Ground Water Appendix

Flooding Appendix

Ground Water Appendix
to
Platte River Recovery Program
Programmatic EIS

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Ground Water Appendix to Platte River Recovery Program EIS

INTRODUCTION

Several opportunities for augmentation of Platte River flows using ground water resources were examined. The river system was divided into three subareas, North Platte, South Platte, and Central Platte, the latter being the Platte River from the confluence at the City of North Platte to Grand Island. Below Grand Island there is no plausible means to introduce ground water into the target reach of the river.

The North Platte did not yield any ground water opportunities that were worthy of serious consideration.

Four proposals were considered on the South Platte. They are Denver Basin ground water pumping, Barr Lake ground water storage and retrieval, Tamarack reregulation, and Pony Express reregulation.

The Central Platte reach proposals for flow augmentation include pumping ground water from the Sand Hills, rergulation by use of Gothenburg Canal, drainage of seeped lands near the river, pumping the ground water mound that has been built beneath the Central Nebraska Public Power and Irrigation District lands, use of the mound as a reservoir by annual recharge and recovery, and drainage of seeped lands in upper reaches on Lost Creek and North Dry Creek.

There are ground water related issues other than flow augmentation. The effect of program flows on wet meadows was studied. A proposal to pump ground water from the river bed to provide cool water to lower the summertime river water temperature was also examined. The impact of program flows on property owners and residents near the river was also studied. In response to extensive public interest in these impacts, considerable new data was collected for the study. All other ground water studies relied upon existing data and cursory field reviews.

SOUTH PLATTE AREA

Denver Basin

Barr Lake Recharge and Recovery

Tamarack Reregulation

Pony Express Reregulation

CENTRAL PLATTE AREA

Sand Hills pumping

Gothenburg Canal Reregulation

Drainage of Seeped Lands Near the River,

Mining the CNPPID Ground Water Mound

Recharge and Recovery in the Mound Area and drainage of seeped lands in upper reaches on

Drainage of seeped lands on Lost Creek and North Dry Creek.

RELATED GROUND WATER ISSUES

Wet Meadows

Temperature Control

Flooding of Provate Property

Ground Water Appendix
to
Platte River Recovery Program
Programmatic EIS

Executive Summary

The Ground Water Appendix includes a description and a brief analysis of each of the ground water elements that are included in the Programmatic EIS. It also includes an analysis of impacts on ground water as a result of Program generated flows.

Ground Water Influences in the Central Platte River Valley

Three ground water elements are included in various plans in the Programmatic EIS. These are use of the ground water mound generated by Nebraska Public Power and Irrigation District (NPPID) as a reservoir, riverside drains, and retiming of return flows through the Gothenburg and Dawson Canals.

The NPPID ground water mound could be used as a reservoir to provide flows to the Platte River in times of shortage. Water would be stored in the mound during times of excess flow. The water would be transported to recharge sites through NPPID distribution facilities. The water could be pumped to the distribution system for irrigation in exchange for water stored in Lake McConaughy or it could be pumped directly to the Platte River for flow enhancement.

While certain areas of the ground water mound contain undesirably high levels of selenium, problems can be avoided by careful planning and implementation of the recharge and recovery facilities.

The Mound is expected to provide up to 25,000 acre-feet annually toward the program goals. This water would be available at a rather modest cost.

The riverside drains plan involves constructing shallow subsurface drains in agricultural lands that are adversely effected by seepage and salinity. The drains would be located on the first or second terrace along the north side of the river. Approximately 100 miles of riverside drains could be constructed with a potential, for producing about 40,000 acre-feet of water annually, of which 8,000 acre-feet is currently consumed by non-beneficial evapotranspiration and therefore, would contribute to program flows. The other 32,000 acre-feet reaches the river under normal conditions.

Water from the Platte River could be diverted to the Dawson and Gothenburg canals during the non-irrigation season. Some of the water would seep into the aquifer from the canals and would return to the river over a period of time. Theoretically, this has the potential to increase flows during times when it would benefit the target species. Based on historic ground water levels in the area, there is little storage capacity in the aquifer under current conditions. It is unlikely that seasonal return flows to the river could be significantly altered. Also, there is a high probability of further damaging agricultural lands that are already suffering losses due to seepage water; and of increased maintenance needs for the two canals as well as other canals and county roads in the treatment area.

The issue of shallow ground water near the river being influenced by program flows is also discussed. There is considerable local lore that program flows would significantly damage agricultural lands and homes at distances of several miles from the river. Scientific analyses have shown that program flows would have only a minor influence on ground water levels a few hundred feet from the river and no influence at all distances of more than 2,500 feet from the river.

Ground Water Influences in the South Platte River Valley

Two proposed elements are discussed in the South Platte Basin. They are Bebee Draw and Tamarack. Tamarack is divided into Phase I and Phase III.

Bebee Draw is an off stream aquifer storage and recovery scheme. Water from the South Platte river would be diverted through existing facilities to Bebee Draw where it would be placed in the aquifer through some type of recharge facilities which are yet to be defined. The aquifer is isolated and bounded by impermeable formations making it an ideal storage facility. It has very good hydraulic characteristics for recovery wells and surface storage facilities which could be used to enhance the flexibility of the recovery and delivery of the water. Bebee Draw has the capacity to 100,000 acre feet of water. The actual volume of water available for storage under the Program is uncertain at the time of this writing.

Tamarack I is located along the south side of the South Platte River in the Tamarack Ranch Wildlife Area. During periods of excess flows in the target area of the Central Platte River, water would be pumped from the South Platte River through wells located near the river's edge and delivered to ponds located in the sand hills to the south. The water would then return to the river through the aquifer in a delayed pattern. Some of the water would return to the river during times of shortage in the target area, thus providing benefits to the target species. Originally the proposal was to 30,000 acre feet annually. An estimated 8,000 acre feet would return to the river at times when the flows would benefit the program. However, further studies have shown the aquifer in that reach of the river does not have sufficient capacity for that magnitude of development. At the time of this writing, a more modest program is being developed.

Tamarack III envisions pumping some 50,000 acre feet annually from wells located along the South Platte River from Ft Morgan to the Nebraska State Line. No specifics are available as to locations of the production wells or the recharge ponds.

Ground Water Influences in the North Platte River Valley

The ground water component associated with the North Platte River is relatively unimportant to flows in the Platte below the City of North Platte. In general, the valley lacks a significant aquifer until it enters the High Plains Aquifer in eastern Wyoming. From there to Lake

McConaughy any influence that the aquifer has on the river or vise versa is overshadowed by the operation of Kingsley Dam. Below Kingsley Dam, the ground water regime is more closely related to the Central Platte Valley and is included in that discussion.

I. Introduction

A. Proposed Endangered Species Recovery Program

Under current operating criteria, the flows in the Central Platte river are, at times, inadequate to meet the needs of four threatened or endangered species. In July 1997, the states of Colorado, Nebraska, and Wyoming, and the U.S. Department of the Interior (DOI), signed a cooperative agreement to make more water available in the river at times when wildlife can use it, and provide more acres for habitat along the river. Numerous agencies in the three states and DOI are working with water user organizations, local farmers and landowners, and environmental groups to develop a Program aimed at improving land and water habitat for four threatened and endangered species that use the Central Platte River in Nebraska.

Such a program requires a Programmatic Environmental Impact Statement (EIS). The proposed program as outlined in the EIS is expected to increase flows in the Central Platte River at certain times and at levels that can be attained within the limited amount of Program water available. The Programmatic EIS presents a proposed Program, and discusses the environmental and social impacts that would be expected to result from implementation of the Program..

The program has yet been implemented. At some time in the future, this Program may modify streamflows to benefit threatened and endangered species. Some people currently experiencing problems with high ground water levels are concerned that such releases, if made in the future, could aggravate existing problems.

This Ground Water appendix documents the ground water related summary and conclusions described in the EIS.

B. Ground Water Issues

The ground water components of the program cover a broad range of issues. The issues include ground water storage and recovery, return flow augmentation by managed ground water recharge, reduction in evapotranspiration by subsurface drainage, managing excess ground water within the Central Nebraska Public Power and Irrigation District, (CNPPID) and shallow ground water levels within the Central Platte Valley. The latter issue concerns both wet meadow enhancement and concern for flooding of basements and farm fields as a result of Program flows.

Several locations for ground water storage and recovery were considered but only Beebe Draw, located between Denver and Greeley Colorado is included as an element in the EIS.

Return flow augmentation involves injection of river water into the aquifer near the river during periods of excess flow in the river. As the water makes its way back to the river through the aquifer some of the water will arrive at the river during periods when flow augmentation is needed for target species. Tamarack phases I and III, and the Dawson-Gothenburg Canal plan envision re-timing of flows through this process.

Reduction in evapotranspiration (evaporation and plant use) would allow return flows to reach the river rather than being lost to non-beneficial uses. Subsurface drains would be installed in areas subject to non-beneficial losses to lower the water table and thus minimize these losses. The water saved would accrue to the river through the drains.

Management of the CNPPID ground water mound is a variation of the storage and recovery scheme. The difference being that much of the storage will occur naturally, and the recovered water can be sent directly to the river for flow augmentation or it can used for irrigation and exchanged for water stored in Lake McConaughy.

Shallow ground water within the Platte river Valley is a two sided issue. Many areas in the Central Platte Valley in Nebraska have been experiencing high ground water levels for several years, causing problems with waterlogged farm fields and flooded basements. Some local land owners are concerned that additional flows generated by the Endangered Species Recovery Program water management will cause existing problems to become worse. At the same time, higher ground water levels in wet meadow areas would be a benefit to some of the target species.

C. Scope of Analysis

Each of the ground water issues will be discussed in terms of implementation procedures, probable benefits or impacts and cost. Discussions are necessarily of a general nature since little site specific data is available for most locations. The Programmatic EIS is typically based upon analysis of existing data. In this instance, data relating river levels to flood plain ground water levels were collected for two growing seasons (1998 and 1999) in order to verify the validity of analytic tools in this geologic setting. The results of that work were published in a separate document titled Ground Water and River Flow Analyses dated May 2001.

The Central Platte flows through the High Plains Aquifer and all ground water activity is in some way related to that aquifer and its unique characteristics. Therefore, our analyses will center around the interaction between the river and the aquifer.

The South Platte above Julesburg is not directly connected to the high Plains Aquifer. Each of the elements involving ground water will be analyzed as a discrete unit.

D. Main Factors Affecting Ground Water

Shallow ground water levels can be beneficial of detrimental. Maintaining shallow water tables on lands classified as wet meadows, provides desirable habitat for the soil organisms that are used by terns, plovers and cranes. Agricultural lands require an aerated root zone for optimum production of crops. Also, homes or other buildings with basements can be damaged by rising ground water levels.

1. Local River and Stream Levels

River levels have an influence on ground water levels near the river. At distances more than a few thousand feet from the river, the water table elevation is generally several feet higher than the river and thus does not react to river levels.

Because ground water moves slowly, river rises and adjacent ground water level rises are not simultaneous if the ground water level is responding to a change in the river. Thus, when ground water levels rise at the same time as the river rises, a third factor (e.g., precipitation) must be involved.

2. Topography

The top of the water table depends on the elevation where ground water comes to the surface (for example at natural streams, springs, man-made drains, or pumps). Groundwater surfaces can never be lower than these discharge points.

Topography also affects how much of the precipitation seeps into the ground, thus increasing the volume of ground water. On steep slopes, a large portion of rainfall runs off as surface water. In flat to gently rolling land, less water runs off and more soaks into the soil. Water that soaks in replenishes soil moisture in the root zone for plants to use, or it moves all the way to the water table and becomes part of the ground water, thus raising the elevation of the water table.

The Platte River Valley is characterized by flat to gently rolling topography and high infiltration rates. Through much of the valley, the primary flood plain lies 1 to 3 feet above the water surface of the river and is flat for several hundred feet away from the river. Therefore, a large portion of rainfall does not run off but infiltrates the soil and moves beyond the root zone to eventually become ground water. The Platte River channel is the lowest point in the Central Platte Valley. Because ground water moves to the lowest point, it generally moves toward the Platte River.

3. Geology and Soils

The surface soil texture controls how fast water can infiltrate the soil to become ground water. In the study area, soils generally are sandy, light textured, and highly permeable. Infiltration in the Platte River Valley is high and the storage capacity is about 15 to 20 percent. One inch of rainfall that reaches the water table raises the water table 5 to 6 inches.

The Central Platte River has a strong connection to the High Plains Aquifer System (the surface soils and the underlying Ogallala formation) (Figure 3). Therefore, water movement between the river and the aquifer system is relatively unrestricted, responding primarily to changes in gradient as the water seeks its lowest level.

4. Climate and Precipitation

The climate dictates the amount of precipitation available for infiltration and the intensity of precipitation events. Higher intensity rainfall produces more runoff while gentler rains tend to produce more infiltration. Central Nebraska usually gets high intensity events (e.g., cloudbursts) in the late spring and summer and longer duration, gentler rains during cooler periods. In general, water table elevations rise in years with above normal rainfall and fall in years with below normal rainfall.

5. Crop Consumptive Use
Vegetation consumes soil moisture, which influences the amount of water added to the water table by rainfall. Evapotranspiration is the amount of water that plants consume and that evaporates from the soil surface. This water is removed from the root zone and does not enter the ground water. Typically, plants draw moisture from the plant root zone, which is 2 to 6 feet in depth. The root zone may be replenished by irrigation or by precipitation. The sandy soils in the Platte River Valley can hold 1 to 2 inches of readily available water per foot of soil (the water holding capacity). When the water holding capacity is exceeded, the surplus water percolates to the water table.

6. Irrigation
Using surface water to irrigate contributes to the ground water while well irrigation depletes the ground water. Up to 70 percent of the surface water brought in for irrigation can end up percolating down to the ground water table through canal and ditch losses and deep percolation. Conversely, using ground water to irrigate lowers ground water levels by the amount of water consumed by plants and evaporation.

Irrigation water in the Platte Valley comes from both ground and surface water. Often, conjunctive use systems supplement canal water with wells. The intermixing probably tends to stabilize the water table.

Ground water irrigation magnifies the normal pattern of lower water tables in dry years because more water is pumped and higher water tables in wet years because added precipitation increases deep percolation and decreases well demands. Long-term intensive pumping will lower the water table locally, but if pumping is discontinued or reduced, the water table will usually recover over time.

7. Urbanization and Development
Urbanization has conflicting influences on the water table. Paving streets and parking lots increases the percentage of runoff from precipitation and decreases seepage to the water table. At the same time excessive watering of lawns, parks and golf courses tends increase seepage and raise the water table. In the study are, there is no indication that urbanization is having a major impact in either direction.

8. Ditches and Drains
Surface water drainage ditches (e.g., roadside ditches) usually contribute locally to the ground water as they convey surface runoff though areas of deeper ground water. Subsurface drains tend to reduce ground water levels by lowering the discharge elevation point. The extent of ditches and drains has not changed significantly in recent years.

II Historic Conditions

The Platte River derives most of its flow from snowmelt in the Rocky Mountains with intermittent flows resulting from summer storms on the plains. The Central and Lower Platte River provides the sole natural outlet for ground water to the north of the rive, and is therefore a gaining stream under natural conditions. However, inflow from ground water is minimal in dry years and even in years of normal precipitation, evapotranspiration in the flood plain can consume all of the water available for accretions. The ground water gradient on the south side of the river, and to the west of the town of Minden, is naturally toward the Republican River. To the east of Minden the gradient is toward the Blue River. Historically, the Central Platte River was characterized by high flows during spring and early summer, but was often completely dry in late summer. As irrigation enterprise developed along the North Platte and South Platte Rivers, the Central Platte became even more prone to zero flows in the late summer.

The North Platte River does not have a significant ground water component due to the shallow underlying aquifer. The South Platte River is dry at some locations during the irrigation season as diversions remove all of the flow, but return flows from ground water provide some flow over most of the length of the river.

The development of CNPPID resulted in a mound of ground water which moved the ground water divide from the southern edge of the Platte to a point some 20 miles farther south. The ground water mound has a much steeper gradient toward the Platte River than does the natural ground water to the north. The ground water mound provides a constant return flow to the river that is sufficient to prevent no-flow occurrences, but not sufficient to meet the needs of the certain species.

A. Ground Water Influences in the Central Platte River Valley

The Platte River Flows from the confluence of the North Platte and the South Platte Rivers at the city of North Platte Nebraska, to its confluence with the Missouri River near Omaha. The target area for this study is from North Platte to Chapman, Nebraska and in this report as the valley is referred to as the Central Platte Valley. Through this reach, the Platte River is in direct communication with the High Plains Aquifer meaning that surface water and ground water are intermingled. Water moves freely across the surface boundary from ground to surface where the ground water is higher in elevation than the river and from surface to ground where the river is higher. This section discusses how various features influence this interaction.

1.Central Nebraska Public Power and Irrigation District Ground Water Mound

A ground water mound has developed under the Central Nebraska Public Power and Irrigation District lands as a result of canal seepage and irrigation deep percolation. The lands are located in Gosper, Phelps, and Kearney Counties, Nebraska on the south side of the Platte River. The Platte River is approximately 300 feet higher in elevation than the Republican River which runs roughly parallel and to the south near the Kansas state line. East of the CNPPID the Platte and Republican rivers diverge and the area is drained by the Little Blue River. Historically the ground water gradient through the CNPPID trended to the southeast toward the Republican and Little Blue Rivers. On a broad scale it was possible for ground water to move from the Platte River to the Republican River or to the Little Blue River. With the development of irrigation in the 1930s, using Platte River water, a ground water mound developed under the irrigated lands. The high point of the mound creates a ground water divide separating the Republican and Platte Rivers. The mound is split nearly in half with the northern half moving toward the Platte. While ground water no longer moves from the Platte to the Republican, the gradient toward the Republican has increased significantly and the mound is composed of water from the Platte river, meaning that more Platte River water is transferred to the Republican than was historically.

The water that is being targeted is contained in the High Plains Aquifer system. Since confusion sometimes exists regarding the Ogallala and the High Plains Aquifer, the following definition will be used herein. The geologic units comprising the High Plains Aquifer system are The Ogallala Formation of Tertiary age and other Tertiary and Quaternary deposits that are saturated and hydraulicly connected to the Ogallala (Pettijohn and Chen, 1984). Loess deposits overlying the Ogallala are part of the High Plains Aquifer and contain all of the ground water mound that has been created through irrigation of the CNPPID.

A proposal has been made to enhance Platte River flows by exploiting the ground water mound under the CNPPID lands. The exact size of the mound is open to discussion. A report published in July 1998 by the Wyoming Attorney General's Office estimates the mound contains 13 to 14 million acre feet of water and is increasing at a rate of 50,000 acre-feet annually. Reclamation estimates the total size of the mound at 8 to 10 million acre feet including the lobe in Lincoln County. Most available records seem to indicate the mound is currently in a state of dynamic equilibrium in which the size fluctuates with climatic cycles but is more or less constant over longer periods of time. Some of the monitoring wells along the southwest slope of the mound seem to indicate localized continued rise of the water table. Other monitoring wells at scattered locations show a slight decline in water table levels in recent years. Variable precipitation combined with other factors such as decreased pumping for irrigation, recent management decisions taken by CNPPID, and natural drainage coming into play, obscures actual trends to the point that definitive evaluation is not practical. Reclamation is continuing to evaluate the data.

2. Riverside Drains

Agricultural lands near the Platte River often experience water logging problems due to the flat gradient toward the river. Some of these lands could be drained by agricultural drains. Lands which are actively cultivated and have a typical spring water table of less than 5 feet would be considered for drainage. Drains would provide supplemental water for in-stream flows as well as benefitting the lands. Alternatively the water could be used for drought cycle sustenance or for enhancement of existing wet meadows. The water would tend to cool the river water to a limited extent during hot weather periods, and would warm the water during winter months.

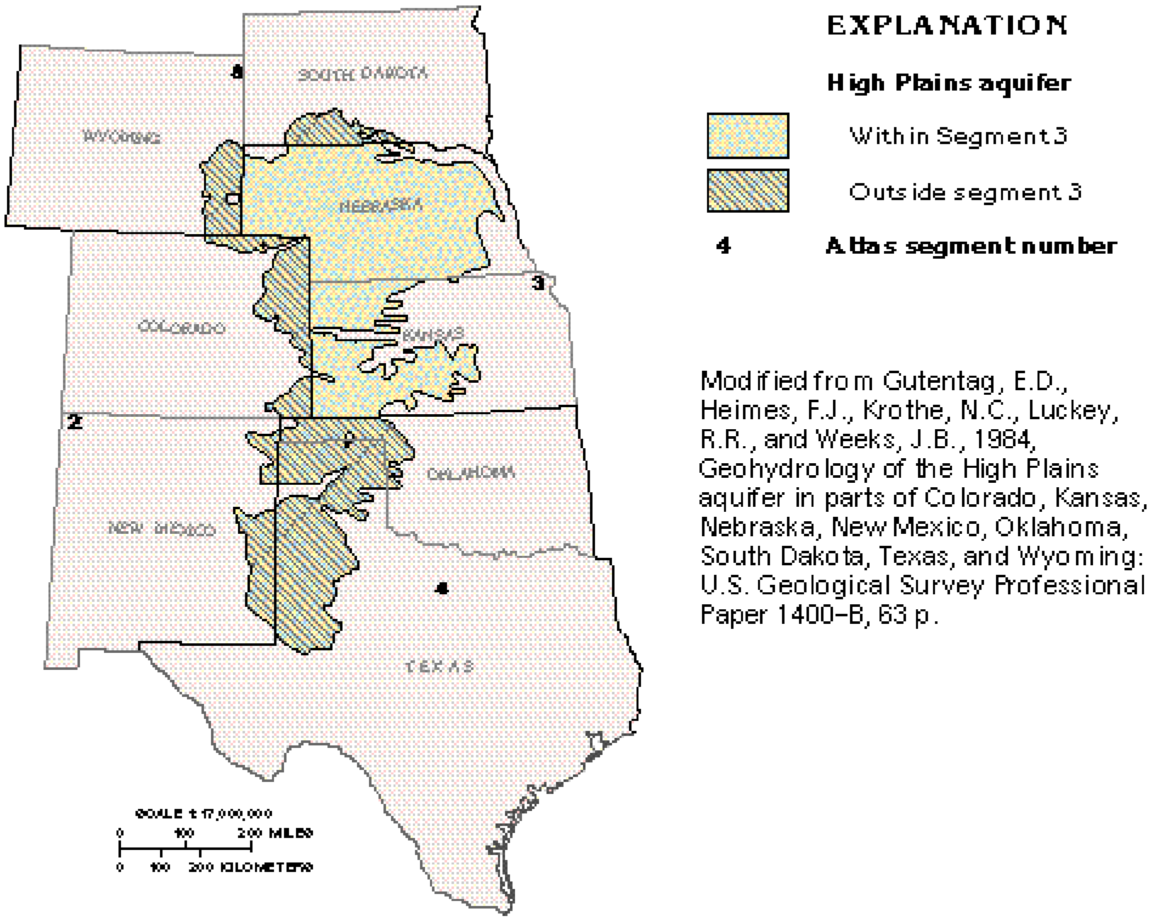


Figure 46. The High Plains aquifer extends over an area of about 174,000 square miles in parts of eight States. The aquifer underlies about 94,200 square miles in Kansas and Nebraska.

Figure showing the High Plains Aquifer and the Mound

Geologic/Hydrologic Setting

The Central Platte River lies in a wide shallow valley embedded in quaternary deposits of sands, gravels, silts and clays. The quaternary deposits overlie the Ogallala Formation and in the Central Platte Valley this combination constitutes the High Plains Aquifer. The soil profile is generally more than 100 feet thick and has relatively high hydraulic conductivity. There are no extensive barriers to ground water movement which would complicate management of the ground water by artificial drainage facilities. The connection between ground water and the Platte River is well established and continuous.

Ground water to the south of the Central Platte is elevated due to seepage from irrigation and related distribution systems. The seepage has created a ground water mound with a gradient toward the Platte River, resulting in continuous accretions to the river from the mound. To the north, the ground water level is generally at or near the elevation of the river and fluctuates with seasonal precipitation and irrigation withdrawals. Water table depths of less than 5 feet are common on both sides of the river.

Geographic Setting

The lands that appear to be adaptable to this plan lie along either side of the Platte River on the first or second terrace. On the south side of the river, lands meeting the criteria of shallow water table, occur intermittently from the Tri County Canal diversion a length of about 70 miles to the east edge of Range 21 West. From there, lands meeting the criteria lie in a continuous strip that extends to the east edge of Range 14 west; a distance of 42 miles. A reasonable estimate for development would be 25 miles of drain in each of the 2 segments for a total of 50 miles of drains.

The areas meeting the water depth criteria on the north side tend to be discontinuous but more broad than those on the south side. The strip generally lies south of highway 30 and is from 1/4 mile to about 3 miles wide. It extends from the town of Maxwell to east of Kearney for a distance of about 100 miles. Within this area, possibly 50 miles of drain could be constructed to produce supplemental flows. About half of these drains would be west of the town of Overton and half would be to the east of Overton.

3. Dawson/Gothenburg Canal

The Gothenburg and Dawson Canals divert water from the Central Platte just upstream of the habitat area. The recharge project would involve diverting river flows into the canals outside of the irrigation season, when flows in the river are in excess of target flows. Much like the Tamarack Project, these waters would return to the river on a lagged basis (approximately 9 years). While all of the waters would be diverted during times of excess to target flows, some of the waters would return during periods of target flow shortages. The average diversions to the Gothenburg and Dawson canals would be approximately 14,000 and 19,000 acre-feet per year respectively, providing an estimated additional average of 2,600 acre-feet per year to target flows, of which half would be allocated to the Program; the remainder is reserved by the State of Nebraska to offset future depletions to the Platte. Due to the nine year lag time for return flows, most of the benefits to the Program would accrue after the first increment of the Program.

4. Shallow ground water

Acreage irrigated from ground water in the Central Platte NRD has increased each year since 1950 and has increased an average of one percent a year for the last ten years. Figure 5 IRR tracks the increases in irrigation wells and acres under irrigation for the Central Platte Natural Resources District (Woodward, 2000, personal communication). At the same time, conservation methods may have reduced the amount of ground water pumping. The State Natural Resources Conservation home page lists numerous ongoing programs designed to retard surface runoff and increase ground water storage and states that "As a result of these efforts, over 160 irrigators are now pumping 4.2 billion gallons [nearly 13,000 acre-feet] less water . . ." (Hinrichs, et al., 2000). Conservation practices such as using low energy precision application sprinkler systems and modified tillage methods decrease net depletion by 7 and 24 percent respectively (Boldt et. al, 1998). These conservation practices are being implemented by farm operators in response to environmental and economic pressures.

While no on-site data have been collected that would support a definitive analysis of how effective the conservation practices have been, a total savings of one percent or more per year over the last ten years seems well within the realm of possibility. Therefore, even as irrigated acreage is slowly increasing, the demand on ground water may be constant or diminishing. This would tend to counteract the overdraft conditions that lowered the water table through the 1960 and 1970 decades.

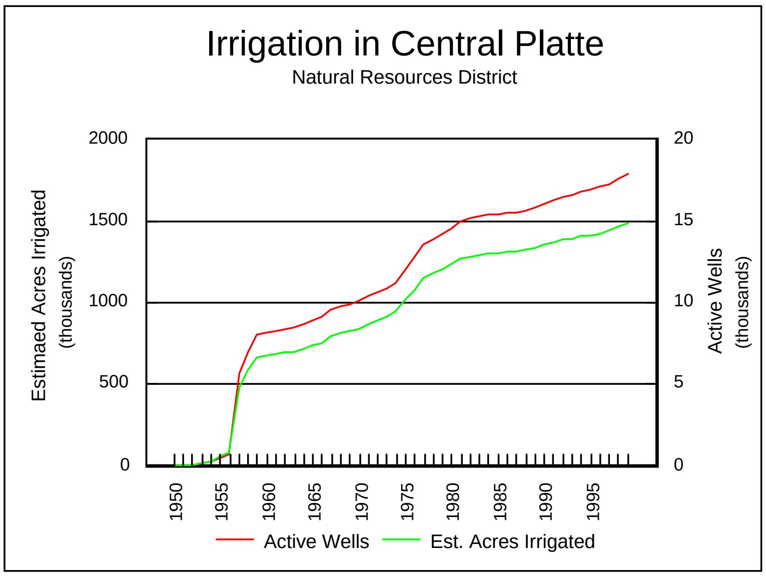


Figure 2 **Irrigation trends**

River levels have an influence on ground water levels near the river. Several thousand feet from the river, the water table elevation is generally several feet higher than the river and thus does not react to river levels.

As ground water moves slowly, river rises and ground water level rises are not simultaneous. Thus, when ground water levels rise at the same time as the river rises, a third factor (e.g., precipitation) must be involved.

Ground water levels in the Central Platte Valley outside the flood plain are typically higher than the river elevation. Therefore, water movement is toward the river. Currently, the one exception is in the Upper Little Blue drainage where irrigation pumpage has exceeded recharge enough to create a large cone of depression.

Within the primary flood plain, the ground surface is often less than 4 or 5 feet above the river water level. In such conditions, evaporation and plant usage work to lower the water table so ground water movement tends to be down the valley parallel to the river. Local conditions reflect day-to-day weather patterns, with water tables rising during wet weather periods and receding during dry periods.

Program flows will significantly influence ground water levels very close to the Platte River. The influence will diminish geometrically as the distance from the river increases and will be unmeasurable at about 2,500 feet from the river. An in depth analysis is presented in a Reclamation report titled Ground Water and River Flow Analysis dated April 2002.

B. Ground Water Influences in the South Platte River Valley

The South Platte River flows across the Denver Basin Aquifers before entering a very limited alluvial aquifer. None of the Program alternatives involves the Denver Basin Aquifers. Therefore, this discussion centers around those features within the alluvial aquifer.

1. Beebe Draw

Beebe Draw is a tributary to the South Platte River. It contains 3 off-stream storage facilities, Barr Lake, Millan Reservoir and Lower Latham Reservoir. The geology of Beebe Draw is such that up to 100,000 acre feet of water could be stored in the aquifer. The aquifer is isolated from the South Platte River so ground water could be managed as an off-stream storage reservoir. Since the aquifer is isolated from the South Platte, it has had no historic influence on the river.

2. Tamarack

The Tamarack re-regulation plan envisions pumping up to 56,000 acre feet annually to recharge ponds located at distances of 1/4 mile to one mile from the river. As these flows return to the River through the aquifer, a significant proportion of the water would reach the river during periods of shortage. The State of Colorado estimates the contribution toward improving target flows to be approximately 17,000 acre feet annually.

Historically, surface irrigation of lands along the South Platte River, using imported water, has raised ground water levels near the river and in turn has increased return flows to the river. Conversely, the advent of ground water pumping in and near the South Platte Valley for irrigation has tended to deplete ground water levels, leading to reduced flows. The well irrigators hold water rights that are junior to most of the surface water irrigators. The State of Colorado has instituted flow augmentation requirements to mitigate the reduced return flows. In this way, flows are made available for the senior water right holders.

Plans for Tamarack flow augmentation program have been contemplated since the early 1980's but it was not until 1999 that a pilot project was implemented.

