-43. NRCS 36-1

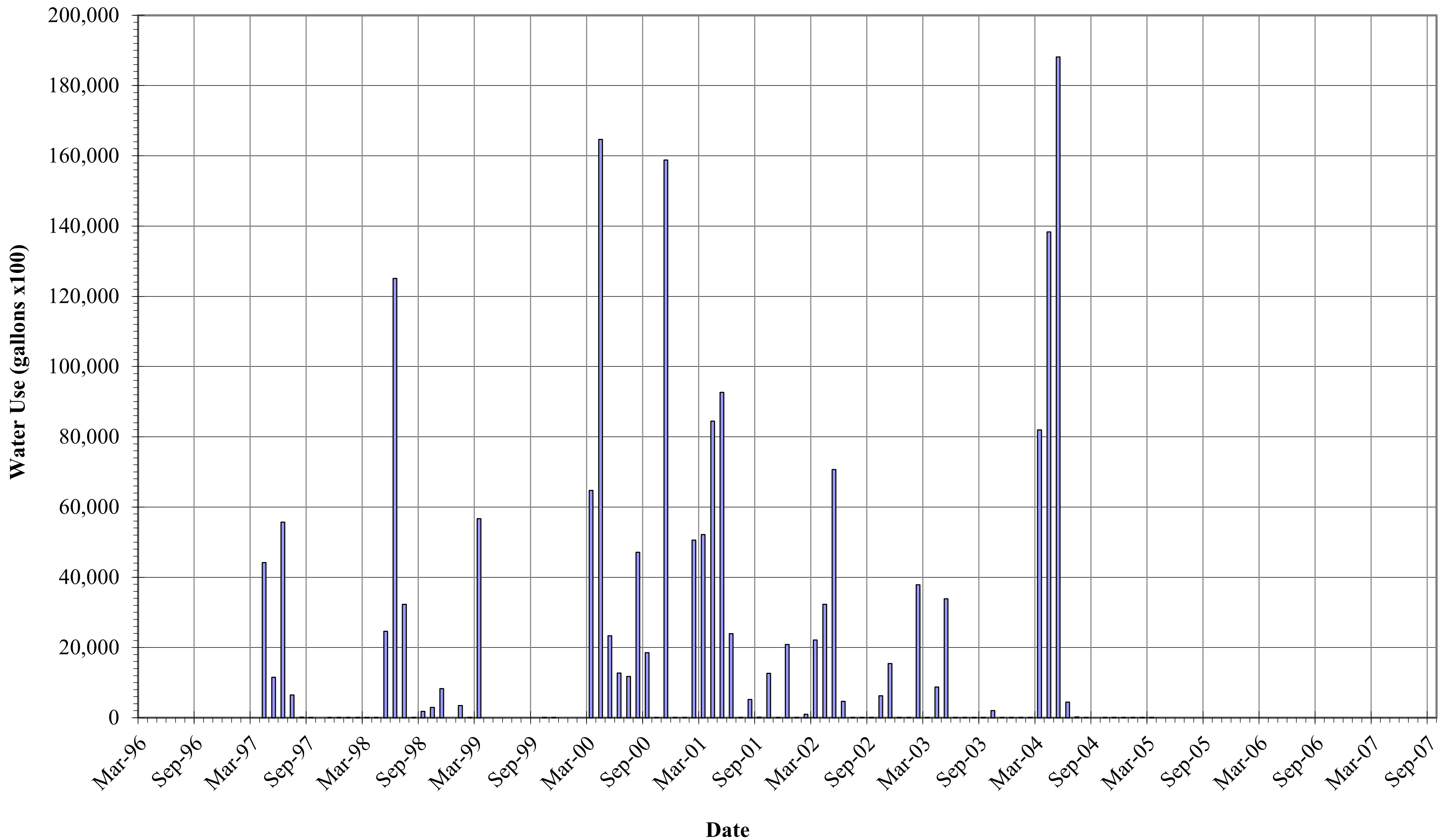


Figure F-44. NRCS 36-2

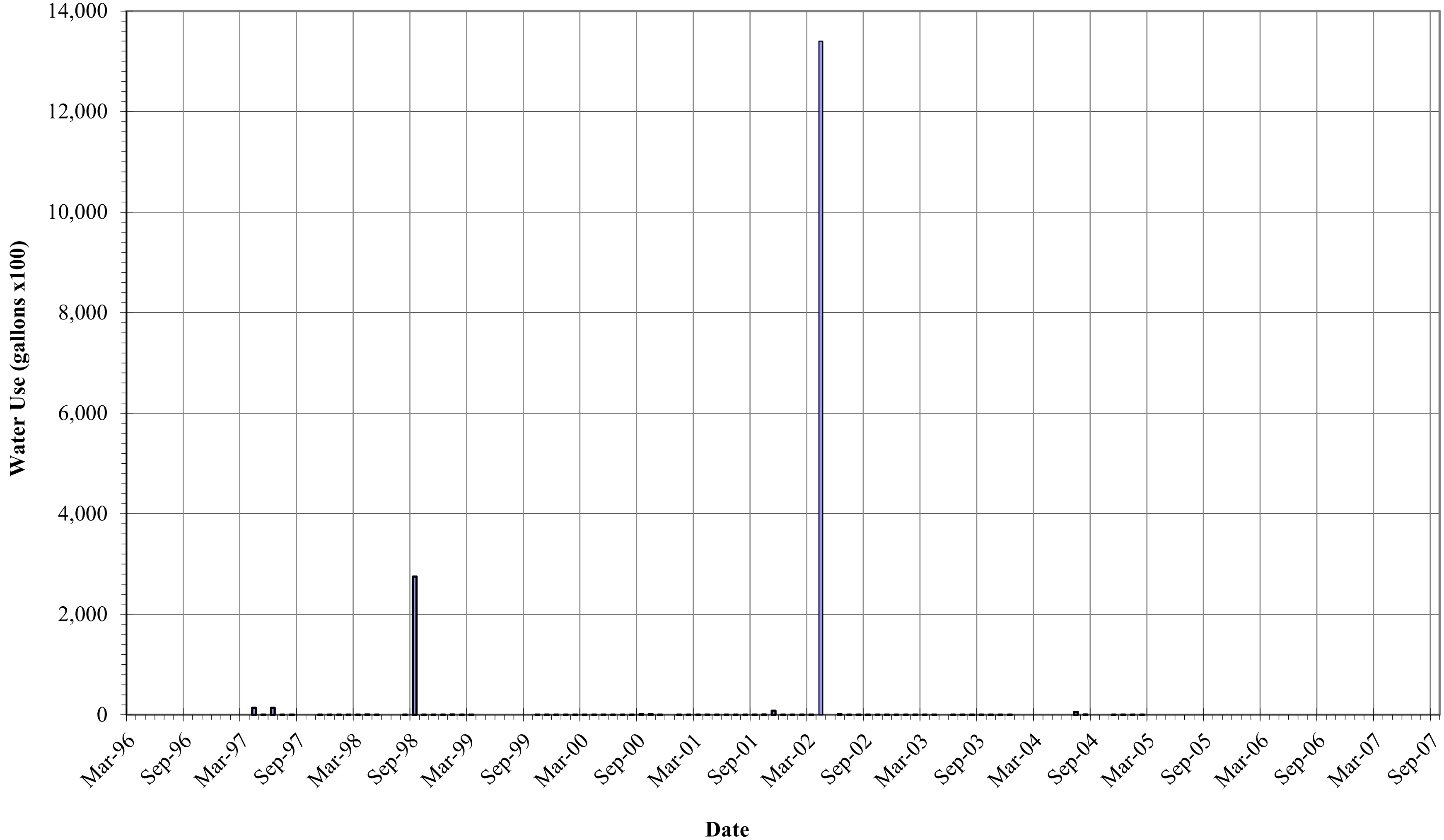


Figure F-45. NRCS 121-1

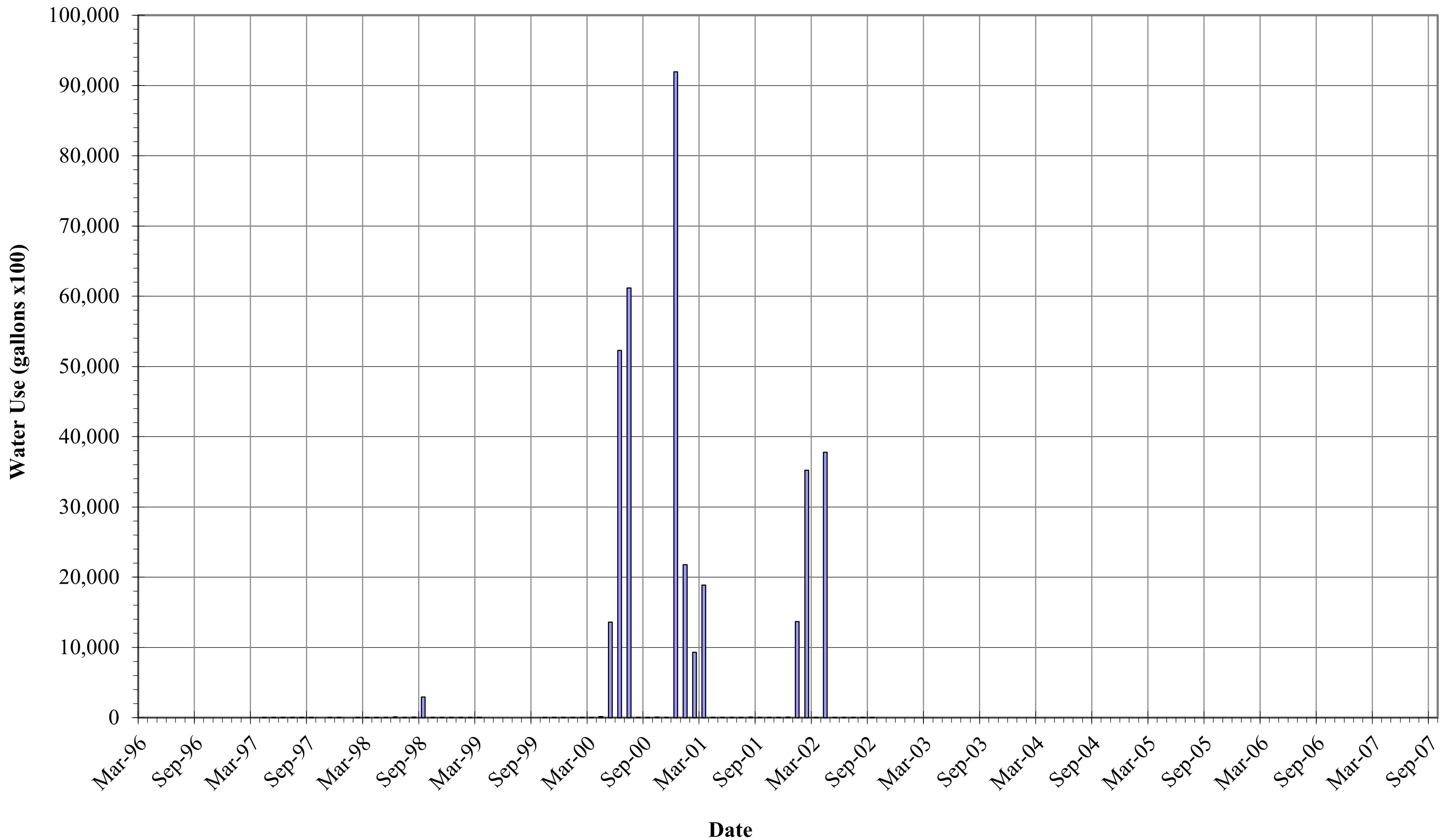


Figure F-46. NRCS 201-1

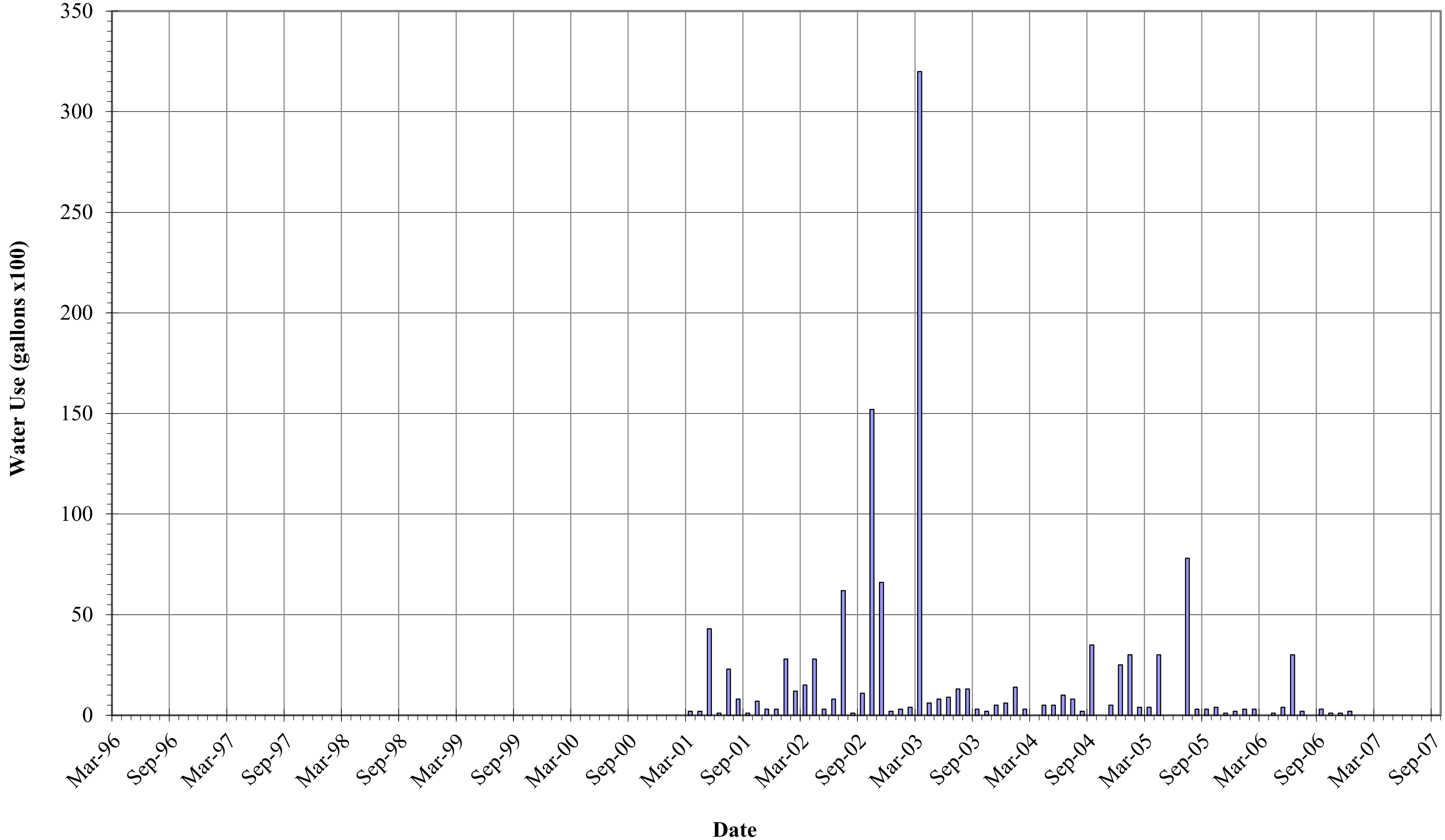


Figure F-47. NRCS 202-1

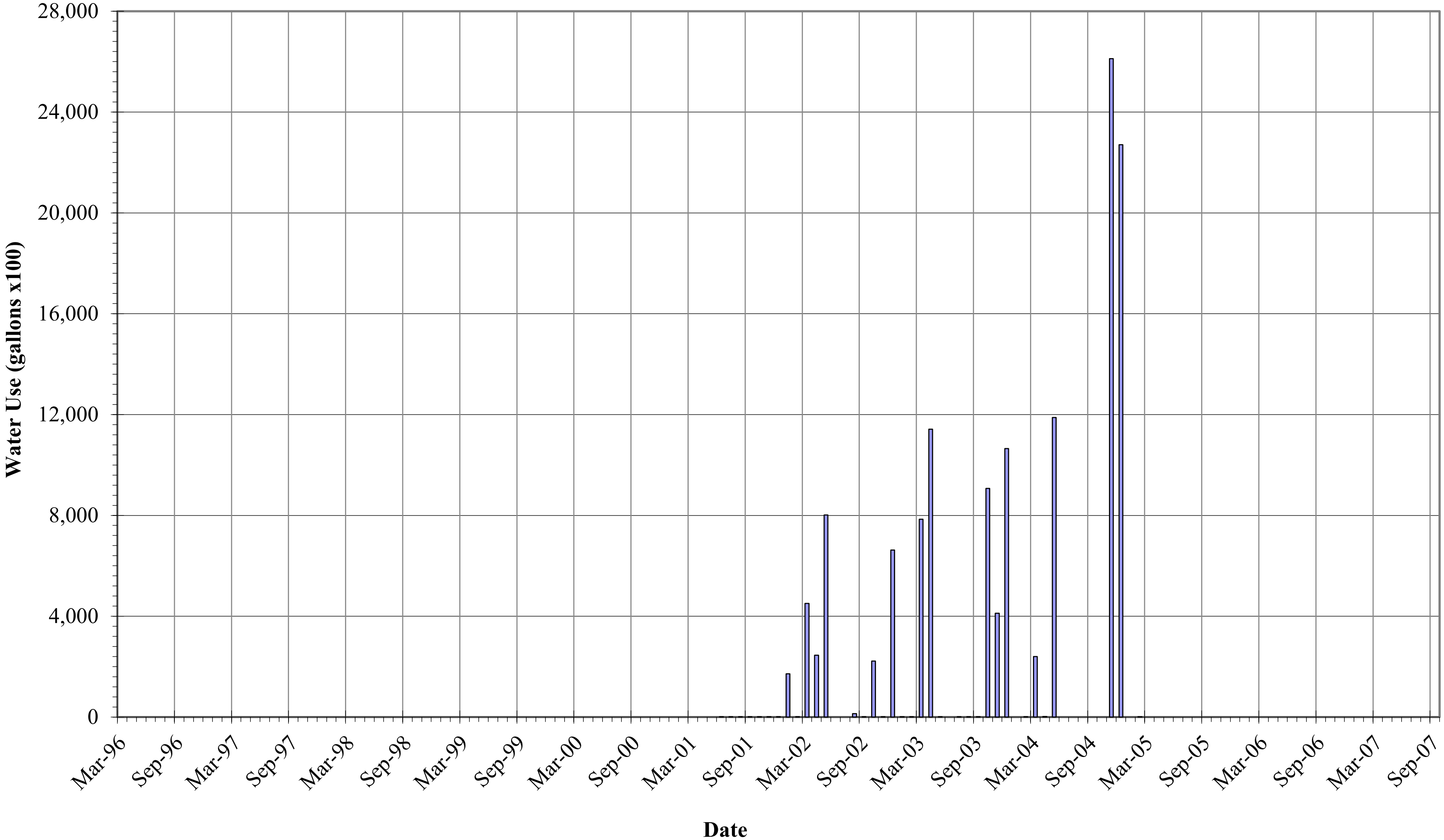


