Lost Creek Basin
Aquifer Recharge and Storage Study

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December 2011

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EXECUTIVE SUMMARY

Water users in the Lost Creek basin are heavily reliant on groundwater from the alluvial aquifer for agricultural, domestic, and commercial uses. The primary goal of this study is to quantify the existing groundwater reservoir and additional available storage capacity in the Lost Creek alluvial aquifer and identify potential sites for aquifer recharge and storage implementation.

The Lost Creek alluvial aquifer consists of unconsolidated sand, gravel, silt, and clay deposited by streams and wind that overly bedrock sedimentary formations. The buried surface of the top of the bedrock is characterized by a major north-south trending channel incised into the bedrock by an ancient river network and filled with alluvial aquifer material. The greatest accumulation of alluvial material follows the channel axis in the central basin where its thickness can exceed 180 feet in places. It thins and pinches out at the margins. A bedrock ridge separates the alluvial aquifer in the Hay Gulch area from the main Lost Creek alluvial aquifer. Spring 2010 water levels in the alluvial aquifer range from close to ground surface in the north to over 120 feet below the ground surface in the south-central portions of the basin. These water levels are similar to historic low-level conditions in the early 1970s over much of the basin. The contour map of water-level elevations, measured in Spring 2010, indicates a water surface sloping to the north, or to the topographically lower part of the basin, at an average gradient of 27 feet per mile. The gradient, or steepness of that slope, decreases to the north.

Groundwater is stored in the saturated part of the alluvial aquifer. The greatest saturated thickness follows the incised bedrock channel axis in the central basin. As much as 120 feet of saturated alluvial aquifer material underlies the northern part of the basin. Because of lower water levels in the south-central portions of the basin, the saturated thickness along the alluvial aquifer channel ranges between 60 and 80 feet in the south. The Lost Creek alluvial aquifer currently holds an estimated 928,000 acre-feet of water in storage using a uniform specific yield of 17% for alluvial materials throughout the basin and water level data from Spring 2010 (Fig. ES-1). The specific yield represents the capacity for the aquifer to store water in the pore spaces and yield it by gravity flow. Groundwater withdrawal during the period 1993 to 2010 in part of the northern and central basin has exceeded recharge by about 5,700 acre-feet/year. As a result, groundwater in storage has decreased by nearly 100,000 acre-feet during this period.

Additional storage potential exists in the unsaturated portion of the alluvial aquifer. The thickest unsaturated alluvial aquifer material is located in the central and southern part of the main alluvial aquifer channel. The thickness of the unsaturated alluvial aquifer ranges from zero to more than 120 feet with much of the alluvial aquifer containing at least 40 feet of unsaturated thickness. As of Spring

2010, an estimated 1,524,800 acre-feet of unsaturated pore volume exists in the alluvial aquifer. This estimate is based on storing water in all available pore space, which may not be practical or desirable. Another way to characterize the available storage volume is to base it on water level stages below ground surface. Accordingly, the estimated volume decreases to 1,209,100 acre-feet by dropping water levels to a depth of 10 feet below the surface. It further reduces to approximately 323,000 acre-feet with water levels held at 50 feet below the surface and to about 105,900 at 75 feet below the surface (Fig. ES-1).

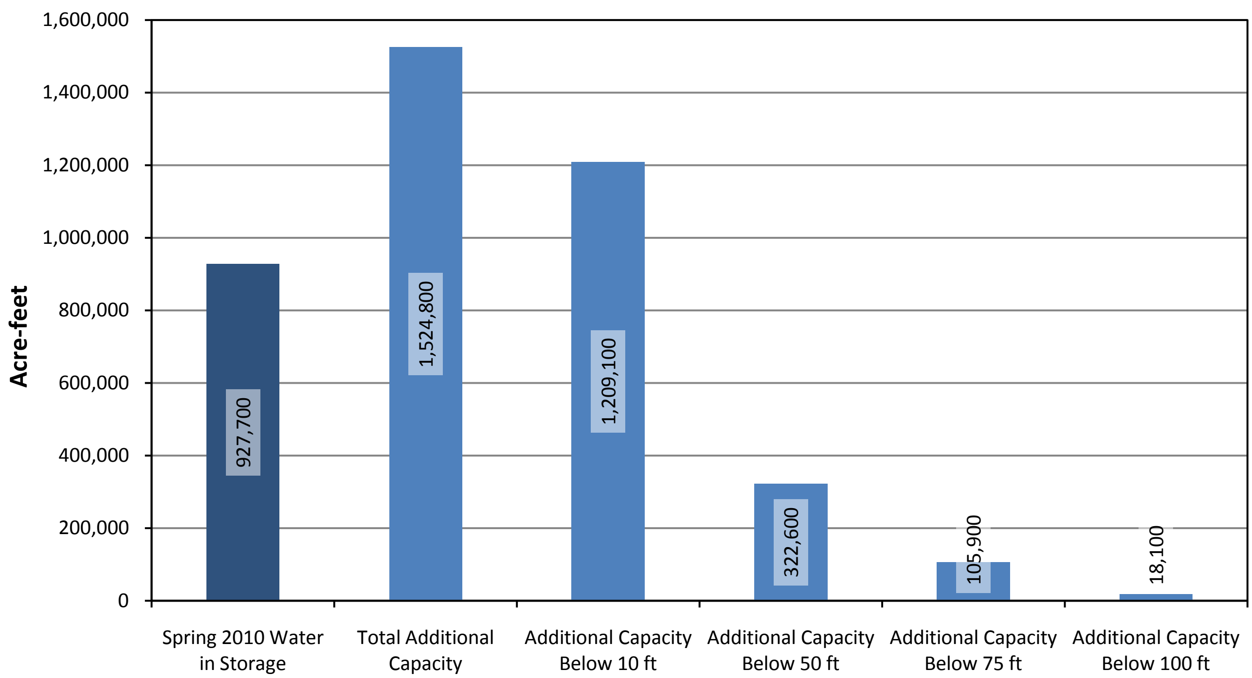


Figure ES-1. Water Storage Volumes in the Lost Creek Primary Alluvial Aquifer

Historic observations and artificial recharge tests indicate effective recharge of the alluvial aquifer is possible in the basin using surface spreading techniques. Areas in the southern and central basin, with the greatest unsaturated alluvial aquifer thickness, represent areas of high potential for implementation of aquifer recharge and storage projects. Areas south of, or in the vicinity of, the intersection of Highway 79 and 144th Avenue likely represent the best recharge locations. In this area, aquifer storage capacity is great, hydraulic conductivity appears high, and northward groundwater flow will help sustain water levels and well pumping rates where historic water levels have declined. Logistically, large parcels of land in proximity to existing water delivery infrastructure are likely to present better opportunities for implementation of an aquifer recharge and storage program.

ACKNOWLEDGMENTS

This project was made possible by the support of the Metro and South Platte Roundtables and the Lost Creek Ground Water Management District and funding provided through a Water Supply Reserve Account (SB06-179) grant from the Colorado Water Conservation Board. We are particularly appreciative of the District's general manager, Mr. Tom Sauter, for his administrative functions on this project. The District board and their legal and technical representatives Andrew Jones and Scott Mefford provided valuable feedback on the draft report. We also appreciate helpful review comments by Andy Moore of the Colorado Water Conservation Board.

The previous published studies and ongoing hydrogeologic work in the basin by the U.S. Geological Survey were very valuable to this study. The cooperation and information provided by L.R. (Rick) Arnold, Suzanne Paschke, and their associates in the USGS Colorado Water Science Center is very much appreciated.

We would also like to acknowledge the cooperation of the Colorado State Board of Land Commissioners and their regional manager, Mr. Matt Pollart, for providing access to state parcels for drilling of test holes. We gratefully appreciate the cooperation of local land owners who have participated in the State's monitoring well program, and extend particular thanks to ranch managers Brad Petersen, John Finegan, Shane Hilzer, and Jim Nichols for logistical assistance and access to their managed wells. The cooperation of Paull Nation, Margaret Medellin, and Jack Hibbert of Renew Strategies was extremely helpful in the process of collecting groundwater data in the basin.

The Colorado Geological Survey was fortunate to hire individuals on a temporary basis to assist on this project. Rob Jaecks compiled and analyzed a variety of geologic, water quality, and hydrologic data; Ken Scott assisted in geologic analysis of drill logs and coordination of the bidding process for new drilling; Andy Horn helped refine the alluvial aquifer distribution, handled logistics and operations for new drilling, supervised and logged the drilling of new test holes, and analyzed water quality data; Will James applied his GIS skills to assist in data analysis and map presentation.

Permanent staff members with the Colorado Geological Survey also provided assistance on this project. Erik Oerter compiled and analyzed raw well data from the Division of Water Resources and the Oil and Gas Conservation Commission; Larry Scott assisted with graphical design and presentation; Peter Barkmann provided valuable input during early review of the report.

INTRODUCTION

The objective of this project is to assess the potential for aquifer recharge and storage implementation in the alluvial aquifer system in the Lost Creek basin (Fig. 1). This study involved collecting and analyzing data to evaluate the recharge potential, storage capacity, and ambient water quality in the study area. The study area encompasses the Lost Creek drainage basin and coincides with the Lost Creek Designated Ground Water Basin boundary (Fig. 1). This project involved analysis and display of collected or acquired data using Geographic Information System (GIS) software, specifically ESRI ArcGIS 10.0. This report, including map figures and data, conveys the results and findings of this study. Data used in the generation of map figures will also be made available as part of the final report.

Background

Groundwater from the alluvial aquifer is the primary water source within the basin and is used for agricultural irrigation, public water supply (municipal, commercial, and domestic), and stock watering. The oldest recorded irrigation well was first used in 1920 and an estimated 250 irrigation wells were pumping by 1967 (Nelson, Haley, Patterson, and Quirk, Inc., 1967). Because basin water users are heavily reliant on groundwater, the Colorado Ground Water Commission (Commission) established the Lost Creek Designated Ground Water Basin (Fig. 2) in May 1968 to enable management of this resource. The Commission declared the central and southern portions of the basin over-appropriated in 1992. Recently, the Commission also declared the northern portion of the basin over-appropriated because of declining water levels.

The Lost Creek Ground Water Management District (District) oversees groundwater use in the basin. The District recently approved plans for exportation of alluvial groundwater. Increased demands from urban growth in conjunction with potential exportation of groundwater from the basin have generated concern over the long-term sustainability of this groundwater resource.

Code (1945) identified groundwater level declines of 2.5 feet per year in the Lost Creek basin during early stages of groundwater development between 1933 and 1942. Potential for artificial recharge of the alluvial aquifer in the Lost Creek basin was also recognized early at Olds Reservoir (an unlined, leaking reservoir) and by the late 1930s the reservoir was being used to recharge the alluvial aquifer during periods of surplus surface water availability (Skinner, 1963). Later, the Forty-Second Colorado General Assembly (1959-1960) funded studies (Senate Bill No. 336) on artificial and natural recharge

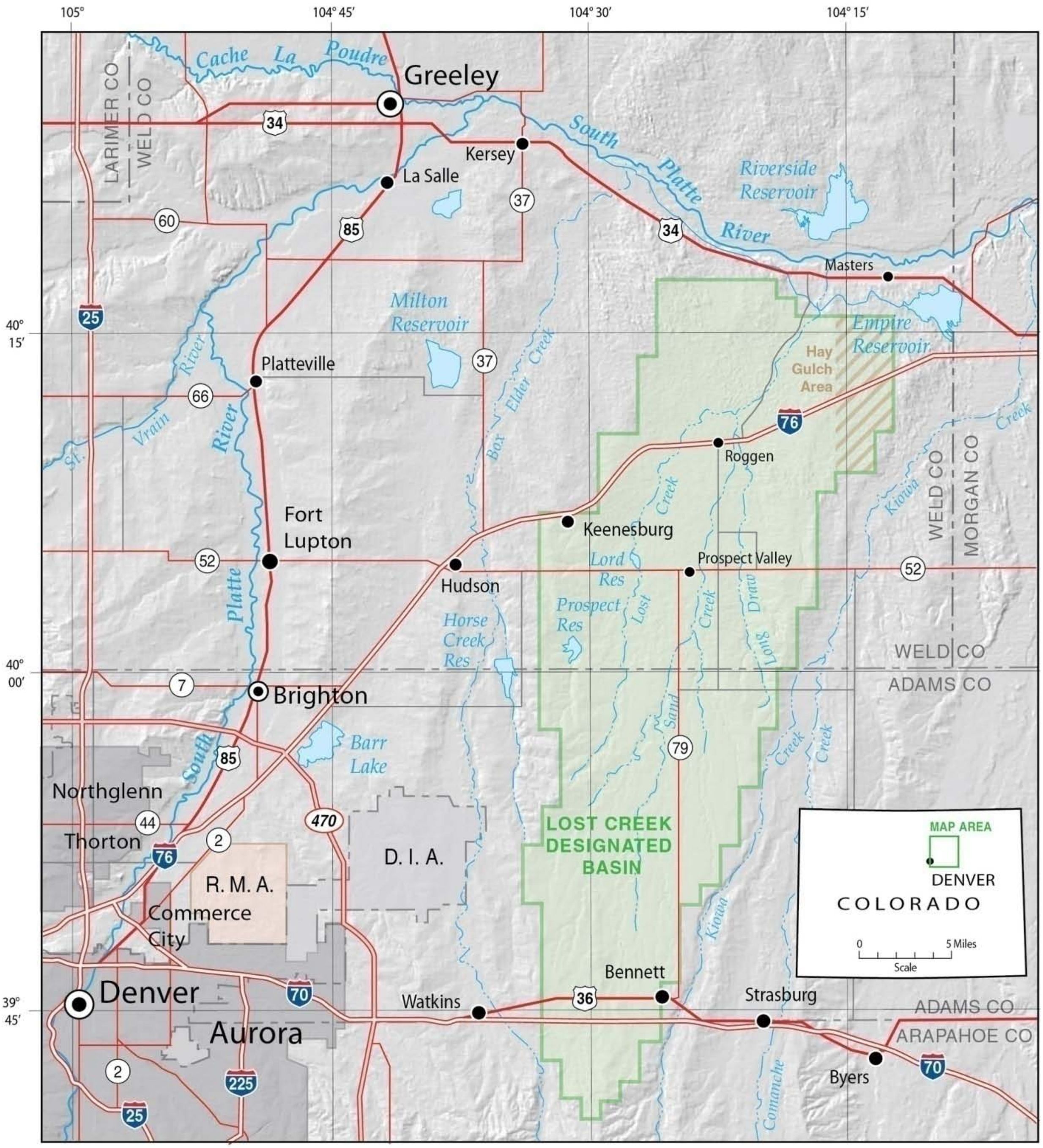


Figure 1. Location of Lost Creek Designated Ground Water Basin

of groundwater reservoirs in Colorado (Colorado State University, 1960). As part of the study of the South Platte River basin, Skinner (1963) conducted an investigation of artificial recharge in the Prospect Valley. Skinner (1963) developed a water budget, documented groundwater levels and quality, and investigated groundwater recharge occurring as a result of seepage of water from Olds Reservoir.

In 2004, the Colorado Geological Survey (CGS) published a statewide assessment of artificial recharge of groundwater in Colorado (Topper and others, 2004). That report identified the highest potential alluvial and bedrock aquifers throughout the state and quantified their available storage capacity on a reconnaissance level. Several tributaries of the South Platte River ranked among the best candidates; however, the Lost Creek basin was not evaluated because it did not meet the minimum area criterion used in the assessment. In 2006, the Colorado legislature passed Senate Bill (SB) 06-193, which directed the Colorado Water Conservation Board (CWCB) to conduct a study of potential underground water storage areas in the South Platte and Arkansas River Basins (CWCB, 2007). Aquifers and locations within these basins were evaluated with regard to 10 criteria representing the hydrogeologic, environmental, and implementation considerations for underground water storage. This evaluation identified the alluvial aquifer in the lower Lost Creek and upper Lost Creek sub-regions in the South Platte River basin as the highest-scoring candidates and estimated storage capacity in the Lost Creek basin to be over 1.4 million acre-feet. Nevertheless, the CWCB study in 2007 was still regional in nature and did not collect or analyze any new hydrogeologic data.

Many more localized project-specific studies have been conducted in the Lost Creek basin and nearby by private entities. Recent study efforts by the State of Colorado and the US Geological Survey (USGS) have focused on developing and analyzing new data for the Lost Creek basin. As part of the South Platte Decision Support System (SPDSS) program, the State of Colorado and its contractors collected and compiled data on water use, aquifer configuration, and aquifer properties throughout the South Platte alluvial aquifer system. The USGS installed monitoring wells and collected water quality data in the southern portion of the basin as part of their National Water Quality Assessment program. In 2005, the USGS, in cooperation with the Lost Creek Ground Water Management District, initiated a project to revise existing numerical groundwater flow models for the area using new data. With cooperative funding from the CWCB, that study was expanded to also collect data on deep percolation (recharge) from irrigation practices (Arnold, 2010).

At the November 2007 board meeting of the District, the CGS gave a presentation on aquifer recharge and storage, which highlighted the findings of the SB06-193 Underground Water Storage Study by the CWCB. That study, conducted according to legislative intent, was not detailed enough to quantify the local hydrologic characteristics nor did it identify specific sites for potential project implementation. The District's board of directors expressed an interest to further pursue a feasibility study for aquifer recharge and storage within the Lost Creek basin.

Scope of this Investigation

This aquifer recharge and storage study integrates new field data collection with information from previous investigations to characterize the hydrogeology of the alluvial aquifer system in the Lost Creek basin. The primary goal of the study is to quantify the existing stored groundwater and additional available storage capacity in the alluvial aquifer in the basin and identify potential sites for aquifer recharge and storage implementation. Additionally, this study characterizes the groundwater resources in the Lost Creek alluvial aquifer and evaluates infrastructure, land ownership, and land uses relating to the implementation of an aquifer recharge and storage project. This report includes detailed information and data on basin climate, bedrock and aquifer configuration, groundwater levels, groundwater quality, and land use/ownership to document existing conditions and assist in basin groundwater management decisions. Data displayed in figures in this report will be provided separately to project participants.

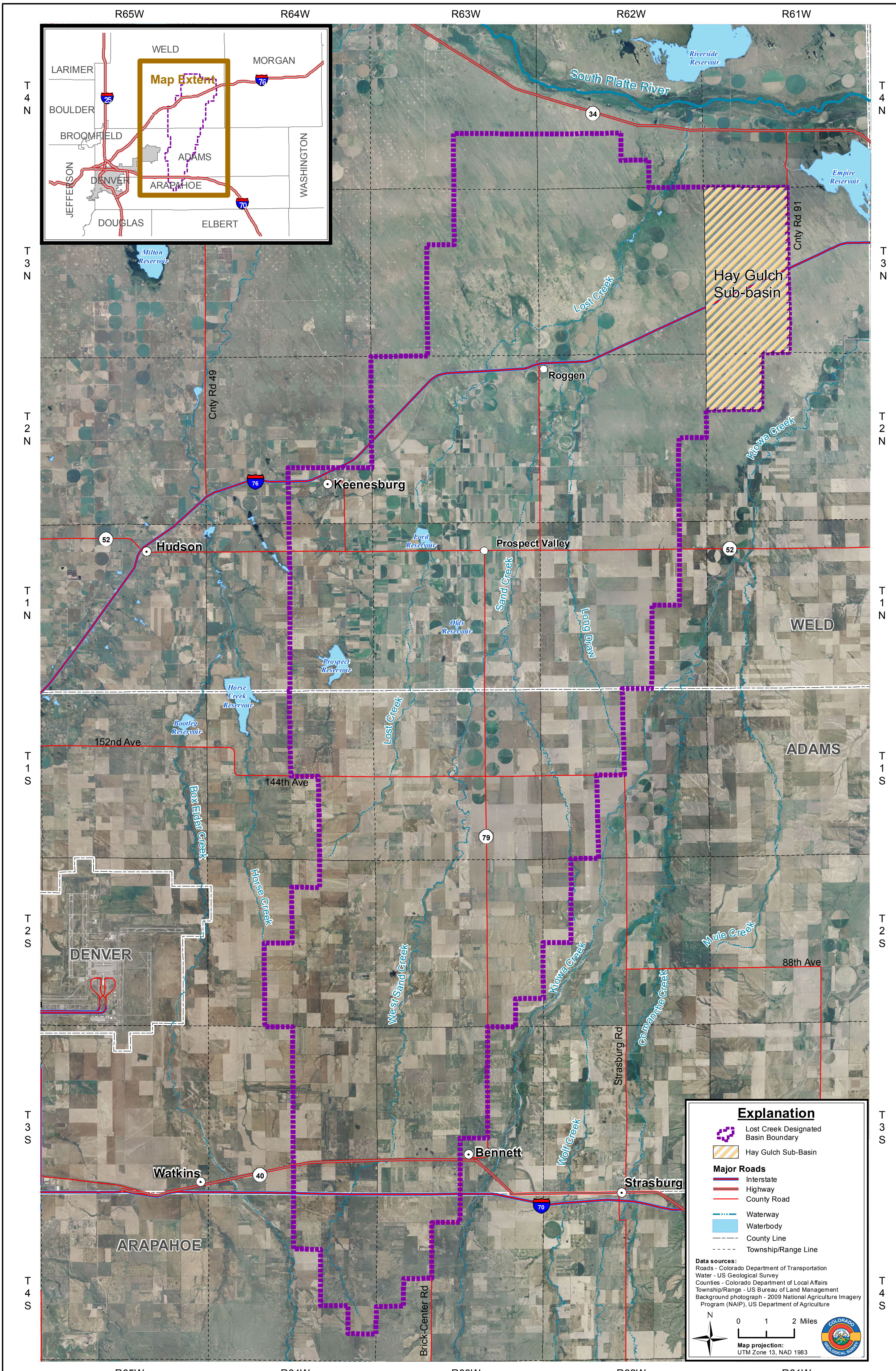
The District committed $3,000 towards a Lost Creek alluvial aquifer recharge and storage feasibility study. The CGS committed $10,000 of in-kind services and agreed to assist with the pursuit of funding for such a study. With CGS's assistance, the District applied for a Water Supply Reserve Account (SB06-179) grant in the amount of $160,000; $80,000 each from the Metro and South Platte Roundtables. Both the Metro and South Platte Roundtables agreed to fund the project from their respective basin accounts. The contract between the District and the Colorado Water Conservation Board was signed on May 26, 2009. An agreement between the District and CGS was executed on June 9, 2009 to authorize CGS to perform the study in accordance with the submitted scope of work. During the process of developing a scope of work for the study, the Morgan County Quality Water District (MCQWD) requested to exclude the Hay Gulch sub-basin from the proposed study. The Lost District board, in consultation and concurrence with CGS staff, agreed to exclude approximately 22 square miles within Hay Gulch from the new activities proposed in this study (Fig. 1).

Description of Study Area

The Lost Creek drainage basin is located to the east and north of Denver County, Colorado on the northeastern edge of the administrative Denver groundwater basin. The Lost Creek basin lies within southeastern Weld County, central Adams County, and the northern portion of Arapahoe County (Fig. 1). The Lost Creek basin lies between Box Elder Creek to the west and Kiowa Creek to the east. The basin encompasses the Lost Creek drainage and its tributaries Long Draw and Sand Creek from south of Bennett to the floodplain of the South Platte River (Fig. 1). All the streams within the basin are ephemeral, have dry sandy streambeds, and flow only in direct response to thunderstorms, snowmelt, or prolonged periods of rainfall. Consequently, these streams are not a reliable water source. Lost Creek basin is primarily rural and the principal industries relate to agricultural products and livestock grazing. Population centers include the towns of Keenesburg, Roggen, Prospect Valley, and Bennett. Development pressure is increasing along the western edge of the basin as growth expands eastward from the Brighton and Denver metropolitan area.

The study area includes the entire Lost Creek Designated Ground Water Basin. The Lost Creek Designated Ground Water Basin encompasses an area of approximately 433 square miles (277,000 acres) and is traversed by Interstate 70 (I-70) in the south and Interstate 76 (I-76) in the north (Fig. 1 and 2). It is approximately 43 miles long and up to 14 miles wide. The Lost Creek drainage basin very nearly coincides with the boundaries of the Designated Ground Water Basin, although the Designated Basin boundary is drawn according to the Public Lands Survey System grid as opposed to the physical features of the drainage basin. The Designated Basin is located in the far northern part of the Denver Basin groundwater administration area, which is defined by the extent of the Fox Hills Sandstone.

Lost Creek is mapped as an intermittent stream channel on the USGS 7.5-minute topographic map series and is located approximately 11 miles east of the town of Hudson. The main mapped intermittent tributary channels to Lost Creek include Sand Creek, West Sand Creek, and Long Draw (Fig. 2). The ground surface elevation varies from 5,870 feet in the southern portion of the basin to 4,550 feet at its northern edge, a vertical relief of about 1,320 feet. Surface and subsurface water in the basin flows generally northward towards the South Platte River. The basin is characterized by gently rolling to flat upland topography with narrow drainage valleys. Prairie grasses and shrubs dominate the native vegetation.



Study Area Geographic Reference Map
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 2

Climatic Considerations

Precipitation is the dominant source of natural groundwater recharge in Lost Creek basin. As a result, climate trends strongly influence the amount of natural recharge. Furthermore, in a basin reliant on water for agriculture, climate trends play a major role in determining both water demand and supply. Understanding the relationship between climate and groundwater in Lost Creek basin is important when developing basin groundwater management plans.

The climate of the Lost Creek basin is semi-arid. Climate records for the period 1931-2010 at Byers and Fort Morgan indicate that the basin receives between 13 and 15 inches of precipitation annually, over 75 percent of which occurs during the spring and summer months of April through September (Fig. 3, Appendix A)(Colorado Climate Center, 2011). Temperatures in the area range from a mean monthly maximum temperature of approximately 90 degrees Fahrenheit (° F) in July to a mean monthly maximum temperature of 40° F in January (Fig. 3). Annual precipitation records at Byers and Fort Morgan exhibit historic periods of generally above-average precipitation during 1941-1950, 1956-1965, 1981-1985, 1991-2000, and 2006-2010; below-average precipitation periods in the area include 1931-1940, 1951-1955, and 1971-1980 (Appendix A). Natural recharge to the alluvial aquifer will be greater during periods of higher precipitation and less during periods of low precipitation, and may be evidenced by changes in groundwater levels.

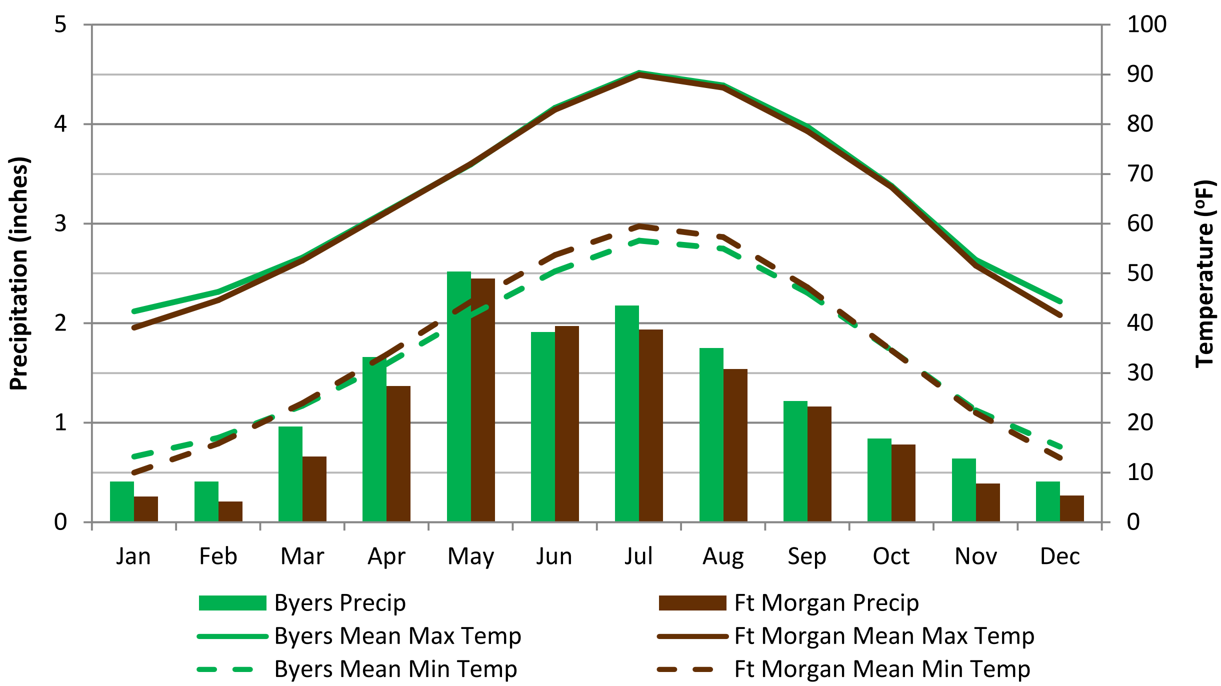


Figure 3. Lost Creek Monthly Climate Data (1931-2010), Byers and Fort Morgan Stations
(Source: Colorado Climate Center)

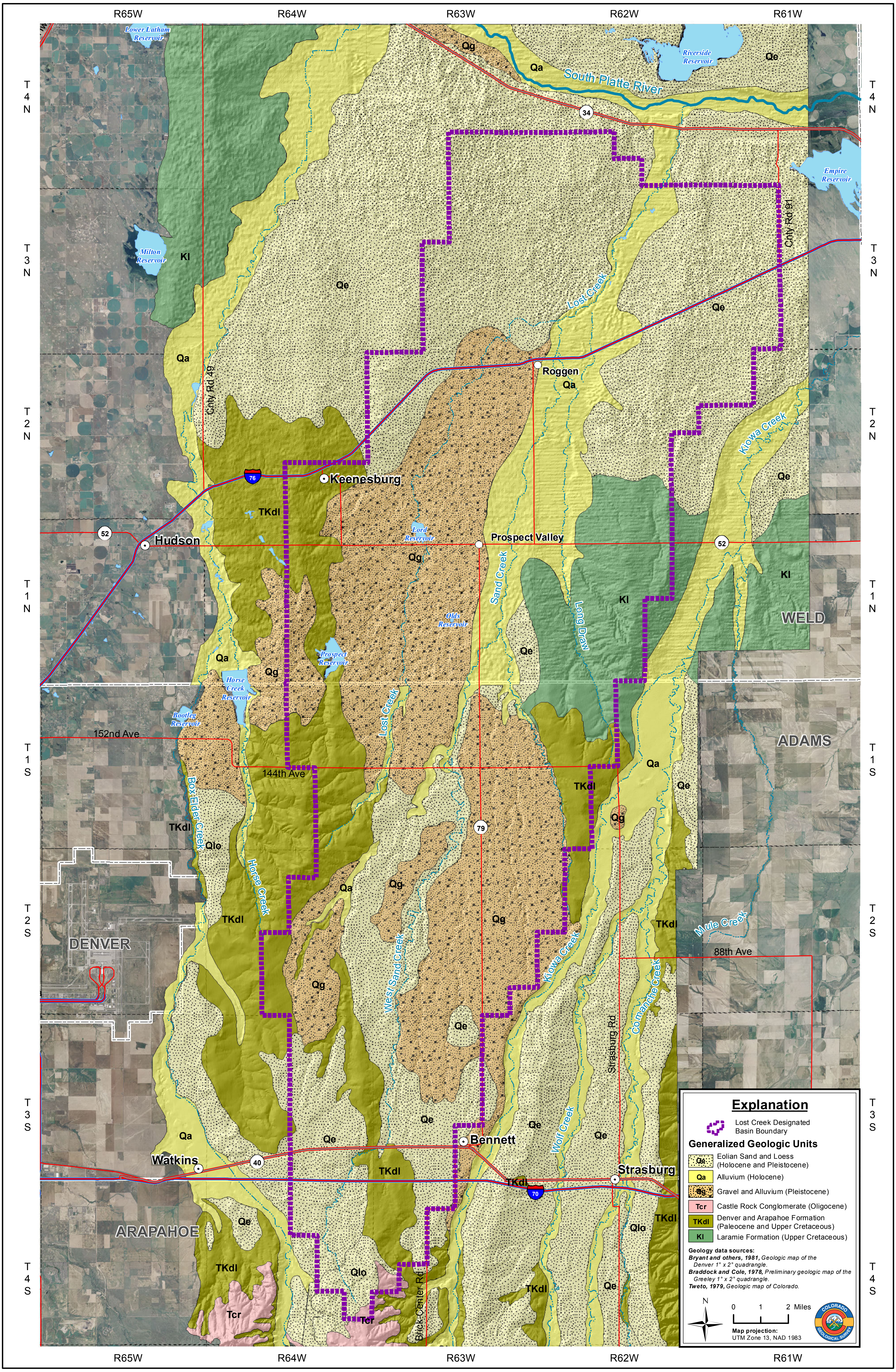
HYDROGEOLOGY OF THE BASIN

Geologic Context

An understanding of the geology of Lost Creek is an important component of understanding the water resources of the area. The geologic units present in the basin form the aquifers that supply groundwater to wells in Lost Creek. The geology of the Lost Creek basin has not been mapped at a detailed scale. A preliminary geologic map of the Greeley 1^{o} x 2^{o} quadrangle was prepared by Braddock and Cole (1978) at a map scale of 1:250,000. A finalized geologic map of the Denver 1^{o} x 2^{o} quadrangle, which lies to the south, was published by Bryant and others (1981), also at a map scale of 1:250,000. Generally, the geology of the basin consists of unconsolidated Quaternary and Holocene (1.8 million years and younger) alluvial and eolian deposits overlying a sequence of slightly southward dipping Tertiary and Upper Cretaceous sedimentary rocks which make up the Denver Basin bedrock aquifer system.

The youngest alluvial deposits consist of gravel, sand, and silt deposited as rivers and streams eroded and reworked sediments of the underlying bedrock and older alluvium. These younger alluvial deposits (Qa) follow present-day river and stream valleys (Fig. 4). Older (Pleistocene) alluvial deposits include the Louviers and Broadway alluvium with some Slocum alluvium (Braddock and Cole, 1978; Bryant and others, 1981). These older alluvial deposits consist generally of clayey silts, sands, and gravels with some pebbles and cobbles (Bryant and others, 1981) and are grouped as gravel and alluvium (Qg) for this study (Fig. 4, Table 1). The older alluvial deposits exist across much of the basin and are present beyond and away from present-day stream systems.

Eolian sand (Qe) covers large areas of the basin and consists of fine to coarse silty sand that locally forms longitudinal dunes trending southeast (Soister, 1965). Braddock and Cole (1978) did not differentiate finer-grained loess from eolian sand in the Greeley geologic map. However, Bryant and others (1981) mapped several small loess deposits in the southernmost portion of the Lost Creek basin. Loess is a wind-blown geologic deposit of silt and silty fine sand. For this study, loess and eolian sand are grouped for geologic representation and evaluation (Fig. 4, Table 1).



Generalized Geologic Map
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 4

Table 1. Geologic Units in the Lost Creek Basin

System	Series	Formation	Map Symbol	Thickness (feet)	Physical Characteristics	Water Supply
Quaternary	Holocene and Pleistocene	Eolian Sand and Loess	Qe	0-100	Sand, silt, and clay; compacted slightly; permeability low to high depending on clay content	Yields small supplies of water locally; important as recharge area
		Piney Creek Alluvium	Qa	0-70	Gravel, sand, silt, and clay with pebbles and cobbles; unconsolidated; permeability medium	Yields small to large quantities of water to domestic, stock, irrigation, municipal, and industrial wells
	Pleistocene	Broadway Alluvium	Qg	0-30	Fine- to coarse-grained humic sand with some silt; well-sorted, crudely to well-stratified; permeability is probably medium	
		Louviers Alluvium		0-100+	Coarse sand, gravel, pebbles, and cobbles; weakly compacted, poorly sorted, well stratified; permeability is generally high	
		Slocum Alluvium		0-40	Gravel, sand, silt, and clay; moderately compacted, poorly sorted, stratified; consists of coarse arkosic sands derived from Dawson Formation; permeability is high in gravels and low in clay/silt layers	
Tertiary	Paleocene	Denver & Arapahoe formations	TKdl	0-1000+/-	Upper part is soft sandy to clayey shale and clay with sandstone lenses; lower part is sand, gravel, and conglomerate with minor clay and shale; likely low permeability in upper part and medium permeability in lower part	Yields small to moderate quantities of water to domestic, stock, municipal, and industrial wells in the southern part of the basin
Cretaceous	Upper Cretaceous					
		Laramie Formation	Kl	0-600+/-	Upper section is fine-grained sandstone and claystone with coal beds; lower section is shaley medium-grained sandstone; permeability is medium	Yields small quantities of water to domestic and stock wells; water quality is generally poor
		Fox Hills Sandstone	Not mapped in study area	50-250+/-	Sandy thin-bedded friable shale in upper 100 feet; fine-grained massive friable sandstone in lower part; medium permeability	Yields moderate quantities of water to domestic, stock, and municipal wells

Information compiled from Bryant and others (1981), Braddock and Cole (1978), Nelson, Haley, Patterson, and Quirk, Inc. (1967), and Bjorklund and Brown (1957).

Paleocene and Upper Cretaceous sedimentary rocks comprising the Denver Basin bedrock aquifer system underlie the Lost Creek alluvium. The Denver Basin is a structural basin within the Great Plains physiographic province that encompasses the Denver metropolitan area extending from Greeley in the north to Colorado Springs in the south. The Lost Creek basin is located near the northeastern edge of the administrative Denver Basin bedrock aquifer system. The administrative Denver Basin is defined from a water resources perspective. In vertically descending order of increasing age, the geologic formations that contain the Denver Basin aquifers are the Dawson, Denver, Arapahoe and Laramie formations, and the underlying Fox Hills Sandstone. The oldest Denver Basin geologic unit, the Fox Hills Sandstone, is not mapped at the surface in Lost Creek basin but underlies the eolian sand deposits in the northernmost part of the basin near the South Platte River (Braddock and Cole, 1978; Barkmann and Dechesne, 2011). The Laramie Formation (Kl) is mapped at the surface to the east and north of Milton Reservoir on the west side of the basin and in the headwater region of Long Draw and Hay Gulch on the east side of the basin. The Arapahoe and Denver formations are not differentiated in the Denver and Greeley quadrangle geologic maps and thus are displayed together as a single unit on the geologic map presented as Figure 4. Because the Lost Creek basin is located on the edge of the greater Denver Basin, more distal from the source of sediment supply, the shallower formations such as the Arapahoe and Denver formations become finer and thinner to the east within the Lost Creek basin (Bryant and others, 1981; Barkmann and Dechesne, 2011). The Denver and Arapahoe formations are present at the surface mainly along the west side of the basin south of Keenesburg and in the southern part of the basin. A remnant of the Tertiary-aged Castle Rock Conglomerate, the youngest of the bedrock units, is exposed at the southern edge of the study area (Fig. 4). Where inconsistencies between the Denver and Greeley quadrangle maps were noted, the geologic map of Colorado by Tweto (1979) at a scale of 1:500,000 was used to reconcile the differences. More detailed descriptions of the alluvial and eolian unconsolidated deposits and underlying Denver Basin bedrock formations present in Lost Creek basin are included in Table 1.

Configuration of the Bedrock Surface

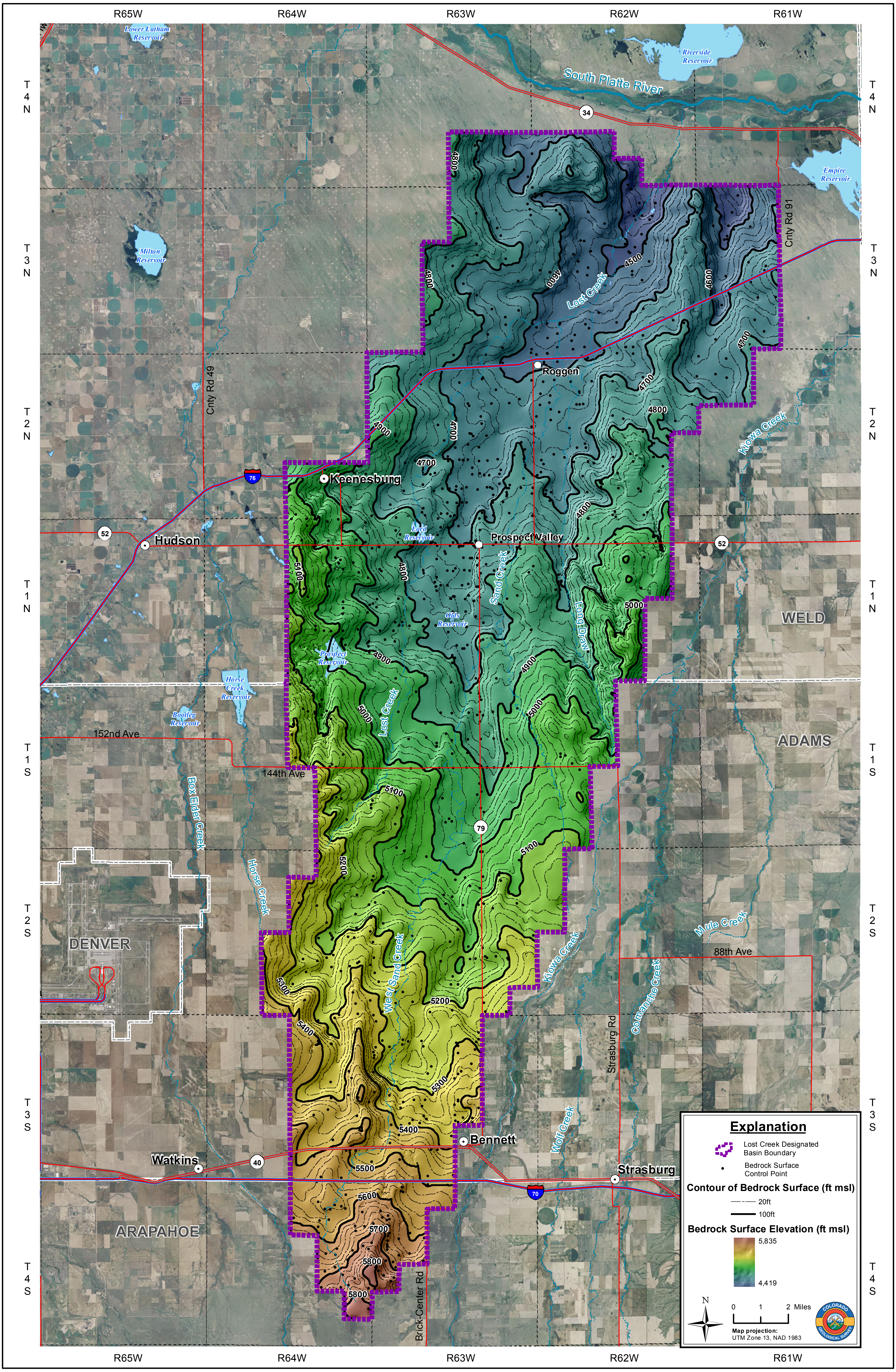
The top of the buried bedrock surface defines the base of the alluvial aquifer in the Lost Creek basin. Prior to, and concurrent with, the deposition of the alluvial and eolian sediments, the bedrock surface was partially or completely exposed at the surface and subjected to erosion. Ancient river and stream systems actively eroded the bedrock surface, depositing alluvium. This process resulted in a system of incised channels, or paleo-valleys, in the bedrock surface, which subsequently filled with alluvial sediment.

This study considers the entire thickness of material above the bedrock to be the alluvial aquifer, except where it is less than 20 feet thick and likely unsaturated. Therefore, a detailed representation of the surface of the top of the bedrock is a critical component for calculating the existing and potential groundwater reservoir in the overlying alluvial aquifer. Our map of the top of bedrock surface, displayed with a 20-foot contour interval, is presented as Figure 5. The bedrock surface contour map shows a bedrock surface with approximately 1,300 feet of vertical relief from south to north across the basin. The bedrock surface slopes to the north at a gradient of approximately 50 to 60 feet per mile in the southern portion of the basin and at a lesser slope of approximately 20 feet per mile in the northern portion.

The bedrock surface contour map depicts a deeply incised paleo-valley extending the length of the basin to join the alluvial valley of the South Platte River. North of Roggen, the paleo-valley underlies the modern alignment of Lost Creek. In the central part of the basin between Roggen and the Weld/Adams county line, the paleo-valley is located between the current drainages of Lost Creek and Sand Creek (Fig. 5). Further to the south, the position of the main paleo-valley is roughly one (1) to two (2) miles east of the modern alignment of West Sand Creek; however, a substantial secondary channel also exists to the west here. The thickest alluvial deposits will be located along the axis of the paleo-valley.

Secondary buried tributary paleo-valleys are also evident along the margins of the basin in the bedrock surface contour map (Fig. 5). A major tributary channel underlies the current location of Long Draw and a deeply-incised channel is also evident in the Hay Gulch area in the northeastern portion of the basin. Hay Gulch appears to be separated from the main paleo-valley of Lost Creek by a bedrock ridge trending roughly north-south. The bedrock structural surface suggests that Hay Gulch may have originated as part of the ancient Kiowa Creek drainage system.

The bedrock surface elevation map is based on 1,102 compiled control points for the Lost Creek basin vicinity. Of these, 928 are within the basin. Control points consist of: (1) lithologic logs from exploration holes, test borings, and water supply wells on file at CGS and the Colorado Division of Water Resources (CDWR), (2) regolith thickness datasets provided by the USGS (Arnold, 2010), and (3) historic information and data published as part of the SPDSS (SPDSS, 2010). They include 682 depth to bedrock data points from the USGS (Arnold, 2010) and an additional 415 new points interpreted by the CGS from exploration borehole logs and water well driller's logs. As part of this study, the CGS also advanced five (5) test borings to determine the depth to bedrock at select locations in the basin.



Bedrock Surface Elevation
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 5

Depth to the top of the bedrock surface at each control point location is based on interpretation of the subsurface contact between the unconsolidated sediments and the underlying bedrock. However, distinguishing the top of the bedrock from the overlying unconsolidated sediments can be subjective, particularly when relying on geologic logs (drillers' logs) submitted by well drillers. Without the presence of thick gravel deposits, distinguishing this subsurface contact is difficult (SPDSS, 2004). During the SPDSS project, geologists logged core of the alluvial and bedrock material. The Denver Formation is described as consisting of semi-consolidated sand, clay (“claystone”), and shale intervals; the Arapahoe Formation is described as friable sandstone and claystone. These materials can often be penetrated with relative ease during drilling because they are weathered and poorly consolidated. This makes distinguishing bedrock from alluvial materials difficult without the detailed lithologic descriptions available from core samples. Many of the bedrock control points used in this study were derived from interpretations of water well drillers’ logs. In this study, the first clay, claystone, shale, or sandstone layer beneath alluvial deposits listed in a driller’s log is considered the top of bedrock. Where drillers' logs describe clay directly overlying shale or sandstone, the top of the overlying clay is considered the top of bedrock. Ground-surface elevations for the control points derive from the 10-meter resolution National Elevation Dataset (NED) digital elevation model (DEM)(U.S. Geological Survey, 1999) based on reported well/boring location coordinates using Geographic Information Systems (GIS)(ESRI ArcGIS 10.0).

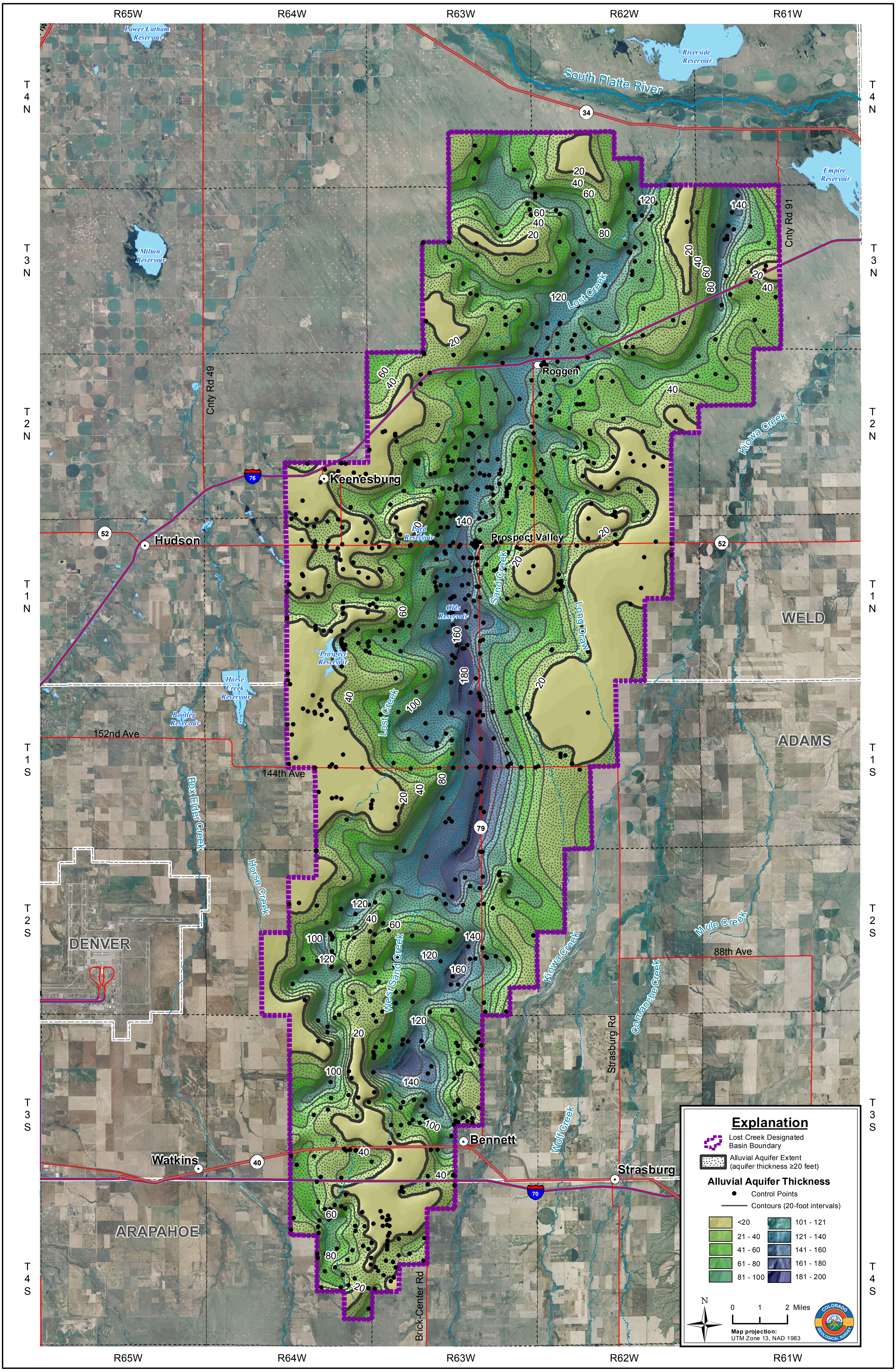
Preparation of the bedrock surface elevation map followed a multi-step process including GIS analyses and interpretation using ArcGIS software (ESRI, ArcGIS 10.0, Spatial Analyst). In this study, the alluvial aquifer includes the entire interval of unconsolidated alluvial and eolian deposits overlying the bedrock. Initially, an alluvial aquifer thickness map was prepared using the depth-to-bedrock control point data. This process utilized ArcGIS software to interpolate a grid (10 meter cell size) of the thickness of alluvial and eolian materials from bedrock depth control points. Next, for visual evaluation, we generated contours of the computer-interpolated alluvial aquifer thickness grid dataset and manually adjusted the contours to address digital artifacts of the interpolation process. When necessary, we evaluated and revisited any outlier control points. This process was followed to develop a refined alluvial aquifer thickness contour dataset and corollary raster grid. The elevation of the top of the bedrock surface was then derived by subtracting the interpreted alluvial aquifer thickness grid dataset from the ground surface elevation DEM. We contoured this calculated grid surface to represent the elevation of the top of the bedrock surface and manually adjusted it using professional judgment to portray a geologic conceptualization consistent with the control data points. We also generated a corresponding raster dataset of the bedrock surface elevation from the contours.

Previously, Nelson, Haley, Patterson, and Quirk, Inc. (1967) contoured the bedrock surface based primarily on subsurface oil and gas shot-hole data, and augmented with data from available water well drillers' logs and from twelve (12) project-specific test borings. Their bedrock surface is also characterized by incised, relatively wide and deep channels separated by bedrock highs which coalesced into a broad valley towards the basin. We used the map by Nelson, Haley, Patterson, and Quirk, Inc. (1967) and an updated generalized bedrock surface structure map by Arnold (2010) as general guidance and comparative control throughout the creation of the bedrock surface elevation map in this study.

Configuration of the Alluvial Aquifer

The thickness and extent of the alluvial aquifer was mapped during the process of generating the bedrock surface described earlier. Figure 6 is a generalized alluvial aquifer thickness contour map and shows the configuration of the alluvial aquifer system. The deeply incised bedrock surface and resulting thick alluvial aquifer channel that dominates the basin are clearly evident in Figure 6. In the main north-south trending channel, the alluvial aquifer thickness is interpreted to be nearly 200 feet at its thickest point south of 144th Avenue. The thickest alluvial aquifer material identified from drill logs was 187 feet. The alluvial aquifer thins to about 110 feet near the northern boundary of the Designated Basin. The main alluvial aquifer channel becomes less dominant in the southern part of the basin where two less-developed channels are separated by a north-south trending bedrock ridge (Fig. 5 and 6). Along the basin margins to the east and west, the alluvial aquifer is thin or nonexistent. In general, the thickest alluvial aquifer materials have the greatest potential to store water and may also be more suitable for groundwater production with high-capacity wells.

The primary purpose of this study is to identify areas suitable for aquifer recharge and storage implementation. With this intent in mind, this study defines the extent of the alluvial aquifer as that area where the alluvial and eolian deposits are 20 feet thick or greater. Storage of groundwater in shallow aquifer material can be problematic for various reasons (e.g., loss of water to surface discharge, flooding of lowlands or basements, increased evapotranspiration). By defining the alluvial aquifer extent at a thickness of 20 feet or greater, we intentionally chose a more conservative approach in our analyses of the existing groundwater in storage and potential storage capacity in the Lost Creek basin alluvial aquifer. In total, the alluvial aquifer extent defined in this study covers 80%, or approximately 345 square miles (221,050 acres) of the 433 square miles (277,105 acres), in the Designated Basin. Approximately 85 square miles (54,250 acres), or 20%, of the basin contains at least 100 feet of alluvial aquifer material.

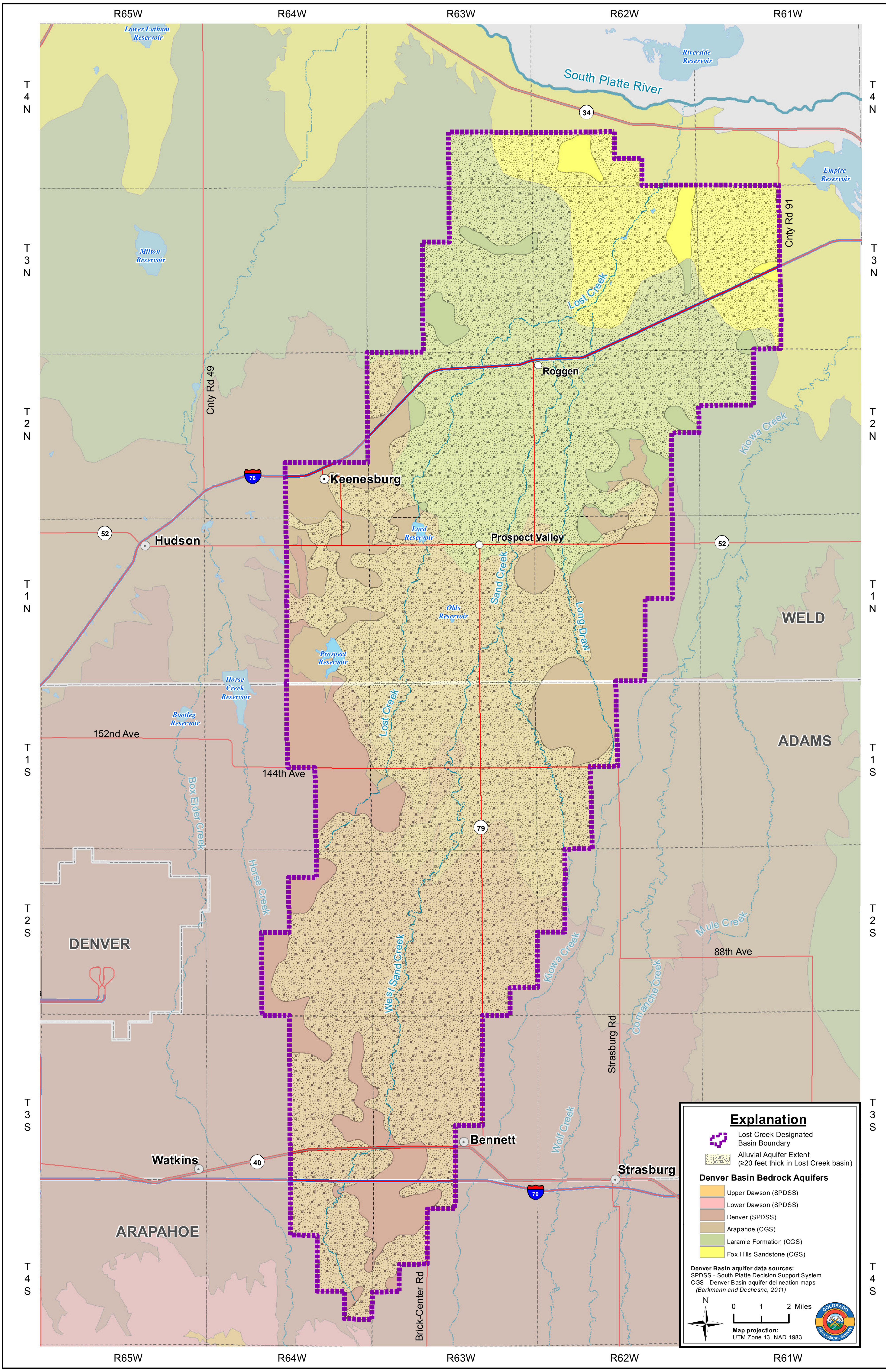


Alluvial Aquifer Thickness and Extent
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 6

Figure 7 portrays the extent of the alluvial aquifer (≥20 feet of alluvial aquifer) and the spatial relationship between the alluvial aquifer and the underlying Denver Basin aquifers. Denver Basin aquifer units directly underlie the alluvial aquifer in most of the basin (Fig. 7).

The hydraulic properties of the alluvial aquifer are discussed in greater detail later in this report. However, hydraulic conductivity in the alluvial aquifer appears to be much greater than in the underlying bedrock aquifers, so the hydraulic communication between the alluvial and bedrock aquifers is assumed to be minimal (Arnold, 2010; SPDSS, 2004). Water levels in the underlying bedrock aquifers also appear to be lower than the alluvial aquifer water levels in much of the basin (SPDSS, 2004; Robson, 1983). As a result, the hydraulic gradient is likely downward, from the alluvial aquifer into the underlying bedrock aquifer, in most places. However, because the hydraulic conductivity of the bedrock aquifer is likely considerably less than that of the unconsolidated alluvial aquifer, any discharge from the alluvial aquifer into the bedrock aquifers is assumed to be very limited. Similarly, in places where the hydraulic gradient is upward, from the bedrock aquifer into the alluvial aquifer, any recharge to the alluvial aquifer is probably very limited relative to recharge from other sources (Arnold, 2010). Nevertheless, although it has been assumed that hydraulic communication between the alluvial aquifer and underlying bedrock aquifers is limited in the area, this relationship has not been well studied.



Alluvial Aquifer and Underlying Bedrock Aquifers
Lost Creek Basin Aquifer Recharge and Storage Study

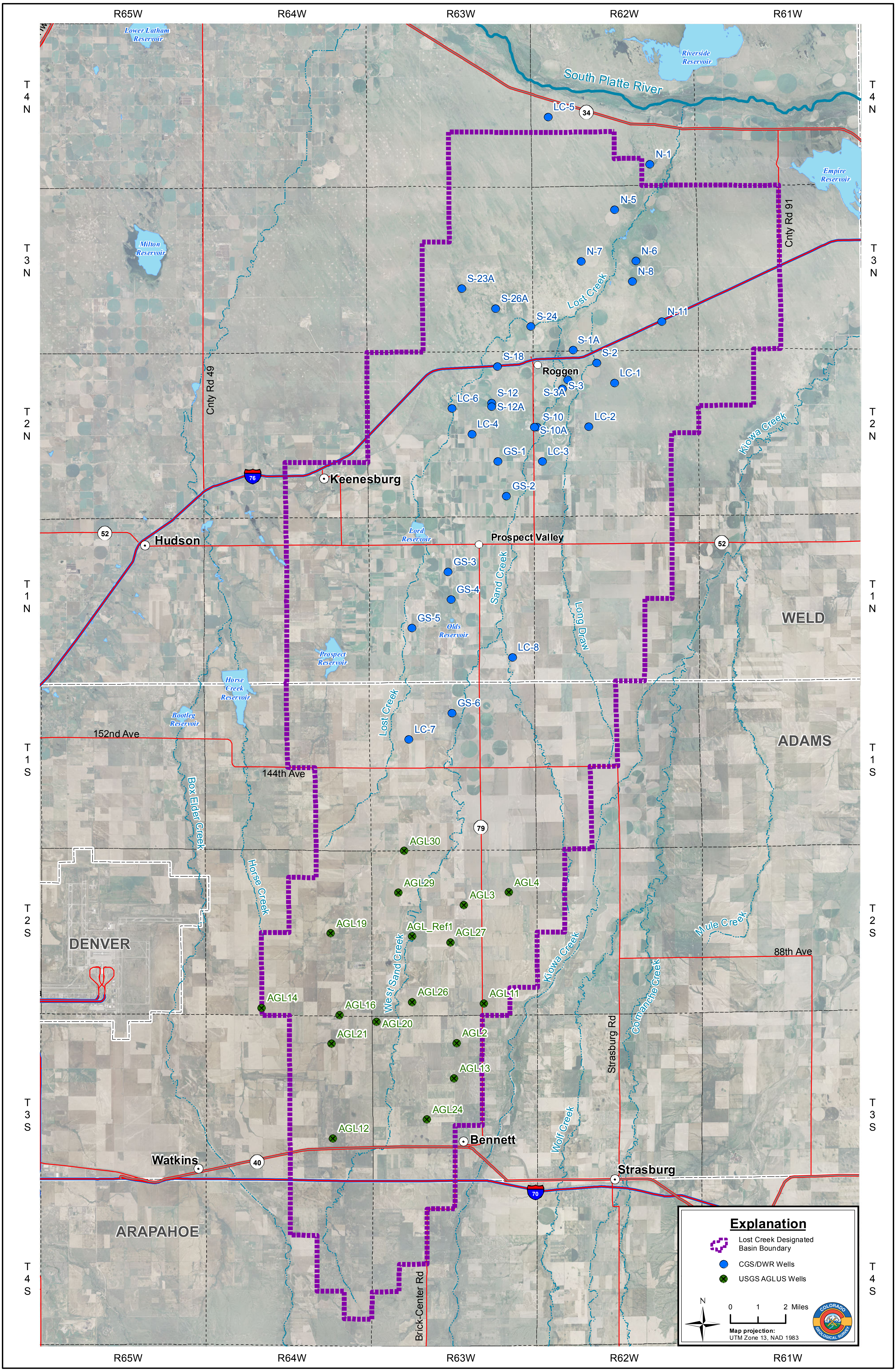
Figure 7

Water levels in a network of alluvial wells in the northern and central parts of the basin have historically been measured by the USGS and the CDWR, typically on an annual basis in spring. While limited data were collected and reported as early as the 1930s, widespread water level data were not collected until around 1970.

Starting July 2009, CGS commenced monitoring of static water levels, on a monthly basis, in all accessible wells which remained part of the CDWR water-level monitoring network at the time to document seasonal water level variations. In 2009 and 2010, CGS also began measuring additional monitoring wells in order to collect static water level data in other areas of the basin (Fig. 8). CGS added wells to replace wells no longer accessible or in which static water levels could not be measured because of active irrigation pumping. We began measuring water levels in wells S-10A and S-12A to replace nearby wells with similar completion intervals (S-10 and S-12) that were often pumping (precluding a static water level measurement); we added well S-3A to replace a nearby well with a similar completion interval which no longer had access for water level measurements. In total, CGS acquired water level measurements from 45 wells during 2009 and 2010 as part of this study. CGS measured water levels in 29 irrigation, stock, domestic, and monitoring wells; under contract with the CGS, the USGS measured water levels in 16 monitoring wells in the southern part of the basin. Figure 8 shows the water-level monitoring network used in this study.

Alluvial Aquifer Groundwater Level Trends

Historic groundwater level trends in the Lost Creek basin are based on the seasonal high water level data, generally collected in early spring. In the mid- to late-1930s, prior to and during the early development of groundwater in the basin, alluvial groundwater levels were generally high. Water levels fluctuated, but generally dropped, from the 1930s and 1940s through the early 1970s. Wells GS-1, GS-2, and LC-3 are the only wells in the monitoring network with historic water level records extending back into the 1930s and 1940s (Appendix B). Water levels in these wells have dropped between 15 and 25 feet over this period of historic record. In most basin areas, historically low water levels existed in the early 1970s (Fig. 9, Appendix B). Figure 9 shows historic water level trends for selected representative wells in the basin with long-term data.



