ARAPAHOE COUNTY

Water Supply Study

11/4/2024 Draft

24

ACKNOWLEDGEMENTS

PROJECT TEAM:

FORSGREN Associates Inc.

Will Koger, PE
Claire Van Kampen, PE
Jeremy Harter, PE
Tara Barnes

LRE WATER

Bill Fronczak, PE, Esq.
Clinton Meyer, PG

Michael Baker INTERNATIONAL

Anne Kuechenmeister
Ted Heyd

VERTEX Consulting Services

Craig Dossey

COUNTY STAFF:

Bryan Weimer, Director of Public Works and Development
Jason Reynold, Planning Division Manager
Loretta Daniel, Long Range Planning Program Manager
Larry Mugler, Planner/Project Specialist
Gary Salazar, Communication Business Partner for Public Works & Development

ADVISORY COMMITTEE MEMBERS:

Jeff Baker, Arapahoe County Board of County Commissioners
Chuck Haskins, Arapahoe County Engineering Division
Sandor Rebek, Arapahoe County Water and Wastewater Authority
Tom Sauter, Lost Creek Groundwater Management District
Andy McClary, North Kiowa Bijou Groundwater Management District
Mark Harding, Rangeview Metropolitan District
Alex Davis, City of Aurora
Laura Coutu, East Cherry Creek Valley Water and Sanitation District
Craig White, Byers Water and Sanitation District
Doug Shewnke, Strasburg Water and Sanitation District
Sarah Young, City of Aurora
Gary May, May Farms
Daniel Krzyzanowski, City of Aurora
Chad Bunger, Town of Bennett
Michael Gradis, City of Centennial
Paul Workman, Cherry Hills Village
J.D. McCrumb, Town of Columbine Valley
John Kettling, Town of Deer Trail
Brad Power, City of Englewood
Lisa Jones, Town of Foxfield
Chuck Line, City of Glendale
Derek Stertz, Greenwood Village
Mike Sutherland, City of Littleton
Andrew Rogge, City of Sheridan
Kip Cheroutes, I-70 Corridor Regional Economic Advancement Partnership
Jeff Vogel, Prosper Land and Development
Rodney Brockelman, Arapahoe County Planning Commission
Jamie Wollman, Arapahoe County Planning Commission
Lisa Darling, South Metro Water Supply Authority
Greg Fisher, Denver Water

ABBREVIATIONS

Common abbreviations used in this report:

AF:	acre-feet
AFD:	acre-feet per day
AFY:	acre-feet per year
BOCC:	Board of County Commissioners
CCF:	hundred cubic feet
CDPHE:	Colorado Department of Public Health and Environment
CIP:	Capital improvement plan
CWCB:	Colorado Water Conservation Board
DOLA:	Department of Local Affairs
DWR:	Division of Water Resources (Office of State Engineer)
FT:	feet
FT-MSL:	feet, mean sea level
GAL:	gallons
GPCD:	gallons per capita per day
GPD:	gallons per day
GPM:	gallons per minute
HP:	horsepower
IPR:	indirect potable reuse
LIRF:	lawn irrigation return flows
KGAL:	one thousand gallons
MAF:	million acre-feet
MCL:	maximum contaminant level
MGAL:	one million gallons
MGD:	million gallons per day
NNT:	not nontributary
NT:	nontributary
SDO:	State Demography Office
SEO:	State Engineer's Office (Office of the State Engineer)
SFE:	single family equivalent
SMWSA:	South Metro Water Supply Authority
WCP:	Water Conservation Plan
WISE:	Water Infrastructure and Supply Efficiency Partnership
WRF:	Water Reclamation Facility
WSMP:	Water Supply Master Plan
WTP:	Water Treatment Plant

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Arapahoe County is Colorado's third most populated county with over 656,000 residents and a land area of 804 square miles. The county stretches from its very urbanized west end comprising a large portion of the Metro Denver area that includes most of Aurora (Colorado's third largest city), to a very rural, agricultural area east of the I-70 corridor.

The County Government (County) has determined that this Water Supply Study (Study) is necessary to update the goals, policies, and strategies related to water resources from the County's 2001 and 2018 Comprehensive Plans (Comp Plans). The primary objective is to promote land-use decisions based on balancing the efficient use of limited water supplies with the needs of current and future residents. The Study is expected to serve as the basis for a water supply element of the Comp Plan for Board of County Commissioners' (BoCC) approval and Planning Commission adoption, and support the following goals:

1. Close potential gaps between future supply and demand.
2. Improve water use efficiency.
3. Extend the life of Denver Basin aquifers to sustain a long-term supply.

To organize and illustrate the County's information related to water supplies, the study team developed a working web-based map that displays interactive geographic information systems (GIS) data relevant to this Study. This web map can be accessed at: https://experience.arcgis.com/experience/a06dd2ff496843b2b227e5cebc0a9124/.

Stakeholder/Public Participation

To build a robust set of supported recommendations, the County engaged with area experts, water providers and jurisdictions and gathered input from the larger community on needs, concerns, and strategies for water supply. An advisory committee was formed made up of officials and staff from jurisdictions, agencies, and interest groups in the county. The committee provided insight into local development and growth patterns, water supply and demand issues, and applicable local processes and regulations.

At a virtual public meeting in January 2024, the study team gave an overview of the findings to date, responded to questions from participants, and shared an on-line engagement tool through which 500 unique participants provided input and over 400 comments were received. Ensuring high water quality and supporting water efficiency measures ranked as the highest priorities. Two countywide open houses followed in April and May, at which the public was invited to comment on the Study's draft policy recommendations.

Projected Water Supplies and Demands

Many variables will shape the county's future and there is a range of possible growth outcomes looking ahead to 2050. The County conservatively selected two scenarios referenced in the 2023 *Colorado Water Plan* to bracket that range and guide demand projections for this Study: "business as usual" and "hot growth." Based on projections from the 2018 Comp Plan, the State Demography Office (SDO) and the Denver Regional Council of Governments (DRCOG), the 2050 population estimates will range from 900,000 to 960,000. Employment is another important statistic to consider when measuring demands to predict nonresidential demand in the county. Based on the projections above, the 2050 employment will range from 532,000 to 595,000.

As shown in Figure ES-1, countywide water demand was approximately 83,400 acre-feet per year (AFY) in 2020 with supplies estimated at 108,200 AFY (not including "no district" groundwater supplies outside of water provider service areas). That demand is expected to grow to between 108,900 and 116,800 AFY in 2050, with water supplies developed to a capacity of 141,650 AFY. With continuing progress on water conservation, 2050 demands could be reduced to a range of 97,200 to 103,700 AFY. As described above and shown in the graphic, supply is projected to be sufficient to meet demand in 2050 under both the Conservation and No Conversation scenarios.

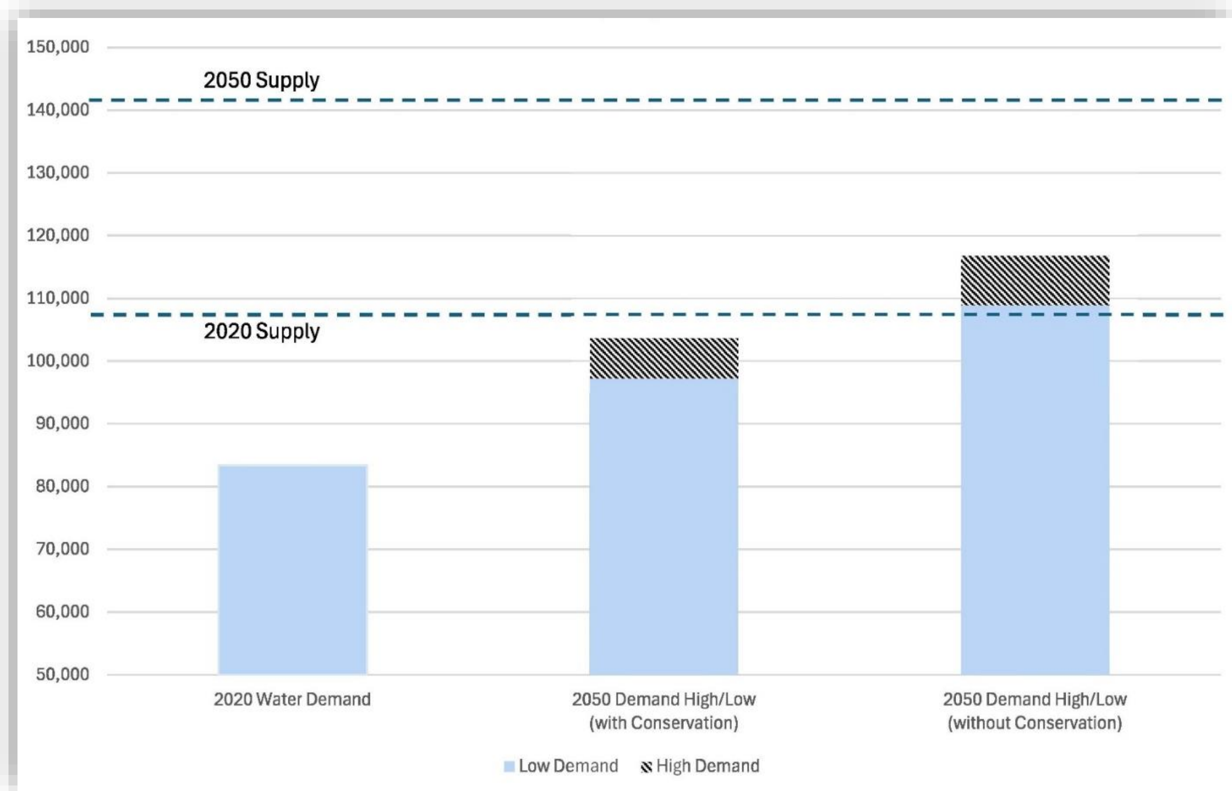


Figure ES-1. Water Supplies and Demands (AFY)

"No district" demands come from unincorporated areas of the county. The "no district" demands are expected to grow from 2,300 AFY in 2020 to a range of 4,800 to 5,600 AFY.

Water providers continue to work toward increasing supplies to meet growing demands within the county. For example, Rangeview Metropolitan District is working toward expanding renewable supplies from Box Elder Creek, with storage in the county. Regionally, the Platte Valley Water Partnership (PVWP), Todd Creek Metropolitan District and Town of Bennett (BennT Project) partnership, and the Water Infrastructure and Supply Efficiency (WISE) partnership all present possible options (briefly described in Section 7).

Although three of the 12 water providers in the county addressed in the supply/demand analysis appear to have potential shortages with respect to 2050 demands, there are opportunities to close those gaps through conservation, agreements with other water providers, and regional partnerships to develop new supplies. Also, available Denver Basin resources are substantial, estimated at a possible production rate of over 51,800 AFY. However, 65 percent of those supplies are in the Laramie-Fox Hills aquifer, expected to be more costly to develop than the other aquifers.

Groundwater Analysis

To estimate how much Denver Basin groundwater is physically available, the study team utilized a groundwater model (Petra™) using extensive data to define water levels, well yields, aquifer properties and saturated thicknesses within the Denver Basin, and both inside and outside the designated basins. This analysis generated regional cross sections and geologic maps for each Denver Basin aquifer, and the model was used to estimate possible production using standard well construction methods. The Colorado Division of Water Resources (CDWR) allows pumping from a decree or determination based on water quantities (volume and associated annual production rate) calculated according to Denver Basin Rules and the state model implementing the Rules ("SB-5 Model"). The Denver Basin Rule allocations compared to this Study's model of physically available water volumes for a representative study area in the middle of the county are shown in Figure ES-2.

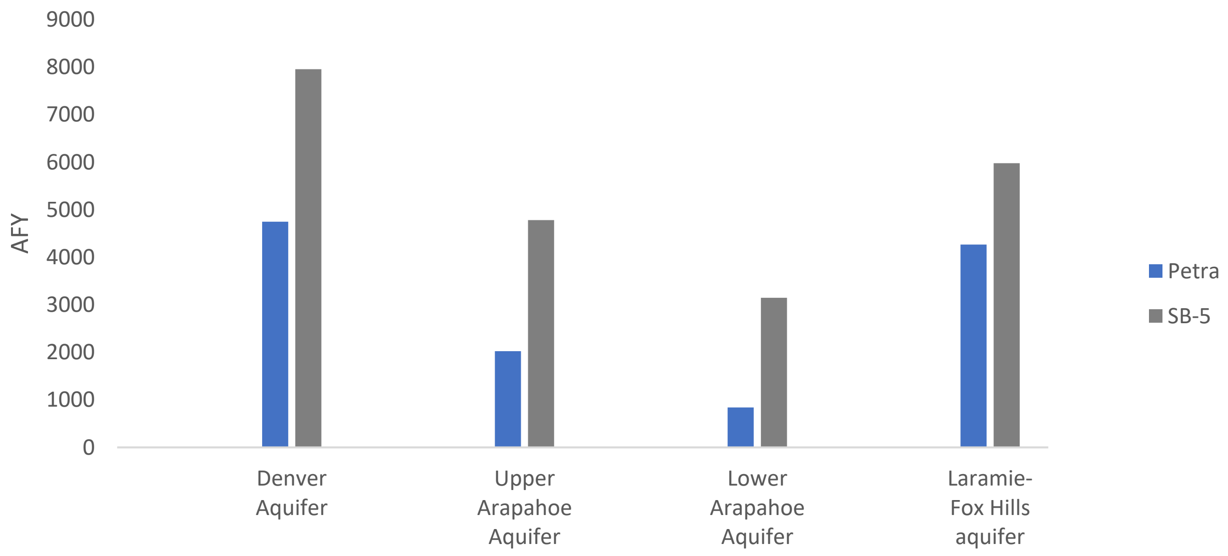


Figure ES-2. Comparison of Groundwater Availability (Petra vs. SB-5)

Physically available groundwater is calculated at approximately 60 percent (on a weighted average) of the Denver Basin Rule allocations for the Denver Basin aquifers.

Water Management Strategies

Increasing demands on water resources throughout the region and increasing costs are expected to drive more efficiency in the management of those resources. Water providers are engaging in these water management strategies: water conservation with a focus on water-wise landscaping; water reuse; and "conjunctive use" (coordinated management of surface water and groundwater supplies to maximize yields)—all pointing toward a more sustainable future.

As indicated in Figure ES-1, water conservation is expected to reduce 2050 demands by 12 percent or more. The largest share of that potential savings is through water-wise landscaping, estimated at 32 to 36 percent of the savings. The County is updating its landscaping standards to promote water efficiency. Those standards will apply to unincorporated areas and can be referenced by communities throughout the county when updating or developing their landscaping standards.

Recommended Policies

The goals and findings of this Study have led to several recommended policies listed in Table ES-1 (see Section 9). The policy recommendations are divided into two categories, Arapahoe County Policies (AP) and Collaborative Policies (CP). Arapahoe County Policies are those that can be led and implemented by the County. Collaborative Policies are beyond the County's responsibilities but could be led by water providers and other interested parties with County support.

For implementation, Policies AP-1, 2, 3 and 8 are regulatory and would require amendments to the County's Land Development Code. The other policy recommendations are advisory and can be implemented by amending the Comp Plan.

Table ES-1: Recommended Policies

Recommended Policies
AP1: Denver Basin Aquifer-specific Annual Withdrawal Production Factor
AP2: Connected Systems
AP3: Early Water Evaluation for Development
AP4: Increase Water Efficiency Regulations in New Development
AP5: Programs, Education and Resources for Water-wise Landscaping
AP6: Encouraging Water Reuse
AP7: Water Management Policy Audit
AP8: Groundwater Systems Best Practices
AP9: Reducing Development Barriers
CP1: Water Rates
CP2: Watershed and Groundwater Quality Protections
CP3: Household Water Efficiency Education
CP4: Leak Detection and System Maintenance
CP5: Supply Infrastructure
CP6: Sustainable Allocations
CP7: Water Provider and Developer Group
CP8: Incorporated Jurisdictions Landscaping Guidelines Support
CP9: Water Services Extensions

SECTION 1.

INTRODUCTION

SECTION 1 – INTRODUCTION

Arapahoe County is Colorado's third most populated county with over 656,000 residents (U.S. Census Bureau estimate, July 1, 2023) and a land area of 804 square miles. The county stretches from its very urbanized west end comprising a large portion of the Metro Denver area that includes most of Aurora (Colorado's third largest city), to a very rural, agricultural area east of the I-70 corridor (see Figure 1-1). While growth continues in the urban areas of Arapahoe County, a handful of rural communities along I-70 including Bennett, Strasburg, Byers and Deer Trail are also seeing some growth resulting from their proximity for commuters.

Purpose

The Arapahoe County Government (County) has determined that this Water Supply Study (Study) is necessary to update the goals, policies, and strategies related to water resources from the 2001 and 2018 Arapahoe County Comprehensive Plans (Comp Plans). Although the County is not a water provider, it is important that the County has such a study to provide water resource planning guidance. The primary objective of the Study is to promote land-use decisions based on balancing the efficient use of limited water supplies with the needs of new residents to have reliable supplies. This Study is also intended to promote cooperation with the water supply entities in their respective water planning efforts, as well as provide the basis for review of proposed water supplies for new development at an early stage of the development process. Following the Planning Commission adoption and Board of County Commissioners (BoCC) certification, the Comp Plan will be appended with the Study and will serve as the basis for a water supply element of the Comp Plan. See Appendix A for a glossary and Appendix B for references.

Background

As part of the 2001 Comp Plan, the County contracted with LRE Water (LRE) for a water resource study of eastern Arapahoe County. The study found that the water demand in that area was approximately 1,200 acre-feet per year (AFY), with essentially all the demand met by groundwater. It was recommended that the County limit groundwater development to 50 percent of that allowed by Colorado statutes, equivalent to a 200-year rule, assuming only that amount of water would be economically recoverable. That meant limiting annual withdrawals to half of what was allowed by statute. The County's Planning Commission adopted that limitation as policy in the 2001 Comp Plan.

The Planning Commission later adopted the 2018 Comp Plan, a long-range guidance document defining broader land use planning policies; policies and strategies for other key County topics; topical elements regarding specific planning issues such as transportation and open space; and subarea plans for specific geographical areas of the county. Both the 2001 and 2018 Comp Plans included policies related to water supply and quality. In 2018, the Planning Commission adopted a policy to base groundwater supply analyses on a more stringent consumption policy, limiting annual withdrawals to one-third the volume allowed by state statutes, equivalent to a 300-year rule. As of now, the adopted policy has not become regulation.

Water Providers

County residents receive water service from municipal providers, special districts, or individual domestic or household wells. Denver Water, the City of Aurora, and the City of Englewood serve most of the urban portion of the county. Three special district/authority providers serve smaller urbanized areas in western Arapahoe County: East Cherry Creek Valley Water and Sanitation District, the Arapahoe County Water and Wastewater Authority, and the Inverness Water and Sanitation District.

Rural subdivisions in east-central Arapahoe County often rely on individual domestic or household wells for their water supply, while suburban developments in that area typically have centralized water and sewer systems provided by a special district. Since 2001, some development has occurred in the two unincorporated communities of Byers and Strasburg, which have districts providing centralized water and sewer services. The towns of Bennett and Deer Trail operate municipal water systems. Most other growth has occurred on individual lots with wells. Many of these lots have been created without County approval due to the exemption of parcels 35 acres and larger from the definition of subdivision under state statutes.

In recent years, the County has approved two major developments within the unincorporated eastern portion of the county. The 930-acre Sky Ranch development is located just east of Aurora along I-70, with a planned buildout of approximately 3,400 households. An even bigger project is Prosper Farms, a 5,120-acre community of up to 9,000 households. Prosper Farms is located south of I-70 along Watkins Road. A special district is proposed to provide both groundwater and surface water for its residents in each of these developments. (See Section 4 for locations of Sky Ranch and Prosper Farms.)

State and Regional Context

In 2015, the State of Colorado adopted *Colorado's Water Plan*. That plan identified objectives, goals, and critical actions needed to ensure that Colorado could maintain the state's values into the future. Many municipalities and special districts have now adopted water supply plans, yet few counties have adopted specific master plan elements to assist in guiding new growth in consideration of water supply.

The Comp Plan includes a strategy to study options and provide guidance to ensure a permanent, long-term water supply. It also references many of the policy and strategy recommendations of the 2023 *Colorado Water Plan,* including a goal to more closely integrate water supply and land use planning.

The 2023 update to the *Colorado Water Plan* identified a series of varying climate, economic and growth scenarios that could result in 230,000 to 740,000 AFY of new demands within Colorado by 2050. Additionally, that updated plan incorporates "basin implementation plans" for each of the state's major river basins. The South Platte/Metro Basin Implementation Plan (BIP) is most relevant to Arapahoe County, and the state and basin plans each identify four overarching action areas. Those for the *Colorado Water Plan* are:

VIBRANT COMMUNITIES	ROBUST AGRICULTURE	THRIVING WATERSHEDS	RESILIENT PLANNING
• counties • municipalities • utilities • cities • towns • businesses • large industries • large and small urban and rural communities • etc.	• established crops and farms • local food • orchards • ranching • ditch companies • acequias • urban agriculture • livestock • dairy • etc.	• environment and recreation, • river health • watershed health • forest health • wildfire mitigation • wildlife and aquatic species protection • etc.	• climate adaptation • planning for climate extremes • education, outreach and engagement • supportive government • etc.

The South Platte/Metro BIP action areas are:

- Meeting the municipal supply gap
- Protecting irrigated agriculture
- Protecting and enhancing watersheds
- Implementing projects

STUDY OBJECTIVES

The objectives of this Arapahoe County Water Supply Study are to:

- **Identify the "current state" of water supplies including existing water demands and how those demands are met by service providers;**
- **Identify the "future state" including projected future water demands by provider to 2050;**
- **Compare existing and future demands to surface water rights and aquifer supply potential;**
- **Identify future groundwater use requirements to be included in the development review process, including potential revisions to the County's Land Development Code;**
- **Identify water supply, efficiencies, and reuse options to meet the expected demands in each service area;**
- **Provide guidance for water conservation measures for county residents and developers;**
- **Identify a more robust process for water service evaluation and new development "will serve letters;" and**
- **Define criteria for review of District water statements.**

The primary objective is to ensure that land-use decisions are made based on balancing the efficient use of limited water supplies with the needs of new residents. The goal is to have a reliable water supply while working in cooperation with the water supply entities in their respective water planning efforts. It is intended that this Study will also provide the basis for reviewing proposed water supplies for new development at an earlier stage of the development process, as recommended in the 2018 Comprehensive Plan.

Groundwater Development

Denver Basin groundwater has been, and will continue to be, a key source of supply in much of central and eastern Arapahoe County as discussed further in this Study. Throughout the county the Denver Basin is characterized by confined aquifers with Artesian pressures driving static water levels above the top of each Denver Basin aquifer. Those pressures have declined for decades and are likely to continue declining, dropping to the top, or below the top, of these aquifers in some areas.

Annual withdrawal rates for wells placed in the Denver Basin aquifers, however, are allocated by the State based on the estimated volume of water in each aquifer underlying a particular parcel of land. The legal framework around use of Denver Basin groundwater reflects the State's policy of maximizing beneficial use of water without injury to other water users. This framework encourages development of the Denver Basin aquifers to the benefit of overlying property owners.

Often, wells for individual residences are drilled just deep enough within one of the Denver Basin aquifers to produce the desired flowrate to minimize well drilling costs. But as surrounding property owners make use of their legally entitled groundwater rights, thereby sharing groundwater in the same Denver Basin aquifer, there can be declines in pressure at wells previously completed and developed, leading to the conclusion that the Denver Basin aquifers in this area are going dry.

To secure sufficient well production, best practices are to drill and complete wells to the bottom of each Denver Basin aquifer, and size the casing, screen and well pumps adequately to lift groundwater water from the base of each Denver Basin aquifer to the surface. While these best practices can increase well drilling and completion costs significantly, they will lead to much greater long-term reliability of groundwater production from the wells completed in the Denver Basin aquifers. This is, in many ways, a paradigm shift recognizing that surrounding property owners are not restricted from making use of their rights to Denver Basin groundwater. It is assumed through this Study that best practices will be applied, allowing groundwater to be used effectively by landowners overlying the Denver Basin aquifers.

Mapping & Data Development

To organize and illustrate the County's information related to water supplies, the study team developed a working web-based map that displays interactive geographic information systems (GIS) data relevant to this Study. The Study area is shown in Figure 1-1. The web map can be accessed at: https://experience.arcgis.com/experience/a06dd2ff496843b2b227e5cebc0a9124/.

This product provides a tool that the County staff can update and develop further to better integrate land use planning and water supply planning in the years ahead. This interactive map can be used to create maps and other visualizations regarding water development, infrastructure, future water demands and opportunities, and expected growth boundaries.

This interactive map includes an extensive set of available data consisting of electronic, digital and GIS files from public sources. It also includes digitized data from water suppliers and other sources when the data was not already in an electronic format. The full data set is then sourced for the interactive GIS web map. The data types and sources compiled for mapping are:

Publicly Available Data:

- Colorado Decision Support System (CDSS)
- Colorado Division of Water Resources (DWR)
- United States Geological Survey (USGS)
- Arapahoe County

Individual Water Providers-Publicly Available Data (Websites)

- Denver Water
- Aurora Water
- Inverness Water and Sanitation District
- Arapahoe County Water and Wastewater Authority
- Town of Foxfield
- Englewood
- South Metro Water Supply Authority
- Rangeview Metropolitan District

Previous work products

- Denver Basin aquifer geological interpretations

Additional supportive GIS references

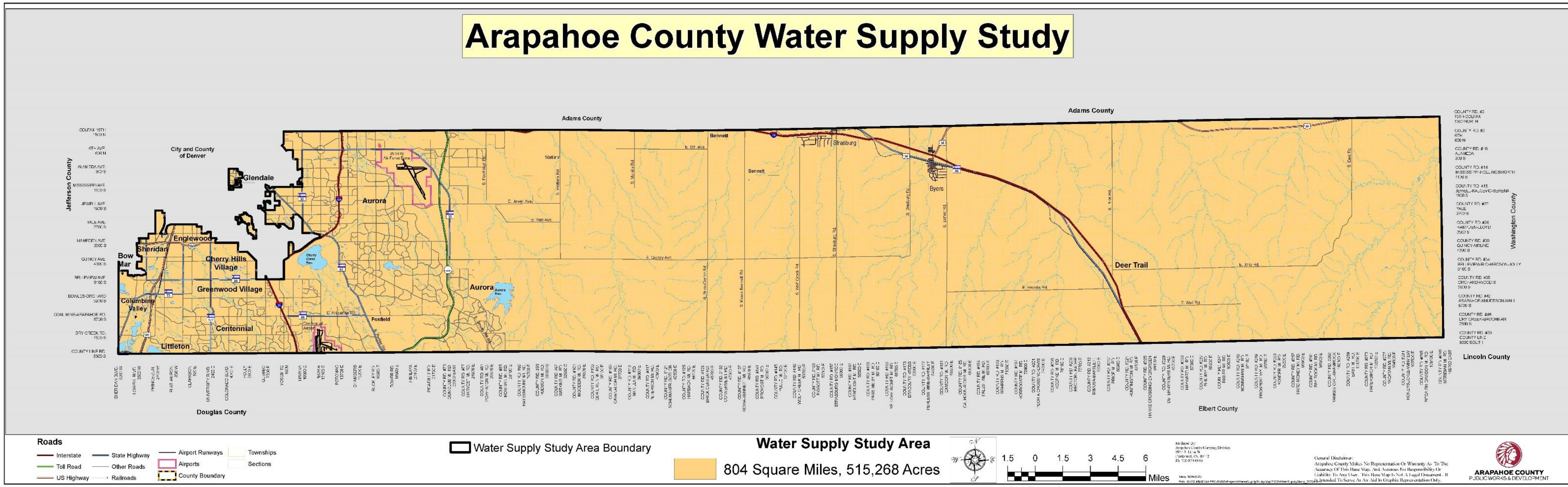


Figure 1-1. Study Area Map

SECTION 2.

STAKEHOLDER/ PUBLIC PARTICIPATION

SECTION 2 – STAKEHOLDER/PUBLIC PARTICIPATION

The County was mindful in seeking input early and at project milestones to refine our understanding of existing conditions, current practices, challenges, and opportunities from the many stakeholders and community members. To build a robust set of supported recommendations, the County developed an engagement plan that connected area experts, water providers and jurisdictions and gathered input from the larger community on needs, concerns, and strategies for water supply in Arapahoe County. This section describes that engagement plan and its results.

Advisory Committee

An advisory committee was formed made up of officials and staff from jurisdictions, agencies, and interest groups in the county, and hybrid meetings offered the flexibility to attend in person or virtually. The committee provided insight into local development and growth patterns, water supply and demand issues, and applicable local processes and regulations. They met five times over the course of the Study: on February 28 and March 30, 2023, for municipal planners only; and on June 13, August 29, and December 13, 2023, and on April 9, 2024, for the full committee. The following entities provided representatives and assisted with outreach to promote engagement activities:

- City of Aurora
- Town of Bennett
- City of Centennial
- Cherry Hills Village
- Town of Columbine Valley
- Town of Deer Trail
- City of Englewood
- Town of Foxfield
- Greenwood Village
- City of Littleton
- Town of Sheridan
- Arapahoe County
- City of Glendale
- I-70 Corridor Regional Economic Advancement Partnership
- Prosper Land and Development
- Arapahoe County Water and Wastewater Authority
- Lost Creek Groundwater Management District
- North Kiowa Bijou Groundwater Management District
- Rangeview Metropolitan District
- East Cherry Creek Valley Water and Sanitation District (WSD)
- Byers WSD
- Strasburg WSD
- May Farms
- South Metro Water Supply Authority
- Denver Water
- Aurora Water

Outreach

Project flyers were distributed that included a QR code and project website link to direct people to an on-line survey. Project information was distributed in newsletters and on social media, and flyers were distributed at in-person events within the county. The study team also shared materials at the County Fair and posted project banners at public libraries.

The advisory committee members shared content with their jurisdictions, and encouraged participation through their respective newsletters, social media, meetings, and websites. The survey was also promoted during a virtual public meeting. Two public open houses were also promoted with postcards mailed to over 1,000 addresses.

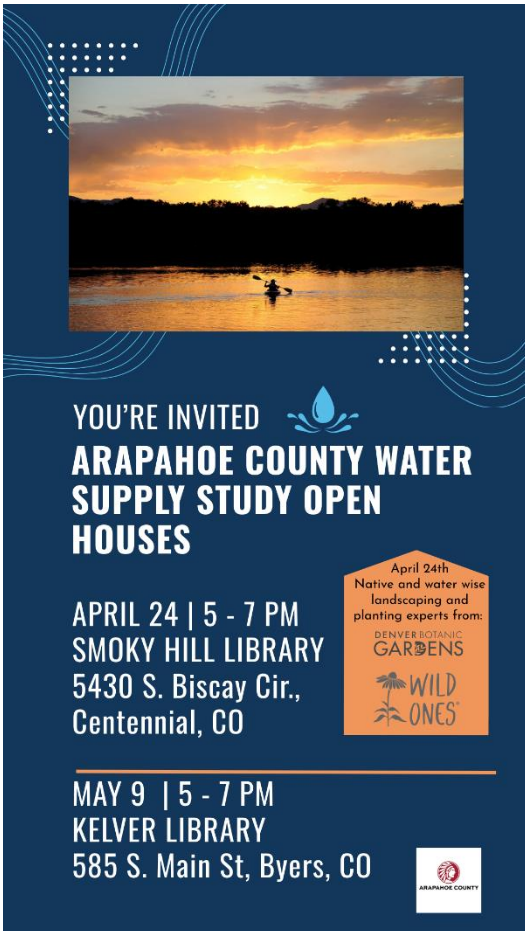


Figure 2-1. Open House Invitation

Community Interest and Question Form

The team also set up a simple online form to offer a way for the community to sign up for project notifications, ask questions and share comments. Responses were provided as questions were received and the team invited participants to join in engagement activities.

Virtual Public Meeting and Open Houses

A virtual public meeting was held on January 30, 2024, and there were 31 attendees. The study team gave an overview of the findings to date, responded to questions from participants, and shared the MetroQuest engagement tool. Participants asked questions about water quality and availability and expressed concerns about future growth. They also shared feedback on proposed recommendations for landscaping changes, water efficiency, and infrastructure.

Two public open houses followed. A flyer (Figure 2-1) promoting the events was distributed online via social media, the website, email correspondence, and in print at libraries and key locations. The first on April 24, 2024, was hosted at the Smoky Hill Library. Two non-profit organizations, the Denver Botanic Gardens and Wild Ones, attended and shared resources with participants. These organizations focus on growing local and drought-tolerant landscaping and were invited based on community interest.

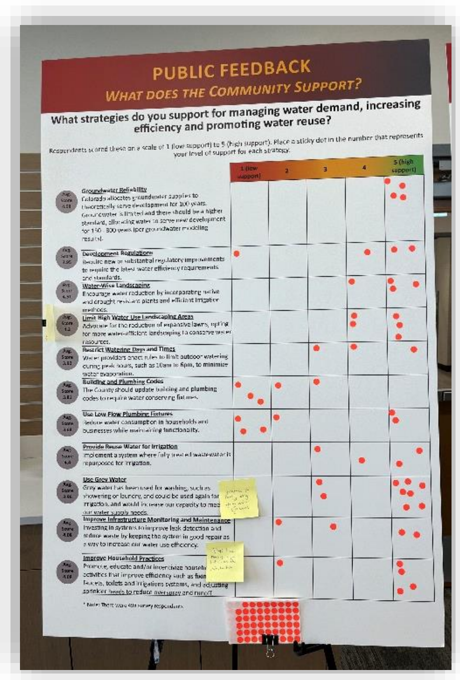


Figure 2-2. Public Open House Board with Participant Input

The open house included large boards with project information and opportunities for providing input (Figure 2-2). The topics were:

- **Project Overview**
- **Public Feedback**
- **Water-wise Landscaping**
- **Water Reuse**
- **Projected Water Demand Increases**
- **Denver Basin Aquifers**
- **Policy Recommendations**

Thirty-four people attended the first open house (Figure 2-3). Participants provided feedback on the strategies for water efficiency, which largely aligned with priorities identified during online engagement. Follow-up discussions led to a more nuanced understanding of those results. Takeaways from discussions with attendees included:

- Participants preferred incentives over additional regulations.
- Low-water, drought-tolerant, and native planting is a key interest for residents. They would like more resources and incentives to support their transition to water-wise landscaping.
- Participants were interested in water reuse, including graywater (from showers, baths, washing machines, and bathroom sinks), but they were unsure exactly what the terms mean and would need assurances regarding health and environmental impacts.
- What agencies provide water service and how responsibilities are delineated between water providers and Arapahoe County can be confusing.

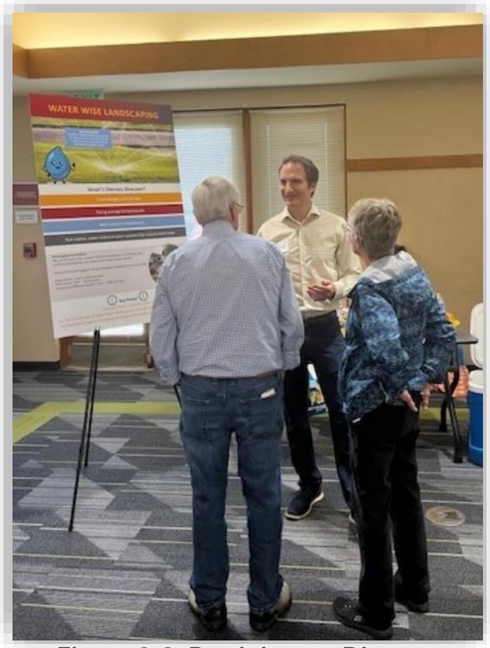


Figure 2-3. Participants Discuss Water-Wise Landscaping at the Smoky Hill Library Open House.

The second open house was held in eastern Arapahoe County at the Kelver Library in Byers on May 9, 2024, with 23 people attending (Figure 2-4). That session included much of the same information from the first session, but featured additional boards focused on water demand increases with and without conservation for the year 2050, and additional information on the Denver Basin aquifers. Key topics included:

- *Concern for groundwater availability among residents with wells.* They see additional development as a potential threat to their water supply.
- *Lack of enforcement for well rules in rural areas.* This has led to residential wells being used for larger-scale operations. This concerns neighbors who are drawing from the same source.
- *Projections for future water demand and availability.* Residents were interested in the details of the modeling and projections, and where their home or business fits into this future.

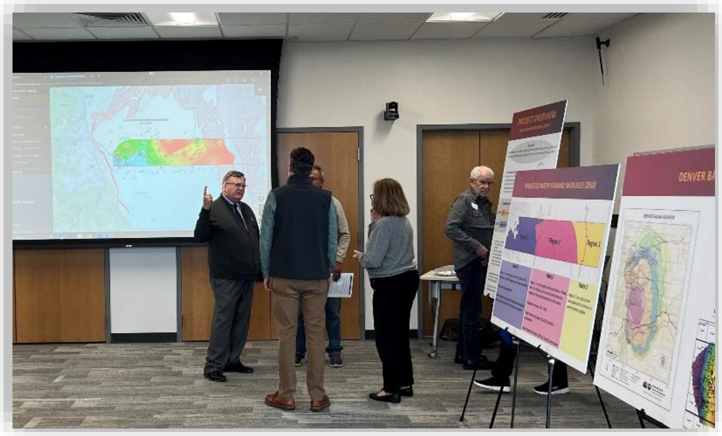


Figure 2-4. Discussions at the Byers Open House

Online Engagement

Arapahoe County used MetroQuest, an online platform, to engage with the community and gather input on the issue of water supply through a project survey. A link to MetroQuest was posted on the County's project website, and the survey was live for 58 days with 500 unique participants providing input. As seen in Figure 2-5, over 15,000 data points occurred and over 400 comments were received. Data collected from the survey results has been used to inform recommendations and next steps as described later in this Study.

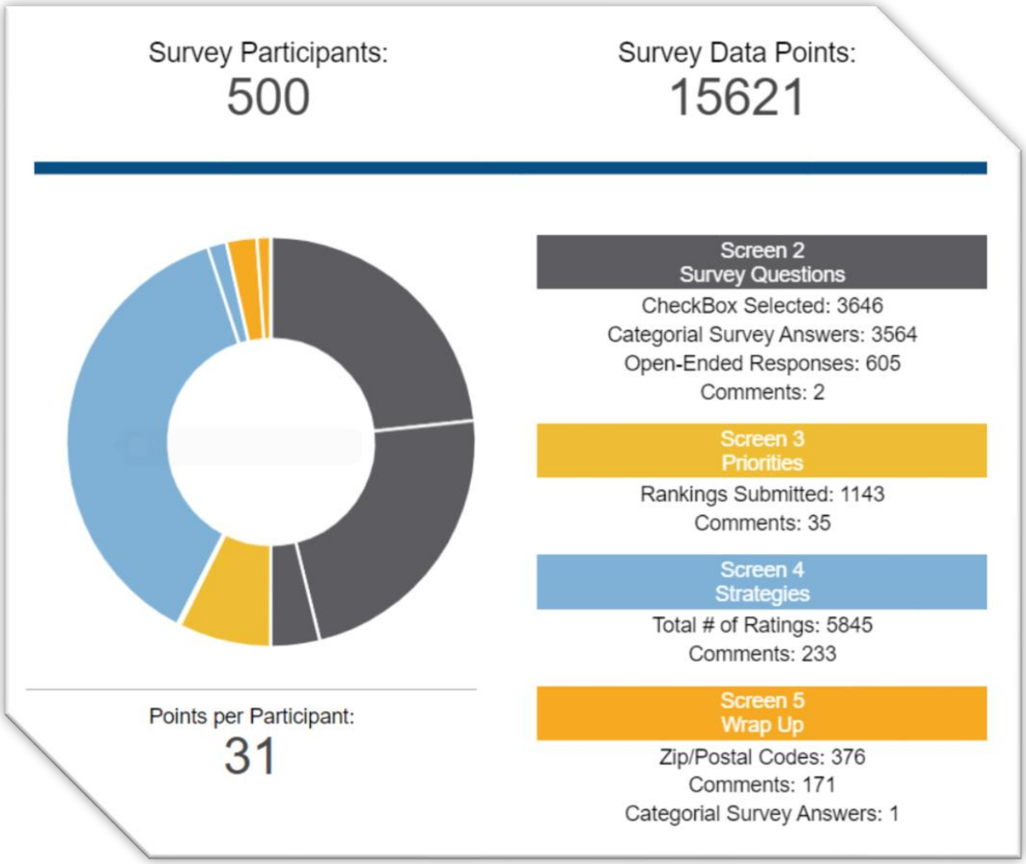


Figure 2-5. Metro-Quest Survey Data Points

MetroQuest is comprised of multiple screens asking questions related to specific categories. The screens included in the survey were:

- **Screen 1 - Welcome:** Provided an overview of the project and key study outcomes.
- **Screen 2 - Survey:** Asked participants about their relationship with water in Arapahoe County.
- **Screen 3 - Priority Ranking:** Asked participants to rank their top three priorities.
- **Screen 4 - Strategies:** Asked participants to rate water strategies within four distinct categories.
- **Screen 5 - Wrap Up:** Asked for basic information and any other thoughts. Shared how the survey data will be used and where participants could find more project information.

Screen 2: Survey

Participants were asked a series of questions about their relationship with water in Arapahoe County, as well as their water efficiency preferences. This screen included five different topics and 18 different questions. Below is a summary of the responses.

1. Your Relationship with Water Supply

What is your connection to water in Arapahoe County?

The majority of respondents (61 percent) were residents, and the second largest group (26 percent) were property owners (Figure 2-6).

Eleven people selected 'other' and included their relationship by name:

- WSD District Manager (1)
- Stakeholder (1)
- Elected Official (2)
- Farmer Irrigated (1)
- Water advocate (1)
- Consulting engineer in water/wastewater industry (1)
- Landscape project planner (1)
- Recreational (1)
- Economic development (1)
- School district (1)

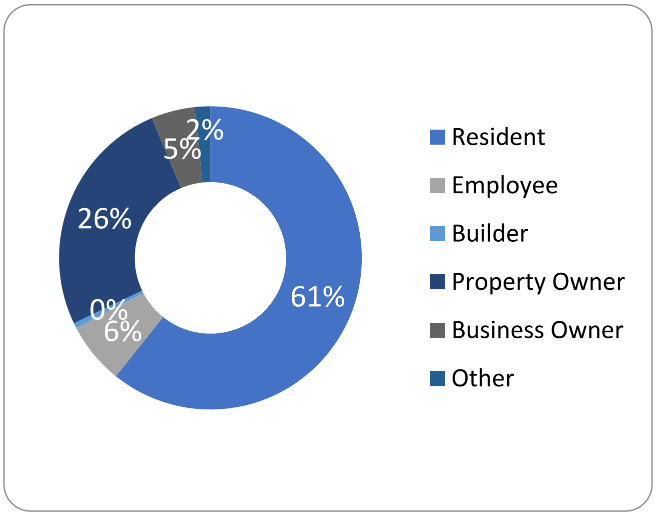


Figure 2-6. Results for "What is your Connection to Water in Arapahoe County?"

Where does your water come from?

Ninety-one percent of respondents get their water from a water provider, five percent responded that they have a private well, one percent responded that they have a community well and three percent were unsure.
Of the 91 percent served by a water provider, they identified the following:

- Arapahoe County Water and Wastewater Authority (38)
- City of Aurora/Aurora Water (94)
- Byers Water District (2)
- City of Englewood (6)
- City of Thornton (1)
- Deer Trail (3)
- Denver Water (93)
- East Cherry Creek Valley WSD (96)
- Englewood (10)
- Not sure (5)
- Platte Canyon (1)
- Rangeview Metro District (2)
- Southgate WSD (4)
- Stonegate Metro District (1)
- Willows Water District (9)

Are you concerned about the future water supply in Arapahoe County?

The majority of respondents (63 percent) were concerned about the future of water in Arapahoe County, with 91 percent either concerned or somewhat concerned (Figure 2-7).

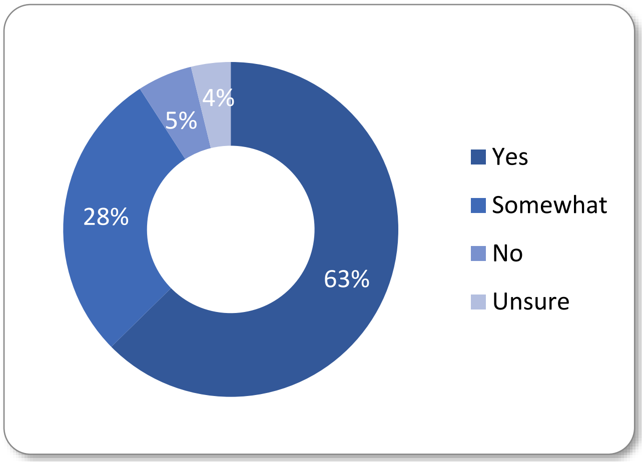


Figure 2-7. Results for "Are you concerned about the future water supply in Arapahoe County?"

2. Water Quality and Supply

What water QUALITY issues have you experienced?

Forty-three percent of respondents did not have a water quality concern, 27 percent noted that they were concerned about taste, 16 percent were concerned about color and 14 percent had "other concerns." Comments for "other" included concerns about hard water, water smell, and pollutants getting into their water source.

What water SUPPLY issues have you experienced?

Eighty percent indicated they have not experienced water supply issues. Fourteen percent have experienced low-pressure, one percent have experienced a dry well and five percent have experienced other issues.

If other for quality or supply, please explain.

Most often, participants responded to this question by saying that they experienced hard water. Several times it was noted that mineral deposits in the water supply seem to be higher than average. Some even noted that their water sometimes has a reddish-brown tint or a particular odor.

Should the County work with water providers to identify funding and resources to build additional reservoirs to increase supplies?

There is support for additional infrastructure investments for reservoirs that increase supply from 60 percent of respondents. However, 34 percent were unsure if this type of investment should be supported, indicating that additional education would be beneficial (Figure 2-8).

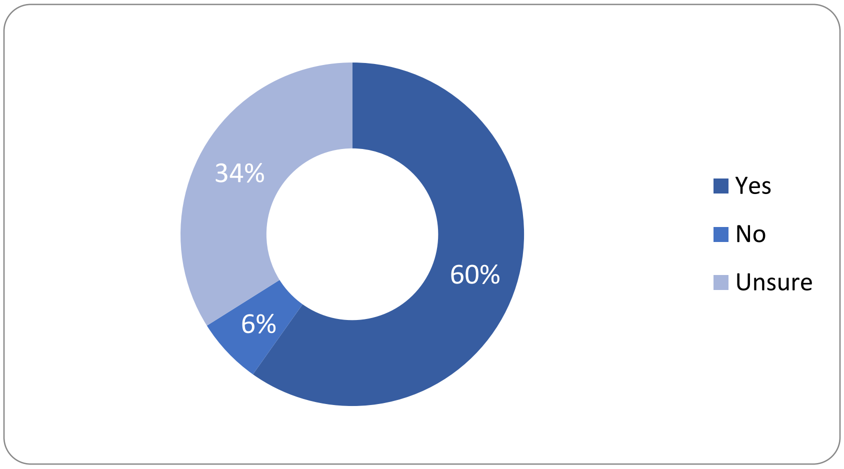


Figure 2-8. Results for "Should the County Work with Water Providers to Identify Funding and Resources to Build Additional Reservoirs to Increase Supplies?"

Water providers operate independently, and supply is not coordinated across the county. Would you support the County allocating resources to have a greater role in water supply delivery to improve efficiency?

The majority of respondents support the County allocating resources to improve water efficiency by having a greater role in supply delivery. However, about a third of respondents were uncertain (Figure 2-9).

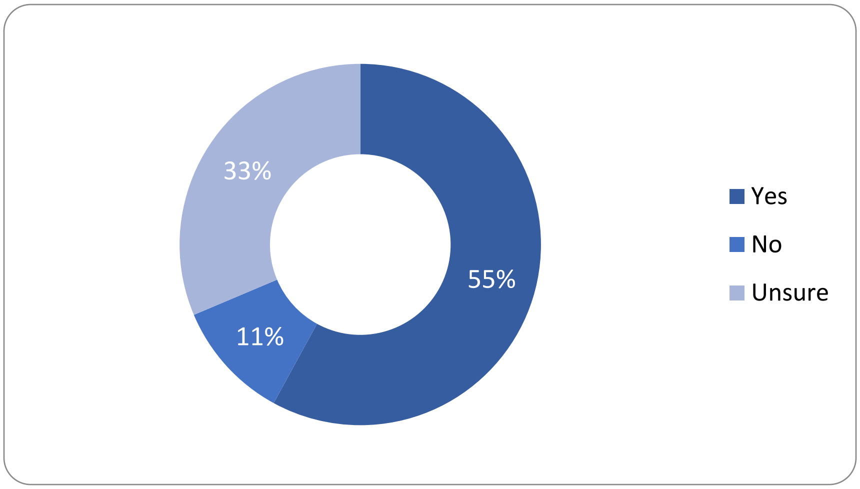


Figure 2-9. Results for "Would you Support the County Allocating Resources to have a Greater Role in Water Supply Delivery to Improve Efficiency?"

3. In-Home Water Recycling and Rain Barrel Practices

Do you have a rain barrel(s) to help with landscape watering?

Eighty-six percent of respondents do not have rain barrel(s), while 14 percent do.

Are you interested in in-home water recycling (such as an in-home filter system for water reuse)?

Most respondents needed more information to respond to this, showing that the concept is not familiar to many. However, only 20 percent said that they are not interested, suggesting that there is interest in learning more and potentially investing in such a system (Figure 2-10).

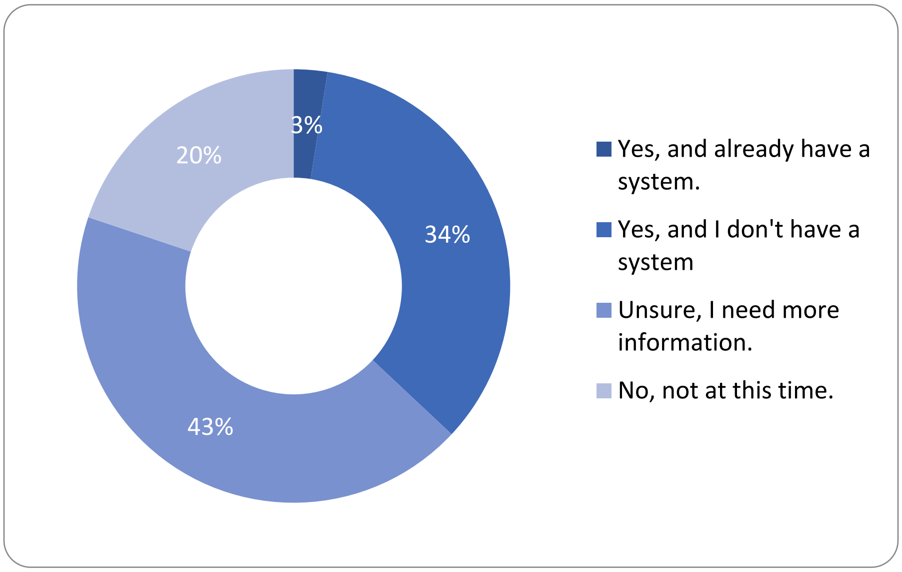


Figure 2-10. Results for "Are you Interested in In-home Water Recycling?"

Do you have any concerns about in-home water recycling? If yes, please explain.

The responses show that people are concerned about the safety of in-home water recycling including the cost, how to retrofit current systems, and how to complete necessary maintenance and repairs. There were also concerns with homeowners' association (HOA) regulations and municipal code restrictions that they may need to navigate.

4. Water Saving Preferences

Where would you want to / how would you be willing to save water?

Responses show there is a diverse range of activities people would be willing to try to save water. The greatest support was for water-wise landscaping at 22 percent, followed by rain/snow melt collection barrels (landscaping water).

If other, please describe.

Eliminating lawn areas with high water demand, and regulating water-intensive fracking, were two repeated comments. Several participants said they already participate in at-home water conservation methods such as limiting car washes and xeriscaping their yards where possible (Figure 2-11).

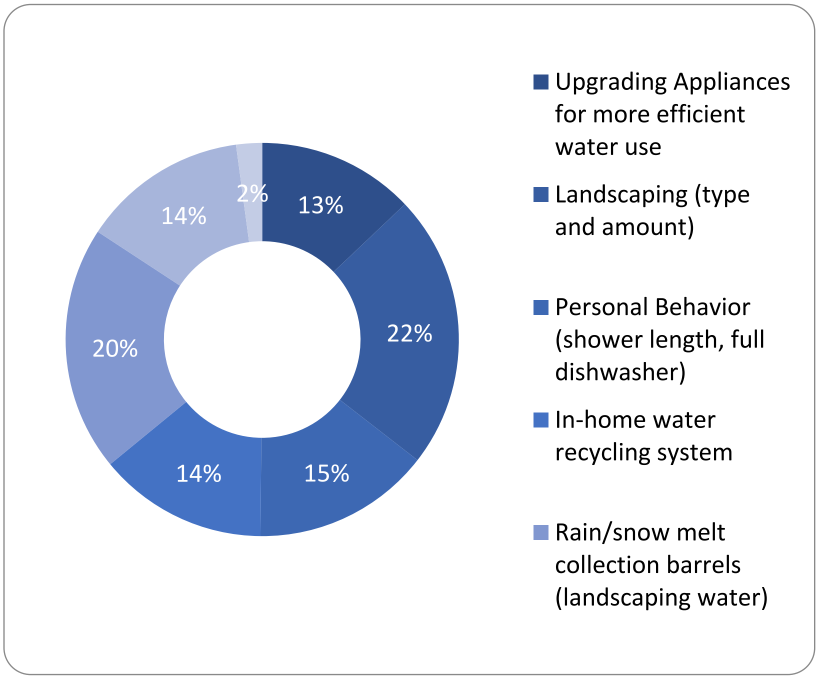


Figure 2-11. Results for "Where and how would Participants be Willing to Save Water?"

5. Water-Wise Landscaping

Would you like to change your landscaping to reduce water usage?

The results show a strong desire to act, with 73 percent answering that they would like to change their landscaping. Among this group, some are concerned about costs and others would like more information on how to make the change. This represents a big opportunity in relation to future water conservation (Figure 2-12).

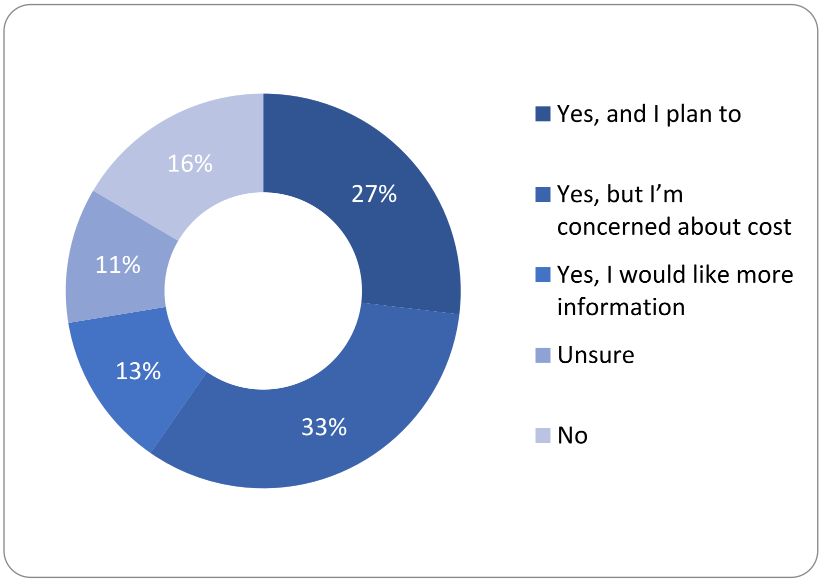


Figure 2-12. Results for "Would you Like to Change your Landscaping to Reduce Water Usage?"

How likely would you be to prioritize buying a home with drought-tolerant landscaping to reduce water consumption and lower your water bill?

Over 50 percent of respondents are likely or very likely to prioritize buying a home with drought-tolerant landscaping, pointing to a market preference for these types of plantings (Figure 2-13).

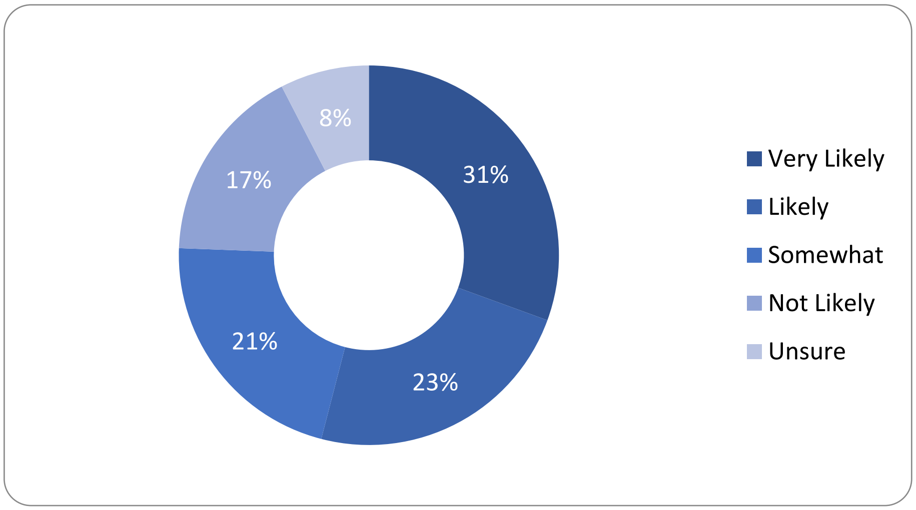


Figure 2-13. Results for "How Likely would you be to Prioritize Buying a Home with Drought-Tolerant Landscaping?"

If you plan to make landscaping changes, which of the following are you considering?

The majority of respondents prefer replacing turf with drought-tolerant landscaping at 48 percent, with another 30 percent preferring drought-tolerant turf (Figure 2-14). The interest in drought-tolerant landscaping points to opportunities to reduce water use through educational programs for planting and additional resources.

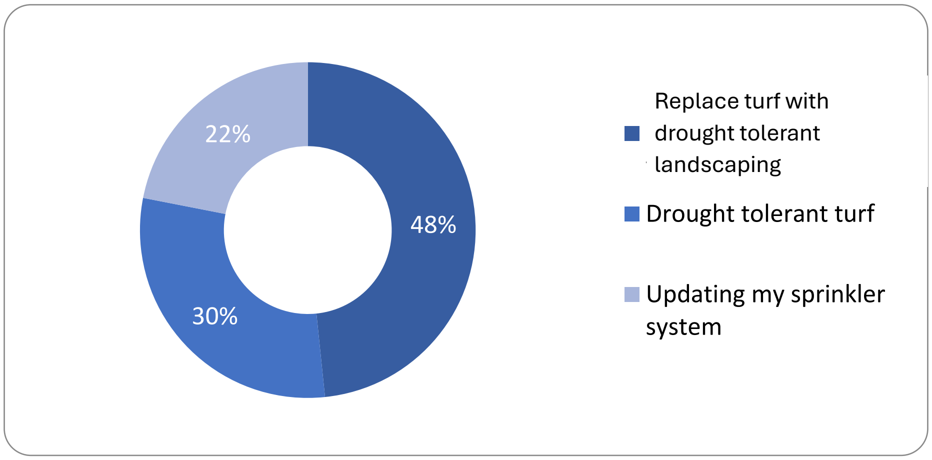


Figure 2-14. Results for "If you Plan to make Landscaping Changes, which of the Following are you Considering?"

Screen 3: Water Supply Priorities

Respondents were asked to rank their priorities when it comes to water supply. Ensuring high water quality was the top priority. The next priorities were supporting efficiency measures, water affordability, future water sources, and planning for climate change. Water affordability and future water sources received the same number of responses. Of note, although planning for climate change was not within the top three ranked priorities, it did receive the second highest amount of “Ranked 1” results. Because the ranking results were averages, this shows that climate change was not selected as many times by respondents, but when it was selected, it ranked higher. This can be seen in Figure 2-15, which shows the ranking results for each selection. Table 2-1 describes the priorities and lists them in order of ranking.

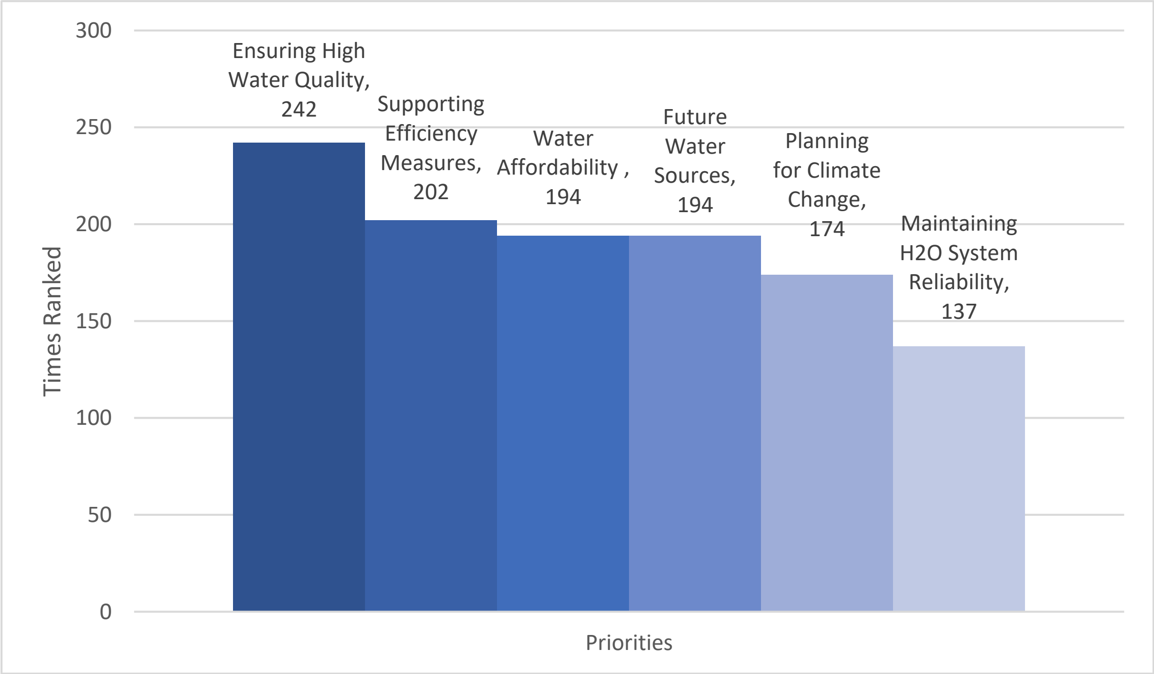


Figure 2-15. Water Supply Priority Ranking

Table 2-1. Water Supply Priority Ranking

Priorities for Water Supply			
Rank	Category	Description	No. of times selected
1	Ensuring High Water Quality	Ensuring high-quality water is a critical health and safety priority for Arapahoe County. The County should work with water providers on strategies that prioritize investing in infrastructure and processes for water quality.	242
2	Supporting Efficiency Measures	Supporting water efficiency measures to sustain water supply into the future is critical. Water efficiency and water conservation both mean reducing water usage to preserve supply for the future. Using water more efficiently increases its availability and increases the likelihood of an available supply in the future.	202
3	Water Affordability	Work with water providers to create strategies and programs for water affordability for low-income residents for a productive and equitable community. Those who rely on wells may see costs drastically increase due to deeper and more complex well drilling needs. Solutions for all community members, regardless of service type, are key.	194
4	Future Water Sources	The County should work with water providers to identify resources and strategies for building new reservoirs, pulling water from western sources, and increasing capacity through infrastructure investments and increased water allocation.	193
5	Planning for Climate Change	As our climate changes, we expect to see the average temperature rise, more extreme heat days, and a greater likelihood of drought. This may impact water availability for our community in the years to come, making proactive measures to protect our supply even more important.	174
6	Maintaining H20 System Reliability	County residents, businesses, and water districts use wells to access underground aquifers, and infrastructure to access water from upstream sources in our watershed. To increase access to these sources, the County should work with water providers to identify ways to invest in infrastructure and ensure adequate water rights are in place.	136

Screen 4: Supply Strategies

The strategy rating screen included four categories and a total of 16 strategies. Figure 2-16 shows the Managing Demand / Land Use Considerations category and its four associated strategies. As shown, details about each strategy were provided so that respondents could rate them on a scale of 1 to 5 stars. Tables 2-2 through 2-5 list the four categories and how the strategies within them ranked. The top three strategies selected across the categories were: water-efficient landscaping, providing reuse water for irrigation, and limiting high-water use landscaping areas.

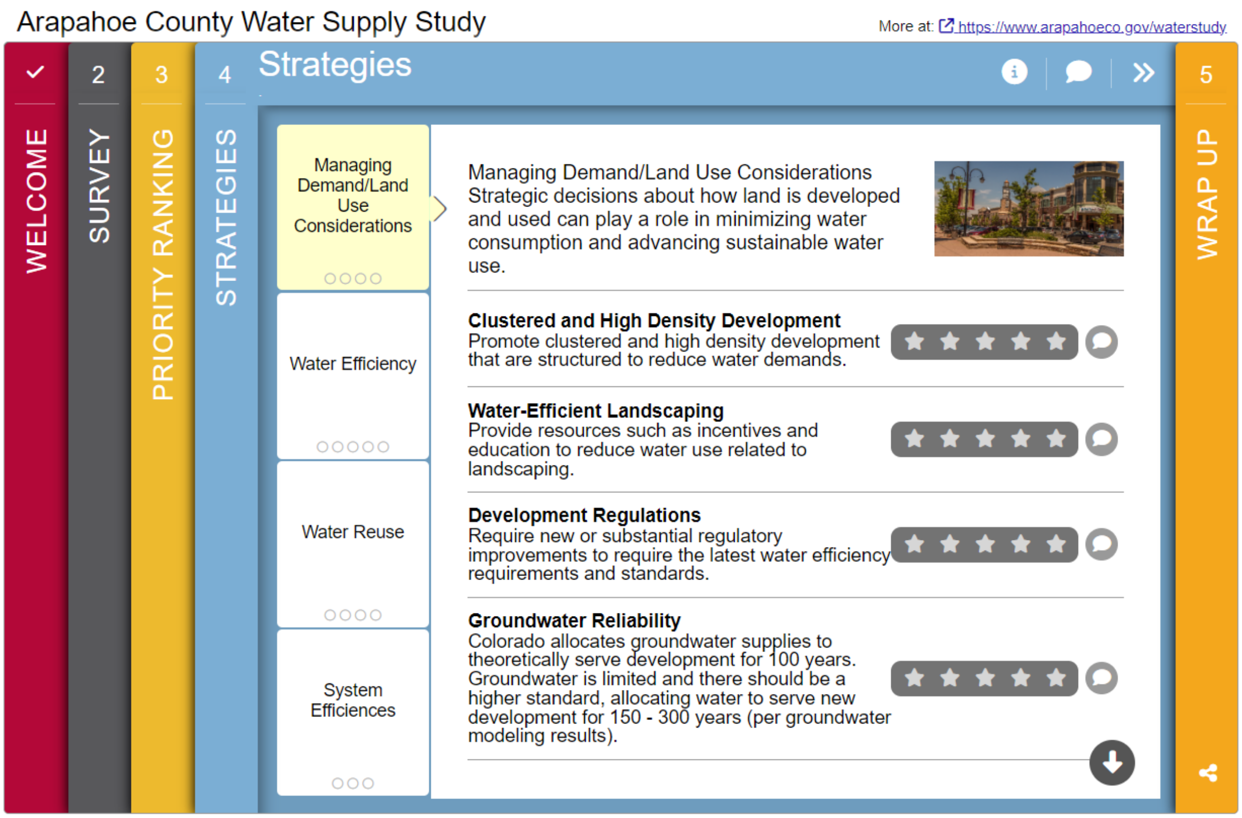


Figure 2-16. Water Supply Strategies Screen

Table 2-2. Managing Demand/Land Use Considerations Category

Managing Demand/Land Use Considerations: Strategic decisions about how land is developed and used can play a role in minimizing water consumption and advancing sustainable water use.			
Strategy	**Description**	**Comment Summary**	**Ranking Average (1-5)**
Water-Efficient Landscaping	Provide resources such as incentives and education to reduce water use related to landscaping.	Support for nice looking native landscaping, given there is incentive for property owners and action is taken to remove turf from nonfunctional areas (like medians, etc.) **17 comments**	4.42
Groundwater Reliability	Colorado allocates groundwater supplies to theoretically serve development for 100 years. Groundwater is limited and there should be a higher standard, allocating water to serve new development for 150 - 300 years (per groundwater modeling results).	Limited support given there is need for additional oversight about how much water is needed for new development and concern about groundwater suitability given toxic runoff and fracking impacts, which could make groundwater unusable and decrease reliability. **16 comments**	4.08
Development Regulations	Require new or substantial regulatory improvements to require the latest water efficiency requirements and standards.	General support for this if the onus is not on single residential landowners and is instead put on commercial properties or other larger corporations or HOA groups. **18 comments**	3.95
Clustered and High-Density Development	Promote clustered and high-density development that is constructed to reduce water demands.	Concern for additional development and the impact it would have on the existing water supply, as well as other infrastructure (i.e., road network, utilities, flood prevention). **21 comments**	3.04

Table 2- 3. Water Efficiency Category

Water Efficiency: By promoting good water stewardship and reducing water waste, our community can improve access to water for years to come.			
Strategy	**Description**	**Comment Summary**	**Ranking Average (1-5)**
Water-Wise Landscaping	Encourage water reduction by incorporating native and drought-resistant plants and efficient irrigation methods.	Support for this strategy and emphasis on encouraging the use of native plants that are amenable to Colorado's climate and not just replacing turf with dirt or rocks. Also incentivizing HOAs to update their bylaws to allow for water-wise landscaping. **12 comments**	4.51
Limit High Water-Use Landscaping Areas	Advocate for the reduction of expansive lawns, opting for more water-efficient landscaping to conserve water resources.	General support but ensuring this is relegated to new development and that HOAs and large corporations are a part of the process. Also making sure that there are still open spaces and lawns left for recreation. **14 comments**	4.3
Restrict Watering Days and Times	Water providers enact rules to limit outdoor watering during peak hours, such as 10 am to 6 pm, to minimize water evaporation.	Water monitoring rules already exist, and it does not seem to be helping. Need more enforcement and better monitoring strategies to ensure landscaping isn't over or underwatered. **12 comments**	3.92
Building and Plumbing Codes	The County should update building and plumbing codes to require water-conserving fixtures.	General support when used for new development and businesses. Ensure the burden is not placed on existing homeowners who cannot afford the updates. **13 comments**	3.81
Use Low-Flow Plumbing Fixtures	Reduce water consumption in households and businesses while maintaining functionality.	General lack of support mostly because there are questions about low-flow fixture efficiencies and whether it improves functionality. **13 comments**	3.68

Table 2-4. Water Reuse Category

Water Reuse: These strategies encompass various water reuse options.			
Strategy	**Description**	**Comment Summary**	**Ranking Average (1-5)**
Provide Reuse Water for Irrigation	Implement a system where fully treated wastewater is repurposed for irrigation.	Generally supportive ensuring it is a safe, reliable, and efficient method of saving and reusing water. **8 comments**	4.4
Use Graywater	Graywater (previously used for washing, showering or laundry) could be used again for irrigation, and would increase our capacity to meet water supply needs.	Concern about how well the water would be treated before using. Need to ensure water is properly treated before agreeing to this strategy. **11 comments**	3.96
Provide Advanced Treatment for Potable Water	Employ advanced treatment processes to transform treated wastewater (reuse water) into potable water.	Concern about efficacy of the treatment, especially when it comes to filtering chemicals and other toxic matter out of the water so that it is safe for drinking. **12 comments**	3.64
Blend Reuse Water and Other Supplies	Combine fully treated water with other water sources and subject it to further treatment to ensure high-quality drinking water.	Generally unsupportive because of concern for water not being treated enough to be safe for drinking. **16 comments**	3.58

Table 2-5. System Efficiencies Category

System Efficiencies: Increasing the efficiency of the system is a strategy to make the best use of water.			
Strategy	**Description**	**Comment Summary**	**Ranking Average (1-5)**
Improve Infrastructure Monitoring and Maintenance	Investing in systems to improve leak detection and reduce waste by keeping the system in good repair is a way to increase our water use efficiency.	General support but concern about the cost of monitoring and maintenance and whether the taxpayer would be held responsible. **11 comments**	4.23
Improve Household Practices	Promote, educate and/or incentivize household activities that improve efficiency such as fixing leaky faucets, toilets and irrigation systems, and adjusting sprinkler heads to reduce overspray and runoff.	Mixed level of support. Comments emphasized providing incentives rather than prohibitions or penalties. **14 comments**	4.12
Community Well System / Regional Water Supply	Would you be in favor of collaborating with neighbors to establish a community well system or regional water supply project for greater long-term reliability, even if it substantially increased the cost of water service?	More than half of respondents were against this and many voiced concerns about how this would work and what the cost to the property owner would be. **21 comments**	2.71

CONCLUSION

Robust public outreach and stakeholder engagement provided valuable input for this Study and demonstrated support for more efficient water use in the future and a need for additional education and outreach.

SECTION 3.

LAND USE & SOCIOECONOMIC SCENARIOS

SECTION 3 – LAND USE & SOCIOECONOMIC SCENARIOS

As noted in Section 1, Arapahoe County has over 656,000 residents (U.S. Census Bureau, July 1, 2023). This section identifies a likely range of land use and socioeconomic scenarios for use in projecting growth in water demands across Arapahoe County through the year 2050. Those demands could be based on a variety of forecasting techniques.

Population Forecast

The County's Planning Division prepared a set of forecasts for the 2018 Comprehensive Plan, predicting a 2040 county population of 875,000. However, the State Demography Office (SDO) has revised its forecast several times since then. A forecast analysis for the Watkins-Bennett subarea study lowered the county forecast to 844,600 for 2045. This Study now provides an opportunity to update the population forecast to 2050.

The 2023 *Colorado Water Plan* used a scenario planning process with five different forecasts using different assumptions about the state's growth. These included: business as usual, weak economy, cooperative growth, adaptive innovation, and hot growth. For Arapahoe County, the 2050 population projection ranged from 845,513 for the "weak economy" scenario to 956,410 for "hot growth."

The County selected two scenarios to bracket a range of growth for this Study. The "weak economy" scenario was thought to be too pessimistic, although that scenario would be consistent with current SDO forecasts. However, for purposes of this Study, being too low would risk underestimating the forecasted need for additional water supplies. For that reason, the County selected "business as usual" for the low-end forecast of 899,738 in 2050. That is also reasonably consistent with the projected population of 875,000 in 2040 used in the 2018 Comprehensive Plan.

The "hot growth" scenario provides the most aggressive growth assumptions for Arapahoe County. It points to a 2050 estimated population of 956,410 or nearly 57,000 higher than the low scenario. (Note that this is still below the county growth forecasts in recent updates of the Transportation and Open Space Plans.) Therefore, this Study is based on an estimated 2050 population range from 900,000 to 960,000 as shown in Figure 3-1.

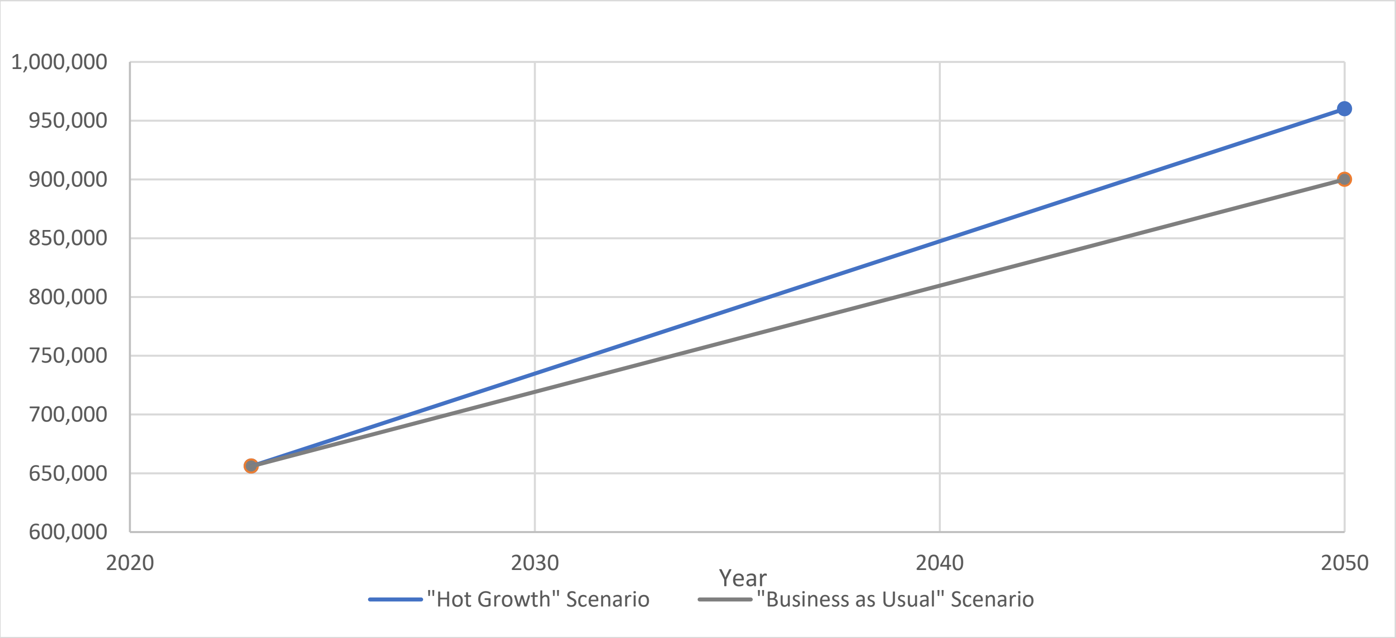


Figure 3-1. Population Forecasts

Employment Forecast

To predict nonresidential demand in the county, an updated employment forecast is needed. Employment is concentrated in several locations in the county, including a major hub within the Arapahoe County Water and Wastewater Authority (ACWWA) service area. Basing the County's water demands solely on residential population would be a severe underestimate.

Even estimating current employment is challenging. Most datasets exclude significant parts of the economy such as government employment or the self-employed. The SDO provides the best available estimate of total employment in the county; estimated at 393,318 in 2020.

The County's Comprehensive Plan forecasts assumed a 2040 employment total of 500,000 compared to the SDO's 2010 estimate of 329,000 jobs. The most recent SDO forecast predicts 531,877 jobs in the county in 2050; 138,559 more than their 2020 estimate. That dataset has a 2040 estimate of 505,877 jobs, fairly consistent with the County's prior forecast.

The most current Denver Regional Council of Governments (DRCOG) forecast dataset has much higher numbers for Arapahoe County employment. The 2020 value (using a forecast starting from a 2010 base) is 434,171 with a 2050 value of 594,294. DRCOG uses the SDO forecasts but appears to have assumed that Arapahoe County will capture a higher share of metropolitan employment. For this Study, the County has selected a 2050 employment range from the SDO's estimate of 532,000 to the DRCOG estimate of 595,000 as shown in Figure 3-2. The 2020 employment range used is 393,318 to 434,171.

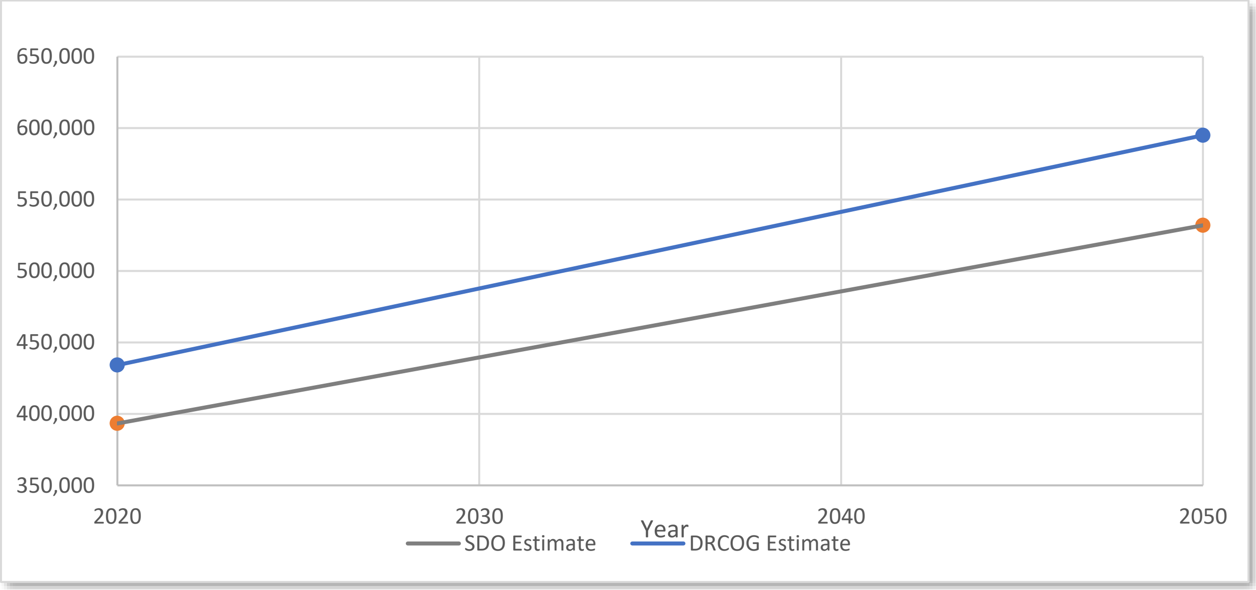


Figure 3-2. Employment Forecasts

Service Area Distribution

The DRCOG small area forecasting process uses a real estate market model at the parcel level to distribute their forecast to small areas. Their traffic analysis zones (TAZs) can be aggregated to the service areas of water providers in Arapahoe County. These appear to be reasonable except for the small places in the eastern county. For water provider forecasts, the County used current estimates of the service connections for Byers, Strasburg and Deer Trail and assumed that they would capture the same proportionate share of the DRCOG forecast for their related TAZs.

Table 3-1 provides the household forecasts for the 12 water providers in the county. The numbers shown will be rounded in later analysis to reflect the appropriate level of forecast uncertainty. The “No District” area is the estimate of households on individual groundwater wells.

Table 3-1. Households Forecast by Water Provider

Households	2020	2050 Low	2050 High
Totals*	***261,095***	***350,200***	***373,540***
Denver	84,118	96,083	99,219
Aurora	128,906	185,319	200,102
ECCV WSD	20,766	26,210	27,636
Englewood	15,944	17,396	17,776
Inverness WSD	990	1421	1534
ACWWA	4836	5375	5517
Sky Ranch	92	3695	4639
Prosper	53	7200	5198
Strasburg	40	45	47
Byers	415	424	426
Deer Trail	300	329	336
Bennett	15	17	118
No District	4620	9694	11,024

*Totals are approximate.

Table 3-2 uses the same method to aggregate TAZ values to provider service areas. The eastern water providers have been adjusted to reflect data from the Census Bureau's job estimates in the OnTheMap application.

Table 3-2. Employment (Jobs) Forecast by Water Provider

Employment	2020	2050 Low	2050 High
Totals*	***427,500***	***532,000***	***595,000***
Denver	202,496	240,397	260,199
Aurora	125,913	166,979	188,434
ECCV WSD	11,105	16,221	18,894
Englewood	33,856	40,997	44,728
Inverness WSD	15,861	16,250	16,454
ACWWA	33,566	41,752	46,029
Sky Ranch	20	188	275
Prosper	80	267	365
Strasburg	150	591	822
Byers	384	384	383
Deer Trail	127	183	213
No District	3931	7065	8702

*Totals are approximate.

SECTION 4.

WATER PROVIDERS

SECTION 4 – WATER PROVIDERS

This section identifies the water providers across the county responsible for securing adequate water supplies to serve their customers. (A list of all the county's water providers can be found in Table 4-1.) First, it is helpful to consider the varying conditions from the more urbanized western area of the county to the agricultural eastern area. For purposes of this Study, the county is divided into three regions (Figure 4-1) with all of the water providers located in Regions 1 and 2.

The regions are as follows:

- Region 1 – Western county boundary to Aurora's planned 2018 eastern annexation boundary. This region is characterized as highly developed/developing, primarily urban, and largely served from renewable surface water supplies.
- Region 2 – Aurora's planned eastern annexation boundary to the County's Tier 3 development boundary east of Deer Trail. This region is primarily unincorporated with a mix of urban and rural development, and largely served from nonrenewable groundwater sources.
- Region 3 – County's Tier 3 development boundary east of Deer Trail. This region is rural, has limited water resources, and is expected to remain exclusively in agriculture.

Table 4-1: Arapahoe County Water Providers

Arapahoe County Water Providers	
Arapahoe County WWA (ACWWA)	Devonshire Heights WSD East Cherry
Bow Mar WSD	East Cherry Creek WSD
Castlewood WSD	Galleria Metropolitan District
Castlewood WSD Districts A, B, C, D & E	Hillcrest WSD
Cherry Creek Valley WSD	Havana WSD
Cherry Creek Village WD	Hi-Lin WSD
Cherry Creek Village Water District	Holly Hills WSD
Cherry Hills Heights WSD	Holly Hills WSD District E
Cherry Hills North WSD	Holly Mutual Water Company
City of Aurora	Inverness WSD
City of Cherry Hills Village	Loretto Heights Re-Sub Water Assn.
City of Englewood	Mansfield Heights WSD
City of Glendale	Panorama Park Water Association
City of Greenwood Village	Platte Canyon WSD
City of Littleton	Rangeview MD
City of Sheridan	South University Place Water Assn.
Columbine WSD	Southeast Englewood Water District
Country Homes Metropolitan District	Southgate Water District
Creek Valley WSD(ECCV)	Southwest Metropolitan WSD
	Willows Water District

Note: WD is Water District; WSD is Water and Sanitation District; WWA is Water and Wastewater Authority; MD is Metropolitan District

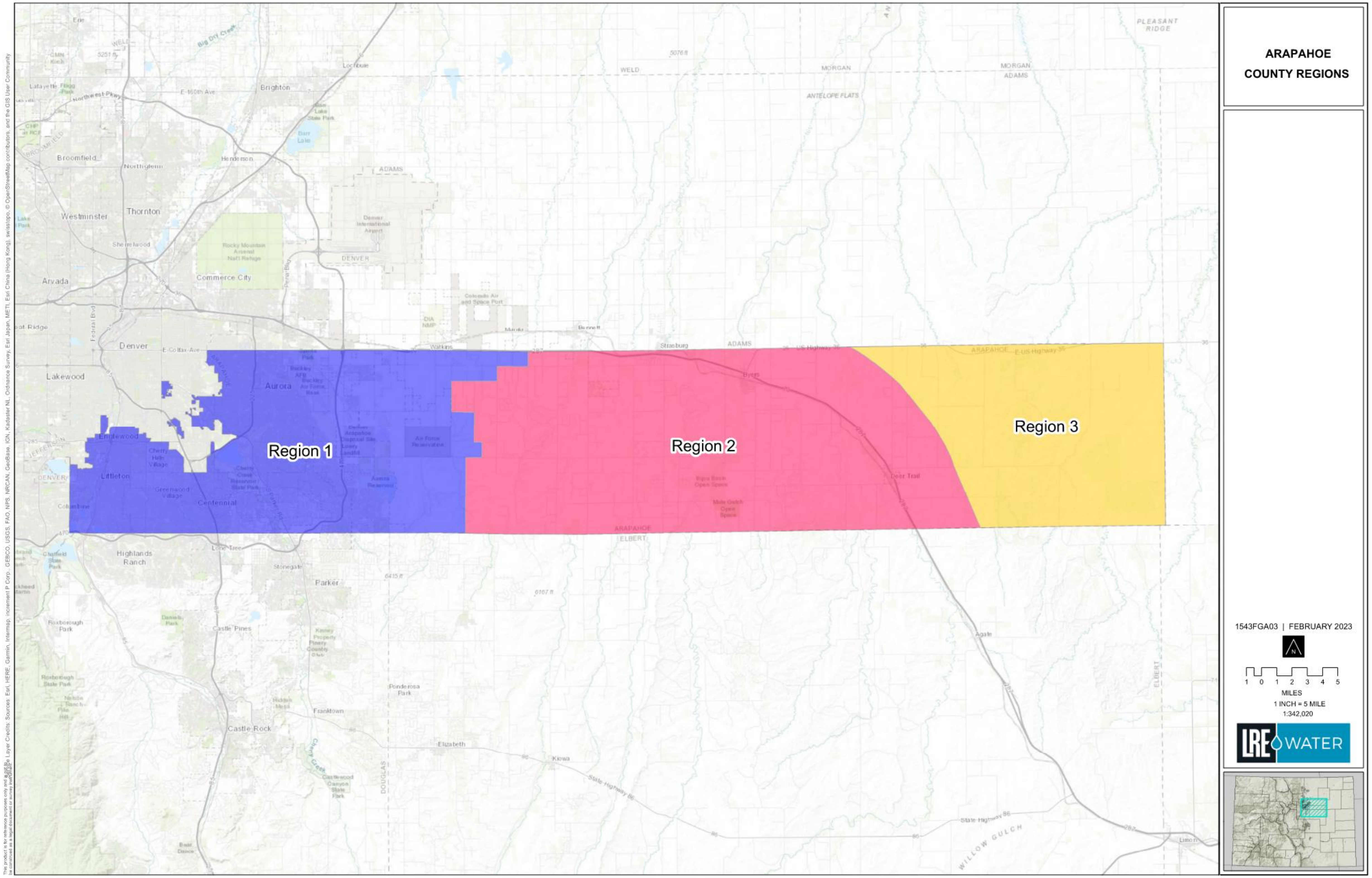


Figure 4-1. Arapahoe County Regions

Region 1 Water Providers

The major water providers in Region 1 include Denver Water (via its connectors), City of Aurora, City of Englewood, Arapahoe County Water and Wastewater Authority (ACWWA), East Cherry Creek Valley (ECCV) Water and Sanitation District (WSD), Inverness WSD (Inverness) and Rangeview Metropolitan District (Rangeview)--including the Sky Ranch master-planned community (Figure 4-2).

Most water supplied in Region 1 is from renewable resources imported to the county. Water is delivered via a complex distribution system from mountain storage west of Arapahoe County, or from the South Platte drainage. A brief description of the major water providers and their water supply and use is provided below.

Denver Water

Denver Water provides water to approximately 1.5 million customers and over thirty water and sewer districts, towns and cities. Its water supply consists of a complex surface water collection system that includes the South Platte, Blue, Fraser and Williams Fork Rivers, and Boulder and Ralston Creeks.

Denver Water stores raw water in Dillon, Eleven Mile Canyon, Williams Fork, Cheeseman, Gross, Chatfield, Wolford Mountain, Antero, Marston, Ralston, Strontia Springs, Meadow Creek, South Complex, North Complex, and Platte Canyon Reservoirs, and Soda and Long Lakes. In Arapahoe County, they provide water under three main contract types for residential service outside the City and County of Denver:

- **Total Service** — Under this type, Denver Water owns the water system and is responsible for its operation, maintenance and replacement. Denver Water reads each customer's meter and bills them at the established "Total Service" rate. In these areas, water service is provided in the same manner as that provided to Denver customers.
- **Read and Bill** — Under this contract type, the distributor owns and is responsible for construction, operation, maintenance, and replacement of its water system to which Denver Water delivers. Denver Water reads each customer's meter and bills them at the established "Read and Bill" rate.
- **Master Meter** — A Master Meter distributor owns and is responsible for construction, operation, maintenance, and replacement of its water system. Denver Water delivers through one or more master meters and bills the distributor at the established "Wholesale (Master Meter)" rate. The distributor is responsible for reading the meters and billing its customers according to the distributor's rate schedules.