C. Ground Water Influences in the North Platte River Valley

The ground water component associated with the North Platte River is relatively unimportant to flows in the Platte below the City of North Platte. In general, the valley lacks a significant aquifer until it enters the High Plains Aquifer in eastern Wyoming. From there to Lake McConaughy any influence that the aquifer has on the river or vise versa is overshadowed by the operation of Kingsley Dam. Below Kingsley Dam, the ground water regime is more closely related to the Central Platte Valley and is included in that discussion.

III Present Conditions

Present conditions for this study are generally taken to be the conditions that existed in 1997. However, considerable controversy existed regarding the effect that Program water would have on local water table elevations. An intensive data gathering effort was carried out during the 1999 and 2000 growing seasons in an attempt to resolve this issue. Therefore, for that one aspect one aspect, the present conditions are those of the 1999 to 2000 study period.

A. Central Platte River

The Platte River Flows from the confluence of the North Platte and the South Platte Rivers at the city of North Platte Nebraska, to its confluence with the Missouri River near Omaha. The target area for this study is from North Platte to Chapman, Nebraska and in this report as the valley is referred to as the Central Platte Valley.

1. Central Nebraska Public Power and Irrigation District Ground Water Mound

CNPPID currently monitors the ground water mound and manages it to some extent. For instance, monitoring well hydrographs are consulted in the decision making process of canal maintenance. If the mound trend is upward canal maintenance may include lining to reduce seepage. If the mound is static or appears in decline, canal maintenance may be limited to cleaning and shaping.

In addition CNPPID has implemented a series of water conservation measures aimed at promoting more efficient irrigation practices. The measures include tiered water pricing, on-farm technical assistance, irrigation scheduling assistance, and a water banking scheme to name a few. The water banking scheme encourages irrigators to conserve part of their yearly allotment of water in normal and wet years. The conserved water, is “banked” and can be delivered in dry years when a larger portion of crop water must come from irrigation. All of these measures tend to reduce the rate of deep percolation losses from the project and thereby stem the growth of the ground water mound.

In certain low-lying areas, ground water encroaches into the root zone of agricultural crops. These primarily occur in and near Dry Creek, Lost Creek, and North Dry Creek. Funk Lagoon, located in the Lost Creek drainage northeast of the town of Funk, is a 2400 acre wetland complex, owned and operated by F&WS. Other than Funk Lagoon, the bulk of the annual recharge to these areas, under current conditions, is evaporated or consumed by plants having little or no beneficial use. Some fraction of the water returns to the Platte River as subsurface flows. Where agricultural crops are grown, production is diminished to various degrees due to the lack of an aerated root zone and elevated soil salinity.

Ground water level changes published in Nebraska Department of Natural Resources WEB site roughly reflect the precipitation levels for the area. In 1997 when all stations in the mound area reported 1 to 5 inches lower than normal precipitation, ground water levels dropped by 1 to 5 feet over a large area of the mound. In 1998 ground water levels were 1 to 2 feet higher near the center of the mound while precipitation was below normal at Elwood but above normal at Holdrege and Kearney. In 1999 ground water levels rose 1 to 5 feet over much of the mound area while precipitation was 2 to 5 inches above normal at all three stations. Ground water changes that occurred during years 2000 and 2001 are not yet published. However, well data provided by Tri Basin NRD clearly shows that the mound continued to grow slowly on its southwest face up to the spring of 2002.

2.Riverside Drains

Currently, a need for drainage exists on much of the land area near the Central Platte River. Few if any drains have been constructed. Reasons for this lack of drain construction probable are some combination of economic considerations, lack of understanding that production could be substantially increased with adequate drainage, and lack of expertise do design effective drainage facilities. In some cases, drainage may be complicated by wetland conservation laws.

3. Gothenburg Canal Recharge Project

Under current conditions, the ground water in the area between the canals and the river is in a state of dynamic equilibrium where inflow and outflow are roughly equal on an annual cycle. Large areas of the irrigated land are subject to reduced crop yields due to high water tables.

A cursory review of USGS Quad sheets and well records retrieved from the NDNR web site indicates that a substantial part of the land area between the Gothenburg canal and the Platte River is currently less than 10 feet to water and fluctuates annually with summer recharge and winter drainout. Several wells closer to the canal have water depths in the 30 foot range. They also have an annual cycle which in some cases is creeping a bit higher each year as recharge exceeds drainout.

The USGS quad sheets indicate numerous wet areas existed in 1970 and the regional water table has risen since then. Several of the well records from NDNR also indicate existing seepage conditions.

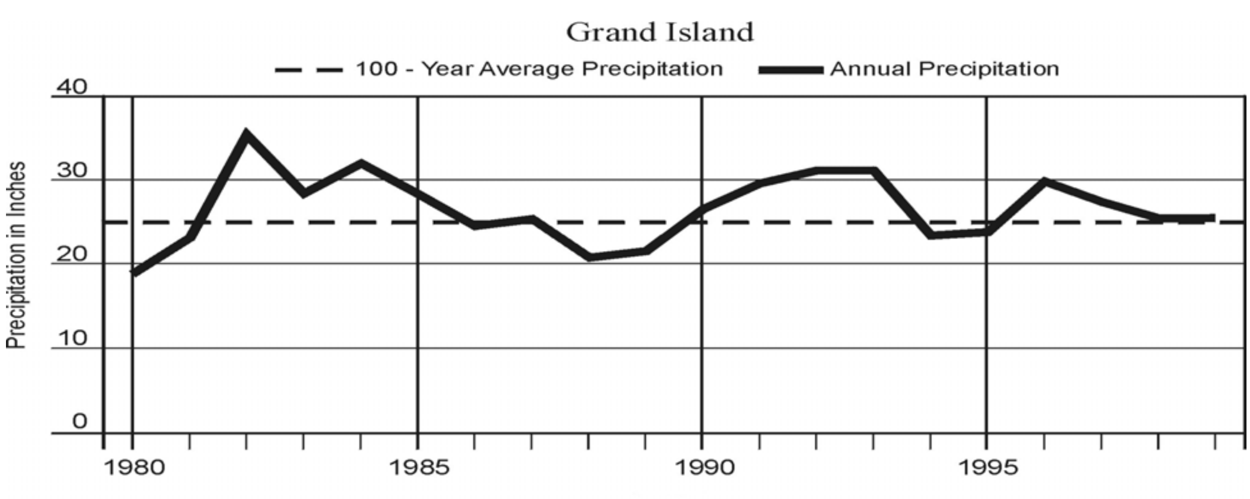
4. Shallow Ground Water

Ground water measurements were taken on several transects extending out from the Platte River to distances of two to five miles during the 1999 and 2000 growing seasons. The measurements were taken in order to gain a clear understanding of the interactions between the river and the ground water in the flood plains and beyond. The conclusion was that Program water would influence the water table only within ½ mile of the river. A full report of the study and the findings is presented in a USBR report <u>Ground Water and River Flow Analysis</u> published in April 2002.

In general, water table elevations rise in years with above normal rainfall and fall in years with below normal rainfall. In the past 20 years, precipitation in the Central Platte Valley has been well above average. Precipitation during the early part of the twentieth century was well above normal. Beginning in the 1930s, it dropped below normal and did not return to above normal until the early 1980s. Since then it has been above normal except for a short period in the early 1990s. Figure 5 PRECIP compares annual precipitation at Grand Island with the one hundred year average precipitation from 1900 to 1999.

From 1980 through 1999, total precipitation at 11 stations in the Central Plate Valley averaged 42 inches greater than normal. The smallest excess precipitation for the period was 20 inches at Paxton, and the largest excess precipitation for the period was 67 inches at Loup City. Several of the stations have received 10 percent or more above normal for the past 19 years. This unusually high precipitation and recharge to ground water over the last 20 years has raised the water table well above levels that existed in the 1950s. High precipitation has also produced generally higher river flows in the last few years. Seven out of the last ten years have seen annual flows higher than the 1935-99 median flows.

Figure 3 Grand Island Precipitation



B. South Platte River

Three elements involving the South Platte River are included in various alternatives. They are Tamarack phase I, Tamarack phase III, and Bebee Draw.

1. Tamarack Phase I

Tamarack phase I has been developed as a pilot project. Currently there are four? recovery wells located next the South Platte River at the west end of the Tamarack Ranch Wildlife Area. The wells pump to two recharge pits located near the valley wall about ½ mile south of the river. A small open waterway has also been constructed. The stream is intended to serve as an outdoor laboratory for study and propagation of threatened and endangered fish species in the South Platte drainage.   The serpentine stream is approximately 1300 feet in length and provided a constant water supply during the summer months. Seepage from the stream returns to the river on a delayed schedule just as the recharge pits do.

2. Tamarack Phase III

Tamarack Phase III is currently undefined except that it extends along the South Platte River from Fort Morgan to the Nebraska state line. The ground water condition in the valley is heavily influenced by irrigation. Surface diversions from the Colorado Big Thompson Project and several private irrigation ditch companies generally maintain the ground water in the valley at somewhat elevated levels, with the typical associated seepage and salinity problems in the areas where surface irrigation is practiced. Irrigation from ground water lowers ground water levels and, in turn, reduces natural accretions to the river. Ground water usage has increased substantially since the middle of the twentieth century causing concerns for senior water right holders on the South Platte. The state of Colorado has instituted a mitigation program in which ground water pumpers are required to pump water to recharge sites at some distance from the river during the non-irrigation season. The recharged water then returns to the river through the aquifer providing increased in-stream flows during the irrigation season.

3. Bebee Draw

Much of the land within the Bebee Draw is under irrigation through a series of canals and reservoirs located in Bebee Draw. The Little Burlington Canal and the Burlington O'Brian Canal deliver water to Barr Lake at the upper end of the draw. From there water is distributed to farmlands in the draw and to Milton Reservoir near the lower end of the draw where it is further distributed to farmlands. Although recharge and recovery plans have been considered by various entities, none are currently in operation.

C. Ground Water Influences in the North Platte River Valley

The ground water component associated with the North Platte River is relatively unimportant to flows in the Platte below the City of North Platte. In general, the valley lacks a significant aquifer until it enters the High Plains Aquifer in eastern Wyoming. From there to Lake McConaughy any influence that the aquifer has on the river or vise versa is overshadowed by the operation of Kingsley Dam. Below Kingsley Dam, the ground water regime is more closely related to the Central Platte Valley and is included in that discussion.

IV. Plan Description for Alternatives

Each program alternative encompasses a suite of elements which would combine to produce the target flows in the Central Platte River. Each of the elements discussed in this document has certain characteristics and will result in a definable influence upon flows in the river. Regardless of the alternative, the ground water element will remain the same. Therefore, each element is discussed only once without regard to any particular alternative. If the reader finds that a ground water related element appears in an alternative of interest, they can locate information about that element in this document.

A. Central Platte River

The Platte River Flows from the confluence of the North Platte and the South Platte Rivers at the city of North Platte Nebraska, to its confluence with the Missouri River near Omaha. The target area for this study is from North Platte to Chapman, Nebraska and in this report as the valley is referred to as the Central Platte Valley.

1. Central Nebraska Public Power and Irrigation District Ground Water Mound

The potential for developing the CNPPID groundwater mound as a reservoir for Platte River flow augmentation was evaluated. The location and magnitude of the CNPPID groundwater mound is shown on Figure 1. The concept is to design a well field that would allow withdrawl of water during the irrigation season, and recharge during periods of excess flows. The pumped water will be discharged to the CNPPID distribution system to be used for irrigation in exchange for water to be released from storage for river flow augmentation. Recharge would be provided through canal seepage, surface spreading, seepage pits, injection wells, injection drains, or some combination of these methods.

Only relatively shallow water table areas were considered and only the top 5 to 10 feet of saturated thickness is to be used as a reservoir. These restrictions were imposed for several reasons.

- Wetland habitat areas can be easily protected if drawdown curves are shallow.
- Low head pumps can be operated on single phase power.
- Power costs are minimized when pumping from shallow depths.
- Well construction costs are small for shallow, small diameter wells.

All of the well spacings, depths, diameters, screened intervals and other design considerations are based on typical aquifer characteristics that have been reported for the service area. This feasibility level estimate will need to be refined by site specific data collection before final designs can be made. However, the estimated values used are reasonable for the target aquifer and are mutually compatible.

Recovery Plan description

To evaluate the feasibility of this proposal, records for wells within the mound area were sorted to include those where water table levels are less than 40 feet from the ground surface and with records in 1995 or later. The mound contains two separate lobes as shown in figure 1. The eastern lobe lies in Gosper, Phelps, and Kearney Counties while the western lobe lies in Lincoln County.

Of the wells located in Lincoln County, all wells meeting the depth to ground water criteria were found to plot along the North Platte and South Platte Rivers and were an average of one mile from the river. Pumping from this area would deplete the river flows; thus the area was not acceptable for development as a well field for this purpose.

Depth to the groundwater mound in Lincoln County typically ranges from 100 feet to more than 200 feet (Bredehoeft and Hinckley, 1998). Pumping the groundwater mound at this depth would be infeasible due to the high cost of well installation and operation. Therefore, the development of a shallow well field to pump water from the groundwater mound, in Lincoln County is not.

The eastern lobe of the mound proved to be more conducive to the reservoir concept. Approximately 160,000 acres of groundwater mound area meet the water depth criteria. These areas are generally north of highway 23 west of Holdrege and north of highway 6 east of Holdrege.

The actual size of the area that will lend itself to the treatment described in this proposal can be determined only by an in-depth study. Factors such as wetland areas, water transport facilities, topography, local aquifer characteristics, availability of a power source, availability of recharge water, and land owner participation will enter into the selection process. The first three items can be observed on USGS quadrangle maps. Two areas that appear to fit the physical criteria have been identified and are shown on figure 2. Both areas are slightly over 20,000 acres in size. It is estimated that 20,000 acres will eventually be developed.

The criteria for establishing well fields includes: Water table depth between 5 and 25 feet from land surface. Location near a canal or lateral and there must be no impact to wetland areas.

Five different pumping scenarios were evaluated using the Theis equation, which is a non-equilibrium well equation, relating pumping time and other factors to well yield. Thus, the cone of depression, or drawdown curve, can be plotted for any given time since pumping began. The equation is for fully penetrating wells. The production wells in this alternative will not be fully penetrating. However, the equation is satisfactory for feasibility level estimates where desired yields are substantially less than practical maximum yields, as they are in this case.

In its simplest form the Theis equation is:

$$S = \frac{114.6QW(u)}{T}$$

Where:

S = drawdown in feet at any point in the vicinity of a well discharging at a constant rate,

Q = the pumping rate in gallons per minute,

T = coefficient of transmissivity of the aquifer in gallons per day per foot, and

$W(u)$ = read "well function of u"and represents an exponential integral.

In the $W(u)$ function u is:

$$u = \frac{1.87 r^2 S}{Tt}$$

Where:

r = distance in feet from the center of a pumped well to the point of measured drawdown

S = Coefficient of storage for the aquifer (dimensionless)

T = Coefficient of transmissivity for the aquifer in gallons per day per foot, and

t = time since pumping started in days.

Henkley etal 1998, reported transmissivity values ranging from 60,000 to 140,000 gal/day/ft for the mound area. The transmissivity, 100,000 gal/day/ft appears to be the predominant value for the mound area. The 90 day typical drawdown for different pumping rates at r = 1865 ft are given in table 1. A radius (*r*) of 1865 feet is used because it represents the mid point between wells placed on a 1/2 mile grid which will fit well with power supplies, canal locations and access roads. The midpoint will be the point of least drawdown. A value of 0.2 for storage is used in this estimate based on typical values for an unconfined aquifer of sandy materials. The pumping time (*t*) of 90 days continuous pumping corresponds with the irrigation season.

Table 1

Pumping Scenarios

GPM	Drawdown at radius 1 foot After 90 Days	Drawdown at radius 1866 Feet After 90 Days	Acre Feet pumped After 90 Days
200	3.8	0.3	79.5
300	5.6	0.5	119.3
400	7.5	0.7	159.1

500	9.4	0.9	198.8
600	11.3	1.03	238.6

Recharge Plan description

Recharge water will be transported to the recharge facilities through the canal system during non-irrigation season at times when excess flows are available in the river. The recharge facilities may consist of pits, wells, pipe drains, surface spreading through irrigation machines, or a combination of these methods. Research conducted by the USBR Kansas-Nebraska Projects Office shows that method each has its strengths and weaknesses. (USBR 1992) Recharge lines (drains), recharge pits, saturated recharge wells, and unsaturated recharge wells were compared. Only the unsaturated wells produced unsatisfactory results. The recharge lines were the most hydraulically efficient. Similar demonstration projects may be useful in determining the preferred recharge methods to be used here.

Pipe drain recharge lines will be placed midway between the wells at a nominal depth of 5 feet.

Tentative Wellfield Sites For Mound Pumping

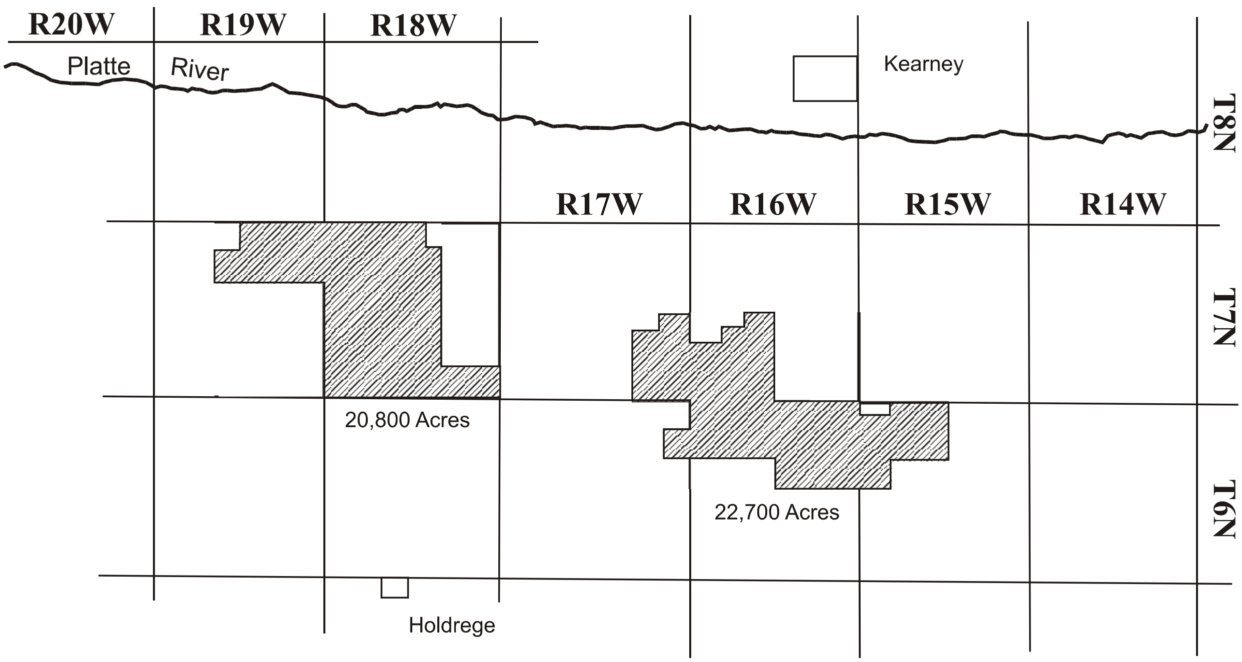


Figure 4 showing location of recharge/recovery plan

Conceptual Pumping/Recharge Layouts

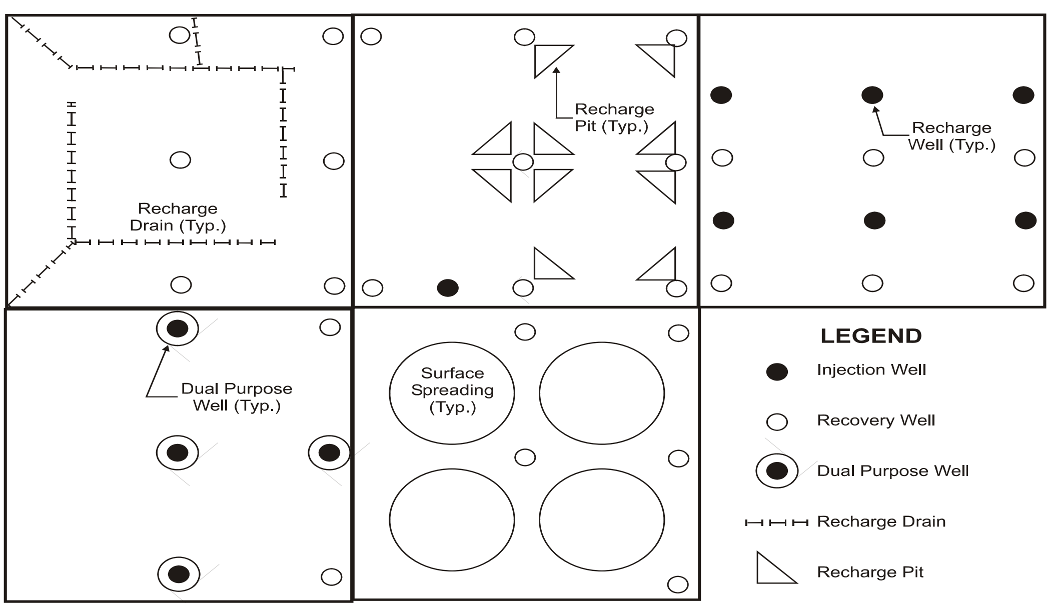


Figure 5 Showing Various Conceptual Plans for Recharge and Recovery

The drains will consist of High Density Polyethylene corrugated perforated pipe laid in a graded sand and gravel envelope. They will be sloped for gravity flow.

Recharge pits will be located in the corners of center pivot irrigation systems. They will be about 3 feet in depth with a berm around the edge to prevent surface flows containing silty sediments from entering. The primary problems with recharge pits are alga growth and the need for frequent cleaning.

Recharge wells would be of similar construction to the production wells and may even be the same wells, although this arrangement can introduce new problems. For instance, if recharge water degrades the aquifer, a production well may be lost.

Surface spreading would be accomplished by operating irrigation machines during the non-irrigation season. Surface spreading is simple and effective but carries relatively high operation and maintenance costs, has relatively high evaporation loses, and may flush nutrients from the root zone. Conceptual layouts of recharge facilities of various types are shown on figure 3.

While certain areas of the ground water mound contain undesirably high levels of selenium, problems can be avoided by careful planning and implementation of the recharge and recovery facilities

Economic Assessment
Development of 20,000 acres in the pattern described in the Well Field Design section would require 125 wells of 12 inch diameter and 60 feet in depth. Each well would require a 220 volt power source and a discharge pipe which could be from ten feet up to ½ mile in length. The wells would be fitted with 7.5 horsepower pumps capable of producing 500 gallons per minute (gpm). Pumping would occur for 90 days each year producing 200 acre-feet of water per well for a total of 25,000 acre-feet annual yield.

The cost of the wells is estimated at $40 per foot plus the pump and appurtenant fixtures for a total $4,000. An average of 1,000 feet from both the power source and the water discharge point seems within the realm of reasonableness and will be assumed for this estimate. The power source will include a transformer and a buried power line. Buried cable is estimated at $1 per foot. Dawson County Rural Electric Company provides power drops of this size for $550. Cost of power at 10 cents per KWH is $1200 per year. The water discharge line will be 4-inch diameter schedule 40 PVC pipe buried 2 feet under ground at an estimated cost of $4 per foot.

Annual maintenance of about $200 per well will be needed. The life expectancy of the well and pump is 25 years. The power source and water line should be useful for at least 25 years and may not need replacing each time the well is replaced. However, for this estimate 25 years will be used for the entire system.

For this proposal, pipe drains as a means of recharge are assumed because they are the most costly to install. Therefore, whatever method is eventually used, the cost estimate will be adequate. The drains costs are estimated at $25,000 per mile and will require 2 to 3 miles of drain per 640 acre section depending on the overall configuration of the system. The maximum requirement of 3 miles is used in this estimate.

Capital Costs

Well installation	125	wells @	$4,000/well =	$500,000
Power drop	125	drops @	$550each =	68,750
Power cable	125,000	feet @	$1/foot =	125,000
Discharge line	125,000	feet @	$4/foot =	500,000
Recharge Pipe Drains	90	miles @	$25,000/mile =	2,250,000
Total Capital Cost				$3,443,750

Total Capital Cost annualized for 25years @6.8750% $292,200

Annual O&m Costs

Routine Maintenance	125	wells @	$200/well =	25,000
Operation	125	wells @	$1,200/well =	150,000
Total Annual O&M				$175,000
Total Annualized Cost				= $467,200

Estimated Annual Yield (Acre-feet)	25,000
Annual Cost per Acre-foot	$19

2. Riverside Drains

General Plan Description

Drains could be constructed across lands on the first or second terrace above the river that are experiencing reduced agricultural productivity due to seepage and salinity. The drains would be constructed in locations and at depths which would provide relief to seeped agricultural lands but would not lower the water level in nearby wetlands. Such construction requires intensive investigations and is not always practical. Some of the lands are wet meadows and would not be considered for this treatment. Only fields that are actively cultivated would be considered for drainage.

If 100 miles of drains were constructed, the flow from the drains would be on the order of 40,000 acre-feet annually of which about 8,000 acre-feet would be salvaged water. The other 32,000 acre-feet currently reach the river and would not add to the flows. Drains on the south side of the river would yield more than drains on the north side because the ground water mound would maintain flows during the non-irrigation season while drains not influenced by the mound would have reduced flows during the late fall and winter.

Much of this water reaches the river under current conditions, and would not add water to the system. However, non-beneficial evapotranspiration reduces the volume of water reaching the river and that water would be recovered and added to the system through pipe drains. The magnitude of non-beneficial evapotranspiration is influenced by topography, geology, depth to ground water, land use and cropping practices, and wetland habitat value. As used here the term non-beneficial evapotranspiration means ground water that evaporates directly from the soil surface, or is used by vegetation which has no value to wildlife or agriculture. The depth of water (acre-feet per acre) may range from about one tenth of a foot per year where cultivated fields remain green after harvest, to more than a foot per year in saline seep areas, sometimes called "slick spots." A reasonable assumption of average depth of water that could be salvaged would be 0.5 feet.

Certain farmsteads and other residences that are found to be adversely affected by the project could be treated in the same fashion. The benefit cost ratio may be less attractive but would add some water to the project while promoting good will and satisfying a Nebraska law that prohibits degradation of property by causing ground water seepage.

The outflow from the drains would be a point source of warm water in the winter and cool water in the summer. Typically, an area of open water will remain during very cold weather periods for several hundred feet downstream from a drain outlet. The same sort of cool water area exists during hot weather periods in the summer. These areas become a haven for small fish which sometimes even migrate up the drains for considerable distances. On Reclamation drainage projects in Nebraska, minnows have been seen in manholes more than 1,000 feet from the drain outlet. The temperature change would not have a significant impact over long reaches of river nor would the cooling or warming extend across the braided channel.

Typical Drain Design

Typical construction would be 6-inch to 18-inch corrugated perforated plastic pipe buried 6 to 10 feet deep and encased in a graded gravel envelope. Typical design depth would be 8 feet. Manholes would be installed as needed or at 1,000 foot spacing. Outlet structures would consist of a 20-foot length of corrugated metal pipe with coarse rock protection on the disturbed section of stream bank. A typical drain would be about 5,000 feet long and would discharge up to a peak of 500 gallons per minute with seasonal variation.

The land area influenced by the drain would average 1/4 mile wide and 1 mile long and would produce 80 acre feet of salvaged water annually. The significant difference between salvaged water quantity and estimated flows from the drain reflects the fact that much of the water reaches the river under current conditions and therefore is not salvaged water. Also, the values assumed for this estimate are of reconnaissance level accuracy and are subject to wide variations upon implementation.

Wet Meadow Enhancement

An alternative use for the water from drained agricultural fields would be to sustain wet meadows through drought cycles or to enhance them during normal precipitation periods. The drains could be routed to the wet meadows where the water would be spread on the surface or distributed through a system of buried pipe drains similar to a septic drain field. Several sites that would lend themselves to this treatment have been identified in bridge sections 10, 11, 12 , and 13. The criteria used to identify the sites was 1) The wet meadow is located near the farmland to be drained to minimize outlet costs, and 2) the wet meadow is several feet lower in elevation than the drained farmland, so that water will flow to the meadow without pumping. The relative area of the drained farmland to the area of wet meadow that can be benefitted is a question at this point. Each situation will be different. A good rule of thumb may be one acre of drained land for one acre of receiving wet meadow.

The drains would need to be provided with an axillary outlet to the river that could be used in the event the wet meadow would be harmed by additional water. In that case the water would be added to the flow in the river, possibly precluding the need to release water from the environmental account in Lake McConaughy. The cost estimate below does not include these additional features.

Possible sites for treatment were identified in the office using USGS 7.5 minute quadrangle sheets, existing monitoring well records from the State of Nebraska web site and from the CNPPID files, satellite images taken on May 26, 1999 with wetness factor emphasize, and color infrared photos taken on May 12, 1999. The most recent precipitation event previous to the 2 photo episodes was on May 4 and 5 when Platte Valley between North Platte and Kearney received between ½ inch and 2 inches of precipitation. Wet soils from that event could possibly be visible in some of the May 12 infrared photos. The soils would have been well dried by the time the May 26 satellite images were taken. The next most recent precipitation event was on April 21 and would have been well dissipated before any of the photos were taken. Only those lands that are under active cultivation were designated. Lands that are not currently cultivated were considered to be wet meadows and therefore exempt from this proposal. These lands could be considered if they do not meet all the criteria of a wet meadow as defined by F&WS. No field verification has been carried out.

Cost Estimate

The cost of the drains would be 10 to 20 dollars per foot. Since the landowners would benefit substantially from this proposal, there may be opportunity for cost sharing. Assuming $100,000 per mile and 50 % cost share, the project cost would be $50,000 per mile. With 30 % overhead and 30% contingencies the total cost is $84,500 per mile.

CAPITAL COSTS

Total Capital Cost ($/mile)	$84,500
Total Capital Cost annualized for 50years @ 6.8750% =	$6,000
ANNUAL O&M COSTS	
Total Annual O&M ($/mile)	$1,000
Total Annualized Cost	$7,000
Estimated Annual Yield (Acre-feet/mile)	80
Annual Cost per Acre-foot	$88

3. Gothenburg and Dawson Canals,

Water from the Platte River would be diverted to the Gothenburg Canal and/or the Dawson Canal during the non-irrigation season and when there are excess river flows available. Diversions would typically be made in October, November, March and April. Seepage from the canals would return to the river over time. The Gothenburg and Dawson Canals are generally located at Standard Depletion Factors (SDF) factors of 100 days and 150 days respectively along the lengths of each canal. (Boyle Engineering Corporation) The SDF factor is the time in days in which 28 percent of the water will reach the river through the aquifer.

Diversions to the Gothenburg and Dawson canals during the non-irrigation season are limited by the capacity of the terminal spillways to 200 cfs and 150 cfs respectively. (Boyle Engineering Corporation) Nebraska Public Power District (NPPD) estimates seepage losses to be about 20 percent from each of the canals. Therefore, the maximum seepage loss that can be lagged back to the river is 40 cfs and 30 cfs or 2400 and 1800 acre feet per 30 day month respectively. Reduction of the winter time drainout period by several months may convert the canals to a condition in which the canal water is in contact with the water table throughout the year and thus significantly reduce the percentage of seepage losses. Additional studies would be needed to evaluate this scenario.