Figure F-48. NRCS 202-2

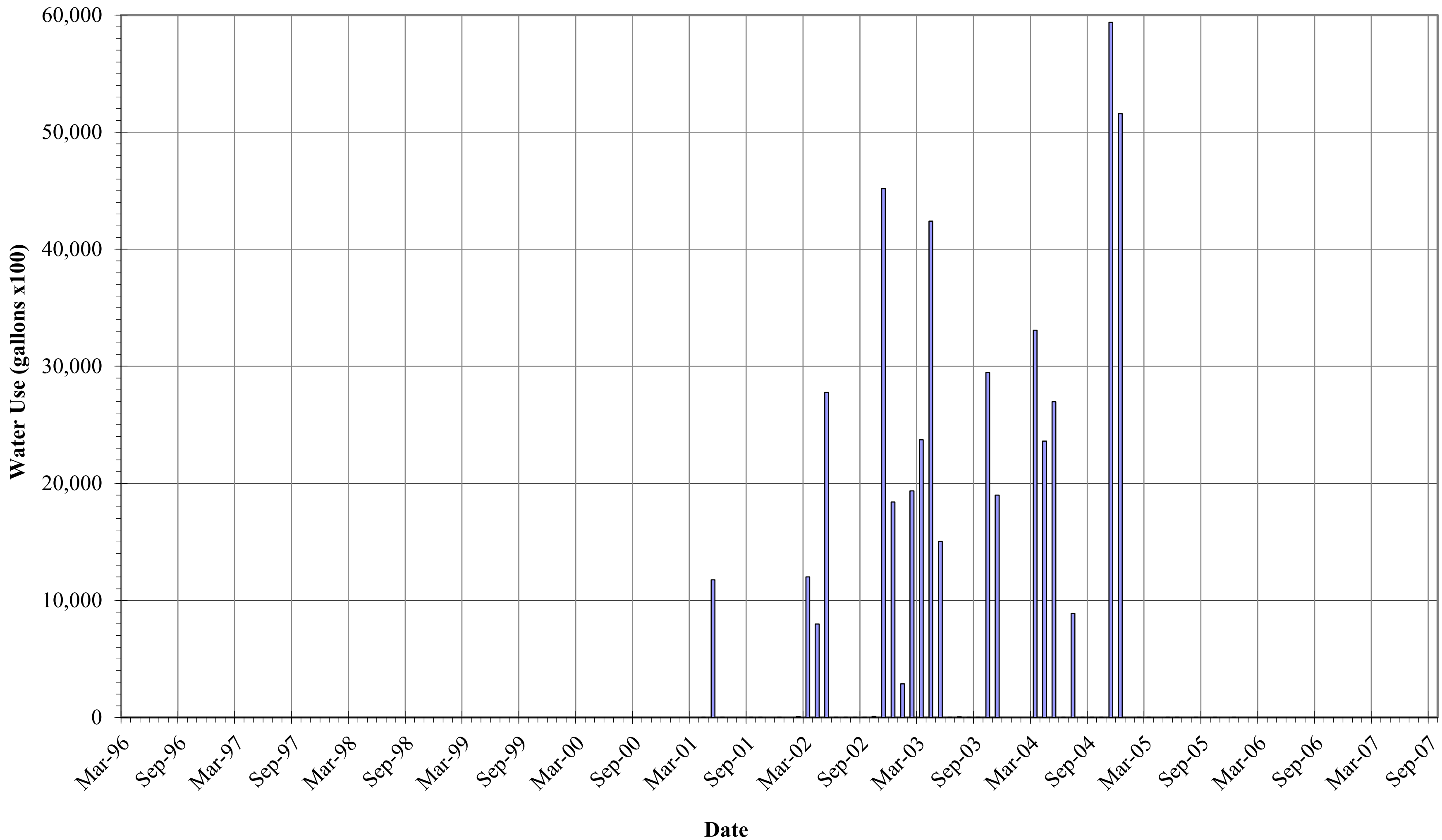


Figure F-49. NRCS 203-1

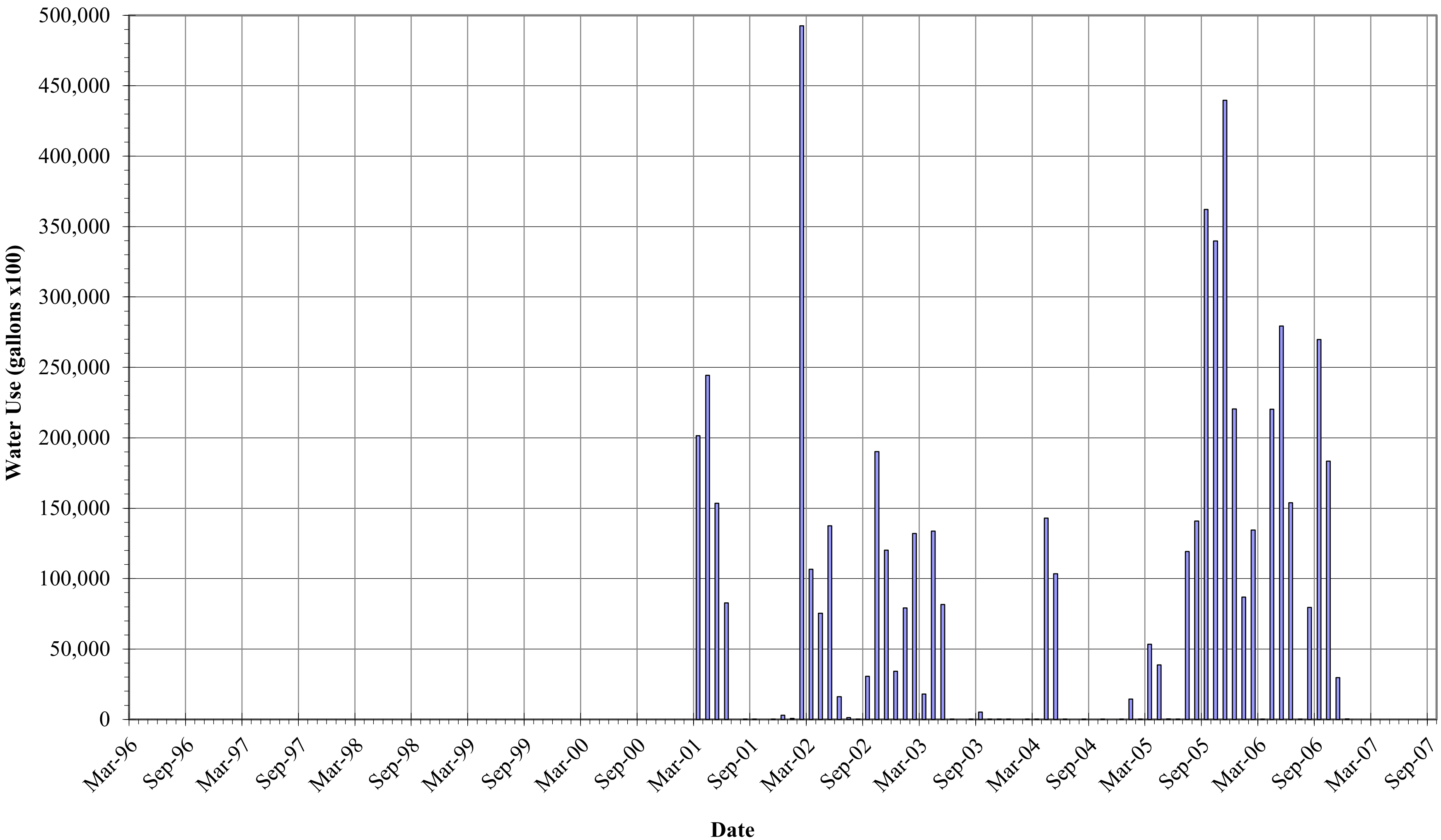


Figure F-50. NRCS 204-1

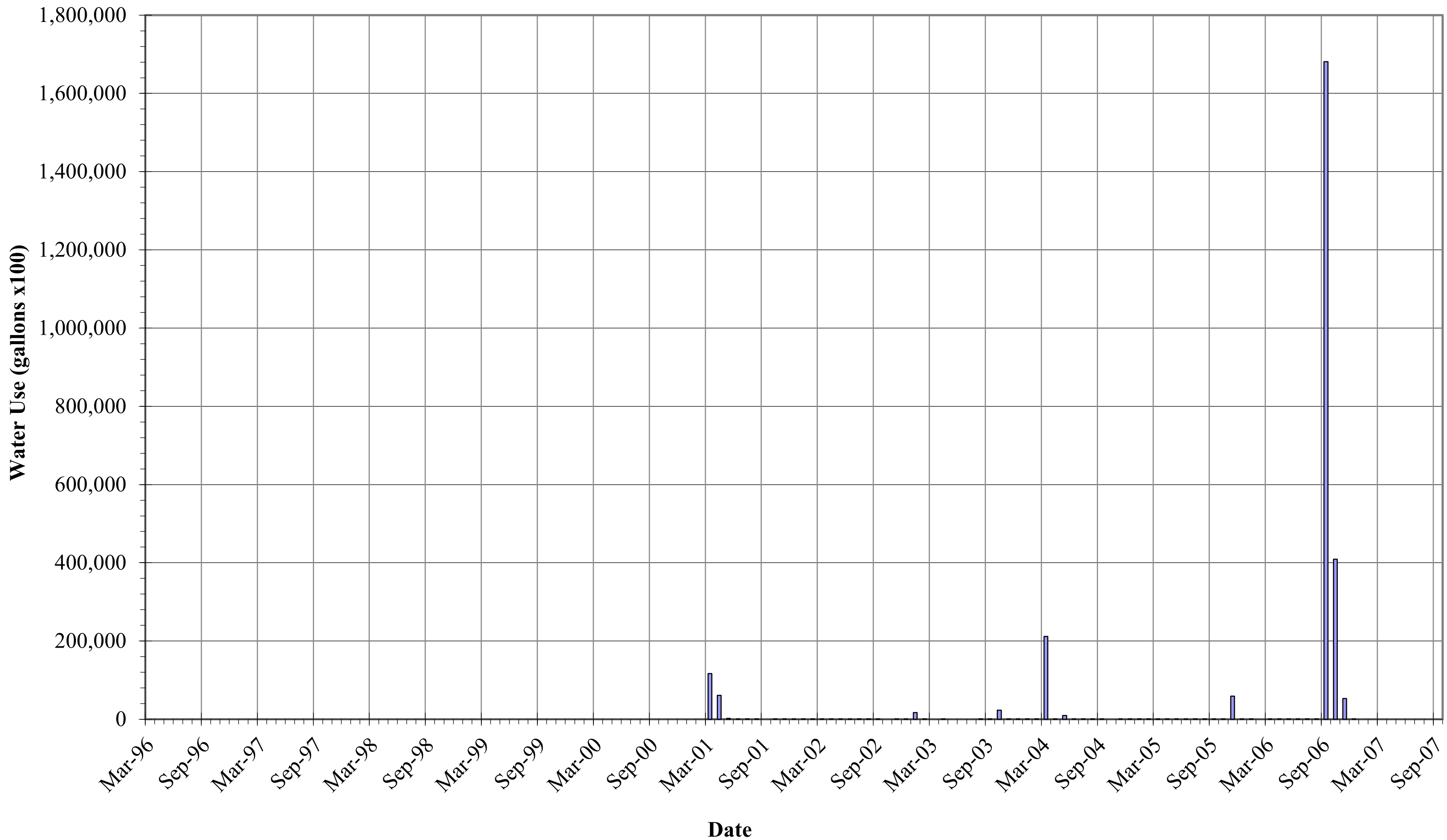


Figure F-51. NRCS 204-2

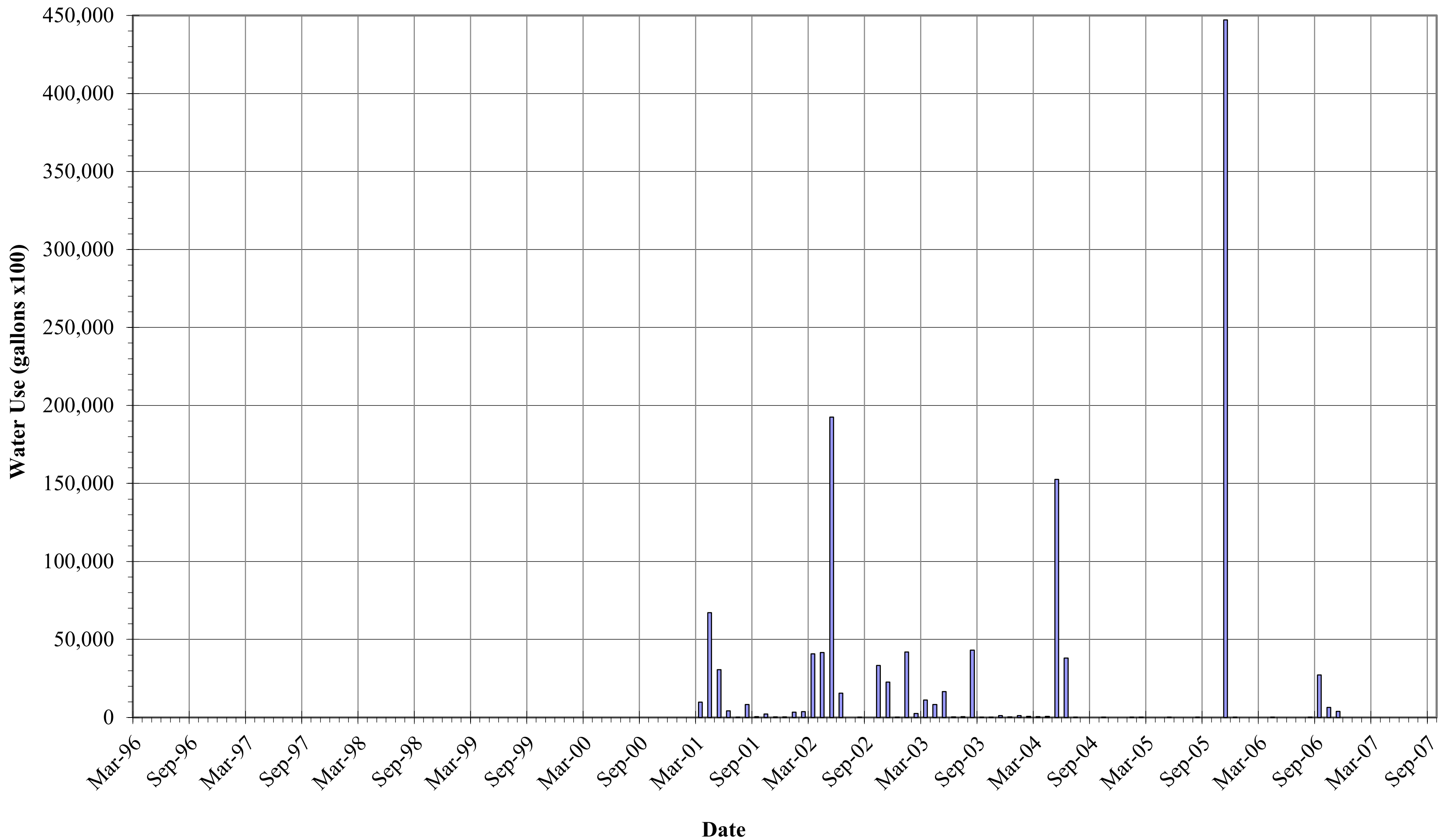


Figure F-52. NRCS 204-3

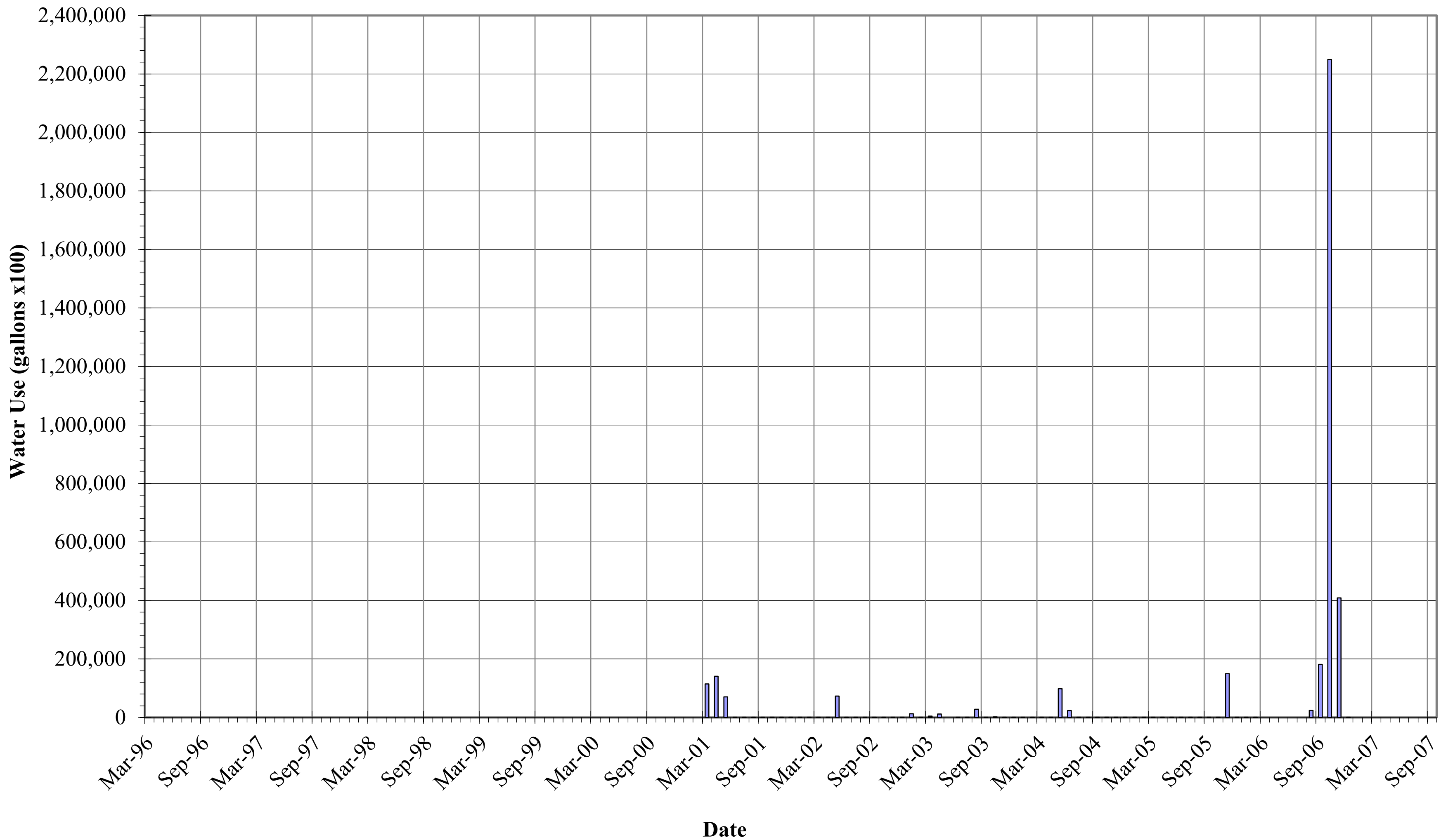