Groundwater Level Monitoring Network
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 8

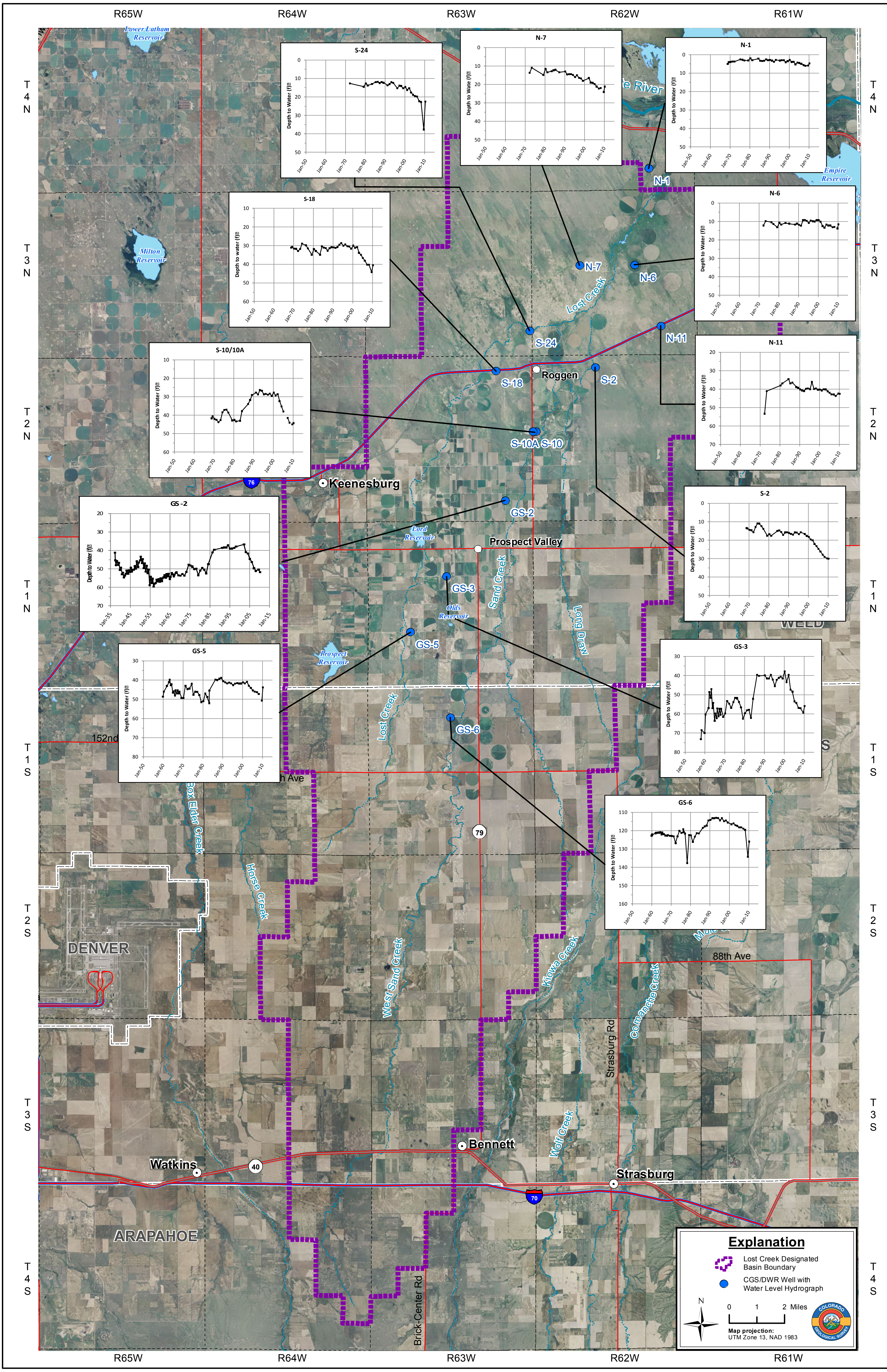


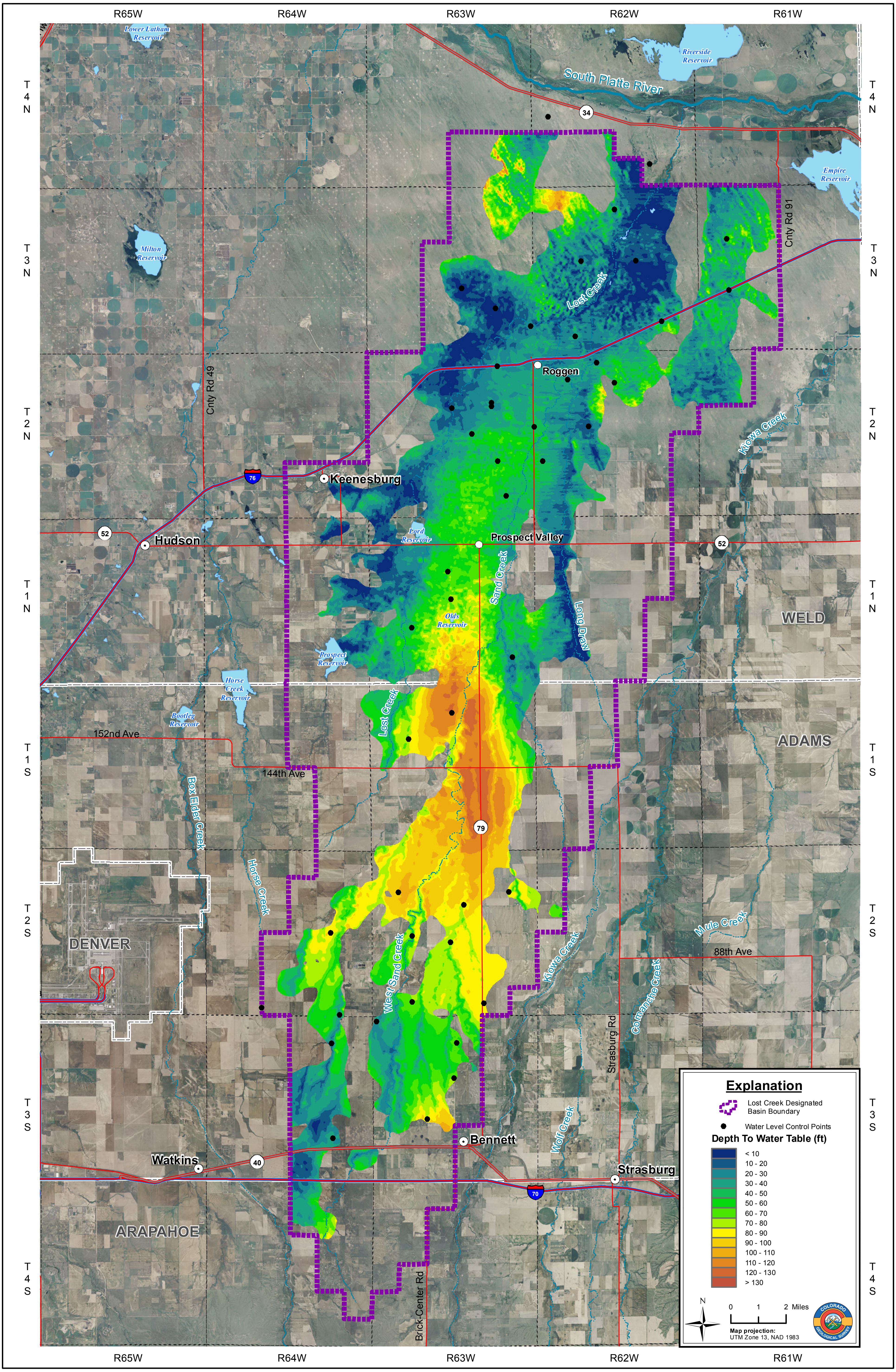
Figure 9

Historic Groundwater Level Trends
Lost Creek Basin Aquifer Recharge and Storage Study

In the central part of the basin, water levels rose to a general high point in the 1990s with many water levels remaining high through 2000. In the northern part of the basin, water levels remained relatively stable from the 1970s through 1990. Since 1990, water levels throughout the basin appear to have dropped with the greatest water level declines occurring between 2000 and 2010 in the central part of the basin where the majority of high-capacity wells are located. Water levels have declined by as much as 20 feet since 1990 in some wells in the central basin. In the northern part of the basin, water level declines since 1990 have generally been less (0-10 feet in most wells) with declines generally decreasing to the north (Fig. 9).

Spring 2010 water levels ranged from only a few feet below the ground surface in the northern part of the basin to depths of greater than 100 feet in parts of the central and southern basin. Figure 10 shows the calculated depth to water throughout the basin. This dataset was generated by subtracting the interpreted groundwater elevation dataset from the ground surface digital elevation model (DEM). The process used in generating the groundwater elevation dataset is described in greater detail later in the report (Fig. 10, Appendix B). Seasonal water level fluctuations during 2009-2010 were greatest in the central part of the basin, on average 6-7 feet, and were less to the north (2-4 feet) and south (1-2 feet). Appendix B contains a detailed summary and discussion of groundwater level trends in the Lost Creek basin.

Historic water level trends in the basin reflect the combined effects of groundwater withdrawals and recharge. Prospect Reservoir is the main distribution point for irrigation water delivered into the basin. Because percolation of applied irrigation water is the primary recharge component in the Lost Creek alluvial aquifer, surface water delivery and storage trends in Prospect Reservoir (Appendix C) closely relate to the inflow of water from infiltration of irrigation water. Groundwater pumping is also likely to be higher during periods when surface water deliveries are low. Moreover, because Olds Reservoir and Lord Reservoir seep water into the Lost Creek alluvial aquifer, diversions and storage in these reservoirs (Appendix C) affects water levels in the alluvial aquifer. Appendix C illustrates historic trends in surface water storage at Prospect Reservoir and diversions and storage at Olds Reservoir and Lord Reservoir using data from CDWR. Periods of lower surface water deliveries existed into the 1970s and 1980s. In general groundwater levels in the basin were low at this time. A period of generally higher surface water deliveries existed from the 1980s until early 2000s and coincides with rising groundwater levels in many areas of the basin. Since the early 2000s, surface water deliveries appear to have declined and wells throughout the basin also exhibit declining groundwater levels during this period.



Depth to Groundwater - Spring 2010
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 10

Alluvial Aquifer Groundwater Surface Elevation

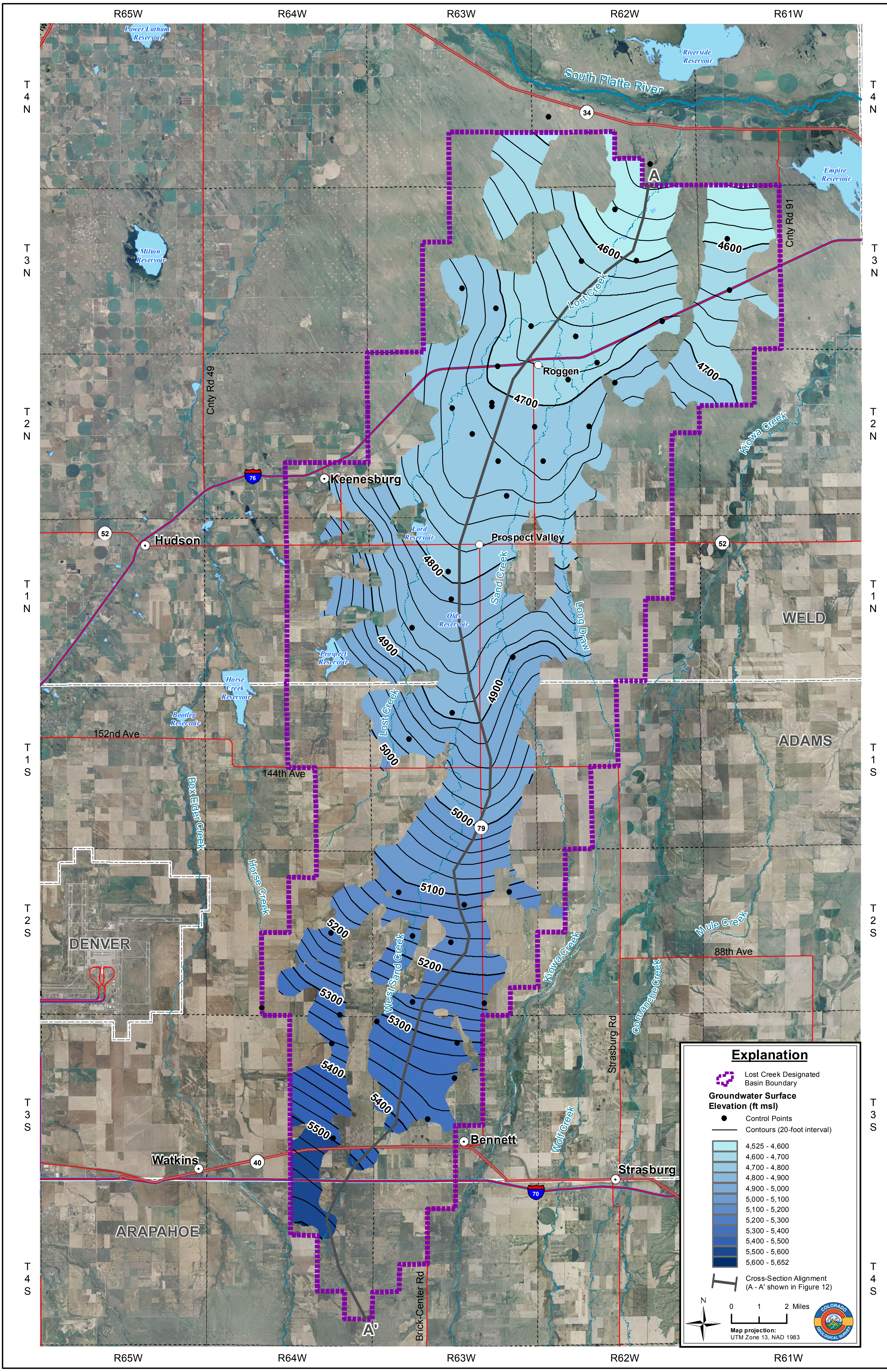
Determination of the current volume of groundwater in storage along with any additional storage volume potential requires delineation of saturated conditions in the aquifer. This study uses the seasonal high water level measured in the Spring of 2010 to represent the elevation of the top of the saturated alluvial aquifer. The groundwater surface (water table) elevation of the alluvial aquifer in Spring 2010 is based on the measured water levels from the 45 monitoring network wells plus two (2) additional water level measurements from Spring 2008 and 2010 in the Hay Gulch sub-basin (HRS Water Consultants, Inc., 2009; Principia Mathematica Inc., 2010). To evaluate historic changes in basin groundwater levels and storage, we also interpreted the groundwater surface elevation during periods of a historic low (Spring 1972) and high (Spring 1993) water levels. Water levels in Spring of 1972 and Spring 1993 represent periods of generally low and high water levels in the central and northern parts of the Lost Creek alluvial aquifer. Although water levels were not consistently low or high in all wells at these points in time, on average these dates represent low and high water level conditions in the largest percentage of wells. Further, we chose Spring 1972 to represent a historic low period because greater spatial distribution of water level data exists for this date.

Water-level control-point locations are based on global positioning systems (GPS) and aerial photography evaluated in GIS. Ground-surface elevations derived from the 10-meter NED digital elevation model (DEM) using the determined control-point locations. Groundwater elevations at each point represent the difference between measured depth to water and the extracted ground surface elevation. Initially, a groundwater surface elevation grid was interpolated for Spring 2010 using the natural-neighbor point interpolation method (ESRI, ArcGIS 10.0, Spatial Analyst) and then converted to a contour dataset. The groundwater surface elevation contours were then compared with ground surface topography and the interpreted bedrock surface and manually adjusted for anomalies. We also repeated this procedure for the Spring 1972 and Spring 1993 datasets. By concurrently working on the three surfaces, we were able to make more informed interpretations of the groundwater surface at each point in time by considering the shape and elevation of the surfaces at other times, particularly in areas where data was sparse. This process facilitated extrapolation to areas where water level control in any of the three datasets was lacking. Nevertheless, because of spatial limitations of historic water level point control data, the groundwater surface elevation contours cover only the northern portion of the basin for Spring 1972 and Spring 1993.

Groundwater Surface - Spring 2010

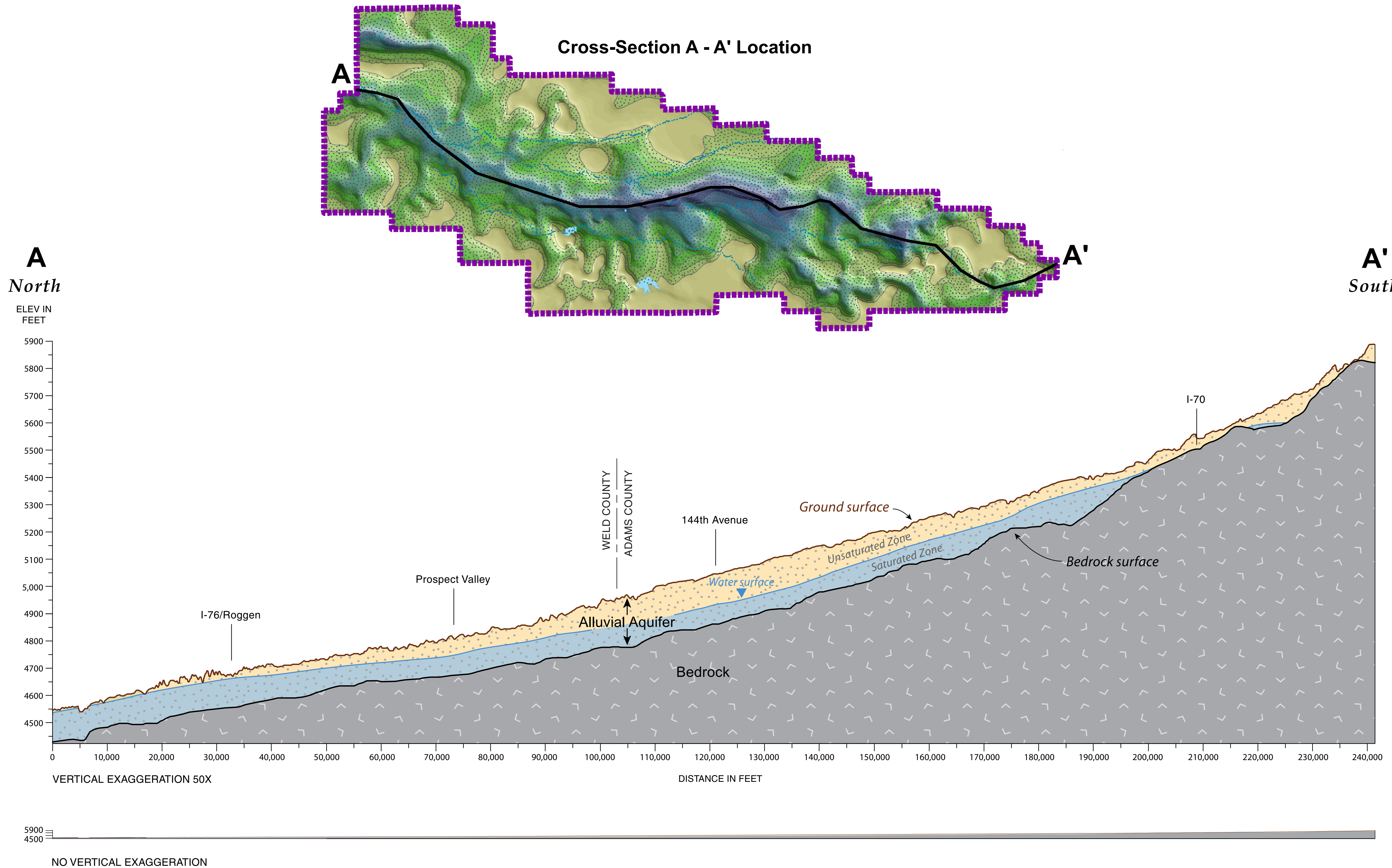
The interpreted groundwater surface in Spring 2010 and the water level control points used in that interpretation are illustrated in Figure 11. As discussed earlier, in areas lacking point control, particularly on the east and west margins of the alluvial aquifer, we interpreted the groundwater surface following bedrock and ground surface contours and using water level data from earlier time periods. The certainty of the groundwater surface in areas lacking water level point control is less. Interpreted groundwater elevations in the Lost Creek alluvial aquifer range from approximately 5,600 feet above mean sea level (msl) in the south to about 4,540 feet msl at the northern edge of the Designated Basin. This translates to an average groundwater gradient of approximately 27 feet per mile (0.005) over the entire length (39.75 miles) of the alluvial aquifer in the Lost Creek basin.

Groundwater flows downgradient and at right angles to the water table contours. The hydraulic gradient and associated flow velocity varies regionally throughout the basin. In the southern portion of the basin, the groundwater gradient is steeper and flows northward towards the center of the alluvial aquifer basin from upland areas receiving recharge. The groundwater gradient in the alluvial aquifer south of the Weld/Adams county line is approximately 35 feet per mile (0.007). In the central part of the basin between the Weld County line and the town of Roggen, the groundwater gradient is considerably flatter (15 feet per mile or 0.003). North of Roggen to the Designated Basin boundary the groundwater gradient is about 19 feet per mile or 0.0035 (Fig. 11). These gradients are estimations using interpreted water flowlines based on the groundwater surface elevation. Figure 12 is a north-south trending cross-section profile of the Lost Creek alluvial aquifer system. This figure illustrates the relationship between the alluvial aquifer groundwater surface, alluvial aquifer thickness, and the underlying bedrock surface in a north-south direction along the alluvial aquifer channel.



Alluvial Groundwater Elevation - Spring 2010
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 11

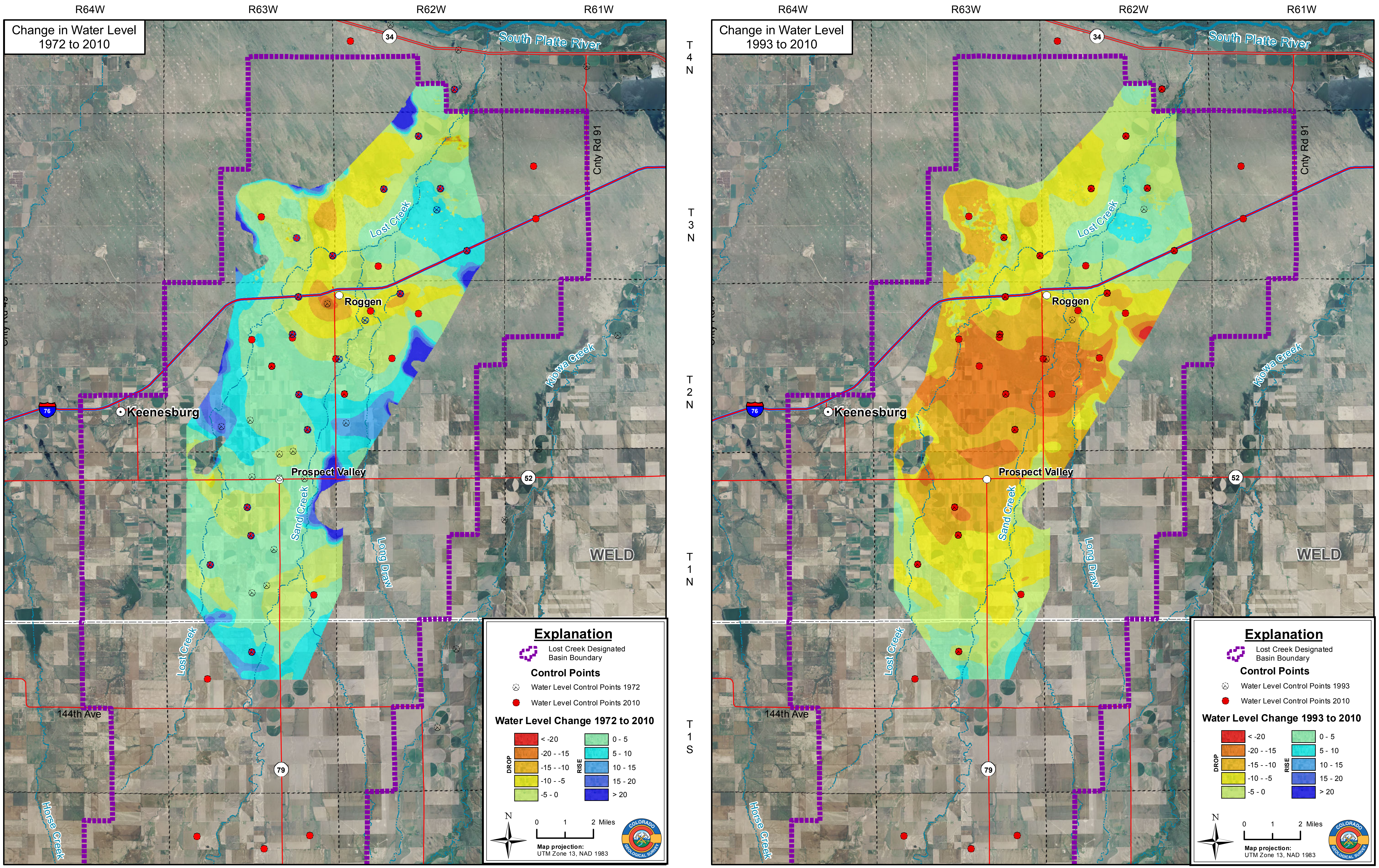


Cross-Section A - A' Along Lost Creek Alluvial Aquifer Channel
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 12

Historic Groundwater Surfaces - Spring 1972 and Spring 1993

To evaluate the change in water levels over time, we interpreted historic alluvial aquifer groundwater surfaces in Spring 1972 and Spring 1993 and compared them with the water surface in Spring 2010 (Fig. 13) in a subarea of the northern and central basin. These comparisons show that water levels in Spring 2010 were higher than in Spring 1972 in many places; however, water levels in the vicinity of Roggen and further north, appear to have dropped between 1972 and 2010. On the other hand, water levels in 2010 were lower than in 1993 throughout much of the central and northern parts of the basin with the greatest declines (>15 feet), exhibited in a large area between Prospect Valley and Roggen (Fig. 13). Although alluvial groundwater levels have declined considerably between 1993 and 2010 in much of the basin, 2010 levels are still near or above historic low water levels in many areas. At the same time, water levels in the northern part of the basin, in particular near Roggen, were lower in 2010 than they were in 1972.



Historic Alluvial Groundwater Elevation Comparison - Spring 1972 and 1993
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 13

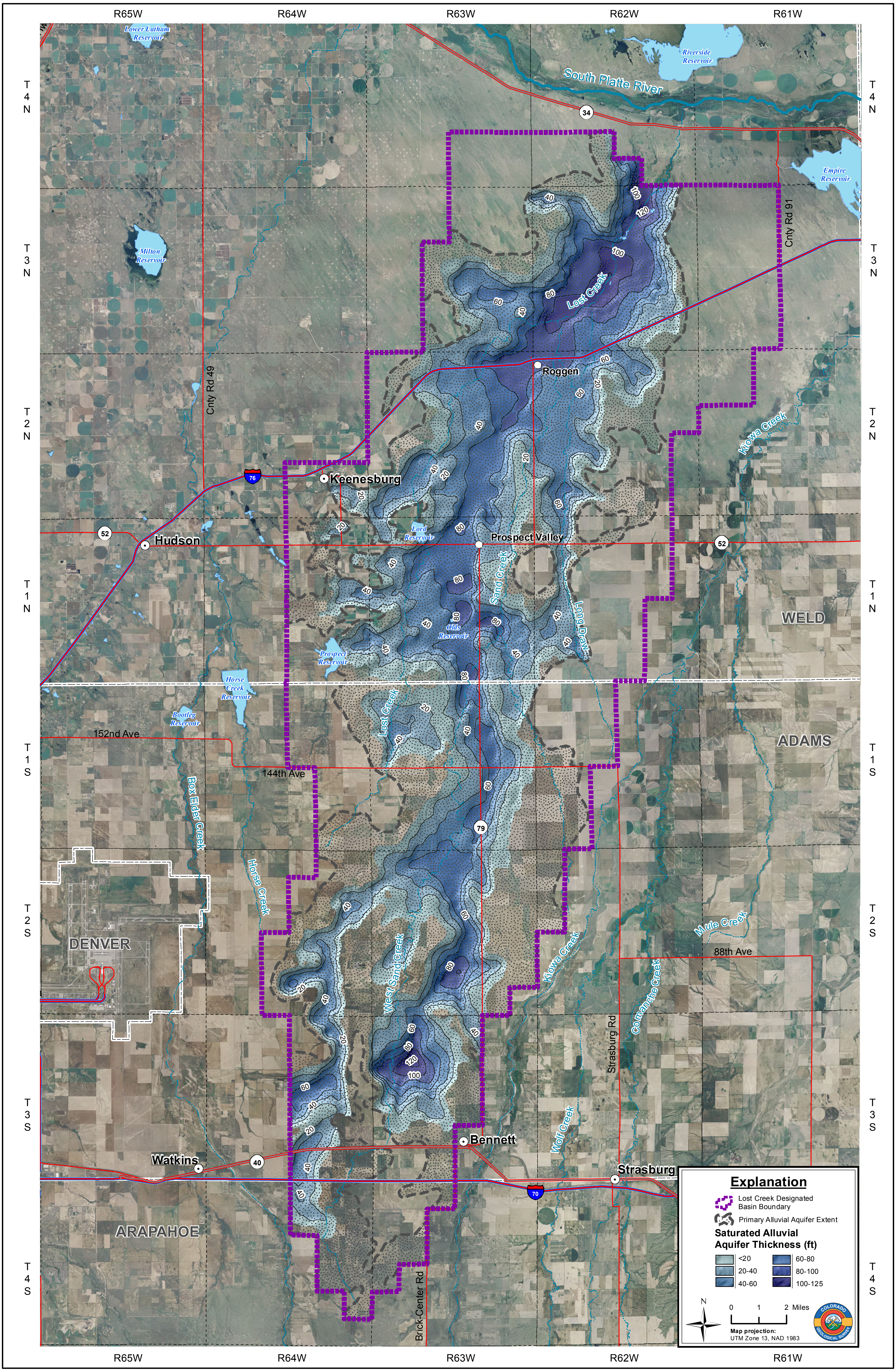
ALLUVIAL AQUIFER STORAGE

For the purpose of estimating the amount of alluvial groundwater in storage within the Lost Creek Designated Ground Water Basin, we excluded from our analysis, thin (<20 ft) or isolated alluvial-aquifer materials along the edges of the basin. Furthermore, because this study focuses on evaluating the potential for recharging and storing additional groundwater in the main Lost Creek alluvial aquifer system, a zone representing the Primary alluvial aquifer extent was also defined. The smaller Primary alluvial aquifer extent includes only those areas of the alluvial aquifer that are likely to be influenced (by pumping or recharge) from within the main Lost Creek alluvial aquifer system. For these purposes, the Primary alluvial aquifer extent does not include the Hay Gulch sub-basin, which appears hydraulically isolated from the main Lost Creek alluvial aquifer system, and also does not include the alluvial aquifer area in the northwestern part of the Designated Basin, which appears to flow directly into the South Platte River alluvial aquifer system. Although recharge of the groundwater in areas outside of the defined Primary Lost Creek alluvial aquifer may be possible, these areas are not suitable for recharging and storing water for use within the main contiguous part of the Lost Creek alluvial aquifer basin.

Groundwater in Storage

The capacity of an aquifer to store water is quantified by its storage coefficient. For unconfined aquifers like the Lost Creek alluvial aquifer, the storage coefficient is equal to the specific yield, which quantifies the pore space that is drainable by gravity. The amount of recoverable water in storage is then calculated as the saturated aquifer volume (saturated thickness times areal extent) multiplied by its storage coefficient or specific yield. The saturated thickness of the Lost Creek alluvial aquifer as of Spring 2010 was calculated in GIS by subtracting the bedrock surface grid dataset from the Spring 2010 groundwater surface grid dataset (ESRI, ArcGIS 10.0, Spatial Analyst). The calculated saturated thickness of the alluvial aquifer in Spring 2010, clipped to the extent of the alluvial aquifer, is displayed in Figure 14. The extent of the Primary Lost Creek alluvial aquifer is also highlighted on Figure 14. Saturated thickness in the alluvial aquifer ranges from zero to a maximum of 123 feet.

Saturated thickness in Lost Creek is greatest along the main alluvial aquifer channel where it is generally 60 feet or greater. Areas with the greatest saturated thickness (>100 ft) are north of Roggen where water levels are shallow and also in the southern end of the basin about two (2) miles north and west of Bennett where the alluvial deposits are thickest.



Saturated Alluvial Aquifer Thickness - Spring 2010
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 14

The total saturated area within the Lost Creek alluvial aquifer (including the Hay Gulch and South Platte River subareas), is approximately 147,000 acres or about 53% of the entire Designated Basin area. Multiplying by the saturated thickness over this area equates to a total saturated aquifer volume of a little over 6 million acre-feet. Within the Primary alluvial aquifer, the total saturated area is approximately 132,000 acres and the total saturated aquifer volume is about 5.5 million acre-feet (Table 2). The specific yield represents that portion of the aquifer volume containing water drainable by gravity flow. Code (1945) determined a specific yield of 17% (0.17) for alluvial aquifer materials in the Prospect area through field and laboratory studies. This specific yield value appears reasonable given ranges of values for sand and silty sand determined by Johnson (1967). Applying a specific yield of 0.17, the total amount of groundwater currently in storage in the Lost Creek alluvial aquifer is calculated to be approximately 1,022,500 acre-feet. About 927,700 acre-feet or 91% of this water is being stored in the Primary alluvial aquifer (Table 2). These calculated volumes are similar to the previous storage calculation of 1,300,000 acre-feet (for Spring 1967) determined by Nelson, Haley, Patterson, and Quirk, Inc. (1967) for the entire Lost Creek basin.

Table 2. Groundwater Storage in the Lost Creek Alluvial Aquifer

Description	Saturated Aquifer Area (acres)	Saturated Aquifer Volume (acre-feet)	Water in Storage[1] (acre-feet)
Current Groundwater Storage			
Spring 2010 - Total Alluvial Aquifer *(Primary + Hay Gulch and S. Platte Subareas)*	147,050	6,014,700	1,022,500
Spring 2010 - Primary Alluvial Aquifer	132,296	5,457,000	927,700
Historic Groundwater Storage Comparisons			
Spring 2010 - Comparison Subarea[2]	---	3,567,500	606,500
Spring 1993 - Comparison Subarea[2]	---	4,138,400	703,500
Spring 1972 - Comparison Subarea[2]	---	3,508,000	596,300
Change 1972 to 1993 - Comparison Subarea[2]	---	630,500	107,200
Change 1993 to 2010 - Comparison Subarea[2]	---	-570,900	-97,100
Change 1972 to 2010 - Comparison Subarea[2]	---	59,600	10,100

[1] Calculated using storage coefficient (specific yield) of 0.17

[2] Subarea of the basin used to compare historic water level and storage changes as shown on Figures 13 & 15

We also calculated historic saturated thickness for Spring 1972 and Spring 1993 in the Primary alluvial aquifer in the central and northern part of Lost Creek basin (Fig. 15). As expected, these datasets show generally less saturated thickness in 1972, during the period of generally low water levels, than in 1993 when water levels were relatively high. At both times, the saturated thickness was greatest in the vicinity and north of Roggen. In fact, the saturated thickness datasets appear very similar in 1972 and 1993 in the northern part of the basin; however, in 1972 the saturated thickness declines relatively quickly with distance south of Roggen (Fig. 15). The calculated water storage volume in a subarea of the Primary alluvial aquifer in the central and northern part of the basin was approximately 596,300 acre-feet in Spring 1972 and approximately 703,500 acre-feet in Spring 1993. By comparison, for the same 80,000-acre area, the calculated water storage volume for Spring 2010 is approximately 606,500 acre-feet. This equals an increase in water storage of 107,200 acre-feet (5,100 acre-feet/yr) between 1972 and 1993 in the central and northern parts of the primary alluvial aquifer. Water storage decreased about 97,100 acre-feet (5,700 acre-feet/yr) between 1993 and 2010 (Table 2). Overall, the amount of water storage in 2010 in this comparison area appears to be very similar to 1972; however, slightly declining water levels in the northern parts of the basin and slightly rising water levels further south indicate the distribution of water has changed (Fig. 15).

Groundwater development in the basin began in the 1930s with approximately 67 wells pumping about 10,000 acre-feet of alluvial groundwater by 1938. By 1961, approximately 200 wells were pumping about 35,000 acre-feet annually. On average, wells pumped more than 44,000 acre-feet each year between 1953 and 1956 (Skinner, 1963). This increased groundwater development in combination with periods of relatively low precipitation and surface water deliveries (Appendices A and C), led to generally declining water levels and the loss of groundwater in storage during the 1950s with historic lows occurring in the late 1960s and into the early 1970s (Fig. 9, Appendix B). More stabilized groundwater pumping, higher than average precipitation, and more consistent surface water deliveries to the basin from the late 1960s through the 1990s, including into Lord and Olds reservoirs (where recharge into the groundwater occurs), raised water levels and increased water storage in the alluvial aquifer (Fig. 9). Since 2000, surface water deliveries have generally been low and groundwater storage in the Lost Creek alluvial aquifer has declined to about where it was in the early 1970s (Fig. 15, Table 2).

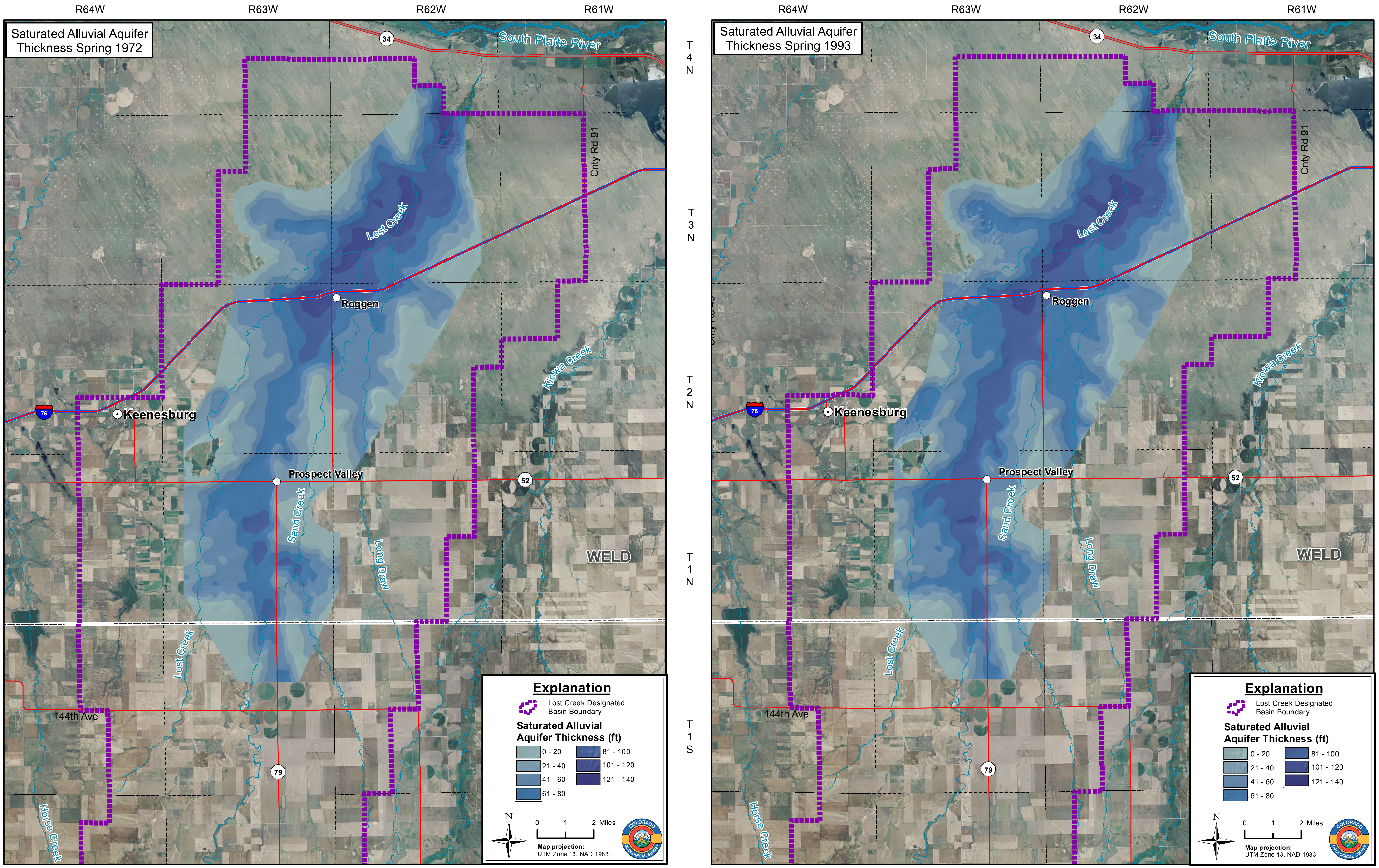


Figure 15

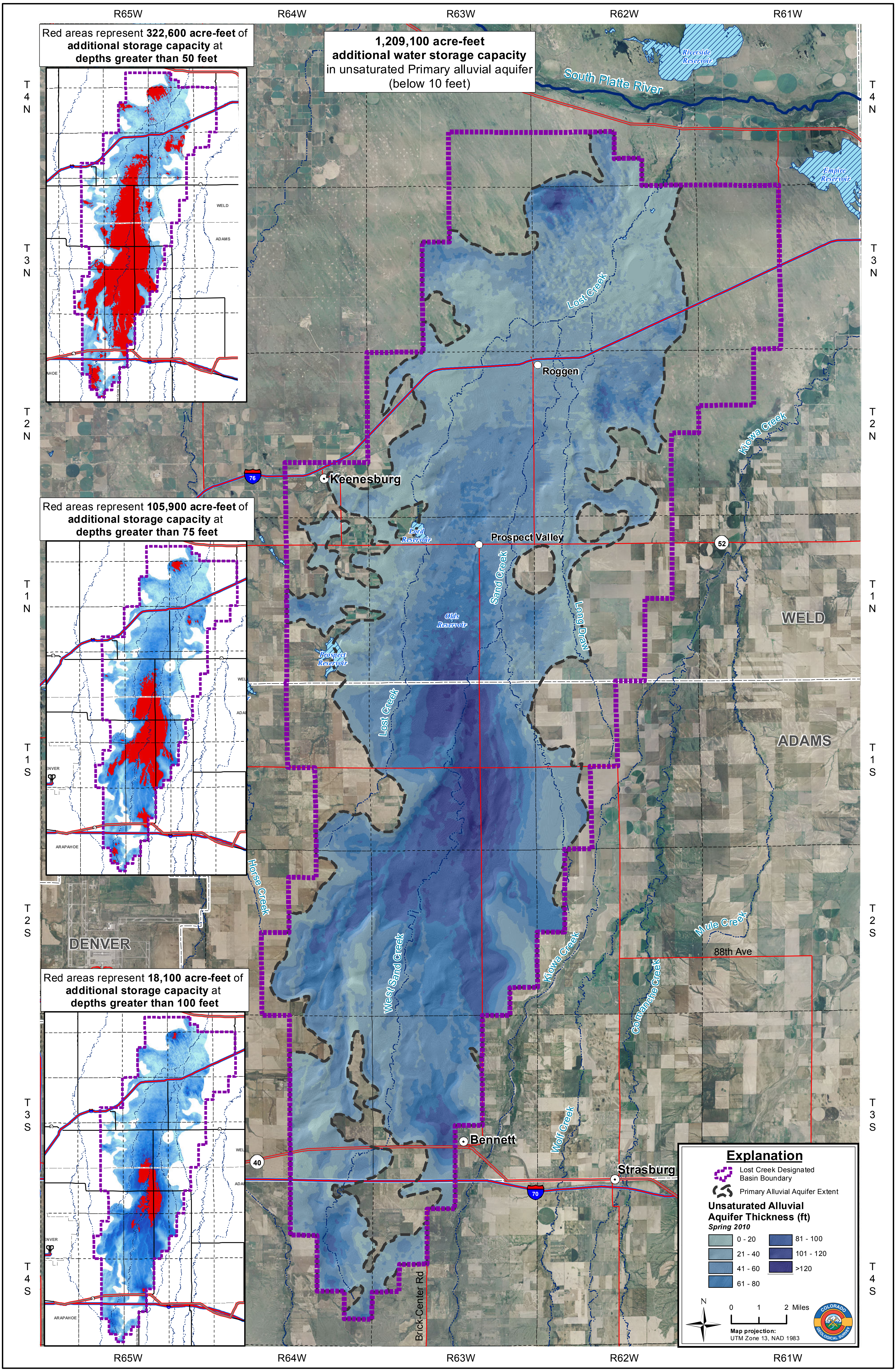
Historic Saturated Alluvial Aquifer Thickness - Spring 1972 and 1993
Lost Creek Basin Aquifer Recharge and Storage Study

Available Storage Capacity

The pore space within the unsaturated portion of the alluvial aquifer provides the reservoir in which additional water can potentially be stored within the Lost Creek basin. The thickness of the unsaturated alluvial aquifer was calculated by subtracting the Spring 2010 groundwater surface dataset from the land surface dataset in GIS (ESRI, ArcGIS, Spatial Analyst). Thickness of the unsaturated Lost Creek alluvial aquifer ranges from zero to greater than 130 feet. The maximum calculated unsaturated thicknesses within the Lost Creek alluvial aquifer are in the vicinity of the junction of 144th Avenue and Highway 78 in the central and southern parts of the basin (Fig. 16). Here the alluvial aquifer is thick and water levels are at relatively greater depths. Unsaturated thickness diminishes to the north, where groundwater levels are shallow and the alluvial aquifer thins.

In Spring 2010, the total volume of unsaturated material within the Lost Creek alluvial aquifer was approximately 10 million acre-feet. Using a specific yield value of 17%, the total unsaturated pore volume is calculated to be approximately 1.7 million acre-feet. Within the Primary Lost Creek alluvial aquifer area, the total volume of unsaturated aquifer material is approximately 9 million acre-feet and the calculated unsaturated pore volume is 1.5 million acre-feet (Table 3). In practice, not all of the unsaturated pore volume within the alluvial aquifer is available, nor should be used, for storage. Groundwater losses from evapotranspiration and surface discharge increase as groundwater levels approach the surface. Furthermore, the risk of damage to soils and structures from shallow groundwater increases as groundwater levels approach the surface. As artificial recharge and storage is considered at a greater scale in the basin, more detailed investigations and modeling should be performed to evaluate the effects of implementing such activities.

In order to more realistically quantify the available storage capacity in the Primary Lost Creek alluvial aquifer and identify areas with the greatest available storage capacity, we calculated the volume of unsaturated alluvial aquifer pore space below four (4) depth horizons: 10 feet, 50 feet, 75 feet, and 100 feet below ground surface. This is similar to using and area-capacity curve tied to elevation for assessing fill volumes for a surface reservoir. Accounting for all unsaturated material within the Primary alluvial aquifer that is deeper than 10 feet below the ground surface, the calculated potential water storage capacity is approximately 1,209,100 acre-feet. The calculated available storage capacity below 50 feet is about 322,600 acre-feet, most of which is located in the central and southern parts of the basin. Below depths of 75 and 100 feet, the calculated potential available storage capacities are approximately 105,900 acre-feet and 18,100 acre-feet, respectively. The locations with deeper storage (>75 feet) are constrained to areas south of Prospect Valley (Fig. 16). Figure 17 shows a graphical comparison of the Spring 2010 calculated volumes of groundwater in storage and potential



Unsaturated Alluvial Aquifer Thickness and Storage Capacity
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 16

available storage capacities. The groundwater storage capacity values calculated in this study appear similar to previous estimates by CWCB. By comparison, CWCB estimated a total of approximately 1,417,000 acre-feet of available groundwater storage capacity in the entire Lost Creek alluvial aquifer system. That value represents estimated storage capacity in the alluvial aquifer below 10 feet using a specific yield of 20% (0.20) (CWCB, 2007).

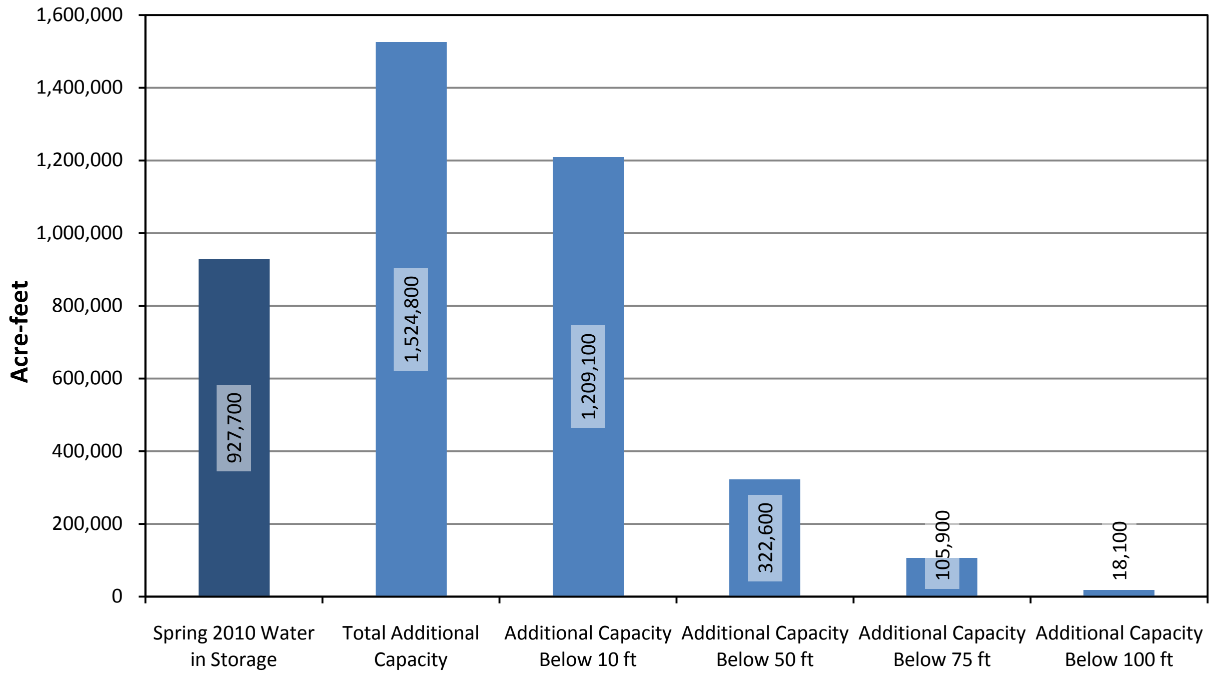


Figure 17. Water Storage Volumes in the Lost Creek Primary Alluvial Aquifer

Table 3. Additional Available Storage Capacity in the Lost Creek Alluvial Aquifer - Spring 2010

Description	**Unsaturated Aquifer Area (acres)**	**Unsaturated Aquifer Volume (acre-feet)**	**Unsaturated Aquifer Pore Volume (acre-feet)**
Total Alluvial Aquifer *(Primary + Hay Gulch and S. Platte Subareas)*	214,800	10,048,700	1,708,300
Total Primary Alluvial Aquifer	189,600	8,969,500	1,524,800
Below 10 Feet - Primary Alluvial Aquifer	181,300	7,112,200	1,209,100
Below 50 Feet - Primary Alluvial Aquifer	74,600	1,897,800	322,000
Below 75 Feet - Primary Alluvial Aquifer	33,500	622,920	105,900
Below 100 Feet - Primary Alluvial Aquifer	9,700	106,700	18,100

*Calculated using storage coefficient (specific yield) of 0.17. Unsaturated pore volume can be calculated under different specific yield scenarios by multiplying specific yield times the unsaturated aquifer volume.

WATER BUDGET

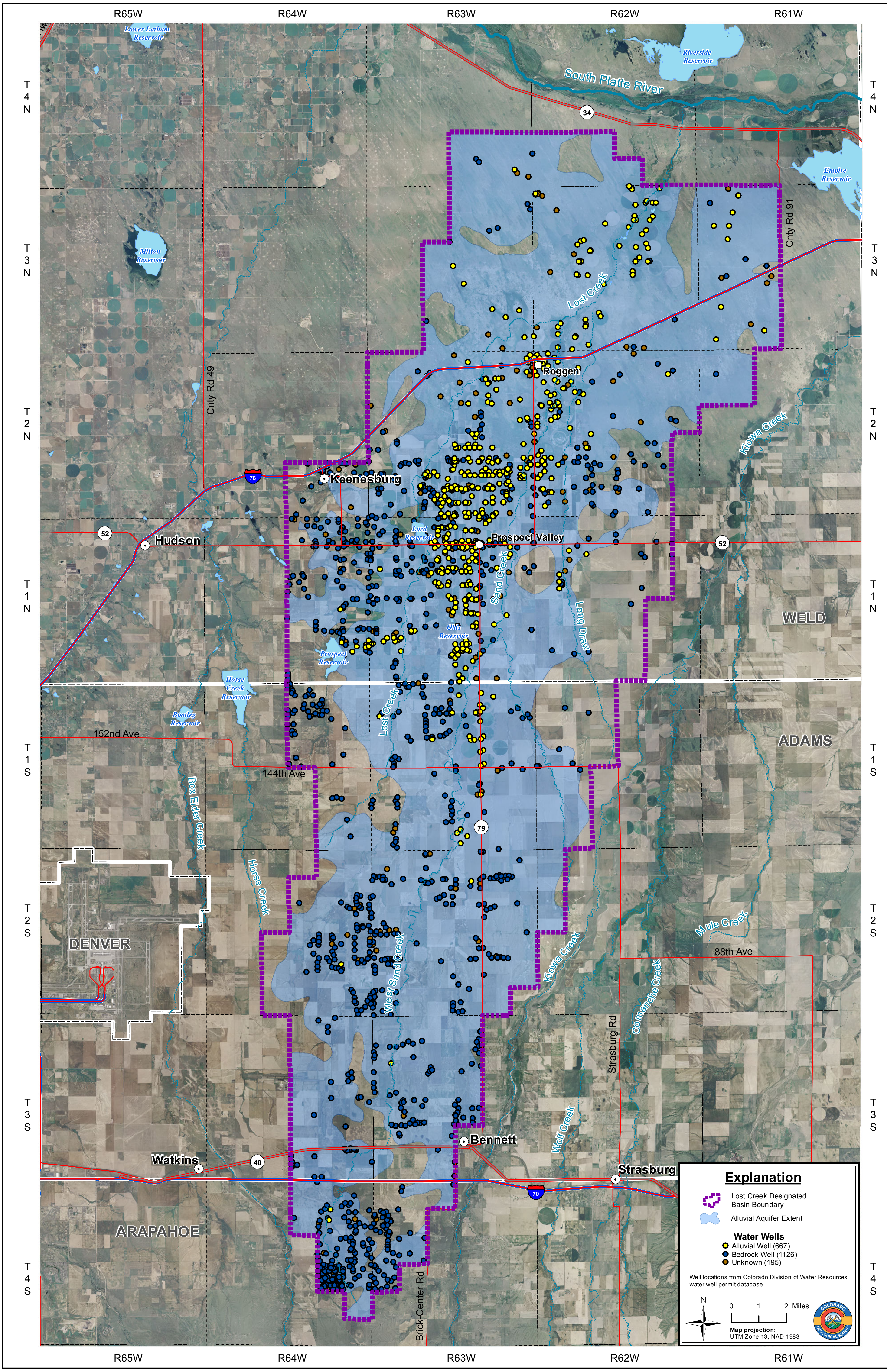
The water budget represents the components of water inflow to the basin and offsetting water outflows. Lost Creek basin water inflows occur primarily through precipitation and irrigation infiltration; the dominant water outflow in the basin is a result of well withdrawals.

Groundwater Development

Information from the well permit database of the Colorado Division of Water Resources (CDWR), State Engineer's Office, indicates that as of approximately June 2009 there were 1,988 permitted wells of record within the Designated Basin. In an effort to identify existing constructed wells, we qualified the well permit database to include only those records with information indicating actual drilling and completion. These records include all use categories (e.g., domestic, livestock, irrigation, etc.) and wells completed in both the alluvial and bedrock aquifers.

Utilizing the previously created datasets representing the configuration of the bedrock surface and alluvial aquifer, we interpreted the producing aquifer for each well record in the CDWR well permit database based on the well construction information provided. This approach maintains the following sequence of first-order criteria to identify wells completed in the alluvial aquifer: 1) the bottom of well perforations are above or less than 10 feet below the top of the bedrock surface, OR 2) the total well depth is above or less than 10 feet below the top of the bedrock surface. Additionally, wells with reported static water level below the top of the bedrock surface classify as bedrock wells. High-capacity wells with reported pumping rates of 1,000 gallons per minute (gpm) or greater were interpreted as alluvial wells. Lastly, wells with reported pumping rates of 500 gpm or more and base of perforations, or well depths, less than 20 feet below the top of the bedrock surface, were classified as alluvial wells to account for the uncertainty of the interpreted bedrock surface.

Figure 18 displays the distribution of registered water wells in the basin according to the interpreted aquifer in which they are completed. This analysis indicates that 667 wells are completed in the alluvial aquifer in Lost Creek basin, 1,126 wells are completed in the bedrock aquifers, and the production interval of 195 wells is unknown. The density of alluvial wells is greatest in the central part of the basin generally in the vicinity of Prospect Valley, south of Roggen and north of the Weld/Adams county line. This is where the alluvial aquifer is relatively thick and wide and where more irrigation-intensive agriculture is located. The mean pumping rate of the alluvial wells on record as of June 2009 is 668 gpm (based on 649 alluvial wells with recorded pumping rates). In contrast the mean pumping rate of the bedrock wells is 32 gpm (from 955 bedrock wells with pumping rates).



Registered Water Wells by Aquifer Completion
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 18

Well Withdrawals and Outflows

Groundwater development for irrigation represents the largest discharge from the alluvial aquifer. Significant development of basin groundwater resources began in the early 1930s in response to a shortage of surface water supplies (Code, 1945). This development progressed rapidly and, by 1944, there were about 87 wells operating in the Prospect Valley area pumping 13,100 acre-ft/yr (Code, 1945). Further development of the alluvial groundwater continued and, by 1967, approximately 250 wells were pumping a total of about 39,000 acre-ft/yr in the Lost Creek basin (Nelson, Haley, Patterson, and Quirk, Inc., 1967). As of 2007, there were about 266 decreed wells in the basin. Using power-use records, power-conversion coefficients, and irrigated acreage data, the estimated actual alluvial groundwater withdrawals from decreed wells within the Lost Creek Designated Ground Water Basin are about 44,300 acre-ft/yr (Arnold, 2010).

Arnold (2010) performed numerical groundwater flow model simulations of the main Lost Creek basin area for the period 1990-2001 assuming steady-state conditions, where water levels and aquifer conditions remain unchanged. Under simulated steady-state conditions, groundwater withdrawals from wells in the modeled area, not including the Hay Gulch area, would be about 26,760 acre-ft/yr. Outflows from the basin also occur through evapotranspiration, particularly in areas where water levels are shallow, and through subsurface groundwater discharge from the north end of the Lost Creek basin. Arnold's (2010) steady-state model simulations estimated about 3,140 acre-ft/yr of evapotranspiration losses and about 6,640 acre-ft/yr of subsurface discharge out of the main Lost Creek basin area (Fig. 19). Simulated steady-state outflows during the modeled period, 1990-2001, totaled about 36,540 acre-ft/yr.

Groundwater Recharge

Recharge to the alluvial aquifer in Lost Creek basin occurs primarily through 1) direct precipitation infiltration, 2) stream water infiltration, 3) percolation of applied irrigation water, and 4) seepage from irrigation ditches and reservoirs. Results from Arnold's (2010) steady-state numerical groundwater model of the main Lost Creek basin (not including the Hay Gulch area) estimate that during the modeled period, 1990-2001, total annual recharge to the main Lost Creek alluvial aquifer was about 36,590 acre-ft/yr. The largest recharge component was from percolation of applied irrigation water (approximately 14,510 acre-ft/yr). About 13,810 acre-ft/yr were estimated to be recharged by precipitation and stream-channel infiltration, 5,490 acre-ft/yr from seepage at reservoirs (primarily Olds

Reservoir), and 2,780 acre-ft/yr through subsurface inflows from irrigation ditches and from outside the model area (Arnold, 2010).

Figure 19 shows the modeled steady-state water budget for the main Lost Creek alluvial aquifer area, as simulated in a groundwater flow model by Arnold (2010). This modeled steady-state water budget represents values under conditions where water inflows are equal to outflows. Such conditions likely do not currently exist in the basin. Historically, a water budget created in 1967 by Nelson, Haley, Patterson, and Quirk, Inc., indicated an average annual water deficit of 41,000 acre-feet for the entire Lost Creek basin at the time. Declining water levels, evidenced in hydrographs for wells throughout most of the basin, suggest that groundwater withdrawals are currently exceeding inflows, although it is not certain by how much.

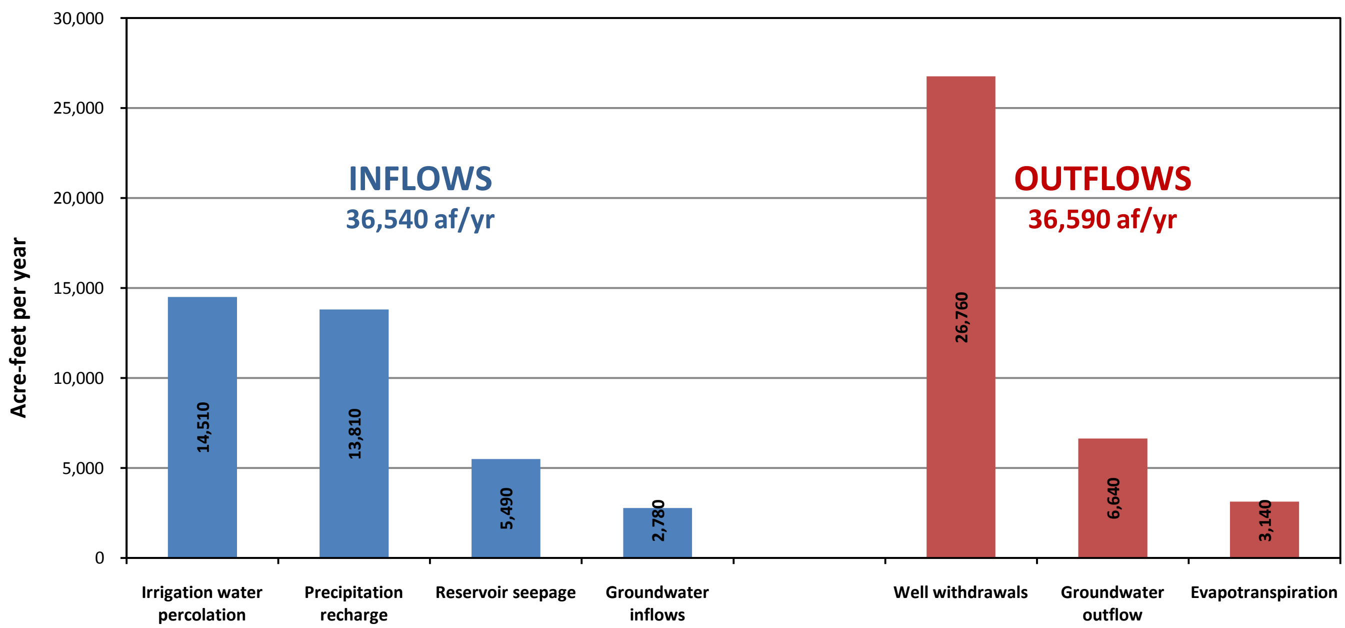


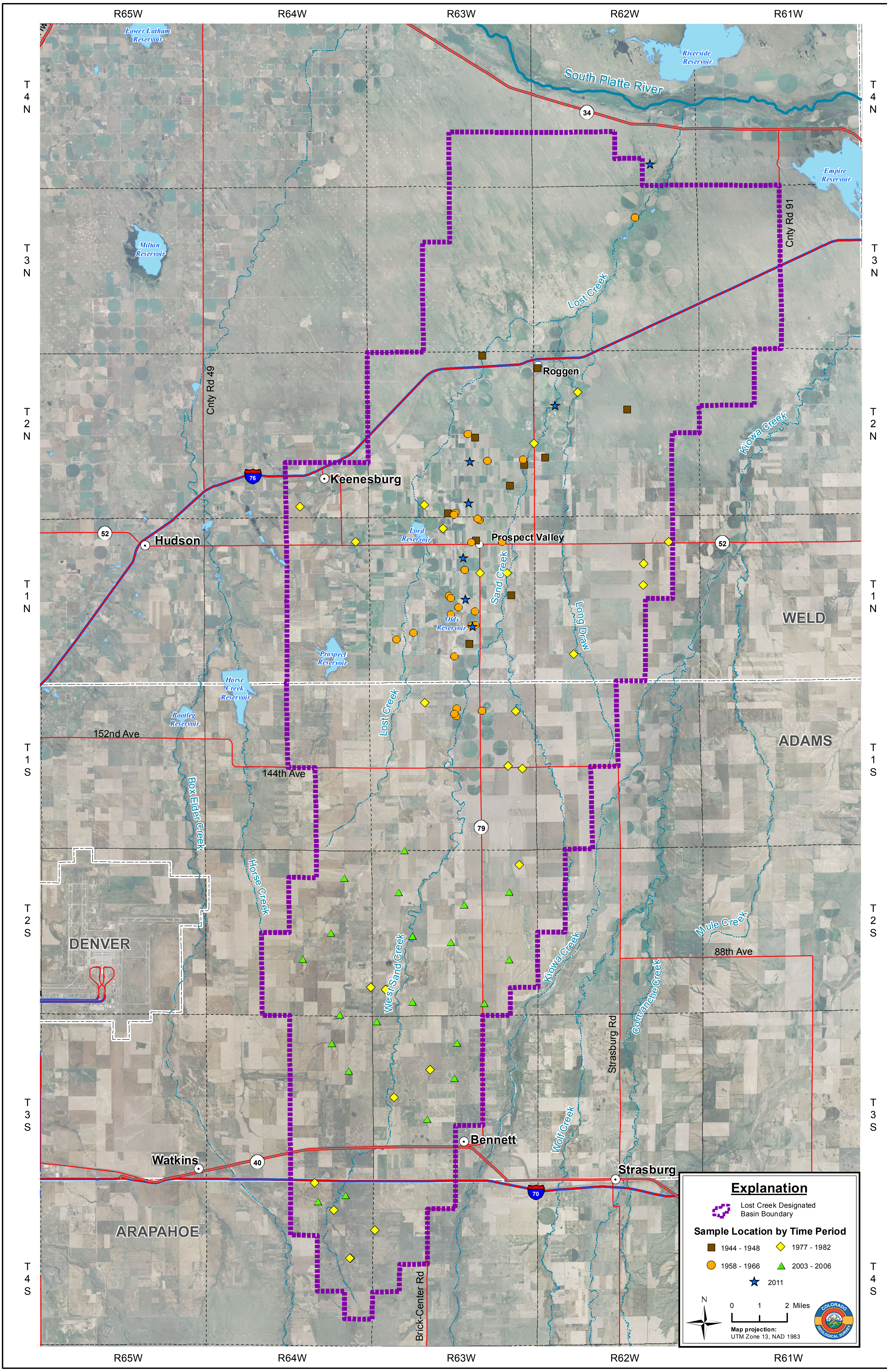
Figure 19. Simulated Steady-State Water Budget for the Main Lost Creek Alluvial Aquifer [from Arnold (2010)].

Groundwater Quality

Water quality is an important environmental consideration when evaluating the feasibility and operation of an aquifer recharge/storage project. Knowledge of the ambient water quality of the alluvial aquifer is important in determining any potential geochemical reactions or water quality degradation that may occur when recharge source water differs chemically from the receiving groundwater. It also provides information to evaluate potential treatment requirements of recharge or extracted water. Furthermore, the chemical composition of the groundwater provides insights for the potential leaching of minerals found in the soil or unsaturated zones or deposition of minerals within the aquifer and any resultant impacts to water quality. The scope of this study was to assemble water quality data for the Lost Creek alluvial aquifer system and characterize general water quality conditions. The water quality data and discussion presented in this report serve as a baseline from which potential environmental considerations can be more thoroughly evaluated prior to any future recharge project implementation actions.

We compiled historic water-quality data for 132 samples from four (4) existing sources (U.S. Geological Survey, 2010; Skinner, 1963; Bjorkland and Brown, 1957; Code, 1945). Additionally, CGS collected eight (8) alluvial groundwater samples in 2011 for laboratory water quality analysis as part of this study. The compiled historic water quality data spanned the period from as early as 1944 through 2011. Figure 20 shows the distribution of historic water quality data in the Lost Creek basin by location and time period. Of the 132 compiled water quality samples, 75 had data with laboratory analysis of select chemical constituents. Other water quality data consisted of basic physical water quality characteristics, typically measured in the field, such as specific conductance, temperature, and pH. All of the compiled water quality data are summarized in Appendix D.

The general physical water quality characteristics for groundwater samples in the Lost Creek alluvial aquifer are shown in Figure 21. The groundwater is generally slightly basic with most samples having pH values between 7.2 and 8.0. Measured temperature for water samples ranges widely with most samples having temperatures between 12 and 20 degrees Celcius (~54-68 degrees Fahrenheit). The measured specific conductance values ranged from a few hundred to over 4,500 micro-Siemens per centimeter (μS/cm). The specific conductance values in most samples were less than 1,000 μS/cm; however, 35% of the samples had specific conductance values greater than 1,000 μS/cm. Specific conductance is an electrical measurement related to the amount and mobility of dissolved ions in the water and can be a general indicator of water quality and total dissolved solids content.