Operation of the canal on a continual basis would eliminate the winter drainourt period raising the regional water table. Increasing the volume of canal losses by extending the period of canal operation would increase the acreage and severity of crop losses. It may also convert certain wet meadows to saline seeps with very low habitat value. The end result would be that a large percentage of the "rescheduled" flows would go to evapotranspiration and never reach the river.

Maintenance requirements for these two canals and the Cozad Canal, which lies below the Dason Canal, would be significantly increased where the water table is in contact with the canal prism during the winter months. At the same time, the opportunity to conduct canal maintenance in the dry would be shortened. Other probable consequences would be increased county road maintenance due to saturated subbase and increased frost heave.

Probable consequences of the proposed project include:

A line of saline seeps will appear at the first escarpment down gradient from the canal.

Some agricultural lands will become too waterlogged to support agricultural crops.

Maintenance on the Cozad Canal will be adversely affected as ground water encroaches on the canal prism.

County road maintenance will be adversely affected as road fills become saturated or at the least, subject to frost heave do to shallow ground water.

More water will be consumptively used directly from the water table by phreatophytes. This additional water will be project water.

4. Shallow Ground Water

No specific plan is being made to influence shallow ground water conditions in the target area. However, some of the elements will have an influence on lowlands lying very near the river. This includes most of the identified wet meadows next to the river or on islands.

Impulse flows generated for the recovery program will affect ground water levels within a few hundred feet of the river for as long as the flow is maintained. Available water for the recovery program is insufficient to maintain impulse flows for more than 2 or 3 days at a time and probably not more than twice a year. When the flow is discontinued the ground water level will return to very near antecedent levels within one day.

Flow augmentation generated for the program during longer periods will increase the depth of water in the river by such a small increment that its impact on ground water levels will be insignificant. A more in-depth discussion on shallow ground water can be found in the Reclamation report Ground Water and River Flow Analysis published in April 2002.

B South Platte River

1. Tamarack

The initial Tamarack Project is referred to as Tamarack I. The Ultimate project is referred to as Tamarack III. The original concept for Tamarack I envisioned 35 production wells, approximately 13 miles of pipeline, and 41 small recharge ponds located in natural depressions, some of which would be lined in order to create wetland habitat. The yearly average diversion was to be 30,000 acre-feet of which of which an estimated 10,000 acre-feet would return to the river during the April through September target period. However, further analysis using MODFLOW modeling has resulted in a scaled down project which is not completely defined as of this writing.

Tamarack III is at this time conceptual in nature. It is expected to extend from Fort Morgan to the Nebraska State line. And will divert up to 56,000 acre-feet annually. The State of Colorado estimates the contribution toward improving target flows to be approximately 17,000 acre feet. In the absence of at least a skeleton plan, it is impossible to evaluate whether the plan can in fact be implemented as envisioned or what impacts may result from the plan.

2. Bebee Draw

Useable storage capacity in Bebee Draw is estimated to be 100,000 acre-feet according to the Barr Lake Report (Third Creek Corporation, 1992). Water would be delivered through existing canals to recharge facilities such as injection wells or seep pits. Production wells would then recover the water as needed for in-stream flows. The plan may include modifying one or more of the three reservoirs to temporarily store pumped ground water.

Wells capable of pumping 4 cubic feet per second are feasible in Bebee Draw. Production of 8,000 acre feet per year would require 125 wells pumping for 100 days. The wells would be located within the 128,000 acre area. Either wells or drains could be used as recharge facilities to fill the aquifer during periods of available water.

The site may be better suited to long term storage than to annual recharge and recovery. The stored water could be used to bridge drought years by providing a base flow high in the South Platte Basin.

The channel below Lower Latham Reservoir will have to be upgraded to accommodate the 500 cubic feet per second flows needed for Program water.

C. Ground Water Influences in the North Platte River Valley

The ground water component associated with the North Platte River is relatively unimportant to flows in the Platte below the City of North Platte. In general, the valley lacks a significant aquifer until it enters the High Plains Aquifer in eastern Wyoming. From there to Lake McConaughy any influence that the aquifer has on the river or vise versa is overshadowed by the operation of Kingsley Dam. Below Kingsley Dam, the ground water regime is more closely related to the Central Platte Valley and is included in that discussion.

V. References

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US Bureau of Reclamation, O'Neill Unit Special Report Ground Water Recharge Plan, January, 1992

APPENDIX A

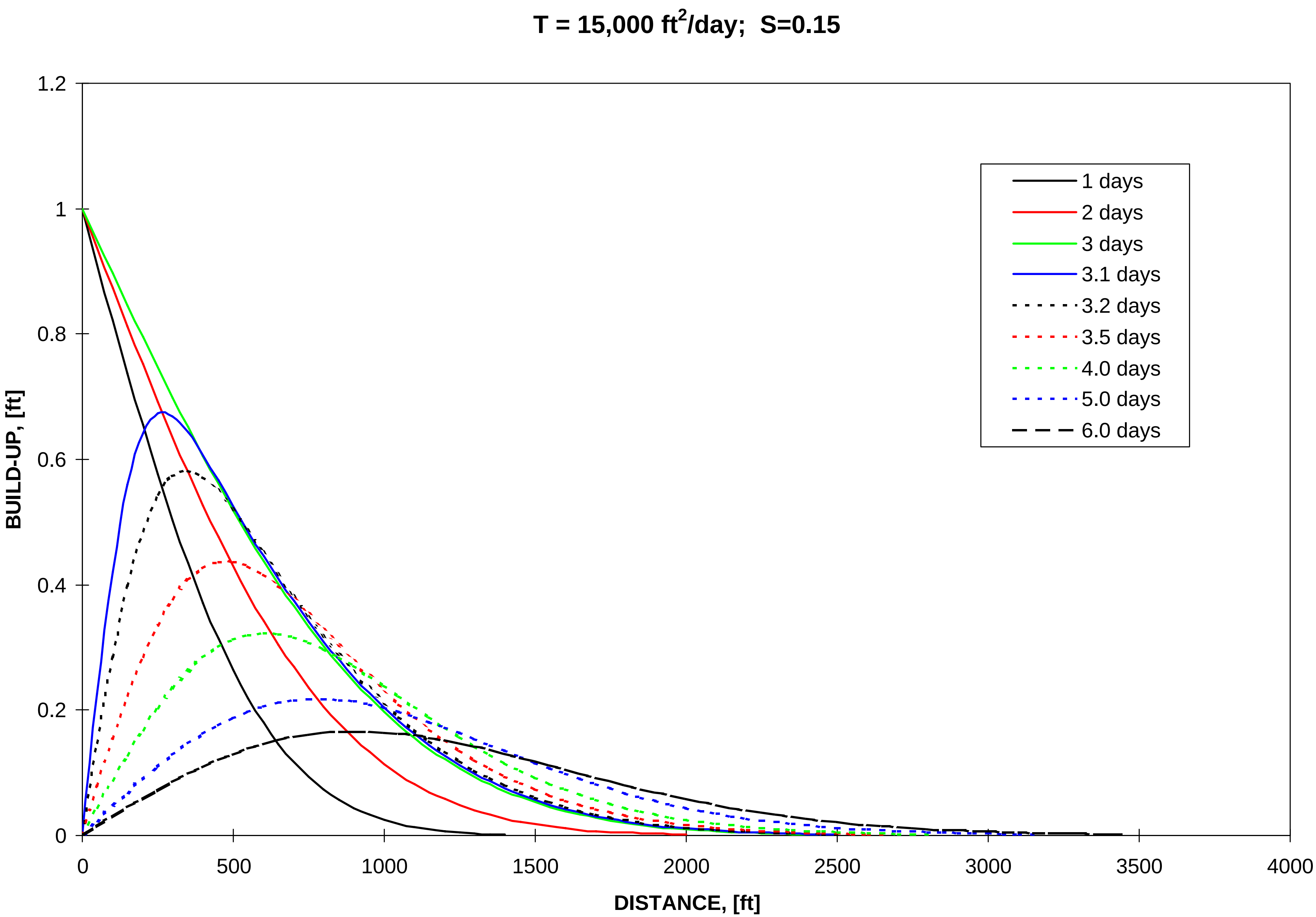
BANK STORAGE

Appendix A contains the explanation of the Bank Storage Analysis and 2 sets of curves showing the result of bank storage for typical releases envisioned under the Program.

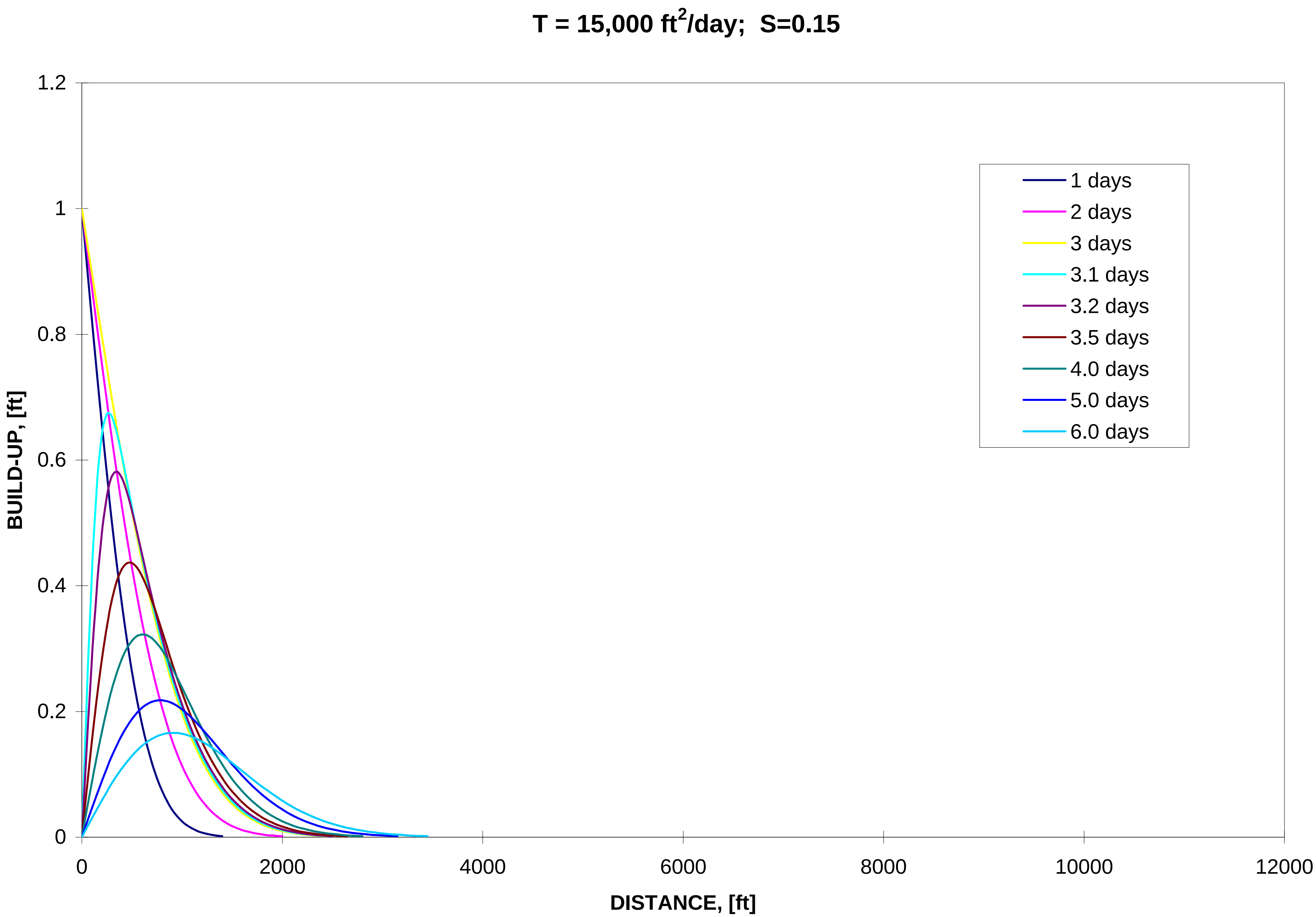
The first set of curves shows how the water table adjacent to the river would respond to a rise of 1 foot in the river elevation for a period of 3 days followed by a return to the original river elevation. It follows the response through day 6. On day 3 the water table near the river reaches its highest level at roughly 7 inches above original at 500 feet from the river. It drops rapidly when the river level returns to normal. At 1500 feet from the river the water table continues to rise reaching a peak about 2 inches higher than normal on day 6. Following day 6 the water table is degrading to its original shape at all locations.

The second set of curves depicts an induced rise in the river surface of 0.4 feet (5 inches) for a period of 30 days followed by a return to original elevation. Curves showing the water table at 10 days, 20 days and 30 days are included. The 30 day rise is roughly 3 inches at 1,000 feet from the river and 1 inch at 3,000 feet from the river.

The aquifer values used in the computations are on the high end of the range of values that is typical for the Central Platte Valley. Lower values would result in a lesser response in the water table.



T = 15,000 ft²/day; S=0.15
BUILD-UP, [ft]
DISTANCE, [ft]
0
0.2
0.4
0.6
0.8
1
1.2
0
500
1000
1500
2000
2500
3000
3500
4000
1 days
2 days
3 days
3.1 days
3.2 days
3.5 days
4.0 days
5.0 days
6.0 days



T = 15,000 ft²/day; S=0.15
BUILD-UP, [ft]
DISTANCE, [ft]
1.2
1
0.8
0.6
0.4
0.2
0
2000
4000
6000
8000
10000
12000
1 days
2 days
3 days
3.1 days
3.2 days
3.5 days
4.0 days
5.0 days
6.0 days

APPENDIX B

DAILY ANALYSIS OF TRANSECTS

Eight well hydrographs were examined with respect to their relationship to the river hydrograph and precipitation events. Direction and time of water table fluctuations were considered as well as magnitude of the change. The statistical relationship and the bank storage potential were also considered.

Four wells from the Alda transects and four from the Minden transects were examined. The wells were selected for analysis based on the distance from the well to the river. Each set of 4 has one well very near the river, one 1/8 to 1/4 mile from the river, one 1/2 to 3/4 mile from the river, and one more than a mile from the river. This covers the range from very close relationship to very poor relationship.

APPENDIX C

STATISTICAL ANALYSIS OF GROUND WATER DATA

Pages S-1 through S-5 present a summary of the statistical analyses.

Pages 1 through 71 present the in depth analyses.

Pages A-1 through A- 27 present plots of the statistical relationships.

Pages B-1 through B-51 present tables of correlations.

Statistical Analysis of Ground Water Data

Statistical analysis of the water surface elevation (WSE) data for 28 observations wells adjacent to the Platte River was performed using a variety of techniques, but primarily correlation analysis, in an attempt to evaluate interrelationships between gage heights in the river at 3 gages, the WSE's, and precipitation estimates for each of the wells. The results are summarized in this section.

There were 28 statistically significant correlations of ground water surface elevation with river surface elevation (river stage), but only 4 with precipitation out of the total of 28 (one for each well). In other words, all of the wells show a significant correlation between WSE and gage height (GH). When the data were transformed into changes in WSE (ΔWSE) by subtracting the previous days WSE and correlating with the change in gage height (ΔGH), there were 20 significant correlations; however, there were 22 significant correlations between ΔWSE and precipitation. This showed that there was actually a relationship between change in WSE and precipitation that was at least as significant as the one between ΔWSE and ΔGH.

To try to assess what was affecting the correlations between the well WSE with GH and precipitation, a data set was created that included various physical measurements and the r−values from the correlations for each of the 28 wells. The physical factors included distance of the well from the river; the ground surface elevation of the well; the minimum, median, and maximum water surface elevation in each well; a numeric reference to the position of the well (*i.e.* 1 is nearest the river and 4 is farthest away); the range in WSE in the well (maximum less the minimum elevation); the difference between the minimum, median, and maximum WSE in the well and the river gage elevation; and the number of WSE observations for each well. It should be noted that, among the wells, some were started later in the monitoring period and some were discontinued before the end of the monitoring period; this raised the possibility that the differences in the monitoring periods influenced the resulting relationships. For this reason the possibility of the influence of data records was evaluated. However, the results showed that this was not a factor that affected the correlations.

The evaluation of the correlation coefficients is summarized in Table S1. The best evaluation variable for the r−values is distance from the river. The first cluster in Table S1 is composed of wells located less than 9,000 feet or about 1¾ miles from the river. The average r−values for three of the four sets of correlations in the near wells are around twice those in the far wells, while the average r−value for the remaining correlation in the near-wells cluster (WSE with GH) is about 1½ times the average in the far-well cluster. It is not surprising that the r−values for the correlations between WSE with GH and ΔWSE with ΔGH are higher for the wells near the river, but the similar result for correlations of WSE and ΔWSE with precipitation was not expected.

Table S1. Summary of Cluster Analysis Results						
	Cluster 1: Summary Statistics			Cluster 2 : Summary Statistics		
Variable	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Distance to the river (ft.)	50	4,032	9,000	11,000	14,864	23,300
r: WSE & GH	0.19	0.62	0.98	0.2	0.4	0.62
r: WSE & precipitation	-0.02	0.12	0.51	-0.12	0.04	0.12
r: ΔWSE & ΔGH	0.03	0.31	0.81	-0.19	0.16	0.3
r: ΔWSE & precipitation	0.05	0.34	0.73	-0.26	0.14	0.33
Gage elevation (ft.)	1894	2113	2333	1894	2191	2333
Distance downstream (mi)	0	41	61	0	27.82	61
Transect number	1	2.76	4	1	2.18	4
Median difference (ft.)	-3.26	2.79	7.58	-9.43	17.48	65.69
Ground surface elev. (ft.)	1898.7	2122.1	2346.7	1896.6	2215.8	2358.8
Well number	1	1.7	3	2	3.2	4
Maximum WSE (ft.)	1896.4	2117.8	2343.1	1890.3	2211.8	2354.1
Elevation range (ft.)	1.2	4.1	10.1	3.1	5.7	10.9

TS-2he wells in many cases are located more than a mile from the river. The water would be expected to take some time to travel that distance if either the river were influencing the wells or the wells were influencing the river. On the assumption that the wells were influencing the river, since in nearly all cases the WSE in the wells was higher than the river, the well WSE were subjected to varying lags to simulate the travel time. For over 80 percent of the wells, the best correlation between the well WSE and the gage WSE was the one with no lags. This indicates that any delay in influence would be less than one day, which is the length of time one lag would represent based on daily data. If there is no time for the interaction to occur, the response must be a common one to a common influence, *e.g.* precipitation, despite the fact that the direct correlations with precipitation are not particularly good. This is further affirmed by the fact that when all of the wells were correlated with each of the gages, the best correlation in the majority of cases was with the Grand Island gage (22 of 28 for WSE-GH), even though one of the other gages was nearer to an individual well. None of the "best" WSE-GH correlations was with the Overton gage and 6 were with the Kearney gage.

Correlations among the WSE of all of the wells were also run. These showed that 94 percent of the correlations were statistically significant (427 of 464). However, 5 of the significant correlations were inverse (negative), so the actual total of positive significant correlations is about 92 percent. This also indicates that the WSE of the ground water is moving in concert over most of the study area.

Correlations between gage data (GH and ΔGH) and lagged precipitation were also run. These showed the "best"correlations between lagged precipitation and GH was based on a 3-4 day lag depending on the gage. Alternatively, the "best" correlations for the ΔGH data were with a 1 day lag and with precipitation sites that were approximately a 1 day travel time away. The travel time between each of the 3 gages is about 1 day.

A similar set of correlations between well WSE and lagged precipitation data increased the number of significant correlations from the 4 noted above to 15. Only 3 of the "best" correlations were with unlagged precipitation data. A similar set of correlations between ΔWSE and lagged precipitation only increased the number of significant correlations from 22 to 23, 15 of which are with unlagged data. This indicates that for most of the wells recharge is rather rapid.

The relationship between several of the wells with the gage heights of tributaries that flowed between adjacent wells in the Overton and Alda transects was investigated. These showed that surface water channels were probably acting as ground water drains, possibly most of time and undoubtedly some of the time. Although there were very good correlations between some of the wells and the intervening tributaries, they did not appear to influence recharge (only discharge).

It was noted early in the study that there was an inverse correlation between various measures of distance east and west, *e.g.* transect number, distance downstream, ground surface elevation, and precipitation. This indicates that precipitation was greater to the west than to the east. Based on a comparison of the precipitation from NEXRAD polygons over the various transects, it was shown that precipitation was generally greater in the south of the study area than to the north. The variation in the precipitation among polygons was up to 8 inches during the study period from March to September. However, the greatest variation is due to the fact that the Minden transect received significantly less precipitation (about 4 inches) than any of the other transects. This result appears to account for the east-west variation, at least in part, and much of the north-south variation. The differences in precipitation, which would differentially affect recharge, could account for some of the variation in the correlations of WSE among the wells.

Regression analysis was performed on the well WSE-GH relationships to evaluate the strength of the relationships that were previously evaluated by correlation analysis. Recall that there were significant correlations for each of the wells with the respective gages. Regressions for each of the relationships showed r^2−values that ranged from 0.03 to 0.96, indicating that the regressions could explain between 3 and 96 percent of the variation in the well WSE in terms of the gage elevation of the river. The rule of thumb for a useful regression relationship in hydrology is to have a minimum r^2−value of 0.75. There were only 3 regressions that had an r^2−value that high. These included the 2 wells in the Minden transect that were adjacent to the river and the equivalent well in the upstream segment of the Alda transect. The r^2−values decreased with distance from the river; *i.e.* 0.78 at 700 feet, 0.95 at 100 feet, and 0.96 at 50 feet moving in a downstream direction. Based on this result, the analysis of the distance from the river was revisited with 3 rather than the earlier 2 groupings. The analysis showed 3 significant groups based on distances from the river; the groupings were < 1000 feet, 1000 to 10,000 feet, and >

10,000 feet. It was also noted that none of the regressions in the Elm Creek transect were useful predictors, apparently because of the influence of the ground water mound upgradient from the river. Predicted rise in ground water due to a 1-foot rise in the river (the maximum considered possible under the program) would range from a foot adjacent to the river to between 0.2 and 0.4 foot (2.4 to 4.8 inches) in the wells farthest from the river in the transects to the north of the river.

The general conclusions that can be drawn from the statistical analysis of surface water and ground water elevations, changes in elevation, and precipitation are the following:

- The wells nearer to the river show a better relationship between the WSE in the wells and the GH in the river than those farther away.
- The relationship between the WSE in the wells and the GH improves with distance downstream through the study area.
- There is no relationship between the unmodified WSE in the wells and precipitation in 90 percent of the wells; however, there is a relationship between the daily change in WSE (ΔWSE) and precipitation in the vast majority (79%) of observation wells in the study area.
- Interestingly the r−values for the relationships between ΔWSE and precipitation and between ΔWSE and ΔGH are both significantly correlated with the r−values for the relationship between WSE and GH.
- The r−values for the relationships between ΔWSE and precipitation and ΔWSE and ΔGH are better in wells nearer the river, but are not significantly correlated with distance downstream in the study area (see Table 17).
- It appears the upstream reaches of the river are gaining flow from ground water most or all of the time, while the reaches farther downstream may be losing flow at least some of the time.
- Intervening tributaries influence the ground water locally, but there are still significant correlations between the WSE of wells beyond the tributaries and the mainstem Platte River gages.

Conclusions based on the lagged correlation analysis include the following:

- Significant correlations among the WSE's for the observation wells, which would indicate a common response of different areas of the same aquifer, were obtained for a set of approximately 90 percent of the wells; another 2 percent were correlated inversely.
- There is a much greater degree of correlation between the change in WSE in the wells nearer the river than those farther from the river.
- Lagged data indicate the recharge from local precipitation is rapid, 1 day or less in most cases.

It is also evident that precipitation amounts varied greatly over the study area. The only conclusion resulting from the analysis of the precipitation data is that the Minden transect received significantly (at least 4 inches) less precipitation than any of the other 3 transects.

Conclusions that were drawn based on the regression analysis of flooding potential were the following:

- Regression analysis indicates that the consistent interaction and probable control of the ground water by the river extends to about 100 feet in some cases. Regressions for wells beyond 100 feet reflect the slope of a broader band of water surface elevation data pairs; in general, when plotted, the band increases in width and decreases in slope at distances beyond 1000 feet. Between 100 and 700 feet (and probably extending a little farther in some cases), the control by the river occurs part, and maybe a majority, of the time, but other influences become important.
- Regressions in the Elm Creek transect do not provide useful predictions, apparently because of the control by the ground water mound.
- With one exception, wells at or nearer than 100 feet from the river showed a 1-foot rise in water surface elevation with a 1-foot rise in the river. Wells farthest from the river, except as noted below, showed a rise of 0.2 to 0.4 foot (2.4 to 4.8 inches).
- The greatest projected effect on the ground water surface elevation based on a regression on the water surface elevation of the river was to wells in the “ground water mound.” One well with a minimum water surface elevation that was 32 feet greater than the river was projected to rise over 2 feet in response to a 1 foot rise in the river. Another well with a minimum water surface elevation of 63 feet above that of the river showed a rise of over 1.1 foot. Because this is not physically possible, the correlation is concluded to be a reflection of a high degree of coincidental rise and fall in surface water and ground water elevations.
- Most of the well-river water surface elevation regressions (23 of 28) have r^2-values less than 0.5, indicating that the river water surface elevation could at best explain less than 50 percent of the variation in the well water surface elevation and in over half the wells, less than 30 percent.
- For most of the wells the “best correlation” with a gage is with the “Grand Island gage.” Lagging the data to compensate for distance does not change this result, although 2 of the wells that correlate best with the gages show a better correlation with the “Grand Island gage” than with the adjacent “Minden gages.” Since the Grand Island gage is downstream from all of the wells, it could control none of them; however, since it is the farthest downstream and likely to show the smoothest hydrograph, it probably acts as the best surrogate for a well hydrograph of any of the gages.

APPENDIX D

USGS SNAPSHOT OF GROUND WATER IN THE
CENTRAL PLATTE VALLEY ON MAY 25-27, 1999

Appendix D contains the following figures

1. Ground water contour map of central Platte Valley

2. Geologic section A-A' near Kearney

3. Geologic section B-B' west of Grand Island

4. Geologic section C-C' east of Grand Island

USGS developed a snapshot of ground water elevation for the entire Central Platte Valley for the end of May 1999. Between May 25 and 27, 1999, USGS personnel measured ground water levels in 77 irrigation wells next to the Platte River and surface water levels at 35 locations along the Platte River. These water levels were measured when little widespread rainfall had occurred, and river discharge was believed to be affected minimally by upstream rain events. This provided a snapshot of ground water conditions.

The groundwater contour map (page 1) shows contours at 20 foot vertical intervals, arrows indicating the direction of groundwater movement, the locations of geologic sections A-A', B-B' and C-C', location of irrigation wells measured for the study, locations of county lines, and the locations of the cities of Grand Island and Kearney. The 3 geologic sections are shown as one would see them from a bridge across the Platte River looking upstream toward the west.

Geologic section A-A' shows the elevations of the ground surface, and the measured water table across the section shown on the ground water contour map. It also identifies the Platte River on the left side of the figure and ends just short of the Wood River on the right side of the figure.

Geologic section B-B' shows the elevations of the ground surface, and the measured water table across the section shown on the ground water contour map. It also identifies several channels of the Platte River, and the Wood River to the right of the Platte. It shows the Platte River as receiving ground water flow from the right and losing to ground water on the left. The right side represents the area west of Grand Island and the left side represents a portion of the Upper Little Blue drainage basin where a significant cone of depression has developed in the ground water due to irrigation pumping.

Geologic section C-C' shows the elevations of the ground surface, and the measured water table across the section shown on the ground water contour map. It also identifies Lincoln Creek on the left side of the figure, the Platte River, the Wood River, Silver Creek, and Prairie Creek at the right side of the figure. Similar to section B=B', it shows the Platte River gaining from the right and losing to the left.

APPENDIX E

HISTORIC PRECIPITATION

Appendix E contains precipitation records for 11 weather stations in the Central Platte Valley, all of which have 100 years of record. The stations generally from west to east are Paxton, Gothenburg, Elwood, Holdrege, Kearney, Minden, Ravenna, Loup City, Grand Island, Central City, and Fullerton.

Figures 1 through 11 are graphs showing the annual precipitation amounts and the 5-year running average for each station.

Figure 12 is a composite graph showing the average and 5-year running average of the 11 stations.

Figure 13 is a graph showing the cumulative departure from average for the 11-station composite. The figure shows that during the first 6 years of the century, precipitation totaled 40 inches more than average. This was followed by near or below average precipitation until 1980 when the cumulative total was 41 inches below average. In the 20 years since 1980, the 41 inch deficit has been eliminated. This means that precipitation in the Platte Valley has been nearly 10 percent above average for the last 20 years.

Table E-1 lists the quantity of above average precipitation during the 19 and 9 year periods since 1980 and 1990, respectively, and the quantity above average per year for each of the eleven stations.

APPENDIX F

WELL TRANSECTS AND DATA

Appendix F contains the data from well monitoring for the period March through September 1999. Bureau of Reclamation installed electronic dataloggers in 26 wells to measure water levels during this time. This data was collected hourly, but the data for the hydrographs are daily. The hydrographs use the 12 noon reading for each day.

To provide context for the ground-water levels, the hydrographs include daily streamflow data on the Platte River. The streamflow data was downloaded from the USGS internet site. The streamflow data is preliminary and subject to revision. This data is at least hourly; some of the data have more than one reading during an hour. The hydrographs show daily data and use the 12 noon reading for each day.

Also included on the hydrographs is the precipitation for the period of time. The precipitation data is NEXrad data as explained in Appendix G.

Figures included in this appendix are:

Figure 1. - Location map of the well transects.

Figures 2 - 6. - Hydrographs of the water levels for wells in the Alda upstream transect. Figure 2 contains all the wells in this transect; following figures are arranged from farthest to closest to the river.

Figures 7 - 10. - Hydrographs of the water levels for wells in the Alda downstream transect. Figure 7 contains all the wells in this transect; following figures are arranged from farthest to closest to the river.

Figures 11 - 15. - Hydrographs of the water levels for wells in the Minden upstream transect. Figure 11 contains all the wells in this transect; following figures are arranged from farthest to closest to the river.