Figure F-53. NRCS 204-4

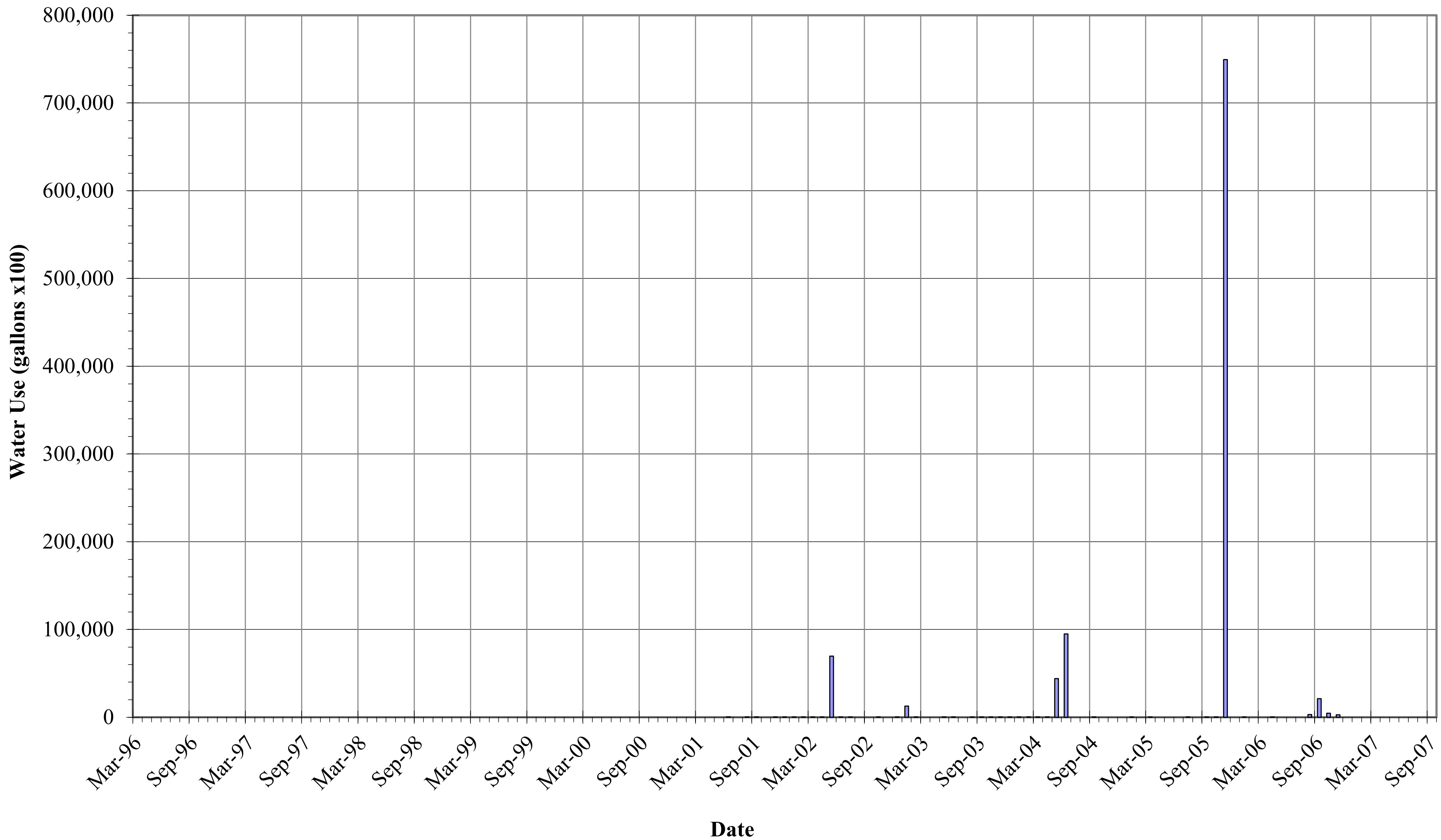


Figure F-54. NRCS 205-1

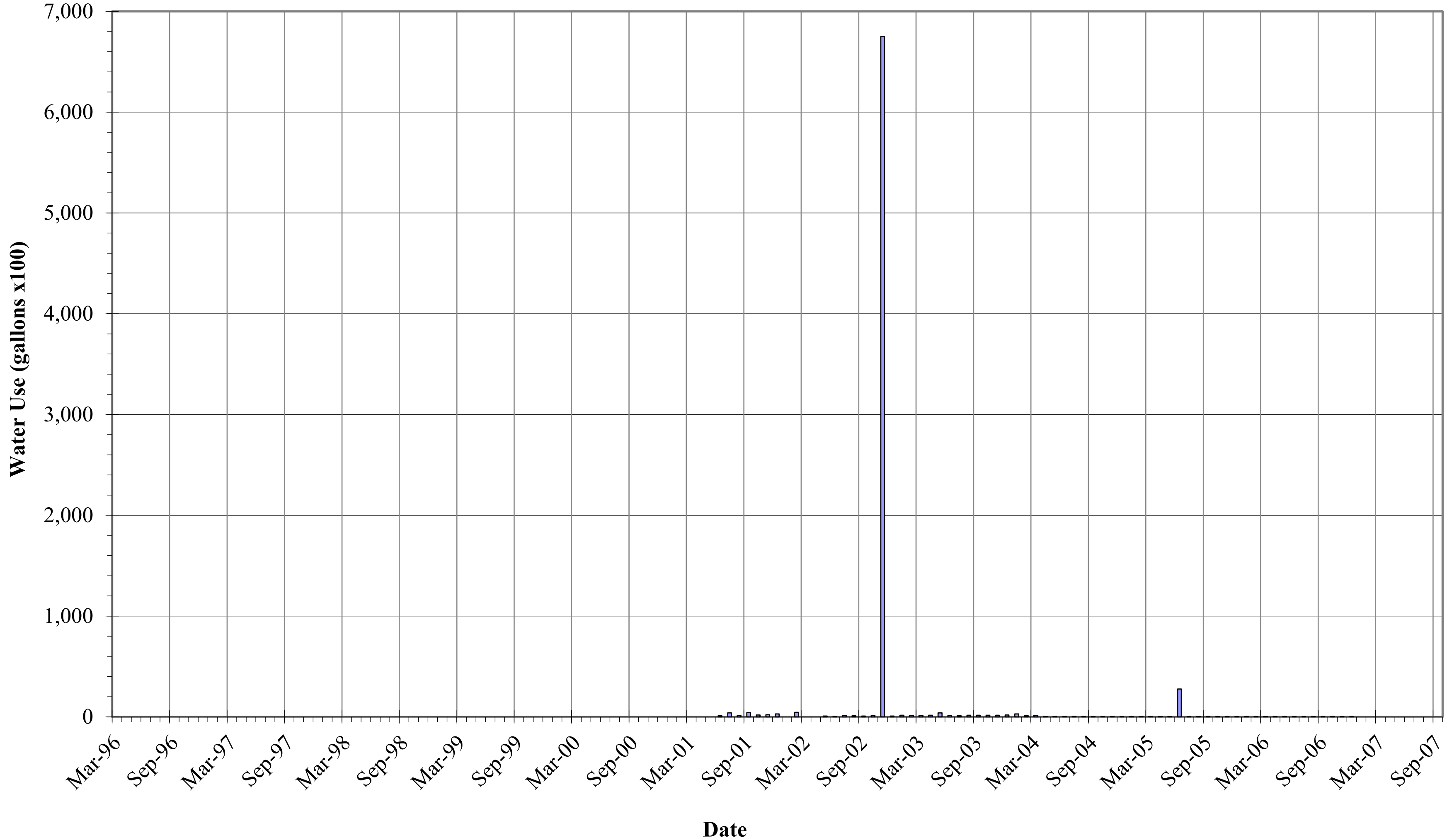


Figure F-55. NRCS 205-2

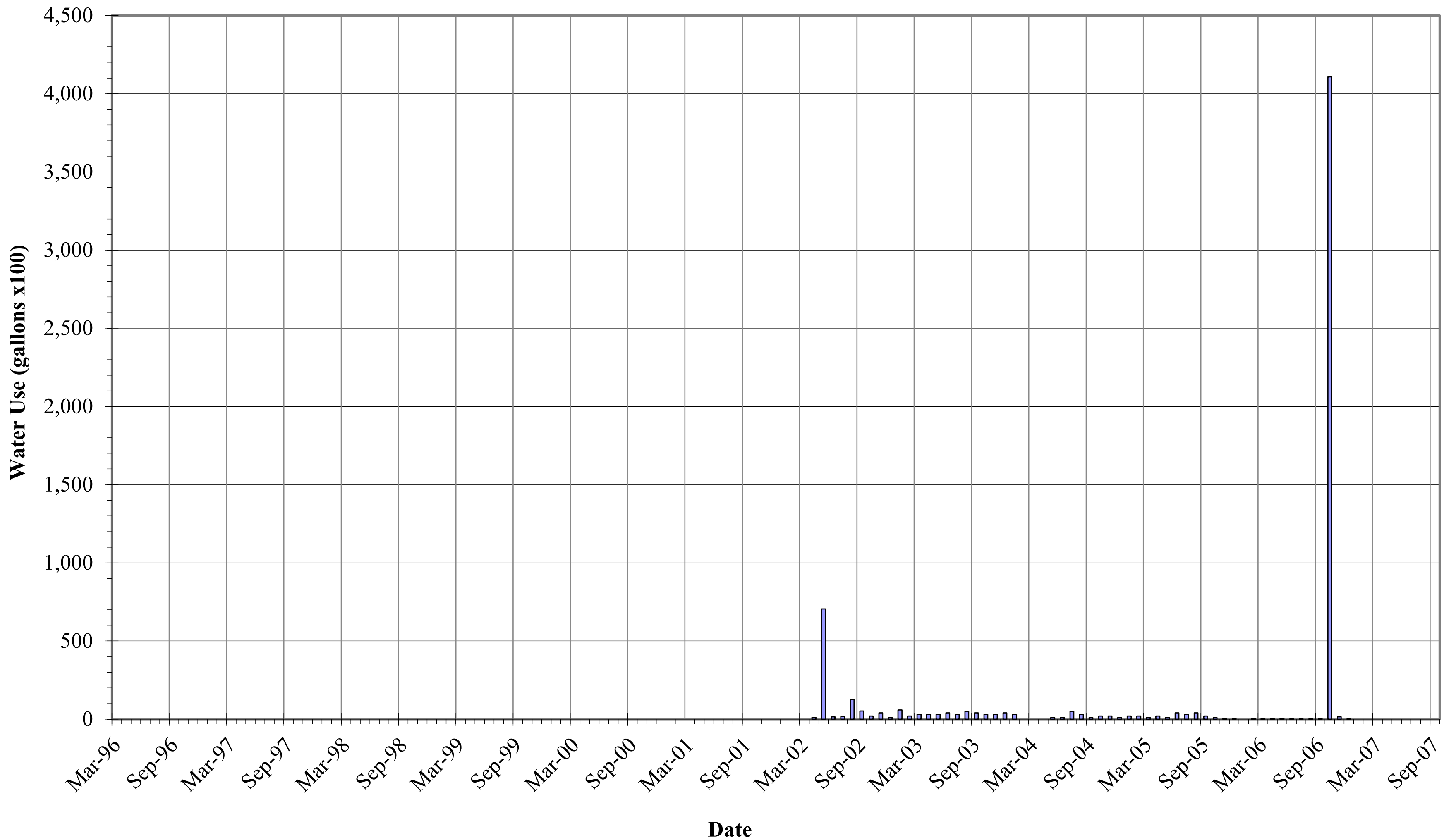


Figure F-56. NRCS 205-3

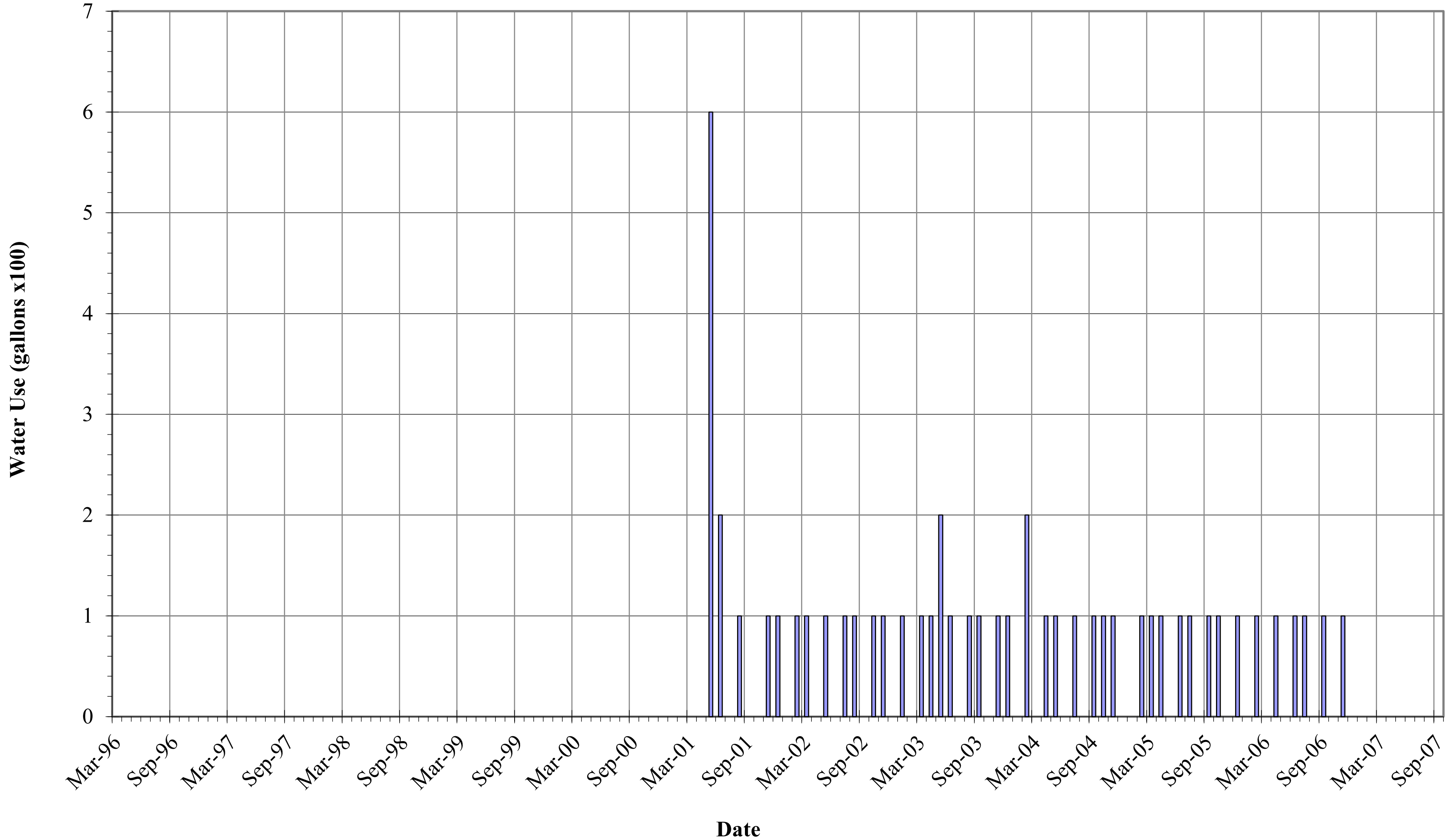


Figure F-57. NRCS 205-4

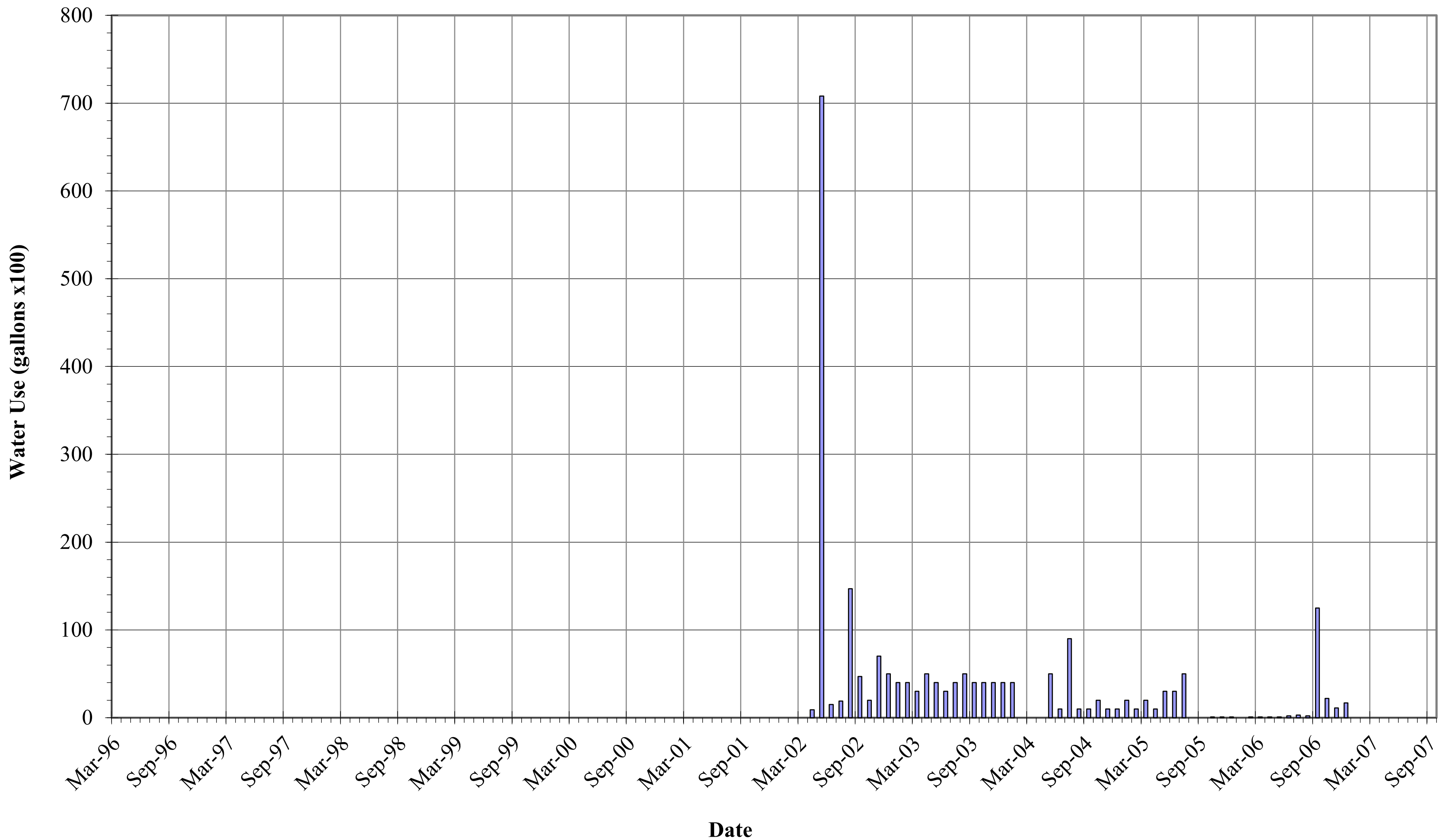