Alluvial Groundwater Quality Sample Locations
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 20

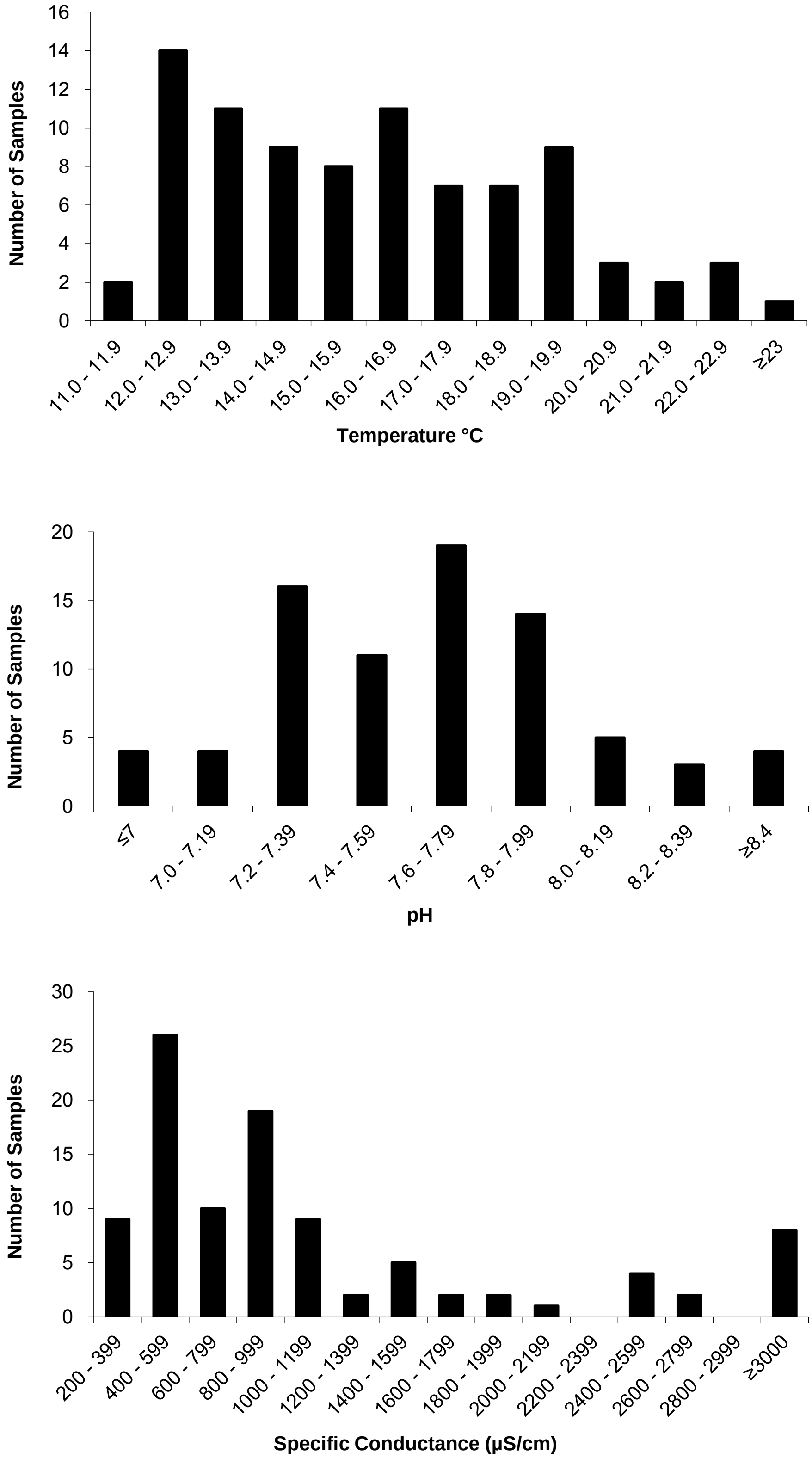
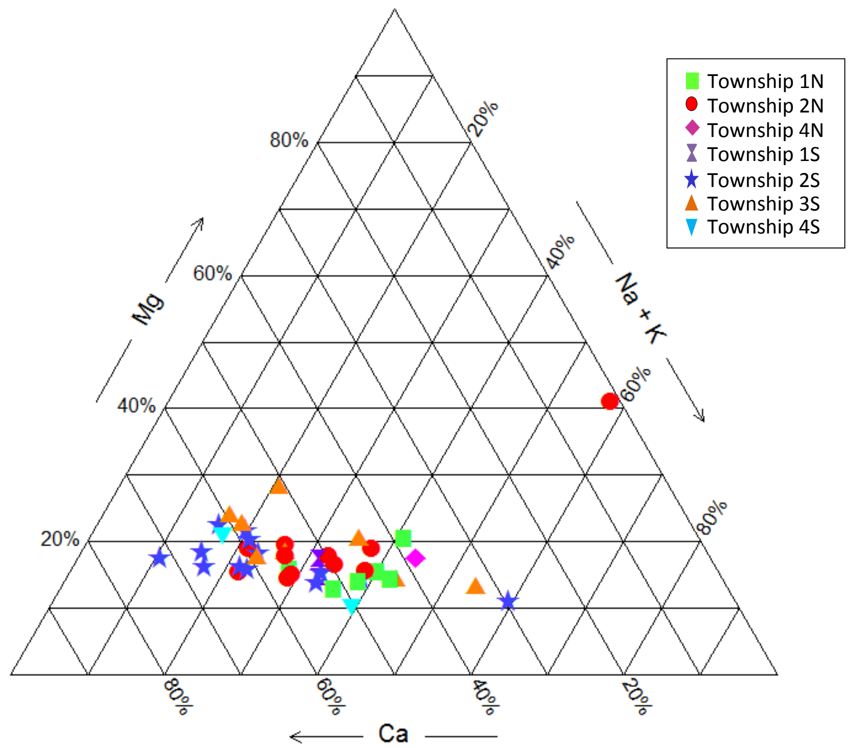


Figure 21. Physical Characteristics of Alluvial Groundwater Quality Samples

The chemical composition of groundwater reflects the chemical characteristics of soil and aquifer materials through which the water has travelled and dissolution processes along this course. One way of generally characterizing water chemistry is according to the relative concentrations of major cations (calcium, magnesium, sodium, potasium) and anions (chloride, bicarbonate, sulfate). Water can be characterized by the proportions of these major cations and anions. However, the chemistry of the groundwater in the Lost Creek alluvial aquifer is difficult to characterize in this manner. Water quality chemical analysis data show that the groundwater is generally calcium-rich (cation proportions of about 40-70%) with lesser proportions of sodium and potassium (together about 15-40%) and magnesium cations (about 10-20%). Anion makeup of the water samples is characterized by relatively low chloride (anion proportions <20%) and dominated by either bicarbonate or sulfate anions (10-80%). Based on the analytical data, water from the alluvial aquifer in the basin is classified as either a calcium-mixed anion or a calcium-sulfate bicarbonate type of water (Fig. 22).

In order to detect any spatial or temporal trends in general water chemistry, we evaluated cation-anion proportions with respect to north-south location (by township) and also by sample date. Figure 22 displays cation-anion proportions annotated by township. No discernible north-south geographic trends in cation-anion proportions are evident in the water quality data. Furthermore, no consistent trends in cation-anion proportions are apparent in evaluations of water quality data with respect to sample date.

The historic groundwater quality results for the Lost Creek alluvial aquifer exhibit highly variable water quality. The majority of samples analyzed indicate the groundwater is high in dissolved solids. Total dissolved solids (TDS) is a measure of the total amount of dissolved inorganic constituents in the water. Generally, TDS concentrations in the basin are below 1,000 milligrams per liter (mg/L) with most results below 500 mg/L (Fig. 23). TDS concentrations appear generally lower in the south and increase to the north towards Roggen (Fig. 24). The area between Prospect Valley and Roggen (Township 2 North) has historically been and continues to be an area with elevated TDS concentrations generally above 1,000 mg/L, with many locations exceeding 2,000 mg/L and some (4 samples) above 4,000 mg/L. North of Roggen few water quality data are available, but TDS concentrations appear lower (<500 mg/L) especially towards the northern edge of the basin (Fig. 23, Appendix D). The US Environmental Protection Agency (EPA) has established a National Secondary Drinking Water Standard, which are non-enforceable aesthetic standards, of 500 mg/L for TDS. Alluvial groundwater in a number of areas in the basin exceeds this drinking water standard. For irrigation, water with TDS values below 1,000 mg/L is "excellent" (Bauder and others, 2011a,b). Between 1,000 and 2,000 mg/L of TDS, water is "permissible" for irrigation use when used in conjunction with appropriate leaching procedures. Water with TDS values above 3,000 mg/L is "unsuitable" for irrigation use (Bauder and others, 2011a).



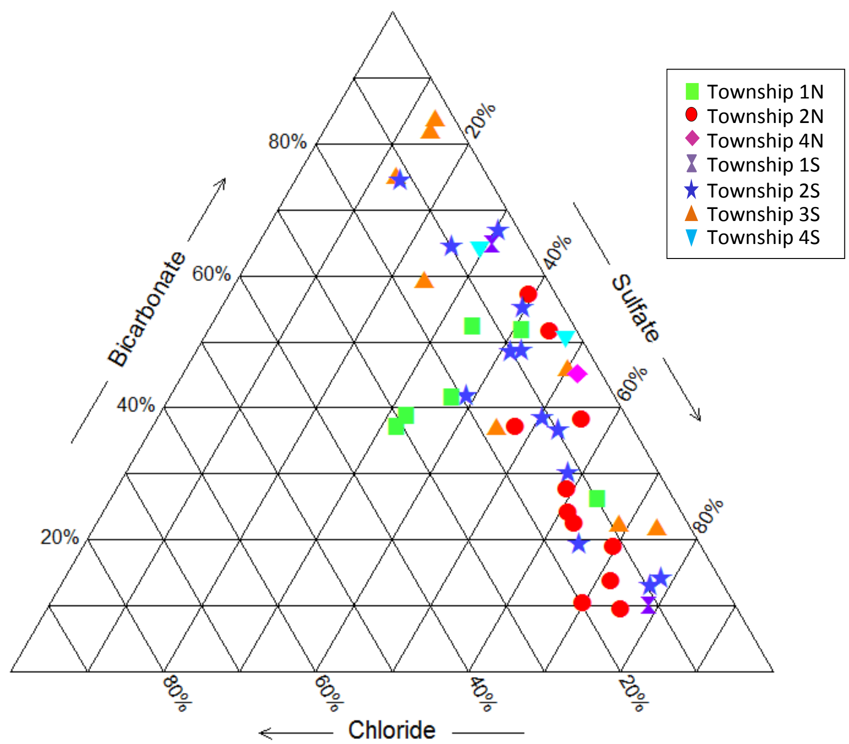
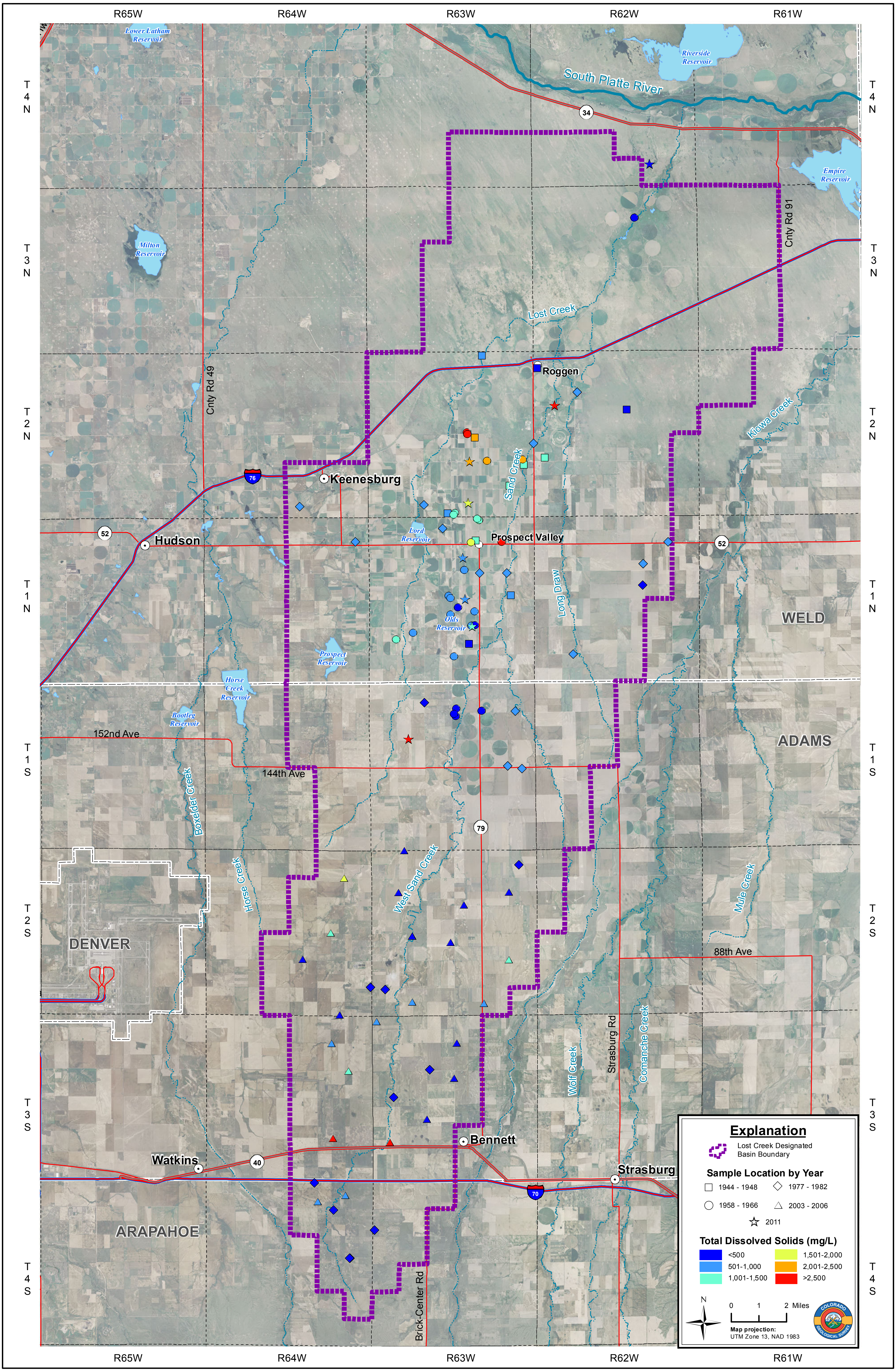


Figure 22. Relative Proportions of Dissolved Ions in Alluvial Groundwater Quality Samples
(Units along axes are percentage of total milliequivalents per liter)



Total Dissolved Solids Concentrations in Alluvial Groundwater
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 23

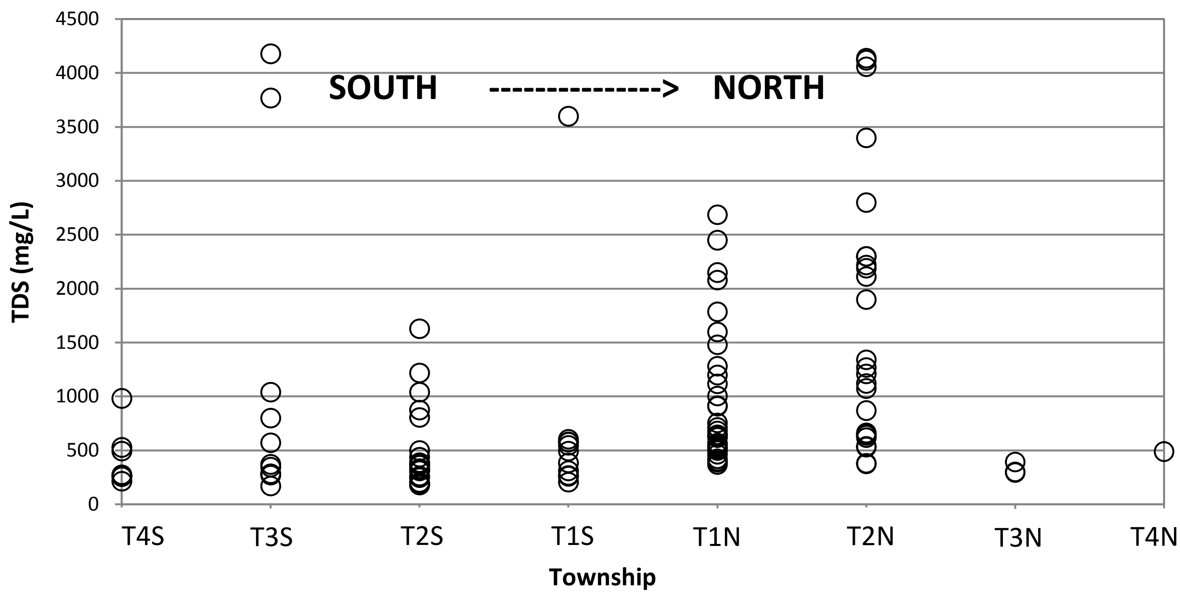
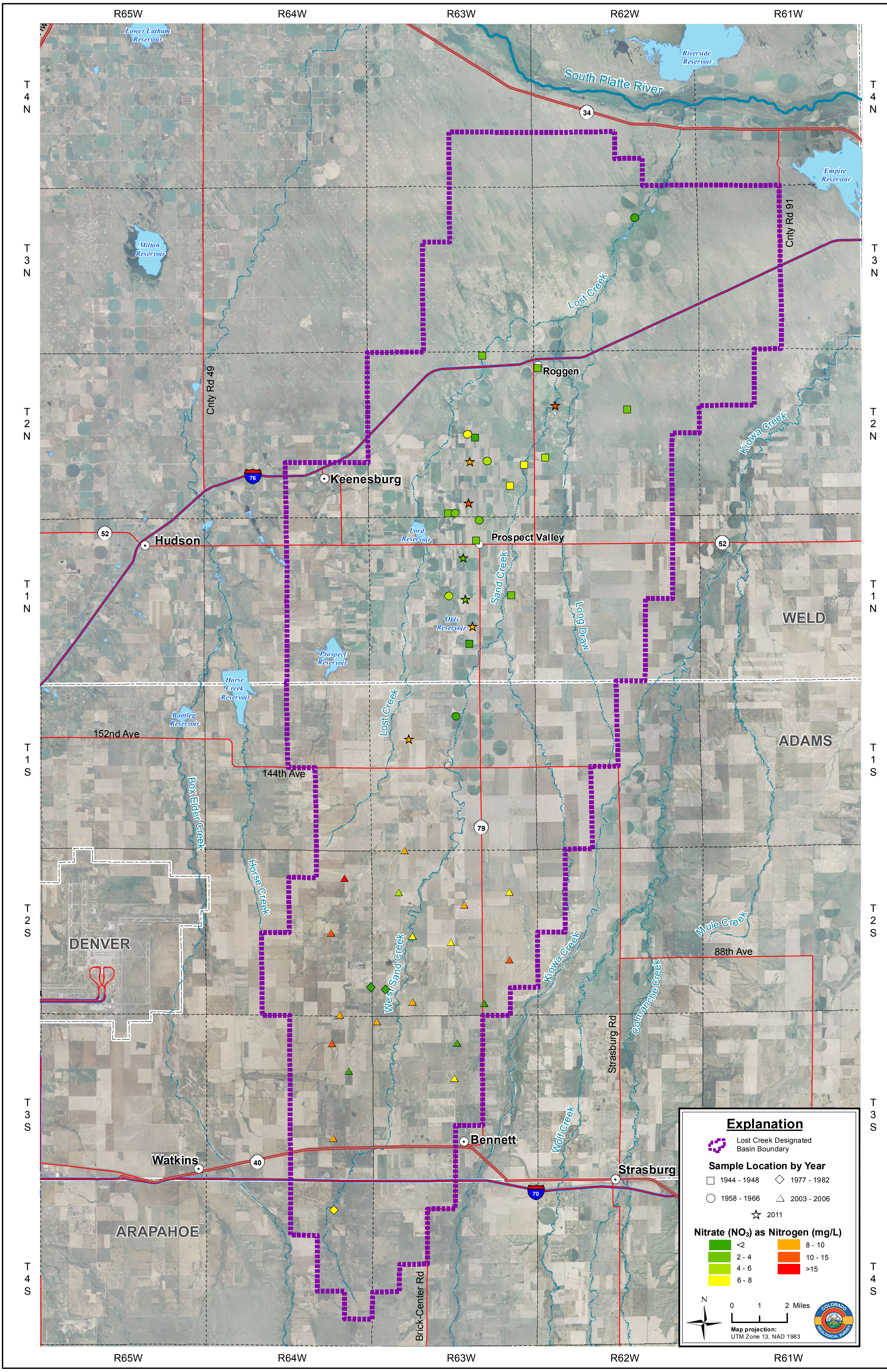


Figure 24. South to North Trend in Total Dissolved Solids Concentrations

Groundwater in the main alluvial aquifer channel in Township 2 North has very high TDS concentrations, for either domestic or agricultural use. This may be a result of historic and current land use practices in the area. Alternatively, the water quality in the alluvial aquifer in this area may be caused by a unique geochemical environment and influence from the underlying bedrock Laramie Formation. When evaluating any potential recharge operations in this part of the basin, a greater level of consideration of the geochemistry of the aquifer and recharge system may be warranted.

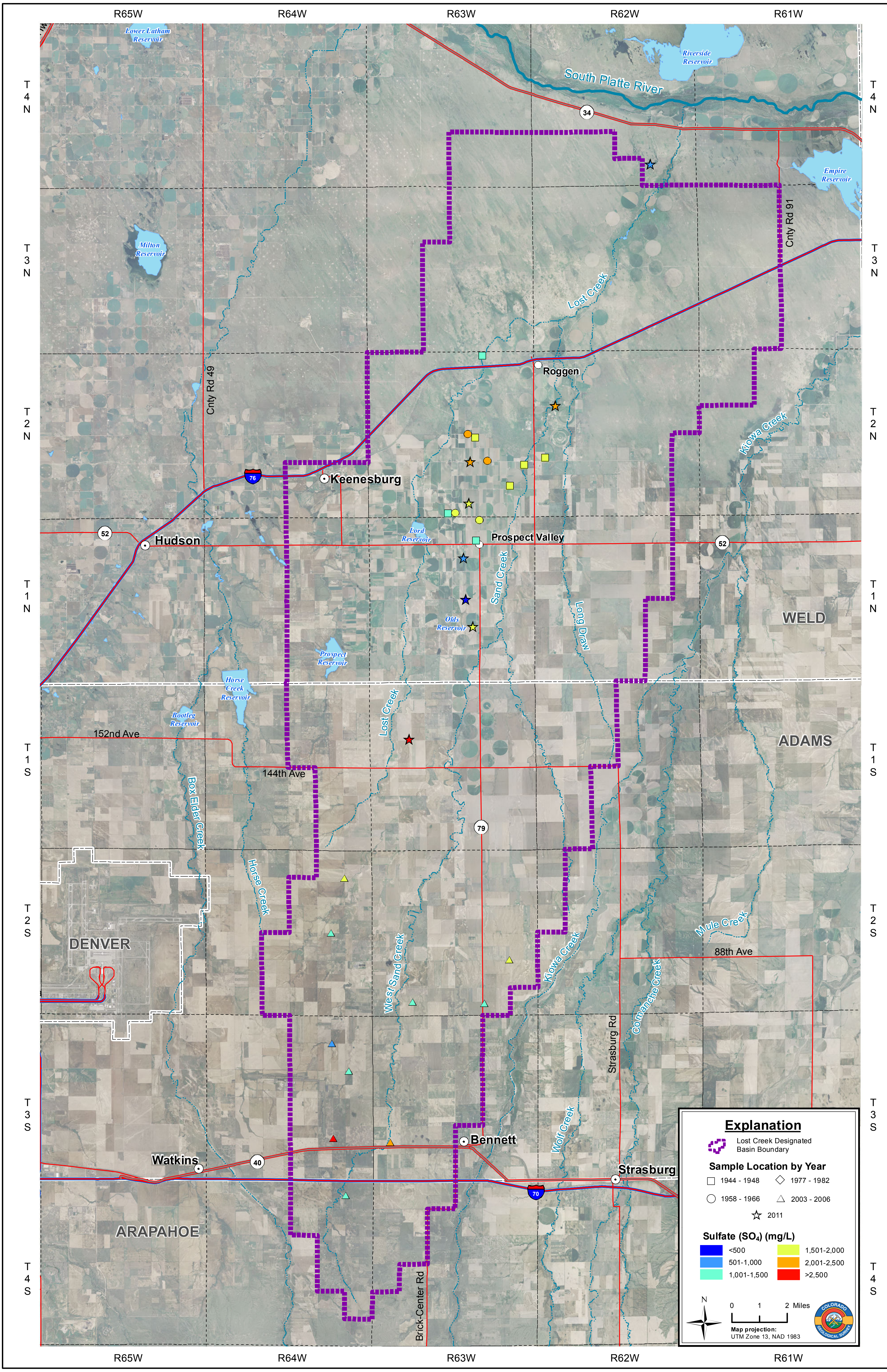
From a water quality perspective, the data compiled in this report (Appendix D) present concerns regarding two additional compounds, nitrate (NO_3) and sulfate (SO_4). Nitrate is a common constituent of fertilizer and is also a by-product of wastewater digestion. The EPA established a Primary Drinking Water Standard maximum contaminant level (MCL) of 10 mg/L for nitrate (as nitrogen). While elevated nitrate concentrations are not uncommon in the basin, only a few samples exceed the MCL (Fig. 25, Appendix D). Elevated nitrate concentrations in irrigation water are usually not of great concern with proper fertilizer and irrigation management (Bauder and others, 2011b).

Sulfate (SO_4) is an inorganic compound that is also present at high levels in many areas of the basin. Sulfate concentrations in the basin are generally highest between Prospect Valley and Roggen with most samples exceeding 500 mg/L and a number of samples above 1,000 mg/L. Other isolated areas have also historically reported high concentrations (Fig. 26). The EPA's aesthetic National Secondary Drinking Water Standard for sulfate is 250 mg/L (Fig. 26, Appendix D). Although sulfate is a major contributor to salinity in the Lost Creek alluvial groundwater, its presence in irrigation water is generally of benefit to agricultural fertility (Bauder and others, 2011b).



Nitrate (NO_3) Concentrations in Alluvial Groundwater
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 25



Sulfate(SO_4) Concentrations in Alluvial Groundwater
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 26

Aquifer Properties

The physical characteristics of the alluvial aquifer are important considerations for aquifer recharge and storage. As discussed earlier, the alluvial deposits comprising the alluvial aquifer consist predominantly of gravelly-sand deposited by rivers and streams that were eroding the bedrock. Overbank or off-channel deposits of the alluvium and eolian deposits also contain finer-grained sandy materials and layers of silt and clay. These intrinsic characteristics of the aquifer material influence the ability and rate of water movement into and within the alluvial aquifer system. Thick or continuous layers of fine materials in the alluvial aquifer will influence the vertical movement or infiltration rate into the aquifer. This lithologic variability is especially important when considering the capability of different mechanisms to effectively recharge the aquifer at specific locations.

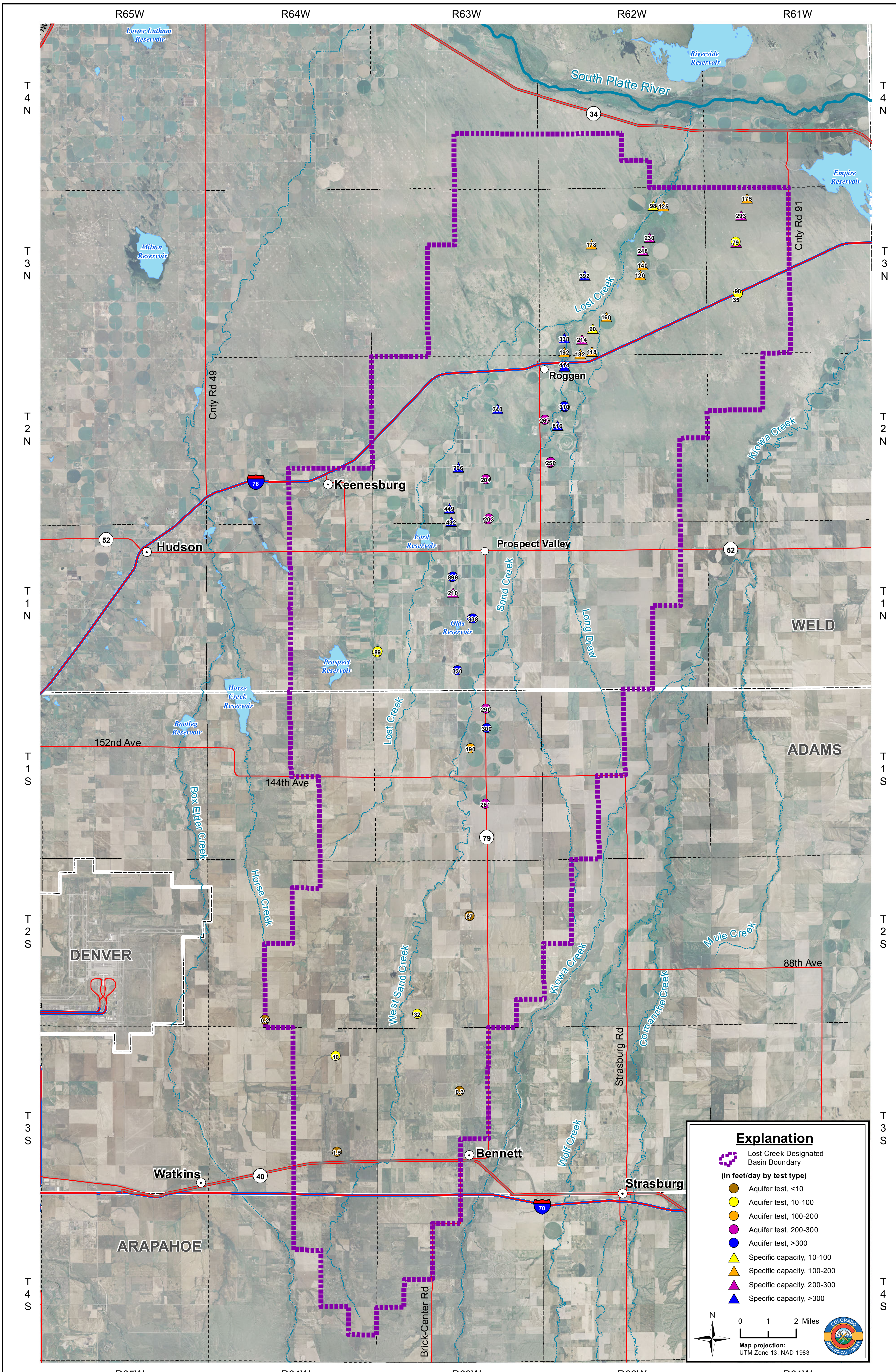
<u>Horizontal Groundwater Flow</u>

A number of aquifer pumping tests have been conducted on alluvial wells within the basin to evaluate the properties of the aquifer material and water level response to well pumping. Hydraulic conductivity and transmissivity are two different measures of the rate at which water can flow through a medium. Hydraulic conductivity represents the ability of water to move through a unit of thickness of the saturated aquifer; whereas, transmissivity is a measure of the volume of water transmitted through the entire saturated aquifer, regardless of thickness. Hydraulic conductivity is expressed in this study using the simplified units of feet per day (ft/d). One foot per day (ft/d) is equal to approximately 7.5 gallons per day per square foot. In this report transmissivity is expressed using the simplified units of feet squared per day (ft^2/d). One foot squared per day (ft^2/d) is equal to approximately 7.5 gallons per day per foot. The hydraulic conductivity of an aquifer can be different in the vertical and horizontal directions. The hydraulic conductivity values cited in this report (except where noted) represent horizontal hydraulic conductivities.

As part of this study we compiled aquifer hydraulic property information from available data sources including USGS reports, consultant reports, and information provided in water court hearings. In total we compiled aquifer test data for 22 locations in the basin. Additionally, Arnold (2010) used conversion and regression equations to estimate transmissivity from well specific capacity at 25 additional locations in the basin. Specific capacity is a measure of well yield (pumping rate in gpm) per foot of drawdown in the water level; it reflects the efficiency of the well and is a function of properties of both the well and aquifer. Although specific capacity is not a direct measure of the hydraulic properties of the aquifer, it is a useful indicator of the aquifer's ability to transmit water into a well bore. We considered these data as a guide in order to compare aquifer properties where aquifer testing data is not available.

Figure 27 shows the estimated hydraulic conductivity of the alluvial aquifer at locations in the basin. A summary of available aquifer hydraulic conductivity and transmissivity data derived from aquifer tests and specific capacity conversions and assembled as part of this study, is included in Table 4. The hydraulic conductivity of the Lost Creek alluvial aquifer ranges greatly with values from less than 1 ft/d to greater than 900 ft/d and transmissivity values of 3 ft^2/d to 58,000 ft^2/d. In the southern part of the basin the hydraulic conductivity of the alluvial aquifer is relatively low with values between 0.22 ft/d and 67 ft/d and a median value of 1.5 ft/d; the median transmissivity in this area is 19 ft^2/d (Beck and others, 2011)(Fig. 27). Within the southern area, the hydraulic conductivity is lowest in the more distal parts of the alluvial aquifer and increases to the north; furthermore, hydraulic conductivity appears to vary according to depth within the aquifer. At one location in the southern part of the basin, the deeper zone of the alluvial aquifer (between 103 and 113 feet deep) has a hydraulic conductivity of only 1 ft/d and a transmissivity of 41 ft^2/d, whereas the shallower zone of the alluvial aquifer (between 83 and 93 feet) has a hydraulic conductivity of about 67 ft/d and a transmissivity of 821 ft^2/d (Beck and others, 2011).

In the central part of the basin roughly between 144th Avenue and Roggen, the hydraulic conductivity of the alluvial aquifer appears greatest with a range of values from 88 to 894 ft/d and a mean value of 365 ft/d. This area has a corresponding mean transmissivity of 19,205 ft^2/d. North of Roggen in the main alluvial aquifer channel (excluding the Hay Gulch sub-basin), the mean hydraulic conductivity is 188 ft/d with a range of 90 to 393 ft/d; the mean transmissivity in this area is 7,587 ft^2/d. The hydraulic conductivity of the alluvial aquifer in Hay Gulch appears to be very similar to that of the northern part of the main Lost Creek alluvial aquifer. In Hay Gulch the mean hydraulic conductivity is 160 ft/d and the mean transmissivity is 7,111 ft^2/d. The aquifer properties derived from well specific capacities have mean and median values comparable to those determined from aquifer test data for both the central and northern parts of the basin. Additionally, from a recharge test conducted in Hay Gulch, the estimated hydraulic conductivity of the shallow alluvial aquifer (eolian sands) in this area is about 35 ft/d (HRS, 2009). The calibrated hydraulic conductivity values used in Arnold's (2010) steady-state numerical groundwater model of the Lost Creek basin ranged from 15 ft/d to 330 ft/d. In this model, the highest calibrated conductivity values, between 270 and 300 ft/d, occur along the main alluvial aquifer channel while lower values, from 15 to 123 ft/d, occur along the margins of the aquifer.



Hydraulic Conductivity of the Alluvial Aquifer
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 27

Area	Hydraulic Conductivity (ft/d)			Transmissivity (ft^2/d)			Aquifer Property Source		
	Mean	*Median*	*Range*	*Mean*	*Median*	*Range*	*Aquifer test*	*Specific capacity*	*All data*
Northern Basin	188	178	90 - 393	7,587	7,100	3,600 - 15,700	0	15	15
Central Basin	365	306	88 - 894	6,780	16,100	5,300 - 58,100	13	7	20
Southern Basin	16.1	1.5	0.2 - 67.4	174	19	3 - 821	7	0	7
Hay Gulch	185	175	79 - 293	7,111	7,000	2,148 - 11,100	5	0	5
TOTAL Basin	237	205	0.2 - 894	11,376	9,100	3 - 58,100	25	22	47

Table 4. Summary of Lost Creek Alluvial Aquifer Property Data

The average linear groundwater flow velocity in the alluvial aquifer can be approximated using Darcy's Law (***V=KI/n***, where ***K*** is horizontal hydraulic conductivity, ***I*** is groundwater gradient, and ***n*** is effective porosity). Considering all available data, the average horizontal hydraulic conductivity of the alluvial aquifer in Lost Creek is about 237 ft/d (median is 205 ft/d). The effective porosity of the alluvial aquifer is estimated to be about 17 percent (from specific yield determined by Code [1945]), and the average groundwater gradient over the length of the Lost Creek alluvial aquifer is about 0.005. As an approximation, under these conditions, groundwater is expected to move between 6 and 7 feet per day, or approximately 0.45 miles per year. In the central and northern parts of the main alluvial aquifer channel north of 144th Avenue, the average hydraulic conductivity is about 289 ft/d and the average groundwater gradient in Spring 2010 is about 0.0033. For this area, the estimated groundwater flow velocity would be about 5.6 ft/d, or about 0.38 miles per year (using effective porosity of 0.17). These calculations assume uniform aquifer conditions and produce average velocity and travel times. Actual conditions can vary considerably since the properties and conditions in the alluvial aquifer are not homogeneous. In addition, local flow velocities may be lesser or greater depending on localized groundwater gradient and aquifer hydraulic conductivity.

Vertical Water Movement

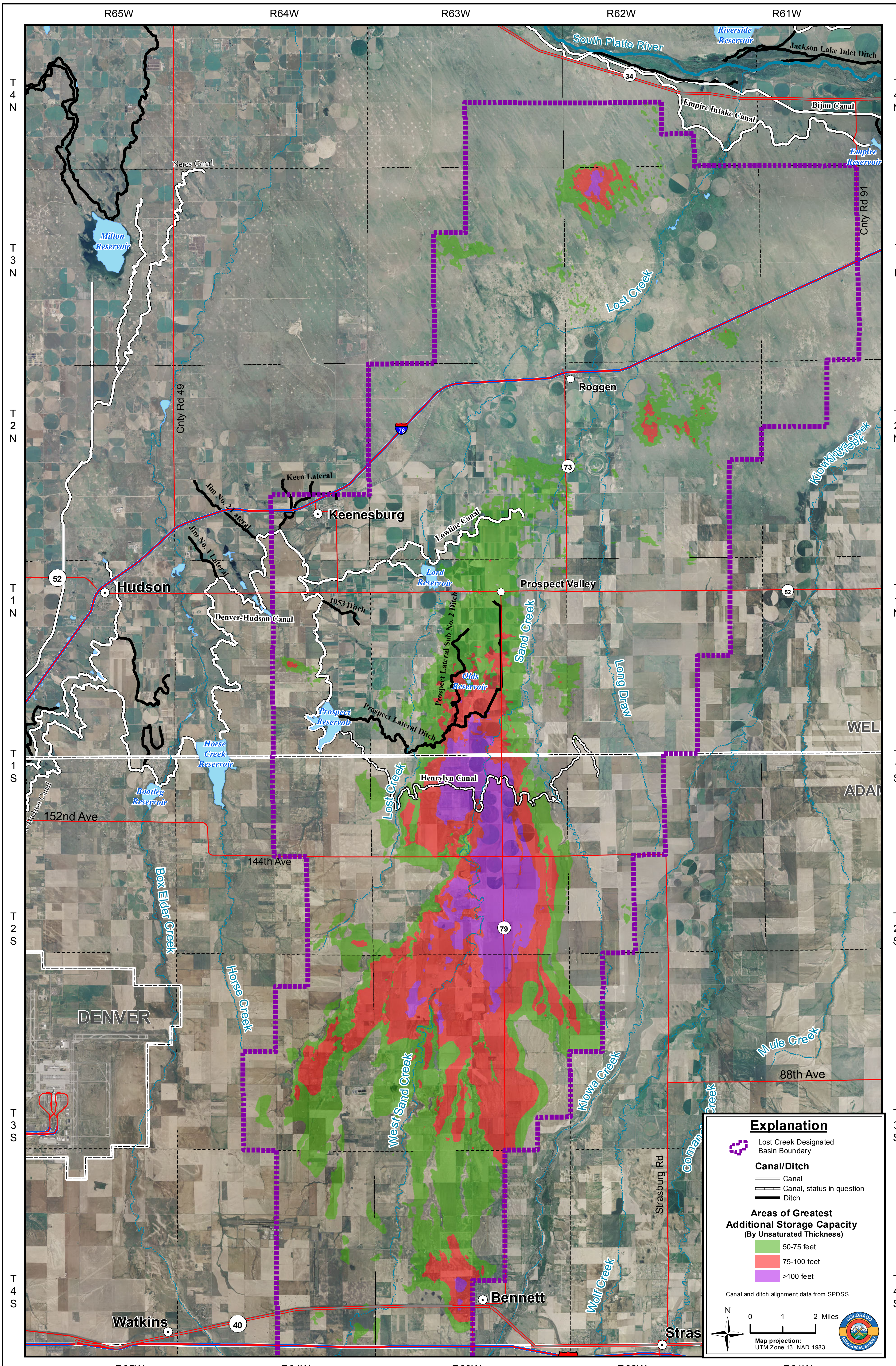
The vertical movement of water into and through the alluvial aquifer is an equally important consideration when evaluating the potential for recharge and storage of groundwater. Artificial recharge of the alluvial aquifer has been actively occurring within the Lost Creek basin since the 1940s. Historic data indicate that on average between 2,500 and 3,000 acre-feet/year are artificially recharged through seepage from Olds Reservoir (Skinner, 1963; Arnold, 2010). Past studies estimate Olds Reservoir seepage rates to be between 42 and 70 acre-feet/day when water is in the reservoir (Code, 1945; Skinner, 1963; Arnold, 2010). Estimates of the vertical infiltration rate at Olds Reservoir are about 1 ft/d [0.73 ft/d by Arnold (2010) and 1.2 ft/d by Skinner (1963)]. Additionally, seepage rates in Lord Reservoir are between 8 and 25 acre-feet/day (Code, 1945; Skinner 1963) and infiltration rates are about 0.1 feet/day at full stage (0.15 ft/d by Arnold [2010] and 0.05 ft/d by Code [1945]). These estimates are helpful in understanding the rate at which water infiltrates vertically through the alluvial aquifer and gives a strong indication of realistic recharge rates achievable through surface water recharge facilities.

Water movement vertically within the alluvial aquifer is likely greater than movement from the alluvial aquifer into underlying bedrock aquifers, even when relatively thick clay zones are present in the alluvial aquifer. The Denver Basin bedrock aquifer units underlying the Lost Creek basin in the southern area, have a median hydraulic conductivity of about 0.5 ft/d and a median transmissivity of 3.7 ft^2/d based on aquifer testing (Beck and others, 2011; SPDSS, 2004). Laboratory measurements on bedrock core samples indicate even lower horizontal hydraulic conductivities of 0.16 to 0.59 ft/d in the Upper Arapahoe Formation and vertical hydraulic conductivities of only 0.0001 to 0.0013 ft/d in the lower portion of the Denver Formation (SPDSS, 2004). These measured hydraulic conductivities resemble those (about 0.5 to 2 ft/d) reported for the Denver Basin aquifers in Robson (1983). Robson (1983) reports a wide range of transmissivities (0-200 ft^2/d) in the Denver Basin bedrock aquifers with areas of higher transmissivity in the south-central part of the basin. Still, these values are considerably below those for the overlying alluvial aquifer. Furthermore, by comparison, clay zones within the alluvial aquifer in the Hay Gulch area appear to have vertical hydraulic conductivities on the order of 0.0084 ft/d, still much higher than vertical hydraulic conductivities measured for the Denver Basin bedrock aquifers. Although these data suggest that hydraulic communication between the alluvial aquifer and underlying bedrock aquifers is likely to be limited in the area, this relationship has still not been well studied.

AVAILABLE INFRASTRUCTURE AND LAND USE/OWNERSHIP

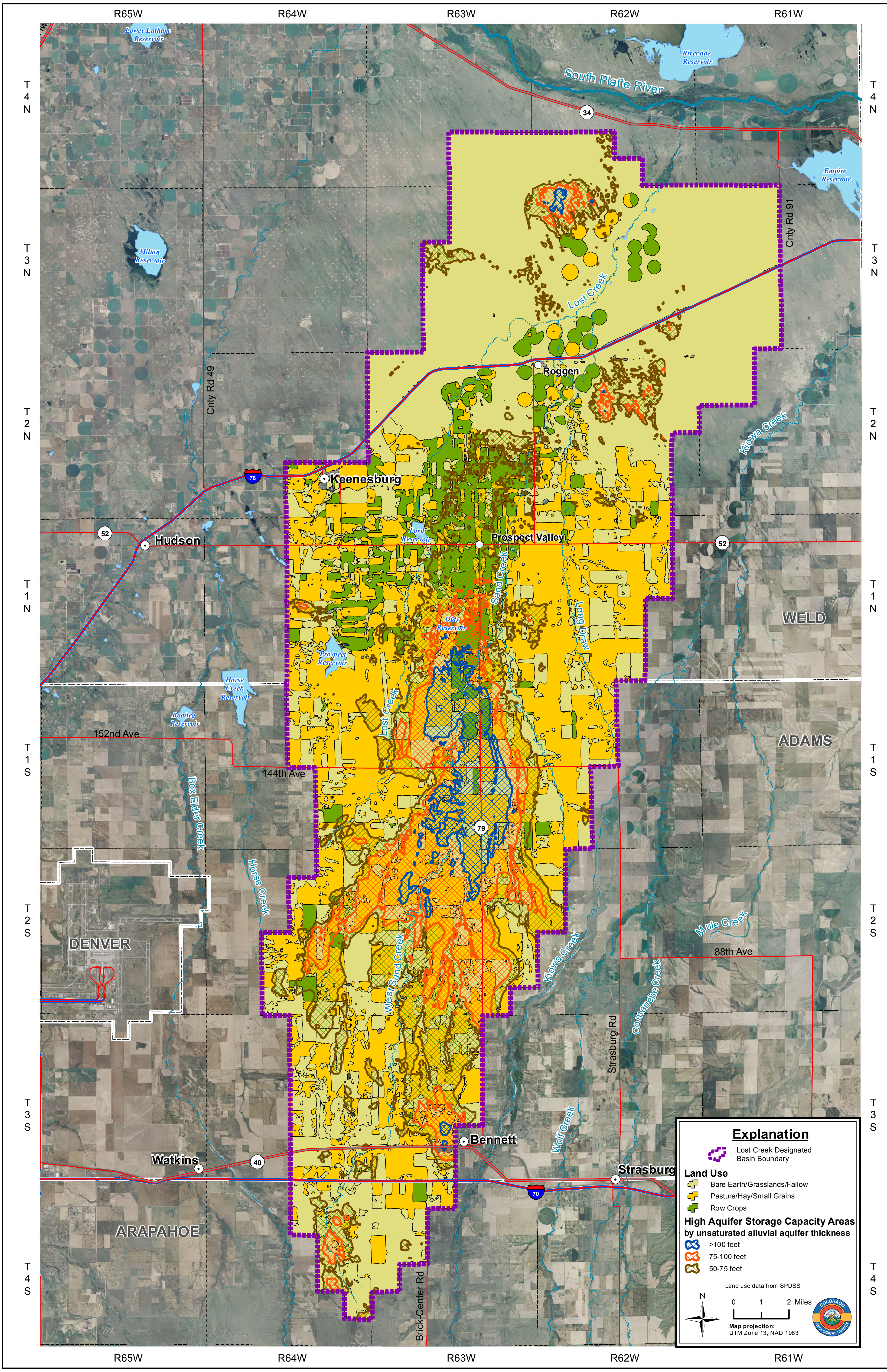
Proximity to existing water infrastructure and land use/ownership is a very important consideration in evaluating the ability to effectively implement an aquifer recharge project. The presence of existing infrastructure, particularly water conveyance features, is an important consideration influencing the cost and overall feasibility of an aquifer recharge/storage project. The sources of water available for storage are not considered in this study; however, it is assumed that the existence of canals, ditches, pipelines, and other water delivery/storage structures presents an opportunity to convey water to a potential recharge location. The location of known existing surface water infrastructure in the basin is shown in Figure 28. Additionally, although not shown on Figure 28, water pipelines exist to the west of the Lost Creek Designated Basin including a Denver Water pipeline which services Denver International Airport, East Cherry Creek Valley Northern Project pipeline, and Aurora Water's Prairie Waters Project. Various types of conveyance infrastructure currently exist in the Lost Creek basin vicinity and could potentially be used to convey water to recharge locations.

Traditional surface infiltration, spreading basins can have a significant land surface impact. Knowledge of the locations and types of land uses and whether lands are publicly or privately owned is valuable in locating and seeking support for potential future recharge projects. Land use data shown in Figure 29 indicate that the majority of the overlying land within the basin is used for agricultural purposes. Grazing and agricultural production dominate the basin land uses. Most of the land is used for pasture, hay, or small grains. In the northern part of the basin much of the area is bare, fallow, or remains natural grasslands for grazing. As part of the study, we also assembled parcel records, showing land ownership, from the counties of Adams, Arapahoe, and Weld (Fig. 30). Land ownership data in Figure 30 is displayed according to parcel size with associated land owner. Lands owned by the Colorado State Land Board are also shown, while properties smaller than 160 acres are not displayed. From a logistical standpoint, publically-owned land or large privately-owned parcels are likely more feasible for implementation of large recharge projects. The areas of greatest storage capacity (unsaturated thicknesses greater than 50 feet), identified earlier in Figure 16, are also outlined on Figure 30. Most of the land within these areas is privately-owned with parcel sizes from less than 160 acres to over 1280 acres. Some state-owned land also exists within the storage areas. The ownership of parcels is displayed on Figure 30 according to size.



Existing Surface Water Delivery Infrastructure
Lost Creek Basin Aquifer Recharge and Storage Study

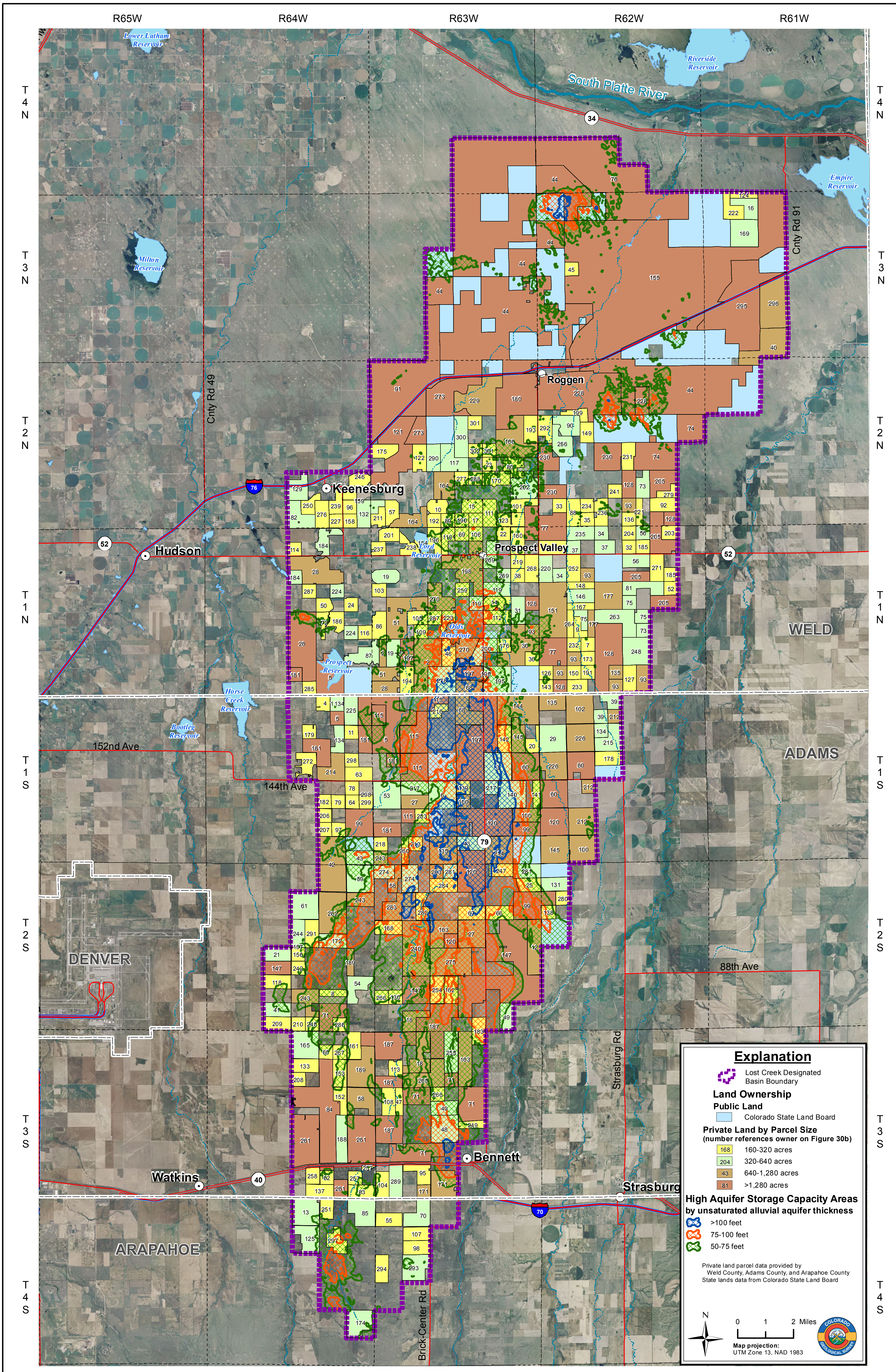
Figure 28



Land Use

Lost Creek Basin Aquifer Recharge and Storage Study

Figure 29



Land Ownership
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 30a

Private Land Holdings 160 - 320 acres

4 = ABBOTT DOUGLAS K	79 = FERRERA CAROL L AND	137 = LEWIS DAVID M AND	194 = PRING RYAN E	251 = SW MANILA LLC
7 = ALLEN ANNA E	80 = FISCHER KAREN A	138 = LEWTON CURTIS D AND	196 = PROSPECT VALLEY HOLS	252 = SWANK ROBERT M 1/2 I
8 = ALLISON ROBERT D AND	83 = FRONT RANGE 1-70 CAP	139 = LEWTON CURTIS D AND	199 = PV WATER III LLC	253 = SWANK WALTER C ET AL
9 = ALTERGOTT DONALD E	86 = GARDNER FRANCES J TR	141 = LEWTON GLENN H UND 5	201 = RAYMOND FAMILY TRUST	254 = TALPERS MERRILL R AN
10 = ARNUSCH HANS & LUCIL	88 = GORGES MAURICE	142 = LEWTON HAROLD L FAMI	203 = REID JANET M	257 = TEAGUE ELSBETH L TRU
11 = ARVEST TRUST COMPANY	89 = GRAYBILL GERALD R &	143 = LEWTON VIRA	204 = REID JOHN H	258 = THOMAS JUDY E TRUST
14 = B & W FARMS	92 = H & M FARMS INC	148 = LINNEBUR JEROME	206 = RICHARD MARY K	259 = THYGESEN INVESTMENT
15 = B&W FARMS A PARTNERS	94 = H & M FARMS INC &	149 = LINNEBUR MICHAEL C &	207 = RICHARD MARY KATHERI	260 = TRAN CONG MINH AND
17 = BECKER ALBERT &	95 = HAHN DOROTHY JEAN LI	150 = LINNEBUR WILLIAM J	208 = RICHMAN MARCIA A ET	264 = TRIPLE K-1/2 INT &
20 = BELTZ JOY V AMENDED	96 = HAIAR DONALD L &	152 = LISCO CARROLL J AND	209 = RITTER BETTY L	266 = TRUPP REAL ESTATE II
22 = BIXBY BERTHA K HEIRS	97 = HALL SHARON S REVOCA	153 = LOPEZ MARY ANN AND	210 = ROEDER ROBERT	267 = TRUPP REAL ESTATE IV
23 = BOND ROSEMARY LUCILL	98 = HARLAN & CAROLYN HAT	154 = LORD RESERVIOR	211 = ROSKOP JUDY A &	268 = TRUPP RUTH TRUSTEE
24 = BOOGHIER PAMELA	101 = HEPNER FREDERICK ALA	156 = MARLATT GENE R	213 = SAFFORD VERNON C/ELL	271 = UNCAPHER JOHN D
25 = BORDNER WILLIAM P AN	103 = HERGENREDER REUBEN (	157 = MARLATT LAWRENCE D	216 = SAUTER MARY F REVOCA	272 = UTE SOUTH LTD LIABIL
32 = BUCHHOLZ PHILIP &	104 = HICKEY CHARLES E	158 = MC MILLAN BARBARA (8	218 = SAUTER VINCENT AND S	276 = VINES SANDRA &
33 = BUCHHOLZ PHILLIP &	105 = HILLENBRAND MARY E	159 = MC MILLAN BARBARA 80	219 = SCHELLENBERG CINDY &	277 = WAGNER DANIEL D &
35 = BUCHHOLZ VINCENT &	106 = HOFFERBER ALBERT &	160 = MCDONALD DOUGLAS L	221 = SCHELLENBERG DAN &	279 = WAGNER MARJORIE L
36 = BUCHHOLZ VINCENT J	107 = HOGARTH, CHARLENE	161 = MEHEEN ENGINEERING C	222 = SCHNEIDER ANNA DOROT	280 = WAGNER SAM AND
38 = BURRY MARK R	108 = HOOKER WILLIAM M TRU	162 = MEYER DIANNE J	223 = SCHRANT CLEM J	282 = WAILES DONNA M
45 = CERVI MIKE	109 = HUMMELL ENA FRANCES	167 = MOORE JANICE	227 = SHARP ERNEST J JR	284 = WAILES WILLIAM K/CHR
46 = CHENEY ENID F	110 = HUWA COREY &	168 = MOORE PARTNERSHIP TH	231 = SHOENEMAN JOEL &	285 = WALKER DONALD &
47 = CISSELL VINCENT J	111 = HUWA RICHARD F	170 = MORRIS SHIRLEY J LIV	232 = SHOENEMAN JOEL 1/2 I	286 = WARNER RONALD D AND
50 = COAN BETTY A	112 = HUWA TYRUN &	173 = MUNDHENKE BRIAN J &	233 = SHOENEMAN M MAGDALEN	287 = WARREN WILLIAM W &
52 = COLLINS RUTH E (10%	113 = HYATT JOHN H	175 = MYERS GARY DOUGLAS (	234 = SIGG HAROLD M &	288 = WEICKUM LYDIA
55 = CONVERSE FAMILY	114 = IRVIN JOHN M	176 = NEMECEK LADISLAV M	236 = SIGG JAMES E (1/3 IN	291 = WINTERS BEVERLY
57 = COX JOHN D	116 = JAKEL PATRICIA A	178 = NIES INC	237 = SIGWARDT LEROY TRUST	292 = WOERNER REALTY INC
62 = DANHAUER PATRICIA EL	118 = JOHNSON ERNEST R AS	179 = O K FARMS CO	238 = SKOW CHARLES E &	294 = WORLOCK, DANA R 1/4
63 = DAO THAO THU ET AL	122 = KAUFFMAN MARK & LEE	182 = PACKARD ROBERT AND S	239 = SLOAN DONALD L	297 = YOUNGBERG, CARL D
64 = DAVIS HOWARD A	123 = KEENE STORAGE	183 = PARIS ROGER GENE	241 = SMILEY LONNIE J &	298 = ZEILER ENTERPRISES L
65 = DAVIS J W C LIMITED	124 = KINGSBURY CHARLES KE	185 = PATTON IRA D	242 = SMITH FARMS THE	299 = ZEILER MARK ALLEN ET
66 = DEMONEY JEANETTE J A	126 = KLAUSNER INC	186 = PESCHEL GARY G &	245 = SOUTHERN STAR CENTRA	301 = ZIMBELMAN JACK W
67 = DEMONEY KENNETH EUGE	127 = KLAUSNER BROS 1/2 IN	190 = PLUSS JULIUS A	246 = SPARROW BRUCE J	302 = ZIMBELMAN KENNETH L
69 = DINNER JANICE R	130 = KRUSE JIM	191 = POWELL NANCY	247 = STA-LEY DEVELOPMENT	
72 = DOUTHIT HUDSON LLC	133 = LARSON LANNY J	192 = PRALLE CRAIG E	249 = STEFFEN BETTY J TRUS	
78 = FERRERA CAROL L	136 = LEDERHOS DAMIAN J	193 = PREMIER FARMS LLC	250 = STEWART RICHARD H &	

Private Land Holdings 320 - 640 acres

3 = 4KL LLC	48 = CLAIR JOHN W	87 = GLOVER CHRIS W &	172 = MUNDELL JOHN SAMUEL	244 = SNIDER JOY MARIE TRU
6 = ABBOTT HERBERT E TRU	49 = CLAIR WARREN G AND	90 = GUARDADO MANUEL &	174 = MURPHY FAMILY PARTNE	248 = STANGER MARTIN C
13 = B & D LAND COMPANY 6	53 = COLORADO MASONS BENE	117 = JAMES MARKETING & AD	184 = PASTELAK STEVE M	255 = TAYLOR RANDY J
16 = BEAGHLER RICHARD L &	54 = CONSERVATION SERVICE	119 = K & M COMPANY	188 = PILAND LOWELL D ET A	256 = TAYLOR RICARDO D &
19 = BELL WILLIAM H &	56 = COOKSEY LYLE V TRUST	125 = KISSLER, DANIEL M	195 = PROSPECT FARM LLC	263 = TRIPLE K &
21 = BENNETT BETTY KATHRY	59 = DALRYMPLE AND SON IN	129 = KRCMARIK SUSAN FLEIS	200 = RASMUSSEN FAMILY FAR	269 = TRUPP RUTH R TRUSTEE
29 = BUCHHOLZ DENNIS M	61 = DALRYMPLE LINDA	131 = L AND L LAND CO	202 = REED REAL ESTATE LP	274 = VANG KEVIN N AND
31 = BUCHHOLZ PETER J JR	70 = DOUBLE A FARMS LTD	132 = LAMBERT INVESTMENT C	215 = SAUTER HELEN T AND	278 = WAGNER HERBERT E
34 = BUCHHOLZ VINCENT	73 = DUSTER FARMS LLC	134 = LAURIDSON DOROTHY LU	217 = SAUTER THOMAS M	281 = WAILES BRUCE L ET AL
37 = BURMEISTER MILDRED L	75 = EPPLE WILLIAM E &	140 = LEWTON GLENN H	220 = SCHELLENBERG CINDY (	289 = WEST BENNETT ASSOCIA
39 = BUSKIRK DONNA IRENE	81 = FORD INGE VEBEKA	146 = LINNEBUR FRED D &	224 = SCHREIBVOGEL KENNETH	290 = WESTERN EQUIPMENT &
41 = CARLSON FAMILY TRUST	82 = FRITZLER ROBERT A &	165 = MINIS ADON CORPORATI	225 = SCHWAB WILLIAM AND	293 = WOODS, JAMES
43 = CAVENDER NORLIN D AN	85 = FURNITURE ROW COLO L	169 = MORGAN CO QUALITY WA	235 = SIGG JAMES E &	300 = ZIMBELMAN FLORA

Private Land Holdings 640 - 1280 acres

2 = 3W FARMS LLC	51 = COAN MICHAEL J	145 = LEWTON WAYNE E	198 = PV WATER II LLC	265 = TRUPP FAMILY FARM LL
12 = ATWATER SHIRLEY	58 = CRISMAN FARMS LLC	151 = LINNEBUR WILLIAM J &	212 = RYBICKA FARMS INC	270 = TURNPIKE LIMITED LIA
18 = BECKER DUANE L AND	68 = DENNING GREGORY FRAN	163 = MEYER RICHARD W AND	214 = SAUTER FARMS INC	275 = VETTER DAVID LEO TRU
27 = BRENNER JERRY AND BR	93 = H & M FARMS INC	164 = MIDNIGHT SUN INC IV	226 = SEVENTH DAY ADVENTIS	283 = WAILES FARMS INC
28 = BRNAK JAMES JOSEPH	100 = HELZER KEVIN L TRUST	166 = MISSOURI ARKANSAS HA	229 = SHIFTING SANDS RANCH	296 = YOCAM JOHN
30 = BUCHHOLZ MARY FRANCE	102 = HER ENTERPRISES	171 = MUEGGE FARMS LLC	240 = SMALL VERLA FAY	
40 = CALVERT ROBERT S JR	135 = LAURIDSON WILLIAM A	177 = NIELSEN CARL TESTAME	243 = SMITH ROBERT C/FLORI	
42 = CAVALIER FAMILY LLC	144 = LEWTON VIRA K	189 = PILAND VIRGIL	262 = TRI-B ASSOCIATES	

Private Land Holdings > 1280 acres

5 = ABBOTT FARMS INC	76 = EQUUS FARMS INC	120 = KALCEVIC FARMS INC	181 = PACKARD FAMILY FARMS	261 = TRANSPORT INDUSTRIAL
26 = BOSKY FARMS LLC	77 = ERKER HAROLD J JR &	121 = KAUFFMAN BROS LTD PA	187 = PILAND LOWELL D	273 = V-CO ENTERPRISES INC
44 = CERVI ENTERPRISES IN	84 = FRONT RANGE AIRPORT	128 = KLAUSNER INC	197 = PV WATER HOLDINGS LL	295 = YOCAM FAMILY LIMITED
60 = DALRYMPLE FARMS II L	91 = GUTTERSEN RANCHES LL	147 = LINNEBUR GENE L AND	205 = REID RANCHES CO	
71 = DOUBLE A FARMS LTD	99 = HELZER FARMS INC	155 = LOST CREEK LAND & CA	228 = SHELTON LAND & CATTL	
74 = EPPLE RUSSELL FARMS	115 = J & R SAUTER LAND LP	180 = OSBORNE HOLLIS P & N	230 = SHOENEMAN FIVE M RAN	

Land Ownership (Referenced to Figure 30a)
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 30b

SUMMARY AND CONCLUSIONS

Water users in the Lost Creek basin rely heavily on groundwater from the alluvial aquifer for agricultural, domestic, and commercial uses. Early groundwater development first began in the 1930s and rapidly increased thereafter. Because the basin has no reliable surface water sources and water users are largely dependent on groundwater, the Colorado Ground Water Commission established the Lost Creek Designated Ground Water Basin in 1968 to enable management of this resource. Recently, the entire basin has been declared over-appropriated. Aquifer recharge and storage is one mechanism for restoring groundwater levels and managing available water supplies. Numerous groundwater recharge and storage studies, dating back to the 1960s, have identified the Lost Creek alluvial aquifer as a primary candidate for groundwater recharge and storage in the South Platte River basin. This study integrates new field data with information from previous studies to further the understanding of the hydrogeology of the alluvial aquifer system in the Lost Creek basin. The primary goals of this study are to quantify the groundwater currently stored in the Lost Creek alluvial aquifer and additional available storage capacity and also to identify potential sites for aquifer recharge and storage project implementation.

The Lost Creek alluvial aquifer consists of unconsolidated sand, gravel, silt, and clay of alluvial (deposited by moving water) and eolian (windblown) origin which overly bedrock sedimentary formations. We mapped the elevation of the bedrock surface in the basin using data from previous investigations and new data developed from corehole logs, test borings, and water well drillers' logs. The buried surface of the top of the bedrock is characterized by a major north-south trending channel incised into the bedrock by an ancient river network and subsequently filled with alluvial material. The deposits that make up the alluvial aquifer cover about 80 percent of the Lost Creek basin area. The alluvial aquifer is thickest, over 180 feet of material in places, in the central basin along the axis of the incised bedrock channel, and thins to the north and south and along the margins of the basin. A bedrock ridge separates the alluvial aquifer in the Hay Gulch area from the main Lost Creek alluvial aquifer.

To meet the study objectives, we constrained the alluvial aquifer materials to define a Primary alluvial aquifer by: 1) excluding areas where less than 20 feet of alluvial aquifer material exist, 2) excluding minor areas of the aquifer (along the basin margins) which are not hydraulically connected to the Lost Creek alluvial aquifer system, and 3) excluding the Hay Gulch area and an isolated section of alluvial aquifer material which drains directly into the South Platte River system in the northwest part of the basin.

To better understand the seasonal operating characteristics of the groundwater reservoir, we collected water-level measurements from 45 wells during a 9-month period from July 2009 through April/May 2010. Spring 2010 high water levels varied from very near the ground surface in the northern part of the basin to greater than 120 feet below ground in parts of the central and southern basin. Seasonal fluctuations between 5-12 feet in the heavily irrigated portions of the basin are not uncommon. Using new water level data, we mapped the alluvial groundwater surface elevation throughout the basin. The contour map of the Spring 2010 water surface indicates that the groundwater gradient is flatter in the central (0.003) and northern (0.0035) parts of the basin than in the southern part (0.007). In general, groundwater flows from the edges of the basin towards the central alluvial aquifer channel and northward towards the South Platte River at an average flow velocity of between one-third to one-half mile per year.

Historic water level data were also compiled to quantify the changes of water in storage with respect to climate, surface water diversion, and water demand. In most parts of the basin, water levels in Spring 2010 were at or near historic low levels. Changes in the amount of groundwater in storage, based on historic water levels, exceed 100,000 acre-feet. In just a part of the northern and central basin, we estimate that during the period from 1993 to 2010, groundwater withdrawals exceeded recharge by about 5,700 acre-feet/yr.

The saturated thickness of the aquifer is the portion of the aquifer below the groundwater surface (water table). With the current water level data, we were able to quantify and map the saturated thickness of the alluvial aquifer, and consequently, estimate the amount of groundwater currently in storage within the aquifer. The capacity for the aquifer material to store water in its pore space is represented by the specific yield. Using a uniform specific yield of 17% for alluvial aquifer materials throughout the basin, we estimate that 927,700 acre-feet of water is currently stored in the Lost Creek Primary alluvial aquifer.

The unsaturated portion of the alluvial aquifer provides the reservoir for storage of additional water in the empty aquifer pore space. The thickest area of unsaturated alluvial aquifer material is located in the central and southern part of the main alluvial aquifer channel. Unsaturated alluvial aquifer thickness values range from zero to more than 120 feet with much of the Primary alluvial aquifer containing at least 40 feet of unsaturated thickness. Again, applying a uniform specific yield of 17%, we estimate the total available pore volume in the Primary alluvial aquifer to be 1,524,800 acre-feet. Practically, however, to avoid basement flooding, surface discharge, and enhanced evapotranspiration, limiting the available storage space to below 10 feet of ground surface results in a potential storage capacity of 1,209,100 acre-feet. Although in practice, not all of this volume may be used for additional water storage, about 322,600 acre-feet is available if water levels were raised to within 50 feet of the ground surface. Further limiting water level rises to the deeper unsaturated areas at depths greater than 75 feet produces an additional capacity of 105,900 acre-feet.