As shown in Table 4-2, Denver Water provides water to 31 Total Service entities, five Read and Bill entities, and six Master Meter entities in Arapahoe County. In addition, Denver Water is a partner with the City of Aurora, ECCV, and South Metro Water Supply Authority (SMWSA) in providing South Platte water through the ECCV and Prairie Waters Pipelines (known as the Water Infrastructure and Supply Efficiency [WISE] partnership).

Denver Water's full storage capacity is approximately 700,000 AF. However, on average, Denver Water has diverted 290,000 AFY to serve an average demand of 225,600 AFY. Approximately 35 percent of its supply goes to serve outside the City and County of Denver with 15.6 percent used within Arapahoe County; an estimated 35,200 AFY based upon the percentage of Denver Water's service area within Arapahoe County.

Denver Water's groundwater use is very limited, with the focus on using the Denver Basin aquifers as storage for drought.

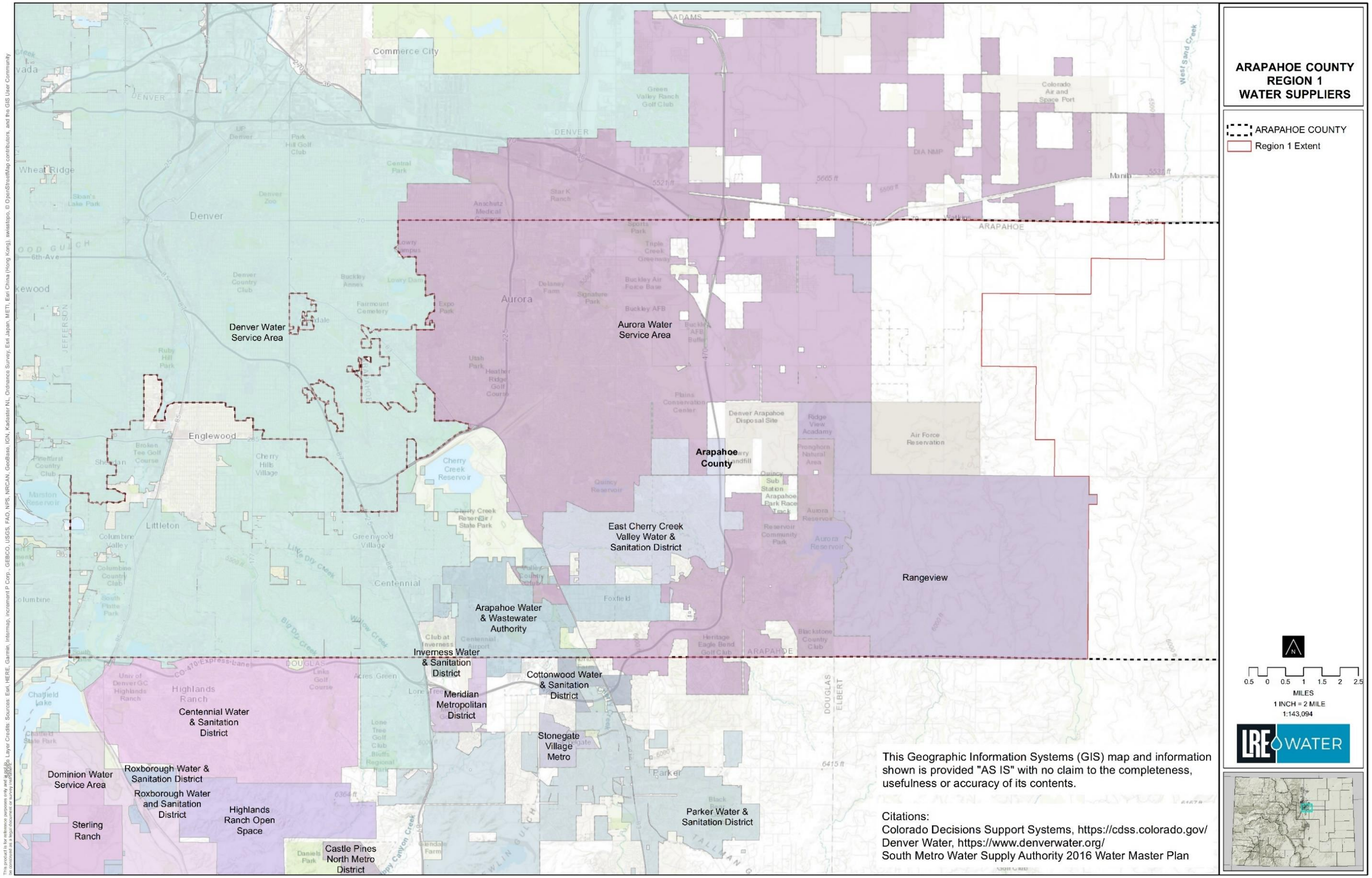


Figure 4-2. Arapahoe County Region 1 Water Suppliers

Table 4-2 Arapahoe County Entities with Denver Water Service

Total Service	Read and Bill	Master Meter
• Panorama Park Water Association • Galleria Metropolitan District • Hi-Lin WSD • Holly Hills WSD • Cherry Hills Heights WSD • Devonshire Heights WSD • South University Place Water Assn. • Cherry Hills North WSD • Hillcrest WSD • Mansfield Heights WSD • City of Cherry Hills Village • Holly Mutual Water Company • City of Sheridan • Loretto Heights Re-Sub Water Assn. • Columbine WSD • City of Littleton • Southeast Englewood Water District • Castlewood WSD • Havana WSD • City of Greenwood Village	• Country Homes Metropolitan District • Southgate Water District • Willows Water District • Southwest Metropolitan WSD • Platte Canyon WSD	• City of Glendale • Cherry Creek Valley WSD • Bow-Mar WSD • Cherry Creek Village Water District • Willows Water District • Inverness WSD

City of Aurora

The City of Aurora essentially serves only customers within its city limits except for its WISE partnership commitments. As with Denver Water, Aurora's water supply consists of a complex surface water collection system that includes the South Platte, Arkansas, and Colorado Rivers. Aurora stores raw water in Spinney Mountain, Homestake, Turquoise Lake, Twin Lakes, Quincy Reservoir, Strontia Springs, Ivanhoe, Pueblo, Holbrook, Aurora and Rampart Reservoirs, and Jefferson Lake. The City also uses some groundwater from the Cherry Creek alluvial aquifer. Aurora does not use any of its Denver Basin groundwater, reserving it for back up and drought supply.

Aurora's current water supply is approximately 50,000 AFY and its total demand is 46,000 AFY. As with Denver Water, only a portion of Aurora's service area is within Arapahoe County. Based upon the share of Aurora's service area in Arapahoe County (60 percent based upon land area) being more developed than outside the county, an estimated 75 percent of Aurora's water demand is within Arapahoe County.

ACWWA

ACWWA relies on Denver Basin groundwater for a portion of their water supply and also imports water from the South Platte alluvium collected near the City of Brighton via the "Northern Project;" an asset of ACWWA.ACWWA has made significant investments in renewable supplies from both the Cherry Creek and South Platte alluviums serving roughly 80 percent of ACWWA's current potable demands. Additionally, ACWWA operates a nonpotable irrigation reuse system. ACWWA provides water to approximately 31,000 residents, including the Town of Foxfield, a portion of northern Douglas County, and Elkhorn Ranch, a satellite system in northern Elbert County. ACWWA has supplied roughly 4,500 AFY on average for 2021-2023 from all its sources.

ECCV

Similar to ACWWA, ECCV relies upon Denver Basin groundwater and is also a partner in the Northern Project. They can supply approximately 9,200 AFY of water from three distinct sources – the Denver Basin, the South Platte alluvium and contract water from Denver Water. Approximately 70 percent of their supply is renewable. Only the Denver Basin groundwater is sourced from within Arapahoe County. ECCV provides water to approximately 55,000 residents.

The City of Englewood

The City of Englewood uses surface water from the mountains for its water supply. Their mountain system consists of Meadow Creek Reservoir near Winter Park. This reservoir is owned by Englewood and operated by Denver Water. Englewood provides water from Meadow Creek Reservoir to Denver Water in exchange for water from Chatfield Reservoir. The City also owns Boreas Pass Ditch, a small trans-mountain diversion that conveys water from the western slope to Chatfield Reservoir. They also own McLellan Reservoir which provides water to the City and to Centennial WSD.

The City of Englewood provides water service for approximately 34,500 residents (2020 estimate). The City produces an average of 6,033 AFY (2017 through 2021).

Inverness WSD

Inverness WSD (IWSD) uses Denver Basin groundwater from four wells, surface water as a member of WISE, and purchases water from Denver Water. Using water from WISE (500 AFY) and Denver Water (600 AFY), IWSD can meet 80 percent of its potable buildout demands with renewable water. In addition, IWSD reuses all of its wastewater for irrigation through a “closed system” with no wastewater discharge. All of IWSD’s wastewater flows to the Lone Tree Creek Reuse Facility operated by ACWWA. IWSD owns a share of that facility’s capacity, and its reuse water is returned to IWSD and stored in a central storage reservoir with a capacity of 440 AF.

Prior to 2008, IWSD essentially served a business park surrounding a golf course and consisted primarily of commercial customers. However, residential use has increased since 2008 to approximately 990 households (2020 estimate).

Rangeview Metropolitan District

Rangeview’s service area includes all 930 acres of the Sky Ranch community (Sky Ranch) and 24,000 acres of the Lowry Ranch. Rangeview leases and owns water rights throughout its service area.

Sky Ranch is proposed to be developed into six neighborhoods with approximately 3,400 residential units (single-family and multi-family units) and 2 million square feet of commercial space with an estimated water need of 2,445 acre-feet per year. Currently, there are approximately 500 single-family homes occupied in Sky Ranch and the community is growing at a pace of about 300 units per year. No development has occurred yet on the Lowry Ranch.

Rangeview also serves The Ridge View Academy (not in operation) and the Arapahoe County Fairgrounds. In addition to its commercial, residential, and irrigation customers in Region 1, Rangeview also provides water to the oil and gas industry in Region 2 through its private-sector service provider, Pure Cycle Corporation.

Rangeview's water supply consists of a mix of Denver Basin groundwater, surface water as a member of WISE, and groundwater development in the Box Elder Creek alluvium (Table 4-3).

Table 4-3. Rangeview's Water Supplies

Water Supply	Amount (AFY)
Denver Basin aquifer (Arapahoe, LFH)	915 from 13 wells
Box Elder Creek Alluvium	1,610 from 4 wells
WISE membership water	900
Storage on the Lowry and Sky Ranches	227

While their water supply is sufficient for current needs (approximately 1,000 AFY on average), Rangeview is evaluating additional surface storage, reuse, and renewable resources. The District plans to increase its supplies, anticipating increased demand as the buildout of Sky Ranch continues, and to serve future development of Lowry Ranch. The County has approved six filings for the Sky Ranch subdivision. An SEO letter dated March 5, 2024, stated that Rangeview has an adequate water supply for a seventh Sky Ranch filing.

Region 2 Water Providers

Water suppliers in Region 2 include Strasburg, Bennett, Byers, and Deer Trail and only Bennett and Deer Trail are incorporated (Figure 4-3). In addition, four of five subdivisions that have been approved by the County with SEO-approved water supply plans are located near either Bennett or Strasburg (Figure 4-4**).**

Most of the water supplied in Region 2 is Denver Basin groundwater except for some limited municipal irrigation. Below is a brief summary of the water supply for each of the water providers in Region 2, including the unincorporated subdivisions.

Strasburg

Strasburg is an unincorporated community of 3,200, with as many as 700 people in the urban area and another 2,500 in the surrounding area.[1] It straddles Adams and Arapahoe Counties and is served by Strasburg WSD entirely on groundwater. Strasburg WSD has nine wells: five in Arapahoe County and four in Adams County.

There are three unincorporated Arapahoe County subdivisions near Strasburg. Strasburg Heights is largely five-acre lots with individual wells in the Arapahoe aquifer.[2] Comanche Crossing consists of 2.5-acre lots with individual wells in the Kiowa Creek alluvium, Arapahoe aquifer or Laramie-Fox Hills aquifer.[3] [4] Finally, the Schmidt subdivision is comprised of 2.5-acre lots with individual wells in the Arapahoe aquifer.[5]

[1] http://www.strasburgwater.com/DistrictBoundaries.php visited on May 24, 2023.
[2] Information obtained from review of SEO well permit files.
[3] Letter dated July 29, 1999 from the SEO.
[4] Letter dated April 1, 2003 from the SEO.
[5] Letter dated June 23, 1977 from the SEO.

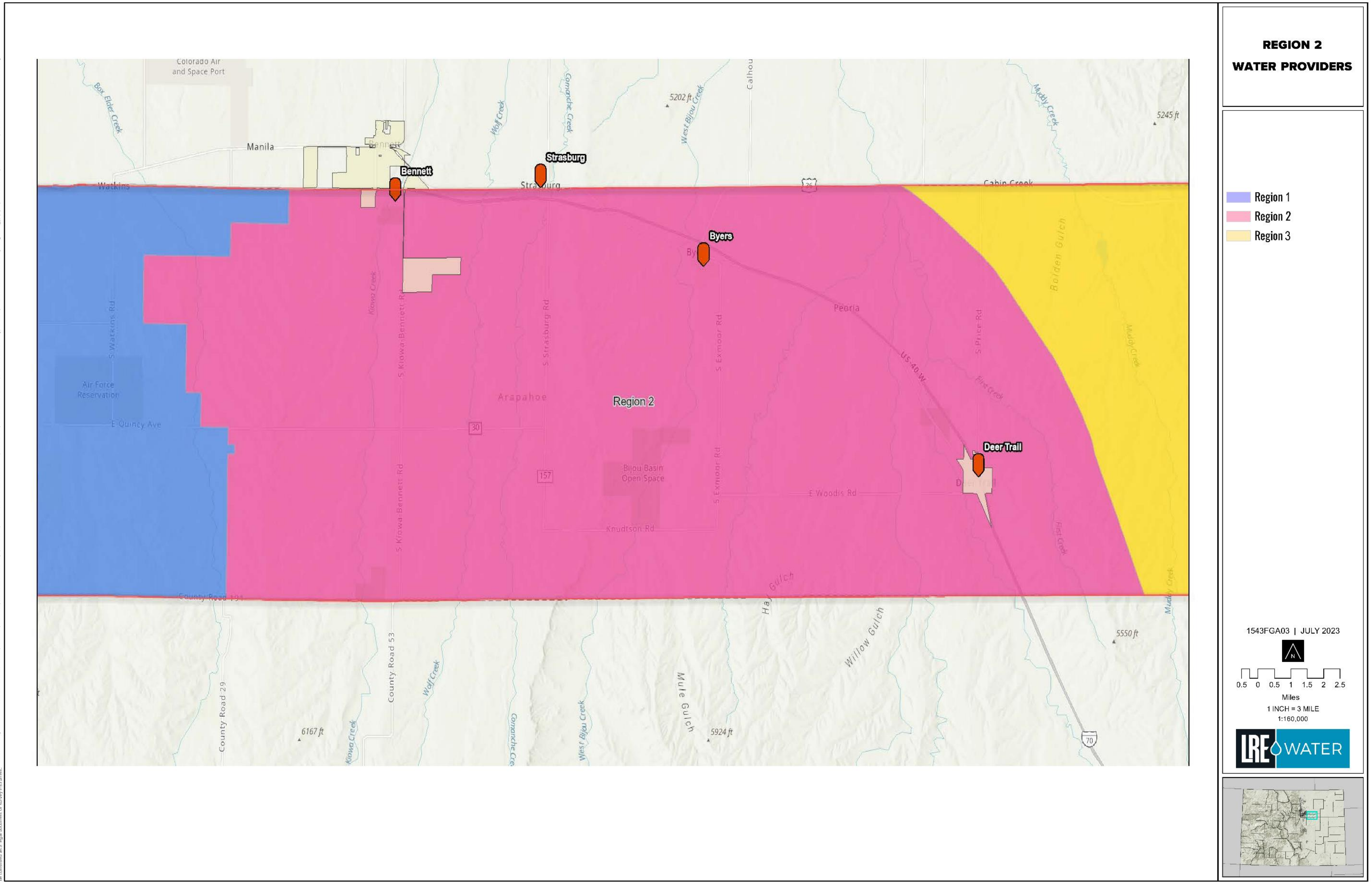


Figure 4-3. Region 2 Water Providers

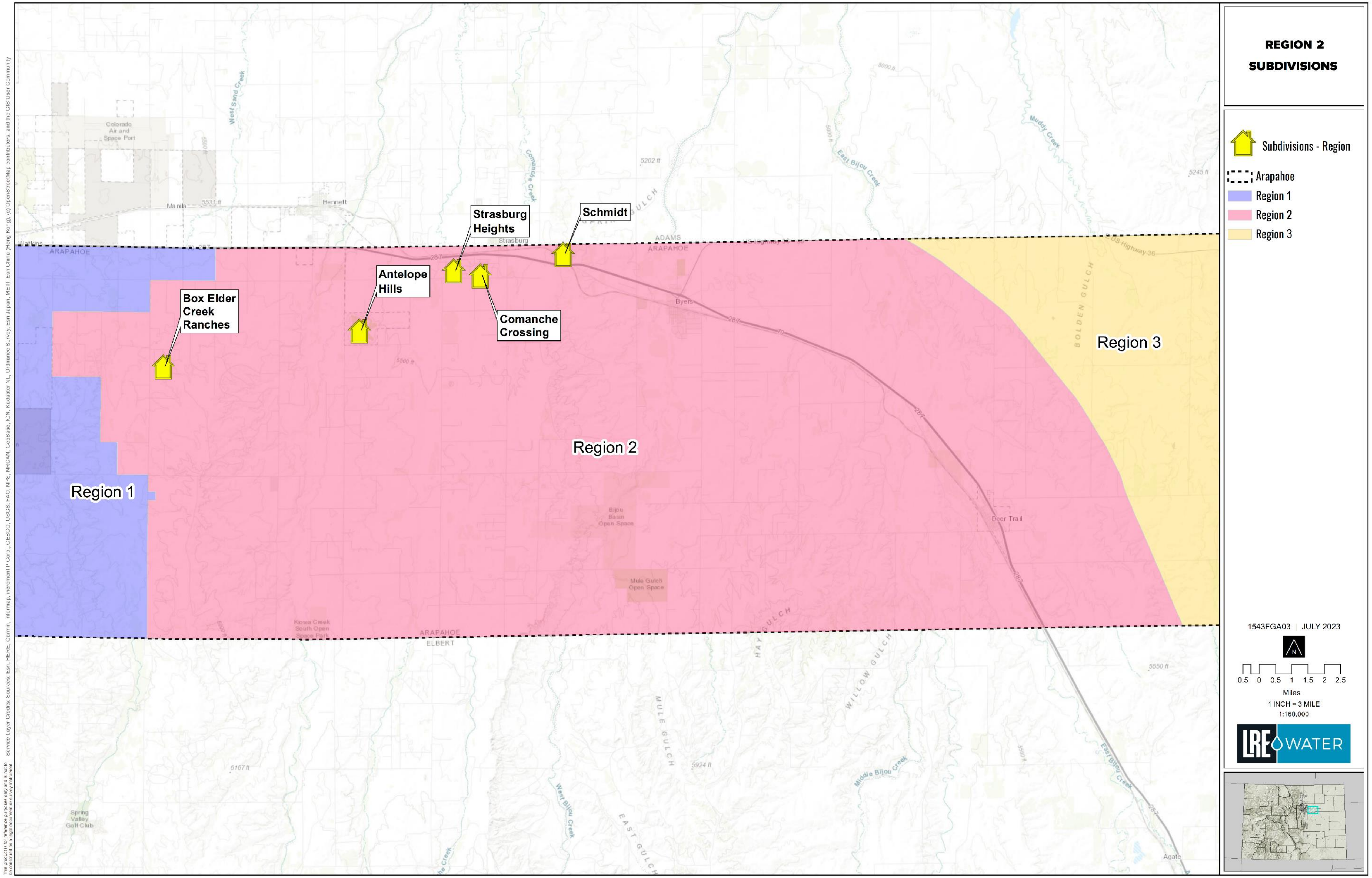


Figure 4-4. Region 2 Subdivisions

Town of Bennett

The incorporated Town of Bennett with 2,900 people[6] also straddles Adams and Arapahoe Counties and is served entirely from Denver Basin groundwater. The Town has 11 wells all within Adams County. Bennett also includes the Antelope Hills subdivision, which has five community wells in the Upper Arapahoe and Laramie-Fox Hills aquifers. The Antelope Hills community well water system is not connected to Bennett's water system.

The Town recently expanded its groundwater supply through acquisition of Laramie Fox-Hills water in Adams County. The Town is also in the process of evaluating and securing access to renewable water supplies to best serve the current and future residents.[7] Bennett joined with the Todd Creek Village Metropolitan District to form the BennT Creek Regional Water Authority. A primary purpose of this authority is to allow the Town and Todd Creek to collaborate on the regional BennT Creek water project—one that would exceed the financial capacity of either entity individually.

The BennT Creek project would consist of diverting junior water rights from the lower South Platte River for delivery through a series of pumps and pipelines to serve the Town and Todd Creek. Because the junior rights will not always be available, particularly during times of drought, the project incorporates several surface and subsurface storage facilities that allow water to be carried over from year to year for delivery during dry periods.[8]

Byers

Byers is an unincorporated community of 1,300 entirely within Arapahoe County. The Byers WSD provides water service from five Laramie Fox-Hills wells. Their supply averages 564 AFY and their water demand averages 167 AFY.[9]

Town of Deer Trail

The incorporated Town of Deer Trail with a population of 1,100 is entirely within Arapahoe County. The Town serves water to its residents from four Laramie Fox-Hills wells with a combined withdrawal of 183 AFY.

Other Unincorporated Subdivisions

In addition to the water providers and neighboring subdivisions previously described, there are other large subdivisions in unincorporated Arapahoe County.

Region 1

In Region 1, there are several subdivisions with on-lot wells near the Town of Foxfield including Chenango, Antelope, Arapahoe Heights, Arapahoe Meadows, and Piney Creek Ranches (Figure 4-5). Their lot sizes range from 2.5 to 5 acres with wells in the Dawson, Denver, and Arapahoe aquifers. Typically, their well permits are issued for one single-family dwelling, up to an acre of irrigation, and domestic animals (i.e., horses) and allow withdrawal of one AFY. Five other subdivisions are relevant, all of which have 2.5-acre lots with individual wells constructed in the Dawson, Denver or Upper Arapahoe aquifers as summarized in Table 4-4.

---

[6] 2020 Bennett Community Profile found at https://townofbennett.colorado.gov/sites/townofbennett/files/2020_BennettCommunityProfile_Small.pdf.
[7] See https://townofbennett.colorado.gov/news-article/bennett-takes-vital-steps-for-securing-water-for-their-future.
[8] Id.
[9] Town of Byers self-assessment.

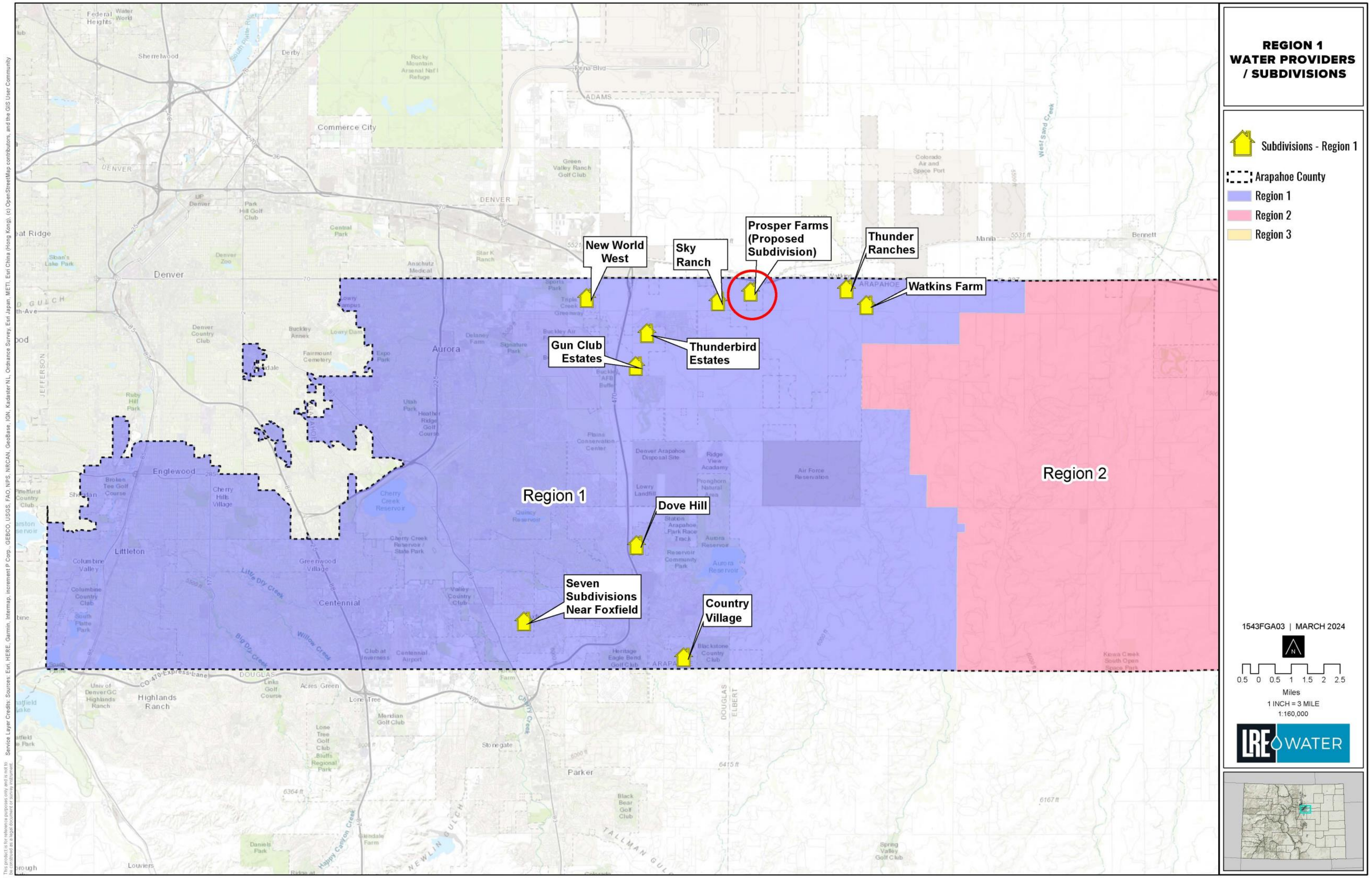


Figure 4-5. Region 1 Water Providers / Subdivisions

Table 4-4. Significant Subdivisions in Region 1

Subdivision	Aquifer(s)	Uses	Withdrawal (AFY)
New World West	Denver and Upper Arapahoe	One single-family dwelling, up to an acre of irrigation, and domestic animals (i.e. horses)	1.0
Thunderbird Estates	Denver and Arapahoe	One single-family dwelling, up to an acre of irrigation, and domestic animals (i.e. horses)	1.0
Gun Club Estates	Denver and Arapahoe	One single-family dwelling, up to an acre of irrigation, and domestic animals (i.e. horses)	1.0
Dove Hill	Denver	One single-family dwelling and 10,000 sf of lawn and garden	<1.0
Country Village	Dawson	One single-family dwelling and 5,000 sf of lawn and garden	<1.0
Fox Ridge Farms	Denver and Larmie-Fox Hills	Municipal use for a 500-unit mobile home park	226.6

Region 2

Besides the Region 2 subdivisions near Bennett and Strasburg previously identified, there are three large subdivisions and one proposed subdivision. The completed subdivisions are summarized in Table 4-5.

Table 4-5. Significant Subdivisions in Region 2

Subdivision	Aquifer for the Wells	Uses	Withdrawal (AFY)
Thunder Ranches	Denver – Subject to an augmentation plan[10]	One single-family dwelling, 17,400 sf of lawn and garden and two domestic animals (i.e. horses)	1.16
Watkins Farms	Denver - Subject to an augmentation plan	One single-family dwelling and 4,000 sf of lawn and garden	0.6
Box Elder Creek Ranches	Denver and Arapahoe	One single-family dwelling, up to 5,000 sf of irrigation, and domestic animals (i.e. horses)	1.0

[10] Each property owner could also access the Arapahoe and Laramie Fox-Hills aquifers.

The proposed subdivision is the Prosper Farms community.[11] The County has approved the first filing for this subdivision. Subsequent filings will require developing a renewable supply to meet demands. Prosper Farms' water supply report provides information on the anticipated development and its water needs.[12] Prosper Farms is proposed for 9,000 residential units (single-family and multi-family), 8 million square feet of commercial space, schools and irrigation. Water needs are estimated at 3,587 AFY for potable use and 1,570 AFY for irrigation at buildout.

The water supply will be combined from Denver Basin groundwater and reuse and lawn irrigation return flows. However, before renewable water can be used, more infrastructure must be installed from ACWWA and a final will-serve letter/agreement must be negotiated with them. At this point, it appears most water for the development will come from renewable sources outside the county or from water reuse. The County has only approved the first filing for this development (900 residential units). Subsequent filings will require securing a renewable supply.

[11] Development's Water Supply Plan Report, HRS Water Consultants (January 2014)
[12] Id.

SECTION 5.

PROJECTED WATER DEMANDS

SECTION 5 – PROJECTED WATER DEMANDS

This section builds on the Land Use & Socioeconomic Scenarios of Section 3 to project 2050 water demands across the county. The projections are also reviewed with respect to data from: previous water provider reports; Arapahoe County GIS; the CDWR; the USGS; county demographics; and water supply questionnaires provided by the County.

From Section 3, Arapahoe County's projected 2050 population for use in this Study ranges from 900,000 to 960,000 in 2050 with reference to the "Business as Usual" and "Hot Growth" scenarios respectively. Projected 2050 employment for use in this Study ranges from 532,000 to 595,000 jobs based on SDO and DRCOG projections respectively. The County is expecting growth primarily in Regions 1 and 2. Region 3 is expected to remain agricultural, with limited water resources and minimal growth.

Projected Growth

The Section 3 analysis can be used to provide a range of projected population, households and employment, both by water service provider and municipality within the county. Most municipalities do not have their own water assets but are served by water providers (for example, Denver Water master meters). For that reason, the study team used the water provider population forecast and added the Town of Bennett from the municipalities forecast for this water demand analysis.

Also, it is noted that the water demand analysis varies from the Section 3 population projected for Prosper Farms, instead using more specific information from their 1041 permit application filed with the County in October 2014. In that document, Prosper Farms estimated 9,000 households with a demand of 0.4 AFY per residence for in-house and irrigation. Commercial water demands at buildout would be equivalent to 4,145 residences with a demand of 0.2 AFY. The study team used these estimates directly for the high-end 2050 forecast and used an 80 percent multiplier for the low-end forecast.

Table 5-1 summarizes the total households by entity and Table 5-2 summarizes the employment estimates by entity (except for Prosper Farms for which the summary is in equivalent residential units).

Table 5-1. Total Household Estimates in Arapahoe County

WATER PROVIDER / MUNICIPALITIES – HOUSEHOLDS IN ARAPAHOE COUNTY			
ENTITY	2020	TOTAL HOUSEHOLDS	
		2050 LOW	2050 HIGH
Aurora	128,906	185,319	200,102
Denver	84,118	96,083	99,219
ECCV	20,766	26,210	27,636
Englewood	15,944	17,396	17,776
ACWWA	4,836	5,375	5,517
Prosper Farms	53	7,200	9,000
Sky Ranch	92	3,695	4,639
Inverness Water	990	1,421	1,534
Byers	415	424	426

WATER PROVIDER / MUNICIPALITIES – HOUSEHOLDS IN ARAPAHOE COUNTY			
ENTITY	2020	TOTAL HOUSEHOLDS	
		2050 LOW	2050 HIGH
Deer Trail	300	329	336
Strasburg	40	45	47
No District	4,620	9,694	11,024
Bennett	15	17	118
Totals	261,095	353,208	377,374

Table 5-2. Total Employment Estimates in Arapahoe County[13]

WATER PROVIDER / MUNICIPALITIES – EMPLOYMENT			
WATER PROVIDER	2020	2050 LOW	2050 HIGH
Aurora	125,913	166,979	188,434
ECCV	11,105	16,221	18,894
ACCWA	33,566	41,752	46,029
Denver	202,496	240,397	260,199
Englewood	33,856	40,997	44,728
Sky Ranch	20	188	275
Inverness Water	15,861	16,250	16,454
Byers	384	384	383
Deer Trail	127	183	213
Strasburg	150	591	822
No District	3,931	7,065	8,702
Bennett	7	11	13
Totals	427,416	531,018	585,146
Prosper Farms	80	3,323	4,154

Estimated Water Demands

The Section 3 growth projections are used along with the calculations, assumptions and references presented in this section. Population estimates for the following entities are used to estimate county water demands:

- Aurora
- Bennett
- Deer Trail
- Englewood
- Denver
- ECCV
- ACWWA
- Prosper Farm
- Sky Ranch
- Byers
- Strasburg
- Inverness
- No District

[13] Prosper Farm Employment Estimates are per an Equivalent Residential Unit for 2050 Low and High based on the 2014 1041 Arapahoe County Application. The 2020 figure is the number of employees estimated by County Staff.

Of these, Denver, Aurora, and ACWWA serve water in counties other than Arapahoe County. To estimate the portion of their supplies served in Arapahoe County, the study team totaled the land for the Denver, Aurora, and ACWWA service areas and the portion of those service areas within Arapahoe County as shown in Table 5-3.

Table 5-3. Service Area Portions within Arapahoe County

SERVICE AREA PORTIONS WITHIN ARAPAHOE COUNTY			
NAME	ACREAGE WITHIN COUNTY	SERVICE AREA	% SERVICE AREA IN COUNTY
Arapahoe County Water & Wastewater Authority	6,997	7,306	95.8
Aurora Water Service Area	59,422	98,527	60.3 (75% water use)*
Denver Water Service Area	34,979	224,066	15.6

* Aurora Water's customers in Arapahoe County represent 75% of Aurora Water's demand.

Estimates/Assumptions for Commercial and Residential Use

The study team estimated or assumed 2020 water demands for commercial use as shown in Table 5-4, and residential use as shown in Table 5-5. References are provided to support the water demand estimates/assumptions.

Table 5-4. Commercial Water Demand Estimates/Assumptions

ENTITY	WATER DEMAND	REFERENCE
City of Aurora	9,000 AFY	Aurora's 2021 Growing Water Smart Self-Assessment
ECCV	24 gpcd	ECCV's 2018 Water Conservation Plan
City of Englewood	52 gpcd	2023 City of Englewood Water Efficiency Plan
Prosper Farm	0.2 AFY per ERU[14]	2014 Arapahoe County 1041 Report
Denver, Sky Ranch, Inverness Water, Byers, Deer Trail, Strasburg, Bennett and No District	61 gpcd	Average of the Aurora, ECCV and Englewood Commercial Demands

Table 5-5. Residential Water Demand Estimates/Assumptions

ENTITY	WATER DEMAND	REFERENCES
City of Aurora	31,000 AFY (20,000 AFY for SF and 11,000 AFY for MF)	Aurora's 2021 Growing Water Smart Self-Assessment
Denver Water	105,000 gals/yr per residence	2020 Denver Water System Fact Book
ACWWA	120 gpcd	ACWWA's 2021 Growing Water Smart Self-Assessment
ECCV	91 gpcd	ECCV's 2018 Water Conservation Plan
Sky Ranch (Rangeview Metropolitan District)	91 gpcd	2022 Rangeview Water Supply Master Plan

[14] ERU is defined as an equivalent residential unit (single-family dwelling).

ENTITY	WATER DEMAND	REFERENCES
City of Englewood	101 gpcd	2023 City of Englewood Water Efficiency Plan
Inverness WSD	105,000 gals/yr per residence	2020 Denver Water System Fact Book as Inverness receives water from Denver Water
Prosper Farms	0.4 AFY per residence	2014 Arapahoe County 1041 Report

The study team also estimated single-family (SF) and multi-family (MF) residential use, and the indoor vs. irrigation demands for commercial, SF and MF residential uses. These estimates are based on reviews of the 2023 City of Englewood Water Efficiency Plan, the 2020 Denver Water System Fact Book, and the 2015 Aurora Municipal Water Efficiency Plan. All of these plans from major water providers were fairly consistent in their percentages of water demand for commercial, SF and MF residential uses. The pro rata shares of SF and MF were determined at 45 and 26 percent respectively for a total 71 percent share of demand dedicated to residential water use. See Table 5-6 for a summary of these estimates/assumptions along with references.

Table 5-6. Indoor and Irrigation Water Demand Assumptions or Estimates

Use[15]	Indoor Water Demand	Irrigation Water Demand	Reference
Single-Family Residential (45% of total water demand)	69.4%	30.6%	Aurora's 2015 Municipal Water Efficiency Plan and 2023 City of Englewood Water Efficiency Plan
Multi-Family Residential (26% of total water demand)	80%	20%	Aurora's 2015 Municipal Water Efficiency Plan and 2023 City of Englewood Water Efficiency Plan
Commercial (21% of total water demand)	65%	35%	Aurora's 2015 Municipal Water Efficiency Plan

Water Demands without Conservation

The water demand estimates/assumptions with the growth projections described above are used to determine 2050 water demand ranges for SF, MF and Commercial[16] needs for each entity. Demands for each use (except for Aurora) were estimated by multiplying the percentage of the entity within the county (Table 5-3) by the per capita number[17] by the respective unit water demand (Tables 5-4 and 5-5). Shares of indoor and irrigation demands were then estimated as shown in Table 5-6 (except for Prosper Farms where indoor and irrigation uses were estimated to be equal).

For the City of Aurora, using data from the Colorado Water-Wise 2021 Assessment, the 2020 annual water uses for SF, MF and commercial were based on the estimated number of households and employees from the Section 3 analysis. Projected increases for the 2050 low and 2050 high estimates were applied for SF, MF and commercial categories. Finally, 75 percent of Aurora's total

[15] Single-family and multi-family use estimates were obtained from Aurora's 2021 Growing Water-Smart Self-Assessment, the City of Aurora's 2015 Municipal Water Efficiency Plan, and the 2023 City of Englewood Water Efficiency Plan. However, for Prosper Farms, the 2014 County 1041 application with estimates of 50% indoor use and 50% irrigation were used.

[16] Commercial use was assumed to occur during the work week; 260 days per year. Several entities did not have commercial use data so demand estimates were not possible but for the entities shown.

[17] The estimated single-family and multi-family demands were based on 2.57 persons per household.

demands were estimated to be within Arapahoe County based on the estimated share of Aurora's development in the county.

Water Demands with Conservation

Water demands for 2050 low and 2050 high were also estimated with conservation savings factors applied as determined in Section 8. The demands for SF, MF and commercial uses for each entity with conservation savings included are shown in Appendix C, Tables 5-9 – 5-14.

Water Demand Conclusions

The water demand analysis results for all categories (SF, MF and commercial) across the county in 2050 compared to 2020 are shown in Table 5-7. Approximately half of the demands are attributable to single-family needs and the other half to multi-family/commercial needs. The greatest increase for an entity will be for Prosper Farms (at about 50 times current demands), as this development has still not been initiated. Other large increases include Sky Ranch (about 12 times current demands) as this development builds out, and unincorporated areas of eastern Arapahoe County with expected increases to be about 2.5 times greater than current needs. Water conservation will help reduce the demands for both Low and High scenarios and has been considered in the table below.

Table 5-7. Single-Family, Multi-Family and Commercial Water Needs Comparison

AFY SINGLE FAMILY and MULTI-FAMILY, COMMERCIAL WATER DEMAND COMPARISON					
	2020	2050 LOW w/o CONSERVATION	2050 LOW w/ CONSERVATION	2050 HIGH w/o CONSERVATION	2050 HIGH w/ CONSERVATION
Single Family	41,417	55,729	49,674	59,491	52,725
Multi-family	23,524	31,648	28,150	33,741	29,893
Commercial	20,858	26,371	23,664	29,124	25,879
Totals	85,799	113,748	101,487	122,356	108,496

As shown in Table 5-8, the county population is projected to increase by approximately 245,000 to 305,000 by 2050 compared to 2020. Employment is projected to increase by approximately 104,000 to 159,000 jobs by 2050. This would result in approximately 33 to 43 percent increase in water demand without conservation and 18 to 26 percent with conservation.

Table 5-8. Demand Analysis

DEMAND ANALYSIS					
	2020	2050 LOW	2050 HIGH	PERCENT INCREASE	
				2050 LOW	2050 HIGH
Total Population	655,070	900,000	960,000	37%	47%
Total Employment	427,722	532,000	586,500	24%	37%
Total Water Use w/o conservation (AFY)	85,799	113,748	122,356	33%	43%
Total Water w/conservation (AFY)		101,487	108,496	18%	26%

SECTION 6.

GROUNDWATER ANALYSIS

SECTION 6 – GROUNDWATER ANALYSIS

Groundwater will continue to be a critical resource heavily relied upon throughout Arapahoe County, particularly in Region 2. This section introduces the available groundwater sources in the county and describes the groundwater analysis performed as a key element of this Study. There are three groundwater sources within the county -- alluvial outside of a designated basin, alluvial within a designated basin and Denver Basin groundwater.[18] However, the Denver Basin is the primary source for current and future development within the county. Based upon review of CDWR records, there are 6,011 groundwater wells within the county (Figure 6-1). As noted in Section 1, an online map displaying interactive GIS data relevant to this Study (Interactive Web Map) can be accessed at: https://experience.arcgis.com/experience/a06dd2ff496843b2b227e5cebc0a9124/.

Alluvial Groundwater

There are two types of groundwater in the alluvium: tributary outside of a designated basin and that within a designated basin. Below is a summary of both types.

Tributary Groundwater Outside of a Designated Basin

Based on CDWR public records, there are 1,719 alluvial wells[19] within the county and outside of a designated basin. Most of these wells are exempt domestic or stock wells (1,099 wells). Most of the non-exempt alluvial wells outside of designated basins have been curtailed because there is not enough augmentation water to account for current and past pumping depletions to surface streams (the South Platte River). A summary of these alluvial wells is provided in Table 6-1 and are shown on in the Interactive Web Map. Additionally, Table 6-2 details all wells in Region 2 where reliance on groundwater is greater.

[18] Denver Basin groundwater is both inside and outside of the designated basins. However, because the CO Groundwater Commission and the State Engineer compute the amount of Denver Basin groundwater in the same manner, it is considered the same inside and outside of the designated basins for this Study.
[19] All wells designated as alluvial, alluvium or all unnamed aquifers with a well depth less than 160 feet below ground surface are considered as alluvial wells.

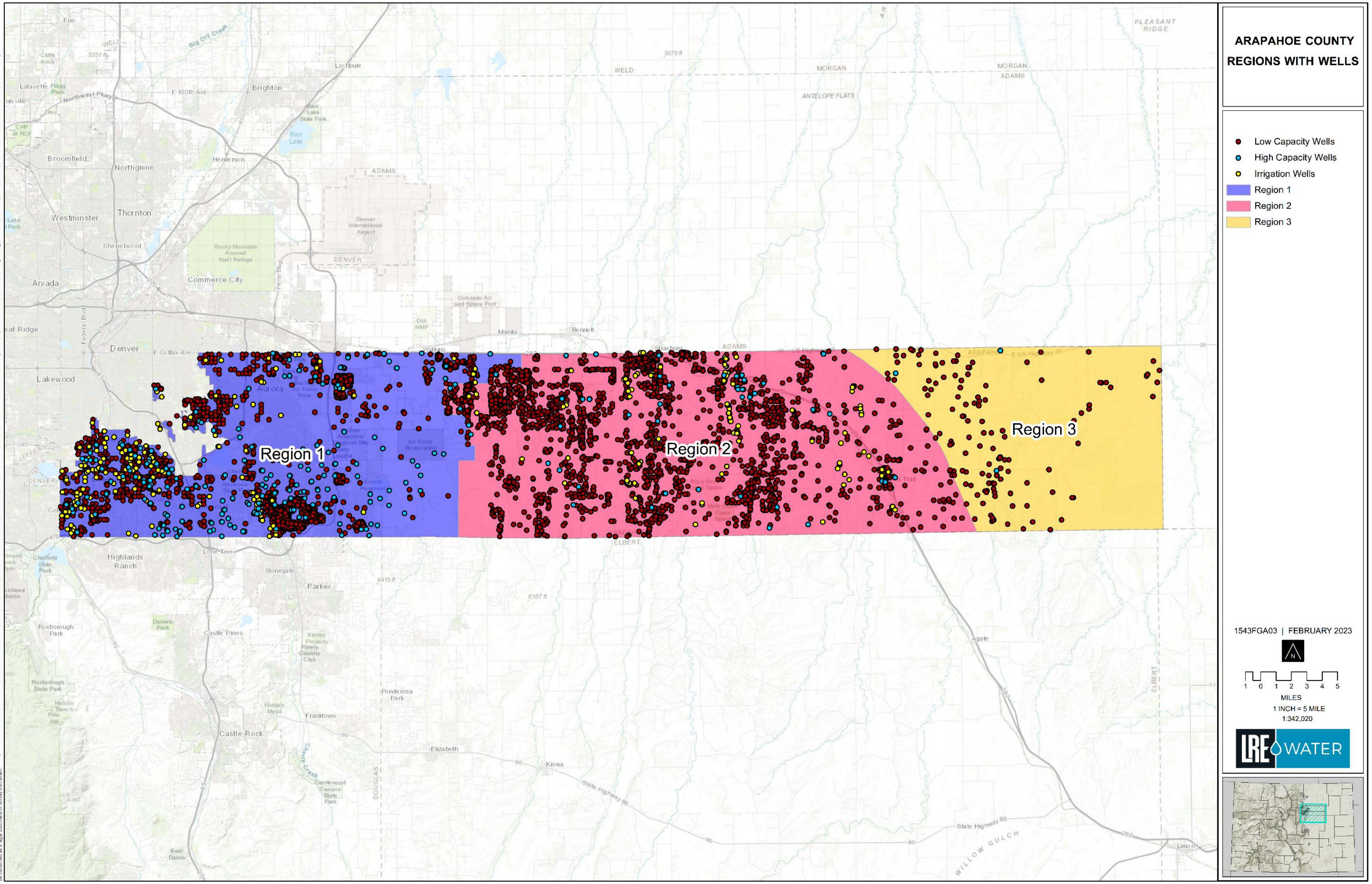


Figure 6-1. Arapahoe County Regions with Wells

Table 6-1. Summary of All Groundwater Wells in Arapahoe County

DESIGNATION	ALLUVIAL	UPPER DAWSON	LOWER DAWSON	DENVER	UPPER ARAPAHOE	LOWER ARAPAHOE	LARAMIE FOX-HILLS
All	2,652	187	240	1,636	934	94	288
Designated Basin – Kiowa Bijou	809	0	0	440	442	0	227
Designated Basin – Lost Creek	104	0	0	128	40	1	1
Outside Designated Basin	1,719	187	240	1,068	452	93	60
Non-Domestic Use – All	772	82	4	267	360	78	83
Non-Domestic Use – Designated Basin - Kiowa Bijou	142	0	0	5	76	0	23
Non-Domestic Use – Designated Basin – Lost Creek	10	0	0	8	2	0	1
Non-Domestic Use – Outside Designated Basin	620	82	4	254	282	78	59
Domestic Use – All	1,860	105	236	1,369	574	16	205
Domestic Use – Designated Basin- Kiowa Bijou	667	0	0	435	366	0	204
Domestic Use – Designated Basin – Lost Creek	94	0	0	120	38	1	0
Domestic Use – Outside Designated Basin	1,099	105	236	814	170	15	1

*Domestic use wells include domestic, household use, and stock wells.
**Non-domestic use designation includes commercial, industrial, irrigation, augmentation, and similar use production wells.

***This table does not include monitoring wells or wells with no aquifer designation

Table 6-2. Summary of All Groundwater Wells in Region 2

DESIGNATION		ALLUVIAL	DAWSON	DENVER	UPPER ARAPAHOE	LOWER ARAPAHOE	LARAMIE FOX-HILLS
Domestic Wells	Domestic Use – All	888	0	730	559	2	200
	Domestic Use – Designated Basin – Kiowa Bijou	696	0	509	486	1	200
	Domestic Use – Designated Basin – Lost Creek	114	0	135	47	0	0
	Domestic Use – Outside Designated Basin	78	0	86	26	1	0
Non-Domestic Use Wells	Non-Domestic Use – All	184	0	2	31	0	27
	Non-Domestic Use – Designated Basin – Kiowa Bijou	177	0	1	26	0	26
	Non-Domestic Use – Designated Basin – Lost Creek	0	0	0	1	0	1
	Non-Domestic Use – Outside Designated Basin	7	0	1	4	0	0
Totals	Total – All	1,072	0	732	590	2	227
	Designated Basin Wells	987	0	645	560	1	227
	Outside Designated Basin	85	0	87	30	1	0

*Domestic use wells include domestic, household use, and stock wells.
**Non-domestic use designation includes commercial, industrial, irrigation, augmentation, and similar use production wells.

***This table does not include monitoring wells or wells with no aquifer designation

Designated Basin Alluvial Groundwater

Two designated basins cross into Arapahoe County--Kiowa Bijou and Lost Creek. Groundwater development within these areas is governed by the Colorado Groundwater Commission ("Commission") and the local groundwater management districts. The role and responsibility of each entity is described in Appendix D.

CDWR records show that the Kiowa Bijou designated basin covers approximately 48 percent of the county and the Lost Creek designated basin covers 2.4 percent. There are 809 and 104 alluvial wells within each, respectively. As with wells located outside of the designated basins, most in the basins are small capacity domestic or stock wells (667 wells and 94 wells, respectively). There are 142 and 10 large capacity wells (final permits) within the Kiowa Bijou and Lost Creek designated basins, respectively, that are used primarily for irrigation.

Denver Basin Groundwater

First, it is helpful to briefly describe this very important aquifer system. From deepest to shallowest, the four main units of the Denver Basin are: the Laramie-Fox Hills aquifer, the Arapahoe aquifer, the Denver aquifer, and the Dawson aquifer (Paschke et. al., 2011) (Figures 6-2 and 6-3). The Arapahoe and Dawson aquifers are each subdivided into two units, the Upper and Lower Arapahoe, and the Upper and Lower Dawson.

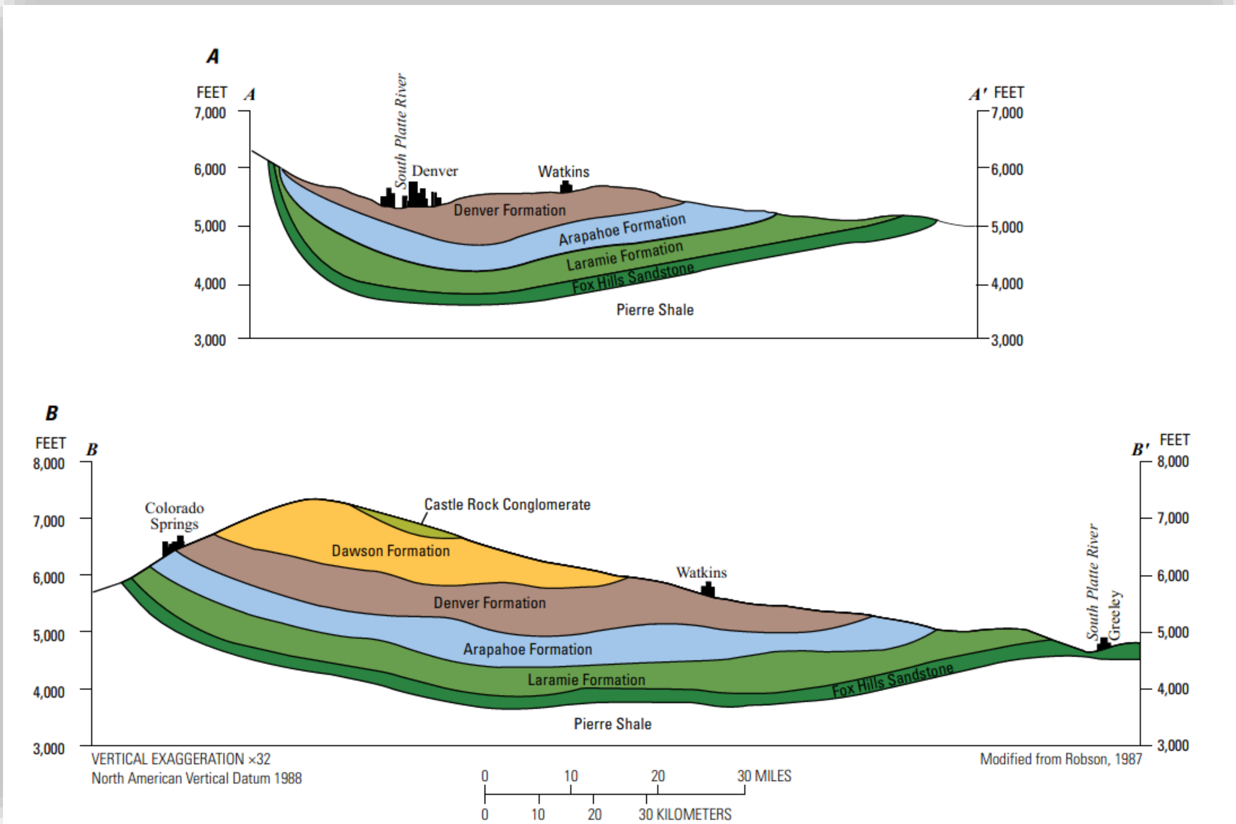


Figure 6-2. Generalized Geologic Cross Section of the Denver Basin Aquifer System (Everett, 2014, modified from Robson, 1987)

Figure 6-3 is a diagram of the Denver Basin illustrating the shape of the geologic units. The Denver Basin is shaped like a giant bowl. As the center of the basin slowly sank over geologic millennia, the bowl was filled with a sequence of sand, silt, and clay deposits that were compressed to form sedimentary rock. The west side of the bowl slopes steeply up against the uplifted Front Range, and the east side of the bowl slopes gently toward the plains.

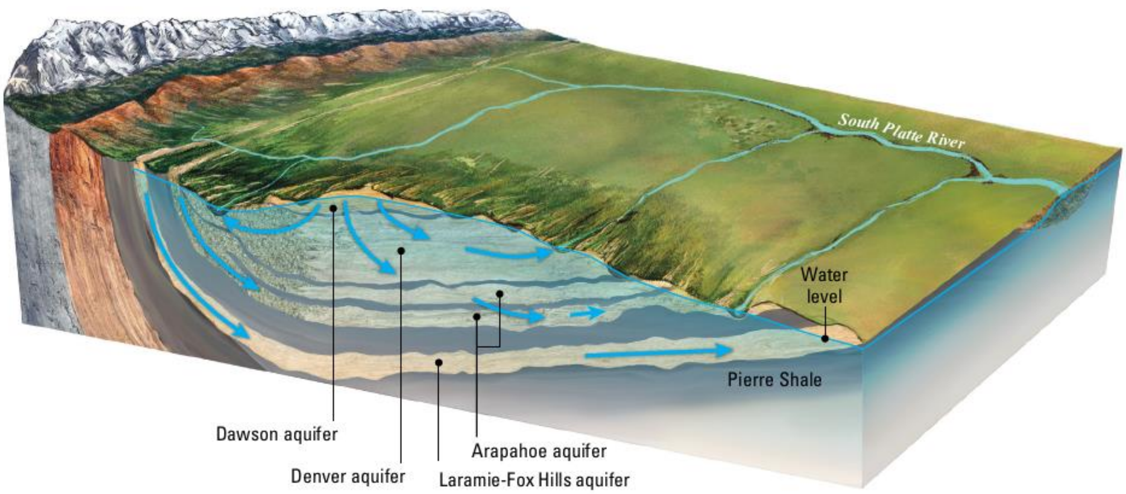


Figure 6-3. Conceptual Diagram of the Denver Basin Aquifer System (from Paschke et. al., USGS, 2011)

In summary:

- The Laramie-Fox Hills aquifer is the deepest and most extensive of the aquifers and its base is approximately 1,700 to 2,500 feet below ground surface (bgs) in the western portion of the County and 500 to 800 feet bgs in the eastern portion of the County. The saturated thickness ranges from 300 to 400 feet.
- The Arapahoe aquifer is split between the Upper Arapahoe and Lower Arapahoe in the western to central portion of the County. The Arapahoe aquifer is undivided in the eastern portion of the County. The Upper Arapahoe aquifer base ranges from 1,050 to 1,500 feet bgs in the western to central portion of the County and the undivided Arapahoe aquifer base ranges from 350 to 450 bgs in the eastern portion of the County. The saturated thickness ranges from 200 to 250 feet.
- The Lower Arapahoe aquifer is only prevalent in the western to central portion of the County and its base ranges from 700 to 1,800 feet bgs. The saturated thickness ranges from 200 to 400 feet.
- The Denver aquifer is also only present in the western to central portion of the County. The aquifer base ranges from 100 to 1,250 feet bgs. The saturated thickness ranges from 100 to 1,000 feet.
- The Lower Dawson is only present in the southwest portion of the County. The aquifer base ranges from 300 to 400 feet bgs. The saturated thickness ranges from 0 to 200 feet.

From CDWR records, there are approximately 2,100 Denver Basin wells within the county outside of the designated basins. Like the alluvial wells, most Denver Basin wells outside of a designated basin are domestic (1,341 wells). Within the designated basins, most are within the Kiowa-Bijou basin (1,109 wells vs. 170 in the Lost Creek basin). As with Denver Basin wells outside of a designated basin, most wells within the designated basins are domestic (1,005 and 159 for the Kiowa-Bijou and Lost Creek, respectively).

Water Levels in the Denver Basin Aquifers

The primary vulnerability associated with Denver Basin wells is the potential for regional declines in the artesian water level (the water levels in the well caused by aquifer pressures). Denver Basin artesian water levels have been on a general decline throughout the entirety of the Denver Basin – including Arapahoe County - (particularly in shallower aquifers) at a moderate rate. Overall, declines have been reported at one to 20 feet per year but can vary based on the aquifer and location.

The study team analyzed all CDWR published data available for the county to assess artesian and aquifer level trends (Appendix E). While the data does not cover every part of each Denver Basin aquifer evenly, most wells are showing a drop in artesian water levels. The data shows that some of the pumping wells cause the water levels to vary significantly over time in a specific area and therefore water level readings are difficult to evaluate. Some wells indicate water levels have dropped below the top of the aquifer (aquifer water level) in certain locations; however, it is not clear whether that is due to local pumping temporarily dropping the water level or a larger regional decline.

Pre-213 Water Right Determinations

Pre-213 Water Rights refer to the Denver Basin water rights permitted prior to May 5, 1973. Pre-213 Water Rights are based upon permits for beneficial use within the Denver Basin. To separate these rights from Denver Basin water rights based upon overlying land, CDWR identifies a land area for the well based upon a cylinder of appropriation that factors in available volume of water beneficially used, specific yield, and the saturated thickness (Pre-213 cylinder). Portions of Pre-213 cylinders that overlap any new land area that is the subject of a new Denver Basin water right, are subtracted from the land area for a given aquifer. The Pre-213 cylinders of appropriation are shown across the county in Figures 6-4 through Figure 6-7.

Current Water Right Determinations

Some landowners within the county have already had Denver Basin allocations determined or decreed by CDWR, the Water Court or the Commission. This typically happens when a landowner seeks to quantify the amount of Denver Basin groundwater underlying their property through either filing of a well permit with CDWR, a determination of water rights with the Commission or an application with the Water Court. In all cases, the CDWR determines the amount of groundwater available for each aquifer at that time. Approximately 35.6 percent of Denver Basin groundwater in the county has been decreed by Water Court or determined by the Commission. These decrees and determinations are shown in Figures 6-4 through Figure 6-7.

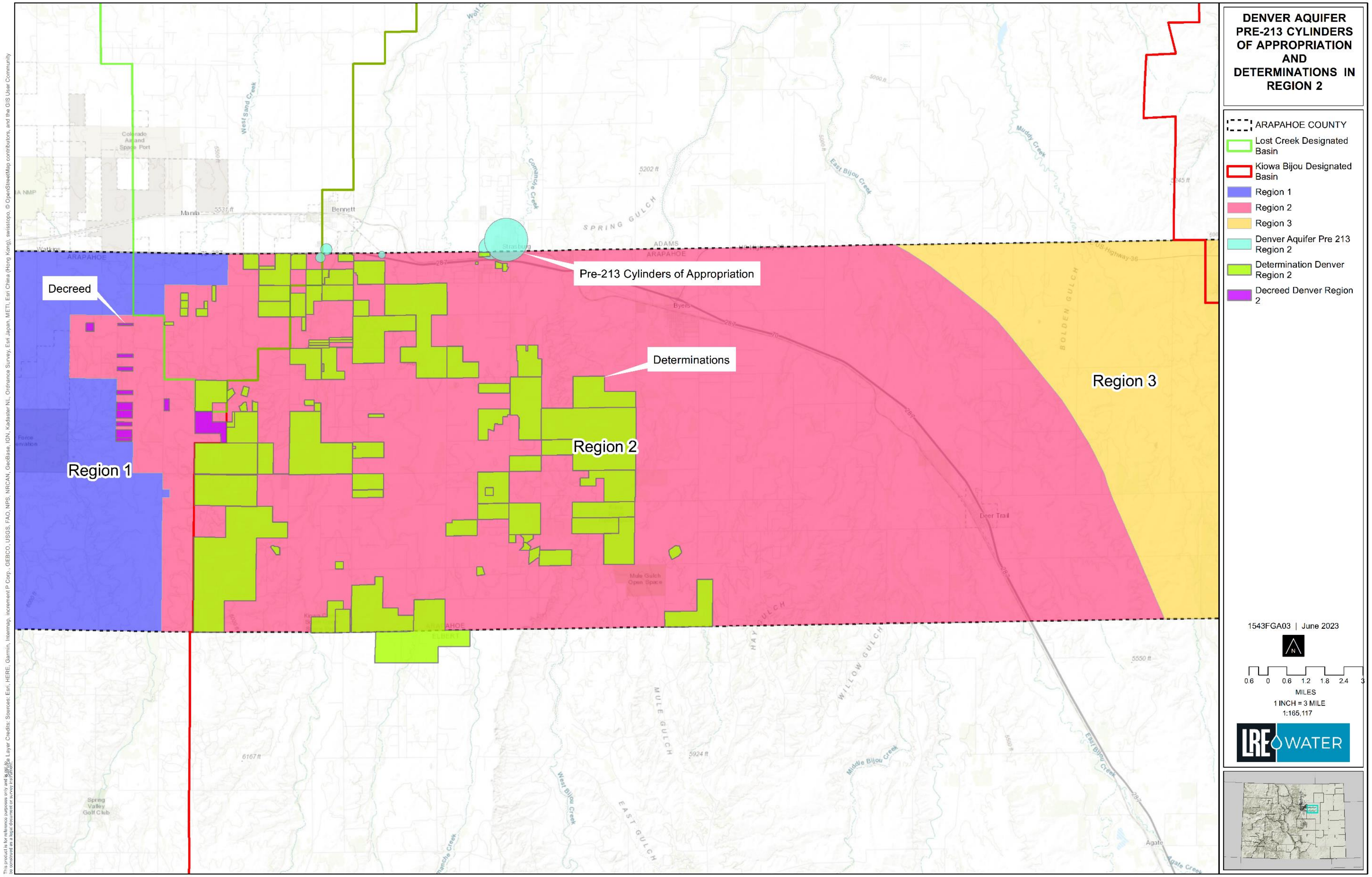


Figure 6-4. Denver Aquifer Pre-213 Cylinders

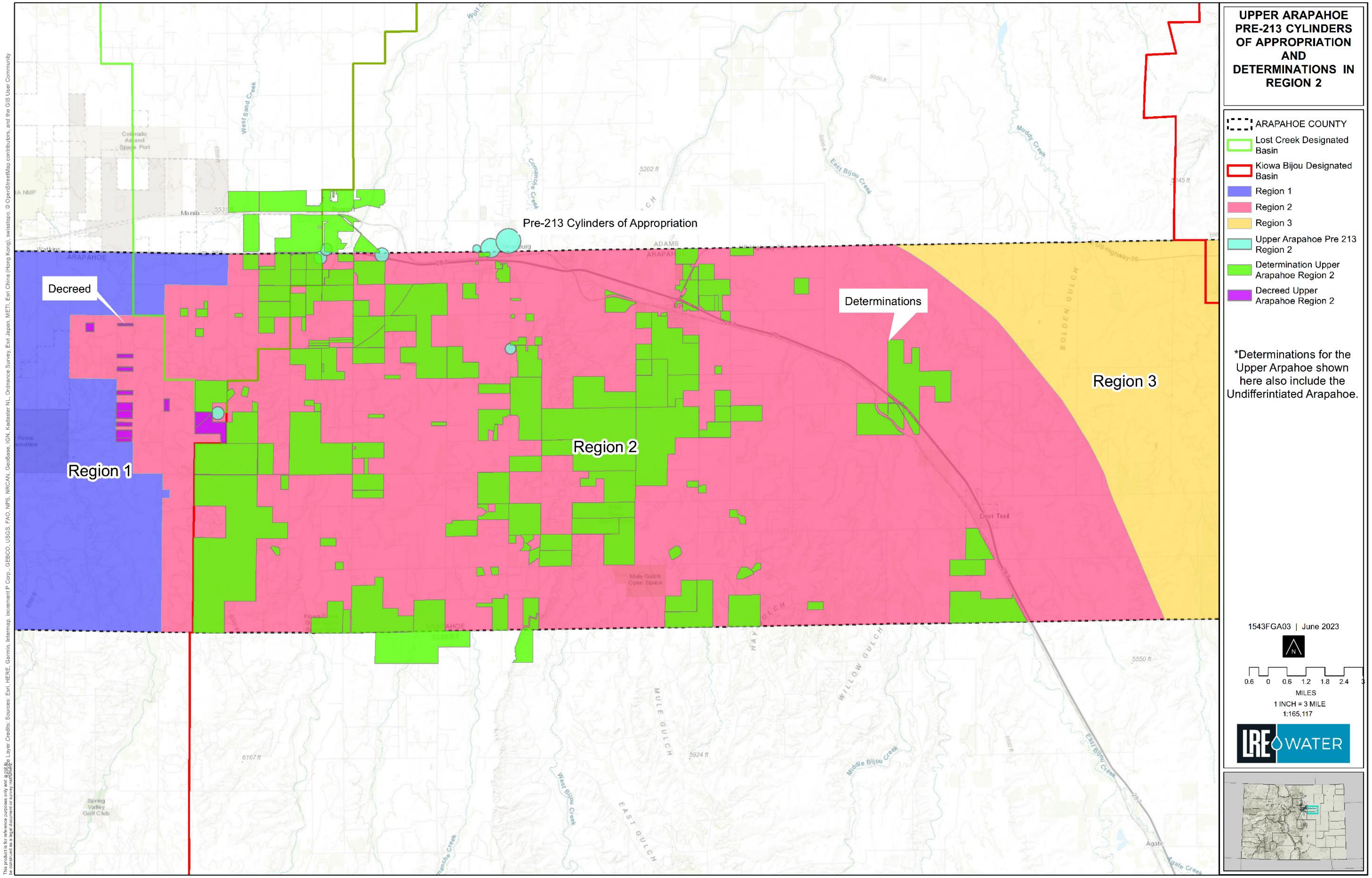


Figure 6-5. Upper Arapahoe Pre-213 Cylinders

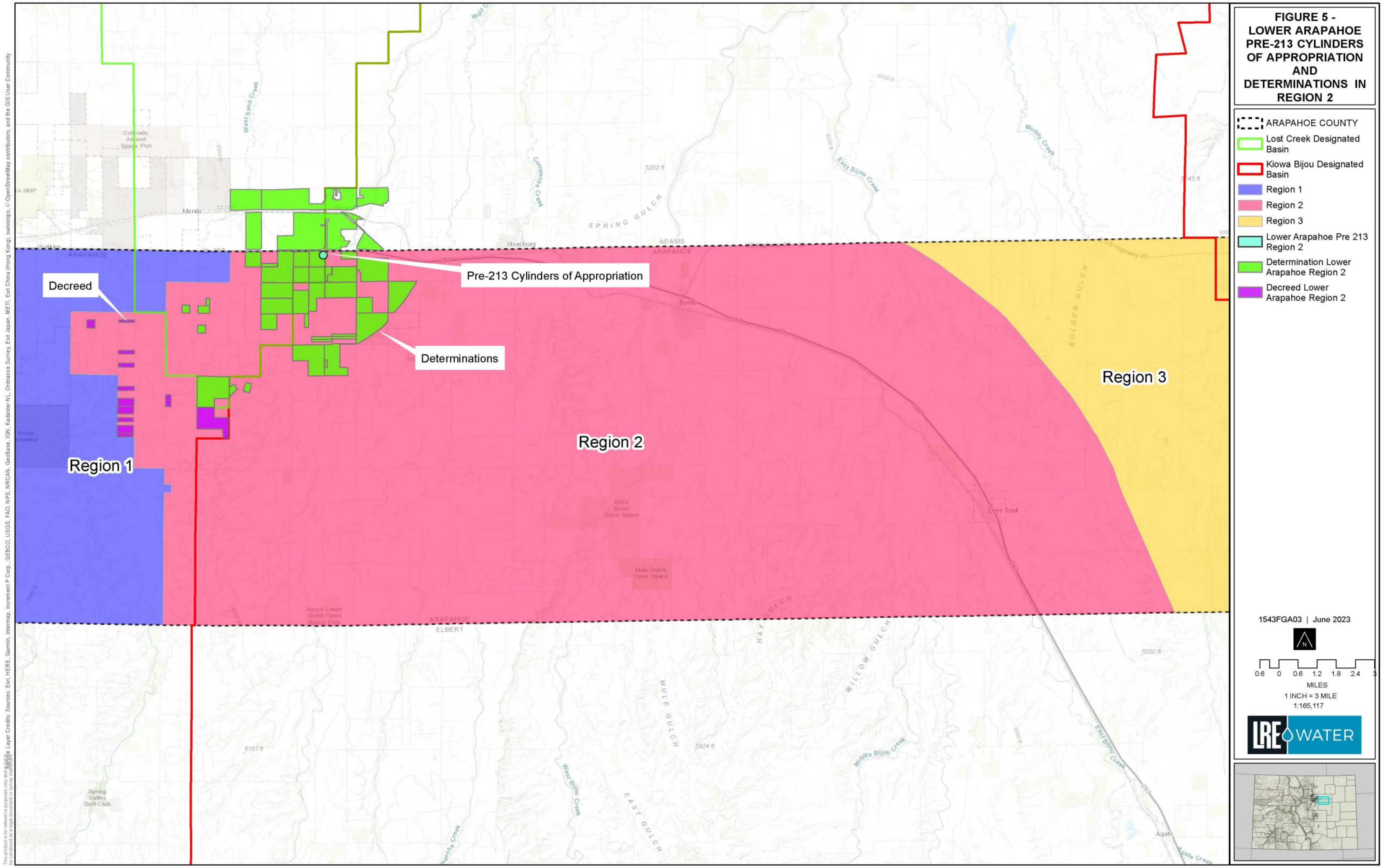


Figure 6-6: Lower Arapahoe Pre-213 Cylinders

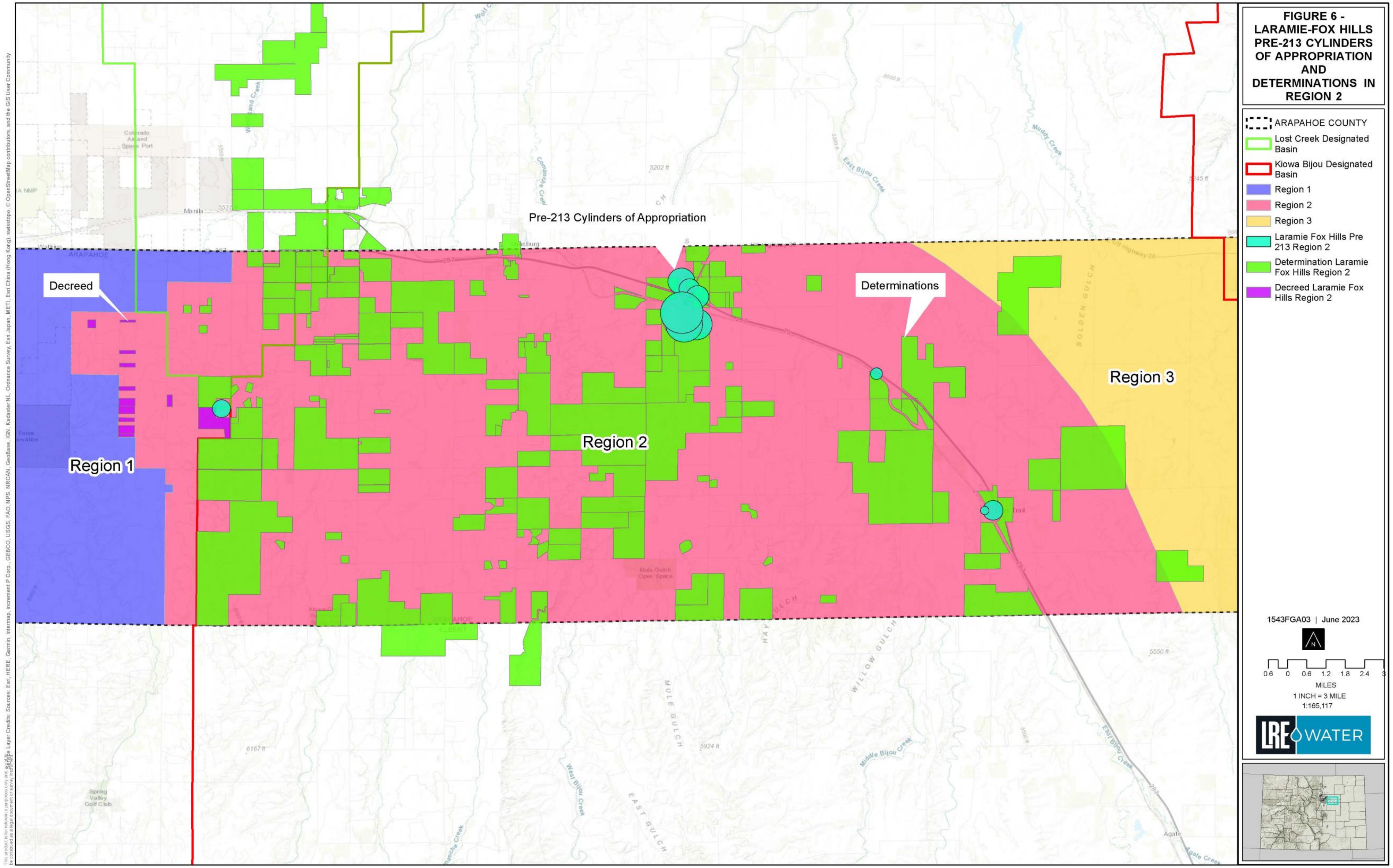


Figure 6-7: Laramie-Fox Hills Pre-213 Cylinders

Exempt and Small Capacity Well Allocations

Based upon CDWR records, the most exempt and small capacity wells in the Denver Basin within the county are issued for withdrawal of one AFY or less. For purposes of this Study, it is conservatively estimated that total Denver Basin groundwater withdrawn annually for these wells is one AFY multiplied by the number of exempt and small capacity wells in each aquifer.

Water Quality

Publicly available water quality data in the county from the USGS is highly limited spatially and temporally. All available data is displayed in the Interactive Web Map. While public data is limited, water quality in the Denver Basin aquifers, in comparison to surface or alluvial groundwater, is generally very clean and requires minimal filtration or processing. Because these aquifers are confined, there are essentially no surface impacts to water quality (i.e., irrigation or other uses). However, there are some water quality concerns from naturally occurring contaminants within the geological formations such as coal beds, arsenic, and radionuclides.

Analysis Background

As part of the project team, LRE collected a significant amount of data from (i) previous Comp Plans they prepared for the County in 2001 and 2021, (ii) Arapahoe County GIS, (iii) Rangeview Metropolitan District ("Rangeview"), (iv) CDWR; (v) USGS; (vi) numerous water supplier websites, and (vii) water supply questionnaires provided by the County.

The groundwater analysis consisted of:

- Dividing the county into three regions, with a focus on Region 2
- Mapping property outside of water service areas
- Mapping water service areas
- Collecting groundwater well decrees and determinations across the county
- Performing Petra modeling to assess the Denver Basin groundwater resources within Region 2
- Collecting and plotting available groundwater quality data
- Collecting and plotting available groundwater level data
- Providing a summary of water regulations regarding groundwater use

Methods Used

The 2001 Comp Plan and 2021 Comp Plan from LRE[20] were supplemented with publicly available data from CDWR, information provided by the County, Rangeview, USGS and numerous water supplier websites. As with the analysis in the 2001 and 2021 reports, CDWR data from constructed wells was used to further define water levels, well yields, aquifer properties and saturated thicknesses within the Denver Basin aquifers, tributary aquifers and designated basin aquifers. For this Study, an additional analysis established a regional geologic framework of major Denver Basin aquifers in the county that included:

[20] See Bibliography attached to Task 2 Memorandum

- Using 241 wireline logs distributed throughout the county and surrounding areas to determine the lateral extent, thickness, and analysis of discrete sand beds within each aquifer; and
- Using geologic interpretation software Petra™ by S&P Global. (See Appendix F for a detailed description on use of the Petra software.)

This analysis generated regional cross sections and geologic maps, including structure maps, isochore maps, and resistivity "net pay" maps for each Denver Basin aquifer. These maps can be seen on the Interactive Web Map. The purpose of this analysis was to more accurately quantify the recovery of Denver Basin groundwater using standard well construction methods. To realistically estimate possible production, LRE followed the Denver Basin Rules and replaced the State's net sand values with the Petra modeling values.

Method of Computing Denver Basin Groundwater in Region 2

Denver Basin groundwater rights both inside and outside of the designated basin are allocated to landowners (or to others with the consent of the landowners) according to overlying land area, saturated thickness (net sands) and specific yield. Water quantities (volume and associated annual production rate) are calculated according to Denver Basin Rules and the state model implementing the Rules ("SB-5 Model"). According to those rules, the volume underlying a parcel of land that can be pumped annually is one percent of the allocation. While CDWR uses the SB-5 Model to determine the legal amount of Denver Basin groundwater under a specific land parcel, the analysis for this Study used the Petra software to estimate the amount in storage within Region 2 that can be physically withdrawn using current well construction methods.[21] The Petra results are used to calculate the recoverable groundwater volume by aquifer, summarized in Table 6-3.

LRE used Equation 1 to compute the groundwater in Region 2 (Table 6-3). For purposes of this Study, Region 1 groundwater characteristics are expected to be very similar to those of Region 2. More site-specific information could be considered for well development in Region 1.

Equation 1:

Vgt = V(Petra) * Sy

Vgt = Total volume of available Denver Basin groundwater per aquifer

V(Petra)* = Net Pay × Acreage of Overlying Land

Sy = Specific Yield of each aquifer as determined in the Denver Basin Rules

[21] No Petra analysis was performed for Region 1 since the majority of the Denver Basin groundwater is unavailable and owned by Denver Water, ECCV, City of Aurora and ACWWA. No analysis was performed for Region 3 because of the lack of Denver Basin groundwater there.

Table 6-3. Recoverable Denver Basin Groundwater Based on Petra Geological Analysis in Region 2

Type		Dawson Aquifer (acre-ft/yr)	Denver Aquifer (acre-ft/yr)	Upper Arapahoe Aquifer** (acre-ft/yr)	Lower Arapahoe Aquifer (acre-ft/yr)	Laramie Fox-Hills Aquifer (acre-ft/yr)
Gross Water Availability	Total Allocated	169	19,165	14,409	722	34,902
	NNT – 4%	0	6,362	6,538	0	7,193
	NNT – Actual	169	12,724	2,824	0	46
	NT	0	80	5,047	722	27,664
Pre-213 (removed)	Total Pre-213 Removed	0	47	48	3	389
	NNT – 4%	0	0	33	0	42
	NNT – Actual	0	47	0	0	0
	NT	0	0	15	3	347
Portion Required to Return to Stream (removed)	Total	0	256	362	14	841
	NNT – 4%	0	254	262	0	288
	NNT – Actual	TBD	TBD	0	0	TBD
	NT	0	2	101	14	553
Estimated Current in Use by Landowners (removed)*		0	730	559	2	200
Total Available		**169**	**18,133**	**13,440**	**703**	**33,473**

Note: NT – Nontributary. NNT – Not-nontributary.
*Assumes that 1 acre foot/year is allocated to domestic wells
** Includes both the Upper Arapahoe and Undifferentiated Arapahoe aquifers

Recoverable Denver Basin groundwater is calculated differently from the Denver Basin Rule calculations using a more detailed subset of well data to quantify the net sand. The Petra analysis approximates the groundwater that can be physically withdrawn using current well construction techniques. The Denver Basin Rule allocates the maximum amount of Denver Basin groundwater that CDWR will allow to be pumped from a decree or determination. To understand the difference between these two datasets, the Denver Basin Rule allocation computations from the 2021 water assessment for Watkins-Bennett Study Area are compared to the physically available water volumes computed using Petra (Table 6-4 and Figure 6-8).

Table 6-4. Comparison of Petra Computation of Physically Available Groundwater vs. Denver Basin Rule Computation (SB-5)

Name	PETRA Groundwater Calculations	Denver Basin Rule Computations	Percent Physically Available vs Denver Basin
	Acre-ft/year	Acre-ft/year	%
Denver Aquifer	4,746	7,954	60%
Upper Arapahoe Aquifer	2,022	4,779	42%
Lower Arapahoe Aquifer	839	3,145	27%
Laramie Fox-Hills Aquifer	4,267	5,975	71%
Total	11,873	21,853	Weighted Average – 59%

* Compared the computations from Petra and Denver Basin Rule Computation for the Watkins/Bennett Study

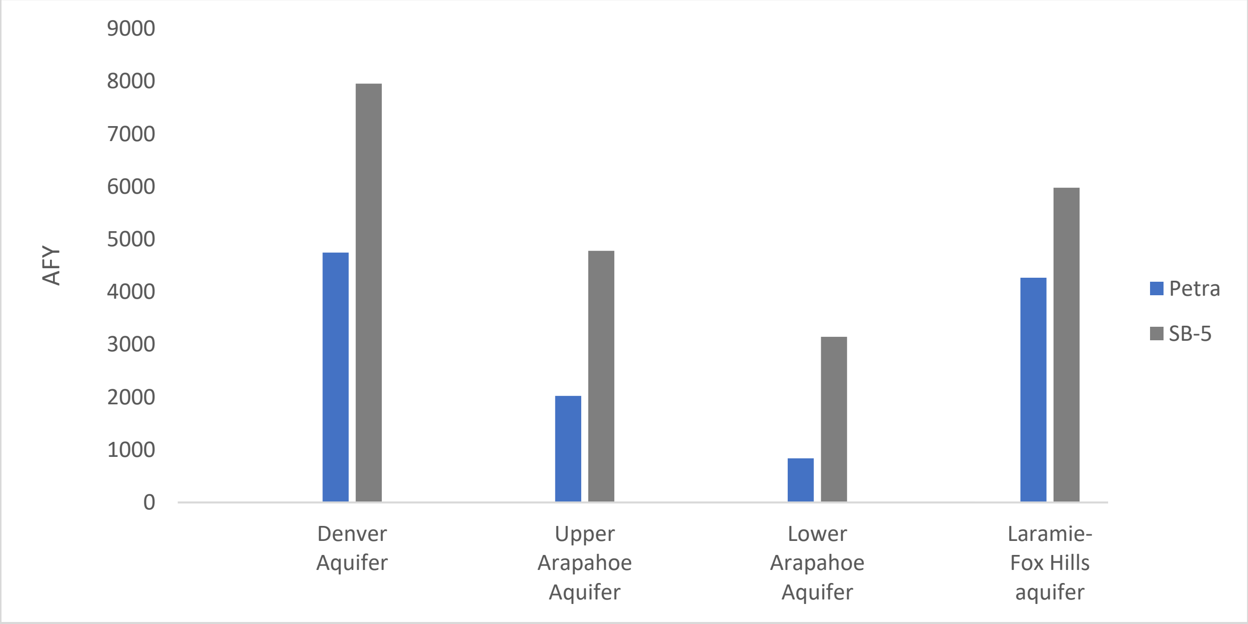


Figure 6-8. Comparison of Groundwater Availability (PETRA VS. SB-5)

Physically available groundwater is calculated at approximately 60 percent (on a weighted average) of the Denver Basin Rule allocations for all of the Denver Basin aquifers in Region 2, however, each aquifer has a different percentage. Although the estimated physical supply of Denver Basin groundwater is calculated by aquifer, groundwater is not homogeneous; it is a complicated resource. Groundwater withdrawals may be more or less than what is estimated depending on aquifer parameters, drilling techniques, well completion and use of alternative technology.

Estimating Denver Basin Groundwater in Region 2

Available Denver Basin groundwater within each aquifer has been calculated from the total amount of groundwater by aquifer using Petra and then subtracting the Pre-213 Water Rights, the amount that must be returned to the alluvium (two or four percent), and the permitted annual withdrawal estimated for exempt or small capacity wells. The percentages of Denver Basin groundwater decreed or determined by aquifer are summarized in Figure 6-9 and in Table 6-5. The determined or decreed Denver Basin water rights have not been subtracted because not all such rights have been used. Some portion of such rights could be purchased, or ownership transferred depending on how the owner wants to use that water.

Table 6-5. Portion of Denver Basin Groundwater in Region 2 That Has Been Decreed or Determined

Aquifer	Total Area in Region 2	Determined or Decreed Portion	
	Acres	Acres	% of Total
Dawson Aquifer	2,783.0	0.0	0.0%
Denver Aquifer	117,018.4	50,460.8	43.1%
Upper Arapahoe Aquifer *	200,041.1	67,659.9	33.8%
Lower Arapahoe Aquifer	24,618.2	8,319.1	33.8%
Laramie Fox-Hills Aquifer	224,418.2	75,825.4	33.8%
Total	568,878.9	202,265.1	Weighted Average - 35.6%

* Includes both the Upper Arapahoe and Undifferentiated Arapahoe aquifers.

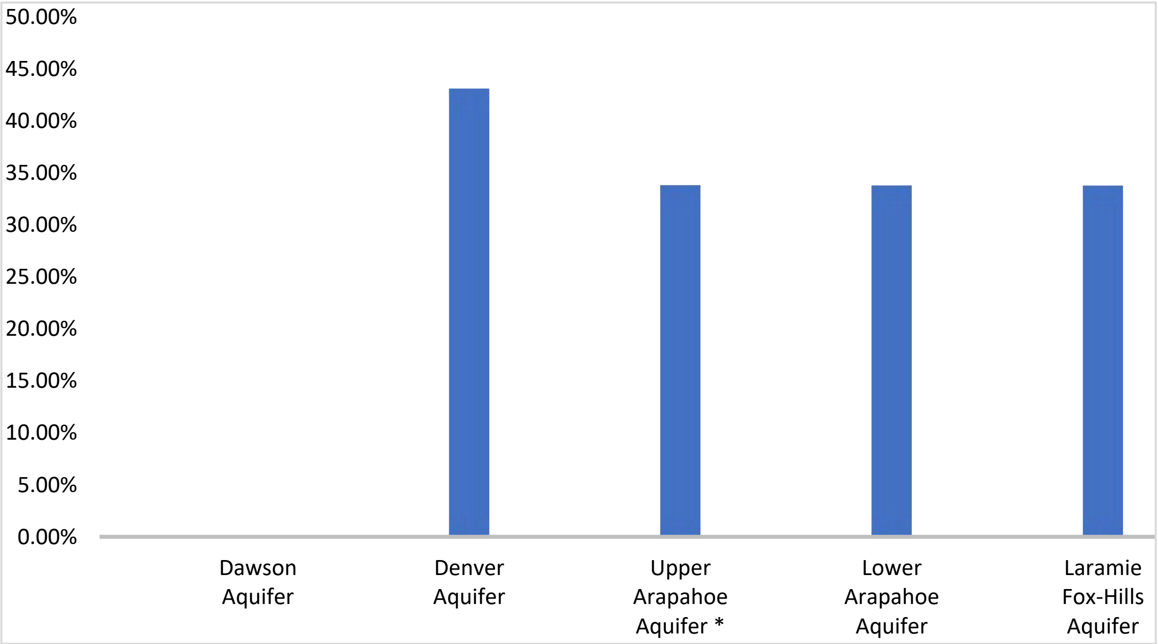


Figure 6-9. Denver Basin Groundwater Decreed/Determined

Once the physical amount of Denver Basin groundwater was computed, the amount that could be legally withdrawn without injury to other water rights was estimated. Not-nontributary groundwater (NNT-Actual and NNT-4%) outside of a designated basin within Region 2 requires an augmentation plan or a replacement plan for withdrawal.[22] As a result, these categories of Denver Basin groundwater are not considered to be a viable source for development in Arapahoe County. As shown in Figure 6-10, a significant portion of the Denver aquifer is NNT-Actual and NNT-4% and only a small fraction is nontributary (NT) groundwater. In the Upper Arapahoe and Laramie-Fox Hills aquifers, the proportion of NNT–Actual is lower and the amount of NNT-4% and NT groundwater is higher.

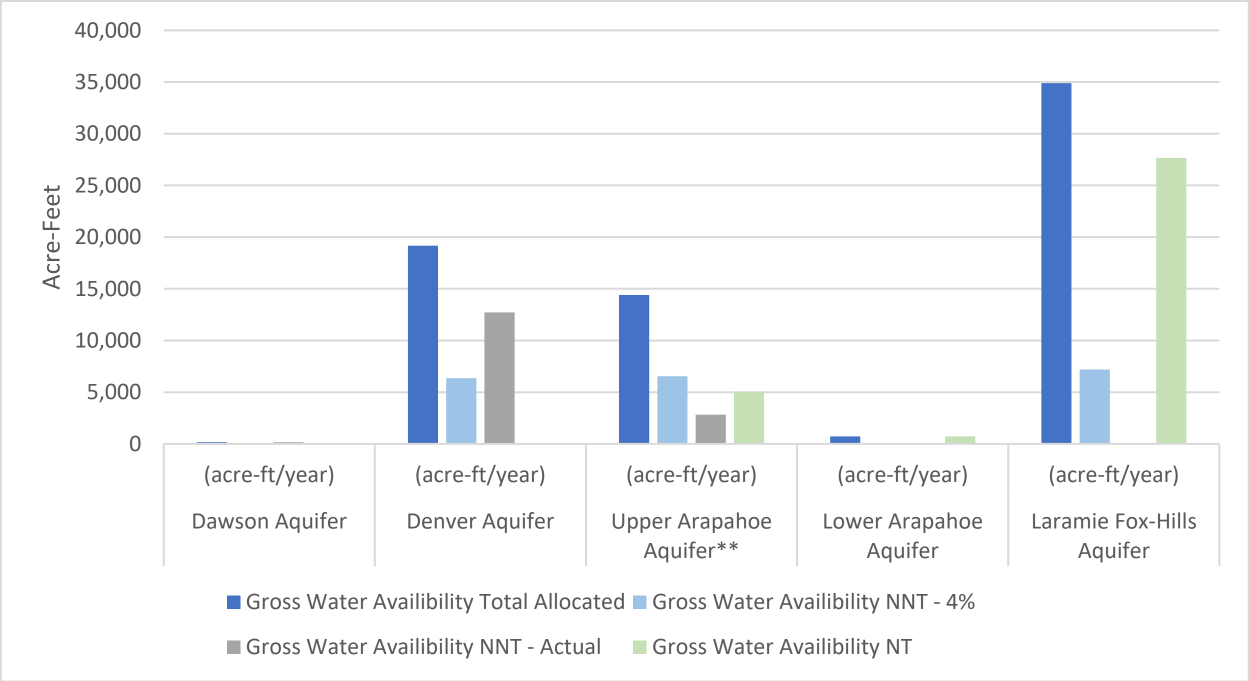


Figure 6-10. Physically Available Denver Basin Groundwater – Region 2

** Includes both the Upper Arapahoe and Undifferentiated Arapahoe aquifers.

Dawson Aquifer

The Dawson aquifer has a small footprint in the southwest corner in Region 2 with some minor quantifiable NNT- Actual groundwater. The aquifer is not very productive within Region 2 and all available groundwater would require an augmentation plan to access. Few wells in the CDWR database are permitted as Dawson wells, however, based upon analysis, some of them appear to be completed in the Denver aquifer because the Dawson aquifer is not present in most of Region 2.