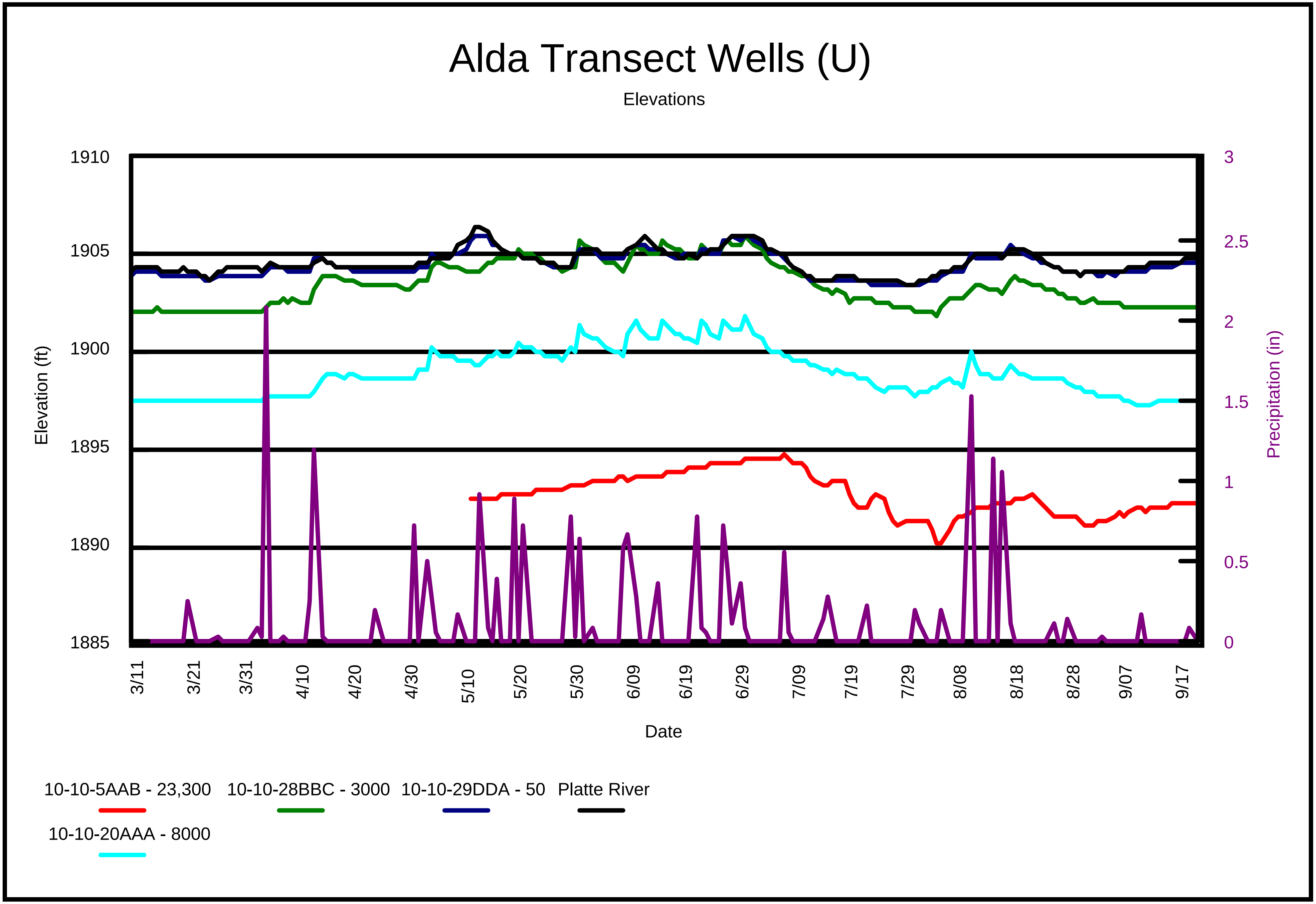
Figure 16 - 19. - Hydrographs of the water levels for wells in the Minden downstream transect. Figure 16 contains all the wells in this transect; following figures are arranged from farthest to closest to the river.

Figure 20 - 24. - Hydrographs of the water levels for wells in the Elm Creek upstream transect. Figure 20 contains all the wells in this transect; following figures are arranged from farthest to closest to the river.

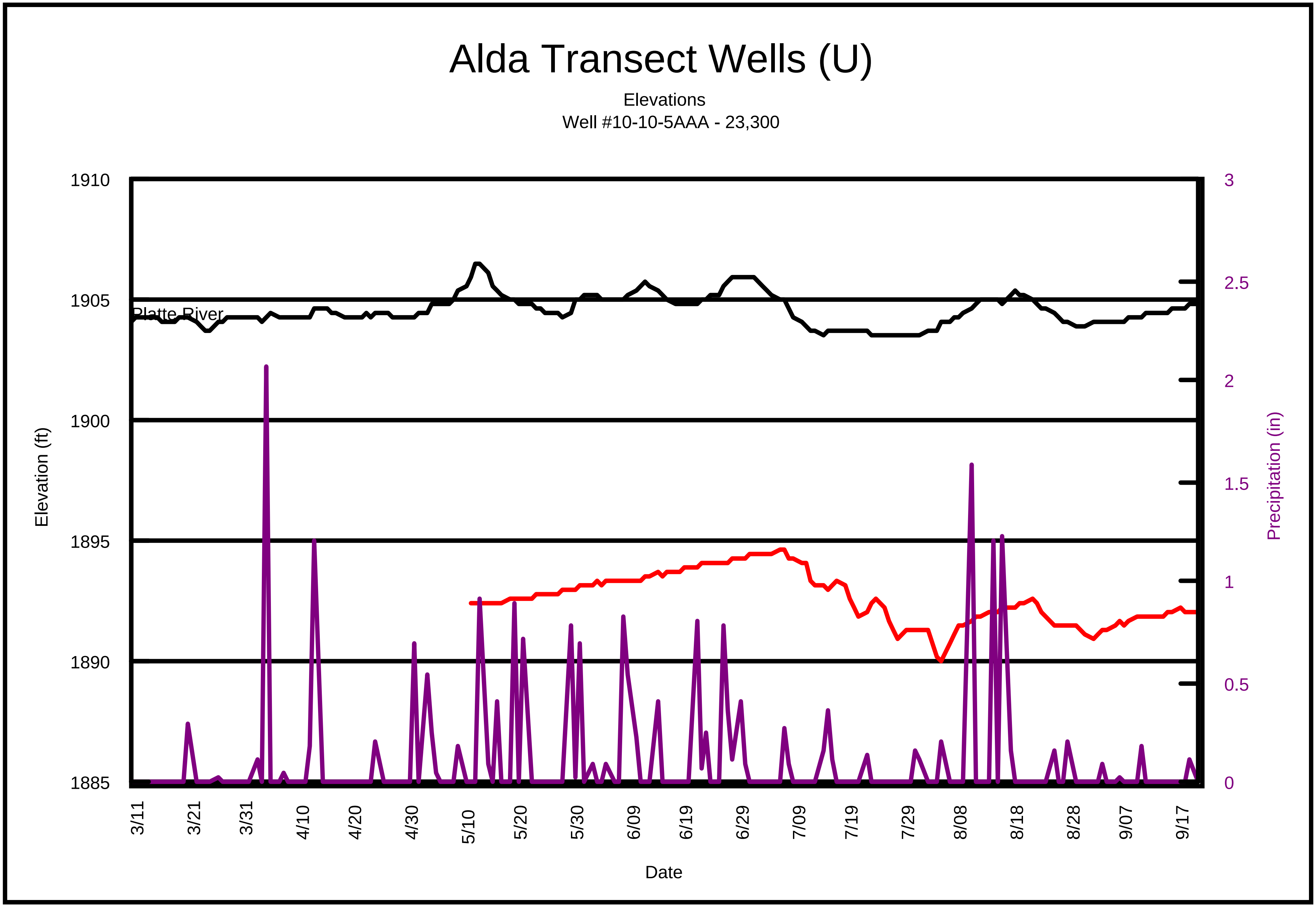
Figures 25 - 29. - Hydrographs of the water levels for wells in the Elm Creek downstream transect. Figure 25 contains all the wells in this transect; following figures are arranged from farthest to closest to the river.

Figures 30 - 33. - Hydrographs of the water levels for wells in the Overton upstream transect. Figure 30 contains all the wells in this transect; following figures are arranged from farthest to closest to the river.

Figures 34 - 37. Hydrographs of the water levels for wells in the Overton downstrem transect. Figure 34 contains all the wells in this transect; following figures are arranged from farthest to closest to the river.



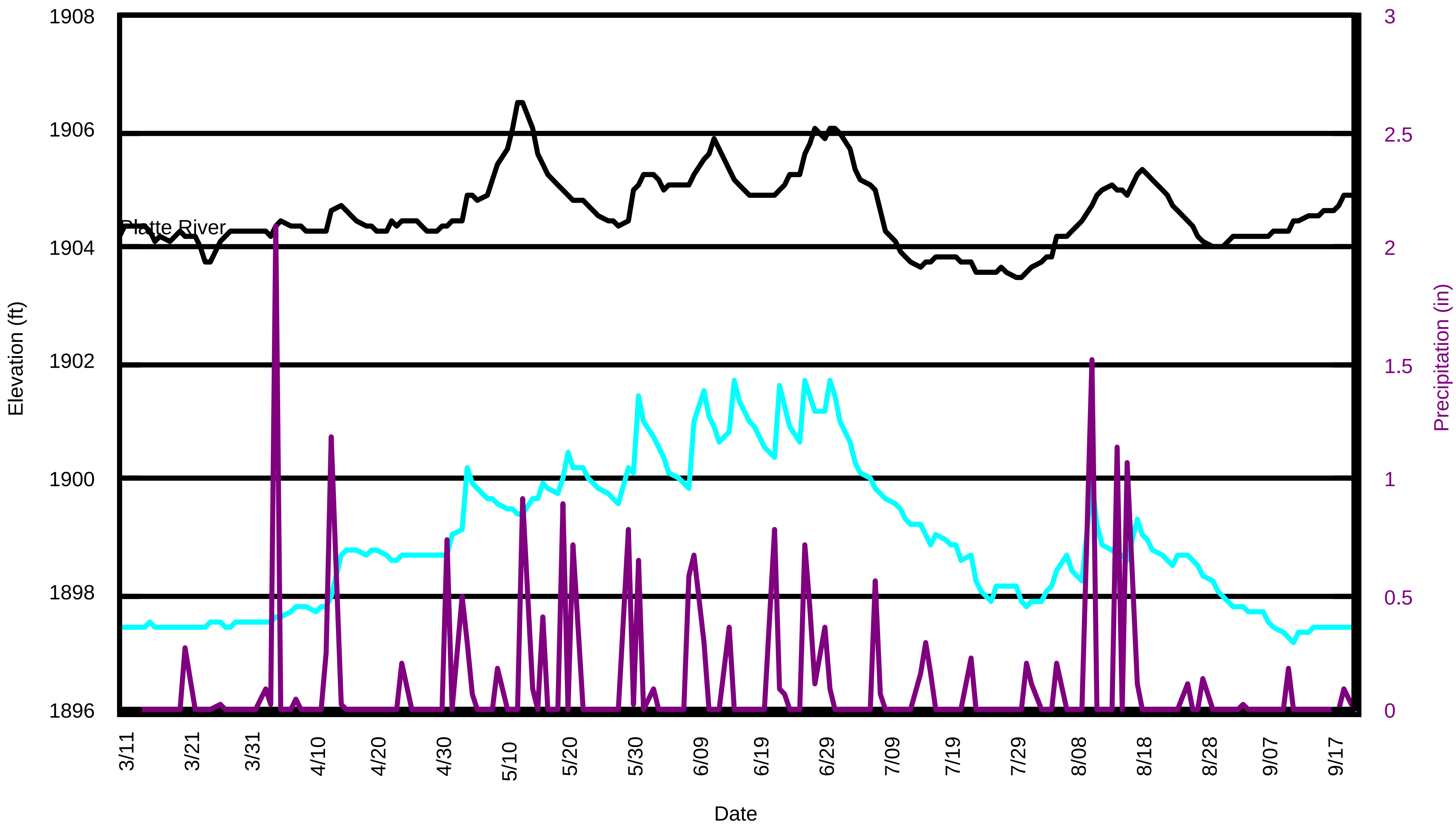
Alda Transect Wells (U)
Elevations
1910
1905
1900
1895
1890
1885
Elevation (ft)
3
2.5
2
1.5
1
0.5
0
Precipitation (in)
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date
10-10-5AAB - 23,300
10-10-28BBC - 3000
10-10-29DDA - 50
Platte River
10-10-20AAA - 8000

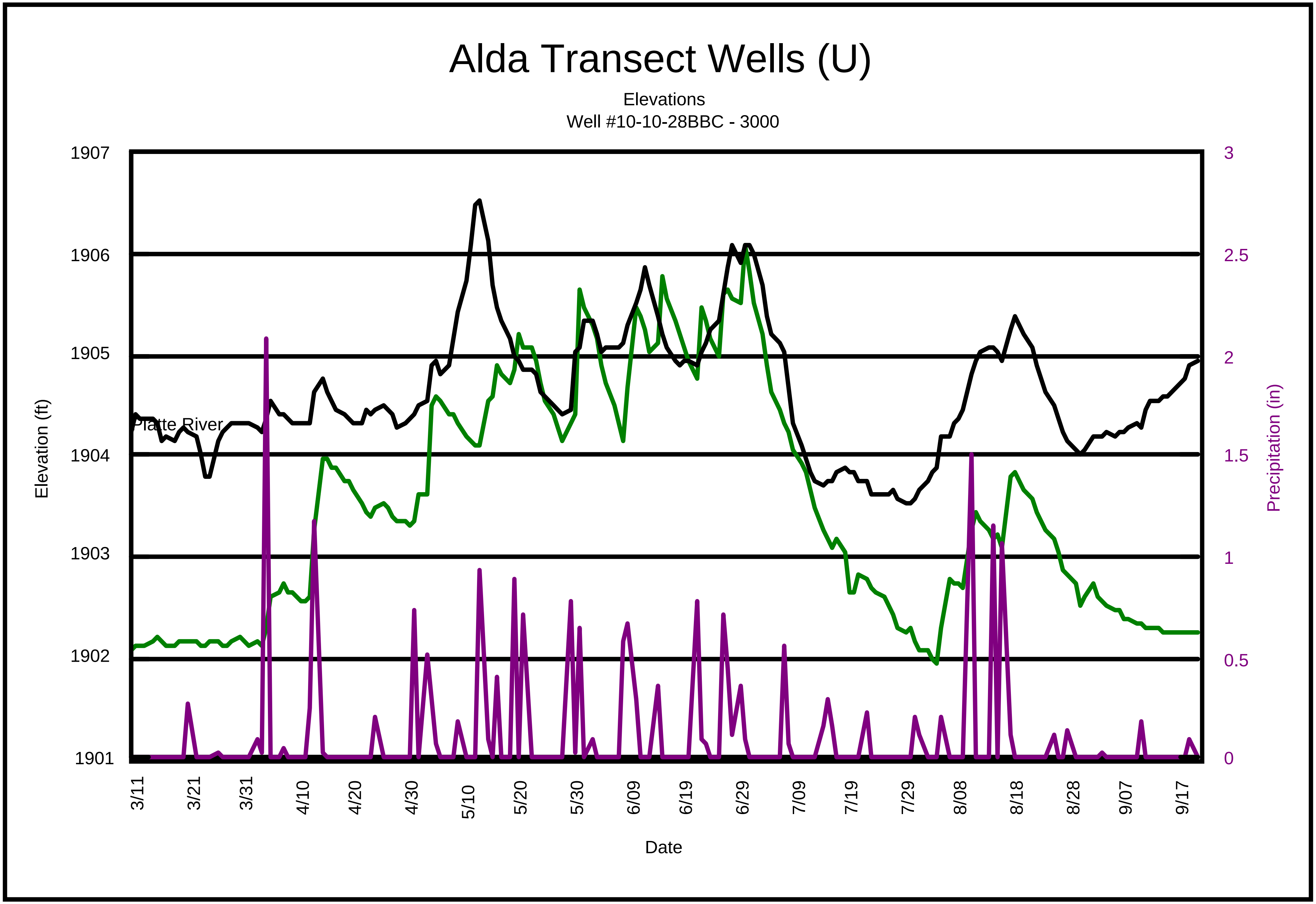


Alda Transect Wells (U)
Elevations
Well #10-10-5AAA - 23,300
1910
1905
1900
1895
1890
1885
Elevation (ft)
Platte River
3
2.5
2
1.5
1
0.5
0
Precipitation (in)
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date

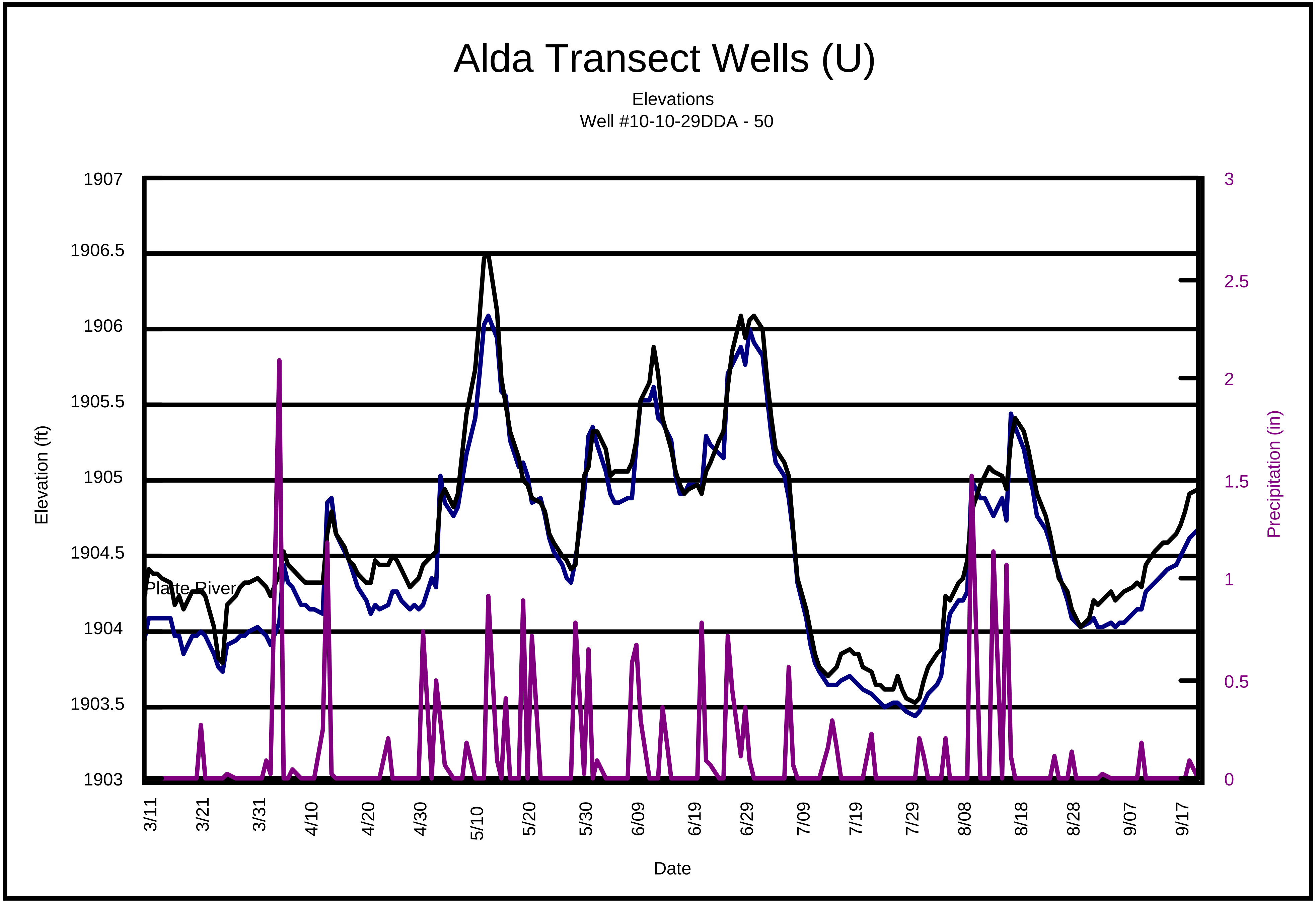
Alda Transect Wells (U)

Elevations
Well #10-10-20AAA - 8000

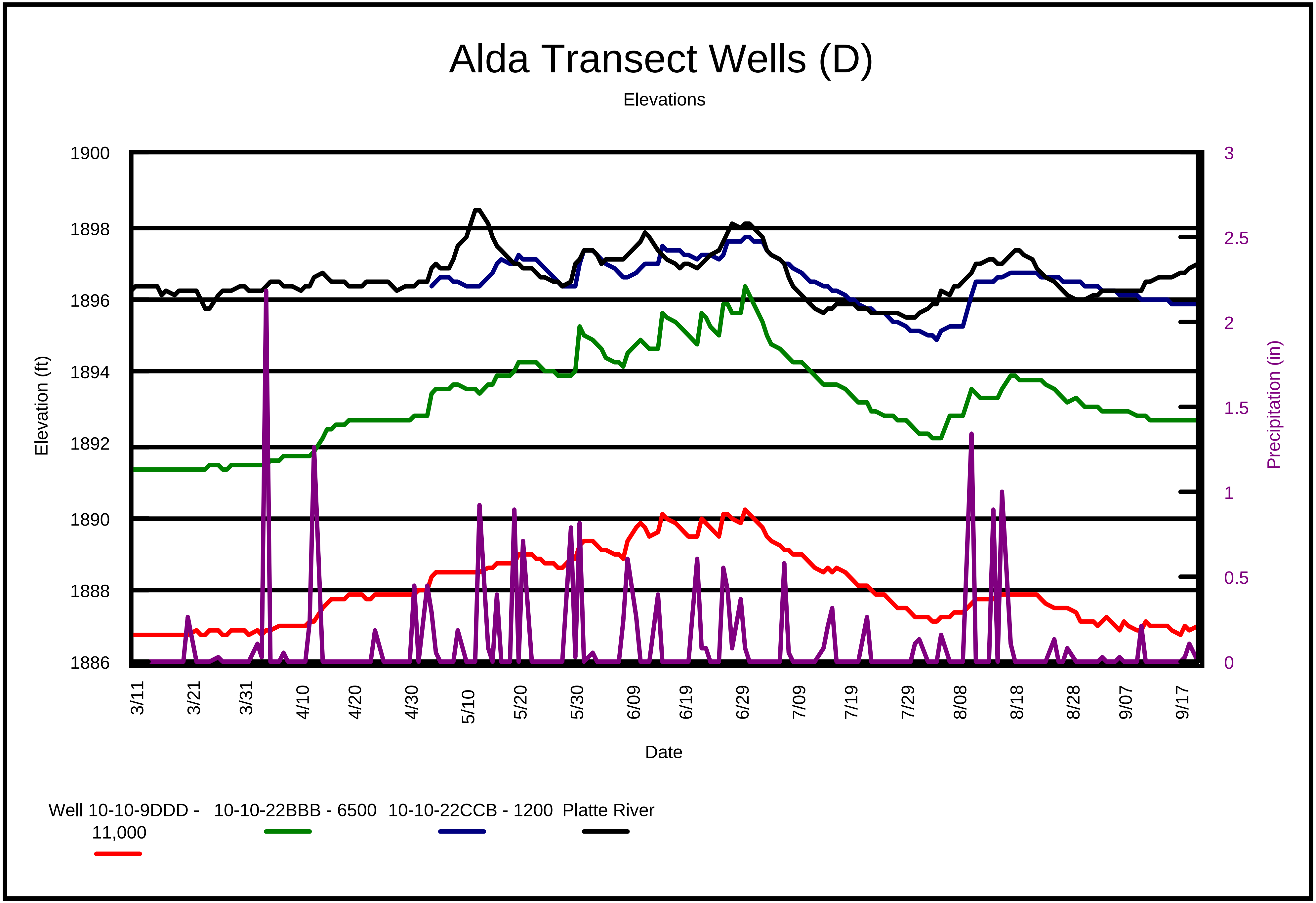




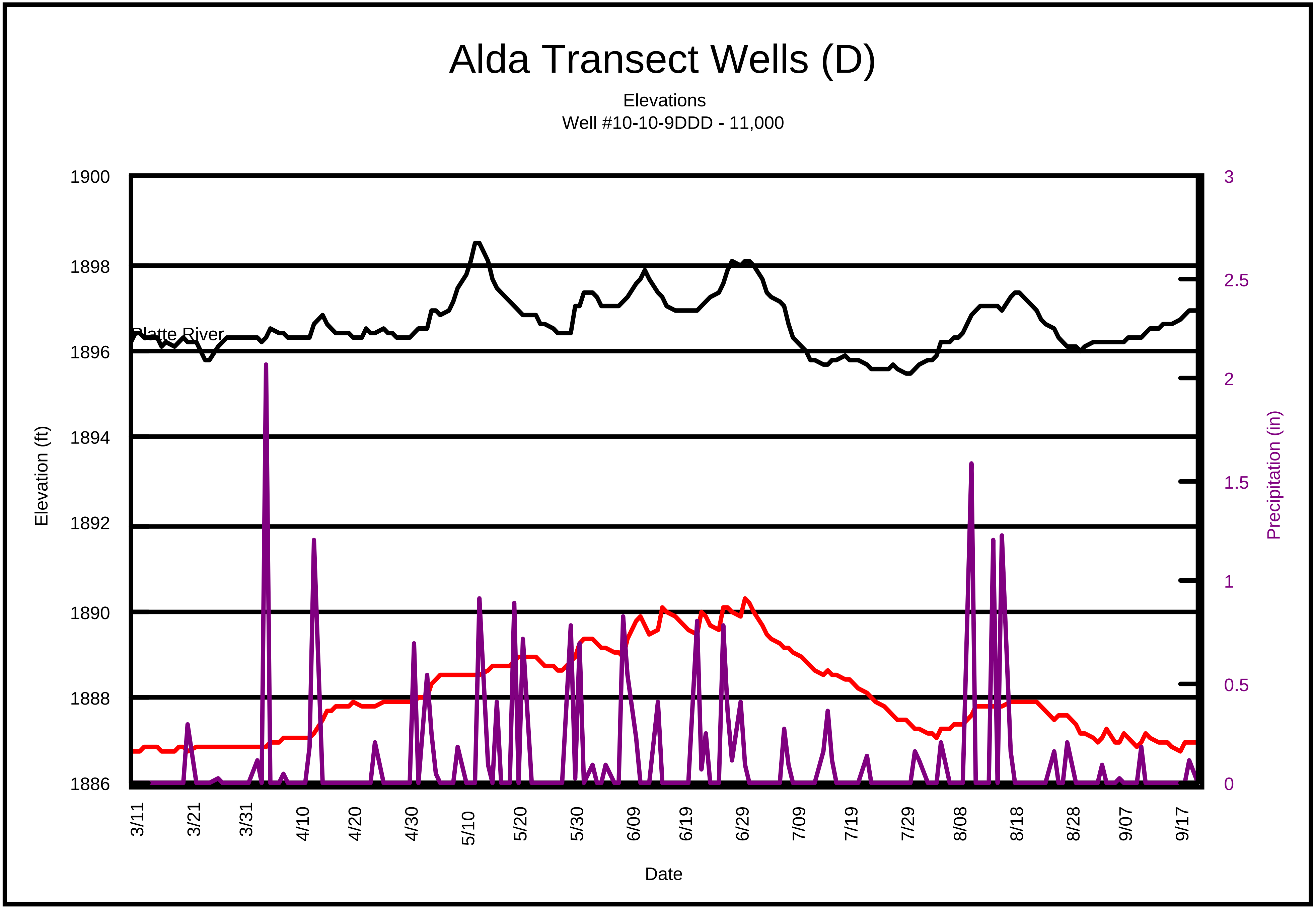
Alda Transect Wells (U)
Elevations
Well #10-10-28BBC - 3000
Elevation (ft)
Precipitation (in)
Platte River
1907
1906
1905
1904
1903
1902
1901
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date



Alda Transect Wells (U)
Elevations
Well #10-10-29DDA - 50
Elevation (ft)
1907
1906.5
1906
1905.5
1905
1904.5
1904
1903.5
1903
Platte River
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date



Alda Transect Wells (D)
Elevations
Elevation (ft)
1900
1898
1896
1894
1892
1890
1888
1886
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date
Well 10-10-9DDD - 11,000
10-10-22BBB - 6500
10-10-22CCB - 1200
Platte River