Figure F-58. NRCS 205-5

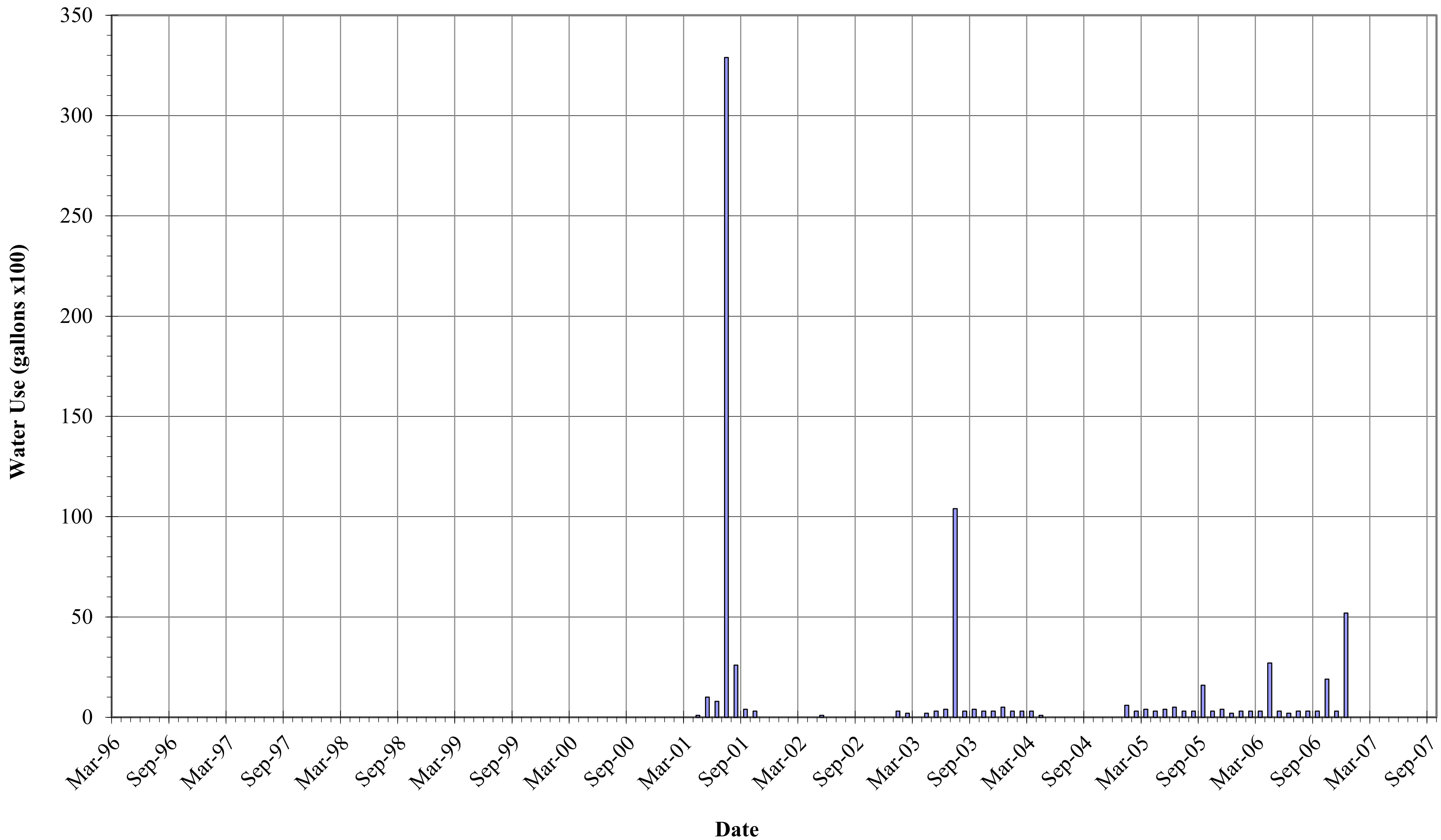


Figure F-59. NRCS 205-6

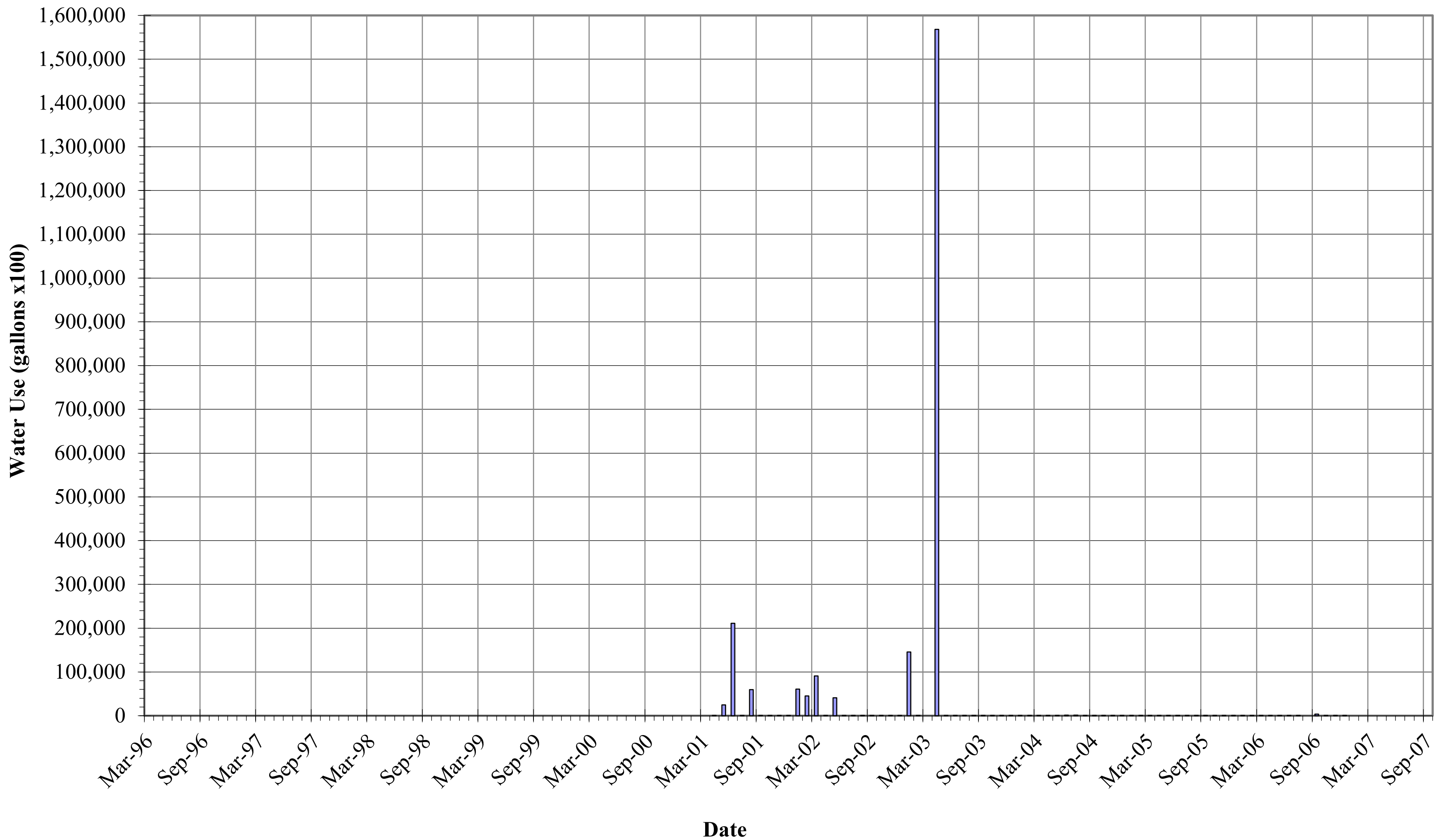
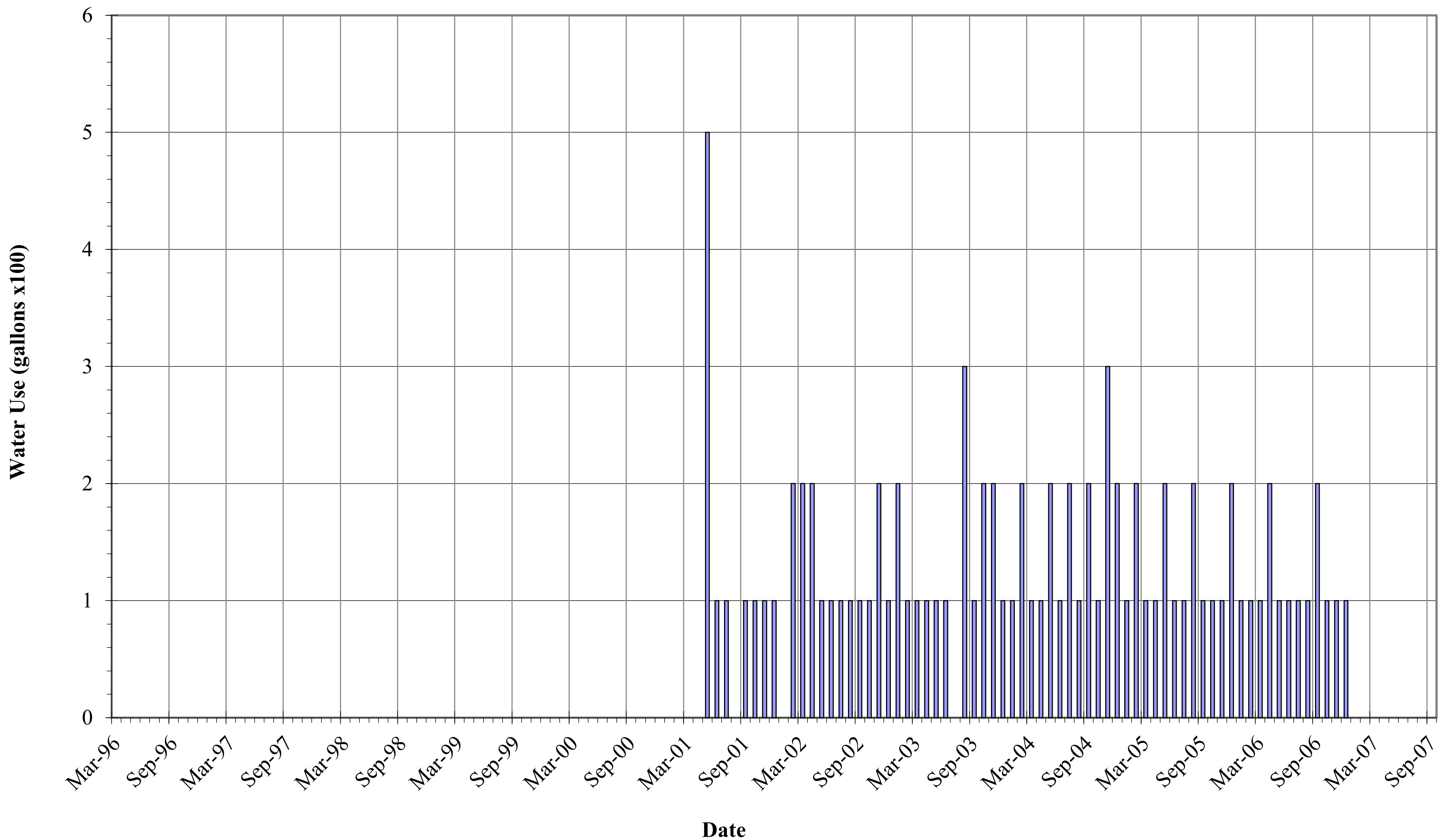


Figure F-60. NRCS 205-7



APPENDIX G:
MONTHLY PRECIPITATION DATA

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Figure G-1. Monthly Rainfall Data - Grove 1