Denver Aquifer

Most of the Denver aquifer wells are in Region 2 (see Table 6-2 and Figure 6-11). There are 732 permitted Denver aquifer wells in Region 2; 86 domestic/small use wells outside of a designated basin and 644 inside designated basins.

[22] See Appendix E for a detailed analysis on the categories of Denver Basin groundwater.

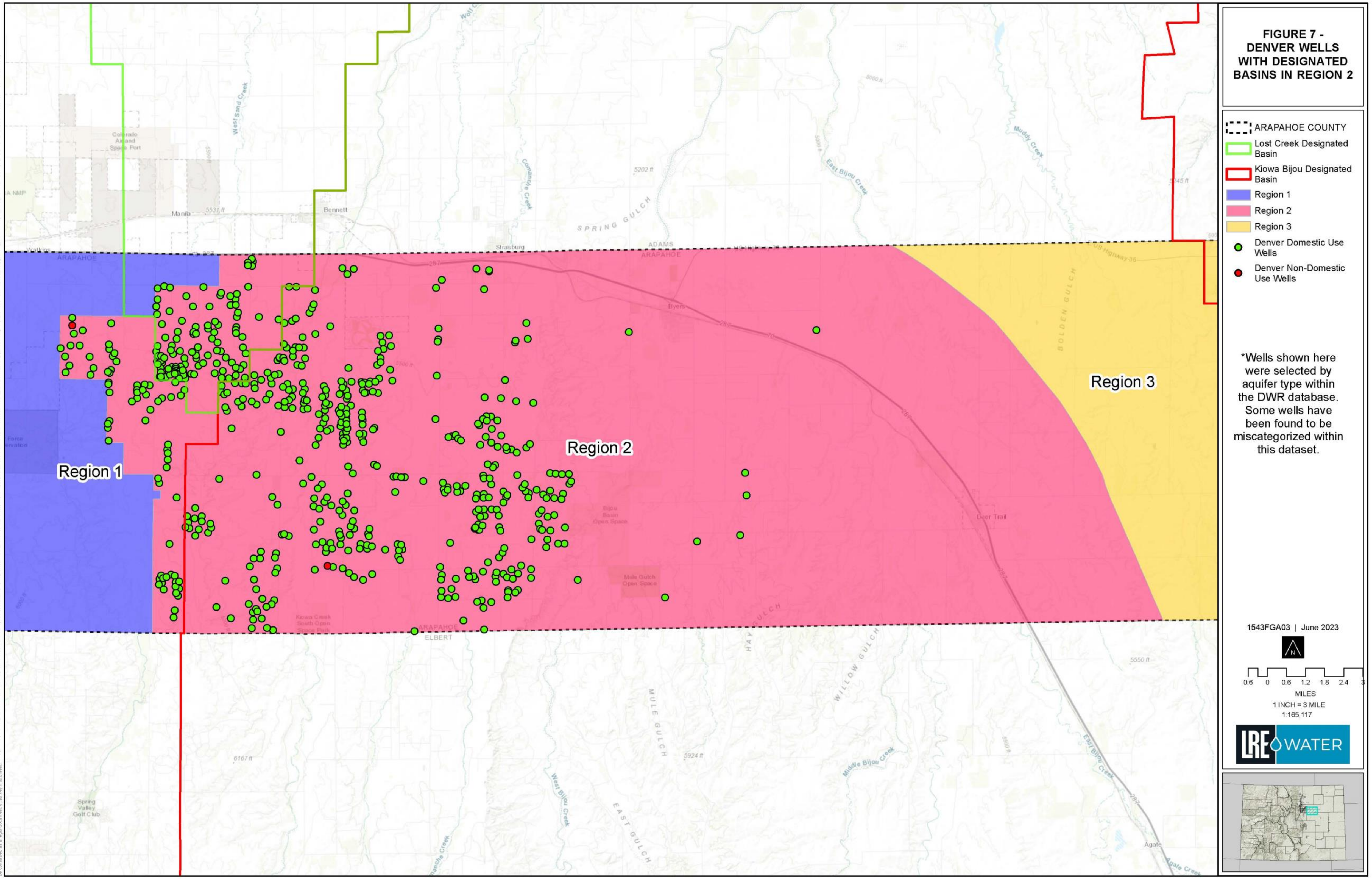


Figure 6-11: Denver Wells with Designated Basins in Region 2

The gross, physically available, 100-year annual appropriation for the Denver aquifer in Region 2 is approximately 19,165 AFY (Table 6-3). When Pre-213 water rights (47 AFY or 0.24 percent), the portion required to be returned to a local stream pursuant to the Denver Basin Rule (256 AFY or 1.3 percent), and exempt small capacity or residential wells (730 AFY or 3.8 percent) are deducted, approximately 18,133 AFY remain. Of that, only a small portion is available for appropriation without requiring an augmentation or replacement plan-- approximately 5,800 AFY. NNT – Actual and NNT – 4% groundwater outside of a designated basin account for about 68 percent of the available Denver aquifer in Region 2.

Upper Arapahoe Aquifer

There are 590 permitted Upper Arapahoe aquifer wells in Region 2 (see Table 6-2 and Figure 6-12). There are 26 domestic/small use Upper Arapahoe wells outside of a designated basin and 533 domestic/small use wells inside designated basins. It should be noted that the Upper Arapahoe aquifer in this analysis includes the Undifferentiated Arapahoe aquifer because this is how the state categorizes the determinations.

The gross, physically available, 100-year annual appropriation for the Upper Arapahoe aquifer in Region 2 is approximately 14,409 AFY (Table 6-3). When Pre-213 water rights (48 AFY or 0.33 percent), the portion required to be returned to alluvium pursuant to the Denver Basin Rules (362 AFY or 2.5 percent), and exempt small capacity or residential wells (559 AFY or 3.9 percent) are deducted, approximately 13,440 AFY remain.

As with the Denver aquifer, only a portion of the Upper Arapahoe aquifer is available for appropriation without requiring an augmentation or replacement plan--approximately 11,600 AFY. The NNT-Actual groundwater accounts for approximately 20 percent of the available Upper Arapahoe aquifer in Region 2.[23]

Lower Arapahoe Aquifer

There are only two permitted Lower Arapahoe aquifer wells in Region 2 (see Table 6-2 and Figure 6-13). There is one domestic/small use Lower Arapahoe well outside of a designated basin and one inside a designated basin within Region 2.

The gross, physically available 100-year annual appropriation for the Lower Arapahoe aquifer in Region 2 is approximately 722 AFY (Table 6-3). When Pre-213 water rights (three AFY or 0.4 percent), the portion required to be returned to a local stream (14 AFY or 2 percent), and exempt small capacity or residential wells (two AFY or 0.3 percent) are deducted, approximately 703 AFY remain.

The Lower Arapahoe aquifer within the Region 2 is designated as NT, therefore, 703 AFY is available for appropriation. However, unlike the Denver and Upper Arapahoe Aquifers, the Lower Arapahoe Aquifer is only found in the northwestern corner of Region 2 and can be unreliable and inconsistent in water production.

Laramie-Fox Hills Aquifer

There are 227 permitted Laramie-Fox Hills aquifer wells in Region 2 (See Table 6-2 and Figure 6-14). There are no domestic/small use Laramie-Fox Hills well outside of a designated basin and 200 inside the designated basins within Region 2.

[23] There is no NNT – 4% Upper Arapahoe aquifer groundwater outside of a designated basin.

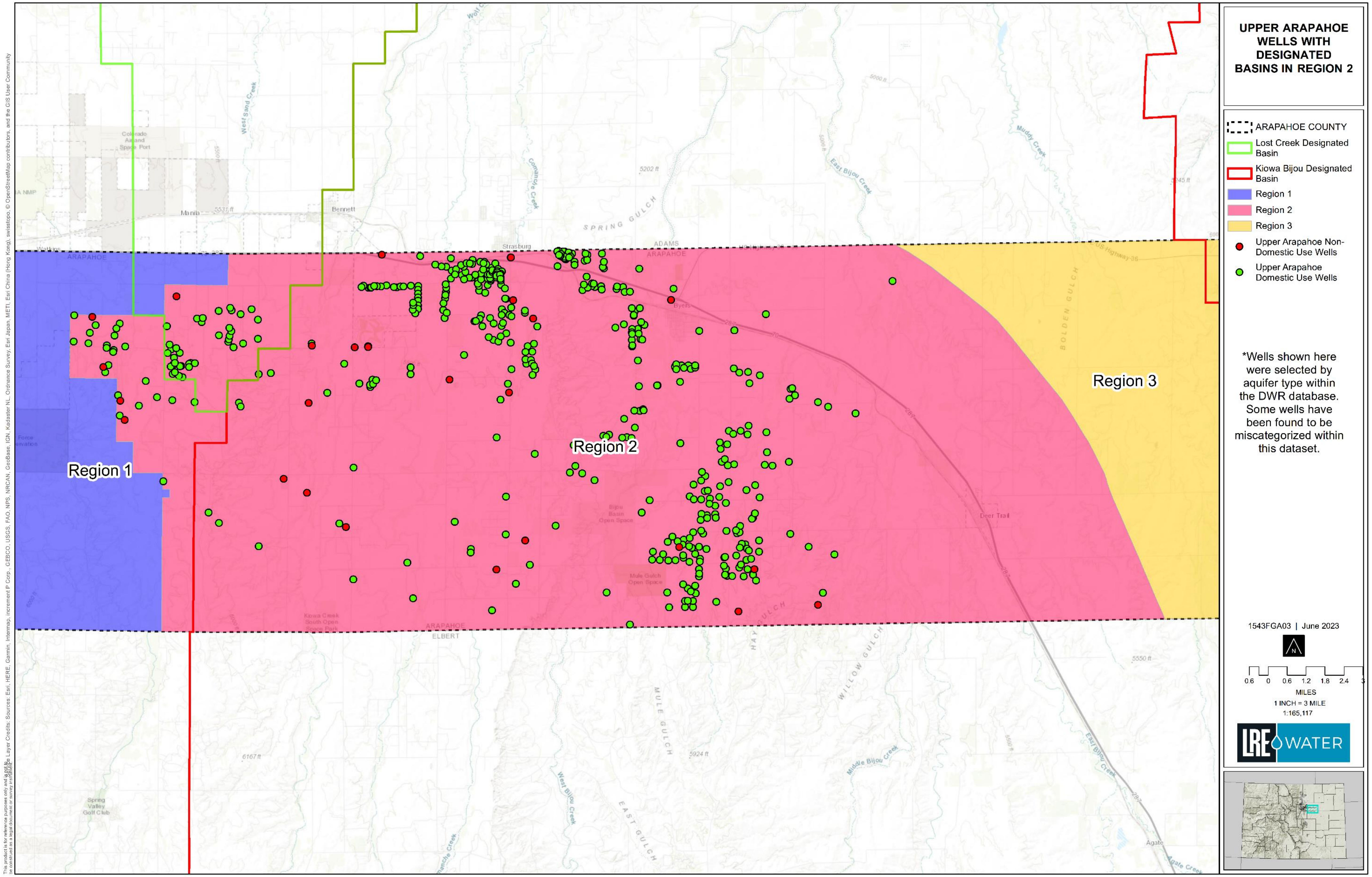


Figure 6-12: Upper Arapahoe Wells with Designated Basins in Region 2

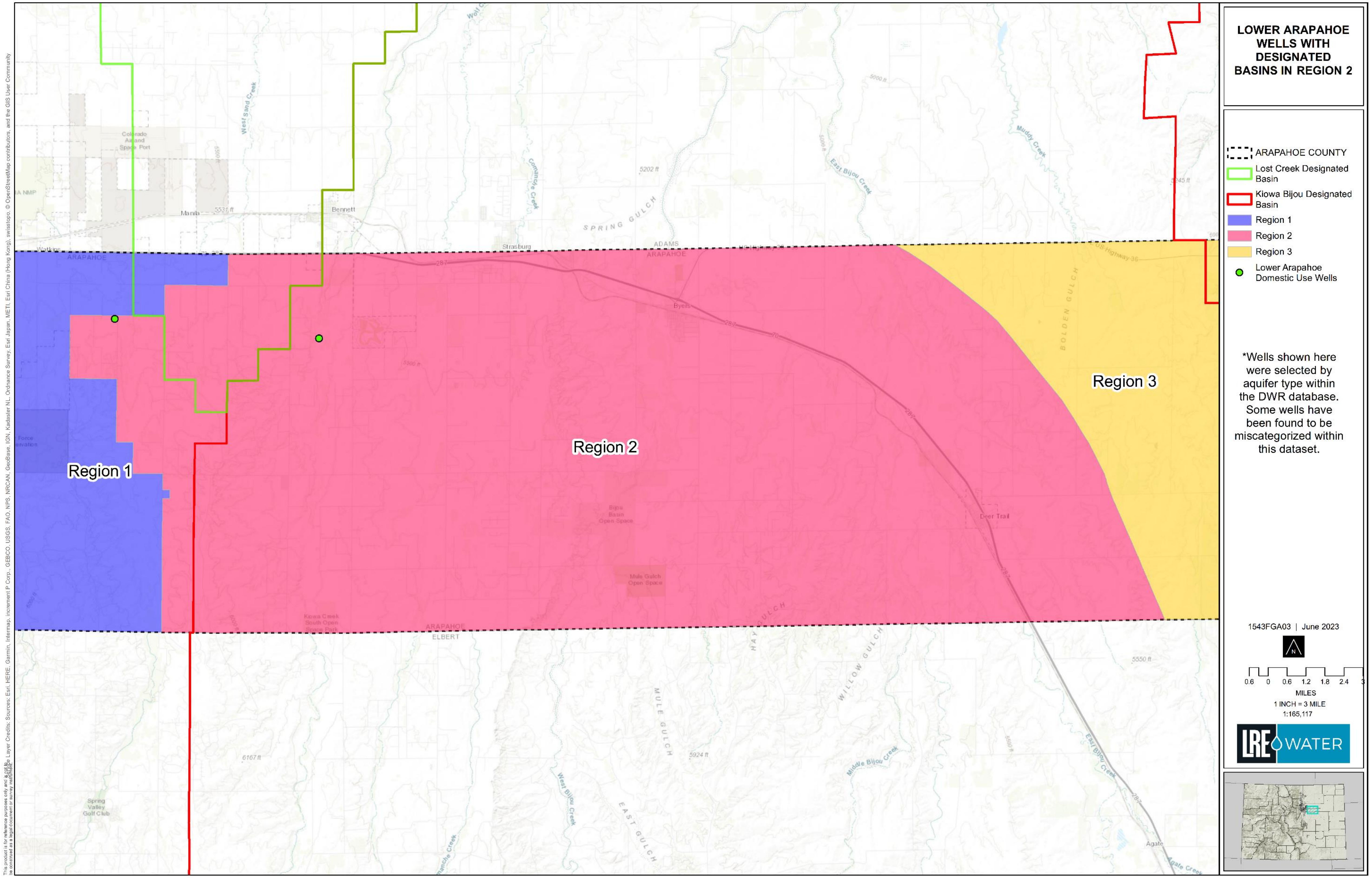


Figure 6-13: Lower Arapahoe Wells with Designated Basins in Region 2

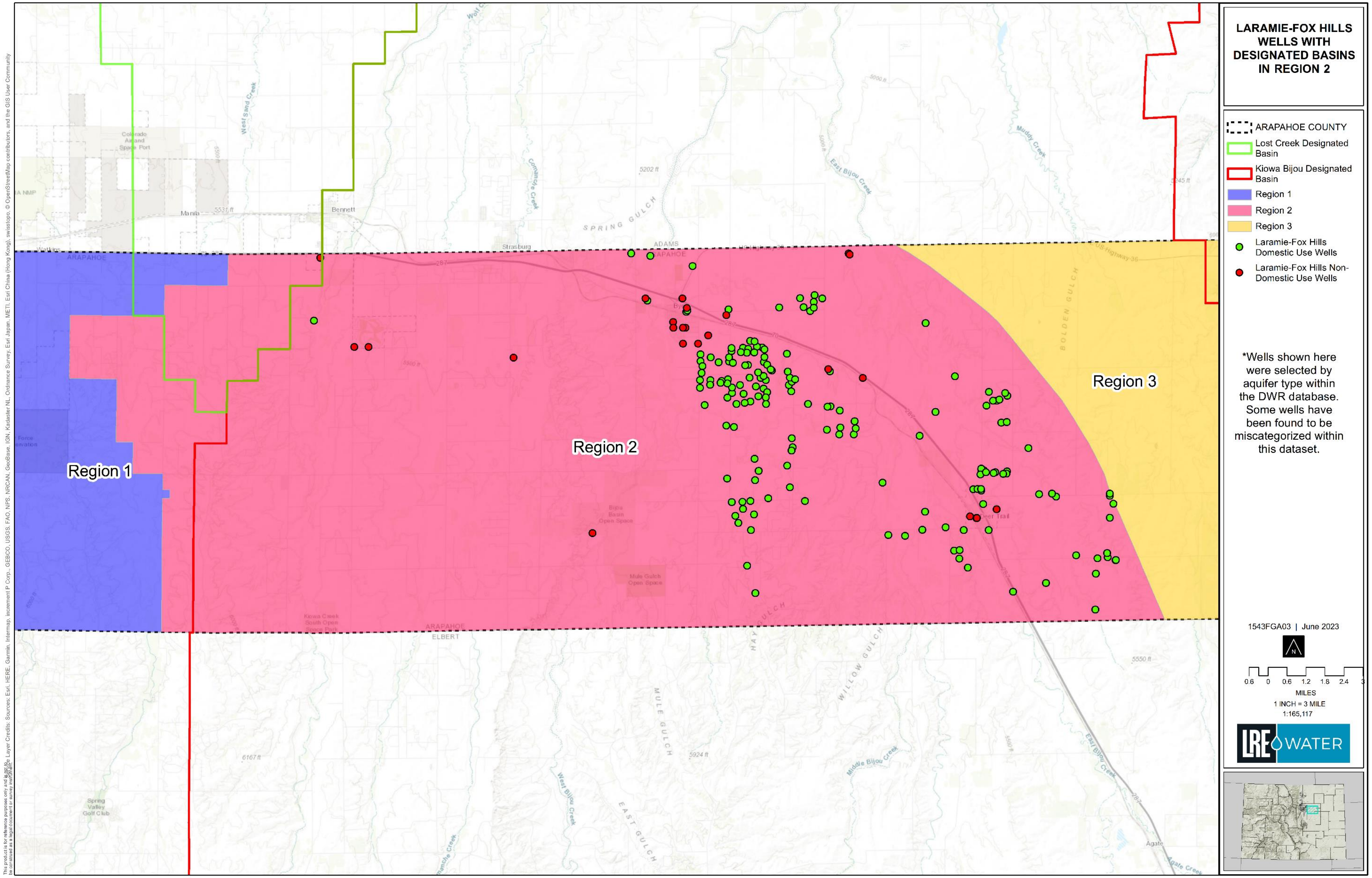


Figure 6-14: Laramie Fox Hills Wells with Designated Basins in Region 2

The gross, physically available 100-year annual appropriation for the Laramie-Fox Hills in Region 2 is approximately 34,902 AFY (Table 3). When Pre-213 water rights (389 AFY or 1.1 percent), the portion required to be returned to a local stream (841 AFY or 2.4 percent), and exempt small capacity or residential wells (200 AFY or 0.57 percent) are deducted, approximately 33,473 AFY remain. There is no NNT-Actual Laramie-Fox Hills aquifer groundwater in Region 2, therefore, 33,743 AFY is available for withdrawal.

While the Laramie Fox-Hills can be appropriated, the aquifer is present deep below the ground surface and is expensive to access. Furthermore, the Laramie Fox-Hills is not homogeneous and can be unreliable and inconsistent for water production.

Conclusions

Here are the conclusions drawn from this evaluation:

1. Denver Basin groundwater use within Region 1 is reduced and is expected to decline in the future; it will primarily be used for drought contingency. Water providers in Region 1 are continuing to develop renewable water resources (including local alluvial groundwater), infrastructure, and reuse.
2. Two designated basins cross into the county – Lost Creek and Kiowa Bijou. Both have groundwater management districts that have some regulatory jurisdiction. The designated basins make up approximately 50.4 percent of the county area.
3. The primary source of future groundwater development within Region 2 (the focus of this analysis) will be the Denver Basin. Alluvial groundwater, either inside or outside the designated basins, will be a minor source due to the complexity of augmentation or changing water rights. In both areas, groundwater is either over-appropriated or impacts senior water rights.
4. There are 10 subdivisions in Region 2 with 20 or more lots-- two outside of the designated basins and eight inside the designated basins. The subdivisions outside of the designated basins have wells issued pursuant to an augmentation plan and court decree. Those within the designated basins have small capacity wells issued for residential/domestic use.
5. Based on the Petra geological analysis, approximately 66,000 AFY of Denver Basin groundwater is available in Region 2. Approximately 24 percent of that is NNT-Actual groundwater that would require an augmentation or replacement plan prior to development.
6. Approximately 35.6 percent of the Denver Basin aquifers in Region 2 have already been allocated by decree or determination.
7. Artesian water levels in Denver Basin aquifers across the county have been declining due to reduced aquifer pressures as these resources are developed.
8. A few Denver Basin wells have levels that have dropped below the tops of the aquifers in some areas of the county.

SECTION 7.

WATER SUPPLIES vs DEMAND

SECTION 7 – WATER SUPPLIES VS. DEMANDS

Having reviewed the water providers responsible for supplying water across Arapahoe County, projecting water demands through 2050 and analyzing the county's critical groundwater supplies in prior sections, this section compares water supplies to demands to identify potential gaps. It also includes a summary of regional projects that could secure additional water supplies for the county.

Water Supplier Projections

Water supply and demand projections are summarized in Table 7-1 and totals for all water providers are shown graphically in Figure 7-1. Table 7-1 identifies:

- Water supplies from the providers in Regions 1 and 2, with planned new supplies coming online by 2050
- Groundwater availability for unincorporated areas of Region 2
- Projected high and low water demands for the water suppliers and unincorporated areas with conservation
- Projected high and low water demands for the water suppliers and unincorporated areas without conservation

Table 7-1. Water Supply and Demand Summary

WATER PROVIDER	Water Supply (AFY) 2020	Total Water Demand (AFY) 2020	Water Supply (AFY) 2050	Total Water Demand (AFY) 2050 Low	Total Water Demand (AFY) 2050 High	Total Water Demand (AFY) 2050 Low w/ Conservation	Total Water Demand (AFY) 2050 High w/ Conservation
Aurora	37,500	30,000	63,750	42,376	46,193	37,733	40,861
Denver	45,240	36,936	45,240	42,633	44,606	38,447	40,057
ECCV	9,200	5,648	9,200	7,170	7,595	6,421	6,771
Englewood	6,033	6,036	6,481	6,754	7,019	6,103	6,319
ACWWA	3,835	3,303	5,620	3,887	4,144	3,503	3,711
Prosper Farms	180	13	6,700	5,600	6,600	2,638	3,282
Sky Ranch/Rangeview	3,652	16	3,652	997	1,254	842	1,054
Inverness Water	1,100	1,091	1,100	1,248	1,295	1,130	1,168
Byers	564	212	564	218	217	198	197
Deer Trail	183	146	183	163	167	147	150
Strasburg	624	26	624	50	62	44	53
Bennett	79	7	79	9	56	7	47
No District	51,846	2,344	51,846	5,560	4,827	4,891	4,277
Total	**160,036**	**85,778**	**195,039**	**116,665**	**124,035**	**102,104**	**107,947**

Denver	5,800	
Upper Arapahoe	11,600	
Lower Arapaho	703	Water availability from the ground water report not requiring augmentation.
Laramie Fox Hills	33,743	

Note: Yellow highlighted rows are the water providers for which, without conservation, demands would exceed supply. Prosper Farms is also highlighted but noted in red text because their water supply plans have not been approved beyond the first filing.

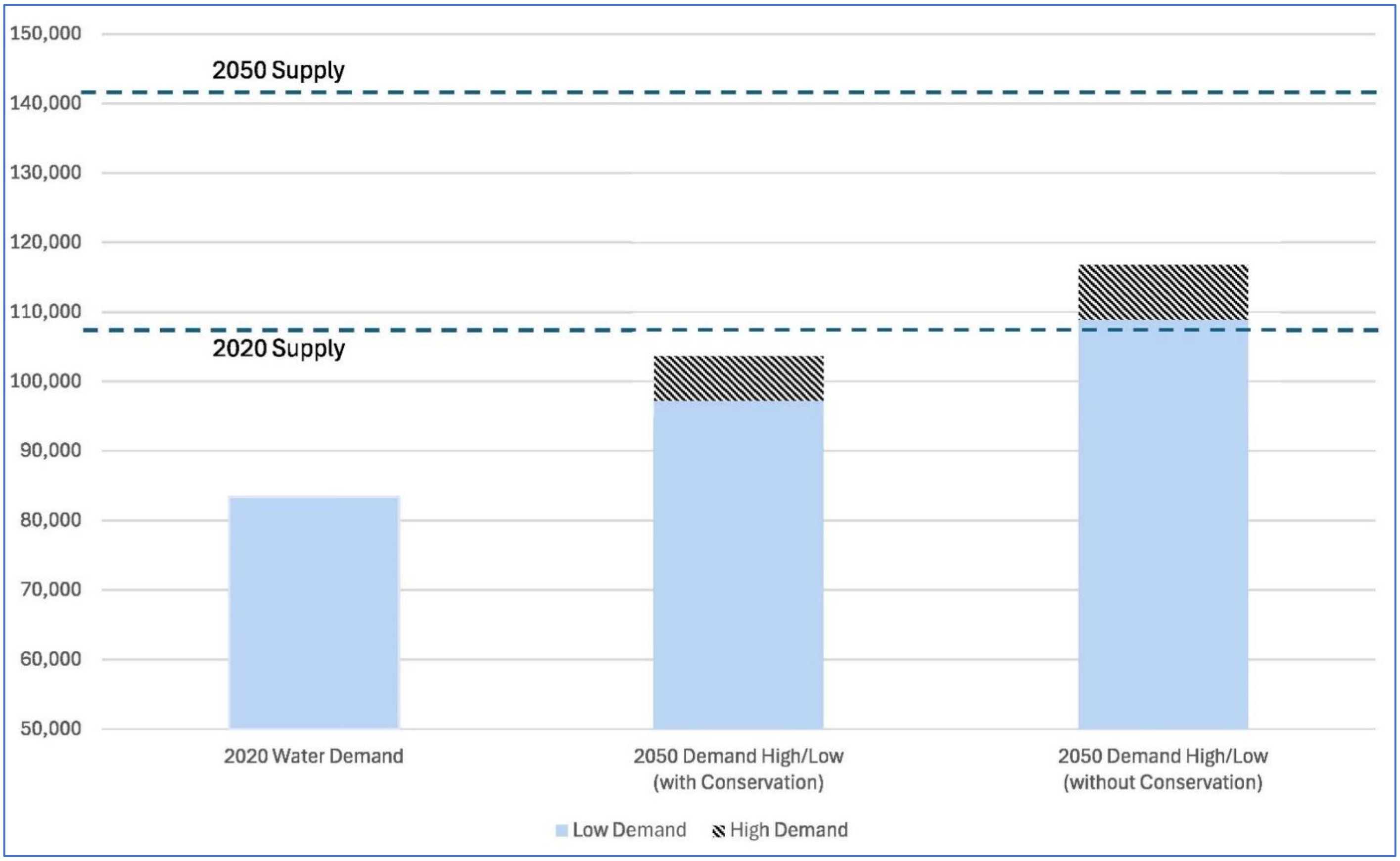


Figure 7-1. Water Supplies and Demands (AFY)

Note: Does not include the "No District" demands or supplies.

The county's population is projected to increase approximately 35 to 45 percent by 2050. With this increase, water demands are projected to increase 34 to 44 percent with no additional conservation. With additional conservation (see Section 8), demands are projected to increase only 19 to 28 percent for that same population growth.

As illustrated in Figures 7-2 through 7-5, projected water supplies exceed water demands for the majority of water providers for both 2020 and 2050. The larger providers (Denver, Aurora, ECCV, Englewood, Rangeview, and ACWWA) continuously review their respective water supply assets, incorporate conservation measures, and secure additional water supply assets as needed to accommodate their growing demands.

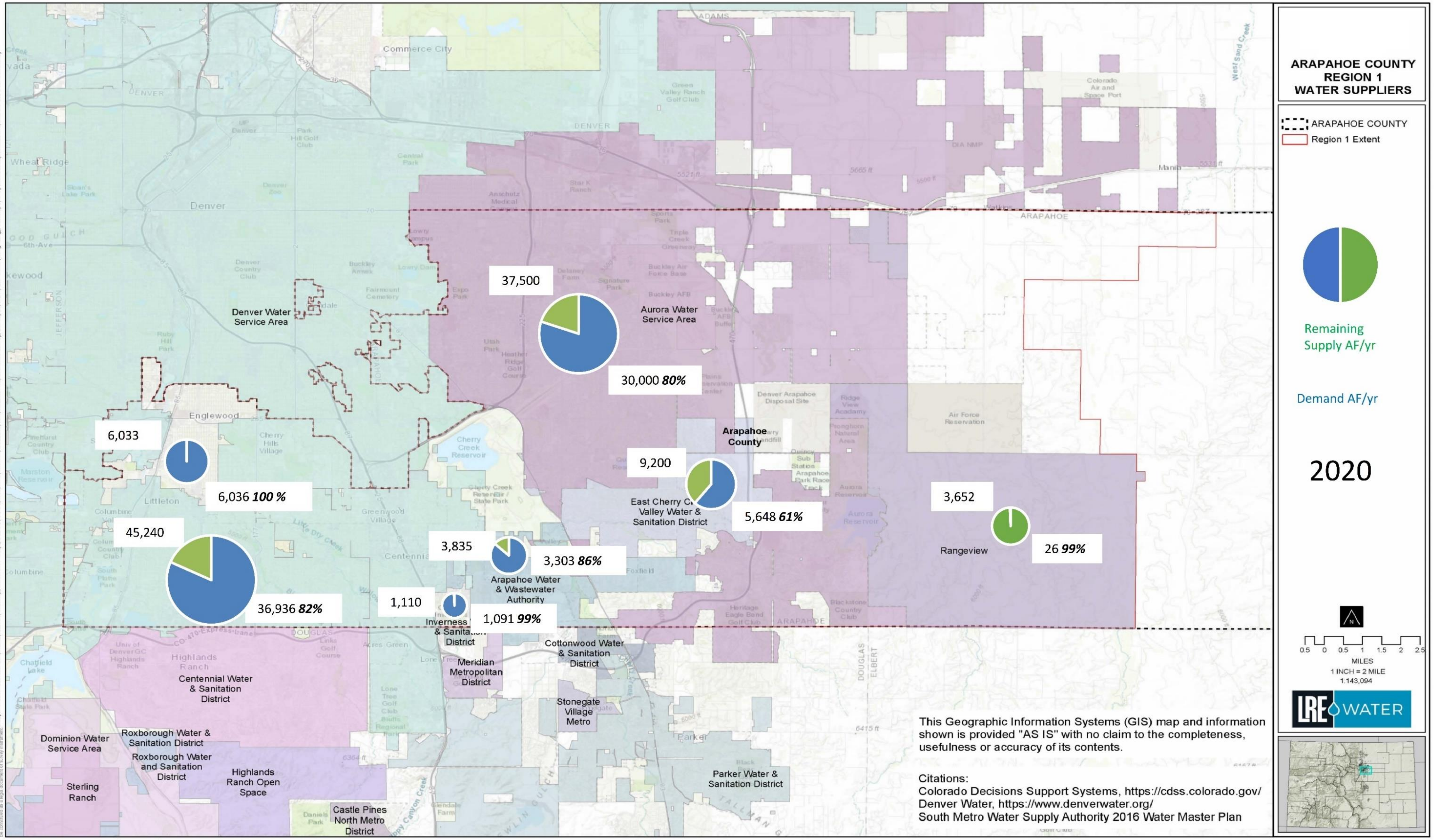


Figure 7-2: Region 1 Supply and Demand 2020

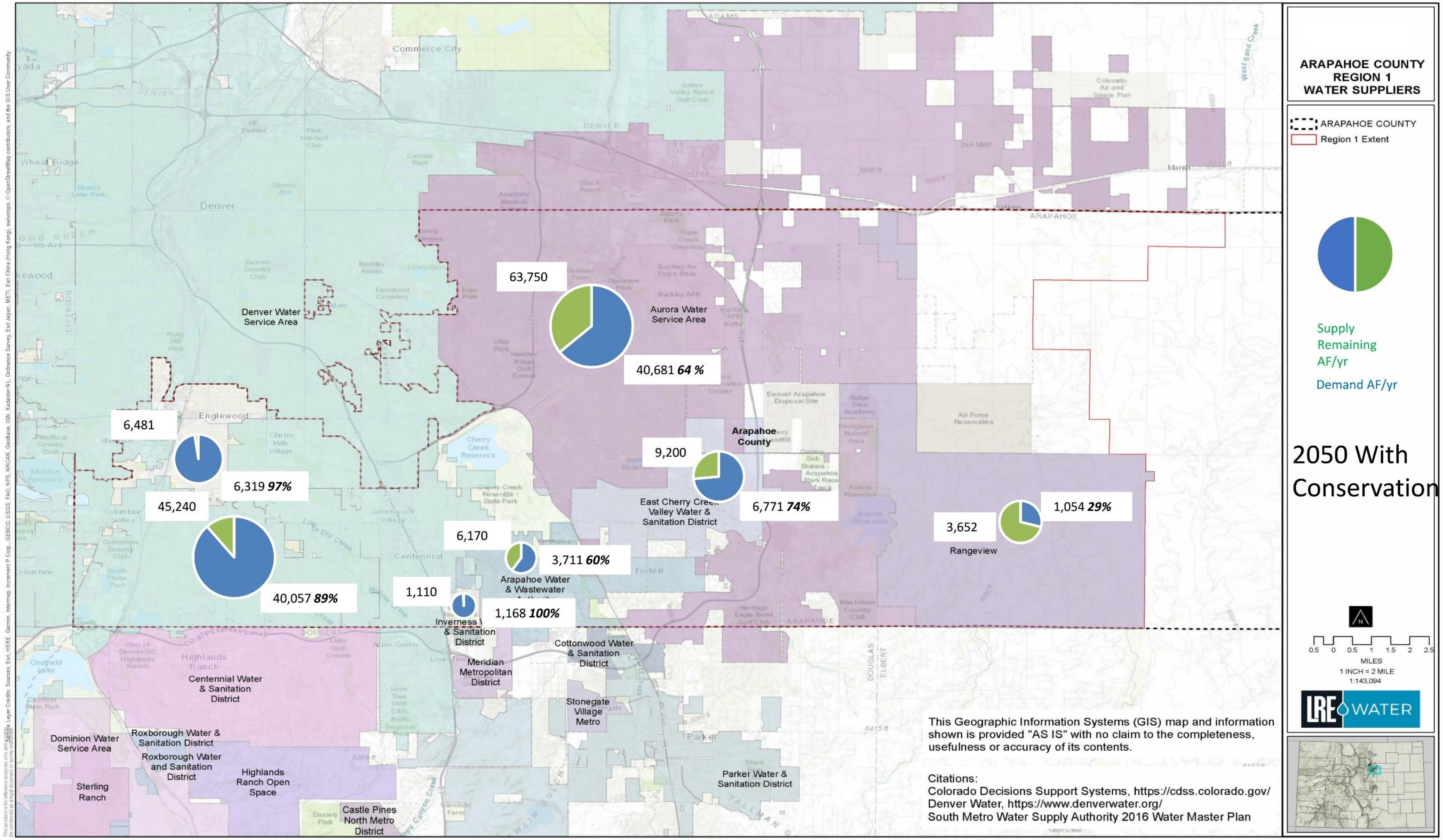


Figure 7-3: Region 1 Supply and Demand 2050

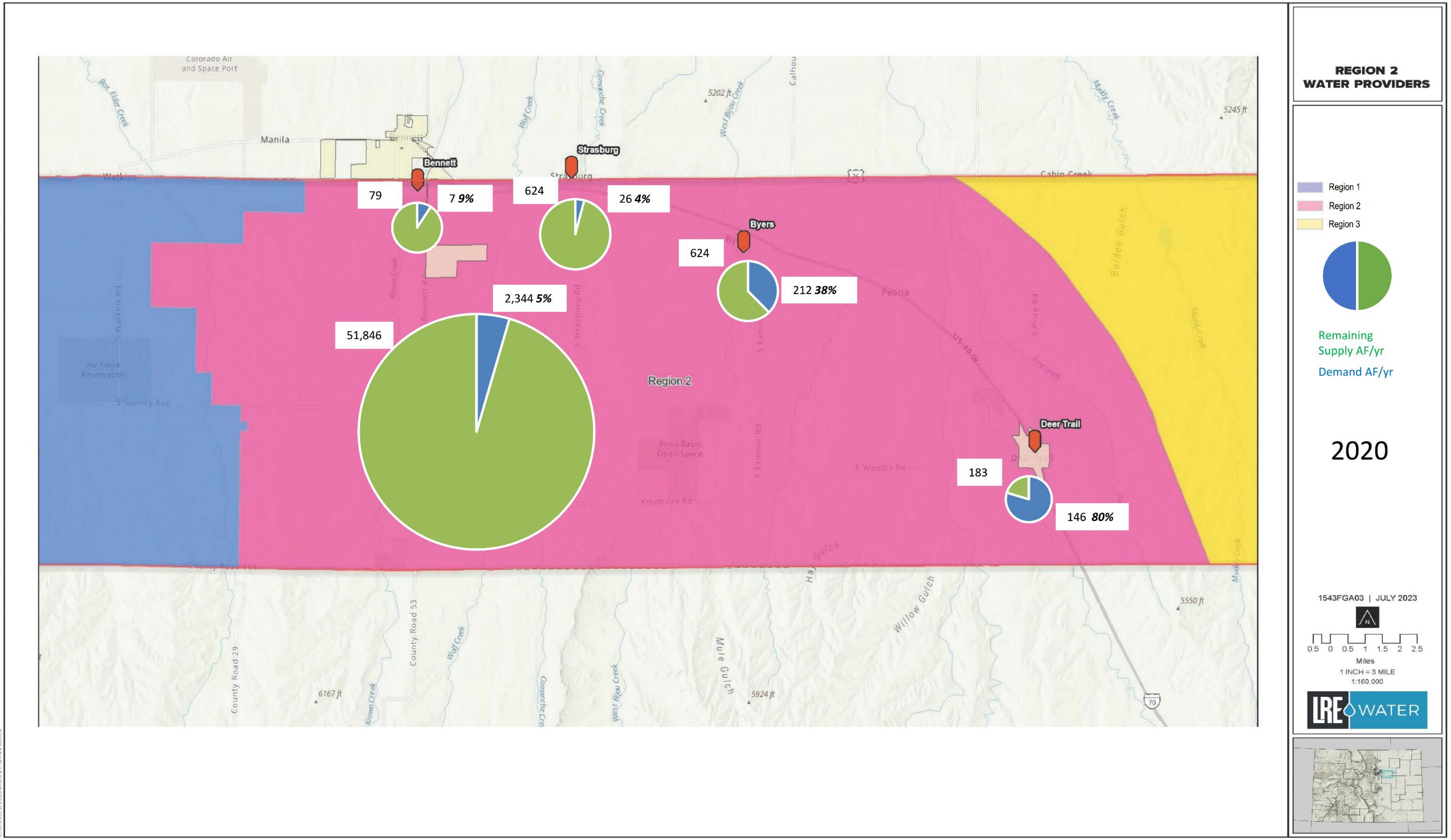


Figure 7-4: Region 2 Supply and Demand 2020

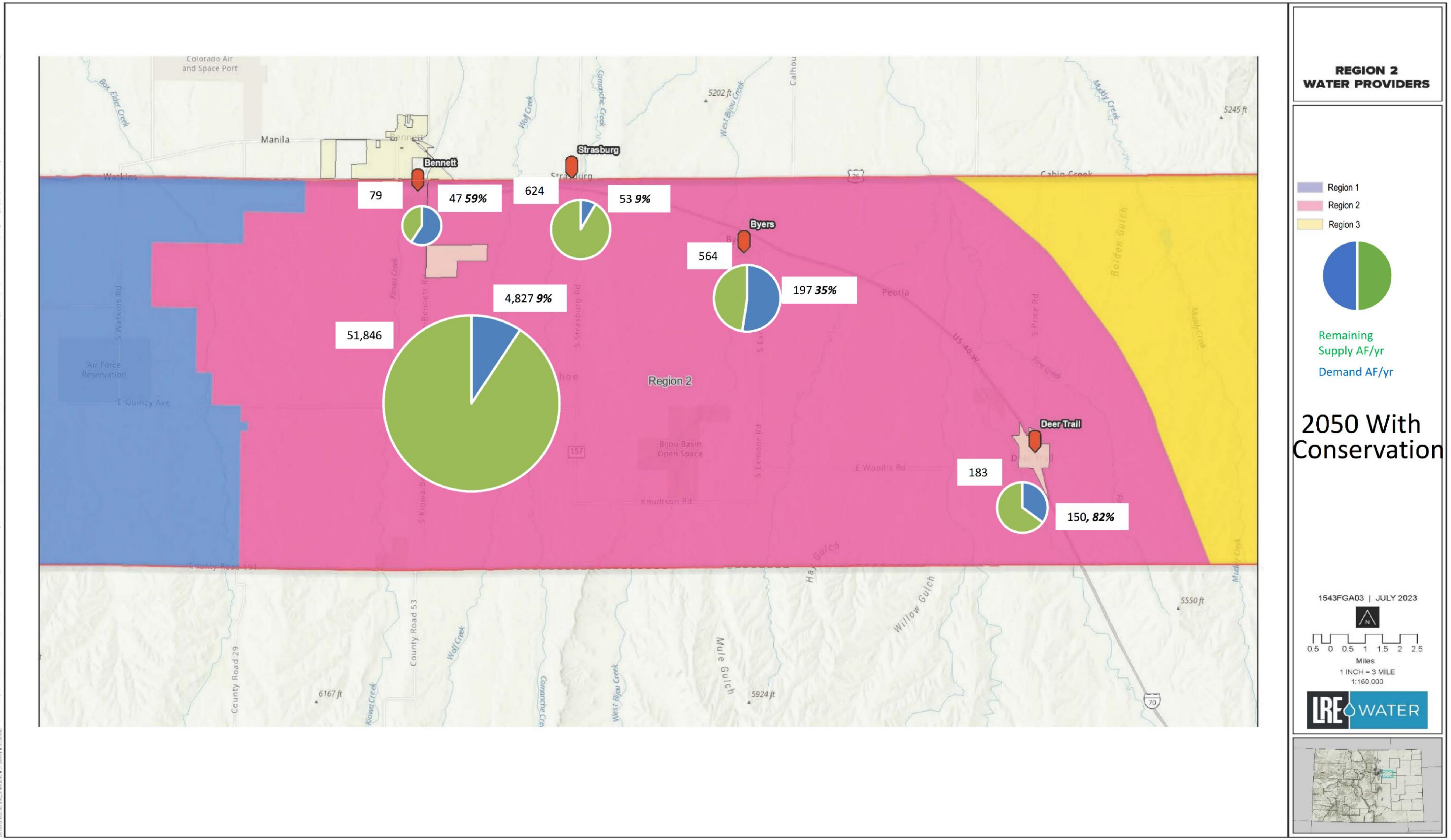


Figure 7-5: Region 2 Supply and Demand 2050

Of the 12 water providers in Arapahoe County ("No District" excluded), only Englewood and Inverness WSD (IWSD) appear to have supply deficiencies with respect to projected demands. From review of the City of Englewood's 2023 water efficiency plan, the City plans to implement conservation measures to ensure that supply meets demand. As shown in Table 7-1, their 2020 supply was roughly equivalent to 2020 demands. With conservation, Englewood's projected 2050 supply is 2.5 percent greater than projected high demand for 2050.

For IWSD, a significant portion of their supply is provided by Denver Water. As previously noted in Section 4, Denver Water has a supply capacity of approximately 700,000 AFY and diverts less than half for its current customers. They could potentially increase diversions when required to meet demands within their service areas, and to satisfy water contracts. Based upon supply and demand projections, Denver Water has more supply in Arapahoe County than demands. This indicates that IWSD could obtain additional supply from Denver Water through future collaboration, by way of the WISE Partnership for example.

In addition to Englewood and IWSD, two more entries listed in Table 7-1 (Prosper Farms and "No District") prompt further analysis. Although Table 1 indicates that Prosper Farms has sufficient supply to meet its anticipated demands, the County has only approved Phase 1 of the development (900 residential units) requiring approximately 180 AFY.[24] This first phase will be supplied by Denver Basin groundwater and the remainder of the development by a combination of renewable supplies and water reuse. However, those renewable supplies have not been secured and therefore, cannot be relied upon.

The "No District" demands are for unincorporated areas in Region 2 of the county. As previously noted, water supply for these areas will be primarily drawn from the Denver Basin. Denver Basin supplies within Region 2 are estimated at nearly 52,000 AFY, far exceeding projected demand. However, 65 percent of that groundwater is in the Laramie-Fox Hills aquifer which can be costly to access and divert.

Potential Water Supplies

Water providers continue to work toward increasing supplies to meet growing demands within the county. For example, Rangeview is working toward expanding renewable supplies from Box Elder Creek, with new reservoir storage east of Aurora Reservoir. Regionally, the Platte Valley Water Partnership (PVWP), Todd Creek Metropolitan District and Town of Bennett (BennT Project) partnership, and the Water Infrastructure and Supply Efficiency (WISE) partnership all present possible options.

The PVWP, a partnership between the Lower South Platte Water Conservancy District (LSPWCD) and Parker Water and Sanitation District (PWSD), is applying to store available South Platte River water in the lower portion of the river for use along the Front Range. This stored water is proposed for conveyance to PWSD's Rueter-Hess Reservoir for municipal purposes. Along this pipeline, there is potential for water to be diverted for agricultural and other uses in Arapahoe County (Figure 7-6).

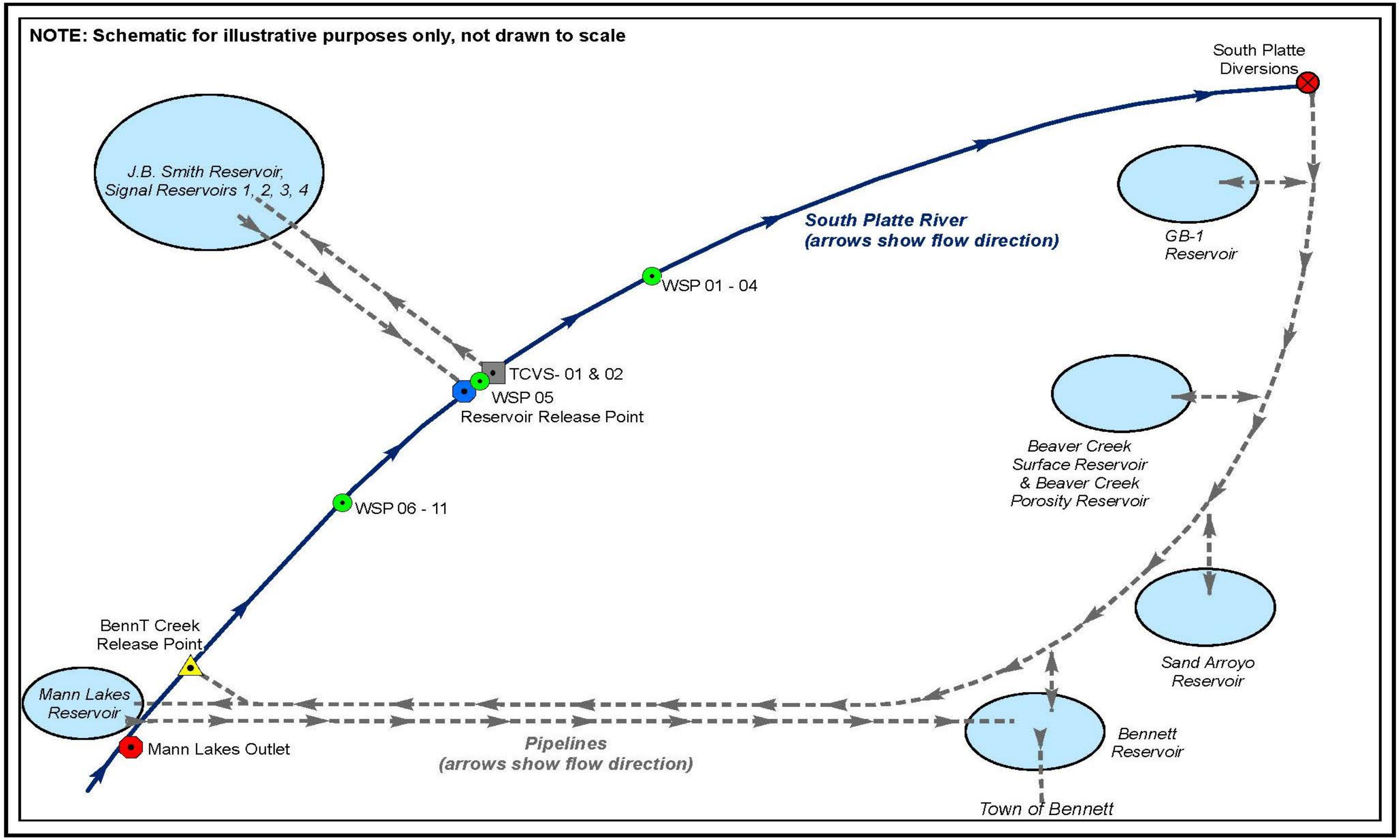
[24] 2014 Arapahoe County 1041 Report

Not to Scale

Figure 7-6: Platte Valley Water Partnership Project Overview

Information obtained from https://pwsd.org/3393/Platte-Valley-Water-Partnership

The BennT Project partnership is also applying to use available South Platte River water for use along the Front Range. This project proposes to use Todd Creek assets near Brighton and storage in the lower portion of the river to manage water for delivery via pipeline to Bennett, and back to the South Platte near Todd Creek. The Town of Bennett has indicated that BennT water will be a portion of their future supply (Figure 7-7). Both the PVWP and BennT partnerships have filed water court applications to access available renewable water on the lower South Platte River. Both are attempting to maximize use of junior priority surface water through additional storage and infrastructure to deliver this water west for their and others' future use.



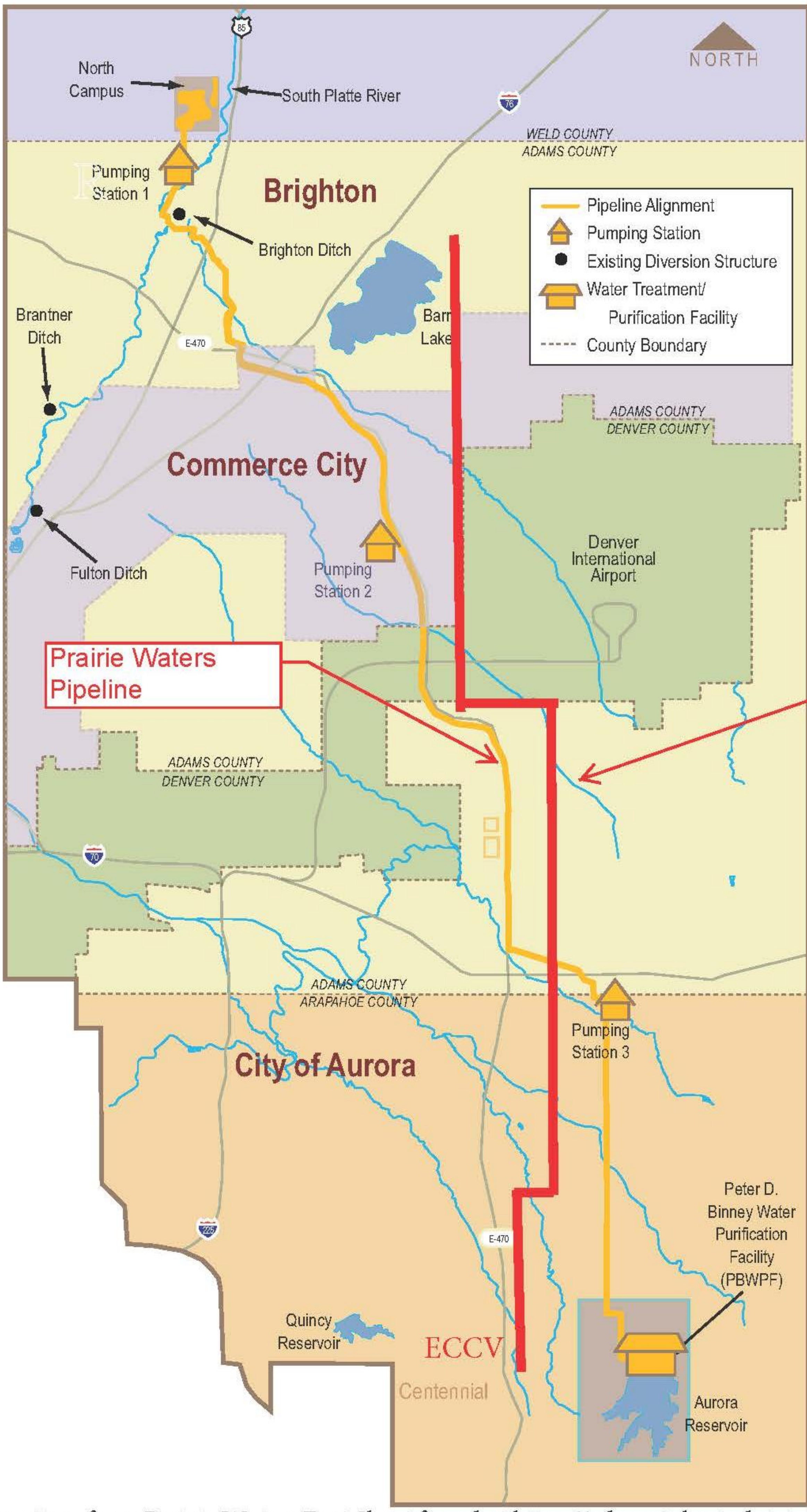
Information obtained from Figure prepared by Jehn Water Consultants as a part of Water Court 1 Application 2020CW3215

Figure 7-7: BennT Partnership Project Overview

The WISE partnership is a collaboration between Denver Water, Aurora and the South Metro Water Supply Authority (SMWSA). South Platte water is diverted near Brighton and piped to Aurora Reservoir for treatment and distribution. The project was initially solely an Aurora Water raw water supply (Prairie Waters Project), but Denver Water and Aurora realized that excess capacity and occasional unused water supplies provided an opportunity for regional cooperation to develop an entirely new water supply; largely one of indirect reuse. The result is that when Denver Water and Aurora cannot use all the water from this system, excess water is available to SMWSA and its 14 members. Rangeview and ECCV are the Arapahoe County members of WISE. Discussions continue on how to increase capacity of the WISE system. Additionally, WISE may even incorporate the Northern Project used by ECCV and ACWWA (Figure 7-8).

Conclusion

Although three of the entities discussed in this section appear to have potential shortages with respect to 2050 demands, there are opportunities to close those gaps through conservation, agreements with other water providers, and regional partnerships to develop new supplies. Available Denver Basin resources are substantial, although 65 percent of those supplies are in the Laramie-Fox Hills aquifer, expected to be more costly to develop than the other aquifers.



Not to Scale

Information form Prairie Waters Fact Sheet found at https://cdnsm5-hosted.civiclive.com/UserFiles/Servers/Server_1881137/File/Residents/Water/PDFs/Water%20Facts%20and%20Reports/PWP%20Fact%20Sheet.2022.pdf

Information collected Northen Project fact sheet found at https://www.eccv.org/files/27955d7cc/Northern+Project+Fact+Sheet.pdf

Figure 7-8. Aurora Prairie Waters and Northern Project General Alignment for WISE

SECTION 8.

WATER MANAGEMENT STRATEGIES

SECTION 8 – WATER MANAGEMENT STRATEGIES

Given the increasing demands on water resources throughout the region, increasing costs are expected to drive more efficiency in the management of those resources. Water providers are giving much more attention to optimizing water uses in their respective service areas and joining with others to develop regional efforts. This section describes those water management strategies: water conservation with a focus on water-conscious landscaping; water reuse; and "conjunctive use"—all pointing toward a more sustainable future.

Water Conservation

Although water conservation is well developed in some areas of Arapahoe County, conservation is expected to expand and mature much more over the next 25 years. This analysis describes the water conservation plans and practices of Arapahoe County water providers, points to further potential to grow those conservation practices, and determines the reduced growth in demand projections that could result through 2050.

Although the County and its municipalities have interests in water sustainability from a land-use perspective, it is the water providers (and some municipalities that provide that service) that are responsible for water conservation planning, emergency planning, and drought planning standards. Smaller providers, however, may have little or no experience in developing conservation plans. Objectives of this Study are to: estimate the effects of water conservation planning on future water demands in the county; and recommend elements of conservation planning to include in the County's land development regulations.

Data and Demand Projections

Current household and employment data was reviewed in Section 5, and projected 2050 high- and low-growth scenarios were used to project water demands. Potential conservation savings for indoor and irrigation uses are then applied to those high- and low-water demand scenarios to develop a range of demands that reflect growing support for water conservation measures. Water demand projections are identified for Aurora, Denver, East Cherry Creek Valley (ECCV) Water and Sanitation District, Englewood, Arapahoe County Water and Wastewater Authority (ACWWA), Prosper Farms, Sky Ranch, Inverness Water and Sanitation District, Byers, Deer Trail, Strasburg, Bennett, and No District (those areas not served from a centralized water system).

Demand Analysis

A handful of water providers in Arapahoe County have prepared water conservation plans or have otherwise addressed water conservation in their planning documents. Projected reductions in the growth of water demands from 2024/2025 through 2050 are estimated from those documents in Table 8-1. No reduction was estimated for Arapahoe County Water and Wastewater Authority (ACWWA) as their 2019 Raw Water Supply Master Plan indicates that buildout is expected between 2031 and 2037.

Most of the planning documents reviewed were somewhat dated, and the focus on water conservation has continued to intensify in recent years. For example, Aurora, the largest water provider in Arapahoe County, has adopted restrictive new requirements on nonfunctional (high water-use) turf, and the State recently expanded a program to fund rebates for such turf replacement. For purposes of this Study, it is reasonable to assume that an increasing conservation ethic will drive larger demand reductions than those that are shown in Table 8-1, particularly as water costs increase rapidly over time.

Table 8-1. Demand Reductions from Water Conservation by 2050

Water Provider	% Demand Reduction
Aurora Water	8
Denver Water	9
East Cherry Creek Valley Water and Sanitation District	9
City of Englewood	2
Arapahoe County Water and Wastewater Authority (ACWWA)	--

Using household and employment projections, reduced growth in water demands is based on low-water landscaping, indoor fixture efficiencies, and increasingly water-conscious customers. It is estimated that landscaping demands can be reduced by as much as 35 percent through sound conservation efforts. For purposes of this Study, varying reductions are estimated for existing and new development depending on whether low-water landscape standards are codified, recommended or simply not addressed, as discussed later in this section.

Additionally, indoor fixture efficiencies and promoting a water-conscious customer base can further improve conservation by approximately 11 percent. It is assumed that existing fixtures will be replaced by 2050 with more efficient fixtures, and that there will be continuing efforts toward customer education.

Water Conservation Impact

The impact of water conservation was determined by applying these reductions to the range of projected 2050 water demands. Demand reductions for single-family and multi-family households from conservation are shown in Tables 8-2 and 8-3. Table 8-2 summarizes the projected reductions for low 2050 residential demands, and Table 8-3 similarly summarizes reductions in high 2050 residential demands.

Table 8-2. Demand Reductions for Low 2050 Residential Projections

Assessment Type	Total Demand (AF/yr)	Reduced Demand (AF/yr)	Demand Reduction (AF/yr)
Single-Family Household Projection	55,729	49,674	6,055
Multi-Family Household Projection	31,648	28,150	3,498
Total	**87,377**	**77,824**	**9,553**

Table 8-3. Demand Reductions for High 2050 Residential Projections

Assessment Type	Total Demand (AF/yr)	Reduced Demand (AF/yr)	Demand Reduction (AF/yr)
Single-Family Household Projection	59,491	52,724	6,676
Multi-Family Household Projection	33,741	29,893	3,848
Total	**93,232**	**82,617**	**10,524**

Figure 8-1 shows projected reductions for low and high single-family demands in 2050, for indoor, irrigation and total uses. Figure 8-2 shows those reductions for multi-family residential demands. As shown, conservation measures are estimated to save 9,550 to 10,520 AFY in residential demands by 2050 (approximately 11 percent savings).

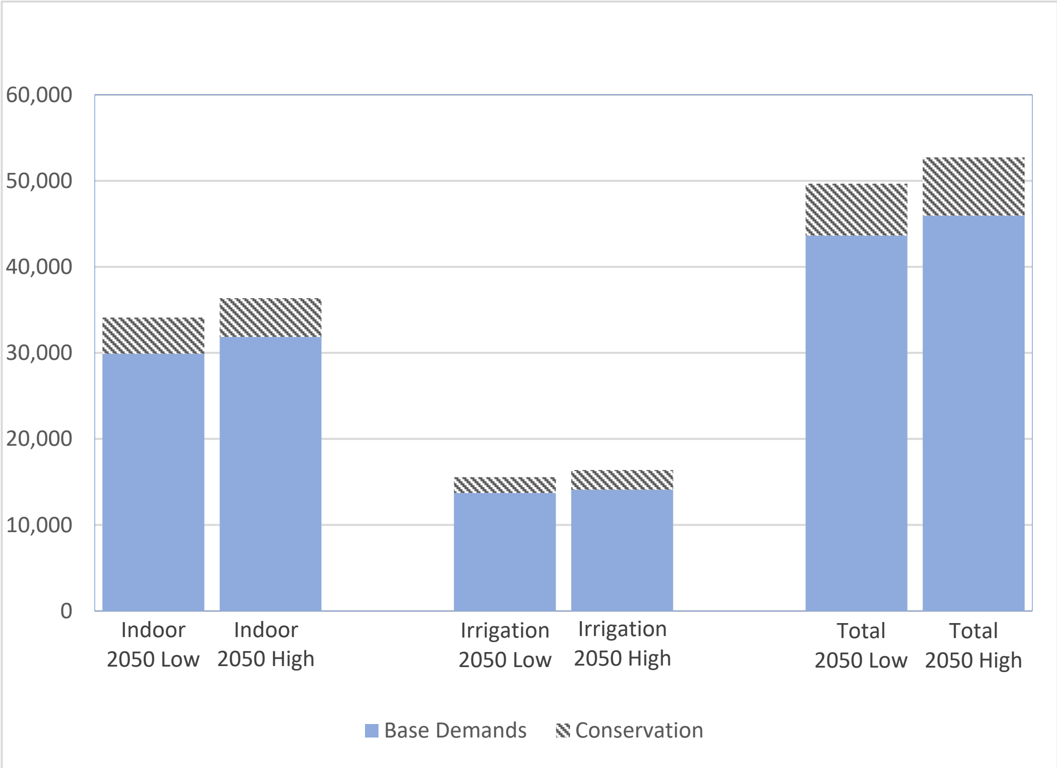


Figure 8-1. Single-Family Demand Projections (AFY)

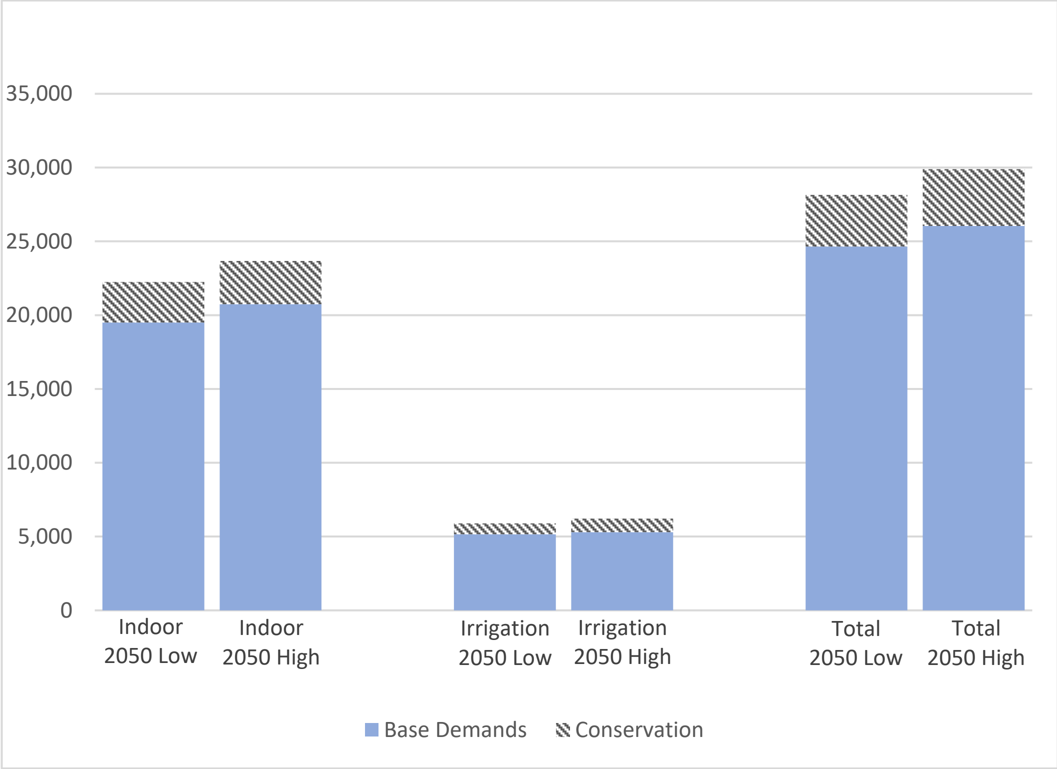


Figure 8-2. Multi-Family Demand Projections (AFY)

Employment demand reductions were also considered based on projections in Section 5. Table 8-4 summarizes the reductions for 2050 low and high projections based on employment. Figure 8-3 shows projected reductions for low and high employment demands in 2050, for indoor, irrigation, and total uses. As shown, conservation measures are estimated to save 2,710 to 3,250 AFY in employment water demands by 2050 (approximately 10-11 percent).

Table 8-4. Demand Reductions for 2050 Projections Based on Employment

Assessment Type	Total Demand (AF/yr)	Reduced Demand (AF/yr)	Demand Reduction (AF/yr)
Low Projection	26,371	23,664	2,707
High Projection	29,125	25,879	3,246

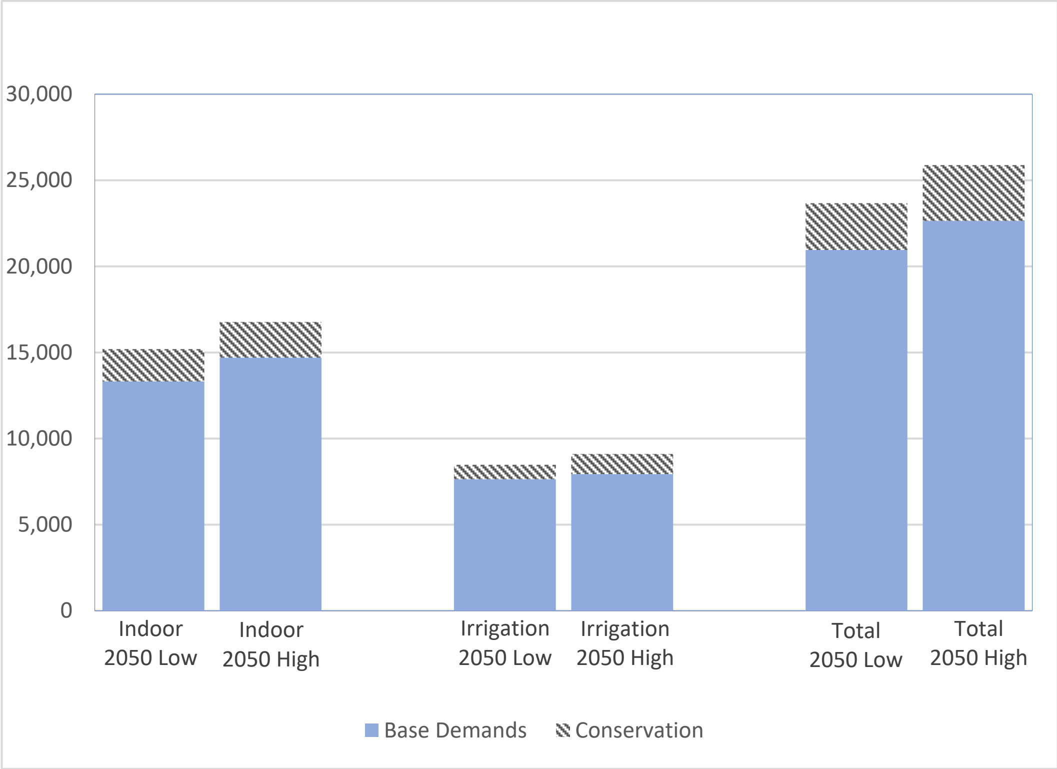


Figure 8-3. Employment Demand Projections (AFY)

Water Conservation Best Practices

There are many more conservation measures in addition to water-conscious landscaping and improved indoor fixture efficiencies. Arapahoe County water providers identified over 50 water conservation measures in their conservation planning documents. *The State of Water Conservation in Colorado* (WaterWise, March 11, 2022) identifies the three most impactful water conservation measures, and they have been implemented by several water providers throughout the county:

1. Inclining Block Rate Structure: The inclining block rate structure is a tiered rate structure in which different rates are assigned for increasing volumes of water used, broken into blocks, where the rates increase as water volume consumed increases. The more water a customer uses, the higher the water rate, resulting in a higher bill. This rate schedule promotes water conservation by deterring customers from excessive water use to prevent high water bills.
2. Leak Detection/Repair: Leaks in the water distribution system piping can lead to significant water loss, and there are now good leak detection technologies available.
3. Water System Efficiency Upgrades. Many water system upgrades, such as replacing old, corroded pipe systems, will reduce water waste.

Other significant water efficiency measures used in Arapahoe County include water-conscious landscaping standards, water reuse, and educational outreach to customers.

Water-Wise Landscaping

The amounts of water used to irrigate single-family, multi-family, and commercial land uses including retail, office, and industrial uses are estimated for this Study. Also estimated is the extent to which converting these uses to water-wise landscaping could reduce demands through 2050. The guiding premise is that ongoing changes to the types of landscaping commonly used throughout the county can play an important role in reducing long-term demand and improving sustainability of long-term water supplies.

A water-wise landscape is one that is functional, attractive, and easily maintained in its natural surroundings. A water-wise landscape also helps to conserve water.

(Utah State University Extension – Center for Water-Efficient Landscaping)

Local Context

Arapahoe County's climate is generally arid and average temperatures have increased in the last 30 years. During the months of June to August, daytime temperatures in the 80s, 90s, and sometimes exceeding 100 degrees are common. Yet, many of the homes, multi-family buildings, and businesses are predominantly landscaped with non-native species from wetter climates.

These plants and trees generally require more water to stay healthy than those native to the Mountain West. Kentucky Blue Grass is one example commonly used for residential lawns. Conversely, Idaho Fescue grass and Douglas Fir trees are native species that can thrive in more arid climates (see Figures 8-4 through 8-7). Also shown is a single-family home in Aurora that was converted to a mixture of drought-tolerant vegetation and rock.


Figure 8-4. A Residential lawn with Water-Intensive Kentucky Blue Grass


Figure 8-5. Idaho Fescue Grass


Figure 8-6. Douglas Fir Tree


Figure 8-7 An Aurora Lawn Converted to Native Vegetation, Mulch and Decorative Rock.

Defining Water-Wise Landscaping

Water-wise landscaping can generally be defined as the use of native plants and hardscape materials that are drought-resistant, and generally require less water and maintenance. It can involve removing non-native plant species that are less tolerant of an arid climate and replacing them with types accustomed to the temperatures, precipitation levels, and aridity associated with a high desert climate, as in Arapahoe County.

The actual landscaping (plant selection and placement) and volume and frequency of irrigation will depend on the context of a given property but overall, less water is required to maintain healthy vegetation. Throughout the Denver metro area, including Arapahoe County, a growing number of applications showcase water-wise landscaping, such as turf removal /replacement programs and restrictions on how much turf can be planted on a given property.

Regulatory Framework

Some jurisdictions within Arapahoe County, including the unincorporated county, have water-wise landscaping requirements adopted into municipal code. Other jurisdictions have recommended practices, but not requirements, and some lack any guidance or requirements. As shown in Table 8-5, most larger jurisdictions and the unincorporated county already have codified provisions that require water-wise landscaping for new development.

Table 8-5. Jurisdictions in Arapahoe County with Water-Wise Landscaping Requirements

Jurisdiction	Requirements codified	Recommendations	Neither
Arapahoe County	✓		
Aurora	✓		
Centennial	✓		
Cherry Hills Village			✓
Columbine Valley			✓
Englewood	✓		
Foxfield			✓
Greenwood Village	✓		
Sheridan		✓	
Littleton	✓		
Glendale			✓
Deer Trail			✓
Bow Mar			✓

For those jurisdictions **with codified requirements,** it is assumed that 10 percent of existing residential and commercial office properties will transition to water-wise landscaping by 2050 based on expected increases in the price of water, incentive and educational campaigns led by municipalities and water providers, and personal preference. For new homes and commercial offices constructed after 2025 subject to code requirements, it is assumed that 100 percent of those properties will have landscaping consistent with water-wise provisions.

For Sheridan, which has **recommendations but not requirements**, it is assumed that 10 percent of existing residential and commercial office properties will transition to water-wise landscaping by

2050 for the same reasons cited above. For new homes and commercial offices constructed after 2025, it is assumed that 20 percent of those properties will include landscaping consistent with water-wise provisions.

For the six jurisdictions **without standards or recommendations**, it is assumed that 10 percent of existing residential and commercial office properties will transition to water-wise landscaping by 2050 for the reasons cited above. It is expected that only 15 percent of newly built residential and commercial office properties will opt for water-wise landscaping.

The percentages noted above are estimates developed to approximate potential demand reductions for outdoor irrigation over the next 25 years. These percentages may ultimately prove higher or lower based on several variables but provide a useful basis for estimating.

Irrigation Demands

Current and projected water demands through 2050 are shown in Section 5. Based on that analysis, outdoor irrigation accounts for approximately 30 percent of total residential and commercial annual demand among the jurisdictions listed in Table 8-5.

Based on several sources reviewed (listed in Appendix B), water-wise landscaping can reduce annual irrigation demand 20 to 50 percent. There is not a consensus on an exact reduction and it depends on several variables. For purposes of this Study, a midpoint of 35 percent was assumed.

Demand Reductions and Long-Term Supply

As shown in Table 8-6, significant reductions in irrigation demands can be achieved across the county in the next 25 years through application of water-wise landscaping. In some instances, the estimated 2050 irrigation demand can be reduced by up to 14 percent. This includes converting some existing residences and commercial uses as well as applying water-wise landscaping to new construction between 2025 and 2050. The values demonstrate that notable reductions in annual demand are possible and that increased acceptance and application of water-wise landscaping can play an important role in managing demand and sustaining a viable, long-term supply. (See Appendix G for calculated estimates.)

Table 8-6. Annual Irrigation Demand Reduction Estimates (in AFY) for Arapahoe County Entities

	Land Use	2025 Water Demand (Irrigation)	Land Use Type	Reduced Water Demand For 2050		
				Single-Family Residential	Multi-Family Residential	Commercial
Arapahoe County	Single Family Residential	2,760	Existing Uses	100	106	92
	Multi-Family Residential	1,043	**New Development** (Low Population Projection)	378	143	125
	Commercial	1,744	**New Development** (High Population Projection)	505	191	207
			Range	*478 - 605*	*249 - 297*	*217 - 332*
City of Aurora	Single Family Residential	4,964	Existing Uses	186	54	132
	Multi-Family Residential	1,784	**New Development** (Low Population Projection)	564	203	211
	Commercial	2,523	**New Development** (High Population Projection)	746	268	350
			Range	*750 - 932*	*257 - 322*	*343 - 482*
City of Centennial	Single Family Residential	2,852	Existing Uses	104	38	170
	Multi-Family Residential	1,078	**New Development** (Low Population Projection)	123	29	203
	Commercial	3,239	**New Development** (High Population Projection)	162	44	338
			Range	*227 - 266*	*67 - 82*	*373 - 508*

	Land Use	2025 Water Demand (Irrigation)	Land Use Type	Reduced Water Demand For 2050		
				Single-Family Residential	Multi-Family Residential	Commercial
City of Cherry Hills	Single Family Residential	138	Existing Uses	5	2	3
	Multi-Family Residential	52	**New Development** (Low Population Projection)	0.25	.08	0.7
	Commercial	93	**New Development** (High Population Projection)	0.35	.13	1
			Range	*5.25-5.35*	*2.08-2.13*	*3.7-4*
Town of Columbine Valley	Single Family Residential	28	Existing Uses	1	0.35	0.7
	Multi-Family Residential	11	**New Development** (Low Population Projection)	0.21	0.07	0.28
	Commercial	24	**New Development** (High Population Projection)	0.25	0.10	0.42
			Range	*1.21-1.25*	*0.42-0.45*	*0.35-0.49*
City of Englewood	Single Family Residential	1,085	Existing Uses	40	15	62
	Multi-Family Residential	410	**New Development** (Low Population Projection)	28	11	68
	Commercial	1,187	**New Development** (High Population Projection)	36	14	112
			Range	*68 - 76*	*26 - 29*	*130 - 174*
Town of Foxfield	Single Family Residential	19	Existing Uses	0.70	0.25	0.35

	Land Use	2025 Water Demand (Irrigation)	Land Use Type	Reduced Water Demand For 2050		
				Single-Family Residential	Multi-Family Residential	Commercial
	Multi-Family Residential	7	**New Development** (Low Population Projection)	0.15	0.05	0.14
	Commercial	14	**New Development** (High Population Projection)	0.23	0.07	0.28
			Range	*0.85-0.93*	*0.30-0.32*	*0.49-0.63*
City of Greenwood Village	Single Family Residential	474	Existing Uses	17	6	117
	Multi-Family Residential	179	**New Development** (Low Population Projection)	20	7	98
	Commercial	2,377	**New Development** (High Population Projection)	26	10	162
			Range	*37 - 43*	*13 - 16*	*215 - 279*
City of Littleton	Single Family Residential	1,284	Existing Uses	46	16	74
	Multi-Family Residential	485	**New Development** (Low Population Projection)	54	26	68
	Commercial	1,405	**New Development** (High Population Projection)	71	27	120
			Range	*100 - 117*	*42 - 43*	*142 - 194*
City of Sheridan	Single Family Residential	145	Existing Uses	5	2	14
	Multi-Family Residential	55	**New Development** (Low	0.45	0.063	5

	Land Use	2025 Water Demand (Irrigation)	Land Use Type	Reduced Water Demand For 2050		
				Single-Family Residential	Multi-Family Residential	Commercial
			Population Projection)			
	Commercial	396	**New Development** (High Population Projection)	0.60	0.11	8
			Range	*5.45 – 5.60*	*2.06 – 2.11*	*19 - 22*
City of Glendale	Single Family Residential	224	Existing Uses	8	8	23
	Multi-Family Residential	85	**New Development** (Low Population Projection)	3	3	7
	Commercial	429	**New Development** (High Population Projection)	4	1	12
			Range	*11-12*	*86-88*	*30-35*
Town of Deer Trail	Single Family Residential	5	Existing Uses	1.75	2	.05
	Multi-Family Residential	2	**New Development** (Low Population Projection)	N/A*	N/A	N/A
	Commercial	1	**New Development** (High Population Projection)	0.46	0.96	0.07
			Range	*1.75- 2.21*	*2 -2.96*	*0.05 – 0.57*
Town of Bow Mar	Single Family Residential	29	Existing Uses	1	1	0.26
	Multi-Family Residential	11	**New Development** (Low Population Projection)	N/A	N/A	0.07
	Commercial	5	**New Development**	N/A	N/A	0.07

	Land Use	2025 Water Demand (Irrigation)	Land Use Type	Reduced Water Demand For 2050		
				Single-Family Residential	Multi-Family Residential	Commercial
			(High Population Projection)			
			Range	*N/A*	*N/A*	*N/A*
Grand Total				**1,685 – 2,066**	**747 - 882**	**1,474 – 2,031**

*In instances where potential water savings was di minimis due to a lack of or minimal increase in the number of dwelling units or commercial property, an estimated volume has not been included.

Possible savings are summarized in Table 8-7, showing that projected 2050 demands can be reduced by 32 to 36 percent through the application of more water-efficient landscaping.

Table 8-7. 2050 Demand Reductions for Landscape

Demand Type	Projected Demand Reduction (AFY)	Projected Landscape Reduction (AFY)	Landscape Share of Projected Reduction
Single-Family Residential	6,055 - 6,676	1,685 - 2,066	28% - 31%
Multi-Family Residential	3,498 - 3,848	747 - 882	21% - 23%
Employment	2,707 - 3,246	1,474 - 2,031	54% - 63%
Total	**12,260 - 13,770**	**3,906 – 4,979**	**32% - 36%**

Looking ahead to the next 25 years, continued and expanded application of water-wise landscaping on residential, commercial, and municipal (e.g., city-owned) properties will play an important role in extending the use of water supplies. Additionally, more coordination between the County, cities and towns, and water districts and authorities on education, messaging, and incentives will be central to this effort. It is feasible if not likely that by 2050, water-wise landscaping will be broadly accepted throughout the county and embraced as a critical water management strategy.

Proposed Conservation Measures

Arapahoe County is not a water provider and cannot implement water conservation measures directly, but the County can influence conservation through land use and development policies and regulations. The County's Public Works and Development Department requires a review of all new developments for unincorporated areas. The Land Development Code is the governing regulation to which new development is subject. Development must follow the Land Development Code for approval, and the Code can be amended to incorporate conservation requirements.

The County is in the process of updating its landscaping standards to promote water efficiency, and those standards can be applied to unincorporated areas of the county. They can also be referenced by communities throughout the county when updating or developing their landscaping standards.

Water Reuse

Another growing water management strategy is that of water reuse; also known as reclamation or recycling, this refers to a wide range of applications in which wastewater is reclaimed to provide a beneficial use. This could be through nonpotable applications, such as irrigation reuse, or potable applications to provide or supplement drinking water. Water reuse can be developed to diversify and extend water supplies. There are different types of reuse, and most have already been implemented to some extent in Arapahoe County.

Types of Water Reuse

Water reuse is grouped into four main categories: nonpotable, indirect potable, direct potable, and exchange. These categories are explained below and illustrated in Figure 8-8.

Nonpotable Reuse: Nonpotable reuse involves treating wastewater to nonpotable standards suitable for the end use and conveying the water via a dedicated nonpotable system. That system type typically feeds irrigation or industrial uses. This can be on a small scale through on-site wastewater treatment to irrigate a particular property, or on a larger, municipal scale with a dedicated nonpotable distribution system. Nonpotable reuse is regulated by the Colorado Department of Public Health and Environment (CDPHE) through Regulation 84, Reclaimed Water Control Regulation, which provides treatment standards based on the application. This is a common type of reuse, and is notably used by Rangeview Metro District for irrigation and industrial uses.

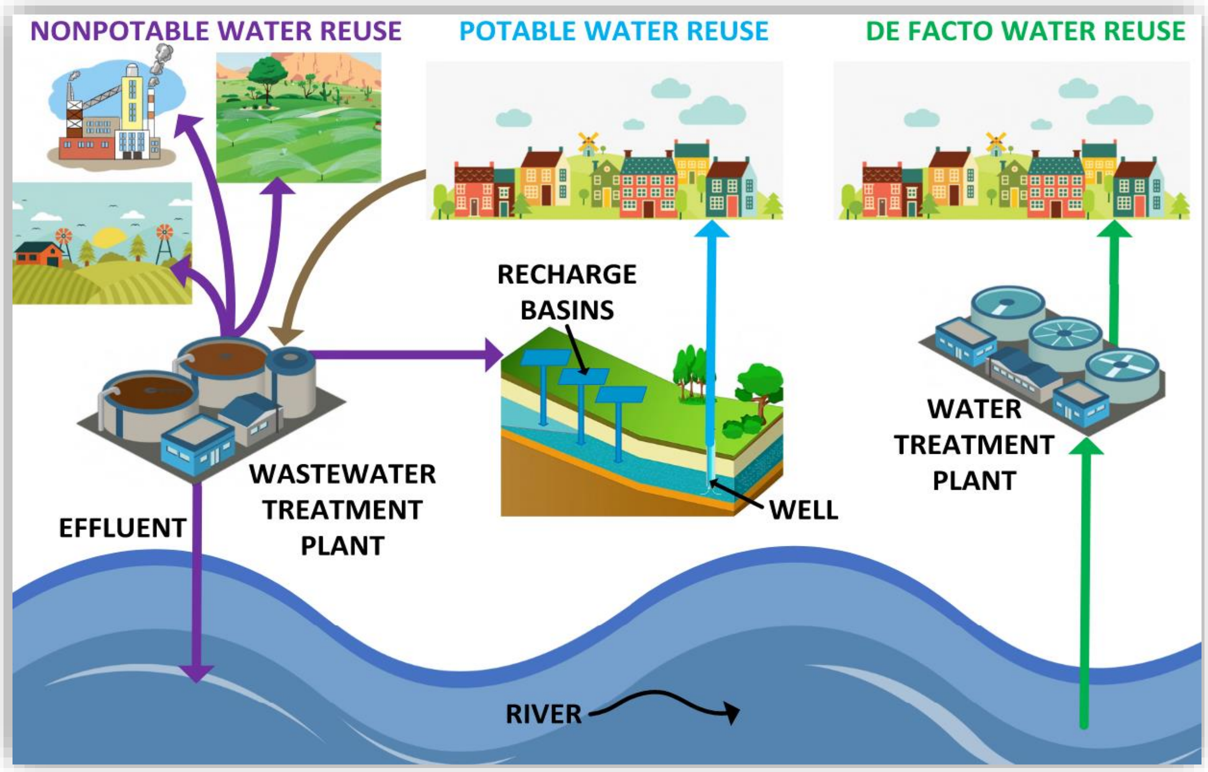


Figure 8-8. Reuse Diagram

Indirect Potable Reuse: Indirect potable reuse (IPR) makes use of an environmental buffer between the wastewater treatment plant's effluent discharge and the supply source for drinking water treatment. When wastewater is treated and discharged into a body of water, like a lake, river, or aquifer, it mixes with the naturally occurring flow for dilution and natural filtration prior to drinking water treatment. Notably, the WISE partnership project is a good example of IPR.

'De facto' IPR commonly occurs across the country where drinking water treatment plants are located downstream of wastewater treatment plants. Two forms of IPR are illustrated in Figure 8-8 by the 'de facto water reuse' and 'potable water reuse' processes.

Direct Potable Reuse: Direct potable reuse (DPR), also known as "pipe to pipe" reuse, is where treated wastewater is directed to a drinking water treatment plant for purification with no environmental buffer. The water must undergo advanced treatment to meet more stringent standards to safeguard public health.

This is an uncommon type of reuse, with no installations in Colorado. However, in 2022, CDPHE added DPR policies to the Primary Drinking Water Regulations, Regulation 11. These policies provide a clear framework on how water providers can incorporate DPR into their systems, and several across the state are now considering DPR in their long-term planning.

Exchange: Reuse by exchange occurs when a water provider diverts surface water or pumps groundwater, and then essentially replaces that water volume by discharge of non-native water (sourced from a confined aquifer like those of the Denver Basin, or surface water imported from a different basin) to satisfy water rights priorities of downstream users. The water can be diverted from an upstream location or pumped from an upgradient well, provided there is no injury to priority water rights between the diversion and return flow discharge points. For example, a water provider supplying Denver Basin water to its customers can divert some surface water at an upstream location and then balance that with return flows of wastewater effluent at the discharge point.

The Northern Project is an example of exchange, which brings renewable water from the South Platte River to the ECCV and ACWWA service areas. Water is collected through the Beebe Draw on the South Platte River, treated at the Northern Water Treatment Plant, and delivered to ECCV and ACWWA through the Northern Pipeline. Although the water supplied through this project is not reuse water, it is an example of how reusable return flows can be exchanged to draw water from another location.

Reuse in Arapahoe County

Some form of indirect reuse has always taken place in Arapahoe County. In recent years, an intentional, concerted effort by several water providers has increased water reuse within the county.

Overview

Several water providers in Arapahoe County include reuse in their water portfolios. Examples are provided below.

Aurora Water: The Prairie Waters project was developed by Aurora Water to maximize use of their renewable water supplies through IPR. This involves conveying water from the South Platte River, downstream of metro Denver's effluent discharge (including Aurora's effluent), to south Aurora through a series of pipes and pump stations, to the Binney Water Treatment Facility. Aurora Water has water rights in the South Platte River, but also benefits from return flow credits from water imported from the Colorado and Arkansas River Basins.

As previously discussed, the WISE partnership is a regional partnership between Aurora Water, Denver Water, and the South Metro WISE Authority. When Aurora Water has excess water in the Prairie Waters system, the WISE members can buy the excess capacity to supply fully reusable exchange water to their customers. The WISE project provides an average of 10,000 AFY of reuse water to WISE members. Rangeview is the only Arapahoe County water provider currently participating in WISE. Aurora Water also has a nonpotable reuse facility, Sand Creek Water Reclamation Facility, which supplies irrigation water to parks and golf courses.

Arapahoe County Water and Wastewater Authority (ACWWA): ACWWA has a nonpotable reuse irrigation system, mostly used for golf courses. The 2015 Municipal Water Efficiency Plan Update states that there is a plan to expand this system in the future.

Denver Water: Denver Water has a nonpotable reuse system that serves parks, schools, golf courses, and industrial institutions. Treated water from the Robert W. Hite Wastewater Treatment Plant enters the Recycling Plant where the water undergoes additional treatment to be reused. (Denver Water is not included in the analysis that follows due to the lack of recent data.)

Denver Water has evaluated reuse for several years, having completed their Direct Potable Water Reuse Demonstration Project between 1979 to 1993 which showed that potable water can be dependably produced from treated wastewater. This demonstration project produced valuable data that helped further the understanding of DPR; a possible long-term strategy for several Colorado water providers as previously noted.

East Cherry Creek Valley Water & Sanitation District (ECCV): ECCV also has a nonpotable reuse irrigation system. Some of ECCV's consumable wastewater return flows are owned by Aurora and therefore, cannot be reused by ECCV. In their 2018 Water Conservation Plan, it was stated that ECCV may pursue the right to reclaim use of the return flows to add more reuse water to its system portfolio. (The analysis that follows does not include consumable wastewater return flows.)

Rangeview Metropolitan District: Rangeview plans to implement several reuse water sources at buildout including nonpotable reuse, direct potable reuse, indirect potable reuse, and exchange. Currently, Rangeview has two zero-discharge wastewater treatment plants, Coal Creek Water Reclamation Facility (WRF) and Sky Ranch WRF, where all the effluent produced is reused for nonpotable irrigation and non-discharging industrial uses. Rangeview is a WISE member that is allocated to receive up to 900 AFY.