Alda Transect Wells (D)
Elevations
Well #10-10-9DDD - 11,000
Elevation (ft)
1900
1898
1896
1894
1892
1890
1888
1886
Platte River
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
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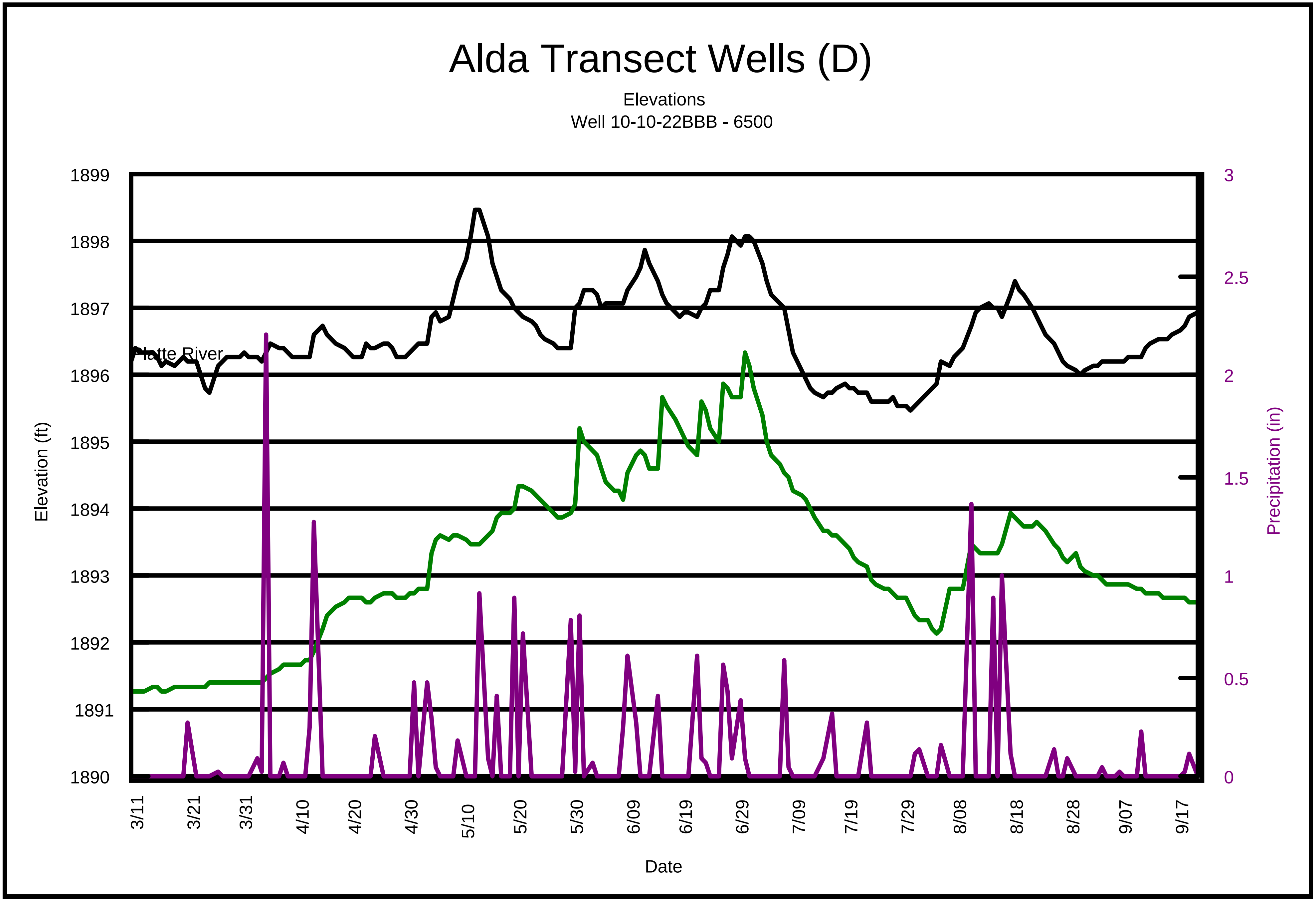
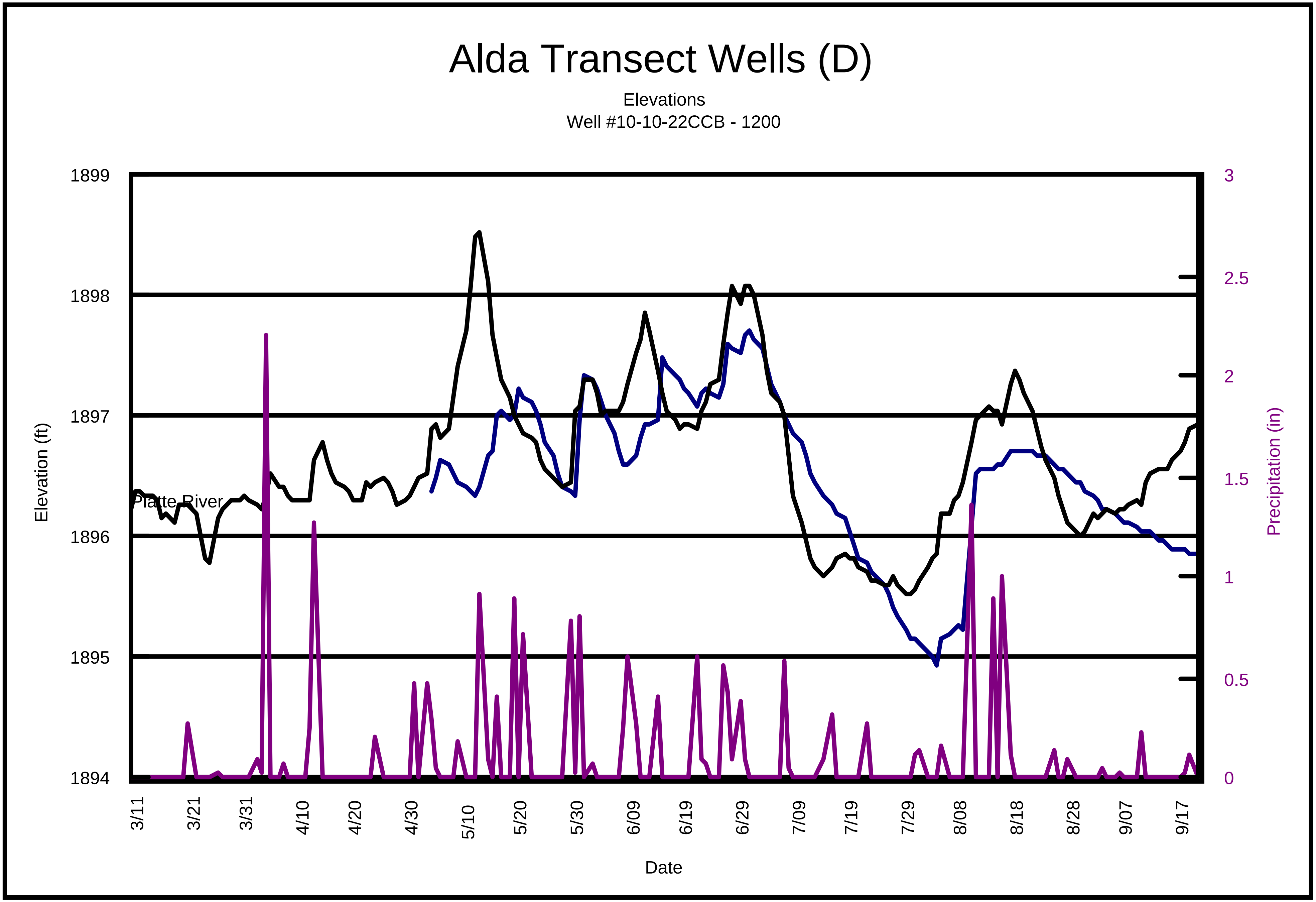
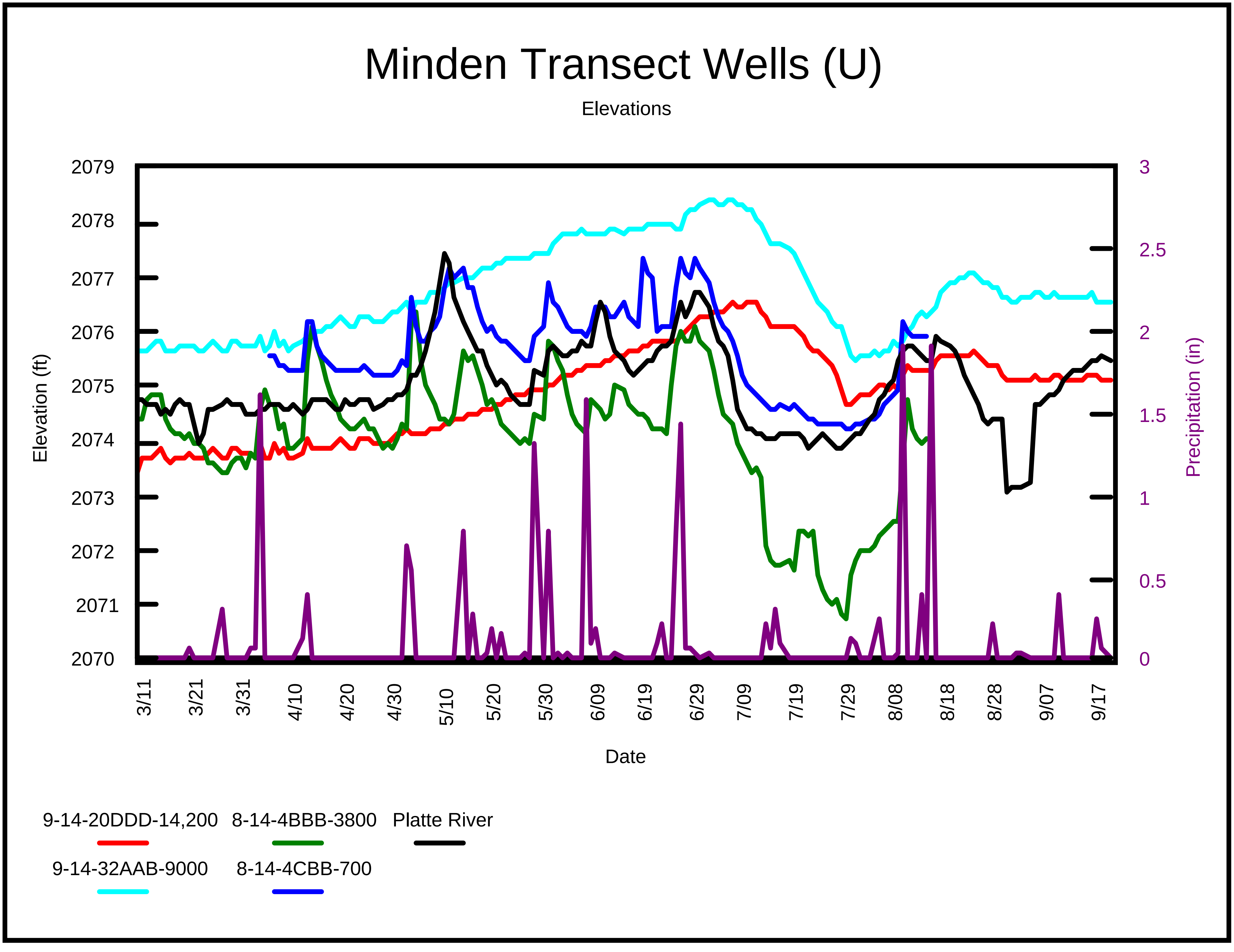
8/18
8/28
9/07
9/17
Date



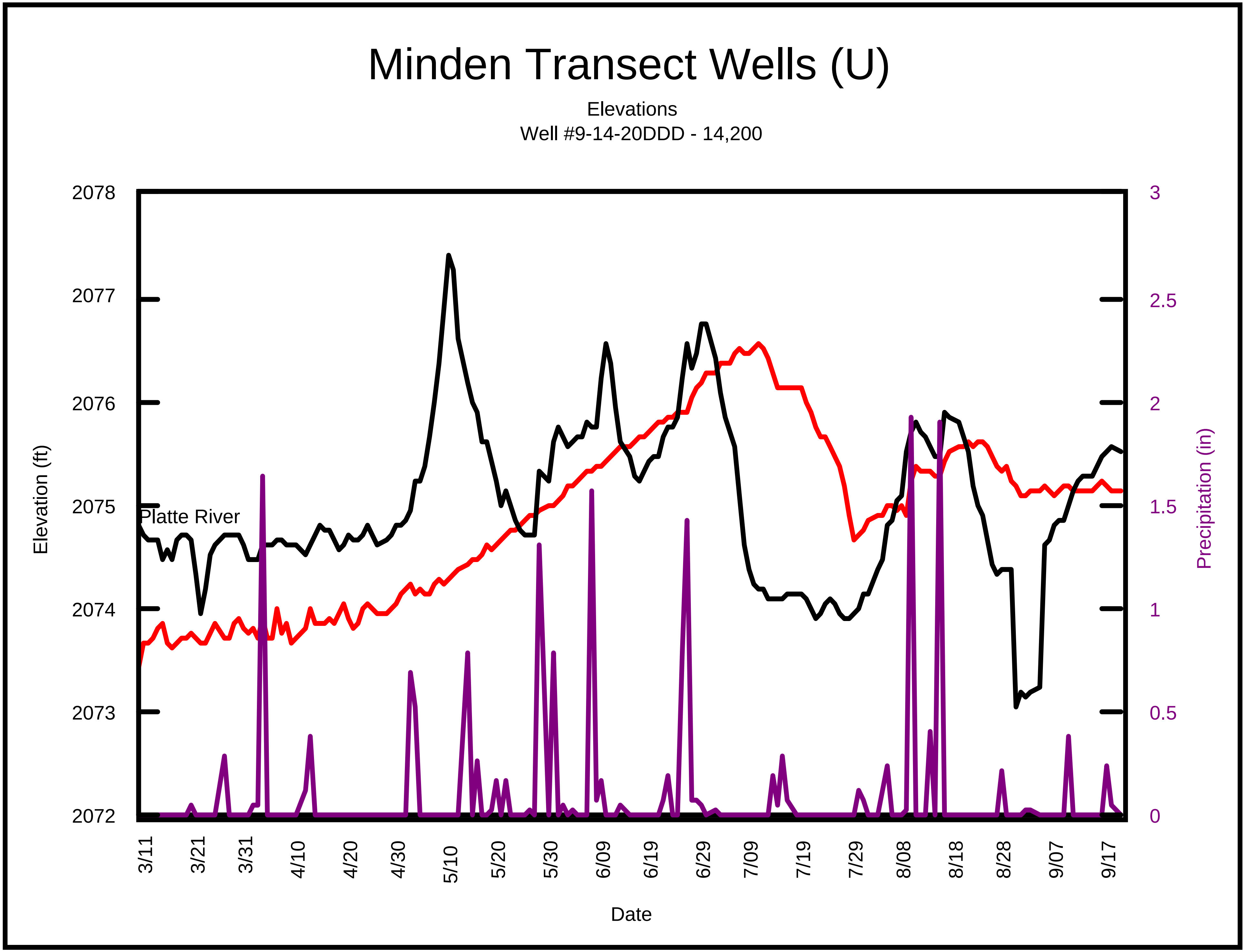
Alda Transect Wells (D)
Elevations
Well 10-10-22BBB - 6500
Platte River
Elevation (ft)
1899
1898
1897
1896
1895
1894
1893
1892
1891
1890
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date



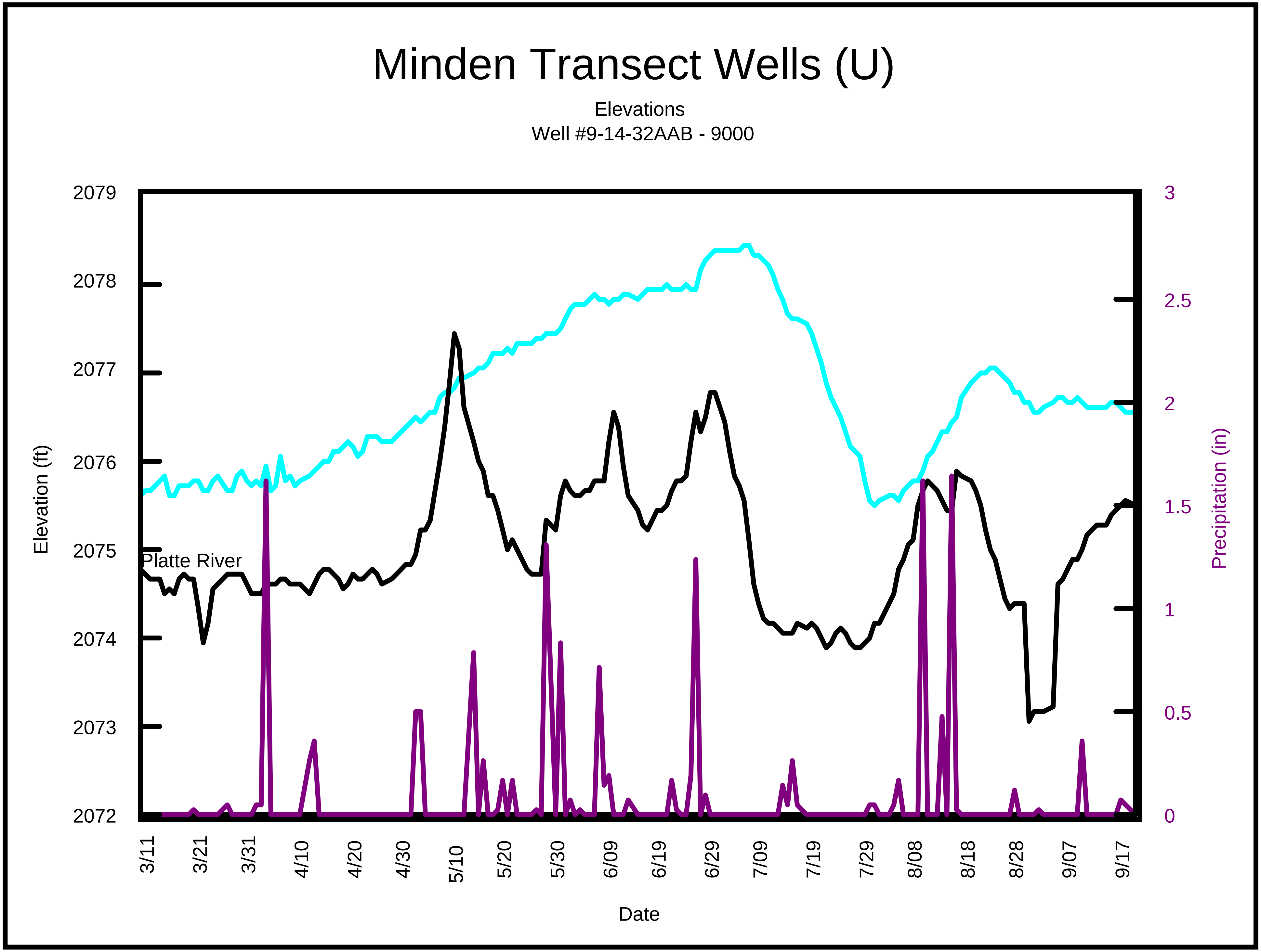
Alda Transect Wells (D)
Elevations
Well #10-10-22CCB - 1200
Elevation (ft)
1899
1898
1897
1896
1895
1894
Platte River
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date



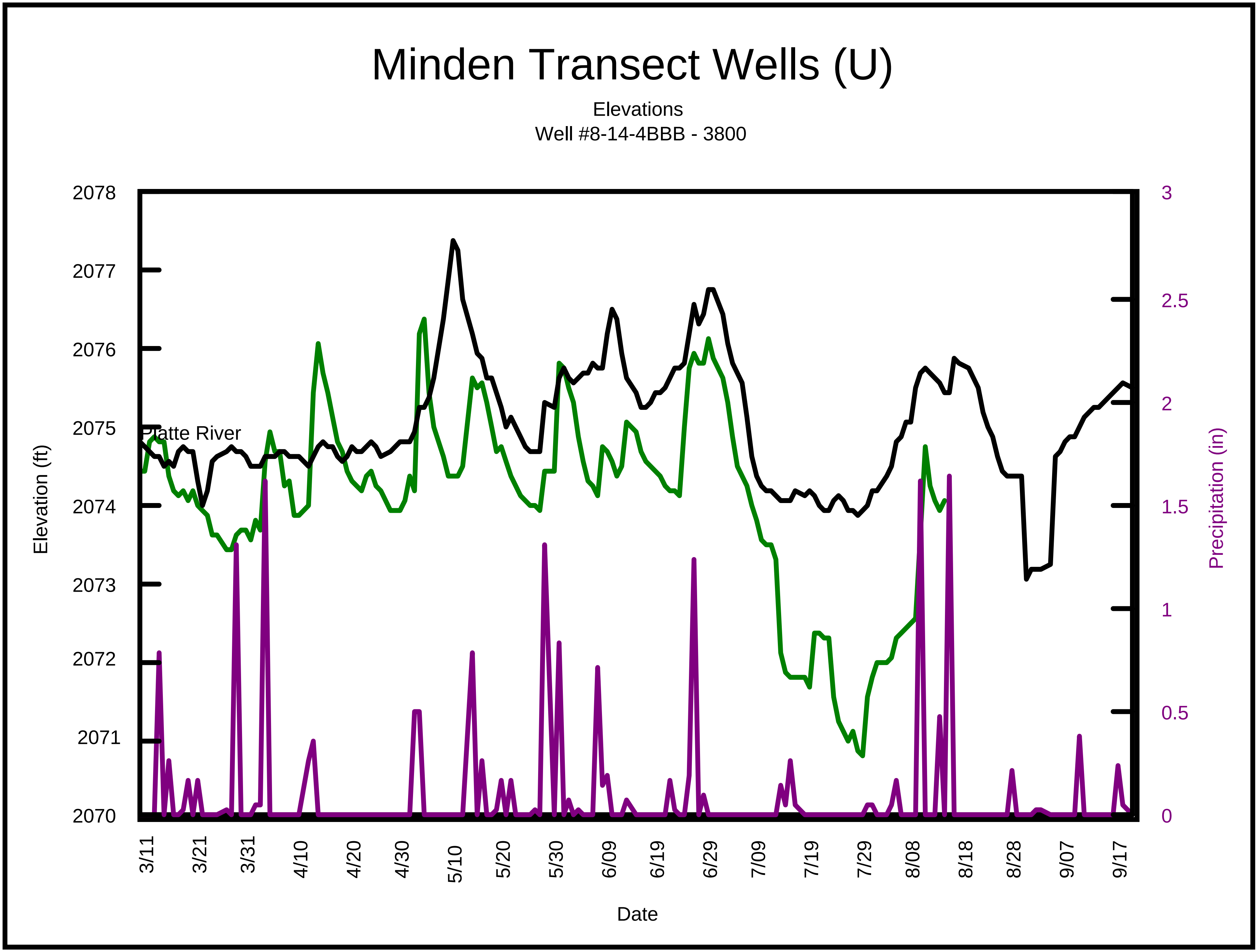
Minden Transect Wells (U)
Elevations
Elevation (ft)
2079
2078
2077
2076
2075
2074
2073
2072
2071
2070
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date
9-14-20DDD-14,200
8-14-4BBB-3800
Platte River
9-14-32AAB-9000
8-14-4CBB-700



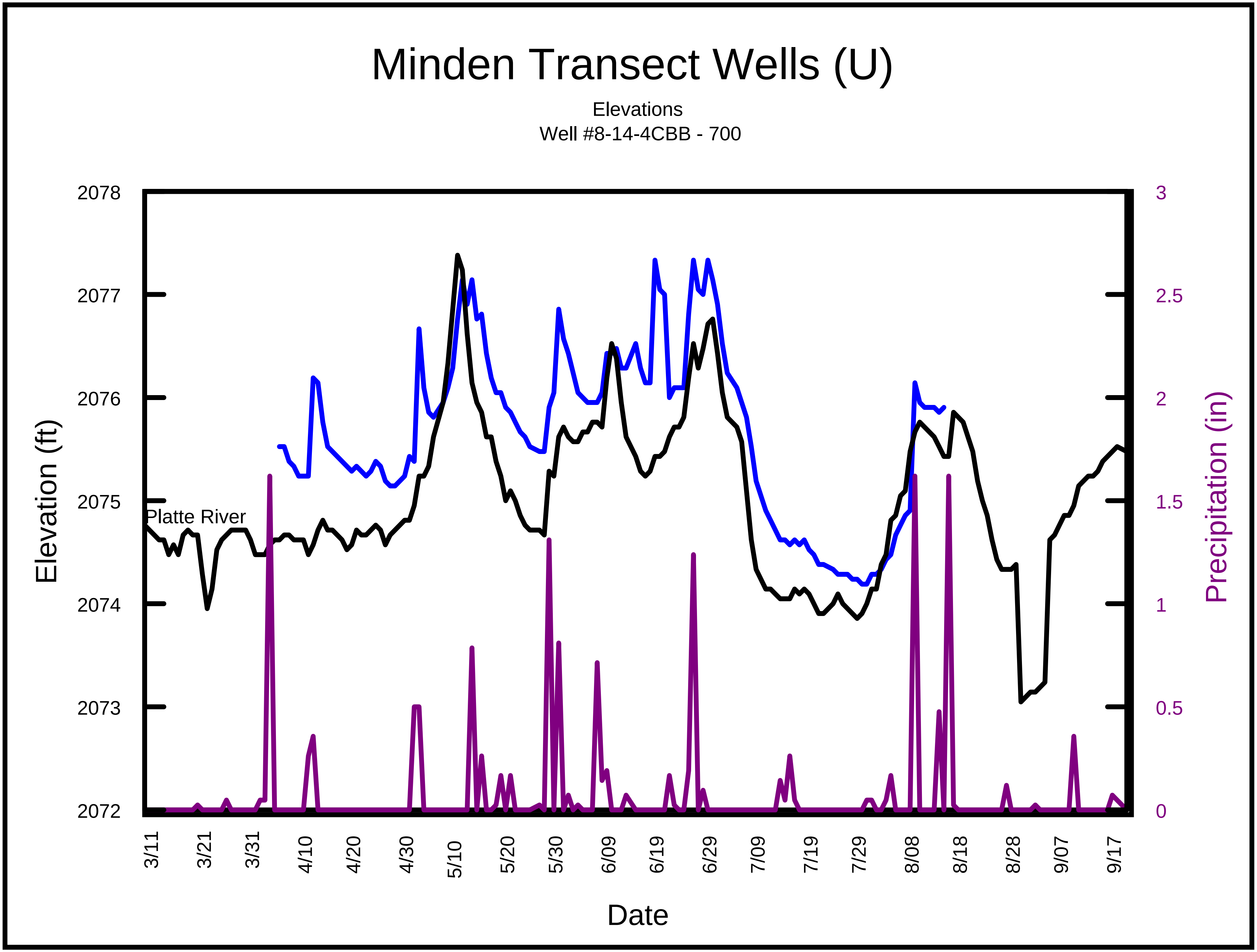
Minden Transect Wells (U)
Elevations
Well #9-14-20DDD - 14,200
Elevation (ft)
2078
2077
2076
2075
2074
2073
2072
Platte River
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date



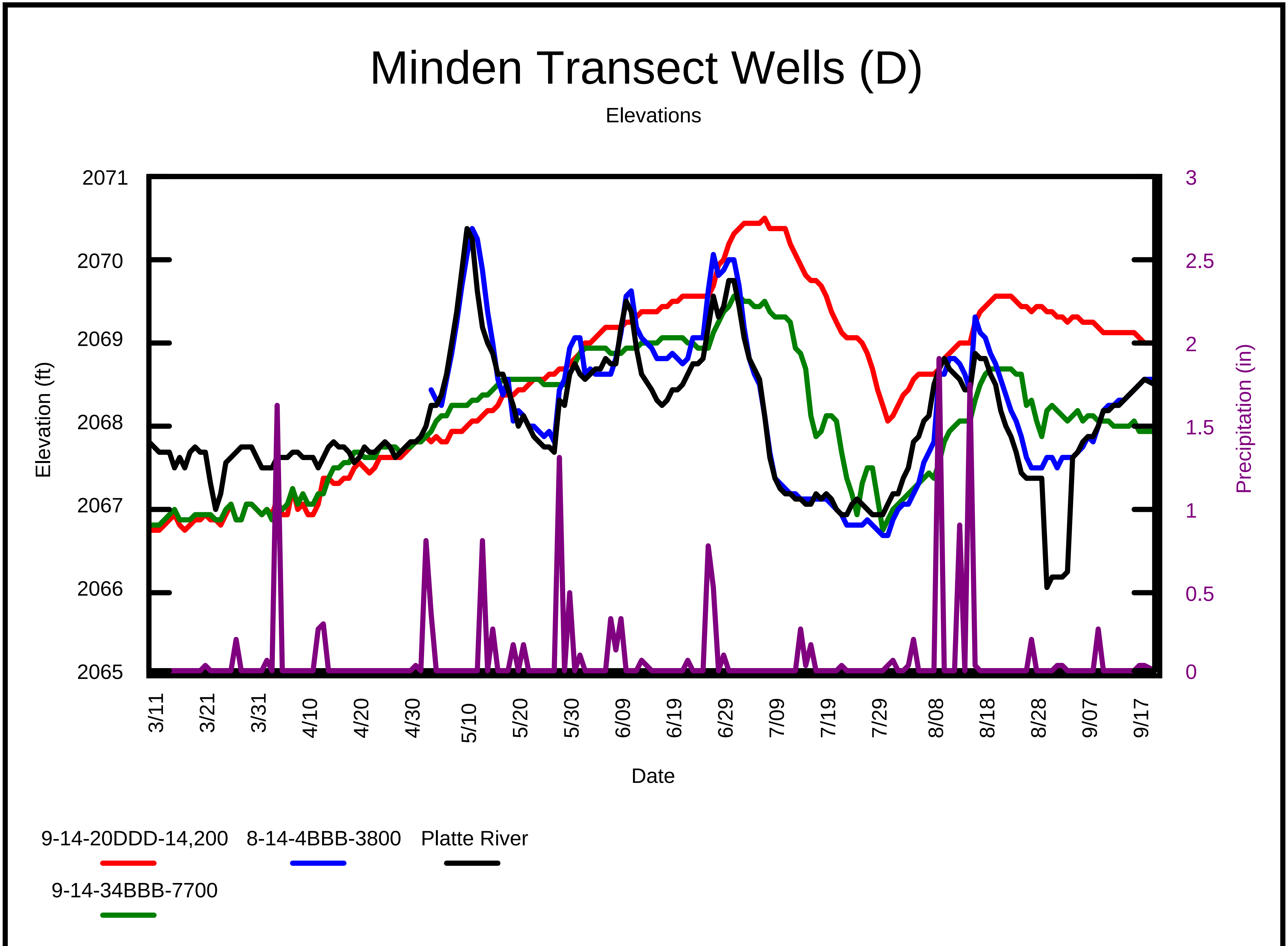
Minden Transect Wells (U)
Elevations
Well #9-14-32AAB - 9000
Elevation (ft)
Precipitation (in)
Platte River
2079
2078
2077
2076
2075
2074
2073
2072
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date



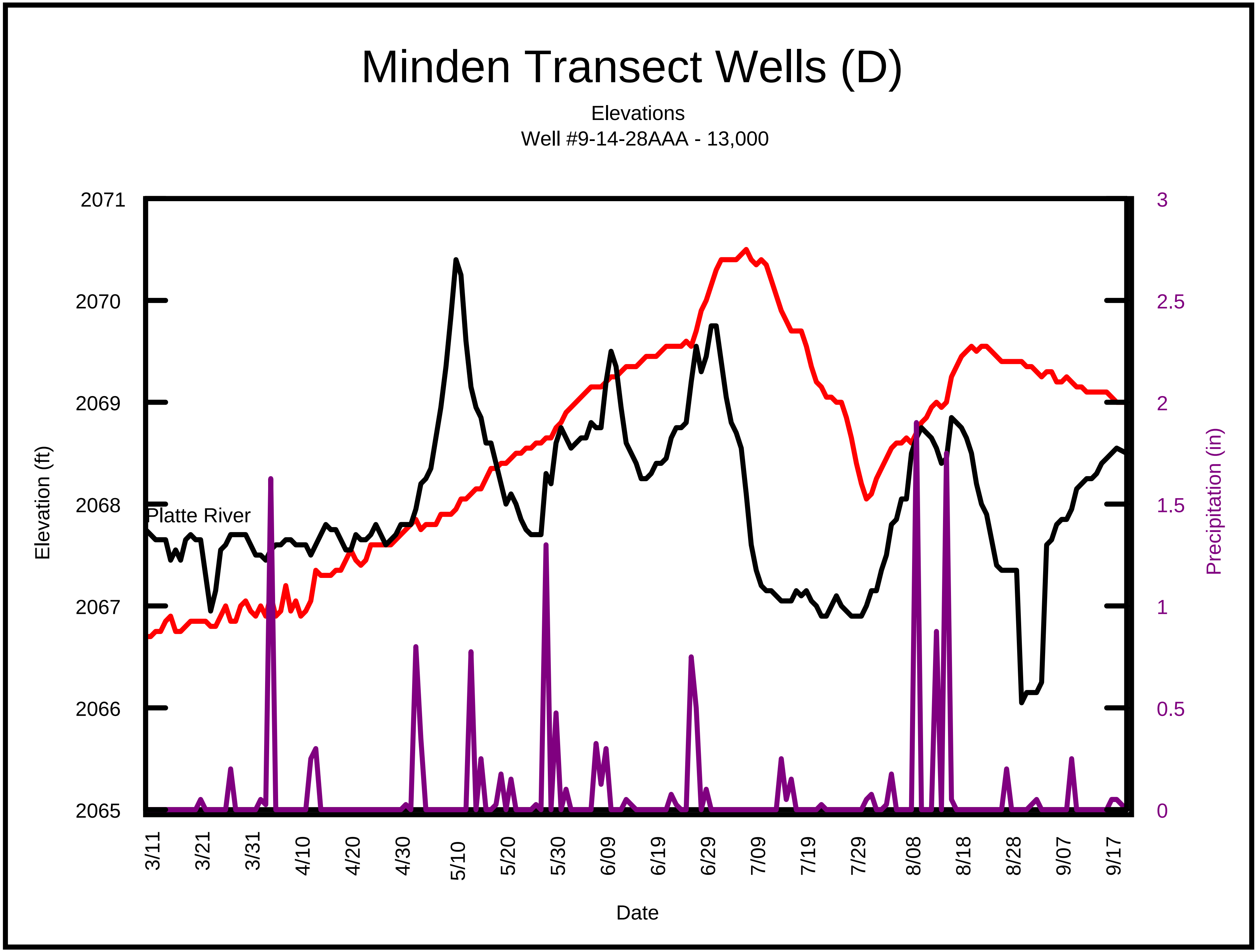
Minden Transect Wells (U)
Elevations
Well #8-14-4BBB - 3800
Elevation (ft)
2078
2077
2076
2075
2074
2073
2072
2071
2070
Platte River
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date