The possibility of recharging the alluvial aquifer in the Lost Creek basin and storing water underground was recognized and implemented in the late 1930s at Olds Reservoir, a 450 acre-feet leaky storage reservoir in the central portion of the basin. A total of 30,000 acre-feet were recharged during the period from 1939 to 1959. Historically, groundwater levels were generally low in the 1970s and high in the 1990s, with differences of as much as 25 feet. Calculation of the historic saturated thickness, in the central and northern part of the basin, for Spring 1972 versus 1993 indicates that more than 100,000 acre-feet of water was added to storage in the alluvial aquifer during this period. Clearly, the capacity of the Lost Creek basin alluvial aquifer to take water into or release water from storage has been demonstrated by both “artificial” and natural operations.

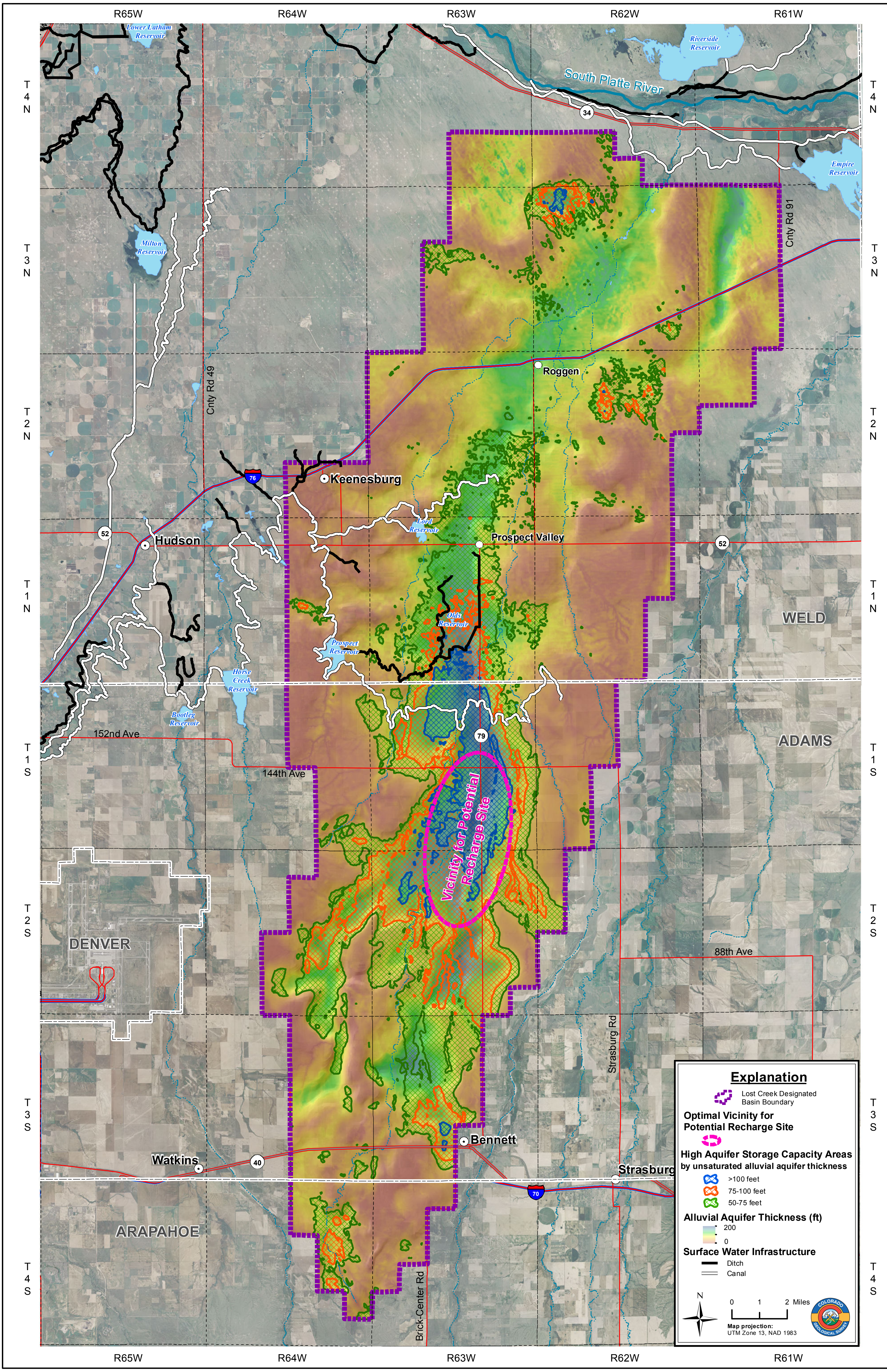
Historic observations and testing indicate effective recharge of the alluvial aquifer is possible, and has been occurring, at Olds Reservoir and Lord Reservoir using surface spreading techniques. Combined, Olds and Lord reservoirs have a potential to recharge a total of as much as 50 to 95 acre-feet/day of water into the Lost Creek alluvial aquifer (Code, 1945; Skinner, 1963; Arnold, 2010). In fact, observation wells adjacent to Olds Reservoir recorded a water level rise of as much as 45 feet during a 4.5-month recharge test in 1959 and 1960 (Skinner, 1963). Continued or increased recharge in Olds Reservoir and Lord Reservoir would locally recharge the alluvial aquifer, particularly in the vicinity of Prospect Valley where the greatest pumping has historically occurred. However, areas in the southern and central basin with the greatest unsaturated alluvial aquifer thickness represent areas of highest potential for implementation of aquifer recharge and storage projects.

The physical characteristics of the alluvial aquifer and existing water quality are also important considerations for aquifer recharge and storage. The presence and thickness of finer-grained materials, particularly continuous beds of clay and silt, can significantly influence ground water infiltration and flow. The hydraulic properties of the aquifer determine the rate of infiltration and groundwater flow. These properties can vary spatially and are important for calculating the aquifer response (e.g., amount of mounding, radius of influence) to recharge operations. Vertical infiltration rates at Olds Reservoir are about 1 ft/day, but are only about 0.1 ft/day at Lord Reservoir. Aquifer and well test data indicate that the hydraulic conductivity of the alluvial aquifer is highest in the central (~365 ft/d) and northern (~188 ft/d) parts of the basin, but is relatively low in the south (~1.5 ft/d). Applying the average horizontal hydraulic conductivity, effective porosity, and groundwater gradient over the length of the basin produces a flow velocity of approximately 6-7 ft/d for natural conditions. A mounding of the water table resulting from recharge operations would increase the local gradient, and subsequently the local groundwater flow rates.

Geochemical reactions in the groundwater environment must be considered when implementing aquifer recharge especially when different source waters are used. Water in the central basin exhibits high TDS concentrations exceeding 2,000 mg/L in most areas with a few locations exceeding 4,000 mg/L. To the north and south TDS concentrations in the water generally are lower. High nitrate concentrations, above primary drinking water standards, also exist in the alluvial groundwater at a number of locations. The ambient water chemistry should be considered according to the chemistry of source recharge water and the goals of the recharge project. Site-specific characterization of aquifer properties and groundwater quality will be essential before constructing and implementing any recharge project.

In addition to the physical considerations of the aquifer, the presence of existing infrastructure and willing landowners are also critical considerations influencing the cost and overall feasibility of an aquifer recharge/storage project. Various types of conveyance infrastructure, in the form of canals and ditches, currently exist in the Lost Creek basin vicinity and could potentially be used to deliver water to a recharge location. As part of this report, we have provided infrastructure maps and land ownership data for use in evaluating potential recharge locations. Much of the Lost Creek basin, particularly in the southern part where storage capacity is greatest, is cultivated for pasture, hay, or small grains. From a logistical standpoint of cooperators, publically-owned land or large privately-owned parcels are likely more feasible for implementation of a recharge project. Most of the lands within the areas of greatest aquifer storage capacity are privately-owned with parcel sizes from less than 160 acres to 1280 acres.

Groundwater in the alluvial aquifer flows generally from south to north in the basin. The most advantageous locations for recharge and storage operations are likely in the southern parts of the basin where the unsaturated zone is thickest (>50 feet). Specifically, areas south of, or in the vicinity of, the intersection of Highway 79 and 144th Avenue likely represent the best recharge locations (Fig. 31). Here aquifer storage capacity is great, hydraulic conductivity appears high, and recharging in this area will also allow water to flow northward to sustain water levels and well pumping rates in parts of the basin where historic water levels have declined. From a logistical standpoint, large parcels of land in proximity to existing water delivery infrastructure likely represent better opportunities for implementation of an aquifer recharge and storage program.



Prospective Alluvial Aquifer Recharge and Storage Locations
Lost Creek Basin Aquifer Recharge and Storage Study

Figure 31

AREAS FOR FURTHER STUDY

The focus of this study was to quantify the amount of water in storage and the available additional storage capacity within the alluvial aquifer of the Lost Creek basin and identify potential areas where aquifer recharge and storage implementation would produce the greatest benefit. Design and selection of a project or facility site will be based on numerous factors including the availability of source recharge water, suitable or cooperative land holdings, and the planned end use of the water. Design and operation of an aquifer storage and recovery facility, or even pilot project, requires numerous considerations. In-depth discussion of these considerations is well beyond the scope of this study, but below we provide a brief introduction to some of the concerns and issues as a primer to project implementation.

Site-specific evaluations are critical to the success of any groundwater recharge and storage project. While this study provides an excellent regional framework, more detailed site-specific investigations should be conducted as groundwater recharge and storage projects are designed and considered. Site-specific investigations should seek to characterize local hydrogeologic conditions in detail and provide an analysis of the anticipated aquifer response to recharging groundwater at a given location. These detailed studies likely should include 1) characterization of the thickness, vertical and lateral continuity, hydraulic conductivity, and mineralogy of alluvial aquifer and vadose zone materials; 2) investigation of the hydrologic relationship between the alluvial aquifer and the underlying bedrock aquifer; 3) hydrologic modeling of effects of potential groundwater recharge project implementation on basin water levels, particularly in areas were water levels are already shallow; 4) evaluation of the water quality of the native alluvial groundwater and source recharge water to be used; and 5) geochemical modeling of potential interactions between the source recharge water and the native groundwater and materials of the Lost Creek alluvial aquifer.

Baseline hydrologic data should be collected to fully understand groundwater levels, hydraulic gradients, and variability in aquifer properties. Detailed subsurface characterization of the aquifer materials, through borehole drilling, coring, geophysical logging, and aquifer testing, in the area of potential recharge sites, is important. The presence and geometry of lower permeability zones in the subsurface will strongly influence the infiltration rate and flow direction. The depth, thickness, lateral extent, and hydraulic properties of different alluvial aquifer materials, including any low-permeability layers, should be well characterized at any proposed recharge locations. Determination of site-specific aquifer characteristics are important for understanding where and how fast recharge water will move at or from a given site. The horizontal and vertical aquifer hydraulic conductivity and thickness and lateral continuity of aquifer materials, particularly any low-permeability layers, will affect how water infiltrates into the aquifer at a location.

Subsurface investigations at potential recharge locations should also determine the depth to the top of the bedrock and attempt to characterize the nature of groundwater interactions between the alluvial and bedrock aquifers. Evaluation of differences in hydraulic conductivity, water levels, and water quality between the alluvial and bedrock aquifer could be helpful in understanding this relationship. Additionally, aquifer testing in both the alluvial and bedrock aquifers may help assess groundwater flow across this contact. Very little data exists with which to understand interactions between the alluvial aquifer and the underlying bedrock aquifer systems, yet the relationship between these aquifer systems may play an important role in the basin groundwater hydrology. Although project-specific investigations of potential recharge locations should evaluate the hydrogeology at a specific location, additional investigation of hydrogeologic conditions throughout the basin would also be helpful in understanding the hydrology of the system.

In order to better evaluate the effects of implementing any recharge project, detailed analyses of impacts on groundwater levels and potential geochemical interactions are needed. These analyses should model potential effects of recharge scenarios using site-specific aquifer data together with basin-wide datasets. Areas which may potentially be impacted by very shallow or discharging groundwater caused by proposed recharge projects should be identified. Furthermore, any recharge project proposals should incorporate strategies for mitigating negative impacts caused by changing water levels. As part of the site-specific investigation process, thorough characterization of the native alluvial aquifer water quality and source recharge water chemistry, will be essential. Complete geochemical analyses of the native and source waters should be performed in order to evaluate potential geochemical reactions that may occur during implementation of a recharge project. If pre-treatment of the source water prior to recharge is required, the post-treatment geochemistry of that water should be taken into account. Furthermore, analysis of the mineralogy of the aquifer material will also be important in identifying potential reactions between the source water and the receiving aquifer materials. With detailed data about the mineralogy of the alluvial aquifer materials and native and source water chemistry, predictive geochemical modeling of interactions between the source water and the groundwater environment will be essential to ensure project success. Laboratory testing of potential geochemical interactions may also be worthwhile, particularly if the results of geochemical modeling are inconclusive.

Design of a recharge system at a site should depend on local hydrogeologic conditions, including physical and geochemical considerations discussed earlier, and any additional practical constraints on implementation of a recharge project at a location. Subsurface aquifer characteristics will be important in selecting the most effective recharge method at a site. Recharge methods might consist of surface (infiltration basins) or subsurface (vadose zone wells, direct injection wells) technologies or a combination of different methods. Different recharge mechanisms have unique considerations that should be addressed in order to evaluate the effectiveness, efficiency, and reliability of proposed recharge projects. Use of surface infiltration basins may effectively recharge the alluvial aquifer in parts of the basin where vertical hydraulic conductivity is high and where low-permeability layers do not impede vertical infiltration of water; however, other mechanisms, including vadose zone wells or injection wells, may be more effective at recharging water in some areas, particularly to deeper parts of the aquifer and below low-permeability zones. The land use, topography, and size of land holding needed will depend upon the recharge method chosen. Infiltration basins, for example, may cover hundreds of acres and have greater surface impacts . Operational aspects of a recharge and recovery program will depend upon the planned end use of the stored water, including length of time for the water to be stored, and the ability to account for the amount of water that can be recovered. The applicability of state and federal water quality regulations, as they relate to potential pre- and post-treatment requirements for recharge water or for extracted water in the vicinity of a recharge site, should also be considered.

Determination of baseline hydrologic data is critical for evaluating and tracking effects of an operational facility. Monitoring wells should be installed to assist in site characterization. Such wells will provide facilities to collect water level and chemistry data prior to implementation of recharge operations; however, but they will also provide points for monitoring changes in the aquifer during project implementation and may also function to satisfy regulatory compliance requirements, if necessary. Clearly, aside from the identification of available storage capacity, numerous additional issues must be considered and planned for in developing a successful aquifer recharge and storage projects. These projects must be managed from both a water quality and water quantity standpoint. Thorough review of site-specific and basin-wide hydrology as they relate to implementation of any recharge project, will increase the probability of project success and minimize the potential for unanticipated impacts.

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APPENDIX A

HISTORIC AND MONTHLY CLIMATE SUMMARY DATA

Lost Creek Monthly Climate Summary (1931-2010), Byers Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Temperature (^oF)	27.8	31.6	38.3	47.1	56.7	66.9	73.4	71.4	62.8	51.1	37.6	29.8	**49.5**
Maximum Temperature (^oF)	42.4	46.3	53.2	62.5	71.9	83.3	90.3	87.8	79.5	67.6	52.7	44.4	**65.1**
Minimum Temperature (^oF)	13.2	17	23.4	31.8	41.6	50.4	56.6	55	46.1	34.5	22.5	15.2	**33.9**
Precipitation (in.)	0.41	0.41	0.96	1.66	2.52	1.91	2.18	1.75	1.22	0.84	0.64	0.41	**14.92**
Precipitation (% of annual)	3%	3%	6%	11%	17%	13%	15%	12%	8%	6%	4%	3%	**100%**
Snowfall (in.)	6.1	5.3	8.8	5.8	0.6	0	0	0	1	2.9	5.8	5.7	**43**

Elevation: 5,100 feet above mean sea level
Location: Latitude = 39^{o}45'; Longitude = 104^{o}08'
Source: Colorado Climate Center

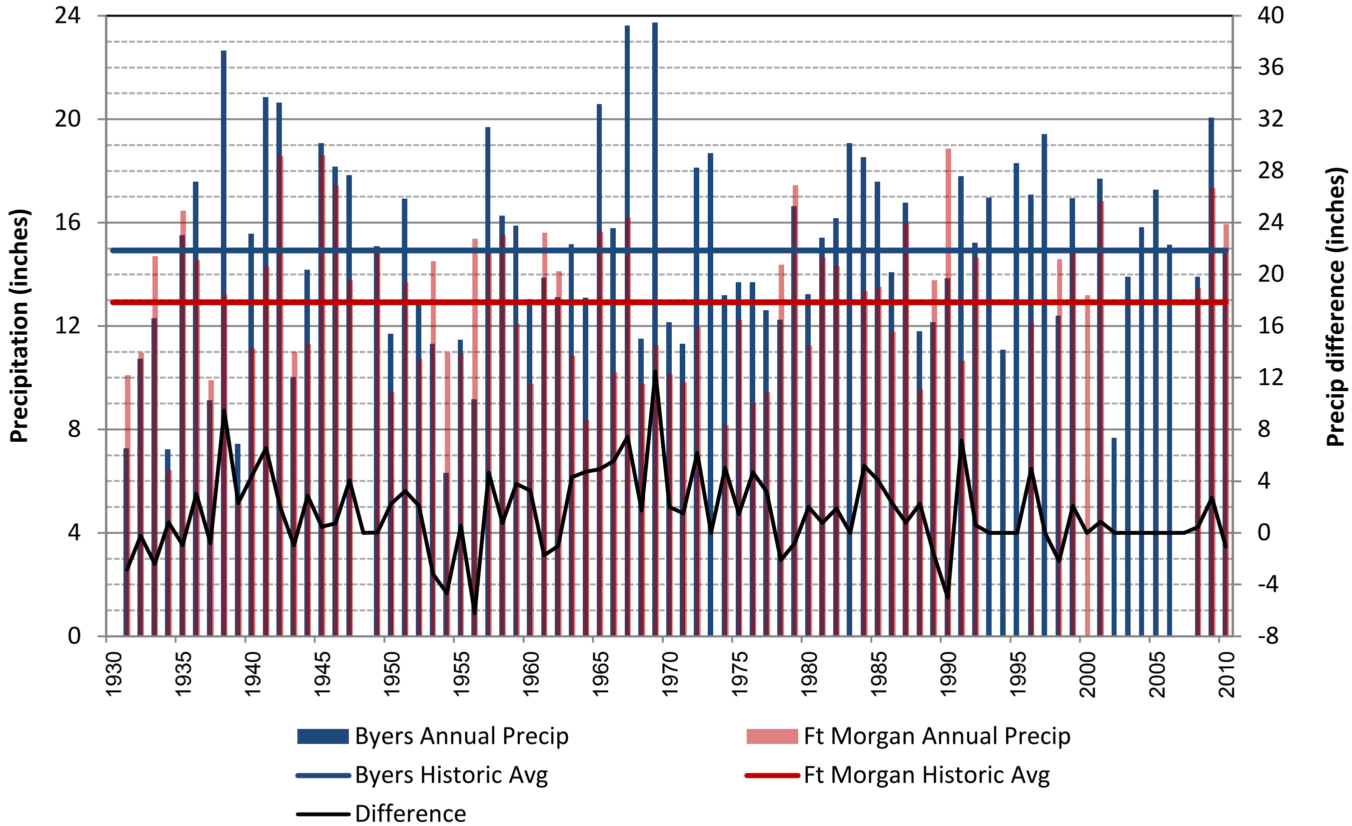
Lost Creek Monthly Climate Summary (1931-2010), Fort Morgan Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Temperature (^oF)	24.5	30.2	38.2	48.0	58.2	68.3	74.7	72.3	62.9	50.9	36.8	27.2	**49.4**
Maximum Temperature (^oF)	39.1	44.6	52.6	62.3	72.0	82.9	89.9	87.3	78.6	67.3	51.6	41.6	**64.2**
Minimum Temperature (^oF)	10.0	15.8	23.9	33.7	44.3	53.7	59.5	57.3	47.2	34.5	22.0	12.9	**34.6**
Precipitation (in.)	0.26	0.21	0.66	1.37	2.45	1.97	1.94	1.54	1.16	0.78	0.39	0.27	**12.92**
Precipitation (% of annual)	2%	2%	5%	11%	19%	15%	15%	12%	9%	6%	3%	2%	**100%**
Snowfall (in.)	4	2.7	5	2.6	0.3	0	0	0	0.3	1	2.7	4.1	**22.9**

Elevation: 4,320 feet above mean sea level
Location: Latitude = 40^{o}15'; Longitude = 103^{o}48'
Source: Colorado Climate Center

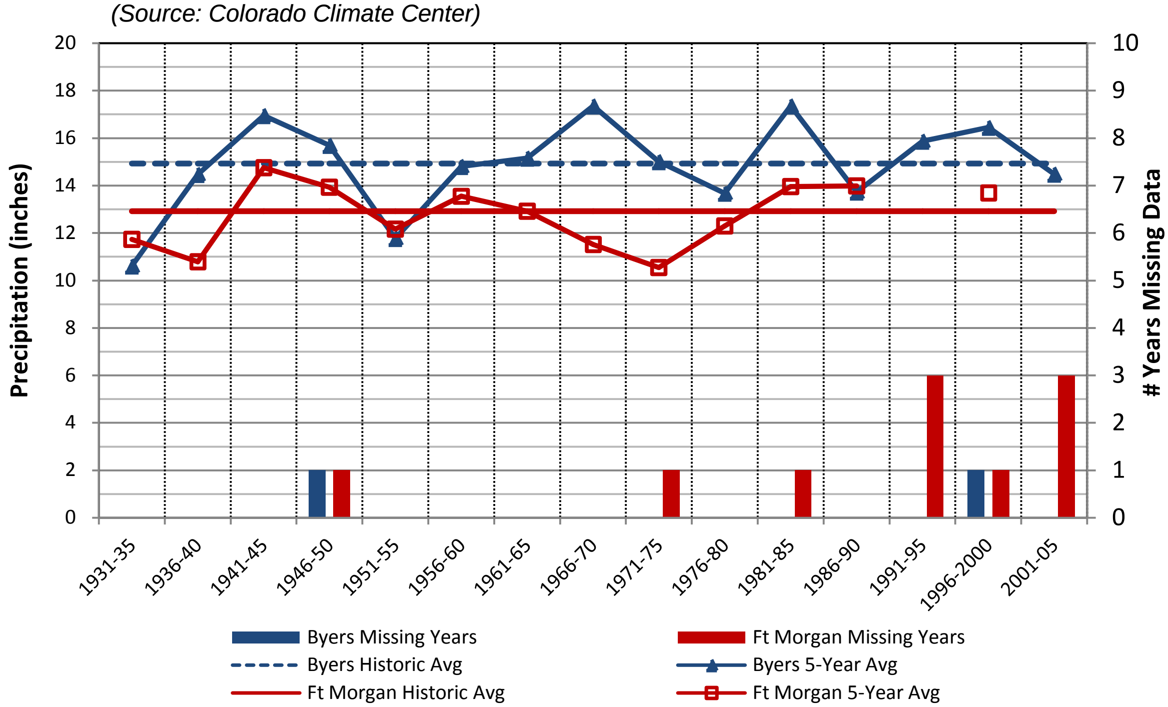
Lost Creek Annual Precipitation (1931-2010), Byers and Fort Morgan Stations

(Source: Colorado Climate Center)



Lost Creek 5-Year Average Precipitation (1931-2010), Byers and Fort Morgan Stations

(Source: Colorado Climate Center)



APPENDIX B

ALLUVIAL GROUNDWATER LEVEL SUMMARY AND DATA

APPENDIX B CONTENTS

Discussion of Groundwater Level Trends

Summary Table of Groundwater Level Trends

Alluvial Groundwater Level Hydrographs from Recent Monitoring Programs
(wells monitored recently by CGS, DWR, and USGS)

WELLS:

GS-1	
GS-2	
GS-3	
GS-4	
GS-5	
GS-6	
N-1	
N-5	
N-6	
N-7	
N-8	(abandoned well, not monitored in 2009-10 for this project)
N-11	
S-1A	
S-2	
S-3/3A	(well S-3 not accessible, instead nearby well S-3A monitored in 2009-10 for this project)
S-10/10A	(well S-10 frequently pumping, instead nearby well S-10A monitored in 2009-10 for this project)
S-12/12A	(well S-12 frequently pumping, nearby well S-12A also monitored in 2009-10 for this project)
S-18	
S-23A	
S-24	
S-26A	
LC-1	(well added to monitoring network in 2009-10 for this project)
LC-2	(well added to monitoring network in 2009-10 for this project)
LC-3	(well added to monitoring network in 2009-10 for this project)
LC-4	(well added to monitoring network in 2009-10 for this project)
LC-5	(well added to monitoring network in 2009-10 for this project)
LC-6	(well added to monitoring network in 2009-10 for this project)
LC-7	(well added to monitoring network in 2010 for this project)
LC-8	(well added to monitoring network in 2010 for this project)
AGLUS REF1	
AGLUS2	
AGLUS3	
AGLUS4	
AGLUS11	
AGLUS12	
AGLUS13	
AGLUS14	
AGLUS16	
AGLUS19	
AGLUS20	
AGLUS21	
AGLUS24	
AGLUS26	
AGLUS27	
AGLUS29	
AGLUS30	(well not accessible in 2009-2010 for this project)

DISCUSSION OF GROUNDWATER LEVEL TRENDS

For discussion of groundwater level trends we divided the Lost Creek basin into three areas: **northern zone**, generally north of I-76; **central zone**, generally south of I-76 to the Weld/Adams county line; and **southern zone**, south of the Weld/Adams county line. In the southern zone, few wells exist with extensive historic water level monitoring data. With the exception of one well (GS-1) at the far northern section of the southern zone, the typical historic period of record for water level data in the southern zone is from 2003-2010, with only one water level measurement in Summer 2003 prior to the commencement of the recent water level monitoring in Fall 2009. A summary of seasonal and historic water level trends in the basin is presented in Table 3. Historic groundwater level trends in the Lost Creek basin are based on the seasonal high water level data, generally in the spring, from the earliest historic spring measurement point to the most recent spring water level measurement. Seasonal water level fluctuation trends are based on the time period July/August 2009 to April/May 2010, generally capturing the low seasonal water level point in the summer or fall and the high seasonal water level point in the spring. Hydrographs and tabular data for all wells in the monitoring network are included in Appendix B.

Northern zone

In the northern zone of the basin, spring water levels in 2010 range from a few feet below ground surface (bgs) to 42 feet bgs with most wells having seasonally high water levels of between approximately 5 and 22 feet bgs. Seasonal water level fluctuations ranged from 0.5 to 18.8 feet. On average the seasonal fluctuation in water levels during the period Summer 2009 to Spring 2010 was about 4 feet; the median value for seasonal water level fluctuation was 2.4 feet. The measured seasonal fluctuation of nearly 19 feet was an extreme for this area.

Historic water level data for many of the monitoring wells in the area start around 1970 and run through 2010; two additional wells have data starting around the early- to mid-1990s. In general, over the period of historic water level record, water levels have dropped an average of 3.7 feet; the median historic water level change is a drop of 2.5 feet. Historic fluctuation trends show that over the period of historic water level record, water levels in monitored wells in this area have fluctuated approximately 6.5 feet (difference between highest and lowest historic spring water level data).

Central zone

In the central zone of the basin, spring water levels in 2010 range from approximately 10 feet bgs to over 74 feet bgs. The average (and median) spring high water level is about 40 feet bgs. In 2009 and 2010 wells monitored in this area exhibited seasonal fluctuations (difference between high and low seasonal water level) of between 1.5 and 13 feet. On average the seasonal fluctuation in water levels between Summer 2009 and Spring 2010 was about 7 feet (Table 3, Appendices A and B).

Historic water level data for monitoring wells in the area start as early as 1934 with many periods of record extending back until around 1960; six wells have water level records from 1960 or earlier and an additional six wells have records beginning between 1960 and 1969. In general, over the period of historic water level record water levels have dropped an average of 5.9 feet in monitored wells in this area; the median historic water level change is a drop of 7.25 feet. Evaluating historic water level change based on the earliest measurement date, water levels in wells in the "central zone" have dropped on average 15 feet since the 1930s and 40s; since the early 1960s water levels have risen on average nearly 5 feet; between 1969 and 2010 (2007 or 2008 for wells S-3 and S-10) water levels have declined on average 9 feet. Historic trends show that over the period of historic water level record, spring water levels in monitored wells in this area have fluctuated approximately 19 feet.

Southern zone

In the southern zone of the basin, spring water levels in 2010 range from approximately 16 feet bgs to over 118 feet bgs. The average spring high water level is about 64 feet bgs (median is about 69 feet bgs. In 2009 and 2010, wells monitored in the “southern zone” exhibited very minimal seasonal fluctuation, on average less than 2 feet with a median value of 0.5 feet. Water levels in well GS-1 in the northernmost portion of the “southern zone” fluctuated nearly 21 feet while all other monitored wells had seasonal water level fluctuations of less than 3 feet, most with water level fluctuations of less than 1 foot.

Historic water level data for monitoring wells in this part of the basin is limited, particularly to the south. Well GS-1 has water level records starting in 1960 and exhibits a water level rise of nearly 3.5 feet during that time; well AGL REF1 has water level data from 2004 and shows little or no change during that period. All other wells in this zone were constructed in Summer 2003 and monitored at that time by the USGS; however, these water levels were measured in the summer and therefore are not considered here for historic comparison of change in spring water levels.

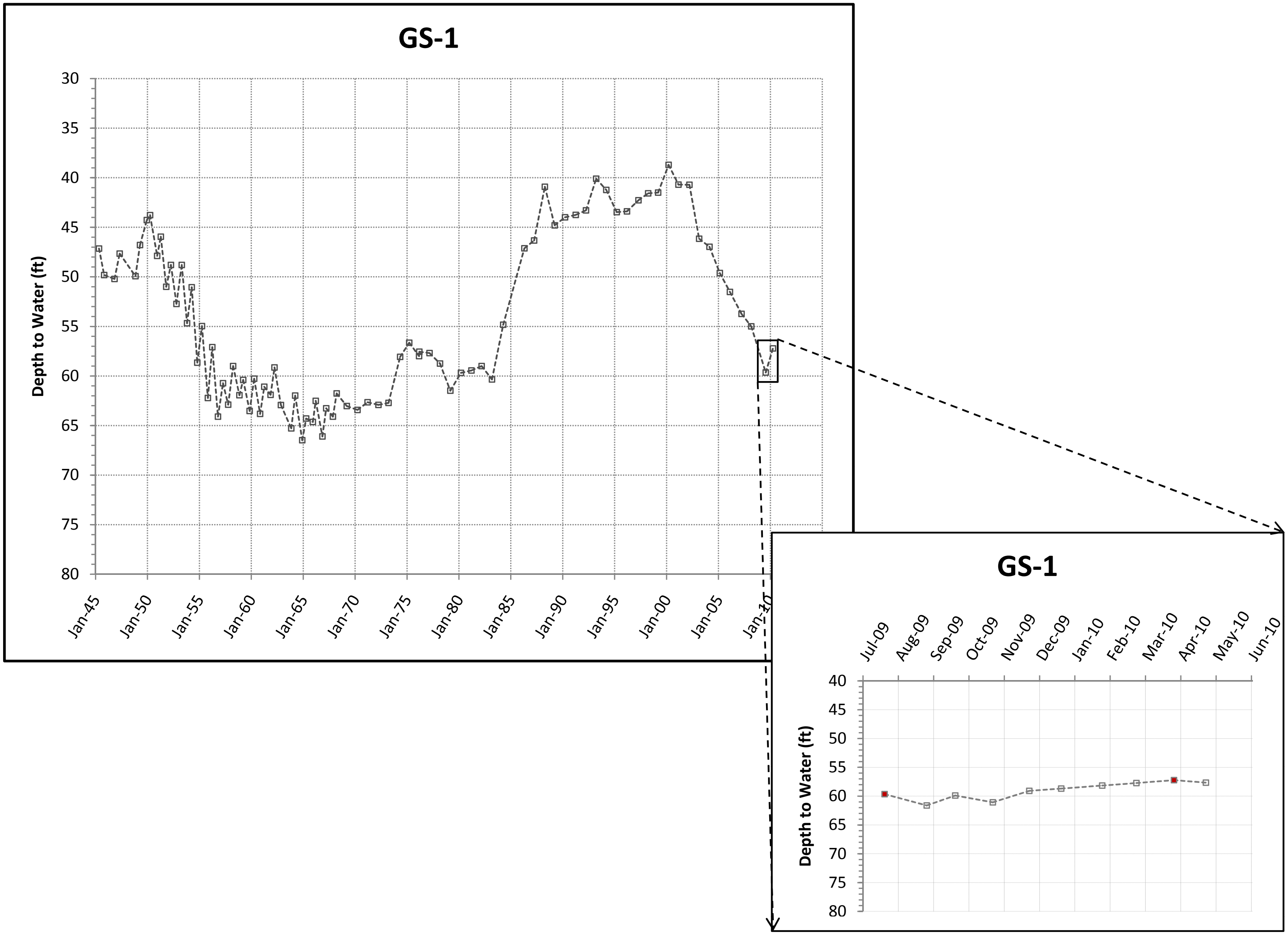
SUMMARY TABLE OF GROUNDWATER LEVEL TRENDS

Well	Historic Spring Water Level Trends			2009-2010 Seasonal Trend				
	Historic fluctuation	Historic change	Historic period	Seasonal fluctuation	Season high DTW	Season low DTW	Season high month	Season low month
Northern zone: generally north of I-76								
LC-5			2009-10	0.48	0.45	0.93	Oct	Feb
N-1	3	-0.5	1969-2010	2.37	4.63	7.00	Apr	Oct
N-5	9	-7.5	1969-2010	3.79	14.57	18.36	Apr	Aug
N-6	3	0.8	1972-2010	2.44	11.35	13.79	Apr	Sep
N-7	10	-7.5	1972-2010	2.95	21.17	24.12	Mar	Sep
N-8		-2.5	1972-2007					
N-11	8	-1	1972-2010	0.83	42.35	43.18	Apr	Sep
S-1A			2009-10	5.46	30.23	35.69	Apr	Sep
S-23A	5	-3.6	1994-2010	0.69	4.92	5.61	Mar	Aug
S-26A	4	-1.8	1993-2010	2.39	3.20	5.59	Mar	Aug
S-24	11	-9.8	1972-2010	18.76	22.50	41.26	Apr	Aug
Mean	**6.63**	**-3.71**		**4.02**	**15.54**	**19.55**		
Median	**6.5**	**-2.5**		**2.42**	**12.96**	**16.08**		
Central zone: generally south of I-76 and north of Weld/Adams county line								
S-2	16	-16	1969-2010	1.54	29.75	31.29	Apr	Oct
S-3	12	-11	1969-2007					
S-3A			2009-10	12.50	30.70	43.20	Apr	Oct
S-10	18	-3.7	1969-2008					
S-10A			2009-10	2.04	44.27	46.31	Mar	Sep
S-12	11	-5	1969-2010	12.94	32.56	45.50	Feb	Sep
S-12A			2009-10	8.00	31.60	39.60	Jan	Nov
S-18	12	-9.5	1969-2010	5.81	40.52	46.33	Mar	Aug
GS-1	23	-10.5	1945-2010	4.39	57.22	61.61	Mar	Aug
GS-2	19	-10.5	1937-2010	12.93	51.76	64.69	Apr	Sep
GS-3	28	13	1958-2010	4.58	55.40	59.98	Apr	Aug
GS-4	29	4.1	1958-2010	12.67	74.21	86.88	Apr	Dec
GS-5	10	2.3	1960-2010	6.93	43.78	50.71	Apr	Sep
LC-1			2009-10	8.39	49.16	57.55	Apr	Nov
LC-2			2009-10	4.12	10.97	15.09	Aug	Dec
LC-3	31	-24	1934-80, 2009-10	3.06	47.83	50.89	Apr	Jan
LC-4		0	1962-79, 2009-10	12.52	32.45	44.97	Apr	Aug
LC-6			2009-10	1.99	9.90	11.89	Oct	Apr
LC-8			2010		28.00		Apr	
Mean	**19**	**-5.90**		**7.15**	**39.42**	**47.28**		
Median	**18**	**-7.25**		**6.37**	**40.52**	**46.32**		

SUMMARY TABLE OF GROUNDWATER LEVEL TRENDS ***(continued)***

Well	Historic Spring Water Level Trends			2009-2010 Seasonal Trend				
	Historic fluctuation	**Historic change**	**Historic period**	**Seasonal fluctuation**	**Season high DTW**	**Season low DTW**	**Season high month**	**Season low month**
Southern zone: south of Weld/Adams county line								
GS-6	12	3.4	1960-2010	20.79	118.64	139.43	Apr	Dec
LC-7			2010		76.84		Jan	
AGL REF1	0	-0.4	2004-2010	1.07	53.27	54.34	Jan	Sep/Nov/May
AGL2			2003, 2009-10	0.20	61.37	61.57	Sep	May
AGL3			2003, 2009-10	0.22	82.09	82.31	Sep	May
AGL4			2003, 2009-10	0.13	70.53	70.66	Feb	May
AGL11			2003, 2009-10	0.13	86.09	86.22	Jan	Feb
AGL12			2003, 2009-10	0.11	31.37	31.48	Oct/Jan	Dec
AGL13			2003, 2009-10	1.30	66.41	67.71	May	Sep
AGL14			2003, 2009-10	2.61	16.63	19.24	Sep	Mar
AGL16			2003, 2009-10	0.97	31.16	32.13	Sep	May
AGL19			2003, 2009-10	0.34	85.83	86.17	Sep/Oct/Dec	May
AGL20			2003, 2009-10	1.28	22.67	23.95	Sep	May
AGL21			2003, 2009-10	0.84	19.92	20.76	Sep	Mar
AGL24			2003, 2009-10	0.46	85.91	86.37	Jan	Mar
AGL26			2003, 2009-10	1.01	72.86	73.87	late Sep	early Sep
AGL27			2003, 2009-10	0.22	67.41	67.63	Dec	May
AGL29			2003, 2009-10	0.21	102.34	102.55	Dec	May
Mean	**6**	**1.50**		**1.88**	**63.96**	**65.08**		
Median	**6**	**1.5**		**0.46**	**68.97**	**67.71**		

ALLUVIAL GROUNDWATER LEVEL HYDROGRAPHS FROM RECENT MONITORING PROGRAMS


GS-1
Depth to Water (ft)
30
35
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75
80
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
GS-1
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
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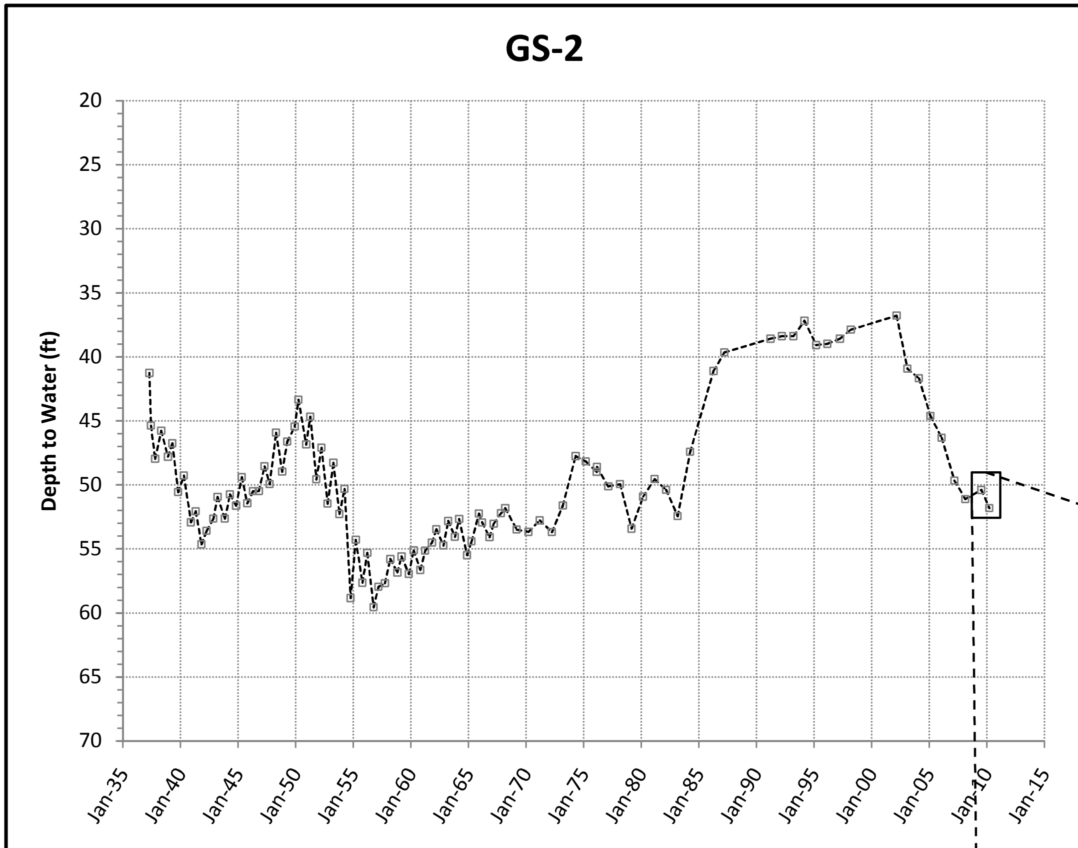
GS-2
Depth to Water (ft)
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Jan-35
Jan-40
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Jan-50
Jan-55
Jan-60
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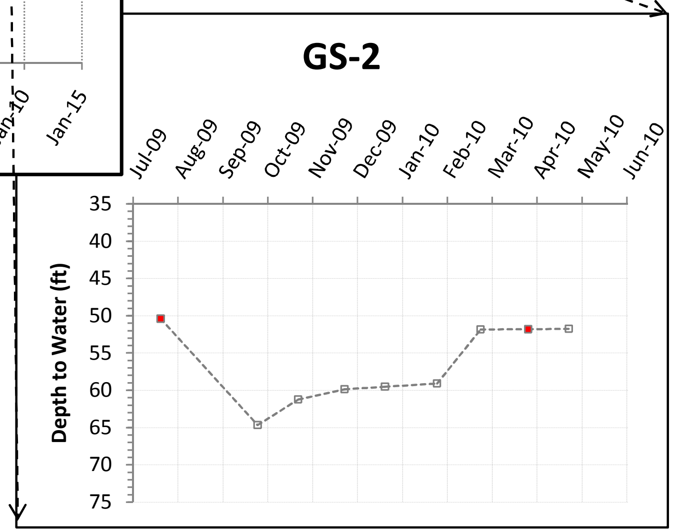
Jan-05
Jan-10
Jan-15


GS-2
Depth to Water (ft)
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
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Mar-10
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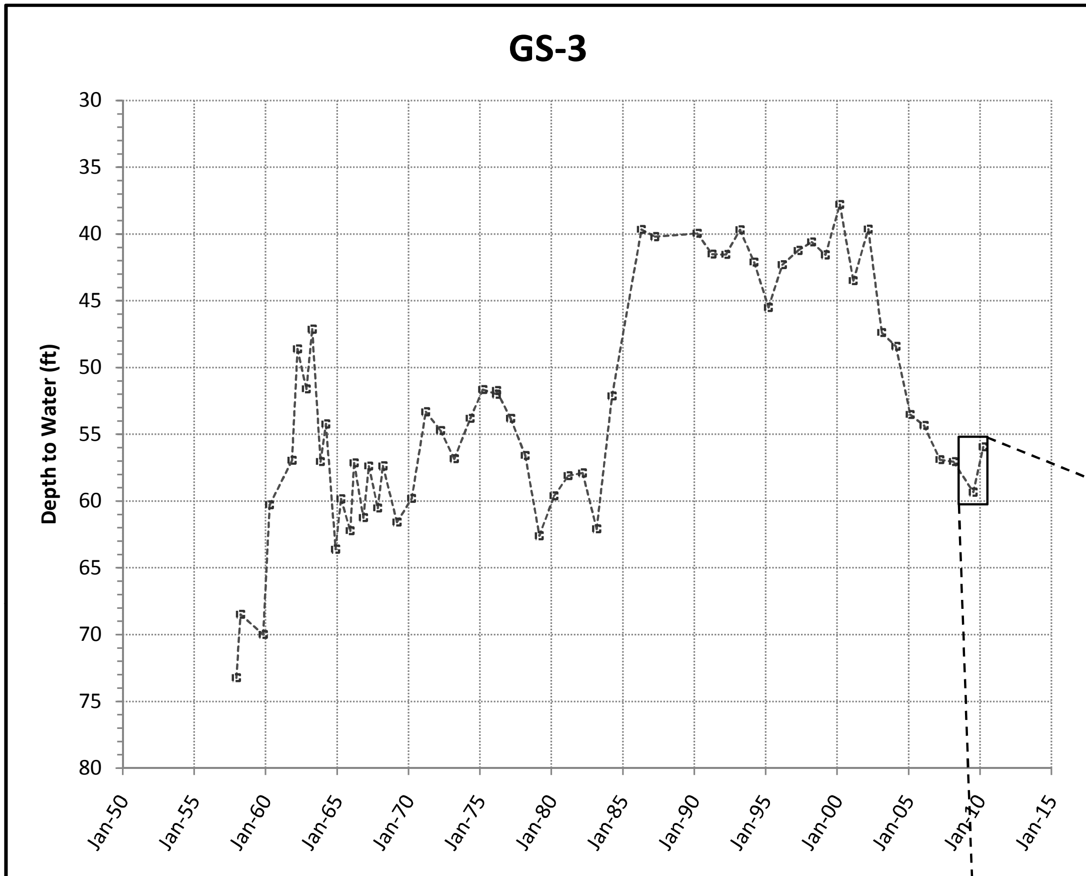
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Depth to Water (ft)
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Jan-50
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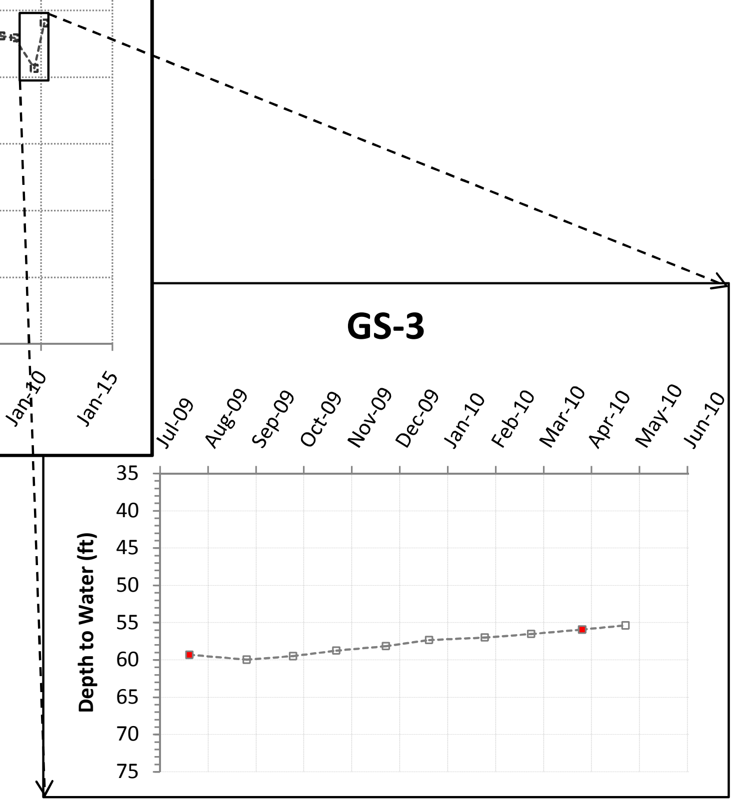
GS-3
Jul-09
Aug-09
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Oct-09
Nov-09
Dec-09
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Apr-10
May-10
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Depth to Water (ft)
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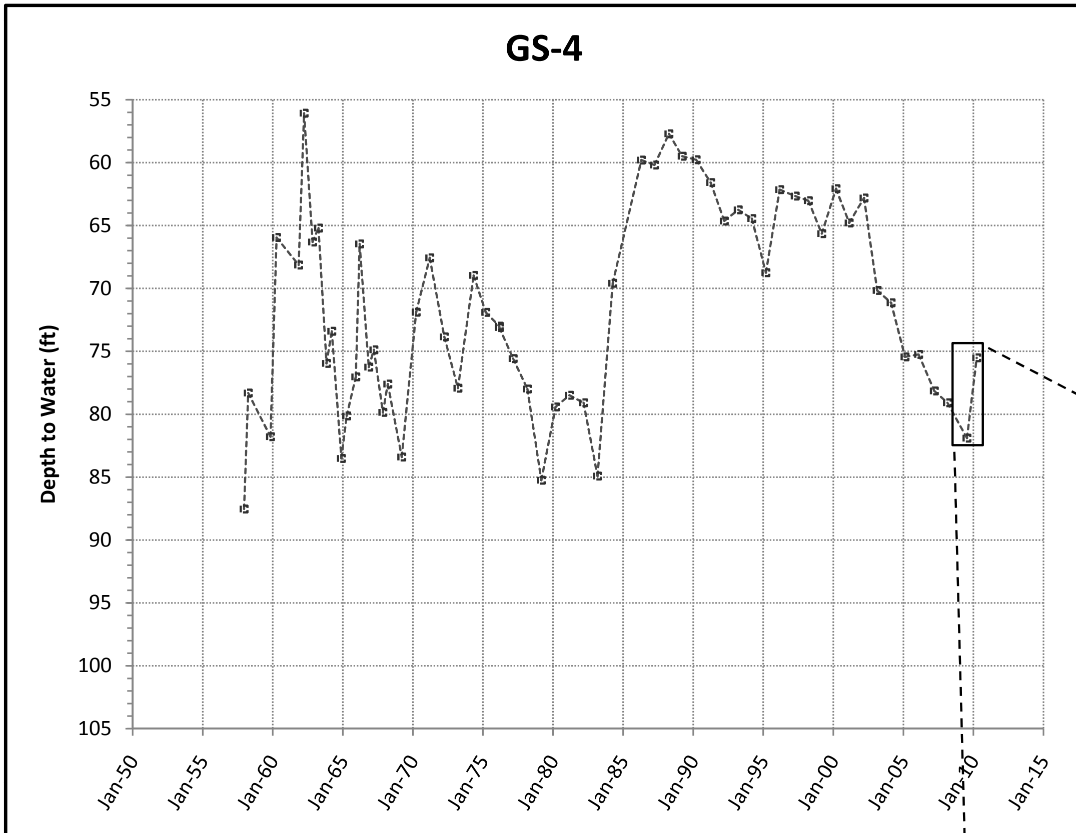
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Depth to Water (ft)
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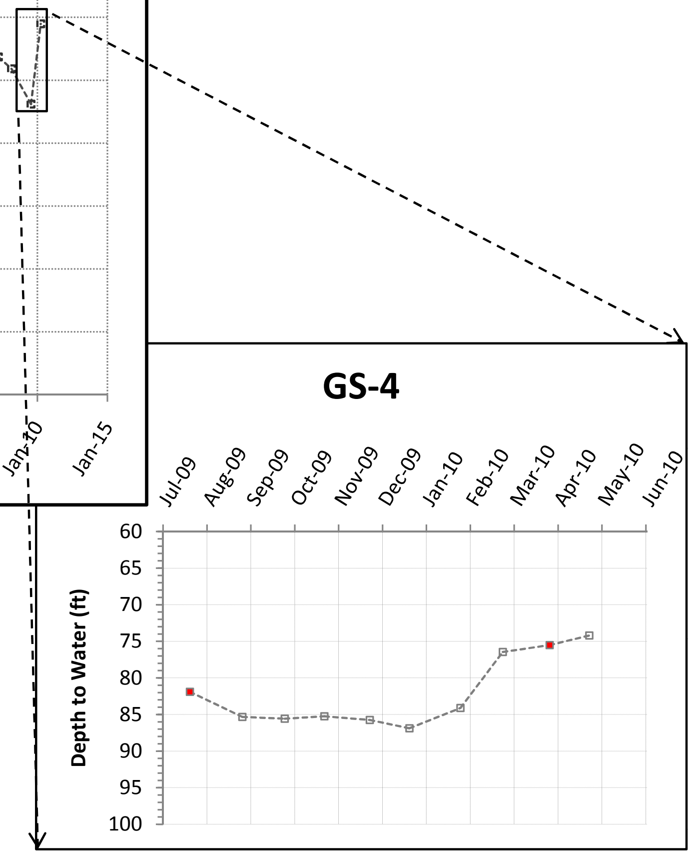
Jan-10
Jan-15


GS-4
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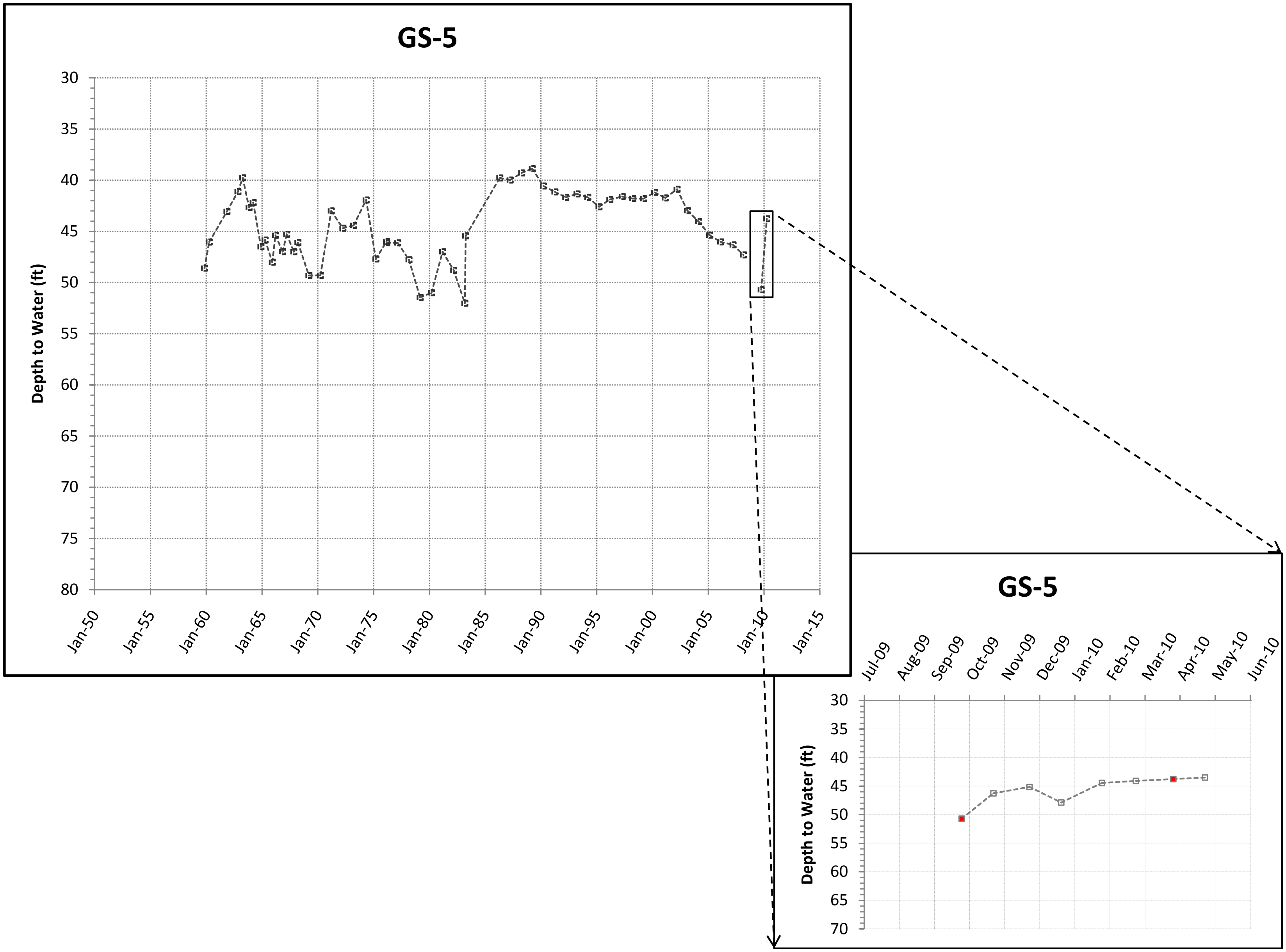
GS-5
Depth to Water (ft)
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Jan-00
Jan-05
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Jan-15
GS-5
Jul-09
Aug-09
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Nov-09
Dec-09
Jan-10
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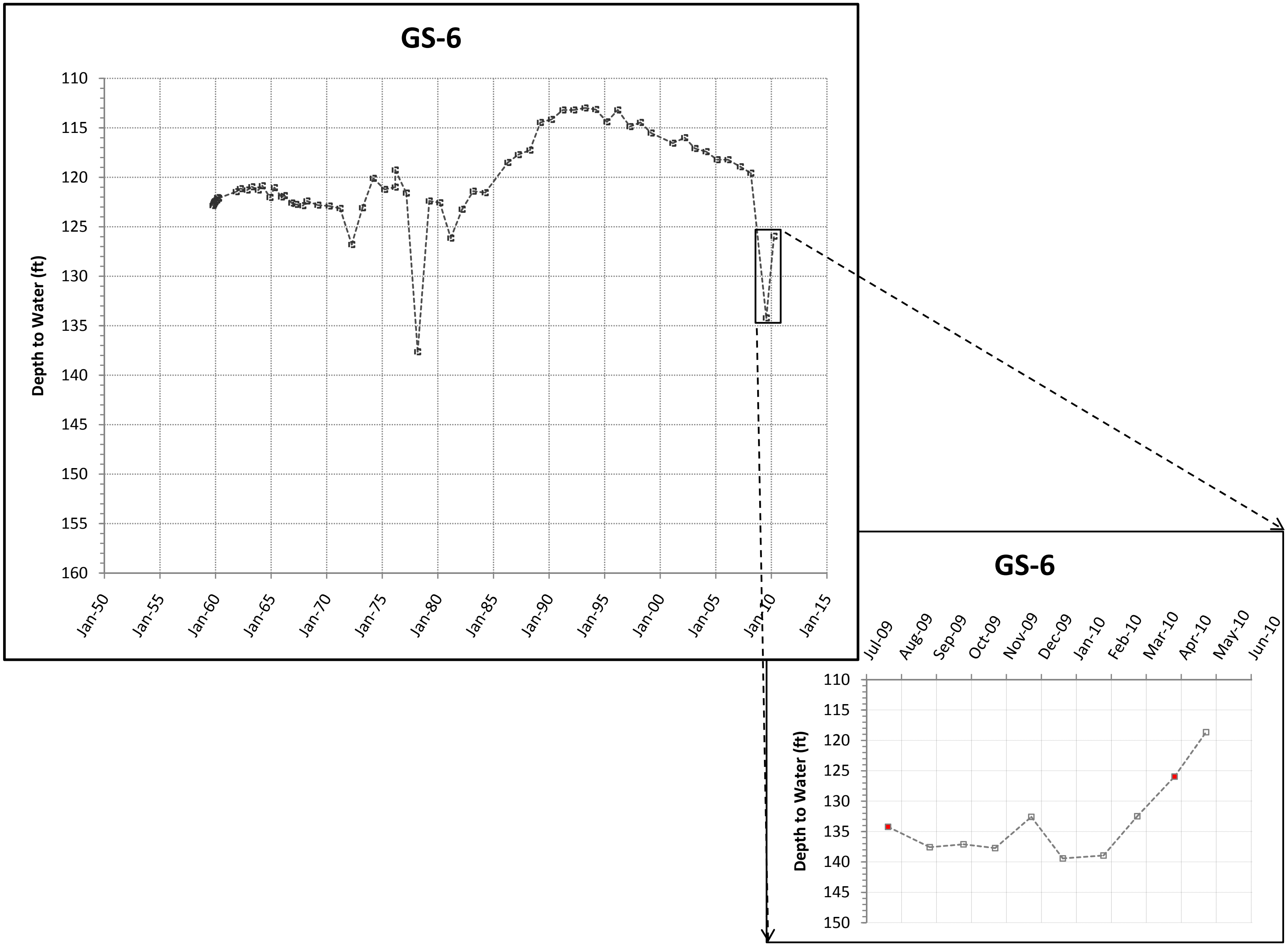
GS-6
Depth to Water (ft)
110
115
120
125
130
135
140
145
150
155
160
Jan-50
Jan-55
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Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
GS-6
Jul-09
Aug-09
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Oct-09
Nov-09
Dec-09
Jan-10
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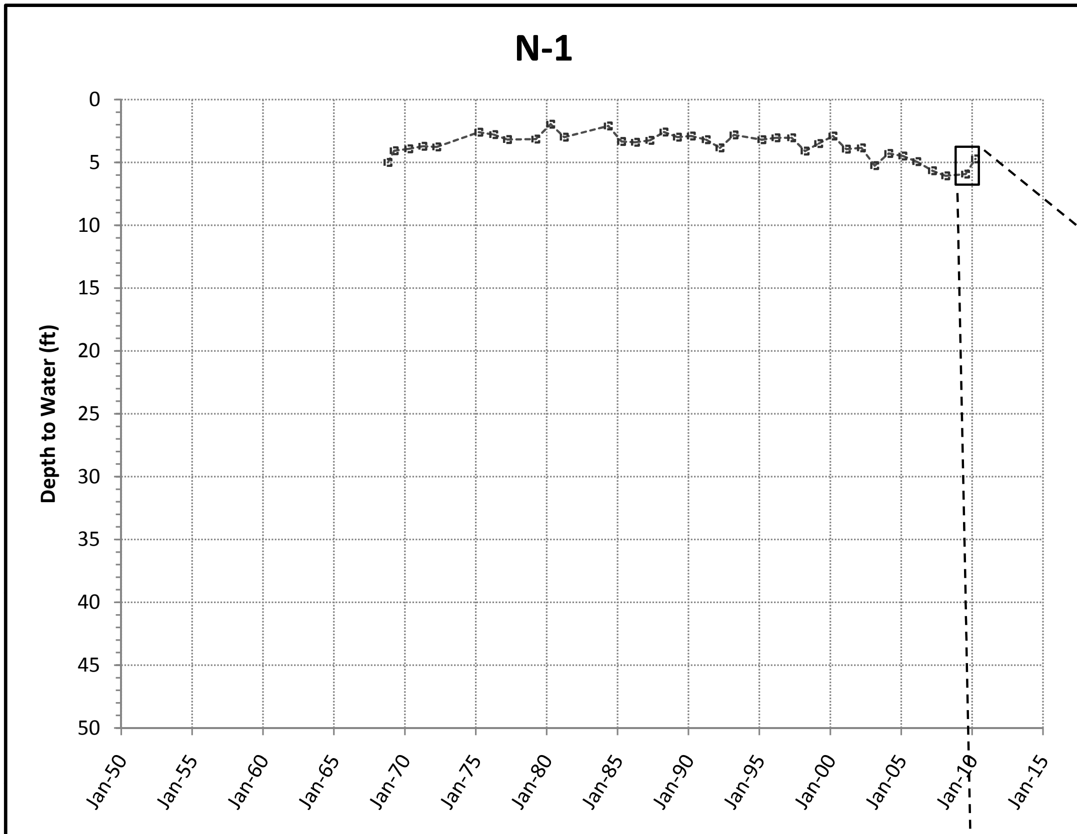
150


N-1
Depth to Water (ft)
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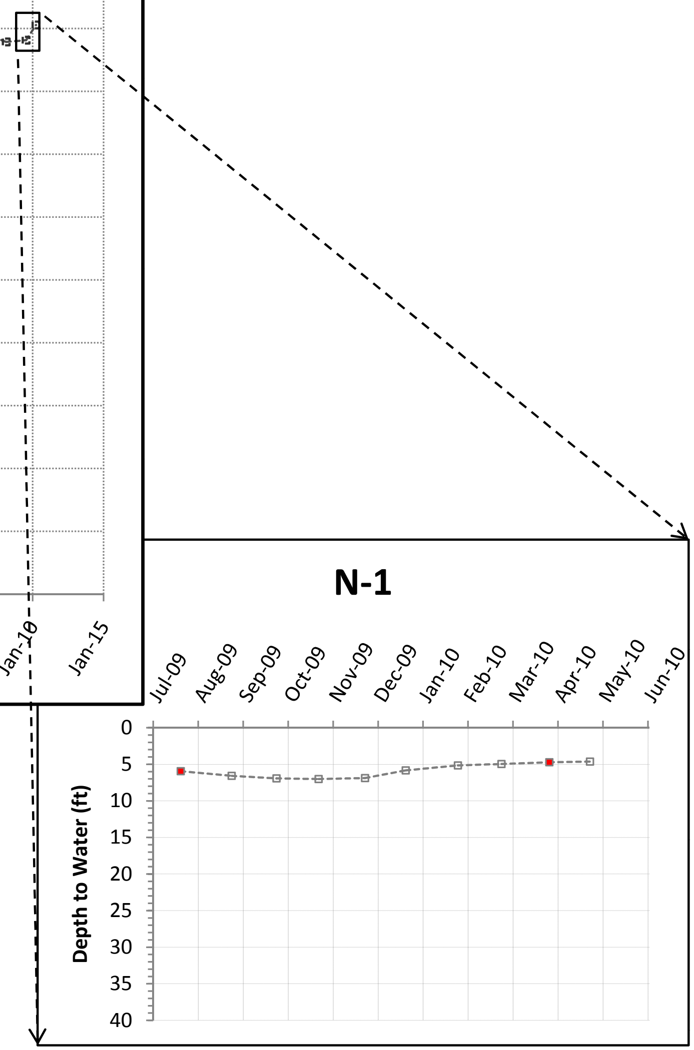
Jan-15