Current and Planned Reuse

While there are currently no large-scale reuse projects confirmed for future development in Arapahoe County, several water providers are planning to expand existing reuse systems as described in the previous section. Additionally, future reuse projects could include indirect or even direct potable reuse, or nonpotable irrigation. Table 8-8 shows current and projected reuse supplies by water provider. The percentage of reuse water was determined by dividing total reuse supplies by total water supplies for each water provider. The values used were taken from available documentation that is dated in some cases, therefore more reuse water may have been added in recent years. This analysis is a conservative estimate of current reuse in Arapahoe County.

The reuse percentage was applied to current and projected water supply quantities developed in Section 5. For this analysis, it is assumed that reuse supplies will grow at the same rate as other supplies. This provides a conservative estimate of future water reuse in Arapahoe County.

Table 8-8. Estimated Reuse

Water Provider	Reuse as Percent of Water Supplies	Current Reuse – 2023 (AFY)	Projected Reuse – 2050 (AFY)
ACWWA	10%	384	562
Aurora Water	9%	3,375	5,738
ECCV	4%	368	368
Sky Ranch (served by Rangeview)	33%	250	1,800

Conjunctive Use

Conjunctive water use is the coordinated management of surface water and groundwater supplies to maximize their yields. Regionally, it consists of balancing the use or storage of renewable surface water supplies when they are available, and groundwater supplies when they are not (possibly due to seasonal or drought conditions). This has taken the form of diverting, storing and treating available surface water to potable standards and then using it to artificially recharge Denver Basin aquifers for later withdrawal in what is known as aquifer storage and recovery (ASR).

Centennial WSD, serving Highlands Ranch, has successfully used ASR for decades and other water suppliers are evaluating it further. The SMWSA is also now evaluating it on a regional scale for possible enhancement of the WISE project. ASR makes use of dual-purpose injection/ extraction wells to store water underground in times of excess, with removal of the stored water to meet peak seasonal, emergency, or future water demands. Excess water can be available during periods of low demand (winter months) or during severe events such as flooding, when water can be captured and treated for injection into the subsurface. During high demand periods, drought or other water demand challenges, the stored water can be withdrawn to meet demands.

Conclusions

As the county's population increases, the need for more efficient management of water resources can be expected to expand and intensify. Conservation measures such as expanded use of water-wise landscaping, are expected to significantly reduce projected demand growth, helping make for a more sustainable future. Water reuse will be expanded as well, helping maximize use of the water developed. More conjunctive water use can also be expected.

SECTION 9.

RECOMMENDED POLICIES

SECTION 9 – RECOMMENDED POLICIES

The policy recommendations presented in this Study are based on data and modeling for future water supply in Arapahoe County. The recommendations were developed in response to input received through on-line engagement (MetroQuest) and were presented to the community for feedback at two open houses. They reflect strong support for water conservation measures such as broad application of water-wise landscaping and infrastructure investments to secure and increase future water supply.

The policy recommendations are divided into two categories, Arapahoe County Policies (AP) and Collaborative Policies (CP). Arapahoe County Policies are those that can be led and implemented by the County, related to land use and regulatory oversight within the County's purview. Collaborative Policies are beyond the County's responsibilities but could be led by water providers and other interested parties with support by the County.

Goals Guiding Policy Recommendations

The following policy recommendations, noted in the introduction of this document, support the identified Study goals and align with the Study's findings relating to water supply and demand. The goals were identified at the onset and provided a focus for evaluating current demands and future needs. They reflect interests in Denver Basin availability and long-term water sustainability throughout the region as previously identified in the County's 2001 and 2018 Comp Plans.

Goal 1 (G1): Close potential gaps between future supply and demand.

Use data and scientific best practices to implement water supply policies and regulations that require new development plans to demonstrate consistency with water supply availability prior to development approval.

Goal 2 (G2): Improve water use efficiency.

Promote and encourage the efficient use of water by all water users and across a range of strategies.

Goal 3 (G3): Extend the life of Denver Basin aquifers to sustain a long-term supply.

Ensure a sustainable water supply that is not only reliant on groundwater but incorporates renewable water, water reuse, and water conservation to extend the life of the available supply.

Table 9-1 provides a summary of the policy recommendations and the alignment with these three goals.

Table 9-1. Policy and Goal Alignment

Policy	G1	G2	G3
AP1: Denver Basin Aquifer-specific Annual Withdrawal Production Factor	✓		✓
AP2: Connected Systems		✓	
AP3: Early Water Evaluation for Development	✓	✓	✓
AP4: Increase Water Efficiency Regulations in New Development		✓	
AP5: Programs, Education and Resources for Water-wise Landscaping	✓	✓	
AP6: Encouraging Water Reuse	✓	✓	✓
AP7: Water Management Policy Audit	✓	✓	✓
AP8: Groundwater Systems Best Practices			✓
AP9: Reducing Development Barriers	✓	✓	
AP10: Graywater Systems		✓	
CP1: Water Rates		✓	✓
CP2: Watershed and Groundwater Quality Protections			✓
CP3: Household Water Efficiency Education		✓	
CP4: Leak Detection and System Maintenance		✓	✓
CP5: Supply Infrastructure			✓
CP6: Sustainable Allocations	✓		✓
CP7: Water Provider and Developer Group	✓	✓	✓
CP8: Incorporated Jurisdictions Landscaping Guidelines Support		✓	
CP9: Water Services Extensions		✓	✓

Arapahoe County Policy Recommendations

The following recommendations would be under the jurisdiction of Arapahoe County. They are titled AP for Arapahoe Policy.

AP1: Denver Basin Annual Production Factors (G1, G3)

Apply an aquifer-specific annual production factor to the groundwater supply standards (based on modeling results) to more accurately reflect the economic productivity of Denver Basin wells in Arapahoe County using current technology. Table 9-2 identifies the production factors.

Table 9-2. Production Factors

Available Water Calculations Watkins/Bennett Study			
Name	Petra Calculation AFY (Physical)	SB 5 Calculation AFY (Legal)	Production Factors
Denver Netpay	4,746	7,954	0.60
Undifferentiated/Upper Arapahoe, Arapahoe Netpay	2,022	4,779	0.42
Lower Arapahoe Netpay	839	3,145	0.27
Laramie-Fox Hills Netpay	4,267	5,975	0.71

HOW DO THE WATER CALCULATIONS WORK?

Example: A property would have the following State allocation of withdrawal rates by aquifer (in AFY), totaling 325 AFY.

- Denver 100
- Upper Arapahoe 75
- Lower Arapahoe 50
- Laramie-Fox Hills 100

Applying the production factors, the aquifers could be expected to economically produce the following rates (in AFY).

- Denver 100 * 0.60 = 60.0
- Upper Arapahoe 75 * 0.42 = 31.5
- Lower Arapahoe 50 * 0.27 = 13.5
- Laramie-Fox Hills 100 * 0.71 = 71.0

Total available groundwater production (assuming nontributary status) would be 176 AFY (not 325 AFY). This value would be compared to estimated demands for the development associated with the property.

AP1: Discussion and Considerations

The Dawson aquifer in Arapahoe County is not included in the table as it is not a feasible option for future development. It is in the southwest portion of the county and either has been deeded to municipalities or serves old subdivisions that have individual on-lot wells mixed within municipalities. It would require an augmentation plan as both the Upper and Lower Dawson aquifers are not-nontributary actual.

Water in the Denver Basin aquifers underlying a property is allocated to allow withdrawal of one percent of the total volume as determined by the Division of Water Resources, the Colorado Groundwater Commission, or the Water Courts. However, there is no guarantee that the determined allocation will last 100 years or longer due to groundwater level declines and other geologic phenomena.

The aquifer production factors shown account for these anticipated and experienced geological phenomena using current technology and Petra modeling. This minimizes the risk that it becomes uneconomical for development to rely on specific Denver Basin aquifer allocations.

Why not a 300-year rule?

This study used current technology to survey and estimate available groundwater by aquifer. Unlike a 300-year rule, the production factors are based on Arapahoe County-specific data and modeling. The production factors allow for the County to adjust the water allocation in accordance with that data and modeling.

It is noted that groundwater modeling for this Study was performed using Region 2 data. For purposes of this Study, Region 1 groundwater characteristics are expected to be very similar to those of Region 2. More site-specific information could be considered for well development in Region 1 as warranted, case by case.

Best available data was modeled for Arapahoe County from the Petra calculations referenced in this water supply study. The production factors are more specific but less conservative than the "300-Year Rule" applied in other counties with heavy reliance on Denver Basin groundwater, including El Paso County. A 300-Year Rule is equivalent to applying a production factor of 0.33 to all aquifers. (This Rule would result in allocation of approximately 107 AFY for the example property shown in the box.)

AP1: Regulatory and Zoning Updates

Applying the production factors to proposed new development would require a change to the Land Development Code. If adopted, the following code and/or regulatory revisions would need to take place:

- **Incorporation into the County's development review**
- **Coordination with the State's Division of Water Resources.**
- **Consideration to allow developers to provide site-specific engineering reports based on groundwater modeling to amend the production factor(s). This would require a more thorough review of development applications by a hydrogeologist at additional cost to the developer.**

AP2: Connected Systems (G2)

Require developers to coordinate with water providers to identify opportunities to connect to a public water system or consolidate individual wells into new or existing water storage, supply, and distribution systems. This would improve delivery efficiency, accuracy for metering use, and mitigate concerns among some well-owners about availability of the long-term water supply.

AP2: Regulatory and Zoning Updates

The threshold for connected systems will be evaluated through a review of the current regulations and zoning. Considerations include:

- **Lot size**
- **Density**
- **Feasibility for consolidation**

AP2: Discussion and Considerations

There would be coordination with the neighboring water supplier to ensure their ability to serve the additional customers.

To support this policy, the County would also identify ways to support governance and funding mechanisms for implementation, such as a metro district, improvement district, and/or grants.

The County, including the Development Review Committee, would also identify the appropriate thresholds for recommending or requiring system connection or consolidation. For example, the County should explore a policy that consolidation studies be required for subdivision proposals with parcels on 2.41 to 18 acres and at least 25 lots. These thresholds may be refined through further discussion but can be used as a starting point.

AP3: Early Water Evaluation for Development (G1, G2, G3)

Require a water supply plan documenting an appropriate supply to serve a proposed development at the earliest stage of the development review process as allowed under state law. The water supply plan should be prepared by the applicant in collaboration with the respective water provider. The water supply plan should prioritize the use of deeper aquifers, as described further in AP8. ”Will-serve” letters from service providers shall include a completed Office of State Engineer Form GWS-76 or equivalent. An example Will-Serve letter format is provided in Appendix H.

AP3: Discussion and Considerations

Currently, Arapahoe County requires a water supply plan at the time of zoning (Comp Plan Strategy PFS 2.1(a)). The timeline for plan submittal would be changed and education on the new process would be rolled out internally and to applicants. Through updated requirements or recommendations, the plan could also include provisions for diversified supplies, such as surface water.

AP3: Regulatory and Zoning Updates

Stages of the zoning process that could require a water supply plan include:

- **Projects requiring a 1041 for a water system or new community.**
- **At the time of zoning**
- **At the time of the preliminary plat with an approved water supply plan**
- **At the time of the final plat.**

For the above list, the water supply plan should be provided at the earliest step in the zoning process.

AP4: Increase Water Efficiency Regulations in New Development (G2)

Review and update development regulations to promote more water-efficient infrastructure and fixtures in new development. This includes updating water conservation measures in accordance with County landscaping regulations.

AP4: Regulatory and Zoning Updates

- **Building and Plumbing Codes**

AP4: Discussion and Considerations

The County could evaluate development regulations to identify opportunities for integrating water efficiency measures. This could include a review of best practices and case studies to support revisions. The public engagement for this study revealed that there is community support for development that incorporates water conservation using water-wise landscaping.

AP5: Programs, Education and Resources for Water-wise Landscaping (G1, G2)

Encourage a countywide transition from non-native, water-intensive landscaping to water-wise landscaping that aligns with the County’s recent landscape code revisions. Provide non-monetary technical assistance, such as grant availability education and application support, best practices from other Front Range jurisdictions (i.e., Castle Rock Water Wiser), and free on-line resources (i.e., Resource Central / Garden in a Box).

Support the use of rain barrels with education to promote them for irrigation at existing residential properties and encourage in new development.

AP5: Discussion and Considerations

The County is updating its landscaping standards in 2024 to align with water conservation goals. This policy would support the intent and implementation of the code updates. This policy also aligns with broad public support heard through the study’s public engagement.

AP6: Encouraging Water Reuse (G1, G2, G3)

Maximize the use of available water supplies by encouraging and not precluding systems for reuse by exchange, indirect potable reuse, direct potable reuse or direct reuse for irrigation and other purposes. Update water-related ordinances and regulations to encourage or require conservation and reuse. For example, encourage nonpotable water supply infrastructure for irrigation and other uses and develop new car wash standards that require reclaimed water systems.

AP6: Discussion and Considerations

It will be necessary to review design standards and in particular subdivision design and site standards to confirm that they encourage and do not preclude reuse systems. Utility easements should not preclude reuse systems.

AP6: Regulatory and Zoning Updates

- **Subdivision Design Standards Revisions**
- **Utility Easements**

AP7: Water Management Policy Audit (G1, G2, G3)

County policies and regulations should be compatible with and not preclude strategies such as water reuse, aquifer storage and recovery (ASR), and other possible aquifer recharge either for community systems or on a regional scale.

AP7: Discussion and Considerations

As part of this audit the County should evaluate the 1041 regulations for compatibility. Additionally, the County should consider how water reuse and ASR strategies can be integrated into existing policies and scaled to size communities and regions. (Reference Comp Plan Strategy PFS 2.3(h).)

AP7: Regulatory and Zoning Updates

- **1041 Regulations**

AP8: Groundwater Systems Best Practices (G3)

For groundwater systems, encourage centralized systems over decentralized systems (based on economic analysis), and require centralized systems to prioritize use from the deeper Arapahoe and Laramie-Fox Hills aquifers ahead of the shallower aquifers, leaving or deferring use of the shallower aquifers for domestic well users unless precluded by site specific aquifer conditions.

AP8: Discussion and Considerations

Central water providers would give a secondary priority to developing wells in the shallow aquifers to preserve capacity for dispersed domestic well users.

A variance could be allowed if water quality in the deeper aquifers would require extensive treatment.

AP9: Reducing Development Barriers (G1, G2)

Reduce barriers to development of more middle and multi-family housing as a means of reducing per capita water consumption relative to single-family housing. This should be inclusive of smaller-scale conversions to multi-family such as accessory dwelling units and converting a single-family home into multiple units.

AP9: Discussion and Considerations

Multi-family housing can help the County meet affordable housing and water conservation goals, with less water used per unit than single-family housing. To support these goals, the County should evaluate ways to reduce barriers to the development of additional multi-family housing.

AP10: Graywater Systems (G2)

Graywater treatment systems should be allowed in new construction projects, pursuant to House Bill 24-1362. This bill will take effect January 1, 2026, and prompts counties and municipalities to allow graywater systems for new construction, subject to a memorandum of understanding with the local health authority and water/wastewater service providers addressing operation and maintenance, and any potential health risks.

AP10: Discussion and Considerations

The proper installation and operation of systems is defined in section 25-8-103(8.4) of House Bill 24-1362. The new state regulations allow for new construction only. There is an opportunity for new development to use graywater to allow for outdoor irrigation in situations where it may otherwise not be allowed or not have available water.

Collaborative Policy Recommendations

Water supply policy is often collaborative and requires coordination across entities. These policy recommendations are opportunities for Arapahoe County to collaborate with water providers, state agencies, and federal agencies. These are labeled CP for collaborative policies.

CP1: Water Rates (G2, G3)

Encourage the adoption and continued use of tiered water rates, which provide a financial disincentive for customers using higher amounts of water.

CP2: Watershed and Groundwater Quality Protections (G3)

Work collaboratively with water providers, stormwater management agencies, federal agencies, and state agencies to protect watersheds and groundwater from contamination and meet or exceed established water quality standards.

CP3: Household Water Efficiency Education (G2)

Support water providers disseminating water provider-created educational materials for household water use efficiency practices such as fixing leaky faucets, toilets, and irrigation systems and adjusting sprinkler heads to reduce overspray and runoff.

CP4: Leak Detection and System Maintenance (G2, G3)

Support water provider best practices to monitor and maintain infrastructure and reduce waste by keeping water systems in a state of good repair.

CP5: Supply Infrastructure (G3)

Support water suppliers in identifying and constructing additional infrastructure improvements to increase storage and available supply. (Please reference Section 7 for a list of regionally identified projects.)

CP6: Sustainable Allocations (G1, G3)

Explore state and federal level coordination to monitor groundwater conditions and manage sustainable allocations from the Denver Basin aquifers in alignment with guidance from the *Colorado Water Plan*.

CP7: Water Provider and Municipal Land Planner Group (G1, G2, G3)

Help establish a water provider and municipal land planner group that meets bi-annually (or at a regular intervals) to discuss opportunities to support water efficiency, system maintenance and policies, regulations, programs, and oversight for extending the life of the water supply. A central goal is sharing information such as population projections, addressing drought conditions, and consistency in comprehensive plans for water conservation for an integrated approach to water management.

CP8: Incorporated Jurisdictions Landscaping Guidelines Support (G2)

Support incorporated jurisdictions in Arapahoe County in their efforts to update landscaping standards to require water-wise, drought-tolerant landscaping for new development. Leveraging the County's 2024 code update or code provisions from other jurisdictions in the county (i.e., Aurora, Centennial, Littleton), create a menu of model regulatory language for future code revisions and supporting documentation on water conservation benefits. Explore best practices from other Front Range jurisdictions (i.e., Castle Rock Water Wiser), and free on-line resources (i.e., Resource Central / Garden in a Box).

CP9: Water Services Extensions (G2, G3)

Extend service to new development from existing water providers rather than developing separate well systems where economically feasible.

CP10: Discussion and Considerations

Several zoning and regulatory considerations or processes that may require updates include:

- Evaluate PUD and Cluster Zoning applicability for subdivisions larger than five lots.
- Consider planning review referral to water providers within two miles of a new development for possible extension of water service.
- For smaller-scale developments, explore possible connection to nearby water providers instead of constructing separate systems.

SECTION 10.

IMPLEMENTING RECOMMENDATIONS

SECTION 10 – IMPLEMENTING RECOMMENDATIONS

This section identifies how the policy recommendations in Section 9 could be incorporated into the County's Land Development Code and Comprehensive Plan, whether as new policies or as amending or revising current policies.

The Land Development Code includes regulations that govern how land is used and developed throughout the county. It does not currently include the policies related to water conservation that are addressed in the Comprehensive Plan. Development design guidelines in the Land Development Code include landscaping water conservation recommendations but no regulations.

The County's Comprehensive Plan includes goals, policies, and strategies related to water supply in the county. While the Comprehensive Plan includes policies, it is advisory and not regulatory as is the Land Development Code. Policies and strategies in the Comprehensive Plan support the three goals listed below.

Goal 1 – Ensure an Adequate Water Supply in Terms of Quantity and Quality for Existing and Future Development

Goal 2 – Integrate Water and Land Use Planning

Goal 3 – Reduce Overall Water Consumption in the County

Recommended policies in this Study largely support policies already in the Comprehensive Plan (see Table 10-1). Amendments can be made to include specifics from the Study that do not overlap with existing policies. Several new policies are recommended to further support water supply conservation throughout the county.

Additionally, some of the policies introduce requirements for new development that would need to be addressed in the Land Development Code. Those recommended policies are shaded in Table 10-1.

Table 10-1. Recommended Policies

Recommended Policy	Policy Goal*	Comprehensive Plan Existing Policy	Change
AP1: Denver Basin Aquifer-specific Annual Withdrawal Reduction Factor	G1, G3	Public Facilities and Services (PFS) 2.3 – Incorporate water-saving actions into land use planning activities	Amend existing policy
AP2: Connected Systems	G2	PFS 2.3 – Incorporate water-saving actions into land use planning activities	Amend existing policy
AP3: Early Water Evaluation for Development	G1, G2, G3	PFS 2.1 – Require adequate water availability for proposed development	Amend existing policy
AP4: Increase Water Efficiency Regulations in New Development	G2	PFS 2.3 – Incorporate water-saving actions into land use planning activities	Amend existing policy
AP5: Programs, Education, and Resources for Water-wise Landscaping	G1, G2	PFS 2.2 – Encourage development to incorporate water wise development practices	Amend existing policy
AP6: Encouraging Water Reuse	G1, G2, G3	PFS 3.3 – Support actions to reuse water	Amend existing policy
AP7: Water Management Policy Audit	G1, G2, G3	N/A	New policy
AP8: Groundwater Systems Best Practices	G3	PFS 3.1 – Encourage water providers to implement best management practices for reducing water demand	Amend existing policy
AP9: Reducing Development Barriers	G1, G2	PFS 2.3 – Incorporate water-saving actions into land use planning activities	Amend existing policy
AP10: Graywater Systems	G2	N/A	New policy
CP1: Water Rates	G2, G3	N/A	New policy
CP2: Watershed and Groundwater Quality Protections	G3	PFS 1.4 – Protect and enhance the quality of drinking water in the county	Amend existing policy
CP3: Household Water Efficiency Education	G2	PFS 3.2 – Create partnerships to implement water demand management and water conservation measures	Amend existing policy
CP4: Leak Detection and System Maintenance	G2, G3	N/A	New policy
CP5: Supply Infrastructure	G3	PFS 1.2 – Reduce dependence on aquifers for long-term water supply	Amend existing policy
CP6: Sustainable Allocations	G1, G3	PFS 1.2 – Reduce dependence on aquifers for long-term water supply	Amend existing policy
CP7: Water Provider and Developer Group	G1, G2, G3	PFS 3.1 – Encourage water providers to implement best management practices for reducing water demand	Amend existing policy
CP8: Incorporated Jurisdictions Landscaping Guidelines Support	G2	PFS 3.2 – Create partnerships to implement water demand management and water conservation measures	Amend existing policy
CP9: Water Services Extensions	G2, G3	N/A	New policy

*Goals

G1 – Closing potential gaps between future supply and demand

G2 – Improving water use efficiency

G3 – Extending the life of Denver Basin aquifers to sustain a long-term supply

APPENDIX A

GLOSSARY

GLOSSARY

A

Acre-foot- The volume of water required to cover one acre to a depth of one foot. Equal to 43,560 cubic feet or 325,851 gallons, or 1,233 cubic meters.

Adjudication—Judicial process to determine the extent and priority of the rights of persons to use water in a river or aquifer system.

Alluvial aquifer—An aquifer formed by material laid down by physical processes in a stream channel or on a floodplain.

Alluvium—Unconsolidated clay, silt, sand, or gravel deposited during recent geologic time by running water in the bed of a stream or on its floodplain.

Appropriation—The right to use water for a beneficial use or the acquisition of such a right gained through the process of diverting water and putting it to a beneficial use.

Appropriative rights— Appropriative water rights, generally found in western states, are created by diversion of water and putting it to beneficial use. Appropriative water rights have a priority based on the date of first usage. In times of shortage, junior appropriators are cut off while senior appropriators receive their full allotment.

Aquifer—A saturated water-bearing formation, or group of formations, which yield water in sufficient quantity to be of consequence as a source of supply.

Aquifer system—Heterogeneous body of interbedded permeable and poorly permeable material that functions regionally as a water-yielding unit. It consists of two or more permeable beds separated at least locally by confining beds that impede vertical ground-water movement, but do not greatly affect the regional hydraulic continuity of the system; includes both saturated and unsaturated parts of permeable materials.

Aquifer yield— Maximum rate of withdrawal that can be sustained by an aquifer. See ***Yield***

Artesian well or artesian spring —A well or spring that taps ground water under pressure beneath an aquiclude so that water rises (though not necessarily to the surface) without pumping. If the water rises above the surface, it is known as a flowing artesian well.

Artificial recharge— Deliberate act of adding water to a ground-water aquifer by means of a recharge project. Artificial recharge can be accomplished via injection wells, spreading basins, or in-stream projects.

Augmentation plan—A court-approved plan that allows a water user to divert water out of priority so long as adequate replacement is made to the affected stream system and water right in quantities and at times so as to prevent injury to the water rights of other users.

B

Basin yield— Maximum rate of withdrawal that can be sustained by the complete hydrogeologic system in a basin without causing unacceptable declines in hydraulic head anywhere in the system or causing unacceptable changes to any other component of the hydrologic cycle in the basin. See ***Yield***.

Bed— A layer of rock in the earth. Also the bottom of a body of water such as a river, lake, or sea.

Bedrock— The solid rock that underlies any unconsolidated sediment or soil. Shale and granites are common types of bedrock in Colorado.

Beneficial use— Use of water, such as domestic, municipal, agricultural, mining, industrial, stock watering, recreation, wildlife, artificial recharge, power generation, or contamination remediation, that provides a benefit. Water rights not put to beneficial use are subject to forfeiture. Historically, very few uses of water have been declared non-beneficial by courts.

C

Capture— water withdrawn artificially from an aquifer derived from a decrease in storage in the aquifer, a reduction in the previous discharge from the aquifer, an increase in the recharge, or a combination of these changes. The decrease in discharge plus the increase in recharge is termed capture. Capture results in reduced surface flows.

Certification— the process whereby a permit to appropriate water is finalized based on the completion of the diversion work and past application of water to the proposed use in accordance with the approved water0right application. A certified water right has a legal, state0issued document that establishes a priority date, type of beneficial use, and the maximum amount of water that can be used annually.

Clean Water Act— The federal law that establishes how the United States will restore and maintain the chemical, physical, and biological integrity of the country's water (oceans, lakes, streams and rivers, ground water, and wetlands). The law provides protection for the country's water for both point and non-point sources of pollution.

Colorado Water Quality Control Act— Legislation to prevent injury to beneficial uses made of state waters, to maximize the beneficial uses of water, and to achieve the maximum practical degree of water quality in Colorado.

Commercial water use— water for motels, hotels, restaurants, office buildings, other commercial facilities, and institutions. The water may be obtained from a public supply or may be self-supplied.

Community water system— A public system that serves a year-round residential population such as a group of homes receiving water from the same source.

Conditional water right— legal preservation of a priority date that provides a water user time to develop a water right while reserving a more senior date. A conditional water right becomes an absolute right water is actually put to beneficial use.

Cone of depression— A cone-shaped depression in the water table around a well or a group of wells. The cone is created by withdrawing ground water more quickly than it can be replaced.

Confined aquifer— An aquifer that is bounded above and below by confining layers. Because of the pressure created in a confined aquifer, the water level in a well drilled into a confined aquifer will rise above the top of the aquifer and, in some instances, above the land's surface.

Conservation— Management of water resources to eliminate waste or maximize efficiency of use.

Conservation storage— storage of water in a reservoir for later release for useful purposes such as municipal and industrial water supply, water quality, or irrigation.

Consumptive use— That portion of water withdrawn from and lost to the immediate surface or ground-water storage environment. Typical withdrawals or uses included evaporation, transpiration, incorporation into products or crops, consumption by humans or livestock, or other removals.

Contaminant— A substance not naturally occurring in water or occurring in an amount that presents a health risk.

Cubic foot per second (cfs) — Rate of discharge representing a volume of cubic foot (28.317 x 10^{-3} m^3) passing a given point during one second. This rate is equivalent to approximately 7.48 gallons (0.0283 m^3) per second.

D

Decree —An official document issued by the court defining the priority, amount, use, and location of water right.

Depletion— Use of water in a manner that makes it no longer available to other users in the same system.

Depletion time— Time indicating how long it would take the watershed or the ground0water system to dry out if surface runoff or ground0water replenishment (recharge) were stopped from an instant onward, and if outflow water maintained at the rate it had at that instant. Depletion times of surficial waters usually are on the order of hours to weeks. They may run into month or years if the river basin includes large lakes. Depletion times of aquifers are usually on the order of tens to hundreds, and often thousands of years. As a consequence, rivers react quickly to precipitation and to abstraction of water, whereas ground-water systems react very sluggishly to these events.

Depth to water—The depth of the water table below the Earth's surface.

Designated basin—An area in which the use of ground water is assumed not to impact the major surface river basin to which the designated basin would otherwise be tributary. Much of eastern Colorado is in designated basins.

Discharge— The volume of water passing a particular point in a unit of time. Units of discharge commonly used include cubic feet per second (cfs) or gallons per minute (gpm).

Disinfection by-products— Chemicals, such as total trihalomethanes, formed from naturally occurring humic or fulvic acids and the disinfectant used to treating water.

Diversion— Physical removal of surface water from a channel. Also, the act of bringing water under control by means of a well, pump, or other device for delivery and distribution for a proposed use.

Domestic well use—Water used for drinking and other purposes by a household, such as from a rural well. Domestic use permits normally allow limited irrigation and outside watering uses.

Drainage basin— Hydrologic unit consisting of a part of the surface of the earth covered by a drainage system made up of a surface stream of body of impounded surface water plus all tributaries. The runoff in a drainage basin is distinct from that of adjacent areas. A river basin is similarly defined.

E

Effluent—Any substance, particularly a liquid, that enters the environment from a point source. Generally, refers to waste-water from a sewage-treatment or industrial plant.

Evaporation—Process of liquid water becoming water vapor, including vaporization from water surfaces, land surfaces, and snowfields, but not through leaf surfaces. Compare with transpiration.

Evapotranspiration—A collective term for water that moves

Exempt Wells — Small non-irrigation wells that are exempt from permitting under the laws of the state.

F

Flow—The volume of water moving past a point during a specified time. Also known as discharge.

Freshwater— Water containing only small quantities (generally less than 1,000 milligrams per liter) of dissolved materials.

G

Goal— Brief, clear statement of an outcome to be reached.

Gravel pack— Coarse sand and gravel placed in the annular space between the borehole and the well casing in the vicinity of the well screen. The purpose of the gravel pack is to minimize the entry of fine sediment into the well, stabilize the borehole, and allow the flow of ground water into the well.

Ground water— Underground water that is generally found in the pore space of rocks or sediments and that can be collected with wells, tunnels, or drainage galleries, or that flows naturally to the Earth's surface via seeps or springs.

Ground-water basin— Geologically and hydrologically defined area that contains one or more aquifers that store and transmit water and will yield significant quantities of water to wells.

Ground-water mining— Pumping ground water from a basin at a rate that exceeds safe yield, thereby extracting ground water that had accumulated over a long period of time.

Ground-water storage— 1) Quantity of water in the saturated zone, or 2) water available only from the storage as opposed to capture.

H

Hydraulic head of (static) head— Height that water in an aquifer can raise itself above an arbitrary reference level (or datum), generally measured in feet or meters. When a borehole is drilled into an aquifer, the level at which the water stands in the borehole (measured with reference to a horizontal datum such as sea level) is, for most purposes, the hydraulic head of water in the aquifer at that location. Ground water possesses energy mainly by virtue of its elevation (elevation head) and of its pressure (pressure head). When ground water moves, some energy is dissipated and therefore a head loss occurs.

Hydraulically connected— A condition in which ground water moves easily between aquifers that are in direct contact. An indication of this condition is that the water levels in both aquifers are approximately equal.

Hydrologic budget or balance— Accounting of the inflow to, outflow from, and storage in a hydrologic unit such as a drainage basin, aquifer, soil zone, lake, or reservoir; the relationship between evaporation, precipitation, runoff, and the change in water storage, expressed by the hydrologic equation.

Hydrologic cycle— The complete cycle that water can pass through, beginning as atmospheric water vapor, turning into precipitation and falling to the earth's surface, moving into aquifers or surface water, and then returning to the atmosphere via evapotranspiration.

Hydrology— the study of the characteristics and occurrence of water, and the hydrologic cycle. Hydrology concerns the science of surface water and ground water, whereas hydrogeology principally focuses on ground water.

Hydrostatic pressure— The pressure exerted by the water at any given point in a body of water or aquifer.

I

Impervious— Resistant to penetration by water or plant root.

Industrial uses— Water used for a wide range of purposes by industries, including cooling water for electrical power generation, manufacturing, food preparation, washing of wastes, etc. The quality needed ranges substantially depending on the use.

Infiltration (soil) — Movement of water from the ground surface into the soil.

Injection well— Well used for injecting water or other fluid into a ground-water aquifer. See ***Artificial recharge.***

Inorganic— Not made of or derived from living matter. Minerals are inorganic.

Instream use— Use of water that does not require withdrawal or diversion from its natural watercourse; for example, the use of water for navigation, recreation, and support of fish and wildlife.

Intermittent flow— Surface water flowing only during periods of seasonal runoff.

Irrigation use— Water applied to the soil surface by center pivots, ditches, or other means or to the soil subsurface by tubes to add to the water available for plant growth.

Isochore - A line representing the variation of pressure with temperature when the volume of the substance operated on is constant

L

Livestock water use— Water for livestock watering, feed lots, dairy operations, fish farming, and other on-farm needs. Livestock as used here includes cattle, sheep, goats, hogs, and poultry.

M

Monitoring well— Non-pumping well used primarily for taking water-quality samples and measuring ground-water levels. See ***Observation well.***

N

Net pay or net sand— These terms are interchangeable and refer to the amount of water bearing sandstones and siltstones within the Denver Basin aquifers.

Nonconsumptive use— Use that leaves the water available for other uses. Examples are hydroelectric power generation and recreational uses.

Non-potable— Water not suitable for drinking.

Nontributary (NT) ground water— Underground water in an aquifer that neither draws from nor contributes to a natural surface stream in any measurable degree.

Not-nontributary (NNT) ground water— Ground-water that is hydrologically connected to a surface stream system.

O

Objective— Specific, measurable, realistic, and timebound condition that must be attained in order to accomplish a particular goal. Objectives define the actions must be taken within a year to reach the strategic goals.

Observation well— Non-pumping well used primarily for observing the elevation of the water table or the piezometric pressure; also to obtain water-quality samples.

Organic— Pertaining to or relating to a compound containing carbon. For example, petroleum products contain organic compounds derived from plant and animal remains.

P

Percolation— Laminar-gravity flow through unsaturated and saturated earth material.

Permeability— 1) Ability of a material (generally an earth material) to transmit fluids (water) through its pores when subjected to pressure of a difference in head. Expressed in units of volume of fluid (water) per unit time per cross section area of material for a given hydraulic head; 2) description of the ease with which a fluid may move through a porous medium; abbreviation of intrinsic permeability. It is a property of the porous medium only, in contrast to hydraulic conductivity, which is a property of both the porous medium and the fluid content of the medium.

Point source— Source of pollution that originates from a single point, such as an outflow pipe from a factory.

Policy— Deliberate system of principles to guide decisions and achieve rational outcomes

Pollution— Contamination from human activities that restricts the uses of water.

Porosity— Fraction of bulk volume of a material consisting of pore space. Porosity determines the capacity of a rock formation to absorb and store ground water.

Porous— Geologically, this term describes rock that permits movement of fluids through small, often microscopic openings, much as water moving through a sponge. Porous rocks may contain gas, oil, or water.

Precipitation— Water in some form that falls from the atmosphere. It can be in the form of liquid (rain or drizzle) or solid (snow, hail, sleet).

Prior appropriation— Doctrine for prioritizing water rights based upon dates of appropriation ("first in time, first in right"). Common method for allocating water rights in the western United States.

Priority— Seniority date of a water right or conditional water right to determine their relative standing to other mater rights and conditional water rights and conditional water rights deriving water from a common source. Priority is a function of both the appropriation date and the relevant adjudication date to the right.

Priority date— The date a water right is established.

R

Raw water— Untreated water.

Recharge— The replenishment of ground water in an aquifer. It can be either natural, through the movement of precipitation into an aquifer, or artificial in the pumping of water into an aquifer.

Recharge area— A geographic area where water enters (recharges) an aquifer. Recharged areas usually coincide with topographically elevated regions where aquifer units crop out at the surface. In these areas infiltrated precipitation is the primary source of recharge. The recharge area also may coincide with the area of hydraulic connection where one aquifer receives flow from another adjacent aquifer.

Reclaimed wastewater— Wastewater treatment plant effluent that has been diverted for beneficial use before it reaches a natural waterway or aquifer.

Recycled water— Water that is used more than once before it passes back into the natural hydrologic system.

Resistivity net pay - Amount of Net Pay or Net Sands as determined by evaluation of geophysical logs to delineate higher resistivity beds (greater than 12 ohm-meters (ohm.m)) which are associated with higher permeability intervals containing favorable lithologies (sandstones and siltstones) for groundwater flow.

Return flow— Part of water that is not consumed and returns to its source or another body of water.

S

Safe drinking Water Act (SDWA) — Federal legislation passed in 1974 that regulates the treatment of water for human consumption and requires testing for and elimination of contaminants that might be present in the water.

Saturated thickness— The vertical thickness of an aquifer that is full of water. The upper surface is the water table. The height of the hydrogeologically defined aquifer unit in which the pore spaces are filled (saturated) with water. For the High Plains aquifer and similar unconfined, unconsolidated aquifers, the saturated thickness is equal to the difference in elevation between the base of the aquifer and the water table. The predevelopment saturated thickness is based on the best available estimate of the elevation of the water table prior to human altercation by ground-water pumping.

Saturated zone— A subsurface zone in which all the interstices are filled with water under pressure greater than atmospheric. The upper surface of the saturation zone is the water table.

Specific storage— Volume of water released from or taken into storage per unit volume of the porous medium per unit change in head. It is the three-dimensional equivalent of storage coefficient or storativity and is equal to storativity divided by aquifer saturated thickness.

State Engineer— The person charged by state law with the supervision and administration of water and the enforcement of decreed priority and legislative enactments. The State Engineer discharges the obligations of the state of Colorado imposed by compact or judicial orders and coordinates the work of the Division of Water Resources with other departments of state government. The State Engineer has rule-making obligations and supervisory control over measurements, record keeping, and distribution of the public water of the state and all employees under his direction and any other such acts as may be reasonable necessary to enable the performance of his duties.

Strategy— The art of devising or employing plans or stratagems toward a goal

Streamflow— Discharge that occurs in a natural channel. A more general term than runoff, streamflow may be applied to discharge whether or not it is affected by diversion or regulation.

Surface water— Water found at the Earth's surface, usually in streams or lakes.

T

Transmissivity— Flow capacity of an aquifer measured in volume per unit time per unit width. Equal to the product of hydraulic conductivity times the saturated thickness of the aquifer.

Treated water— Water that has been filtered and disinfected.

Tributary— A tributary is generally regarded as a surface water drainage system which is interconnected with a river system. Under Colorado law, all surface and ground water, the withdrawals of which would affect the rate or direction of flow of a surface stream within 100 years, is considered to be tributary to a natural stream.

U

Unconfined aquifer— An aquifer that is not bounded above by a confining bed; water levels in wells screened in an unconfined aquifer coincide with the elevation of the water table.

Unsaturated zone— Also known as the vadose zone, this is the area of soil or rock just above the water table.

V

Void— Pore space or other openings in rock. The openings can be very small to cave-size and are filled with water below the water table.

W

Wastewater— Water that carries wastes from homes, businesses, and industries.

Water court— A specific district court that has exclusive jurisdiction to hear and adjudicate water matters. There are seven water courts in Colorado, a judge, who is also district court judge, presides over each court.

Water level— The level of water in a well or aquifer. It can be measured as depth below the ground surface or as an elevation related to a datum, such as sea level.

Water quality— Physical, chemical, and biological characteristics of water and how they relate to it for a particular use.

Water Quality Control Act— Colorado statute enacted in 1981 to protect, maintain, and improve the quality of state waters through prevention, abatement, and control of water pollution. This act created the nine-member Water Quality Control Commission that is responsible for developing specific water quality policy.

Water right— Any vested or appropriation right under which a person may lawfully divert and use water. It is a real property right appurtenant to and severable from the land on or in connection with which the water is used. Water rights pass as an appurtenance with a conveyance of the land by deed, lease, mortgage, will, or inheritance.

Watershed— An area from which water drains and contributes to a given point on a stream or river.

Water table— A fluctuating demarcation line between the unsaturated (vadose) zone and the saturated (phreatic) zone that forms an aquifer. It may rise or fall depending on precipitation (rainfall) trends. The water table is semi-parallel to the land surface above but is not always a consistent straight line. Because of impervious beds of shale, etc., local water tables can be perched above the area's average water table.

Water year— Twelve-month period in

which the U.S. Geological Survey reports surface water supplies. Water years begin October 1 and end the following September 30 and are designated by the calendar year in which the water year ends.

Well— A vertical excavation into an underground rock formation.

Well permit— the granting of permission by the State Engineer allowing the digging of a hole in search of ground water to apply to beneficial use. A written permit obtained from the State giving permission to dig a hole to find groundwater.

Well yield— Pumping rate that can be supplied by a well without drawing the water level in the well below the pump intake. See ***Yield.***

Y

Yield— Amount of water that can be supplied from a reservoir, aquifer, basin, or other system during a specified interval of time. This time period may vary from a day to several years depending upon the size of the system involved.

SOURCES

Topper, R., K. L. Spray, W. H. Bellis, J. L. Hamilton, and P. E. Barkmann. SP-53 Ground Water Atlas of Colorado. Special Publications, SP-53. Denver, CO: Colorado Geological Survey, Division of Minerals and Geology, Department of Natural Resources, 2003.

APPENDIX B

REFERENCES

REFERENCES

Below is a listing of the related documents referenced for this Study and interactive mapping.

Arapahoe County Water and Wastewater Authority 2015 Municipal Water Efficiency Plan Update, Clear Water Solutions, 2015

2021 Annual Comprehensive Financial Report for the Year Ended December 31, 2021, Denver Water

City of Englewood – Drinking Water Quality Report 2022 Covering Data for Calendar Year 2021, City of Englewood, 2022

Water Supply – Prairie Waters Project, Aurora Water [map]

Water Supply and Demand Questions, Sandor Rebek Arapahoe Country Water and Wastewater Authority

Aurora Integrated Water Master Plan, MWH, now part of Stantec*,* September 2017

Aurora Water's System FAQ, Aurora Water, July 22, 2019

Growing Water Smart: Community Self-Assessment, Alexander Davis Aurora Water

Aurora Raw Water Supply [map]

Personal Assessment, Byers

City and County of Denver Board of Water Commissioners Denver Water Distributor Contract Boundaries, Denver Water August 5th, 2019 [map]

2022 Water Supply Management Plan Rangeview Metropolitan District, Providence Infrastructure Consultants, 2022

ACWWA Flow Project Map, circa 2018 [map] (x2 in folder, appear to be the same)

Getting Water to You, City of Englewood

In the Water Court in and For Water Division I, State of Colorado Case No. W-7254, Signed 1976

City and County of Denver Board of Water Commissioners Water Collections System, December 30th, 2022, Denver Water [map]

Master Plan Overview 2016 Regional Master Plan Update, South Metro Water Supply Authority (SMWSA), 2016

Denver One Water Plan, City and County of Denver, Colorado Water Conservation Board, Denver Water, Metro Wastewater Reclamation District, Mile High Flood District, The Greenway Foundation/The water Connection*,* September 2021

Growing Water Smart: Community Self-Assessment, Rangeview Metropolitan District, 2021

City and County of Denver Board of Water Commissioners: Denver Water Service Areas, Denver Water March 31, 2015, [map]

Strasburg Sanitation and Water District Water System Improvements Preliminary Engineering Report, JDS-HYDRO Consultants, June 2012

Water Efficiency Plan, Denver Water

Consumer Confidence Report (CCR) Certificate of Delivery Form, Signed. Craig A White April 25th, 2022. PWSID: C00103010

Bennett Town of 2023 Drinking Water Quality Report Covering Data for Calendar Year 2022, Public Water System ID: CO0101020

Box Elder Creek Ranches, Dr. Jeris A. Danielson, Deputy State Engineer September 28th, 1976.

Consumer Confidence Report (CCR) Certificate of Delivery Form, Kelly Conover, District Admin June 30th, 2022. PWSID: CO 0203012

Comanche Crossing Subdivision, Office of the State Engineer Division of Water Resources, Dept. of Natural Resources, State of Colorado, Kenneth W. Knox, July 29th, 1999; *Turner Rezoning, Case No. 80-25 (Comanche Crossing),* Arapahoe County Planning Dept. Division of Water Resources, Hal D. Simpson, June 10, 1980

Deer Trail Town of 2022 Drinking Water Quality Report Covering Data for Calendar Year 2021, Public Water System ID: CO0103030

Inverness Water and Sanitation District Tax Authority #4381 Arapahoe County Tax Authority #4020 Douglas County, December 23rd, 2019 [MAP]

Prosper, Colorado Water Supply Plan Report, HRS Water Consultants, INC. January 2014

Sky Ranch Filing 4 Project nos. ASP20-010 & PF20-007 Portion of the W ½ of Section 3, Township 4 South, Range 65 West, 6th P.M. Water Division 1, District 2, Colorado Division of Water Resources, Joanna Williams January 28th, 2021.

Thunder Ranches Subdivision P98-145 NE ¼ Section 6, T4S, R64W, 6th P.M. Water Division 1, Water District 1, Office of the State Engineer Division of Water Resources, Dept. of Natural Resources, State of Colorado, Kenneth W. Knox, August 25th, 1998

Thunderbird Estates, Division of Water Resources, Jeris A. Danielson Deputy State Engineer, October 23rd 1973

Groundwater Availability of the Denver Basin Aquifer System, Colorado. United States Geological Survey, 2011. ISBN 978-1-4113-3121-1

Water Conservation Plan, Inverness Water and Sanitation District, March 2011

Denver Water System Fact Book, Denver Water, Circa. 2020

Water Efficiency Management Guide – Landscaping and Irrigation, Environmental Protection Agency, 2017

Xeriscaping, Encyclopedic Entry, National Geographic, https://education.nationalgeographic.org/resource/xeriscaping/

Xeriscaping: A Great Way to Save Water, Aquasana webpage, https://www.aquasana.com/info/xeriscaping-water-conservation-lawn-pd.html

Xeriscape, City of Fort Collins, Colorado webpage, https://www.fcgov.com/utilities/residential/conserve/water-efficiency/xeriscape

How Much Water Does a Xeriscape Lawn Save Per Year?, SEF Construction & Landscape, Inc., 2023 https://www.seflandscaping.com/post/how-much-water-does-a-xeriscape-lawn-save-per-year

Outdoor Water Use in the United States, Environmental Protection Agency, 2017

Centennial, Colorado Turf Replacement Program webpage, https://www.centennialwater.org/conservation/rebates-and-incentives/turf-replacement-program-177

2001 Water Resource Study for Eastern Arapahoe County

2015 Colorado Water Plan

2018 Arapahoe County Comprehensive Plan

2019 Technical Update to the Colorado Water Plan

2021 Eastern Arapahoe County Water Resources Assessment

2022 Eastern Arapahoe County Water Needs Assessment

2022 South Platte Basin Implementation Plan

Arapahoe County 2050 population growth projections

Current GIS Mapping

July 2022 Recommendations for Water Efficient Landscapes

2023 Colorado Water Plan

APPENDIX C

TABLES 5-9 THROUGH 5-14

Table 5-9 –Water Demands per Entity for Single-Family Dwellings without Conservation

Water Demand - Single Family Water Use	63%	SF Use (45% divided by the total residential use 71%)										
	Households			Water Demand (Values in AF/yr)								
WATER PROVIDER	2020	2050 Low	2050 High	2020			2050 Low			2050 High		
					In house (69.4%)	IRR (30.6%)		In house (69.4%)	IRR (30.6%)		In house (69.4%)	IRR (30.6%)
Aurora	81,597	117,307	126,665	15,000	10,410	4,590	21,564	14,966	6,599	23,285	16,160	7,125
Denver	53,247	60,821	62,806	17,159	11,908	5,251	19,599	13,602	5,997	20,239	14,046	6,193
ECCV	13,145	16,591	17,494	3,444	2,390	1,054	4,346	3,016	1,330	4,583	3,181	1,402
Englewood	10,093	11,012	11,252	2,935	2,037	898	3,202	2,222	980	3,272	2,271	1,001
ACWWA	3,061	3,402	3,492	1,058	734	324	1,175	816	360	1,206	837	369
Sky Ranch	58	2,339	2,936	16	11	5	626	435	192	786	546	241
Inverness Water	627	899	971	202	140	62	290	201	89	312.91	217	96
Prosper Farms	34	4,558	5,697	13	7	7	1,823	912	912	2,279	1,139	1,139
Byers	263	268	270	123	85	37	125	87	38	126	87	38
Deer Trail	190	208	213	89	61	27	97	67	30	99	69	30
Strasburg	25	28	30	12	8	4	13	9	4	14	10	4
Bennett	9	11	75	4	3	1	5	3	2	35	24	11
No District	2,924	6,136	6,978	1,364	947	417	2,862	1,986	876	3,255	2,259	996
Totals	165,273	223,581	238,878	41,417	28,741	12,676	55,729	38,322	17,407	59,491	40,845	18,646

Table 5-10 –Water Demands per Entity for Multi-Family Dwellings without Conservation

Water Demand - Multi Family Water Use	37%	MF Use (26% divided by the total residential use 71%)										
	Households			Water Demand (Values in AF/yr)								
WATER PROVIDER	2020	2050 Low	2050 High	2020			2050 Low			2050 High		
					In house (80%)	IRR (20%)		In house (80%)	IRR (20%)		In house (80%)	IRR (20%)
Aurora	47,180	67,827	73,237	8,250	6,600	1,650	11,860	9,488	2,372	12,807	10,245	2,561
Denver	30,787	35,166	36,314	9,921	7,937	1,984	11,332	9,066	2,266	11,702	9,362	2,340
ECCV	7,600	9,593	10,115	1,991	1,593	398	2,513	2,011	503	2,650	2,120	530
Englewood	5,836	6,367	6,506	1,697	1,357	339	1,851	1,481	370	1,892	1,513	378
ACWWA	1,770	1,967	2,019	611	489	122	680	544	136	698	558	140
Sky Ranch	34	1,352	1,698	9	7	2	362	290	72	455	364	91
Inverness Water	362	520	561	117	93	23	168	134	34	181	145	36
Prosper Farms	19	2,635	3,294	8	4	4	1,054	527	527	1,318	659	659
Byers	152	155	156	71	57	14	74	59	15	73	58	15
Deer Trail	110	120	123	51	41	10	57	46	11	57	46	11
Strasburg	15	16	17	7	5	1	8	6	2	8	6	2
Bennett	5	6	43	3	2	1	3	2	1	20	16	4
No District	1,691	3,548	4,035	789	631	158	1,685	1,348	337	1,882	1,505	376
Totals	95,561	129,274	138,119	23,524	18,817	4,707	- 31,648	25,002	6,646	- 33,741	26,598	7,143

Table 5-11 –Water Demands per Entity for Commercial without Conservation

WATER PROVIDER/MUNICIPALITIES - Employment												
				Water Demand (Values in AF/yr)								
WATER PROVIDER	**2020**	**2050 Low**	**2050 High**	**2020**			**2050 Low**			**2050 High**		
					Indoor (65%)	IRR (35%)		Indoor (65%)	IRR (35%)		Indoor (65%)	IRR (35%)
Aurora	125,913	166,979	188,434	6,750	4,388	2,363	8,951	5,818	3,133	10,102	6,566	3,536
ECCV	11,105	16,221	18,894	213	138	74	311	202	109	361.83	235	127
ACCWA	33,566	41,752	46,029	1,634	1,062	572	2,032	1,321	711	2,240.45	1,456	784
Denver	202,496	240,397	260,199	9,856	6,407	3,450	11,701	7,606	4,095	12,665	8,232	4,433
Englewood	33,856	40,997	44,728	1,405	913	492	1,701	1,106	595	1,856	1,206	650
Sky Ranch	20	188	275	1	0.6	0.3	9	6	3	13	9	5
Inverness Water	15,861	16,250	16,454	772	502	270	791	514	277	801	521	280
Byers	384	384	383	19	12	7	19	12	7	19	12	7
Deer Trail	127	183	213	6	4	2	9	6	3	10	7	4
Strasburg	150	591	822	7	5	3	29	19	10	40	26	14
No District	3,931	7,065	8,702	191	124	67	344	224	120	424	275	148
Bennett	7	11	13	0.34	0.22	0.12	0.54	0.35	0.19	0.63	0.41	0.22
SubTotal	427,416	531,018	585,146	20,855	13,555	7,299	25,898	16,833	9,064	28,532	18,546	9,986
Prosper Farms	80	3,323	4,154	3.89	1.9	1.9	473	237	237	592	296	296
Total Water Demand				20,858	13,557	7,301	26,371	17,070	9,301	29,124	18,842	10,282

Table 5-12 –Water Demands per Entity for Single Family Dwellings With Conservation

Water Demand - Single Family Water Use	SF Use (45% divided by the total residential use 71%)													
	Households		**Water Demand (Values in AF/yr)**											
WATER PROVIDER	**2050 Low**	**2050 High**	**2050 Low**						**2050 High**					
				In house (69.4%	IRR (30.6%)	Indoor reduction	Irrigation reduction	Total Water Demand		In house (69.4%	IRR (30.6%)	Indoor reduction	Irrigation reduction	Total Water Demand
Aurora	117,307	126,665	21,564	14,966	6,599	1,646	744	19,174	23,285	16,160	7,125	1,778	929	20,578
Denver	60,821	62,806	19,599	13,602	5,997	1,496	401	17,702	20,239	14,046	6,193	1,545	469	18,225
ECCV	16,591	17,494	4,346	3,016	1,330	332	117	3,898	4,583	3,181	1,402	350	142	4,091
Englewood	11,012	11,252	3,202	2,222	980	244	55	2,902	3,272	2,271	1,001	250	63	2,959
ACWWA	3,402	3,492	1,175	816	360	90	22	1,064	1,206	837	369	92	25	1,089
Sky Ranch	2,339	2,936	626	435	192	48	54	524	786	546	241	60	72	655
Inverness Water	899	971	290	201	89	22	10	258	312.91	217	96	24	12	277
Prosper Farms	4,558	5,697	1,823	912	912	100	285	1,438	2,279	1,139	1,139	125	365	1,789
Byers	268	270	125	87	38	10	2	114	126	87	38	10	2	115
Deer Trail	208	213	97	67	30	7	2	88	99	69	30	8	2	90
Strasburg	28	30	13	9	4	1	0	12	14	10	4	1	0	12
Bennett	11	75	5	3	2	0	0	5	35	24	11	3	3	29
No District	6,136	6,978	2,862	1,986	876	218	148	2,496	3,255	2,259	996	248	190	2,816
Totals	223,581	238,878	55,729	38,322	17,407	4,215	1,840	49,673	59,491	40,845	18,646	4,493	2,274	52,724

Table 5-13 –Water Demands per Entity for Multi-Family Dwellings With Conservation

Water Demand - Multi Family Water Use	MF Use (26% divided by the total residential use 71%)													
	Households		Water Demand (Values in AF/yr)						Water Supply					
WATER PROVIDER	2050 Low	2050 High	2050 Low						2050 High					
				In house (80%)	IRR (20%)	Indoor reduction	Irrigation reduction	Total Water Demand		In house (80%)	IRR (20%)	Indoor reduction	Irrigation reduction	Total Water Demand
Aurora	67,827	73,237	11,860	9,488	2,372	1,044	268	10,549	12,807	10,245	2,561	1,127	334	11,346
Denver	35,166	36,314	11,332	9,066	2,266	997	151	10,184	11,702	9,362	2,340	1,030	177	10,495
ECCV	9,593	10,115	2,513	2,011	503	221	44	2,248	2,650	2,120	530	233	54	2,363
Englewood	6,367	6,506	1,851	1,481	370	163	21	1,668	1,892	1,513	378	166	24	1,702
ACWWA	1,967	2,019	680	544	136	60	8	612	698	558	140	61	9	627
Sky Ranch	1,352	1,698	362	290	72	32	21	310	455	364	91	40	27	388
Inverness Water	520	561	168	134	34	15	4	149	181	145	36	16	5	160
Prosper Farms	2,635	3,294	1,054	527	527	58	172	825	1,318	659	659	72	218	1,027
Byers	155	156	74	59	15	6	1	67	73	58	15	6	1	66
Deer Trail	120	123	57	46	11	5	1	51	57	46	11	5	1	52
Strasburg	16	17	8	6	2	1	0	7	8	6	2	1	0	7
Bennett	6	43	3	2	1	0	0	3	20	16	4	2	1	17
No District	3,548	4,035	1,685	1,348	337	148	58	1,479	1,882	1,505	376	166	72	1,645
Totals	129,274	138,119	31,648	25,002	6,646	2,750	748	28,150	33,741	26,598	7,143	2,926	922	29,893

Table 5-14 –Water Demands per Entity for Commercial With Conservation

WATER PROVIDER	2050 Low	2050 High	2050 Low						2050 High					
				Indoor (65%)	IRR (35%)	Indoor reduction	Irrigation reduction	Total Water Demand		Indoor (65%	IRR (35%)	Indoor reduction	Irrigation reduction	Total Water Demand
Aurora	166,979	188,434	8,951	5,818	3,133	640	301	8,010	10,102	6,566	3,536	722	442	8,937
ECCV	16,221	18,894	311	202	109	22	12	276	362	235	127	26	19	317
ACCWA	41,752	46,029	2,032	1,321	711	145	60	1,827	2,240	1,456	784	160	85	1,995
Denver	240,397	260,199	11,701	7,606	4,095	837	304	10,561	12,665	8,232	4,433	906	422	11,338
Englewood	40,997	44,728	1,701	1,106	595	122	47	1,533	1,856	1,206	650	133	66	1,658
Sky Ranch	188	275	9	6	3	1	1	8	13	9	5	1	1	11
Inverness Water	16,250	16,454	791	514	277	57	11	723	801	521	280	57	13	731
Byers	384	383	19	12	7	1	0	17	19	12	7	1	0	17
Deer Trail	183	213	9	6	3	1	0	8	10	7	4	1	1	9
Strasburg	591	822	29	19	10	2	2	24	40	26	14	3	4	34
No District	7,065	8,702	344	224	120	25	17	302	424	275	148	30	27	366
Bennett	11	13	1	0.35	0.19	0	0	0	0.63	0.41	0.22	0	0	1
SubTotal	531,018	585,146	25,898	16,833	9,064	1,852	756	23,290	28,532	18,546	9,986	2,040	1,079	25,413
Prosper Farms	3,323	4,154	473	237	237	26	73	375	592	296	296	33	93	466
Total Water Demand			26,371	17,070	9,301	1,878	829	23,664	29,124	18,842	10,282	2,073	1,173	25,879

APPENDIX D

SUMMARY OF STATE AND LOCAL REGULATIONS THAT MAY AFFECT GROUNDWATER DEVELOPMENT IN ARAPAHOE COUNTY

1. SUMMARY OF STATE AND LOCAL REGULATIONS THAT MAY AFFECT GROUNDWATER DEVELOPMENT IN ARAPAHOE COUNTY

1.1 STATE REGULATIONS

State Regulations regarding groundwater development in Arapahoe County are evaluated under two main criteria – non-exempt or large capacity wells and exempt or small capacity wells. Non-exempt wells are rights issued by the Water Court or the State Engineer outside the designated basins that exceed the limited use of exempt wells.[1] Large capacity wells are wells within the designated basin that exceed the limited use of small capacity wells. Both exempt and small capacity well permits are issued by the State Engineer with the presumption that due to the limited use no injury will occur to vested water rights.

This discussion is divided into the non-exempt and large capacity wells and the exempt and small capacity wells.

1.1.1 Non-Exempt and Large Capacity Well Regulations

1.1.1.1 Tributary Ground Water

Tributary ground water, from a legal perspective, is ground water that is outside the boundaries of a designated basin and administered within the prior appropriation doctrine. The Colorado State Constitution established the prior appropriation doctrine (priority system) with regard to developing surface water and tributary water supplies. Therefore, surface water and tributary ground water may be developed only if all older senior water rights are not injured. Injury usually is considered as a reduction in the ability to divert for beneficial use, the full quantity of the right at the time the right is in priority. Injury has also come to include a reduction in water quality.

The Colorado State Engineer administers tributary water rights on a priority basis. This means that if sufficient water is not available to meet the demand, junior water rights may not divert and are considered at that time to be out-of-priority. Because most of the surface water was appropriated early in Colorado's history, before the technology to develop tributary ground water existed, tributary ground water is almost universally so junior that it is out-of-priority most of the time.

State legislature created a process where both junior surface water and tributary ground water supplies can be developed provided there is a court-approved augmentation plan that prevents injury to senior water rights. This is done by replacing in the stream the depletion caused by junior diversions so that there is sufficient water in the stream for the

---

[1] See C.R.S. §37-90-137 and §37-92-602

senior rights. In addition, injury from a junior tributary well to an existing more senior tributary well is also recognized and may be proven through the use of groundwater modeling and other tools.

A depletion to a stream is that amount of water that is consumptively used and never returned to the stream. The consumptive use is less than the amount diverted because some portion of the diversion typically returns to the river system. In the case of tributary ground water, the concept of a stream depletion is somewhat more complex because a well may either intercept ground water that was flowing to a stream and cause a future depletion; or it may induce water to flow out of the stream and into the aquifer and thereby also cause a stream depletion. Because ground water flows through an aquifer very slowly, a stream depletion resulting from well pumping is delayed by days, months or years. This time delay must be considered in the augmentation plan. Moreover, the augmentation plan for diversions of tributary ground water can last decades if not centuries based upon the modeling used to compute the depletions to the stream system.

A common practice in Colorado is to retire irrigated crop-land from production and to change the use of the portion of the water right that was consumed (evapotranspired) by the plants to municipal use. The portion that was not consumed is no longer diverted and remains in the river for use by other water rights. Diversion could either be by an irrigation canal or by an irrigation well. However, even an irrigation well most likely will require augmentation.

1.1.1.2 Non-Tributary, Denver Basin and Designated Ground Water

Public water resources that are not a part of a natural stream, i.e. ground water resources that have a de minimus effect on any surface water, are not subject to the prior appropriation doctrine and are allocated and administered pursuant to the State legislature's plenary powers. In exercise of its powers the State legislature has over the years, created non-tributary groundwater outside a designated basin (C.R.S. §37-90-137(4); Denver Basin non-tributary and not non-tributary ground water (C.R.S. §37-90-137, and designated groundwater (C.R.S. §37-90-107) that is not subject to the prior appropriation doctrine.[2]

To develop these ground water supplies in Colorado requires a well permit issued by the State Engineers Office (SEO) of the Colorado Division of Water Resources or the Colorado Ground Water Commission if the well is located in a designated ground water basin. The applicable well permit regulations depend upon the intended location of the well (inside or outside a designated basin), the intended use, the aquifer that is the source of supply and, for the Denver Basin Aquifers, the class of the aquifer.

---

[2] See Upper Black Squirrel Creek Ground Water Management District v. Goss, 993 P.2d 1177, 1182-1183 (Colo. 2000).

Non-Tributary Groundwater

Even though this is a class of groundwater identified by the State Legislature, no non-tributary groundwater exists within the County. However, the Denver Basin groundwater, which does exist in the County references the Non-Tributary Groundwater Rules in the Denver Basin Rules.[3] These rules and the underlying statute, C.R.S. § 37-90-137(4), regulate non-tributary groundwater underlying the subject area outside the designated basins.

Denver Basin Groundwater

Denver Basin Aquifer ground water can be appropriated by permit upon application to the Colorado Division of Water Resources or through application to the Water Courts provided that the ground water has not been previously appropriated.[4]

The total appropriation for each aquifer is determined by multiplying the total land area claimed to be owned or controlled by the applicant by the water saturated thickness of sand, silt and gravel contained in the aquifer as portrayed on maps included in the State Engineer's Denver Basin Rules.[5] This is then multiplied by the specific yield contained in those same rules for the appropriate aquifer. Specific yield is the ratio of water drainable by gravity to the rock volume including the water (both drainable and undrainable). The amount that may be withdrawn annually is one percent of the total appropriation. In this way, the aquifer life is theoretically a minimum of 100 years. The parcels of land included in the application need to be contiguous, or nearly so, to be considered as a single appropriation.

Ownership of the land is not required; however, consent from the current landowner is required to appropriate the ground water. While all of the ground water in the various aquifers beneath a parcel may be appropriated, a well may only withdraw water from one aquifer. Therefore, to develop multiple aquifers requires multiple wells and permits. As many wells as are required to withdraw the water can be permitted.[6]

As indicated above, Colorado also allows the appropriation to be adjudicated in Water Court. This process quantifies the appropriation. The primary purpose of adjudicating a ground water appropriation fixes the amount so that it cannot be reduced by future changes in the law. The Water Court routinely retains jurisdiction to adjust the adjudicated appropriation based upon the actual saturated thickness determined when wells are drilled.

---

[3] See Designated Basin Rules, 2 CCR 410-1.
[4] See C.R.S. § 37-90-137(4)
[5] See The Denver Basin Rules, 2CCR 402-6
[6] See Statewide NonTributary Ground Water Rules, 2CCR 402-7

Within the Denver Basin, there are two classes of ground water: not non-tributary and non-tributary, with not non-tributary divided into 4 percent replacement and actual replacement depending upon the distance of the well to the tributary groundwater outcrop.[7] These classes have varying requirements related to the relative connection between the ground water and tributary groundwater systems as shown in **Table** _____. Each Denver Basin aquifer contains all three classes of ground water.

Current law in Colorado also requires that the anti-speculation test be met to withdraw Denver Basin ground water. Essentially, this is the test that the applicant has a current intended need for the water. This is accomplished by the applicant indicating their intended use of the groundwater on their property or off their property if a contract is provided or the land on which the water is to be used is owned by the applicant. The State Engineer will evaluate the reasonableness of the intended beneficial uses and will only allow those uses that are not speculative in nature if an application is filed with the State Engineer or provide such comments to the Water Court if a decree is sought.

The foregoing discussion applies to the portions of the Denver Basin Aquifers that are outside of designated basins. A discussion of Denver Basin appropriation within a designated basin is provided in the next section.

Large Capacity Wells and Determination of Water Right for the Denver Basin Allocation (Within Designated Basins)

There are two types of designated ground water, water other than the Denver Basin groundwater and Denver Basin groundwater. Regarding water other than Denver Basin groundwater, the Commission evaluates alluvial and bedrock groundwater. These types of designated are under the sole jurisdiction of the Colorado Groundwater Commission ("Commission").

Alluvial groundwater within the designated basins is permitted under Rule 5.2.[8] For the two designated basins within the County (Lost Creek and Kiowa-Bijou) the Commission has determined that the alluvial aquifers in both basins are over appropriated and therefore no new large capacity wells will be issued without a replacement plan. However, existing alluvial large capacity wells can be changed from the current use to another use so long as the well owner complies with C.R.S. § 37-90-111 and Designated Basin Rule 7.0. To change the use of an existing designated alluvial well, the well owner will be limited to historic consumptive use that is computed through evaluating the use of the well for a minimum of 10 years prior to a change of use. Moreover, if this change of use seeks export of the water outside the local district then the district may prohibit such export. Finally, these changes of water right are subject to

[7] See C.R.S. § 37-90-137(9)
[8] See Designated Basin Rules, 2CCR 410-1.

the anti-speculation doctrine wherein if the water is intended to be used for uses that are not supported (i.e., municipal use outside a municipality) or off the well owners land, contracts or other legal documents must be presented. These changes are also continuous and may require significant time and resources to fully prosecute.

Bedrock designated groundwater is permitted under Rule 5.4, however, there is no bedrock groundwater within the County.

Designated Denver Basin groundwater is within the County and this groundwater is permitted under Rule 5.3. The Commission, since 1985, prior to its initial rules and subsequent amendments, adopted policies to follow the statutory and regulatory procedures for allocation of Denver Basin groundwater outside the designated basins. Section 37-90-107 (7) of the Colorado Revised Statues establishes determinations of water rights for the allocation of designated Denver Basin groundwater and well permits for the withdrawal of designated Denver Basin ground water pursuant to the designations. Prior to this Act, determinations for available water from these aquifers could not be granted within the designated basins. It was a big hindrance in planning water supply for new subdivisions. To establish a well water right, a well must be completed prior to the permit expiration date. If a well was not constructed in time, the permit expired. A new application and a *new public notice* were required prior to issuance of a permit even if the requested permit was the same as the expired permit. A new notice could result in filing of objections and potential litigation. Under the Section 37-90-107 (7), once a determination is approved, well permits could be issued later in accordance with terms and conditions of approval of the determination without the need for a public notice. The determination of water right is the final allocation of designated Denver Basin groundwater (subject to site-specific conditions). Determinations of water right have greatly helped the landowners and municipalities in planning a legal water supply without necessarily having to construct a well.

If a replacement plan is required by Commission rules to withdraw water from a not non-tributary source, it must first be approved, after due public notice, before any well permits could be issued. However, due to almost no surface water sources within the designated basins and highly limited alluvial aquifer sources, finding water to replace depletions is difficult within the designated basin. To address this issue and allow reasonable use of ground water from these aquifers and to promote economic development within these basins the Commission does not require a replacement plan for a well withdrawing not non-tributary 4 percent water and only has to demonstrate annual replacement. This is different than outside designated basins because post pumping depletions do not have to be replaced. Moreover, a well pumping not non-tributary full replacement zone water is required to replace actual annual impact to the alluvial aquifer in a replacement plan but only up to the first 100 years and then replace actual annual impact beyond 100 years only until pumping ceases. Again, no post pumping replacement is required.

As with current law in Colorado outside designated basin, within the designated basin the anti-speculation test be met. The Commission will only allow the intended beneficial uses that are not speculative in nature. Moreover, inside the designated basins for which a local groundwater management district is present, the local district may restrict export of the groundwater from the Denver Basin aquifers if the export will cause the injury to the district. The portion of the water right that historically was consumed, can then be used for municipal purposes without causing injury, providing that the water right is in priority, the timing of the use is not changed or if the return flow is not changed. If the timing of use or the return flows are changed, additional protection of senior water rights is required. This can be in the form of storing the return flow component in a reservoir and releasing it at the proper times to the river to protect the senior water rights.

1.1.2 Exempt and Small Capacity Well Regulations

As indicated above, exempt and small capacity wells are issued by the State Engineer with the presumption that due to the limited use no injury will occur to vested water rights. These uses are limited by the respective statutes C.R.S. §37-92-602 (exempt) and §37-90-105 (small capacity). Below is a discussion of the limited uses of each category of permit.

1.1.2.1 Exempt Permits Limitations of Use

From a use perspective, the exempt well permitting procedures generally fall into the following three categories:

1) Domestic well serving a single household on a lot of at least 35 acres in size.
2) Domestic wells on lots less than 35 acres in size.
3) All other uses.

The State Engineer will issue a well permit with a withdrawal rate of 15 gallons per minute for uses within up to three homes, one acre of home gardens and lawns, and domestic animals on lots at least 35 acres in size. Moreover, for lots greater than 35 acres in size, the State Engineer will also issue livestock permits, fire-fighting permits, monitoring well permits and permits for drinking and sanitary uses within one commercial business.

Well permits on lots less than 35 acres in size will only be issued if one of the following conditions are met:

1) The lot was in existence prior to June 1, 1972
2) In subdivisions approved after June 1, 1972 where recommendations on the water supply were made in the review process

3) The wells will produce water from the non-tributary Denver Basin Aquifers. The use may not be limited to in-house use only; however, it is commonly limited.

Typically, unless the well is sought to withdraw water from the Denver Basin Aquifer or is in an approved subdivision with a water supply recommendation from the State Engineer, wells will only be issued for in-house use, drinking and sanitary uses within one commercial business, monitoring or firefighting. On these small lots, livestock and more expansive domestic uses will typically not be issued and non-exempt wells with augmentation will be required.

1.1.2.2 Small Capacity Permit Limitations of Use

Uses for small capacity wells within a designated basin including; in-house use, drinking, and sanitary uses within one commercial business will not be restricted. So long as the lot on which the well is sought is in existence prior to June 1, 1972 and the lot is at least 35 acres in size, the State Engineer can issue a well with a withdrawal rate up to 50 gallons per minute for (i) domestic purposes (three single-family dwellings, one acre of lawn and garden and domestic animals; (ii) livestock; (iii) within one commercial business; (iv) fire-fighting; and (v) monitoring. However, the maximum annual withdrawal cannot exceed 5 acre-feet unless the local ground water management district allows a greater annual withdrawal.

If the well will produce water from the designated Denver Basin Aquifers, then the volume will be limited to that amount underlying the specific parcel.

Finally, as mentioned above, local ground water management districts may restrict the issuance of a small capacity well (or increase the annual withdrawal) through properly adopted rules. However, the statute does not allow the local groundwater management district the right to prohibit the issuance of small capacity wells.

In the County, two local ground water management districts are present – Lost Creek and North Kiowa Bijou. Within each local district, the district has adopted rules that would further restrict the issuance of small capacity wells. Within the Lost Creek Ground Water Management District, the district restricts small capacity wells to 15 gallons per minute. Moreover, the district has rules that limit domestic use to 0.4 acre-foot per residence, 1 acre-foot for livestock and 1 acre-foot for commercial purposes. The district has a rule that prohibits small capacity wells with the alluvium and the Denver aquifer, however, this rule is in direct conflict with the Colorado Revised Statutes wherein limitations are allowed not prohibition.

Within the North Kiowa Bijou Ground Water Management District, the district only requires that the State Engineer issue a permit no greater than 15 gallons per minute unless approval is made for a greater amount by the district.

1.2 COUNTY REGULATIONS AFFECTING GROUND WATER DEVELOPMENT

In the Arapahoe County Comprehensive Plan, adopted June 19, 2001, Strategy PFS 1.5(a) states: “To allow time to obtain and secure a renewable source of water, the County will consider requiring water districts that serve development in areas east of Gun Club Road to prepare service plans using a conservative aquifer life assumption of a 100-Year supply, non-tributary groundwater classification only, assuming a 50 percent recovery factor.” This approach is what the State Engineer has used to provide recommendations for adequate water supply for subdivisions referred to its office. Using this approach the State Engineer has indicated that the non-tributary or the augmented not non-tributary ground water must meet a 200-year supply. While this is the most recent strategy, the County is recommending that a 300-year water supply be implemented for non-renewable resources.

For the Denver Basin Aquifers use in Arapahoe County this requirement is usually met by reducing the land development density so that the water demand is one-half to one-third of what could be appropriated by a well permit. Other methods of supplying water such as reusing water, or using a combination of both surface water and ground water are usually permissible with the appropriate decrees and authorization.

1.3 OTHER GROUND WATER REGULATIONS

The State and local health departments regulate both domestic and municipal wells. Their primary focus is on water quality issues. Domestic well regulation is limited to requiring a well to be a specific distance from septic leach fields. Municipal wells, whether owned by a community, special district or private water company, are required to meet water quality standards mandated in the Federal Safe Drinking Water Act and regulations from the Colorado Water Quality Control Division. Generally, water treatment is limited to disinfection. Occasionally, treatment to remove iron and manganese is also done. Consequently, the health department regulations do not tend to limit the use of ground water.

APPENDIX E

WATER LEVELS FOR THE DENVER BASIN AQUIFERS

WATER LEVELS FOR THE DENVER BASIN AQUIFERS

ARAPAHOE COUNTY, COLORADO

Introduction

LRE Water used publically available data from the Colorado Division of Water Resources (DWR) and the United States Geological Survey National Water Information Mapper (NWIS) to prepare graphs of the Dawson, Denver, Arapahoe (Upper and Lower) and Laramie Fox-Hills. This data was collected by the respective agencies from various sources with some water level data from wells being more detailed than others.

The data presented is the best available water level data that is publicly available in Arapahoe County. It is noted that a few time series of water levels change more rapidly between measurements than would normally be expected. LRE recognizes that some of the wells measured on a regular basis are near pumping wells which would affect the water level measurements. This effect, along with the spatially sparse dataset, make it difficult to be certain about the water elevation trends on the aquifer scale.

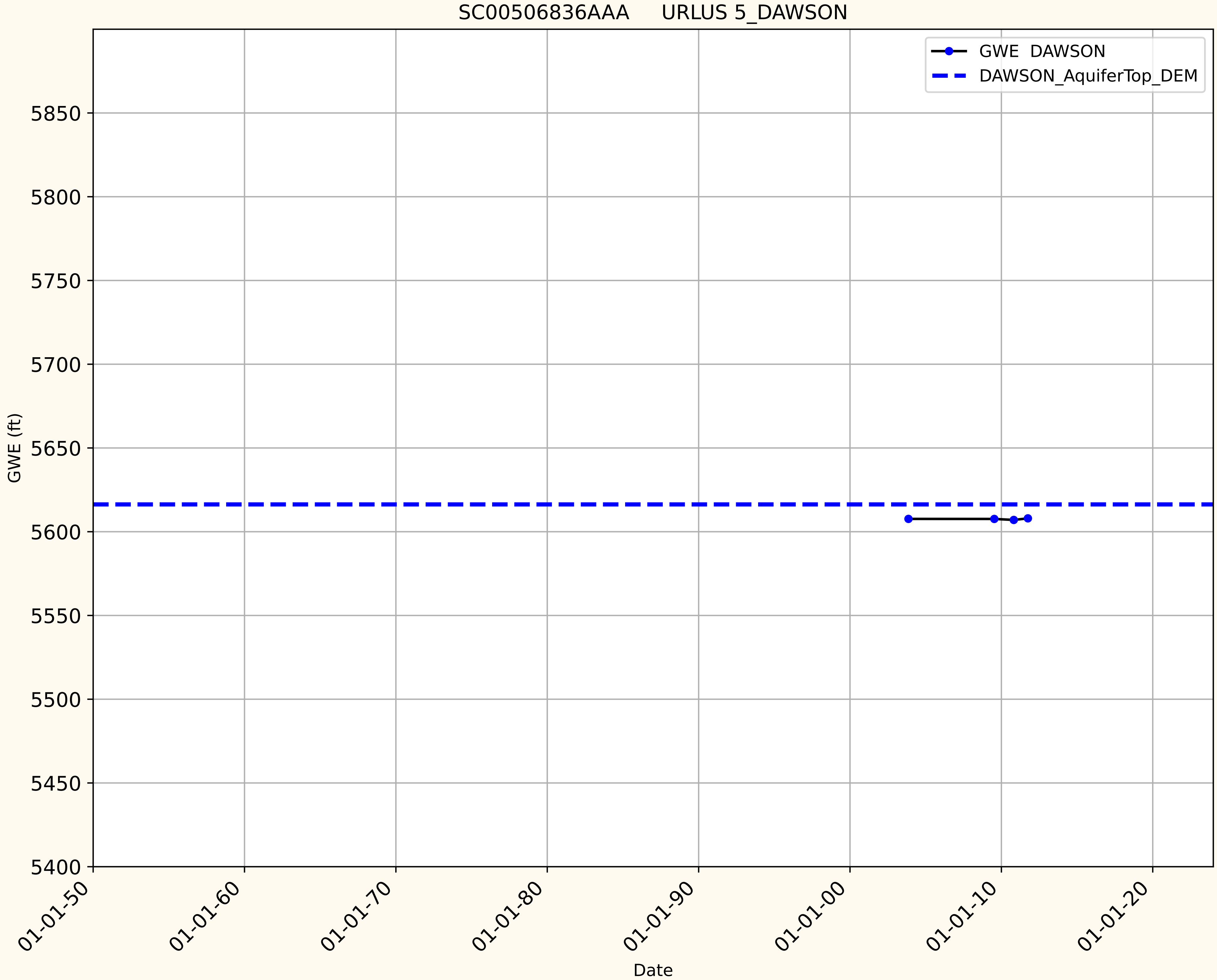
It is also noted that the Ground Water Elevation (GWE) for each aquifer is presented as the elevation above sea level. The elevation for each aquifers varies due to ground surface elevation changes. Water level data was collected from digital elevation models (DEM) or structure maps. This is noted after each aquifer top or bottom.

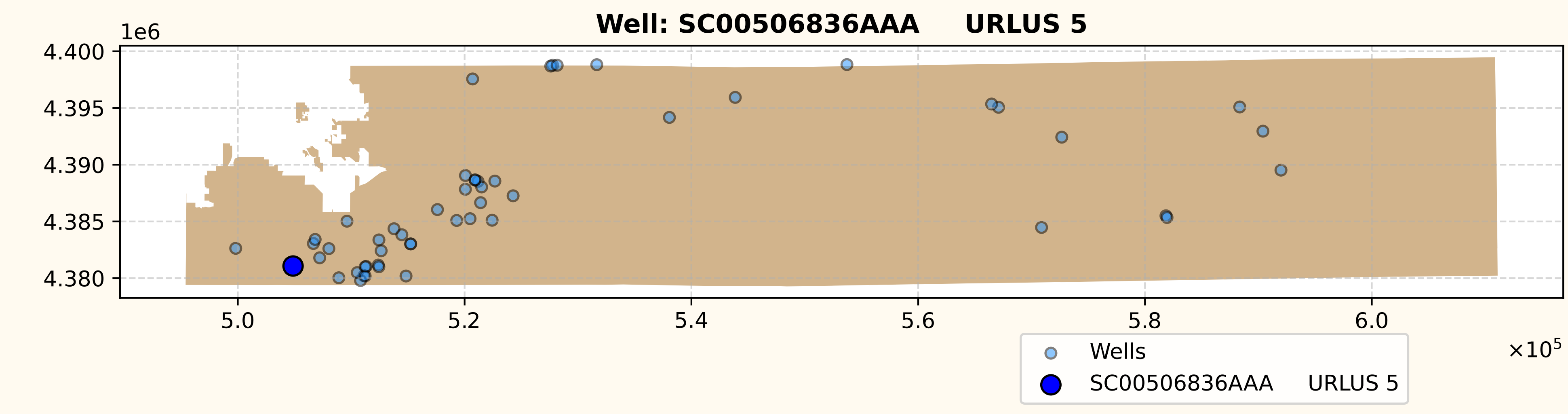
The Dawson aquifer water level is represented by a dashed blue line. The Denver aquifer water level is represented by a green dashed line. The Upper Arapahoe and Lower Arapahoe aquifer water level is represented by orange dashed and dotted lines, respectively. The Laramie Fox Hills aquifer water level is represented by a dashed red line.

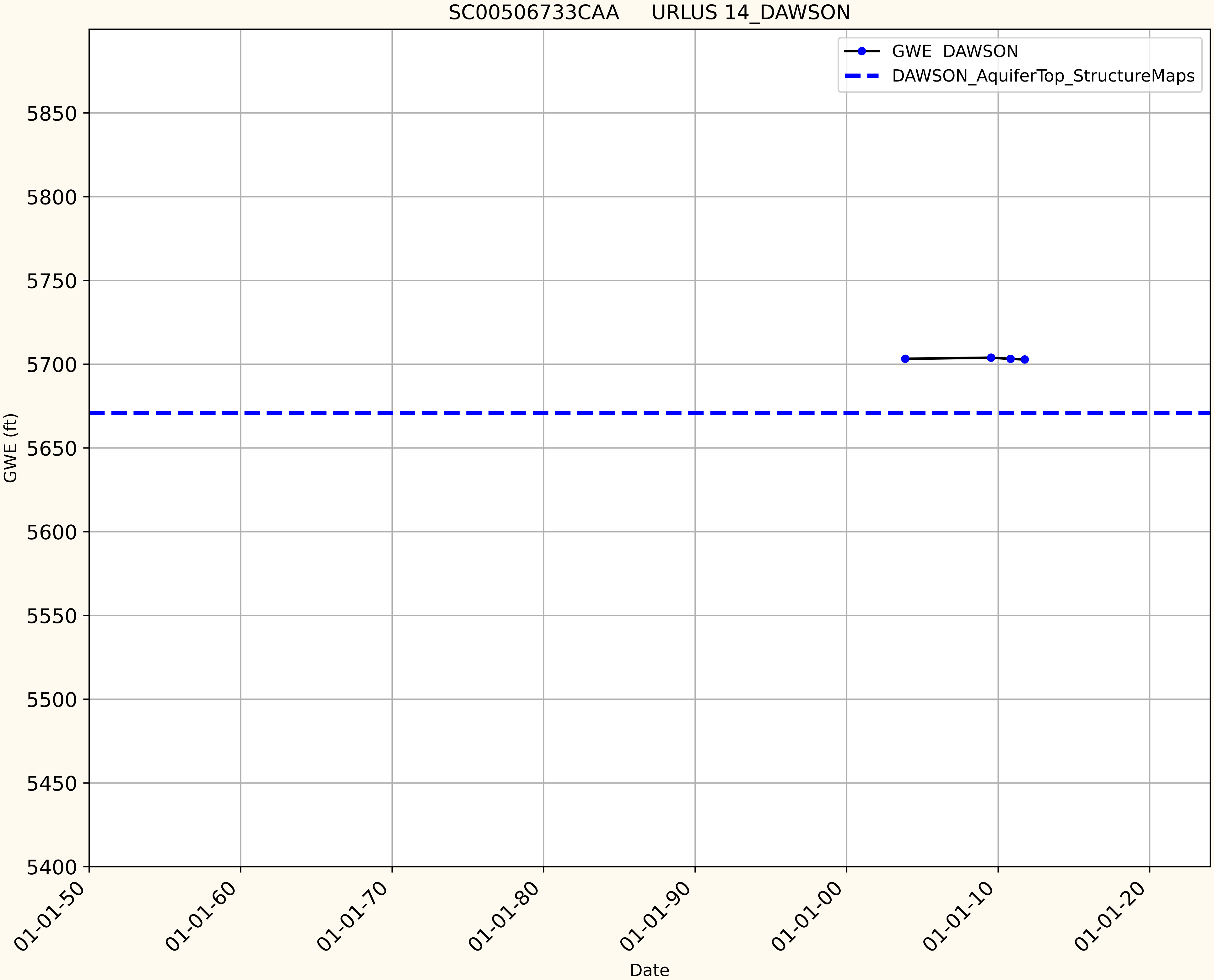
Tops and bottoms of screened intervals in each well (if available from the data) are teal dashed and dotted lines, respectively.

A map of the county and the location of the well with the water level measurement is located on the bottom of each graph.