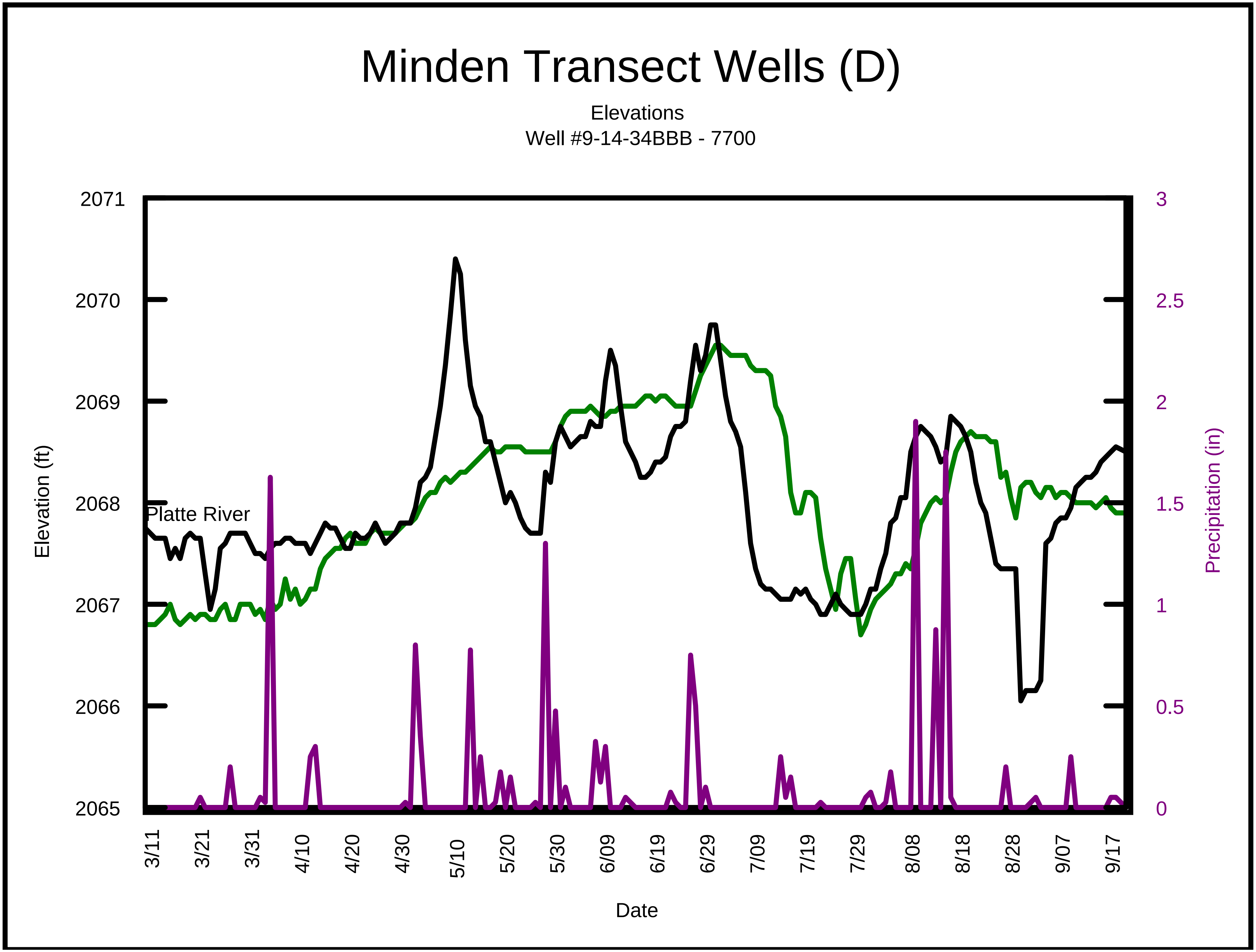
Minden Transect Wells (U)
Elevations
Well #8-14-4CBB - 700
Elevation (ft)
Precipitation (in)
Platte River
2078
2077
2076
2075
2074
2073
2072
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date



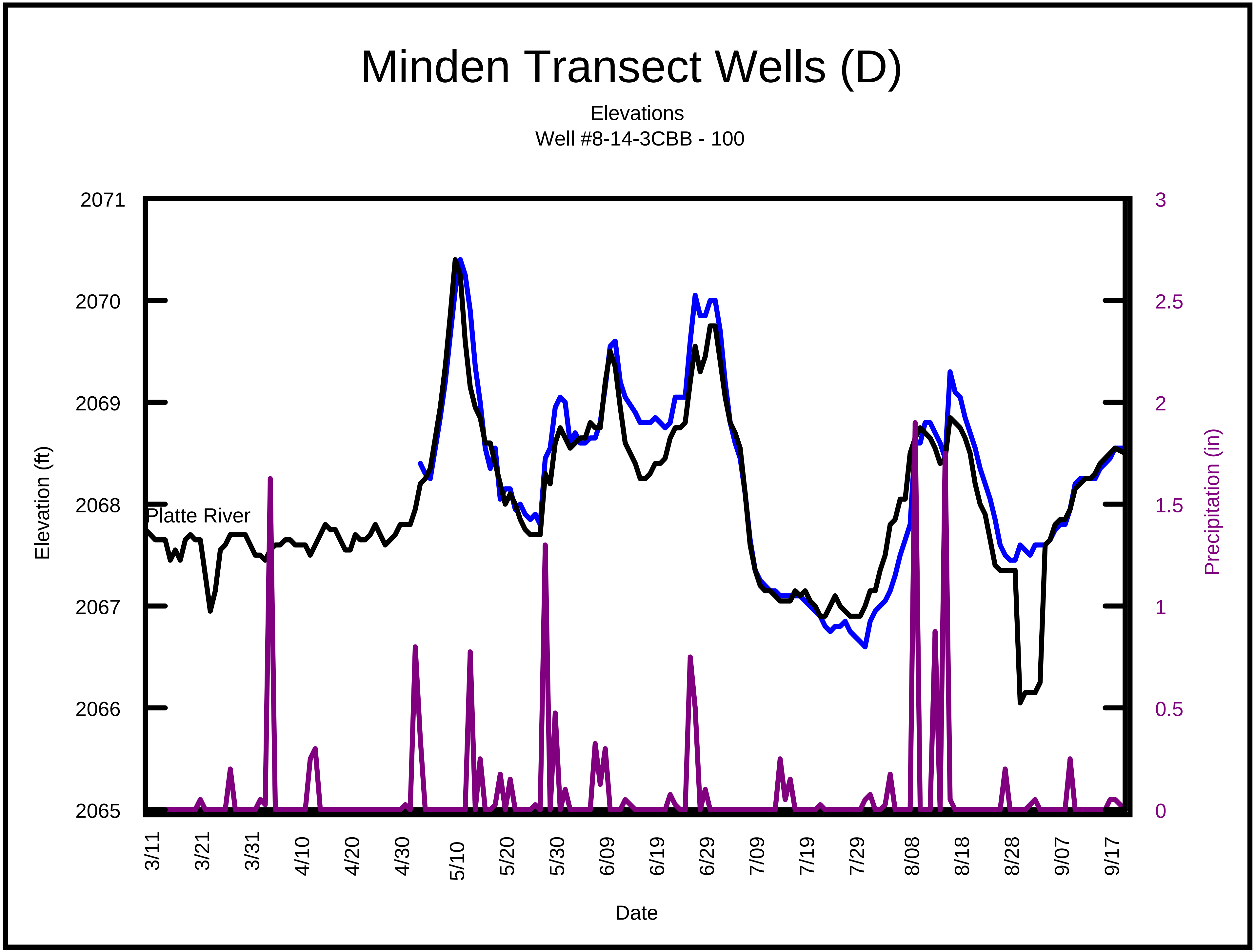
Minden Transect Wells (D)
Elevations
Elevation (ft)
2071
2070
2069
2068
2067
2066
2065
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date
9-14-20DDD-14,200
8-14-4BBB-3800
Platte River
9-14-34BBB-7700



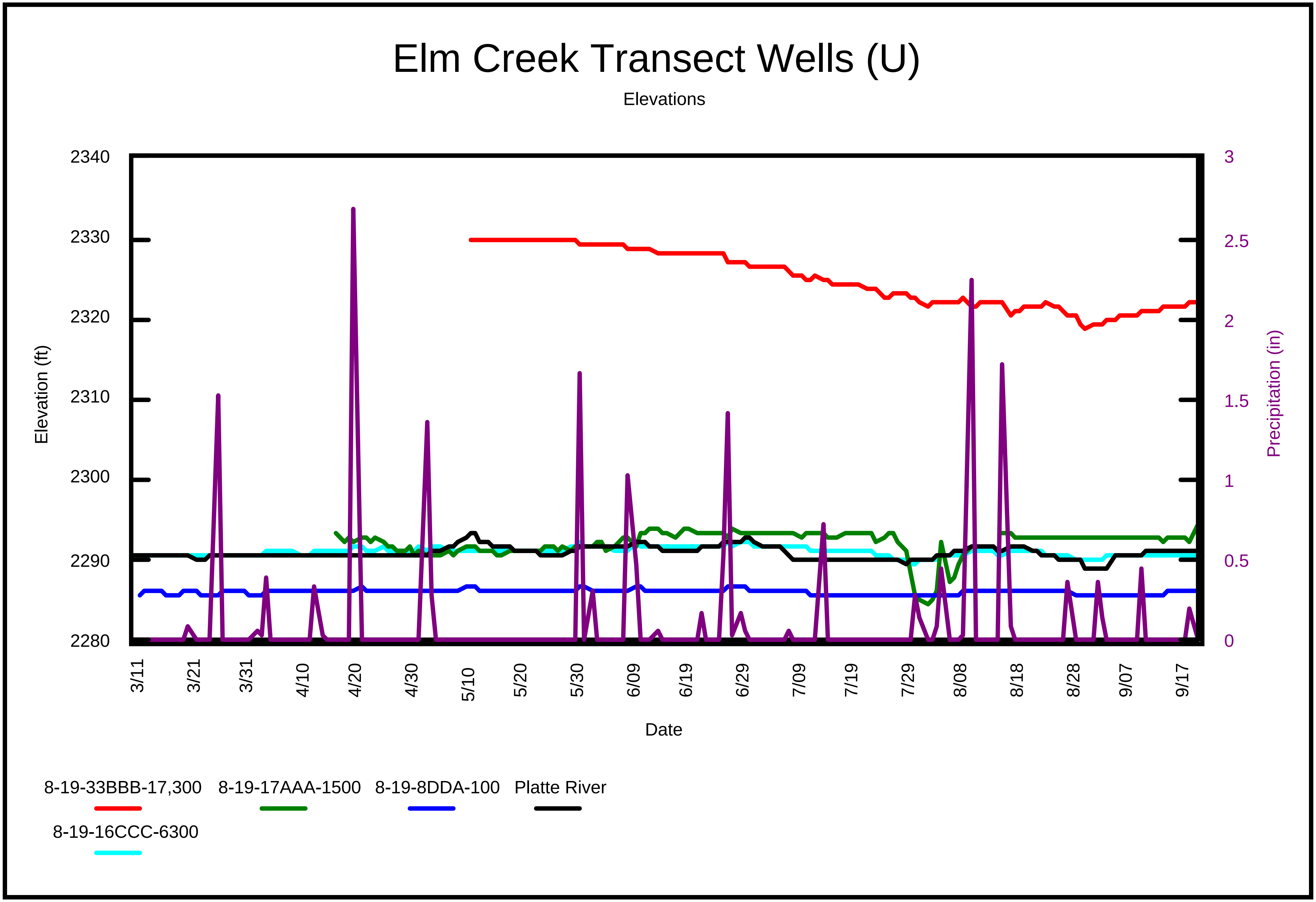
Minden Transect Wells (D)
Elevations
Well #9-14-28AAA - 13,000
2071
2070
2069
2068
2067
2066
2065
Elevation (ft)
Platte River
3
2.5
2
1.5
1
0.5
0
Precipitation (in)
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date



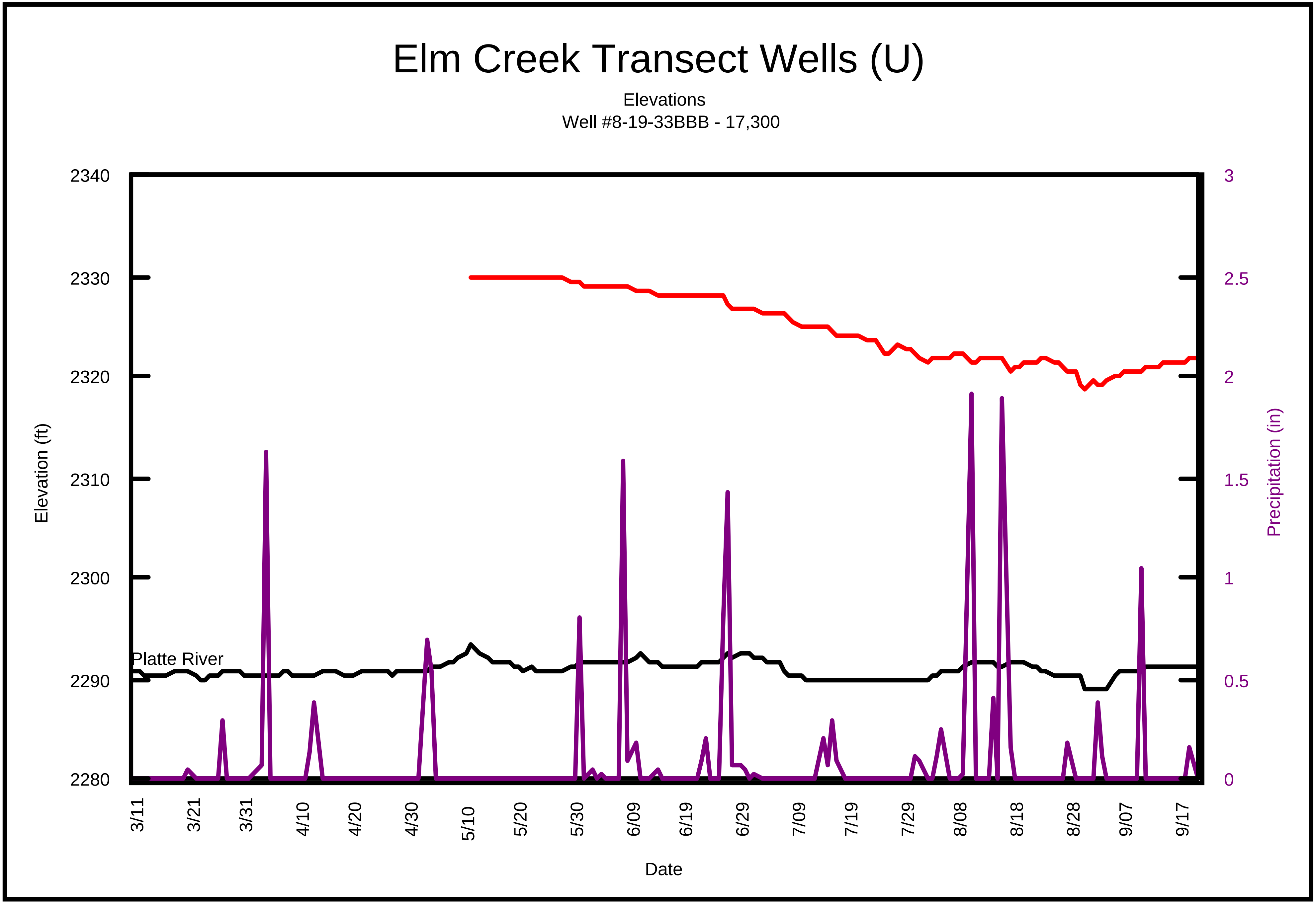
Minden Transect Wells (D)
Elevations
Well #9-14-34BBB - 7700
Elevation (ft)
2071
2070
2069
2068
2067
2066
2065
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
Platte River
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date



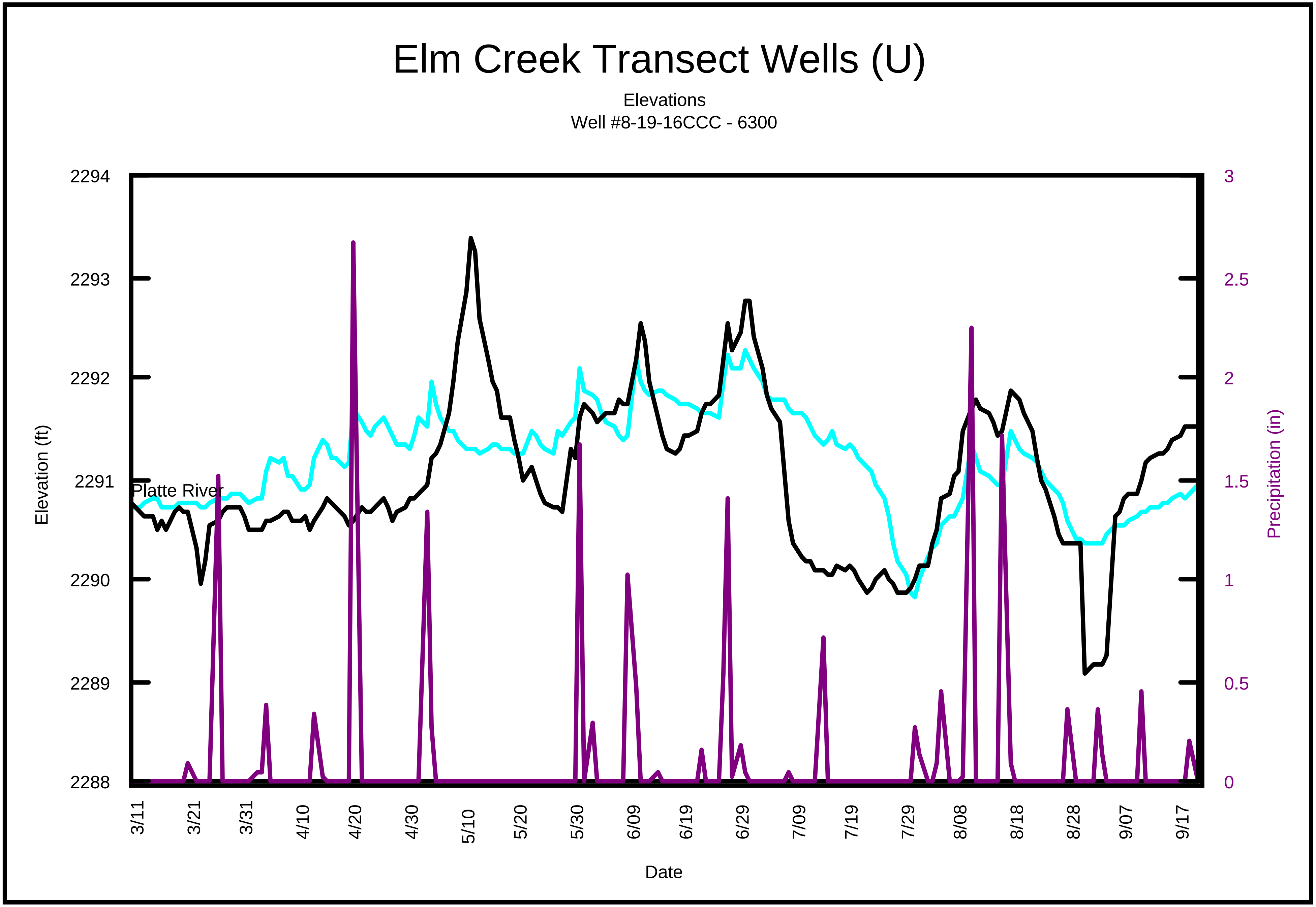
Minden Transect Wells (D)
Elevations
Well #8-14-3CBB - 100
Elevation (ft)
2071
2070
2069
2068
2067
2066
2065
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
Platte River
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date



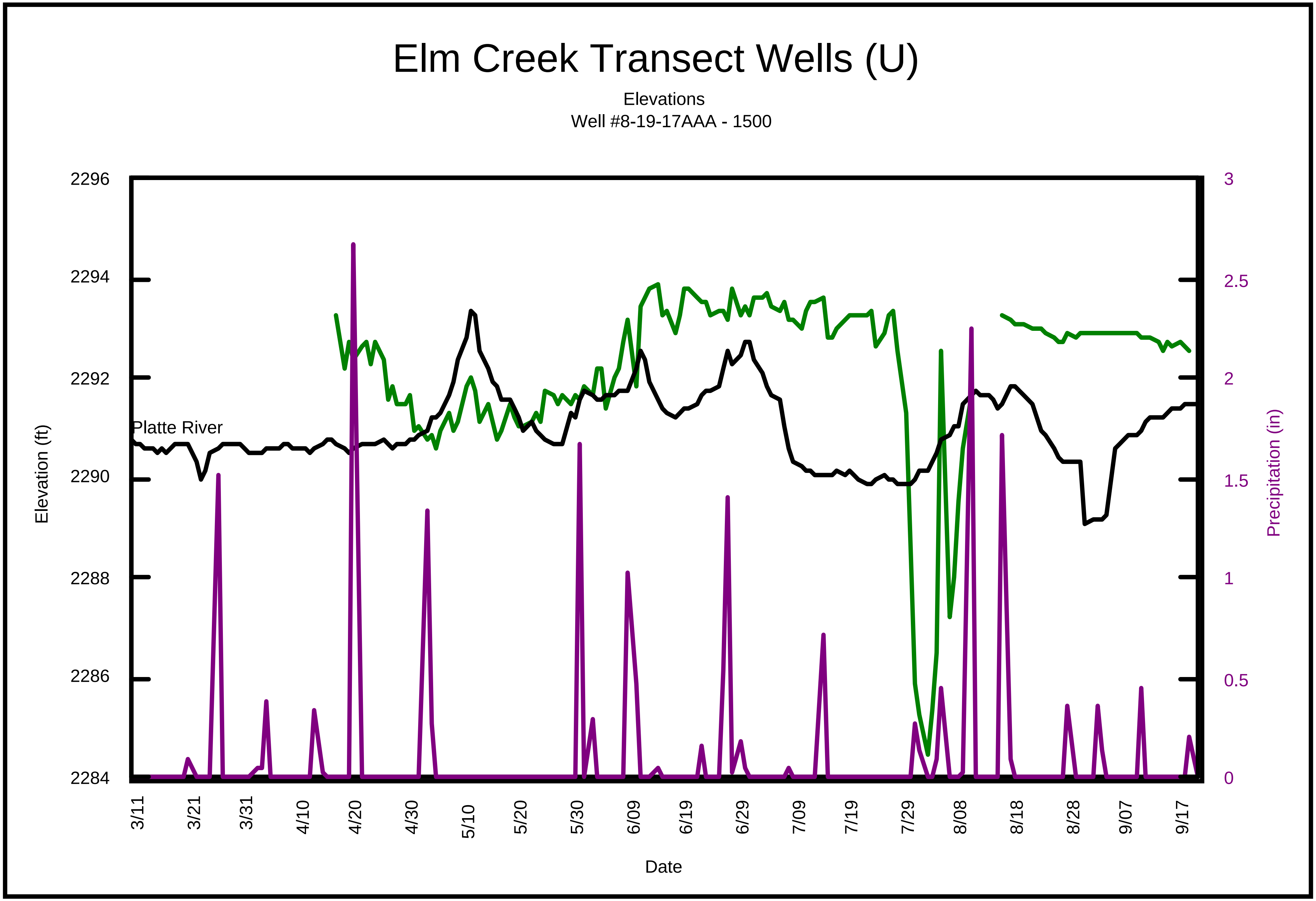
Elm Creek Transect Wells (U)
Elevations
Elevation (ft)
2340
2330
2320
2310
2300
2290
2280
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date
8-19-33BBB-17,300
8-19-17AAA-1500
8-19-8DDA-100
Platte River
8-19-16CCC-6300

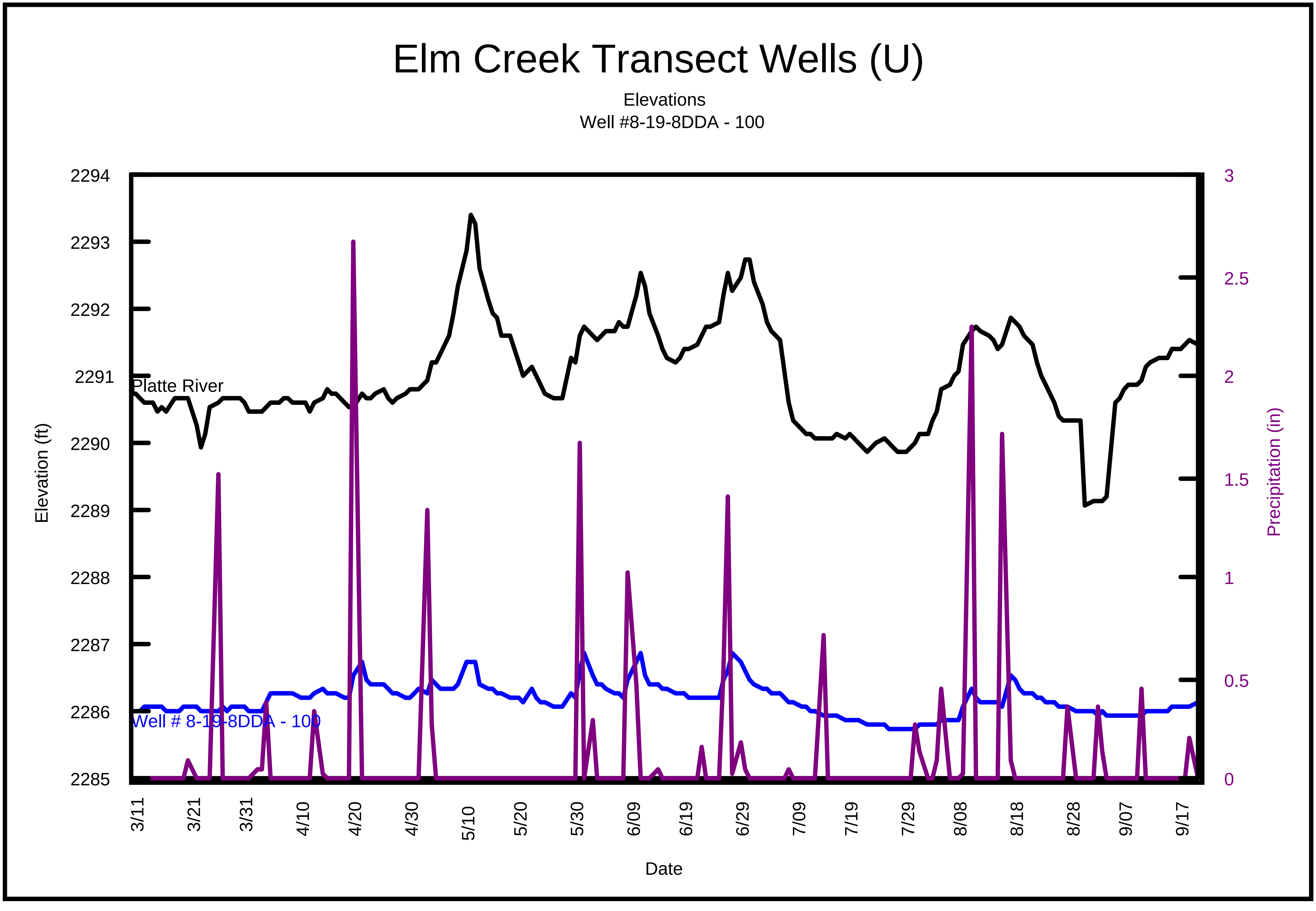


Elm Creek Transect Wells (U)
Elevations
Well #8-19-33BBB - 17,300
Elevation (ft)
2340
2330
2320
2310
2300
2290
2280
Platte River
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date

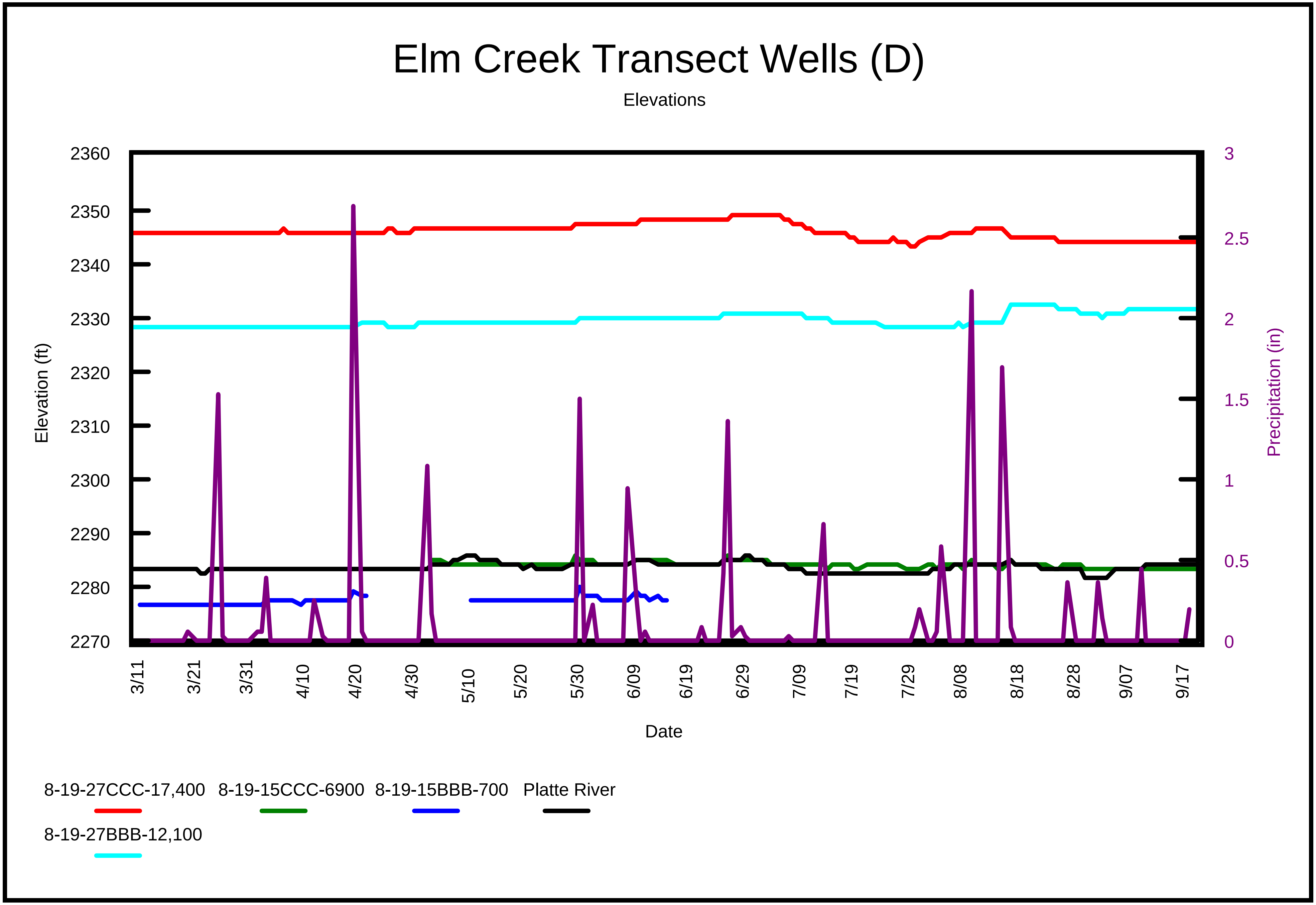


Elm Creek Transect Wells (U)
Elevations
Well #8-19-16CCC - 6300
Elevation (ft)
2294
2293
2292
2291
2290
2289
2288
Platte River
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date