N-1
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
0
5
10
15
20
25
30
35
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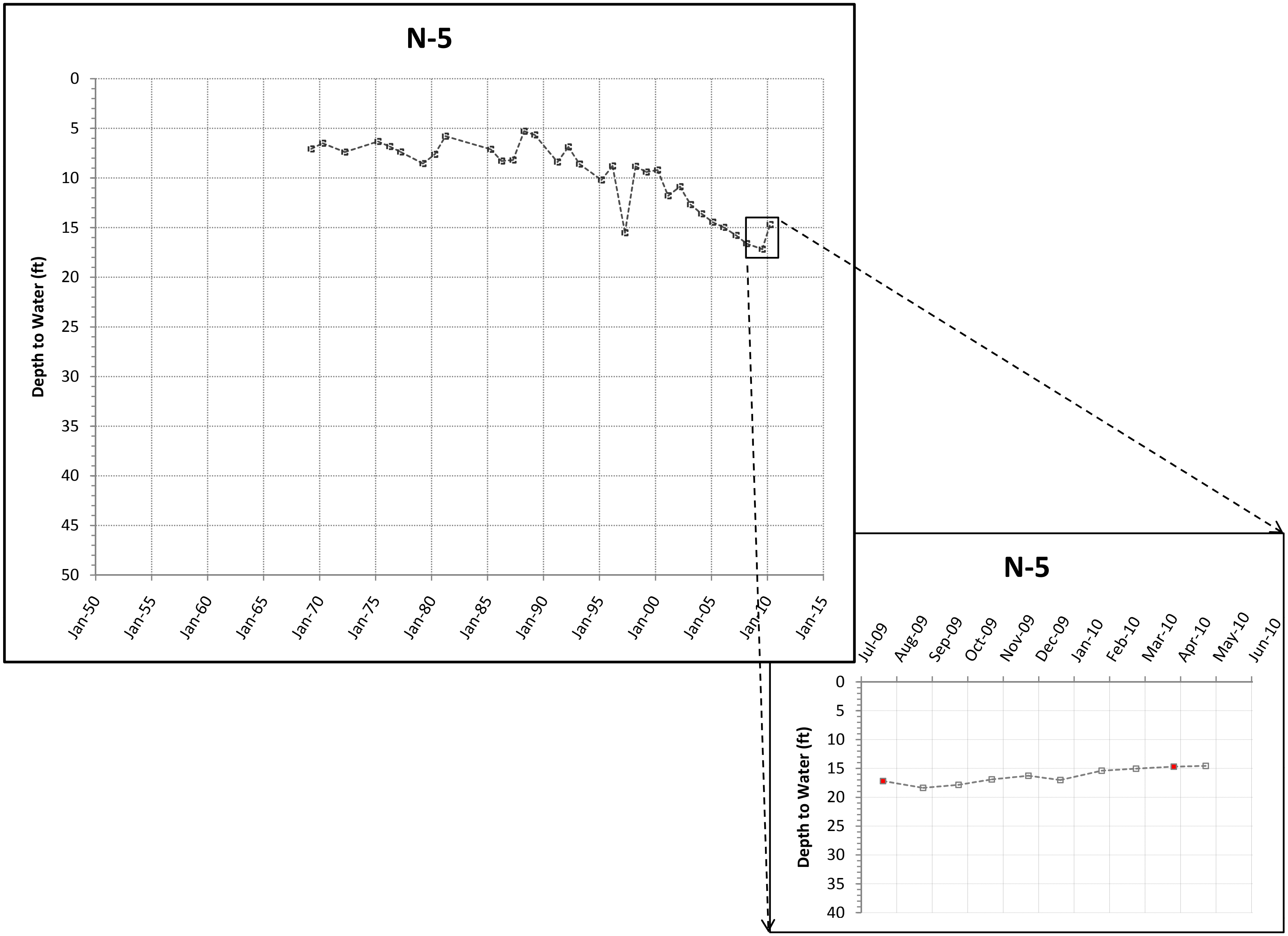
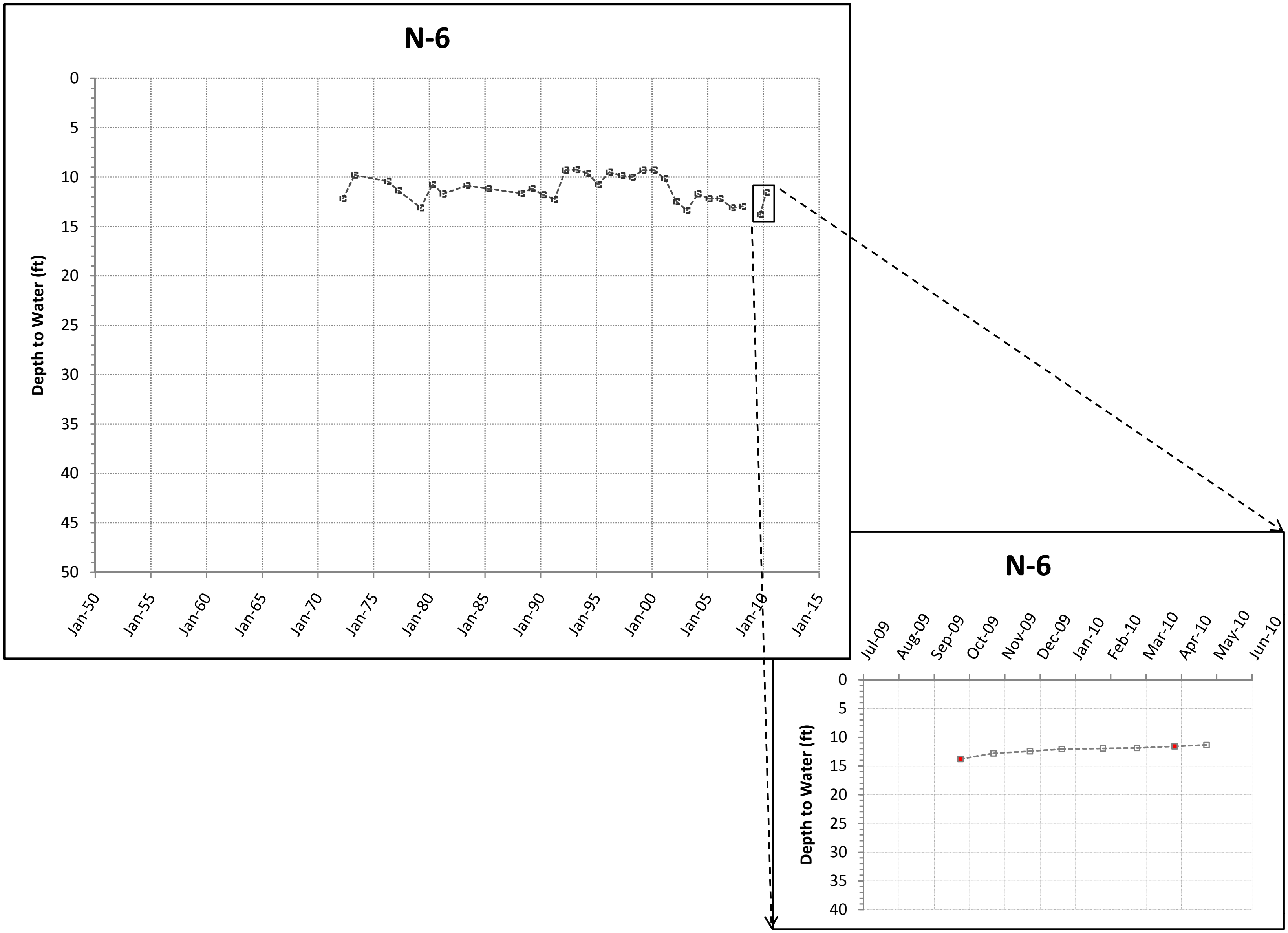

N-5
Depth to Water (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
N-5
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
0
5
10
15
20
25
30
35
40


N-6
Depth to Water (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
N-6
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
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5
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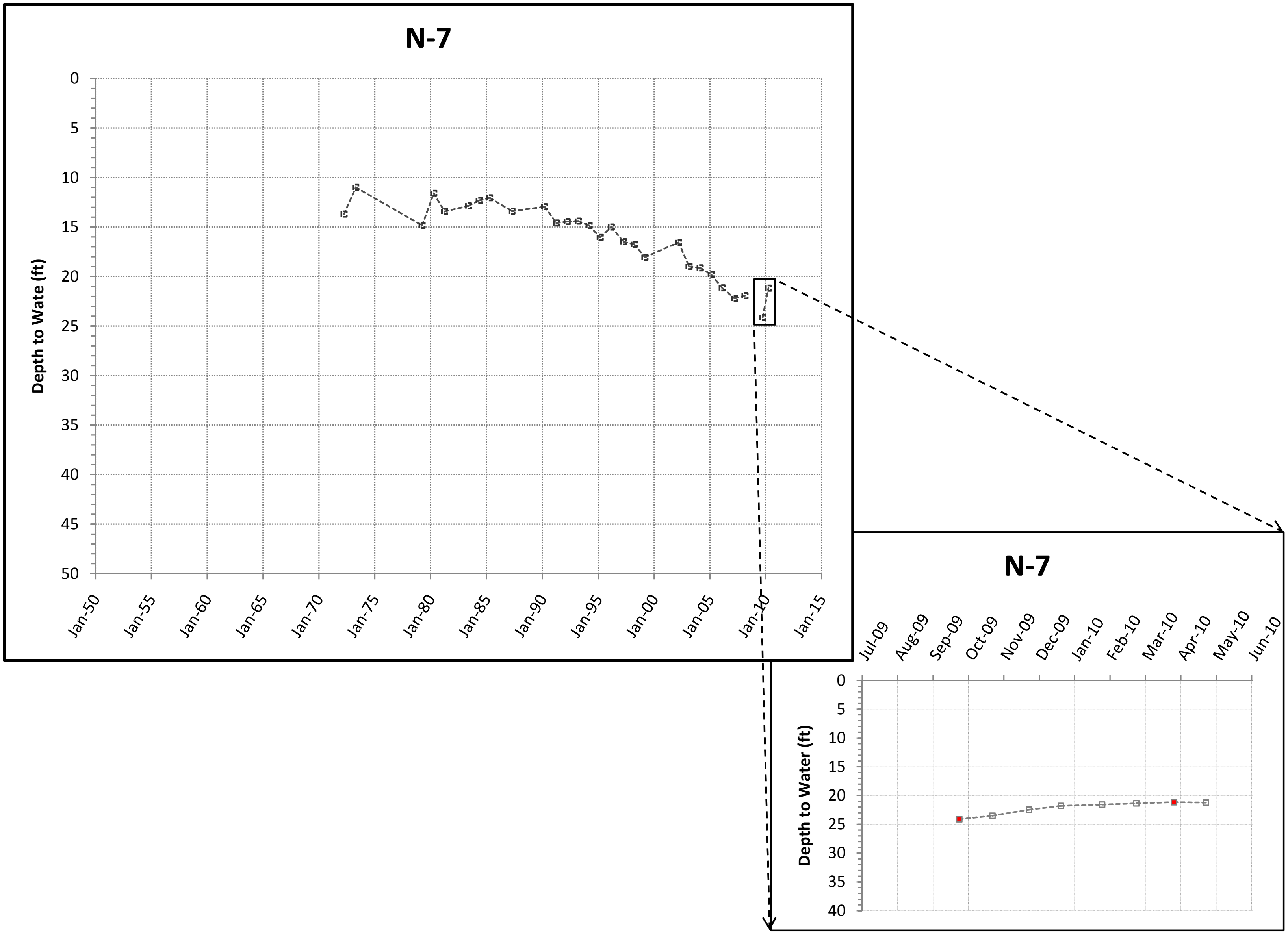
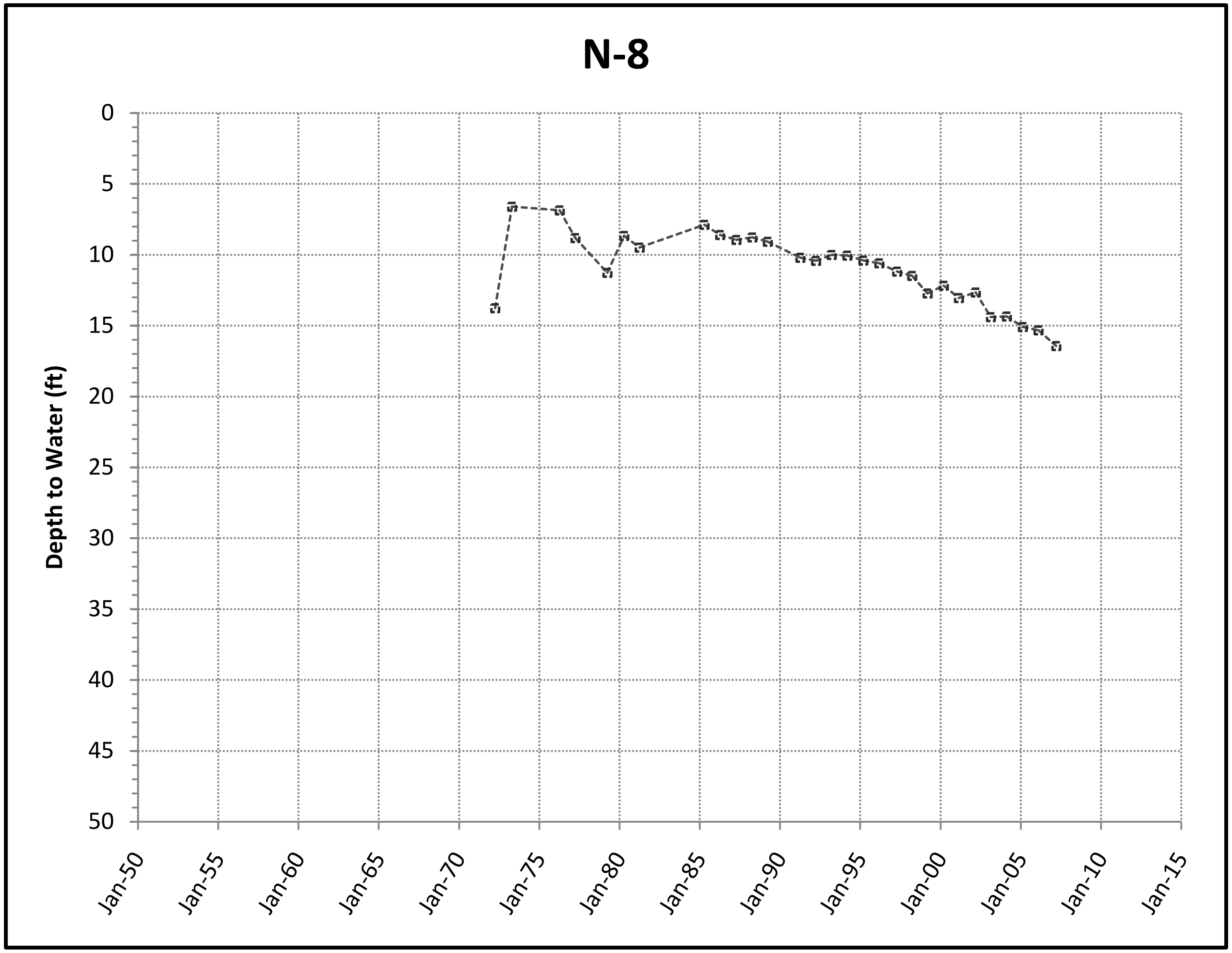
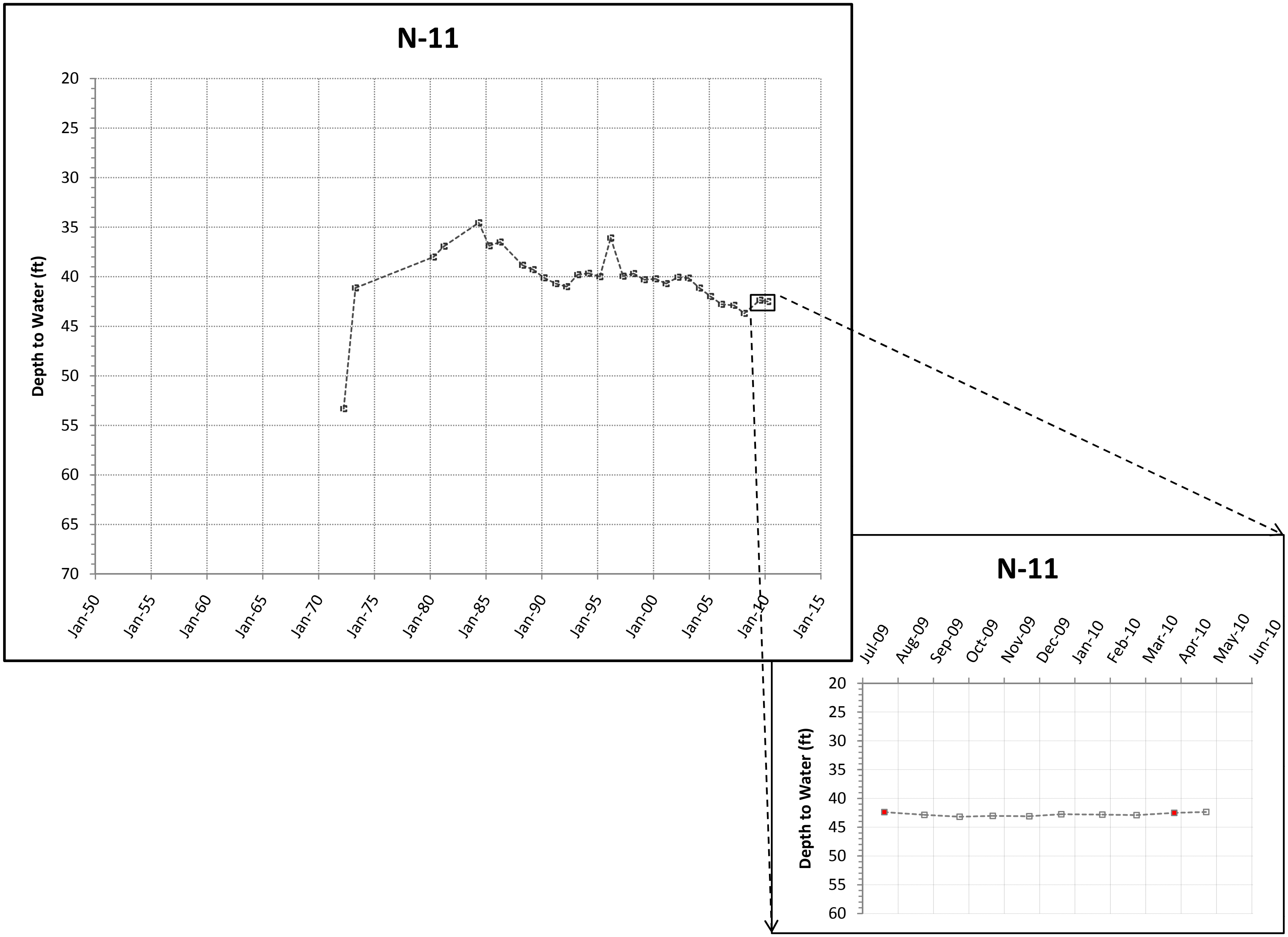
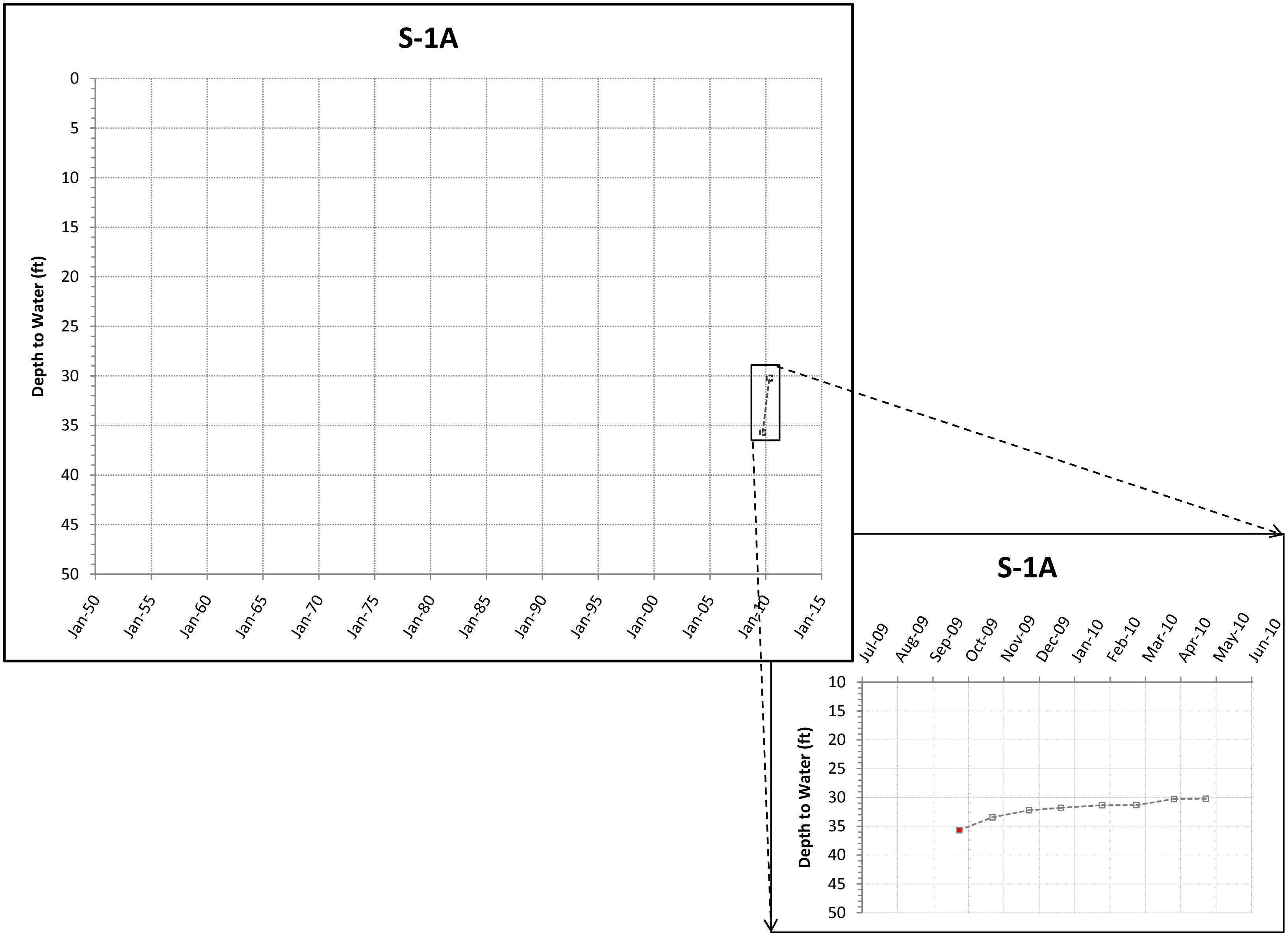
20
25
30
35
40

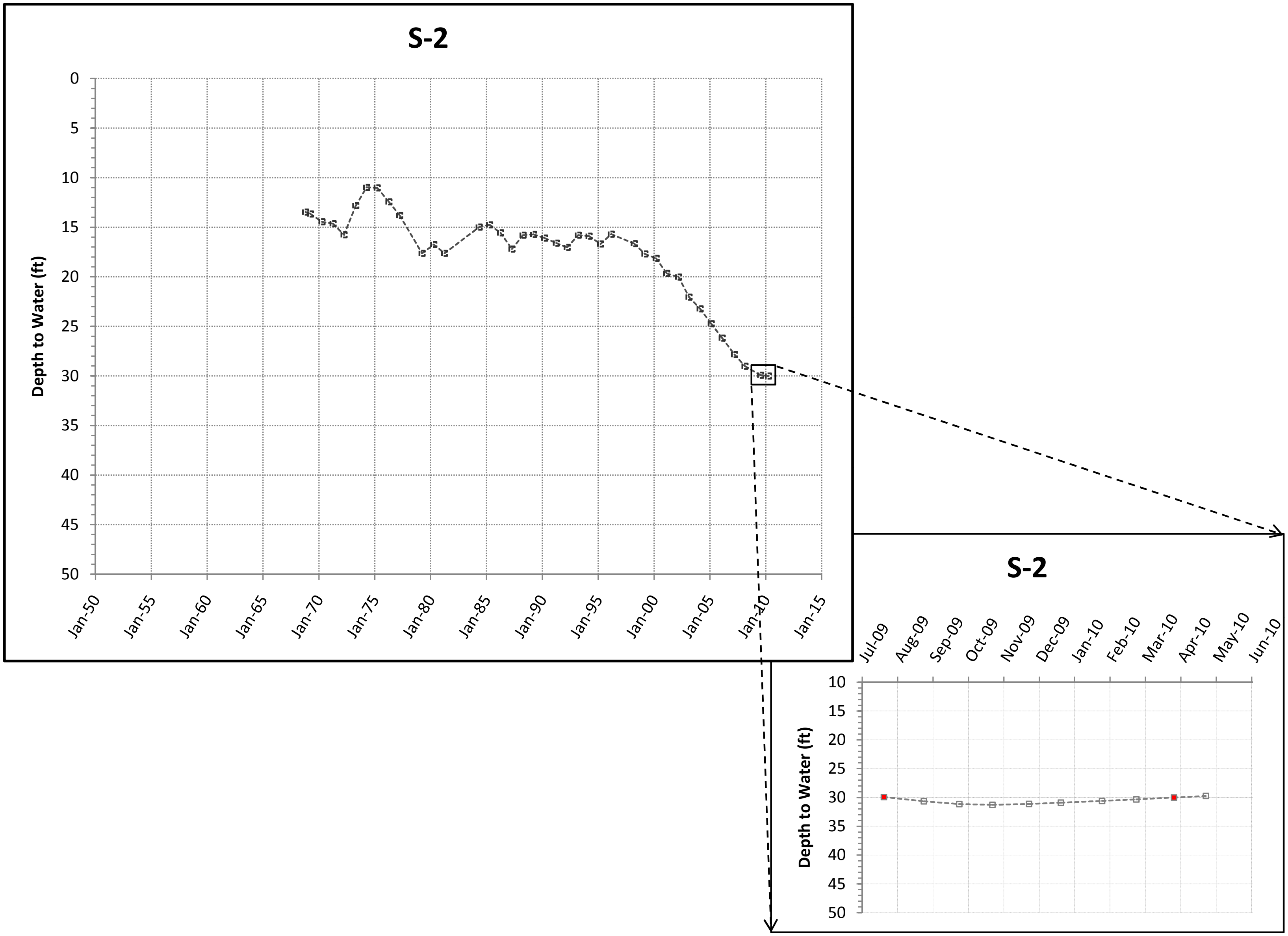

N-7
Depth to Wate (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
N-7
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
0
5
10
15
20
25
30
35
40

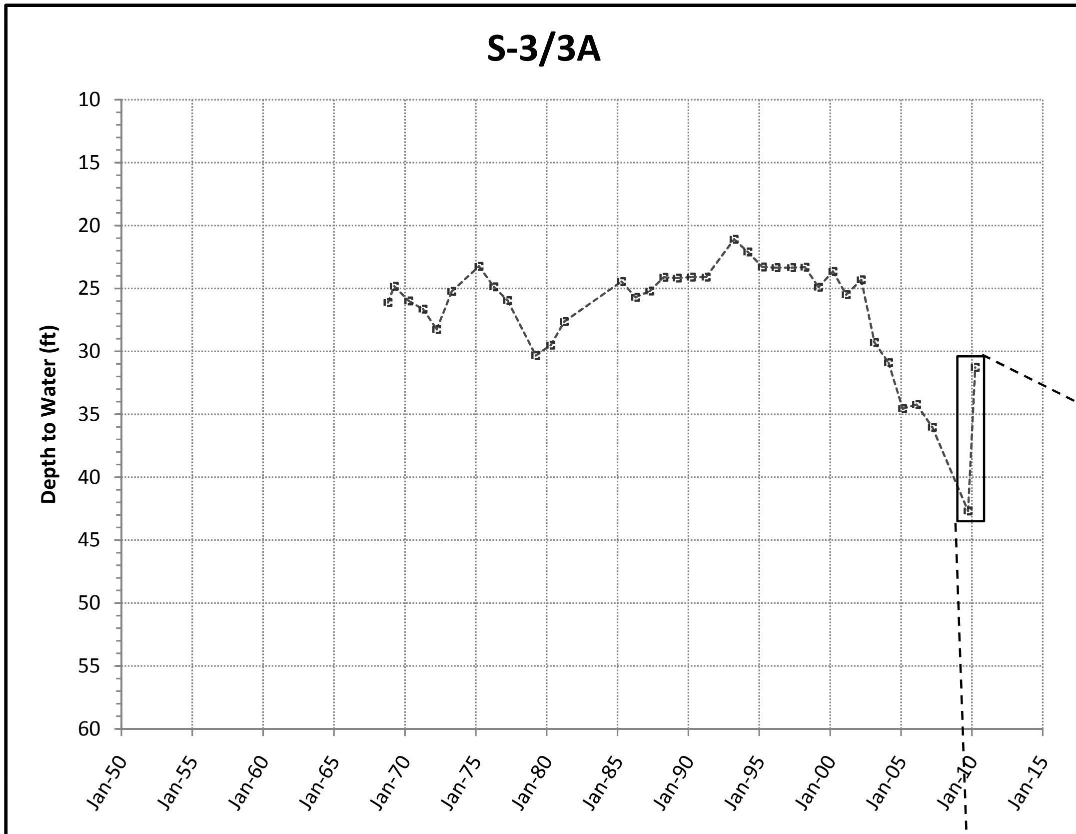

N-8
Depth to Water (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15

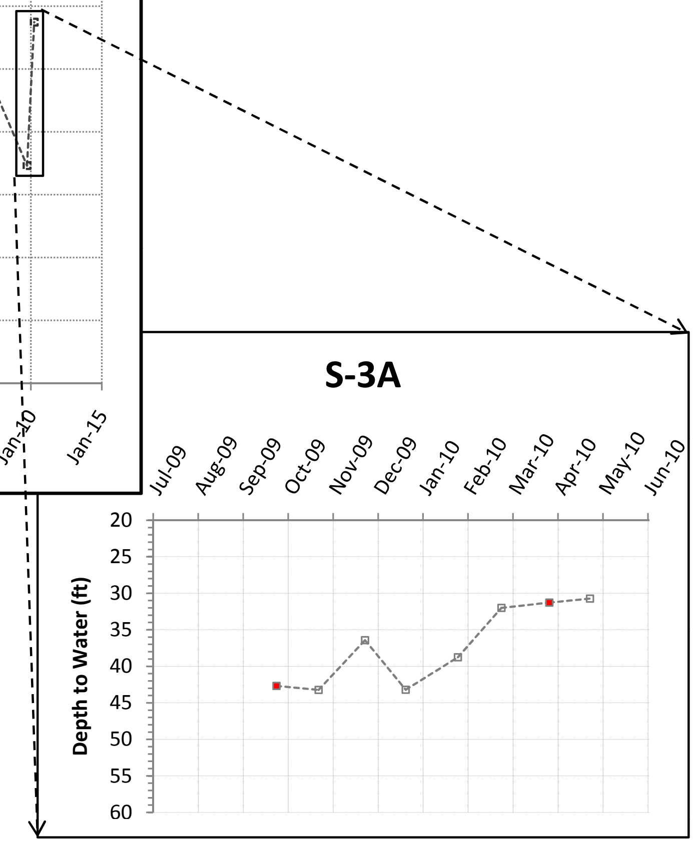


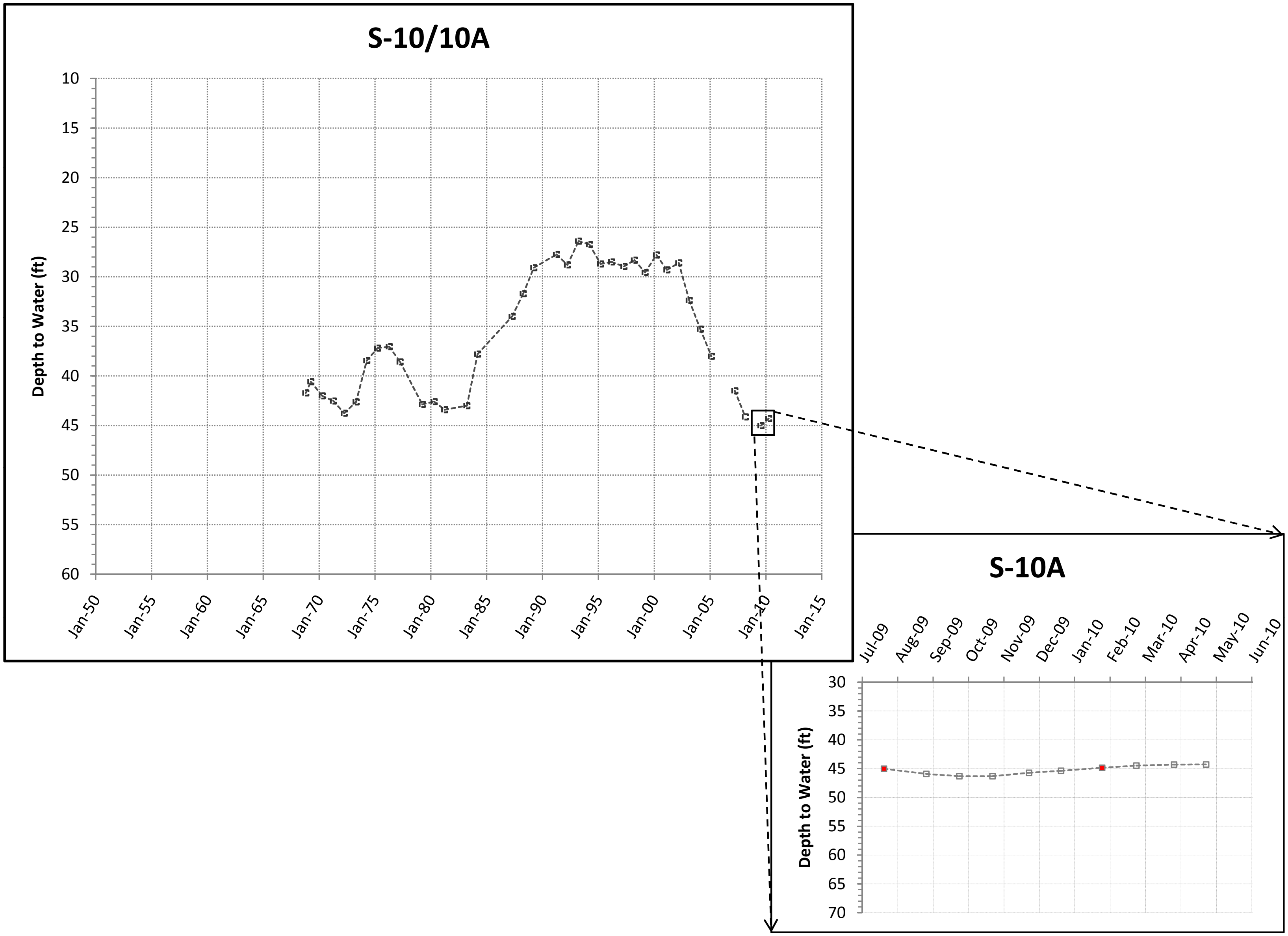
N-11
Depth to Water (ft)
20
25
30
35
40
45
50
55
60
65
70
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
N-11
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
20
25
30
35
40
45
50
55
60


S-1A
Depth to Water (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
S-1A
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
10
15
20
25
30
35
40
45
50

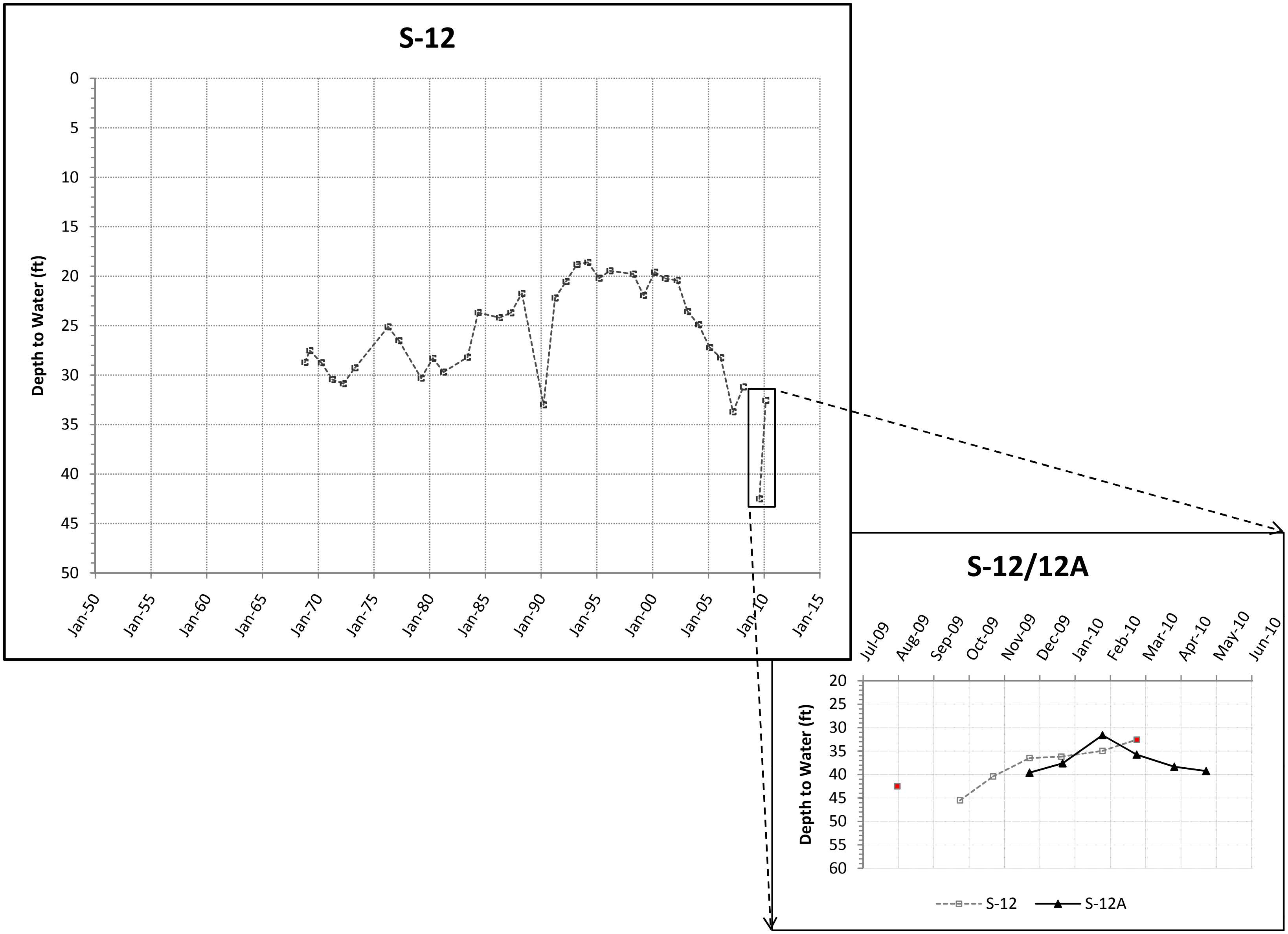

S-2
Depth to Water (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
S-2
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
10
15
20
25
30
35
40
45
50


S-3/3A
Depth to Water (ft)
10
15
20
25
30
35
40
45
50
55
60
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15


S-3A
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
20
25
30
35
40
45
50
55
60



S-10/10A
Depth to Water (ft)
10
15
20
25
30
35
40
45
50
55
60
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
S-10A
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
30
35
40
45
50
55
60
65
70



S-12
Depth to Water (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
S-12/12A
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
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25
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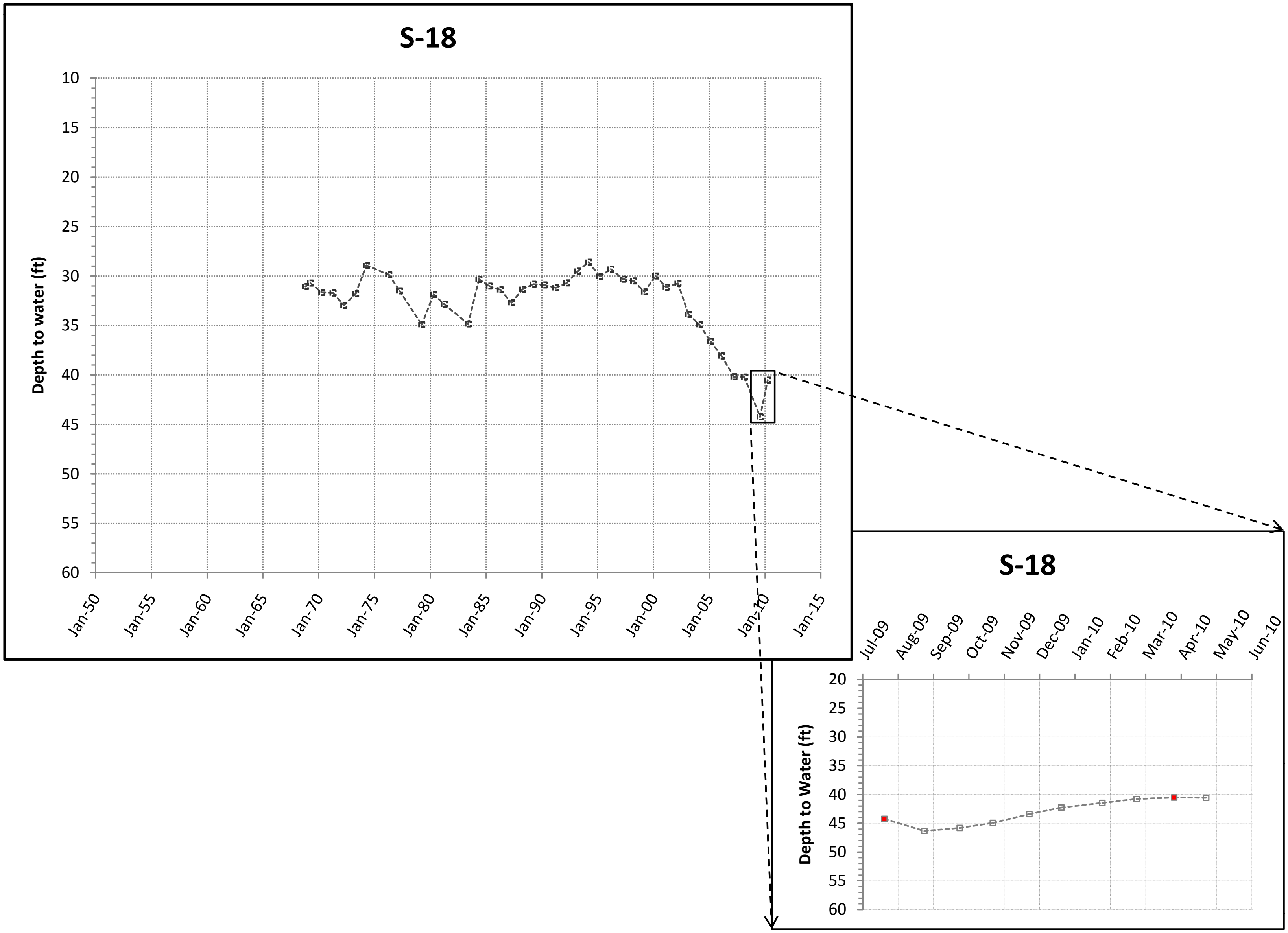
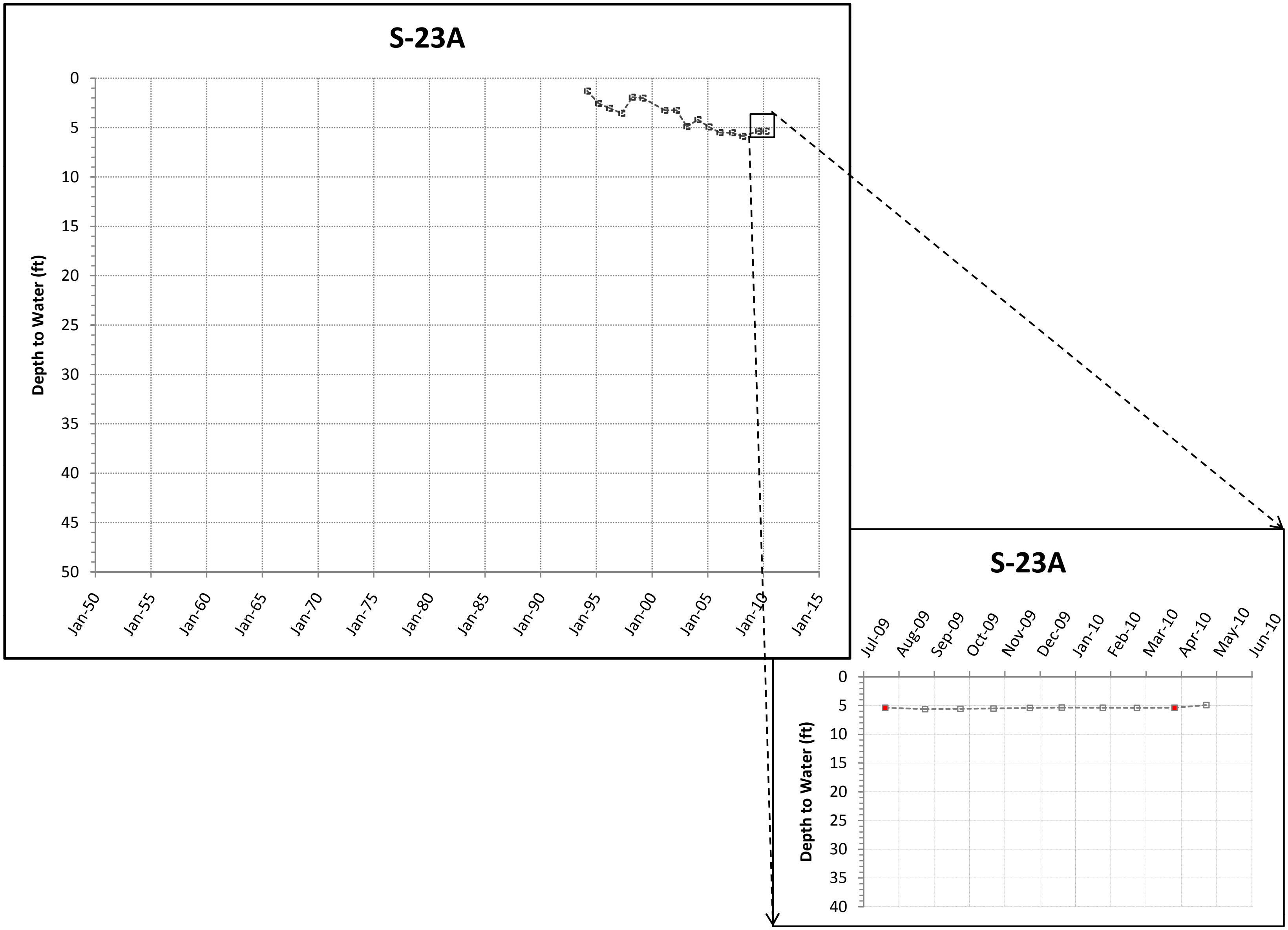
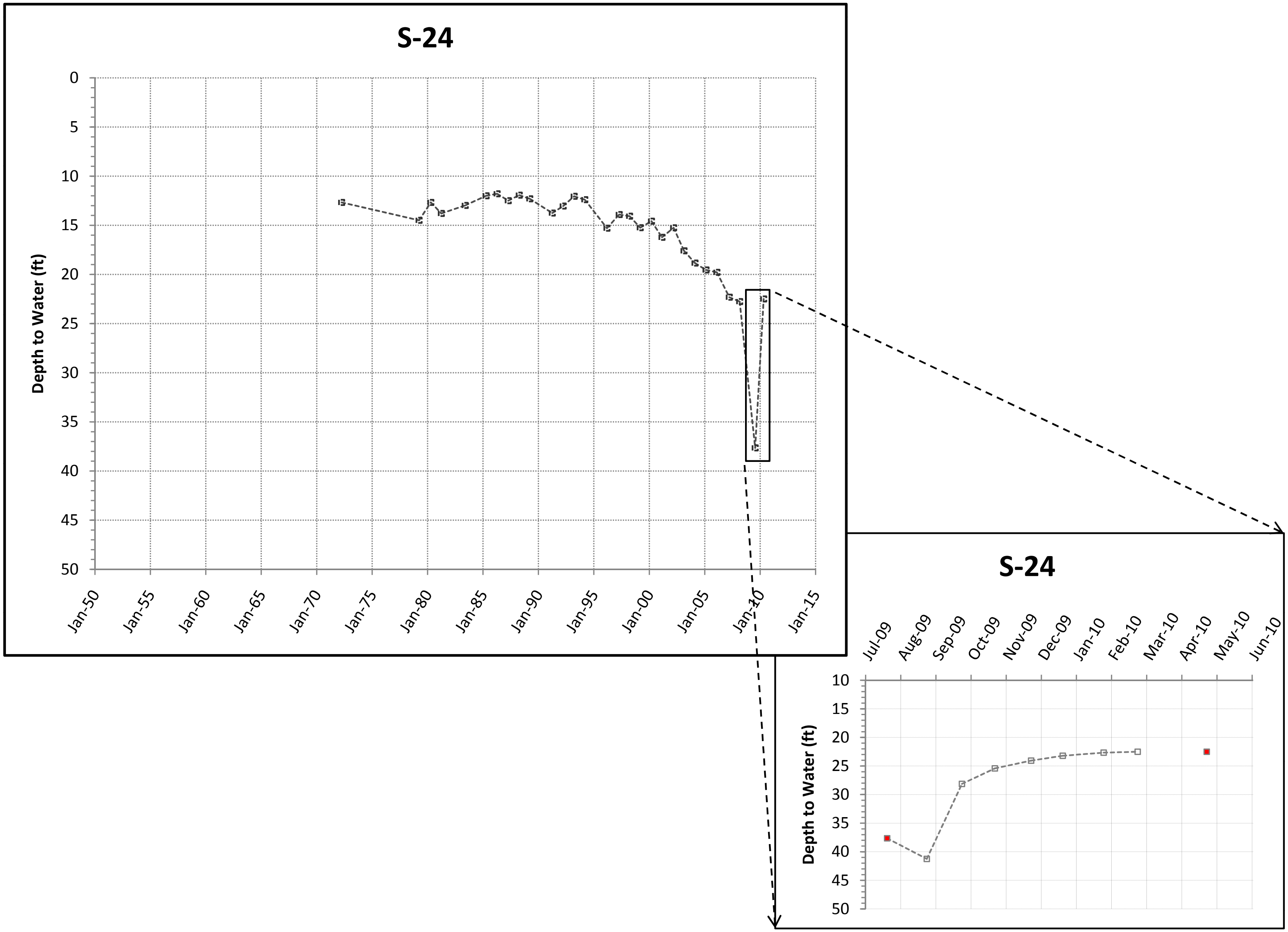
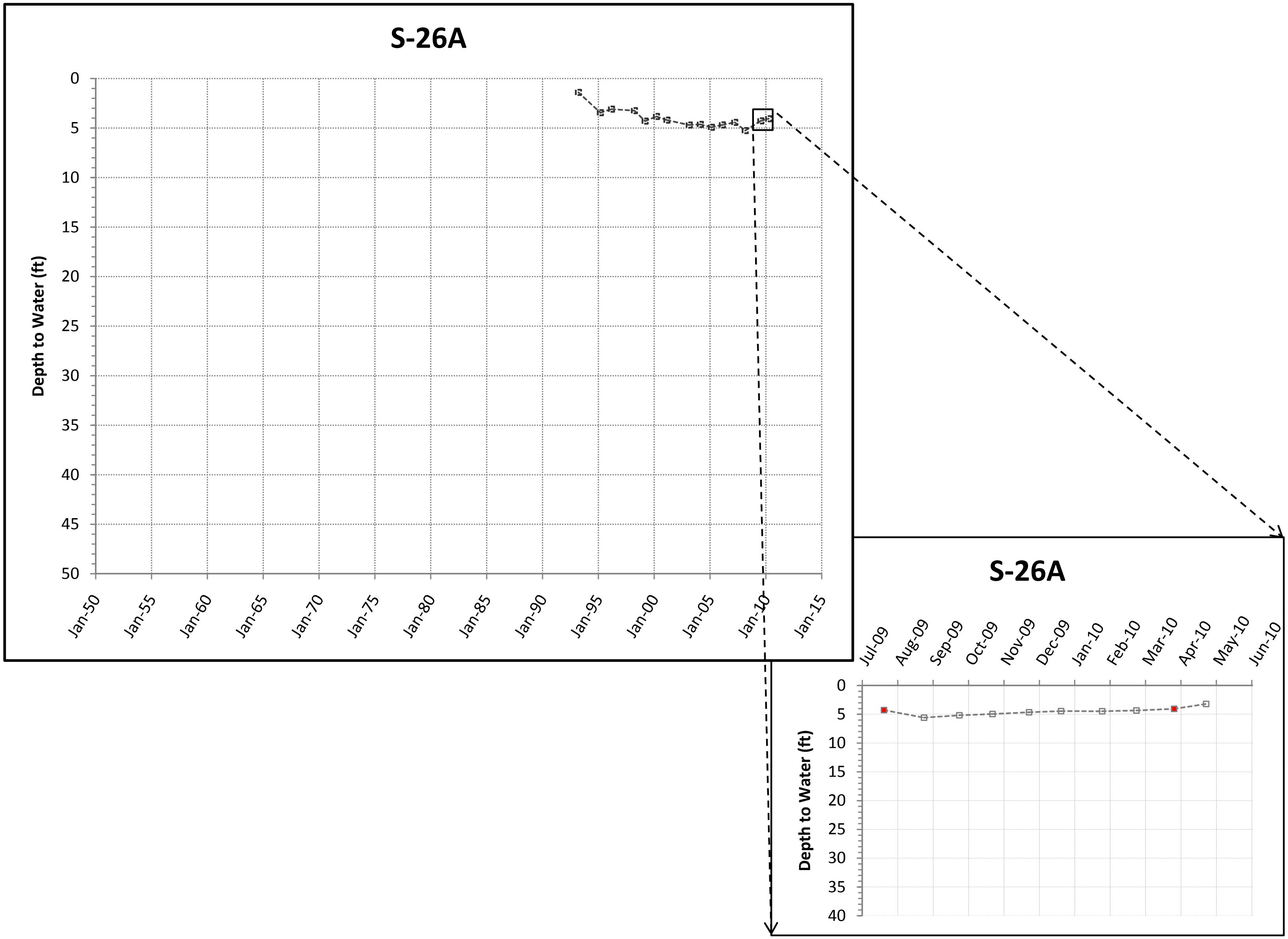
55
60
S-12
S-12A

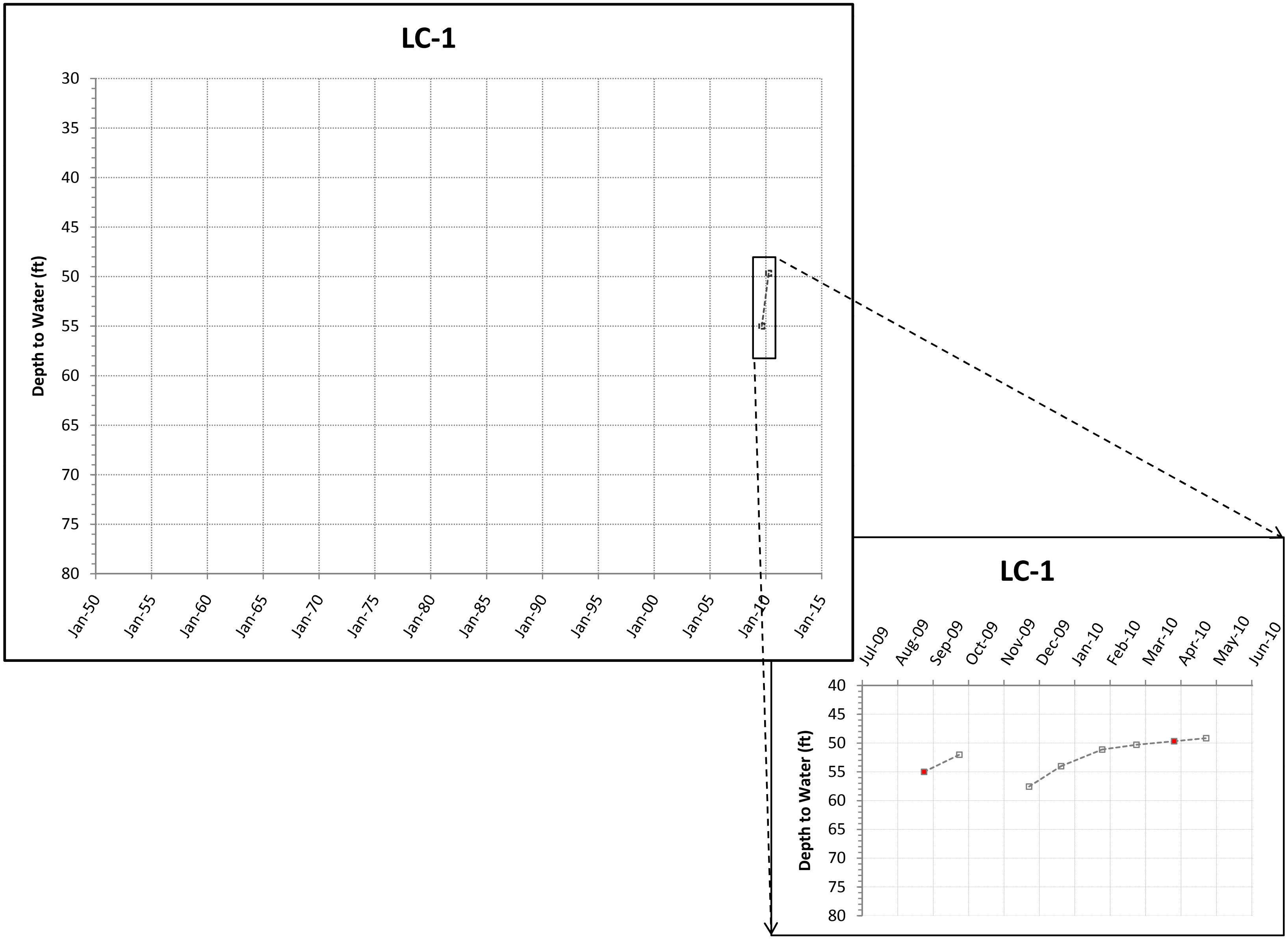

S-18
Depth to water (ft)
10
15
20
25
30
35
40
45
50
55
60
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
S-18
Depth to Water (ft)
20
25
30
35
40
45
50
55
60
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10

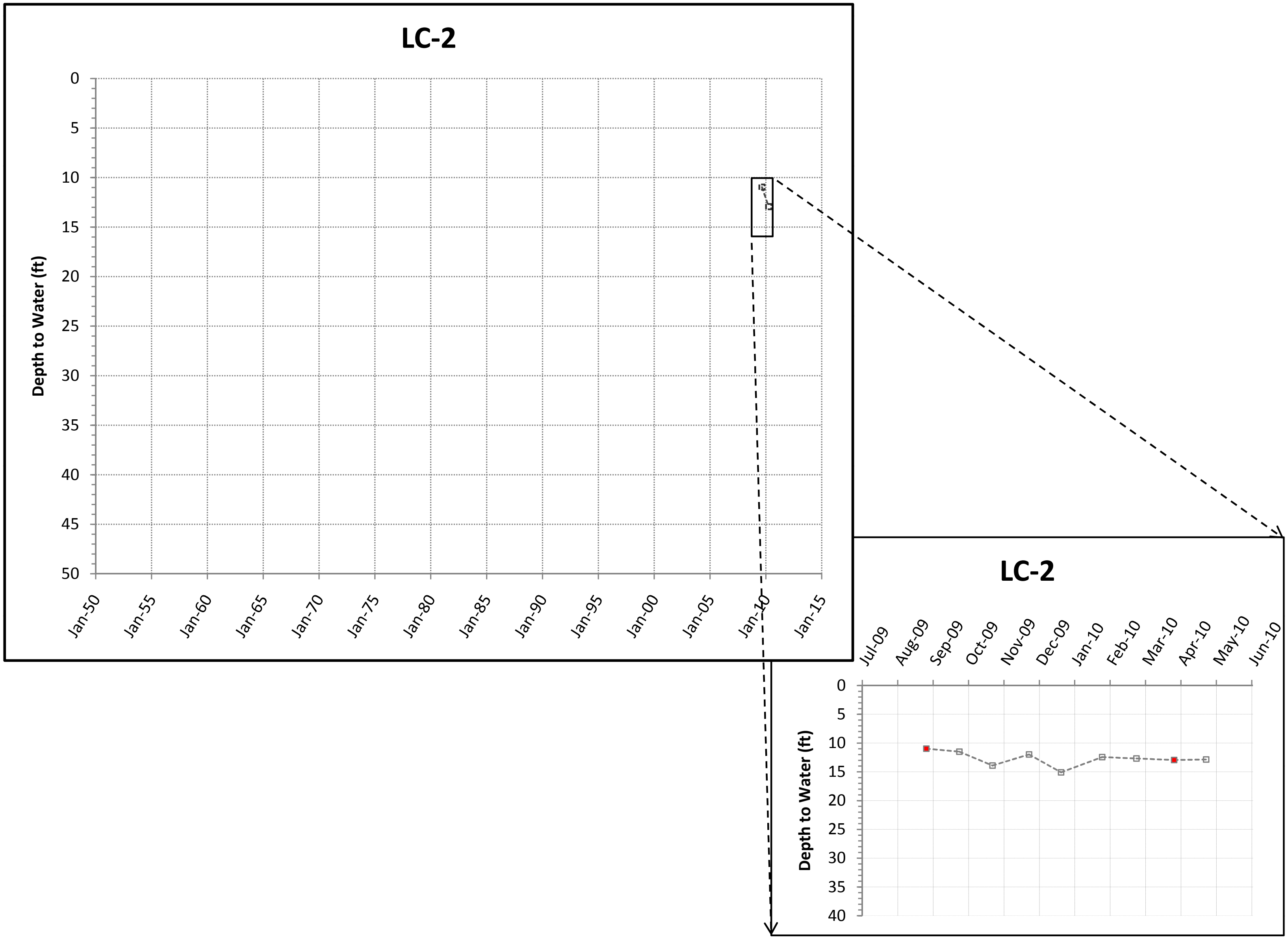


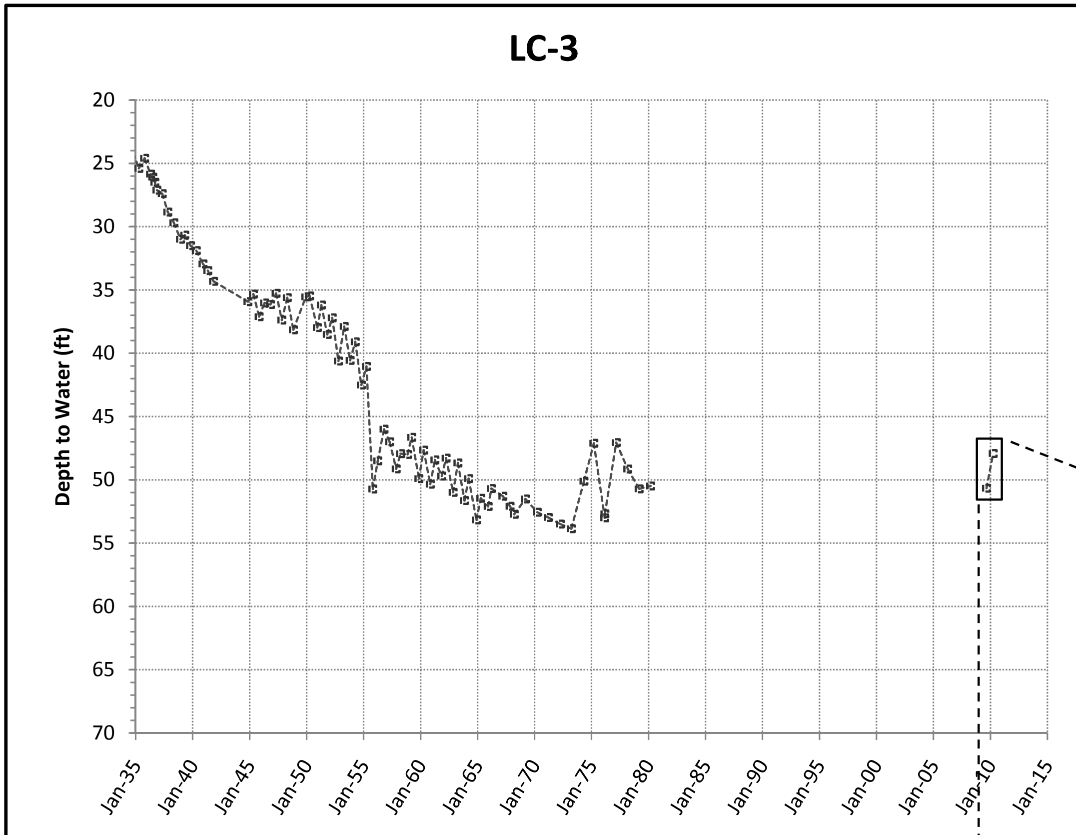
S-23A
Depth to Water (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
S-23A
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
0
5
10
15
20
25
30
35
40

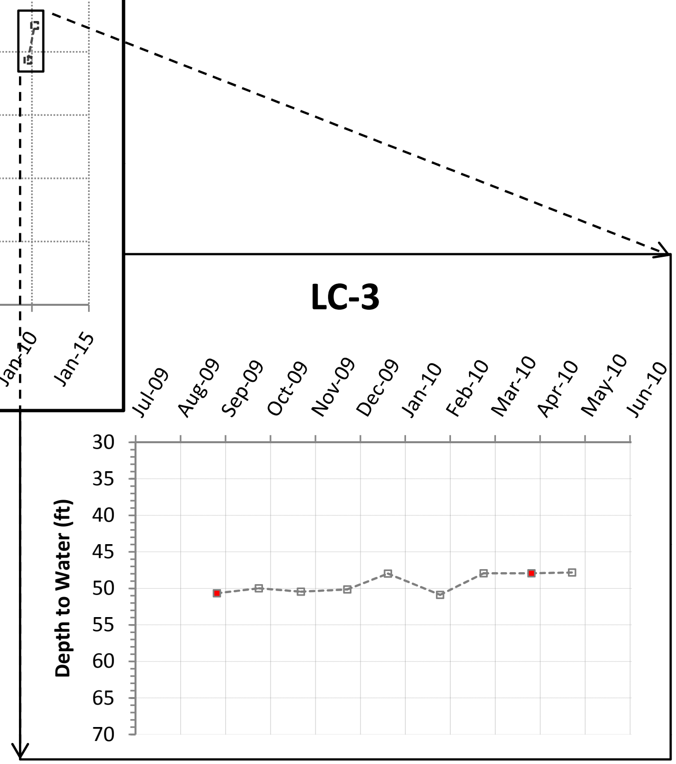

S-24
Depth to Water (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
S-24
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
10
15
20
25
30
35
40
45
50

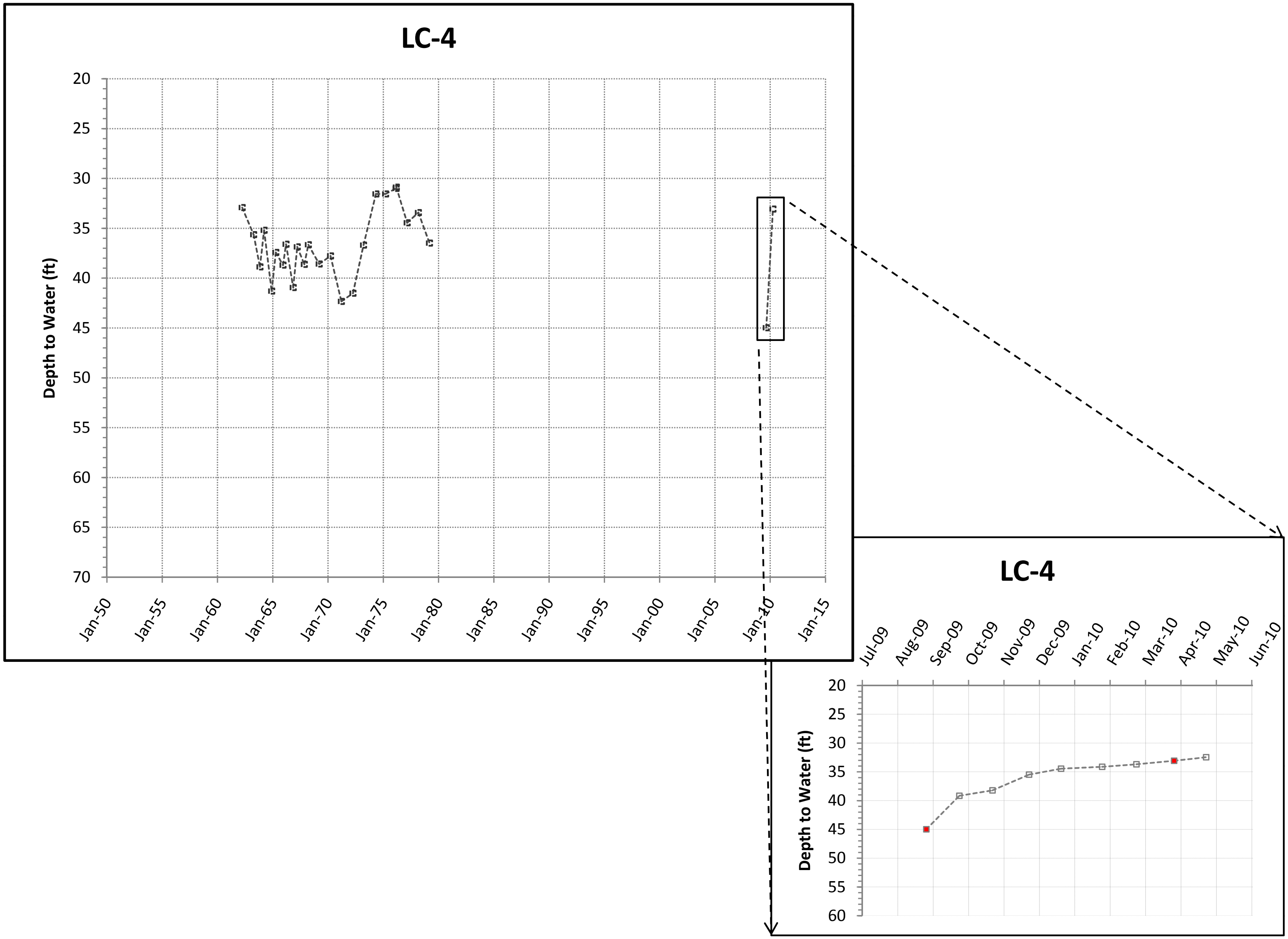

S-26A
Depth to Water (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
S-26A
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
0
5
10
15
20
25
30
35
40