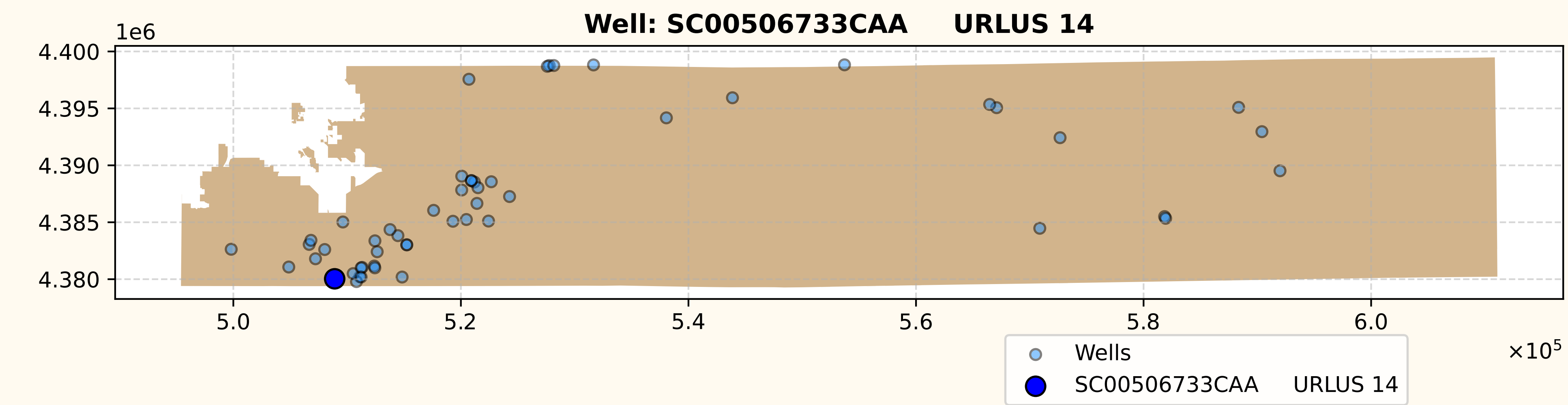
WATER LEVELS



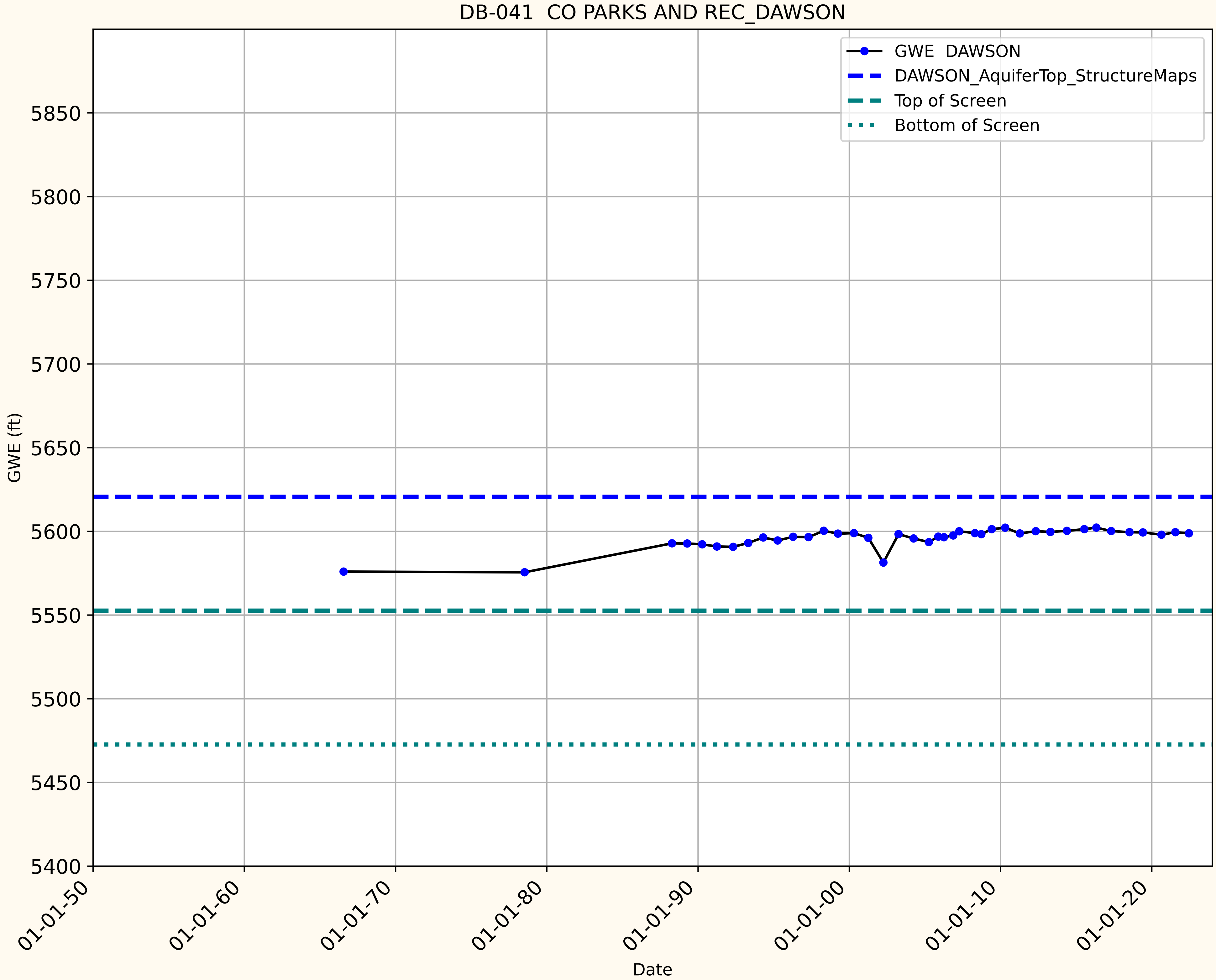




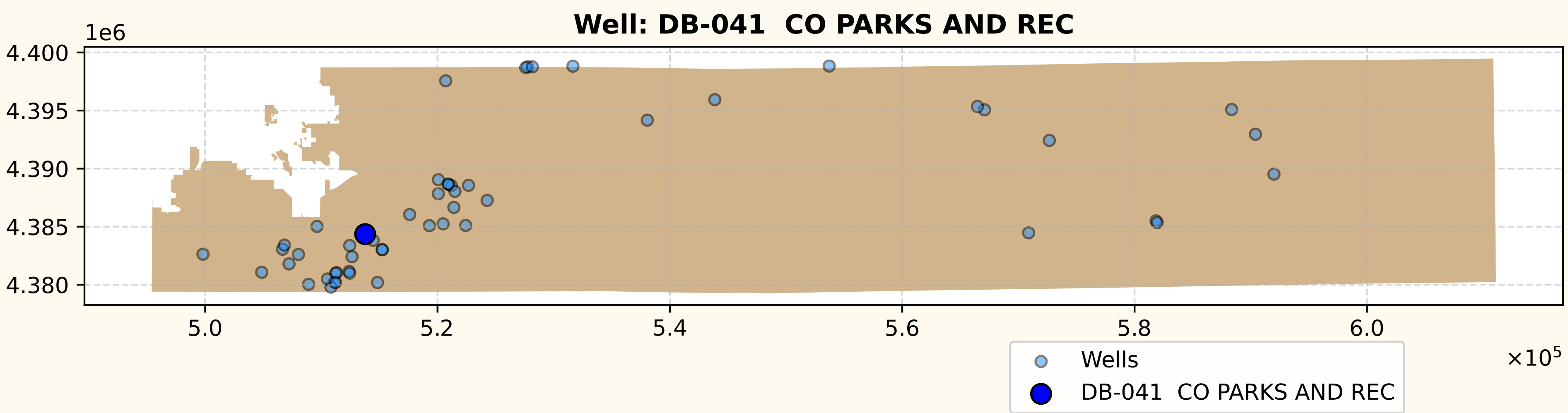
SC00506733CAA URLUS 14_DAWSON
GWE DAWSON
DAWSON_AquiferTop_StructureMaps
5850
5800
5750
5700
5650
5600
5550
5500
5450
5400
GWE (ft)
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20
Date



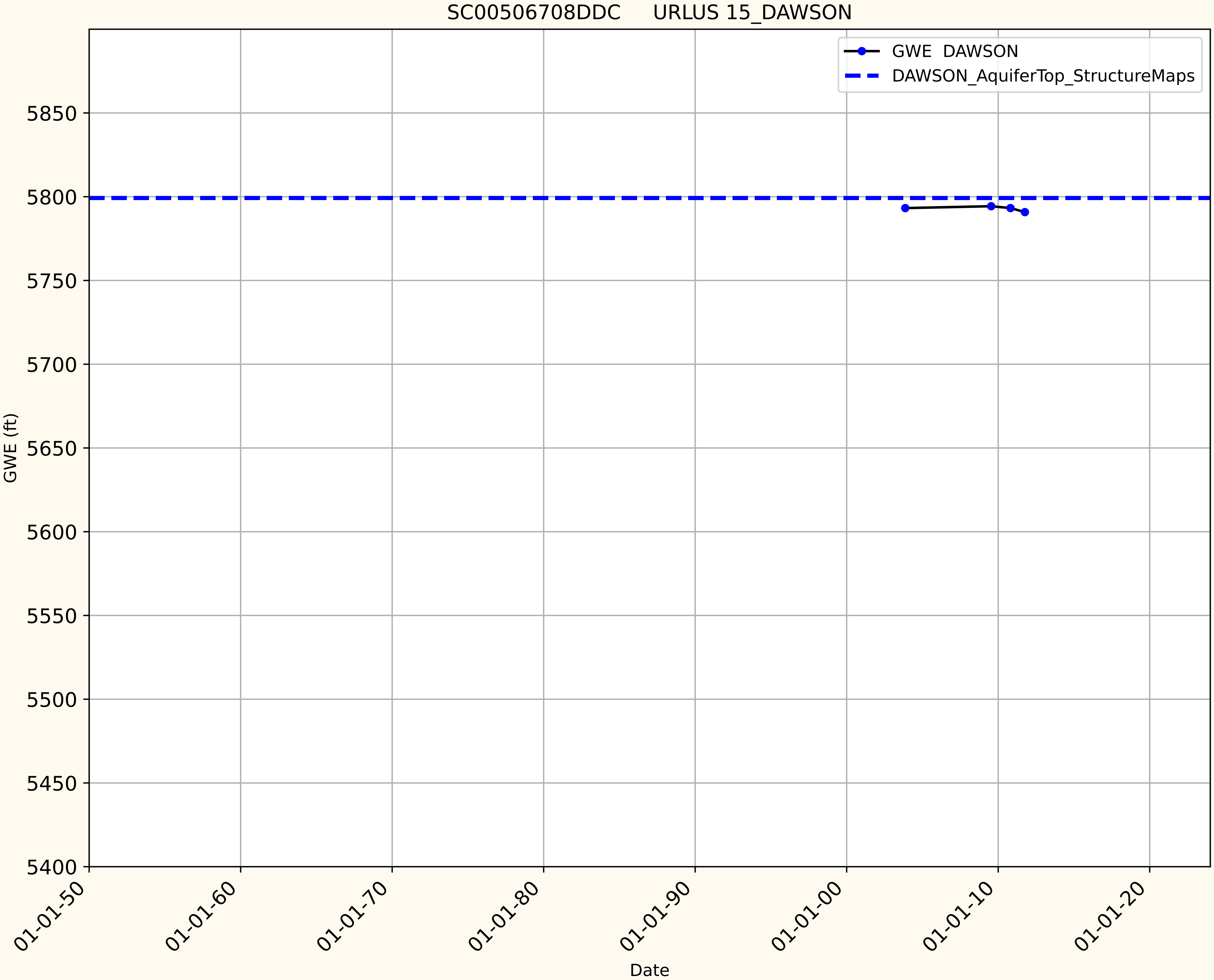
Well: SC00506733CAA URLUS 14
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
SC00506733CAA URLUS 14



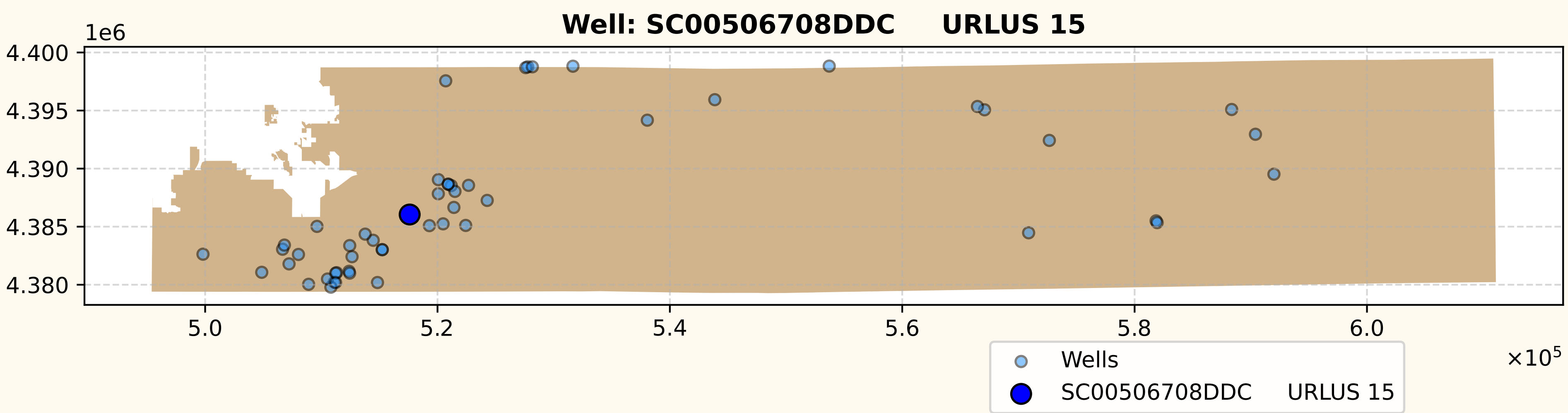
DB-041 CO PARKS AND REC_DAWSON
GWE DAWSON
DAWSON_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
5400
5450
5500
5550
5600
5650
5700
5750
5800
5850
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20
Date



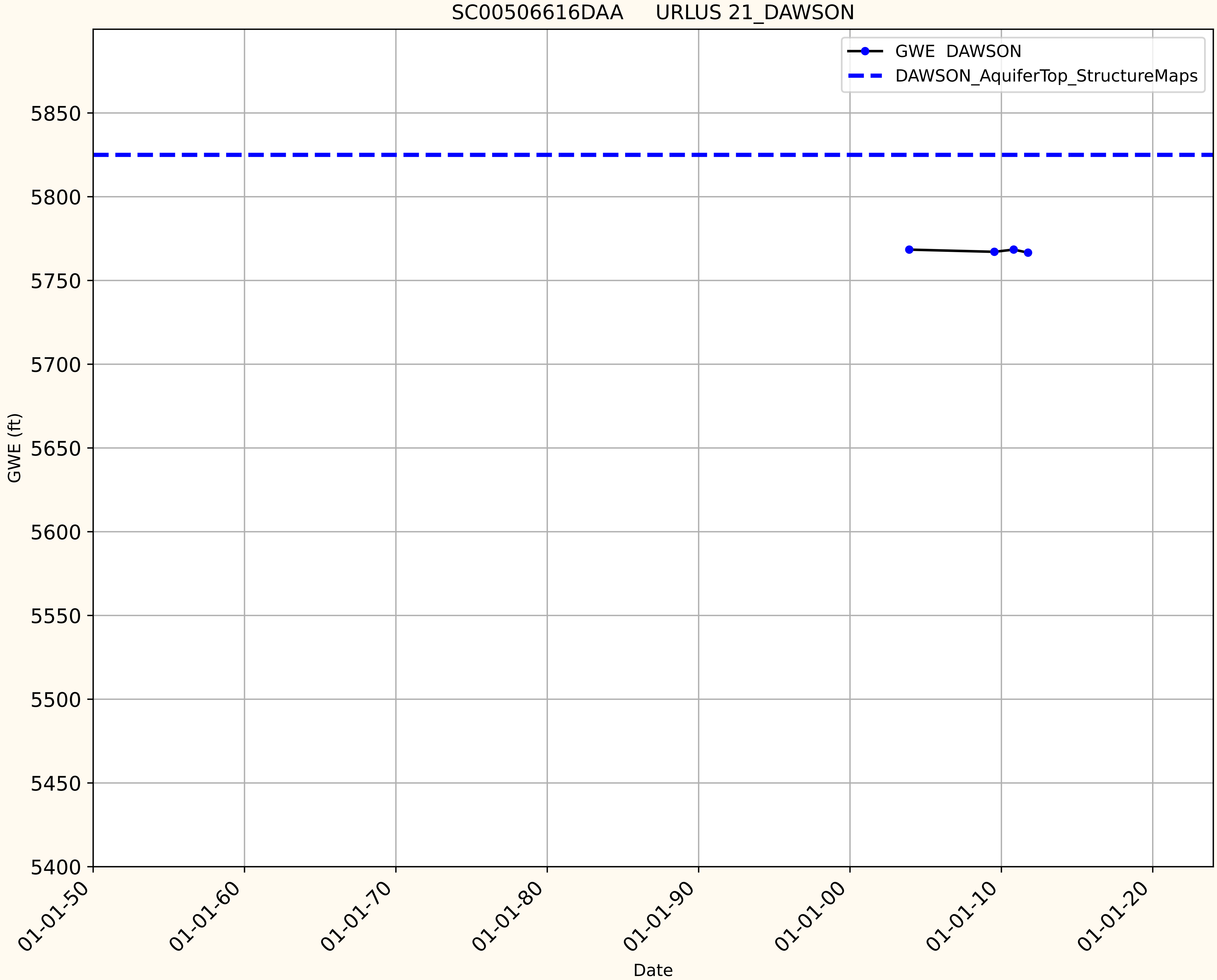
Well: DB-041 CO PARKS AND REC
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
DB-041 CO PARKS AND REC

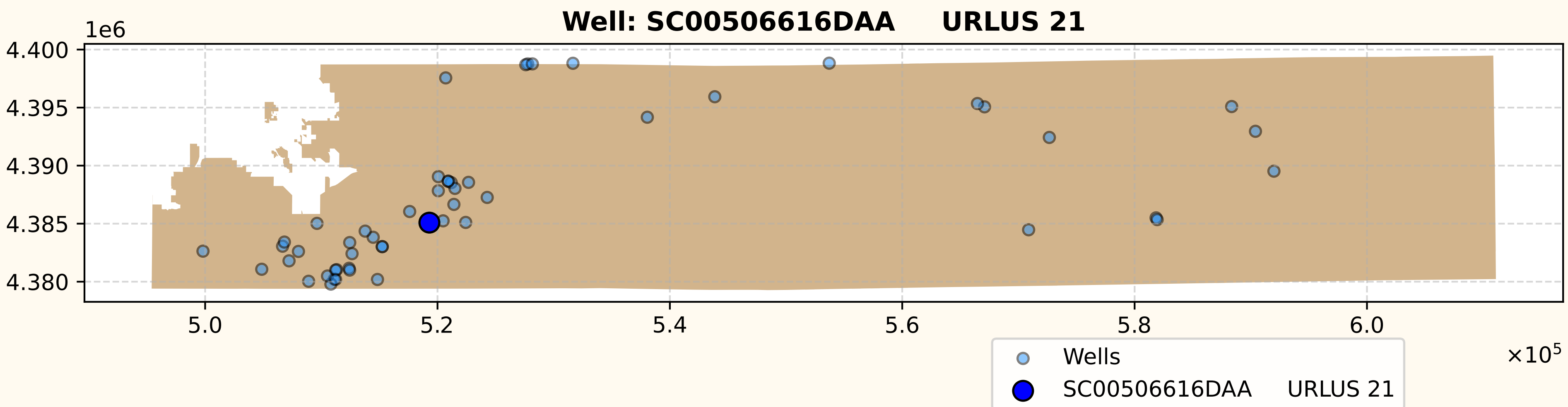


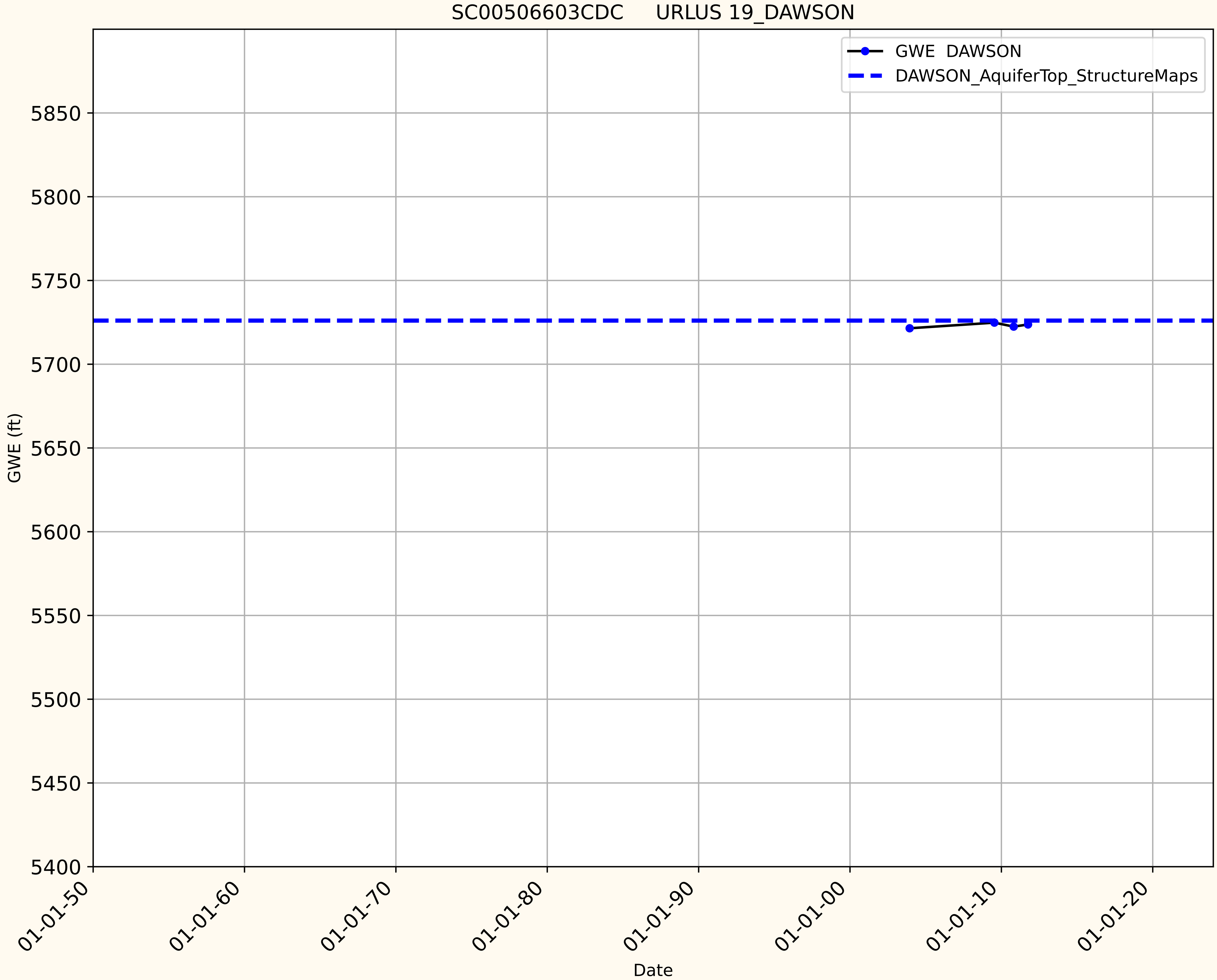
SC00506708DDC URLUS 15_DAWSON
GWE DAWSON
DAWSON_AquiferTop_StructureMaps
GWE (ft)
5850
5800
5750
5700
5650
5600
5550
5500
5450
5400
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20
Date

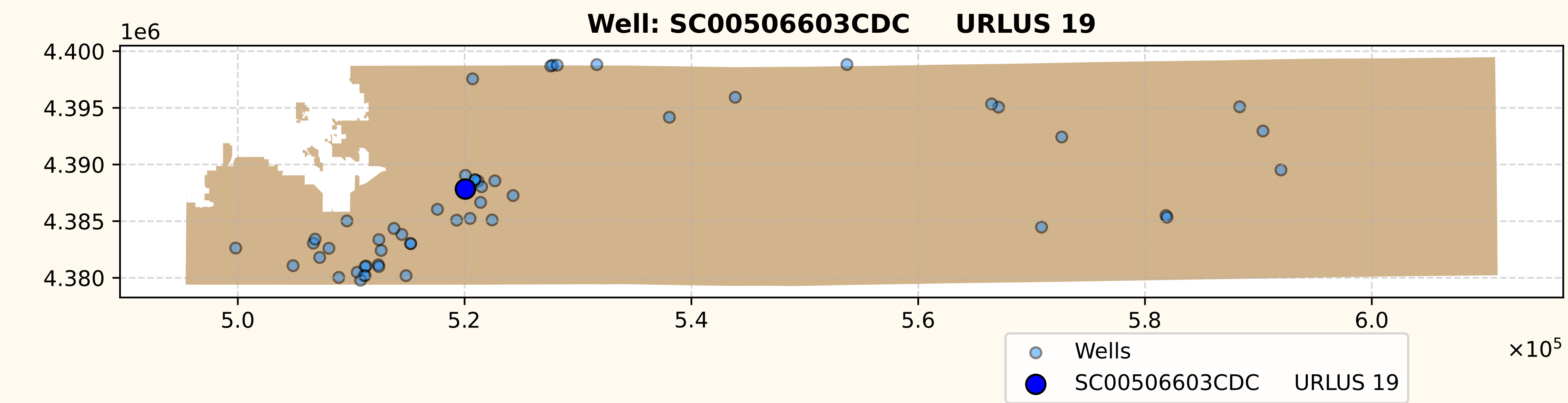


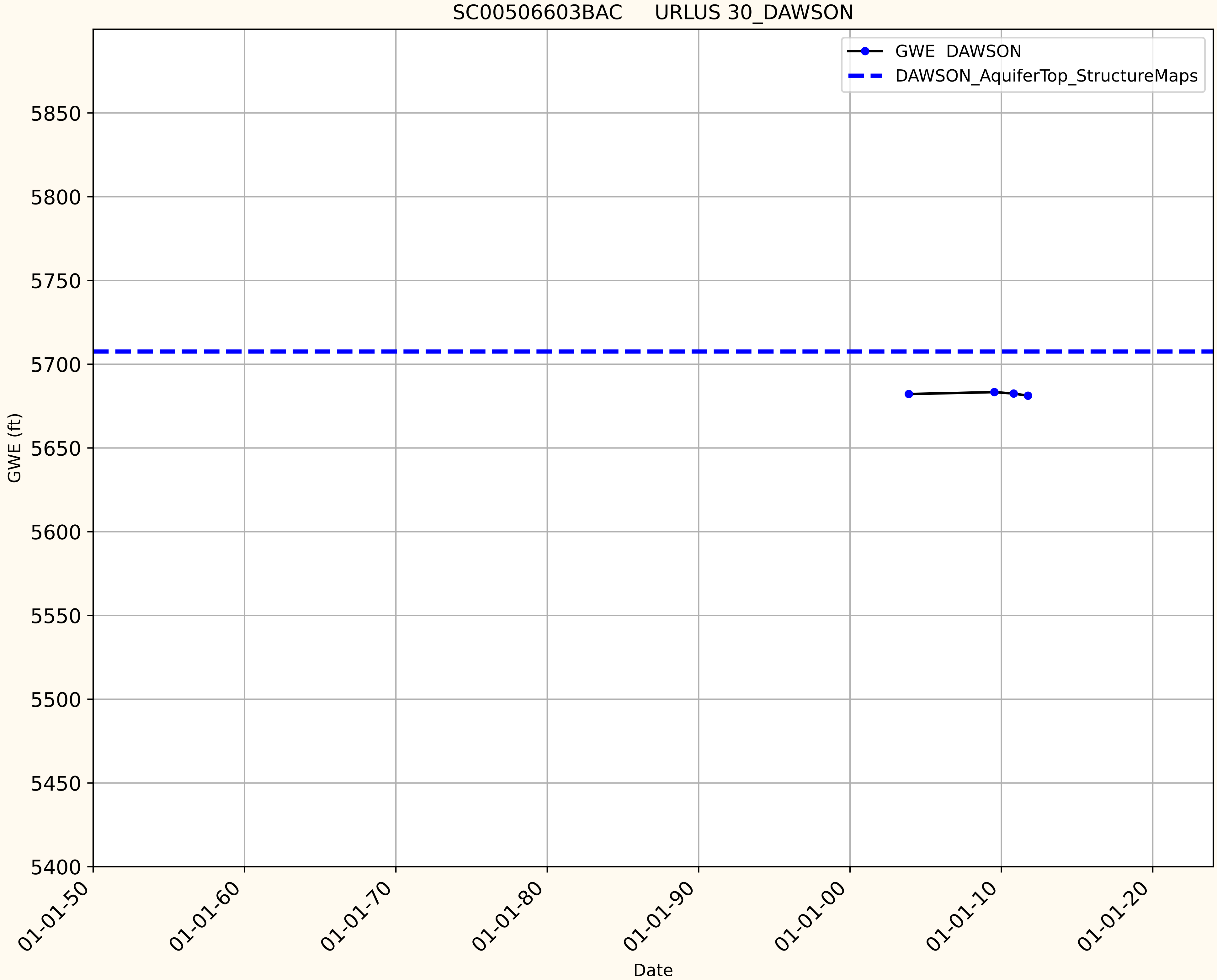
Well: SC00506708DDC URLUS 15
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
SC00506708DDC URLUS 15

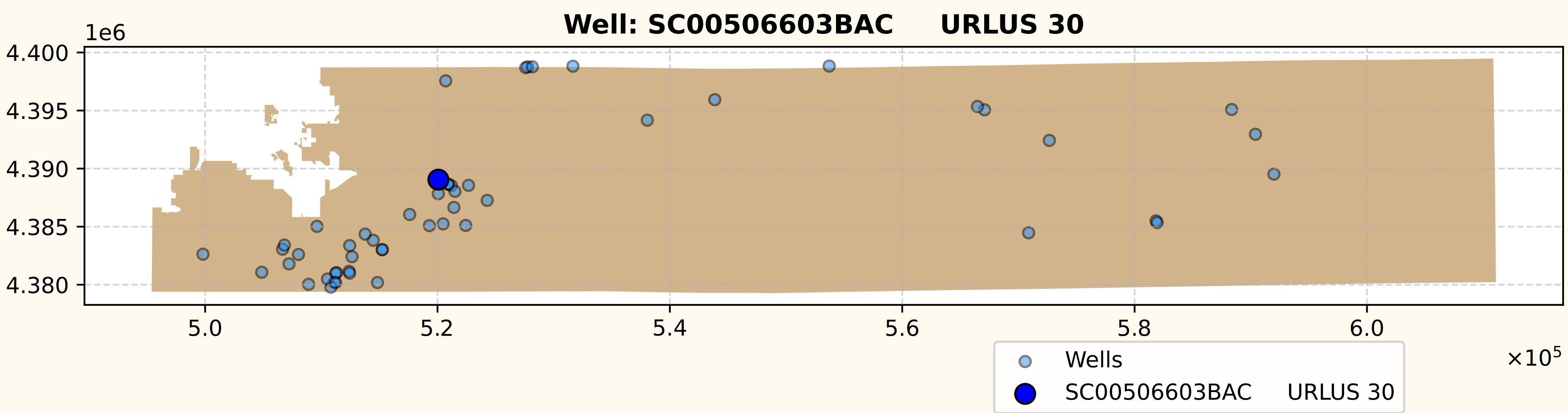

SC00506616DAA URLUS 21_DAWSON
GWE DAWSON
DAWSON_AquiferTop_StructureMaps
GWE (ft)
5400
5450
5500
5550
5600
5650
5700
5750
5800
5850
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20
Date

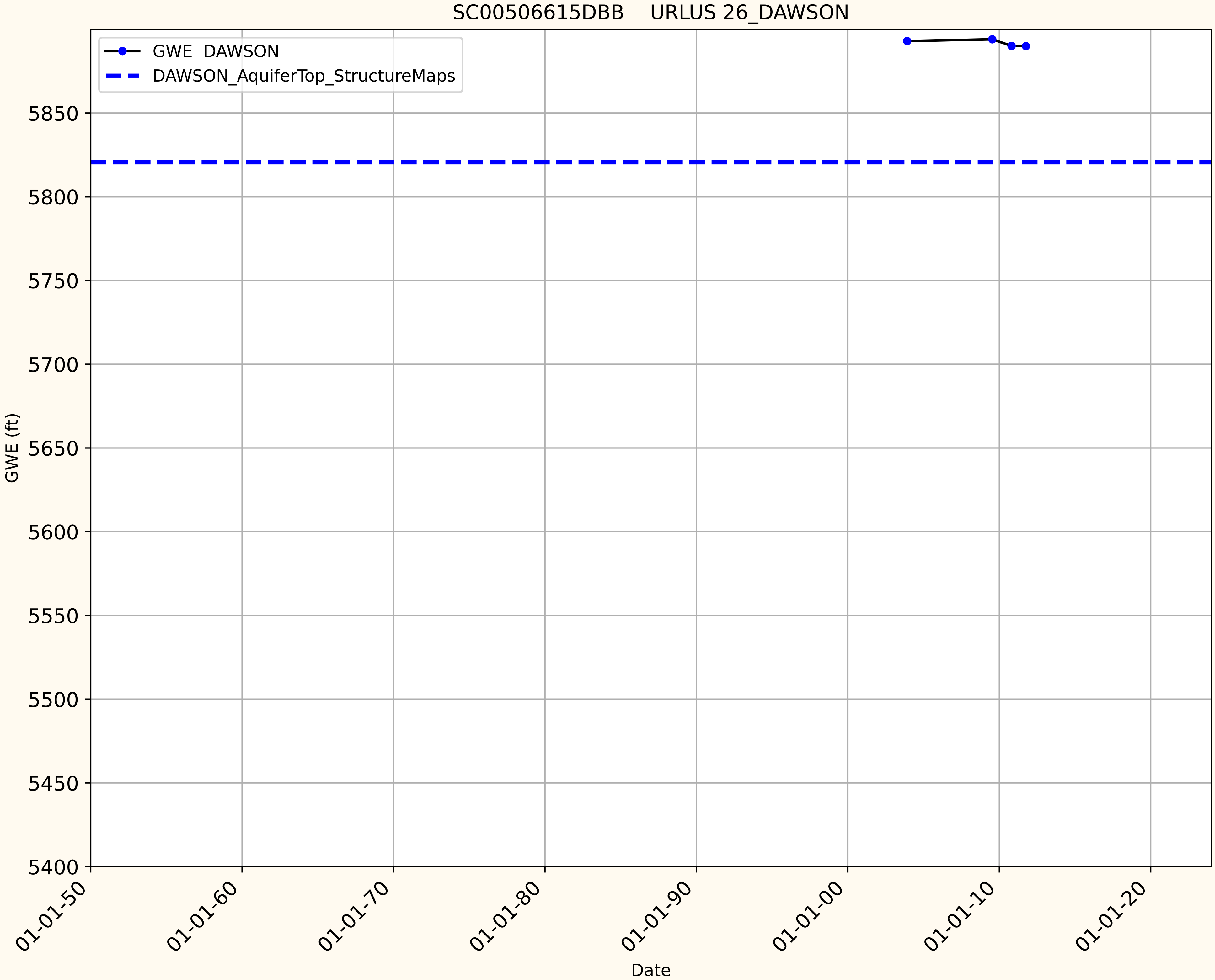

Well: SC00506616DAA URLUS 21
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
SC00506616DAA URLUS 21

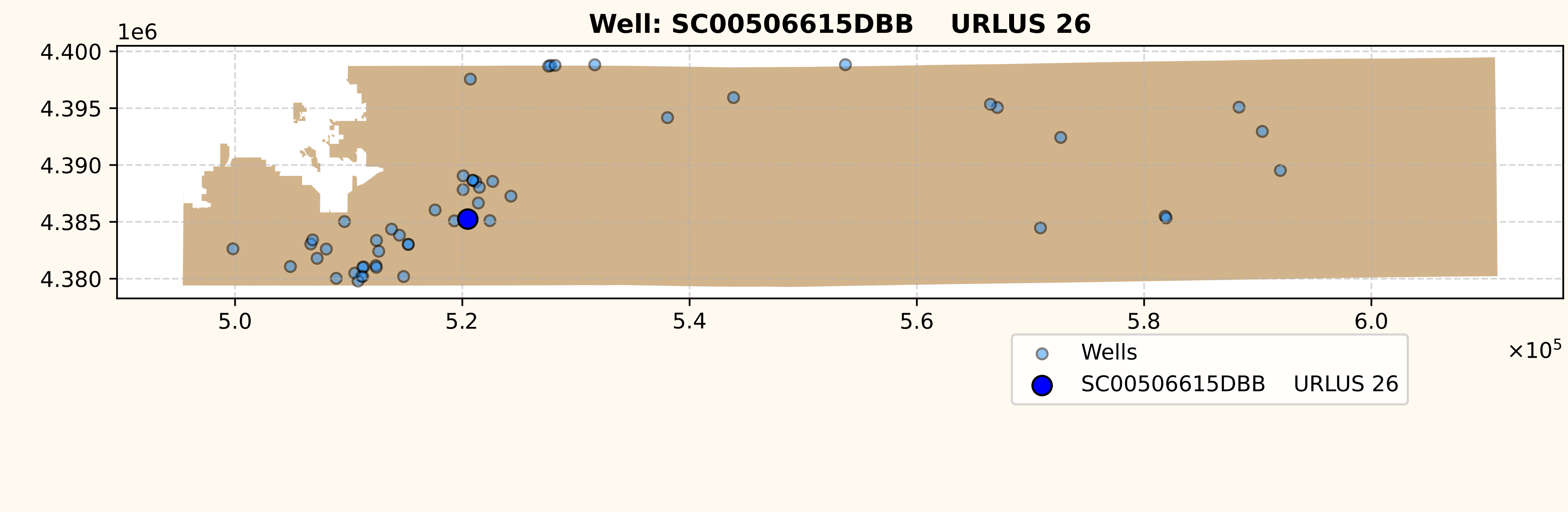

SC00506603CDC URLUS 19_DAWSON
GWE DAWSON
DAWSON_AquiferTop_StructureMaps
GWE (ft)
5850
5800
5750
5700
5650
5600
5550
5500
5450
5400
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20
Date

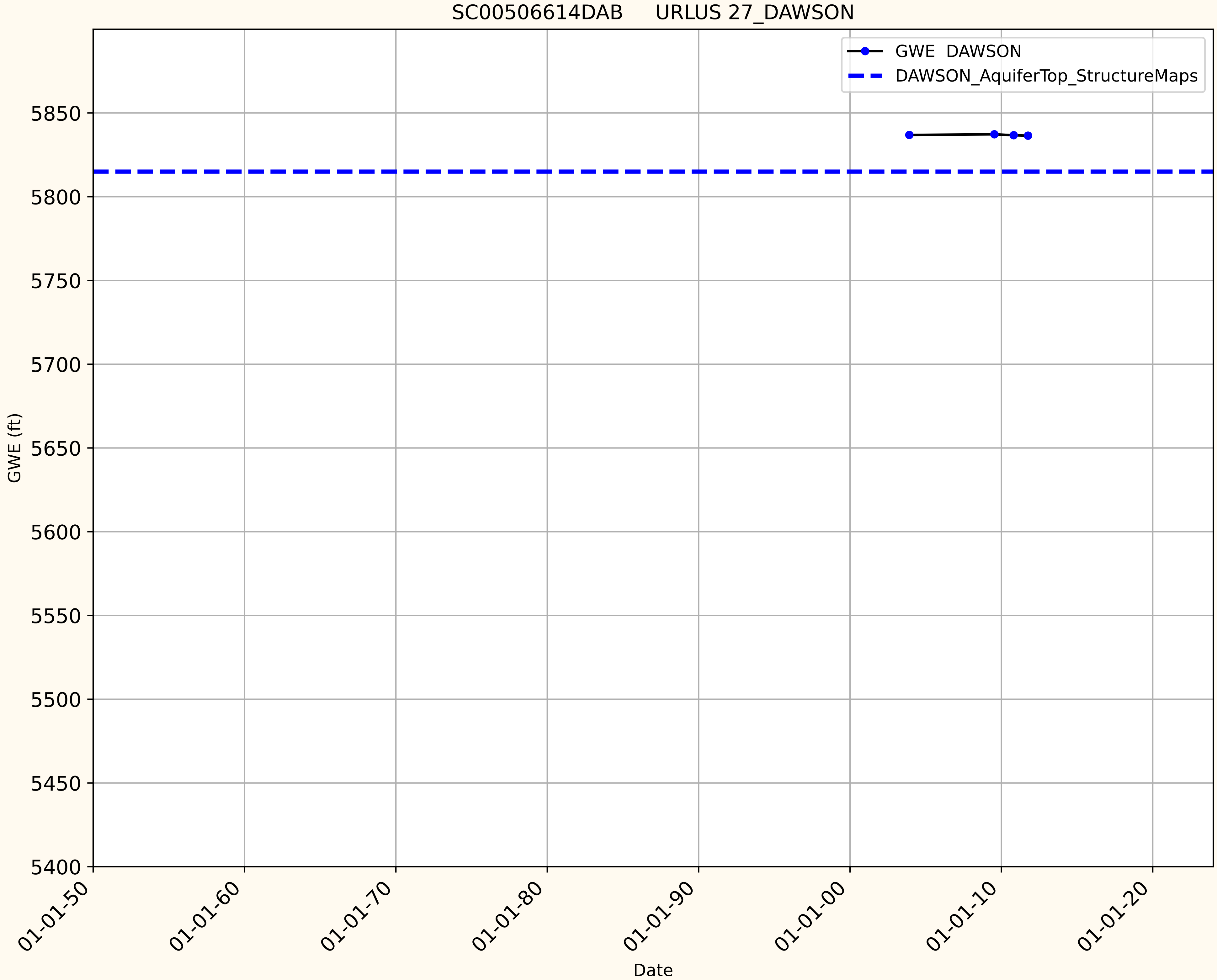

Well: SC00506603CDC URLUS 19
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
SC00506603CDC URLUS 19

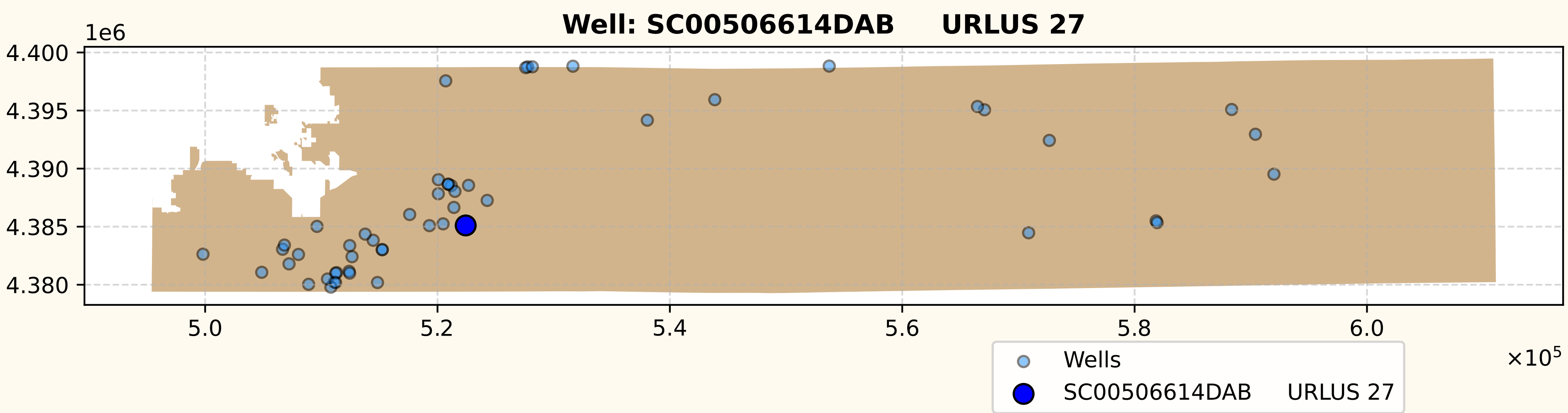

SC00506603BAC URLUS 30_DAWSON
GWE DAWSON
DAWSON_AquiferTop_StructureMaps
GWE (ft)
5850
5800
5750
5700
5650
5600
5550
5500
5450
5400
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20
Date

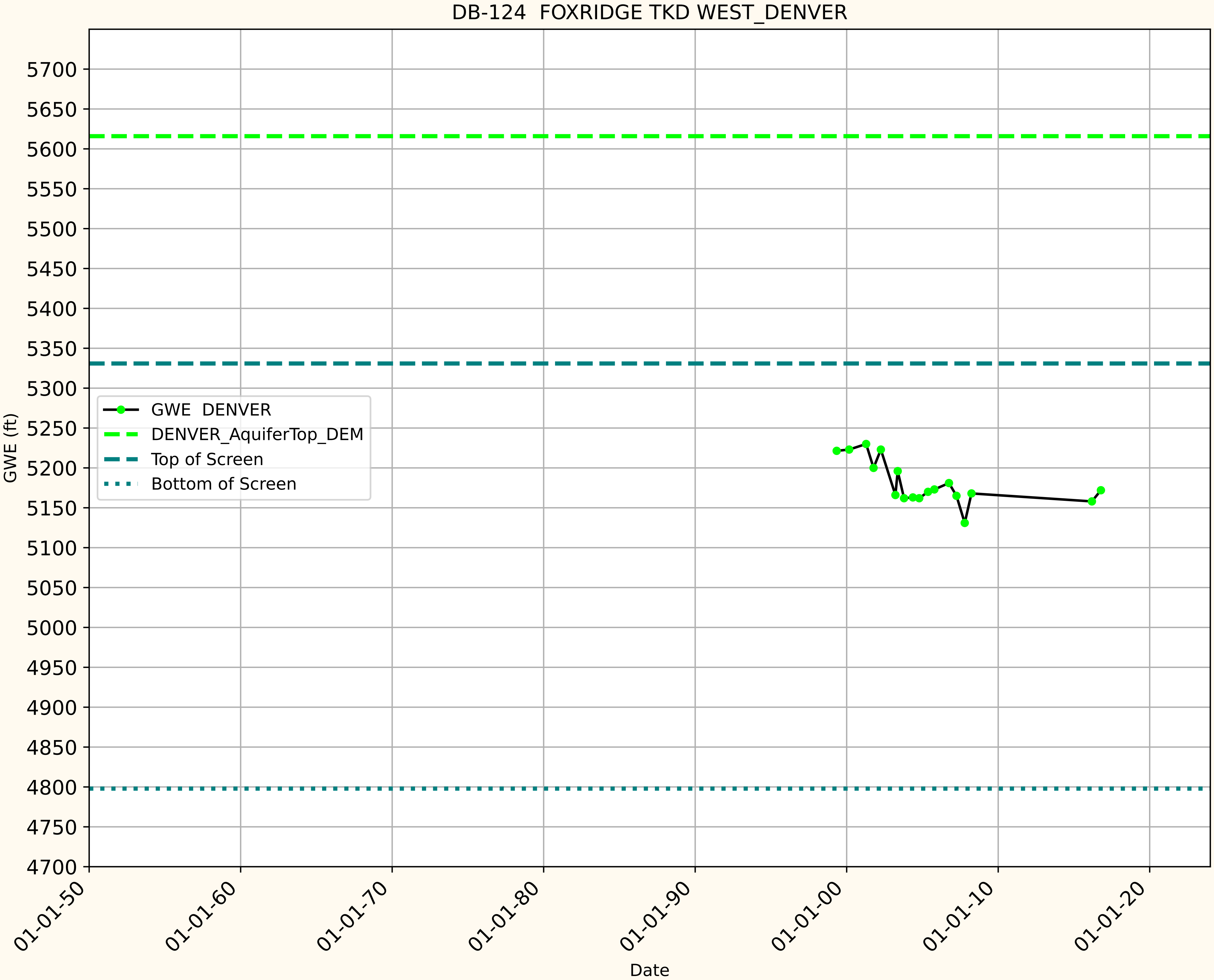

Well: SC00506603BAC URLUS 30
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
SC00506603BAC URLUS 30

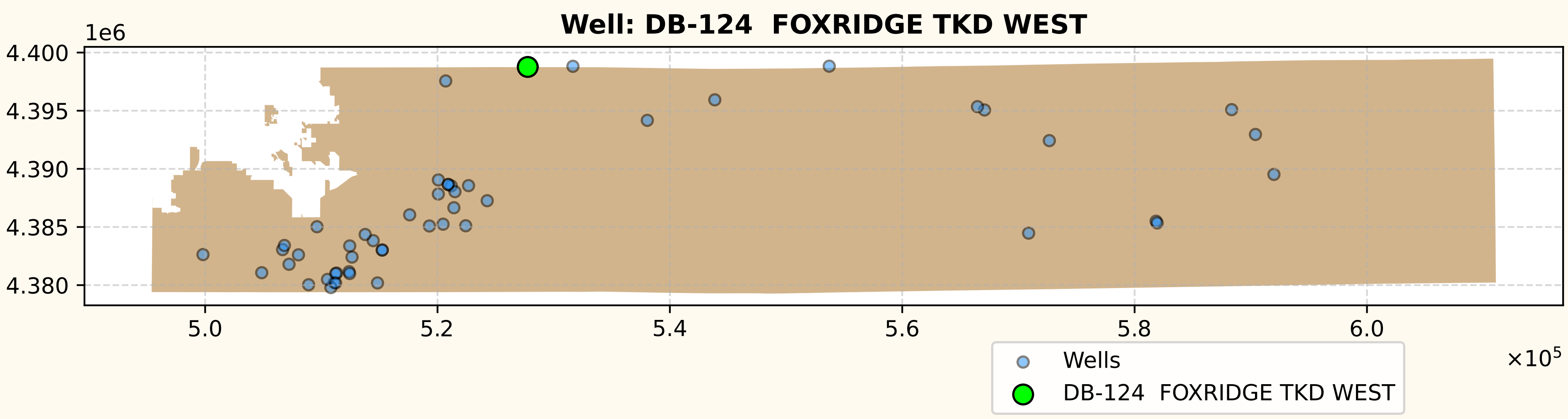

SC00506615DBB   URLUS 26_DAWSON
GWE DAWSON
DAWSON_AquiferTop_StructureMaps
GWE (ft)
5850
5800
5750
5700
5650
5600
5550
5500
5450
5400
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20
Date

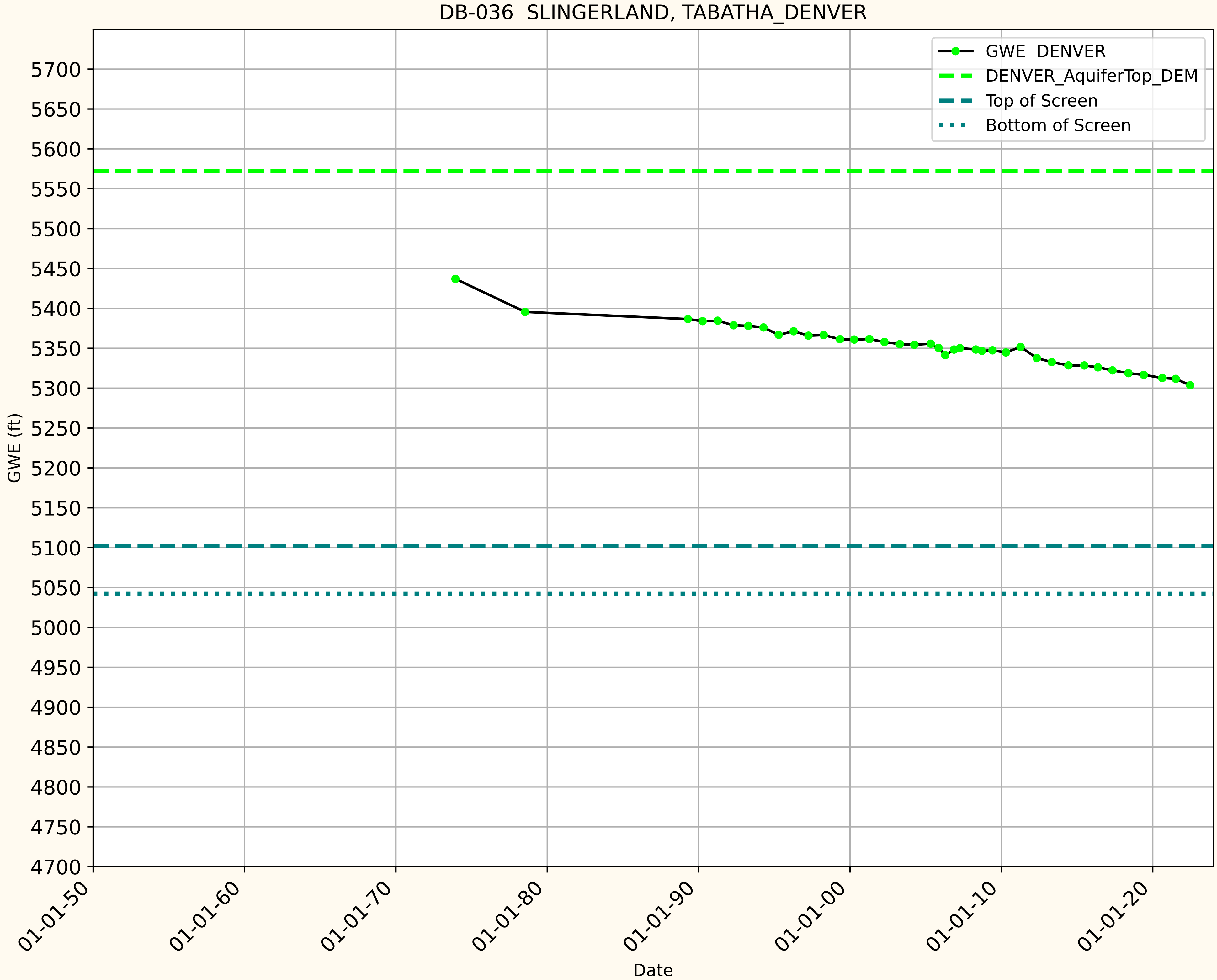

Well: SC00506615DBB   URLUS 26
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
SC00506615DBB   URLUS 26


SC00506614DAB URLUS 27_DAWSON
GWE DAWSON
DAWSON_AquiferTop_StructureMaps
GWE (ft)
5850
5800
5750
5700
5650
5600
5550
5500
5450
5400
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20
Date

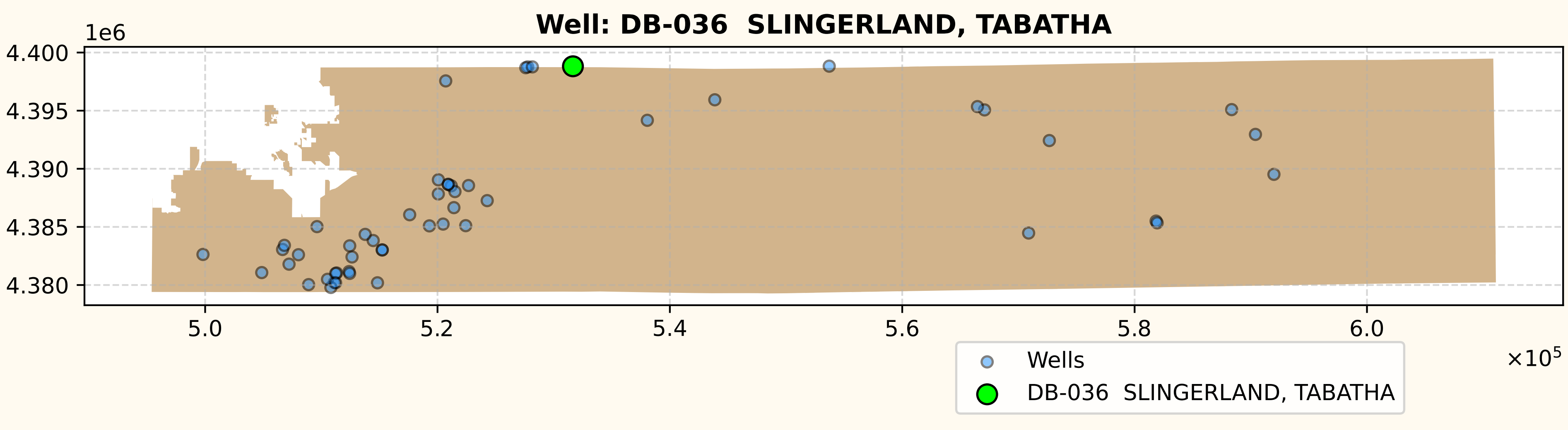

Well: SC00506614DAB URLUS 27
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
SC00506614DAB URLUS 27


DB-124 FOXRIDGE TKD WEST_DENVER
GWE (ft)
Date
GWE DENVER
DENVER_AquiferTop_DEM
Top of Screen
Bottom of Screen
5700
5650
5600
5550
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

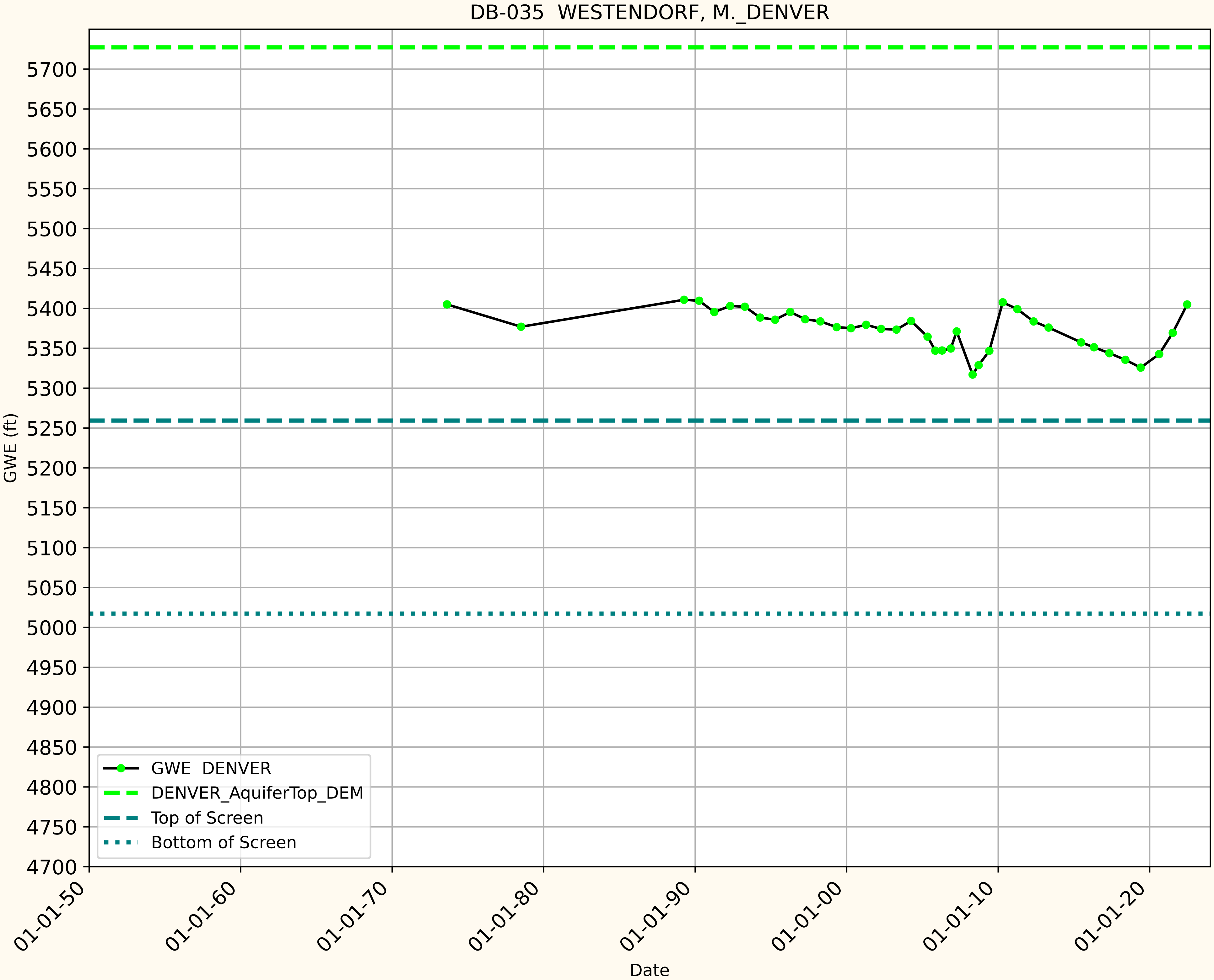

Well: DB-124 FOXRIDGE TKD WEST
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
DB-124 FOXRIDGE TKD WEST

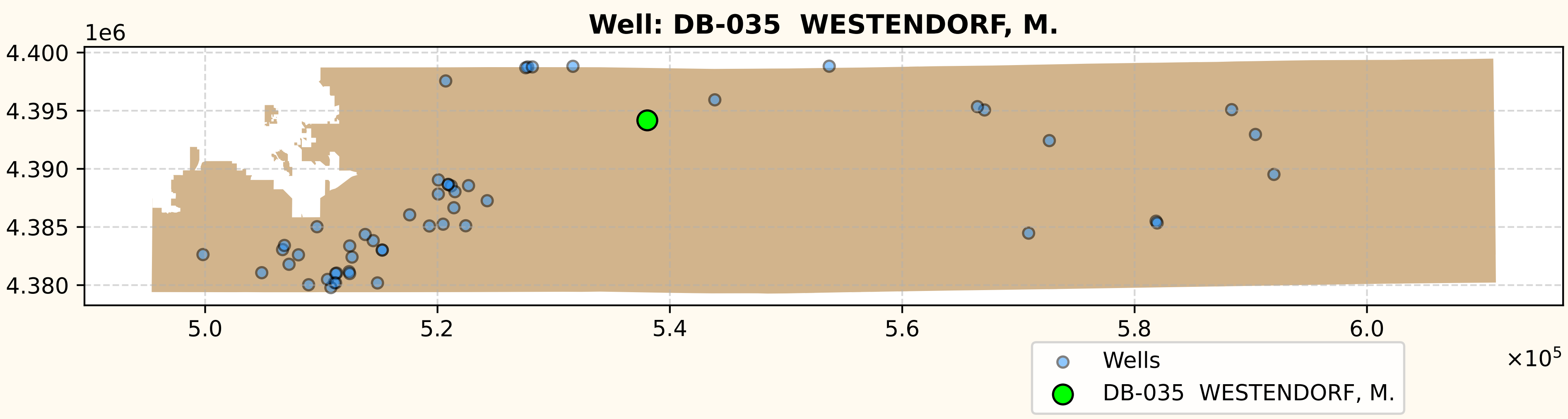


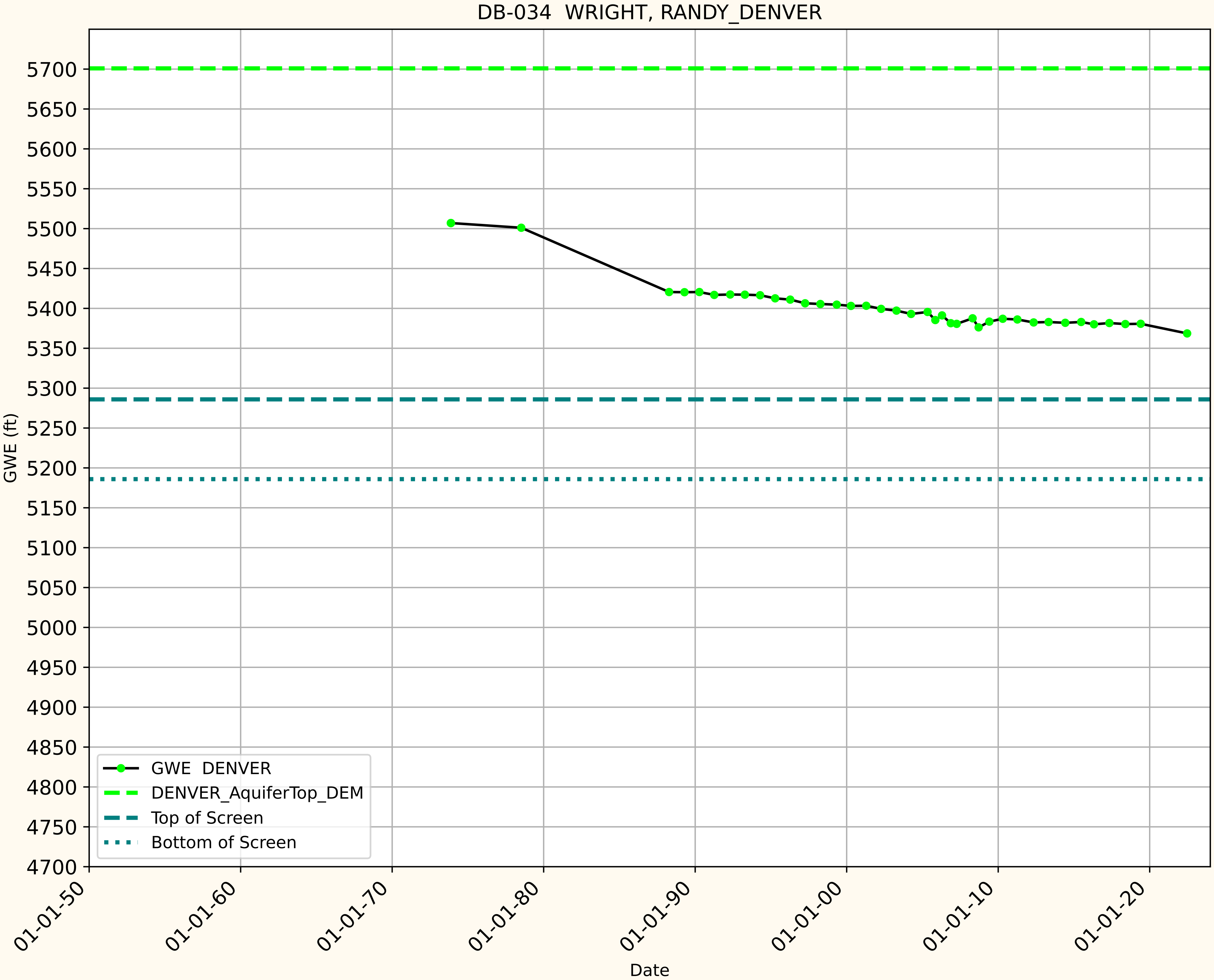
DB-036 SLINGERLAND, TABATHA_DENVER
GWE DENVER
DENVER_AquiferTop_DEM
Top of Screen
Bottom of Screen
GWE (ft)
5700
5650
5600
5550
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20
Date



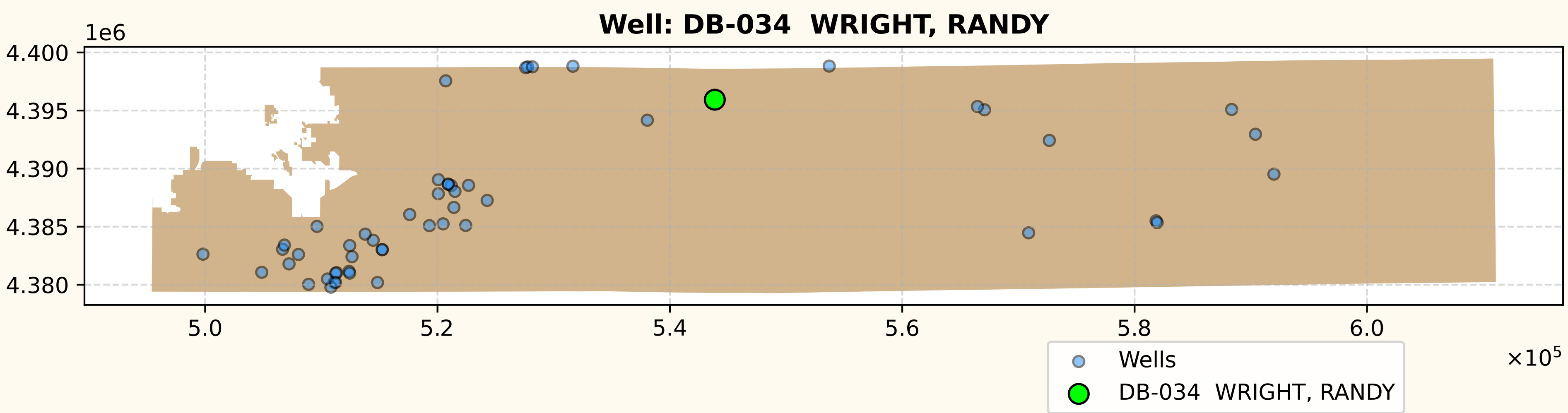
Well: DB-036 SLINGERLAND, TABATHA
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
DB-036 SLINGERLAND, TABATHA


DB-035 WESTENDORF, M._DENVER
GWE (ft)
Date
GWE DENVER
DENVER_AquiferTop_DEM
Top of Screen
Bottom of Screen
5700
5650
5600
5550
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

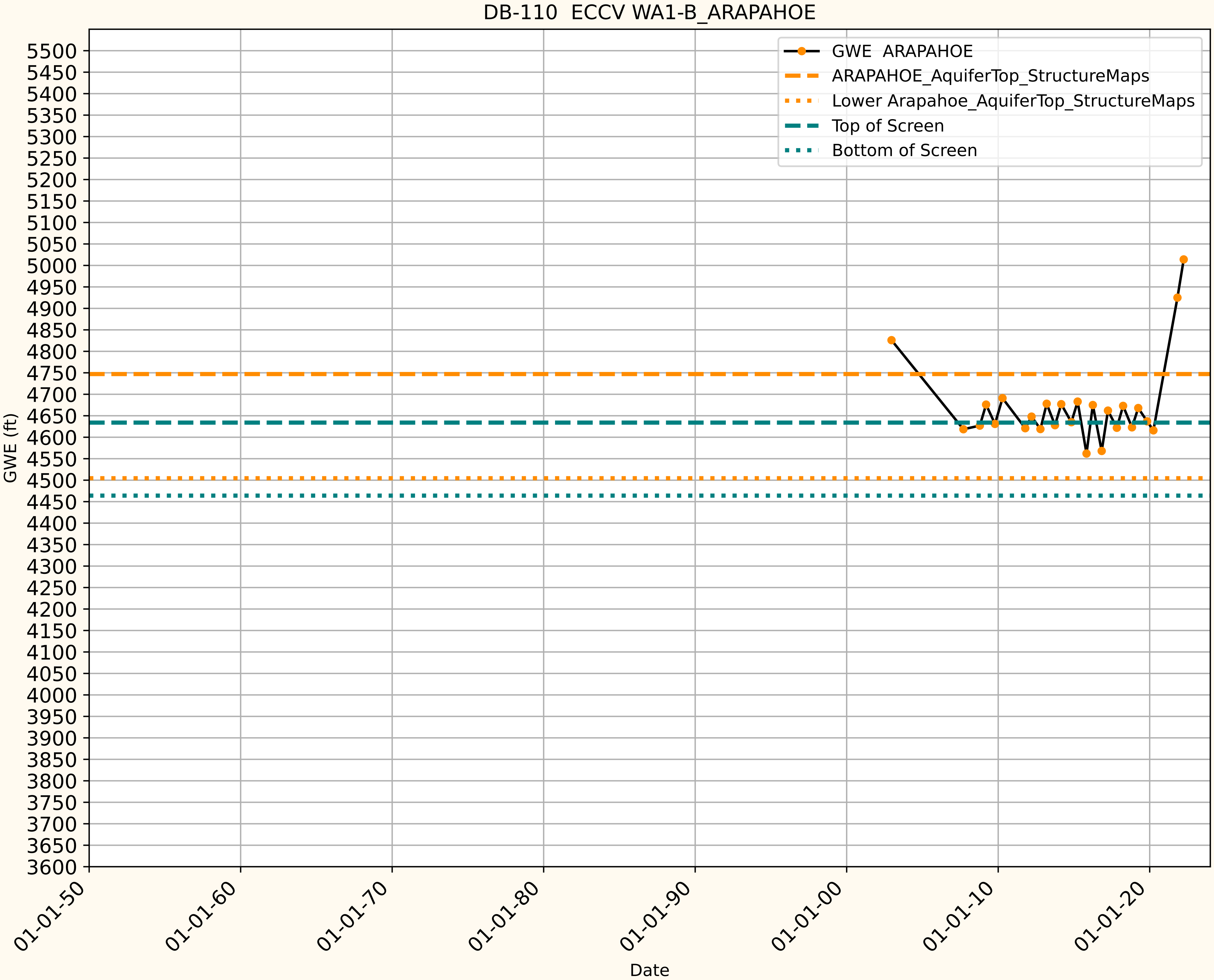

Well: DB-035 WESTENDORF, M.
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
DB-035 WESTENDORF, M.



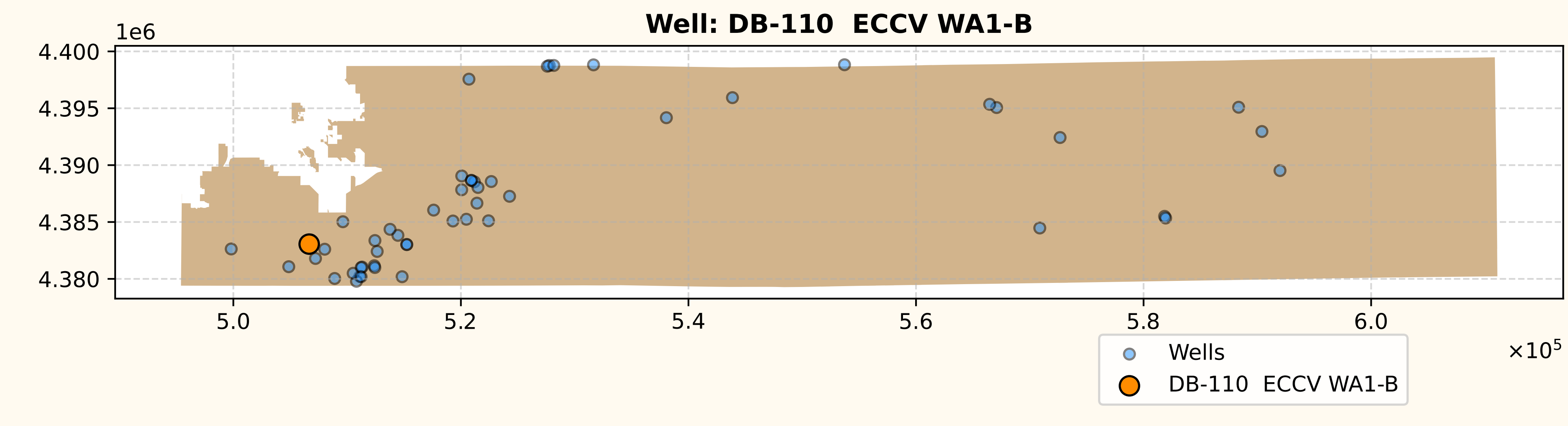
DB-034 WRIGHT, RANDY_DENVER
GWE (ft)
Date
GWE DENVER
DENVER_AquiferTop_DEM
Top of Screen
Bottom of Screen



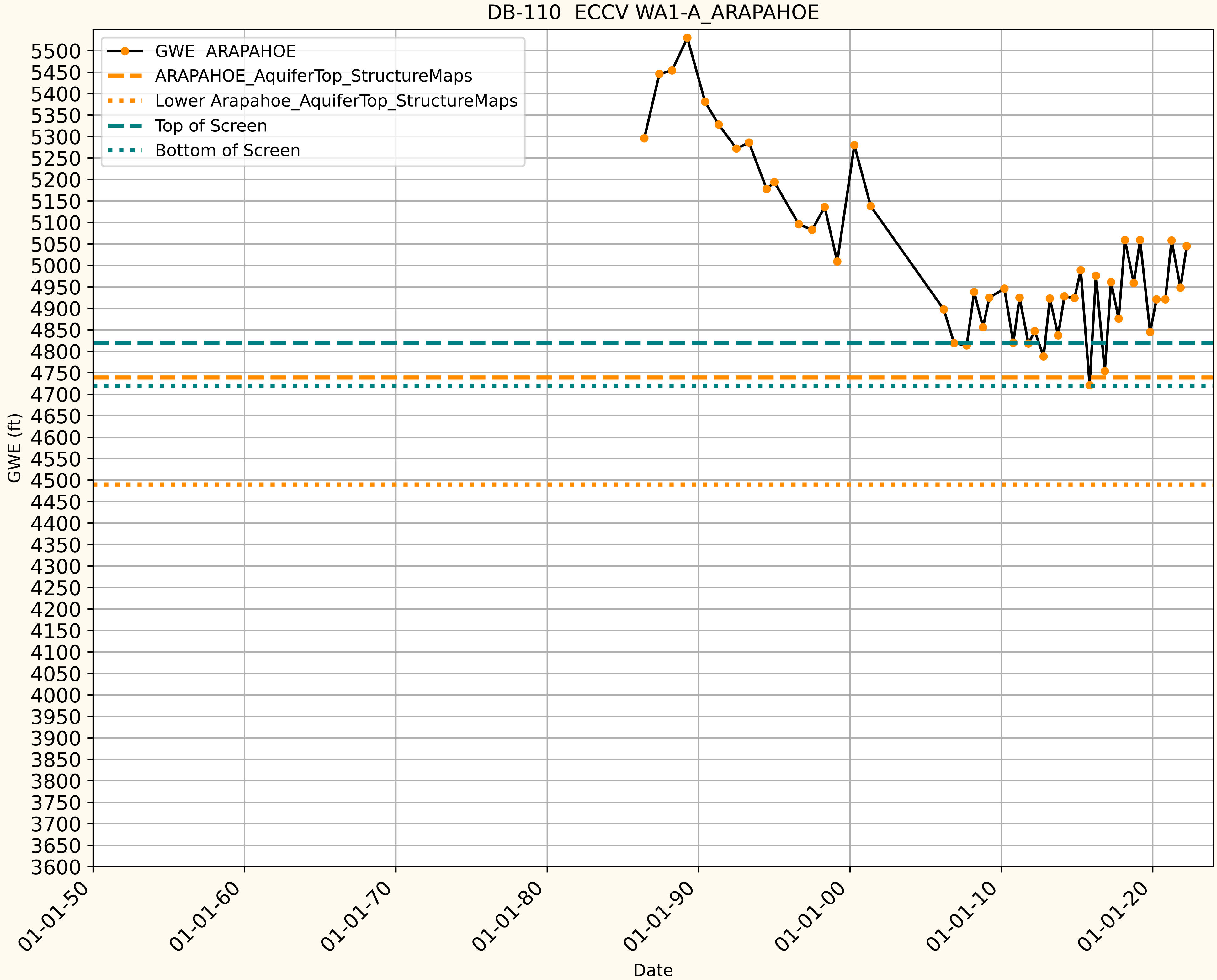
Well: DB-034 WRIGHT, RANDY
1e6
×10^5
Wells
DB-034 WRIGHT, RANDY



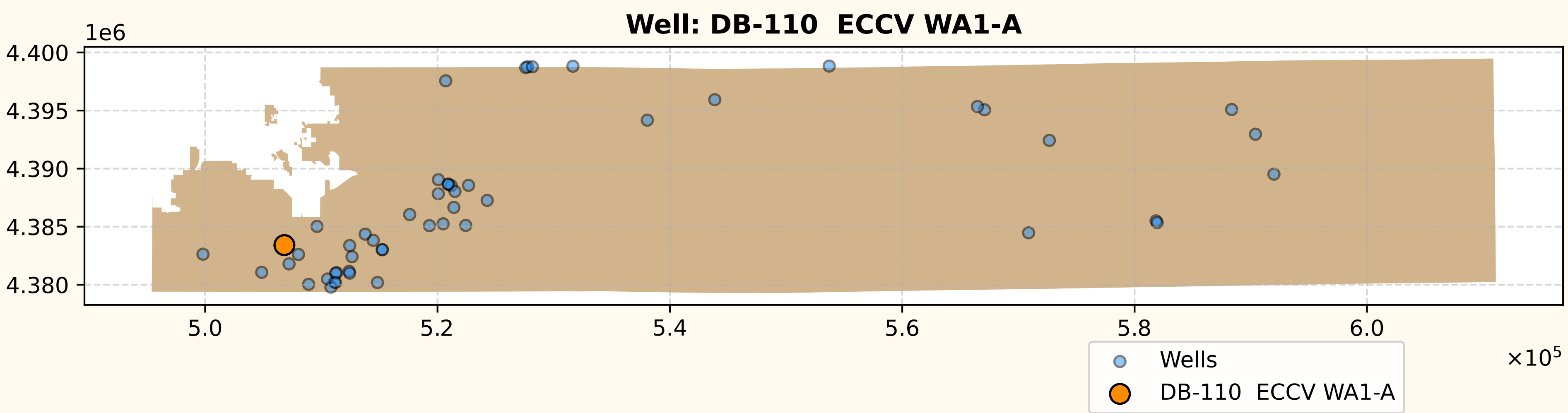
DB-110 ECCV WA1-B_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20



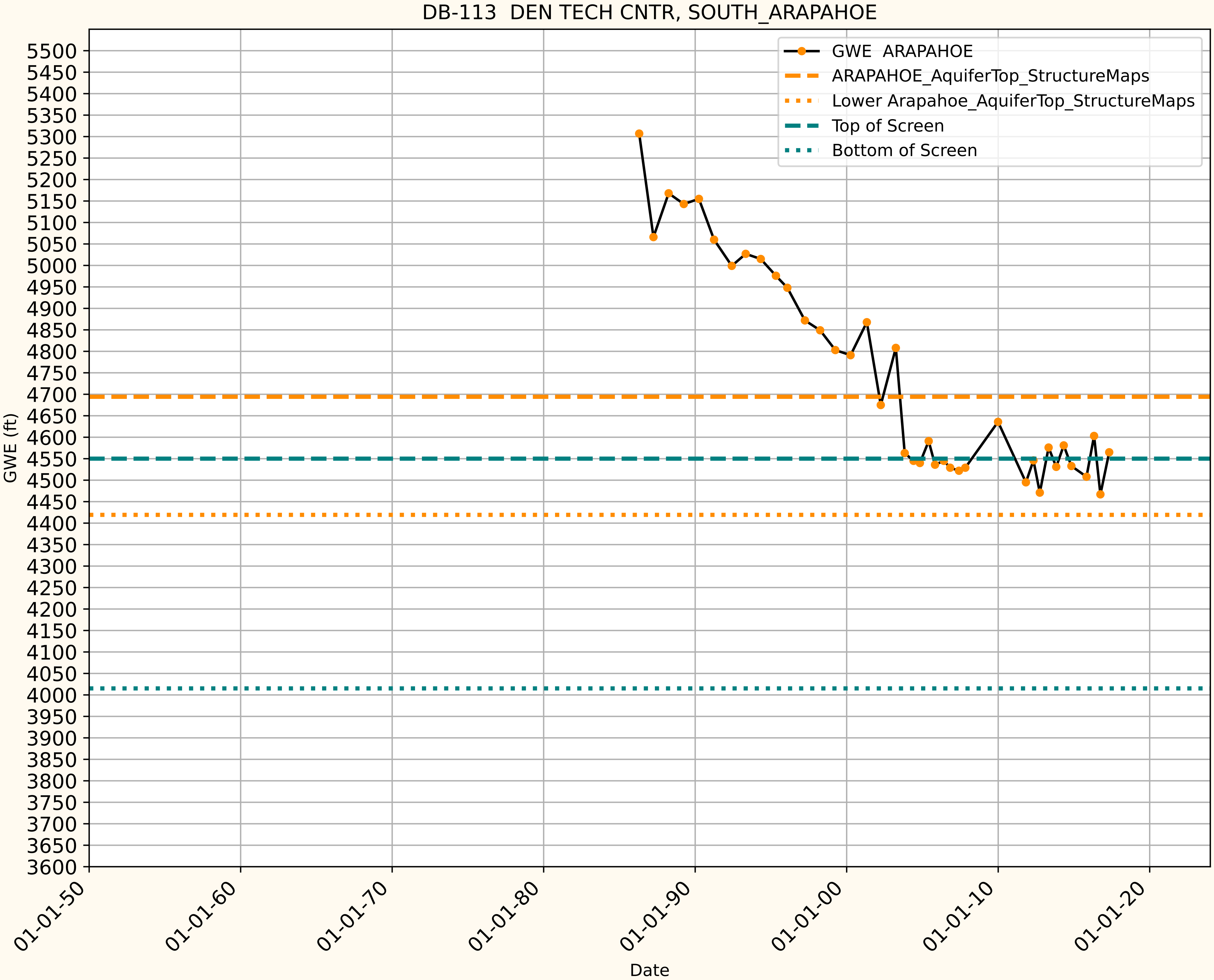
Well: DB-110 ECCV WA1-B
1e6
×10^5
Wells
DB-110 ECCV WA1-B

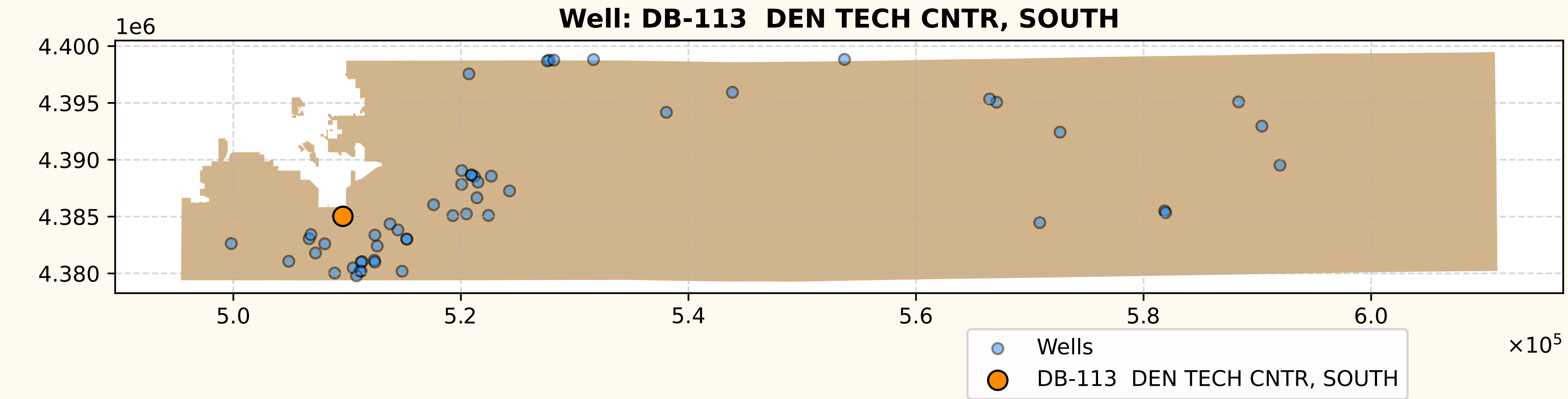


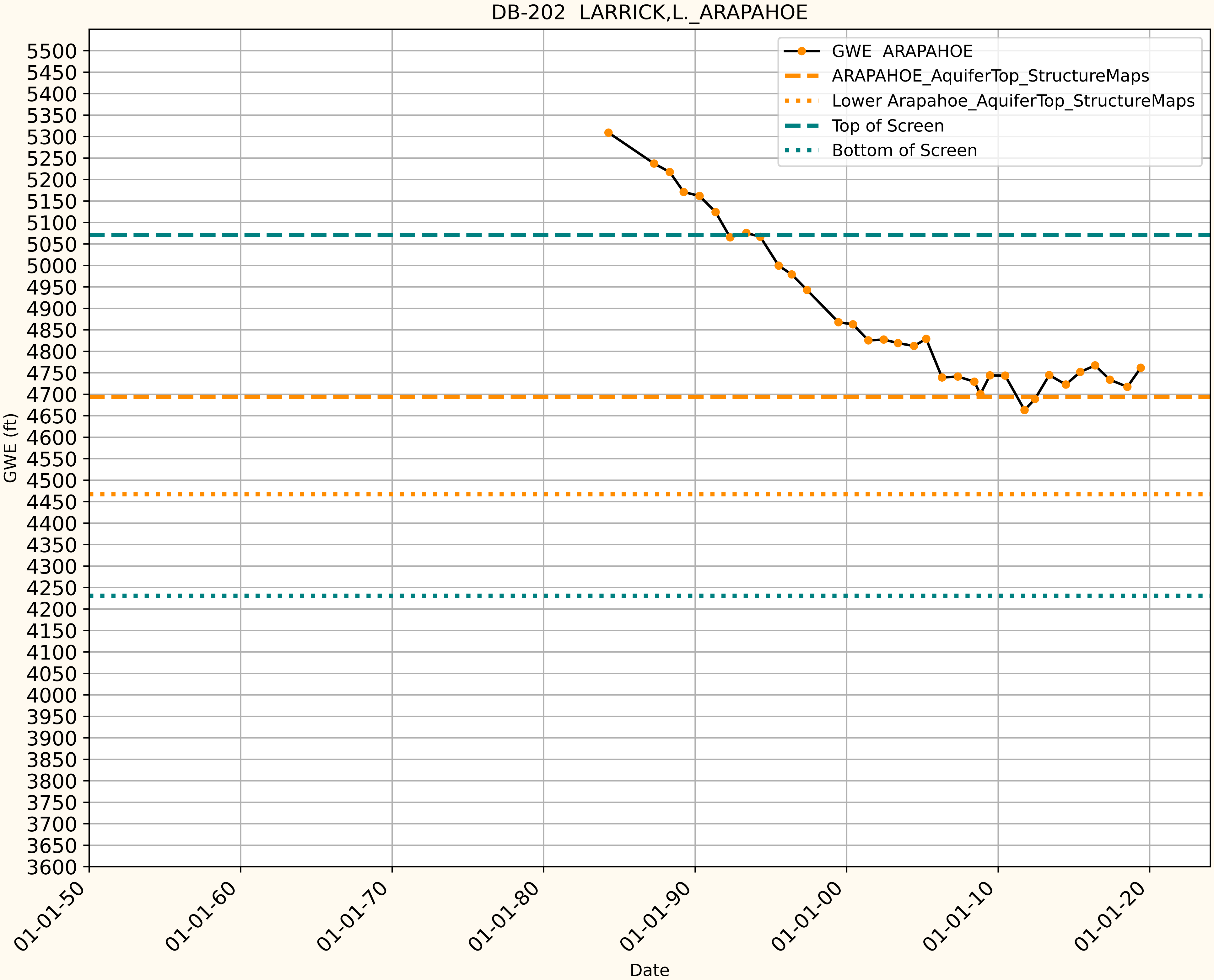
DB-110 ECCV WA1-A_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
3750
3700
3650
3600
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

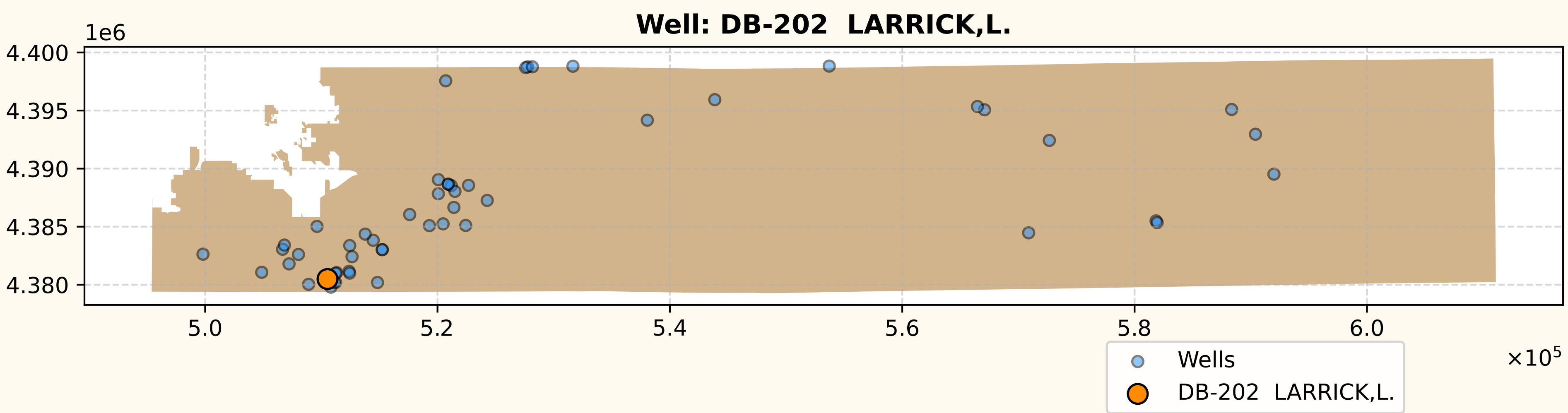


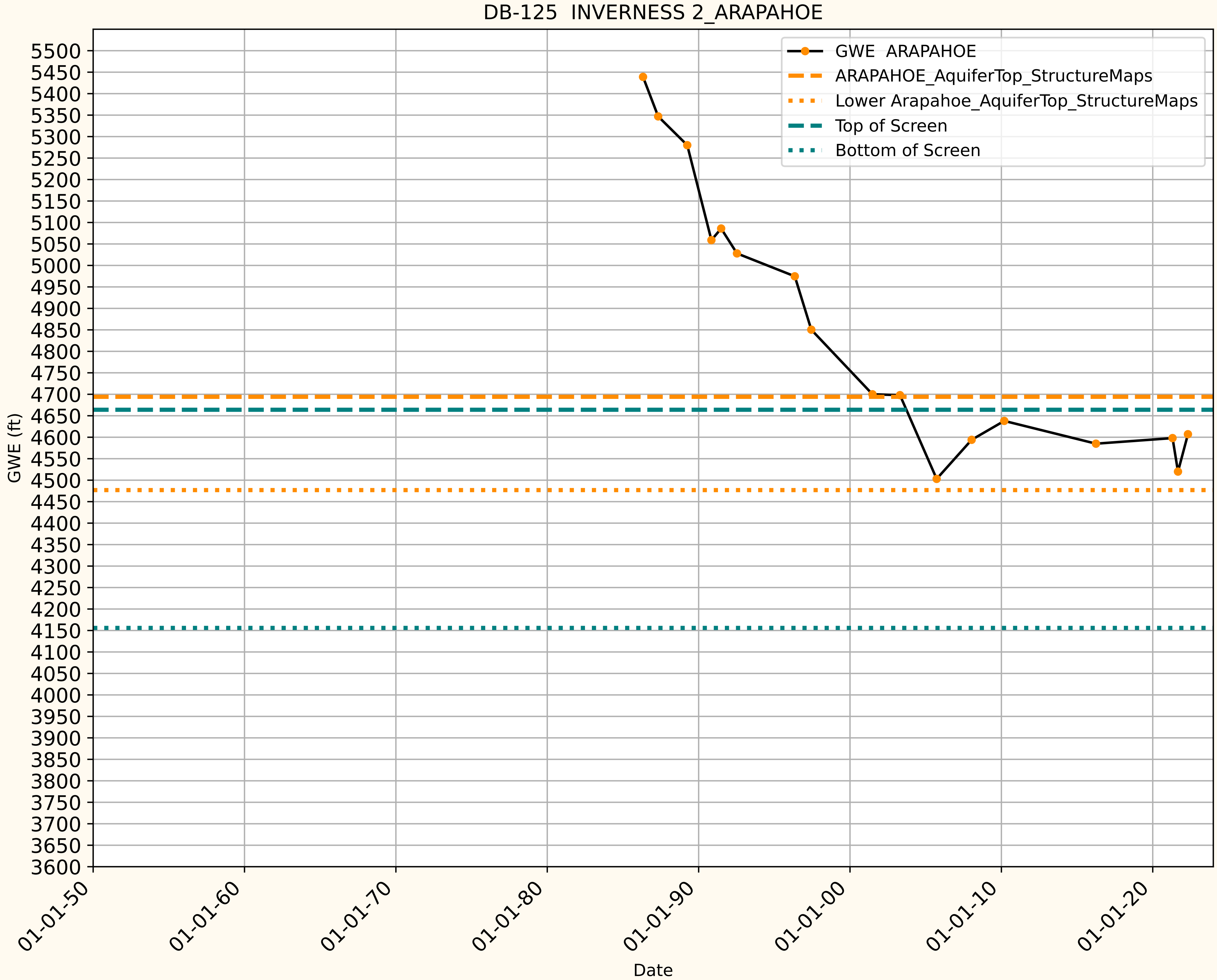
Well: DB-110 ECCV WA1-A
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
DB-110 ECCV WA1-A

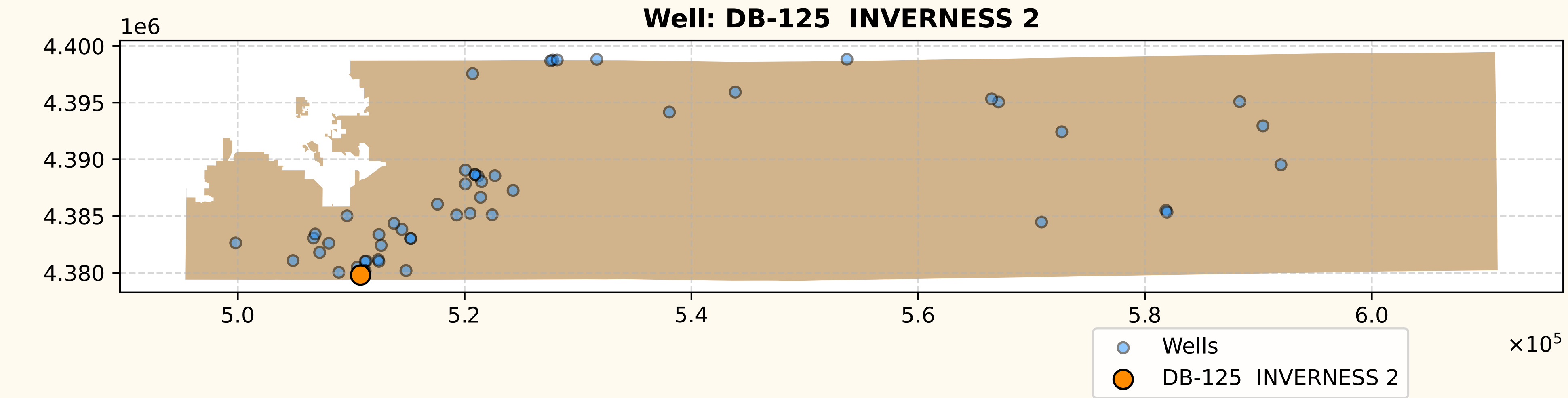

DB-113 DEN TECH CNTR, SOUTH_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

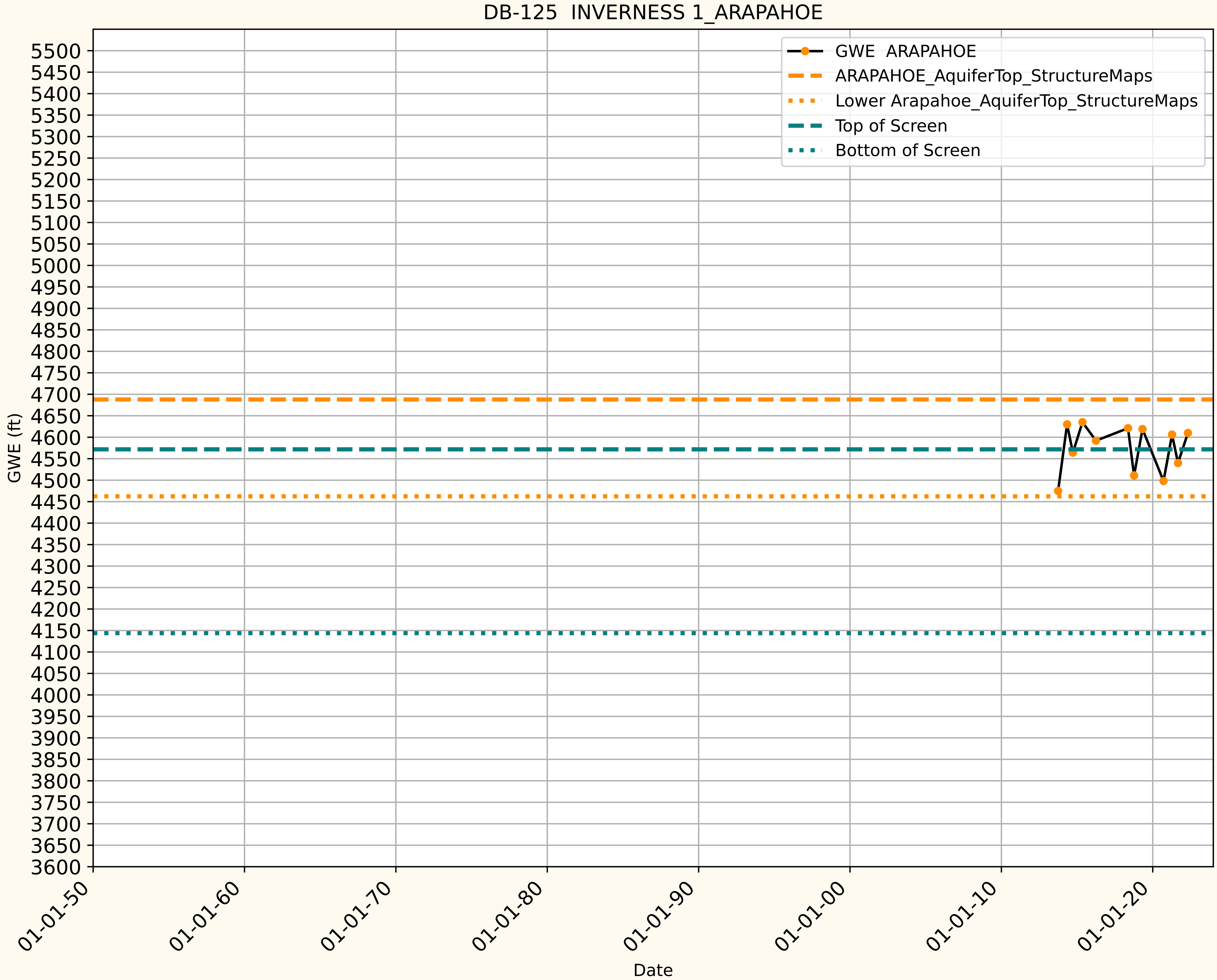

Well: DB-113 DEN TECH CNTR, SOUTH
1e6
$\times10^5$
Wells
DB-113 DEN TECH CNTR, SOUTH


DB-202 LARRICK,L._ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

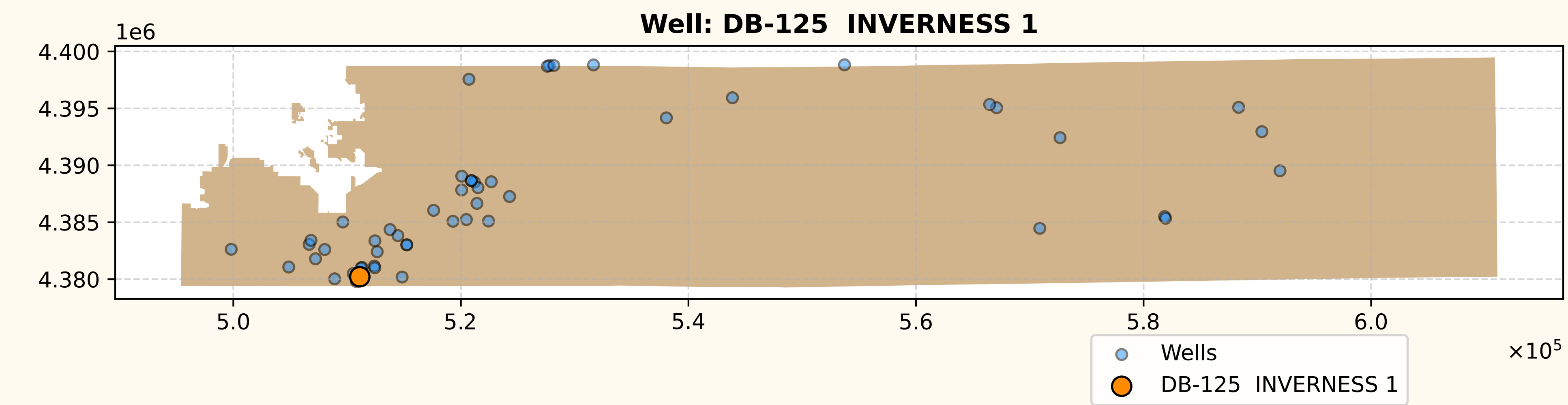

Well: DB-202 LARRICK,L.
1e6
×10^5
Wells
DB-202 LARRICK,L.