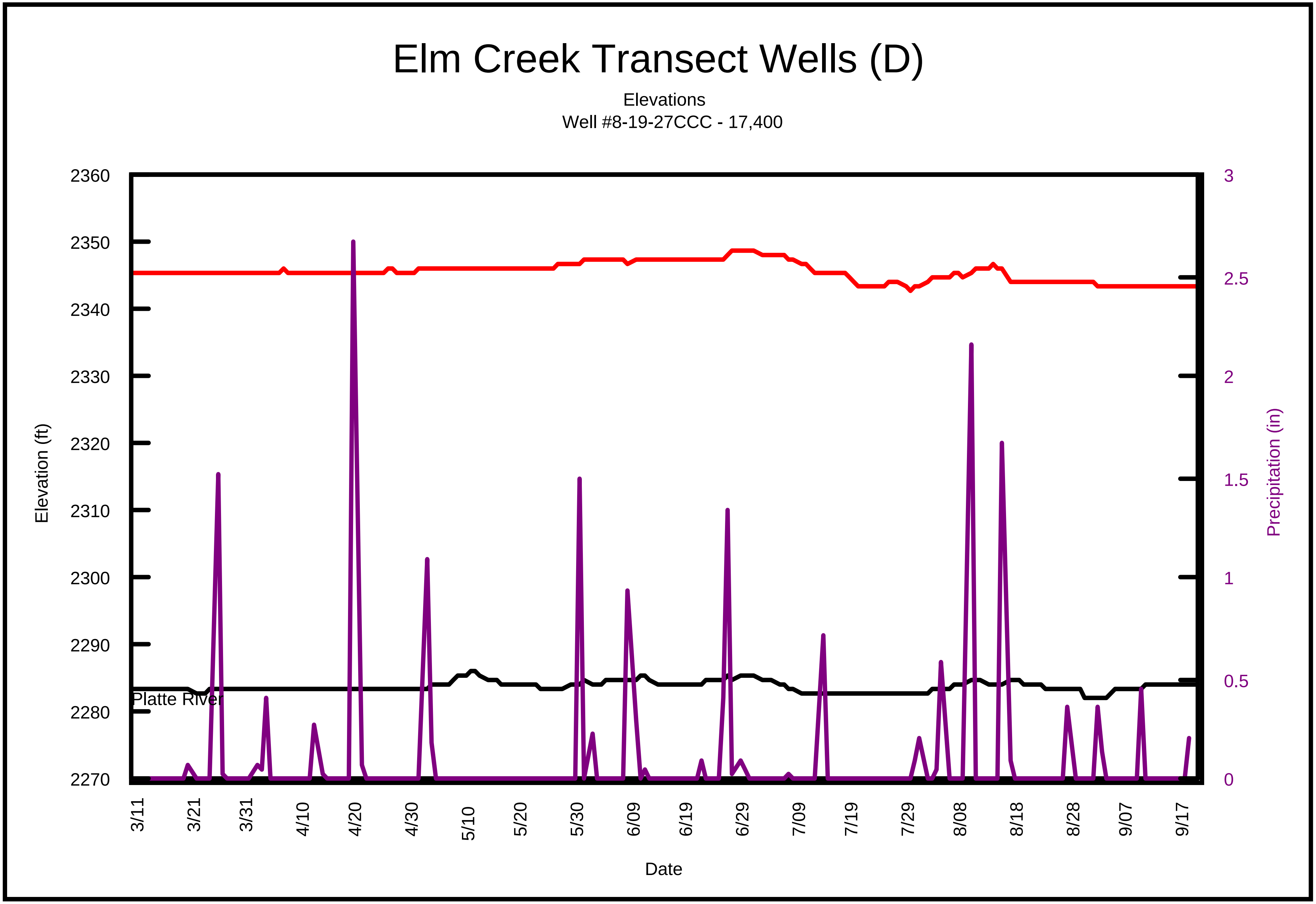

Elm Creek Transect Wells (U)
Elevations
Well #8-19-17AAA - 1500
Elevation (ft)
2296
2294
2292
2290
2288
2286
2284
Platte River
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date



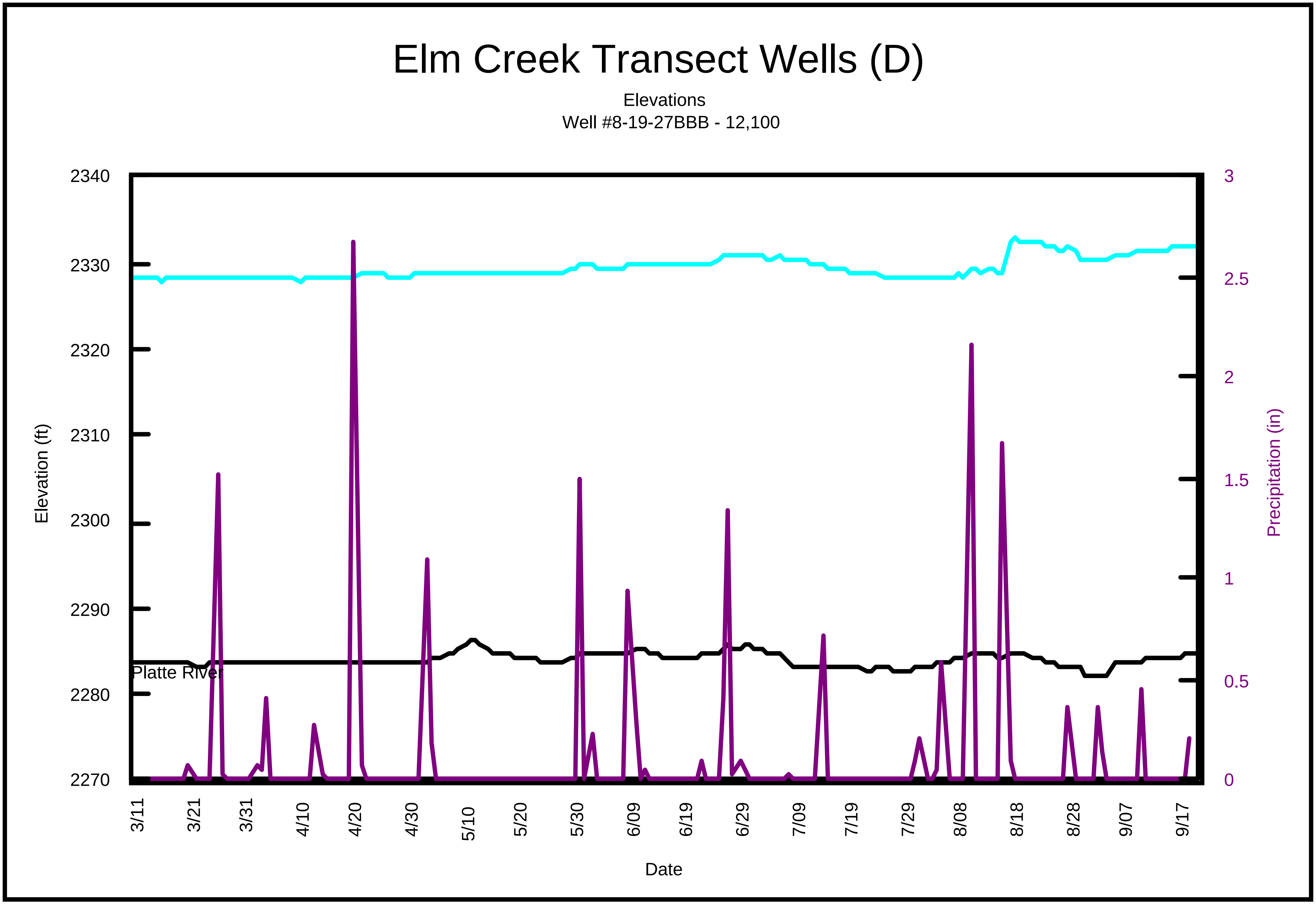
Elm Creek Transect Wells (U)
Elevations
Well #8-19-8DDA - 100
Elevation (ft)
2294
2293
2292
2291
2290
2289
2288
2287
2286
2285
Platte River
Well # 8-19-8DDA - 100
3
2.5
2
1.5
1
0.5
0
Precipitation (in)
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date

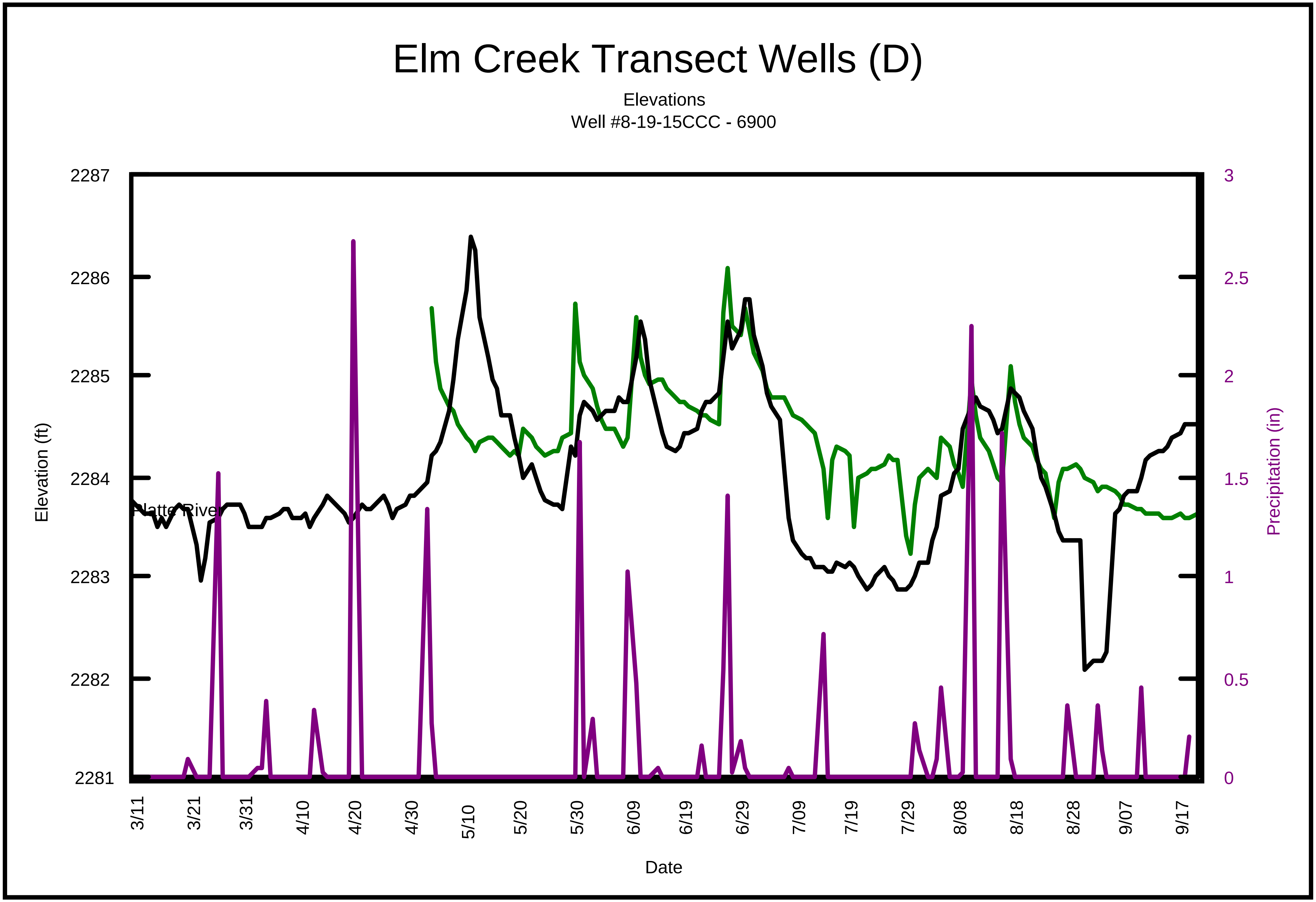


Elm Creek Transect Wells (D)
Elevations
Elevation (ft)
2360
2350
2340
2330
2320
2310
2300
2290
2280
2270
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date
8-19-27CCC-17,400
8-19-15CCC-6900
8-19-15BBB-700
Platte River
8-19-27BBB-12,100

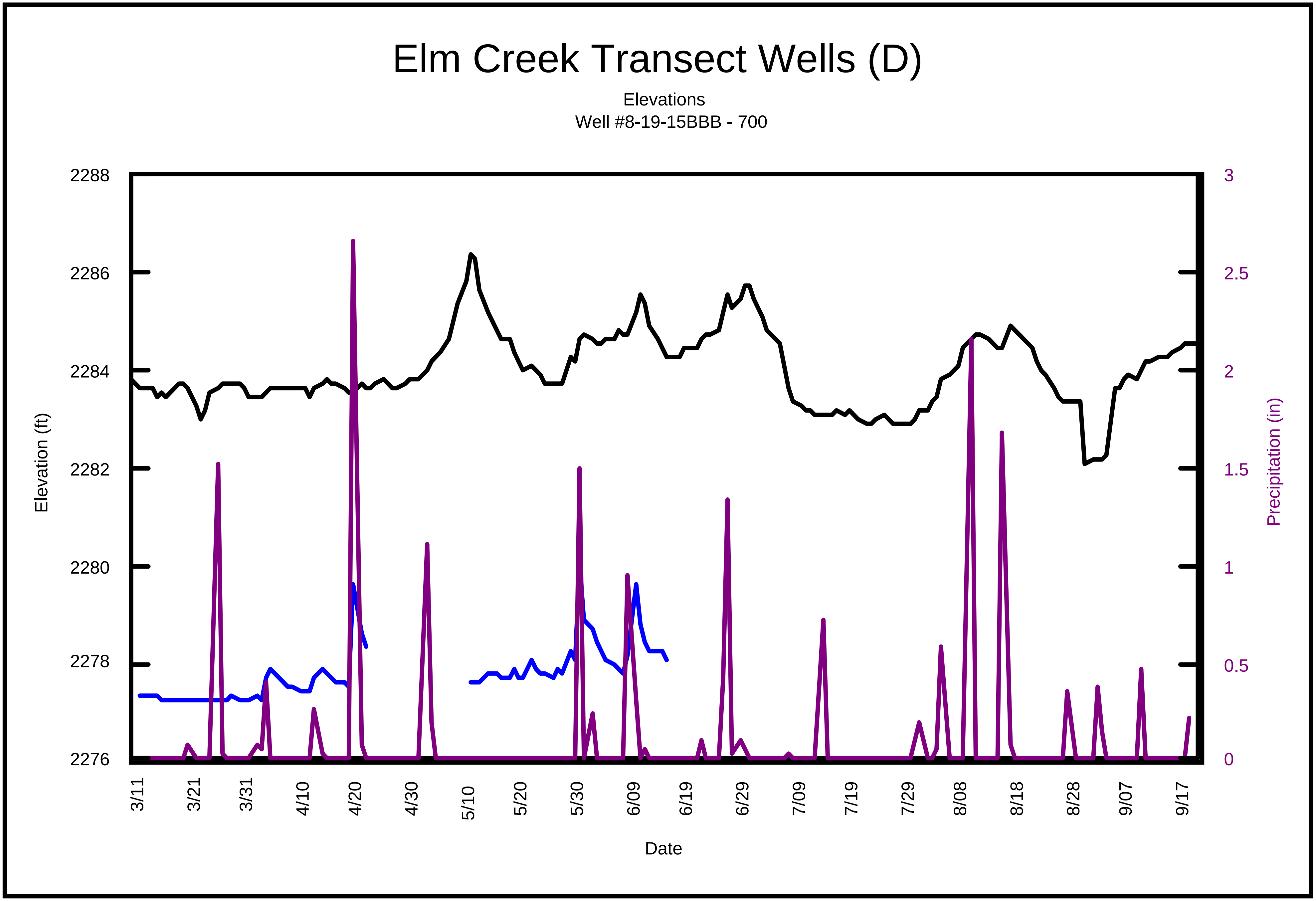


Elm Creek Transect Wells (D)
Elevations
Well #8-19-27CCC - 17,400
Elevation (ft)
2360
2350
2340
2330
2320
2310
2300
2290
2280
2270
Platte River
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date

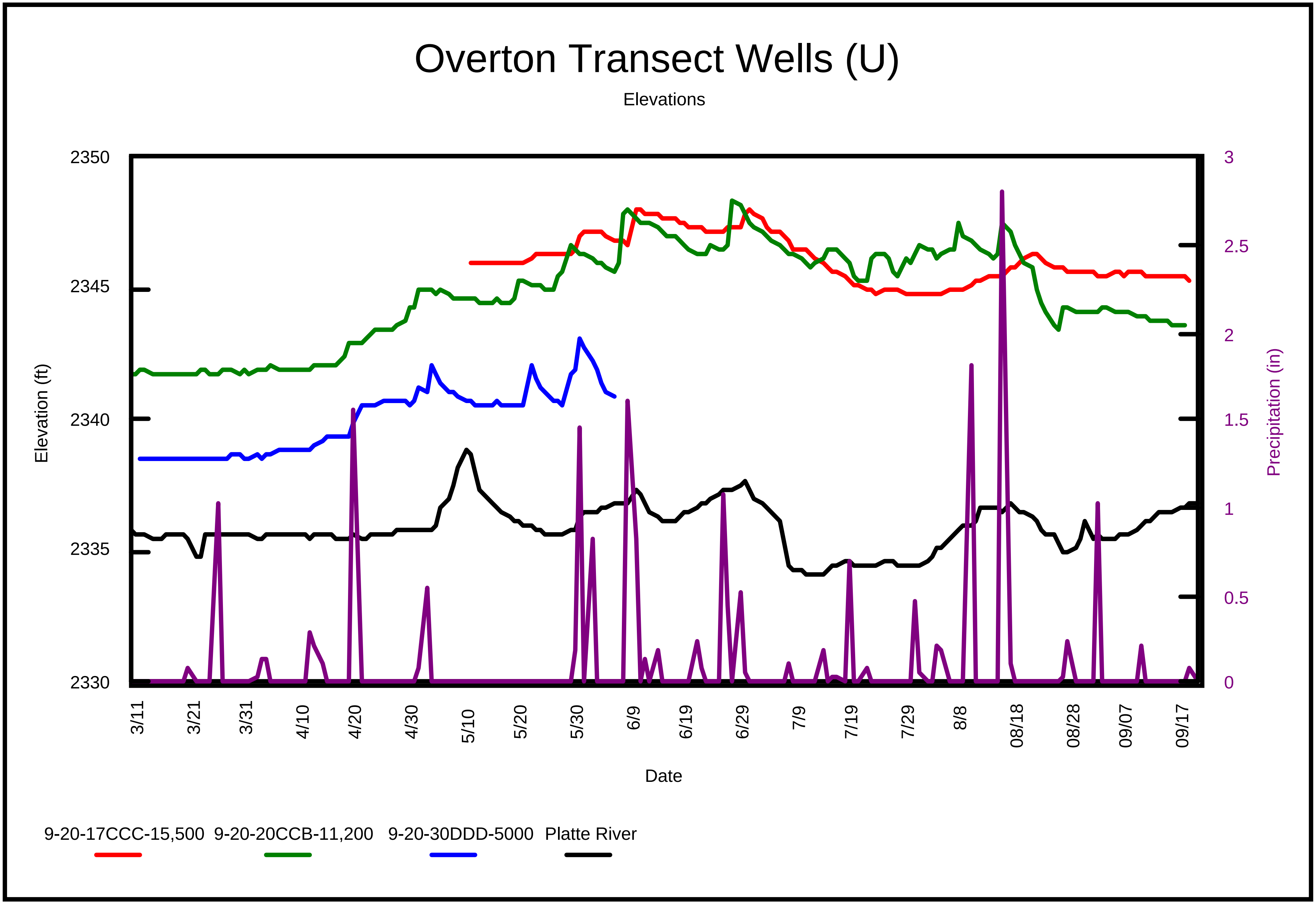

Elm Creek Transect Wells (D)
Elevations
Well #8-19-27BBB - 12,100
2340
2330
2320
2310
2300
2290
2280
2270
Elevation (ft)
3
2.5
2
1.5
1
0.5
0
Precipitation (in)
Platte River
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date

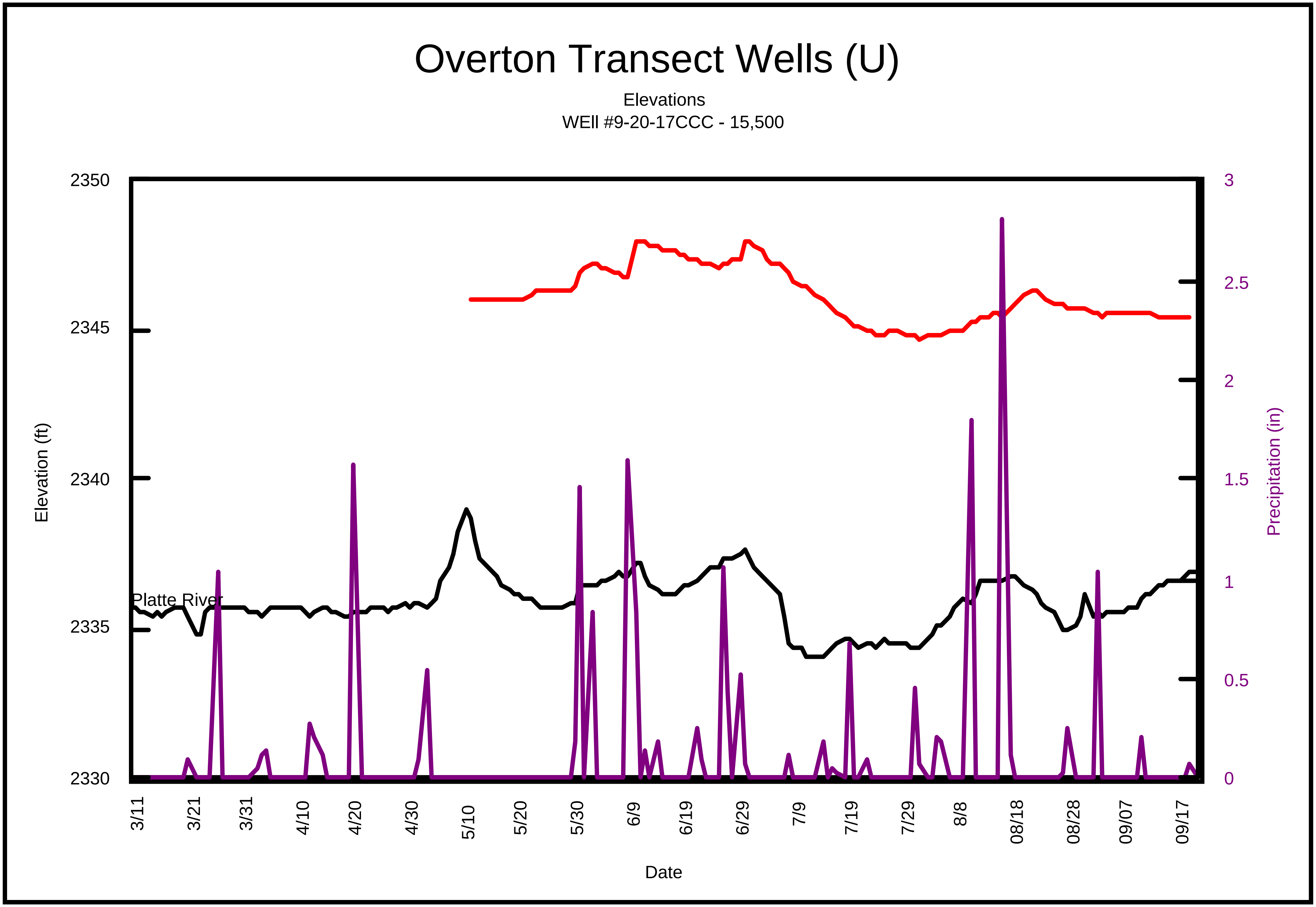


Elm Creek Transect Wells (D)
Elevations
Well #8-19-15CCC - 6900
Elevation (ft)
2287
2286
2285
2284
2283
2282
2281
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
Platte River
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date

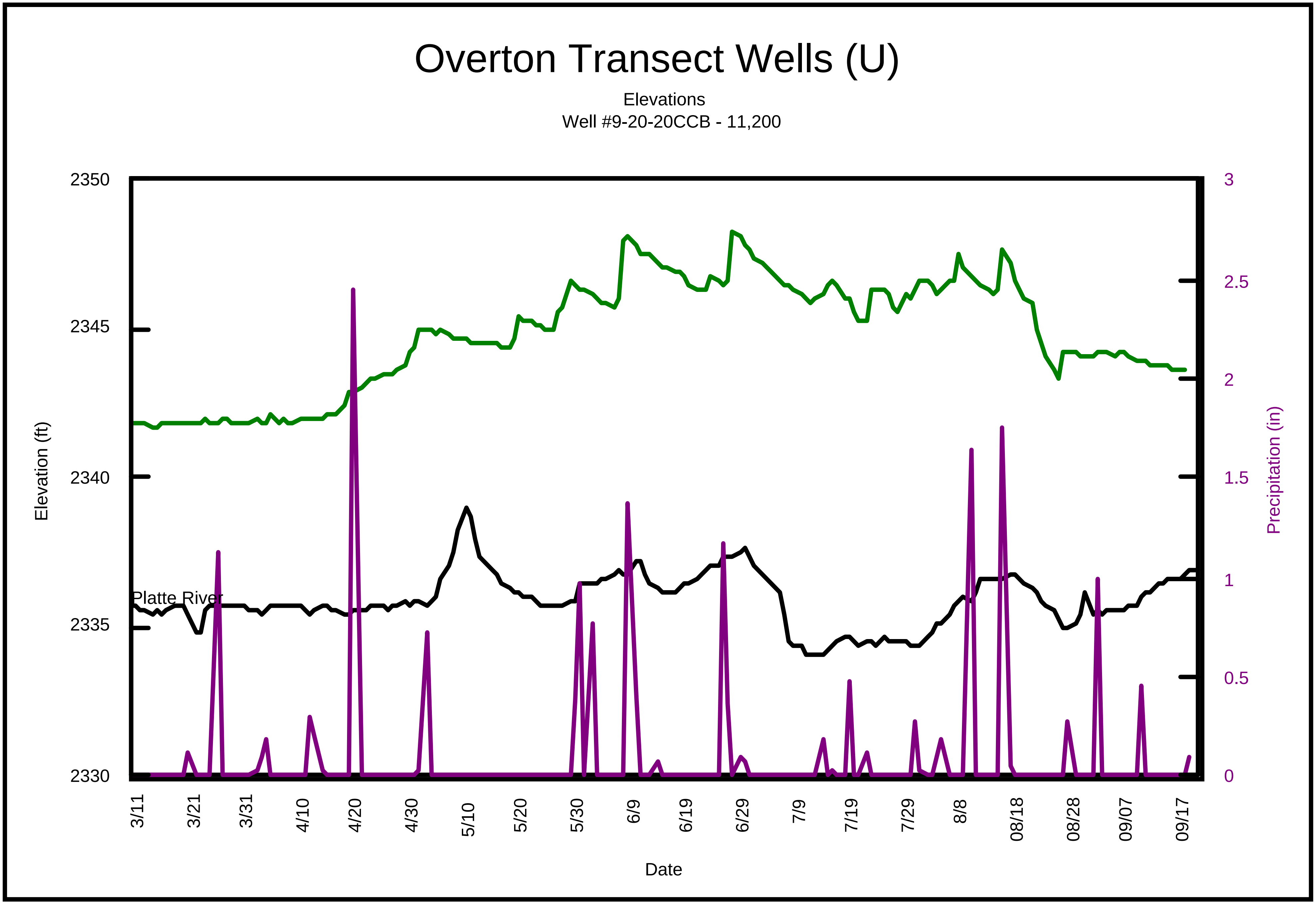


Elm Creek Transect Wells (D)
Elevations
Well #8-19-15BBB - 700
Elevation (ft)
2288
2286
2284
2282
2280
2278
2276
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/09
6/19
6/29
7/09
7/19
7/29
8/08
8/18
8/28
9/07
9/17
Date