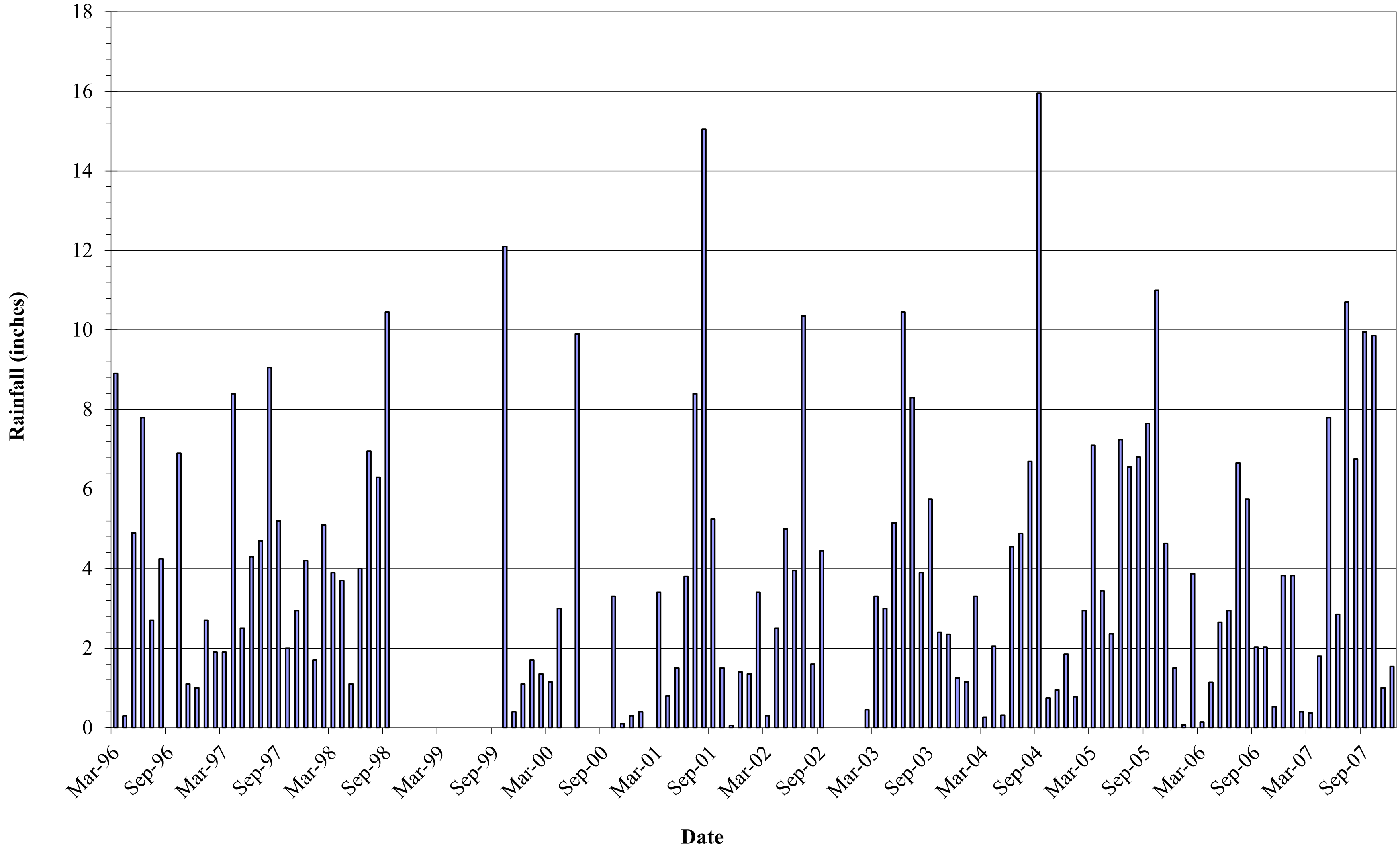

Figure G-2. Monthly Rainfall Data - Grove 2

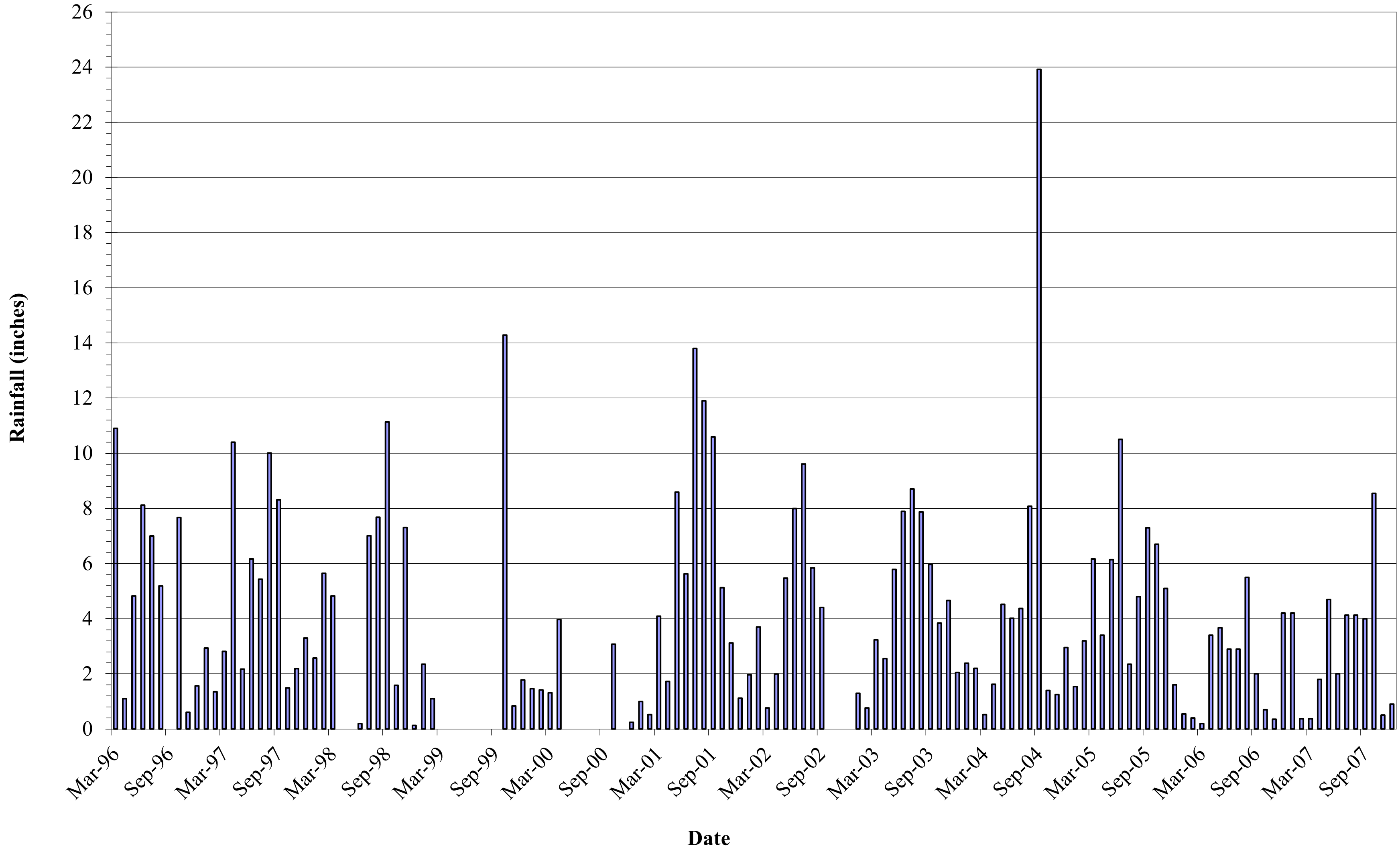

Figure G-3. Monthly Rainfall Data - Grove 3

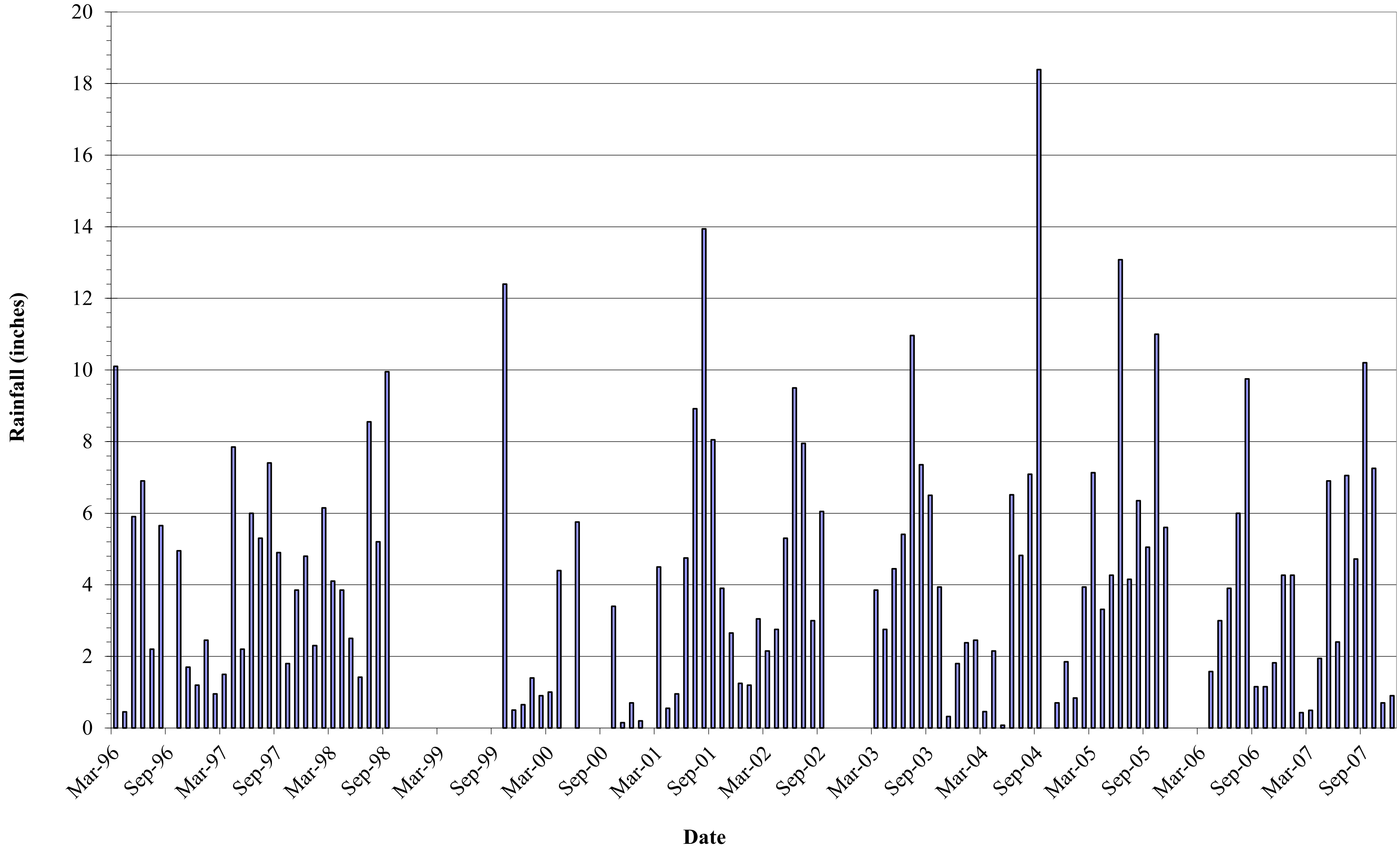

Figure G-4. Monthly Rainfall Data - Grove 4

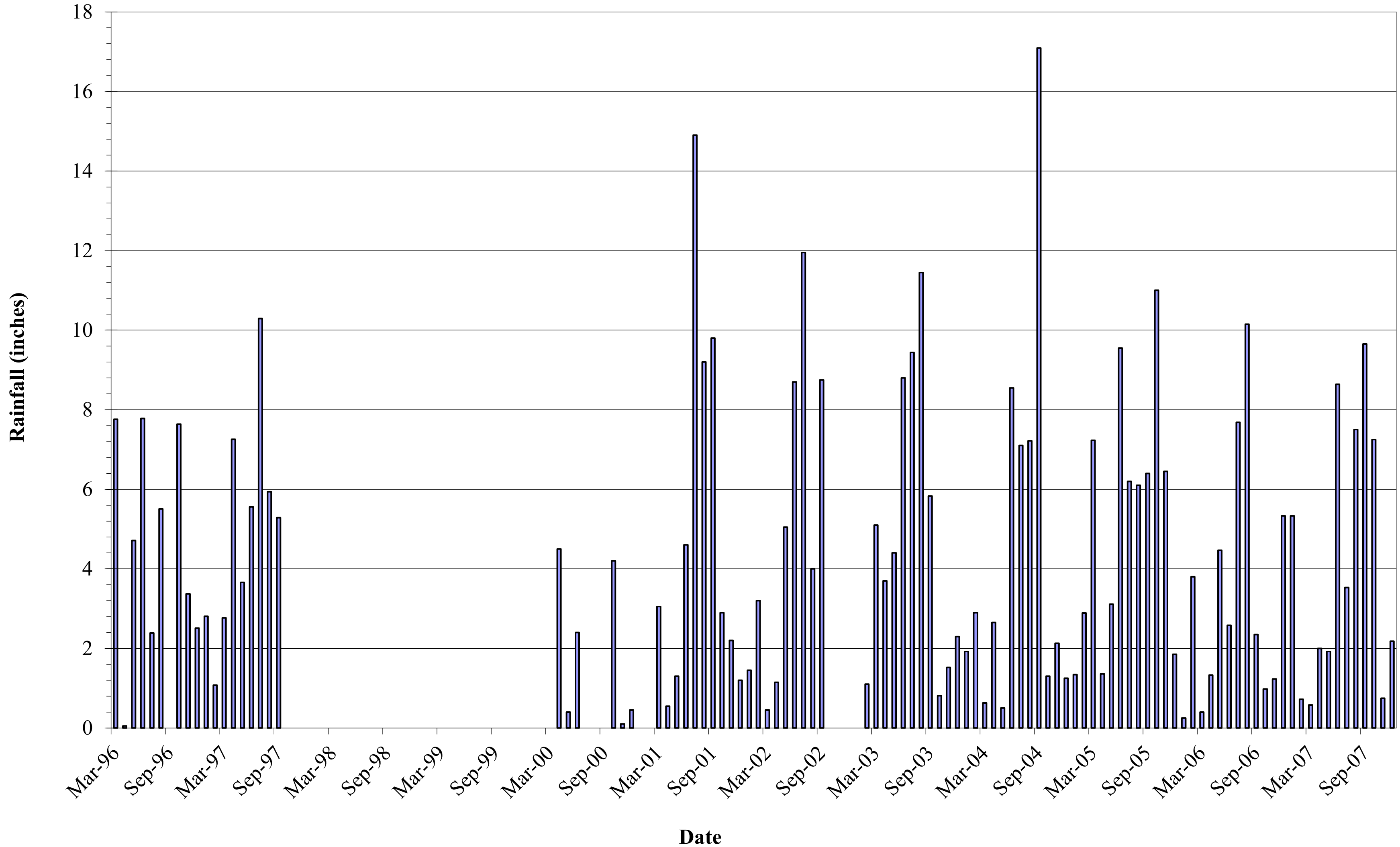

Figure G-5. Monthly Rainfall Data - Grove 5

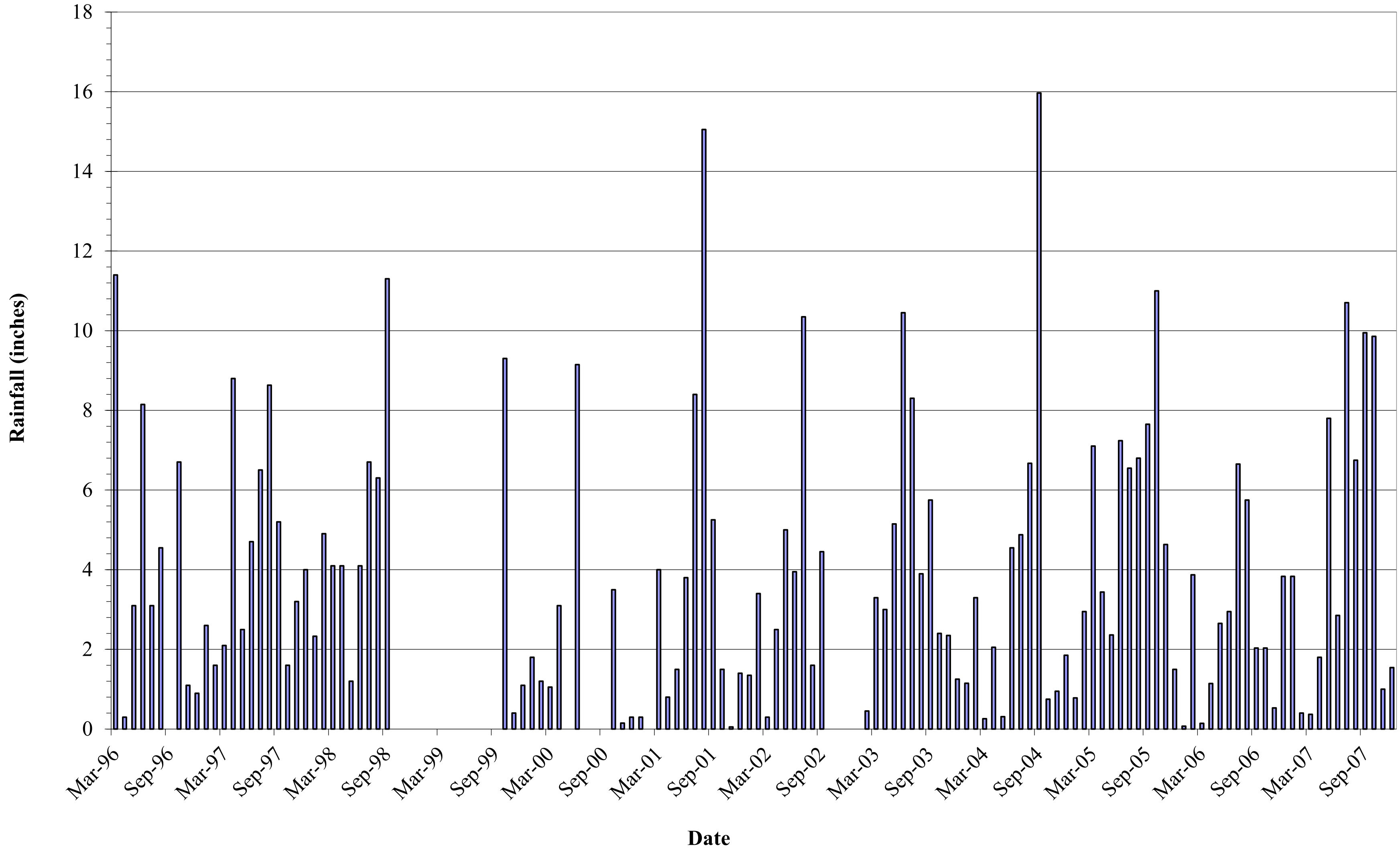

Figure G-6. Monthly Rainfall Data - Grove 6

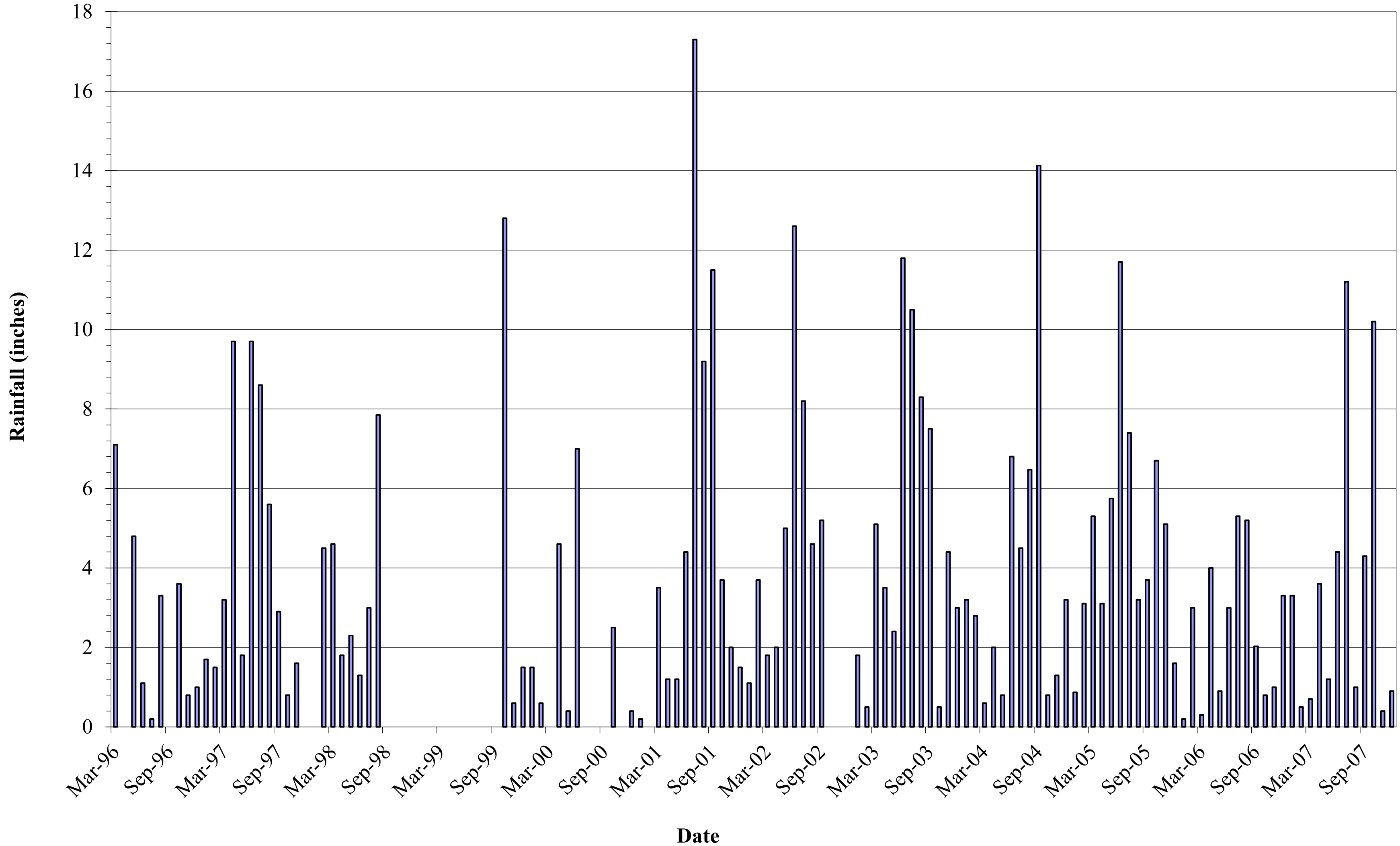