DB-125 INVERNESS 2_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

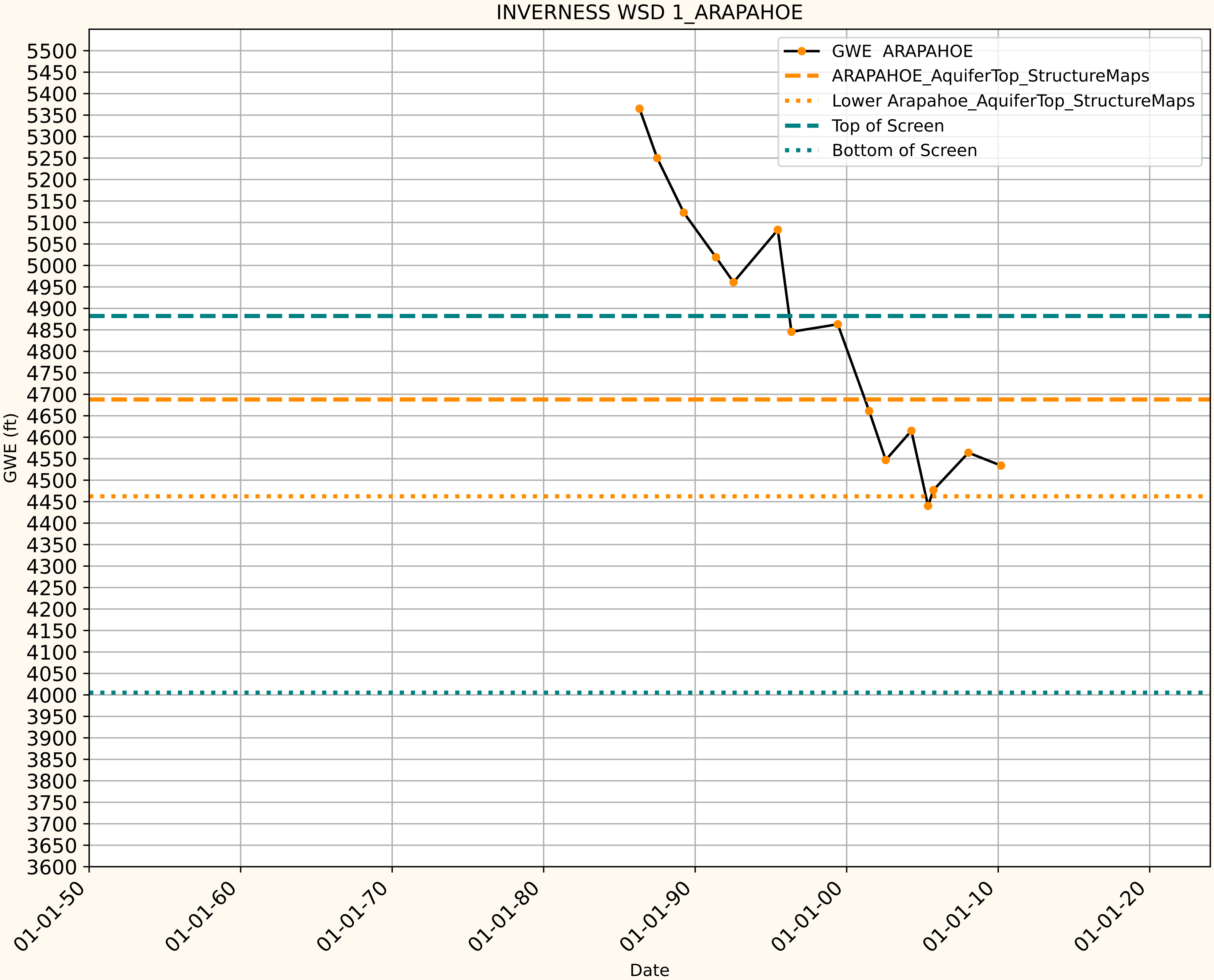

Well: DB-125 INVERNESS 2
1e6
×10^5
Wells
DB-125 INVERNESS 2

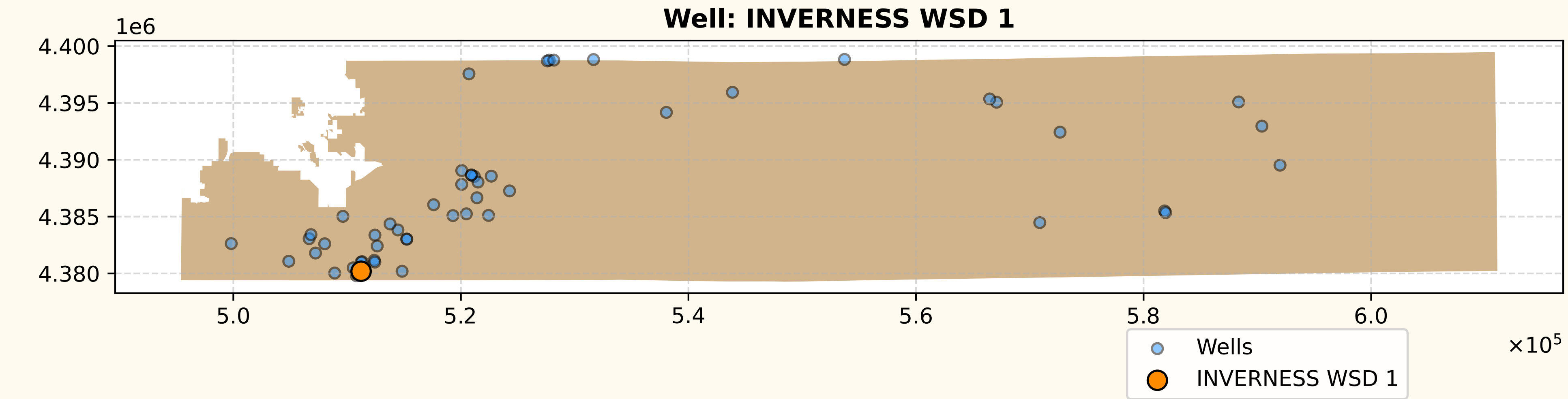


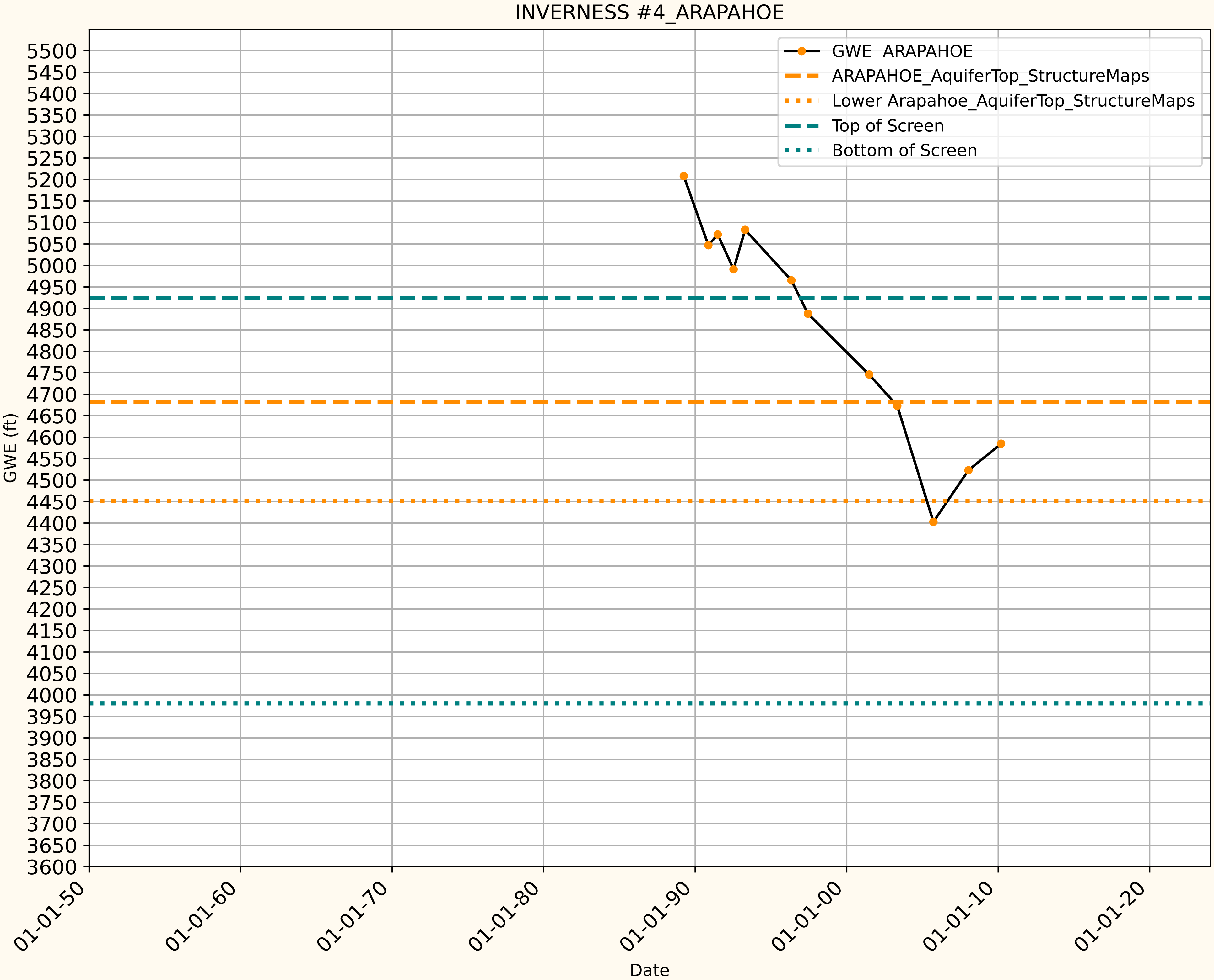
DB-125 INVERNESS 1_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
3750
3700
3650
3600
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20



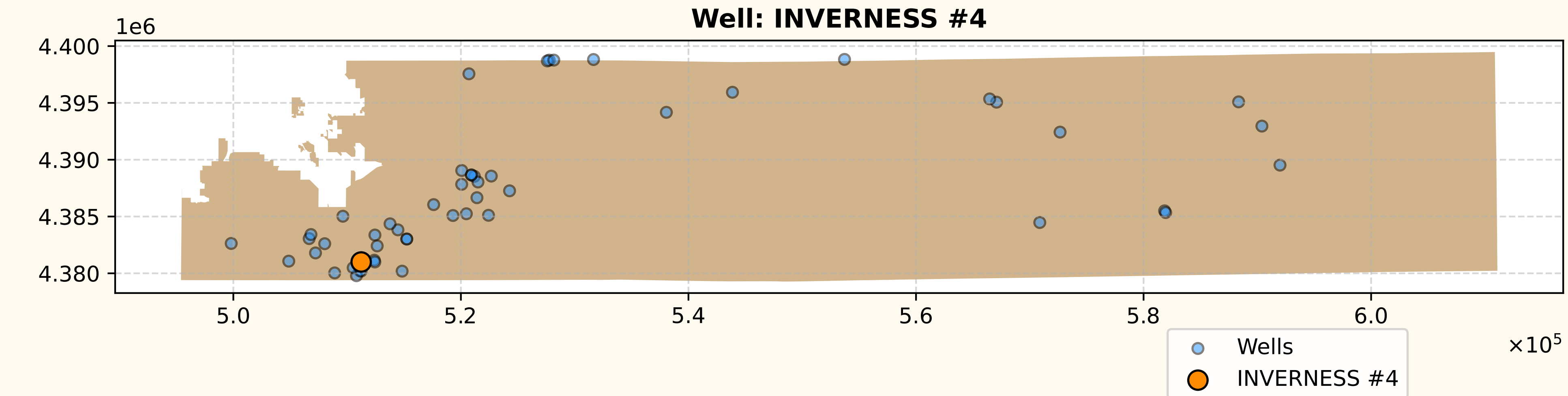
Well: DB-125 INVERNESS 1
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
DB-125 INVERNESS 1


INVERNESS WSD 1_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

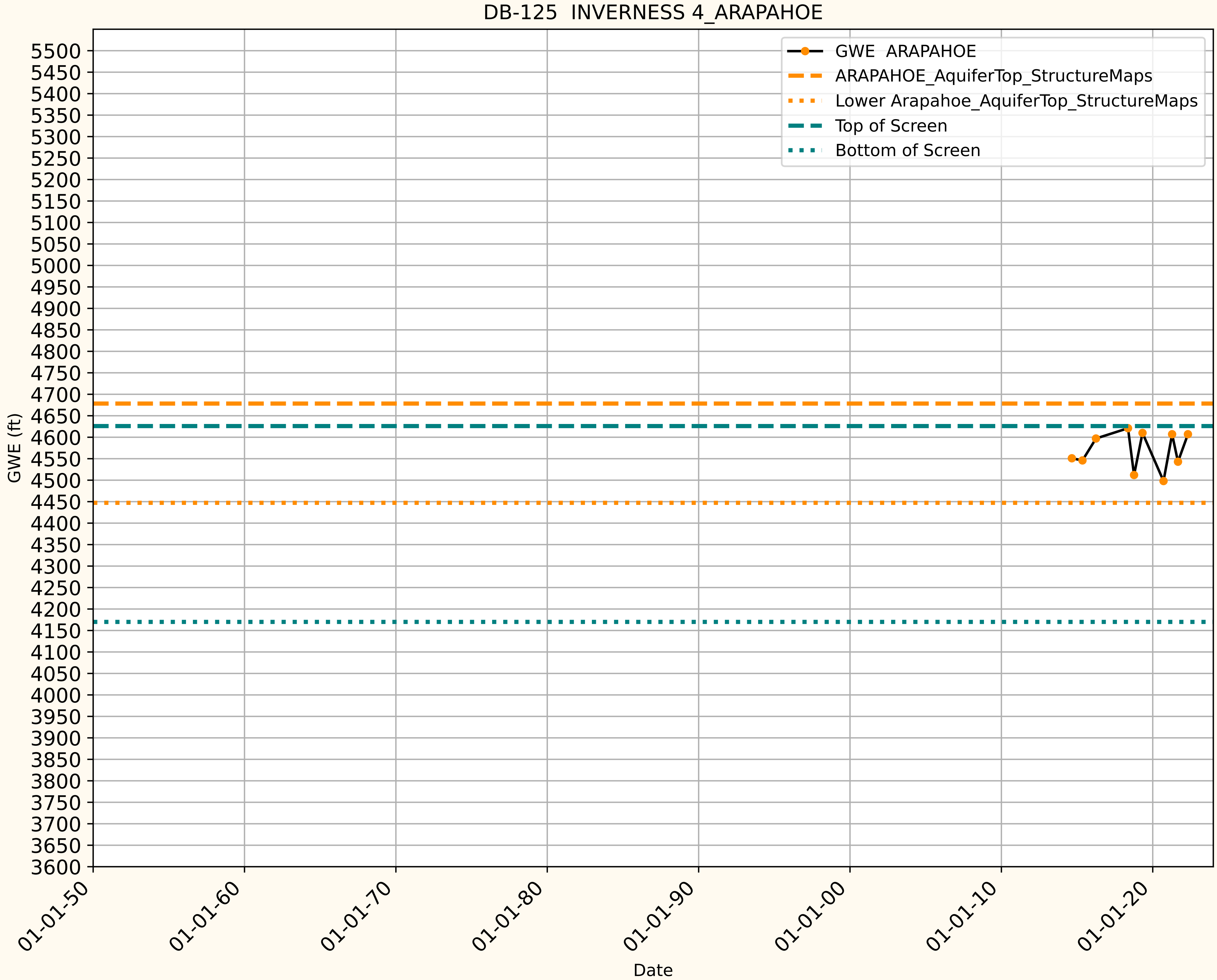

Well: INVERNESS WSD 1
1e6
×10^5
Wells
INVERNESS WSD 1



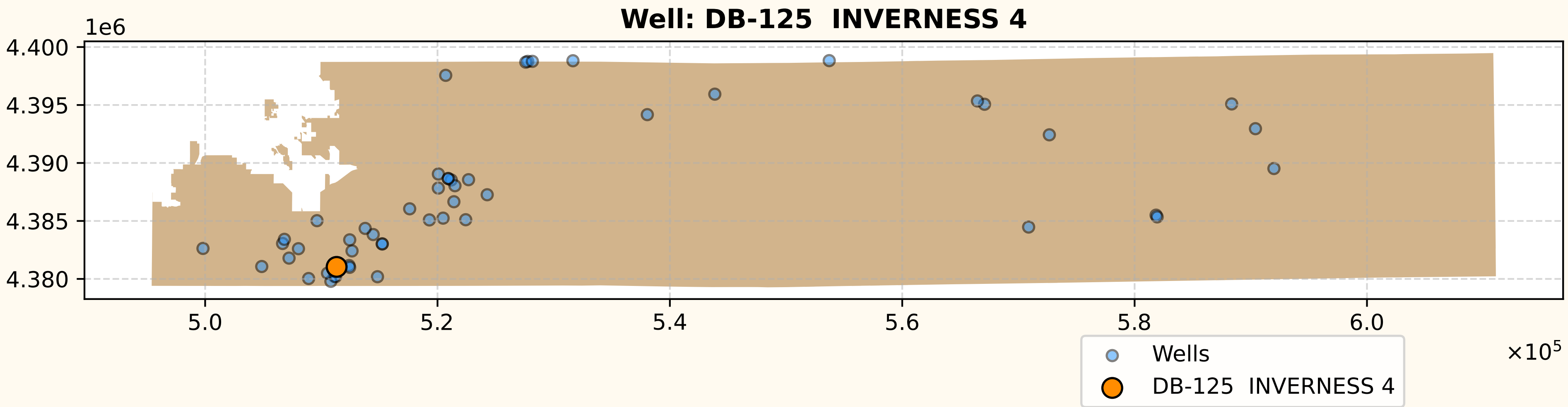
INVERNESS #4_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
3750
3700
3650
3600
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20



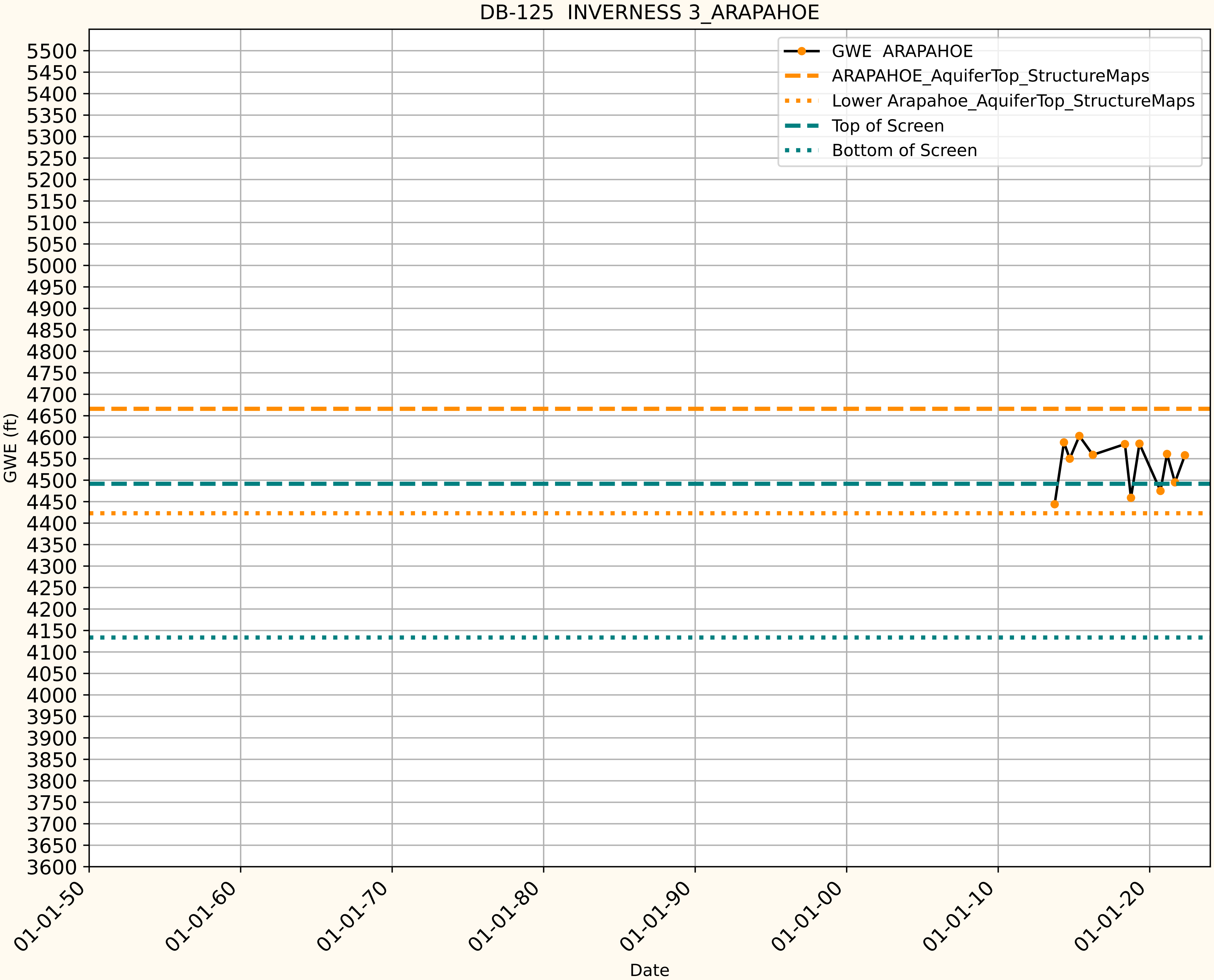
Well: INVERNESS #4
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
INVERNESS #4

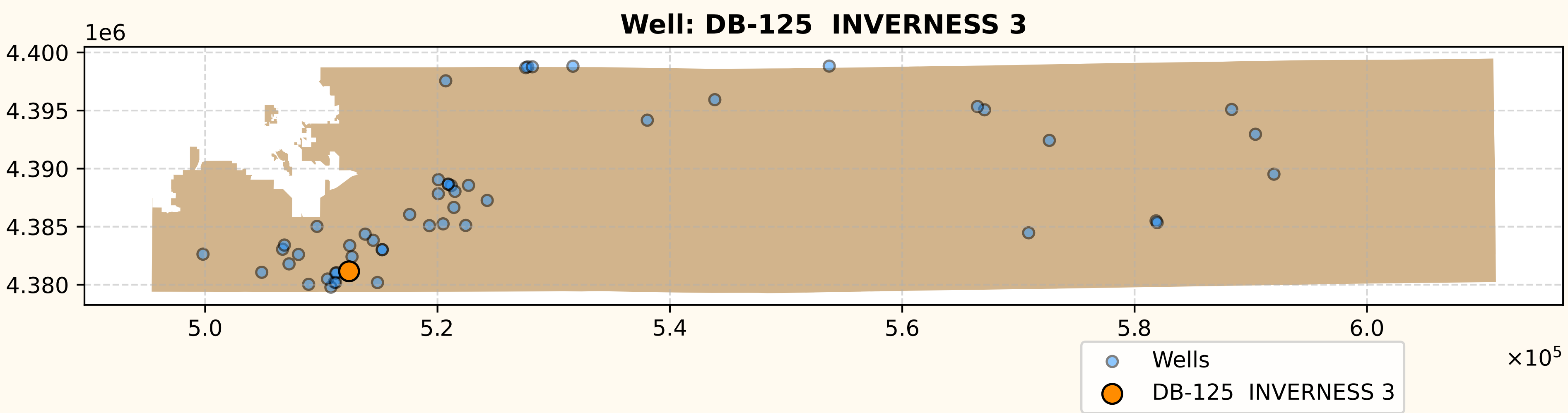


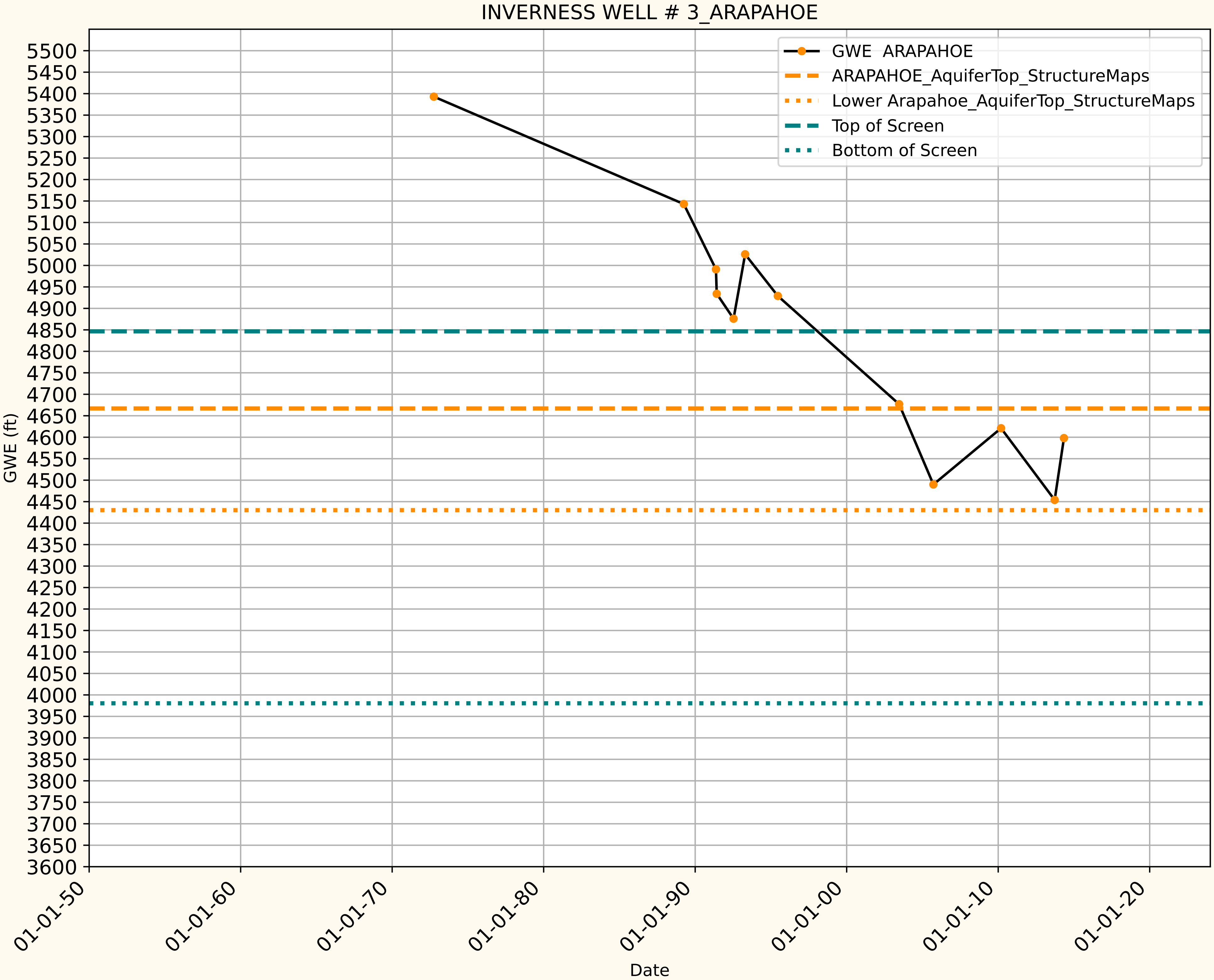
DB-125 INVERNESS 4_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
3750
3700
3650
3600
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20
Date

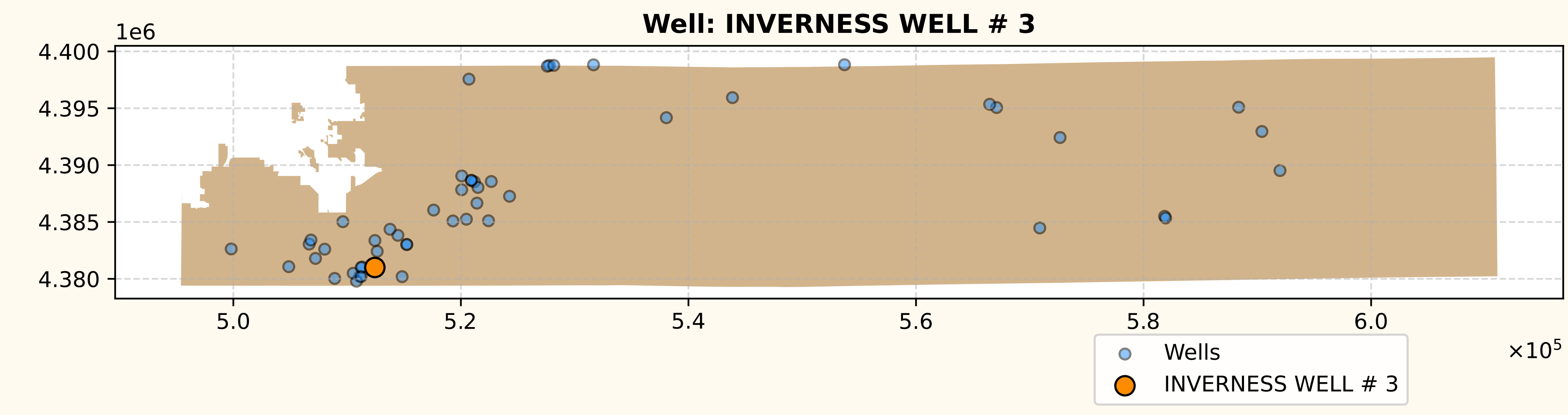


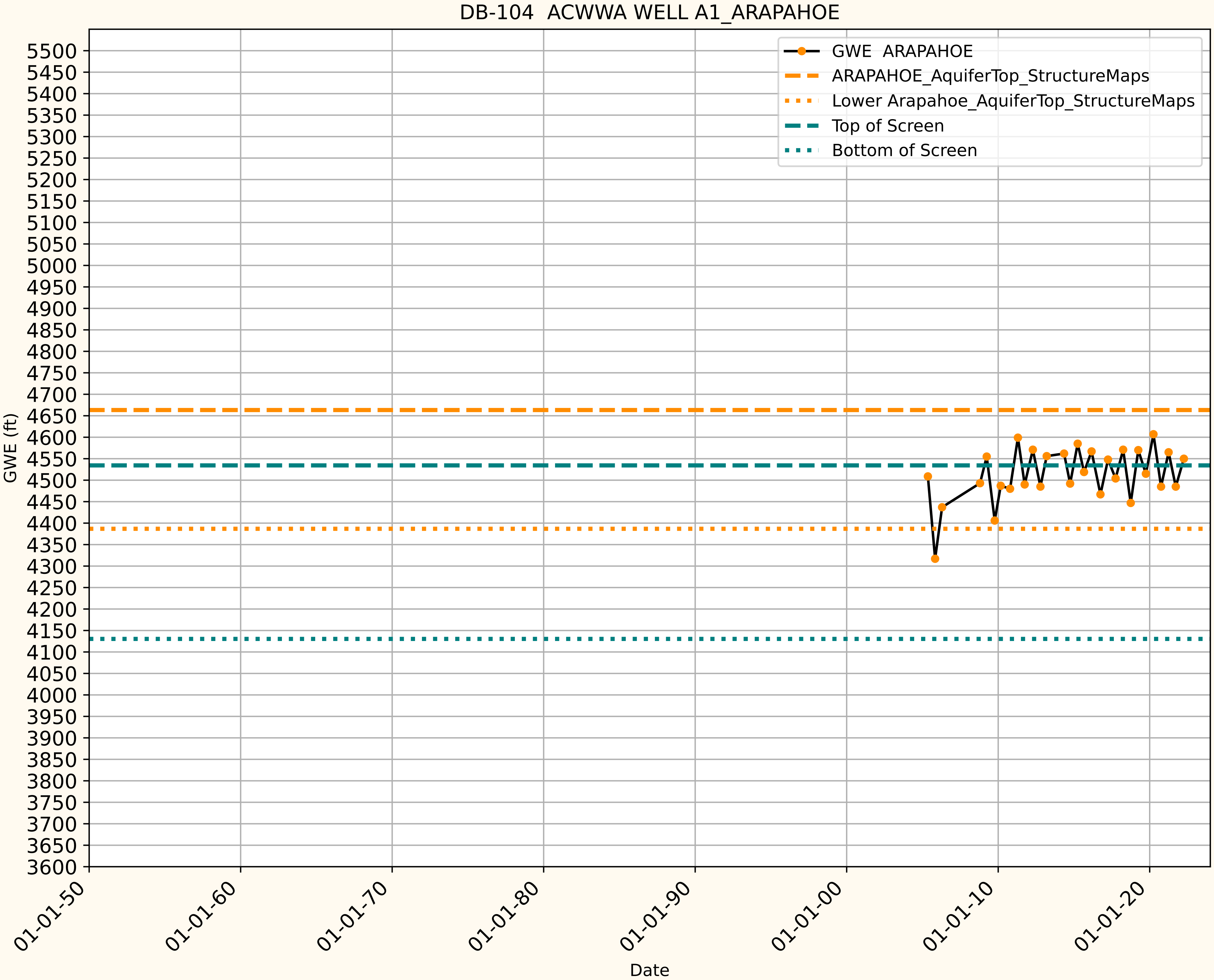
Well: DB-125 INVERNESS 4
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
DB-125 INVERNESS 4


DB-125 INVERNESS 3_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
3750
3700
3650
3600
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

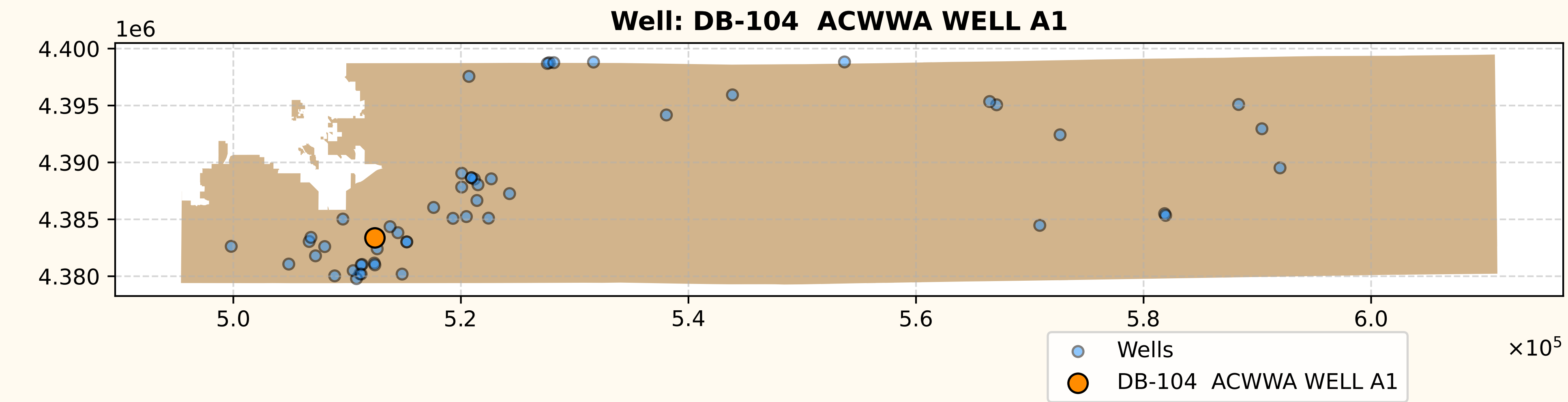

Well: DB-125 INVERNESS 3
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
$\times10^5$
Wells
DB-125 INVERNESS 3


INVERNESS WELL # 3_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
3750
3700
3650
3600
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

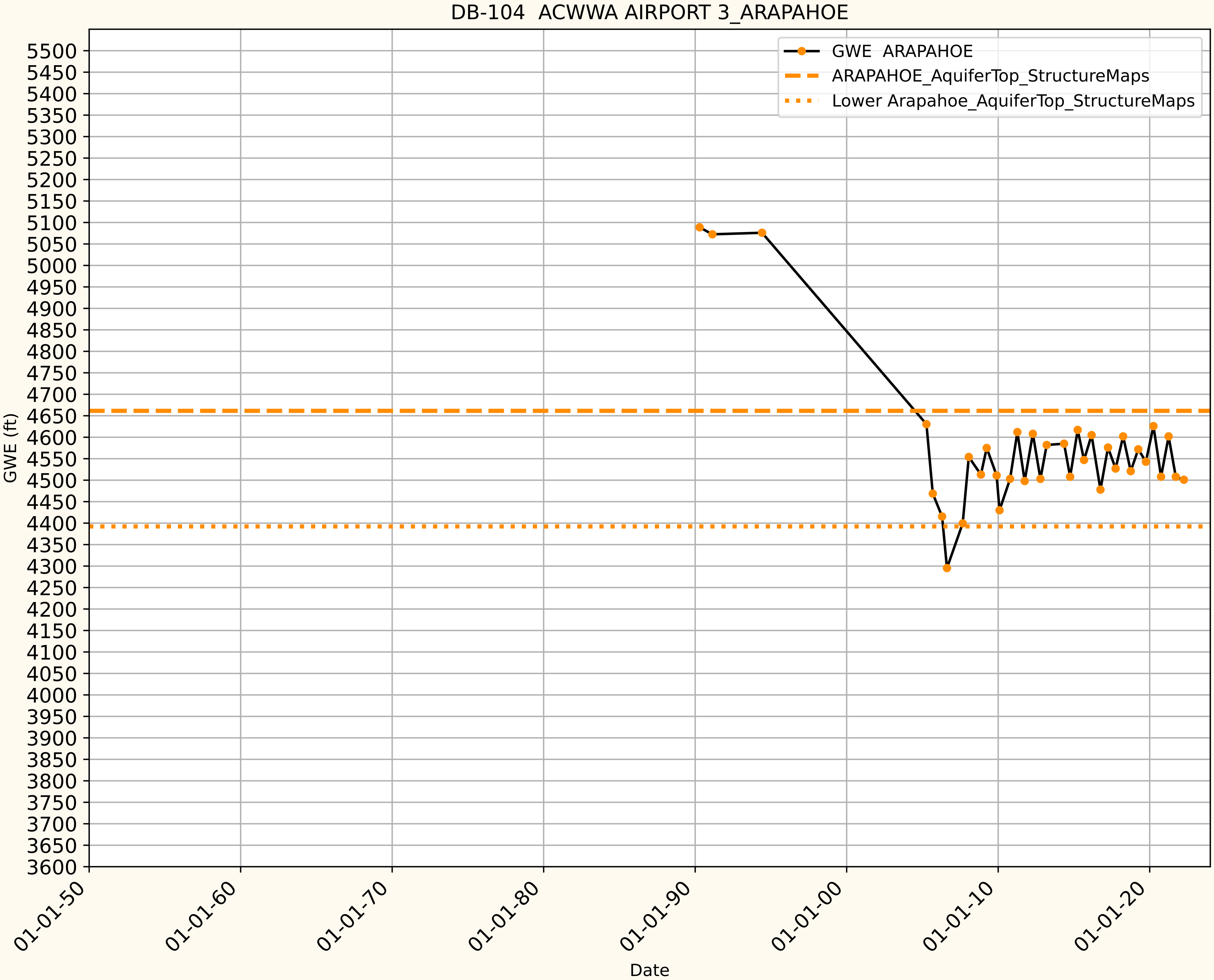

Well: INVERNESS WELL # 3
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
INVERNESS WELL # 3

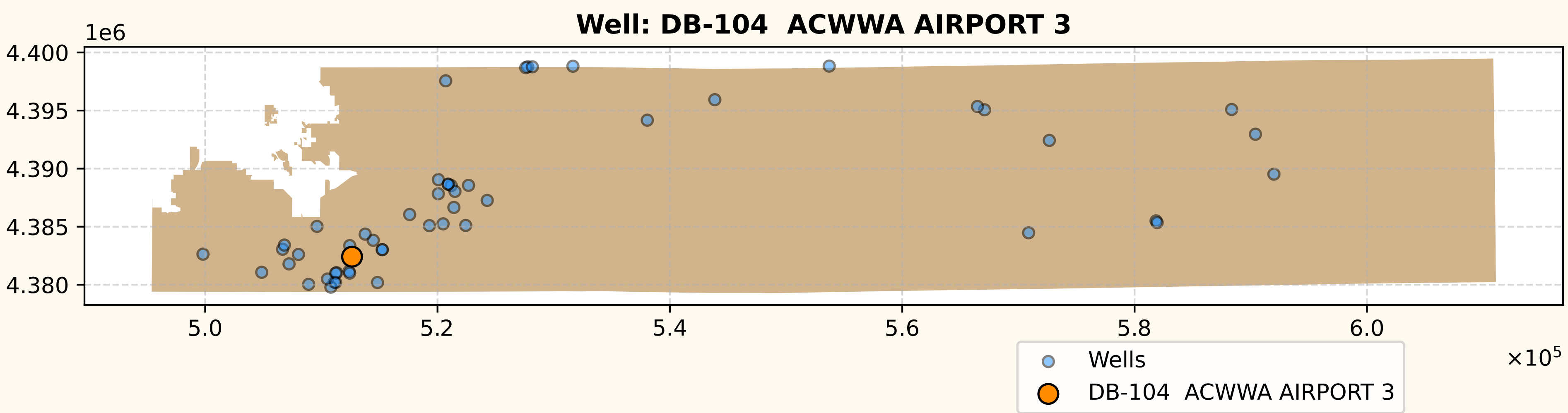


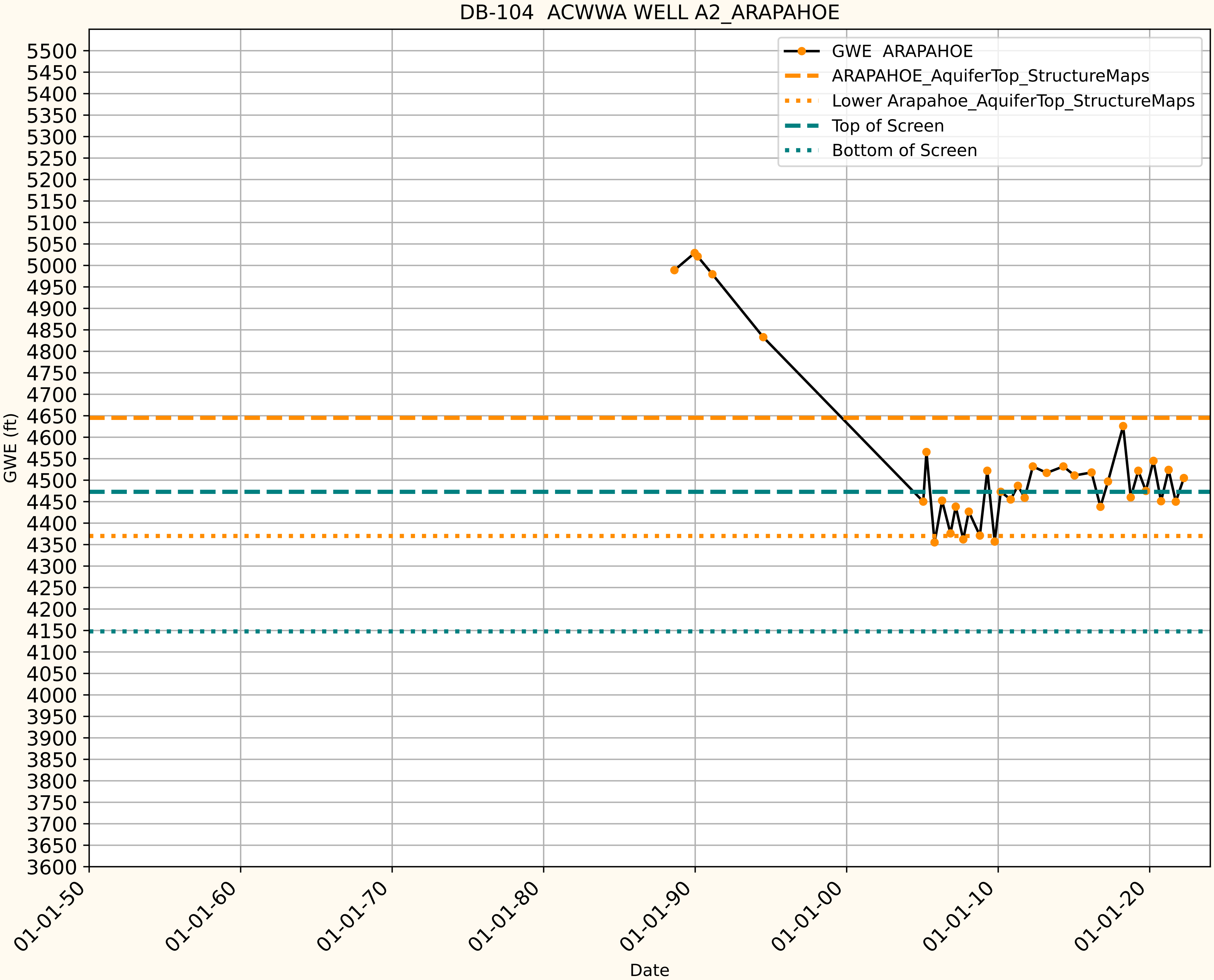
DB-104 ACWWA WELL A1_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
3750
3700
3650
3600
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20
Date



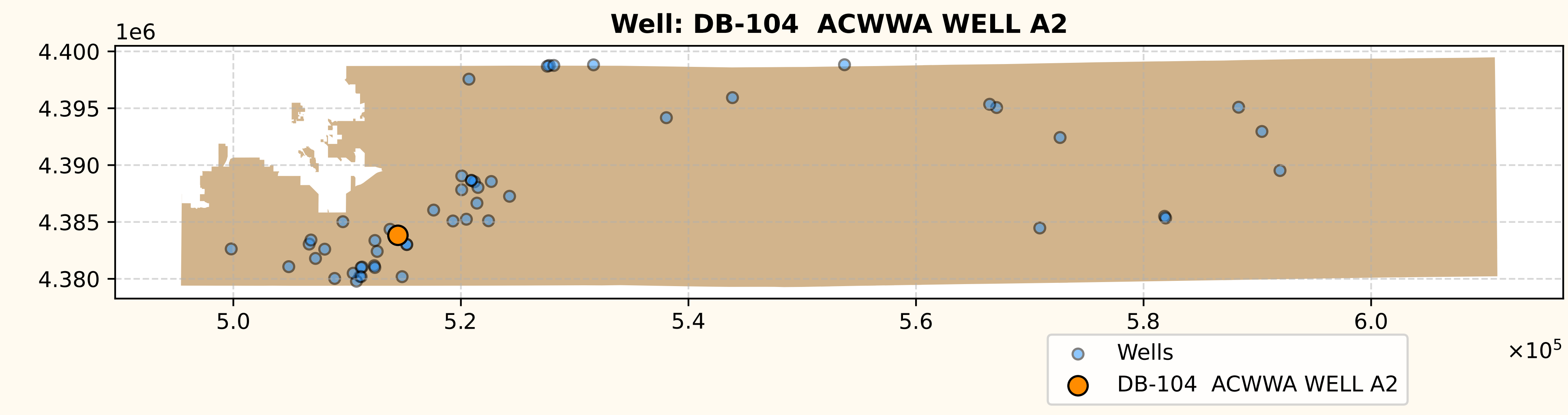
Well: DB-104 ACWWA WELL A1
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10⁵
Wells
DB-104 ACWWA WELL A1


DB-104 ACWWA AIRPORT 3_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
GWE (ft)
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
3750
3700
3650
3600
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20
Date

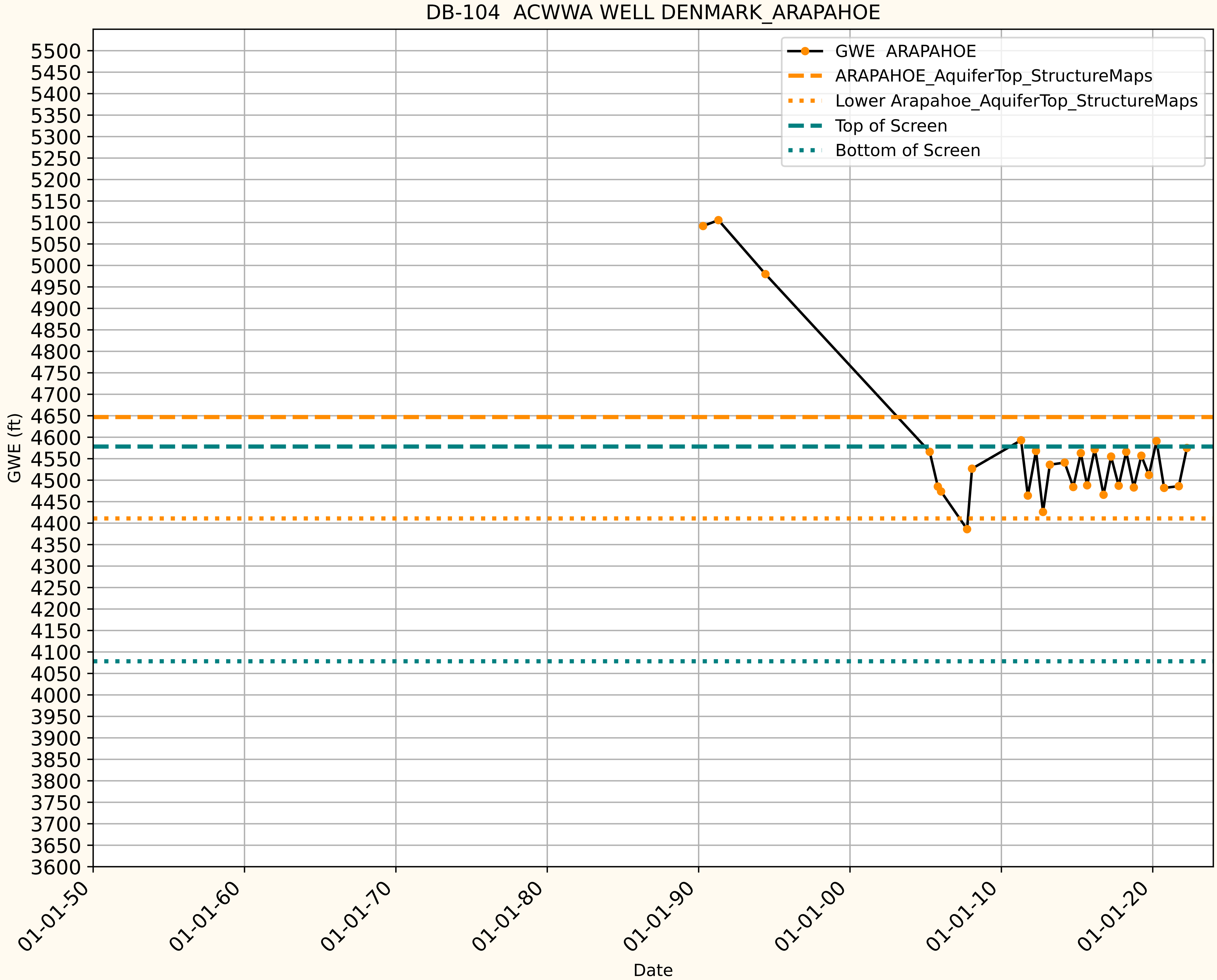

Well: DB-104 ACWWA AIRPORT 3
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
DB-104 ACWWA AIRPORT 3

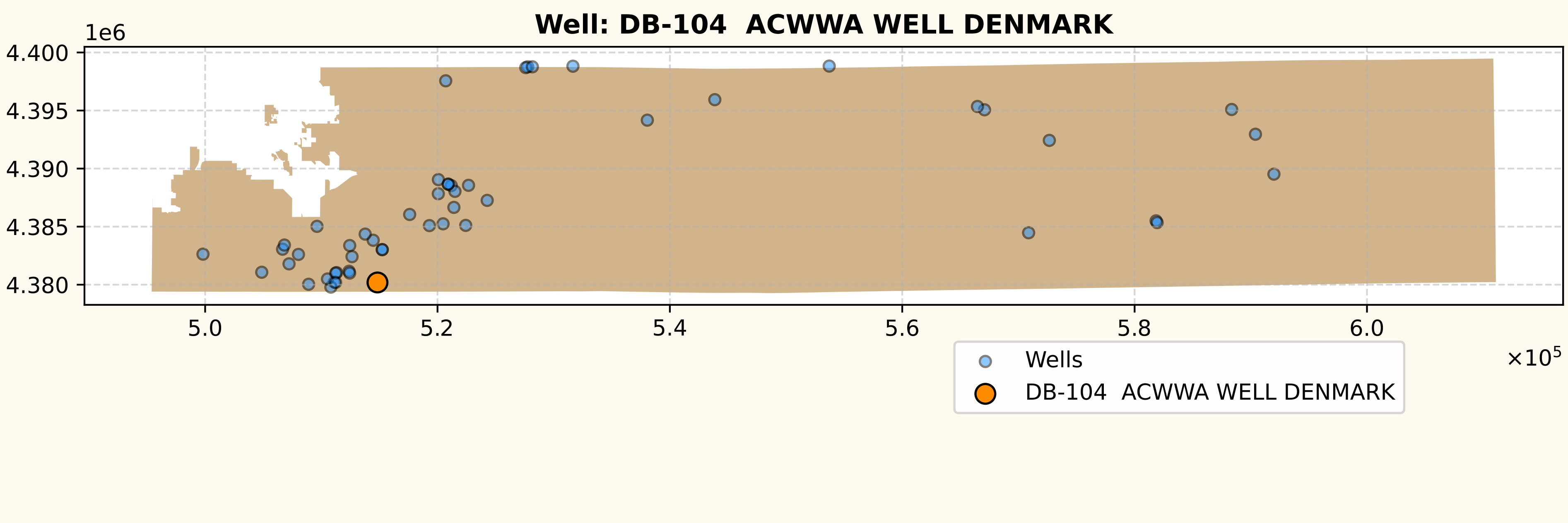


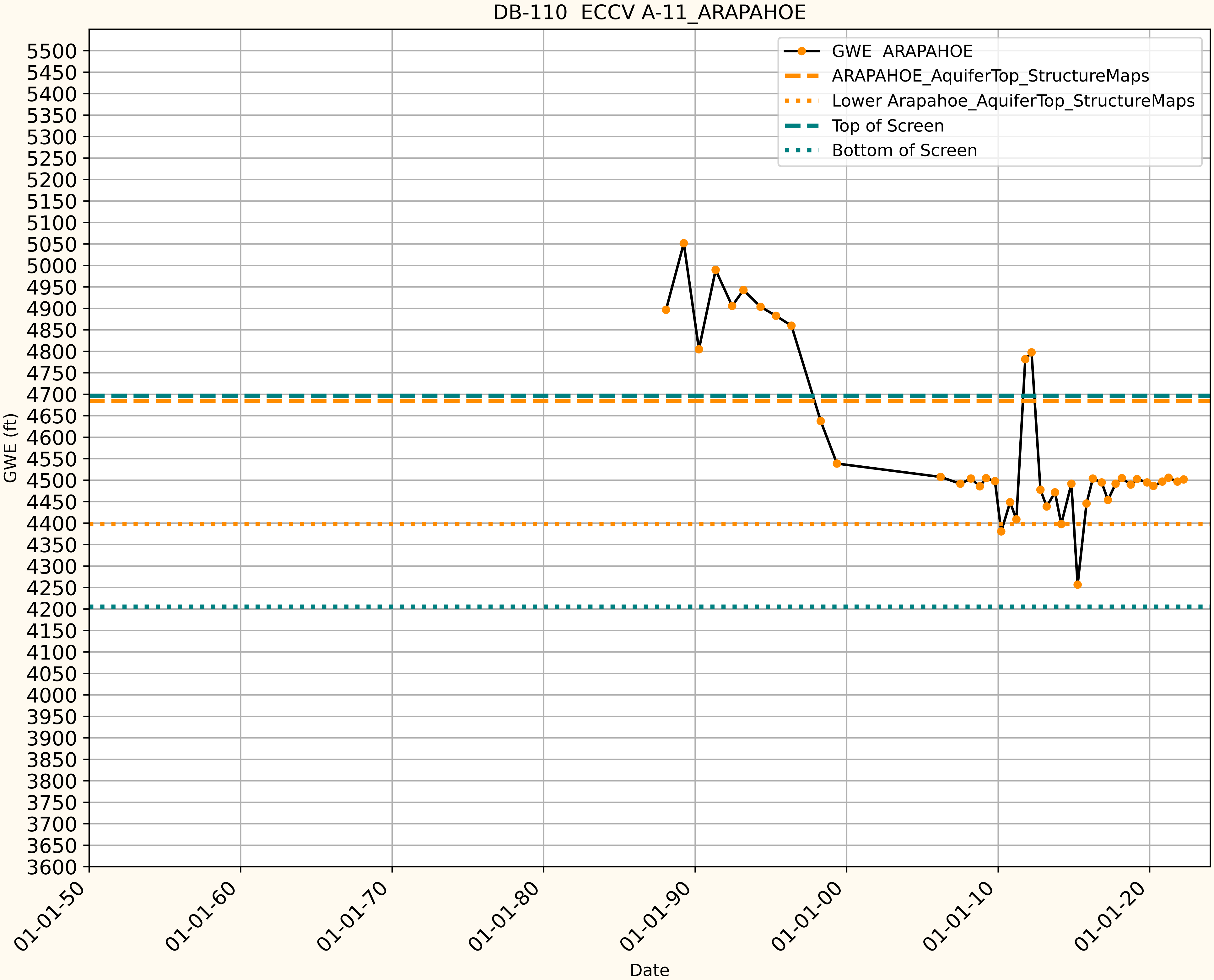
DB-104 ACWWA WELL A2_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
3750
3700
3650
3600
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

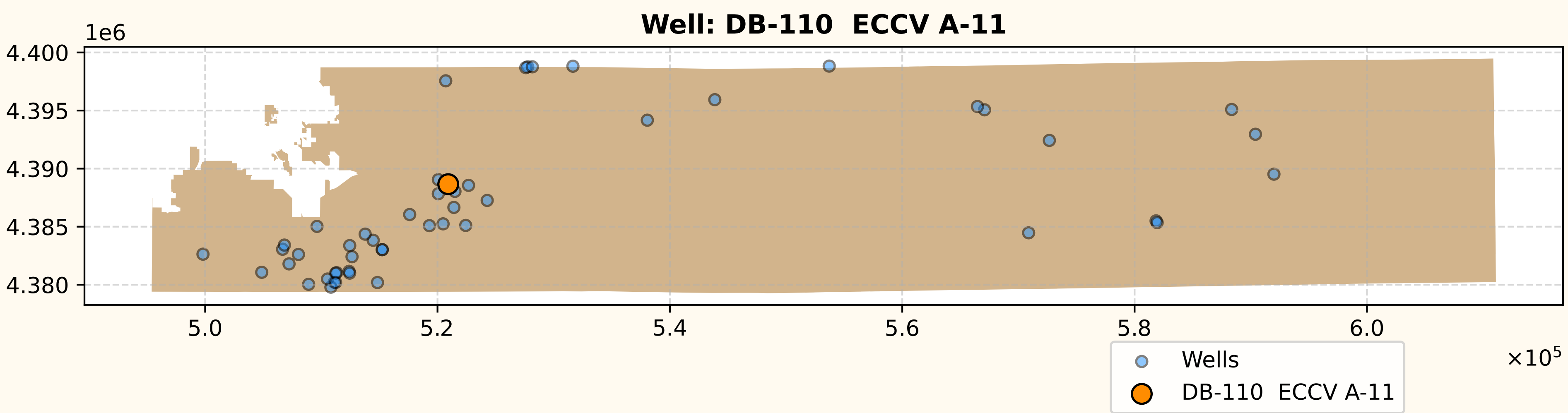


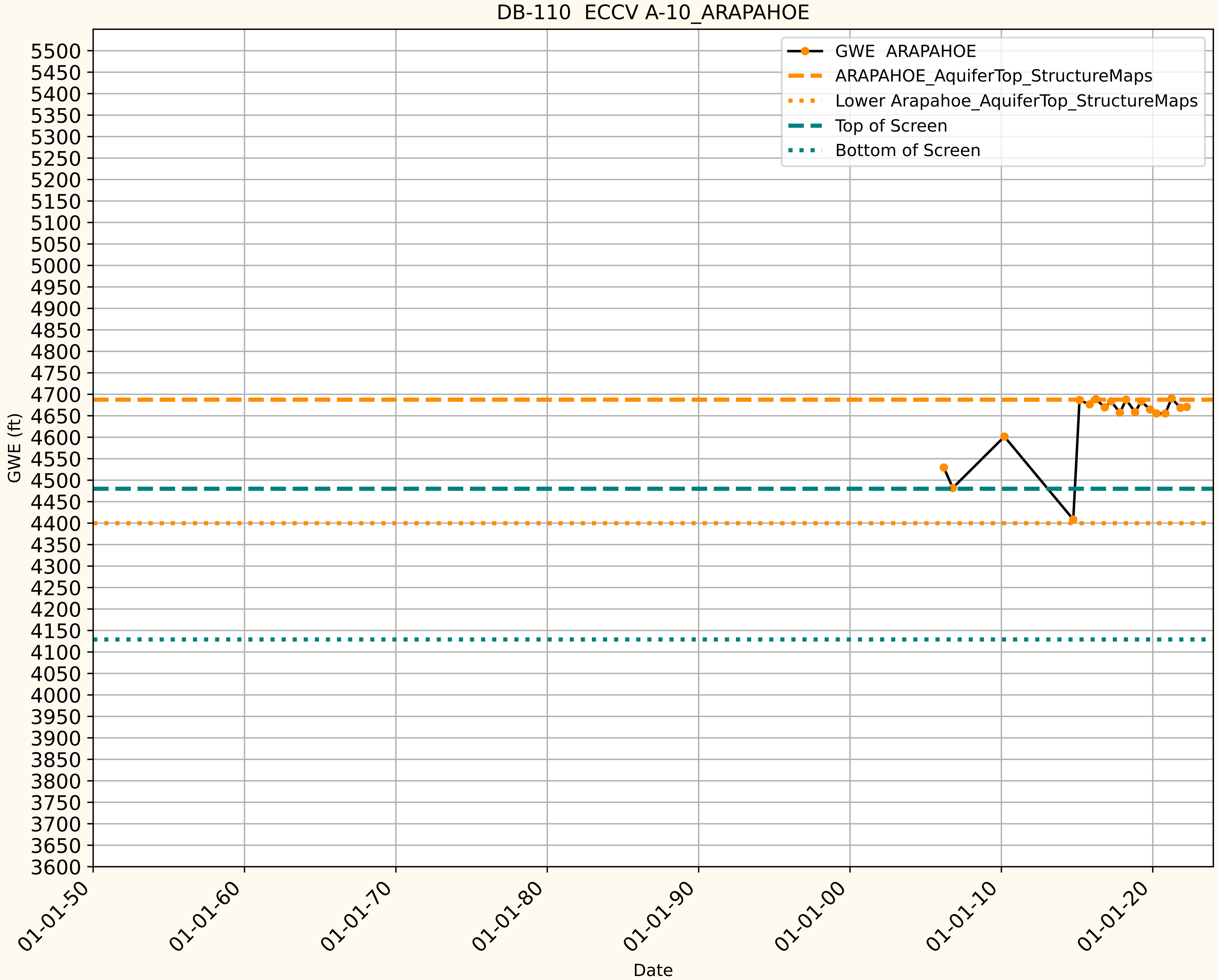
Well: DB-104 ACWWA WELL A2
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
DB-104 ACWWA WELL A2

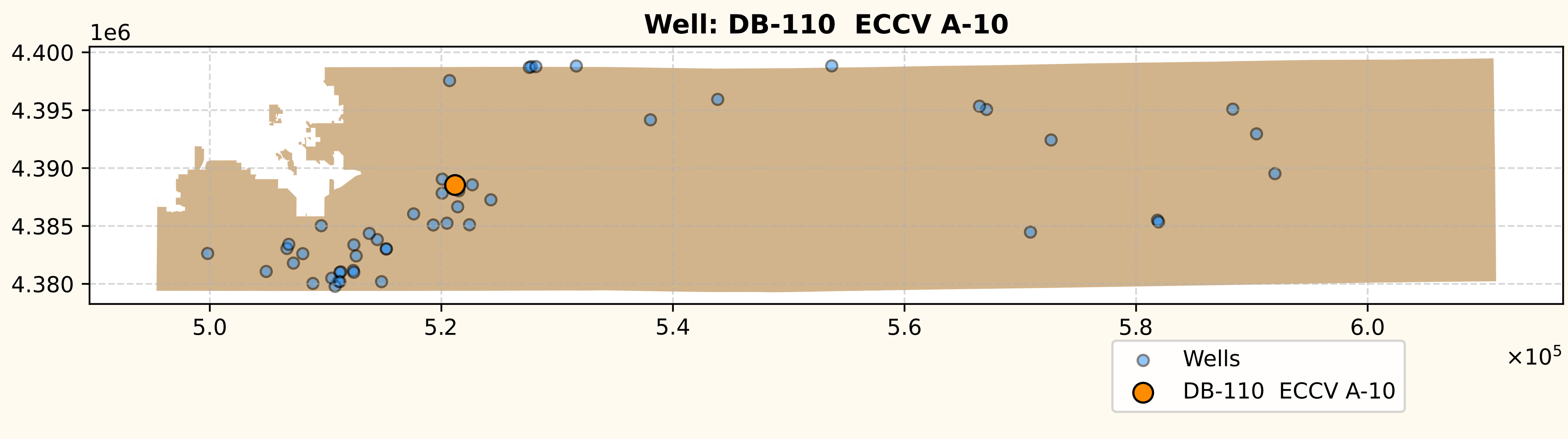

DB-104 ACWWA WELL DENMARK_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

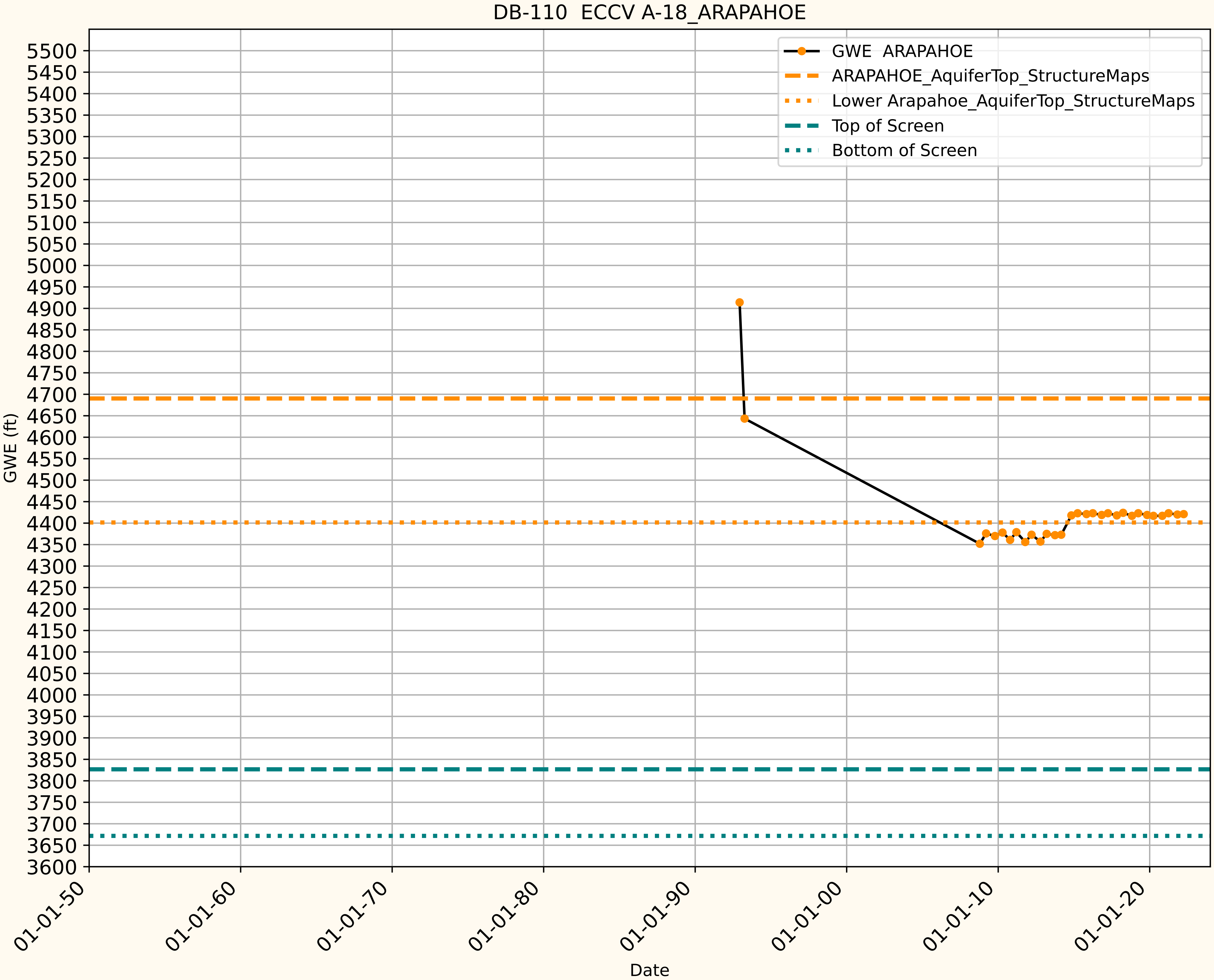

Well: DB-104 ACWWA WELL DENMARK
1e6
×10^5
Wells
DB-104 ACWWA WELL DENMARK


DB-110 ECCV A-11_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

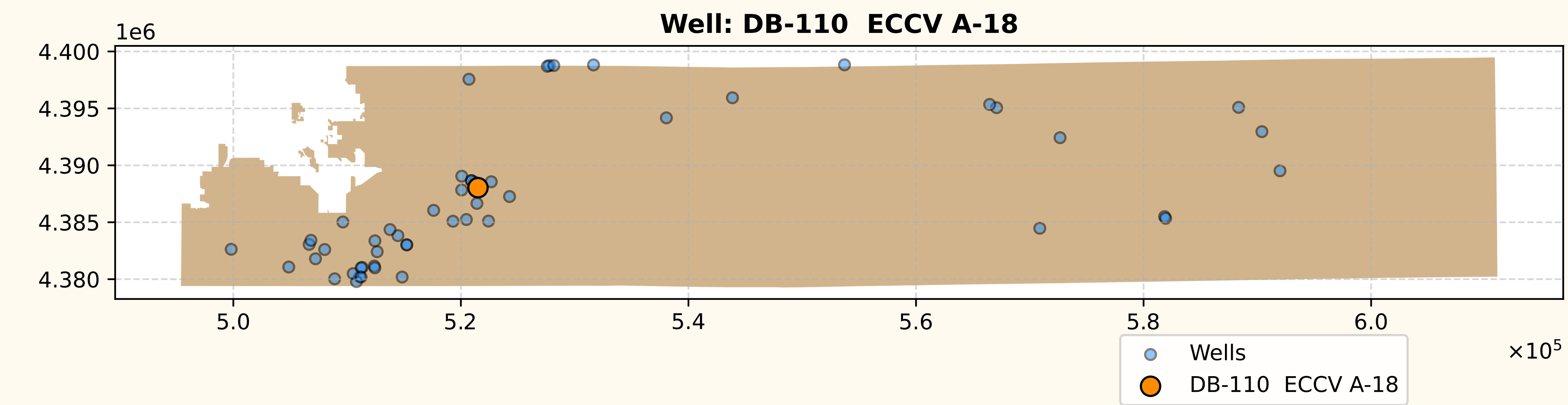

Well: DB-110 ECCV A-11
1e6
×10^5
Wells
DB-110 ECCV A-11


DB-110 ECCV A-10_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
3750
3700
3650
3600
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

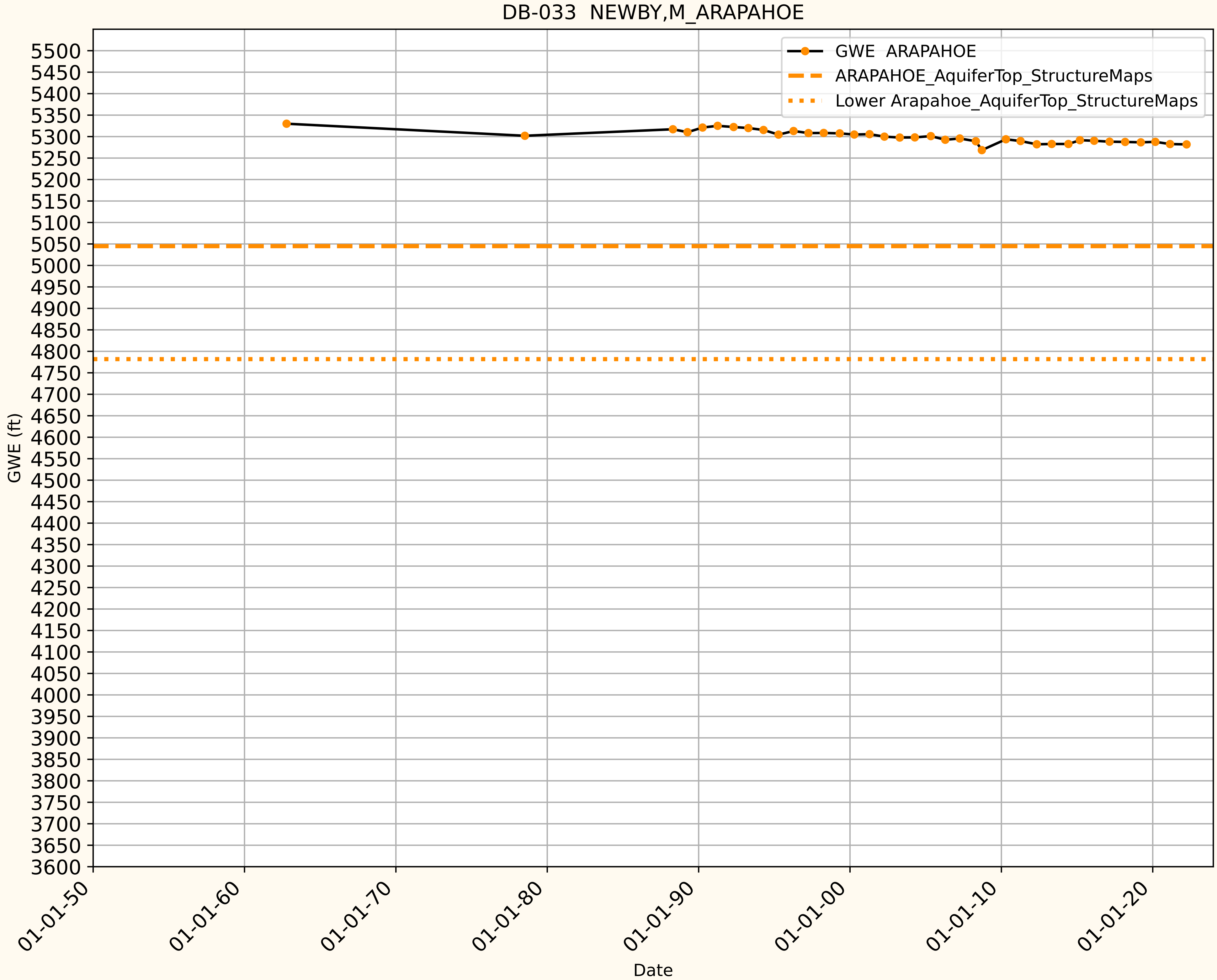

Well: DB-110 ECCV A-10
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
DB-110 ECCV A-10



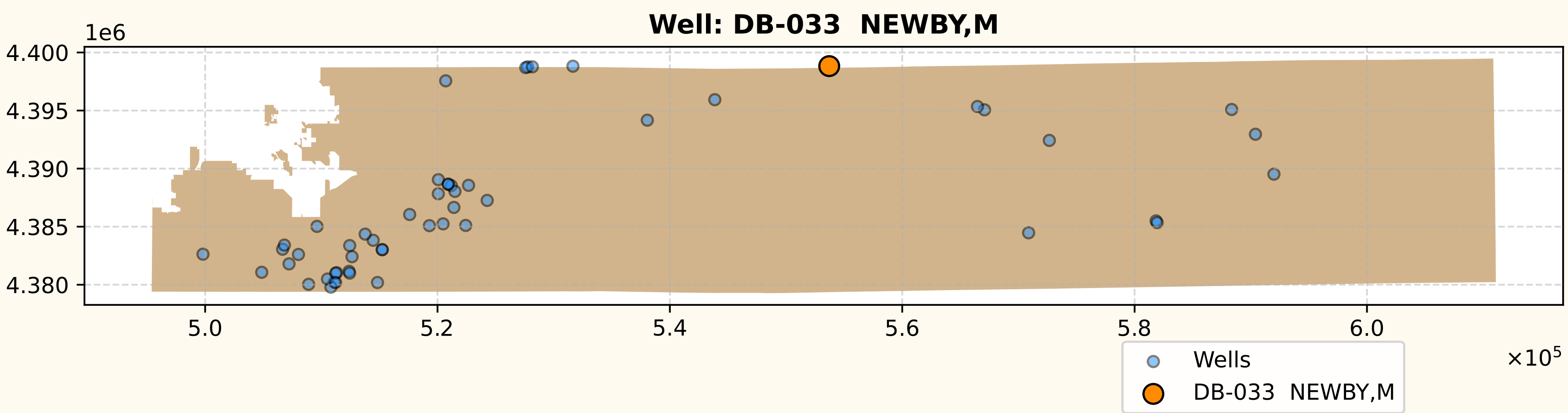
DB-110 ECCV A-18_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
3750
3700
3650
3600
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20



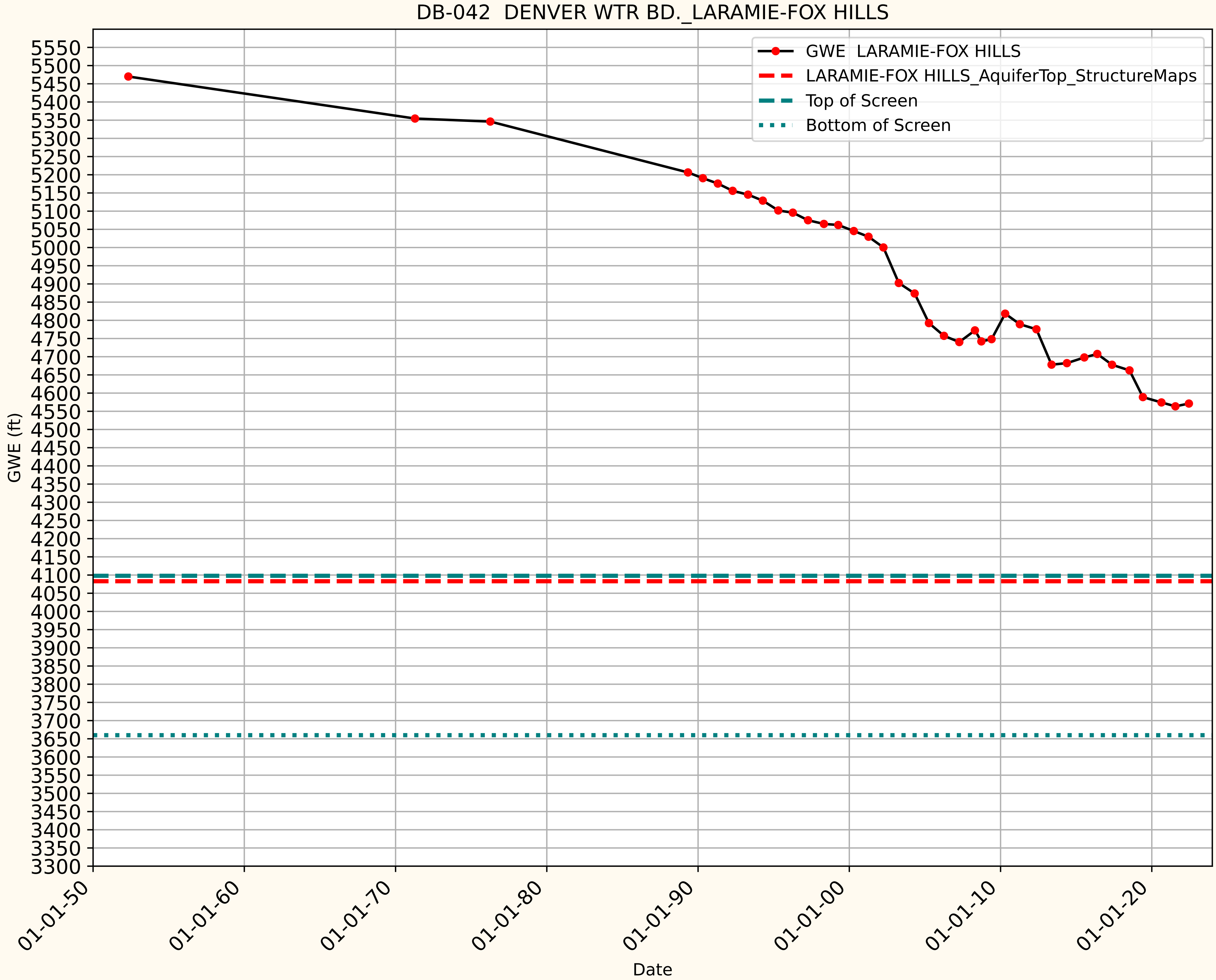
Well: DB-110 ECCV A-18
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
DB-110 ECCV A-18

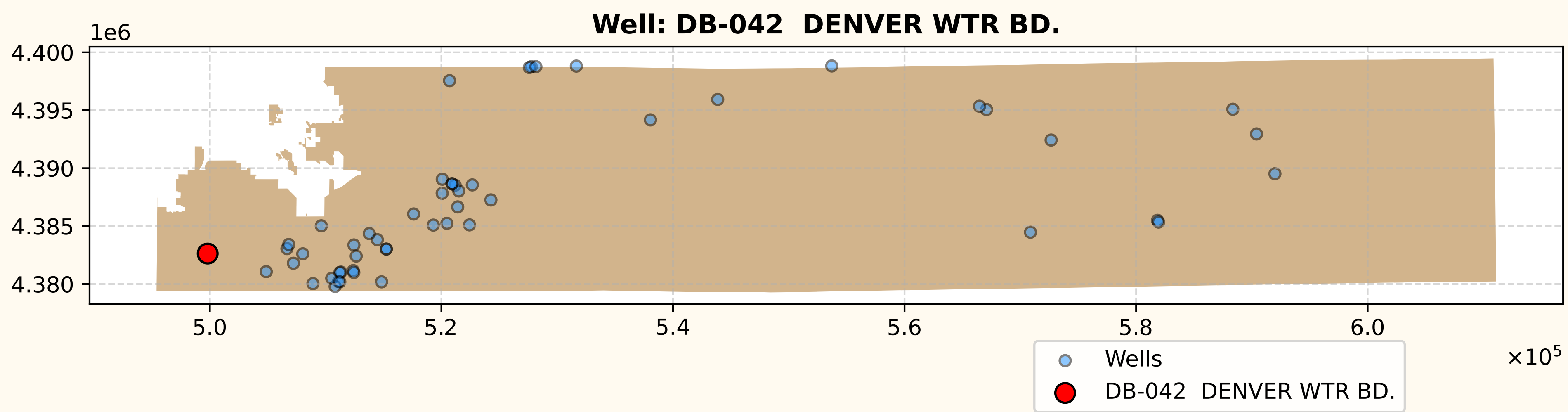


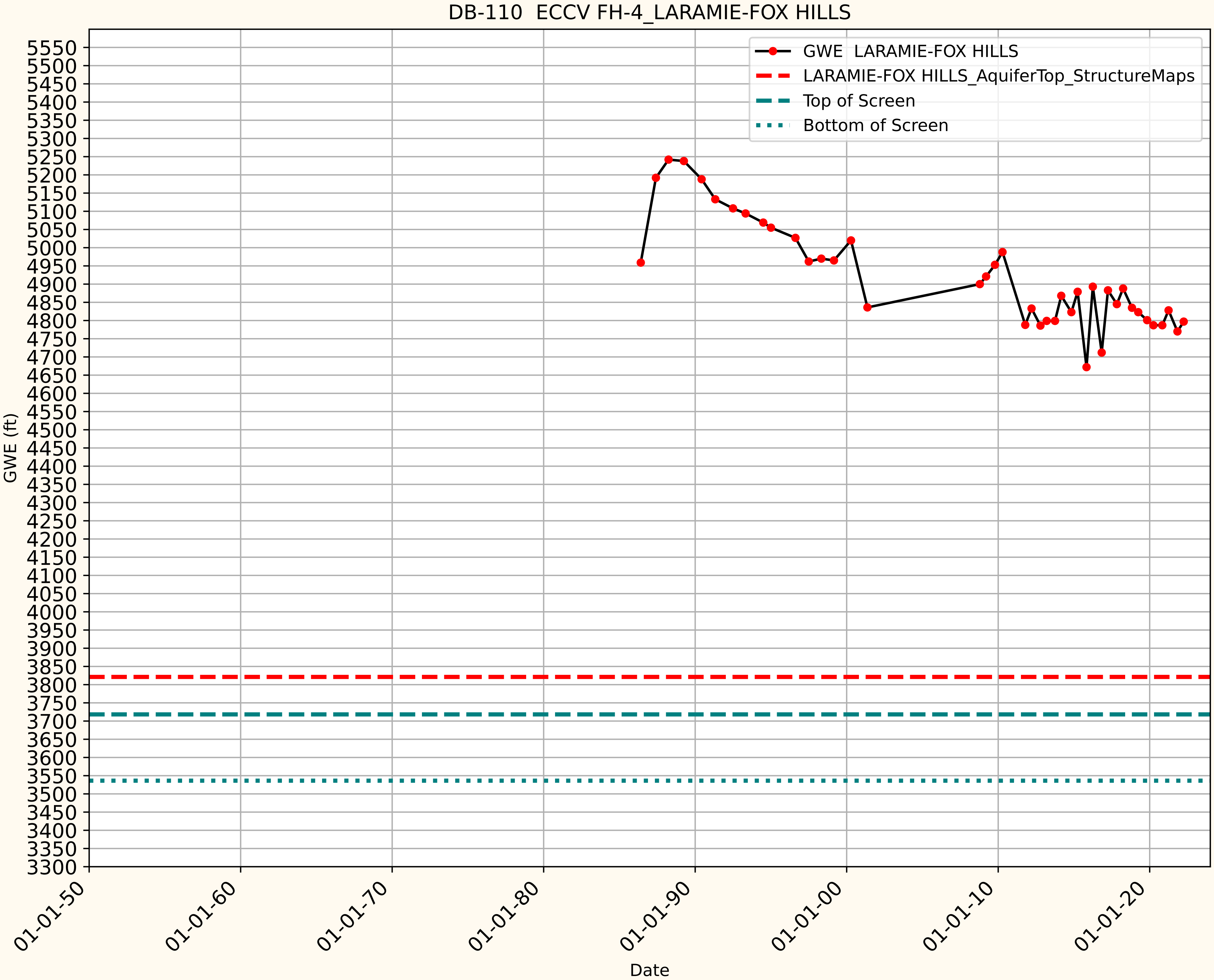
DB-033 NEWBY,M_ARAPAHOE
GWE ARAPAHOE
ARAPAHOE_AquiferTop_StructureMaps
Lower Arapahoe_AquiferTop_StructureMaps
GWE (ft)
Date