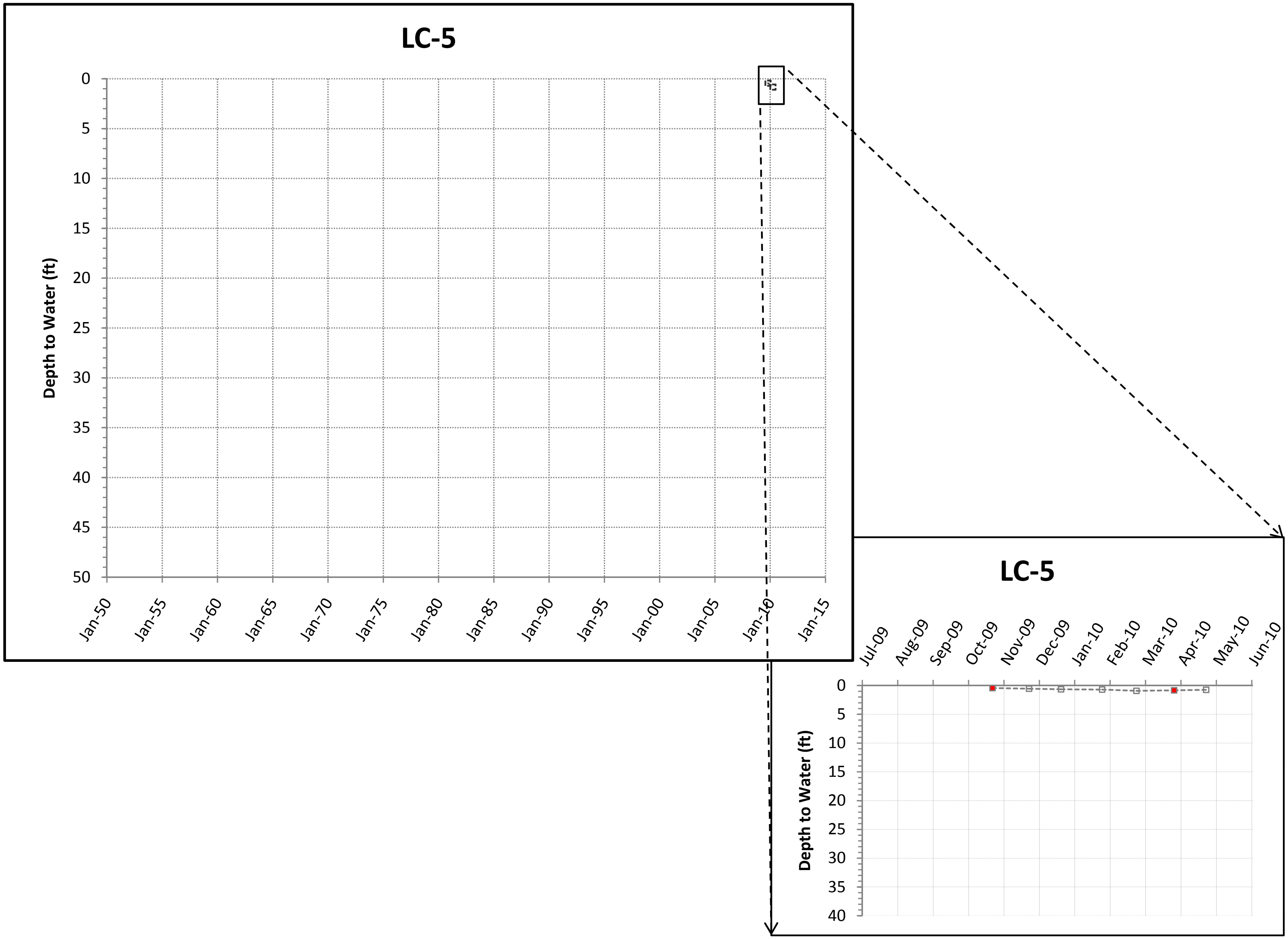

LC-1
Depth to Water (ft)
30
35
40
45
50
55
60
65
70
75
80
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
LC-1
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
40
45
50
55
60
65
70
75
80


LC-2
Depth to Water (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
LC-2
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
0
5
10
15
20
25
30
35
40

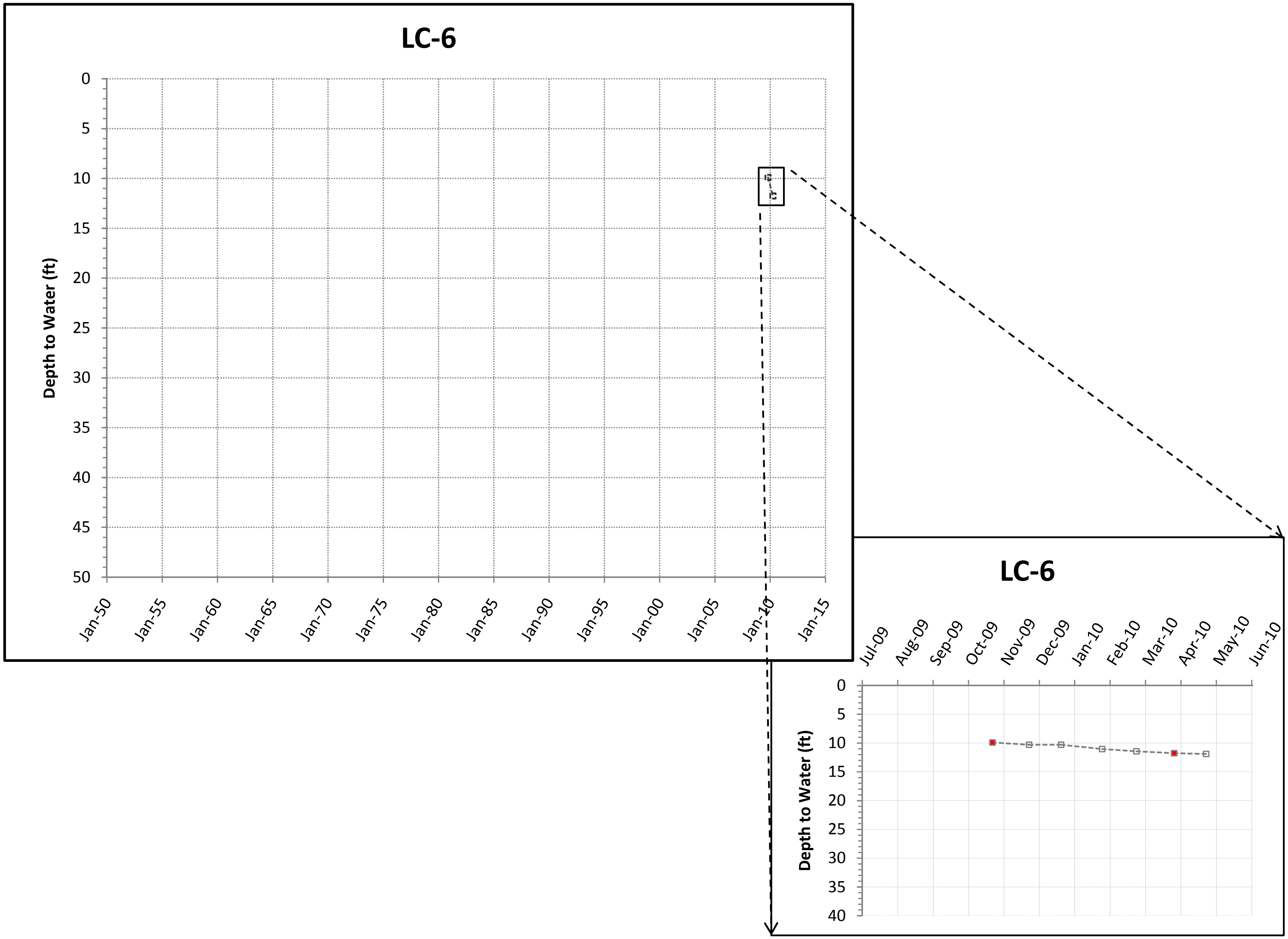

LC-3
Depth to Water (ft)
20
25
30
35
40
45
50
55
60
65
70
Jan-35
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15

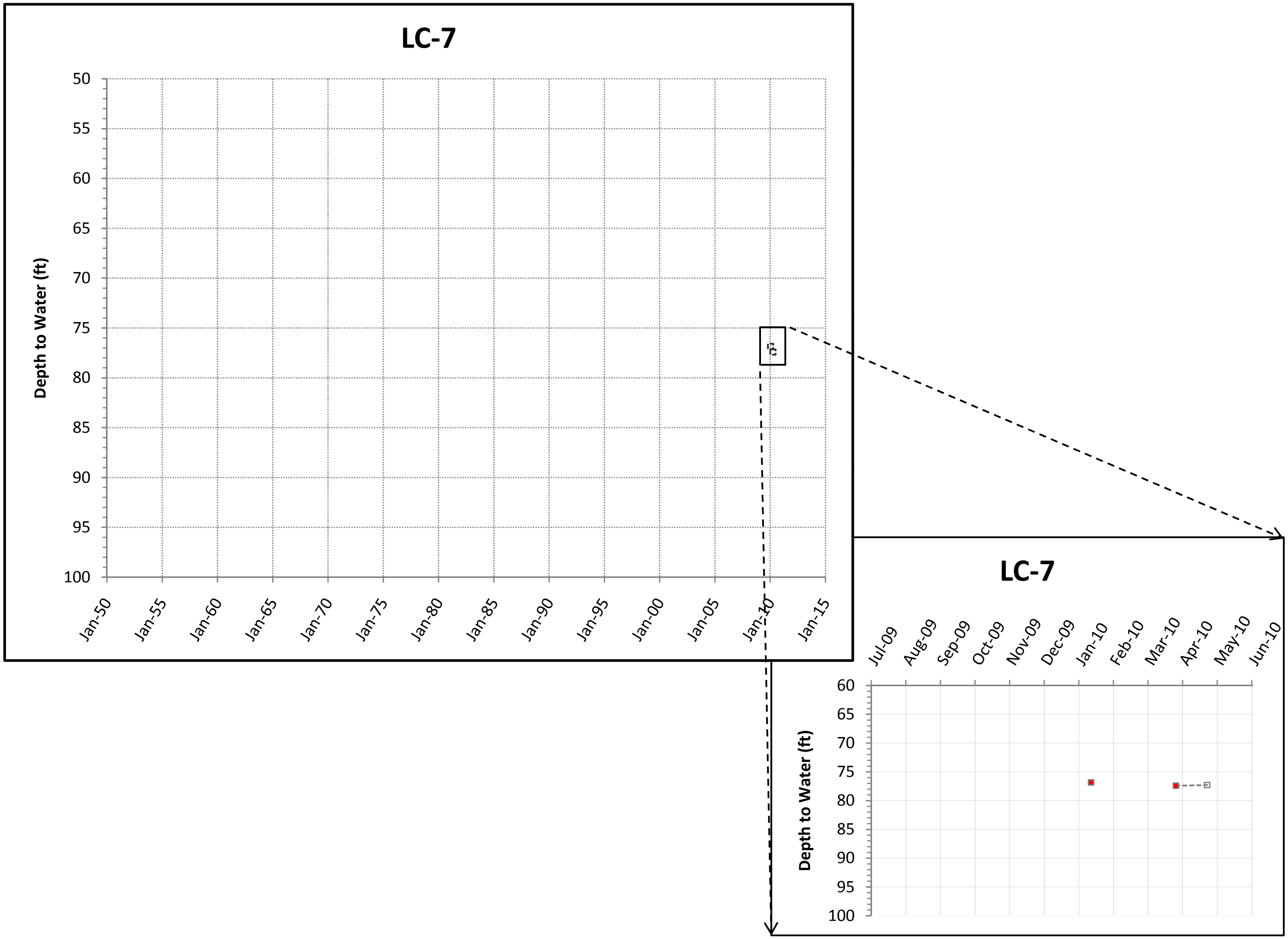

LC-3
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
30
35
40
45
50
55
60
65
70


LC-4
Depth to Water (ft)
20
25
30
35
40
45
50
55
60
65
70
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
LC-4
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
20
25
30
35
40
45
50
55
60

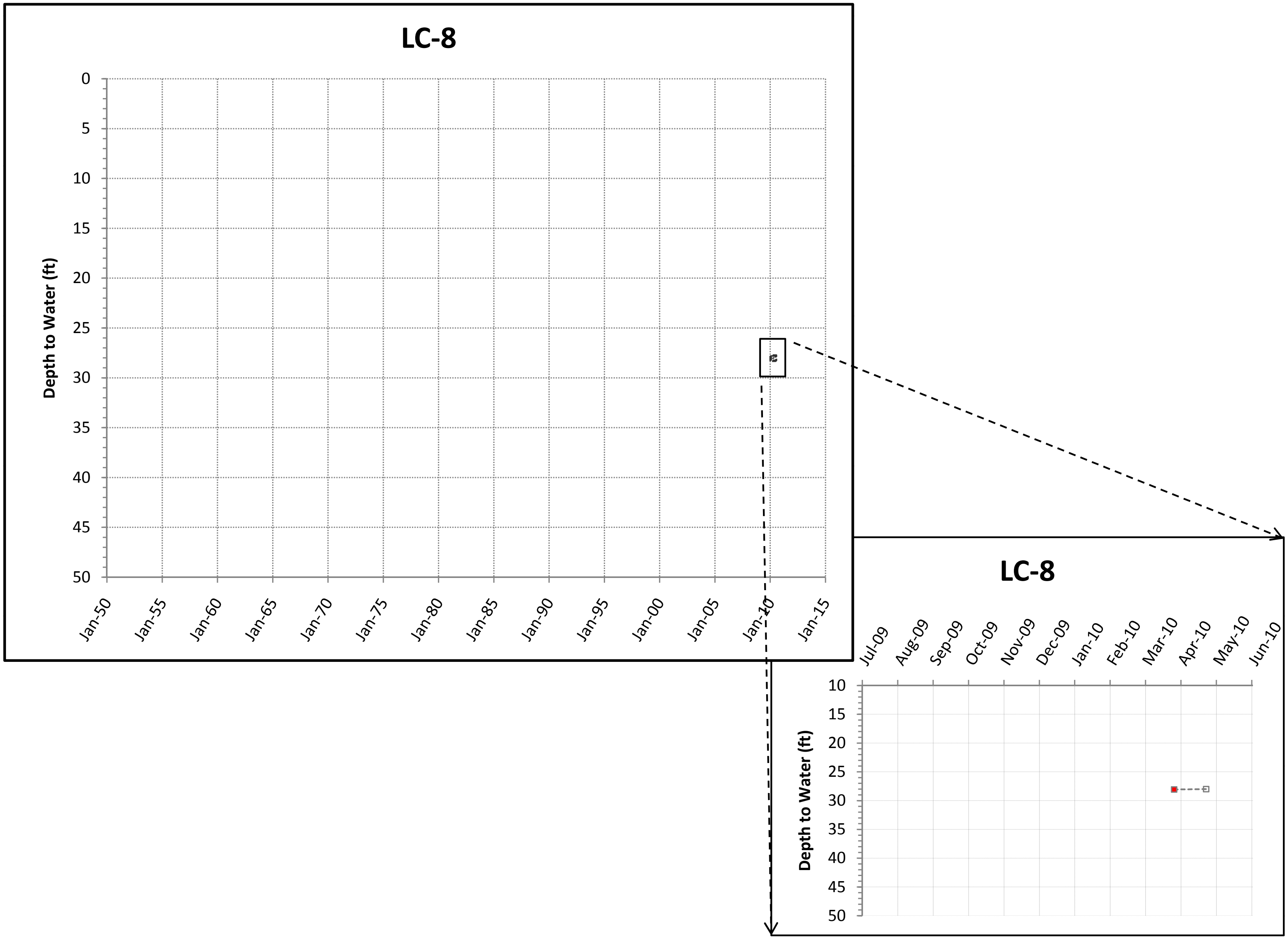


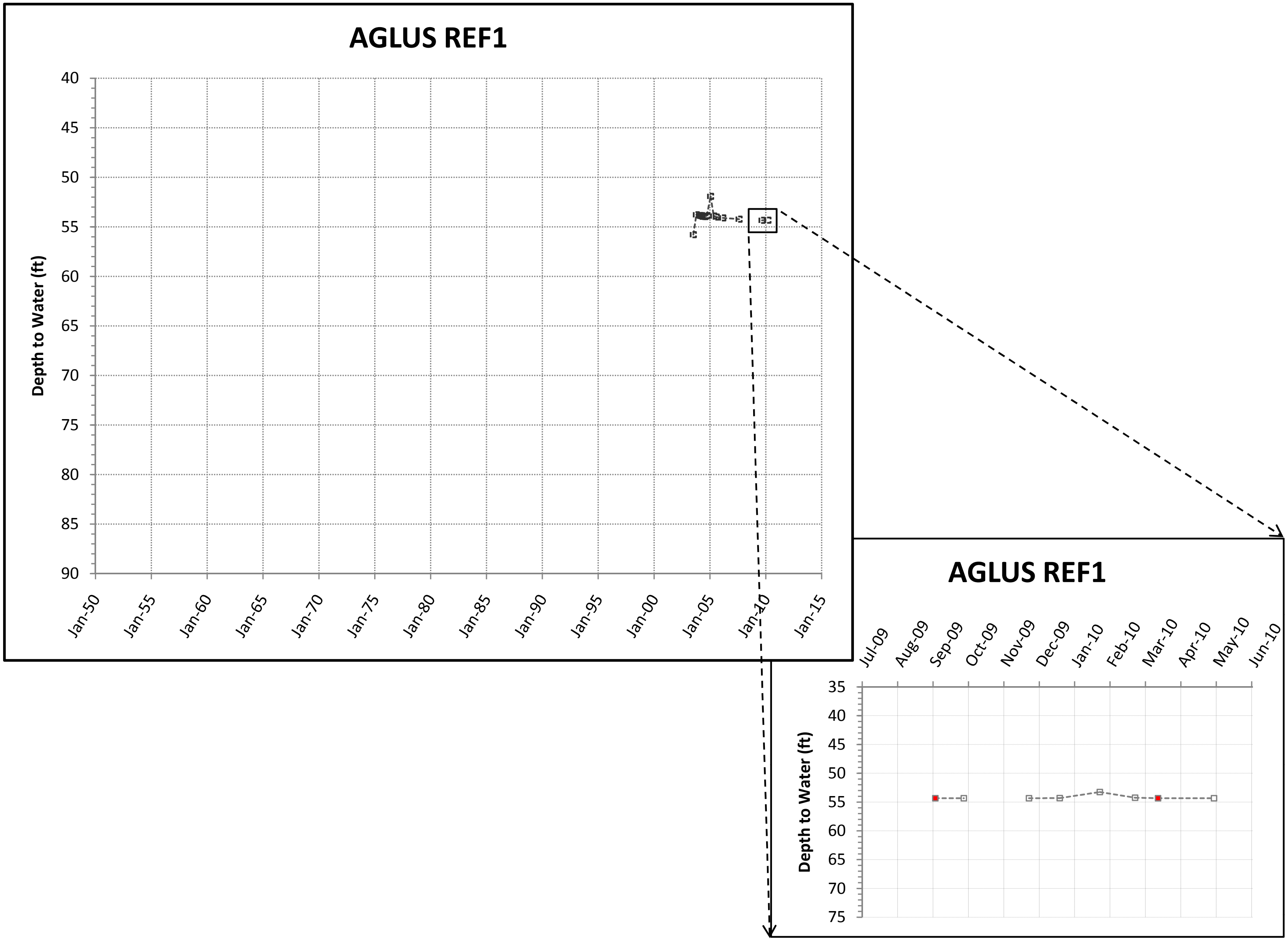
LC-5
Depth to Water (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
LC-5
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
0
5
10
15
20
25
30
35
40

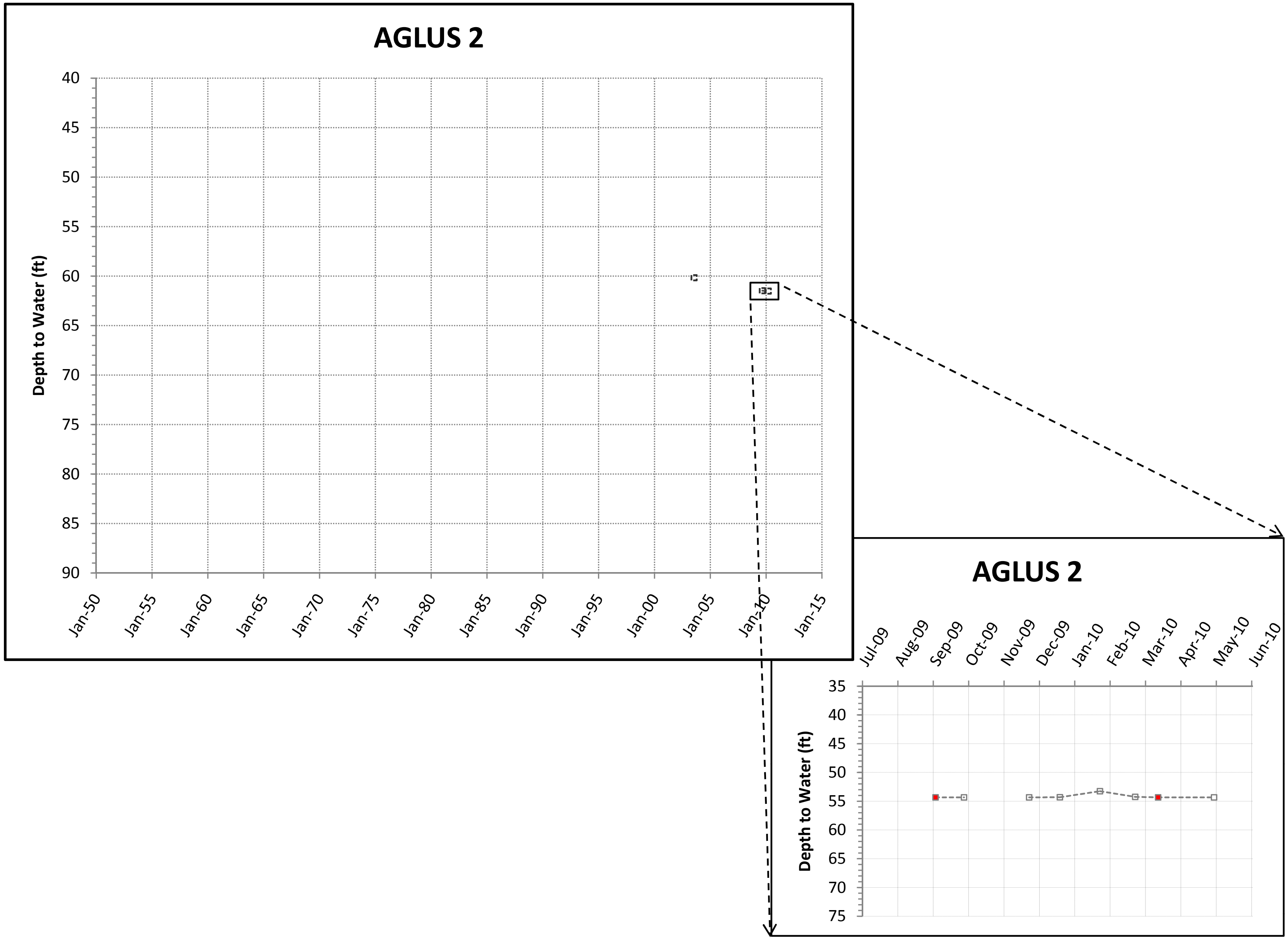

LC-6
Depth to Water (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
LC-6
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
0
5
10
15
20
25
30
35
40



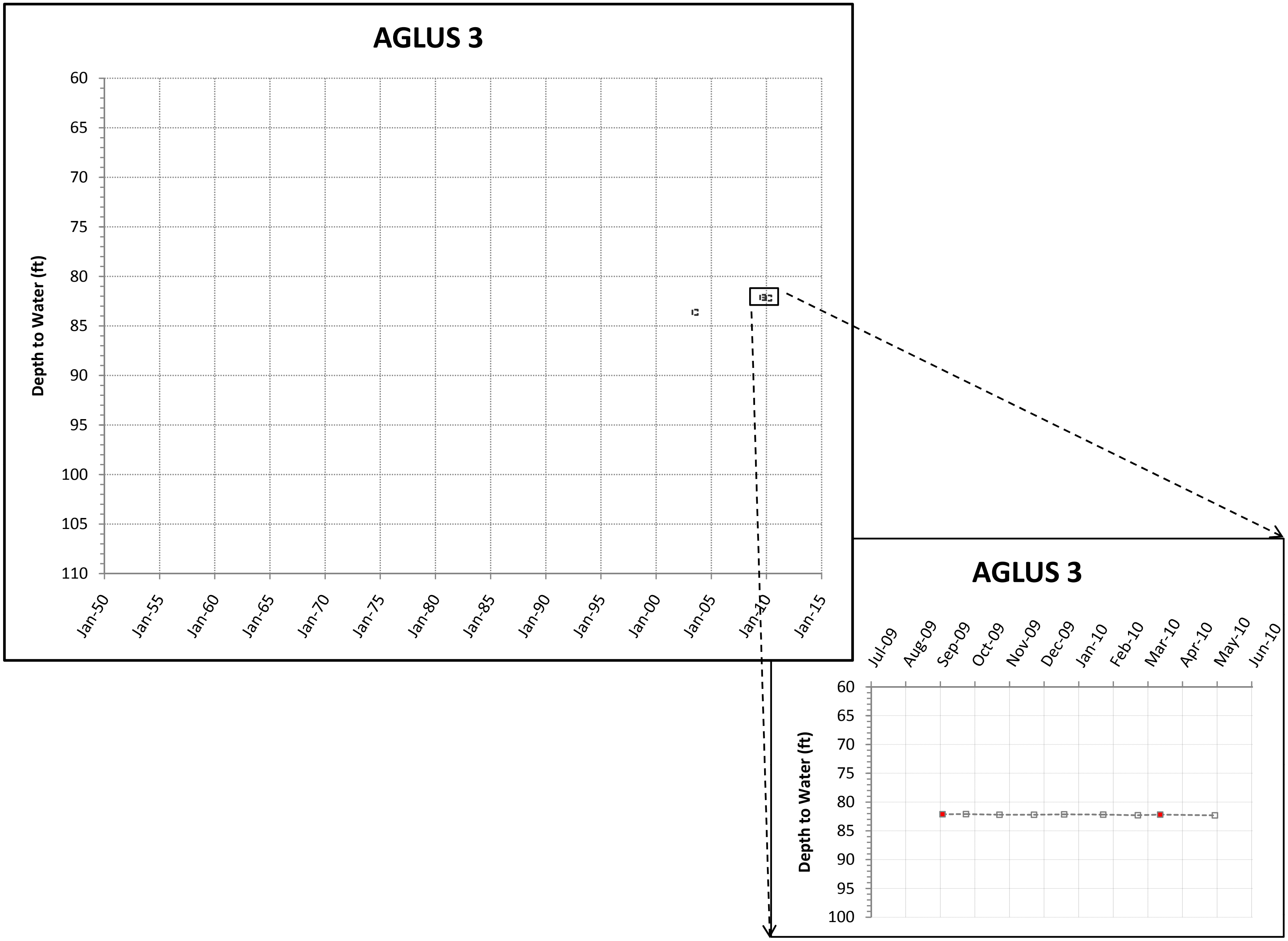
LC-7
Depth to Water (ft)
50
55
60
65
70
75
80
85
90
95
100
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
LC-7
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
60
65
70
75
80
85
90
95
100


LC-8
Depth to Water (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
LC-8
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
10
15
20
25
30
35
40
45
50

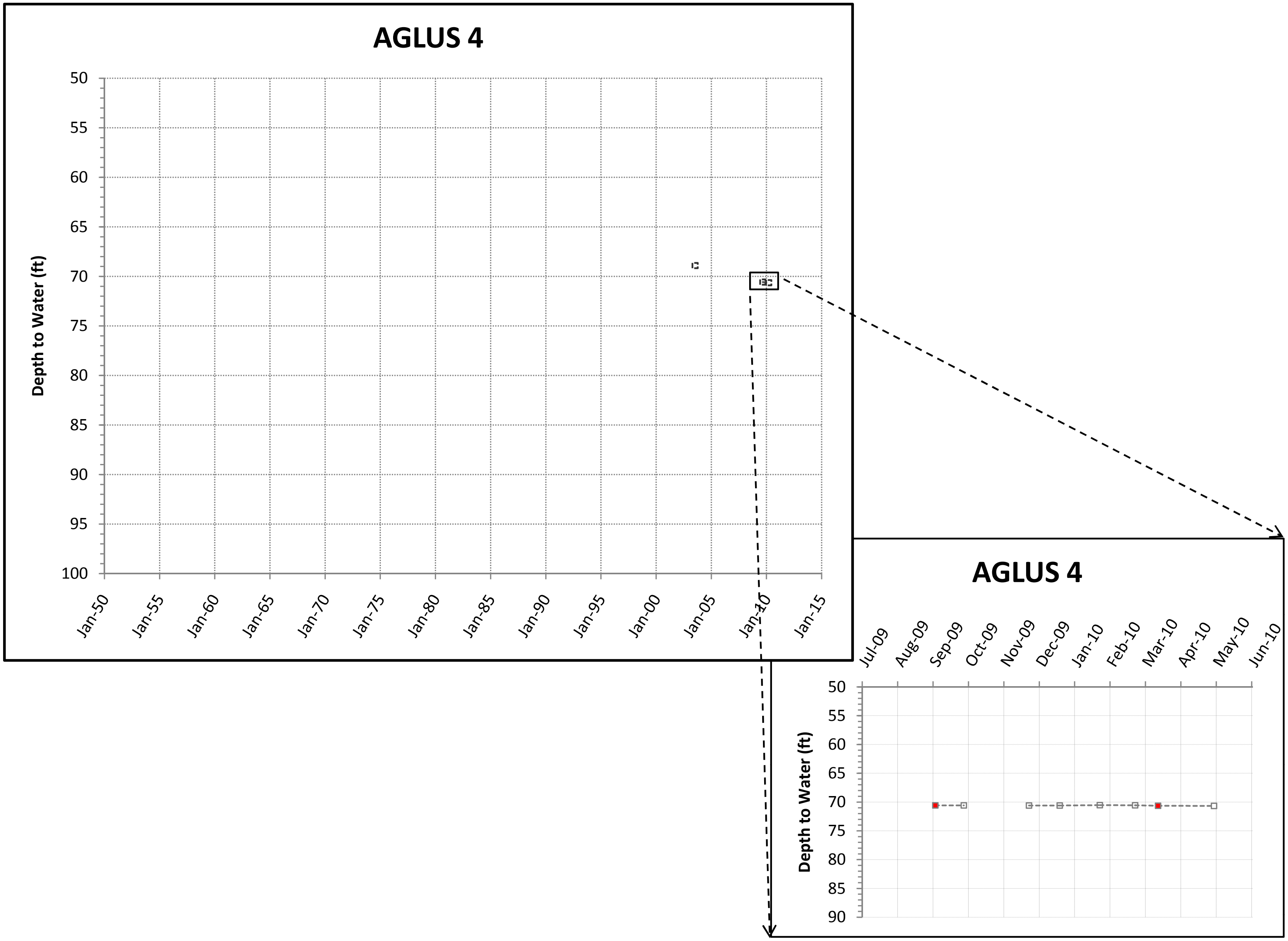

AGLUS REF1
Depth to Water (ft)
40
45
50
55
60
65
70
75
80
85
90
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
AGLUS REF1
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
35
40
45
50
55
60
65
70
75

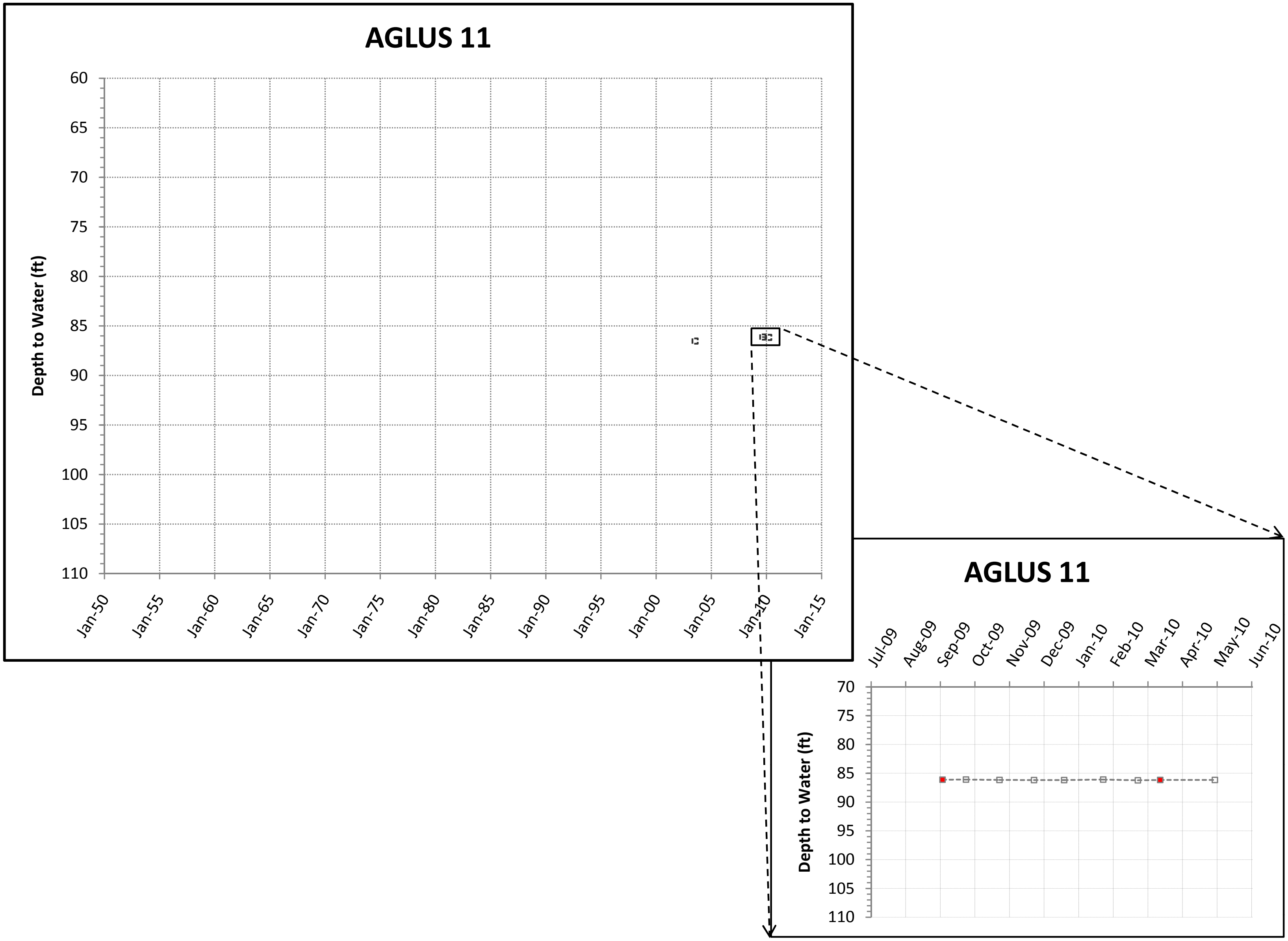


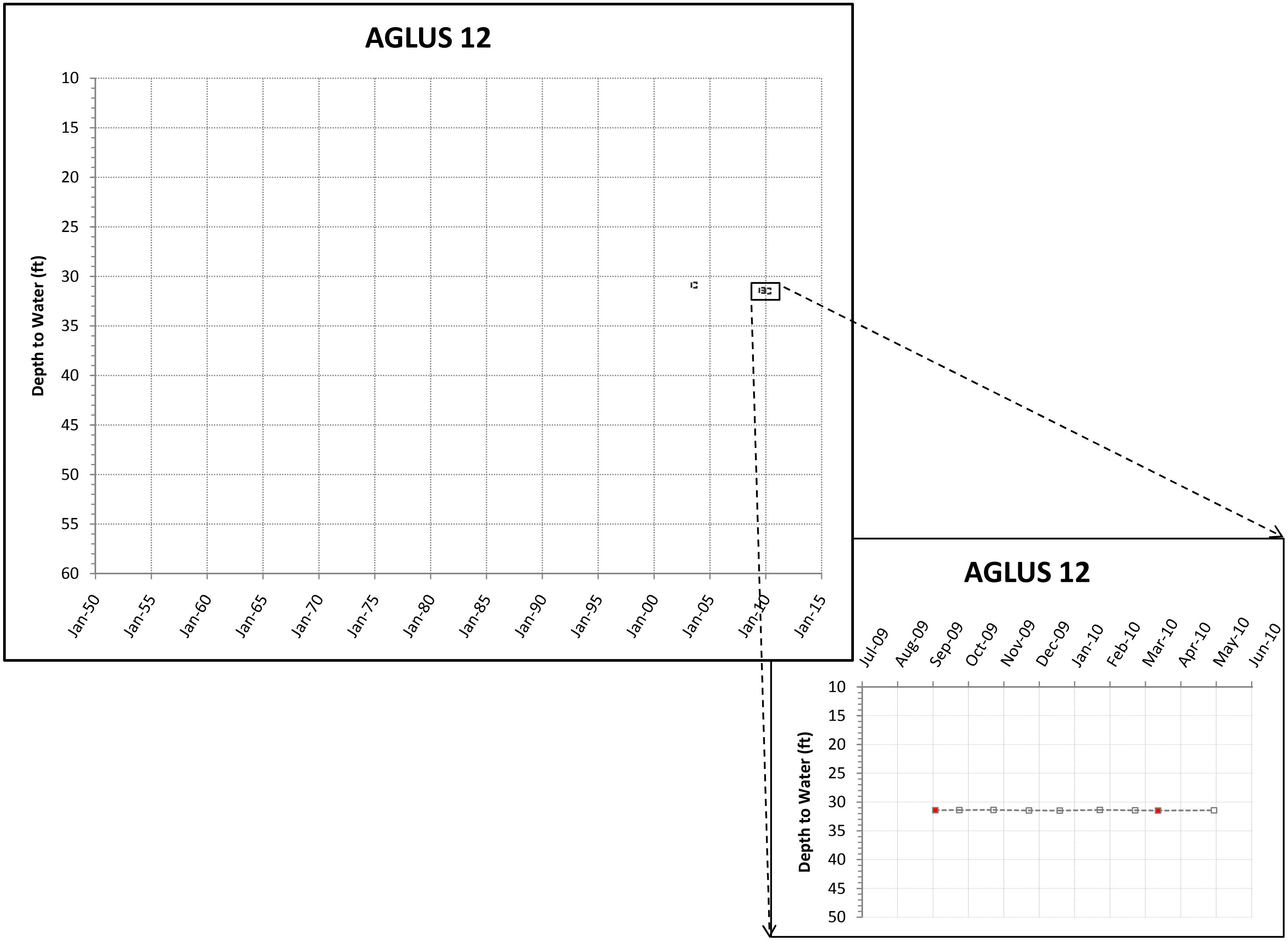
AGLUS 2
Depth to Water (ft)
40
45
50
55
60
65
70
75
80
85
90
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
AGLUS 2
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
35
40
45
50
55
60
65
70
75



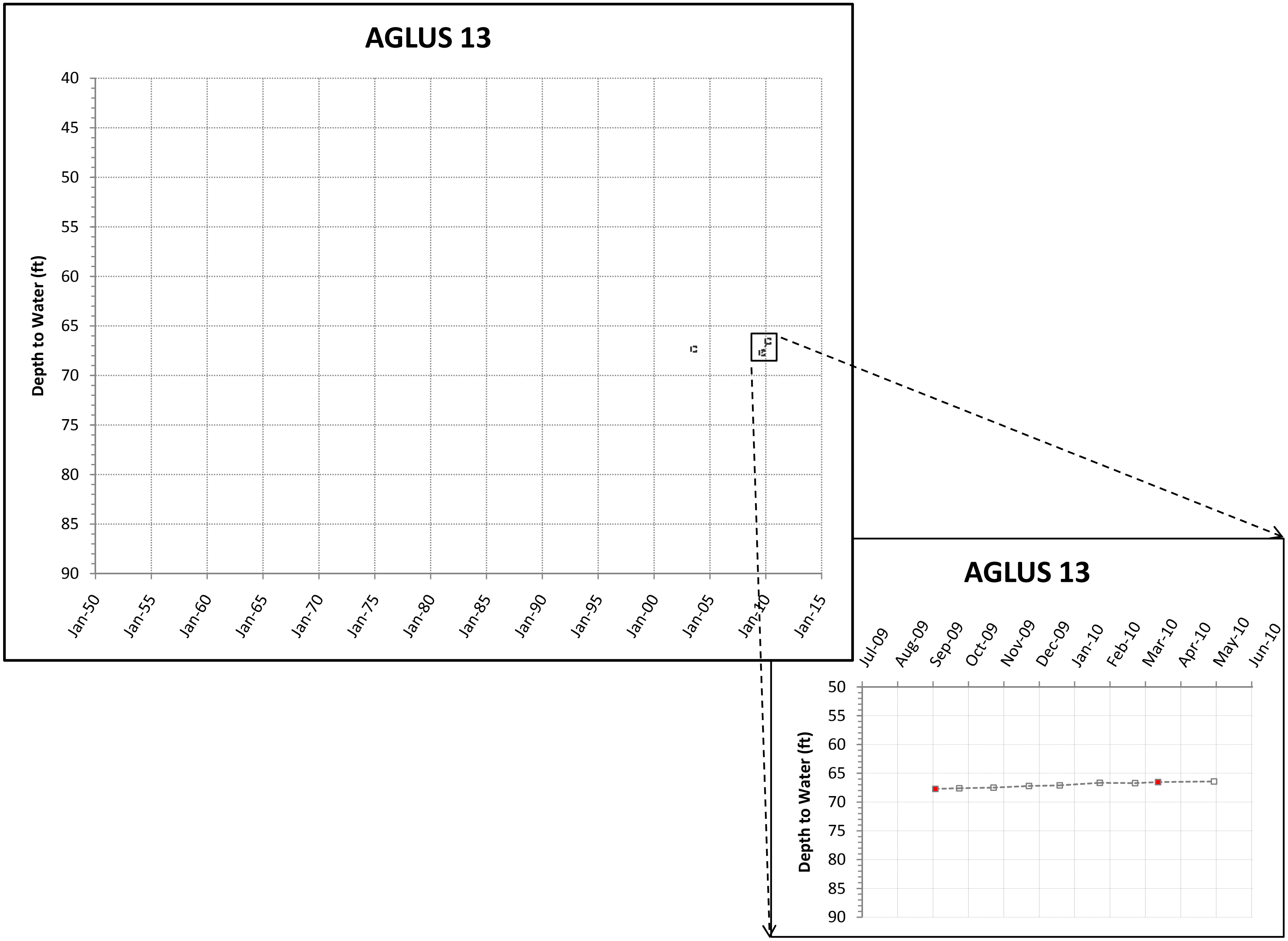
AGLUS 3
Depth to Water (ft)
60
65
70
75
80
85
90
95
100
105
110
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
AGLUS 3
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
60
65
70
75
80
85
90
95
100


AGLUS 4
Depth to Water (ft)
50
55
60
65
70
75
80
85
90
95
100
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
AGLUS 4
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
50
55
60
65
70
75
80
85
90

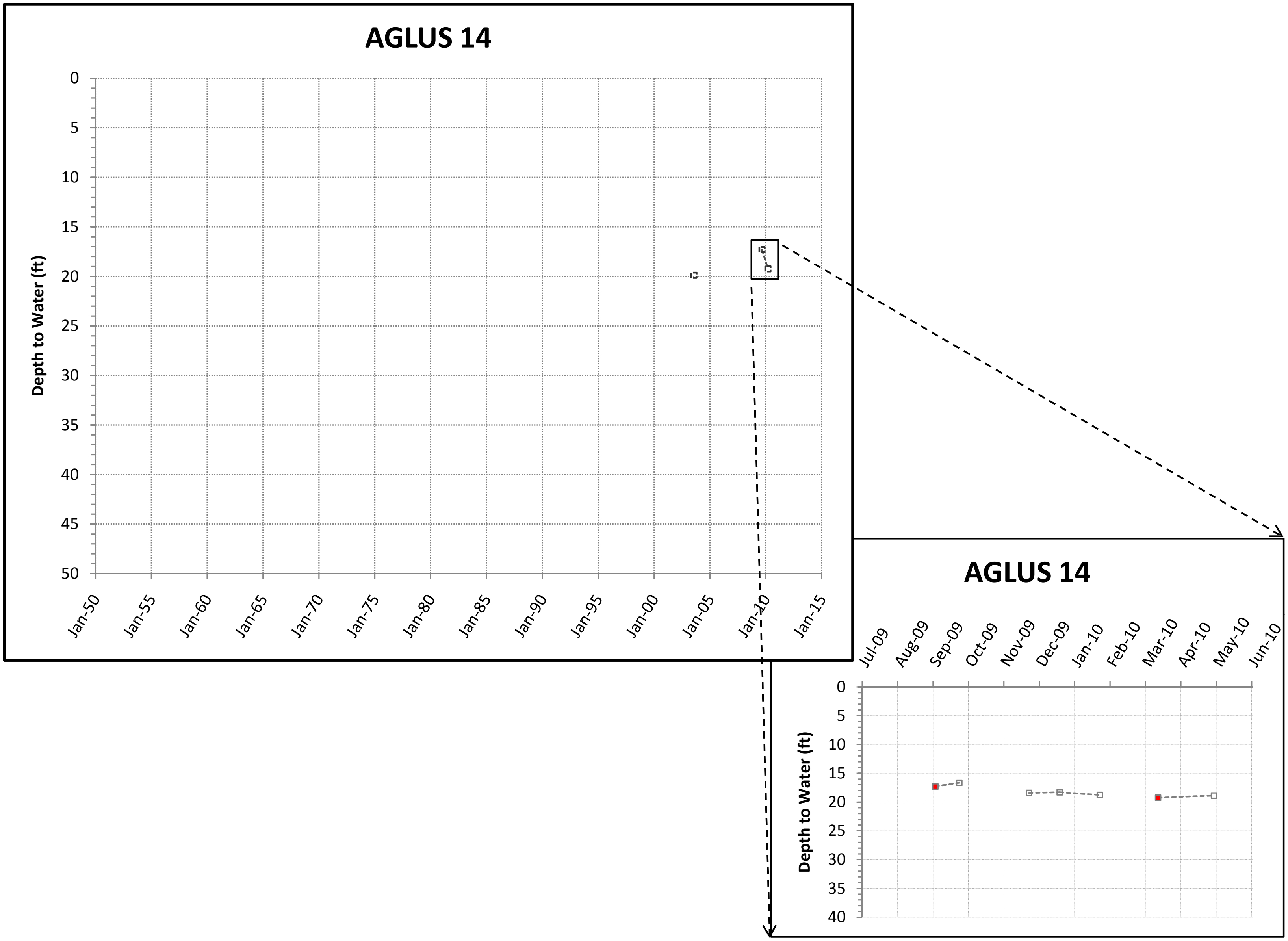

AGLUS 11
Depth to Water (ft)
60
65
70
75
80
85
90
95
100
105
110
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
AGLUS 11
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
70
75
80
85
90
95
100
105
110

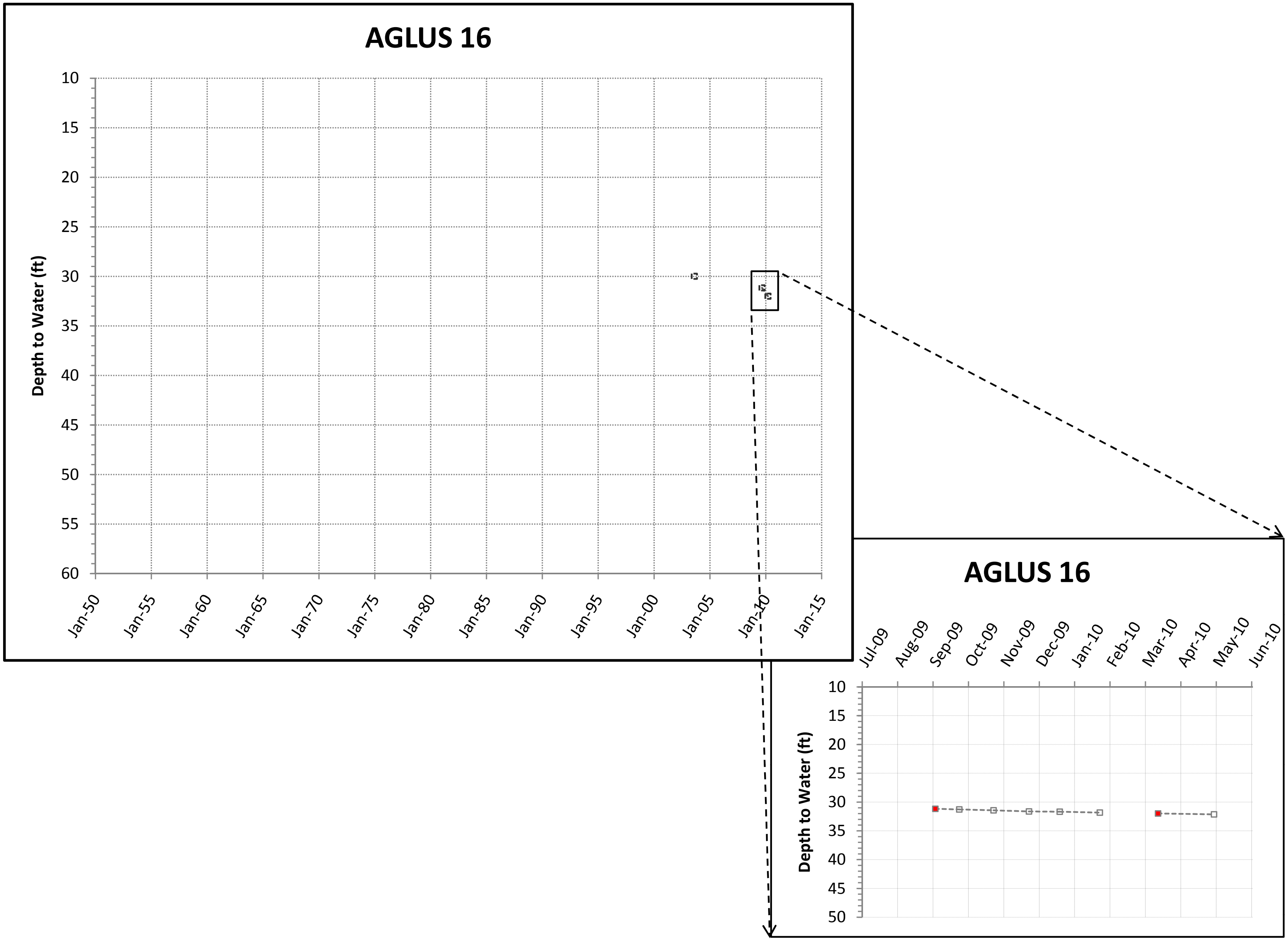


AGLUS 12
Depth to Water (ft)
10
15
20
25
30
35
40
45
50
55
60
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
AGLUS 12
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
10
15
20
25
30
35
40
45
50

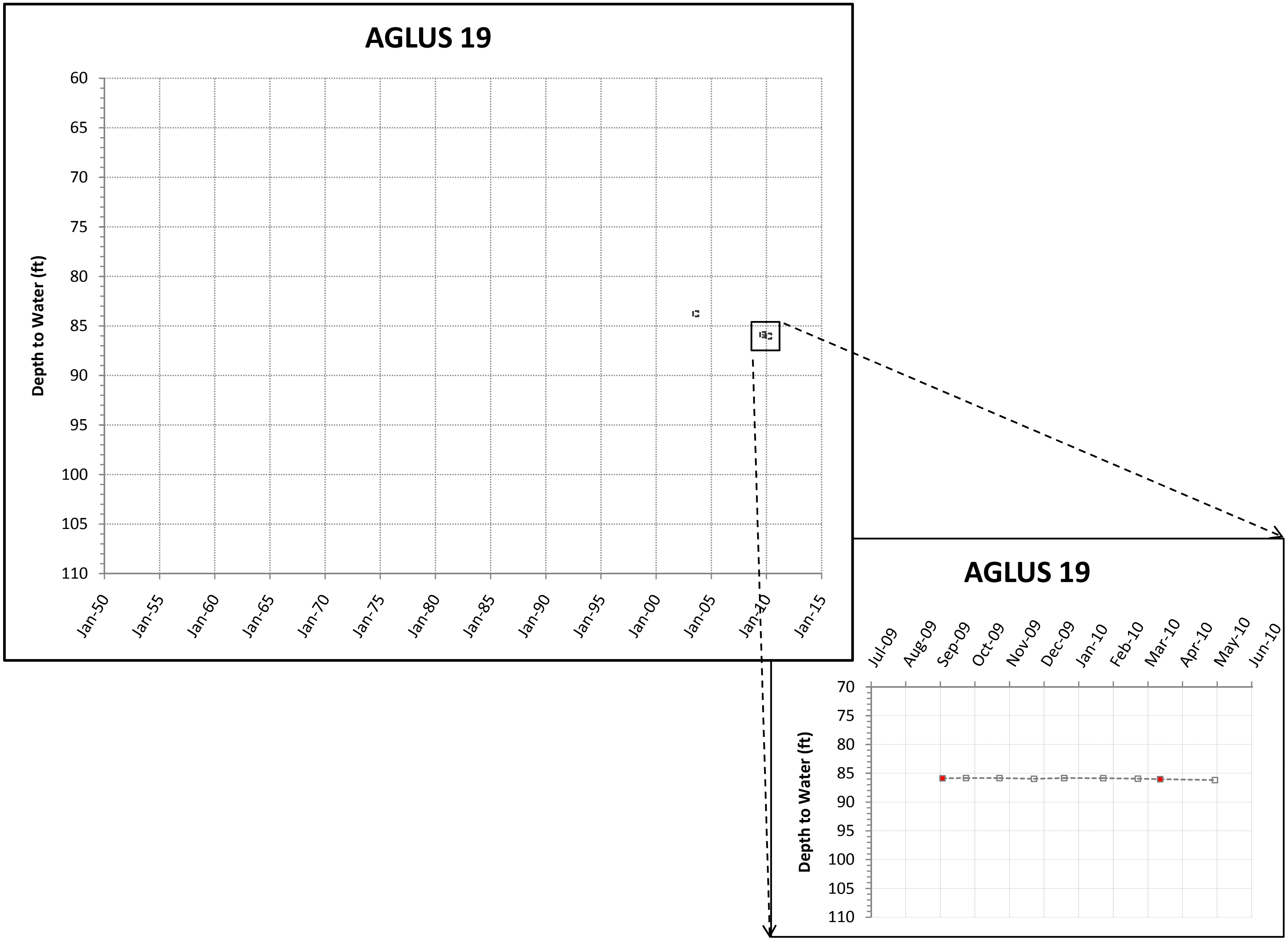


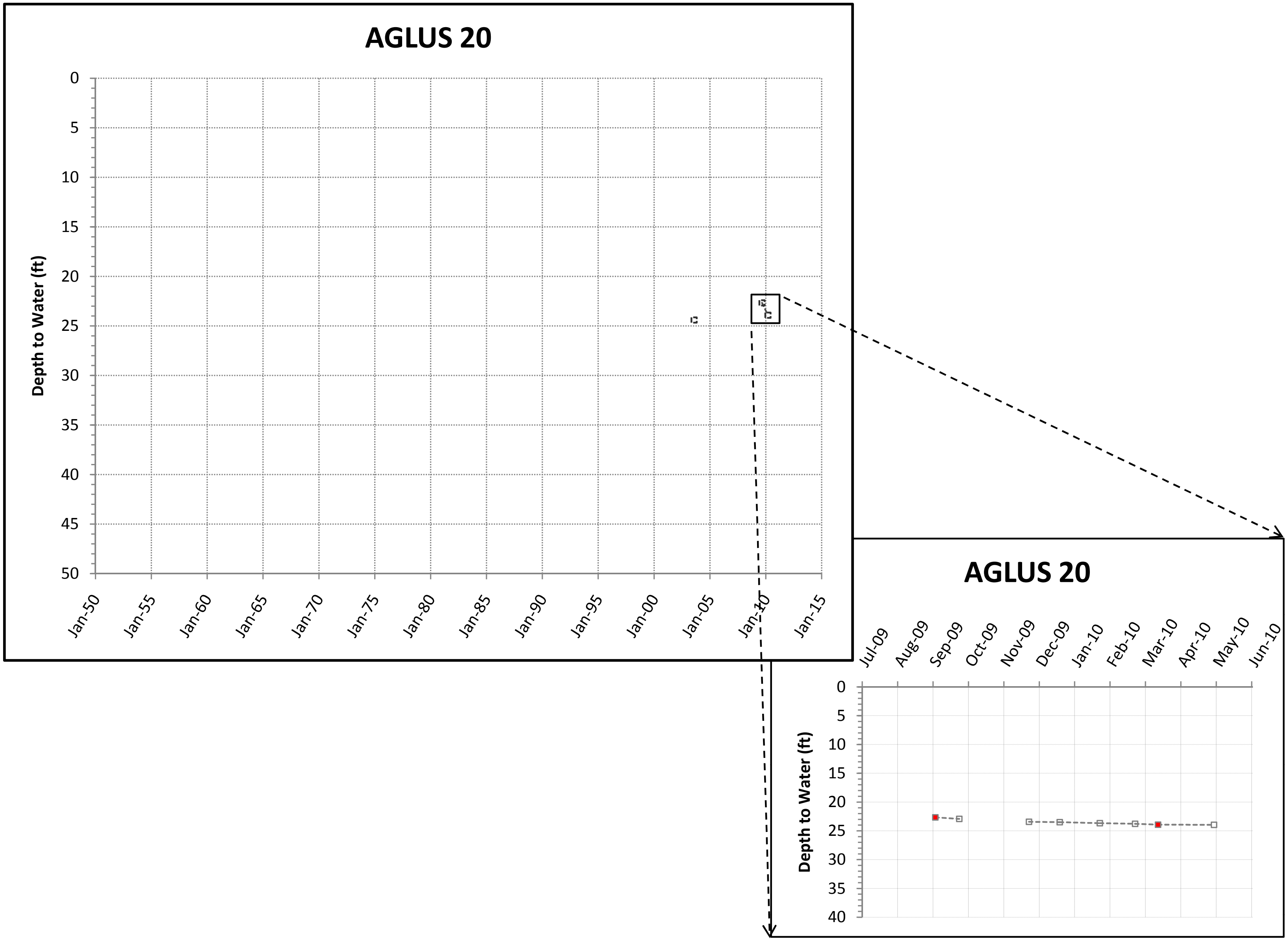
AGLUS 13
Depth to Water (ft)
40
45
50
55
60
65
70
75
80
85
90
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
AGLUS 13
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
50
55
60
65
70
75
80
85
90

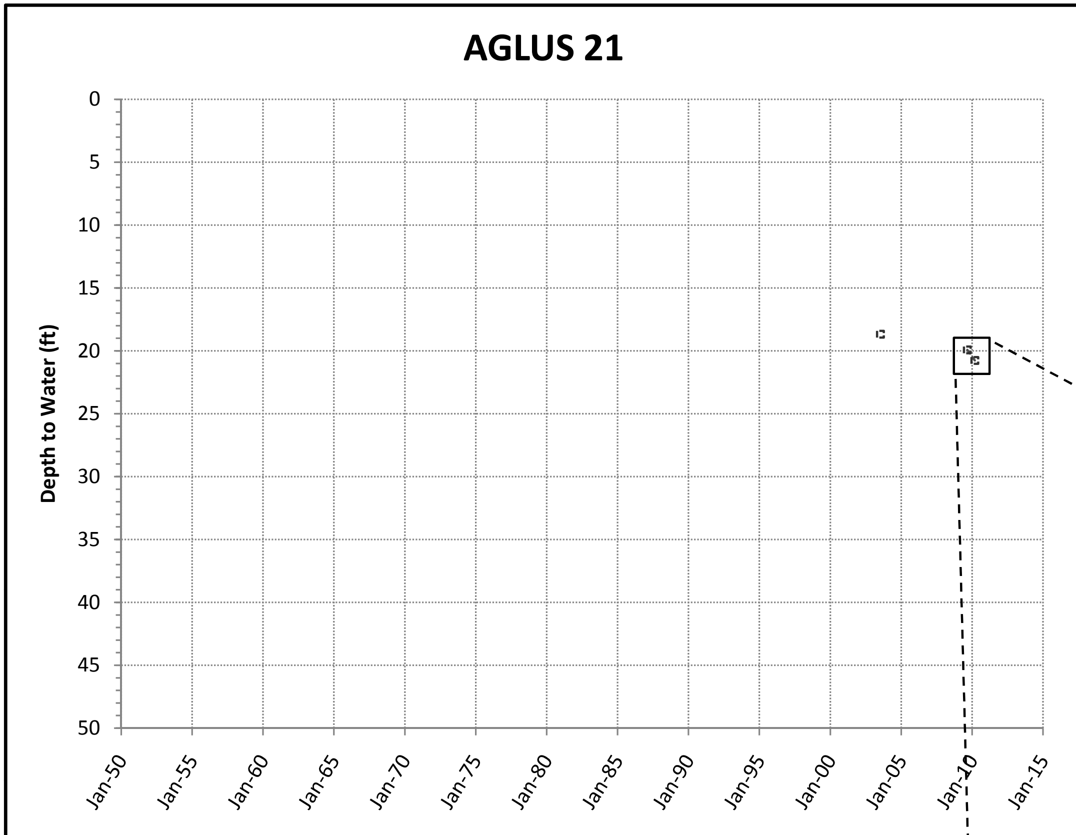

AGLUS 14
Depth to Water (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
AGLUS 14
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
0
5
10
15
20
25
30
35
40



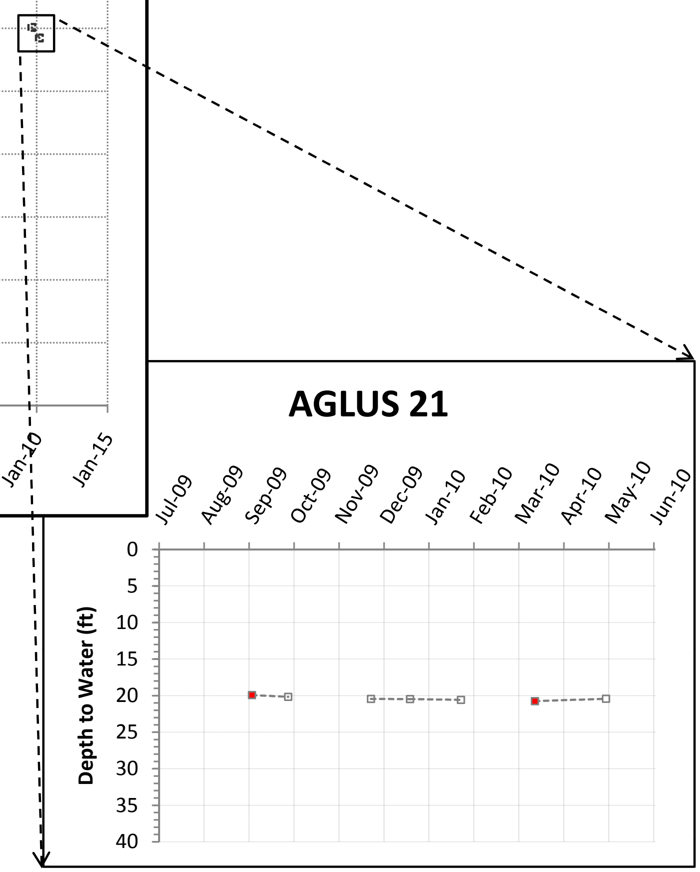
AGLUS 16
Depth to Water (ft)
10
15
20
25
30
35
40
45
50
55
60
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
AGLUS 16
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
10
15
20
25
30
35
40
45
50


AGLUS 19
Depth to Water (ft)
60
65
70
75
80
85
90
95
100
105
110
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
AGLUS 19
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
70
75
80
85
90
95
100
105
110

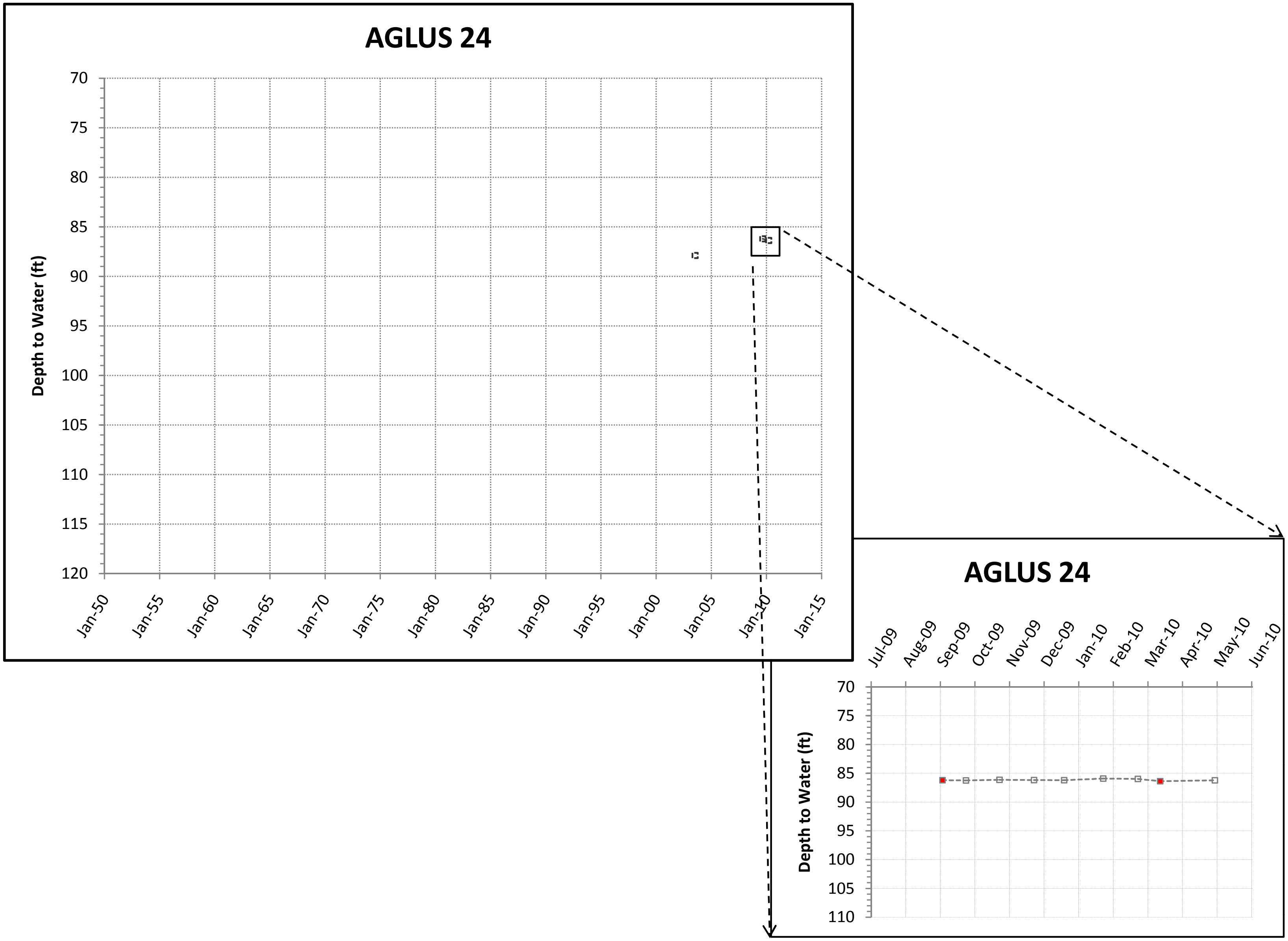

AGLUS 20
Depth to Water (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
AGLUS 20
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
0
5
10
15
20
25
30
35
40