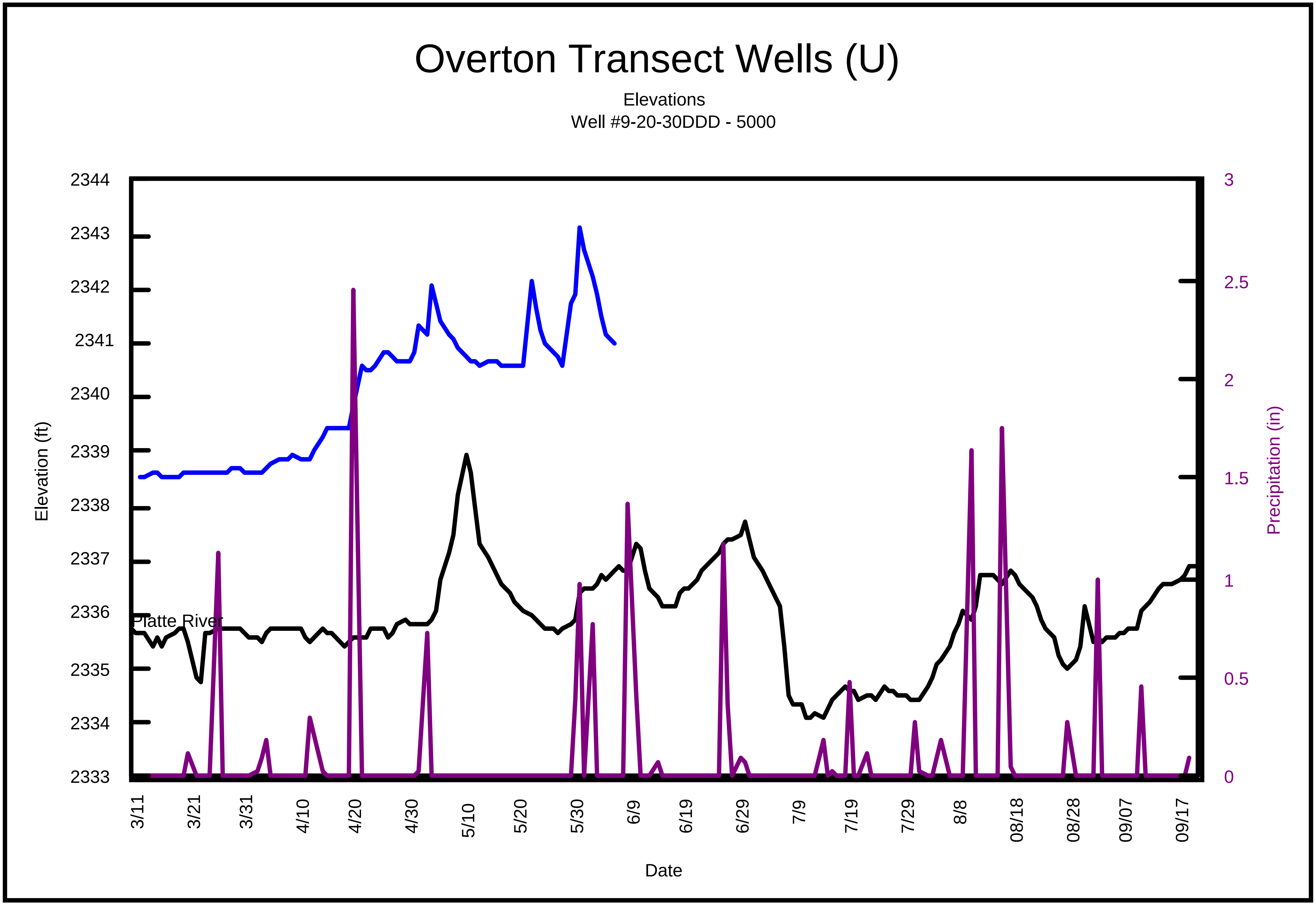

Overton Transect Wells (U)
Elevations
2350
2345
2340
2335
2330
Elevation (ft)
3
2.5
2
1.5
1
0.5
0
Precipitation (in)
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/9
6/19
6/29
7/9
7/19
7/29
8/8
08/18
08/28
09/07
09/17
Date
9-20-17CCC-15,500
9-20-20CCB-11,200
9-20-30DDD-5000
Platte River



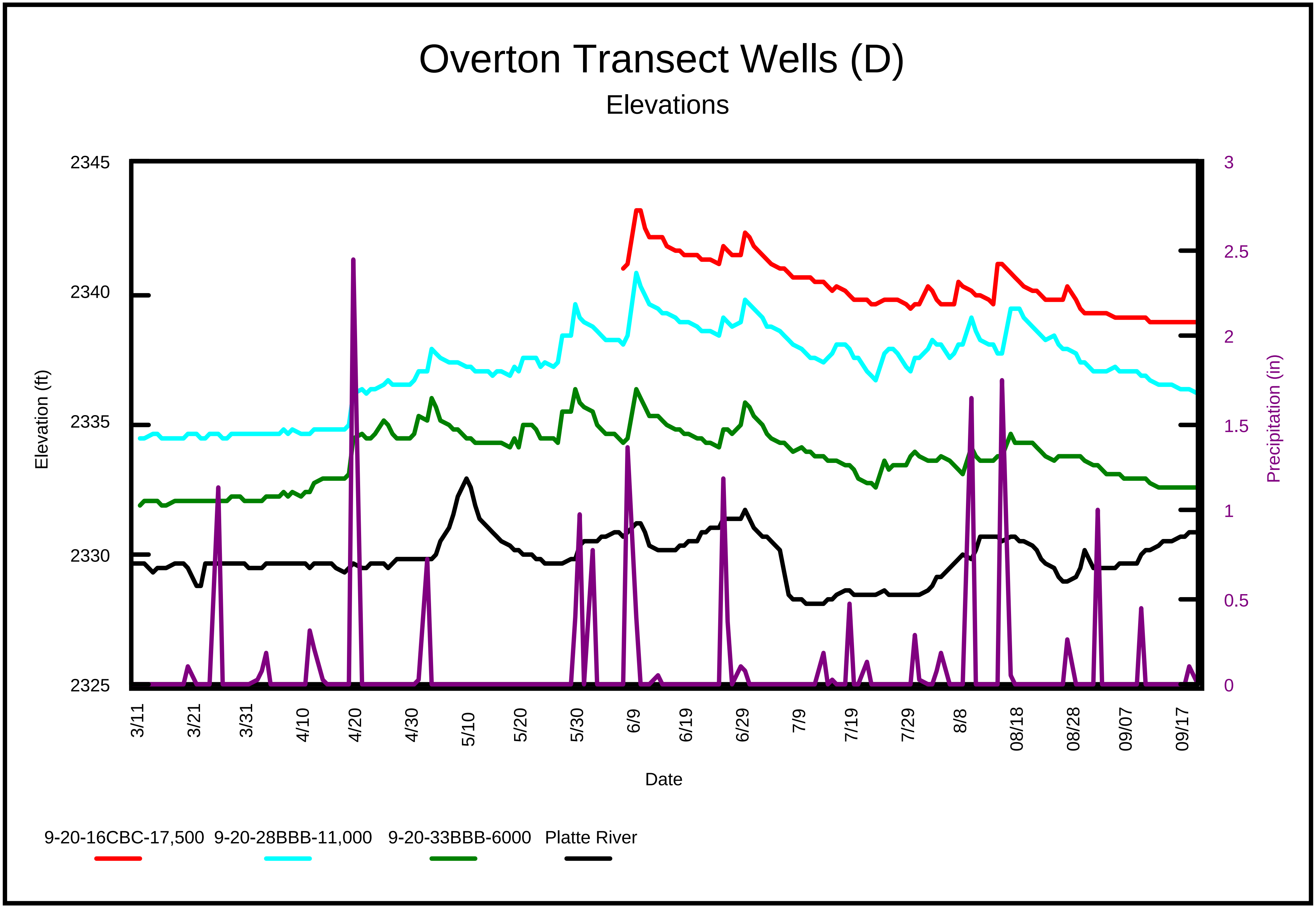
Overton Transect Wells (U)
Elevations
WEll #9-20-17CCC - 15,500
Elevation (ft)
2350
2345
2340
2335
2330
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
Platte River
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/9
6/19
6/29
7/9
7/19
7/29
8/8
08/18
08/28
09/07
09/17
Date



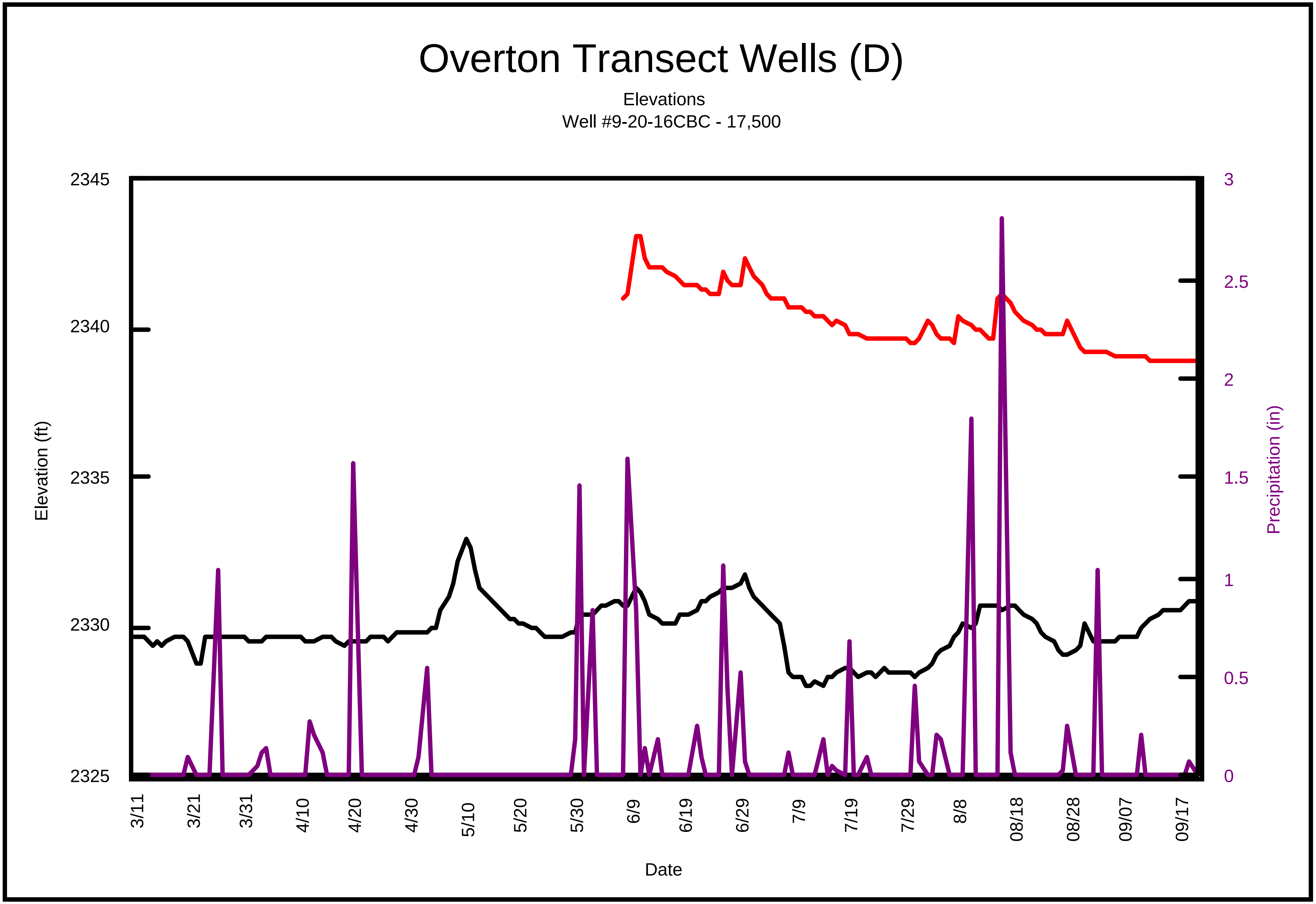
Overton Transect Wells (U)
Elevations
Well #9-20-20CCB - 11,200
Elevation (ft)
Precipitation (in)
Platte River
2350
2345
2340
2335
2330
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/9
6/19
6/29
7/9
7/19
7/29
8/8
08/18
08/28
09/07
09/17
Date



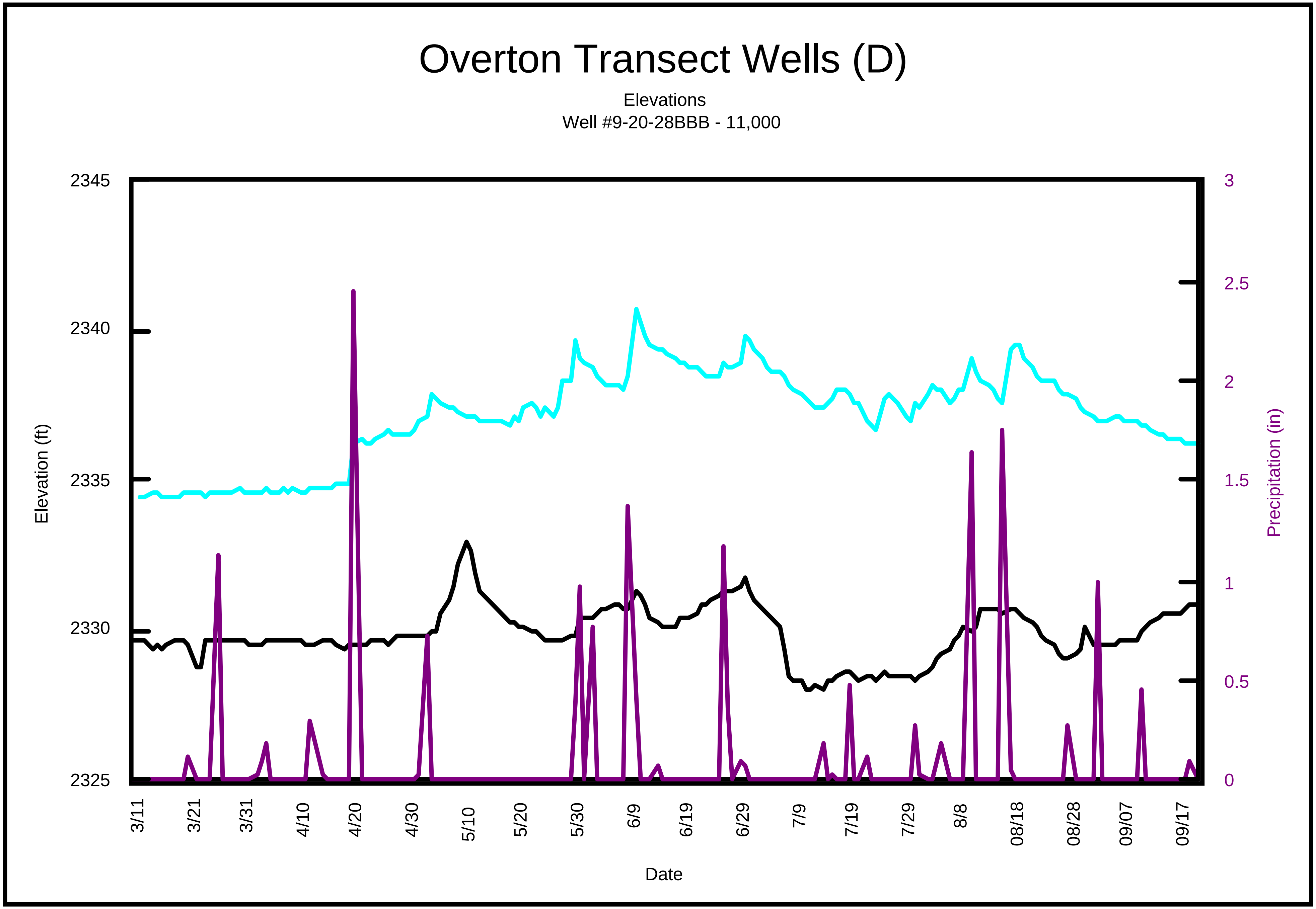
Overton Transect Wells (U)
Elevations
Well #9-20-30DDD - 5000
Elevation (ft)
2344
2343
2342
2341
2340
2339
2338
2337
2336
2335
2334
2333
Platte River
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/9
6/19
6/29
7/9
7/19
7/29
8/8
08/18
08/28
09/07
09/17
Date



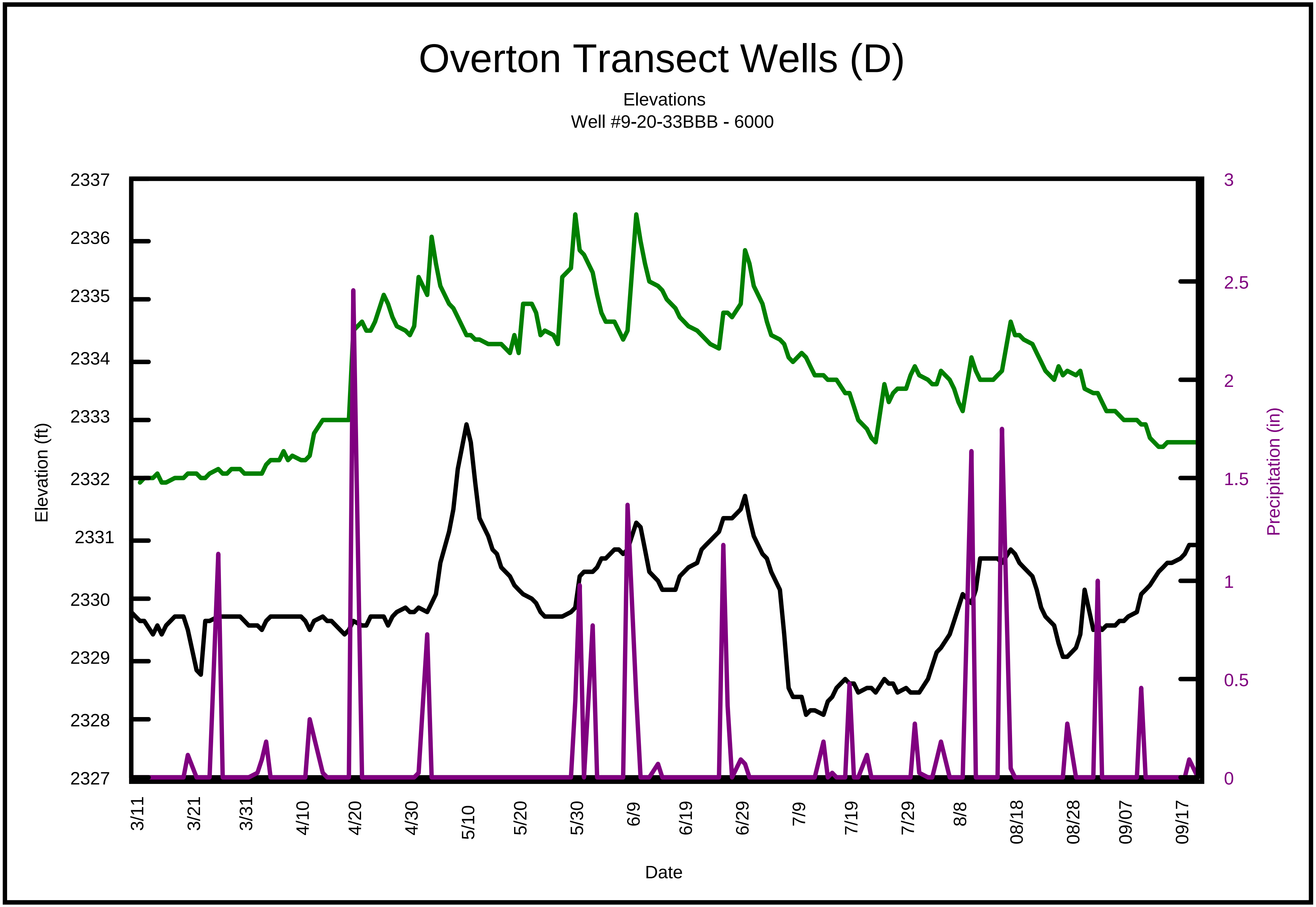
Overton Transect Wells (D)
Elevations
Elevation (ft)
2345
2340
2335
2330
2325
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/9
6/19
6/29
7/9
7/19
7/29
8/8
08/18
08/28
09/07
09/17
Date
9-20-16CBC-17,500
9-20-28BBB-11,000
9-20-33BBB-6000
Platte River



Overton Transect Wells (D)
Elevations
Well #9-20-16CBC - 17,500
Elevation (ft)
2345
2340
2335
2330
2325
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/9
6/19
6/29
7/9
7/19
7/29
8/8
08/18
08/28
09/07
09/17
Date



Overton Transect Wells (D)
Elevations
Well #9-20-28BBB - 11,000
Elevation (ft)
2345
2340
2335
2330
2325
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/9
6/19
6/29
7/9
7/19
7/29
8/8
08/18
08/28
09/07
09/17
Date



Overton Transect Wells (D)
Elevations
Well #9-20-33BBB - 6000
Elevation (ft)
2337
2336
2335
2334
2333
2332
2331
2330
2329
2328
2327
Precipitation (in)
3
2.5
2
1.5
1
0.5
0
3/11
3/21
3/31
4/10
4/20
4/30
5/10
5/20
5/30
6/9
6/19
6/29
7/9
7/19
7/29
8/8
08/18
08/28
09/07
09/17
Date

APPENDIX G

Source Information on Precipitation Data

Precipitation data that are plotted with the monitoring well data are obtained from radar data of the Missouri Basin Regional Forecast Center, NOAA. The radar data are collected hourly by grid cell.

The grid coordinate system used to identify the location of stations and basin boundaries is the same coordinate system as used by the Hydrologic Rainfall Analysis Project (HRAP). The grid is based on a polar stereographic map projection with a standard latitude of 60^0 North and standard longitude of 105^0 West. The mesh length at 60^0 North latitude is 4.7625 km; mesh lengths at other latitudes can be computed from:

$$z = 4.7625/((1+\sin 60^0)/(1+\sin 0))$$

The mesh lengths at the Platte River are approximately 4 km x 4 km or 4 square miles.

The orientation and mesh length of the grid contains the National Meteorological Center Limited Fine Mesh (LFM I) and the NWS Manually Digitized Radar (MDR) grids as subsets. The HRAP grid mesh length is 1/40 and 1/10 the size of the LFM I and MDR mesh lengths, respectively. Figure 1 shows the MDR box location map of the United States. Each MDR box has 100 HRAP grid cells. Figure 2 shows the division of the United States into the regional forecast centers based on river basins.

Figure 3 shows the area of interest for this study with the HRAP grid cell identifiers. The location of the National Weather Service gauging stations is marked by an “X” on this figure. Figures 4, 5, and 6 show the HRAP grid cell identifiers for each well. Figure 7 is a graphic example of the data for these cells. It shows rainfall for the wells on July 25, 1999, one of the wettest days of 1999 in this area. The small numbers in the grid cells on this figure indicate the amount of precipitation for that grid cell.

The data is sent to our internet computer in a tar file by the MBRFC. Typically, there are 3 days of data included in each file: the current date, the preceding date, and the date preceding the preceding date (e.g., a file sent on January 10 would include data for January 10, January 9, and January 8). Using netCDF, computer routines developed by UCAR (University Corporation for Atmospheric Research) to provide a common data access method for the various Unidata applications, the data from the tar file is extracted and combined with the grid cell identifiers so it can be used to display NEXRAD data in a mapping format. An assessment of the directory file structure is made to determine if changes to data previously collected have been made and to ensure we retain the most current and accurate data.

After the data have been extracted and combined with the grid cell identifiers, the data are moved to the spreadsheet with the data from the monitoring wells.

NEXRAD PRECIPITATION DATA

The Bureau of Reclamation is working on several projects in the western United States using WSR-88D (Weather Surveillance Radar-1988 Doppler, also known as NEXt generation weather RADar or NEXRAD) based Quantitative Precipitation Estimates (QPE) over watersheds draining into reservoirs. While the Central Platte area is not one of the active projects, the technology and the data are available for the area.

The NEXRAD data is used to estimate the precipitation in discrete cells that are 4 kilometers on a side or roughly 4 square miles.

NEXRAD DATA

NEXRAD precipitation estimates are derived products produced by the NWS Radar Product Generators (RPGs). The radar reflectivity data are converted to rainfall rates using a *Z-R* relationship, and precipitation accumulations are then calculated (Crum et al., 1993; Klazura and Imy, 1993). Level I data are the analog signals from the Radar Data Acquisition (RDA) site, Level II data are the digital base data output from the RDA signal processor, and Level III data are the base and derived products/algorithm output produced by the NWS NEXRAD RPGs. Following are descriptions of the Level III HDP products.

Stage I: Stage I precipitation processing, also referred to as the NEXRAD Precipitation Processing Subsystem (PPS), runs on the NEXRAD computers (RPGs) located at the NWS local Weather Forecast Offices. The PPS generates the Hourly Digital Precipitation (HDP) accumulation product that uses the Hydrologic Rainfall Analysis Project (HRAP) grid cells, sized at about 4- by 4-kilometer (km).

Stage II: Stage II precipitation processing creates hourly precipitation estimates (HDP) using Stage I output in combination with rain gage data. Rain gage data are used to adjust the radar data, using an objective analysis procedure, to create a multi-sensor hourly precipitation estimated accumulation analysis. At present, the Stage I output data are passed to the NWS River Forecast Centers (RFC) for follow-up Stage II and Stage III precipitation processing.

Stage III: Stage III processing mosaics (merges) the Stage II analyses from individual radars, using tools that allow the forecaster to analyze and edit the individual multi-sensor analysis to create an HDP product for the entire RFC's area of responsibility. These data are generated into Network Common Data Format (NetCDF) or xmrg (binary file format) files.

The digital hourly NEXRAD precipitation estimates are automatically collected into the AWARDS computer via File Transfer Protocol (FTP) from the RFCs within 45-minutes of the next hour. Once a full 24 hours are accumulated, computer programs produce 24-hour summaries and make them available on the Internet site maps (images).

- -

Reclamation's NEXRAD Web page (Internet site) for the AWARDS program is at:

http://www.usbr.gov/rsmg/nexrad.

NEXRAD data for the High Plains are received hourly via an automated file transfer process from the National Weather Service Missouri Basin River Forecast Center in Pleasant Hill, MO.

The data have been retrieved and stored for the cells that contain the wells that Reclamation monitored during the spring and summer of 1999. The data were used in the analyses of the water table fluctuations in lieu of data from weather stations located several miles distant.

The figures in this appendix are:

1. NWS Manually Digitized Radar (MDR) box location map of the United States.

2. Division of the United States into the NWS Regional Forecast Centers based on river basins.

3. Area of interest for this study with the HRAP grid cell identifiers.

4-6. HRAP grid cell identifiers for each well.

7. Precipitation map of all wells for July 25, 1999, one of the wettest days of 1999 for this area.

REFERENCES

Brower, L.A., and C.L. Hartzell, 1998: Agricultural Water Resources Decision Support System (AWARDS). *Proceedings, 14th Technical Conference - 1998, U.S. Committee on Irrigation and Drainage*, pp 127-140.

Crum, T.D., Alberty, R.L., and Burgess, D.W., 1993: Recording, Archiving, and Using WSR-88D Data. Bulletin American Meteorological Society, 74, pp. 645-653.

Klazura, G.E. and Imy, D.A., 1993: A Description of the Initial Set of Analysis Products Available from the NEXRAD WSR-88D System. Bulletin American Meteorological Society, 74, pp. 1293-1311.

APPENDIX H

YEAR 2000 MONITORING RESULTS

Sixteen wells were monitored during the year 2000 beginning in March. Due to technical difficulties with the monitoring equipment, some of the data was lost. However, the data that was saved indicates that no significant events occurred during the period of missed data. All of the problems were corrected by May 2, 2000.

The hydrographs contained in this appendix show the relative elevations of each well and the river at the transect location. The NEXRAD precipitation estimate is included on each hydrograph. Wells that were monitored in 1999 and 2000 have the 1999 data shown along with the respective river elevations and NEXRAD precipitation for 1999.

Wells in the Alda and Elm Creek transects are often several feet different than the river elevation. In that case, minor changes in the hydrograph are hard to detect due to the large vertical scale required to show both hydrographs. This problem was overcome by reprinting the hydrographs showing a difference from mean rather than the true elevation. Both prints are included.

EXECUTIVE SUMMARY

THE ISSUE: HIGH GROUND WATER LEVELS

Many areas in the Central Platte Valley in Nebraska have been experiencing high ground water levels for several years, causing problems with waterlogged farm fields and flooded basements. Some local land owners are concerned that additional flows generated by the Endangered Species Recovery Program (Program) water management will cause existing problems to become worse.

ANALYSIS OF INTERRELATED FACTORS

To determine the range of potential effects from the Program's proposed environmental water account, Reclamation analyzed the relationships of ground water levels, river flows, and precipitation. Our major findings were:

Topography.– Aquifer recharge from precipitation in central Nebraska is relatively high due to the generally flat terrain and the sandy soil textures.

Geology and soils.– The aquifer is highly permeable and has positive connection to the Platte River (meaning ground water can flow easily between the aquifer and the river).

Climate.– Precipitation has been well above normal since 1980, which contributes to water tables that are higher than they have been since the 1950s (the onset of extensive irrigation pumping) and are generally rising.

Irrigation.– Irrigation from river diversions has raised the water table within the irrigated areas and near canals and reservoirs. Irrigation by wells has tended to lower water tables or at least reduce the flow toward the river.

River levels

- River levels have an influence on ground water levels near the river. At distances more than a few thousand feet from the river, the water table elevation is generally several feet higher than the river and thus does not react to river levels.

- Because ground water moves slowly, river rises and adjacent ground water level rises are not simultaneous if the ground water level is responding to a change in the river. Thus, when ground water levels rise at the same time as the river rises, a third factor (e.g., precipitation) must be involved.
- Infiltration in the Platte River Valley is high and the storage capacity is about 15 to 20 percent. One inch of rainfall that reaches the water table raises the water table 5 to 6 inches.

- Ground water levels in the Central Platte Valley outside the flood plain are typically higher than the river elevation. Therefore, water movement is toward the river. Currently, the one exception is in the Upper Little Blue River drainage where irrigation pumpage has exceeded recharge enough to create a large cone of depression.

- Within the primary flood plain, the ground surface is typically 1 to 3 feet above the river water level. In such conditions, evaporation and plant usage work to lower the water table to roughly the same elevation as the river. When this condition develops, ground water movement tends to be down the valley parallel to the river.

- From 1980 to 1999, the area has received a total of 42 inches more than normal precipitation. The least accumulation was 20 inches at Paxton and the greatest was 67 inches at Loup City. Several of the stations have received 10 percent or more above normal for the past 19 years.

PROGRAM FLOWS

During the first increment of the Proposed Program (10 to 13 years), the Program will seek to provide improved flows in the Central Platte River for endangered species. Two proposed types of Program water releases were analyzed:

- **Pulse flows** would raise the river level at most 10 to 12 inches (but not above full bank capacity) for 3 days. Under this regime, ground water levels would raise 1½ inches 500 feet from the river and ½ inch 2,000 feet from the river for a short time. Ground water levels would not be affected more than 3,500 feet from the river.

- **Base flow augmentation** would add 500 and 1000 cfs to existing flows. These increases would be provided several times during the average year to meet various species' needs. Flows would raise the river by about 5 inches. If this continued for 30 days, ground water levels would raise by 3 inches 500 feet from the river and 1 inch 2,000 feet from the river. Ground water levels would not be affected more than 3,000 feet from the river.

PROBLEM: HIGH GROUND WATER LEVELS

> People currently experiencing problems with high ground water levels are concerned that higher river flows could aggravate their problems.
>
> The Platte River Endangered Species Recovery Program is examining possible future alternatives to modify flows to help endangered species. These river flows have not been implemented. implemented.

Low-lying areas along the Platte River Valley in Nebraska (from North Platte east to Grand Island and beyond) are subject to high ground water levels. These levels can cause waterlogged farm fields and flooded basements. In recent years, these problems have been somewhat more widespread for a variety of interrelated reasons. In the summer of 1999, for example, yearly rainfall totals ran almost 7 inches above normal. Irrigation was delayed well past the normal start of the irrigation season and irrigation managers reported that they had "a high water table problem all over." The only pumps running were those draining basements and flooded fields (*Kearney Hub*, "June rain surplus puts irrigation pumps on hold," July 1, 1999).

At the same time, flows in the Platte River at certain times in the year are not enough to meet the needs of several endangered species. In July 1997, the states of Colorado, Nebraska, and Wyoming, and the U.S. Department of the Interior (DOI), signed a cooperative agreement to make more water available in the river at times when wildlife can use it, and provide more acres for habitat along the river. Numerous agencies in the three states and DOI are working with water user organizations, local farmers and landowners, and environmental groups to develop a Program aimed at improving land and water habitat for four threatened and endangered species that use the Central Platte River in Nebraska. These groups have not yet completed work on a Proposed Program. At some time in the future, this Program may modify streamflows to benefit threatened and endangered species. Some people currently experiencing problems are concerned that such releases, if made in the future, could aggravate existing problems from high ground water levels.