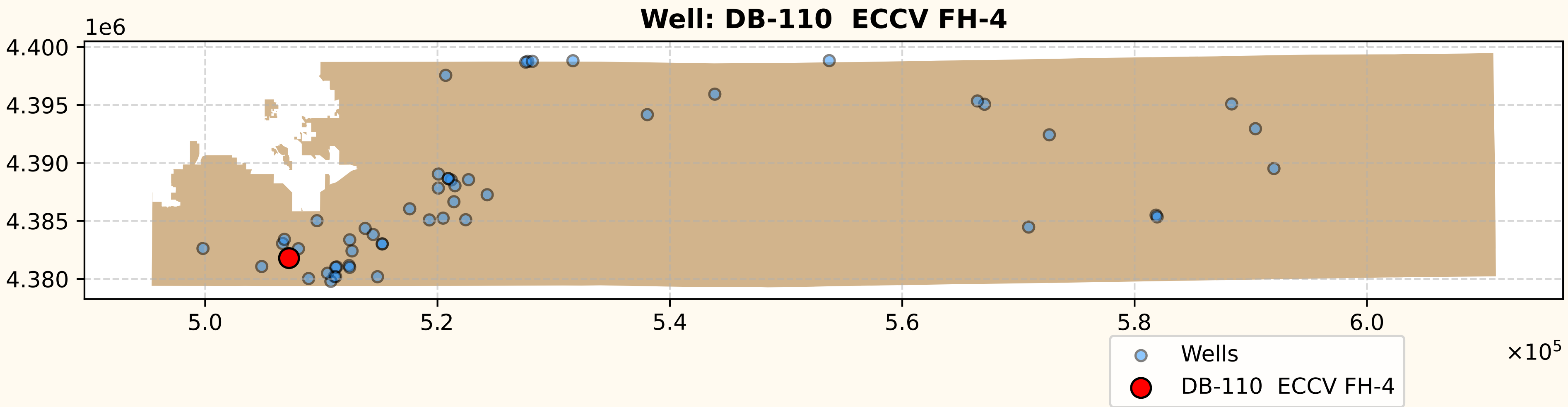


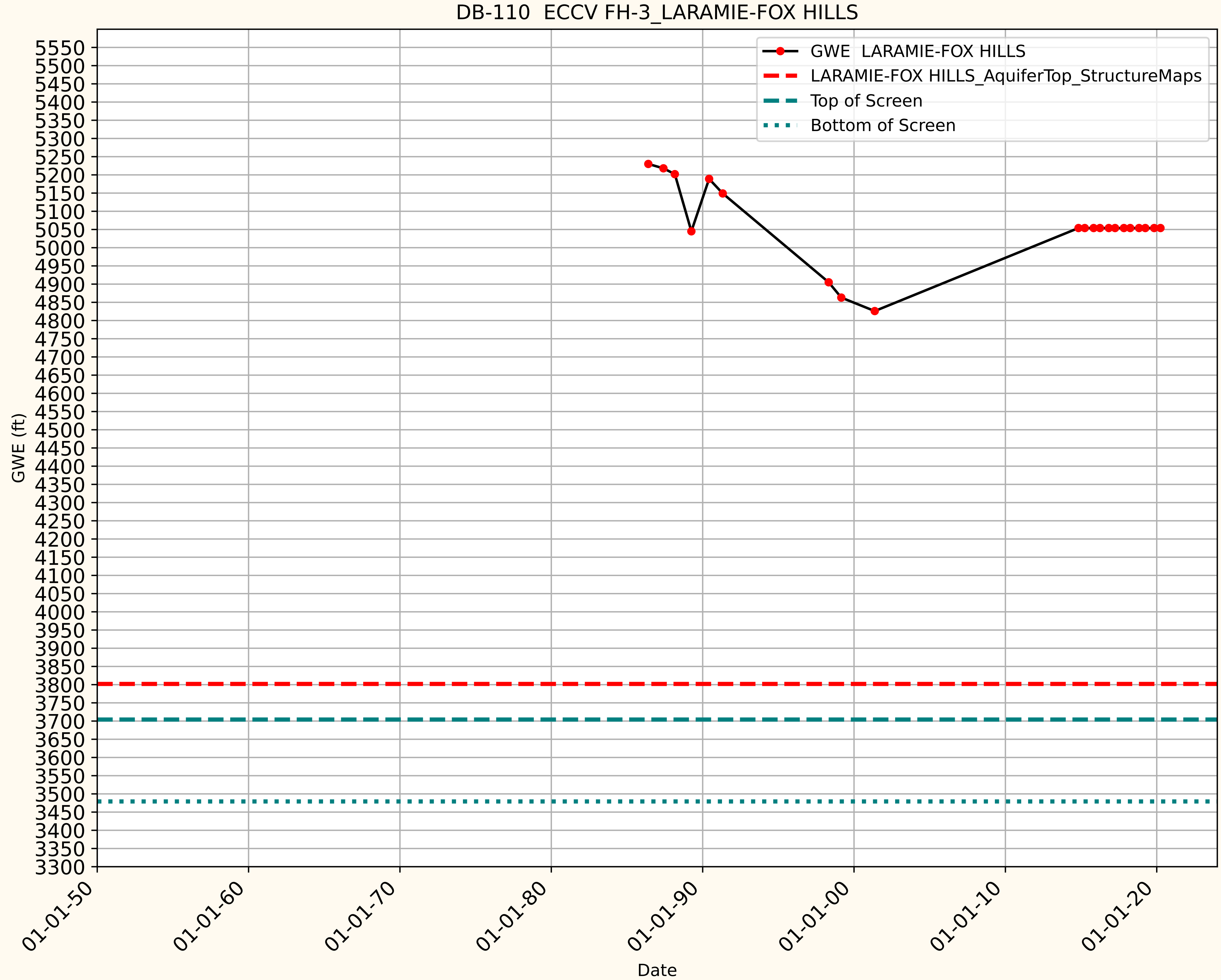
Well: DB-033 NEWBY,M
Wells
DB-033 NEWBY,M

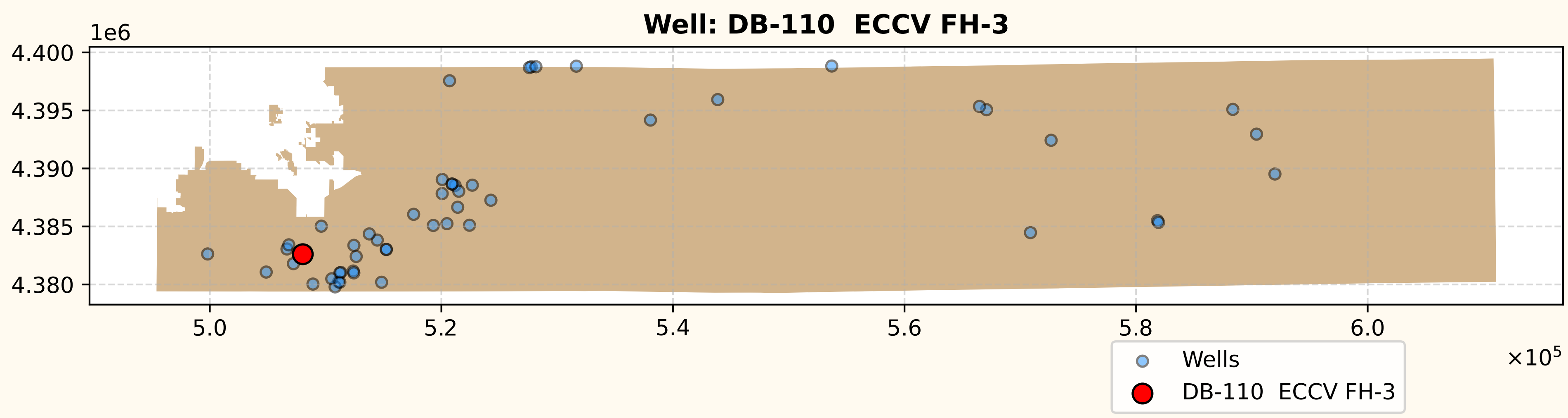

DB-042 DENVER WTR BD._LARAMIE-FOX HILLS
GWE LARAMIE-FOX HILLS
LARAMIE-FOX HILLS_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

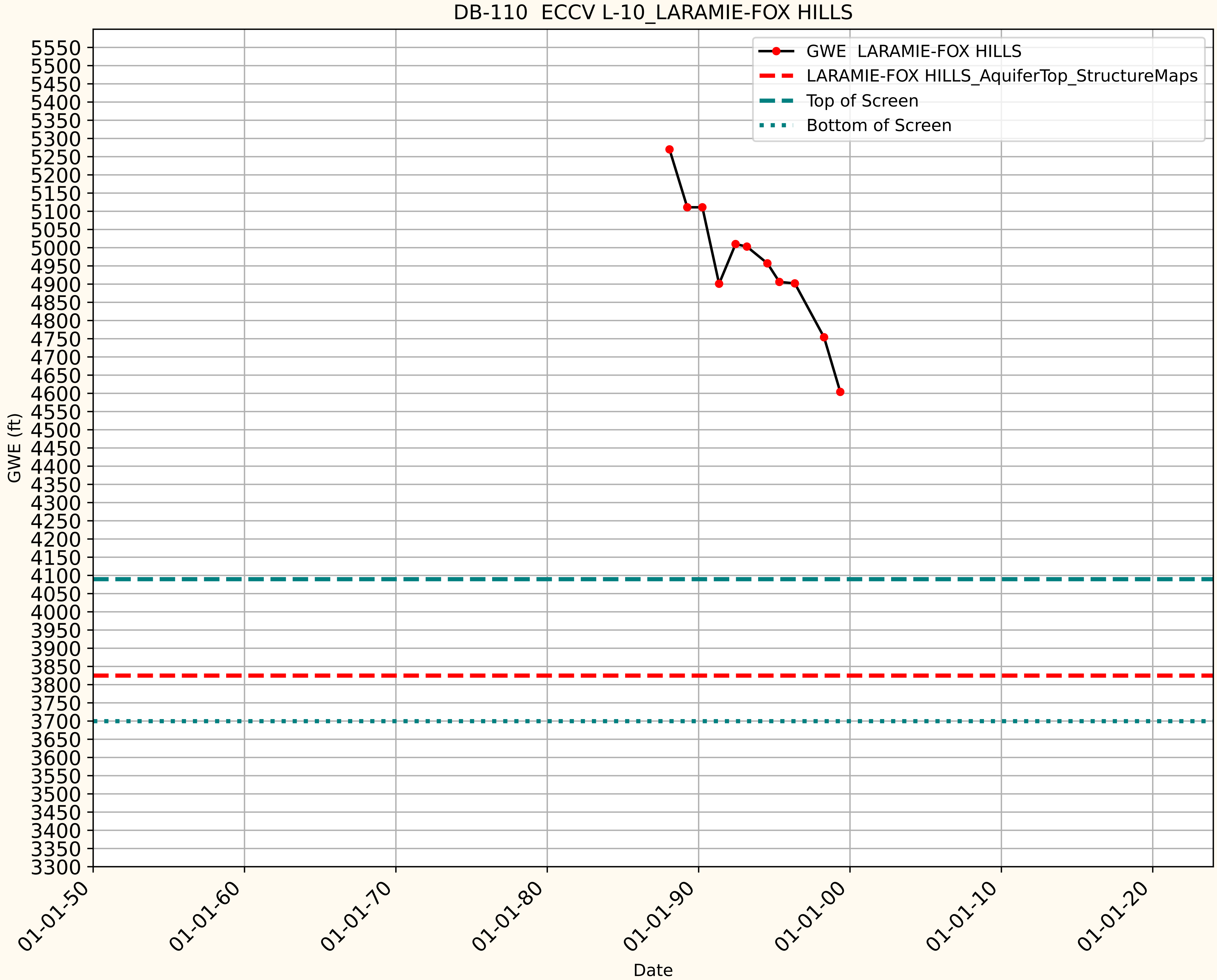

Well: DB-042 DENVER WTR BD.
1e6
Wells
DB-042 DENVER WTR BD.
×10^5

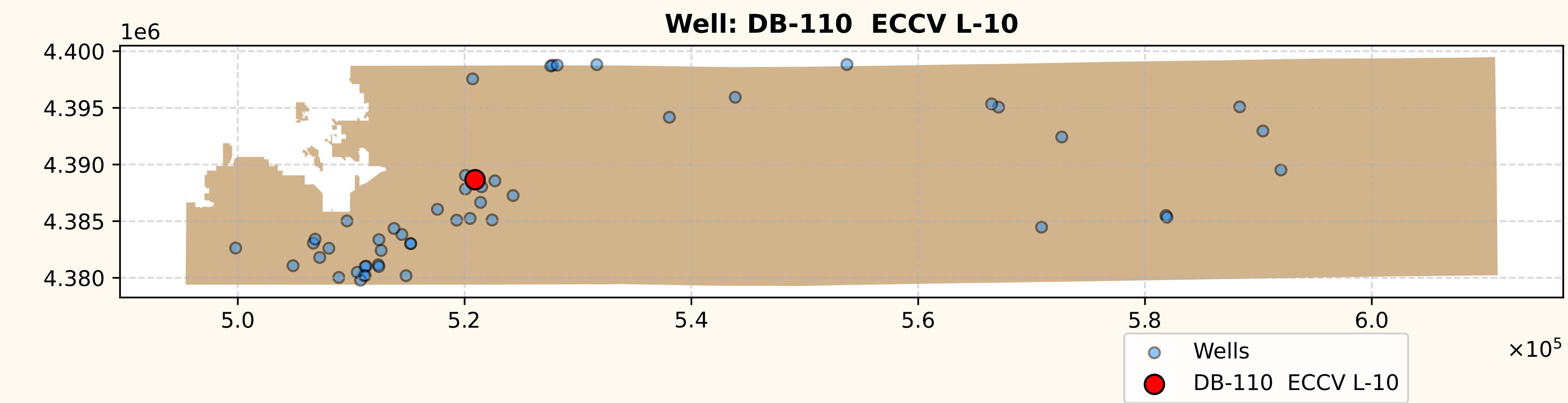

DB-110 ECCV FH-4_LARAMIE-FOX HILLS
GWE LARAMIE-FOX HILLS
LARAMIE-FOX HILLS_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

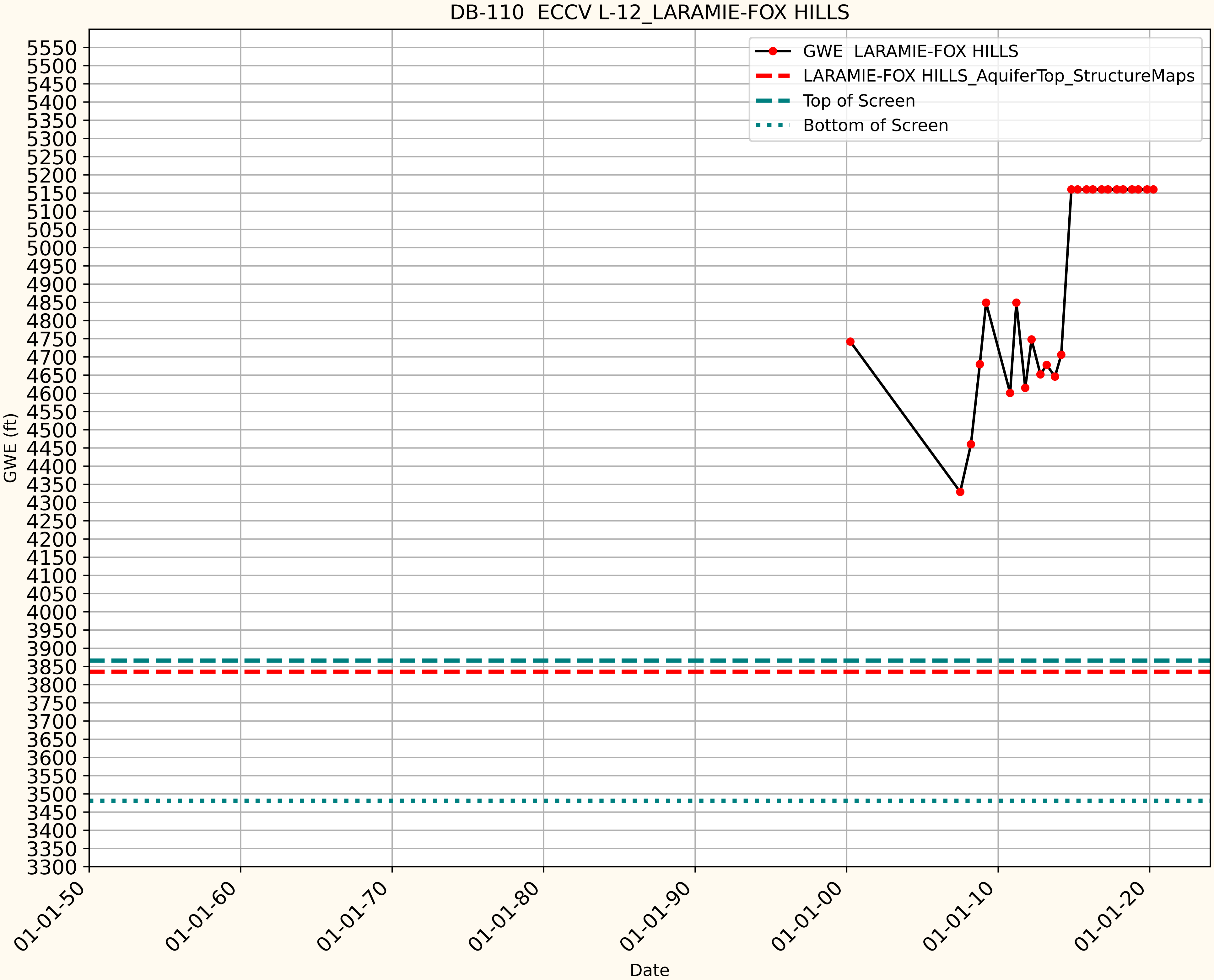

Well: DB-110 ECCV FH-4
1e6
×10^5
Wells
DB-110 ECCV FH-4


DB-110 ECCV FH-3_LARAMIE-FOX HILLS
GWE LARAMIE-FOX HILLS
LARAMIE-FOX HILLS_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

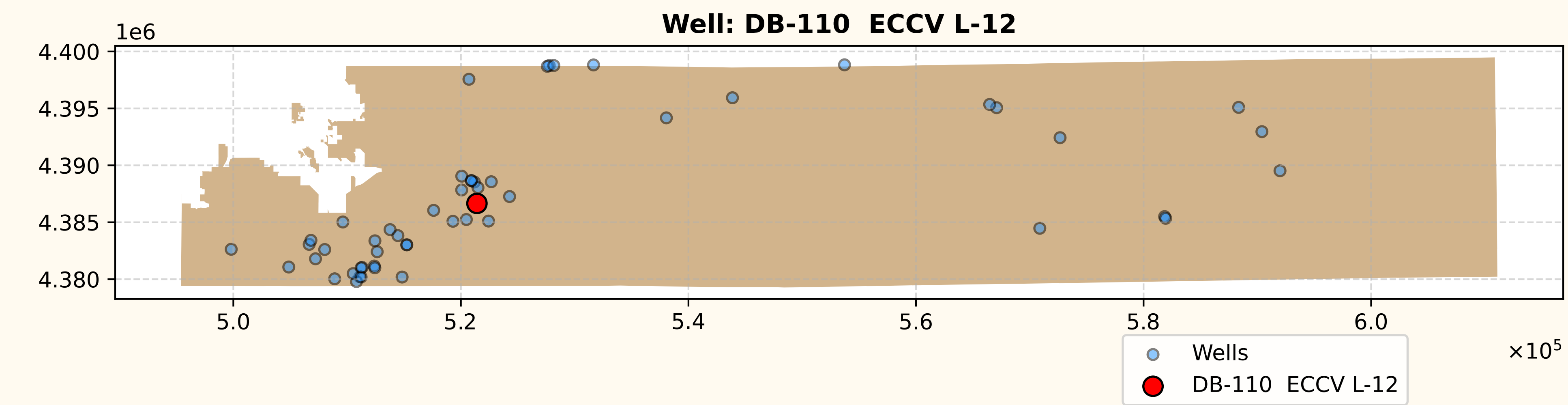

Well: DB-110 ECCV FH-3
1e6
×10^5
Wells
DB-110 ECCV FH-3


DB-110 ECCV L-10_LARAMIE-FOX HILLS
GWE (ft)
Date
GWE LARAMIE-FOX HILLS
LARAMIE-FOX HILLS_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

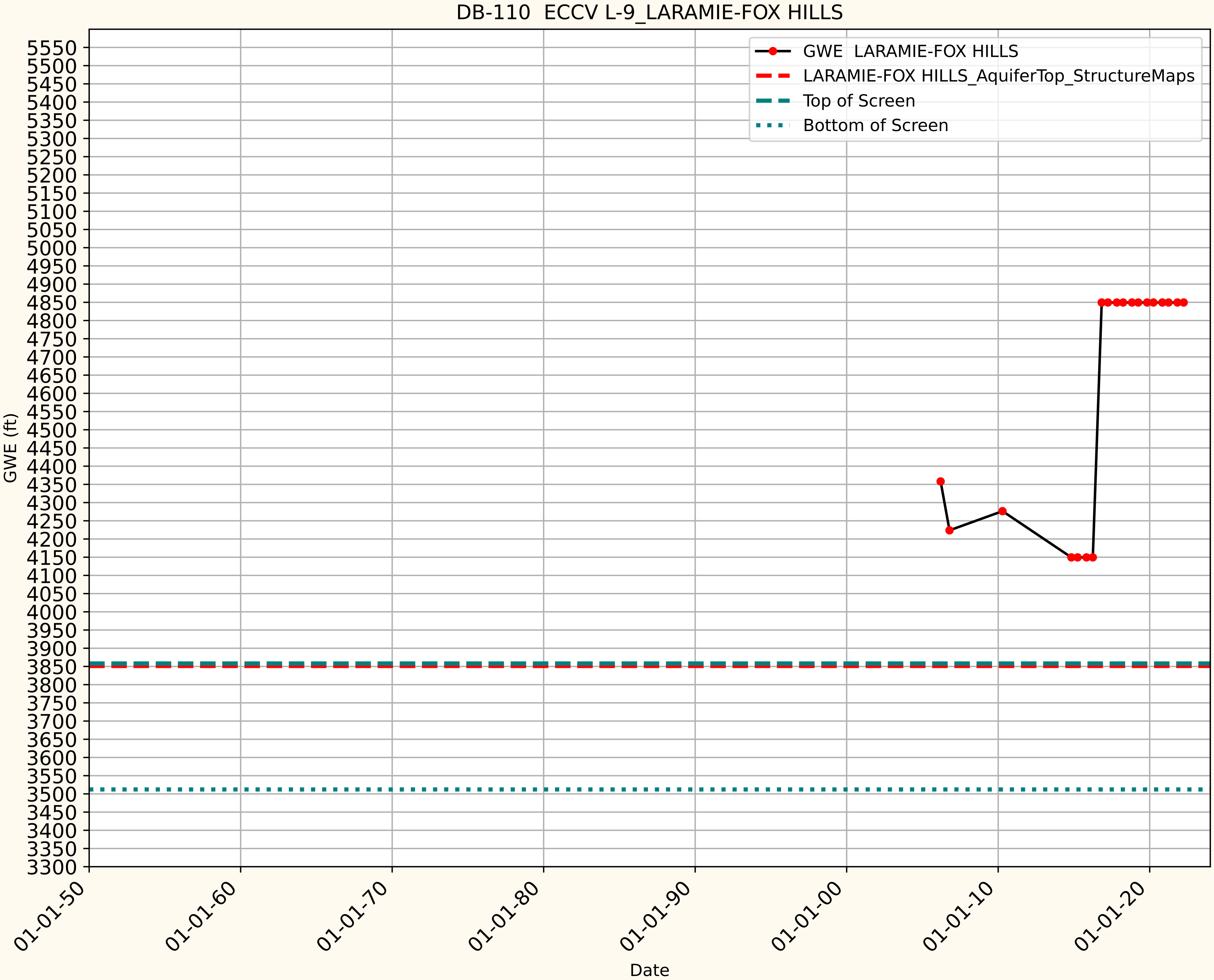

Well: DB-110 ECCV L-10
1e6
×10^5
Wells
DB-110 ECCV L-10



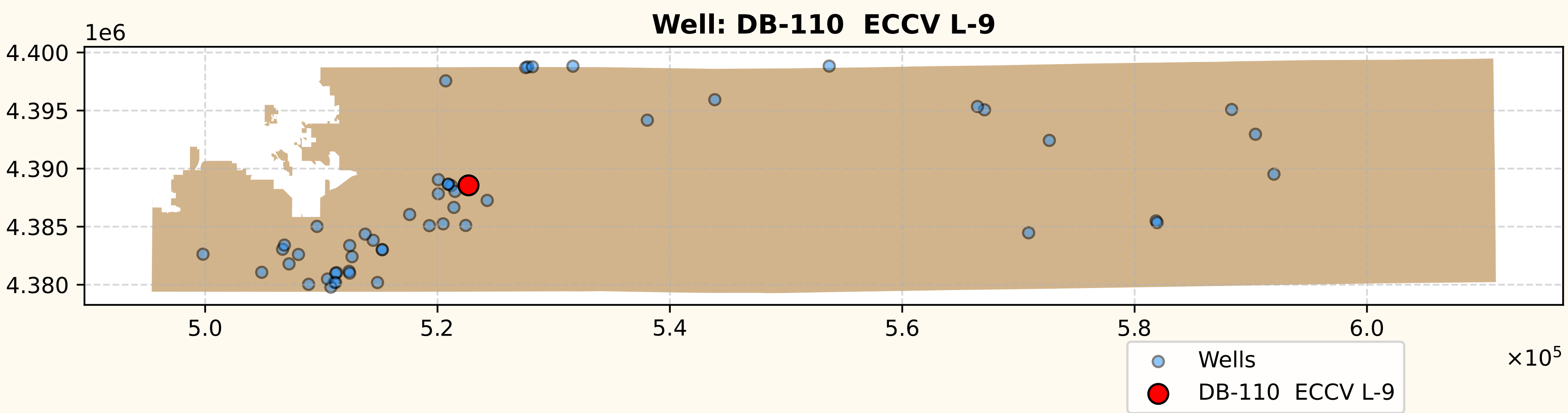
DB-110 ECCV L-12_LARAMIE-FOX HILLS
GWE LARAMIE-FOX HILLS
LARAMIE-FOX HILLS_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
5550
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
3750
3700
3650
3600
3550
3500
3450
3400
3350
3300
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20



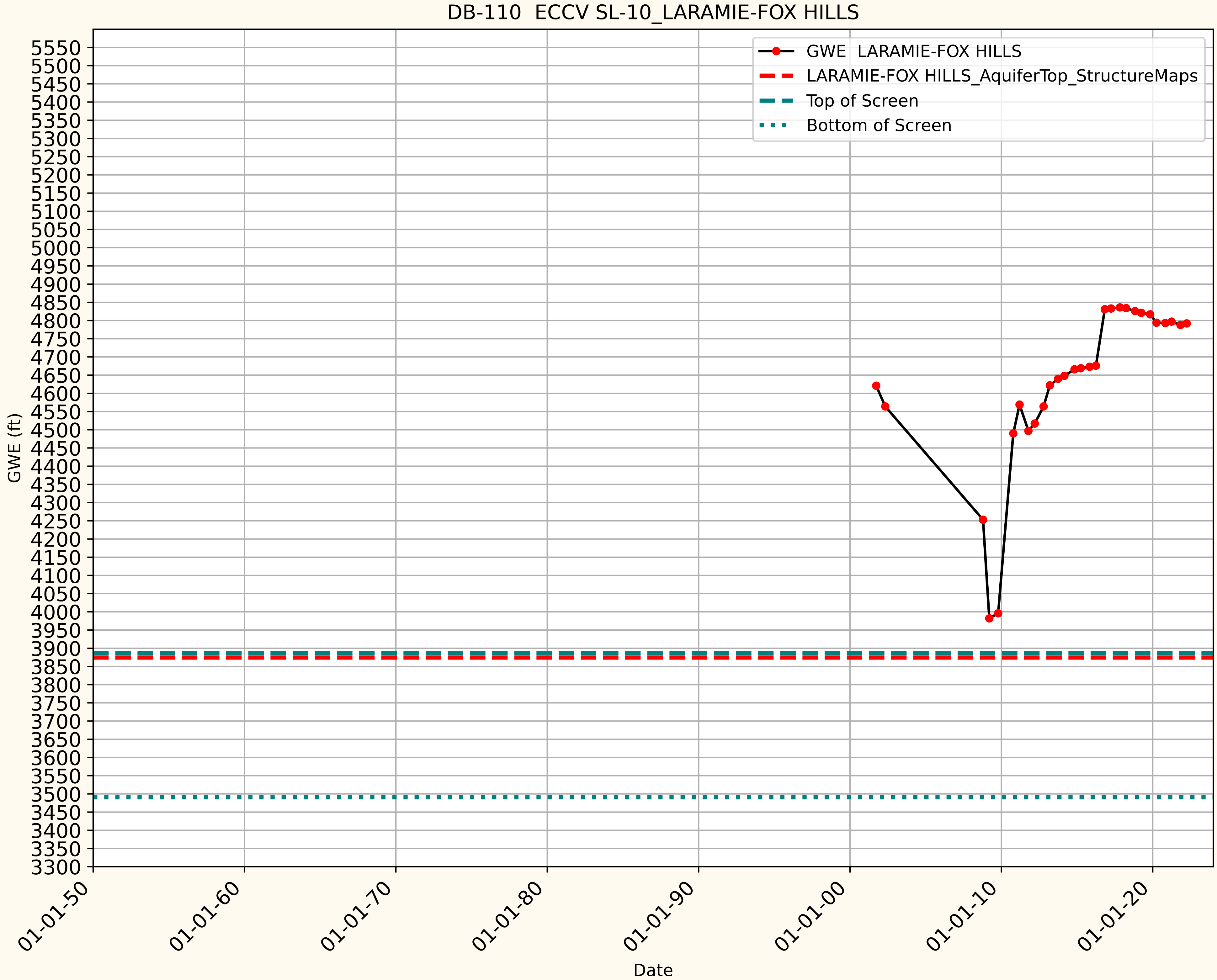
Well: DB-110 ECCV L-12
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
DB-110 ECCV L-12

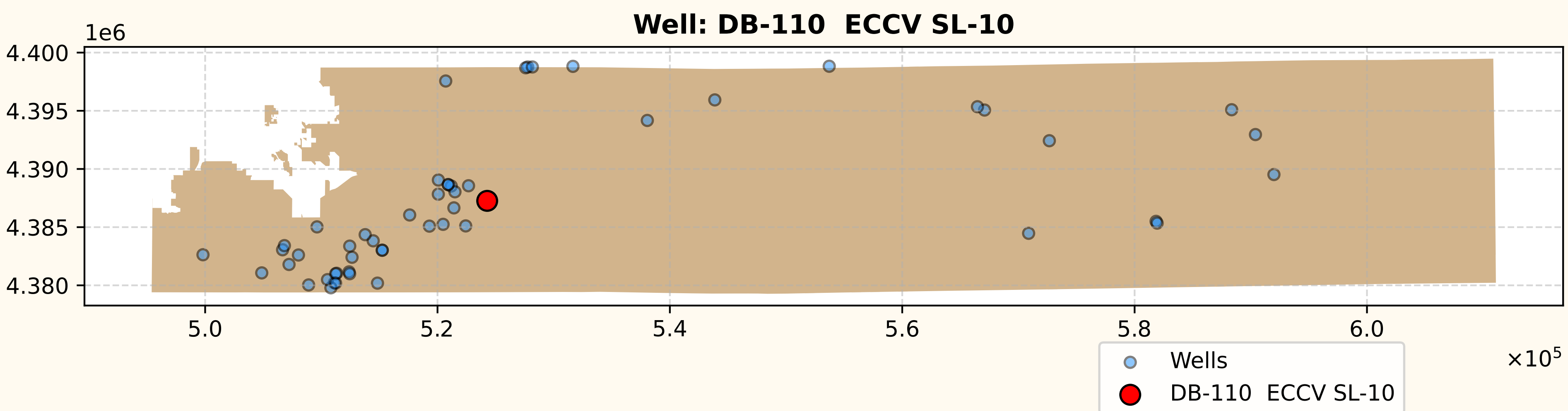


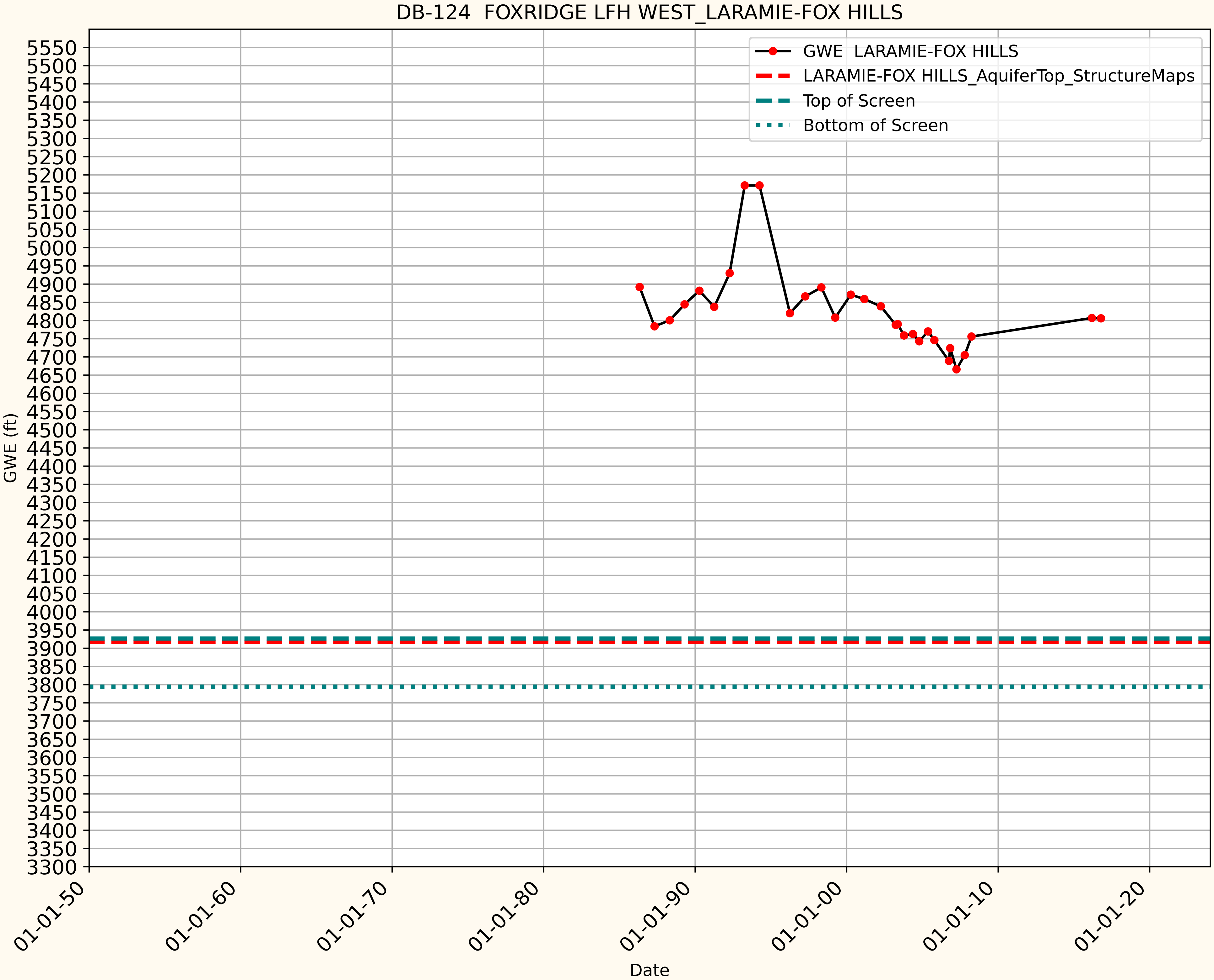
DB-110 ECCV L-9_LARAMIE-FOX HILLS
GWE LARAMIE-FOX HILLS
LARAMIE-FOX HILLS_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

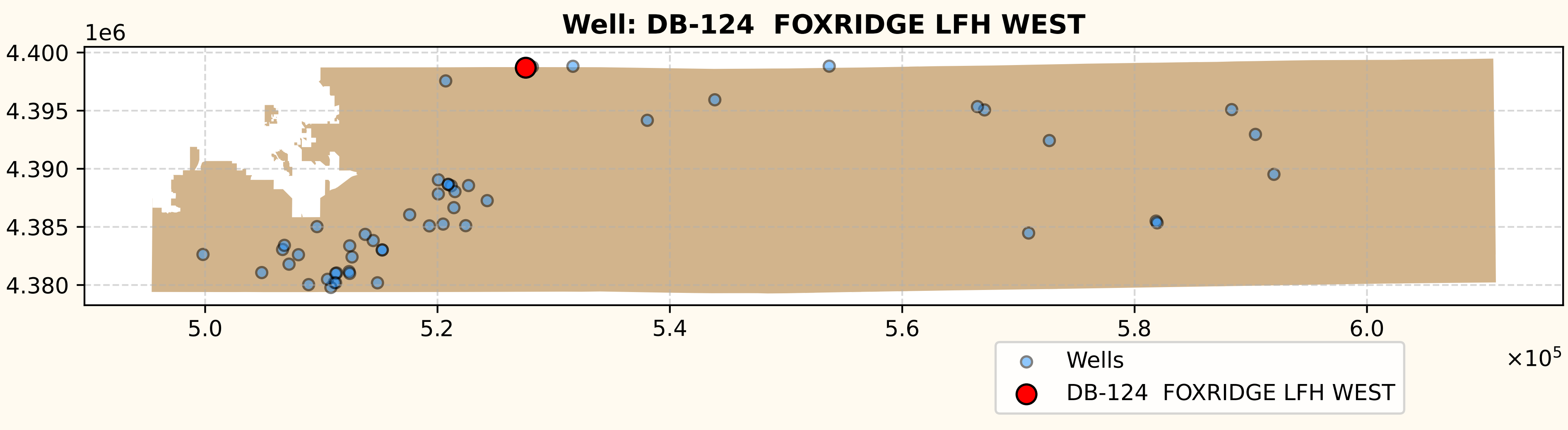


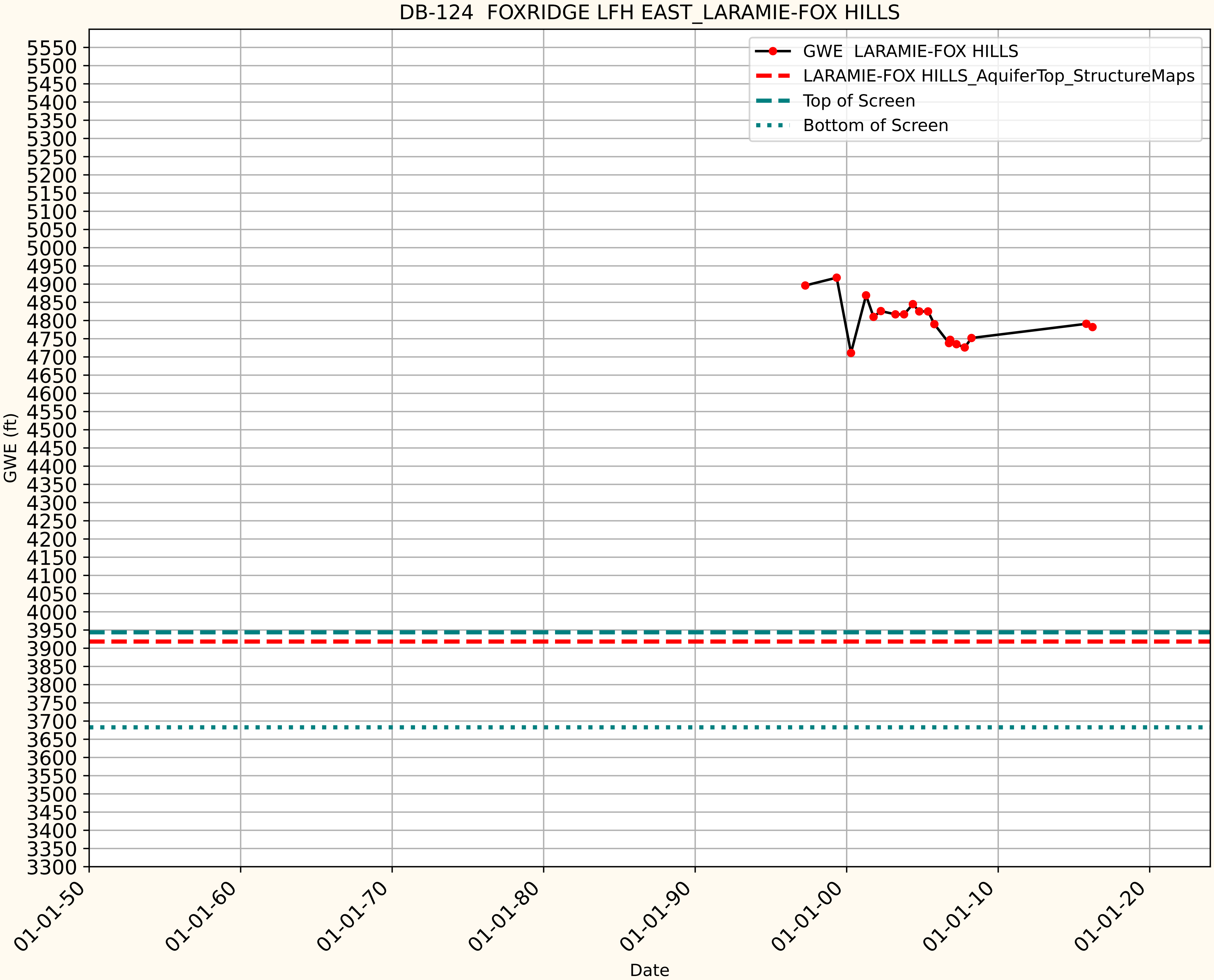
Well: DB-110 ECCV L-9
1e6
×10^5
Wells
DB-110 ECCV L-9


DB-110 ECCV SL-10_LARAMIE-FOX HILLS
GWE LARAMIE-FOX HILLS
LARAMIE-FOX HILLS_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

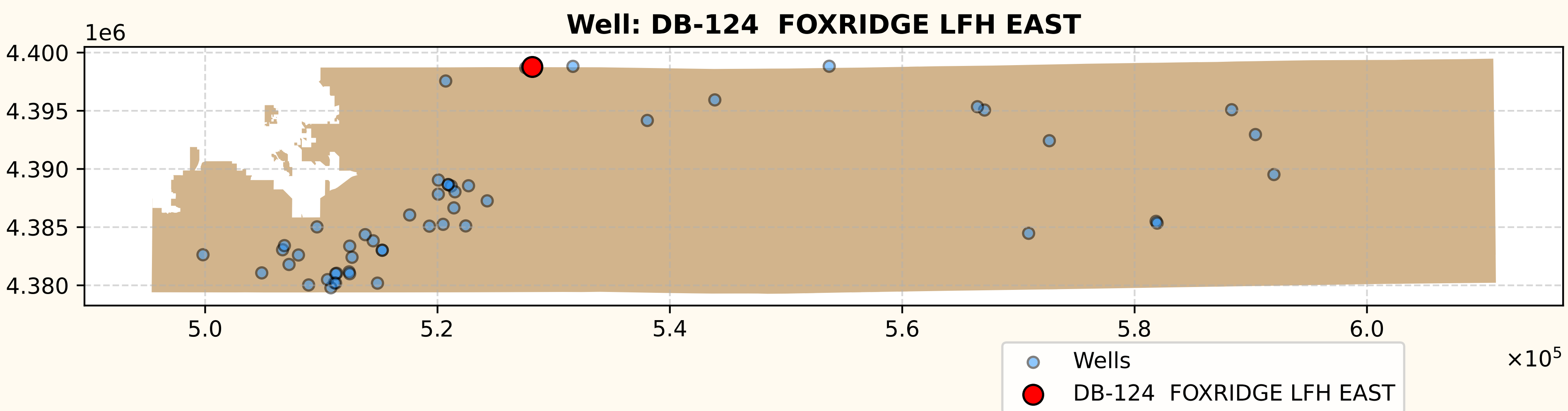

Well: DB-110 ECCV SL-10
1e6
Wells
DB-110 ECCV SL-10
×10^5


DB-124 FOXRIDGE LFH WEST_LARAMIE-FOX HILLS
GWE LARAMIE-FOX HILLS
LARAMIE-FOX HILLS_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
5550
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
3750
3700
3650
3600
3550
3500
3450
3400
3350
3300
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20


Well: DB-124 FOXRIDGE LFH WEST
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
DB-124 FOXRIDGE LFH WEST

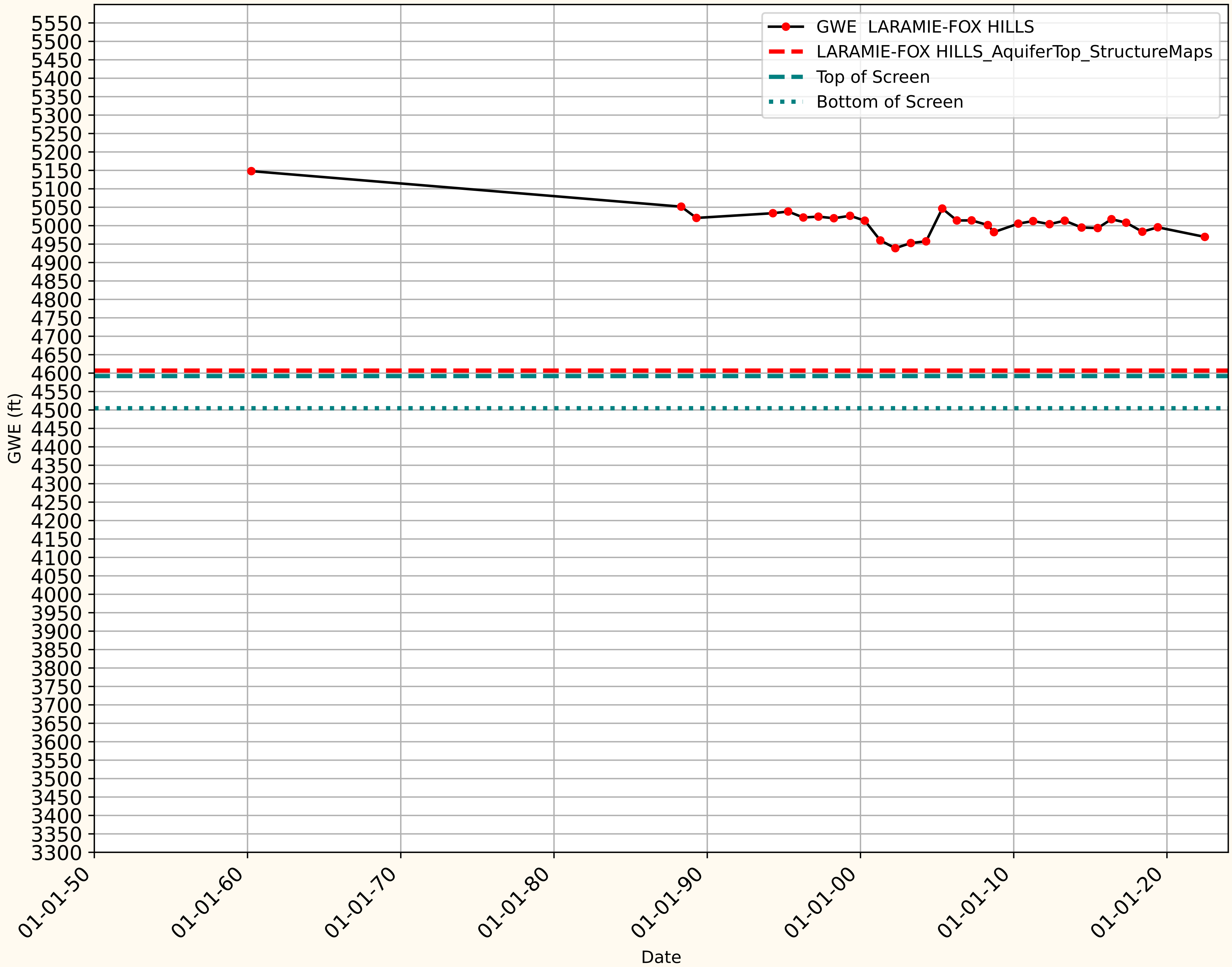


DB-124 FOXRIDGE LFH EAST_LARAMIE-FOX HILLS
GWE LARAMIE-FOX HILLS
LARAMIE-FOX HILLS_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
5550
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
3750
3700
3650
3600
3550
3500
3450
3400
3350
3300
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20
Date

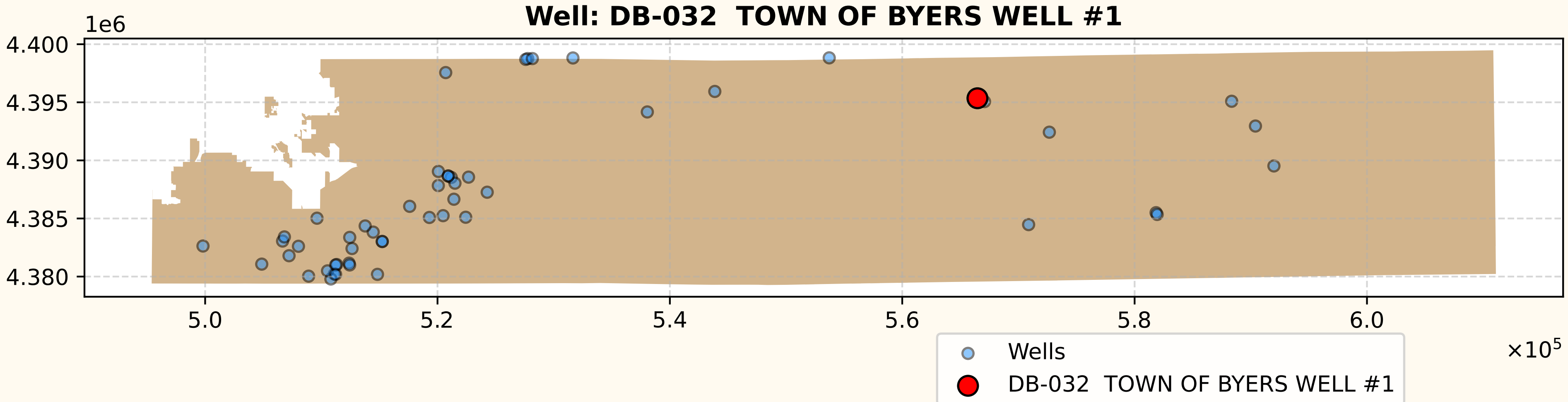


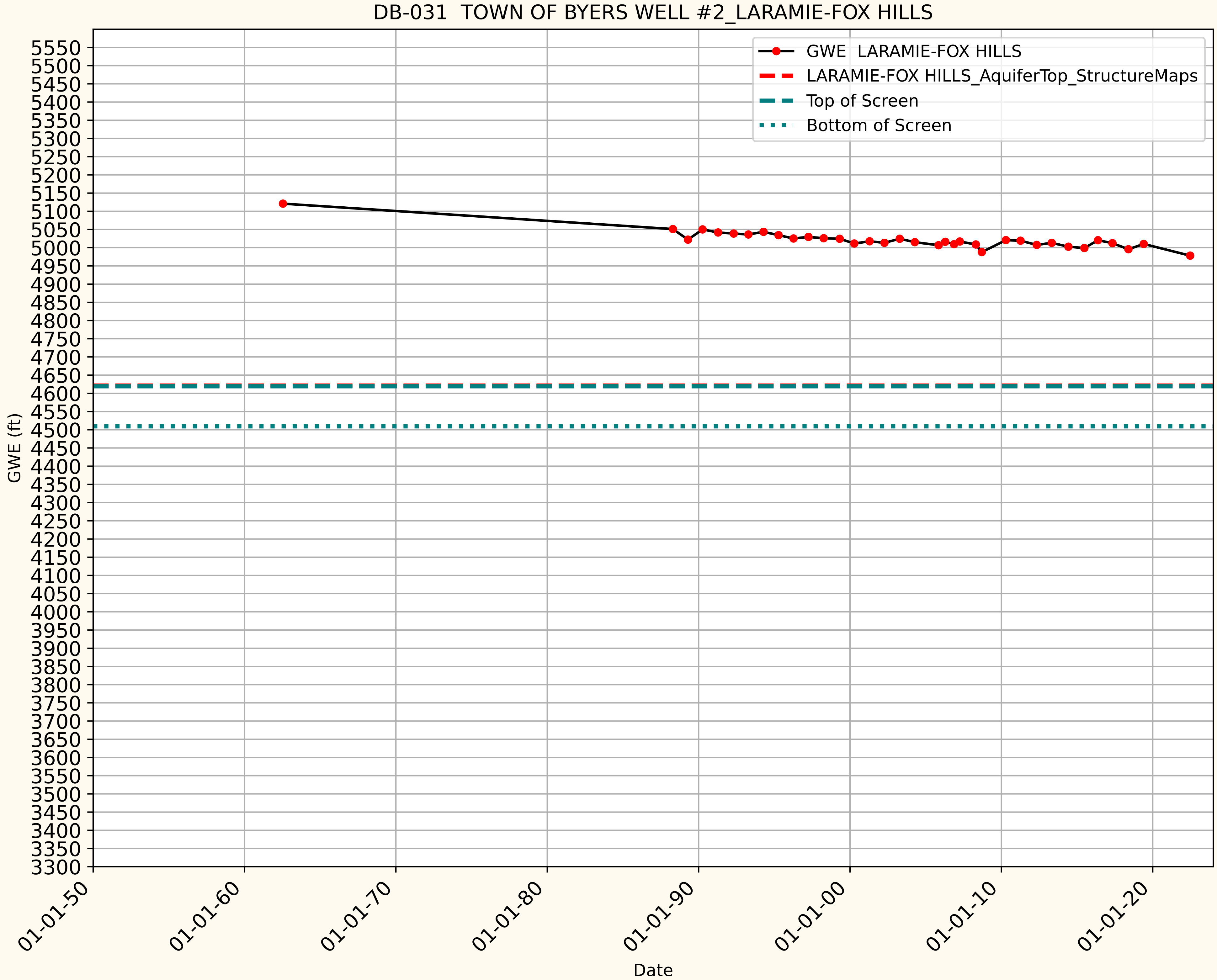
Well: DB-124 FOXRIDGE LFH EAST
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
DB-124 FOXRIDGE LFH EAST

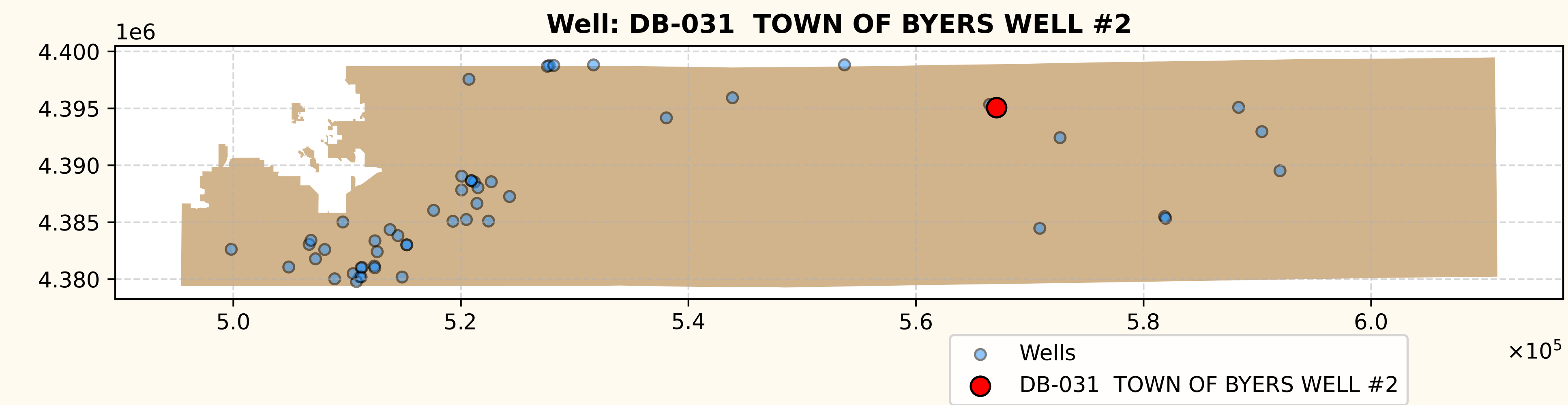
DB-032 TOWN OF BYERS WELL #1_LARAMIE-FOX HILLS

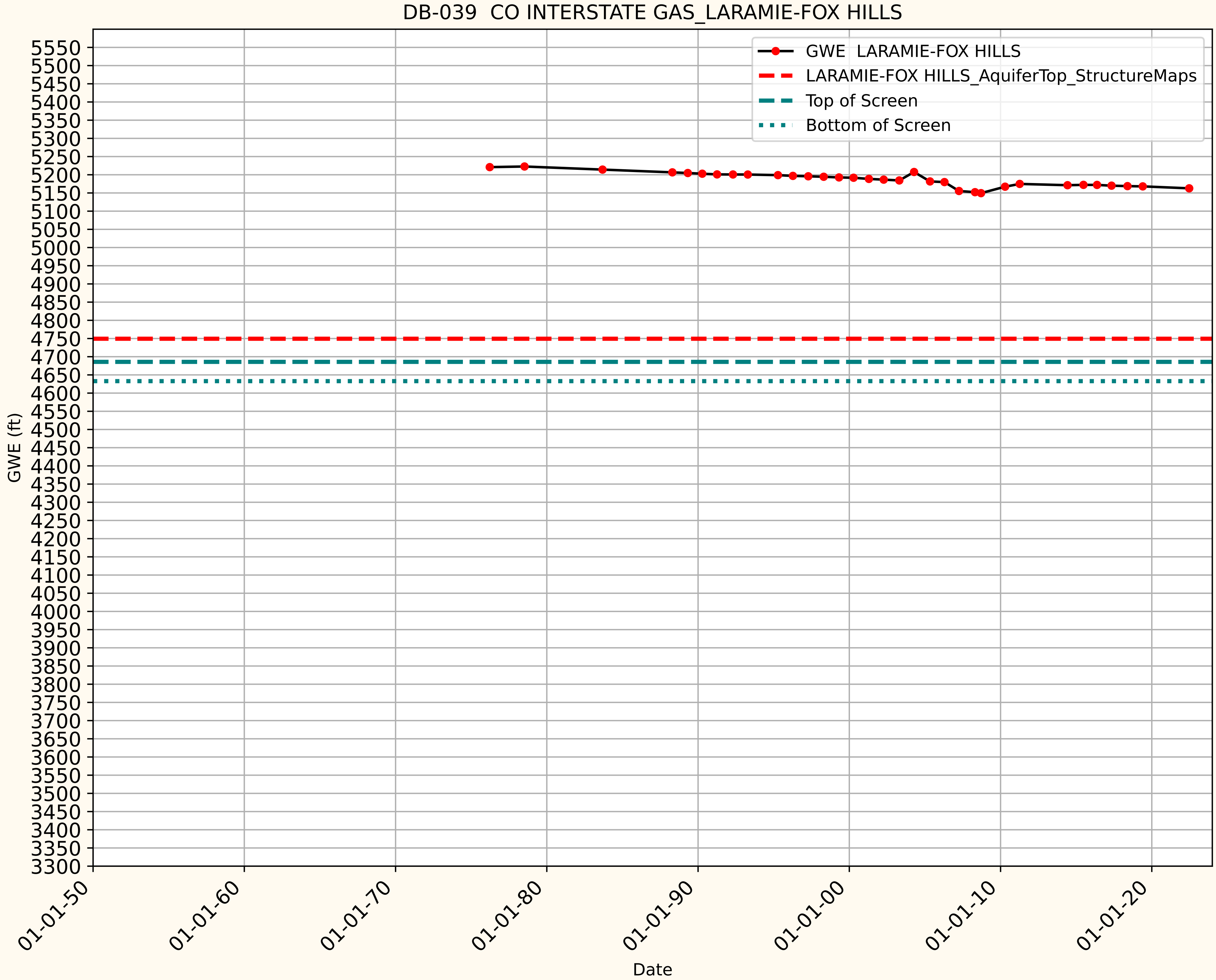


Well: DB-032 TOWN OF BYERS WELL #1

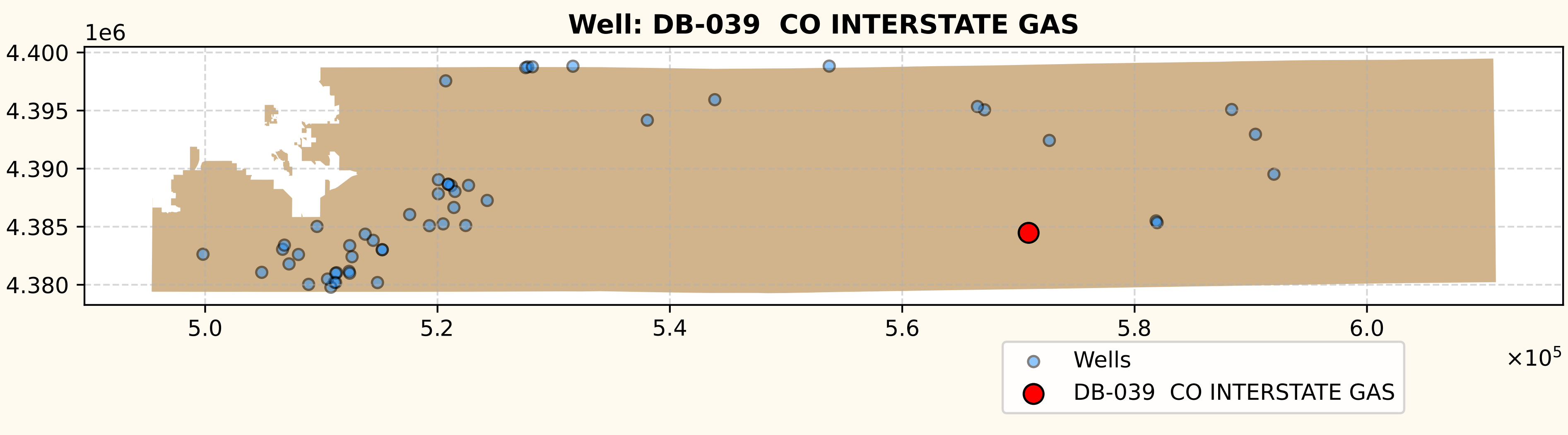



DB-031 TOWN OF BYERS WELL #2_LARAMIE-FOX HILLS
GWE LARAMIE-FOX HILLS
LARAMIE-FOX HILLS_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
5550
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
3750
3700
3650
3600
3550
3500
3450
3400
3350
3300
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

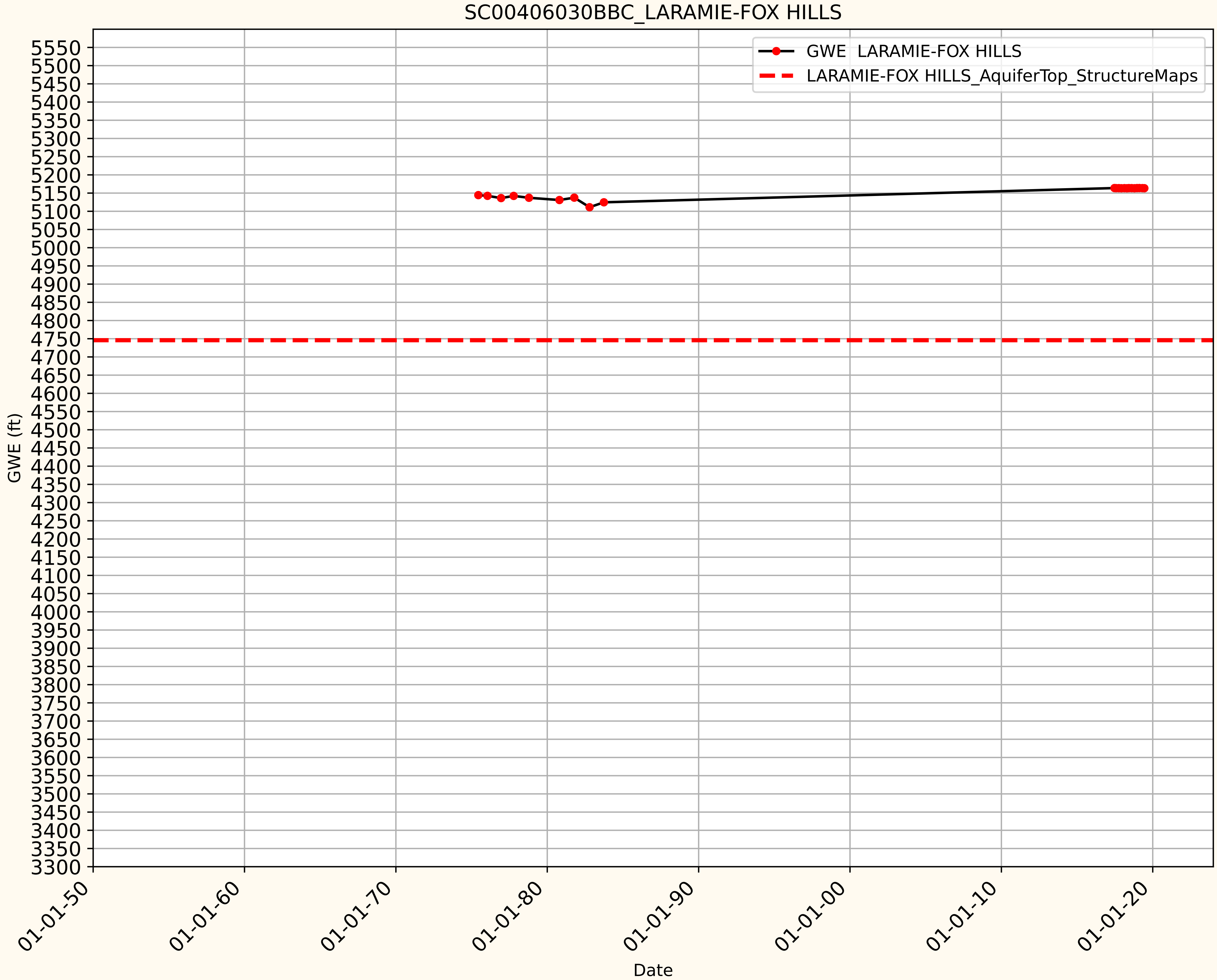

Well: DB-031 TOWN OF BYERS WELL #2
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
DB-031 TOWN OF BYERS WELL #2

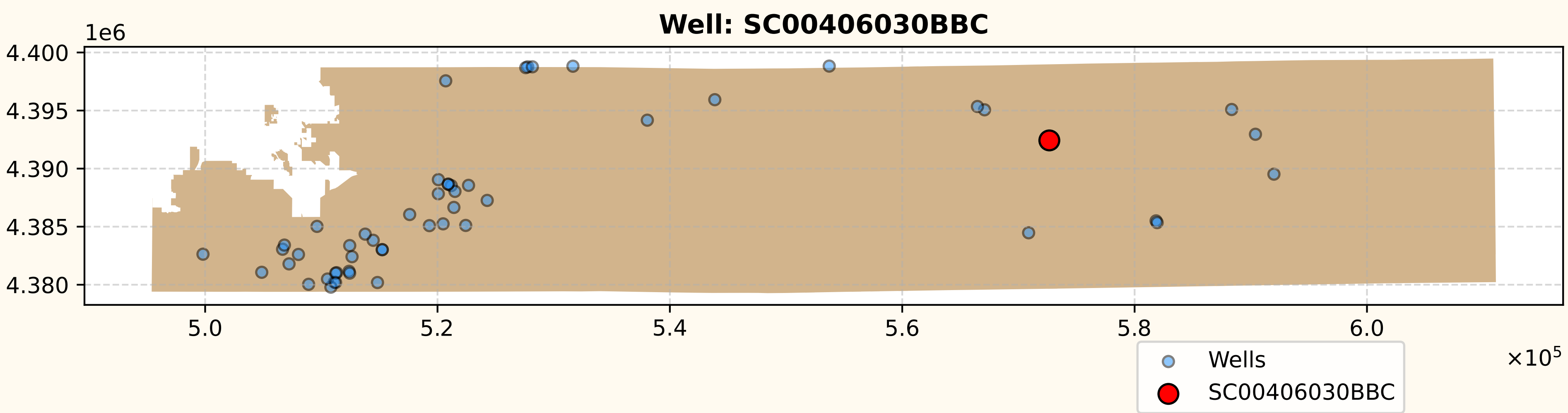


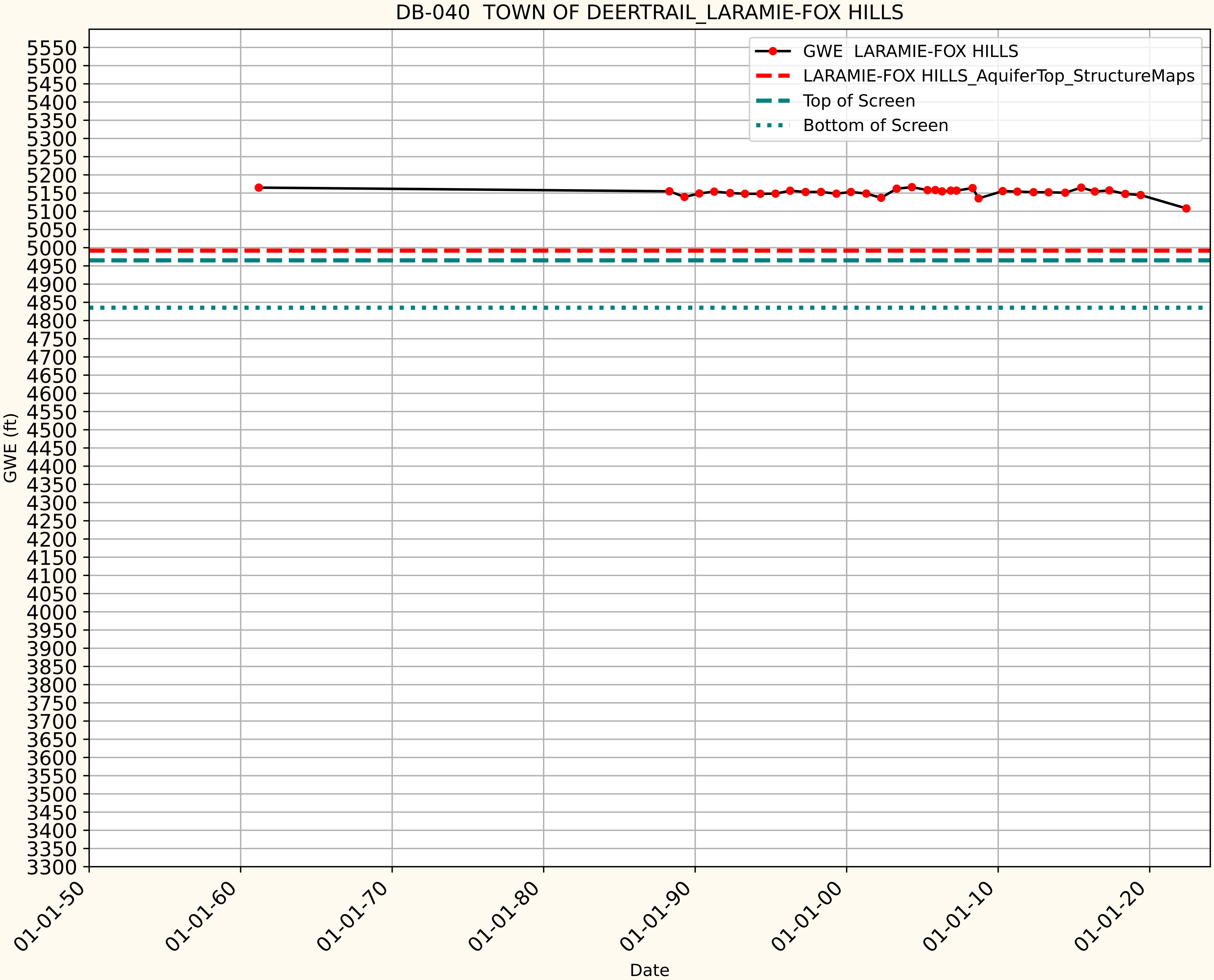
DB-039 CO INTERSTATE GAS_LARAMIE-FOX HILLS
GWE LARAMIE-FOX HILLS
LARAMIE-FOX HILLS_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
5550
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
3750
3700
3650
3600
3550
3500
3450
3400
3350
3300
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20
Date



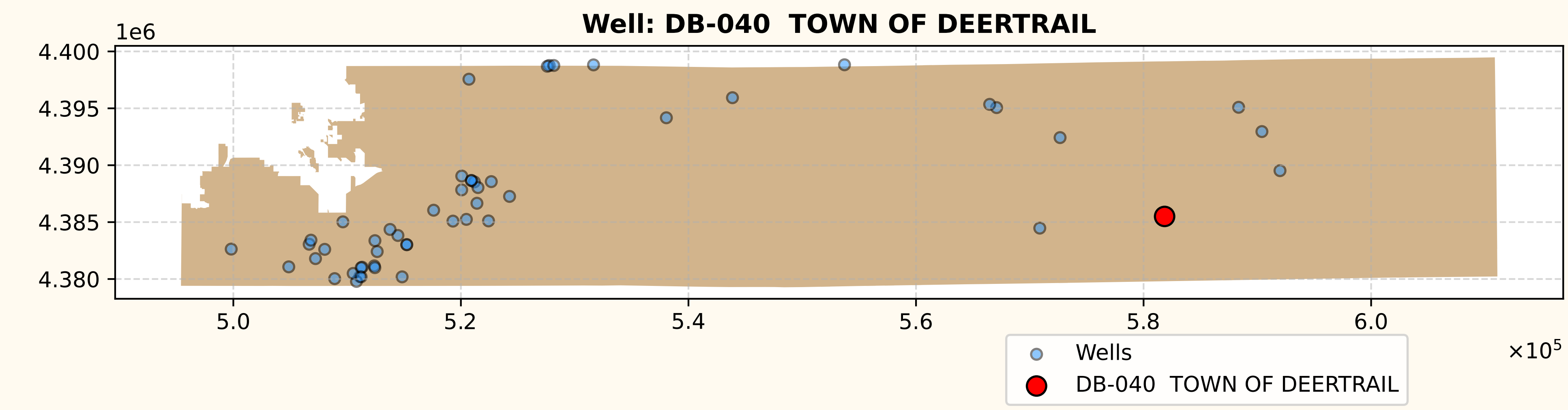
Well: DB-039 CO INTERSTATE GAS
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
DB-039 CO INTERSTATE GAS


SC00406030BBC_LARAMIE-FOX HILLS
GWE LARAMIE-FOX HILLS
LARAMIE-FOX HILLS_AquiferTop_StructureMaps
GWE (ft)
Date
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

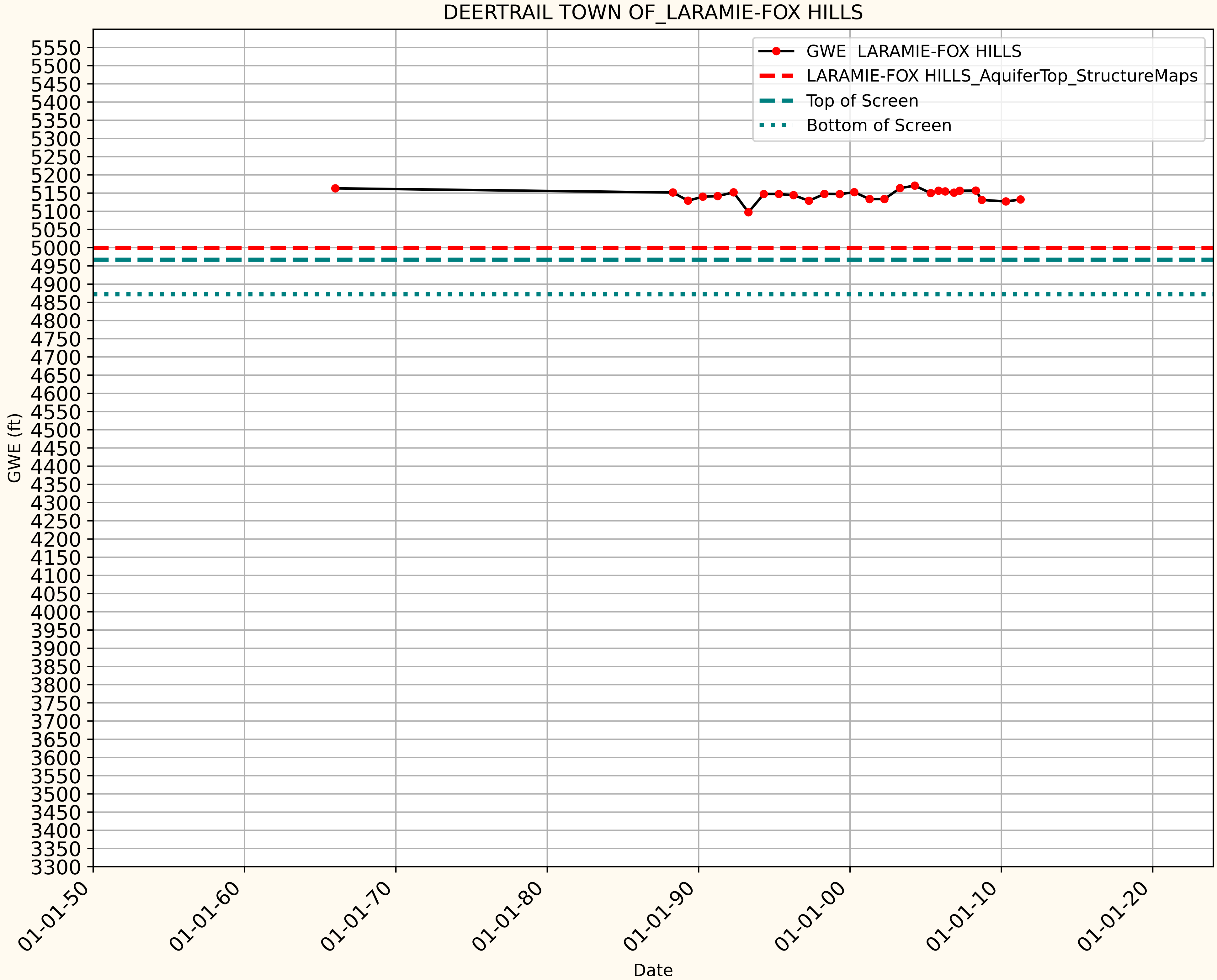

Well: SC00406030BBC
1e6
×10^5
Wells
SC00406030BBC

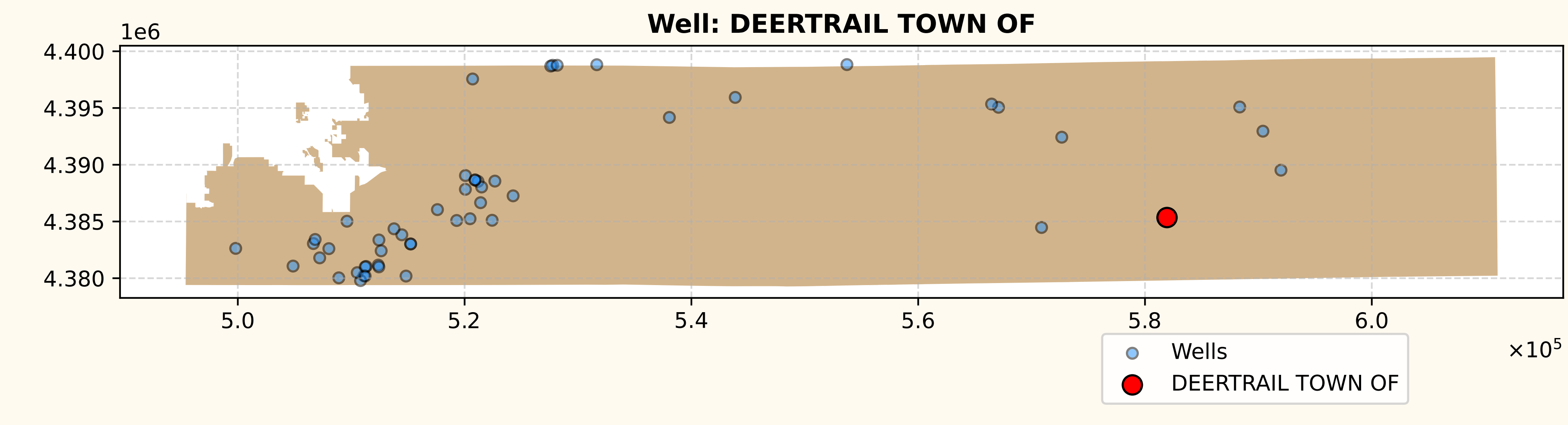


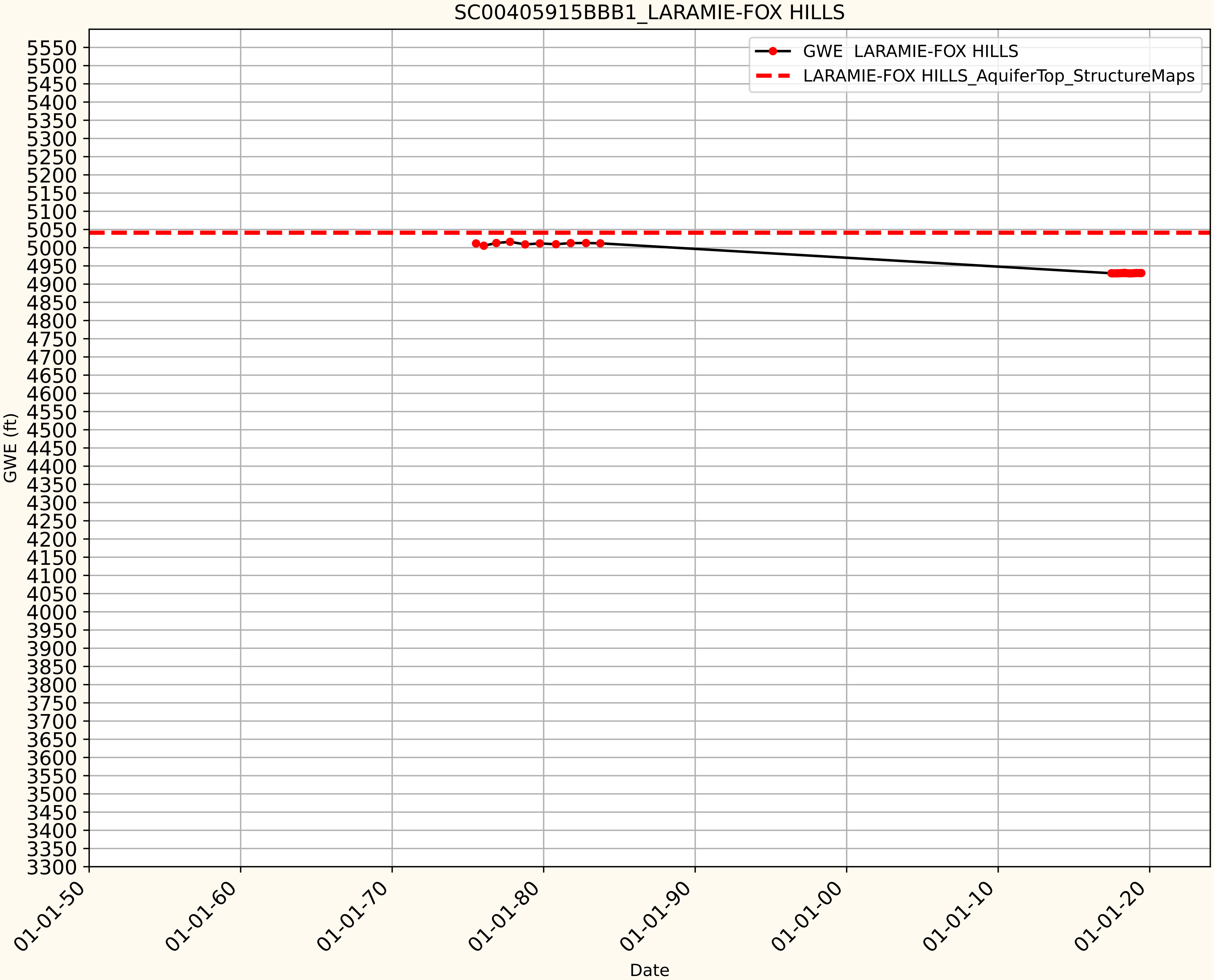
DB-040 TOWN OF DEERTRAIL_LARAMIE-FOX HILLS
GWE LARAMIE-FOX HILLS
LARAMIE-FOX HILLS_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20



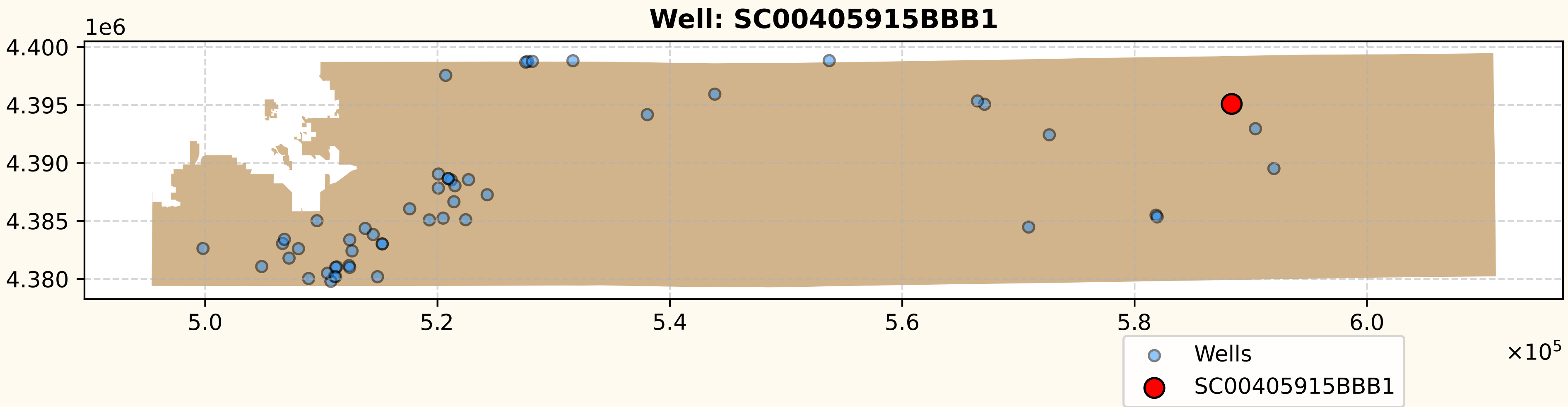
Well: DB-040 TOWN OF DEERTRAIL
1e6
×10^5
Wells
DB-040 TOWN OF DEERTRAIL


DEERTRAIL TOWN OF_LARAMIE-FOX HILLS
GWE LARAMIE-FOX HILLS
LARAMIE-FOX HILLS_AquiferTop_StructureMaps
Top of Screen
Bottom of Screen
GWE (ft)
Date
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

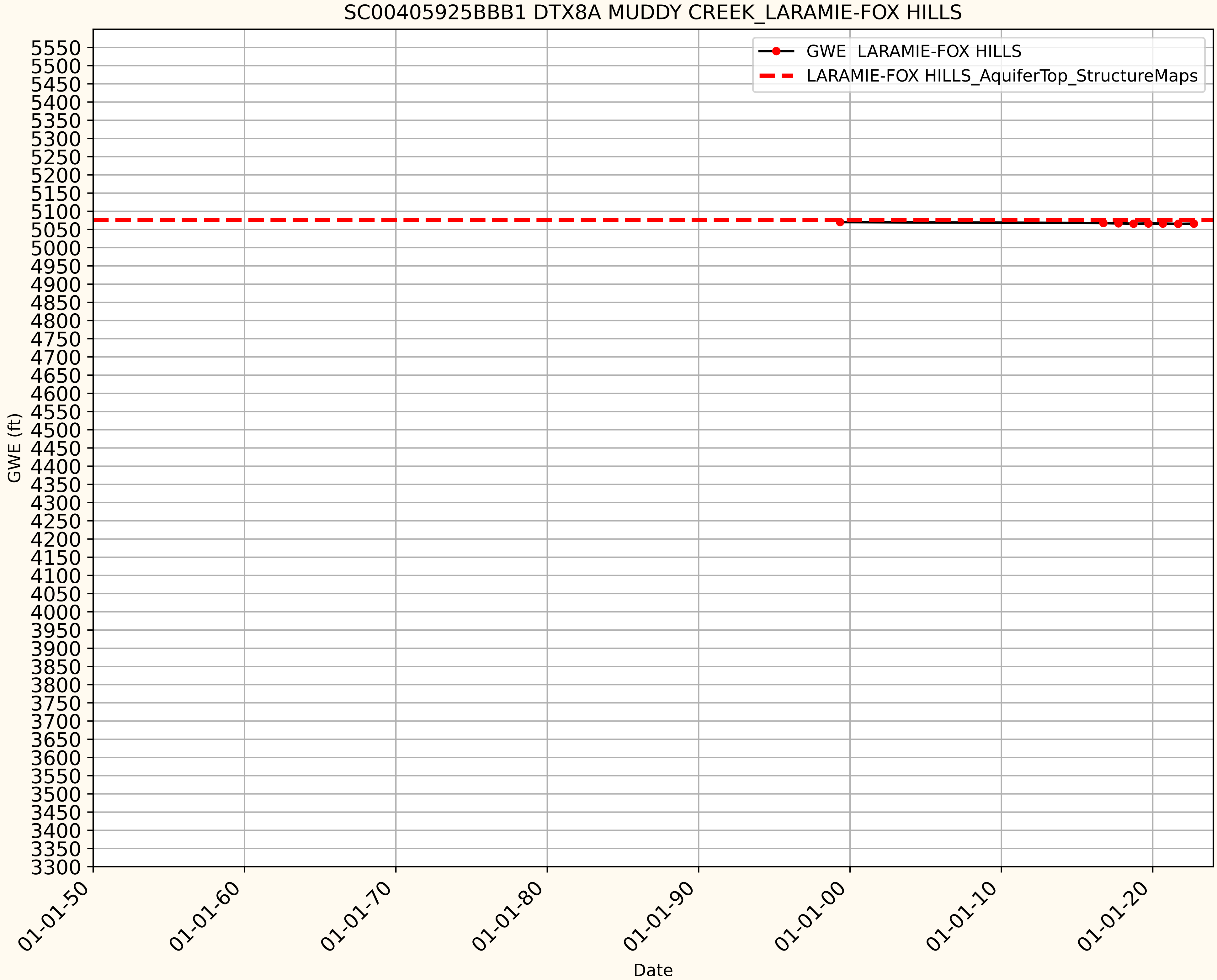

Well: DEERTRAIL TOWN OF
1e6
×10^5
Wells
DEERTRAIL TOWN OF

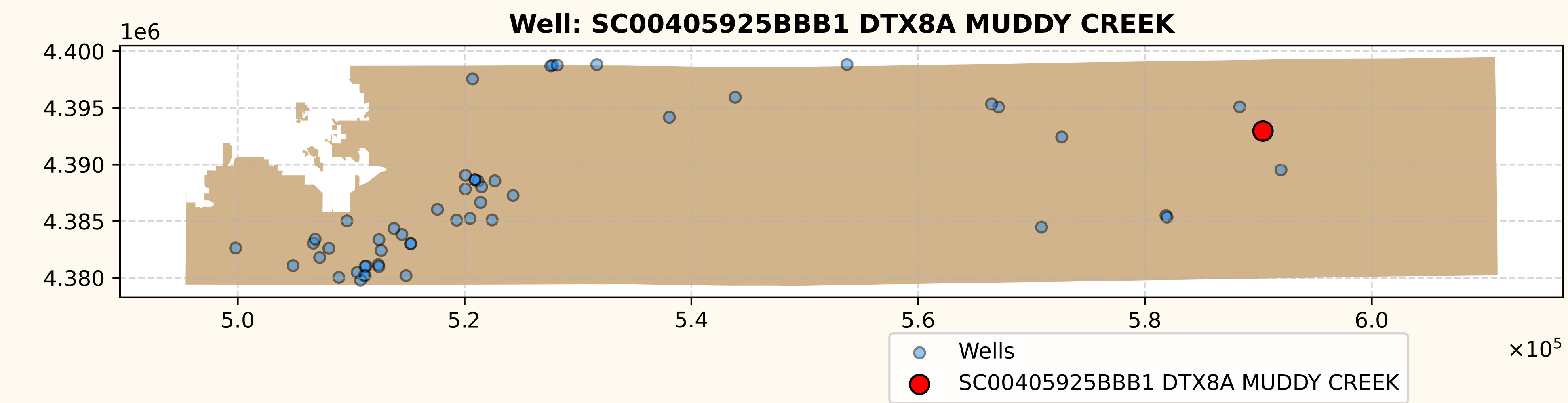


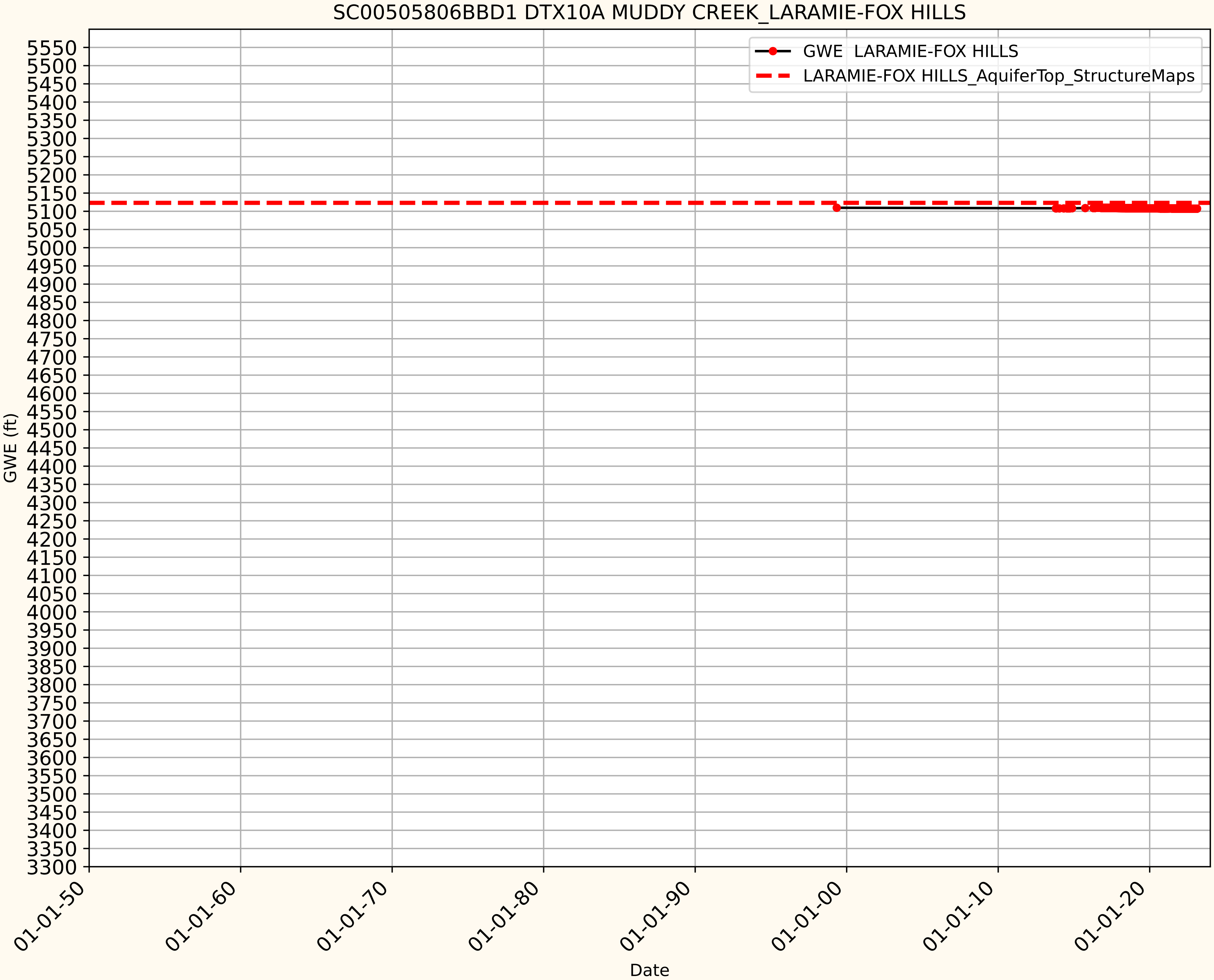
SC00405915BBB1_LARAMIE-FOX HILLS
GWE LARAMIE-FOX HILLS
LARAMIE-FOX HILLS_AquiferTop_StructureMaps
GWE (ft)
Date
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20

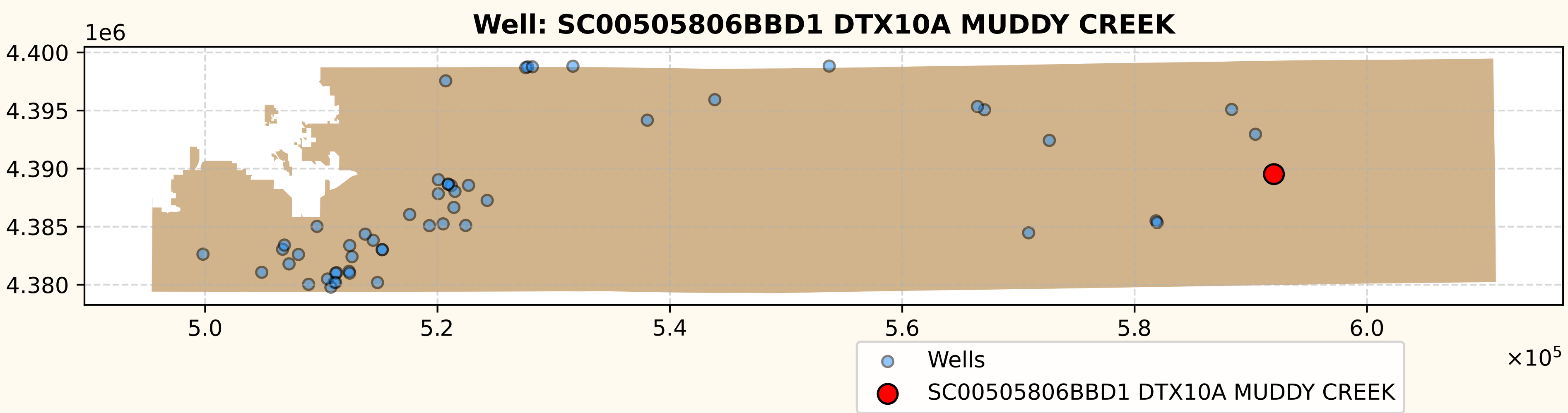


Well: SC00405915BBB1
1e6
×10^5
Wells
SC00405915BBB1


SC00405925BBB1 DTX8A MUDDY CREEK_LARAMIE-FOX HILLS
GWE LARAMIE-FOX HILLS
LARAMIE-FOX HILLS_AquiferTop_StructureMaps
GWE (ft)
Date
5550
5500
5450
5400
5350
5300
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
4750
4700
4650
4600
4550
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
3750
3700
3650
3600
3550
3500
3450
3400
3350
3300
01-01-50
01-01-60
01-01-70
01-01-80
01-01-90
01-01-00
01-01-10
01-01-20


Well: SC00405925BBB1 DTX8A MUDDY CREEK
1e6
4.400
4.395
4.390
4.385
4.380
5.0
5.2
5.4
5.6
5.8
6.0
×10^5
Wells
SC00405925BBB1 DTX8A MUDDY CREEK


SC00505806BBD1 DTX10A MUDDY CREEK_LARAMIE-FOX HILLS
GWE LARAMIE-FOX HILLS
LARAMIE-FOX HILLS_AquiferTop_StructureMaps
GWE (ft)
Date


Well: SC00505806BBD1 DTX10A MUDDY CREEK
Wells
SC00505806BBD1 DTX10A MUDDY CREEK

APPENDIX F

PETRA ANALYSIS FOR THE DENVER BASIN AQUIFER

PETRA™ ANALYSIS FOR THE DENVER BASIN AQUIFER

ARAPAHOE COUNTY, COLORADO

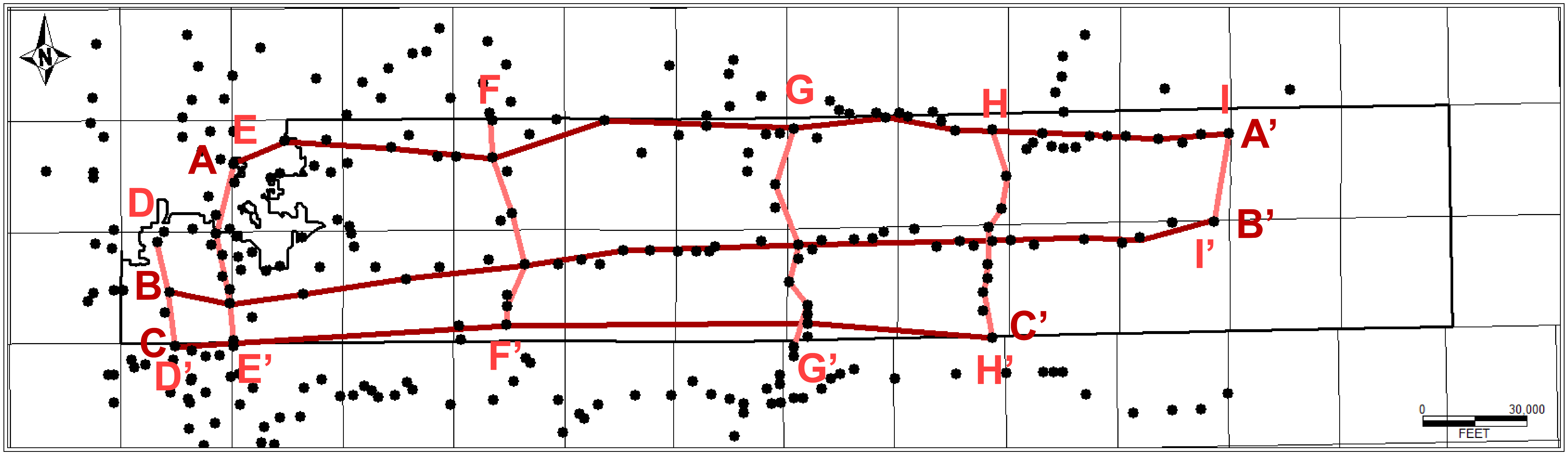
Introduction

LRE Water used the geologic interpretation software Petra™ by S&P Global to store and analyze well data and associated well logs to create regional cross sections and geologic maps, including structure maps, isochore maps, and resistivity “net pay” maps for each Denver Basin aquifer. These maps can be seen on Interactive Web Map.