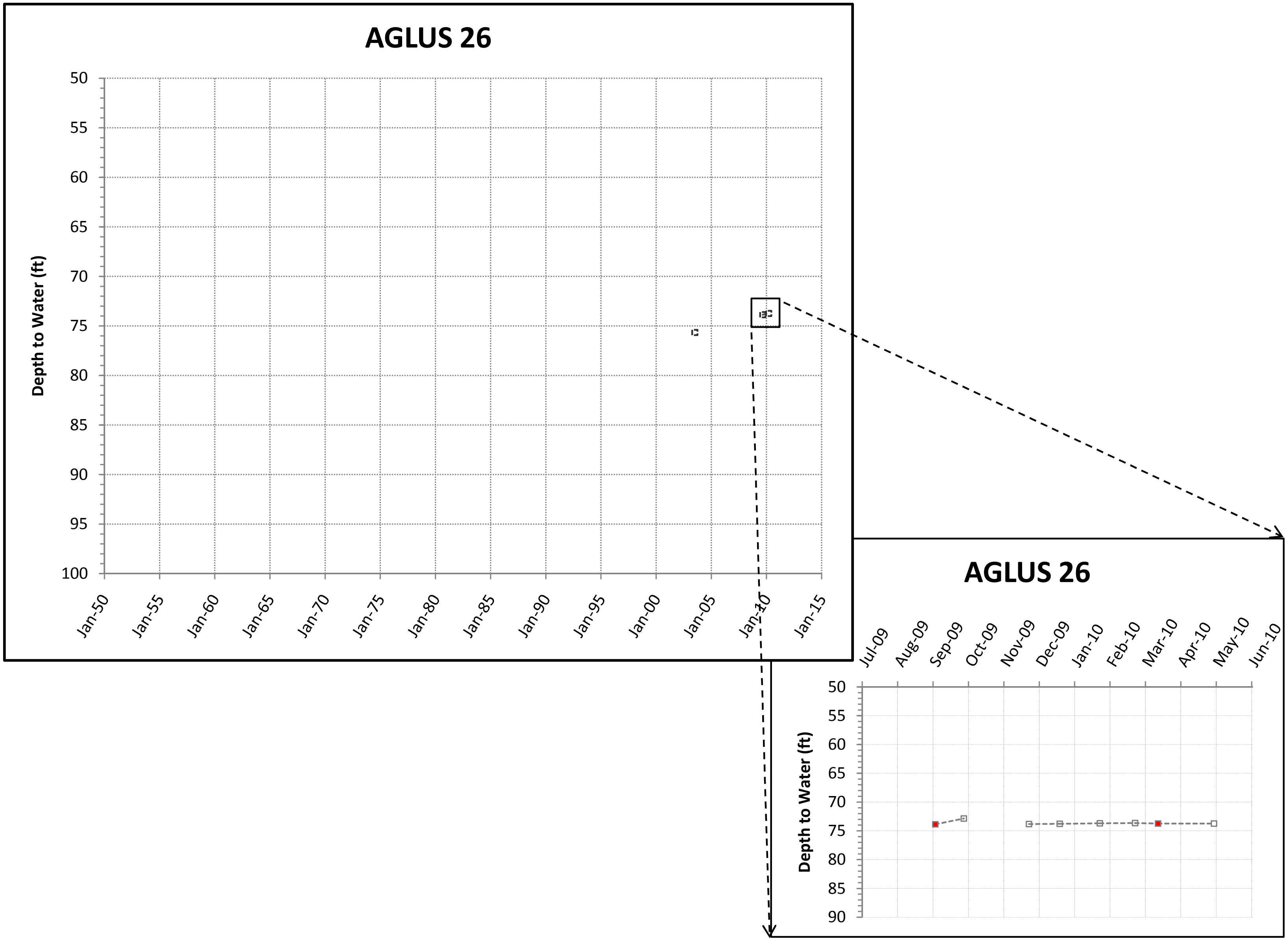


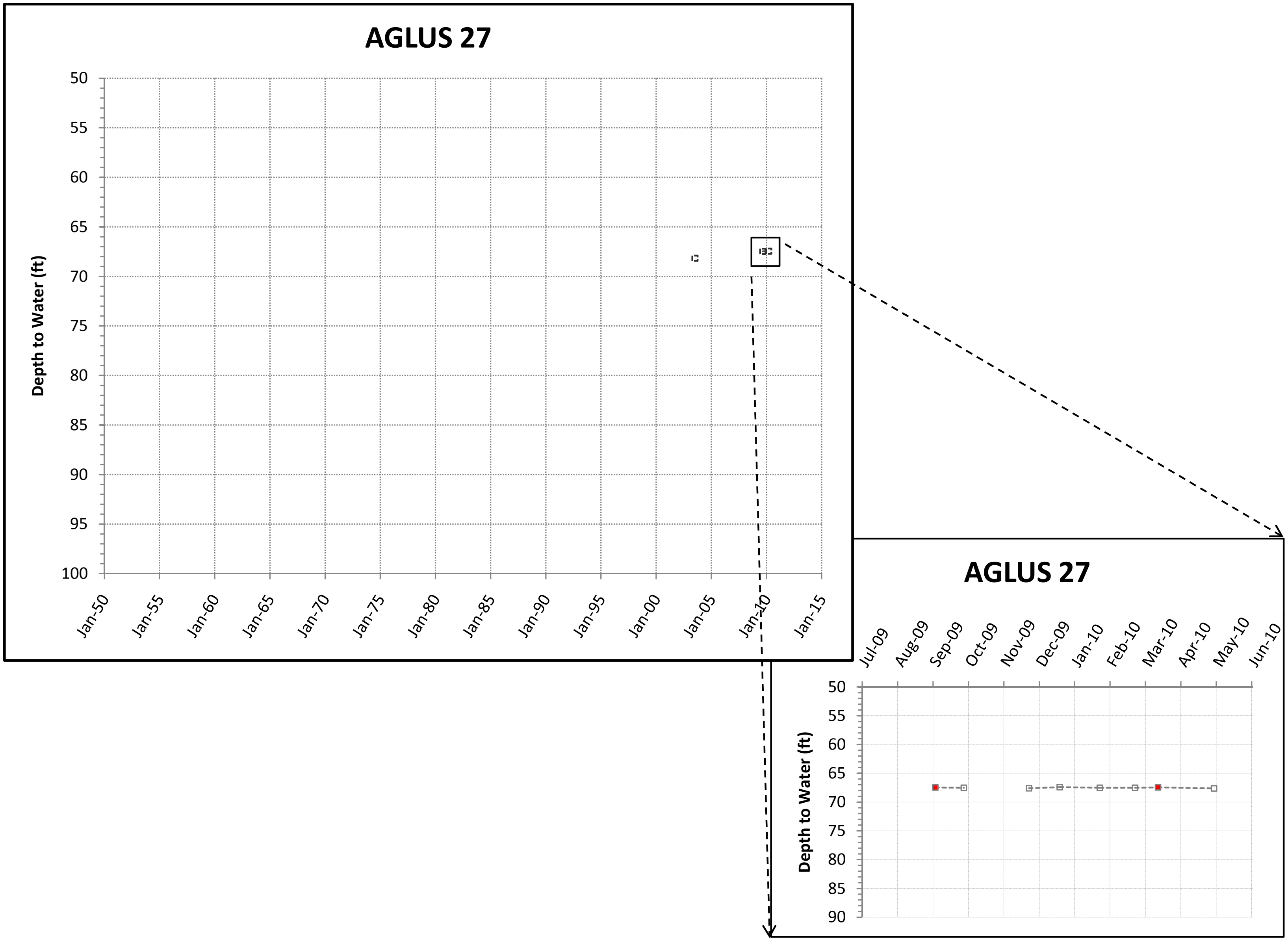
AGLUS 21
Depth to Water (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15

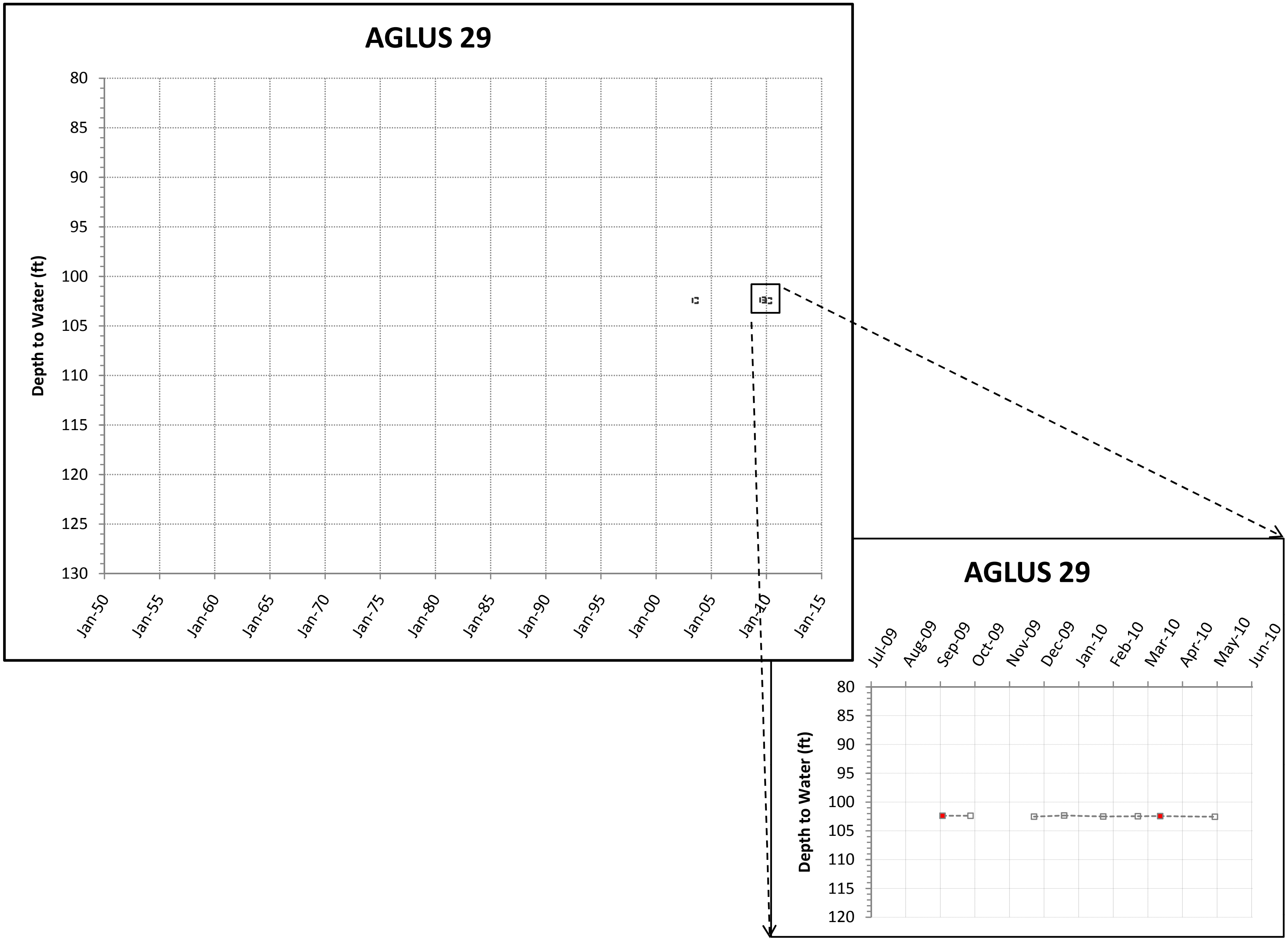


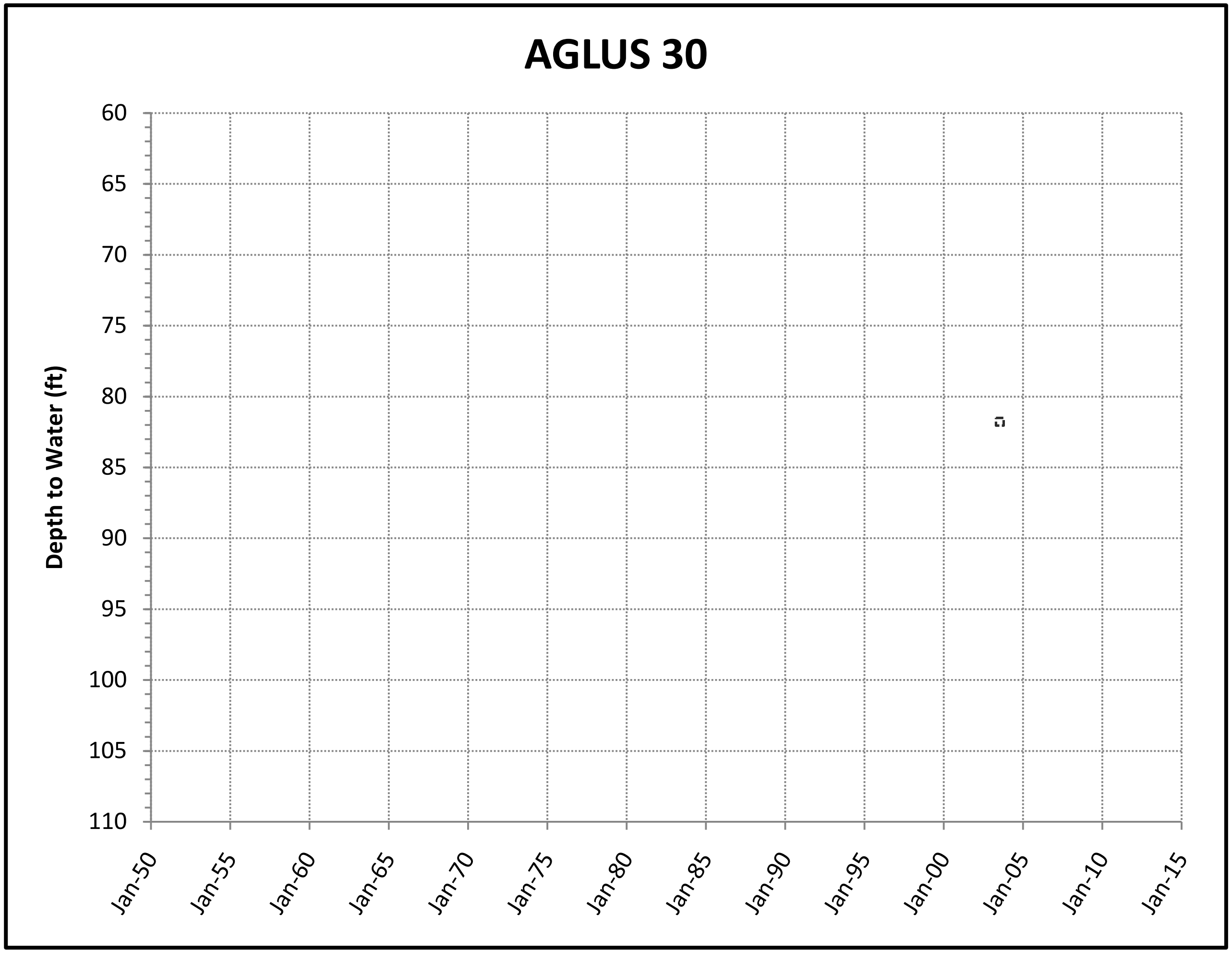
AGLUS 21
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
0
5
10
15
20
25
30
35
40


AGLUS 24
Depth to Water (ft)
70
75
80
85
90
95
100
105
110
115
120
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
AGLUS 24
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
70
75
80
85
90
95
100
105
110


AGLUS 26
Depth to Water (ft)
50
55
60
65
70
75
80
85
90
95
100
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
AGLUS 26
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
50
55
60
65
70
75
80
85
90


AGLUS 27
Depth to Water (ft)
50
55
60
65
70
75
80
85
90
95
100
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
AGLUS 27
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
50
55
60
65
70
75
80
85
90


AGLUS 29
Depth to Water (ft)
80
85
90
95
100
105
110
115
120
125
130
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15
AGLUS 29
Jul-09
Aug-09
Sep-09
Oct-09
Nov-09
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Depth to Water (ft)
80
85
90
95
100
105
110
115
120



AGLUS 30
Depth to Water (ft)
60
65
70
75
80
85
90
95
100
105
110
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15

RECENT LOST CREEK ALLUVIAL AQUIFER WATER LEVEL DATA

Recent Lost Creek Alluvial Aquifer Water Level Data

Data collected during 2009-2010 as part of the Lost Creek Basin Aquifer Recharge and Storage Study

Location	Permit #	Name	USGS ID	Date	Measured By	Measurement	Stick Up	Depth below ground surface	Comments	Total Depth	Location
SB00206323DCD		GS-1	400701104240201	7/20/09	CGS	60.75	1.10	59.65		82	
SB00206323DCD		GS-1	400701104240201	8/26/09	CGS	62.71	1.10	61.61		82	**UTM X**
SB00206323DCD		GS-1	400701104240201	9/20/09	CGS	60.99	1.10	59.89		82	**551052.1**
SB00206323DCD		GS-1	400701104240201	10/23/09	CGS	62.17	1.10	61.07		82	**UTM Y**
SB00206323DCD		GS-1	400701104240201	11/24/09	CGS	60.19	1.10	59.09		82	**4440894**
SB00206323DCD		GS-1	400701104240201	12/22/09	CGS	59.79	1.10	58.69		82	
SB00206323DCD		GS-1	400701104240201	1/27/10	CGS	59.26	1.10	58.16		82	
SB00206323DCD		GS-1	400701104240201	2/26/10	CGS	58.82	1.10	57.72		82	
SB00206323DCD		GS-1	400701104240201	3/31/10	CGS	58.32	1.10	57.22		82	
SB00206323DCD		GS-1	400701104240201	4/28/10	CGS	58.75	1.10	57.65		82	
SB00206336BCB		GS-2	400554104234001	7/20/09	CGS	50.91	0.50	50.41		82	
SB00206336BCB		GS-2	400554104234001	9/25/09	CGS	65.19	0.50	64.69		82	**UTM X**
SB00206336BCB		GS-2	400554104234001	10/23/09	CGS	61.75	0.50	61.25		82	**551561**
SB00206336BCB		GS-2	400554104234001	11/24/09	CGS	60.37	0.50	59.87		82	**UTM Y**
SB00206336BCB		GS-2	400554104234001	12/22/09	CGS	60.04	0.50	59.54		82	**4438872**
SB00206336BCB		GS-2	400554104234001	1/27/10	CGS	59.61	0.50	59.11		82	
SB00206336BCB		GS-2	400554104234001	2/26/10	CGS	52.35	0.50	51.85		82	
SB00206336BCB		GS-2	400554104234001	3/31/10	CGS	52.32	0.50	51.82		82	
SB00206336BCB		GS-2	400554104234001	4/28/10	CGS	52.26	0.50	51.76		82	
SB00106309DDC		GS-3	400240104260601	7/20/09	CGS	62.24	2.90	59.34		101	
SB00106309DDC		GS-3	400240104260601	8/26/09	CGS	62.88	2.90	59.98		101	**UTM X**
SB00106309DDC		GS-3	400240104260601	9/25/09	CGS	62.41	2.90	59.51		101	**548132.1**
SB00106309DDC		GS-3	400240104260601	10/23/09	CGS	61.65	2.90	58.75		101	**UTM Y**
SB00106309DDC		GS-3	400240104260601	11/24/09	CGS	61.07	2.90	58.17		101	**4434448**
SB00106309DDC		GS-3	400240104260601	12/22/09	CGS	60.25	2.90	57.35		101	
SB00106309DDC		GS-3	400240104260601	1/27/10	CGS	59.91	2.90	57.01		101	
SB00106309DDC		GS-3	400240104260601	2/26/10	CGS	59.42	2.90	56.52		101	
SB00106309DDC		GS-3	400240104260601	3/31/10	CGS	58.85	2.90	55.95		101	
SB00106309DDC		GS-3	400240104260601	4/28/10	CGS	58.30	2.90	55.40		101	
SB00106316DDD	6693-R	GS-4	400240104255901	7/20/09	CGS	82.41	0.50	81.91		150	
SB00106316DDD	6693-R	GS-4	400240104255901	8/26/09	CGS	86.33	0.50	85.33		150	**UTM X**
SB00106316DDD	6693-R	GS-4	400240104255901	9/25/09	CGS	86.08	0.50	85.58		150	**548323.1**
SB00106316DDD	6693-R	GS-4	400240104255901	10/23/09	CGS	85.75	0.50	85.25		150	**UTM Y**
SB00106316DDD	6693-R	GS-4	400240104255901	11/24/09	CGS	86.24	0.50	85.74		150	**4432842**
SB00106316DDD	6693-R	GS-4	400240104255901	12/22/09	CGS	87.38	0.50	86.88		150	
SB00106316DDD	6693-R	GS-4	400240104255901	1/27/10	CGS	84.60	0.50	84.10		150	
SB00106316DDD	6693-R	GS-4	400240104255901	2/26/10	CGS	76.96	0.50	76.46		150	
SB00106316DDD	6693-R	GS-4	400240104255901	3/31/10	CGS	76.02	0.50	75.52		150	
SB00106316DDD	6693-R	GS-4	400240104255901	4/28/10	CGS	74.71	0.50	74.21		150	
SB00106329ABB		GS-5	400146104273501	7/20/09	CGS		2.00	NA	**ON**	100	
SB00106329ABB		GS-5	400146104273501	8/26/09	CGS		2.00	NA	**ON**	100	**UTM X**
SB00106329ABB		GS-5	400146104273501	9/25/09	CGS	52.71	2.00	50.71		100	**546024.7**
SB00106329ABB		GS-5	400146104273501	10/23/09	CGS	48.26	2.00	46.26		100	**UTM Y**
SB00106329ABB		GS-5	400146104273501	11/24/09	CGS	47.14	2.00	45.14		100	**4431176.3**
SB00106329ABB		GS-5	400146104273501	12/22/09	CGS	49.89	2.00	47.89		100	
SB00106329ABB		GS-5	400146104273501	1/27/10	CGS	46.45	2.00	44.45		100	
SB00106329ABB		GS-5	400146104273501	2/26/10	CGS	46.10	2.00	44.10		100	
SB00106329ABB		GS-5	400146104273501	3/31/10	CGS	45.78	2.00	43.78		100	
SB00106329ABB		GS-5	400146104273501	4/28/10	CGS	45.50	2.00	43.50		100	
SC00106310BBB	14856-R	GS-6	395904104252901	7/20/09	CGS	135.61	1.40	134.21		180	
SC00106310BBB	14856-R	GS-6	395904104252901	8/26/09	CGS	138.98	1.40	137.58		180	**UTM X**
SC00106310BBB	14856-R	GS-6	395904104252901	9/25/09	CGS	138.50	1.40	137.10		180	**548372**
SC00106310BBB	14856-R	GS-6	395904104252901	10/23/09	CGS	139.12	1.40	137.72		180	**UTM Y**
SC00106310BBB	14856-R	GS-6	395904104252901	11/24/09	CGS	133.99	1.40	132.59		180	**4426200.9**
SC00106310BBB	14856-R	GS-6	395904104252901	12/22/09	CGS	140.83	1.40	139.43		180	
SC00106310BBB	14856-R	GS-6	395904104252901	1/27/10	CGS	140.35	1.40	138.95		180	
SC00106310BBB	14856-R	GS-6	395904104252901	2/26/10	CGS	133.87	1.40	132.47		180	
SC00106310BBB	14856-R	GS-6	395904104252901	3/31/10	CGS	127.36	1.40	125.96		180	
SC00106310BBB	14856-R	GS-6	395904104252901	4/28/10	CGS	120.04	1.40	118.64		180	
SB00406235BAC		N-1		7/20/09	CGS	7.73	1.80	5.93		50.65	
SB00406235BAC		N-1		8/24/09	CGS	8.38	1.80	6.58		50.65	**UTM X**
SB00406235BAC		N-1		9/24/09	CGS	8.73	1.80	6.93		50.65	**559945.7**
SB00406235BAC		N-1		10/23/09	CGS	8.80	1.80	7.00		50.65	**UTM Y**
SB00406235BAC		N-1		11/24/09	CGS	8.68	1.80	6.88		50.65	**4458283.8**
SB00406235BAC		N-1		12/22/09	CGS	7.64	1.80	5.84		50.65	
SB00406235BAC		N-1		1/27/10	CGS	6.95	1.80	5.15		50.65	
SB00406235BAC		N-1		2/26/10	CGS	6.76	1.80	4.96		50.65	
SB00406235BAC		N-1		3/31/10	CGS	6.52	1.80	4.72		50.65	
SB00406235BAC		N-1		4/28/10	CGS	6.43	1.80	4.63		50.65	
SB00306203CCC		N-5		7/20/09	CGS	17.68	0.50	17.18			
SB00306203CCC		N-5		8/24/09	CGS	18.86	0.50	18.36			**UTM X**
SB00306203CCC		N-5		9/24/09	CGS	18.35	0.50	17.85			**557888.8**
SB00306203CCC		N-5		10/23/09	CGS	17.41	0.50	16.91			**UTM Y**
SB00306203CCC		N-5		11/24/09	CGS	16.77	0.50	16.27			**4455609.1**
SB00306203CCC		N-5		12/22/09	CGS	17.51	0.50	17.01			
SB00306203CCC		N-5		1/27/10	CGS	15.90	0.50	15.40			
SB00306203CCC		N-5		2/26/10	CGS	15.55	0.50	15.05			
SB00306203CCC		N-5		3/31/10	CGS	15.20	0.50	14.70			
SB00306203CCC		N-5		4/28/10	CGS	15.07	0.50	14.57			
SB00306214BAC	12174-F	N-6		7/20/09	CGS		1.00	NA	**ON**	87	
SB00306214BAC	12174-F	N-6		8/24/09	CGS		1.00	NA	**ON**	87	**UTM X**
SB00306214BAC	12174-F	N-6		9/24/09	CGS	17.12	3.33	13.79	**Meas. thru discharge**	87	**559122.7**
SB00306214BAC	12174-F	N-6		10/23/09	CGS	16.13	3.33	12.80	**Meas. thru discharge**	87	**UTM Y**
SB00306214BAC	12174-F	N-6		11/24/09	CGS	15.76	3.33	12.43	**Meas. thru discharge**	87	**4452630.9**
SB00306214BAC	12174-F	N-6		12/22/09	CGS	15.39	3.33	12.06	**Meas. thru discharge**	87	
SB00306214BAC	12174-F	N-6		1/27/10	CGS	15.29	3.33	11.96	**Meas. thru discharge**	87	
SB00306214BAC	12174-F	N-6		2/26/10	CGS	15.20	3.33	11.87	**Meas. thru discharge**	87	
SB00306214BAC	12174-F	N-6		3/31/10	CGS	14.90	3.33	11.57	**Meas. thru discharge**	87	
SB00306214BAC	12174-F	N-6		4/28/10	CGS	14.68	3.33	11.35	**Meas. thru discharge**	87	

Recent Lost Creek Alluvial Aquifer Water Level Data (continued)

Data collected during 2009-2010 as part of the Lost Creek Basin Aquifer Recharge and Storage Study

Location	Permit #	Name	USGS ID	Date	Measured By	Measurement	Stick Up	Depth below ground surface	Comments	Total Depth	Location
SB00306227DAD	12225-F	N-7		7/20/09	CGS		0.55	NA	**ON**	109	
SB00306227DAD	12225-F	N-7		8/24/09	CGS		0.55	NA	**ON**	109	**UTM X**
SB00306227DAD	12225-F	N-7		9/24/09	CGS	24.67	0.55	24.12		109	**555913.7**
SB00306227DAD	12225-F	N-7		10/23/09	CGS	24.05	0.55	23.50		109	**UTM Y**
SB00306227DAD	12225-F	N-7		11/24/09	CGS	23.00	0.55	22.45		109	**4452606.4**
SB00306227DAD	12225-F	N-7		12/22/09	CGS	22.35	0.55	21.80		109	
SB00306227DAD	12225-F	N-7		1/27/10	CGS	22.14	0.55	21.59		109	
SB00306227DAD	12225-F	N-7		2/26/10	CGS	21.92	0.55	21.37		109	
SB00306227DAD	12225-F	N-7		3/31/10	CGS	21.72	0.55	21.17		109	
SB00306227DAD	12225-F	N-7		4/28/10	CGS	21.77	0.55	21.22		109	
SB00306222ACC		N-8		7/20/09	CGS		0.20	NA	**Abandoned**	48	
SB00306222ACC		N-8								48	**UTM X**
SB00306222ACC		N-8								48	**558919.6**
SB00306222ACC		N-8								48	**UTM Y**
SB00306222ACC		N-8								48	**4451429.8**
SB00306222ACC		N-8								48	
SB00306226DCD		N-11		7/20/09	CGS	43.57	1.20	42.37		59.3	
SB00306226DCD		N-11		8/24/09	CGS	44.05	1.20	42.85		59.3	**UTM X**
SB00306226DCD		N-11		9/24/09	CGS	44.38	1.20	43.18		59.3	**560640.6**
SB00306226DCD		N-11		10/23/09	CGS	44.23	1.20	43.03		59.3	**UTM Y**
SB00306226DCD		N-11		11/24/09	CGS	44.29	1.20	43.09		59.3	**4449081.8**
SB00306226DCD		N-11		12/22/09	CGS	43.94	1.20	42.74		59.3	
SB00306226DCD		N-11		1/27/10	CGS	44.02	1.20	42.82		59.3	
SB00306226DCD		N-11		2/26/10	CGS	44.11	1.20	42.91		59.3	
SB00306226DCD		N-11		3/31/10	CGS	43.71	1.20	42.51		59.3	
SB00306226DCD		N-11		4/28/10	CGS	43.55	1.20	42.35		59.3	
SB00306232BCC		S-1A		9/24/09	CGS	38.46	2.77	35.69		105	
SB00306232BCC		S-1A		10/23/09	CGS	36.22	2.77	33.45		105	**UTM X**
SB00306232BCC		S-1A		11/24/09	CGS	35.00	2.77	32.23		105	**555590**
SB00306232BCC		S-1A		12/22/09	CGS	34.58	2.77	31.81		105	**UTM Y**
SB00306232BCC		S-1A		1/27/10	CGS	34.12	2.77	31.35		105	**4448205**
SB00306232BCC		S-1A		2/26/10	CGS	34.10	2.77	31.33		105	
SB00306232BCC		S-1A		3/31/10	CGS	33.05	2.77	30.28		105	
SB00306232BCC		S-1A		4/28/10	CGS	33.00	2.77	30.23		105	
SB00206204BDD		S-2		7/20/09	CGS	31.13	1.20	29.93		36.15	
SB00206204BDD		S-2		8/24/09	CGS	31.86	1.20	30.66		36.15	**UTM X**
SB00206204BDD		S-2		9/24/09	CGS	32.35	1.20	31.15		36.15	**556832**
SB00206204BDD		S-2		10/23/09	CGS	32.49	1.20	31.29		36.15	**UTM Y**
SB00206204BDD		S-2		11/24/09	CGS	32.32	1.20	31.12		36.15	**4446650.7**
SB00206204BDD		S-2		12/22/09	CGS	32.11	1.20	30.91		36.15	
SB00206204BDD		S-2		1/27/10	CGS	31.81	1.20	30.61		36.15	
SB00206204BDD		S-2		2/26/10	CGS	31.53	1.20	30.33		36.15	
SB00206204BDD		S-2		3/31/10	CGS	31.21	1.20	30.01		36.15	
SB00206204BDD		S-2		4/28/10	CGS	30.95	1.20	29.75		36.15	
SB00206208BCD	31563-FP	S-3		7/20/09	CGS		0.00	NA	**ON**	89	
SB00206208BCD	31563-FP	S-3		8/24/09	CGS		0.00		**No access**	89	**UTM X**
SB00206208BCD	31563-FP	S-3		9/24/09	CGS		0.00		**Replaced w/ S-3A**	89	**554834.6**
SB00206208BCD	31563-FP	S-3								89	**UTM Y**
SB00206208BCD	31563-FP	S-3								89	**4445138.7**
SB00206208BCD	31563-FP	S-3								89	
SB00206208BAB	9523	S-3A		9/24/09	CGS	43.19	0.50	42.69		96	
SB00206208BAB	9523	S-3A		10/23/09	CGS	43.72	0.50	43.22		96	**UTM X**
SB00206208BAB	9523	S-3A		11/24/09	CGS	36.91	0.50	36.41		96	**555156**
SB00206208BAB	9523	S-3A		12/22/09	CGS	43.71	0.50	43.21		96	**UTM Y**
SB00206208BAB	9523	S-3A		1/27/10	CGS	39.26	0.50	38.76		96	**4445660**
SB00206208BAB	9523	S-3A		2/26/10	CGS	32.50	0.50	32.00		96	
SB00206208BAB	9523	S-3A		3/31/10	CGS	31.77	0.50	31.27		96	
SB00206208BAB	9523	S-3A		4/28/10	CGS	31.23	0.50	30.73		96	
SB00206218CBC		S-10		7/20/09	CGS		0.20	NA	**ON**	90	
SB00206218CBC		S-10		8/20/09	CGS		0.20		**Replaced w/ S-10A**	90	**UTM X**
SB00206218CBC		S-10								90	**553351.2**
SB00206218CBC		S-10								90	**UTM Y**
SB00206218CBC		S-10								90	**4442907**
SB00206218CBC		S-10								90	
SB00206218CBC	10869-R	S-10A		7/20/09	CGS	46.06	1.05	45.01		90	
SB00206218CBC	10869-R	S-10A		8/26/09	CGS	46.96	1.05	45.91		90	**UTM X**
SB00206218CBC	10869-R	S-10A		9/24/09	CGS	47.36	1.05	46.31		90	**553185.3**
SB00206218CBC	10869-R	S-10A		10/23/09	CGS	47.35	1.05	46.30		90	**UTM Y**
SB00206218CBC	10869-R	S-10A		11/24/09	CGS	46.76	1.05	45.71		90	**4442909.4**
SB00206218CBC	10869-R	S-10A		12/22/09	CGS	46.42	1.05	45.37		90	
SB00206218CBC	10869-R	S-10A		1/27/10	CGS	45.90	1.05	44.85		90	
SB00206218CBC	10869-R	S-10A		2/26/10	CGS	45.52	1.05	44.47		90	
SB00206218CBC	10869-R	S-10A		3/31/10	CGS	45.35	1.05	44.30		90	
SB00206218CBC	10869-R	S-10A		4/28/10	CGS	45.32	1.05	44.27		90	
SB00206311CDD	10477-F	S-12		7/20/09	CGS		0.00		**Road closed**	90	
SB00206311CDD	10477-F	S-12		7/31/09	CGS	42.50	0.00	42.50	**Owner meas.**	90	
SB00206311CDD	10477-F	S-12		8/24/09	CGS		0.00		**ON**	90	**UTM X**
SB00206311CDD	10477-F	S-12		9/24/09	CGS	45.50	0.00	45.50		90	**550697.2**
SB00206311CDD	10477-F	S-12		10/23/09	CGS	40.40	0.00	40.40		90	**UTM Y**
SB00206311CDD	10477-F	S-12		11/24/09	CGS	36.49	0.00	36.49		90	**4444309**
SB00206311CDD	10477-F	S-12		12/22/09	CGS	36.20	0.00	36.20		90	
SB00206311CDD	10477-F	S-12		1/27/10	CGS	34.96	0.00	34.96		90	
SB00206311CDD	10477-F	S-12		2/26/10	CGS	32.56	0.00	32.56		90	
SB00206311CDD	10477-F	S-12		3/31/10	CGS		0.00			90	
SB00206311CDD	10477-F	S-12		4/28/10	CGS		0.00			90	
SB00206311CDD		S-12A		11/24/09	CGS	41.49	1.89	39.60		92.7	
SB00206311CDD		S-12A		12/23/09	CGS	39.51	1.89	37.62		92.7	**UTM X**

Recent Lost Creek Alluvial Aquifer Water Level Data (continued)

Data collected during 2009-2010 as part of the Lost Creek Basin Aquifer Recharge and Storage Study

Location	Permit #	Name	USGS ID	Date	Measured By	Measurement	Stick Up	Depth below ground surface	Comments	Total Depth	Location
SB00206311CDD		S-12A		3/31/10	CGS	40.23	1.89	38.34		92.7	**4444119**
SB00206311CDD		S-12A		4/28/10	CGS	41.15	1.89	39.26		92.7	
SB00206302DBA		S-18		7/20/09	CGS	44.24	0.00	44.24			
SB00206302DBA		S-18		8/24/09	CGS	46.33	0.00	46.33			**UTM X**
SB00206302DBA		S-18		9/24/09	CGS	45.82	0.00	45.82			**551025.8**
SB00206302DBA		S-18		10/23/09	CGS	44.95	0.00	44.95			**UTM Y**
SB00206302DBA		S-18		11/24/09	CGS	43.40	0.00	43.40			**4446452**
SB00206302DBA		S-18		12/22/09	CGS	42.28	0.00	42.28			
SB00206302DBA		S-18		1/27/10	CGS	41.47	0.00	41.47			
SB00206302DBA		S-18		2/26/10	CGS	40.79	0.00	40.79			
SB00206302DBA		S-18		3/31/10	CGS	40.52	0.00	40.52			
SB00206302DBA		S-18		4/28/10	CGS	40.57	0.00	40.57			
SB00306322CAD		S-23A		7/20/09	CGS	7.21	1.85	5.36			
SB00306322CAD		S-23A		8/24/09	CGS	7.46	1.85	5.61			**UTM X**
SB00306322CAD		S-23A		9/24/09	CGS	7.41	1.85	5.56			**548941.1**
SB00306322CAD		S-23A		10/23/09	CGS	7.36	1.85	5.51			**UTM Y**
SB00306322CAD		S-23A		11/24/09	CGS	7.25	1.85	5.40			**4451018.8**
SB00306322CAD		S-23A		12/22/09	CGS	7.19	1.85	5.34			
SB00306322CAD		S-23A		1/27/10	CGS	7.22	1.85	5.37			
SB00306322CAD		S-23A		2/26/10	CGS	7.24	1.85	5.39			
SB00306322CAD		S-23A		3/31/10	CGS	7.21	1.85	5.36			
SB00306322CAD		S-23A		4/28/10	CGS	6.77	1.85	4.92			
SB00306325DDD		S-24		7/20/09	CGS	38.84	1.20	37.64			
SB00306325DDD		S-24		8/24/09	CGS	42.46	1.20	41.26			**UTM X**
SB00306325DDD		S-24		9/24/09	CGS	29.32	1.20	28.12			**552995**
SB00306325DDD		S-24		10/23/09	CGS	26.61	1.20	25.41			**UTM Y**
SB00306325DDD		S-24		11/24/09	CGS	25.26	1.20	24.06			**4448787.3**
SB00306325DDD		S-24		12/22/09	CGS	24.40	1.20	23.20			
SB00306325DDD		S-24		1/27/10	CGS	23.86	1.20	22.66			
SB00306325DDD		S-24		2/26/10	CGS	23.71	1.20	22.51			
SB00306325DDD		S-24		3/31/10	CGS		1.20				
SB00306325DDD		S-24		4/28/10	CGS	23.70	1.20	22.50			
SB00306326ACA		S-26A		7/20/09	CGS	6.08	1.80	4.28			
SB00306326ACA		S-26A		8/24/09	CGS	7.39	1.80	5.59			**UTM X**
SB00306326ACA		S-26A		9/24/09	CGS	6.97	1.80	5.17			**550933.5**
SB00306326ACA		S-26A		10/23/09	CGS	6.75	1.80	4.95			**UTM Y**
SB00306326ACA		S-26A		11/24/09	CGS	6.45	1.80	4.65			**4449823.9**
SB00306326ACA		S-26A		12/22/09	CGS	6.24	1.80	4.44			
SB00306326ACA		S-26A		1/27/10	CGS	6.26	1.80	4.46			
SB00306326ACA		S-26A		2/26/10	CGS	6.14	1.80	4.34			
SB00306326ACA		S-26A		3/31/10	CGS	5.86	1.80	4.06			
SB00306326ACA		S-26A		4/28/10	CGS	5.00	1.80	3.20			
SB00206209AAA	24577	LC-1		8/24/09	CGS	57.65	2.65	55.00			
SB00206209AAA	24577	LC-1		9/24/09	CGS	54.66	2.65	52.01			**UTM X**
SB00206209AAA	24577	LC-1		10/23/09	CGS		2.65		**Windmill running**		**557875**
SB00206209AAA	24577	LC-1		11/24/09	CGS	60.20	2.65	57.55	**Cascading H2O?**		**UTM Y**
SB00206209AAA	24577	LC-1		12/22/09	CGS	56.67	2.65	54.02			**4445499**
SB00206209AAA	24577	LC-1		1/27/10	CGS	53.78	2.65	51.13			
SB00206209AAA	24577	LC-1		2/26/10	CGS	52.94	2.65	50.29			
SB00206209AAA	24577	LC-1		3/31/10	CGS	52.32	2.65	49.67			
SB00206209AAA	24577	LC-1		4/28/10	CGS	51.81	2.65	49.16			
SB00306216CBC		LC-2		8/26/09	CGS	11.67	0.70	10.97		34	
SB00306216CBC		LC-2		9/24/09	CGS	12.19	0.70	11.49		34	**UTM X**
SB00306216CBC		LC-2		10/23/09	CGS	14.60	0.70	13.90		34	**556378**
SB00306216CBC		LC-2		11/24/09	CGS	12.67	0.70	11.97		34	**UTM Y**
SB00306216CBC		LC-2		12/22/09	CGS	15.79	0.70	15.09		34	**4442944**
SB00306216CBC		LC-2		1/27/10	CGS	13.14	0.70	12.44		34	
SB00306216CBC		LC-2		2/26/10	CGS	13.37	0.70	12.67		34	
SB00306216CBC		LC-2		3/31/10	CGS	13.64	0.70	12.94		34	
SB00306216CBC		LC-2		4/28/10	CGS	13.56	0.70	12.86		34	
SB00206219CDC	31650	LC-3		8/26/09	CGS	51.76	1.10	50.66		85	
SB00306219CDC	31650	LC-3		9/24/09	CGS	51.08	1.10	49.98		85	**UTM X**
SB00306219CDC	31650	LC-3		10/23/09	CGS	51.55	1.10	50.45		85	**553674**
SB00306219CDC	31650	LC-3		11/24/09	CGS	51.25	1.10	50.15		85	**UTM Y**
SB00306219CDC	31650	LC-3		12/22/09	CGS	49.08	1.10	47.98		85	**4440905**
SB00306219CDC	31650	LC-3		1/27/10	CGS	51.99	1.10	50.89		85	
SB00306219CDC	31650	LC-3		2/26/10	CGS	49.04	1.10	47.94		85	
SB00306219CDC	31650	LC-3		3/31/10	CGS	49.02	1.10	47.92		85	
SB00306219CDC	31650	LC-3		4/28/10	CGS	48.93	1.10	47.83		85	
SB00306315???		LC-4		8/26/09	CGS	45.97	1.00	44.97		82	
SB00306315???		LC-4		9/24/09	CGS	40.15	1.00	39.15		82	**UTM X**
SB00306315???		LC-4		10/23/09	CGS	39.22	1.00	38.22		82	**549533**
SB00306315???		LC-4		11/24/09	CGS	36.47	1.00	35.47		82	**UTM Y**
SB00306315???		LC-4		12/22/09	CGS	35.46	1.00	34.46		82	**4442491**
SB00306315???		LC-4		1/27/10	CGS	35.12	1.00	34.12		82	
SB00306315???		LC-4		2/26/10	CGS	34.68	1.00	33.68		82	
SB00306315???		LC-4		3/31/10	CGS	34.07	1.00	33.07		82	
SB00306315???		LC-4		4/28/10	CGS	33.45	1.00	32.45		82	
SB00406219ACC		LC-5		10/23/09	CGS	2.65	2.20	0.45		33.8	
SB00406219ACC		LC-5		11/24/09	CGS	2.75	2.20	0.55		33.8	**UTM X**
SB00406219ACC		LC-5		12/22/09	CGS	2.85	2.20	0.65		33.8	**553994**
SB00406219ACC		LC-5		1/27/10	CGS	2.90	2.20	0.70		33.8	**UTM Y**
SB00406219ACC		LC-5		2/26/10	CGS	3.13	2.20	0.93		33.8	**4461030**
SB00406219ACC		LC-5		3/31/10	CGS	3.03	2.20	0.83		33.8	
SB00406219ACC		LC-5		4/28/10	CGS	2.95	2.20	0.75		33.8	
SB026315BBB		LC-6		10/23/09	CGS	10.00	0.10	9.90		15	
SB026315BBB		LC-6		11/24/09	CGS	10.40	0.10	10.30		15	**UTM X**

Recent Lost Creek Alluvial Aquifer Water Level Data (continued)

Data collected during 2009-2010 as part of the Lost Creek Basin Aquifer Recharge and Storage Study

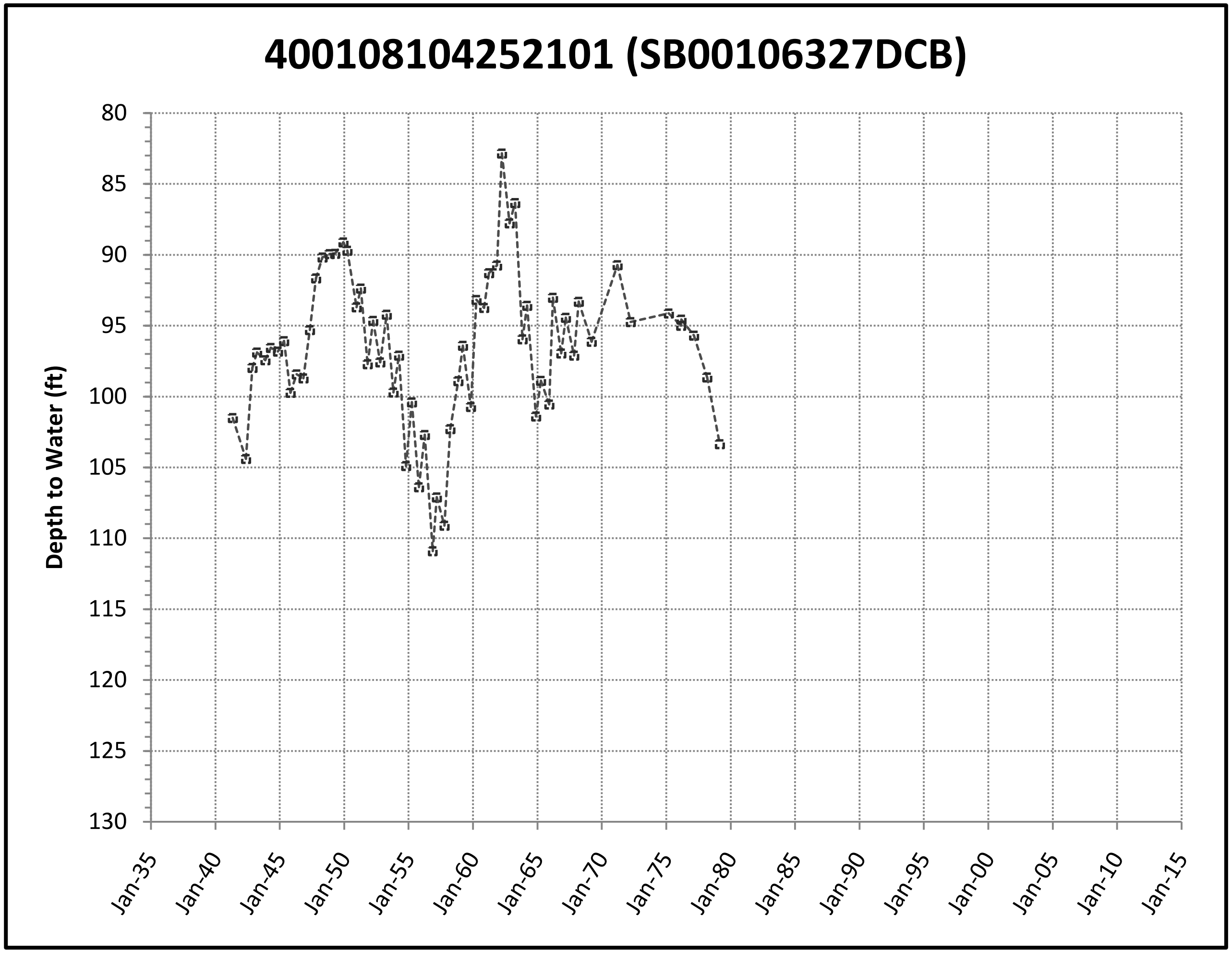
Location	Permit #	Name	USGS ID	Date	Measured By	Measurement	Stick Up	Depth below ground surface	Comments	Total Depth	Location
SB026315BBB		LC-6		2/26/10	CGS	11.53	0.10	11.43		15	**4444013**
SB026315BBB		LC-6		3/31/10	CGS	11.86	0.10	11.76		15	
SB026315BBB		LC-6		4/28/10	CGS	11.99	0.10	11.89		15	
SB016308BD		LC-7		1/14/10	CGS	72.14	-4.70	76.84		103	**UTM X**
SB016308BD		LC-7		2/20/10						103	**545855**
SB016308BD		LC-7		3/31/10		72.71	-4.70	77.41		103	**UTM Y**
SB016308BD		LC-7		4/28/10		72.59	-4.70	77.29		103	**4424655**
SB016308BD		LC-7								103	
SB00106336AAB		LC-8		3/31/10	CGS	28.96	0.90	28.06		30.1	**UTM X**
SB00106336AAB		LC-8		4/28/10		28.90	0.90	28.00		30.1	**551911**
SB00106336AAB		LC-8									**UTM Y**
SB00106336AAB		LC-8									**4429455**
SC00206320BAA		AGLUS REF1	395201104274001	9/3/09	USGS	56.38	2.04	54.34		73.3	
SC00206320BAA		AGLUS REF1	395201104274001	9/28/09	USGS	56.37	2.04	54.33		73.3	**UTM X**
SC00206320BAA		AGLUS REF1	395201104274001	10/24/09	USGS		2.04		**Mud**	73.3	**546067**
SC00206320BAA		AGLUS REF1	395201104274001	11/24/09	USGS	56.38	2.04	54.34		73.3	**UTM Y**
SC00206320BAA		AGLUS REF1	395201104274001	12/21/09	USGS	56.36	2.04	54.32		73.3	**4413147**
SC00206320BAA		AGLUS REF1	395201104274001	1/25/10	USGS	55.31	2.04	53.27		73.3	
SC00206320BAA		AGLUS REF1	395201104274001	2/25/10	USGS	56.29	2.04	54.25		73.3	
SC00206320BAA		AGLUS REF1	395201104274001	3/17/10	USGS	56.37	2.04	54.33		73.3	
SC00206320BAA		AGLUS REF1	395201104274001	5/5/10	USGS	56.38	2.04	54.34		73.3	
SC00306310BBB		AGLUS 2	394838104255301	9/3/09	USGS	63.47	2.00	61.47		73.4	
SC00306310BBB		AGLUS 2	394838104255301	9/24/09	USGS	63.45	2.00	61.45		73.4	**UTM X**
SC00306310BBB		AGLUS 2	394838104255301	10/24/09	USGS	63.37	2.00	61.37		73.4	**548652**
SC00306310BBB		AGLUS 2	394838104255301	11/24/09	USGS	63.51	2.00	61.51		73.4	**UTM Y**
SC00306310BBB		AGLUS 2	394838104255301	12/21/09	USGS	63.50	2.00	61.50		73.4	**4406911**
SC00306310BBB		AGLUS 2	394838104255301	1/25/10	USGS	63.47	2.00	61.47		73.4	
SC00306310BBB		AGLUS 2	394838104255301	2/25/10	USGS	63.47	2.00	61.47		73.4	
SC00306310BBB		AGLUS 2	394838104255301	3/17/10	USGS	63.51	2.00	61.51		73.4	
SC00306310BBB		AGLUS 2	394838104255301	5/5/10	USGS	63.57	2.00	61.57		73.4	
SC00206310CDD		AGLUS 3	395300104253301	9/3/09	USGS	84.62	2.50	82.12		93.49	
SC00206310CDD		AGLUS 3	395300104253301	9/24/09	USGS	84.59	2.50	82.09		93.49	**UTM X**
SC00206310CDD		AGLUS 3	395300104253301	10/24/09	USGS	84.69	2.50	82.19		93.49	**549073**
SC00206310CDD		AGLUS 3	395300104253301	11/24/09	USGS	84.71	2.50	82.21		93.49	**UTM Y**
SC00206310CDD		AGLUS 3	395300104253301	12/21/09	USGS	84.64	2.50	82.14		93.49	**4414978**
SC00206310CDD		AGLUS 3	395300104253301	1/25/10	USGS	84.67	2.50	82.17		93.49	
SC00206310CDD		AGLUS 3	395300104253301	2/25/10	USGS	84.78	2.50	82.28		93.49	
SC00206310CDD		AGLUS 3	395300104253301	3/17/10	USGS	84.68	2.50	82.18		93.49	
SC00206310CDD		AGLUS 3	395300104253301	5/5/10	USGS	84.81	2.50	82.31		93.49	
SC00206311DAA		AGLUS 4	395324104234301	9/3/09	USGS	73.07	2.50	70.57		82.12	
SC00206311DAA		AGLUS 4	395324104234301	9/28/09	USGS	73.07	2.50	70.57		82.12	**UTM X**
SC00206311DAA		AGLUS 4	395324104234301	10/24/09	USGS		2.50		**Mud**	82.12	**551702**
SC00206311DAA		AGLUS 4	395324104234301	11/24/09	USGS	73.11	2.50	70.61		82.12	**UTM Y**
SC00206311DAA		AGLUS 4	395324104234301	12/21/09	USGS	73.11	2.50	70.61		82.12	**4415726**
SC00206311DAA		AGLUS 4	395324104234301	1/25/10	USGS	73.03	2.50	70.53		82.12	
SC00206311DAA		AGLUS 4	395324104234301	2/25/10	USGS	73.05	2.50	70.55		82.12	
SC00206311DAA		AGLUS 4	395324104234301	3/17/10	USGS	73.14	2.50	70.64		82.12	
SC00206311DAA		AGLUS 4	395324104234301	5/5/10	USGS	73.16	2.50	70.66		82.12	
SC00206335CBB		AGLUS 11	394953104244601	9/3/09	USGS	88.62	2.50	86.12		97.1	
SC00206335CBB		AGLUS 11	394953104244601	9/24/09	USGS	88.60	2.50	86.10		97.1	**UTM X**
SC00206335CBB		AGLUS 11	394953104244601	10/24/09	USGS	88.65	2.50	86.15		97.1	**550241**
SC00206335CBB		AGLUS 11	394953104244601	11/24/09	USGS	88.69	2.50	86.19		97.1	**UTM Y**
SC00206335CBB		AGLUS 11	394953104244601	12/21/09	USGS	88.67	2.50	86.17		97.1	**4409221**
SC00206335CBB		AGLUS 11	394953104244601	1/25/10	USGS	88.59	2.50	86.09		97.1	
SC00206335CBB		AGLUS 11	394953104244601	2/25/10	USGS	88.72	2.50	86.22		97.1	
SC00206335CBB		AGLUS 11	394953104244601	3/17/10	USGS	88.66	2.50	86.16		97.1	
SC00206335CBB		AGLUS 11	394953104244601	5/5/10	USGS	88.65	2.50	86.15		97.1	
SC00306426CAA		AGLUS 12	394539104305901	9/3/09	USGS	33.91	2.50	31.41		44.43	
SC00306426CAA		AGLUS 12	394539104305901	9/24/09	USGS	33.89	2.50	31.39		44.43	**UTM X**
SC00306426CAA		AGLUS 12	394539104305901	10/24/09	USGS	33.87	2.50	31.37		44.43	**541412**
SC00306426CAA		AGLUS 12	394539104305901	11/24/09	USGS	33.95	2.50	31.45		44.43	**UTM Y**
SC00306426CAA		AGLUS 12	394539104305901	12/21/09	USGS	33.98	2.50	31.48		44.43	**4401333**
SC00306426CAA		AGLUS 12	394539104305901	1/25/10	USGS	33.87	2.50	31.37		44.43	
SC00306426CAA		AGLUS 12	394539104305901	2/25/10	USGS	33.94	2.50	31.44		44.43	
SC00306426CAA		AGLUS 12	394539104305901	3/17/10	USGS	33.97	2.50	31.47		44.43	
SC00306426CAA		AGLUS 12	394539104305901	5/5/10	USGS	33.93	2.50	31.43		44.43	
SC00306316ADD		AGLUS 13	394731104260001	9/3/09	USGS	70.21	2.50	67.71		84.3	
SC00306316ADD		AGLUS 13	394731104260001	9/24/09	USGS	70.10	2.50	67.60		84.3	**UTM X**
SC00306316ADD		AGLUS 13	394731104260001	10/24/09	USGS	69.99	2.50	67.49		84.3	**548508**
SC00306316ADD		AGLUS 13	394731104260001	11/24/09	USGS	69.71	2.50	67.21		84.3	**UTM Y**
SC00306316ADD		AGLUS 13	394731104260001	12/21/09	USGS	69.59	2.50	67.09		84.3	**4404842**
SC00306316ADD		AGLUS 13	394731104260001	1/25/10	USGS	69.16	2.50	66.66		84.3	
SC00306316ADD		AGLUS 13	394731104260001	2/25/10	USGS	69.21	2.50	66.71		84.3	
SC00306316ADD		AGLUS 13	394731104260001	3/17/10	USGS	69.04	2.50	66.54		84.3	
SC00306316ADD		AGLUS 13	394731104260001	5/5/10	USGS	68.91	2.50	66.41		84.3	
SC00206432DDA		AGLUS 14	394947104335201	9/3/09	USGS	19.04	1.75	17.29		33.37	
SC00206432DDA		AGLUS 14	394947104335201	9/24/09	USGS	18.38	1.75	16.63		33.37	**UTM X**
SC00206432DDA		AGLUS 14	394947104335201	10/24/09	USGS	NA	1.75		**Mud**	33.37	**537250**
SC00206432DDA		AGLUS 14	394947104335201	11/24/09	USGS	20.16	1.75	18.41		33.37	**UTM Y**
SC00206432DDA		AGLUS 14	394947104335201	12/21/09	USGS	20.06	1.75	18.31		33.37	**4408967**
SC00206432DDA		AGLUS 14	394947104335201	1/25/10	USGS	20.51	1.75	18.76		33.37	
SC00206432DDA		AGLUS 14	394947104335201	2/25/10	USGS		1.75			33.37	
SC00206432DDA		AGLUS 14	394947104335201	3/17/10	USGS	20.99	1.75	19.24		33.37	
SC00206432DDA		AGLUS 14	394947104335201	5/5/10	USGS	20.62	1.75	18.87		33.37	
SC00206435DDC		AGLUS 16	394933104304101	9/3/09	USGS	33.31	2.15	31.16		43.7	
SC00206435DDC		AGLUS 16	394933104304101	9/24/09	USGS	33.42	2.15	31.27		43.7	**UTM X**

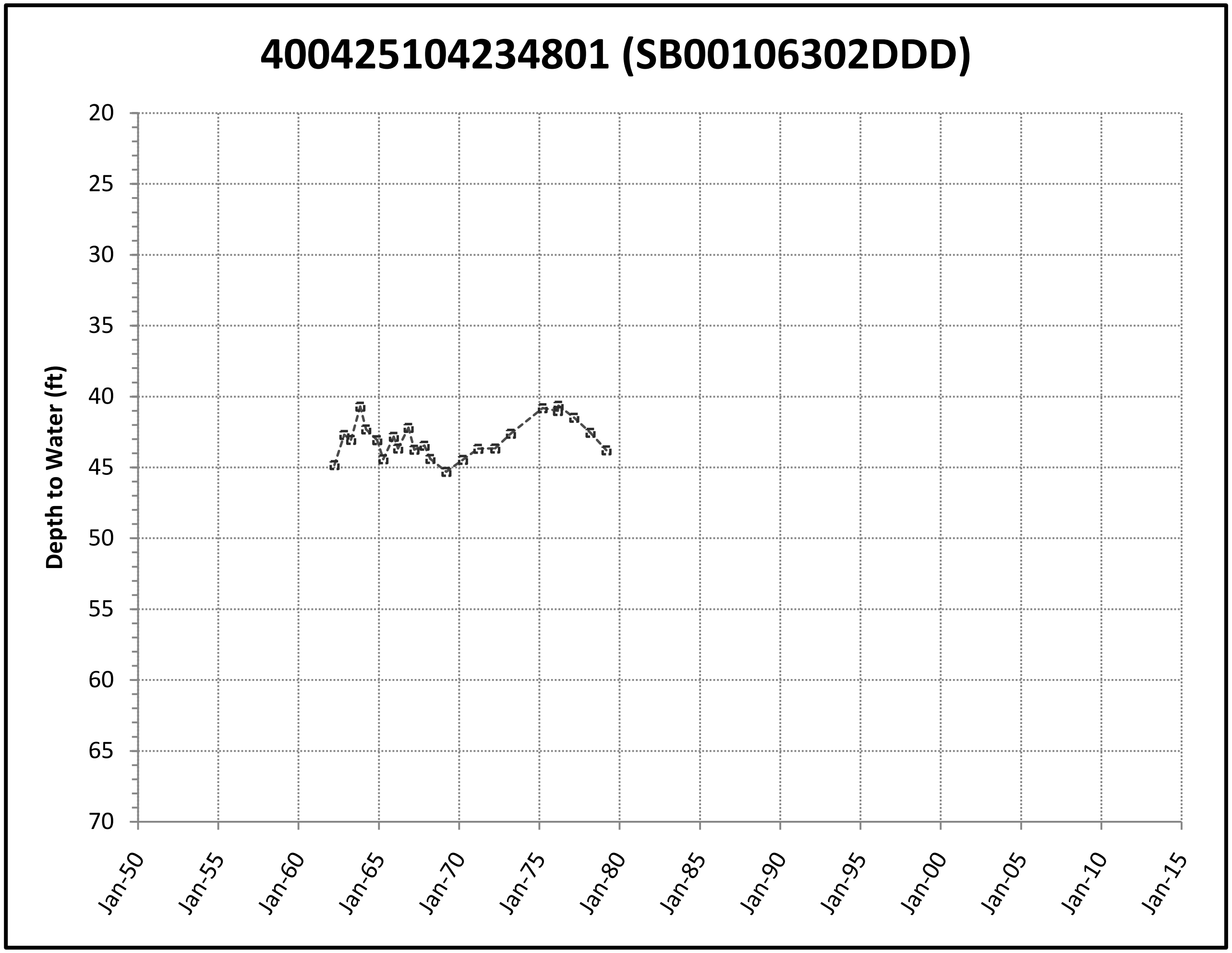
Recent Lost Creek Alluvial Aquifer Water Level Data (continued)

Data collected during 2009-2010 as part of the Lost Creek Basin Aquifer Recharge and Storage Study

Location	Permit #	Name	USGS ID	Date	Measured By	Measurement	Stick Up	Depth below ground surface	Comments	Total Depth	Location
SC00206435DDC		AGLUS 16	394933104304101	12/21/09	USGS	33.83	2.15	31.68		43.7	**4408549**
SC00206435DDC		AGLUS 16	394933104304101	1/25/10	USGS	33.98	2.15	31.83		43.7	
SC00206435DDC		AGLUS 16	394933104304101	2/25/10	USGS		2.15			43.7	
SC00206435DDC		AGLUS 16	394933104304101	3/17/10	USGS	34.14	2.15	31.99		43.7	
SC00206435DDC		AGLUS 16	394933104304101	5/5/10	USGS	34.28	2.15	32.13		43.7	
SC00206423BAA		AGLUS 19	395208104310201	9/3/09	USGS	87.78	1.90	85.88		94	
SC00206423BAA		AGLUS 19	395208104310201	9/24/09	USGS	87.73	1.90	85.83		94	**UTM X**
SC00206423BAA		AGLUS 19	395208104310201	10/24/09	USGS	87.73	1.90	85.83		94	**541283**
SC00206423BAA		AGLUS 19	395208104310201	11/24/09	USGS	87.87	1.90	85.97		94	**UTM Y**
SC00206423BAA		AGLUS 19	395208104310201	12/21/09	USGS	87.73	1.90	85.83		94	**4413326**
SC00206423BAA		AGLUS 19	395208104310201	1/25/10	USGS	87.75	1.90	85.85		94	
SC00206423BAA		AGLUS 19	395208104310201	2/25/10	USGS	87.83	1.90	85.93		94	
SC00206423BAA		AGLUS 19	395208104310201	3/17/10	USGS	87.93	1.90	86.03		94	
SC00206423BAA		AGLUS 19	395208104310201	5/5/10	USGS	88.07	1.90	86.17		94	
SC00306306BBD		AGLUS 20	394919104291001	9/3/09	USGS	25.25	2.58	22.67		29.1	
SC00306306BBD		AGLUS 20	394919104291001	9/24/09	USGS	25.51	2.58	22.93		29.1	**UTM X**
SC00306306BBD		AGLUS 20	394919104291001	10/24/09	USGS	NA	2.58		**Mud**	29.1	**543967**
SC00306306BBD		AGLUS 20	394919104291001	11/24/09	USGS	26.00	2.58	23.42		29.1	**UTM Y**
SC00306306BBD		AGLUS 20	394919104291001	12/21/09	USGS	26.08	2.58	23.50		29.1	**4408149**
SC00306306BBD		AGLUS 20	394919104291001	1/25/10	USGS	26.24	2.58	23.66		29.1	
SC00306306BBD		AGLUS 20	394919104291001	2/25/10	USGS	26.36	2.58	23.78		29.1	
SC00306306BBD		AGLUS 20	394919104291001	3/17/10	USGS	26.50	2.58	23.92		29.1	
SC00306306BBD		AGLUS 20	394919104291001	5/5/10	USGS	26.53	2.58	23.95		29.1	
SC00306411ABB		AGLUS 21	394838104310001	9/3/09	USGS	22.07	2.15	19.92		28.31	
SC00306411ABB		AGLUS 21	394838104310001	9/28/09	USGS	22.31	2.15	20.16		28.31	**UTM X**
SC00306411ABB		AGLUS 21	394838104310001	10/24/09	USGS	NA	2.15		**Mud**	28.31	**541354**
SC00306411ABB		AGLUS 21	394838104310001	11/24/09	USGS	22.59	2.15	20.44		28.31	**UTM Y**
SC00306411ABB		AGLUS 21	394838104310001	12/21/09	USGS	22.63	2.15	20.48		28.31	**4406861**
SC00306411ABB		AGLUS 21	394838104310001	1/25/10	USGS	22.72	2.15	20.57		28.31	
SC00306411ABB		AGLUS 21	394838104310001	2/25/10	USGS		2.15			28.31	
SC00306411ABB		AGLUS 21	394838104310001	3/17/10	USGS	22.91	2.15	20.76		28.31	
SC00306411ABB		AGLUS 21	394838104310001	5/5/10	USGS	22.57	2.15	20.42		28.31	
SC00306320DDA		AGLUS 24	394614104270701	9/3/09	USGS	88.61	2.40	86.21		101.34	
SC00306320DDA		AGLUS 24	394614104270701	9/24/09	USGS	88.64	2.40	86.24		101.34	**UTM X**
SC00306320DDA		AGLUS 24	394614104270701	10/24/09	USGS	88.54	2.40	86.14		101.34	**546930**
SC00306320DDA		AGLUS 24	394614104270701	11/24/09	USGS	88.57	2.40	86.17		101.34	**UTM Y**
SC00306320DDA		AGLUS 24	394614104270701	12/21/09	USGS	88.60	2.40	86.20		101.34	**4402443**
SC00306320DDA		AGLUS 24	394614104270701	1/25/10	USGS	88.31	2.40	85.91		101.34	
SC00306320DDA		AGLUS 24	394614104270701	2/25/10	USGS	88.38	2.40	85.98		101.34	
SC00306320DDA		AGLUS 24	394614104270701	3/17/10	USGS	88.77	2.40	86.37		101.34	
SC00306320DDA		AGLUS 24	394614104270701	5/5/10	USGS	88.62	2.40	86.22		101.34	
SC00206332BDD		AGLUS 26	394919104291001	9/3/09	USGS	76.17	2.30	73.87		83.74	
SC00206332BDD		AGLUS 26	394919104291001	9/28/09	USGS	75.16	2.30	72.86		83.74	**UTM X**
SC00206332BDD		AGLUS 26	394919104291001	10/24/09	USGS	NA	2.30		**Mud**	83.74	**546069**
SC00206332BDD		AGLUS 26	394919104291001	11/24/09	USGS	76.12	2.30	73.82		83.74	**UTM Y**
SC00206332BDD		AGLUS 26	394919104291001	12/21/09	USGS	76.08	2.30	73.78		83.74	**4409299**
SC00206332BDD		AGLUS 26	394919104291001	1/25/10	USGS	75.98	2.30	73.68		83.74	
SC00206332BDD		AGLUS 26	394919104291001	2/25/10	USGS	75.95	2.30	73.65		83.74	
SC00206332BDD		AGLUS 26	394919104291001	3/17/10	USGS	76.04	2.30	73.74		83.74	
SC00206332BDD		AGLUS 26	394919104291001	5/5/10	USGS	76.03	2.30	73.73		83.74	
SC00206321ADB		AGLUS 27	395149104260701	9/3/09	USGS	69.27	1.80	67.47		83.98	
SC00206321ADB		AGLUS 27	395149104260701	9/28/09	USGS	69.31	1.80	67.51		83.98	**UTM X**
SC00206321ADB		AGLUS 27	395149104260701	10/24/09	USGS	NA	1.80		**Mud**	83.98	**548284**
SC00206321ADB		AGLUS 27	395149104260701	11/24/09	USGS	69.41	1.80	67.61		83.98	**UTM Y**
SC00206321ADB		AGLUS 27	395149104260701	12/21/09	USGS	69.21	1.80	67.41		83.98	**4412794**
SC00206321ADB		AGLUS 27	395149104260701	1/25/10	USGS	69.32	1.80	67.52		83.98	
SC00206321ADB		AGLUS 27	395149104260701	2/25/10	USGS	69.32	1.80	67.52		83.98	
SC00206321ADB		AGLUS 27	395149104260701	3/17/10	USGS	69.26	1.80	67.46		83.98	
SC00206321ADB		AGLUS 27	395149104260701	5/5/10	USGS	69.43	1.80	67.63		83.98	
SC00206307DAA		AGLUS 29	395324104281401	9/3/09	USGS	104.13	1.75	102.38		113.25	
SC00206307DAA		AGLUS 29	395324104281401	9/28/09	USGS	104.12	1.75	102.37		113.25	**UTM X**
SC00206307DAA		AGLUS 29	395324104281401	10/24/09	USGS	NA	1.75		**Mud**	113.25	**545249**
SC00206307DAA		AGLUS 29	395324104281401	11/24/09	USGS	104.27	1.75	102.52		113.25	**UTM Y**
SC00206307DAA		AGLUS 29	395324104281401	12/21/09	USGS	104.09	1.75	102.34		113.25	**4415692**
SC00206307DAA		AGLUS 29	395324104281401	1/25/10	USGS	104.26	1.75	102.51		113.25	
SC00206307DAA		AGLUS 29	395324104281401	2/25/10	USGS	104.22	1.75	102.47		113.25	
SC00206307DAA		AGLUS 29	395324104281401	3/17/10	USGS	104.20	1.75	102.45		113.25	
SC00206307DAA		AGLUS 29	395324104281401	5/5/10	USGS	104.30	1.75	102.55		113.25	
SC00206305BBA		AGLUS 30	395443104275901	9/3/09	USGS	NA	1.20	NA	**Dry**	103.32	
SC00206305BBA		AGLUS 30	395443104275901	9/28/09	USGS	NA	1.20	NA	**Dry**	103.32	**UTM X**
SC00206305BBA		AGLUS 30	395443104275901	10/24/09	USGS	NA	1.20	NA	**Mud**	103.32	**545600**
SC00206305BBA		AGLUS 30	395443104275901	11/24/09	USGS	NA	1.20	NA	**Dry**	103.32	**UTM Y**
SC00206305BBA		AGLUS 30	395443104275901				1.20			103.32	**4418145**
SC00206305BBA		AGLUS 30	395443104275901				1.20			103.32	