Figure G-7. Monthly Rainfall Data - Grove 7

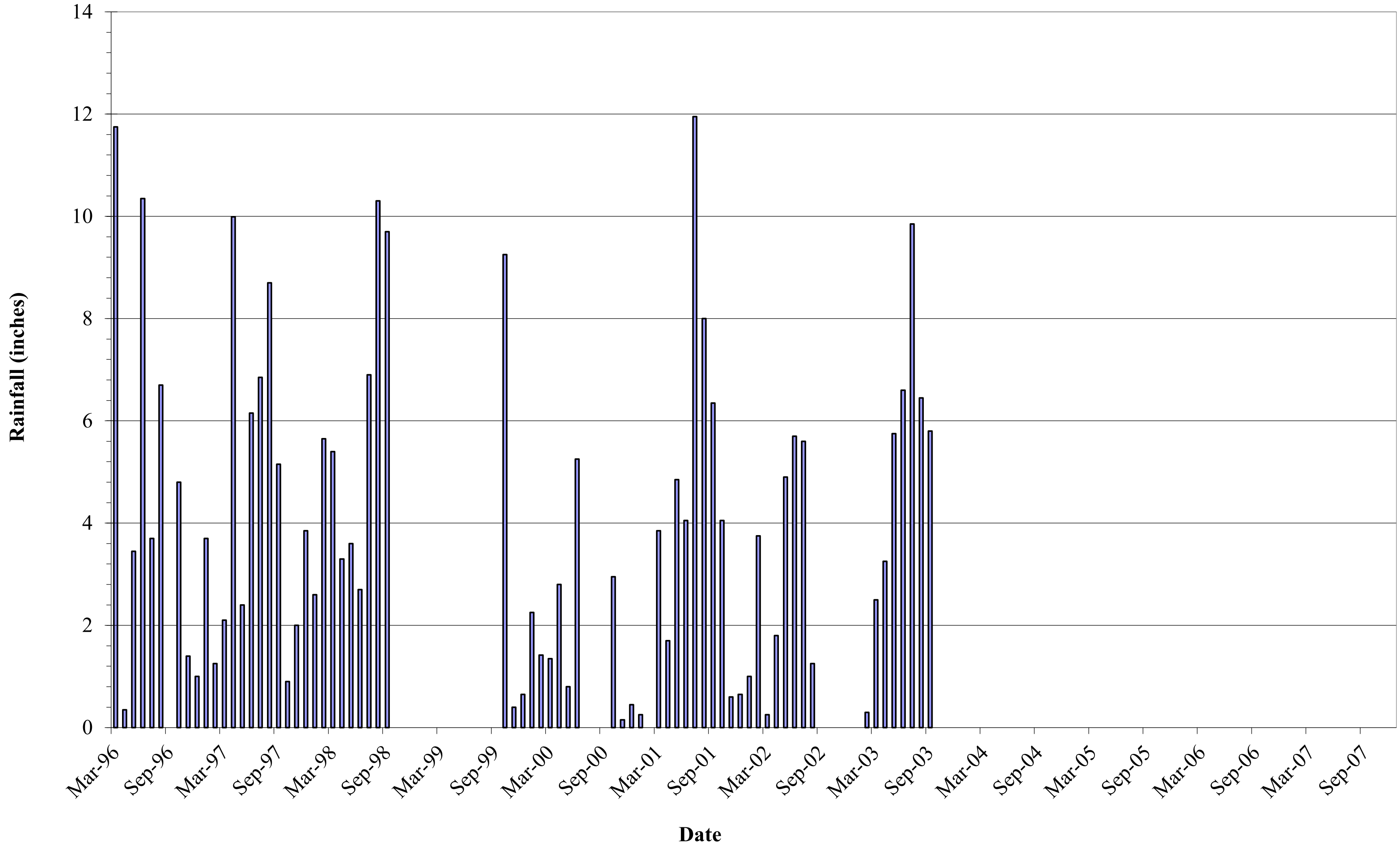

Figure G-8. Monthly Rainfall Data - Grove 8

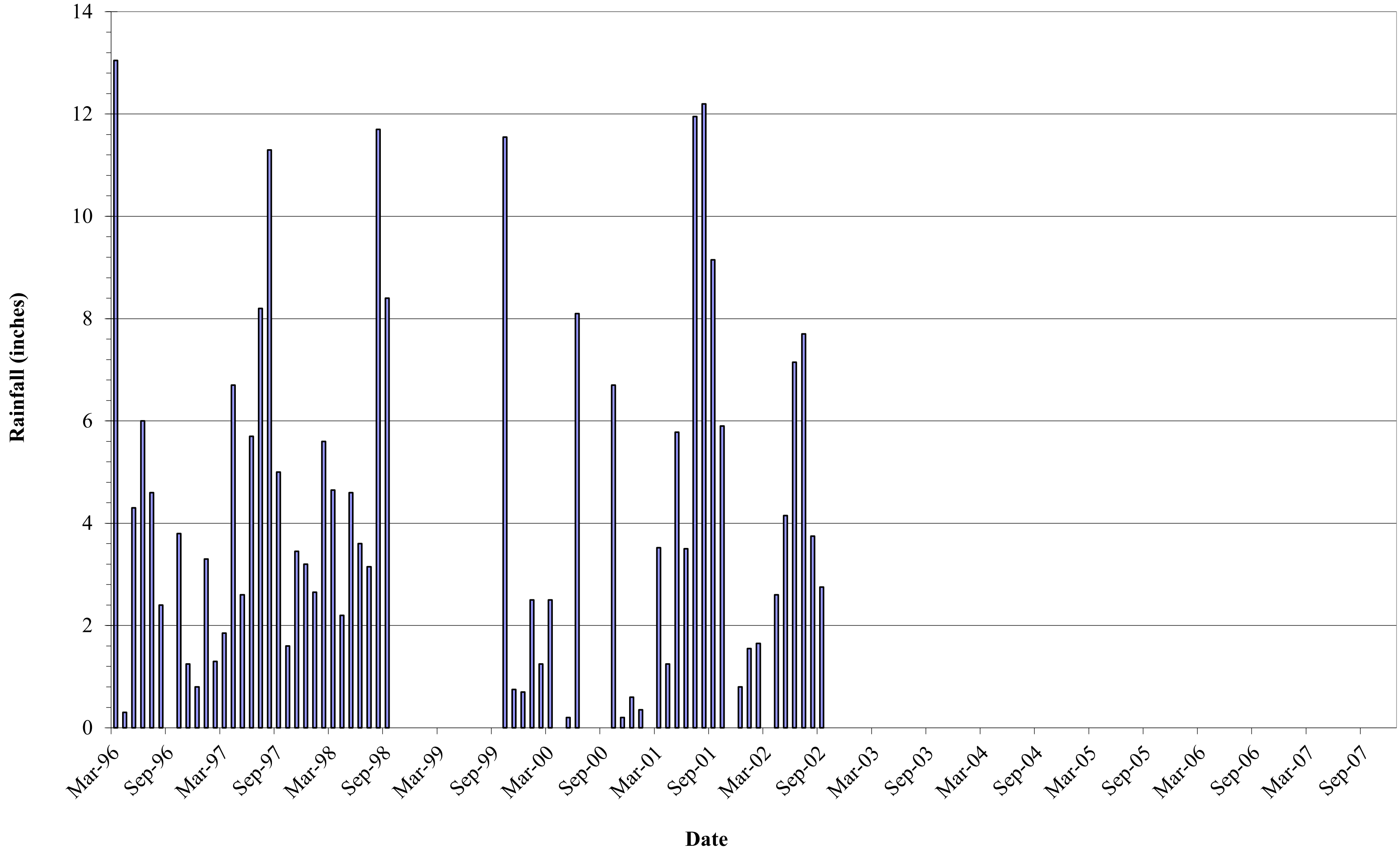

Figure G-9. Monthly Rainfall Data - Grove 11

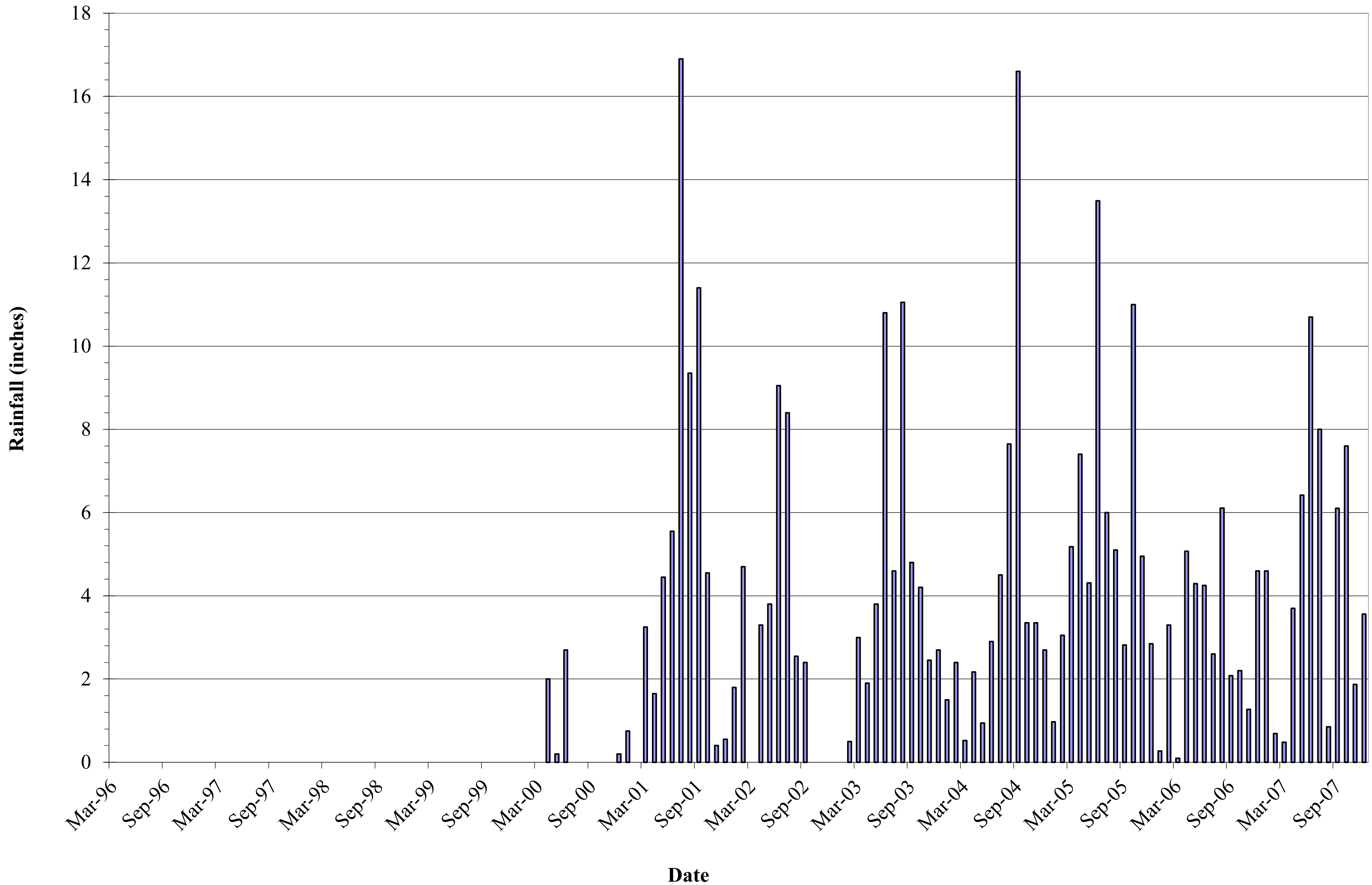

Figure G-10. Monthly Rainfall Data - Grove 12

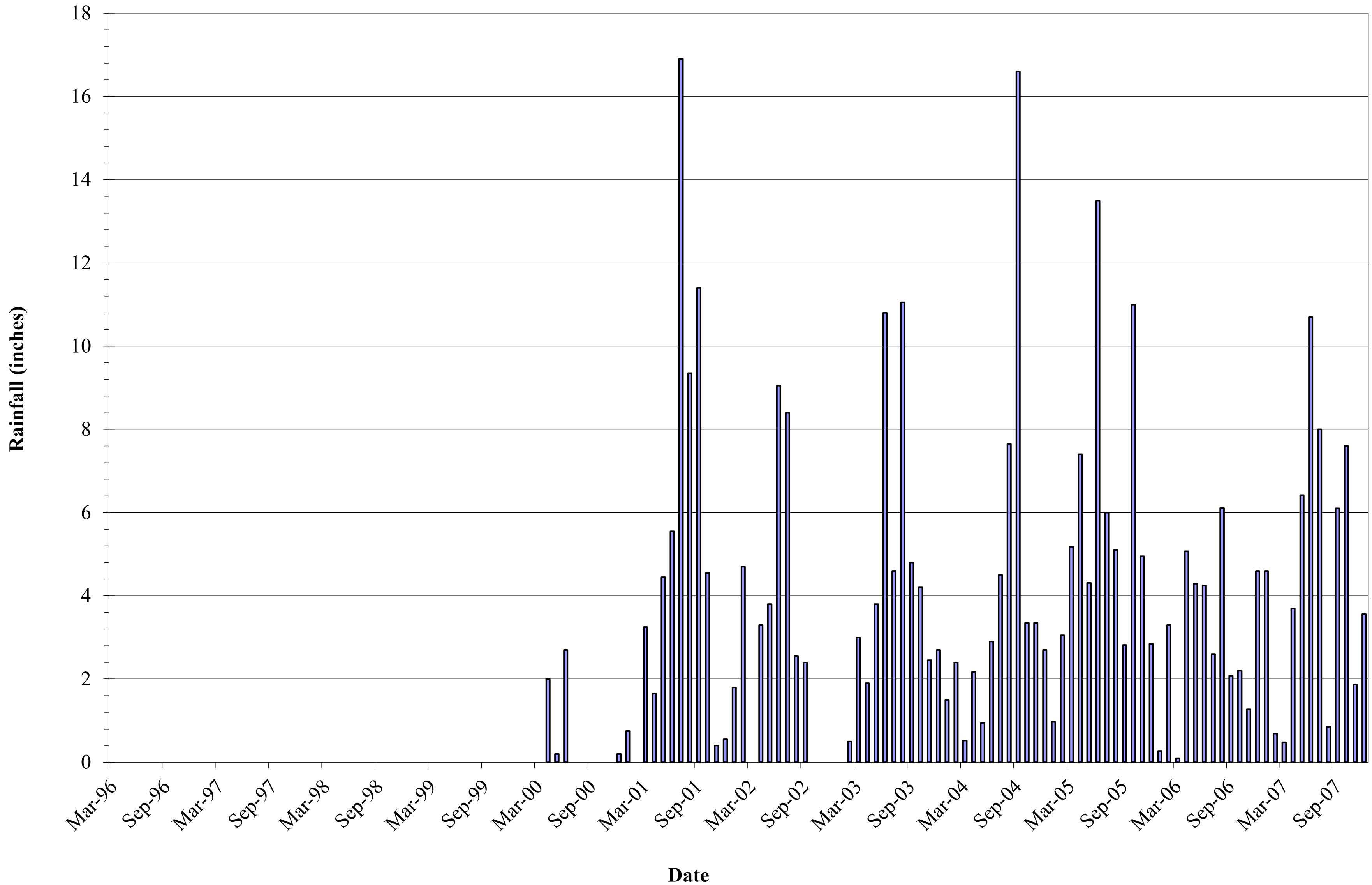

Figure G-11. Monthly Rainfall Data - Grove 13

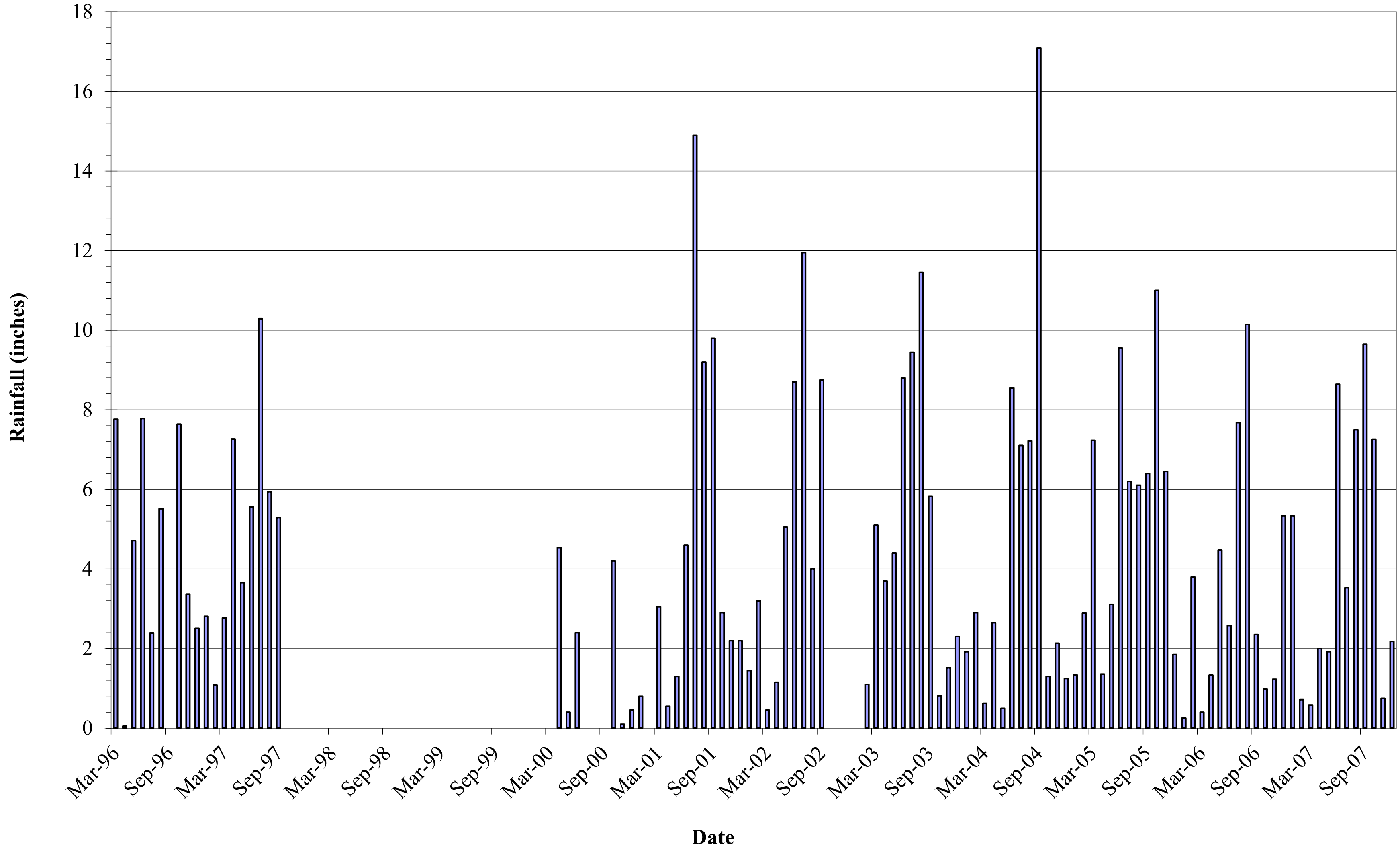

Figure G-12. Monthly Rainfall Data - Grove 14