Structure maps show the regional extent of each aquifer and provide information regarding the depth to the aquifer top and base. Structure maps can be used to inform well planning efforts such as where each aquifer occurs in the subsurface based on their occurrence in nearby wells.

Isochore maps show gross aquifer thickness and how it varies over the Arapahoe County region.

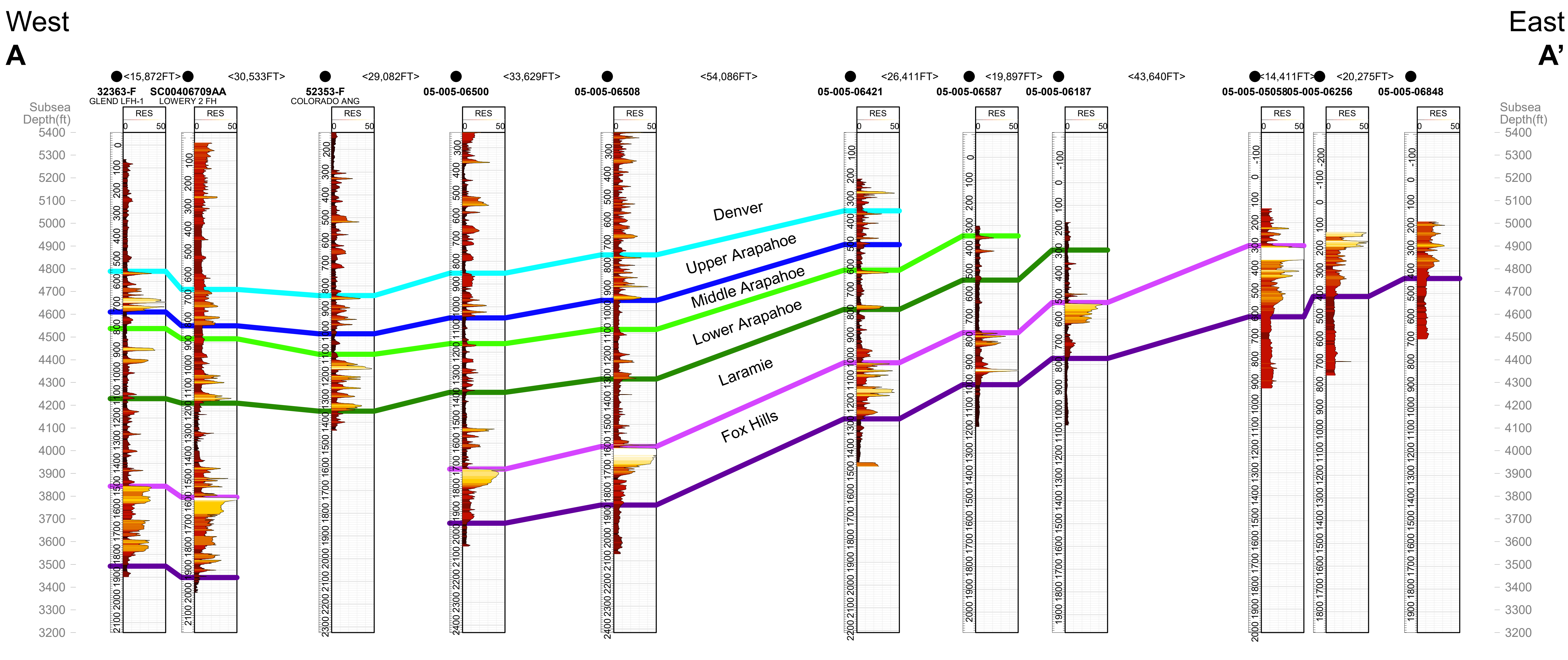
Resistivity “net pay” maps, created using a cut-off of 12 ohm-meters (ohm.m), calculated in 1,000 ft by 1,000 ft squares, were used to delineate higher resistivity beds, which are associated with higher permeability intervals (such as beds of sand) that contain favorable lithologies for groundwater flow. Beds with resistivities of 12 ohm.m or greater were identified and consolidated as a method to quantify and isolate intervals that contribute to producibility within an aquifer’s gross thickness.

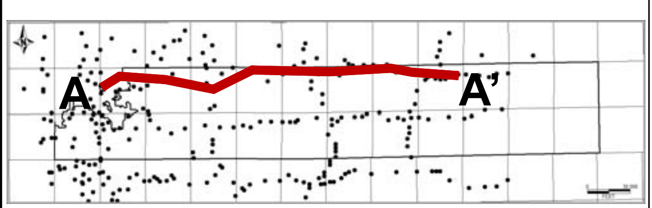


DATE: 5/16/2023

Overview Map
Cross Section Lines

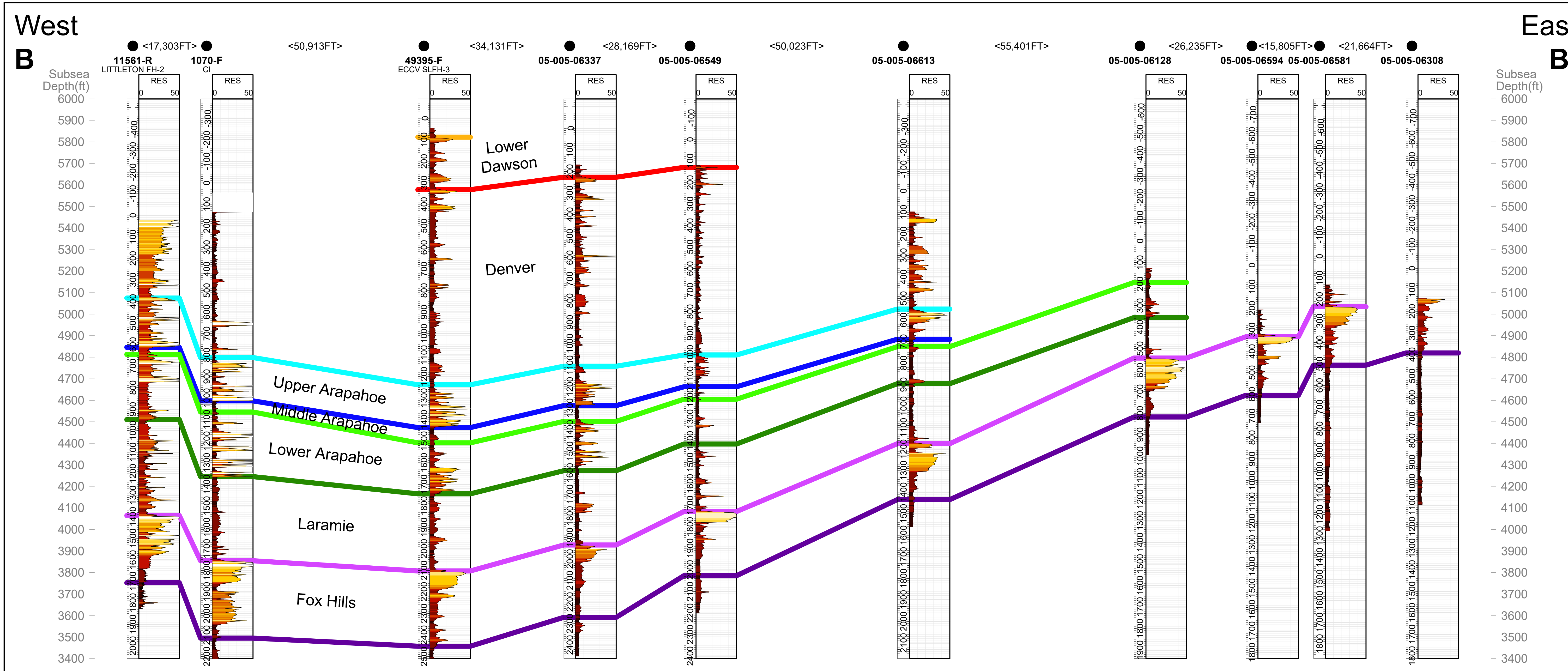
LRE WATER
CONNECTING WATER TO LIFE
1221 Auraria Parkway
Denver, CO 80204

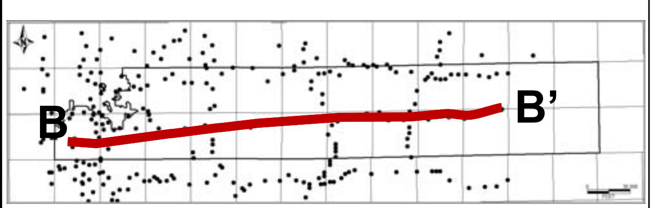




Regional Cross Section
West to East 1

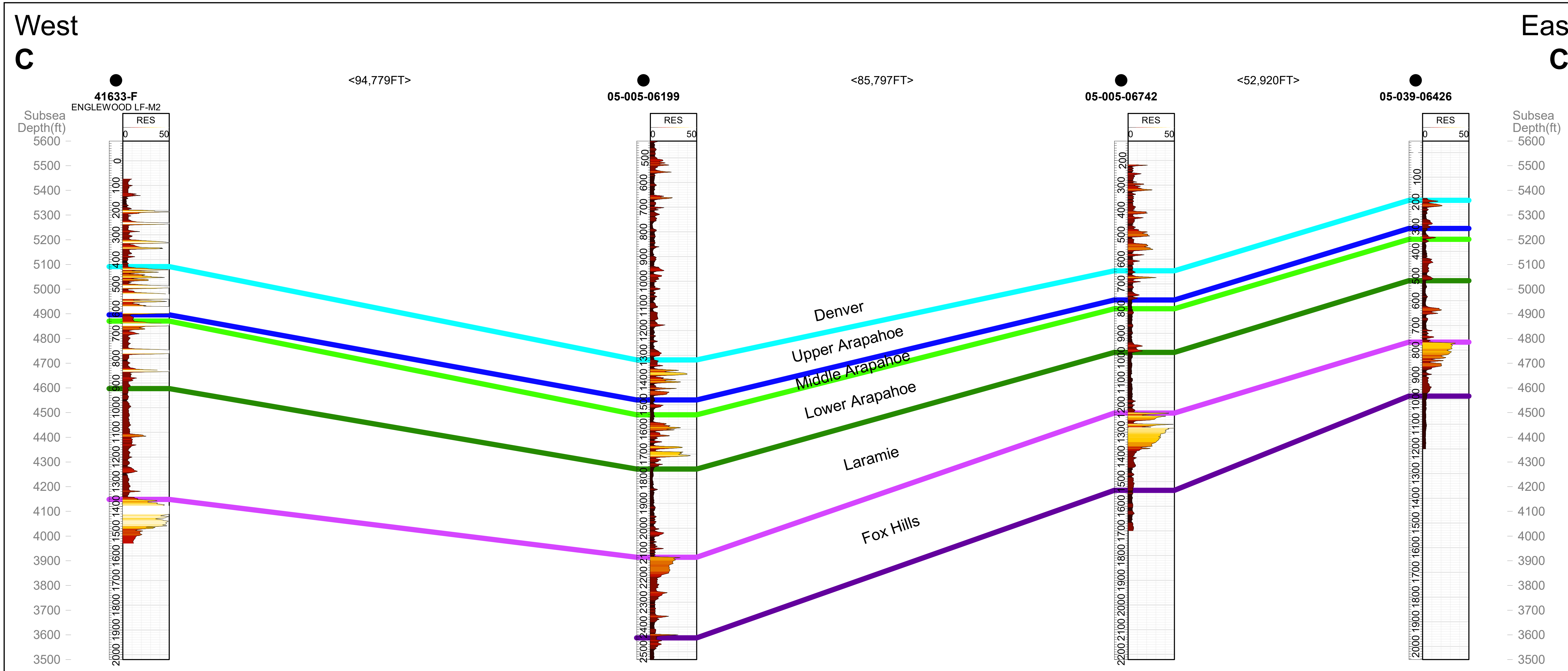
CONNECTING WATER TO LIFE
1221 Auraria Parkway
Denver, CO 80204

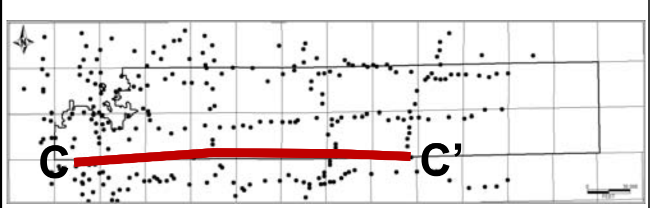




Regional Cross Section
West to East 2

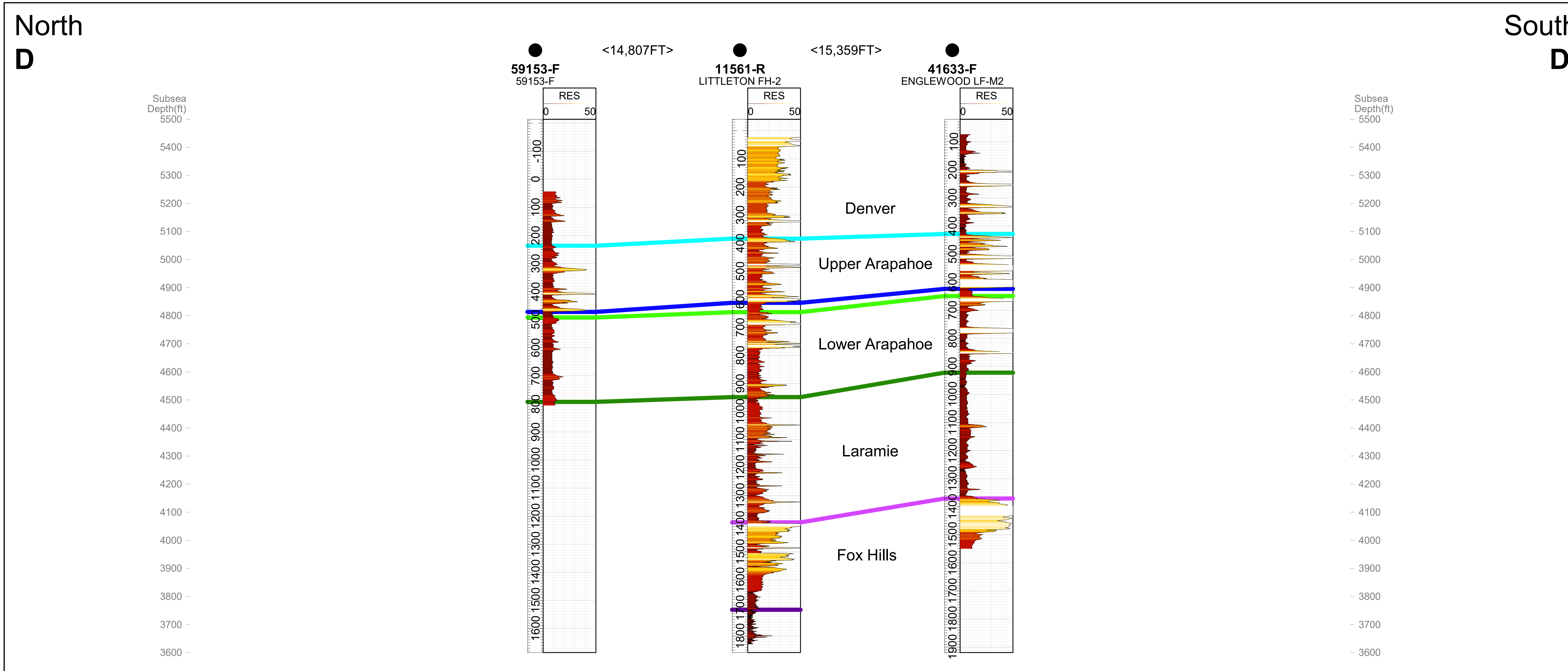
CONNECTING WATER TO LIFE
1221 Auraria Parkway
Denver, CO 80204

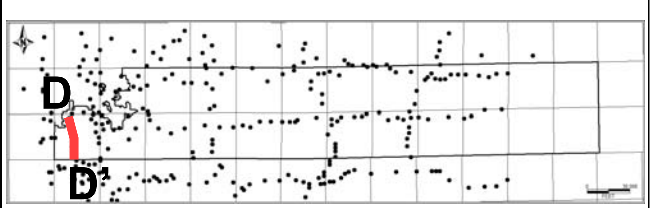




Regional Cross Section
West to East 3

LRE WATER
CONNECTING WATER TO LIFE
1221 Auraria Parkway
Denver, CO 80204



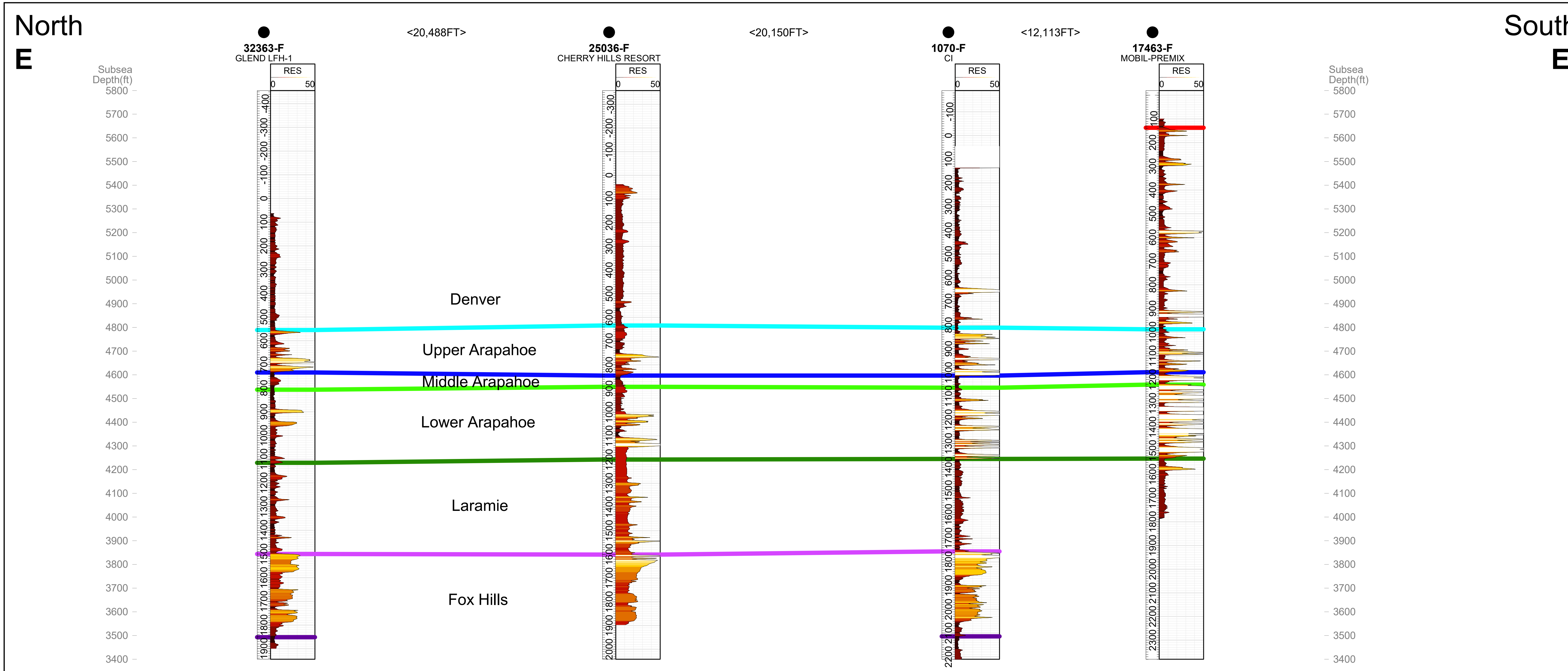


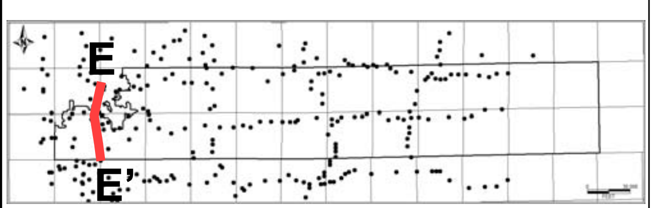
Regional Cross Section

North to South 1

CONNECTING WATER TO LIFE

1221 Auraria Parkway
Denver, CO 80204



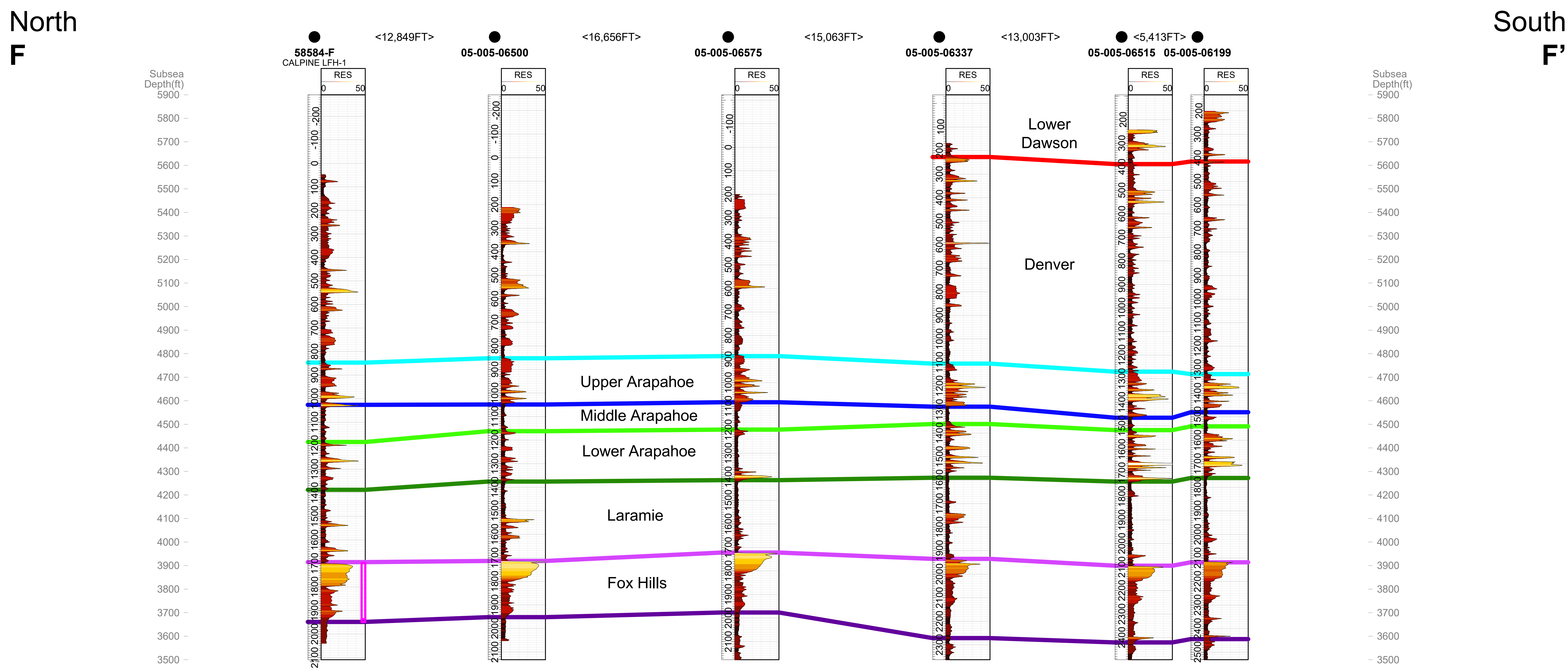


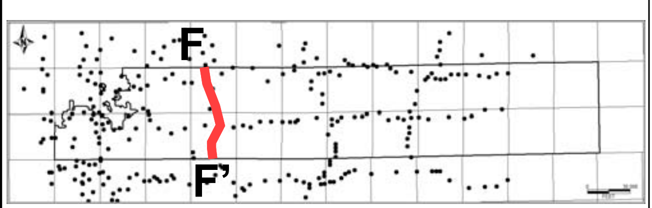
Regional Cross Section

North to South 2

LRE WATER
CONNECTING WATER TO LIFE

1221 Auraria Parkway
Denver, CO 80204

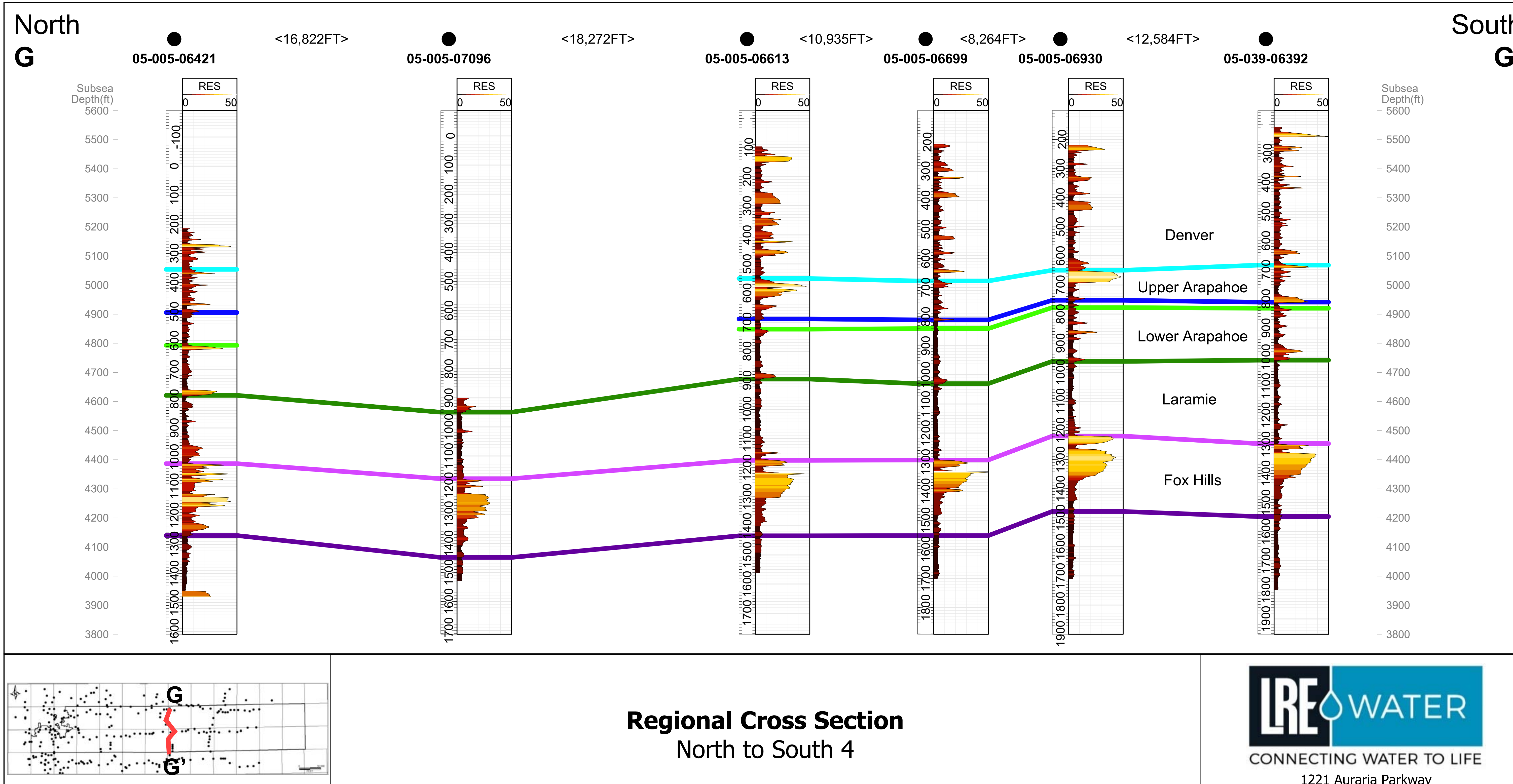




Regional Cross Section

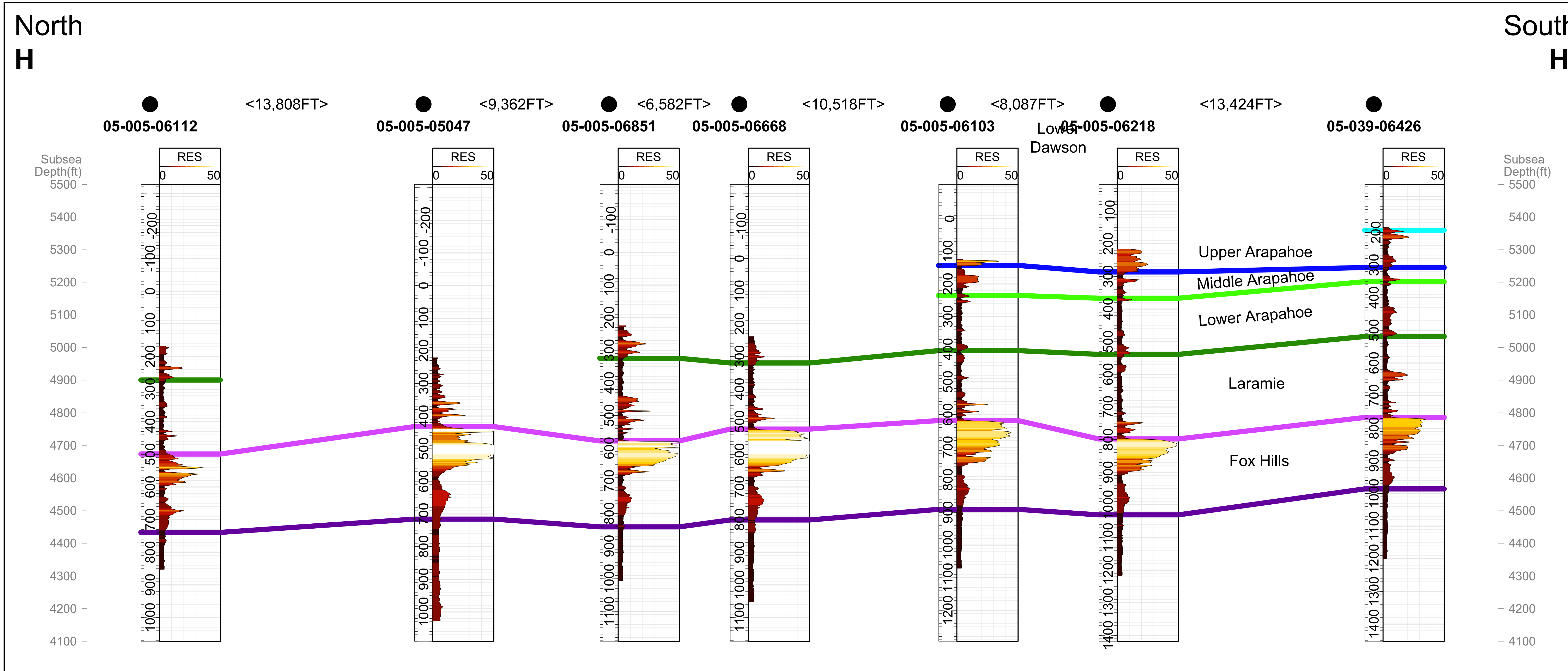
North to South 3

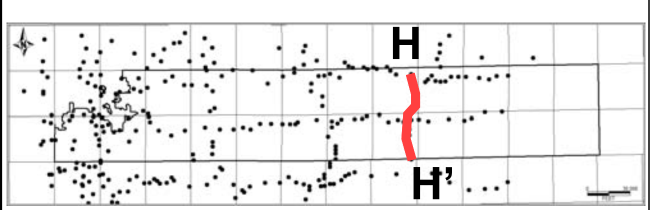
LRE WATER
CONNECTING WATER TO LIFE
1221 Auraria Parkway
Denver, CO 80204



Regional Cross Section
North to South 4

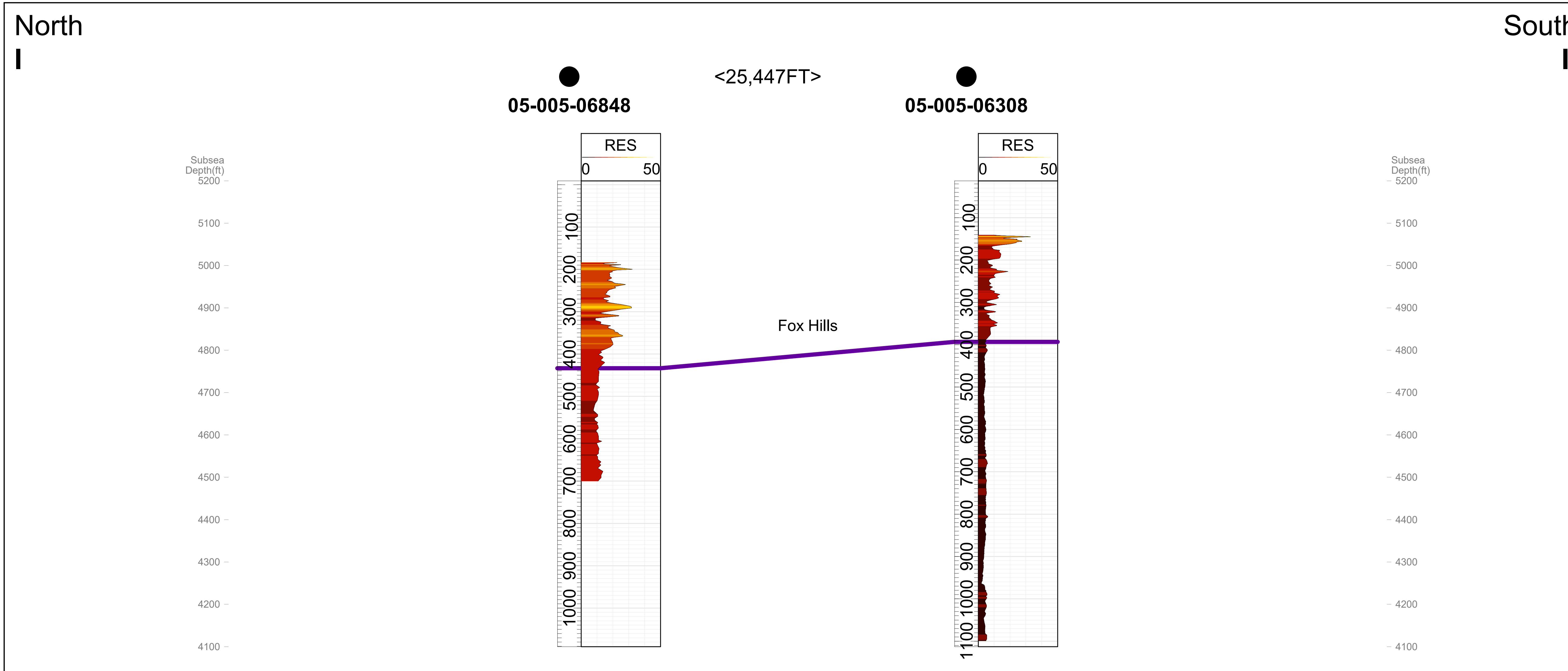
LRE WATER
CONNECTING WATER TO LIFE
1221 Auraria Parkway
Denver, CO 80204

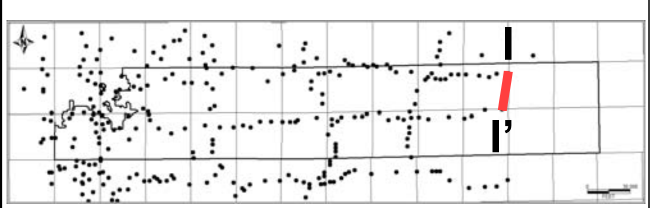




Regional Cross Section
North to South 5

CONNECTING WATER TO LIFE
1221 Auraria Parkway
Denver, CO 80204





Regional Cross Section
North to South 6

CONNECTING WATER TO LIFE
1221 Auraria Parkway
Denver, CO 80204

APPENDIX G

DEMAND REDUCTION ESTIMATE CALCULATIONS

Demand Reduction Estimate Calculations

Arapahoe County – Single Family

2025 (Existing)

Number of Existing Homes – 26,104

Existing irrigation demand is 2,760 acre-feet.

Ten percent (0.10) of existing homes (2,610) will convert to water-wise landscaping by 2050.

Each of these homes currently uses approximately 0.11 acre-feet per year for outdoor irrigation.

Maximum possible reduction = 2610 x .11 = 287 acre-feet.

Thirty five percent of 287 = 100 acre-feet of reduced demand.

2050 (Low)

Number of forecasted homes = 36,323

Projected irrigation usage is 3,840 acre-feet.

It's assumed that 100 percent of new homes will include water-wise landscaping.

Maximum possible increase in irrigation demand (from 2025) is 1,080 acre-feet.

Assuming a 35 percent reduction in demand = 378 acre-feet of reduced demand

2050 High

Number of forecasted homes = 39,754

Projected irrigation usage is 4,203 acre-feet.

It's assumed that 100 percent of new homes will include water-wise landscaping.

Maximum possible increase in irrigation demand (from 2020) is 1,443 acre-feet.

Assuming a 35 percent reduction in demand = 505 acre-feet of reduced demand

Arapahoe County – Multi-Family

2025 (Existing)

Number of Existing Units – 15,093

Existing irrigation usage is 1,043 acre-feet.

Ten percent (0.10) of existing units (1,509) will convert to water-wise landscaping by 2050.

Each of these homes currently uses approximately .07 acre-feet per year for outdoor irrigation.

Multiplied by 1,509 units = 106 acre-feet of reduced demand.

2050 (Low)

Number of forecasted homes = 21,002

Projected irrigation usage is 1,451 acre-feet.

100 percent of new homes will incorporate water wise landscaping based on proposed changes to code

Maximum possible increase in irrigation demand (from 2020) is 408 acre-feet.

Assuming a 35 percent reduction in demand = 143 acre-feet of reduced demand.

2050 (High)

Number of forecasted homes = 22,986

Projected irrigation usage is 1,588 acre-feet.

100 percent of new homes will incorporate water wise landscaping based on proposed changes to code.

Maximum possible increase in irrigation demand (from 2025) is 545 acre-feet.

Assuming a 35 percent reduction in demand = 191 acre-feet of reduced demand.

Arapahoe County – Commercial

2025 (Existing)

Number of Existing Jobs – 52,045

Current irrigation demand is 1,744 acre-feet.

Fifteen percent (0.15) of existing commercial property will convert to water-wise landscaping by 2050.

Fifteen percent of 1,744 acre = 261 acre-feet.

Thirty five percent of 261 acre-feet = 91 acre-feet of reduced demand.

<u>2050 (Low)</u>

Number of Forecasted Jobs – 62,663

Forecasted irrigation demand is 2,100 acre-feet.

It's assumed that 100 percent of new commercial demand (for irrigation) will include water-wise landscaping.

New demand = 2100 – 1744 = 356 acre-feet.

Assuming a 35 percent reduction in demand = 125 acre-feet of reduced demand.

<u>2050 (High)</u>

Number of Forecasted Jobs – 69,686

Forecasted irrigation demand is 2,335 acre-feet.

100 percent of new commercial property will include water-wise landscaping.

New demand = 2,335 – 1744 = 591 acre-feet.

Assuming a 35 percent reduction in demand = 207 acre-feet of reduced demand.

City of Aurora – SINGLE FAMILY

Water-wise requirements in Code – Yes

<u>2025 (Existing)</u>

Number of Existing Homes – 88,559

Current irrigation demand is 4,964 acre-feet.

Ten percent (0.10) of existing homes will convert to water-wise landscaping by 2050 = 8,855 homes.

Each of these homes currently uses approximately 0.06 acre-feet per year for outdoor irrigation.

Maximum reduction (if 100 percent) would be 531 acre-feet.

35 percent reduction is =186 acre-feet of reduced demand

2050 (Low)

Number of forecasted homes = 117,289

Forecasted irrigation demand = 6,575 acre-feet

It's assumed that 100 percent of new residential will include water-wise landscaping.

New demand = 6575-4964 = 1,611

Thirty five percent of 1,611 acre-feet = 564 acre-feet of reduced demand.

2050 High

Number of forecasted homes = 126,566

Projected irrigation demand is 7,095 acre-feet.

It's assumed that 100 percent of new homes will include water wise landscaping.

New demand = 7095 - 4964 = 2,131 acre-feet

Thirty five percent of 2,131 acre-feet = 746 acre-feet of reduced demand.

City of Aurora – MULTI-FAMILY

2025 (Existing)

Number of Existing Units – 51,204

Existing irrigation usage is 1,784 acre-feet.

Ten percent (0.10) of existing homes (5,120) will convert to water-wise landscaping by 2050.

Each unit uses .03 acre-feet / year for outdoor irrigation.

Maximum savings (100 percent) would be 154 acre-feet.

35 percent reduction would be 54 acre-feet of reduced demand.

2050 (Low)

Number of forecasted homes = 67,816

Projected irrigation demand is 2,363 acre-feet.

It's assumed 100 percent of new homes will incorporate water wise landscaping.

Maximum possible increase in irrigation demand (from 2025) is 579 acre-feet.

Thirty five percent of 579 acre-feet = 203 acre-feet of reduced demand.

2050 (High)

Number of forecasted homes = 73,180

Projected irrigation demand is 2,550 acre-feet.

It's assumed 100 percent of new homes will incorporate water wise landscaping.

Maximum possible increase in irrigation demand (from 2025) is 766 acre-feet.

Thirty five percent of 766 = 268 acre-feet of reduced demand.

City of Aurora – COMMERCIAL

2025 (Existing)

Number of Existing Jobs – 134,857

Current irrigation demand is 2,523 acre-feet.

Fifteen percent (0.15) of existing commercial property will convert to water-wise landscaping by 2050.

Fifteen percent of 2,523 = 378 acre-feet

Thirty five percent of 378 acre-feet is 132 acre-feet of reduced demand.

2050 (Low)

Number of Forecasted Jobs – 167,091

Forecasted irrigation demand is 3,126 acre-feet.

100 percent of new demand (added) will include water-wise landscaping.

New maximum demand = 603 acre-feet.

Thirty-five percent of 603 is 211acre-feet of reduced demand.

2050 (High)

Number of Forecasted Jobs – 188,414

Forecasted irrigation demand is 3,525 acre-feet.

100 percent of new demand (added) will include water-wise landscaping.

New maximum demand = 1,002 acre-feet.

Thirty five percent of 1,002 acre-feet is 350 acre-feet of reduced demand.

City of Centennial – SINGLE FAMILY

2020 (Existing)

Number of Existing Homes – 26,977

Current irrigation demand is 2,852 acre-feet.

Ten percent (0.10) of existing homes will convert to water-wise landscaping by 2050 = 2,697

Each of these homes currently uses approximately 0.11 acre-feet per year for outdoor irrigation.

Maximum reduction (if 100 percent) would be 297 acre-feet.

35 percent reduction is = 104 acre-feet of reduced demand.

2050 (Low)

Number of forecasted homes = 30,285

Forecasted irrigation demand = 3,202 acre-feet

It's assumed that 100 percent of new residential will include water-wise landscaping.

New demand = 3202-2852 = 350 acre-feet

Thirty five percent of 350 acre-feet = 123 acre-feet of reduced demand

2050 High

Number of forecasted homes = 31,353

Projected irrigation demand is 3,314 acre-feet.

It's assumed that 100 percent of new residential will include water-wise landscaping.

New demand = 3314 - 2852 = 462 acre-feet

Thirty five percent of 462 acre-feet = 162 acre-feet of reduced demand

City of Centennial – MULTI-FAMILY

2025 (Existing)

Number of Existing Homes – 15,598

Current irrigation demand is 1,126 acre-feet.

Ten percent (0.10) of existing homes will convert to water-wise landscaping by 2050 = 1,559

Each of these homes currently uses approximately 0.07 acre-feet per year for outdoor irrigation.

Maximum reduction (if 100 percent) would be 109 acre-feet.

35 percent reduction is = 38 acre-feet of reduced demand

2050 (Low)

Number of forecasted homes = 17,511

Forecasted irrigation demand = 1,210 acre-feet

It's assumed that 100 percent of new residential will include water-wise landscaping.

New demand = 1210-1126 = 84 acre-feet

Thirty five percent of 84 acre-feet = 29 acre-feet of reduced demand

2050 High

Number of forecasted homes = 18,128

Projected irrigation demand is 1,253 acre-feet.

It’s assumed that 100 percent of new residential will include water-wise landscaping.

New demand = 1253 - 1126 = 127 acre-feet

Thirty five percent of 127 acre-feet = 44 acre-feet of reduced demand

City of Centennial – COMMERCIAL

<u>2020 (Existing)</u>

Number of Existing Jobs – 96,661

Current irrigation demand is 3,239 acre-feet.

Fifteen percent (0.15) of existing commercial property will convert to water-wise landscaping by 2050.

Fifteen percent of 3085 is 486 acre-feet.

Thirty five percent of 486 acre-feet is 170 acre-feet of reduced demand.

<u>2050 (Low)</u>

Number of Forecasted Jobs – 113,996

Forecasted irrigation demand is 3,820 acre-feet.

100 percent of new demand (added) will include water-wise landscaping

New maximum demand = 581 acre-feet.

Thirty-five percent of 581 is 203 acre-feet of reduced demand.

<u>2050 (High)</u>

Number of Forecasted Jobs – 125,464

Forecasted irrigation demand is 4,205 acre-feet.

100 percent of new demand (added) will include water-wise landscaping.

New maximum demand = 966 acre-feet.

Thirty five percent of 966 acre-feet is 338 acre-feet of reduced demand.

City of Englewood – SINGLE FAMILY

2025 (Existing)

Number of Existing Homes – 10,265

Current irrigation demand is 1,085 acre-feet.

Ten percent (0.10) of existing homes will convert to water-wise landscaping by 2050 = 1,026

Each of these homes currently uses approximately 0.11 acre-feet per year for outdoor irrigation.

Maximum reduction (if 100 percent) would be 112 acre-feet.

35 percent reduction is = 40 acre-feet of reduced demand

2050 (Low)

Number of forecasted homes = 11,010

Forecasted irrigation demand = 1,164 acre-feet.

It's assumed that 100 percent of new residential will include water-wise landscaping.

New demand = 1164-1085 = 79 acre-feet

Thirty five percent of 79 acre-feet = 28 acre-feet of reduced demand

2050 High

Number of forecasted homes = 11,250

Projected irrigation demand is 1,189 acre-feet.

100 percent of new homes will incorporate water wise landscaping based on proposed changes to code.

New demand = 1189-1085 = 104 acre-feet

Thirty five percent of 104 acre-feet = 36 acre-feet of reduced demand

City of Englewood – MULTI-FAMILY

2020 (Existing)

Number of Existing Homes – 5,935

Current irrigation demand is 410 acre-feet.

Ten percent (0.10) of existing homes will convert to water-wise landscaping by 2050 = 593

Each of these homes currently uses approximately 0.07 acre-feet per year for outdoor irrigation.

Maximum reduction (if 100 percent) would be 42 acre-feet.

35 percent of 42 acre-feet = 15 acre-feet of reduced demand.

2050 (Low)

Number of forecasted homes = 6,367

Forecasted irrigation demand = 440 acre-feet

It's assumed that 100 percent of new residential will include water-wise landscaping.

New demand = 30 acre-feet

Thirty five percent of 30 acre-feet = 11 acre-feet of reduced demand

2050 High

Number of forecasted homes = 6,506

Projected irrigation demand is 450 acre-feet.

100 percent of new homes will incorporate water wise landscaping based on proposed changes to code

New demand = 40 acre-feet

Thirty five percent of 40 acre-feet = 14 acre-feet of reduced demand.

City of Englewood – COMMERCIAL

2020 (Existing)

Number of Existing Jobs – 35,430

Current demand is 1,187 acre-feet.

Fifteen percent (0.15) of existing commercial property will convert to water-wise landscaping by 2050.

Fifteen percent of 1,187 is 178 acre-feet.

Thirty five percent of 178 acre-feet is 62 acre-feet of reduced demand.

2050 (Low)

Number of Forecasted Jobs – 41,167

Forecasted Demand is 1,380 acre-feet.

100 percent of new demand (added) will include water-wise landscaping.

New maximum demand = 193 acre-feet.

Thirty-five percent of 193 is 68 acre-feet of reduced demand.

2050 (High)

Number of Forecasted Jobs – 44,962

Forecasted Demand is 1,507 acre-feet.

100 percent of new demand (added) will include water-wise landscaping.

New maximum demand = 320 acre-feet.

Thirty five percent of 320 acre-feet is 112 acre-feet of reduced demand.

City of Greenwood Village – SINGLE FAMILY

2025 (Existing)

Number of Existing Homes – 4,809

Current demand is 474 acre-feet.

Ten percent (0.10) of existing homes will convert to water-wise landscaping by 2050 = 480

Each of these homes currently uses approximately 0.10 acre-feet per year for outdoor irrigation.

Maximum reduction (if 100 percent) would be 48 acre-feet.

35 percent reduction is = 17 acre-feet of reduced demand

2050 (Low)

Number of forecasted homes = 5379

Forecasted demand = 530 acre-feet

It's assumed that 100 percent of new residential will include water-wise landscaping.

New demand = 530-474 = 56 acre-feet

Thirty five percent of 56 acre-feet = 20 acre-feet of reduced demand

2050 High

Number of forecasted homes = 5562

Projected irrigation usage is 548 acre-feet.

100 percent of new homes will incorporate water wise landscaping based on proposed changes to code.

New demand = 548-474= 74 acre-feet

Thirty five percent of 74 acre-feet = 26 acre-feet

City of Greenwood Village – MULTI FAMILY

2020 (Existing)

Number of Existing Homes – 2781

Current demand is 179 acre-feet.

Ten percent (0.10) of existing homes will convert to water-wise landscaping by 2050 = 278

Each of these homes currently uses approximately 0.06 acre-feet per year for outdoor irrigation.

Maximum reduction (if 100 percent) would be 18 acre-feet.

35 percent reduction is = 6 acre-feet of reduced demand

2050 (Low)

Number of forecasted homes = 3110

Forecasted demand = 200 acre-feet

It’s assumed that 100 percent of new residential will include water-wise landscaping.

New demand = 21 acre-feet

Thirty five percent of 21 acre-feet = 7 acre-feet of reduced demand

<u>2050 High</u>

Number of forecasted homes = 3216

Projected irrigation usage is 207 acre-feet.

100 percent of new homes will incorporate water wise landscaping based on proposed changes to code.

New demand = 28 acre-feet

Assuming a 35 percent reduction in demand = 10 acre-feet of reduced demand

City of Greenwood Village – COMMERCIAL

<u>2020 (Existing)</u>

Number of Existing Jobs – 65,460

Current demand is 2,377 acre-feet.

Fifteen percent (0.15) of existing commercial property will convert to water-wise landscaping by 2050.

Fifteen percent of 2,237 is 335 acre-feet.

Thirty five percent of 335 acre-feet is 117 acre-feet of reduced demand.

<u>2050 (Low)</u>

Number of Forecasted Jobs – 73,161

Forecasted Demand is 2,656 acre-feet.

100 percent of new demand (added) will include water-wise landscaping.

New maximum demand = 279 acre-feet.

Thirty-five percent of 279 is 98 acre-feet of reduced demand.

2050 (High)

Number of Forecasted Jobs – 78,255

Forecasted Demand is 2,841 acre-feet.

100 percent of new demand (added) will include water-wise landscaping.

New maximum demand = 464 acre-feet.

Thirty five percent of 464 acre-feet is 162 acre-feet of reduced demand.

City of Littleton – Single Family

2025 (Existing)

Number of Existing Homes – 13,016

Current demand is 1,284 acre-feet

Ten percent (0.10) of existing homes will convert to water-wise landscaping by 2050 = 1,301 homes.

Each of these homes currently uses approximately 0.10 acre-feet per year for outdoor irrigation.

Maximum reduction (if 100 percent) would be 130 acre-feet.

Thirty five percent of 130 is = 46 acre-feet of reduced demand

2050 (Low)

Number of forecasted homes = 14,592

Forecasted demand = 1439 acre-feet

It's assumed that 100 percent of new residential will include water-wise landscaping.

New demand = 1439-1284 = 155

Thirty five percent of 155 acre-feet = 54 acre-feet of reduced demand

2050 High

Number of forecasted homes = 15,101

Projected irrigation usage is 1489 acre-feet.

100 percent of new homes will incorporate water wise landscaping based on proposed changes to code

New demand = 1489 - 1284= 205 acre-feet

Thirty five percent of 205 acre-feet = 71 acre-feet of reduced demand

City of Littleton – Multi-Family

2020 (Existing)

Number of Existing Homes – 7,526

Current demand is 485 acre-feet.

Ten percent (0.10) of existing homes will convert to water-wise landscaping by 2050 = 752

Each of these homes currently uses approximately 0.06 acre-feet per year for outdoor irrigation.

Maximum reduction (if 100 percent) would be 45 acre-feet.

Thirty five percent of 45 acre-feet = 16 acre-feet of reduced demand

2050 (Low)

Number of forecasted homes = 8,437

Forecasted demand = 544 acre-feet

It's assumed that 100 percent of new residential will include water-wise landscaping.

New demand = 73 acre-feet

Thirty five percent of 73 acre-feet = 26 acre-feet of reduced demand

2050 High

Number of forecasted homes = 8731

Projected irrigation usage is 563 acre-feet.

100 percent of new homes will incorporate water wise landscaping based on proposed changes to code

New demand = 78 acre-feet

Thirty five percent of 78 acre-feet = 27 acre-feet of reduced demand

City of Littleton – Commercial

2025 (Existing)

Number of Existing Jobs – 38,686

Current demand is 1,405 acre-feet.

Fifteen percent (0.15) of existing commercial property will convert to water-wise landscaping by 2050.

Fifteen percent of 1,405 is 211 acre-feet.

Thirty five percent of 211 acre-feet is 74 acre-feet of reduced demand.

2050 (Low)

Number of Forecasted Jobs – 44,372

Forecasted Demand is 1611 acre-feet.

100 percent of new demand (added) will include water-wise landscaping.

New maximum demand = 194 acre-feet.

Thirty-five percent of 194 is 68 acre-feet of reduced demand.

2050 (High)

Number of Forecasted Jobs – 48,134

Forecasted Demand is 1748 acre-feet.

100 percent of new demand (added) will include water-wise landscaping

New maximum demand = 343 acre-feet.

Thirty five percent of 343 acre-feet is 120 acre-feet of reduced demand.

City of Sheridan – Single Family

<u>2025 (Existing)</u>

Number of Existing Homes – 1,467

Current demand is 145 acre-feet

Ten percent (0.10) of existing homes will convert to water-wise landscaping by 2050 = 146 homes.

Each of these homes currently uses approximately 0.10 acre feet per year for outdoor irrigation.

Maximum reduction (if 100 percent) would be 15 acre-feet.

35 percent reduction is = 5 acre-feet of reduced demand

<u>2050 (Low)</u>

Number of forecasted homes = 1531

Estimated # new homes = 64

Twenty percent will apply water wise landscaping = 13 homes

Each home would use approximately 0.10 acre-feet / year for irrigation.

This would equal 1.3 acre-feet per year for the 13 homes.

Thirty five percent reduction would be 0.45 acre feet / year of reduced demand.

<u>2050 High</u>

Number of forecasted homes = 1551

Estimated # new homes = 84

Twenty percent will apply water wise landscaping =17 homes

Each home would use approximately 0.10 acre-feet / year for irrigation

This would equal 1.7 acre-feet per year for the 17 homes

Thirty five percent reduction would be 0.60 acre feet / year of reduced demand.

City of Sheridan – Multi Family

<u>2020 (Existing)</u>

Number of Existing Homes – 848

Current demand is 55 acre-feet.

Ten percent (0.10) of existing homes will convert to water-wise landscaping by 2050 = 85

Each of these homes currently uses approximately 0.06 acre-feet per year for outdoor irrigation.

Maximum reduction (if 100 percent) would be 5 acre-feet.

35 percent reduction is = 2 acre-feet of reduced demand.

2050 (Low)

Number of forecasted homes = 885

Estimated # of new homes = 17

Twenty percent will apply water wise landscaping = 3 homes

Each home will use approximately 0.06 acre-feet / year for irrigation.

This would equal 0.18 acre feet per year for 3 homes.

Thirty five percent reduction would be 0.063 acre feet/ year of reduced demand.

2050 High

Number of forecasted homes = 897

Estimated # of new homes = 29

Twenty percent will apply water wise landscaping = 5 homes

Each home would use approximately 0.06 acre feet / year for irrigation

This would equal 0.30-acre fee per year for 5 homes.

Thirty five percent reduction would be 0.11 acre feet/ year of reduced demand.

City of Sheridan – Commercial

2025 (Existing)

Number of Existing Jobs – 10,914

Current demand is 396 acre-feet.

Ten percent (0.10) of existing commercial property will convert to water-wise landscaping by 2050.

Ten percent of 396 is 39 acre-feet.

Thirty five percent of 39 acre-feet is 14 acre-feet of reduced demand.

2050 (Low)

Number of Forecasted Jobs – 12,907

Forecasted Demand is 469 acre-feet.

New demand = 73 acre feet

Twenty percent of new demand will include water-wise landscaping = 15 acre feet

Thirty-five percent of 15 is 5 acre-feet of reduced demand.

2050 (High)

Number of Forecasted Jobs – 14,224

Forecasted Demand is 516 acre-feet.

New demand = 120 acre feet

Twenty percent of new demand (added) will include water-wise landscaping = 24 acre-feet

Thirty five percent of 24 acre-feet is 8 acre-feet of reduced demand.

Cherry Hills Village – Single Family

2025 (Existing)

Number of Existing Homes – 1,398

Current demand is 138 acre-feet.

Ten percent (0.10) of existing homes will convert to water-wise landscaping by 2050 = 139 homes

Each of these homes currently uses approximately 0.10 acre feet per year for outdoor irrigation.

Maximum reduction (if 100 percent) would be 14 acre-feet.

35 percent reduction is = 5 acre-feet of reduced demand

<u>2050 (Low)</u>

Number of forecasted homes = 1435

Estimated # new homes = 37

Twenty percent will apply water wise landscaping = 7 homes

Each home would use approximately 0.10 acre-feet / year for irrigation.

This would equal 0.70 acre-feet per year for the 7 homes.

Thirty five percent reduction would be 0.25 acre feet / year of reduced demand.

<u>2050 High</u>

Number of forecasted homes = 1446

Estimated # new homes = 48

Twenty percent will apply water wise landscaping =10 homes

Each home would use approximately 0.10 acre-feet / year for irrigation.

This would equal 1 acre-foot per year for the 10 homes

Thirty five percent reduction would be 0.35 acre feet / year of reduced demand.

Cherry Hills Village – Multi Family

<u>2025 (Existing)</u>

Number of Existing Homes – 808

Current demand is 52 acre-feet

Ten percent (0.10) of existing homes will convert to water-wise landscaping by 2050 = 81

Each of these homes currently uses approximately 0.06 acre-feet per year for outdoor irrigation.

Maximum reduction (if 100 percent) would be 5 acre-feet.

35 percent reduction is = 2 acre-feet of reduced demand.

2050 (Low)

Number of forecasted homes = 830

Estimated # of new homes = 22

Twenty percent will apply water wise landscaping = 4 homes

Each home will use approximately 0.06 acre-feet / year for irrigation.

This would equal 0.24 acre feet per year for the 4 homes.

Thirty five percent reduction would be 0.08 acre feet/ year of reduced demand.

2050 High

Number of forecasted homes = 836

Estimated # of new homes = 28

Twenty percent will apply water wise landscaping = 6 homes

Each home would use approximately 0.06 acre feet / year for irrigation

This would equal 0.36-acre fee per year for 6 homes.

Thirty five percent reduction would be 0.13 acre-feet/ year of reduced demand.

Cherry Hills Village – Commercial

2025 (Existing)

Number of Existing Jobs – 2,561.

Current demand is 93 acre-feet.

Ten percent (0.10) of existing commercial property will convert to water-wise landscaping by 2050.

Ten percent of 93 is 9 acre-feet.

Thirty five percent of 9 acre-feet is 3 acre-feet of reduced demand.

2050 (Low)

Number of Forecasted Jobs – 2,834

Forecasted Demand is 103 acre-feet.

New demand = 10 acre-feet

Twenty percent of new demand will include water-wise landscaping = 2 acre-feet

Thirty-five percent of 2 is 0.7 acre-feet of reduced demand.

2050 (High)

Number of Forecasted Jobs – 14,224

Forecasted Demand is 109 acre-feet.

New demand = 16 acre-feet

Twenty percent of new demand (added) will include water-wise landscaping = 3 acre-feet

Thirty five percent of 3 acre feet is 1-acre foot of reduced demand.

Foxfield – Single Family

2025 (Existing)

Number of Existing Homes – 177

Current demand is 19 acre-feet.

Ten percent (0.10) of existing homes will convert to water-wise landscaping by 2050 = 18 homes

Each of these homes currently uses approximately 0.11 acre feet per year for outdoor irrigation.

Maximum reduction (if 100 percent) would be 2 acre-feet.

35 percent reduction is = 0.70 acre-feet of reduced demand.

2050 (Low)

Number of forecasted homes = 199

Estimated # new homes = 22

Twenty percent will apply water wise landscaping = 4 homes

Each home would use approximately 0.11 acre-feet / year for irrigation.

This would equal 0.44 acre-feet per year for the 4 homes.

Thirty five percent reduction would be 0.15 acre feet / year of reduced demand.

2050 High

Number of forecasted homes = 207

Estimated # new homes = 30

Twenty percent will apply water wise landscaping =6 homes

Each home would use approximately 0.11 acre-feet / year for irrigation.

This would equal 0.66 acre-feet per year for the 6 homes

Thirty five percent reduction would be 0.23 acre-feet / year of reduced demand.

Foxfield – Multi Family

2025 (Existing)

Number of Existing Homes – 103

Current demand is 7 acre-feet

Ten percent (0.10) of existing homes will convert to water-wise landscaping by 2050 = 10

Each of these homes currently uses approximately 0.07 acre-feet per year for outdoor irrigation.

Maximum reduction (if 100 percent) would be 0.7 acre-feet.

35 percent reduction is = 0.25 acre-feet of reduced demand.

2050 (Low)

Number of forecasted homes = 115

Estimated # of new homes = 12

Twenty percent will apply water wise landscaping = 2 homes

Each home will use approximately 0.07 acre-feet / year for irrigation.

This would equal 0.14 acre feet per year for the 2 homes.

Thirty five percent reduction would be 0.05 acre feet/ year of reduced demand.

<u>2050 High</u>

Number of forecasted homes = 120

Estimated # of new homes = 17

Twenty percent will apply water wise landscaping = 3 homes

Each home would use approximately 0.07 acre-feet / year for irrigation.

This would equal 0.21 acre-feet per year for 3 homes.

Thirty five percent reduction would be 0.07 acre-feet/ year of reduced demand.

Foxfield – Commercial

<u>2025 (Existing)</u>

Number of Existing Jobs – 412.

Current demand is 14 acre-feet.

Ten percent (0.10) of existing commercial property will convert to water-wise landscaping by 2050.

Ten percent of 14 is 1-acre foot.

Thirty five percent of 1-acre foot is 0.35 acre-feet of reduced demand.

<u>2050 (Low)</u>

Number of Forecasted Jobs – 485

Forecasted Demand is 16 acre-feet.

New demand = 2 acre-feet

Twenty percent of new demand will include water-wise landscaping = 0.4 acre-feet

Thirty-five percent of 0.4 is 0.14 acre-feet of reduced demand.

2050 (High)

Number of Forecasted Jobs – 534

Forecasted Demand is 18 acre-feet.

New demand = 4 acre-feet

Twenty percent of new demand (added) will include water-wise landscaping = 0.8 acre-feet

Thirty five percent of 0.8 acre feet is 0.28-acre foot of reduced demand.

Columbine Valley – Single Family

2025 (Existing)

Number of Existing Homes – 282

Current demand is 28 acre-feet.

Ten percent (0.10) of existing homes will convert to water-wise landscaping by 2050 = 28 homes

Each of these homes currently uses approximately 0.10 acre feet per year for outdoor irrigation.

Maximum reduction (if 100 percent) would be 3 acre-feet.

35 percent reduction is = 1 acre-feet of reduced demand

2050 (Low)

Number of forecasted homes = 310

Estimated # new homes = 28

Twenty percent will apply water wise landscaping = 6 homes

Each home would use approximately 0.10 acre-feet / year for irrigation.

This would equal 0.60 acre-feet per year for the 6 homes.

Thirty five percent reduction would be 0.21 acre feet / year of reduced demand.

2050 High

Number of forecasted homes = 318

Estimated # new homes = 36

Twenty percent will apply water wise landscaping =7 homes

Each home would use approximately 0.10 acre-feet / year for irrigation.

This would equal 0.70 acre-feet per year for the 7 homes

Thirty five percent reduction would be 0.25 acre feet / year of reduced demand.

Columbine Valley – Multi Family

2025 (Existing)

Number of Existing Homes – 163

Current demand is 11 acre-feet.

Ten percent (0.10) of existing homes will convert to water-wise landscaping by 2050 = 16

Each of these homes currently uses approximately 0.07 acre-feet per year for outdoor irrigation.

Maximum reduction (if 100 percent) would be 1 acre-foot.

35 percent reduction is = 0.35 acre-feet of reduced demand.

2050 (Low)

Number of forecasted homes = 179

Estimated # of new homes = 16

Twenty percent will apply water wise landscaping = 3 homes

Each home will use approximately 0.07 acre-feet / year for irrigation.

This would equal 0.21 acre feet per year for the 3 homes.

Thirty five percent reduction would be 0.07 acre feet/ year of reduced demand.

2050 High

Number of forecasted homes = 184

Estimated # of new homes = 21

Twenty percent will apply water wise landscaping = 4 homes

Each home would use approximately 0.07 acre-feet / year for irrigation.

This would equal 0.28 acre-feet per year for 4 homes.

Thirty five percent reduction would be 0.10 acre-feet/ year of reduced demand.

Columbine Valley – Commercial

2025 (Existing)

Number of Existing Jobs – 657

Current demand is 24 acre-feet.

Ten percent (0.10) of existing commercial property will convert to water-wise landscaping by 2050.

Ten percent of 24 is 2 acre-feet.

Thirty five percent of 2-acre foot is 0.7 acre-feet of reduced demand.

2050 (Low)

Number of Forecasted Jobs – 765

Forecasted Demand is 28 acre-feet.

New demand = 4 acre-feet

Twenty percent of new demand will include water-wise landscaping = 0.8 acre-feet

Thirty-five percent of 0.8 is 0.28 acre-feet of reduced demand.

2050 (High)

Number of Forecasted Jobs – 837

Forecasted Demand is 30 acre-feet.

New demand = 6 acre-feet

Twenty percent of new demand (added) will include water-wise landscaping = 1.2 acre-feet

Thirty five percent of 0.8 acre-foot is 0.42-acre foot of reduced demand.

Bow Mar – Single Family

2025 (Existing)

Number of Existing Homes – 297

Existing irrigation demand is 29 acre-feet.

Ten percent (0.10) of existing homes (29) will convert to water-wise landscaping by 2050.

Each of these homes currently uses approximately 0.10 acre-feet per year for outdoor irrigation.

Maximum possible reduction = 29 x .10 = 2.9 acre-feet

Thirty five percent of 1.0-acre foot of reduced demand.

2050 (Low)

Number of forecasted homes = 299

Projected irrigation usage is 29 acre-feet.

It's assumed that 20 percent of new homes (less than one home) will include water-wise landscaping.

Maximum possible increase in irrigation demand (from 2025) is de minimis.

Given limited amount of growth in the number of new homes, no notable reductions would be achieved.

2050 High

Number of forecasted homes = 300

Projected irrigation usage is 30 acre-feet.

It's assumed that 20 percent of new homes (less than one home) will include water-wise landscaping.

Maximum possible increase in irrigation demand (from 2025) is de minimis.

Given limited amount of growth in the number of new homes, no notable reductions would be achieved.

Bow Mar – Multi-Family

2025 (Existing)

Number of Existing Units – 172

Existing irrigation usage is 11 acre-feet.

Ten percent (0.10) of existing units (17) will convert to water-wise landscaping by 2050.

Each of these homes currently uses approximately .06 acre-feet per year for outdoor irrigation.

Multiplied by 17 units = 1-acre foot of reduced demand.

2050 (Low)

Number of forecasted homes = 173

Projected irrigation usage is 11 acre-feet.

It's assumed that 20 percent of new homes (less than one home) will include water-wise landscaping.

Maximum possible increase in irrigation demand (from 2025) is de minimis.

Given limited amount of growth in the number of new homes, no notable reductions would be achieved.

2050 (High)

Number of forecasted homes = 173

Projected irrigation usage is 11 acre-feet.

It's assumed that 20 percent of new homes (less than one home) will include water-wise landscaping.

Maximum possible increase in irrigation demand (from 2025) is de minimis.

Given limited amount of growth in the number of new homes, no notable reductions would be achieved.

Bow Mar – Commercial

2025 (Existing)

Number of Existing Jobs – 117

Current irrigation demand is 5 acre-feet.

Fifteen percent (0.15) of existing commercial property will convert to water-wise landscaping by 2050.

Fifteen percent of 5 acre-feet = 0.75 acre-feet

Thirty five percent of 0.75 acre-feet = 0.26 acre-feet of reduced demand.

<u>2050 (Low)</u>

Number of Forecasted Jobs – 147

Forecasted irrigation demand is 6 acre-feet.

It's assumed that 20 percent of new commercial demand (for irrigation) will include water-wise landscaping.

New demand = 1-acre foot x .20 =.20

Assuming a 35 percent reduction in demand = 0.07 acre-feet of reduced demand.

<u>2050 (High)</u>

Number of Forecasted Jobs – 166

Forecasted irrigation demand is 6 acre-feet.

It's assumed that 20 percent of new commercial demand (for irrigation) will include water-wise landscaping.

New demand = 1-acre foot x .20 =.20

Assuming a 35 percent reduction in demand = 0.07 acre-feet of reduced demand.

Deer Trail – Single Family

<u>2025 (Existing)</u>

Number of Existing Homes – 45

Existing irrigation demand is 5 acre-feet.

Ten percent (0.10) of existing homes (5) will convert to water-wise landscaping by 2050.

Each of these homes currently uses approximately 0.11 acre-feet per year for outdoor irrigation.

Maximum possible reduction = 45 x .11 = 5 acre-feet

Thirty five percent of 5 = 1.75 acre-feet of reduced demand.

2050 (Low)

Number of forecasted homes = 44

Projected irrigation usage is 5 acre-feet.

No new homes are projected to be constructed under the low growth scenario so no savings would be achieved.

2050 High

Number of forecasted homes = 103

Projected irrigation usage is 11 acre-feet.

Each home uses approximately 0.11 acre-feet for irrigation.

It's assumed that 20 percent of new homes (12 homes) will include water-wise landscaping.

Maximum possible increase in irrigation demand is 12 homes x .11 acre-feet = 1.32 acre-feet

Thirty-five percent of maximum possible demand = 1.32 x .35 = 0.46-acre feet.

Deer Trail – Multi-Family

2025 (Existing)

Number of Existing Units – 26

Existing irrigation usage is 2 acre-feet.

Ten percent (0.10) of existing units (2.6) will convert to water-wise landscaping by 2050.

Each of these homes currently uses approximately .08 acre-feet per year for outdoor irrigation.

Multiplied by 26 units = 2 acre-feet of reduced demand.

2050 (Low)

Number of forecasted homes = 25

Projected irrigation usage is 2 acre-feet.

No new homes are projected to be constructed under the low growth scenario so no savings would be achieved.

2050 (High)

Number of forecasted homes = 60

Projected irrigation usage is 4 acre-feet.

It's assumed that 20 percent of new homes (34 homes) will include water-wise landscaping.

Maximum possible increase in irrigation demand (from 2025) is 34 x .08 =2.7 acre-feet

Assuming a 35 percent reduction in demand = 0.96 acre-feet of reduced demand.

Deer Trail – Commercial

2025 (Existing)

Number of Existing Jobs – 30

Current irrigation demand is 1-acre foot.

Fifteen percent (0.15) of existing commercial property will convert to water-wise landscaping by 2050.

Fifteen percent of 1-acre foot = 0.15-acre foot

Thirty five percent of 0.15-acre foot = .05 feet of reduced demand.

2050 (Low)

Number of Forecasted Jobs – 39

Forecasted irrigation demand is 1-acre foot.

It's assumed that 100 percent of new commercial demand (for irrigation) will include water-wise landscaping.

No new demand is forecasted so no savings would be achieved.

2050 (High)

Number of Forecasted Jobs – 45

Forecasted irrigation demand is 2 acre-feet.

It's assumed that 20 percent of new commercial demand (for irrigation) will include water-wise landscaping.

New demand = 1-acre foot x .20 =.20

Assuming a 35 percent reduction in demand = 0.07 acre-feet of reduced demand.

Glendale – Single Family

2025 (Existing)

Number of Existing Homes – 2,272

Existing irrigation demand is 224 acre-feet.

Ten percent (0.10) of existing homes (227) will convert to water-wise landscaping by 2050.

Each of these homes currently uses approximately 0.10 acre-feet per year for outdoor irrigation.

Maximum possible reduction = 227 x .10 = 22 acre-feet

Thirty five percent of 22 = 8 acre-feet of reduced demand.

2050 (Low)

Number of forecasted homes = 2,720

Projected irrigation usage is 268 acre-feet.

It's assumed that 20 percent of new homes (2,720-2,272 x .20=90 new homes) will include water-wise landscaping.

Maximum possible increase in irrigation demand (from 2025) is 90*.10 = 9 acre-feet.

Assuming a 35 percent reduction in demand = 3 acre-feet of reduced demand

2050 High

Number of forecasted homes = 2,865

Projected irrigation usage is 283 acre-feet.

It’s assumed that 20 percent of new homes (2,865-2,272 x .20 = 119 homes will include water-wise landscaping.

Maximum possible increase in irrigation demand (from 2025) is 119 x.10 = 12 acre-feet

Assuming a 35 percent reduction in demand = 4 acre-feet of reduced demand

Glendale – Multi-Family

2025 (Existing)

Number of Existing Units – 1,314 units

Existing irrigation usage is 85 acre-feet.

Ten percent (0.10) of existing units (131) will convert to water-wise landscaping by 2050.

Each of these homes currently uses approximately .06 acre-feet per year for outdoor irrigation.

Multiplied by 131 = 8 acre-feet of reduced demand.

2050 (Low)

Number of forecasted homes = 1,573 units

Projected irrigation usage is 100 acre-feet.

It’s assumed that 20 percent of new homes (1,573-1,314 x .20=52 new homes) will include water-wise landscaping.

Maximum possible increase in irrigation demand (from 2025) is 52 x .06 = 3 acre-feet.

Assuming a 35 percent reduction in demand = 1 acre-foot of reduced demand.

2050 (High)

Number of forecasted homes -1,657 units

Projected irrigation usage is 107 acre-feet.

It’s assumed that 20 percent of new homes (1,657-1,314 x .20=69 new homes) will include water-wise landscaping.

Maximum possible increase in irrigation demand (from 2025) is 69 x .06 = 4 acre-feet

Assuming a 35 percent reduction in demand = 1-acre foot of reduced demand.

Glendale – Commercial

2025 (Existing)

Number of Existing Jobs – 11,807

Current irrigation demand is 429 acre-feet.

Fifteen percent (0.15) of existing commercial property will convert to water-wise landscaping by 2050.

Fifteen percent of 429 acre-feet = 64 acre-feet

Thirty five percent of 64 acre-feet = 23 acre-feet of reduced demand.

2050 (Low)

Number of Forecasted Jobs – 12,363

Forecasted irrigation demand is 449 acre-feet.

It’s assumed that 20 percent of new commercial demand (for irrigation) will include water-wise landscaping.

New demand = 449-429 = 20 acre-feet.

Assuming a 35 percent reduction in demand = 7 acre-feet of reduced demand.

2050 (High)

Number of Forecasted Jobs – 12,731

Forecasted irrigation demand is 462 acre-feet.

Twenty percent of new commercial property will include water-wise landscaping.

New demand = 462 – 429 = 33 acre-feet.

Assuming a 35 percent reduction in demand = 12 acre-feet of reduced demand.

APPENDIX H

WILL-SERVE LETTER FORMAT

WILL-SERVE LETTER FORMAT

Will-Serve Letter Format

1. SERVICE PROVIDER: ______________________________________ Date: ____________
2. Applicant Name: ____
3. Phone No.: ________________________ 3. Email: ___________________________
4. Mailing Address: ____
5. City: ______________________ State: ______________ Zip Code: ________________
6. Property Address, City, Zip: ____
   (If different from Mailing Address)
7. Assessor's Parcel Number: ____
8. Will-Serve Request for: ☐ Water Only ☐ Sewer Only ☐ Water & Sewer
9. Type of Construction:
   ☐ Existing construction ☐ Proposed construction ☐ New building
   ☐ Building addition ☐ Building replacement/correction
10. Type of Structure(s) to be served:
   ☐ Single-Family Residence ☐ Residential Development ☐ Multi-Family Residential
   ☐ Commercial ☐ Industrial
11. Proposed Meter/Line Sizes*:

   Potable: ________________________ Est. Annual Volume (gal.) ________________

   Irrigation: ______________________ Est. Annual Volume (gal.) ________________

   Sewer: _________________________ Est. Annual Volume (gal.) ________________

   *See Rules and Regulations.

12. Is the applicant working with another public agency (County, City, etc.)? ☐ Yes ☐ No

   Agency ____________________ Contact Name ____________________ Phone No. ___________

13. To account for anticipated pumping conditions based on modeling, service providers must apply the aquifer production factors listed below to their remaining Denver Basin water rights as the basis for any will-serve commitments issued after January 1, 2025. Alternatively, the service provider may submit a site-specific analysis for review and concurrence by Arapahoe County if an adjustment to these factors is warranted.

    a. Denver – 0.60
    b. Upper Arapahoe/Undifferentiated – 0.42
    c. Lower Arapahoe – 0.27
    d. Laramie-Fox Hills – 0.71

14. Attachment(s) as required:

    ☐ Map showing site location and project layout
    ☐ Accounting of estimated overall annual demand
    ☐ Updated balance sheet quantifying developed water rights:
    - Dedicated to current customer demands
    - Previously dedicated to vested development and active will-serve commitments
    - Reserved for this will-serve commitment
    - Still available

CAPACITY CONFIRMATION

WATER

_________________________ (service provider) has uncommitted capacity in its water supply system of __________ AFY and has the capacity to serve the requesting development.

WASTEWATER

_________________________ (service provider) has uncommitted capacity in its wastewater treatment system of __________ MGD and has the capacity to serve the requesting development.

This service commitment will expire on _________________________ ***(date) if not acted upon*** (typically one year after the date of the will-serve letter).

Service Provider

Signature: ______________________________________ Date: _______________