ALLUVIAL GROUNDWATER LEVEL HYDROGRAPHS FROM HISTORIC MONITORING PROGRAMS


400108104252101 (SB00106327DCB)
Depth to Water (ft)
80
85
90
95
100
105
110
115
120
125
130
Jan-35
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15



400425104234801 (SB00106302DDD)
Depth to Water (ft)
20
25
30
35
40
45
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60
65
70
Jan-50
Jan-55
Jan-60
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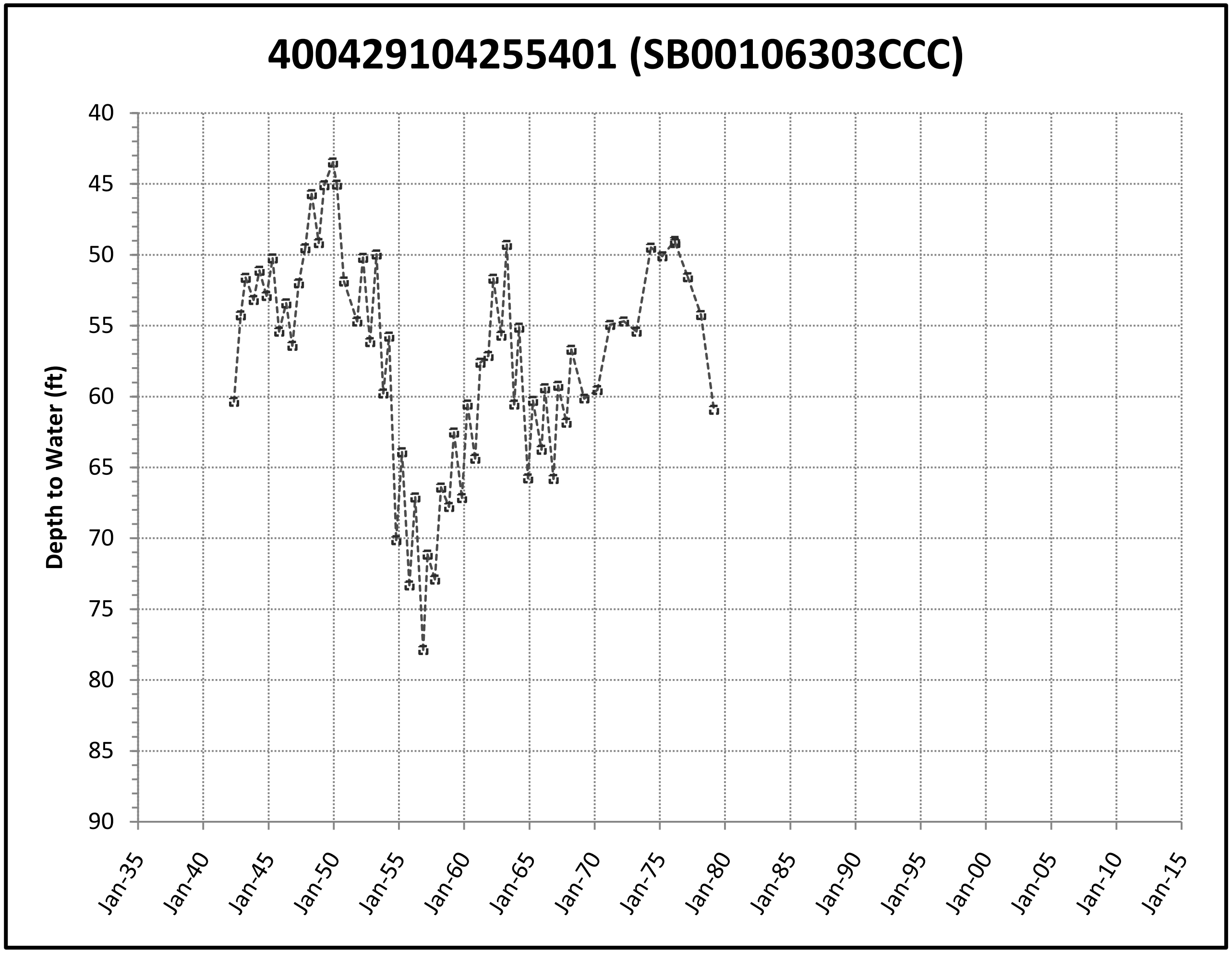
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15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Depth to Water (ft)
40
45
50
55
60
65
70
75
80
85
90
Jan-35
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
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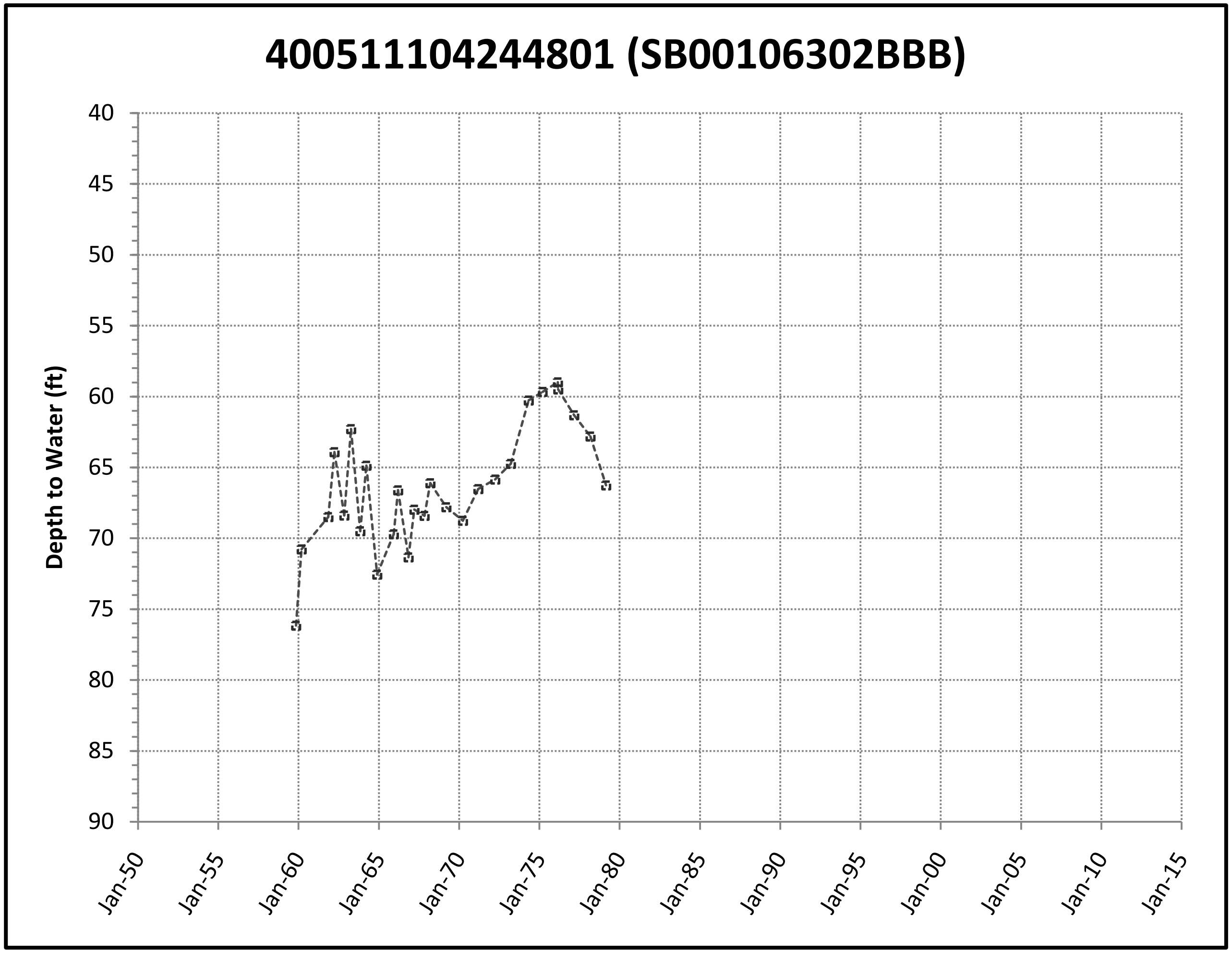
Jan-00
Jan-05
Jan-10
Jan-15


400511104244801 (SB00106302BBB)
Depth to Water (ft)
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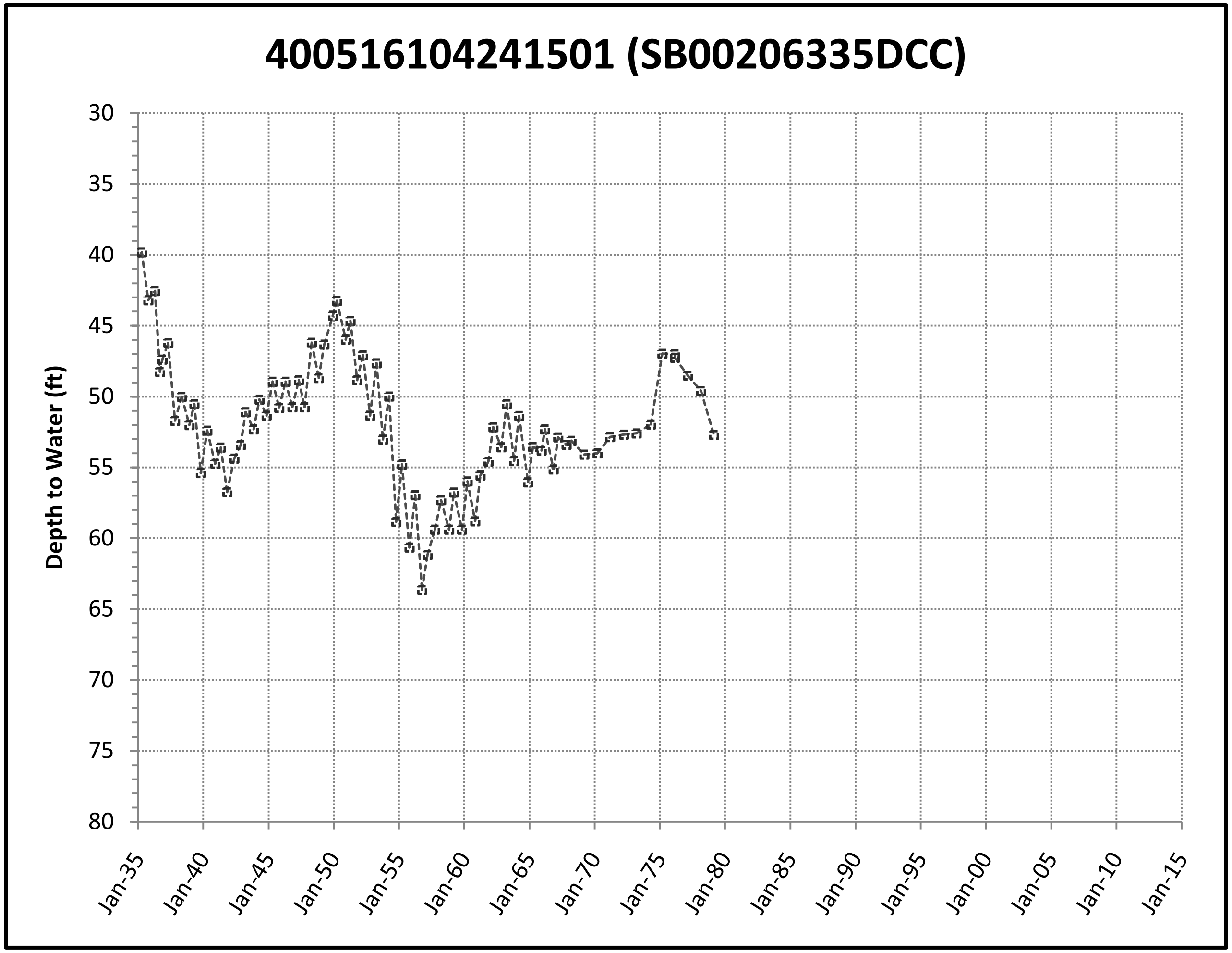
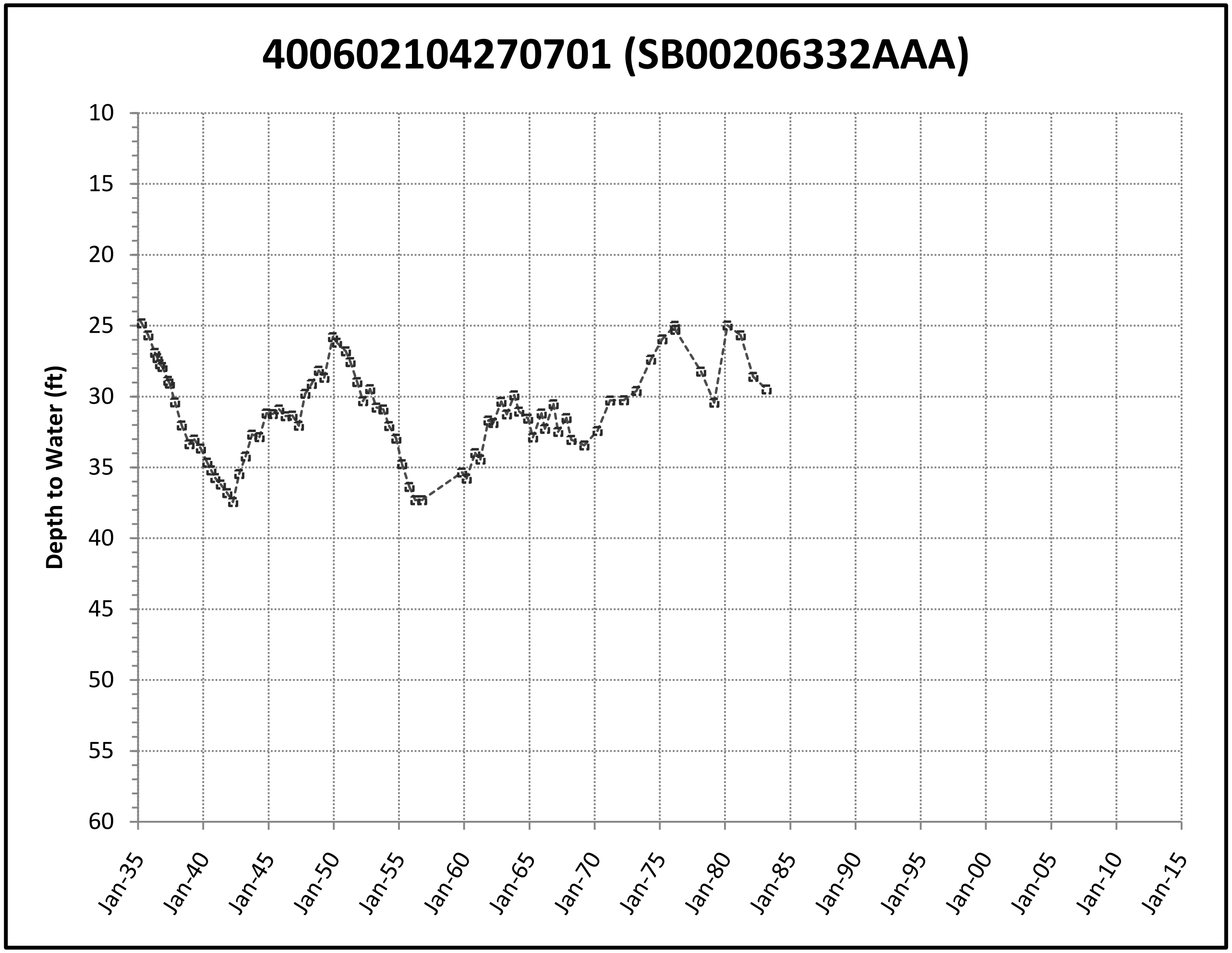
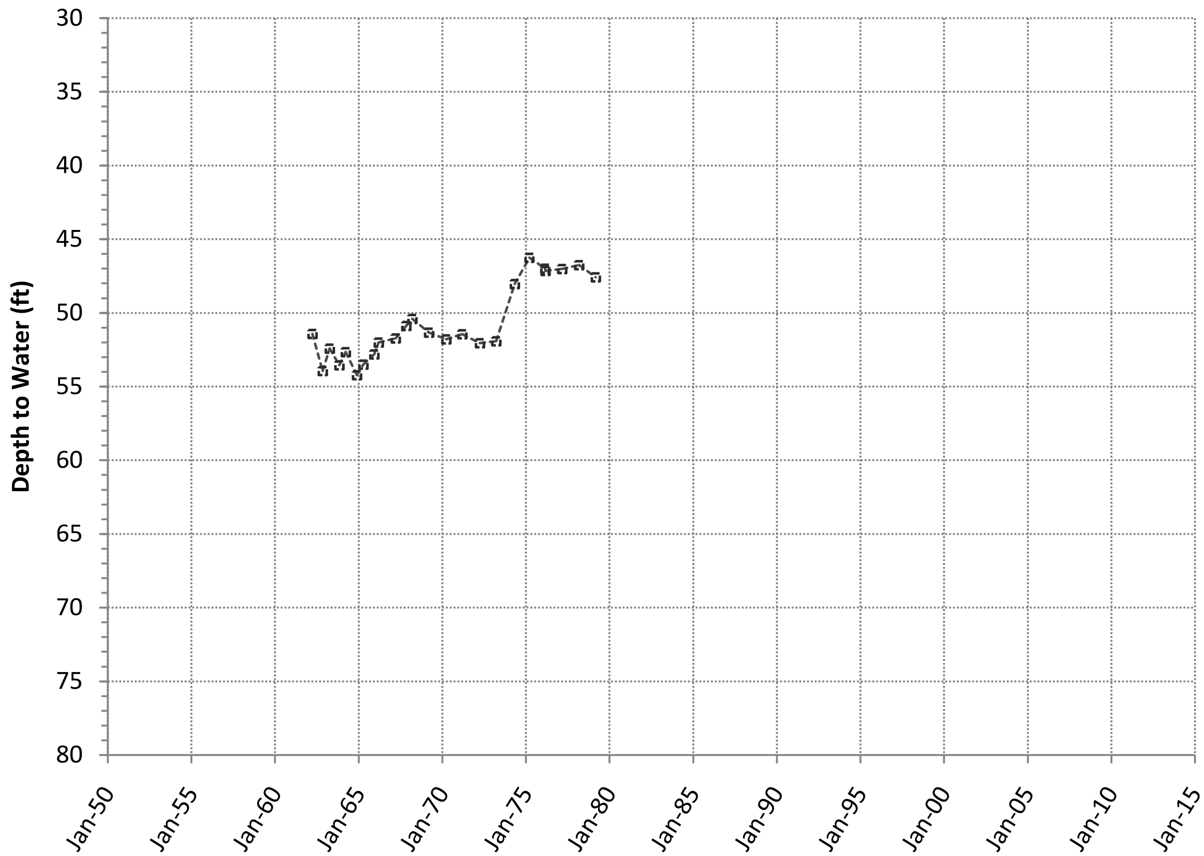
45
50
55
60
65
70
75
80
85
90
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15

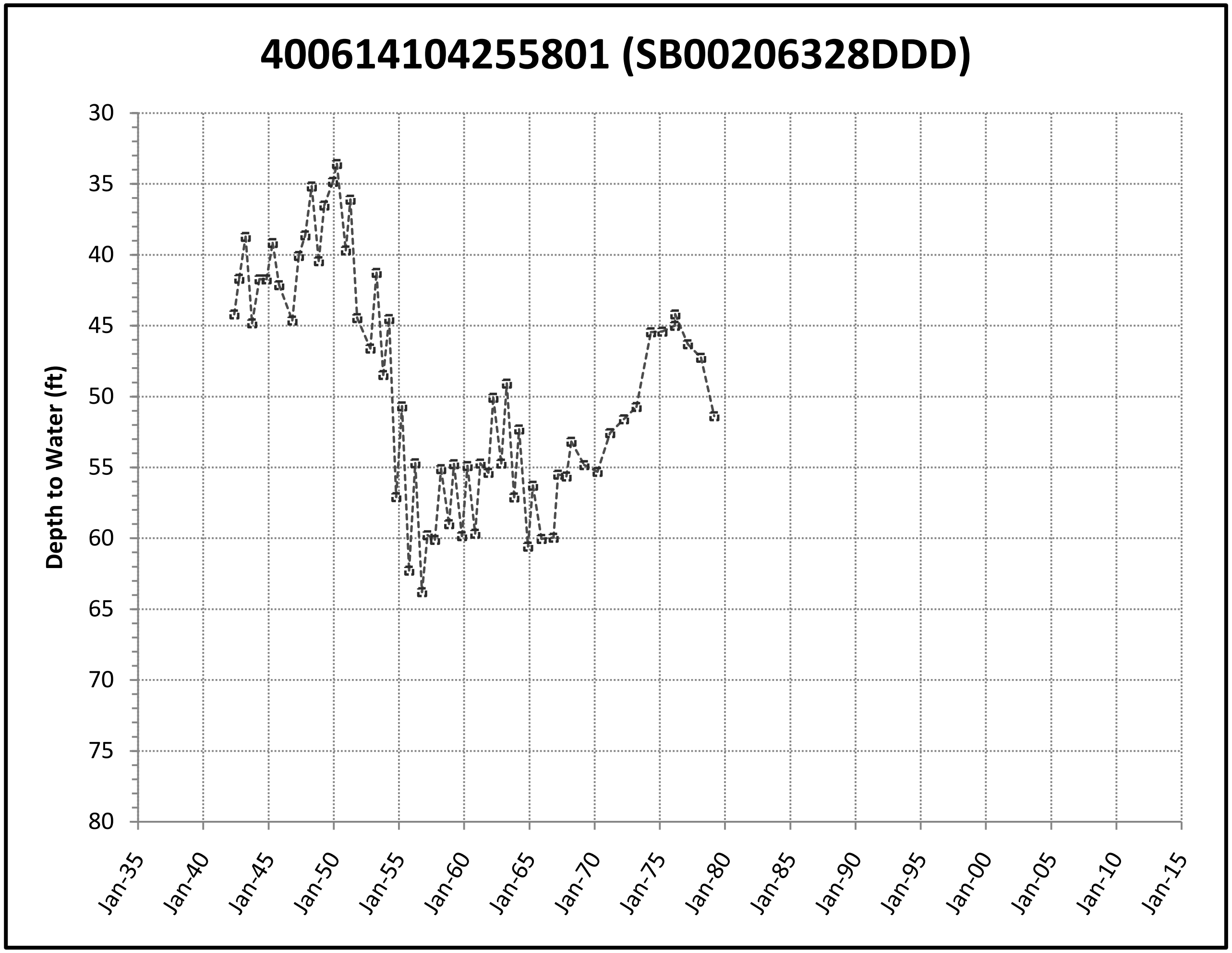

400516104241501 (SB00206335DCC)
Depth to Water (ft)
30
35
40
45
50
55
60
65
70
75
80
Jan-35
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15



400602104270701 (SB00206332AAA)
Depth to Water (ft)
10
15
20
25
30
35
40
45
50
55
60
Jan-35
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15

400607104220701 (SB00206231BAB)




400614104255801 (SB00206328DDD)
Depth to Water (ft)
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35
40
45
50
55
60
65
70
75
80
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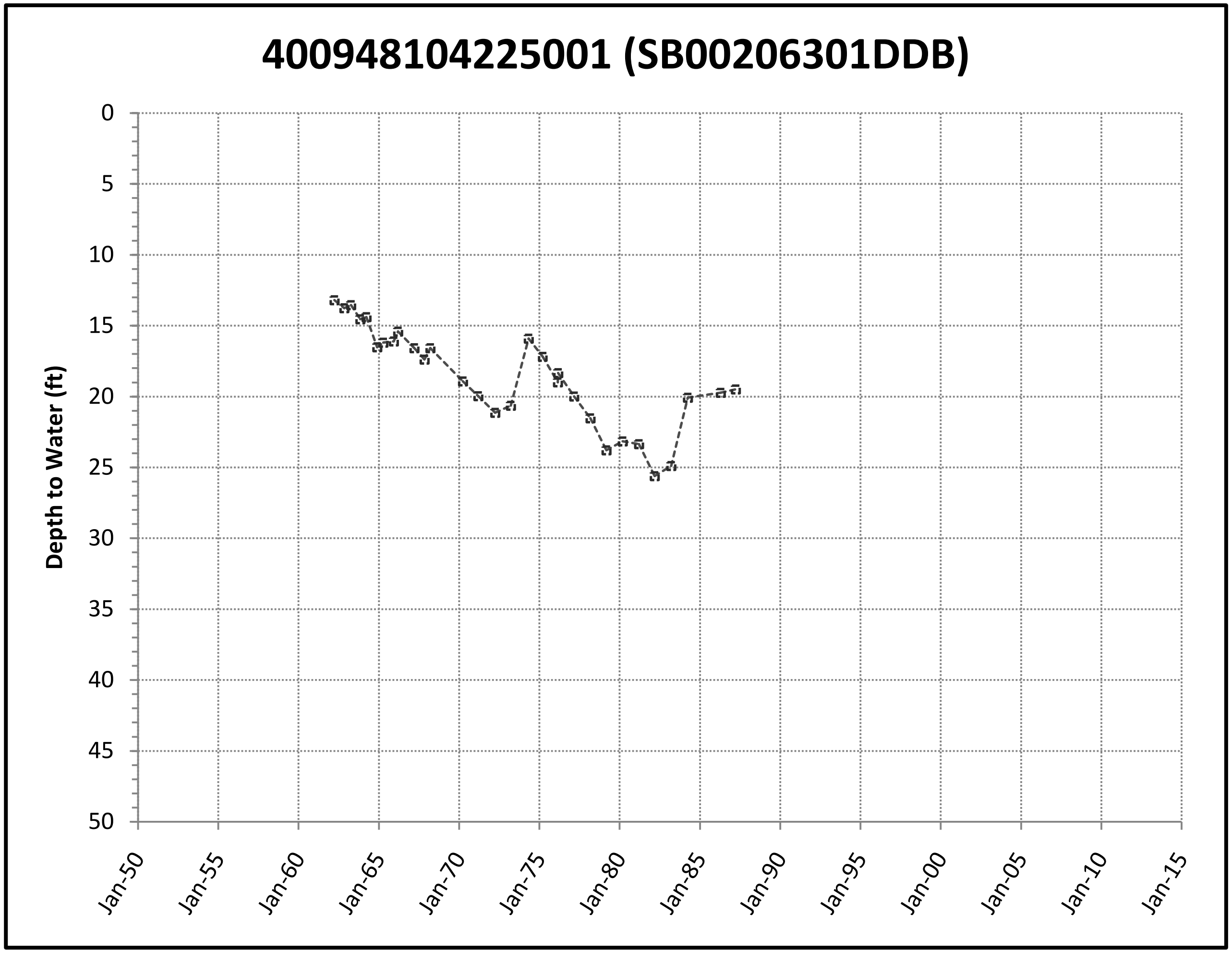
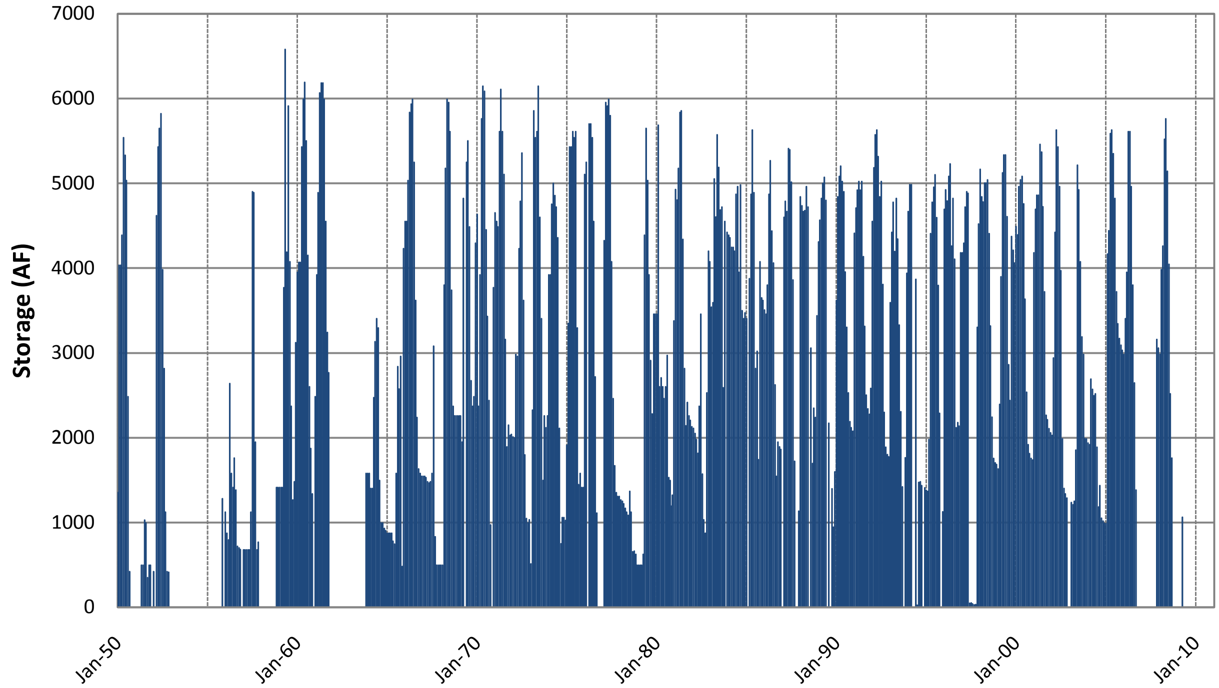
Jan-40
Jan-45
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15


400948104225001 (SB00206301DDB)
Depth to Water (ft)
0
5
10
15
20
25
30
35
40
45
50
Jan-50
Jan-55
Jan-60
Jan-65
Jan-70
Jan-75
Jan-80
Jan-85
Jan-90
Jan-95
Jan-00
Jan-05
Jan-10
Jan-15

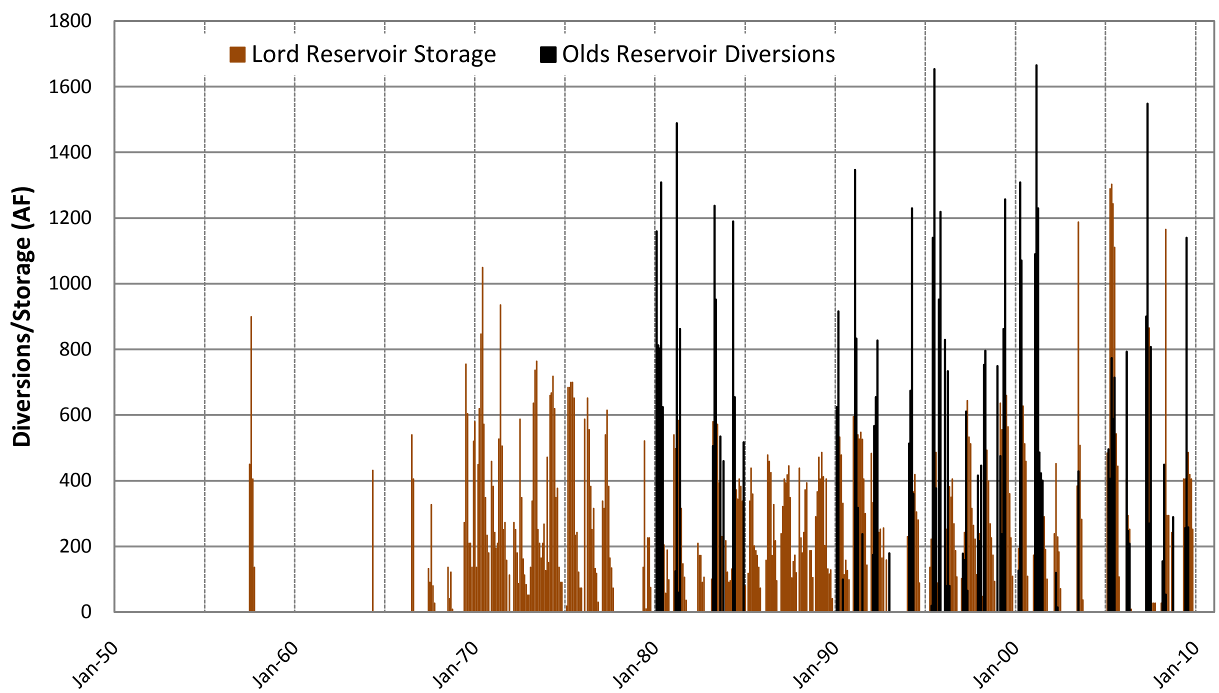
APPENDIX C

LOST CREEK SURFACE WATER STORAGE AND DIVERSIONS



Lost Creek Surface Water Storage at Prospect Reservoir

(Source: Colorado Division of Water Resources)



Lost Creek Surface Water Diversions and Storage in Lord and Olds Reservoirs

(Source: Colorado Division of Water Resources)

APPENDIX D

ALLUVIAL GROUNDWATER QUALITY DATA

SUMMARY OF CHEMICAL ANALYSES OF GROUNDWATER FROM THE ALLUVIAL AQUIFER IN THE LOST CREEK BASIN

Site ID	Sample Date	Data Source	Water Level (ft bls)	Well Depth (ft bls)	Temp °C	pH	Specific Conductance (µS)	Total Dissolved Solids mg/L	Hardness (as $CaCO_3$) mg/L	SAR ratio	Silica (SiO_2) mg/L	Cations (mg/L)					Anions (mg/L)						Metals (µg/L, unless noted with *)										
												Calcium	Magnesium	Manganese	Sodium	Potassium	Bicarbonate (as HCO_3)	Chloride	Fluoride	Nitrate (as N)	Ortho-phosphate (as P)	Sulfate	Arsenic*	Boron*	Cadmium	Chromium	Copper	Iron	Molybdenum	Nickel	Selenium*	Silver	Uranium
SB00106213AD	8/16/1948	Bjorklund & Brown, 1957		76		7.5	566	390	239		54	76.0	12.0		26.0	4.0	210	11.0	0.4	5.1		89		0.18				0.0					
SB00106215DAA1	6/12/1978	NWIS			16		837	500																									
SB00106210DAD1	6/29/1978	NWIS			18.5	7.7	850	**631**	17	27	14	5.0	1.1	<0.01	260.0	2.2		34.0	2.5	0.0	0.05	6						0.2					
SB00106210DAD1	6/14/1978	NWIS			13		1060	**630**																									
SB00106202DDD1	6/8/1978	NWIS			22		890	**520**																									
SB00106232BAA1	6/9/1978	NWIS			19		837	**501**																									
SB00106304ACD1	6/7/1978	NWIS			17		900	**541**																									
SB00106302DDC	10/3/1962	Skinner, 1963						**2687**																									
SB00106303AAA	10/3/1962	Skinner, 1963						**1118**																									
SB00106303CCC	9/14/1960	Skinner, 1963																															
SB00106303DCD	10/3/1962	Skinner, 1963						**1787**																									
SB00106303DD	11/15/1944	Code, 1945	62	80		7.9		**1006**			19	163.6	40.2		25.9			68.0		3.6		402											
SB00106310CDD	4/27/1960	Skinner, 1963						**646**																									
SB00106310CDD	10/3/1962	Skinner, 1963						**713**																									
SB00106313CC	10/26/1948	Skinner, 1963		40.5		7.9	806	**568**	256		17	76.0	16.0		74.0	8.0	262	38.0	1.6	2.3		136		0.8				**2.1**					
SB00106316DD	6/1/1960	Skinner, 1963				7.7		**527**	225			59.0	19.0		70.0	4.4	158	76.0	0.4	6.0		108											
SB00106316DDD	6/10/1960	Skinner, 1963						**755**																									
SB00106316DDD	9/14/1960	Skinner, 1963																															
SB00106321DAA	10/3/1962	Skinner, 1963						**560**																									
SB00106322ADC	4/27/1960	Skinner, 1963						**915**																									
SB00106322BCA	9/14/1960	Skinner, 1963																															
SB00106322BCA	10/3/1962	Skinner, 1963						465																									
SB00106322DCD	9/14/1960	Skinner, 1963																															
SB00106322DCD	10/3/1962	Skinner, 1963						**635**																									
SB00106322DDC	4/27/1960	Skinner, 1963						403																									
SB00106327DB	11/15/1944	Code, 1945	92	171		7.7		369			22	62.9	10.2		29.5			20.0		0.2		88											
SB00106327DB	9/13/1948	Skinner, 1963		172		7.6	548	422	243		26	76.0	13.0		42.0	4.4	216	17.0	0.4	1.6		135		0.16				0.0					
SB00106327DCB	9/14/1960	Skinner, 1963																															
SB00106329ABC	10/3/1962	Skinner, 1963						**910**																									
SB00106330ADD	10/3/1962	Skinner, 1963						**1282**																									
SB00106334BBB	9/14/1960	Skinner, 1963																															
SB00106334BBB	10/3/1962	Skinner, 1963						**635**																									
SB00106313BBB1	6/12/1978	NWIS			14		875	**513**																									
SB00106314BBB1	6/7/1978	NWIS			18		873	**516**																									
SB00106302BBB	8/16/1966	NWIS			13.3	7.5	2790	**2450**	1400	2.3	23	441.0	68.0		195.0	7.6		152.0	0.2			1280		0.3							0.000		
SB00106302BBB	9/22/1965	NWIS			13.3	7.6	2450	**2080**	1200	2	26	355.0	80.0		160.0	6.5		134.0	0.9			1040											
SB00106302BBB	9/3/1964	NWIS			12.8	7.7	2440	**2150**	1200	2.1	23	385.0	66.0		170.0	6.7		132.0	1.5			1090											
SB00106302BBB	9/24/1963	NWIS			12.8	7.2	2080	**1600**	960	1.8	25	295.0	56.0		129.0	6.3		120.0	2.0			787											
SB00106302BBB	10/2/1962	NWIS			13.3	7.7	1930	**1480**	900	1.7	25	281.0	50.0		115.0	5.8		108.0	0.2			724											
SB00106310BDD	6/9/2011	CGS		139	12.4	7.5	973	**620**				96	17		86	4.6	256	76		3.3		180											
SB00106315CDC	6/9/2011	CGS		150	12.2	7.4	1105	**640**				90	18		98	6.4	256	110		2.4		170											
SB00106322DD	6/9/2011	CGS		164	13.8	7.3	1588	**1200**				180	27		140	5.8	281	61		10		540											
SB00106401DCC1	6/8/1978	NWIS			21		1110	**682**																									
SB00206207DCD	6/9/2011	CGS		142	13.7	7.3	3840	**2800**				380	78		360	12	281	**310**		**15**		1500											
SB00206206CB2	11/6/1948	Skinner, 1963				7.6	544	375	226		25	0.7	15.0		40.0	0.0	183	7.0	0.6	2.2		126		0.15				0.0					
SB00206215BA	8/30/1948	Skinner, 1963		87		7.5	462	382	203		21	60.0	13.0		31.0	4.0	182	6.0	0.6	2.3		99		0				0.0					
SB00206219CD	11/5/1948	Skinner, 1963		87		7.8	1510	**1120**	626		17	200.0	31.0		113.0	9.2	234	90.0	1.6	4.8		516		0.12				0.2					
SB00206219BCB1	6/15/1978	NWIS			19		891	**531**																									
SB00206208ACC1	6/29/1978	NWIS			17.5	8.3	700	**662**	14	31	14	4.2	0.9	<0.01	270.0	2.8		43.0	2.7	0.0	0.22	7.6						0.1					
SB00206208ACC1	6/16/1978	NWIS			15		1090	**641**																									
SB00206302CC	7/27/1948	Skinner, 1963		81		7.6	882	**618**	298		25	83.0	22.0		82.0	2.0	219	20.0	0.8	3.0		252		0.12				0.0					
SB00206315DDC	10/3/1962	Skinner, 1963						**4120**																									
SB00206322AA	11/15/1944	Code, 1945	20	84		7.3		**2191**			27	329.3	60.0		1.8			160.0		0.9		832											
SB00206324DCC	10/3/1962	Skinner, 1963						**2113**																									
SB00206325AB2	7/26/1948	Skinner, 1963		80		7.4	1760	**1340**	809		28	260.0	39.0		103.0	4.0	307	108.0	0.2	7.4		612		0.3				0.0					
SB00206325CC1	7/26/1948	Skinner, 1963		74		7.6	1690	**1270**	733		26	231.0	38.0		135.0	6.0	326	90.0	0.5	7.4		548		0.2				0.1					
SB00206333DD2	7/30/1948	Skinner, 1963		87		7.9	1200	**870**	457		24	137.0	28.0		107.0	3.2	297	70.0	0.4	2.1		300		0.42				0.1					
SB00206334CC	6/1/1960	Skinner, 1963				7.6		**1210**	780			237.0	46.0		96.0	4.6	100	94.0	0.4	3.7		632											
SB00206334CCC	6/10/1960	Skinner, 1963						**1075**																									
SB00206333CBB1	6/16/1978	NWIS			19		895	**539**																									
SB00206323CD	8/16/1966	NWIS			12.8	7.9	2520	**2220**	1300	1.9	21	400.0	67.0		152.0	6.9		140.0	0.4			1190		0.11							0.000		
SB00206323CD	9/3/1964	NWIS		117	12.2	7.3	2540	**2300**	1300	2	21	418.0	71.0		164.0	6.9		136.0	0.6			1260											
SB00206315DDC	8/16/1966	NWIS		82	11.7	7.8	4590	**4140**	2000	4.8	20	593.0	117.0		486.0	8.5		**292.0**	0.5			2230		0.24							0.000		
SB00206315DDC	9/22/1965	NWIS		82	11.7	7.5	4550	**4060**	2000	4.5	21	577.0	124.0		457.0	9.1		**290.0**	0.6			2140											
SB00206315DDC	9/3/1964	NWIS		82	12.2	7.6	3550	**3400**	1900	2.7	21	565.0	114.0		273.0	8.2		192.0	0.2			1910											
SB00206322CDC	6/9/2011	CGS		115	12.6	7.2	3200	**2300**				350	76		260	8.4	317	190		10		1300											
SB00206334ADD	6/9/2011	CGS		131	12.9	7.2	2600	**1900**				310	61		170	7.2	342	120		**11**		990											
SB00206434DBB1	6/12/1978	NWIS			20		1080	**649**																									
SB00306210ABD	8/22/1966	NWIS		60	13.9	7.6	608	393	190	2	18	57.0	11.0		64.0	3.1		8.2	0.8			131		0.06							0.000		
SB00306210ABD	9/22/1965	NWIS		60	12.2	7	463	296	150	1.4	19	43.0	9.7		38.0	1.1		4.3	1.0			85											
SB00306210ABD	9/3/1964	NWIS		60		7.3	446	300	150	37	18	43.0	9.6		40.0	2.8		6.8	0.8			84											
SC00106302CCC	6/10/1960	Skinner, 1963						384																									
SC00106302CCC	10/3/1962	Skinner, 1963						261																									
SB00406235BAC	6/9/2011	CGS		52	13.1	7.8	763	490				62	17		80	3.2	232	8.8		0.044		210											
SC00106308CDC	6/9/2011	CGS		103	19.8	7.3	4320	**3600**				530	110		370	9.2	354	230		10		2200											

SUMMARY OF CHEMICAL ANALYSES OF GROUNDWATER FROM THE ALLUVIAL AQUIFER IN THE LOST CREEK BASIN

Site ID	Sample Date	Data Source	Water Level (ft bls)	Well Depth (ft bls)	Temp °C	pH	Specific Conductance (µS)	Total Dissolved Solids mg/L	Hardness (as $CaCO_3$) mg/L	SAR ratio	Silica (SiO_2) mg/L	Cations (mg/L)					Anions (mg/L)						Metals (µg/L, unless noted with *)										
												Calcium	Magnesium	Manganese	Sodium	Potassium	Bicarbonate (as HCO_3)	Chloride	Fluoride	Nitrate (as N)	Ortho-phosphate (as P)	Sulfate	Arsenic*	Boron*	Cadmium	Chromium	Copper	Iron	Molybdenum	Nickel	Selenium*	Silver	Uranium
SC00106303CC	6/10/1960	Skinner, 1963						268																									
SC00106310BB	6/1/1960	Skinner, 1963				8.2		311	166			52.0	8.8		36.0	2.6	178	7.0	0.5	1.3		67											
SC00106310BBB	10/3/1962	Skinner, 1963						206																									
SC00106301CDC1	6/5/1978	NWIS			16		915	**547**																									
SC00106304CBC1	6/8/1978	NWIS			19		840	495																									
SC00106324ABB1	6/6/1978	NWIS			14		1000	**578**																									
SC00106313CCC1	6/29/1978	NWIS			21	7.9	950	**579**	9	35	15	2.8	0.5		240.0	1.6		22.0	2.1	0.0	0.13	8.1						0.0					
SC00106313CCC1	6/5/1978	NWIS			19		936	**605**																									
SC00206331ABB1	6/28/1978	NWIS			19	8.4	581	367	88	4.5	16	29.0	3.8	<0.01	96.0	2.3		12.0	1.3	0.6	0.04	110						0.0					
SC00206331ABB1	5/31/1978	NWIS			13.5		594	364																									
SC00206301CAA1	6/15/1978	NWIS			12		409	248																									
SC00206335CBB AGLUS11	7/15/2003	NWIS	86.52		17	7.1	1130	**807**	420	1.9	25	133.0	21.0	0.00	91.5	6.1	278	43.0	0.6	0.7	0.07	321	0.001	0.055	0.02	0.5	1.9		3.8	2.44	0.004	< 0.2	11
SC00206332BDD AGLUS26	7/7/2003	NWIS	75.66		13.7	7.4	1170	**874**	480	1.3	23	147.0	27.6	0.00	64.4	5.0	218	49.2	0.4	9.8	0.04	331	0.002	0.085	< 0.04	1.2	1.5		1.5	5.73	0.036	< 0.2	13.2
SC00206323DDD AGLUS10	8/19/2003	NWIS	68.31		17.1	7.4	1560	**1220**	680	1.3	18	198.0	44.4	0.02	75.0	5.0	131	56.0	0.7	**13.8**	< 0.09	615	0.003	0.071	0.05	0.5	2.4	0.0	7.1	35.3	0.040	< 0.2	8.99
SC00206321ADB AGLUS27	7/14/2003	NWIS	68.17		18.7	7.3	636	437	260	0.9	22	80.9	12.6	0.00	32.8	4.0	183	18.8	0.2	6.4	0.07	127	0.001	0.044	< 0.04	1.2	0.8		1.5	2.71	0.010	< 0.2	7.07
SC00206320BAA AGLUSREF1	8/31/2006	NWIS	56.14		18.3	8	310	202	130	0.2	25	40.1	6.2	0.00	4.3	3.5	89	11.5	0.1	6.6	0.061	20.8	0.001	0.02	< 0.04	1.1	< 0.40		0.9	0.38	0.004	< 0.2	0.82
SC00206320BAA AGLUSREF1	7/15/2004	NWIS	53.94		15	7.6	256	191	120	0.2	27	40.0	5.3	0.00	4.8	3.4	90	10.6	0.2	6.1	0.049	17.6	0.001	0.029	< 0.04	1	0.3		1.2	0.79	0.003	< 0.2	0.95
SC00206320BAA AGLUSREF1	4/8/2004	NWIS	53.88		14.7	7.6	228	187	120	0.2	25	39.8	6.2	ND	5.1	3.2	89	10.3	0.2	6.4	0.053	17.6											
SC00206320BAA AGLUSREF1	1/30/2004	NWIS	53.87		14.1	7.9	275	186	120	0.2	24	39.6	5.9	ND	5.0	3.3	107	9.7	0.2	6.1	0.053	15.8											
SC00206320BAA AGLUSREF1	10/17/2003	NWIS	53.78		15.5	8	257	180	120	0.2	25	38.6	6.0	ND	5.6	3.5	95	9.7	0.2	5.8	0.05	13.4											
SC00206320BAA AGLUSREF1	7/10/2003	NWIS	55.79		19.7	7.9	271	182	110	0.3	22	36.4	5.6	0.01	8.2	3.2	105	8.9	0.3	6.1	0.04	13.8	0.001	0.032	< 0.04	1.5	0.8		2	1.55	0.003	< 0.2	1.3
SC00206310CDD AGLUS3	7/17/2003	NWIS	83.63		15.5	7.2	474	311	190	0.5	24	61.4	9.1	0.00	16.3	3.4	96	25.7	0.2	9.2	0.08	70.9	0.001	0.027	< 0.04	1	0.4		1.3	1.99	0.005	< 0.2	2.55
SC00206311DAA AGLUS4	7/17/2003	NWIS	68.91		16	6.8	578	381	230	0.8	24	74.0	11.7	0.00	27.3	4.9	154	18.8	< 0.17	7.9	0.13	104	0.002	0.036	< 0.04	1.3	0.6		0.7	2.32	0.006	< 0.2	6.78
SC00206307DAA AGLUS29	7/23/2003	NWIS	102.43		16.7	7.7	462	315	170	1.2	21	52.3	9.3	0.00	36.6	2.8	151	8.3	0.7	4.5	0.04	85.6	0.001	0.061	< 0.04	1.8	0.5	0.0	2.5	1.89	0.007	< 0.2	3.56
SC00206305BBA AGLUS30	7/18/2003	NWIS	81.77		16.2	7.4	563	388	240	0.5	22	75.2	12.8	0.00	18.3	4.3	201	18.0	< 0.17	9.4	0.03	63.2	0.000	0.034	< 0.04	2.4	1.6		0.6	1.8	0.004	< 0.2	5.62
SC00206425DDD1	7/17/1980	NWIS			27	7.8	480	329	27	9.3	10	8.3	1.4	ND	110.0	1.6		8.6	1.4	0.3		84						0.0					
SC00206425DDD1	5/12/1978	NWIS			12	7.4	550	330	36	8	11	11.0	2.1	<0.01	110.0	2.1		8.4	1.2	0.1	0.01	85						0.1					
SC00206425DDD1	5/26/1977	NWIS			14.5	8	580																										
SC00206424DDC1	6/16/1977	NWIS			16.5	7.8	900																										
SC00206414CAB1	6/11/1977	NWIS			16.5	7.9	600																										
SC00206410CDD1	5/17/1977	NWIS			15	**8.6**	450																										
SC00206410CDD3	7/17/1980	NWIS			17	8.4	600																										
SC00206402ADD1	6/16/1977	NWIS			17	**8.7**	820																										
SC00206422CDD AGLUS15	8/6/2003	NWIS	49.09		18.5	8	414	263	130	1.4	11	40.9	7.6	0.03	36.4	4.1	177	4.0	0.5	< 0.06	< 0.02	63.9	0.001	0.038	0.03	< 0.8	0.9		8.7	2.38	0.001	< 0.2	3.5
SC00206423BAA AGLUS19	8/5/2003	NWIS	83.77		16	7.5	1480	**1040**	300	5	21	88.3	19.8	0.02	202.0	5.3	167	78.8	0.5	**10.5**	0.03	441	0.002	0.053	0.05	1.2	4.6	0.0	2.7	1.98	**0.050**	< 0.2	3.94
SC00206435DDC AGLUS16	8/13/2003	NWIS	29.99		15.5	6.8	710	499	290	0.8	24	85.7	17.9	0.00	32.0	6.1	150	24.8	< 0.17	9.8	0.22	156	0.002	0.051	< 0.04	0.5	1.4		0.4	2.47	0.027	< 0.2	2.32
SC00206412BBB AGLUS18	7/31/2003	NWIS	38.75		14.3	7.2	1870	**1630**	1000	1.2	19	295.0	65.2	0.00	85.4	5.4	194	60.0	0.2	**16.0**	< 0.09	845	0.002	0.045	0.03	0.9	3.4	0.0	1.2	5.65	0.031	< 0.2	24.1
SC00306328ADA1	5/22/1978	NWIS					784																										
SC00306318DDC1	5/22/1978	NWIS			14.5		301	171																									
SC00306309CCC1	6/28/1978	NWIS			19	7.9	580	371	58	6.3	14	20.0	1.9	0.05	110.0	2.1		13.0	1.0	0.0	< 0.010	130						0.2					
SC00306309CCC1	5/19/1978	NWIS			15		585	345																									
SC00306330DBB AGLUS23	8/14/2003	NWIS	36.66		15.8	6.7	4080	**3770**	1200	8.2	12	341.0	82.4	**0.31**	647.0	11.3	761	180.0	0.2	< 0.06	< 0.02	1860	0.001	0.066	< 0.07	0.5	8.8	**3.9**	0.6	13.3	0.003	< 0.4	0.13
SC00306320DDA AGLUS24	7/16/2003	NWIS	87.88		22.5	7.6	483	283	200	1	13	58.6	11.8	**0.13**	31.1	2.8	259	4.2	0.9	< 0.06	0.06	34.5	0.004	0.075	< 0.04	< 0.8	0.4	0.1	5.7	2.58	<0.0005	< 0.2	0.73
SC00306316ADD AGLUS13	7/24/2003	NWIS	67.34		20.8	7.8	418	271	180	0.6	20	50.5	11.8	0.00	17.0	3.4	135	21.3	0.4	6.9	0.03	44.9	0.001	0.041	< 0.04	1.4	0.9		2.7	2.84	0.009	< 0.2	3.29
SC00306310BBB AGLUS2	7/22/2003	NWIS	60.16		16.5	7.7	481	283	170	1.4	21	45.8	12.7	0.00	40.1	3.1	253	7.2	0.4	1.9	0.03	35	0.001	0.069	< 0.04	0.6	0.6		3.3	0.97	0.002	< 0.2	9.46
SC00306306BBD AGLUS20	8/4/2003	NWIS	24.4		14.7	7.3	951	**572**	420	0.7	26	120.0	29.2	0.00	35.2	6.1	409	37.4	< 0.17	9.1	0.22	57.5	0.002	0.088	0.03	1.4	1.3	0.0	1.5	4.61	0.005	< 0.2	**46.1**
SC00306413BBA AGLUS25	8/6/2003	NWIS	34.6		12.6	7	1520	**1040**	480	3.3	9	143.0	28.6	**0.18**	164.0	6.3	467	23.5	0.3	0.3	< 0.02	406	0.000	0.056	0.06	0.9	3.8	0.0	2	6.94	0.001	< 0.2	0.46
SC00306411ABB AGLUS21	7/21/2003	NWIS	18.67		14.4	7.2	1140	**800**	460	1.2	22	141.0	25.4	ND	61.0	5.9	256	71.8	0.3	**10.1**	0.22	249	0.002	0.073	0.09	0.7	1.6	0.0	4.4	2.66	0.022	< 0.2	22.2
SC00306426CAA AGLUS12	8/4/2003	NWIS	30.87		16.7	6.5	4280	**4180**	2400	2.4	26	609.0	203.0	**0.22**	265.0	40.6	755	86.0	0.5	8.3	0.28	2040	0.005	0.771	0.23	1.3	19	<0.08	4.6	25.2	**0.093**	< 0.4	**146**
SC00406307CCB1	5/12/1982	NWIS			13	8	350	274	64	5.1	13	22.0	2.3	0.03	91.0	3.4		8.5	2.6	0.0		5		0.06				0.1			<0.001		
SC00406307CCB1	7/10/1978	NWIS			18.5		432	260																									
SC00406412BBB	8/13/1979	NWIS			16		670	495	290	1	29	92.0	15.0		39.0	5.3		50.0	0.6	6.3		140						0.0					
SC00406403AAA1	7/10/1978	NWIS			22		325	215																									
SC00406413CCA1	5/12/1982	NWIS			12	8.2	410	269	42	6.1	13	15.0	1.2	0.02	89.0	2.7		9.3	1.7	0.2		< 5.0		0.06				0.1			<0.001		
SC00406413CCA1	7/10/1978	NWIS			20.5		433	257																									
SC00406402CCB AGLUS22	8/14/2003	NWIS	53.47		17.8	7.3	773	**528**	290	2.1	12	96.7	12.1	**0.14**	83.6	5.6	349	19.7	0.3	< 0.60	< 0.18	127	0.001	0.054	0.04	< 0.8	1.2	0.0	4.4	7.21	0.001	< 0.2	1
SC00406401CBB AGLUSREF2	7/30/2003	NWIS	20.61		18.2	7.1	1290	**983**	700	1	14	207.0	42.8	**0.08**	60.4	9.3	476	9.5	0.3	< 0.06	< 0.02	351	0.000	0.074	< 0.04	< 0.8	2	0.3	0.4	3.91	<0.0005	< 0.2	0.14

NOTES:
Bold text indicates MCL/SMCL exceedance
Shaded areas indicate duplicate wells
* value in mg/L
ND = below detection limit
Values in red have been converted from Bicarbonate as CaCO3 to Bicarbonate as HCO3

APPENDIX E

CGS 2011 COREHOLE LOGS

Colorado Geological Survey / Drill Log Form

Client:	CGS	Date:	1/25/11	Surf. Elev: NA		Geologist: A. Horn	
Project No:	2704	Hole Ident:	LC-TH-01	Casing Dia: 2.25"	Core Dia: 1"	Borehole TD: 30'	Well TD: NA
Site:	Lost Creek Basin	Location:	T3N, R62W, s 12, SW/4 of NE/4			Completion: NA	Stick-up: NA
Driller/Rig:	7822DT Track-mounted DPT	Samples:	Continuous Core, Field Lithologic Logging			Depth to water: NA	

Depth (ft)	Geologic Description	Sample Depth (ft)	USCS	Blow Counts at 6",12",18",(bpf)	Soil Density	Graphic Log	Well Materials CSG	Well Materials ANN
0-5	SAND, fine, yellowish orange, well sorted (dune sand) dry		SW					
5 - 10	SAND, fine, yellowish orange, well sorted (dune sand) dry		SW					
10 - 15	SAND, fine, yellowish orange, well sorted (dune sand) dry ~5 mm oxide stained zone at 14.5 ft		SW					
15 - 18	SAND, fine, yellowish orange, well sorted (dune sand) dry		SW					
18 - 20	CLAY, stiff, yellowish orange, slightly moist, stiff, med plasticity whitish calcareous zones observed.		CL					
20 - 24.9	CLAY, stiff, yellowish orange, w/ whitish nodules, slightly moist, med. stiff, oxide staining common		CL					
24.9 - 25	Highly oxidized, hard zone							

Colorado Geological Survey / Drill Log Form

Site:	Lost Creek Basin	Hole Ident: LC-TH-01	Page 2 of 2

Depth (ft)	Geologic Description	Sample Depth (ft)	USCS	Blow Counts at 6",12",18",(bpf)	Soil Density	Graphic Log	Well Materials CSG	Well Materials ANN
25 - 30	CLAY, light brown, hard, w/ bluish zones, ~2mm whitish nodules, Gypsum flakes at 29.5		CL					

Colorado Geological Survey / Drill Log Form

Client: CGS	Date: 1/25/11	Surf. Elev:		Geologist: A. Horn			
Project No: 2704	Hole Ident: LC-TH-02	Casing Dia: 2.25"	Core Dia: 1"	Borehole TD: 40		Well TD: NA	
Site: Lost Creek Basin	Location: T2N, R63W, S16, NW/4 of SE/4			Completion: NA		Stick-up: NA	
Driller/Rig: 7822DT Track-mounted DPT	Samples: Continuous Core, Field Lithologic Logging			Depth to water: 30'			

Depth (ft)	Geologic Description	Sample Depth (ft)	USCS	Blow Counts at 6",12",18",(bpf)	Soil Density	Graphic Log	Well Materials CSG	Well Materials ANN
0 - 5	SAND, fine, light brown, becoming silty with depth		SW					
5 - 10	SILT, w/ clay, light brown, med. plasticity		ML					
10 - 15	CLAY, silty, light brown, soft, becoming firm with depth		CL					
15 - 20	CLAY, light brown, med. stiff, moist		CL					
20 - 22.5	CLAY, light brown, med. stiff, moist		CL					
22.5 - 25	CLAY, silty, light brown, med. soff, moist		CL					
	becoming sandy at 24.5							

Colorado Geological Survey / Drill Log Form

Site: Lost Creek	Hole Ident: LC-TH-02	Page 2 of 2

Depth (ft)	Geologic Description	Sample Depth (ft)	OVM (ppm)	Blow Counts at 6",12",18",(bpf)	Soil Density	Graphic Log	Well Materials CSG	Well Materials ANN
25 - 29	SAND, fine, yellowish orange, w/ trace clay, clay interbeds		SW					
29 - 30	SAND, fine, yellowish orange, moist		SW					
30 - 35	SAND, fine, yellowish orange, wet, occasional clayey interbeds soft		SW					
35 - 35.7	SAND, coarse, yellowish orange, trace gravel, wet.		SW					
35.7 - 40	CLAYSTONE, light brown, oxidized, firm, gray to dark gray w/ yellowish orange zones, moist		CL					

Colorado Geological Survey / Drill Log Form

Client:	CGS	Date:	1/25/11	Surf. Elev: NA		Geologist:	A. Horn
Project No:	2704	Hole Ident:	LC-TH-03	Casing Dia: 2.25"	Core Dia: 1"	Borehole TD: 35	Well TD: NA
Site:	Lost Creek Basin	Location:	T1S, R64W, S13, SW/4 of SE/4			Completion: NA	Stick-up: NA
Driller/Rig:	7822DT Track-mounted DPT	Samples:	Continuous Core, Field Lithologic Logging			Depth to water:	32.5'

Depth (ft)	Geologic Description	Sample Depth (ft)	USCS	Blow Counts at 6",12",18",(bpf)	Soil Density	Graphic Log	Well Materials CSG	Well Materials ANN
0 - 5	SILT, sandy w/ trace clay, brown, slightly moist, med. plasticity (1' recovered)		ML					
5 - 10	SILT, sandy w/ trace clay, brown, slightly moist, med. plasticity (1' recovered)		ML					
10 - 14.9	SAND, medium, silty, brown, dry (4' recovered)		SM					
14.9 - 20	CLAYSTONE, grayish brown, hard, calcareous zones ~0.1' thick w/ orangeish yellow zones		CL					
20 - 25	CLAYSTONE, grayish brown, hard, calcareous zones ~0.1' thick w/ orangeish yellow zones		CL					

Colorado Geological Survey / Drill Log Form

Site: Lost Creek	Hole Ident: LC-TH-03	Page 2 of 2

Depth (ft)	Geologic Description	Sample Depth (ft)	OVM (ppm)	Blow Counts at 6",12",18",(bpf)	Soil Density	Graphic Log	Well Materials CSG	Well Materials ANN
35 - 30	CLAYSTONE, grayish brown, hard, calcareous zones ~0.1' thick w/ orangeish yellow zones		CL					
30 - 32.5	CLAYSTONE, grayish brown, hard, calcareous zones ~0.1' thick w/ orangeish yellow zones		CL					
32.5 - 34.5	SILT, sandy, brownish orange, soft, wet		ML					
34.5 - 35	CLAYSTONE, grayish brown, hard, calcareous zones ~0.1' thick w/ orangeish yellow zones		CL					

Colorado Geological Survey / Drill Log Form

Client: CGS	Date: 1/25/11	Surf. Elev: NA		Geologist: A. Horn	
Project No: 2704	Hole Ident: LC-TH-02	Casing Dia: 2.25"	Core Dia: 1"	Borehole TD: 35	Well TD: NA
Site: Lost Creek Basin	Location: T1N, R64W, s 36, SW/4 of NW/4			Completion: NA	Stick-up: NA
Driller/Rig: 7822DT Track-mounted DPT	Samples: Continuous Core, Field Lithologic Logging			Depth to water: NA	

Depth (ft)	Geologic Description	Sample Depth (ft)	OVM (ppm)	Blow Counts at 6",12",18",(bpf)	Soil Density	Graphic Log	Well Materials CSG	Well Materials ANN
0 - 1.5	SILT, light brown, finely bedded, dry		ML					
1.5 - 5	SILT, sandy, very light brown, dry (3' recovery)		ML					
5 - 10	SILT, sandy, very light brown grading to reddish brown w/ depth, finely bedded, dry (2' recovery)		ML					
10 - 15	SILT, sandy, reddish brown w/ ~1 - 2 mm calcareous interbeds and nodules, hard, dry		ML					
15 - 20	SILT, sandy, reddish brown w/ trace clay, hard, dry low plasticity. (2' recovery)		ML					
20 - 25	SILT, sandy, reddish brown w/ trace clay, stiff, slightly moist med. - low plasticity.		ML					

Colorado Geological Survey / Drill Log Form

Site: Lost Creek Basin	Hole Ident: LC-TH-02	Page 2 of 2

Depth (ft)	Geologic Description	Sample Depth (ft)	USCS	Blow Counts at 6",12",18",(bpf)	Soil Density	Graphic Log	Well Materials CSG	Well Materials ANN
25 - 25.5	SILT, as above, increasing clay with depth.		ML					
25.5 - 28	CLAYSTONE, silty, yellowish orange, w/ calcareous interbeds very slightly moist, hard.		CL					
28 - 30	CLAYSTONE, light grayish brown, very slightly moist, hard.		CL					
30 - 35	CLAYSTONE, light grayish brown, w/ 0.1' thick silty orange interbeds, very slightly moist, hard.		CL					

Colorado Geological Survey / Drill Log Form

Client: CGS	Date: 1/25/11	Surf. Elev: NA	Geologist: A. Horn
Project No: 2704	Hole Ident: LC-TH-05	Casing Dia: 2.25" / Core Dia: 1"	Borehole TD: 19 / Well TD: NA
Site: Lost Creek Basin	Location: T3S, R63W, s 31, NE/4 of NE/4		Completion: NA / Stick-up: NA
Driller/Rig: 7822DT Track-mounted DPT	Samples: Continuous Core, Field Lithologic Logging		Depth to water: NA

Depth (ft)	Geologic Description	Sample Depth (ft)	USCS	Blow Counts at 6",12",18",(bpf)	Soil Density	Graphic Log	Well Materials CSG	Well Materials ANN
0 - 1	SILT, dark brown, moist (topsoil)		ML					
2 - 5	CLAYSTONE, brown, hard, slightly moist (4' recovered)		CL					
5 - 10	CLAYSTONE, with silty and sandy zones, light brown, stiff, slightly moist		CL					
10 - 15	CLAYSTONE, with silty and sandy zones, brown, w/ ~5mm calcareous nodules, stiff, slightly moist		CL					
15 - 19	CLAYSTONE, with silty zones, brown grading to grayish brown w/ orangish brown zones at depth, hard, slightly moist		CL					
19	refusal on fibrous gypsum nodule							