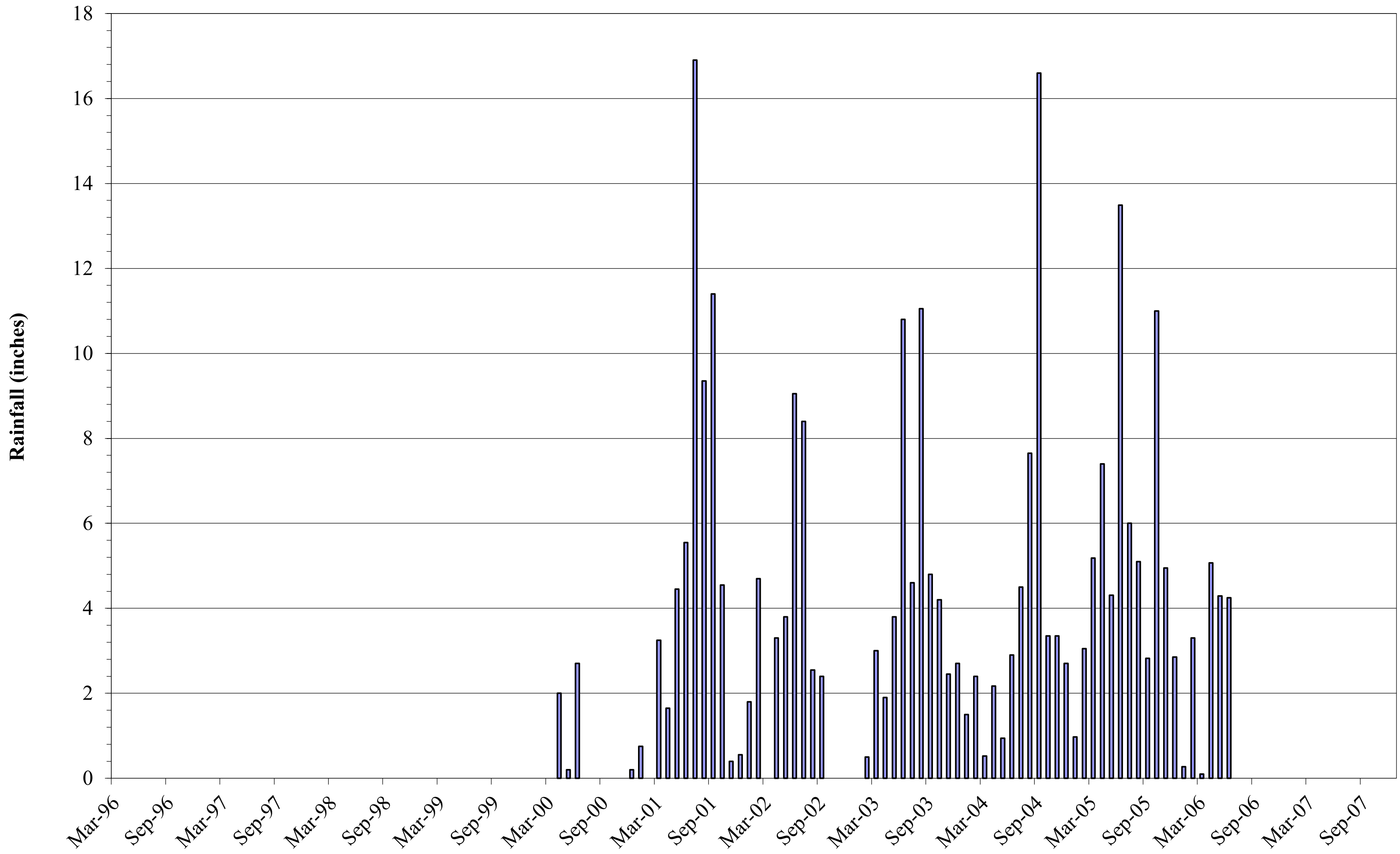

Figure G-13. Monthly Rainfall Data - Grove 29

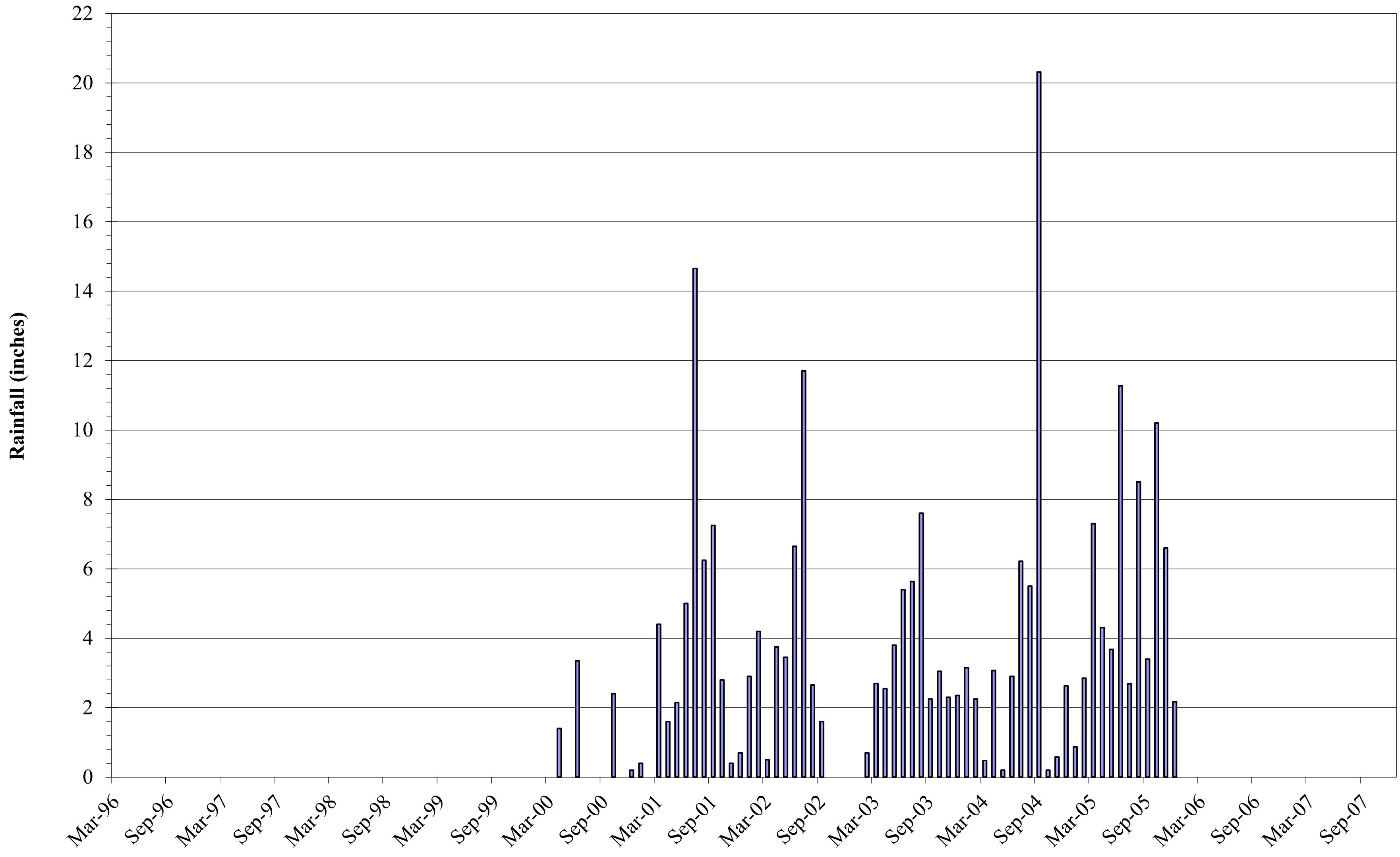

Figure G-14. Monthly Rainfall Data - Grove 35

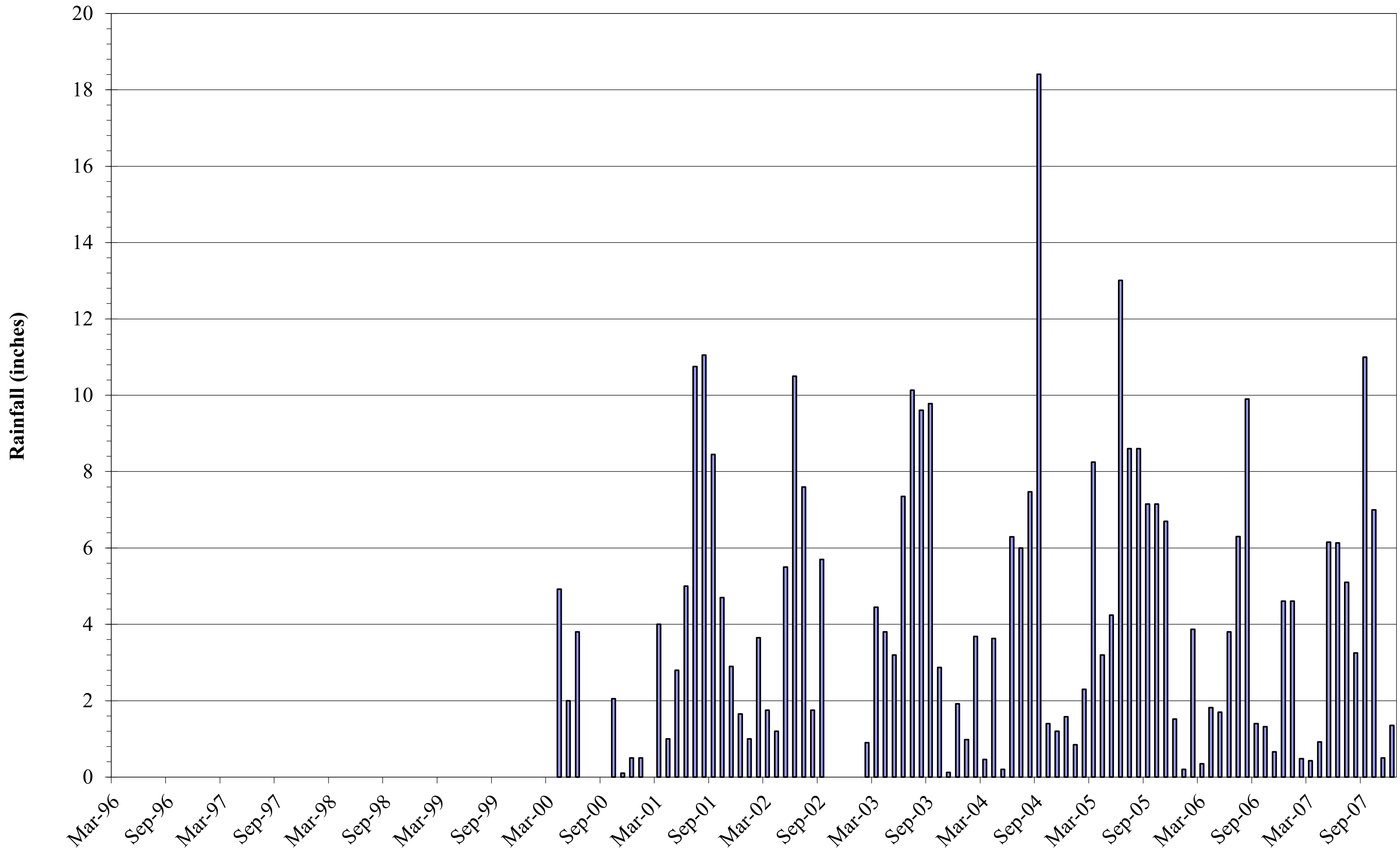

Figure G-15. Monthly Rainfall Data - Grove 36

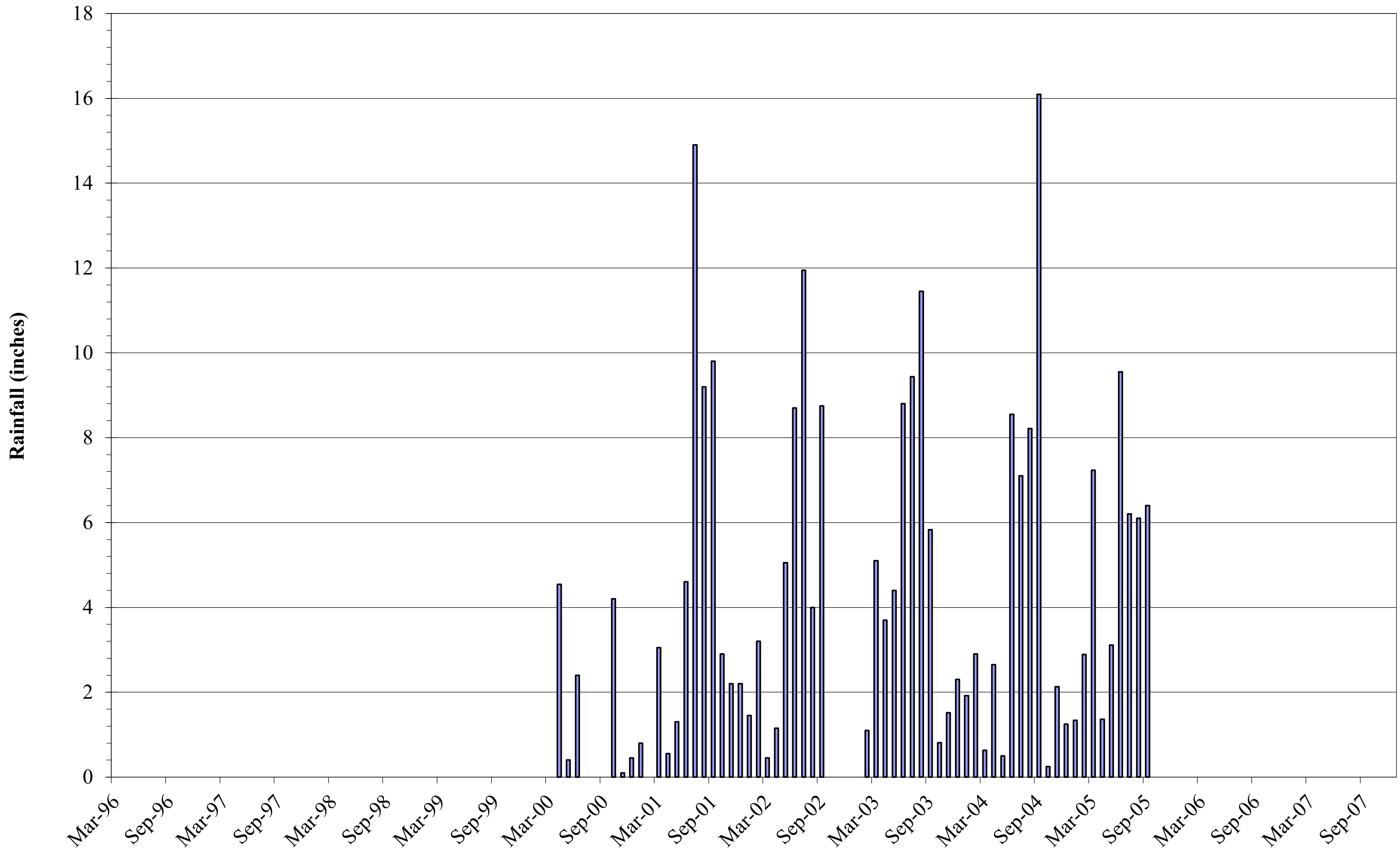

Figure G-16. Monthly Rainfall Data - Grove 121

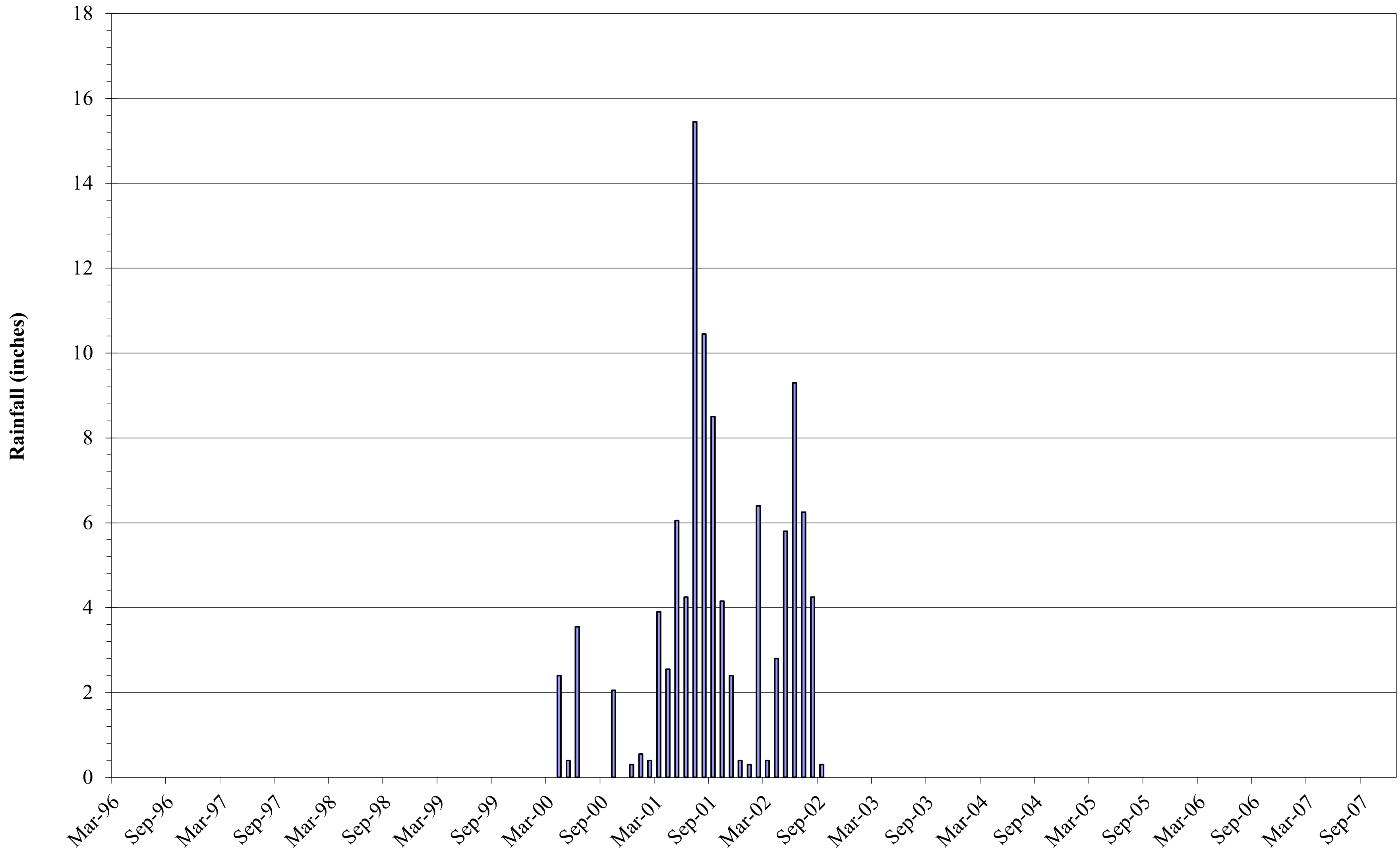

Figure G-17. Monthly Rainfall Data - Grove 201

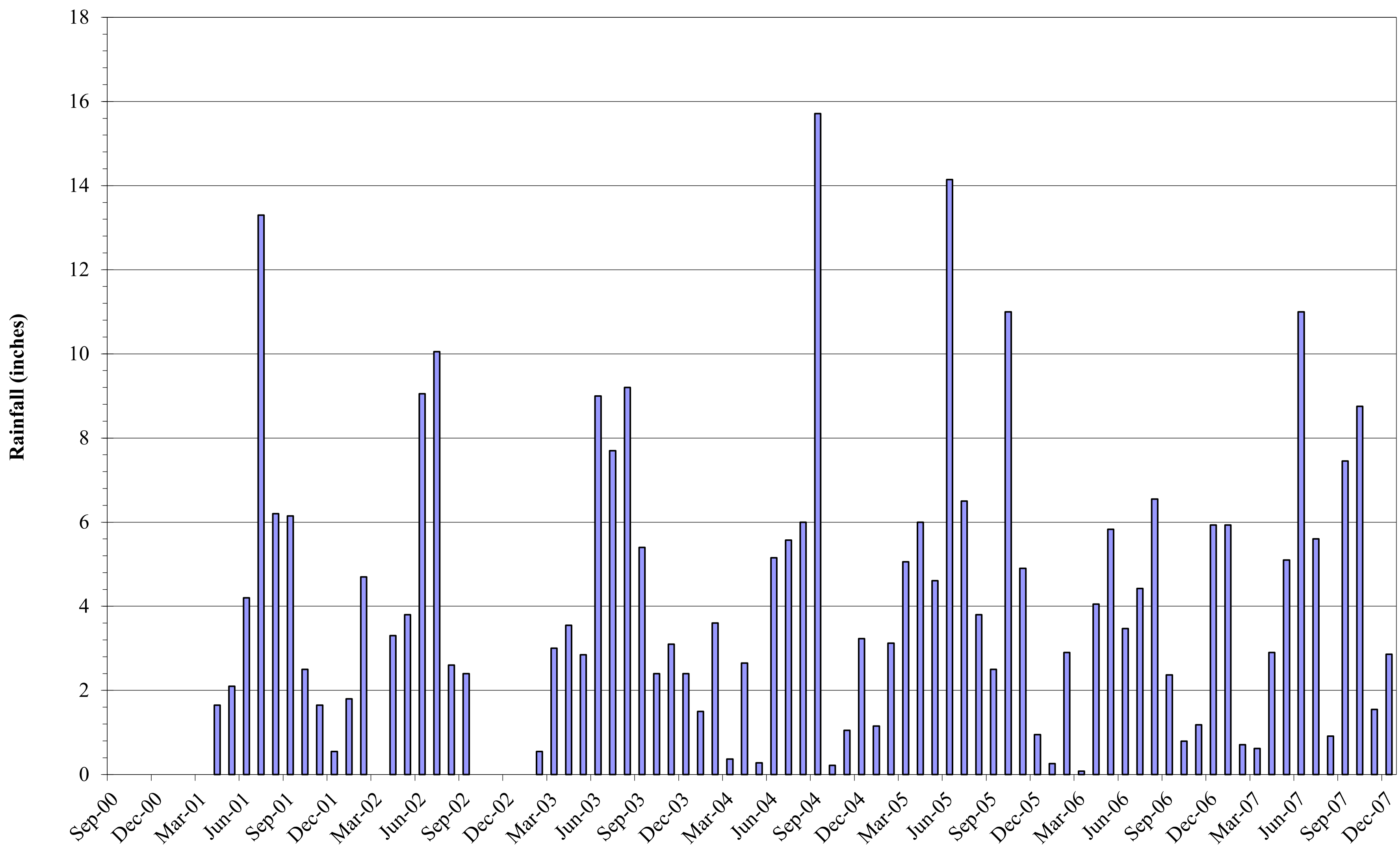

Figure G-18. Monthly Rainfall Data - Grove 202

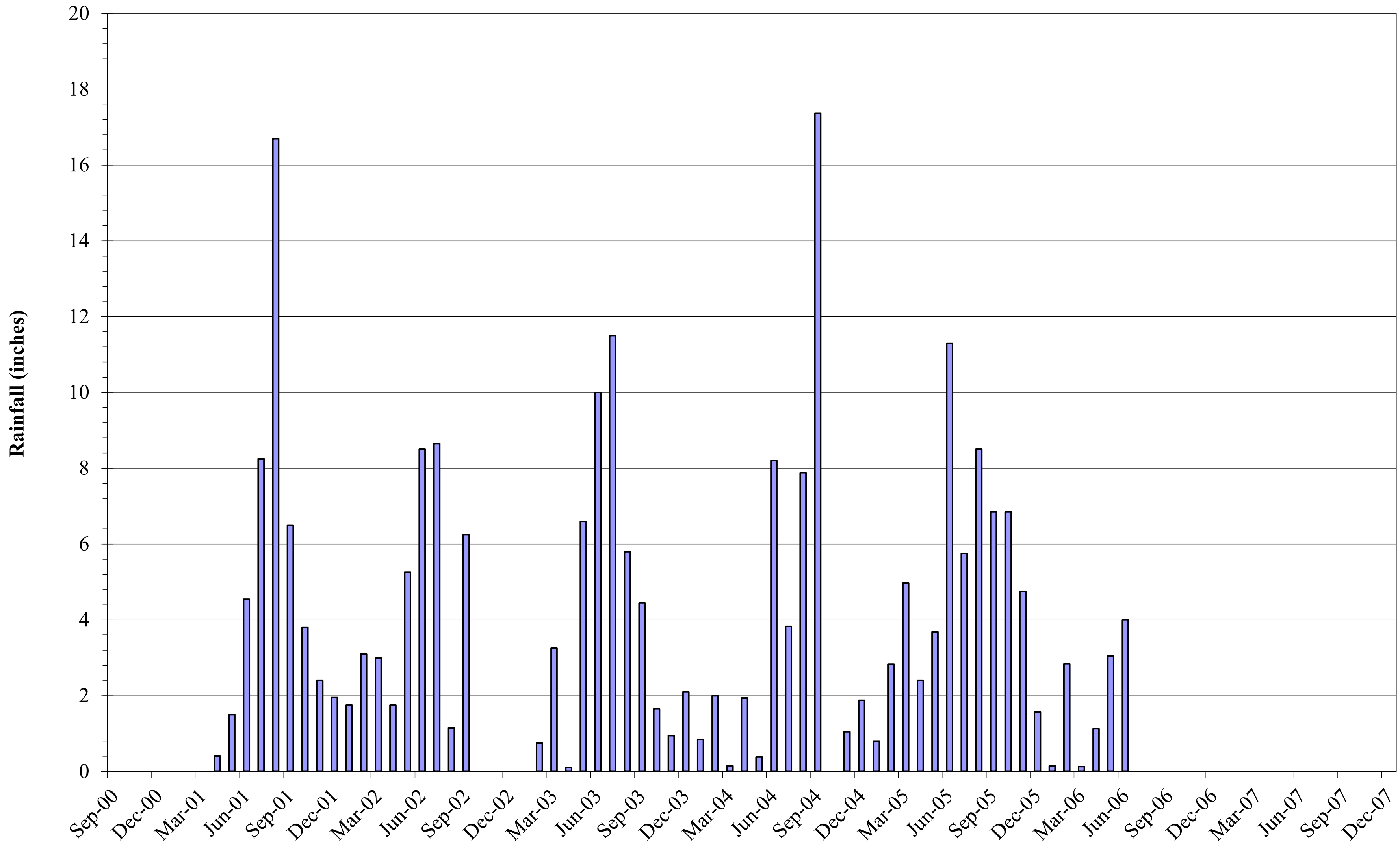

Figure G-19. Monthly Rainfall Data - Grove 203

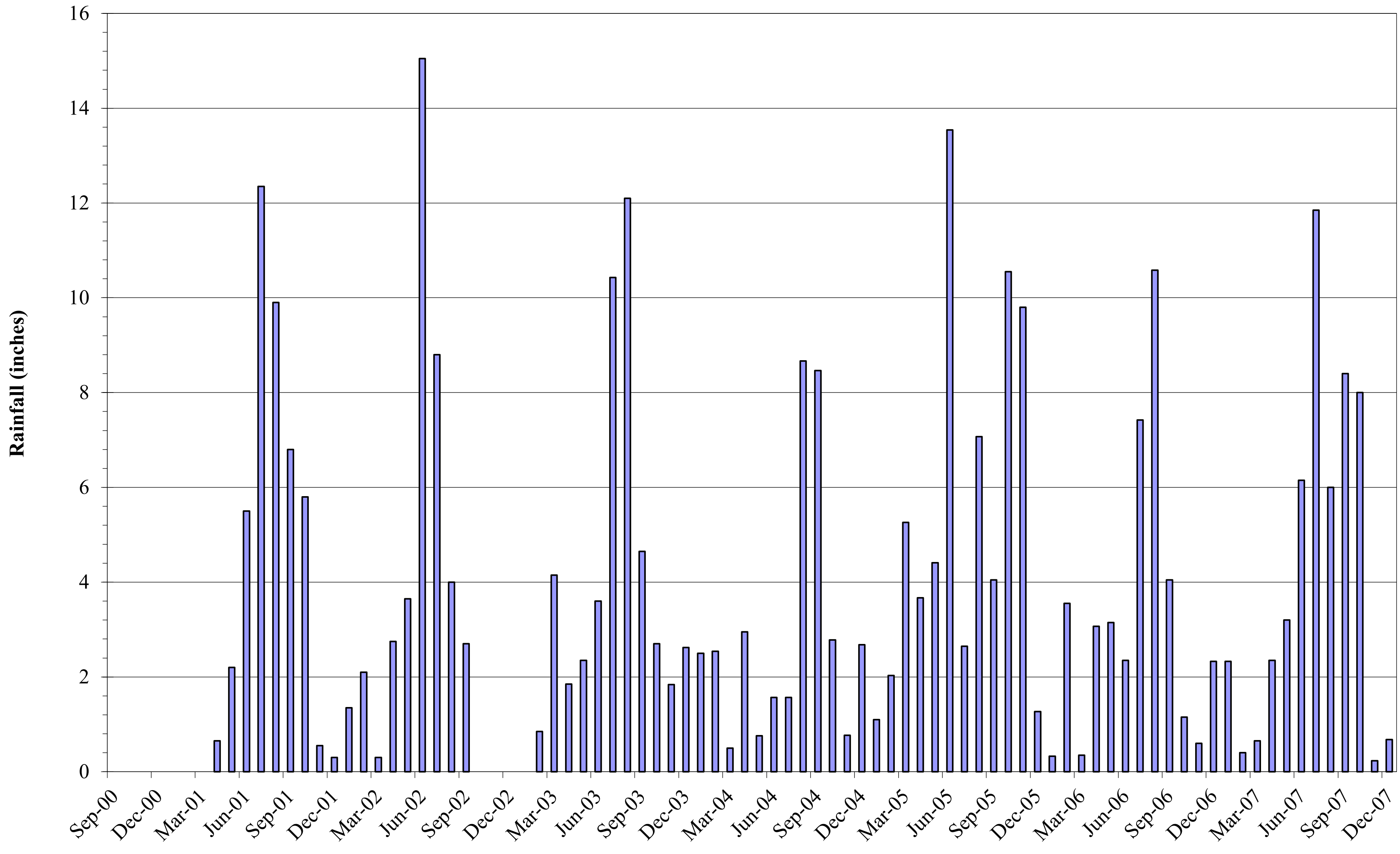

Figure G-20. Monthly Rainfall Data - Grove 204

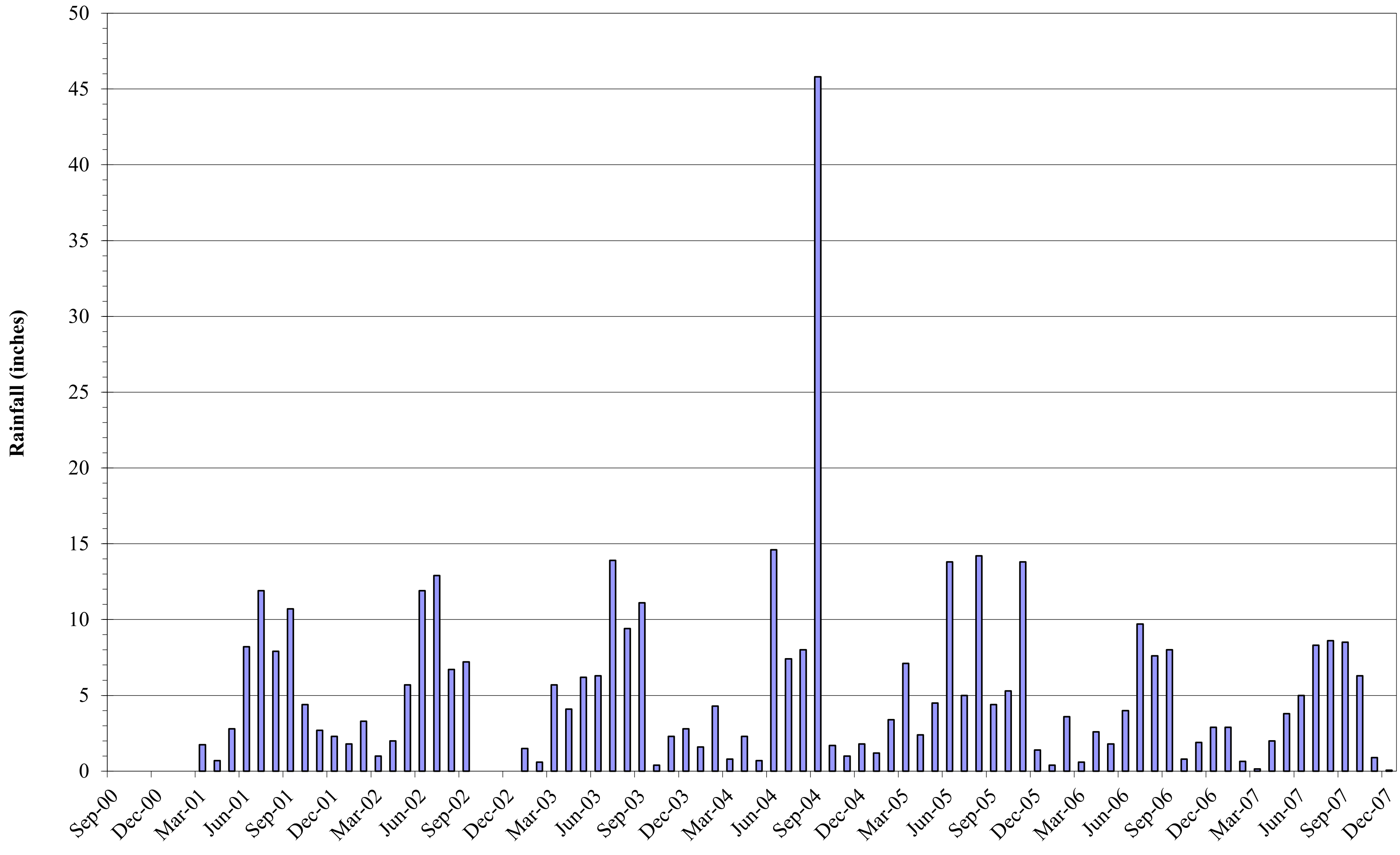

Figure G-21. Monthly Rainfall Data - Grove 205

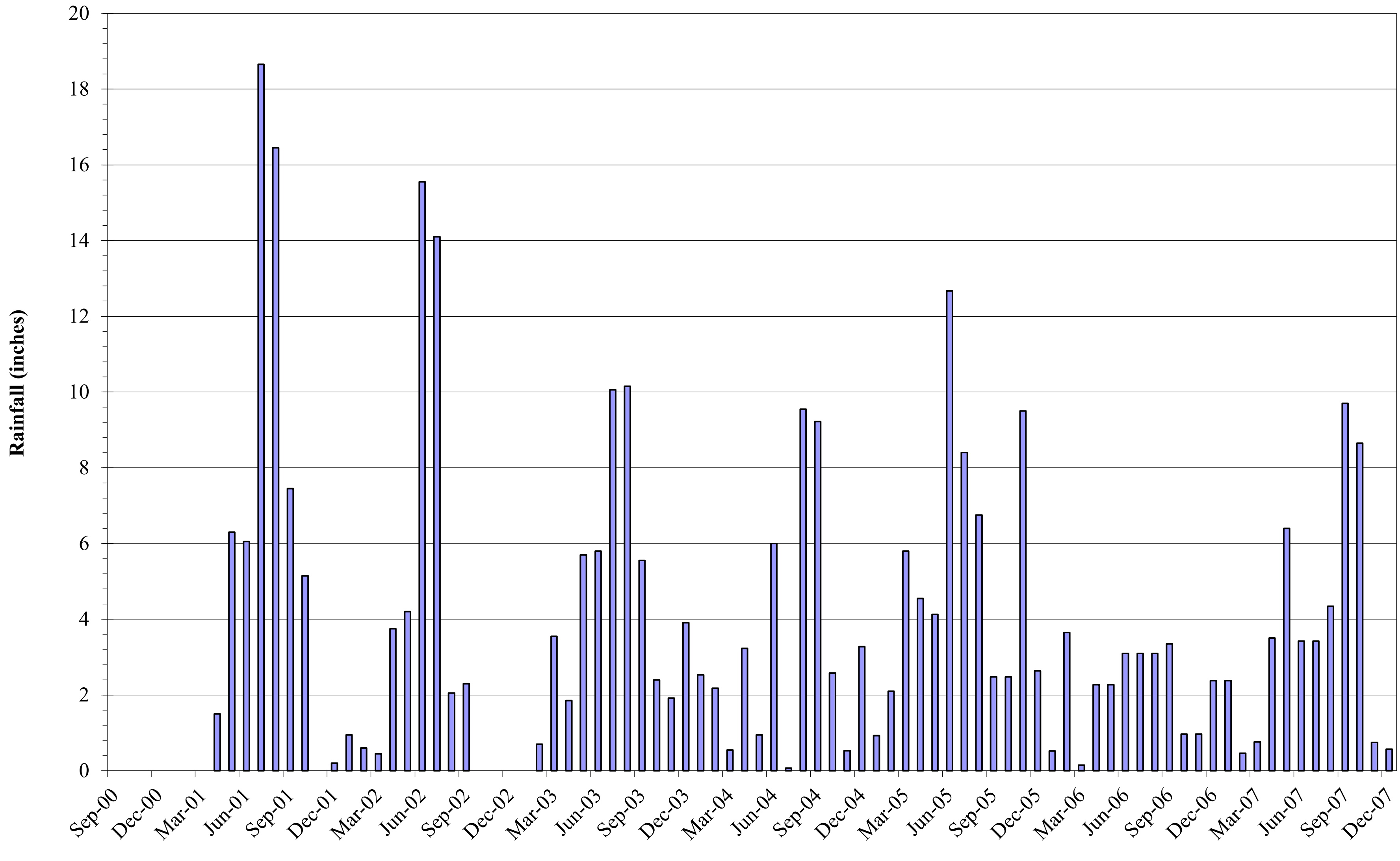

Figure G-22. Monthly Rainfall Data - Grove 206

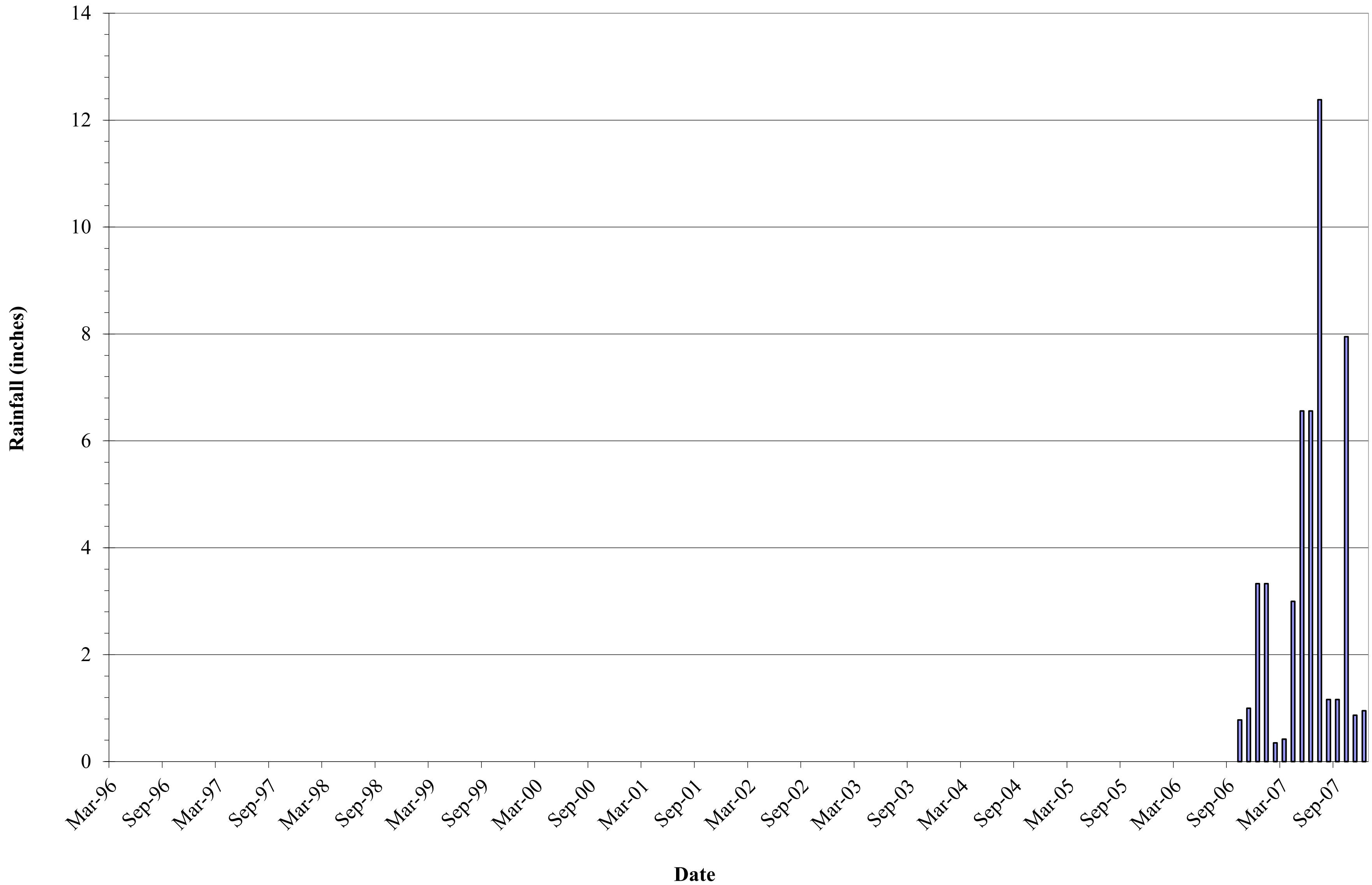

Figure G-23. Monthly Rainfall Data - Grove 207